Description of FITS headers at the NOT

Tapio Pursimo
Anlaug Amanda Djupvik
Saskia Prins

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1   Introduction

This document describes the FITS files produced at the NOT per early 2014 and the proposed upgrades in order to define the full set of FITS header keywords to use for all common-user instruments at the NOT.

We base our upgrades on the extensive work to standardize the data format and FITS headers at the NOT, the document "FITS observations files at the NOT" [Prins 2004]. Most of the upgrades suggested in this document have been implemented over the years 2004-2011. Nevertheless, the current set of FITS keywords is far from complete, in the sense that they should provide a complete and unique description of the data, useful for post-processing/pipeline reduction and archiving.

In this version we suggest a number of new keywords. We also refer to new references that have appeared, such as the new FITS standard version 3.0, see [Pence et al. 2010], which replaces all prior versions, along with the updated version of ESO's "Data Interface Control Document" GEN-SPE-ESO-19400-0794 (dicd_v5.pdf) from July 2011 [ESO DICB v5], and we try as far as possible to follow the ESO convention and naming, except for the ESO hierarchical keywords definitions. We have checked all time-related keywords with the FITS Time WCS Draft, v.0.982, [Rots et al. 2013].

This version is open for comments/suggestions/changes although it is already based on a number of meetings, discussions and emails.

2   Conventions and definitions used

2.1   FITS standard

The FITS standard is fully contained in the paper "Definition of the Flexible Image Transport System (FITS) version 3.0" [Pence et al. 2010] which replaces all prior versions. The main changes since version 2.0 [Hanisch et al. 2001], is the support for 64-bit integers in images and tables, variable-length arrays in tables, and new world coordinate system conventions based on [Greisen et al. 2002], [Calabretta et al. 2002] and [Greisen et al. 2006]. The new FITS standard is produced by the FITS Working Group of the IAU.

Mandatory keywords are keywords that must be used in all FITS files. A **Reserved keyword** is an optional keyword that must be used only in the manner defined by the FITS standard.

Apart from the Mandatory and Reserved keywords from the FITS standard, astronomical observatories and space organizations have all invented their own keywords to meet their own specific needs. The only restriction here is that FITS header cards should follow the format

conventions [Pence et al. 2010] (see below for a short description), and that the Mandatory and Reserved keywords should only be used as described in the FITS standard.

2.2 Short description of FITS file structures and header card format

A FITS file consists of a sequence of one or more header and data units (HDUs) optionally followed by special records. The structure of a FITS file is based on blocks with a length of 2880 bytes. Each HDU consists of a header and an optional data array of which the dimensions are specified in the FITS header. The first HDU is known as the primary HDU, any subsequent HDU is known as an extension HDU.

The NOT data uses Multi-Extension FITS (MEF) format as the default observation file format for all common-user instruments since January 2006, also for single image data. It is possible to set a flag (INHERIT) in the primary header, which indicates whether the header information from the primary header is included (inherited) in the new FITS header, when the data array from an extension is exported into a new separate FITS file.

Each header consists of a sequence of one or more 2880-byte blocks which holds 36 80-character card images. If the number of cards required is not an exact multiple of 36, a number of blank card images (filled with ASCII blanks) is inserted. Following each header is a data unit that consists of a sequence of zero or more 2880-byte blocks. These blocks contain an N-dimensional data array whose size and structure are described by the mandatory keywords in the header.

There is no limit on the total size of a FITS file imposed by the FITS standard, nor on the size of an individual HDU [Pence et al. 2010], although software packages can be limited.

A FITS header card includes a keyword, a value indicator, a value field, and an optional comment [Pence et al. 2010]. The keyword can be maximum 8 characters long, and goes into column 1-8. The value indicator is normally '= ', equals sign in column 9, blank in column 10. Only in the case of commentary keywords (COMMENT, HISTORY, or blank keyword field), the value indicator can be omitted and any ASCII text is allowed in columns 9-80. If the value indicator is present, columns 11-80 contain the value of the keyword followed by an optional comment. If a comment is present, it must be preceded by a slash '/'; a space between the value and the slash is recommended. Formats of the value field are listed in Section 5. Most fixed formats run from columns 11-30, followed by the recommended space in column 31, the slash in column 32, and the comments in columns 33-80.

If the units of the keyword value are specified in the comment field, it is recommended that the units string be enclosed in square brackets at the beginning of the comment field, separated from the slash '/' by a single space character. Square brackets in the comment field should be used only for this purpose according to [Pence et al. 2010].

A notable non-standard FITS keyword format convention is the ESO HIERARCH keyword convention [ESO DICB v2], where the keyword begins in column 11 and can have any number of characters as long as it fits within columns 11-80 and leaves enough space for the value indicator and value field.

3 The current status of FITS headers and data structure

In this section we describe the current situation regarding FITS headers and data structure. These are a result of upgrades made over the years 2004 to 2013, based either on suggestions and priority settings given in [Prins 2004] or by the need for new keywords not previously anticipated. Some of the major upgrades were:

- introduction of unique filenames (with a two-character instrument prefix)

- introduction of Multi-Extension FITS (MEF) format for all instruments

- multiple chip images (MOSCA) and multiple readout images (NOTCam) stored in separate image extensions

- NOTCam and StanCam images are flipped in X to have standard FITS orientation

- a common naming policy for optical elements keywords introduced for all instruments

- the units for the value field are included in the comment field (not always)

- new keywords for the Atmospheric Dispersion Corrector (ADC)

- new keywords for the three baffle lamps (not implemented for all instruments yet)

The implementation was mainly made through a post-processing script NOT2MEF, converting both the data structure and the header provided by the data acquisition system (BIAS[1]) into a more complete Multi-Extension-FITS structured file, and populating the additional header keywords. The NOT2MEF translator program is still being used for all instruments, except for ALFOSC, which was upgraded with a new controller, CCD3[2], in July 2011 and since then produces the final dataproduct in MEF format with the header keywords set directly from the data acquisition software.

Many suggested upgrades are still pending implementation, however, and there are also a number missing keyword not listed in [Prins 2004]. The major cause for a new FITS header revision document, is therefore to define an *as-complete-as-possible* set of FITS header keywords for all instruments.

The main shortcomings per today:

- mising full observing description (image category, image type and observing mode)

- missing proposal information (PI, OB identification, script name)

- missing some telescope status (hatches, tracking etc.)

- missing weather station information

- expmode only available for NOTCam

- missing NOTCam array voltages

- missing special data structure for future NOTCam *burst* mode (fast photometry)

- missing WCS for spectroscopy

- missing angular distance to Sun and Moon, plus moon illumination

- non-optimal handling of the time keeping

- missing comment and/or units of the keywords

- Right Ascnsion format, currently RA is in decimal degrees, however some (iraf) packages request decimal hours. Also the RA sexagesimal format is visible only from the RA-keyword comment field (added by JHT 161013)

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[1] Brorfelde Image Acquisition System, Copenhagen University Observatory.
[2] Copenhagen University Observatory (CUO) generation 3 CCD controllers.

3.1 Notes on the individual instruments

ALFOSC Since July 2011 ALFOSC runs with the new controller CCD3COMM which creates proper MEF format data products and provide the header keywords directly, hence, the use of NOT2MEF for data translation is no longer needed for ALFOSC. Data consist of unsigned 32-bit data, which is stored in FITS files as 32-bit signed integers with a BZERO offset of 2^{31}

STANCAM StanCam uses NOT2MEF to translate data format and headers. All StanCam images are flipped in X before being stored. Data consist of unsigned 16-bit data, which is stored in FITS files as 16-bit signed integers with a BZERO offset of 2^{15}

NOTCAM NOTCam uses NOT2MEF to translate data format and headers. All images are flipped in X before being stored. Data consist of unsigned 16-bit data, which is stored in FITS files as 16-bit signed integers with a BZERO offset of 2^{15}

NOTCam will be upgraded with a new controller which allows for typcial infrared data acquisition modes, i.e. high image rates. This allows for an additional fast photometry observing mode, referred to as *burst* mode, where only minimal header information is required per image in order to minimize overheads. Only one common full fits header will be required for all the individual images taken in one burst, as described in [Djupvik et al. 2012].

MOSCA MOSCA uses NOT2MEF to translate data format and headers. Data consist of unsigned 16-bit data, which is stored in FITS files as 16-bit signed integers with a BZERO offset of 2^{15}

FIES FIES uses NOT2MEF to translage data format and headers. Data consist of unsigned 16-bit data, which is stored in FITS files as 16-bit signed integers with a BZERO offset of 2^{15}

4 Proposed upgrade

FITS v3.0 [Pence et al. 2010] is supposed to replace all prior versions. This means that our FITS header comment line in ALFOSC headers that refers to the A&A paper which is version 2.0 of FITS from 2001, should be updated accordingly. This COMMENT shall be added to the header of all instruments.

4.1 Grouping FITS headers into classes/packages

We basically follow the original suggestion for the NOT in [Prins 2004] for groups/classes of keywords, and add new keywords in the classes where they belong. Thus, the tables in Sect. 5 are copied updated, but kept in the same format as in the original document. We check that nothing is in conflict with [Pence et al. 2010].

4.2 The complete observation description

Following the ESO standard, see [ESO DICB v5], it was decided to use a similar scheme to fully describe an observation or a data product. This is done by defining three main keywords[3]:

1. an image category (IMAGECAT)

2. an image type (IMAGETYP)

3. an observing mode (OBS_MODE)

   In the following, each of these are shortly described with examples and suggestions of implementation. Only certain combinations of these are valid. As is the case with ESO, the Tables of IMAGETYP and OBS_MODE values are not complete lists since new instruments and observation techniques will alter the list values.

4.2.1 IMAGECAT

IMAGECAT is a new keyword in the NOT fits headers. It defines the image category and can take any of the values listed in Table 1. The IMAGECAT keyword can be used to select data for public release. While CALIB data can be released immediately, SCIENCE data has a propriety period of one year. The calibration data taken while pointing to a target will have value CALIB_ON_OBJECT. ACQUISITION and CALIB_ON_OBJECT will follow the SCIENCE data propriety period.

Table 1: Allowed values for the image category keyword IMAGECAT.

Value	Explanation
SCIENCE	Any scientific object
CALIB	Any calibration source
CALIB_ON_OBJECT	A calibration exposure pointing to an object
ACQUISITION	Any acquisition exposure to verify telescope pointing
TECHNICAL	Any data for instrument performance/setup (e.g. QC, through-focus, lintest)
TEST	Any data taken to test instrument or software

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[3]We have selected completely different names for these keywords. At ESO they are DPR CATG, DPR TYPE and DPR TECH, for data product category, type and technique, respectively.

- In line with ESO, only one value can be selected. The default setting should be 'SCIENCE'. Scripts should always reset the keyword back to 'SCIENCE' when ending.

- Scripts taking calibration data, such as *alfosc.easyflat, alfosc.calibexp, alfosc.alfosc-calib, fies.fies-calib, fies.easythar, fies.easyhalo, notcam.skyflat, notcam.calibexp, notcam.as05-jhk etc.* shall set IMAGECAT to 'CALIB'.

- Detector QC scripts like *alfosc.qc-script, the automatic FIESgainron script, notcam.lintest, mosca.qc-script, and stancam.qc-script* shall set IMAGECAT to TECHNICAL. This goes also for other technical data obtained, such as shutter tests, images taken to align optical elements, pointing model observations, finding rotation centre on the sky, etc.

- The acquisition images obtained while running e.g. *alfosc.acquisition, stancam.acquisition, and in the future notcam.acquisition*, should set IMAGECAT to 'ACQUISITION'.

- At ESO the category TEST is used to mark data taken in order to test an instrument or a software. We could follow the same, since distinguising TECHNICAL from TEST category is useful for internal archiving.

When observing manually without scripts the observer would have to type in IMAGECAT to set it differently from SCIENCE in order to prevent that science data is set to the wrong category.

4.2.2 IMAGETYP

IMAGETYP is a keyword already in use at the NOT. It describes the image type and can take one or more of the values listed in Table 2, separated by comma (no blanks) and in the given order (i.e. 'FLAT,SKY' rather than 'SKY,FLAT'), following the "general-to-specific" order. ESO recommends to limit the number to three. These are a subset of the image types available at ESO[4], but should be sufficient to describe data at NOT, also taking into account the future observing modes with NOTCam made possible with a new controller, as well as the future instrument NTE.

