

CCfits

2.5

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Contents

1	CCfits Documentation	1
1.1	Introduction	2
1.2	About this Manual	2
1.3	Release Notes for Version 2.5 Jan 2016	3
1.4	Authors and Acknowledgements	4
2	Implementation Notes	4
3	Installing the Package	6
3.1	Platforms	6
3.2	Building	6
3.2.1	Instructions for Building CCfits on UNIX-like platforms:	6
3.2.2	Instructions for Microsoft Windows build:	8
4	Getting Started	9
4.1	Driver Program	9
5	Writing Primary Images and Image Extensions	11
6	Creating and Writing to an Ascii Table Extension	14
7	Creating and Writing to a Binary Table Extension	18
8	Copying an Extension between Files	22
9	Selecting Table Data	23
10	Reading Header information from a HDU	24
11	Reading an Image	25
12	Reading a Table Extension	26
13	Reading with Extended File Name Syntax	27

14 Previous Release Notes	28
15 What's Present, What's Missing, and Calling CFITSIO	33
15.1 What's Not Present	34
15.2 Calling CFITSIO	34
16 Todo List	34
17 Module Index	35
17.1 Modules	35
18 Namespace Index	35
18.1 Namespace List	35
19 Class Index	35
19.1 Class Hierarchy	35
20 Class Index	37
20.1 Class List	37
21 Module Documentation	40
21.1 FITS Exceptions	40
22 Namespace Documentation	41
22.1 CCfits Namespace Reference	41
22.1.1 Detailed Description	43
22.1.2 Enumeration Type Documentation	43
22.1.3 Function Documentation	43
22.2 FITSUtil Namespace Reference	44
22.2.1 Detailed Description	44
23 Class Documentation	44
23.1 CCfits::AsciiTable Class Reference	44
23.1.1 Detailed Description	45
23.1.2 Constructor & Destructor Documentation	45

23.1.3	Member Function Documentation	47
23.2	CCfits::BinTable Class Reference	47
23.2.1	Detailed Description	49
23.2.2	Constructor & Destructor Documentation	49
23.2.3	Member Function Documentation	50
23.3	CCfits::Column Class Reference	51
23.3.1	Detailed Description	56
23.3.2	Constructor & Destructor Documentation	56
23.3.3	Member Function Documentation	57
23.4	CCfits::Column::InsufficientElements Class Reference	65
23.4.1	Detailed Description	66
23.4.2	Constructor & Destructor Documentation	66
23.5	CCfits::Column::InvalidDataType Class Reference	67
23.5.1	Detailed Description	67
23.5.2	Constructor & Destructor Documentation	67
23.6	CCfits::Column::InvalidNumberOfRows Class Reference	68
23.6.1	Detailed Description	68
23.6.2	Constructor & Destructor Documentation	68
23.7	CCfits::Column::InvalidRowNumber Class Reference	69
23.7.1	Detailed Description	69
23.7.2	Constructor & Destructor Documentation	69
23.8	CCfits::Column::InvalidRowParameter Class Reference	70
23.8.1	Detailed Description	70
23.8.2	Constructor & Destructor Documentation	70
23.9	CCfits::Column::NoNullValue Class Reference	71
23.9.1	Detailed Description	71
23.9.2	Constructor & Destructor Documentation	71
23.10	CCfits::Column::RangeError Class Reference	72
23.10.1	Detailed Description	72
23.10.2	Constructor & Destructor Documentation	72
23.11	CCfits::Column::WrongColumnType Class Reference	73

23.11.1 Detailed Description	73
23.11.2 Constructor & Destructor Documentation	73
23.12CCfits::ExtHDU Class Reference	74
23.12.1 Detailed Description	77
23.12.2 Constructor & Destructor Documentation	77
23.12.3 Member Function Documentation	78
23.13CCfits::ExtHDU::WrongExtensionType Class Reference	83
23.13.1 Detailed Description	84
23.13.2 Constructor & Destructor Documentation	84
23.14CCfits::FITS Class Reference	84
23.14.1 Detailed Description	88
23.14.2 Constructor & Destructor Documentation	88
23.14.3 Member Function Documentation	92
23.15CCfits::FITS::CantCreate Class Reference	97
23.15.1 Detailed Description	98
23.15.2 Constructor & Destructor Documentation	98
23.16CCfits::FITS::CantOpen Class Reference	98
23.16.1 Detailed Description	99
23.16.2 Constructor & Destructor Documentation	99
23.17CCfits::FITS::NoSuchHDU Class Reference	100
23.17.1 Detailed Description	100
23.17.2 Constructor & Destructor Documentation	100
23.18CCfits::FITS::OperationNotSupported Class Reference	101
23.18.1 Detailed Description	101
23.18.2 Constructor & Destructor Documentation	101
23.19CCfits::FitsError Class Reference	102
23.19.1 Detailed Description	102
23.19.2 Constructor & Destructor Documentation	102
23.20CCfits::FitsException Class Reference	102
23.20.1 Detailed Description	103
23.20.2 Constructor & Destructor Documentation	104

23.20.3 Member Function Documentation	104
23.21CCfits::FitsFatal Class Reference	104
23.21.1 Detailed Description	104
23.21.2 Constructor & Destructor Documentation	105
23.22CCfits::FITSUtil::auto_array_ptr< X > Class Template Reference	105
23.22.1 Detailed Description	106
23.23CCfits::FITSUtil::CAarray< T > Class Template Reference	106
23.23.1 Detailed Description	107
23.24CCfits::FITSUtil::CVAarray< T > Class Template Reference	107
23.24.1 Detailed Description	107
23.25CCfits::FITSUtil::CVarray< T > Class Template Reference	107
23.25.1 Detailed Description	108
23.26CCfits::FITSUtil::MatchName< T > Class Template Reference	108
23.26.1 Detailed Description	108
23.27CCfits::FITSUtil::MatchNum< T > Class Template Reference	108
23.27.1 Detailed Description	109
23.28CCfits::FITSUtil::MatchPtrName< T > Class Template Reference	109
23.28.1 Detailed Description	109
23.29CCfits::FITSUtil::MatchPtrNum< T > Class Template Reference	109
23.29.1 Detailed Description	110
23.30CCfits::FITSUtil::MatchType< T > Class Template Reference	110
23.30.1 Detailed Description	110
23.31CCfits::FITSUtil::UnrecognizedType Class Reference	110
23.31.1 Detailed Description	111
23.32CCfits::HDU Class Reference	111
23.32.1 Detailed Description	114
23.32.2 Member Function Documentation	115
23.33CCfits::HDU::InvalidExtensionType Class Reference	120
23.33.1 Detailed Description	121
23.33.2 Constructor & Destructor Documentation	121
23.34CCfits::HDU::InvalidImageDataType Class Reference	121

23.34.1 Detailed Description	122
23.34.2 Constructor & Destructor Documentation	122
23.35CCfits::HDU::NoNullValue Class Reference	122
23.35.1 Detailed Description	123
23.35.2 Constructor & Destructor Documentation	123
23.36CCfits::HDU::NoSuchKeyword Class Reference	123
23.36.1 Detailed Description	124
23.36.2 Constructor & Destructor Documentation	124
23.37CCfits::ImageExt< T > Class Template Reference	124
23.37.1 Detailed Description	125
23.37.2 Member Function Documentation	126
23.38CCfits::Keyword Class Reference	127
23.38.1 Detailed Description	129
23.38.2 Constructor & Destructor Documentation	129
23.38.3 Member Function Documentation	129
23.39CCfits::PHDU Class Reference	130
23.39.1 Detailed Description	132
23.39.2 Constructor & Destructor Documentation	133
23.39.3 Member Function Documentation	133
23.40CCfits::Table Class Reference	137
23.40.1 Detailed Description	138
23.40.2 Constructor & Destructor Documentation	139
23.40.3 Member Function Documentation	139
23.41CCfits::Table::NoSuchColumn Class Reference	142
23.41.1 Detailed Description	143
23.41.2 Constructor & Destructor Documentation	143

1 CCfits Documentation

CCfits requires CFITSIO

1.1 Introduction

CCfits is an object oriented interface to the cfitsio library. cfitsio is a widely used library for manipulating FITS (Flexible Image Transport System) formatted files. This following documentation assumes prior knowledge of the FITS format and some knowledge of the use of the cfitsio library, which is in wide use, well developed, and available on many platforms.

Readers unfamiliar with FITS but in need of performing I/O with FITS data sets are directed to the first cfitsio manual, available at <http://heasarc.gsfc.nasa.gov/docs/software/fitsio/fitsio.html>. Information about the FITS file format and the current standard is available from <http://fits.gsfc.nasa.gov>

The **CCfits** library provides an interface that allows the user to manipulate FITS format data through the high-level building blocks of FITS files and Header-Data Units (HDUs). The implementation is designed to hide the details of performing FITS I/O from the user, who will write calls that manipulate FITS objects by passing filenames and lists of strings that represent HDUs, keywords, image data and data columns. Unlike cfitsio, which typically requires several calls to access data (*e.g. open file, move to correct header, determine column containing table data, read data*) **CCfits** is designed to make reading data atomic. For example, it exploits internally existing optimization techniques for FITS I/O, choosing the optimal reading strategy as available [see the cfitsio manual, Chapter 13] when data are read on initialization. Data written by **CCfits** will also be compliant with the FITS standard by specification of class constructors representing FITS dataset elements.

CCfits necessarily works in a fundamentally different way than cfitsio. The general pattern of usage for **CCfits** is: create a FITS object, which either opens a disk file or creates a new disk file, create references to existing or new HDU objects within it, and manipulated the data through the references. For files with Write access the library is designed to keep the FITS object on disk in sync with the memory copy. The additional memory copy increases the resources required by a calling program in return for some flexibility in accessing the data.

1.2 About this Manual

This document lays out the specification for the **CCfits** library.

The next sections document the installation procedure and the demonstration program *cookbook* which gives examples of usage with comments.

Following sections give a list of what is implemented in **CCfits** compared to the cfitsio library. For background information and as an example there is a section describing how **CCfits** is to be used in XSPEC, for which it was originally designed, which may serve to give the reader some insight into the design decisions made.

1.3 Release Notes for Version 2.5 Jan 2016

Backwards Compatibility Issues:

- As part of an effort to allow tables to hold multiple columns with the same name (see "Enhancements" section), the Table class now stores Column objects in an internal multimap rather than a map. This affects the public interface in 2 places: the ExtHDU::column() and Table::column() accessor functions. These used to return a std::map reference, but now return a std::multimap (using new typedef 'ColMap' defined in [CCfits.h](#)).
- Removed the ImageExt<T>::image() accessor function from the public interface. This was only ever intended for internal use.

Enhancements:

- Added scripts for building with the CMake system, primarily intended for builds on Windows platforms.
- New functions: ExtHDU::copyColumn, HDU::readNextKey, HDU::resetImageRead, and a new Column::read overload for returning a single row into a std::vector.
- Keyword reads can now convert numerical types into strings.
- Added support for variable-width string columns (with new ValueType enum = VTstring).
- Image write functions are now allowed to dynamically increase the size of the outer dimension as needed. The corresponding NAXIS keyword will be updated automatically.
- Tables can now handle having multiple columns with the same column name. (Also see "Backwards Compatibility" section.)
- Added support for read/write of LONGLONG types for images.
- Added handling of 'D' exponent notation when reading keyword values with floating-point types.

Bug Fixes:

- Improved memory caching when reading images, reducing the number of unnecessary disk reads.
- Removed header inclusion of [config.h](#) due to potential conflicts with users' customized autotools [config.h](#) files.

- HDU's '<<' output operator was not showing output for the highest numbered axis.
- Removed unused NewColumn.h code file.
- Fixed memory leak in internal Column::setLimits function.
- Added #include statements to various files, the absence of which was causing compilation failures on recent Windows Visual Studio builds.
- Added missing 'break' statement for Tlonglong case in internal FITSType2String function.
- Replaced a valarray operation in [ColumnVectorData.h](#) file which caused a compiler glitch on certain Mac platforms. (This was previously released as a patch.)
- Fix made to HDU's getHistory and getComments internal search algorithm.
- Fix to FITS::addTable function for case where new table shares its name with a pre-existing HDU but has a different version number.
- Fix to memory management for certain Column write operations.

For a more complete listing, see the CHANGES file distributed with the software. For earlier versions, see [Previous Release Notes](#).

1.4 Authors and Acknowledgements

[CCfits](#) was written as part of a re-engineering effort for the X-Ray data analysis program, XSPEC. It was designed using Rational Rose and originally implemented on a Solaris platform by Ben Dorman to whom blame should be attached. Sandhia Bansal worked on part of the implementation and, and Paul Kunz (pfkeb@slac.stanford.edu) wrote the configuration scheme and dispensed helpful advice: both are also thanked profusely for the port to Windows2000/VC++.net. Thanks to R. Mathar (MPIA) and - Patrik Jonsson (Lick Obs.) for contributing many helpful suggestions and bug reports, and ports to HP-UX and AIX respectively.

[CCfits](#) is currently maintained by Craig Gordon and Bryan Irby (ccfits@heasarc.gsfc.nasa.gov). Suggestions and bug reports are welcome, as are offers to fill out parts of the implementation that are missing. We are also interested in knowing which parts of cfitsio that are not currently supported should be the highest priority for future extensions.

2 Implementation Notes

This section comments on some of the design decisions for [CCfits](#). We note the role of cfitsio in [CCfits](#) as the underlying "engine," the use of the C++ standard library. We also

explain some of the choices made for standard library containers in the implementation - all of which is hidden from the user [as it should be].

Most importantly, the library wraps rather than replaces the use of cfitsio library; it does not perform direct disk I/O. The scheme is designed to retain the well-developed facilities of cfitsio (in particular, the extended file syntax), and make them available to C++ programmers in an OO framework. Some efficiency is lost over a 'pure' C++ FITS library, since the internal C implementation of many functions requires processing if blocks or switch statements that could be recoded in C++ using templates. However, we believe that the current version strikes a reasonable compromise between developer time, utility and efficiency.

The implementation of [CCfits](#) uses the C++ Standard Library containers and algorithms [also referred to as the Standard Template Library, (STL)] and exception handling. Here is a summary of the rationale behind the implementation decisions made.

- HDUs are contained within a FITS object using a `std::multimap<string, HDU*>` object.
 1. The map object constructs new array members on first reference
 2. Objects stored in the map are sorted on entry and retrieved efficiently using binary search techniques.
 3. The pointer-to-HDU implementation allows for polymorphism: one set of operations will process all HDU objects within the FITS file
 4. String objects (`char*`) are represented by the `std::string` class, which has a rich public interface of search and manipulation facilities.
- Scalar column data [one entry per cell] are implemented using `std::vector<T>` objects.
- Vector column data [multiple and either fixed or variable numbers of entries per cell] are implemented using `std::vector<std::valarray<T>>` objects. The `std::valarray` template is intended for optimized numeric processing. `valarrays` are have the following desirable features:
 1. they are dynamic, but designed to be allocated in full on construction rather than dynamic resizing during operation: this is, what is usually needed in FITS files.
 2. They have built-in vectorized transcendental functions (e.g. `std::valarray<T> sin(const std::valarray<T>&)`).
 3. They provide `std::valarray<T> apply(T f(const T&))` operation, to apply a function `f` to each element
 4. They provide slicing operations [see the "Getting Started" section for a simple example].

- Exceptions are provided in for by a FitsException hierarchy, which prints out messages on errors and returns control to wherever the exception is caught. Non-zero status values returned by cfitsio are caught by subclass FitsError, which prints the string corresponding to an input status flag. FitsException's other subclasses are thrown on array bounds errors and other programming errors. Rare [we hope] errors that indicate programming flaws in the library throw FitsFatal errors that suggest that the user report the bug.

3 Installing the Package

3.1 Platforms

CCfits is generally supported on the same platforms as **HEASOFT**, and on Windows with VC++ 7.0 or later. See the HEASOFT [supported platforms](#) page.

3.2 Building

To build and install **CCfits** from source code on a UNIX-like (e.g. UNIX, Linux, or Cygwin) platform, take the following steps. For building on a Microsoft Windows platform with - Visual Developer Studio, see below.

3.2.1 Instructions for Building CCfits on UNIX-like platforms:

1. Configure

By default, the GCC compiler and linker will be used. If you want to compile and link with a different compiler and linker, you can set some environment variable before running the configure script. For example, to use Sun's C++ compiler, do the following:

```
> setenv CXX CC (csh syntax)
```

or

```
> export CXX=CC (bash syntax)
```

You can set the absolute path to the compiler you want to use if necessary.

CCfits requires that the CFITSIO package, version 3.08 or later, is available on your system. See

<http://heasarc.gsfc.nasa.gov/docs/software/fitsio/fitsio.-html>

for more information. The configure script that you will run takes an option to specify the location of the CFITSIO package.

If the CFITSIO package is installed in a directory consisting of a 'lib' subdirectory containing "libcfitsio.a" or "libcfitsio.so" and an 'include' subdirectory containing "fitsio.h", then you can run the configure script with a single option. For example, if the cfitsio package is installed in this fashion in /usr/local/cfitsio/ then the configure script option will be

```
--with-cfitsio=/usr/local/cfitsio
```

If the CFITSIO package is not installed in the above manner, then you need to run the configure script with two options, one to specify the include directory and the other to specify the library directory. For example, if the cfitsio package was built in /home/user/cfitsio/ then the two options will be

```
--with-cfitsio-include=/home/user/cfitsio --with-cfitsio-libdir=/home/user/cfitsio
```

For users of HEASOFT (instead of stand-alone CFITSIO): Note that modern distributions of HEASOFT only include a "libcfitsio_X.XX.so" library by default, but the configure script needs to find "libcfitsio.so", so you will need to create a symbolic link in \$HEADAS/lib/ linking libcfitsio.so -> libcfitsio_X.XX.so in order for [CCfits](#) to configure properly. You can then configure [CCfits](#) using "--with-cfitsio=\$HEADAS/lib".

You have the option of carrying out the build in a separate directory from the source directory or in the same directory as the source. In either case, you need to run the configure script in the directory where the build will occur. For example, if building in the source directory with the cfitsio directory in /usr/local/cfitsio/ then the configure command should be issued like this:

```
> ./configure --with-cfitsio=/usr/local/cfitsio
```

If you do the build in a separate directory from the source, you may need to issue the configure command something like this:

```
> ../CCfits/configure --with-cfitsio=/usr/local/cfitsio
```

The configure script will create the Makefile with the path to the compiler you choose (or GCC by default), and the path to the CFITSIO package. The configure script has other options, such as the install location. To see these options type

```
> ./configure --help
```

2. Build

Building the C++ shared library and Java classes will be done automatically by running make without arguments like this:

```
> gmake
```

3. Install

To install, type:

```
> make install
```

The default install location will be /usr/local/lib for the library and /usr/local/include for

the header files. You can change this with the `--prefix` option when you configure, or with something like...

```
> make DESTDIR=/usr/local/CCfits install
```

3.2.2 Instructions for Microsoft Windows build:

These instructions follow similar steps to the building of the CFITSIO library on Windows, described at

<http://heasarc.gsfc.nasa.gov/FTP/software/fitsio/c/README-E.win>

and rely having the following already installed on your system:

a) Microsoft Visual Studio b) The CMake build system available from <http://www.cmake.org> c) The CFITSIO library available from

<http://heasarc.gsfc.nasa.gov/docs/software/fitsio/fitsio.html>

1. After unzipping and untarring the **CCfits** source code tarball, the source code will appear in a new **CCfits** subdirectory.

2. Open the Visual Studio Developer Command Prompt window and create a directory named "CCfits.build" parallel to this **CCfits** source code directory.

```
mkdir CCfits.build cd CCfits.build
```

This will be the directory from which CMake generate its files and performs the build.

3. Decide which CMake generator you will want to use. The full list is shown by doing `cmake.exe /?`

We've done successful builds using Visual Studio's 'nmake' utility, and so recommend choosing "NMake Makefiles" as the generator option. However if you wish to perform the build inside a Visual Studio IDE, you should choose the appropriate "Visual Studio <version>" generator.

4. Now run `cmake.exe` to generate the necessary Makefiles. With this command you must specify the path to your CFITSIO library and header files by setting the 'DCMAKE_PREFIX_PATH' option. This path should be set to the root directory of your CFITSIO installation, from which it will look in `\lib` and `\include` subdirectories for the library and header files respectively. Your full `cmake` command may then look like:

```
CCfits.build>cmake.exe -G"NMake Makefiles" -DCMAKE_PREFIX_PATH=C:\path\to\your\CFITSIO ..\CCfits
```

If you wish to eventually install **CCfits** at any place other than the default location ("C:\Program Files"), you should pass an additional flag to the `cmake` command above:

```
-DCMAKE_INSTALL_PREFIX=C:\path\to\your\CCfits\installation
```

5. Build and install [CCfits](#):

```
CCfits.build> nmake
```

If all goes well you should now have a CCfits.lib library and cookbook.exe executable in your CCfits.build directory. To test the build you can run cookbook.exe, which should generate 3 output FITS files: atestfil, btestfil, and ctestfil.fit.

Now install CCfits.lib and its header files into the default installation location, or the directory you specified in step 4:

```
CCfits.build> nmake install
```

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4 Getting Started

The program cookbook.cxx, analogous to the cookbook.c program supplied with cfitsio, was generated to test the correct functioning of the parts of the library and to provide a demonstration of its usage.

The code for cookbook is reproduced here with commentary as worked example of the usage of the library.

4.1 Driver Program

```
// The CCfits headers are expected to be installed in a subdirectory of
// the include path.

// The <CCfits> header file contains all that is necessary to use both the
// CCfits
// library and the cfitsio library (for example, it includes fitsio.h) thus
// making
// all of cfitsio's macro definitions available.

#ifdef HAVE_CONFIG_H
#include "config.h"
#endif

// this includes 12 of the CCfits headers and will support all CCfits
// operations.
// the installed location of the library headers is $(ROOT)/include/CCfits

// to use the library either add -I$(ROOT)/include/CCfits or #include
// <CCfits/CCfits>
// in the compilation target.

#include <CCfits>

#include <cmath>
```

```
// The library is enclosed in a namespace.

using namespace CCfits;

int main();
int writeImage();
int writeAscii();
int writeBinary();
int copyHDU();
int selectRows();
int readHeader();
int readImage();
int readTable();
int readExtendedSyntax();

int main()
{

    FITS::setVerboseMode(true);

    try
    {

        if (!writeImage()) std::cerr << " writeImage() \n";
        if (!writeAscii()) std::cerr << " writeAscii() \n";
        if (!writeBinary()) std::cerr << " writeBinary() \n";
        if (!copyHDU()) std::cerr << " copyHDU() \n";
        if (!readHeader()) std::cerr << " readHeader() \n";
        if (!readImage()) std::cerr << " readImage() \n";
        if (!readTable()) std::cerr << " readTable() \n";
        if (!readExtendedSyntax()) std::cerr << " readExtendedSyntax() \n";
        if (!selectRows()) std::cerr << " selectRows() \n";

    }
    catch (FitsException&)
    // will catch all exceptions thrown by CCfits, including errors
    // found by cfitsio (status != 0)
    {

        std::cerr << " Fits Exception Thrown by test function \n";

    }
    return 0;
}
```

The simple driver program illustrates the setting of verbose mode for the library, which makes all internal exceptions visible to the programmer. This is primarily for debugging purposes; exceptions are in some cases used to transfer control in common circumstances (e.g. testing whether a file should be created or appended to in write operations). Most of the exceptions will not produce a message unless this flag is set.

Nearly all of the exceptions thrown by [CCfits](#) are derived from `FitsException`, which is caught by reference in the above example. This includes all nonzero status codes returned by `cfitsio` by the following construct (recall that in the [cfitsio library](#) nearly all functions return a non-zero status code on error, and have a final argument status of type `int`):

```
if ( [cfitsio call](args,...,&status)) throw FitsError(status);
```

`FitsError`, derived from `FitsException`, uses a `cfitsio` library call to convert the status code to a string message.

The few exceptions that are not derived from `FitsException` indicate fatal conditions implying bugs in the library. These print a message suggesting the user contact [HEASARC](#) to report the problem.

Note also the lack of statements for closing files in any of the following routines, The destructor (dtor) for the `FITS` object does this when it falls out of scope. A call

`FITS::destroy()` throw()

is provided for closing files explicitly; `destroy()` is also responsible for cleaning up the `FITS` object and deallocating its resources.

When the data are being read instead of written, the user is expected to copy the data into other program variables [rather than use references to the data contained in the `FITS` object].

The routines in this program test the following functionality:

`writImage()` [Writing Primary Images and Image Extensions](#)

`writeAscii()` [Creating and Writing to an Ascii Table Extension](#)

`writeBinary()` [Creating and Writing to a Binary Table Extension](#)

`copyHDU()` [Copying an Extension between Files](#)

`selectRows()` [Selecting Table Data](#)

`readHeader()` [Reading Header information from a HDU](#)

`readImage()` [Reading an Image](#)

`readTable()` [Reading a Table Extension](#)

`readExtendedSyntax()` [Reading with Extended File Name Syntax](#)

5 Writing Primary Images and Image Extensions

This section of the code demonstrates creation of images. Because every fits file must have a PHDU element, all the `FITS` constructors (ctors) instantiate a `PHDU` object. - In the case of a new file, the default is to establish an empty `HDU` with `BITPIX = 8`

(BYTE_IMG). **A current limitation of the code is that the data type of the PHDU cannot be replaced after the FITS file is created.** Arguments to the FITS ctors allow the specification of the data type and the number of axes and their lengths. An image extension of type float is also written by calls in between the writes to the primary header demonstrating switch between HDUs during writes.

Note that in the example below data of type *float* is written to an image of type *unsigned int*, demonstrating both implicit type conversion and the cfitsio extension to unsigned data.

User keywords can be added to the PHDU after successful construction and these will both be accessible as container contents in the in-memory FITS object as well as being written to disk by cfitsio.

Images are represented by the standard library valarray template class which supports vectorized operations on numeric arrays (e.g. taking the square root of an array) and slicing techniques.

The code below also illustrates use of C++ standard library algorithms, and the facilities provided by the std::valarray class.

```
int writeImage()
{
    // Create a FITS primary array containing a 2-D image
    // declare axis arrays.
    long naxis = 2;
    long naxes[2] = { 300, 200 };

    // declare auto-pointer to FITS at function scope. Ensures no resources
    // leaked if something fails in dynamic allocation.
    std::auto_ptr<FITS> pFits(0);

    try
    {
        // overwrite existing file if the file already exists.

        const std::string fileName("!atestfil.fit");

        // Create a new FITS object, specifying the data type and axes for the
        // primary
        // image. Simultaneously create the corresponding file.

        // this image is unsigned short data, demonstrating the cfitsio
        // extension
        // to the FITS standard.

        pFits.reset( new FITS(fileName , USHORT_IMG , naxis , naxes ) );
    }
    catch (FITS::CantCreate)
    {
        // ... or not, as the case may be.
        return -1;
    }
}
```

```

// references for clarity.

long& vectorLength = naxes[0];
long& numberOfRows = naxes[1];
long nelelements(1);

// Find the total size of the array.
// this is a little fancier than necessary ( It's only
// calculating naxes[0]*naxes[1]) but it demonstrates use of the
// C++ standard library accumulate algorithm.

nelements = std::accumulate(&naxes[0],&naxes[naxis],1,std::multiplies<long>
    ());

// create a new image extension with a 300x300 array containing float data.

std::vector<long> extAx(2,300);
string newName ("NEW-EXTENSION");
ExtHDU* imageExt = pFits->addImage(newName,FLOAT_IMG,extAx);

// create a dummy row with a ramp. Create an array and copy the row to
// row-sized slices. [also demonstrates the use of valarray slices].
// also demonstrate implicit type conversion when writing to the image:
// input array will be of type float.

std::valarray<int> row(vectorLength);
for (long j = 0; j < vectorLength; ++j) row[j] = j;
std::valarray<int> array(nelements);
for (int i = 0; i < numberOfRows; ++i)
{
    array[std::slice(vectorLength*static_cast<int>(i),vectorLength,1)] =
        row + i;
}

// create some data for the image extension.
long extElements = std::accumulate(extAx.begin(),extAx.end(),1,
    std::multiplies<long>());
std::valarray<float> randData(extElements);
const float PIBY (M_PI/150.);
for ( int jj = 0 ; jj < extElements ; ++jj)
{
    float arg = PIBY*jj;
    randData[jj] = std::cos(arg);
}

long fpixel(1);

// write the image extension data: also demonstrates switching between
// HDUs.
imageExt->write(fpixel,extElements,randData);

//add two keys to the primary header, one long, one complex.

long exposure(1500);
std::complex<float> omega(std::cos(2*M_PI/3.),std::sin(2*M_PI/3));
pFits->pHDU().addKey("EXPOSURE", exposure,"Total Exposure Time");

```

```

pFits->pHDU().addKey("OMEGA",omega," Complex cube root of 1 ");

// The function PHDU& FITS::pHDU() returns a reference to the object
// representing
// the primary HDU; PHDU::write( <args> ) is then used to write the data.

pFits->pHDU().write(fpixel,nelements,array);

// PHDU's friend ostream operator. Doesn't print the entire array, just the
// required & user keywords, and is provided largely for testing purposes
// [see
// readImage() for an example of how to output the image array to a
// stream].

std::cout << pFits->pHDU() << std::endl;

return 0;
}

```

6 Creating and Writing to an Ascii Table Extension

In this section of the program we create a new Table extension of type `AsciiTbl`, and write three columns with 6 rows. Then we add another copy of the data two rows down (starting from row 3) thus overwriting values and creating new rows. We test the use of null values, and writing a date string. Implicit data conversion, as illustrated for images above, is supported. However, writing numeric data as character data, supported by `cfitsio`, is *not* supported by `CCfits`.

Note the basic pattern of `CCfits` operations: they are performed on an object of type `FITS`. Access to HDU extension is provided by `FITS::` member functions that return references or pointers to objects representing HDUs. Extension are never created directly (all extension ctors are protected), but only through the functions `FITS::addTable` and `FITS::addImage` which add extensions to an existing `FITS` object, performing the necessary `cfitsio` calls.

