AstroSat
Looking Back, Looking Ahead

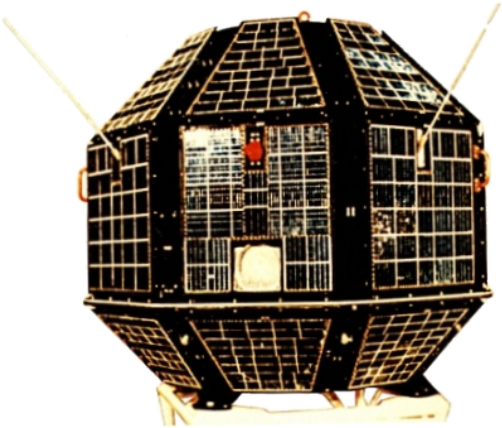
Seetha, S.

ASSC Workshop
On
Advanced AstroSat Data Analysis, IUCAA
21-30 June, 2021

Beginning

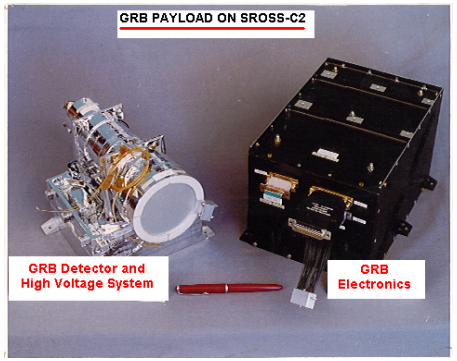
- Space Science in India began using Balloon facility of TIFR in Hyderabad, and the Sounding Rockets from Thumba; These are still operational, for Astronomy and atmospheric astronomy experiments

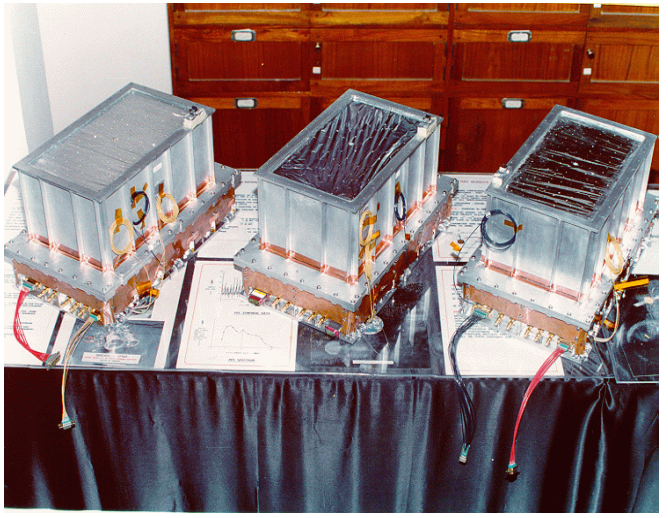
- The first Indian satellites AryaBhata and Bhaskara-I also carried astronomy experiments



Piggy back Experiments on Satellites

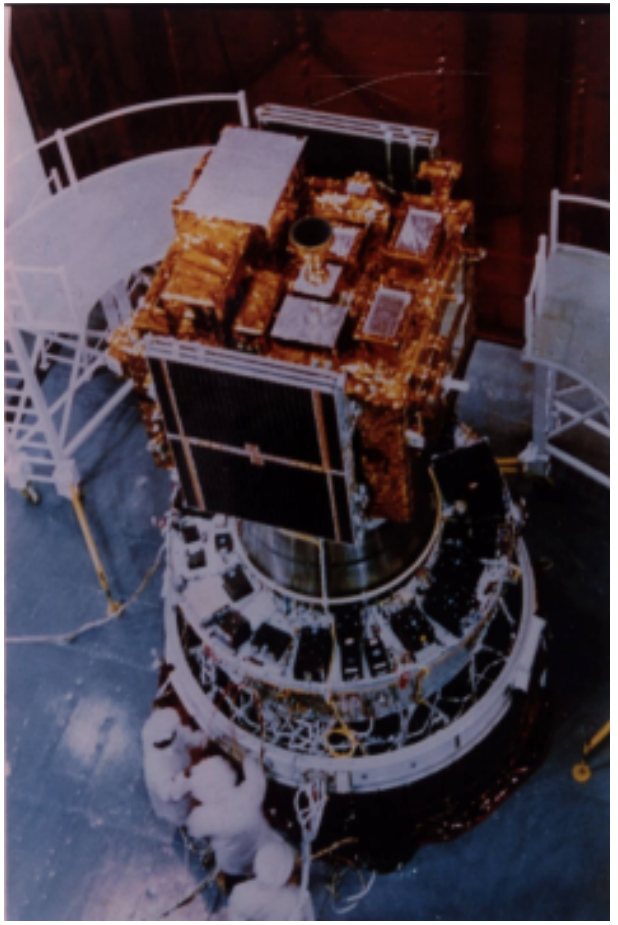
- When Indian Launch vehicles were available, science experiments got a ride on several Indian satellites
- Gamma Ray burst experiment on SROSS series of Satellites
- Indian X-ray Astronomy Experiment (IXAE) by TIFR and ISRO, on IRS-P3
- Solar X-ray Experiment on GSAT-2
- In parallel, Cosmic ray experiment Anuradha, and RT-2 experiment were also flown using foreign satellites





