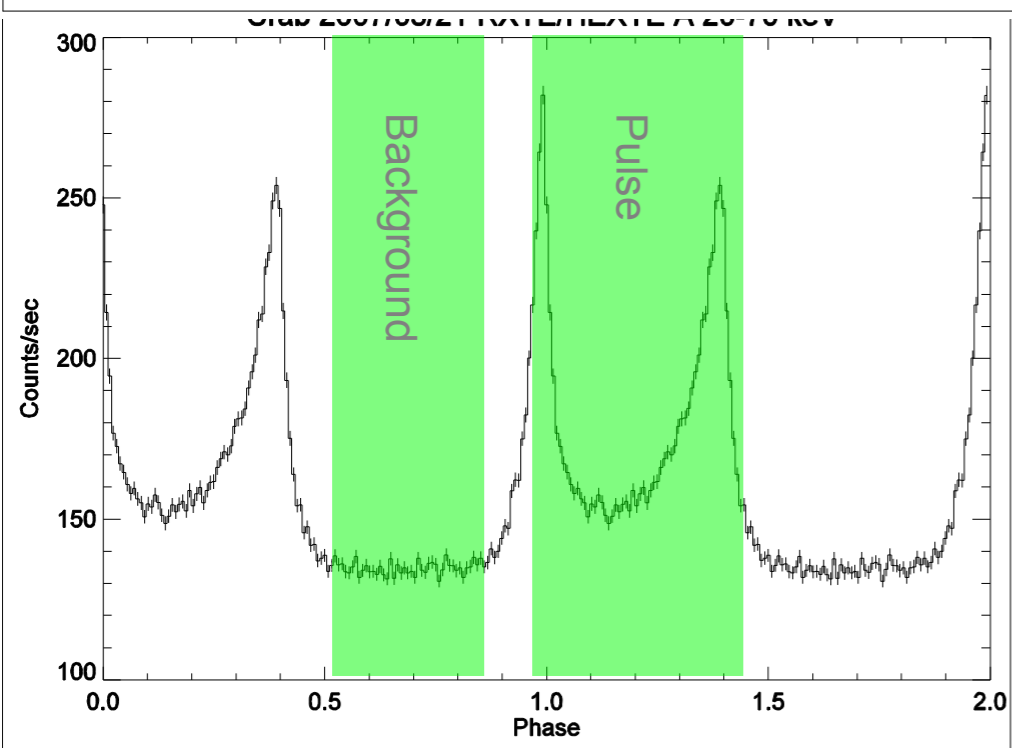
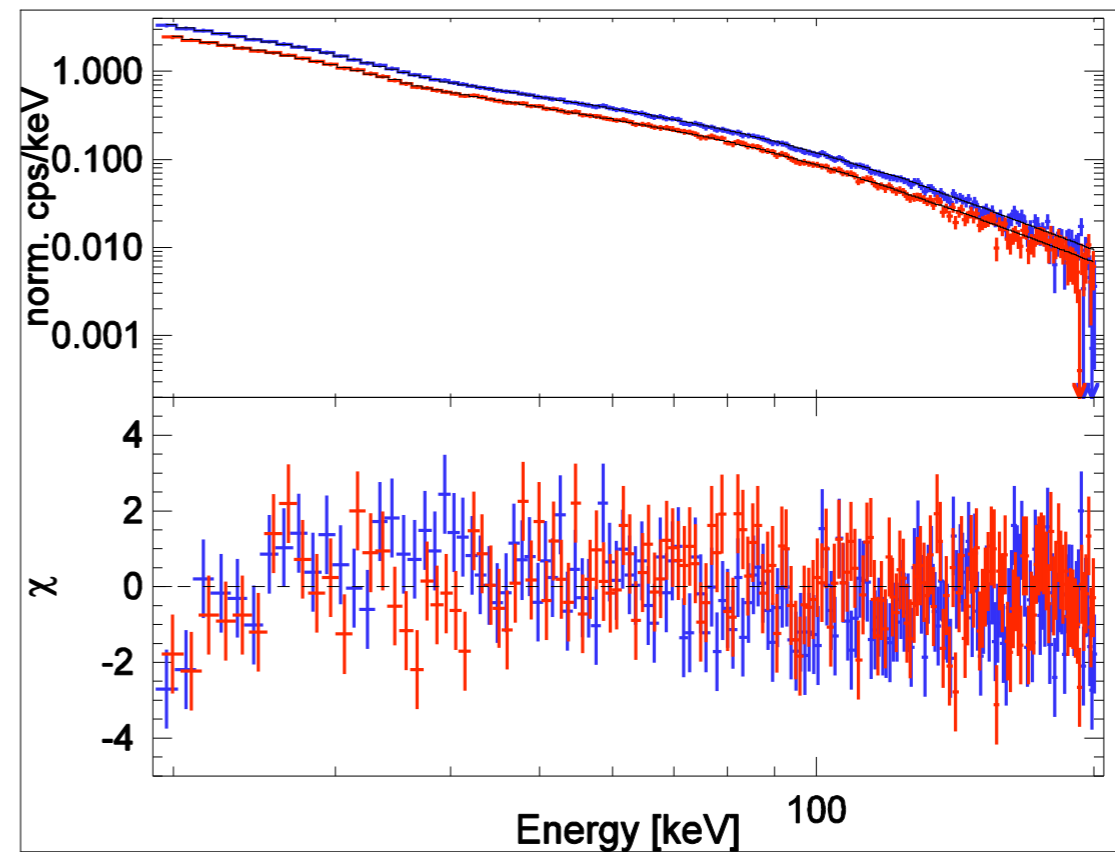
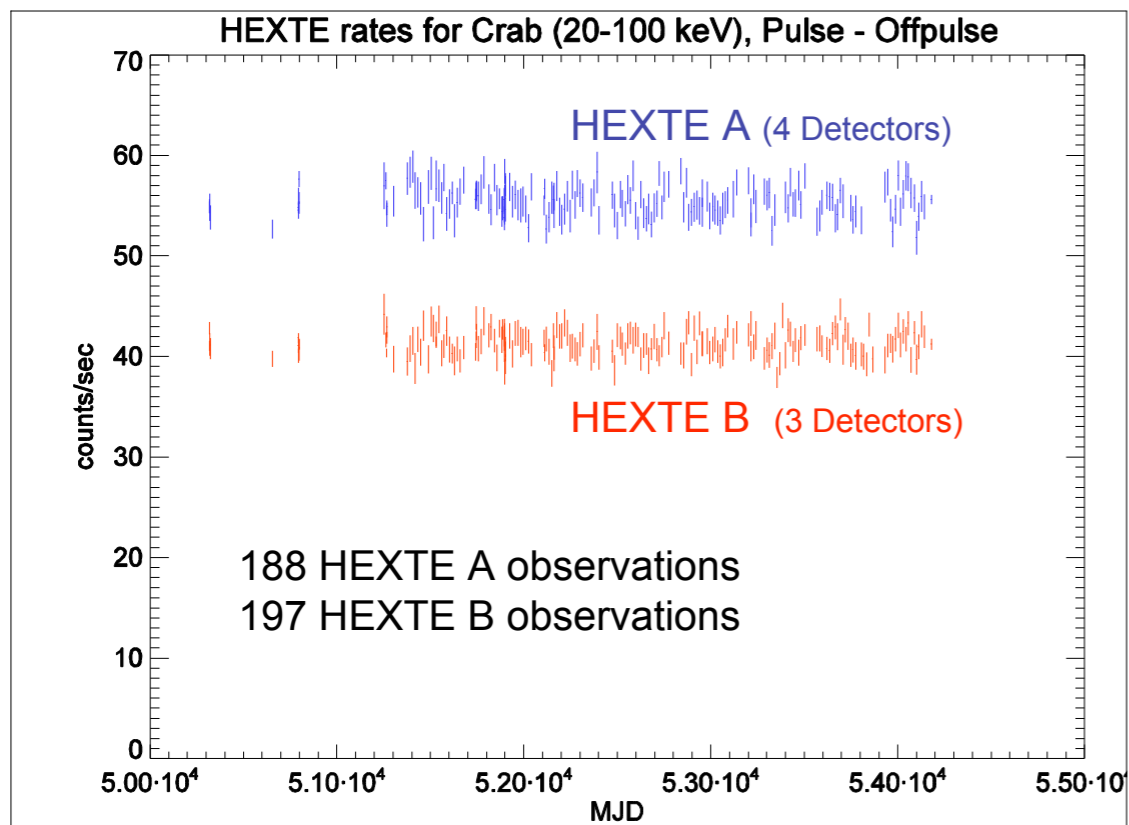


