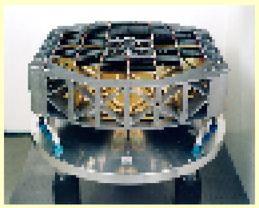
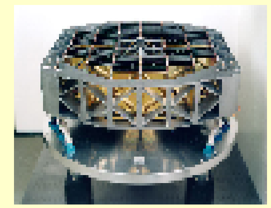
XMM-Newton (X-cross)-calibration



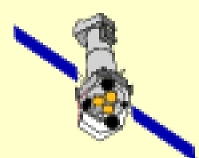


Presentation
Chandra Calibration Workshop
25/26 October 2004

Marcus G. F. Kirsch

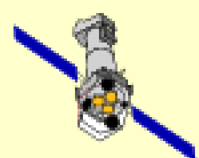
on behalf of

The EPIC consortium
The ESAC EPIC and RGS IDTs

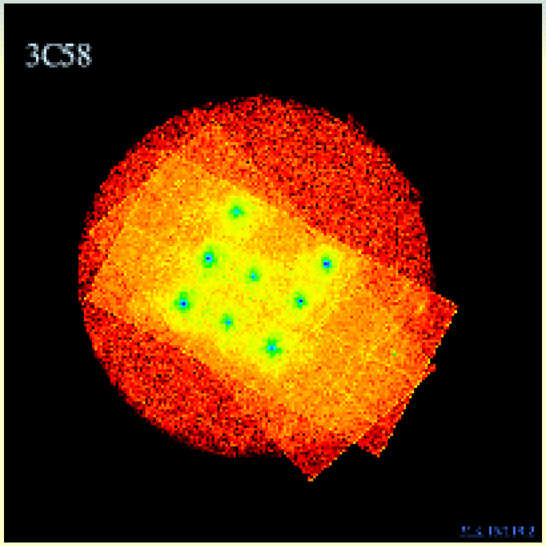


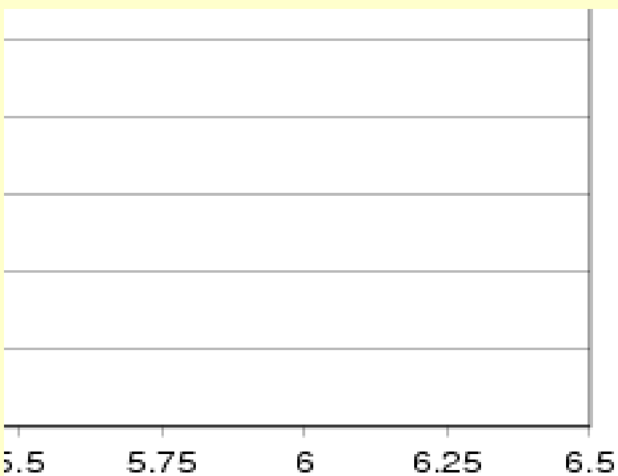
progress in calibration

- general EPIC
  - **Vignetting & Astrometry refinement :** offset of around 1' in the telescope axis from nominal determined and implemented. The new consideration of the right optical axis position improves the vignetting correction: differences in flux for off axis sources for each camera from ±14 % down to ± 5 % (XMM-SOC-CAL-SRN-156), new optical axis position required also a new BORESIGHT that was refined in combination with the MOS metrology (XMM-SOC-CAL-SRN-168, XMM-SOC-CAL-SRN-166)
  - **PSF:** refinement of parameterisation that yields consistent spectral fits for various different annular extraction regions (XMM-SOC-CAL-SRN-0167) → in the case of piled-up point sources, excising the piled-up core is now considered to be a valid analytical strategy
- MOS
  - **QE & RMF:** significant change in the low energy redistribution characteristics of the MOS cameras with time probably due to an increase in the surface charge loss property of the CCDs which degrades the low energy resolution. Epoch dependant calibration files have been produced which reflect these changes, but users should be aware that uncertainties in the model of the redistribution function of the MOS cameras remain. Spectral fitting can be performed down to 150 eV, but in these cases it is recommended that a systematic error of 2 % be applied (XMM-SOC-CAL-SRN-169)
  - **MOS Gain:** improvement in the epoch dependent CTI and Gain correction has reduced the uncertainty in the energy calibration from 10 to 5 eV for the imaging modes (XMM-SOC-CAL-SRN-161)
  - **MOS Timing Mode CTI:** improving earlier over correction by debugging some erroneous code in SAS. MOS Timing mode energy accuracy does now agree with the imaging modes within 0.3 %
- pn
  - **Low energy noise rejection for pn:** *epreject* corrects shifts in the energy scale of specific pixels due to high-energy particles hitting the EPIC PN detector during offset map calculation and suppresses the detector noise at low energies. In the case of timing mode data, flagging of soft flare events may be performed. (XMM-SOC-CAL-SRN-162)
  - **SW CTI correction** refinement. (XMM-SOC-CAL-SRN-172)
  - **Gold edge residuals** could be improved by modifying the telescope effective area (XMM-SOC-CAL-SRN-174)
- RGS
  - **QE:** RGS spectra between 6 and 7 Å now useful
  - **BG** model tool available with next SAS