The `FITS::addTable` function takes as one of its last arguments a HDU Type parameter, which needs to be `AsciiTbl` or `BinTbl`. The default is to create a `BinTable` (see next function).

Similarly, access to column data is provided through the functions `ExtHDU::Column`, which return references to columns specified by name or index number - see the documentation for the class `ExtHDU` for details.

`addTable` returns a pointer to `Table`, which is the abstract immediate superclass of the concrete classes `AsciiTable` and `BinTable`, whereas `addImage` returns a pointer to `ExtHDU`, which is the abstract base class of all `FITS` extensions. These base classes implement the public interface necessary to avoid the user of the library needing to downcast to a concrete type.

```

int writeAscii ()

//*****
// Create an ASCII Table extension containing 3 columns and 6 rows *
//*****
{
    // declare auto-pointer to FITS at function scope. Ensures no resources
    // leaked if something fails in dynamic allocation.
    std::auto_ptr<FITS> pFits(0);

    try
    {

        const std::string fileName("atestfil.fit");

        // append the new extension to file created in previous function call.

        // CCfits writing constructor.

        // if this had been a new file, then the following code would create
        // a dummy primary array with BITPIX=8 and NAXIS=0.

        pFits.reset( new FITS(fileName,Write) );
    }
    catch (CCfits::FITS::CantOpen)
    {
        // ... or not, as the case may be.
        return -1;
    }

    unsigned long rows(6);
    string hduName("PLANETS_ASCII");
    std::vector<string> colName(3,"");
    std::vector<string> colForm(3,"");
    std::vector<string> colUnit(3,"");

    /* define the name, datatype, and physical units for the 3 columns */
    colName[0] = "Planet";
    colName[1] = "Diameter";
    colName[2] = "Density";

    colForm[0] = "a8";
    colForm[1] = "i6";
    colForm[2] = "f4.2";

    colUnit[0] = "";
    colUnit[1] = "km";
    colUnit[2] = "g/cm^-3";

    std::vector<string> planets(rows);

    const char *planet[] = {"Mercury", "Venus", "Earth",
                           "Mars", "Jupiter", "Saturn"};
    const char *mnemoy[] = {"Many", "Volcanoes", "Erupt",
                           "Mulberry", "Jam", "Sandwiches", "Under",

```

```

        "Normal", "Pressure"};

long diameter[] = { 4880,    12112,    12742,    6800,    143000,
                  121000};
float density[] = { 5.1f,    5.3f,    5.52f,    3.94f,    1.33f,    0.69
                  f};

// append a new ASCII table to the fits file. Note that the user
// cannot call the Ascii or Bin Table constructors directly as they
// are protected.

Table* newTable = pFits->addTable(hduName, rows, colName, colForm, colUnit,
    AsciiTbl);
    size_t j = 0;
for ( ; j < rows; ++j) planets[j] = string(planet[j]);

// Table::column(const std::string& name) returns a reference to a Column
// object

try
{
    newTable->column(colName[0]).write(planets, 1);
    newTable->column(colName[1]).write(diameter, rows, 1);
    newTable->column(colName[2]).write(density, rows, 1);

}
catch (FitsException&)
{
    // ExtHDU::column could in principle throw a NoSuchColumn exception,
    // or some other fits error may ensue.
    std::cerr << " Error in writing to columns - check e.g. that columns
of specified name "
                << " exist in the extension \n";

}

// FITSUtil::auto_array_ptr<T> is provided to counter resource leaks that
// may arise from C-arrays. It is a std::auto_ptr<T> analog that calls
// delete[] instead of delete.

FITSUtil::auto_array_ptr<long> pDiameter(new long[rows]);
FITSUtil::auto_array_ptr<float> pDensity(new float[rows]);
long* Cdiameter = pDiameter.get();
float* Cdensity = pDensity.get();

Cdiameter[0] = 4880; Cdiameter[1] = 12112; Cdiameter[2] = 12742; Cdiameter[
3] = 6800;
Cdiameter[4] = 143000; Cdiameter[5] = 121000;

Cdensity[0] = 5.1f; Cdensity[1] = 5.3f; Cdensity[2] = 5.52f;
    Cdensity[3] = 3.94f; Cdensity[4] = 1.33f; Cdensity[5] = 0.69;

// this << operator outputs everything that has been read.

std::cout << *newTable << std::endl;

```

```

pFits->pHDU().addKey("NEWVALUE",42," Test of adding keyword to different
extension");

pFits->pHDU().addKey("STRING",std::string(" Rope "), "trailing blank
test 1 ");

pFits->pHDU().addKey("STRING2",std::string("Cord"), "trailing blank test
2 ");
// demonstrate increaing number of rows and null values.
long ignoreVal(12112);
long nullNumber(-999);
try
{
    // add a TNULn value to column 2.
    newTable->column(colName[1]).addNullValue(nullNumber);
    // test that writing new data properly expands the number of rows
    // in both the file).write(planets,rows-3);
    newTable->column(colName[2]).write(density,rows,rows-3);
    // test the undefined value functionality. Undefineds are replaced on
    // disk but not in the memory copy.
    newTable->column(colName[1]).write(diameter,rows,rows-3,&ignoreVal);
}
catch (FitsException&)
{
    // this time we're going to ignore problems in these operations
}

// output header information to check that everything we did so far
// hasn't corrupted the file.

std::cout << pFits->pHDU() << std::endl;

std::vector<string> mnemon(9);
for ( j = 0; j < 9; ++j) mnemon[j] = string(mnemoy[j]);

// Add a new column of string type to the Table.
// type, columnName, width, units. [optional - decimals, column number]
// decimals is only relevant for floatingpoint data in ascii columns.
newTable->addColumn(Tstring,"Mnemonic",10," words ");
newTable->column("Mnemonic").write(mnemon,1);

// write the data string.
newTable->writeDate();

// and see if it all worked right.
std::cout << *newTable << std::endl;

return 0;
}

```

7 Creating and Writing to a Binary Table Extension

The Binary Table interface is more complex because there is an additional parameter, the vector size of each 'cell' in the table, the need to support variable width columns, and the desirability of supporting the input of data in various formats.

The interface supports writing to vector tables the following data structures: C-arrays (T*), std::vector<T> objects, std::valarray<T> objects, and std::vector<valarray<T>>. The last of these is the internal representation of the data.

The function below exercises the following functionality:

- Create a BinTable extension
- Write vector rows to the table
- Insert table rows
- Write complex data to both scalar and vector columns.
- Insert Table columns
- Delete Table rows
- Write HISTORY and COMMENT cards to the Table

```
int writeBinary ()

//*****
// Create a BINARY table extension and write and manipulate vector rows
//*****
{
    std::auto_ptr<FITS> pFits(0);

    try
    {
        const std::string fileName("atestfil.fit");
        pFits.reset( new FITS(fileName,Write) );
    }
    catch (CCfits::FITS::CantOpen)
    {
        return -1;
    }

    unsigned long rows(3);
    string hduName("TABLE_BINARY");
    std::vector<string> colName(7,"");
    std::vector<string> colForm(7,"");
    std::vector<string> colUnit(7,"");

    colName[0] = "numbers";
```



```

colName[1] = "sequences";
colName[2] = "powers";
colName[3] = "big-integers";
colName[4] = "dcomplex-roots";
colName[5] = "fcomplex-roots";
colName[6] = "scalar-complex";

colForm[0] = "8A";
colForm[1] = "20J";
colForm[2] = "20D";
colForm[3] = "20V";
colForm[4] = "20M";
colForm[5] = "20C";
colForm[6] = "1M";

colUnit[0] = "magnets";
colUnit[1] = "bulbs";
colUnit[2] = "batteries";
colUnit[3] = "mulberries";
colUnit[4] = "";
colUnit[5] = "";
colUnit[6] = "pico boo";

std::vector<string> numbers(rows);

const string num("NUMBER-");
for (size_t j = 0; j < rows; ++j)
{
#ifdef HAVE_STRSTREAM
    std::ostringstream pStr;
#else
    std::ostringstream pStr;
#endif
    pStr << num << j+1;
    numbers[j] = string(pStr.str());
}

const size_t OFFSET(20);

// write operations take in data as valarray<T>, vector<T> , and
// vector<valarray<T> >, and T* C-arrays. Create arrays to exercise the C++
// containers. Check complex I/O for both float and double complex types.

std::valarray<long> sequence(60);
std::vector<long> sequenceVector(60);
std::vector<std::valarray<long> > sequenceVV(3);

for (size_t j = 0; j < rows; ++j)
{
    sequence[OFFSET*j] = 1 + j;
    sequence[OFFSET*j+1] = 1 + j;
    sequenceVector[OFFSET*j] = sequence[OFFSET*j];
    sequenceVector[OFFSET*j+1] = sequence[OFFSET*j+1];
    // generate Fibonacci numbers.
    for (size_t i = 2; i < OFFSET; ++i)

```

```

    {
        size_t elt (OFFSET*j +i);
        sequence[elt] = sequence[elt-1] + sequence[elt - 2];
        sequenceVector[elt] = sequence[elt] ;
    }
    sequenceVV[j].resize(OFFSET);
    sequenceVV[j] = sequence[std::slice(OFFSET*j,OFFSET,1)];
}

std::valarray<unsigned long> unsignedData(60);
unsigned long base (1 << 31);
std::valarray<double> powers(60);
std::vector<double> powerVector(60);
std::vector<std::valarray<double> > powerVV(3);
std::valarray<std::complex<double> > croots(60);
std::valarray<std::complex<float> > fcroots(60);
std::vector<std::complex<float> > fcroots_vector(60);
std::vector<std::valarray<std::complex<float> > > fcrootv(3);

// create complex data as 60th roots of unity.
double PIBY = M_PI/30.;

for (size_t j = 0; j < rows; ++j)
{
    for (size_t i = 0; i < OFFSET; ++i)
    {
        size_t elt (OFFSET*j+i);
        unsignedData[elt] = sequence[elt];
        croots[elt] = std::complex<double>(std::cos(PIBY*elt), std::sin(
PIBY*elt));
        fcroots[elt] = std::complex<float>(croots[elt].real(), croots[
elt].imag());
        double x = i+1;
        powers[elt] = pow(x, j+1);
        powerVector[elt] = powers[elt];
    }
    powerVV[j].resize(OFFSET);
    powerVV[j] = powers[std::slice(OFFSET*j,OFFSET,1)];
}

FITSUtil::fill(fcroots_vector, fcroots[std::slice(0,20,1)]);

unsignedData += base;
// syntax identical to Binary Table

Table* newTable = pFits->addTable(hduName, rows, colName, colForm, colUnit);

// numbers is a scalar column

newTable->column(colName[0]).write(numbers, 1);

// write valarrays to vector column: note signature change
newTable->column(colName[1]).write(sequence, rows, 1);
newTable->column(colName[2]).write(powers, rows, 1);
newTable->column(colName[3]).write(unsignedData, rows, 1);

```

```

newTable->column(colName[4]).write(croots,rows,1);
newTable->column(colName[5]).write(fcroots,rows,3);
newTable->column(colName[6]).write(fcroots_vector,1);
// write vectors to column: note signature change

newTable->column(colName[1]).write(sequenceVector,rows,4);
newTable->column(colName[2]).write(powerVector,rows,4);

std::cout << *newTable << std::endl;

for (size_t j = 0; j < 3 ; ++j)
{
    fcrootv[j].resize(20);
    fcrootv[j] = fcroots[std::slice(20*j,20,1)];
}

// write vector<valarray> object to column.

newTable->column(colName[1]).writeArrays(sequenceVV,7);
newTable->column(colName[2]).writeArrays(powerVV,7);


// create a new vector column in the Table

newTable->addColumn(Tfloat,"powerSeq",20,"none");

// add data entries to it.

newTable->column("powerSeq").writeArrays(powerVV,1);
newTable->column("powerSeq").write(powerVector,rows,4);
newTable->column("dcomplex-roots").write(croots,rows,4);
newTable->column("powerSeq").write(sequenceVector,rows,7);


std::cout << *newTable << std::endl;

// delete one of the original columns.

newTable->deleteColumn(colName[2]);


// add a new set of rows starting after row 3. So we'll have 14 with
// rows 4,5,6,7,8 blank

newTable->insertRows(3,5);

// now, in the new column, write 3 rows (sequenceVV.size() = 3). This
// will place data in rows 3,4,5 of this column,overwriting them.

newTable->column("powerSeq").writeArrays(sequenceVV,3);
newTable->column("fcomplex-roots").writeArrays(fcrootv,3);

// delete 3 rows starting with row 2. A Table:: method, so the same

```

```

// code is called for all Table objects. We should now have 11 rows.

newTable->deleteRows(2,3);

//add a history string. This function call is in HDU:: so is identical
//for all HDUs

string hist("This file was created for testing CCfits write functionality")
;
hist += " it serves no other useful purpose. This particular part of the
file was ";
hist += " constructed to test the writeHistory() and writeComment()
functionality" ;

newTable->writeHistory(hist);

// add a comment string. Use std::string method to change the text in the
message
// and write the previous junk as a comment.

hist.insert(0, " COMMENT TEST ");

newTable->writeComment(hist);

// ... print the result.

std::cout << *newTable << std::endl;

return 0;
}

```

8 Copying an Extension between Files

Copying extensions from one fits file to another is very straightforward. A complication arises, however, because [CCfits](#) requires every FITS object to correspond to a conforming FITS file once constructed. Thus we provide a custom constructor which copies the primary HDU of a "source" FITS file into a new file. Subsequent extensions can be copied by name or extension number as illustrated below.

Note that the simple call

```
FITS::FITS(const std::string& filename)
```

Reads the headers for all of the extensions in the file, so that after the FITS object corresponding to *infile* in the following code is instantiated, all extensions are recognized [read calls are also provided to read only specific HDUs - see below].

In the example code below, the file *outFile* is written straight to disk. Since the code never requests that the HDUs being written to that file are read, the user needs to add statements to do this after the copy is complete.

```

int copyHdu()
{
    //*****
    // copy the 1st and 3rd HDUs from the input file to a new FITS file
    //*****

    const string inFileName("atestfil.fit");
    const string outFileName("btestfil.fit");

    int status(0);

    status = 0;

    remove(outFileName.c_str());          // Delete old file if it already exists

    // open the existing FITS file
    FITS inFile(inFileName);

    // custom constructor FITS::FITS(const string&, const FITS&) for
    // this particular task.

    FITS outFile(outFileName,inFile);

    // copy extension by number...
    outFile.copy(inFile.extension(2));

    // copy extension by name...
    outFile.copy(inFile.extension("TABLE_BINARY"));

    return 0;
}

```

9 Selecting Table Data

This function demonstrates the operation of filtering a table by selecting rows that satisfy a condition and writing them to a new file, or overwriting a table with the filtered data. A third mode, where a filtered dataset is appended to the file containing the source data, will be available shortly, but is currently not supported by cfitsio.

The expression syntax for the conditions that may be applied to table data are described in the [cfitsio manual](#). In the example below, we illustrate filtering with a boolean expression involving one of the columns.

The two flags at the end of the call to FITS::filter are an 'overwrite' flag - which only has meaning if the inFile and outFile are the same, and a 'read' flag. overwrite defaults to true. The second flag is a 'read' flag which defaults to false. When set true the user has immediate access to the filtered data.

(Also see the section "Reading with Extended File Name Syntax")

```

int selectRows()
{
    const string inFile("atestfil.fit");
    const string outFile("btestfil.fit");
    const string newFile("ctestfil.fit");
    remove(newFile.c_str());

    // test 1: write to a new file
    std::auto_ptr<FITS> pInfile(new FITS(inFile,Write,string("
PLANETS_ASCII")));
    FITS* infile(pInfile.get());
    std::auto_ptr<FITS> pNewfile(new FITS(newFile,Write));
    ExtHDU& source = infile->extension("PLANETS_ASCII");
    const string expression("DENSITY > 3.0");

    Table& sink1 = pNewfile->filter(expression,source,false,true);

    std::cout << sink1 << std::endl;

    // test 2: write a new HDU to the current file, overwrite false, read
    true.
    // AS OF 7/2/01 does not work because of a bug in cfitsio, but does
    not
    // crash, simply writes a new header to the file without also writing
    the
    // selected data.
    Table& sink2 = infile->filter(expression,source,false,true);

    std::cout << sink2 << std::endl;

    // reset the source file back to the extension in question.
    source = infile->extension("PLANETS_ASCII");

    // test 3: overwrite the current HDU with filtered data.

    Table& sink3 = infile->filter(expression,source,true,true);

    std::cout << sink3 << std::endl;

    return 0;
}

```

10 Reading Header information from a HDU

This function demonstrates selecting one HDU from the file, reading the header information and printing out the keys that have been read and the descriptions of the columns.

The readData flag is by default false (see below for the alternative case), which means that the data in the column is not read.

```
int readHeader()
```

```

{

    const string SPECTRUM("SPECTRUM");

    // read a particular HDU within the file. This call reads just the
    header
    // information from SPECTRUM

    std::auto_ptr<FITS> pInfile(new FITS("file1.pha",Read,SPECTRUM));

    // define a reference for clarity. (std::auto_ptr<T>::get returns a
    pointer

    ExtHDU& table = pInfile->extension(SPECTRUM);

    // read all the keywords, excluding those associated with columns.

    table.readAllKeys();

    // print the result.

    std::cout << table << std::endl;

    return 0;
}

```

11 Reading an Image

Image reading calls are made very simple: the FITS object is created with the read-DataFlag set to true, and reading is done on construction. The following call

`image.read(contents)`

calls

`PHDU::read(std::valarray<S>& image).`

This copies the entire image from the FITS object into the `std::valarray` object contents, sizing it as necessary. `PHDU::read()` and `ExtHDU::read()` [for image extensions] take a range of arguments that support (a) reading the entire image - as in this example; (b) sections of an image starting from a given pixel; (c) rectangular subsets. See the class references for PHDU and ExtHDU for details.

```

int readImage()
{
    std::auto_ptr<FITS> pInfile(new FITS("atestfil.fit",Read,true));

    PHDU& image = pInfile->pHDU();

    std::valarray<unsigned long> contents;

```

```

// read all user-specified, coordinate, and checksum keys in the image
image.readAllKeys();

image.read(contents);

// this doesn't print the data, just header info.
std::cout << image << std::endl;

long ax1(image.axis(0));
long ax2(image.axis(1));

for (long j = 0; j < ax2; j+=10)
{
    std::ostream_iterator<short> c(std::cout, "\t");
    std::copy(&contents[j*ax1], &contents[(j+1)*ax1-1], c);
    std::cout << '\n';
}

std::cout << std::endl;
return 0;
}

```

12 Reading a Table Extension

Reading table data is similarly straightforward (unsurprisingly, because this application is exactly what [CCfits](#) was designed to do easily in the first place).

The two extensions are read on construction, including all the column data [`readDataFlag == true`] and then printed.

Note that if the data are read as part of the construction, then [CCfits](#) uses the row-optimization techniques describe in chapter 13 of the `cfitsio` manual; a chunk of data equal to the size of the available buffer space is read from contiguous disk blocks and transferred to memory storage, as opposed to each column being read in turn. Thus the most efficient way of reading files is to acquire the data on construction.

```

int readTable()
{
    // read a table and explicitly read selected columns. To read instead
    // all the
    // data on construction, set the last argument of the FITS constructor
    // call to 'true'. This functionality was tested in the last release.
    std::vector<string> hdus(2);
    hdus[0] = "PLANETS_ASCII";
    hdus[1] = "TABLE_BINARY";

    std::auto_ptr<FITS> pInfile(new FITS("atestfil.fit", Read, hdus, false));

    ExtHDU& table = pInfile->extension(hdus[1]);
}

```



```

std::vector < valarray <int > > pp;
table.column("powerSeq").readArrays( pp, 1,3 );

std::vector < valarray <std::complex<double> > > cc;
table.column("dcomplex-roots").readArrays( cc, 1,3 );

std::valarray < std::complex<float> > ff;
table.column("fcomplex-roots").read( ff, 4 );

std::cout << pInfile->extension(hdus[0]) << std::endl;

std::cout << pInfile->extension(hdus[1]) << std::endl;

return 0;
}

```

13 Reading with Extended File Name Syntax

It is also possible to apply extended file name syntax (as described in chapter 10 of the cfitsio manual) when reading data. The function below shows a typical example using the basic [CCfits::FITS](#) constructor.

The extended syntax is entered as part of the file name string. In this case it specifies an HDU and a row selection criterion dependent upon the values in the column named "Density." Any read operations performed on this HDU will only see rows which meet the "Density > 5.2" condition. Also the current header position in the file is automatically placed at the specified HDU upon construction of the FITS object.

Extended file name syntax can also be used with the FITS constructors which take specific HDU names or indices as arguments. However if the extended syntax specifies an HDU, that HDU must also be among those specified as a FITS constructor argument, otherwise a [CCfits::FITS::OperationNotSupported](#) exception is thrown. For example:

```

FITS fits(new FITS("myFile.fit[HDU_A]",Read,string("HDU_A"))); // OK
FITS fits(new FITS("myFile.fit[HDU_B]",Read,string("HDU_A"))); // Error

```

(Note - The extended file name feature which allows the opening of a particular image located in the row of a table remains unsupported in [CCfits](#).)

```

int readExtendedSyntax()
{
    // Current extension will be set to PLANETS_ASCII after construction:
    std::auto_ptr<FITS> pInfile(new FITS("btestfil.fit[PLANETS_ASCII][Density >
    5.2]"));
    std::cout << "\nCurrent extension: "
              << pInfile->currentExtensionName() << std::endl;

    Column& col = pInfile->currentExtension().column("Density");
    std::vector<double> densities;

    // nRows should only include rows with density column vals > 5.2.
    const int nRows = col.rows();
}

```

```
col.read(densities, 1, nRows);
for (int i=0; i<nRows; ++i)
    std::cout << densities[i] << " ";
std::cout << std::endl;

return 0;
}
```

14 Previous Release Notes

Release Notes for Version 2.4 Dec 2011

Fixes:

- Compressed images may now be written with BITPIX=32. This fix was made by internally storing the image array as int types rather than longs (see backwards compatibility issues).
- For variable-width columns, the write functions now allow all of the same type conversions as had been working with fixed-width columns.
- The null-value versions of the primary and extension image write functions are now working.
- The basic FITS constructor can now handle files containing multiple extensions which have the same name AND version number. (Note that this is still not a recommended file structure.)
- BinTable's addColumn function now automatically first makes itself the current extension so that the user doesn't have to call ExtHDU::makeThisCurrent().
- Bug fix to Table's deleteRows function. This error had been preventing the output stream operator from working on vector columns after rows had been deleted.

Backwards Compatibility Issue:

- For images of BITPIX=32, [CCfits](#) now stores the values in a valarray of ints rather than longs. This affects the public interface in one place: the return type of the ImageExt<T>::image() function.

Release Notes For Version 2.3 Nov 2010

Enhancements to [CCfits](#):

- 3 previously protected functions are now made public: Keyword::keytype(), PHDU::simple(), and PHDU::extend().
- New function: ExtHDU::isCompressed().

- Uses less memory during the image loading operations for primary and extension HDUs.
- When the basic version of the FITS constructor is called in Write mode on a pre-existing file, it will now automatically read ALL of the headers rather than just the primary. This makes it conform more closely to the Read mode behavior, and it makes things easier when trying to append new HDUs to files containing an unknown number of existing HDUs. (See Backwards Compatibility)

Bug Fixes:

- In the 2 FITS class deleteExtension functions, the index numbers of all HDU objects which follow the deleted are now decremented by one. (See Backwards Compatibility)
- Fix to the PHDU write functions which take a nullValue argument. Neither could be instantiated due to an invalid static_cast of pointers.
- Fix needed for the FITS::copy function to allow the Columns in the newly created HDU to be modifiable.
- The basic version of the FITS constructor, when in Write mode, was ignoring the user's readDataFlag and optional primary keys input.
- An error in the (seldom instantiated) Image class assignment operator was preventing compilation with the nvcc compiler.
- On 64-bit Linux only, a bad cast error is triggered when trying to read an image of type signed or unsigned long, into a valarray with the opposite signed/unsigned qualifier.
- All of the FITS::read functions now perform a check to prevent multiple entries of the same HDU from appearing in the FITS::extension() multimap.
- For case of Columns of type unsigned longs, the object's lower data limit value was left uninitialized.

Backwards Compatibility Issues:

- If you're calling either FITS::deleteExtension function AND you have saved references to any of the ExtHDU objects which follow the deleted object, note that those ExtHDUs will now have an index number 1 less than before. Their indices will now correctly match what's actually in the FITS file.
- When using the basic version of the FITS constructor in Write mode on a pre-existing file, you no longer need to first call FITS::read to access any of the - ExtHDUs. These are now read automatically, same as when this constructor is called in Read mode. However this change shouldn't require the removal of the FITS::read calls from your code. They will merely be redundant if left in.

Release Notes For Version 2.2 Sep 2009

Enhancements to [CCfits](#):

- Added an auto-generated pkg-config file to the stand-alone distribution.
- Added an option for case-insensitive searching in the ExtHDU and Table Column get-by-name functions.
- The public functions column() and numCols() have been added to the ExtHDU interface. They were previously available only in the derived Table class.
- New resetRead and getNullValue functions for Column class.
- Improved the documentation for the nullValue versions of the Column read/write member functions.

Bug Fixes:

- Converted non-standard calls to vector and valarray end iterators. These were causing runtime exceptions when built with Microsoft Visual C++ v9.0.
- The Column addNullValue function now works for cases where the null value argument is of a type that requires casting to match the type of data stored in the Column.
- Fix to the Column writeArrays function for the case where valarrays of varying length were sent to fixed-width columns. It was previously sending along a default null value even when the user did not request one.
- Fix for reading and writing complex data types to scalar columns. The first "first-Row" complex values were not being written or read.
- Renamed private FITS::extension() function to extensionMap(). This is to prevent user from having to explicitly declare a const FITS pointer in order to use the public const FITS::extension*() function.

Backwards Compatibility Issue:

- To prevent overloading ambiguity resulting from the new flag added to ExtHDU/ Table get-by-name Column functions for case-insensitive searches, the protected column(string,Column*) function has been renamed to setColumn. As this is a protected function, the change should not affect standard usage of [CCfits](#).

Changes for [CCfits](#) 2.1 release Nov 2008

- Modified several FITS constructors and FITS::open function to allow proper handling of CFITSIO **extended filename syntax**.

- Extended filename syntax example added to cookbook.
- Fix made to FITS::read function for case of missing EXTVER keyword when searching for HDU with extver > 1.
- Removed inclusion of the internal-only CFITSIO fitsio2.h file from Column.cxx. LONGLONG limits definitions are now found in fitsio.h.

Changes for [CCfits](#) 2.0 release Feb 2008

Enhancements to [CCfits](#):

- **Checksum Capability:** 4 checksum related functions have been added to the HDU class, which now allows users to set and verify checksums directly from inside [CCfits](#).
- **Capturing Error Messages:** The FitsException base class now stores its output error message, and it can be retrieved from any of the exception subclass objects with a call to the new FitsException::message() function.
- **Improved Keyword Handling:** New functions copyAllKeys, keywordCategories, and a second addKey function have been added to the HDU class. The Keyword class now offers a public setValue function to modify an existing keyword. Also the class member documentation for keyword related functions has been upgraded and expanded.
- **Image Scaling:** In the HDU class (for instances of its PHDU and image ExtHDU subclasses), scale and zero set functions can now write BSCALE and BZERO keywords to the file. A new suppressScaling function has been added to temporarily turn off scaling. The ImageExt<T> class has also been added to the documentation.
- **Miscellaneous New Functions:** Table::getRowsize() (submitted by Patrik - Jonsson), Fits::fitsPointer(), Column::parent().

Bug Fixes:

- FITS constructor in Write mode caused a segmentation fault when used on read-only files. (Reported by Gerard Zins)
- Column write functions were not turning off NULL checking even when the nulval pointer was set to 0. (Reported by Gerard Zins)
- For the FITS constructor which takes an existing FITS object as an argument, when given the filename of an existing file (and without the '!' specifier), it places a new primary HDU in the first extension. It shouldn't allow a write operation at all in this case. (Reported by Andy Beardmore)
- Some additional #include statements are needed for compilation on a test version of g++4.3 (Reported by Aurelien Jarno)

Backwards Compatibility Issues:

- The following documented public access member functions have now been removed or made protected/private. As these functions were either never fully implemented or could not successfully be used from external code, it is hoped that these removals will not break any pre-existing code: `FITS::clone`, `HDU::setKeyword`, the `HDU::bitpix` set function, the `Keyword` class constructors.

Changes for [CCfits](#) 1.8 release 10/07.

- Fixes made to bugs in `Column` write and `writeArrays` functions which were preventing the writing of variable-width columns. Also now allows writing to fixed-width columns with arrays that are shorter than the fixed width.
- The `HDU::readAllKeys()` function will no longer throw if it is unable to read a particular keyword. Instead it will skip it and move to the next keyword. This was done primarily to prevent it from tripping on undefined keywords.

Changes for [CCfits](#) 1.7 release 6/07. Fixes for the following bugs:

- The `FITS::copy` function merely wrote the copied HDU to the file, but did not allow it to be accessed for further modifications within [CCfits](#).
- When reading compressed images, [CCfits](#) should use the `ZBITPIX` and `ZNAXIS` keywords rather than `BITPIX` and `NAXIS`. (Fix is based on a patch submitted by Patrik Jonsson.)
- The `BSCALE` keyword was being ignored if the `BZERO` keyword didn't also exist.
- Cases of out-of-scope usage of `std::string`'s `c_str()` pointers, could potentially cause crash. (Fix submitted by Jeremy Sanders.)

