Monitoring of EPIC-pn Timing

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Epic Calibration Meeting, 27 April 2017

Outline

- Report on routine calibration observations of the Crab
  - Relative timing
  - Absolute timing
- Report on the pulse profile anomaly in Timing mode

Relative and absolute timing monitoring

- *Absolute timing*: locating events in time with reference to standard time defined by atomic clocks or other satellites.

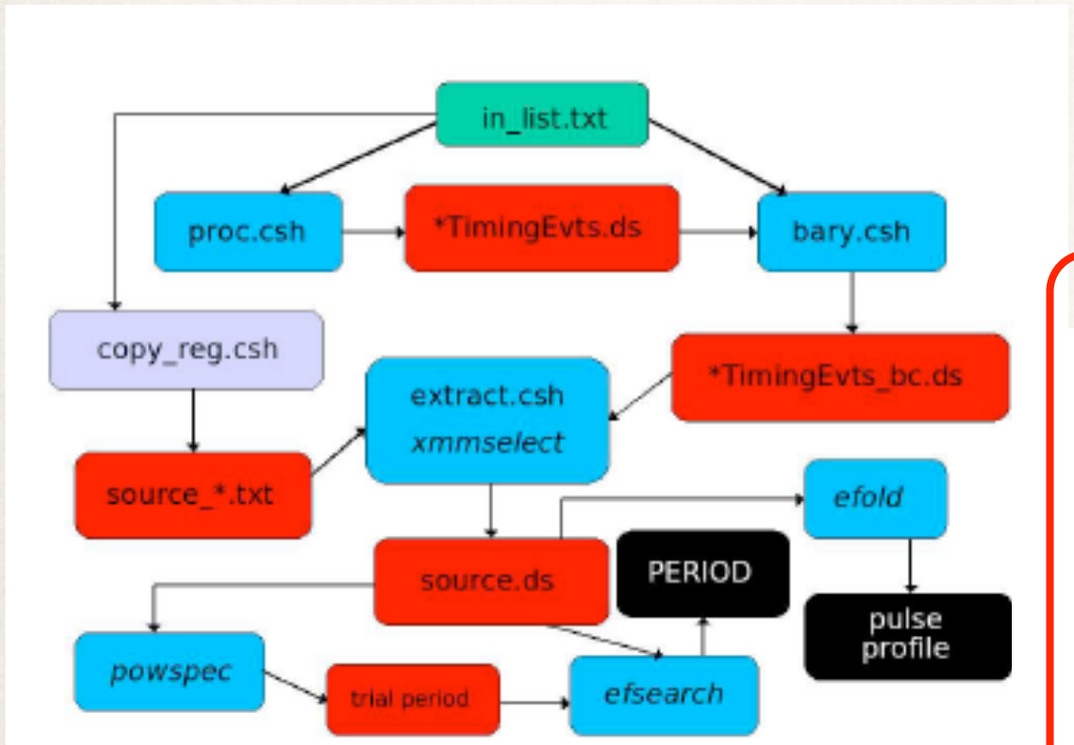
- *Relative timing*: the capacity to measure time intervals and periodicity reliably.

- Crab observed twice per semester (spring, autumn).

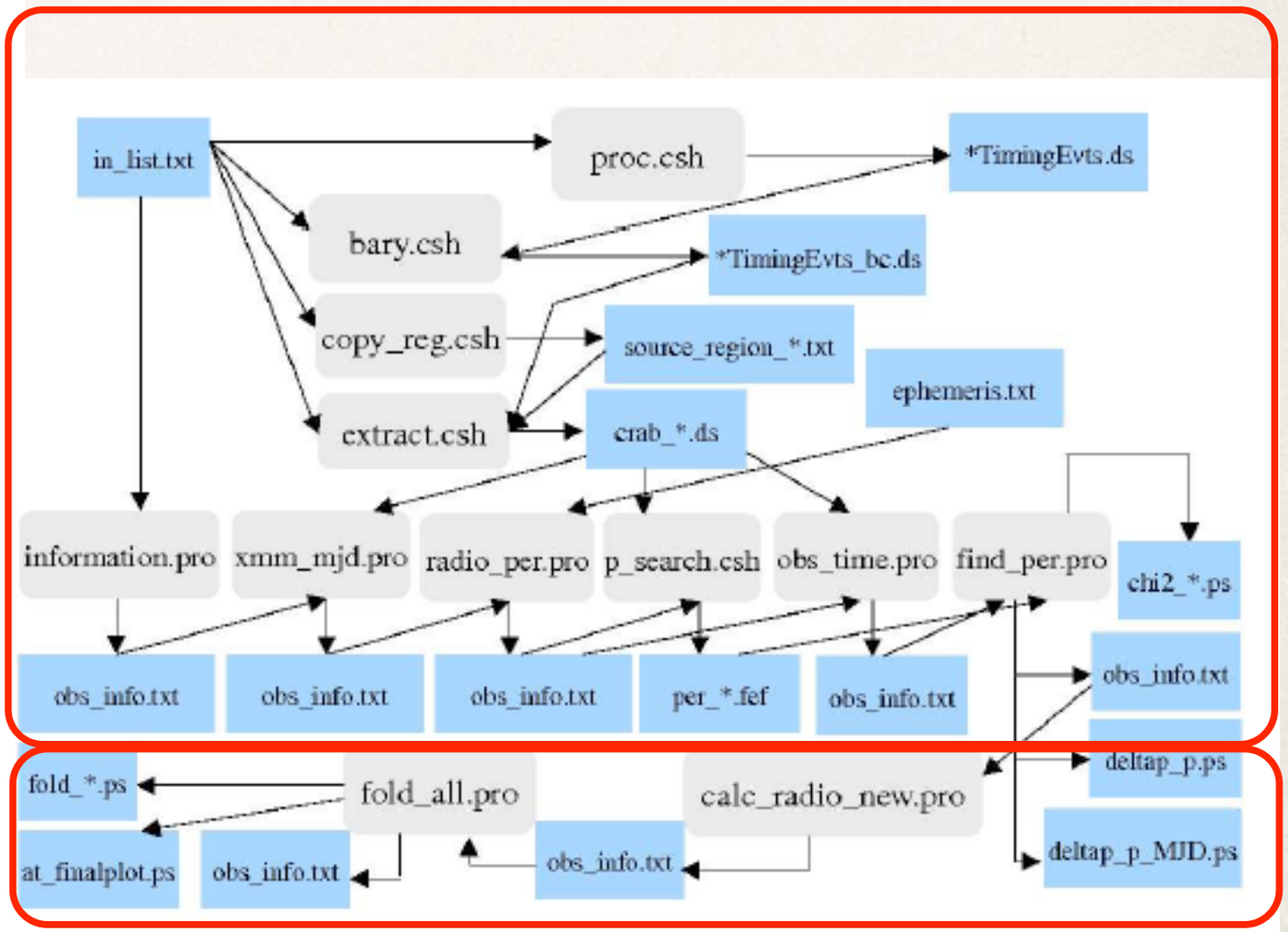
- T_{exp} at least 10 ks, half in Timing and half in Burst mode.

- Scheduled at different phases of a single orbit to cover different time delays and G/S data links.

