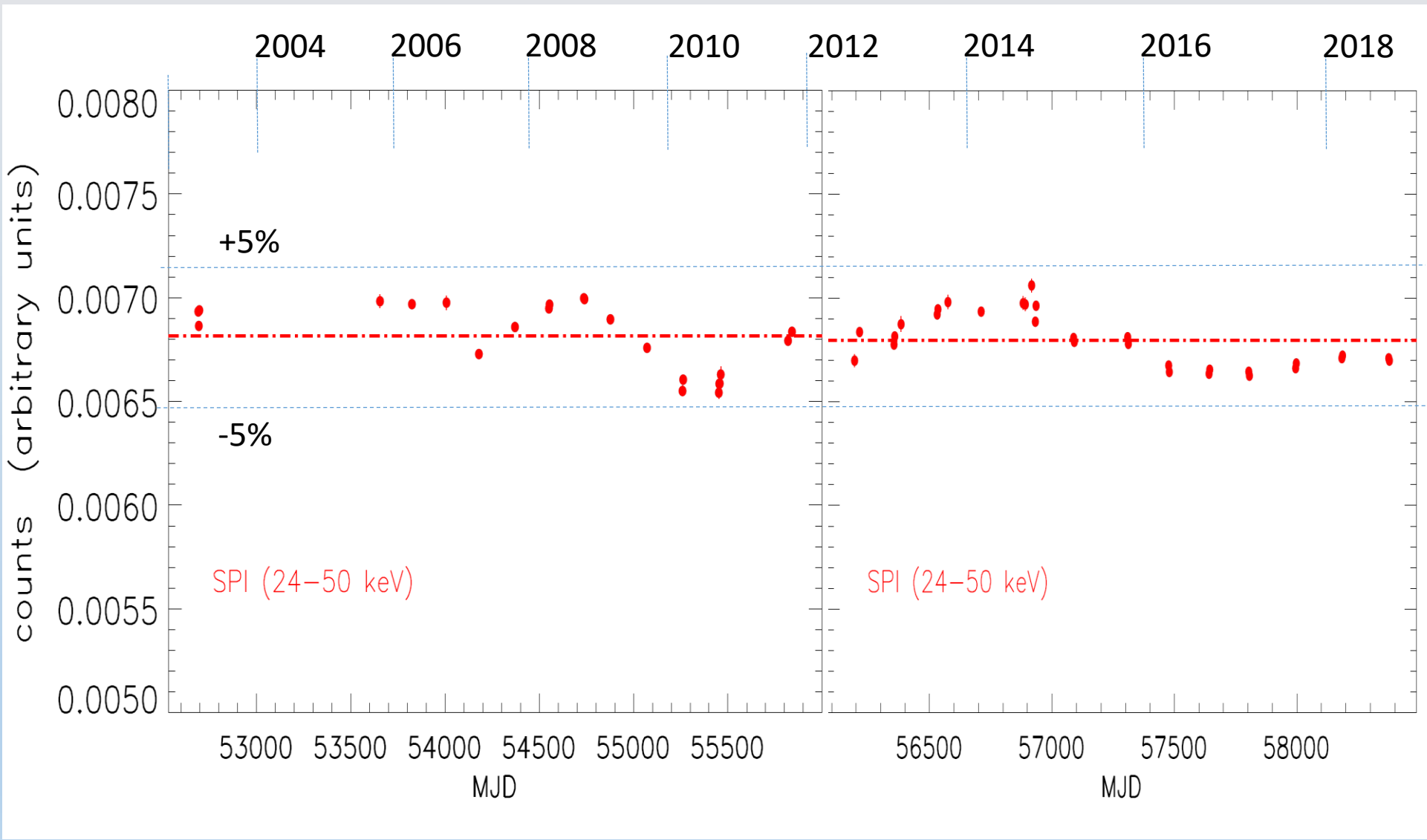
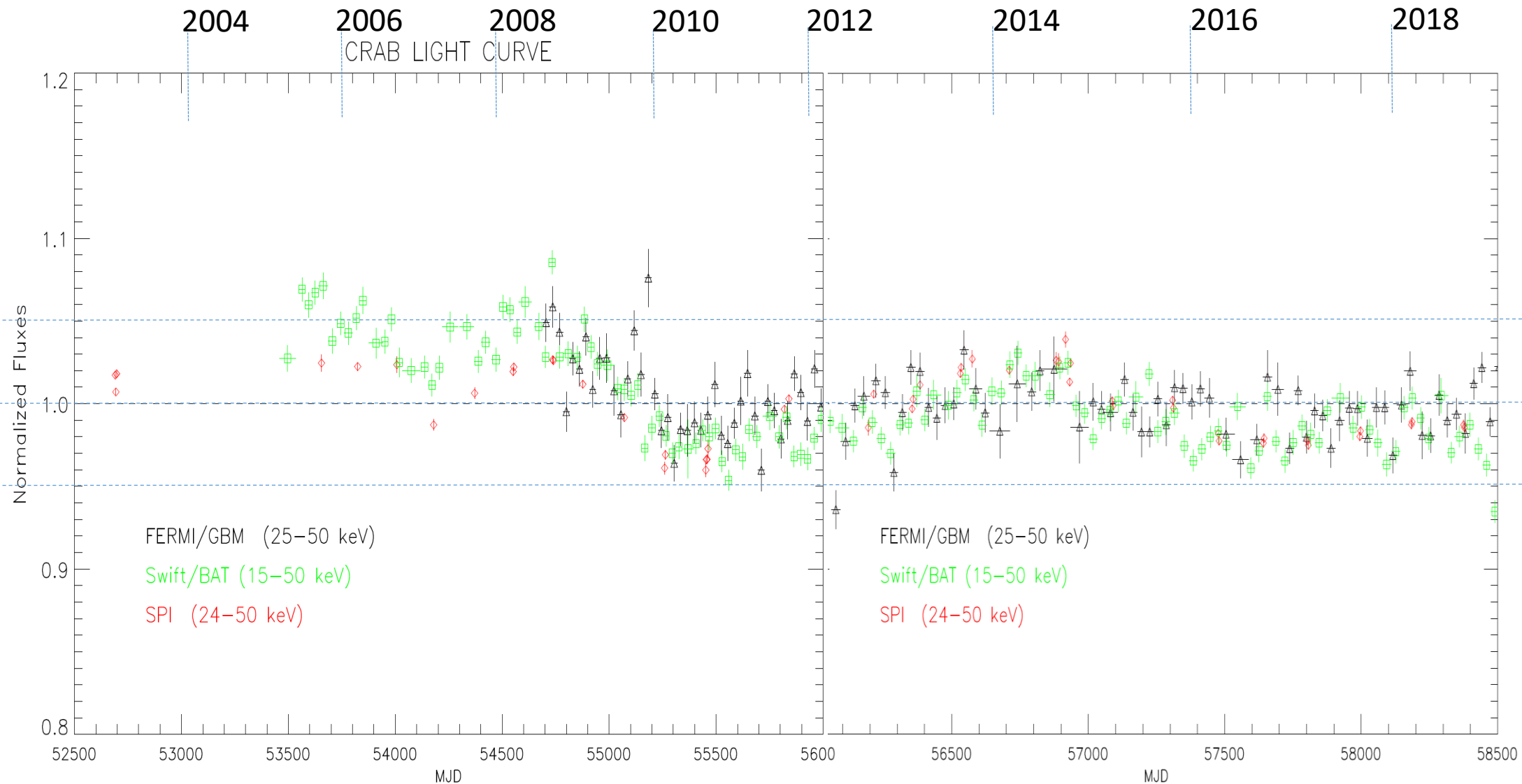