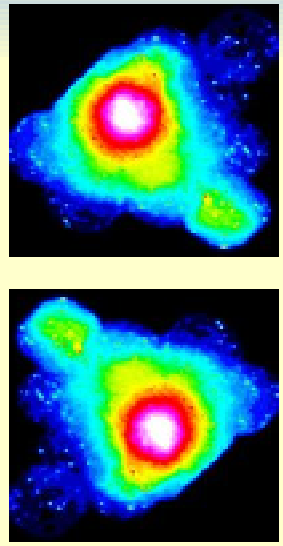


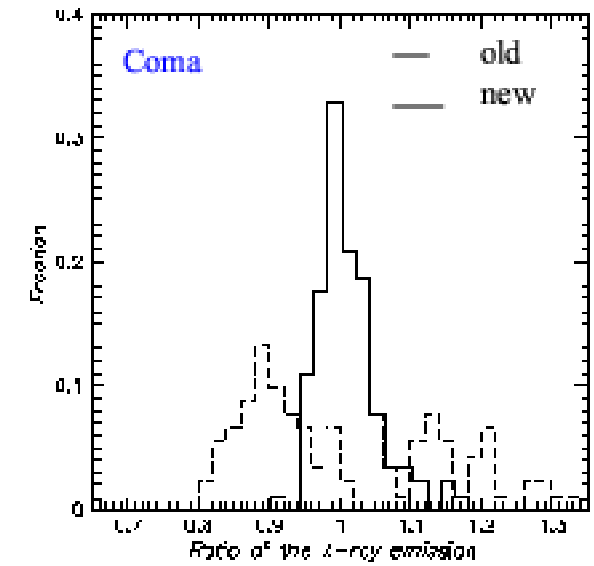
Vignetting





M. Kirsch



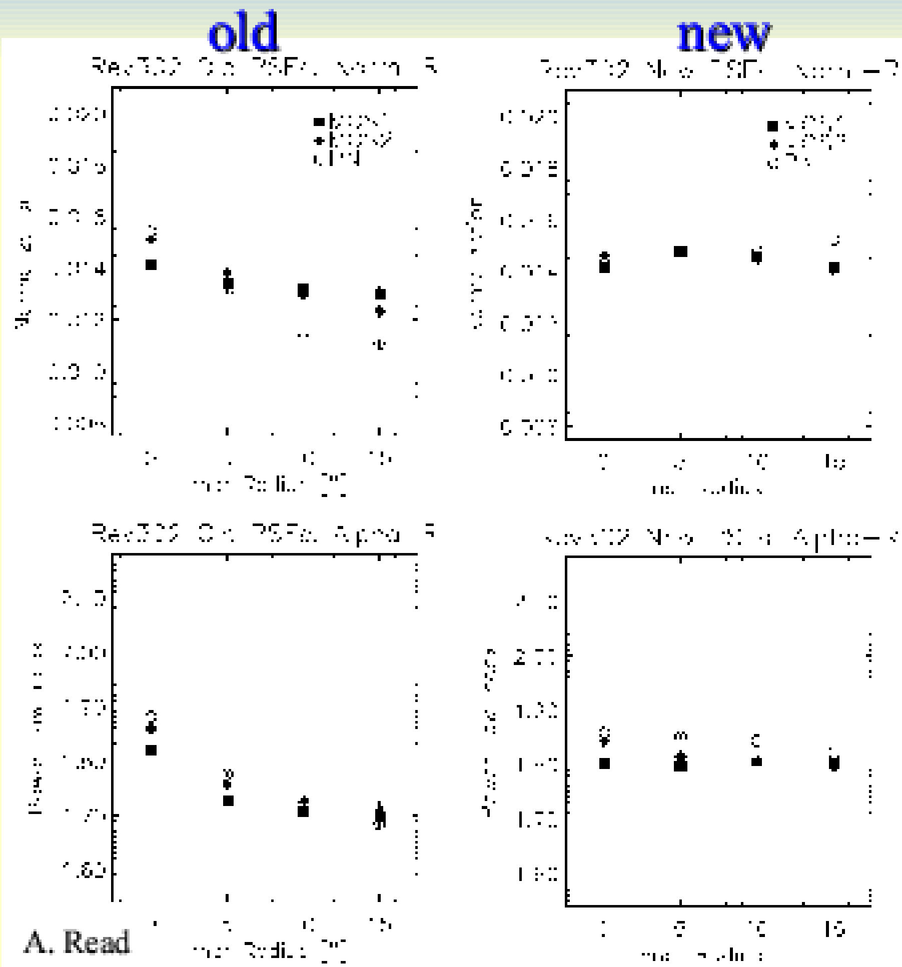


A. Finoguenov

- **Coma Cluster:**
14 % r.m.s. scatter in the surface brightness decreased to 3-5% r.m.s. (comparable with the statistical noise)

- **3C58:**
flux variation off axis reduced from ± 10 % down to ± 1-2 % for both MOSs

