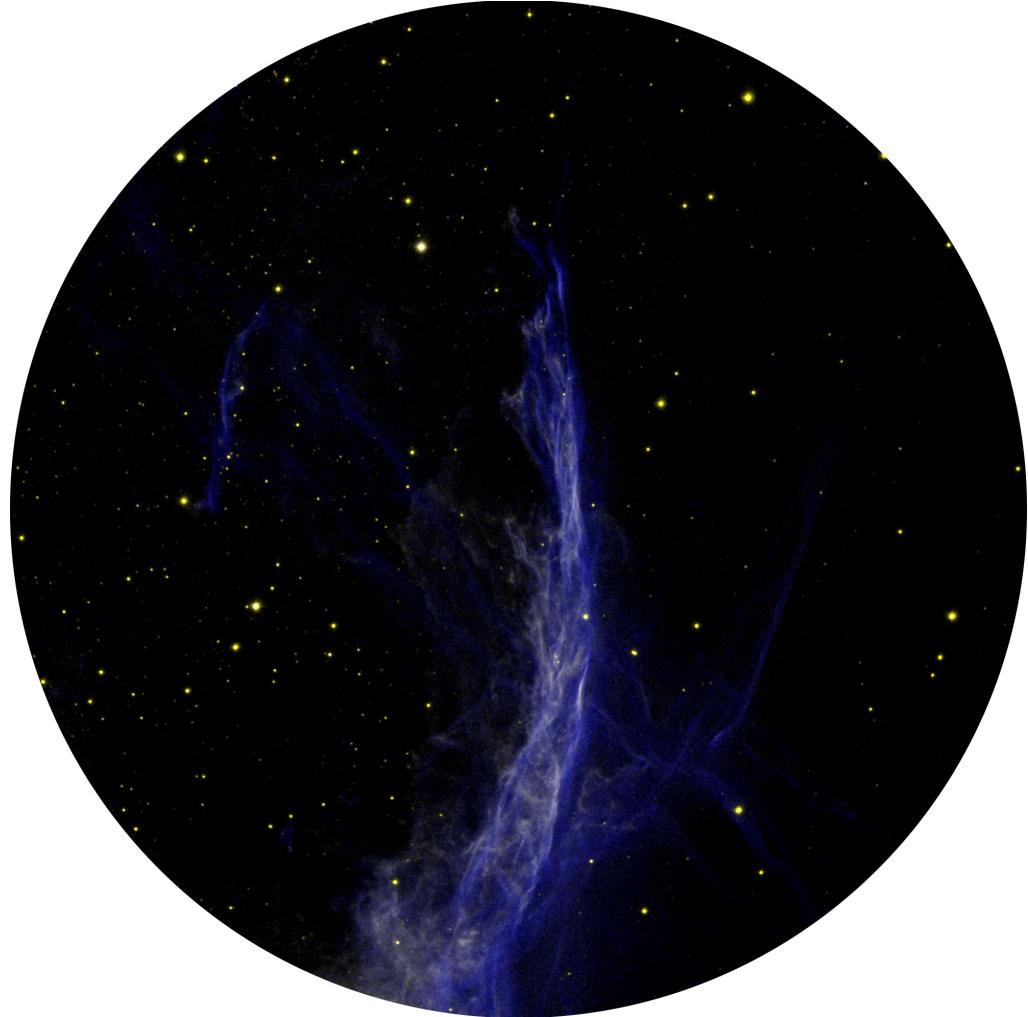


AstroSat UVIT data and analysis

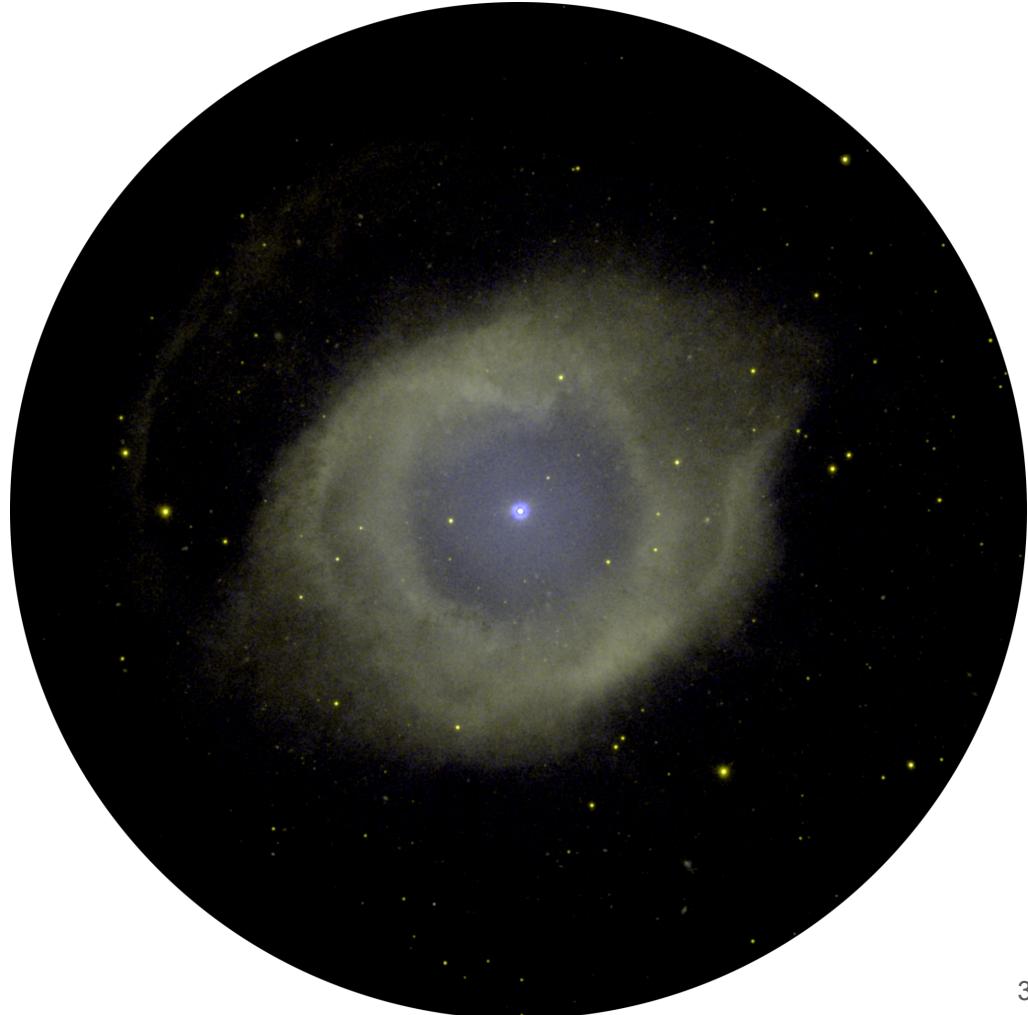
AstroSat UVIT Payload Operations Centre
Indian Institute of Astrophysics, Bangalore

Email: uvit.atc@iiap.res.in

Veil Nebula



Helix Nebula



M101



Visit UVIT Image Gallery on flickr

UVIT Image Gallery

by [llap.scope](#)

The UVIT project is a collaboration between the following institutes from India: Indian Institute of Astrophysics (IIA), Bengaluru, Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune, and National Centre for Radio Astrophysics (NCRA) (TIFR), Pune, various departments and centres of ISRO, and the Canadian Space Agency (CSA).

