Status of XMM-Newton instrument calibration

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on behalf of the whole EPIC & RGS Instrument Teams

Outline

- Status of EPIC calibration
  - 2-D PSF
  - Refinement of the pn redistribution
  - Improved modelling of the MOS redistribution
  - Rate-dependent CTI and quality of energy reconstruction in pn Timing Modes
- Status of RGS calibration
  - "Auditing the RGS effective area model"
- XMM-Newton internal cross-calibration

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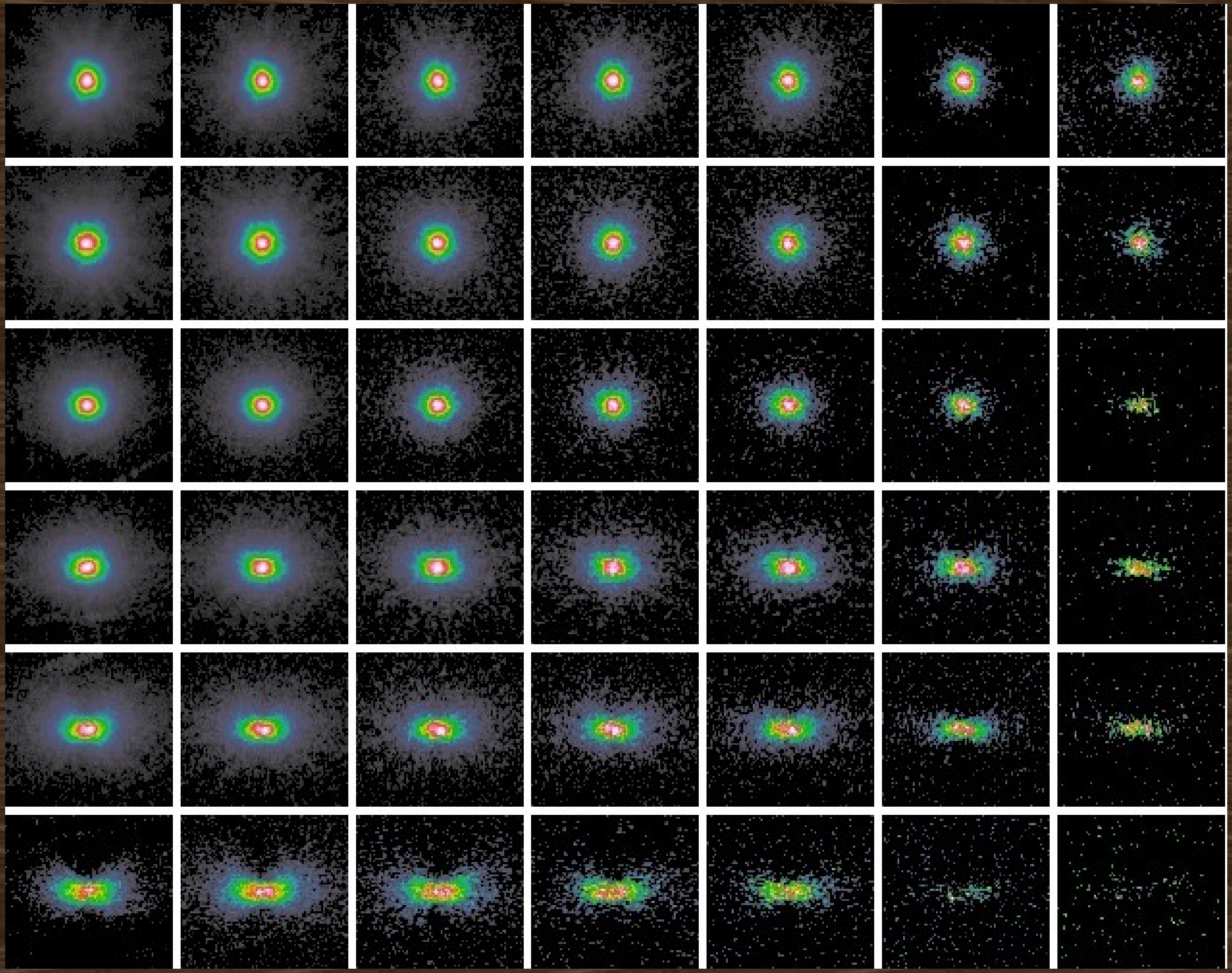
2-D PSF: elliptical envelope

(courtesy A.Read)



- Stack PA-corrected images of many sources in 2XMM for different energies and off-axis angles
- Fit the stacks with a beta- plus central Gaussian (MOS only) profiles
- Create new CCF (ELLBETA extension)
- Update CAL and `arfgen`

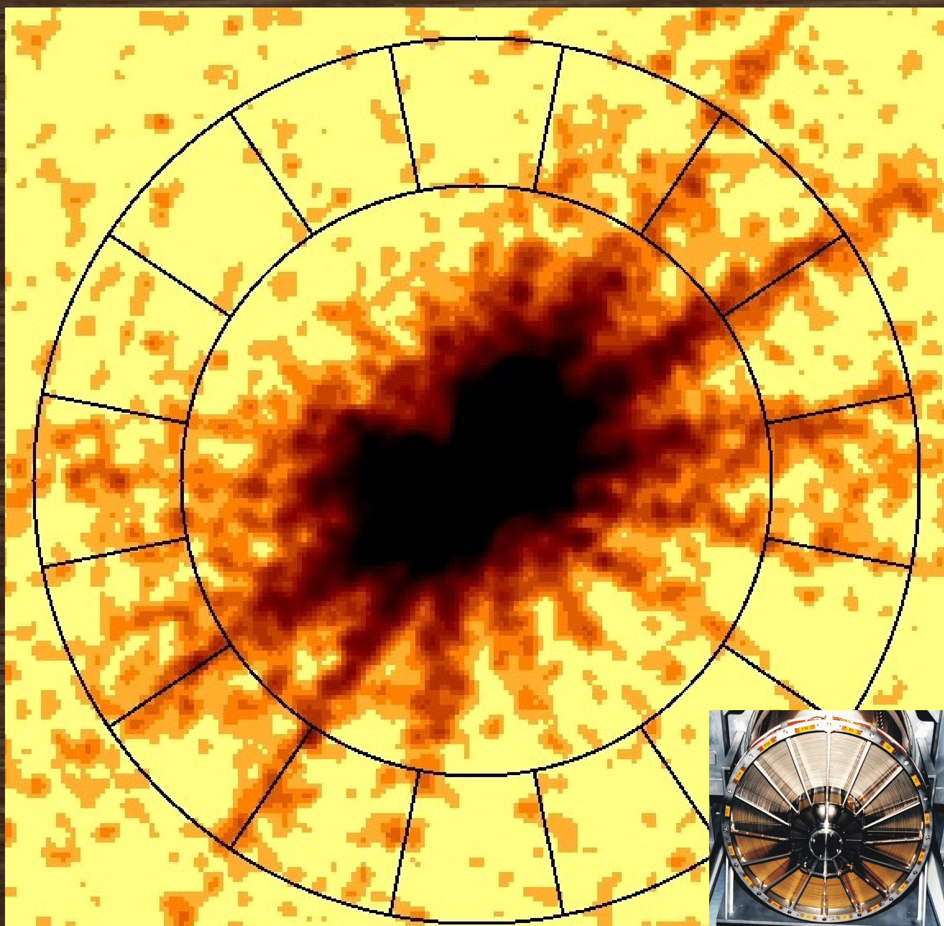
Available as of SASv8.0 via a switch (non-default)

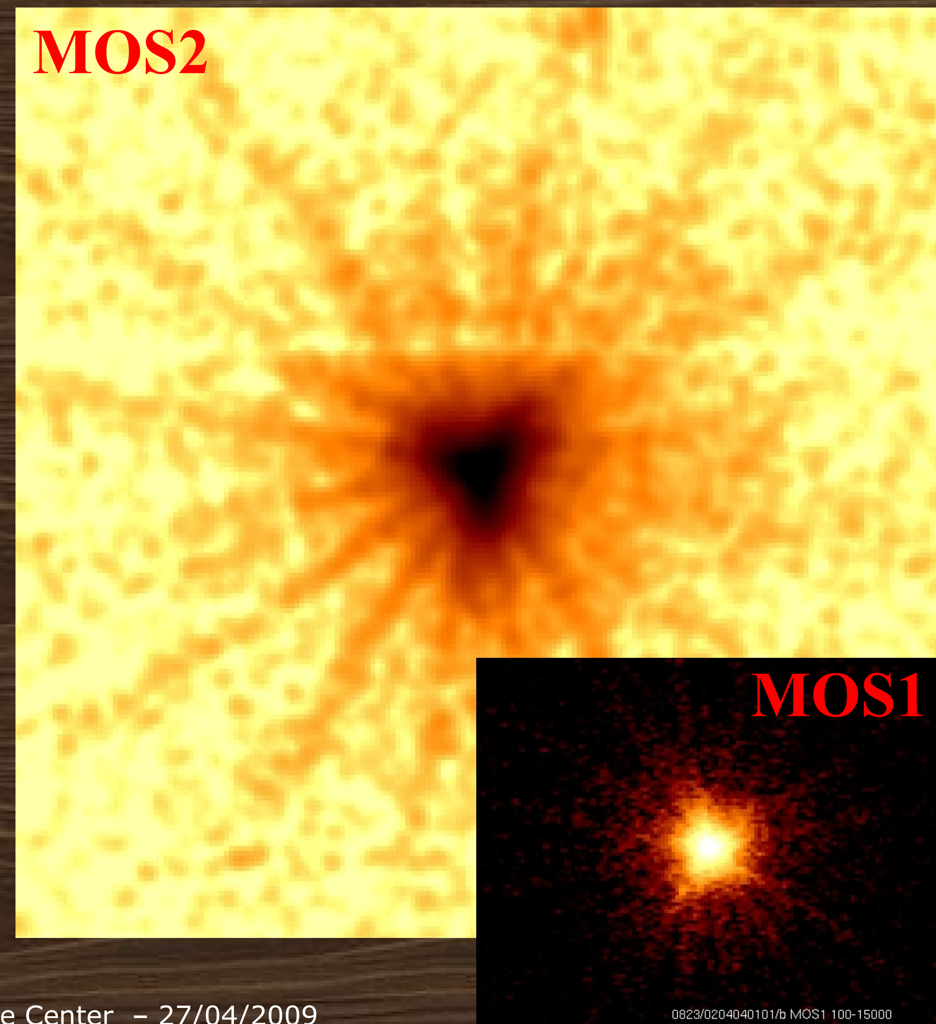
Full PSF

(courtesy A.Read)