PSF: re-calibration

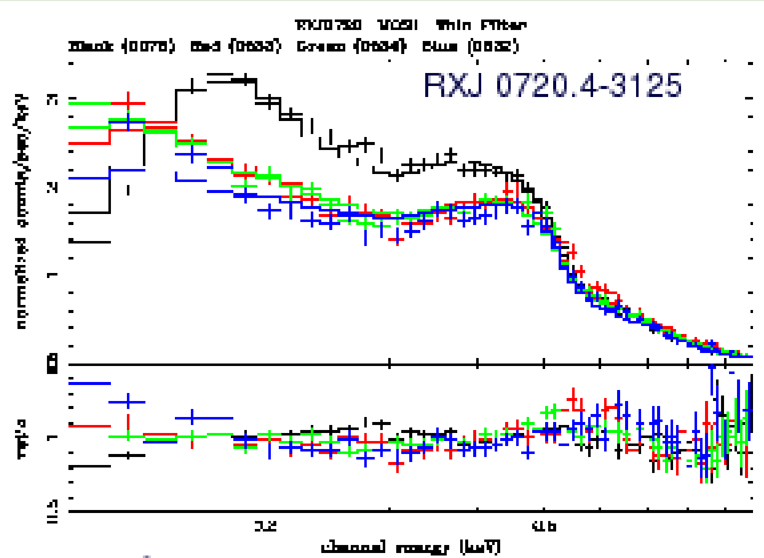


fitted normalization (top) and power-law index (bottom) vary as a function of extraction region (left to right: 0-30" circle, 5-40" annulus, 10-50" annulus, 15-60" annulus), using the old CCF PSFs (left) and the new CCF PSFs (right) for the MCG-06-30-15 Rev.302 data.

