UPDATE ON THE XMM-NEWTON CALIBRATION STATUS

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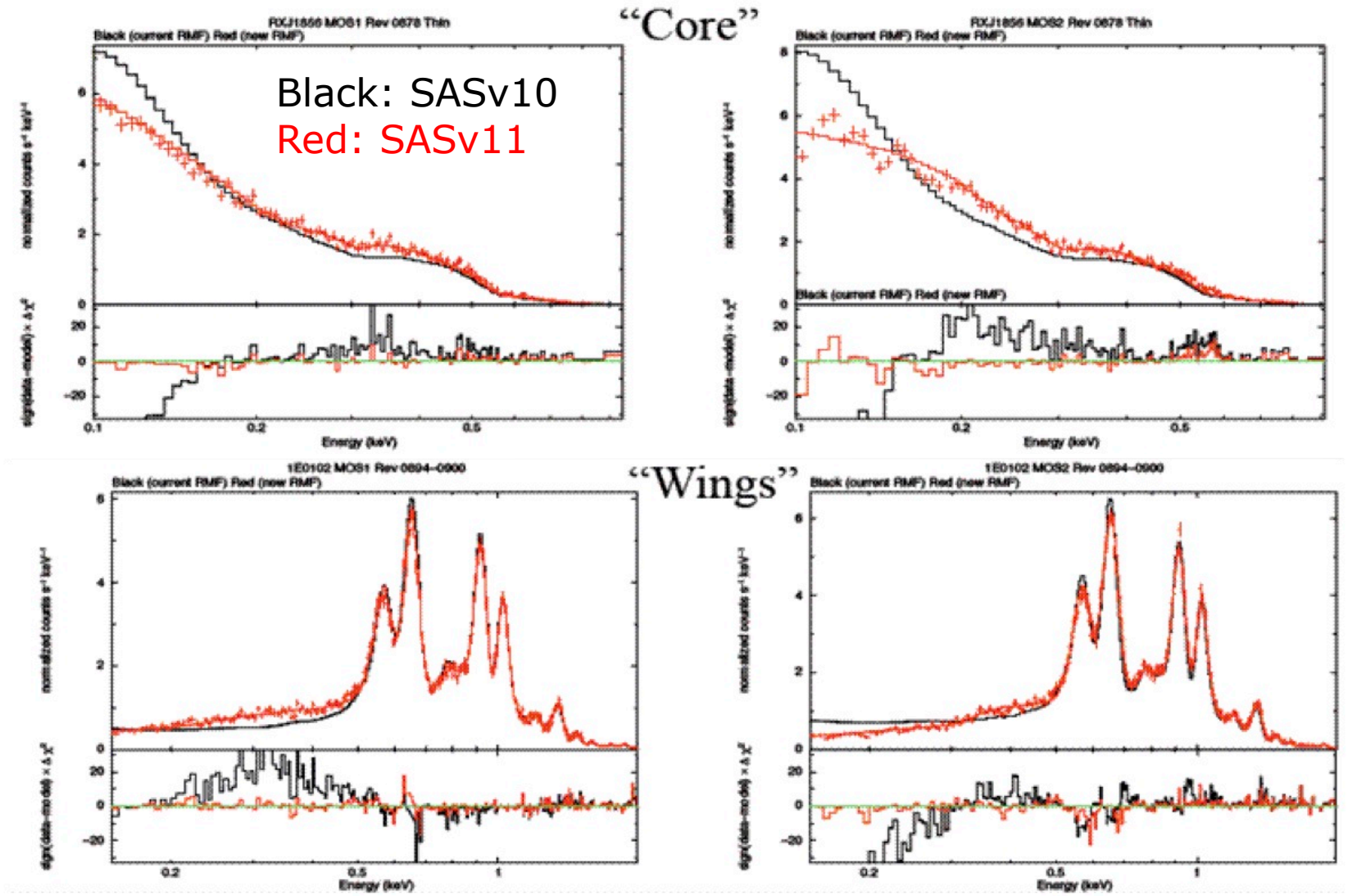
Outline

- What happened in 2010-11
  - New EPIC-MOS redistribution
  - Upgrade EPIC-pn redistribution
  - Update of the EPIC-pn Long Term CTI
  - Improvements in the 2-D PSF
  - Update of the RGS contamination time evolution
  - RGS-to-pn rectification
- Internal cross-calibration status
- What's likely to happen in 2011-2012

MOS redistribution: method

1. Define an empirical model of the ground-based redistribution measurements
2. Define appropriate regions to characterize the redistribution "patch" (close to the boresight)
3. Define an appropriate set of epochs to characterize the time evolution (13)
4. Define a set of standard candles, with their pn/RGS models
   - RXJ1856-3754, RXJ0720.4-325 (INS), ζ Puppis (O star), 1E0102-7219 (SNR), Mkn279 (soft AGN), Cal83 (WD), MnK_{α}
5. Iterate the parameter of the red^{on} and an overall normalization factor to minimize a χ^2-like function
6. Check the results on a sample of different sources

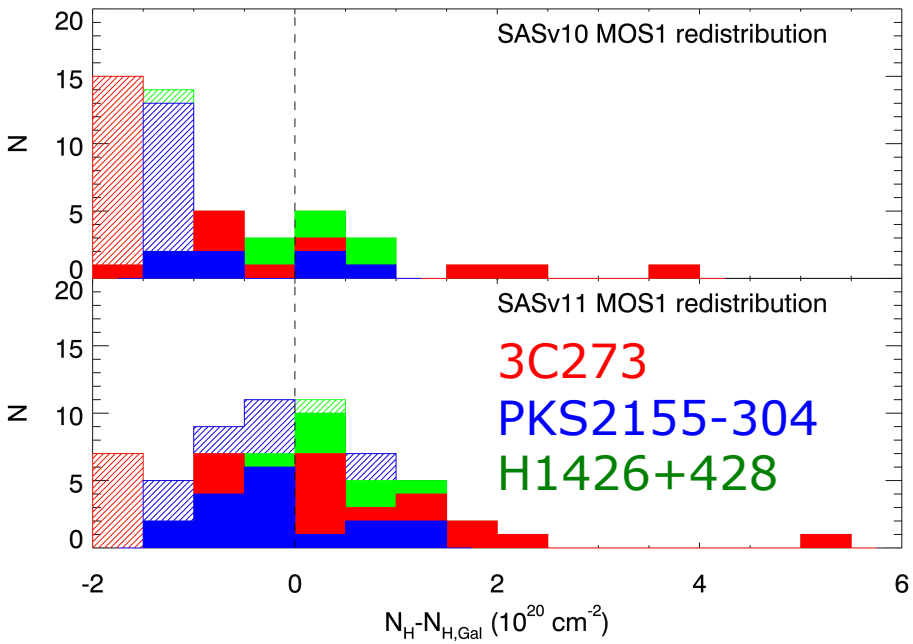
MOS redistribution: results I.

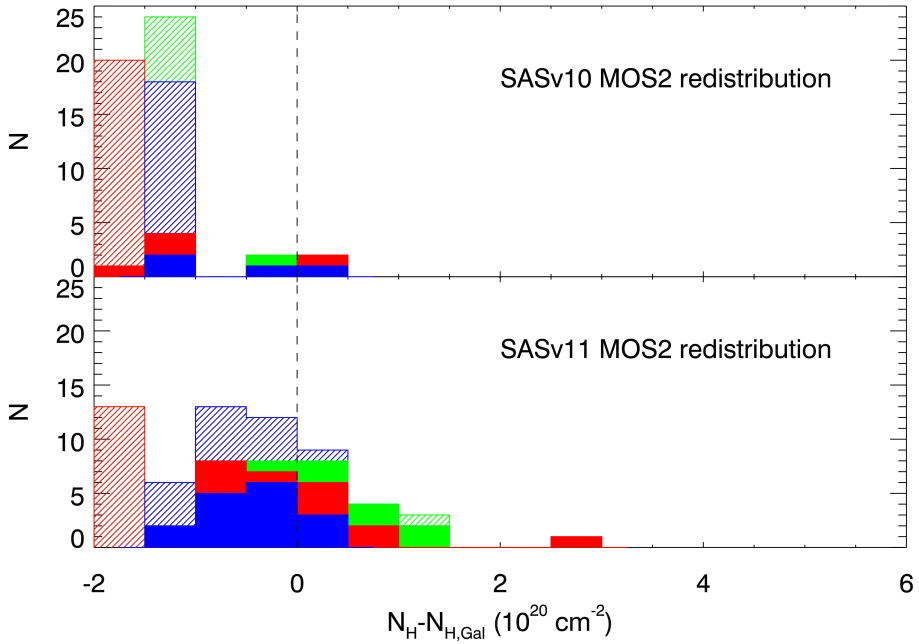


(Sembay et al. 2011)

MOS redistribution results: II.

Astrophysical indication that we are on the right track: most of the lower-than-Galactic photoelectric absorption N_Hs measured in blazars disappear



