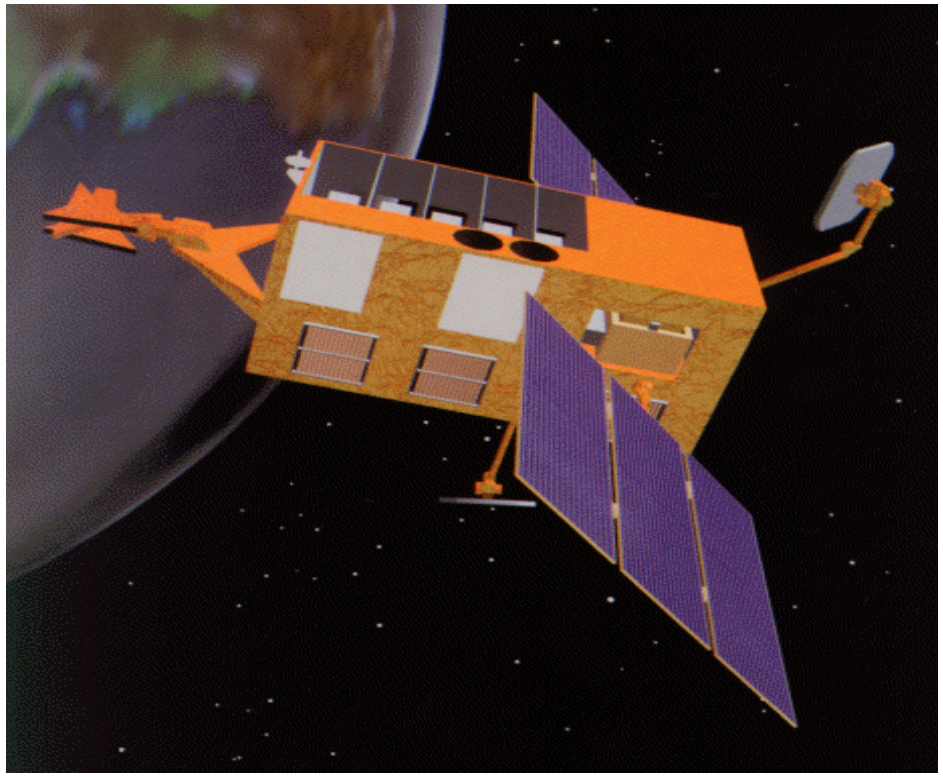
RXTE

Presentation to the 2006 Senior Review of Mission Operations and Data Analysis



The Rossi X-Ray Timing Explorer

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RXTE Why Continuing RXTE is Important

Combination of capabilities unmatched by any other mission —

- Large collecting area, low background, timing from 1 μs to 10 Ms
- Fast onboard data processing and high data rates to the ground
- Continuous monitoring of the X-ray sky and rapid response
- Highly flexible scheduling
- Unmatched high observation density and long campaigns

These capabilities make RXTE uniquely able to —

- Study the strongly curved spacetime near neutron stars and black holes
- Discover and study accreting millisecond pulsars
- Study nuclear burning on the surfaces of rapidly spinning neutron stars
- Seek evidence of black hole spins
- Test theories of the disk-jet connection