"Spokes" (and sub-) with a source position-independent orientation

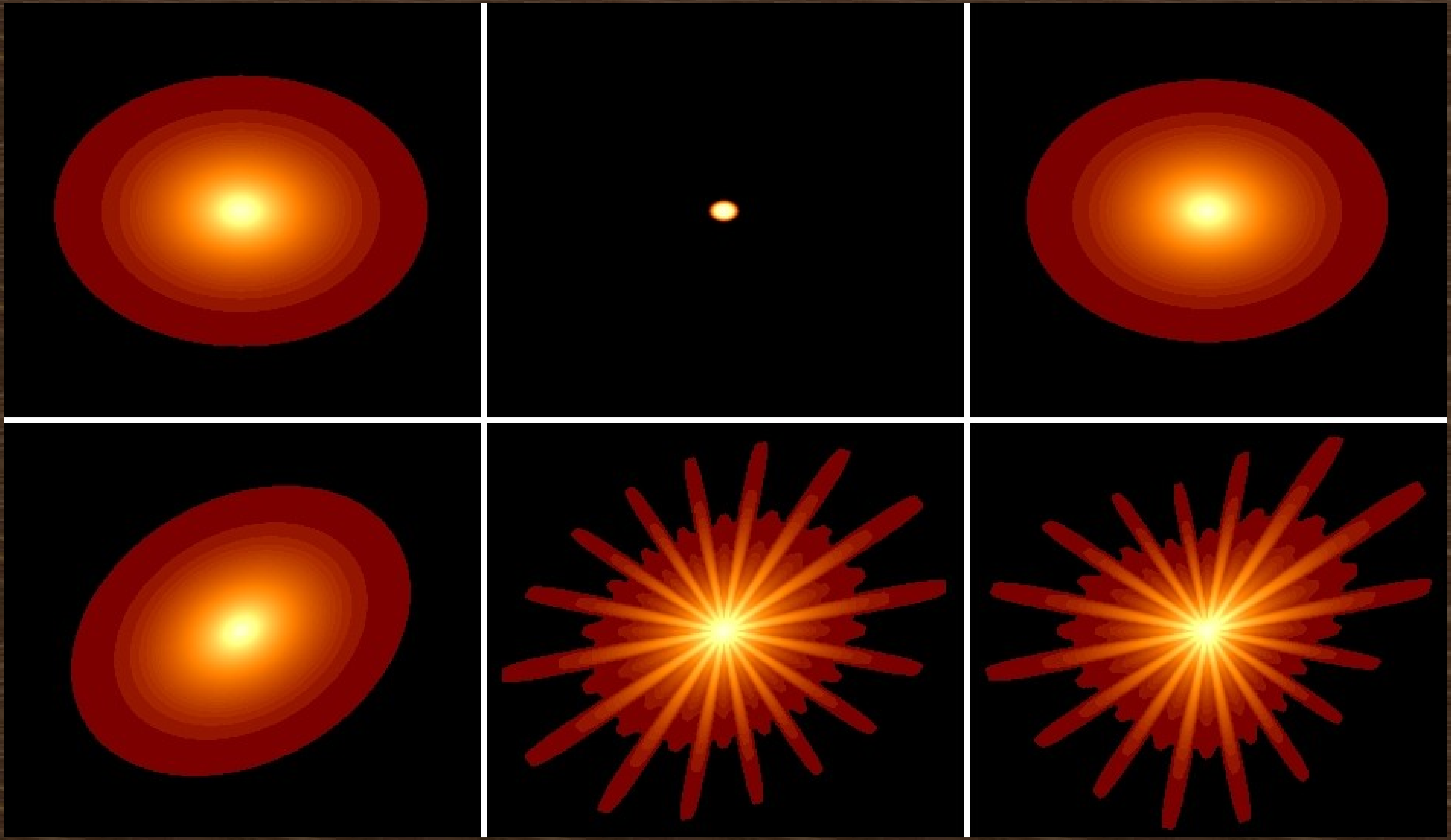
Azimuthally-dependent modulation





How SAS builds the 2-D PSF

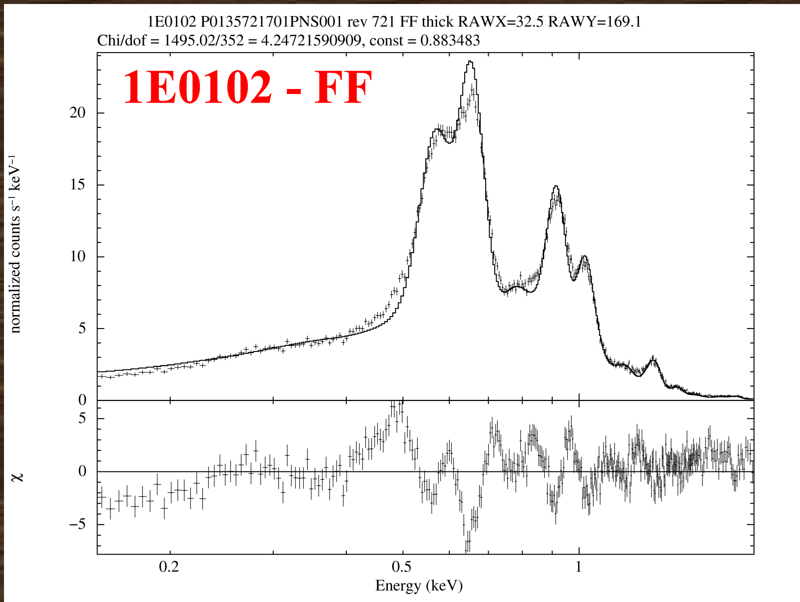
(courtesy A.Read)

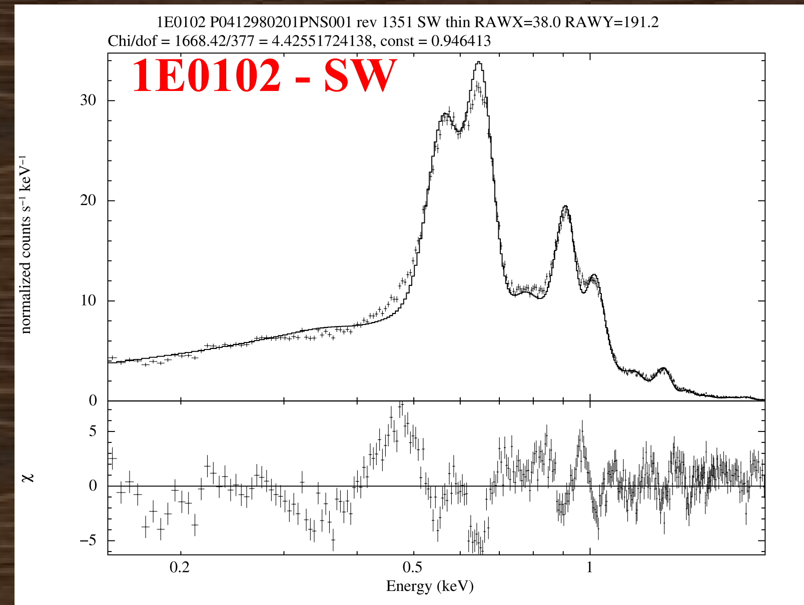


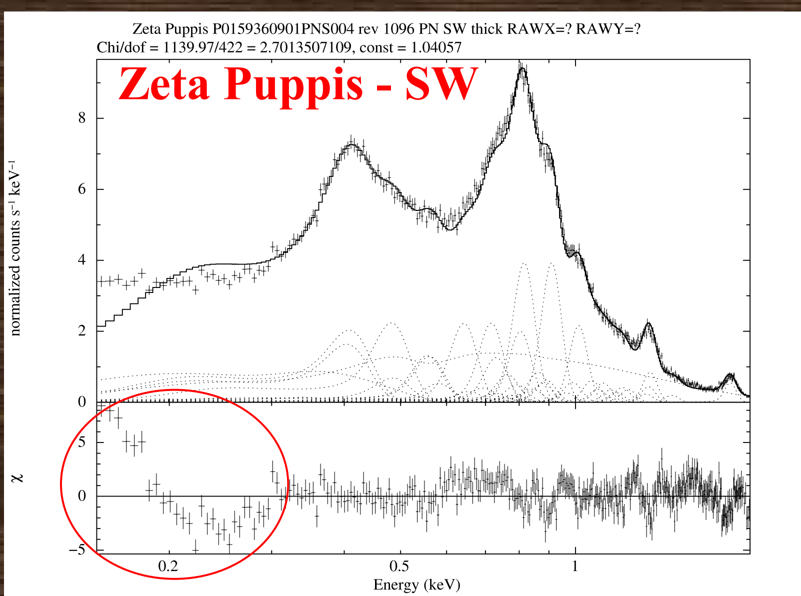
[1] Elliptical PSF at a given E and θ [2] Gaussian "core" (MOS only) [3] Combine 1+2 [4] Rotate to correct source PA [5] Azimuthal spoke filtering [6] Azimuthal modulation

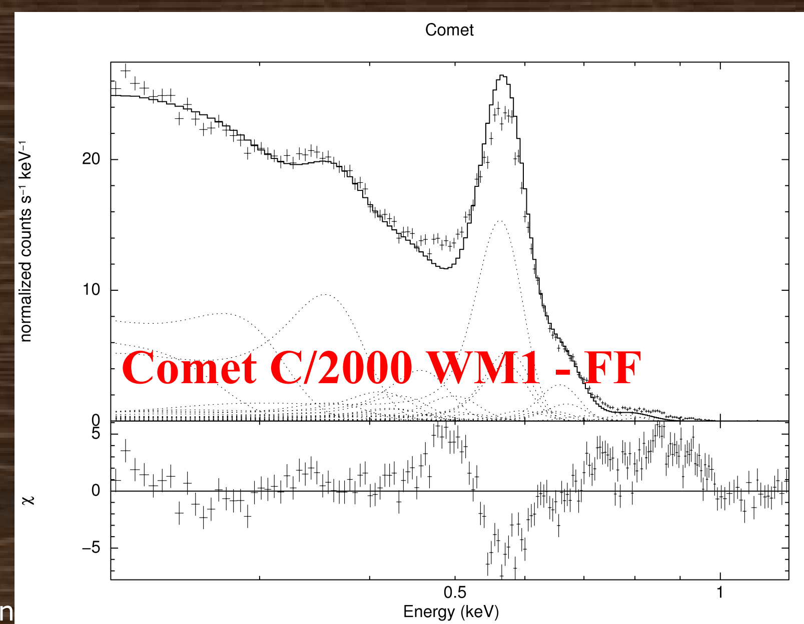
pn redistribution: the problem

(courtesy F.Haberl)



