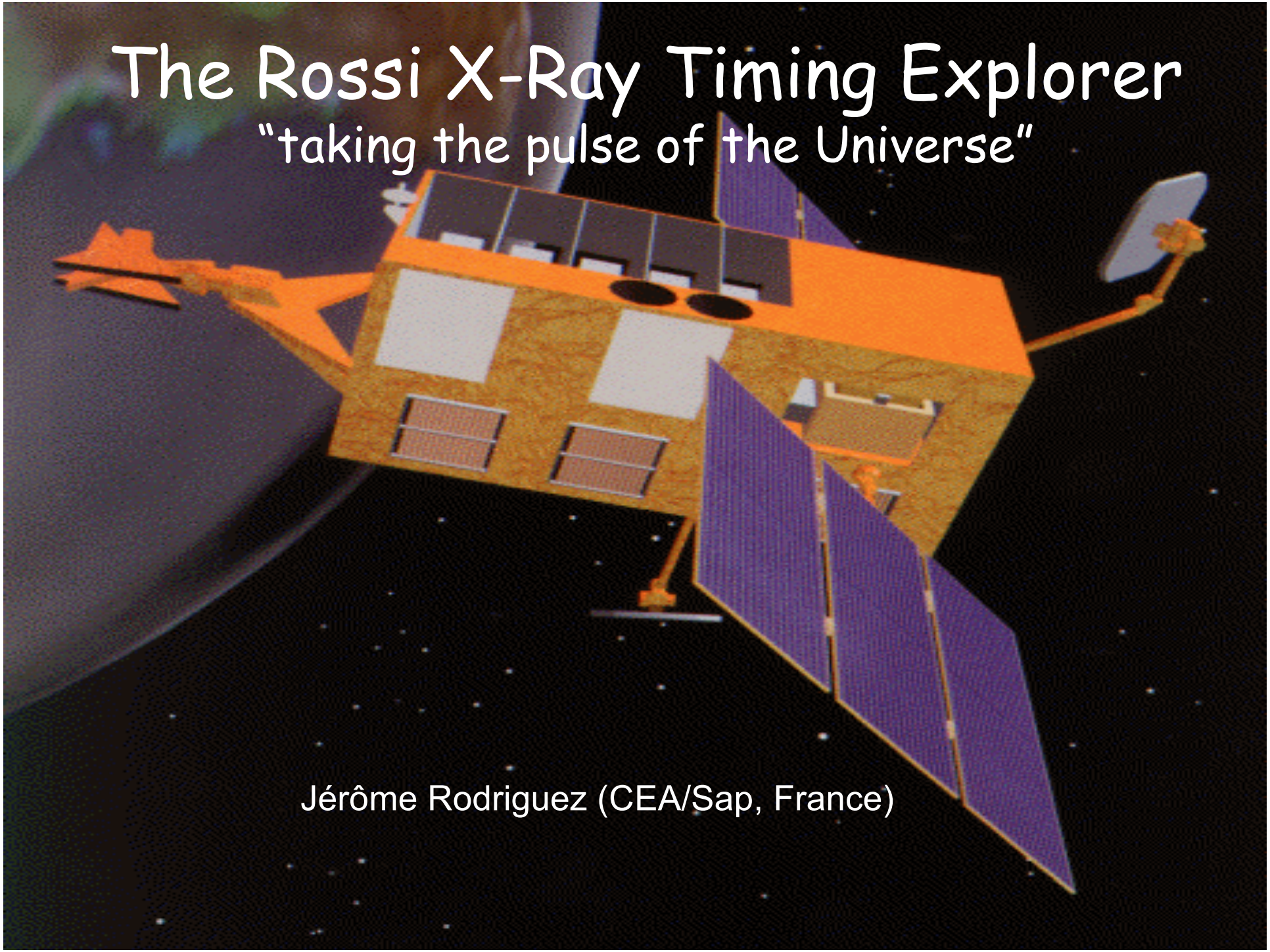
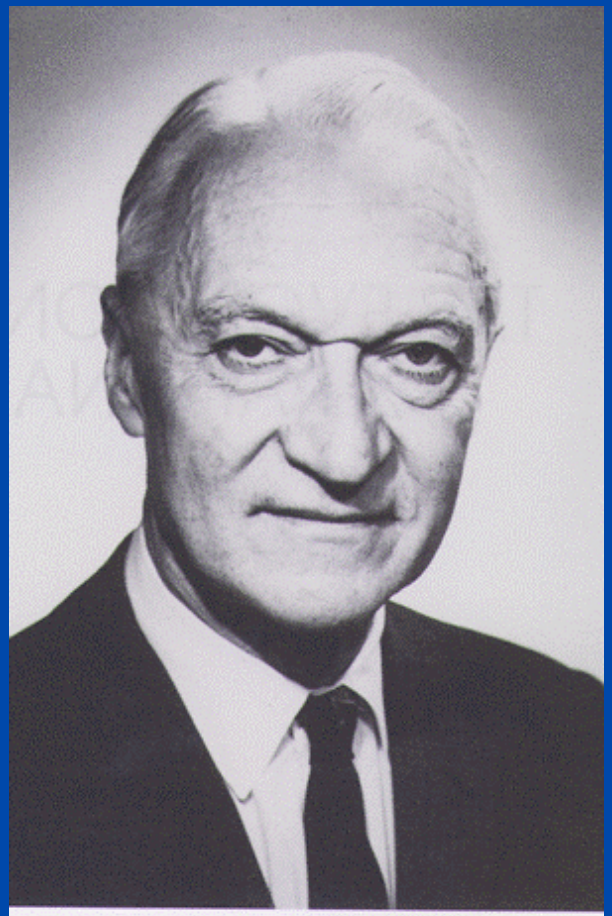
The Rossi X-Ray Timing Explorer

