
# 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-9 (Announcement of Opportunity) cycle :***
***1 April 2020 – 30 September 2020***

***The last date for submission of proposals: 14th November, 5pm (IST )***

**Current allocation of Observing Time on AstroSat**

***~65% (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.
- Justification of requested observing time : spectral and / or temporal simulations.
- **New Section : Report on previous successful AstroSat proposals by PI if any.**

**Technical Justification:** (2-page )

- Target visibility: Astroviewer output, AVIS output.
- 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
- 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.
- 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.
- 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 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) Triggering criteria (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)

# 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)<br>< 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. In such a case, proposers should make SXT the primary instrument, even if SXT does not serve the primary science.

# Astroviewer Tool: web based tool

https://webapps.issdc.gov.in/astroviewer/jsp/UserInput.jsp

*AstroSat visibility period for observations of a target of interest.*

**Inputs :**

- Name of the source.
- Right Ascension and Declination of the source in degrees.
- Start/End Time of the proposed duration of observation in UT.

**DEFAULT WRITTEN IN THE webpage**: Angle Limits between Roll and Sun (ROS), Angle Limits between Negative Roll and Sun,Angle Limits between Roll and Moon (ROM), Angle Limits between Roll and velocity vector (RAM), Earth Limb angle.

**To avoid any damage to coating of the primary mirror of UVIT/SXT, due to atomic oxygen, a minimum angle of $12^0$ is kept between the ram direction and the roll-axis, i.e. axis of UVIT.**

**To avoid damage/UV-assisted contamination due to radiation from Sun/bright-Earth/ Moon, a minimum angle of $45^0/12^0/15^0$ is kept between the axis and Sun/ bright-Earth/Moon at all times even if UVIT is not observing.**

# Astroviewer Web-interface

# Astroviewer Source Visibility: Cygnus X-1

ASTROSAT
View Opportunity Duration
System(RUN) time in U.T: 2019 11 8 10 26 48 0

Celestial Source Name : CygnusX1 RA(deg): 299.58700 Dec(deg): 35.20100
Epoch(UT): 2020 3 1 0 0 0 0
Propagation duration in days: 214.000000

Entry and Exit timings of the source viewing

| orbno | Entrance(UT) | Exit(UT) | dur(min) |
|---|---|---|---|
| 024160 | 2020 03 17 11 41 00 000 | 2020 03 17 12 10 00 000 | 29.000 |
| 024161 | 2020 03 17 12 23 25 328 | 2020 03 17 13 03 56 430 | 40.518 |
| 024162 | 2020 03 17 13 31 00 000 | 2020 03 17 13 54 00 000 | 23.000 |
| 024162 | 2020 03 17 14 00 49 799 | 2020 03 17 14 41 21 143 | 40.522 |
| 024163 | 2020 03 17 15 19 00 000 | 2020 03 17 16 18 45 956 | 59.766 |
| 024164 | 2020 03 17 17 05 00 000 | 2020 03 17 17 56 10 771 | 51.180 |
| 024165 | 2020 03 17 18 49 00 000 | 2020 03 17 19 33 35 501 | 44.592 |

Total View duration(does not account all operational constraints) of the source(RA: 299.587000(degrees) Dec: 35.201000(degrees) for the given user period is : 284421.000000(min)

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

# Astroviewer Source Visibility:

# Cygnus X-1

ASTROSAT
View opportunity duration in Eclipse(UVIT)

Celestial Source Name : CygnusX1 RA(deg): 299.58700 Dec(deg): 35.20100
Epoch(UT): 2020 3 1 0 0 0 0
Propagation duration in days: 214.000000

Entry and Exit timings of the source viewing duration in eclipse(UVIT)

| orbno | Entrance(UT) | Exit(UT) | dur(min) |
|---|---|---|---|
| 024161 | 2020 03 17 12 40 40 524 | 2020 03 17 13 03 56 430 | 23.265 |
| 024162 | 2020 03 17 14 18 06 370 | 2020 03 17 14 41 21 143 | 23.246 |
| 024163 | 2020 03 17 15 55 32 454 | 2020 03 17 16 18 45 956 | 23.225 |

