VISTA DATA FLOW SYSTEM (VDFS)

for VISTA & WFCAM data

Pipeline / Science Archive Interface Control Document

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Contents

1 SCOPE

This Interface Control Document (ICD) for the VISTA Data Flow System (VDFS) describes the data flow subsystem interface between the data processing centre (CASU at the IoA, Cambridge) and the science archive centre (WFAU at the IfA, Edinburgh). Details of the types and specifications of VISTA/WFCAM processed data being transfered, along with the transfer protocols (file naming, transfer method and procedure), are given. The details of this ICD have been agreed between CASU and WFAU. The present document is derived from a similar ICD concerning WFCAM data only (VDF–WFA–WSA–004, Issue 3), and has been updated and generalised to be applicable to data from both instruments.

The ICD is intended to be a formal interface control agreement between the data processing centre at CASU and the archive centre at WFAU in Edinburgh. The processing centre/archive centre interface is the final subsystem interface in the data flow chain, and is subject to the rules laid out herein. The ICD concerns VISTA and WFCAM data only; all other data ingested into VDFS science archives are outside the scope of interface control (the archives also ingest publicly released data products, e.g. SDSS and 2MASS etc., from other non–CASU sources). Any toolkit codes delivered to WFAU from CASU must produce data products that adhere to the rules laid out here, but details of those codes are outwith the scope of this document.

The ICD is meant to be a technical reference: its intended audience is the software engineers and scientists working on processing and archiving in the data flow. It takes the form of a formal agreement between CASU and WFAU, but must also satisfy other external bodies, namely the JAC and the UKIDSS survey science consortium for WFCAM, and analogous oversight and survey science groups for VISTA.

2 OVERVIEW

This document is structured as follows. In Section 3, we describe the fundamental rules that the interface shall adhere to, including a statement of the primary data format, FITS. Then, in Section 4, we describe the top-level specifications for data being transfered between Cambridge and Edinburgh, including a description of FITS conventions, keywords, file naming conventions, units and systems of physical quantities. Sections 5 and 6 go on to describe in explicit detail the data structures that are transfered. Then, Section 7 describes the transfer methods and procedures that achieve the data flow from Cambridge to Edinburgh. Finally, security issues are dealt with in Section 8.

Generally, this document is modelled on the ESO Data Interface Control Document [1], and follows as closely as possible the specifications provided therein. For WFCAM, a data flow system overview is provided in [2], and fundamental metadata description (i.e. FITS frame headers and keywords) is given in [3]. The WFCAM JAC/CASU interface is defined and described in [4]; CASU pipeline processing for VISTA and WFCAM data is described in documents available at [5]. Other applicable data flow system documents are listed in Section 11.

3 FUNDAMENTALS

3.1 WFAU Ingest

The archives at WFAU shall ingest data from CASU; there will be no transfer of WFCAM data between JAC and WFAU for example, nor will there be any direct transfer of VISTA data from Chile to WFAU.

3.2 Data transfer method

WFAU shall ingest data via the internet; tapes and/or 'pluggable' disks will not be employed. The implications for required network bandwidth are discussed in AD01. More details are given in Section 7.

3.3 Format

WFCAM data output from CASU shall be provided in standard FITS format (as specified in [6]) only. VISTA data shall be expressed in ESO hierarchical FITS, as described in [1]. Data shall not be expressed in any other format, e.g. the UK Starlink Hierarchical Data Structure format (NDFs). The FITS standard is mature, universally accepted and ideal for transporting both bulk pixel and catalogue data. We note that CASU and WFAU both use the `CFITSIO` library [7] to read and write FITS files. VISTA science products may also be produced using the ESO CPL/QFITS FITS–writing package

Images (32 bit integer) and confidence maps (16 bit integer) shall be supplied as losslessly compressed files with an anticipated $\sim \times 4$ saving in transfer and storage requirements (see later). FITS binary tables shall be in native format.

3.4 Transfered data

Data transfered from CASU shall consist of processed pixels (where the processing steps are specified by the observing protocol used), confidence maps, derived source catalogues and associated description data; no raw pixel data will be transfered to (or held in) the archives. Where irreversible stages such as stacking or mosaicing have been done as part of the reduction procedure, the individual component images and catalogues shall be transferred also. Library calibration frames shall be transfered (e.g. dark frames, flat fields, master skies) for use by users (not for any processing at the archive end).

4 TOP–LEVEL DATA SPECIFICATION

4.1 Preliminaries

Processed frames shall be stored in FITS format, following the guidelines set out in [1]:

- the images comprising a multi–device image frame shall be stored in different image extensions of the same FITS container file (a multi–extension FITS, or MEF, file); data pixels belonging to one chip's image shall be stored in one image extension (guideline–2);
- the primary data array in the MEF file shall be empty (guideline–3);
- keywords describing the dataset in the MEF file as a whole shall be written into the primary HDU, keyword INHERIT set to T to indicate this and extension–specific metadata written into the corresponding HDU (guideline–5)
- single mosaic image products may be written in standard FITS primary HDU files OR in MEF files with one extension, depending on the application code that generates them.

Derived source catalogues corresponding to each image extension shall be written as FITS binary tables in extensions of a single, separate MEF file with a similarly empty primary array. The headers for the catalogue MEF shall contain all the information of image MEF headers plus ancillary processing keywords and values.

4.2 General FITS keywords

Keywords shall follow the standards set out in [1] and [6] and as described in [3] (for WFCAM data) and [15] (for VISTA). Keywords and associated values written to the HDS container files produced by the WFCAM DAS must, where appropriate, be propagated through the JAC/CASU interface, through the data processing pipeline and into the science archive. Similarly, VISTA camera DAS metadata must be propagated through the data flow system.

The first keyword in any extension HDU must be `XTENSION`, and it's value shall take on only `'IMAGE   '` or `'BINTABLE'`; the EXTNAME keyword is used to identify the extension with a particular device detector and a unique ID for each device used in the respective infrared cameras must be propagated through the data flow via an assigned keyword. Binary tables shall have every column described by keywords `TTYPEn`, `TFORMn` and `TUNITn` (see later).

World Co-ordinate System (WCS; ie. astrometric) information shall be propagated using a set of standard keywords described in the latest FITS WCS standards [11, 12] by Greisen and Calabretta.

Pipeline data products must pass NOFS FITS verification (via checks employing `fverify`) to be acceptable to the archive.

4.3 Physical units

Physical units shall comply with SI units and their derivatives with a few exceptions for astronomical convenience (see [1] Section 9, Table 14).

Celestial co-ordinates shall be expressed in a system described by primary HDU keyword RADESYS; it is anticipated that this will have `ICRS` (i.e. Hipparcos/Tycho) over the lifetime of WFCAM, but this may of course change for VISTA. The keyword `EQUINOX` shall be included for backwards compatibility to explicitly give an equinox for older software (note that raw VISTA data is expected to use FK5 until the whole VLT system is brought into line with IAU 1997).

4.4 File naming conventions

For WFCAM, CASU/JAC/ATC have an agreed policy on filenames; furthermore, it is UKIRT policy to use run numbers that reset back to 1 each night. For ease of tracking files through the data flow system, the CASU/WFAU interface follows the same policy, with conventions for processed products, as follows:

- at the telescope, the DAS produces files called `wayyyymmdd_12345.sdf`, `wbyyyymmdd_12345.sdf` and so on, where the a,b,c,d correspond to detector, w stands for wfcam and `12345` is the 5 digit run number;
- CASU shall create 2D raw MEF files from the individual NDFs as a precursor to input to the processing pipeline front–end, with names of the form `wyyyymmdd_nnnnn.fit` and processed filenames of the form `wyyyymmdd_nnnnn_suffix.fit` where `yyyymmdd` is the UT date of observation, `nnnnn` is the UKIRT DAS running number (reset to 1 on a nightly basis) and `_suffix` is a combination of an underscore character plus two–letter abbreviations indicating pipeline processing actions: `_sf` = interleaved superframe, `_st` = stack, `_sf_st` = stacked superframe, `_sf_tl` = tiled superframe etc. Catalogues generated from frames shall be `rootname_cat.fits` and confidence maps for frames `rootname_conf.fit`, etc.

When a file is the result of a combination of several files, the run number of the first file in the list of combined files shall be used for the filename of the combined data file.

For VISTA, the file naming convention shall be similar.

4.5 Convention for null values

The ANSI/IEEE–754 floating–point number standard defines certain special values that are used to represent such quantities as not-a-number (NaN), denormalized, underflow, overflow, and infinity (see the Appendix in the NOST FITS standard [6] or the NOST FITS User's Guide for a list of these values). The CFITSIO routines that read floating point data in FITS files recognize these IEEE special values and by default interpret the overflow and infinity values as being equivalent to a NaN, and convert the underflow and denormalized values into zeros. In cases where programmers may want access to the raw IEEE values without any modification by CFITSIO, this can be done by calling the fits_read_img or fits_read_col routines while specifying 0.0 as the value of the NULLVAL parameter. This will force CFITSIO to simply pass the IEEE values through to the application program without any modification.

Since most of the binary tables contain floating point numbers there is no need to specify null values as these can be specified transparently in CFITSIO. Null floats shall be set to FLOATNULLVAL (equivalent to IEEE not-a-number) and the CFITSIO routines used as normal. For any integer columns, the FITS null value shall be explicitly defined by the TNULLn keyword.

5 DETAILED DATA SPECIFICATION: WFCAM

5.1 Data obtained at the time of observation

Observations shall be described via the keywords OBSERVER, USERID, OBSREF, PROJECT, MSBID, OBJECT, SURVEY and SURVEY_I keywords. Instrumental characteristics, set–ups and parameters shall be described by keywords as detailed in [3], including instrument detector configuration (e.g. array used DETECTOR; number of integrations NINT), detector controller information (e.g. camera read mode READMODE; read–out application CAPPLICN), optical configuration (e.g. filter name FILTER; base focus position FOC_MM) and observing conditions/environment (e.g. air temperature AIRTEMP; relative humidity HUMIDITY; opacity data CSOTAU). All these FITS keys will be propagated through the data flow chain from the DAS to the WFCAM Science Archive (WSA).

5.2 Data products

5.2.1 Corrected pixel data

The CASU pipeline corrects WFCAM pixels into a product that is instrument–signature free. The reduction steps involved in doing so, the derived astrometric and (first–cut) photometric calibrations and resulting DQC information generated shall be propagated into the WSA using FITS keys detailed in the appendices in Section 9. Appendix 9.1 shows example FITS keys for the primary HDU; Appendix 9.2 shows an example of an extension set. Differences in the FITS keys in primary extension HDUs for combined frame products shall be limited to the propagation of provenance information, i.e. a list of the individual frames that have been combined in the pipeline to create a combined frame product will be listed as a set of PROVnnn keywords. Library calibration frames shall have identical FITS keys to science frames, but library frame keywords for library frames will not refer to other frames (e.g. library flatfields will not be flatfielded, etc).

Pixel data values shall be represented in 4–byte integer numbers (i.e. BITPIX=+32) and CFITSIO 'Rice' tile compression [14] shall be employed to facilitate efficient storage and network transfer. Whenever possible, all processing will maintain the original units, i.e. if the original raw data run from 0 to 100,000 ADU, the range in data numbers in processed frames will be similar. At this stage, we allow for the posisbility of use of BSCALE and BZERO FITS keywords and values to recast 4-byte integers into floating point numbers.

5.2.2 Source catalogues

The standard set of CASU source detection parameters can be found in [5]. An example FITS header for a catalogue MEF is given in Appendix 9.3. The following are an extract of the corresponding FITS binary table details for each catalogue attribute (`TFORM` is 1E throughout):

```
No.  Name                    TTYPE                     TUNIT

 1   Seq. no.                Sequence_number             -
 2   Isophotal flux          Isophotal_flux             ADU
 3   X co-ordinate           X_coordinate              pixels
 4   Error in X              X_coordinate_error        pixels
 5   Y co-ordinate           Y_coordinate              pixels
 6   Error in Y              Y_coordinate_error        pixels
 7   Gaussian sigma          Gaussian_sigma            pixels
 8   Ellipticity             Ellipticity                 -
 9   Position angle          Position_angle           degrees
10   Areal profile  1        Areal_1_profile           pixels
.
.
17   Areal profile  8        Areal_8_profile           pixels
18   Peak height             Peak_height                ADU
19   Peak height error       Peak_height_error          ADU
20   Aperture flux 1         Aperture_flux_1            ADU
21   Aperture flux 1 error   Aperture_flux_1_error      ADU
22   Aperture flux 2         Aperture_flux_2            ADU
23   Aperture flux 2 error   Aperture_flux_2_error      ADU
.
.
44   Aperture flux 13        Aperture_flux_13           ADU
45   Aperture flux 13 error  Aperture_flux_13_error     ADU
46   Petrosian radius        Petrosian_radius          pixels
47   Kron radius             Kron_radius               pixels
48   Hall radius             Hall_radius               pixels
49   Petrosian flux          Petrosian_flux             ADU
50   Petrosian flux error    Petrosian_flux_error       ADU
51   Kron flux               Kron_flux                  ADU
52   Kron flux error         Kron_flux_error            ADU
53   Hall flux               Hall_flux                  ADU
54   Hall flux error         Hall_flux_error            ADU
55   Error bit flag          Error_bit_flag            flag
56   Sky level               Sky_level                  ADU
57   Sky variance            Sky_variance               ADU
58   Child/parent            Parent_or_child_flag      flag
59   Right Ascension         RA                       radians
60   Declination             DEC                      radians
61   Classification          Classification            flag
62   Profile statistic       Class_statistic          N-sigma
63   PSF flux                PSF_flux                   ADU
64   PSF flux error          PSF_flux_error             ADU
65   PSF fitted X            PSF_fit_X                 pixels
```

66	PSF fitted X error	PSF_fit_X_error	pixels
67	PSF fitted Y	PSF_fit_Y	pixels
68	PSF fitted Y error	PSF_fit_y_error	pixels
69	PSF fit chi-squared	PSF_fit_chi2	-
70	nu	PSF_fit_dof	-
71	1D Sersic flux	1D_Sersic_flux	ADU
72	Scale length	1D_Sersic_scale_len	-
73	Power law index	1D_Sersic_index	-
74	Error in 1D fit	1D_Sersic_fit_chi2	-
75	1D Sersic fit nu	1D_Sersic_fit_nu	-
76	2D Sersic flux	2D_Sersic_flux	ADU
77	Scale length	2D_Sersic_scale_len	-
78	Power law index	2D_Sersic_index	-
79	Error in 2D fit	2D_Sersic_fit_chi2	-
80	2D Sersic fit nu	2D_Sersic_fit_nu	-

The attribute set and binary table format for CASU standard list–driven source re-measurement (known colloquially as 'co-located list–driven photometry') shall be the same as the standard 80 parameter set described above, but some attributes will of course have subtle changes in their precise meanings as follows:

- RA and Dec shall be the input position, not a derived position;
- X and Y shall be the derived centre–of–gravity within a default aperture as opposed to the first moments of the thresholded, connected pixel distribution.