"taking the pulse of the Universe"



Jérôme Rodriguez (CEA/Sap, France)

The 'R' in RXTE



Photograph courtesy of the MIT Museum

- In 1996, after its launch XTE has been renamed Rossi-XTE in honour of Bruno B. Rossi
- Prof. Bruno B. Rossi († 1993) is a pioneer of X-ray astronomy.
- Discovery of Sco X-1 in 1962, by a team composed of Riccardo Giacconi, Herb Gursky, Frank Paolini & Bruno B. Rossi

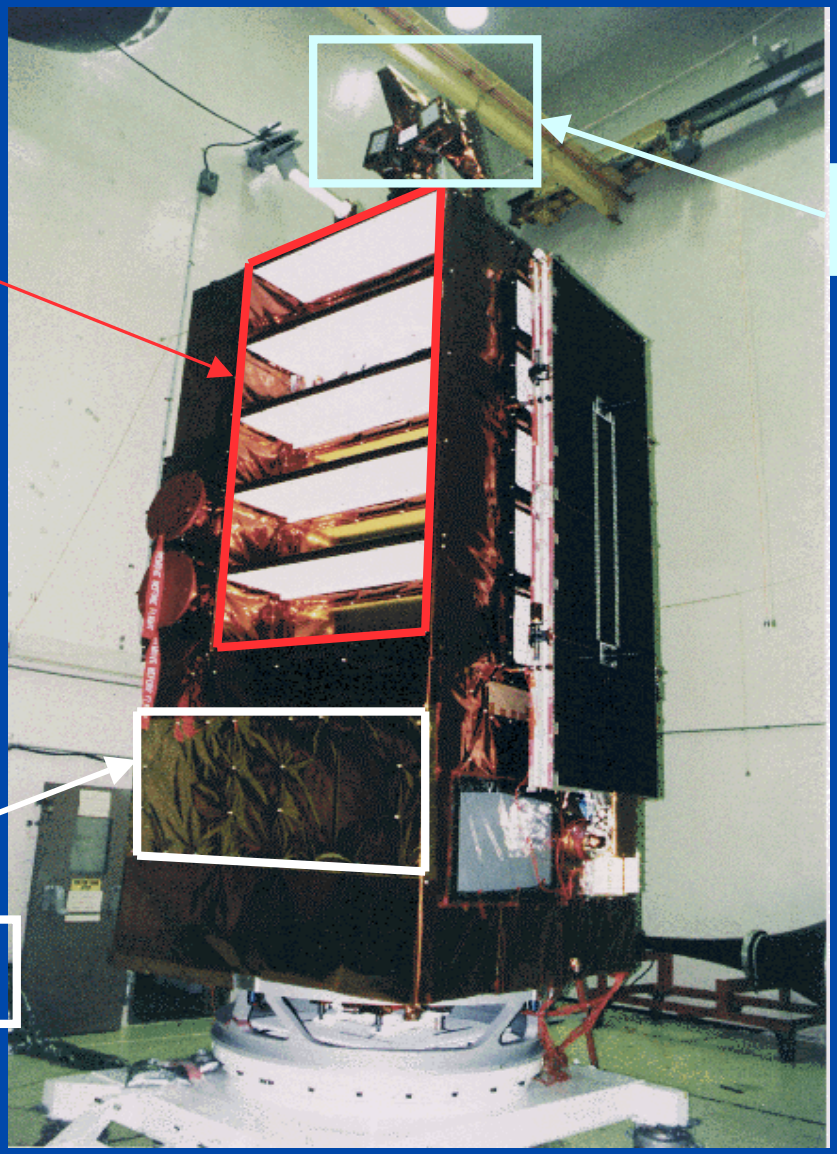
Mission Characteristics

- Lifetime : 30 December 1995 to the present
- Energy Range : 2 - 250 keV
- Special Features : Very large collecting area and all-sky monitoring of bright sources
- Payload :
  - All-Sky Monitor (ASM)
  - Proportional Counter Array (PCA)
  - High Energy X-ray Timing Experiment (HEXTE)
- Low Earth Orbit, ~ 90 minutes period

VERY HIGH FLEXIBILITY of its scheduling => unprecedented instrument to study all type of X-ray emitting objects

