RXTE/PCA Calibration Status

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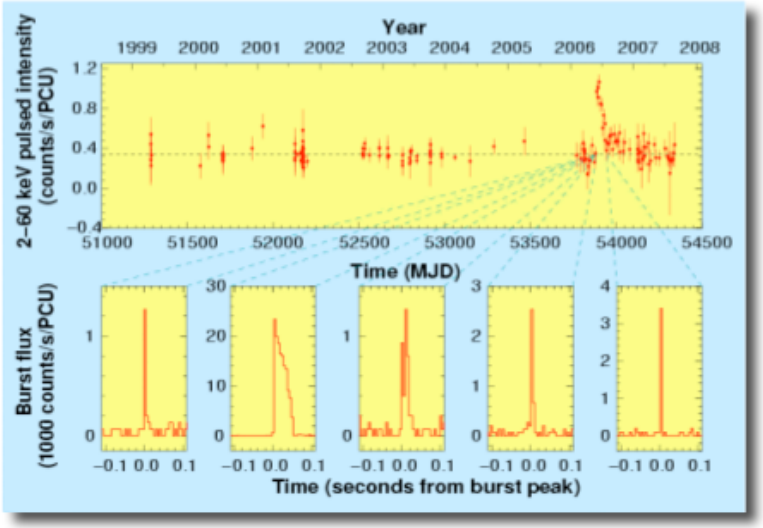
IACHEC, Schloss Ringberg 2008

Outline

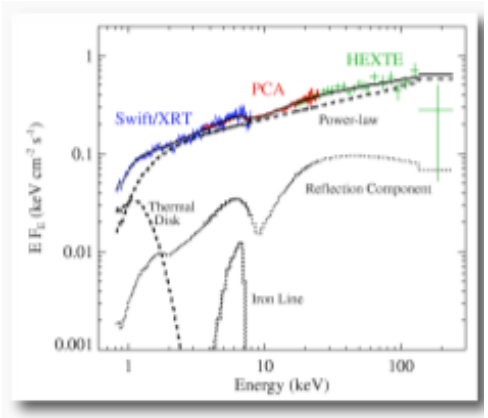
- PCA is a mature instrument undergoing a calibration update
  - Launched December 30, 1995
  - Operations currently approved through Feb 2009
- Previous presentations concentrate on our calibration successes
- This talk concentrates on what is left undone, and which may be left to the archival users
- Calibration makes substantial use of the power-law approximation to the Crab. (tomorrow we may learn what is wrong with this)

RXTE/PCA characteristics

- Large area: ~7000 cm^2
- Dynamic range:
  - ~10^{-11} to 10^{-7} erg/s/cm^2
  - ~μ-sec to years
- Flexible, "all" sky pointing enables multiwavelength campaigns



PSR 1846-0248, a rotation powered pulsar that shows magnetar behaviour. (Gavriil et al. 2008) - an example of an investigation that uses dynamic range in timing, scheduling flexibility

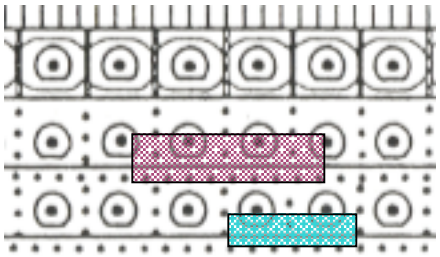


Smeared reflection features (in the hard state) with Swift.

Simultaneous observations of Galactic Black Hole (GRO J1650-500)

