CCfits Reference Manual

2.1

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1 CCfits Documentation

CCfits-2.1 requires `cfitsio` version 3.08 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.

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

1.3 Release Notes For Version 2.1 Nov 2008

- Modified several FITS constructors and FITS::open function to allow proper handling of CFITSIO **extended filename syntax**.
- Extended filename syntax example added to cookbook.
- Fix made to FITS::read function for case of missing EXTVER keyword when searching for HDU with extver > 1.

- Removed inclusion of the internal-only CFITSIO fitsio2.h file from Column.cxx. LONGLONG limits definitions are now found in fitsio.h.

1.4 Release Notes For Version 2.0 Feb 2008

Enhancements to CCfits:

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

Bug Fixes:

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

Backwards Compatibility Issues:

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

For a more complete listing, see the CHANGES file distributed with the software. For earlier versions, see Previous Release Notes.

1.5 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

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 3.02 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 Microsft 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 instanciating 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

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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 resonable compromise between developer time, utility and efficiency.

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

- HDUs are contained within a FITS object using a std::multimap<string, HDU*> object.
    1. The map object constructs new array members on first reference
    2. Objects stored in the map are sorted on entry and retrieved efficiently using binary search techniques.
    3. The pointer-to-HDU implementation allows for polymorphism: one set of operations will process all HDU objects within the FITS file
    4. String objects (char*) are represented by the std::string class, which has a rich public interface of search and manipulation facilities.
- Scalar column data [one entry per cell] are implemented using std::vector<T> objects.
- Vector column data [multiple and either fixed or variable numbers of entries per cell] are implemented using std::vector<std::valarray <T> > objects. The std::valarray template is intended for optimized numeric processing. valarrays are have the following desirable features:
    1. they are dynamic, but designed to be allocated in full on construction rather than dynamic resizing during operation: this is, what is usually needed in FITS files.
    2. They have built-in vectorized transcendental functions (e.g. *std::valarray<T> sin(const std::valarray<T>&).*
    3. They provide std::valarray<T> apply(T f(const T&)) operation, to apply a function f to each element
    4. They provide slicing operations [see the "Getting Started" section for a simple example].
- Exceptions are provided in for by a FitsException hierarchy, which prints out messages on errors and returns control to wherever the exception is caught. Non-zero status values returned by cfitsio are caught by subclass FitsError, which prints the string corresponding to an input status flag. FitsException's other sub-classes 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 anciliary 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 readExtendedSyntax();

int main()
{


     FITS::setVerboseMode(true);

     try

     {

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

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

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

     }
    return 0;
}
```

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

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

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

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

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

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

FITS::destroy() throw()

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

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

The routines in this program test the following functionality:

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

readExtendedSyntax() Reading with Extended File Name Syntax

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 nelements(1);


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

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

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

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

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

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

    // create some data for the image extension.
    long extElements = std::accumulate(extAx.begin(),extAx.end(),1,std::multiplies<long>());
    std::valarray<float> 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::ostrstream 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.

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

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

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


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


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

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

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

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

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

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

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


        return 0;
 }
```

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-specifed, 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 Reading with Extended File Name Syntax

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

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

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

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

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

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

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

   // nRows should only include rows with density column vals > 5.2.
   const int nRows = col.rows();
   col.read(densities, 1, nRows);
   for (int i=0; i<nRows; ++i)
      std::cout << densities[i] << "  ";
   std::cout << std::endl;

