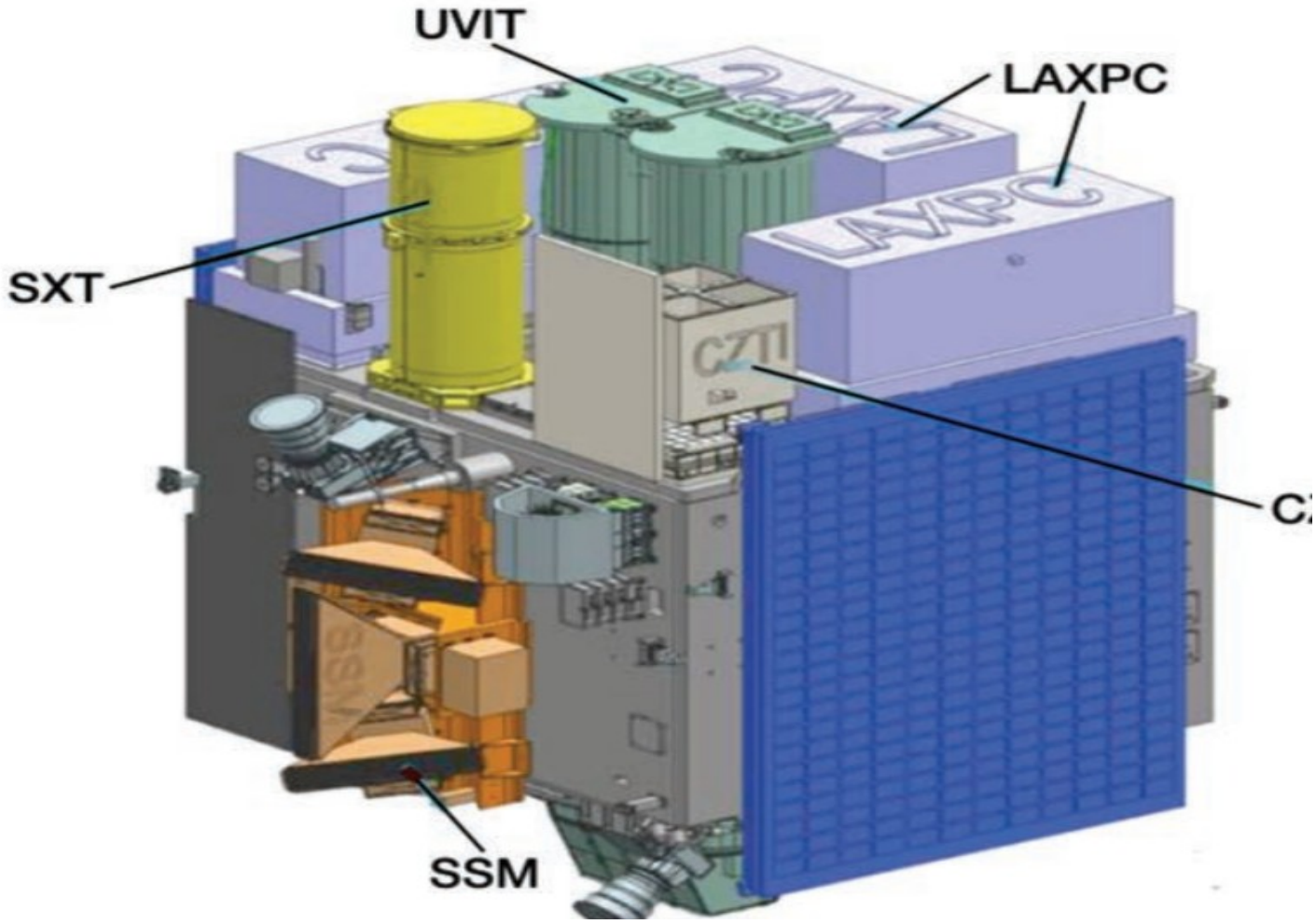
Timing properties of Cyg X-1 with AstroSat/LAXPC



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Collaboration: LAXPC Science Team

January, 2017

Cyg X-1

- Confirmed black hole binary
- Persistently bright
- One of the brightest X-ray binaries

LAXPC

- Large Area X-ray Proportional Counter
- Energy Coverage of 3-80 keV
- Three LAXPC units