Phase Resolved Analysis of the Crab pulsar using RXTE/PCA & HEXTE

Slawomir Suchy

Rick Rothschild
Katja Pottschmidt
Keith Jahoda

Last year on IACHEC



Total time: 78 ks
 $\Gamma = 1.930 \pm 0.003$
red $\chi^2 = 1.14 / 341$ dofs

Adding the PCA data

Different
PCA data modes:

E16us16B

E16us16M

E250us128M

E2us8B

E4us16B

E4us16M

Adding the PCA data

Different
PCA data modes:

E16us16B

E16us16M

E250us128M

E2us8B

E4us16B

E4us16M

Reducing usable Obsids
to ~150
with approx 800s each

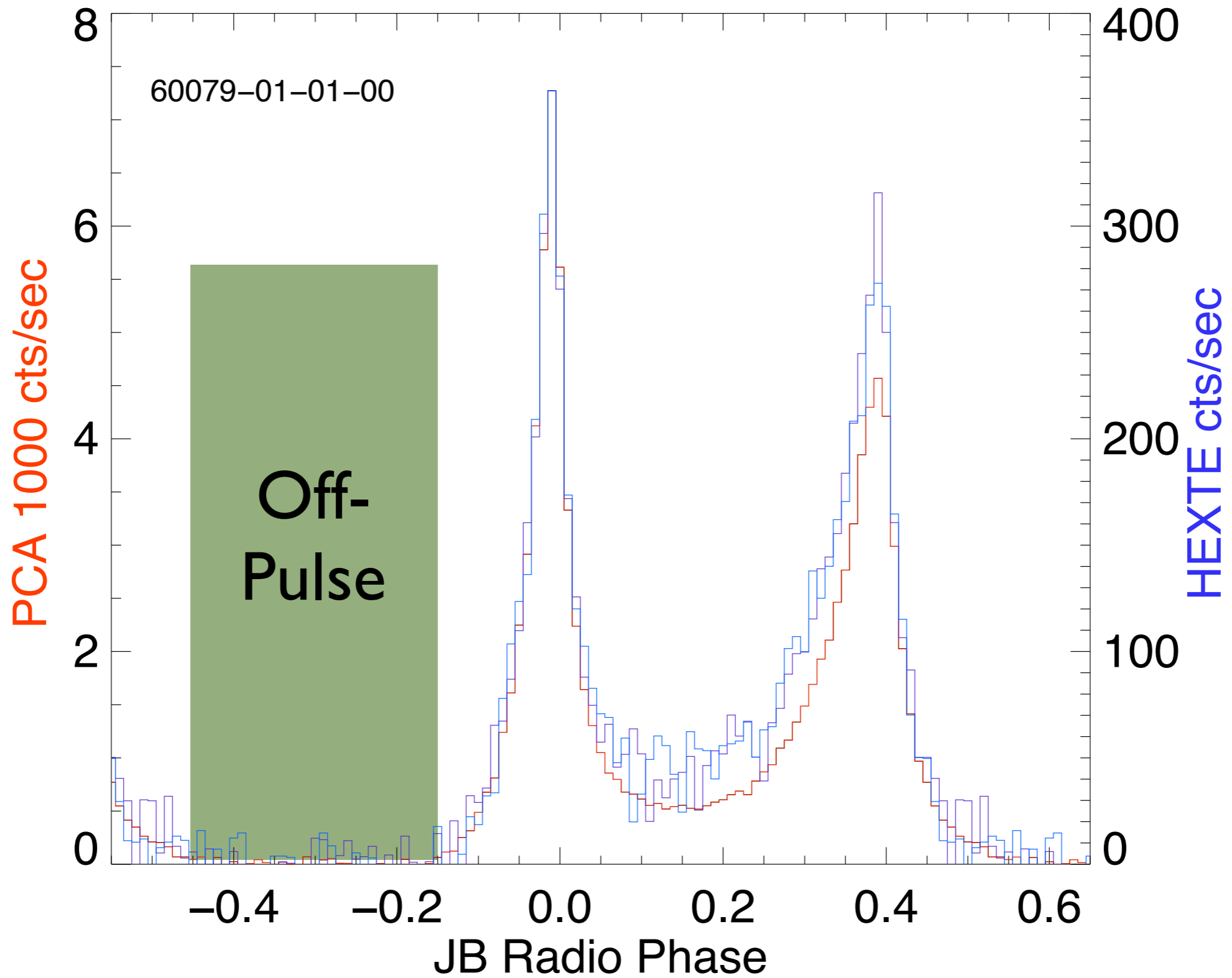
Analysis

Extract pulse profile for each obsid using
Jodrell Banks Ephemeris (found 1 glitch during last years analysis)
(100 phase bins, visual checks for phase alignment)