15 photos • 76 views



Pinwheel Galaxy : M 101



NGC 55



NGC 253



NGC 300

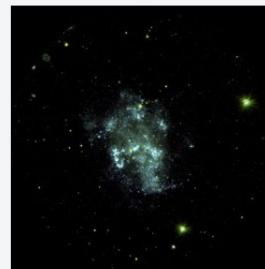


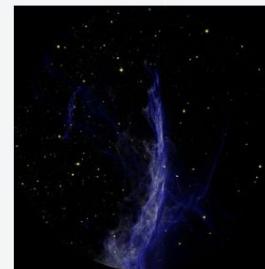
Phantom Galaxy M74









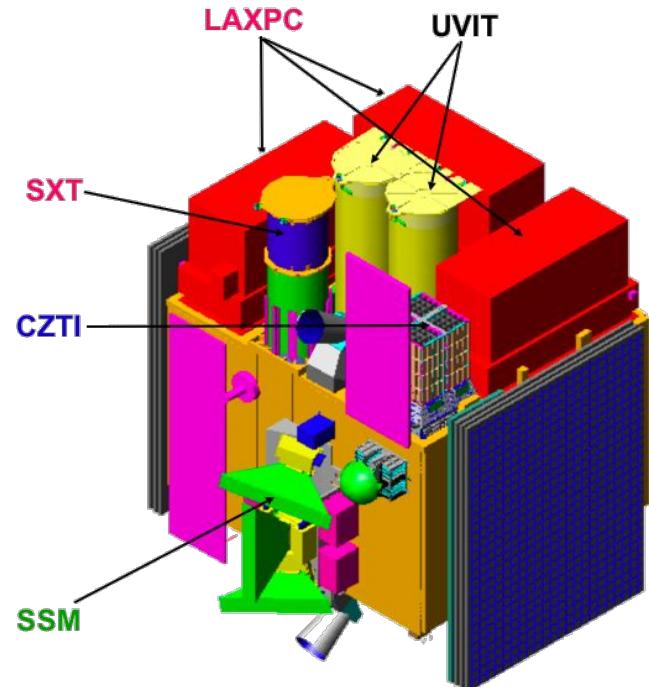




5

AstroSat Mission

- Launched on 28th September 2015.
- 650 km near equatorial orbit.
- Five payloads, including UVIT.
- The expected lifetime was 5 years.
- AstroSat completed 10 years in orbit last September.



How to observe with AstroSat

- Operated as an observatory.
- Proposal-based observatory time allocation.
- Proposal opportunity every year.
- Data becomes public after a proprietary period.
- Data available from ISSDC AstroSat archive.

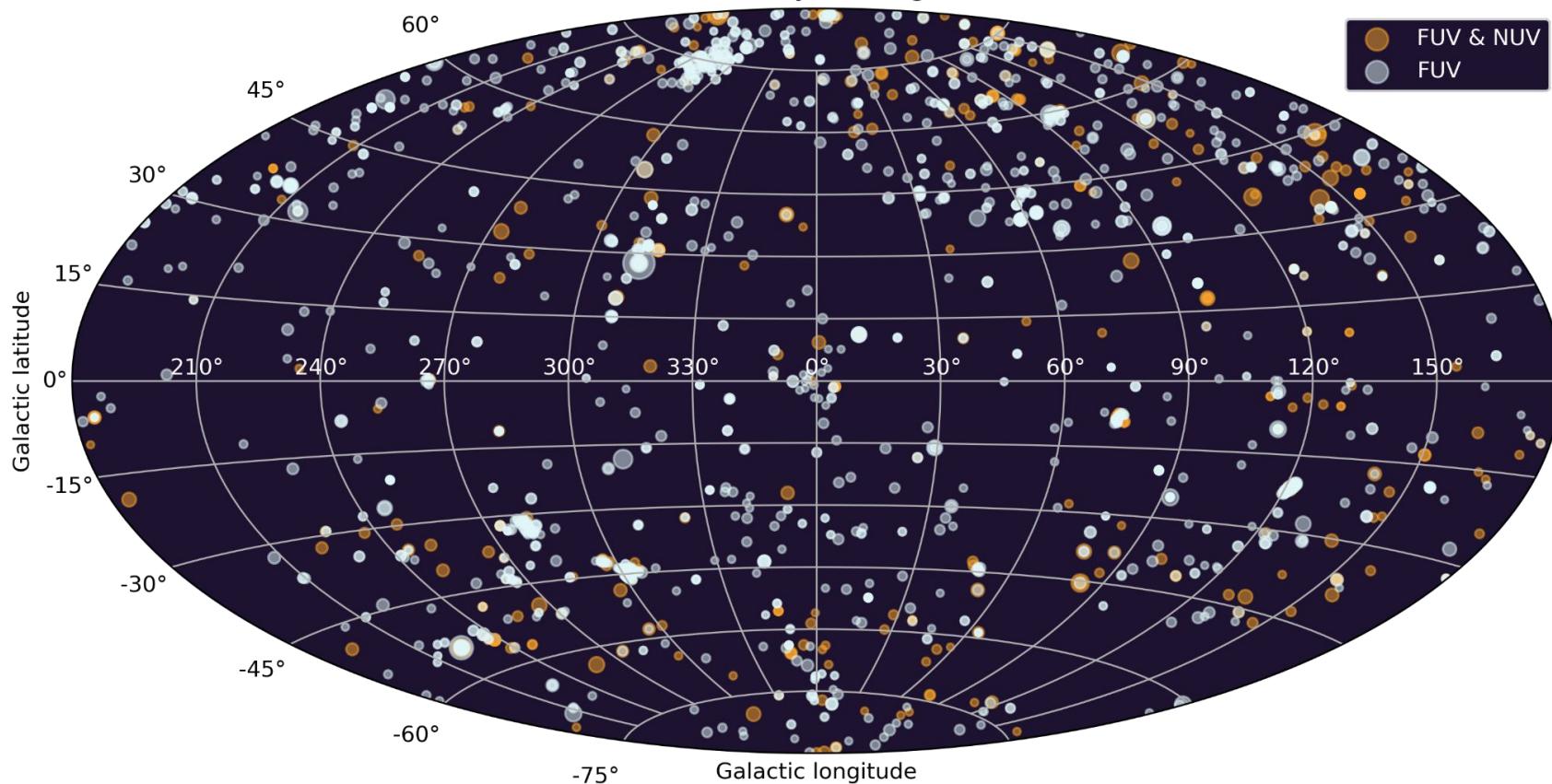


UltraViolet Imaging Telescope (UVIT)

- Primarily an imaging instrument.
- Imaging could be done simultaneously in three channels:
 - FUV (1300-1800 Å)
 - NUV (2000-3000 Å)
 - VIS (3200-5500 Å)
- The field of view has a diameter of 28 arcmin.
- Spatial resolution (FWHM) is <1.8 arcsec.



UVIT Sky Pointings



GALEX

vs

UVIT



UltraViolet Imaging Telescope (UVIT)

- Filters are available to select a band in each channel.
- Gratings for low-resolution slitless spectroscopy.
- Twin telescopes, each with a primary mirror of ~375 mm diameter.



