IUCAA

AstroSat Proposal Preparation

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Proposal/Observing Cycles

ISRO has established AstroSat as an astronomical observatory and over the last few years, has periodically released announcements of opportunity (AO) calls, soliciting proposals from national and international Astronomy community to observe using AstroSat instruments.

AO-11 (Announcement of Opportunity) cycle :
1 October 2021 – 30 September 2022

The last date for submission of proposals: 25th March 2021.

Current allocation of Observing Time on AstroSat

~55% (Indian observers) and 20% (International Observers.)

Astrosat Proposals:

Scientific Justification: (4-page limit)

- Describe scientific background & motivation for the proposed observation.
- Scientific objectives, selection of targets, & demonstrating scientific feasibility with estimates of signal-to noise, flux/count rate expected.
- Feasibility of requested observing time : spectral and / or temporal simulations.
- Justification that why the science case requires new observations if prior arxival data is available.
- **New Section : Report on previous successful AstroSat proposals by PI if any.**

Technical Justification: (2-page)

- Target visibility: AVIS tool output or Astroviewer tool output.
- Selection of the primary & secondary instruments.
- Details of bright UV sources in the field of UVIT and near the field as per the list of mandatory safety checks.
- Selection of filters, S/N for the requested exposure (after accounting for source counts, background, nearby source).
- Details of time constraint: Coordinated observations with other observatories, etc. Monitoring duration and frequency, Trigger criteria of AToO.

Proposal Types

(a) Regular pointing (with or without any time constraints):

- Simplest type of proposal is without any time constraint.
- Proposals for one or more targets requesting one pointing per target.
- Time Constraint proposals needs stronger science justification then a regular without time constraint proposals (No need to enter any time constraint if your target is visible intermittently.)
- For each target in a proposal with time constraint, only one observation will be made. Multiple time constraints may be given only for the ease of scheduling.
- Time constraints should be consistent with the AVIS/Astroviewer tools outputs.
- If multiple observations are required, then write monitoring proposal or seperate proposal.

Proposal Types

(b) Monitoring proposals : In this cycle, proposers can request monitoring observations with a minimum interval of 3 days between two consecutive observations.

- Multiple observations of a single target with specified intervals between successive observations.
- All observations are identical i.e., exposure time and instrument configuration do not change from one observation to another observation.
- Successive observations need not equally spaced: Linear, Logarithmic or arbitary.
- Constraints on the mission operation-- Strong justification needed.
- Recommended to propose only one target in one monitoring Proposal.

Two additional inputs required:

(i) Number of observations

(ii) Interval between successive observations (in days)

Proposal Types

(c) Anticipated ToO proposals:

- Interesting astronomical event is foreseen but the exact timing of the event is unknown.
- Estimate of triggering criteria, its probability and trigger duration, and provide relevant justification.
- Anticipated ToO proposals cannot request for follow-up observations in the same proposal.
- Strong scientific justification needed.

Three additional inputs required:

(i) How is the triggering criteria met (e. g., the source flux crosses certain threshold or a black X-ray binary makes a transition to a particular state, etc.)

(ii) Estimated probability of occurrence (between 0 and 1)

(iii) Expected duration of the event (in hours) and how is the trigger duration estimated.

(iv) ATAC chair will review the trigger request and may accept.

Proposal Types

(d) AstroSat Long Term Key Proposal (ALTKP):

ALTKP **t**arget specific science problems demanding long term AstroSat observations from teams of users.

- Address key science that cannot be achieved with the currently available data. Preference shall be given to proposals which will have wider interest in the astronomy community.
- Preference will be given to proposals utilizing simultaneous multi-wavelength observation capability of AstroSat. Use of multiple payloads will be encouraged.
- A detailed and extended Scientific Justification (up to six pages) must be provided, addressing

(i) The scientific merits, by giving examples of previous similar surveys/monitoring programmes of other observatories and how the proposed programme improves upon them.

(ii) A stronger justification for monitoring proposals.

(iii) A proven expertise in analysing AstroSat data and listing of the earlier accepted AstroSat proposals and publications based on them.

(iv) PDFs and young researchers are encouraged to lead the project.

Observing efficiencies for different payloads

OBSERVATION TIME / OBSERVING EFFICIENCY = STARE TIME

STARE TIME >> OBSERVATION TIME

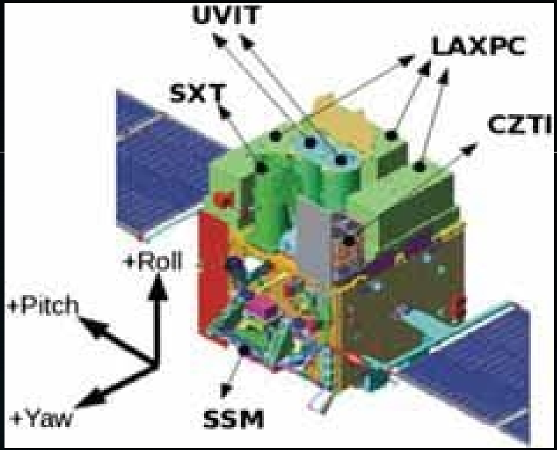
payload	observing efficiency
UVIT[1]	15% (for field sizes 250x250 or larger) < 15% (for smaller fields, see table below)
SXT	25%
LAXPC	45%
CZTI	45%

fuv/nuv field size	frame rate	maximum exposure time per orbits (subjected to 15% observing efficiency)
100x100	640/sec	200 sec
150x150	300/sec	454 sec
200x200	180/sec	769 sec
250x250	115/sec	1162 sec
300x300	82/sec	1470 sec
400x400	61/sec	2500 sec
full field	29/sec	3571 sec

