MIPS 24 Micron Pipeline Description Document

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1.0 MIPS-24 Introduction

The Multi-Band Imaging Photometer for Spitzer, or MIPS, has a camera the operates at a central wavelength of about 24 microns. It provides the shortest wavelength and highest spatial resolution (6'') capability of MIPS. The 128x128 pixel detector is made from arsenic doped silicon (notated Si:As) and is often referred to as the Silicon array or the MIPS-24 array. In this document, the 24 micron instrument of MIPS is referred to as MIPS-24.

The MIPS-24 micron software pipelines are comprised of a series of modules that are run sequentially in order to transform raw data from the spacecraft to a final, calibrated data product. The various pipelines are described and each module is explained in a step-by–step manner. We describe the final versions of the pipeline (S18.12 and S18.13) that were used to reprocess the entire cryogenic mission for MIPS. The data products from this final reprocessing are available for download from the Spitzer Heritage Archive at http://ssc.spitzer.caltech.edu/spitzerdataarchives/ or at http://sha.ipac.caltech.edu/applications/Spitzer/SHA.

This final reprocessing of the mission includes a NEW pipeline for the MIPS-24 micron instrument for photometry mode data. The new pipeline, known as the Enhanced BCD pipeline (or EBCD pipeline) provides improved flat fielding for all the photometry modes of MIPS-24, both for primary data and for parallel data when the MIPS-24 array was read out while the Germanium arrays (MIPS-70 and MIPS-160) were the primary scientific instrument. The new pipeline was applied only to photometry modes and not to scan modes, because the dark spot artifacts that are seen to move on the array with scan mirror position affect the photometry modes the most. If these spots are not correctly flat-fielded, spot residual artifacts will remain in the final products (at the ~1-2% level), as was often the case in the original BCD products. The final calibrated data products for the Enhanced BCD pipeline are called EBCDs (filename *_ebcd.fits), instead of BCDs. For continuity, both the original BCD and new EBCD products are available from the Spitzer Heritage Archive.

The BCD and EBCD science pipelines described here are for the "SUR" mode (sample up the ramp) observations, whereby each DCE (data collection event) downloaded from the spacecraft is comprised of a "slope" image in the first plane and an initial 0.5 second "difference" image in the second plane (thus the raw DCE FITS file *_raw.fits has dimension 128x128x2). The slope image is computed with on-board spacecraft software that uses a linear regression fit to slope of the non-destructively read ramps during the exposure. Although the MIPS-24 micron electronics allow for the array to be read out in "Raw" mode, meaning that all of the 0.5 second samples during an integration are saved to a buffer on board the telescope and downloaded in entirety, this mode was not possible to use in normal operations because the data rate was too high for the on-board buffers to store the data without data loss. The Raw mode was used only used for initial calibration and engineering purposes. It was not made available as an AOT for any scientific observations.

For more information on MIPS-24, please consult the MIPS Instrument Handbook at:

http://ssc.spitzer.caltech.edu/mips/mipsinstrumenthandbook/

2.0 MIPS-24 Basic Calibrated Data (BCD) SUR-Mode Science Pipeline: Producing BCDs and Enhanced BCDs (EBCDs)

The goal of the BCD pipeline is to produce calibrated data in surface brightness units (MJy/sr) from raw spacecraft data.

The BCD (pipeline script ID, or header keyword PLSCRPID 1021) and EBCD (pipeline script ID 1061) pipelines are essentially the same pipeline and follow the same steps in the same order, with the difference being that the Enhanced data products have improved flat fielding, as described in section 3. The pipeline steps are individual modules, each of which has a specific task and each of which typically requires a control data file (cdf, or namelist) with parameters specific to that module. The sequence of modules and their namelists are described below. Enhanced products are made only for MIPS-24 photometry mode. Due to limitations of the downlink architecture, essentially running the pipeline twice with different pipeline script IDs was deemed the best way to implement the creation and archiving of enhanced data products. A cdf file called aorflat.nl is invoked by a "superwrapper" script for the BCD pipeline proper starts. It allows the BCD pipeline to determine if the input data is photometry mode, and if so, then it commands the calibration data server find the correct flat field files for producing EBCD products.

The input raw spacecraft DCE's (Data Collection Events) have 2 planes, the slope and difference planes, which are both operated on by the subsequent pipeline modules unless noted. The slope and difference are split into separate FITS files late in the pipeline and then used together to make the final BCD or EBCD, as described below.

After the 1021 and 1061 pipelines are run, pipelines 1038 and 1030 are run, respectively, to add pointing information, organize and populate the header keywords, and add sky background model information to the header of the final BCD or EBCD, as described below.

BCD/EBCD pipeline steps:

HDRUPD8

This module updates the FITS header typically by adding FITS keywords, comments, and HISTORY lines (such as when a module has been run). It is called many times during the course of the pipeline and is not repeated for the description below.

SANITY_DATATYPE

The input to this first module is the SUR-mode data from the spacecraft. It reads in 2 cdf files, listed below. This module verifies header keywords such as instrument, channel and observing mode, and checks for any missing data. It writes results of this check to tables, but they are not used by subsequent modules for a successful check.

```
sanity_datatype_criteria.tbl
|  status           | criteria                                        |
|   c               |     c                                           |
   normal             1&&2&&3&&4&&11&&12&&13&&14&&16
```

```
   correct_pipeline   5||8||9
   SUR_mode_data      11&&14
   no_missing_data    17
   no_missing_groups  !18
```

```
sanity_datatype_conditions_SUR.tbl
| index | keyword     | test   | value   |
| int   | c           |   c    | c       |
  1       INSTRUME       =       MIPS
  2       CHNLNUM        =       1
  3       DCENUM         >=      0
  4       EXPID          >=      0
  5       PIPENUM        =       401
  6       PIPENUM        =       402
  7       PIPENUM        =       403
  8       PIPENUM        =       404
  9       PIPENUM        =       405
 10       PIPENUM        =       406
 11       NAXIS          =       3
 12       NAXIS1         =       128
 13       NAXIS2         =       128
 14       NAXIS3         =       2
 15       NAXIS3         >       2
 16       GROUPS         >       1
 17       MISSDATA       =       F
 18       MANCPKT        >       0
```

QATOOL_DCE

Quality Assurance characterization, and bulk statistics on the DCE.

```
qatool_DCE.nl
&QATOOLIN
  Comment = 'Generic namelist file for qatool, default values.',
  FITS_Image_Filename = '../fos16.fits',
  Data_Out_Filename_Base = 'qa/qatool_DCE',
  Comment = 'Operation: 1=Include ReadOut-Channel Statistics,
2=Exclude',
  Operation = 1,
  NBinsHistogram = 41,
  NDevHistHalfWidth = 5,
  Comment = 'Data_Plane: 1=All, 2=First, 3=Last',
  Data_Plane = 1,
  Box_X_Position = 1,
  Box_Y_Position = 1,
  Box_X_Width = 128,
  Box_Y_Height = 128,
  CentralFraction1 = 0.81,
  CentralFraction2 = 0.72,
  NEdge = 0,
  KeywordPrefix = 'dce',
  StatisticsGroup = 1,
  Comment = 'Operation_Datascale: 1=Include computation; 2=Exclude',
```

```
  Operation_Datascale = 2,
 &END
```

TRANHEAD

Tranhead reads in a FITS file, modifies the existing header keywords, and writes a new FITS header along with the FITS data. Tranhead performs the important task of translating keywords with very little meaning in English to comprehensible keywords, and it reads in the Command Telemetry Dictionary to do so. It also derives the exposure-time keywords and inserts many keywords (from another namelist file, Keyword_Include_List.dat) required for subsequent pipeline steps into the header. Gain keywords for each of the readout channels are also written to the header based on the values in the namelist file. For MIPS-24, the gain (# electrons per DN) is 5 for all four channels.

Tranhead.nl

```
 &TRANHEADIN
 Comment = 'Generic namelist file for tranhead, default values.',
 Comment = 'Operation: 1=Forward translation, 2=Reverse translation',
 Operation = 1,
 Comment = 'Default two-digit suffix for reverse translation',
 Key_Suffix = '02',
 CentralFraction1 = 1.0,
 CentralFraction2 = 1.0,
 Gain1 = 5.0,
 Gain2 = 5.0,
 Gain3 = 5.0,
 Gain4 = 5.0,
 Ignore_Frames_1st = 1,
 Ignore_Frames_2nd_and_higher = 1,
 CE_Side = 1,
&END

&IMFLIPROTIN
 Comment = 'Generic namelist file for imfliprot.',
 Log_Filename = 'stdout',
 Comment = 'Flip: 1 = Flip, 0 = No Flip (in x, top left pixel is reference)',
 Flip = 1,
 Comment = 'Rotate: 0, 90, 180, 270 in clockwise rotation',
 Rotate = 0,
&END
```

IMFLIPROT

IMFLIPROT flips the data array such that the x axis is reversed. This corrects the image orientation so that it is properly projected onto the sky. It reads in the tranhead.nl file for the appropriate commands in the IMFLIPROTIN command block.

MEDFILTER

Medfilter applies a spatial median filter on the data as a pre-processing step to finding spots in the BCD (but not EBCD) pipeline. It is run but not used for EBCDs. The median filter is 21x21 pixels and the spot location is limited to a certain range of x and y positions (for the darkest spot on the array).

Black_spot.nl

run_medfilter = 1

run_inverse = 1

```
run_detect = 1
run_select = 1
select_conditions = "x > 116  and x < 123 and y < 128 and y > 61"
select_columns = "x,y,flux"

&MEDFILTER
  Window_X = 21,
  Window_Y = 21,
  N_Outliers_Per_Window = 100,
&END

&DETECT
  Detection_Max_Area         = 90000,
  Detection_Min_Area         = 6,
  Detection_Threshold        = 2,
  N_Edge = 1,
&END
```

IMARITH

Imarith is used to multiply the input array by -1 so that dark spots appear as peaks instead of depressions. There is no namelist file.

DETECT

Detect is a source extraction program designed to detect bright, peaked, but not necessarily point-like objects in the image. It is used on the inverted input data to detect the position of the darkest fiducial spots on the array in order to find a close x,y position in the library of spotmap flats. It is used in the BCD pipeline only.

Detect reads in the namelist file black_spot.nl as used in medfilter (see above), setting the maximum and minim areas (in pixels) to find a “peak”, and detection threshold.

CALTRANS

This is the module that finds and transfers the desired calibration data, including flat fielding, dark current, and linearity correction files from the database. The namelist file determines whether a campaign or fallback superflat is used (with the value of CalRule).

Caltrans.nl

```
 &CALTRANS_MIPS1SUR_401
  Comment = 'Rule number for pmask, rowfluxcorr',
  CalRule = '0;0',
 &end

 &CALTRANS_MIPS1RAW_402
  Comment = 'Rule number for pmask',
  CalRule = '0',
 &end

 &CALTRANS_MIPS1RAW_403
  Comment = 'Rule numbers for darkest_raw, pmask',
  CalRule = '0;0',
 &end

 &CALTRANS_MIPS1SUR_404
  Comment = 'Rule numbers for darkest_sur, lincal, pmask, rowfluxcorr',
  CalRule = '0;0;0;0',
 &end

# For CALTRANS_MIPS1SUR_405 blockname below, the "CalRule" string is
# *only* used if SpotMatch_with_Gradient_Corr = 1 below, in which case it
# will correspond to the following caltypes: darkest_sur, spotmap, lincal,
# pmask, fluxconv, rowfluxcorr and flatfield.
# use 0;0;0;0;0;0;0 for I&T testing

 &CALTRANS_MIPS1SUR_405
  Comment = 'IMPORTANT - the flatfield rule should agree with the one in namelist block
CALTRANS_AORFLAT_415',
  Comment = 'If want to query superflat from mips1fallback, then uncomment:',
  CalRule = '0;0;0;0;0;0;0',
  Comment = 'If want to query superflat from mips1metadata, then uncomment:',
  #CalRule = '0;0;0;0;0;0;100',
  Comment = 'If want to query superflat from mips1metadata, nearest in time:',
  #CalRule = '0;0;0;0;0;0;300',

 &end

 #ensure the block is never used
 &CALTRANS_MIPS1SUR_JUNKJUNK
  Comment = 'Rule number for pmask',
  CalRule = '0',
 &end

 &CALTRANS_MIPS1SUR_AORFLAT_405
```

```
 Comment = 'Rule number for pmask and closest-in-time-early aorspot calfile',
 CalRule = '0;100',
&end


#NOTE: nearest in time metadata is rule 300 for above
#
#
# Following is used in science pipeline 405 (SUR). Set "pick_spot_match_flat"
# to 1 if want to pick flat by matching characteristic spot position
# together with mirror position, otherwise, set to 0 and only mirror
# position matching will be performed. Flat is found such that its
# SPOT_X, SPOT_Y, CSM_RATE and CSM_PRED fall within:
# (dce_posx +/- SearchInterval), (dce_posy +/- SearchInterval),
# (dce_scan_rate +/- RateInterval) and (dce_csm_pred +/- csm_predInterval).
# If spot_xy/mirror match not found, default to using scan-mirror dependent
# flat alone. If latter not found, default to using specific (superflat)
# for corresponding scan rate. Note that _ops_ software treats the
# "SearchInterval" as starting with the minimum: *_Min and works up to
# *_Max in intervals of *_Min. SearchInterval is incremented until
# caltrans succeeds with query. Offline software assumes single value:
# SearchInterval = xy_SpotPosition_SearchInterval_Max.
# If SpotMatch_with_Gradient_Corr = 1, then same as above except that we
# query for the spotmap and the superflat (with charactersitc gradient) and
# multiply these together to create a DCE-dependent flat for use downstreanm.

pick_spot_match_flat = 1
SpotMatch_with_Gradient_Corr = 1
xy_SpotPosition_SearchInterval_Max = 0.20
xy_SpotPosition_SearchInterval_Min = 0.05
scanMirrorDACIntervalChop = 0.5
scanMirrorDACIntervalSlow = 0.5
scanMirrorDACIntervalMedium = 0.5
scanMirrorDACIntervalFast = 0.5

&CALTRANS_MIPS1RAW_406
 Comment = 'Rule numbers for darkest_raw, flatfield, lincal, pmask, fluxconv',
 CalRule = '0;0;0;0;0',
&end

&CALTRANS_MIPS1SUR_407
 Comment = 'Rule number for pmask',
 CalRule = '0',
&end

&CALTRANS_MIPS1RAW_408
```

```
 Comment = 'Rule number for pmask',
 CalRule = '0',
&end

&CALTRANS_MIPS1RAW_409
 Comment = 'Rule number for pmask',
 CalRule = '0',
&end

&CALTRANS_MIPS1SUR_410
 Comment = 'Rule number specified on command line in w_flatfield_postproc_initiate will
override this',
 CalRule = '0',
&end

&CALTRANS_MIPS1SUR_411
 Comment = 'Rule number for pmask',
 CalRule = '0',
&end

&CALTRANS_AORFLAT_415
 Comment = 'Rule number for pmask, flatfield for the aorflat ensemble pipeline',
 Comment = 'IMPORTANT - the flatfield rule should agree with the one in namelist block
CALTRANS_MIPS1SUR_405',
 Comment = ' Change flatfield rule to 0 (fallback), to never use campaign aor gainflat',
 CalRule = '0;0',
 Comment = ' Change flatfield rule to 300, for closest in time',
 #CalRule = '0;300',
&end

&CALTRANSptgIN
 Comment = 'Rule numbers for
mips24_cdelt12_distort;instrument_FOV.tbl;mirrorparameters.tbl',
 CalRule = '0;0;0',
&end

&RUNSINGLEFRAMEPSEIN
 Comment = 'Rule numbers for pmask, prfmap',
 CalRule = '0;0',
&end

&RUNMOPEXIN
 Comment = 'Rule numbers for pmask, prfmap, mosaicprf',
 CalRule = '0;0;0',
&END
```

```
&RUNMOSAICTPMIN
  Comment = 'Rule numbers for pmask ',
  CalRule = '0',
 &END
```

CVTI2R4

This module converts the data from integer (I*2) to real (R*4) and also corrects for 0.5 DN truncation. It creates the dmask (BCD mask) and replaces missing data with NaNs. There is no namelist file.