Create spectra for each phasebin
during pulse, using off-pulse as background

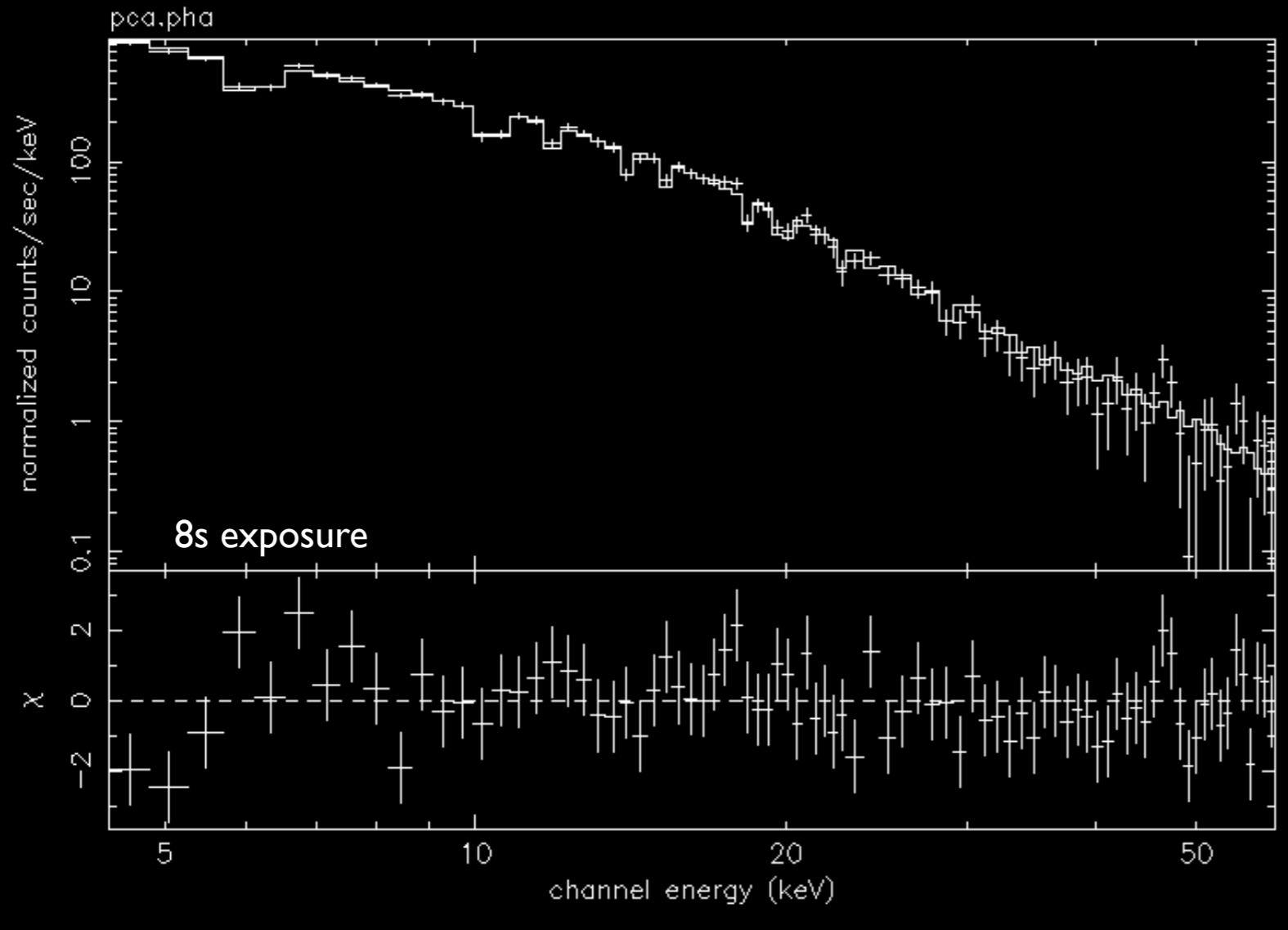
Sum individual AO cycles together
to increase statistics
(especially for HEXTE)

