SWIFT-UVOT-CALDB-104
Date Original Submitted: 17th October 2005

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Revision #1

Revised by: Peter Curran

Pages Changed: 1-7

Comments:
Expanded & updated from psf caldb doc #1 to include wings. White filter added.

SWIFT UVOT CALDB RELEASE NOTE

SWIFT-UVOT-CALDB-104: POINT SPREAD FUNCTION

Summary:

This product provides the curve of growth (COG) of the UVOT Point Spread Function (PSF) for the 7 broad-band filters, V, B, U, UVW1, UVM2, UVW2 and White. When performing the curve can be used to determine the percentage of the emission contained in a circular aperture.

Component Files:

Table 1:

FILE NAME	VALID DATE	RELEASE DATE	VERSION
swureef2009*v104.fits	Nov 2004	Sep 2009	004
swureef20041120v103.fits	Nov 2004	Nov 2004	003
swureef20041120v102.fits	Nov 2004	Nov 2004	002
swureef20041120v101.fits	Nov 2004	Nov 2004	001

Scope of Document:

This document contains a description of the point spread function (PSF) Curve of Growth (COG) analysis performed to produce the COG calibration products for the UVOT calibration database.

Changes:

The original PSF calibration document only calculated COGs out to 5 arcsec (the "core"). Here we extend the COGs from 5 arcsec out to 30 arcsec (the "wings") and re-derive COGs for the core. White filter COG is added.

Reason For Update:

To extend the COGs from 5 arcsec out to 30 arcsec (the "wings") and to redo the previous cores.

Expected Updates:

It is expected that further analysis of the off-axis PSF will be performed. Further analysis of variations with count rate, spacecraft voltage, spacecraft pointing, orbital position, etc. may also have to be carried out.

Caveat Emptor:

The PSF calculations are related to the apertures used to determine the zero-points. In the previous version of this document and COG, the maximum radius was set at 5 arcsec; in this version the maximum radius is extended to 30 arcsec. The normalization of the COGs to 1.0 at 5 arcsec is maintained so as to agree with the photometric calibration.

The UVOT PSF narrows with high count-rates due to the effect of coincidence loss[1]. At very high count-rates the PSF is highly distorted. For the core region we have determined the "average" PSFs for the filter in

[1] Coincidence loss causes a narrow spike in the middle of the PSF and a trough around it. This is due to the fact that nearly every event in the wings of the PSF will be coincident with one in the centre and being therefore read as one event, the position is an 'average' position which will be nearer the middle.

question, which do not take the count rate into account. For the wings we use only sources with a count-rate less than 5 cts/sec (0.055 counts per frame); cores have count rates of between 10 and 20 cts/s (0.11 – 0.22 counts per frame) so that coincidence loss is not a serious issue.

The focus of UVOT varies with spacecraft voltage as Swift goes in and out of eclipse. The width of the PSF is affected by this by up to 8% FWHM (see M. Still calibration document), though it is not the dominant source of PSF variation.

Core PSFs were derived from summed images and therefore may be affected by some blurring. The asymmetry of the PSF which is <~0.2 arcsec (Table 1) is a measure of this blurring but the FWHM obtained from the summed images is consistent with the non-summed frames.

The COGs of the wings were derived from only one source in each filter and as such they cannot be treated as a true average; they are a representative example of how PSF at radii greater than 5 arcsec. The newly derived core PSFs used multiple sources and are a better average below 5 arcsec, hence we have combined the two works. However, PSFs, given the possible affects described above, are image dependent and the values and COGs described here are to be treated as representative examples.

Data Used:

The observations detailed in Table 2 were used for the cores of the UV and optical filters. For the wings, summed observations of short GRB fields were used for B, V and White, while observations of the Chandra Deep Field – South (CDF-S) were used for U, UVW1, UVW2, UVM2 (Table 3).