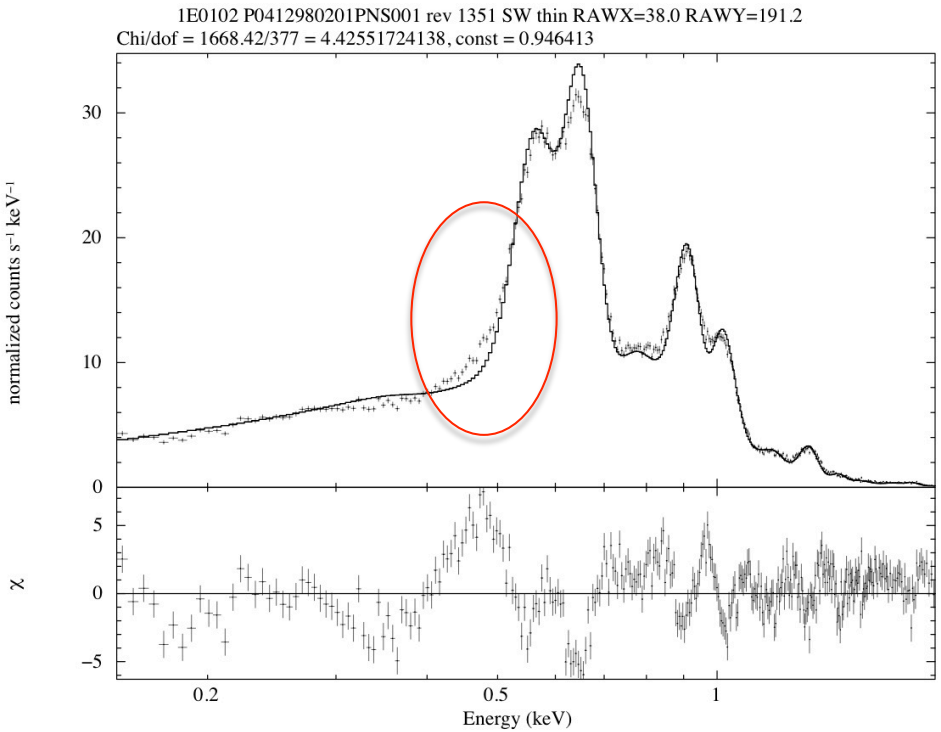


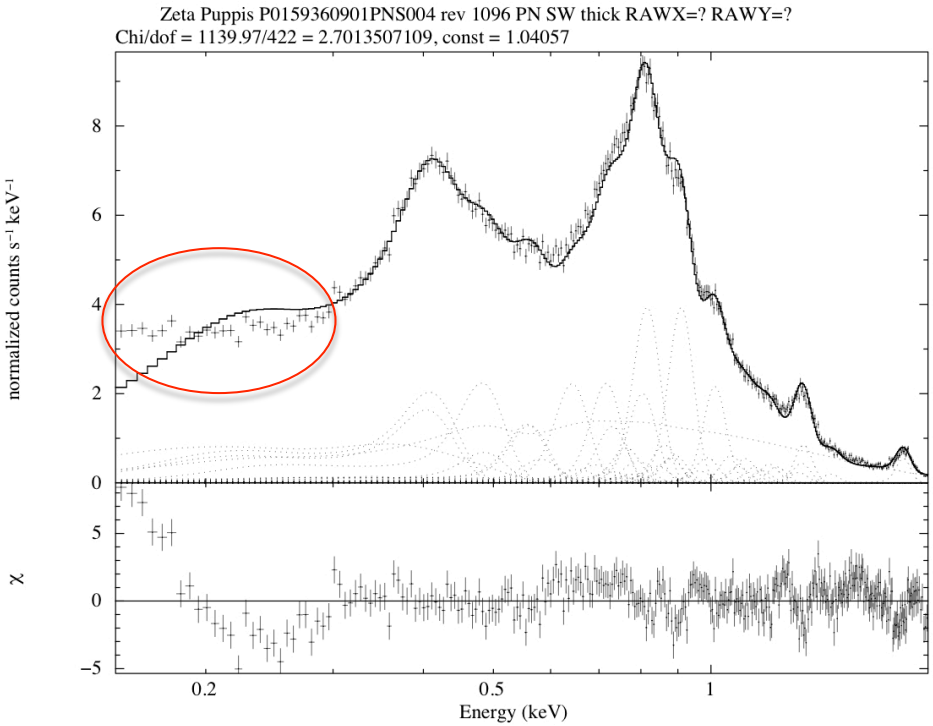
(dashed histogram: lower limits)

pn redistribution: the problem

Recalibration of the EPIC-pn redistribution parameters (SAS-independent change) using RGS-based model of line-rich sources

REDIST_CCF_0010 (Old)



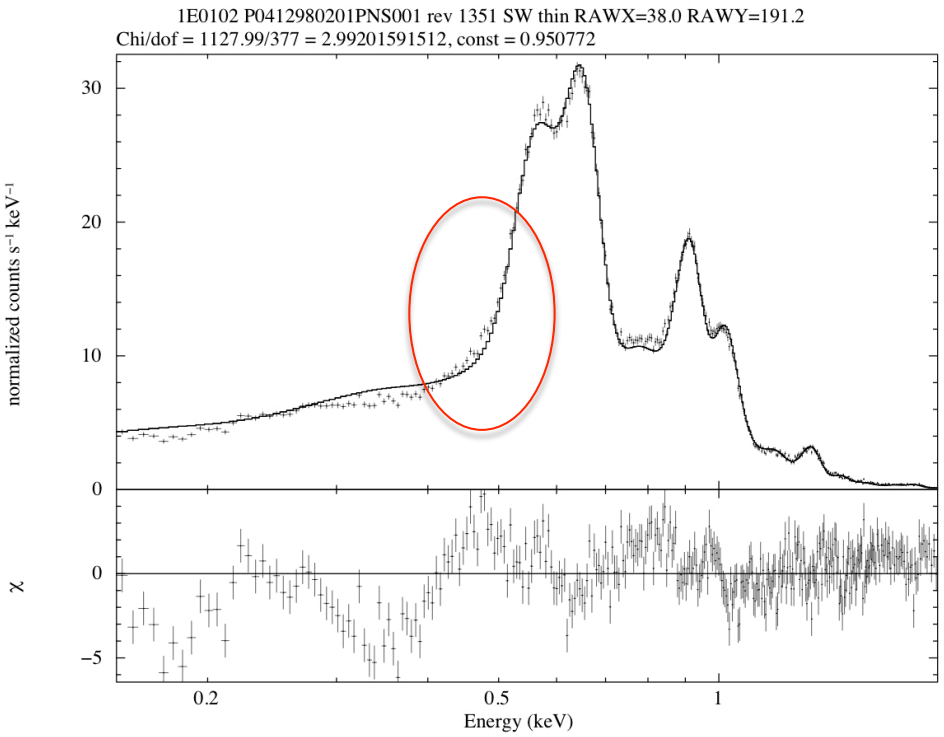


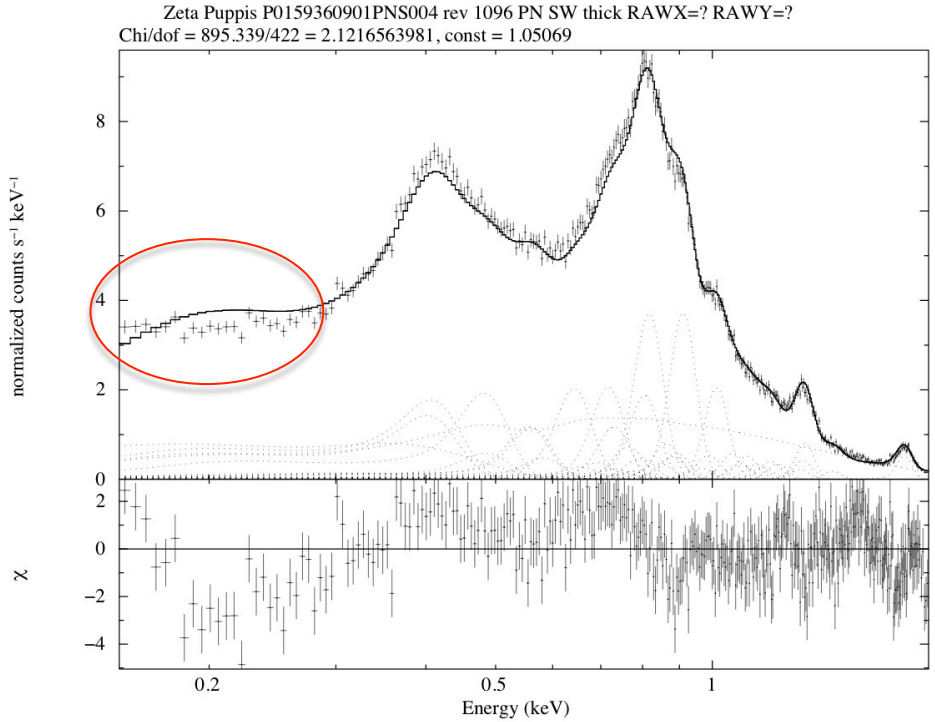
(Haberl et al. 2010)

pn redistribution: the solution I.

Recalibration of the EPIC-pn redistribution parameters (SAS-independent change) using RGS-based model of line-rich sources

REDIST_CCF_0011 (New)

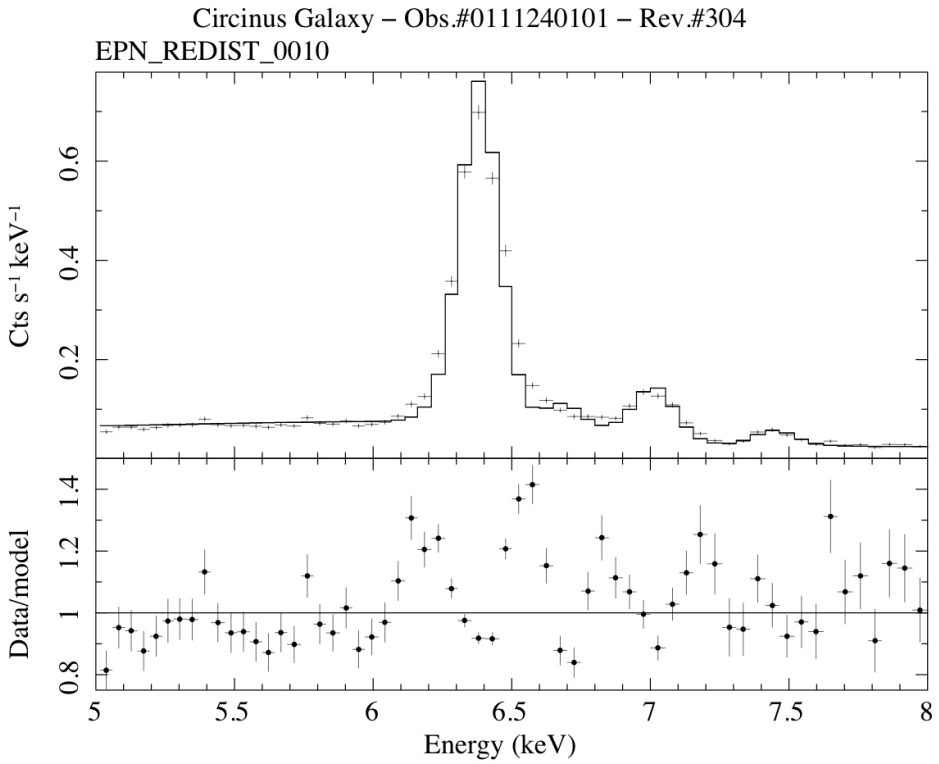




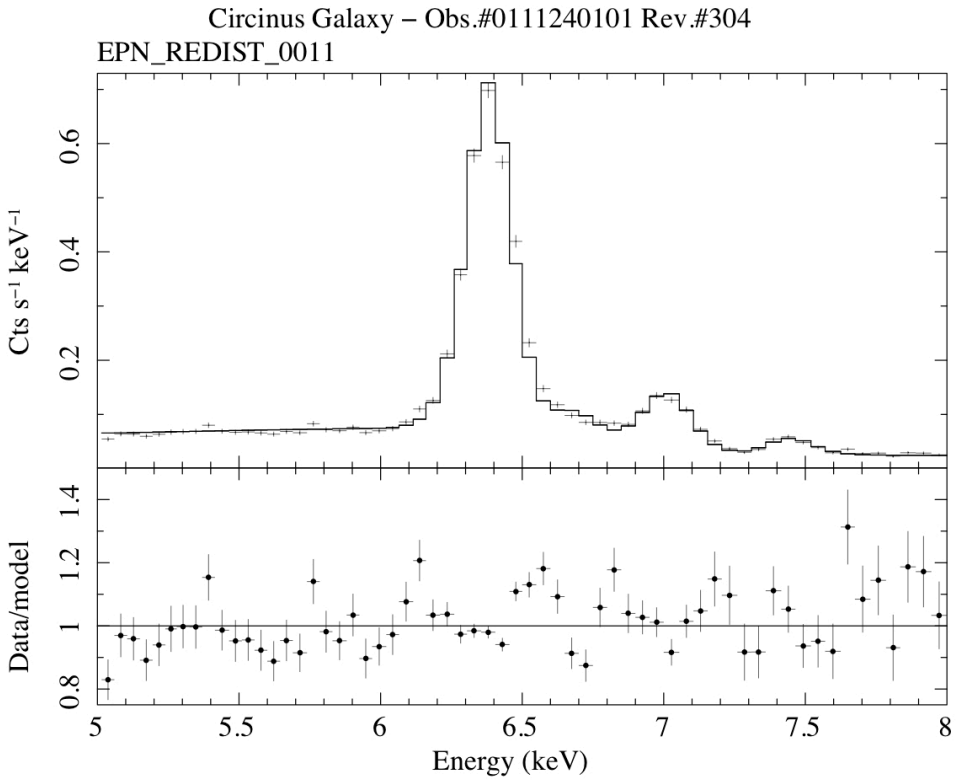
(Haberl et al. 2010)

pn redistribution: the solution II.