Pulse Profile



Spectra from 1 Obsid

data and folded model



powerlaw

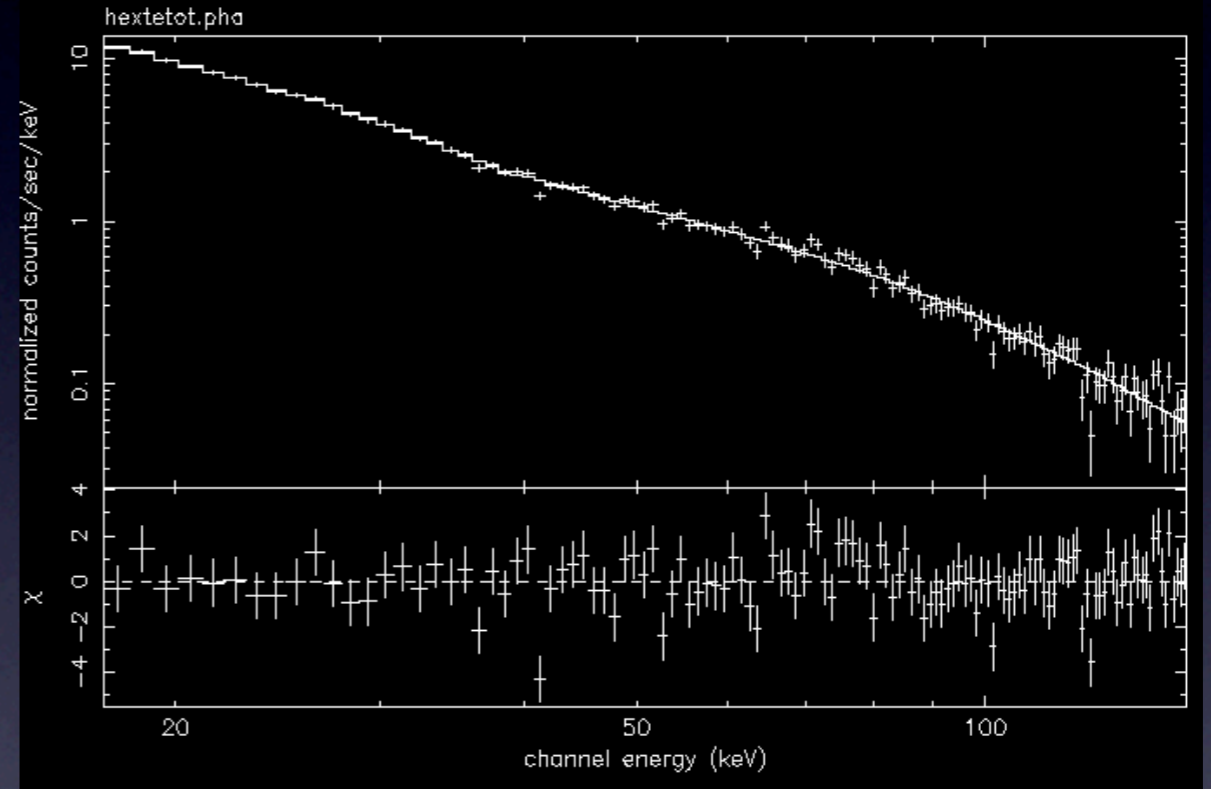
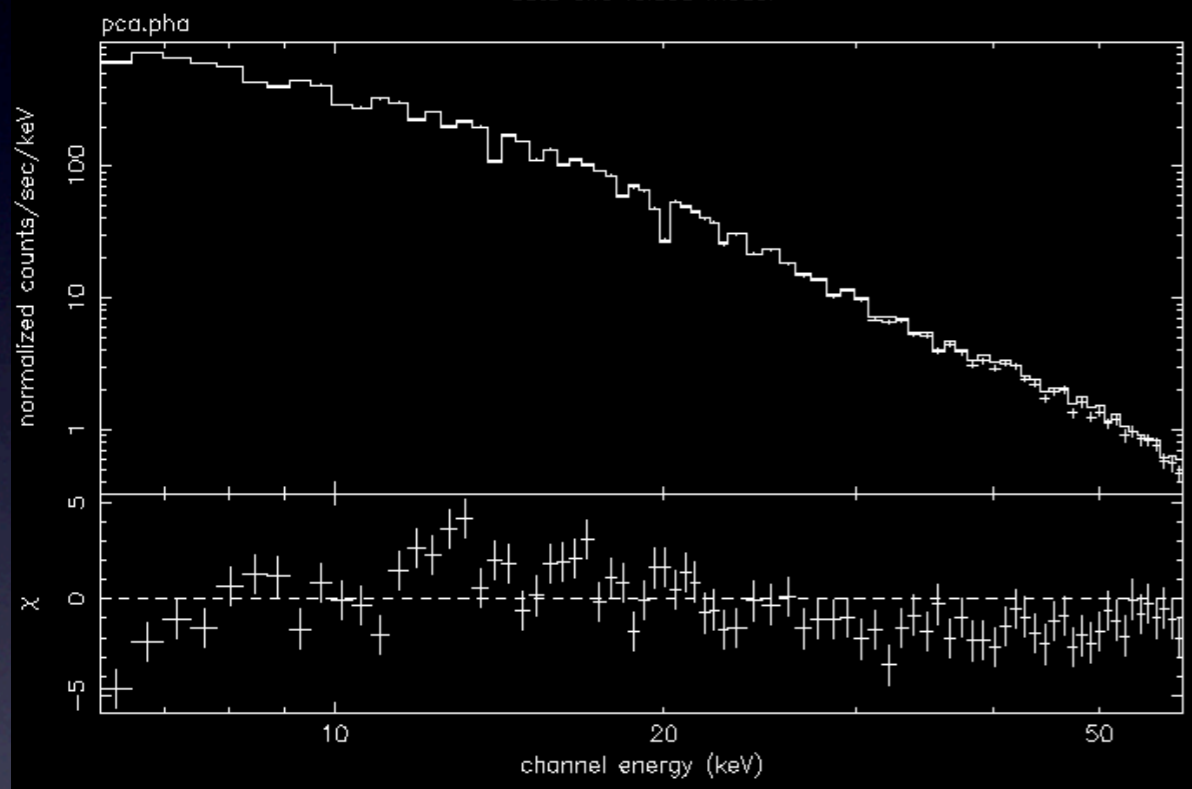
$$\Gamma = 1.96 \pm 0.03$$

red $\chi^2 : 0.98$

/ dofs 82

Phase resolved Spectra

On I Phasebin: summed over AO6 (~200s)



model: powerlaw

$$\Gamma = 1.973 \pm 0.005$$

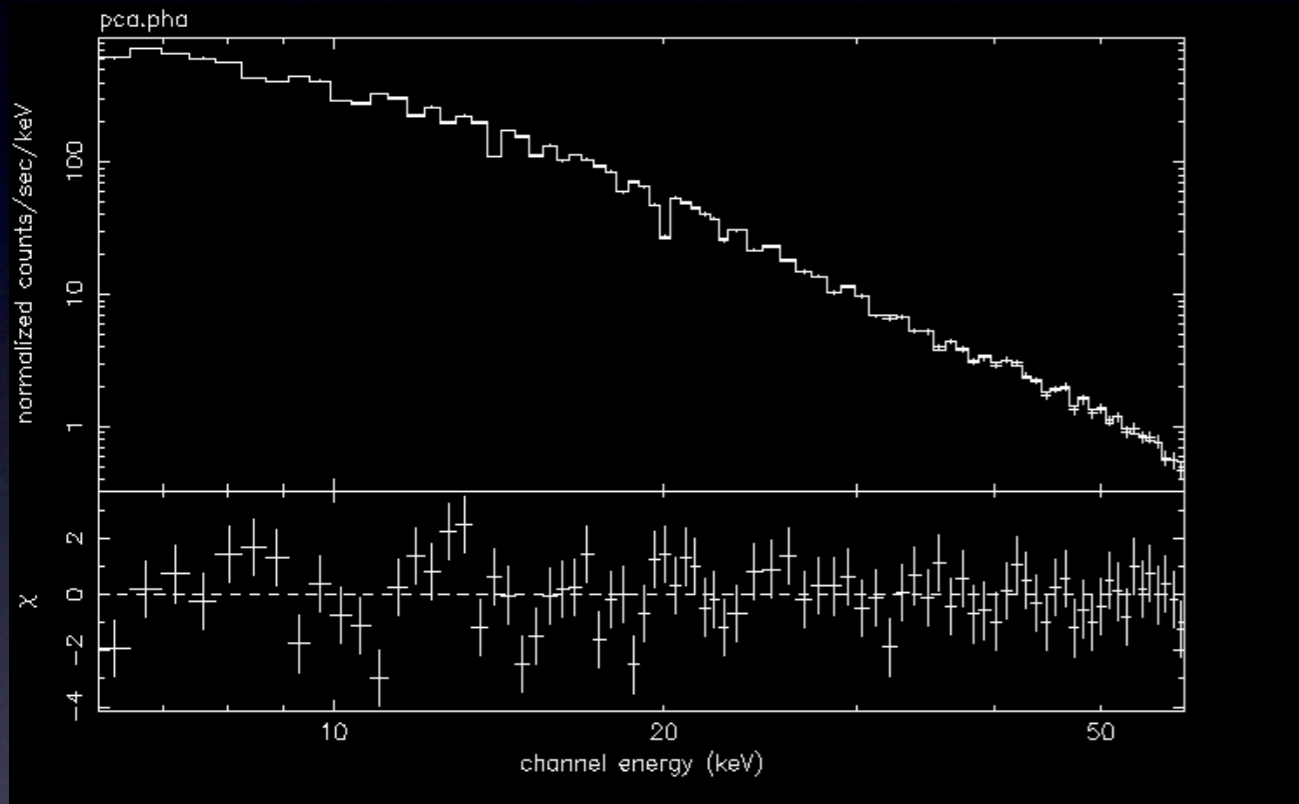
$$\text{red } \chi^2 = 2.9 / \text{dofs } 78$$

$$\Gamma = 2.14 \pm 0.02$$

$$\text{red } \chi^2 = 1.32 / \text{dofs } 125$$

Phase resolved Spectra

On I Phasebin: summed over AO6 (~200s)