- IMAGETYP can currently be set, for each instrument, with the sequencer commands [instrument].imtype. This is very handy for scripting and should be kept. Another suggestion mentioned was to make different expose commands such as "exp" and "stdexp" that set the imagetype to OBJECT and STD, respectively. Since we have many expose commands already (exp/mexp/frame) there will be very many combinations of settings available, also one may want to specify which type of standard, and then it gets messy. If observations are mainly performed by scripts the imagetype is set accordingly.

- The default should be OBJECT, and all scripts should end setting IMAGETYP back to OBJECT.

- Calibration scripts should set the IMAGETYP accordingly, like e.g. *notcam.skyflat, alfosc.easyflat* currently set IMAGETYP to FLAT, and all *calibexp* scripts set the spectroscopy lamps to WAVE or LAMP. Should be updated to use multiple values.

- Focus scripts (and/or the focus pyramid in the beam) should set IMAGETYP to 'FOCUS'.

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[4]We have exluded ESO values such as ASTROMETRY,SCREEN,PSF-CALIBRATOR,SLIT,FIBER, FMTCHK,ORDERDEF,OzPoz.

Table 2: Allowed values for image type keyword IMAGETYP.

Value	Explanation
OBJECT	Any observation of an unspecified object
STD	Any observation of a standard celestial calibration source
BIAS	Readout frame
DARK	Dark exposure (shutter closed)
FLAT	Any flat field exposure
SKY	Any observation of an "empty" field in the sky
LAMP	Any lamp exposure
DOME	Any dome exposure
FLUX	Any flux standard (spectroscopy and photometry)
VELOC	Any radial-velocity standard
HPOL	Any high-polarization standard
ZPOL	Any zero-polarization standard
WAVE	Any (instrument-internal) wavelength calibration
SLIT	Any non-spectroscopic exposure using a slit
FOCUS	Any focus exposure
COUNTTEST	Any count test exposure used to check exposure times (added at the NOT)

- IMAGETYP is automatically set to DARK when the shutter is closed and to BIAS if also the extime is zero (for CCDs, not for IR arrays).

- Different types of standard calibration sources can be specified using 'STD,FLUX' for a photometric or flux standard, or for high-polarization standards 'STD,HPOL'.

Currently at NOT, the IMAGETYP keyword contains only one value. With this upgrade it will be possible to set for example 'FLAT,SKY' for skyflats and 'FLAT,DOME' for domeflats. This has consequences for existing pipelines and reduction scripts will need modification (e.g. mkflat in notcam.cl) A particular setting for NOTCam beamswitch observations is the current the use of the value 'SKY' for the OFF field observed in the alternating ON-OFF target stream ('OBJECT' for the ON field). This was implemented in *notcam.beamswitch* to facilitate the reductions, and it is not in contradiction with the ESO convention we have adopted.

4.2.3 OBS_MODE

OBS_MODE[5] defines the observing mode or technique, and at NOT this keyword can take any of the values listed in Table 3. This mode is already partially implemented at the NOT with IMAGING and SPECTROSCOPY as the only values set until now. Note that these differ from the ESO values IMAGE and SPECTRUM. We recommend keeping our already introduced values. Another difference with ESO and NOT is that we define an image as either IMAGING or SPECTROSCOPY with POLARIMETRY as an additional description, i.e. one can have either imaging polarimetry or spectro-polarimetry. At ESO 'POLARIMETRY'[6] is a stand-alone value.

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[5]The keyword OBS_MODE is listed among the commonly used HEASARC keywords in [NASA FCG dictionary of common keywords] where the definition is: "The value field shall contain a character string which gives the observing mode of the observation. This is used in cases where the instrument or detector can be configured to operate in different modes which significantly affect the resulting data. Examples: 'SLEW', 'RASTER', or 'POINTING'".

[6]ESO has Wollaston and wiregrid to describe polarimetry. Wollaston does not fully describe our current FAPOL setup, so we suggest instea the more generic DUAL-BEAM, which is then provided by either a Wollaston

Table 3: Allowed values for the bserving technique keyword OBS_MODE.

Value	Explanation
IMAGING	Any image that is not a spectrum
SPECTROSCOPY	Any spectrum
LONGSLIT	A long-slit spectrum
ECHELLE	A cross-dispersed spectrum
FIBERECHELLE	A cross-dispersed spectrum through a fiber
MOS	Multiple object spectroscopy through a pre-manufactured mask[7]
POLARIMETRY	Polarimetric exposure
CORONOGRAPHY	Coronography exposure
FOCUSPYR	Focus pyramid exposure
SIMULTHAR	Simultaneous target and ThAr exposure
WIRE_GRID	Wire grid polarimetry (polarizers)
DUAL-BEAM	Dual-beam (provided by Calcite plates or Wollastons)
RETARDER	Retarder plate (for instance lambda/2 and lambda/4 for FAPOL)
NODDING	Exposure using telescope nodding/dithering

Most of the OBS_MODE settings are determined by the current instrument setup (at the start of the exposure) and should be set automatically, based on optical elements, through the observing system. Probably the only user-interactive setting of OBS_MODE is for the value 'NODDING'[8], set by the dither scripts.

- The OBS_MODE can contain one or more of the above values, separated by comma, and if more than one then they should appear in the above order.

- For ALFOSC and NOTCam, instruments that can do both imaging and spectroscopy, the value shall be set to 'SPECTROSCOPY' if there is a grism in the beam and to 'IMAGING' if not.

- All FIES data will have OBS_MODE set to 'SPECTROSCOPY,FIBERECHELLE' and future polarimetry is accounted for by adding 'POLARIMETRY'.

- Use of a coronagraph (ALFOSC only) will set OBS_MODE to 'IMAGING,CORONOGRAPHY'

- Observations obtained with telescope offsetting between images (dithering) will have OBS_MODE set to 'IMAGING,NODDING' or 'SPECTROSCOPY,NODDING'.

The value NODDING will be added to OBS_MODE by the sequencer script that defines the dither observation, which also will set two more keywords to define the total number of noddings to be done, and the nodding position in the current image. See Tab. 13 for details.

4.2.4 EXAMPLES

As examples of proper combinations of these three keywords, we describe a dithered twilight imaging flat as follows:

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or a Calcite, and add RETARDER. Future modes of polarisation in NTE and FIES must be describable with the keywords we now define.

[8]We here adopted NODDING from ESO, but we could use our own DITHER, for instance. This is more in line with our terminology, also for the OB generator.

IMAGECAT = 'CALIB'
IMAGETYP = 'FLAT,SKY'
OBS_MODE = 'IMAGING,NODDING'

While for instance a FIES simultaneous target and ThAr exposure is described with:

IMAGECAT = 'SCIENCE'
IMAGETYP = 'OBJECT,WAVE'
OBS_MODE = 'SPECTROSCOPY,FIBERECHELLE,SIMULTHAR'

And a series of exposures taken with the focus pyramid or a through-focus sequence:

IMAGECAT = 'TECHNICAL'
IMAGETYP = 'FOCUS'
OBS_MODE = 'IMAGING,[FOCUSPYR]'

The images (with and without slit) taken during an acquisition on slit/fiber:

IMAGECAT = 'ACQUISITION'
IMAGETYP = 'OBJECT'
OBS_MODE = 'IMAGING'

A flux standard observed with ALFOSC:

IMAGECAT = 'CALIB'
IMAGETYP = 'STD,FLUX'
OBS_MODE = 'SPECTROSCOPY,LONGSLIT'

A zero-polarization standard star spectrum taken with the ALFOSC WeDoWo:

IMAGECAT = 'CALIB'
IMAGETYP = 'STD,ZPOL'
OBS_MODE = 'SPECTROSCOPY,POLARIMETRY,DUAL-BEAM'

A science target imaged with ALFOSC and FAPOL (using either the lambda/2 or the lambda/4 retarder; the calcite plate providing the dual-beam):

IMAGECAT = 'SCIENCE'
IMAGETYP = 'OBJECT'
OBS_MODE = 'IMAGING,POLARIMETRY,DUAL-BEAM,RETARDER'

A dithered science target observed in imaging mode with ALFOSC, MOSCA, StanCam or NOTCam:

IMAGECAT = 'SCIENCE'
IMAGETYP = 'OBJECT'
OBS_MODE = 'IMAGING,NODDING'

Table 4: An example of ALFOSC spectroscopy target acquisition, calibrations and science frames

Image	IMAGECAT	IMAGETYP	OBS_MODE
A binned full-frame	ACQUISITION	OBJECT	IMAGING
A windowed image	ACQUISITION	OBJECT	IMAGING
An image of the slit	ACQUISITION	OBJECT, SLIT	IMAGING
A HeNe frame	CALIB	WAVE	SPECTROSCOPY, LONGSLIT
A halogen image	CALIB	FLAT, LAMP	SPECTROSCOPY, LONGSLIT
A Science frame	SCIENCE	OBJECT	SPECTROSCOPY, LONGSLIT
A bias frame	CALIB	BIAS	

4.3 Proposal information

In addition to the above three main keywords to describe the observation, a full description of the data requires information on to the proposal ID, the PI info, the observing block (OB) identification, the observing script name, exposure mode parameters etc.

Here we have to define what phase 1 and phase 2 proposal info is required in the header, what additional keywords are needed. But all the details go in the tables at the end of the document, in any case.

4.4 Notes on the implementation

We note that a full description of the exact implementation of the FITS header keywords is not the scope of this document. Nevertheless, it is worth mentioning that minimizing overheads in the data acquisition is a major concern. Therefore it should be considered which keywords need to be set real-time, and which can be implemented in a post-processing manner.

We note that some parameters have double set of keywords with values recorded both at the start and the end of the integration.

Some special observing modes may need only a minimum set of header keywords. For example, the future "burst" mode for very fast imaging with NOTCam requires only a minimum set of timing keywords for each individual image extension header. This special data product, see [Djupvik et al. 2012], will probably be stored in a huge file with each single image in an extension, adding up to a total of hundred(s) of extensions. The full set FITS header keywords will be recorded only in the primary header.

4.5 Proposed classes/packages

The FITS headers of NOT data files will consist of the following classes/packages. Mandatory keywords are listed first. Going top-down and following ESO Guidelines [ESO DICB v2] nr 3, 5, and 7 regarding the order of the subsequent FITS keyword classes/packages loosely the list could be as follows:

Note, this is a provisional list and needs to be re-organized

- FITS mandatory keywords

- WCS (World Coordinate Systems)

- Data description (including imagetype, PI info, Observing script, command info)

- Observation

- Object information

- Site information

- Meteo (external measurements)

- TCS (including dome and internal measurements)

- Adapter (CCDprobe, ADC, or any other piece of foreoptics, like a general polarization unit)

- Autoguider

- FASU

- Other calibration lamps (Baffle lamp, halogen lamp on the dome floor)

- Instrument

- Detector (allow for channel/multiple amplifier information)

- Pipeline/postprocessing/Quality Control

- Any other...

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5   NOT FITS documentation

The following documentation for FITS headers for NOT common-user instruments is adopted from [Prins 2004]. It includes the keyword origin, format of the value field, contents of the value field where fixed, contents of comment field, status, implementation priority.
Possible values for the keyword origin are:

Mandatory	Mandatory keywords are required in every header data unit. They should only be used as described in [Pence et al. 2010], and should be written in fixed format.
Reserved	Reserved keywords should only be used for meanings as described in [Pence et al. 2010]. The values of reserved keywords can be expressed either in fixed or in free format.
NOT	Keywords defined at NOT. The values of NOT keywords can be expressed either in fixed or in free format.
NOAO	Keywords defined at NOAO, including those for use with IRAF. The values of NOAO-style keywords can be expressed either in fixed or in free format.
HEASARC	Keywords defined by the NASA HEASARC FITS Working Group
CUO	Perhaps CUO for a lot of the detector information??

Possible formats for the keyword value are:

Fixed B	Boolean/Logical in fixed format. T or F in column 30
Free B	Boolean/Logical in free format. T or F in any column between columns 11-80
Fixed I	Integer in fixed format. Right justified in columns 11-30
Free I	Integer in free format. In any column between columns 11-80
Fixed F	Real floating point number in fixed format. Right justified in columns 11-30
Free F	Real floating point number in free format. In any column between columns 11-80
Fixed C	Character string in fixed format. Single opening quote in column 11, followed by the string starting in column 12. Closing single quote in any column between columns 20-80.
Free C	Character string in free format. Starting and closing quote in any column between columns 11-80

Possible values for the keyword status are:

Implemented	This keyword is present in the current NOT FITS headers of all instruments.
New	A new keyword is proposed for the NOT FITS headers.
Remove	This keyword is present in the current NOT FITS headers, but its use should be discontinued. XXX who can think of a better value for this status? (I thought of obsolete, but that does not seem appropriate, since some of the keywords refer to things which make good sense in a different context)
Revise	This keyword is present in the current NOT FITS headers, but needs to be revised. This entry holds the proposed revised version.