AstroSat/LAXPC Observation of Cyg X-1 in Hard State

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ASTROSAT/LAXPC OBSERVATION OF CYGNUS X-1 IN THE HARD STATE

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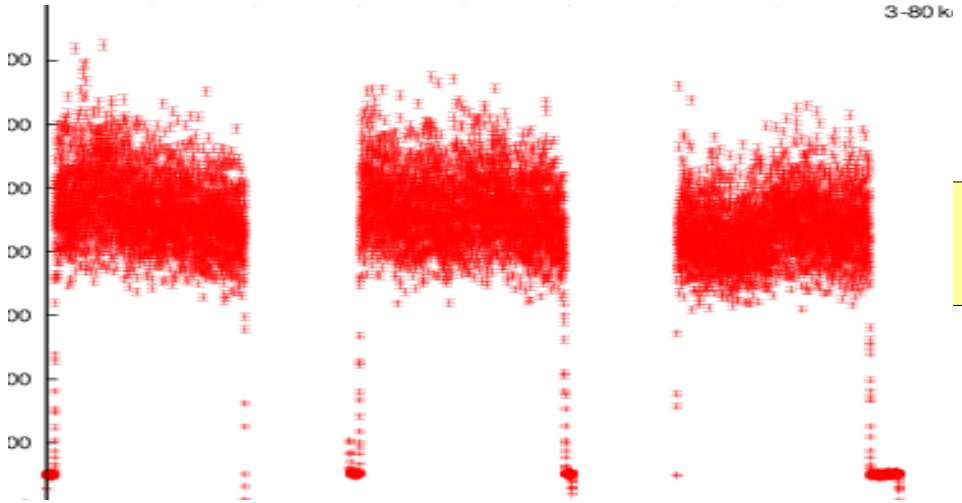
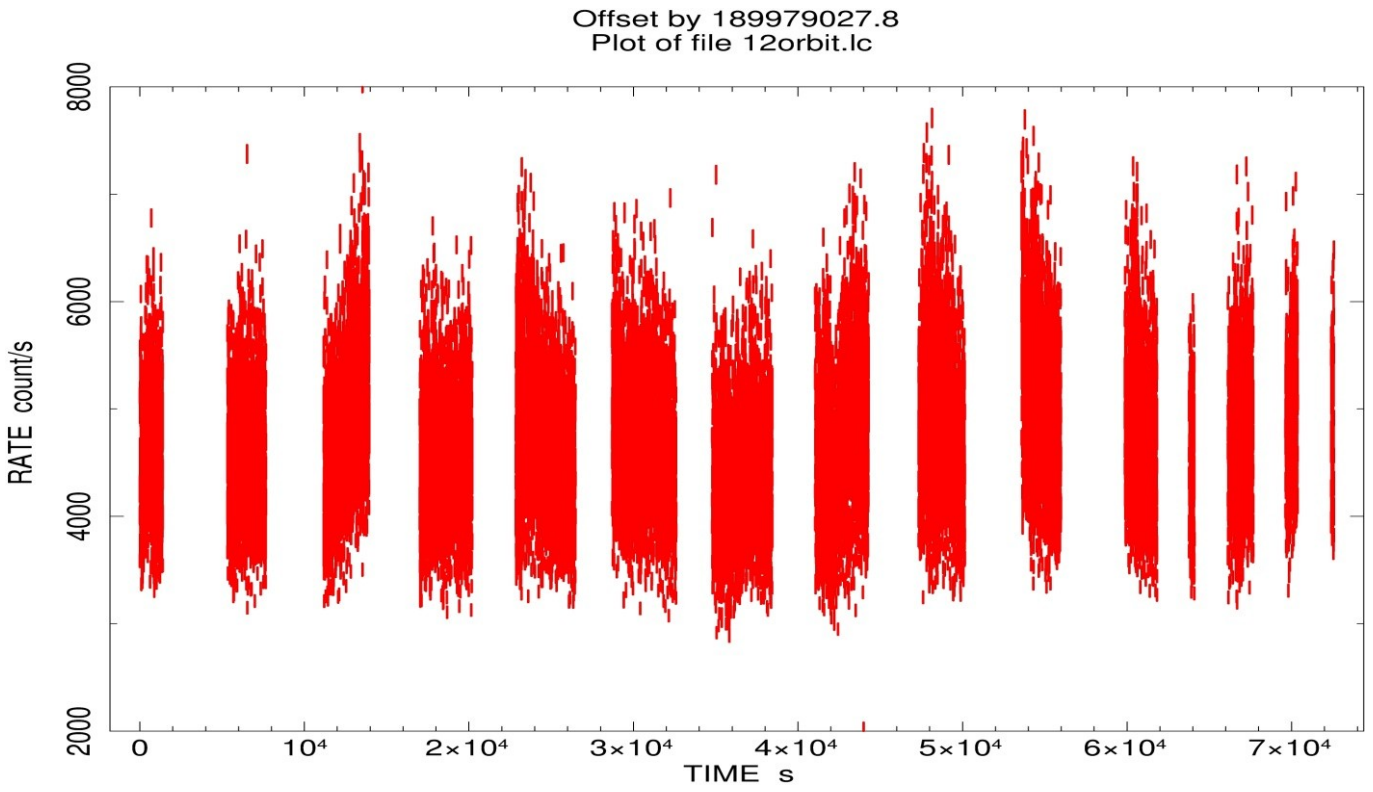
ABSTRACT