RXTE Noteworthy Accomplishments Since 2004

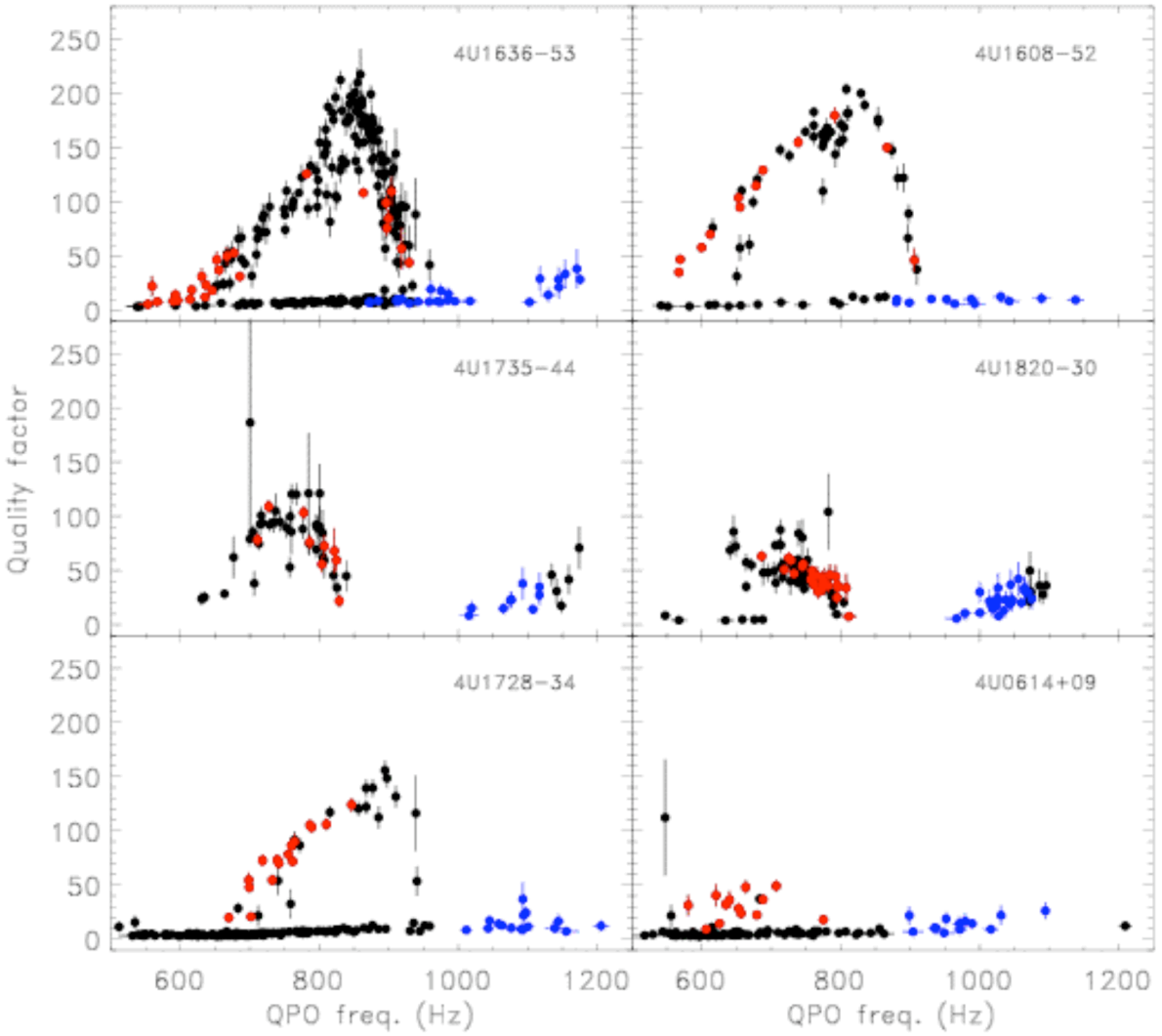
- Discovery of the predicted effects of an innermost stable circular orbit (ISCO) on the kilohertz QPOs of three weak-field accreting neutron stars in LMXBs and evidence for an ISCO in two other neutron stars in LMXBs.
- Discovery of 2 more accretion-powered millisecond pulsars and 2 more nuclear-powered millisecond pulsars.
- Pathbreaking binary-phase resolved spectroscopy of a black-hole system.
- Discovery of a second flaring pulsar SWIFT J1626.6–5156.
- Determination of the fundamental cyclotron frequency in A0535+26.
- Discovery of 20–625 Hz X-ray oscillations in strongly magnetic neutron stars ("magnetars"), possibly due to torsional oscillations of the solid stellar crust.
- Discovery of an X-ray flare coincident with a superluminal radio jet ejection.
- Discovery of a very hard spectrum in the nova outburst of RS Oph with a strong Fe line.
- Discovery of an X-ray flare in Mkn 421 that follows a TeV flare, challenging the standard theory of the generation TeV flare.