Table 5: FITS mandatory class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
				Primary header		
SIMPLE	Mandatory	Fixed B	T	Conform FITS standard	Implemented	This is a mandatory for the primary header and must not appear in extension headers. A value of F signifies that the file does not conform to this standard.
BITPIX	Mandatory	Fixed I		Bits per pixel	Implemented	Table 28 below
NAXIS	Mandatory	Fixed I		Number of axes in data array	Implemented	A non-negative integer no greater than 999 representing the number of axes in the associated data array. A value of zero signifies that no data follow the header in the HDU.
END	Mandatory		No value	End of header unit	Implemented	
				Conforming extensions		
XTENSION	Mandatory	Fixed C		see comment 1	Implemented	A character string giving the name of the extension type
BITPIX	Mandatory			see comment 1	Implemented	
NAXIS	Mandatory			see comment 1	Implemented	
NAXISn	Mandatory			see comment 1	Implemented	
PCOUNT	Mandatory	I	0	see comment 1	Implemented	In IMAGE this must have the value 0
GCOUNT	Mandatory	I	1	see comment 1	Implemented	In IMAGE this must have the value 1
END	Mandatory			see comment 1	Implemented	

Comment 1 (XTENSION -) *See the 'Value', 'Comment field' and 'Description' from http://heasarc.gsfc.nasa.gov/docs/fcg/standard_dict.html*

Comment 2 (Mandatory Keyword Order -) *Primary header: The SIMPLE keyword is required to be the first keyword in the primary header of all FITS files. The* **primary header** *must contain the other mandatory keywords in the order given. Other keywords must not intervene between the SIMPLE keyword and the last NAXISn keyword.* **Conforming extensions**: *All conforming extensions, whether or not further specified in the FITS 3.0 standard, must use the keywords defined above in the Table in the order specified. Other keywords must not intervene between the XTENSION keyword and the GCOUNT keyword.*

Table 6: General descriptive keywords

Keyword	Origin & Format		Value field	Comment field	Status	Notes
ORIGIN	Reserved	Free C	NOTSA	Nordic Optical Telescope Scientific Association	Incomplete	Organization or institution responsible for creating the FITS file
EXTEND	Reserved	Fixed B	T	FITS dataset may contain extensions	Implemented	Only Primary HDU, advisory keyword. If the value is T then there may be conforming extensions.

Table 6: General descriptive keywords ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
COMMENT	Reserved	C			Implemented	Any comments regarding the FITS file. May occur any number of times in the FITS header.
HISTORY	Reserved	C			New	History of step and procedures associated with data.
FILENAME	NOAO	Free C	cccciiiii	Filename on disk	Implemented	The host file name used to record the original data
CREATOR	HEASARC	Free C	CCD3COMM	The software and version that created the file	Revise	Comment field missing. For CCD3COMM the version is missing. For NOT2MEF the version is included. The value field shall contain a character string giving the name, and optionally, the version of the program that originally created the current FITS HDU.

Comment 3 (Other keywords -) *Keywords from http://heasarc.gsfc.nasa.gov/docs/fcg/common_dict.html which are probably not needed by us*
FILETYPE,ROOTNAME,CONFIGUR Also: NEXTEND,HDUNAME,HDUVER,HDULEVEL,TLMINn TLMAXn TDMINn TDMAXn TDBINn, HDUCLASS HDU-DOC HDUVERS HDUCLASn

Comment 4 (Bibliographic reserved kywords -) *AUTHOR- Character string identifying who compiled the information in the data associated with the header.*
REFERENCE-Character string citing where the data associated with the header are published.

Table 7: Describing observations keyword

Keyword	Origin & Format		Value field	Comment field	Status	Notes
TELESCOP	Reserved	Free C	NOT	Name of telescope	Revise	
INSTRUME	Reserved	C		Name of instrument	Revise	
OBSERVER	Reserved	C		Observer who acquired the data	Incomplete	Not set in a reliable way, should be taken from a database
OBJECT	Reserved	C		Name of the object observed	Revise	"Shall contain a character string giving a name for the object observed" according to [Pence et al. 2010]. Currently not set in a reliable way, see comment 5.
OBSERVAT	NOAO	Free C	'LaPalma '		Revise	
LONGITUD	NOT	Free F	-17.88508	[deg] telescope geodetic longitude	New	Human readable coordinate.
LATITUD	NOT	Free F	+28.75728	[deg] telescope geodetic latitude	New	Human readable coordinate.
ELEVAT	NOT	Free F	2382	[m] elevation above sea level in meters	New	Human readable coordinate.

Table 7: Describing observations keyword ... continued

Keyword	Origin & Format	Value field	Comment field	Status	Notes
OBJRA	NOAO	F		[deg] Catalogue RA in decimal degrees	Revise	
OBJDEC	NOAO	F		[deg] Catalogue DEC in decimal degrees	Implemented	
OBJPMRA	NOT	F		["/yr] Catalogue proper motion in RA in arcsec per year	Revise	
OBJPMDEC	NOT	F		["/yr] Catalogue proper motion in DEC in arcsec per year	Revise	
OBJEQUIN	NOAO	F	2000.0	Catalogue equinox for coordinates	Implemented	
OBJRADEC	NOAO	C		Catalogue coordinate reference system	New	
IMAGECAT	NOT	C		Image Category	New	See Table 1 for details.
IMAGETYP	NOAO	C		Image type	Revise	Not set in a reliable way. See Table 2 for details.
OBS_MODE	NOT	C		Observing technique/mode	Revise	Partially implemented. See Table 3 for details.
TITLE	ROSAT	C		Title for the observation or data	New	The value field shall contain a character string giving a title that is suitable for display purpose
EXPMODE	NOT	C		Exposure command	Revise	A string containing the sequencer command used to start an exposure, e.g. 'exp-count -f -m 100 1200'. Only available for NOTCam
		Keywords which should be removed				
TCSTGT	NOT	C		Catalogue object name	Remove	Contents are fine, but keyword name is rather cryptic. See comment 5.

Comment 5 (OBJECT -) *The OBJECT keyword should substitute TCSTGT to always be set with the TCS catalogue target name. The old "free" use of OBJECT will be substituted by another keyword, for instance an already existing ROSAT keyword called TITLE, or: LABEL, INFO, OBSINFO ..., suggestions?. If telescope is parked in zenith, OBJECT='zenith', or not parked but idle, OBJECT = 'idle'?*

Comment 6 (EXPMODE -) *Since EXPTIME can be different for each image extension for NOTCam and not available in the primary header, EXPMODE must be used to inform about the exposure time in observing logs etc.*

Table 8: Date, Time and timing Keywords

Keyword	Origin & Format	Value field	Comment field	Status	Notes
DATE	Reserved	C		Date/time of HDU creation	Revise	

Table 8: Date, Time and timing Keywords ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
DATE-OBS	Reserved	C		Date/time of Start of observation	Implemented	Start of observation in yyyy-mm-ddThh:mm:ss.s format, unless other interpretation is clearly exlained in the comment field. Shutter opening time (?).
DATE-BEG	Reserved	C		Date/time of start of data	New	Start of integration. See comment 8.
DATE-AVG	Reserved	C		Calender date of mid-point of the observation	Implemented	
DATE-END	Reserved	C		End of observation	New	End of observation in yyyy-mm-ddThh:mm:ss.s format, unless other interpretation is clearly exlained in the comment field.
MJD-OBS	Reserved	F		Modified Julian Date (JD - 2 400 000.5) of the start of the observation	New	Modified Julian Date (JD - 2 400 000.5) of the start of the observation, unless another interpretation is explained in the comment field.
MJD-BEG	Reserved	F		Modified JD of the start of data	New	See comment 8 .
MJD-AVG	Reserved	F		Modified JD of the mid-point of the observation	New	
MJD-END	Reserved	F		Modified JD of the end of the observation	New	
MJDREF		F		Zero point in MJD	New	Can be split into two keywords MJDREFI and MJDREFF for the integer and decimal part, respectively.
BJD-OBS		F			New	Barycentre-corrected Julian Date of midtime of observation
TREFPOS		C		Time reference position	New	Default is Topocenter See sect. 4.1.3 in [Rots et al. 2013]
TIMESYS		F	UTC	The temporal reference frame	New	Strongly recommended. The default is UTC.
TIMEUNIT		C	s	The time unit	New	The default is seconds.
TIMSYER		F		[s] Absolute time error	New	
TIMRDER		F		[s] Relative time error	New	
ST	NOT	F		Sidereal time at start (9h:0m:23.1s)	Implemented	
STX	NOT			Sidereal time in sexagesimal format	New	sexagesimal format in value field
TM_START	NOT	Fixed F		[s] Start of integration [tbd]	Revise	Currently: Seconds since midnight with human-readable version in Comment Field.
TM_END	NOT	Fixed F		[s] UT end of CCD readout	Revise	Seconds since midnight. Is the end of readout interesting for astronomers? The end of integration is much more interesting.

Table 8: Date, Time and timing Keywords ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
EXPTIME	NOAO	F		[s] Exposure time	Revise	The exact definition of 'exposure time' is mission dependent and may, for example, include corrections for shutter open and close duration, detector dead time, vignetting, or other effects
GEXPTIME		F		[s] Duration of one of multiple frames	New?	
XPOSURE		F		[s] Net exposure time	New	Corrected for dead time and lost time. If the HDU contains multiple time slices, it shall be the total accumulated exposure time. See Sect. 4.6 in [Rots et al. 2013].
TELAPSE		F		[s] Time elapsed between start and end of observation	New	The value field shall contain a floating point number giving the difference between the stop and start times of the observation in units of seconds. This keyword is synonymous with the ELAPTIME keyword. Useful for data streams e.g. NIR "burst mode".
			Keywords which are probably not needed			
JD-OBS					New	Julian Date of midtime of observation in fractional days
			Keywords which should be removed			
TM-START	CUO	Fixed I		04/45/58 UT start time	Remove	Identical to TM_START for FIES, MOSCA and NOTCAM. Integer nr of seconds since midnight; has human-readable version of time in comment field.
UT	NOT			TCS UTC at start (4h:46m:1.0s)	Remove	See comment 11.

Comment 7 (Representation of Time Coordinates -) *See the keywords in [Rots et al. 2013]*

Comment 8 (DATE-BEG -) *While the keyword DATE-OBS denotes the start of an observation, it may not always refer to the exact start of the exposure (e.g. the NOTCam pre-read, shutter opening time, etc.). According to [Rots et al. 2013] one should use DATE-BEG, DATE-AVG, and DATE-END to define the start time of data, the average time of data, and the stop time of data. These are all date-time strings. The corresponding is valid for the MJD-xxx keywords (float). It is also recommended to use the keywords TSTART and TSTOP for the start and end of data given as relative to a time reference value, a possible alternative to our TM_START and TM_END, although the latter gives end of readout.*

Comment 9 (TIMESYS -) *Strongly recommended. Default time system to use is UTC. If the UTC is taken from a GPS receiver, then it needs to be known whether the GPS receiver has implemented the necessary corrections to the satellite clocks and ionosphere. The absolute time error is given with keyword TIMSYER and the relative error (between time stamps) with TIMRDER. See [Rots et al. 2013].*

Comment 10 (EXPOSURE, TELAPSE -) *These keywords are synonymous with the EXPTIME and ELAPTIME keywords. LIVETIME-exposure time after dead-time correction; ONTIME-integration time during the observation. The keyword for exposure time corrected for deadtime is suggested to be XPOSURE by [Rots et al. 2013].*

Comment 11 (UT -) *TSTART, TSTOP, DATEREF can be used as alternative/additional times with decimal time for DATE-OBS and DATE-END where DATEREF is the reference time*

Table 9: Reserved keywords that describe arrays

Keyword	Origin & Format		Value field	Comment field	Status	Notes
BSCALE	Reserved	F		Linear factor in scaling equation	Revise	Default 1.0
BZERO	Reserved	F		Zero point in scaling equation	Revise	Default 0.0
BUNIT	Reserved	C	Count	Physical unit of pixel values	Revise	Change to ADU
BLANK	Reserved	I		Represents pixels that have an un-defined physical value	New	Shall be used only with positive values of BITPIX
DATAMAX	Reserved	F		Maximum physical value	Revise	Physical value after scaling, now Integer
DATAMIN	Reserved	F		Mininum physical value	Revise	Physical value after scaling, now Integer

Comment 12 (Keyword field is blank -) *This keyword may be used to supply any comments regarding the FITS file. It is frequently used for aesthetic purposes to provide a break between goups of related keywords in the header. BLANK keyword shall be used only in primary array headers or IMAGE extension headers with positive values of BITPIX (i.e., in arrays with integer data).*

Table 10: Extension keywords

Keyword	Origin & Format		Value field	Comment field	Status	Notes
EXTNAME	Reserved	C		Name of the extension	Implemented	
EXTVER	Reserved	I		version of the extension	New	Distinguish different extensions with the same type and name (XTENSIONm EXTNAME)
EXTLEVEL	Reserved	I		hierarchical level of the extension	New	The highest level is 1, Specify the level of hierarchy of extension levels of the extension containing it
IMAGEID	NOAO	I		Image identification	Revise	Integer version of EXTNAME. The image identification when there are multiple images within an observation. For detectors with CCDs this would be a unique number assigned to each amplifier in the detector.