   return 0;
}
```

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

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

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

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

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

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

Extended file name syntax (chapter 10 of the cfitsio manual) is supported in general, though not the feature which allows the opening of a particular image stored in the row of a table.

2.15.1 What's Not Present

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

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

The hierarchical grouping routines are not supported.

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

2.15.2 Calling CFITSIO

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

2.16 Previous Release Notes

Changes for CCfits 1.8 release 10/07.

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

Changes for CCfits 1.7 release 6/07. Fixes for the following bugs:

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

Changes for CCfits 1.6 release 11/06

- Added capbility to write compressed images, including 6 new wrapper public functions in FITS class.
- In FITS::addImage, corrected the logic which checks for a pre-existing image extension with the same version number.
- CFITSIO 3.02 renamed fitsfile struct member rice_nbits to noise_nbits. Made corresponding change in copyFitsPtr function in FITSUtil.cxx. As it stands, this makes this version of CCfits incompatible with earlier versions of CFITSIO

- In FITS.h definition, removed both friend declarations of HDUCreator Make functions. It seems neither function needs to be a friend, and one of them is actually private. Some compilers don't allow this (report came from MS VisualC++ user).
- Bug fix in Make function of HDUCreator.cxx. When creating a new ImageExt (and not the primary), it was only passing the version number along for float and double types. This causes problems when there is more than 1 image extension with the same name, and it needs the version number to distinguish them.
- A couple of bug fixes to the first/last/stride version of PHDU read image subset. It was not passing the proper parameters to fits_read_subset, and was not always correctly resizing the internal m_image array.

2.17 Todo List

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

Member CCfits::FITS::addTable(const String &hduName, int rows, const std::vector< String > &columnName=stdvector< String >(), const std::vector< String > &columnFmt=stdvector< String >(), const std::vector< String > &columnUnit=stdvector< String >(), HduType type=BinaryTbl, int version=1)
the code should one day check that the version keyword is higher than any other versions already added to the FITS object (although cfitsio doesn't do this either).

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

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:

4 CCfits Namespace Index

4.1 CCfits Namespace List

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

5 CCfits Hierarchical Index

5.1 CCfits Class Hierarchy

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

6 CCfits Class Index

6.1 CCfits Class List

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

7 CCfits Page Index

7.1 CCfits Related Pages

Here is a list of all related documentation pages:

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::NoNullValue

  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.

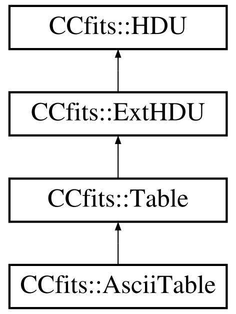
10 CCfits Class Documentation

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 copy constructor

- virtual void readData (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())

  read columns and keys specified in the input array.

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

  add a new column to an existing table HDU.

Protected Member Functions

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

  reading constructor: Construct a AsciiTable extension from an extension of an existing disk file.

- AsciiTable (FITSBase *p, const String &hduName, int rows, const std::vector< String > &columnName=std::vector< String >(), const std::vector< String > &columnFmt=std::vector< String >(), const std::vector< String > &columnUnit=std::vector< String >(), int version=1)

  writing constructor: create new Ascii Table object with the specified columns

- AsciiTable (FITSBase *p, int number)

  read AsciiTable with HDU number `number` *from existing file.*

- ~AsciiTable ()

  destructor.

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 Ascii Table object with the specified columns

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

Parameters:

- ***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.

10.1.3 Member Function Documentation

10.1.3.1 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.

10.1.3.2 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.

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 ()
  constructor. allows creation of pointer to null, can be modified by reset()
- auto_array_ptr (auto_array_ptr< X > &right) throw ()
  copy constructor
- ~auto_array_ptr ()
  destructor.
- void operator= (auto_array_ptr< X > &right)
  assignment operator: transfer of ownership semantics
- X & operator * () throw ()
  deference operator
- X & operator[ ] (size_t i) throw ()
  return a reference to the ith element of the array
- X operator[ ] (size_t i) const throw ()
  return a copy of the ith element of the array
- X * get () const
  *return a token for the underlying content of *this*
- X * release () throw ()

return underlying content of ∗this, transferring memory ownership

- X ∗ reset (X ∗p) throw ()

  change the content of the auto_array_ptr to p

Static Public Member Functions

- static void remove (X ∗&x)

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

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.

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

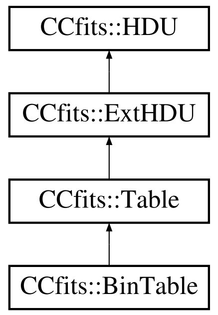
- FITSUtil.h

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 copy constructor

- virtual void readData (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())

  read columns and keys specified in the input array.

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

  add a new column to an existing table HDU.

Protected Member Functions

- BinTable (FITSBase ∗p, const String &hduName=String(""), bool readFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)

  reading constructor.

- BinTable (FITSBase ∗p, const String &hduName, int rows, const std::vector< String > &columnName=std::vector< String >(), const std::vector< String > &columnFmt=std::vector< String >(), const std::vector< String > &columnUnit=std::vector< String >(), int version=1)

  writing constructor

- BinTable (FITSBase ∗p, int number)

  read BinTable with HDU number `number` from existing file represented by fitsfile pointer p.

- ~BinTable ()

  destructor.

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.

10.3.3 Member Function Documentation

10.3.3.1 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.

10.3.3.2 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.

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)
  operator returning C array for use with image data.

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

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>`

Inherited by CCfits::ColumnData< T >, and CCfits::ColumnVectorData< T >.

Public Member Functions

- Column (const Column &right)

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

- virtual ~Column ()

  destructor.

- virtual void readData (long firstRow, long nelements, long firstElem=1)=0

  read method.

- int rows () const

  return the number of rows in the table.

- void setDisplay ()

  set the TDISPn keyword

- virtual void setDimen ()

  set the TDIMn keyword.

- Table * parent () const

  return a pointer to the Table which owns this Column

- int index () const

  get the Column index (the n in TTYPEn etc).

- bool isRead () const

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

- long width () const

  return column data width

- size_t repeat () const
  get the repeat count for the rows
- bool varLength () const
  boolean, set to true if Column has variable length vector rows.
- double scale () const
  get TSCALn value
- double zero () const
  get TZEROn value
- const String & display () const
  return TDISPn keyword
- const String & dimen () const
  return TDIMn keyword
- ValueType type () const
  returns the data type of the column
- const String & format () const
  return TFORMn keyword
- const String & unit () const
  get units of data in Column (TUNITn keyword)
- const String & name () const
  return name of Column (TTYPEn keyword)
- template< typename S>
  void write (const std::vector< S > &indata, long firstRow)
  write a vector of values into a scalar column starting with firstRow
- template< typename S>
  void write (const std::valarray< S > &indata, long firstRow)
  write a valarray of values into a scalar column starting with firstRow
- template< typename S>
  void write (S *indata, long nRows, long firstRow)
  write a C array of size nRows into a scalar Column starting with row firstRow.

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

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

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

  write a valarray of values into a scalar column starting with firstRow with undefined values set to nullValue.

- template<typename S>
  void write (S *indata, long nRows, long firstRow, S *nullValue)

  write a C array into a scalar Column, processing undefined values.

- template<typename S>
  void write (const std::valarray< S > &indata, long nRows, long firstRow)

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

- template<typename S>
  void write (const std::vector< S > &indata, long nRows, long firstRow)

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

- template<typename S>
  void write (S *indata, long nElements, long nRows, long firstRow)

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

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

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

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

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