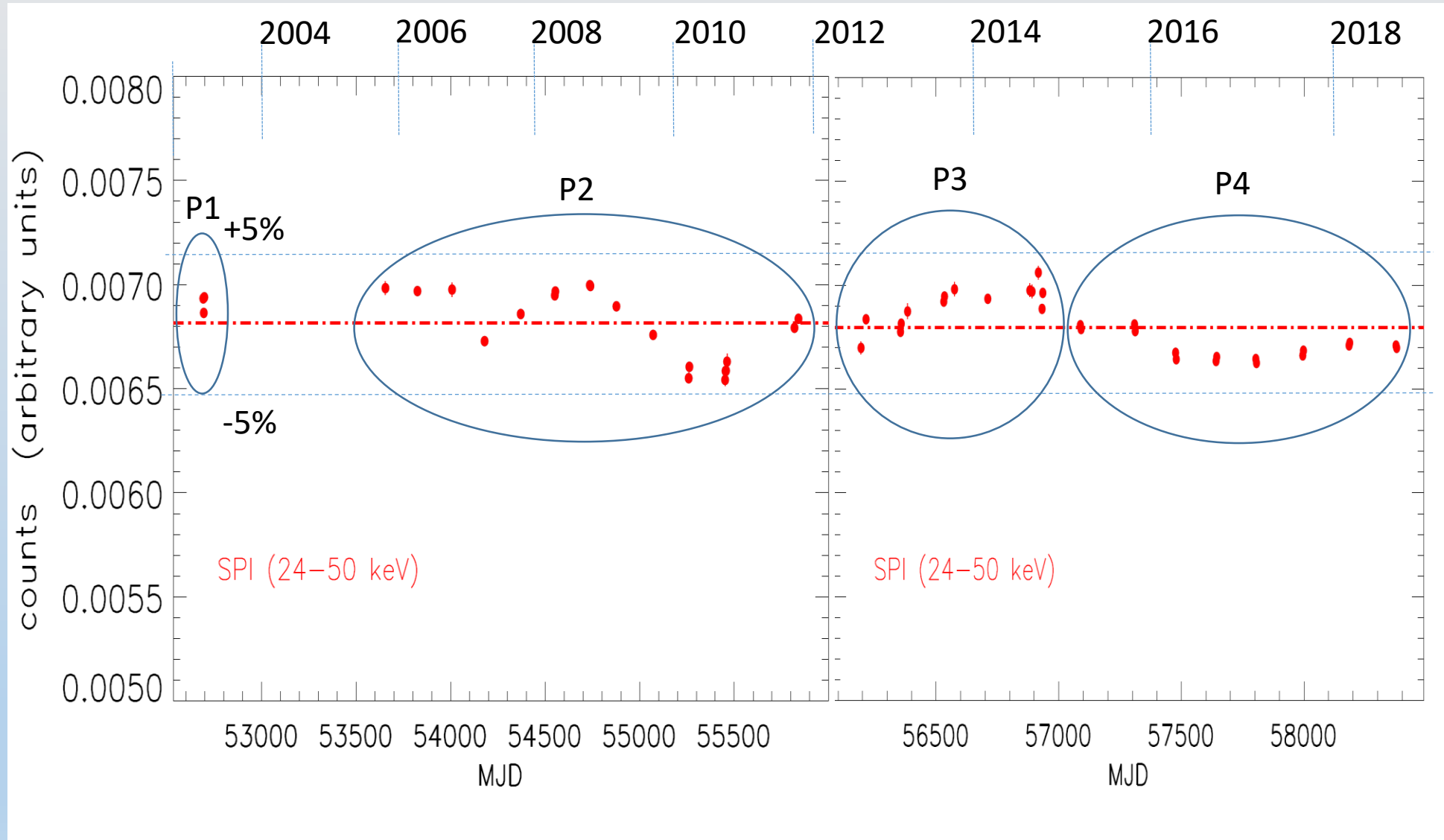