UVIT filters

Properties of Individual Filters Are Shown for the Three Channels

Filter Name	Filter	λ_{mean} (Å)	$\Delta\lambda$ (Å)
FUV:			
F148W	CaF2-1	1481	500
F148Wa	CaF2-2	1485	500
F154W	BaF2	1541	380
F172M	Silica	1717	125
F169M	Sapphire	1608	290
NUV:			
N242W	Silica-1	2418	785
N242Wa	Silica-2	2418	785
N245M	NUVB13	2447	280
N263M	NUVB4	2632	275
N219M	NUVB15	2196	270
N279N	NUVN2	2792	90
VIS:			
V347M	VIS1	3466	400
V391M	VIS2	3909	400
V461W	VIS3	4614	1300
V420W	BK7	4200	2200
V435ND	ND1	4354	2200

The UVIT filters in VIS, NUV and FUV channels

VIS			NUV			FUV		
Filter ID	Old filter name	New filter name	Filter ID	Old filter name	New filter name	Filter ID	Old filter name	New filter name
F1	VIS3	V461W	F1	Silica - 1	N242W	F1	CaF2 - 1	F148W
F2	VIS2	V391M	F2	NUVB15	N219M	F2	BaF2	F154W
F3	VIS1	V347M	F3	NUVB13	N245M	F3	Sapphire	F169M
F4	ND1	V435ND	F4	Grating		F4	Grating - 1	
F5	BK7	V420W	F5	NUVB4	N263M	F5	Silica	F172M
			F6	NUVN2	N279N	F6	Grating - 2	
			F7	Silica - 2	N242Wa	F7	CaF2 - 2	F148Wa

HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)

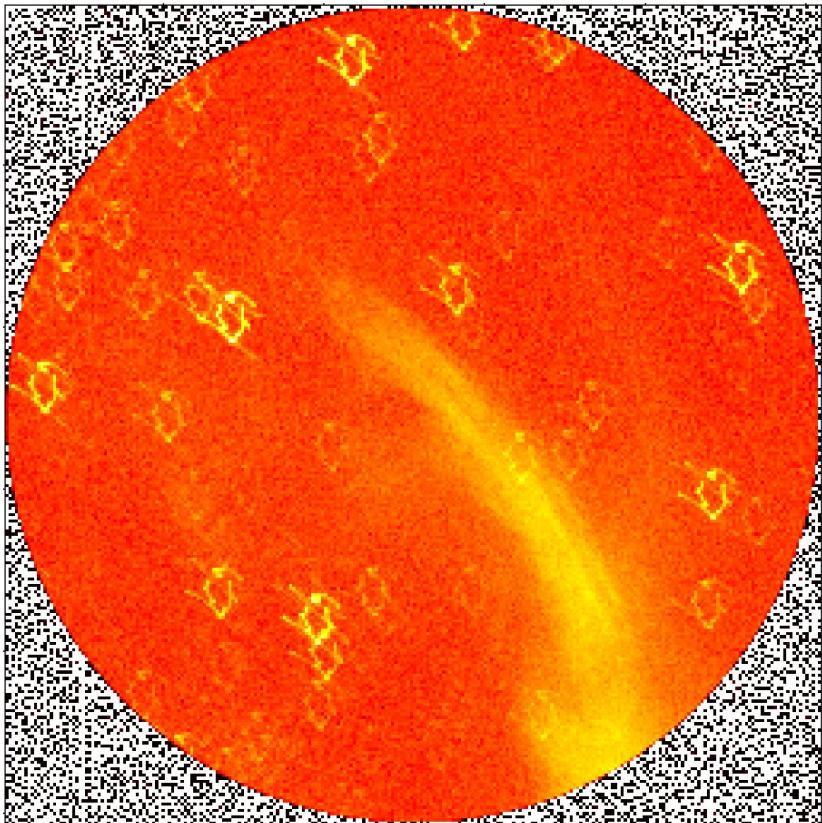


UVIT data reduction

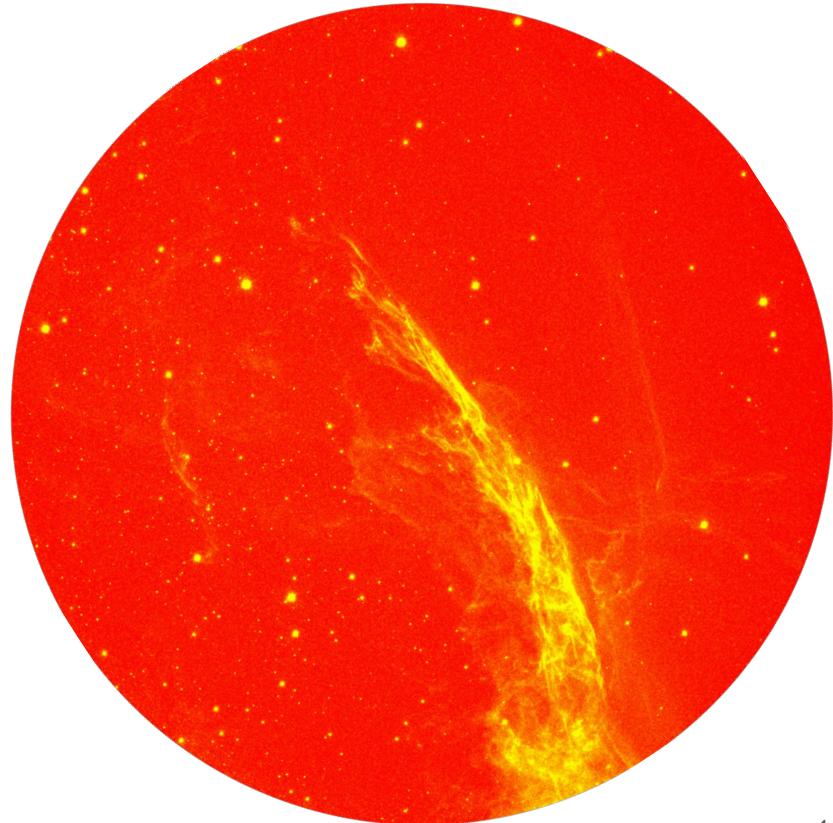
- UVIT data reduction involves the conversion of the low-level (Level1) data to high-level (Level2) data.
- Level1 data mainly consist of
 - ~1-second VIS images and
 - UV photon counting data without pointing drift correction.
- Level2 data contain
 - UV photon counting data with flat-field, distortion, and drift corrections
 - Derived products from Level2 photon counting data:
 - Count-rate and error images and
 - Exposure maps