ASTROSAT
occult duration

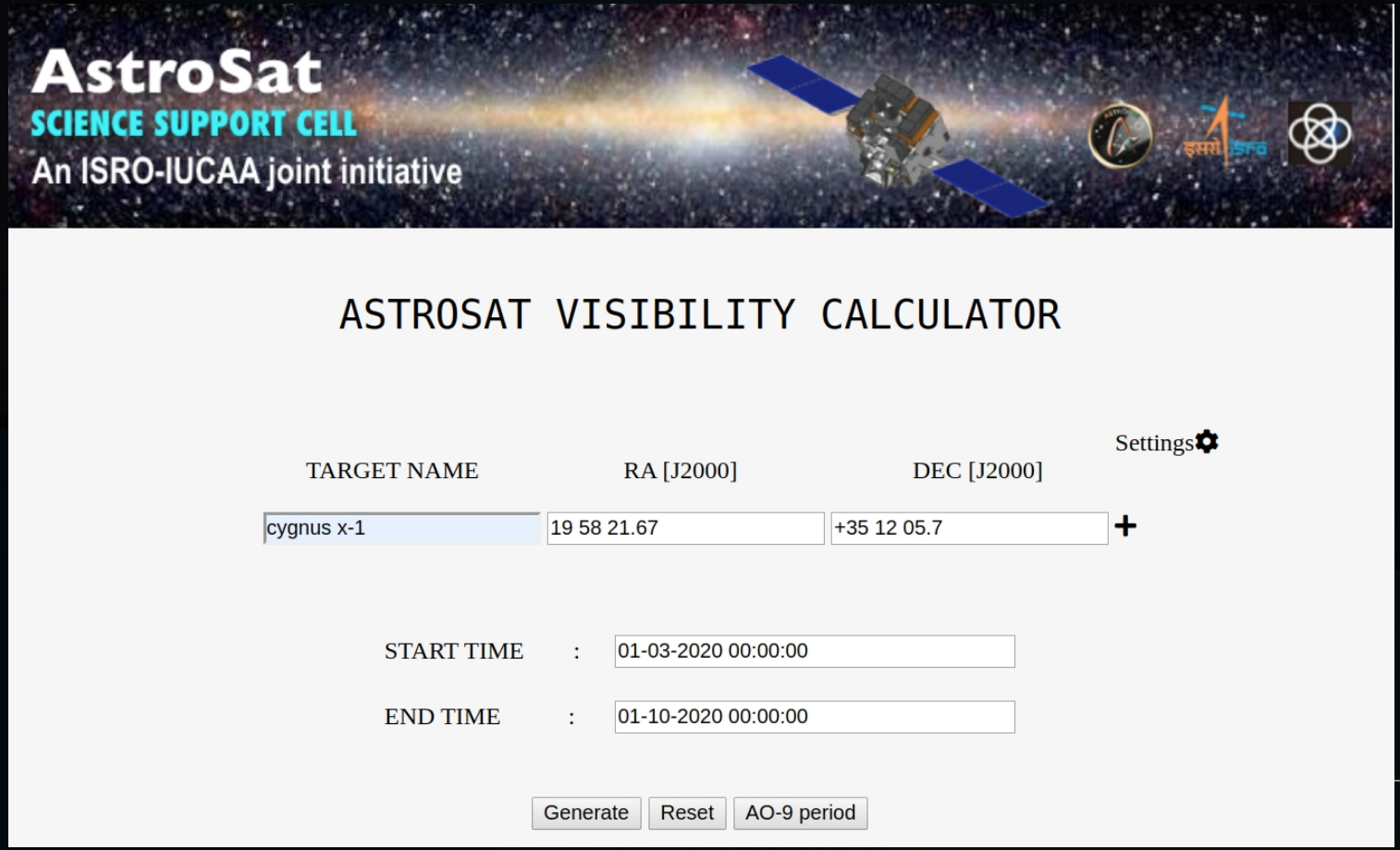
Celestial Source Name : CygnusX1 RA(deg): 299.58700 Dec(deg): 35.20100
Epoch(UT): 2020 3 1 0 0 0 0
Propagation duration in days: 214.000000

Entry and Exit timings of the Occult duration of source

| orbno | Entrance(UT) | Exit(UT) | dur(min) |
|---|---|---|---|
| 023917 | 2020 03 01 00 13 20 587 | 2020 03 01 00 52 55 993 | 39.5901 |
| 023918 | 2020 03 01 01 50 46 144 | 2020 03 01 02 30 21 413 | 39.5878 |
| 023919 | 2020 03 01 03 28 11 732 | 2020 03 01 04 07 46 959 | 39.5871 |
| 023920 | 2020 03 01 05 05 37 362 | 2020 03 01 05 45 12 490 | 39.5855 |
| 023921 | 2020 03 01 06 43 02 846 | 2020 03 01 07 22 37 967 | 39.5854 |
| 023922 | 2020 03 01 08 20 28 554 | 2020 03 01 09 00 03 602 | 39.5841 |
| 023923 | 2020 03 01 09 57 54 046 | 2020 03 01 10 37 29 016 | 39.5828 |
| 023924 | 2020 03 01 11 35 19 717 | 2020 03 01 12 14 54 645 | 39.5821 |