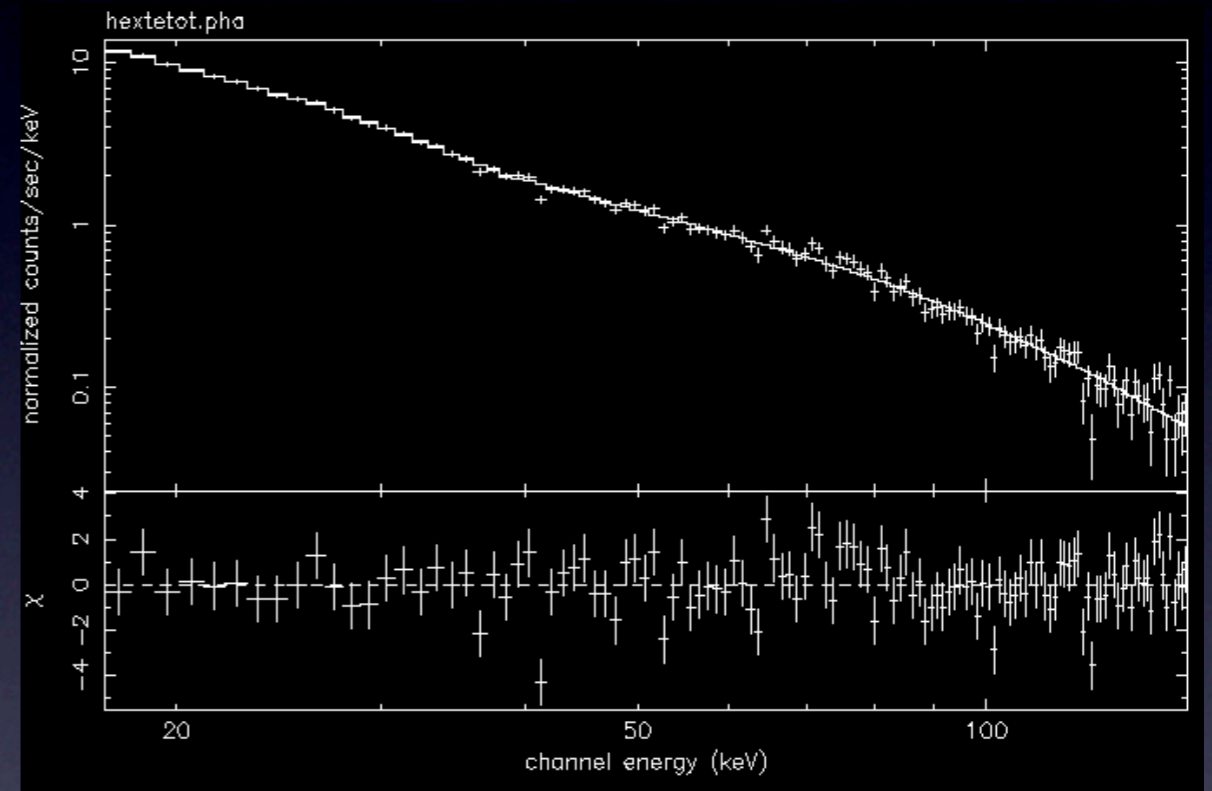
model: bkn powerlaw

$$\Gamma_1 = 1.937 \pm 0.008$$

$$\Gamma_2 = 2.06 \pm 0.02$$

$$E_{\text{Break}} = 15.4 \text{ keV}$$

$$\text{red } \chi^2 = 1.18 / \text{dofs } 76$$



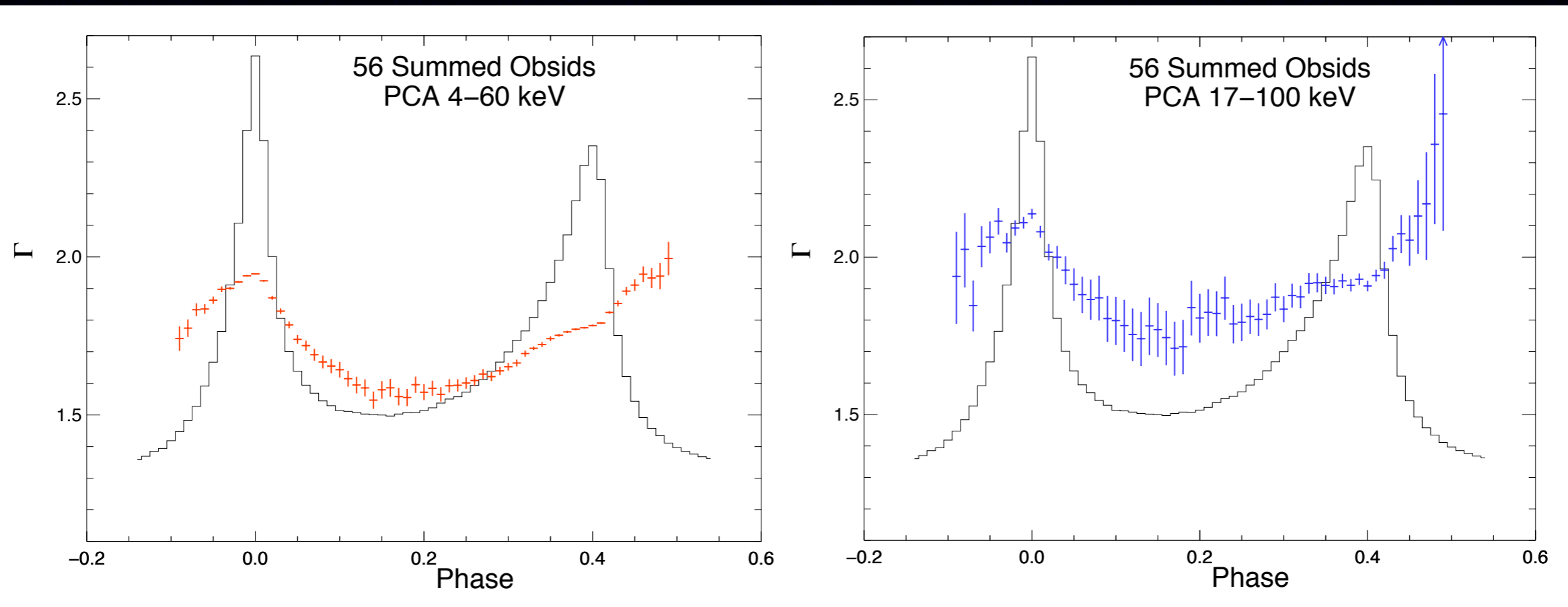