SATMASK

Satmask detects hard and soft saturated pixels in the slope and difference planes and records them in the dmask. This flagging is based on the difference image—if the value in the difference image equals or exceeds a threshold, then the pixel is flagged in the dmask (later called the bmask) as "soft" saturated. For the difference image, all pixels are zero unless the exceed a certain count rate (600 DN/sample time) and the pixels with nonzero values are candidates for later pixel replacement of the slope image. Hard saturated are saturated even in the difference image and are marked in the dmask. Satmask also has the capability to replace soft saturated pixels in the slope image with difference image pixels, and that capability is used near the end of the pipeline.

```
Satmask.nl
 &SATMASKIN
  Comment = 'Generic namelist file for satmask, default values.',
  Comment = 'Saturation threshold in difference plane for a 30 sec exposure in units of
DN/sampling-time',
  Diff_Sat_Threshold = 1000,
  PMaskFatal = 4352,
  DMaskFatal = 16384,
  DMask_soft_sat = 8192,
  DMask_hard_sat = 4,
  Comment = 'Replace fatal input pixels with NaNs in processing? 0=No; 1=Yes',
  Replace_With_NaN = 1,
 &END
```

DNTOFLUX

DNTOFLUX converts the original data units of DN/sample time to DN/second. The sample time for MIPS-24 is approximately 0.5 second**.** The module is generic and the multiplication factor (in this case a factor of ~1.907) is used in the command line rather than in a namelist file

SLOPERROR

Sloperror estimates the noise in the image, allowing for read noise (in electrons) and noise from excess counts due to droop (see droopop)

Sloperror.nl

```
&SLOPERRIN
  Comment = 'Generic namelist file for sloperror.',
  Log_Filename = 'stdout',
  Read_Noise = 45,
  Confusion_Sigma = 0,
  Comment = 'Droop coefficient for prior removal of droop (non-photoelectron counts will contaminate Poisson noise estimate)',
  Droop_Coef = 0.33,
  PMaskFatal = 16384,
  DMaskFatal = 16384,
 &END
```

ROWFLUXCORR

Rowfluxcorr corrects for excess flux due to the “read-2” effect. The read-2 effect is due to an offset in the second nondestructive read that causes the slope to be overestimated. The effect produces a gradient across the array that depends on detector coordinate and overall background level. The correction is very small (<<1%) and is applied as an analytic function subtracted from SUR slope values.

Rowfluxcorr.nl

```
 &rfcIn
  DMaskBit = 3,
  MaskD = 16384,
  PixScale = 1,
 &end
```

DESATSLOPE

In order to estimate the true amount of droop on the array, saturated pixels must be “desaturated” using the linearity model coefficients (lincal.fits). If desaturation is not been performed, then the droop due to saturated pixels would be underestimated. A dmask bit is set if the pixel was desaturated.

Desatslope.nl

```
 &DESATSLOPEIN
  Comment = 'Generic namelist file for desatslope, default values.',
  Comment = 'FITS header keyword for total frame count',
  CmdFrm_Keyword = 'DCE_FRMS',
  Comment = 'Number of frames to ignore for linearization (only used if not in header)',
  Ignore_Frames1 = 1,
  Ignore_Frames2 = 1,
  PMaskFatal = 8192,
```

```
 DMaskFatal = 16384,
 CMaskFatal = 256,
 Comment = 'Dmask bit indicating slope pixel was desaturated',
 DMaskDESAT = 16,
&END
```

DROOPOPMIPS

Droop correction calculated and applied (subtracted from each pixel). The droop coefficient is 0.33. The droop for each pixel is the sum of pixel value over the entire array excluding the current pixel times the coefficient. It is typically close to constant over the array**.** In cases where pixels are hard saturated, the proper droop correction cannot be determined; such cases may show a notable DC offset from neighboring BCD's in background level.

Droopop.nl

```
&DROOPOPIN
 Comment = 'Parameters for DROOPOP module',
 Droop_Coef = 0.33,
 Droop_Error = 0.01,
 First_Plane_Droop = 1,
 FITS_Pmask = '',
 FITS_Dmask = '',
 FITS_Cmask = '',
 PMASK_FATAL = 16384,
 DMASK_FATAL = 16384,
 CMASK_FATAL = 16384,
&end
```

ROWDROOP

It was thought pre-launch that there was an analog to full-array droop that also occurred within a row (causing a horizontal stripe through a bright source). After launch, it was found that this effect is nonexistent or too small to measure and correct. The module still run but the coefficients are set to zero so that it does not affect the data.

Rowdroop.nl

```
 &ROWDROOPIN
  Comment = 'Parameters for ROWDROOPOP module',
  CC_1 = 0.0,
  CC_2 = 0.0,
  CC_3 = 0.0,
  CC_4 = 0.0,
  UCC_1 = 0.5e-5,
  UCC_2 = 0.5e-5,
  UCC_3 = 0.5e-5,
  UCC_4 = 0.5e-5,
  PMASK_FATAL = 32767,
  DMASK_FATAL = 16384,
&end
```

CUBESUB

CUBESUB subtracts the dark current from the data by subtracting the appropriate dark current file that was retrieved from the database by CALTRANS. The level of the dark current is very low (just a few DN/sec) and does not appear to depend on integration time—it is truly very dark.

```
Cubesub.nl
&CUBESUBIN
  Operation = 1,
  PMASK_FATAL = 4352,
  DMASK_FATAL = 16384,
  CMASK_FATAL = 6144,
 &end
```

SLOPECORR

Slopecorr applies the non-linearity correction to each pixel in the slope image. The correction is determined by a calibration file, mips24_lincal.fits , in order to produce linearized data. The non-linearity coefficients were determined pre-launch but were found to be correct for the post-lauch data. The functional form is a quadratic: DN(obs)= m*t – A*t^2. The first plane of the calibration file corresponds to A/m^2 and the third plane is the1-sigma uncertainty in this quantity, with the second plane unused. The magnitude of these values are very small (the array is quite linear).
A/m^2 is typically about 2e-6. The number of frames to ignore is set in the namelist, which adjusts the total number of non-destructive reads to properly correct the linearity.

```
Sloopecorr.nl
 &SLOPECORRIN
  Comment = 'Generic namelist file for slopecorr, default values.',
  Comment = 'Number of frames to ignore for linearization (only used if not in header)',
  Ignore_Frames1 = 1,
  Ignore_Frames2 = 1,
  PMaskFatal = 4352,
  DMaskFatal = 0,
  CMaskFatal = 16384,
  Comment = 'Dmask bit indicating pixel was not linearized',
  DMaskNotLin = 4096,
 &END
```

SPOTMATCHING

In order to perform flat fielding, two images must be furnished to the following flat field module, FLATAP. The first is smoothly varying, overall flat field (often a campaign flat) as described in Section 6. The other is the "spotmap" (for the BCD pipeline) or the "shifted spot template" (for the EBCD pipeline)—both are described in Section 6. The product of these two FITS files is the flat field. At this point in the pipeline CALTRANS has already retrieved the appropriate spot maps. The spotmap for the BCD pipeline is determined early in the pipeline as described previously, and is NOT an ensemble process, but is run on each DCE independently.

There is an extra ensemble pipeline (1081) that is run on the entire AOR for the EBCD pipeline, which we describe here, before the flat fielding is performed.
Thus, the flow of the BCD/EBCD pipeline is interrupted here in order to describe this separate ensemble pipeline that is run prior to flatfielding. This pipeline runs the following modules:

STACKLAYER
This module stacks together the linearized data from the previous steps into a three-dimensional FITS cube for the EBCD pipeline. It is also run on the mask and uncertainty images.

CALTRANS
This is called to provide the necessary input files to perform the spotmatching.

SCI_SPOTFLAT
This is the module that performs the spotmatching in the y direction and writes the relative offset between the current AOR spot positions and a reference template to the header (keyword SPOT_DY; SPOT_DX is also written but is always 0). It shifts the appropriate template planes matching the CSM_PRED positions present in the AOR with a spline algorithm. The details on the determination of the shift are provided in Section 6. It reads in, on a command line, the "qfile" that specifies the location of the darkest spot on the array.

The qfile for photometry mode (the only mode for which EBCD products are made) is below. Comments describing the columns in this file are contained in this file. It contains a complete listing of the spot locations for all CSM_PRED positions used in photometry modes.

qfile_1_phot.csv

```
0,1000,0.0402,3,50,64,64,0,0,32,32,32,32,64,64,1,,,,
1830.5,1000,0.0403,3,50,50,50,0,0,32,32,32,32,10,56,0.9048,,,,
1834.625,1000,0.01,3,5,54,109,0,0,49,106,57,1,54,109,0.982,,,,
1863.375,1000,0.04,3,5,116,127,0,0,111,124,119,1,116,127,0.8272,,,,
1864.5,1,0.0401,3,5,116,127,0,0,110,121,122,127,116,127,0.8427,,,99,100
1866,1000,0.04,3,5,116,126,0,0,111,123,119,1,116,126,0.8247,,,,
1876.625,1000,0.0403,3,50,50,50,0,0,112,116,120,127,116,124,0.8243,,,,
1876.75,1000,0.0403,3,50,50,50,0,0,112,116,120,127,116,124,0.8285,,,,
1877.5,1000,0.04,3,5,116,124,0,0,111,121,119,126,116,124,0.8311,,,,
```

```
1886,1,0.0401,3,5,117,122,0,0,110,118,123,127,117,122,0.8219,,,99,100
1892.125,1000,0.04,3,5,117,121,0,0,112,118,120,123,117,121,0.8273,,,,
1907.5,1,0.0401,3,5,117,118,0,0,110,114,123,123,117,118,0.8331,,,99,100
1920.75,1000,0.04,3,5,117,115,0,0,112,112,120,117,117,115,0.8033,,,91,92
1920.875,1000,0.04,3,5,117,115,0,0,112,112,120,117,117,115,0.8109,,,,
1922.875,1000,0.0403,3,50,50,50,0,0,113,106,121,122,117,114,0.8079,,,,
1923,1000,0.0403,3,50,50,50,0,0,113,106,121,122,117,114,0.8124,,,,
1929,1,0.0401,3,5,117,113,0,0,110,110,123,119,117,113,0.8023,,,99,100,,
1942.25,1000,0.04,3,5,117,111,0,0,112,108,120,113,117,111,0.8192,,,,,,
1949.5,1000,0.04,3,5,117,109,0,0,112,106,120,111,117,109,0.7909,,,91,92,,
1949.625,1000,0.04,3,5,117,109,0,0,112,106,120,111,117,109,0.8094,,,,,,
1969.125,1000,0.0403,3,50,50,50,0,0,32,32,32,32,118,79,0.8035,,,,,,
1978.25,1000,0.04,3,5,117,103,0,0,112,100,120,105,117,103,0.79,,,,,,
1978.375,1000,0.04,3,5,117,103,0,0,112,100,120,105,117,103,0.8108,,,91,92,,
1992.625,1000,0.04,3,5,117,100,0,0,112,97,120,102,117,100,0.8052,,,,,,
1999.875,1000,0.04,3,5,117,98,0,0,112,95,120,100,117,98,0.7991,,,113,114,,
2007,1000,0.04,3,5,117,97,0,0,112,94,120,99,117,97,0.795,,,113,114,91,92
2007.125,1000,0.04,3,5,117,97,0,0,112,94,120,99,117,97,0.8118,,,113,114,,
2014.25,1000,0.04,3,5,117,95,0,0,112,92,120,97,117,95,0.8035,,,113,114,,
2021.5,1000,0.04,3,5,117,94,0,0,112,91,120,96,117,94,0.817,,,113,114,,
2035.75,1000,0.04,3,5,117,91,0,0,112,88,120,93,117,91,0.8176,,,91,92,,
2044.875,1000,0.0403,3,50,50,50,0,0,32,32,32,32,118,79,0.8092,,,,,,
2064.5,1000,0.04,3,5,118,85,0,0,113,82,121,87,118,85,0.8272,,,91,92,,
2071.75,1000,0.04,3,5,118,83,0,0,113,80,121,85,118,83,0.8026,,,,,,
2091,1000,0.0403,3,50,50,50,0,0,114,61,122,77,118,69,0.7908,,,,,,
2091.125,1000,0.0403,3,50,50,50,0,0,114,61,122,77,118,69,0.7923,,,,,,
2093.25,1000,0.04,3,5,118,78,0,0,107,117,115,122,118,78,0.83,112,120,91,92,,
2106.5,1,0.0401,3,5,118,75,0,0,110,72,123,79,118,75,0.83,112,117,99,100,,
2122,1000,0.04,3,5,118,72,0,0,107,111,115,116,118,72,0.83,112,114,,,,
2128,1,0.0401,3,5,118,71,0,0,110,68,123,75,118,71,0.83,112,113,99,100,,
2136.5,1000,0.04,3,5,118,69,0,0,107,108,115,113,118,69,0.83,112,111,,,,
2137.25,1000,0.0403,3,50,50,50,0,0,114,51,122,67,118,59,0.7859,,,,,,
2137.375,1000,0.0403,3,50,50,50,0,0,114,48,122,64,118,56,0.9048,,,,,,
2148,1000,0.04,3,5,118,67,0,0,107,106,115,111,118,67,0.83,112,109,,,,
2149.5,1,0.0401,0,50,118,66,0,0,110,63,123,70,118,66,0.83,112,108,99,100,,
2150.75,1000,0.04,0,50,118,66,0,0,107,105,115,110,118,66,0.83,112,108,,,,
2179.5,1000,0.04,0,50,118,60,0,0,107,99,115,104,118,60,0.83,112,102,,,,
2183.5,1000,0.0403,3,50,50,50,0,0,114,48,122,64,118,56,0.8243,,,,,,
# csm,plane sigma,spot thresh, usage, prio, primary x, primary y, secondary x,
secondary
y,xmin,ymin,xmax,ymax,xdark,ydark,pdark,xother,yother,aper1,aper2,aper3,aper4
#,,,,,
#,# csm,column containing CSM_PRED for this spot,,,
#,plane sigma,"sigma used for this csm_pred plane in weighted calculation mean
global dy offset, this is treated like a standard deviation, so higher numbers mean
less weight",,,
#,spot thresh,decrease from 1.0 mirrorflat nominal to be considered in a spot,,,
#,usage,how this spot is treated in the selection hierarchy for all potential
CSM_PRED values,,,
#,,"use_srch_equalweight, use_srch_lowestweight, use_srch_weighted,
use_srch_median, use_primary, use_energetic, use_both_combined",,,
#,prio,Selection priority of this spot - dx dy from highest priority of all science
spots meeting snr threshold ,,,
#,primary x,"x location of a pixel in the primary spot, 1-origin indexing like
DS9",,,
#,primary y,"y location of a pixel in the primary spot, 1-origin indexing like
DS9",,,
#,secondary x,x location of a pixel in the secondary spot,,,set usage key=0 if no
secondary spot
#,secondary y,y location of a pixel in the secondary spot,,,set usage key=0 if no
secondary spot
#,xmin,optional rectangular box outlining spot,,,
#,ymin,,,,
#,xmax,,,,
#,ymax,,,,
```

```
#,xdark,from cal_spotflat qfile_guess - x location of darkest pixel,,,
#,ydark,from cal_spotflat qfile_guess - y location of darkest pixel,
#,pdark,pixel value of darkest pixel,
#,xother,"x location of darkest part of alternative spot, used for CSM_PRED>=
2093.25",
#,yother,"y location of darkest part of alternative spot, used for CSM_PRED>=
2093.25",
# CSM_PRED values 1834.625,1863.375, 1864.5 and 1866 have no usable spots, change
YMAX < YMIN per CR8083
# spot thresh is no longer used (rectangular boxes specify spot locations) This
value now specifies instrument mode,,,
#,0.04,unassigned,
#,0.0401,small field photometry,
#,,,
# $Id: qfile_1_phot.csv,v 1.18 2009/02/19 01:33:46 davidh Exp $,,
```

Additional explanation of the above file follows:

\# csm plane sigma spot thresh usage prio primary x primary y secondary x secondary y xmin ymin xmax ymax xdark ydark pdark xother yother aper1 aper2 aper3 aper4

\#

\# csm column containing CSM_PRED for this spot

\# plane sigma sigma used for this csm_pred plane in weighted calculation mean global dy offset, this is treated like a standard deviation, so higher numbers mean less weight

\# spot thresh decrease from 1.0 mirrorflat nominal to be considered in a spot

\# usage how this spot is treated in the selection hierarchy for all potential CSM_PRED values

\# use_srch_equalweight, use_srch_lowestweight, use_srch_weighted, use_srch_median, use_primary, use_energetic, use_both_combined

\# prio Selection priority of this spot - dx dy from highest priority of all science spots meeting snr threshold

\# primary x x location of a pixel in the primary spot, 1-origin indexing like DS9

\# primary y y location of a pixel in the primary spot, 1-origin indexing like DS9

\# secondary x x location of a pixel in the secondary spot
set usage key=0 if no secondary spot

\# secondary y y location of a pixel in the secondary spot
set usage key=0 if no secondary spot

\# xmin optional rectangular box outlining spot

\# ymin

#	xmax

#	ymax

#	xdark	from cal_spotflat qfile_guess - x location of darkest pixel

#	ydark	from cal_spotflat qfile_guess - y location of darkest pixel

#	pdark	pixel value of darkest pixel

#	xother	x location of darkest part of alternative spot, used for CSM_PRED>= 2093.25

#	yother	y location of darkest part of alternative spot, used for CSM_PRED>= 2093.25

# CSM_PRED values 1834.625	1863.375		1864.5 and 1866 have no usable spots	change YMAX < YMIN per CR8083

THIS IS THE END OF THE SPOTMATCHING SECTION

The BCD/EBCD pipeline steps resume here:

CSMLAYER
CSMLAYER returns a FITS file corresponding to the layer of the shifted template plane containing the spotmap matching the BCD (for that CSM_PRED position). This is run for the EBCD processing and is essentially ignored for the BCD processing.

