

CCfits Reference Manual

1.7

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Contents

1	CCfits Documentation	1
2	CCfits User's Guide	4
3	CCfits Module Index	29
4	CCfits Namespace Index	29
5	CCfits Hierarchical Index	29
6	CCfits Class Index	31
7	CCfits Page Index	33
8	CCfits Module Documentation	34
9	CCfits Namespace Documentation	35
10	CCfits Class Documentation	36

1 CCfits Documentation

CCfits-1.7 requires `cfitsio` version 3.02 or later

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.

- [Installing the Package](#)
- [Getting Started](#)
- [Implementation Notes](#)
- [What's Present, What's Missing](#)

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

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 Visual-C++ 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.

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 CCfits User's Guide

2.1 User Guide Contents

Installing the Package	5
Implementation Notes	7
Xspec and CCfits	8
Getting Started	9
Writing The Primary Image	12
Creating and Writing to an Ascii Table Extension	14
Creating and Writing to a Binary Table Extension	17
Copying an Extension between Files	22
Selecting Table Data	23
Reading Header information from a HDU	24
Reading an Image	25
Reading a Table Extension	26
What's Present, What's Missing	27
Todo List	28

2.2 Installing the Package

2.2.1 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.

2.2.2 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.

2.2.2.1 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 2.0 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
```

2.2.2.2 Instructions for Microsoft Windows build: Compiling CCfits with MS VC++ requires VC++ 7.0 or later. This is the compiler that comes with Visual Studio.NET. Earlier versions of the compiler has too many defects in the area of instantiating templates.

Take the following steps.

1. Compile the C++ code. Open the vs.net/CCfits/CCfits.sln file with Visual Studio.NET. The includes paths have been set to find the cfitsio build directory at the same level as the CCfits directory. If this is not the case, use Visual Studio.NET to edit the include paths and extra library paths to where you have cfitsio installed.

Next, just use the build icon or the build menu item.

To build the test program, cookbook, use the vs.net/cookbook.cookbook.sln file

Author: Paul_Kunz@slac.stanford.edu Revised 1 Nov 2006 by Bryan Irby

2.3 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` 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.

2.4 Xspec and CCfits

This section is provided for background. Users of CCfits need not read it except to understand how the library was conceived and therefore what its strengths and weaknesses are likely to be in this initial release.

2.4.1 About XSPEC

XSPEC is a general-purpose, multi-mission X-Ray spectral data analysis program which fits data with theoretical models by convolving those models through the instrumental responses. In XSPEC 11.x and all prior versions that use FITS format data, each individual data file format that is supported can have up to 4 ancillary files. That is, for each data file, there can be a response, correction, background and auxiliary response (efficiency) file. Additionally there are table models that read FITS format data. All told, therefore, much duplicated procedural code for reading FITS data can be eliminated by use of the greater encapsulation provided by CCfits. XSPEC's primary need is to read FITS floating point Binary Tables. XSPEC also creates simulated data by convolving users' models with detector responses, so it also has a need for writing tabular data. Images are not used in XSPEC. We have provided a support for image operations which has undergone limited testing compared to the reading interface for table extensions.

2.4.2 New Data Formats

New formats to be read in XSPEC that are specialized for a particular satellite mission can be supported almost trivially by adding new classes that read data specified with different FITS format files. A single constructor call specifying the required columns and keys is all that is needed to read FITS files, rather than a set of individual cfitsio calls. The library is designed to encourage the "resource acquisition is initialization" model of resource management; CCfits will perform more efficiently if data are read on construction.

2.4.3 Modularity

Third, in an object oriented design, it is possible to make a program only loosely dependent on current implementation assumptions. In XSPEC, data are read as SF and FITS format (of three different varieties) and the user interface is written in tcl/tk. Both of these assumptions could be changed over the future life of the program. Thus the design of XSPEC, and any similar program, consists of defining an abstract DataSet class which has a subclass that uses FITS data. The virtual functions that support reading and writing can easily be overloaded by alternatives to FITS. Thus, the class library specified here fits in with the need for modularity in design.

2.5 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.

2.5.1 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 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 (!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:

`writeImage()` [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](#)

2.6 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.

    nelelements = 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> ranData(extElements);
const float PIBY (M_PI/150.);
for ( int jj = 0 ; jj < extElements ; ++jj)
{
    float arg = PIBY*jj;
    ranData[jj] = std::cos(arg);
}

long fpixel(1);

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

//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;
}

```

2.7 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,    0.69f};

    // 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 TNULLn 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;
}

```

2.8 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;
}

```

2.9 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;
}
```

2.10 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.

```
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;
}
```


2.11 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;
}
```

2.12 Reading an Image

Image reading calls are made very simple: the FITS object is created with the readDataFlag 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;
}

```

2.13 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;
}

```

2.14 What's Present, What's Missing

Functionality missing from the initial release falls into two categories: facilities that are designed to be supported but are incompletely implemented, and facilities for which there is no support at present. Functions not supported are, of course, accessible through standard calls to cfitsio. However, calls that modify the data that are not supported by the CCfits library will cause differences between the FITS file and the FITS object. Modifying the fits file using the CCfits interface after using cfitsio calls will likely lead to unexpected results.

In addition, it has not been possible to exercise the entire library before release, particularly because of the many functions implemented as member templates. These are created when an application is linked to the library using either g++ and SunPro CC. Much of the read interface for Table extensions, however, has been tested thoroughly during the development of XSPEC.

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) the user is ex-

pected to know the data type of the keyword value in this release. 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.

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. The extended file name syntax described in chapters 10 and 11 of the cfitsio manual is not yet supported as it internally creates in-memory objects. This will be supported in a future release.

2.15 Todo List

Member `CCfits::AsciiTable::AsciiTable(FITSBase *p, const String &hduName, int rows, const std::vector< String > &columns)`
 {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)`
 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

3 CCfits Module Index

3.1 CCfits Modules

Here is a list of all modules:

FITS Exceptions 34

4 CCfits Namespace Index

4.1 CCfits Namespace List

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

FITSUtil (**FITSUtil** is a namespace containing functions used internally by CCfits, but which might be of use for other applications) 35

5 CCfits Hierarchical Index

5.1 CCfits Class Hierarchy

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

CCfits::FITSUtil::auto_array_ptr< X >	40
CCfits::FITSUtil::CAarray< T >	46
CCfits::Column	47
CCfits::FITSUtil::CVAarray< T >	70
CCfits::FITSUtil::CVarray< T >	71
CCfits::FITS	83

CCfits::FitsException	102
CCfits::Column::InsufficientElements	61
CCfits::Column::InvalidDataType	62
CCfits::Column::InvalidNumberOfRows	64
CCfits::Column::InvalidRowNumber	65
CCfits::Column::InvalidRowParameter	66
CCfits::Column::NoNullValue	67
CCfits::Column::RangeError	68
CCfits::Column::WrongColumnType	69
CCfits::ExtHDU::WrongExtensionType	82
CCfits::FITS::CantCreate	97
CCfits::FITS::CantOpen	98
CCfits::FITS::NoSuchHDU	99
CCfits::FITS::OperationNotSupported	100
CCfits::FitsError	101
CCfits::FITSUtil::UnrecognizedType	137
CCfits::HDU::InvalidExtensionType	113
CCfits::HDU::InvalidImageDataType	114
CCfits::HDU::NoNullValue	115
CCfits::HDU::NoSuchKeyword	116
CCfits::Table::NoSuchColumn	135
CCfits::FitsFatal	104
CCfits::HDU	105
CCfits::ExtHDU	72
CCfits::Table	129

CCfits::AsciiTable	36
CCfits::BinTable	43
CCfits::PHDU	123
CCfits::Keyword	117
CCfits::FITSUtil::MatchName< T >	120
CCfits::FITSUtil::MatchNum< T >	121
CCfits::FITSUtil::MatchPtrName< T >	121
CCfits::FITSUtil::MatchPtrNum< T >	122
CCfits::FITSUtil::MatchType< T >	122

6 CCfits Class Index

6.1 CCfits Class List

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

CCfits::AsciiTable (Class Representing Ascii Table Extensions)	36
CCfits::FITSUtil::auto_array_ptr< X > (A class that mimics the std:: library auto_ptr class, but works with arrays)	40
CCfits::BinTable (Class Representing Binary Table Extensions. Contains columns with scalar or vector row entries)	43
CCfits::FITSUtil::CAarray< T > (Function object returning C array from a valarray. see CVarray for details)	46
CCfits::Column (Abstract base class for Column objects)	47
CCfits::Column::InsufficientElements (Exception thrown if the data supplied for a write operation is less than declared)	61
CCfits::Column::InvalidDataType (Exception thrown for invalid data type inputs)	62
CCfits::Column::InvalidNumberOfRows (Exception thrown if user enters a non-positive number for the number of rows to write)	64

CCfits::Column::InvalidRowNumber (Exception thrown on attempting to read a row number beyond the end of a table)	65
CCfits::Column::InvalidRowParameter (Exception thrown on incorrect row writing request)	66
CCfits::Column::NoNullValue (Exception thrown if a null value is specified without support from existing column header)	67
CCfits::Column::RangeError (Exception to be thrown for inputs that cause range errors in column read operations)	68
CCfits::Column::WrongColumnType (Exception thrown on attempting to access a scalar column as vector data)	69
CCfits::FITSUtil::CVAarray< T > (Function object returning C array from a vector of valarrays. see CVarray for details)	70
CCfits::FITSUtil::CVarray< T > (Function object class for returning C arrays from standard library objects used in the FITS library implementation)	71
CCfits::ExtHDU (Base class for all FITS extension HDUs, i.e. Image Extensions and Tables)	72
CCfits::ExtHDU::WrongExtensionType (Exception to be thrown on unmatched extension types)	82
CCfits::FITS (Memory object representation of a disk FITS file)	83
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)	99
CCfits::FITS::OperationNotSupported (Thrown for unsupported operations, such as attempted to select rows from an image extension)	100
CCfits::FitsError (FitsError is the exception thrown by non-zero cfitsio status codes)	101
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::HDU (Base class for all HDU [Header-Data Unit] objects)	105
CCfits::HDU::InvalidExtensionType (Exception to be thrown if user requests extension type that can not be understood as ImageExt , AsciiTable or BinTable)	113
CCfits::HDU::InvalidImageDataType (Exception to be thrown if user requests creation of an image of type not supported by cfitsio)	114
CCfits::HDU::NoNullValue (Exception to be thrown on seek errors for keywords)	115
CCfits::HDU::NoSuchKeyword (Exception to be thrown on seek errors for keywords)	116
CCfits::Keyword (Abstract base class implementing the common behavior of Keyword objects)	117
CCfits::FITSUtil::MatchName< T > (Predicate for classes that have a name attribute; match input string with instance name)	120
CCfits::FITSUtil::MatchNum< T > (Predicate for classes that have an index attribute; match input index with instance value)	121
CCfits::FITSUtil::MatchPtrName< T > (As for MatchName , only with the input class a pointer)	121
CCfits::FITSUtil::MatchPtrNum< T > (As for MatchNum , only with the input class a pointer)	122
CCfits::FITSUtil::MatchType< T > (Function object that returns the FITS ValueType corresponding to an input intrinsic type)	122
CCfits::PHDU (Class representing the primary HDU for a FITS file)	123
CCfits::Table	129
CCfits::Table::NoSuchColumn (Exception to be thrown on a failure to retrieve a column specified either by name or index number)	135
CCfits::FITSUtil::UnrecognizedType (Exception thrown by MatchType if it encounters data type incompatible with cfitsio)	137

7 CCfits Page Index

7.1 CCfits Related Pages

Here is a list of all related documentation pages:

Implementation Notes	7
Getting Started	9
Writing Primary Images and Image Extensions	12
Creating and Writing to an Ascii Table Extension	14
Creating and Writing to a Binary Table Extension	17
Copying an Extension between Files	22
Selecting Table Data	23
Reading Header information from a HDU	24
Reading an Image	25
Reading a Table Extension	26
Installing the Package	5
What's Present, What's Missing	27
Todo List	28

8 CCfits Module Documentation

8.1 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::NoSuchHDU](#)

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

- class [CCfits::FITS::CantOpen](#)
thrown on failure to open existing file
- class [CCfits::FITS::CantCreate](#)
thrown on failure to create new file
- class [CCfits::FITS::OperationNotSupported](#)
thrown for unsupported operations, such as attempted to select rows from an image extension.
- class [CCfits::FitsException](#)
[FitsException](#) is the base class for all exceptions thrown by this library.
- class [CCfits::FitsError](#)
[FitsError](#) is the exception thrown by non-zero cfitsio status codes.
- 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::NoSuchKeyword](#)
exception to be thrown on seek errors for keywords.
- class [CCfits::HDU::NotNullValue](#)
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.