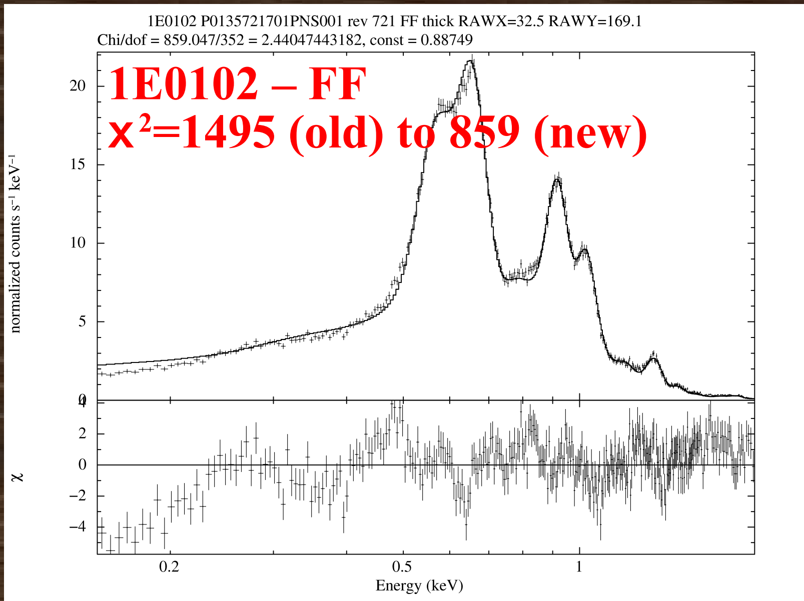


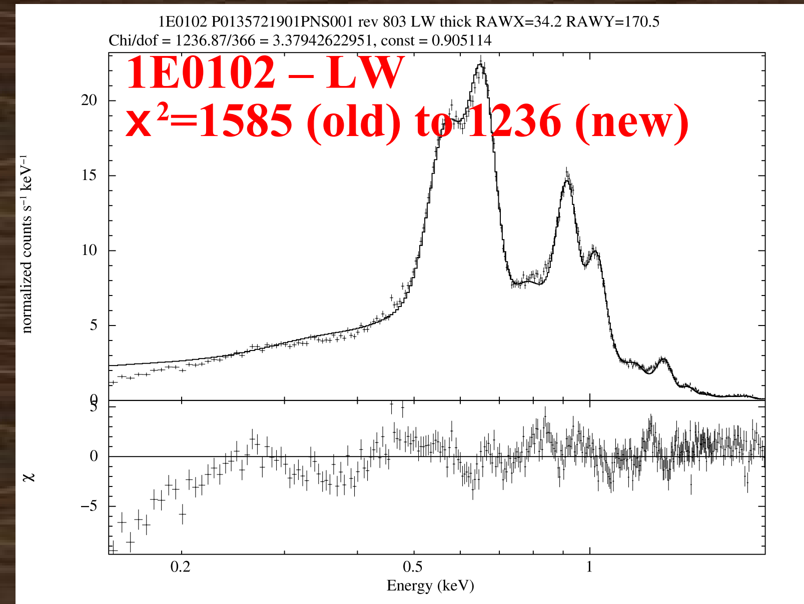


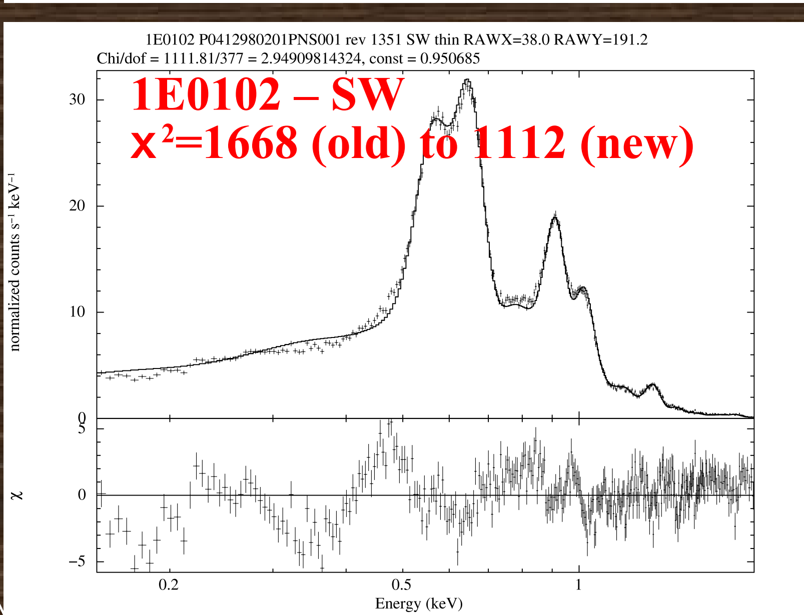


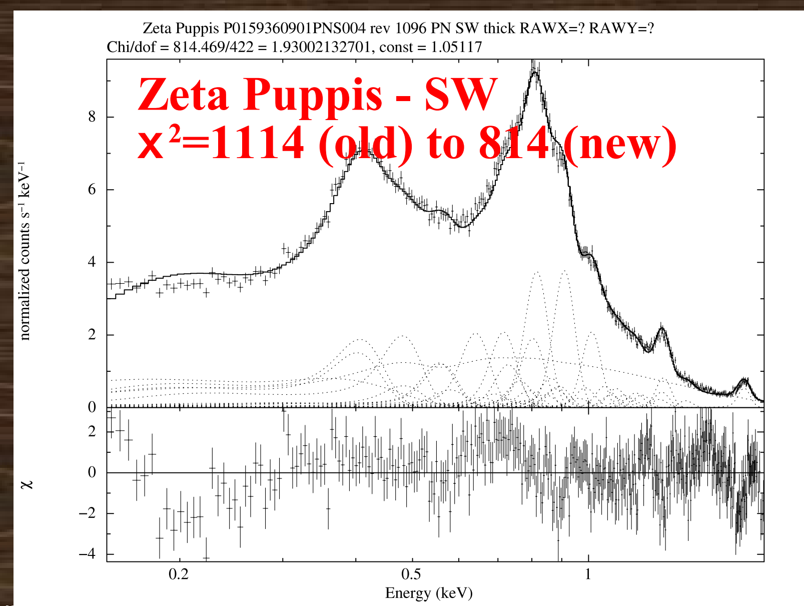
Results

(courtesy F.Haberl)



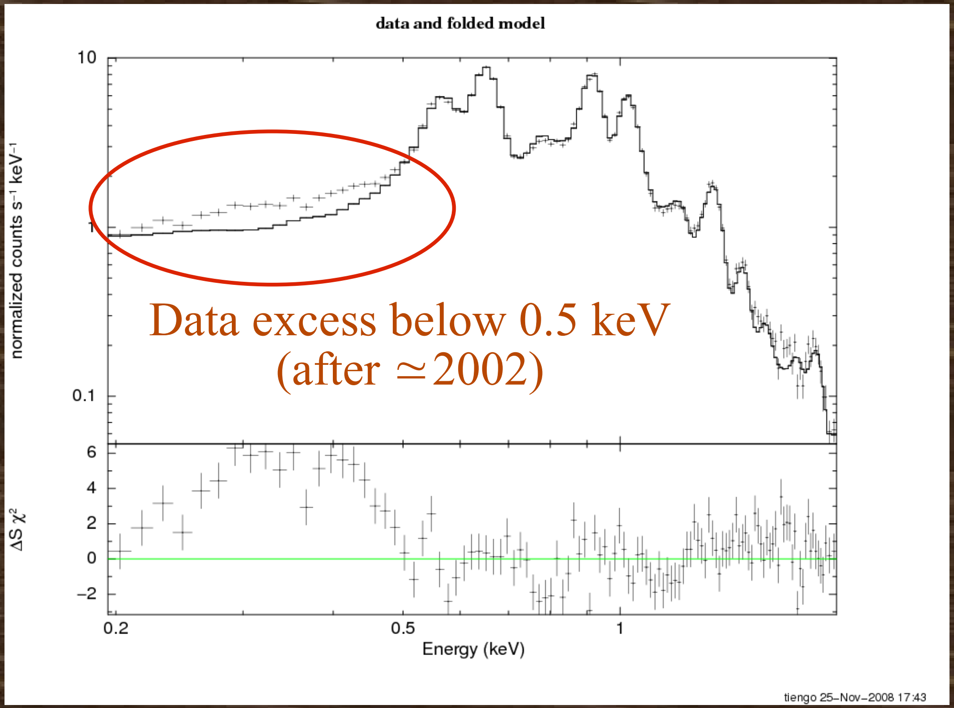


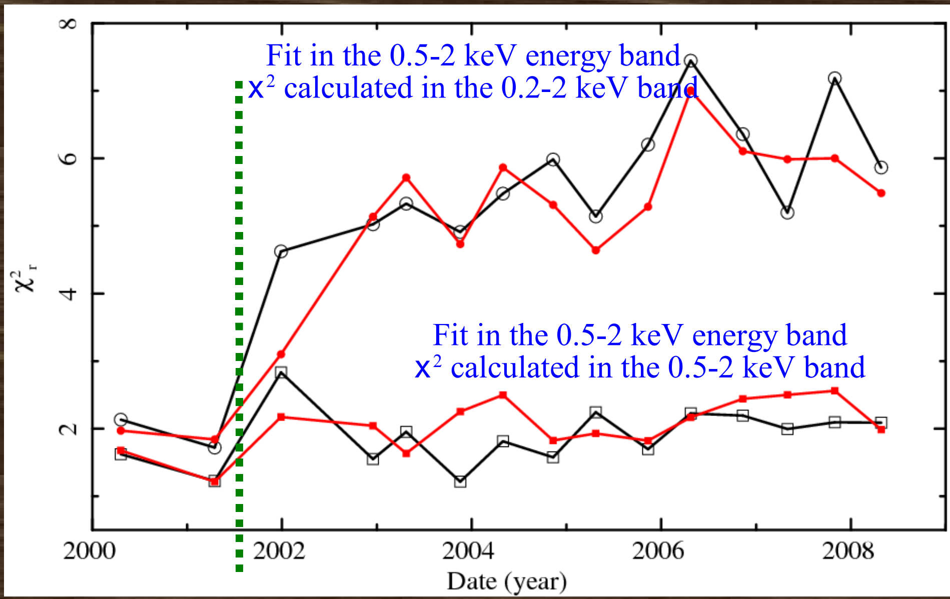




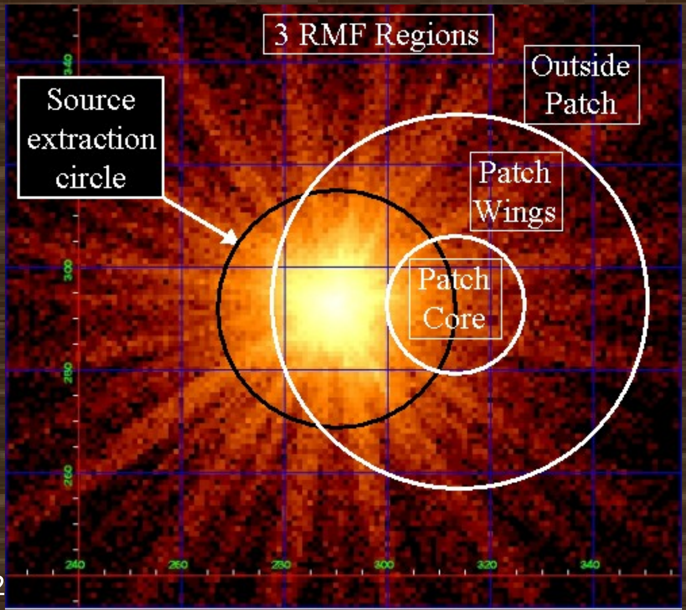
MOS redistribution patch: the problem

(courtesy A.Tiengo)