We report the first analysis of data from *AstroSat*/LAXPC observations of Cygnus X-1 in January 2016. LAXPC spectra reveals that the source was in the canonical hard state, represented by a prominent thermal Comptonization component having a photon index of ~ 1.8 and high temperature $kT_e > 60$ keV along with weak reflection and possible disk emission. The power spectrum can be characterized by two broad lorentzian functions centered at ~ 0.4 and ~ 3 Hz. The r.m.s of the low frequency component decreases from $\sim 15\%$ at around 4 keV to $\sim 10\%$ at around 50 keV, while that of the high frequency one varies less rapidly from $\sim 13.5\%$ to $\sim 11.5\%$ in the same energy range. The time lag between the hard (20–40 keV) and soft (5–10 keV) bands varies in a step-like manner being nearly constant at ~ 50 milli-seconds from 0.3 to 0.9 Hz, decreasing to ~ 8 milli-seconds from 2 to 5 Hz and finally dropping to ~ 2 milli-seconds for higher frequencies. The time lags increase with energy for both the low and high frequency components. The event mode LAXPC data allows for



1 second binned light curve from three AstroSat orbits during Jan, 2016

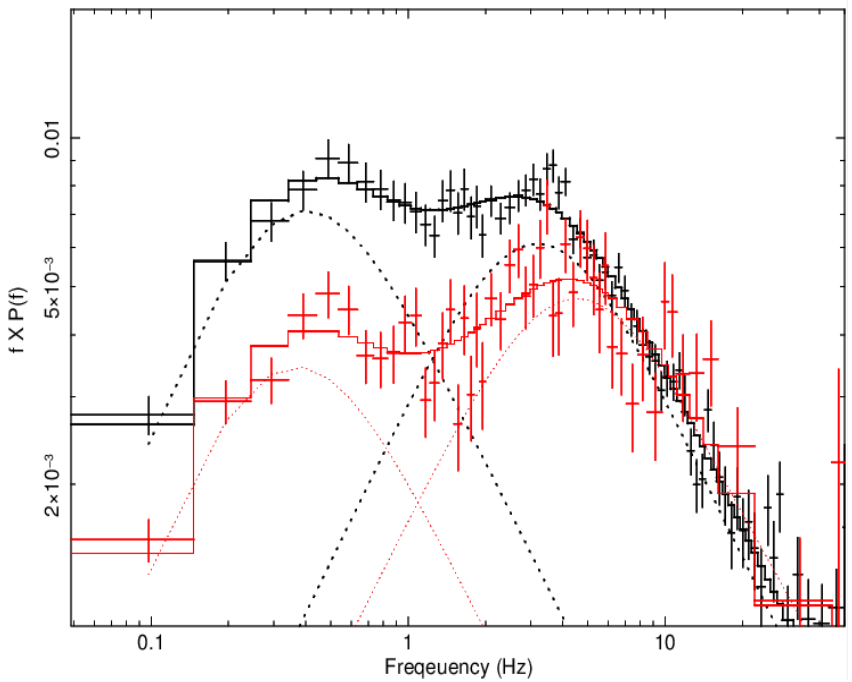
LAXPC observation of Cyg X-1 : 12 orbits

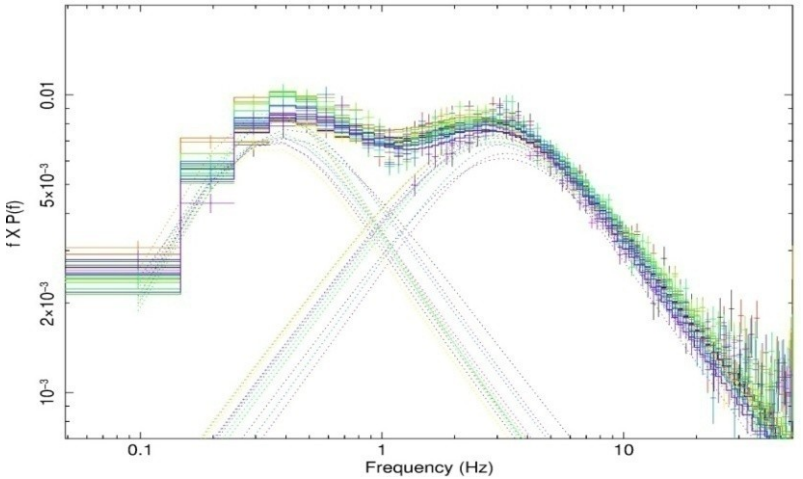


1 second binned light curve in 3-80 keV energy range from 12 orbits

Orbit Number: 1521-1533
Start Date: 8 January, 2016 19: 57: 05
End Date : 9 January, 2016 16: 06: 45