9 CCfits Namespace Documentation

9.1 FITSUtil Namespace Reference

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

9.1.1 Detailed Description

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

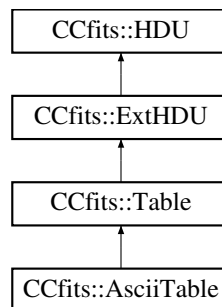
10 CCfits Class Documentation

10.1 CCfits::AsciiTable Class Reference

Class Representing Ascii [Table](#) Extensions.

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

Inheritance diagram for CCfits::AsciiTable::



Public Member Functions

- virtual [AsciiTable](#) * [clone](#) (FITSBase *p) const
- virtual void [readData](#) (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())
- virtual void [addColumn](#) (ValueType type, const String &columnName, long repeatWidth, const String &colUnit=String(""), long decimals=0, size_t columnNumber=0)

Protected Member Functions

- [AsciiTable](#) (FITSBase *p, const String &hduName=String(""), bool readFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)
- [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)
- [AsciiTable](#) (FITSBase *p, int number)
- [~AsciiTable](#) ()

10.1.1 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.

10.1.2 Constructor & Destructor Documentation

10.1.2.1 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:

p pointer to FITSBase object for internal use

hduName name of [AsciiTable](#) object to be read.

readFlag flag to determine whether to read data on construction

keys (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

version (optional) version number. If not specified, will read the first extension that matches hduName.

10.1.2.2 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 [AsciiTable](#) 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:

hduName name of [AsciiTable](#) object to be written

rows number of rows in the table (NAXIS2)

columnName array of column names for columns to be constructed.

columnFmt array of column formats for columns to be constructed.

columnUnit (optional) array of units for data in columns.

version (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}

10.1.2.3 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.

10.1.2.4 CCfits::AsciiTable::~~AsciiTable () [protected]

destructor.

10.1.3 Member Function Documentation**10.1.3.1 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:

type The data type of the column to be added

columnName The name of the column to be added

repeatWidth 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.

colUnit an optional field specifying the units of the data (TUNITn)

decimals optional parameter specifying the number of decimals for an ascii numeric column

columnNumber 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](#).

10.1.3.2 AsciiTable * CCfits::AsciiTable::clone (FITSBase * *p*) const [virtual]

virtual copy constructor

Implements [CCfits::ExtHDU](#).

10.1.3.3 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

10.2 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 ()
- [auto_array_ptr](#) (auto_array_ptr< X > &right) throw ()
- [~auto_array_ptr](#) ()
- void [operator=](#) (auto_array_ptr< X > &right)
- X & [operator*](#) () throw ()
- X & [operator\[\]](#) (size_t i) throw ()
- X [operator\[\]](#) (size_t i) const throw ()
- X * [get](#) () const
- X * [release](#) () throw ()
- X * [reset](#) (X *p) throw ()

Static Public Member Functions

- static void [remove](#) (X *&x)

10.2.1 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.

10.2.2 Constructor & Destructor Documentation

10.2.2.1 `template<typename X> CCfits::FITSUtil::auto_array_ptr< X >::auto_array_ptr (X * p = 0) throw () [explicit]`

constructor. allows creation of pointer to null, can be modified by [reset\(\)](#)

10.2.2.2 `template<typename X> CCfits::FITSUtil::auto_array_ptr< X >::auto_array_ptr (auto_array_ptr< X > & right) throw () [explicit]`

copy constructor

10.2.2.3 `template<typename X> CCfits::FITSUtil::auto_array_ptr< X >::~~auto_array_ptr ()`

destructor.

10.2.3 Member Function Documentation

10.2.3.1 `template<typename X> X * CCfits::FITSUtil::auto_array_ptr< X >::get () const`

return a token for the underlying content of *this

10.2.3.2 `template<typename X> X & CCfits::FITSUtil::auto_array_ptr< X >::operator * () throw ()`

deference operator

10.2.3.3 `template<typename X> void CCfits::FITSUtil::auto_array_ptr< X >::operator= (auto_array_ptr< X > & right)`

assignment operator: transfer of ownership semantics

10.2.3.4 `] template<typename X> X CCfits::FITSUtil::auto_array_ptr< X >::operator[] (size_t i) const throw ()`

return a copy of the *i*th element of the array

10.2.3.5 `] template<typename X> X & CCfits::FITSUtil::auto_array_ptr< X >::operator[] (size_t i) throw ()`

return a reference to the *i*th element of the array

10.2.3.6 `template<typename X> X * CCfits::FITSUtil::auto_array_ptr< X >::release () throw ()`

return underlying content of *this, transferring memory ownership

10.2.3.7 `template<typename X> void CCfits::FITSUtil::auto_array_ptr< X >::remove (X *&x) [static]`

utility function to delete the memory owned by x and set it to null.

10.2.3.8 `template<typename X> X * CCfits::FITSUtil::auto_array_ptr< X >::reset (X *p) throw ()`

change the content of the `auto_array_ptr` to p

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

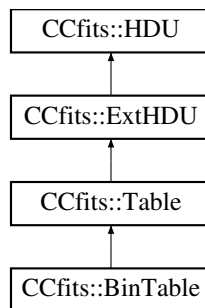
- FITSUtil.h

10.3 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 [BinTable](#) * `clone` (FITSBase *p) const
- virtual void `readData` (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())

- virtual void [addColumn](#) (ValueType type, const String &columnName, long repeatWidth, const String &colUnit=String(""), long decimals=0, size_t columnNumber=0)

Protected Member Functions

- [BinTable](#) (FITSBase *p, const String &hduName=String(""), bool readFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)
- [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)
- [BinTable](#) (FITSBase *p, int number)
- [~BinTable](#) ()

10.3.1 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.

10.3.2 Constructor & Destructor Documentation

10.3.2.1 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:

- p* Pointer to FITSBase class, an internal implementation detail
- hduName* name of [BinTable](#) object to be read.
- readFlag* flag to determine whether to read data on construction
- keys* (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
- version* (optional) version number. If not specified, will read the first extension that matches hduName.

10.3.2.2 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:

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

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

10.3.2.3 CCfits::BinTable::BinTable (FITSBase * *p*, int *number*) [protected]

read [BinTable](#) with [HDU](#) number number from existing file represented by fitsfile pointer p.

10.3.2.4 CCfits::BinTable::~~BinTable () [protected]

destructor.

10.3.3 Member Function Documentation

10.3.3.1 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:

type The data type of the column to be added

columnName The name of the column to be added

repeatWidth 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.

colUnit an optional field specifying the units of the data (TUNITn)

decimals optional parameter specifying the number of decimals for an ascii numeric column

columnNumber 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](#).

10.3.3.2 BinTable * CCfits::BinTable::clone (FITSBase * *p*) const [virtual]

virtual copy constructor

Implements [CCfits::ExtHDU](#).

10.3.3.3 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

10.4 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)

10.4.1 Detailed Description

template<typename T> class CCfits::FITSUtil::CAarray< T >

function object returning C array from a valarray. see [CVarray](#) for details

10.4.2 Member Function Documentation

10.4.2.1 template<typename T> T * [CCfits::FITSUtil::CAarray< T >::operator\(\)](#) (const std::valarray< T > &inArray)

operator returning C array for use with image data.

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

- FITSUtil.h

10.5 CCfits::Column Class Reference

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

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

Public Member Functions

- [Column](#) (const [Column](#) &right)
- virtual [~Column](#) ()
- virtual void [readData](#) (long firstRow, long nelements, long firstElem=1)=0
- int [rows](#) () const
- void [setDisplay](#) ()

- virtual void [setDimen](#) ()
- int [index](#) () const
- bool [isRead](#) () const
- long [width](#) () const
- size_t [repeat](#) () const
- bool [varLength](#) () const
- double [scale](#) () const
- double [zero](#) () const
- const String & [display](#) () const
- const String & [dimen](#) () const
- ValueType [type](#) () const
- const String & [format](#) () const
- const String & [unit](#) () const
- const String & [name](#) () const
- template<typename S> void [write](#) (const std::vector< S > &indata, long first-Row)
- template<typename S> void [write](#) (const std::valarray< S > &indata, long first-Row)
- template<typename S> void [write](#) (S *indata, long nRows, long firstRow)
- template<typename S> void [write](#) (const std::vector< S > &indata, long first-Row, S *nullValue)
- template<typename S> void [write](#) (const std::valarray< S > &indata, long first-Row, S *nullValue)
- template<typename S> void [write](#) (S *indata, long nRows, long firstRow, S *nullValue)
- template<typename S> void [write](#) (const std::valarray< S > &indata, long n-Rows, long firstRow)
- template<typename S> void [write](#) (const std::vector< S > &indata, long n-Rows, long firstRow)
- template<typename S> void [write](#) (S *indata, long nElements, long nRows, long firstRow)
- template<typename S> void [write](#) (const std::valarray< S > &indata, long n-Rows, long firstRow, S *nullValue)
- template<typename S> void [write](#) (const std::vector< S > &indata, long n-Rows, long firstRow, S *nullValue)
- template<typename S> void [write](#) (S *indata, long nElements, long nRows, long firstRow, S *nullValue)
- template<typename S> void [write](#) (const std::valarray< S > &indata, const std::vector< long > &vectorLengths, long firstRow)
- template<typename S> void [write](#) (const std::vector< S > &indata, const std::vector< long > &vectorLengths, long firstRow)
- template<typename S> void [write](#) (S *indata, long nElements, const std::vector< long > &vectorLengths, long firstRow)

- template<typename S> void [writeArrays](#) (const std::vector< std::valarray< S > > &indata, long firstRow)
- template<typename S> void [writeArrays](#) (const std::vector< std::valarray< S > > &indata, long firstRow, S *nullValue)
- template<typename S> void [read](#) (std::vector< S > &vals, long first, long last)
- template<typename S> void [read](#) (std::valarray< S > &vals, long first, long last)
- template<typename S> void [read](#) (std::valarray< S > &vals, long rows)
- template<typename S> void [readArrays](#) (std::vector< std::valarray< S > > &vals, long first, long last)
- template<typename S> void [read](#) (std::vector< S > &vals, long first, long last, S *nullValue)
- template<typename S> void [read](#) (std::valarray< S > &vals, long first, long last, S *nullValue)
- template<typename S> void [read](#) (std::valarray< S > &vals, long rows, S *nullValue)
- template<typename S> void [readArrays](#) (std::vector< std::valarray< S > > &vals, long first, long last, S *nullValue)
- template<typename T> void [addNullValue](#) (T nullVal)

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="")
- [Column](#) ([Table](#) *p=0)
- fitsfile * [fitsPointer](#) ()
- void [makeHDUCurrent](#) ()
- virtual std::ostream & [put](#) (std::ostream &s) const
- const String & [comment](#) () const

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.