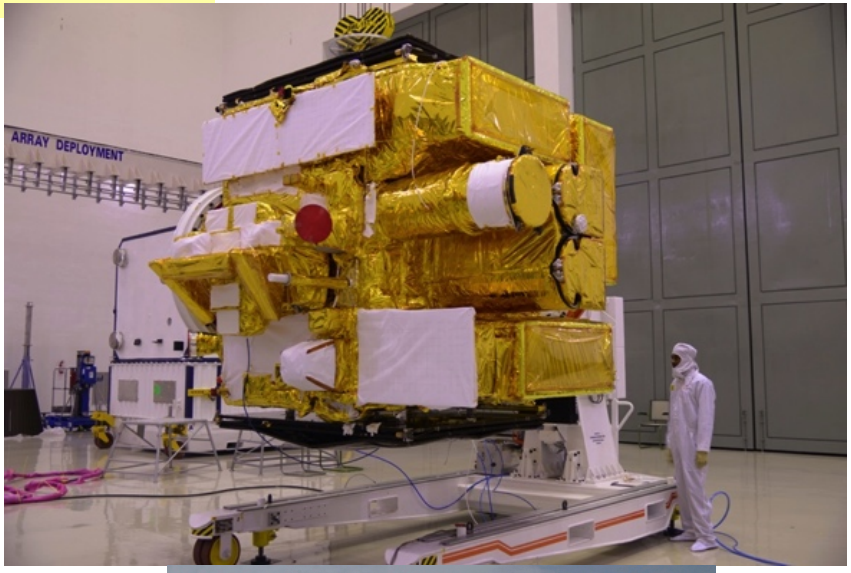
Foundation for AstroSat

- Success of the piggy back experiments led the scientific teams to propose for a full fledged Astronomy satellite mission.
- The capability of IRS-P3 to point IXAE and observe individual sources in the sky
- Scientific and Technical capability to realise the payloads



About AstroSat

- The first dedicated multi-wavelength astronomy satellite from India
- Collaboration of ISRO and several Science Institutes/University/Agency
- Launched on 28 Sept. 2015, by PSLV-XL C30 into a 650km orbit, 6 degree inclination; Has completed 5 years of design life
- Five main payloads + charge particle monitor



Ultraviolet Imaging Telescope (UVIT)

To image the sky simultaneously in three wavelengths: FUV (130-180 nm), NUV (200-300 nm), and VIS (320-550 nm).

Indian Institute of Astrophysics (IIA) - IUCAA. Collaboration with Canadian Space Agency (CSA); UV Optics - LEOS

- Twin Ritchey-Chretien, Two mirror system
- Intensified CMOS in photon counting / integration mode
- Image resolution ~ goal 1.8” ; achieved <1.5”
- Best image resolution in UV over a large FOV (28’)
- VIS channel used for drift corrections
- Present status – FUV and VIS channels operating with same sensitivity after launch

Soft X-ray Telescope (SXT)

X-ray spectrum and variability studies in the energy range 0.3 to 8 keV.

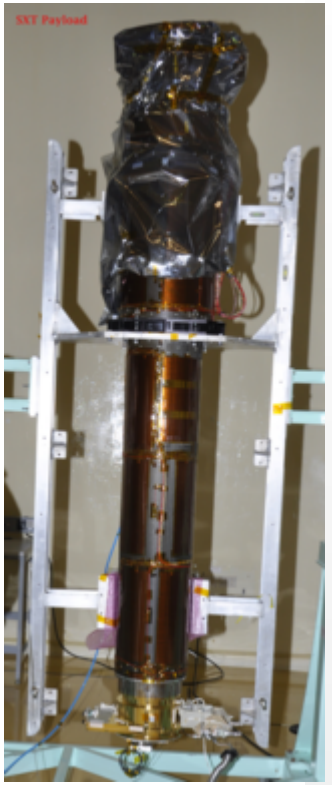
Tata Institute of Fundamental Research (TIFR), with Univ. of Leicester, UK,

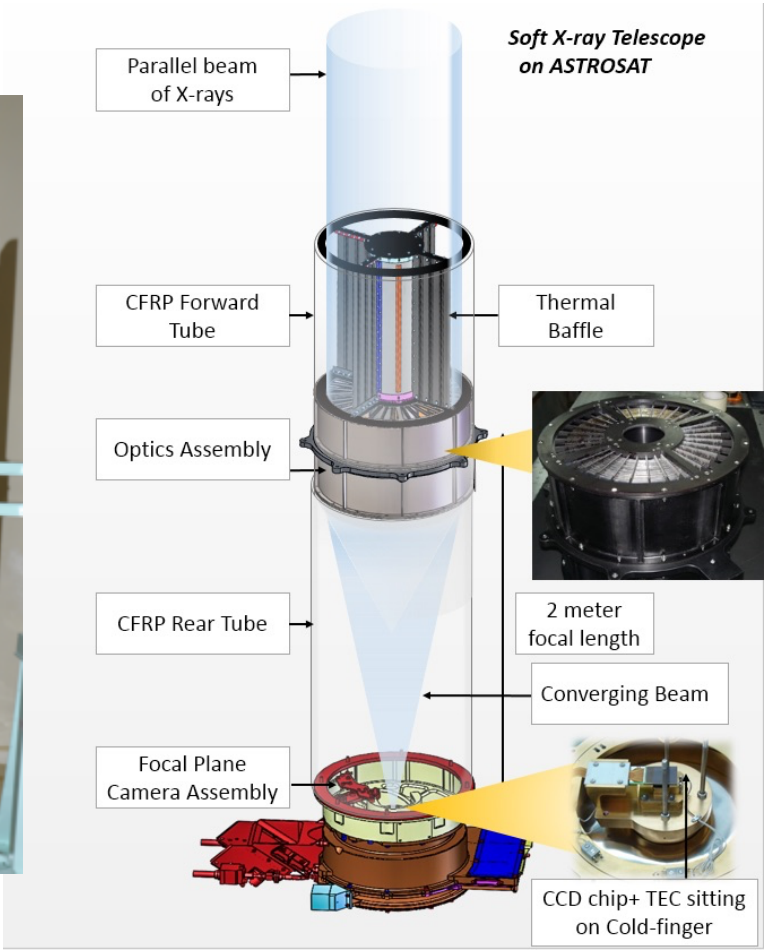
Thin conical foil (Wolter-I approx.)
Gold coated Aluminum mirrors for grazing incidence;

2-metre focal length telescope
Focal plane camera with a cooled CCD

WIDE ANGLE (~ 40' dia)
PSF (FWHM) 70" on axis
Half Energy Width (HEW) 2' ± 10"
Effective area : 128 @ 1.5keV; 22 @ 6keV

Present status- Operating with same sensitivity after launch





Large Area X-ray Proportional Counters (LAXPC)

X-ray spectrum and variability studies in the energy range 3 to 80 keV.