UVIT data processing

unprocessed

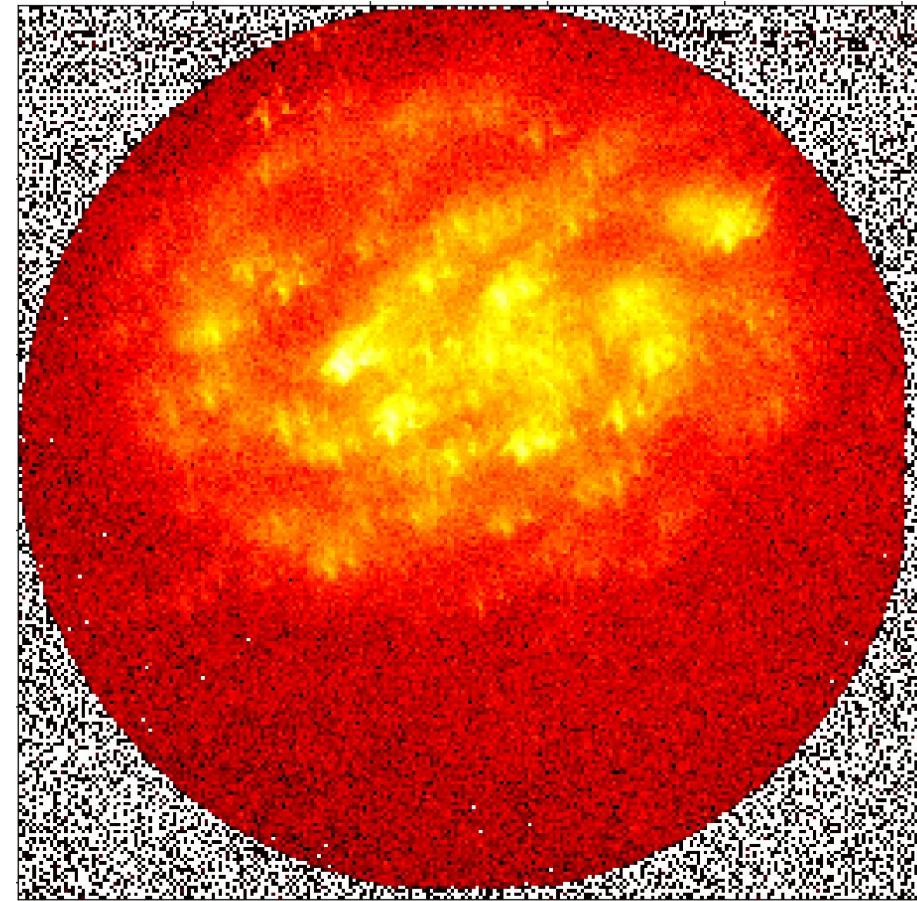


processed

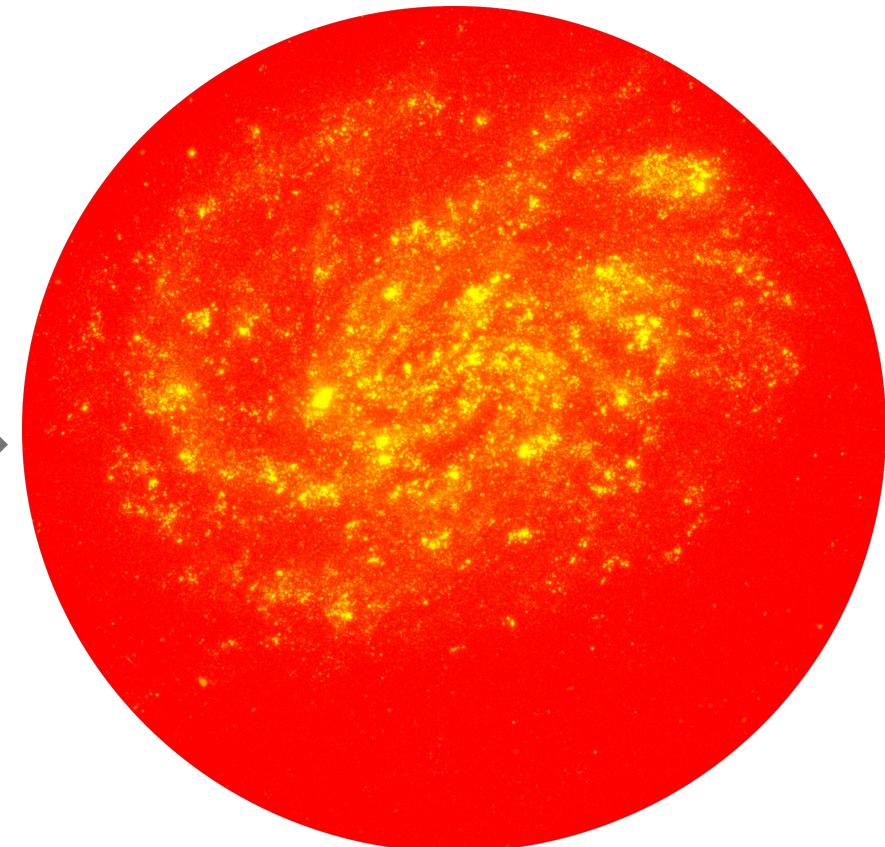


UVIT data processing

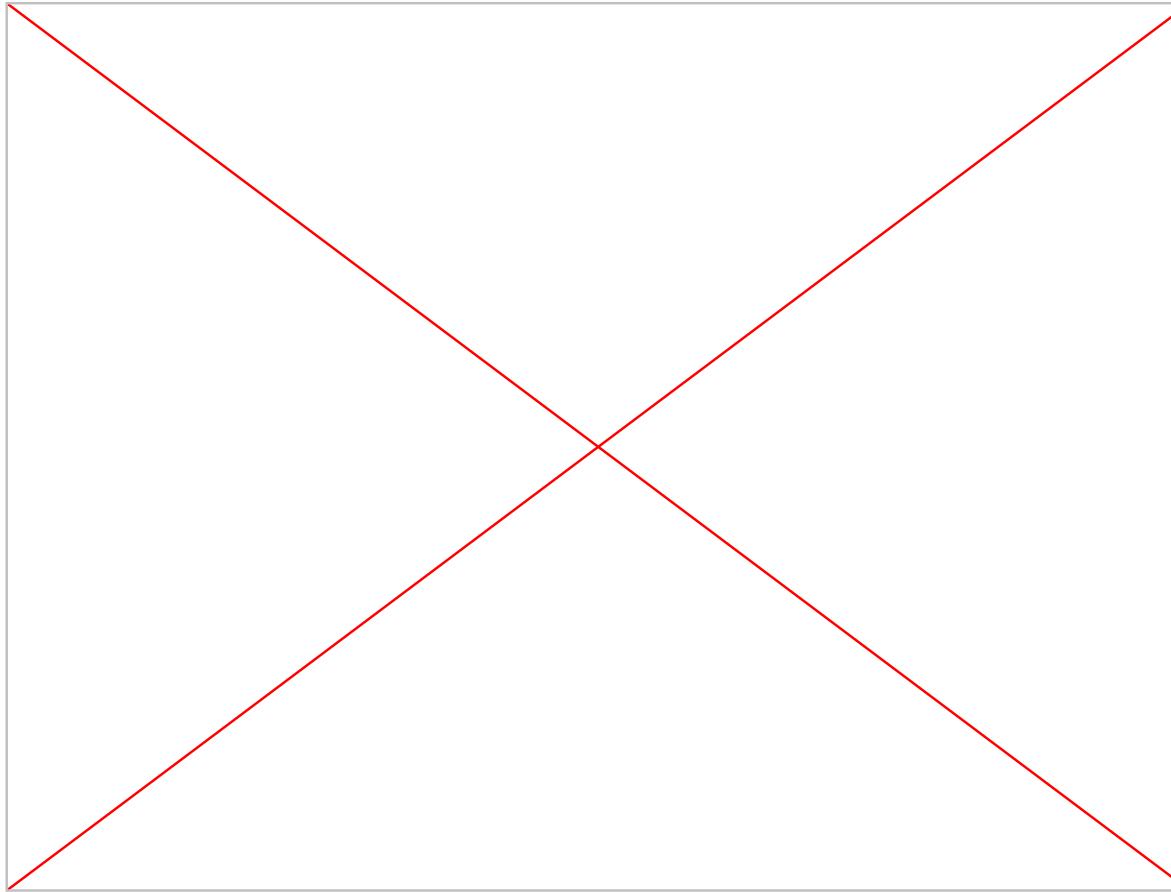
unprocessed



processed



A rare case of large AstroSat pointing drift



Why is UV astrometry difficult?