An automated process

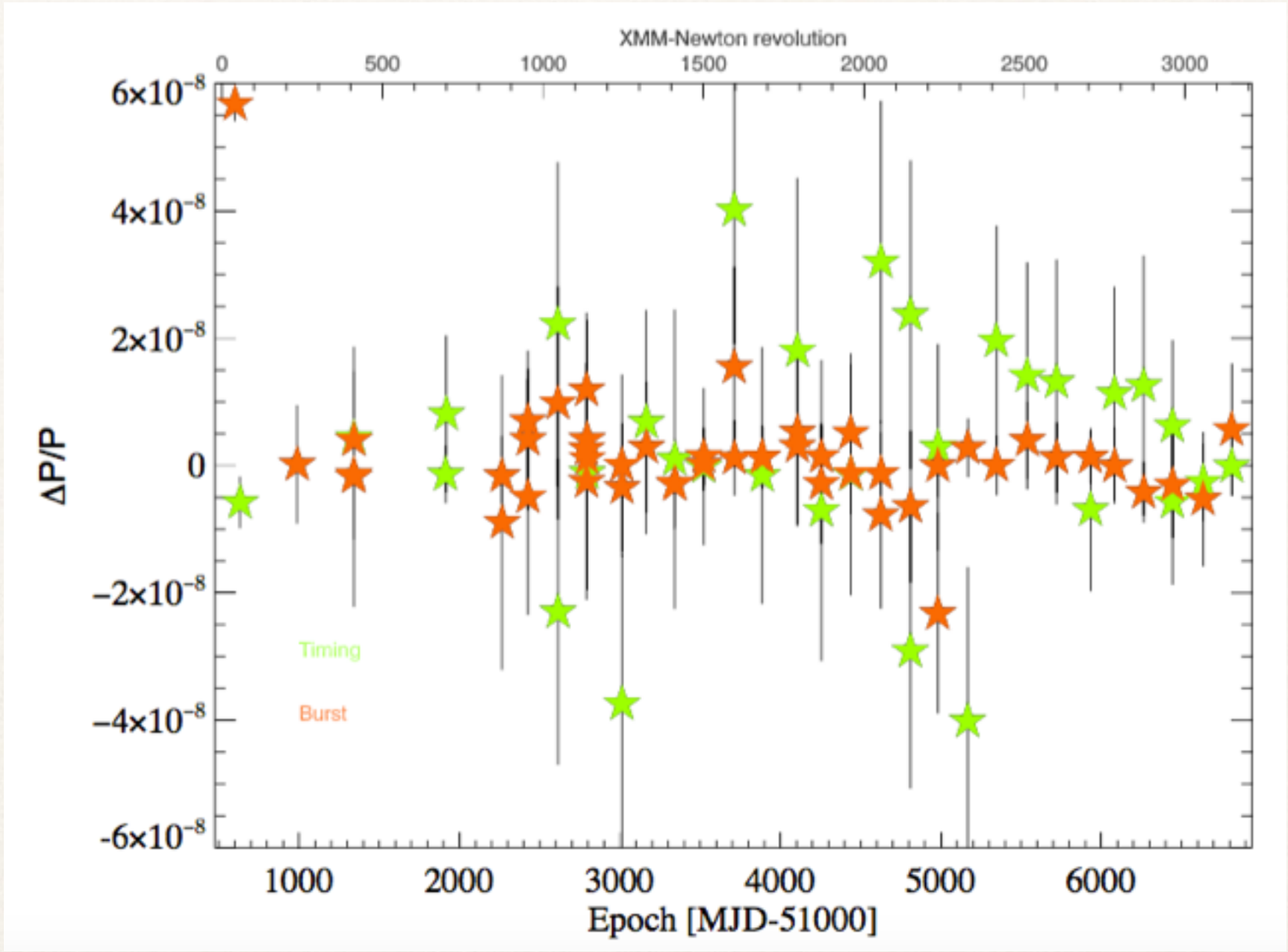


Relative timing



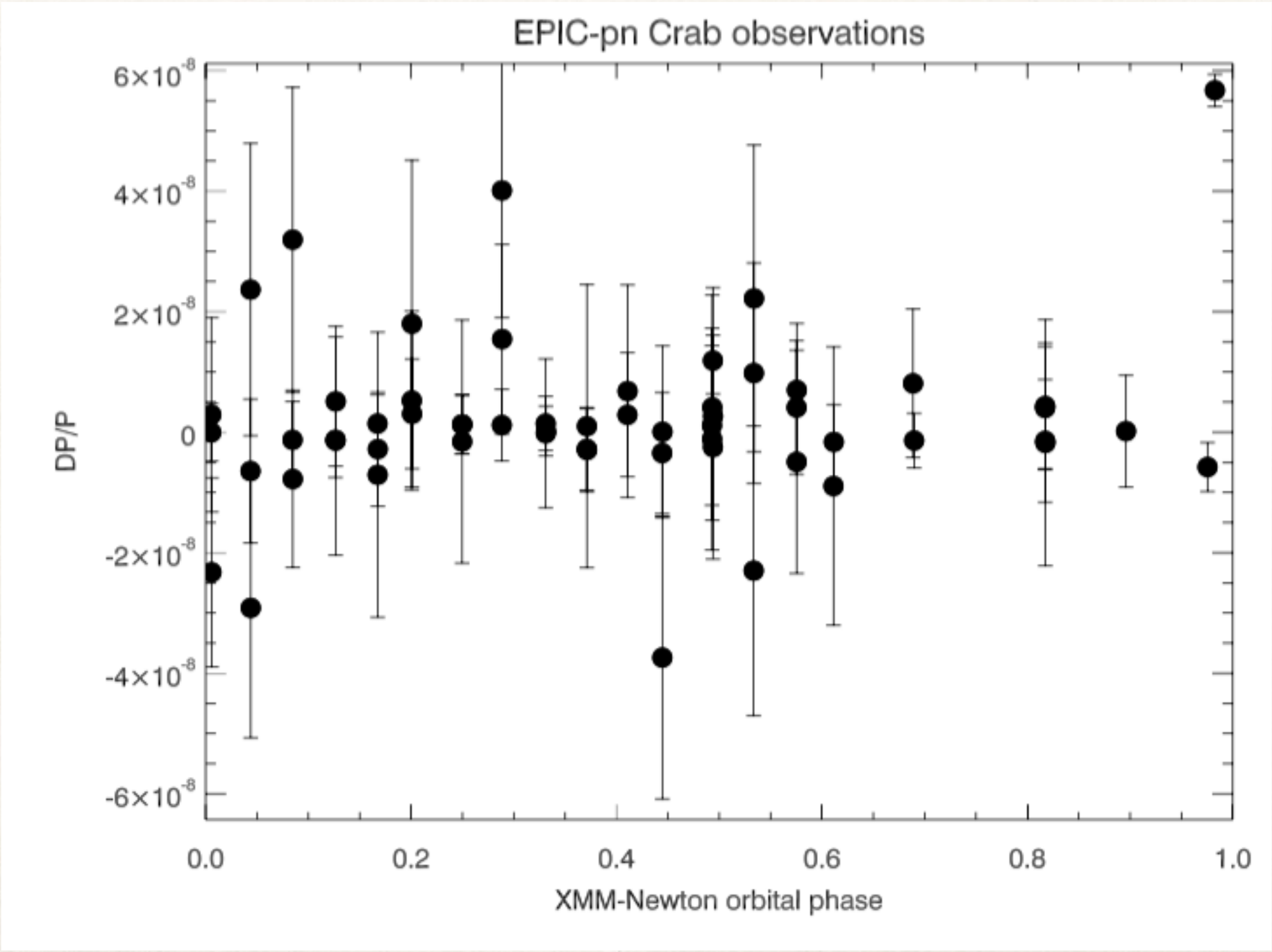
Absolute timing

Relative Timing

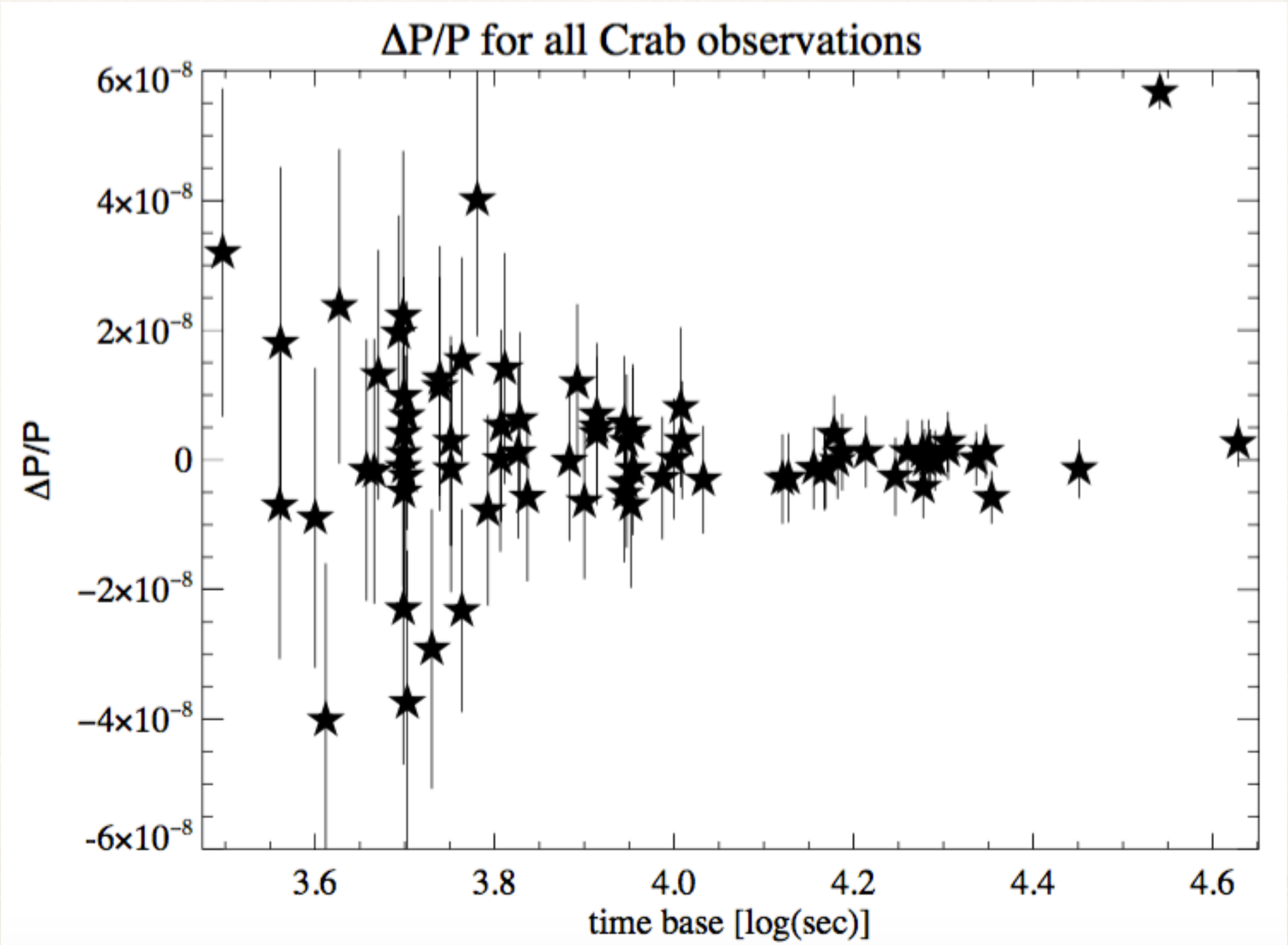


- Relative deviation of the observed pulse period with respect to the most accurate radio data (Crab ephemeris from Jodrell Bank) is $< 3 \times 10^{-8}$.