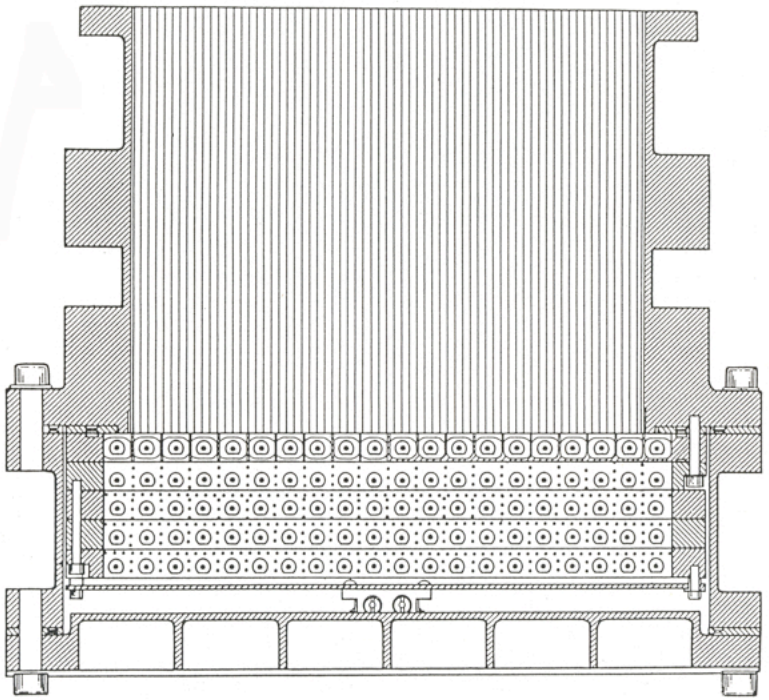
Energy response

Matrix generator assumes slab elements



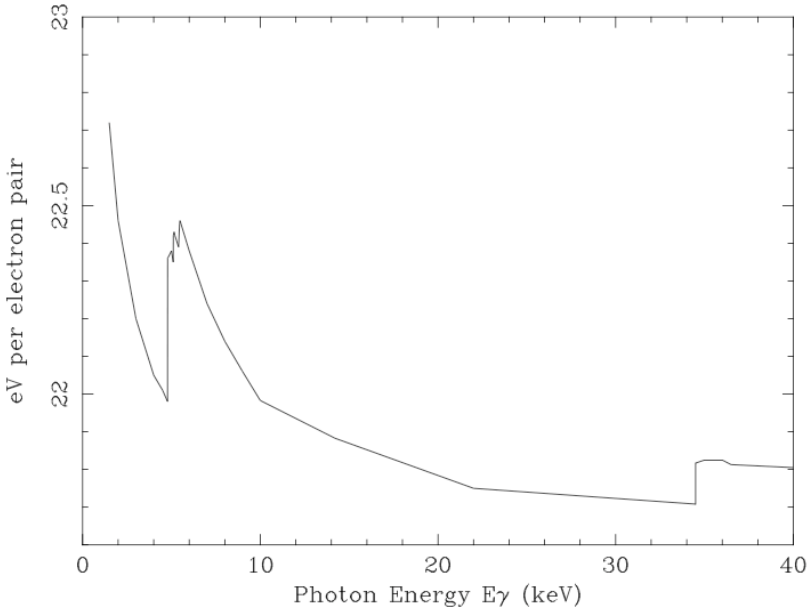
Interior window (25 μ mylar) spans ~1.3 cm x 10 cm, supports 0.05 or 1 atm.

Boundary between layers is formed by 4 wire ground plane in each 1.3 cm cell

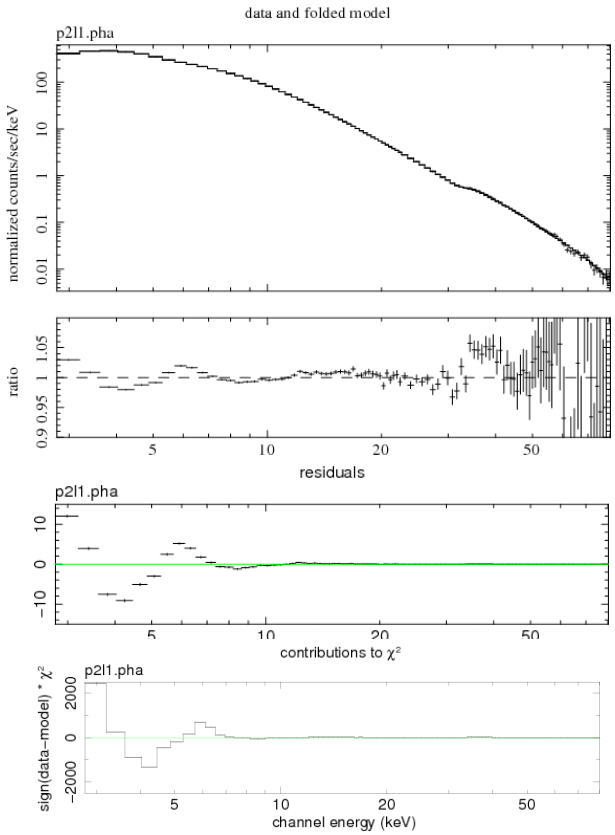


Energy response

- Discontinuities in energy scale at L-edge are ~half of best atomic theory.
  - Pcarmf reduces "contrast" in eV/ion pair by ~0.5
- ΔE (L3,L2,L1) = 0.085, 0.032, 0.012 keV
- ΔE (K) = 0.18 keV



Energy response



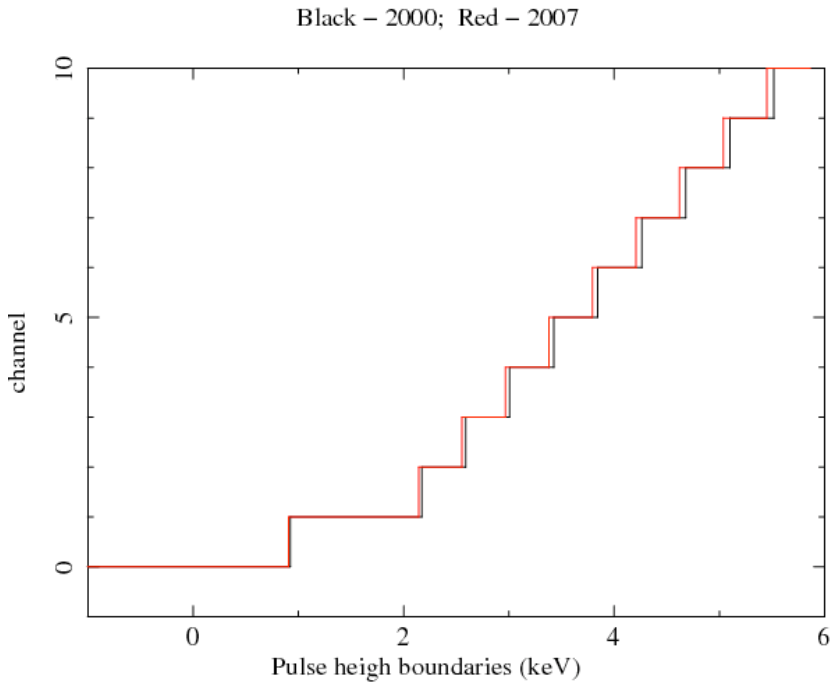
Power law fits to Crab show percent level deviations in “ratio”; “resid” and “chi” can be large (and are exposure dependent)

