

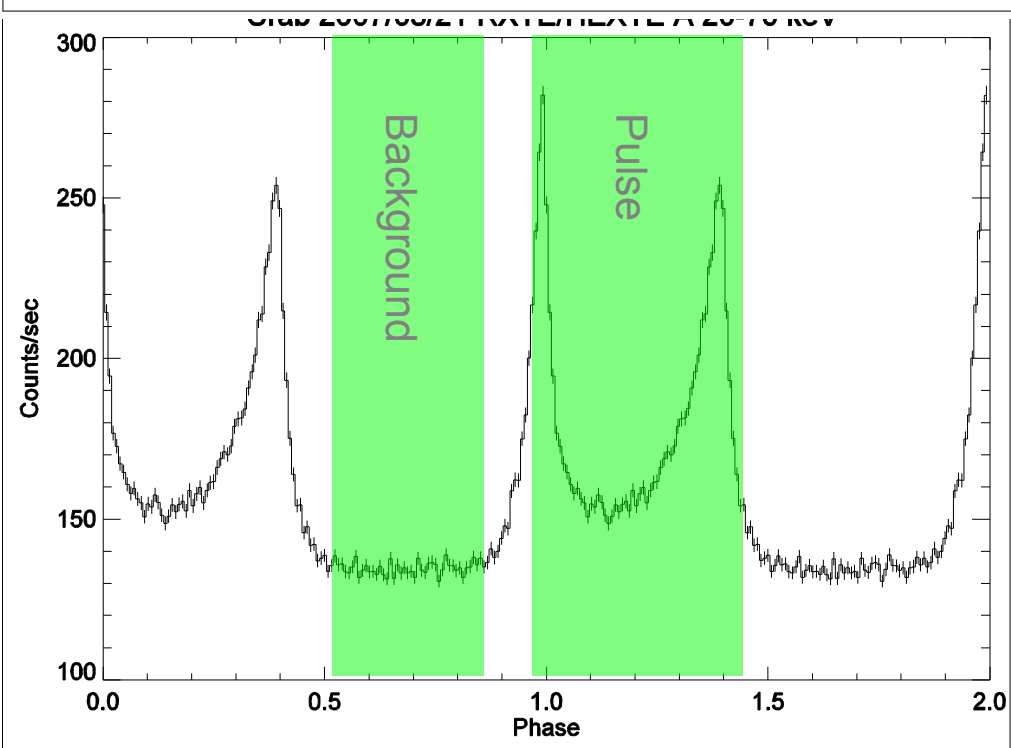
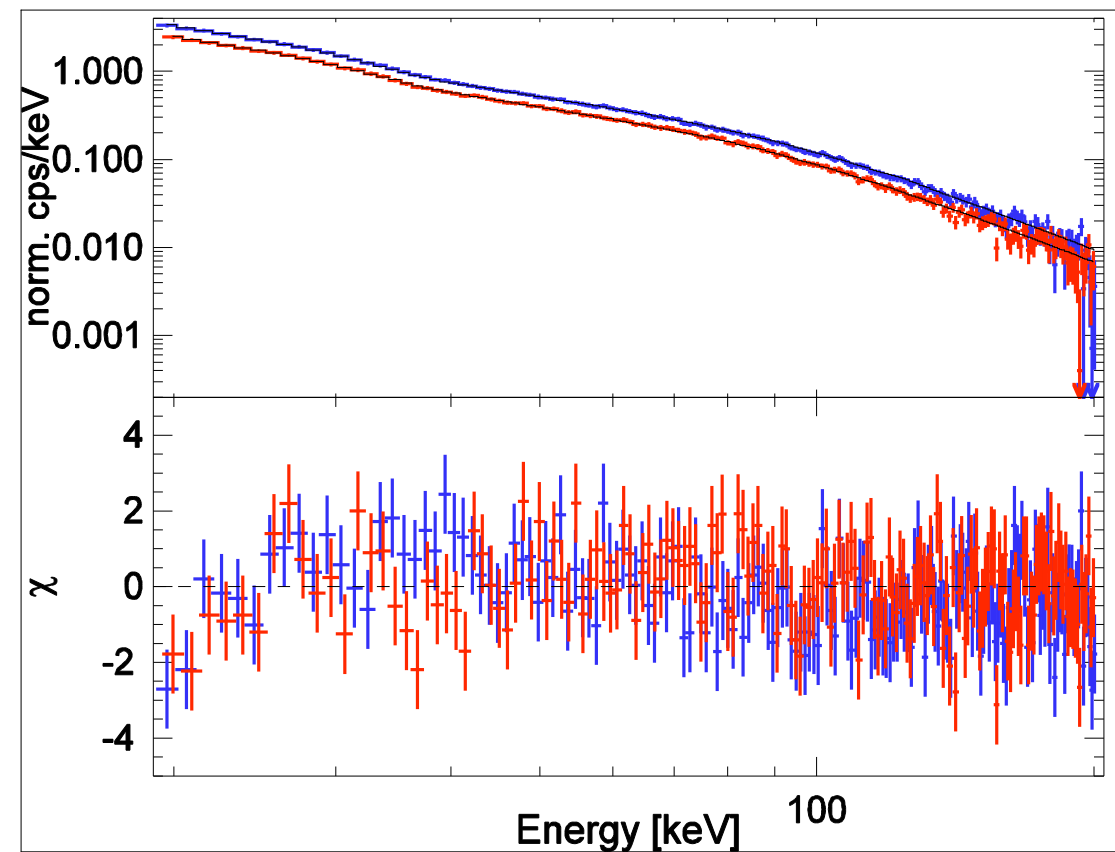
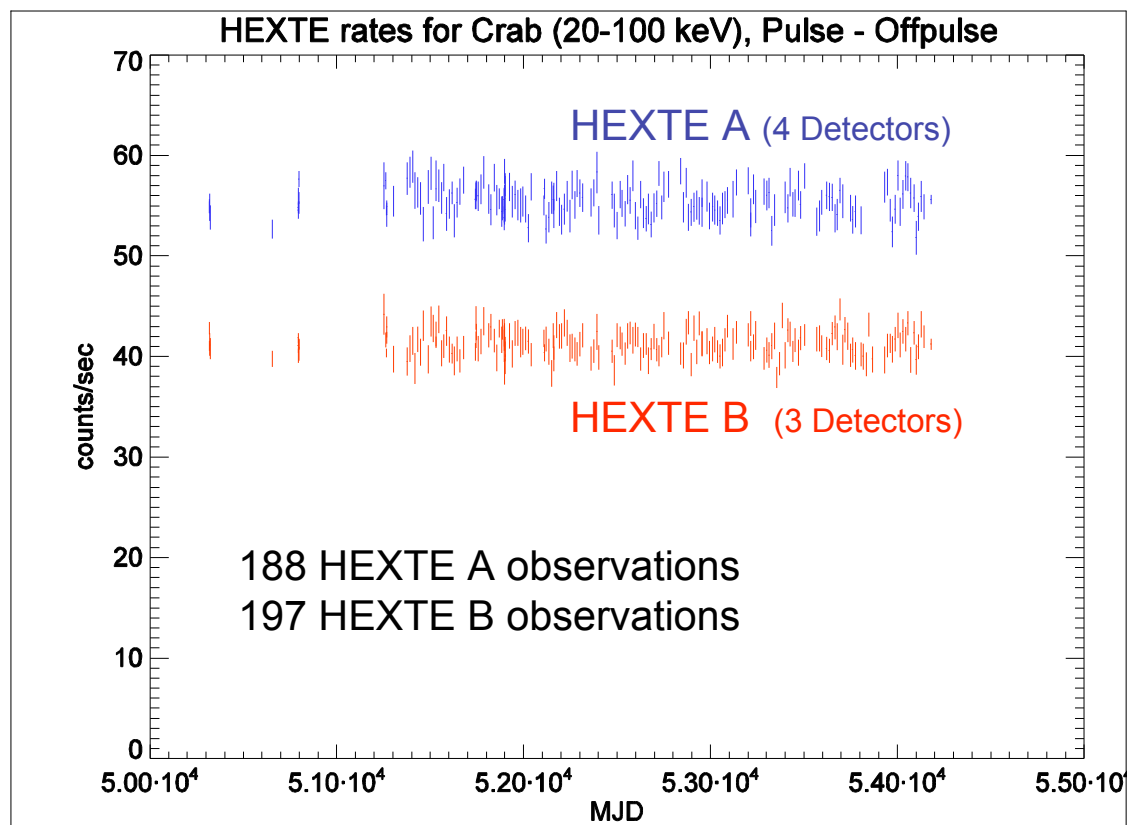
# Phase Resolved Analysis of the Crab pulsar using RXTE/PCA & HEXTE