- template<typename S>
  void write (S *indata, long nElements, long nRows, long firstRow, S *nullValue)

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

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

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

- template<typename S>
void write (const std::vector< S > &indata, const std::vector< long > &vectorLengths, long firstRow)

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

- template<typename S>
void write (S ∗indata, long nElements, const std::vector< long > &vectorLengths, long firstRow)

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

- template<typename S>
void writeArrays (const std::vector< std::valarray< S > > &indata, long firstRow)

  write a vector of valarray objects to the column, starting at row firstRow >= 1

- template<typename S>
void writeArrays (const std::vector< std::valarray< S > > &indata, long firstRow, S ∗nullValue)

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

- template<typename S>
void read (std::vector< S > &vals, long first, long last)

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

- template<typename S>
void read (std::valarray< S > &vals, long first, long last)

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

- template<typename S>
void read (std::valarray< S > &vals, long rows)

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

- template<typename S>
void readArrays (std::vector< std::valarray< S > > &vals, long first, long last)

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

- template<typename S>
  void read (std::vector< S > &vals, long first, long last, S ∗nullValue)

  Retrieve data from a scalar column into a std::vector, setting nullvalue.

- template<typename S>
  void read (std::valarray< S > &vals, long first, long last, S ∗nullValue)

  Retrieve data from a scalar column into a std::valarray, setting undefined values.

- template<typename S>
  void read (std::valarray< S > &vals, long rows, S ∗nullValue)

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

- template<typename S>
  void readArrays (std::vector< std::valarray< S > > &vals, long first, long last, S ∗nullValue)

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

- template<typename T>
  void addNullValue (T nullVal)

  Set the TNULLn keyword for the column.

Protected Member Functions

- Column (int columnIndex, const String &columnName, ValueType type, const String &format, const String &unit, Table ∗p, int rpt=1, long w=1, const String &comment="")

  new column creation constructor

- Column (Table ∗p=0)

  Simple constructor to be called by subclass reading ctors.

- fitsfile ∗ fitsPointer ()

  fits pointer corresponding to fits file containing column data.

- void makeHDUCurrent ()

  make HDU containing this the current HDU of the fits file.

- virtual std::ostream & put (std::ostream &s) const

  internal implementation of << operator.

- const String & comment () const

retrieve comment for Column

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 (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 TTYPEn
- ***type*** used for determining class of T in ColumnData<T>, ColumnVectorData<T>
- ***format*** the column data format, TFORMn keyword
- ***unit*** the column data unit, TUNITn 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.

10.5.3 Member Function Documentation

10.5.3.1 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)

10.5.3.2 int CCfits::Column::rows () const

return the number of rows in the table.

return number of rows in the Column

10.5.3.3 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.

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

get TZEROn value

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

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

return TDISPn keyword

TDISPn is suggested format for output of column data.

10.5.3.6 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.

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

return TFORMn keyword

TFORMn specifies data format stored in disk file.

10.5.3.8 template<typename S> void CCfits::Column::write (const std::vector< S > & *indata*, long *firstRow*) [inline]

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

Parameters:

- ***indata*** The data to be written.
- ***firstRow*** The first row to be written

10.5.3.9 template<typename S> void CCfits::Column::write (const std::valarray< S > & *indata*, long *firstRow*) [inline]

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

10.5.3.10 template<typename S> void CCfits::Column::write (S * *indata*, long *nRows*, long *firstRow*) [inline]

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

10.5.3.11 template< typename S > void CCfits::Column::write (const std::vector< S > & *indata*, long *firstRow*, S * *nullValue*) [inline]

write a vector 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

10.5.3.12 template< typename S > void CCfits::Column::write (const std::valarray< S > & *indata*, long *firstRow*, S * *nullValue*) [inline]

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

10.5.3.13 template< typename S > void CCfits::Column::write (S * *indata*, long *nRows*, long *firstRow*, S * *nullValue*) [inline]

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

10.5.3.14 template<typename S> void CCfits::Column::write (const std::valarray< S > & *indata*, long *nRows*, long *firstRow*) [inline]

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

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

Parameters:

indata The data to be written.

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

firstRow The first row to be written

10.5.3.15 template<typename S> void CCfits::Column::write (const std::vector< S > & *indata*, long *nRows*, long *firstRow*) [inline]

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

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

Parameters:

indata The data to be written.

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

firstRow The first row to be written

10.5.3.16 template<typename S> void CCfits::Column::write (S ∗ *indata*, long *nElements*, long *nRows*, long *firstRow*) [inline]

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

10.5.3.17 template<typename S> void CCfits::Column::write (const std::valarray< S > & *indata*, long *nRows*, long *firstRow*, S * *nullValue*) [inline]

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

see version without undefined processing for details.

10.5.3.18 template<typename S> void CCfits::Column::write (const std::vector< S > & *indata*, long *nRows*, long *firstRow*, S * *nullValue*) [inline]

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

see version without undefined processing for details.

10.5.3.19 template<typename S> void CCfits::Column::write (S * *indata*, long *nElements*, long *nRows*, long *firstRow*, S * *nullValue*) [inline]

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

see version without undefined processing for details.

10.5.3.20 template<typename S> void CCfits::Column::write (const std::valarray< S > & *indata*, const std::vector< long > & *vectorLengths*, long *firstRow*) [inline]

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

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

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

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

Parameters:

- ***indata*** The data to be written
- ***vectorLengths*** the number of elements to write to each successive row.
- ***firstRow*** the first row to be written.

10.5.3.21 template<typename S> void CCfits::Column::write (const std::vector< S > & *indata*, const std::vector< long > & *vectorLengths*, long *firstRow*) `[inline]`

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

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

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

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

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

10.5.3.23 template<typename S> void CCfits::Column::writeArrays (const std::vector< std::valarray< S > > & *indata*, long *firstRow*) `[inline]`

write a vector of valarray objects to the column, starting at row firstRow >= 1

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

Parameters:

- ***indata*** The data to be written
- ***firstRow*** the first row to be written.

10.5.3.24 template<typename S> void CCfits::Column::writeArrays (const std::vector< std::valarray< S > > & *indata*, long *firstRow*, S * *nullValue*) [inline]

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

see version without undefined processing for details.

10.5.3.25 template<typename S> void CCfits::Column::read (std::vector< S > & *vals*, long *first*, long *last*) [inline]

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.

10.5.3.26 template<typename S> void CCfits::Column::read (std::valarray< S > & *vals*, long *first*, long *last*) [inline]

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.

10.5.3.27 template<typename S> void CCfits::Column::read (std::valarray< S > & *vals*, long *rows*) [inline]

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).

10.5.3.28 template<typename S> void CCfits::Column::readArrays (std::vector< std::valarray< S > > & *vals*, long *first*, long *last*) [inline]

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.

10.5.3.29 template<typename S> void CCfits::Column::read (std::vector< S > & *vals*, long *first*, long *last*, S * *nullValue*) [inline]

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

10.5.3.30 template<typename S> void CCfits::Column::read (std::valarray< S > & *vals*, long *first*, long *last*, S * *nullValue*) [inline]

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

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

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

10.5.3.32 template< typename T> void CCfits::Column::addNullValue (T *nullVal*) `[inline]`

Set the TNULLn 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).

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

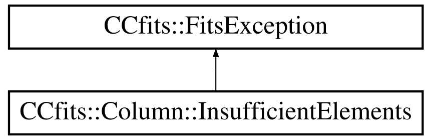
- Column.h
- Column.cxx
- ColumnT.h

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

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:

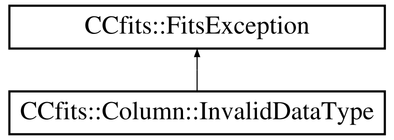
- Column.h
- Column.cxx

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)

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

