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1 Introduction

Req. GR13

This document describes the "interface" between the Pipeline and users of the data products. Since the Pipeline is "data driven" the products of the Pipeline are files on disk.

2 Reduced Data

The Pipeline has 4 primary forms of reduced data, which are written to the `$ORAC_DATA_OUT` directory. The data directory will be

```
/jcmtdata/reduced/scuba2_x/YYYYMMDD
```

at the summit, where the `x` is `long` for long-wave data and `short` for short wave data. The "date" directory has to be inside the "wavelength" directory to simplify disk mounting issues (since the directory has to be local to the specific reduction machine). This layout is identical to that used for UKIRT's WFCAM.[5]

The different possible reduced data products are:

- 2-D images of the sky. These will contain both astrometry and variance information as well as images of the pixel weights. ***Req. PR10***
- Polarization information from polarimeter observations: a cube of I, Q and U Stokes parameters (assuming the observing mode generates I information); and a FITS binary table catalogue containing the polarization magnitude and direction (including errors) for each position in the cube. ***Req. PR11*** ***Req. PR13***
- A 3-D spectral cube from FTS observations.
- Sky temperatures from a Skydip and corresponding model fit.

The 2-D images, 3-D images and Stokes cubes will all be stored as NDFs, with astrometry information provided by AST FrameSets[8,1] which can support both spatial and spectral coordinate frames. All images will be flux calibrated. The sky-dip data will be stored in a 1-D array, with the fit stored as a 1-D array in the SCUBA2 data extension.

Polarization catalogues will be written in the format described in the POLPACK documentation.[2]

Output filenames will be of the form `gXYYYYMMDD_NNNNN_SSS.sdf`, where `g` indicates that the file is the output of a group operation (a group is created even if the observation is the only member of the group), `X` is a letter, either `l` or `s`, indicating whether the data are from the long or short wave array, `YYYYMMDD` is the UT date of the observation, `NNNNN` is the group number (zero padded), corresponding to the first observation in the group, and `SSS` is a string indicating the type of output product: `mos` for image mosaics, `iqu` for IQU cubes and `cub` for 3-D spectral cubes. Polarization catalogues will have a `.FIT` file extension and use `pol` as the file output product specifier.

Other intermediate files will adopt the same format, simply varying `SSS` depending on the step involved. Intermediate files generated from single frame processing (as opposed to group co-adding) will replace the `g` prefix with the letter `s`. Intermediate files themselves do not form part of the "public" data product interface.

Some observing modes, in particular SCAN, may result in additional data products (e.g. some measure of the atmospheric noise power spectrum). This information will be added to the ICD as it becomes known.

3 Catalogue Products

During group processing, the images will be analysed to determine whether they contain any point sources. Detected sources will be extracted and their position and flux will be written to a catalogue file of the same name as the group image but with a `.cat` file extension. These catalogue files will be updated whenever a new group image is created and will be written using the (human-readable) STL format.[3] It is trivial to convert STL to VOTable format. ***Req. PR19***

4 Quality Control Parameters

As the Pipeline proceeds, data quality parameters are calculated and stored in log files. These log files provide results for single observations in order to track instrument and telescope behaviour throughout the night. Catalogue files associated with specific group images are described in the previous section. By convention these files are named `log.xxx` where `xxx` describes the property that present in the log file (e.g. `integrated` for integrated fluxes, `peak` for peak fluxes, `pointing` for pointing offsets etc.). ORAC-DR log files usually use a simple space-delimited catalogue format, although this is not mandated by the current interface.

The exact contents of the log files will be fixed for the Critical Design Review. The following discussion uses the existing SCUBA pipeline log files[7] as a basis for discussion.

In the following descriptions UT dates of observations are stored in *YYYYMMDD.frac* format. This is the standard currently in use for ORAC-DR and was initially driven by the lack of a Perl interface to the freely available Starlink version of SLALIB in Fortran (as opposed to the C version). This limitation is no longer in place so in principal we could switch to Modified Julian Date for these columns.

4.1 *log.integrated*

The integrated flux for all the point sources located in the field. The flux is calculated for each observation independently rather than for the combined group, and therefore provides time domain information through the night (which can be plotted by the strip chart tool[4]).

The columns are as follows:

ID Unique ID for the source (since we will not necessarily know the source name), derived from the observation number and the (arbitrary) sequence number of the source in the field in question (starting at 1), e.g. `00052_01` for the first source detected from observation 52.

UT The time of the observation in *YYYYMMDD.frac* format.

RA Right Ascension of the source in *hh:mm:ss.ss* format.

Dec Declination of the source in *sddd:mm:ss.s* format.

Filter The filter name used for the flux measurement.

Flux Integrated source flux in mJy.

RMS RMS Error of the source flux in mJy.

S/N Signal-to-noise of the flux measurement.

ApDiam Diameter of the aperture used for the measurement.

Numpix Number of pixels present in the aperture.

Rms/pix Noise per pixel (mJy).

Seeing The seeing during the observation (in arcsec). This can come from the SMA seeing monitor.

El The elevation of the observation in decimal degrees.

Tau225 The average opacity at 225 GHz during the observation. Presumably from the WVM.

4.2 *log.peak*

Similar to the *log.integrated* except that the fluxes are calculated by fitting to the beam (e.g. using the Kappa PSF task) and reported in Jy/beam. Also includes a determination of the average beam-size in the field.

ID Unique ID for the source (since we will not necessarily know the source name), derived from the observation number and the (arbitrary) sequence number of the source in the field in question (starting at 1). e.g. `00052_01` for the first source detected from observation 52.

UT The time of the observation in *YYYYMMDD.frac* format.