Tata Institute of Fundamental Research (TIFR) with Raman Research Institute (RRI)

Three large gas-filled proportional counters with light weight multi- layer Collimators

Achieved after launch ~6000sqcm effective area (all three LAXPCs) at 20 keV;

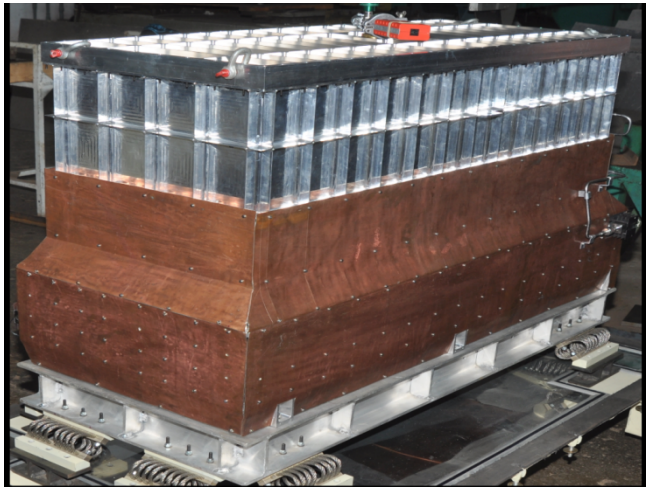
Geometric Area: 10800 cm^2

Energy range: 3- 80 keV

Time resolution: 10 µs;

FOV : 1 x 1 sq.deg

Present Status: LAXPC 2 operational. LAXPC 1 reduced gain,



Cadmium Zinc Telluride Imager (CZTI)

Variability, Polarisation and Spectral studies in the 20-100 keV.energy band

Tata Institute of Fundamental Research (TIFR) with Vikram Sarabhai Space Centre (VSSC) and Inter-University Centre for Astronomy and Astrophysics (IUCAA)

- 64 CZT detector modules
- Passive Collimator above which there is a Coded Aperture Mask (CAM)
- Collimator becomes transparent above 100keV and useful for detecting GRBs

Imaging with coded mask detectors consiting of 64 modules in 4 quadrants

Geometric area: 976 sq.cm

Each module: 256 pixels of 2.46 mm x 2.46 mm with depth 5mm

Present Status: operational. Along with Charge Particle Monitor (CPM)

Scanning Sky Monitor (SSM)

Detection & Variability studies of X-ray transients in 2.5-10 keV energy band

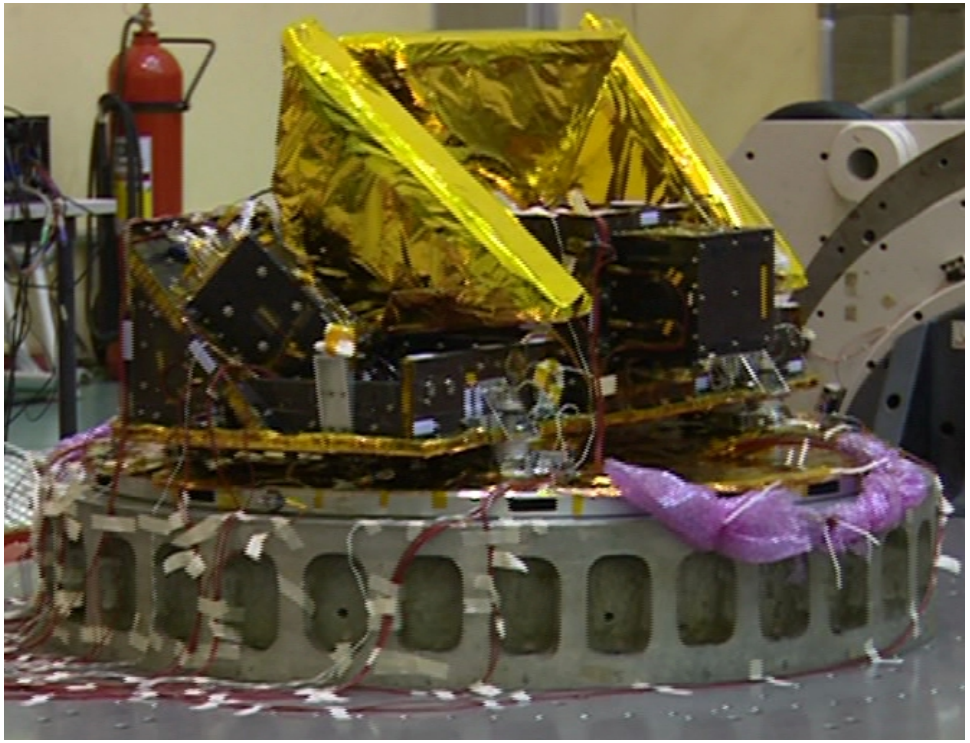
U. R. Rao Satellite Centre (URSC) and Inter-University Centre for Astronomy and Astrophysics (IUCAA)

Scans the sky for Long term monitoring of bright X-ray sources in binaries, and detection and location of X-ray transients.