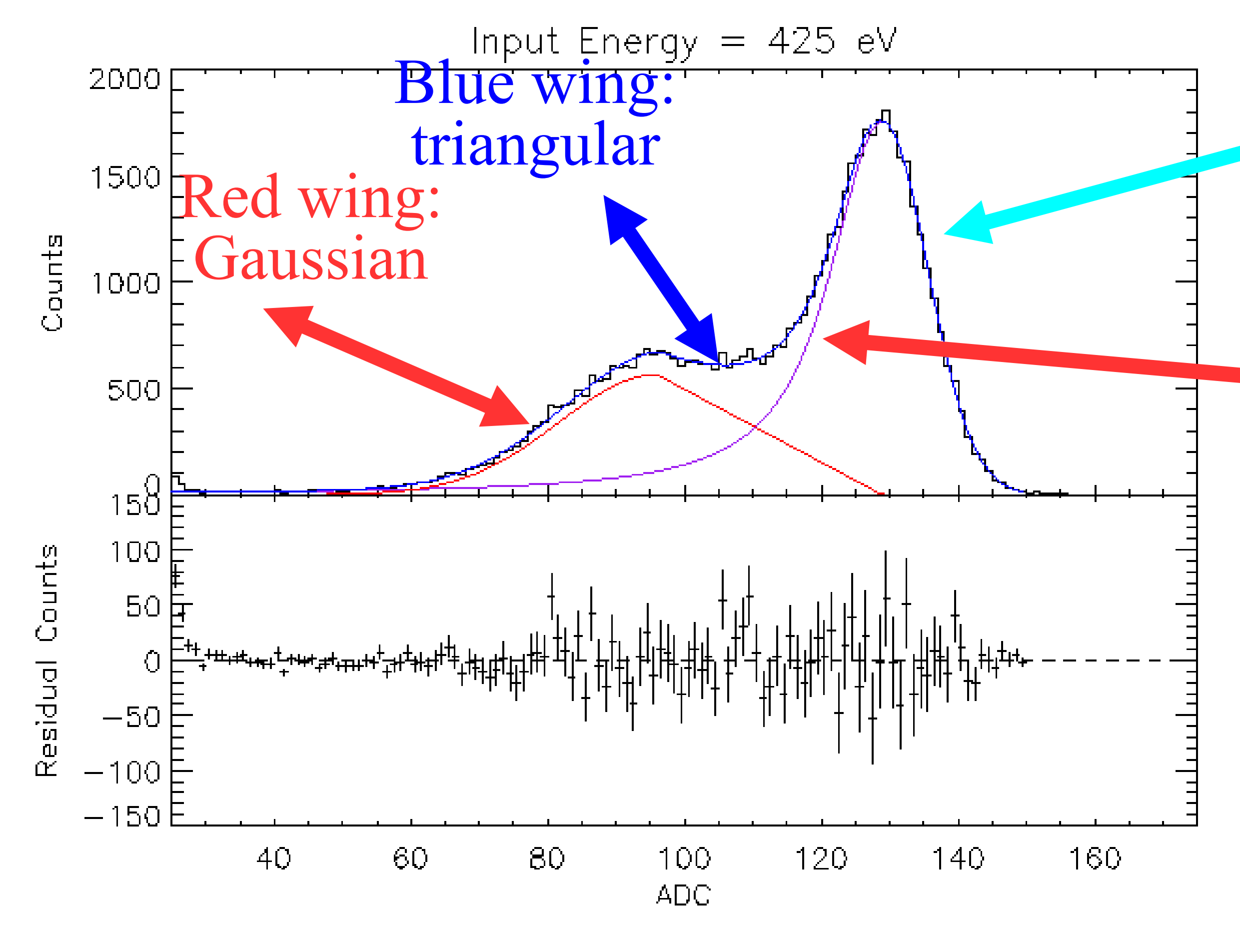


Effect due to not perfect calibration of the "MOS redistribution patch"



The new VRMF model

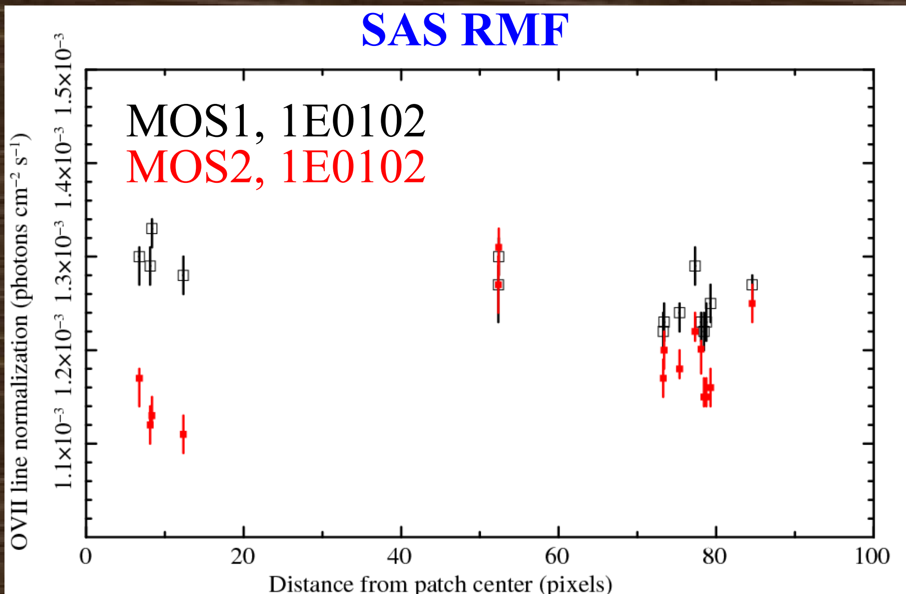
(courtesy S.Sembay)

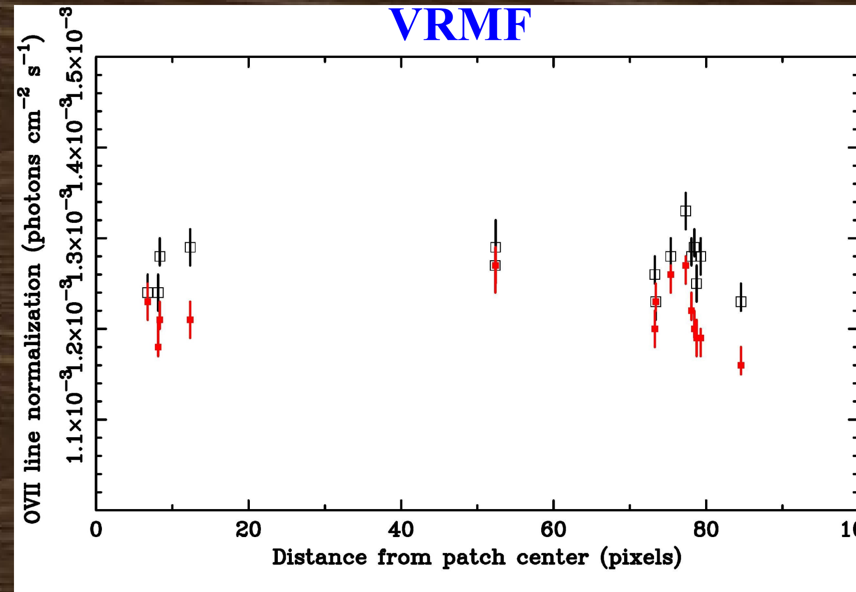


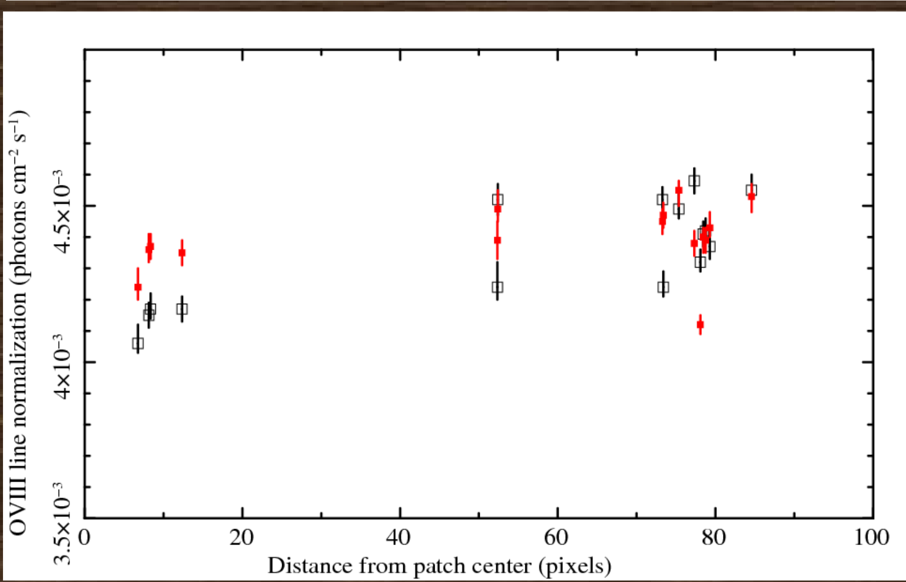
- Four parameters determine the overall shape: E_{peak}, $\sigma = a + b\sqrt{E}$, normalization
- ~30 times faster than the current SAS method

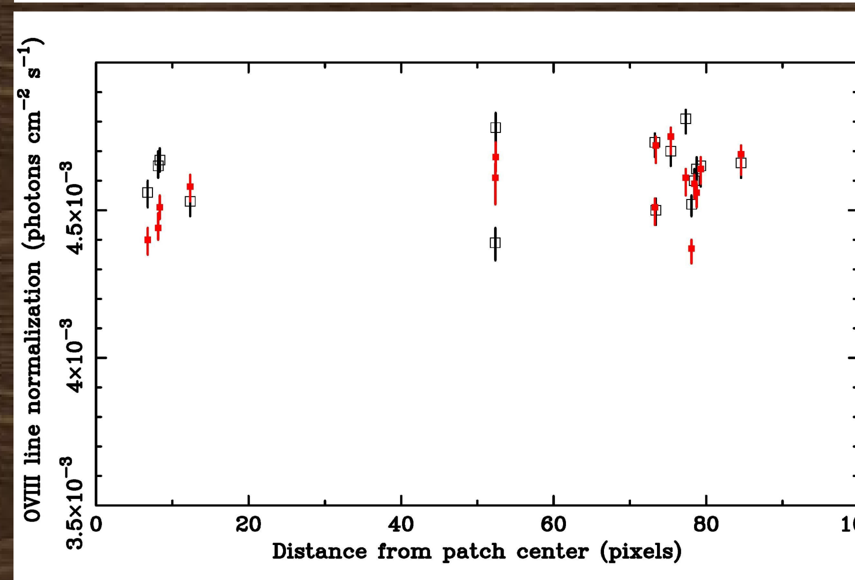
Results: line normalizations (O)