Old (0010)



New (0011)



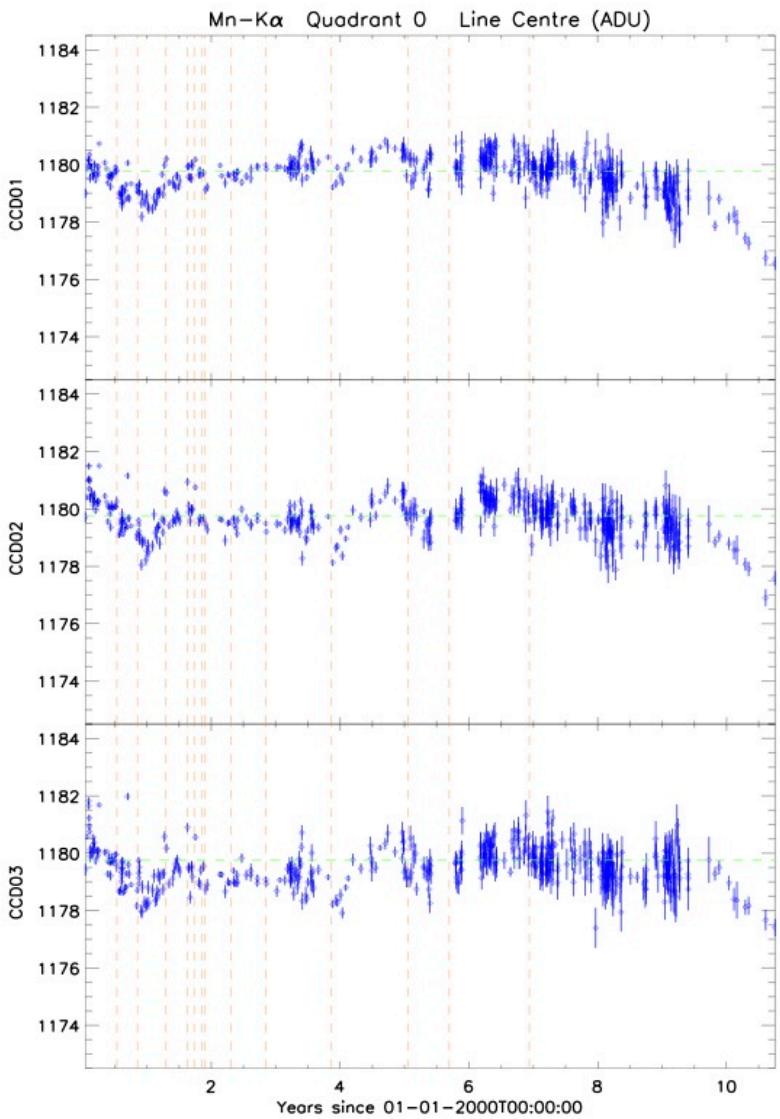
(Haberl et al. 2010)

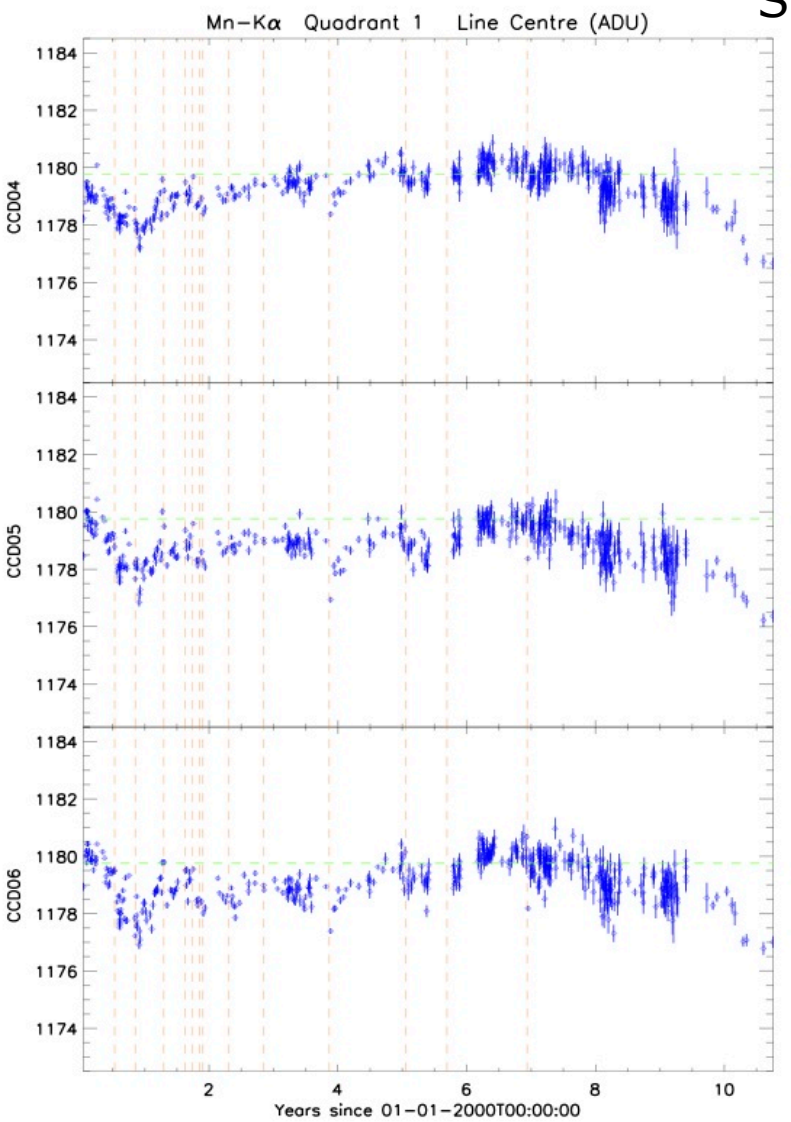
EPIC-pn Long-Term CTI (LTCTI)

- EPIC-pn suffers of a secular degradation of the CTI, whose calibration needs to be periodically updated
- Observations taken in 2009-2010 exhibited deviations in the line energy reconstruction by as much as 50 eV
- Update needed. Released in *December 2010*
- Opportunity seized to implement changes in the algorithm:
  - LTCTI is now applied in the SAS through the exact formula [$CTI \propto f(t)^{RAWY}$] rather than through a cubic approximation thereof
  - The CTI is based on the calibration line CCD-averaged spectra over the entire CCD except for CCD#4, where a position close to the nominal boresight is chosen