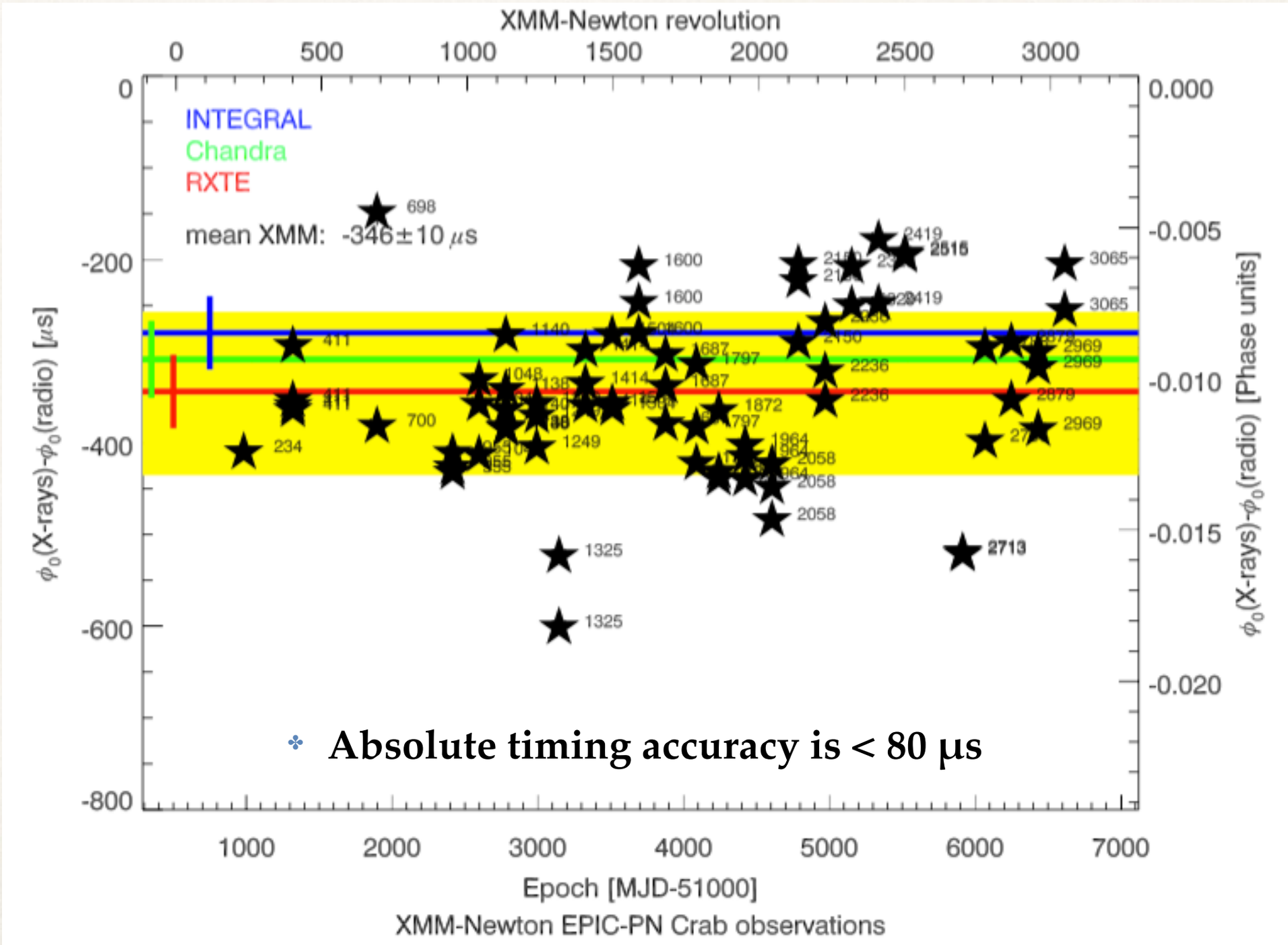
Relative Timing



Relative Timing

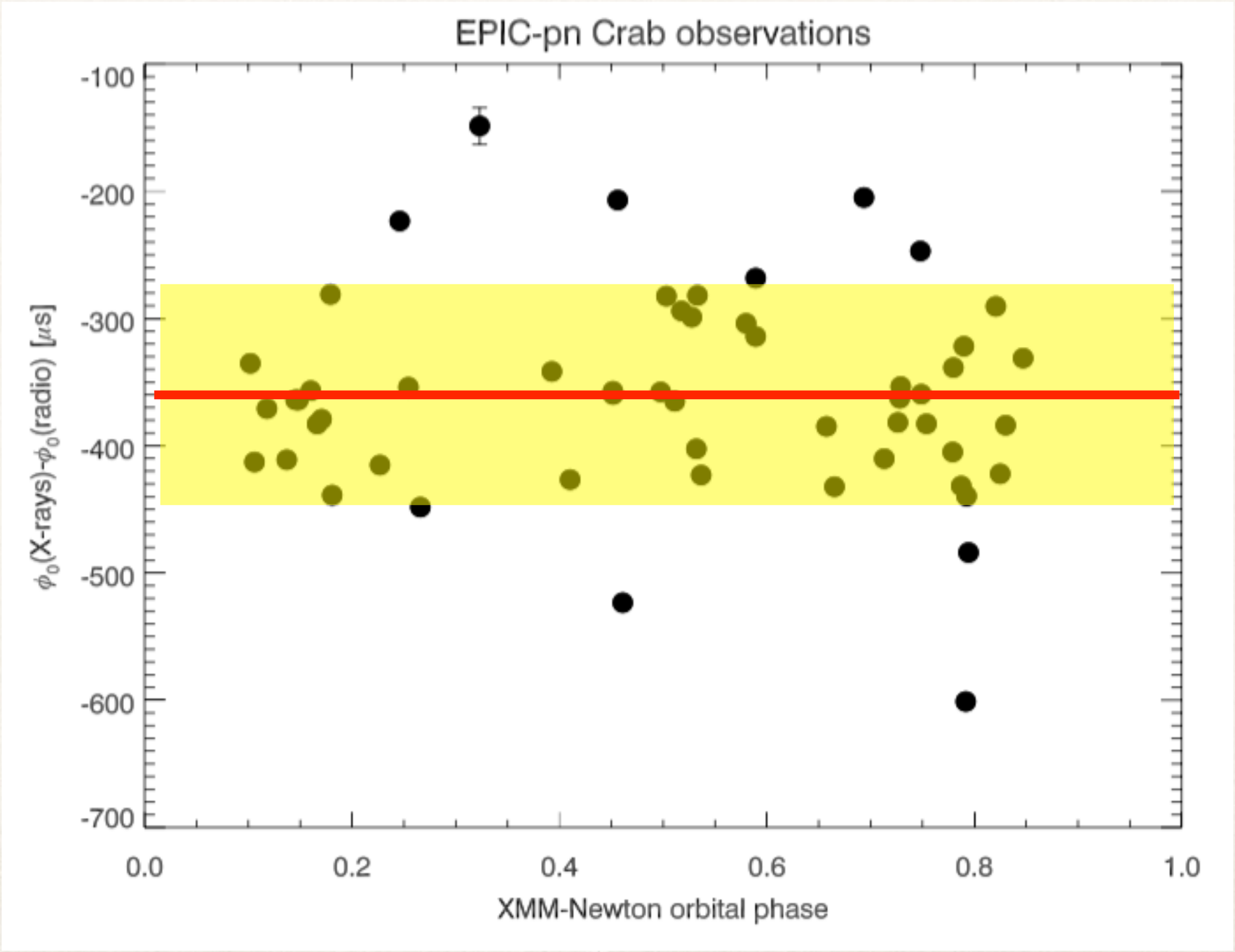


Absolute Timing



- **Absolute timing accuracy is < 80 μs**

Absolute Timing



Pulse profile anomaly in Timing mode

XMM-Newton **Calibration Technical Note**

Seasonal pulse profile distortions in the EPIC-pn timing observations of the Crab pulsar