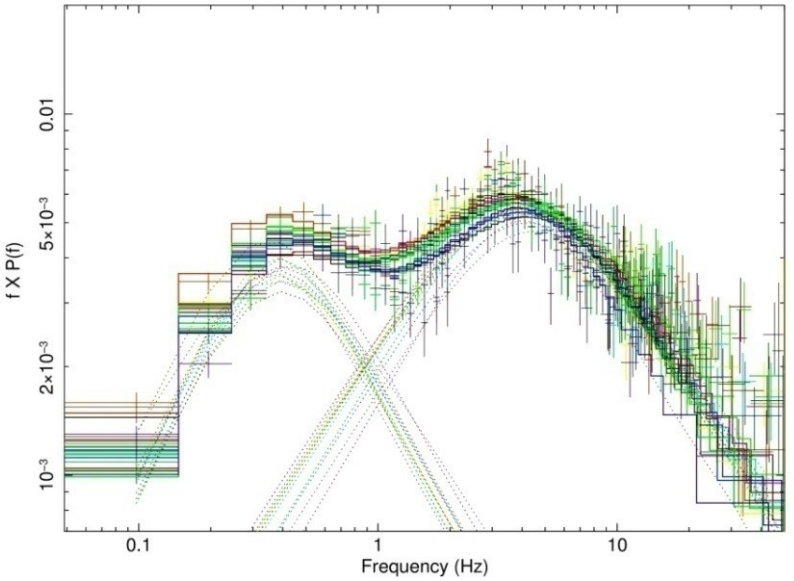
Power Density Spectra: 12 orbits





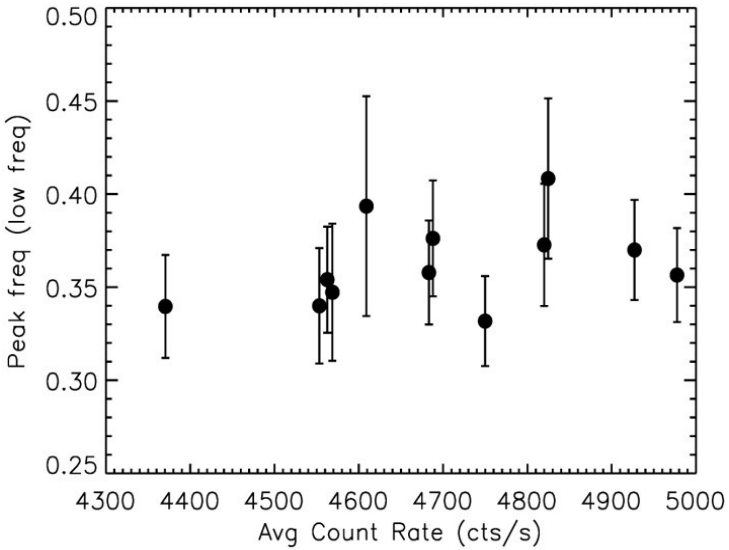
PDS for 12 orbits in 3-10 keV

- Two broad peaks are seen in PDS
- Fitted with two broad Lorentzians
- Shift in peak frequencies is noticed for 12 orbits.