model: powerlaw

$$\Gamma = 2.14 \pm 0.02$$

$$\text{red } \chi^2 = 1.32 / \text{dofs } 125$$

Phase resolved Spectra

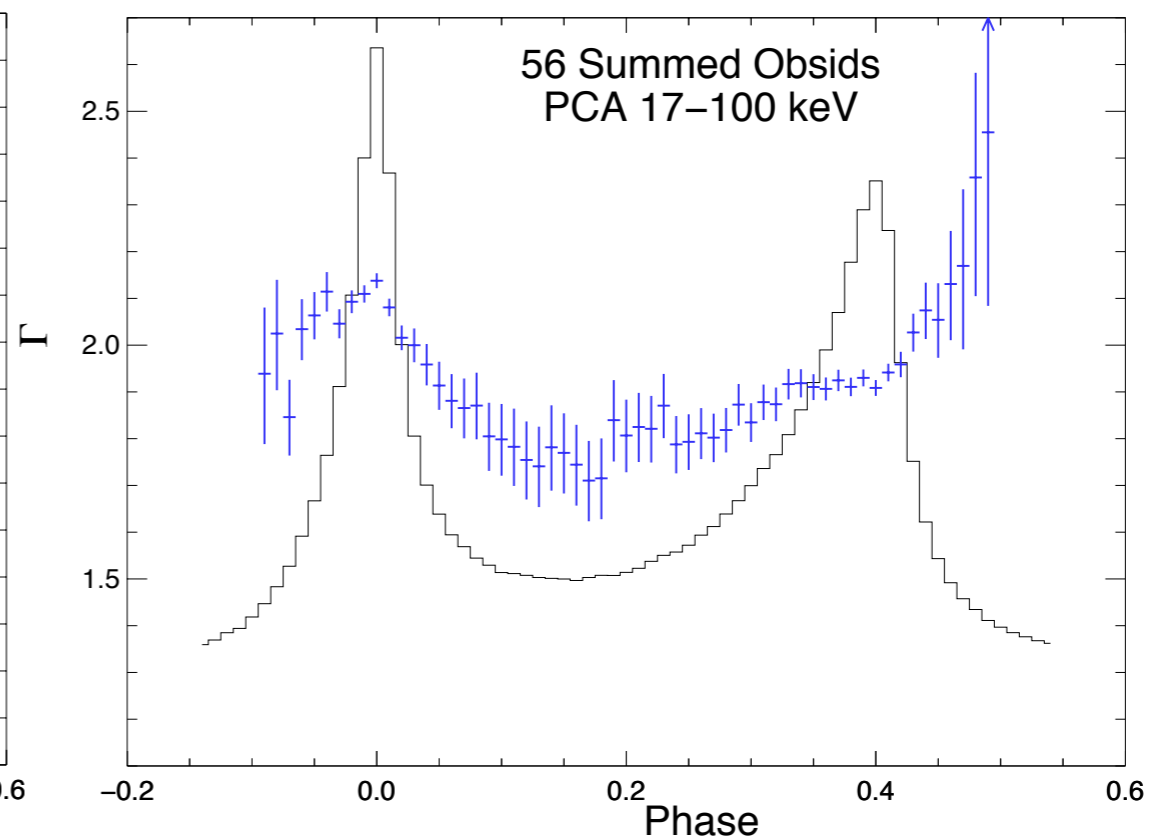
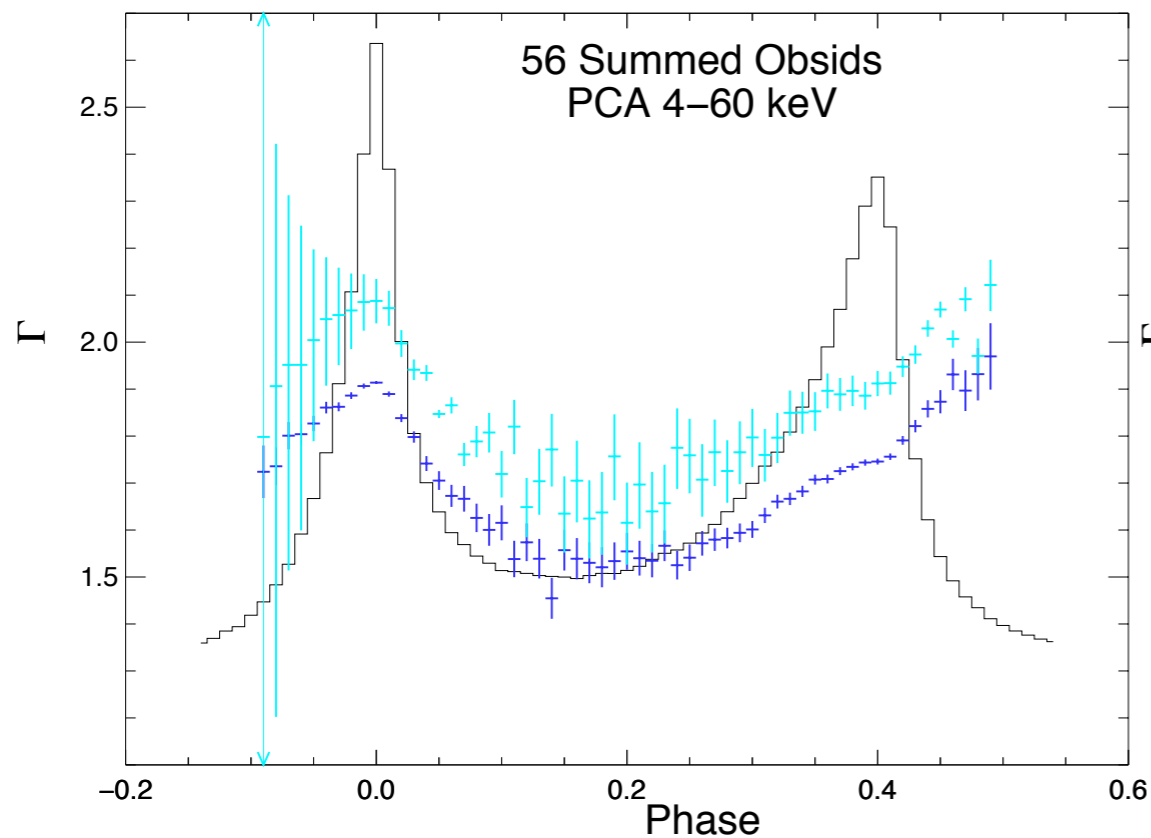
Individual Phasebins