(courtesy A.Tiengo)



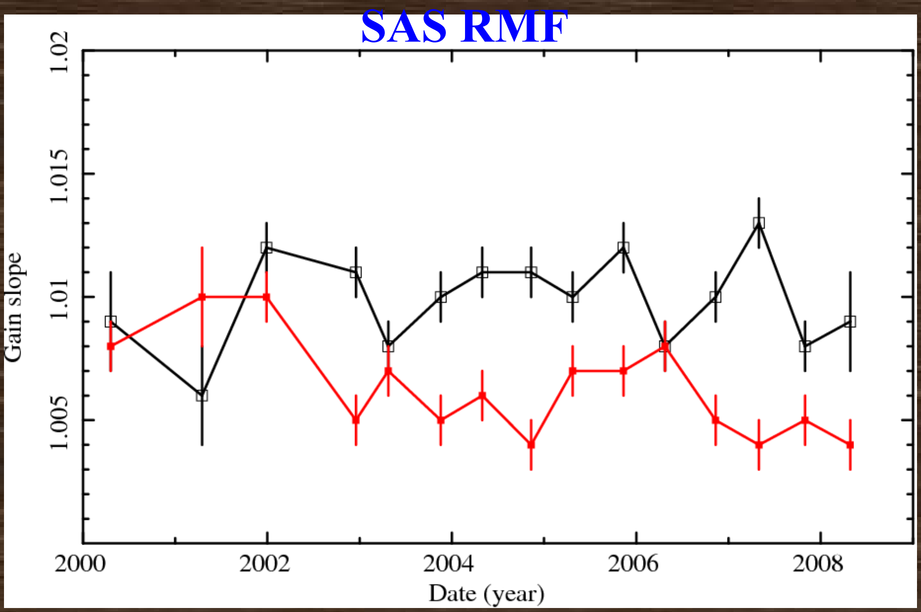


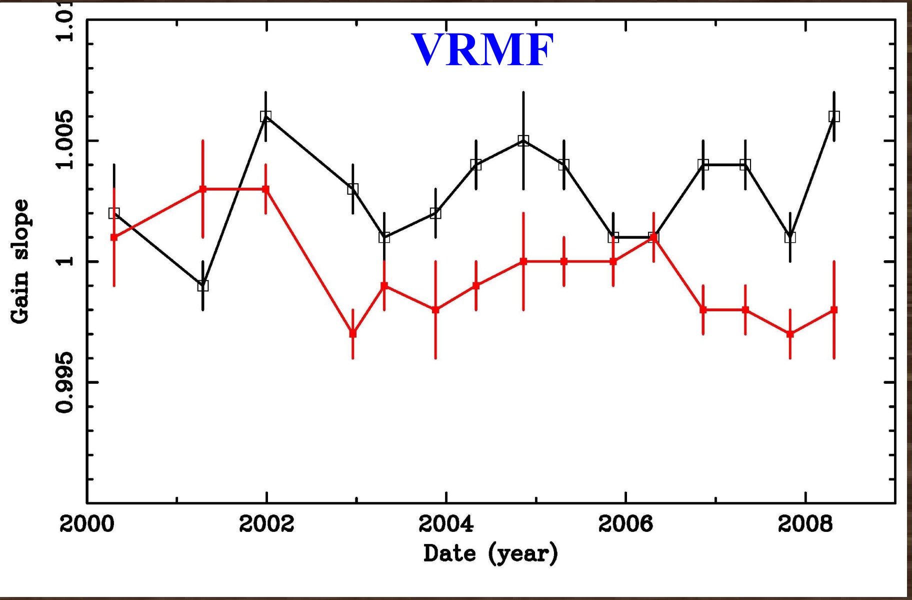


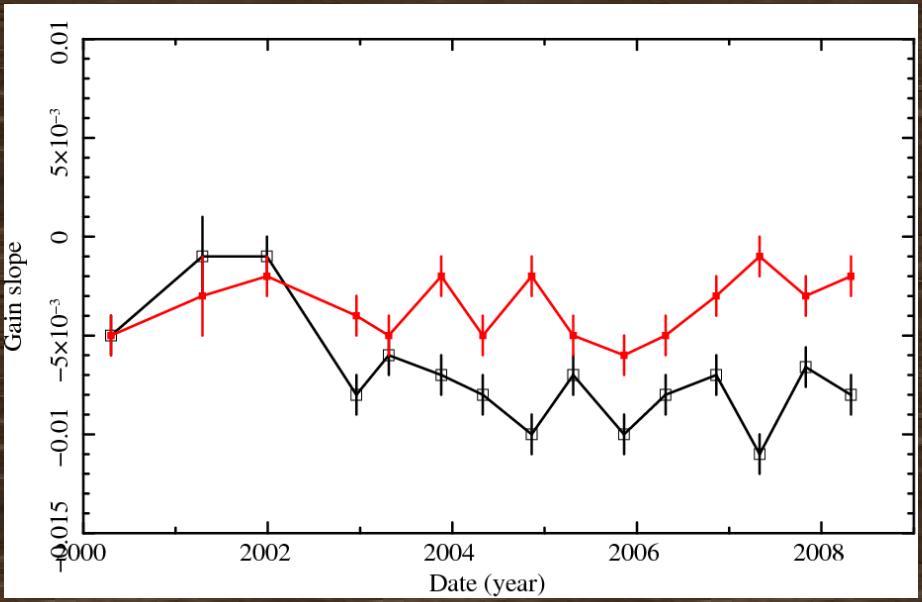


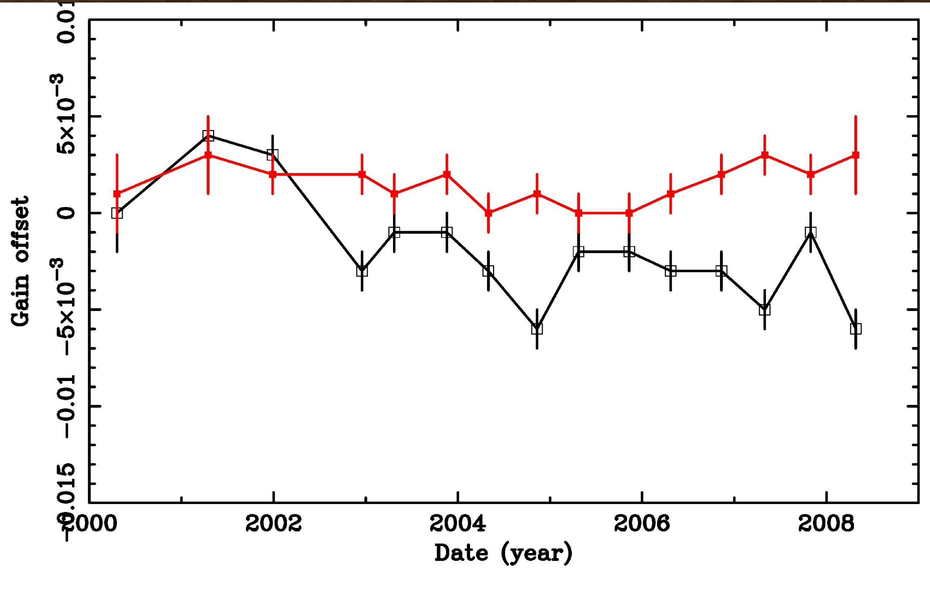
As a bonus we gain the gain

(courtesy A.Tiengo)