Technical view

PCA: 5 PCUs



ASM: 3 cameras

HEXTE: 2 Clusters

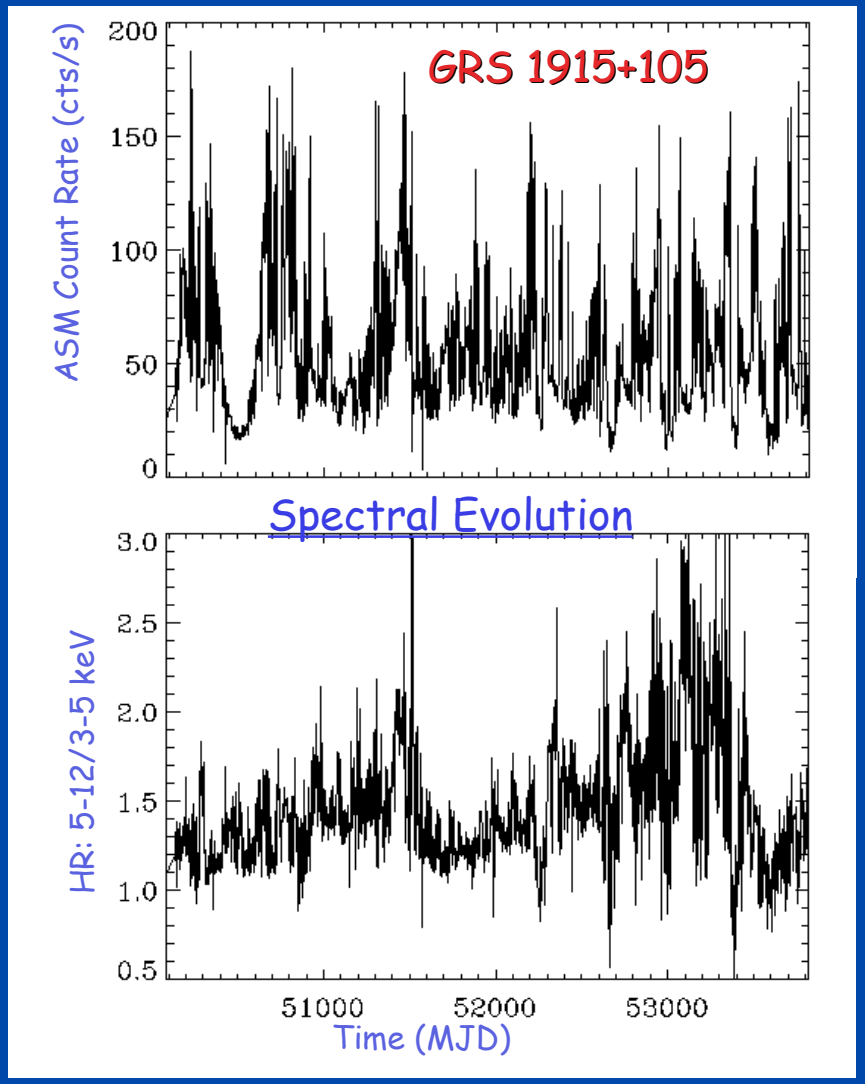
The All Sky Monitor

Built by the Center for Space Research at MIT
The principal investigator is Dr. Alan M. Levine

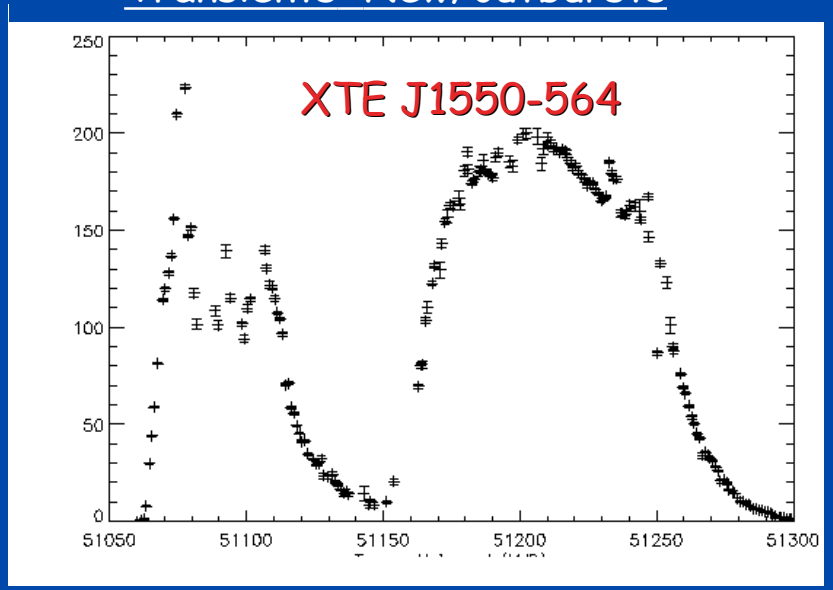
- 3 Scanning Shadow Camera (SSC), 6° x 90° FOV/SSC
- Collecting area: 90 cm2, Effective area/SSC: 10 cm2, 30 cm2, 23 cm2 @2, 5, 10 keV
- Xenon proportional counter, position-sensitive
- Sensitivity: 20 mCrab
- Spatial resolution: 3' x 15'
- 1 Crab <=> 75 cts/s (1.5-12 keV)
- 3 spectral channels 1.5-3, 3-5, 5-12 keV
- Time resolution: histograms accumulated every 90s
- 80% of the sky every 90 minutes (1 RXTE orbit)