SXT observing time of 10ks will result in a total stare time of 40ks, and the observing time of 6ks for UVIT (full field), and 18ks for LAXPC and CZTI.

Relative angle :

Payload	Angle between Payload Boresight and Body Roll (deg)
UVIT	0.0419
SXT	0.0512
LAXPC 10	0.1605
LAXPC 20	0.1844
LAXPC 30	0.1486
LAXPC MEAN	0.1514
CZTI	0.0041

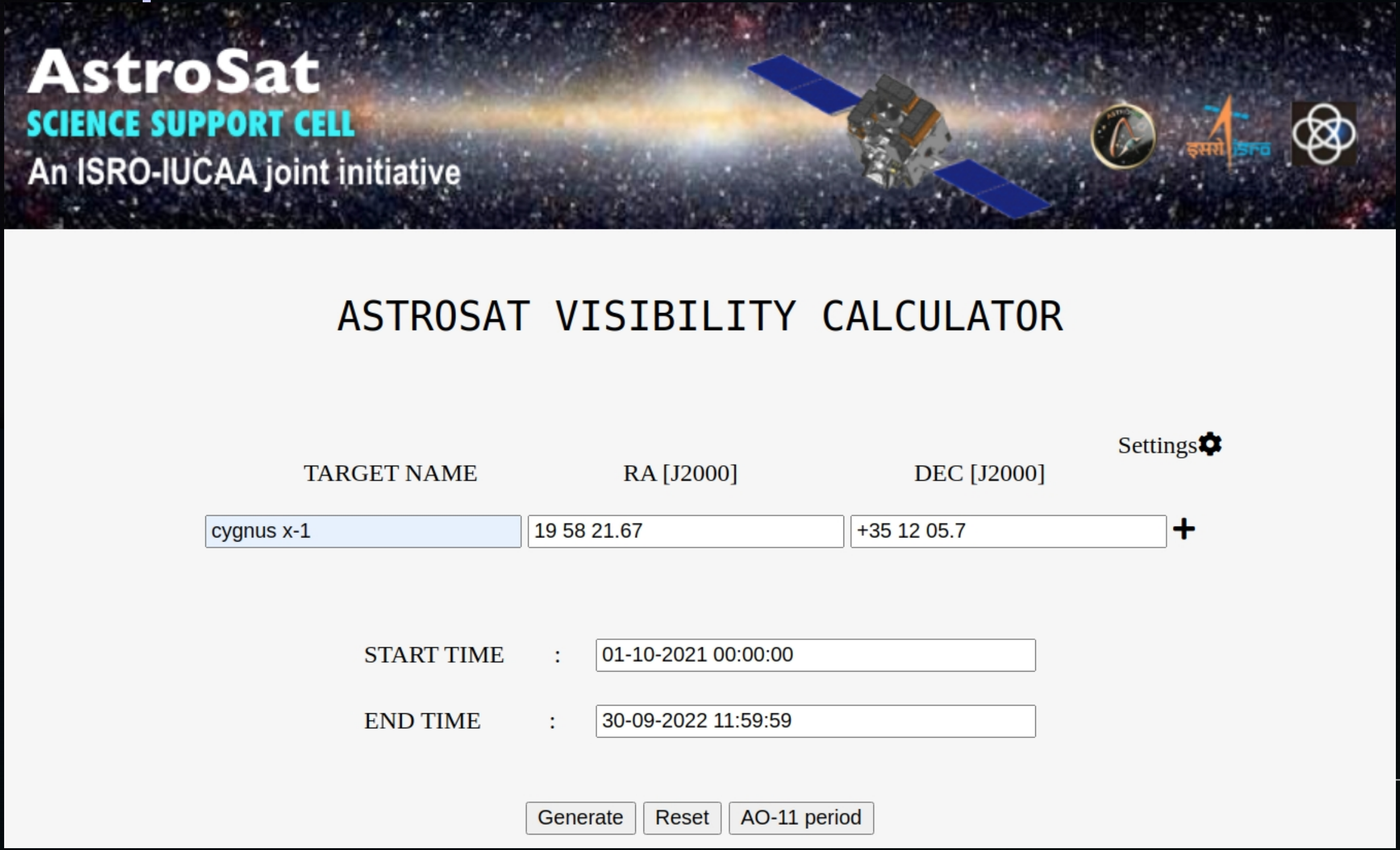


These offsets are of the order of a few arcmins. Therefore, the proposers should use the PC mode when SXT is not the primary instrument. This is because, the source may be out of the SXT FoV for the FW mode in this case. However, one may need to use the SXT FW mode for some science goals in order to reduce pile-up and/or to have better time resolution from SXT. In such a case, proposers should make SXT the primary instrument, even if SXT does not serve the primary science.