Table 2: Fields used to derive core COGs and FWHMs (with approximate asymmetry errors) measured from DAOPhot

Filter	ObsID	Exp (sec)	FWHM (arcsec)	Asymm (arcsec)
uvw2	sw00180977000uw2_rw.img[]	3926	2.92	0.22
uvm2	sw00054550003um2_rw.img[]	771	2.45	0.06
uvw1	sw00178750015uw1_rw.img[]	2035	2.37	0.19
u	sw00156467005uuu_rw.img[]	5939	2.37	0.19

b	sw00180977001ubb_rw.img[]	2321	2.19	0.25
v	sw00158593002uvv_rw.img[]	19764	2.18	0.30
white	sw00130088009uwh_rw.img[]	15201	2.31	0.15

Table 3: Fields and sources used to derive wing COGs.

Field	Target ID	Filter	Exp	RA	Dec	RATE
			sec			cts/sec
060313	00201487	Wh	40,277	66.617845	-10.872028	4.710
060121	00020027	V	35,880	137.590759	45.674053	2.102
050813	00150139	B	38,745	241.989110	11.245261	2.953
CDF-S	00037172	U	~120,000	53.136856	-27.863359	4.584
CDF-S	00037172	UVW1	~120,000	53.136814	-27.863359	0.742
CDF-S	00037172	UVM2	~120,000	53.136840	-27.863381	0.179
CDF-S	00037172	UVW2	~120,000	53.136842	-27.863390	0.215

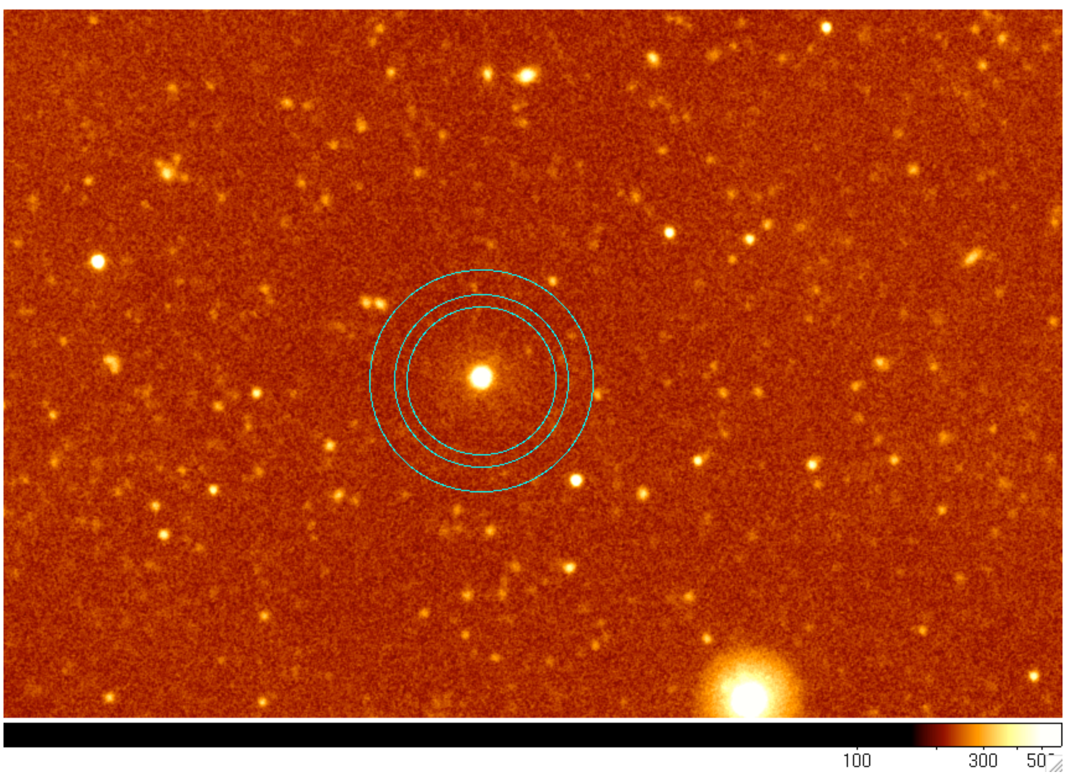

Figure 1: Chandra Deep Field – South (CDF-S); U filter. Inner circle is PSF region and outer annulus is sky region.