Changes for [CCfits](#) 1.6 release 11/06

- Added capability to write compressed images, including 6 new wrapper public functions in `FITS` class.
- In `FITS::addImage`, corrected the logic which checks for a pre-existing image extension with the same version number.
- `CFITSIO` 3.02 renamed `fitsfile` struct member `rice_nbits` to `noise_nbits`. Made corresponding change in `copyFitsPtr` function in `FITSUtil.cxx`. As it stands, this makes this version of [CCfits](#) incompatible with earlier versions of `CFITSIO`
- In [FITS.h](#) definition, removed both friend declarations of `HDUCreator` `Make` functions. It seems neither function needs to be a friend, and one of them is actually private. Some compilers don't allow this (report came from MS VisualC++ user).

- Bug fix in Make function of HDUCreator.cxx. When creating a new ImageExt (and not the primary), it was only passing the version number along for float and double types. This causes problems when there is more than 1 image extension with the same name, and it needs the version number to distinguish them.
- A couple of bug fixes to the first/last/stride version of PHDU read image subset. It was not passing the proper parameters to fits_read_subset, and was not always correctly resizing the internal m_image array.

15 What's Present, What's Missing, and Calling CFITSIO

Most of the functionality of cfitsio described in Chapter 5 of the cfitsio manual is present, although [CCfits](#) is designed to provide atomic read/write operations rather than primitive file manipulation. For example, opening and creating FITS files are private operations which are called by reading and writing constructors. Similarly, errors are treated by C++ exception handling rather than returning status codes, and moving between HDUs within a file is a primitive rather than an atomic operation [in [CCfits](#), operations typically call an internal HDU::makeThisCurrent() call on a specific table or image extension, and then perform the requested read/write operation].

Read/Write operations for keys (in the HDU class) are provided; these implement calls to fits_read_key and fits_update_key respectively. In the case of keywords, which have one of five data types (Integer, Logical, String, Floating and Complex) [CCfits](#) will handle certain type conversions between the keyword value and the data type of the user-supplied variable. This is described in detail in the Keyword class reference page. In reading image and table data, intrinsic type conversions are performed as in cfitsio with the exception that reading numeric data into character data is **not** supported. There is an extensive set of member functions supporting equivalents of most of cfitsio's read/write operations: the classes PHDU [primary HDU] and ExtHDU [with subclasses template <typename T> ImageExt<T>], provide multiple overloaded versions of read and write functions. The Column class, instances of which can be held in Table instances [with subclasses AsciiTable and BinTable] has also an extensive set of read/write operations.

A special constructor is provided which creates a new file with the Primary HDU of a source file. A FITS::copy(const HDU&) function copies HDUs from one file into another. Support for filtering table rows by expression is provided by a FITS::filter(...) call which may be used to create a new filtered file or overwrite an existing HDU (see cfitsio manual section 5.6.4).

Functions are provided for adding and deleting columns, and inserting and deleting rows in tables.

HDU objects also have functions to implement writing of history, comment and date keys.

Extended file name syntax (chapter 10 of the cfitsio manual) is supported in general,

though not the feature which allows the opening of a particular image stored in the row of a table.

15.1 What's Not Present

The coordinate library manipulations [cfitsio manual chapter 7] are not supported.

The iterator work functions [cfitsio manual chapter 6] are not supported. Many of the functions provided are easier to implement using the properties of the standard library, since the standard library containers either allow vectorized operations (in the case of valarrays) or standard library algorithms that take iterators or pointers. In some ways the `fits_iterate_data` function provide an alternative, approach to the same need for encapsulation addressed by [CCfits](#).

The hierarchical grouping routines are not supported.

Explicit opening of in-memory data sets as described in Chapter 9 of the manual is *not* supported since none of the FITS constructors call the appropriate cfitsio primitives.

15.2 Calling CFITSIO

To gain any functionality currently missing in [CCfits](#), it is possible of course to call the underlying CFITSIO library functions directly. The [CCfits](#) FITS and HDU classes both have the public member function `fitsPointer()`, which returns the fitsfile pointer required in CFITSIO function calls. One should use caution when doing this however, since any I/O changes made this way will NOT be mirrored in the [CCfits](#) FITS object (nor its component objects) associated with the file. Therefore once a FITS object has been bypassed this way, it is safest to just not use that object again, and instead continue calling CFITSIO directly or instantiate a new FITS object that will pick up the current file state.

16 Todo List

Member [CCfits::AsciiTable::AsciiTable](#) (FITSBase *p, const String &hduName, int rows, const std::vector< String > &columnName=std::vector< String >(), const std::vector< String > &columnFmt=std::vector< String >(), const std::vector< String > &columnUnit=std::vector< String >(), int version=1)
{enforce equal dimensions for arrays input to AsciiTable, BinTable writing ctor}

Member [CCfits::FITS::addImage](#) (const String &hduName, int bpix, std::vector< long > &naxes, int version=1)
Add a function for replacing the primary image

Member [CCfits::FITS::addTable](#) (const String &hduName, int rows, const std::vector< String > &columnName=std::vector< String >(), const std::vector< String > &columnFmt=std::vector< String >(), const std::vector< String > &columnUnit=std::vector< String >(), HduType type=BinaryTbl, int version=1)

the code should one day check that the version keyword is higher than any other versions already added to the FITS object (although cfitsio doesn't do this either).

Class [CCfits::PHDU](#)

Implement functions that allow replacement of the primary image

17 Module Index

17.1 Modules

Here is a list of all modules:

FITS Exceptions [40](#)

18 Namespace Index

18.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

[CCfits](#)
Namespace enclosing all [CCfits](#) classes and globals definitions [41](#)

[FITSUtil](#)
[FITSUtil](#) is a namespace containing functions used internally by [C-Cfits](#), but which might be of use for other applications [44](#)

19 Class Index

19.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

CCfits::Column [51](#)

CCfits::FITS [84](#)

CCfits::FitsException	102
CCfits::Column::InsufficientElements	65
CCfits::Column::InvalidDataType	67
CCfits::Column::InvalidNumberOfRows	68
CCfits::Column::InvalidRowNumber	69
CCfits::Column::InvalidRowParameter	70
CCfits::Column::NoNullValue	71
CCfits::Column::RangeError	72
CCfits::Column::WrongColumnType	73
CCfits::ExtHDU::WrongExtensionType	83
CCfits::FITS::CantCreate	97
CCfits::FITS::CantOpen	98
CCfits::FITS::NoSuchHDU	100
CCfits::FITS::OperationNotSupported	101
CCfits::FitsError	102
CCfits::FITSUtil::UnrecognizedType	110
CCfits::HDU::InvalidExtensionType	120
CCfits::HDU::InvalidImageDataType	121
CCfits::HDU::NoNullValue	122
CCfits::HDU::NoSuchKeyword	123
CCfits::Table::NoSuchColumn	142
CCfits::FitsFatal	104
CCfits::FITSUtil::auto_array_ptr< X >	105
CCfits::FITSUtil::CAarray< T >	106
CCfits::FITSUtil::CVAarray< T >	107

<code>CCfits::FITSUtil::CArray< T ></code>	107
<code>CCfits::FITSUtil::MatchName< T ></code>	108
<code>CCfits::FITSUtil::MatchNum< T ></code>	108
<code>CCfits::FITSUtil::MatchPtrName< T ></code>	109
<code>CCfits::FITSUtil::MatchPtrNum< T ></code>	109
<code>CCfits::FITSUtil::MatchType< T ></code>	110
<code>CCfits::HDU</code>	111
<code>CCfits::ExtHDU</code>	74
<code>CCfits::ImageExt< T ></code>	124
<code>CCfits::Table</code>	137
<code>CCfits::AsciiTable</code>	44
<code>CCfits::BinTable</code>	47
<code>CCfits::PHDU</code>	130
<code>CCfits::Keyword</code>	127

20 Class Index

20.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

<code>CCfits::AsciiTable</code>	
Class Representing Ascii <code>Table</code> Extensions	44
<code>CCfits::BinTable</code>	
Class Representing Binary <code>Table</code> Extensions. Contains columns with scalar or vector row entries	47
<code>CCfits::Column</code>	
Abstract base class for <code>Column</code> objects	51

CCfits::Column::InsufficientElements	
Exception thrown if the data supplied for a write operation is less than declared	65
CCfits::Column::InvalidDataType	
Exception thrown for invalid data type inputs	67
CCfits::Column::InvalidNumberOfRows	
Exception thrown if user enters a non-positive number for the number of rows to write	68
CCfits::Column::InvalidRowNumber	
Exception thrown on attempting to read a row number beyond the end of a table	69
CCfits::Column::InvalidRowParameter	
Exception thrown on incorrect row writing request	70
CCfits::Column::NoNullValue	
Exception thrown if a null value is specified without support from existing column header	71
CCfits::Column::RangeError	
Exception to be thrown for inputs that cause range errors in column read operations	72
CCfits::Column::WrongColumnType	
Exception thrown on attempting to access a scalar column as vector data	73
CCfits::ExtHDU	
Base class for all FITS extension HDUs, i.e. Image Extensions and Tables	74
CCfits::ExtHDU::WrongExtensionType	
Exception to be thrown on unmatched extension types	83
CCfits::FITS	
Memory object representation of a disk FITS file	84
CCfits::FITS::CantCreate	
Thrown on failure to create new file	97
CCfits::FITS::CantOpen	
Thrown on failure to open existing file	98
CCfits::FITS::NoSuchHDU	
Exception thrown by HDU retrieval methods	100

CCfits::FITS::OperationNotSupported	
Thrown for unsupported operations, such as attempted to select rows from an image extension	101
CCfits::FitsError	
FitsError is the exception thrown by non-zero cfitsio status codes	102
CCfits::FitsException	
FitsException is the base class for all exceptions thrown by this library	102
CCfits::FitsFatal	
[potential] base class for exceptions to be thrown on internal library error	104
CCfits::FITSUtil::auto_array_ptr< X >	
A class that mimics the std:: library auto_ptr class, but works with arrays	105
CCfits::FITSUtil::CAarray< T >	
Function object returning C array from a valarray. see CVarray for details	106
CCfits::FITSUtil::CVAarray< T >	
Function object returning C array from a vector of valarrays. see C-Varray for details	107
CCfits::FITSUtil::CVarray< T >	
Function object class for returning C arrays from standard library objects used in the FITS library implementation	107
CCfits::FITSUtil::MatchName< T >	
Predicate for classes that have a name attribute; match input string with instance name	108
CCfits::FITSUtil::MatchNum< T >	
Predicate for classes that have an index attribute; match input index with instance value	108
CCfits::FITSUtil::MatchPtrName< T >	
As for MatchName , only with the input class a pointer	109
CCfits::FITSUtil::MatchPtrNum< T >	
As for MatchNum , only with the input class a pointer	109

CCfits::FITSUtil::MatchType< T >	Function object that returns the FITS ValueType corresponding to an input intrinsic type	110
CCfits::FITSUtil::UnrecognizedType	Exception thrown by MatchType if it encounters data type incompatible with cfitsio	110
CCfits::HDU	Base class for all HDU [Header-Data Unit] objects	111
CCfits::HDU::InvalidExtensionType	Exception to be thrown if user requests extension type that can not be understood as ImageExt , AsciiTable or BinTable	120
CCfits::HDU::InvalidImageDataType	Exception to be thrown if user requests creation of an image of type not supported by cfitsio	121
CCfits::HDU::NoNullValue	Exception to be thrown on seek errors for keywords	122
CCfits::HDU::NoSuchKeyword	Exception to be thrown on seek errors for keywords	123
CCfits::ImageExt< T >		124
CCfits::Keyword	Abstract base class defining the interface for Keyword objects	127
CCfits::PHDU	Class representing the primary HDU for a FITS file	130
CCfits::Table		137
CCfits::Table::NoSuchColumn	Exception to be thrown on a failure to retrieve a column specified either by name or index number	142

21 Module Documentation

21.1 FITS Exceptions

Classes

- class [CCfits::Column::RangeError](#)

exception to be thrown for inputs that cause range errors in column read operations.

- class [CCfits::ExtHDU::WrongExtensionType](#)

Exception to be thrown on unmatched extension types.

- class [CCfits::FITS::CantCreate](#)

thrown on failure to create new file

- class [CCfits::FITS::CantOpen](#)

thrown on failure to open existing file

- class [CCfits::FITS::NoSuchHDU](#)

exception thrown by [HDU](#) retrieval methods.

- class [CCfits::FITS::OperationNotSupported](#)

thrown for unsupported operations, such as attempted to select rows from an image extension.

- class [CCfits::FitsError](#)

[FitsError](#) is the exception thrown by non-zero *cfitsio* status codes.

- class [CCfits::FitsException](#)

[FitsException](#) is the base class for all exceptions thrown by this library.

- class [CCfits::FitsFatal](#)

[potential] base class for exceptions to be thrown on internal library error.

- class [CCfits::FITSUtil::UnrecognizedType](#)

exception thrown by [MatchType](#) if it encounters data type incompatible with *cfitsio*.

- class [CCfits::HDU::InvalidExtensionType](#)

exception to be thrown if user requests extension type that can not be understood as [ImageExt](#), [AsciiTable](#) or [BinTable](#).

- class [CCfits::HDU::InvalidImageDataType](#)

exception to be thrown if user requests creation of an image of type not supported by *cfitsio*.

- class [CCfits::HDU::NoNullValue](#)

exception to be thrown on seek errors for keywords.

- class [CCfits::HDU::NoSuchKeyword](#)

exception to be thrown on seek errors for keywords.

- class [CCfits::Table::NoSuchColumn](#)

Exception to be thrown on a failure to retrieve a column specified either by name or index number.

22 Namespace Documentation

22.1 CCfits Namespace Reference

Namespace enclosing all [CCfits](#) classes and globals definitions.

Classes

- class [AsciiTable](#)
Class Representing Ascii [Table](#) Extensions.
- class [BinTable](#)
Class Representing Binary [Table](#) Extensions. Contains columns with scalar or vector row entries.
- class [Column](#)
Abstract base class for [Column](#) objects.
- class [ExtHDU](#)
base class for all [FITS](#) extension HDUs, i.e. Image Extensions and Tables.
- class [FITS](#)
Memory object representation of a disk [FITS](#) file.
- class [FitsError](#)
[FitsError](#) is the exception thrown by non-zero cfitsio status codes.
- class [FitsException](#)
[FitsException](#) is the base class for all exceptions thrown by this library.
- class [FitsFatal](#)
[potential] base class for exceptions to be thrown on internal library error.
- class [HDU](#)
Base class for all [HDU](#) [Header-Data Unit] objects.
- class [ImageExt](#)
- class [Keyword](#)
Abstract base class defining the interface for [Keyword](#) objects.
- class [PHDU](#)
class representing the primary [HDU](#) for a [FITS](#) file.
- class [Table](#)

Typedefs

- typedef std::multimap < std::string, [CCfits::Column](#) * > [ColMap](#)
Type definition for a table's column container.

Enumerations

- enum [ValueType](#)
[CCfits](#) value types and their CFITSIO equivalents (in caps)

Functions

- `std::ostream & operator<< (std::ostream &s, const CCfits::HDU &right)`
Output operator for HDU objects. Primarily for testing purposes.
- `std::ostream & operator<< (std::ostream &s, const FITS &right)`
Output operator. Calls output operators for HDUs in turn.
- `std::ostream & operator<< (std::ostream &s, const Column &right)`
output operator for Column objects.

22.1.1 Detailed Description

Namespace enclosing all CCfits classes and globals definitions.

22.1.2 Enumeration Type Documentation

22.1.2.1 enum CCfits::ValueType

CCfits value types and their CFITSIO equivalents (in caps)

Tnull, Tbit = TBIT, Tbyte = TBYTE, Tlogical = TLOGICAL, Tstring = TSTRING, Tushort = TUSHORT, Tshort = TSHORT, Tuint = TUINT, Tint = TINT, Tulong = TULONG, -
 Tlong = TLONG, Tlonglong = TLONGLONG, Tfloat = TFLOAT, Tdouble = TDOUBLE,
 Tcomplex = TCOMPLEX, Tdblcomplex=TDBLCOMPLEX, VTbit=-TBIT, VTbyte=-TBY-
 TE, VTlogical=-Tlogical, VTstring=-TSTRING, VTushort=-TUSHORT, VTshort=-TSHO-
 RT, VTuint=-TUINT, VTint=-TINT, VTulong=-TULONG, VTlong=-TLONG, VTlonglong=-
 TLONGLONG, VTfloat=-TFLOAT, VTdouble=-TDOUBLE, VTcomplex=-TCOMPLEX, -
 VTdblcomplex=-TDBLCOMPLEX

22.1.3 Function Documentation

22.1.3.1 `std::ostream & operator<< (std::ostream & s, const FITS & right) [inline]`

Output operator. Calls output operators for HDUs in turn.

This operator acts similarly to the `fcool fdump` for a fits file, except that there is no free-
 dom to output partial information.

The current implementation of this operator for PHDU objects only outputs the array
 sizes, not the data, which that for tables prints the data also.

Provision of this operator is intended largely for debugging purposes.

22.2 FITSUtil Namespace Reference

[FITSUtil](#) is a namespace containing functions used internally by [CCfits](#), but which might be of use for other applications.

22.2.1 Detailed Description

[FITSUtil](#) is a namespace containing functions used internally by [CCfits](#), but which might be of use for other applications.

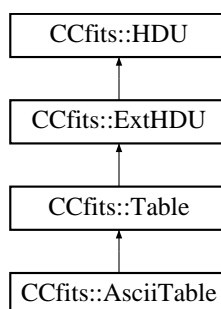
23 Class Documentation

23.1 CCfits::AsciiTable Class Reference

Class Representing Ascii [Table](#) Extensions.

```
#include <AsciiTable.h>
```

Inheritance diagram for CCfits::AsciiTable:



Public Member Functions

- virtual void [addColumn](#) ([ValueType](#) type, const String &columnName, long repeatWidth, const String &colUnit=String(""), long decimals=0, size_t columnNumber=0)
add a new column to an existing table [HDU](#).
- virtual [AsciiTable](#) * [clone](#) (FITSBase *p) const
virtual copy constructor
- virtual void [readData](#) (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())
read columns and keys specified in the input array.

Protected Member Functions

- [AsciiTable](#) (FITSBase *p, const String &hduName=String(""), bool readFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)
reading constructor: Construct a [AsciiTable](#) extension from an extension of an existing disk file.
- [AsciiTable](#) (FITSBase *p, const String &hduName, int rows, const std::vector< String > &columnName=std::vector< String >(), const std::vector< String > &columnFmt=std::vector< String >(), const std::vector< String > &columnUnit=std::vector< String >(), int version=1)
writing constructor: create new [Ascii Table](#) object with the specified columns
- [AsciiTable](#) (FITSBase *p, int number)
*read [AsciiTable](#) with [HDU](#) number *number* from existing file.*
- [~AsciiTable](#) ()
destructor.

23.1.1 Detailed Description

Class Representing Ascii [Table](#) Extensions.

May only contain columns with scalar row entries and a small range of data types. [AsciiTable](#) (re)implements functions prescribed in the [Table](#) abstract class. The implementations allow the calling of cfitsio specialized routines for [AsciiTable](#) header construction.

Direct instantiation of [AsciiTable](#) objects is disallowed: they are created by explicit calls to [FITS::addTable](#)(...), [FITS::read](#)(...) or internally by one of the [FITS](#) ctors on initialization. The default for [FITS::addTable](#) is to produce [BinTable](#) extensions.

23.1.2 Constructor & Destructor Documentation

23.1.2.1 CCfits::AsciiTable::AsciiTable (FITSBase * p, const String & hduName = String(""), bool readFlag = false, const std::vector< String > & keys = std::vector<String>(), int version = 1) [protected]

reading constructor: Construct a [AsciiTable](#) extension from an extension of an existing disk file.

The [Table](#) is specified by name and optional version number within the file. An array of strings representing columns or keys indicates which data are to be read. The column data are only read if readFlag is true. Reading on construction is optimized, so it is more efficient to read data at the point of instantiation. This favours a "resource acquisition is initialization" model of data management.

Parameters

<i>p</i>	pointer to FITSBase object for internal use
<i>hduName</i>	name of AsciiTable object to be read.
<i>readFlag</i>	flag to determine whether to read data on construction
<i>keys</i>	(optional) a list of keywords/columns to be read. The implementation will determine which are keywords. If none are specified, the constructor will simply read the header
<i>version</i>	(optional) version number. If not specified, will read the first extension that matches hduName.

23.1.2.2 `CCfits::AsciiTable::AsciiTable (FITSBase * p, const String & hduName, int rows, const std::vector< String > & columnName = std::vector<String>(), const std::vector< String > & columnFmt = std::vector<String>(), const std::vector< String > & columnUnit = std::vector<String>(), int version = 1)` [protected]

writing constructor: create new [Ascii Table](#) object with the specified columns

The constructor creates a valid [HDU](#) which is ready for [Column::write](#) or [insertRows](#) operations. The disk [FITS](#) file is update accordingly. The data type of each column is determined by the `columnFmt` argument (TFORM keywords). See [cfitsio](#) documentation for acceptable values.

Parameters

<i>hduName</i>	name of AsciiTable object to be written
<i>rows</i>	number of rows in the table (NAXIS2)
<i>column-Name</i>	array of column names for columns to be constructed.
<i>columnFmt</i>	array of column formats for columns to be constructed.
<i>columnUnit</i>	(optional) array of units for data in columns.
<i>version</i>	(optional) version number for HDU .

The dimensions of `columnType`, `columnName` and `columnFmt` must match, although this is not enforced at present.

Todo {enforce equal dimensions for arrays input to [AsciiTable](#), [BinTable](#) writing ctor}

23.1.2.3 `CCfits::AsciiTable::AsciiTable (FITSBase * p, int number)` [protected]

read [AsciiTable](#) with [HDU](#) number `number` from existing file.

This is used internally by methods that need to access HDUs for which no EXTNAME [or equivalent] keyword exists.

23.1.3 Member Function Documentation

23.1.3.1 void CCfits::AsciiTable::addColumn (ValueType *type*, const String & *columnName*, long *repeatWidth*, const String & *colUnit* = String(""), long *decimals* = 0, size_t *columnNumber* = 0) [virtual]

add a new column to an existing table [HDU](#).

Parameters

<i>type</i>	The data type of the column to be added
<i>column-Name</i>	The name of the column to be added
<i>repeatWidth</i>	for a string valued, this is the width of a string. For a numeric column it supplies the vector length of the rows. It is ignored for ascii table numeric data.
<i>colUnit</i>	an optional field specifying the units of the data (TUNITn)
<i>decimals</i>	optional parameter specifying the number of decimals for an ascii numeric column
<i>column-Number</i>	optional parameter specifying column number to be created. If not specified the column is added to the end. If specified, the column is inserted and the columns already read are reindexed. This parameter is provided as a convenience to support existing code rather than recommended.

Reimplemented from [CCfits::ExtHDU](#).

23.1.3.2 void CCfits::AsciiTable::readData (bool *readFlag* = false, const std::vector< String > & *keys* = std::vector<String>()) [virtual]

read columns and keys specified in the input array.

See [Table](#) class documentation for further details.

Implements [CCfits::ExtHDU](#).

The documentation for this class was generated from the following files:

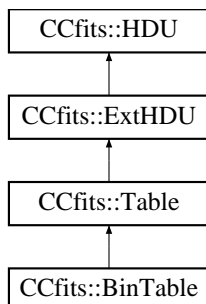
- AsciiTable.h
- AsciiTable.cxx

23.2 CCfits::BinTable Class Reference

Class Representing Binary [Table](#) Extensions. Contains columns with scalar or vector row entries.

```
#include <BinTable.h>
```

Inheritance diagram for CCfits::BinTable:



Public Member Functions

- virtual void [addColumn](#) ([ValueType](#) type, const String &columnName, long repeatWidth, const String &colUnit=String(""), long decimals=0, size_t columnNumber=0)
add a new column to an existing table [HDU](#).
- virtual [BinTable](#) * [clone](#) (FITSBase *p) const
virtual copy constructor
- virtual void [readData](#) (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())
read columns and keys specified in the input array.

Protected Member Functions

- [BinTable](#) (FITSBase *p, const String &hduName=String(""), bool readFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)
reading constructor.
- [BinTable](#) (FITSBase *p, const String &hduName, int rows, const std::vector< String > &columnName=std::vector< String >(), const std::vector< String > &columnFmt=std::vector< String >(), const std::vector< String > &columnUnit=std::vector< String >(), int version=1)
writing constructor
- [BinTable](#) (FITSBase *p, int number)
*read [BinTable](#) with [HDU](#) number *number* from existing file represented by fitsfile pointer p.*
- [~BinTable](#) ()
destructor.

23.2.1 Detailed Description

Class Representing Binary [Table](#) Extensions. Contains columns with scalar or vector row entries.

[BinTable](#) (re)implements functions prescribed in the [Table](#) abstract class. The implementations allow the calling of cfitsio specialized routines for [BinTable](#) header construction. functions particular to the [BinTable](#) class include those dealing with variable width columns

Direct instantiation of [BinTable](#) objects is disallowed: they are created by explicit calls to [FITS::addTable\(... \)](#), [FITS::read\(...\)](#) or internally by one of the [FITS](#) ctors on initialization. For addTable, creation of BinTables is the default.

23.2.2 Constructor & Destructor Documentation

23.2.2.1 CCfits::BinTable::BinTable (FITSBase * *p*, const String & *hduName* = String(""), bool *readFlag* = false, const std::vector< String > & *keys* = std::vector<String>(), int *version* = 1) [protected]

reading constructor.

Construct a [BinTable](#) extension from an extension of an existing disk file. The [Table](#) is specified by name and optional version number within the file. An array of strings representing columns or keys indicates which data are to be read. The column data are only read if readFlag is true. Reading on construction is optimized, so it is more efficient to read data at the point of instantiation. This favours a "resource acquisition is initialization" model of data management.

Parameters

<i>p</i>	Pointer to FITSBase class, an internal implementation detail
<i>hduName</i>	name of BinTable object to be read.
<i>readFlag</i>	flag to determine whether to read data on construction
<i>keys</i>	(optional) a list of keywords/columns to be read. The implementation will determine which are keywords. If none are specified, the constructor will simply read the header
<i>version</i>	(optional) version number. If not specified, will read the first extension that matches hduName.

```
23.2.2.2 CCfits::BinTable::BinTable ( FITSBase * p, const String & hduName, int rows, const
std::vector< String > & columnName = std::vector<String>(), const
std::vector< String > & columnFmt = std::vector<String>(), const
std::vector< String > & columnUnit = std::vector<String>(), int
version = 1 ) [protected]
```

writing constructor

The constructor creates a valid [HDU](#) which is ready for [Column::write](#) or [insertRows](#) operations. The disk [FITS](#) file is update accordingly. The data type of each column is determined by the *columnFmt* argument (TFORM keywords). See [cfitsio](#) documentation for acceptable values.

Parameters

<i>p</i>	Pointer to FITSBase class, an internal implementation detail
<i>hduName</i>	name of BinTable object to be written
<i>rows</i>	number of rows in the table (NAXIS2)
<i>column-Name</i>	array of column names for columns to be constructed.
<i>columnFmt</i>	array of column formats for columns to be constructed.
<i>columnUnit</i>	(optional) array of units for data in columns.
<i>version</i>	(optional) version number for HDU .

The dimensions of *columnType*, *columnName* and *columnFmt* must match, but this is not enforced.

23.2.3 Member Function Documentation

```
23.2.3.1 void CCfits::BinTable::addColumn ( ValueType type, const String & columnName,
long repeatWidth, const String & colUnit = String(""), long decimals = 0, size_t
columnNumber = 0 ) [virtual]
```

add a new column to an existing table [HDU](#).

Parameters

<i>type</i>	The data type of the column to be added
<i>column-Name</i>	The name of the column to be added
<i>repeatWidth</i>	for a string valued, this is the width of a string. For a numeric column it supplies the vector length of the rows. It is ignored for ascii table numeric data.
<i>colUnit</i>	an optional field specifying the units of the data (TUNITn)
<i>decimals</i>	optional parameter specifying the number of decimals for an ascii numeric column

<i>column-Number</i>	optional parameter specifying column number to be created. If not specified the column is added to the end. If specified, the column is inserted and the columns already read are reindexed. This parameter is provided as a convenience to support existing code rather than recommended.
----------------------	--

Reimplemented from [CCfits::ExtHDU](#).

23.2.3.2 `void CCfits::BinTable::readData (bool readFlag = false, const std::vector< String > & keys = std::vector<String>()) [virtual]`

read columns and keys specified in the input array.

See [Table](#) class documentation for further details.

Implements [CCfits::ExtHDU](#).

The documentation for this class was generated from the following files:

- BinTable.h
- BinTable.cxx

23.3 CCfits::Column Class Reference

Abstract base class for [Column](#) objects.

```
#include <Column.h>
```

Inherited by [CCfits::ColumnData< T >](#), and [CCfits::ColumnVectorData< T >](#).

Classes

- class [InsufficientElements](#)
Exception thrown if the data supplied for a write operation is less than declared.
- class [InvalidDataType](#)
Exception thrown for invalid data type inputs.
- class [InvalidNumberOfRows](#)
Exception thrown if user enters a non-positive number for the number of rows to write.
- class [InvalidRowNumber](#)
Exception thrown on attempting to read a row number beyond the end of a table.
- class [InvalidRowParameter](#)
Exception thrown on incorrect row writing request.
- class [NoNullValue](#)

Exception thrown if a null value is specified without support from existing column header.

- class [RangeError](#)
exception to be thrown for inputs that cause range errors in column read operations.
- class [WrongColumnType](#)
Exception thrown on attempting to access a scalar column as vector data.