10.5.1 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.

10.5.2 Constructor & Destructor Documentation

10.5.2.1 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.

10.5.2.2 CCfits::Column::~~Column () [virtual]

destructor.

10.5.2.3 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:

columnIndex The column number

columnName The column name, keyword TTYPE*n*

type used for determining class of T in ColumnData<T>, ColumnVectorData<T>

format the column data format, TFORM*n* keyword

unit the column data unit, TUNIT*n* keyword

p the Table pointer

rpt (optional) repeat count for the row (== 1 for AsciiTables)

w the row width

comment comment to be added to the header.

10.5.2.4 CCfits::Column::Column (Table * *p* = 0) [protected]

Simple constructor to be called by subclass reading ctors.

10.5.3 Member Function Documentation

10.5.3.1 template<typename T> void CCfits::Column::addNullValue (T *nullVal*)

Set the TNULL*n* keyword for the column.

Only relevant for integer valued columns, TNULLn 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 TNULLn. (For floating point columns a system NaN values is used).

10.5.3.2 `const String & CCfits::Column::comment () const [inline, protected]`

retrieve comment for [Column](#)

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

return TDIMn keyword

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

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

return TDISPn keyword

TDISPn is suggested format for output of column data.

10.5.3.5 `fitsfile * CCfits::Column::fitsPointer () [protected]`

fits pointer corresponding to fits file containing column data.

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

return TFORMn keyword

TFORMn specifies data format stored in disk file.

10.5.3.7 `int CCfits::Column::index () const [inline]`

get the [Column](#) index (the n in TTYPEn etc).

10.5.3.8 `bool CCfits::Column::isRead () const [inline]`

flag set to true if the entire column data has been read from disk

10.5.3.9 `void CCfits::Column::makeHDUCurrent () [protected]`

make [HDU](#) containing this the current [HDU](#) of the fits file.

10.5.3.10 `const String & CCfits::Column::name () const` [inline]

return name of [Column](#) (TTYPEn keyword)

10.5.3.11 `std::ostream & CCfits::Column::put (std::ostream & s) const`
[protected, virtual]

internal implementation of << operator.

10.5.3.12 `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

10.5.3.13 `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, setting undefined values.

If the column is of integer type, then any column value that equals this null value is set equal to the value of the TNULLn keyword. An exception is thrown if TNULLn is not specified. See cfitsio documentation for further details

Parameters:

vals The output container. The function will resize this as necessary

first,last the span of row numbers to read.

nullValue pointer to integer value regarded as undefined

10.5.3.14 `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, setting nullvalue.

If the column is of integer type, then any column value that equals this null value is set equal to the value of the TNULLn keyword. An exception is thrown if TNULLn is not specified. See cfitsio documentation for further details

Parameters:

vals The output container. The function will resize this as necessary

first,last the span of row numbers to read.

nullValue pointer to integer value regarded as undefined

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

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

Parameters:

- vals* The output valarray object
- rows* The row number to be retrieved (starting at 1).

10.5.3.16 `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:

- vals* The output container. The function will resize this as necessary
- first, last* the span of row numbers to read.

10.5.3.17 `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:

- vals* The output container. The function will resize this as necessary
- first, last* the span of row numbers to read.

10.5.3.18 `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:

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

10.5.3.19 `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:

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

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

read method.

Parameters:

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

10.5.3.21 `size_t CCfits::Column::repeat () const [inline]`

get the repeat count for the rows

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

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

10.5.3.23 `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.

10.5.3.24 `void CCfits::Column::setDimen () [inline, virtual]`

set the TDIMn keyword.

10.5.3.25 `void CCfits::Column::setDisplay ()`

set the TDISPn keyword

10.5.3.26 `ValueType CCfits::Column::type () const` [inline]

returns the data type of the column

10.5.3.27 `const String & CCfits::Column::unit () const` [inline]

get units of data in [Column](#) (TUNITn keyword)

10.5.3.28 `bool CCfits::Column::varLength () const` [inline]

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

10.5.3.29 `long CCfits::Column::width () const` [inline]

return column data width

10.5.3.30 `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 column with specified number of entries written per row.

10.5.3.31 `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.

10.5.3.32 `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 clearly designed for wrapping calls to multiple variable-width vector column rows, the code is written to write a variable number of elements to fixed-width column rows (cfitsio requires these operations to be done on a row-by-row basis).

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:

indata The data to be written

vectorLengths the number of elements to write to each successive row.

firstRow the first row to be written.

10.5.3.33 `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.

10.5.3.34 `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 valarray version for details.

10.5.3.35 `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.

10.5.3.36 `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:

indata The data to be written.

nElements The size of *indata*

nRows the number of rows to which to write the data.

firstRow The first row to be written

10.5.3.37 `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

see valarray version for details.

10.5.3.38 `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.

This and the equivalent vector version write a vector of values into *nRows*. 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:

indata The data to be written.

nRows the number of rows to which to write the data.

firstRow The first row to be written

10.5.3.39 `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:

indata The data to be written.

nRows The size of the data array to be written

firstRow The first row to be written

nullValue Pointer to the value in the input array to be set to undefined values

10.5.3.40 `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* with undefined values set to *nullValue*.

Parameters:

indata The data to be written.

firstRow The first row to be written

nullValue Pointer to the value in the input array to be set to undefined values

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

write a vector of values into a row starting with firstRow with undefined values set to nullValue.

Parameters:

indata The data to be written.

firstRow The first row to be written

nullValue Pointer to the value in the input array to be set to undefined values

10.5.3.42 `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:

indata The data to be written.

nRows The size of the data array to be written

firstRow The first row to be written

10.5.3.43 `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:

indata The data to be written.

firstRow The first row to be written

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

write a vector of values into a row starting with firstRow

Parameters:

indata The data to be written.

firstRow The first row to be written

10.5.3.45 `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

10.5.3.46 `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

10.5.3.47 `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:

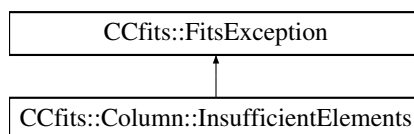
- Column.h
- Column.cxx
- ColumnT.h

10.6 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)

10.6.1 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.

10.6.2 Constructor & Destructor Documentation

10.6.2.1 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:

- msg* A specific diagnostic message, usually the column name
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

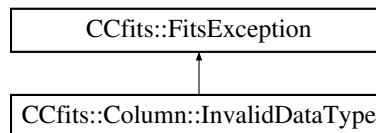
- Column.h
- Column.cxx

10.7 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)

10.7.1 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).

10.7.2 Constructor & Destructor Documentation

10.7.2.1 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:

- str* A specific diagnostic message
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

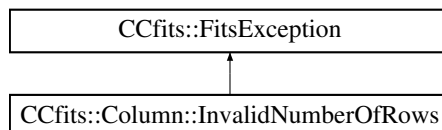
- Column.h
- Column.cxx

10.8 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](#) (size_t number, bool silent=true)

10.8.1 Detailed Description

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

10.8.2 Constructor & Destructor Documentation

10.8.2.1 CCfits::Column::InvalidNumberOfRows::InvalidNumberOfRows (size_t *number*, bool *silent* = true)

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

Parameters:

- number* The number of rows entered.
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

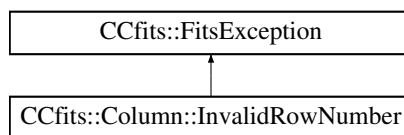
- Column.h
- Column.cxx

10.9 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)

10.9.1 Detailed Description

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

10.9.2 Constructor & Destructor Documentation

10.9.2.1 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:

- diag* A specific diagnostic message, usually the column name.
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

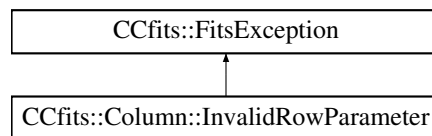
- Column.h
- Column.cxx

10.10 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)

10.10.1 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.

10.10.2 Constructor & Destructor Documentation

10.10.2.1 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:

- diag* A specific diagnostic message, usually the column name
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

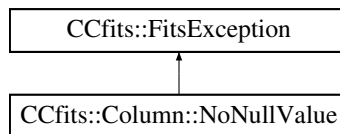
- Column.h
- Column.cxx

10.11 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)

10.11.1 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).

10.11.2 Constructor & Destructor Documentation

10.11.2.1 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:

- diag* A specific diagnostic message
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

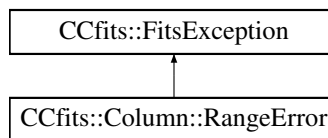
- Column.h
- Column.cxx

10.12 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)

10.12.1 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.

10.12.2 Constructor & Destructor Documentation

10.12.2.1 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:

- msg* A specific diagnostic message
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

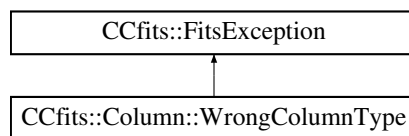
- Column.h
- Column.cxx

10.13 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)

10.13.1 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.

10.13.2 Constructor & Destructor Documentation

10.13.2.1 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:

- diag* A specific diagnostic message, usually the column name.
- silent* 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

10.14 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)

10.14.1 Detailed Description

```
template<typename T> class CCfits::FITSUtil::CVAarray< T >
```

function object returning C array from a vector of valarrays. see [CVarray](#) for details

10.14.2 Member Function Documentation

10.14.2.1 `template<typename T> T * CCfits::FITSUtil::CVAarray< T >::operator() (const std::vector< std::valarray< T > > &inArray)`

operator returning C array for use with vector column data.

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

- FITSUtil.h

10.15 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)`

10.15.1 Detailed Description

template<typename T> class CCfits::FITSUtil::CVarray< 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 [CVarray](#), [CAarray](#), and [CVAarray](#).

An alternative function, `CharArray`, is provided to deal with the special case of vector string arrays.

10.15.2 Member Function Documentation

10.15.2.1 template<typename T> T * [CCfits::FITSUtil::CVarray< T >::operator\(\)](#) (const std::vector< T > &inArray) [inline]

operator returning C array for use with scalar column data.

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

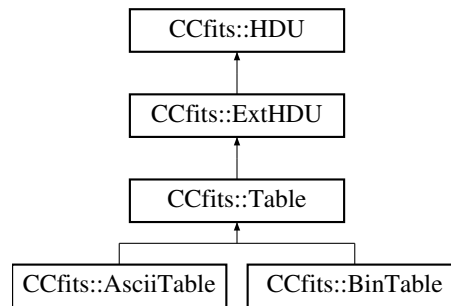
- `FITSUtil.h`

10.16 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`:



Public Member Functions

- [ExtHDU](#) (const [ExtHDU](#) &right)
- virtual [~ExtHDU](#) ()
- virtual void [readData](#) (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())=0
- const String & [name](#) () const
- virtual [HDU](#) * [clone](#) (FITSBase *p) const =0
- virtual void [makeThisCurrent](#) () const
- virtual [Column](#) & [column](#) (const String &colName) const
- virtual [Column](#) & [column](#) (int colIndex) const
- virtual long [rows](#) () const
- virtual void [addColumn](#) (ValueType type, const String &columnName, long repeatWidth, const String &colUnit=String(""), long decimals=-1, size_t columnNumber=0)
- virtual void [deleteColumn](#) (const String &columnName)
- int [version](#) () const
- void [version](#) (int value)
- template<typename S> void [write](#) (const std::vector< long > &first, long nElements, const std::valarray< S > &data, S *nullValue)
- template<typename S> void [write](#) (long first, long nElements, const std::valarray< S > &data, S *nullValue)
- template<typename S> void [write](#) (const std::vector< long > &first, long nElements, const std::valarray< S > &data)
- template<typename S> void [write](#) (long first, long nElements, const std::valarray< S > &data)
- template<typename S> void [write](#) (const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::valarray< S > &data)
- template<typename S> void [read](#) (std::valarray< S > &image)
- template<typename S> void [read](#) (std::valarray< S > &image, long first, long nElements, S *nullValue)

- template<typename S> void [read](#) (std::valarray< S > &image, const std::vector< long > &first, long nElements, S *nullValue)
- template<typename S> void [read](#) (std::valarray< S > &image, const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::vector< long > &stride)
- template<typename S> void [read](#) (std::valarray< S > &image, long first, long nElements)
- template<typename S> void [read](#) (std::valarray< S > &image, const std::vector< long > &first, long nElements)
- 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)

Static Public Member Functions

- static void [readHduName](#) (const fitsfile *fptr, int hduIndex, String &hduName, int &hduVersion)

Protected Member Functions

- [ExtHDU](#) (FITSBase *p, HduType xtype, const String &hduName, int version)
- [ExtHDU](#) (FITSBase *p, HduType xtype, const String &hduName, int bitpix, int naxis, const std::vector< long > &axes, int version)
- [ExtHDU](#) (FITSBase *p, HduType xtype, int number)
- long [pcount](#) () const
- void [pcount](#) (long value)
- long [gcount](#) () const
- void [gcount](#) (long value)
- HduType [xtension](#) () const
- void [xtension](#) (HduType value)

Classes

- class [WrongExtensionType](#)

Exception to be thrown on unmatched extension types.

