

Large Area X-ray Proportional Counter (LAXPC): recent results

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Following talks today will present LAXPC results in this conference

Ranjeev Misra Cyg X-1

Aru Beri 4U 1636-536

Mayukh Pahari Microquasars at different spectral states

Anjali Rao Timing properties in black hole binaries

Jayashree Roy 4U 0115+63

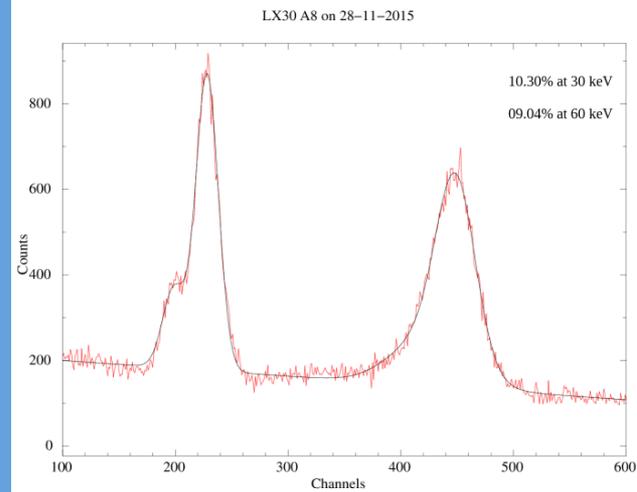
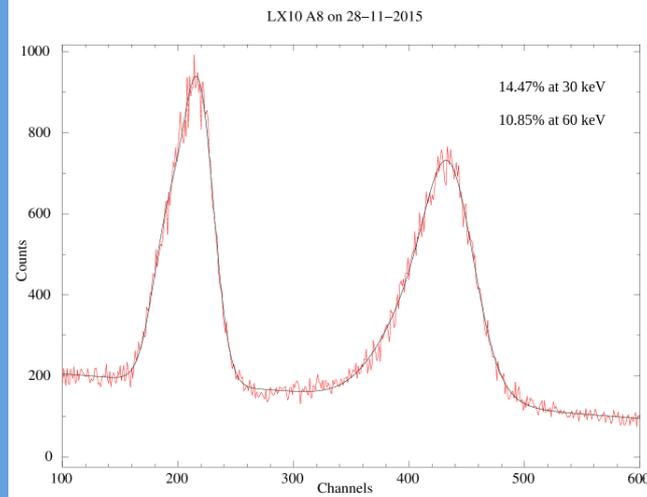
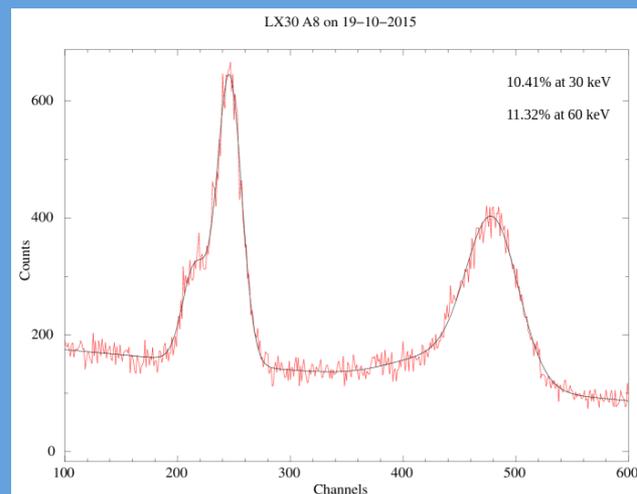
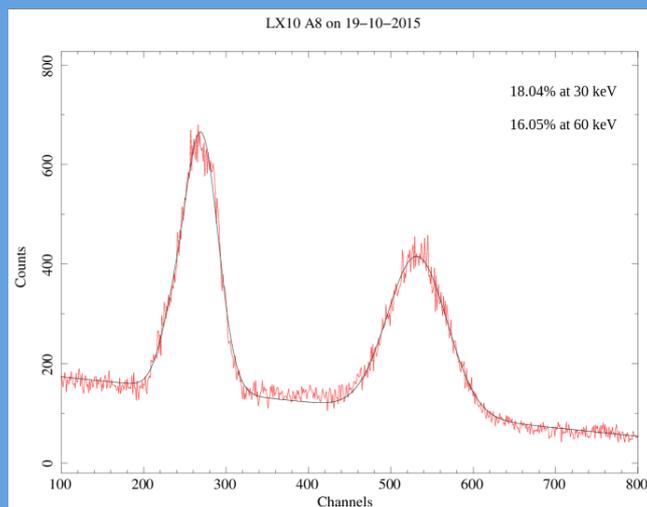


LAXPC: Large Area X-ray Proportional Counters (~419 Kg) (became fully operational on 19th Oct. 2015)

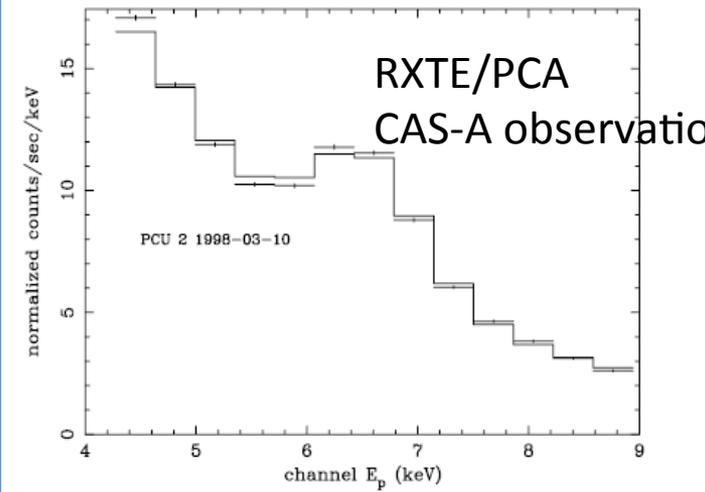
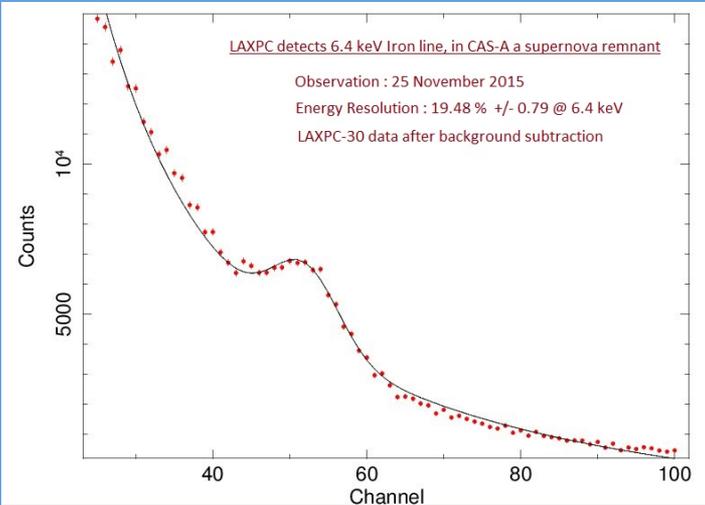
A broad energy band (3 - 80 keV) with high detection efficiency of X-ray above 20 keV and high timing resolution 10 μ sec.

- Three co-aligned identical LAXPC detectors
- Each with a multi-wire-multi-layer configuration filled with 90%Xe +10% Methane gas at 1520 torr. Energy resolution (12%@22 keV)
- A 50 micron thick aluminized Mylar window for X-ray entrance
Mylar film support -- by a honeycomb window support collimator
- A narrow field of view of .8x.8 degs provided by *mechanical collimators made of a sandwich of 50 μ Sn + 25 μ Cu + 100 μ Al* co-aligned with the window support collimator and sitting above it.
- Blocking shield on sides and bottom : 1mm Sn + 0.2 mm Cu

Each of the LAXPC detectors has an onboard gas purification system. This system will be operated as and when required to purify the gas filled in the detector by command. It is expected that energy resolution of LAXPC detector will degrade as impurity increases.

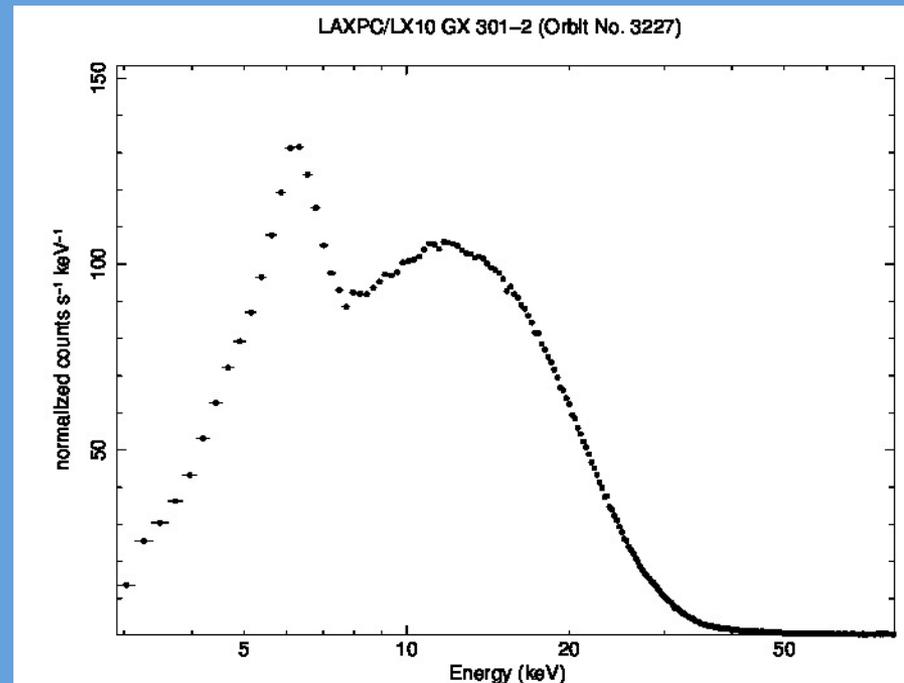


Energy resolution at 6.4 keV in orbit: We achieved around 20% Energy resolution as proposed.