EPIC-pn LTCTI: EPIC_CTI_0022

Status in 2010

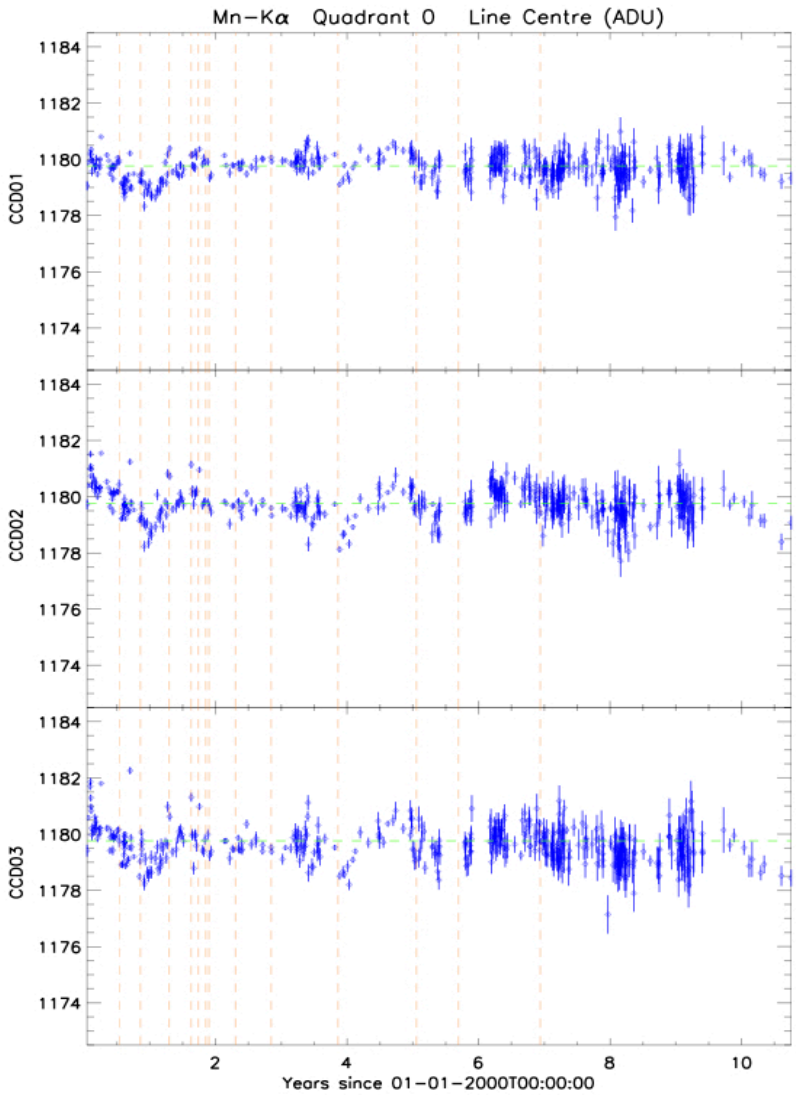


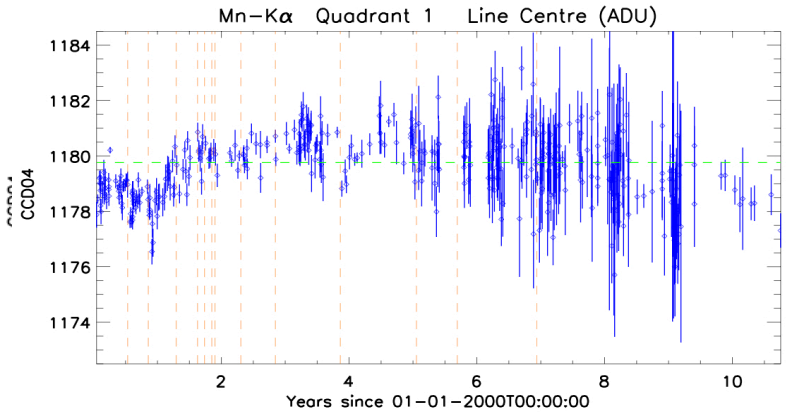


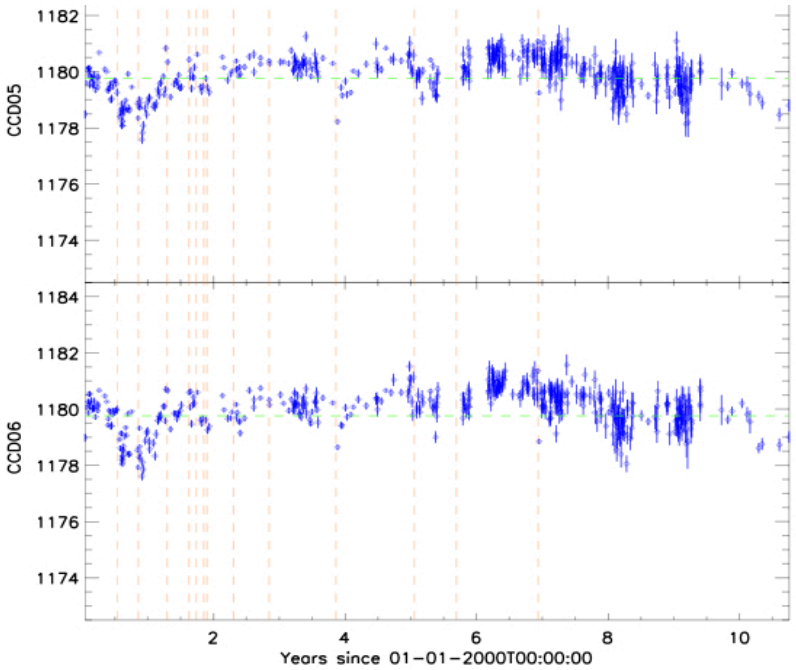
(Smith et al. 2010)

EPIC-pn LTCTI: EPIC_CTI_0023

Status now

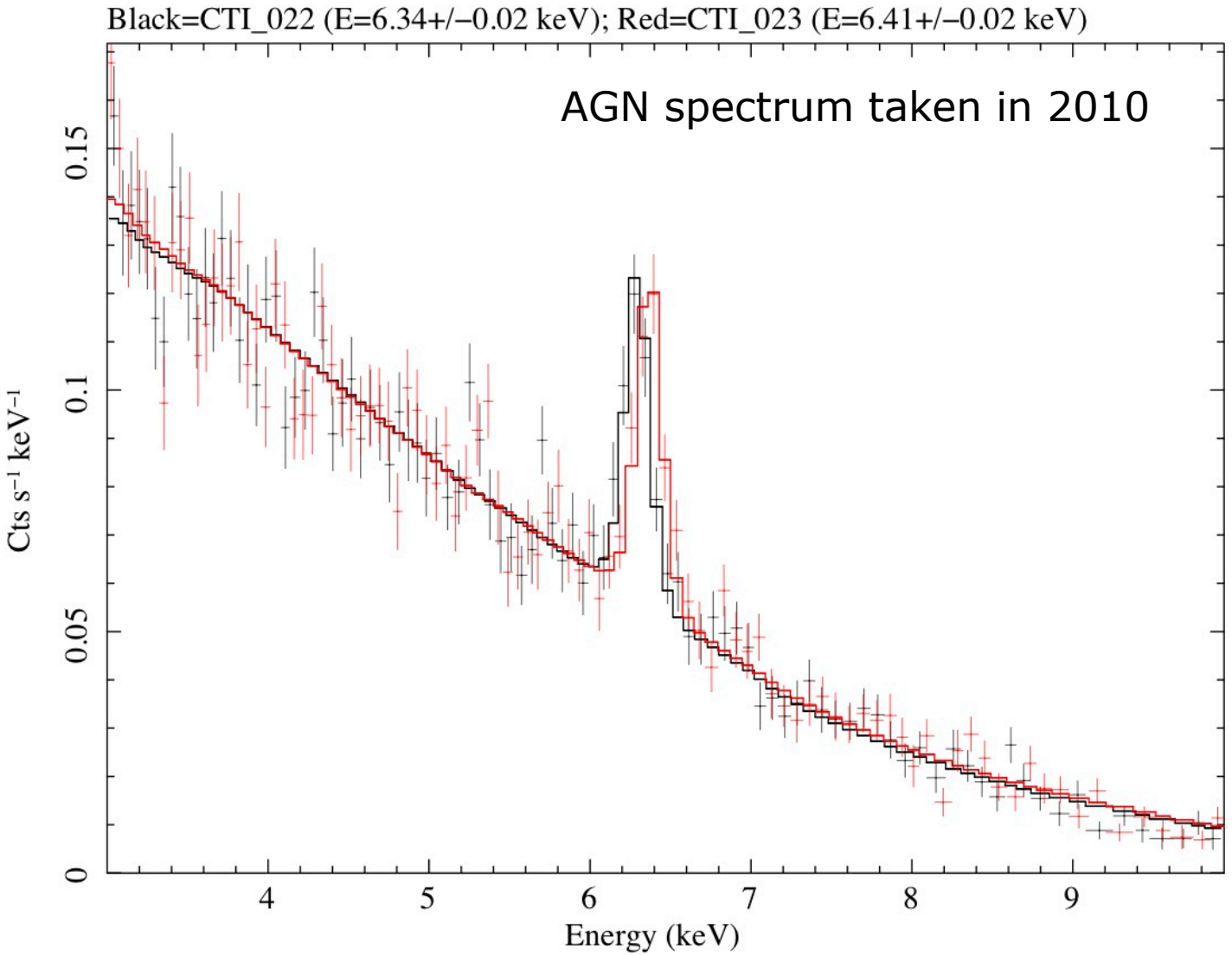






(Smith et al. 2010)

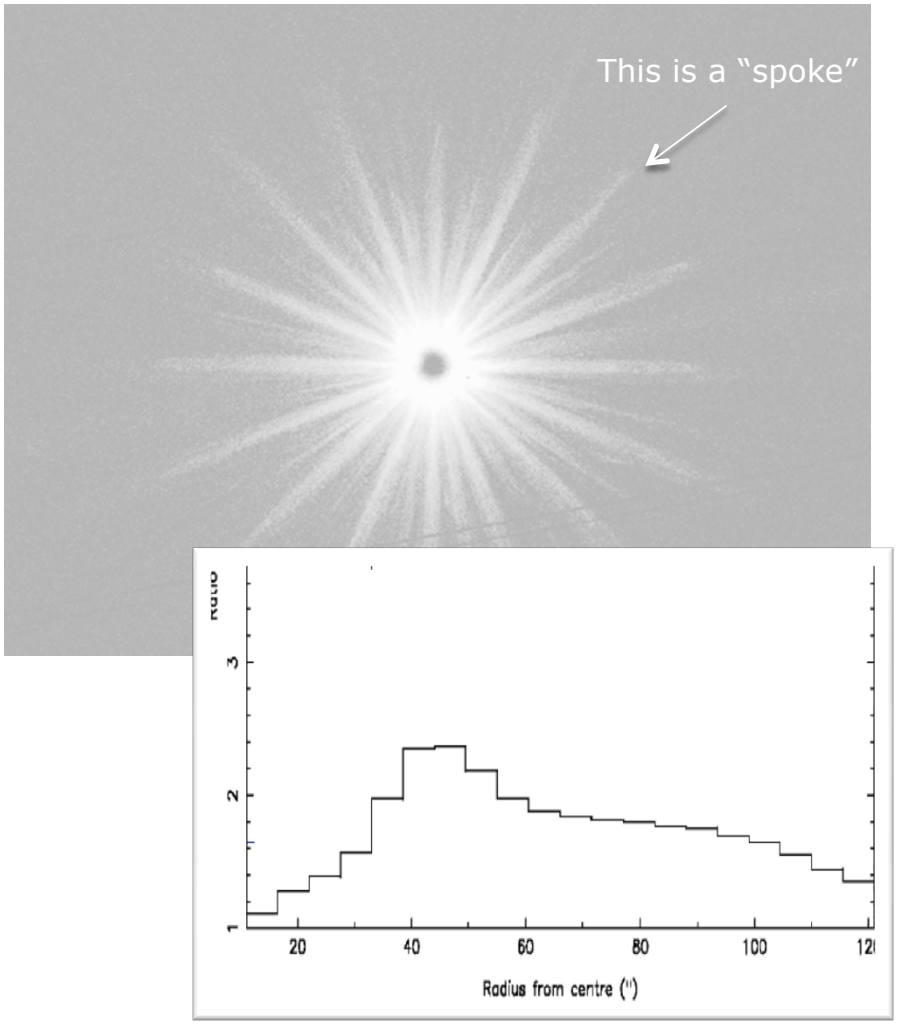
EPIC-pn LTCTI: results I.