10.16.1 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

10.16.2 Constructor & Destructor Documentation

10.16.2.1 CCfits::ExtHDU::ExtHDU (const [ExtHDU](#) & *right*)

copy constructor

10.16.2.2 CCfits::ExtHDU::~~ExtHDU () [virtual]

destructor

10.16.2.3 CCfits::ExtHDU::ExtHDU (FITSBase * *p*, HduType *xtype*, const String & *hduName*, int *version*) [protected]

default constructor, required as Standard Library Container content.

10.16.2.4 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.

10.16.2.5 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.

10.16.3 Member Function Documentation

10.16.3.1 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:

- type** The data type of the column to be added
- columnName** The name of the column to be added
- repeatWidth** 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.
- colUnit** an optional field specifying the units of the data (TUNITn)
- decimals** optional parameter specifying the number of decimals for an ascii numeric column
- columnNumber** 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](#).

10.16.3.2 ExtHDU * CCfits::ExtHDU::clone (FITSBase * p) const [pure virtual]

virtual copy constructor

Implements [CCfits::HDU](#).

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

10.16.3.3 Column & CCfits::ExtHDU::column (int colIndex) 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](#).

10.16.3.4 Column & CCfits::ExtHDU::column (const String & colName) const [virtual]

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

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](#).

10.16.3.5 `void CCfits::ExtHDU::deleteColumn (const String & columnName)`
[virtual]

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

Parameters:

columnName The name of the column to be deleted.

Exceptions:

WrongExtensionType if extension is an image.

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

10.16.3.6 `void CCfits::ExtHDU::gcount (long value)` [inline, protected]

set required gcount keyword value

10.16.3.7 `long CCfits::ExtHDU::gcount () const` [inline, protected]

return required gcount keyword value

10.16.3.8 `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](#).

10.16.3.9 `const String & CCfits::ExtHDU::name () const` [inline]

return the name of the extension.

10.16.3.10 `void CCfits::ExtHDU::pcount (long value)` [inline, protected]

set required pcount keyword value

10.16.3.11 `long CCfits::ExtHDU::pcount () const` [inline, protected]

return required pcount keyword value

10.16.3.12 `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.

10.16.3.13 `template<typename S> void CCfits::ExtHDU::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

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

read an image section starting at a specified pixel

10.16.3.15 `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)`

read an image subset

10.16.3.16 `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:

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

10.16.3.17 `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:

image The receiving container, a std::valarray reference

first The first pixel from the array to read [a long value]

nElements The number of values to read

nullValue A pointer containing the value in the table to be considered as undefined. See cfitsio for details

10.16.3.18 `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.

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

read data from [HDU](#) depending on readFlag and keys.

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

10.16.3.20 `static void CCfits::ExtHDU::readHduName (const fitsfile * fp, 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.

10.16.3.21 `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](#).

10.16.3.22 void CCfits::ExtHDU::version (int *value*) [inline]

set the extension version number

10.16.3.23 int CCfits::ExtHDU::version () const [inline]

return the extension version number.

10.16.3.24 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 <= 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:

firstVertex the coordinates specifying lower and upper vertices of the n-dimensional slice

lastVertex

data The data to be written

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

write array starting from specified pixel number, without undefined data processing

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

write array starting from specified n-tuple, without undefined data processing

10.16.3.27 `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.

10.16.3.28 `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:

first an n-tuple of dimension equal to the image dimension specifying the first pixel in the range to be written

nElements number of pixels to be written

data array of data to be written

nullValue pointer to null value (data with this value written as undefined; needs the BLANK keyword to have been specified).

10.16.3.29 `void CCfits::ExtHDU::xtension (HduType value) [inline, protected]`

set the extension type

10.16.3.30 `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:

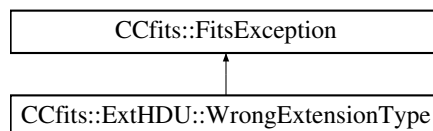
- ExtHDU.h
- ExtHDU.cxx
- ExtHDUT.h

10.17 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)

10.17.1 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.

10.17.2 Constructor & Destructor Documentation

10.17.2.1 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:

msg A specific diagnostic message

silent 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

10.18 CCfits::FITS Class Reference

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

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

Public Member Functions

- [FITS](#) (const String &name, RWmode mode=Read, bool readDataFlag=false, const std::vector< String > &primaryKeys=std::vector< String >())
- [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)
- [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)
- [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](#) (const String &name, int bitpix, int naxis, long *naxes)
- [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 >())
- [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)
- [~FITS](#) ()
- void [deleteExtension](#) (const String &doomed, int version=1)
- void [read](#) (const String &hduName, bool readDataFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)
- void [read](#) (const std::vector< String > &hduNames, bool readDataFlag=false)
- 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 >())
- [FITS * clone](#) () const
- const [ExtHDU](#) & [extension](#) (int i) const
- [ExtHDU](#) & [extension](#) (int i)
- const [ExtHDU](#) & [extension](#) (const String &hduName, int version=1) const
- const [PHDU](#) & [pHDU](#) () const

- [PHDU](#) & [pHDU](#) ()
- [ExtHDU](#) & [extension](#) (const String &hduName, int version=1)
- void [read](#) (int hduIndex, bool readDataFlag=false, const std::vector< String > &keys=std::vector< String >())
- [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)
- [ExtHDU](#) * [addImage](#) (const String &hduName, int bpix, std::vector< long > &naxes, int version=1)
- void [destroy](#) () throw ()
- void [flush](#) ()
- const String & [currentExtensionName](#) () const
- 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)
- const ExtMap & [extension](#) () const
- void [resetPosition](#) ()
- const String & [name](#) () const
- void [copy](#) (const [HDU](#) &source)
- [Table](#) & [filter](#) (const String &expression, [ExtHDU](#) &inputTable, bool overwrite=true, bool readData=false)
- [ExtHDU](#) & [currentExtension](#) ()
- void [deleteExtension](#) (int doomed)
- void [setCompressionType](#) (int compType)
- void [setTileDimensions](#) (const std::vector< long > &tileSizes)
- void [setNoiseBits](#) (int noiseBits)
- int [getCompressionType](#) () const
- void [getTileDimensions](#) (std::vector< long > &tileSizes) const
- int [getNoiseBits](#) () const

Static Public Member Functions

- static void [clearErrors](#) ()
- static bool [verboseMode](#) ()
- static void [setVerboseMode](#) (bool value)

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.

10.18.1 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.

10.18.2 Constructor & Destructor Documentation

10.18.2.1 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 filename string is passed directly to the cfitsio library: thus all of the extended filename syntax described in the cfitsio manual should work as documented.

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.

The file name is the only required argument. If the mode is Write and the file does not already exist, a default primary [HDU](#) will be created in the file with BITPIX=8 and NAXIS=0: this mode is designed for writing [FITS](#) files with table extensions only. For

files with image data the constructor that specified the data type and number of axes should be called.

Parameters:

- name* The name of the [FITS](#) file to be read/written
- mode* The read/write mode: must be Read or Write
- readDataFlag* boolean: read data on construction if true
- primaryKeys* 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 [Fits-Exception](#) error to produce more illuminating message.

10.18.2.2 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.

Parameters:

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

10.18.2.3 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.

Parameters:

hduNames array of [HDU](#) names to be read. see above for other parameter definitions.

10.18.2.4 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

Parameters:

fileName New file to be created.

source A previously created [FITS](#) object to be copied.

see above for other parameter definitions.

10.18.2.5 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:

hduVersions an optional version number for each [HDU](#) to be read

hduKeys an array of keywords for each [HDU](#) to be read. see above for other parameter definitions.

10.18.2.6 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::p-HDU\(\).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](#).

Valid values of `bitpix` are given in the `fitsio.h` header. 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:

- name*** The file to be written to disk
- bitpix*** the datatype of the primary image (see `cfitsio` documentation for allowed values.
- naxis*** the data dimension of the primary image
- naxes*** the array of axis lengths for the primary image. Ignored if `naxis=0`, 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:

10.18.2.7 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.

Parameters:

- hduIndex*** The index of the [HDU](#) to be read. see above for other parameter definitions.

10.18.2.8 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:

- name** The name of the [FITS](#) file to be read
- mode** The read/write mode: must be Read or Write
- searchKeys** A string vector of keywords to search for in each header
- searchValues** 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.
- readDataFlag** boolean: if true, read data if [HDU](#) is found
- hduKeys** Allows optional reading of keys in the [HDU](#) that is searched for if it is successfully found
- primaryKey** Allows optional reading of primary header keys on construction
- version** Optional version number. If specified, checks the EXTVERS keyword.

Exceptions:

- [FitsError](#) thrown on non-zero status code from cfitsio when not overridden by [Fits-Exception](#) error to produce more illuminating message.

10.18.2.9 CCfits::FITS::~~FITS ()

destructor

10.18.3 Member Function Documentation**10.18.3.1 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 second call.

Todo

Add a function for replacing the primary image

10.18.3.2 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:

- rows* The number of rows in the table to be created.
- columnName* A vector containing the table column names
- columnFmt* A vector containing the table column formats
- columnUnit* (Optional) a vector giving the units of the columns.
- type* 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).

10.18.3.3 static void CCfits::FITS::clearErrors () [static]

clear the error stack and set status to zero.

10.18.3.4 [FITS](#) * CCfits::FITS::clone () const

clone function: to allow implementation later of reference counting.

10.18.3.5 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.

10.18.3.6 CCfits::FITS::currentExtension ()

return a non-const reference to whichever is the current extension.

10.18.3.7 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).

10.18.3.8 void CCfits::FITS::deleteExtension (int *doomed*)

Delete extension specified by extension number.

This is an overloaded member function, provided for convenience. It differs from the above function only in what argument(s) it accepts.

10.18.3.9 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.

Parameters:

doomed the name of the extension to be deleted

version 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.

10.18.3.10 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.

10.18.3.11 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.

10.18.3.12 ExtHDU & CCfits::FITS::extension (const String & *hduName*, int *version* = 1) [inline]

return [FITS](#) extension by name and (optionally) version number.

10.18.3.13 `const ExtHDU & CCfits::FITS::extension (const String & hduName, int version = 1) const`

return [FITS](#) extension by name and (optionally) version number.

10.18.3.14 `FITS::ExtHDU & CCfits::FITS::extension (int i)`

return [FITS](#) extension by index number. non-const version. see const version for details.