UVIT FUV



DSS



UVIT data release version 7

Regenerated high-level UVIT data products

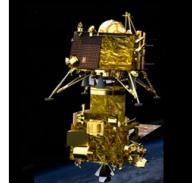
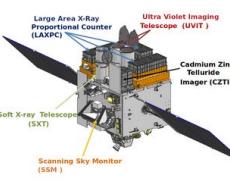
- Addressed the problems in the previous pipeline.
- Introduction of new combined data products.
- Improved metadata, quality metrics, and data accessibility.
- The UVIT POC assesses the quality of each Level2 dataset through automated and visual checks.
- Joseph, Prajwel, et al. "UVIT data release version 7: Regenerated high-level UVIT data products" Journal of Astrophysics and Astronomy 46.2 (2025): 41.

We are transitioning to a new archive: **pradan.issdc.gov.in**

 ISRO Science Data Archive (ISDA)

Home ▾

PRADAN hosted data sets

UVIT calibration

- Tandon, S. N., et al. "In-orbit calibrations of the ultraviolet imaging telescope." *The Astronomical Journal* 154.3 (2017): 128.
 - First calibration paper.
- Tandon, S. N., et al. "Additional calibration of the ultraviolet imaging telescope on board AstroSat." *The Astronomical Journal* 159.4 (2020): 158.
 - Second and latest calibration paper.
 - **Take Zero Point Magnitudes from here!**

Aperture correction

Table 11

Encircled and Associated Error Energy as a Function of Radius in Subpixels

Radius	% Energy (NUV)	% Energy (FUV)
1.5	29.9	28.1
2.0	42.0	40.7
2.5	52.0	51.1
3.0	59.3	59.1
4.0	68.8	68.9
5.0	74.5	74.6
7.0	81.3	81.4
9.0	85.1	85.0
12.0	89.3	88.6
15.0	92.1	91.3
20.0	95.2	94.5
30.0	97.6	96.9
40.0	98.4	97.7
50.0	98.8	98.3
70.0	99.4	99.1
80.0	99.6	99.5
95.0	100.0	100.0

Note. This is based on the analysis of the data obtained using the silica filter in NUV and the CaF₂ filter in FUV.

- Tandon, S. N., et al. "Additional calibration of the ultraviolet imaging telescope on board AstroSat." *The Astronomical Journal* 159.4 (2020): 158.

Saturation correction

- If your source count-rate is high, you need to apply saturation correction.
- Saturation correction prescription is provided in **Tandon, S. N., et al.** "In-orbit calibrations of the ultraviolet imaging telescope." *The Astronomical Journal* 154.3 (2017): 128.

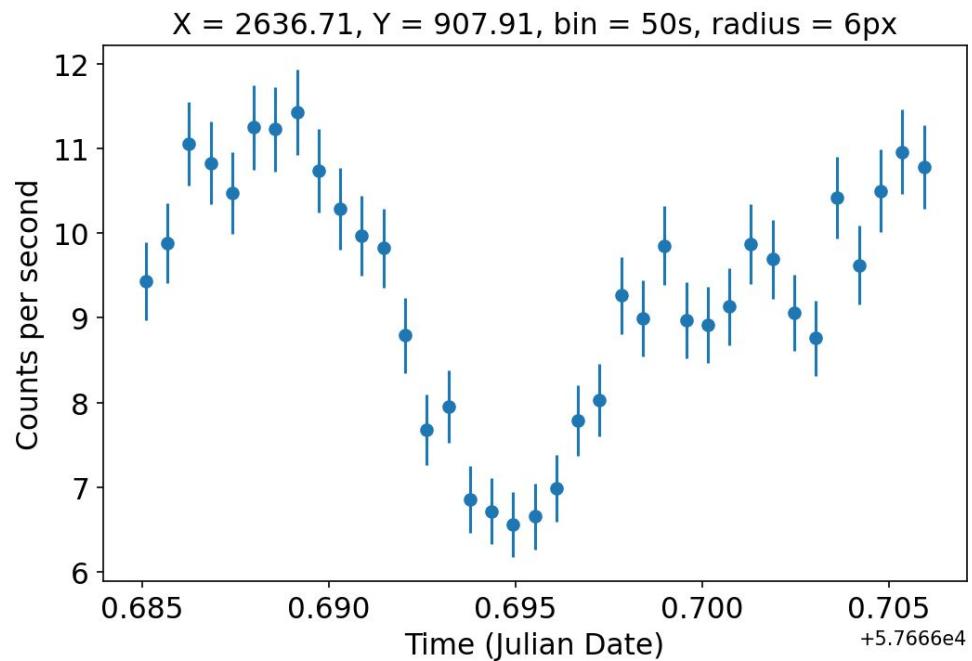
$$\text{CPF5} = (1 - \exp(-\text{ICPF5})) \quad (11)$$

$$\text{ICORR} = (\text{ICPF5}) - (\text{CPF5}) \quad (12)$$

$$\text{RCORR} = \text{ICORR} \times (0.89 - 0.30 \times (\text{ICORR})^2), \quad (13)$$

