FITS observation files at the NOT

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1 Introduction

This document describes the current FITS files that are produced at the NOT (Section 3), and proposes future changes (Section 4). The importance of uniform and adequate FITS header information is stressed (Section 2). A standard documentation for all NOT FITS headers is proposed (Section 5). The intention of the proposed changes is to serve as a starting point for further discussion.

> The lists of FITS header classes/packages and the tables with all the FITS keyword information (Tables 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 are open for comments, suggestions and additions! Please send in suggestions for new instrument-specific keywords in the instrument classes.

1.1 Document history

Version ... At some point a proper FITS dictionary will probably need to become a separate document.

Version 0.6, 2004-5-25 New keywords BIASSEC, TRIMSEC, NWINDOWS, PETALS OBSGEO-X, OBSGEO-Y, OBSGEO-Z

Mid-observation date-time keywords MID-OBS, JD-OBS, BJD-OBS moved from TCS to Observation class

Tables updated, several new keywords have now been implemented! Autoguider: AUXPOS, AUYPOS. FASU: CMIRROR, CLAMPn, CLAMPNMn, CLAMPIDn

Text changes.

Version 0.5, 2004-03-31 New keywords:

NCCENWAV, CCDPROBE (previously tbd), CTYPEn, RDNOISE.

Changed/added shutter keywords.

MCSHUTTR, NCSHUTTR, FISHUTTR, ALSHUTTR, SCSHUTTR

Changed NOTCAM keywords.

NCAMERA (LENS) NCFOCUS (CAMERA) NCAMID (NCLENSID in v0.3) NCAMPOS (NCLNSPOS in v0.3) NCAMSTEP (NCLNSSTP in v0.3)

Version 0.4, 2004-03-01 Changed meteo keyword names.

AMBTEMP (METTMP in v0.3) DEWPOINT (METDEWP in v0.3) RELHUM (METRELHU in v0.3) AVRGWIND (METWIND in v0.3) MAXWIND (METMXWND in v0.3) WINDDIR (METWNDIR in v0.3) ATMPRESS (METPRESS in v0.3) DIMMSEE (METDIMM in v0.3) DUST (METDUST in v0.3)

Added notes in WCS table.

Version 0.3, 2004-02-17 Added keyword classes/packages. Added new keywords. First version to be sent to all NOT staff for comments.

Version 0.2, 2004-01 Defined NOT FITS documentation tables. Defined keyword classes/packages.

Version 0.1, 2003-12 First draft. FITS documentation becomes a separate document (previously part of dataflow document).

1.2 References

[1] Definition of the Flexible Image Transport System (FITS), Hanisch, R. J.; Farris, A.; Greisen, E. W., et al., 2001, A&A 376, 359 (IAU FITS Working Group (IAU-FWG) endorsed version of NOST 100-2.0, NASA/Science Office of Standards and Technology
http://archive.stsci.edu/fits/fits_standard/
Part of the FITS standard.

[2] Greisen, E.W. & Calabretta, M., Representations of world coordinates in FITS, 2002, A&A 395, 1061, Approved by the IAU-FWG as part of the FITS standard.

[3] Calabretta, M. & Greisen, E.W., Representations of celestial coordinates in FITS, 2002, A&A 395, 1077, Approved by the IAU-FWG as part of the FITS standard.

[4] Information on new FITS headers at the NOT, 2002, Clasen, J.W.
http://www.not.iac.es/technical/astronomical/FITS-header/

[5] The ESO Data Interface Control Document
http://archive.eso.org/DICB/dic-2.0/dic-2.0.4.pdf

[6] ESO mandatory header keywords
http://archive.eso.org/DICB/dic-1.1/dic_1.1.0_AppB.pdf

[7] NOAO FITS Keyword Dictionary: Version 1.0
http://iraf.noao.edu/iraf/web/projects/ccdmosaic/imagedef/fitsdic.html

[8] ING document INS-DAS-26: Observation files produced by UltraDAS, 2003, Rixon, G., Rees, S., Bassom, R., Bevil, C.
http://www.ing.iac.es/~docs/ins/das/ins-das-26/ins-das-26.html

[9] Greisen, E. G.; Valdes, F. G.; Calabretta, M. R.; Allen, S. L., Representations of Spectral Coordinates in FITS
http://www.aoc.nrao.edu/~egreisen/scs_022404.ps.gz
FITS proposal, not yet part of the FITS standard

[10] ISO8601:2000(E) Representation of dates and times

[11] Specifications concerning designations for astronomical radiation sources outside the solar system, Task Group on Astronomical Designations of IAU Commission 5,
http://cdsweb.u-strasbg.fr/iau-spec.htx

[12] Dictionary of commonly used FITS keywords
http://heasarc.gsfc.nasa.gov/docs/fcg/common_dict.html

2 The importance of adequate FITS header information

To allow the astronomical data obtained at the NOT to be used to their full potential, now and in the future, the data need to be self-contained with all relevant information present in the FITS headers as much as possible. Various international collaborations (among which OPTICON of which NOT is a full member) have stressed the importance of making available the observational data by means of WWW accessible archives. Holding all the relevant summary information is a prerequisite for a future searchable data archive.

Secondly, any local postprocessing such as (but not restricted to) automatic logging, quick-look facilities, quality control tools and pipeline data reduction will also require and rely on extensive FITS header information.

Thirdly, normal data reduction by visiting observers at their home institutes strongly benefits and more and more relies on complete FITS header information.

The FITS header information in the data files that are currently produced at the NOT is not sufficient for any of these purposes. Essential information that is readily available to the observing system goes unrecorded in the data files. At the moment for example, the celestial coordinate reference system is never recorded in the FITS headers, its equinox is only recorded in ALFOSC and STANCAM data. Information on the status of the calibration unit and the autoguider are not recorded at all. Only apparent positions of objects in an unspecified coordinate system are recorded, not catalogue positions with proper motions and a reference coordinate system. This makes it very difficult to recover archival data based on positions only.

The current FITS headers only provide the minimum of information needed for the PI of a programme to reduce and analyse the files using standard astronomical data reduction packages. A future data reduction pipeline or an outside archive user will not have at their disposal the same amount of secondary information as the observer at the telescope.