Three Position-sensitive gas-filled proportional Counters. Mounted on a rotating platform

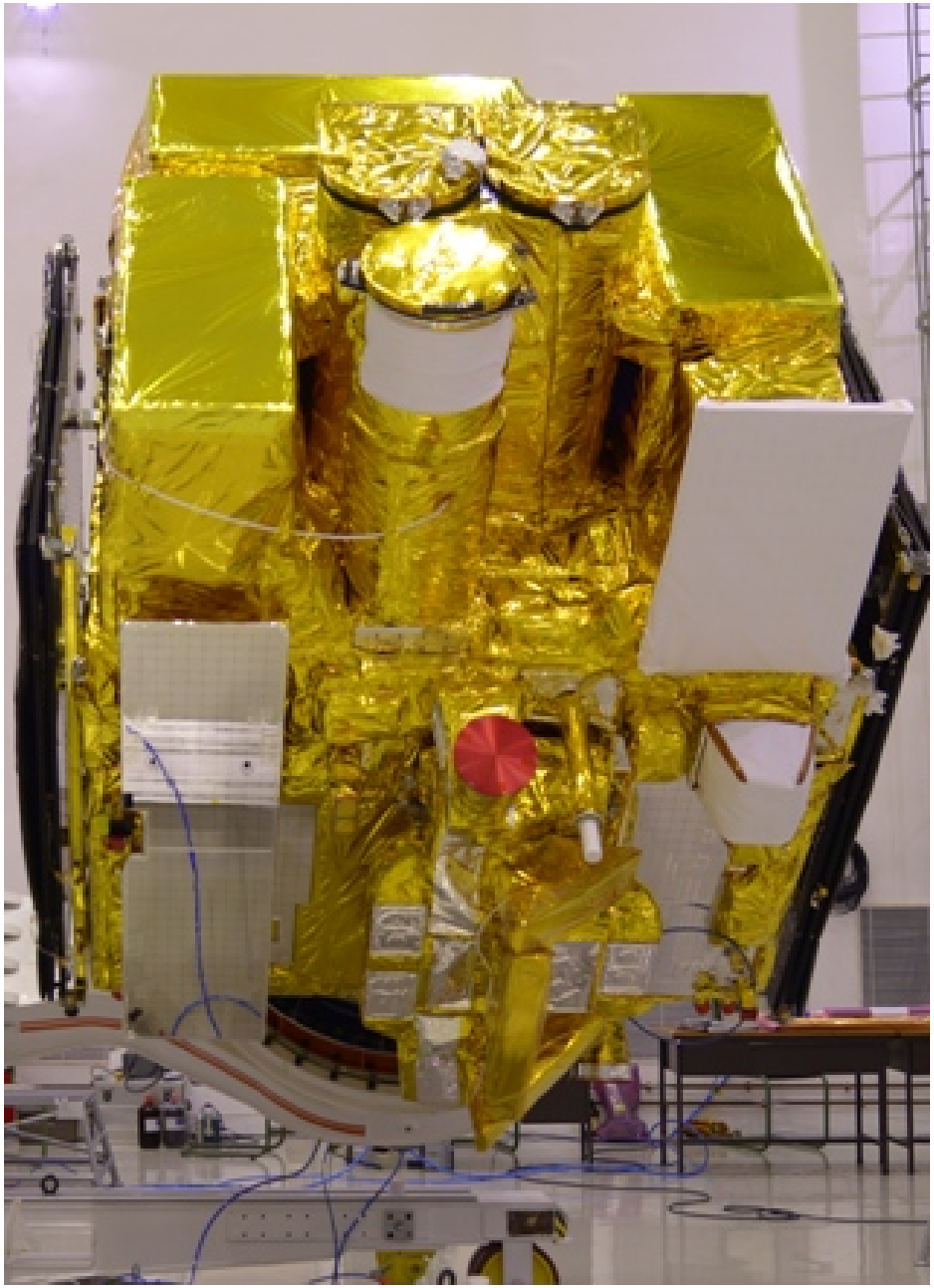
Platform rotates from 5-355 degree and back, in step and stare mode. Can be made to point in a particular direction based on ground command.

Present Status: SSM3 Operational, SSM2 lower gain. Data requires long term corrections; yet to be made public