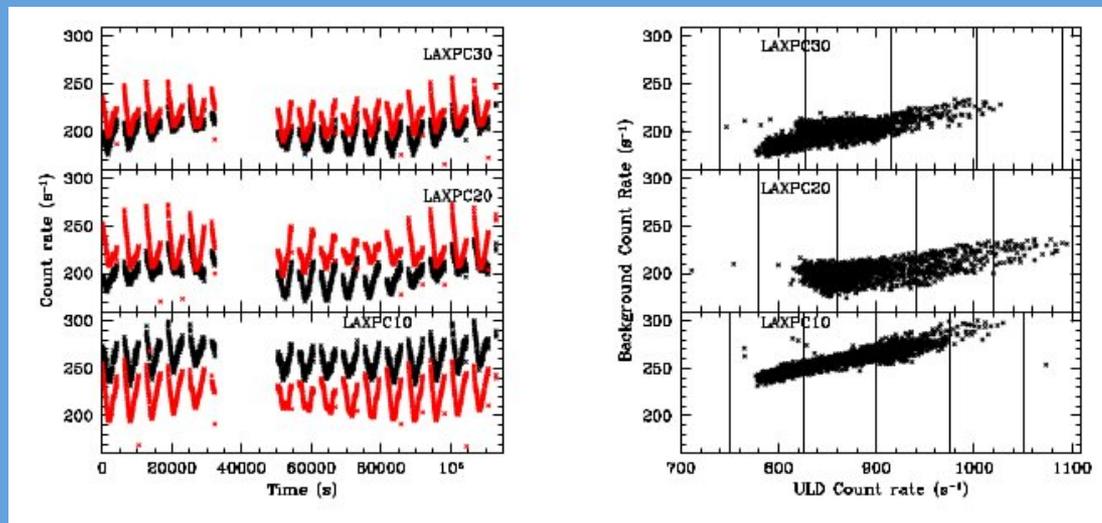
CAS –A (supernova remnant) observation LAXPC30 (left top) and RXTE/PCA (left bottom).

GX 301-2 observation in early May 2016 show similar Resolution (Iron line is clearly visible ar 6.4 keV)

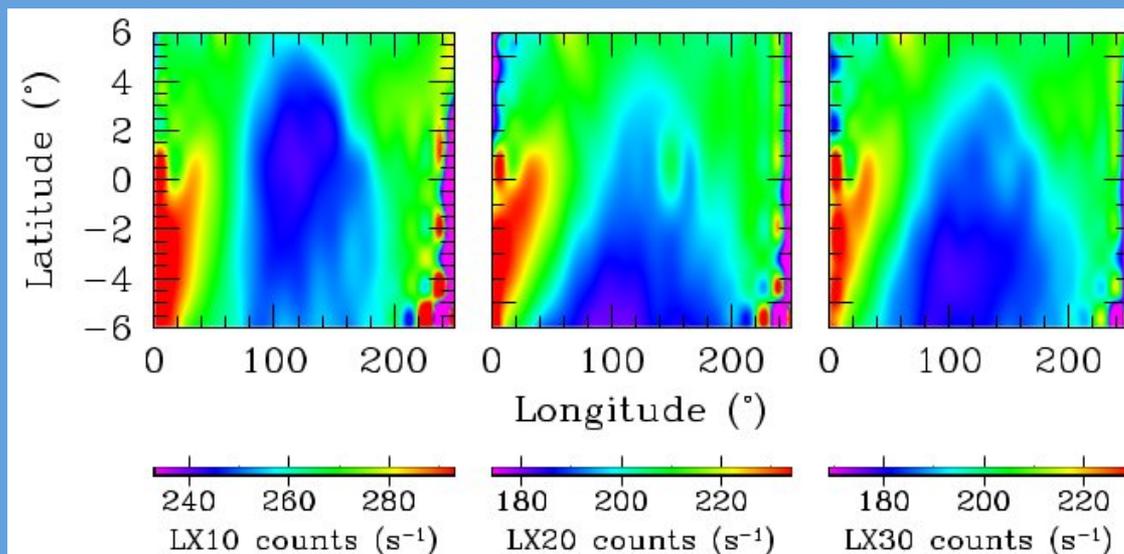


LAXPC background models

ULD red X/4, black is Background for March, 2016 one day data, our background estimate has 4% uncertainty.