CRAB NEBULA LONG TERM  
EVOLUTION  
as seen by  
INTEGRAL SPI  
2003 - 2018

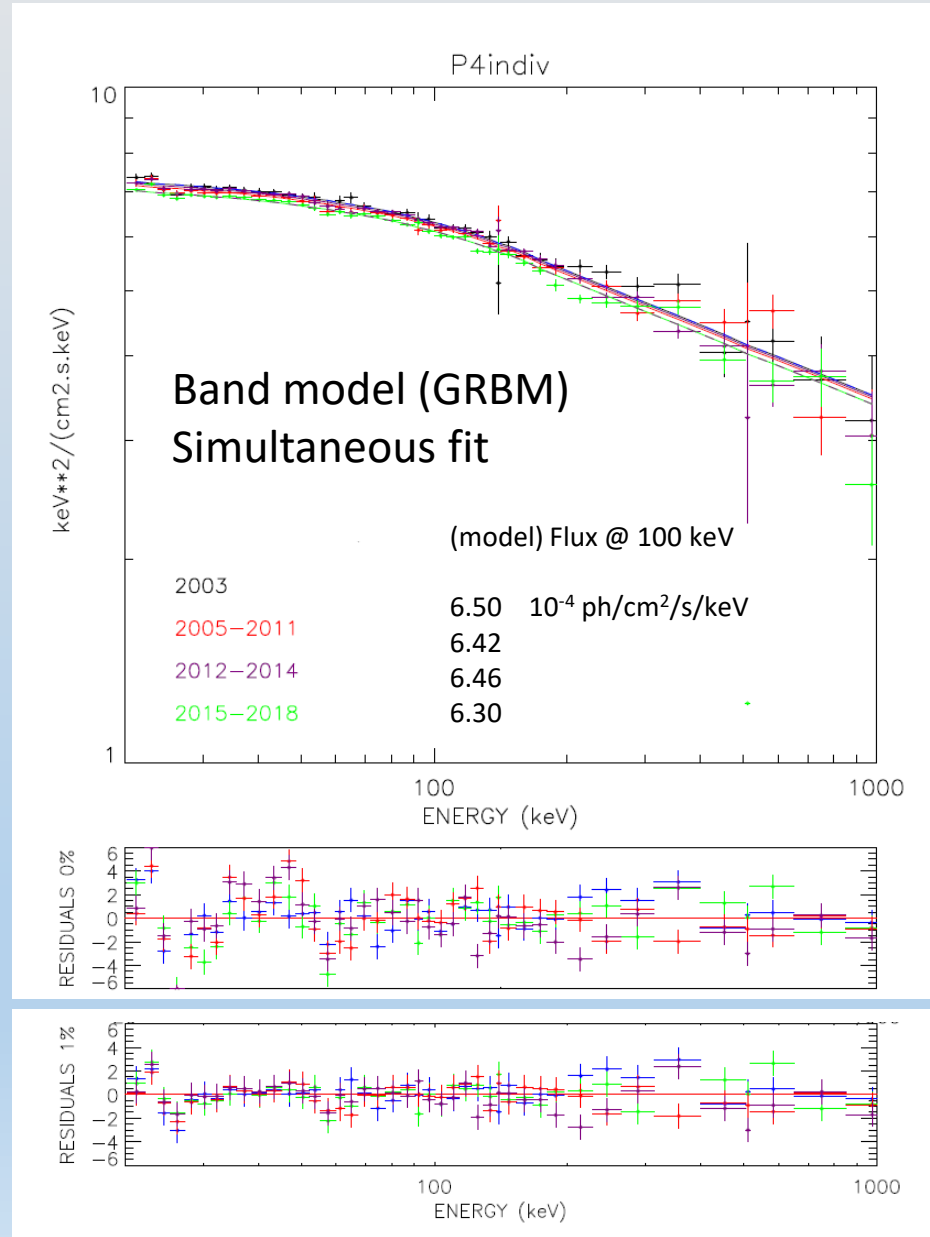
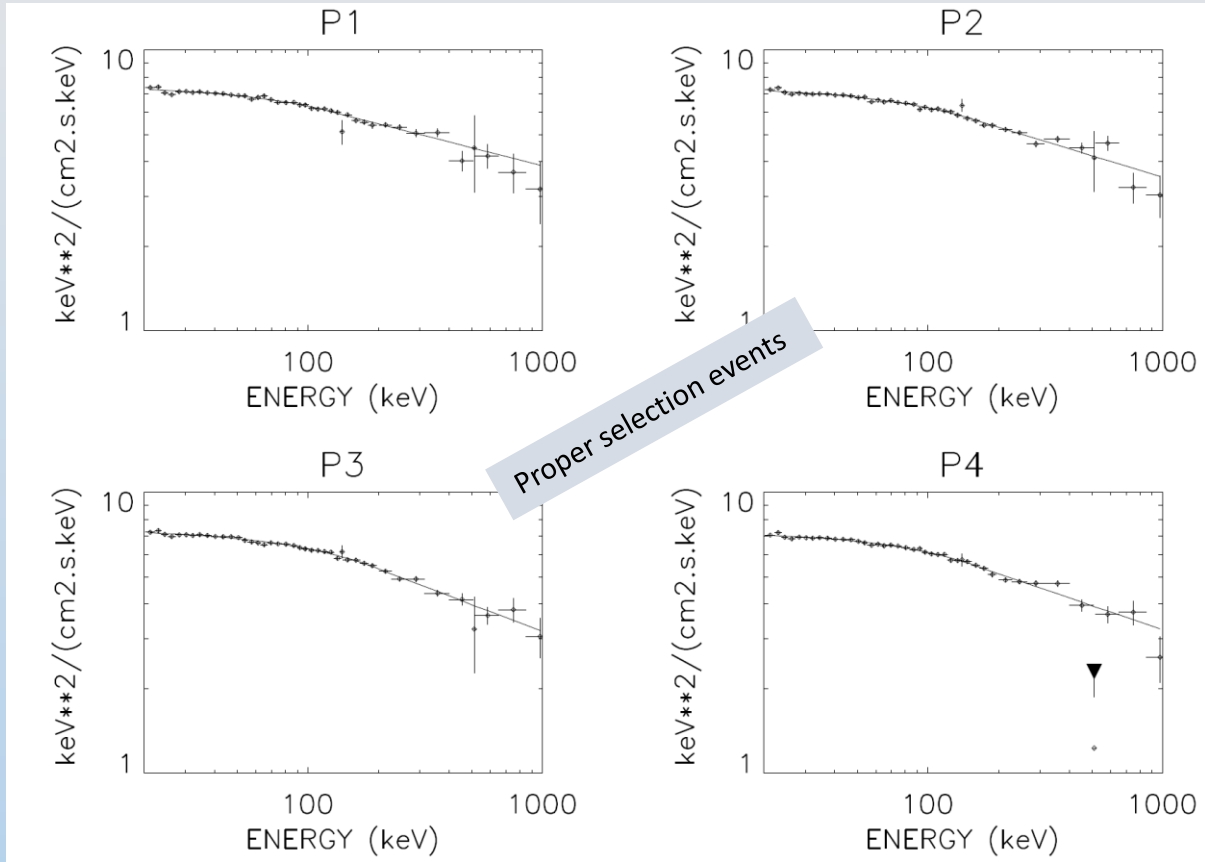