RXTE

Discovering and Measuring Innermost Stable Circular Orbits (ISCOs)

Since 2004

- RXTE has discovered several predicted effects of an ISCO in six NS LMXBs
- It has shown that these occur in many accreting weak-field neutron stars
- Finds that $Q \equiv \nu/\delta\nu$ varies systematically with ν but not with F_x or X-ray color
- 10^6 s observations of 2–3 other NS LMXBs will support or disprove this



RXTE

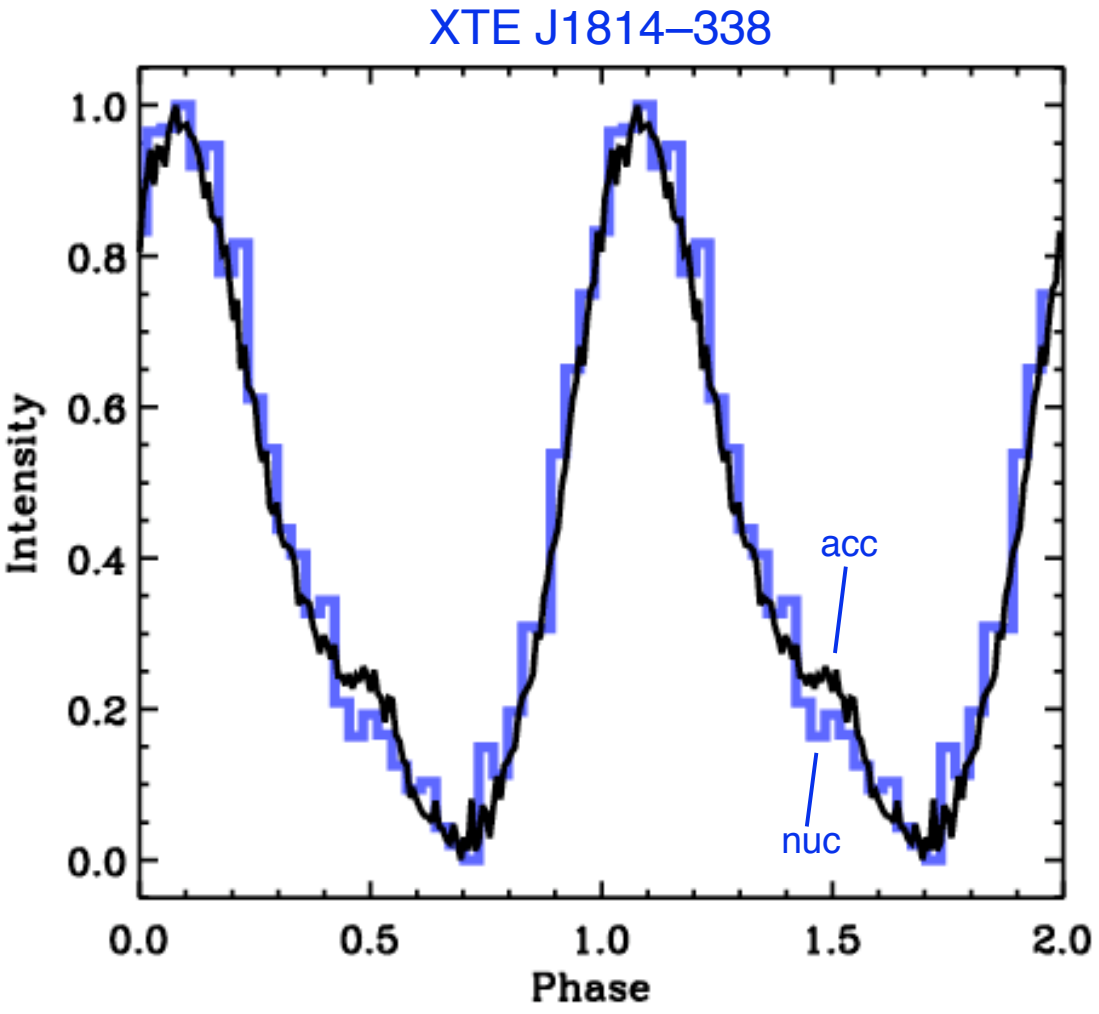
Discovering Millisecond X-ray Pulsars
And Using Them to Advance Understanding