FLATAP

Flatap applies the flat-field correction in order to adjust for pixel-to-pixel variations in responsivity and illumination. The flatfield used is determined by caltrans and the pipeline number. Different flat fields are used for the BCD and EBCD products as described in Section 6. The flat field is the product of the overall smooth gain flat and a spotmap (or shifted template image for the EBCDs) and these are input separately to the module. The linearized data from the previous step is divided by this product to produce the flat-fielded BCD/EBCD.

```
Flatap.nl
&FLATAPIN
  PmaskMask = 4352,
  CmaskMask = 0,
  DmaskMask = 16384,
&end
```

DNTOFLUX

Here DNTOFLUX is used to convert the flat-fielded data units from DN/sec to Megajanskys per steradian (MJy/sr). The conversion factor is found in the cal file mips24_fluxconv.tbl and is 0.0447. The keyword BUNIT in the header is updated accordingly.

Dntoflux.nl

```
 &DNTOFLUXIN
  Comment = 'Generic namelist file for dntoflux. See cal. file: mips24_fluxconv.tbl for
conversion factors',
  BunitString = MJy/sr,
 &END
```

DARKDRIFT

Darkdrift adjusts the DC level of columns of the array to mitigate the effects of “jailbars” caused by having four independent readout channels with independently fluctuating DC levels. Channel 1 is consistently the “noisy” readout channel and is excluded from the calculation of the trimmed average of the other 3. This trimmed average is then used as the fiducial background value and the other 4 channel averages are adjusted by adding the difference between their individual column averages and the background value.

This module also writes keywords to the header to indicate what DC levels have been subtracted from each of the 4 readout channels in order to remove “jailbars” and what the trimmed average background level is.

Darkdrift.nl

```
&DARKDRIFTIN
  Comment = 'Namelist file for darkdrift.',
  Log_Filename = 'stdout',
  Comment = 'Transpose Image: 1=Don't, 2=Do',
  Transpose = 1,
  Comment = 'Parameters for trimmed average and uncertainty calculations',
  CentralFraction1 = 0.9,
  CentralFraction2 = 0.9,
  Comment = 'Data_Plane: 1=All, 2=First, 3=Last',
  Data_Plane = 2,
  Comment = 'Mult_Corr: 0=Additive, 1=Multiplicative',
  Mult_Corr = 0,
  Comment = 'RO_Chan_To_Exclude: 0=None or specify 1-4',
  RO_Chan_To_Exclude = 1,
&END
```

SATMASK

This is the second time SATMASK is called in the BCD pipeline. Here it replaces soft saturated pixels in slope image with unsaturated pixels from difference image and updates dmask with history of which pixels were replaced. This time the module reads in the namelist replacepixel.nl . It is then called again and applied to the BCD uncertainty file because replaced pixels will have (higher) uncertainties from the difference image rather than the slope

replacepixel.nl:

```
 &SATMASKIN
  Comment = 'Generic namelist file for satmask (replace-pixel
operation), default values.',
  PMaskFatal = 4352,
  DMaskFatal = 16384,
  Comment = 'Replace fatal input pixels with NaNs in output? 0=No;
1=Yes',
  Replace_With_NaN = 1,
 &END
```

SPLIT2PLANECUBE

This module splits the 2-plane cube into slope and difference images and associated uncertainty and mask files that are single plane files. The Bmask (BCD mask) is created and contains all of the bit flags from the BCD processing, combining slope and difference information. The bmask is archived (but not the dmask).

MEDFILTER

Pixels marked as outliers could correspond to cosmic rays and could be ignored in the mopex (mosaic) pipeline, although this option is not used at all in the MIPS-24 archived mosaics. The namelist file detect_radhit.nl is used for this module and the subsequent DETECT module.

Detect_radhit.nl

```
&MEDFILTER
  Window_X               = 21,
  Window_Y               = 21,
  N_Outliers_Per_Window  = 100,
# Fatal bits to avoid in pmask,
  Mask_Value_1           = 17408,
# Fatal bits to avoid in dmask,
  Mask_Value_2           = 8224,
&END

&DETECT_RADHIT
# Detection_Max_Area (Optional, default is 3),
  Detection_Max_Area     = 4,
# Segmentation_Threshold (Optional, default is 3.),
  Segmentation_Threshold = 3.,
# Radhit_Threshold (Optional, default is 6.),
  Radhit_Threshold       = 10.,
# RadHit_Bit to set in dmask if radhit detected,
  RadHit_Bit             = 9,
# Fatal bits to avoid in pmask,
  Mask_Value_1           = 17408,
# Fatal bits to avoid in dmask,
  Mask_Value_2           = 8224,
```

```
&END
```

DETECT_RADHIT

This module uses the namelist file above, detect_radhit.nl. It inputs the spatially median filtered images, detects potential radhits (anomalously bright pixels) in a single frame and stores it in the bmask.

QATOOL

Quality assurance statistics run on BCD/EBCD.

Qatool.nl

```
 &QATOOLIN
  Comment = 'Generic namelist file for qatool, default values.',
  Comment = 'Operation: 1=Include ReadOut-Channel Statistics,
2=Exclude',
  Operation = 1,
  NBinsHistogram = 41,
  NDevHistHalfWidth = 5,
  Comment = 'Data_Plane: 1=All, 2=First, 3=Last',
  Data_Plane = 2,
  Box_X_Position = 1,
  Box_Y_Position = 1,
  Box_X_Width = 128,
  Box_Y_Height = 128,
  CentralFraction1 = 0.81,
  CentralFraction2 = 0.72,
  NEdge = 0,
  KeywordPrefix = 'bcd',
  StatisticsGroup = 1,
  Comment = 'Operation_Datascale: 1=Include computation; 2=Exclude',
  Operation_Datascale = 2,
 &END
```

CHKMASK

Statistics performed on the Bmask

QALOADER

QALOADER loads the output statistics from QATOOL into the database

END OF 1061/1021(BCD) pipelines

Additional modules from the 1030/1038 pipeline (pointing transfer) that are run at the end of the BCD pipeline:

CALTRANS

Caltrans is run again to find appropriate calibration files for pointing transfer

GETPH_ONLINE

This module reads the pointing history file relevant to this DCE.

MIRRORSYNCH

This module reads in scan mirror parameters to calculate pointing information. Fields of view and mirror axis vectors are read from calibration file mips24_mirrorparameters.tbl

BORESIGHTTRAN

This module reads in the scan mirror history file and computes the center of MIPS_24 boresight

ANGLEAVG

This module computes the average angle on sky of given field of view during the DCE , taking into account mirror angles, pixel sizes, and distortion parameters from calibration file mips24_cdelt12_distort.tbl.

HDRUPDATE

This module apparently has the same capability as HDRUPD8 but is a separate module. Pointing keywords are added to Raw, difference, slope, BCD files and their associated uncertainty files, and the bmask.

BGMODEL

Given the field of view, instrument/wavelength, pointing, and position of the spacecraft in the solar system, this background model module, computes the estimated sky background in MJy/sr based on a model. Background contributions from the zodiacal light, interstellar medium, and cosmic IR background are calculated and populated in header keywords ZODY_EST, ISM_EST, and CIB_EST.

FPGEN

FPGEN, or the final product generator, organizes, renames, and populates FITS header keywords for major pipeline products. It is run on the following data products: Raw, difference, slope, BCD, EBCD and associated uncertainty files and bmask.

It reads in a template file (below). The template includes descriptive comments for each keyword and only the keywords relevant to the current BCD are populated. The template includes an inclusive list of keywords for all MIPS-24 modes in a single file.

For MIPS-24, the final product generator populates the header keywords via three methods:

1) PASSTHRU: pass through existing header keyword from data product, reproduced with the same keyword and value (but comment can be overwritten)
2) RENAME: renames an existing header keyword to a new keyword that is more desireable

3) DATABASE: acquires the keyword from the database

The fpg template file (fpg.tpl) for MIPS-24 is reproduced below:

```
#
# FPG template file for mips24 BCD products
#
#-------------------------------------------------------------------
#
# Last updated by S. Stolovy 4/21/2003
# Last updated by F. Masci   5/13/2003
#                 -corrected datatype for CSM_SKY
# Last updated by F. Masci   5/20/2003
#                 -added FBIDDTO keyword(s).
#                 -removed FILENAME (PASSTHRU) string since RAWFILE
#                  gives the same thing.
#                 -added FILETYPE (PASSTHRU) string per software changes.
# Last updated by F. Masci   5/21/2003
#                 -added CE_SIDE keyword
# Last updated by F. Masci   5/30/2003
#                 -removed obselete keywords to support CD-matrix scheme
#                 -added CD-matrix keywords
# Last updated by F. Masci   6/5/2003
#                 - Changed ICRF to ICRS in EQUINOX. This was a typo.
# Last updated by F. Masci   6/9/2003
#                 - Added calibration product acquisition time stamp keywords:
#                   SCETDARK, SCETFLAT, SCETNONL, SCETPMSK, SCETDNT,
#                   SCETDNT1, SCETDNT2
# Last updated by F. Masci 12/18/2003
#                 - Changed SIRTF to Spitzer in TELESCOP and INSTRUME
#                   comment fields.
# Last updated by F. Masci 02/27/2004
#                 - Changed [Sec] to [1/65535 Sec] for FINESYNC and shortened
#                   comment fields.
# Last updated by F. Masci 04/06/2004
#                 - Included CSM_AVG keyword (which is needed for
#                   debugging purposes).
# Last updated by F. Masci 04/20/2004
#                 - Changed CMDDCES to CMD_DCES per Frayer's requrest
#                   for consistency with mipsGe.
# Last updated by F. Masci 04/27/2004
#                 - Updated comment fields for:
#                   ANCSMGN     CSMM Gain Adjustment DAC
#                   AVDSUBV     [Volts] VD Sub Voltage
#                   FRMFLYBK    [Frames] CSMM Flyback Duration
# Last updated by F. Masci 04/29/2004
#                 - Updated to DS_IDENT from DS_ADSID (old)
# Last updated by F. Masci 05/14/2004
#                 - Changed comment field of EXPTIME keyword
# Last updated by F. Masci 05/18/2004
#                 - Changed comment field of FOVNAME, FOVID to
#                   "Field of View Name for Commanded" and
#                   "Field of View ID for Commanded Pointing" respectively.
# Last updated by F. Masci 06/21/2004
#                 - Added new keywords: BPHFNAME, BPHFNAM1, BPHFNAM2,
#                   FOVVERSN, RECONFOV to support superboresight design.
#                   AI's have been generated to get this into other
#                   instruments too.
# Last updated by F. Masci 09/2/2004
#                 - Numeric in MJD_OBS comment changed to JD-2400000.5
#                 - Removed DITHPOS
# Last updated by F. Masci 01/13/2005
```

```
#                  - Added PTGDIFFX and PTGDIFFY keywords which
#                    represent differences between requested and
#                    reconstructed pointing along X and Y in native pixel
#                    frame.
# Last updated by F. Masci 02/04/2005
#                  - Added SPOT_X and SPOT_Y which represent
#                    positions of the characteristic spot.
# Last updated by F. Masci 02/14/2005
#                  - Added FLATUSED which represents the actual root
#                    filename of the flatfield used on the science BCD.
# Last updated by F. Masci 04/28/2005
#                  - Added ZODY_EST, ISM_EST and CIB_EST from background
#                    model under PHOTOMETRY section, just like for IRAC.
# Last updated by F. Masci 05/31/2005
#                  - Added FBIDSFLT, EPIDSFLT, SCETSFLT, EPIDSPOT,
#                    FBIDSPOT and SCETSPOT for superflat and spot-map
#                    used to make gradient corrected flat.
# Last updated by F. Masci 06/02/2005
#                  - Added SPOTMAP (value=filename) for cases where
#                    spot-map is queried for making gradient correction.
# Last updated by S. Stolovy 12/12/2005 (darkdrift keywords)
#
# Last updated by S. Stolovy 4/9/2007, added Heliocentric keywords to TIME section
#
# Last updated by R. Laher 10/17/2007
#                  - Updated for new darkdrift output keyword names (see CR #7856)
#                  - Changed PASSTHRU to RENAME to revert to old darkdrift keyword
names
#                  - Improved keyword comments, including adding MJy/sr
# Last updated by S. Stolovy 4/9/2008, add/rename keywords DXSHIFT and DYSHIFT for
new aorflats
# Another update by S. Stolovy 5/22/2008 to correctly rename the above keywords and
remove tabs
# Last updated by D. Henderson 1/22/2009, passthru CSMLAYER, TDSTAMP, GDSTAMP
keyword
# Another update, D. Henderson, 5/28/2009, passthru PTSCRPID per CR8360s
# Added database keyword ENHAN160 to distinghish 160small and 160enh, 8/20/09
#------------------------------------------------------------------
#
# KEYIN   TYPE         ACTION     KEYOUT      COMMENT
#
SIMPLE    TLOGICAL     PASSTHRU   SIMPLE      Fits standard
BITPIX    TINT         PASSTHRU   BITPIX      -32 = 4-BYTE FLOAT, 16 = 2-BYTE
INTEGER
NAXIS     TINT         PASSTHRU   NAXIS       STANDARD FITS FORMAT
NAXIS1    TINT         PASSTHRU   NAXIS1
NAXIS2    TINT         PASSTHRU   NAXIS2
NAXIS3    TINT         PASSTHRU   NAXIS3
FILETYPE  TSTRING      PASSTHRU   FILETYPE    Image type
TELESCOP  TSTRING      PASSTHRU   TELESCOP    Spitzer Space Telescope
INSTRUME  TSTRING      PASSTHRU   INSTRUME    Spitzer Space Telescope
                                               instrument ID
CHNLNUM   TINT         PASSTHRU   CHNLNUM     This image: 1=24um,2=70um,3=160um
          TSTRING      DATABASE   AOT_TYPE    Observation Template Type
          TSTRING      DATABASE   AORLABEL    AOR Label
          TSTRING      DATABASE   REQTYPE     Request type (AOR, IER, or SER)
EXPTYPE   TSTRING      PASSTHRU   EXPTYPE     Exposure Type
APERTURE  TINT         RENAME     FOVID       Field of View ID for Commanded
Pointing
APERNAME  TSTRING      RENAME     FOVNAME     Field of View Name for Commanded
                                               Pointing
          TINT         DATABASE   PRIMEARR    (1=prime,2=not prime,3=not valid)
RDOUTMOD  TSTRING      PASSTHRU   RDOUTMOD    Readout mode
CSMLAYER  TINT         PASSTHRU   CSMLAYER    Layer number in template file
                                               used for flat correction
```