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:

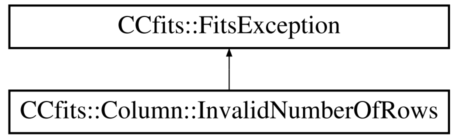
- Column.h
- Column.cxx

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)

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

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

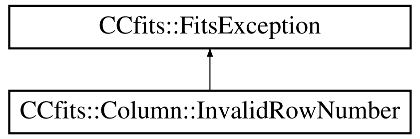
- Column.cxx

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)

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

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:

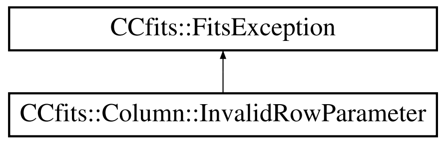
- Column.h
- Column.cxx

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

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:

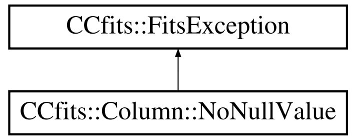
- Column.h
- Column.cxx

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

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 an 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:

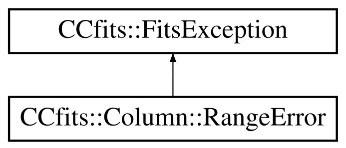
- Column.h
- Column.cxx

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

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:

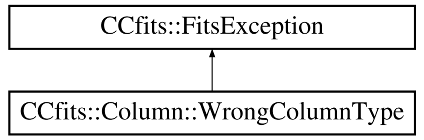
- Column.h
- Column.cxx

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

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)
  operator returning C array for use with vector column data.

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

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)
  operator returning C array for use with scalar column data.

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.

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

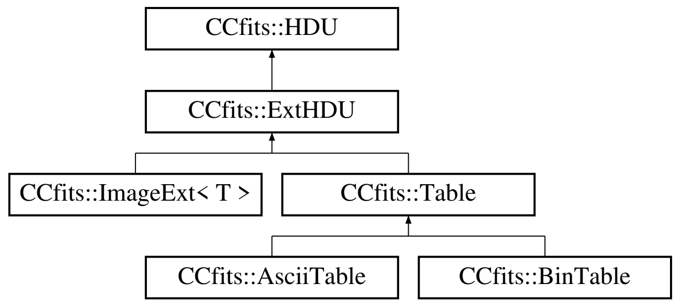
- FITSUtil.h

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)

  copy constructor

- virtual ~ExtHDU ()

  destructor

- virtual void readData (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())=0

  read data from HDU depending on readFlag and keys.

- const String & name () const

  return the name of the extension.

- virtual HDU ∗ clone (FITSBase ∗p) const =0 *virtual copy constructor*

- virtual void makeThisCurrent () const

  move the fitsfile pointer to this current HDU.

- virtual Column & column (const String &colName) const

  return a reference to a Table column specified by name.

- virtual Column & column (int colIndex) const

  return a reference to a Table column specified by column index.

- virtual long rows () const

  return the number of rows in the extension.

- virtual void addColumn (ValueType type, const String &columnName, long repeatWidth, const String &colUnit=String(""), long decimals=-1, size_t columnNumber=0)

  add a new column to an existing table HDU.

- virtual void deleteColumn (const String &columnName)

  delete a column in a Table extension by name.

- virtual long getRowsize () const

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

- int version () const

  return the extension version number.

- void version (int value)

  set the extension version number

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

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

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

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

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

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

- template<typename S>
  void write (long first, long nElements, const std::valarray< S > &data)

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

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

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

- template<typename S>
  void read (std::valarray< S > &image)

  Read image data into container.

- template<typename S>
  void read (std::valarray< S > &image, long first, long nElements, S ∗nullValue)

  read part of an image array, processing null values.

- template<typename S>
  void read (std::valarray< S > &image, const std::vector< long > &first, long nElements, S ∗nullValue)

  read part of an image array, processing null values.

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

  read an image subset

- template<typename S>
  void read (std::valarray< S > &image, long first, long nElements)

  read an image section starting at a specified pixel

- template<typename S>
  void read (std::valarray< S > &image, const std::vector< long > &first, long nElements)

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

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

  read an image subset into valarray image, processing null values

Static Public Member Functions

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

  read extension name.

Protected Member Functions

- ExtHDU (FITSBase *p, HduType xtype, const String &hduName, int version)

  default constructor, required as Standard Library Container content.

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

  writing constructor.

- ExtHDU (FITSBase *p, HduType xtype, int number)

  ExtHDU constructor for getting ExtHDUs by number.

- long pcount () const

  return required pcount keyword value

- void pcount (long value)

  set required pcount keyword value

- long gcount () const

  return required gcount keyword value

- void gcount (long value)

  set required gcount keyword value

- HduType xtension () const

  return the extension type

- void xtension (HduType value)

  set the extension type

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 (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.

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

ExtHDU constructor for getting ExtHDUs by number.

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

10.16.3 Member Function Documentation

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

read extension name.

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

10.16.3.2 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.

10.16.3.3 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.

10.16.3.4 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.

10.16.3.5 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.

10.16.3.6 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.

10.16.3.7 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.

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

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

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

Reimplemented in CCfits::Table.

10.16.3.9 template<typename S> void CCfits::ExtHDU::write (const std::vector< long > & *first*, long *nElements*, const std::valarray< S > & *data*, S ∗ *nullValue*) [inline]

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).

10.16.3.10 template<typename S> void CCfits::ExtHDU::write (long *first*, long *nElements*, const std::valarray< S > & *data*, S ∗ *nullValue*) [inline]

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.

10.16.3.11 template<typename S> void CCfits::ExtHDU::write (const std::vector< long > & *firstVertex*, const std::vector< long > & *lastVertex*, const std::valarray< S > & *data*) [inline]

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

10.16.3.12 template<typename S> void CCfits::ExtHDU::read (std::valarray< S > & *image*) `[inline]`

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.

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

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

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

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.

10.16.3.15 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*, S * *nullValue*) `[inline]`

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.

10.16.3.16 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:

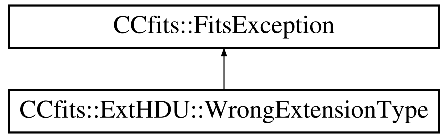
- ExtHDU.h
- ExtHDU.cxx
- ExtHDUT.h

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)

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

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 >())

  basic constructor

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

  Open a FITS file and read a single specified HDU.

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

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

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

  FITS read constructor in full generality.

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

  Constructor for creating new FITS objects containing images.

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

  read a single numbered HDU.

- FITS (const String &name, RWmode mode, const std::vector< String > &searchKeys, const std::vector< String > &searchValues, bool readDataFlag=false, const std::vector< String > &hduKeys=std::vector< String >(), const std::vector< String > &primaryKey=std::vector< string >(), int version=1) *open fits file and read HDU which contains supplied keywords with [optional] specified values (sometimes one just wants to know that the keyword is present).*

- ~FITS ()

  destructor

- void deleteExtension (const String &doomed, int version=1)

  Delete extension specified by name and version number.

- void read (const String &hduName, bool readDataFlag=false, const std::vector< String > &keys=std::vector< String >(), int version=1)

  get data from single HDU from disk file.

- void read (const std::vector< String > &hduNames, bool readDataFlag=false)

  get data from a set of HDUs from disk file.

- void read (const std::vector< String > &hduNames, const std::vector< std::vector< String > > &keys, bool readDataFlag=false, const std::vector< int > &hduVersions=std::vector< int >())

  get data from a set of HDUs from disk file, specifying keys and version numbers.

- void read (int hduIndex, bool readDataFlag=false, const std::vector< String > &keys=std::vector< String >())

  read an HDU specified by index number.

- void read (const std::vector< String > &searchKeys, const std::vector< String > &searchValues, bool readDataFlag=false, const std::vector< String > &hduKeys=std::vector< String >(), int version=1)

  read method for read header or HDU that contains specified keywords.

- const ExtHDU & extension (int i) const

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

- fitsfile ∗ fitsPointer () const

  return the CFITSIO fitsfile pointer for this FITS object

- ExtHDU & extension (int i)

  return FITS extension by index number. non-const version. see const version for details.