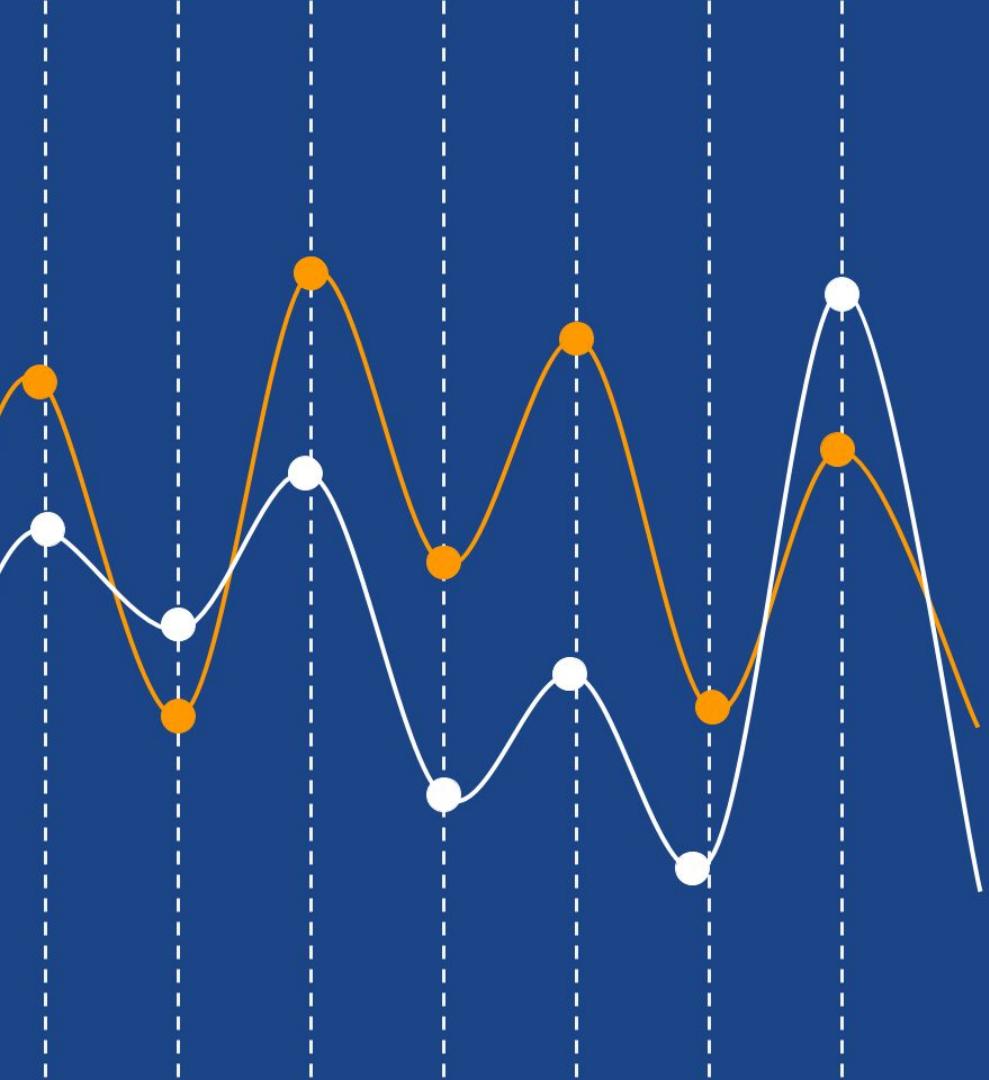
Curvit: create light curves from UVIT data

<https://curvit.readthedocs.io/en/latest/>



Curvit

An open-source Python package to
generate light curves from UVIT data



Visit

<https://github.com/prajwel/curvit>

Installation

pip install curvit

Requirements

- Python 3.7 or higher
- Astropy
- Astroalign
- Aafitrans
- Astroquery
- Matplotlib
- Numpy
- Photutils
- Scipy

Documentation at

<https://curvit.readthedocs.io>



Welcome to Curvit's documentation! This website will walk you through the steps of installing and getting familiarized with Curvit and creating light curves using UVIT data.

Important

If you use Curvit for work presented in a publication or talk, please help by providing a [Citation](#).

Caution

The software is under [active development](#). For new features and bug fixes, please check [Changelog](#).

CONTENTS:

- [Preamble](#)
- [Installation](#)
- [Getting started](#)
- [Citation](#)
- [API](#)
- [Report bugs and contribute](#)
- [Changelog](#)

UV variability studies with UVIT

- Lots of data is in the public domain.
- Submit a new proposal!
- A time resolution of ~66 msec.
- Even higher time resolution is also possible.



Required input FITS file



UVIT L2 events list

L2 events list

Frame counts	Fx	Fy	ENP	MJD_L2
:	:	:	:	:
3	2461.9	2918.0	28.5	213453019.048
3	3139.5	3651.2	25.6	213453019.048
4	875.9	2924.2	23.8	213453019.084
4	1444.0	3605.5	23.7	213453019.084
4	2166.7	3934.6	24.8	213453019.084
5	3355.4	1229.8	25.6	213453019.120
5	3216.9	1497.7	26.3	213453019.120
5	2798.5	3836.8	25.7	213453019.120
6	3113.4	2230.7	27.5	213453019.156
6	4367.8	2483.6	20.7	213453019.156
:	:	:	:	:

Two main functions

makecurves

Automatically detects sources in the events list, creates light curves for all of them.

curve

If you have a single source of interest of known coordinates, use this function.

Both functions can do automatic background estimation, aperture correction, & saturation correction.

Curvit workflow

UVIT L2 events list

makecurves

curve

Get data from PRADAN

UVIT L2 data is available
from the PRADAN
AstroSat archive.

**Identify and study
sources of interest**

The automatic source
detection and light curve
generation will help to
identify interesting
sources.

Study sources of interest

To extract the light curve
for a single source.

makecurves example run

```
import curvit
curvit.makecurves(events_list = 'AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.fits.gz',
                   background = 'auto')
```

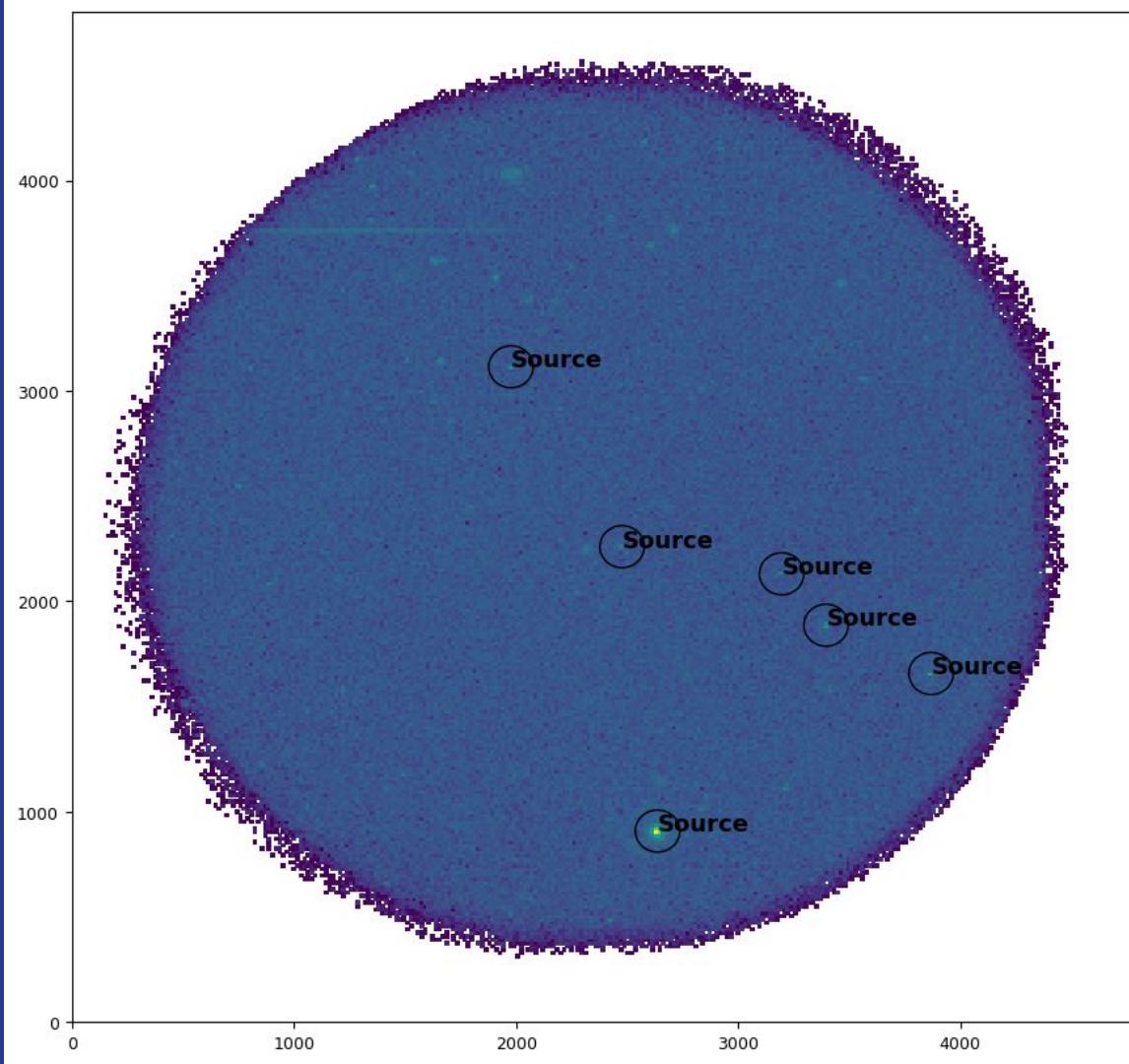
```
Detected source coordinates saved in file:
* sources_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.coo
Detected sources are plotted in the image:
* sources_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.png

The estimated background CPS = 0.00332 +/-0.00066
```