Uses/Advantages of the ASM

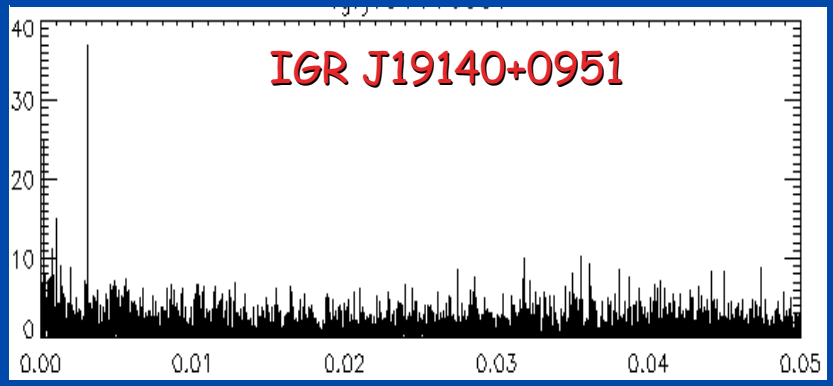
Long term evolution



Transients: New/outbursts



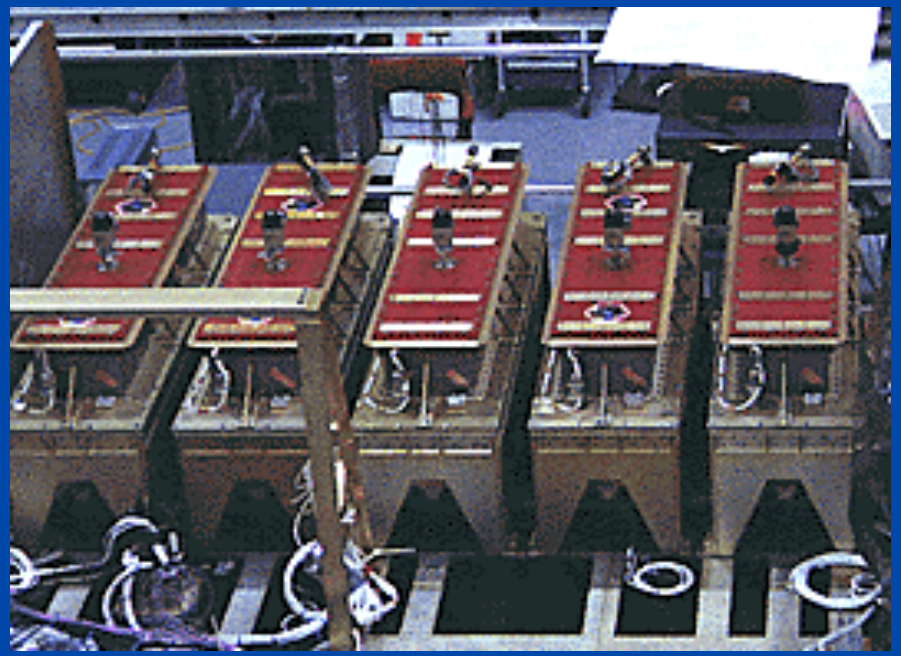
Periods in X-ray lightcurves



The Proportional Counter Array

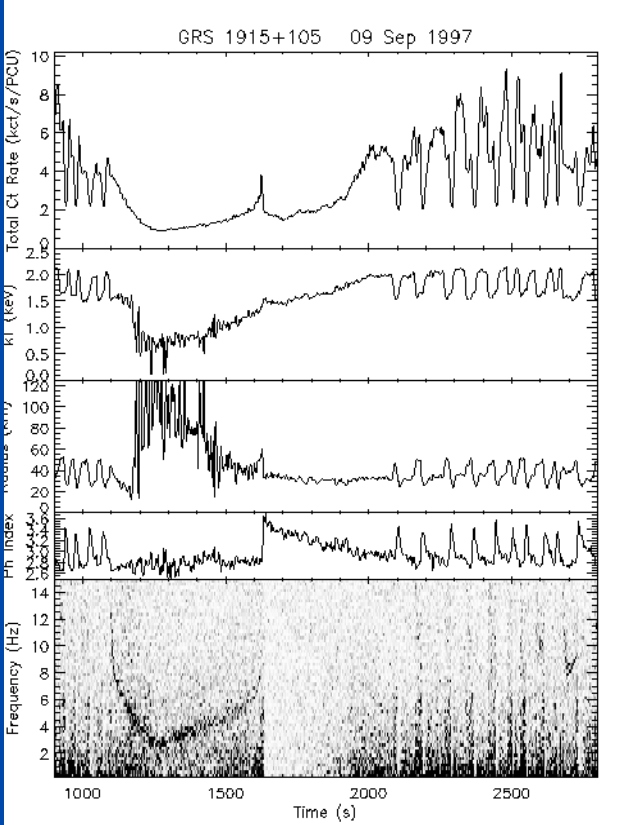
Built by the EUD (formerly 'LHEA') @ GSFC
The principal investigator is Dr. Jean H. Swank

- 5 proportional counters (PCU)
- Total collecting area: 6500 cm^2
- Energy range: 2 - 60 keV
- Energy resolution: < 18% at 6 keV
- Time resolution: 1 μs
- Spatial resolution: collimator with 1° FWHM
- Sensitivity: 0.1 mCrab
- Background: 2 mCrab