Public Member Functions

- [Column](#) (const [Column](#) &right)
copy constructor, used in copying Columns to standard library containers.
- virtual [~Column](#) ()
destructor.
- template<typename T >
void [addNullValue](#) (T nullVal)
Set the TNULLn keyword for the column.
- const String & [dimen](#) () const
return TDIMn keyword
- const String & [display](#) () const
return TDISPn keyword
- const String & [format](#) () const
return TFORMn keyword
- template<typename T >
bool [getNullValue](#) (T *nullVal) const
Get the value of the TNULLn keyword for the column.
- int [index](#) () const
get the [Column](#) index (the n in TTYPEEn etc).
- bool [isRead](#) () const
flag set to true if the entire column data has been read from disk
- const String & [name](#) () const
return name of [Column](#) (TTYPEEn keyword)
- [Table](#) * [parent](#) () const
return a pointer to the [Table](#) which owns this [Column](#)
- template<typename S >
void [read](#) (std::vector< S > &vals, long first, long last)
Retrieve data from a scalar column into a std::vector.
- template<typename S >
void [read](#) (std::valarray< S > &vals, long first, long last)
Retrieve data from a scalar column into a std::valarray.
- template<typename S >
void [read](#) (std::valarray< S > &vals, long rows)

return a single row of a vector column into a std::valarray

- template<typename S >
void [read](#) (std::vector< S > &vals, long rows)
return a single row of a vector column into a std::vector
- template<typename S >
void [read](#) (std::vector< S > &vals, long first, long last, S *nullValue)
Retrieve data from a scalar column into a std::vector, applying nullValue when relevant.
- template<typename S >
void [read](#) (std::valarray< S > &vals, long first, long last, S *nullValue)
Retrieve data from a scalar column into a std::valarray, applying nullValue when relevant.
- template<typename S >
void [read](#) (std::valarray< S > &vals, long rows, S *nullValue)
return a single row of a vector column into a std::valarray, setting undefined values
- template<typename S >
void [readArrays](#) (std::vector< std::valarray< S > > &vals, long first, long last)
return a set of rows of a vector column into a vector of valarrays
- template<typename S >
void [readArrays](#) (std::vector< std::valarray< S > > &vals, long first, long last, S *nullValue)
return a set of rows of a vector column into a container, setting undefined values
- virtual void [readData](#) (long firstRow, long nelements, long firstElem=1)=0
Read (or reread) data from the disk into the [Column](#) object's internal arrays.
- size_t [repeat](#) () const
get the repeat count for the rows
- void [resetRead](#) ()
reset the Column's isRead flag to false
- int [rows](#) () const
return the number of rows in the table.
- double [scale](#) () const
get TSCALn value
- virtual void [setDimen](#) ()
set the TDIMn keyword.
- void [setDisplay](#) ()
set the TDISPn keyword
- [ValueType](#) type () const
returns the data type of the column
- const String & [unit](#) () const
get units of data in [Column](#) (TUNITn keyword)
- bool [varLength](#) () const

boolean, set to true if [Column](#) has variable length vector rows.

- long [width](#) () const
return column data width
- template<typename S >
void [write](#) (const std::vector< S > &indata, long firstRow)
write a vector of values into a scalar column starting with firstRow
- template<typename S >
void [write](#) (const std::valarray< S > &indata, long firstRow)
write a valarray of values into a scalar column starting with firstRow
- template<typename S >
void [write](#) (S *indata, long nRows, long firstRow)
write a C array of size nRows into a scalar [Column](#) starting with row firstRow.
- template<typename S >
void [write](#) (const std::vector< S > &indata, long firstRow, S *nullValue)
write a vector of values into a scalar column starting with firstRow, replacing elements equal to nullValue with the [FITS](#) null value.
- template<typename S >
void [write](#) (const std::valarray< S > &indata, long firstRow, S *nullValue)
write a valarray of values into a scalar column starting with firstRow, replacing elements equal to nullValue with the [FITS](#) null value.
- template<typename S >
void [write](#) (S *indata, long nRows, long firstRow, S *nullValue)
write a C array into a scalar [Column](#), processing undefined values.
- template<typename S >
void [write](#) (const std::valarray< S > &indata, long nRows, long firstRow)
write a valarray of values into a range of rows of a vector column.
- template<typename S >
void [write](#) (const std::vector< S > &indata, long nRows, long firstRow)
write a vector of values into a range of rows of a vector column
- template<typename S >
void [write](#) (S *indata, long nElements, long nRows, long firstRow)
write a C array of values into a range of rows of a vector column
- template<typename S >
void [write](#) (const std::valarray< S > &indata, long nRows, long firstRow, S *nullValue)
write a valarray of values into a range of rows of a vector column.
- template<typename S >
void [write](#) (const std::vector< S > &indata, long nRows, long firstRow, S *nullValue)
write a vector of values into a range of rows of a vector column, processing undefined values

- template<typename S >
void [write](#) (S *indata, long nElements, long nRows, long firstRow, S *nullValue)
write a C array of values into a range of rows of a vector column, processing undefined values.
- template<typename S >
void [write](#) (const std::valarray< S > &indata, const std::vector< long > &vectorLengths, long firstRow)
write a valarray of values into a column with specified number of entries written per row.
- template<typename S >
void [write](#) (const std::vector< S > &indata, const std::vector< long > &vectorLengths, long firstRow)
write a vector of values into a column with specified number of entries written per row.
- template<typename S >
void [write](#) (S *indata, long nElements, const std::vector< long > &vectorLengths, long firstRow)
write a C-array of values of size nElements into a vector column with specified number of entries written per row.
- template<typename S >
void [writeArrays](#) (const std::vector< std::valarray< S > > &indata, long firstRow)
write a vector of valarray objects to the column, starting at row firstRow >= 1
- template<typename S >
void [writeArrays](#) (const std::vector< std::valarray< S > > &indata, long firstRow, S *nullValue)
write a vector of valarray objects to the column, starting at row firstRow >= 1, processing undefined values
- double [zero](#) () const
get TZERO value

Protected Member Functions

- [Column](#) (int columnIndex, const String &columnName, [ValueType](#) type, const String &format, const String &unit, [Table](#) *p, int rpt=1, long w=1, const String &comment="")
new column creation constructor
- [Column](#) ([Table](#) *p=0)
Simple constructor to be called by subclass reading ctors.
- const String & [comment](#) () const
retrieve comment for [Column](#)
- fitsfile * [fitsPointer](#) ()
fits pointer corresponding to fits file containing column data.

- void `makeHDUCurrent` ()
make HDU containing this the current HDU of the fits file.
- virtual `std::ostream & put (std::ostream &s) const`
internal implementation of << operator.

23.3.1 Detailed Description

Abstract base class for `Column` objects.

Columns are the data containers used in `FITS` tables. Columns of scalar type (one entry per cell) are implemented by the template subclass `ColumnData<T>`. Columns of vector type (vector and variable rows) are implemented with the template subclass `ColumnVectorData<T>`. `AsciiTables` may only contain Columns of type `ColumnData<T>`, where T is an implemented `FITS` data type (see the `CCfits.h` header for a complete list). This requirement is enforced by ensuring that `AsciiTable`'s `addColumn` method may only create an `AsciiTable` compatible column. The `ColumnData<T>` class stores its data in a `std::vector<T>` object.

`BinTables` may contain either `ColumnData<T>` or `ColumnVectorData<T>`. For `ColumnVectorData`, T must be a numeric type: string vectors are handled by `ColumnData<T>`; string arrays are not supported. The internal representation of the data is a `std::vector<std::valarray<T> >` object. The `std::valarray` class is designed for efficient numeric processing and has many vectorized numeric and transcendental functions defined on it.

Member template functions for read/write operations are provided in multiple overloads as the interface to data operations. Implicit data type conversions are supported but where they are required make the operations less efficient. Reading numeric column data as character arrays, supported by `cfitsio`, is not supported by `CCfits`.

As a base class, `Column` provides protected accessor/mutator inline functions to allow only its subclasses to access data members.

23.3.2 Constructor & Destructor Documentation

23.3.2.1 CCfits::Column::Column (const Column & right)

copy constructor, used in copying Columns to standard library containers.

The copy constructor is for internal use only: it does not affect the disk fits file associated with the object.

23.3.2.2 CCfits::Column::Column (int columnIndex, const String & columnName, ValueType type, const String & format, const String & unit, Table * p, int rpt = 1, long w = 1, const String & comment = " ") [protected]

new column creation constructor

This constructor allows the specification of:

Parameters

<i>columnIndex</i>	The column number
<i>column-Name</i>	The column name, keyword TTYPE <i>n</i>
<i>type</i>	used for determining class of T in ColumnData<T>, ColumnVectorData<T>
<i>format</i>	the column data format, TFORM <i>n</i> keyword
<i>unit</i>	the column data unit, TUNIT <i>n</i> keyword
<i>p</i>	the Table pointer
<i>rpt</i>	(optional) repeat count for the row (== 1 for AsciiTables)
<i>w</i>	the row width
<i>comment</i>	comment to be added to the header.

23.3.3 Member Function Documentation

23.3.3.1 `template<typename T > void CCfits::Column::addNullValue (T nullVal)`

Set the TNULL*n* keyword for the column.

Only relevant for integer valued columns, TNULL*n* is the value used by cfitsio in undefined processing. All entries in the table equal to an input "null value" are set equal to the value of TNULL*n*. (For floating point columns a system NaN value is used).

23.3.3.2 `const String & CCfits::Column::dimen () const [inline]`

return TDIM*n* keyword

represents dimensions of data arrays in vector columns. for scalar columns, returns a default value.

23.3.3.3 `const String & CCfits::Column::display () const [inline]`

return TDISP*n* keyword

TDISP*n* is suggested format for output of column data.

23.3.3.4 `const String & CCfits::Column::format () const [inline]`

return TFORM*n* keyword

TFORM*n* specifies data format stored in disk file.

23.3.3.5 `template<typename T > bool CCfits::Column::getNullValue (T * nullVal) const`

Get the value of the TNULL*n* keyword for the column.

Only relevant for integer valued columns. If the TNULLn keyword is present, its value will be written to **nullVal* and the function returns *true*. If the keyword is not found or its value is undefined, the function returns *false* and **nullVal* is not modified.

Parameters

<i>nullVal</i>	A pointer to the variable for storing the TNULLn value.
----------------	---

23.3.3.6 `template<typename S> void CCfits::Column::read (std::vector< S> & vals, long first, long last)`

Retrieve data from a scalar column into a `std::vector`.

This and the following functions perform implicit data conversions. An exception will be thrown if no conversion exists.

Parameters

<i>vals</i>	The output container. The function will resize this as necessary
<i>first,last</i>	the span of row numbers to read.

23.3.3.7 `template<typename S> void CCfits::Column::read (std::valarray< S> & vals, long first, long last)`

Retrieve data from a scalar column into a `std::valarray`.

Parameters

<i>vals</i>	The output container. The function will resize this as necessary
<i>first,last</i>	the span of row numbers to read.

23.3.3.8 `template<typename S> void CCfits::Column::read (std::valarray< S> & vals, long row)`

return a single row of a vector column into a `std::valarray`

Parameters

<i>vals</i>	The output valarray object
<i>row</i>	The row number to be retrieved (starting at 1).

23.3.3.9 `template<typename S> void CCfits::Column::read (std::vector< S> & vals, long row)`

return a single row of a vector column into a `std::vector`

Parameters

<i>vals</i>	The output vector object
<i>row</i>	The row number to be retrieved (starting at 1).

23.3.3.10 `template<typename S> void CCfits::Column::read (std::vector< S > & vals, long first, long last, S * nullValue)`

Retrieve data from a scalar column into a `std::vector<`, applying `nullValue` when relevant.

If both `nullValue` and `*nullValue` are not 0, then any undefined values in the file will be converted to `*nullValue` when copied into the `vals` vector. See `cfitsio` documentation for further details

Parameters

<i>vals</i>	The output container. The function will resize this as necessary
<i>first,last</i>	the span of row numbers to read.
<i>nullValue</i>	pointer to value to be applied to undefined elements.

23.3.3.11 `template<typename S> void CCfits::Column::read (std::valarray< S > & vals, long first, long last, S * nullValue)`

Retrieve data from a scalar column into a `std::valarray`, applying `nullValue` when relevant.

If both `nullValue` and `*nullValue` are not 0, then any undefined values in the file will be converted to `*nullValue` when copied into the `vals` valarray. See `cfitsio` documentation for further details

Parameters

<i>vals</i>	The output container. The function will resize this as necessary
<i>first,last</i>	the span of row numbers to read.
<i>nullValue</i>	pointer to value to be applied to undefined elements.

23.3.3.12 `template<typename S> void CCfits::Column::read (std::valarray< S > & vals, long rows, S * nullValue)`

return a single row of a vector column into a `std::valarray`, setting undefined values

return a single row of a vector column into a `std::vector`, setting undefined values

23.3.3.13 `template<typename S> void CCfits::Column::readArrays (std::vector< std::valarray< S > > & vals, long first, long last)`

return a set of rows of a vector column into a vector of valarrays

Parameters

<i>vals</i>	The output container. The function will resize this as necessary
<i>first,last</i>	the span of row numbers to read.

23.3.3.14 `template<typename S > void CCfits::Column::readArrays (std::vector< std::valarray< S > > & vals, long first, long last, S * nullValue)`

return a set of rows of a vector column into a container, setting undefined values

Parameters

<i>vals</i>	The output container. The function will resize this as necessary
<i>first,last</i>	the span of row numbers to read.
<i>nullValue</i>	pointer to integer value regarded as undefined

23.3.3.15 `void CCfits::Column::readData (long firstRow = 1, long nelements = 1, long firstElem = 1) [pure virtual]`

Read (or reread) data from the disk into the [Column](#) object's internal arrays.

This function normally does not need to be called. See the **resetRead** function for an alternative way of performing a reread from disk.

Parameters

<i>firstRow</i>	The first row to be read
<i>nelements</i>	The number of elements to read
<i>firstElem</i>	The number of the element on the first row to start at (ignored for scalar columns)

23.3.3.16 `void CCfits::Column::resetRead () [inline]`

reset the Column's isRead flag to false

This forces the data to be reread from the disk the next time a read command is called on the [Column](#), rather than simply retrieving the data already stored in the [Column](#) object's internal arrays. This may be useful for example if trying to reread a [Column](#) using a different nullValue argument than for an earlier read.

23.3.3.17 `int CCfits::Column::rows () const`

return the number of rows in the table.

return number of rows in the [Column](#)

23.3.3.18 `double CCfits::Column::scale () const` `[inline]`

get TSCALn value

TSCALn is used to convert a data array represented on disk in integer format as floating. Useful for compact storage of digitized data.

23.3.3.19 `template<typename S> void CCfits::Column::write (const std::vector< S> & indata, long firstRow)`

write a vector of values into a scalar column starting with firstRow

Parameters

<i>indata</i>	The data to be written.
<i>firstRow</i>	The first row to be written

23.3.3.20 `template<typename S> void CCfits::Column::write (const std::valarray< S> & indata, long firstRow)`

write a valarray of values into a scalar column starting with firstRow

Parameters

<i>indata</i>	The data to be written.
<i>firstRow</i>	The first row to be written

23.3.3.21 `template<typename S> void CCfits::Column::write (S * indata, long nRows, long firstRow)`

write a C array of size nRows into a scalar [Column](#) starting with row firstRow.

Parameters

<i>indata</i>	The data to be written.
<i>nRows</i>	The size of the data array to be written
<i>firstRow</i>	The first row to be written

23.3.3.22 `template<typename S> void CCfits::Column::write (const std::vector< S> & indata, long firstRow, S * nullValue)`

write a vector of values into a scalar column starting with firstRow, replacing elements equal to nullValue with the [FITS](#) null value.

If *nullValue* is not 0, the appropriate [FITS](#) null value will be substituted for all elements of *indata* equal to **nullValue*. For integer type columns there must be a pre-existing T-NULLn keyword to define the [FITS](#) null value, otherwise a [FitsError](#) exception is thrown.

For floating point columns, the [FITS](#) null is the IEEE NaN (Not-a-Number) value. See the cfitsio fits_write_colnull function documentation for more details.

Parameters

<i>indata</i>	The data to be written.
<i>firstRow</i>	The first row to be written
<i>nullValue</i>	Pointer to the value for which equivalent <i>indata</i> elements will be replaced in the file with the appropriate FITS null value.

23.3.3.23 `template<typename S> void CCfits::Column::write (const std::valarray< S > &indata, long firstRow, S * nullValue)`

write a valarray of values into a scalar column starting with firstRow, replacing elements equal to nullValue with the [FITS](#) null value.

If *nullValue* is not 0, the appropriate [FITS](#) null value will be substituted for all elements of *indata* equal to **nullValue*. For integer type columns there must be a pre-existing T-NULLn keyword to define the [FITS](#) null value, otherwise a [FitsError](#) exception is thrown. For floating point columns, the [FITS](#) null is the IEEE NaN (Not-a-Number) value. See the cfitsio fits_write_colnull function documentation for more details.

Parameters

<i>indata</i>	The data to be written.
<i>firstRow</i>	The first row to be written
<i>nullValue</i>	Pointer to the value for which equivalent <i>indata</i> elements will be replaced in the file with the appropriate FITS null value.

23.3.3.24 `template<typename S> void CCfits::Column::write (S * indata, long nRows, long firstRow, S * nullValue)`

write a C array into a scalar [Column](#), processing undefined values.

Parameters

<i>indata</i>	The data to be written.
<i>nRows</i>	The size of the data array to be written
<i>firstRow</i>	The first row to be written
<i>nullValue</i>	Pointer to the value in the input array to be set to undefined values

23.3.3.25 `template<typename S> void CCfits::Column::write (const std::valarray< S > &indata, long nRows, long firstRow)`

write a valarray of values into a range of rows of a vector column.

The primary use of this is for fixed width columns, in which case Column's repeat attribute is used to determine how many elements are written to each row; if `indata.size()` is too small an exception will be thrown. If the column is variable width, the call will write `indata.size()/nRows` elements to each row.

Parameters

<i>indata</i>	The data to be written.
<i>nRows</i>	the number of rows to which to write the data.
<i>firstRow</i>	The first row to be written

23.3.3.26 `template<typename S > void CCfits::Column::write (const std::vector< S > & indata, long nRows, long firstRow)`

write a vector of values into a range of rows of a vector column

The primary use of this is for fixed width columns, in which case Column's repeat attribute is used to determine how many elements are written to each row; if `indata.size()` is too small an exception will be thrown. If the column is variable width, the call will write `indata.size()/nRows` elements to each row.

Parameters

<i>indata</i>	The data to be written.
<i>nRows</i>	the number of rows to which to write the data.
<i>firstRow</i>	The first row to be written

23.3.3.27 `template<typename S > void CCfits::Column::write (S * indata, long nElements, long nRows, long firstRow)`

write a C array of values into a range of rows of a vector column

Details are as for vector input; only difference is the need to supply the size of the C-array.

Parameters

<i>indata</i>	The data to be written.
<i>nElements</i>	The size of indata
<i>nRows</i>	the number of rows to which to write the data.
<i>firstRow</i>	The first row to be written

23.3.3.28 `template<typename S > void CCfits::Column::write (const std::valarray< S > & indata, long nRows, long firstRow, S * nullValue)`

write a valarray of values into a range of rows of a vector column.

see version without undefined processing for details.

23.3.3.29 `template<typename S> void CCfits::Column::write (const std::vector< S > & indata, long nRows, long firstRow, S * nullValue)`

write a vector of values into a range of rows of a vector column, processing undefined values

see version without undefined processing for details.

23.3.3.30 `template<typename S> void CCfits::Column::write (S * indata, long nElements, long nRows, long firstRow, S * nullValue)`

write a C array of values into a range of rows of a vector column, processing undefined values.

see version without undefined processing for details.

23.3.3.31 `template<typename S> void CCfits::Column::write (const std::valarray< S > & indata, const std::vector< long > & vectorLengths, long firstRow)`

write a valarray of values into a column with specified number of entries written per row.

Data are written into `vectorLengths.size()` rows, with `vectorLength[n]` elements written to row `n+firstRow -1`. Although primarily intended for wrapping calls to multiple variable-width vector column rows, it may also be used to write a variable number of elements to fixed-width column rows.

When writing to fixed-width column rows, if the number of elements sent to a particular row are fewer than the column's repeat value, the remaining elements in the row will not be modified.

Since cfitsio does not support null value processing for variable width columns this function and its variants do not have version which process undefined values

Parameters

<i>indata</i>	The data to be written
<i>vector- Lengths</i>	the number of elements to write to each successive row.
<i>firstRow</i>	the first row to be written.

23.3.3.32 `template<typename S> void CCfits::Column::write (const std::vector< S > & indata, const std::vector< long > & vectorLengths, long firstRow)`

write a vector of values into a column with specified number of entries written per row.

Intended for writing a varying number of elements to multiple rows in a vector column, this may be used for either variable or fixed-width columns. See the `indata` valarray version of this function for a complete description.

23.3.3.33 `template<typename S> void CCfits::Column::write (S * indata, long nElements,
const std::vector< long > & vectorLengths, long firstRow)`

write a C-array of values of size *nElements* into a vector column with specified number of entries written per row.

Intended for writing a varying number of elements to multiple rows in a vector column, this may be used for either variable or fixed-width columns. See the *indata* valarray version of this function for a complete description.

23.3.3.34 `template<typename S> void CCfits::Column::writeArrays (const std::vector<
std::valarray< S > > & indata, long firstRow)`

write a vector of valarray objects to the column, starting at row *firstRow* ≥ 1

Intended for writing a varying number of elements to multiple rows in a vector column, this may be used for either variable or fixed-width columns. When writing to fixed-width column rows, if the number of elements sent to a particular row are fewer than the column's repeat value, the remaining elements in the row will not be modified.

Parameters

<i>indata</i>	The data to be written
<i>firstRow</i>	the first row to be written.

23.3.3.35 `template<typename S> void CCfits::Column::writeArrays (const std::vector<
std::valarray< S > > & indata, long firstRow, S * nullValue)`

write a vector of valarray objects to the column, starting at row *firstRow* ≥ 1 , processing undefined values

see version without undefined processing for details.

23.3.3.36 `double CCfits::Column::zero () const [inline]`

get TZEROn value

TZEROn is an integer offset used in the implementation of unsigned data

The documentation for this class was generated from the following files:

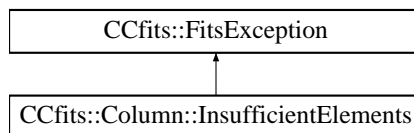
- Column.h
- Column.cxx
- ColumnT.h

23.4 CCfits::Column::InsufficientElements Class Reference

Exception thrown if the data supplied for a write operation is less than declared.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::InsufficientElements:



Public Member Functions

- [InsufficientElements](#) (const String &msg, bool silent=true)

Exception ctor, prefixes the string "FitsError: not enough elements supplied for write operation: " before the specific message.

23.4.1 Detailed Description

Exception thrown if the data supplied for a write operation is less than declared.

This circumstance generates an exception to avoid unexpected behaviour after the write operation is completed. It can be avoided by resizing the input array appropriately.

23.4.2 Constructor & Destructor Documentation

23.4.2.1 CCfits::Column::InsufficientElements::InsufficientElements (const String & msg, bool silent = true)

Exception ctor, prefixes the string "FitsError: not enough elements supplied for write operation: " before the specific message.

Parameters

<i>msg</i>	A specific diagnostic message, usually the column name
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

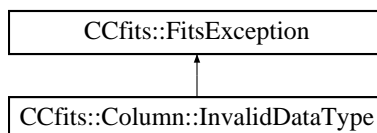
- Column.h
- Column.cxx

23.5 CCfits::Column::InvalidDataType Class Reference

Exception thrown for invalid data type inputs.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::InvalidDataType:



Public Member Functions

- [InvalidDataType](#) (const String &str=string(), bool silent=true)

Exception ctor, prefixes the string "FitsError: Incorrect data type: " before the specific message.

23.5.1 Detailed Description

Exception thrown for invalid data type inputs.

This exception is thrown if the user requests an implicit data type conversion to a datatype that is not one of the supported types (see fitsio.h for details).

23.5.2 Constructor & Destructor Documentation

23.5.2.1 CCfits::Column::InvalidDataType::InvalidDataType (const String &str = string(), bool silent = true)

Exception ctor, prefixes the string "FitsError: Incorrect data type: " before the specific message.

Parameters

<i>str</i>	A specific diagnostic message
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

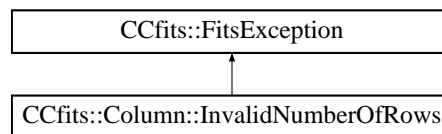
- Column.h
- Column.cxx

23.6 CCfits::Column::InvalidNumberOfRows Class Reference

Exception thrown if user enters a non-positive number for the number of rows to write.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::InvalidNumberOfRows:



Public Member Functions

- [InvalidNumberOfRows](#) (int number, bool silent=true)
Exception ctor, prefixes the string "Fits Error: number of rows to write must be positive" before the specific message.

23.6.1 Detailed Description

Exception thrown if user enters a non-positive number for the number of rows to write.

23.6.2 Constructor & Destructor Documentation

23.6.2.1 CCfits::Column::InvalidNumberOfRows::InvalidNumberOfRows (int *number*, bool *silent* = true)

Exception ctor, prefixes the string "Fits Error: number of rows to write must be positive" before the specific message.

Parameters

<i>number</i>	The number of rows entered.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

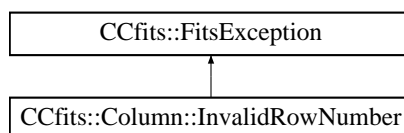
- Column.h
- Column.cxx

23.7 CCfits::Column::InvalidRowNumber Class Reference

Exception thrown on attempting to read a row number beyond the end of a table.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::InvalidRowNumber:



Public Member Functions

- [InvalidRowNumber](#) (const String &diag, bool silent=true)

Exception ctor, prefixes the string "FitsError: Invalid Row Number - Column: " before the specific message.

23.7.1 Detailed Description

Exception thrown on attempting to read a row number beyond the end of a table.

23.7.2 Constructor & Destructor Documentation

23.7.2.1 CCfits::Column::InvalidRowNumber::InvalidRowNumber (const String & diag, bool silent = true)

Exception ctor, prefixes the string "FitsError: Invalid Row Number - Column: " before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message, usually the column name.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

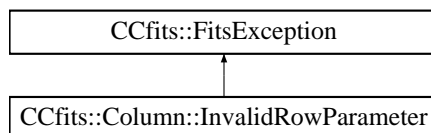
- Column.h
- Column.cxx

23.8 CCfits::Column::InvalidRowParameter Class Reference

Exception thrown on incorrect row writing request.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::InvalidRowParameter:



Public Member Functions

- [InvalidRowParameter](#) (const String &diag, bool silent=true)

Exception ctor, prefixes the string "FitsError: row offset or length incompatible with column declaration " before the specific message.

23.8.1 Detailed Description

Exception thrown on incorrect row writing request.

This exception is thrown if the user requests writing more data than a fixed width row can accommodate. An exception is thrown rather than a truncation because it is likely that the user will not otherwise realize that data loss is happening.

23.8.2 Constructor & Destructor Documentation

23.8.2.1 CCfits::Column::InvalidRowParameter::InvalidRowParameter (const String & diag, bool silent = true)

Exception ctor, prefixes the string "FitsError: row offset or length incompatible with column declaration " before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message, usually the column name
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

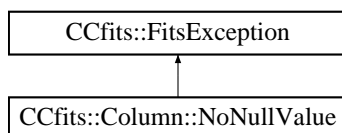
- Column.h
- Column.cxx

23.9 CCfits::Column::NoNullValue Class Reference

Exception thrown if a null value is specified without support from existing column header.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::NoNullValue:



Public Member Functions

- [NoNullValue](#) (const String &diag, bool silent=true)

Exception ctor, prefixes the string "Fits Error: No null value specified for column: " before the specific message.

23.9.1 Detailed Description

Exception thrown if a null value is specified without support from existing column header.

This exception is analogous to the fact that cfitsio returns a non-zero status code if -TNULLn doesn't exist and a null value (convert all input data with the null value to the TNULLn keyword) is specified. It is only relevant for integer type data (see cfitsio manual for details).

23.9.2 Constructor & Destructor Documentation

23.9.2.1 CCfits::Column::NoNullValue::NoNullValue (const String & diag, bool silent = true)

Exception ctor, prefixes the string "Fits Error: No null value specified for column: " before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

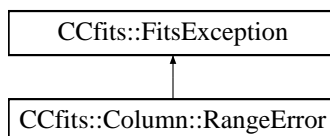
- Column.h
- Column.cxx

23.10 CCfits::Column::RangeError Class Reference

exception to be thrown for inputs that cause range errors in column read operations.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::RangeError:



Public Member Functions

- [RangeError](#) (const String &msg, bool silent=true)

Exception ctor, prefixes the string "FitsError: Range error in operation " before the specific message.

23.10.1 Detailed Description

exception to be thrown for inputs that cause range errors in column read operations.

Range errors here mean (last < first) in a request to read a range of rows.

23.10.2 Constructor & Destructor Documentation

23.10.2.1 CCfits::Column::RangeError::RangeError (const String & msg, bool silent = true)

Exception ctor, prefixes the string "FitsError: Range error in operation " before the specific message.

Parameters

<i>msg</i>	A specific diagnostic message
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

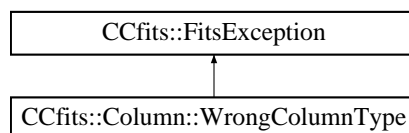
- Column.h
- Column.cxx

23.11 CCfits::Column::WrongColumnType Class Reference

Exception thrown on attempting to access a scalar column as vector data.

```
#include <Column.h>
```

Inheritance diagram for CCfits::Column::WrongColumnType:



Public Member Functions

- [WrongColumnType](#) (const String &diag, bool silent=true)

Exception ctor, prefixes the string "FitsError: Attempt to return scalar data from vector column, or vice versa - Column: " before the specific message.

23.11.1 Detailed Description

Exception thrown on attempting to access a scalar column as vector data.

This exception will be thrown if the user tries to call a read/write operation with a signature appropriate for a vector column on a scalar column, or vice versa. For example in the case of write operations, the vector versions require the specification of (a) a number of rows to write over, (b) a vector of lengths to write to each row or (c) a subset specification. The scalar versions only require a number of rows if the input array is a plain C-array, otherwise the range to be written is the size of the input vector.