- fitting a gaussian (in “absorption”) near 4.1 keV typically produces an equivalent width ~50 eV

At Xenon-L edge, there are discontinuous changes in quantum efficiency, partial charge collection, and energy to channel relationship.

Energy response

- Gradual shift in energy scale, combined with difficulties in low energy incomplete charge collection are a challenge
  - Fixed channel selection includes lower energies as time goes on; leads to higher reduced chi-square

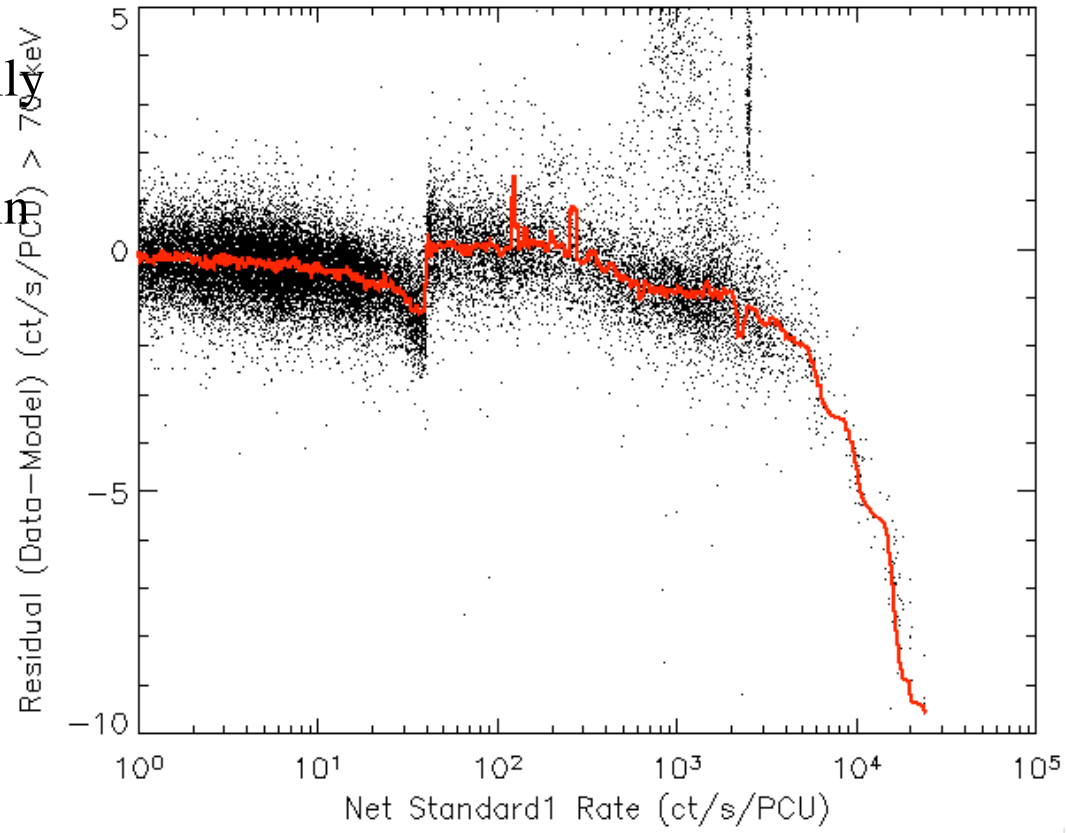


- Self veto probabilities have no energy depenence

PCA Background

Net rate above 70 keV typically expected to be near 0

- Over-subtraction occurs in both faint and bright background models



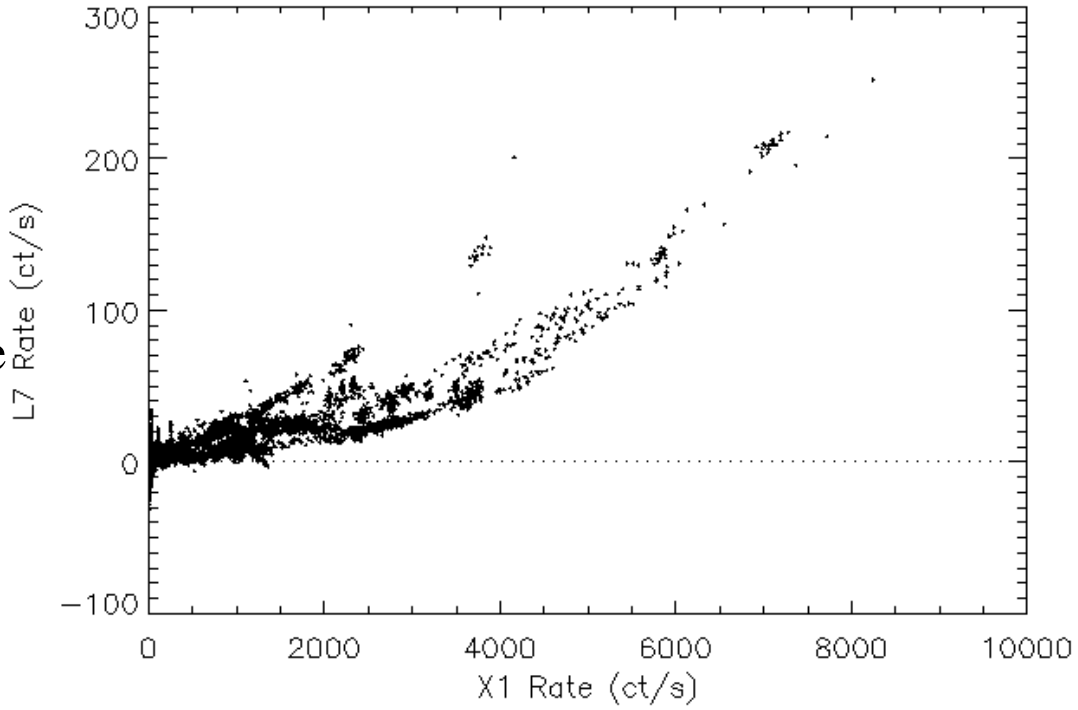
PCA Background

Occultations allow measurements of L7 vs source rate