New results since 2004 –

- More evidence that accretion- and nuclear-powered oscillations are both due to spin
- Can use waveforms to determine M/R

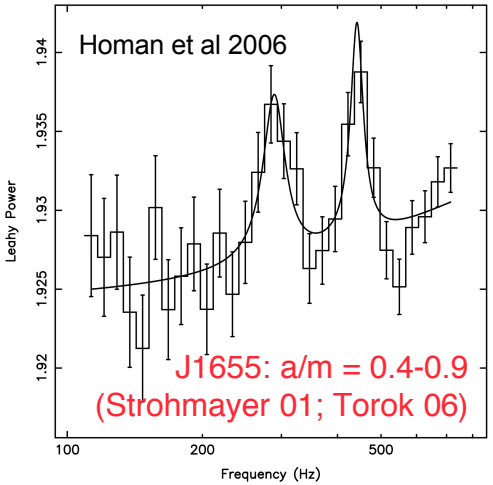
Puzzles —

- Where on the star are the brightness patterns?
- Why are the waveforms so sinusoidal?
- Why are accretion-powered oscillations so weak?
- Why do oscillation phases sometimes change rapidly?



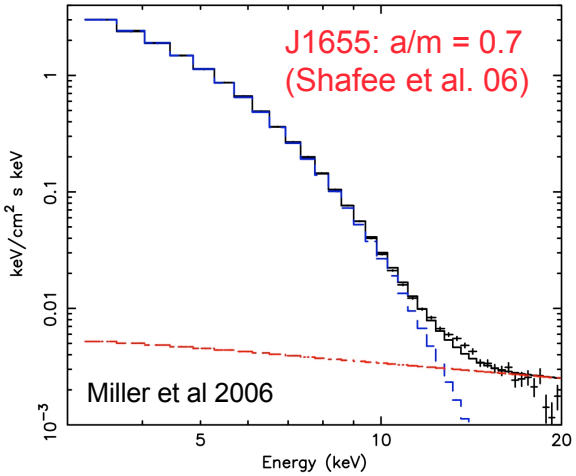
Bhattacharyya et al. 2005

Reaching Toward Black Hole Spin



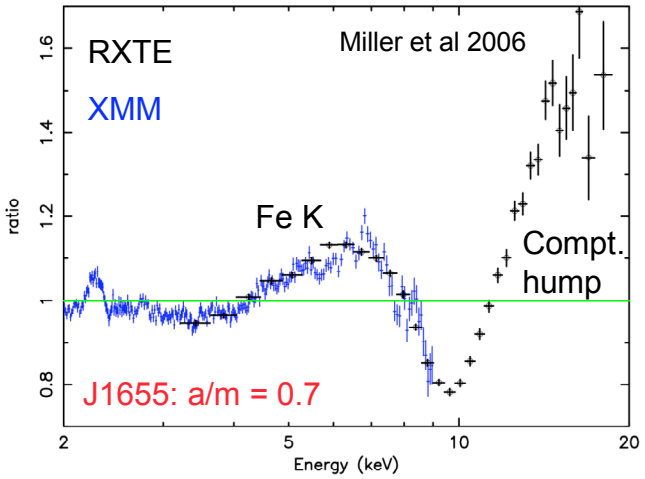
High frequency QPOs:
inner disk frequencies