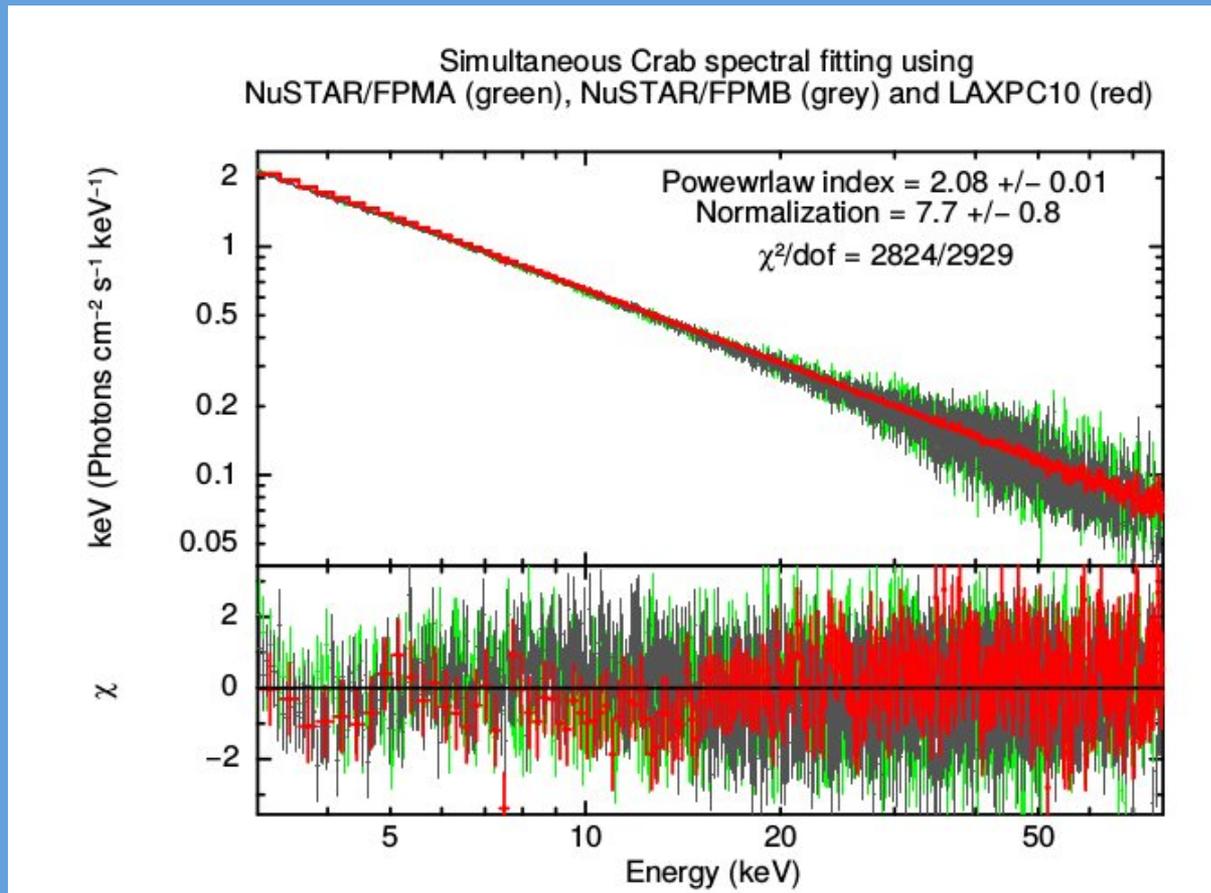


Antia et al 2017



LAXPC instrument capabilities: Crab

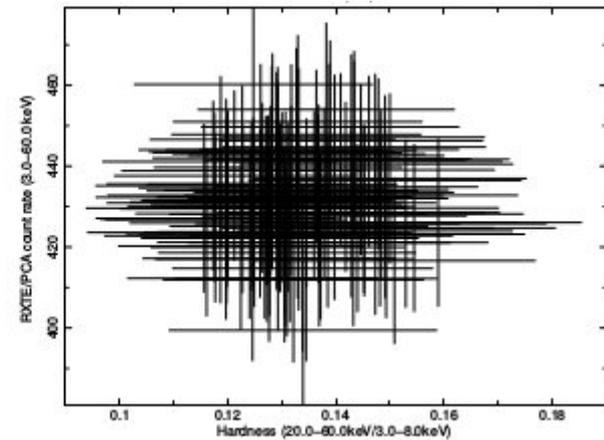
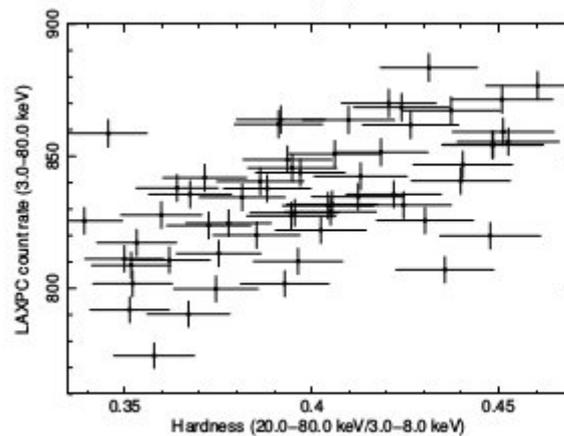
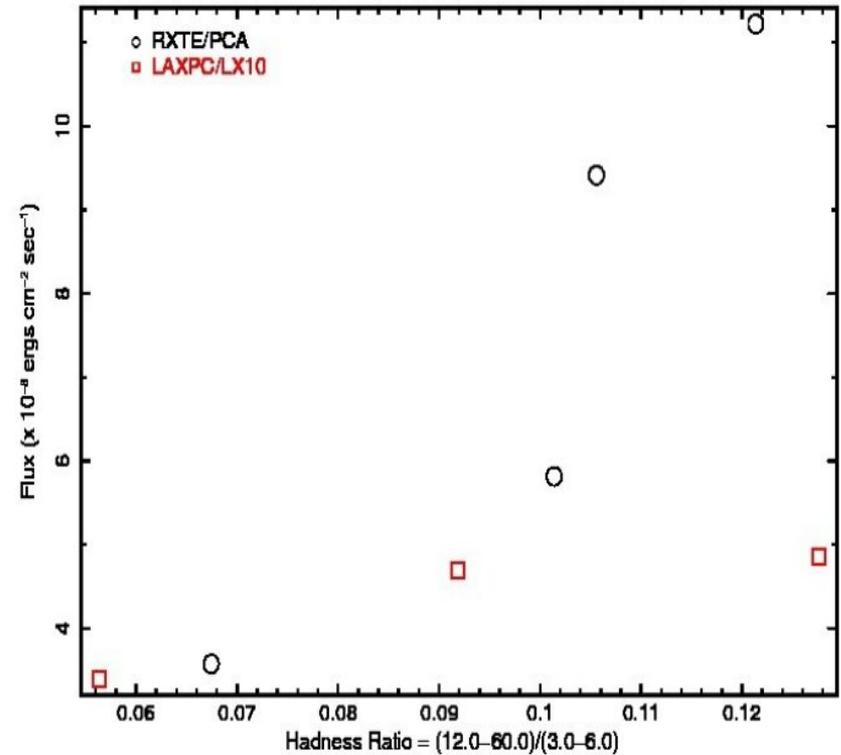
At present, NASA's NuSTAR and LAXPC instrument are only two X-ray space instruments which cover 3-80 keV energy range. Here we show fit to simultaneous LAXPC and NuSTAR data of Crab (a X-ray pulsar) taken on 1st April, 2016. It is a good fit with reduced chi square ~ 1 . NuSTAR data shows large spread at high energy which suggests that its detection efficiency decreases fast at > 30 keV.



Hardness ratio HR2

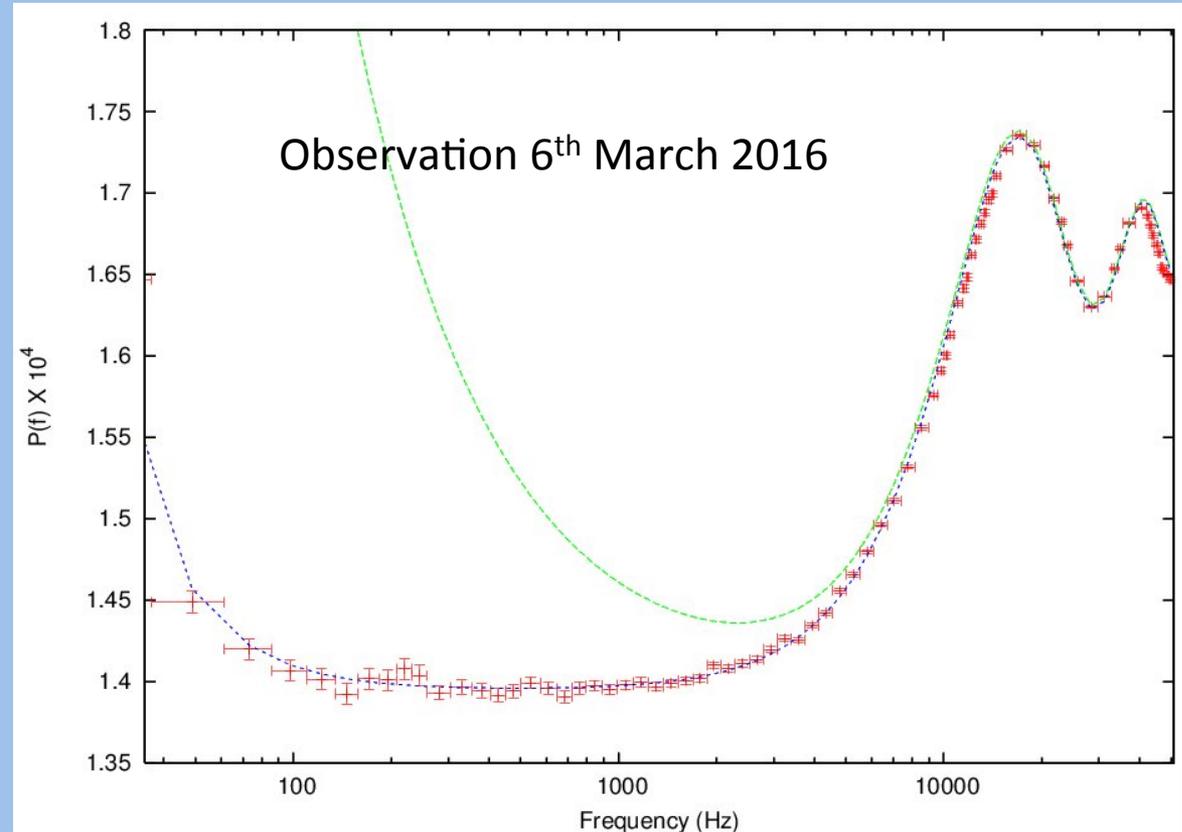
Calculated from spectral fit for GRS 1915+105 soft state (effective area, dead time corr).

From observed counts in different energy bands in H1743-322



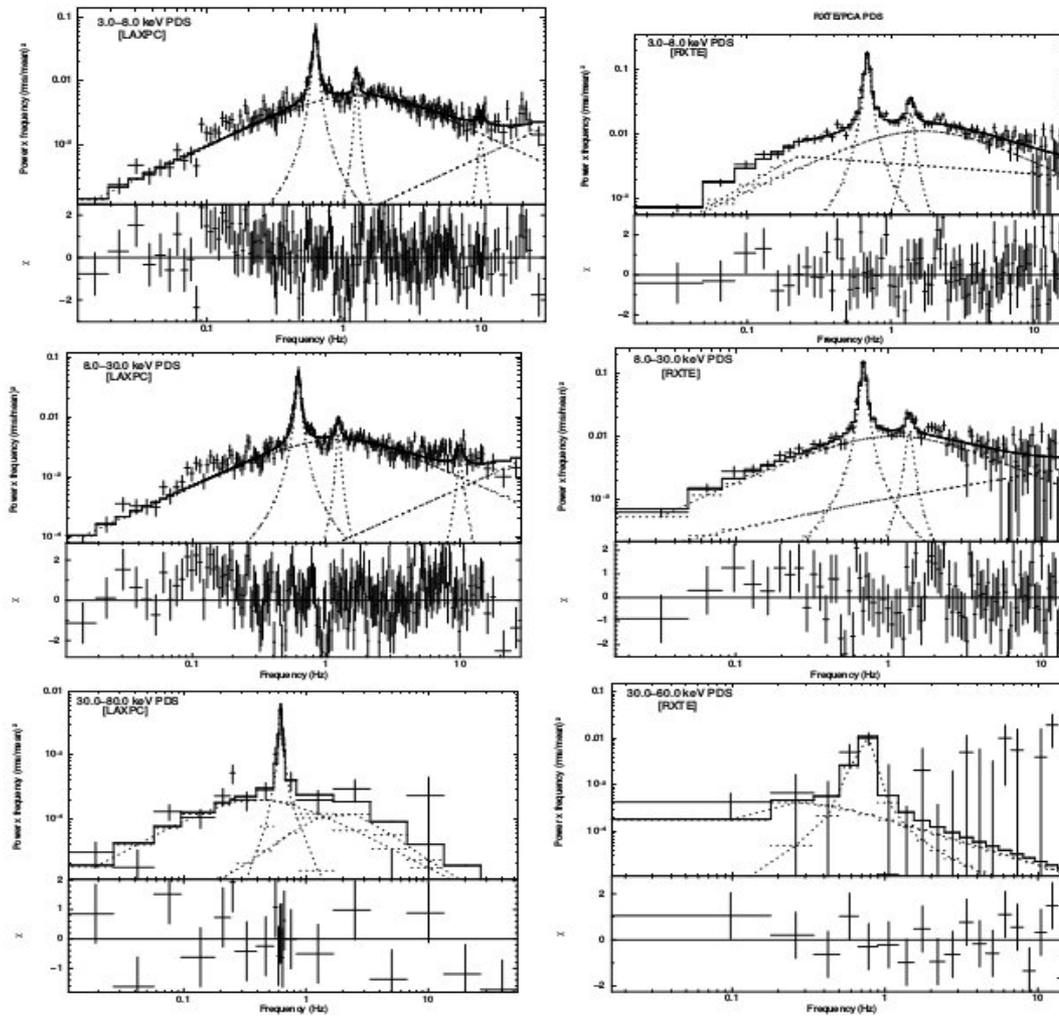
LAXPC instrument capabilities: QPO (Quasi Periodic Oscillation) detection

Rebinned power density spectra of GRS 1915+105 (a microquasar) in SPL state. It matches well with the predicted Poisson noise level with dead time 42.3 microseconds and a low frequency power low component. The green line shows the expected peak power of a QPO with quality factor $Q=4$ and rms of 5%. LAXPC instrument would detect QPO of such a strength easily till 3000 Hz.