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IACHEC - Schloss Ringberg - May 2008

# 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



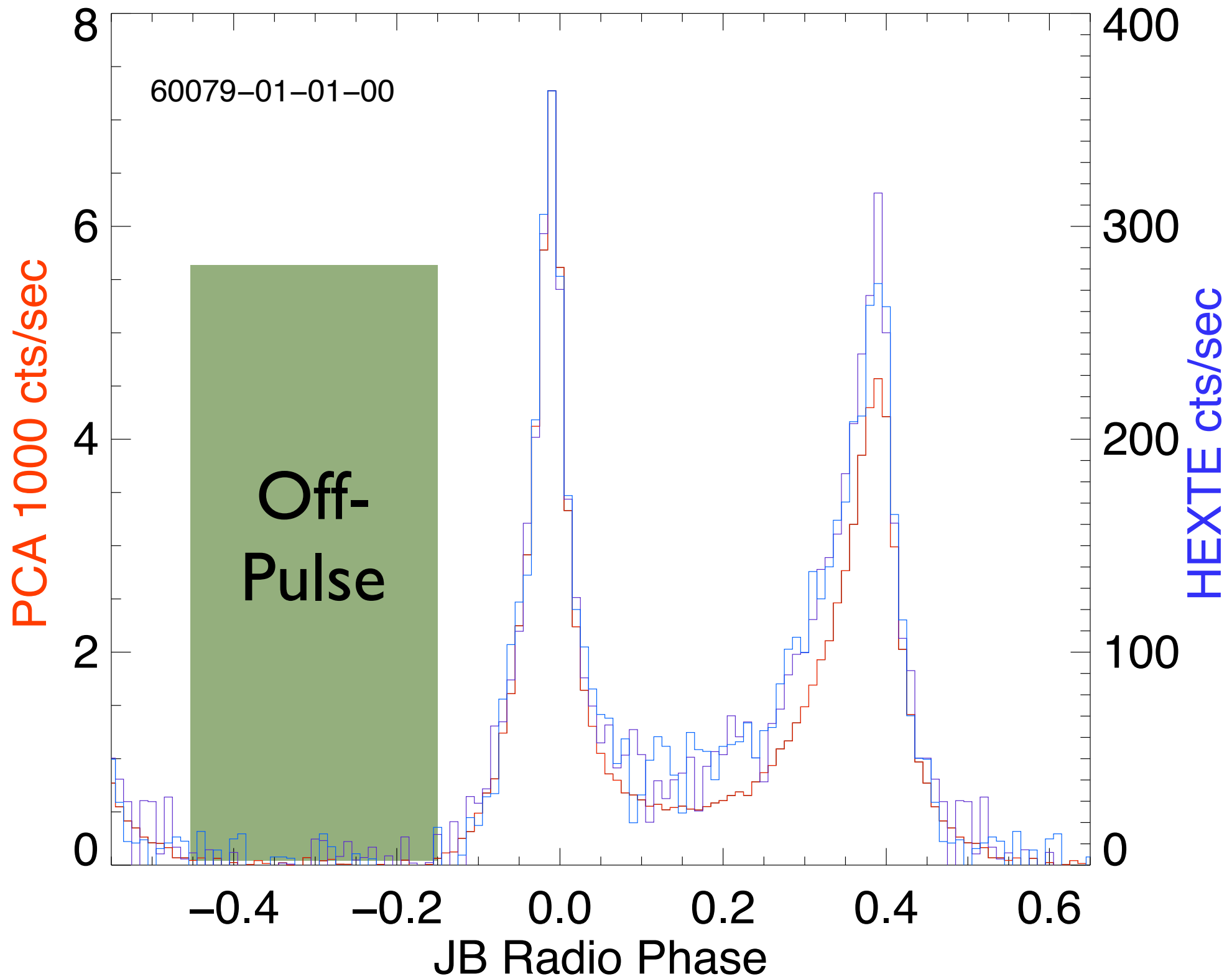
# Analysis

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)