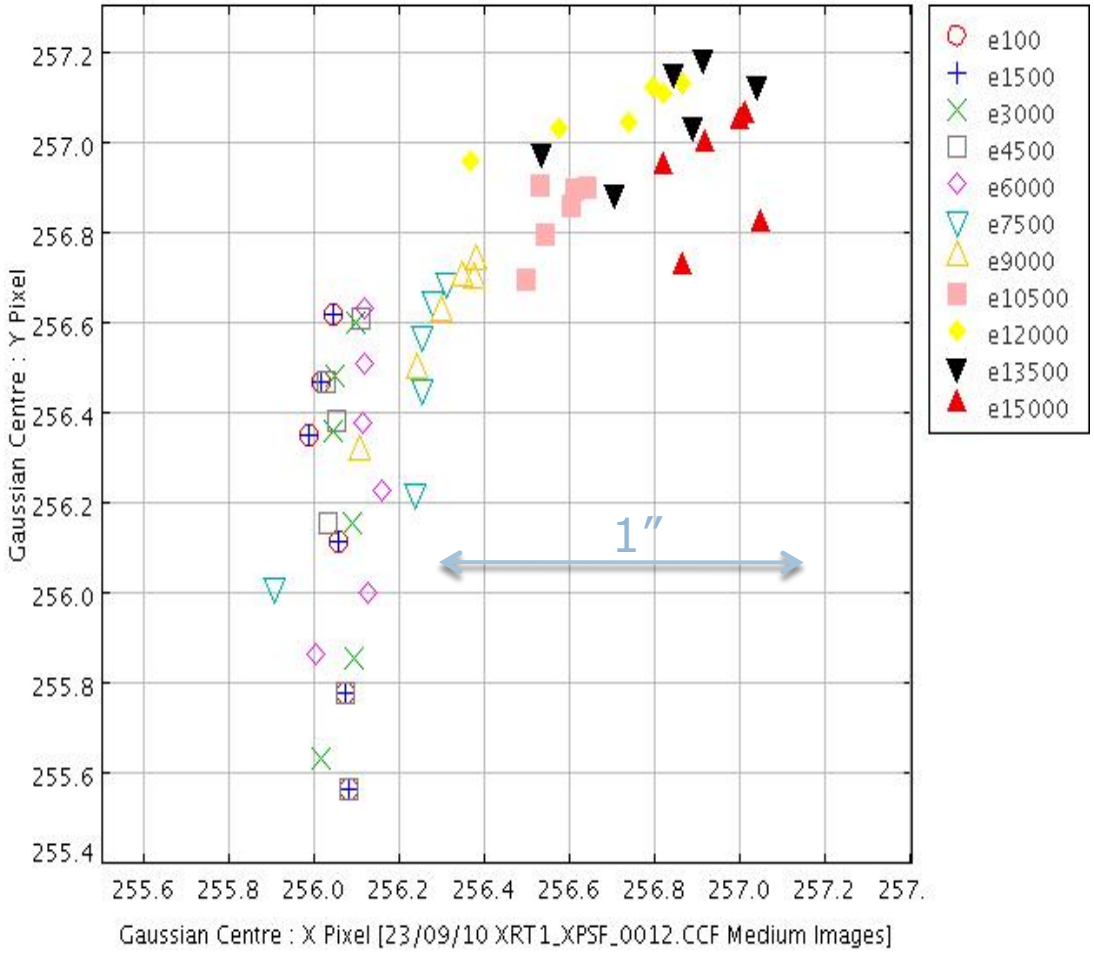
(Smith et al. 2010)

2-D PSF (ELLBETA) improvements

(Courtesy A.Read & R.Owen)

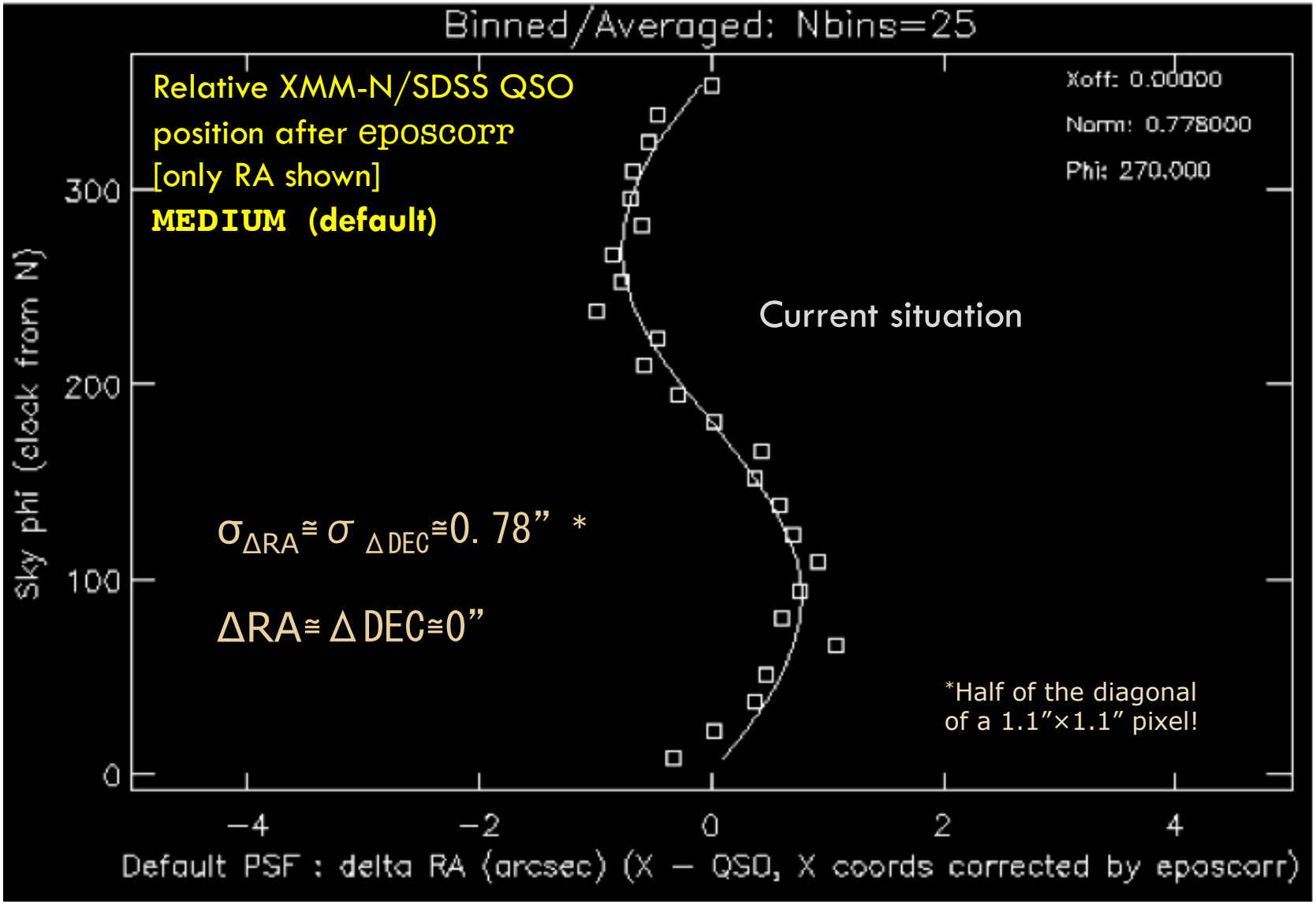


1. Recalibrated the spokes' intensity and radial dependency



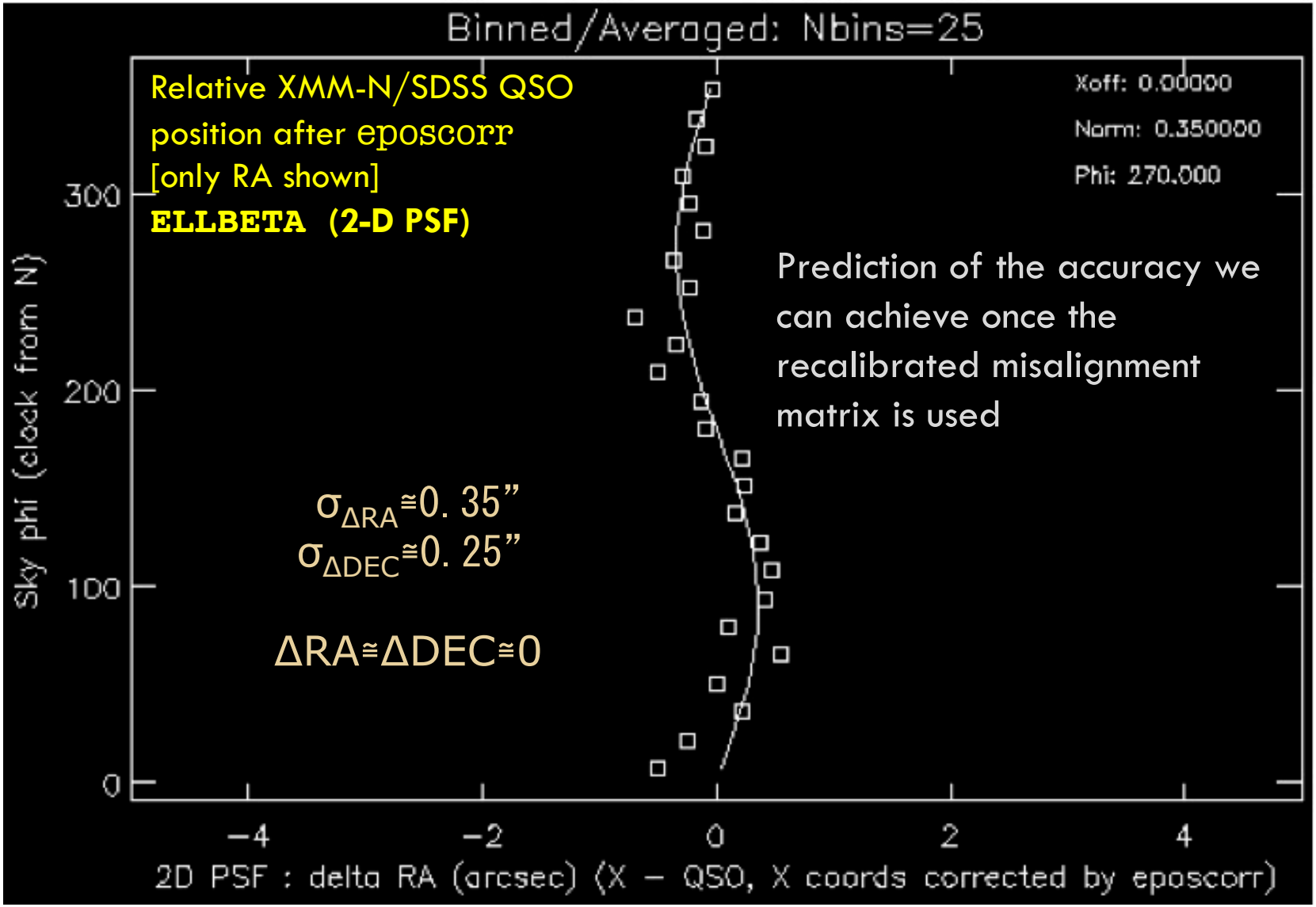
2. Discovered a positional inaccuracy of ±1 pixel in the centroiding of the *current* PSF (MEDIUM)