PCA has large red. χ^2

Phase resolved Spectra

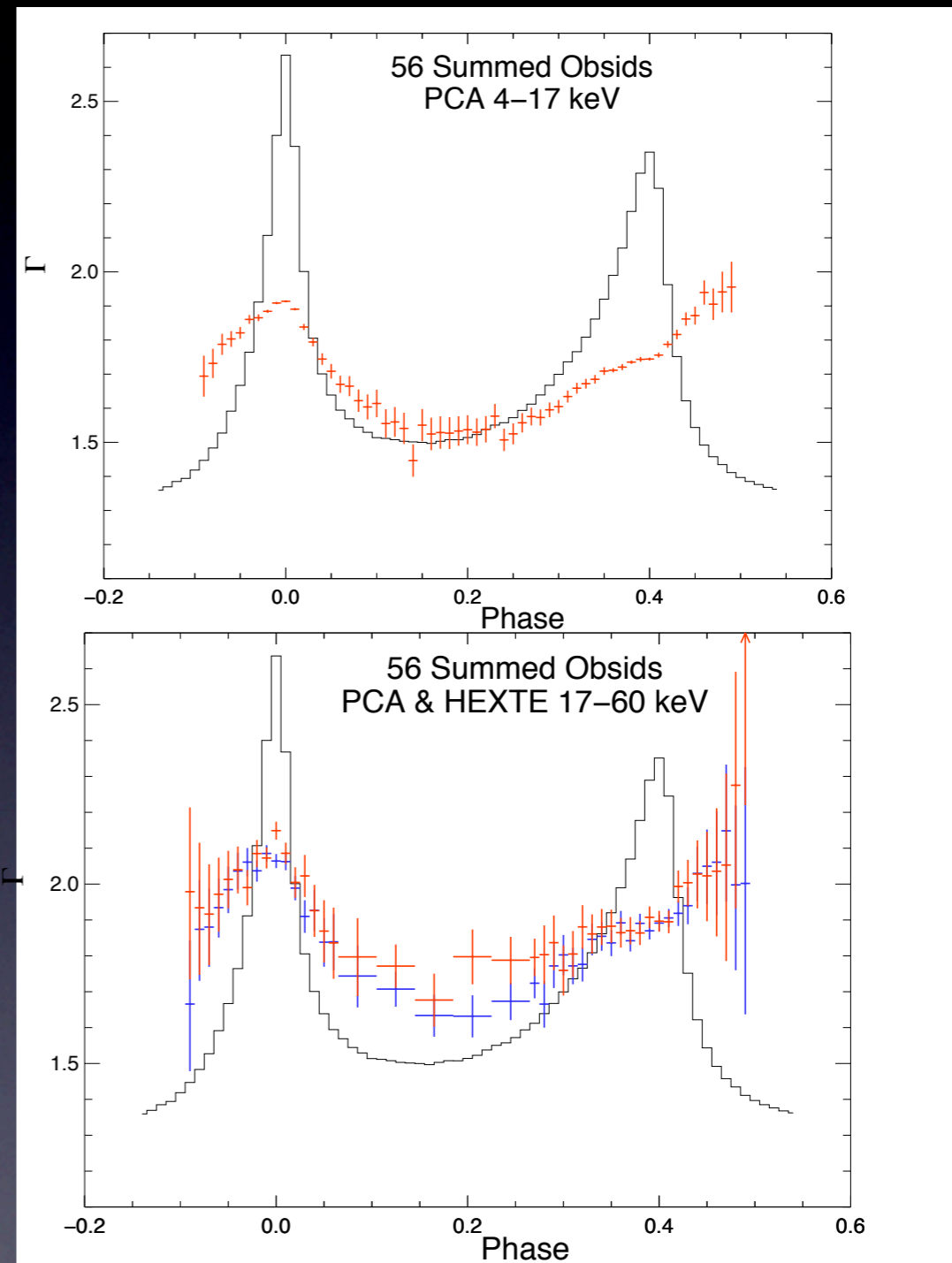
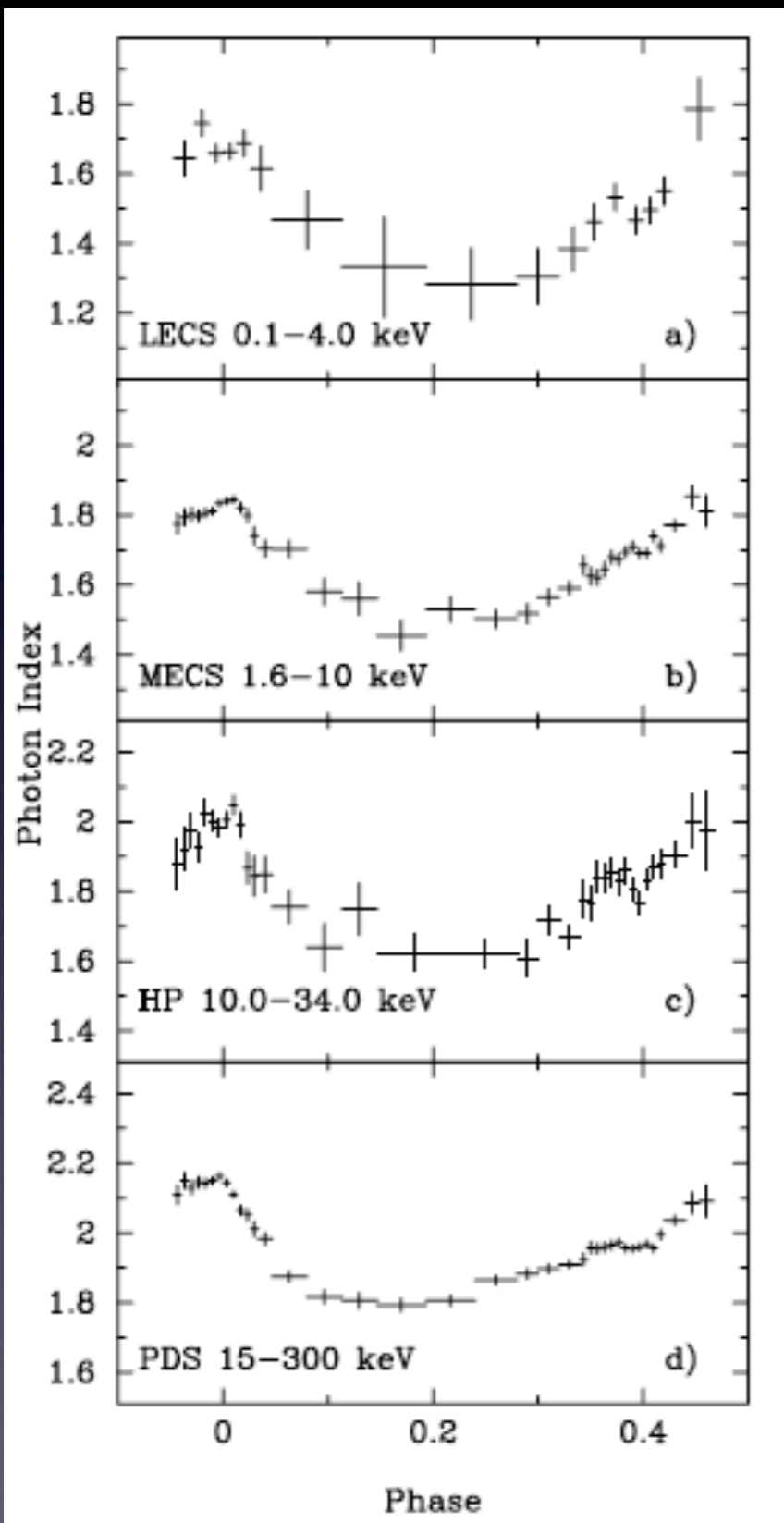
Individual Phasebins