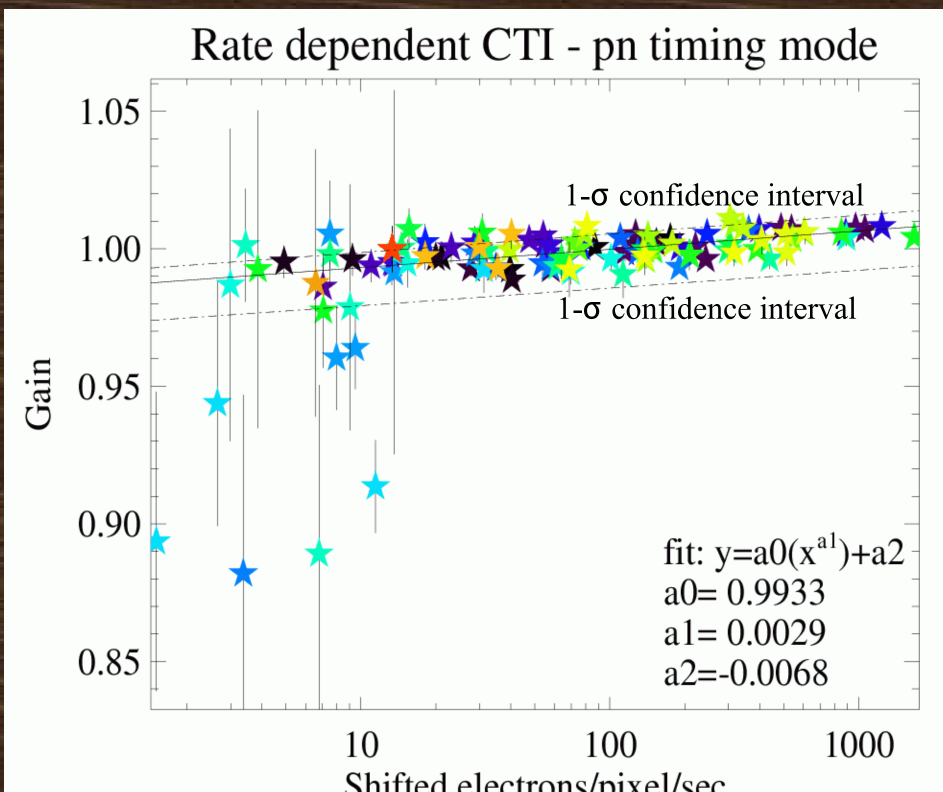


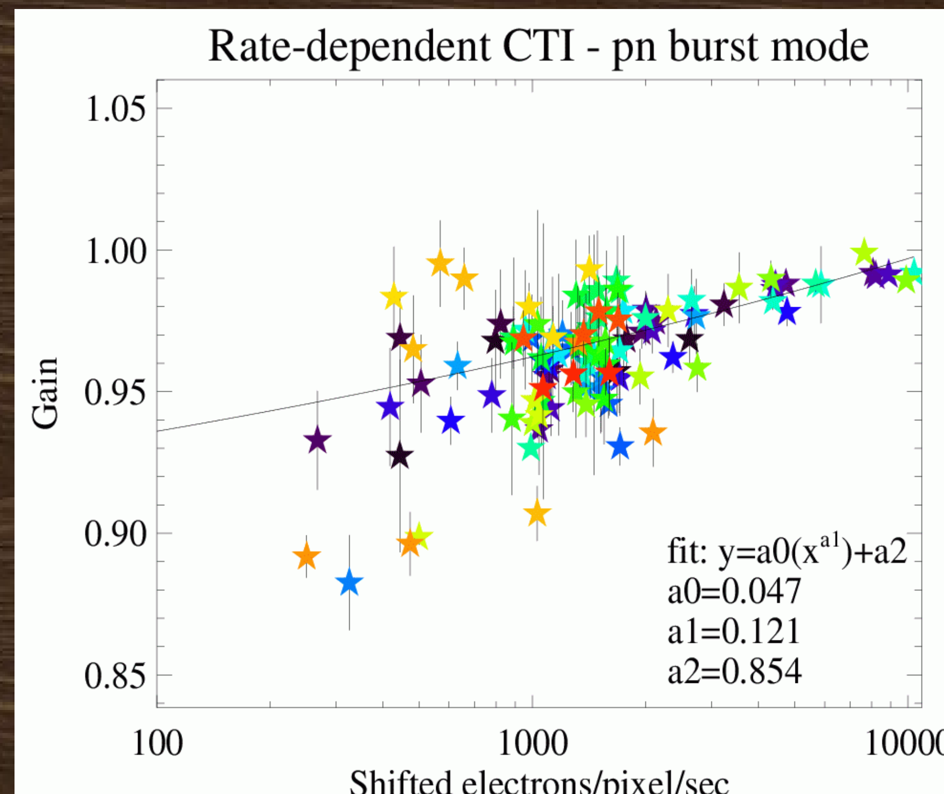




Rate-dependent CTI for pn fast modes

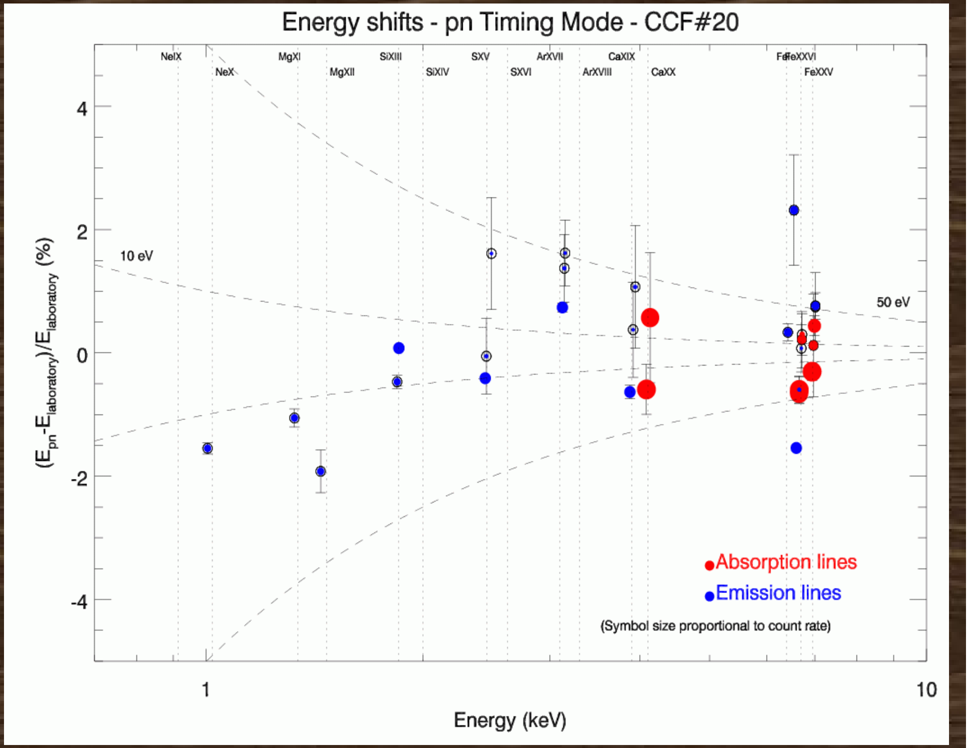
- Count-rate dependent shift of the energy scale
- Supported as of SASv8.0 – CCF available as of December 2008
- Calibrated on a sample of non variable sources: 42 observations in Timing and 36 observations in Burst Mode



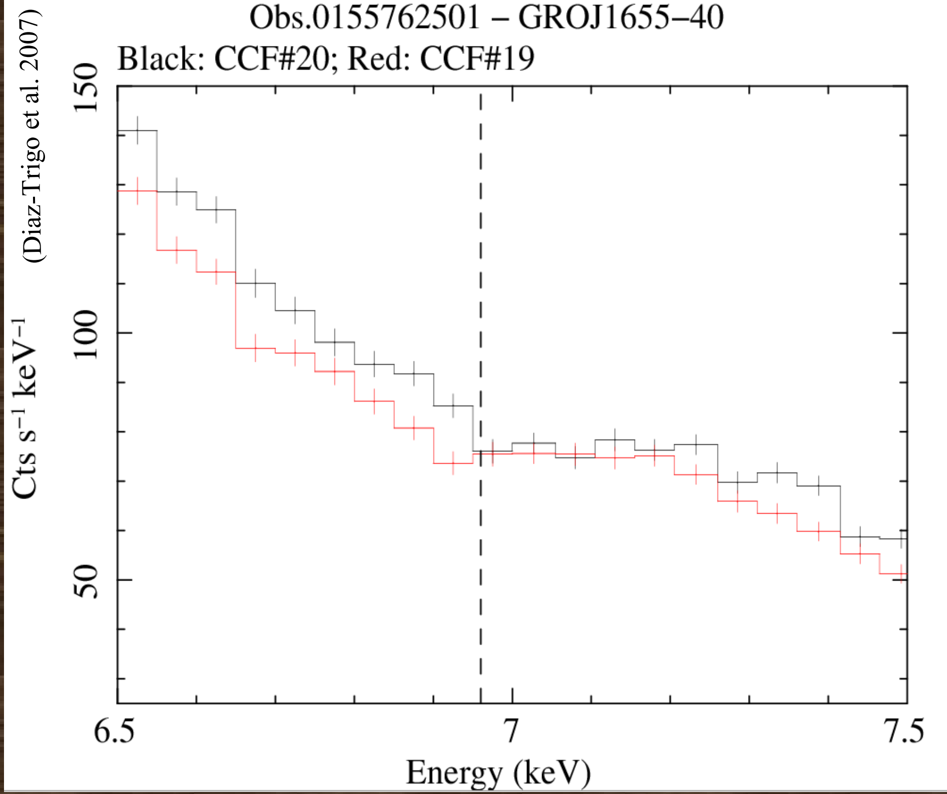


Post RDCTI spectral quality assessment

Timing Mode



Burst Mode



Difference to the laboratory energies:

▫ **20 eV (E<2 keV),** ▫ **50 eV (E≅6 keV)**

CCF#19: E=6.93± 0.02 keV
CCF#20: E=6.982± 0.017 keV
Nominal: 6.969-6.983 keV

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The *XMM-Newton* RGS effective area model

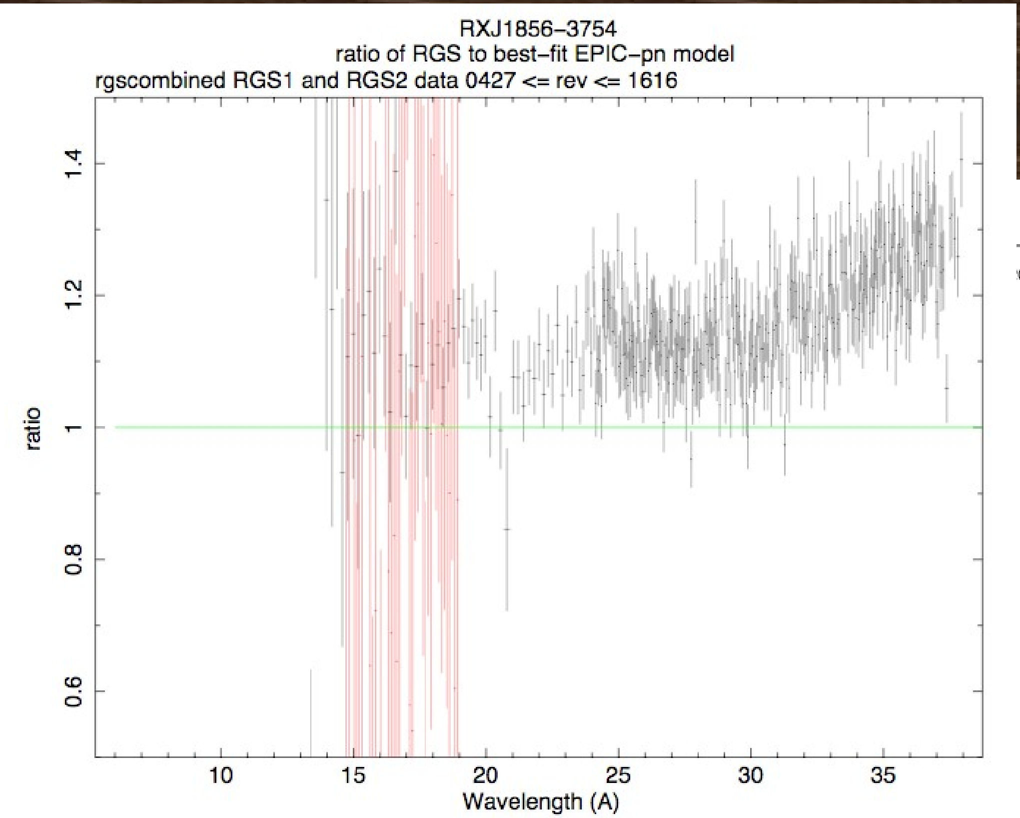
EFFAREACORR CCF = absorption(C*(t-t0),λ)) × areaCorrection(λ)