# GRBM, Band model

$$A(E) = \begin{cases} A(E) = K(E/100)^{\alpha_1} \exp(-E/E_c) & \text{if } E < E_c(\alpha_1 - \alpha_2) \\ A(E) = K[(\alpha_1 - \alpha_2)E_c/100]^{(\alpha_1 - \alpha_2)} (E/100)^{\alpha_2} \exp(-(\alpha_1 - \alpha_2)) & \text{if } E > E_c(\alpha_1 - \alpha_2) \end{cases}$$



## GRBM, Band model

0.5 % syst.

## Broken PL model

Period Number	$\alpha_1$	$E_c$ keV	$\alpha_2$	$\chi^2$
P1 446 ks	2.00	601	2.22	77.01 (39)
P2 1.94 Ms	2.01	620	2.25	82.4 (39)
P3 1.82 Ms	2.0	602	2.32	71.9 (39)
P4 2.2 Ms	1.99	505	2.28	85.9 (39)
Tot	2.0	572.3	2.27	351.2 (165)

Period Number	$\alpha_1$	$E_b$ keV	$\alpha_2$	$\chi^2$
P1 446 ks	2.06	66.0	2.19	83.7 (39)
P2 1.94 Ms	2.08	61.2	2.23	92.9 (39)
P3 1.82 Ms	2.08	93.0	2.27	107.6 (39)
P4 2.2 Ms	2.07	82.8	2.26	104.8 (39)
Tot	2.08	86.0	2.25	426.08 (165)

## MULTIPLE EVENTS / SINGLE EVENTS

DEFINITION : 1 PHOTON – TWO (OR MORE) DETECTORS HIT

COMPTON DIFFUSION **THEN** PHOTO-ABS.

42 PAIRS OF ADJACENT DETECTORS (= PSEUDO-DETECTORS)

COMPTON EFF. > PHOTO ABS EFF. →

- $E > \sim 100$  keV
- $\sim 20$  % of the total efficiency in this energy range