The FITS keywords that are currently written in the data files are not uniform for the different instruments. For example, there are 3 different keywords for the pressure at the detector. Leaving this as it is, would make data base design and programming for quality control tools and a searchable archive unnecessarily complex.

Currently 3 (out of a total of 5) of the common user instruments have conflicting information in the FITS headers regarding the dimensions of the data array. This needs to be remedied as soon as possible.

As a first step towards pipeline data reduction, automated observing logs, quality control tools, and a searchable data archive, the FITS header information in the NOT data files needs to be enhanced and properly documented. To facilitate the combining of a future NOT data archive with other European 'Virtual Observatory'-like efforts, coordination in terms of formats, indexing standards, naming conventions, etc., is desirable. The normal visiting observers will benefit greatly from improved FITS formats and headers, since data reduction will be more straight forward and less time-consuming; the astronomers can proceed to the step of scientifically assessing the astronomical information more quickly.

3 Current NOT observation files

The astronomical and/or calibration data are recorded on disc by the CCD controller BIAS (Brorfelde Image Acquisition System) which was developed at Copenhagen. Currently there is a different flavour of BIAS software for every instrument/CCD combination. As a result of this, even the information that is common to all instruments is not recorded identically for the different instruments.

3.1 Current data structure

Mostly for historic reasons there is no uniform data structure in use at the NOT. In Table 1 the current data formats for the different common-user and frequently-used visitor instruments are summarized. Observing data for ALFOSC and STANCAM are recorded as a simple FITS image, i.e., a primary header unit and an associated image (see Section 3.2.1 for an overview of FITS terminology). NOTCAM data are recorded as a simple FITS 3-dimensional array, i.e., a primary header unit and an associated data cube. NOTCAM data have incomplete header information: several parameters are only specified for 2 dimensions, leaving the third dimension undefined. This is in conflict with the FITS standard [3], and causes problems with IRAF.

MOSCA and FIES data also have inconsistent header information regarding the dimensions: there is a parameter defined for a 3-dimensional data array, while the actual data array is 2-dimensional. This is in conflict with the FITS standard [1]. Recording NOTCAM and MOSCA data in Multi-Extension FITS (MEF, see Section 3.2.2) files would solve many current problems and limitations. This is also the recommendation of the near-infrared imaging and optical imaging NOT Instrument User Groups in their 2003 reports. Unfortunately MEF is not supported at the NOT, although it has become a standard for multi-channel data at most other facilities (a.o., ESO, NOAO, ING, Gemini, CFHT). The only awareness of the possibility of MEF is found in the ALFOSC FITS headers: EXTEND equals F.

> Work-around to convert NOT formats to MEF (SP - Mar 2004): a preliminary programme using the CFITSIO library was written by SP to postprocess BIAS output into MEF with enhanced header information and solved dimensionality conflicts.

> Problem: The effort required to rewrite the BIAS software to accommodate the proposed changes in the FITS files (formats and headers) versus the new CCD controller being developed by Copenhagen that will require completely new software.

> I think that priority 1 and 2 (see Section 5) header information that is currently available to the observing system (and therefore requires limited effort to be included in the FITS headers) should be included in the current software within XX months.

> Changing the format to MEF for multi-channel data is a much more fundamental change. This should definitely be done in collaboration with Copenhagen, and may have to wait for the new controllers, but this depends on Copenhagen timescales .

> ESO's guidelines [5] nr 1 and nr 2 dictate the use of MEF for multiple chip and window data. This conflicts with the current NOT data formats. We could of course still get inspiration from the rest of ESO's guidelines, with the exception of the ESO hierarchical keywords definition (see Section 3.2.2). This would be the same approach as VISTA.

3.1.1 Notes on the individual instruments

ALFOSC

STANCAM

NOTCAM NOTCAM data have incomplete header information, as several WCS parameters are only specified for 2 dimensions, leaving the third dimension undefined. This is in conflict with the FITS standard [3], and causes problems with IRAF.

Data are recorded as a cube with up to 16 images, depending on read-out mode and user settings. In ramp sampling mode the total integration time is divided into several readouts, and each readout has an associated image in the cube. These images currently share the same header information which only lists the total integration time. MEF needed.

Table 1: Current data formats

Instrument	Type	Data format	Notes
ALFOSC	FITS		
Stancam	FITS		
NOTCAM	FITS	Cube: $\leq 16 \times 1024 \times 1024$	Nr of planes is defined by user
MOSCA	FITS	$4 \times 2k \times 2k$, default $2k \times 2k$	Combined data from 4 $2k \times 2k$ CCDs into 1 image. Default: $2\times$ 2 binning
FIES	FITS		
SOFIN	FITS		
TURPOL	ASCII		

MOSCA MOSCA data have conflicting mandatory headers regarding the dimensions: NAXIS equals 2, ie data is recorded in a 2-dimensional array, yet NAXIS3 is also specified.

Although MOSCA consists of 4 different CCDs with physical gaps in between, the data are effectively combined into a single FITS image. Because of memory restrictions the overscan region is usually not recorded. MEF needed!

FIES FIES data have conflicting mandatory headers regarding the dimensions: NAXIS equals 2, ie data is recorded in a 2-dimensional array, yet NAXIS3 is also specified.

SOFIN (visitor instrument) SOFIN data files have rather complete instrument information, but no TCS information in the FITS headers.

TURPOL (visitor instrument) TURPOL does not produce FITS files, but TURPOL-only ASCII data files, which are to be reduced with a dedicated reduction programme (POLRED).

3.2   Current FITS headers

Currently every instrument/CCD combination has its own version of the BIAS CCD controller software. These different versions of BIAS produce similar but non-identical header information in the FITS files. Currently there are 3 different keywords to record the pressure at the detector, 2 for the gainmode, 2 for the readout mode, 3 for the start time, 2 for the detector name, etc.

Currently no information at all is recorded for the autoguider, for the calibration unit inside FASU, for the baffle lamps, for the dome shutters, for the CCD-probe, for meteorological conditions. Only apparent positions of objects in an unspecified coordinate system are recorded, not catalogue positions with proper motions and a reference coordinate system.