Avis Online Interface

AstroSat visibility period for observations of a target of interest.

http://astrosat-ssc.iucaa.in:8080/AstroVisCal/

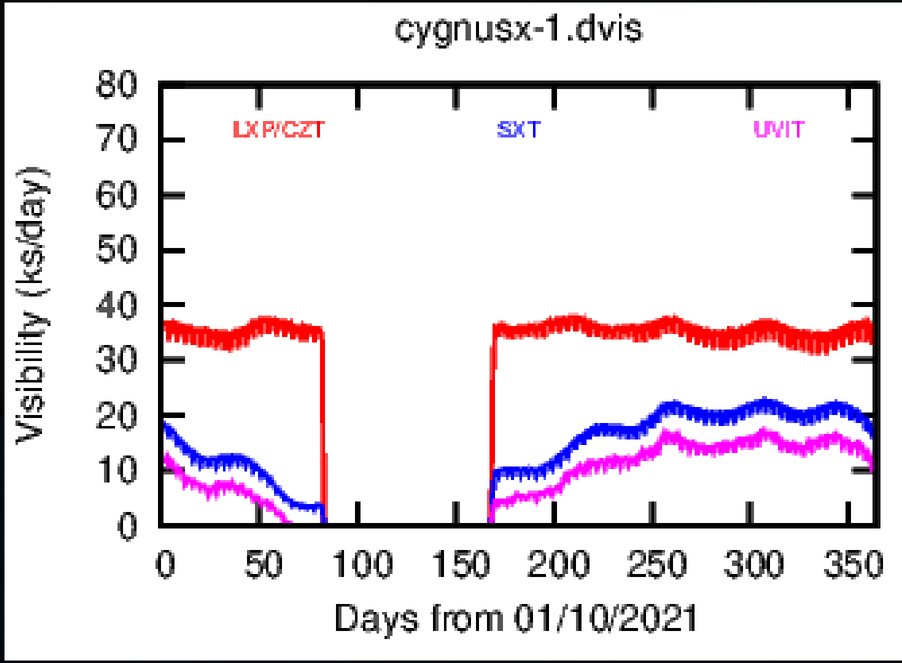


AVIS Source Visibility: Cygnus X-1

```
# Astrosat Mission. Orbital Period  5860.38 s
# Visibility for cygnusx-1 RA2000: 299.5903 deg Dec2000:  35.2016 deg
# Starting on 1/10/2021 0:0:0.0UT : MJD  59488.0000000
# Constraints: Sun  65.0 Moon 15.0 Ram 12.0 Limb 12.0 NegRollSun  30.0
# SAA Trapz LatRef  -6.0 Long Min -110.0 Max    0.0 Slope L  3.50 R  0.00
# St.MET, elapsed days, MJD, min Ram, Sun ang, Moon ang, vis (s): LXP/CZT, SXT, UVT
#--------------------------------------------------------------------------------------
370742400.00    0.0680556 59488.0680556  30.0 110.0 120.8    3180.0  1680.0  1310.0
370748260.38    0.1361111 59488.1361111  30.0 110.0 120.9    2820.0  1740.0  1370.0
370754120.76    0.2041667 59488.2041667  30.0 110.0 121.0    2340.0  1680.0  1310.0
370759981.15    0.2715278 59488.2715278  30.0 109.9 121.1    1980.0  1680.0  1090.0
370765841.53    0.3395833 59488.3395833  29.9 109.9 121.2    2100.0  1680.0  1090.0
370771701.91    0.4076389 59488.4076389  29.9 109.8 121.2    2340.0  1440.0   850.0
370777562.29    0.4750000 59488.4750000  29.9 109.8 121.3    2520.0  1080.0   710.0
370783422.68    0.5430556 59488.5430556  29.8 109.8 121.4    2220.0   660.0   290.0
370789283.06    0.6111111 59488.6111111  29.9 109.7 121.4    2220.0   480.0     0.0
370795143.44    0.6784722 59488.6784722  29.8 109.7 121.4    2340.0   660.0     0.0
370801003.82    0.7465278 59488.7465278  29.8 109.7 121.5    2820.0  1080.0   710.0
370806864.21    0.8145833 59488.8145833  29.8 109.6 121.5    3120.0  1320.0   950.0
370812724.59    0.8819444 59488.8819444  29.7 109.6 121.5    3360.0  1680.0  1310.0
370818584.97    0.9500000 59488.9500000  29.8 109.6 121.5    3420.0  1680.0  1310.0
370824445.35    1.0180556 59489.0180556  29.7 109.5 121.5    3480.0  1680.0  1310.0
370830305.74    1.0854167 59489.0854167  29.7 109.5 121.5    3060.0  1680.0  1310.0
370836166.12    1.1534722 59489.1534722  29.7 109.5 121.5    2640.0  1620.0  1250.0
370842026.50    1.2215278 59489.2215278  29.7 109.4 121.4    2280.0  1680.0  1310.0
370847886.88    1.2888889 59489.2888889  29.7 109.4 121.4    1740.0  1680.0  1090.0
370853747.27    1.3569444 59489.3569444  29.6 109.4 121.4    2280.0  1680.0  1090.0
370859607.65    1.4250000 59489.4250000  29.6 109.3 121.3    2520.0  1380.0   790.0
370865468.03    1.4923611 59489.4923611  29.6 109.3 121.2    2580.0   900.0   530.0
370871328.41    1.5604167 59489.5604167  29.6 109.3 121.2    2220.0   540.0   170.0
370877188.79    1.6284722 59489.6284722  29.6 109.2 121.1    2220.0   480.0     0.0
370883049.18    1.6958333 59489.6958333  29.5 109.2 121.0    2460.0   720.0     0.0
370888909.56    1.7638889 59489.7638889  29.5 109.2 120.9    2820.0  1080.0   710.0
370894769.94    1.8319444 59489.8319444  29.5 109.1 120.8    3180.0  1440.0  1070.0
370900630.32    1.8993056 59489.8993056  29.5 109.1 120.7    3360.0  1620.0  1250.0
370906490.71    1.9673611 59489.9673611  29.5 109.1 120.6    3420.0  1680.0  1310.0
370912351.09    2.0354167 59490.0354167  29.5 109.0 120.4    3360.0  1680.0  1310.0
370918211.47    2.1027778 59490.1027778  29.5 109.0 120.3    2940.0  1620.0  1250.0
```