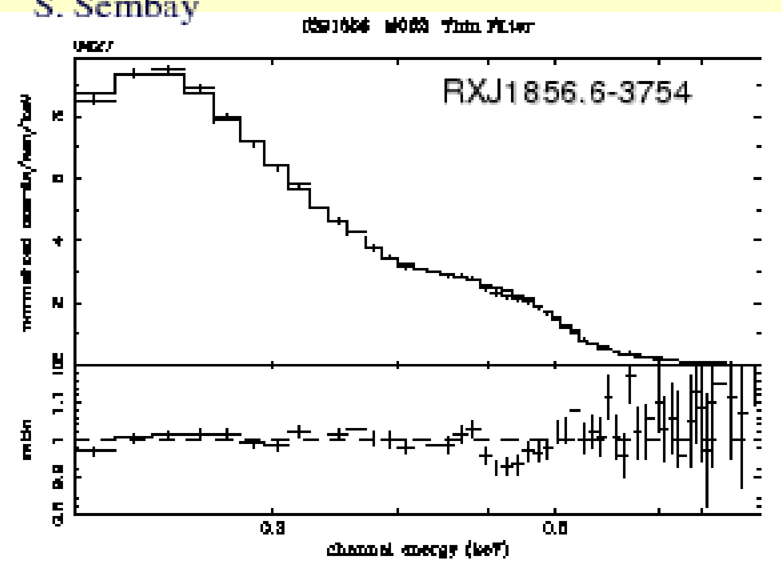
A. Read

- Refinement of King function parameterisation of the three EPIC PSFs.
- The linear dependencies of the PSF core radius r_0 and slope α with energy, obtained through earlier studies, have been found to be incorrect.
- Usage of the new PSFs yields consistent spectral fits for various different annular extraction regions such as are used in the analysis of piled-up sources.
- A consequence of improvements to the model of the PSF is that, in the case of piled-up point sources, excising the piled-up core is now considered to be a valid analytical strategy. Users should use the *epatplot* SAS package to assess the presence and level of pile-up.

MOS: low energy monitoring



S. Sembay



- **RXJ 0720.4-3125** was supposed to be NON variable however turned out as variable (A&A 2004,415L31D) assuming the column density is the same from observation to observation N_H is ~1.3E20 which is about 3E19 higher than measurements in the literature
- BB parameters allowed to vary. BB temperature fit shows an increase of about 3-4 eV which is consistent with the literature.
- generally poor fit is probably due to a combination of calibration uncertainties with the rmf and that the spectrum may not be a simple BB
- significant change in the low energy redistribution characteristics of the MOS cameras with time probably due to an increase in the surface charge loss property of the CCDs which degrades the low energy resolution
- **NO** evidence for contaminant
- epoch dependant calibration files have been produced which reflect these changes

- strategy changed: now **RXJ1856.6-3754** used as low energy monitor
- the best fit parameters give an N_H of 0.93E20, kT=63 eV (close to published values) but a reduced chi-squared of 1.75. A 2% systematic error makes the Chi-squared acceptable.
- this illustrates the point that the returned physical parameters are consistent with previous measurements, but the calibration needs refining.