	/ PROPOSAL INFORMATION			
OBSRVR	TSTRING	PASSTHRU	OBSRVR	Observer Name (Last, First)
OBSRVRID	TINT	PASSTHRU	OBSRVRID	Observer ID of Principal Investigator
PROCYCL	TINT	PASSTHRU	PROCYCL	Proposal Cycle
	TINT	DATABASE	PROGID	Program ID
	TSTRING	DATABASE	PROTITLE	Program Title
	TINT	DATABASE	PROGCAT	Program Category
	/ TIME AND EXPOSURE INFORMATION			
DATE_OBS	TSTRING	PASSTHRU	DATE_OBS	Date & time at DCE start
MJD_OBS	TDOUBLE	PASSTHRU	MJD_OBS	[days] MJD at DCE start (JD2400000.5)
HMJD_OBS	TDOUBLE	PASSTHRU	HMJD_OBS	[days] Corresponding Heliocen. Mod. Julian Date
UTCS_OBS	TDOUBLE	PASSTHRU	UTCS_OBS	[sec] J2000 ephem. time at DCE start
SCLK_OBS	TDOUBLE	PASSTHRU	SCLK_OBS	[sec] SCLK time (since 1/1/1980) at DCE start
SPTZR_X	TDOUBLE	PASSTHRU	SPTZR_X	[km] Heliocentric J2000 x position
SPTZR_Y	TDOUBLE	PASSTHRU	SPTZR_Y	[km] Heliocentric J2000 y position
SPTZR_Z	TDOUBLE	PASSTHRU	SPTZR_Z	[km] Heliocentric J2000 z position
SPTZR_VX	TDOUBLE	PASSTHRU	SPTZR_VX	[km/s] Heliocentric J2000 x velocity
SPTZR_VY	TDOUBLE	PASSTHRU	SPTZR_VY	[km/s] Heliocentric J2000 y velocity
SPTZR_VZ	TDOUBLE	PASSTHRU	SPTZR_VZ	[km/s] Heliocentric J2000 z velocity
SPTZR_LT	TDOUBLE	PASSTHRU	SPTZR_LT	[sec] One-way light time to Sun's center
ET_OBS	TDOUBLE	PASSTHRU	ET_OBS	[sec] Ephemeris time (seconds past J2000 epoch)
SAMPTIME	TFLOAT	PASSTHRU	SAMPTIME	[sec] Sample integration time
EXPTIME	TFLOAT	PASSTHRU	EXPTIME	[sec] Integration time per pixel per BCD
IGN_FRM1	TINT	PASSTHRU	IGN_FRM1	Initial frames ignored for dcenum = 0
IGN_FRM2	TINT	PASSTHRU	IGN_FRM2	Initial frames ignored for dcenum > 0
SATTHDIF	TINT	PASSTHRU	SATTHDIF	[DN/SAMPTIME] Saturation Thres. in difference
	TLOGICAL	DERIVED	BOOSTFRM	T if DCE with bias boost
	/ READOUT (JAILBAR) CORRECTION INFORMATION			
DRICRTYP	TINT	PASSTHRU	ROCRTYPE	Readout (jailbar) corr. type (0=add, 1=mult)
DRIROEXC	TINT	PASSTHRU	ROCHEXCL	Readout chan. excluded from backgrnd.(0 = None)
DDBKGD01	TFLOAT	RENAME	DRIBKGND	Background estimate for readout corr. (MJy/sr)
DDCR01_1	TFLOAT	RENAME	DRICORR1	Value subtracted from readout chan. 1 (MJy/sr)
DDCR01_2	TFLOAT	RENAME	DRICORR2	Value subtracted from readout chan. 2 (MJy/sr)
DDCR01_3	TFLOAT	RENAME	DRICORR3	Value subtracted from readout chan. 3 (MJy/sr)
DDCR01_4	TFLOAT	RENAME	DRICORR4	Value subtracted from readout chan. 4 (MJy/sr)
	/ TARGET AND POINTING INFORMATION			
TARGETNA	TSTRING	RENAME	OBJECT	Object Name
	TSTRING	DATABASE	OBJTYPE	Object Type
CRVAL1	TDOUBLE	PASSTHRU	CRVAL1	[deg] RA at CRPIX1,CRPIX2 averaged over DCE

CRVAL2	TDOUBLE	PASSTHRU	CRVAL2	[deg] DEC at CRPIX1,CRPIX2 averaged over DCE
RA_HMS	TSTRING	PASSTHRU	RA_HMS	[hh:mm:ss.s] CRVAL1 as sexigesimal
DEC_DMS	TSTRING	PASSTHRU	DEC_DMS	[dd:mm:ss] CRVAL2 as sexigesimal
CD1_1	TDOUBLE	PASSTHRU	CD1_1	[deg/pix] CD matrix element 1_1
CD1_2	TDOUBLE	PASSTHRU	CD1_2	[deg/pix] CD matrix element 1_2
CD2_1	TDOUBLE	PASSTHRU	CD2_1	[deg/pix] CD matrix element 2_1
CD2_2	TDOUBLE	PASSTHRU	CD2_2	[deg/pix] CD matrix element 2_2
RADESYS	TSTRING	PASSTHRU	RADESYS	International Celestial Reference System
EQUINOX	TFLOAT	PASSTHRU	EQUINOX	Equinox for ICRS celestial coord. system
CTYPE1	TSTRING	PASSTHRU	CTYPE1	RA---TAN with distortion in pixel space
CTYPE2	TSTRING	PASSTHRU	CTYPE2	DEC--TAN with distortion in pixel space
CRPIX1	TFLOAT	PASSTHRU	CRPIX1	Reference pixel along axis 1
CRPIX2	TFLOAT	PASSTHRU	CRPIX2	Reference pixel along axis 2
CRDER1	TDOUBLE	PASSTHRU	CRDER1	[deg] Uncertainty in CRVAL1
CRDER2	TDOUBLE	PASSTHRU	CRDER2	[deg] Uncertainty in CRVAL2
UNCRTWST	TDOUBLE	RENAME	UNCRTPA	[deg] Uncertainty in position angle
CSDRADEC	TDOUBLE	PASSTHRU	CSDRADEC	[deg] Costandard deviation in RA and Dec
SIGRA	TDOUBLE	PASSTHRU	SIGRA	[arcsec] RMS dispersion in RA over DCE
SIGDEC	TDOUBLE	PASSTHRU	SIGDEC	[arcsec] RMS dispersion in DEC over DCE
SIGPA	TDOUBLE	PASSTHRU	SIGPA	[arcsec] RMS dispersion of PA over DCE
	TDOUBLE	DATABASE	RA_REF	[deg] Commanded RA (J2000) of ref. position
	TDOUBLE	DATABASE	DEC_REF	[deg] Commanded Dec (J2000) of ref. position
RA_RQST	TDOUBLE	PASSTHRU	RA_RQST	[deg] Requested RA at CRPIX1
DEC_RQST	TDOUBLE	PASSTHRU	DEC_RQST	[deg] Requested Dec at CRPIX2
PA_RQST	TDOUBLE	PASSTHRU	PA_RQST	[deg] Reqst. pos. angle of TPF Z axis (E of N)
PA	TDOUBLE	PASSTHRU	PA	[deg] pos. angle of axis 2 (E of N,+=CCW)
PXSCAL1	TDOUBLE	PASSTHRU	PXSCAL1	[arcsec/pix] Scale for axis 1 at CRPIX1,CRPIX2
PXSCAL2	TDOUBLE	PASSTHRU	PXSCAL2	[arcsec/pix] Scale for axis 2 at CRPIX1,CRPIX2
	TFLOAT	DATABASE	PM_RA	[arcsec/yr] Proper Motion in RA (J2000)
	TFLOAT	DATABASE	PM_DEC	[arcsec/yr] Proper Motion in Dec (J2000)
CSM_PRED	TFLOAT	PASSTHRU	CSM_PRED	[DAC] Predicted mirror start pos
CSM_SKY	TFLOAT	PASSTHRU	CSM_SKY	[arcsec] Predicted mirror start pos on sky
CSM_RATE	TFLOAT	PASSTHRU	CSM_RATE	[milli-arcsec/sec] Mirror scan rate
CSM_AVG	TFLOAT	PASSTHRU	CSM_AVG	[degree] Average mirror position during exposure
SPOT_X	TFLOAT	PASSTHRU	SPOT_X	[pix] X-position of spot
SPOT_Y	TFLOAT	PASSTHRU	SPOT_Y	[pix] Y-position of spot
SIG_JIT	TDOUBLE	RENAME	RMS_JIT	[arcsec] RMS jitter during DCE
SIG_JITY	TDOUBLE	RENAME	RMS_JITY	[arcsec] RMS jitter during DCE along Y
SIG_JITZ	TDOUBLE	RENAME	RMS_JITZ	[arcsec] RMS jitter during DCE along Z
CSD_JTYZ	TDOUBLE	PASSTHRU	SIG_JTYZ	[arcsec] YZ costandard deviation of jitter
PTGDIFF	TDOUBLE	PASSTHRU	PTGDIFF	[arcsec] offset btwn actual and rqsted pntng

PTGDIFFX	TDOUBLE	PASSTHRU	PTGDIFFX	[arcsec] rqsted - actual pntng along axis 1
PTGDIFFY	TDOUBLE	PASSTHRU	PTGDIFFY	[arcsec] rqsted - actual pntng along axis 2
USEDBPHF	TLOGICAL	PASSTHRU	USEDBPHF	T if Boresight Pointing History File was used
BPHFNAME	TSTRING	PASSTHRU	BPHFNAME	Boresight Pointing History Filename
BPHFNAM1	TSTRING	PASSTHRU	BPHFNAM1	Boresight Pointing History Filename 1
BPHFNAM2	TSTRING	PASSTHRU	BPHFNAM2	Boresight Pointing History Filename 2
FOVVERSN	TSTRING	PASSTHRU	FOVVERSN	FOV/BodyFrames file version used
RECONFOV	TSTRING	PASSTHRU	RECONFOV	Reconstructed Field of View
	/ MOVING TARGET INFORMATION			
	TINT	DATABASE	NAIFID	NAIF ID number for target
	TSTRING	DATABASE	NAIFNAME	Solar System Object name
	TSTRING	DATABASE	EPHMFILE	Ephemeris file used for moving target
	TSTRING	DATABASE	MTEPOCH	[Julian date] Epoch
	TSTRING	DATABASE	T_PERI	[Julian date] Perihelion date
	TDOUBLE	DATABASE	LITOMEGA	[deg] Argument of perihelion w.r.t. ecliptic
	TDOUBLE	DATABASE	BIGOMEGA	[deg] Long. of ascending node w.r.t. ecliptic
	TFLOAT	DATABASE	ECCENTR	Eccentricity
	TDOUBLE	DATABASE	PERIHELI	[AU] Perihelion distance
	TFLOAT	DATABASE	INCLINAT	[deg] Inclination of orbit
	/ DISTORTION KEYWORDS			
A_ORDER	TINT	PASSTHRU	A_ORDER	polynomial order, axis 1, detector to sky
A_0_2	TDOUBLE	PASSTHRU	A_0_2	distortion coefficient
A_0_3	TDOUBLE	PASSTHRU	A_0_3	distortion coefficient
A_1_1	TDOUBLE	PASSTHRU	A_1_1	distortion coefficient
A_1_2	TDOUBLE	PASSTHRU	A_1_2	distortion coefficient
A_2_0	TDOUBLE	PASSTHRU	A_2_0	distortion coefficient
A_2_1	TDOUBLE	PASSTHRU	A_2_1	distortion coefficient
A_3_0	TDOUBLE	PASSTHRU	A_3_0	distortion coefficient
A_DMAX	TDOUBLE	PASSTHRU	A_DMAX	[pixel] maximum correction
B_ORDER	TINT	PASSTHRU	B_ORDER	polynomial order, axis 2, detector to sky
B_0_2	TDOUBLE	PASSTHRU	B_0_2	distortion coefficient
B_0_3	TDOUBLE	PASSTHRU	B_0_3	distortion coefficient
B_1_1	TDOUBLE	PASSTHRU	B_1_1	distortion coefficient
B_1_2	TDOUBLE	PASSTHRU	B_1_2	distortion coefficient
B_2_0	TDOUBLE	PASSTHRU	B_2_0	distortion coefficient
B_2_1	TDOUBLE	PASSTHRU	B_2_1	distortion coefficient
B_3_0	TDOUBLE	PASSTHRU	B_3_0	distortion coefficient
B_DMAX	TDOUBLE	PASSTHRU	B_DMAX	[pixel] maximum correction
AP_ORDER	TINT	PASSTHRU	AP_ORDER	polynomial order, axis 1, sky to detector
AP_0_1	TDOUBLE	PASSTHRU	AP_0_1	distortion coefficient
AP_0_2	TDOUBLE	PASSTHRU	AP_0_2	distortion coefficient
AP_0_3	TDOUBLE	PASSTHRU	AP_0_3	distortion coefficient
AP_1_0	TDOUBLE	PASSTHRU	AP_1_0	distortion coefficient
AP_1_1	TDOUBLE	PASSTHRU	AP_1_1	distortion coefficient
AP_1_2	TDOUBLE	PASSTHRU	AP_1_2	distortion coefficient
AP_2_0	TDOUBLE	PASSTHRU	AP_2_0	distortion coefficient
AP_2_1	TDOUBLE	PASSTHRU	AP_2_1	distortion coefficient
AP_3_0	TDOUBLE	PASSTHRU	AP_3_0	distortion coefficient
BP_ORDER	TINT	PASSTHRU	BP_ORDER	polynomial order, axis 2, sky to detector
BP_0_1	TDOUBLE	PASSTHRU	BP_0_1	distortion coefficient
BP_0_2	TDOUBLE	PASSTHRU	BP_0_2	distortion coefficient
BP_0_3	TDOUBLE	PASSTHRU	BP_0_3	distortion coefficient