2005: recurrence of 3:2 QPOs in a transient BH demands gravity, not gas



Accretion disk spectra:
radius of the inner disk

2004-2006: complex new disk models include spin, hardening, accretion rate

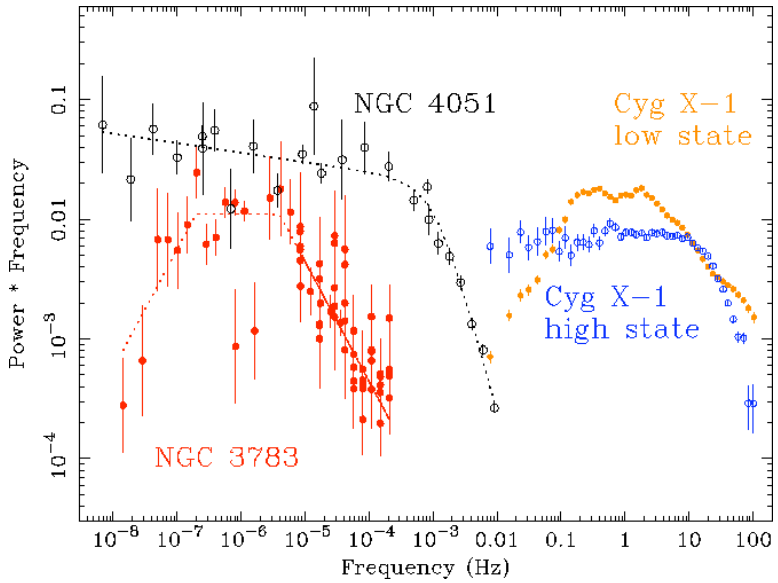


Relativistic disk reflection:
Doppler shifts of inner orbits

2002: relativistic lines found in stellar-mass black holes; we now know when to look

Measuring black hole spin and its effects is a fundamental test of GR. We are now making real progress toward measuring black hole spin. *RXTE makes this possible*: it enables 3 independent approaches with frequency coverage, observing flexibility, & calibrated broad energy range.

RXTE Connections Across the BH Mass Scale

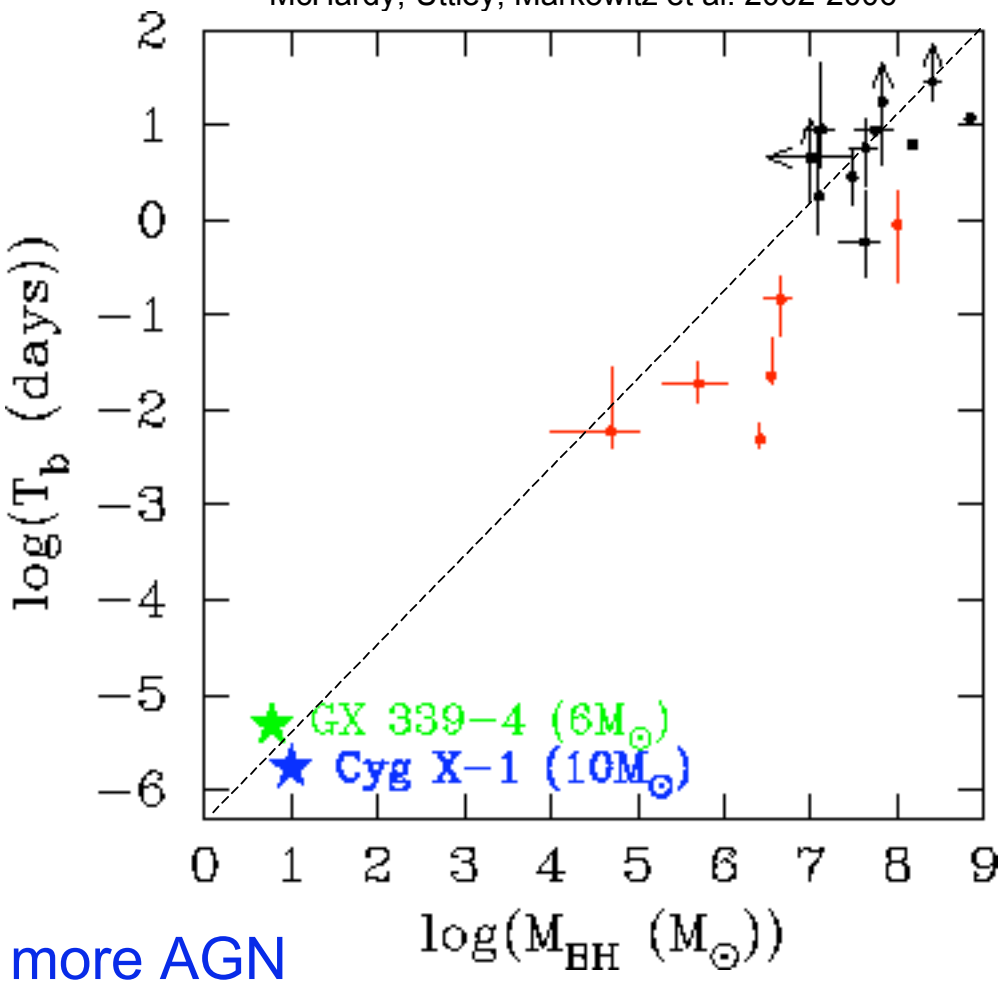


RXTE monitoring shows that all black holes from 10^1 to 10^7 M_o have break frequencies.