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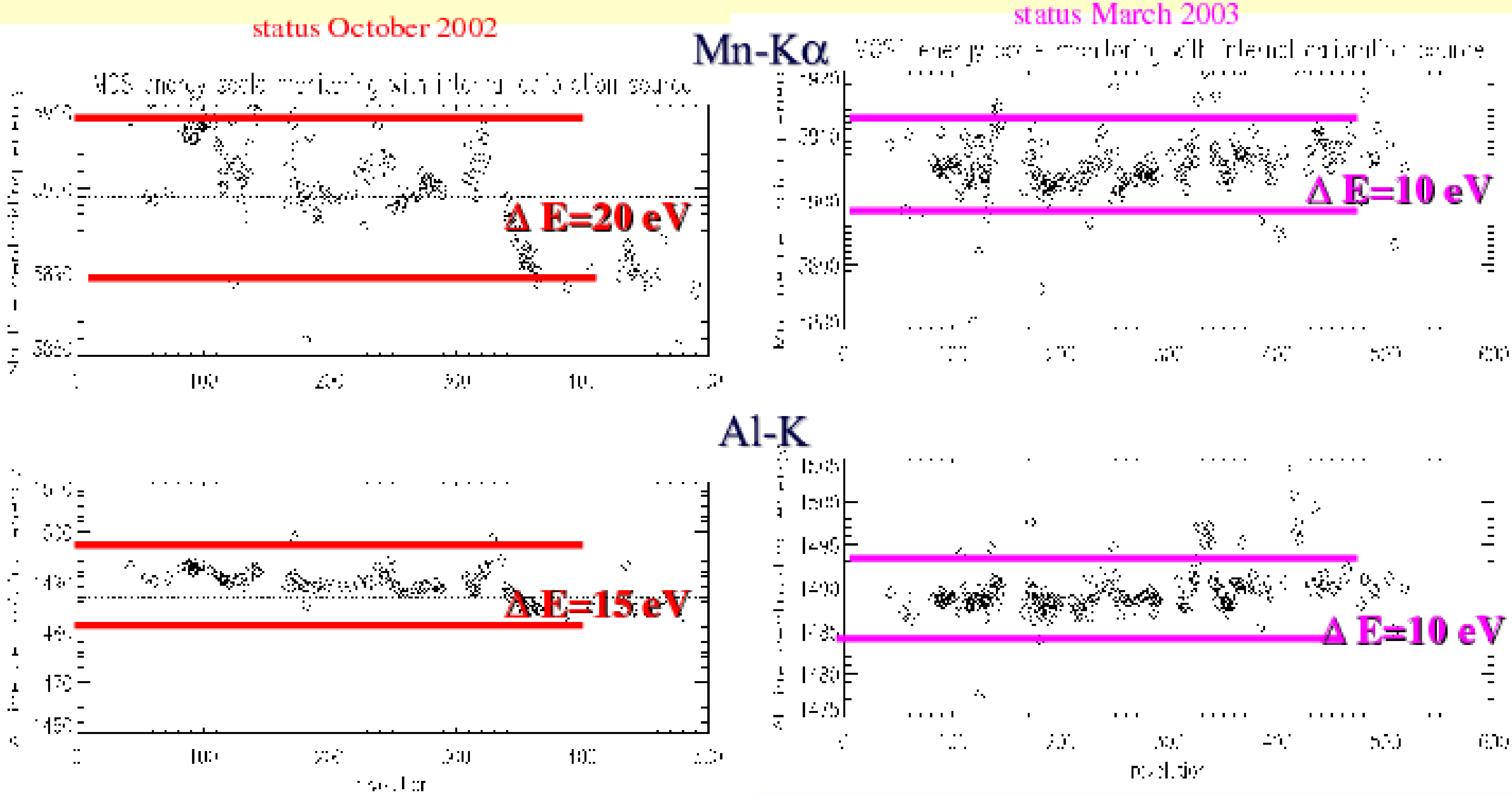
European Space Astronomy Center