Aperture sizes and PSFs shall be specified as before; note that fluxes may of course go negative due to noise in a given aperture at a given position. The reasons for keeping the list–driven format as close as possible to the standard isophotal parameter format is to maintain maximum flexibility in the system, and to ensure that existing software (e.g. classifying, source merging etc.) can work in the same way for both types of extracted source lists.

6 DETAILED DATA SPECIFICATION: VISTA

In general, the only difference between VISTA FITS and WFCAM FITS data shall be in the use of ESO hierarchical FITS headers. Of course, the exact keyword set used to describe VISTA data will be different to that for WFCAM. Appendix 9.4 gives example VISTA FITS headers, which illustrate use of ESO hierarchical FITS. This example is taken from AD03, where more details can be found.

6.1 Data obtained at the time of observation

Instrumental characteristics, set–ups and parameters shall be described by keywords as detailed in AD03; example FITS headers can be seen in Appendix 9.4.

6.2 Data products

Post–pipeline, and pre–archive, some extra header items will be added, notably the Quality–Control Measures; keyword sets shall be similar to the examples given in the Appendices for WFCAM data.

6.2.1 Corrected pixel data

In addition to those referenced above, keyword categories as described in [1] shall be employed, e.g. *Process* (`PRO`) and *Quality Control* (`QC`) etc. Additional example sets of hierarchical keywords are given in Appendix 9.4.3.

6.2.2 Source catalogues

VISTA source extraction parameters shall be the same as those for WFCAM (see Section 5.2.2).

7 TRANSFER METHODS & PROCEDURES

7.1 Method

Transfer shall be via the Internet (i.e. JANET) or alternatively a private internet (e.g. UKLight) using standard protocols possibly tuned for optimal performance. The data to be transferred shall reside in Cambridge on specific file systems; WFAU has an account on this system. Directories of processed nights data are set up as the pipeline is running. While processing and writing to a given directory is still running a directory lock file is used to denote the 'in progress' operations. After completion of processing, the lock file is removed and a semaphor file ('`OK_TO_COPY`') is written enabling a remote client task to automatically initiate data transfer to Edinburgh. Once the transfer is complete, the WFAU transfer application writes a semaphor file ('`SUCCESSFULLY_READ`') into the nightly directory. WFAU shall not copy any directory that has no `OK_TO_COPY` file present, and of course will not recopy any directory with `SUCCESSFULLY_READ` present. CASU shall not move or alter data in any way in the interval between `OK_TO_COPY` being flagged and `SUCCESSFULLY_READ` being written; after successful transfer, CASU are free to move/delete data as and when necessary. In AD01 we give details of on–going network bandwidth experiments with large data volumes and employing various transfer protocols; transfer methods tested include ftp, scp, GridFTP and sftp. Currently, a bespoke multithreaded scp application is employed to transfer WFCAM data from CASU to WFAU, but it is anticipated that a higher performance solution will be employed for VISTA data (see AD01).

7.2 Procedure

Location of data is guaranteed by the pipeline and will be in an observation–date–driven directory structure to which WFAU will have secure, direct access. 'Handshaking', e.g. notification of readiness, is achieved using a lockfile system as outlined above; verification of successful transfer includes automatic checking within the transfer utility employed via the number and size of files transferred.

In AD02, we give more details of the transfer task software, including error handling and transfer logging.

7.3 Updates

In the event of pipeline reruns over previous data (e.g. because of improvements in instrumental correction and/or source extraction software) the interface as a whole will be the same regardless of whether data being transfered is first–run or re–run as long as the archive system can cope with overwriting issues within and storage of repeat data. These are dealt with in the database design presented in AD02.

8 SECURITY ISSUES

Nightly processed data shall be held online at CASU until transfer of those data to WFAU is verified. As noted before, secure transfer protocols will be employed between CASU and WFAU to protect data from malicious corruption or access by unauthorised users. Although not strictly speaking a CASU/WFAU interface issue, raw data will be held online in Cambridge (and also offline in a tape store in another building) as the primary UK backup in case of any catastrophic data loss further down the data flow (raw WFCAM data is archived offline at JAC, and raw VISTA and WFCAM survey data at ESO/Garching).

References

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[2] WFCAM Science Archive overview document; http://www.roe.ac.uk/~nch/wfcam/VDF-WFA-WSA-001-I1/VDF-WFA-WSA-001-I1.html

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[4] JAC–CASU Interface Control Document, http://www.jach.hawaii.edu/UKIRT/instruments/wfcam/commissioning/ICDs/WFCAM_JAC_CASU_ICD.html

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[11] Representations of world co-ordinates in FITS, Greisen E.W., Calabretta M.R., A&A, 395, 1061 (2002)

[12] Representations of celestial co-ordinates in FITS, Calabretta M.R., Greisen E.W., A&A, 395, 1077 (2002)

[13] The UKIDSS Proposal; http://www.ukidss.org/sciencecase/sciencecase.html

[14] Adaptive, lossless compression of 2–D astronomical images; Sabbey C.N., ASP Conf. Ser., 172, 129 (1999)

[15] VISTA Data Reduction Library Design, Issue 1.4, 2006–06–15, VIS–SPE–IOA–20000–0010

9 APPENDICES

9.1 Primary HDU FITS keys from CASU pipeline–processed WFCAM image data

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
TELESCOP= 'UKIRT             ' / Telescope name
INSTRUME= 'WFCAM             ' / Instrument
DHSVER  = 'UKDHS 2002 Oct 31 ' / Data handling version
HDTFILE = 'wfcam.hdt         ' / Name of global hdt file
OBSERVER= '                  ' / Observers names
USERID  = '                  ' / Userid logged in as
OBSREF  = '                  ' / PATT or other reference
PROJECT = 'U/UKIDSS/GPS7'      / Time-allocation code
SURVEY  = '                  ' / Survey name
SURVEY_I= '                  ' / Pointing ID within survey
MSBID   = '122600944ce2aa61f97fcc0f755df41f' / Id min.-schedulable block
RMTAGENT= 'none    '           / Name of remote agent
AGENTID = 'none    '           / Unique identifier for remote agent
OBJECT  = 'gps_l0b10:0_0:0_0'  / Object name from telescope
RECIPE  = 'JITTER  '           / Data reduction recipe to be used
OBSTYPE = 'OBJECT  '           / BIAS|DARK|SKYFLAT|DOMEFLAT|OBJECT|SKY|FOCUS
OBSNUM  =                  204 / Observation number
GRPNUM  =                  204 / Group number applied to all members
GRPMEM  =                    T / Group membership
TILENUM =                  204 / Tile number applied to all members
STANDARD=                    F / Is the target a standard star observation?
NJITTER =                    2 / Number of positions in tel jitter pattern
JITTER_I=                    1 / Serial number in this tel jitter pattern
JITTER_X=                 0.00 / [arcsec] X (RA) offset in tel jitter pattern
JITTER_Y=                 0.00 / [arcsec] Y (Dec) offset in tel jitter pattern
NUSTEP  =                    4 / Number of positions in microstep pattern
USTEP_I =                    1 / Serial number in this microstep pattern
USTEP_X =                 0.00 / [arcsec] X (RA) offset in microstep pattern
USTEP_Y =                 0.00 / [arcsec] Y (Dec) offset in microstep pattern
NFOC    =                    0 / Number of positions in focus scan
NFOCSCAN=                    0 / Number of focus scans in focus test
UTDATE  = '20060428'           / UT date as integer in yyyymmdd format
DATE-OBS= '2006-04-28T12:29:18.010' / Date time (UTC) of start of observation
DATE-END= '2006-04-28T12:29:24.499' / Date time (UTC) of end of observation
MJD-OBS =          53853.52035 / DATE-OBS as Modified Julian Date
WCSAXES =                    2 / Number of axes in world co-ordinate system
RADESYS = 'FK5     '           / Mean IAU 1984 equatorial co-ordinates
EQUINOX =             2000.000 / [yr] Equinox of object position
TRACKSYS= 'J2000   '           / Telescope tracking coordinate system
RABASE  =           17.1331306 / [h] Right ascension of base position
DECBASE =          -23.5104778 / [deg] Declination of base position
TELRA   =           17.1331306 / [h] Current telescope right ascension
TELDEC  =          -23.5104778 / [deg] Current telescope declination
GSRA    =           17.1305500 / [h] Right ascension of guide star
GSDEC   =          -23.5137889 / [deg] Declination of guide star
TRAOFF  =                0.000 / [arcsec] Telescope offset in RA
TDECOFF =                0.000 / [arcsec] Telescope offset in Dec
AMSTART =                1.397 / Airmass at start of observation
AMEND   =                1.398 / Airmass at end of observation
NINT    =                    1 / Number of integrations in observation
READMODE= 'CDS     '           / Name of camera readmode
EXP_TIME=             5.000000 / [s] Integration time per exposure
NEXP    =                    1 / Number of exposures in integration
READINT =             0.000000 / [s] Interval between reads
```

```
NREADS  =                    2 / Number of reads per exposure
AIRTEMP =                0.363 / [degC] Air temperature
BARPRESS=              614.262 / [mbar] Ambient pressure
DEWPOINT=              -32.433 / [degC] Dewpoint
DOMETEMP=                0.671 / [degC] Dome temperature
HUMIDITY=                6.412 / Relative Humidity
MIRR_NE =                5.046 / [degC] Mirror temperature NE
MIRR_NW =                3.413 / [degC] Mirror temperature NW
MIRR_SE =                1.782 / [degC] Mirror temperature SE
MIRR_SW =                2.348 / [degC] Mirror temperature SW
MIRRBTNW=                7.324 / [degC] Mirror bottom temp. SW
MIRRTPNW=                5.652 / [degC] Mirror top temp. SW
SECONDAR=               -0.650 / [degC] Temperature of secondary
TOPAIRNW=                1.415 / [degC] Top air NW
TRUSSENE=                2.540 / [degC] Truss leg ENE
TRUSSWSW=                0.089 / [degC] Truss leg WSW
WIND_DIR=               93.152 / [deg] Wind direction, azimuth
WIND_SPD=               10.313 / [km/h] Wind speed
CSOTAU  =                0.050 / Tau at 225 GHz from CSO
TAUDATE = '2006-04-28T12:24'   / Time and date of Tau reading
TAUSRC  = 'CSO225GHZ'          / Source of opacity data
M2_X    =               -0.800 / [mm]   M2 X (E-W) raw position
M2_Y    =                0.000 / [mm]   M2 Y (N-S) raw position
M2_Z    =                2.256 / [mm]   M2 Z (focus) raw position
M2_U    =                2.600 / [mrad] M2 U (N-S tilt) raw position
M2_V    =                3.100 / [mrad] M2 V (E-W tilt) raw position
M2_W    =                0.000 / [mrad] M2 W (axial rotation) raw position
TCS_FOC =               -0.420 / telescope (TCS) focus
FOC_POSN=                0.220 / [mm] Internal focus position
FOC_ZERO=                3.500 / [mm] Focus zero-point position
FOC_OFFS=                0.000 / [mm] Focus offset
FOC_FOFF=                0.220 / [mm] Focus filter offset
FILTER  = 'J       '           / Filter name
UTSTART =            12.488334 / [h] Start time of integration
UTEND   =            12.490000 / [h] End time of integration
FOC_I   =                    0 / Serial number in focus scan
FOC_OFF =                0.000 / [mm] Offset from nominal focus pos
RQ_MINSB= '15.5    '           / [mag/arcsec**2] requested min J sky brightness
RQ_MAXSB= '100.0   '           / [mag/arcsec**2] requested max J sky brightness
RQ_MNSEE= '0.00    '           / [arcsec] requested min seeing
RQ_MXSEE= '0.7     '           / [arcsec] requested max seeing
RQ_MINCL= '0       '           / [percentage] requested min cloud coverage
RQ_MAXCL= '0       '           / [percentage] requested max cloud coverage
RQ_MNTAU= '0       '           / requested min tau constraint
RQ_MXTAU= '        '           / requested max tau constraint
RQ_MINMN= '0       '           / [percentage] req. min illumination moon
RQ_MAXMN= '100     '           / [percentage] req. max illumination moon
HABASE  =           -8.8497245 / [deg] Hour angle
APER_X  =                0.000 / [arcsec] Aperture X axis coordinate
APER_Y  =                0.000 / [arcsec] Aperture Y axis coordinate
ISU2PORT= 'Lost    '           / ISU2 port name
ISU2POFF=                    0 / ISU2 port offset
ISU2TOFF=                    0 / ISU2 tilt offset
GUIDING = 'ON      '           / Guider status: OFF|ON|PAUSED
GUIDFFOC= '                  ' / Fast guider CCD fine focus
AGFREQ  =               20.000 / Autoguider: Frequency
FGMODE  = 'Fast Guider'        / Fast guider mode
IZ5     =                0.000 / Astigmatism: IZ5
HZ5SH   =             -310.000 / Astigmatism: HZ5SH
HZ5CH   =               12.000 / Astigmatism: HZ5CH
HZ5SD   =             -119.000 / Astigmatism: HZ5SD
HZ5CD   =              421.000 / Astigmatism: HZ5CD
IZ6     =             -856.000 / Astigmatism: IZ6
HZ6SH   =             -893.000 / Astigmatism: HZ6SH
HZ6CH   =              583.000 / Astigmatism: HZ6CH
HZ6SD   =             -274.000 / Astigmatism: HZ6SD
HZ6CD   =              915.000 / Astigmatism: HZ6CD
Z7      =             -405.000 / Coma: Z7
Z8      =             1450.000 / Coma: Z8
WEBEAM  =             -405.000 / Topend: W-E beam
NSBEAM  =               45.000 / Topend: N-S beam
IZ9     =             1299.000 / Trefoil: IZ9
HZ9SH   =              277.000 / Trefoil: HZ9SH
```

