

## GAIA UV filter check tool (Dated 14 March 2018)

The UVIT ~28 arc-minute field of view can have potential bright objects that can trigger a BOD (Bright object detection). The BOD will stop UVIT from further observations and put the payload in low power mode. The occurrence of a BOD thus severely affects the operations of ASTROSAT. Observers are therefore advised to check a field having a radius of 20 arc-min centred on the target of interest (when UVIT is chosen as the primary instrument) for bright objects and chose the appropriate filters that can avoid a BOD. This 20 arc-min search radius has to be carried out when UVIT is the primary instrument. However, if SXT or LAXPC is the primary instrument, there is a need to widen the search due to offsets of SXT (0.0721 degree) and LAXPC (0.1156 degree) relative to UVIT. Therefore, if SXT is the prime instrument the search radius has to be increased from 20 arc-min to 25 arc-min and if LAXPC is the primary instrument, the search radius has to be increased from 20 arc-min to 28 arc-min. This check has to be done in both the optical and UV bands. For UV bands, the resources from GALEX and TD1 catalog have to be used.

To facilitate the choice of safe UV filters (both for FUV and NUV) for observations, a software tool called, GAIA has been developed at the UVIT-POC. GAIA can be used to check for the safety of the field of interest for observation in FUV and NUV channels of UVIT that will not trigger a BOD. The tool however has certain drawbacks which is given at the end. This tool makes use of archival data from the MAST GALEX archives. The tool works as follows. Given the co-ordinates of the target and the primary instrument, the tool goes to GALEX archive and downloads the image from GALEX. It identifies five brightest objects from the image. For those five brightest objects, it gets their magnitudes in FUV and NUV from GALEX catalog (mag\_cat). For the same five brightest objects, the tool also does photometry on a 7 x 7 box and derives the magnitude (mag\_image). The reasons for doing the photometry are the following

1. For bright objects (saturated), the magnitudes given by the GALEX catalog is not correct. This conclusion was arrived at by taking into account the PSF used to get the magnitude in GALEX catalog, as the GALEX catalog also gives the PSF used to derive the magnitude. For saturated stars the magnitudes quoted in GALEX catalog is over a larger PSF
2. For extended sources, again the magnitude given by the GALEX catalog is inaccurate, because here too, the quoted magnitude is derived over a larger PSF
3. For non-saturated point sources, the magnitude derived by doing photometry over a 7 x 7 pixel box (1 pixel = 1.5 arcsec) matches with the magnitude given in the GALEX catalog

Thus, for each of the five brightest sources in the field, the tool will have two magnitudes, one obtained from the catalog and the other derived from local photometry. Among the two available magnitudes, the tool chooses the one that is close to the true one by using a combination of magnitude difference between the two approaches and the PSF, based on the following algorithm

```
if (mag_diff < 1.2 and FWHM < 0.0043 deg)
{
  NUV_mag = mag_cat
  FUV_mag = mag_cat
}
else
{
  NUV_mag = mag_image
  FUV_mag = mag_image
}
```

**Fig: 1.** Algorithm to get the magnitudes based on local photometry and GALEX magnitudes

If the magnitudes thus obtained are brighter than 15 mag, correction for saturation is done using  $M_{\text{corr}} = C_0 + (C_1 * M_{\text{obs}} + C_2)^{1/2}$  (Camarota & Holberg 2014, MNRAS, 438, 3111). This equation is valid in the magnitude range of 1.5 to 17.5 in FUV and 9.5 to 17.5 in NUV. The coefficients  $C_0$  and  $C_1$  for FUV and NUV bands used for the correction is given in Table 1.

**Table 1:** Coefficients to correct for saturation in the GALEX magnitudes

Coefficient	NUV	FUV
$C_0$	2.634	5.371
$C_1$	26.316	20.000
$C_2$	-245.329	-210.200

From the corrected magnitudes, the tool calculates the expected count rates in various UVIT filters using Table 2 and prints them in the output. The filters for which the count rates are lesser than 1500 in both NUV and FUV are safe for observations.