10.18.3.15 `const FITS::ExtHDU & CCfits::FITS::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.

10.18.3.16 `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.

10.18.3.17 `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.

10.18.3.18 `int CCfits::FITS::getCompressionType () const`

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

10.18.3.19 int CCfits::FITS::getNoiseBits () const

Get the cfitsio noisebits parameter used when compressing floating-point images.

10.18.3.20 void CCfits::FITS::getTileDimensions (std::vector< long > & tileSizes) const

Get the current settings of dimension sizes for tiles used in image compression.

Parameters:

tileSizes A vector to be filled with cfitsio's current tile dimension settings. CCfits will resize this vector to contain the proper number of values.

10.18.3.21 const std::string & CCfits::FITS::name () const

return filename of file corresponding to [FITS](#) object

10.18.3.22 [PHDU](#) & CCfits::FITS::pHDU ()

return a reference to the primary [HDU](#).

10.18.3.23 const [PHDU](#) & CCfits::FITS::pHDU () const

return a const reference to the primary [HDU](#).

10.18.3.24 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:

searchKeys A string vector of keywords to search for in each header

searchValues 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.

readDataFlag boolean: if true, read data if [HDU](#) is found

hduKeys Allows optional reading of keys in the [HDU](#) that is searched for if it is successfully found

version Optional version number. If specified, checks the EXTVERS keyword.

10.18.3.25 `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.

10.18.3.26 `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.

10.18.3.27 `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.

10.18.3.28 `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.

10.18.3.29 `CCfits::FITS::resetPosition ()`

explicit call to set the fits file pointer to the primary.

10.18.3.30 `void CCfits::FITS::setCompressionType (int compType)`

set the compression algorithm to be used when adding image extensions to the [FITS](#) object.

Parameters:

compType 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.

10.18.3.31 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.

10.18.3.32 void CCfits::FITS::setTileDimensions (const std::vector< long > & *tileSizes*)

Set the dimensions of the tiles into which the image is divided during compression.

Parameters:

tileSizes A vector of length N containing the tile dimensions. 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.

10.18.3.33 void CCfits::FITS::setVerboseMode (bool *value*) [inline, static]

set verbose setting for library

10.18.3.34 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:

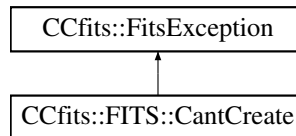
- FITS.h
- FITS.cxx

10.19 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)

10.19.1 Detailed Description

thrown on failure to create new file

10.19.2 Constructor & Destructor Documentation

10.19.2.1 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:

- msg* A specific diagnostic message, the name of the file that was to be created.
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

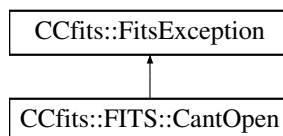
- FITS.h
- FITS.cxx

10.20 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)

10.20.1 Detailed Description

thrown on failure to open existing file

10.20.2 Constructor & Destructor Documentation

10.20.2.1 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:

- diag* A specific diagnostic message, the name of the file that was to be created.
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

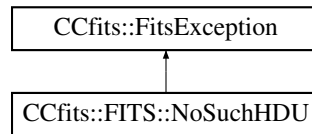
- FITS.h
- FITS.cxx

10.21 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)

10.21.1 Detailed Description

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

10.21.2 Constructor & Destructor Documentation

10.21.2.1 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:

diag A specific diagnostic message, usually the name of the extension whose read was attempted.

silent 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:

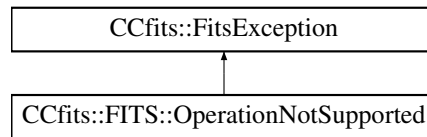
- FITS.h
- FITS.cxx

10.22 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)

10.22.1 Detailed Description

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

10.22.2 Constructor & Destructor Documentation

10.22.2.1 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:

msg A specific diagnostic message.

silent if true, print message whether [FITS::verboseMode](#) is set or not.

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

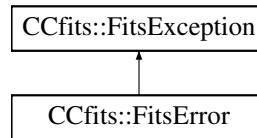
- FITS.h
- FITS.cxx

10.23 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)

10.23.1 Detailed Description

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

10.23.2 Constructor & Destructor Documentation

10.23.2.1 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:

- errornum* The cfitsio status code produced by the error.
- silent* A boolean controlling the printing of messages

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

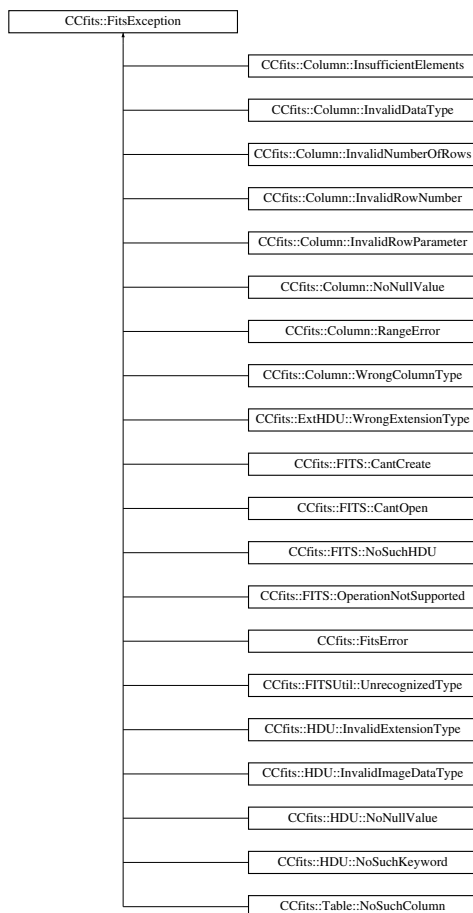
- FitsError.h
- FitsError.cxx

10.24 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)

10.24.1 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.

10.24.2 Constructor & Destructor Documentation

10.24.2.1 CCfits::FitsException::FitsException (const string & *diag*, bool & *silent*)

Parameters:

- diag* A diagnostic string to be printed optionally.
- silent* A boolean controlling the printing of messages

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

- FitsError.h
- FitsError.cxx

10.25 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)

10.25.1 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.

10.25.2 Constructor & Destructor Documentation

10.25.2.1 CCfits::FitsFatal::FitsFatal (const string & *diag*)

Prints a message starting "*** CCfits Fatal Error: ..." and calls *terminate()*.

Parameters:

diag A diagnostic string to be printed identifying the context of the error.

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

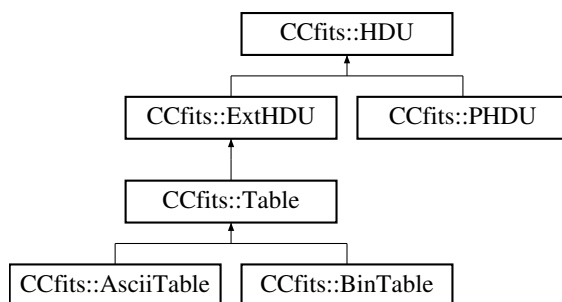
- FitsError.h
- FitsError.cxx

10.26 CCfits::HDU Class Reference

Base class for all [HDU](#) [Header-Data Unit] objects.

```
#include <HDU.h>
```

Inheritance diagram for CCfits::HDU::

**Public Member Functions**

- [HDU](#) (const [HDU](#) &right)
- bool [operator==](#) (const [HDU](#) &right) const
- bool [operator!=](#) (const [HDU](#) &right) const
- virtual [HDU](#) * [clone](#) (FITSBase *p) const =0
- fitsfile * [fitsPointer](#) () const
- virtual void [makeThisCurrent](#) () const
- std::map< String, [Keyword](#) * > [keyWord](#) ()
- [Keyword](#) & [keyWord](#) (const String &keyName)
- const String & [getHistory](#) ()
- const String & [getComments](#) ()
- void [writeHistory](#) (const String &history="Generic History String")
- void [writeComment](#) (const String &comment="Generic Comment")
- void [writeDate](#) ()
- FITSBase * [parent](#) () const

- void [readAllKeys](#) ()
- long [axes](#) () const
- long [axis](#) (size_t index) const
- void [index](#) (int value)
- void [deleteKey](#) (const String &doomed)
- long [bitpix](#) () const
- void [bitpix](#) (long value)
- int [index](#) () const
- const string & [history](#) () const
- const string & [comment](#) () const
- virtual double [zero](#) () const
- virtual double [scale](#) () const
- const std::map< string, [Keyword](#) * > & [keyWord](#) () const
- const [Keyword](#) & [keyWord](#) (const string &keyname) const
- void [setKeyWord](#) (const string &keyname, [Keyword](#) &value)
- template<typename T> [Keyword](#) & [addKey](#) (const String &name, T val, const String &comment)
- template<typename T> void [readKey](#) (const String &keyName, T &val)
- template<typename T> void [readKeys](#) (std::vector< String > &keyNames, std::vector< T > &vals)

Protected Member Functions

- [HDU](#) (FITSBase *p=0)
- [HDU](#) (FITSBase *p, int bitpix, int naxis, const std::vector< long > &axes)
- virtual [~HDU](#) ()
- std::vector< long > & [naxes](#) ()

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 [NoNullValue](#)
exception to be thrown on seek errors for keywords.
- class [NoSuchKeyword](#)
exception to be thrown on seek errors for keywords.

10.26.1 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].

10.26.2 Constructor & Destructor Documentation

10.26.2.1 CCfits::HDU::HDU (const [HDU](#) & *right*)

copy constructor

10.26.2.2 CCfits::HDU::HDU ([FITSBase](#) * *p* = 0) [protected]

default constructor, called by [HDU](#) subclasses that read from [FITS](#) files.

10.26.2.3 CCfits::HDU::HDU ([FITSBase](#) * *p*, int *bitpix*, int *naxis*, const [std::vector](#)< long > & *axes*) [protected]

constructor for creating new [HDU](#) objects, called by [HDU](#) subclasses writing to [FITS](#) files.

10.26.2.4 CCfits::HDU::~~HDU () [protected, virtual]

destructor

10.26.3 Member Function Documentation

10.26.3.1 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.

Parameters:

Parameters:

name (String) The keyword name
value (T = String, float, std::complex<float>, int, or bool
comment (String) the keyword value

Note the limitations on T, which arise for historical reasons (i.e. since keywords do not contain explicit type information, routines in CCfits must assign a type). The limitation may be removed in a future release

It is possible however to create a keyword of any of the allowed data types in fitsio (see the cfitsio manual section 4.3). The required calls are, e.g. for a floating point double valued keyword:

```
NewKeyword<double> keyCreate( hdu, double val1 ); Keyword* key1 = Key-
word keyCreate.MakeKeyword(keyName1, const String& comment); keyCreate.key-
Data(val2); Keyword* key2 = Keyword keyCreate.MakeKeyword(keyName2, const
String& comment);
```

```
key1->write(); key2->write();
```

... which is essentially what addKey does for its allowed types.

10.26.3.2 long CCfits::HDU::axes () const [inline]

return the number of axes in the HDU data section (always 2 for tables).

10.26.3.3 long CCfits::HDU::axis (size_t index) const [inline]

return the length of HDU data axis i.

10.26.3.4 void CCfits::HDU::bitpix (long value) [inline]

set the data type keyword

10.26.3.5 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.

10.26.3.6 HDU * CCfits::HDU::clone (FITSBase *p) const [pure virtual]

virtual copy constructor, to be implemented in subclasses.

Implemented in CCfits::AsciiTable, CCfits::BinTable, CCfits::ExtHDU, and CCfits::PHDU.