Apart from listing the readout mode no information is recorded for the individual amplifiers (a proper way to record data for individual amplifiers requires MEF). For many other parameters readings are recorded only at the start of the integration, (AIRMASS, ... etc). It would be desirable to have readings at the end of the integration as well.

At the moment a lot of important information is written into the comment fields (see Section 3.2.1 for FITS terminology) of the FITS header cards. This has been a workaround for supplying more header information, without having to record it in a separate FITS keyword. For a future archive all important information should be in the form of keywords and associated values, with an optional comment field which is only explanatory, and does not hold essential information.

Now many keyword values are written in a format which differs slightly from the recommended fixed formats [1], columns shifted by 1 position, etc. At the moment no libraries (ie CFITSIO) are used to write the headers. The use of libraries would make it easier to write headers in the recommended fixed format.

3.2.1 Short description of FITS terminology

The FITS standard consists of 3 parts [1], [2], [3]. Part 1 defines the FITS standard, in terms of structures, formats and data array and header information organization. Here the mandatory FITS header cards which define a file as a valid FITS file are described, among these are cards that describe the structure and size of the subsequent data array.. Part 1 also describes several 'Reserved' keywords for specific astronomical meanings, which should only be used as described in the FITS standard.

Parts 2 and 3 describe world coordinate systems and celestial coordinate systems and introduce many more 'Reserved' keywords for astronomical concepts related to coordinate systems, projections. Another extension to the standard describing representations of spectral coordinates in FITS is under development [9].

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

3.2.2 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.

Currently at the NOT, all FITS files are simple FITS files without extensions: the primary HDU is the only HDU in the observation files. In the case of Multi Extension FITS (MEF), there can be several extension HDUs, each with a data array and their own FITS header with the information that is relevant to that specific data array. In the case of MEF the primary HDU often only contains a header with general information, and no data array. It is also possible to use MEF for single image data. In fact, ING uses MEF as the default observation file format [8] for all instruments. The use of extensions requires the keyword EXTEND to be present in the primary header. 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.

A FITS header card includes a keyword, a value indicator, a value field, and an optional comment [1]. 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.

A notable non-standard FITS keyword format convention is the ESO HIERARCH keyword convention [5], 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.

4 Proposed changes

- Adequate data structures

- Uniform FITS keywords for all instruments

- Group FITS headers into classes/packages

- Document all FITS headers in use at NOT

4.1 Adequate data structures and FITS keywords

All observation files produced at the NOT should be valid FITS files. To this end the header information for NOTCAM, MOSCA, and FIES which conflicts with the FITS standard should be remedied as soon as possible. The implementation of MEF for MOSCA and NOTCAM data files should be studied.

The information in the FITS headers should be enhanced (see Section 3.2). Many new keywords will be necessary. It is recommended to include the units for the value field in the comment field of the FITS header.

The FITS keywords that are currently written in the data files for the different instruments should be made uniform as much as possible. For example, there are 3 different keywords for the pressure at the detector. Leaving this as it is, would make data base design and programming for quality control tools and a searchable archive unnecessarily complex.

In order to avoid future code diversion and to alleviate software maintenance it is recommended that there be one common version of the software that writes the FITS header information. The use of libraries (e.g., CFITSIO) to write the FITS headers should be considered.

4.2 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 [5] nr 3, 5, and 7 regarding the order of the subsequent FITS keyword classes/packages loosely (following them strictly is not possible since we do not have MEF), the list could be as follows:

- 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 polization 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...

5 NOT FITS documentation

A standard documentation for the FITS headers for NOT common-user instruments is proposed. This documentation includes 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 [1], and should be written in fixed format.
Reserved	Reserved keywords should only be used for meanings as described in [1], [2], [3]. 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:

Current	This keyword is present in the current NOT FITS headers, but needs to be revised. This entry holds the current version (for the proposed changes see Revised).
Implemented	This keyword is present in the current NOT FITS headers of all instruments.
Incomplete	This keyword is present in the current NOT FITS headers of some instruments.
New	A new keyword is proposed for the NOT FITS headers.
Non-uniform	This keyword is present in the current NOT FITS headers of some or all instruments. The contents are not identical , and should be revised to make them more uniform (for the proposed changes see Revised).
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)
Revised	This keyword is present in the current NOT FITS headers, but needs to be revised. This entry holds the proposed revised version.

Possible values for the implementation priority for new and revised keywords are :

1 a	This keyword is essential and needs to be implemented as soon as possible. The information is available in the current system.
1 b	This keyword is essential and needs to be implemented as soon as possible. The necessary information is not available in the current system.
2 a	This keyword is required for automated postprocessing. The information is available in the current system.
2 b	This keyword is required for automated postprocessing. The necessary information is not available in the current system.
3 a	This keyword holds important information. The information is available in the current system.
3 b	This keyword holds important information. The necessary information is not available in the current system.
4 a	This keyword holds non-essential information. The information is available in the current system.
4 b	This keyword holds non-essential information. The necessary information is not available in the current system.

Table 2: FITS mandatory class/package

Keyword	Origin & Format		Value field	Comment field	Status	Priority	& Notes
SIMPLE	Mandatory	Fixed B	T	Conform FITS standard	Implemented	1 a	
BITPIX	Mandatory	Fixed I	16	Bits per pixel	Implemented	1 a	
NAXIS	Mandatory	Fixed I		Nr of axes in data array	Implemented	1 a	
NAXISn	Mandatory	Fixed I		Nr of elements along axis n	Implemented	1 a	
NAXIS3					Remove	1	FIES and MOSCA
EXTEND	Mandatory	Fixed B	F	FITS extensions enabled?	Remove	1	Only present for ALFOSC, see comment 1
END	Mandatory		No value	End of header unit	Implemented	1 a	

Comment 1 (MEF - SP) *EXTEND is only mandatory if a FITS file contains extensions [1]. As long as MEF (multi-extension FITS) is not supported in NOT data files, there should not be anything related to it in the headers either!*