23.11.2 Constructor & Destructor Documentation

23.11.2.1 CCfits::Column::WrongColumnType::WrongColumnType (const String & diag, bool silent = true)

Exception ctor, prefixes the string "FitsError: Attempt to return scalar data from vector column, or vice versa - Column: " before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message, usually the column name.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

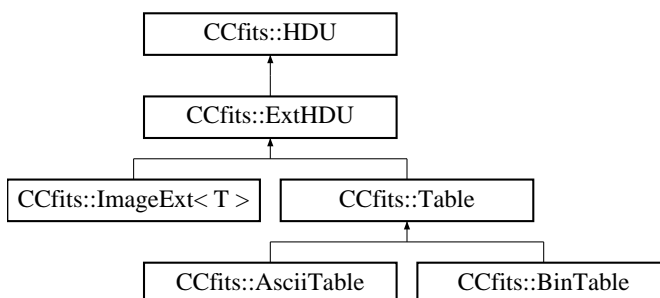
- Column.h
- Column.cxx

23.12 CCfits::ExtHDU Class Reference

base class for all [FITS](#) extension HDUs, i.e. Image Extensions and Tables.

```
#include <ExtHDU.h>
```

Inheritance diagram for CCfits::ExtHDU:



Classes

- class [WrongExtensionType](#)
Exception to be thrown on unmatched extension types.

Public Member Functions

- [ExtHDU](#) (const [ExtHDU](#) &right)
copy constructor
- virtual [~ExtHDU](#) ()
destructor
- virtual void [addColumn](#) ([ValueType](#) type, const String &columnName, long repeatWidth, const String &colUnit=String(""), long decimals=-1, size_t columnNumber=0)
add a new column to an existing table [HDU](#).
- virtual [HDU](#) * [clone](#) (FITSBase *p) const =0
virtual copy constructor
- virtual [Column](#) & [column](#) (const String &colName, bool caseSensitive=true) const

return a reference to a [Table](#) column specified by name.

- virtual [Column](#) & [column](#) (int collIndex) const

return a reference to a [Table](#) column specified by column index.

- virtual const [ColMap](#) & [column](#) () const

return a reference to the multimap containing the columns.

- virtual void [copyColumn](#) (const [Column](#) &inColumn, int collIdx, bool insertNewCol=true)

copy a column (from different or same [HDU](#) and file) into an existing table [HDU](#).

- virtual void [deleteColumn](#) (const String &columnName)

delete a column in a [Table](#) extension by name.

- virtual long [getRowsize](#) () const

return the optimal number of rows to read or write at a time

- bool [isCompressed](#) () const

return true if image is stored using compression.

- virtual void [makeThisCurrent](#) () const

move the fitsfile pointer to this current [HDU](#).

- const String & [name](#) () const

return the name of the extension.

- virtual int [numCols](#) () const

return the number of Columns in the [Table](#) (the `TFIELDS` keyword).

- template<typename S >

void [read](#) (std::valarray< S > &image)

Read image data into container.

- template<typename S >

void [read](#) (std::valarray< S > &image, long first, long nElements, S *nullValue)

read part of an image array, processing null values.

- template<typename S >

void [read](#) (std::valarray< S > &image, const std::vector< long > &first, long nElements, S *nullValue)

read part of an image array, processing null values.

- template<typename S >

void [read](#) (std::valarray< S > &image, const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::vector< long > &stride)

read an image subset

- template<typename S >

void [read](#) (std::valarray< S > &image, long first, long nElements)

read an image section starting at a specified pixel

- template<typename S >

void [read](#) (std::valarray< S > &image, const std::vector< long > &first, long nElements)

read an image section starting at a location specified by an n-tuple

- template<typename S >
void **read** (std::valarray< S > &image, const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::vector< long > &stride, S *nullValue)
read an image subset into valarray image, processing null values
- virtual void **readData** (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())=0
read data from HDU depending on readFlag and keys.
- virtual long **rows** () const
return the number of rows in the extension.
- int **version** () const
return the extension version number.
- void **version** (int value)
set the extension version number
- template<typename S >
void **write** (const std::vector< long > &first, long nElements, const std::valarray< S > &data, S *nullValue)
Write a set of pixels to an image extension with the first pixel specified by an n-tuple, processing undefined data.
- template<typename S >
void **write** (long first, long nElements, const std::valarray< S > &data, S *nullValue)
write array to image starting with a specified pixel and allowing undefined data to be processed
- template<typename S >
void **write** (const std::vector< long > &first, long nElements, const std::valarray< S > &data)
write array starting from specified n-tuple, without undefined data processing
- template<typename S >
void **write** (long first, long nElements, const std::valarray< S > &data)
write array starting from specified pixel number, without undefined data processing
- template<typename S >
void **write** (const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::valarray< S > &data)
write a subset (generalize slice) of data to the image

Static Public Member Functions

- static void **readHduName** (const fitsfile *fptr, int hduIndex, String &hduName, int &hduVersion)
read extension name.

Protected Member Functions

- [ExtHDU](#) (FITSBase *p, HduType xtype, const String &hduName, int version)
default constructor, required as Standard Library Container content.
- [ExtHDU](#) (FITSBase *p, HduType xtype, const String &hduName, int bitpix, int naxis, const std::vector< long > &axes, int version)
writing constructor.
- [ExtHDU](#) (FITSBase *p, HduType xtype, int number)
ExtHDU constructor for getting ExtHDUs by number.
- long [gcount](#) () const
return required gcount keyword value
- void [gcount](#) (long value)
set required gcount keyword value
- long [pcount](#) () const
return required pcount keyword value
- void [pcount](#) (long value)
set required pcount keyword value
- HduType [xtension](#) () const
return the extension type
- void [xtension](#) (HduType value)
set the extension type

23.12.1 Detailed Description

base class for all [FITS](#) extension HDUs, i.e. Image Extensions and Tables.

[ExtHDU](#) needs to have the combined public interface of [Table](#) objects and images. It achieves this by providing the same set of read and write operations as [PHDU](#), and also providing the same operations for extracting columns from the extension as does [Table](#) [after which the column interface is accessible]. Differentiation between extension types operates by exception handling: .i.e. attempting to access image data structures on a [Table](#) object through the [ExtHDU](#) interface will or trying to return a [Column](#) reference from an Image extension will both throw an exception

23.12.2 Constructor & Destructor Documentation

23.12.2.1 CCfits::ExtHDU::ExtHDU (FITSBase * p, HduType xtype, const String & hduName, int bitpix, int naxis, const std::vector< long > & axes, int version)
[protected]

writing constructor.

The writing constructor forces the user to supply a name for the [HDU](#). The bitpix, naxes and naxis data required by this constructor are required [FITS](#) keywords for any HDUs.

23.12.2.2 `CCfits::ExtHDU::ExtHDU (FITSBase * p, HduType xtype, int number)`
`[protected]`

[ExtHDU](#) constructor for getting ExtHDUs by number.

Necessary since EXTNAME is a reserved, not required, keyword. But a synthetic name is supplied by static [ExtHDU::readHduName](#) which is called by this constructor.

23.12.3 Member Function Documentation

23.12.3.1 `void CCfits::ExtHDU::addColumn (ValueType type, const String & columnName, long repeatWidth, const String & colUnit = String(" "), long decimals = -1, size_t columnNumber = 0)` `[virtual]`

add a new column to an existing table [HDU](#).

Parameters

<i>type</i>	The data type of the column to be added
<i>column-Name</i>	The name of the column to be added
<i>repeatWidth</i>	for a string valued, this is the width of a string. For a numeric column it supplies the vector length of the rows. It is ignored for ascii table numeric data.
<i>colUnit</i>	an optional field specifying the units of the data (TUNITn)
<i>decimals</i>	optional parameter specifying the number of decimals for an ascii numeric column
<i>column-Number</i>	optional parameter specifying column number to be created. If not specified the column is added to the end. If specified, the column is inserted and the columns already read are reindexed. This parameter is provided as a convenience to support existing code rather than recommended.

Reimplemented in [CCfits::AsciiTable](#), and [CCfits::BinTable](#).

23.12.3.2 `Column & CCfits::ExtHDU::column (const String & colName, bool caseSensitive = true) const` `[virtual]`

return a reference to a [Table](#) column specified by name.

If the *caseSensitive* parameter is set to false, the search will be case-insensitive. The overridden base class implementation [ExtHDU::column](#) throws an exception, which is thus the action to be taken if self is an image extension

Exceptions

WrongExtensionType	see above
------------------------------------	-----------

Reimplemented in [CCfits::Table](#).

23.12.3.3 Column & CCfits::ExtHDU::column (int *colIdx*) const [virtual]

return a reference to a [Table](#) column specified by column index.

This version is provided for convenience; the 'return by name' version is more efficient because columns are stored in an associative array sorted by name.

Exceptions

WrongExtensionType	thrown if *this is an image extension.
------------------------------------	--

Reimplemented in [CCfits::Table](#).

23.12.3.4 const ColMap & CCfits::ExtHDU::column () const [virtual]

return a reference to the multimap containing the columns.

Exceptions

WrongExtensionType	thrown if *this is an image extension.
------------------------------------	--

Reimplemented in [CCfits::Table](#).

23.12.3.5 void CCfits::ExtHDU::copyColumn (const Column & *inColumn*, int *colIdx*, bool *insertNewCol* = true) [virtual]

copy a column (from different or same [HDU](#) and file) into an existing table [HDU](#).

This is meant to provide the same functionality as CFITSIO's fits_copy_col, and therefore does not work with columns with variable length fields. Copying a column from an [AsciiTable](#) to a [BinTable](#) is prohibited. colIdx range should be from 1 to nCurrentCols+1 if inserting, or 1 to nCurrentCols if replacing.

Parameters

<i>inColumn</i>	The Column object which is to be copied
<i>colIdx</i>	The position for which the copied Column will be placed (first colIdx = 1).
<i>insertNewCol</i>	If 'true', new Column will be inserted in or appended to table. If 'false', Column will replace current Column at position = colIdx.

Reimplemented in [CCfits::Table](#).

23.12.3.6 void CCfits::ExtHDU::deleteColumn (const String & *columnName*) [virtual]

delete a column in a [Table](#) extension by name.

Parameters

<i>column-Name</i>	The name of the column to be deleted.
--------------------	---------------------------------------

Exceptions

WrongExtensionType	if extension is an image.
------------------------------------	---------------------------

Reimplemented in [CCfits::Table](#).

23.12.3.7 long CCfits::ExtHDU::getRowsize () const [virtual]

return the optimal number of rows to read or write at a time

A wrapper for the CFITSIO function fits_get_rowsize, useful for obtaining maximum I/O efficiency. This will throw if it is not called for a [Table](#) extension.

Reimplemented in [CCfits::Table](#).

23.12.3.8 bool CCfits::ExtHDU::isCompressed () const

return true if image is stored using compression.

This is simply a wrapper around the CFITSIO fits_is_compressed_image function. It will throw if this is not an Image extension.

23.12.3.9 void CCfits::ExtHDU::makeThisCurrent () const [virtual]

move the fitsfile pointer to this current [HDU](#).

This function should never need to be called by the user since it is called internally whenever required.

Reimplemented from [CCfits::HDU](#).

23.12.3.10 int CCfits::ExtHDU::numCols () const [virtual]

return the number of Columns in the [Table](#) (the TFIELD keyword).

Exceptions

WrongExtensionType	thrown if *this is an image extension.
------------------------------------	--

Reimplemented in [CCfits::Table](#).

23.12.3.11 `template<typename S> void CCfits::ExtHDU::read (std::valarray< S > & image)`

Read image data into container.

The container image contains the entire image array after the call. This and all the other variants of `read()` throw a [WrongExtensionType](#) exception if called for a [Table](#) object.

23.12.3.12 `template<typename S> void CCfits::ExtHDU::read (std::valarray< S > & image, long first, long nElements, S * nullValue)`

read part of an image array, processing null values.

Implicit data conversion is supported (i.e. user does not need to know the type of the data stored. A [WrongExtensionType](#) extension is thrown if *this is not an image.

Parameters

<i>image</i>	The receiving container, a std::valarray reference
<i>first</i>	The first pixel from the array to read [a long value]
<i>nElements</i>	The number of values to read
<i>nullValue</i>	A pointer containing the value in the table to be considered as undefined. See cfitsio for details

23.12.3.13 `template<typename S> void CCfits::ExtHDU::read (std::valarray< S > & image, const std::vector< long > & first, long nElements, S * nullValue)`

read part of an image array, processing null values.

As above except for

Parameters

<i>first</i>	a vector<long> representing an n-tuple giving the coordinates in the image of the first pixel.
--------------	--

23.12.3.14 `template<typename S> void CCfits::ExtHDU::read (std::valarray< S > & image, const std::vector< long > & firstVertex, const std::vector< long > & lastVertex, const std::vector< long > & stride, S * nullValue)`

read an image subset into valarray image, processing null values

The image subset is defined by two vertices and a stride indicating the 'denseness' of the values to be picked in each dimension (a stride = (1,1,1,...) means picking every pixel in every dimension, whereas stride = (2,2,2,...) means picking every other value in each dimension.

23.12.3.15 `static void CCfits::ExtHDU::readHduName (const fitsfile * fptr, int hduIndex, String & hduName, int & hduVersion) [static]`

read extension name.

Used primarily to allow extensions to be specified by HDU number and provide their name for the associative array that contains them. Alternatively, if there is no name keyword in the extension, one is synthesized from the index.

23.12.3.16 `long CCfits::ExtHDU::rows () const [virtual]`

return the number of rows in the extension.

Exceptions

WrongExtensionType	thrown if *this is an image extension.
------------------------------------	--

Reimplemented in [CCfits::Table](#).

23.12.3.17 `template<typename S > void CCfits::ExtHDU::write (const std::vector< long > & first, long nElements, const std::valarray< S > & data, S * nullValue)`

Write a set of pixels to an image extension with the first pixel specified by an n-tuple, processing undefined data.

All the overloaded versions of [ExtHDU::write](#) perform operations on *this if it is an image and throw a [WrongExtensionType](#) exception if not. Where appropriate, alternate versions allow undefined data to be processed

Parameters

<i>first</i>	an n-tuple of dimension equal to the image dimension specifying the first pixel in the range to be written
<i>nElements</i>	number of pixels to be written
<i>data</i>	array of data to be written
<i>nullValue</i>	pointer to null value (data with this value written as undefined; needs the BLANK keyword to have been specified).

23.12.3.18 `template<typename S > void CCfits::ExtHDU::write (long first, long nElements, const std::valarray< S > & data, S * nullValue)`

write array to image starting with a specified pixel and allowing undefined data to be processed

parameters after the first are as for version with n-tuple specifying first element. these two version are equivalent, except that it is possible for the first pixel number to exceed the range of 32-bit integers, which is how long datatype is commonly implemented.

23.12.3.19 `template<typename S> void CCfits::ExtHDU::write (const std::vector< long > & firstVertex, const std::vector< long > & lastVertex, const std::valarray< S > & data)`

write a subset (generalize slice) of data to the image

A generalized slice/subset is a subset of the image (e.g. one plane of a data cube of size \leq the dimension of the cube). It is specified by two opposite vertices. The equivalent cfitsio call does not support undefined data processing so there is no version that allows a null value to be specified.

Parameters

<i>firstVertex</i>	the coordinates specifying lower and upper vertices of the n-dimensional slice
<i>lastVertex</i>	
<i>data</i>	The data to be written

23.12.3.20 `HduType CCfits::ExtHDU::xtension () const [inline, protected]`

return the extension type

allowed values are ImageHDU, AsciiTbl, and BinaryTbl

The documentation for this class was generated from the following files:

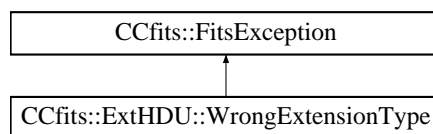
- ExtHDU.h
- ExtHDU.cxx
- ExtHDUT.h

23.13 CCfits::ExtHDU::WrongExtensionType Class Reference

Exception to be thrown on unmatched extension types.

`#include <ExtHDU.h>`

Inheritance diagram for CCfits::ExtHDU::WrongExtensionType:



Public Member Functions

- [WrongExtensionType](#) (const String &msg, bool silent=true)

Exception ctor, prefixes the string "Fits Error: wrong extension type" before the specific message.

23.13.1 Detailed Description

Exception to be thrown on unmatched extension types.

This exception is to be thrown if the user requested a particular extension and it does not correspond to the expected type.

23.13.2 Constructor & Destructor Documentation

23.13.2.1 CCfits::ExtHDU::WrongExtensionType::WrongExtensionType (const String & msg, bool silent = true)

Exception ctor, prefixes the string "Fits Error: wrong extension type" before the specific message.

Parameters

<i>msg</i>	A specific diagnostic message
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

- ExtHDU.h
- ExtHDU.cxx

23.14 CCfits::FITS Class Reference

Memory object representation of a disk [FITS](#) file.

```
#include <FITS.h>
```

Classes

- class [CantCreate](#)
thrown on failure to create new file
- class [CantOpen](#)
thrown on failure to open existing file
- class [NoSuchHDU](#)
exception thrown by [HDU](#) retrieval methods.
- class [OperationNotSupported](#)

thrown for unsupported operations, such as attempted to select rows from an image extension.

Public Member Functions

- **FITS** (const String &name, RWmode mode=Read, bool readDataFlag=false, const std::vector< String > &primaryKeys=std::vector< String >())

basic constructor

- **FITS** (const String &name, RWmode mode, const string &hduName, bool readDataFlag=false, const std::vector< String > &hduKeys=std::vector< String >(), const std::vector< String > &primaryKey=std::vector< String >(), int version=1)

*Open a **FITS** file and read a single specified **HDU**.*

- **FITS** (const String &name, RWmode mode, const std::vector< String > &hduNames, bool readDataFlag=false, const std::vector< String > &primaryKey=std::vector< String >())

- **FITS** (const String &fileName, const **FITS** &source)

*create a new **FITS** object and corresponding file with copy of the primary header of the source If the filename corresponds to an existing file and does not start with the '!' character the construction will fail with a **CantCreate** exception.*

- **FITS** (const String &name, RWmode mode, const std::vector< String > &hduNames, const std::vector< std::vector< String > > &hduKeys, bool readDataFlag=false, const std::vector< String > &primaryKeys=std::vector< String >(), const std::vector< int > &hduVersions=std::vector< int >())

***FITS** read constructor in full generality.*

- **FITS** (const String &name, int bitpix, int naxis, long *naxes)

*Constructor for creating new **FITS** objects containing images.*

- **FITS** (const string &name, RWmode mode, int hduIndex, bool readDataFlag=false, const std::vector< String > &hduKeys=std::vector< String >(), const std::vector< String > &primaryKey=std::vector< String >())

*read a single numbered **HDU**.*

- **FITS** (const String &name, RWmode mode, const std::vector< String > &searchKeys, const std::vector< String > &searchValues, bool readDataFlag=false, const std::vector< String > &hduKeys=std::vector< String >(), const std::vector< String > &primaryKey=std::vector< string >(), int version=1)

*open fits file and read **HDU** which contains supplied keywords with [optional] specified values (sometimes one just wants to know that the keyword is present).*

- **~FITS** ()

destructor

- **ExtHDU** * **addImage** (const String &hduName, int bpix, std::vector< long > &naxes, int version=1)

*Add an image extension to an existing **FITS** object. (File with w or rw access).*

- **Table** * **addTable** (const String &hduName, int rows, const std::vector< String > &columnName=std::vector< String >(), const std::vector< String > &columnFmt=std::vector< String >(), const std::vector< String > &columnUnit=std::vector< String >(), HduType type=BinaryTbl, int version=1)

*Add a table extension to an existing **FITS** object. Add extension to **FITS** object for file with w or rw access.*
- void **copy** (const HDU &source)

*copy the **HDU** source into the **FITS** object.*
- ExtHDU & **currentExtension** ()

return a non-const reference to whichever is the current extension.
- const String & **currentExtensionName** () const

return the name of the extension that the fitsfile is currently addressing.
- void **deleteExtension** (const String &doomed, int version=1)

Delete extension specified by name and version number.
- void **deleteExtension** (int doomed)

Delete extension specified by extension number.
- void **destroy** () throw ()

*Erase **FITS** object and close corresponding file.*
- const ExtHDU & **extension** (int i) const

*return **FITS** extension by index number. N.B. The input index number is currently defined as enumerating extensions, so the extension(1) returns **HDU** number 2.*
- ExtHDU & **extension** (int i)

*return **FITS** extension by index number. non-const version. see const version for details.*
- const ExtHDU & **extension** (const String &hduName, int version=1) const

*return **FITS** extension by name and (optionally) version number.*
- ExtHDU & **extension** (const String &hduName, int version=1)

*return **FITS** extension by name and (optionally) version number.*
- const ExtMap & **extension** () const

return const reference to the extension container
- **Table** & **filter** (const String &expression, ExtHDU &inputTable, bool overwrite=true, bool readData=false)

*Filter the rows of the inputTable with the condition expression, and return a reference to the resulting **Table**.*
- fitsfile * **fitsPointer** () const

*return the CFITSIO fitsfile pointer for this **FITS** object*
- void **flush** ()

flush buffer contents to disk
- int **getCompressionType** () const

Get the int specifying the compression algorithm to be used when adding an image extension.

- int [getNoiseBits](#) () const
Get the cfitsio noisebits parameter used when compressing floating-point images.
- void [getTileDimensions](#) (std::vector< long > &tileSizes) const
Get the current settings of dimension sizes for tiles used in image compression.
- const String & [name](#) () const
return filename of file corresponding to [FITS](#) object
- const [PHDU](#) & [pHDU](#) () const
return a const reference to the primary [HDU](#).
- [PHDU](#) & [pHDU](#) ()
return a reference to the primary [HDU](#).
- void [read](#) (const String &hduName, bool readDataFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)
get data from single [HDU](#) from disk file.
- void [read](#) (const std::vector< String > &hduNames, bool readDataFlag=false)
get data from a set of [HDUs](#) from disk file.
- void [read](#) (const std::vector< String > &hduNames, const std::vector< std::vector< String > > &keys, bool readDataFlag=false, const std::vector< int > &hduVersions=std::vector< int >())
get data from a set of [HDUs](#) from disk file, specifying keys and version numbers.
- void [read](#) (int hduIndex, bool readDataFlag=false, const std::vector< String > &keys=std::vector< String >())
read an [HDU](#) specified by index number.
- void [read](#) (const std::vector< String > &searchKeys, const std::vector< String > &searchValues, bool readDataFlag=false, const std::vector< String > &hduKeys=std::vector< String >(), int version=1)
read method for read header or [HDU](#) that contains specified keywords.
- void [resetPosition](#) ()
explicit call to set the fits file pointer to the primary.
- void [setCompressionType](#) (int compType)
set the compression algorithm to be used when adding image extensions to the [FITS](#) object.
- void [setNoiseBits](#) (int noiseBits)
Set the cfitsio noisebits parameter used when compressing floating-point images.
- void [setTileDimensions](#) (const std::vector< long > &tileSizes)
Set the dimensions of the tiles into which the image is divided during compression.

Static Public Member Functions

- static void [clearErrors](#) ()
clear the error stack and set status to zero.

- static void `setVerboseMode` (bool value)
set verbose setting for library
- static bool `verboseMode` ()
return verbose setting for library

23.14.1 Detailed Description

Memory object representation of a disk [FITS](#) file.

Constructors are provided to get [FITS](#) data from an existing file or to create new [FITS](#) data sets. Overloaded versions allow the user to

a) read from one or more specified extensions, specified by EXTNAME and VERSION or by [HDU](#) number. b either just header information or data on construction c) to specify scalar keyword values to be read on construction d) to open and read an extension that has specified keyword values e) create a new [FITS](#) object and corresponding file, including an empty primary header.

The memory fits object as constructed is always an image of a valid [FITS](#) object, i.e. a primary [HDU](#) is created on construction.

calling the destructor closes the disk file, so that [FITS](#) files are automatically deleted at the end of scope unless other arrangements are made.

23.14.2 Constructor & Destructor Documentation

23.14.2.1 `CCfits::FITS::FITS (const String & name, RWmode mode = Read, bool readDataFlag = false, const std::vector< String > & primaryKeys = std::vector<String>())`

basic constructor

This basic constructor makes a [FITS](#) object from the given filename. The file name is the only required argument. The file name string is passed directly to the cfitsio library: thus the extended file name syntax described in the cfitsio manual should work as documented. (Though the extended file name feature which allows the opening of a particular image located in the row of a table is currently unsupported.)

If the mode is Read [default]: It will read all of the headers in the file, and all of the data if the readDataFlag is supplied as true. It will also read optional primary keys. Upon completion, the the last header in the file will become the current extension. (However if the file name includes extended syntax selecting a particular extension, that extension will be the current one.)

If the mode is Write and the file already exists: The file is opened in read-write mode, all of the headers of the file are read, and all of the data if the readDataFlag is supplied as true. It will also read optional primary keys. For backwards compatibility with older

versions of [CCfits](#) (which only read the primary when in Write mode for pre-existing files), the primary will become the current extension.

If the mode is Write and the file does NOT exist (or is overwritten using '!' syntax): A default primary [HDU](#) will be created in the file with BITPIX=8 and NAXIS=0. However if you wish to create a new file with image data in the primary, the version of the [FITS](#) constructor that specifies the data type and number of axes should be used instead.

Parameters

<i>name</i>	The name of the FITS file to be read/written
<i>mode</i>	The read/write mode: must be Read or Write
<i>readDataFlag</i>	boolean: read data on construction if true
<i>primaryKeys</i>	Allows optional reading of primary header keys on construction

Exceptions

NoSuchHDU	thrown on HDU seek error either by index or {name,version}
FitsError	thrown on non-zero status code from cfitsio when not overridden by FitsException error to produce more illuminating message.

```
23.14.2.2 CCfits::FITS::FITS ( const String & name, RWmode mode, const string &
    hduName, bool readDataFlag = false, const std::vector< String > & hduKeys =
    std::vector<String>(), const std::vector< String > & primaryKey =
    std::vector<String>(), int version = 1 )
```

Open a [FITS](#) file and read a single specified [HDU](#).

This and similar constructor variants support reading table data.

Optional arguments allow the reading of primary header keys and specified data from hduName, the [HDU](#) to be read. An object representing the primary [HDU](#) is always created: if it contains an image, that image may be read by subsequent calls.

If extended file name syntax is used and selects an extension other than hduName, a [FITS::OperationNotSupported](#) exception will be thrown.

Parameters

<i>name</i>	The name of the FITS file to be read
<i>mode</i>	The read/write mode: takes values Read or Write
<i>hduName</i>	The name of the HDU to be read.
<i>hduKeys</i>	Optional array of keywords to be read from the HDU
<i>version</i>	Optional version number. If not supplied the first HDU with name <i>hduName</i> is read see above for other parameter definitions

23.14.2.3 `CCfits::FITS::FITS (const String & name, RWmode mode, const std::vector< String > & hduNames, bool readDataFlag = false, const std::vector< String > & primaryKey = std::vector<String>())`

This is intended as a convenience where the file consists of single versions of HDUs and data only, not keys are to be read.

If extended file name syntax is used and selects an extension not listed in `hduNames`, a `FITS::OperationNotSupported` exception will be thrown.

Parameters

<code>hduNames</code>	array of HDU names to be read.
-----------------------	--

see above for other parameter definitions.

23.14.2.4 `CCfits::FITS::FITS (const String & fileName, const FITS & source)`

create a new [FITS](#) object and corresponding file with copy of the primary header of the source. If the filename corresponds to an existing file and does not start with the '!' character the construction will fail with a `CantCreate` exception.

Parameters

<code>fileName</code>	New file to be created.
<code>source</code>	A previously created FITS object to be copied.

see above for other parameter definitions.

23.14.2.5 `CCfits::FITS::FITS (const String & name, RWmode mode, const std::vector< String > & hduNames, const std::vector< std::vector< String > > & hduKeys, bool readDataFlag = false, const std::vector< String > & primaryKeys = std::vector<String>(), const std::vector< int > & hduVersions = std::vector<int>())`

[FITS](#) read constructor in full generality.

Parameters

<code>hduVersions</code>	an optional version number for each HDU to be read
<code>hduKeys</code>	an array of keywords for each HDU to be read. see above for other parameter definitions.

23.14.2.6 `CCfits::FITS::FITS (const String & name, int bitpix, int naxis, long * naxes)`

Constructor for creating new [FITS](#) objects containing images.

This constructor is only called for creating new files (mode is not an argument) and

creates a new primary [HDU](#) with the datatype & axes specified by `bitpix`, `naxis`, and `naxes`. The data are added to the new fits object and file by subsequent calls to [FITS::pHDU\(\).write\(<arguments> \)](#)

A file with a compressed image may be creating by appending to the end of the file name the same "[compress ...]" syntax specified in the cfitsio manual. Note however that the compressed image will be placed in the first extension and NOT in the primary [HDU](#).

If the filename corresponds to an existing file and does not start with the '!' character the construction will fail with a [CantCreate](#) exception.

The arguments are:

Parameters

<i>name</i>	The file to be written to disk
<i>bitpix</i>	the datatype of the primary image. <i>bitpix</i> may be one of the following CFITSIO constants: BYTE_IMG, SHORT_IMG, LONG_IMG, FLOAT_IMG, DOUBLE_IMG, USHORT_IMG, ULONG_IMG, LONGLONG_IMG. Note that if you send in a <i>bitpix</i> of USHORT_IMG or ULONG_IMG, CCfits will set HDU::bitpix() to its signed equivalent (SHORT_IMG or LONG_IMG), and then set BZERO to 2^{15} or 2^{31} .
<i>naxis</i>	the data dimension of the primary image
<i>naxes</i>	the array of axis lengths for the primary image. Ignored if <code>naxis = 0</code> , i.e. the primary header is empty. extensions can be added arbitrarily to the file after this constructor is called. The constructors should write header information to disk:

```
23.14.2.7 CCfits::FITS::FITS ( const string & name, RWmode mode, int hduIndex,
    bool readDataFlag = false, const std::vector< String > & hduKeys =
    std::vector<String>(), const std::vector< String > & primaryKey =
    std::vector<String>() )
```

read a single numbered [HDU](#).