# Avis Online Interface

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

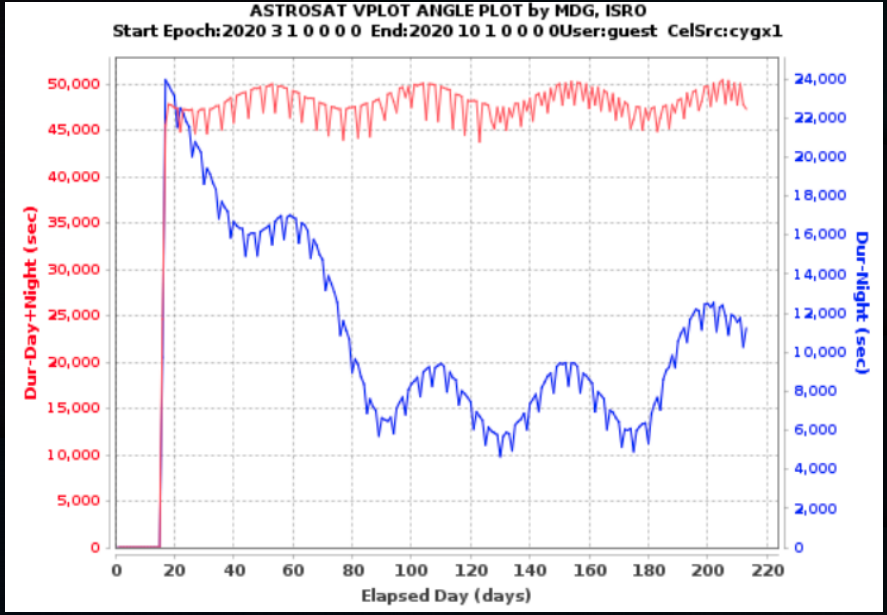


# AVIS Source Visibility: Cygnus X-1

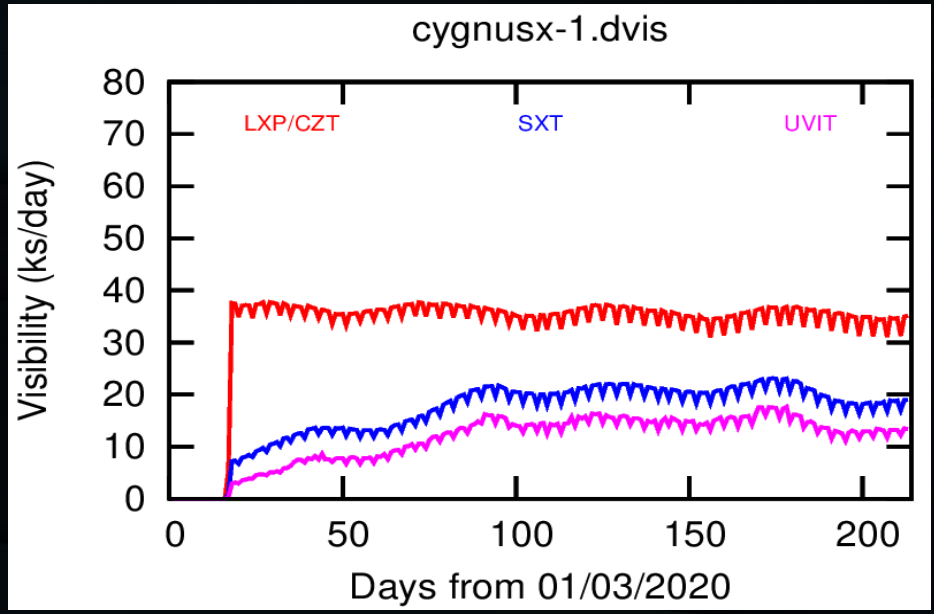
```
# Astrosat Mission. Orbital Period  5860.38 s
# Visibility for cygnusx-1 RA2000: 299.5903 deg Dec2000:  35.2016 deg
# Starting on 1/3/2020 0:0:0.0UT : MJD  58909.0000000
# Constraints: Sun  65.0 Moon 15.0 Ram 12.0 Limb 12.0 NegRollSun  30.0
# SAA Trapz LatRef  -6.0 Long Min -110.0 Max    0.0 Slope L  3.50 R  0.00
# St.MET, elapsed days, MJD, min Ram, Sun ang, Moon ang, vis (s): LXP/CZT, SXT, UVT
#-------------------------------------------------------------------------------
320716800.00    0.0680556 58909.0680556  41.2  58.6  97.5       0.0     0.0     0.0
320722660.38    0.1361111 58909.1361111  41.2  58.6  97.9       0.0     0.0     0.0
320728520.76    0.2041667 58909.2041667  41.2  58.7  98.3       0.0     0.0     0.0
320734381.15    0.2715278 58909.2715278  41.2  58.7  98.8       0.0     0.0     0.0
320740241.53    0.3395833 58909.3395833  41.2  58.7  99.2       0.0     0.0     0.0
320746101.91    0.4076389 58909.4076389  41.2  58.7  99.6       0.0     0.0     0.0
320751962.29    0.4750000 58909.4750000  41.3  58.7 100.0       0.0     0.0     0.0

323816942.28   35.9493056 58944.9493056  32.8  74.4 114.9    2160.0  1080.0   710.0
323822802.66   36.0173611 58945.0173611  32.8  74.5 114.5    2100.0  1140.0   770.0
323828663.04   36.0854167 58945.0854167  32.9  74.5 114.1    1920.0  1080.0   710.0
323834523.43   36.1527778 58945.1527778  32.9  74.5 113.7    2220.0  1140.0   770.0
323840383.81   36.2208333 58945.2208333  32.9  74.6 113.3    2520.0  1140.0   770.0
323846244.19   36.2888889 58945.2888889  33.0  74.6 113.0    2820.0  1080.0   710.0
323852104.57   36.3562500 58945.3562500  33.0  74.6 112.5    3180.0  1140.0   770.0
```

