

Boresight - MIPS Instrument Pointing Calibration

This document describes a Software Interface Specification (SIS) for calibrating the offset between the PCRS and MIPS arrays. **This is required as a function of scan-mirror angle for the 24mm, 70mm (wide field), 70mm (narrow field), 70mm (SED) and 160mm operating modes.** The SSC pipeline development team will use this information to estimate and refine array pointings for arbitrary mirror positions using a robust interpolation scheme.

The current (tentative) strategy for IOC consists of acquiring dithered images of a single bright star at 9 uniformly spaced positions on the array for a *fixed scan-mirror angle*. Several scan mirror angles will be sampled for each band (and operating mode). It is assumed that an algorithm similar to that presented in J. Fowler's "Instrument Position Calibration" document (dated 8-13-1999) will be followed. Transformations involving the scan-mirror mechanism were not treated in this document.

We envisage being provided with the following for each IR-band (and mode contained therein):

1. For a given *mirror position*, a transformation matrix consisting of nine elements that relates the boresight pointing (Telescope Pointing Frame - TPF) to that in the array system (Instrument Pointing Frame – IPF). It will be desirable to have the accompanying Euler angles (α , β , γ) describing this rotation sequence and/or the matrix element equations defining these angles. It is suggested these nine matrix elements be provided in the following indexed notation:

$$T = \begin{pmatrix} T_{11} & T_{12} & T_{13} \\ T_{21} & T_{22} & T_{23} \\ T_{31} & T_{32} & T_{33} \end{pmatrix}$$

2. The mirror positions and boresight (PCRS) pointing (and hence TPF-to-IPF transformation matrix) must be known at the same time. Pointing and mirror position telemetry will be sampled asynchronously at a 2 Hz rate. A simple linear interpolation of scan mirror positions at the PCRS pointing sample times is suggested to ensure simultaneity of these quantities.
3. There will be a separate T matrix for each position of the scan mirror. It is expected that several scan mirror positions over the range of interest will be sampled. The scan mirror position is specified by the FITS header keyword "SM_POSN" (Chapter 11 of 674-MIPS-300D) after conversion by FOS.
4. For each *array*, there is a corresponding error covariance matrix V which expresses the positional errors along each axis of instrument array coordinate system independent of the boresight pointing. This should effectively include the uncertainty in the scan-mirror angle about its rotation axis. If V_Y and V_Z are

the error variances in the Y and Z position in arcseconds² (the X axis points outwards from the array center) and V_{YZ} the error covariance between the Y and Z positions,

$$V = \begin{pmatrix} 0 & 0 & 0 \\ 0 & V_Y & V_{YZ} \\ 0 & V_{YZ} & V_Z \end{pmatrix} \equiv \begin{pmatrix} 0 & 0 & 0 \\ 0 & V_{22} & V_{23} \\ 0 & V_{32} & V_{33} \end{pmatrix}$$

5. To summarize, there will be a T matrix for each mirror position. Several scan-mirror positions will be sampled over the range of interest for each array. Additionally, there will be an “effective” error covariance matrix V for each instrument array plane (IPF). To first order, this error matrix will be independent of scan-mirror position, although this should be checked. These quantities should be provided for the 24 μm , 70 μm (wide field), 70 μm (narrow field), 70 μm (SED) and 160 μm operating modes.