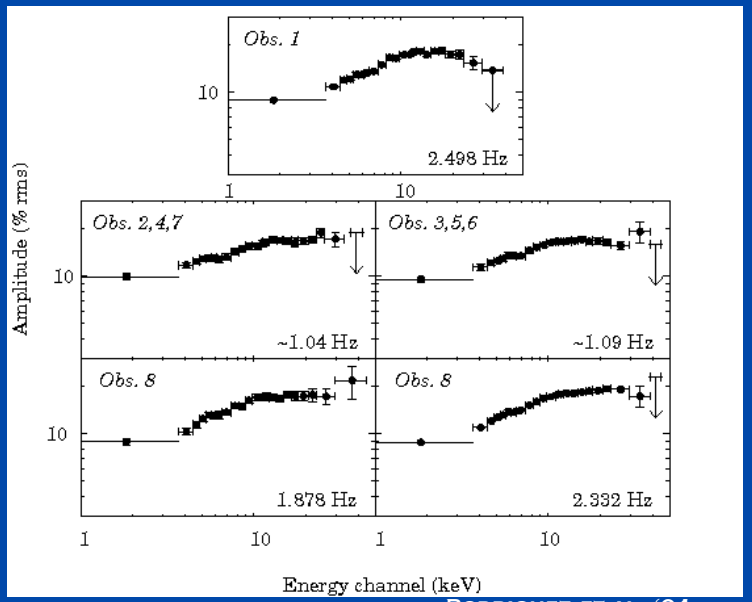


PCA: Dedicated to timing analysis (1)

Study of QPOs & Spectro-temporal analysis



SWANK ET AL. '98, MARKWARDT ET AL. '99



RODRIGUEZ ET AL. '04

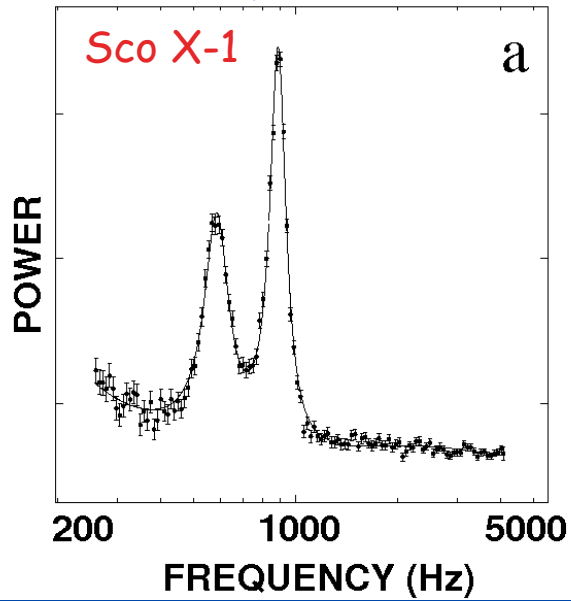
Large collecting area => « spectra » of QPOs

Spectral and temporal fitting short time scales => spectro-temporal connections

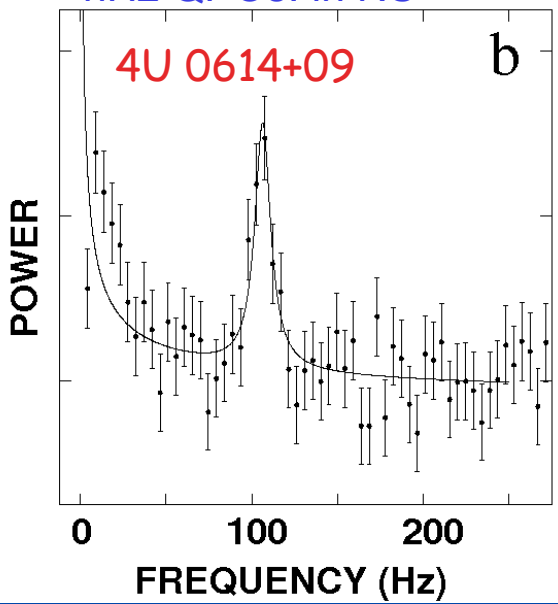
PCA: Dedicated to timing analysis (2)