Table 3: FITS WCS class/package, see comments 3

Keyword	Origin & Format		Value field	Comment field	Status	Priority	& Notes
RADECSYS	Reserved	Fixed C	FK5	Reference celestial coordinate system	New	1 a	see comments 3, 2
EQUINOX	Reserved	Fixed F	2000.0	Equinox of coordinate system	Incomplete	1 a	Missing for NOTCAM and MOSCA. See comments 3, 2.
BSCALE	Reserved				Implemented	1 a	
BZERO	Reserved				Implemented	1 a	
BUNIT	Reserved		C	Physical unit of pixel values	New	3 a	
CTYPEn	Reserved		C		New	3 a	Coordinate name represented by axis n
CRPIXn	Reserved		I		Current		Format (I) not compliant with [1]
CRPIXn	Reserved		F		Revised	3 a	Location of ref point along axis n
CRVALn	Reserved		I		Current		Format (I) not compliant with [1]
CRVALn	Reserved		F		Revised	3 a	Value of coordinate n at ref point CRPIXn
CDELTn	Reserved		I		Current		Format (I) not compliant with [1]
CDELTn	Reserved		F		Revised	3 a	Partial derivative of CTYPEn coordinate with respect to pixel index in units of CTYPEn coordinate

Comment 2 (WCS2 -) *EQUINOX should always be accompanied by RADECSYS [3]. FK4 requires MJD-OBS as well, FK5 does not [3]. If neither EQUINOX nor RADECSYS are present in the FITS headers (as is currently the case for NOTCAM and MOSCA) the celestial coordinate system [3] defaults to ICRS (International Celestial Reference System).*

Comment 3 (WCS -) *Apparently, proper WCS have been on the NOT's ToDo-List for a long time. Implementing WCS header information is recommended by the near-infrared and optical imaging NOT Instrument User Groups in their 2003 reports. Even approximate WCS information would be very valuable for archival and quick-look reduction purposes.*

NOTCAM data have special WCS problems caused by inconsistencies in the NOTCAM FITS headers, causing problems in IRAF. (In short, in NOTCAM data, simple WCS are given for a 2 dimensional array, while NOTCAM data are recorded as a 3-dimensional array. IRAF treats the NOTCAM data as a FITS file that is compliant with the FITS standard [3], resulting in assumptions which are not valid for NOTCAM, since NOTCAM data files do not follow the standard.)

As this is quite complicated, (spherical trigonometry related to the projection, and the placement precision for the instruments come in) as a first step I only define the 2 fundamental keywords which are missing: RADECSYS, and EQUINOX. Later on, we have to decide whether we want full WCS, or just the basic framework needed to use astrometric routines in data reduction packages.

Table 4: FITS Data description class/package

Keyword	Origin & Format		Value field	Comment field	Status	Priority & Notes	
DATE	Reserved			Creation date of FITS file	Implemented		CFITSIO fits_write_date writes DATE keyword in 'yyyy-mm-ddThh:mm:ss' format. See comments 10, 9
ORIGIN	Reserved	Free C	BIAS		Current	3 a	FITS Standard [1] restricts use of this keyword to organization/institution
ORIGIN	Reserved	Free C	NOTSA		Revised	3 a	
CREATOR	HEASARC	Free C	BIAS Vn.n	Version nr of obs system	New	3 a	See comment 4
FILENAME	NOT	Free C	cciiiiii	Filename on disk	Implemented		Not unique, see comment 5.
IMAGETYP	NOAO				Incomplete	2 b	Missing for NOTCAM and MOSCA. Not set in a reliable way. See comment 6
DATAMAX	Reserved	F		Maximum physical value	Implemented		Physical value after scaling
DATAMIN	Reserved	F		Mininum physical value	Implemented		Physical value after scaling
PROPID					New	3b	Proposal ID
PROPTITL					New	3b	Proposal title
PINAME					New	3b	PI name
tbd					New	3b	Observing script/observing block info
EXPMODE	NOT	C			Incomplete		Only for NOTCAM. Command used to start integration. Possibly change keyword name into something more generic.

Comment 4 (CREATOR - SP) *JC thinks BIAS version info is redundant, since although there are many versions of BIAS, there is only 1 BIAS per instrument. I do not agree! Especially if we will be going through a software changing phase, BIAS version info is important. I can also envisage stable situations where different set-ups of the same instrument would use a different BIAS.*

Comment 5 (FILENAME - SP) *The cciiiiii-format filenames are not unique. Files from different instruments can have the same filename. Even if it were unique, the cciiiiii-format has to be complemented with a increasing integer index for database use.*

Comment 6 (IMAGETYP - SP) *IMAGETYP (object, flat, bias, dark, etc) is extremely useful for data reduction and automated postprocessing if set correctly. At the moment it is usually an empty string. This keyword is not set automatically by the data-taking system, but optionally by the observer for ALFOSC, STANCAM and FIES. Therefore it is only marginally useful. It is not enough to include the possibility of writing this keyword into the header, it should be set automatically depending on the type of integration. ING uses several commands to start an integration depending on the type, and thus setting this keyword. Another possibility is the use of Observing Block-like scripts, the setting of the IMAGETYP keyword could be included therein.*

Table 5: FITS Site class/package

Keyword	Origin & Format			Value field	Comment field	Status	Priority & Notes	
OBSERVAT	IRAF?	Free	C	LaPalma		Implemented		
TELESCOP	Reserved	Free	C	NOT		Implemented		
LONGITUD	???	Free	F	-17.88508	Telescope longitude [degrees]	New	4 a	
LATITUD	???	Free	F	+28.75728	Telescope latitude [degrees]	New	4 a	
ELEVAT	???	Free	F	2382	Elevation above sea level [meters]	New	4 a	
OBSGEO-X	Reserved	Fixed F		5327395.9638	Cartesian X [meters]	New	4a	See comment 7, proposed in [9].
OBSGEO-Y	Reserved	Fixed F		-1719170.4876	Cartesian Y [meters]	New	4a	See comment 7, proposed in [9].
OBSGEO-Z	Reserved	Fixed F		3051490.7660	Cartesian Z [meters]	New	4a	See comment 7, proposed in [9].