Comment 13 (Extension keywords -) *These may appear in the primary header with analogous meaning as in the extensions. It is recommended that they have unique combination of values in each HDU of the FITS file.*

Table 11: FITS WCS representation reserved keywords

Keyword	Origin & Format		Value field	Comment field	Status	Notes
WCSAXES	Reserved	I		Number of Axes in the WCS description	New	This keyword, if present, must precede all WCS keywords except NAXIS
CTYPE	Reserved	C		Axis type	Implemented	Coordinate type & an algorithm code for computing the world coordinate value.
CUNITi	Reserved	C		Physical units of CRVAL and CDELT for axis i	Implemented	Celestial coordinate systems must be degrees. see [Pence et al. 2010]
CRPIXj	Reserved	F		Reference point	Implemented	
CRVALi	Reserved	F		World Coordinate value at the reference point of axis i	Implemented	World Coordinate value at the reference point of axis i
CDELT	Reserved	F		Coordinate increment along axis	Revise	Value must not be zero
CDi_j	Reserved	F		Linear transformation matrix	Implemented	An exclusive alternative to PC-matrix
CRDERi	Reserved	F		Coordinate random error	New	default 0.0, non-negative
CSYERi	Reserved	F		Coordinate systematic error	New	default 0.0, non-negative
PCi_j	Reserved	F		Linear transformation matrix	New	Not needed see Comment 18
PVi_m	Reserved	F		Numeric parameter values for intermediate world coordinate axis i	New	Not needed see Comment 18
PSi_m	Reserved	C		Character-valued for intermediate world coordinate axis i	New	Not needed see Comment 18
WCS celestial coordinates						
RADESYS	Reserved	Fixed C		Reference celestial coordinate system	New	Allowed values, see Table 24 in [Pence et al. 2010], see ??
RADECSYS		C	FK5		Remove	Deprecated. Use RADESYS instead.
EQUINOX	Reserved	Fixed F	2000.0	Epoch of the mean equator in years	Revise	Comment field empty for MO & NC
LONPOLE	Reserved	F		Longitude in the native coordinate system of the celestial system's north pole	New ??	
LATPOLE	Reserved	F		Latitude in the native coordinate system of the celestial system's north pole	New ??	
WCS spectral coordinates						
SPECSYS	Reserved	C		The reference frame for the use of spectral coordinates	New	Valid values, see Table 27 in [Pence et al. 2010]
SSYSOBS	Reserved	C		The spectral reference frame that is constant over the range of non-spectral world coordinates	New	Default TOPOCENT, valid values, see Table 27 in [Pence et al. 2010].
OBSGEO-X	Reserved	Fixed F	5327395.9638	[m] Cartesian X in meters	Revise	
OBSGEO-Y	Reserved	Fixed F	-1719170.4876	[m] Cartesian Y in meters	Revise	

Table 11: FITS WCS representation reserved keywords ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
OBSGEO-Z	Reserved	Fixed F	3051490.7660	[m] Cartesian Z in meters	Revise	
VELOSYS	Reserved	F		[m/s] Radial velocity wrt standard of rest	New	RV between the observer and the selected standard of rest in the direction of the celestial reference coordinate.

Comment 14 (Reserved depreceted WCS keywords -) *CROTAi, EPOCH, hould not be used*

Comment 15 (WCSAXES -) *Not implemented, maybe needed if spectroscopy WCS are used. Other reserved spectral WCS keywords (SSYSSRC, ZSOURCE, VELANGLE), see in detail [Pence et al. 2010].*

Comment 16 (BURST -) *Time may enter as a third axis. For the future NOTCam BURST mode of observing, a cube of N short exposures (exptime=t) are to be stored in the same file. This requires NAXIS=3, time being the 3rd dimension, NAXIS3=N, CUNIT3=s, CRPIX3=t, CRVAL3="relative time of first frame", CDELT3="axis scale at reference point", and CTYPE3 = UTC.*

Comment 17 (OBSGEO -) *See also [Rots et al. 2013] for calculation. The ITRS cartesian coordinates are the preferred coordinate system, and although similarly defined geodetic coordinates are regocnized (OBSGEO-B,OBSGEO-L, and OBSGEO-H), only one set of coordinates is allowed in a give HDU. 09-07-2013. AAD.*

Comment 18 (PC vs CD matrix -) *PCi_j and CDi_j forms of the transformation matrix are mutually exclusive, and must not appear together in the same HDU. CD matrix is equivalent to PC when CDELT is unity.*

The PC formalism came before CD matrix.. It refers to the simple linear transformation matrix with rotation and skew in the first step and then the physical scaling as a 2nd step, hence the need for the keyword CDELT, representing the physical scale.

The CD formalism was developed for the HST (and incorporated in IRAF) in order to do both rotation, skewness and scaling in the same matrix multiplication, thereby discarding the need for the CDELT keyword.

Both are allowed (but not mixed) and Greisen et al. advocate for the usefulness of the PC formalism if one needs to correct for a distortion only in pixel coordinates, and later do the scaling.

The CD matrix is useful in the case of simple 2D images, as we already have it, but the PC matrix should be used if one wants to add time and/or frequency as a third and/or fourth dimension in the transformation, i.e. valid for the future NOTCam burst mode, for instance.

Note, if no CDi_j keywords are present then the header shall be interpreted as being in PCi_j form whether or not any PCi_j keywords are actually present in the HDU.

Table 12: Keywords that describe the telescope pointing

Keyword	Origin & Format		Value field	Comment field	Status	Notes
RA	NOAO	F	173.1132917441	[deg] Right Ascension at start (11h:32m:27.1s)	Implemented	Units in decimal degrees. The coordinate reference frame is given by the RADECSYS keyword, and the coordinate epoch is given by the EQUINOX keyword. See Tab. 11

Table 12: Keywords that describe the telescope pointing ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
DEC	NOAO	F	27.71005616547	[deg] Declination at start (27d:42m:36.2s)	Implemented	see RA, above
RAH	NOT?	F		Right Ascension at start in decimal hours	New	
RAX	NOT	C	11:32:27.1	[hour] Right Ascension at start (sexagesimal)	New	
DEX	NOT	C	27:42:36.2	[deg] Declination at start (sexagesimal)	New	
HA	NOAO	F		[hour] Hour angle at start in decimal hours	New	+-12,The time stamp from DATE-OBS
AZIMUTH	NOT	F	91.1357574463	[deg] Telescope azimuth at start, West from South	Revise	See comment 19.
TELALT		F	72.353225708	[deg] Telescope altitude at start	Revise	No need to have separate zenith distance keyword
AIRMASS	NOAO	F	1.0493801507883	Airmass at start (sec(z))	Implemented	
AIRMASS2	NOT	F		Airmass at end (sec(z))	New	
AIRM-MID	NOT	F		Airmass at the time of DATE-AVG (sec(z))	New	
FIELD	NOT	F	90.0022	[deg] Field rotation at start	Current	The time from DATE-OBS
SKYPA	NOT	F		[deg] Sky position angle at start	New	Measured XX of XX, see comment 19.
ROTPOS	NOT	F		[deg] Rotator angle at start	Current	The time from DATE-OBS
ROTPOS2	NOT	F		[deg] Rotator angle at end	New	The time from DATE-END
IPARANG	NOT	F		[deg] Rotator angle where slit is vertical wrt horizon	New	
PARANG	NOT	F		[deg] Parallactic angle at start	New	The time from DATE-OBS
PARANG2	NOT	F		[deg] Parallactic angle at end	New	The time from DATE-END
SLITPA	NOT	F		[deg] Sky position angle of slit	New	
PARALDIF	NOT	F		[deg] Difference between SLITPA and true parallactic angle	New	
TELFOCUS	NOT	F		Telescope focus at start	Implemented	This is the focus after taking into account any filter etc dependent delta focus.
SUNANGLE	STSCI	F		[deg] Angle between the observation and the Sun	New	The time from DATE-OBS
MOONANGL	STSCI	F		[deg] Angle between the obsservation and the Moon	New	The value field shall contain a floating point number giving the angle between the direction of the observation (e.g., the optical axis of the telescope or the position of the target) and the moon, measured in degrees. The time from DATE-OBS

Table 12: Keywords that describe the telescope pointing ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
MOONILLU	NOT	F		[%] Moon illumination in percentage	New	The time from DATE-OBS
TRACKMOD	NOT	C		Tracking mode (normal, differential, none)	New	Tracking mode
DTRCK_RA	NOT	F		["/hour] Differential tracking rate in RA in arcsec per hour	New	Set to zero when TRACKMOD is normal.
DTRCK_DE	NOT	F		["/hour] Differential tracking rate in DEC in arcsec per hour	New	Set to zero when TRACKMOD is normal.

Comment 19 (ANGLES -) *All positional angular measurements should have a clear definition. E.g., measured East from North.*

Comment 20 (RAX,DEX -) *New keywords RAX and DEX in sexagesimal coordinates in the Value field. The accuracy of the coordinates should be defined.*

Comment 21 (PARANG -) *This is the keyword name ESO uses for the parallactic angle. Replaces the previous suggestion PRALLAC. The keyword IPARANG is used for our so-called "instrument parallactic angle", the reference position for the rotator such that the slit used is vertical wrt horizon. The suggested keyword PARALDIF is perhaps not needed since we have IPARANG, ROTPOS and ROTPOS2. Comments?*

Comment 22 (TRACKMODE -) *NOAO defines tracking rates with the keywords TELTKRA, TELTKDEC in units of arcsec per second. We enter the differential tracking rates at the TCS in units of arcsec per hour, which is why we should use this unit in the headers as well. (ESO uses TRAK RATEA and TRAK RATED in mas/sec).*

Table 13: Bibliographic/Proposal/Observing Block class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
PROPID	NOT	C	47-130	Proposal ID	New	
PROPTITL	NOT	C		Proposal title	New	
PINAME	NOT	C		PI name	New	
GROUPID	NOT	C		Observing group identification	New	
BLOCKID	NOT	C		Observing block identification	New	
OB_NAME	NOT	C		Observing block name	New	
SEQID	NOT	C		Observing block sequence number	New	
OB_SCRPT	NOT	C		Observing script name	New	
REQIMQ	NOT	F	1.0	["] Requested Image Quality (max seeing)	New	
REQAIRM	NOT	F	1.0	Requested maximum airmass	New	
REQSKY	NOT	C	Photometric	Requested sky transmission	New	

Table 13: Bibliographic/Proposal/Observing Block class/package ...
continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes	
REQMOON	NOT	C	Dark	Requested Background	New		Current use
REQMOOND	NOT	C	30	[deg] Requested minimum moon distance	New		Future use?
REQMOONI	NOT	I	20	[%] Requested maximum moon illumination	New		Future use?
REQWV	NOT	F	10	[mm] Requested maximum Water Vapour Column Density	New		Future use?
RELEASE	NOT	C	2013-05-30	End of proprietary period	New		format YYYY-MM-DD
CMMTcccc					New	3b	Observer comment ????