Discovery of high Freq. QPOs

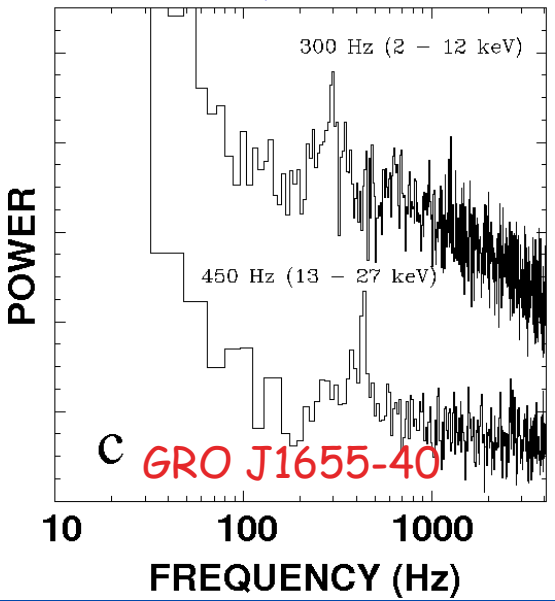
Twin kHz QPOs in NS



hHz QPOs: in NS



« kHz » QPOs in BH

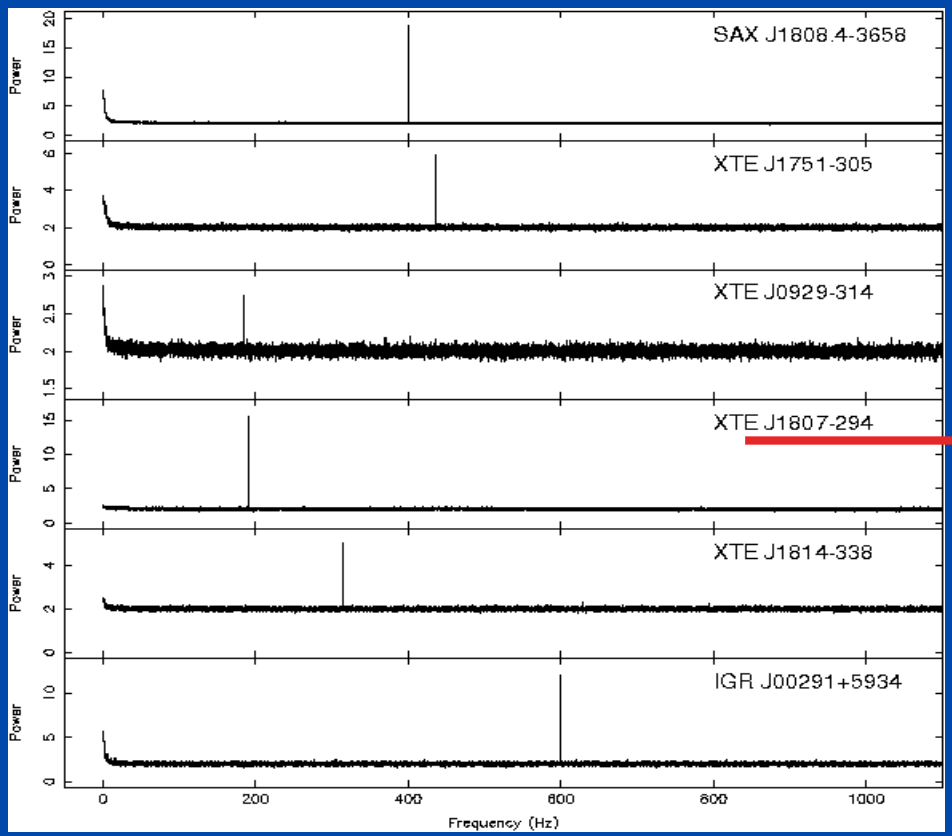


Review by van der Klis, astro-ph '04; to be published in '06

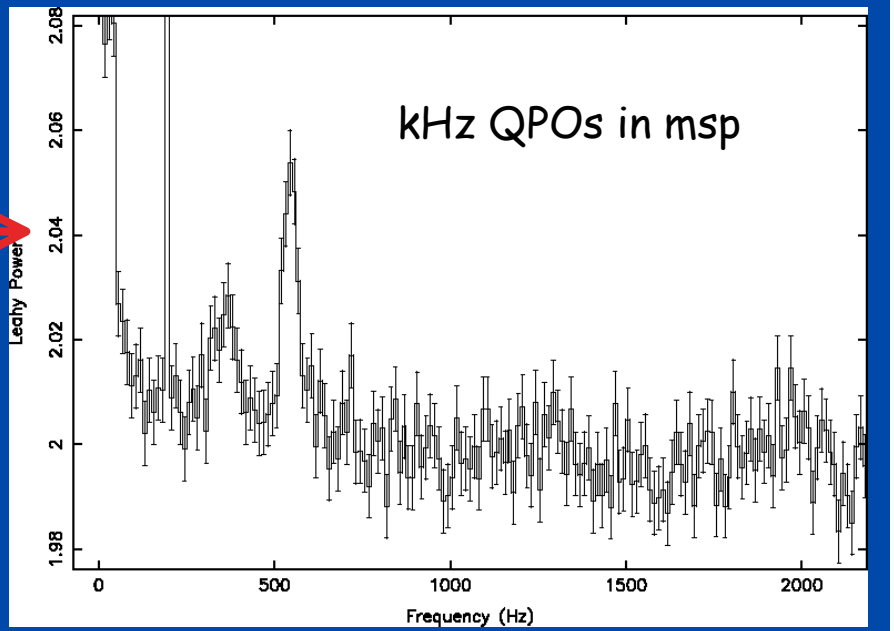
PCA: Dedicated to timing analysis (3)

Discovery of Accreting ms pulsars

=> Coherent pulsations => Spin
=> Msp = missing link between slow isolated pulsars and radio ms pulsars