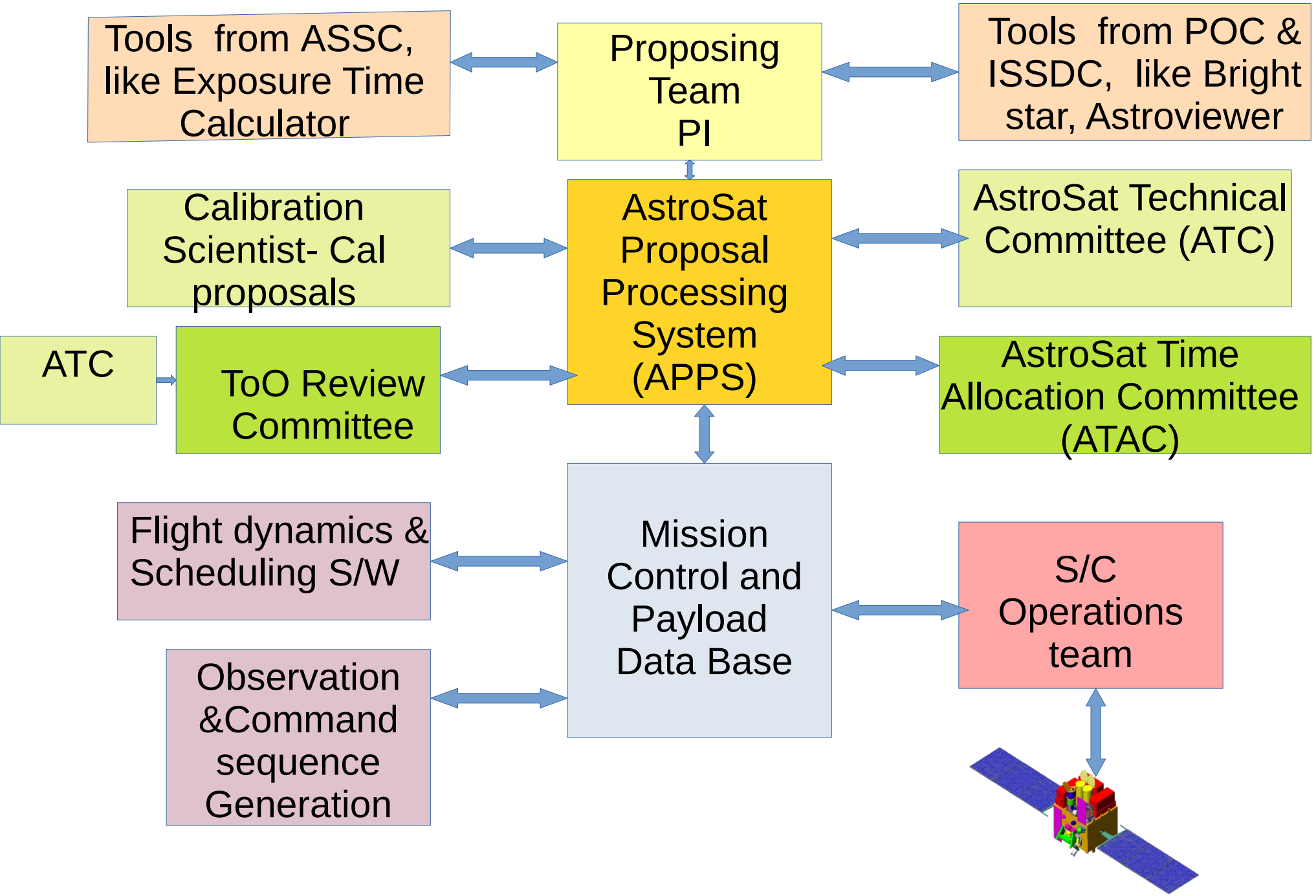


S/C and Payload

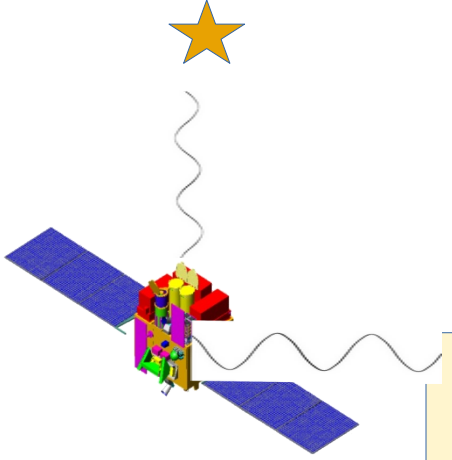
- Other support for payloads, like doors, thermal control, composite parts fabrication, mounting interfaces etc. apart from Satellite, launch and operations and data dissemination by various centres of ISRO
- Payload operation Centres at TIFR, IIA, IUCAA and URSC
- AstroSat Science Support Cell at IUCAA for tools, updates, workshops, training etc.
- AstroSat Time allocation and Technical Committees



Observational methodology



Data related



Data Reception

P/L segregated data

Payload Operations Centres

Performance & data Validation, Quality report and L2 products Calibration

L0 and L1 data, with pP/L and Health data of P/L, S/C, and auxiliary data on orbit etc.
L1 data orbit wise and merged for Observation ID for a proposal

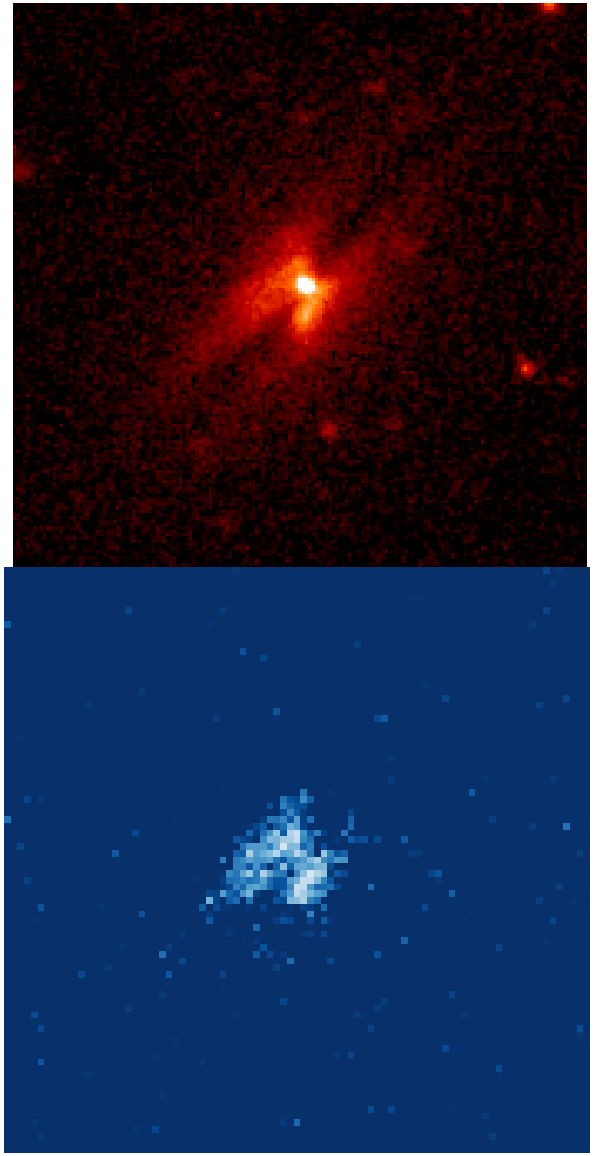
Astrobrowse
Hosts validated L1, L2 data of payloads