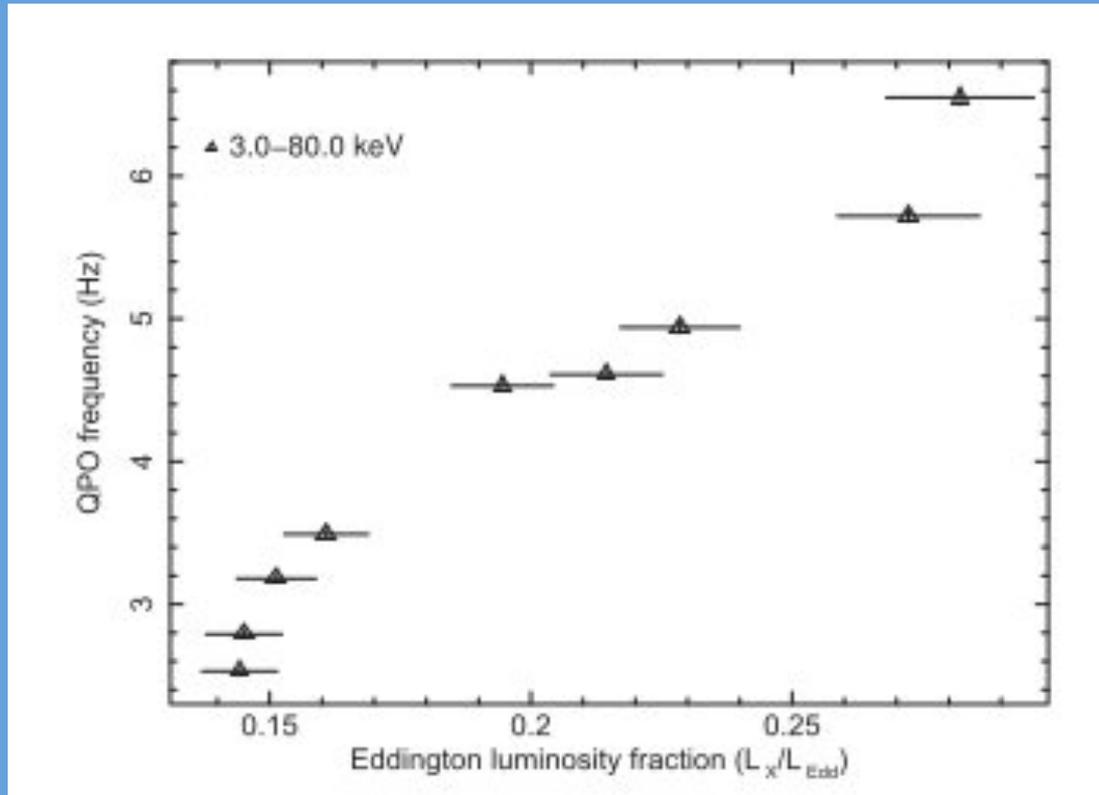


Yadav et al. ApJ 2016, 833,27

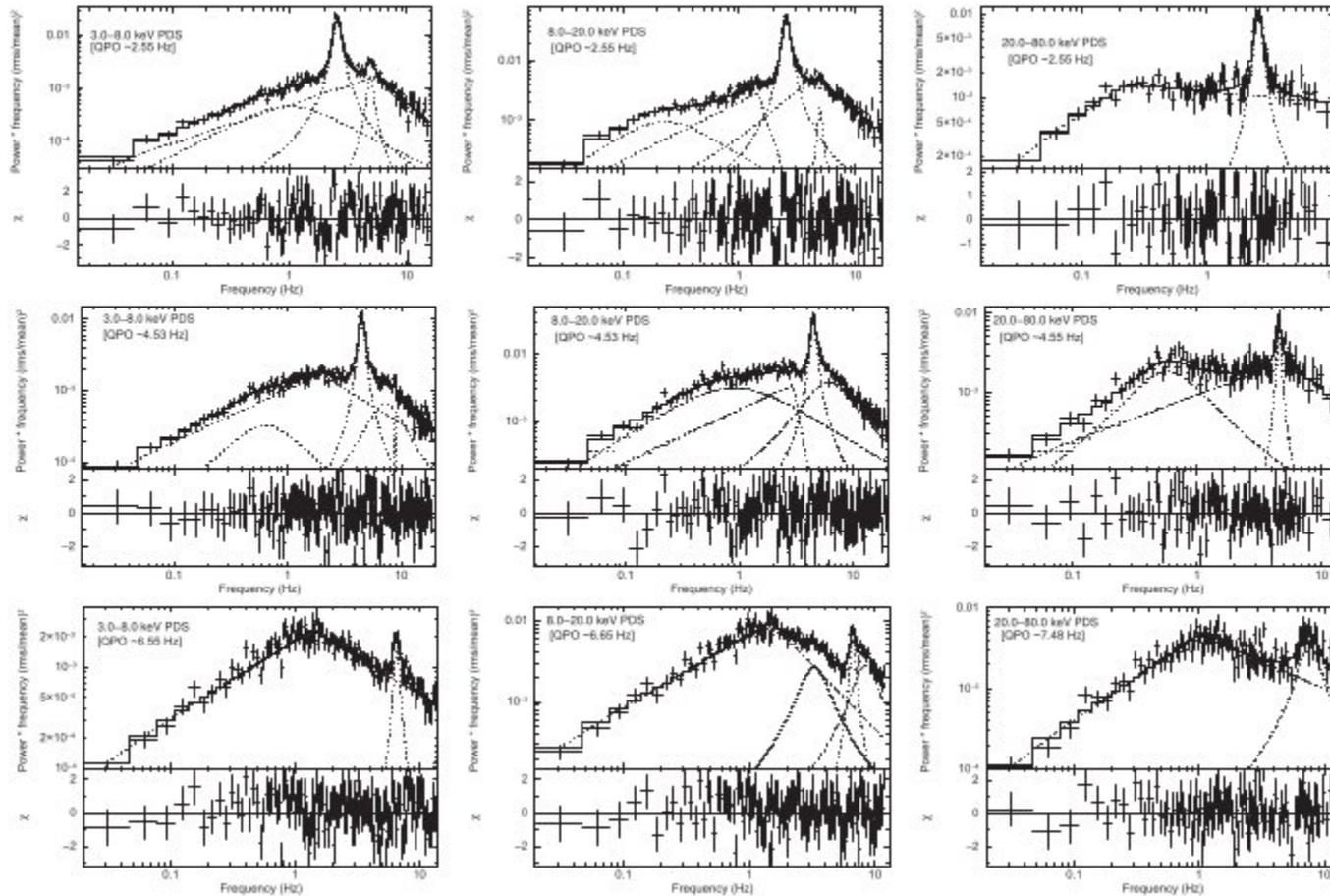
LAXPC OBSERVATIONS OF H 1743-322



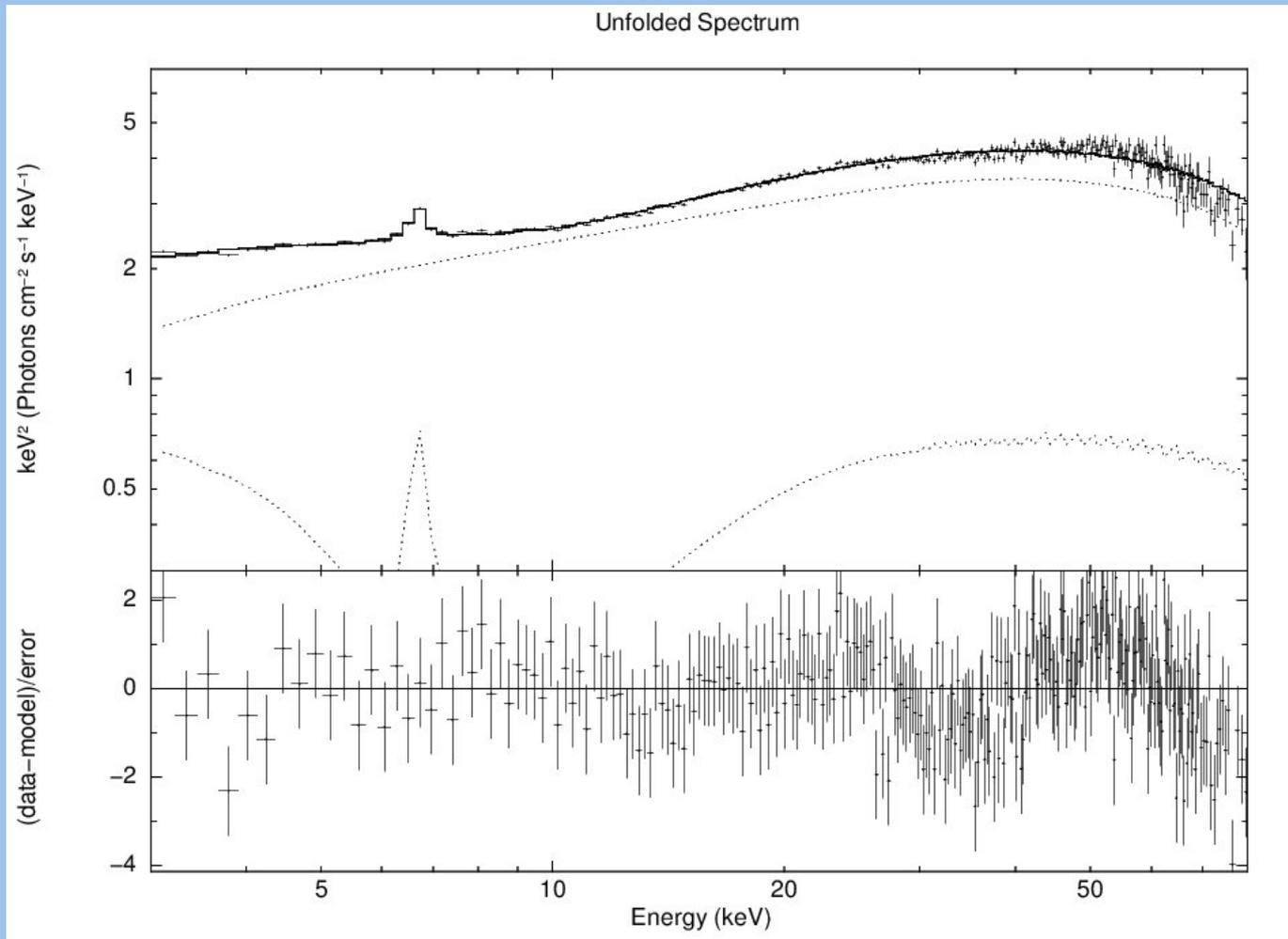
During GRS 1915+105 observation during 5-7th March, 2016 SPL (steep power law) X-ray state was observed for ~13 hrs. QPO frequency changes from 2.5 Hz to 6 Hz.