Constructor analogous to the version that reads by name. This is required since [HDU](#) extensions are not required to have the EXTNAME or HDUNAME keyword by the standard. If there is no name, a dummy name based on the [HDU](#) number is created and becomes the key.

If extended file name syntax is used and selects an extension other than `hduIndex`, a [FITS::OperationNotSupported](#) exception will be thrown.

Parameters

<i>hduIndex</i>	The index of the HDU to be read. see above for other parameter definitions.
-----------------	---

```
23.14.2.8 CCfits::FITS::FITS ( const String & name, RWmode mode, const std::vector<
String > & searchKeys, const std::vector< String > & searchValues,
bool readDataFlag = false, const std::vector< String > & hduKeys =
std::vector<String>(), const std::vector< String > & primaryKey =
std::vector<string>(), int version = 1 )
```

open fits file and read [HDU](#) which contains supplied keywords with [optional] specified values (sometimes one just wants to know that the keyword is present).

Optional parameters allows the reading of specified primary [HDU](#) keys and specified columns and keywords in the [HDU](#) of interest.

Parameters

<i>name</i>	The name of the FITS file to be read
<i>mode</i>	The read/write mode: must be Read or Write
<i>searchKeys</i>	A string vector of keywords to search for in each header
<i>search-Values</i>	A string vector of values those keywords are required to have for success. Note that the keys must be of type string. If any value does not need to be checked the corresponding searchValue element can be empty.
<i>readData-Flag</i>	boolean: if true, read data if HDU is found
<i>hduKeys</i>	Allows optional reading of keys in the HDU that is searched for if it is successfully found
<i>primaryKey</i>	Allows optional reading of primary header keys on construction
<i>version</i>	Optional version number. If specified, checks the EXTVER keyword.

Exceptions

FitsError	thrown on non-zero status code from cfitsio when not overridden by FitsException error to produce more illuminating message.
---------------------------	--

23.14.3 Member Function Documentation

```
23.14.3.1 void CCfits::FITS::addImage ( const String & hduName, int bpix, std::vector< long >
& naxes, int version = 1 )
```

Add an image extension to an existing [FITS](#) object. (File with w or rw access).

Does not make primary images, which are built in the constructor for the [FITS](#) file. The image data is not added here: it can be added by a call to one of the [ExtHDU::write](#) functions.

bpix may be one of the following CFITSIO constants: BYTE_IMG, SHORT_IMG, LONG_IMG, FLOAT_IMG, DOUBLE_IMG, USHORT_IMG, ULONG_IMG, LONGLONG_IMG.

Note that if you send in a *bpix* of USHORT_IMG or ULONG_IMG, CCfits will set HDU::bitpix() to its signed equivalent (SHORT_IMG or LONG_IMG), and then set BZERO to 2¹⁵ or 2³¹.

Todo Add a function for replacing the primary image

23.14.3.2 `Table * CCfits::FITS::addTable (const String & hduName, int rows, const std::vector< String > & columnName = std::vector<String>(), const std::vector< String > & columnFmt = std::vector<String>(), const std::vector< String > & columnUnit = std::vector<String>(), HduType type = BinaryTbl, int version = 1)`

Add a table extension to an existing FITS object. Add extension to FITS object for file with w or rw access.

Parameters

<i>rows</i>	The number of rows in the table to be created.
<i>column-Name</i>	A vector containing the table column names
<i>columnFmt</i>	A vector containing the table column formats
<i>columnUnit</i>	(Optional) a vector giving the units of the columns.
<i>type</i>	The table type - AsciiTbl or BinaryTbl (defaults to BinaryTbl) the lists of columns are optional - one can create an empty table extension but if supplied, colType, columnName and colFmt must have equal dimensions.

Todo the code should one day check that the version keyword is higher than any other versions already added to the FITS object (although cfitsio doesn't do this either).

23.14.3.3 `void CCfits::FITS::copy (const HDU & source)`

copy the HDU source into the FITS object.

This function adds a copy of an HDU from another file into *this. It does not create a duplicate of an HDU in the file associated with *this.

23.14.3.4 `const String & CCfits::FITS::currentExtensionName () const`

return the name of the extension that the fitsfile is currently addressing.

If the extension in question does not have an EXTNAME or HDUNAME keyword, then the function returns \$HDU\$n, where n is the sequential HDU index number (primary HDU = 0).

23.14.3.5 void CCfits::FITS::deleteExtension (const String & *doomed*, int *version* = 1)

Delete extension specified by name and version number.

Removes extension from [FITS](#) object and memory copy. The index numbers of all [HDU](#) objects which follow this in the file will be decremented by 1.

Parameters

<i>doomed</i>	the name of the extension to be deleted
<i>version</i>	an optional version number, the EXTVER keyword, defaults to 1

Exceptions

NoSuchHDU	Thrown if there is no extension with the specified version number
FitsError	Thrown if there is a non-zero status code from cfitsio, e.g. if the delete operation is applied to a FITS file opened for read only access.

23.14.3.6 void CCfits::FITS::deleteExtension (int *doomed*)

Delete extension specified by extension number.

The index numbers of all [HDU](#) objects which follow this in the file will be decremented by 1.

23.14.3.7 void CCfits::FITS::destroy () throw ()

Erase [FITS](#) object and close corresponding file.

Force deallocation and erase of elements of a [FITS](#) memory object. Allows a reset of everything inside the [FITS](#) object, and closes the file. The object is inaccessible after this call.

destroy is public to allow users to reuse a symbol for a new file, but it is identical in operation to the destructor.

23.14.3.8 const std::multimap< std::String, ExtHDU * > & CCfits::FITS::extension () const

return const reference to the extension container

This is useful for such operations as [extension\(\).size\(\)](#) etc.

23.14.3.9 Table & CCfits::FITS::filter (const String & *expression*, ExtHDU & *inputTable*, bool *overwrite* = true, bool *readData* = false)

Filter the rows of the *inputTable* with the condition *expression*, and return a reference to the resulting [Table](#).

This function provides an object oriented version of cfitsio's `fits_select_rows` call. The expression string is any boolean expression involving the names of the columns in the input table (e.g., if there were a column called "density", a valid expression might be "DENSITY > 3.5": see the cfitsio documentation for further details).

[N.B. the "append" functionality described below does not work when linked with cfitsio 2.202 or prior because of a known issue with that version of the library. This causes the output to be a new extension with a correct header copy and version number but without the filtered data]. If the `inputTable` is an Extension HDU of this FITS object, then if `overwrite` is true the operation will overwrite the `inputTable` with the filtered version, otherwise it will append a new HDU with the same extension name but the next highest version (EXTVER) number available.

23.14.3.10 void CCfits::FITS::flush ()

flush buffer contents to disk

Provides manual control of disk writing operation. Image data are flushed automatically to disk after the write operation is completed, but not column data.

23.14.3.11 void CCfits::FITS::getTileDimensions (std::vector< long > & tileSizes) const

Get the current settings of dimension sizes for tiles used in image compression.

Parameters

<i>tileSizes</i>	A vector to be filled with cfitsio's current tile dimension settings. CCfits will resize this vector to contain the proper number of values.
------------------	--

23.14.3.12 void CCfits::FITS::read (const String & hduName, bool readDataFlag = false, const std::vector< String > & keys = std::vector<String>(), int version = 1)

get data from single HDU from disk file.

This is provided to allow the adding of additional HDUs to the FITS object after construction of the FITS object. After the `read()` functions have been called for the FITS object, subsequent read method to the Primary, ExtHDU, and Column objects will retrieve data from the FITS object in memory (those methods can be called to read data in those HDU objects that was not read when the HDU objects were constructed).

All the read functions will throw NoSuchHDU exceptions on seek errors since they involve constructing HDU objects.

The parameter definitions are as documented for the corresponding constructor.

23.14.3.13 `void CCfits::FITS::read (const std::vector< String > & hduNames, bool readDataFlag = false)`

get data from a set of HDUs from disk file.

This is provided to allow reading of HDUs after construction. see above for parameter definitions.

23.14.3.14 `void CCfits::FITS::read (const std::vector< String > & hduNames, const std::vector< std::vector< String > > & keys, bool readDataFlag = false, const std::vector< int > & hduVersions = std::vector<int>())`

get data from a set of HDUs from disk file, specifying keys and version numbers.

This is provided to allow reading of HDUs after construction. see above for parameter definitions.

23.14.3.15 `void CCfits::FITS::read (int hduIndex, bool readDataFlag = false, const std::vector< String > & keys = std::vector<String>())`

read an [HDU](#) specified by index number.

This is provided to allow reading of HDUs after construction. see above for parameter definitions.

23.14.3.16 `CCfits::FITS::read (const std::vector< String > & searchKeys, const std::vector< String > & searchValues, bool readDataFlag = false, const std::vector< String > & hduKeys = std::vector<String>(), int version = 1)`

read method for read header or [HDU](#) that contains specified keywords.

Parameters

<i>searchKeys</i>	A string vector of keywords to search for in each header
<i>search-Values</i>	A string vector of values those keywords are required to have for success. Note that the keys must be of type string. If any value does not need to be checked the corresponding searchValue element can be empty.
<i>readData-Flag</i>	boolean: if true, read data if HDU is found
<i>hduKeys</i>	Allows optional reading of keys in the HDU that is searched for if it is successfully found
<i>version</i>	Optional version number. If specified, checks the EXTVER keyword.

23.14.3.17 `void CCfits::FITS::setCompressionType (int compType)`

set the compression algorithm to be used when adding image extensions to the [FITS](#) object.

Parameters

<i>compType</i>	Currently 3 symbolic constants are defined in cfitsio for specifying compression algorithms: GZIP_1, RICE_1, and PLIO_1. See the cfitsio documentation for more information about these algorithms. Entering NULL for compType will turn off compression and cause normal FITS images to be written.
-----------------	--

23.14.3.18 void CCfits::FITS::setNoiseBits (int *noiseBits*)

Set the cfitsio noisebits parameter used when compressing floating-point images.

The default value is 4. Decreasing the value of noisebits will improve the overall compression efficiency at the expense of losing more information.

23.14.3.19 void CCfits::FITS::setTileDimensions (const std::vector< long > & *tileSizes*)

Set the dimensions of the tiles into which the image is divided during compression.

Parameters

<i>tileSizes</i>	A vector of length N containing the tile dimesions. If N is less than the number of dimensions of the image it is applied to, the unspecified dimensions will be assigned a size of 1 pixel. If N is larger than the number of image dimensions, the extra dimensions will be ignored.
------------------	--

The default cfitsio behavior is to create tiles with dimensions NAXIS1 x 1 x 1 etc. up to the number of image dimensions.

23.14.3.20 bool CCfits::FITS::verboseMode () [inline, static]

return verbose setting for library

If true, all messages that are reported by exceptions are printed to std::cerr.

The documentation for this class was generated from the following files:

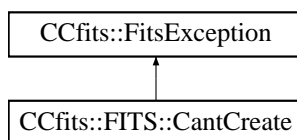
- FITS.h
- FITS.cxx

23.15 CCfits::FITS::CantCreate Class Reference

thrown on failure to create new file

```
#include <FITS.h>
```

Inheritance diagram for CCfits::FITS::CantCreate:



Public Member Functions

- [CantCreate](#) (const String &diag, bool silent=false)

Exception ctor prefixes the string: "FITS Error: Cannot create file " before specific message.

23.15.1 Detailed Description

thrown on failure to create new file

23.15.2 Constructor & Destructor Documentation

23.15.2.1 CCfits::FITS::CantCreate::CantCreate (const String & msg, bool *silent* = false)

Exception ctor prefixes the string: "FITS Error: Cannot create file " before specific message.

This exception will be thrown if the user attempts to write to a protected directory or attempts to create a new file with the same name as an existing file without specifying overwrite [overwrite is specified by adding the character '!' before the filename, following the cfitsio convention].

Parameters

<i>msg</i>	A specific diagnostic message, the name of the file that was to be created.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

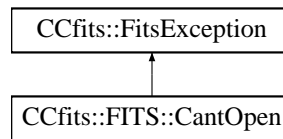
- FITS.h
- FITS.cxx

23.16 CCfits::FITS::CantOpen Class Reference

thrown on failure to open existing file


```
#include <FITS.h>
```

Inheritance diagram for CCfits::FITS::CantOpen:



Public Member Functions

- [CantOpen](#) (const String &diag, bool silent=true)
Exception ctor prefixes the string: "FITS Error: Cannot create file " before specific message.

23.16.1 Detailed Description

thrown on failure to open existing file

23.16.2 Constructor & Destructor Documentation

23.16.2.1 CCfits::FITS::CantOpen::CantOpen (const String & diag, bool silent = true)

Exception ctor prefixes the string: "FITS Error: Cannot create file " before specific message.

This exception will be thrown if users attempt to open an existing file for write access to which they do not have permission, or of course if the file does not exist.

Parameters

<i>diag</i>	A specific diagnostic message, the name of the file that was to be created.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

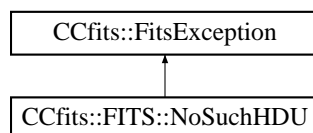
- FITS.h
- FITS.cxx

23.17 CCfits::FITS::NoSuchHDU Class Reference

exception thrown by [HDU](#) retrieval methods.

```
#include <FITS.h>
```

Inheritance diagram for CCfits::FITS::NoSuchHDU:



Public Member Functions

- [NoSuchHDU](#) (const String &diag, bool silent=true)

Exception ctor, prefixes the string "FITS Error: Cannot read HDU in FITS file:" before the specific message.

23.17.1 Detailed Description

exception thrown by [HDU](#) retrieval methods.

23.17.2 Constructor & Destructor Documentation

23.17.2.1 CCfits::FITS::NoSuchHDU::NoSuchHDU (const String & diag, bool silent = true)

Exception ctor, prefixes the string "FITS Error: Cannot read HDU in FITS file:" before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message, usually the name of the extension whose read was attempted.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

Exception to be thrown by failed seek operations

The documentation for this class was generated from the following files:

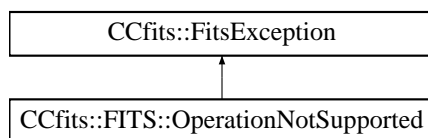
- FITS.h
- FITS.cxx

23.18 CCfits::FITS::OperationNotSupported Class Reference

thrown for unsupported operations, such as attempted to select rows from an image extension.

```
#include <FITS.h>
```

Inheritance diagram for CCfits::FITS::OperationNotSupported:



Public Member Functions

- [OperationNotSupported](#) (const String &msg, bool silent=true)
Exception ctor, prefixes the string "FITS Error: Operation not supported:" before the specific message.

23.18.1 Detailed Description

thrown for unsupported operations, such as attempted to select rows from an image extension.

23.18.2 Constructor & Destructor Documentation

23.18.2.1 CCfits::FITS::OperationNotSupported::OperationNotSupported (const String & msg, bool *silent* = true)

Exception ctor, prefixes the string "FITS Error: Operation not supported:" before the specific message.

Parameters

<i>msg</i>	A specific diagnostic message.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

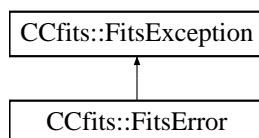
- FITS.h
- FITS.cxx

23.19 CCfits::FitsError Class Reference

[FitsError](#) is the exception thrown by non-zero cfitsio status codes.

```
#include <FitsError.h>
```

Inheritance diagram for CCfits::FitsError:



Public Member Functions

- [FitsError](#) (int errornum, bool silent=true)
ctor for cfitsio exception: translates status code into cfitsio error message

23.19.1 Detailed Description

[FitsError](#) is the exception thrown by non-zero cfitsio status codes.

23.19.2 Constructor & Destructor Documentation

23.19.2.1 CCfits::FitsError::FitsError (int *errornum*, bool *silent* = true)

ctor for cfitsio exception: translates status code into cfitsio error message

The exception prefixes the string "Fits Error: " to the message printed by cfitsio.

Parameters

<i>errornum</i>	The cfitsio status code produced by the error.
<i>silent</i>	A boolean controlling the printing of messages

The documentation for this class was generated from the following files:

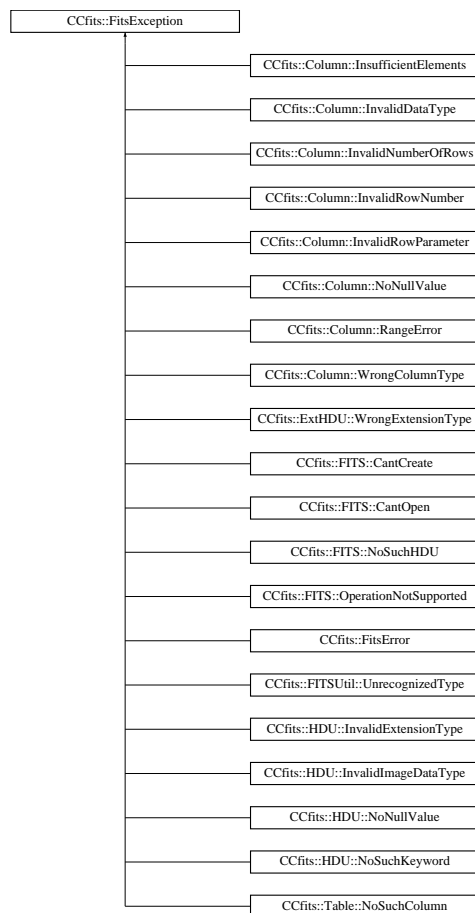
- FitsError.h
- FitsError.cxx

23.20 CCfits::FitsException Class Reference

[FitsException](#) is the base class for all exceptions thrown by this library.

```
#include <FitsError.h>
```

Inheritance diagram for CCfits::FitsException:



Public Member Functions

- [FitsException](#) (const string &msg, bool &silent)
- const string & [message](#) () const
returns the error message

23.20.1 Detailed Description

[FitsException](#) is the base class for all exceptions thrown by this library.

All exceptions derived from this class can be caught by a single 'catch' clause catching [FitsException](#) by reference (which is the point of this base class design).

A static "verboseMode" parameter is provided by the [FITS](#) class to control diagnostics - if [FITS::verboseMode\(\)](#) is true, all diagnostics are printed (for debugging purposes). If not, then a boolean *silent* determines printing of messages. Each exception derived from [FitsException](#) must define a default value for the *silent* parameter.

23.20.2 Constructor & Destructor Documentation

23.20.2.1 CCfits::FitsException::FitsException (const string & *diag*, bool & *silent*)

Parameters

<i>diag</i>	A diagnostic string to be printed optionally.
<i>silent</i>	A boolean controlling the printing of messages

23.20.3 Member Function Documentation

23.20.3.1 const string & CCfits::FitsException::message () const `[inline]`

returns the error message

This returns the diagnostic error message associated with the exception object, and which is accessible regardless of the verboseMode and silent flag settings.

The documentation for this class was generated from the following files:

- FitsError.h
- FitsError.cxx

23.21 CCfits::FitsFatal Class Reference

[potential] base class for exceptions to be thrown on internal library error.

```
#include <FitsError.h>
```

Public Member Functions

- [FitsFatal](#) (const string &diag)
*Prints a message starting "*** CCfits Fatal Error: ..." and calls terminate()*

23.21.1 Detailed Description

[potential] base class for exceptions to be thrown on internal library error.

As of this version there are no subclasses. This error requests that the user reports this circumstance to HEASARC.

23.21.2 Constructor & Destructor Documentation

23.21.2.1 CCfits::FitsFatal::FitsFatal (const string & *diag*)

Prints a message starting "*** CCfits Fatal Error: ..." and calls *terminate()*

Parameters

<i>diag</i>	A diagnostic string to be printed identifying the context of the error.
-------------	---

The documentation for this class was generated from the following files:

- FitsError.h
- FitsError.cxx

23.22 CCfits::FITSUtil::auto_array_ptr< X > Class Template Reference

A class that mimics the std:: library auto_ptr class, but works with arrays.

```
#include <FITSUtil.h>
```

Public Member Functions

- [auto_array_ptr](#) (X *p=0) throw ()
constructor. allows creation of pointer to null, can be modified by [reset\(\)](#)
- [auto_array_ptr](#) (auto_array_ptr< X > &right) throw ()
copy constructor
- [~auto_array_ptr](#) ()
destructor.
- X * [get](#) () const
*return a token for the underlying content of *this*
- X & [operator*](#) () throw ()
deference operator
- void [operator=](#) (auto_array_ptr< X > &right)
assignment operator: transfer of ownership semantics
- X & [operator\[\]](#) (size_t i) throw ()
return a reference to the ith element of the array
- X [operator\[\]](#) (size_t i) const throw ()
return a copy of the ith element of the array

- X * [release](#) () throw ()
*return underlying content of *this, transferring memory ownership*
- X * [reset](#) (X *p) throw ()
change the content of the [auto_array_ptr](#) to p

Static Public Member Functions

- static void [remove](#) (X *&x)
utility function to delete the memory owned by x and set it to null.

23.22.1 Detailed Description

template<typename X>class CCfits::FITSUtil::auto_array_ptr< X >

A class that mimics the std:: library auto_ptr class, but works with arrays.

This code was written by Jack Reeves and first appeared C++ Report, March 1996 edition. Although some authors think one shouldn't need such a contrivance, there seems to be a need for it when wrapping C code.

Usage: replace

```
float* f = new float[200];
```

with

```
FITSUtil::auto_array_ptr<float> f(new float[200]);
```

Then the memory will be managed correctly in the presence of exceptions, and delete will be called automatically for *f* when leaving scope.

The documentation for this class was generated from the following file:

- FITSUtil.h

23.23 CCfits::FITSUtil::CAarray< T > Class Template Reference

function object returning C array from a valarray. see [CVarray](#) for details

```
#include <FITSUtil.h>
```

Public Member Functions

- T * [operator\(\)](#) (const std::valarray< T > &inArray)
operator returning C array for use with image data.

23.23.1 Detailed Description

```
template<typename T>class CCfits::FITSUtil::CAarray< T >
```

function object returning C array from a valarray. see [CVarray](#) for details

The documentation for this class was generated from the following file:

- FITSUtil.h

23.24 CCfits::FITSUtil::CVAarray< T > Class Template Reference

function object returning C array from a vector of valarrays. see [CVarray](#) for details

```
#include <FITSUtil.h>
```

Public Member Functions

- T * [operator\(\)](#) (const std::vector< std::valarray< T > > &inArray)
operator returning C array for use with vector column data.

23.24.1 Detailed Description

```
template<typename T>class CCfits::FITSUtil::CVAarray< T >
```

function object returning C array from a vector of valarrays. see [CVarray](#) for details

The documentation for this class was generated from the following file:

- FITSUtil.h

23.25 CCfits::FITSUtil::CVarray< T > Class Template Reference

Function object class for returning C arrays from standard library objects used in the [FITS](#) library implementation.

```
#include <FITSUtil.h>
```

Public Member Functions

- T * [operator\(\)](#) (const std::vector< T > &inArray)
operator returning C array for use with scalar column data.

23.25.1 Detailed Description

```
template<typename T>class CCfits::FITSUtil::CArray< T >
```

Function object class for returning C arrays from standard library objects used in the [FITS](#) library implementation.

There are 3 versions which convert `std::vector<T>`, `std::valarray<T>`, and `std::vector<std::valarray<T> >` objects to pointers to T, called [CArray](#), [CAarray](#), and [CVAarray](#).

An alternative function, `CharArray`, is provided to deal with the special case of vector string arrays.

The documentation for this class was generated from the following file:

- `FITSUtil.h`

23.26 CCfits::FITSUtil::MatchName< T > Class Template Reference

predicate for classes that have a name attribute; match input string with instance name.

```
#include <FITSUtil.h>
```

23.26.1 Detailed Description

```
template<class T>class CCfits::FITSUtil::MatchName< T >
```

predicate for classes that have a name attribute; match input string with instance name.

Usage: `MatchName<NamedClass> Ex;`

`list<NamedClass> ListObject;`

... ..

```
find_if(ListObject.begin(),ListObject().end(),bind2nd(Ex,"needle"));
```

Since most of the classes within [CCfits](#) are not implemented with lists, these functions are now of little direct use.

The documentation for this class was generated from the following file:

- `FITSUtil.h`

23.27 CCfits::FITSUtil::MatchNum< T > Class Template Reference

predicate for classes that have an index attribute; match input index with instance value.

```
#include <FITSUtil.h>
```

23.27.1 Detailed Description

```
template<class T>class CCfits::FITSUtil::MatchNum< T >
```

predicate for classes that have an index attribute; match input index with instance value.

Usage: MatchName<IndexedClass> Ex;

list<NamedClass> ListObject;

... ..

```
find_if(ListObject.begin(),ListObject().end(),bind2nd(Ex,5));
```

Since most of the classes within [CCfits](#) are implemented with std::maps rather than lists, these functions are now of little direct use.

The documentation for this class was generated from the following file:

- FITSUtil.h

23.28 CCfits::FITSUtil::MatchPtrName< T > Class Template Reference

as for [MatchName](#), only with the input class a pointer.

```
#include <FITSUtil.h>
```

23.28.1 Detailed Description

```
template<class T>class CCfits::FITSUtil::MatchPtrName< T >
```

as for [MatchName](#), only with the input class a pointer.

The documentation for this class was generated from the following file:

- FITSUtil.h

23.29 CCfits::FITSUtil::MatchPtrNum< T > Class Template Reference

as for [MatchNum](#), only with the input class a pointer.

```
#include <FITSUtil.h>
```

23.29.1 Detailed Description

```
template<class T>class CCfits::FITSUtil::MatchPtrNum< T >
```

as for [MatchNum](#), only with the input class a pointer.

The documentation for this class was generated from the following file:

- FITSUtil.h

23.30 CCfits::FITSUtil::MatchType< T > Class Template Reference

function object that returns the [FITS](#) ValueType corresponding to an input intrinsic type

```
#include <FITSUtil.h>
```

23.30.1 Detailed Description

```
template<typename T>class CCfits::FITSUtil::MatchType< T >
```

function object that returns the [FITS](#) ValueType corresponding to an input intrinsic type

This is particularly useful inside templated class instances where calls to `cfitsio` need to supply a value type. With this function one can extract the value type from the class type.

usage:

```
MatchType<T> type;
```

```
ValueType dataType = type();
```

Uses run-time type information (RTTI) methods.

The documentation for this class was generated from the following file:

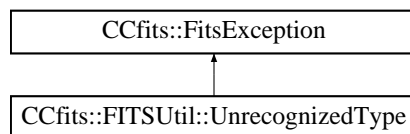
- FITSUtil.h

23.31 CCfits::FITSUtil::UnrecognizedType Class Reference

exception thrown by [MatchType](#) if it encounters data type incompatible with `cfitsio`.

```
#include <FITSUtil.h>
```

Inheritance diagram for `CCfits::FITSUtil::UnrecognizedType`:



23.31.1 Detailed Description

exception thrown by [MatchType](#) if it encounters data type incompatible with cfitsio.

The documentation for this class was generated from the following files:

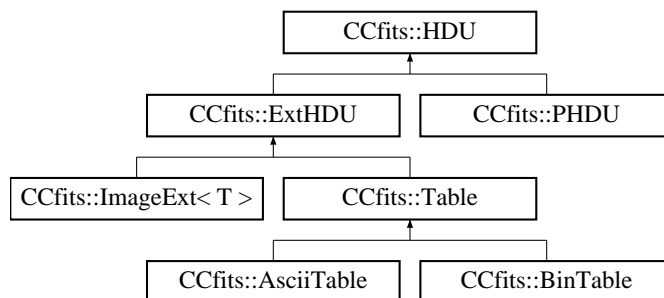
- FITSUtil.h
- FITSUtil.cxx

23.32 CCfits::HDU Class Reference

Base class for all [HDU](#) [Header-Data Unit] objects.

```
#include <HDU.h>
```

Inheritance diagram for CCfits::HDU:



Classes

- class [InvalidExtensionType](#)
exception to be thrown if user requests extension type that can not be understood as [ImageExt](#), [AsciiTable](#) or [BinTable](#).
- class [InvalidImageDataType](#)
exception to be thrown if user requests creation of an image of type not supported by cfitsio.
- class [NotNullValue](#)

exception to be thrown on seek errors for keywords.

- class [NoSuchKeyword](#)

exception to be thrown on seek errors for keywords.