BP_1_0	TDOUBLE	PASSTHRU	BP_1_0	distortion coefficient
BP_1_1	TDOUBLE	PASSTHRU	BP_1_1	distortion coefficient
BP_1_2	TDOUBLE	PASSTHRU	BP_1_2	distortion coefficient
BP_2_0	TDOUBLE	PASSTHRU	BP_2_0	distortion coefficient
BP_2_1	TDOUBLE	PASSTHRU	BP_2_1	distortion coefficient
BP_3_0	TDOUBLE	PASSTHRU	BP_3_0	distortion coefficient
	/ PHOTOMETRY			
BUNIT	TSTRING	PASSTHRU	BUNIT	Units of image data
DNTCNVF1	TFLOAT	RENAME	FLUXCONV	Flux Conv. factor (DN/s to BUNIT)
GAIN1	TFLOAT	RENAME	GAIN	e/DN conversion
ZODY_EST	TFLOAT	PASSTHRU	ZODY_EST	[MJy/sr] Zodiacal Background Estimate
ISM_EST	TFLOAT	PASSTHRU	ISM_EST	[MJy/sr] Interstellar Medium Estimate
CIB_EST	TFLOAT	PASSTHRU	CIB_EST	[MJy/sr] Cosmic IR Background Estimate
	/ GENERAL MAPPING KEYWORDS			
	TINT	DATABASE	CYCLENUM	Current cycle number
	TINT	DATABASE	COLUMN	Current column number
	TINT	DATABASE	ROW	Current row number
	TINT	DATABASE	MAPNUM	Current map cycle number
CLPOSNUM	TINT	PASSTHRU	CLPOSNUM	Current cluster position
	TINT	DATABASE	SCLEGNUM	Scan leg number
	TSTRING	DATABASE	SCANDIR	Scan direction
	/ MIPS SCAN MAP			
	TSTRING	DATABASE	SCANRATE	Scan map rate (slow, med, fast)
	TLOGICAL	DATABASE	REQ160	160 micron data required (T/F)
	TLOGICAL	DATABASE	FASTRES	160 micron fast reset (T/F)
	TINT	DATABASE	XSCNOFF	[arcsec] Cross-scan offset
	TINT	DATABASE	INSCNOFF	[arcsec] In-scan offset
	TINT	DATABASE	NSCANLEG	Number of scan legs
	TFLOAT	DATABASE	SCANLEN	[deg] Scan leg length
	TINT	DATABASE	STEPFOR	[arcsec] Cross-scan step size for fwd leg
	TINT	DATABASE	STEPREV	[arcsec] Cross-scan step size for rev leg
	TINT	DATABASE	NMAPCYCL	Number of Scan Map Cycles
	/ MIPS PHOTOMETRY-SUPER RESOLUTION			
	TLOGICAL	DATABASE	SELEC24	MIPS-24 selected
	TLOGICAL	DATABASE	LARGE24	MIPS-24 Field Size; T=large, F=small
	TFLOAT	DATABASE	DELTA24	[arcsec] Distance to sky ref. position
	TINT	DATABASE	NCYCL24	Number of MIPS-24 photometry cycles
	TLOGICAL	DATABASE	RMAP24	MIPS-24 Raster Map (T/F)
	TINT	DATABASE	NCOLS24	Number of MIPS-24 columns in raster map
	TINT	DATABASE	NROWS24	Number of MIPS-24 rows in raster map
	TSTRING	DATABASE	CSTEP24	[arcsec] MIPS-24 raster map col. step size
	TSTRING	DATABASE	RSTEP24	[arcsec] MIPS-24 raster map row step size
	TINT	DATABASE	MCYCLE24	Number of MIPS-24 raster map cycles
	TLOGICAL	DATABASE	SELEC70	MIPS-70 selected
	TLOGICAL	DATABASE	LARGE70	MIPS-70 Field Size; T=large, F=small
	TFLOAT	DATABASE	DELTA70	[arcsec] Distance to sky ref. position
	TLOGICAL	DATABASE	FINESCAL	Image scale (T= fine, F=default)
	TINT	DATABASE	NCYCL70	Number of MIPS-70 photometry cycles
	TLOGICAL	DATABASE	RMAP70	MIPS-70 Raster Map (T/F)

	TINT	DATABASE	NCOLS70	Number of MIPS-70 columns in raster map
	TINT	DATABASE	NROWS70	Number of MIPS-70 rows in raster map
	TSTRING	DATABASE	CSTEP70	[arcsec] MIPS-70 raster map col. step size
	TSTRING	DATABASE	RSTEP70	[arcsec] MIPS-70 raster map row step size
	TINT	DATABASE	MCYCLE70	Number of MIPS-70 raster map cycles
	TLOGICAL	DATABASE	SELEC160	MIPS-160 selected
	TLOGICAL	DATABASE	LARGE160	MIPS-160 Field Size; T=large, F=small
	TFLOAT	DATABASE	DELTA160	[arcsec] Distance to sky ref. position
	TINT	DATABASE	NCYCL160	Number of MIPS-160 photometry cycles
	TLOGICAL	DATABASE	RMAP160	MIPS-160 Raster Map (T/F)
	TINT	DATABASE	NCOLS160	Number of MIPS-160 columns in raster map
	TINT	DATABASE	NROWS160	Number of MIPS-160 rows in raster map
	TSTRING	DATABASE	CSTEP160	[arcsec] MIPS-160 raster map col. step size
	TSTRING	DATABASE	RSTEP160	[arcsec] MIPS-160 raster map row step size
	TINT	DATABASE	MCYCLE160	Number of MIPS-160 raster map cycles
	TLOGICAL	DATABASE	ENHAN160	MIPS-160 Enhanced Mode;T=160 enh,F=160 sm

/ MIPS TOTAL POWER MODE (TPM)

	TLOGICAL	DATABASE	SEL24TP	MIPS-24 selected
	TINT	DATABASE	NCY24TP	Number of 24 micron cycles
	TLOGICAL	DATABASE	SEL70TP	MIPS-70 selected
	TINT	DATABASE	NCY70TP	Number of 70 micron cycles
	TLOGICAL	DATABASE	SEL160TP	MIPS-160 selected
	TINT	DATABASE	NCY160TP	Number of 160 micron cycles

/ INSTRUMENT TELEMETRY DATA

CE_SIDE	TINT	PASSTHRU	CE_SIDE	Common Electronics Side (1=A,2=B)
GRPARVTC	TFLOAT	PASSTHRU	GRPARVTC	[Sec] Coarse Spacecraft Group Time
GRPARVTF	TFLOAT	PASSTHRU	GRPARVTF	[Sec] Fine Spacecraft Group Time
CRSESYNC	TINT	PASSTHRU	CRSESYNC	[Sec] Mirror Sync Pulse Coarse Time
FINESYNC	TDOUBLE	PASSTHRU	FINESYNC	[1/65535 Sec] Mirror Sync Pulse Fine Time
CSM_MOD	TINT	PASSTHRU	CSM_MOD	CSMM Mode: 0=Chop,1=Ramp
ANCSMDIR	TINT	PASSTHRU	ANCSMDIR	CSMM Ramp Dir:0=neg=forward,1=pos=reverse
DCE_FRMS	TINT	PASSTHRU	DCE_FRMS	[Fr/DCE] Ge Frames per DCE Command
FRMFLYBK	TINT	PASSTHRU	FRMFLYBK	[Frames] CSMM Flyback Duration
CSM_SLP	TDOUBLE	PASSTHRU	CSM_SLP	[DAC/s] CSMM Ramp Slope Command
DCE_CALC	TINT	PASSTHRU	DCE_CALC	DCEs per Calibration Cycle Command
ACREJCNT	TINT	PASSTHRU	ACREJCNT	Command Reject Counter
AIRSPCNT	TINT	PASSTHRU	AIRSPCNT	Invalid Response Count
ALIMVCNT	TINT	PASSTHRU	ALIMVCNT	Limit Violation Counter
AFIFOBAD	TINT	PASSTHRU	AFIFOBAD	Science Data FIFO Bad Half Full Interrupts
ASDMGRFA	TINT	PASSTHRU	ASDMGRFA	SDM Groups Not Accepted By CDH
ALSTERLD	TINT	PASSTHRU	ALSTERLD	Last Error Id
ALSTERPM	TINT	PASSTHRU	ALSTERPM	Last Error Parameter
ATOTALER	TINT	PASSTHRU	ATOTALER	Total Errors Posted Count
CSM_POS	TDOUBLE	PASSTHRU	CSM_POS	[DAC] CSMM Position Output
CSM_POSF	TDOUBLE	PASSTHRU	CSM_POSF	[DAC] CSMM Fine Position DAC
CSM_POSC	TDOUBLE	PASSTHRU	CSM_POSC	[DAC] CSMM Coarse Position DAC
ANCSMCUR	TDOUBLE	PASSTHRU	ANCSMCUR	[uAmps]
ANCSMGN	TDOUBLE	PASSTHRU	ANCSMGN	CSMM Gain Adjustment DAC
CSM_OFFS	TDOUBLE	PASSTHRU	CSM_OFFS	[arcsec] CSMM Position Offset DAC Output

ANCSMPS1	TDOUBLE	PASSTHRU	ANCSMPS1	[DAC] CSMM Scanpos1 Command
ANCSMPS2	TDOUBLE	PASSTHRU	ANCSMPS2	[DAC] CSMM Scanpos2 Command
ANCSMRP1	TDOUBLE	PASSTHRU	ANCSMRP1	[DAC] CSMM Relpos1 Command
ANCSMRP2	TDOUBLE	PASSTHRU	ANCSMRP2	[DAC] CSMM Relpos2 Command
ANCSMSTP	TDOUBLE	PASSTHRU	ANCSMSTP	[DAC] CSMM Scanoffset Command
CSM_PIDX	TINT	PASSTHRU	CSM_PIDX	Scan Position Index
CMD_DCES	TINT	PASSTHRU	CMD_DCES	Number of DCEs in Exposure
CSM_OOLC	TINT	PASSTHRU	CSM_OOLC	CSMM Out Of Limits Count
SC_SYNCC	TINT	PASSTHRU	SC_SYNCC	Total HTG CSMM to SC Synch Pulse Count
GROUPCNT	TINT	PASSTHRU	GROUPCNT	MIPS Group Count Per DCE
GROUPIDX	TINT	PASSTHRU	GROUPIDX	MIPS Exp. Manager Index for Next SDM Group
ANIMCYFC	TINT	PASSTHRU	ANIMCYFC	Frames per Image Cycle Commanded
ANHTGEFC	TINT	PASSTHRU	ANHTGEFC	HTG Frames In Exposure Counter
IMGCYCLC	TINT	PASSTHRU	IMGCYCLC	Total Image Cycles Since HTG Ready
EXPIMGCY	TINT	PASSTHRU	EXPIMGCY	Image Cycles in Exposure Counter
ANCALCYC	TINT	PASSTHRU	ANCALCYC	DCEs completed in Calibration Cycle
D24FRAME	TINT	PASSTHRU	D24FRAME	Total D24 Frame Count
D24EXPDC	TINT	PASSTHRU	D24EXPDC	D24 DCEs in Exposure Counter
CMD_T_24	TFLOAT	PASSTHRU	CMD_T_24	[Deg_K]
AD24TMPA	TFLOAT	PASSTHRU	AD24TMPA	[Deg_K]
AD24TMPB	TFLOAT	PASSTHRU	AD24TMPB	[Deg_K]
ACSMMTMP	TFLOAT	PASSTHRU	ACSMMTMP	[Deg_K]
ACEBOXTM	TFLOAT	PASSTHRU	ACEBOXTM	[Deg_C]
AD24STMI	TFLOAT	PASSTHRU	AD24STMI	[uAmps]
AD24HTRI	TFLOAT	PASSTHRU	AD24HTRI	[uAmps]
AVDSUBV	TFLOAT	PASSTHRU	AVDSUBV	[Volts] VD Sub Voltage
APROFF1V	TFLOAT	PASSTHRU	APROFF1V	[Volts]
APROFF2V	TFLOAT	PASSTHRU	APROFF2V	[Volts]
APROFF3V	TFLOAT	PASSTHRU	APROFF3V	[Volts]
APROFF4V	TFLOAT	PASSTHRU	APROFF4V	[Volts]
AD24ANLI	TFLOAT	PASSTHRU	AD24ANLI	[uAmps]
ABASTMCR	TINT	PASSTHRU	ABASTMCR	Coarse Component of CE Base Time
ABASTMFN	TINT	PASSTHRU	ABASTMFN	Fine Component of CE Base Time
AFSWMJRV	TINT	PASSTHRU	AFSWMJRV	CE Flight Software Major Version Number
AFSWMINV	TINT	PASSTHRU	AFSWMINV	CE Flight Software Minor Version Number
AD24PWEN	TINT	PASSTHRU	AD24PWEN	Det 24u Power Enable Commanded State
AD24SITM	TINT	PASSTHRU	AD24SITM	Det 24u Temperature Sensor Status
AD24PWRS	TINT	PASSTHRU	AD24PWRS	Det 24u Power Enable Status
AD24TMSE	TINT	PASSTHRU	AD24TMSE	Det 24u Temperature Sensor Comanded State
AD24STMC	TINT	PASSTHRU	AD24STMC	Det 24u Stimulator Enable Commanded State
A24HTDAC	TINT	PASSTHRU	A24HTDAC	D24 Heater DAC Load Value
A24HTCMD	TINT	PASSTHRU	A24HTCMD	MIPS D24 Heater Enable Commanded State
AD24ANLS	TINT	PASSTHRU	AD24ANLS	MIPS D24 Anneal Status
A24HTMEN	TINT	PASSTHRU	A24HTMEN	D24 Heater Monitor Enable Status
HSPLSTMC	TINT	PASSTHRU	HSPLSTMC	MIPS Scan Mirror Pulse Timestamp Coarse
HSPLSTMF	TINT	PASSTHRU	HSPLSTMF	MIPS Scan Mirror Pulse Timestamp Fine
SC_AT_Q1	TFLOAT	PASSTHRU	SC_AT_Q1	ATDT_SC_QUATERNION_Q1
SC_AT_Q2	TFLOAT	PASSTHRU	SC_AT_Q2	ATDT_SC_QUATERNION_Q2
SC_AT_Q3	TFLOAT	PASSTHRU	SC_AT_Q3	ATDT_SC_QUATERNION_Q3
SC_AT_Q4	TFLOAT	PASSTHRU	SC_AT_Q4	ATDT_SC_QUATERNION_Q4
SC_R8_X	TFLOAT	PASSTHRU	SC_R8_X	[asec/s]
SC_R8_Y	TFLOAT	PASSTHRU	SC_R8_Y	[asec/s]
SC_R8_Z	TFLOAT	PASSTHRU	SC_R8_Z	[asec/s]
SLEWING	TINT	PASSTHRU	SLEWING	ACG_MANEUVER_IN_PROGRESS