- -source contributes to L7
- -Dependence is probably spectral, and certainly more complex than just rate

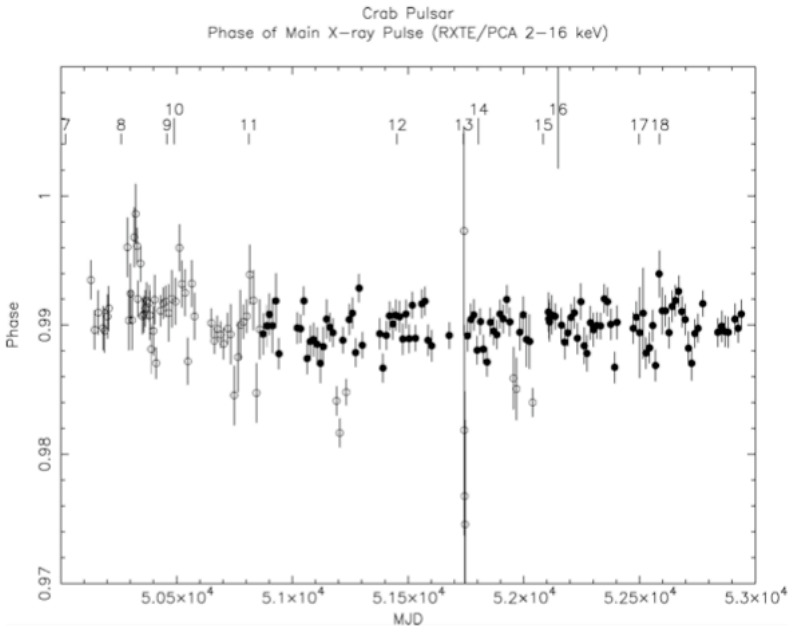
-Additional issues

- -Statistical error in L7 (typ 10% in 16 sec) introduces excess variance on short time scales
- -Tools report expected poisson error in bkg; should report systematic error in



Absolute Timing Calibration

- Micro-second time tags
- Few micro-second uncertainty
- Statistical error in comparison of X-ray/radio phase for Crab now smaller than scatter



Power Spectra

Assuming paralyzable deadtime

$$P_d(f) = P_1 - P_2 cos(\frac{\pi f}{f_{Nyq}})$$

$$P_1 = 2[1 - 2r_0 t_d(1 - \frac{t_d}{2t_b})] \text{and}$$

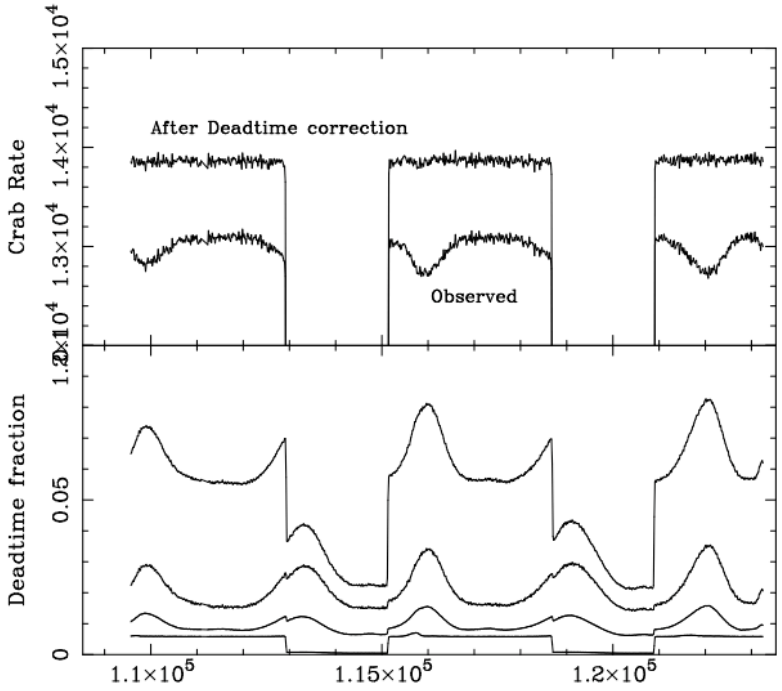
$$P_2 = 2r_0 t_d \frac{N-1}{N}(\frac{t_d}{t_b})$$