Comment 23 (PERIOD -) *Proposed by Peter, however the period is in PROPID, is this keyword needed?*

Table 14: Keywords that denote non-standard FITS keyword format conventions

Keyword	Origin & Format		Value field	Comment field	Status	Notes
HIERARCH	ESO	C		Denotes the HIERARCH keyword convention		see text
INHERIT	STSCI	C		Extension inherits primary header keywords	Implemented	The presence of this keyword with a value = T in an extension header indicates that the keywords contained in the primary header (except the FITS Mandatory keywords, and any COMMENT, HISTORY or 'blank' keywords) are to be inherited, or logically included in that extension header.
CONTINUE	HEASARC	C		denotes the CONTINUE long string keyword convention	New	The character string value may be continued on any number of consecutive CONTINUE keywords, thus effectively allowing arbitrarily long strings to be written as keyword value

Comment 24 (CONTINUE -) *The CONTINUE keyword, when followed by spaces in columns 9 and 10 of the card image and a character string enclosed in single quotes starting in column 11 or higher, indicates that the quoted string should be treated as a continuation of the character string value in the previous header keyword. To conform to this convention, the character string value on the previous keyword must end with the ampersand character ('&'), but the ampersand is not part of the value string and should be deleted before concatenating the strings together.*

Table 15: File checksum keywords

Keyword	Origin & Format		Value field	Comment field	Status	Notes
CHECKSUM	Cheksum	C		checksum for the current HDU	New	The value field of the CHECKSUM keyword shall contain a 16 character string, left justified starting in column 12, containing the ASCII encoded complement of the checksum of the FITS HDU (Header and Data Unit).
DATASUM	Cheksum	C		checksum of the data records	New	The value field of the DATASUM keyword shall be a character string containing the unsigned integer value of the checksum of the data records of the HDU.
CHECKVER	Cheksum	C		version of checksum algorithm	New	The value field of the CHECKVER keyword shall contain a string, unique in the first 8 characters, which distinguishes between any future alternative checksum algorithms which may be defined.

Comment 25 (DATASUM -) *For dataless HDU's, this keyword may either be omitted, or the value field shall contain the string value '0', which is preferred. A missing DATASUM keyword asserts no knowledge of the checksum of the data records*

Comment 26 (CHECKVER -) *The default value for a missing keyword shall be 'COMPLEMENT' which will represent the algorithm defined in the current proposal. It is recommended that this keyword be omitted from headers which implement the default ASCII encoded 32-bit 1's complement algorithm.*

Comment 27 (CHECKSUM -) *see http://fits.gsfc.nasa.gov/registry/checksum.html and http://arxiv.org/pdf/1201.1345v1.pdf*

Table 16: FITS meteo class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
AMBTEMP	NOT	F		[deg C] Ambient temperature in degrees Celsius (at start)	Revise	Outside temperature. NB! This keyword is currently used in STANCAM for the camera controller temperature.
DEWPOINT	NOT	F		[deg C] Dew point in degrees Celsius (at start)	New	
RELHUM	NOT	F		[%] Relative humidity in percentage (at start)	New	
WINDAVG	NOT	F		[m/s] Average wind speed in meters/sec	New	Filtered WS from TCS? Or average over the observation?
WINDMAX	NOT	F		[m/s] Maximum wind speed in m/sec	New	Maximum wind speed during the observation?

Table 16: FITS meteo class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
WINDDIR	NOT	F		[deg] Wind direction in degrees, measured East of North (at start)	New	Average wind direction. Measured XX of XX. See comments 19, 29
ATMPRESS	NOT	F		[hPa] Atmospheric pressure in hPa (at start)	New	
DIMMING	NOT	F		["] ING DIMM seeing in arc seconds (at start)	New	
DIMMING2	NOT	F		["] ING XX DIMM seeing in arc seconds (at start)	New	
DIMMSTNG	NOT	F		["] TNG DIMM seeing in arc seconds (at start)	New	
AEROSOLS	NOT	F		[micrograms/m3̂] Dust in micro grams / cubic meter	New	Other option is just dust status:0,1,2 no dust, a bit dusty, get your light sables!
FOCTEMP	NOT	F		[deg C] Focus temperature in degrees Celsius (at start)	New	
H2OVAPOR	NOT	F		[mm] Precipitable water vapor column density (at start)	New	

Comment 28 (METEO -) *Time stamp should be included to the comment field. The external measurements should have a timestamp attached (in comments field). Reasonable maximum ages would be 900s on DIMM measurements, 1800s on DUST and H2OVAPOR (before and after exposure). If the data is older than that the value should be 'N/A'. The keywords could be like DIMMING, DIMMING2, DIMMTNG etc*

Comment 29 (WINDDIR -) *TCS currently uses different zeropoint (South =0) for wind direction compared to web weather (North =0). The angles that enter the FITS header, such as AZIMUTH and WINDDIR, output from the TCS in the TCS definition (west of south), could/should be corrected in order to follow the standard definition (east of north)?*

Table 17: FITS Dome class/package, see comment **??**

Keyword	Origin & Format		Value field	Comment field	Status	Notes
MIRRORC	NOT	C	Open	Mirror cover position at start	New	Closed, Undefined, or Open
LOHATCH	NOT	C	Open	Lower hatch position at start	New	Closed, Undefined, or Open
UPHATCH	NOT	C	Open	Upper hatch position at start	New	Closed, Undefined, or Open
SIDEPRT1	NOT	C	Open	Side port 1 position at start	New	Closed, Undefined, or Open
SIDEPRT2	NOT	C	Open	Side port 2 position at start	New	Closed, Undefined, or Open
SIDEPRT3	NOT	C	Open	Side port 3 position at start	New	Closed, Undefined, or Open
SIDEPRT4	NOT	C	Open	Side port 4 position at start	New	Closed, Undefined, or Open
TELTEMP	NOT	F		[deg C] Telescope structure temperature	New	Adopted temp for internal focus correction.

Comment 30 (DOMEAZ -) *Should follow AZIMUTH (the telescope). This keyword is not needed.*

Table 18: FITS Adapter class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
CCDPROBE	NOT	C	park	CCD probe position	Revise	Values should change from park/split/ccd to park/fies/stancam
ADCARM	NOT	C	OUT	ADC arm position	Implemented	
ADCMODE	NOT	C	MANUAL	ADC mode	Implemented	When ADCARM is 'OUT', ADCMODE is MANUAL for all instruments, expect for ALFOSC where it is '0' (zero). Should be made consistent.
ADC1ANG	NOT	F	-0.00088	ADC prism 1 angle at start	Revise	The time from DATE-OBS
ADC2ANG	NOT	F	-0.00059	ADC prism 2 angle at start	Revise	The time from DATE-OBS
ADC1ENC	NOT	I	-99	ADC prism 1 encoder position	Revise	The time from DATE-OBS
ADC2ENC	NOT	I	-99	ADC prism 2 encoder position	Revise	The time from DATE-OBS
FIPOL	NOT	C	OUT	FIES polarizer arm IN/OUT or 1/0	New?	Dual beam polarizer
FIRETARD	NOT	C	OUT	FIES lambda/4 IN/OUT	New?	Retarder plate arm in or out
FIRETANG	NOT	F	0.	FIES lambda/4 retarder angle	New?	Retarder plate angle

Comment 31 (FIPOL -) *To be discussed what to call the future components of FIES polarimetry.*

Table 19: FITS autoguider class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
AUXPOS	NOT	I	139484	Autoguider probe X position	Implemented	
AUYPOS	NOT	I	16468	Autoguider probe Y position	Implemented	
AUBXXPOS	NOT	I	255	Autoguider star box X position	Implemented	
AUBXYPOS	NOT	I	255	Autoguider star box Y position	Implemented	
AUBXSIZE	NOT	I	11	Autoguider star box size	New	Default = 11
AUSBXPOS	NOT	I	300	Autoguider sky box X position	New	
AUSBYPOS	NOT	I	300	Autoguider sky box Y position	New	
AUSTATUS	NOT	I	3	Autoguider status (0=off,1=?,2=?,3=on,4=?,5=?)	Revise	
AUGAREA	NOT	C		Guide area used	New	
AUGSCID	NOT	C		Guide star GSC2.3 ID	New	Guide star GSC2.3 ID
AUGSRA	NOT	F		[deg] Guide star RA	New	Guide star GSC2.3 RA
AUGSDEC	NOT	F		[deg] Guide star DEC	New	Guide star GSC2.3 DEC
AUFMAG	NOT	F	11.0	[mag] Guidestar GSC F-mag	New	Guide star GSC F-mag

continued...

Table 19: FITS autoguider class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
AUJMAG	NOT	F	11.2	[mag] Guidestar GSC J-mag	New	Guide star GSC J-mag
AUFOCUS	NOT	I	475	Autguider focus at start	New	
AUSEEING	NOT	F	0.7	["] Autoguider seeing estimate in arcsec	New	
AUFLTID	NOT	I	2	Autoguider filter ID number	New	Using TCS ID number.
AUFLTNM	NOT	C	red	Autoguider filter name	New	
BOXMORA	NOT	F		["/hour] Box-motion RA rate	New	Default = 0.0
BOXMODEC	NOT	F		["/hour] Box-motion DEC rate	New	Default = 0.0

Table 20: FITS Baffle Lamp class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
BFLMP1	NOT	Fixed I	1=ON, 0=OFF	Baffle lamp 1 (on/off)	Revise	
BFLMP1ID	NOT	Free C	Model 64614 OSRAM 12 V 75W G5,3. Installed 11-07-2008.	Baffle lamp 1 ID	Revise	
BFLMP1NM	NOT	Free C	Halogen	Baffle lamp 1 verbose name	Revise	
BFLMP2	NOT	Fixed I	1=ON, 0=OFF	Baffle lamp 2 (on/off)	Revise	
BFLMP2ID	NOT	Free C	Oriel Pencil Shape spectral lamp 6030. Installed 2008.	Baffle lamp 2 ID	Revise	
BFLMP2NM	NOT	Free C	Argon	Baffle lamp 2 verbose name	Revise	
BFLMP3	NOT	Fixed I	1=ON, 0=OFF	Baffle lamp 3 (on/off)	Revise	
BFLMP3ID	NOT	Free C	Oriel Pencil Shape spectral lamp 6033. Installed 2004.	Baffle lamp 3 ID	Revise	
BFLMP3NM	NOT	Free C	Xenon	Baffle lamp 3 verbose name	Revise	

Table 21: FITS FASU (MOSCA) class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
FSHUTTER	NOT	I	'0'/'1'	FASU shutter status ('Open')	New	Value could be also 0/1
FAFLTNM	NOT	C		FASU 1/A Filter name	Implemented	
FAFLTID	NOT	I		FASU 1/A NOT filter number	Implemented	Unique NOT ID nummer.
FAFLTPOS	NOT	I		FASU 1/A Slot position	Implemented	Position of filter in wheel.
FBFLTNM	NOT	C		FASU 2/B Filter name	Implemented	
FBFLTID	NOT	I		FASU 2/B Filter NOT filter number	Implemented	Unique NOT ID nummer.
FBFLTPOS	NOT	I		FASU 2/B Slot position	Implemented	Position of filter in wheel.
CMIRROR	NOT	I?		FASU calibration mirror position	Implemented	See comment 32

Table 21: FITS FASU (MOSCA) class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
CLAMPn	NOT	I?	0/1	FASU calibration lamp_n is off	Implemented	
CLAMPNMn	NOT	C		FASU calibration lamp _n name	Implemented	
CLAMPIDn	NOT	Free C		FASU calibration lamp_n id	Implemented	Unique, technical ID
FARETARD	NOT	I?		Position of Retarder Plate	Implemented	'In' or 'Out', see comment 32
FAPOLID	NOT	C		FAPOL Retarder Plate ID	Implemented	
FARETANG	NOT	F		Retarder Plate Angle	Implemented	the values is -9999 when the Retarder Plate is out of the beam

Comment 32 (CMIRROR - TP) *At the moment CMIRROR has value 0 or 1 and the Comment field is either 'FASU calibration mirror is out' or 'FASU calibration mirror is in', the CLAMP_n has a similar status note that FARETARD has different logic. We should have a consitent way of desribing ON-OFF, OPEN-CLOSED values. At the moment it is mixed between 'ON'-'OFF', 'OPEN'-'CLOSED', '0'-'1'. Maybe the value for 'ON'/'OPEN' could be '1' and '0' for 'OFF'/'CLOSED' and '-99' for unkonwn/undefined/notknown? The comment field could have text like 'CLAMP1 is off', 'ALFOSC shutter is closed' etc.*

Comment 33 (FAPOLID -) *The value is either '620', 'lambda/2' or 'lambda/4'.*

Table 22: FITS ALFOSC class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
ALAPRTNM	NOT	C		ALFOSC aperture wheel. Name	Implemented	Aperture description. Slit, mask, calcite plate etc
ALAPRTID	NOT	I		ALFOSC aperture wheel. ID	Implemented	
ALAPRPOS	NOT	I		ALFOSC aperture wheel. Slot Position	Implemented	
ALAPRSTP	NOT	I		ALFOSC aperture wheel. Step Position	Implemented	
ALAPRORI	NOT	I?		ALFOSC aperture wheel. Element Orientation	Implemented	
ALAPRALG	NOT	I?		ALFOSC aperture wheel. Aperture aligned	Implemented	
ALFLTNM	NOT	C		ALFOSC filter wheel. Name	Implemented	
ALFLTID	NOT	I		ALFOSC filter wheel. NOT filter number	Implemented	
ALFLTPOS	NOT	I		ALFOSC filter wheel. Slot Position	Implemented	
ALFLTSTP	NOT	I		ALFOSC filter wheel. Step Position	Implemented	
ALFLTORI	NOT	I?		ALFOSC filter wheel. Element Orientation	Implemented	
ALSHSTAT	NOT	I?		ALFOSC shutter status	New	See comment 32 above

continued...