/ DATA FLOW KEYWORDS

DATE	TSTRING	PASSTHRU	DATE	[YYYY-MM-DDThh:mm:ss UTC] file creation date
ORIGIN	TSTRING	RENAME	ORIGIN0	Site where raw-FITS file was written
CREATOR	TSTRING	RENAME	CREATOR0	SW system that created raw-FITS file
SIS_SVER	TSTRING	PASSTHRU	SIS_SVER	SIS SW VERsion of CREATOR0
AORKEY	TLONG	PASSTHRU	AORKEY	AOR or IER key. Astro. Obs Req/Instr Eng Req
DS_IDENT	TSTRING	PASSTHRU	DS_IDENT	Data Set Identification for ADS/journals
EXPID	TINT	PASSTHRU	EXPID	Exposure ID (0-9999)
DCENUM	TINT	PASSTHRU	DCENUM	DCE number (0-9999)
TLMGRPS	TINT	PASSTHRU	TLMGRPS	Number of expected telemetry groups
FILE_VER	TINT	PASSTHRU	FILE_VER	Version of the raw file made by SIS
DATEFILE	TSTRING	RENAME	RAWDATE	SIS file creation date
FILENAME	TSTRING	RENAME	RAWFILE	Raw data file name
CPT_VER	TSTRING	PASSTHRU	CPT_VER	Channel Param Table FOS versioN
EXPDFLAG	TLOGICAL	PASSTHRU	EXPDFLAG	(T/F) expedited DCE
MISS_LCT	TINT	PASSTHRU	MISS_LCT	Total Missed Line Cnt in this FITS
MANCPKT	TLOGICAL	PASSTHRU	MANCPKT	T if this FITS is Missing Ancillary Data
MISSDATA	TLOGICAL	PASSTHRU	MISSDATA	T if this FITS is Missing Image Data
PAONUM	TINT	PASSTHRU	PAONUM	PAO Number
CAMPAIGN	TSTRING	PASSTHRU	CAMPAIGN	Campaign
DCEID	TINT	PASSTHRU	DCEID	Data-Collection-Event ID
DCEINSID	TINT	PASSTHRU	DCEINSID	DCE Instance ID
DPID	TINT	PASSTHRU	DPID	Data Product Instance ID
PIPENUM	TINT	PASSTHRU	PIPENUM	Pipeline Script Number
PIPETYPE	TINT	RENAME	PLSCRPID	Pipeline Script ID
PTSCRPID	TINT	PASSTHRU	PTSCRPID	Pointing Transfer Script ID
SOS_VER	TINT	PASSTHRU	SOS_VER	Data-Product Version
PLVID	TINT	PASSTHRU	PLVID	Pipeline Version ID
CALID	TINT	PASSTHRU	CALID	CalTrans Version ID
CTD_VER	TSTRING	PASSTHRU	CTD_VER	Commanded telemetry data version
CALBUNIT	TSTRING	PASSTHRU	CALBUNIT	Units for which cal. data applies
EXPECTN	TINT	PASSTHRU	EXPECTN	Expected num. inputs for ensemble
ACTUALN	TINT	PASSTHRU	ACTUALN	Actual num. inputs in ensemble
EPVERSN	TINT	PASSTHRU	EPVERSN	Ensemble Product Version
EPID	TINT	PASSTHRU	EPID	Ensemble Product ID
	/ CALIBRATION HISTORY			
EPIDDARK	TSTRING	PASSTHRU	EPIDDARK	Dark ensemble product ID
EPIDFLAT	TSTRING	PASSTHRU	EPIDFLAT	Flat ensemble product ID
EPIDSFLT	TSTRING	PASSTHRU	EPIDSFLT	Super-flat ensemble product ID
EPIDSPOT	TSTRING	PASSTHRU	EPIDSPOT	Spot-map ensemble product ID
EPIDNONL	TSTRING	PASSTHRU	EPIDNONL	Non-lin. ensemble product ID
EPIDROWF	TSTRING	PASSTHRU	EPIDROWF	Row-flux corr. ensemble product ID
FBIDDARK	TSTRING	PASSTHRU	FBIDDARK	Dark fallback product ID
FBIDFLAT	TSTRING	PASSTHRU	FBIDFLAT	Flat fallback product ID
FBIDSFLT	TSTRING	PASSTHRU	FBIDSFLT	Super-flat fallback product ID
FBIDSPOT	TSTRING	PASSTHRU	FBIDSPOT	Spot-map fallback product ID
FLATUSED	TSTRING	PASSTHRU	FLATUSED	Flatfield used
SPOTMAP	TSTRING	PASSTHRU	SPOTMAP	Spot-map used
FBIDNONL	TSTRING	PASSTHRU	FBIDNONL	Non-linearity fallback product ID
FBIDROWF	TSTRING	PASSTHRU	FBIDROWF	Row-flux corr. fallback product ID
FBIDPMSK	TSTRING	PASSTHRU	FBIDPMSK	Pixel-mask fallback product ID
FBIDDNT	TSTRING	PASSTHRU	FBIDDNT	DN-to-Flux single file fallback ID
FBIDDNT1	TSTRING	PASSTHRU	FBIDDNT1	DN-to-Flux interp. file 1 fallback ID
FBIDDNT2	TSTRING	PASSTHRU	FBIDDNT2	DN-to-Flux interp. file 2 fallback ID
SCETDARK	TSTRING	PASSTHRU	SCETDARK	Dark product acquisition time
SCETFLAT	TSTRING	PASSTHRU	SCETFLAT	Flat product acquisition time
SCETSFLT	TSTRING	PASSTHRU	SCETSFLT	Super-flat acquisition time
SCETSPOT	TSTRING	PASSTHRU	SCETSPOT	Spot-map acquisition time
SCETNONL	TSTRING	PASSTHRU	SCETNONL	Non-linearity acquisition time
SCETROWF	TSTRING	PASSTHRU	SCETROWF	Row-flux corr. acquisition time

SCETPMSK	TSTRING	PASSTHRU	SCETPMSK	Pixel-mask acquisition time
SCETDNT	TSTRING	PASSTHRU	SCETDNT	Time of DN-to-Flux single fallback file
SCETDNT1	TSTRING	PASSTHRU	SCETDNT1	Time of DN-to-Flux interp. file 1
SCETDNT2	TSTRING	PASSTHRU	SCETDNT2	Time of DN-to-Flux interp. file 2
SPOT_DX	TFLOAT	PASSTHRU	SPOT_DX	[pix] X shift applied to spot flat
SPOT_DY	TFLOAT	PASSTHRU	SPOT_DY	[pix] Y shift applied to spot flat
SPOTFLAT	TSTRING	PASSTHRU	SPOTFLAT	
GAINFLAT	TSTRING	PASSTHRU	GAINFLAT	

3.0 MIPS-24 Raw-mode BCD Science pipeline

(Pipeline script ID 1029)

As described in the introduction, Raw mode was not used in any scientific capacity during the mission. It was used to derive the linearity coefficients pre-launch, and those coefficients were deemed to be applicable to the post-launch data. It was used very rarely for engineering and testing by the SSC during the mission. The raw pipeline was built pre-launch and remained unchanged throughout the mission. The correction to the linearity algorithm that was implemented during the mission for the SUR data was not implemented in the Raw pipeline.

Here we describe the raw pipeline steps. **WE DO NOT REPEAT THE DESCRIPTION OF THOSE MODULES THAT ARE ALREADY DESCRIBED IN THE SUR-MODE BCD PIPELINE DESCRIPTION.** Those modules that are called and invoked in the same way as in the SUR BCD pipeline are simply listed and the reader is encouraged to find the description in the BCD pipeline description (Section 2). We note that the modules HDRUPD8 and the equivalent HDRUPDATE are run multiple times, many of which are simply to add a HISTORY line to the FITS header that the module has run. They are therefore not listed every time the header is updated by the pipeline (it is listed at the beginning here).

HDRUPD8

SANITY_DATATYPE

QATOOL_DCE

TRANHEAD

IMFLIPROT

CALTRANS

CVTI2R4

SNESTIMATOR

BASECAL

Basecal.nl

```
&bascin
 dosn=  F,
 maskd=  18432,
 maskp=  17920,
 maxdn=    65535.0,
 mindn=   -9.90000E+25,
&end
```

IMAGEST

Imagest is run twice in the pipeline. This first time, it is run in operational mode 2, where the entire cube of ramps is desaturated.

```
Radiation hits and nonlinear response are not corrected; the goal of
this desaturation is to estimate the droop correction, which is the
next step in the pipeline.  Here, all of the planes are retained. Later
in the Raw pipeline (see below), this module is run again in another
operational mode that does a robust slope estimate for the entire
integration time for each pixel.

Imagest.nl
&ImagIn
  Debug = F,
  MaskD = 16384,
  MaskP = 16384,
  Z = 2.0,
  WellDepth = 400000,
  DetRad = T,
 &end
```

DROOPOPMIPS

ROWDROOP

CUBESUB

This module performs the multiplane dark subtraction for raw mode, reading in the raw dark calibration data products.

```
Cubesub.nl
 &CUBESUBIN
  Operation = 1,
  PMASK_FATAL = 4352,
  DMASK_FATAL = 16384,
  CMASK_FATAL = 6144,
 &end
```

LINEARIZ

```
Lineariz.nl
 &LineIN
  MaskC = 16384,
  MaskD = 8192,
  MaskP = 16384,
 &end
```

RADHIT

```
Radhit.nl
 &RADHIT
  Readnoise = 45,
  NominalRHMag = 260,
  RHPriorProb = 0.001,
  DeclThresh = 0.999,
  MaxNumHits = 5,
```

```
  Gain = 5.0,
 &end
```

FLATAP

```
&FLATAPIN
  PmaskMask = 4352,
  CmaskMask = 0,
  DmaskMask = 16384,
&end
```

IMAGEST

Imagest is run here in operational mode 1, whereby the ramp slope of each pixel is estimated and an image is computed corresponding to the slopes at the highest plane level (the total length of the exposure). In this mode, pixels with radiation hits are ignored so that the slope estimate is not contaminated.

```
This time, a different namelist is read in, in order to fit the slope.
imagest_slope_est.nl
 &ImagIn
  Debug = F,
  MaskD = 24576,
  MaskP = 18176,
  Dbit =  3,9,12,6,7,8,10,13,14
  Bbit =  2,3,4,6,7,8,9,10,11
  MinPln = 1,1,1,1,1,1,1,1,1
  Z = 2.0,
  NRadSkip = 2,
 &end
```

DNTOFLUX

QATOOL

CHKMASK

QATOOL_DCE

QALOADER

Subsequent to these modules, the pointing transfer modules, background model estimation, and final product generator would be run as described at the end of Section 2.

4.0 Dark Current Calibration Pipelines for SUR and RAW Modes

A. SUR-mode Dark Current Calibration Pipeline

(Pipeline script ID's 1000 and 1030)

Data for the dark current pipeline are taken with the cryogenic scan mirror in the "dark" position. In practice, it was observed that this position was truly dark—with an increase in exposure time there was no accumulation of counts and therefore no detected photons hitting the array. Therefore, the dark exposures used to calibrate MIPS-24 data were taken from 10 second exposures and were applied to the entire set of MIPS-24 data, regardless of exposure time. The pipeline from one input AOR is described below, but for the S18.12 – S18.13 final reprocessing of the data, new darks were applied that were a median of ~100 individual dark products taken during the course of the cryogenic mission. The SUR-mode dark pipeline was typically run twice per campaign (at the beginning and at the end—check this!). Because of the different character and readout time of the DCENUM=0 (sur1) vs. DCENUM>0 (sur2) exposures, a separate dark product is produced for DCENUM=0 data and DCENUM>0 data. The DCENUM=0 darks have a gradient in the y direction over the array, and the DCENUM>0 exposures are flat with the exception of vertical jailbars caused by the noisy readout (channel 1). We note the very low count rate in the darks; the median across the array for the DCENUM>0 (sur2) dark is only 2.7 DN/sec. The dark data products are available from the archive and are called: mips24_dark_090804_sur1.fits and mips24_dark090804_sur2.fits. Each has an associated mask (*_cmask.fits) and uncertainty (*_uncert.fits) file.

The dark pipeline requires only minimal processing of the input data. As there are no photons hitting the array and there is a very low count rate, there are no non-linear effects or illumination or pixel responsivity effects to correct. Most of the BCD pipeline modules are executed AFTER the dark subtraction, so they are not present in the dark pipeline itself.

1) Individual DCE pipeline steps :

The first part of the SUR-mode dark pipeline is exactly the same as the SUR mode BCD pipeline, through **ROWFLUXCORR.**

Then there are an additional three modules for quality assurance, statistics on the mask and loading into the database:

QATOOL

CHKMASK

QALOADER loads data into database for ensemble processing

2) Ensemble pipeline steps:

CALTRANS

DARKEST

DARKEST is the process that reads in a list of files processed as described above and averages them together with a trimmed average algorithm. The namelist is below.

The output is a dark product

```
Darkest.nl
 &DARKESTIN
  comment = 'Parameters for DARKEST module',
  Trim_Frac = 0.3,
  Asym_Trim = 0.0,
  Med_Fac = 5.0,
  Read_Noise = 45,
  PMASK_FATAL = 1792,
  DMASK_FATAL = 16384,
  CMASK_FATAL = 0,
 &end
```

HDRUPD8

CALKEYWORDS

CALKEYWORDS takes an input list of keywords and performs a trimmed average over keyword values over all of the input files in the ensemble. The result is written to the header of the calibration product.

```
Calkeywords.nl

&CALKEYWORDSIN
 Comment = 'Namelist file for calkeywords',
 Log_Filename = 'stdout',
 Comment = 'Parameters for trimmed average and uncertainty
caliculations',
 CentralFraction1 = 0.9,
 CentralFraction2 = 0.9,
 Comment = '1=Do not average DATE-OBS keywords, 2=DO',
 Operation = 2,
 Comment = '0:Not blessed; 512-1023:Don't use (rejected); 1024-
2047:Blessing unnecessary (use anyway); 2048-4095:Blessed',
 Comment = 'Wrapper w_mips24_flatfield.pl will detect environment
variable FLATCALSTATUS is set, then override following cdf parameter',
 calDataStatus = 0,
&END
```

List of keywords to be averaged and populated in header:

```
cal_epkeywords.txt

CHNLNUM
GAIN
DCE_CALC
EXPTIME
CSM_POSC
CSM_POSF
CSM_POS
ANCSMCUR
```

```
ANCSMRP1
ANCSMRP2
CSM_SLP
CSM_PRED
CSM_RATE
CSM_SKY
ANCSMSTP
ACSMMTMP
ANCSMGN
CSM_OFFS
ANCSMPS1
ANCSMPS2
CSM_PIDX
GROUPCNT
GROUPIDX
CMD_T_24
AD24TMPA
AD24TMPB
AD24STMI
AD24HTRI
AVDSUBV
APROFF1V
APROFF2V
APROFF3V
APROFF4V
AD24ANLI
```

SFDC SFDC means "Split FITS Data Cube" ; since each input product has two planes (slope and difference), the slope and difference planes are split and the difference plane is subsequently ignored by the dark pipeline and only the slope image is used. A single dark product is used for all subsequent BCD processing (i.e. for both the slope and the difference image). This module is applied to the dark, mask and uncertainty files.

QATOOL

CHKMASK

QALOADER Assigns database and ensemble product IDs.

HDRUPDATE Applied to each of the dark, mask and uncertainty files

FPGEN Applied to each of the dark, mask and uncertainty files

B. Raw-Mode Dark Current Calibration Pipeline

Because Raw mode was not supported as an allowed observing mode to the astronomical community, Raw-mode darks were not routinely taken during the mission. In fact, darks made from 30 second raw exposures prelaunch were used as the fallback darks for raw mode. Filenames of these darks are mips24_darkest_raw1.fits (for DCENUM =0) and mips24_darkest_raw2.fits (for DCENUM>0) and associated mask (*_cmask.fits) and uncertainty (*_uncert.fits) files.

The pipeline steps are the same as the SUR mode ones described above, with the following exceptions:

1) After the noise estimation step, the module **BASECAL** was run. **BASECAL** corrects all the planes in the cube for non-zero baseline values at t=0.

And for ensemble process:

2) For the ensemble process, **DARKEST** was run, which reads in a list of files and averages cubes of data, preserving the format (128x128x60 for the 30-sec exposures).

This produces the final raw dark data product.

```
Darkest.nl
 &DARKESTIN
  comment = 'Parameters for DARKEST module',
  Trim_Frac = 0.3,
  Asym_Trim = 0.0,
  Med_Fac = 5.0,
  Read_Noise = 45,
  PMASK_FATAL = 1792,
  DMASK_FATAL = 16384,
  CMASK_FATAL = 0,
 &end
```

5.0 Linearity Calibration Pipeline

The linearity calibration pipeline was run pre-launch and verified early in the mission and then applied to the entire mission. The resulting linearity calibration data product contains the linearity coefficients as described in this document in the SUR science pipeline description of the module slopecorr.

The linearity pipeline takes as input 30 second (60 plane) Raw mode data.

It follows the same steps as the raw science pipeline with the following exceptions:

1) The pipeline runs all of the same modules up to

CUBESUB (i.e. everything before **LINEARIZ**).

2) Then it runs **QATOOL** (quality assurance on image)**,** does statistics on the mask (**CHKMASK**) and loads the result into the database (**QALOADER**) to

be combined with other similar data cubes in an ensemble process.

The ensemble process requires a list of Raw-mode cubes processed as described above.

3) The module **LINCAL** does the actual non-linearity model estimate, combining all of the input files. It produces the output data product (mips24_lincal.fits) containing quadratic coefficients to be applied to the science pipelines to correct for non-linearity.

Lincal.nl

```
&lincin
  pmaskmax = 17920,
  dmaskmax = 2048,
  minimg = 5,
  dynhi = -9,
  dynlo = 99999,
  bmax = 500000.0,
  maxdmp = 5, dmpneg = t,
  ntable = 2000,
  ngpmax = 20, nsearch = 2,
  sigmax = 10000.0,
  slopemin = 0.4,
  satstats = t,
  dnsat = 20000,
&end
```

4) **QATOOL**, **CHKMASK** and **QALOADER** (to load the linearity data product into the database) are run.