```
HZ9CH   =             -730.000 / Trefoil: HZ9CH
HZ9SD   =             -188.000 / Trefoil: HZ9SD
HZ9CD   =            -1106.000 / Trefoil: HZ9CD
IZ10    =              398.000 / Trefoil: IZ10
HZ10SH  =              121.000 / Trefoil: HZ10SH
HZ10CH  =               80.000 / Trefoil: HZ10CH
HZ10SD  =             -136.000 / Trefoil: HZ10SD
HZ10CD  =             -299.000 / Trefoil: HZ10CD
Z11     =               52.000 / Spherical: Z11
AAMP    =              949.670 / Astigmatism: amplitude
APHI    =               29.199 / Astigmatism: angle
TAMP    =              469.433 / Trefoil: Amplitude
TPHI    =               49.843 / Trefoil: angle
TEL_FOFF=               -3.350 / focus offset for inst. filter
DETTEMPB=                 74.4 / [K] DET_TEMP alternate sensor
DETTEMPS=                 75.0 / [K] Det temperature setpoint
DET_HTP =                 78.0 / [percent] Det heater level
CCD_TEMP=                160.3 / [K] AG CCD temperature
CCDTEMPS=                160.0 / [K] AG CCD temperature setpoint
CCD_HTP =                 12.0 / [percent] AG CCD heater level
FS_TEMP =                 66.6 / [K] CCC 1st stage temperature
LNC_TEMP=                 91.6 / [K] LN can temperature
SS_TEMP =                 17.9 / [K] CCC 2nd stage temperature
M3_TEMP =                111.3 / [K] M3 temperature
TR_TEMP =                120.5 / [K] Top ring temperature
RS_TEMP =                134.2 / [K] Rad shield temperature
CP_TEMP =                192.8 / [K] Cor plate temperature
SC_TEMP =                275.5 / [K] SCSU cab temperature
CC_PRES =         4.20000e-06 / [mbar] Cryostat Pressure
HISTORY 20060502 12:44:20
HISTORY    $Id: cir_wfcam_convert.c,v 1.6 2005/10/19 09:13:45 jim Exp $
HISTORY 20060615 16:02:07
HISTORY    $Id: cir_compress_fits.c,v 1.8 2005/04/19 12:36:53 jim Exp $
MAGZPT  =                24.16 / Photometric ZP (mags) for default extinction
MAGZRR  =                 0.01 / Photometric ZP error (mags)
EXTINCT =                 0.05 / Extinction coefficient (mags)
WSA_TIME= '        '           / WSA time stamp
WSA_MFID=                    0 / WSA Multiframe ID
END
```

9.2 Extension HDU FITS keys from CASU pipeline–processed WFCAM image data

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                    8 / width of table in bytes
NAXIS2  =                 4133 / number of rows in table
PCOUNT  =             13902564 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    1 / number of fields in each row
TTYPE1  = 'COMPRESSED_DATA'    / label for field   1
TFORM1  = '1PB(3599)'          / data format of field: variable length array
EXTNAME = 'COMPRESSED_IMAGE'   / name of this binary table extension
ZIMAGE  =                    T / extension contains compressed image
ZBITPIX =                   32 / data type of original image
ZNAXIS  =                    2 / dimension of original image
ZNAXIS1 =                 4133 / length of original image axis
ZNAXIS2 =                 4133 / length of original image axis
ZTILE1  =                 4133 / size of tiles to be compressed
ZTILE2  =                    1 / size of tiles to be compressed
ZCMPTYPE= 'RICE_1  '           / compression algorithm
ZNAME1  = 'BLOCKSIZE'          / compression block size
ZVAL1   =                   32 / pixels per block
CAMNUM  =                    1 / Number of WFCAM camera (1, 2, 3 or 4)
HDTFILE2= 'wfcam2.hdt        ' / Name of camera-specific hdt file
CTYPE1  = 'RA---ZPN'           / Algorithm type for axis 1
CTYPE2  = 'DEC--ZPN'           / Algorithm type for axis 2
CRPIX1  =       5.9923252E+03 / Dither offset Y
CRPIX2  =      -1.8867648E+03 / Dither offset Y
```

```
CRVAL1  =        2.5699976E+02 / [deg] Right ascension at the reference pixel
CRVAL2  =       -2.3510918E+01 / [deg] Declination at the reference pixel
CRUNIT1 = 'deg     '           / Unit of right ascension co-ordinates
CRUNIT2 = 'deg     '           / Unit of declination co-ordinates
CD1_1   =       -1.6019899E-07 / Transformation matrix element
CD1_2   =       -5.5693643E-05 / Transformation matrix element
CD2_1   =        5.5711880E-05 / Transformation matrix element
CD2_2   =       -1.6556235E-07 / Transformation matrix element
PV2_1   =                   1. / Pol.coeff. for pixel -> celestial coord
PV2_2   =         0.000000E+00 / Pol.coeff. for pixel -> celestial coord
PV2_3   =                 -50.
DETECTOR= 'RSC Hawaii 2'       / Type of detector array used
DETECTID= 'RSC:H2:60'          / Serial number of detector array
DROWS   =                 2048 / [pixel] Number of detector rows
DCOLUMNS=                 2048 / [pixel] Number of detector columns
RDOUT_X1=                    1 / Start column of array readout
RDOUT_X2=                 2048 / Start column of array readout
RDOUT_Y1=                    1 / Start row    of array readout
RDOUT_Y2=                 2048 / Start row    of array readout
PIXLSIZE=               0.4000 / [arcsec] Pixel size
PCSYSID = 'wfacq1  '           / PC system identifier
SDSUID  = '1e1d1c17'           / Serial number of SDSU controller
CAPPLICN= 'do_mean_wfcam_cds'  / Name of camera readout application
CAMROLE = 'master  '           / Camera role (master|slave|unsync)
CAMPOWER= 'On      '           / Camera power (On|Off)
RUNID   = '/home/wfcam/ucam/data/run00000345' / Name of raw data file
READOUT = 'CDS     '           / Camera readout (CDS|NDR|SAR|RRR)
GAIN    =                4.500 / [electrons/ADU] Detector gain
DET_TEMP=                 74.4 / [K] Detector array temperature
CNFINDEX=             13865262 / Configuration index
READNOIS=                  25. / Readnoise estimate
DARKCOR = 'Done with: dark_20060428_5_CDS_1.fit[1] and scale 1'
FLATCOR = 'Done with: pJ_flat_may2006.fit[1]'
CIR_CPM = 'w20060428_00204_sf_st_conf.fit[1]' / Confidence Map
DECURTN = 'Done    '           / De-curtaining done
CURTNRNG=             49.65332 / Range of decurtain correction
XTALK   = 'Done    '
SKYSUB  = 'Done with sky_20060428_204_J.fit[1] and scale factor 1'
CIR_XOFF=                   0. / Dither offset X
CIR_YOFF=             15.98773 / Dither offset Y
CIRMED  =             627.9613 / Latest estimate of background
CIR_BVAR=             159.1486 / Latest estimate of background variance
CIR_ZERO=            -4.644684 / Pedestal value relative to group average
CIR_SCAL=                   1. / Background scale relative to group maximum
SKYLEVEL=               628.18 / Sky level estimate from IMCORE
SKYNOISE=                 8.78 / Sky noise estimate from IMCORE
PROV0000= 'w20060428_00204_sf_st.fit[1]: formed from imdither of:' / Output file
PROV0001= 'w20060428_00204_sf.fit[1]' / Card # 1
PROV0002= 'w20060428_00208_sf.fit[1]' / Card # 2
SEEING  =             5.395313 / Average FWHM (pixels)
NUMBRMS =                 2089
STDCRMS =            0.1114304
WCSPASS =                    2
RAZP02  =             10.09369 / [arcsec] Ref RA shift pass 0 to 2 (new - old)
DECZP02 =            -1.578503 / [arcsec] Ref Dec shift pass 0 to 2 (new - old)
ELLIPTIC=            0.2457458 / Ellipticity estimate from IMCORE
MAGZPT  =                24.16 / Photometric ZP (mags) for default extinction
MAGZRR  =                 0.01 / Photometric ZP error (mags)
EXTINCT =                 0.05 / Extinction coefficient (mags)
HISTORY 20060502 12:44:20
HISTORY    $Id: cir_compress_fits.c,v 1.8 2005/04/19 12:36:53 jim Exp $
HISTORY 20060615 16:02:07
HISTORY    $Id: cir_compress_fits.c,v 1.8 2005/04/19 12:36:53 jim Exp $
HISTORY 20060615 17:30:00
HISTORY    $Id: cir_create_file.c,v 1.10 2004/09/03 10:48:45 jim Exp $
HISTORY 20060615 17:30:02
HISTORY    $Id: cir_stage1.c,v 1.11 2005/12/15 14:44:04 jim Exp $
HISTORY 20060615 17:31:04
HISTORY    $Id: cir_qblkmed.c,v 1.9 2005/08/12 14:35:19 jim Exp $
HISTORY 20060615 17:32:36
HISTORY    $Id: cir_xtalk.c,v 1.5 2005/10/17 14:58:50 jim Exp $
HISTORY 20060615 20:01:58
HISTORY    $Id: cir_arith.c,v 1.8 2005/02/25 10:14:55 jim Exp $
```

```
HISTORY 20060615 20:36:17
HISTORY    $Id: cir_create_file.c,v 1.10 2004/09/03 10:48:45 jim Exp $
HISTORY 20060615 20:36:22
HISTORY    $Id: cir_imcombine.c,v 1.35 2005/06/10 08:38:35 jim Exp $
HISTORY 20060615 20:37:29
HISTORY    $Id: cir_imcore.c,v 1.11 2004/09/07 14:18:52 jim Exp $
HISTORY 20060615 20:37:44
HISTORY    $Id: cir_create_file.c,v 1.10 2004/09/03 10:48:45 jim Exp $
HISTORY 20060615 20:40:34
HISTORY    $Id: cir_imcore.c,v 1.11 2004/09/07 14:18:52 jim Exp $
HISTORY 20060615 20:43:35
HISTORY    $Id: cir_platesol.c,v 1.10 2005/08/09 11:04:52 jim Exp $
PERCORR =                   0. / Percentage sky correction
PROJP1  =                   1. /
PROJP3  =                 -50. /
NUMZPT  =                 2920 / Number of standards used
NIGHTZPT=                22.77 / Average photometric ZP (mags) for night
NIGHTZRR=                 0.24 / Photometric ZP sigma for night (mags)
BSCALE  =               0.7071 /
END
```

`BSCALE` and `BZERO` shall default to 1.0 and 0.0 respectively if absent from the keyword list. `FLATCOR` is used to tell the pipeline how to do the flat fielding. If done, then it has the words 'Done with' and the name of the flat field file. `RSTANOM` is the reset anomaly correction. This example shows that it has been done with a median–linear filter with box sizes of 50 and 25 pixels respectively. `CIR_CPM` is the confidence map.