Yadav et al. ApJ 2016 , 833,27



Cyg X-1 Energy spectrum

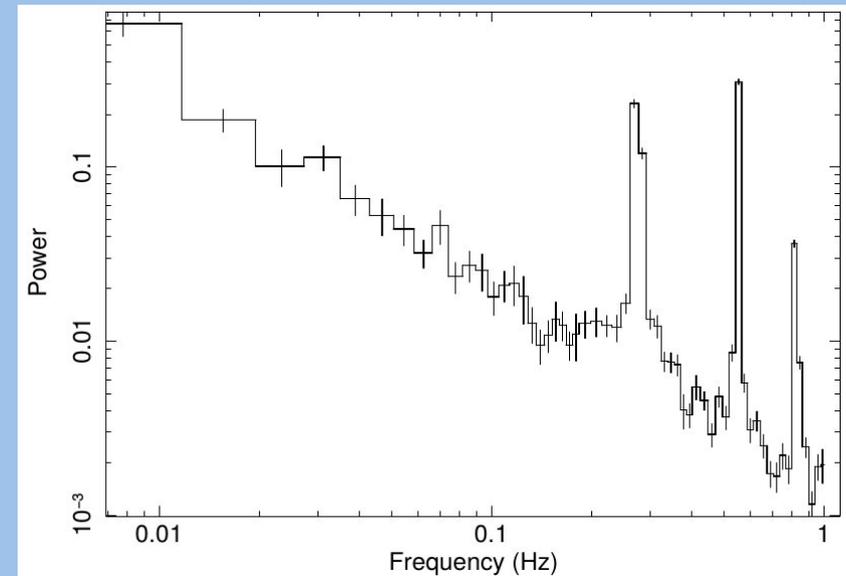
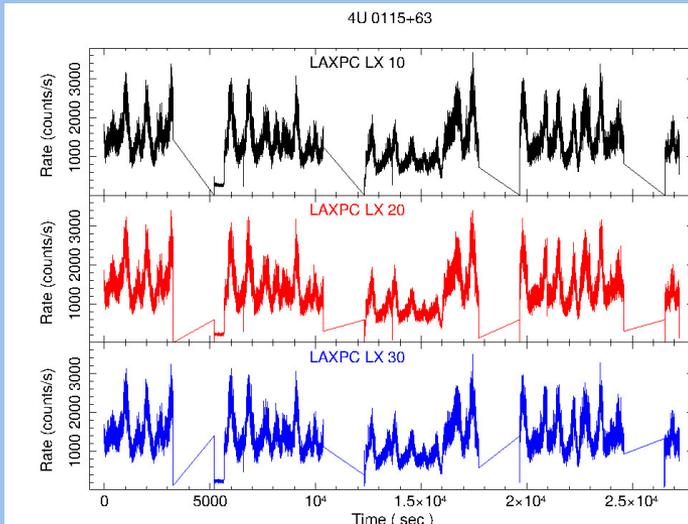
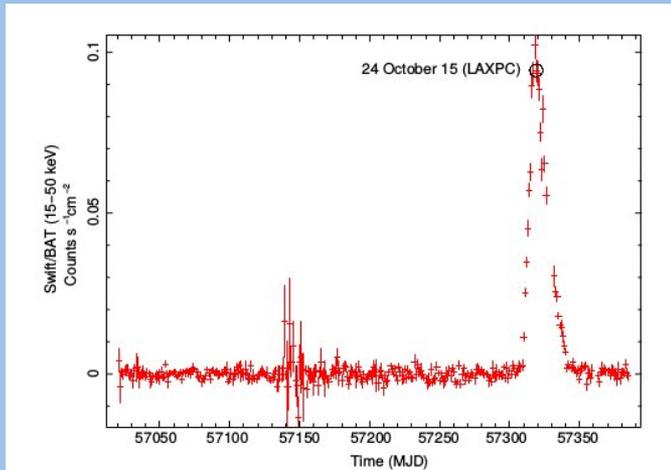


Ranjeev et al ApJ 2016 in press

First light results: 4U 0115+63 (a pulsar in outburst)

Transient X-ray pulsar (3.6 seconds) 4U0115+63.

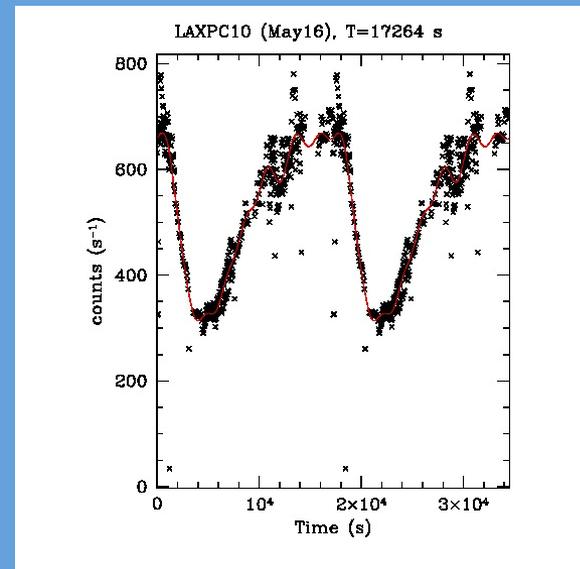
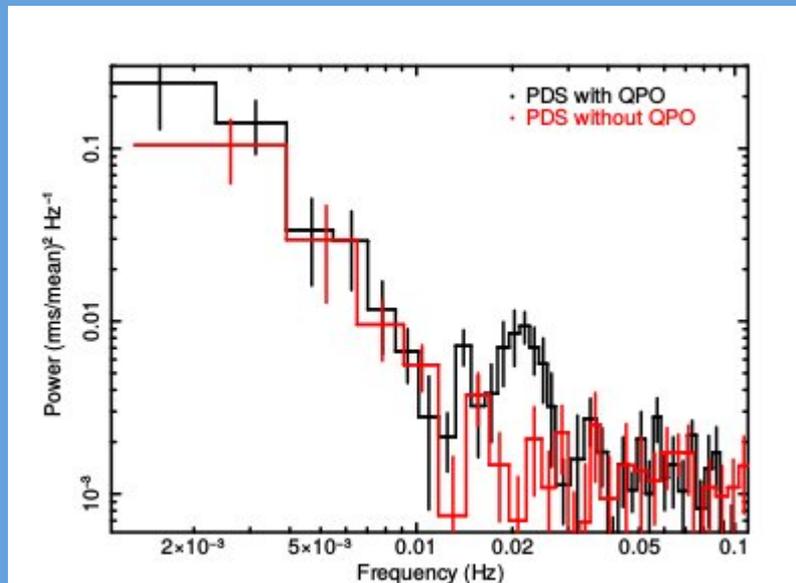
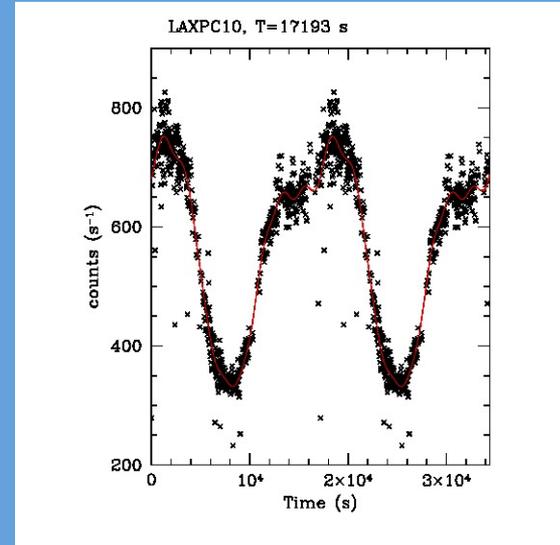
High Mass X-ray Binary with a neutron star (high magnetic field) companion that accretes mass