Table 22: FITS ALFOSC class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
SHSTAT			OPEN CLOSED	Shutter status	Current	
ALGRNM	NOT	C		ALFOSC grism wheel. Name	Implemented	
ALGRID	NOT	I		ALFOSC grism wheel. ID	Implemented	
ALGRPOS	NOT	I		ALFOSC grism wheel. Slot Position	Implemented	
ALGRSTP	NOT	I		ALFOSC grism wheel. Step Position	Implemented	
ALGRORI	NOT	I?		ALFOSC grism wheel. Element Orientation	Implemented	
ALGRALG	NOT	I?		ALFOSC grism wheel. Grism aligned	Implemented	
ALFOCUS	NOT	I?		ALFOSC camera focus position	Implemented	
ALCENWAV	NOT	F?		ALFOSC spectroscopy center wavelength	Implemented	Units are missing [nm or A?]
tbd					New	Grism dispersion [A /pix ?]

Table 23: FITS NOTCAM class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
SHSTAT		C	'OPEN'	Commanded shutter position.	Current	No feedback on actual shutter position.
NCSHUTTR	NOT	C	Open/closed	NOTCam shutter status (commanded)	New	No shutter pos feedback.
APERTUR					Old	Keyword kept in header, value is blank
NCAPRNM	NOT	C	'Open Large '	NOTcam aperture wheel. Name	Implemented	
NCAPRID	NOT	I	1006	NOTcam aperture wheel. NOT ID	Implemented	
NCAPRPOS	NOT	I	4	NOTcam aperture wheel. Slot pos	Implemented	
NCAPRSTP	NOT	I	28360	NOTcam aperture wheel. Step pos	Implemented	
NCAPRALG	NOT	B	'N '	NOTcam aperture wheel. Aligned	Implemented	
NCAPRORI	NOT	C	'Any'	NOTcam aperture wheel. Orientation	Implemented	
NCAPRSLX	NOT	F		[pix] X-value of slit position A	Implemented	
NCAPRSLY	NOT	F		[pix] Y-value of slit position A	Implemented	
FILTER1				NOTcam Filter 1 ID, step position	Old	(kept with blank value)
FILTER2				NOTcam Filter 2 ID, step position	Old	(kept with blank value)
NCFLTNMn	NOT			NOTcam filter wheel n. Name	Implemented	
NCFLTIDn	NOT			NOTcam filter wheel n. NOT ID	Implemented	
NCFLTPOn	NOT			NOTcam filter wheel n. Slot pos	Implemented	

continued...

Table 23: FITS NOTCAM class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
NCFLTSTn	NOT			NOTcam filter wheel n. Step pos	Implemented	
NCFLTORn	NOT			NOTcam flt wheel n. Orientation	Implemented	
STOP				NOTcam Stop ID, step position	Old	(kept with blank value)
NCSTPNM	NOT			NOTcam stop wheel. Name	Implemented	
NCSTPID	NOT			NOTcam stop wheel. NOT ID	Implemented	
NCSTPPOS	NOT			NOTcam stop wheel. Slot pos	Implemented	
NCSTPSTP	NOT			NOTcam stop wheel. Step pos	Implemented	
NCSTPALG	NOT			NOTcam stop wheel. Aligned	Implemented	
NCSTPORI	NOT			NOTcam stop wheel. Orientation	Implemented	
GRISM				NOTcam Grism ID, step position	Old	(kept with blank value)
NCGRNM	NOT			NOTcam grism wheel. Name	Implemented	
NCGRID	NOT			NOTcam grism wheel. NOT ID	Implemented	
NCGRPOS	NOT			NOTcam grism wheel. Slot pos	Implemented	
NCGRSTP	NOT			NOTcam grism wheel. Step pos	Implemented	
NCGRALG	NOT			NOTcam grism wheel. Aligned	Implemented	
NCGRORI	NOT			NOTcam grism wheel. Orientation	Implemented	
tbd				[nm?/pix] Grism dispersion	New?	
LENS				NOTcam Lens ID, step position	Old	(kept with blank value)
CAMERA		Free C		NOTcam Camera focus.	Old	(kept with blank value)
NCCAMNM	NOT			NOTcam lens wheel. Name	Implemented	
NCCAMID	NOT			NOTcam lens wheel. NOT ID	Implemented	
NCCAMPOS	NOT			NOTcam lens wheel. Slot pos	Implemented	
NCCAMSTP	NOT			NOTcam lens wheel. Step pos	Implemented	
NCCAMALG	NOT			NOTcam lens wheel. Aligned	Implemented	
NCCAMORI	NOT			NOTcam lens wheel. Orientation	Implemented	
NCFOCUS	NOT	I	4650	Internal focus, detector plate step position.	Revise	Comment field to be revised.
COLDTBL	NOT	F		[deg C] Cold Table temperature	Implemented	
OUTVESS	NOT	F		[deg C] Outer Vessel temperature	Implemented	
CNTWHEE	NOT	F		[deg C] Center Wheel temperature	Implemented	
PRESSUR	NOT	F	1.51E-04	[mbar] NOTCam cryotstat pressure	Revise	add [mbar] in Comment field.

Table 24: FITS STANCAM class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
STSHSTAT	NOT	I?	StanCam shutter status		New	See comments 32 and ?? above
STFLTNM	NOT	C	Stancam Filter Name		Implemented	

continued...

Table 24: FITS STANCAM class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
STFLTID	NOT	I	Stancam Filter Number		Implemented	See commnets ??
STFLTPOS	NOT	I	Stancam Filter Position		Implemented	

Table 25: FITS FIES class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
FIFOCUS	NOT	F		FIES internal focus position	Implemented	
FILSL	NOT	S?		FIES Lamp selector name	Implemented	
FILSLPOS	NOT	I?		FIES Lamp selector pos	Implemented	
CALSHUT	NOT	I?		FIES Calibration shutter state	Implemented	
CALSHUTN	NOT	F?		Number of times shutter was opened (simulthar)	Implemented	
CALSHUTD	NOT	F?		Total time (sec.) shutter was open (simulthar)	Implemented	
FIFMSKNM	NOT	S?		FIES Fiber Mask positon name	Implemented	
FIFMSKID	NOT	I?		FIES Fiber Mask ID	Implemented	
FIFMSKPS	NOT	I?		FIES Fiber Mask positon	Implemented	
FIBUNDLE	NOT	S?		FIES bundle name ???	Implemented	
FICARMNM	NOT	S?		FIES Calibration arm name	Implemented	
FICARMID	NOT	I?		FIES Calibration arm ID	Implemented	
FICARMPS	NOT	I?		FIES Calibration arm position	Implemented	
FILMPn	NOT	I	1/0	FIES Calibration lamp status	Implemented	
FILMPNMn	NOT	S?		FIES Calib lamp name	Implemented	
FILMPIDn	NOT	S?		FIES calib lamp ID	Implemented	
FITMPnn	NOT	Fixed F		[K] FIES temperature nn	New	
SHSTAT					Current	OPEN ???
FISHUTTR					Revise	FIES shutter status
EXPMETER		F		[adu] Exp-meter count at end of exposure	New	For FIES when exp-meter is used.
FIPRESnn	NOT	Fixed F		[hPa] FIES room airpressure	New	
FIHUMnn	NOT	Fixed F		[%] FIES room humidity	New	

Comment 34 (FITMPnn -) *FIES temperature reading at location nn. If 9 readings are enough keyword could become FIESTMPn. Maybe the temperature should be in [C] rather than [K]. Also should this be FITEMPnn, instead of FITMPnn? Note that the accuracy of the individual sensors is bad, as they are only roughly calibrated, but to record relative temperature changes the precision should be high: xx.xx degree..*

Table 26: FITS DETECTOR class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
			Detector ID etc			
DETNAME	NOT	C		Detector name	Current	Revise, see comments 36
CHIPID	NOT	C			Current	Revises see comments 36
DETNAME	NOT	Free C		Verbose description of detector	Revise	
DETID	NOT	Free C		Unique, technical reference ID of detector	Revise	
DETCTRID	NOT	C		Which controller board version	New	
DETCLKID	NOT	C		Which clock board version	New	
DETMODE0	NOT	I		Detector mode	Revise	Comment field does not explain what the integer value means. Only for ALFOSC.
MPP	NOT	Fixed I	1=ON, 0=OFF	Multi Pinned Phase	Revise	See comment 38
			Detector readout properties			
XOVERSC		I			Revise	Is this keyword needed?
YOVERSC		I			Revise	Is this keyword needed?
AOVERSC		I		???		Only present for ALFOSC. Artificial overscan Rarely used.
XOVERSC2					New	X underscan
TSAM	NOT	I		[??] Clamp and sample time in clocks	Revise	Only available for ALFOSC. What is the unit?
FPIX	NOT	I		[pix/s] Readout speed in pixels per second	Revise	Only for ALFOSC. Note wrong units, should be 'kpix'.
DETSECn	NOT	C		Location in final mosaic for amplifier n	Implemented	Only for NOTCam?
CCDSECn	NOT	C		Location in amplifier mosaic	Implemented	
DATASEC	NOT	C		Location of data pixels	Implemented	
TRIMSEC	NOAO	C		Location of useful data	Revise	Image section [x1:x2, y1:y2] holding illuminated pixels
BIASSEC	NOAO	C			New	Image section holding non-illuminated pixels
NWINDOWS		Fixed I			New	Number of readout windows
DETWIN1	NOT	C			Revise	Readout window 1 [x1:x2, y1:y2]
CCDSUM				On-chip binning factors	Implemented	
DETXBIN	NOT	I		On-chip binning factor in X	Revise	available for ALFOSC, FIES StanCam, informative only
DETYBIN	NOT	I		On-chip binning factor in Y	Revise	Comment field wrong and insufficient.
GAINM		Free C		High or Low	Current	FIES, MOSCA, STANCAM
GAINn		Fixed F		[e-/ADU] Gain Factor	Revise	
RDNOISEn		Fixed F		[e-] Read-out noise in electrons	Revise	