`PROV0000` simply gives the name of the current output image, while `PROVnnnn` gives a list of the images that went to forming this image. Note: `RAZPmn` and `DECZPmn` – the WCS is fit twice. `WCSPASS` = 0 is just a WCS from header information. `WCSPASS` = 1 is a fit to just the bright stars and `WCSPASS` = 2 is a fit to all stars in the generated catalogue. `RAZPmn,DECZPmn` is the zero-point shift between `WCSPASS` = m and `WCSPASS` = n. For m = 0, n = 1 it's an indication of how good the telescope pointing is. For m = 1, n = 2, it's an indication of how good the fit is (e.g. do we even have the right region here?) since for this combination the zeropoint should be very small.

Note that the processed image data will be 32 bit integer. Although if one coaverages a set of dithered frames (not to mention flatfielding and so on) all the arithmetic is done using real numbers internally. When one creates the output product, to approximately maintain the original quantisation accuracy of the ADC one can 'scale' the data on–the–fly using the normal CFITSIO routines by doing something along the following lines: if one sets up the output file with, say:

```
BITPIX  =                   32 /
BZERO   =                  0.0 /
BSCALE  =                  0.1 /
```

and then writes it out as `call ftppre(outunit,1,1,npix,map,status)` where map is an r*4 array and reads it back via `call ftgpve(outunit,1,1,npix,nullval,sap,anynull,status)` one gets an rms error of 0.037; c.f. 0.37 with default `BSCALE` of 1.0; if we use `BSCALE` = 1 / no-of-frames-in-stack we stay at the ADC quantisation noise we started with, as if we had coadded them.

This works perfectly well and other packages (eg. `DS9`) read in the data correctly as one would expect. Furthermore, pixel data files expressed in this way also compress more or less the same as normal int*4 files i.e. by roughly a factor of 4 (although more extensive checks are needed to see if this is really a typical factor and how the compression changes with the number of images in a stack). Note that ±0.5 quantisation noise is totally negligible in NIR imagers but we feel the above is a sensible and conservative approach, and that lossless compression of integer data numbers is prefered to (albeit negligibly) lossy compression of floating point data numbers.

9.3 Example FITS keys from a catalogue MEF

Primary HDU (excluding keys inherited from corresponding image data):

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   16 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
END
```

Each extension HDU:

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                  320 / width of table in bytes
NAXIS2  =                12874 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                   80 / number of fields in each row
TTYPE1  = 'Sequence_number'    / label for field   1
TFORM1  = '1E      '           / data format of field: 4-byte REAL
TUNIT1  = 'Number  '           / physical unit of field
TTYPE2  = 'Isophotal_flux'     / label for field   2
TFORM2  = '1E      '           / data format of field: 4-byte REAL
TUNIT2  = 'ADU     '           / physical unit of field
TTYPE3  = 'X_coordinate'       / label for field   3
TFORM3  = '1E      '           / data format of field: 4-byte REAL
TUNIT3  = 'Pixels  '           / physical unit of field
TTYPE4  = 'X_coordinate_err'   / label for field   4
TFORM4  = '1E      '           / data format of field: 4-byte REAL
TUNIT4  = 'Pixels  '           / physical unit of field
TTYPE5  = 'Y_coordinate'       / label for field   5
TFORM5  = '1E      '           / data format of field: 4-byte REAL
TUNIT5  = 'Pixels  '           / physical unit of field
TTYPE6  = 'Y_coordinate_err'   / label for field   6
TFORM6  = '1E      '           / data format of field: 4-byte REAL
TUNIT6  = 'Pixels  '           / physical unit of field
TTYPE7  = 'Gaussian_sigma'     / label for field   7
TFORM7  = '1E      '           / data format of field: 4-byte REAL
TUNIT7  = 'Pixels  '           / physical unit of field
TTYPE8  = 'Ellipticity'        / label for field   8
TFORM8  = '1E      '           / data format of field: 4-byte REAL
TUNIT8  = 'Number  '           / physical unit of field
TTYPE9  = 'Position_angle'     / label for field   9
TFORM9  = '1E      '           / data format of field: 4-byte REAL
TUNIT9  = 'Degrees '           / physical unit of field
TTYPE10 = 'Areal_1_profile'    / label for field  10
TFORM10 = '1E      '           / data format of field: 4-byte REAL
TUNIT10 = 'Pixels  '           / physical unit of field
TTYPE11 = 'Areal_2_profile'    / label for field  11
TFORM11 = '1E      '           / data format of field: 4-byte REAL
TUNIT11 = 'Pixels  '           / physical unit of field
TTYPE12 = 'Areal_3_profile'    / label for field  12
TFORM12 = '1E      '           / data format of field: 4-byte REAL
TUNIT12 = 'Pixels  '           / physical unit of field
TTYPE13 = 'Areal_4_profile'    / label for field  13
TFORM13 = '1E      '           / data format of field: 4-byte REAL
TUNIT13 = 'Pixels  '           / physical unit of field
TTYPE14 = 'Areal_5_profile'    / label for field  14
TFORM14 = '1E      '           / data format of field: 4-byte REAL
TUNIT14 = 'Pixels  '           / physical unit of field
TTYPE15 = 'Areal_6_profile'    / label for field  15
TFORM15 = '1E      '           / data format of field: 4-byte REAL
TUNIT15 = 'Pixels  '           / physical unit of field
TTYPE16 = 'Areal_7_profile'    / label for field  16
TFORM16 = '1E      '           / data format of field: 4-byte REAL
```

```
TUNIT16 = 'Pixels  '           / physical unit of field
TTYPE17 = 'Areal_8_profile'    / label for field  17
TFORM17 = '1E      '           / data format of field: 4-byte REAL
TUNIT17 = 'Pixels  '           / physical unit of field
TTYPE18 = 'Peak_height'        / label for field  18
TFORM18 = '1E      '           / data format of field: 4-byte REAL
TUNIT18 = 'ADU     '           / physical unit of field
TTYPE19 = 'Peak_height_err'    / label for field  19
TFORM19 = '1E      '           / data format of field: 4-byte REAL
TUNIT19 = 'ADU     '           / physical unit of field
TTYPE20 = 'Aper_flux_1'        / Fitted flux within 1/2* core radius
TFORM20 = '1E      '           / data format of field: 4-byte REAL
TUNIT20 = 'ADU     '           / physical unit of field
TTYPE21 = 'Aper_flux_1_err'    / Error in fitted flux within 1/2* core radius
TFORM21 = '1E      '           / data format of field: 4-byte REAL
TUNIT21 = 'ADU     '           / physical unit of field
TTYPE22 = 'Aper_flux_2'        / Fitted flux within 1/sqrt(2)* core radius
TFORM22 = '1E      '           / data format of field: 4-byte REAL
TUNIT22 = 'ADU     '           / physical unit of field
TTYPE23 = 'Aper_flux_2_err'    / Error in fitted flux within 1/sqrt(2)* core rad
TFORM23 = '1E      '           / data format of field: 4-byte REAL
TUNIT23 = 'ADU     '           / physical unit of field
TTYPE24 = 'Aper_flux_3'        / Fitted flux within 1* core radius
TFORM24 = '1E      '           / data format of field: 4-byte REAL
TUNIT24 = 'ADU     '           / physical unit of field
TTYPE25 = 'Aper_flux_3_err'    / Error in fitted flux within 1* core radius
TFORM25 = '1E      '           / data format of field: 4-byte REAL
TUNIT25 = 'ADU     '           / physical unit of field
TTYPE26 = 'Aper_flux_4'        / Fitted flux within sqrt(2)* core radius
TFORM26 = '1E      '           / data format of field: 4-byte REAL
TUNIT26 = 'ADU     '           / physical unit of field
TTYPE27 = 'Aper_flux_4_err'    / Error in fitted flux within sqrt(2)* core radiu
TFORM27 = '1E      '           / data format of field: 4-byte REAL
TUNIT27 = 'ADU     '           / physical unit of field
TTYPE28 = 'Aper_flux_5'        / Fitted flux within 2* core radius
TFORM28 = '1E      '           / data format of field: 4-byte REAL
TUNIT28 = 'ADU     '           / physical unit of field
TTYPE29 = 'Aper_flux_5_err'    / Error in fitted flux within 2* core radius
TFORM29 = '1E      '           / data format of field: 4-byte REAL
TUNIT29 = 'ADU     '           / physical unit of field
TTYPE30 = 'Aper_flux_6'        / Fitted flux within 2*sqrt(2)* core radius
TFORM30 = '1E      '           / data format of field: 4-byte REAL
TUNIT30 = 'ADU     '           / physical unit of field
TTYPE31 = 'Aper_flux_6_err'    / Error in fitted flux within 2*sqrt(2)* core rad
TFORM31 = '1E      '           / data format of field: 4-byte REAL
TUNIT31 = 'ADU     '           / physical unit of field
TTYPE32 = 'Aper_flux_7'        / Fitted flux within 4* core radius
TFORM32 = '1E      '           / data format of field: 4-byte REAL
TUNIT32 = 'ADU     '           / physical unit of field
TTYPE33 = 'Aper_flux_7_err'    / Error in fitted flux within 4* core radius
TFORM33 = '1E      '           / data format of field: 4-byte REAL
TUNIT33 = 'ADU     '           / physical unit of field
TTYPE34 = 'Aper_flux_8'        / Fitted flux within 5* core radius
TFORM34 = '1E      '           / data format of field: 4-byte REAL
TUNIT34 = 'ADU     '           / physical unit of field
TTYPE35 = 'Aper_flux_8_err'    / Error in fitted flux within 5* core radius
TFORM35 = '1E      '           / data format of field: 4-byte REAL
TUNIT35 = 'ADU     '           / physical unit of field
TTYPE36 = 'Aper_flux_9'        / Fitted flux within 6* core radius
TFORM36 = '1E      '           / data format of field: 4-byte REAL
TUNIT36 = 'ADU     '           / physical unit of field
TTYPE37 = 'Aper_flux_9_err'    / Error in fitted flux within 6* core radius
TFORM37 = '1E      '           / data format of field: 4-byte REAL
TUNIT37 = 'ADU     '           / physical unit of field
TTYPE38 = 'Aper_flux_10'       / Fitted flux within 7* core radius
TFORM38 = '1E      '           / data format of field: 4-byte REAL
TUNIT38 = 'ADU     '           / physical unit of field
TTYPE39 = 'Aper_flux_10_err'   / Error in fitted flux within 7* core radius
TFORM39 = '1E      '           / data format of field: 4-byte REAL
TUNIT39 = 'ADU     '           / physical unit of field
TTYPE40 = 'Aper_flux_11'       / Fitted flux within 8* core radius
TFORM40 = '1E      '           / data format of field: 4-byte REAL
TUNIT40 = 'ADU     '           / physical unit of field
```

```
TTYPE41 = 'Aper_flux_11_err'   / Error in fitted flux within 8* core radius
TFORM41 = '1E      '           / data format of field: 4-byte REAL
TUNIT41 = 'ADU     '           / physical unit of field