Proposal PI

Data made open to all Users after lock-in period

IC 4329 A

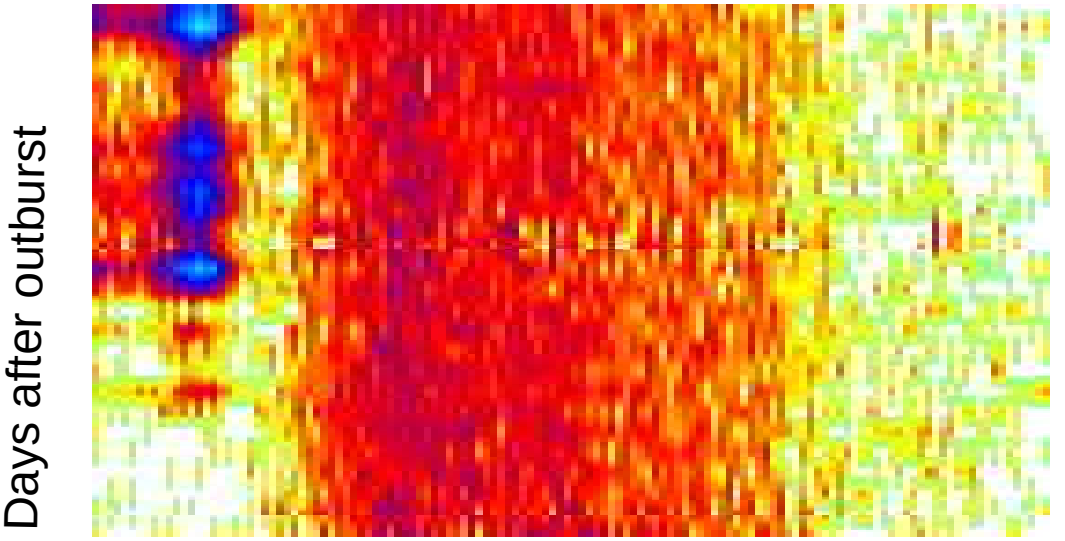
- IC 4329 A is 2nd brightest Seyfert I AGN
- Observed in FUV and NUV during 2017; Best spatial resolution
- Edge-on host galaxy and central dust lane observed. The bright AGN observed in NUV, but obscured by dust in FUV;
- Intrinsic spectrum of the AGN is extracted,after applying and emission line corrections, and fitted with disc model.
- Results indicate that UV emission is consistent with a truncated disc > 80 Rg



Dewangan, Gulab C.; Tripathi, P.; Papadakis, I. E, et al,., 2021, MNRAS, 504, 401

V 3890 Sgr, Nova Outburst

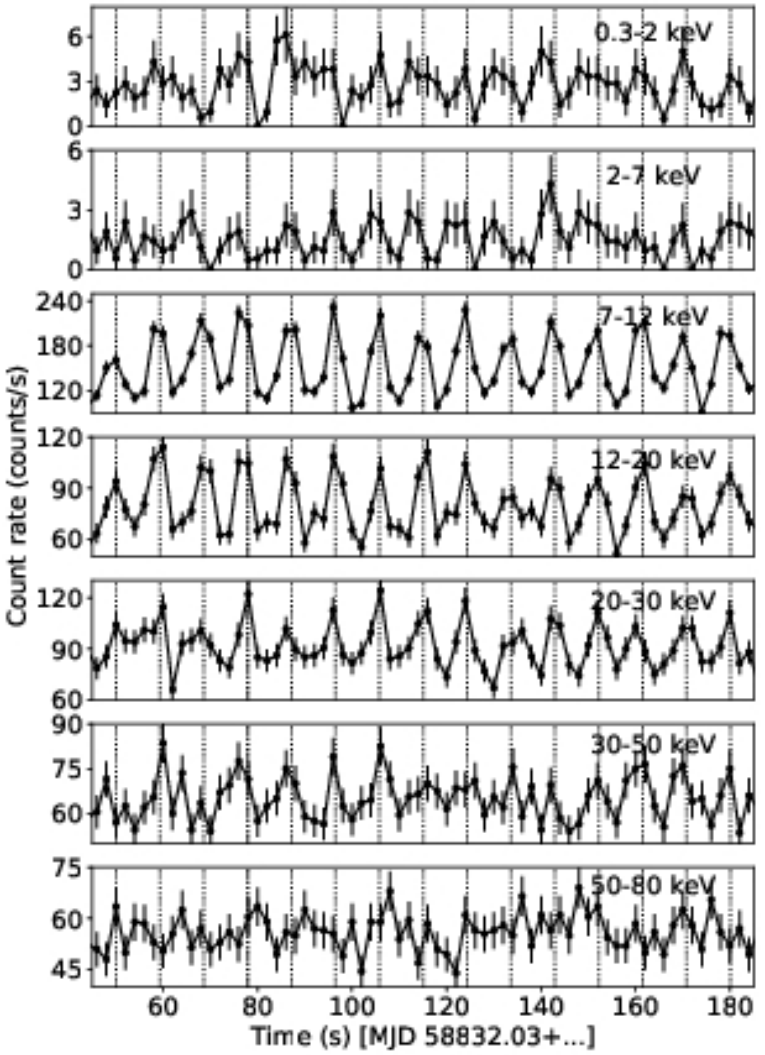
- Symbiotic Recurrent (time scale 28 y) Nova V3890 Sgr, outburst during Sept. 2019. Observed in two slots ~8.2-9.9 d, and 15.9-19.6d
- The source was observed to become super-soft from day 8.6, residual burning on WD
- In 2nd slot, SSS component still bright with episode of fading and renrightening