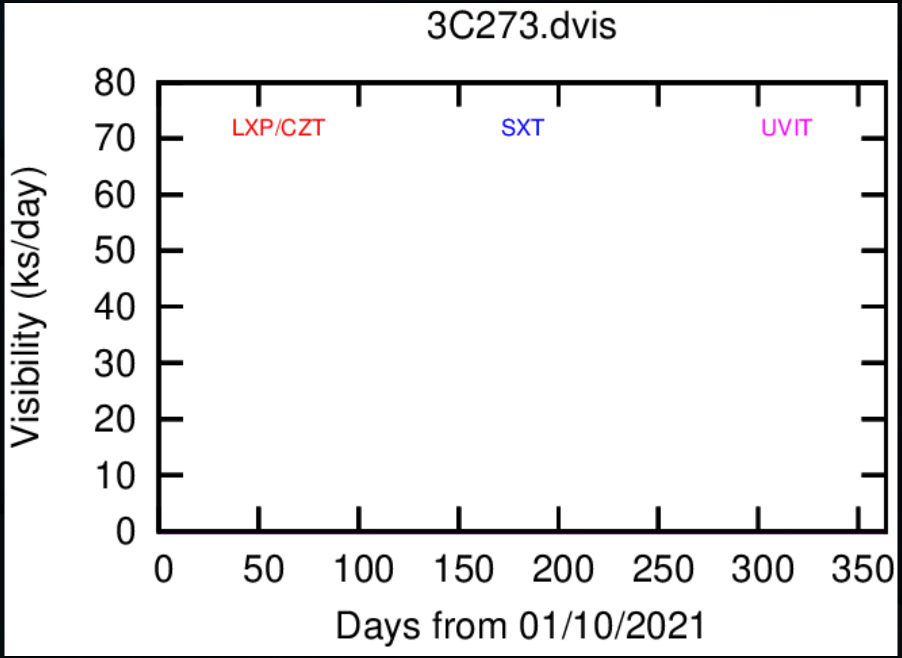
AVIS Source Visibility

Cygnus X-1



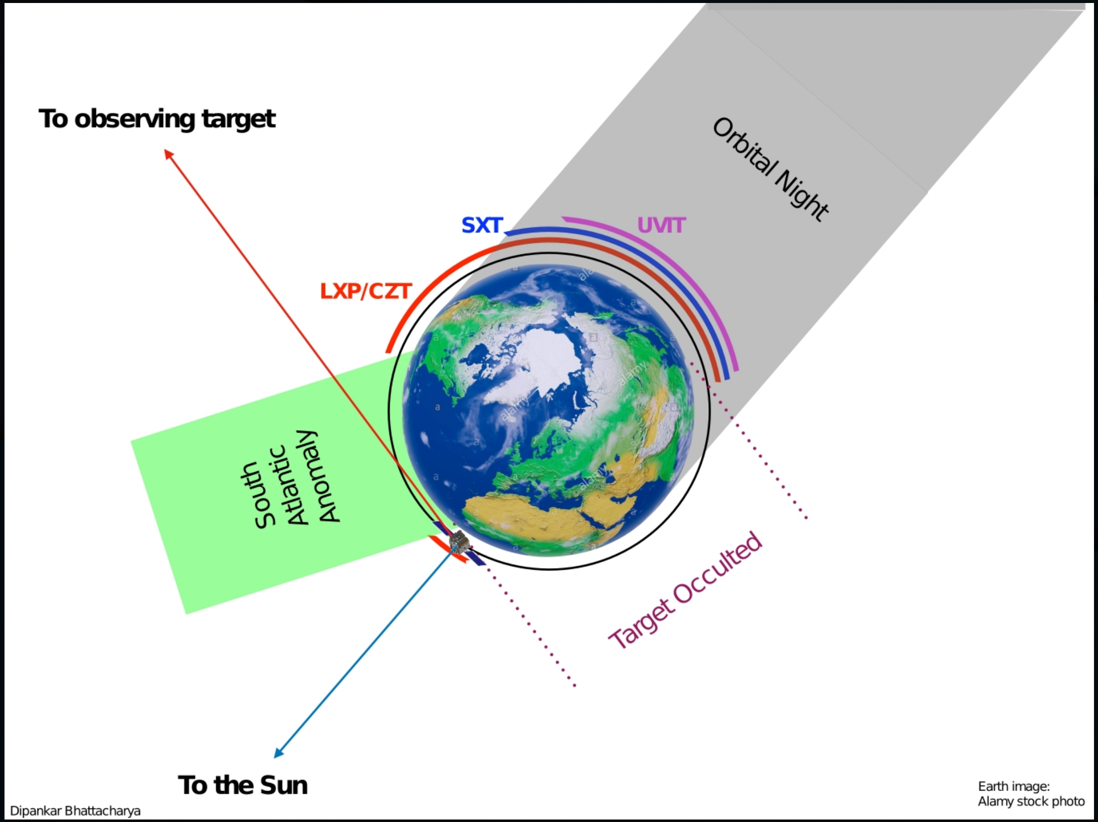
3C 273

(R.A. : 12 29 06.699, Dec. : +02 03 08.598)



If your science case requires time constraints, ensure that the time constraints are covered by the visibility windows.

AstroSat payloads receive different exposures per orbit.



SXT and UVIT can observe only during orbital night. For UVIT there is the additional overhead of switching on after the orbital night begins and switching off before orbital night ends. SXT does not undergo such an on-off sequence.

All instruments are switched off during SAA.

UVIT VIS filter checking tool (Theia)

Theia (VIS Filter Checking Tool)

UVIT VIS Filter Check

★ Note:

- This tool is intended to check the appropriate filter for use with the VIS channel of UVIT.
- Please choose the primary instrument and provide the RA and DEC of the source in sexagesimal units.