TTYPE42 = 'Aper_flux_12'       / Fitted flux within 10* core radius
TFORM42 = '1E      '           / data format of field: 4-byte REAL
TUNIT42 = 'ADU     '           / physical unit of field
TTYPE43 = 'Aper_flux_12_err'   / Error in fitted flux within 10* core radius
TFORM43 = '1E      '           / data format of field: 4-byte REAL
TUNIT43 = 'ADU     '           / physical unit of field
TTYPE44 = 'Aper_flux_13'       / Fitted flux within 12* core radius
TFORM44 = '1E      '           / data format of field: 4-byte REAL
TUNIT44 = 'ADU     '           / physical unit of field
TTYPE45 = 'Aper_flux_13_err'   / Error in fitted flux within 12* core radius
TFORM45 = '1E      '           / data format of field: 4-byte REAL
TUNIT45 = 'ADU     '           / physical unit of field
TTYPE46 = 'Petr_radius'        / label for field  46
TFORM46 = '1E      '           / data format of field: 4-byte REAL
TUNIT46 = 'Pixels  '           / physical unit of field
TTYPE47 = 'Kron_radius'        / label for field  47
TFORM47 = '1E      '           / data format of field: 4-byte REAL
TUNIT47 = 'Pixels  '           / physical unit of field
TTYPE48 = 'Hall_radius'        / label for field  48
TFORM48 = '1E      '           / data format of field: 4-byte REAL
TUNIT48 = 'Pixels  '           / physical unit of field
TTYPE49 = 'Petr_flux'          / label for field  49
TFORM49 = '1E      '           / data format of field: 4-byte REAL
TUNIT49 = 'ADU     '           / physical unit of field
TTYPE50 = 'Petr_flux_err'      / label for field  50
TFORM50 = '1E      '           / data format of field: 4-byte REAL
TUNIT50 = 'ADU     '           / physical unit of field
TTYPE51 = 'Kron_flux'          / label for field  51
TFORM51 = '1E      '           / data format of field: 4-byte REAL
TUNIT51 = 'ADU     '           / physical unit of field
TTYPE52 = 'Kron_flux_err'      / label for field  52
TFORM52 = '1E      '           / data format of field: 4-byte REAL
TUNIT52 = 'ADU     '           / physical unit of field
TTYPE53 = 'Hall_flux'          / label for field  53
TFORM53 = '1E      '           / data format of field: 4-byte REAL
TUNIT53 = 'ADU     '           / physical unit of field
TTYPE54 = 'Hall_flux_err'      / label for field  54
TFORM54 = '1E      '           / data format of field: 4-byte REAL
TUNIT54 = 'ADU     '           / physical unit of field
TTYPE55 = 'Error_bit_flag'     / label for field  55
TFORM55 = '1E      '           / data format of field: 4-byte REAL
TUNIT55 = 'Number  '           / physical unit of field
TTYPE56 = 'Sky_level'          / label for field  56
TFORM56 = '1E      '           / data format of field: 4-byte REAL
TUNIT56 = 'ADU     '           / physical unit of field
TTYPE57 = 'Sky_rms '           / label for field  57
TFORM57 = '1E      '           / data format of field: 4-byte REAL
TUNIT57 = 'ADU     '           / physical unit of field
TTYPE58 = 'Parent_or_child'    / label for field  58
TFORM58 = '1E      '           / data format of field: 4-byte REAL
TUNIT58 = 'Number  '           / physical unit of field
TTYPE59 = 'RA      '           / label for field  59
TFORM59 = '1E      '           / data format of field: 4-byte REAL
TUNIT59 = 'RADIANS '           / physical unit of field
TTYPE60 = 'DEC     '           / label for field  60
TFORM60 = '1E      '           / data format of field: 4-byte REAL
TUNIT60 = 'RADIANS '           / physical unit of field
TTYPE61 = 'Classification'     / label for field  61
TFORM61 = '1E      '           / data format of field: 4-byte REAL
TUNIT61 = 'Flag    '           / physical unit of field
TTYPE62 = 'Statistic'          / label for field  62
TFORM62 = '1E      '           / data format of field: 4-byte REAL
TUNIT62 = 'N-sigma '           / physical unit of field
TTYPE63 = 'Blank63 '           / label for field  63
TFORM63 = '1E      '           / data format of field: 4-byte REAL
TUNIT63 = 'Blank63 '           / physical unit of field
TTYPE64 = 'Blank64 '           / label for field  64
TFORM64 = '1E      '           / data format of field: 4-byte REAL
TUNIT64 = 'Blank64 '           / physical unit of field
TTYPE65 = 'Blank65 '           / label for field  65
```

```
TFORM65 = '1E      '           / data format of field: 4-byte REAL
TUNIT65 = 'Blank65 '           / physical unit of field
TTYPE66 = 'Blank66 '           / label for field  66
TFORM66 = '1E      '           / data format of field: 4-byte REAL
TUNIT66 = 'Blank66 '           / physical unit of field
TTYPE67 = 'Blank67 '           / label for field  67
TFORM67 = '1E      '           / data format of field: 4-byte REAL
TUNIT67 = 'Blank67 '           / physical unit of field
TTYPE68 = 'Blank68 '           / label for field  68
TFORM68 = '1E      '           / data format of field: 4-byte REAL
TUNIT68 = 'Blank68 '           / physical unit of field
TTYPE69 = 'Blank69 '           / label for field  69
TFORM69 = '1E      '           / data format of field: 4-byte REAL
TUNIT69 = 'Blank69 '           / physical unit of field
TTYPE70 = 'Blank70 '           / label for field  70
TFORM70 = '1E      '           / data format of field: 4-byte REAL
TUNIT70 = 'Blank70 '           / physical unit of field
TTYPE71 = 'Blank71 '           / label for field  71
TFORM71 = '1E      '           / data format of field: 4-byte REAL
TUNIT71 = 'Blank71 '           / physical unit of field
TTYPE72 = 'Blank72 '           / label for field  72
TFORM72 = '1E      '           / data format of field: 4-byte REAL
TUNIT72 = 'Blank72 '           / physical unit of field
TTYPE73 = 'Blank73 '           / label for field  73
TFORM73 = '1E      '           / data format of field: 4-byte REAL
TUNIT73 = 'Blank73 '           / physical unit of field
TTYPE74 = 'Blank74 '           / label for field  74
TFORM74 = '1E      '           / data format of field: 4-byte REAL
TUNIT74 = 'Blank74 '           / physical unit of field
TTYPE75 = 'Blank75 '           / label for field  75
TFORM75 = '1E      '           / data format of field: 4-byte REAL
TUNIT75 = 'Blank75 '           / physical unit of field
TTYPE76 = 'Blank76 '           / label for field  76
TFORM76 = '1E      '           / data format of field: 4-byte REAL
TUNIT76 = 'Blank76 '           / physical unit of field
TTYPE77 = 'Blank77 '           / label for field  77
TFORM77 = '1E      '           / data format of field: 4-byte REAL
TUNIT77 = 'Blank77 '           / physical unit of field
TTYPE78 = 'Blank78 '           / label for field  78
TFORM78 = '1E      '           / data format of field: 4-byte REAL
TUNIT78 = 'Blank78 '           / physical unit of field
TTYPE79 = 'Blank79 '           / label for field  79
TFORM79 = '1E      '           / data format of field: 4-byte REAL
TUNIT79 = 'Blank79 '           / physical unit of field
TTYPE80 = 'Blank80 '           / label for field  80
TFORM80 = '1E      '           / data format of field: 4-byte REAL
TUNIT80 = 'Blank80 '           / physical unit of field
EXTNAME = 'APM-BINARYTABLE'    / name of this binary table extension
DATE    = '2006-06-15T19:39:35' / file creation date (YYYY-MM-DDThh:mm:ss UT)
.
.
.
SKYLEVEL=               628.18 / Median sky brightness (counts/pixel)
SKYNOISE=                 8.78 / Pixel noise at sky level (counts)
HISTORY 20060615 20:37:29
HISTORY    $Id: cir_imcore.c,v 1.11 2004/09/07 14:18:52 jim Exp $
HISTORY 20060615 20:37:44
HISTORY    $Id: cir_create_file.c,v 1.10 2004/09/03 10:48:45 jim Exp $
.
.
.
NXOUT   =                 4133 / X-axis size of image
NYOUT   =                 4133 / Y-axis size of image
THRESHOL=                10.97 / Isophotal analysis threshold (counts)
MINPIX  =                    4 / Minimum size for images (pixels)
CROWDED =                    1 / Crowded field analysis flag (0 none, 1 active)
RCORE   =                 5.00 / Core radius for default profile fit (pixels)
SEEING  =             5.395313 / Average FWHM (pixels)
HISTORY 20060615 20:40:34
HISTORY    $Id: cir_imcore.c,v 1.11 2004/09/07 14:18:52 jim Exp $
NUMBRMS =                 2089
WCSPASS =                    2
STDCRMS =    0.111430391669273
```

```
HISTORY 20060615 20:43:43
HISTORY    $Id: cir_catcoord.c,v 1.7 2004/08/19 11:34:23 jim Exp $
ELLIPTIC=            0.2457458 / Average stellar ellipticity (1-b/a)
CLASSIFD=                    T / Class flag: -1 stellar, 1 non-stellar, 0 noise
SATURATE=             12497.84 / Average saturation level in frame
APCORPK =             4.261357 / Stellar aperture correction - peak height
APCOR1  =             1.537767 / Stellar aperture correction - 1/2x core flux
APCOR2  =             1.027226 / Stellar aperture correction - core/sqrt(2) flux
APCOR3  =            0.5166855 / Stellar aperture correction - core flux
APCOR4  =            0.2371197 / Stellar aperture correction - sqrt(2)x core flu
APCOR5  =           0.09944248 / Stellar aperture correction - 2x core flux
APCOR6  =           0.04034615 / Stellar aperture correction - 2sqrt(2)x core fl
APCOR7  =                   0. / Stellar aperture correction - 4x core flux
COMMENT Symbolic translation for GAIA ellipse plotting........
SYMBOL1 = '{Ellipticity Position_angle Areal_1_profile Classification} {el'
SYMBOL2 = 'lipse blue (1.0-$Ellipticity) $Position_angle+90 {} $Classific'
SYMBOL3 = 'ation==1} {sqrt($Areal_1_profile*(1.0-$Ellipticity)/3.142)} : {'
SYMBOL4 = 'Ellipticity Position_angle Areal_1_profile Classification} {el'
SYMBOL5 = 'lipse red (1.0-$Ellipticity) $Position_angle+90 {} $Classific'
SYMBOL6 = 'ation==-1} {sqrt($Areal_1_profile*(1.0-$Ellipticity)/3.142)} :'
SYMBOL7 = '{Ellipticity Position_angle Areal_1_profile Classification} {el'
SYMBOL8 = 'lipse green (1.0-$Ellipticity) $Position_angle+90 {} $Classifi'
SYMBOL9 = 'cation==0} {sqrt($Areal_1_profile*(1.0-$Ellipticity)/3.142)}'
HISTORY 20060615 20:43:43
HISTORY    $Id: cir_classify.c,v 1.15 2006/03/17 11:30:27 jim Exp $
MAGZPT  =                24.16  / Photometric ZP (mags) for default extinction
MAGZRR  =                 0.01  / Photometric ZP error (mags)
EXTINCT =                 0.05  / Extinction coefficient (mags)
NUMZPT  =                 2920  / Number of standards used
PERCORR =                 0.00  / Percentage sky correction
HISTORY    $Id: photom_wfcam v0.6  MJI prototype toolkit $
NIGHTZPT=                22.77  / Average photometric ZP (mags) for night
NIGHTZRR=                 0.24  / Photometric ZP sigma for night (mags)
HISTORY    $Id: photom_wfcam v0.6  MJI prototype toolkit $
HISTORY    $Id: photom_wfcam v0.7  MJI prototype toolkit $
END
```