# Astroviewer Source Visibility

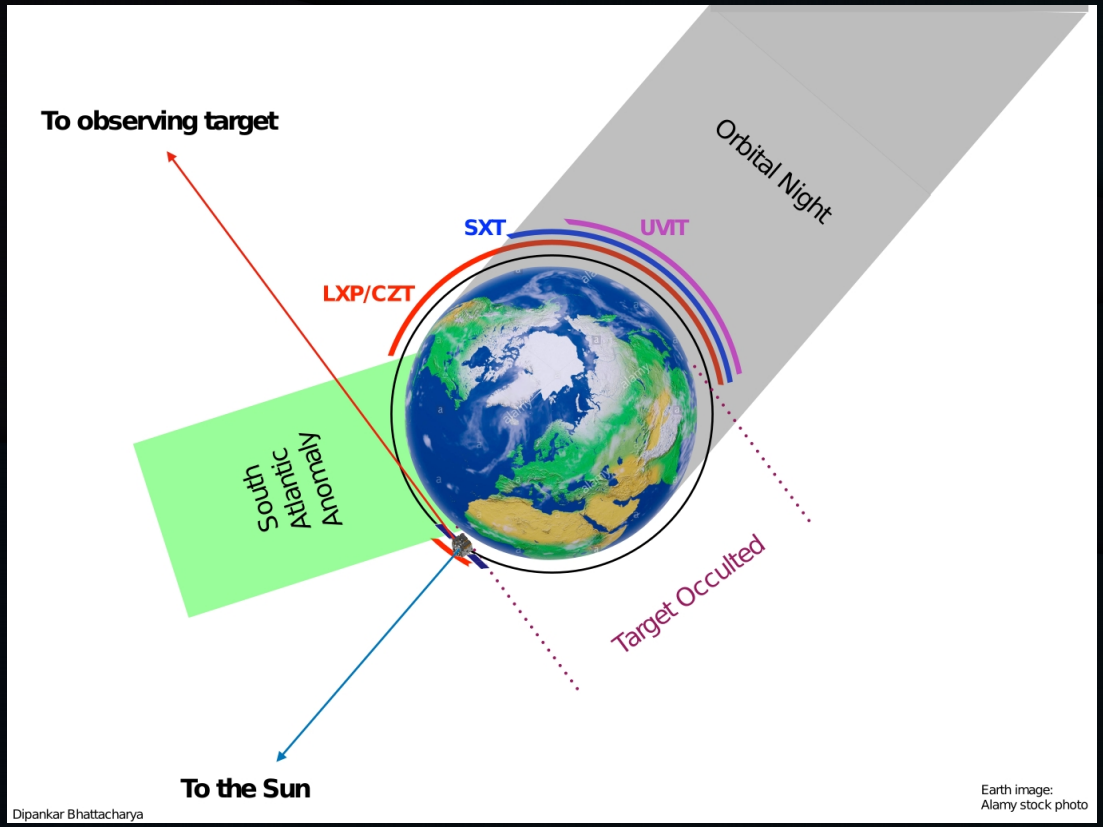



# AVIS Source Visibility




# Cygnus X-1

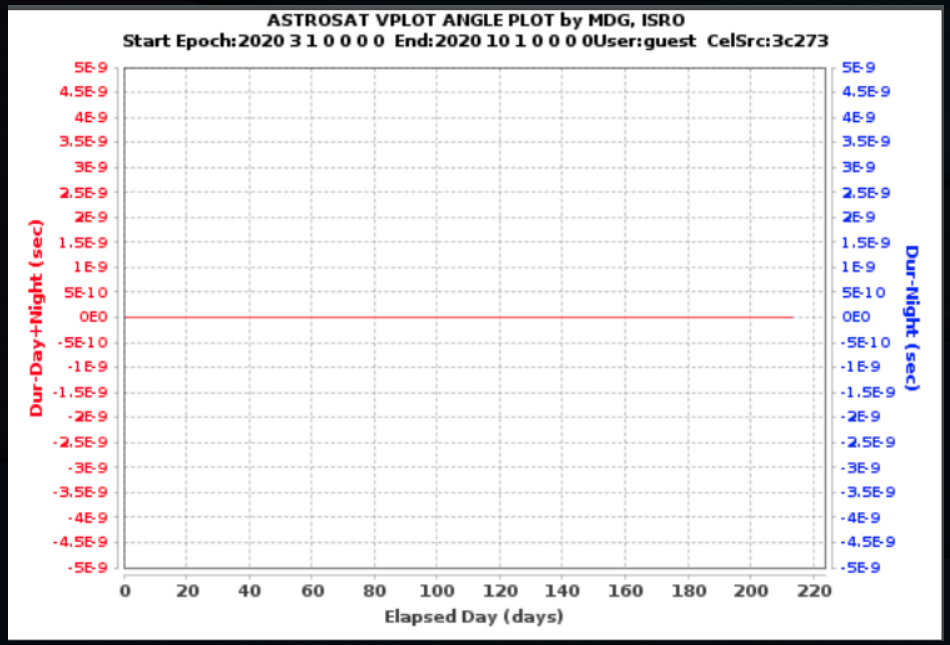
# AstroSat payloads receive different exposures per orbit.



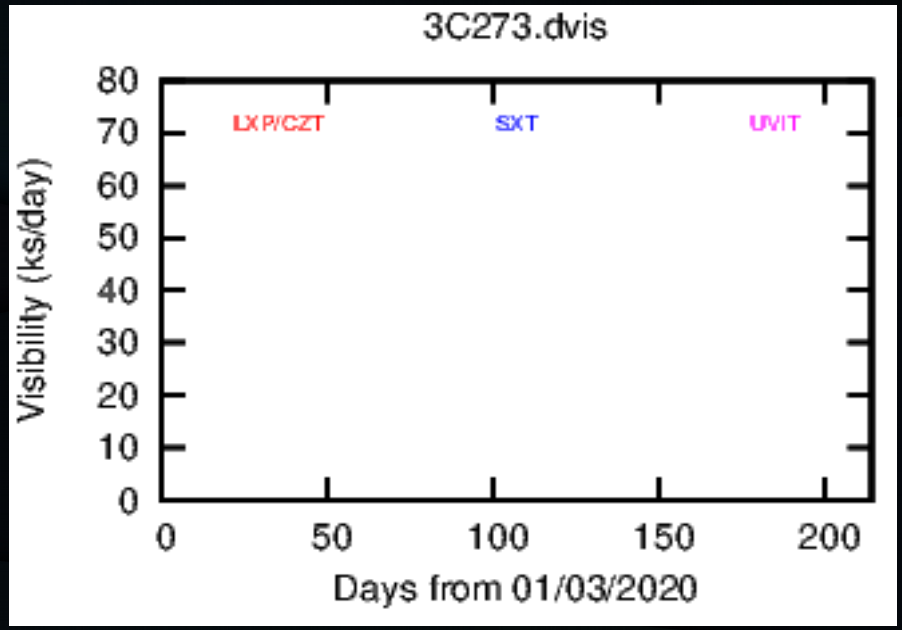

SXT and UVIT can observe only during orbital night. For UVIT there is the additional overhead of switching on after the orbital night begins and switching off before orbital night ends. SXT does not undergo such an on-off sequence.

All instruments are switched off during SAA.

# Astroviewer Source Visibility




# AVIS Source Visibility




## 3C 273

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

# Astroviewer Source Visibility:

## 3C 273

ASTROSAT
View Opportunity Duration
System(RUN) time in U.T: 2019 11 8 10 8 48 0

Celestial Source Name : 3c273 RA(deg): 187.27500 Dec(deg): 2.05200
Epoch(UT): 2020 3 1 0 0 0 0
Propagation duration in days: 214.000000

Entry and Exit timings of the source viewing

| orbno | Entrance(UT) | Exit(UT) | dur(min) |
|---|---|---|---|

no time all the attitude constraints were met for this source for the given period

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ASTROSAT
View opportunity duration in Eclipse(UVIT)

Celestial Source Name : 3c273 RA(deg): 187.27500 Dec(deg): 2.05200
Epoch(UT): 2020 3 1 0 0 0 0
Propagation duration in days: 214.000000

Entry and Exit timings of the source viewing duration in eclipse(UVIT)

| orbno | Entrance(UT) | Exit(UT) | dur(min) |
|---|---|---|---|

no time all the attitude constraints were met for this source for the given period