- const ExtHDU & extension (const String &hduName, int version=1) const

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

- const PHDU & pHDU () const

    return a const reference to the primary HDU.

- PHDU & pHDU ()

    return a reference to the primary HDU.

- ExtHDU & extension (const String &hduName, int version=1)

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

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

    Add a table extension to an existing FITS object. Add extension to FITS object for file with w or rw access.

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

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

- void destroy () throw ()

    Erase FITS object and close corresponding file.

- void flush ()

    flush buffer contents to disk

- const String & currentExtensionName () const

    return the name of the extension that the fitsfile is currently addressing.

- const ExtMap & extension () const

    return const reference to the extension container

- void resetPosition ()

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

- const String & name () const

    return filename of file corresponding to FITS object

- void copy (const HDU &source)

    copy the HDU source into the FITS object.

- Table & filter (const String &expression, ExtHDU &inputTable, bool overwrite=true, bool readData=false)

  Filter the rows of the inputTable with the condition expression, and return a reference to the resulting Table.

- ExtHDU & currentExtension ()

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

- void deleteExtension (int doomed)

  Delete extension specified by extension number.

- void setCompressionType (int compType)

  set the compression algorithm to be used when adding image extensions to the FITS object.

- void setTileDimensions (const std::vector< long > &tileSizes)

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

- void setNoiseBits (int noiseBits)

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

- int getCompressionType () const

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

- void getTileDimensions (std::vector< long > &tileSizes) const

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

- int getNoiseBits () const

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

Static Public Member Functions

- static void clearErrors ()

  clear the error stack and set status to zero.

- static bool verboseMode ()

  return verbose setting for library

- static void setVerboseMode (bool value)

  set verbose setting for library

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. 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 filename string is passed directly to the cfitsio library: thus the extended filename syntax described in the cfitsio manual should work as documented. (Though the extended file name feature which allows the opening of a particular image located in the row of a table is currently unsupported.) If in Read mode and the extended syntax selects a particular extension, that extension will become the current HDU position upon construction.

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 overriden by FitsException 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.

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

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.

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

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

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::pHDU().write(<arguments>)

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

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

The arguments are:

Parameters:

name The file to be written to disk

bitpix the datatype of the primary image. *bitpix* may be one of the following CFITSIO constants: BYTE_IMG, SHORT_IMG, LONG_IMG, FLOAT_IMG, DOUBLE_IMG, USHORT_IMG, ULONG_IMG. Note that if you send in a *bitpix* of USHORT_IMG or ULONG_IMG, CCfits will set HDU::bitpix() to its signed equivalent (SHORT_IMG or LONG_IMG), and then set BZERO to 2^15 or 2^31.

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.

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

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 overriden by FitsException error to produce more illuminating message.

10.18.3 Member Function Documentation

10.18.3.1 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.

10.18.3.2 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.

10.18.3.3 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.

10.18.3.4 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.

10.18.3.5 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.

10.18.3.6 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.

10.18.3.7 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).

10.18.3.8 void CCfits::FITS::addImage (const String & *hduName*, int *bpix*, std::vector< long > & *naxes*, int *version* = `1`)

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

Does not make primary images, which are built in the constructor for the FITS file. The image data is not added here: it can be added by a call to one of the ExtHDU::write functions.

bpix may be one of the following CFITSIO constants: BYTE_IMG, SHORT_IMG, LONG_IMG, FLOAT_IMG, DOUBLE_IMG, USHORT_IMG, ULONG_IMG. Note that if you send in a *bpix* of USHORT_IMG or ULONG_IMG, CCfits will set HDU::bitpix() to its signed equivalent (SHORT_IMG or LONG_IMG), and then set BZERO to 2^15 or 2^31.

Todo

Add a function for replacing the primary image

10.18.3.9 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.

10.18.3.10 void CCfits::FITS::flush ()

flush buffer contents to disk

Provides manual control of disk writing operation. Image data are flushed automatically to disk after the write operation is completed, but not column data.

10.18.3.11 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 HDUn, where n is the sequential HDU index number (primary HDU = 0).

10.18.3.12 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.

10.18.3.13 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.

10.18.3.14 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.

10.18.3.15 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.

10.18.3.16 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.

10.18.3.17 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 dimesions. If N is less than the number of dimensions of the image it is applied to, the unspecified dimensions will be assigned a size of 1 pixel. If N is larger than the number of image dimensions, the extra dimensions will be ignored.

The default cfitsio behavior is to create tiles with dimensions NAXIS1 x 1 x 1 etc. up to the number of image dimensions.

10.18.3.18 void CCfits::FITS::setNoiseBits (int *noiseBits*)

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

The default value is 4. Decreasing the value of noisebits will improve the overall compression efficiency at the expense of losing more information.

10.18.3.19 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.

10.18.3.20 bool CCfits::FITS::verboseMode () `[inline, static]`

return verbose setting for library

If true, all messages that are reported by exceptions are printed to std::cerr.

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

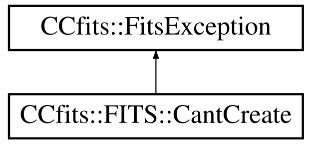
- FITS.h
- FITS.cxx

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)
  Exception ctor prefixes the string: "FITS Error: Cannot create file " before specific message.

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:

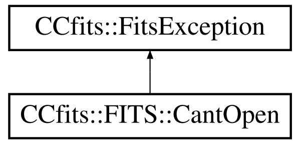
- FITS.h
- FITS.cxx

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)

  Exception ctor prefixes the string: "FITS Error: Cannot create file " before specific message.

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:

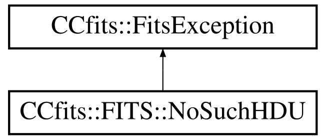
- FITS.h
- FITS.cxx

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)

    Exception ctor, prefixes the string "FITS Error: Cannot read HDU in FITS file:" before the specific message.

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:

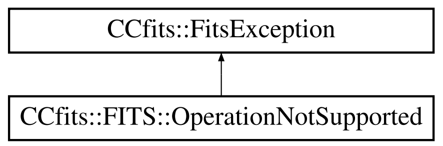
- FITS.h
- FITS.cxx

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)
  Exception ctor, prefixes the string "FITS Error: Operation not supported:" before the specific message.

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:

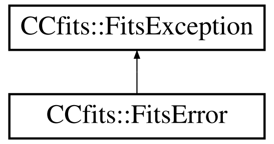
- FITS.h
- FITS.cxx

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)

  ctor for cfitsio exception: translates status code into cfitsio error message

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:

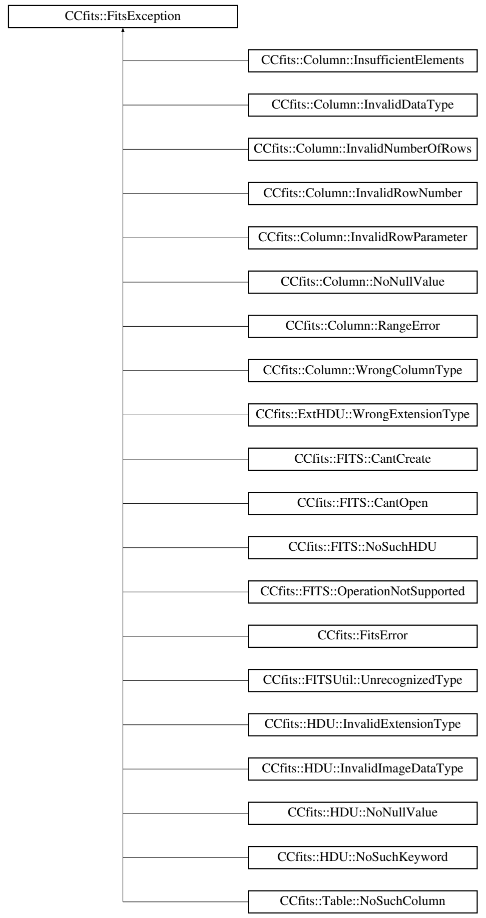
- FitsError.h
- FitsError.cxx

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)
- const string & message () const

  returns the error message

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

10.24.3 Member Function Documentation

10.24.3.1 const string & CCfits::FitsException::message () const `[inline]`

returns the error message

This returns the diagnostic error message associated with the exception object, and which is accessible regardless of the verboseMode and silent flag settings.

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

- FitsError.h
- FitsError.cxx

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)

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

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:

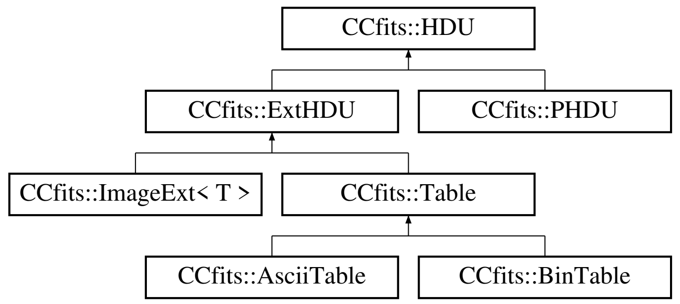
- FitsError.h
- FitsError.cxx

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)

  copy constructor

- bool operator== (const HDU &right) const

  equality operator

- bool operator!= (const HDU &right) const

  inequality operator

- virtual HDU ∗ clone (FITSBase ∗p) const =0

  virtual copy constructor, to be implemented in subclasses.

- fitsfile ∗ fitsPointer () const

  return the fitsfile pointer for the FITS object containing the HDU

- FITSBase ∗ parent () const

  return reference to the pointer representing the FITSBase object containing the HDU

- virtual void makeThisCurrent () const

  move the fitsfile pointer to this current HDU.

- const String & getComments ()

  read the comments from the HDU and add it to the FITS object.

- const string & comment () const

  return the comment string previously read by getComment()

- void writeComment (const String &comment="Generic Comment")

  write a comment string.

- const String & getHistory ()