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M. J. Freyberg (MPE Garching)

March 24, 2017

Pulse profile anomaly in Timing mode

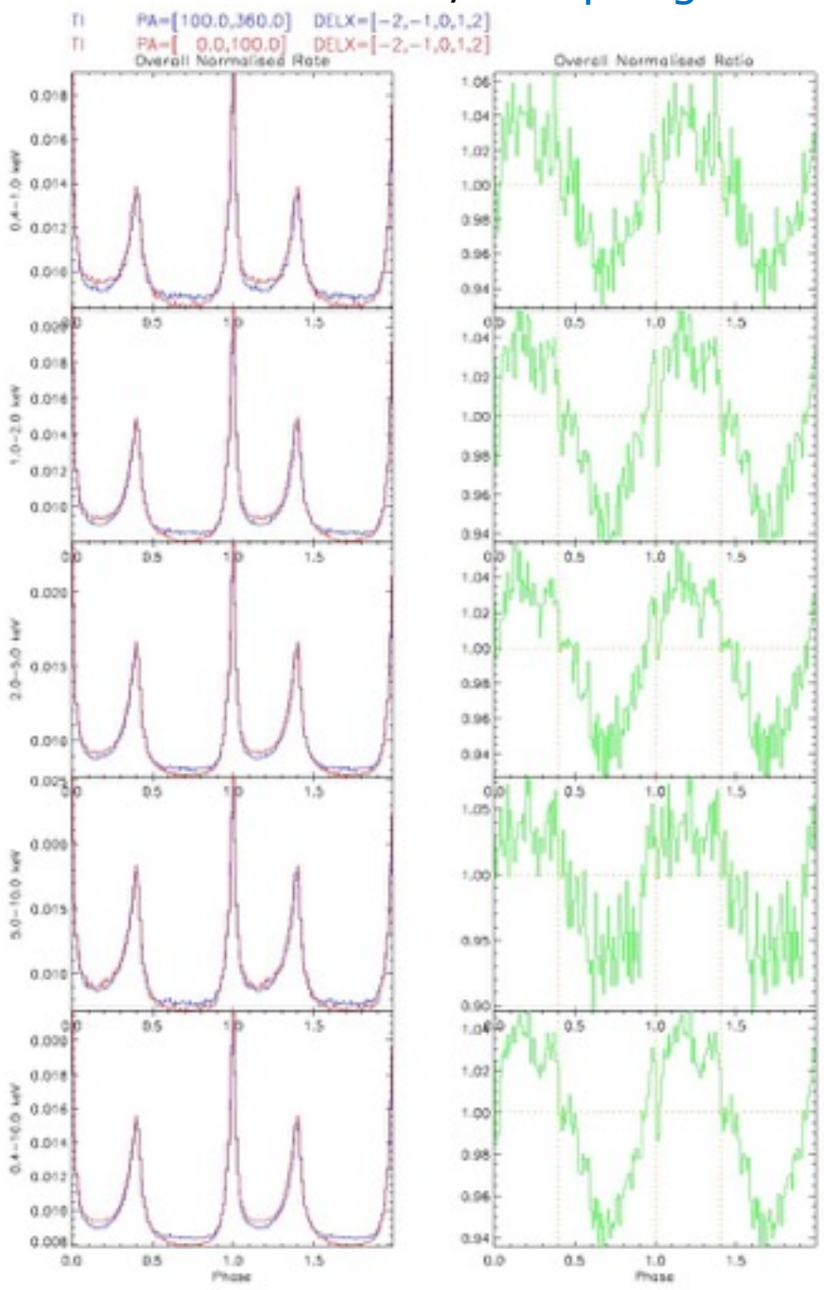
- The pulse profile of the Crab in TI mode show systematic differences between Spring and Autumn observations. BU mode observations are unaffected.

- Spring TI mode profiles are similar to those of BU mode observations. Autumn TI mode profiles are distorted (excess/deficit of counts in the inter-pulse valleys).

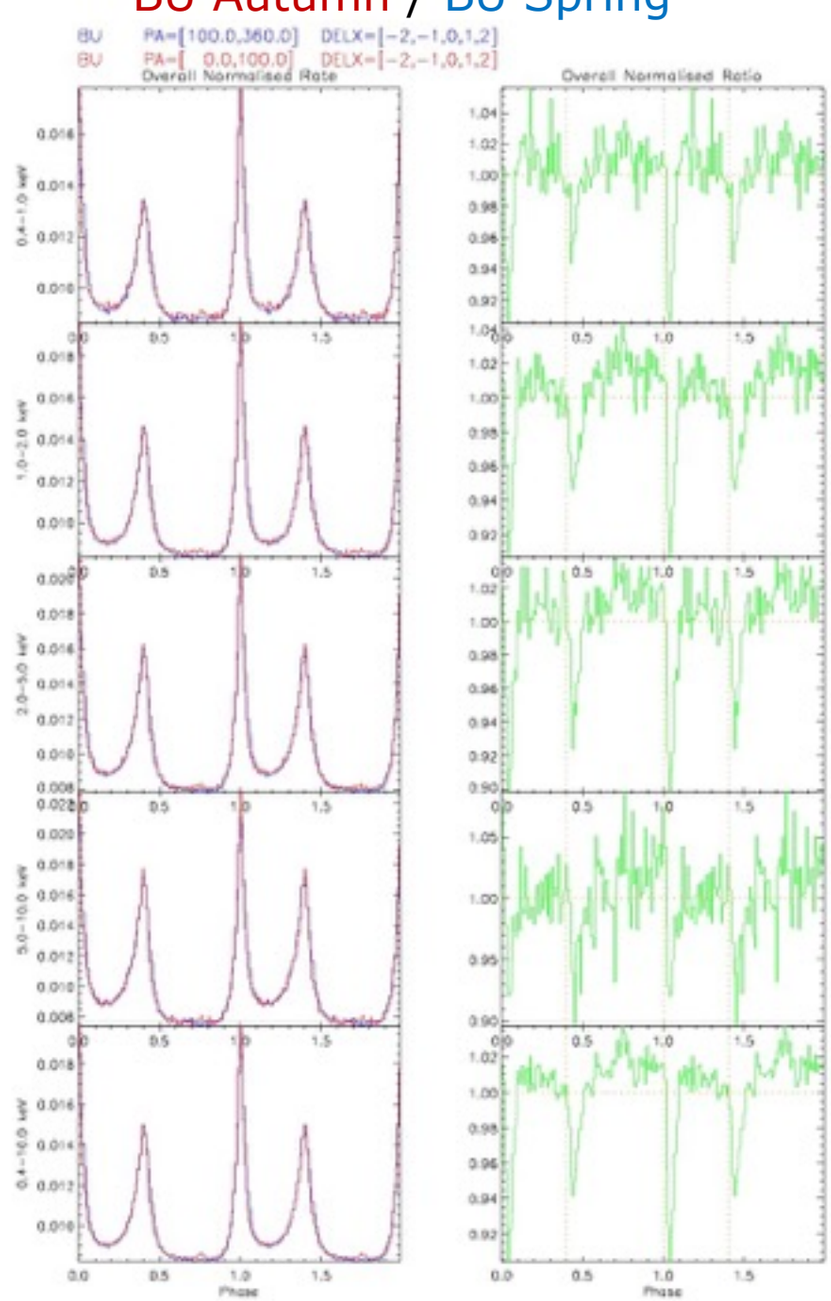
- This effect has been present since beginning of mission.