$$P_{vle}(f) = 2r_{vle} r_0 \tau^2 (\frac{\sin \pi\tau f}{\pi\tau f})^2$$

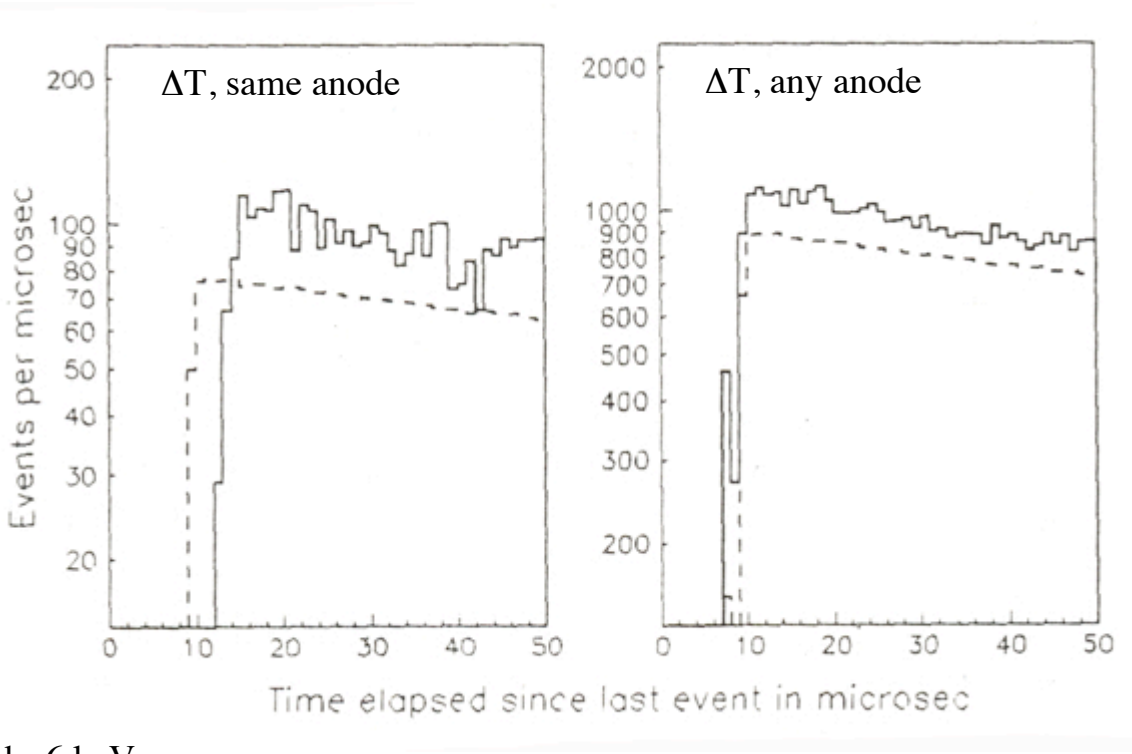
Suggests that the deadtime is complicated

Fitting t_d, τ to power spectra gives 8.8, 138 μsec (Wei, 2006, MIT thesis)

But "flattening" the Crab light curve requires 10, 170 μsec (Jahoda et al., 2006, ApJS)