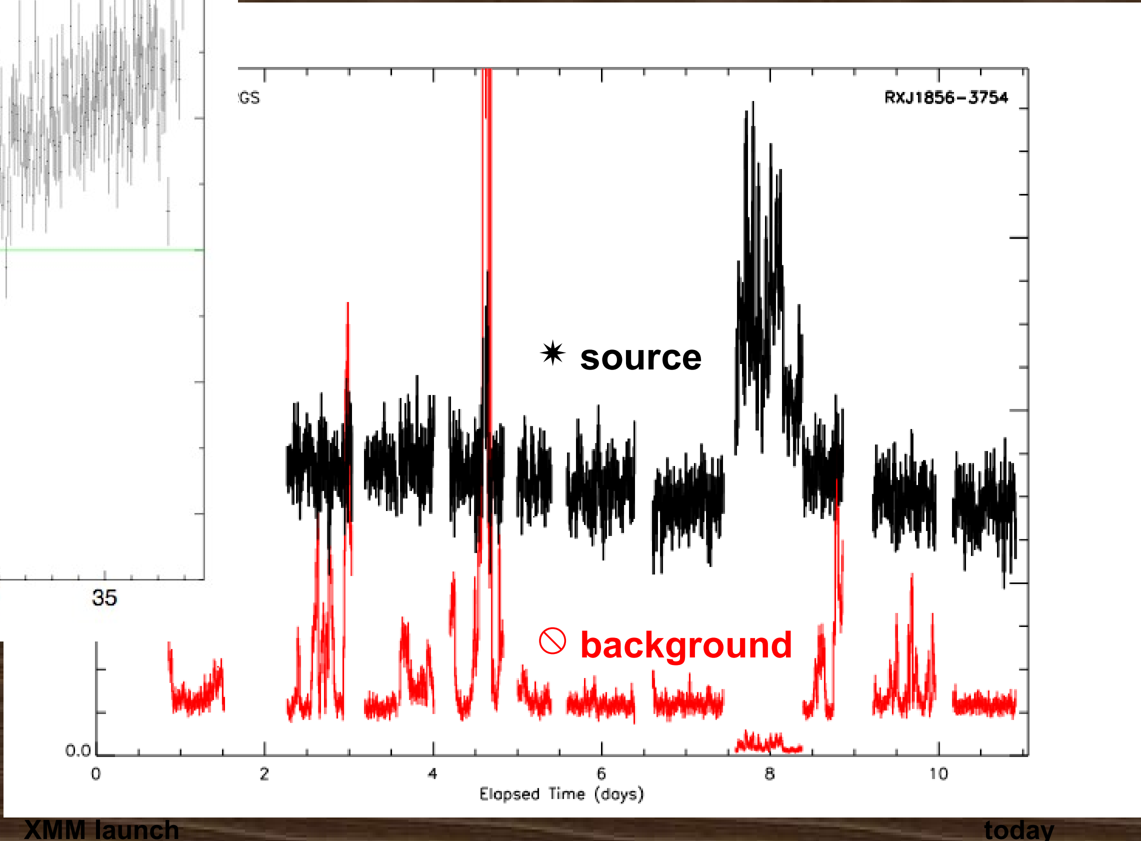
- thickness of carbon contamination C*(t-t0) increasing linearly with time
  - RXJ1856-3754 constant

- areaCorrection(λ)
  - Mkn421 power-law spectrum
    - slope estimated from centre of the RGS waveband
  - Crab adjustment

- time-variable model parameters unchanged since last year

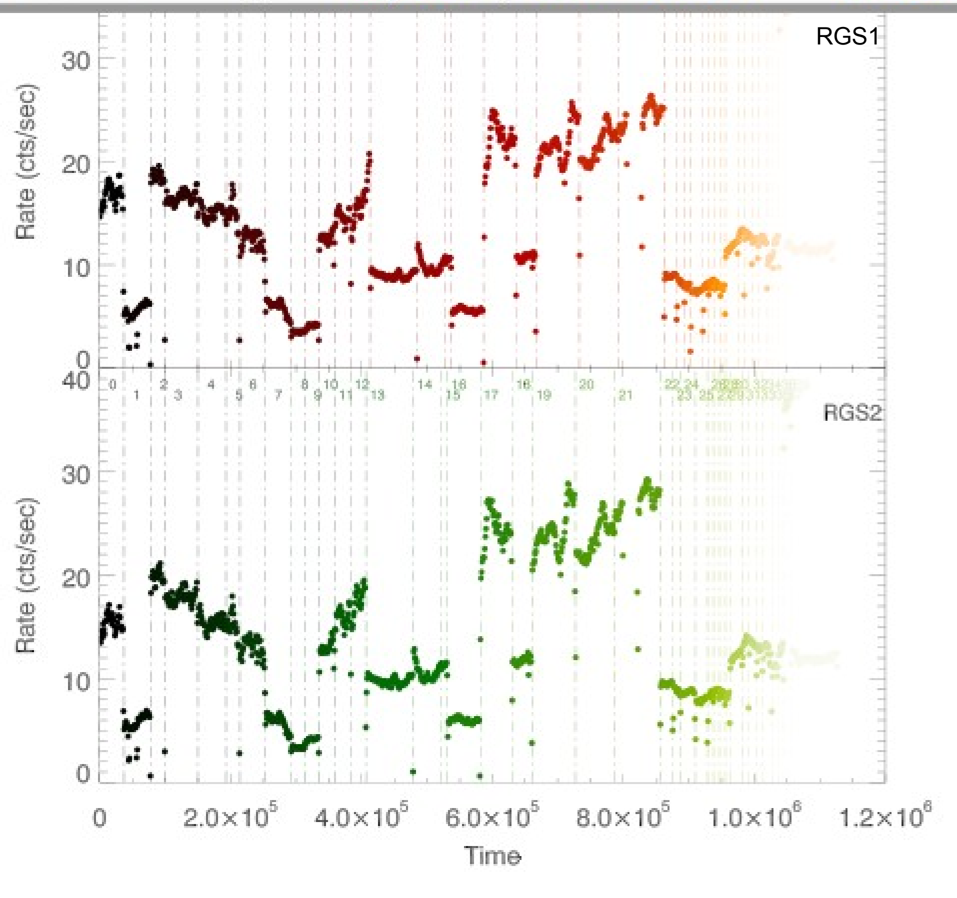
rgscombined RXJ1856-3754 compared to EPIC-*pn* model

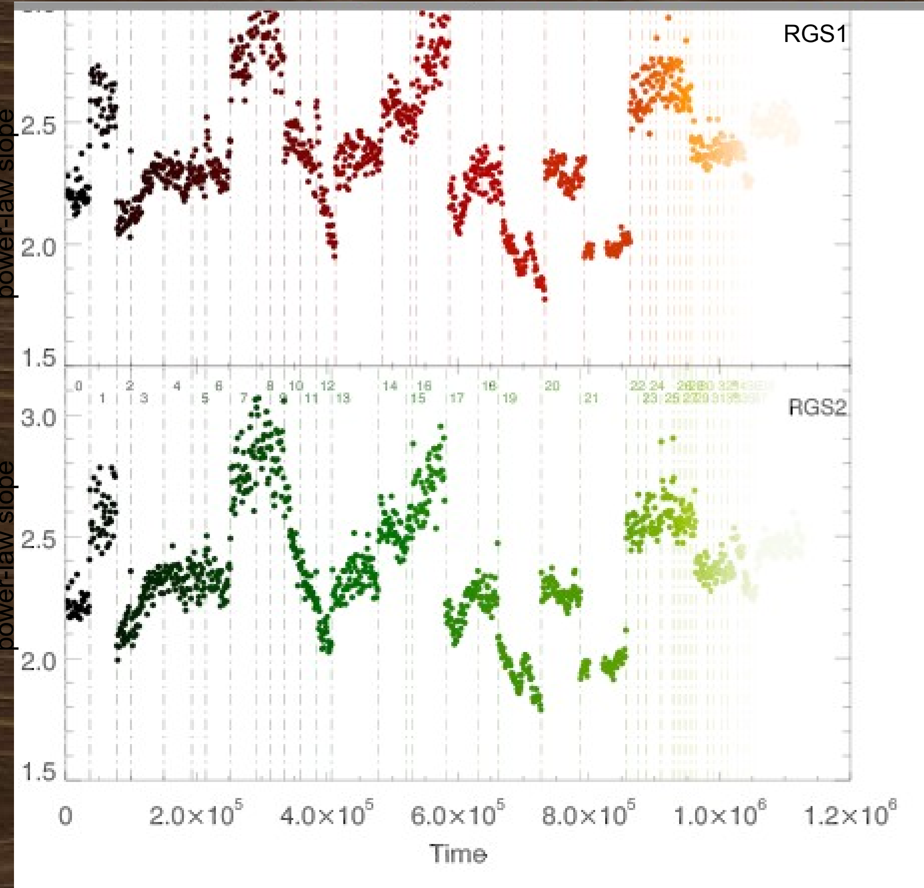




RXJ1856-3754's unvarnished `rgslccorr` history

Mkn421's RGS history in 1ks shots





de la Calle, Mingo, Ibarra

Audit of the RGS effective-area model

- RXJ1856+3754
  - constant enough
  - complementary contamination information required
    - contamination build-up more complex than assumed ?
  - model inconsistencies
    - IACHEC's job
- Mkn421
  - far from constant in flux or slope within XMM exposures
  - spectral curvature argued in the literature
    - *cf* SRON Crab nebula analysis
- Small background issues

What now ?

- Joint XMM calibration issues
    - EPIC pile-up
        - selection regions extensively assessed
- New RGS constraint
        - RXJ1856-3754 model constant
- continuum sources ⊕ **line-rich sources**
    - RGS ⇔ EPIC
    - Better constrained contamination history
        - NVI lines near 29 Å in ζ Pup