Table 26: FITS DETECTOR class/package ... continued

Keyword	Origin & Format	Value field	Comment field	Status	Notes
DARK	F		[e-/hr/pix] Dark current	Revise	This needs a time stamp when measured
ZERO0-0	F		[adu] Bias level ?	Revise	
GAIN0-0	F			Revise	
VBHA0-0	F		[Volts] Bias high A	Revise	
VBHB0-0	F		[Volts] Bias high B	Revise	
VBHC0-0	F		[Volts] Bias high C	Revise	
VBLA0-0	F		[Volts] Bias low A	Revise	
VBLB0-0	F		[Volts] Bias low A	Revise	
QCDDATE	C		Amplifier characteristics reference date	Implemented	Undefined values for ALFOSC, FIES, StanCam.
AMPLMODE			A / B or AB	Revise	Current comment field makes no sense for MOSCA where default readout mode is A4RR; FIES spelling 'AMPLM'
SATURATE	NOT	F	[adu] Approximate saturation level	New	
LINLIMIT	NOT	F	[adu] Approximate adu level where non-linearity exceeds 1%	New	
			Pressure & temperature		
P_DEWAR				Revise	ALFOSC, FIES, MOSCA.
CCDTEMP	F			Current	ALFOSC, STANCAM, FIES, MOSCA. Change unit from Celsius to Kelvin, see comments ??, 37.
DETTEMP	F		NOTCAM detector temperature	Revise	Only for NOTCAM. See comment 37
REFTEMP	F		Detector reference temperature [K]	New	
LN2TEMP	F			Revise	ALFOSC, FIES, MOSCA. Dewar temperature. Units in Celsius, see comments ??, 37.
AMBTEMP				Remove??	Camera controller temp. Only for STANCAM, see comment 37.
CRYOTEMP	F		Dewar temperature [K]	Revise	See comment 37
			CCD keywords		
VSHI	NOT	I	[?] Voltage?	Revise	Only for ALFOSC.
VSLO	NOT	I	[?]	Revise	Only for ALFOSC.
VPHI	NOT	I	[?]	Revise	Only for ALFOSC.
VPLO	NOT	I	[?]	Revise	Only for ALFOSC.
			NIR array keywords		
READMODE	NOT	C	Readout mode	New	Ramp-sampling, Fowler-sampling etc.
NSAMP	NOT	I	Number of sample reads	New	See comment 40.
VRESETn	NOT	I	00550	[mVolts] Reset voltage	New	For amplifier n=1,2,3,4, NOTCam
VBIASGn	NOT	I	03800	[mVolts] Biasgate voltage	New	For amplifier n=1,2,3,4, NOTCam

Table 26: FITS DETECTOR class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status	Notes
VDCOFFn	NOT	I	03500	[mVolts] DC-offset voltage	New	For amplifier n=1,2,3,4, NOTCam
			Remove?			
ROTATE	NOT	F		[deg] Rotation of image	Remove?	Implemented for ALFOSC only. Orientation?
MIRROR_X		C	F/T	Image is mirrored across horizontal axis	Remove ?	ALFOSC only.
MIRROR_Y		C	F/T	Image is mirrored across vertical axis	Remove?	ALFOSC only.

Comment 35 (DETXBIN, DETYBIN, CCDSUM -) *DETXBIN, DETYBIN keywords are informative only (present in the HDU[0]). CCDSUM is used for calculating the plate scale etc.*

Comment 36 (DETNAME -) *According to [Clasen, 2002] DETNAME is the replacement of CHIPID. The contents of DETNAME and CHIPID are very similar It might be useful to maintain two keywords (c.f., ESO guideline 38, [ESO DICB v2]), one (DETNAME) with a verbose description of the detector , and the other with a technical reference ID. Either some NOT detector number, or a batch number, serial number or other unique ID.*

Comment 37 (TEMPERATURES -) *Recommended unit for temperatures [Hanisch et al. 2001] is Kelvin in stead of Celsius. Maybe Celsius to the value field and Kelvin to the Comment field ?*
There are a lot of temperature keywords: CCDTEMP (detector temperature), LN2TEMP (dewar temperature, missing for STANCAM), AMBTEMP (camera controller temperature, only for STANCAM), plus the NOTCAM keywords: DETTEMP, COLDTBL, OUTVESS, CNTWHEE. The NOTCAM keyword DETTEMP would work in all instruments with a detector. CRYOTEMP (iso LN2TEMP) would work for all cryostats. See also comment ??.
It appears that our notation won't be consistent, e.g. WINDDIR, WINDAVG vs. CCDTEMP, LN2TEMP. Maybe COLDHEAD/FINGER/DEWARTEMP or something similar would be more informative/general keyword name

Comment 38 (MPP -) *FITS headers for FIES and new ALFOSC detectors have MPP=0 (off), although MPP is not available for this type of device. I feel that things which are completely impossible should not be listed in the headers.*
    Anton Norup Sorensen (CUO) says:

    MPP (multi-pinned phase) mode is used by several manufacturers. The EEV CCDs currently at NOT do not support MPP, but others of that brand do. E2V's name for MPP is AIMO. The TK1024 of StanCam does support MPP mode.

Comment 39 (FIXEDFREE -) *The current format is free, but strongly resembles fixed (columns shifted by 1 position, etc). It is recommended [Hanisch et al. 2001] formats should be fixed as much as possible. The use of libraries (CFITSIO) would make this much easier to achieve.*

Comment 40 (NSAMP -) *For the ramp-sampling readout mode NSAMP gives the number of reads (excluding the reset level read) in any image extension, and EXPTIME/NSAMP gives the time between reads. In the case that simple Fowler sampling is used (current exp and mexp), NSAMP is always unity. In the future multiple fowler sampling mode, NSAMP is the number of multiple pre and post reads. The NSAMP keyword together with keywords EXPTIME, READMODE and/or EXPMODE will be necessary and sufficient to fully distinguish all exposure types for NOTCam, also with the new NOTCam controller, see [Djupvik et al. 2012]. In the case that multiple images are averaged before storage, the NCOMBINE keyword is generated while EXPTIME and NSAMP remain valid.*

Table 27: FITS Post-processing & Quality control class/package

Keyword	Origin & Format		Value field	Comment field	Status	Notes
QCSTATUS	NOT	C	None		New	Quality control status (TBD)
QCRDATE	NOT	C	2011-10-12	Instrument rotation centre reference date	Revise	Value is UNDEFINED for ALFOSC AND MOSCA missing from FIES
CRXn	NOT	F		Reference pixel on 1st axis of amplifier n	Revise?	Rotation centre X for amplifier n=1,2,3,4, found only from NOTCam
CRYn	NOT	F		Reference pixel on 2nd axis of amplifier n	Revise?	Rotation centre X for amplifier n=1,2,3,4, found only from NOTCam
PPSTATUS	NOT	C	None		New	Postprocessing (pipeline, ...) status
FWHMAVG	NOT	F		["] Post-proc average FWHM	New	TBD
FWHMERR	NOT	F		["] Standard deviation of FWHM	New	TBD
ELLAVG	NOT	F		Average ellipticity	New	TBD
ELLERR	NOT	F		Error of ellipticity	New	TBD
NSTARS	NOT	I		Number of stars used for FWHM estimate	New	TBD
SKYSUBIM	NOT	C		Name of image used to subtract sky	New	
PHOTZERO	NOT	F		[mag] Post-proc zero point	New	Future ? TBD

Comment 41 (CRXn, CRYn -) *For each of the four NOTCam amplifiers the rotation centre is given in X and Y (i.e. negative numbers gives offset from amplifier border). The full-frame value goes into CRPIX1 and CRPIX2, as for the other instruments.*

Comment 42 (QC -) *Any keywords for spectrosopy/FIES ?*

6   Keywords which need to be fixed

In this section we list the keywords which need revisons or corrections.

∗AMBTEMP used only as StanCam controller temperature, this could be used as the weather station or the dome temperature

∗AUSTATUS Autoguider status changes from "on" or "off" to 5 integer values taken from the TCS status. Comment field should explain the coding

∗BIASSEC This keyword should be for the recommended overscan region (apart from NIR arrays), this would be useful for pipeline data reduction. At the moment can be found only from ALFOSC.

∗BUNIT the present value is 'count' for all instruments, should we change this to 'adu' (allowed by Pence 2010 Table 4)?

∗CCDPROBE current values are 'park/split/ccd' should they be 'park/FIES/StanCam'?

∗CCDTEMP revise to DETTEMP, see Table 26 above.

∗Should 'CREATOR' comment has 'BIAS' as well for NOT2MEF data? now it is 'rev. date: 2006-06-29, CFITSIO V2.51', see also the comments below.

∗CTYPEn maybe the comment field should be 'Axis type', now FIES has 'Coordinate type of 1st/2nd axis' and the other instruments 'Gnomonic projection'. See the Table 11 above.

∗DARK Not present in NOTCam.

∗DATAMIN,DATAMAX The value field shall always contain a floating point number, regardless of the value of BITPIX, all instruments have now integer. The Pence et al (2010) describes this as the 'minimum/maximum valid physical value'. Should be moved from the primary header to the 'Array HDU' and added to the NOTCam headers. see the Table 9 above.

∗DATE-OBS, The seconds are given with 3 decimal digits for ALFOSC, while only one for the other instruments. This should be considered together with the timing accuracy.

∗DETNAME Comment field is empty for all instruments. The keywords DETNAME, CHIPID, CCDNAME should be revised, see Table 26 above.

∗DETWIN1 is this needed for FIES?

∗EXPMODE should be added for all instruments, not only NOTCam. Takes the string of the sequencer command given to start an exposure (or a multiple exposure), e.g. 'exp-count -f -m 100 1200'.

∗EXPTIME ALFOSC have some times three decimals sometimes none

∗FILENAME Should we add the explanation for the naming policy on the comment field (w for 2013, a for january etc.)?

∗IMAGETYP revise see the Table 7 above

∗LN2TEMP Maybe revise, see Table 26 above

∗OBJECT revise see the Table 7 above

∗OBSERVAT Should the value be e.g. 'laplama' and comment 'Observatorio Roque de Los Muchachos, La Palma'?

∗OBSERVER the value is not set in a reliable way, should be taken from the database

∗OBSGEO-X the units are missing

∗OBSGEO-Y the units are missing

∗OBSGEO-Z the units are missing

∗RA typing error in the Comment field 'ascention' – 'ascension'

∗RADESYS,RADECSYS the present keyword RADECSYS is deprecated,RADESYS should be used instead.

∗SHSTAT As we should have FASU shutter info in ALFOSC as well maybe the SHSTAT should be revised to e.g. ALSHSTAT, FASHSTAT, NCSHSTAT etc. see Tables 22,23,24,25 above.

∗TELESCOP should the value-field be 'Nordic Optical Telescope (NOT)' instead of 'NOT'?

∗Possibly remove TM_START/TM-START from all FITS headers, however for overhead control

timestamps such as, open/close shutter start/end read out are interesting.

∗TRIMSEC can be found from MOSCA and NOTCam, this would be useful for pipeline data reduction. Note the comment field should be the same for all instruments, now MOSCA 'Section of useful data' NOTCam 'Location of useful data'

∗XOVERSC,YOVERSC the present value is 50 for ALFOSC and 0 for the other instruments. The comment field is missing. It is not clear what is the use of this keyword. If we keep this, should this be in the HDU[0] or conforming header (I think conforming)?

∗UT This is not needed as the same information is given by reserved keyword 'DATE-OBS', Remove from all instruments

∗All angular measurement should have a clear definition

∗Baffle lamp keywords should be included in all instruments, not only NOTCam

∗ALFOSC CMIRROR vs FARETARD the logic is slightly different for CMIRROR the value & comment are ' 1 / FASU calibration mirror is in' or ' 0 / FASU calibration mirror is out' and for FARETARD e.g. "OUT ' / Position of Retarder Plate' Maybe CMIRROR and FARETARD should have similar logic?

∗CHIPID Comment field is empty for all instruments. Almost identical values with DETNAME. According to [Clasen, 2002] DETNAME is the replacement of CHIPID. The contents of DET-NAME and CHIPID are very similar in each instrument. It might be useful to maintain two keywords (c.f., ESO guideline 38, [ESO DICB v2]), one (DETNAME) with a verbose description of the detector , and the other (I prefer DETID in stead of CHIPID for easy reading that it belongs in the DETECTOR class) with a technical reference ID. Either some NOT detector number, or a batch number, serial number or other unique ID.

∗DEWAR PRESSEURE It seems there are two different keywords for recording the pressure (and it still is not enough, as STANCAM does not have any at all!). I prefer to keep PRESSURE, with the option to have PRESSURn, if it would be necessary/interesting to have readings of the pressure at different locations.

PRESSUR	NOTCAM
P_DEWAR	ALFOSC, FIES, MOSCA

ALFOSC has a comment field 'Dewar pressure ' but no units. Note, before there were two different keywords for recording the pressure.

(∗Possibly remove 'EXTEND' from all conforming extensions?)

∗Pence et al 2010 EXTNAME keyword : The value field shall contain a character string to be used to distinguish among different extensions of the same type, i.e., with the same value of XTENSION, in a FITS file. Within this context, the primary array should be considered as equivalent to an IMAGE extension. '

∗HISTORY Maybe this should be used whenever a file is postprocessed. In FIES postprocessed files there is a description of procedures, however not the exact values.