- We suggest to use only one VIS filter for continuity of tracking.

Primary Instrument: UVIT

RA: 09:55:33 — For eg.: 12:12:12 (hms)

DEC: +69:03:55 — For eg.: -20:10:14 (dms)

Submit | Reset

Source : M81

Primary Instrument: UVIT **RA:** 09:55:33 **DEC:** +69:03:55

RA (hms)	DEC (dms)	mag	B-V	SpecType	VIS3	VIS2	VIS1	ND1	BK7
09:57:00.78	+68:54:06.444	9.25	1.045	K4	6067.5	417.7	253.6	136.4	7161.5
09:55:04.176	+68:54:05.724	9.256	0.415	F5	10800.0	1733.3	1334.8	242.4	14100.0
09:55:04.176	+68:54:05.724	9.284	0.482	F5	10500.0	1689.2	1300.9	236.2	13800.0
09:58:01.5648	+68:57:24.336	10.258	0.422	F5	4273.5	688.8	530.4	96.3	5615.8
09:53:17.676	+69:02:48.156	10.446	1.335	K7	1756.0	103.4	47.7	39.3	2050.8
09:55:01.0296	+68:56:22.488	10.591	0.712	G8	2459.1	290.4	225.6	54.8	3099.8
09:55:02.6808	+68:56:21.984	10.657	0.668	G5	2314.0	273.3	212.3	51.6	2917.0