Comment 7 (OBSGEO - SP) *Cartesian Coordinates (XYZ) allow for Geodetic quality three dimensional positioning on an earth centered ellipsoid. Values were calculated using the package provided at http://www.ngs.noaa.gov/TOOLS/XYZ/xyz.html for converting between Geodetic Latitude-Longitude-Ellipsoid_ht and XYZ on the GRS80 Ellipsoid (based on GPS values from the NOT technical details).*

Table 6: FITS Observation class/package

Keyword	Origin & Format		Value field	Comment field	Status	Priority & Notes	
DATE-OBS	Reserved			End of observation	Non-uniform	1 a	Used for end of read-out while comment field says Start or end of observation. See comments 8, 10, 11
DATE-OBS	Reserved		C	Start of observation	Revised	1 a	Start of observation in yyyy-mm-ddThh:mm:ss.s format. See comments 8, 10, 11
OBSERVER	Reserved				Incomplete		Missing for MOSCA. Not set in a reliable way.
INSTRUME	Reserved				Implemented		
OBS_MODE	HEASARC	Free	C	Instrumental mode	New	2a	eg Long-slit spectroscopy, multi-object spectroscopy, crossdispersed (echelle) spectroscopy, imaging, fastphotometry, polarimetry, etc.
EXPTIME					Current		Empty comment field
EXPTIME				Exposure time [s]	Revised		

continued...

Table 6: FITS Observation class/package ... continued

Keyword	Origin & Format		Value field	Comment field	Status		Priority & Notes
TM_START	NOT	Fixed I		Start of integration [tbd]	Non-uniform		Integer nr of seconds since midnight. Has human-readable version of time in comment field. See comments 11,9, 10
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. See comment 11,9, 10
TM_END	NOT	Fixed I		UT end of CCD readout [s]	Non-uniform		Integer nr of seconds since midnight. Is the end of readout interesting for astronomers?? The end of integration is much more interesting.
TM_END	NOT	C		UTC end of integration	Revised		yyyy-mm-ddThh:mm:ss.s format
MID-OBS					New	b?	Date and time of mid-observation in yyyy-mm-ddThh:mm:ss format [10], [1]
JD-OBS					New	b?	Julian Date of midtime of observation in fractional days
BJD-OBS					New	b?	Barycentre-corrected Julian Date of midtime of observation

Comment 8 (DATE-OBS - SP) *The recommended use [1] of the DATE-OBS keyword is for the start of the observation. Currently the keyword DATE-OBS is used to record the date at the end of read-out. This is allowed if properly documented, but the information in the comment field is empty for FIES and MOSCA, 'Start of observation' for STANCAM, and for the new ALFOSC CCD 'End of observation' (older ALFOSC data have 'Start of observation' identical to STANCAM).*

For astronomical purposes it is much more interesting to record the start time and date of the exposure than the date at the end of the CCD readout. I prefer to use the DATE-OBS keyword for the start of the observation in yyyy-mm-ddThh:mm:ss.s format (see also comment 11).

I have done some investigations to see what happens around midnight: Example: nc070032.fits (STANCAM) Exposure starts and ends on March 7 before midnight, but readout finishes after midnight on March 8. FITS header information says:

DATE-OBS= '2004-03-08' Start of observation
EXPTIME = 10.000 /
TM_START= 86388 / 23:59:48 UT start of integration
TM_END = 42 / 00:00:42 UT end of CCD readout

Comment 9 (UTC - SP) *UT and UTC are both used in the headers, interchangeably it seems. Until 1972 UTC was called UT. Formally, Universal Time (UT) is earth rotation based and slightly irregular, while Coordinated Universal Time (UTC) is atomic clocks based. GPS uses UTC, so the instrument time-stamps should be UTC as well.*

Comment 10 (DATESTIMES - SP) *The recommended format [10], [1] for dates and times is yyyy-mm-ddThh:mm:ss. The yyyy-mm-dd format is compliant with [1] and [10]. DATE must be in UTC (see comment 9) , if in the yyyy-mm-ddThh:mm:ss.s format [1].*
FIES and NOTCAM have hh/mm/ss in comment field.

Comment 11 (TIMES - SP) *JC has explained the different timestamps to me:*

TM_START	ICS time at start of integration.
TM-START	ICS time at start of integration, identical to TM_START. Extra copy put in by Copenhagen for MOSCA, NOTCAM and FIES.
UT	TCS time at start. Previously TCS kept more accurate time than ICS. Since XXX all ICS times are GPS-based.
TM_END	ICS time at the end of the readout

	Apart from the above timestamps, there are also 2 datestamps:
DATE	Creation date of FITS file
DATE-OBS	End of read-out! (this keyword is usually used for the start of the observation, see also comment 8)

	Proposed new astronomical time/date stamps:
MID-OBS	UTC date and time of mid-observation in yyyy-mm-ddThh:mm:ss format
JD-OBS	Julian date of midtime of observation in fractional days
BJD-OBS	Barycentre-corrected Julian date of midtime of observation in fractional days

TM_START and TM_END are expressed in integer seconds since midnight, with a human-readable version in the comment field. UT is expressed in fractional hours since midnight, with a human-readable version in the comment field. Integer seconds are programmer-friendly, hh:mm:ss is astronomer-friendly, fractional hours (hh.hhh) are neither!

We have to think how we can reduce the number of timestamps (so we can introduce some new! MID-OBS, JD-OBS, BJD-OBS). We could remove TM-START, and combine the information from DATE-OBS and TM_START into one keyword (DATE-OBS) in the recommended format [10], [1] for dates and times yyyy-mm-ddThh:mm:ss.

Table 7: FITS Object class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
OBJECT	Reserved			Implemented	Not set in a reliable way. see comment 12.
TCSTGT	NOT			Current	Contents are fine, but keyword name is rather cryptic. See comment 12.
OBJNAME	NOAO			Revised	2 ? Standard name for target. The name should follow IAU standards [11]. See comment 12.
OBJRA				New	2 a Catalogue RA
OBJDEC				New	2 a Catalogue DEC
OBJPMRA				New	2 a Catalogue proper motion in RA

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Table 7: FITS Object class/package ... continued

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
OBJPMDEC				New	2 a Catalogue proper motion in DEC
OBJRADEC	NOAO			New	2 a Coordinate reference system for object coordinates
OBJEQUIN	NOAO			New	2 a Equinox for object coordinates
tbd				New	Moving objects (asteroids, NEO) position/velocity info

Comment 12 (OBJNAME - SP) *The information from OBJNAME should be used in an archive as the object name, rather than the information from OBJECT, as OBJECT typically includes observer comments like filterinfo and exposure times.*

Table 8: FITS meteo class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
AMBTEMP				New	a ? Outside temperature. This keyword is currently used in STANCAM for the camera controller temperature.
DEWPOINT				New	a ? Dewpoint
RELHUM				New	a ? Relative humidity
AVRGWIND				New	a ? Average wind speed during observation
MAXWIND				New	a ? Maximum wind speed measured during observation
WINDDIR		[degrees]		New	a ? Average wind direction. Measured XX of XX. See comments 13, 14
ATMPRESS				New	a ? Atmospheric pressure
DIMMSEE				New	b ? DIMM seeing
DUST				New	b ? Dust measurements, what are the appropriate units, grams per cubic meter? (requires a dust meter) Other option, just dust status:0,1,2 no dust, a bit dusty, get your light sables!