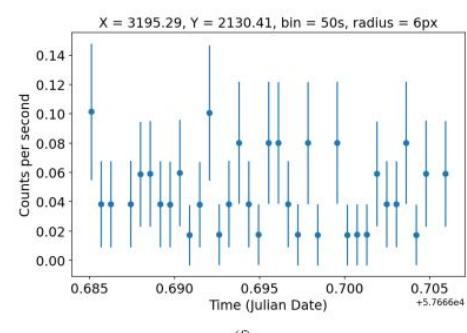
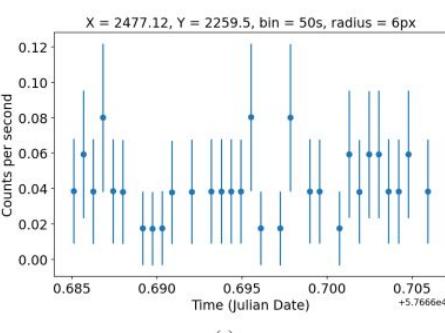
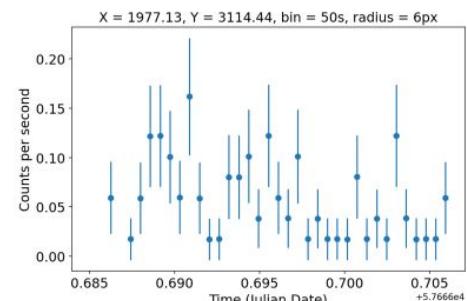
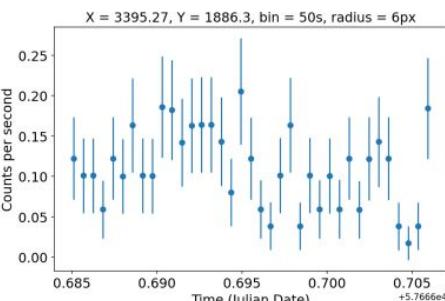
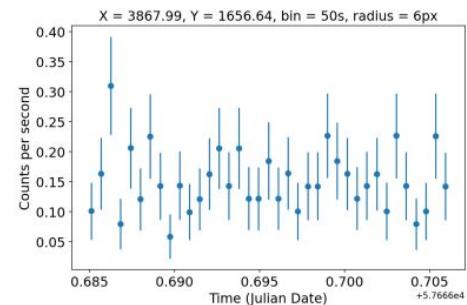
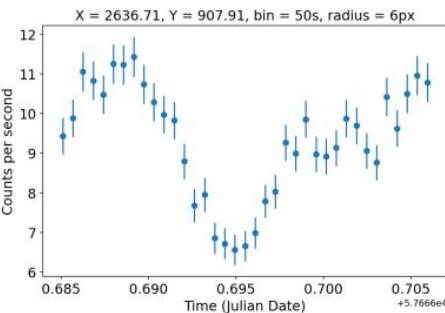
```
----- light curves -----
* makecurves_2636.71_907.91_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.png
* makecurves_3867.99_1656.64_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.png
* makecurves_3395.27_1886.3_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.png
* makecurves_1977.13_3114.44_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.png
* makecurves_2477.12_2259.5_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.png
* makecurves_3195.29_2130.41_AS1G06_084T01_9000000710uvtfIIPC00F1_l2ce.png
```

Done!

makecurves example run



makecurves example run



curve example run

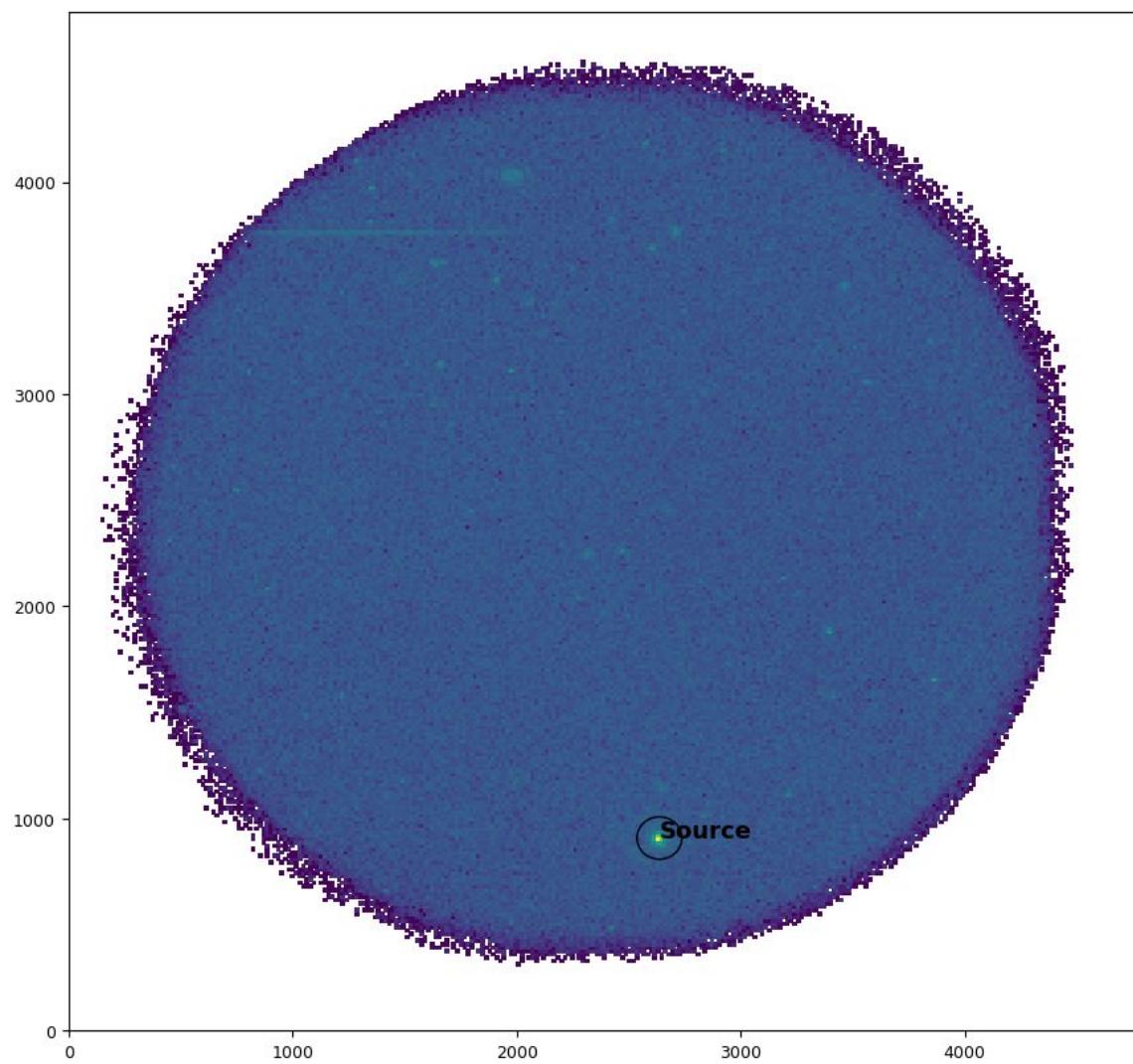
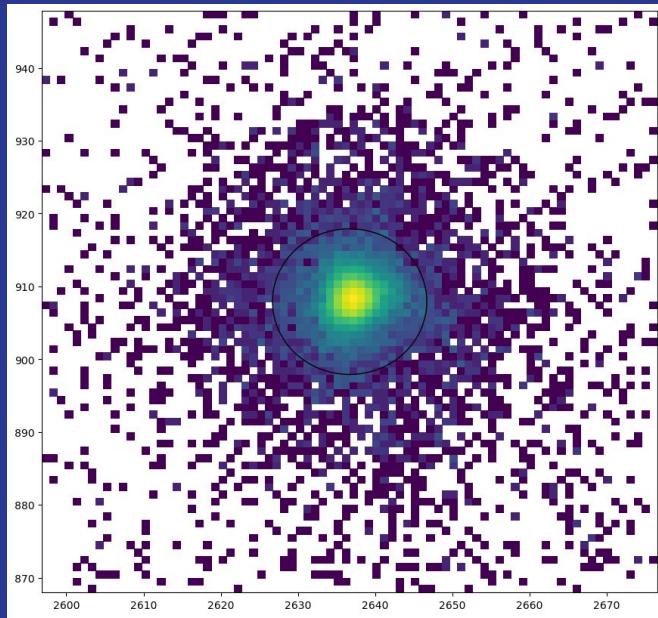
```
curvit.curve(events_list = 'AS1G06_084T01_9000000710uvtFIIPC00F1_l2ce.fits.gz',
              xp = 2636.71, yp = 907.91,
              radius = 10,
              bwidth = 25,
              background = 'auto')
```