Agrawal et al 2017

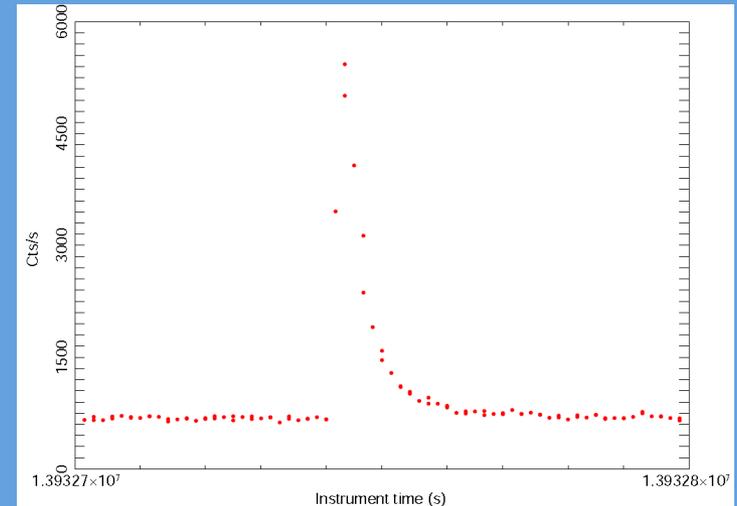
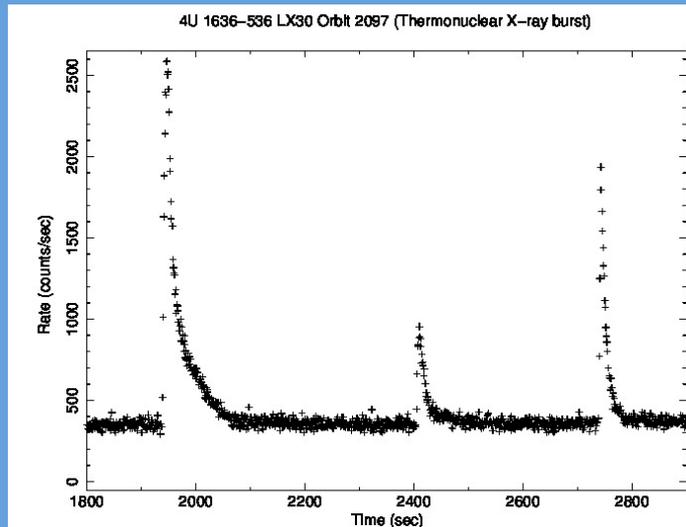
Cyg X-3 Microquasar
4.8 hours orbital period
Often strong radio jets

Mayukh et al 2017



LAXPC observation of Thermonuclear bursts and high frequency Quasi Periodic Oscillation (HF QPOs): LAXPC observed thermonuclear bursts in two neutron star X-ray binaries; 4U 1636-536 and 4U 1728-34 during instrument verification phase. These are thermonuclear (atom bomb) explosions on accreting neutron star. Rise time is ~ 1 sec (X-ray flux rises by a factor of ~ 10) and decay time 10-100 sec.

4U 1728-34

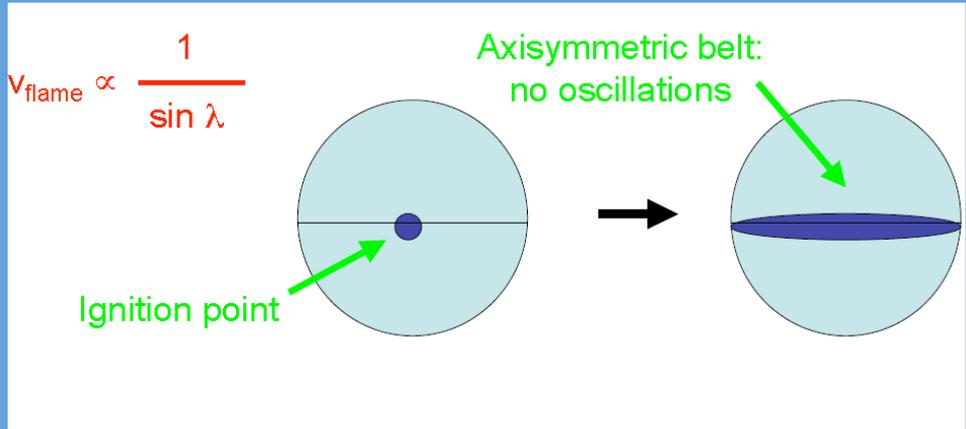
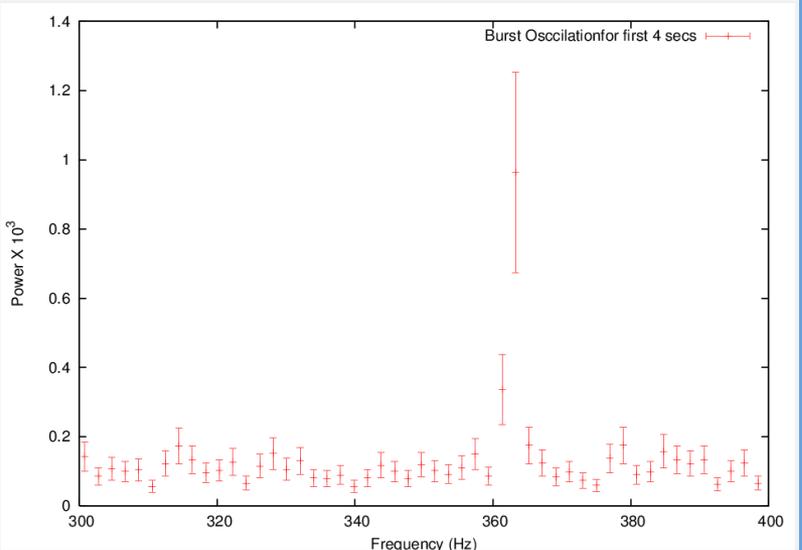
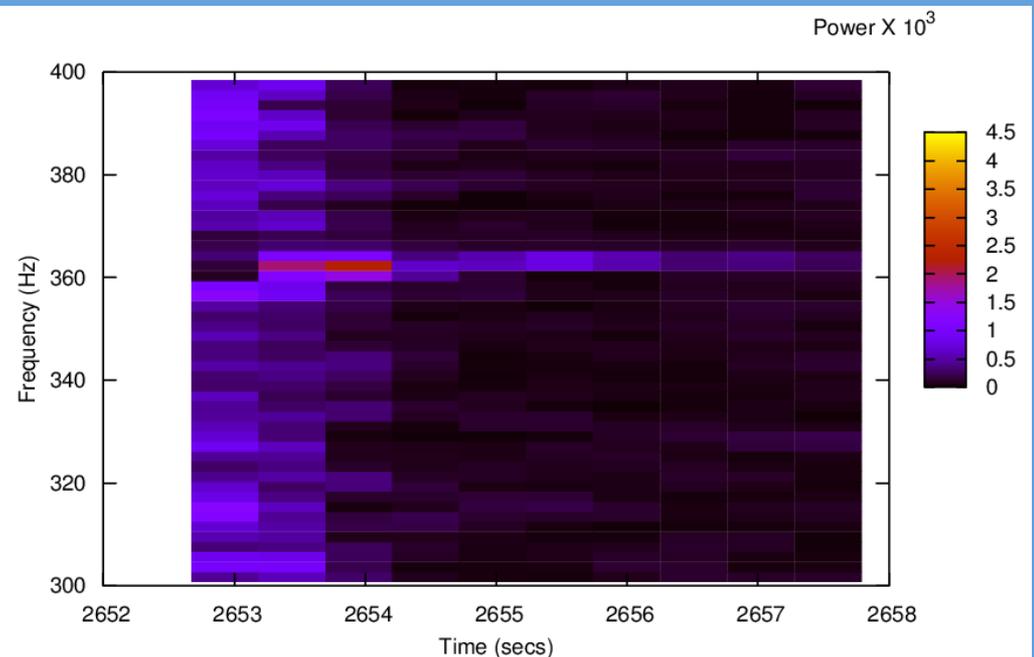


Paul et al 2017

Sudip et al 2017

Top panel shows dynamic power density Spectrum from LAXPC observation of 4U 1728-34.

We observed burst oscillation for first four sec at 362.7 Hz (top panel). It suggests that this thermonuclear bursts happens at Equator and spreads in four sec and Become axisymmetric belt and QPO Disappears (bottom panel)