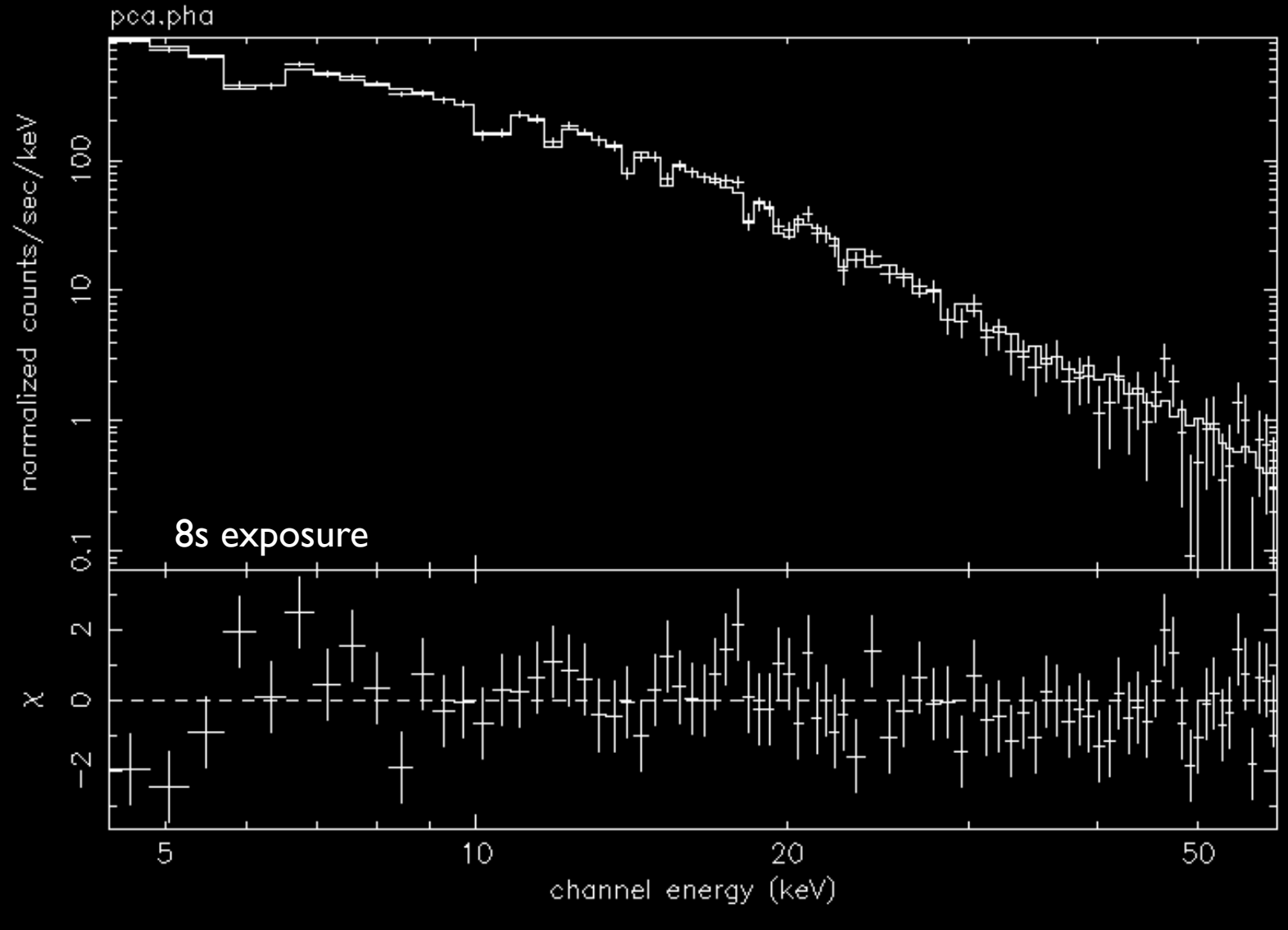
# Pulse Profile





# Spectra from 1 Obsid

data and folded model