10.26.3.7 const string & CCfits::HDU::comment () const [inline]

return the comment string previously read by `getComment()`

10.26.3.8 void CCfits::HDU::deleteKey (const String & *doomed*)

delete a keyword from the header

removes *doomed* from the [FITS](#) file and from the [FITS](#) object

10.26.3.9 fitsfile * CCfits::HDU::fitsPointer () const

return the fitsfile pointer for the [FITS](#) object containing the [HDU](#)

10.26.3.10 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

10.26.3.11 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

10.26.3.12 const string & CCfits::HDU::history () const [inline]

return the history string previously read by `getHistory()`

10.26.3.13 int CCfits::HDU::index () const [inline]

return the [HDU](#) number

10.26.3.14 void CCfits::HDU::index (int *value*) [inline]

set the [HDU](#) number

10.26.3.15 const [Keyword](#) & CCfits::HDU::keyWord (const string & *keyname*) const [inline]

return a (previously read) keyword from the [HDU](#) object. const version

10.26.3.16 `const std::map< string, Keyword * > & CCfits::HDU::keyWord () const` [inline]

return the associative array containing the [HDU](#) Keywords that have been read so far.

10.26.3.17 `Keyword & CCfits::HDU::keyWord (const String & keyName)` [inline]

return a (previously read) keyword from the [HDU](#) object.

10.26.3.18 `std::map< String, Keyword * > CCfits::HDU::keyWord ()` [inline]

return the associative array containing the [HDU](#) keywords so far read.

10.26.3.19 `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](#).

10.26.3.20 `std::vector< long > & CCfits::HDU::naxes ()` [inline, protected]

return the [HDU](#) data axis array.

10.26.3.21 `bool CCfits::HDU::operator!= (const HDU & right) const`

inequality operator

10.26.3.22 `bool CCfits::HDU::operator== (const HDU & right) const`

equality operator

10.26.3.23 `const FITSBase *& CCfits::HDU::parent () const`

return reference to the pointer representing the FITSBase object containing the [HDU](#)

10.26.3.24 `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\(\)](#).

Note that `readAllKeys` can only construct keys of type string, float, `complex<float>`, integer, and bool because the [FITS](#) header records do not encode exact type information.

10.26.3.25 `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, float, int, `std::complex<float>`, and bool.

10.26.3.26 `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, float, int, `std::complex<float>`, and bool.

10.26.3.27 `double CCfits::HDU::scale () const [inline, virtual]`

return the BSCALE keyword value

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

10.26.3.28 `void CCfits::HDU::setKeyWord (const string & keyname, Keyword & value) [inline]`

set [Keyword](#) keyname to specified value

10.26.3.29 `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.

10.26.3.30 `void CCfits::HDU::writeDate ()`

write a date string to `*this`.

10.26.3.31 `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.

10.26.3.32 `double CCfits::HDU::zero () const [inline, virtual]`

return the BZERO keyword value

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

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

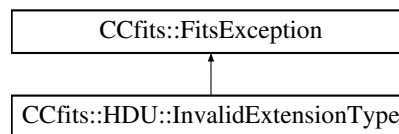
- HDU.h
- HDU.cxx

10.27 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)

10.27.1 Detailed Description

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

10.27.2 Constructor & Destructor Documentation

10.27.2.1 CCfits::HDU::InvalidExtensionType::InvalidExtensionType (const string & *diag*, bool *silent* = true)

Exception ctor, prefixes the string "Fits Error: Extension Type: " before the specific message.

Parameters:

- diag* A specific diagnostic message
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

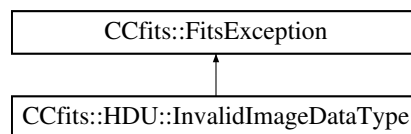
- HDU.h
- HDU.cxx

10.28 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)

10.28.1 Detailed Description

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

10.28.2 Constructor & Destructor Documentation

10.28.2.1 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:

diag A specific diagnostic message

silent 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

10.29 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)

10.29.1 Detailed Description

exception to be thrown on seek errors for keywords.

10.29.2 Constructor & Destructor Documentation

10.29.2.1 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:

- diag* A specific diagnostic message, the name of the [HDU](#) if not the primary.
- silent* if true, print message whether [FITS::verboseMode](#) is set or not.

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

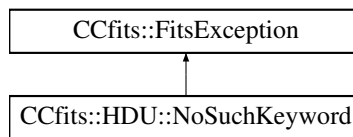
- HDU.h
- HDU.cxx

10.30 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)

10.30.1 Detailed Description

exception to be thrown on seek errors for keywords.

10.30.2 Constructor & Destructor Documentation

10.30.2.1 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:

- diag* A specific diagnostic message, usually the name of the keyword requested.
- silent* 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

10.31 CCfits::Keyword Class Reference

Abstract base class implementing the common behavior of `Keyword` objects.

```
#include <Keyword.h>
```

Public Member Functions

- `Keyword` (const `Keyword` &right)
- `Keyword` (const String &keyname, ValueType keytype, `HDU` *p, const String &comment="")
- virtual `~Keyword` ()
- `Keyword` & `operator=` (const `Keyword` &right)
- bool `operator==` (const `Keyword` &right) const
- bool `operator!=` (const `Keyword` &right) const
- virtual `Keyword` * `clone` () const =0
- virtual void `write` ()=0
- fitsfile * `fitsPointer` () const
- const String & `comment` () const
- const String & `name` () const

Protected Member Functions

- ValueType `keytype` () const
- void `keytype` (ValueType value)
- const `HDU` * `parent` () const

10.31.1 Detailed Description

Abstract base class implementing the common behavior of `Keyword` objects.

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.

10.31.2 Constructor & Destructor Documentation

10.31.2.1 CCfits::Keyword::Keyword (const [Keyword](#) & *right*)

copy constructor

10.31.2.2 CCfits::Keyword::Keyword (const String & *keyname*, ValueType *keytype*, [HDU](#) * *p*, const String & *comment* = " ")

[Keyword](#) constructor.

This is the common behavior of Keywords of any type. Constructor is protected as the class is abstract.

10.31.2.3 CCfits::Keyword::~~Keyword () [virtual]

virtual destructor

10.31.3 Member Function Documentation

10.31.3.1 [Keyword](#) * CCfits::Keyword::clone () const [pure virtual]

virtual copy constructor

10.31.3.2 const String & CCfits::Keyword::comment () const [inline]

return the comment field of the keyword

10.31.3.3 fitsfile * CCfits::Keyword::fitsPointer () const

return a pointer to the [FITS](#) file containing the parent [HDU](#).

10.31.3.4 void CCfits::Keyword::keytype (ValueType *value*) [inline, protected]

set keyword type.

10.31.3.5 ValueType CCfits::Keyword::keytype () const [inline, protected]

return the type of a keyword

10.31.3.6 `const String & CCfits::Keyword::name () const` `[inline]`

return the name of a keyword

10.31.3.7 `bool CCfits::Keyword::operator!= (const Keyword & right) const`

inequality operator

10.31.3.8 `Keyword & CCfits::Keyword::operator= (const Keyword & right)`

assignment operator

10.31.3.9 `bool CCfits::Keyword::operator== (const Keyword & right) const`

equality operator

10.31.3.10 `const HDU * CCfits::Keyword::parent () const` `[inline, protected]`

return a pointer to parent [HDU](#).

10.31.3.11 `void CCfits::Keyword::write ()` `[pure virtual]`

write operation

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

- [Keyword.h](#)
- [Keyword.cxx](#)
- [KeywordT.h](#)

10.32 CCfits::FITSUtil::MatchName< T > Class Template Reference

predicate for classes that have a name attribute; match input string with instance name.

`#include <FITSUtil.h>`

10.32.1 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

10.33 CCfits::FITSUtil::MatchNum< T > Class Template Reference

predicate for classes that have an index attribute; match input index with instance value.

```
#include <FITSUtil.h>
```

10.33.1 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

10.34 CCfits::FITSUtil::MatchPtrName< T > Class Template Reference

as for [MatchName](#), only with the input class a pointer.

```
#include <FITSUtil.h>
```

10.34.1 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

10.35 CCfits::FITSUtil::MatchPtrNum< T > Class Template Reference

as for [MatchNum](#), only with the input class a pointer.

```
#include <FITSUtil.h>
```

10.35.1 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

10.36 CCfits::FITSUtil::MatchType< T > Class Template Reference

function object that returns the [FITS](#) ValueType corresponding to an input intrinsic type

```
#include <FITSUtil.h>
```

10.36.1 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:

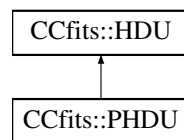
- FITSUtil.h

10.37 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` ()
- virtual `PHDU * clone` (FITSBase *p) const =0
- virtual void `zero` (double value)
- virtual double `zero` () const
- virtual double `scale` () const
- template<typename S> void `write` (const std::vector< long > &first, long nElements, const std::valarray< S > &data, S *nullValue)
- template<typename S> void `write` (long first, long nElements, const std::valarray< S > &data, S *nullValue)
- template<typename S> void `write` (const std::vector< long > &first, long nElements, const std::valarray< S > &data)
- template<typename S> void `write` (long first, long nElements, const std::valarray< S > &data)
- 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)
- template<typename S> void `read` (std::valarray< S > &image, long first, long nElements)

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

Protected Member Functions

- `PHDU (const PHDU &right)`
- `PHDU (FITSBase *p, int bpix, int naxis, const std::vector< long > &axes)`
- `PHDU (FITSBase *p=0)`
- `virtual void initRead ()`

10.37.1 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

10.37.2 Constructor & Destructor Documentation

10.37.2.1 CCfits::PHDU::~~PHDU () [virtual]

destructor

Destructor

10.37.2.2 CCfits::PHDU::PHDU (const PHDU & right) [protected]

copy constructor

required for cloning primary HDUs when copying FITS files.

10.37.2.3 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

10.37.2.4 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>.

10.37.3 Member Function Documentation**10.37.3.1 virtual PHDU* CCfits::PHDU::clone (FITSBase * p) const [pure virtual]**

virtual copy constructor, to be implemented in subclasses.

Implements CCfits::HDU.

10.37.3.2 void CCfits::PHDU::initRead () [protected, virtual]

Implements CCfits::HDU.

10.37.3.3 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.

10.37.3.4 `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)`

read an image subset

10.37.3.5 `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:

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

10.37.3.6 `template<typename S> void CCfits::PHDU::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

10.37.3.7 `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:

image The receiving container, a std::valarray reference

first The first pixel from the array to read [a long value]

nElements The number of values to read

nullValue A pointer containing the value in the table to be considered as undefined. See cfitsio for details

10.37.3.8 `template<typename S> void CCfits::PHDU::read (std::valarray< S > & image, long first, long nElements)`

read an image section starting at a specified pixel

10.37.3.9 double CCfits::PHDU::scale () const [virtual]

return the BSCALE keyword value

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

10.37.3.10 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 <= 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:

firstVertex The coordinates specifying lower and upper vertices of the n-dimensional slice

lastVertex

stride 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.

data The data to be written

10.37.3.11 template<typename S> void CCfits::PHDU::write (long *first*, long *nElements*, const std::valarray< S > & *data*)

write array starting from specified pixel number, without undefined data processing

10.37.3.12 template<typename S> void CCfits::PHDU::write (const std::vector< long > & *first*, long *nElements*, const std::valarray< S > & *data*)

write array starting from specified n-tuple, without undefined data processing

10.37.3.13 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.

10.37.3.14 `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:

first an n-tuple of dimension equal to the image dimension specifying the first pixel in the range to be written

nElements number of pixels to be written

data array of data to be written

nullValue pointer to null value (data with this value written as undefined; needs the BLANK keyword to have been specified).

10.37.3.15 `double CCfits::PHDU::zero () const [virtual]`

return the BZERO keyword value

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

10.37.3.16 `void CCfits::PHDU::zero (double value) [virtual]`

Set the BZERO keyword value.