6.0 MIPS-24 Flatfield Calibration Pipeline and Methodology for BCD and EBCD Products

Introduction:

The MIPS field of view is scanned in one axis by spacecraft slewing, and in another axis by slewing a scan mirror internal to the instrument. The mirror scan direction is nearly perfectly aligned with the Y detector pixel direction, and for the purposes of the spotmatching software applied, assumes no offset in the X direction.

A flat pickoff mirror directs light to the 24 micron detector. There are low reflectivity spots on the pickoff mirror for MIPS (possibly due to paint) and discovered only after launch. They appear to be undetected in the other MIPS arrays but are quite obvious in the MIPS-24 data. (See MIPS Instrument Data Handbook for more details and images of the spots). As reimaged onto the MIPS-24 detector array in photometry mode, some are quite dark and concentrated and of a similar size to an astronomical point source, with the deepest spot having about a 20% opacity relative to neighboring regions. Other spots are much fainter, elongated and more diffuse, possibly as a result of multiple reflections within the optical path. In the scan modes, the darkest spots appear elongated along the scan (Y) direction in streaks of approximately x, y an z pixels for the slow, medium, and fast scan modes, respectively.

As the scan mirror moves to different commanded positions (reflected in the header keyword CSM_PRED, meaning predicted cryogenic scan mirror position), the spots and the sky are reimaged onto different parts of the array, shifting along the y detector axis.

It was found soon after launch that not only were there spots all over the array of various depths, but the spot locations in detector coordinates did not perfectly repeat from one observation to the next for the same commanded scan mirror position. From analysis of spot locations of many AORs during various campaigns, it appears that the repeatability can remain quite stable for many AOR's in sequence but unpredictably jump to another position that is systematically offset in the y direction. This jump can happen during a campaign or between campaigns, but it has not been shown conclusively to happen during an AOR, although such an occurrence is possible. The cause of this overall shift of the spots (and therefore, absolute pointing) is not known. It was found that this shift in relative spot position never exceeds 1 detector pixel (2.5'') from one AOR to another.

In the BCD pipeline, an X and Y position of the deepest available spot was calculated for each DCE independently. However, results were not always good, and spot residuals, where the flat fields did not compensate correctly for the spots, are quite common. For EBCDs (ONLY MIPS-24 photometry mode), a single Y offset relative to a static template was derived for each AOR. The EBCD spotmatching, which uses a completely different method than the BCD spotmatching, takes advantage of better statistics by using all of the DCE's in the AOR, with the exception of those with DCENUM=0, which are not as well calibrated. Both methods are described in more detail below.

For both the BCDs and EBCDs, an attempt is made to separate out the smoothly varying overall responsivity and illumination flat field (referred to as the campaign flat or superflat for the BCDs and the gainflat for the EBCDs) from the pattern of spots which move about the array with (referred to as the spotmap for BCDs and the spotflat for EBCDs). The total flatfield is the product of the two components. The flat fielding is accomplished by dividing the linearized data by the flat field product. A record of which files were use for each of the components can be found in the CALIBRATION HISTORY section of the data header.

The following paragraph is extracted from the MIPS Instrument Data Handbook, and we refer to this handbook for further details and figures showing the improvement of the EBCDs over the BCDs for photometry mode.

Starting in S18.12 (the final reprocessing data version for the cryogenic Spitzer mission), the Enhanced BCD (EBCD) pipeline was introduced for MIPS-24 photometry mode. Scan mode remains the same as in previous software versions. The EBCD products generally have improved flat fielding, especially with regard to removing spot residuals Occasionally, the EBCD pipeline will not find a good spot match, but in general, there is a great improvement over previous data products. Parallel data (taken when MIPS-70 or MIPS-160 were the primary arrays) also have improved flat fielding, especially for the 160 Enhanced mode, which had no spot correction previous to S18.12 (see Figure 6.5). For photometry data, both EBCD (new flat fielding method) and BCD (old flat fielding method) products are archived. However, in the final reprocessing, only one version of the post-BCD mosaic is produced, and that mosaic is made from EBCDs. The calibration flat field files for the the EBCDs have a new format of a data cube shifted to match the spot positions of each photometry AOR, with the planes of the cube in order of ascending scan mirror position (CSM_PRED). The flat fields applied are the product of the appropriate spotflat and the overall gainflat. The spotflat used in each EBCD is reflected in the EBCD header keyword CSMLAYER.

A. BCD Flatfield Pipeline

The flatfield product from this pipeline is a smoothly varying map of the overall illumination convolved with detector pixel responsivity of the MIPS-24 array. The products from this pipeline (the overall “gain” flat) are produced by stacking normalized input files together. The combination of many different CSM_PRED positions tends to remove most of the effects of the dark spots.

This flat field pipeline was run for each campaign and the resultant “campaign flat” was applied and multiplied by an appropriately matched spotmap to produce the flat field for each BCD. The campaign flat is always made from a flatfield raster map taken in small field photometry mode (this is applied for all modes of MIPS-24). We note that early in the mission, the campaign flat observation was not scheduled at the beginning of the campaign and some of those campaign flats were contaminated by latent images from previous observations. For those campaigns, a “clean” fallback flat field was applied instead of the campaign flat. The spotmaps are chosen to match as best as possible the x and y position of a fiducial dark spot on the array and are also matched for scan rate.

The flatfield pipeline is essentially the same as the BCD pipeline except that it stops just after slopecorr (the linerarization step) and then inputs those linearized data into an ensemble process where files are normalized and combined with a trimmed average algorithm to make the final campaign flat product.

The same pipeline (pipeline script ID 1032) produces both the BCD flatfield and the EBCD flatfield products. We describe here

the pipeline steps and describe in much more detail the new EBCD flatfield methodology in section B.

Flatfield pipeline steps:

(header update modules have been omitted)

1) Preprocessing: This is identical to the SUR-MODE BCD SCIENCE PIPELINE through **SLOPECORR (SEE SECTION 2).**

ADDITIONAL STEPS:

QATOOL

CHKMASK

QALOADER

2) ENSEMBLE PROCESSING:

CALTRANS

STACKLAYER

This is an EBCD module. STACKLAYER here inputs lists of input data from the previous steps and stacks them into 3 dimensional FITS cubes for each of the linearized data, the mask, and the uncertainty images.

CAL_SPOTFLAT

This is an EBCD module. CAL_SPOTFLAT is the module that actually calculates the flatfield (gain flat) for EBCDs. The algorithm is described in section B below and is set by the namelist file to run only on photometry mode science data or photometry mode flat field data. The primary output data product is the flatfield gainflat and its mask and uncertainty images, but several more pipeline steps are needed to finalize them.

aorflat.nl

```
&SCISUPWRAP_phot
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=pfl, pht, which uses caltrans',
   comment = 'The following describes the plScriptId science
superwrapper, which uses caltrans instead of the aorflat_cache',
   aorflat_plScriptId = 1021,
   comment = 'The following describes the plscriptid where
aorflat_cache is used instead of using caltrans to pass aorflat files',
   testmode_plScriptId = 0,
   comment = 'The science superwrapper now uses the plscriptId of the
aorflat ensemble pipeline for a database call AR8422",
   comment = 'If this number is zero, the superwrapper wont complain,
but simply will use closest-in-time-early strategy. AR8422",
   ensemble_plScriptId = 0,
&END

&SCISUPWRAP_sscn
```

```
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=scn, sfl, slow rate',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
&END

&SCISUPWRAP_mscn
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=scn, sfl, medium rate',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
&END

&SCISUPWRAP_fscn
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=scn, sfl, fast rate',
   aorflat_plScriptId = 0,
   Comment = "this is to test selfcal gainflats and mirror templates
made with shell scripts. Make this 0 for production.",
   testmode_plScriptId = 1020,
&END

&SCISUPWRAP_cal
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=cal',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
&END

&SCISUPWRAP_sfl
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=sfl',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
&END

&SCISUPWRAP_p1
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=p1',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
&END

&SCISUPWRAP_fp1
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=fp1',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
&END

&SCISUPWRAP_tpm
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=tpm',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
```

```
&END

&SCISUPWRAP_sed
   Comment = 'Namelist block for bcd pipeline plscriptnum=405, with
exptype=tfl',
   aorflat_plScriptId = 0,
   testmode_plScriptId = 0,
&END

&CALKEYWORDSIN
      Comment = "Enter the subpixel shifted template file and ancillary
files into the SODB for subsequent usage in bcd processing",
      GetKeywordsFromCalData = 1,
      FITS_Image_List_Filename = 'input1_linearized',
      Ensemble_Info_Filename = 'ensemble_info.txt',
      Keyword_List_Filename = 'aorflat_calkeyword_inputlist.txt',
      readoutMode = 'SUR',
      Comment = "operation=2 means average over SCLK_OBS to calculate
SCLK_CAL. There is 1 file to average",
      Operation = 2,
      ancFileSuffix = 'unc,msk,csm,gain,gmsk',
      calDataStatus = 2048,
&END

&AORFLAT_ensemble_phot
   Comment = 'Namelist block for ensemble pipeline plscriptnum=415, for
exptype pht and pfl',
   Comment combine = spot_usage_enum {planecombine_mean,
planecombine_median, planecombine_weightmean,
planecombine_weightmedian},
   combine = 1,
   Comment 'testmode = -1 for clean exit when no template files exist
';
   Comment 'testmode = +1 to update the aorflat cache';
   Comment 'testmode = 0 to run the pipeline but not update the aorflat
cache';
   testmode = 0,
   Comment = ' used to eliminate DCE 0 layers that should not be used
to make science spotflats',
   linearized_plscriptid = 1061,
&END

&AORFLAT_ensemble_sscn
   Comment = 'Namelist block for ensemble pipeline plscriptnum=415, for
exptype scn and sfl, slow scan rate',
   testmode = -1,
&END

&AORFLAT_ensemble_mscn
   Comment = 'Namelist block for ensemble pipeline plscriptnum=415, for
exptype scn and sfl, medium scan rate',
   testmode = -1,
&END

&AORFLAT_ensemble_fscn
```

```
   Comment = 'Namelist block for ensemble pipeline plscriptnum=415, for
exptype scn and sfl, fast scan rate',
   testmode = -1,
&END

&AORFLAT_ensemble_tpm
   Comment = 'Namelist block for ensemble pipeline plscriptnum=415, for
exptype tpm and ft and tfl',
   testmode = -1,
&END

&FLATFIELD_postproc_phot
   Comment = 'Namelist block for flatfield pfl mode ',
   preproc_plScriptId  = 0,
   Comment = 'the code always loads the metadata tables, so
aorflat_plscriptid is not applicable',
   testmode_plScriptId = 1032,
   aorflat_plScriptId  = 0,
&END

&FLATFIELD_postproc_sscn
   Comment = 'Namelist block for flatfield scan mode with
CSM_RATE=2580',
   preproc_plScriptId  = 1033,
   testmode_plScriptId = 0,
   aorflat_plScriptId  = 0,
&END

&FLATFIELD_postproc_mscn
   Comment = 'Namelist block for flatfield scan mode with
CSM_RATE=6320',
   preproc_plScriptId  = 1033,
   testmode_plScriptId = 0,
   aorflat_plScriptId  = 0,
&END

&FLATFIELD_postproc_fscn
   Comment = 'Namelist block for flatfield scan mode with
CSM_RATE=6320',
   preproc_plScriptId  = 1033,
   testmode_plScriptId = 0,
   aorflat_plScriptId  = 0,
&END
```

STACKLAYER

This is an EBCD module. It is called again to replicate the same file structure as used historically in the BCD flatfield pipeline, with the first plane being the flat field (gain flat), the second plane being the uncertainty image, and the third plane being the same uncertainty image. In the original BCD flatfield algorithm, there are two versions of the uncertainty image used in the last two planes. This file structure remained in place for the mission despite the fact that only one uncertainty plane was used.

CALTRANS

FLATFIELD

This is the module that creates the flat field for the BCD product. It inputs the list of linearized data, normalizes each input image, and combines them together with a trimmed average operation. The primary output data product is the flatfield gainflat and its mask and uncertainty images, but several more pipeline steps are needed to finalize them.

flatfield.nl

```
 &FLATFIELDIN
  Comment = 'Generic namelist file for flatfield, default values.',
  Ancillary_File_Path = '../flatfield',
  Log_Filename = 'stdout',
  Comment = 'Parameters for trimmed average and uncertainty
calculations',
  CentralFraction1 = 0.5,
  CentralFraction2 = 0.5,
  NDeltaThresh = 5.0,
  Comment = 'Data_Plane: 1=All, 2=First, 3=Last',
  Data_Plane = 2,
  NEdge = 10,
  PMaskMax = 16383,
  DMaskMax = 16383,
  Comment = 'Following is for normalizing input images to their trimmed
means',
  Trim_Ave_Norm = 1,
  ImageNormCenFrac1 = 0.9,
  ImageNormCenFrac2 = 0.8,
 &END
```

DARKDRIFT

This “jailbar” correction as described in Section 2 is only applied to the BCD flat. We note that DARKDRIFT is run AGAIN at the end of the BCD pipeline to both BCD and EBCD products, which essentially corrects any residual jailbar effects. The effect is small enough that it was never determined if it was an additive or multiplicative effect, or both, but an additive correction after flat fielding yielded very good results, regardless of whether or not the flat had already been corrected for jailbars.

CALKEYWORDS (see description for dark pipeline in section 4)

QATOOL

CHKMASK

QALOADER

FPGEN

B. EBCD Flatfield Methodology

1. Creation of spotflat templates and gainflats

Preparation of the flatfield:

The small field photometry AOT is observed with 7 different scan mirror positions. Each scan mirror position views a different portion of the pickoff mirror. Each individual DCE (data collection event) is normalized by the median over all pixels, to remove any variation in flatfield values due to different backgrounds in the flat field observation itself.

The deepest spots on the pickoff mirror occupy a small portion of the array for any scan mirror position. A key assumption is made that at least 2 out of the small field photometry scan mirror positions are unaffected by mirror spots, and thus have identical reflectivity on the pickoff mirror.

Flatfields are prepared for each of the 7 different scan mirror positions. Each of the 7 flatfields uses an outlier rejection algorithm to reject pixels that have been contaminated either by cosmic rays or bright astronomical sources. This algorithm is called the skew-kurtosis algorithm and is documented below.

If there were no spots on the pickoff mirror, each of the 7 different flatfields, one for each small field photometry scan mirror position, would be identical. Because of the spots on the pickoff mirror, some of the flatfields have lower gain values because of the spots. The effect of the pickoff mirror spots on the gainflat is removed by selecting, on a pixel-by-pixel basis, the two highest flatfield values over the different scan mirror planes and averaging them.

Preparation of the mirror reflectivity templates:

The mirror reflectivity templates are calculated from flatfield observations unique to each instrument mode. They are normalized by the small field photometry gainflat to remove pixel-to-pixel responsivity/illumination variations and reveal the pickoff mirror spots on individual scan mirror positions. The gainflat is smooth and has no spots.

Each flatfield input DCE is corrected by the small field photometry gainflat, normalized by the median over all pixels, and segregated by scan mirror position. The same skew-kurtosis rejection algorithm is used to reject pixels with radiation effects or sources.

The pixel-by-pixel median over each scan mirror position is the mirror reflectivity template. Because the small field photometry gainflat has been factored in, individual pixel gain variations are removed and what is left is a reflectivity ranges between 0.8 at a minimum and 1.0 at a maximum.

The skew-kurtosis algorithm for trimming outliers and calculating the background median
----

The distribution of background pixels is assumed to be symmetric about the mode. This means the skewness moment is zero. For samples drawn only from the background distribution, the mode is thus equal to the median.