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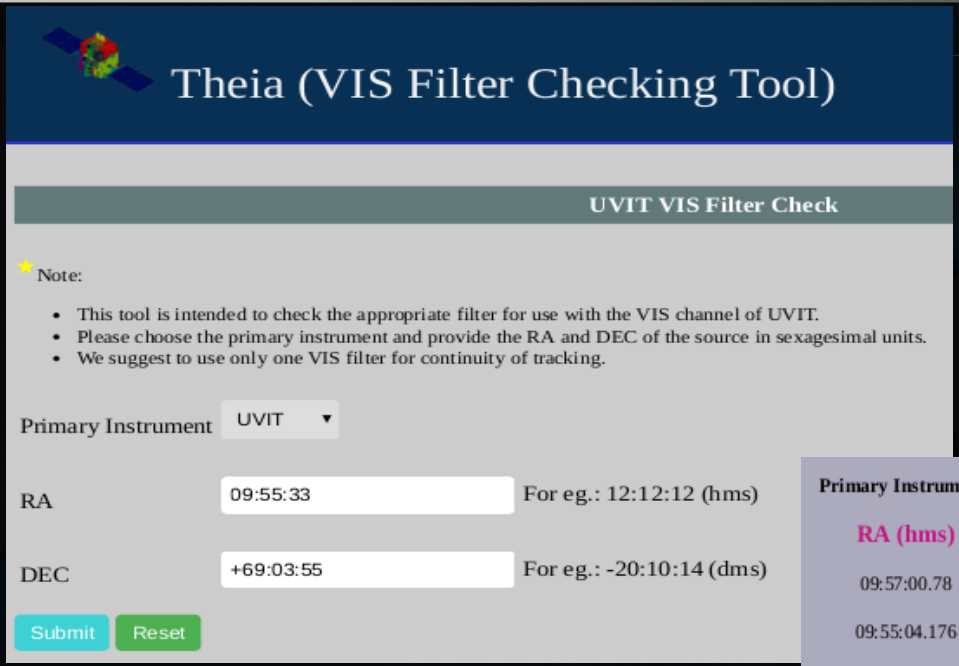
ASTROSAT
occult duration

Celestial Source Name : 3c273 RA(deg): 187.27500 Dec(deg): 2.05200
Epoch(UT): 2020 3 1 0 0 0 0
Propagation duration in days: 214.000000

Entry and Exit timings of the Occult duration of source

| orbno | Entrance(UT) | | | | | | | Exit(UT) | | | | | | | dur(min) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 023916 | 2020 | 03 | 01 | 00 | 00 | 00 | 000 | 2020 | 03 | 01 | 00 | 23 | 54 | 144 | 23.9024 |
| 023917 | 2020 | 03 | 01 | 01 | 19 | 24 | 537 | 2020 | 03 | 01 | 02 | 01 | 18 | 950 | 41.9069 |
| 023918 | 2020 | 03 | 01 | 02 | 56 | 49 | 345 | 2020 | 03 | 01 | 03 | 38 | 43 | 806 | 41.9077 |
| 023919 | 2020 | 03 | 01 | 04 | 34 | 14 | 223 | 2020 | 03 | 01 | 05 | 16 | 08 | 700 | 41.9080 |
| 023920 | 2020 | 03 | 01 | 06 | 11 | 39 | 091 | 2020 | 03 | 01 | 06 | 53 | 33 | 496 | 41.9067 |