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

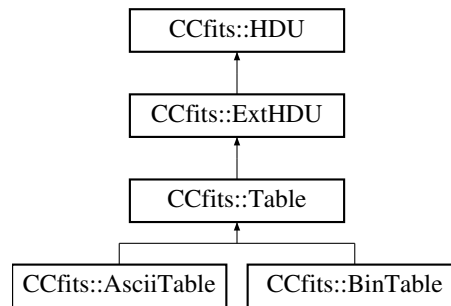
The documentation for this class was generated from the following files:

- PHDU.h
- PHDU.cxx
- PHDUT.h

10.38 CCfits::Table Class Reference

```
#include <Table.h>
```

Inheritance diagram for CCfits::Table::



Public Member Functions

- [Table](#) (const [Table](#) &right)
- virtual [~Table](#) ()
- const std::map< String, [Column](#) * > & [column](#) () const
- virtual [Column](#) & [column](#) (const String &colName) const
- virtual [Column](#) & [column](#) (int colIndex) const
- virtual long [rows](#) () const
- void [updateRows](#) ()
- void [rows](#) (long numRows)
- virtual void [deleteColumn](#) (const String &columnName)
- void [insertRows](#) (long first, long number=1)
- void [deleteRows](#) (long first, long number=1)
- void [deleteRows](#) (const std::vector< long > &rowList)
- virtual std::map< string, [Column](#) * > & [column](#) ()

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)
- [Table](#) (FITSBase *p, HduType xtype, const String &hduName=String(""), int version=1)
- [Table](#) (FITSBase *p, HduType xtype, int number)
- void [init](#) (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())
- virtual void [column](#) (const String &colname, [Column](#) *value)
- int [numCols](#) () const
- void [numCols](#) (int value)

Classes

- class [NoSuchColumn](#)

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

10.38.1 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

10.38.2 Constructor & Destructor Documentation

10.38.2.1 CCfits::Table::Table (const [Table](#) & right)

copy constructor

10.38.2.2 CCfits::Table::~~Table () [virtual]

destructor

10.38.2.3 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:

- p* The [FITS](#) file in which to place the new [HDU](#)
- xtype* An HduType enumerator defined in CCfits.h for type of table (AsciiTbl or BinaryTbl)
- hduName* The name of this [HDU](#) extension
- rows* The number of rows in the new [HDU](#) (the value of the NAXIS2 keyword).
- columnName* a vector of names for the columns.
- columnFmt* the format strings for the columns
- columnUnit* the units for the columns.
- version* a version number

10.38.2.4 CCfits::Table::Table (FITSBase * *p*, HduType *xtype*, const String & *hduName* = String(" "), int *version* = 1) [protected]

Constructor to be called by operations that read [Table](#) specified by *hduName* and *version*.

10.38.2.5 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.

10.38.3 Member Function Documentation

10.38.3.1 void CCfits::Table::column (const String & *colname*, [Column](#) * *value*) [protected, virtual]

set the column with name *colname* to the input value.

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

10.38.3.2 std::map< string, [Column](#) * > & CCfits::Table::column () [inline, virtual]

return a reference to the array containing the columns.

To be used in the implementation of subclasses.

10.38.3.3 [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 *colIndex* to the diagnostic message printed when the exception is thrown

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

10.38.3.4 **Column** & CCfits::Table::column (const String & colName) const [virtual]

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

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 from [CCfits::ExtHDU](#).

10.38.3.5 const std::map< String, **Column** * > & CCfits::Table::column () const [inline]

return a reference to the array 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.

10.38.3.6 void CCfits::Table::deleteColumn (const String & columnName) [virtual]

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

Parameters:

columnName The name of the column to be deleted.

Exceptions:

WrongExtensionType if extension is an image.

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

10.38.3.7 void CCfits::Table::deleteRows (const std::vector< long > & rowlist)

delete a set of rows in the table specified by an input array.

Parameters:

rowlist The vector of row numbers to be deleted.

Exceptions:

FitsError thrown if the underlying cfitsio call fails to return without error.

10.38.3.8 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:

first the start row of the range

number the number of rows to delete; defaults to 1.

Exceptions:

[FitsError](#) thrown if the cfitsio call fails to return without error.

10.38.3.9 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.

10.38.3.10 void CCfits::Table::insertRows (long *first*, long *number* = 1)

insert empty rows into the table

Parameters:

first the start row of the range

number the number of rows to insert.

Exceptions:

[FitsError](#) thrown if the underlying cfitsio call fails to return without error.

10.38.3.11 void CCfits::Table::numCols (int *value*) [inline, protected]

set the number of Columns in the [Table](#)

10.38.3.12 int CCfits::Table::numCols () const [inline, protected]

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

10.38.3.13 void CCfits::Table::rows (long *numRows*) [inline]

set the number of rows in the [Table](#).

10.38.3.14 long CCfits::Table::rows () const [inline, virtual]

return the number of rows in the table (NAXIS2).

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

10.38.3.15 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:

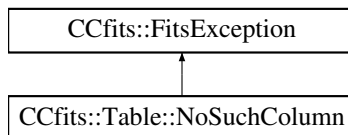
- [Table.h](#)
- [Table.cxx](#)

10.39 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)
- [NoSuchColumn](#) (int index, bool silent=true)

10.39.1 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.

10.39.2 Constructor & Destructor Documentation

10.39.2.1 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:

name the requested column name

silent if true, print message whether [FITS::verboseMode](#) is set or not.

10.39.2.2 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:

index the requested column number

silent if true, print message whether [FITS::verboseMode](#) is set or not.

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

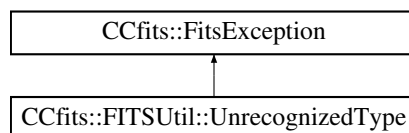
- Table.h
- Table.cxx

10.40 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::



10.40.1 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

Index

- ~AsciiTable
 - CCfits::AsciiTable, [38](#)
- ~BinTable
 - CCfits::BinTable, [45](#)
- ~Column
 - CCfits::Column, [50](#)
- ~ExtHDU
 - CCfits::ExtHDU, [74](#)
- ~FITS
 - CCfits::FITS, [89](#)
- ~HDU
 - CCfits::HDU, [107](#)
- ~Keyword
 - CCfits::Keyword, [117](#)
- ~PHDU
 - CCfits::PHDU, [124](#)
- ~Table
 - CCfits::Table, [130](#)
- ~auto_array_ptr
 - CCfits::FITSUtil::auto_array_ptr,
[41](#)
- addColumn
 - CCfits::AsciiTable, [38](#)
 - CCfits::BinTable, [45](#)
 - CCfits::ExtHDU, [75](#)
- addImage
 - CCfits::FITS, [89](#)
- addKey
 - CCfits::HDU, [107](#)
- addNullValue
 - CCfits::Column, [51](#)
- addTable
 - CCfits::FITS, [89](#)
- AsciiTable
 - CCfits::AsciiTable, [37](#), [38](#)
- auto_array_ptr
 - CCfits::FITSUtil::auto_array_ptr,
[40](#), [41](#)
- axes
 - CCfits::HDU, [108](#)
- axis
 - CCfits::HDU, [108](#)
- BinTable
 - CCfits::BinTable, [44](#), [45](#)
- bitpix
 - CCfits::HDU, [108](#)
- CantCreate
 - CCfits::FITS::CantCreate, [97](#)
- CantOpen
 - CCfits::FITS::CantOpen, [98](#)
- CCfits::AsciiTable, [36](#)
- CCfits::AsciiTable
 - ~AsciiTable, [38](#)
 - addColumn, [38](#)
 - AsciiTable, [37](#), [38](#)
 - clone, [39](#)
 - readData, [39](#)
- CCfits::BinTable, [42](#)
- CCfits::BinTable
 - ~BinTable, [45](#)
 - addColumn, [45](#)
 - BinTable, [44](#), [45](#)
 - clone, [46](#)
 - readData, [46](#)
- CCfits::Column, [47](#)
 - ~Column, [50](#)
 - addNullValue, [51](#)
 - Column, [50](#), [51](#)
 - comment, [51](#)
 - dimen, [51](#)
 - display, [52](#)
 - fitsPointer, [52](#)
 - format, [52](#)
 - index, [52](#)
 - isRead, [52](#)
 - makeHDUCurrent, [52](#)
 - name, [52](#)
 - put, [52](#)
 - read, [53](#), [54](#)
 - readArrays, [54](#), [55](#)
 - readData, [55](#)
 - repeat, [55](#)
 - rows, [55](#)
 - scale, [55](#)

- setDimen, [56](#)
 - setDisplay, [56](#)
 - type, [56](#)
 - unit, [56](#)
 - varLength, [56](#)
 - width, [56](#)
 - write, [56–60](#)
 - writeArrays, [60](#)
 - zero, [61](#)
- CCfits::Column::InsufficientElements, [61](#)
- CCfits::Column::InsufficientElements InsufficientElements, [62](#)
- CCfits::Column::InvalidDataType, [62](#)
- CCfits::Column::InvalidDataType InvalidDataType, [63](#)
- CCfits::Column::InvalidNumberOfRows, [63](#)
- CCfits::Column::InvalidNumberOfRows InvalidNumberOfRows, [64](#)
- CCfits::Column::InvalidRowNumber, [64](#)
- CCfits::Column::InvalidRowNumber InvalidRowNumber, [65](#)
- CCfits::Column::InvalidRowParameter, [65](#)
- CCfits::Column::InvalidRowParameter InvalidRowParameter, [66](#)
- CCfits::Column::NoNullValue, [66](#)
- CCfits::Column::NoNullValue NoNullValue, [67](#)
- CCfits::Column::RangeError, [67](#)
- CCfits::Column::RangeError RangeError, [68](#)
- CCfits::Column::WrongColumnType, [68](#)
- CCfits::Column::WrongColumnType WrongColumnType, [69](#)
- CCfits::ExtHDU, [71](#)
- CCfits::ExtHDU
 - ~ExtHDU, [74](#)
 - addColumn, [75](#)
 - clone, [75](#)
 - column, [75, 76](#)
 - deleteColumn, [76](#)
 - ExtHDU, [74](#)
 - gcount, [76](#)
 - makeThisCurrent, [76](#)
 - name, [77](#)
 - pcount, [77](#)
 - read, [77, 78](#)
 - readData, [78](#)
 - readHduName, [79](#)
 - rows, [79](#)
 - version, [79](#)
 - write, [79, 80](#)
 - xtension, [81](#)
- CCfits::ExtHDU::WrongExtensionType, [81](#)
- CCfits::ExtHDU::WrongExtensionType WrongExtensionType, [82](#)
- CCfits::FITS, [82](#)
- ~FITS, [89](#)
- addImage, [89](#)
- addTable, [89](#)
- clearErrors, [90](#)
- clone, [90](#)
- copy, [90](#)
- currentExtension, [90](#)
- currentExtensionName, [91](#)
- deleteExtension, [91](#)
- destroy, [91](#)
- extension, [92](#)
- filter, [92](#)
- FITS, [85–88](#)
- flush, [93](#)
- getCompressionType, [93](#)
- getNoiseBits, [93](#)
- getTileDimensions, [93](#)
- name, [93](#)
- pHDU, [93, 94](#)
- read, [94, 95](#)
- resetPosition, [95](#)
- setCompressionType, [95](#)
- setNoiseBits, [95](#)
- setTileDimensions, [96](#)
- setVerboseMode, [96](#)
- verboseMode, [96](#)
- CCfits::FITS::CantCreate, [96](#)