Public Member Functions

- [HDU](#) (const [HDU](#) &right)
copy constructor
- template<typename T >
[Keyword](#) & [addKey](#) (const String &name, T val, const String &comment)
create a new keyword in the HDU with specified value and comment fields
- [Keyword](#) * [addKey](#) (const [Keyword](#) *inKeyword)
create a copy of an existing Keyword and add to HDU
- long [axes](#) () const
return the number of axes in the HDU data section (always 2 for tables).
- long [axis](#) (size_t index) const
return the size of axis numbered index [zero based].
- long [bitpix](#) () const
return the data type keyword.
- virtual [HDU](#) * [clone](#) (FITSBase *p) const =0
virtual copy constructor, to be implemented in subclasses.
- const string & [comment](#) () const
return the comment string previously read by getComment()
- void [copyAllKeys](#) (const [HDU](#) *inHdu)
copy all keys from another header
- void [deleteKey](#) (const String &doomed)
delete a keyword from the header
- fitsfile * [fitsPointer](#) () const
return the fitsfile pointer for the FITS object containing the HDU
- std::pair< unsigned long, unsigned long > [getChecksum](#) () const
compute and return the checksum values for the HDU without creating or modifying the CHECKSUM/DATASUM keywords.
- const String & [getComments](#) ()
read the comments from the HDU and add it to the FITS object.
- const String & [getHistory](#) ()
read the history information from the HDU and add it to the FITS object.
- const string & [history](#) () const
return the history string previously read by getHistory()
- void [index](#) (int value)
set the HDU number

- int [index](#) () const
return the HDU number
- std::map< String, [Keyword](#) * > & [keyWord](#) ()
return the associative array containing the HDU keywords so far read.
- [Keyword](#) & [keyWord](#) (const String &keyName)
return a (previously read) keyword from the HDU object.
- const std::map< string, [Keyword](#) * > & [keyWord](#) () const
return the associative array containing the HDU Keywords that have been read so far.
- const [Keyword](#) & [keyWord](#) (const string &keyname) const
return a (previously read) keyword from the HDU object. const version
- virtual void [makeThisCurrent](#) () const
move the fitsfile pointer to this current HDU.
- bool [operator!=](#) (const HDU &right) const
inequality operator
- bool [operator==](#) (const HDU &right) const
equality operator
- FITSBase * [parent](#) () const
return reference to the pointer representing the FITSBase object containing the HDU
- void [readAllKeys](#) ()
read all of the keys in the header
- template<typename T >
void [readKey](#) (const String &keyName, T &val)
read a keyword of specified type from the header of a disk FITS file and return its value.
- template<typename T >
void [readKeys](#) (std::vector< String > &keyNames, std::vector< T > &vals)
read a set of specified keywords of the same data type from the header of a disk FITS file and return their values
- [Keyword](#) & [readNextKey](#) (const std::vector< String > &incList, const std::vector< String > &excList, bool searchFromBeginning=false)
Read the next key in the HDU which matches a string in incList, and does not match string in excList.
- virtual void [resetImageRead](#) ()
force next image reading operation to read from file instead of object cache.
- virtual double [scale](#) () const
return the BSCALE keyword value
- virtual void [scale](#) (double value)
set the BSCALE keyword value for images (see warning for images of int type)
- virtual void [suppressScaling](#) (bool toggle=true)
turn off image scaling regardless of the BSCALE and BZERO keyword values
- void [updateChecksum](#) ()

- update the CHECKSUM keyword value, assuming DATASUM exists and is correct*
- `std::pair< int, int > verifyChecksum () const`
 - verify the HDU by computing the checksums and comparing them with the CHECKSUM/DATASUM keywords*
- `void writeChecksum ()`
 - compute and write the DATASUM and CHECKSUM keyword values*
- `void writeComment (const String &comment="Generic Comment")`
 - write a comment string.*
- `void writeDate ()`
 - write a date string to *this.*
- `void writeHistory (const String &history="Generic History String")`
 - write a history string.*
- `virtual double zero () const`
 - return the BZERO keyword value*
- `virtual void zero (double value)`
 - set the BZERO keyword value for images (see warning for images of int type)*

Static Public Member Functions

- `static std::vector< int > keywordCategories ()`
 - return the enumerated keyword categories used by `readAllKeys()` and `copyAllKeys()`*

Protected Member Functions

- `HDU (FITSBase *p=0)`
 - default constructor, called by HDU subclasses that read from FITS files.*
- `HDU (FITSBase *p, int bitpix, int naxis, const std::vector< long > &axes)`
 - constructor for creating new HDU objects, called by HDU subclasses writing to FITS files.*
- `virtual ~HDU ()`
 - destructor*
- `std::vector< long > & naxes ()`
 - return the HDU data axis array.*

23.32.1 Detailed Description

Base class for all HDU [Header-Data Unit] objects.

HDU objects in CCfits are either PHDU (Primary HDU objects) or ExtHDU (Extension HDU) objects. Following the behavior. ExtHDUs are further subclassed into ImageExt or Table objects, which are finally AsciiTable or BinTable objects.

HDU's public interface gives access to properties that are common to all HDUs, largely required keywords, and functions that are common to all HDUs, principally the manipulation of keywords and their values.

HDUs must be constructed by HDUCreator objects which are called by [FITS](#) methods. Each [HDU](#) has an embedded pointer to a FITSBase object, which is private to [FITS](#) [FITSBase is a pointer encapsulating the resources of [FITS](#). For details of this coding idiom see Exceptional C++ by Herb Sutter (2000) and references therein].

23.32.2 Member Function Documentation

23.32.2.1 `template<typename T> Keyword & CCfits::HDU::addKey (const String & name, T value, const String & comment)`

create a new keyword in the [HDU](#) with specified value and comment fields

The function returns a reference to keyword object just created. If a keyword with this name already exists, it will be overwritten. Note that this is mostly intended for adding user-defined keywords. It should not be used to add keywords for which there are already specific [HDU](#) functions, such as scaling or checksum. Nor should it be used for image or column structural keywords, such as BITPIX, NAXIS, TFORMn, etc. As a general rule, it is best to use this for keywords belonging to the same categories listed in the [keywordCategories\(\)](#) function.

Parameters:

Parameters

<i>name</i>	(String) The keyword name
<i>value</i>	(Recommended T = String, double, std::complex<float>, int, or bool
<i>comment</i>	(String) the keyword value

It is possible to create a keyword with a value of any of the allowed data types in fitsio (see the cfitsio manual section 4.3). However one should be aware that if this keyword value is read in from the file at a later time, it will be stored in a templated [Keyword](#) subclass (KeyData<T>) where T will be one of the recommended types listed above. Also see [Keyword::value](#) (T& val) for more details.

23.32.2.2 `Keyword * CCfits::HDU::addKey (const Keyword * inKeyword)`

create a copy of an existing [Keyword](#) and add to [HDU](#)

This is particularly useful for copying Keywords from one [HDU](#) to another. For example the inKeyword pointer might come from a different HDU's std::map<string,Keyword*>. If a keyword with this name already exists, it will be overwritten. The return value is a pointer to the newly created [Keyword](#) inserted into this [HDU](#). Also see [copyAllKeys\(\)](#).

23.32.2.3 `long CCfits::HDU::axis (size_t index) const` `[inline]`

return the size of axis numbered index [zero based].

return the length of [HDU](#) data axis *i*.

23.32.2.4 `long CCfits::HDU::bitpix () const` `[inline]`

return the data type keyword.

Takes values denoting the image data type for images, and takes the fixed value 8 for tables.

23.32.2.5 `void CCfits::HDU::copyAllKeys (const HDU * inHdu)`

copy all keys from another header

Parameters:

Parameters

<i>inHdu</i>	(const HDU*) An existing HDU whose keys will be copied.
--------------	---

This will copy all keys that exist in the keyWord map of *inHdu*, and which belong to one of the keyword classes returned by the [keywordCategories\(\)](#) function. This is the same group of keyword classes used by [readAllKeys\(\)](#).

23.32.2.6 `void CCfits::HDU::deleteKey (const String & doomed)`

delete a keyword from the header

removes *doomed* from the [FITS](#) file and from the [FITS](#) object

23.32.2.7 `std::pair< unsigned long, unsigned long > CCfits::HDU::getChecksum () const`

compute and return the checksum values for the [HDU](#) without creating or modifying the CHECKSUM/DATASUM keywords.

Wrapper for the CFITSIO function fits_get_chksum: This returns a std::pair<unsigned long, unsigned long> where the pair's first data member holds the datasum value and second holds the hdusum value.

23.32.2.8 `const String & CCfits::HDU::getComments ()`

read the comments from the [HDU](#) and add it to the [FITS](#) object.

The comment string found in the header is concatenated and returned to the calling function

23.32.2.9 `const String & CCfits::HDU::getHistory ()`

read the history information from the [HDU](#) and add it to the [FITS](#) object.

The history string found in the header is concatenated and returned to the calling function

23.32.2.10 `static std::vector< int > CCfits::HDU::keywordCategories () [static]`

return the enumerated keyword categories used by [readAllKeys\(\)](#) and [copyAllKeys\(\)](#)

This returns a vector of integers indicating which categories of keywords apply for the [readAllKeys](#) and [copyAllKeys](#) functions. The list of categories currently hardcoded is: TYP_CMPRS_KEY (20), TYP_CKSUM_KEY (100), TYP_WCS_KEY (110), TYP_REFSYS_KEY (120), and TYP_USER_KEY (150).

For the list of ALL keyword categories, see the CFITSIO documentation for the [fits_get_keyclass](#) function.

23.32.2.11 `void CCfits::HDU::makeThisCurrent () const [virtual]`

move the fitsfile pointer to this current [HDU](#).

This function should never need to be called by the user since it is called internally whenever required.

Reimplemented in [CCfits::ExtHDU](#).

23.32.2.12 `void CCfits::HDU::readAllKeys ()`

read all of the keys in the header

This member function reads keys that are not meta data for columns or image information, [which are considered to be part of the column or image objects]. Also, history and comment keys are read and returned by [getHistory\(\)](#) and [getComment\(\)](#). The exact list of keyword classes this will read is returned by the function [keywordCategories\(\)](#).

Note that [readAllKeys](#) can only construct keys of type string, double, `complex<float>`, integer, and bool because the [FITS](#) header records do not encode exact type information.

23.32.2.13 `template<typename T > void CCfits::HDU::readKey (const String & keyName, T & val)`

read a keyword of specified type from the header of a disk [FITS](#) file and return its value.

T is one of the types String, double, float, int, `std::complex<float>`, and bool. If a [Keyword](#) object with the name *keyName* already exists in this [HDU](#) due to a previous read call, then this will re-read from the file and create a new [Keyword](#) object to replace the existing one.

23.32.2.14 `template<typename T> void CCfits::HDU::readKeys (std::vector< String > & keyNames, std::vector< T > & vals)`

read a set of specified keywords of the same data type from the header of a disk [FITS](#) file and return their values

T is one of the types String, double, float, int, std::complex<float>, and bool.

23.32.2.15 `Keyword & CCfits::HDU::readNextKey (const std::vector< String > & incList, const std::vector< String > & excList, bool searchFromBeginning = false)`

Read the next key in the [HDU](#) which matches a string in incList, and does not match string in excList.

Parameters:

Parameters

<i>incList</i>	Vector of strings specifying keyword names to search.
<i>excList</i>	Vector of strings specifying names to exclude from search. This may be left empty.
<i>searchFromBeginning</i>	If 'true', search will be conducted from the start of the HDU . Otherwise it starts from the current position.

This is a wrapper around the CFITSIO fits_find_nextkey function. It reads in and returns the next keyword whose name matches matches one of the strings in incList, which may contain wild card characters (*, ?, and #). It will exclude keywords whose name matches a string in excList. If no keyword is found, a FitError is thrown.

By default the search is conducted from the current keyword position in the [HDU](#). If searchFromBeginning is set to 'true', search will start from the beginning of the [HDU](#). If [HDU](#) is not the currently open extension, this will make it so and start the keyword search from the beginning.

23.32.2.16 `void CCfits::HDU::resetImageRead () [inline, virtual]`

force next image reading operation to read from file instead of object cache.

[Note: It is not necessary to call this function for normal image reading operations.] - For primary HDUs and image extensions, this forces the next read operation to retrieve data from the file regardless of whether the data has already been read and stored in the HDU's internal arrays. This does nothing if the [HDU](#) does not contain an image.

Reimplemented in [CCfits::ImageExt< T >](#).

23.32.2.17 `void CCfits::HDU::scale (double value) [inline, virtual]`

set the BSCALE keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BSCALE keyword

in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the [bitpix\(\)](#) return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function `fits_get_img_equivtype` to make the determination). If this situation occurs, the function will throw a [FitsException](#).

Reimplemented in [CCfits::PHDU](#), and [CCfits::ImageExt< T >](#).

23.32.2.18 `void CCfits::HDU::suppressScaling (bool toggle = true) [virtual]`

turn off image scaling regardless of the BSCALE and BZERO keyword values

For *toggle* = true, this turns off image scaling for future read/writes by resetting the scale and zero to 1.0 and 0.0 respectively. It does NOT modify the BSCALE and BZERO keywords. If *toggle* = false, the scale and zero values will be restored to the keyword values.

Reimplemented in [CCfits::ImageExt< T >](#).

23.32.2.19 `void CCfits::HDU::updateChecksum ()`

update the CHECKSUM keyword value, assuming DATASUM exists and is correct

Wrapper for the CFITSIO function `fits_update_chksum`: This recomputes and writes the CHECKSUM value with the assumption that the DATASUM value is correct. If the DATASUM keyword doesn't yet exist or is not up-to-date, use the [HDU::writeChecksum](#) function instead. This will throw a [FitsError](#) exception if called when there is no DATASUM keyword in the header.

23.32.2.20 `std::pair< int, int > CCfits::HDU::verifyChecksum () const`

verify the [HDU](#) by computing the checksums and comparing them with the CHECKSUM/DATASUM keywords

Wrapper for the CFITSIO function `fits_verify_chksum`: The data unit is verified correctly if the computed checksum equals the DATASUM keyword value, and the [HDU](#) is verified if the entire checksum equals zero (see the CFITSIO manual for further details).

This returns a `std::pair<int,int>` where the pair's first data member = DATAOK and second = HDUOK. DATAOK and HDUOK values will be = 1 if verified correctly, 0 if the keyword is missing, and -1 if the computed checksum is not correct.

23.32.2.21 `void CCfits::HDU::writeChecksum ()`

compute and write the DATASUM and CHECKSUM keyword values

Wrapper for the CFITSIO function `fits_write_chksum`: This performs the datasum and

checksum calculations for this [HDU](#), as described in the CFITSIO manual. If either the DATASUM or CHECKSUM keywords already exist, their values will be updated.

23.32.2.22 `void CCfits::HDU::writeComment (const String & comment =
"Generic Comment")`

write a comment string.

A default value for the string is given ("Generic Comment String") so users can put a placeholder call to this function in their code.

23.32.2.23 `void CCfits::HDU::writeHistory (const String & history =
"Generic History String")`

write a history string.

A default value for the string is given ("Generic History String") so users can put a placeholder call to this function in their code.

23.32.2.24 `void CCfits::HDU::zero (double value) [inline, virtual]`

set the BZERO keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BZERO keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the [bitpix\(\)](#) return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function `fits_get_img_equivtype` to make the determination). If this situation occurs, the function will throw a [FitsException](#).

Reimplemented in [CCfits::PHDU](#), and [CCfits::ImageExt< T >](#).

The documentation for this class was generated from the following files:

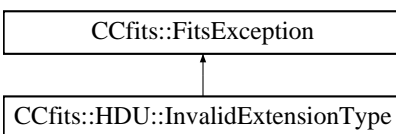
- HDU.h
- HDU.cxx

23.33 CCfits::HDU::InvalidExtensionType Class Reference

exception to be thrown if user requests extension type that can not be understood as [ImageExt](#), [AsciiTable](#) or [BinTable](#).

```
#include <HDU.h>
```

Inheritance diagram for CCfits::HDU::InvalidExtensionType:



Public Member Functions

- [InvalidExtensionType](#) (const string &diag, bool silent=true)

Exception ctor, prefixes the string "Fits Error: Extension Type: " before the specific message.

23.33.1 Detailed Description

exception to be thrown if user requests extension type that can not be understood as [ImageExt](#), [AsciiTable](#) or [BinTable](#).

23.33.2 Constructor & Destructor Documentation

23.33.2.1 CCfits::HDU::InvalidExtensionType::InvalidExtensionType (const string & *diag*, bool *silent* = true)

Exception ctor, prefixes the string "Fits Error: Extension Type: " before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

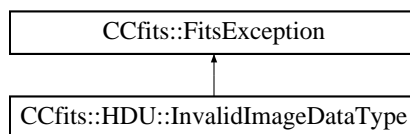
- HDU.h
- HDU.cxx

23.34 CCfits::HDU::InvalidImageDataType Class Reference

exception to be thrown if user requests creation of an image of type not supported by cfitsio.

```
#include <HDU.h>
```

Inheritance diagram for CCfits::HDU::InvalidImageDataType:



Public Member Functions

- [InvalidImageDataType](#) (const string &diag, bool silent=true)

Exception ctor, prefixes the string "Fits Error: Invalid Data Type for Image " before the specific message.

23.34.1 Detailed Description

exception to be thrown if user requests creation of an image of type not supported by cfitsio.

23.34.2 Constructor & Destructor Documentation

23.34.2.1 CCfits::HDU::InvalidImageDataType::InvalidImageDataType (const string & *diag*, bool *silent* = true)

Exception ctor, prefixes the string "Fits Error: Invalid Data Type for Image " before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

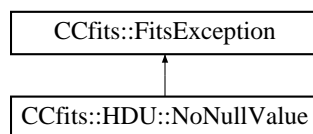
- HDU.h
- HDU.cxx

23.35 CCfits::HDU::NoNullValue Class Reference

exception to be thrown on seek errors for keywords.

```
#include <HDU.h>
```

Inheritance diagram for CCfits::HDU::NoNullValue:



Public Member Functions

- [NoNullValue](#) (const string &diag, bool silent=true)

Exception ctor, prefixes the string "Fits Error: No Null Pixel Value specified for Image " before the specific message.

23.35.1 Detailed Description

exception to be thrown on seek errors for keywords.

23.35.2 Constructor & Destructor Documentation

23.35.2.1 CCfits::HDU::NoNullValue::NoNullValue (const string & diag, bool *silent* = true)

Exception ctor, prefixes the string "Fits Error: No Null Pixel Value specified for Image " before the specific message.

Parameters

<i>diag</i>	A specific diagnostic message, the name of the HDU if not the primary.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

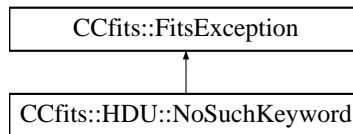
- HDU.h
- HDU.cxx

23.36 CCfits::HDU::NoSuchKeyword Class Reference

exception to be thrown on seek errors for keywords.

```
#include <HDU.h>
```

Inheritance diagram for CCfits::HDU::NoSuchKeyword:



Public Member Functions

- [NoSuchKeyword](#) (const string &diag, bool silent=true)
Exception ctor, prefixes the string "Fits Error: Keyword not found: " before the specific message.

23.36.1 Detailed Description

exception to be thrown on seek errors for keywords.

23.36.2 Constructor & Destructor Documentation

23.36.2.1 CCfits::HDU::NoSuchKeyword::NoSuchKeyword (const string & *diag*, bool *silent* = true)

Exception ctor, prefixes the string "Fits Error: Keyword not found: " before the specific message.

Parameters

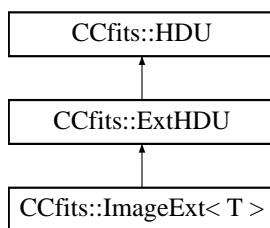
<i>diag</i>	A specific diagnostic message, usually the name of the keyword requested.
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

- HDU.h
- HDU.cxx

23.37 CCfits::ImageExt< T > Class Template Reference

Inheritance diagram for CCfits::ImageExt< T >:



Public Member Functions

- virtual `~ImageExt()`
destructor
- virtual `ImageExt< T > * clone (FITSBase *p) const`
virtual copy constructor
- virtual void `readData` (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())
read Image extension HDU data
- virtual void `resetImageRead()`
force next image reading operation to read from file instead of object cache.
- virtual void `scale` (double value)
set the BSCALE keyword value for images (see warning for images of int type)
- virtual double `scale()` const
return the BSCALE keyword value
- virtual void `suppressScaling` (bool toggle=true)
turn off image scaling regardless of the BSCALE and BZERO keyword values
- virtual void `zero` (double value)
set the BZERO keyword value for images (see warning for images of int type)
- virtual double `zero()` const
return the BZERO keyword value

23.37.1 Detailed Description

`template<typename T>class CCfits::ImageExt< T >`

`ImageExt<T>` is a subclass of `ExtHDU` that contains image data of type `T`.

23.37.2 Member Function Documentation

23.37.2.1 `template<typename T> void CCfits::ImageExt< T >::readData (bool readFlag = false, const std::vector< String > & keys = std::vector<String>()) [virtual]`

read Image extension [HDU](#) data

Called by [FITS](#) ctor, not intended for general use. parameters control how much gets read on initialization.

Parameters

<i>readFlag</i>	read the image data if true
<i>key</i>	a vector of strings of keyword names to be read from the HDU

Implements [CCfits::ExtHDU](#).

23.37.2.2 `template<typename T> void CCfits::ImageExt< T >::resetImageRead () [virtual]`

force next image reading operation to read from file instead of object cache.

[Note: It is not necessary to call this function for normal image reading operations.] - For primary HDUs and image extensions, this forces the next read operation to retrieve data from the file regardless of whether the data has already been read and stored in the HDU's internal arrays. This does nothing if the [HDU](#) does not contain an image.

Reimplemented from [CCfits::HDU](#).

23.37.2.3 `template<typename T> void CCfits::ImageExt< T >::scale (double value) [virtual]`

set the BSCALE keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BSCALE keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the [bitpix\(\)](#) return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function `fits_get_img_equivtype` to make the determination). If this situation occurs, the function will throw a [FitsException](#).

Reimplemented from [CCfits::HDU](#).

23.37.2.4 `template<typename T> void CCfits::ImageExt< T >::suppressScaling (bool toggle = true) [virtual]`

turn off image scaling regardless of the BSCALE and BZERO keyword values

For *toggle* = true, this turns off image scaling for future read/writes by resetting the scale and zero to 1.0 and 0.0 respectively. It does NOT modify the BSCALE and BZERO keywords. If *toggle* = false, the scale and zero values will be restored to the keyword values.

Reimplemented from [CCfits::HDU](#).

23.37.2.5 `template<typename T> void CCfits::ImageExt< T >::zero (double value) [virtual]`

set the BZERO keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BZERO keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the [bitpix\(\)](#) return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function `fits_get_img_equivtype` to make the determination). If this situation occurs, the function will throw a [FitsException](#).

Reimplemented from [CCfits::HDU](#).

The documentation for this class was generated from the following file:

- ImageExt.h

23.38 CCfits::Keyword Class Reference

Abstract base class defining the interface for [Keyword](#) objects.

```
#include <Keyword.h>
```

Inherited by `CCfits::KeyData< T >`.

Public Member Functions

- virtual [~Keyword](#) ()
virtual destructor
- virtual [Keyword](#) * [clone](#) () const =0
virtual copy constructor

- const String & [comment](#) () const
return the comment field of the keyword
- fitsfile * [fitsPointer](#) () const
return a pointer to the [FITS](#) file containing the parent [HDU](#).
- [ValueType](#) [keytype](#) () const
return the type of a keyword
- const String & [name](#) () const
return the name of a keyword
- bool [operator!=](#) (const [Keyword](#) &right) const
inequality operator
- [Keyword](#) & [operator=](#) (const [Keyword](#) &right)
assignment operator
- bool [operator==](#) (const [Keyword](#) &right) const
equality operator
- template<typename T >
void [setValue](#) (const T &newValue)
modify the value of an existing [Keyword](#) and write it to the file
- template<typename T >
T & [value](#) (T &val) const
get the keyword value
- virtual void [write](#) ()
left in for historical reasons, this seldom needs to be called by users

Protected Member Functions

- [Keyword](#) (const [Keyword](#) &right)
copy constructor
- [Keyword](#) (const String &keyname, [ValueType](#) keytype, [HDU](#) *p, const String &comment="")
[Keyword](#) constructor.
- void [keytype](#) ([ValueType](#) value)
set keyword type.
- const [HDU](#) * [parent](#) () const
return a pointer to parent [HDU](#).

23.38.1 Detailed Description

Abstract base class defining the interface for [Keyword](#) objects.

[Keyword](#) object creation is normally performed inside [FITS](#) constructors or [FITS::read](#), [HDU::readKey](#), and [HDU::addKey](#) functions. Output is performed in [HDU::addKey](#) functions and [Keyword::setValue](#).

Keywords consists of a name, a value and a comment field. Concrete templated subclasses, [KeyData<T>](#), have a data member that holds the value of keyword.

Typically, the mandatory keywords for a given [HDU](#) type are not stored as object of type [Keyword](#), but as intrinsic data types. The [Keyword](#) hierarchy is used to store user-supplied information.

23.38.2 Constructor & Destructor Documentation

23.38.2.1 `CCfits::Keyword::Keyword (const String & keyname, ValueType keytype, HDU * p, const String & comment = " ") [protected]`

[Keyword](#) constructor.

This is the common behavior of Keywords of any type. Constructor is protected as the class is abstract.

23.38.3 Member Function Documentation

23.38.3.1 `template<typename T > void CCfits::Keyword::setValue (const T & newValue)`

modify the value of an existing [Keyword](#) and write it to the file

Parameters

<i>newValue</i>	(T) New value for the Keyword
-----------------	---

Allowed T types: This must copy *newValue* to a data member of type U in the [Keyword](#) subclass [KeyData<U>](#) (see description for [Keyword::value](#) (T& val) for more details). To avoid compilation errors, it is generally best to provide a *newValue* of type T = type U, though the following type conversions will also be handled:

T (from newValue)	U (to Keyword obj)
float	double, float
double	double, float (will lose precision)
int	double, float, int, integer string

23.38.3.2 `template<typename T > T & CCfits::Keyword::value (T & val) const`

get the keyword value

Parameters

<i>val</i>	(T) Will be filled with the keyword value, and is also the function return value.
------------	---

Allowed T types: `CCfits` stores keyword values of type `U` in a templated subclass of `Keyword`, `KeyData<U>`. Normally `U` is set when reading the `Keyword` in from the file, and is limited to types `int`, `double`, `string`, `bool`, and `complex<float>`. (The exception is when the user has created and added a new `Keyword` using an `HDU::addKey` function, in which case they might have specified other types for `U`.) To avoid compilation errors, the user should generally try to provide a *val* of type `T = type U`, though there is some flexibility here as the following conversions are handled:

T (to val)	U (from <code>Keyword</code> obj)
float	double (will lose precision), float, int, integer string
double	double, float, int, integer string
int	int, integer string
string	double, float, int, string

More conversions may be added in the future as the need arises.

23.38.3.3 void CCfits::Keyword::write () [virtual]

left in for historical reasons, this seldom needs to be called by users

This writes the `Keyword` to the file, and is called internally during `HDU::addKey` operations or the `Keyword::setValue` function. It shouldn't normally need to be called explicitly.

The documentation for this class was generated from the following files:

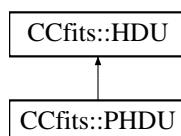
- `Keyword.h`
- `Keyword.cxx`
- `KeywordT.h`

23.39 CCfits::PHDU Class Reference

class representing the primary `HDU` for a `FITS` file.

```
#include <PHDU.h>
```

Inheritance diagram for `CCfits::PHDU`:



Public Member Functions

- virtual `~PHDU ()`
destructor
- virtual `PHDU * clone (FITSBase *p) const =0`
virtual copy constructor, to be implemented in subclasses.
- bool `extend () const`
Returns the value of the Primary's EXTEND keyword.
- template<typename S >
void `read (std::valarray< S > &image, long first, long nElements)`
read an image section starting at a specified pixel
- template<typename S >
void `read (std::valarray< S > &image, long first, long nElements, S *nullValue)`
read part of an image array, processing null values.
- template<typename S >
void `read (std::valarray< S > &image, const std::vector< long > &first, long nElements)`
read an image section starting at a location specified by an n-tuple
- template<typename S >
void `read (std::valarray< S > &image, const std::vector< long > &first, long nElements, S *nullValue)`
read part of an image array, processing null values.
- template<typename S >
void `read (std::valarray< S > &image, const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::vector< long > &stride)`
read an image subset
- template<typename S >
void `read (std::valarray< S > &image, const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::vector< long > &stride, S *nullValue)`
read an image subset into valarray image, processing null values
- virtual void `readData (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())=0`
read primary HDU data
- virtual void `scale (double value)`
set the BSCALE keyword value for images (see warning for images of int type)
- virtual double `scale () const`
return the BSCALE keyword value
- bool `simple () const`
Returns the value of the Primary's SIMPLE keyword.

- template<typename S >
void [write](#) (const std::vector< long > &first, long nElements, const std::valarray< S > &data, S *nullValue)
Write a set of pixels to an image extension with the first pixel specified by an n-tuple, processing undefined data.
- template<typename S >
void [write](#) (long first, long nElements, const std::valarray< S > &data, S *nullValue)
write array to image starting with a specified pixel and allowing undefined data to be processed
- template<typename S >
void [write](#) (const std::vector< long > &first, long nElements, const std::valarray< S > &data)
write array starting from specified n-tuple, without undefined data processing
- template<typename S >
void [write](#) (long first, long nElements, const std::valarray< S > &data)
write array starting from specified pixel number, without undefined data processing
- template<typename S >
void [write](#) (const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::vector< long > &stride, const std::valarray< S > &data)
write a subset (generalize slice) of data to the image
- virtual void [zero](#) (double value)
set the BZERO keyword value for images (see warning for images of int type)
- virtual double [zero](#) () const
return the BZERO keyword value

Protected Member Functions

- [PHDU](#) (const [PHDU](#) &right)
copy constructor
- [PHDU](#) (FITSBase *p, int bpix, int naxis, const std::vector< long > &axes)
Writing Primary [HDU](#) constructor, called by PrimaryHDU<T> class.
- [PHDU](#) (FITSBase *p=0)
Reading Primary [HDU](#) constructor.
- virtual void [initRead](#) ()

23.39.1 Detailed Description

class representing the primary [HDU](#) for a [FITS](#) file.

A [PHDU](#) object is automatically instantiated and added to a [FITS](#) object when a [FITS](#) file is accessed in any way. If a new file is created without specifying the data type for

the header, [CCfits](#) assumes that the file is to be used for table extensions and creates a dummy header. [PHDU](#) instances are *only* created by [FITS](#) ctors. In the first release of [CCfits](#), the Primary cannot be changed once declared.

[PHDU](#) and [ExtHDU](#) provide the same interface to writing images: multiple overloads of the templated [PHDU::read](#) and [PHDU::write](#) operations provide for (a) writing image data specified in a number of ways [C-array, `std::vector`, `std::valarray`] and with input location specified by initial pixel, by n-tuple, and by rectangular subset [generalized slice]; (b) reading image data specified similarly to the write options into a `std::valarray`.