Comment 13 (ANGLES -) *All positional angular measurements should have a clear definition. E.g., measured east from north.*

Comment 14 (WINDDIR - IS, TP) *TCS currently uses different zeropoint (South =0) for wind direction compared to web weather (North =0). TP prefers a keyword name with AZ(imuth) in it, WINDAZ?*

Table 9: FITS TCS class/package, see comment 15

Keyword	Origin & Format	Value field	Comment field	Status		Priority & Notes
UT	NOT		TCS UTC at start (4h:46m:1.0s)	Implemented		See comments 11, 16.
ST	NOT		Sidereal time at start (9h:0m:23.1s)	Implemented		See comment 16.
RA	NOT		Right ascention at start (5h:33m:33.41s)	Implemented		See comment 16. In RADECSYS system with EQUINOX equinox.
DEC	NOT		Declination at start (-1d:9m:25.5s)	Implemented		See comment 16. In RADECSYS system with EQUINOX equinox.
AIRMASS	NOT		Airmass at start (sec(z))	Implemented		See comments 15, 16.
AZIMUTH				New	a	Telescope azimuth. Measured XX of XX, see comment 13.
TELALT			[degrees]	New	a	Telescope altitude
ZD			[degrees]	New	a	Zenith distance
DOMEAZ			Dome azimuth [degrees]	New	a	Dome azimuth. Measured XX of XX. See comments 13, 17.
DOMESTAT				New	a	Dome status, open tracking, closed
tbd				New	a ?	Top shutter position, include in DOMESTAT??
tbd				New	a ?	Bottom shutter position, include in DOMESTAT??
PETALS				New	a ?	Mirror petals position
FIELD	NOT		Field rotation at start	Current		See comment 16. This keyword name and its comment field do not reflect the contents.
SKYPA	NOT		Sky position angle at start [degrees]	Revised		Replacement of FIELD. Measured XX of XX, see comment 13.
ROTPOS	NOT		Rotator angle at start	Current		See comment 16
ROTANG	NOT		Rotator angle at start. [degrees]	Revised		See comment 13.
TELFOCUS	NOT		Telescope focus at start	Implemented		See comment 16, This is the focus after taking into account any filter etc dependent delta focus.
TRACKMOD	NOT			New	a	Tracking mode

Comment 15 (TCS -) *Many parameters (meteo, airmass, etc) are sampled by the TCS at a very high frequency. It would be interesting to have not just a reading in the FITS headers at the beginning, but also at the end or mid-point of the observation.*

Comment 16 (SLASH - SP) *The position of the slash between the value and the comment is column 32 for most of the other headers, only the headers in the TCS class have the slash in column 33. This is allowed by the FITS standard [1], but does not look nice.*

Comment 17 (DOMEAZ - IS,TP) *Should follow AZIMUTH (telescope). Maybe not necessary?*

Table 10: FITS Adapter class/package

Keyword	Origin & Format		Value field	Comment field	Status	Priority & Notes	
CCDPROBE	NOT	C			New	3 b	CCDprobe position: park, split, ccd

Table 11: FITS autoguider class/package

Keyword	Origin & Format		Value field	Comment field	Status	Priority & Notes	
AUSTATUS	NOT				New	?	Autoguider status (On, off, guide star lost...)
AUINTFR	NOT	I		Number of autoguider frames to integrate	New	?	
AUXPOS	NOT			Autoguider X position	Implemented	3 a	2003-05-04 Implemented for ALFOSC and NOT-CAM, other instruments pending
AUYPOS	NOT			Autoguider Y position	Implemented	3 a	2003-05-04 Implemented for ALFOSC and NOT-CAM, other instruments pending
AUBOX	NOT				New	?	Autoguider box, see comment 18
AUFOCUS	NOT				New	?	Autoguider focus
AUSEEING	NOT				New	?	Autoguider seeing estimate
AU???	NOT				New	3a	Guide star coordinates
AU???	NOT				New	3a	Guide star V-mag
AU???	NOT				New	3b	Guide star ID

Comment 18 (AUBOX - IS) *The center of the star box, background box and integration box all have X and Y positions related to pixels in the ScanBeam frame grabber. It should also be noted if the star box is continously moved or not.*

Table 12: FITS FASU class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
FSHUTTER	NOT		FASU shutter status	New	?
AFILTER	NOT			Current	FASU #A Filter description. See comment 19.
AFILTID	NOT			Current	NOT Filter number. 0. See comment 19.
AFILTPOS	NOT			Current	FASU #A filter position (0-6). See comment 19.
BFILTER	NOT			Current	FASU #B Filter description. See comment 19.
BFILTID	NOT			Current	NOT Filter number. 0. See comment 19.
BFILTPOS	NOT			Current	FASU #B filter position (0-6). See comment 19.
FAFLTNM	NOT		FASU A Filter name	Revised	Astronomical name, Johnson B, Halpha, etc. See comment 19.