- CCfits::FITS::CantCreate
 - CantCreate, 97
- CCfits::FITS::CantOpen, 98
- CCfits::FITS::CantOpen
 - CantOpen, 98
- CCfits::FITS::NoSuchHDU, 99
- CCfits::FITS::NoSuchHDU
 - NoSuchHDU, 99
- CCfits::FITS::OperationNotSupported, 100
- CCfits::FITS::OperationNotSupported
 - OperationNotSupported, 100
- CCfits::FitsError, 101
- CCfits::FitsError
 - FitsError, 101
- CCfits::FitsException, 102
- CCfits::FitsException
 - FitsException, 103
- CCfits::FitsFatal, 103
- CCfits::FitsFatal
 - FitsFatal, 104
- CCfits::FITSUtil::auto_array_ptr, 39
 - ~auto_array_ptr, 41
 - auto_array_ptr, 40, 41
 - get, 41
 - operator *, 41
 - operator =, 41
 - operator [], 41
 - release, 42
 - remove, 42
 - reset, 42
- CCfits::FITSUtil::CAarray, 46
 - operator(), 47
- CCfits::FITSUtil::CVAarray, 70
 - operator(), 70
- CCfits::FITSUtil::CVarray, 70
 - operator(), 71
- CCfits::FITSUtil::MatchName, 119
- CCfits::FITSUtil::MatchNum, 120
- CCfits::FITSUtil::MatchPtrName, 120
- CCfits::FITSUtil::MatchPtrNum, 121
- CCfits::FITSUtil::MatchType, 121
- CCfits::FITSUtil::UnrecognizedType, 136
- CCfits::HDU, 104
 - ~HDU, 107
- addKey, 107
- axes, 108
- axis, 108
- bitpix, 108
- clone, 108
- comment, 108
- deleteKey, 108
- fitsPointer, 108
- getComments, 109
- getHistory, 109
- HDU, 106, 107
- history, 109
- index, 109
- keyWord, 109, 110
- makeThisCurrent, 110
- naxes, 110
- operator !=, 110
- operator ==, 110
- parent, 110
- readAllKeys, 110
- readKey, 111
- readKeys, 111
- scale, 111
- setKeyWord, 111
- writeComment, 111
- writeDate, 111
- writeHistory, 112
- zero, 112
- CCfits::HDU::InvalidExtensionType, 112
- CCfits::HDU::InvalidExtensionType
 - InvalidExtensionType, 113
- CCfits::HDU::InvalidImageDataType, 113
- CCfits::HDU::InvalidImageDataType
 - InvalidImageDataType, 114
- CCfits::HDU::NoNullValue, 114
- CCfits::HDU::NoNullValue
 - NoNullValue, 115
- CCfits::HDU::NoSuchKeyword, 115
- CCfits::HDU::NoSuchKeyword
 - NoSuchKeyword, 116
- CCfits::Keyword, 116
 - ~Keyword, 117
 - clone, 118
 - comment, 118

- fitsPointer, 118
- keytype, 118
- Keyword, 117
- name, 118
- operator!=, 118
- operator=, 118
- operator==, 119
- parent, 119
- write, 119
- CCfits::PHDU, 122
 - ~PHDU, 124
 - clone, 124
 - initRead, 124
 - PHDU, 124
 - read, 124–126
 - scale, 126
 - write, 126, 127
 - zero, 127, 128
- CCfits::Table, 128
 - ~Table, 130
 - column, 131, 132
 - deleteColumn, 132
 - deleteRows, 132
 - init, 133
 - insertRows, 133
 - numCols, 133
 - rows, 134
 - Table, 129, 130
 - updateRows, 134
- CCfits::Table::NoSuchColumn, 134
- CCfits::Table::NoSuchColumn
 - NoSuchColumn, 135
- clearErrors
 - CCfits::FITS, 90
- clone
 - CCfits::AsciiTable, 39
 - CCfits::BinTable, 46
 - CCfits::ExtHDU, 75
 - CCfits::FITS, 90
 - CCfits::HDU, 108
 - CCfits::Keyword, 118
 - CCfits::PHDU, 124
- Column
 - CCfits::Column, 50, 51
- column
 - CCfits::ExtHDU, 75, 76
 - CCfits::Table, 131, 132
- comment
 - CCfits::Column, 51
 - CCfits::HDU, 108
 - CCfits::Keyword, 118
- copy
 - CCfits::FITS, 90
- currentExtension
 - CCfits::FITS, 90
- currentExtensionName
 - CCfits::FITS, 91
- deleteColumn
 - CCfits::ExtHDU, 76
 - CCfits::Table, 132
- deleteExtension
 - CCfits::FITS, 91
- deleteKey
 - CCfits::HDU, 108
- deleteRows
 - CCfits::Table, 132
- destroy
 - CCfits::FITS, 91
- dimen
 - CCfits::Column, 51
- display
 - CCfits::Column, 52
- extension
 - CCfits::FITS, 92
- ExtHDU
 - CCfits::ExtHDU, 74
- filter
 - CCfits::FITS, 92
- FITS
 - CCfits::FITS, 85–88
- FITS Exceptions, 34
- FitsError
 - CCfits::FitsError, 101
- FitsException
 - CCfits::FitsException, 103
- FitsFatal
 - CCfits::FitsFatal, 104
- fitsPointer
 - CCfits::Column, 52

- CCfits::HDU, [108](#)
- CCfits::Keyword, [118](#)
- FITSUtil, [35](#)
- flush
 - CCfits::FITS, [93](#)
- format
 - CCfits::Column, [52](#)
- gcount
 - CCfits::ExtHDU, [76](#)
- get
 - CCfits::FITSUtil::auto_array_ptr, [41](#)
- getComments
 - CCfits::HDU, [109](#)
- getCompressionType
 - CCfits::FITS, [93](#)
- getHistory
 - CCfits::HDU, [109](#)
- getNoiseBits
 - CCfits::FITS, [93](#)
- getTileDimensions
 - CCfits::FITS, [93](#)
- HDU
 - CCfits::HDU, [106](#), [107](#)
- history
 - CCfits::HDU, [109](#)
- index
 - CCfits::Column, [52](#)
 - CCfits::HDU, [109](#)
- init
 - CCfits::Table, [133](#)
- initRead
 - CCfits::PHDU, [124](#)
- insertRows
 - CCfits::Table, [133](#)
- InsufficientElements
 - CCfits::Column::InsufficientElements, [62](#)
- InvalidDataType
 - CCfits::Column::InvalidDataType, [63](#)
- InvalidExtensionType
 - CCfits::HDU::InvalidExtensionType, [113](#)
- InvalidImageDataType
 - CCfits::HDU::InvalidImageDataType, [114](#)
- InvalidNumberOfRows
 - CCfits::Column::InvalidNumberOfRows, [64](#)
- InvalidRowNumber
 - CCfits::Column::InvalidRowNumber, [65](#)
- InvalidRowParameter
 - CCfits::Column::InvalidRowParameter, [66](#)
- isRead
 - CCfits::Column, [52](#)
- keytype
 - CCfits::Keyword, [118](#)
- Keyword
 - CCfits::Keyword, [117](#)
- keyWord
 - CCfits::HDU, [109](#), [110](#)
- makeHDUCurrent
 - CCfits::Column, [52](#)
- makeThisCurrent
 - CCfits::ExtHDU, [76](#)
 - CCfits::HDU, [110](#)
- name
 - CCfits::Column, [52](#)
 - CCfits::ExtHDU, [77](#)
 - CCfits::FITS, [93](#)
 - CCfits::Keyword, [118](#)
- naxes
 - CCfits::HDU, [110](#)
- NoNullValue
 - CCfits::Column::NoNullValue, [67](#)
 - CCfits::HDU::NoNullValue, [115](#)
- NoSuchColumn
 - CCfits::Table::NoSuchColumn, [135](#)
- NoSuchHDU
 - CCfits::FITS::NoSuchHDU, [99](#)
- NoSuchKeyword
 - CCfits::HDU::NoSuchKeyword, [116](#)

- numCols
 - CCfits::Table, [133](#)
- OperationNotSupported
 - CCfits::FITS::OperationNotSupported, [100](#)
- operator *
 - CCfits::FITSUtil::auto_array_ptr, [41](#)
- operator!=
 - CCfits::HDU, [110](#)
 - CCfits::Keyword, [118](#)
- operator()
 - CCfits::FITSUtil::CAarray, [47](#)
 - CCfits::FITSUtil::CVAarray, [70](#)
 - CCfits::FITSUtil::CVarray, [71](#)
- operator=
 - CCfits::FITSUtil::auto_array_ptr, [41](#)
 - CCfits::Keyword, [118](#)
- operator==
 - CCfits::HDU, [110](#)
 - CCfits::Keyword, [119](#)
- operator[]
 - CCfits::FITSUtil::auto_array_ptr, [41](#)
- parent
 - CCfits::HDU, [110](#)
 - CCfits::Keyword, [119](#)
- pcount
 - CCfits::ExtHDU, [77](#)
- PHDU
 - CCfits::PHDU, [124](#)
- pHDU
 - CCfits::FITS, [93](#), [94](#)
- put
 - CCfits::Column, [52](#)
- RangeError
 - CCfits::Column::RangeError, [68](#)
- read
 - CCfits::Column, [53](#), [54](#)
 - CCfits::ExtHDU, [77](#), [78](#)
 - CCfits::FITS, [94](#), [95](#)
 - CCfits::PHDU, [124–126](#)
- readAllKeys
 - CCfits::HDU, [110](#)
- readArrays
 - CCfits::Column, [54](#), [55](#)
- readData
 - CCfits::AsciiTable, [39](#)
 - CCfits::BinTable, [46](#)
 - CCfits::Column, [55](#)
 - CCfits::ExtHDU, [78](#)
- readHduName
 - CCfits::ExtHDU, [79](#)
- readKey
 - CCfits::HDU, [111](#)
- readKeys
 - CCfits::HDU, [111](#)
- release
 - CCfits::FITSUtil::auto_array_ptr, [42](#)
- remove
 - CCfits::FITSUtil::auto_array_ptr, [42](#)
- repeat
 - CCfits::Column, [55](#)
- reset
 - CCfits::FITSUtil::auto_array_ptr, [42](#)
- resetPosition
 - CCfits::FITS, [95](#)
- rows
 - CCfits::Column, [55](#)
 - CCfits::ExtHDU, [79](#)
 - CCfits::Table, [134](#)
- scale
 - CCfits::Column, [55](#)
 - CCfits::HDU, [111](#)
 - CCfits::PHDU, [126](#)
- setCompressionType
 - CCfits::FITS, [95](#)
- setDimen
 - CCfits::Column, [56](#)
- setDisplay
 - CCfits::Column, [56](#)
- setKeyWord
 - CCfits::HDU, [111](#)
- setNoiseBits

CCfits::FITS, [95](#)

setTileDimensions
CCfits::FITS, [96](#)

setVerboseMode
CCfits::FITS, [96](#)

Table
CCfits::Table, [129](#), [130](#)

type
CCfits::Column, [56](#)

unit
CCfits::Column, [56](#)

updateRows
CCfits::Table, [134](#)

varLength
CCfits::Column, [56](#)

verboseMode
CCfits::FITS, [96](#)

version
CCfits::ExtHDU, [79](#)

width
CCfits::Column, [56](#)

write
CCfits::Column, [56–60](#)
CCfits::ExtHDU, [79](#), [80](#)
CCfits::Keyword, [119](#)
CCfits::PHDU, [126](#), [127](#)

writeArrays
CCfits::Column, [60](#)

writeComment
CCfits::HDU, [111](#)

writeDate
CCfits::HDU, [111](#)

writeHistory
CCfits::HDU, [112](#)

WrongColumnType
CCfits::Column::WrongColumn-
Type, [69](#)

WrongExtensionType
CCfits::ExtHDU::Wrong-
ExtensionType, [82](#)

xtension
CCfits::ExtHDU, [81](#)

zero
CCfits::Column, [61](#)
CCfits::HDU, [112](#)
CCfits::PHDU, [127](#), [128](#)