# UVIT VIS filter checking tool (Theia)




## Source : M81

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

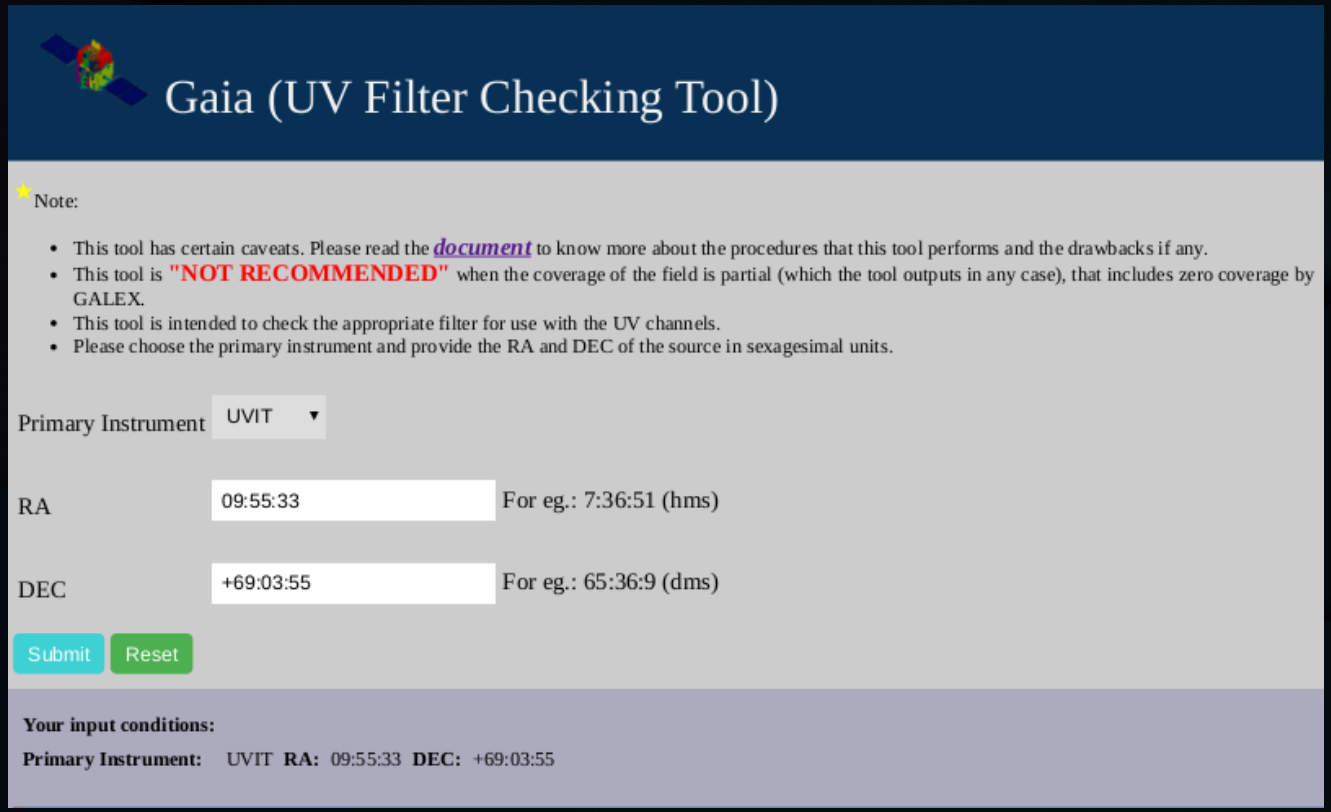
| RA (hms) | DEC (dms) | mag | B-V | SpecType | VIS3 | VIS2 | VIS1 | ND1 | BK7 |
|---|---|---|---|---|---|---|---|---|---|
| 09:57:00.78 | +68:54:06.444 | 9.25 | 1.045 | K4 | 6067.5 | 417.7 | 253.6 | 136.4 | 7161.5 |
| 09:55:04.176 | +68:54:05.724 | 9.256 | 0.415 | F5 | 10800.0 | 1733.3 | 1334.8 | 242.4 | 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)

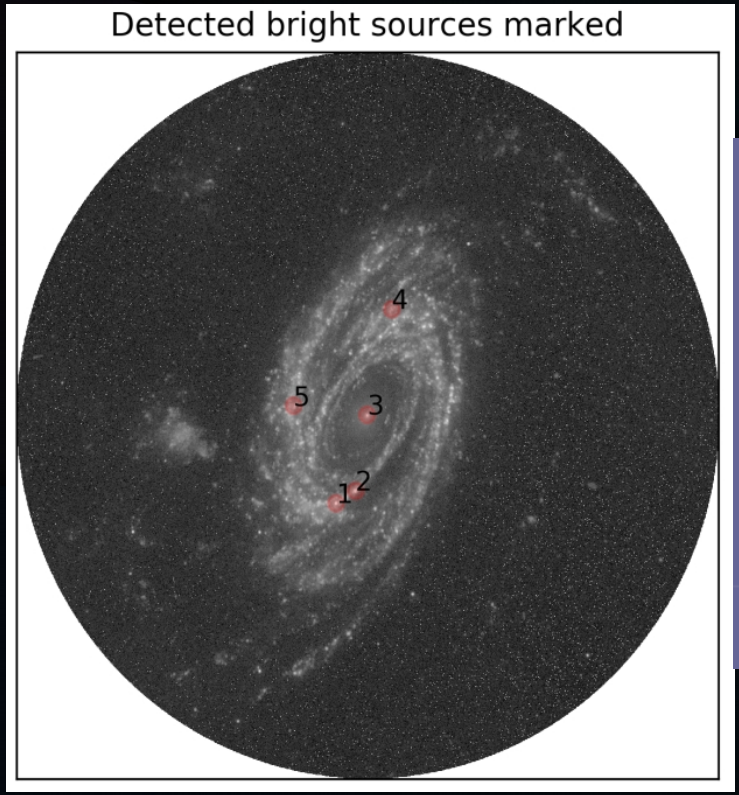
"Further, for good tracking of the aspect, there should be at least 2 stars within 12' radius of the target with count rates greater than 30 c/sec (for good S/N) and lesser than 1000 c/sec (to avoid saturation) in the chosen filter. "