powerlaw

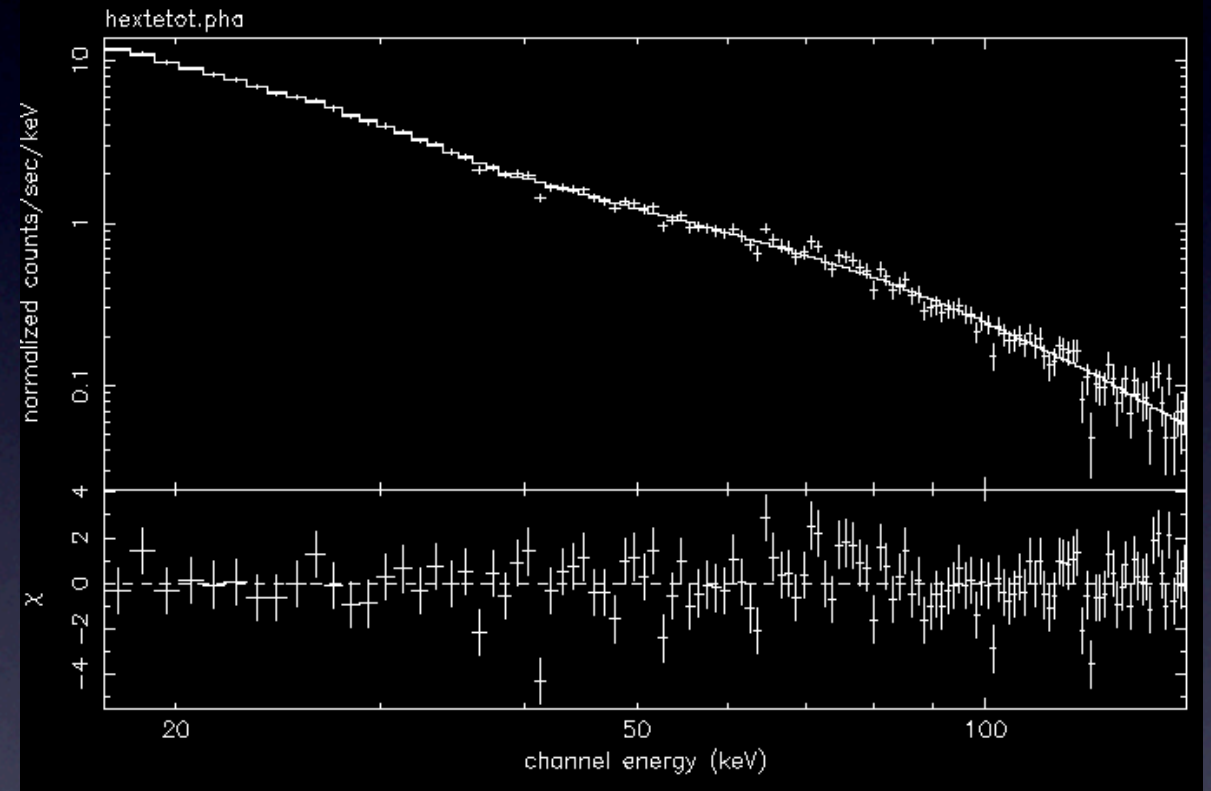
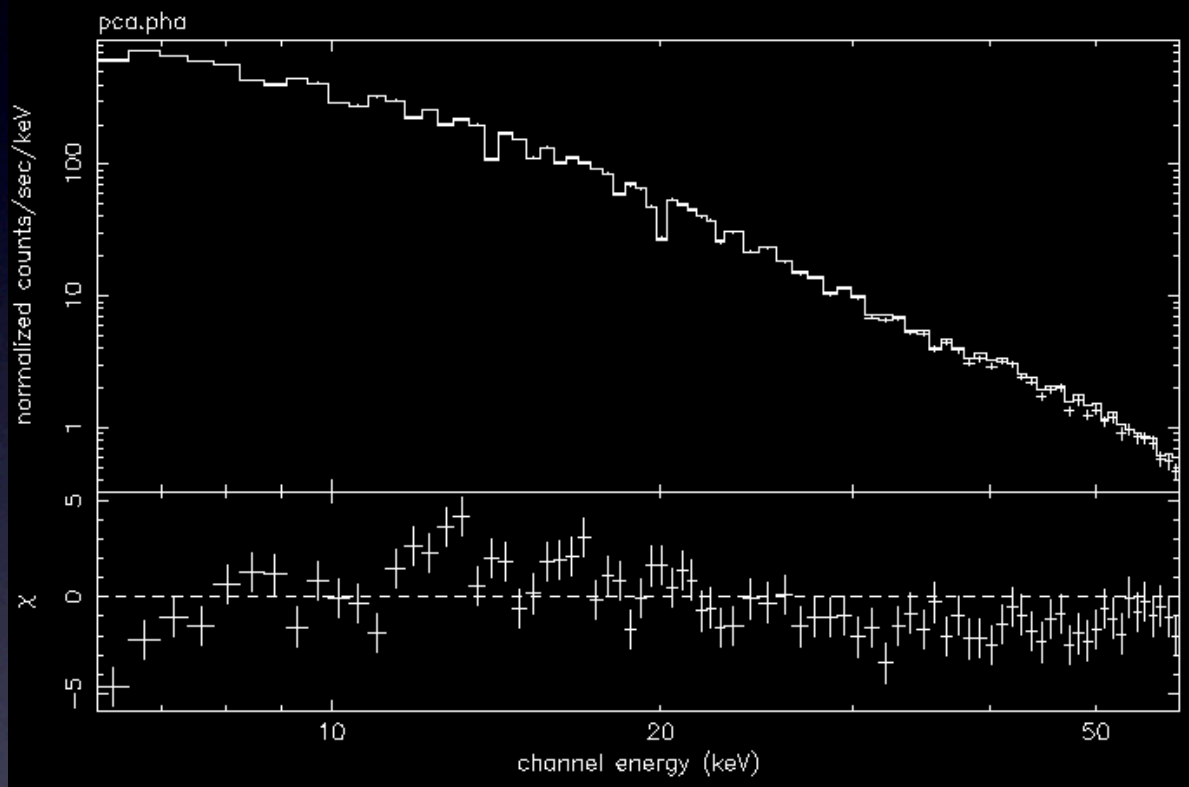
$$\Gamma = 1.96 \pm 0.03$$