9.4 Example VISTA hierarchical FITS keywords for image data

9.4.1 Primary HDU keywords

```
SIMPLE  =                    T / Standard FITS format (NOST-100.0)
BITPIX  =                    8 / # of bits storing pix values
NAXIS   =                    0 / # of axes in frame
EXTEND  =                    T / Extension may be present
ORIGIN  = 'ESO     '                    / European Southern Observatory
DATE    = '2006-07-04T12:26:01'         / Date this file was written
TELESCOP= 'VISTA   '                    / ESO Telescope Name
INSTRUME= 'VIRCAM  '                    / Instrument used.
OBJECT  = 'Bit of the sky'     / Original target.
RA      =             5.874096          / 00:23:29.7 RA (J2000) pointing (deg)
DEC     =            -72.15028          / -72:09:01.0 DEC (J2000) pointing (deg)
EQUINOX =                2000.          / Standard FK5 (years)
RADECSYS= 'FK5     '                    / Coordinate reference frame
EXPTIME =           10.0000000          / Integration time
MJD-OBS =       53920.51807589          / Obs start
DATE-OBS= '2006-07-04T12:26:01.7569'    / Observing date
UTC     =            44756.040          / 12:25:56.040 UTC at start (sec)
LST     =             9231.018          / 02:33:51.018 LST at start (sec)
PI-COI  = 'J.Lewis-P.Bunclark' / PI-COI name.
OBSERVER= 'Peter Bunclark'     / Name of observer.
ORIGFILE= 'VIRCAM_IMG_OBS185_0001.fits' / Original File Name
COMMENT VISTA IR Camera OS $Revision: 0.23 $
HIERARCH ESO ADA ABSROT END  =      0.00000 / Abs rot angle at exp end (deg)
HIERARCH ESO DET DIT         =   10.0000000 / Integration Time
HIERARCH ESO DET NCORRS NAME = 'Double  '   / Read-Out Mode Name
HIERARCH ESO DET NDIT        =            1 / # of Sub-Integrations
HIERARCH ESO DPR CATG        = 'SCIENCE '   / Observation category
HIERARCH ESO DPR TECH        = 'IMAGE,JITTER' / Observation technique
```

```
HIERARCH ESO DPR TYPE        = 'OBJECT  '   / Observation type
HIERARCH ESO INS DATE        = '2006-07-01' / Instrument release date (yyyy-mm-d
HIERARCH ESO INS FILT1 DATE  = '2006-06-08T08:38:04' / Filter index time
HIERARCH ESO INS FILT1 FOCUS =       -0.300 / Filter focus offset [mm]
HIERARCH ESO INS FILT1 ID    = '        '   / Filter unique id
HIERARCH ESO INS FILT1 NAME  = 'J       '   / Filter name
HIERARCH ESO INS FILT1 NO    =            0 / Filter wheel position index
HIERARCH ESO INS FILT1 SWSIM =            F / If T, filter wheel simulated
HIERARCH ESO INS FILT1 WLEN  =     1250.000 / Filter effective wavelength [nm]
HIERARCH ESO INS HB1 SWSIM   =            F / If T, heart beat device simulated
HIERARCH ESO INS LSC1 SETP1  =         0.00 / Temperature set-point [K]
HIERARCH ESO INS LSC1 SETP2  =         0.00 / Temperature set-point [K]
HIERARCH ESO INS LSC1 SWSIM  =            F / If T, lakeshore ctrllr simulated
HIERARCH ESO INS LSM1 SWSIM  =            F / If T, lakeshore monitor simulated
HIERARCH ESO INS LSM2 SWSIM  =            F / If T, lakeshore monitor simulated
HIERARCH ESO INS LSM3 SWSIM  =            F / If T, lakeshore monitor simulated
HIERARCH ESO INS PRES1 VAL   =        0.000 / Pressure [mbar]
HIERARCH ESO INS PRES2 VAL   =        0.000 / Pressure [mbar]
HIERARCH ESO INS PRES3 VAL   =        0.000 / Pressure [mbar]
HIERARCH ESO INS PRES4 VAL   =        0.000 / Pressure [mbar]
HIERARCH ESO INS PRES5 VAL   =        0.000 / Pressure [mbar]
HIERARCH ESO INS PRES6 VAL   =        0.000 / Pressure [mbar]
HIERARCH ESO INS SENSOR6 SWSIM=           F / If T, function software simulated
HIERARCH ESO INS TEMP1 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP10 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP11 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP12 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP13 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP14 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP15 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP16 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP17 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP18 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP19 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP2 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP20 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP21 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP22 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP23 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP24 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP25 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP26 VAL  =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP3 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP4 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP5 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP6 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP7 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP8 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS TEMP9 VAL   =        0.000 / Temperature [K]
HIERARCH ESO INS THERMAL DET MEAN=     0.00 / Detector mean temperature [K]
HIERARCH ESO INS THERMAL DET TARGET=  70.00 / Detector target temperature [K]
HIERARCH ESO INS THERMAL ENABLE=          T / If T, enable thermal control
HIERARCH ESO INS VAC1 SWSIM  =            F / If T, vacuum sensor simulated
HIERARCH ESO OBS DID         = 'ESO-VLT-DIC.OBS-1.11' / OBS Dictionary
HIERARCH ESO OBS GRP         = '0       '   / linked blocks
HIERARCH ESO OBS ID          =           -1 / Observation block ID
HIERARCH ESO OBS NAME        = 'Maintenance' / OB name
HIERARCH ESO OBS OBSERVER    = 'Peter Bunclark' / Observer Name
HIERARCH ESO OBS PI-COI ID   =            0 / ESO internal PI-COI ID
HIERARCH ESO OBS PI-COI NAME = 'J.Lewis-P.Bunclark' / PI-COI name
HIERARCH ESO OBS PROG ID     = 'CASU Simulated Data' / ESO program identificatio
HIERARCH ESO OBS START       = '2006-07-04T12:25:44' / OB start time
HIERARCH ESO OBS TARG NAME   = 'Bit of the sky' / OB target name
HIERARCH ESO OBS TPLNO       =            1 / Template number within OB
HIERARCH ESO OCS DET1 IMGNAME= 'VIRCAM_IMG_OBS' / Data File Name.
HIERARCH ESO OCS EXPNO       =            1 / Exposure number of dwell
HIERARCH ESO OCS NEXP        =            1 / Number of exposures per dwell
HIERARCH ESO OCS RECIPE      = 'DEFAULT '   / Data reduction recipe to be used
HIERARCH ESO OCS REQTIME     =       10.000 / Requested integration time [s]
HIERARCH ESO TEL ABSROT START=        0.000 / Abs rotator angle at start
HIERARCH ESO TEL AIRM END    =        1.000 / Airmass at end
HIERARCH ESO TEL AIRM START  =        1.000 / Airmass at start
HIERARCH ESO TEL ALT         =       39.206 / Alt angle at start (deg)
```

```
HIERARCH ESO TEL AMBI FWHM END=       -1.00 / Observatory Seeing queried from AS
HIERARCH ESO TEL AMBI FWHM START=     -1.00 / Observatory Seeing queried from AS
HIERARCH ESO TEL AMBI PRES END=      750.00 / Observatory ambient air pressure q
HIERARCH ESO TEL AMBI PRES START=    750.00 / Observatory ambient air pressure q
HIERARCH ESO TEL AMBI RHUM   =          12. / Observatory ambient relative humi
HIERARCH ESO TEL AMBI TAU0   =     0.000000 / Average coherence time
HIERARCH ESO TEL AMBI TEMP   =        10.00 / Observatory ambient temperature qu
HIERARCH ESO TEL AMBI WINDDIR=           0. / Observatory ambient wind directio
HIERARCH ESO TEL AMBI WINDSP =        10.00 / Observatory ambient wind speed que
HIERARCH ESO TEL AO ALT      =     0.000000 / Altitude of last closed loop aO
HIERARCH ESO TEL AO DATE     = '        '   / Last closed loop aO
HIERARCH ESO TEL AO M1 DATE  = '2006-07-04T12:26:01' / Last M1 update
HIERARCH ESO TEL AO M2 DATE  = '2006-07-04T12:26:00' / Last M2 update
HIERARCH ESO TEL AO MODES    =            0 / Which aO modes corrected closed lo
HIERARCH ESO TEL AZ          =       12.300 / Az angle at start (deg) S=0,W=90
HIERARCH ESO TEL DATE        = '1954-03-05T07:25:00' / TCS installation date
HIERARCH ESO TEL DID         = 'ESO-VLT-DIC.TCS-01.00' / Data dictionary for TEL
HIERARCH ESO TEL DID1        = 'ESO-VLT-DIC.VTCS-0.2' / Additional data dict. fo
HIERARCH ESO TEL DOME STATUS = 'FULLY-OPEN' / Dome status
HIERARCH ESO TEL ECS FLATFIELD=           0 / Flat field level
HIERARCH ESO TEL ECS MOONSCR =         0.00 / Moon screen position
HIERARCH ESO TEL ECS VENT1   =         0.00 / State of vent i
HIERARCH ESO TEL ECS VENT2   =         0.00 / State of vent i
HIERARCH ESO TEL ECS VENT3   =         0.00 / State of vent i
HIERARCH ESO TEL ECS WINDSCR =         0.00 / Wind screen position
HIERARCH ESO TEL FOCU ID     = 'CA      '   / Telescope focus station ID
HIERARCH ESO TEL FOCU VALUE  =        0.000 / M2 setting (mm)
HIERARCH ESO TEL GEOELEV     =        2530. / Elevation above sea level (m)
HIERARCH ESO TEL GEOLAT      =     -24.6157 / Tel geo latitute (+=North) (deg)
HIERARCH ESO TEL GEOLON      =     -70.3976 / Tel geo longitude (+=East) (deg)
HIERARCH ESO TEL GUID FWHM   =         0.00 / Seeing measured by autoguider
HIERARCH ESO TEL GUID STATUS = 'OFF     '   / Status of autoguider
HIERARCH ESO TEL ID          = 'v 0.46  '   / TCS version number
HIERARCH ESO TEL M2 ACENTRE  =         0.00 / M2 centring alpha
HIERARCH ESO TEL M2 ATILT    =         0.00 / M2 tilt alpha
HIERARCH ESO TEL M2 BCENTRE  =         0.00 / M2 centring beta
HIERARCH ESO TEL M2 BTILT    =         0.00 / M2 tilt beta
HIERARCH ESO TEL M2 Z        =      0.00000 / Focussing position of M2 in Z coor
HIERARCH ESO TEL MOON DEC    =     -9.70387 / -09:42:13.9 DEC (J2000) (deg)
HIERARCH ESO TEL MOON RA     =   199.385494 / 13:17:32.5 RA (J2000) (deg)
HIERARCH ESO TEL OPER        = 'Operator name not set' / Telescope Operator
HIERARCH ESO TEL PARANG END  =        0.000 / Parallactic angle at end (deg)
HIERARCH ESO TEL PARANG START=        0.000 / Parallactic angle at start (deg)
HIERARCH ESO TEL POSANG      =        0.000 / Rot position angle at start
HIERARCH ESO TEL TARG ALPHA  =     2329.783 / Alpha coordinate for the target
HIERARCH ESO TEL TARG COORDTYPE= 'M       ' / Coordinate type (M=mean A=apparent
HIERARCH ESO TEL TARG DELTA  =  -720901.000 / Delta coordinate for the target
HIERARCH ESO TEL TARG EPOCH  =     2000.000 / Epoch
HIERARCH ESO TEL TARG EPOCHSYSTEM= 'J       ' / Epoch system (default J=Julian)
HIERARCH ESO TEL TARG EQUINOX=     2000.000 / Equinox
HIERARCH ESO TEL TARG PARALLAX=       0.000 / Parallax
HIERARCH ESO TEL TARG PMA    =     0.000000 / Proper Motion Alpha
HIERARCH ESO TEL TARG PMD    =     0.000000 / Proper motion Delta
HIERARCH ESO TEL TARG RADVEL =        0.000 / Radial velocity
HIERARCH ESO TEL TH M1 TEMP  =         0.00 / M1 superficial temperature
HIERARCH ESO TEL TH STR TEMP =         0.00 / Telescope structure temperature
HIERARCH ESO TEL TRAK STATUS = 'NORMAL  '   / Tracking status
HIERARCH ESO TPL DID         = 'ESO-VLT-DIC.TPL-1.9' / Data dictionary for TPL
HIERARCH ESO TPL EXPNO       =            1 / Exposure number within template
HIERARCH ESO TPL ID          = 'VIRCAM_img_obs_paw' / Template signature ID
HIERARCH ESO TPL NAME        = 'VIRCAM pawprint observation' / Template name
HIERARCH ESO TPL NEXP        =           12 / Number of exposures within templat
HIERARCH ESO TPL PRESEQ      = 'VIRCAM_img_obs_paw.seq' / Sequencer script
HIERARCH ESO TPL START       = '2006-07-04T12:25:44' / TPL start time
HIERARCH ESO TPL VERSION     = '$Revision: 0.36 $' / Version of the template
JITTER_I=                  1          / Sequence number of jitter
JITTER_X=             -1.000          / X offset in jitter pattern [arcsec]
JITTER_Y=             -1.000          / Y offset in jitter pattern [arcsec]
JITTRNUM=                  1          / Value of 1st OBSNUM in jitter seq
JITTR_ID= 'Jitter3u'                  / Name of jitter pattern
NJITTER =                  3          / Number of jitter positions
NUSTEP  =                  4          / Number of microstep positions
OBSNUM  =                  1          / Observation number
```

```
RECIPE  = 'DEFAULT '                    / Data reduction recipe to be used
REQTIME =              10.000           / Requested integration time [s]
USTEPNUM=                   1           / Value of 1st OBSNUM in ustep seq
USTEP_I =                   1           / Sequence number of ustep
USTEP_ID= 'Ustep2x2'                    / Name of ustep pattern
USTEP_X =               0.000           / X offset in ustep pattern [arcsec]
USTEP_Y =               0.000           / Y offset in ustep pattern [arcsec]
END
```