# 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.

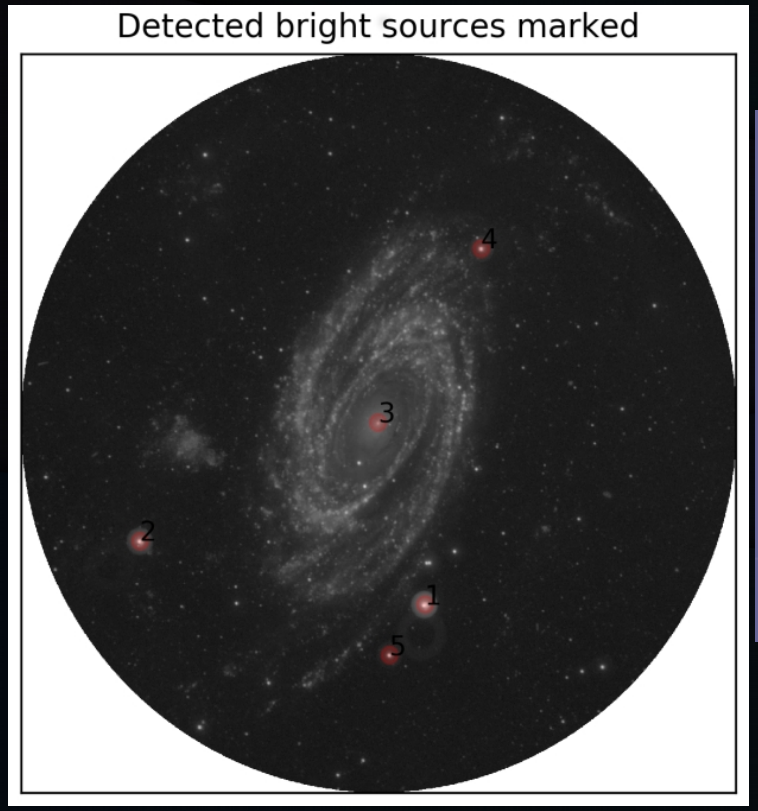
# UVIT FUV filter checking tool Output (Gaia) : M81




| 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.

# Light curve simulator: LAXPC

**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**

# Light curve 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

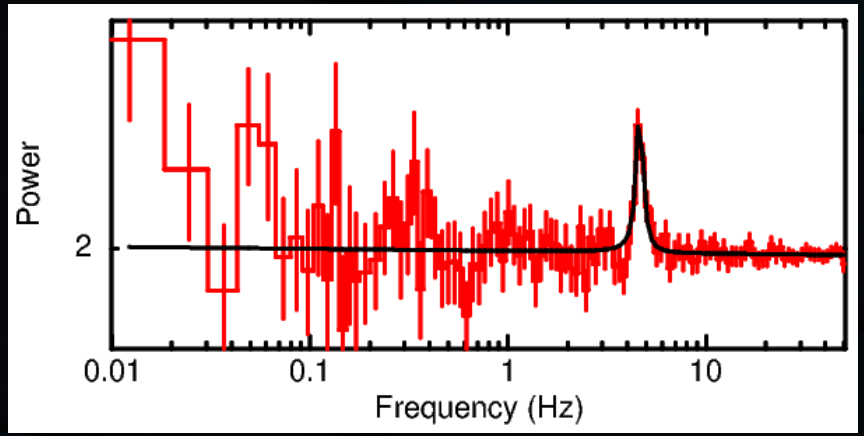
(4) R.M.S of QPO : 0.06

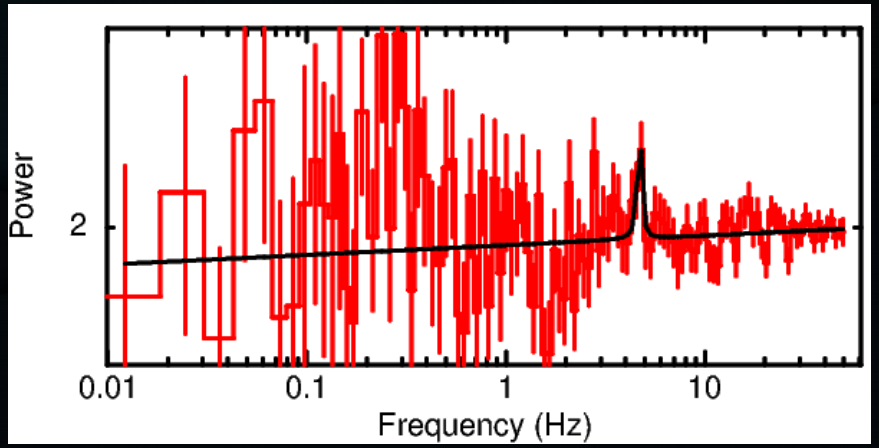
(5) Index of power-law continuum of powerlaw spectrum : 1

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

# Simulated QPO in 15-25 keV using LAXPC lightcurve

**>laxpc_find_freqlag -l 0.01 -h 50.0 -f 4.6 -p 1 -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