**Table 2:** Count-rates in FUV (for a magnitude of 18.22) and NUV (for a magnitude of 20.00). This is used by GAIA to get the count-rates in any UVIT filters

FUV: GALEX magnitude of 18.22 mag corresponds to the following rates in UVIT		NUV: GALEX magnitude of 20.00 mag corresponds to the following rates in UVIT	
Filter	Count rate	Filter	Count rate
CaF2	1	Silica	1
BaF2	0.85	NUV-B4	0.22
Sapphire	0.63	NUV-B13	0.27
Silica	0.22	NUV-B15	0.074
		NUV-N2	0.055

### Choice of FUV/NUV filters (Only NUV GALEX images are available)

If only NUV images are in the GALEX archive, the tool gets the magnitude in NUV using the algorithm quoted in Fig. 1, corrects for saturation (if needed) and get the FUV (GALEX) magnitude using Rayleigh – Jeans approximation as

$$m^{\text{FUV}} = m^{\text{NUV}} - 1.65$$

It then calculates the expected count-rates for FUV and NUV filters in UVIT using Table 2.

### Choice of FUV/NUV filters (GALEX images are NOT available)

If the required field is not covered by GALEX NUV images, there is a lot of uncertainty. In case the field lies in any of the bright areas (within  $\pm 30$  deg. Galactic latitude or LMC or SMC) any exposures in NUV and FUV are not permissible. **However, check the ASTROSAT proposers guide for a possibility to observe such fields from A05.** Alternatively, if the field lies outside the bright areas, the brightest source within 20' radius (when UVIT is the primary instrument) should be checked in TD1 (<http://heasarc.gsfc.nasa.gov/db-perl/W3Browse/w3table.pl?tablehead=name>)

([%3Dtd1&Action=More+Options](#)) and the counts calculated for the selected filters, so as to check that the limits are not exceeded. The absence of sources is taken as presence of a source with a flux of  $2 \times 10^{-13}$  erg/sec/cm<sup>2</sup>/A and the count-rate for this flux in various UVIT filters are given in Table 3.

**Table 3:** Count-rates in UVIT filters for a flux of  $2 \times 10^{-13}$  erg/sec/cm<sup>2</sup>/A in TD-1

FUV-filters	FUV Count-rate	NUV-filters	NUV count-rates
CaF2-1	74.5	Silica	955
CaF2-2	67.3	NUV-B15	59.6
BaF2	60.0	NUV-B13	275.8
Sapphire	50.0	NUV-B4	218.5
Silica	17.3	NUV-N2	50.6

Depending on the presence or absence of TD1 sources, the tool utilising Table 3, prints the expected count-rates in UVIT filters.

### Summary of the functioning of GAIA

1. The tool takes as input the alpha and dec in sexagesimal units
2. The tool also takes the primary instrument chosen by the user
3. After getting inputs (1) and (2) from the user, the tool goes to GALEX archives and download the GALEX catalog and one GALEX tile each for NUV and FUV. The download GALEX tile is the one that has the central co-ordinate closest to the one entered by the user
4. Do photometry on the download GALEX images, get the magnitudes of five brightest stars and also get the magnitude of the same stars from the GALEX catalog
5. Apply the algorithm given in Fig. 1 arrive at the final NUV and FUV magnitudes, do saturation correction if needed and prints out the expected count rates in all FUV and NUV filters
6. If only GALEX NUV images are available, follow (3), (4) and (5), for NUV, get the FUV using Rayleigh-Jeans criteria and print out the count rates in all FUV and NUV filters
7. If GALEX images are not available and the field is above the +/- 30 deg galactic latitude constrains the tool uses TD1 and Table 3 and prints out the expected count rates in FUV and NUV filters

## **Outputs produced by the tool**

Using the various procedures outlined above the tool calculates the count rates in various UVIT filters and it prints the following

1. Image taken from GALEX archives. The size of the image depends on the prime instrument chosen by the proposers. If UVIT is the prime instrument, the image size will have a field of view of radius 20 arc-min. For SXT and LAXPC the displayed image will have a field of view of 25 arc-min and 28 arc-min respectively. The five brightest stars are also marked on the images
2. Expected count rates in all NUV and FUV filters.

## **Cautions in using the tool**

1. The tool works on each individual tiles (each tile is 1.2 degree diameter) taken from GALEX archives and it is perfectly correct when the full image is produced in the output
2. It is possible that the field a proposer wishes to observe is NOT covered in a single tile of GALEX and many tiles of GALEX has to be combined to check for the availability of GALEX observations. The GAIA tool currently does not have this capability
3. If the tool displays a partial field in the output, there is a possibility of bright sources outside this field and proposers are requested to check themselves the GALEX field for their availability.