Singh, K.P., Girish, V., Pavana, M. et al., 2021 MNRAS, 501, 36

Be/X-ray binary RX J0209.6−7427

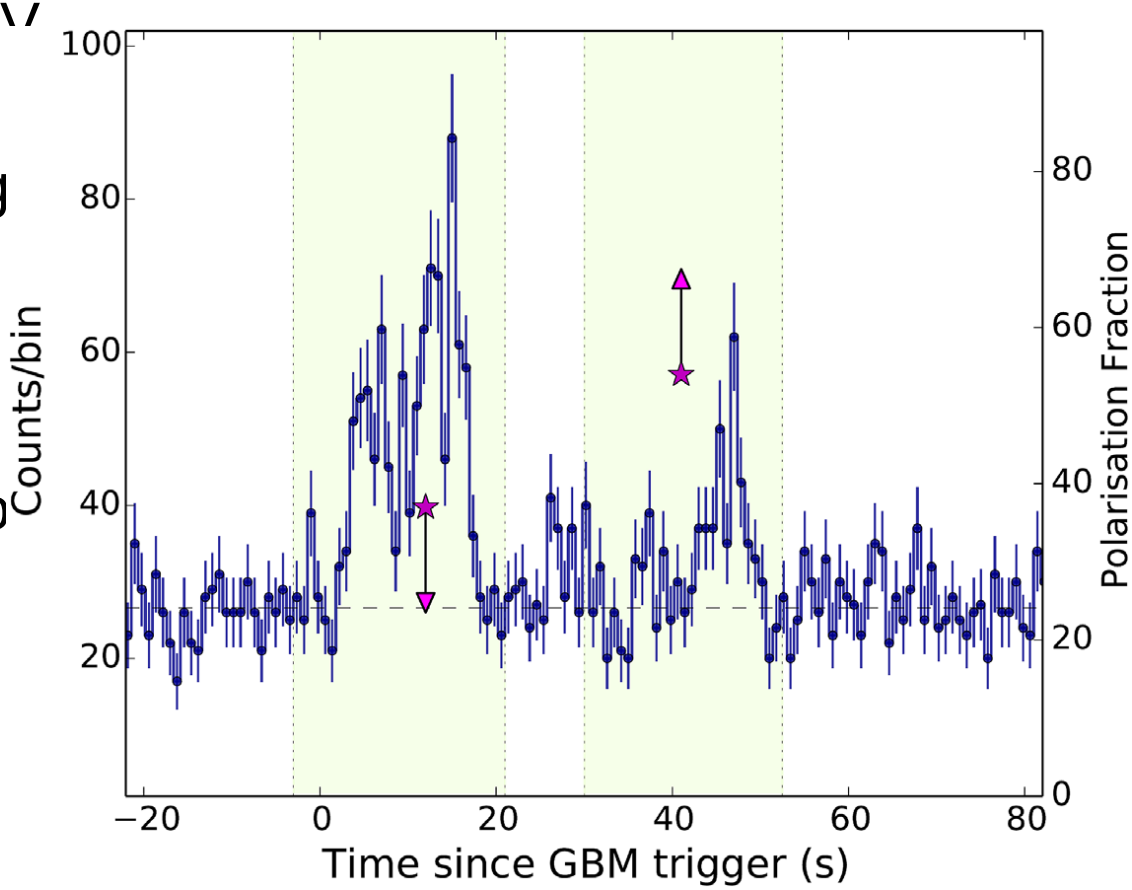
- SXT and LAXPC observations of Nov. 2019;
- 9.29s spin of N*, detected by NICER, observed till energies of 80keV.
- LAXPC data indicate spin up, observed over long term by FERMI.
- Spin up observed is ~ 1000 times higher than that from other Be/X-ray pulsars



Chandra, A.D. , Roy, J., Agrawal, P.C. et al., 2020, MNRAS, 495, 2664

GRB 160325A

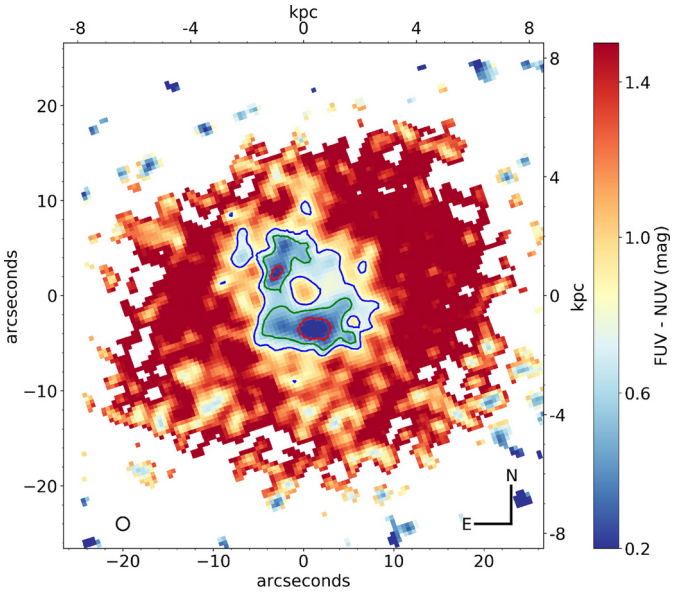
- GRB observed in the main FOV of CZTI
- Showed two episodes of flaring
- The light curve corresponds to Compton events from the detector
- The polarisation is estimated fo the portions in the shaded region
- The polarisation for the second peak is much higher at least 43% at 1.5 sigma