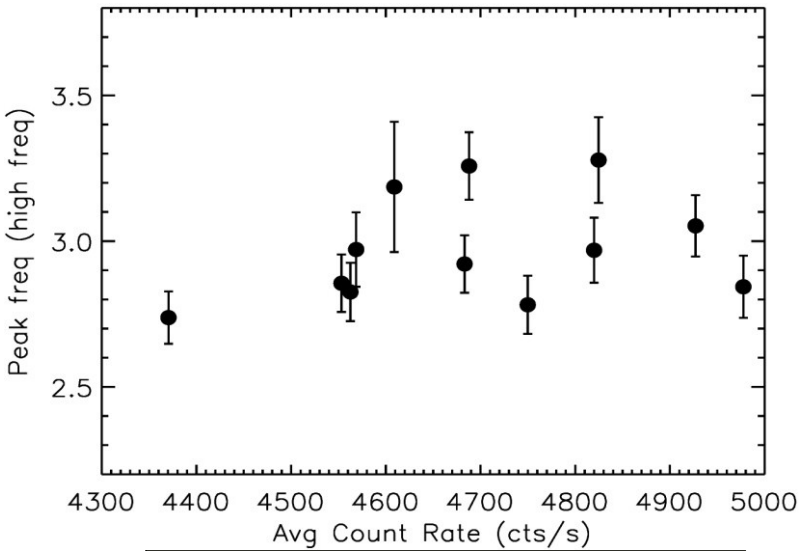


PDS for 12 orbits in 20-40 keV

Variation of peak frequencies: 12 orbits

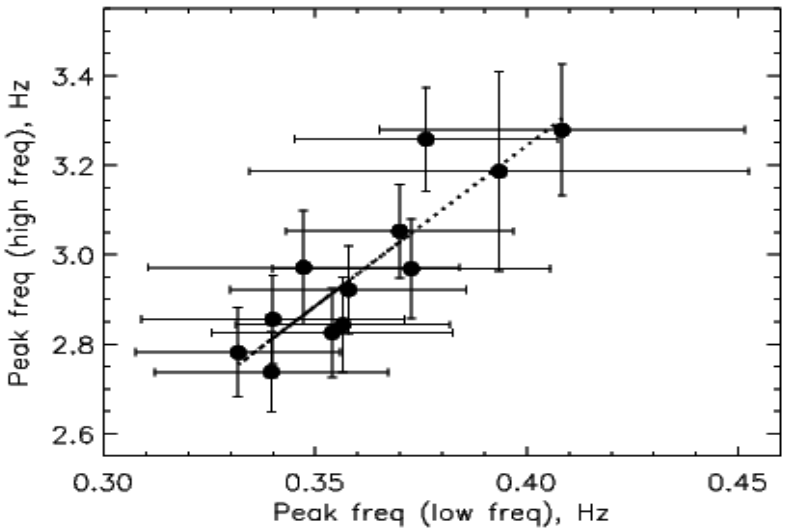


Low peak frequency with count rate



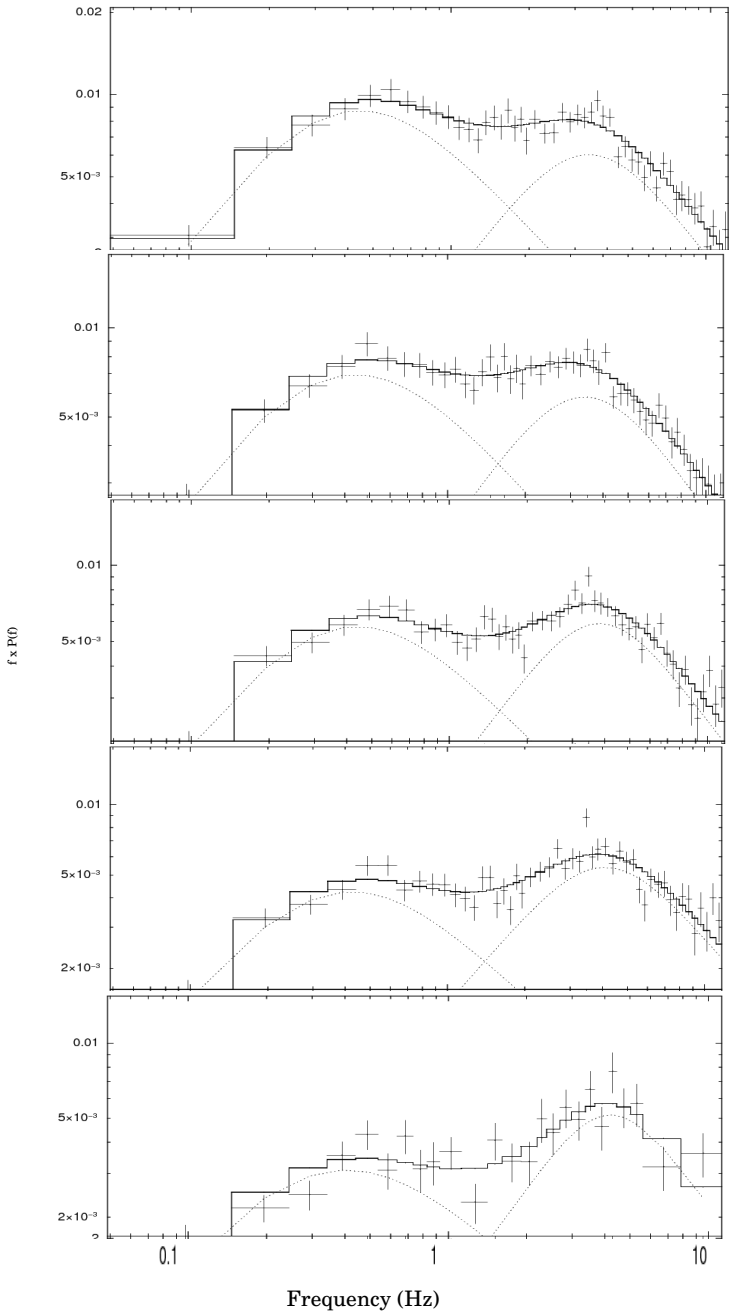
High peak frequency with count rate

- Studied variation of peak frequencies with count rate
- No correlation is seen between peak frequencies and count rate
- Correlation is found between the low and high peak frequencies