9.4.2 Extension HDU FITS keys

```
XTENSION= 'IMAGE   '           / IMAGE extension
BITPIX  =                   32 / # of bits per pix value
NAXIS   =                    2 / # of axes in data array
NAXIS1  =                 2048 / # of pixels in axis1
NAXIS2  =                 2048 / # of pixels in axis2
PCOUNT  =                    0 / number of random group parameters
GCOUNT  =                    1 / number of random groups
EXTNAME = 'DET1.CHIP1'         / Extension name
EXTVER  = 1 / Extension version
ORIGIN  = 'ESO     ' / European Southern Observatory
DATE    = '2006-07-04T12:26:12.7141' / Date the file was written
EXPTIME =           10.0000000 / Integration time
MJD-OBS =       53920.51807589 / Obs start 2006-07-04T12:26:01.757
DATE-OBS= '2006-07-04T12:26:01.7569' / Observing date
CTYPE1  = 'RA---ZPN' / Coord type of celestial axis 1
CTYPE2  = 'DEC--ZPN' / Coord type of celestial axis 2
CRVAL1  =             5.874096 / RA at reference pixel
CRVAL2  =            -72.15028 / Dec at reference pixel
CRPIX1  =               5401.6 / Pixel coordinate at ref point
CRPIX2  =               6860.8 / Pixel coordinate at ref point
CDELT1  = 9.49444444444444E-05 / Coordinate increment
CDELT2  = -9.49444444444444E-05 / Coordinate increment
ORIGFILE= 'VIRCAM_IMG_OBS185_0001_DET01.fits' / Original File Name
CD1_1   = 5.81347849634012E-21 / WCS transform matrix element
CD1_2   = 9.49444444444444E-05 / WCS transform matrix element
CD2_1   = -9.49444444444444E-05 / WCS transform matrix element
CD2_2   = -5.81347849634012E-21 / WCS transform matrix element
HIERARCH ESO DET CHIP ID     = 'ESO-Virgo35' / Detector ID
HIERARCH ESO DET CHIP LIVE = T / Detector live or broken
HIERARCH ESO DET CHIP NAME   = 'Virgo-Sim' / Detector name
HIERARCH ESO DET CHIP NO     = 1 / Unique Detector Number
HIERARCH ESO DET CHIP NX     = 1024 / Pixels in X
HIERARCH ESO DET CHIP NY     = 1024 / Pixels in Y
HIERARCH ESO DET CHIP PXSPACE= 1.850e-05 / Pixel-Pixel Spacing
HIERARCH ESO DET CHIP TYPE   = 'IR' / The Type of Det Chip
HIERARCH ESO DET CHIP VIGNETD = F / Detector chip vignetted?
HIERARCH ESO DET CHIP X      = 1 / Detector position x-axis
HIERARCH ESO DET CHIP Y      = 4 / Detector position y-axis
HIERARCH ESO DET CHOP FREQ   = 0 / Chopping Frequency
HIERARCH ESO DET CON OPMODE  = 'SIMULATION' / Operational Mode
HIERARCH ESO DET DID         = 'ESO-VLT-DIC.IRACE-1.37' / Dictionary Name and Re
HIERARCH ESO DET DIT         = 10.0000000 / Integration Time
HIERARCH ESO DET DITDELAY    = 0.000 / Pause Between DITs
HIERARCH ESO DET EXP NAME    = 'VIRCAM_IMG_OBS185_0001' / Exposure Name
HIERARCH ESO DET EXP NO      = 117 / Exposure number
HIERARCH ESO DET EXP UTC     = '2006-07-04T12:26:12.7141' / File Creation Time
HIERARCH ESO DET FRAM NO     = 1 / Frame number
HIERARCH ESO DET FRAM TYPE   = 'INT' / Frame type
HIERARCH ESO DET FRAM UTC    = '2006-07-04T12:26:12.1786' / Time Recv Frame
HIERARCH ESO DET IRACE ADC1 DELAY= 7 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC1 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC1 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC1 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC1 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC1 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC10 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC10 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC10 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC10 FILTER2= 0 / ADC Filter2 Adjustment
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HIERARCH ESO DET IRACE ADC10 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC10 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC11 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC11 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC11 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC11 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC11 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC11 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC12 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC12 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC12 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC12 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC12 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC12 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC13 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC13 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC13 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC13 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC13 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC13 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC14 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC14 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC14 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC14 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC14 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC14 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC15 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC15 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC15 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC15 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC15 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC15 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC16 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC16 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC16 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC16 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC16 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC16 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC2 DELAY= 7 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC2 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC2 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC2 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC2 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC2 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC3 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC3 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC3 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC3 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC3 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC3 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC4 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC4 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC4 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC4 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC4 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC4 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC5 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC5 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC5 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC5 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC5 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC5 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC6 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC6 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC6 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC6 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC6 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC6 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC7 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC7 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC7 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC7 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC7 HEADER= 1 / Header of ADC Board
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HIERARCH ESO DET IRACE ADC7 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC8 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC8 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC8 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC8 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC8 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC8 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE ADC9 DELAY= 0 / ADC Delay Adjustment
HIERARCH ESO DET IRACE ADC9 ENABLE= 1 / Enable ADC Board (0/1)
HIERARCH ESO DET IRACE ADC9 FILTER1= 0 / ADC Filter1 Adjustment
HIERARCH ESO DET IRACE ADC9 FILTER2= 0 / ADC Filter2 Adjustment
HIERARCH ESO DET IRACE ADC9 HEADER= 1 / Header of ADC Board
HIERARCH ESO DET IRACE ADC9 NAME= 'VISTA-AQ-GRP' / Name for ADC Board
HIERARCH ESO DET IRACE SEQCONT= 'F' / Sequencer Continuous Mode
HIERARCH ESO DET MINDIT      = 0.4006000 / Minimum DIT
HIERARCH ESO DET MODE NAME   = '' / DCS Detector Mode
HIERARCH ESO DET NCORRS      = 2 / Read-Out Mode
HIERARCH ESO DET NCORRS NAME = 'Double' / Read-Out Mode Name
HIERARCH ESO DET NDIT        = 1 / # of Sub-Integrations
HIERARCH ESO DET NDITSKIP    = 0 / DITs skipped at 1st.INT
HIERARCH ESO DET RSPEED      = 2 / Read-Speed Factor
HIERARCH ESO DET RSPEEDADD   = 0 / Read-Speed Add
HIERARCH ESO DET VOLT1 CLKHI1= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI10= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI11= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI12= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI13= 0.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI14= 0.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI15= 0.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI16= 0.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI2= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI3= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI4= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI5= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI6= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI7= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI8= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHI9= 5.0000 / Set Value High-Clock
HIERARCH ESO DET VOLT1 CLKHINM1= 'clk1Hi LSYNC' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM10= 'clk10Hi READ' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM11= 'clk11Hi VDD' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM12= 'clock12Hi LRST' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM13= 'clock13Hi' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM14= 'clock14Hi' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM15= 'clock15Hi' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM16= 'clock16Hi' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM2= 'clk2Hi CLK1' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM3= 'clk3Hi CLKB1' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM4= 'clk4Hi CLK2' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM5= 'clk5Hi CLKB2' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM6= 'clk6Hi FSYNC' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM7= 'clk7Hi VCLK' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM8= 'clk8Hi RESET' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHINM9= 'clk9Hi RESETEN' / Name of High-Clock
HIERARCH ESO DET VOLT1 CLKHIT1= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT10= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT11= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT12= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT13= 0.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT14= 0.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT15= 0.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT16= 0.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT2= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT3= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT4= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT5= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT6= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT7= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT8= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKHIT9= 5.0000 / Tel Value High-Clock
HIERARCH ESO DET VOLT1 CLKLO1= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO10= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO11= 5.0000 / Set value Low-Clock
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HIERARCH ESO DET VOLT1 CLKLO12= 5.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO13= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO14= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO15= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO16= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO2= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO3= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO4= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO5= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO6= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO7= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO8= 0.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLO9= 5.0000 / Set value Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM1= 'clk1Lo LSYNC' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM10= 'clk10Lo READ' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM11= 'clk11Lo VDD' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM12= 'clock12Lo LRST' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM13= 'clock13Lo' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM14= 'clock14Lo' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM15= 'clock15Lo' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM16= 'clock16Lo' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM2= 'clk2Lo CLK1' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM3= 'clk3Lo CLKB1' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM4= 'clk4Lo CLK2' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM5= 'clk5Lo CLKB2' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM6= 'clk6Lo FSYNC' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM7= 'clk7Lo VCLK' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM8= 'clk8Lo RESET' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLONM9= 'clk9Lo RESETEN' / Name of Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT1= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT10= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT11= 5.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT12= 5.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT13= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT14= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT15= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT16= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT2= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT3= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT4= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT5= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT6= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT7= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT8= 0.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 CLKLOT9= 5.0000 / Tel Value Low-Clock
HIERARCH ESO DET VOLT1 DC1   = 4.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC10  = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC11  = 5.9560 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC12  = 0.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC13  = 0.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC14  = 0.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC15  = 0.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC2   = 5.4000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC3   = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC4   = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC5   = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC6   = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC7   = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC8   = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DC9   = 5.0000 / Set value DC-Voltage
HIERARCH ESO DET VOLT1 DCNM1 = 'DC1 VRESET1-2-3-4' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM10= 'DC10 VLOAD4' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM11= 'DC11 Reference RevB' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM12= 'DC12' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM13= 'DC13' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM14= 'DC14' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM15= 'DC15' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM2 = 'DC2 Reference' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM3 = 'DC3 BIASGATE' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM4 = 'DC4 BIASPOWER' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM5 = 'DC5 VDDA' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM6 = 'DC6 DRAIN' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM7 = 'DC7 VLOAD1' / Name of DC-voltage
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HIERARCH ESO DET VOLT1 DCNM8 = 'DC8 VLOAD2' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCNM9 = 'DC9 VLOAD3' / Name of DC-voltage
HIERARCH ESO DET VOLT1 DCTA1 = 3.9990 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA10= 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA11= 5.9521 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA12= 0.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA13= 0.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA14= 0.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA15= 0.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA2 = 5.3955 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA3 = 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA4 = 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA5 = 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA6 = 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA7 = 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA8 = 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTA9 = 5.0000 / Tel Value 1 for DC
HIERARCH ESO DET VOLT1 DCTB1 = 3.9990 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB10= 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB11= 5.9521 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB12= 0.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB13= 0.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB14= 0.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB15= 0.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB2 = 5.3955 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB3 = 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB4 = 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB5 = 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB6 = 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB7 = 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB8 = 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET VOLT1 DCTB9 = 5.0000 / Tel Value 2 for DC
HIERARCH ESO DET WIN NX = 2048 / # of Pixels in X
HIERARCH ESO DET WIN NY = 2048 / # of Pixels in Y
HIERARCH ESO DET WIN STARTX  = 1 / Lower left X ref
HIERARCH ESO DET WIN STARTY  = 1 / Lower left Y ref
HIERARCH ESO DET WIN TYPE    = 0 / Win-Type: 0=SW/1=HW
INHERIT = T / Extension inherits primary header
PV2_1   =                   1. / WCS parameter value term
PV2_2   =                   0. / WCS parameter value term
PV2_3   =                  42. / WCS parameter value term
PV2_4   =                   0. / WCS parameter value term
PV2_5   =                   0. / WCS parameter value term
END
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9.4.3 Additional example keywords for processed VISTA data

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HIERARCH ESO QC DID          = 'ESO-VLT-DIC.VIRCAM_QC         ' / Data dictionar
HIERARCH ESO QC DARKCURRENT  = 200.000000      / average dark current on frame [
HIERARCH ESO QC DARKRMS      = 3.456000        / RMS noise of combined dark fram
HIERARCH ESO QC RESETDIFF_RMS= 0.000000        / [adu] RMS new-library reset fra
HIERARCH ESO QC DARKDIFF_RMS = 0.000000        / [adu] RMS new-library dark fram
HIERARCH ESO QC PARTICLE_RATE= 20.500000       / cosmic ray/spurion rate [count/
HIERARCH ESO QC RESETRMS     = 0.000000        / RMS noise in combined reset fra
HIERARCH ESO QC READNOISE    = 150.000000      / readnoise [electron].
HIERARCH ESO QC FLATRMS      = 0.000000        / RMS flatfield pixel sens per de
HIERARCH ESO QC GAIN         = 1.600000        / gain [e/ADU].
HIERARCH ESO QC BAD_PIXEL_STAT= 0.006000       / fraction of bad pixels/detector
HIERARCH ESO QC GAIN_CORRECTION= 0.950000      / detector median flatfield/globa
HIERARCH ESO QC LINEARITY    = 0.030000        / percentage average non-linearit
HIERARCH ESO QC LINFITQUAL   = 0.000000        / RMS fractional error in lineari
HIERARCH ESO QC SATURATION   = 65535.000000    / saturation level of bright star
HIERARCH ESO QC PERSIST_DECAY= 40.000000       / mean exponential time decay con
HIERARCH ESO QC PERSIST_ZERO = 0.800000        / fractional persistence at T0 (e
HIERARCH ESO QC CROSS_TALK   = 1.000000        / average values for cross-talk c
HIERARCH ESO QC WCS_DCRVAL1  = 5.555550e-04    / actual WCS zero point X - raw h
HIERARCH ESO QC WCS_DCRVAL2  = -5.555500e-04   / actual WCS zero point Y - raw h
HIERARCH ESO QC WCS_DTHETA   = 1.000000e-02    / actual WCS rotation PA - raw PA
HIERARCH ESO QC WCS_SCALE    = 9.444400e-05    / measured WCS plate scale per de
HIERARCH ESO QC WCS_SHEAR    = 1.000000e-04    / power of cross-terms in WCS sol
HIERARCH ESO QC WCS_RMS      = 9.444400e-06    / robust RMS of WCS solution for
```