red  $\chi^2 : 0.98$

/ dofs 82

# Phase resolved Spectra

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



model: powerlaw

$$\Gamma = 1.973 \pm 0.005$$

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

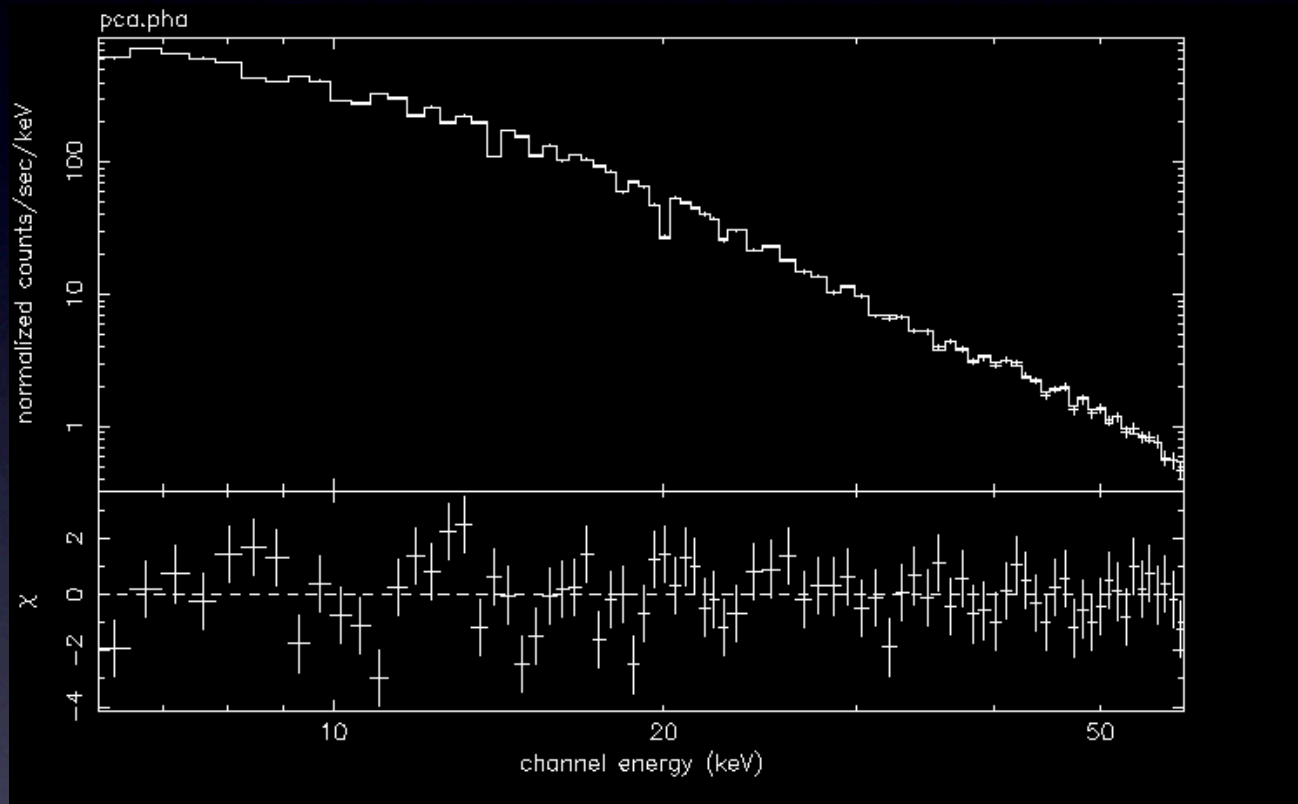
$$\Gamma = 2.14 \pm 0.02$$

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



# Phase resolved Spectra

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



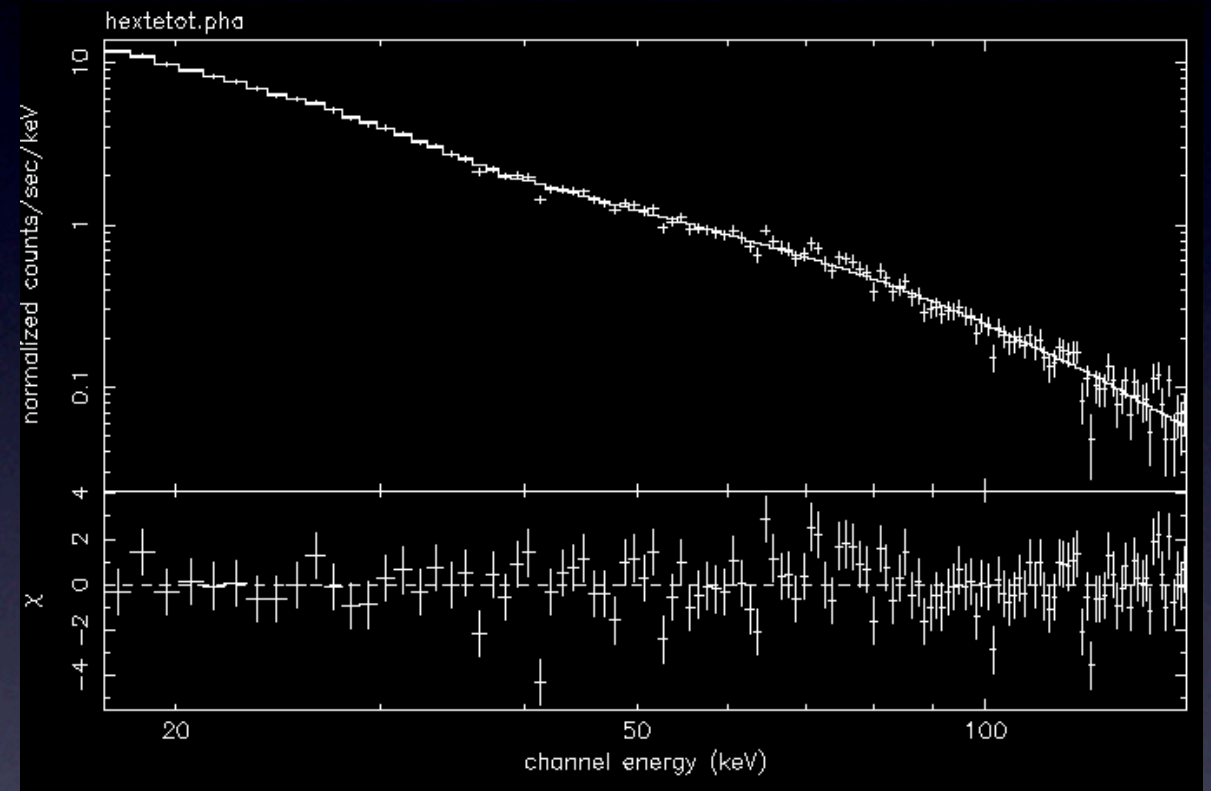