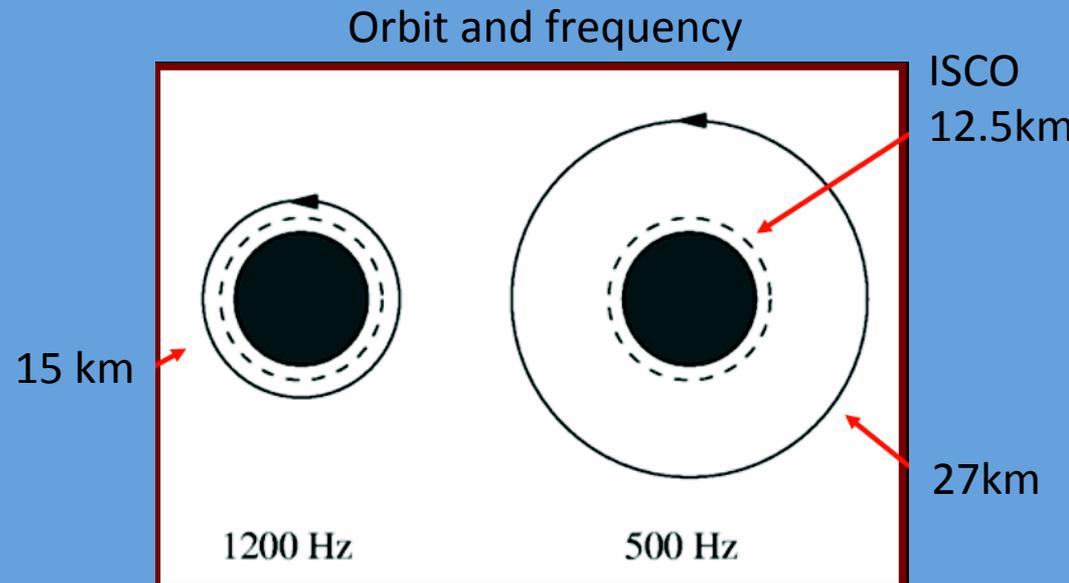
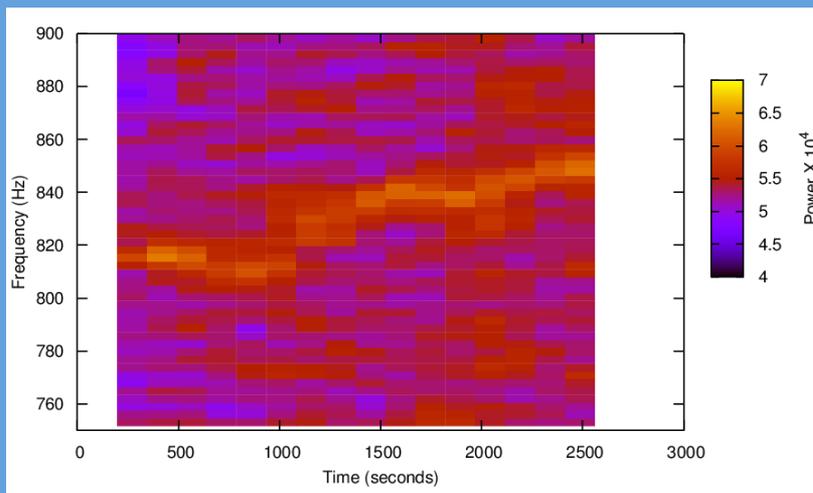


High Frequency Quasi-periodic Oscillations (HF QPOs) :

HF QPOs probe regions close to the compact objects (Neutron star and black hole Systems) which are characterized by very high gravity and magnetic field.

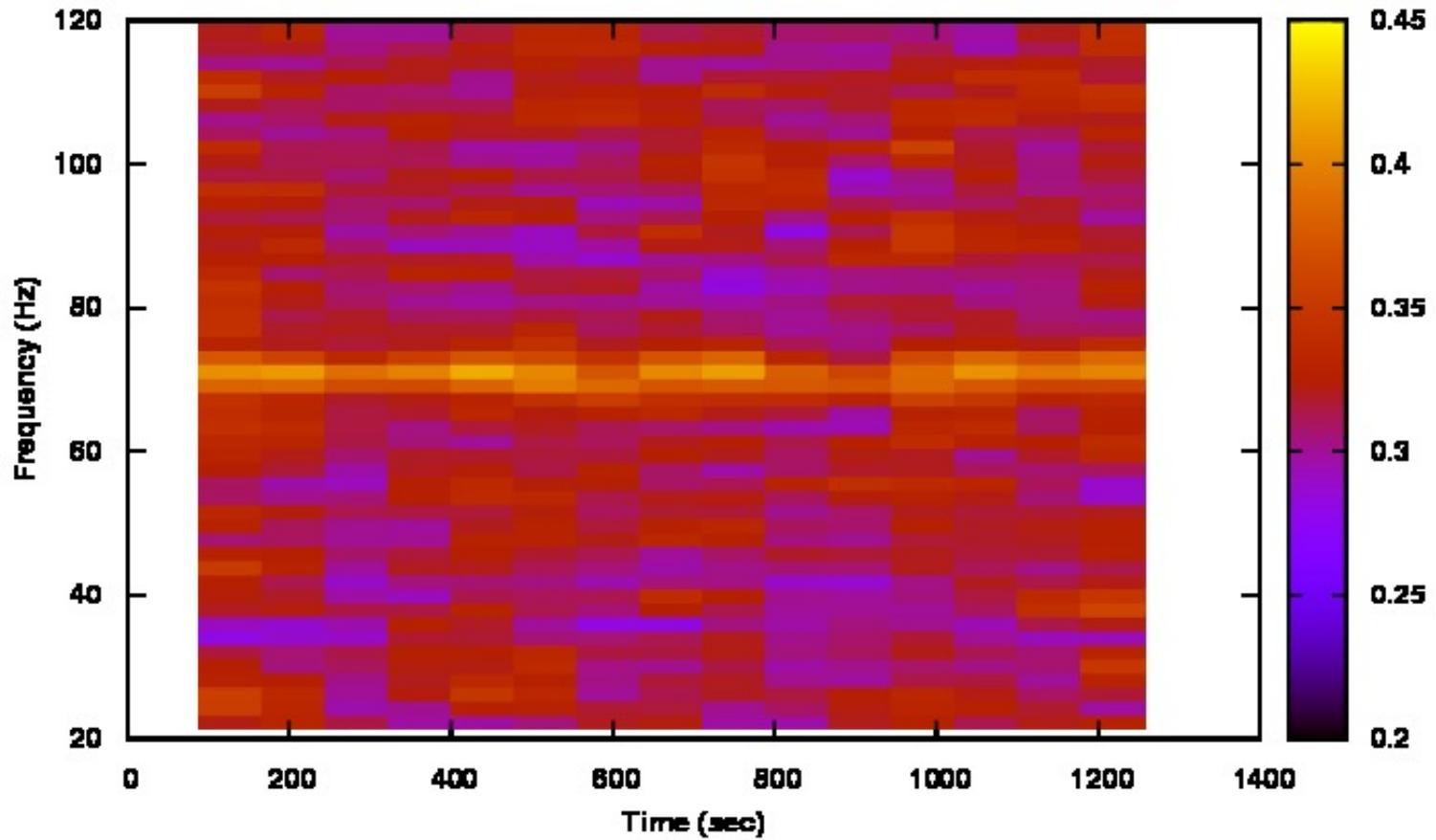
Observed frequency is always < 1.2 KHz (for $\sim 2 M_{\text{sun}}$). The innermost stable circular orbit (ISCO) is around 12.5 km which corresponds to 1.2 KHz (right panel). Left panel shows dynamic Power density spectrum from LAXPC observations. As mass falls, qpo evolves (rises) and explores extreme conditions near neutron star. QPO frequency evolves from ~ 820 Hz to 850 Hz

Left panel shows dynamic power density Spectrum from LAXPC observation of 4U 1728-34. We observed 820 Hz HF QPOs showing drift to higher frequency.