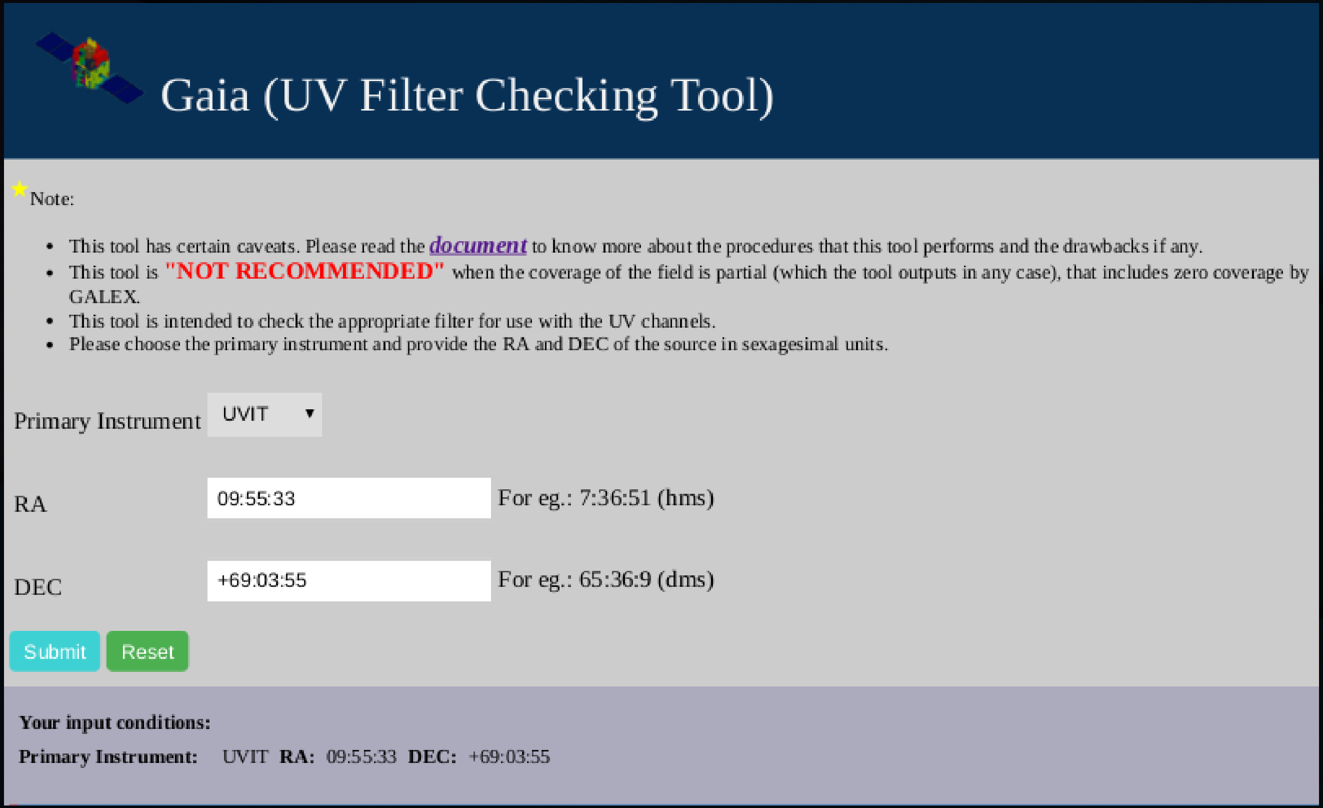
Safe VIS filter(s) for this field: VIS2, VIS1, ND1

(Safe limit for VIS filter: 4800 cps)

"Further, for good tracking of the aspect, there should be at least 2 stars within 12' radius of the target with count rates greater than 30 c/sec (for good S/N) and lesser than 1000 c/sec (to avoid saturation) in the chosen filter. "

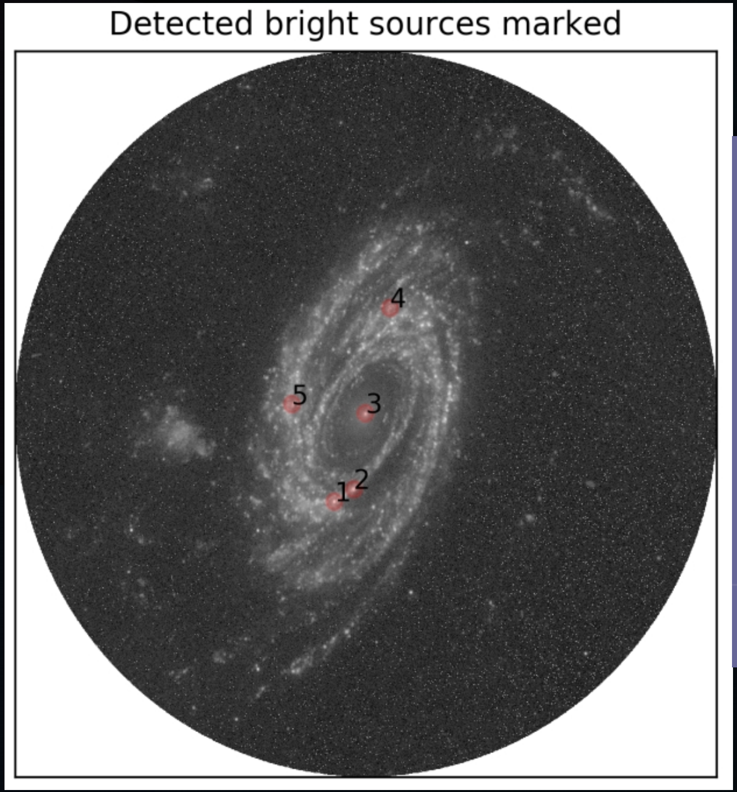
The VIS channel is primarily used for the spacecraft tracking.

UVIT FUV/NUV filter checking tool (Gaia) : M81



- The UVIT ~20 arc-minute field of view can have potential bright objects that can trigger a BOD (Bright object detection).
- Due to offsets relative to UVIT :(1) SXT : primary instrument search 25 arc min around TOI and (2) LAXPC: primary instrument search 28 arc min around TOI.
- The filters for which the count rates are lesser than 1500 in both NUV and FUV are safe for observations.