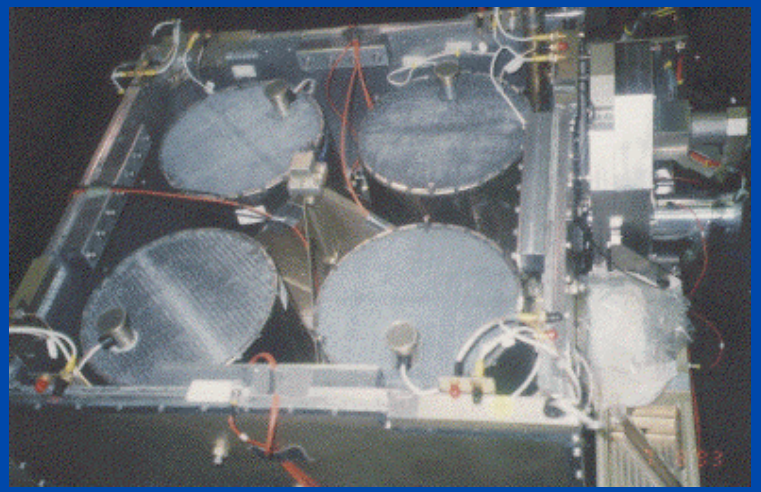
Review by Wijnands, astro-ph '05



The High Energy Timing Experiment

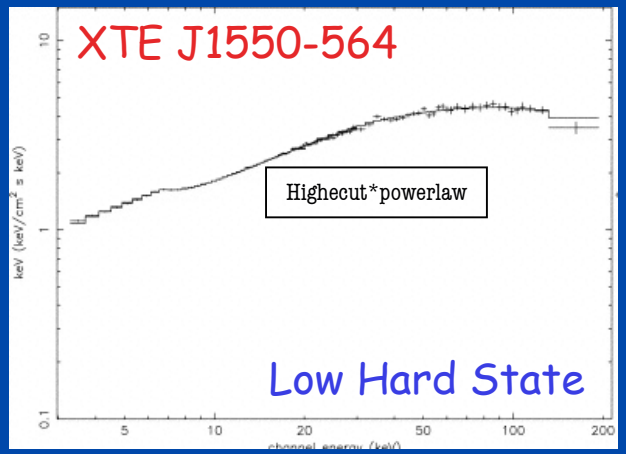
Built by the CASS at UCSD.
The principal investigator is Dr. Rick E. Rotschild

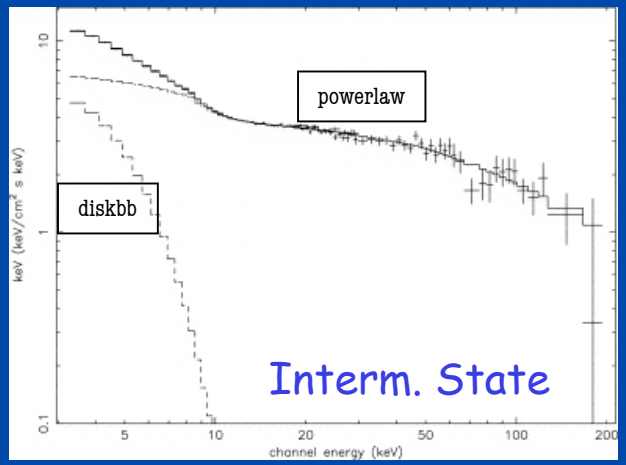
- Detectors: 2 clusters of 4 NaI/CsI scintillation counters
- Cluster ``rock'' (beamswitch) along mutually orthogonal directions 1.5 or 3.0° off source
- Energy range: 15 - 250 keV
- Energy resolution: 15% at 60 keV
- Time sampling: 8 microsecond
- Field of view: 1 degree FWHM
- Collecting area: 2 times 800 cm^2
- 1 Crab = 360 count/s per HEXTE cluster
- Background: 50 count/s per HEXTE cluster



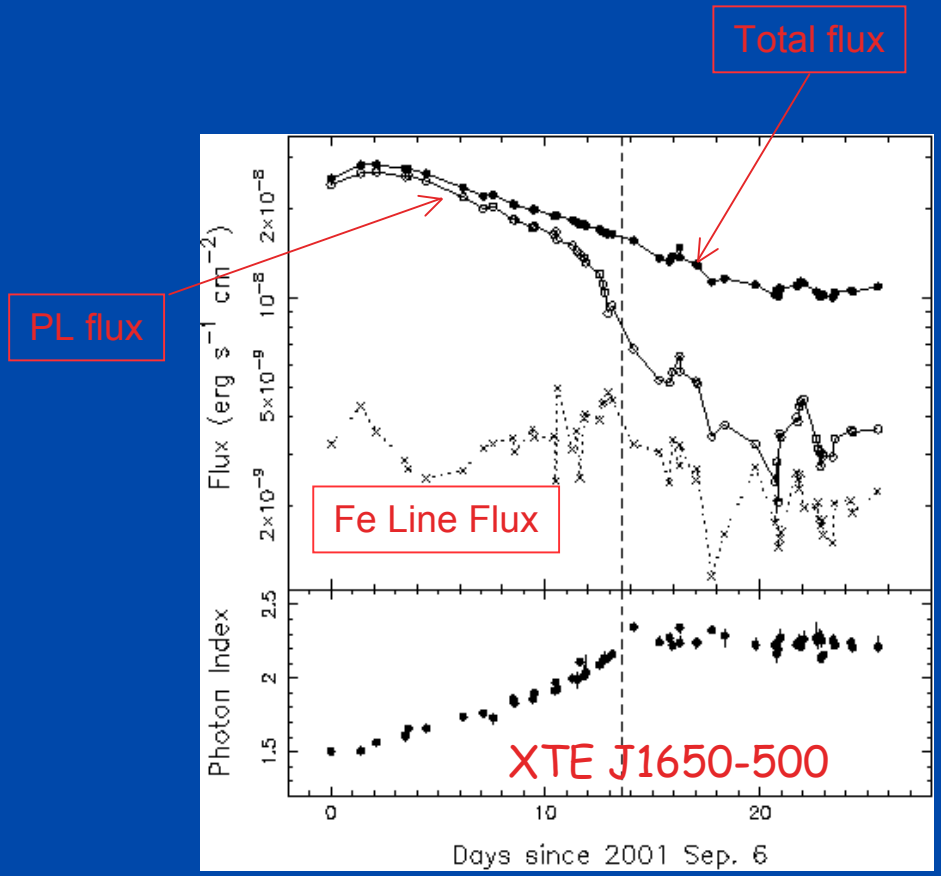
3-200 keV spectral analysis (1)