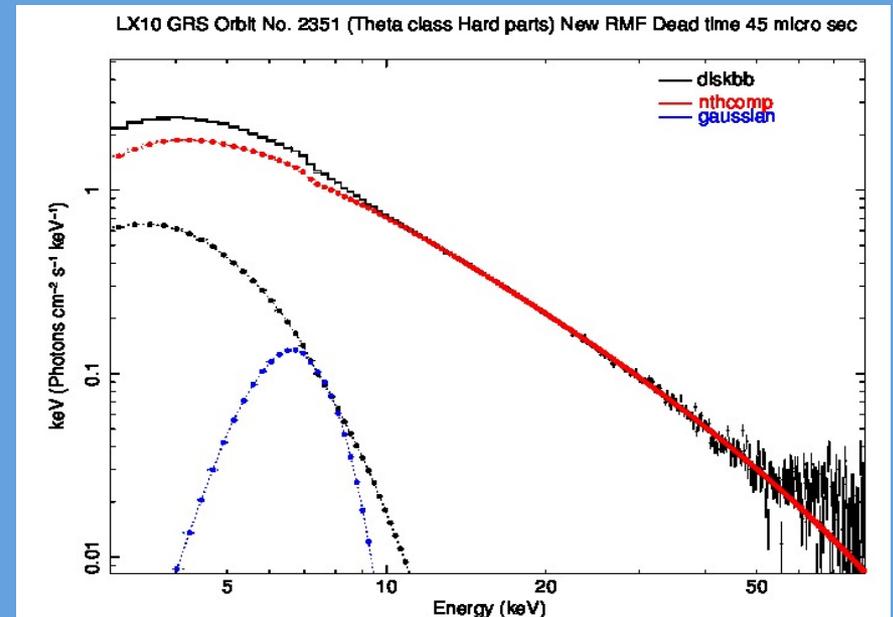
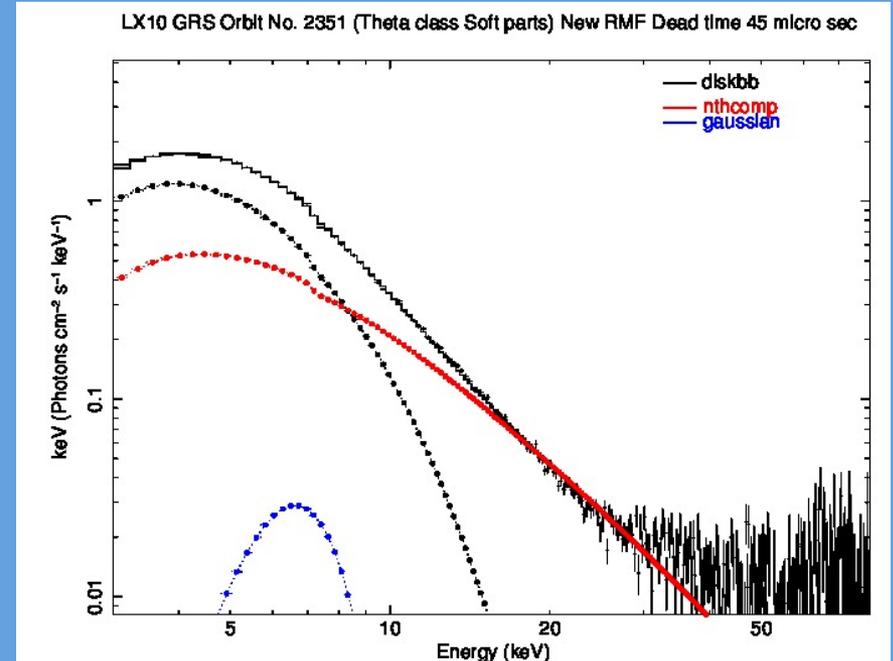
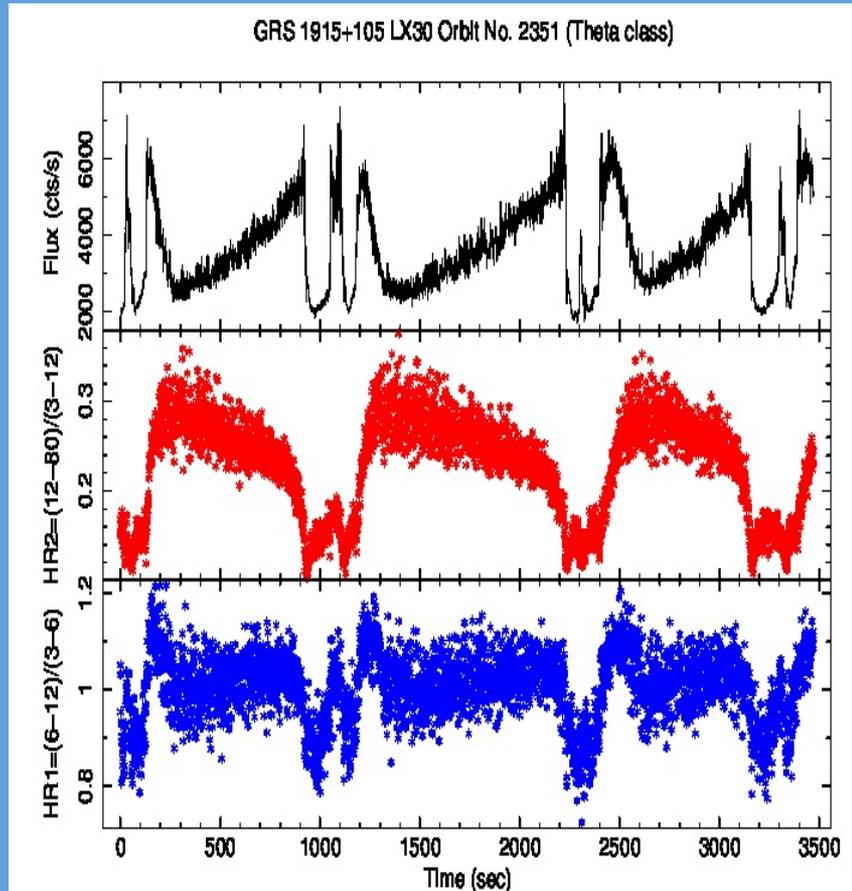


Jai Verdhana et al 2017

GRS 1915+105

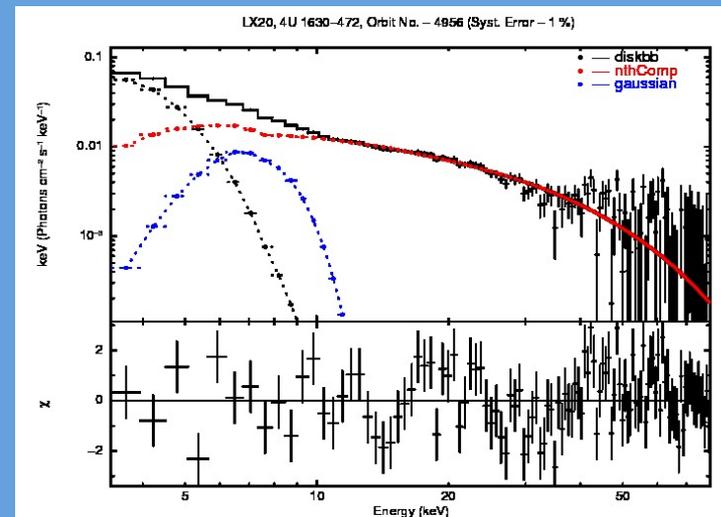
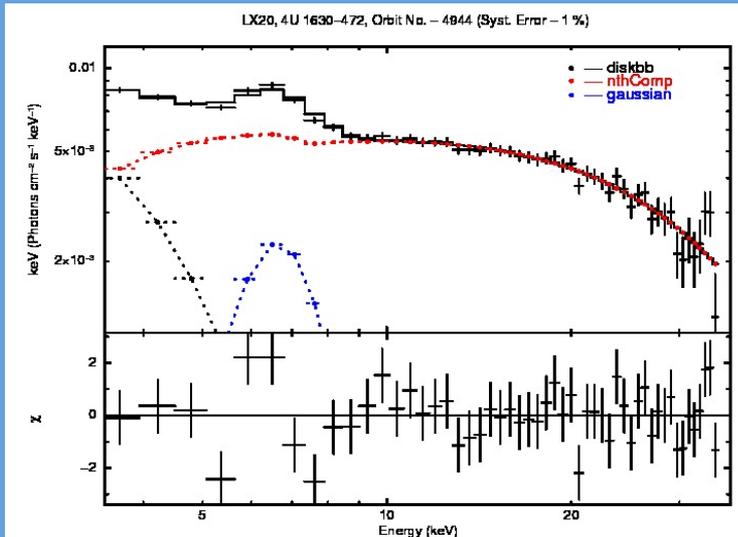
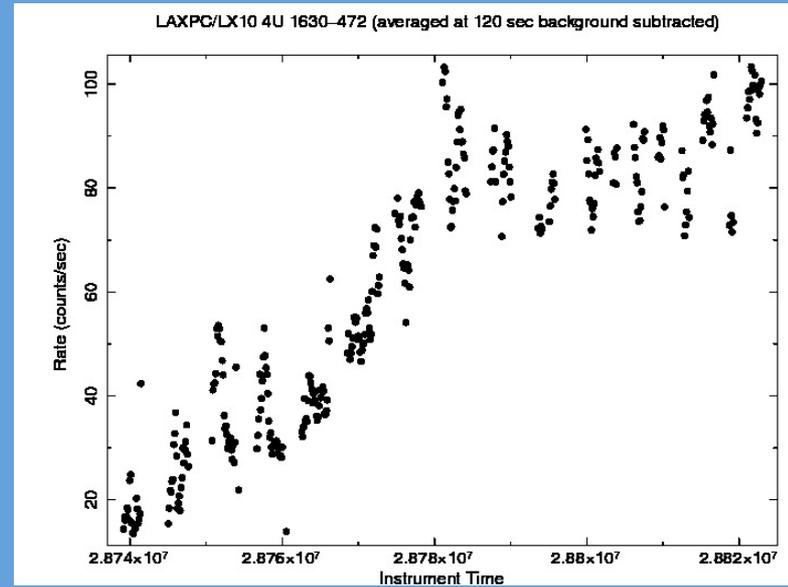
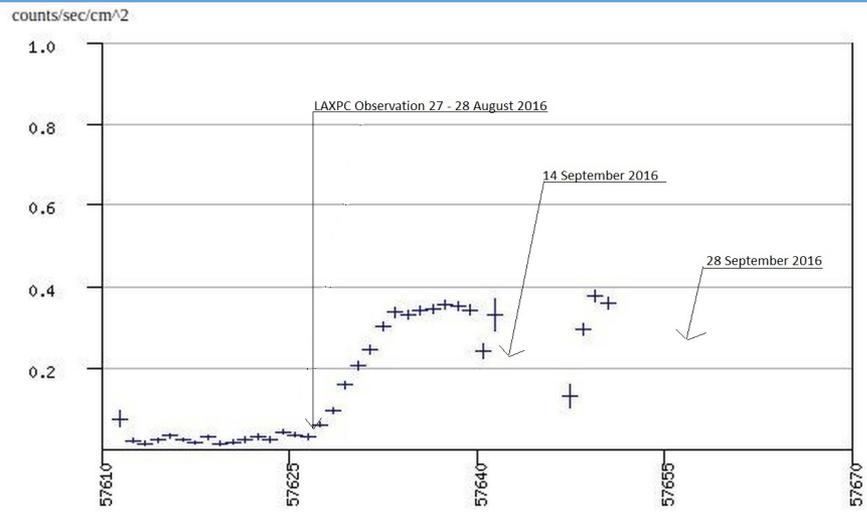


Radio jets observed simultaneously with GMRT Radio flares during X-ray theta class: 5-7 March 2016



Simultaneous multiwavelength observation with Southampton group and others

Most valuable Catch: 4U 1630-472; Black hole binary in outburst



Summary

1. We have got high quality LAXPC data , background model and detector response. Research students are welcome to join LAXPC data analysis.
2. We have LAXPC workshop next week (18-21 January, 2017) on LAXPC data analysis. It is for limited participants and we had to regret some of the participants.
3. We will have short TIFR visits (3 weeks) program to support LAXPC data analysis specially for university students.

Thanks !

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Vikram Sarabhai Space Centre, Trivandrum, Space Applications Centre, Ahmedabad
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