2-D PSF astrometry improvement: impact



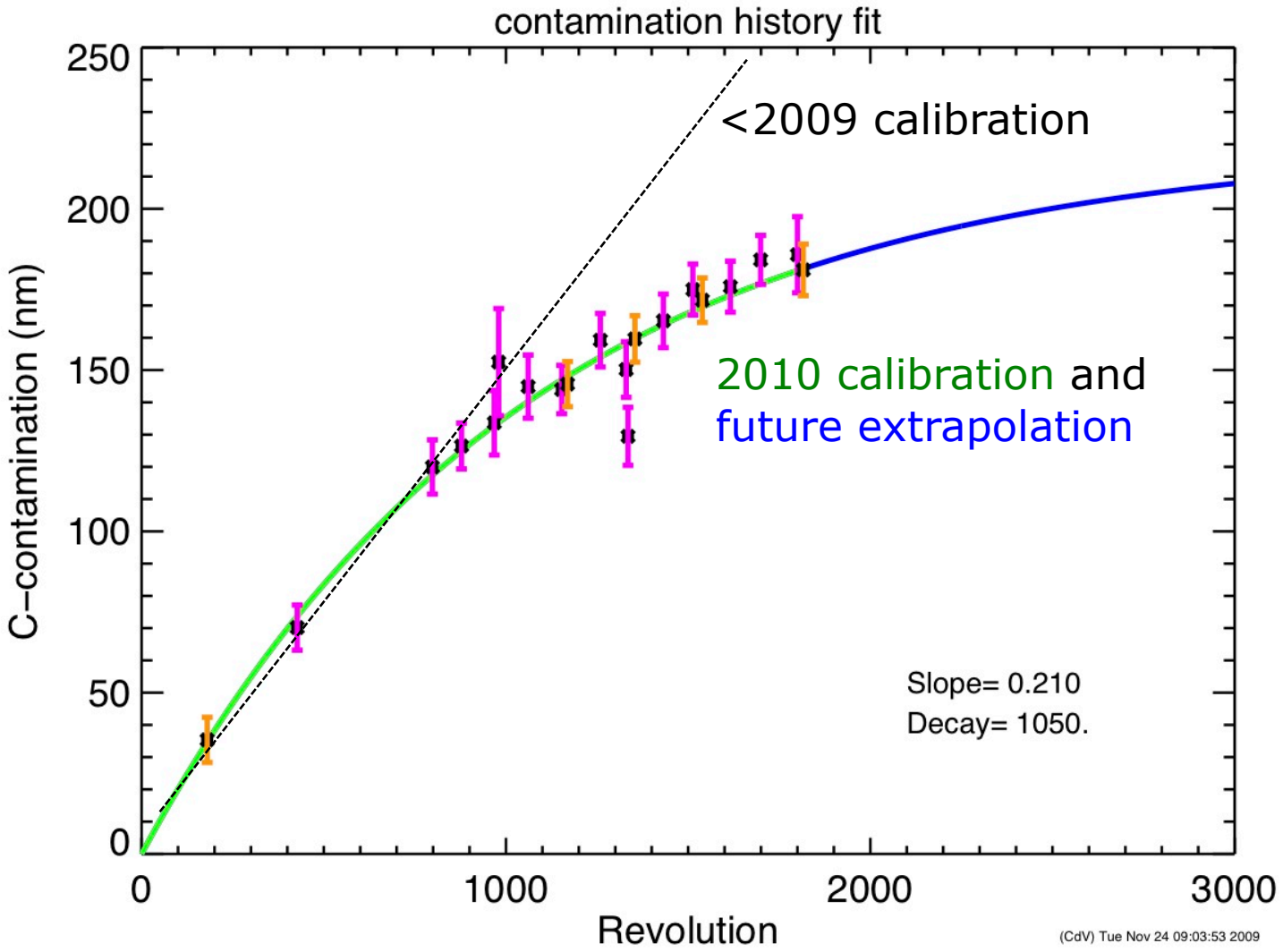
(Courtesy A.Read)

2-D PSF astrometry improvement: impact



(Courtesy A.Read)

RGS contamination

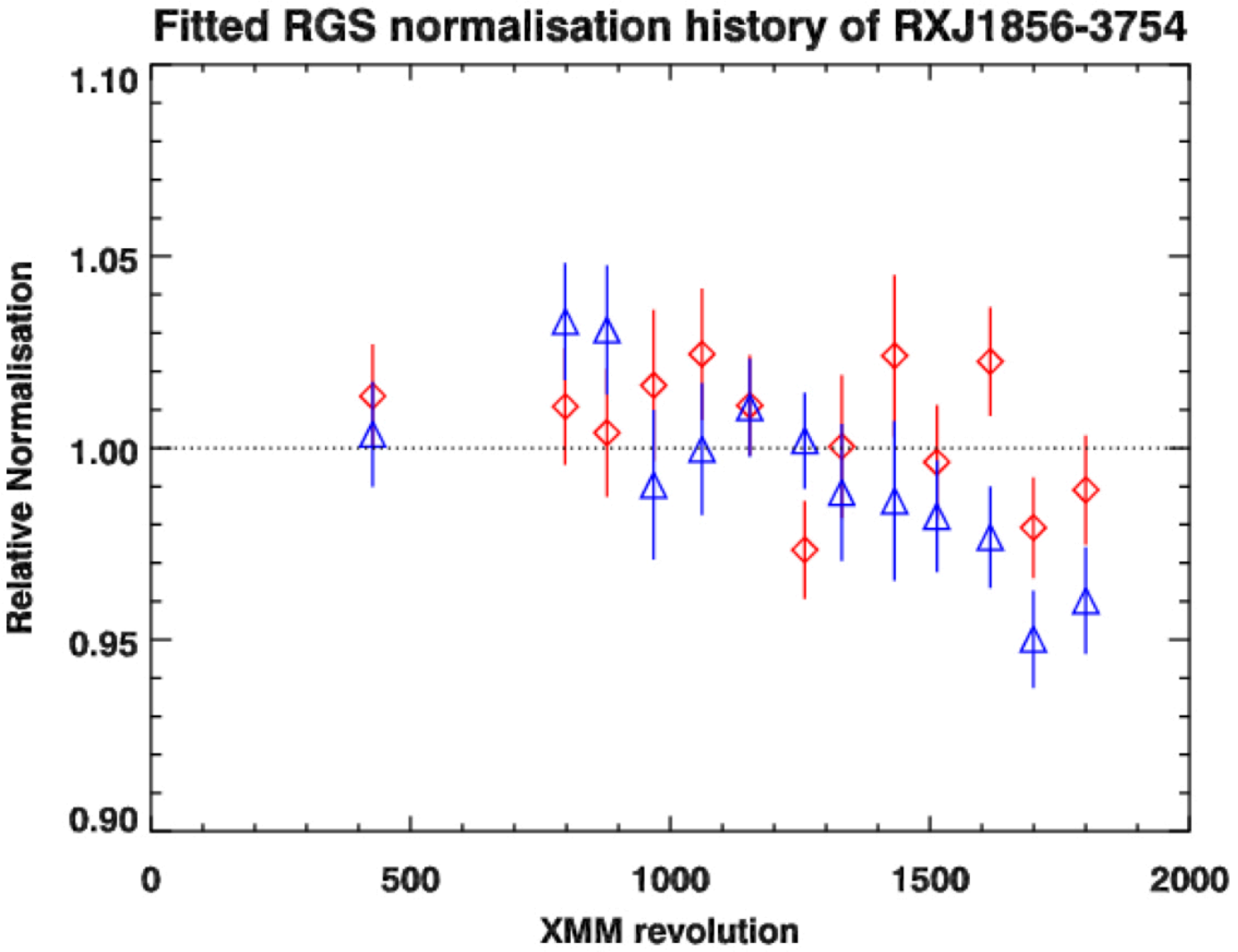


(Courtesy RGS)

RGS contamination: results

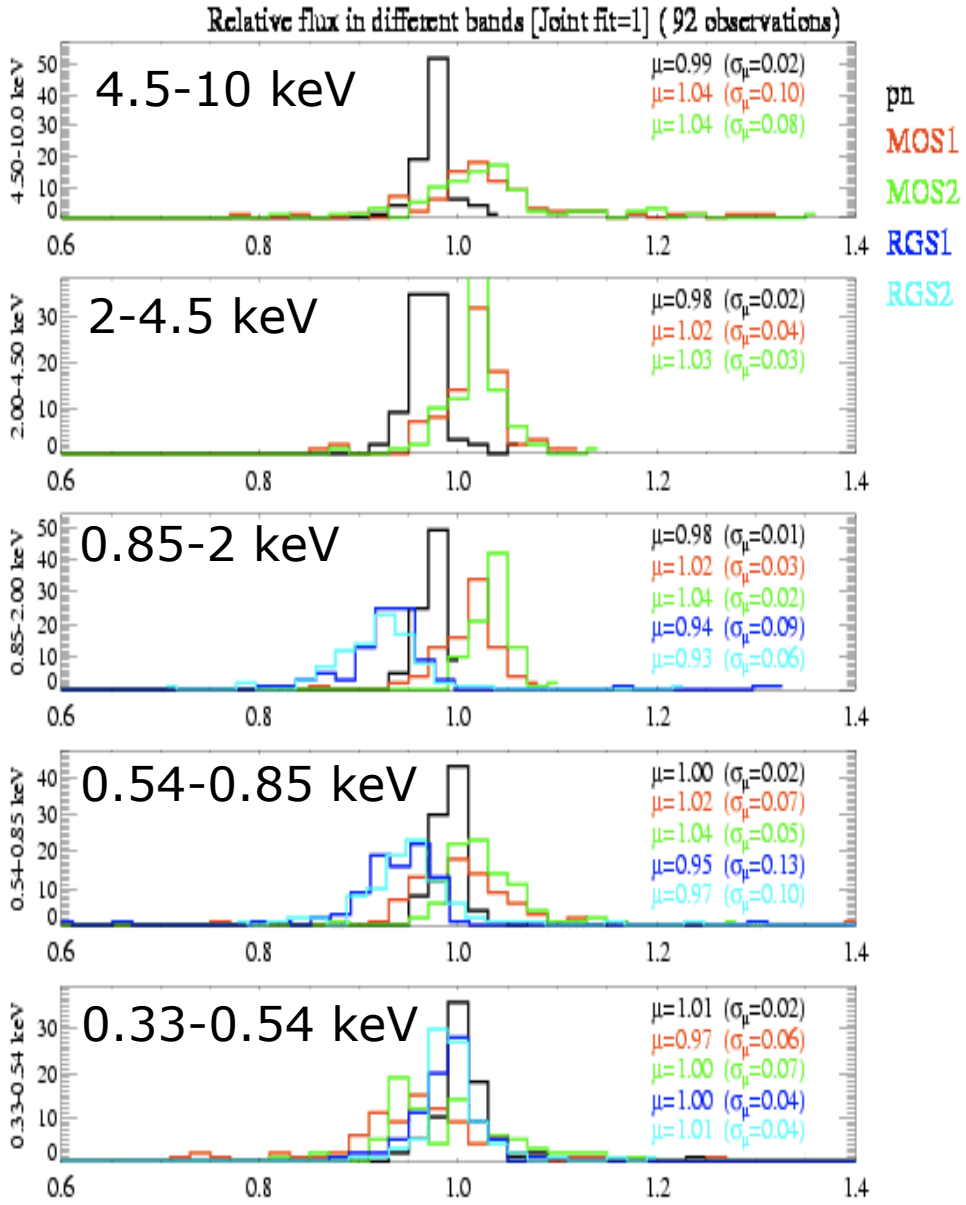
RXJ1856-3754 blackbody (Burwitz et al. 2003) spectral parameters