The flatfield pixels are drawn from one of several distributions:

1. The background distribution
2. Pixels contaminated by a source within the flatfield
3. Pixels contaminated by a radiation particle

Pixels drawn from distribution 2 or distribution 3 are much larger than background pixels. Discriminating contaminated pixels from background pixels is reduced to finding a cutoff value, and any pixel higher than the cutoff value is either contaminated by a source or has been contaminated by a radiation hit. All trimming of pixels is determined by the cutoff value, and only pixels larger than the cutoff value will be discarded and not used in calculating the median of the background distribution.

All pixels taking part in the background calculation are first sorted in ascending order, and the sorted pixel set is examined in ascending order.
For each ascending pixel value, the skewness and kurtosis parameters are calculated for all pixels with value less than the given pixel. The threshold for discarding pixels contaminated by sources or radiation hits is set by the highest pixel value that causes a negative-to-positive transition in the skewness parameter or a negative to positive transition in the kurtosis parameter. Either transition indicates that positive skewness has been encountered, or "fat tails" on the edge of the background distribution have been encountered.

Once the cutoff value has been determined, the median of the pixels less than the cutoff determines the background.

2. Spotmatching procedure

Determination of a global subpixel shift across all scan mirror positions (aka CSM_PRED planes) is the function of the spotmatching software. This subpixel shift will be used to calibrate out the effects of scan mirror offset by calculating a new template file with a subpixel shift specific to the AOR.

Rectangular area of each CSM_PRED plane used for spotmatching

Each CSM_PRED/rate combination has a rectangular area of the focal plane used for spotmatching. This information is kept in comma-separated text file. The values of xmin, xmax, ymin and ymax that describe the rectangular area of a fiducial spot (typically the darkest spot on the array for that CSM_PRED position) are kept in the following cdf files:

qfile_1_fscn.csv qfile_1_mscn.csv qfile_1_phot.csv qfile_1_sscn.csv

The spotmatching process operates on a reference spot template made from calibration data, and a science spot template made from observation data. Each CSM_PRED plane is acted on independently, producing a different subpixel shift for each reference template plane. The template planes are constructed to be smooth, with bad pixels (marked in the pmask file) filled in through nearest neighbor mean interpolation. Pixel values outside the spot regions 1, with reductions between 0 and 1 corresponding to spots on the pickoff mirror. Template uncertainty values are calculated from using a full-width-half max calculation as part of calculating the template values themselves with a median operation.

There are four FITS files that make up a reference template set: **template value, template uncertainty and template mask fitscubes, and a fourth file giving CSM_PRED for each fitscube plane.** These reference template files are retrieved from the Spitzer Heritage Archive in the cal directory as they are used as starting values to create a correction due to scan-mirror offset during the AOR. The four files for photometry are:

```
mips24_flat_090930_aorspotcsm.fits
mips24_flat_090930_aorspotmsk.fits
mips24_flat_090930_aorspotunc.fits
mips24_flat_090930_aorspotval.fits
```

A trial shift for each rectangular area and the goal function

The shifted reference template is performed by a spline fit to the template pixels:

Prepare spline tables for column I of rectangular area.

Calculate shifted_reference_template[X][Y](dy) =

Spline-interpolated column-X at coordinate Y+dy

Using the algorithm in Numerical Recipes in C (Second Edition), Section 3.3 (Cubic Spline the derivative column D is calculated for a particular column X. This table is calculated once for each column in a template plane, then is used as many times as needed for the (Ymax-Ymin) pixel interpretations.

Independent variable	Tabulated quantity	Second Derivative D table
Ymin	pix[X][Ymin]	D[Ymin]
Ymin+1	pix[X][Ymin+1]	D[Ymin+1]
…	…	…
Ymax-1	pix[X][Ymax-1]	D[Ymax-1]
Ymax	pix[X][Ymax]	D[Ymax]

NOTE: [] signifies an array in these tables

The cubic spline (in the y direction only) needs to have beginning and ending boundary conditions specified for the derivative. Because the spot bounding box has its edges in regions without spots, the values of the template pixels are all 1, and both the first and second derivates are zero. The D table above is the tabulated values of second derivative; the boundary conditions are D[Ymin] = D[Ymax] set = 0.

Once the D array is calculated, the individual interpolated pixels are found by:

Here pix[x][y] is the 2-dimensional array value of the input data (here it is the linearized.fits file in the EBCD pipeline before flat fielding is applied).

Interpolated	pix[X][Y+dy]

```
calculate u=1-dy

pix[X][Y+dy]=   dy*pix[X][Y]   +u*pix[X][Y+1]
                               +((dy)^3 - dy)*D[Y]/6
                               +(u^3  - u)*D[Y+1]/6
```

Calculating the subpixel shift of the AOR relative to the spot template

The subpixel shift for each CSM_PRED plane is determined by a minimization operation using a golden section search (see "Numerical Recipes" section 10.1 for an explanation of this search). The reference template is shifted for various subpixel shifts, and the goal function is computed. Note that the absence of spots, the Dif[I][J] value is 0.

Dif[X][Y][dy]=sci_template[X][Y]/shifted_reference_template[X][Y+dy] – 1

There are various ways that were experimented with to produce a goal function, or the function to be minimized. Minimizing the sum-squared-error over all the pixels in the rectangular area for the CSM_PRED plane was empirically determined to be the most robust method to calculate the subpixel offset for the spot position.

Goal[dy] = sum over all X,Y in spotmatch area, Dif[X][Y][dy]^2

Searching for a minimum in the goal function

The golden section search technique was chosen to minimize the goal function because it does not depend on the existence or calculation of a derivative of the goal. The science templates and reference templates are constructed to be continuous. But, mathematically, continuity does not imply the existence of a derivative.

The golden section search technique requires that the function minimum is bracketed before applying the algorithm. This bracket operation is performed by evaluating the Goal function on an equal interval mesh between -1 pixels shift and +1 pixels shift. The spacing of the mesh is controlled by a command line option, but it is set in the pipeline scripts to be 0.1 pixels. The initial minimization bracket is the interval +/- 0.1 pixels from the minimum of the mesh. That is, the values of Goal[-1.0], Goal[-0.9], Goal[-0.8] …Goal[0], Goal[0.1] … Goal[0.9] , Goal[+1.0] are tabulated and a minimum tabulated value is found.

The tabulated mesh points neighboring the minimum mesh bracket the minimum. For example, if Goal[0.3] is the minimum, the bracket is (0.2, 0.4).

The golden section search is used to reduce the segment length of the bracket 25 iterations. At each step the size of the bracket is multiplied by 0.61 This number of iterations will reduce length of the bracket by a factor 6E-6. Thus, the minimum is located to within 0.2 * 6E-6 or to within 1E-5 pixels.

Combining the subpixel shifts for the various CSM_PRED planes

A quick example is taken from the printout from AOR=18188032. The search process yields a dy value for each CSM_PRED plane, with the search result found:

template k	csm_pred	xmin	ymin	xmax	ymax	dy	Srch_rslt
4	1864.500	110	121	122	127	0.1097	6.58E-03
9	1886.000	110	118	123	127	0.1272	4.09E-03
11	1907.500	110	114	123	123	0.1069	3.73E-03
16	1929.000	110	110	123	119	0.0714	3.15E-03
36	2106.500	110	72	123	79	0.0781	2.92E-03
38	2128.000	110	68	123	75	0.0812	3.61E-03
43	2149.500	110	63	123	70	0.0644	4.02E-03

The columns are labeled as follows:

Template_k	plane number within reference template fitscube
Csm_pred	the CSM_PRED for the plane
Xmin	minimum X value for the spotmatch area on the plane
Ymin	minimum Y value for the spotmatch area on the plane
Xmax	maximum X value for the spotmatch area on the plane
Ymax	maximum Y value for the spotmatch area on the plane
Dy	subpixel shift resulting in minimum Goal
Srch_rslt	Goal[dy] function at the minimum

The software has various algorithms for combining the subpixel shifts for the various CSM_PRED planes. They are different because each mirror position apparently has a different value of scattered light that affects the fidelity of the spots in the spotmap. The algorithm that is turned on is to use the median of the dy values for the various CSM_PRED planes. In the above example, the median dy value is 0.0812.

Applying the gainflat and shifted template corrections

Once the collective subpixel shift is determined for the AOR, the reference template is shifted, using splines, to produce the subpixel shifted template file. The SPOT_DY value is the subpixel shift actually used.

The gainflat corrects pixel-to-pixel gain variations, and the subpixel shifted template file, corrects the spots on the pickoff mirror convolved with the uncertainty in actual scan mirror position. The total flat field is the product of the appropriate plane in the shifted template file and the gainflat.

Appendix A.

CSM_PRED positions in template file and origin of each template plane

This listing appears in the headers of both the spot template file (suffix *sflat.fits) and in the header of the cal file of CSM_PRED positions (suffix *sfcsm.fits)/

The CSM_PRED positions are listed in ascending order. The very first plane (plane 0) of the spot template cube is a 128x128 image consisting of all 1's. This is used as a fallback in the case where the CSM_PRED position of the input file could not be matched to one of the positions in the cube (this should not ever happen but it was important to have the fallback there to enable the AOR to process completely if any of the planes failed for some reason to find a CSM_PRED).

```
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
COMMENT subpixel shifted mirrorflat from sci_spotflat
COMM1   = 'Spot flat multi-plane file with one plane for each photometry mode' /
COMM2   = 'scan mirror position in ascending order of keyword CSM_PRED.' /
COMM3   = 'The Enhanced BCD (ebcd) flat field is product of appropriate plane' /
COMM4   = 'of this file and first plane of gain flat file.' /
CSMPOS01=   0000.000   /   grouping = FALLFLAT
CSMPOS02=   1830.500   /   grouping = LARGE70
CSMPOS03=   1834.625   /   grouping = ENH160Y
CSMPOS04=   1863.375   /   grouping = ENH160Y
CSMPOS05=   1864.500   /   grouping = SMALL24
CSMPOS06=   1866.000   /   grouping = LARGE160
CSMPOS07=   1876.625   /   grouping = LARGE70
CSMPOS08=   1876.750   /   grouping = LARGE70
CSMPOS09=   1877.500   /   grouping = MELANGE
CSMPOS10=   1886.000   /   grouping = SMALL24
CSMPOS11=   1892.125   /   grouping = ENH160Y
CSMPOS12=   1907.500   /   grouping = SMALL24
CSMPOS13=   1920.750   /   grouping = MELANGE
CSMPOS14=   1920.875   /   grouping = ENH160Y
CSMPOS15=   1922.875   /   grouping = LARGE70
```

CSMPOS16= 1923.000 / grouping = LARGE70

CSMPOS17= 1929.000 / grouping = SMALL24

CSMPOS18= 1942.250 / grouping = MELANGE

CSMPOS19= 1949.500 / grouping = MELANGE

CSMPOS20= 1949.625 / grouping = ENH160Y

CSMPOS21= 1969.125 / grouping = LARGE70

CSMPOS22= 1978.250 / grouping = MELANGE

CSMPOS23= 1978.375 / grouping = ENH160Y

CSMPOS24= 1992.625 / grouping = LARGE24

CSMPOS25= 1999.875 / grouping = LARGE24

CSMPOS26= 2007.000 / grouping = MELANGE

CSMPOS27= 2007.125 / grouping = LARGE24

CSMPOS28= 2014.250 / grouping = LARGE24

CSMPOS29= 2021.500 / grouping = LARGE24

CSMPOS30= 2035.750 / grouping = MELANGE

CSMPOS31= 2044.875 / grouping = LARGE70

CSMPOS32= 2064.500 / grouping = MELANGE

CSMPOS33= 2071.750 / grouping = MELANGE

CSMPOS34= 2091.000 / grouping = LARGE70

CSMPOS35= 2091.125 / grouping = LARGE70

CSMPOS36= 2093.250 / grouping = MELANGE

CSMPOS37= 2106.500 / grouping = SMALL24

CSMPOS38= 2122.000 / grouping = ENH160Y

CSMPOS39= 2128.000 / grouping = SMALL24

CSMPOS40= 2136.500 / grouping = MELANGE

CSMPOS41= 2137.250 / grouping = LARGE70

CSMPOS42= 2137.375 / grouping = LARGE70

CSMPOS43= 2148.000 / grouping = LARGE160

CSMPOS44= 2149.500 / grouping = SMALL24

CSMPOS45= 2150.750 / grouping = ENH160Y

CSMPOS46= 2179.500 / grouping = ENH160Y

CSMPOS47= 2183.500 / grouping = LARGE70

TMPLATEG= 'AORsets:FALLFLAT,SKEWKURT2; at 2009/08/29 00:43:00 UTC'

TMPLATE0= 'AORsets:SMALL24,FALLFLAT; at 2009/08/29 01:16:10 UTC'

TMPLATE1= 'AORsets:LARGE24,FALLFLAT; at 2009/08/29 01:08:33 UTC'

TMPLATE2= 'AORsets:MELANGE,FALLFLAT; at 2009/08/29 01:52:24 UTC'

TMPLATE3= 'AORsets:LARGE70,FALLFLAT; at 2009/09/09 17:21:43 UTC'

TMPLATE4= 'AORsets:LARGE160,FALLFLAT; at 2009/08/29 01:05:25 UTC'

TMPLATE5= 'AORsets:ENH160,FALLFLAT; at 2009/08/29 01:01:03 UTC,dy= 0.370'

CHNLNUM = 1

SPOTFLAT= 'AORsets:FALLFLAT,SKEWKURT2; at 2009/08/29 00:43:00 UTC,dy=-0.235'

GAINFLAT= 'AORsets:FALLFLAT,SKEWKURT2; at 2009/08/29 00:43:00 UTC'

FILETYPE= 'Mirrorflat spot calibration fitscube, enhanced version'

Appendix B:
Data Product Differences : BCD vs. EBCD

The only difference between the FITS data values in the BCD (filename *_bcd.fits) vs. EBCD (filename *_ebcd.fits) are that a different flat field was applied. The associated uncertainty images are therefore also different between the BCD and EBCD products. However, there are a number of additional differences between the two files in the FITS data header keywords. FITS data headers have a few keywords that are unique to each of the BCD and EBCD's.

They are described below:

The EBCD headers have:

PLSCRPID 1021 Pipeline script ID (this is the ID of the EBCD pipeline, prior to pointing transfer)

CSMLAYER Layer (plane starting with 0) number in template file used for flat field correction

SPOT_DX x shift applied to spotflat template in detector coordinates; value should always be 0 because spotmatching algorithm does not look for shifts in x

SPOT_DY y shift applied to spotflat template in detector coordinates

SPOTFLAT Identifying string indicating origin of spotflat template used

GAINFLAT Identifying string indicating origin of gainflat used. This will have the AORKEY of the applied campaign flat in the keyword value string if one was used; alternatively, the string FALLFLAT will appear if the campaign flat was not used and instead a fallback gain flat was used. A campaign flat is usually preferable because it was taken at the beginning of the same campaign as the observation, so may have similar overall flat field characteristics. However, some campaigns (particularly the early ones, when the flats were not scheduled early in the campaign) have flat fields that are corrupted by latent images from previous observations. For those campaigns, we have applied the "clean" fallback gainflat.

The BCD headers have:

PLSCRPID 1061 Pipeline script ID for BCD pipeline prior to pointing transfer

SPOT_X X position of spot on array in detector coordinates

SPOT_Y Y position of spot on array in detector coordinates

Depending on whether the flat field procedure found a matching spot or not, the BCD header can have:

EPIDSPOT Spot-map ensemble product ID (could appear in both BCD and EBCD headers but not actually used in EBCD pipeline)

EPIDSFLT Super-flat ensemble product ID

FBIDSPOT Spot-map fallback product ID

SPOTMAP Spot-map used

FLATUSED Single flat field (including spots and overall illumination) if spotmatching fails. In this case, a spotmap and smooth superflat (gainflat) are not used separately and instead a single flat field fallback that depends only on scan rate and mirror position is used. Failure to find a spotmatch is most common in fast scan mode, where the spot streak is the shallowest and the background emission is relatively high.