NOT CRUCIAL FOR SPECTRAL ANALYSIS BUT FOR  
**POLARIMETRY**

# GRBM, Band model

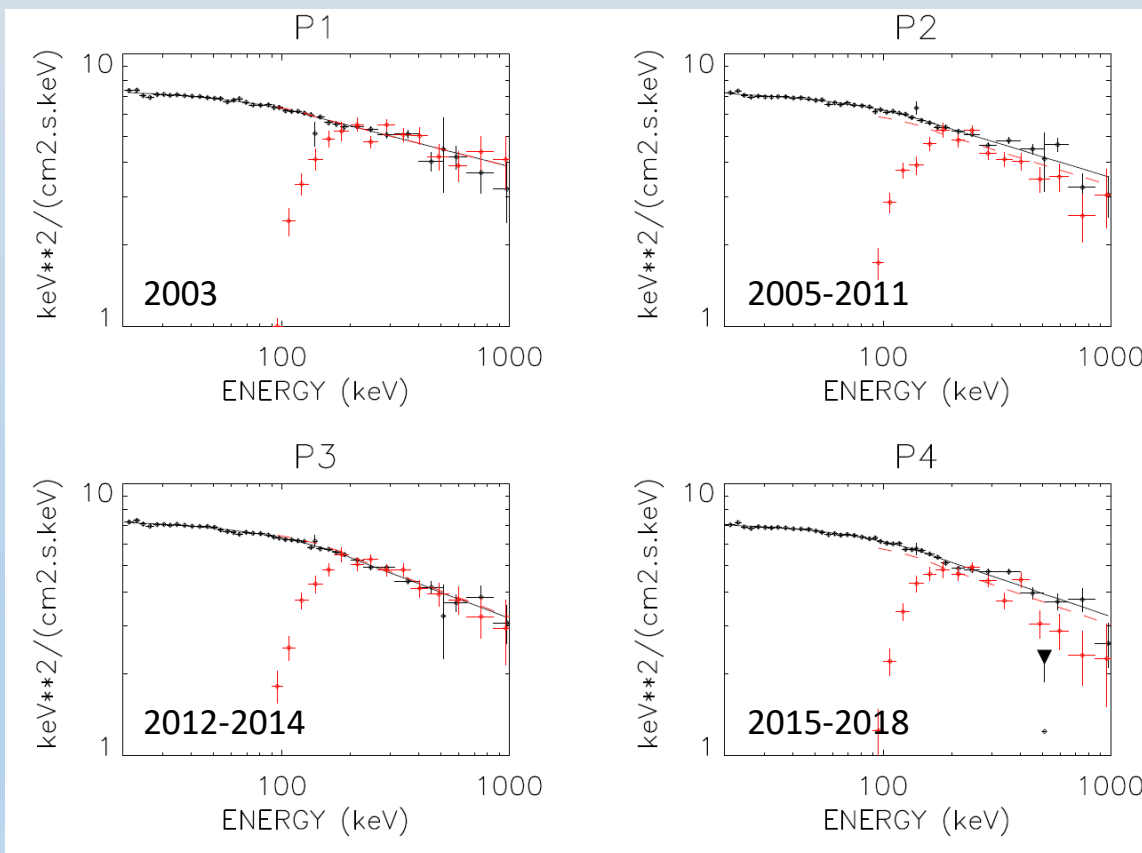
Period Number	$\alpha_1$	Ec keV	$\alpha_2$	$\chi^2$
P1 446 ks	2.00	601	2.22	77.01 (39)
P2 1.94 Ms	2.01	620	2.25	82.4 (39)
P3 1.82 Ms	2.0	602	2.32	71.9 (39)
P4 2.2 Ms	1.99	505	2.28	85.9 (39)
Tot	2.0	572.3	2.27	351.2 (165)

$\alpha = -2.00$   
 $\beta = -2.22$   
 $E_c = 593.0 \text{ keV}$

(model) Flux @ 100 keV  
 6.49 / 6.67  $10^{-4} \text{ ph/cm}^2/\text{s/keV}$

$\alpha = -2.00$   
 $\beta = -2.32$   
 $E_c = 603.3 \text{ keV}$

(model) Flux @ 100 keV  
 6.48 / 6.74  $10^{-4} \text{ ph/cm}^2/\text{s/keV}$



$\alpha = -2.00$   
 $\beta = -2.26$   
 $E_c = 609.7 \text{ keV}$

(model) Flux @ 100 keV  
 6.41 / 6.16  $10^{-4} \text{ ph/cm}^2/\text{s/keV}$

$\alpha = -1.99$   
 $\beta = -2.29$   
 $E_c = 522.7 \text{ keV}$

(model) Flux @ 100 keV  
 6.30 / 6.03  $10^{-4} \text{ ph/cm}^2/\text{s/keV}$

## CONCLUSIONS

### CRAB NEBULA EMISSION SPECTRAL SHAPE above 20 keV

BAND MODEL (much better than broken PL)

ALPHA 1 = -2.0 ( → X-rays)

ALPHA 2 = -2.26 ( →  $\gamma$ -rays)

$E_c = \sim 600$  keV

flux @ 100 keV  $\sim 6.4 \cdot 10^{-4}$  ph/cm<sup>2</sup>/s/keV

FLUX STABILITY AT A FEW % LEVEL

SPECTRAL SHAPE UNCHANGED

AT LEAST AT THE FIRST ORDER

FOR 16 YEARS

CRAB NEBULA  $\sim$  STANDARD CANDLE FOR HARD X-RAYS

ALLOWS TO COMPARE OBSERVATIONS NOT STRICTLY

SIMULTANEOUS → FINE FOR CROSS-CALIB IN X/HARD-X RAYS