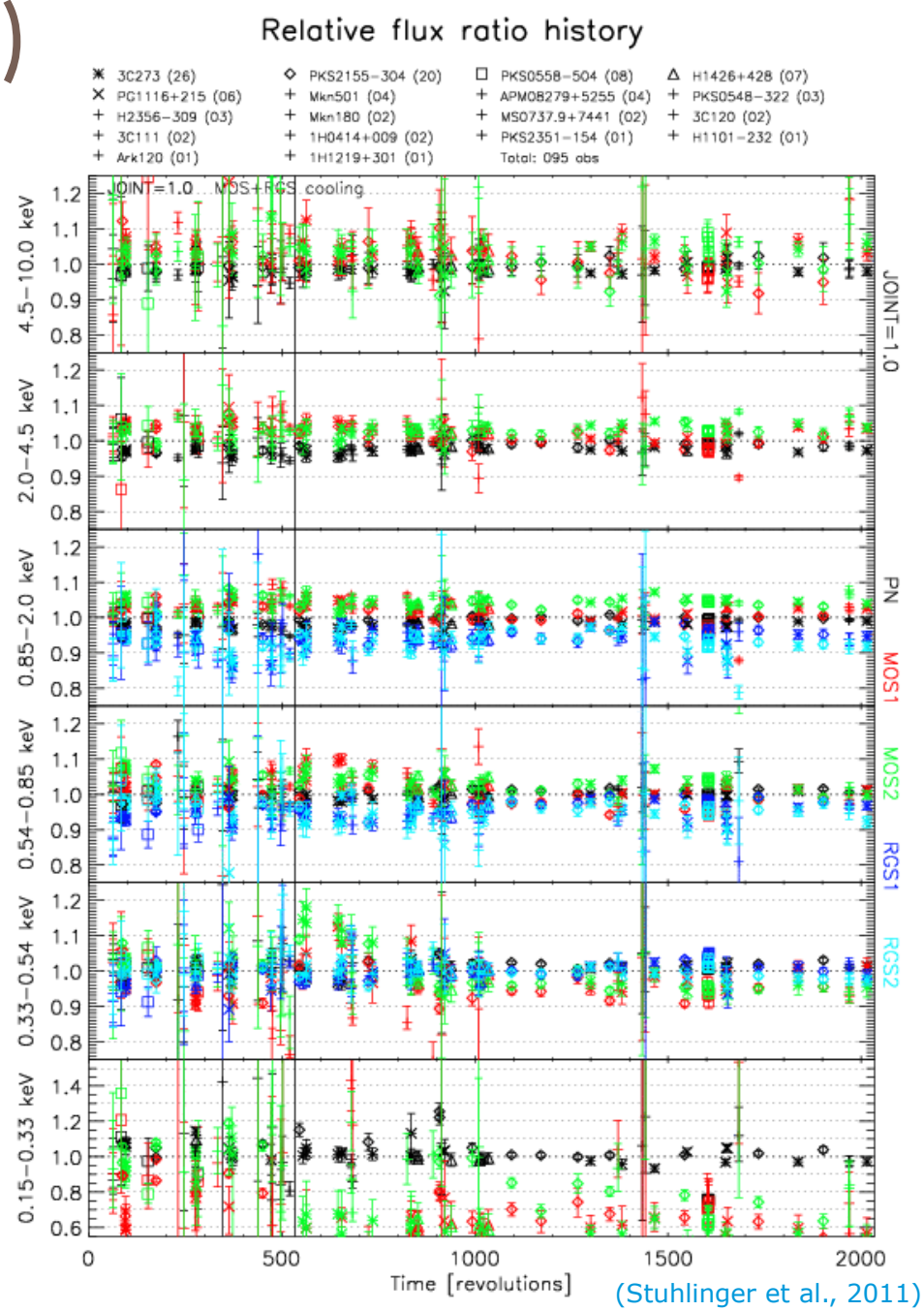
	N_H (10^{18} cm^{-2})	kT (eV)	Norm. ($x10^4$)
RGS	6.1 (f)	61.67± 0.12	3.19
pn	4.76± 0.15	61.11± 0.09	3.18± 0.02



(Courtesy RGS)

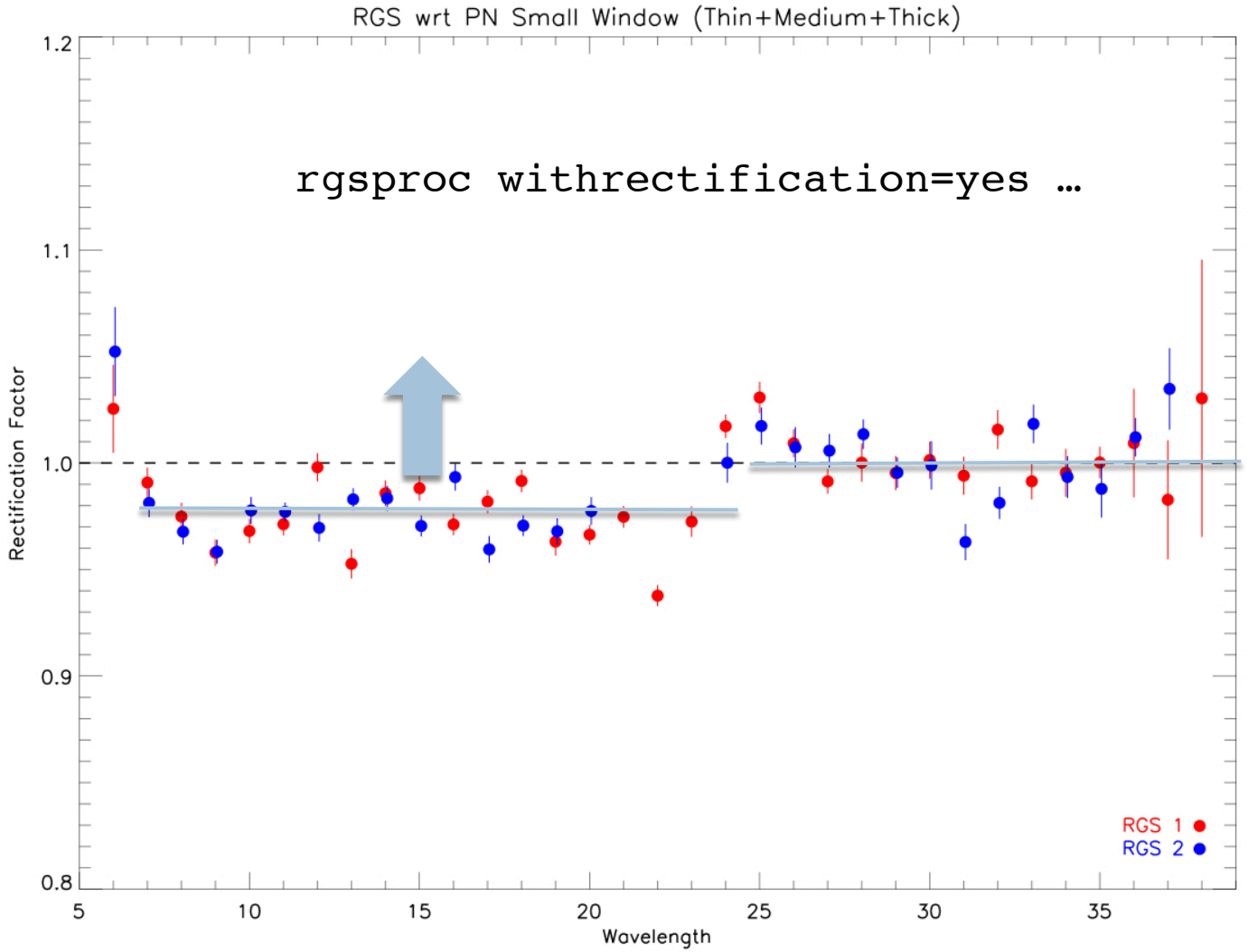
Cross-calibration (on-axis)





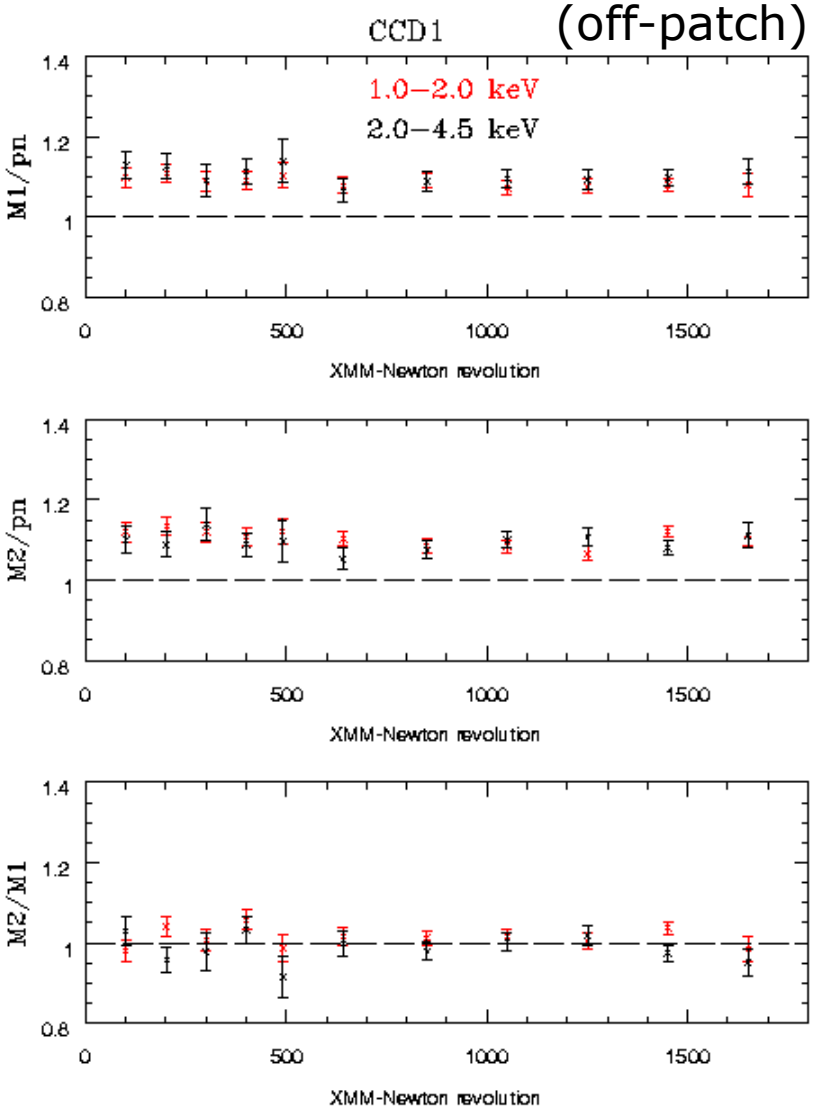
(Stuhlinger et al., 2011)