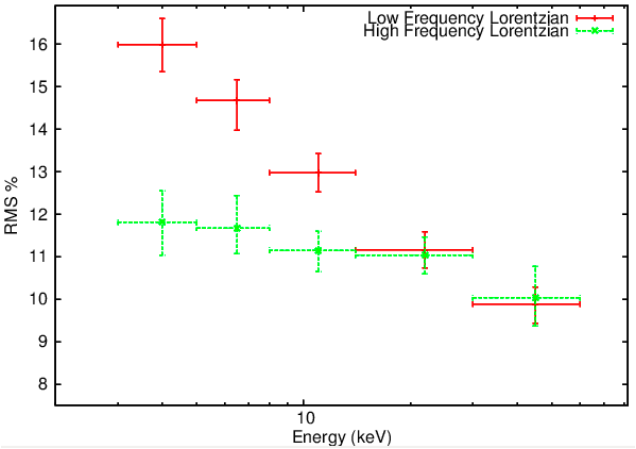
Low vs. High peak frequencies

RMS with energy : 12 orbits

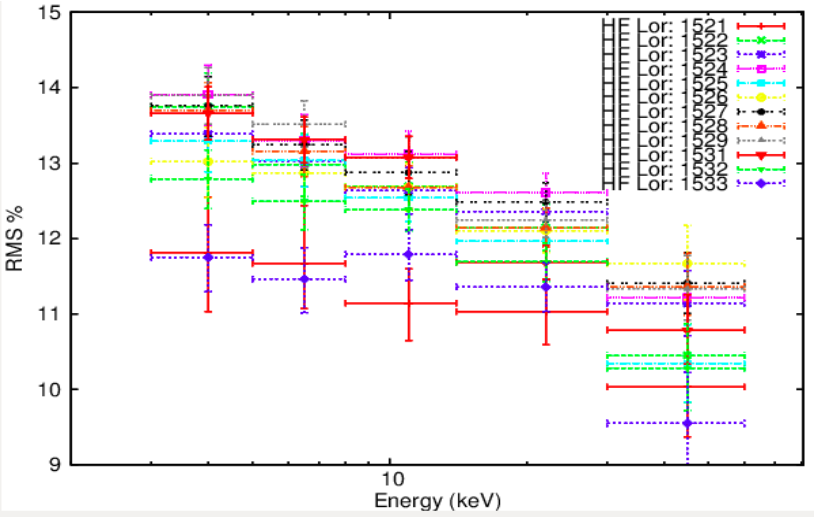


- High frequency component does not change significantly with energy.
- Low frequency component changes with energy.

RMS with energy : 12 orbits

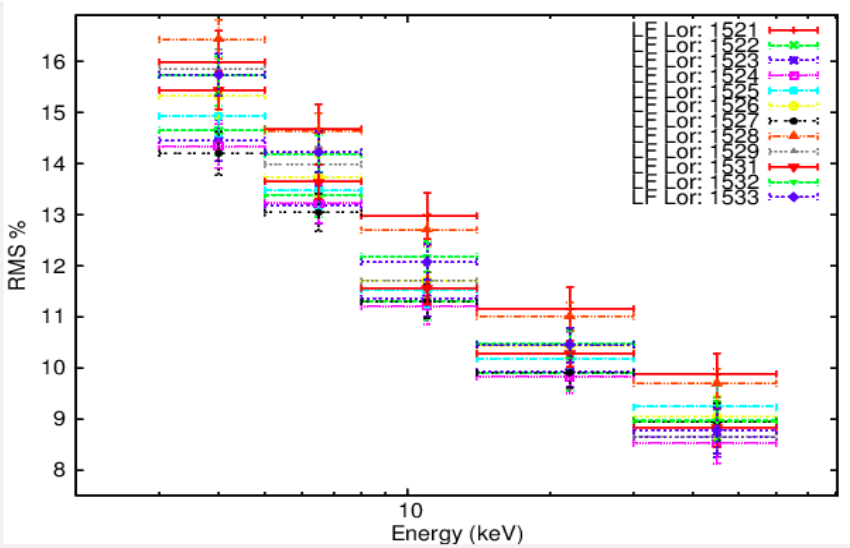


RMS with energy for orbit1521 at low and high peak frequencies



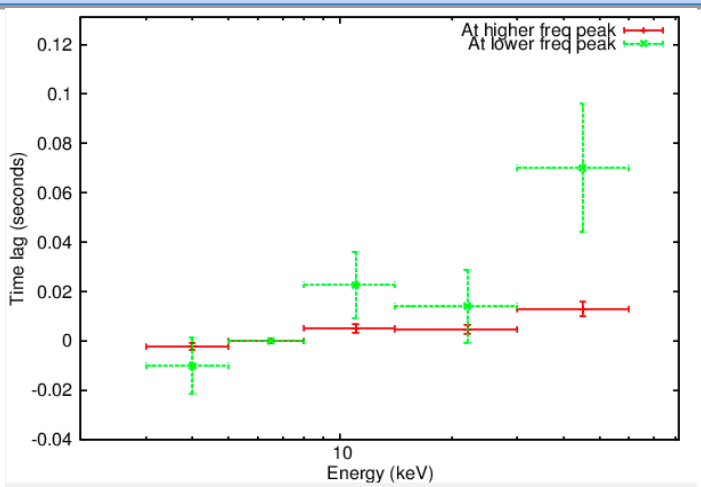
RMS with energy for 12 orbits at high peak frequency

- RMS for high peak frequency remains almost constant
- RMS for low peak frequency decreases
- Similar trend is seen in all the 12 orbits