Todo Implement functions that allow replacement of the primary image

23.39.2 Constructor & Destructor Documentation

23.39.2.1 `CCfits::PHDU::~~PHDU()` `[virtual]`

destructor

Destructor

23.39.2.2 `CCfits::PHDU::PHDU(const PHDU & right)` `[protected]`

copy constructor

required for cloning primary HDUs when copying [FITS](#) files.

23.39.2.3 `CCfits::PHDU::PHDU(FITSBase * p, int bpix, int naxis, const std::vector< long > & axes)` `[protected]`

Writing Primary [HDU](#) constructor, called by `PrimaryHDU<T>` class.

Constructor used for creating new [PHDU](#) (i.e. for writing data to [FITS](#)). also doubles as default constructor since all arguments have default values, which are passed to the [HDU](#) constructor

23.39.2.4 `CCfits::PHDU::PHDU(FITSBase * p = 0)` `[protected]`

Reading Primary [HDU](#) constructor.

Constructor used when reading the primary [HDU](#) from an existing file. Does nothing except initialize, with the real work done by the subclass `PrimaryHDU<T>`.

23.39.3 Member Function Documentation

23.39.3.1 `void CCfits::PHDU::initRead()` `[protected, virtual]`

Read image header and update fits pointer accordingly.

Private: called by ctor.

Implements [CCfits::HDU](#).

23.39.3.2 `template<typename S> void CCfits::PHDU::read (std::valarray< S> & image, long first, long nElements, S * nullValue)`

read part of an image array, processing null values.

Implicit data conversion is supported (i.e. user does not need to know the type of the data stored. A WrongExtensionType extension is thrown if *this is not an image.

Parameters

<i>image</i>	The receiving container, a std::valarray reference
<i>first</i>	The first pixel from the array to read [a long value]
<i>nElements</i>	The number of values to read
<i>nullValue</i>	A pointer containing the value in the table to be considered as undefined. See cfitsio for details

23.39.3.3 `template<typename S> void CCfits::PHDU::read (std::valarray< S> & image, const std::vector< long> & first, long nElements, S * nullValue)`

read part of an image array, processing null values.

As above except for

Parameters

<i>first</i>	a vector<long> representing an n-tuple giving the coordinates in the image of the first pixel.
--------------	--

23.39.3.4 `template<typename S> void CCfits::PHDU::read (std::valarray< S> & image, const std::vector< long> & firstVertex, const std::vector< long> & lastVertex, const std::vector< long> & stride, S * nullValue)`

read an image subset into valarray image, processing null values

The image subset is defined by two vertices and a stride indicating the 'denseness' of the values to be picked in each dimension (a stride = (1,1,1,...) means picking every pixel in every dimension, whereas stride = (2,2,2,...) means picking every other value in each dimension.

23.39.3.5 `void CCfits::PHDU::readData (bool readFlag = false, const std::vector< String> & keys = std::vector<String>()) [pure virtual]`

read primary [HDU](#) data

Called by [FITS](#) ctor, not intended for general use. parameters control how much gets

read on initialization. An abstract function, implemented in the subclasses.

Parameters

<i>readFlag</i>	read the image data if true
<i>key</i>	a vector of strings of keyword names to be read from the primary HDU

23.39.3.6 void CCfits::PHDU::scale (double *value*) [virtual]

set the BSCALE keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BSCALE keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the [bitpix\(\)](#) return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function [fits_get_img_equivtype](#) to make the determination). If this situation occurs, the function will throw a [FitsException](#).

Reimplemented from [CCfits::HDU](#).

23.39.3.7 template<typename S > void CCfits::PHDU::write (const std::vector< long > & *first*, long *nElements*, const std::valarray< S > & *data*, S * *nullValue*)

Write a set of pixels to an image extension with the first pixel specified by an n-tuple, processing undefined data.

All the overloaded versions of [PHDU::write](#) perform operations on *this if it is an image and throw a WrongExtensionType exception if not. Where appropriate, alternate versions allow undefined data to be processed

Parameters

<i>first</i>	an n-tuple of dimension equal to the image dimension specifying the first pixel in the range to be written
<i>nElements</i>	number of pixels to be written
<i>data</i>	array of data to be written
<i>nullValue</i>	pointer to null value (data with this value written as undefined; needs the BLANK keyword to have been specified).

23.39.3.8 template<typename S > void CCfits::PHDU::write (long *first*, long *nElements*, const std::valarray< S > & *data*, S * *nullValue*)

write array to image starting with a specified pixel and allowing undefined data to be processed

parameters after the first are as for version with n-tuple specifying first element. these two version are equivalent, except that it is possible for the first pixel number to exceed the range of 32-bit integers, which is how long datatype is commonly implemented.

23.39.3.9 `template<typename S> void CCfits::PHDU::write (const std::vector< long > & firstVertex, const std::vector< long > & lastVertex, const std::vector< long > & stride, const std::valarray< S > & data)`

write a subset (generalize slice) of data to the image

A generalized slice/subset is a subset of the image (e.g. one plane of a data cube of size \leq the dimension of the cube). It is specified by two opposite vertices. The equivalent cfitsio call does not support undefined data processing so there is no version that allows a null value to be specified.

Parameters

<i>firstVertex</i>	The coordinates specifying lower and upper vertices of the n-dimensional slice
<i>lastVertex</i>	
<i>stride</i>	Pixels to skip in each to dimension, e.g. stride = (1,1,1,...) means picking every pixel in every dimension, whereas stride = (2,2,2,...) means picking every other value in each dimension.
<i>data</i>	The data to be written

23.39.3.10 `void CCfits::PHDU::zero (double value) [virtual]`

set the BZERO keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BZERO keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the `bitpix()` return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function `fits_get_img_equivtype` to make the determination). If this situation occurs, the function will throw a [FitsException](#).

Reimplemented from [CCfits::HDU](#).

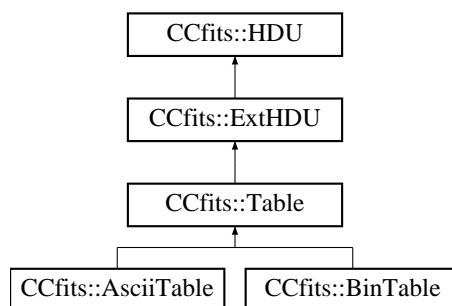
The documentation for this class was generated from the following files:

- PHDU.h
- PHDU.cxx
- PHDUT.h

23.40 CCfits::Table Class Reference

```
#include <Table.h>
```

Inheritance diagram for CCfits::Table:



Classes

- class [NoSuchColumn](#)

Exception to be thrown on a failure to retrieve a column specified either by name or index number.

Public Member Functions

- [Table](#) (const [Table](#) &right)
copy constructor
- virtual [~Table](#) ()
destructor
- virtual [Column](#) & [column](#) (const String &colName, bool caseSensitive=true) const
return a reference to a [Table](#) column specified by name.
- virtual [Column](#) & [column](#) (int colIndex) const
return a reference to the column identified by colIndex
- virtual const [ColMap](#) & [column](#) () const
return a reference to the multimap containing the columns.
- virtual [ColMap](#) & [column](#) ()
return a reference to the multimap containing the columns.
- virtual void [copyColumn](#) (const [Column](#) &inColumn, int colIdx, bool insertNewCol=true)
copy a column (from different or same HDU and file) into an existing table HDU.
- virtual void [deleteColumn](#) (const String &columnName)

- delete a column in a [Table](#) extension by name.*
- void [deleteRows](#) (long first, long number=1)
delete a range of rows in a table.
- void [deleteRows](#) (const std::vector< long > &rowList)
delete a set of rows in the table specified by an input array.
- virtual long [getRowSize](#) () const
return the optimal number of rows to read or write at a time
- void [insertRows](#) (long first, long number=1)
insert empty rows into the table
- virtual int [numCols](#) () const
return the number of Columns in the [Table](#) (the TFIELD keyword).
- virtual long [rows](#) () const
return the number of rows in the table (NAXIS2).
- void [rows](#) (long numRows)
set the number of rows in the [Table](#).
- void [updateRows](#) ()
update the number of rows in the table

Protected Member Functions

- [Table](#) (FITSBase *p, HduType xtype, const String &hduName, int rows, const std::vector< String > &columnName, const std::vector< String > &columnFmt, const std::vector< String > &columnUnit=std::vector< String >(), int version=1)
Constructor to be used for creating new HDUs.
- [Table](#) (FITSBase *p, HduType xtype, const String &hduName=String(""), int version=1)
Constructor to be called by operations that read [Table](#) specified by hduName and version.
- [Table](#) (FITSBase *p, HduType xtype, int number)
[Table](#) constructor for getting Tables by number.
- void [init](#) (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())
- void [numCols](#) (int value)
set the number of Columns in the [Table](#)

23.40.1 Detailed Description

[Table](#) is the abstract common interface to Binary and Ascii [Table](#) HDUs.

[Table](#) is a subclass of [ExtHDU](#) that contains an associative array of [Column](#) objects. It implements methods for reading and writing columns

23.40.2 Constructor & Destructor Documentation

23.40.2.1 `CCfits::Table::Table (FITSBase * p, HduType xtype, const String & hduName, int rows, const std::vector< String > & columnName, const std::vector< String > & columnFmt, const std::vector< String > & columnUnit = std::vector<String>(), int version = 1)` [protected]

Constructor to be used for creating new HDUs.

Parameters

<i>p</i>	The FITS file in which to place the new HDU
<i>xtype</i>	An HduType enumerator defined in CCfits.h for type of table (AsciiTbl or BinaryTbl)
<i>hduName</i>	The name of this HDU extension
<i>rows</i>	The number of rows in the new HDU (the value of the NAXIS2 keyword).
<i>columnName</i>	a vector of names for the columns.
<i>columnFmt</i>	the format strings for the columns
<i>columnUnit</i>	the units for the columns.
<i>version</i>	a version number

23.40.2.2 `CCfits::Table::Table (FITSBase * p, HduType xtype, int number)` [protected]

[Table](#) constructor for getting Tables by number.

Necessary since EXTNAME is a reserved not required keyword, and users may thus read [FITS](#) files without an extension name. Since an [HDU](#) is completely specified by extension number, this is part of the public interface.

23.40.3 Member Function Documentation

23.40.3.1 `Column & CCfits::Table::column (const String & colName, bool caseSensitive = true) const` [virtual]

return a reference to a [Table](#) column specified by name.

If the *caseSensitive* parameter is set to false, the search will be case-insensitive. The overridden base class implementation [ExtHDU::column](#) throws an exception, which is thus the action to be taken if self is an image extension

Exceptions

<i>WrongExtensionType</i>	see above
---------------------------	-----------

Reimplemented from [CCfits::ExtHDU](#).

23.40.3.2 Column & CCfits::Table::column (int *colIndex*) const [virtual]

return a reference to the column identified by *colIndex*

Throws [NoSuchColumn](#) if the index is out of range -index must satisfy (1 <= index <= numCols()).

N.B. the column number is assigned as 1-based, as in FORTRAN rather than 0-based as in C.

Exceptions

Table::NoSuchColumn	passes <i>colIndex</i> to the diagnostic message printed when the exception is thrown
-------------------------------------	---

Reimplemented from [CCfits::ExtHDU](#).

23.40.3.3 const ColMap & CCfits::Table::column () const [inline, virtual]

return a reference to the multimap containing the columns.

This public version might be used to query the size of the column container in a routine that manipulates column table data.

Reimplemented from [CCfits::ExtHDU](#).

23.40.3.4 ColMap & CCfits::Table::column () [inline, virtual]

return a reference to the multimap containing the columns.

To be used in the implementation of subclasses.

23.40.3.5 void CCfits::Table::copyColumn (const Column & *inColumn*, int *colIdx*, bool *insertNewCol* = true) [virtual]

copy a column (from different or same [HDU](#) and file) into an existing table [HDU](#).

This is meant to provide the same functionality as CFITSIO's fits_copy_col, and therefore does not work with columns with variable length fields. Copying a column from an [AsciiTable](#) to a [BinTable](#) is prohibited. *colIdx* range should be from 1 to nCurrentCols+1 if inserting, or 1 to nCurrentCols if replacing.

Parameters

<i>inColumn</i>	The Column object which is to be copied
<i>colIdx</i>	The position for which the copied Column will be placed (first <i>colIdx</i> = 1).
<i>insertNewCol</i>	If 'true', new Column will be inserted in or appended to table. If 'false', Column will replace current Column at position = <i>colIdx</i> .

Reimplemented from [CCfits::ExtHDU](#).

23.40.3.6 void CCfits::Table::deleteColumn (const String & *columnName*) [virtual]

delete a column in a [Table](#) extension by name.

Parameters

<i>column-Name</i>	The name of the column to be deleted.
--------------------	---------------------------------------

Exceptions

WrongExtensionType	if extension is an image.
------------------------------------	---------------------------

Reimplemented from [CCfits::ExtHDU](#).

23.40.3.7 void CCfits::Table::deleteRows (long *first*, long *number* = 1)

delete a range of rows in a table.

In both this and the overloaded version which allows a selection of rows to be deleted, the cfitsio library is called first to perform the operation on the disk file, and then the [FITS](#) object is updated.

Parameters

<i>first</i>	the start row of the range
<i>number</i>	the number of rows to delete; defaults to 1.

Exceptions

FitsError	thrown if the cfitsio call fails to return without error.
---------------------------	---

23.40.3.8 void CCfits::Table::deleteRows (const std::vector< long > & *rowlist*)

delete a set of rows in the table specified by an input array.

Parameters

<i>rowlist</i>	The vector of row numbers to be deleted.
----------------	--

Exceptions

FitsError	thrown if the underlying cfitsio call fails to return without error.
---------------------------	--

23.40.3.9 `long CCfits::Table::getRowSize () const` [virtual]

return the optimal number of rows to read or write at a time

A wrapper for the CFITSIO function `fits_get_rowsize`, useful for obtaining maximum I/O efficiency. This will throw if it is not called for a [Table](#) extension.

Reimplemented from [CCfits::ExtHDU](#).

23.40.3.10 `void CCfits::Table::init (bool readFlag = false, const std::vector< String > & keys = std::vector<String>())` [protected]

"Late Constructor." wrap-up of calls needed to construct a table. Reads header information and sets up the array of column objects in the table.

Protected function, provided to allow the implementation of extensions of the library.

23.40.3.11 `void CCfits::Table::insertRows (long first, long number = 1)`

insert empty rows into the table

Parameters

<i>first</i>	the start row of the range
<i>number</i>	the number of rows to insert.

Exceptions

FitsError	thrown if the underlying cfitsio call fails to return without error.
---------------------------	--

23.40.3.12 `void CCfits::Table::updateRows ()`

update the number of rows in the table

Called to force the [Table](#) to reset its internal "rows" attribute. public, but is called when needed internally.

The documentation for this class was generated from the following files:

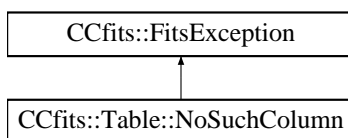
- [Table.h](#)
- [Table.cxx](#)

23.41 CCfits::Table::NoSuchColumn Class Reference

Exception to be thrown on a failure to retrieve a column specified either by name or index number.

```
#include <Table.h>
```

Inheritance diagram for CCfits::Table::NoSuchColumn:



Public Member Functions

- [NoSuchColumn](#) (const String &name, bool silent=true)
Exception ctor for exception thrown if the requested column (specified by name) is not present.
- [NoSuchColumn](#) (int index, bool silent=true)
Exception ctor for exception thrown if the requested column (specified by name) is not present.

23.41.1 Detailed Description

Exception to be thrown on a failure to retrieve a column specified either by name or index number.

When a [Table](#) object is created, the header is read and a column object created for each column defined. Thus if this exception is thrown the column requested does not exist in the [HDU](#) (note that the column can easily exist and not contain any data since the user controls whether the column will be read when the [FITS](#) object is instantiated).

It is expected that the index number calls will be primarily internal. The underlying implementation makes lookup by name more efficient.

The exception has two variants, which take either an integer or a string as parameter. These are used according to the accessor that threw them, either by name or index.

23.41.2 Constructor & Destructor Documentation

23.41.2.1 CCfits::Table::NoSuchColumn::NoSuchColumn (const String & name, bool silent = true)

Exception ctor for exception thrown if the requested column (specified by name) is not present.

Message: Fits Error: cannot find [Column](#) named: *name* is printed.

Parameters

<i>name</i>	the requested column name
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

23.41.2.2 CCfits::Table::NoSuchColumn::NoSuchColumn (int *index*, bool *silent* = true)

Exception ctor for exception thrown if the requested column (specified by name) is not present.

Message: Fits Error: column not present - [Column](#) number *index* is printed.

Parameters

<i>index</i>	the requested column number
<i>silent</i>	if true, print message whether FITS::verboseMode is set or not.

The documentation for this class was generated from the following files:

- Table.h
- Table.cxx

Index

- ~PHDU
 - CCfits::PHDU, 133
- AsciiTable
 - CCfits::AsciiTable, 45, 46
- BinTable
 - CCfits::BinTable, 49
- CCfits, 41
 - ValueType, 43
 - operator<<, 43
- CCfits::AsciiTable, 44
 - AsciiTable, 45, 46
 - addColumn, 47
 - readData, 47
- CCfits::BinTable, 47
 - BinTable, 49
 - addColumn, 50
 - readData, 51
- CCfits::Column, 51
 - Column, 56
 - addNullValue, 57
 - dimen, 57
 - display, 57
 - format, 57
 - getNullValue, 57
 - read, 58, 59
 - readArrays, 59, 60
 - readData, 60
 - resetRead, 60
 - rows, 60
 - scale, 60
 - write, 61–64
 - writeArrays, 65
 - zero, 65
- CCfits::Column::InsufficientElements, 65
 - InsufficientElements, 66
- CCfits::Column::InvalidDataType, 67
 - InvalidDataType, 67
- CCfits::Column::InvalidNumberOfRows, 68
 - InvalidNumberOfRows, 68
- CCfits::Column::InvalidRowNumber, 69
 - InvalidRowNumber, 69
- CCfits::Column::InvalidRowParameter, 70
 - InvalidRowParameter, 70
- CCfits::Column::NoNullValue, 71
 - NoNullValue, 71
- CCfits::Column::RangeError, 72
 - RangeError, 72
- CCfits::Column::WrongColumnType, 73
 - WrongColumnType, 73
- CCfits::ExtHDU, 74
 - ExtHDU, 77
 - addColumn, 78
 - column, 78, 79
 - copyColumn, 79
 - deleteColumn, 79
 - getRowsize, 80
 - isCompressed, 80
 - makeThisCurrent, 80
 - numCols, 80
 - read, 80, 81
 - readHduName, 81
 - rows, 82
 - write, 82
 - xtension, 83
- CCfits::ExtHDU::WrongExtensionType, 83
 - WrongExtensionType, 84
- CCfits::FITS, 84
 - FITS, 88–91
 - addImage, 92
 - addTable, 93
 - copy, 93
 - currentExtensionName, 93
 - deleteExtension, 93, 94
 - destroy, 94
 - extension, 94
 - filter, 94
 - flush, 95
 - getTileDimensions, 95
 - read, 95, 96
 - setCompressionType, 96
 - setNoiseBits, 97
 - setTileDimensions, 97
 - verboseMode, 97

- CCfits::FITS::CantCreate, [97](#)
 - CantCreate, [98](#)
- CCfits::FITS::CantOpen, [98](#)
 - CantOpen, [99](#)
- CCfits::FITS::NoSuchHDU, [100](#)
 - NoSuchHDU, [100](#)
- CCfits::FITS::OperationNotSupported, [101](#)
 - OperationNotSupported, [101](#)
- CCfits::FITSUtil::CAarray< T >, [106](#)
- CCfits::FITSUtil::CVAarray< T >, [107](#)
- CCfits::FITSUtil::CVarray< T >, [107](#)
- CCfits::FITSUtil::MatchName< T >, [108](#)
- CCfits::FITSUtil::MatchNum< T >, [108](#)
- CCfits::FITSUtil::MatchPtrName< T >, [109](#)
- CCfits::FITSUtil::MatchPtrNum< T >, [109](#)
- CCfits::FITSUtil::MatchType< T >, [110](#)
- CCfits::FITSUtil::UnrecognizedType, [110](#)
- CCfits::FITSUtil::auto_array_ptr< X >, [105](#)
- CCfits::FitsError, [102](#)
 - FitsError, [102](#)
- CCfits::FitsException, [102](#)
 - FitsException, [104](#)
 - message, [104](#)
- CCfits::FitsFatal, [104](#)
 - FitsFatal, [105](#)
- CCfits::HDU, [111](#)
 - addKey, [115](#)
 - axis, [115](#)
 - bitpix, [116](#)
 - copyAllKeys, [116](#)
 - deleteKey, [116](#)
 - getChecksum, [116](#)
 - getComments, [116](#)
 - getHistory, [116](#)
 - keywordCategories, [117](#)
 - makeThisCurrent, [117](#)
 - readAllKeys, [117](#)
 - readKey, [117](#)
 - readKeys, [117](#)
 - readNextKey, [118](#)
 - resetImageRead, [118](#)
 - scale, [118](#)
 - suppressScaling, [119](#)
 - updateChecksum, [119](#)
 - verifyChecksum, [119](#)
 - writeChecksum, [119](#)
 - writeComment, [120](#)
 - writeHistory, [120](#)
 - zero, [120](#)
- CCfits::HDU::InvalidExtensionType, [120](#)
 - InvalidExtensionType, [121](#)
- CCfits::HDU::InvalidImageDataType, [121](#)
 - InvalidImageDataType, [122](#)
- CCfits::HDU::NoNullValue, [122](#)
 - NoNullValue, [123](#)
- CCfits::HDU::NoSuchKeyword, [123](#)
 - NoSuchKeyword, [124](#)
- CCfits::ImageExt
 - readData, [126](#)
 - resetImageRead, [126](#)
 - scale, [126](#)
 - suppressScaling, [126](#)
 - zero, [127](#)
- CCfits::ImageExt< T >, [124](#)
- CCfits::Keyword, [127](#)
 - Keyword, [129](#)
 - setValue, [129](#)
 - value, [129](#)
 - write, [130](#)
- CCfits::PHDU, [130](#)
 - ~PHDU, [133](#)
 - PHDU, [133](#)
 - initRead, [133](#)
 - read, [134](#)
 - readData, [134](#)
 - scale, [135](#)
 - write, [135, 136](#)
 - zero, [136](#)
- CCfits::Table, [137](#)
 - Table, [139](#)
 - column, [139, 140](#)
 - copyColumn, [140](#)
 - deleteColumn, [141](#)
 - deleteRows, [141](#)
 - getRowsize, [141](#)
 - init, [142](#)
 - insertRows, [142](#)
 - updateRows, [142](#)
- CCfits::Table::NoSuchColumn, [142](#)

- NoSuchColumn, [143](#), [144](#)
- CantCreate
 - CCfits::FITS::CantCreate, [98](#)
- CantOpen
 - CCfits::FITS::CantOpen, [99](#)
- Column
 - CCfits::Column, [56](#)
- ExtHDU
 - CCfits::ExtHDU, [77](#)
- FITS
 - CCfits::FITS, [88–91](#)
- FITS Exceptions, [40](#)
- FITSUtil, [44](#)
- FitsError
 - CCfits::FitsError, [102](#)
- FitsException
 - CCfits::FitsException, [104](#)
- FitsFatal
 - CCfits::FitsFatal, [105](#)
- InsufficientElements
 - CCfits::Column::InsufficientElements, [66](#)
- InvalidDataType
 - CCfits::Column::InvalidDataType, [67](#)
- InvalidExtensionType
 - CCfits::HDU::InvalidExtensionType, [121](#)
- InvalidImageDataType
 - CCfits::HDU::InvalidImageDataType, [122](#)
- InvalidNumberOfRows
 - CCfits::Column::InvalidNumberOfRows, [68](#)
- InvalidRowNumber
 - CCfits::Column::InvalidRowNumber, [69](#)
- InvalidRowParameter
 - CCfits::Column::InvalidRowParameter, [70](#)
- Keyword
 - CCfits::Keyword, [129](#)
- NoNullValue
 - CCfits::Column::NoNullValue, [71](#)
 - CCfits::HDU::NoNullValue, [123](#)
- NoSuchColumn
 - CCfits::Table::NoSuchColumn, [143](#), [144](#)
- NoSuchHDU
 - CCfits::FITS::NoSuchHDU, [100](#)
- NoSuchKeyword
 - CCfits::HDU::NoSuchKeyword, [124](#)
- OperationNotSupported
 - CCfits::FITS::OperationNotSupported, [101](#)
- PHDU
 - CCfits::PHDU, [133](#)
- RangeError
 - CCfits::Column::RangeError, [72](#)
- Table
 - CCfits::Table, [139](#)
- ValueType
 - CCfits, [43](#)
- WrongColumnType
 - CCfits::Column::WrongColumnType, [73](#)
- WrongExtensionType
 - CCfits::ExtHDU::WrongExtensionType, [84](#)
- addColumn
 - CCfits::AsciiTable, [47](#)
 - CCfits::BinTable, [50](#)
 - CCfits::ExtHDU, [78](#)
- addImage
 - CCfits::FITS, [92](#)
- addKey
 - CCfits::HDU, [115](#)
- addNullValue
 - CCfits::Column, [57](#)
- addTable
 - CCfits::FITS, [93](#)
- axis
 - CCfits::HDU, [115](#)
- bitpix
 - CCfits::HDU, [116](#)
- column
 - CCfits::ExtHDU, [78](#), [79](#)
 - CCfits::Table, [139](#), [140](#)
- copy

- CCfits::FITS, [93](#)
- copyAllKeys
 - CCfits::HDU, [116](#)
- copyColumn
 - CCfits::ExtHDU, [79](#)
 - CCfits::Table, [140](#)
- currentExtensionName
 - CCfits::FITS, [93](#)
- deleteColumn
 - CCfits::ExtHDU, [79](#)
 - CCfits::Table, [141](#)
- deleteExtension
 - CCfits::FITS, [93](#), [94](#)
- deleteKey
 - CCfits::HDU, [116](#)
- deleteRows
 - CCfits::Table, [141](#)
- destroy
 - CCfits::FITS, [94](#)
- dimen
 - CCfits::Column, [57](#)
- display
 - CCfits::Column, [57](#)
- extension
 - CCfits::FITS, [94](#)
- filter
 - CCfits::FITS, [94](#)
- flush
 - CCfits::FITS, [95](#)
- format
 - CCfits::Column, [57](#)
- getChecksum
 - CCfits::HDU, [116](#)
- getComments
 - CCfits::HDU, [116](#)
- getHistory
 - CCfits::HDU, [116](#)
- getNullValue
 - CCfits::Column, [57](#)
- getRowSize
 - CCfits::ExtHDU, [80](#)
 - CCfits::Table, [141](#)
- getTileDimensions
 - CCfits::FITS, [95](#)
- init
 - CCfits::Table, [142](#)
- initRead
 - CCfits::PHDU, [133](#)
- insertRows
 - CCfits::Table, [142](#)
- isCompressed
 - CCfits::ExtHDU, [80](#)
- keywordCategories
 - CCfits::HDU, [117](#)
- makeThisCurrent
 - CCfits::ExtHDU, [80](#)
 - CCfits::HDU, [117](#)
- message
 - CCfits::FitsException, [104](#)
- numCols
 - CCfits::ExtHDU, [80](#)
- operator<<
 - CCfits, [43](#)
- read
 - CCfits::Column, [58](#), [59](#)
 - CCfits::ExtHDU, [80](#), [81](#)
 - CCfits::FITS, [95](#), [96](#)
 - CCfits::PHDU, [134](#)
- readAllKeys
 - CCfits::HDU, [117](#)
- readArrays
 - CCfits::Column, [59](#), [60](#)
- readData
 - CCfits::AsciiTable, [47](#)
 - CCfits::BinTable, [51](#)
 - CCfits::Column, [60](#)
 - CCfits::ImageExt, [126](#)
 - CCfits::PHDU, [134](#)
- readHduName
 - CCfits::ExtHDU, [81](#)
- readKey
 - CCfits::HDU, [117](#)
- readKeys

- CCfits::HDU, [117](#)
- readNextKey
 - CCfits::HDU, [118](#)
- resetImageRead
 - CCfits::HDU, [118](#)
 - CCfits::ImageExt, [126](#)
- resetRead
 - CCfits::Column, [60](#)
- rows
 - CCfits::Column, [60](#)
 - CCfits::ExtHDU, [82](#)
- scale
 - CCfits::Column, [60](#)
 - CCfits::HDU, [118](#)
 - CCfits::ImageExt, [126](#)
 - CCfits::PHDU, [135](#)
- setCompressionType
 - CCfits::FITS, [96](#)
- setNoiseBits
 - CCfits::FITS, [97](#)
- setTileDimensions
 - CCfits::FITS, [97](#)
- setValue
 - CCfits::Keyword, [129](#)
- suppressScaling
 - CCfits::HDU, [119](#)
 - CCfits::ImageExt, [126](#)
- updateChecksum
 - CCfits::HDU, [119](#)
- updateRows
 - CCfits::Table, [142](#)
- value
 - CCfits::Keyword, [129](#)
- verboseMode
 - CCfits::FITS, [97](#)
- verifyChecksum
 - CCfits::HDU, [119](#)
- write
 - CCfits::Column, [61–64](#)
 - CCfits::ExtHDU, [82](#)
 - CCfits::Keyword, [130](#)
 - CCfits::PHDU, [135](#), [136](#)
- writeArrays
 - CCfits::Column, [65](#)
- writeChecksum
 - CCfits::HDU, [119](#)
- writeComment
 - CCfits::HDU, [120](#)
- writeHistory
 - CCfits::HDU, [120](#)
- xtension
 - CCfits::ExtHDU, [83](#)
- zero
 - CCfits::Column, [65](#)
 - CCfits::HDU, [120](#)
 - CCfits::ImageExt, [127](#)
 - CCfits::PHDU, [136](#)