∗LONGITUD, LATITUD, ELEVAT Human readable telescope coordinates, as the cartesian OBSGEO-XYZ

∗CUNIT maybe the comment field should be 'Physical units of CRVAL and CDELT for axis i', now 'Unit of first axis' (ALFOSC), 'Unit of 1st axis' (other than ALFOSC)

∗BSCALE according to Pence 2010, the values should be real ('1.0') instead of integer ('1'), all instruments all header units

∗BZERO according to Pence 2010, the values should be real instead of integer, all instruments all header units

∗CDELT is implemented for FIES only

ON-OFF, OPEN-CLOSED: We should have a consitent way of desribing ON-OFF, OPEN-CLOSED values. At the moment it is mixed between 'ON'-'OFF', 'OPEN'-'CLOSED', '0'-'1'.

Maybe the value for ON'/'OPEN' could be '1' and '0' for 'OFF'/'CLOSED' and '-99' for un-konwn/undefined/notknown? The comment field could have text like 'CLAMP1 is off', 'AL-FOSC shutter is closed' etc.

- ALFOSC HDU[0]:

- missing/incomplete comment field

  – ALAPRTID Should the description be 'NOT id' instead of 'ID'?
  – BIASSEC Comment field is empty
  – CCDTEMP Units are missing
  – CREATOR should the verion number be added?
  – DATAMIN,DATAMAX remove
  – DATE the comment field is 'HDU creation' in contrast to other instruments 'file creation date (YYYY-MM-DDThh:mm:ss UT)'
  – DATE-AVG, comment field is 'Mid-point of exposure' as with NOTCam, but FIES, MOSCA, StanCam have 'Midpoint of observation'
  – DATE-OBS, comment field is 'Start of exposure', but FIES, StanCam have 'Start of obser-vation'
  – DETNAME Comment field is empty
  – DETWIN1 Comment field is empty
  – DETYBIN Maybe typing error in the Comment field, ' T binning ' vs 'Y binning'?
  – EXPTIME units are missing ('[s]'), the recommended Comment field is '[s] Exposure time in seconds'
  – FPIX units are missing and maybe a typing error ' 200 / Readout speed in pix/sec' either value should be '200 000' or the comment 'kpix/sec'
  – INSTRUME Comment field is missing
  – LN2TEMP Units are missing
  – MIRROR_X,MIRROR_Y, not sure about the meaning of the present value and comment 'F / Image is mirrored across horizontal axis' Perhaps INVERTX, INVERTY as used by DS9 are better keyword names?
  – NWINDOWS Comment field and units are missing
  – OBSERVAT Comment field is missing
  – OBSERVER the comment field could be 'Observer who acquired the data'
  – ORIGIN Comment field is missing (other instruments have 'Nordic Optical Telescope Scien-tific Association')
  – P_DEWAR units are missing
  – RA units are missing, typing error in the Comment field
  – RADESYS (,RADECSYS) Comment field is missing
  – ROTPOS units are missing
  – TELALT units are missing
  – TELESCOP Comment field ('Name of telescope') is missing
  – TSAM units are missing
  – VPHI Comment field and units are missing
  – VPLO Comment field and units are missing
  – VSHI Comment field and units are missing
  – VSLO Comment field and units are missing

– Maybe ALGRID,FAPOLID, etc the comment field should be 'ALFOSC grism wheel. NOT
ID' instead of 'ALFOSC grism wheel. ID', the same as the Comment field in FAFLTID

ALFOSC HDU[1]:

• missing/incomplete comment field

– BIASSEC comment field is missing
– BUNIT comment field ('Physical unit of data array') is missing
– DARK Comment field has only units, no description. Maybe a time stamp should be included.
– CCDNAME comment field is missing
– CCDSUM comment field is missing
– DATAMIN, DATAMAX keywords are missing
– EXTNAME comment field is missing
– GAIN0-0 comment field and units are missing
– IMAGEID comment field is missing
– RA units are missing, typing error in the Comment field
– ZERO0-0 comment field and units are missing

NOTCam HDU[0]:

• Should we continue using EXMODE or change this to 'EXPCMD'?

• missing/incomplete comment field:

– DATE-AVG, comment field is 'Mid-point of exposure' as with NOTCam, but FIES, MOSCA,
StanCam have 'Midpoint of observation'
– DATE-OBS, comment field is 'Start of sequence', but FIES, StanCam have 'Start of obser-
vation'
– DETNAME Comment field is empty
– DETTEMP,COLDTBL ,OUTVESS,CNTWHEE units are missing. Also these keywords
should have prefix 'NC'
– EXPMODE Comment field is missing
– EQUINOX Comment field is missing
– FILENAME Comment field is missing
– IMAGETYP Comment field is missing
– INSTRUME Comment field is missing
– NCFOCUS the Comment field should be 'Internal focus, detector plate step position' and
not as currently stated: 'NOTCam internal camera step position'.
– OBSERVAT Comment field is missing
– OBSERVER the comment field ('Observer who acquired the data') is missing
– OBS_MODE Comment field is missing
– RADESYS (,RADECSYS) Comment field is missing
– ROTPOS units are missing
– SHSTAT Comment field is missing, maybe revise the keyword name
– TELALT units are missing
– TELESCOP Comment field ('Name of telescope') is missing

NOTCam HDU[1]:

• missing/incomplete comment field

– CCDNAME comment field is missing

- – DATAMIN, DATAMAX keywords are missing
- – IMAGEID comment field is missing

FIES HDU[0]:

- CCDTEMP Units are missing, Comment field is empty

- Should we use EXMODE/'EXPCMD' for 'simulthar'?

- EXPTIME Comment field ('[s] Exposure time in seconds') is missing

- DATAMIN,DATAMAX remove

- DETNAME Comment field is empty

- DETXBIN,DETYBIN Comment field is missing

- FIBUNDLE Comment field is missing

- FILENAME Comment field is missing

- IMAGETYP Comment field is missing

- INSTRUME Comment field is missing

- LN2TEMP Units are missing, Comment field is empty

- MPP Units are missing (?), Comment field is empty

- OBS_MODE Comment field is missing

- OBSERVAT Comment field is missing

- OBSERVER the comment field ('Observer who acquired the data') is missing

- P_DEWAR units are missing and Comment field are missing

- RA units are missing, typing error in the Comment field

- RADESYS (,RADECSYS) Comment field is missing

- ROTPOS units are missing

- SHSTAT Comment field is missing, maybe revise the keyword name

- TELALT units are missing

- TELESCOP Comment field ('Name of telescope') is missing

FIES HDU[1]:

- CCDNAME comment field is missing

- CDELTi the values should be float, now integer

- CRPIXi the values should be float, now integer

- CRVALi the values should be float, now integer

- DARK Comment field has only units, no description. Maybe a time stamp should be included.

- DATAMIN, DATAMAX keywords are missing

- IMAGEID comment field is missing

MOSCA HDU[0]:

- missing/incomplete comment field

  - – CCDTEMP Units are missing, Comment field is empty
  - – DATE-OBS Comment field ('Start of observation') is missing
  - – DATAMIN,DATAMAX remove
  - – DETNAME Comment field is empty

- DETXBIN,DETXBIN keywords are missing
- EXPTIME Comment field ('[s] Exposure time in seconds') is missing
- EQUINOX Comment field is missing
- FILENAME Comment field is missing
- IMAGETYP Comment field is missing
- INSTRUME Comment field is missing
- LN2TEMP Units are missing, Comment field is empty
- MPP Units are missing (?), Comment field is empty
- OBSERVAT Comment field is missing
- OBSERVER the comment field ('Observer who acquired the data') is missing
- OBS_MODE Comment field is missing
- P_DEWAR units are missing and Comment field are missing
- RA units are missing, typing error in the Comment field
- RADESYS (,RADECSYS) Comment field is missing
- ROTPOS units are missing
- SHSTAT Comment field is missing, maybe revise the keyword name
- TELALT units are missing
- TELESCOP Comment field ('Name of telescope') is missing

MOSCA HDU[1]:

- missing/incomplete comment field

  - CCDNAME comment field is missing
  - DARK Comment field has only units, no description. Maybe a time stamp should be included.
  - DATAMIN, DATAMAX keywords are missing
  - IMAGEID comment field is missing

StanCam HDU[0]:

- missing/incomplete comment field

  - CCDTEMP Units are missing, Comment field is empty
  - DATAMIN,DATAMAX remove
  - DETNAME Comment field is empty
  - DETWIN1 Comment field is missing
  - DETXBIN,DETXBIN Comment field is missing
  - EXPTIME Comment field ('[s] Exposure time in seconds') is missing
  - FILENAME Comment field is missing
  - IMAGETYP Comment field is missing
  - INSTRUME Comment field is missing
  - MPP Units are missing (?), Comment field is empty
  - NWINDOWS Comment field is missing
  - OBSERVAT Comment field is missing
  - OBSERVER the comment field ('Observer who acquired the data') is missing
  - OBS_MODE Comment field is missing
  - P_DEWAR units are missing and Comment field are missing
  - RA units are missing, typing error in the Comment field

- RADESYS (,RADECSYS) Comment field is missing
- ROTPOS units are missing
- SHSTAT Comment field is missing, maybe revise the keyword name
- TELALT units are missing
- TELESCOP Comment field ('Name of telescope') is missing

StanCam HDU[1]:

- missing/incomplete comment field

    - CCDNAME comment field is missing
    - DARK Comment field has only units, no description. Maybe a time stamp should be included.
    - DATAMIN, DATAMAX keywords are missing
    - IMAGEID comment field is missing

7 Updates since Saskia's report

- FASU keyword naming Done

- ALFOSC keyword naming Done

- NOTCAM keyword naming Done

- filter naming policy Done

8 Appendix A

Table 28: Interpretation of valid BITPIX value

Value	Data represented
8	Character or unsigned binary integer
16	16-bit two's complement binary integer
32	32-bit two's complement binary integer
64	64-bit two's complement binary integer
-32	IEEE single precision floating point
-64	IEEE double precision floating point

9 Appendix B

Other reserved kewords used for e.g. tables etc. TSCALn, TZEROn, TNULLn, TTYPEn, TUNITn, TDISPn, TDIMn, THEAP PTYPEn, PSCALn, PZEROn.

Table 29: Reserved keywords

Keyword Description	Primary Array
Creation of the HDU	DATE
Organisation	ORIGIN
FITS allowed to contain extensions	EXTENDED
(Block size	BLOCKED, Deprecated)
Time	DATE-OBS
Time	DATExxxx
Telescope	TELESCOPE
Instrument	INSTRUME
Who acquired	OBSERVER
Name for the object	OBJECT
Who published	AUTHOR
ADS or DOI refernce	REFERNCE
Any comment	COMMENT
History of step and procedures associated with data	HISTORY
Pixel to physical value transofrmation	BSCALE
Pixel to physical value transofrmation	BZERO
Describe the physical units	BUNIT
Pixels with an undefined physical value	BLANK
Maximum valid physical value	DATAMAX
Minimum valid physical value	DATAMIN
Different extension name	EXTNAME
Extension number with the same type and name	EXTVER
Hierarchy of extension levels	EXTLEVEL

Table 30: Reserved WCS keywords

Keyword Description	Primary Array
Coordinate dimensionality	WCSAXESa
Axis type	CTYPEia
Axis units	CUNITia
Reference value	CRVALia
Coordinate increment	CDELTia
Reference point	CRPIXja
(Coordinate rotation	CROTAi)
Transformation matrix	PCi_ja
Transformation matrix	CDi_ja
Coordinate parameter	PVi_ma
Coordinate parameter	PSi_ma
Coordinate name	WCSNAMEa
Coordinate axis name	CNAMEia
Random error	CRDERia
Systematic error	CSYERia
Coordinate rotation	LONPOLEa
Coordinate rotation	LATPOLEa
Coordinate epoch	EQUINOXa
(Coordinate epoch	EPOCH)
Date of observation	MJD-OBS
Average date of observation	MJD-AVG
Date/time of observation	DATE-OBS
Average date/time of obs	DATE-AVG
Reference frame	RADESYSa (or RADECSYS4)
Line rest frequency (Hz)	RESTFRQa (RESTFREQ)
Line rest vacuum wavelength (m)	RESTWAVa
Spectral reference frame	SPECSYSa
Spectral reference frame	SSYSOBSa
Spectral reference frame	SSYSSRCa
Observation X (m)	OBSGEO-X
Observation Y (m)	OBSGEO-Y
Observation Z (m)	OBSGEO-Z
Radial velocity (m s^{-1})	VELOSYSa
Redshift of source	ZSOURCEa
Angle of true velocity	VELANGLa