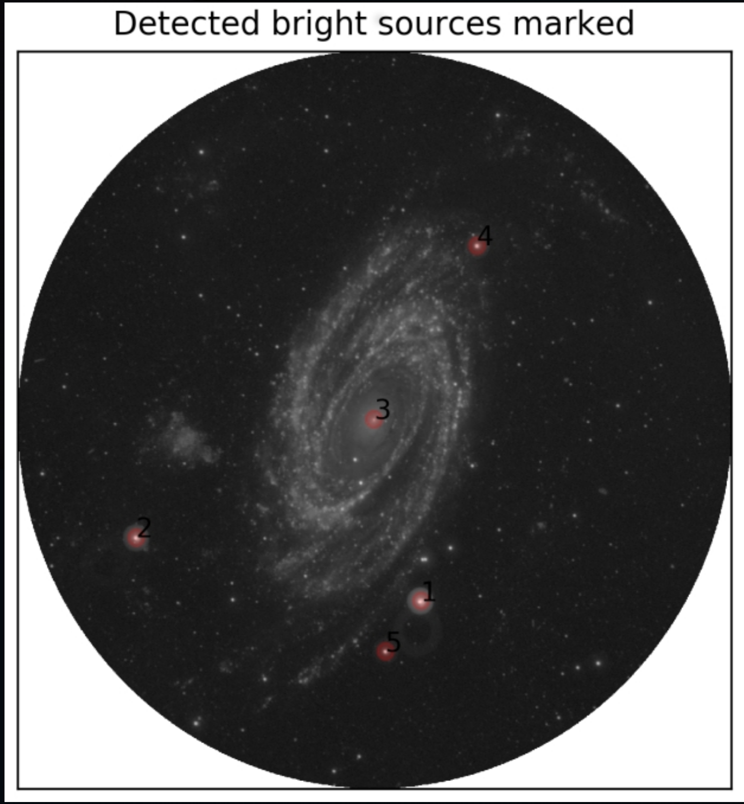
UVIT FUV filter checking tool Output (Gaia) : M81



Sl No.	RA (hms)	DEC (dms)	Mag	Mag_corrected	CaF2	BaF2	Sapphire	Silica
1	09:55:52.9035	+68:59:04.1618	17.00	17.00	3.07	2.61	1.94	0.68
2	09:55:40.836	+68:59:45.6445	17.47	17.47	1.99	1.70	1.26	0.44
3	09:55:33.3968	+69:03:54.9094	17.86	17.86	1.40	1.19	0.88	0.31
4	09:55:17.8651	+69:09:45.5203	19.03	19.03	0.47	0.40	0.30	0.10
5	09:56:20.5133	+69:04:24.0355	18.71	18.71	0.64	0.54	0.40	0.14

Safe filters in FUV: ['CaF2', 'FUV-grating', 'BaF2', 'Sapphire', 'Silica']

UVIT NUV filter checking tool Output (Gaia) : M81



Sl No.	RA (hms)	DEC (dms)	Mag	Mag_corrected	Silica	B4	B13	B15	N2
1	09:55:04.023	+68:54:04.5626	13.62	13.27	493.37	108.54	133.21	36.51	27.14
2	09:58:01.5542	+68:57:24.1729	14.18	13.94	265.16	58.34	71.59	19.62	14.58
3	09:55:33.3968	+69:03:54.9094	16.95	16.95	16.56	3.64	4.47	1.23	0.91
4	09:54:28.6523	+69:13:21.7527	15.01	15.01	98.90	21.76	26.70	7.32	5.44
5	09:55:25.8475	+68:51:21.1462	15.68	15.68	53.25	11.72	14.38	3.94	2.93

Safe filters in NUV: ['Silica', 'NUV-grating', 'NUV-B4', 'NUV-B13', 'NUV-B15', 'NUV-N2']

Special cases in using the GAIA tool :

- 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 if mag_diff < 1.2 and PSF FWHM < 0.0043 deg, then NUV magnitude is considered from galex catelogue else from image photometry. The FUV (GALEX) magnitude is calculated using Rayleigh – Jeans approximation as,

  $$m_{FUV} = m_{NUV} – 1.65.$$

  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 ±30 degree Galactic latitude or LMC or SMC) any exposures in NUV and FUV are not permissible.

- 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.

Special cases in using the GAIA tool :

Choice of FUV/NUV filters (GALEX images are NOT available and the field is above the +/- 30 deg galactic latitude) : The field should be checked in TD1 catelogue and counts should be calculated for selected filters for safe limits. The absence of sources in 20 arc min radius is taken as presence of a source with a flux of 2 x 10^{-13} erg/sec/cm^2/A and the count-rate for this flux in various UVIT filters are given in Table 3 of http://uvit.iiap.res.in/Software/gaia/docs/gaia_procedure_1.0.pdf

Table 3: Count-rates in UVIT filters for a flux of 2 x 10^{-13} erg/sec/cm^2/A inTD-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.

Event file simulator: LAXPC

Tool is used to simulate event file for LAXPC. The simulated event file can the be used to construct simulated energy dependent lightcurves, power spectra, energy and frequency dependent time-lags using the laxpc data analysis software.