Pulse profile anomaly in Timing mode

TI Autumn / TI Spring

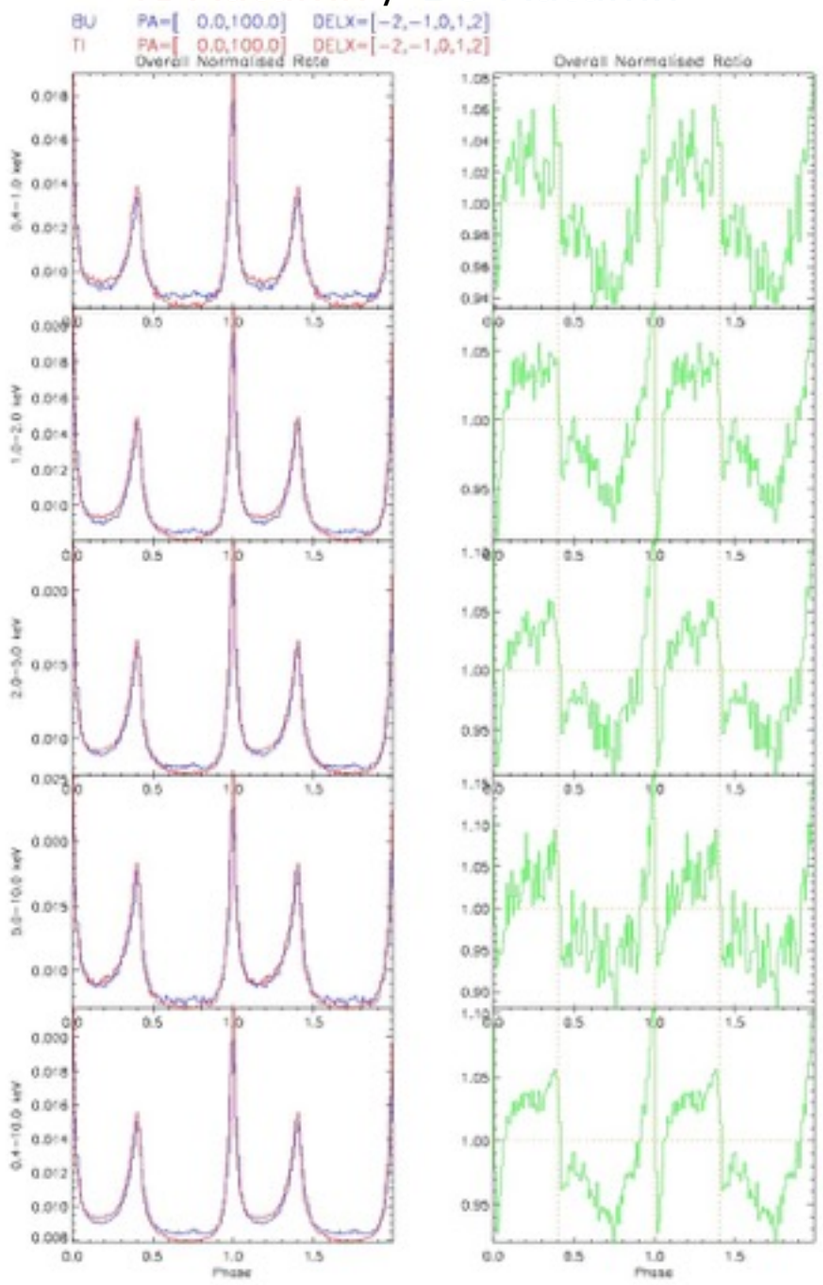


BU Autumn / BU Spring

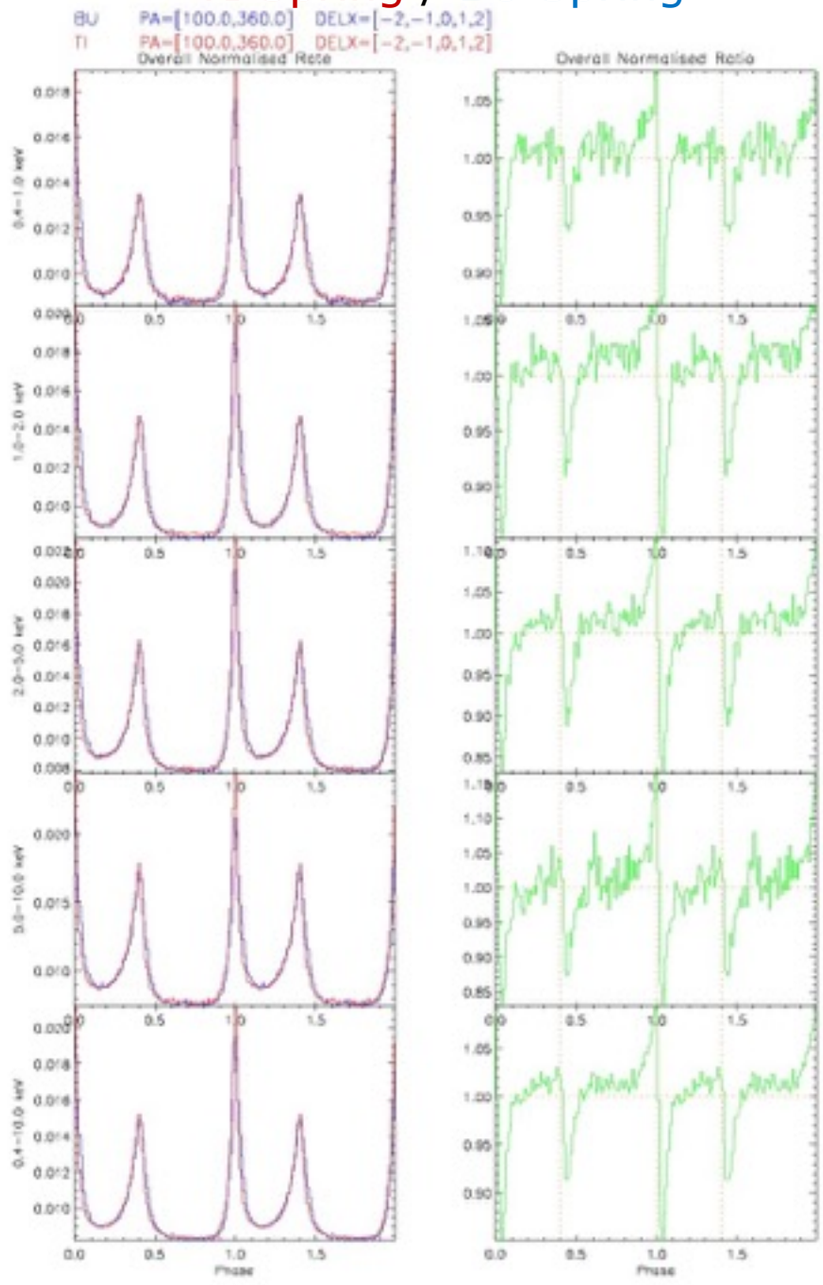


Pulse profile anomaly in Timing mode

TI Autumn / BU Autumn



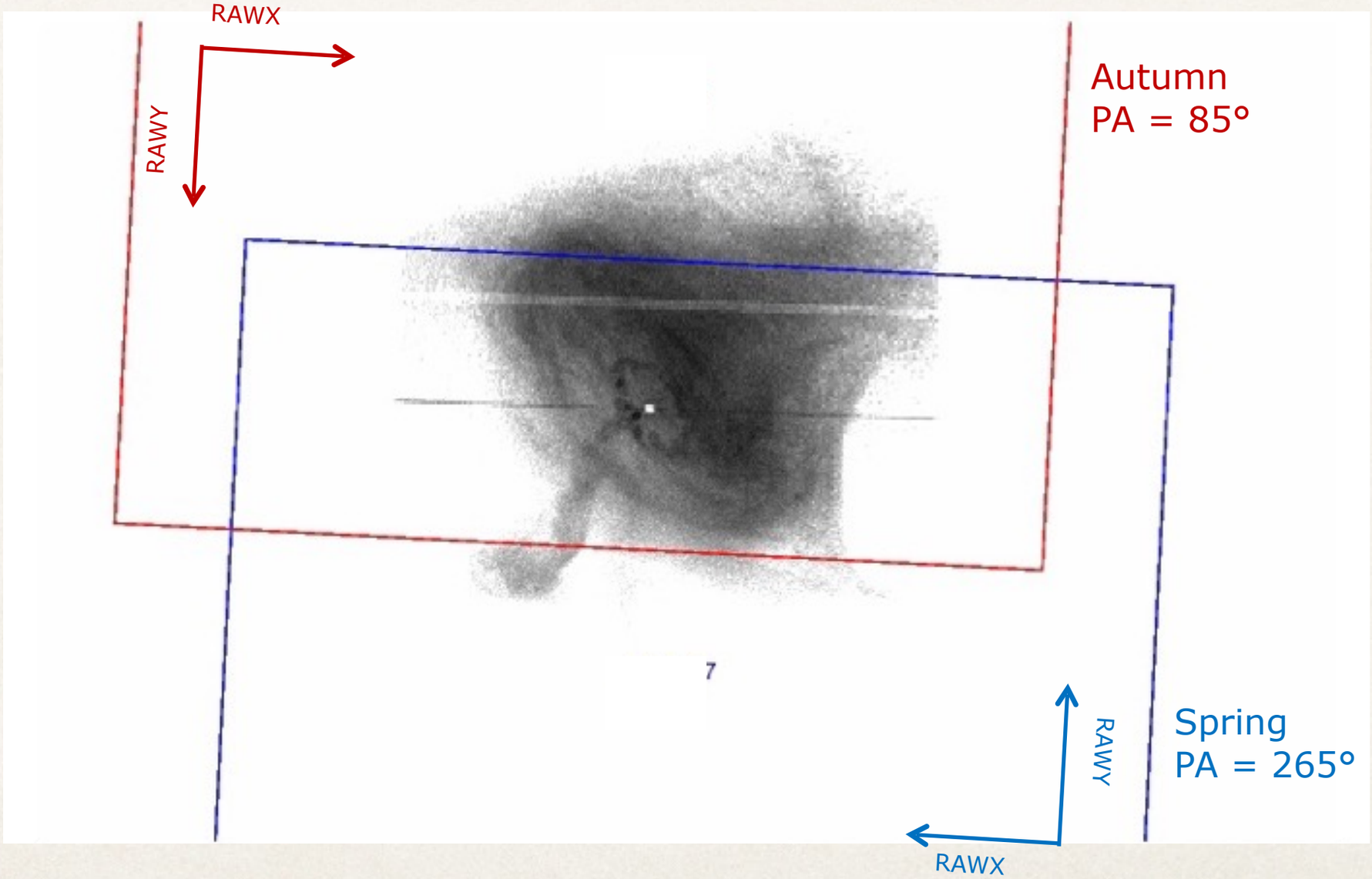
TI Spring / BU Spring



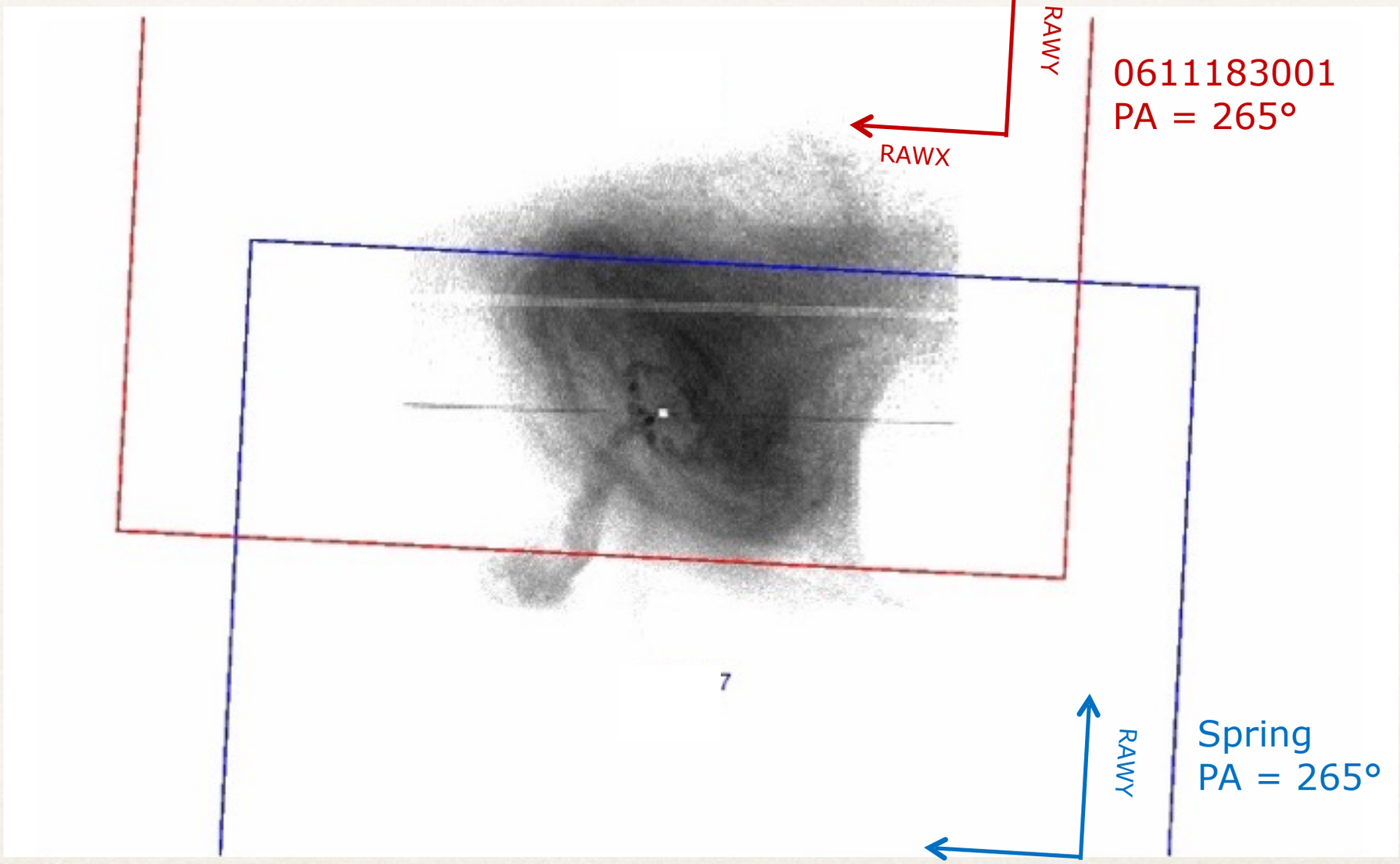
Pulse profile anomaly in Timing mode

- Investigation of the anomaly:
  - Change in position angle