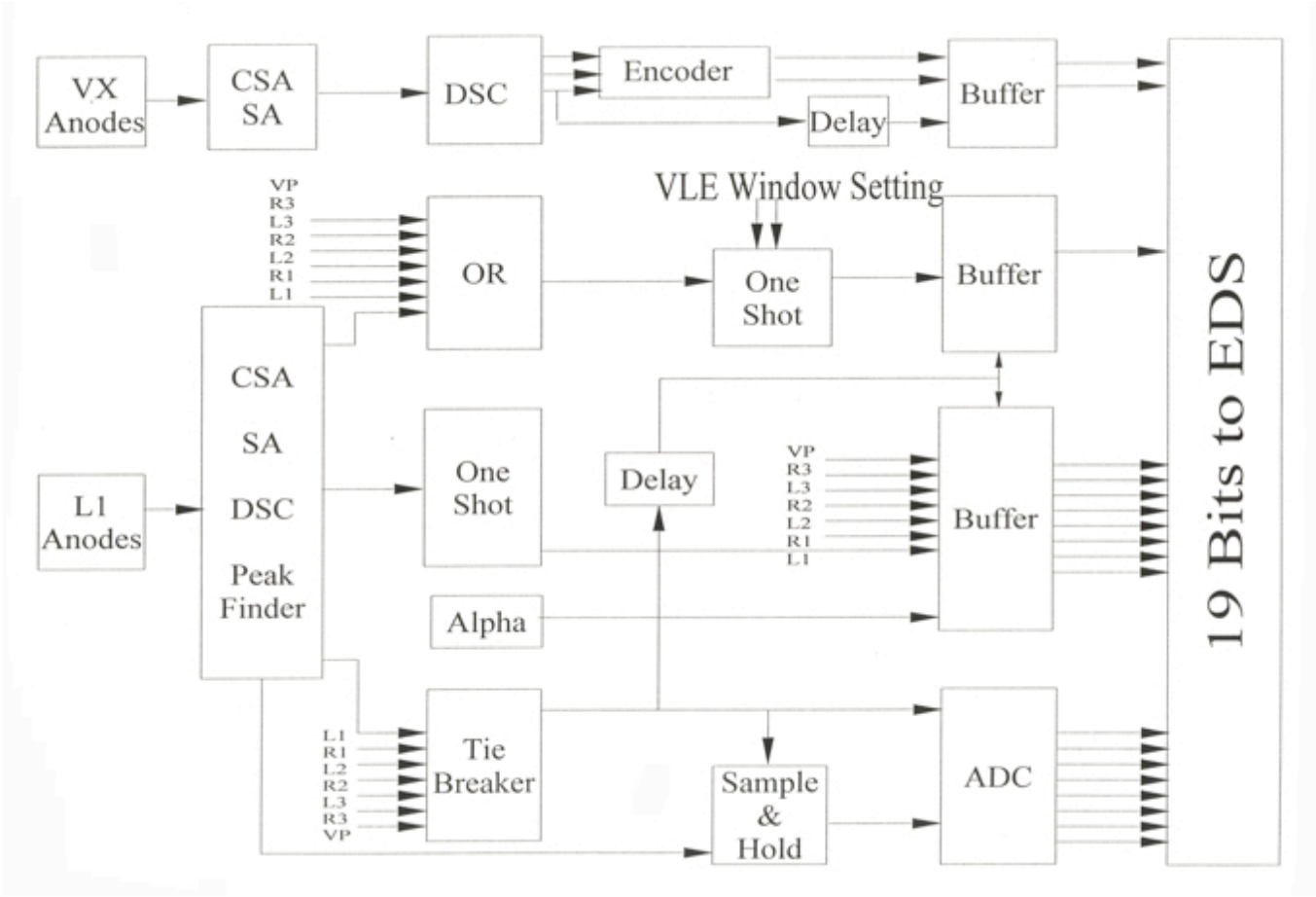


Energy Dependence of dead time



Dashed - 6 keV
Solid - 22 keV

Timing Logic

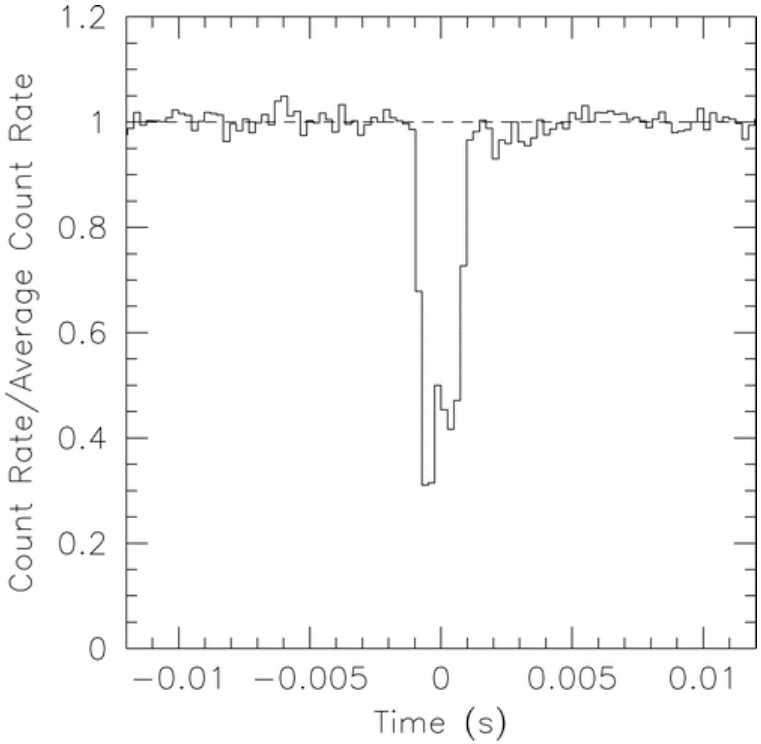


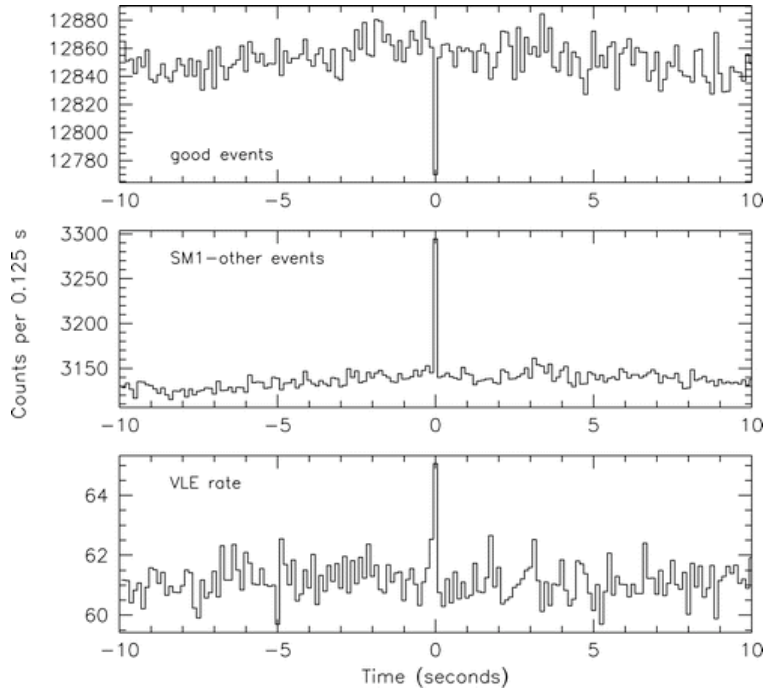
Paralyzable deadtime

Non-Paralyzable deadtime

Dips and TNO

