

CalibrationStatus/PointSpreadFunction

Title: BAT Point Spread Function

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Document:	SWIFT-BAT-CALDB-PSF-v1

1. Summary

This document describes the BAT point spread function (PSF) is approximately a truncated pyramidal frustum with a width of 22.5 arcmin (FWHM).

2. Component Files

None.

3. Scope of Document

This document relates to the determination of the BAT point spread function.

4. Reason for Update

Initial document.

5. Discussion

The BAT is not a focussing optics imager. All images must be reconstructed using cross correlation techniques. Thus, the point spread function itself is dependent on the

reconstruction technique and the geometry of the instrument.

BAT images are created by forming a sliding cross correlation between the mask aperture pattern and the detector array. There are several relevant quantities.

Quantity	Value
Focal Length	1 m
Mask tile width	5 mm
Detector pitch	4.2 mm
Detector width	4.0 mm

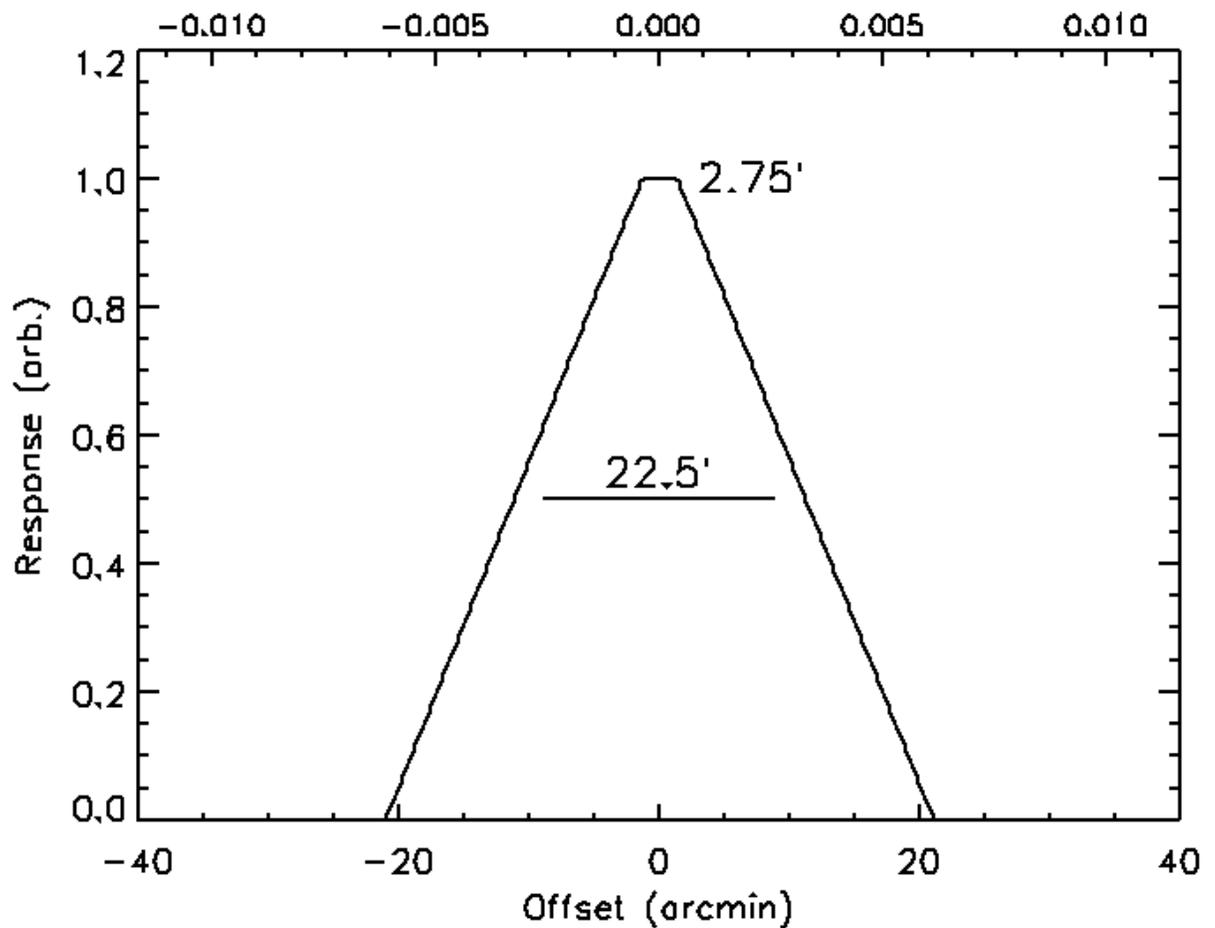


Figure 1. Cross section of the BAT PSF (= PSF1). This is a lateral cross section of the BAT 2D PSF along either the IMX or IMY direction, at any position. The bottom axis is labeled as arcminutes for a source at the center of the field of view. The top axis is labeled in tangent plane units.