model: bkn powerlaw

$$\Gamma_1 = 1.937 \pm 0.008$$

$$\Gamma_2 = 2.06 \pm 0.02$$

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

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



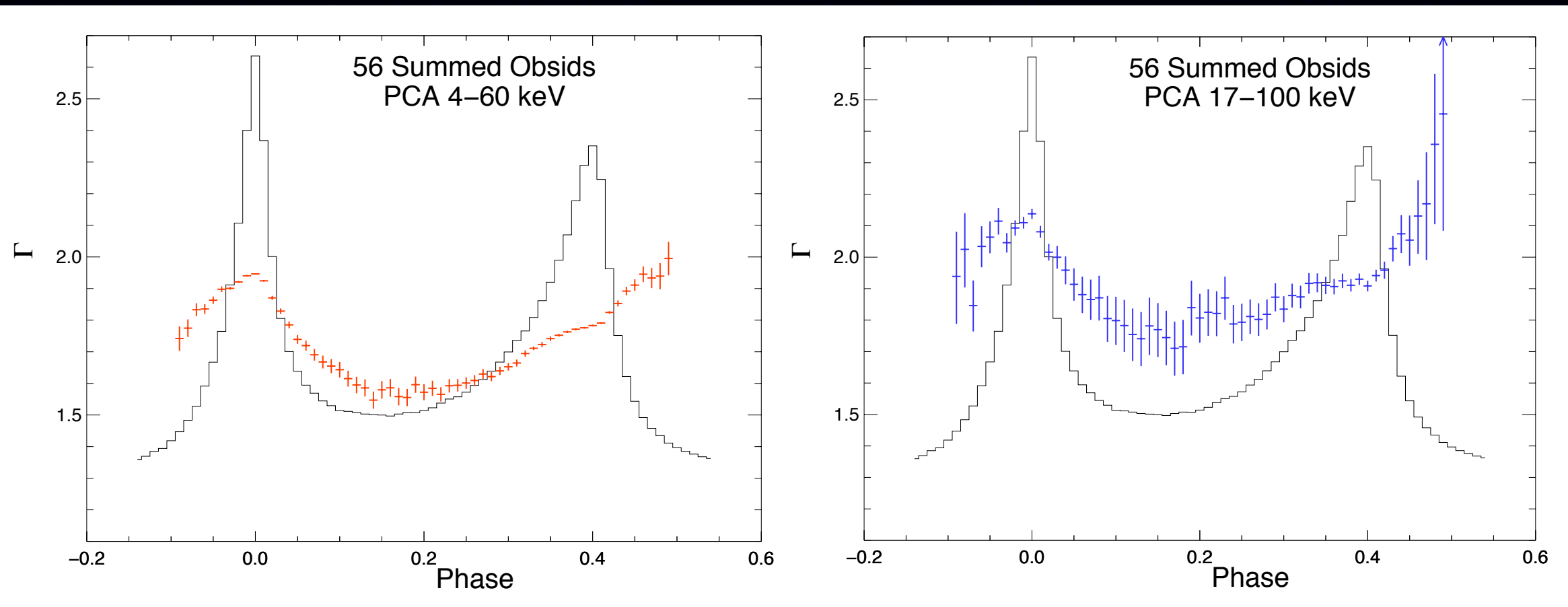
model: powerlaw

$$\Gamma = 2.14 \pm 0.02$$

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

# Phase resolved Spectra

## Individual Phasebins

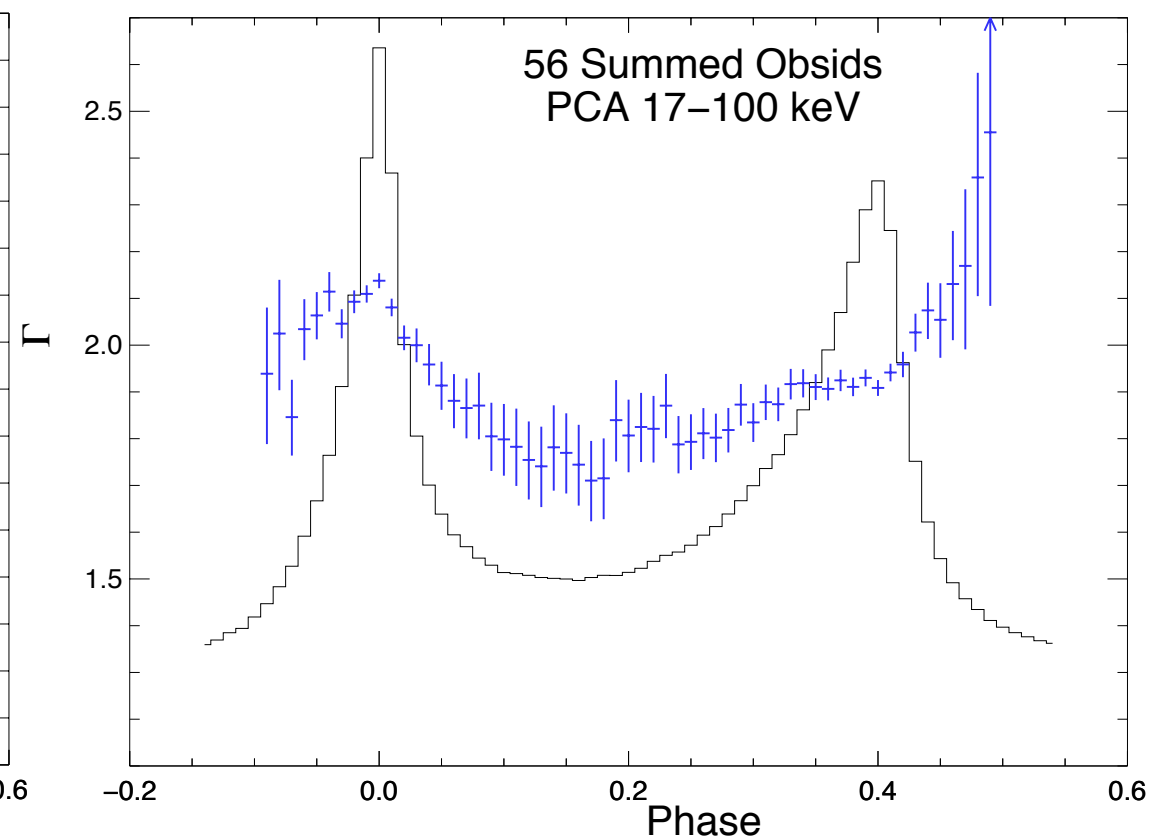
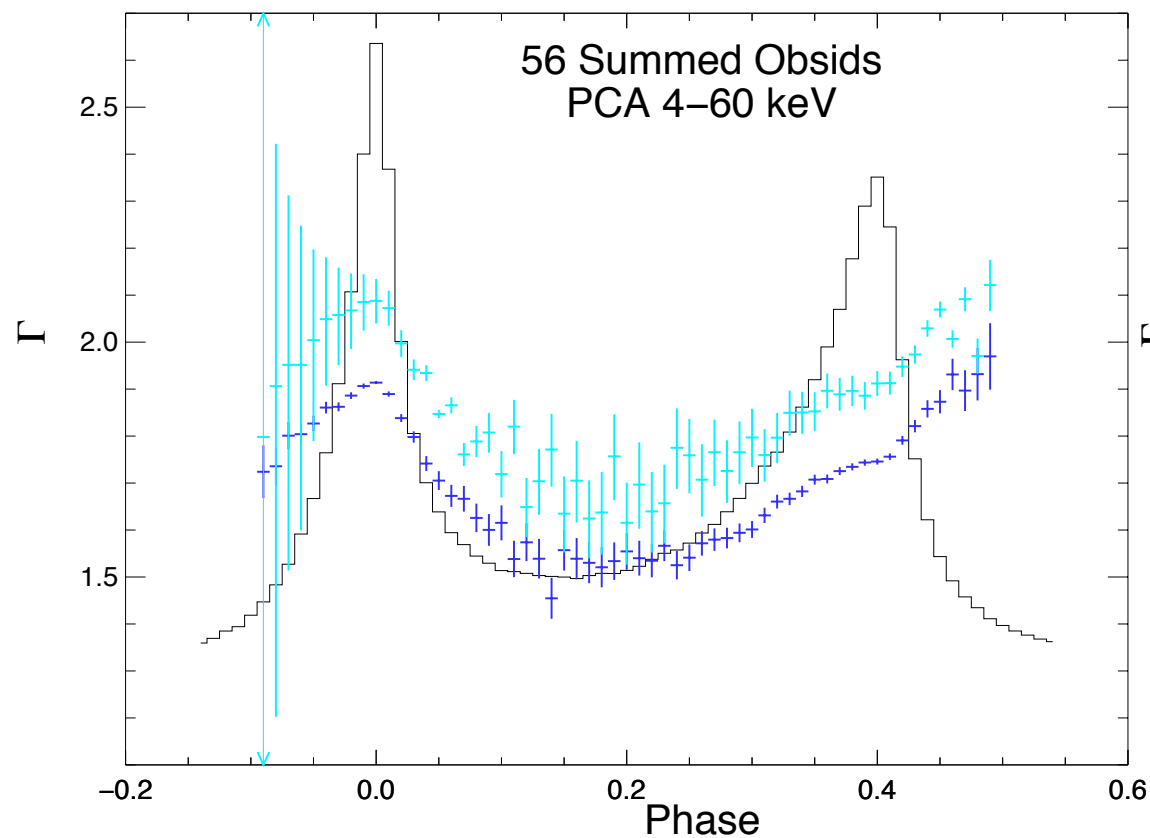