Description of Analysis:

We acquired a number of fields, in each filter from the UVOT archive (see previous section). Within these fields we identified point source like objects with counts rates of between 10 and 20 (cores) or 0.1 and 5.0 (wings) using the ftool uvotdetect and over-plotted these count rates on the image for visual display within DS9. The count rates were chosen as such so that the selected objects would be bright enough to acquire a PSF yet not so bright that coincidence loss would become an issue. From the identified sources we choose 6 – 20 relatively isolated ones with which to calculate the core PSF. Unfortunately for the wings there was only one such object in each filter/field (Table 3). Nearby neighbors to the PSF objects would lead to difficulties in estimating the background count level.

PSF Photometry:

A 30 pixel / 15 arsec (cores) or 60 pixel / 30 arcsec (wings) radius analytical (Moffat 15 model plus look up table) PSF was created from the selected sources using the DAOPHOT package (Stetson 1987) within IRAF. This temporary PSF was then subtracted from nearby sources to remove nearby sources and improve the field, and the PSF was recalculated. This final analytical PSF was then subtracted from other stars in the field to test the goodness via the residuals.

The core FWHM is calculated from the average sigma parameter of the Moffat 15 model (average of par1 and par2) times 2.3548 and scaled to arcesec. Asymmetry (standard deviation of par1 and par2) is calculated likewise.

Curves of growth:

The PSFs of the core and wings were integrated over radius to convert to curve of growths (COGs) using the IDL script 'uvot_psf'[2]. The core COG is

[2] Written by A. Breeveld 2002, modified by P. Curran 2009

normalized to 1.0 at 10 pixels (5 arcsec) while the wing COGs are normalized to 1.0 at 60 pixels (30 arcsec).

The observed wing COGs (at radii greater than 5 arcsec; see Appendix) were fit with 2 Gaussians, centered at zero arcsec. The fit wing COGs (rescaled to agree with the cores at 5 arcsec) were then combined with the core COGs to give the correct COGs from 0 to 30 arcsec (see figure and CALDB file).