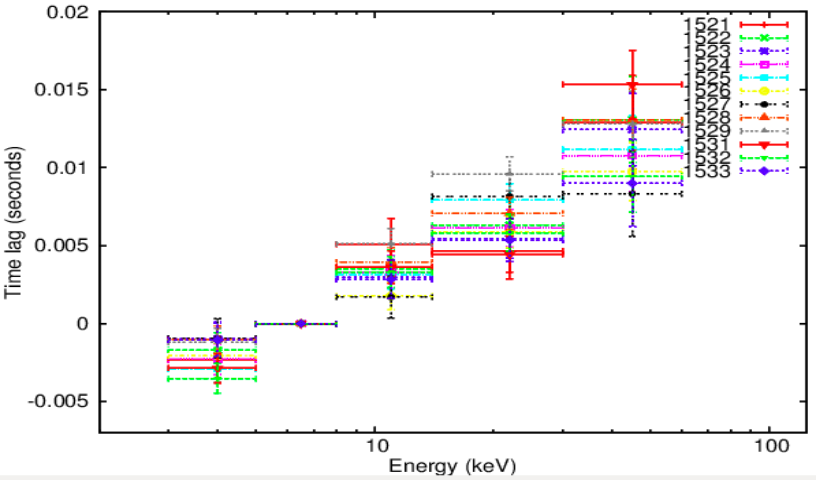


RMS with energy for 12 orbits at low peak frequency

Time lag with energy : 12 orbits

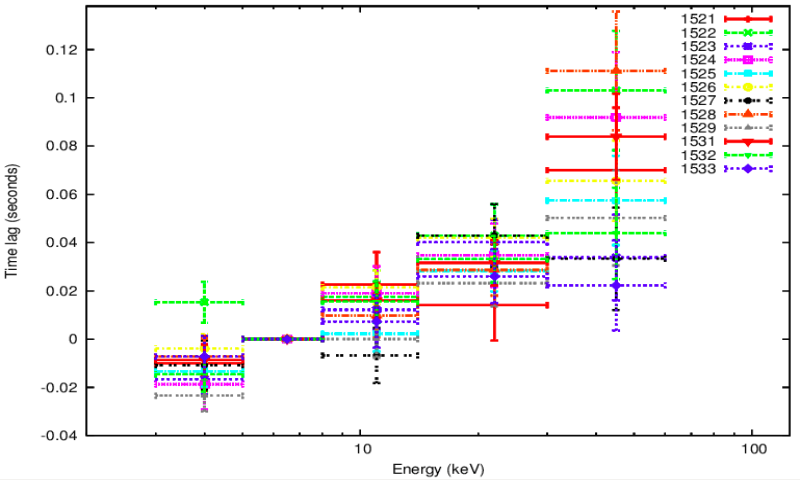


Time lag with energy for orbit1521 at low and high peak frequencies



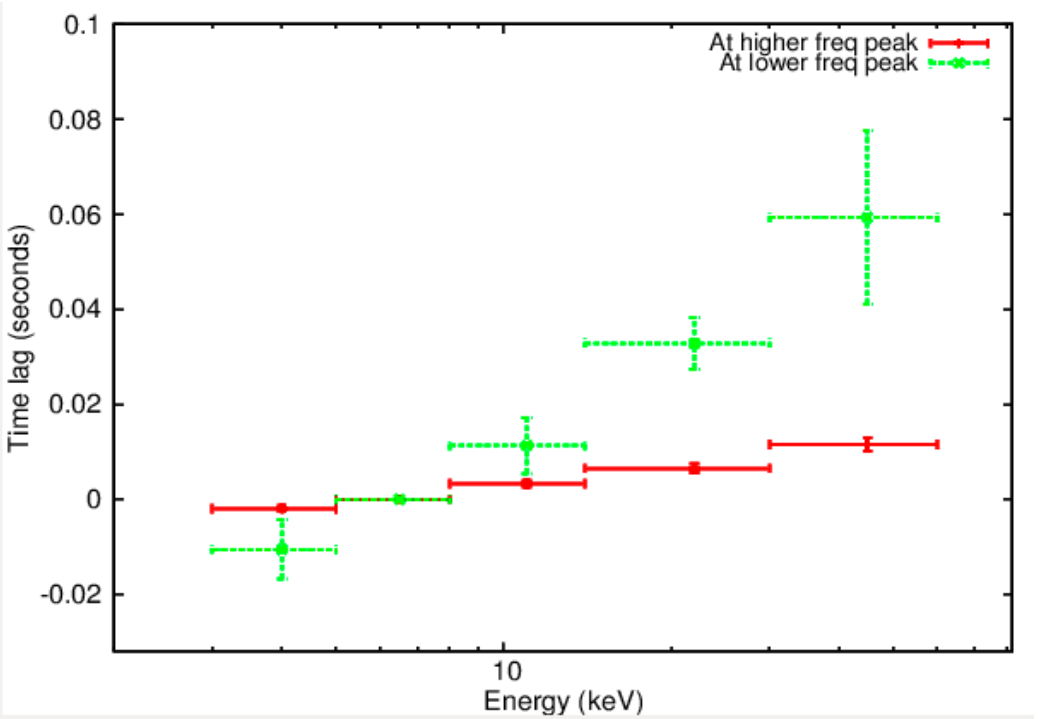
Time lag with energy for 12 orbits at high peak frequencies