Try broken powerlaw

with $E_{\text{Break}} = 15.4 \text{ keV}$

Energy Dependence



Already observed
by BeppoSax
(Massaro et al. 2000)

2 different approaches

Approaches

Pravdo et al.

Analyzes RXTE data from
AOI with single PL and
Broken PL.

but has a total of only
2000s observation

Massaro et al.

BeppoSAX / ISGRI

Multi-Component Model:
$$F(E) = A (E/E_0)^{-(a+b\text{Log}(E/E_0))}$$

Still work in Progress with 2/3 of data still to add.

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A possible Mini Crab?

Source

- current *RXTE*-PCA PCU 2 rate, 3–20 keV top layer: **14.5 counts/s (Crab 1800 counts/s)**
- $D \sim 4.2$ kpc
- $P \sim 150$ ms
- unusually high \dot{P}
- characteristic age ~ 1600 yr

Ginga (Kawai 93)
CGRO (Ulmer 93, Matz 94, Kuiper 99)
RXTE (Marsden 97, Rots 98)
BeppoSax (Cusumano 01)
Chandra (Yatsu 05, DeLaney 05)
INTEGRAL (Forot 06)

Katja Pottschmidt (UCSD)

Pulse – Off-Pulse Fit

add sub-ObsIDs

$\Phi = 0.12 - 0.48 \Leftrightarrow$ peak.pha
 $\Phi = 0.72 - 1.02 \Leftrightarrow$ off.pha
 (Rots et al., 1998)

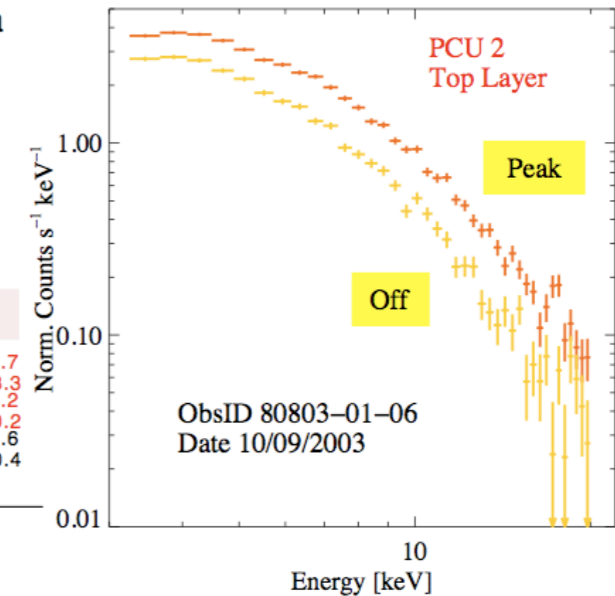
data 1:1 peak.pha
 back 1:1 off.pha

phabs × power

Typical Parameters

$N_H [10^{22} \text{ cm}^{-2}] = 3.3^{+3.7}_{-3.3}$
 $\Gamma = 1.4^{+0.2}_{-0.2}$
 $A_\Gamma^a = 1.1^{+0.6}_{-0.4}$
 $F_{4-10 \text{ keV}}^b = 4.4$

$a 10^{-2} \frac{\text{ph}}{\text{keV cm}^2 \text{ s}} @ 1 \text{ keV},$
 $b 10^{-11} \frac{\text{erg}}{\text{cm}^2 \text{ s}}$



Katja Pottschmidt (UCSD)

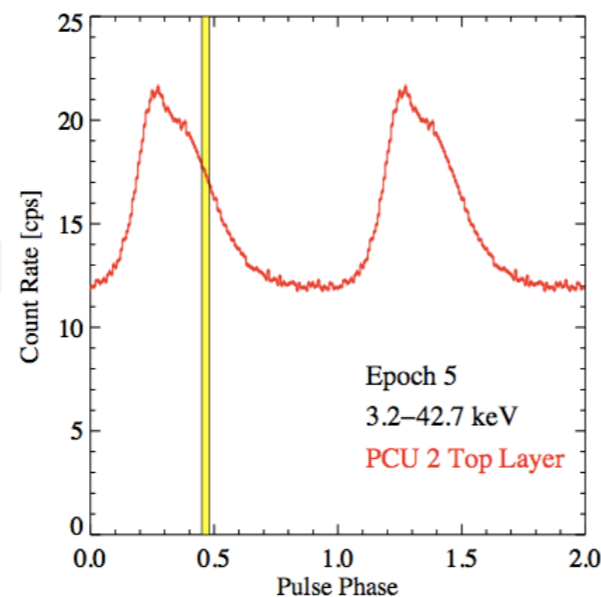
CASS

Epoch-Averaged Pulse Profiles

Epoch 3 81.2 ks
 Epoch 4 37.6 ks
 Epoch 5 224.6 ks

Next Step

- phase-resolved spectroscopy for $\Delta\Phi \sim 0.03$ bins
- highest resolution so far (?)



Katja Pottschmidt (UCSD)

CASS

Curvature powerlaw
 in spectrum with *BeppoSax*
 (Cusumano et al. 2001)

Work will be done to see how
 spectra changes throughout the
 pulse profile

Summary

Crab “powerlaw” is not stable throughout the pulse profile.

So when using pulse - offpulse, one has to define a “standard phase” additional to a “standard candle” on which calibration should be performed

BI 509 Flux