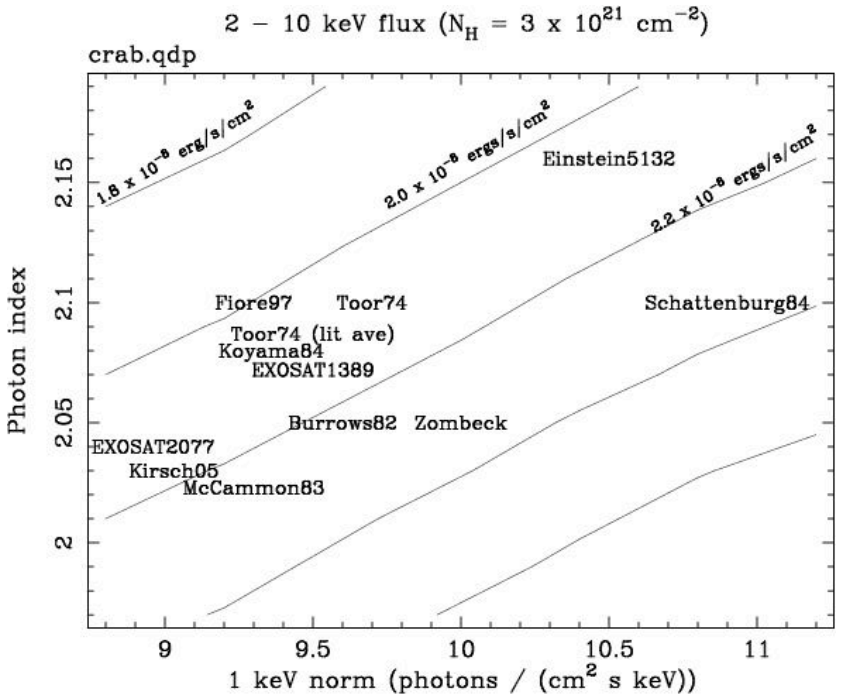
Sco X-1 is in ecliptic, has many counts per msec, and might be occulted by km sized Trans Neptunian Objects (TNO). Chang et al. (astro-ph/0701851) find dips (!) but the dips appear to have in instrumental origin :(