  read the history information from the HDU and add it to the FITS object.
- const string & history () const
  return the history string previously read by getHistory()
- void writeHistory (const String &history="Generic History String")
  write a history string.
- void writeDate ()
  *write a date string to *this.*
- long axes () const
  return the number of axes in the HDU data section (always 2 for tables).
- long axis (size_t index) const
  return the size of axis numbered index [zero based].
- void index (int value)
  set the HDU number
- int index () const
  return the HDU number
- long bitpix () const
  return the data type keyword.
- virtual double scale () const
  return the BSCALE keyword value
- virtual void scale (double value)
  set the BSCALE keyword value for images (see warning for images of int type)
- virtual double zero () const
  return the BZERO keyword value
- virtual void zero (double value)
  set the BZERO keyword value for images (see warning for images of int type)
- void suppressScaling (bool toggle=true)
  turn off image scaling regardless of the BSCALE and BZERO keyword values

- void writeChecksum ()
  compute and write the DATASUM and CHECKSUM keyword values
- void updateChecksum ()
  update the CHECKSUM keyword value, assuming DATASUM exists and is correct
- std::pair< int, int > verifyChecksum () const
  verify the HDU by computing the checksums and comparing them with the CHECKSUM/DATASUM keywords
- std::pair< unsigned long, unsigned long > getChecksum () const
  compute and return the checksum values for the HDU without creating or modifying the CHECKSUM/DATASUM keywords.
- void deleteKey (const String &doomed)
  delete a keyword from the header
- void readAllKeys ()
  read all of the keys in the header
- void copyAllKeys (const HDU *inHdu)
  copy all keys from another header
- std::map< String, Keyword * > & keyWord ()
  return the associative array containing the HDU keywords so far read.
- Keyword & keyWord (const String &keyName)
  return a (previously read) keyword from the HDU object.
- const std::map< string, Keyword * > & keyWord () const
  return the associative array containing the HDU Keywords that have been read so far.
- const Keyword & keyWord (const string &keyname) const
  return a (previously read) keyword from the HDU object. const version
- template<typename T>
  void readKey (const String &keyName, T &val)
  read a keyword of specified type from the header of a disk FITS file and return its value.

- template<typename T>
  void readKeys (std::vector< String > &keyNames, std::vector< T > &vals)

  read a set of specified keywords of the same data type from the header of a disk FITS file and return their values

- template<typename T>
  Keyword & addKey (const String &name, T val, const String &comment)

  create a new keyword in the HDU with specified value and comment fields

- Keyword ∗ addKey (const Keyword ∗inKeyword)

  create a copy of an existing Keyword and add to HDU

Static Public Member Functions

- static std::vector< int > keywordCategories ()

  return the enumerated keyword categories used by readAllKeys() and copyAllKeys()

Protected Member Functions

- HDU (FITSBase ∗p=0)

  default constructor, called by HDU subclasses that read from FITS files.

- HDU (FITSBase ∗p, int bitpix, int naxis, const std::vector< long > &axes)

  constructor for creating new HDU objects, called by HDU subclasses writing to FITS files.

- virtual ∼HDU ()

  destructor

- std::vector< long > & naxes ()

  return the HDU data axis array.

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 Member Function Documentation

10.26.2.1 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.

10.26.2.2 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

10.26.2.3 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.

10.26.2.4 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

10.26.2.5 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.

10.26.2.6 long CCfits::HDU::axis (size_t *index*) const `[inline]`

return the size of axis numbered index [zero based].

return the length of HDU data axis i.

10.26.2.7 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.

10.26.2.8 void CCfits::HDU::scale (double *value*) `[inline, virtual]`

set the BSCALE keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BSCALE keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the bitpix() return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function fits_get_img_-

equivtype to make the determination). If this situation occurs, the function will throw a FitsException.

Reimplemented in CCfits::ImageExt< T >, and CCfits::PHDU.

10.26.2.9 void CCfits::HDU::zero (double *value*) [inline, virtual]

set the BZERO keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BZERO keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the bitpix() return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function fits_get_img_-equivtype to make the determination). If this situation occurs, the function will throw a FitsException.

Reimplemented in CCfits::ImageExt< T >, and CCfits::PHDU.

10.26.2.10 void CCfits::HDU::suppressScaling (bool *toggle* = `true`)

turn off image scaling regardless of the BSCALE and BZERO keyword values

For *toggle* = true, this turns off image scaling for future read/writes by resetting the scale and zero to 1.0 and 0.0 respectively. It does NOT modify the BSCALE and BZERO keywords. If *toggle* = false, the scale and zero values will be restored to the keyword values.

10.26.2.11 void CCfits::HDU::writeChecksum ()

compute and write the DATASUM and CHECKSUM keyword values

Wrapper for the CFITSIO function fits_write_chksum: This performs the datasum and checksum calculations for this HDU, as described in the CFITSIO manual. If either the DATASUM or CHECKSUM keywords already exist, their values will be updated.

10.26.2.12 void CCfits::HDU::updateChecksum ()

update the CHECKSUM keyword value, assuming DATASUM exists and is correct

Wrapper for the CFITSIO function fits_update_chksum: This recomputes and writes the CHECKSUM value with the assumption that the DATASUM value is correct. If the DATASUM keyword doesn't yet exist or is not up-to-date, use the HDU::writeChecksum function instead. This will throw a FitsError exception if called when there is no DATASUM keyword in the header.

10.26.2.13 std::pair< int, int > CCfits::HDU::verifyChecksum () const

verify the HDU by computing the checksums and comparing them with the CHECKSUM/DATASUM keywords

Wrapper for the CFITSIO function fits_verify_chksum: The data unit is verified correctly if the computed checksum equals the DATASUM keyword value, and the HDU is verified if the entire checksum equals zero (see the CFITSIO manual for further details).

This returns a std::pair<int,int> where the pair's first data member = DATAOK and second = HDUOK. DATAOK and HDUOK values will be = 1 if verified correctly, 0 if the keyword is missing, and -1 if the computed checksum is not correct.

10.26.2.14 std::pair< unsigned long, unsigned long > CCfits::HDU::getChecksum () const

compute and return the checksum values for the HDU without creating or modifying the CHECKSUM/DATASUM keywords.

Wrapper for the CFITSIO function fits_get_chksum: This returns a std::pair<unsigned long, unsigned long> where the pair's first data member holds the datasum value and second holds the hdusum value.

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

delete a keyword from the header

removes *doomed* from the FITS file and from the FITS object

10.26.2.16 void CCfits::HDU::readAllKeys ()

read all of the keys in the header

This member function reads keys that are not meta data for columns or image information, [which are considered to be part of the column or image objects]. Also, history and comment keys are read and returned by getHistory() and getComment(). The exact list of keyword classes this will read is returned by the function keywordCategories().

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

10.26.2.17 void CCfits::HDU::copyAllKeys (const HDU * *inHdu*)

copy all keys from another header

Parameters:

Parameters:

inHdu (const HDU∗) An existing HDU whose keys will be copied.

This will copy all keys that exist in the keyWord map of *inHDU*, and which belong to one of the keyword classes returned by the keywordCategories() function. This is the same group of keyword classes used by readAllKeys().

10.26.2.18 static std::vector< int > CCfits::HDU::keywordCategories () [static]

return the enumerated keyword categories used by readAllKeys() and copyAllKeys()

This returns a vector of integers indicating which categories of keywords apply for the readAllKeys and copyAllKeys functions. The list of categories currently hardcoded is: TYP_CMPRS_KEY (20), TYP_CKSUM_KEY (100), TYP_WCS_KEY (110), TYP_REFSYS_KEY (120), and TYP_USER_KEY (150).

For the list of ALL keyword categories, see the CFITSIO documentation at: `http://heasarc.gsfc.nasa.gov/docs/software/fitsio/c/c_user/node50.html`

10.26.2.19 template<typename T> void CCfits::HDU::readKey (const String & *keyName*, T & *val*) [inline]

read a keyword of specified type from the header of a disk FITS file and return its value.

T is one of the types String, double, float, int, std::complex<float>, and bool. If a Keyword object with the name *keyName* already exists in this HDU due to a previous read call, then this will re-read from the file and create a new Keyword object to replace the existing one.

10.26.2.20 template<typename T> void CCfits::HDU::readKeys (std::vector< String > & *keyNames*, std::vector< T > & *vals*) [inline]

read a set of specified keywords of the same data type from the header of a disk FITS file and return their values

T is one of the types String, double, float, int, std::complex<float>, and bool.

10.26.2.21 template<typename T> Keyword & CCfits::HDU::addKey (const String & *name*, T *value*, const String & *comment*) [inline]

create a new keyword in the HDU with specified value and comment fields

The function returns a reference to keyword object just created. If a keyword with this name already exists, it will be overwritten. Note that this is mostly intended for adding user-defined keywords. It should not be used to add keywords for which there are already specific HDU functions, such as scaling or checksum. Nor should it be used for image or column structural keywords, such as BITPIX, NAXIS, TFORMn, etc. As a general rule, it is best to use this for keywords belonging to the same categories listed in the keywordCategories() function.