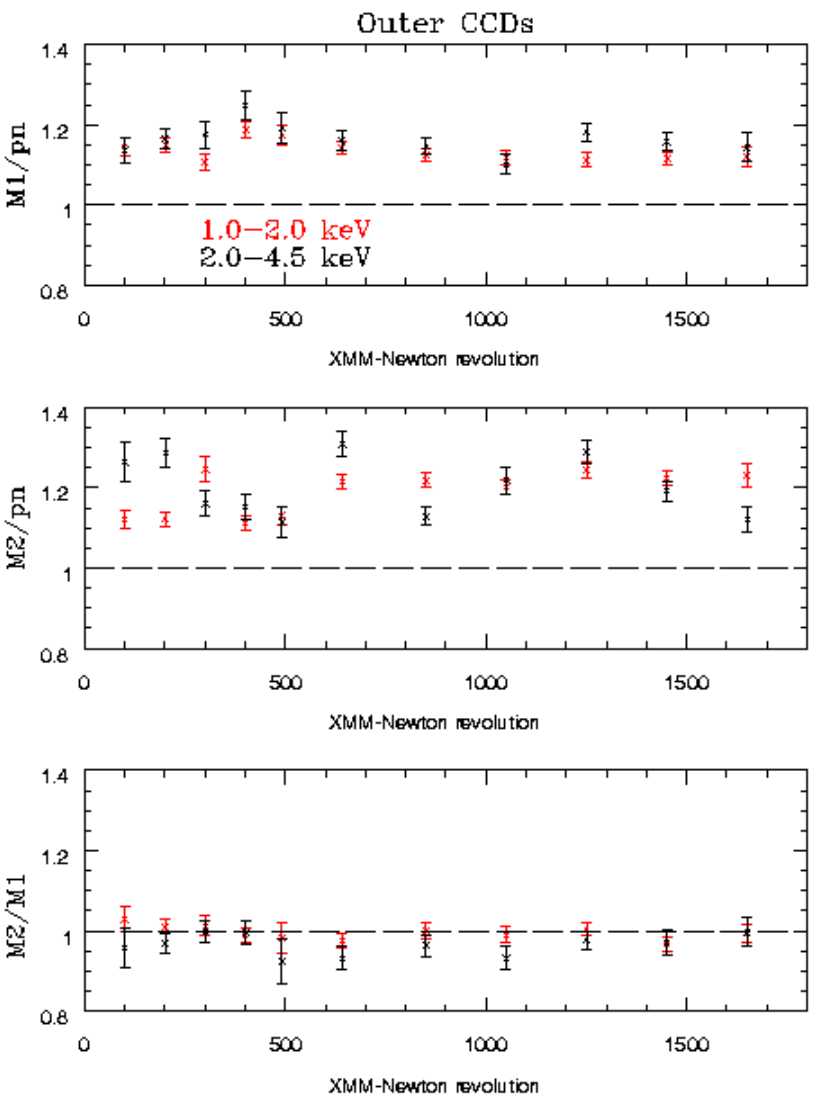
RGS-to-pn rectification



(Pollock & Gonzaléz-Riestra 2010)

Cross-calibration (off-axis)





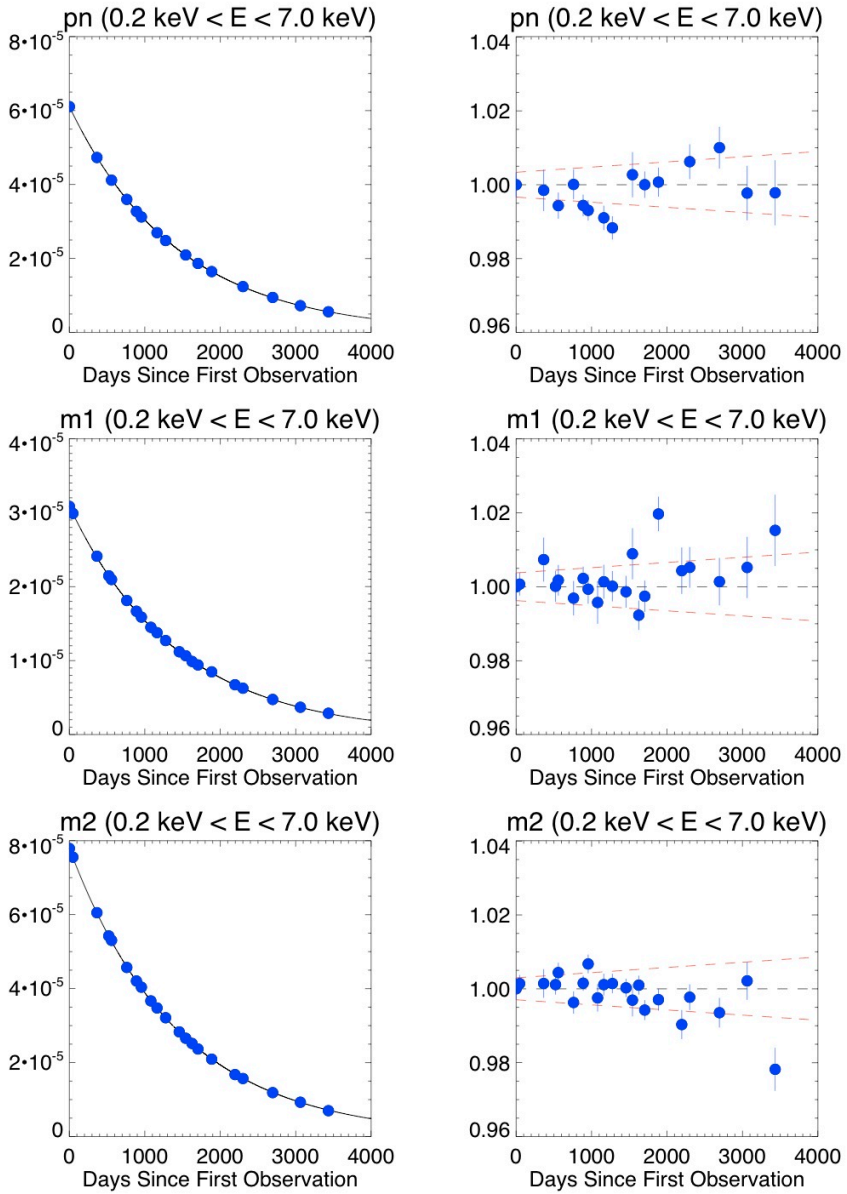
(Courtesy S.Sembay)

QE temporal evolution

The on-board calibration source - thanks to its perfectly known decay time (2.7 years) - provides in principle a safe reference to evaluate the evolution of the EPIC effective area.

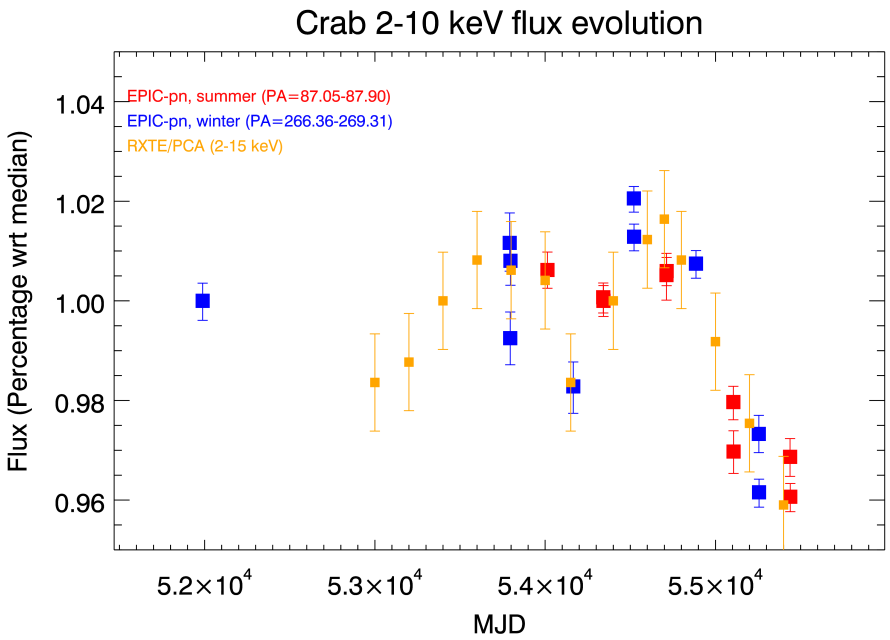
One needs only to count the events in CAL-CLOSED exposures …

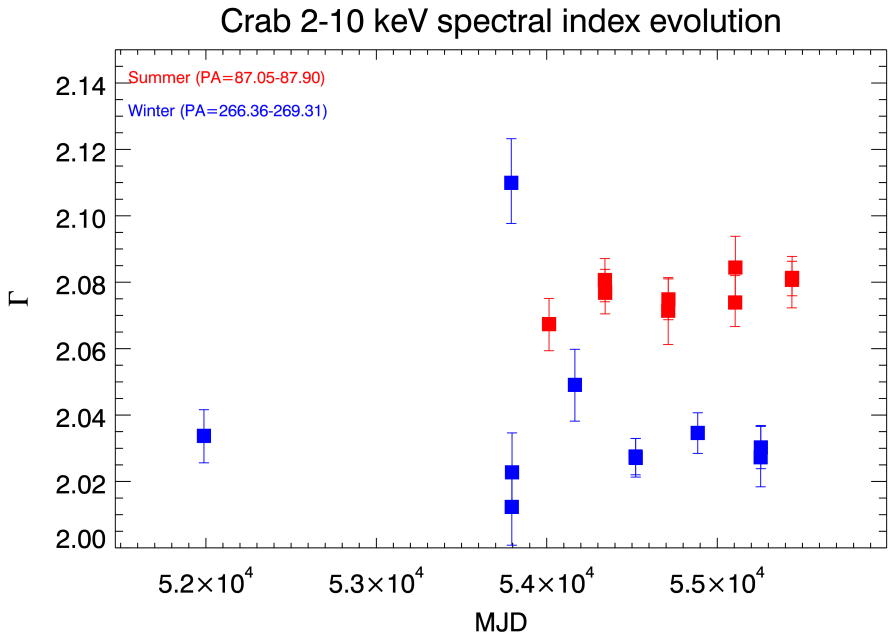
[red dashed lines: statistical uncertainties]



(Courtesy S.Sembay)

Crazy Crab (EPIC-pn in Burst Mode)





Outline (for the 7th IACHEC talk)

- 2-D PSF default model as of SASv11.5 (fall 2011)
  - Spokes' recalibration implemented
  - Astrometry problem corrected via recalibration of the mis-alignment matrix
  - `arfgen` Encircled Energy Fraction calculation fully validated
- MOS2, late epochs redistribution refined
- EPIC-pn Imaging modes resolution time evolution (if any) calibrated
- EPIC-pn Fast modes (Timing and Burst) entirely revised
- EPIC-pn Timing Mode blank fields event lists publicly available
- New spatially-dependent gain correction in EPIC-pn (algorithm by *K.Dennerl*) implemented in SASv11.5
- Azimuthal-dependence of the EPIC-MOS vignetting (RGA obscuration) corrected
- RGS line-spread function recalibrated
- RGS temperature- and SAA-dependent wavelength correction calibrated
- **Overall cross-calibration goal: internal XMM-Newton cross-calibration ≤3% (on-axis), ≤5% off-axis**