Table 12: FITS FASU class/package ... continued

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
FAFLTID	NOT		FASU A Filter ID	Revised	Unique NOT ID nummer. See comment 19.
FAFLTPOS	NOT		FASU A Filter wheel position	Revised	Position of filter in wheel. See comment 19.
FAFLTSTP	NOT		FASU A Filter stepper position	New	Position of stepper motor. See comment 19.
FBFLTNM	NOT		FASU B Filter name	Revised	Astronomical name, Johnson B, Halpha, etc. See comment 19.
FBFLTID	NOT		FASU B Filter ID	Revised	Unique NOT ID nummer. See comment 19.
FBFLTPOS	NOT		FASU B Filter wheel position	Revised	Position of filter in wheel. See comment 19.
FBFLTSTP	NOT		FASU B Filter stepper position	New	Position of stepper motor. See comment 19.
CMIRROR	NOT		Comparison mirror position	Implemented	3 a NEW!!! (2004-04) In or out
CLAMPn	NOT		Comparison lamp_n status	Implemented	3 a NEW!!! (2004-04) On or off
CLAMPNMn	NOT		Comparison lamp_n name	Implemented	3 a NEW!!! (2004-04) HeNe, ThAr, etc
CLAMPIDn	NOT	Free C	Comparison lamp_n ID	Implemented	3 a NEW!!! (2004-04) Unique, technical ID
FAPOL	NOT		Fapol optics position	New	1 a 1/0 in or out
FAPLATE	NOT		FAPOL polarization plate	New	1 b Quarter-wave or half-wave.
FAPANG	NOT		FAPOL polarizer angle [degrees]	New	?
POLARIZA	NOT			Current	'N/A','270', '0' / FAPO not in light path ,/ FAPO 270 Degrees polarization, / FAPO 0 Degrees polarization
COMMENT				Current	'270 deg '

Comment 19 (FASU-FILTERS -) *I would prefer to have the keywords for the A en B wheels plus contents indexed with 1 and 2 (FFLTNMn, FFLTIDn, FFLTPOSn, FFLTSTPn, example FFLTNMn leading to FFLTNM1 and FFLTNM2 in stead of FAFLTNM and FBFLTNM, but others prefer to keep the A and B in the keywords.*

Table 13: FITS Other calibration lamps, see comment 20

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
LAMSTATn					3 b Lamp n (baffle lamp, dome floor lamp) on/off, see comment 20
LAMPIDn					3 b Lamp technical ID, see comment 20
LAMPNMn					3 b Lamp verbose name, see comment 20

Comment 20 (LAMPS - SP) *For completeness, I here include the halogen lamps on the telescope baffle and on the dome floor. These are manually switched on/off, and there are currently no means to include any status information in the FITS headers, other than an optional, voluntary comment by the observer.*

Table 14: FITS ALFOSC class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
ALSHUTTR				New	
APERTUR				Current	ALFOSC Aperture ID, step position ???
ALAPRTNM				New	Aperture description. Slit, mask, calcite plate etc
ALAPRTID				Revised	Unique aperture ID
ALAPRPOS				New	ALFOSC aperture wheel position
ALAPRSTP				New	ALFOSC aperture wheel stepper motor position
FILTER				Current	ALFOSC Filter Description
FILTID				Current	NOT Filter number
FILTPOS				Current	ALFOSC Filter wheel step position
ALFLTNM				Revised	Astronomical name, Johnson B, Halpha, etc.
ALFLTID				Revised	Technical unique NOT filter ID
ALFLTPOS				Revised	Filter wheel position
ALFLTSTP				New	Filter wheel stepper motor position
GRISM				Current	ALFOSC grism
ALGRNM				New	Grism name
ALGRID				Revised	Grism ID
ALGRPOS				New	Grism wheel position
ALGRSTP				New	Grism wheel stepper motor position
CAMERA	Free C			Current	Change format from string to float
ALFOCUS	Fixed F			Revised	
ALCENWAV				New	b (Approximate) central wavelength [nm or A?]
tbd				New	b Grism dispersion [A /pix ?]

Table 15: FITS NOTCAM class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
SHSTAT				Current	??? OPEN, What exactly does this mean?
NCSHUTTR				Revised	
APERTUR				Current	NOTcam Aperture ID, step position
NCAPRTNM				New	Aperture description.
NCAPRTID				Revised	Unique aperture ID
NCAPRPOS				New	Aperture wheel position
NCAPRSTP				New	Aperture wheel stepper motor position
FILTER1				Current	NOTcam Filter 1 ID, step position
FILTER2				Current	NOTcam Filter 2 ID, step position
NCFLTNMn				New	Astronomical name, JHK, [FeII], etc

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Table 15: FITS NOTCAM class/package ... continued

Keyword	Origin & Format	Value field	Comment field	Status		Priority & Notes
NCFLTIDn				Revised		Technical unique NOT filter ID
NCFLTPOn				New		Filter wheel position
NCFLTSTn				New		Filter wheel stepper motor position
STOP				Current		NOTcam Stop ID, step position
NCSTOPNM				New		Stop description
NCSTOPID				Revised		Stop ID
NCSTPPOS				New		Stop wheel position
NCSTPSTP				New		Grism wheel stepper motor position
GRISM				Current		NOTcam Grism ID, step position
NCGRSNM				New		Grism name
NCGRSID				Revised		Grism ID
NCGRSPOS				New		Grism wheel position
NCGRSSTP				New		Grism wheel stepper motor position
NCCENWAV				New	b	(Approximate) central wavelength [nm or μm]
tbd				New	b	Grism dispersion [nm?/pix]
LENS				Current		NOTcam Lens ID, step position
CAMERA	Free C			Current		NOTcam Camera focus. Change keyword name. Change format from string to float
NCAMERA				New		Camera description
NCFOCUS				Revised		NOTcam Camera focus
NCAMID				Revised		Camera ID
NCAMPOS				New		Camera wheel position
NCAMSTP				New		Camera wheel stepper motor position
COLDTBL	F		Cold Table temperature	Current		See comment 21
OUTVESS	F		Outer Vessel temperature	Current		See comment 21
CNTWHEE	F		Center Wheel temperature	Current		See comment 21
NCTMPn	NOT	F		Revised	3 a	See comment 21

Comment 21 (NOTCAMTMP -) *The contents of the NOTCAM temperature FITS header cards are fine, but I would like to change their names to include an abbreviation for NOTCAM and for TMP. Possibly the indexed NCTMPn, with cold table, outer vessel, center wheel in the comment field.*

Table 16: FITS MOSCA class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
SHSTAT				Current	
MCSHUTTR				Revised	MOSCA shutter status

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

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
					I have included some keywords for MOSCA in the detector class. Tapio, Graham and others, please send in suggestions!