Spectral transitions in X-ray sources, evolution of spectral components





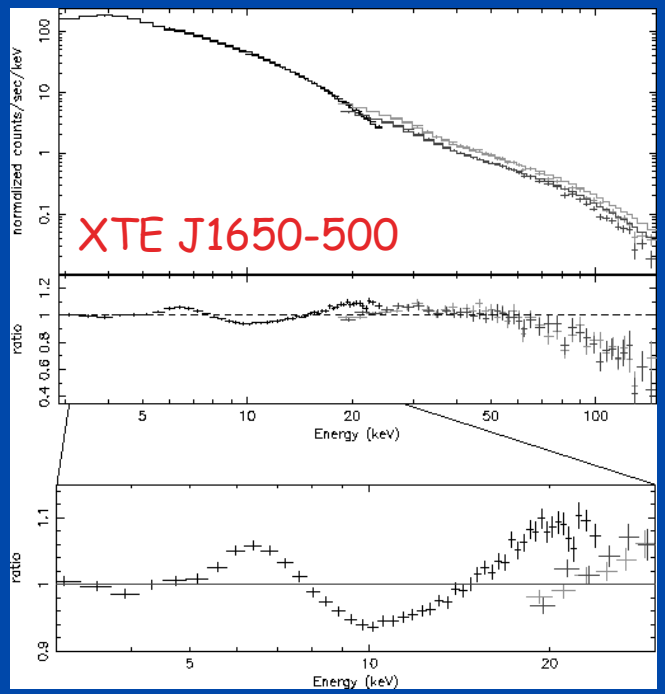
Rodriguez et al. '03



Rossi et al. '05

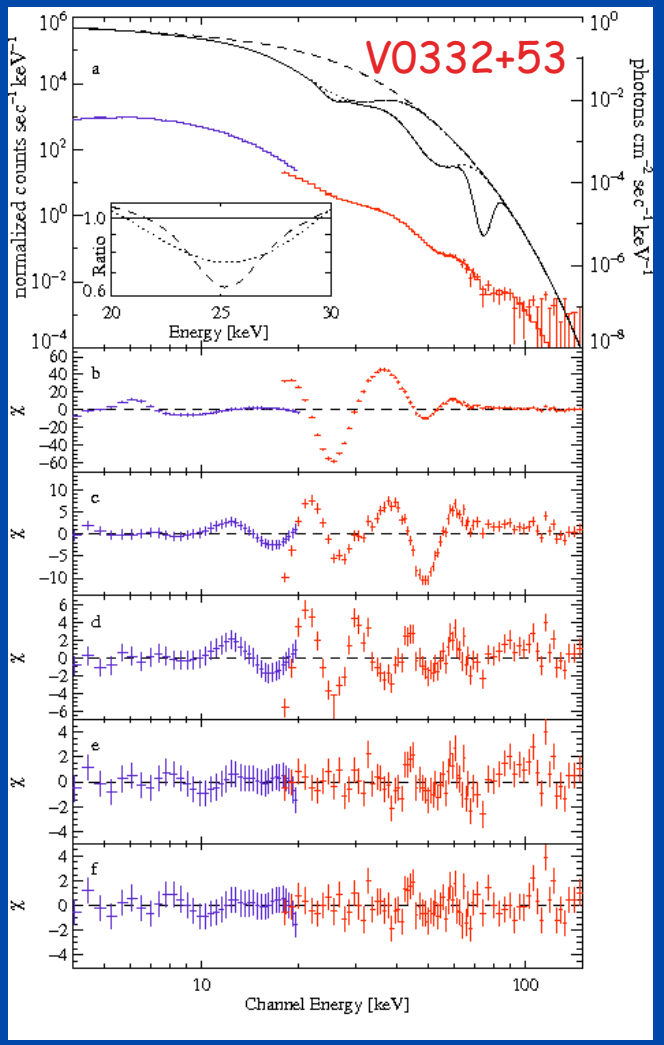
3-200 keV spectral analysis (2)

Reflection component



Rossi et al. '05

(multiple) Cyclotron lines



Kreykenbohm et al. '05

Data reduction

Data reduction straightforward
Entirely based on ftools/HEASOFT

=>RXTE Getting started guide:
http://rxte.gsfc.nasa.gov/docs/xte/start_guide.html

=>RXTE Cook Book:
http://rxte.gsfc.nasa.gov/docs/xte/recipes/cook_book.html

=>The ABC of RXTE:
http://rxte.gsfc.nasa.gov/docs/xte/abc/contents.html

Some of the (numerous) discoveries

- o "kilohertz" QPO's in NS & BH systems
- o ms coherent pulsations in LMXBs (=> ms X-ray pulsars)
- o spin periods in LMXRB
- o Extensive observations of spectral transitions in transient systems
- o Black hole reflection component
- o Temporal properties tightly linked to spectral properties
- o Connection of TeV-keV flaring in blazars
- o More pulsars with cyclotron resonance lines

References

•RXTE: Bradt, H.V., Rothschild, R.E., and Swank, J.H., '93 *A& A Supp. Series*, 97, 355

•ASM: Levine et al. '96, ApJ, 469, L33

•PCA:

–Jahoda et al. '96, proc. SPIE, 2808

http://universe.gsfc.nasa.gov/xrays/programs/rxte/pca/InOrbitPerformanceAndCalibrationOfPCA_SPIE96.pdf

–Jahoda et al. '06, astro-ph 0511531, APJS, April '06

•HEXTE: Rothschild et al. '98, ApJ 496, 538