PCA has large red.  $\chi^2$



# Phase resolved Spectra

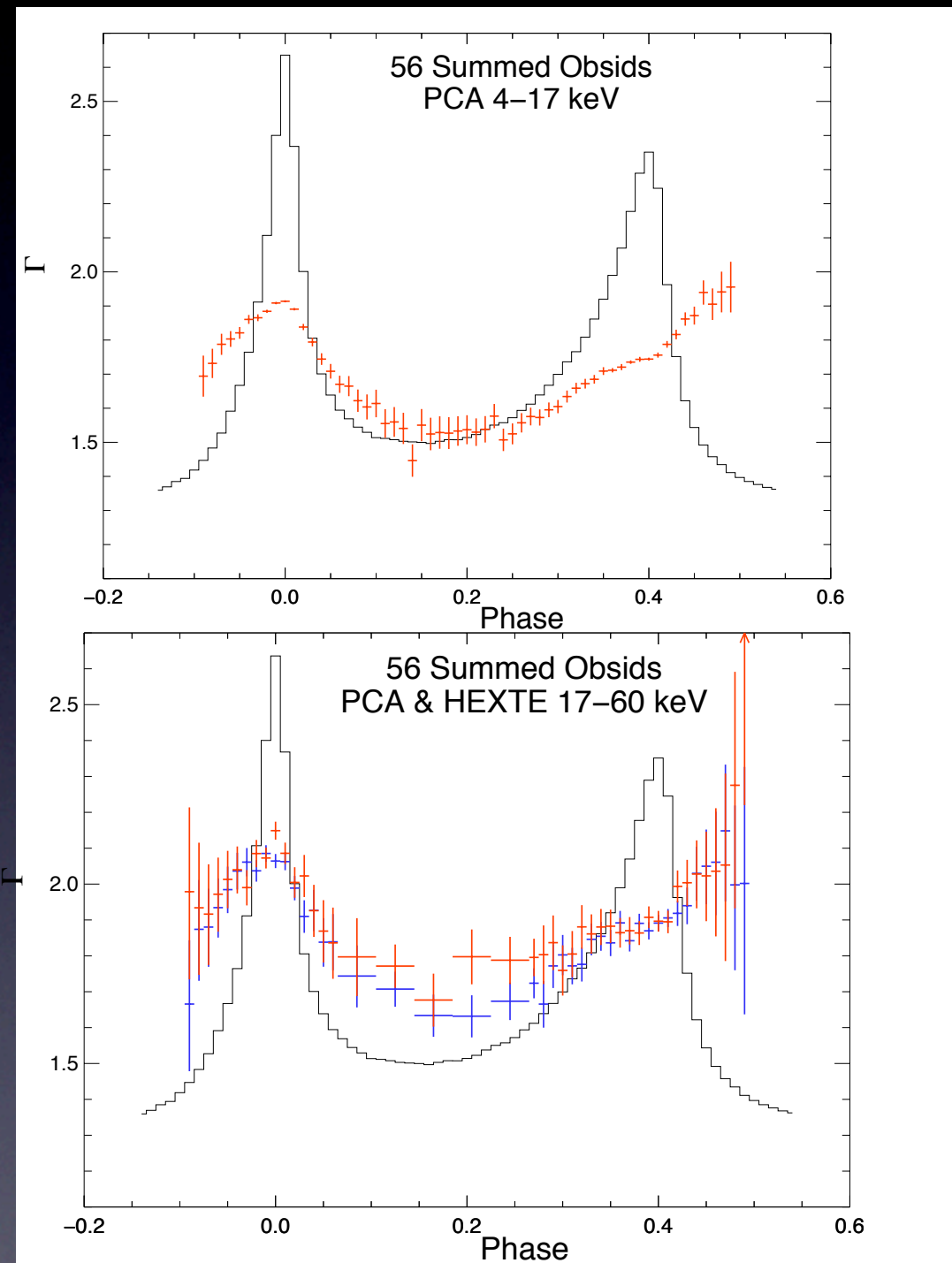
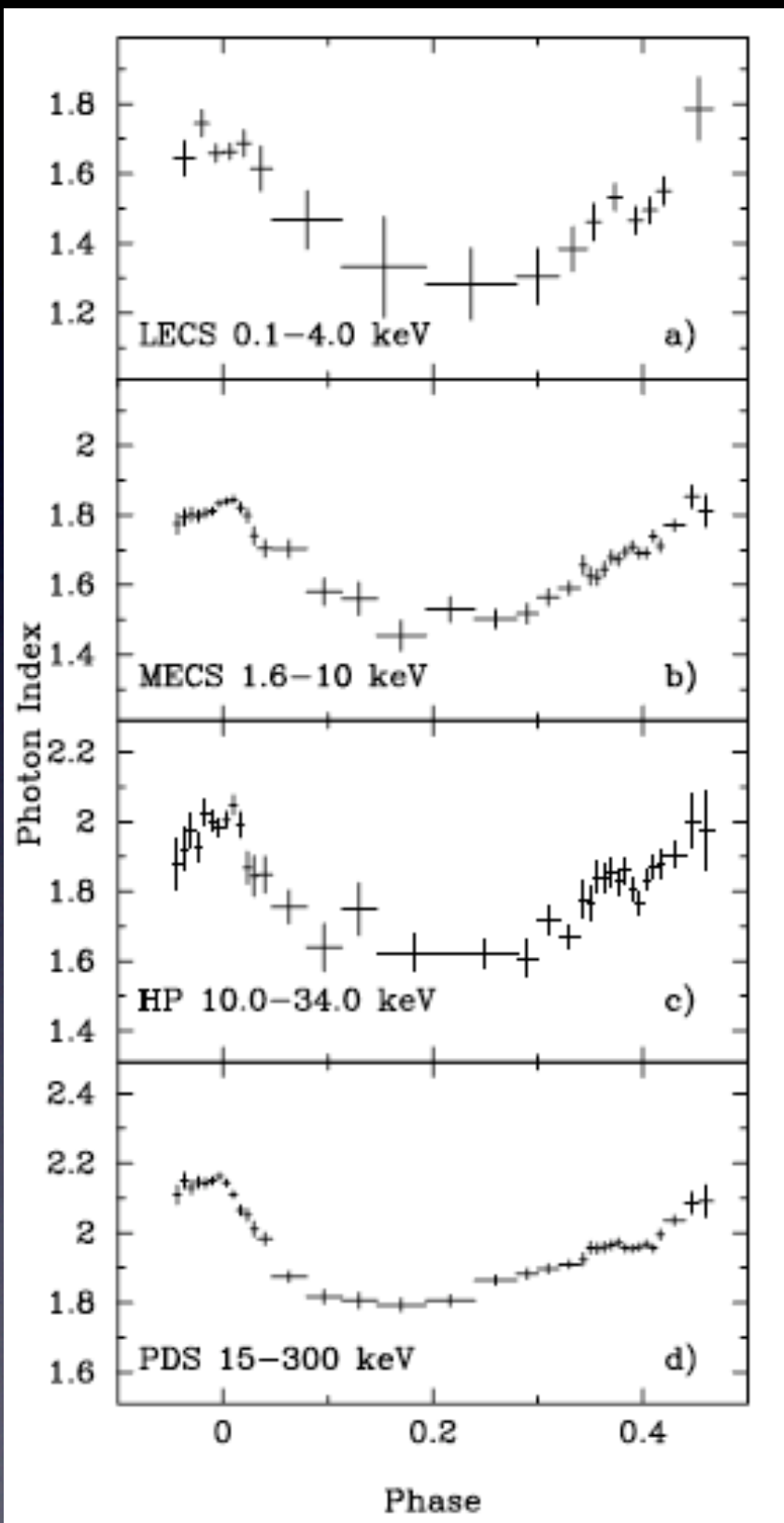
## Individual Phasebins