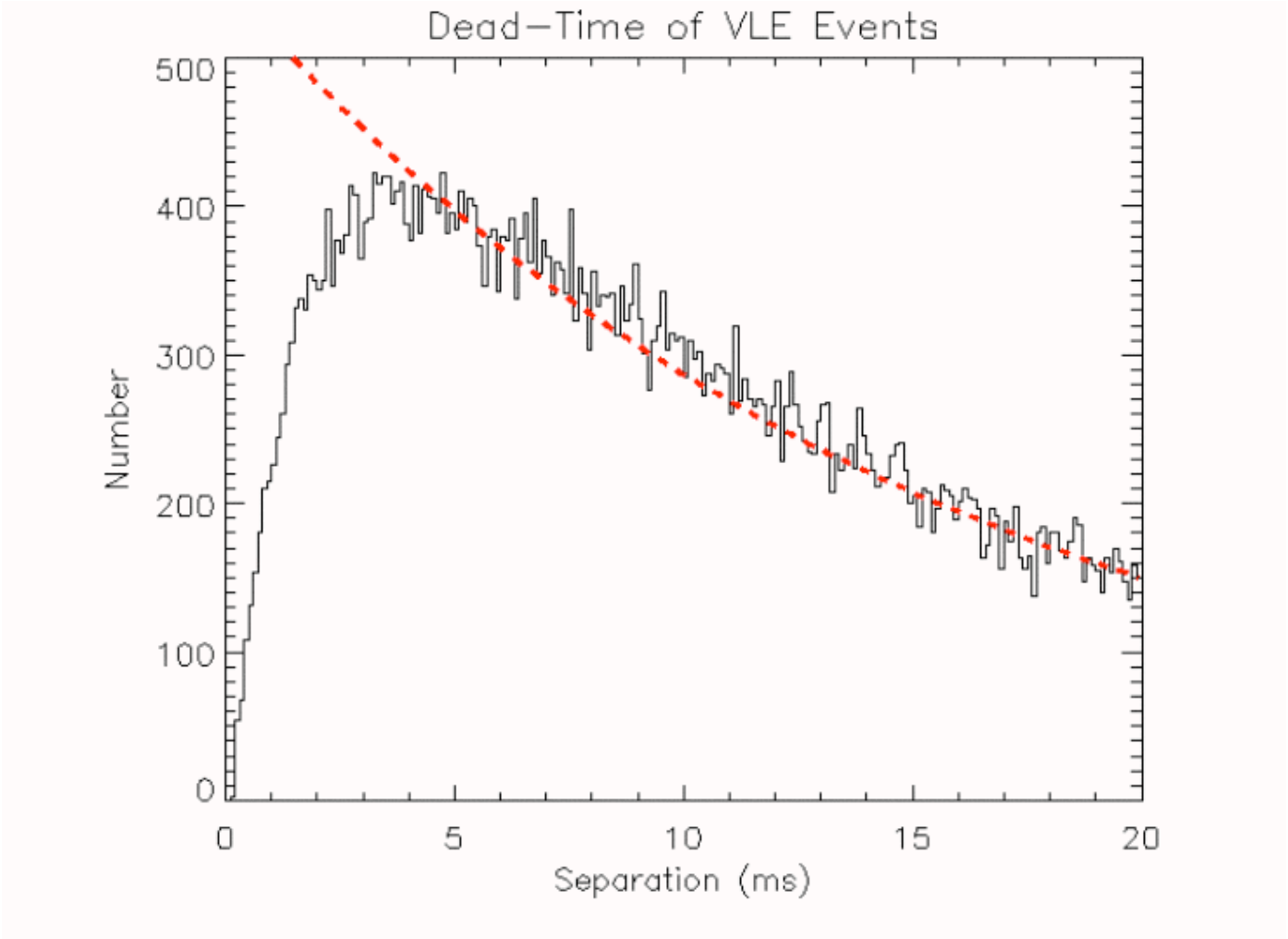


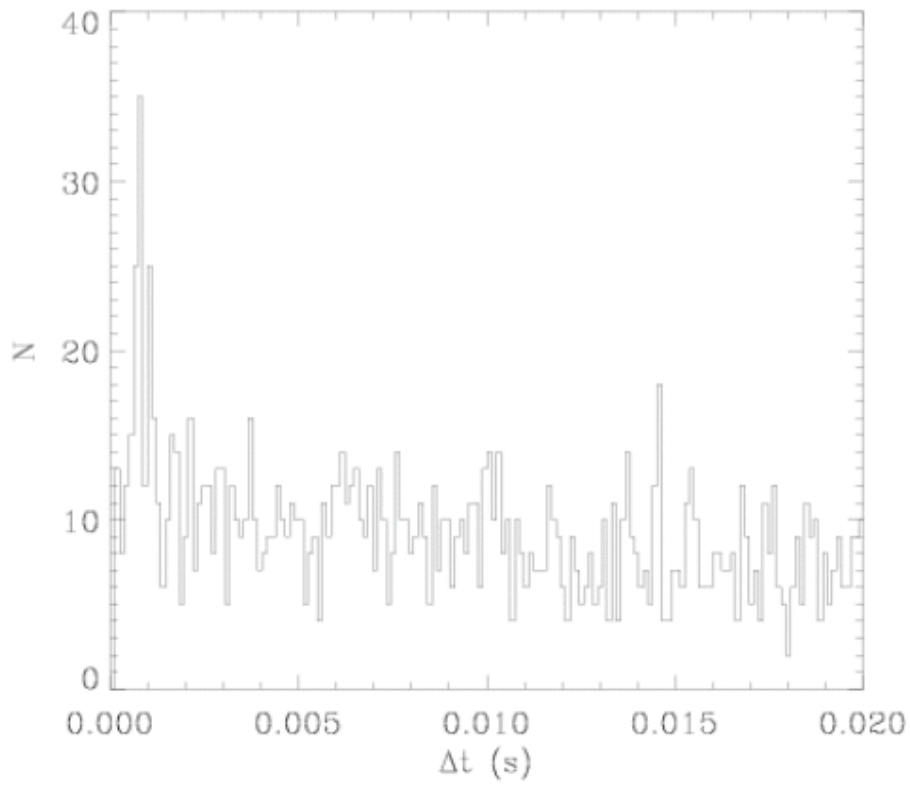


Collimator transmission

- Absolute area normalized to “Crab” (Zombeck value, which is high)
- Flux in 2-10 keV
- Crab flux plot
- No energy dependence in arf, likely a slight over simplification




Dead-Time of VLE Events
Number
Separation (ms)
0
100
200
300
400
500
0
5
10
15
20


40
30
20
10
0
N
0.000
0.005
0.010
0.015
0.020
Δt (s)