Scaling break timescales gives masses that agree with reverberation/dispersion masses.

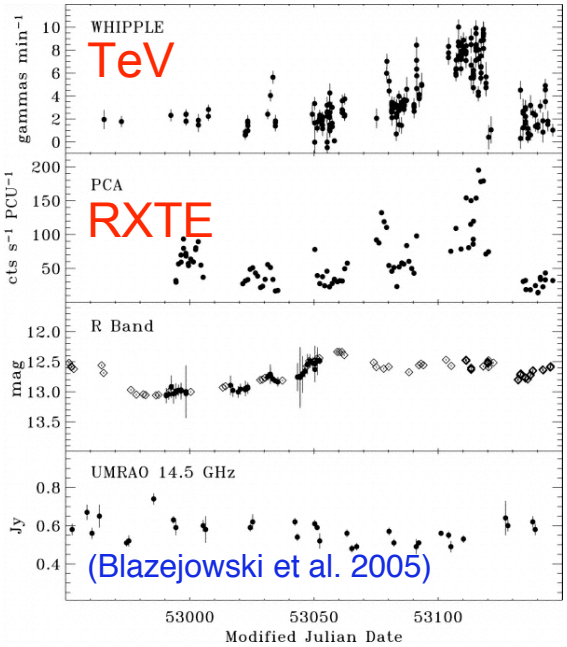
The central engine in black holes must scale a simple way with black hole mass.

McHardy, Uttley, Markowitz et al. 2002-2006

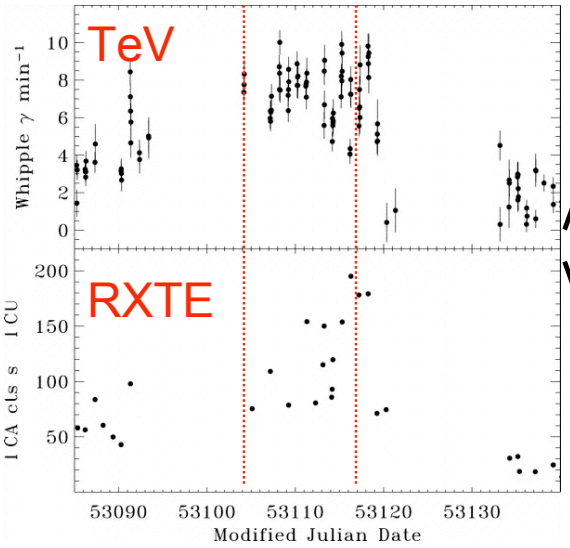


RXTE will measure breaks in 6 more AGN in the next 2+ yrs, in a wider range of AGN.

RXTE The Coming GeV and TeV Explosion



Jet monitoring of Mkn 421



TeV precedes X-ray flare; standard Comptonization models need revision.

GLAST 10 MeV - 100 GeV will help to complete the high energy picture.