- Time lags are calculated with respect to 5-8 keV band
- Similar trends of time lags for 12 orbits



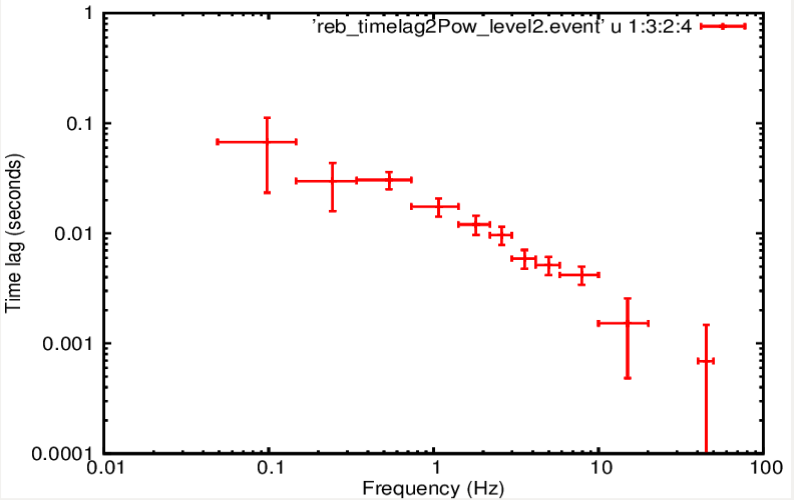
Time lag with energy for 12 orbits at low peak frequencies

Time lag with energy : 12 orbits

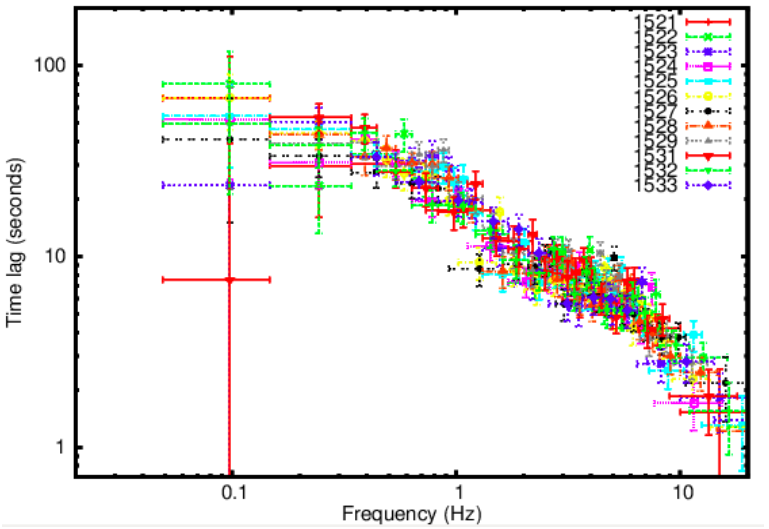


Average time lag as a function of energy

Time lag with frequency : 12 orbits

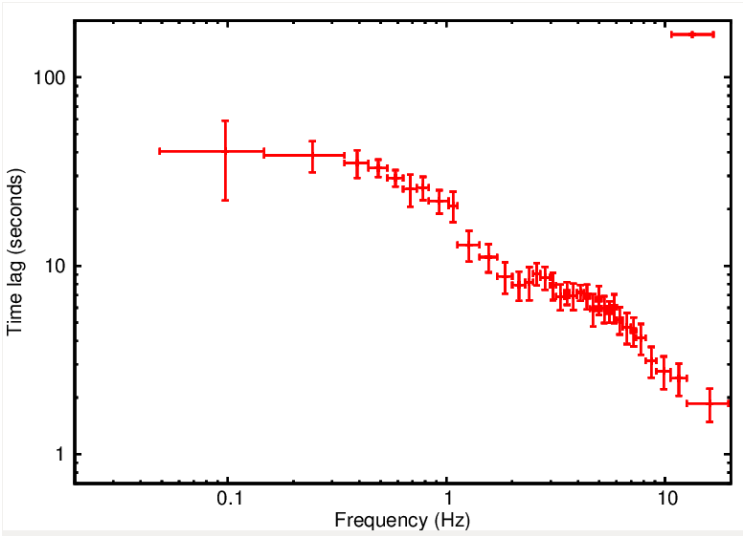


Time lag with frequency for orbit 1521



Time lag with frequency for 12 orbits

- Time lag decreases with increasing frequency
- Similar trends of time lags for 12 orbits
- Averaged the time lags



Average time lag with frequency for 12 orbits

Future Work : Flux resolved spectroscopy
Study of Coherence function

Softwares

All the softwares used to generate the results presented here are available on the website of AstroSat Science Support Cell

Thank you ..