Pulse profile anomaly in Timing mode

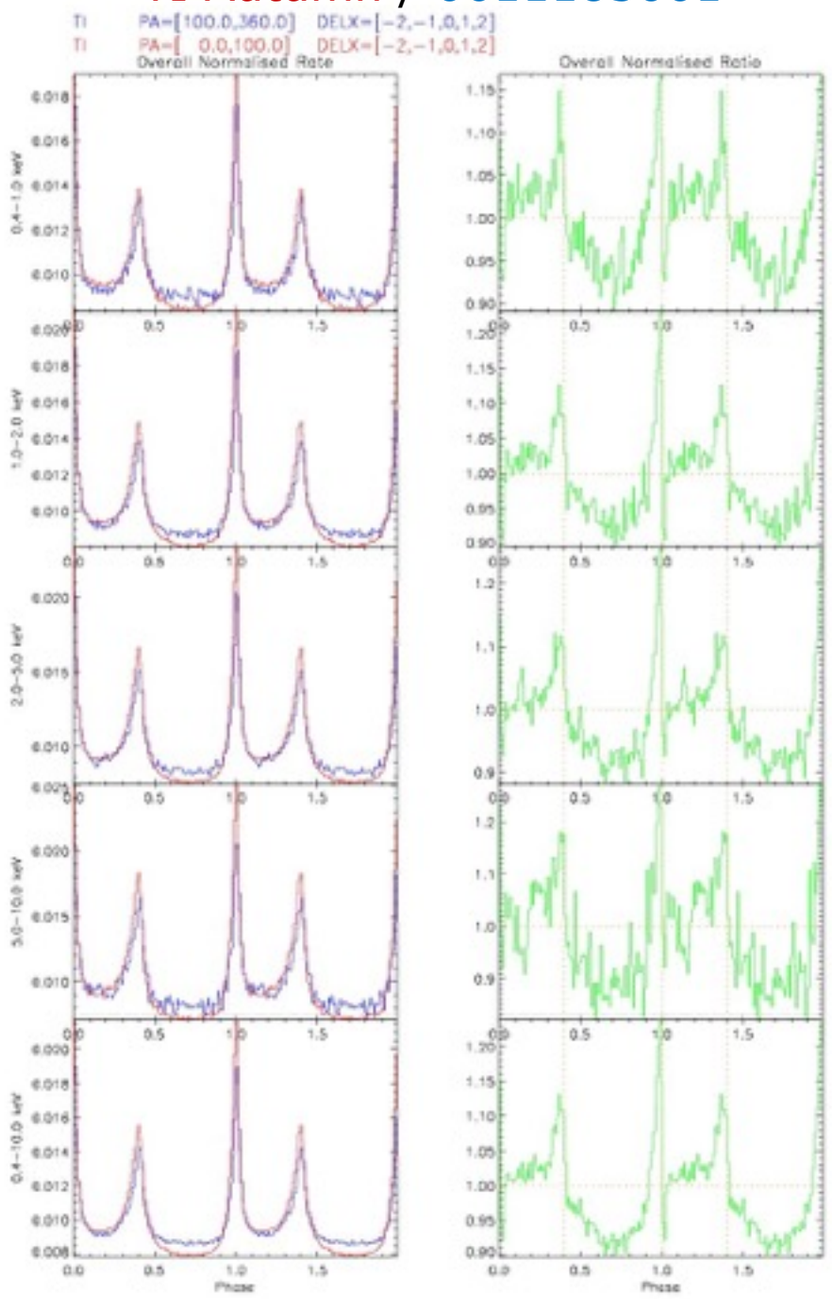


Pulse profile anomaly in Timing mode



Pulse profile anomaly in Timing mode

TI Autumn / 0611183001



0.4-1.0 keV

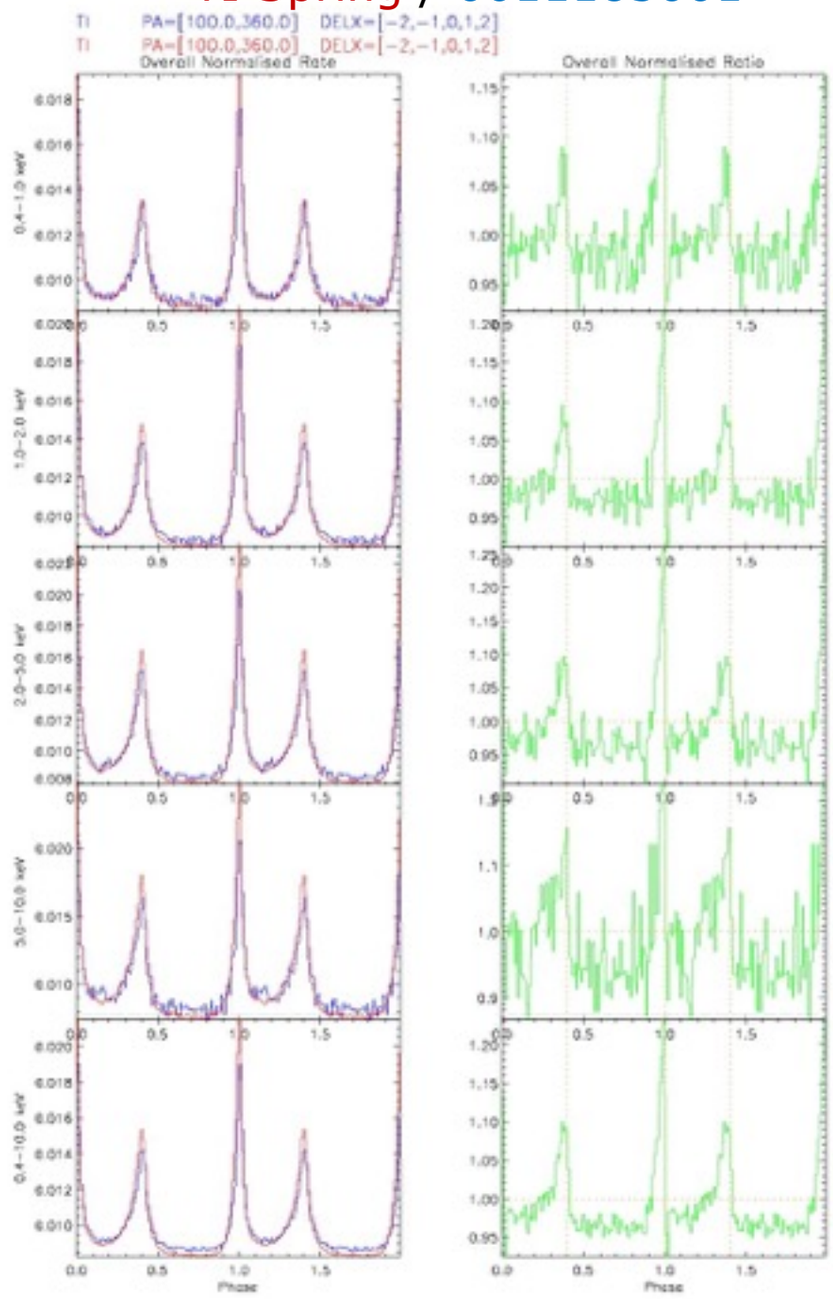
1.0-2.0 keV

2.0-5.0 keV

5.0-10 keV

0.4-10 keV

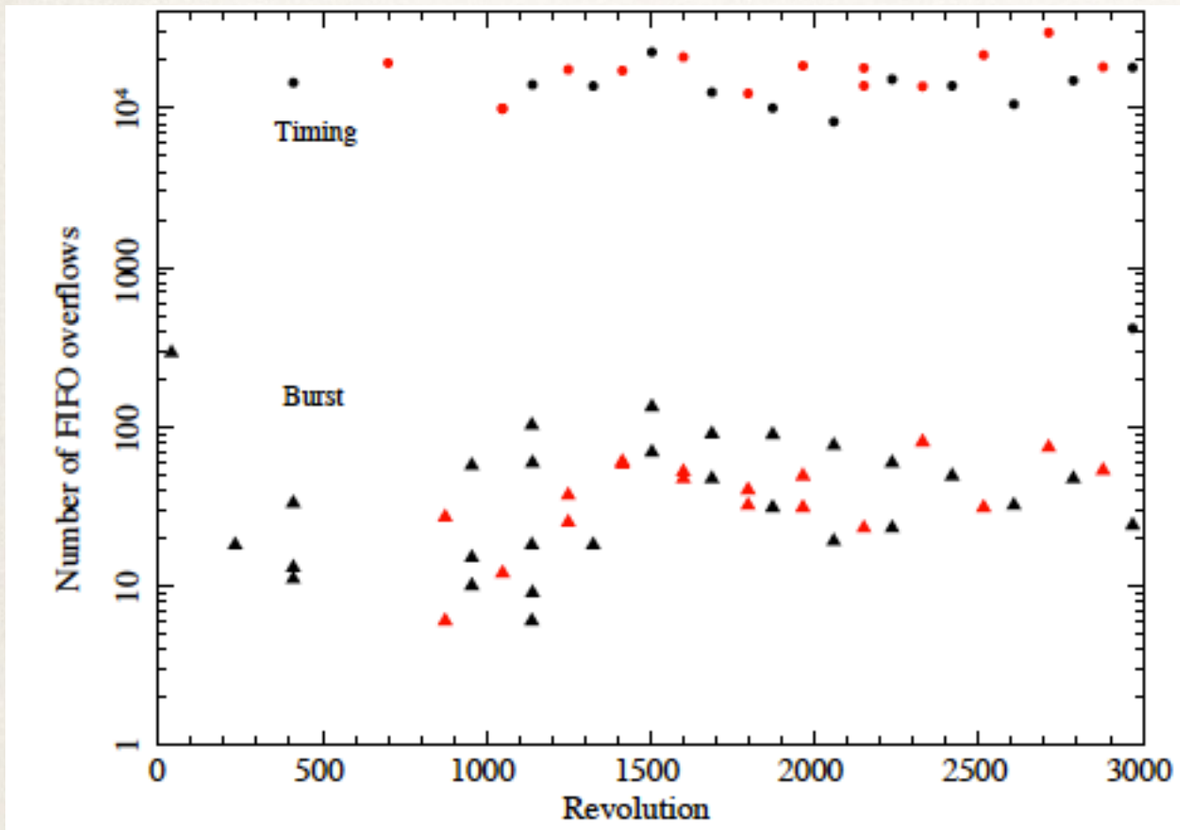
TI Spring / 0611183001

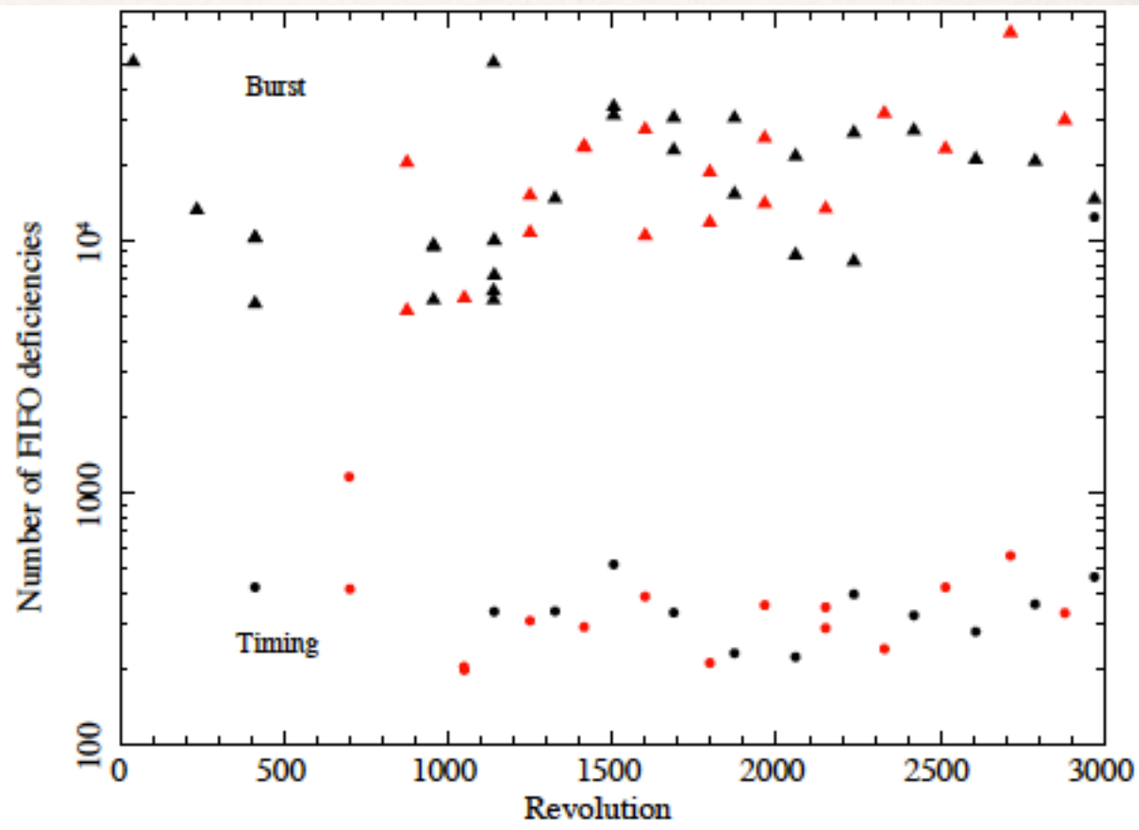


Pulse profile anomaly in Timing mode