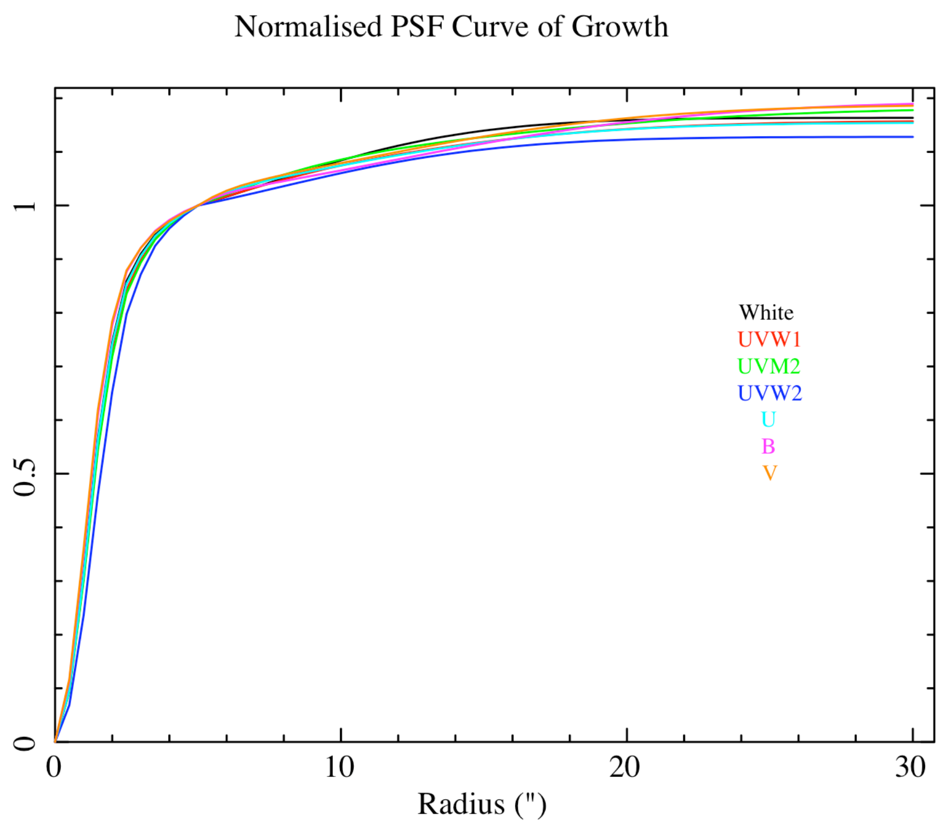

Figure 2: Normalized Curves of Growth (CALDB) out to 30 arcsec

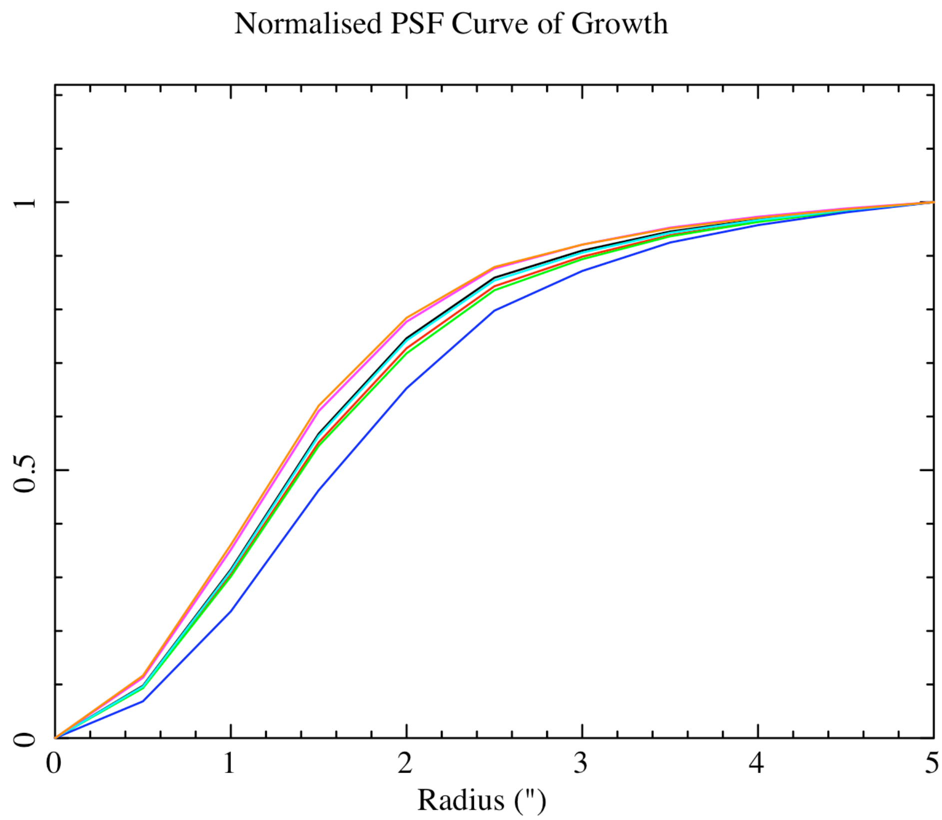

Figure 3: Normalized Curves of Growth (CALDB) out to 5 arcsec