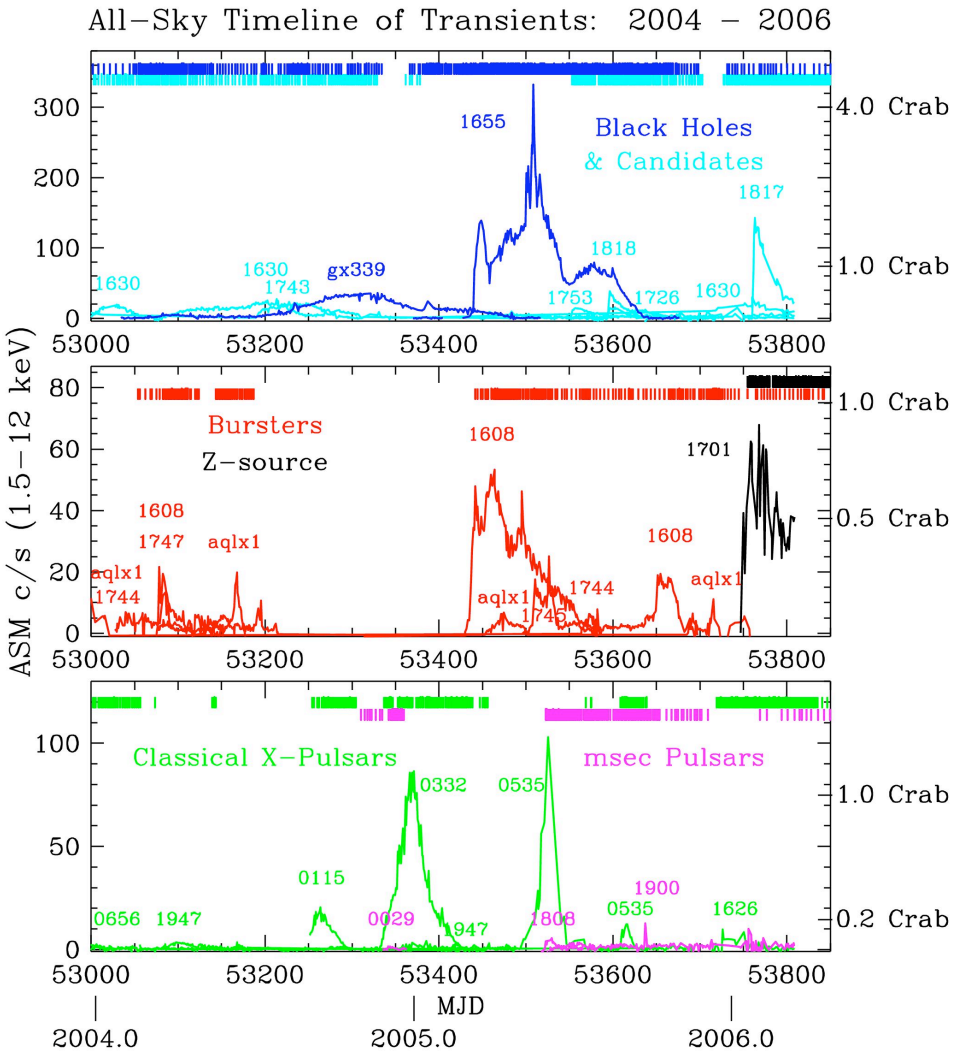
"Without RXTE, GLAST's results will be compromised." D. A. Smith, GLAST

"The absence of the ASM will be a major setback to TeV astronomy."
Trevor Weekes, VERITAS

"Only RXTE can provide reliable simultaneous observations."
Werner Hofmann, HESS

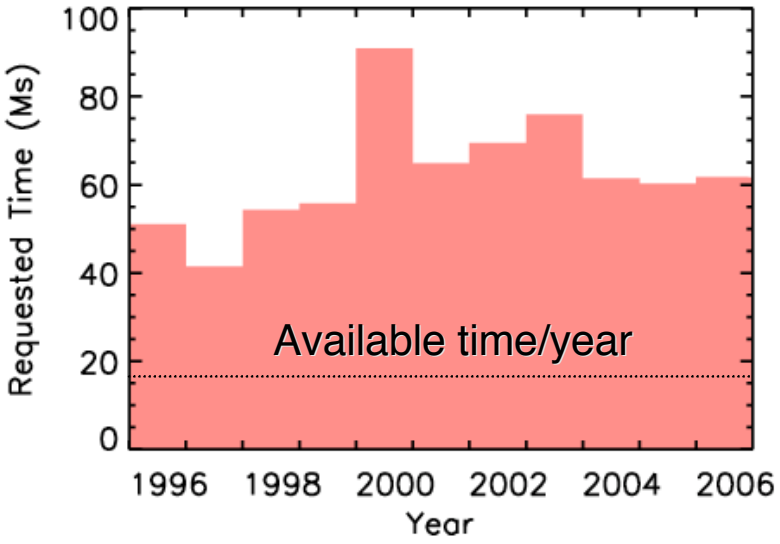
RXTE The Essential Tool for Understanding Accretion

- Understanding accretion requires both a long observing baseline, and many pointed observations.
- RXTE: 2 important capabilities:
  1) high time resolution
  2) high observation density
  In both cases, RXTE is an order of magnitude improvement over other X-ray missions.
- Without RXTE accretion studies would lack context and other missions would be partially blinded.
- RXTE is the only mission, present or planned, that can provide both of these essential capacities.