As seen from a point on the detector plane, a mask grid cell at the center of the field of

view subtends 17.2 arcmin (= (5 mm)/(1 m) radians). Such a point-like receptor has a box-car response function: either on or off if the receptor is below an open grid cell. However, detectors are not point receptors; they have a finite size. If the mask cells were a point-like pin-hole, then the detector subtends a 14.4 arcmin portion of the focal plane. The actual response is a convolution of these two box-car functions, which produces a triangular-like response (Figure 1

The response is not perfectly triangular because the detectors do not completely fill their cells. There is a 0.2 mm space between each detector, which causes a slight flattening of the response at the center of the PSF.

The above discussion regards one dimension of the point spread function, say in the IMX direction (= PSF1(IMX)). However, the instrument properties are generally identical in the IMY direction, so the response function is the same in that direction as well (= PSF1(IMY)). The two dimensional response function is simply the product of the two functions:

$$\text{PSF}(\text{IMX}, \text{IMY}) = \text{PSF1}(\text{IMX}) * \text{PSF1}(\text{IMY})$$

This function is essentially a truncated pyramidal frustum. However, the contours of the actual PSF function are more smooth and rounded than for a pyramid.

The measured PSF is shown below.

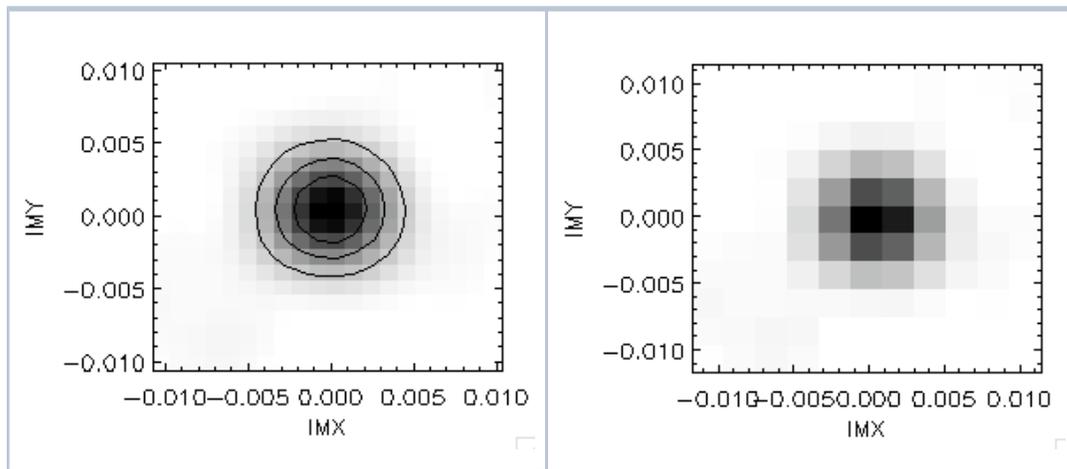


Figure 2. Images of the BAT point spread function for 4-times oversampling (left) and 2-times oversampling (right; the default of batfftimage). The contours indicate 25%, 50% and 75% of unit response.

As shown, BAT point spread function is approximately a truncated pyramidal frustum. The measured width of the point spread function is 22.5 arcminutes (FWHM on-axis). In tangent plane coordinates, the PSF shape is very uniform across the BAT field of

view; i.e. the FWHM is $\tan(22.5') = 0.0065$ in image coordinates. Figure 2 shows the point spread function for a bright source at two oversampling levels.

6. Off-Axis PSF

As a source moves farther off axis, the transformation between tangent projection and true spherical angles becomes more distorted. The width of the point spread function follows this model:

$$\begin{aligned} \text{FWHM}_X &= 22.5' / (1 + \text{IMX}^2) \\ \text{FWHM}_Y &= 22.5' / (1 + \text{IMY}^2) \end{aligned}$$

where IMX and IMY are the tangent plane coordinates. This distortion occurs in celestial coordinates. The PSF shape and width are unchanged in instrument tangent plane coordinates.

7. Caveat Emptor

NOTE: Some literature quotes the PSF width as 17 arcmin. This value is incorrect, since it does not account for the finite size of the detectors. The correct PSF width is 22.5 arcmin (FWHM).

Also, it should be noted that the focal length of the instrument is slightly dependent on energy. Thus, it is possible for far off-axis sources to be elongated in the radial direction in an energy-dependent way.

8. Expected Updates

The PSF is not expected to change.

last edited 2006-05-29 21:10:44 by CraigMarkwardt