- Investigation of the anomaly:
  - Change in position angle
  - Housekeeping parameters

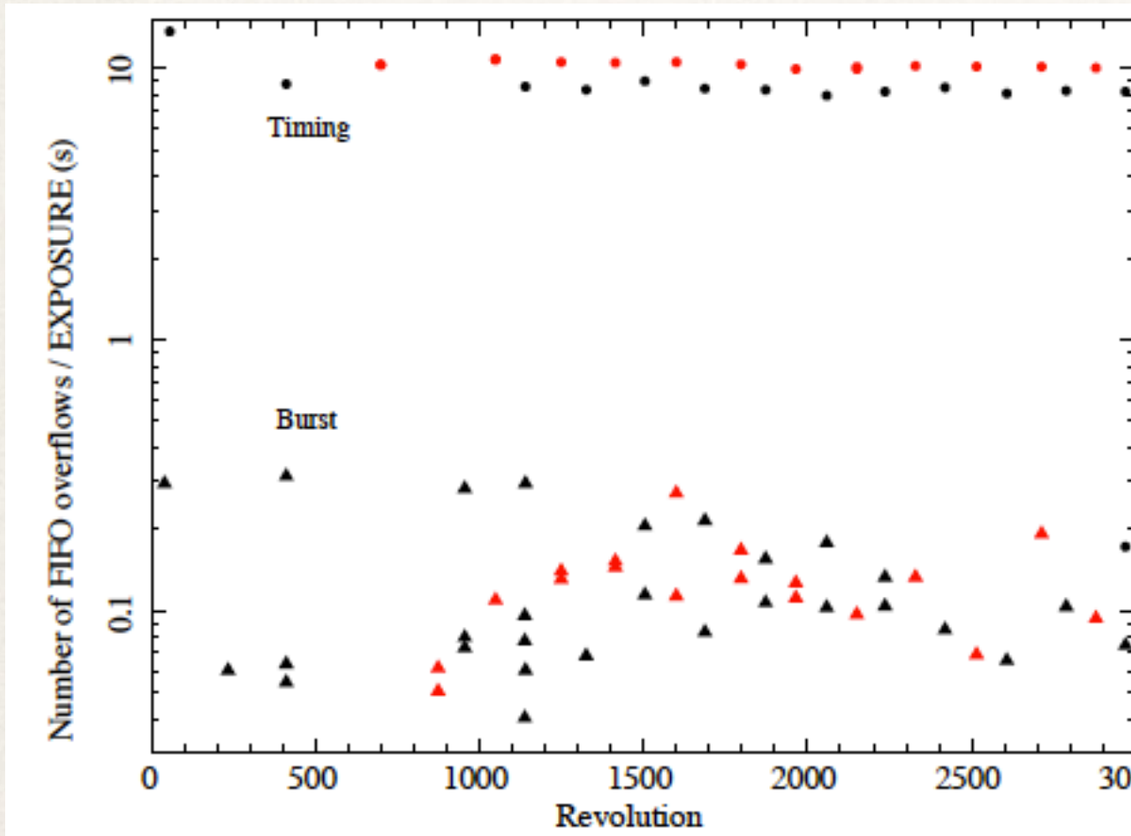
Pulse profile anomaly in Timing mode

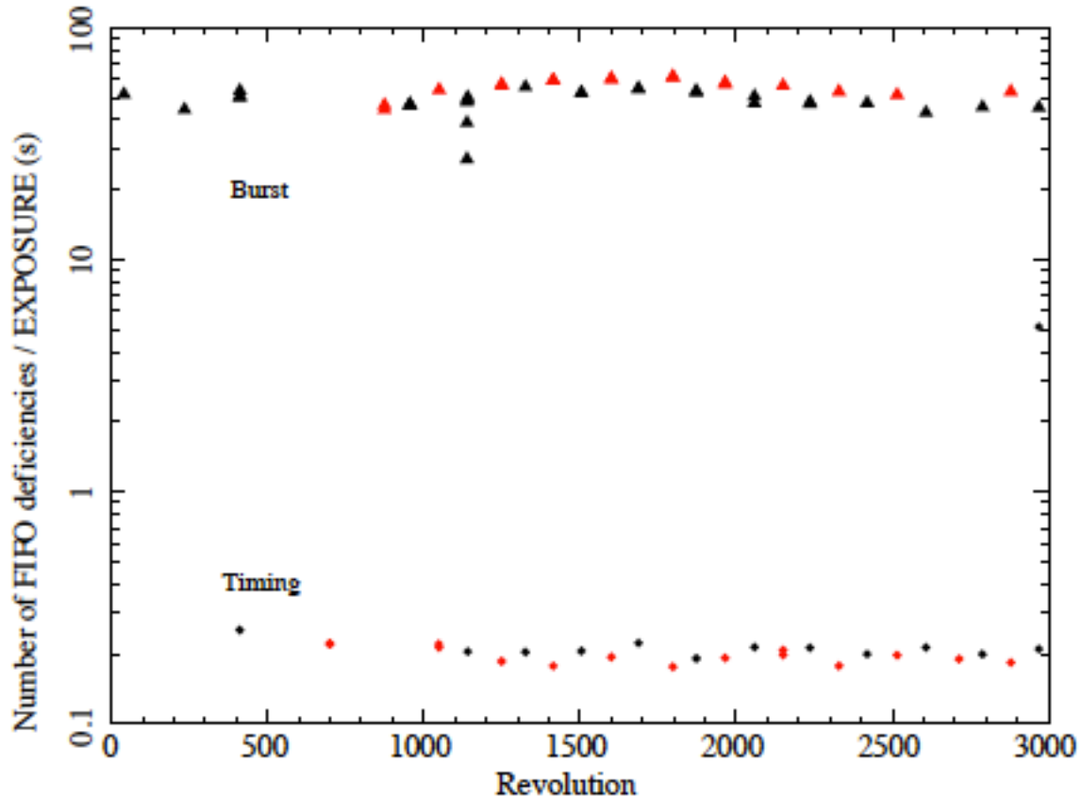




- Number of FIFO overflows much higher in TI than in BU mode.
- Apparently, no seasonal effect observed…

Pulse profile anomaly in Timing mode





- Normalized number of FIFO overflows is systematically higher in Autumn in TI observations. No trend is observed for BU mode observations.

Pulse profile anomaly in Timing mode

- Preliminary conclusions:
  - FIFO overflows cause a loss of counts at different phases of the Crab pulse profile.
  - Seasonal dependence is due to the different number of counts gathered on-board because of the different coverage of the nebula.
  - For very bright sources do not use TI, but rather BU.