Sharma, V., Iyyani, S., Bhattacharya, D. et al, 2020, MNRAS, 493, 5218

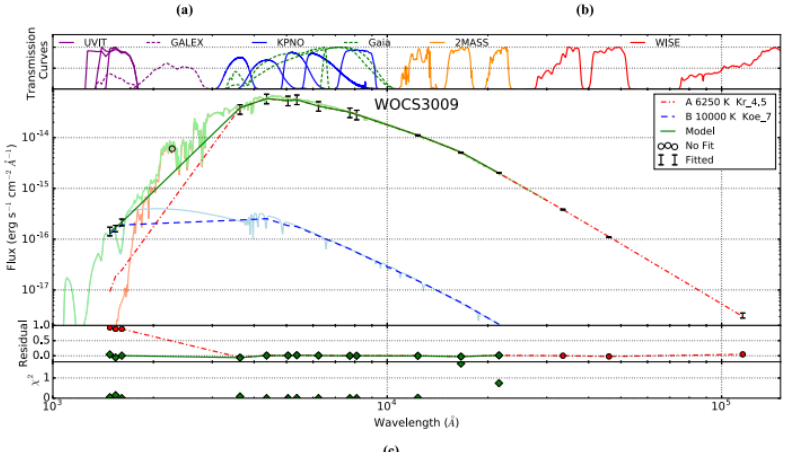
Results from galaxy mergers & Star clusters

- NGC 7252 (atoms for peace)galaxy indicative of a merger 600-700Myr back; has a single nucleus with two tidal tails.
- The nucleus also has star forming regions of much younger ages



George, K. Joseph P., Mondal C. et al. 2018, A&A, 613, L9

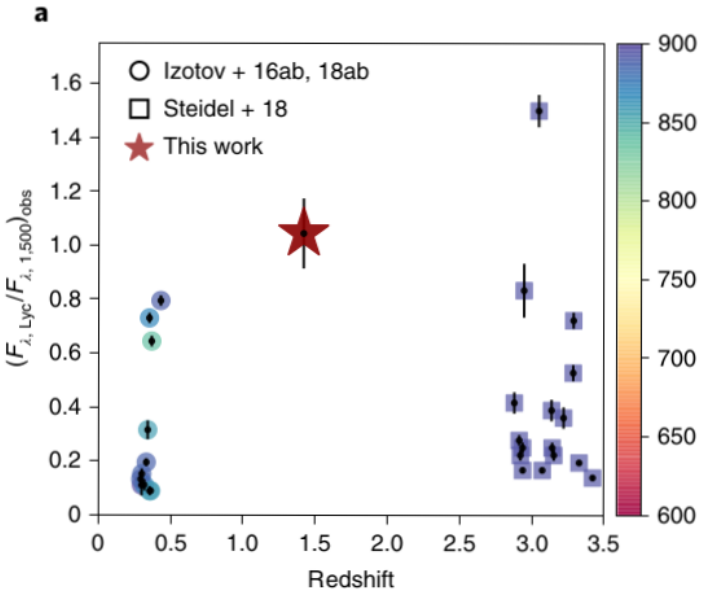
- Star clusters are found to have several BSS, as detected with UV obs.
- Many are in binaries as indicated by spectral fitting, with some of them with extremely low mass WDs

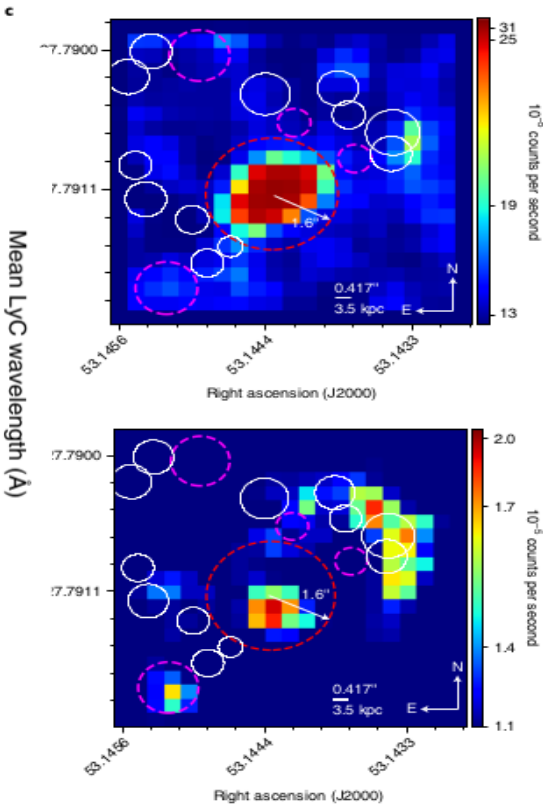


Jadhav V. V., Sindhu N., Subramaniam A. 2019, ApJ, 886,

LyC emission from z~1.42 galaxy

- First detection of Lyman Continuum in the 0.5<z<2.5 region
- AUDF s01 selected from Hubble Extreme deep field, as galaxy with strong Hα and O[III] lines
- UV emission detected in NUV (redshifted Lyman C. at 2188.8A), and FUV (red shifted EUV ~ 537-723A)
- First detection of redshifted EUV emission (rest frame 600 A) Ca constrain the EUV spectrum
- The fesc found to be at least 20%;





Kanak Saha, Shyam Tandon, Simmonds, C et al., 2020, Nature Astronomy, https://doi.org/10.1038/s41550-020-1173-5

Special Issue of J. Ap. A

- ~60 papers
- Latest Results
- Will be released soon

Sincere Thanks to all those who made it Happen and those who continue …

And

A Warm Welcome to those who want to join

Thank You