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.



# B1509 - 58

## 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  $\sim 1600$  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)

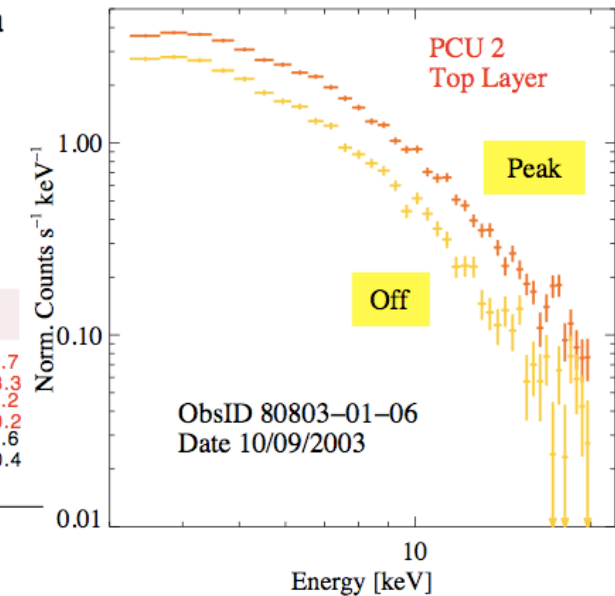
data 1:1 peak.pha  
 back 1:1 off.pha

**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)

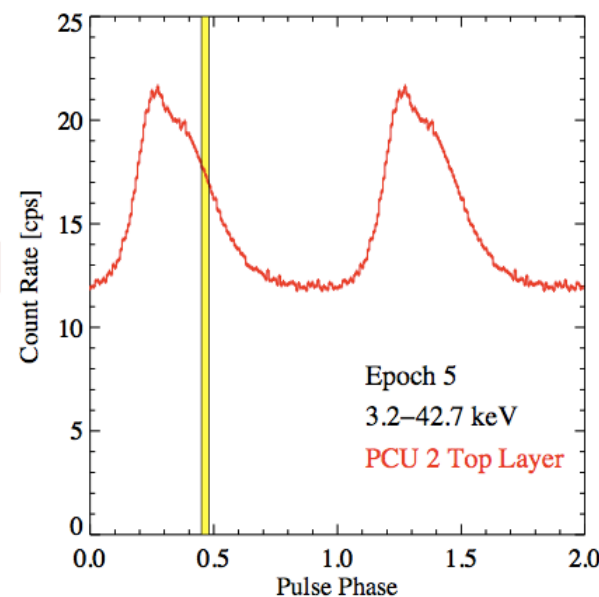
CASS

### 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 (?)



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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