RA Right Ascension of the source in *hh:mm:ss.ss* format.

Dec Declination of the source in *sddd:mm:ss.s* format.

Filter The filter name used for the flux measurement.

Flux Peak flux in mJy/beam.

RMS RMS Error of the source flux in mJy/beam.

S/N Signal-to-noise of the flux measurement.

FWHM Fitted FWHM of the point source in arcsec.

Seeing The seeing during the observation (in arcsec).

El The elevation of the observation in decimal degrees.

Tau225 The average opacity at 225 GHz during the observation. Presumably from the WVM.

4.3 *log.beam*

Reports the average beam-size of all point sources detected in an observation frame.

The observation number.

UT The time of the observation in *YYYYMMDD.frac* format.

Filter The filter name used for the flux measurement.

FWHM Average fitted FWHM of the point source in arcsec. This will be identical to the value in *log.peak* if there is only a single source in the field.

ErrBeam Percentage of flux present in the error beam.

Seeing The seeing during the observation (in arcsec).

El The elevation of the observation in decimal degrees.

Tau225 The average opacity at 225 GHz during the observation. Presumably from the WVM.

4.4 *log.fcf*

Req. PR8

The Flux Conversion Factor calculated from calibrator sources.

The observation number.

UT The time of the observation in *YYYYMMDD.frac* format.

Target The name of the calibration source.

Filter The filter name used for the FCF measurement.

FWHM Average fitted FWHM of the calibrator (in arcsec).

El The elevation of the observation in decimal degrees.

Seeing The seeing during the observation (in arcsec).

Tau225 The average opacity at 225 GHz during the observation. Presumably from the WVM.

FCF The FCF in the units specified in the next column.

FCF_Err Error in the FCF (in the same units as the FCF).

FCF_units Either ARCSEC for Jy/arcsec^2/V or BEAM for Jy/beam/V.

4.5 *log.nefd*

The noise equivalent flux density (in mJy/$\sqrt{\mathrm{Hz}}$). This quantity provides a measure of the performance of the instrument and can be used to confirm that the noise is reducing correctly during long observations. It will only be calculated for DREAM/STARE observations that consist of at least 50 individual sub-frames (for statistics) and a point source.

4.6 *log.pointing*

Pointing offsets derived from pointing observations.

The observation number.

Target The name of the pointing source.

UT The time of the pointing in *YYYYMMDD.frac* format.

Filter The filter name.

Az The azimuth of the pointing observation in decimal degrees.

El The elevation of the pointing observation in decimal degrees.

DAZ The derived azimuth pointing offset in arcsec.

DEL The derived elevation pointing offset in arcsec.

ErrAz Error in derived azimuth pointing offset [arcsec].

ErrEl Error in derived elevation pointing offset [arcsec].

Seeing The seeing during the observation (in arcsec).

Tau225 The average opacity at 225 GHz during the observation. Presumably from the WVM.

4.7 *log.focus*

Focus offsets derived from focus observations.

The observation number.

Target The name of the focus/align source.

UT The time of the pointing in *YYYYMMDD.frac* format.

Filter The filter name.

Axis The axis being adjusted (X, Y or Z).

Az The azimuth of the observation in decimal degrees.

El The elevation of the observation in decimal degrees.

DXYZ The derived focus shift (mm).

Seeing The seeing during the observation (in arcsec).

Tau225 The average opacity at 225 GHz during the observation. Presumably from the WVM.

4.8 *log.noise*

Bolometer noise statistics and sky-noise for each observation.

The observation number.

UT The time of the observation in *YYYYMMDD.frac* format.

Filter The filter name.

El The elevation of the observation in decimal degrees.

Bolnoise Average bolometer noise across the array (mV).

Sky D.C. sky signal (mV).

Seeing The seeing during the observation (in arcsec).

Tau225 The average opacity at 225 GHz during the observation. Presumably from the WVM.

More noise statistics may be added to this file as our understanding of the data improves.

5 Engineering Data

Some acquisition modes, e.g. array setup and flat-fielding, are performed as engineering observations and stored in the engineering directories (see SC2/SOF/IC210/01[6]). Those observations are reduced using a variant of the Pipeline that writes results to the engineering directories,

```
/jcmtdata/reduced/eng/scuba2/sx/YYYYMMDD/
```

in a similar manner to non-engineering data. The Pipeline will reduce these data and write the results to an NDF file, one per sub-array, with the names being `sxYYYYMMDD_flat.sdf` and `sxYYYYMMDD_setup.sdf`, where the `x` represents the sub-array label (`a` to `f` as described in SC2/SOF/IC210/01). The content of these files has not yet been decided. These files will be manually installed to a directory where the historical files can be stored. Raw engineering data will not be archived, but the reduced data (especially the flat-field) data must be made available to the Pipeline.

6 Index files

Index files generated by the Pipeline for book-keeping activities are for internal use only and are not part of the public interface.

References

[1] D. S. Berry. Providing Improved WCS Facilities Through the Starlink AST and NDF Libraries. In *ASP Conf. Ser. 238: Astronomical Data Analysis Software and Systems X*, pages 129–+, 2001.

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[4] Andy Gibb. SCUBA-2 StripChart Utility. SCUBA-2 Project SC2/SOF/S210/006, 2005.

[5] Nigel C. Hambly, Mike J. Irwin, and Jim Lewis. VISTA Data Flow System for VISTA & WFCAM data: WSA Interface Control Document. Technical report, WFAU, Edinburgh, 2003.

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[8] Rodney F. Warren-Smith and David S. Berry. AST – a library for handling world coordinate systems in astronomy. Starlink User Note 211, Starlink Project, CCLRC, 2002.