Compilation: gfortran simul.f libcfitsio.a -o Event_simul

Input files : input_fak_specfiles and input_simul

Usage : ./Event_simul

Output : simul_level2.event.fits

Event file simulator: LAXPC (Maxi J1659-152)

Input_fak_specfiles:

(1) Spectrum (fake it/real) file:

Spectra.fak

(2) Background spectrum file:

Backspec.fak

(3) Response file : lx20v1.0.rsp

(4) No. of proportional counters on: 1

(5) Name of output event file:

simul_level2.event.fits

input_simul:

(1) Exposure time for simulation in seconds : 5000

(2) Frequency of QPO in Hz : 4.6

(3) Width of QPO in Hz : 0.25

(4) R.M.S of QPO : 0.06

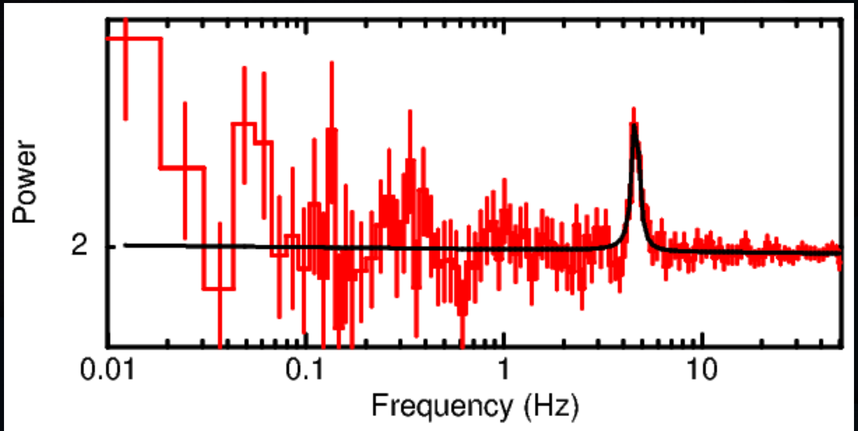
(5) Index of power-law continuum of powerlaw spectrum : 1

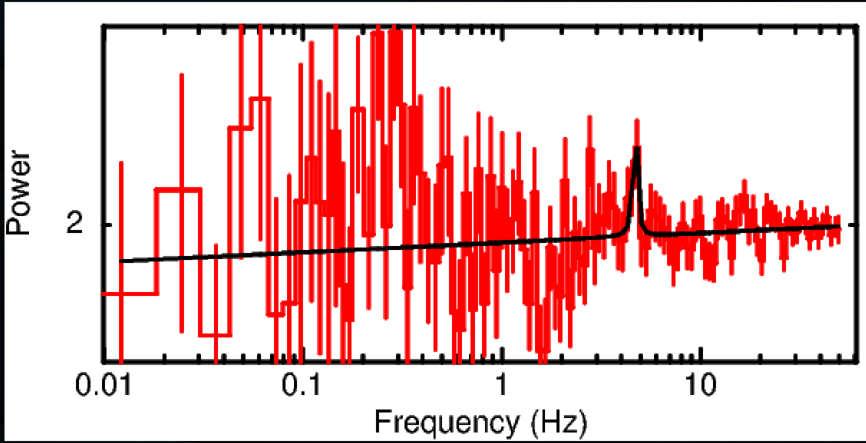
(6) Normalization of power-law continuum : 1e-4

Simulated QPO in 15-25 keV using LAXPC lightcurve:

(i)>laxpc_find_freqlag -l 0.01 -h 50.0 -f 4.6 -p 1 -e eneinput simul_level2.event.fits
gnuplot> plot '1Pow_level2.event' u 3:8 w l (this plots frequency versus power)

(ii)>laxpc_make_lightcurve -p 1 -t 1.0 -e eneinput simul_level2.event.fits





15000 sec exposure

Frequency = 4.6±0.05 Hz
Width=0.41±0.19 Hz,
Q-factor 11.3,   7 sigma

2000 sec exposure

Frequency = 4.6±0.1 Hz,
Width 0.18±0.8 Hz ,
Unable to constraint 1 sigma
error on normalization 0.6

Thank you

Exposure time calculation of UVIT limitation:

- The partial fields are only used if the source of interest is bright and can have **> 0.5 counts/frame for full field**. In such cases, largest possible partial fields should be used to get a rate about 0.5 counts/frame (certainly < 0.8 counts/frame).
- Exposure time calculation for each orbit requires the total data for FUV and NUV images ((Number of FUV frames + Number of NUV frames) * 32000 + Time of exposure * 500000) < **10^{10} bits/orbit.**

South Atlantic Anomaly (SAA)

The South Atlantic Anomaly (SAA) is an area where the Earth's inner Van Allen radiation belt comes closest to the Earth's surface, dipping down to an altitude of 200 kilometres (120 mi). This leads to an increased flux of energetic particles in this region and exposes orbiting satellites to higher-than-usual levels of radiation.

The effect is caused by the non-concentricity of the Earth and its magnetic dipole. The SAA is the near-Earth region where the Earth's magnetic field is weakest relative to an idealized Earth-centered dipole field.