Parameters:

Parameters:

name (String) The keyword name

value (Recommended T = String, double, std::complex<float>, int, or bool

comment (String) the keyword value

It is possible to create a keyword with a value of any of the allowed data types in fitsio (see the cfitsio manual section 4.3). However one should be aware that if this keyword value is read in from the file at a later time, it will be stored in a templated Keyword subclass (KeyData<T>) where T will be one of the recommended types listed above. Also see Keyword::value (T& val) for more details.

10.26.2.22 Keyword ∗ CCfits::HDU::addKey (const Keyword ∗ *inKeyword*)

create a copy of an existing Keyword and add to HDU

This is particularly useful for copying Keywords from one HDU to another. For example the inKeyword pointer might come from a different HDU's std::map<string,Keyword∗>. If a keyword with this name already exists, it will be overwritten. The return value is a pointer to the newly created Keyword inserted into this HDU. Also see copyAllKeys().

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

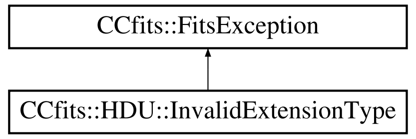
- HDU.h
- HDU.cxx

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

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:

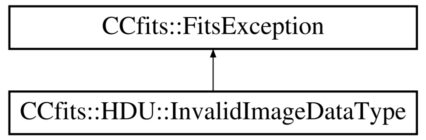
- HDU.h
- HDU.cxx

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)
  Exception ctor, prefixes the string "Fits Error: Invalid Data Type for Image " before the specific message.

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:

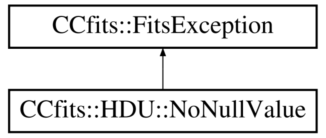
- HDU.h
- HDU.cxx

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)
  Exception ctor, prefixes the string "Fits Error: No Null Pixel Value specified for Image " before the specific message.

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:

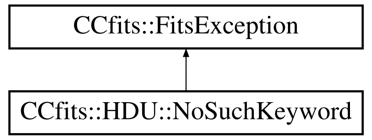
- HDU.h
- HDU.cxx

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)
  Exception ctor, prefixes the string "Fits Error: Keyword not found: " before the specific message.

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.

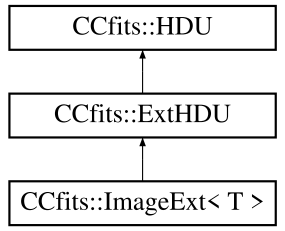
silent if true, print message whether FITS::verboseMode is set or not.

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

- HDU.h
- HDU.cxx

10.31 CCfits::ImageExt< T > Class Template Reference

Inheritance diagram for CCfits::ImageExt< T >::



Public Member Functions

- virtual ~ImageExt ()

  destructor

- virtual ImageExt< T > ∗ clone (FITSBase ∗p) const

  virtual copy constructor

- virtual void readData (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())

  read Image extension HDU data

- const std::valarray< T > & image () const

  return the image data

- virtual void zero (double value)

  set the BZERO keyword value for images (see warning for images of int type)

- virtual void scale (double value)
  set the BSCALE keyword value for images (see warning for images of int type)
- virtual double zero () const
  return the BZERO keyword value
- virtual double scale () const
  return the BSCALE keyword value

10.31.1 Detailed Description

template<typename T> class CCfits::ImageExt< T >

ImageExt<T> is a subclass of ExtHDU that contains image data of type T.

10.31.2 Member Function Documentation

10.31.2.1 template<typename T> void CCfits::ImageExt< T >::readData (bool *readFlag* = `false`, const std::vector< String > & *keys* = `std::vector<String>()`) `[inline, virtual]`

read Image extension HDU data

Called by FITS ctor, not intended for general use. parameters control how much gets read on initialization.

Parameters:

readFlag read the image data if true

key a vector of strings of keyword names to be read from the HDU

Implements CCfits::ExtHDU.

10.31.2.2 template<typename T> void CCfits::ImageExt< T >::zero (double *value*) `[inline, virtual]`

set the BZERO keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BZERO keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the bitpix() return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function fits_get_img_-equivtype to make the determination). If this situation occurs, the function will throw a FitsException.

Reimplemented from CCfits::HDU.

10.31.2.3 template<typename T> void CCfits::ImageExt< T >::scale (double *value*) `[inline, virtual]`

set the BSCALE keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BSCALE keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the bitpix() return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function fits_get_img_-equivtype to make the determination). If this situation occurs, the function will throw a FitsException.

Reimplemented from CCfits::HDU.

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

- ImageExt.h

10.32 CCfits::Keyword Class Reference

Abstract base class defining the interface for Keyword objects.

`#include <Keyword.h>`

Inherited by CCfits::KeyData< T >.

Public Member Functions

- virtual ~Keyword ()
  virtual destructor
- Keyword & operator= (const Keyword &right)
  assignment operator

- bool operator== (const Keyword &right) const

  equality operator

- bool operator!= (const Keyword &right) const

  inequality operator

- virtual Keyword ∗ clone () const =0

  virtual copy constructor

- virtual void write ()

  left in for historical reasons, this seldom needs to be called by users

- fitsfile ∗ fitsPointer () const

  return a pointer to the FITS file containing the parent HDU.

- const String & comment () const

  return the comment field of the keyword

- const String & name () const

  return the name of a keyword

- template<typename T>
  T & value (T &val) const

  get the keyword value

- template<typename T>
  void setValue (const T &newValue)

  modify the value of an existing Keyword and write it to the file

Protected Member Functions

- Keyword (const Keyword &right)

  copy constructor

- Keyword (const String &keyname, ValueType keytype, HDU ∗p, const String &comment="")

  Keyword constructor.

- ValueType keytype () const

  return the type of a keyword

- void keytype (ValueType value)
  set keyword type.
- const HDU * parent () const
  return a pointer to parent HDU.

10.32.1 Detailed Description

Abstract base class defining the interface for Keyword objects.

Keyword object creation is normally performed inside FITS constructors or FITS::read, HDU::readKey, and HDU::addKey functions. Output is performed in HDU::addKey functions and Keyword::setValue.

Keywords consists of a name, a value and a comment field. Concrete templated subclasses, KeyData<T>, have a data member that holds the value of keyword.

Typically, the mandatory keywords for a given HDU type are not stored as object of type Keyword, but as intrinsic data types. The Keyword hierarchy is used to store user-supplied information.

10.32.2 Constructor & Destructor Documentation

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

Keyword constructor.

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

10.32.3 Member Function Documentation

10.32.3.1 void CCfits::Keyword::write () [virtual]

left in for historical reasons, this seldom needs to be called by users

This writes the Keyword to the file, and is called internally during HDU::addKey operations or the Keyword::setValue function. It shouldn't normally need to be called explicitly.

10.32.3.2 template<typename T> T & CCfits::Keyword::value (T & *val*) const [inline]

get the keyword value

Parameters:

Parameters:

val (T) Will be filled with the keyword value, and is also the function return value.

Allowed T types: CCfits stores keyword values of type U in a templated subclass of Keyword, **KeyData<U>**. Normally U is set when reading the Keyword in from the file, and is limited to types int, double, string, bool, and complex<float>. (The exception is when the user has created and added a new Keyword using an HDU::addKey function, in which case they might have specified other types for U.) To avoid compilation errors, the user should generally try to provide a *val* of type T = type U, though there is some flexibility here as the following conversions are handled:

T (to val)	**U** (from Keyword obj)
float	double (will lose precision), float, int, integer string
double	double, float, int, integer string
int	int, integer string

More conversions may be added in the future as the need arises.

10.32.3.3 template<typename T> void CCfits::Keyword::setValue (const T & *newValue*) [inline]

modify the value of an existing Keyword and write it to the file

Parameters:

Parameters:

newValue (T) New value for the Keyword

Allowed T types: This must copy *newValue* to a data member of type U in the Keyword subclass **KeyData<U>** (see description for Keyword::value (T& val) for more details). To avoid compilation errors, it is generally best to provide a *newValue* of type T = type U, though the following type conversions will also be handled:

T (from newValue)	**U** (to Keyword obj)
float	double, float
double	double, float (will lose precision)
int	double, float, int, integer string

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

- Keyword.h

- Keyword.cxx
- KeywordT.h

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

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

`#include <FITSUtil.h>`

10.33.1 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

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

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

`#include <FITSUtil.h>`

10.34.1 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

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

as for MatchName, only with the input class a pointer.

`#include <FITSUtil.h>`

10.35.1 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

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

as for MatchNum, only with the input class a pointer.

`#include <FITSUtil.h>`

10.36.1 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

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

function object that returns the FITS ValueType corresponding to an input intrinsic type

`#include <FITSUtil.h>`

10.37.1 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:

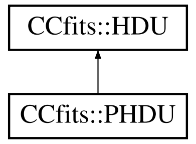
- FITSUtil.h

10.38 CCfits::PHDU Class Reference

class representing the primary HDU for a FITS file.