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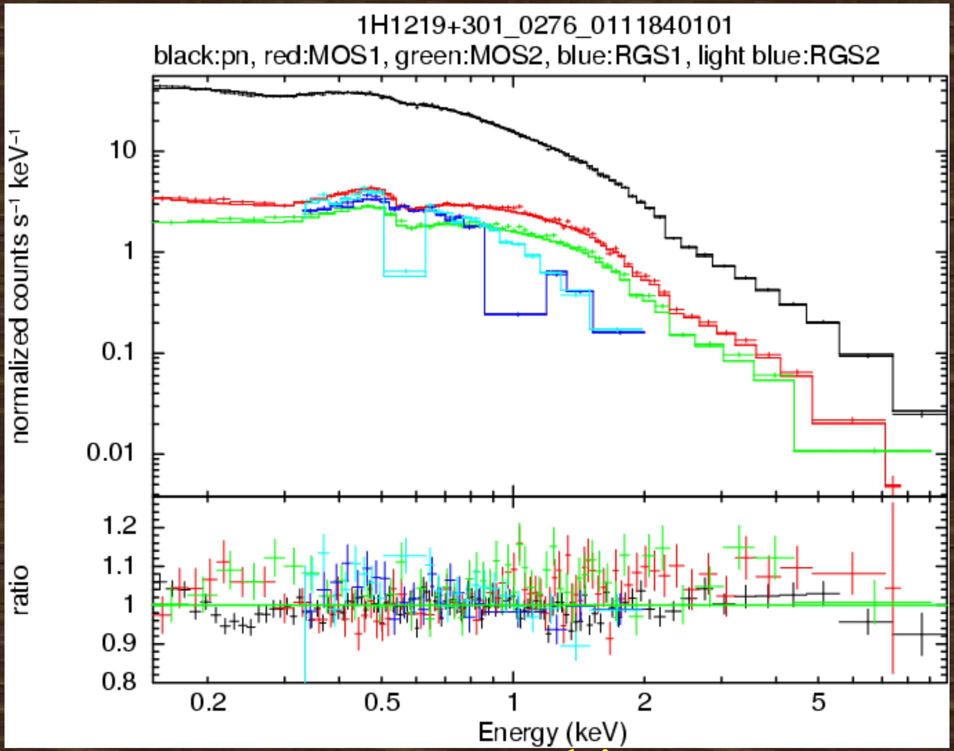
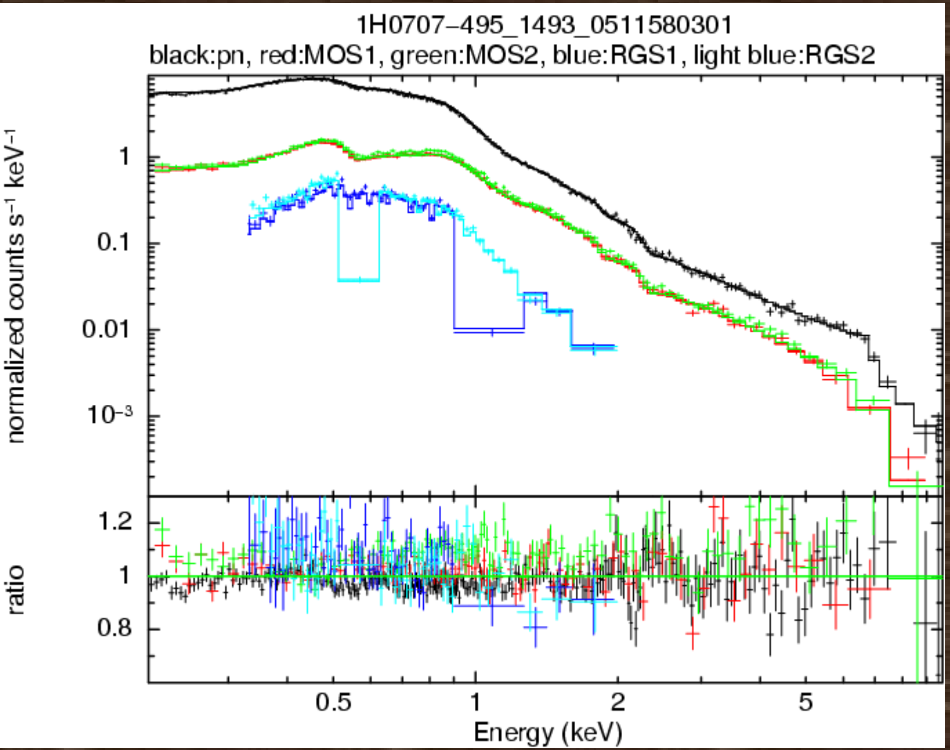
Cross-calibration XMM-Newton database

Database of ~150 observation of different sources, optimally reduced, fit with spectral models defined on a source-by-source basis

Public interface available at:
http://xmm2.esac.esa.int/external/xmm_sw_cal/calib/cross_cal/index.php

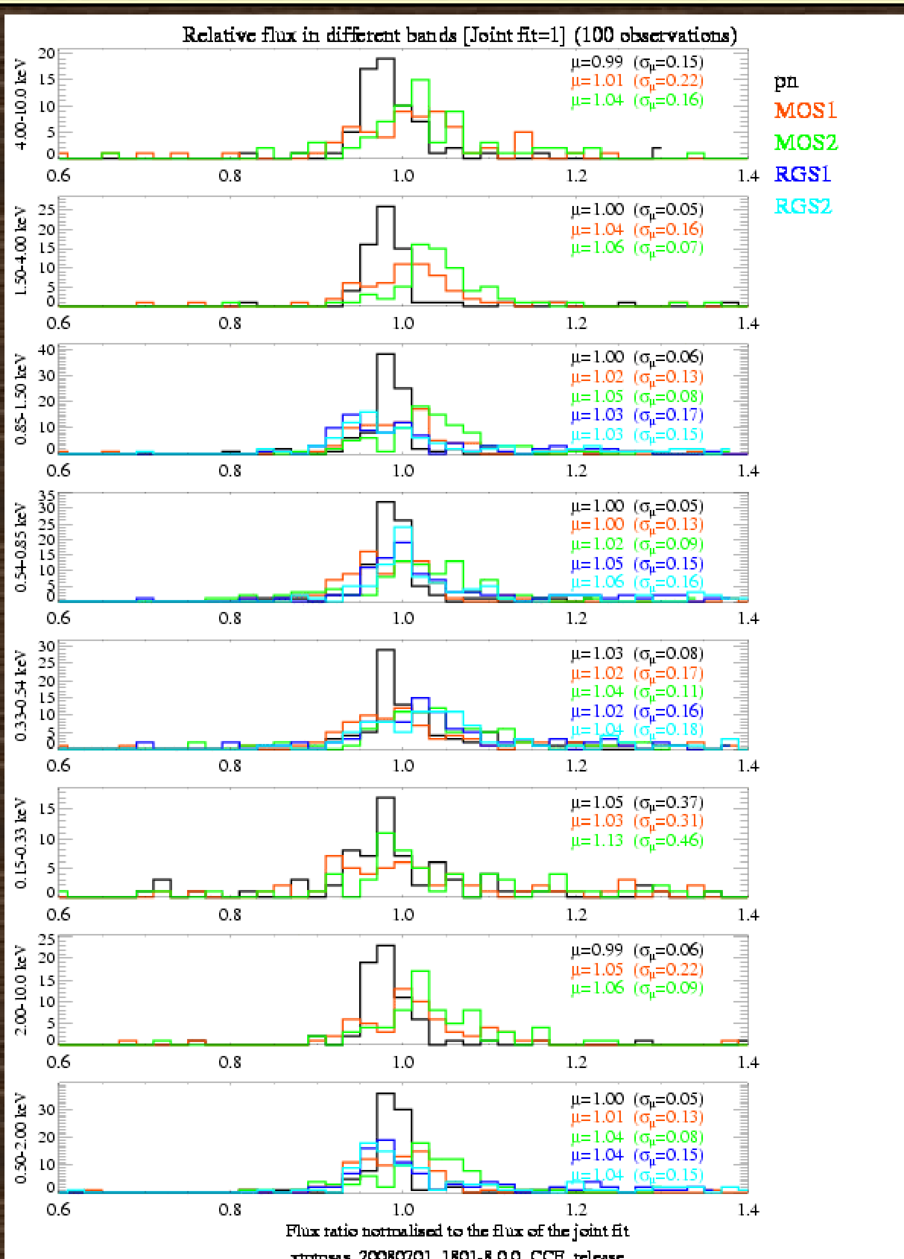


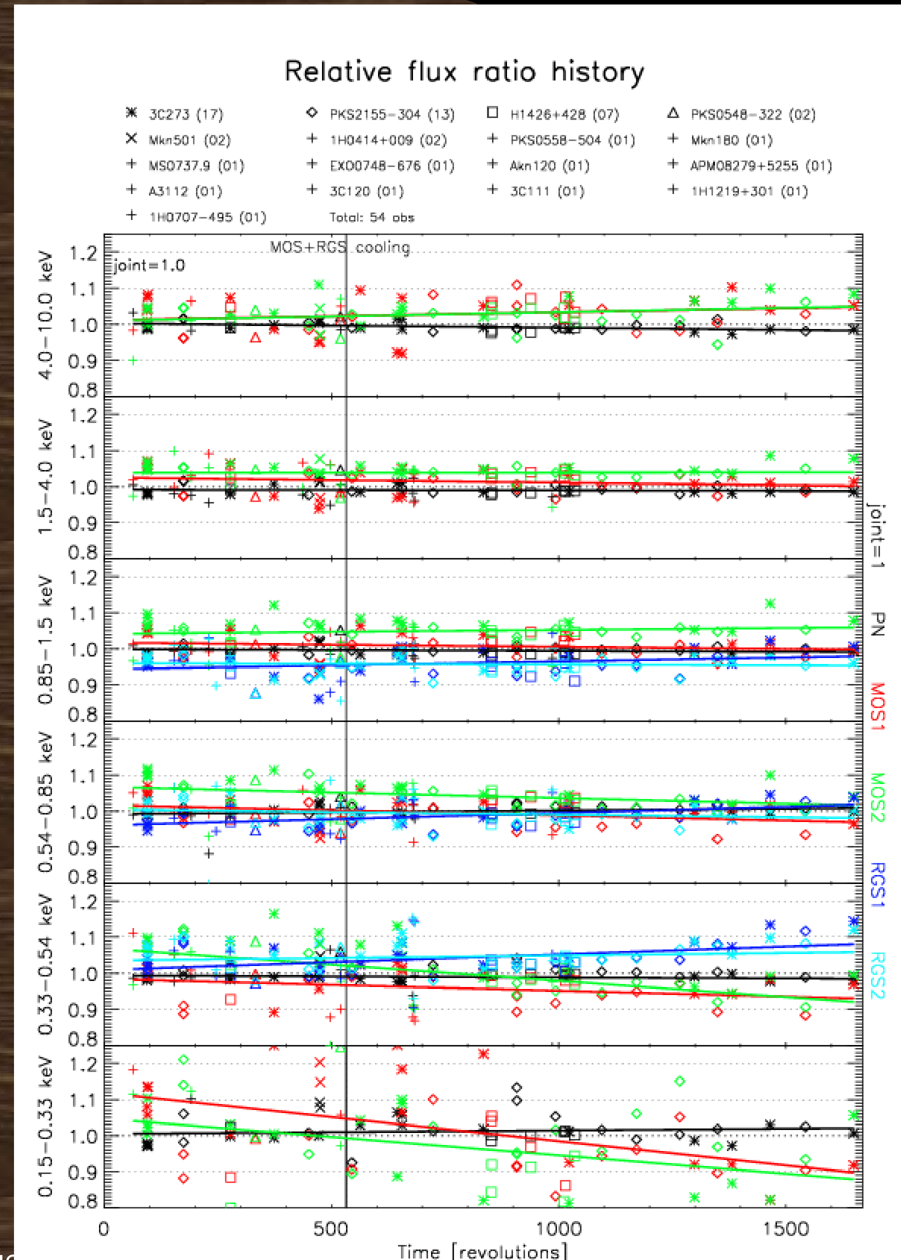
BL Lac object



Narrow Line Seyfert 1

Statistical flux evaluation for SASv8.0





Summary of XMM-Newton XCAL

- Above ~0.8 keV, MOS fluxes are higher by on average 5-8% than pn.
- Several MOS flux ratios show decrease, dependent on energy band.
- High deviations for MOS/pn flux ratios below 0.3 keV.
- RGS flux ratios are stable for all energy bands.
- Above O-edge RGS (up to 1.5 keV) and EPIC-pn agree to 2% on average.
- Below O-edge RGS fluxes are on average 5-10% higher than EPIC-pn.

EPIC and RGS are consistent on average within 10%.