RXTE

Popular and Productive



Total time requested is steady

Many proposals - 128 for cycle 11

Many unique PIs, about 400 users

Many coordinated observations

Most popular bytes served by HEASARC

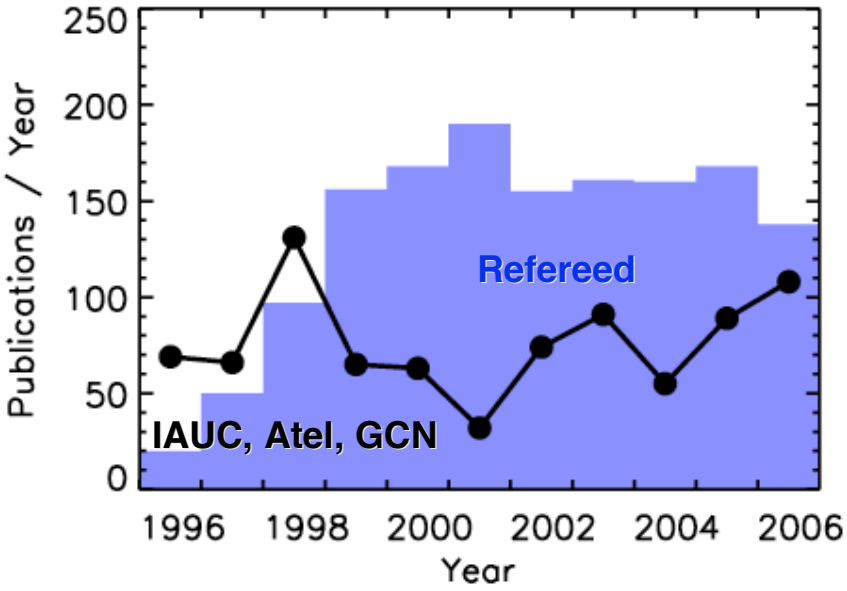
Publications steady, >1 per proposal

Discoveries steady

6 theses since 2004 Senior Review

Papers have impact - frequently cited

Teacher workshops are popular



RXTE

Robust and Sensitive Hardware

Summary: The hardware is ready for three more years

The PCA continues to operate well, with mild degradation

Detectors are operated selectively to preserve lifetime and minimize discharges

- AGN monitoring observations reach background fluctuation limits in 1000s with 1 PCU
- 4 and 5 detectors are used for observations with a focus on short time-scale timing

The HEXTE detectors have shown no degradation

Rocking was stopped for cluster A because of a tendency to stop, in case it would not resume when commanded

- The HEXTE PI and postdoc have found cluster A & B backgrounds proportional

The ASM has 67% of its initial sensitivity

No reason is known now why it will not last 3 more years

The Spacecraft is functioning well

The orbit has lowered from 580 km to 490 km - where the background is halved but the lifetime still far exceeds 3 years

RXTE

Streamlined Manpower and Costs

Manpower (Full Time Equivalents):

	1997 (Peak)	2004 (1st full cost+)	2007 (proposed)
Mission Operations	16.00	10.00	5.25
SOF	12.00	3.50	2.30
GOF	16.00	3.45	1.60
ITs	33.00 (w gs)	10.88	6.60 (wo gs)
Total	77	27.83	15.75
Allotment (K$):			
Total (real year)*	7718	5844	4055 (minimum)
GO	2117	753	850 (optimum)

•1997 is not full cost, GO not included

+ Full costs changed with time, making it very difficult to extrapolate back

Cost reduction change:

Operations	24x7	12x7(auto)	8x5 (auto)
Processing	tapes, in XSSDC	internet,by GOF	sc calcs to MOC
Help		reduced support	more reduction
Calibration	in-orbit vs lab	practice	matrixed personnel

Summary: RXTE is an excellent value