```
#include <PHDU.h>
```

Inheritance diagram for CCfits::PHDU::



Public Member Functions

- virtual ~PHDU ()

  destructor

- virtual void readData (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())=0

  read primary HDU data

- virtual PHDU * clone (FITSBase *p) const =0

  virtual copy constructor, to be implemented in subclasses.

- virtual void zero (double value)

  set the BZERO keyword value for images (see warning for images of int type)

- virtual void scale (double value)

  set the BSCALE keyword value for images (see warning for images of int type)

- virtual double zero () const

  return the BZERO keyword value

- virtual double scale () const

  return the BSCALE keyword value

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

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

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

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

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

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

- template<typename S>
  void write (long first, long nElements, const std::valarray< S > &data)

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

- template<typename S>
  void write (const std::vector< long > &firstVertex, const std::vector< long > &lastVertex, const std::vector< long > &stride, const std::valarray< S > &data)

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

- template<typename S>
  void read (std::valarray< S > &image, long first, long nElements)

  read an image section starting at a specified pixel

- template<typename S>
  void read (std::valarray< S > &image, long first, long nElements, S ∗nullValue)

  read part of an image array, processing null values.

- template<typename S>
  void read (std::valarray< S > &image, const std::vector< long > &first, long nElements)

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

- template<typename S>
  void read (std::valarray< S > &image, const std::vector< long > &first, long nElements, S ∗nullValue)

  read part of an image array, processing null values.

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

  read an image subset

- template<typename S>
  void read (std::valarray< S > &image, const std::vector< long > &firstVertex,

const std::vector< long > &lastVertex, const std::vector< long > &stride, S ∗nullValue)

read an image subset into valarray image, processing null values

Protected Member Functions

- PHDU (const PHDU &right)

  copy constructor

- PHDU (FITSBase ∗p, int bpix, int naxis, const std::vector< long > &axes)

  Writing Primary HDU constructor, called by PrimaryHDU<T> class.

- PHDU (FITSBase ∗p=0)

  Reading Primary HDU constructor.

- virtual void initRead ()

10.38.1 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

10.38.2 Constructor & Destructor Documentation

10.38.2.1 CCfits::PHDU::∼PHDU () `[virtual]`

destructor

Destructor

10.38.2.2 CCfits::PHDU::PHDU (const PHDU & *right*) `[protected]`

copy constructor

required for cloning primary HDUs when copying FITS files.

10.38.2.3 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

10.38.2.4 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>.

10.38.3 Member Function Documentation

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

read primary HDU data

Called by FITS ctor, not intended for general use. parameters control how much gets read on initialization. An abstract function, implemented in the subclasses.

Parameters:

- ***readFlag*** read the image data if true
- ***key*** a vector of strings of keyword names to be read from the primary HDU

10.38.3.2 void CCfits::PHDU::zero (double *value*) [virtual]

set the BZERO keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BZERO keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the bitpix() return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function fits_get_img_-equivtype to make the determination). If this situation occurs, the function will throw a FitsException.

Reimplemented from CCfits::HDU.

10.38.3.3 void CCfits::PHDU::scale (double *value*) [virtual]

set the BSCALE keyword value for images (see warning for images of int type)

For primary HDUs and image extensions, this will add (or update) the BSCALE keyword in the header. The new setting will affect future image array read/writes as described in section 4.7 Data Scaling of the CFITSIO manual. For table extensions this function does nothing.

WARNING: If the image contains **integer-type data** (as indicated by the bitpix() return value), the new scale and zero value combination must not be such that the scaled data would require a floating-point type (this uses the CFITSIO function fits_get_img_-equivtype to make the determination). If this situation occurs, the function will throw a FitsException.

Reimplemented from CCfits::HDU.

10.38.3.4 template<typename S> void CCfits::PHDU::write (const std::vector< long > & *first*, long *nElements*, const std::valarray< S > & *data*, S * *nullValue*) [inline]

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).

10.38.3.5 template<typename S> void CCfits::PHDU::write (long *first*, long *nElements*, const std::valarray< S > & *data*, S ∗ *nullValue*) `[inline]`

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.

10.38.3.6 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*) `[inline]`

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, whearas stride = (2,2,2,...) means picking every other value in each dimension.

data The data to be written

10.38.3.7 template<typename S> void CCfits::PHDU::read (std::valarray< S > & *image*, long *first*, long *nElements*, S ∗ *nullValue*) `[inline]`

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

10.38.3.8 template<typename S> void CCfits::PHDU::read (std::valarray< S > & *image*, const std::vector< long > & *first*, long *nElements*, S ∗ *nullValue*) `[inline]`

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.

10.38.3.9 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*) `[inline]`

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.

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

Read image header and update fits pointer accordingly.

Private: called by ctor.

Implements CCfits::HDU.

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

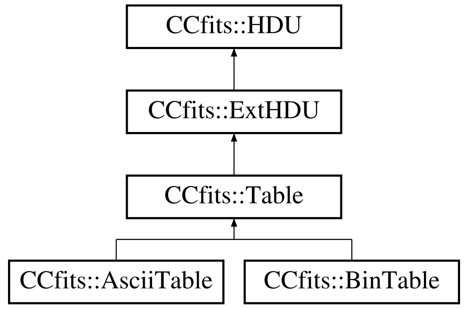
- PHDU.h

- PHDU.cxx
- PHDUT.h

10.39 CCfits::Table Class Reference

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

Inheritance diagram for CCfits::Table::



Public Member Functions

- Table (const Table &right)
  copy constructor
- virtual ∼Table ()
  destructor
- const std::map< String, Column ∗ > & column () const
  return a reference to the array containing the columns.
- virtual Column & column (const String &colName) const
  return a reference to a Table column specified by name.
- virtual Column & column (int colIndex) const
  return a reference to the column identified by colIndex
- virtual long rows () const
  return the number of rows in the table (NAXIS2).
- void updateRows ()

update the number of rows in the table

- void rows (long numRows)

  set the number of rows in the Table.

- virtual void deleteColumn (const String &columnName)

  delete a column in a Table extension by name.

- void insertRows (long first, long number=1)

  insert empty rows into the table

- void deleteRows (long first, long number=1)

  delete a range of rows in a table.

- void deleteRows (const std::vector< long > &rowList)

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

- virtual long getRowsize () const

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

- virtual std::map< string, Column * > & column ()

  return a reference to the array containing the columns.

Protected Member Functions

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

  Constructor to be used for creating new HDUs.

- Table (FITSBase *p, HduType xtype, const String &hduName=String(""), int version=1)

  Constructor to be called by operations that read Table specified by hduName and version.

- Table (FITSBase *p, HduType xtype, int number)

  Table constructor for getting Tables by number.

- void init (bool readFlag=false, const std::vector< String > &keys=std::vector< String >())
- virtual void column (const String &colname, Column *value)

set the column with name colname to the input value.

- int numCols () const

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

- void numCols (int value)

  set the number of Columns in the Table

Classes

- class NoSuchColumn

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

10.39.1 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

10.39.2 Constructor & Destructor Documentation

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

Constructor to be used for creating new HDUs.

Parameters:

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

10.39.2.2 CCfits::Table::Table (FITSBase * *p*, HduType *xtype*, int *number*) [protected]

Table constructor for getting Tables by number.

Necessary since EXTNAME is a reserved not required keyword, and users may thus read FITS files without an extension name. Since an HDU is completely specified by extension number, this is part of the public interface.

10.39.3 Member Function Documentation

10.39.3.1 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.

10.39.3.2 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.

10.39.3.3 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.

10.39.3.4 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.

10.39.3.5 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.

10.39.3.6 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.

10.39.3.7 void CCfits::Table::deleteRows (long *first*, long *number* = 1)

delete a range of rows in a table.

In both this and the overloaded version which allows a selection of rows to be deleted, the cfitsio library is called first to perform the operation on the disk file, and then the FITS object is updated.

Parameters:

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.

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

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

Parameters:

rowlist The vector of row numbers to be deleted.

Exceptions:

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

10.39.3.9 long CCfits::Table::getRowsize () const [virtual]

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

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

Reimplemented from CCfits::ExtHDU.

10.39.3.10 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.

10.39.3.11 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.

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

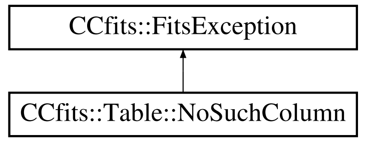
- Table.h
- Table.cxx

10.40 CCfits::Table::NoSuchColumn Class Reference

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

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

Inheritance diagram for CCfits::Table::NoSuchColumn::



Public Member Functions

- NoSuchColumn (const String &name, bool silent=true)

  Exception ctor for exception thrown if the requested column (specified by name) is not present.

- NoSuchColumn (int index, bool silent=true)

  Exception ctor for exception thrown if the requested column (specified by name) is not present.

10.40.1 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 id 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.

10.40.2 Constructor & Destructor Documentation

10.40.2.1 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.

10.40.2.2 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:

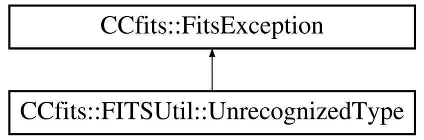
- Table.h
- Table.cxx

10.41 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::



10.41.1 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

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