Table 17: FITS STANCAM class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
SCSHUTTR				New	STANCAM shutter status
FILTER				Current	Stancam Filter Name V#9
FILTPOS				Current	Stancam Filter Position
SCFILTNM				Revised	Astronomical name, Johnson B, Halpha, etc.
SCFILTID				Revised	Technical unique NOT filter ID
SCFLTPOS				Revised	Filter wheel position
SCFLTSTP				New	Filter wheel stepper motor position

Table 18: FITS FIES class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
SHSTAT				Current	OPEN ???
FISHUTTR				Revised	FIES shutter status
tbd	NOT			New	Fiber position
tbd	NOT C	Manual		New	Fiber placement mode
FITMPnn	NOT Fixed F		[K] FIES temperature nn	New	FIES temperature reading at location nn. If 9 readings are enough keyword could become FIESTMPn

Table 19: FITS DETECTOR class/package

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
DETNAME	NOT			Current	3 a	See comments 22, 23.
CHIPID	NOT			Current		See comments 22, 23. Only present for NOTCAM and MOSCA. Currently identical to DETNAME for MOSCA, and similar to DETNAME for NOTCAM.

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

Keyword	Origin & Format		Value field	Comment field	Status	Priority & Notes
DETNAME	NOT	Free C		Verbose description of detector	Revised	
DETID	NOT	Free C		Unique, technical reference ID of detector	Revised	
DETCTRID	NOT	C		Which controller board	New	3a
MPP	NOT	Fixed I	1=ON, 0=OFF	Multi Pinned Phase	Revised	See comment 27
XOVERSC					Incomplete	ALFOSC, MOSCA, FIES
YOVERSC					Incomplete	ALFOSC, MOSCA, FIES
AOVERSC			???			Only present for ALFOSC. Artificial overscan. Rarely used.
tbd						X underscan
tbd						Y underscan
TRIMSEC	NOAO	C			New	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
DETWINn	NOT	C			New	Readout window n [x1:x2, y1:y2]
DETXBIN	NOT	I			New	Binning factor in x or serial direction
DETYBIN	NOT	I			New	Binning factor in y direction
DETXBINn					New	Binning factor in x axis, detector n; no need for this keyword in MEF!
DETYBINn					New	Binning factor in y axis, detector n; no need for this keyword in MEF!
PRESSURE					Incomplete	ALFOSC only. See comment 24
PRESSUR					Incomplete	NOTCAM only. See comment 24
P_DEWAR					Incomplete	MOSCA, FIES only. See comment 24
CCDTEMP		F			Current	ALFOSC, STANCAM, FIES, MOSCA. Change unit from Celsius to Kelvin, see comments 25, 26.
DETTEMP		F		NOTCAM detector temperature	Incomplete	Only for NOTCAM. See comment 26
DETTEMP		F		Detector temperature [K]	Revised	See comment 26
REFTEMP		F		Detector reference temperature [K]	New	
LN2TEMP		F			Incomplete	ALFOSC, FIES, MOSCA. Dewar temperature. Empty comment field. Change unit from Celsius to Kelvin, see comments 25, 26.
AMBTEMP					Remove??	Camera controller temp. Only for STANCAM, see comment 26.
CRYOTEMP		F		Dewar temperature [K]	Revised	See comment 26
GAINMODE		Free C		High or Low	Incomplete	ALFOSC, STANCAM
GAINM		Free C		High or Low	Current	FIES, MOSCA

continued...

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

Keyword	Origin & Format	Value field	Comment field	Status	Priority & Notes
GAIN	Fixed F		Gain Factor [e-/ADU]	Revised	See comment 23.
RDNOISE	Fixed F		Read-out noise [e-]]	New	See comment 23.
AMPLMODE			A / B or AB	Incomplete	ALFOSC, STANCAM
AMPLM			A / B or AB	Current	FIES and MOSCA. Current comment field makes no sense for MOSCA where default readout mode is A4RR
AMPLMODE			Readout mode	Revised	

Comment 22 (DETNAME - SP) *According to [4] DETNAME is the replacement of CHIPID. At present CHIPID is only present for NOTCAM and MOSCA.The contents of DETNAME and CHIPID are identical for MOSCA, and very similar for NOTCAM. It might be useful to maintain two keywords (c.f., ESO guideline 38, [5]), 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.*

Comment 23 (MOSCA - SP) *For MOSCA detector information should not be in primary header, but in extension headers.*

Comment 24 (PRESSURE - SP) *It seems there are 3 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
PRESSURE   ALFOSC
P_DEWAR   MOSCA, FIES

Comment 25 (TEMP-UNITS - SP) *Recommended unit for temperatures [1] is Kelvin in stead of Celsius.*

Comment 26 (TEMPERATURES - TP,GC, SP) *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, CN-TWHEE. The NOTCAM keyword DETTEMP would work in all instruments with a detector. CRYOTEMP (iso LN2TEMP) would work for all cryostats. See also comment 21.*
Apparently (see eg,. minutes staff meeting 2004-01-09), the temperature readings are not to be trusted...

Comment 27 (MPP - SP) *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 28 (FIXEDFREE - SP) *The current format is free, but strongly resembles fixed (columns shifted by 1 position, etc). It is recommended [1] formats should be fixed as much as possible. The use of libraries (CFITSIO) would make this much easier to achieve.*

Table 20: FITS Post-processing class/package

Keyword	Origin & Format		Value field	Comment field	Status	Priority & Notes
PPSTATUS	NOT	C	None		New	Postprocessing (pipeline, ...) status

Table 21: FITS Quality control class/package

Keyword	Origin & Format		Value field	Comment field	Status	Priority & Notes
QCSTATUS	NOT	C	None		New	Quality control status

6 ToDo list May 25, 2004

- timing: start exposure , shutter open, shutter closed, end exposure, end of readout

- FASU keyword naming

- ALFOSC keyword naming

- NOTCAM keyword naming

- filter naming policy

- which units for grism dispersion? ALDISPER A/mm, NCDISPER μ/mm

- check priorities

- Autoguider: see AUBOX comment

- angle definitions