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HIERARCH ESO QC MEAN_SKY     = 12345.120000    / mean sky level [ADU].
HIERARCH ESO QC SKY_NOISE    = 2000.000000     / RMS sky noise [ADU].
HIERARCH ESO QC SKY_RESET_ANOMALY= 123.450000  / systematic variation in sky acr
HIERARCH ESO QC NOISE_OBJ    =          150    / number of classified noise obje
HIERARCH ESO QC IMAGE_SIZE   = 0.500000        / mean stellar image FWHM [arcsec
HIERARCH ESO QC APERTURE_CORR= 0.456000        / 2 arcsec [mag] diam aperture fl
HIERARCH ESO QC ELLIPTICITY  = 0.021100        / mean stellar ellipticity [scala
HIERARCH ESO QC ZPT_2MASS    = 26.500000       / 1st-pass photometric zeropoint
HIERARCH ESO QC ZPT_STDS     = 26.400000       / photometric zeropoint [mag].
HIERARCH ESO QC LIMITING_MAG = 24.567000       / limiting mag ie. depth of expos
HIERARCH ESO QC FRINGE_RATIO = 0.000000        / [scalar] Ratio of sky noise bef
HIERARCH ESO QC ILLUMCOR_RMS = 0.000000        / [mag] RMS in illumination corre
HIERARCH ESO QC RESETDIFF_MED= 0.000000        / Median new-library reset frame
HIERARCH ESO QC DARKDIFF_MED = 0.000000        / Median new-library dark frame [
HIERARCH ESO QC FLATRATIO_MED= 0.000000        / Median new/library flat frame [
HIERARCH ESO QC FLATRATIO_RMS= 0.000000        / RMS new/library flat frame [sca
HIERARCH ESO QC MAGZPT       = 0.000000        / Photometric zero point [mag].
HIERARCH ESO QC MAGZERR      = 0.000000        / Photometric zero point error [m
HIERARCH ESO QC MAGNZPT      = 0.000000        / Number of stars in zero point c
HIERARCH ESO QC RESET_MED    = 0.000000        / median reset level
HIERARCH ESO QC DARKMED      = 0.000000        / median dark counts
HIERARCH ESO DRS DID         = 'ESO-VLT-DIC.VIRCAM_DRS        ' / Data dictionar
HIERARCH ESO DRS XTCOR       = 'UNKNOWN '      / Crosstalk matrix table
HIERARCH ESO DRS DARKCOR     = 'UNKNOWN '      / dark image
HIERARCH ESO DRS DARKSCL     = 0.000000        / Dark scale factor
HIERARCH ESO DRS FRINGEi     = 'UNKNOWN '      / Fringe file of nth pass
HIERARCH ESO DRS FRNGSCi     = 0.000000        / scale factor nth defringe pass
HIERARCH ESO DRS FLATCOR     = 'UNKNOWN '      / flat field image
HIERARCH ESO DRS ZPIM1       = 0.000000        / [mag] photometric zeropoint
HIERARCH ESO DRS ZPSIGIM1    = 0.000000        / [mag] RMS in photometric zeropo
HIERARCH ESO DRS ZPIM2       = 0.000000        / [mag] photometric zeropoint
HIERARCH ESO DRS ZPSIGIM2    = 0.000000        / [mag] RMS in photometric zeropo
HIERARCH ESO DRS LIMIT_MAG1  = 0.000000        / [mag] Limiting magnitude 1*core
HIERARCH ESO DRS LIMIT_MAG2  = 0.000000        / [mag] Limiting magnitude 2*core
HIERARCH ESO DRS MAGNZPTIM   =            0    / Number of stars used photometri
HIERARCH ESO DRS ZPALL1      = 0.000000        / [mag] photometric zeropoint
HIERARCH ESO DRS ZPSIGALL1   = 0.000000        / [mag] RMS in photometric zeropo
HIERARCH ESO DRS ZPALL2      = 0.000000        / [mag] photometric zeropoint
HIERARCH ESO DRS ZPSIGALL2   = 0.000000        / [mag] RMS in photometric zeropo
HIERARCH ESO DRS MAGNZPTALL  =            0    / Number of stars used photometri
HIERARCH ESO DRS XOFFMICRO   = 0.000000        / X-pixels to microstep input ima
HIERARCH ESO DRS YOFFMICRO   = 0.000000        / Y-pixels to microstep input ima
HIERARCH ESO DRS XOFFDITHER  = 0.000000        / X-pixels to jitter input image
HIERARCH ESO DRS YOFFDITHER  = 0.000000        / Y-pixels to jitter input image
HIERARCH ESO DRS PROVXXXX    = 'UNKNOWN '      / Input file #
HIERARCH ESO DRS SKYLEVEL    = 0.000000        / [ADU] Mean sky level
HIERARCH ESO DRS SKYNOISE    = 0.000000        / [ADU] Mean sky noise
HIERARCH ESO DRS LINCOR      = 'UNKNOWN '      / Channel table
HIERARCH ESO DRS FLATIN      = 'UNKNOWN '      / flat field used
HIERARCH ESO DRS BPMIN       = 'UNKNOWN '      / bad pixel map used
HIERARCH ESO DRS PERMASK     = 'UNKNOWN '      / persistence mask used
HIERARCH ESO DRS STDCRMS     = 0.000000        / [arcsec] RMS of the WCS fit
HIERARCH ESO DRS NUMBRMS     =            0    / no. of stars in WCS fit
HIERARCH ESO DRS WCSRAOFF    = 0.000000        / [arcsec] diff in RA after proc.
HIERARCH ESO DRS WCSDECOFF   = 0.000000        / [arcsec] diff in DEC after proc
HIERARCH ESO DRS BACKMED     = 0.000000        / [adu] Background median value
HIERARCH ESO DRS CLASSIFD    =            0    / Catalogue has been classified.
HIERARCH ESO DRS THRESHOL    = 0.000000        / [adu] Isophotal analysis thresh
HIERARCH ESO DRS MINPIX      =            0    / [pixels] Minimum size for image
HIERARCH ESO DRS CROWDED     =            0    / Crowded field analysis flag
HIERARCH ESO DRS RCORE       = 0.000000        / [pixels] Core radius
HIERARCH ESO DRS SEEING      = 0.000000        / [pixels] The estimated seeing
HIERARCH ESO PRO CATG        = 'INTERLEAVED_IMAGE' / Category of pipeline produc
HIERARCH ESO PRO DID         = '?Dictionary?' / Data dictionary for PRO
HIERARCH ESO PRO CATG        = 'INTERLEAVED_IMAGE' / Category of pipeline produc
HIERARCH ESO PRO TYPE        = 'REDUCED' / Product type
HIERARCH ESO PRO REC1 ID     = 'vircam_jitter_microstep_process' / Pipeline reci
HIERARCH ESO PRO REC1 DRS ID = 'cpl-2.1.2' / Data Reduction System identifier
HIERARCH ESO PRO REC1 PIPE ID= 'vircam/0.3.0' / Pipeline (unique) identifier
HIERARCH ESO PRO REC1 RAW1 NAME= 'VIRCAM_IMG_OBS185_0001.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW1 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW2 NAME= 'VIRCAM_IMG_OBS185_0002.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW2 CATG= 'SCIENCE_IMAGE' / Category of raw frame
```

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HIERARCH ESO PRO REC1 RAW3 NAME= 'VIRCAM_IMG_OBS185_0003.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW3 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW4 NAME= 'VIRCAM_IMG_OBS185_0004.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW4 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW5 NAME= 'VIRCAM_IMG_OBS185_0005.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW5 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW6 NAME= 'VIRCAM_IMG_OBS185_0006.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW6 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW7 NAME= 'VIRCAM_IMG_OBS185_0007.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW7 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW8 NAME= 'VIRCAM_IMG_OBS185_0008.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW8 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW9 NAME= 'VIRCAM_IMG_OBS185_0009.fits' / File name of ra
HIERARCH ESO PRO REC1 RAW9 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW10 NAME= 'VIRCAM_IMG_OBS185_0010.fits' / File name of r
HIERARCH ESO PRO REC1 RAW10 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW11 NAME= 'VIRCAM_IMG_OBS185_0011.fits' / File name of r
HIERARCH ESO PRO REC1 RAW11 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO REC1 RAW12 NAME= 'VIRCAM_IMG_OBS185_0012.fits' / File name of r
HIERARCH ESO PRO REC1 RAW12 CATG= 'SCIENCE_IMAGE' / Category of raw frame
HIERARCH ESO PRO DATANCOM    = 12 / Number of combined frames
HIERARCH ESO PRO REC1 CAL1 NAME= 'master_dark.fits' / File name of calibration f
HIERARCH ESO PRO REC1 CAL1 CATG= 'MASTER_DARK' / Category of calibration frame
HIERARCH ESO PRO REC1 CAL1 DATAMD5= '27f574cb01a69896697c062ac5af4e35' / MD5 sig
HIERARCH ESO PRO REC1 CAL2 NAME= 'master_twilight_flat.fits' / File name of cali
HIERARCH ESO PRO REC1 CAL2 CATG= 'MASTER_TWILIGHT_FLAT' / Category of calibratio
HIERARCH ESO PRO REC1 CAL2 DATAMD5= 'c1b152ef3bcb93f36c06f333ddc2ea87' / MD5 sig
HIERARCH ESO PRO REC1 CAL3 NAME= 'master_confidence_map.fits' / File name of cal
HIERARCH ESO PRO REC1 CAL3 CATG= 'MASTER_CONF' / Category of calibration frame
HIERARCH ESO PRO REC1 CAL3 DATAMD5= 'b150c2ba2d1c09833dcdc9837bf31f94' / MD5 sig
HIERARCH ESO PRO REC1 CAL4 NAME= 'channel3.fits' / File name of calibration fram
HIERARCH ESO PRO REC1 CAL4 CATG= 'CHANNEL_TABLE' / Category of calibration frame
HIERARCH ESO PRO REC1 CAL4 DATAMD5= '351aaf8a8b5efe614d2b6f5018773d61' / MD5 sig
HIERARCH ESO PRO REC1 CAL5 NAME= 'phot.fits' / File name of calibration frame
HIERARCH ESO PRO REC1 CAL5 CATG= 'PHOTCAL_TAB' / Category of calibration frame
HIERARCH ESO PRO REC1 CAL6 NAME= 'master_readgain.fits' / File name of calibrati
HIERARCH ESO PRO REC1 CAL6 CATG= 'READGAIN_TABLE' / Category of calibration fram
HIERARCH ESO PRO REC1 CAL6 DATAMD5= '' / MD5 signature of calib frame
HIERARCH ESO PRO REC1 PARAM1 NAME= 'ipix' / no comment
HIERARCH ESO PRO REC1 PARAM1 VALUE= '5' / no comment
HIERARCH ESO PRO REC1 PARAM2 NAME= 'thr' / no comment
HIERARCH ESO PRO REC1 PARAM2 VALUE= '2' / no comment
HIERARCH ESO PRO REC1 PARAM3 NAME= 'icrowd' / no comment
HIERARCH ESO PRO REC1 PARAM3 VALUE= 'false' / no comment
HIERARCH ESO PRO REC1 PARAM4 NAME= 'rcore' / no comment
HIERARCH ESO PRO REC1 PARAM4 VALUE= '4' / no comment
HIERARCH ESO PRO REC1 PARAM5 NAME= 'nb' / no comment
HIERARCH ESO PRO REC1 PARAM5 VALUE= '64' / no comment
HIERARCH ESO PRO REC1 PARAM6 NAME= 'catpath' / no comment
HIERARCH ESO PRO REC1 PARAM6 VALUE= '/data/cass55c/vista/v2mass' / no comment
HIERARCH ESO PRO REC1 PARAM7 NAME= 'savecat' / no comment
HIERARCH ESO PRO REC1 PARAM7 VALUE= 'true' / no comment
HIERARCH ESO PRO REC1 PARAM8 NAME= 'ext' / no comment
HIERARCH ESO PRO REC1 PARAM8 VALUE= '1' / no comment
HIERARCH ESO DRS NDITCOR     = T / Corrected for NDITs
HIERARCH ESO DRS DARKCOR     = 'master_dark.fits[DET1.CHIP1]' / Image used for d
HIERARCH ESO DRS DARKSCL     = 1. / Scaling factor used in dark correction
HIERARCH ESO DRS LINCOR      = 'channel3.fits' / no comment
HIERARCH ESO DRS FLATCOR     = 'master_twilight_flat.fits[DET1.CHIP1]' / Image u
HIERARCH ESO DRS BACKMED     = -50.49648 / no comment
HIERARCH ESO DRS XOFFMICRO   = 0. / no comment
HIERARCH ESO DRS YOFFMICRO   = 0. / no comment
HIERARCH ESO DRS PROV0001    = 'VIRCAM_IMG_OBS185_0001.fits[DET1.CHIP1]' / Input
HIERARCH ESO DRS PROV0002    = 'VIRCAM_IMG_OBS185_0002.fits[DET1.CHIP1]' / Input
HIERARCH ESO DRS PROV0003    = 'VIRCAM_IMG_OBS185_0003.fits[DET1.CHIP1]' / Input
HIERARCH ESO DRS PROV0004    = 'VIRCAM_IMG_OBS185_0004.fits[DET1.CHIP1]' / Input
```

10 ACRONYMS & ABBREVIATIONS

ADnn : Applicable Document No. nn
CASU : Cambridge Astronomical Survey Unit
CPL : Common Pipeline Library (ESO Data Management Division)
DAS : Data Acquisition System
ESO : European Southern Observatory
FITS : Flexible Image Transport System
GCS : Galactic Clusters Survey (UKIDSS)
GPS : Galactic Plane Survey (UKIDSS)
GridFTP : Grid File Transfer Protocol
HDS : Hierarchical Data System
HDU : Header Data Unit (FITS nomenclature)
ICRS : International Co-ordinate Reference System
JAC : Joint Astronomy Centre
LAS : Large Area Survey (UKIDSS)
MEF : Multi–Extension FITS
NDF : N–dimensional Data Format
NOST : NASA/Science Office of Standards and Technology
RAID : Redundant Array of Inexpensive Disks
SDSS : Sloan Digitial Sky Survey
VDFS : VISTA Data Flow System
UKIDSS : UKIRT Deep Infrared Sky Survey – see [13]
UKIRT : United Kingdom Infrared Telescope
VISTA: Visible and Infrared Survey Telescope for Astronomy
WCS : World Co-ordinate System
WFAU : Wide Field Astronomy Unit (Edinburgh)
WSA : WFCAM Science Archive
2MASS : 2 Micron All–Sky Survey

11 APPLICABLE DOCUMENTS AND REFERENCES

AD01	Science Archive Hardware Design [9]	VDF–WFA–VSA–006 Issue: 1.0, September 2006
AD02	Science Archive Database Design [10]	VDF–WFA–VSA–007 Issue: 1.0, September 2006
AD03	VDFS Data Reduction Library Design [15]	VIS–SPE–IOA–20000-0010 Issue: 1.4, 2006–06–15

12 CHANGE RECORD

Issue	Date	Section(s) Affected	Description of Change/Change Request Reference/Remarks
Draft 0.1	11/01/2005	All	New document based on VDF–WFA–WSA–004, Issue 3.0
Final draft 1.0	August 2006	All	Revised for current WFCAM and putative VISTA headers
1.0	September	All	Final UK VDFS FDR issue; incorporates CASU input

13 NOTIFICATION LIST

The following people should be notified by email whenever a new version of this document has been issued:

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