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Spitzer Space Telescope MIPS Germanium Pipeline

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Abstract. The MIPS Germanium data reduction pipelines present challenges to remove a wide variety of detector artifacts and still operate efficiently in a loosely coupled multiprocessor environment. The system scheduling architecture is designed to sequentially execute four stages of pipelines. Each pipeline stage is built around perl scripts that can invoke Fortran/C/C++ modules or Informix database stored procedures. All inter-pipeline communication is via the database.

The pipeline stages are the elimination of nonlinear and radiation artifacts in the flux measurement, the calibration of the fluxes with both onboard and stellar calibration sources, applying post-facto pointing information, and assembling individual exposures into mosaics.

1. Germanium Detector Description

The MIPS germanium detectors arrays are a 32 × 32 gallium-doped germanium (Ge:Ga) array for 70 microns and a 5 arc-minute field; and a 2 × 20 Ge:Ga array, mechanically stressed to extend its photoconductive response to 200 microns, with a field of 0.5 × 5 arcminutes. On-board calibrators are provided for each array. Additionally, it has a scan mirror to provide mapping with a very efficient use of telescope time. The three arrays (two germanium and a 24 micron silicon array), calibrators, scan mirror, and optics compose the cryogenic part of the MIPS. That is, these components are mounted, as in the pictures below, inside the SIRTF cryostat and cooled by superfluid liquid helium to a temperature of about 1.5K, 1.5 degrees above absolute zero, or -457 degrees Fahrenheit.

2. Detector operation and deriving photometric flux

The detectors generate a current ideally proportional to the incident flux. The detector electronics integrates this current in a charge well for each pixel. The accumulated charge is sampled 8 times per second for each pixel. Typical integration times range from 3 to 10 seconds.

1. Several nonlinearity, hysteresis, and environmental effects must be compensated for by the pipeline software.
2. Saturation - the charge well has a finite capacity and the A/D converter has a maximum value of 65535.
3. Nonlinearity - the voltage/charge curve has a predictable, nonlinear, and reproducible relationship.

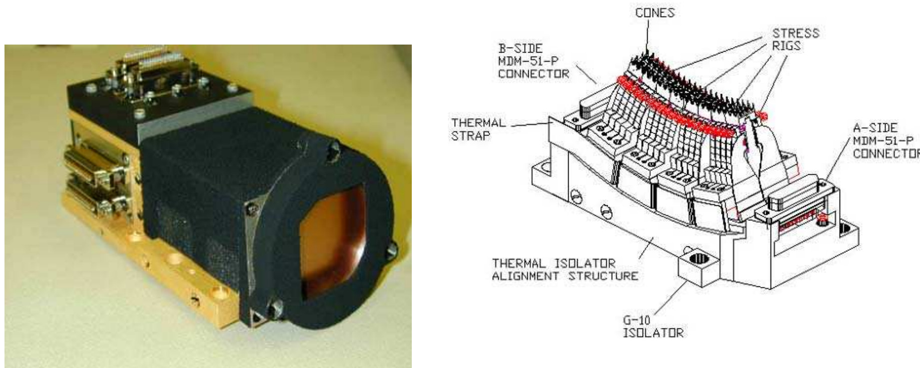

Figure 1. 70 micron and 160 micron MIPS detectors.

4. Responsivity variations - the instantaneous responsivity of the detectors varies over time due to various factors (accumulated radiation dose since anneal, hysteresis over several time scales).
5. Single Event Radiation Hits - charged particles (cosmic rays) introduce discontinuities in the stored well charge.
6. Dark Current - each pixel has a dark current present even in the absence of photometric illumination.
7. Illumination Correction - each pixel has an optical path to the sky characterized by a coefficient for each pixel.

3. Dataprocessing pipeline organization

The data processing activity is broken into four major pipeline threads for scheduling purposes. Each thread may execute multiple instances of a processing script on a particular data set. Within a given thread, the script execution on behalf of any one instance is independent of all other instances. This enables loosely coupled multiprocessing with as many as forty networked servers, which offers many performance advantages.

This pipeline operates on a dataset where each pixel is sampled many times during the integration interval (e.g., $32\times32\times80$ for a 10 second exposure). It produces a single array representing the current presented to the well during the integration time.

There are four threads which are invoked to complete the data processing.

1. Flux calibration thread - this pipeline operates on many different exposures and generates the binary calibrated data for each exposure. This pipeline takes out the detector signatures of varying responsivity, dark current, and illumination correction. The source of the responsivity variation is removed using the internal stim calibration source. Another responsivity variation relates to the average background pixel illumination and is removed by a hipass filter to enhance data from sources of small angular extent on the sky.

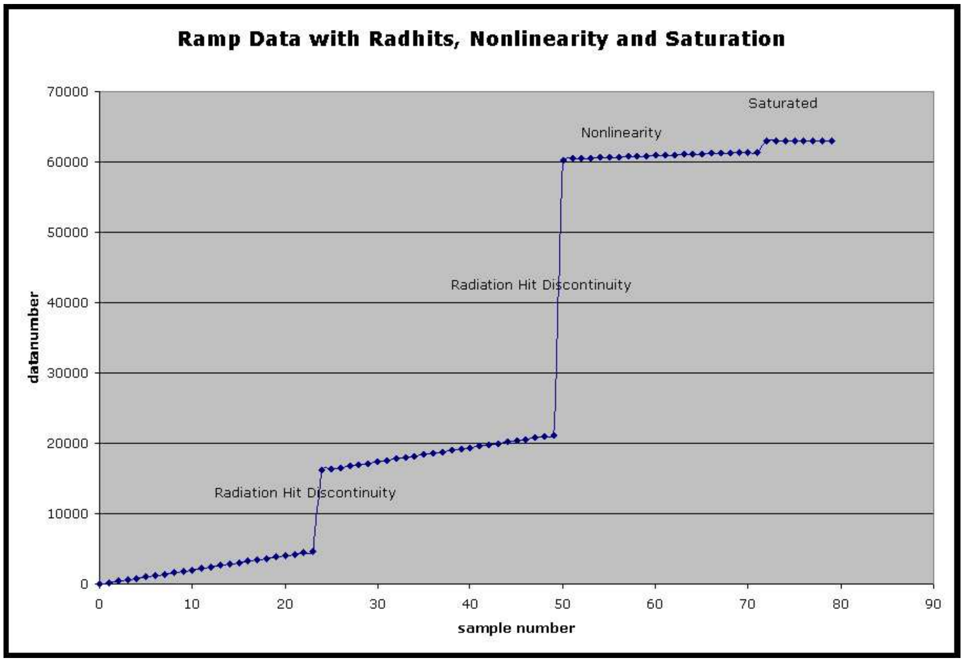

Figure 2. A generic charge ramp.

2. Pointing refinement thread - this inserts the observed coordinates for an observation, replacing the predicted coordinates available up to this point.
3. Image mosaic thread- this thread takes many exposures and uses the redundant information to generate an aggregate image.

3.1. Current Estimation Thread

Here are the functional steps for the Current Estimation Thread

1. Saturation detection
2. Electronic nonlinearity
3. Detect radiation hits and segment
4. Segment slope fusion yielding current and uncertainty

3.2. Flux Calibration Thread

Here are the functional steps for the Flux Calibration Thread.

1. Interpolate stimflash exposures (internal calibration source)
2. Normalize all exposures by interpolated stimflash
3. Subtract the dark current (calibration file)
4. Divide by the illumination correction
5. Mark all observations too close to stims
6. Output raw image and uncertainty
7. Perform hipass filtering operation
8. Output filtered image and uncertainty

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References

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