The estimated background CPS = 0.00329 +/- 0.00066

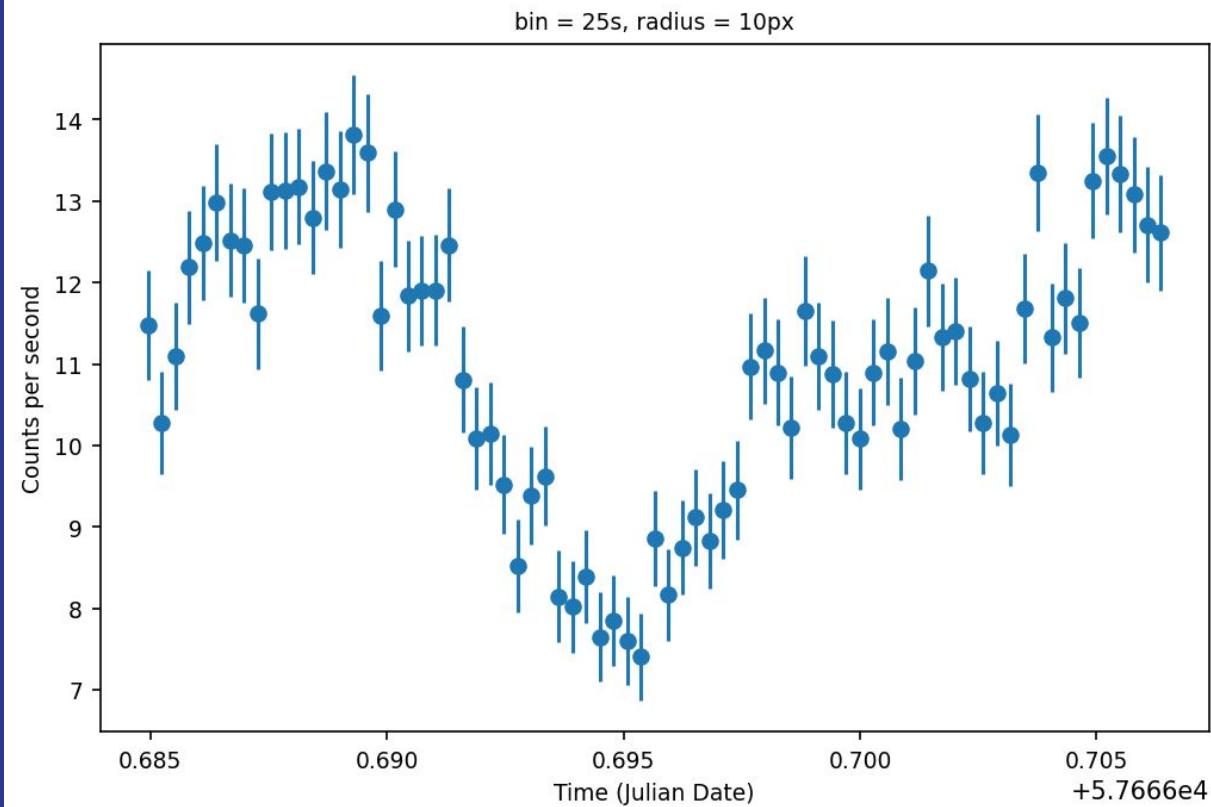
```
----- curve -----
source: source_AS1G06_084T01_9000000710uvtFIIPC00F1_l2ce.png
        source_zoomed_AS1G06_084T01_9000000710uvtFIIPC00F1_l2ce.png
data: curve_2636.71_907.91_AS1G06_084T01_9000000710uvtFIIPC00F1_l2ce.dat
plot: curve_2636.71_907.91_AS1G06_084T01_9000000710uvtFIIPC00F1_l2ce.png
```

Done!

curve example run



curve example run



Curvit paper is published on JAA (AstroSat Special issue)

J. Astrophys. Astr. (2021) 42:25
<https://doi.org/10.1007/s12036-020-09680-5>

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DATA PIPELINE

Curvit: An open-source Python package to generate light curves from UVIT data

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Abstract. *Curvit* is an open-source Python package that facilitates the creation of light curves from the data collected by the Ultra-Violet Imaging Telescope (UVIT) onboard AstroSat, India's first multi-wavelength astronomical satellite. The input to *Curvit* is the calibrated events list generated by the UVIT-Payload Operation Center (UVIT-POC) and made available to the principal investigators through the Indian Space Science Data Center. The features of *Curvit* include: (i) automatically detecting sources and generating light curves for all the detected sources and (ii) custom generation of light curve for any particular source of interest. We present here the capabilities of *Curvit* and demonstrate its usability on the UVIT observations of the intermediate polar FO Aqr as an example. *Curvit* is publicly available on GitHub at <https://github.com/prajwel/curvit>.

Keyword. AstroSat—UVIT—variability.