MOS: reconstructed energies



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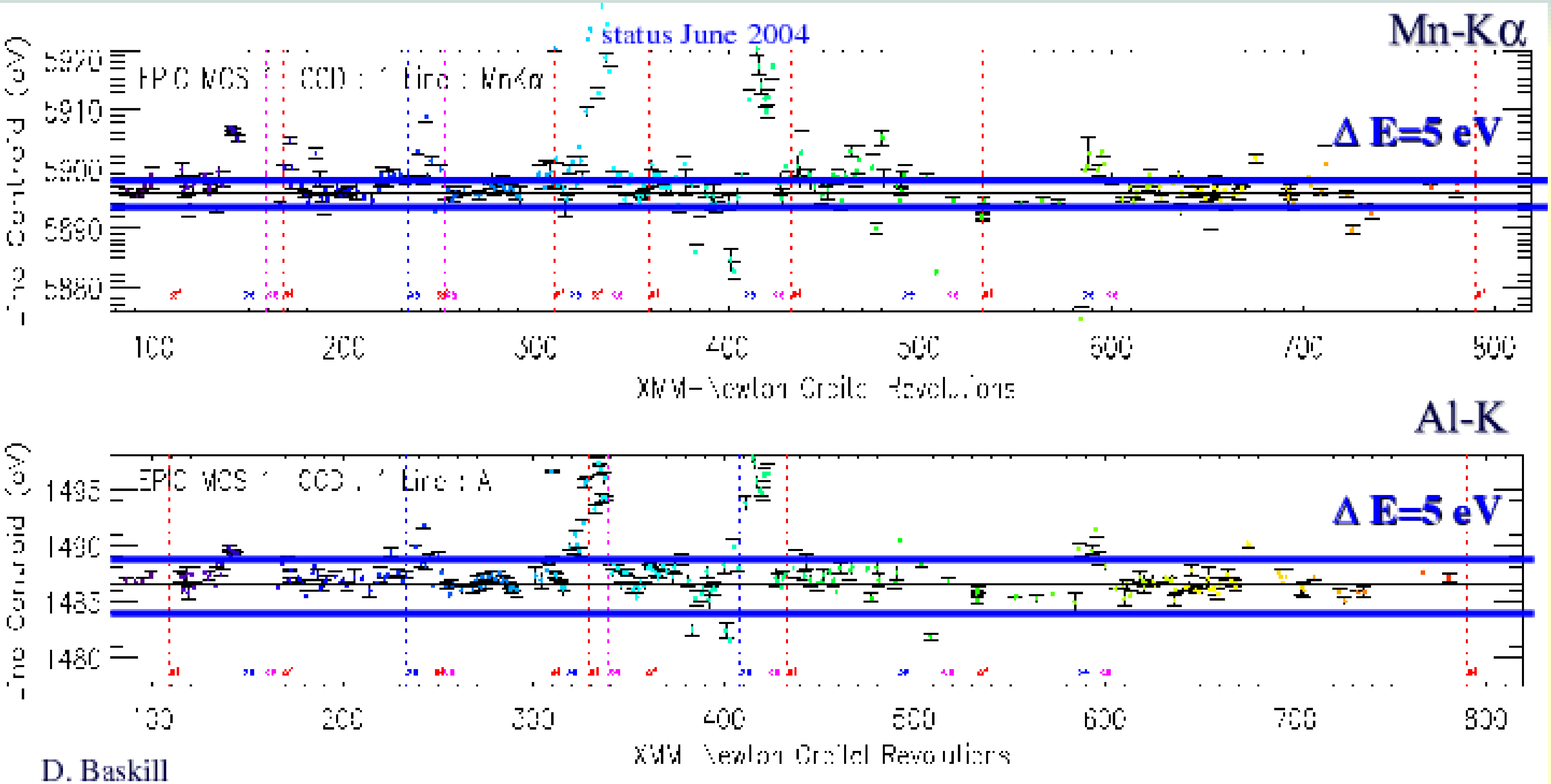
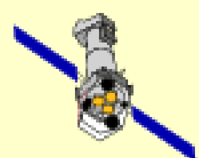
MOS: reconstructed energies



➡ improvement in the epoch dependent CTI and Gain correction in SAS 6.0.0 has reduced the uncertainty from 10 to 5 eV for the MOS cameras.



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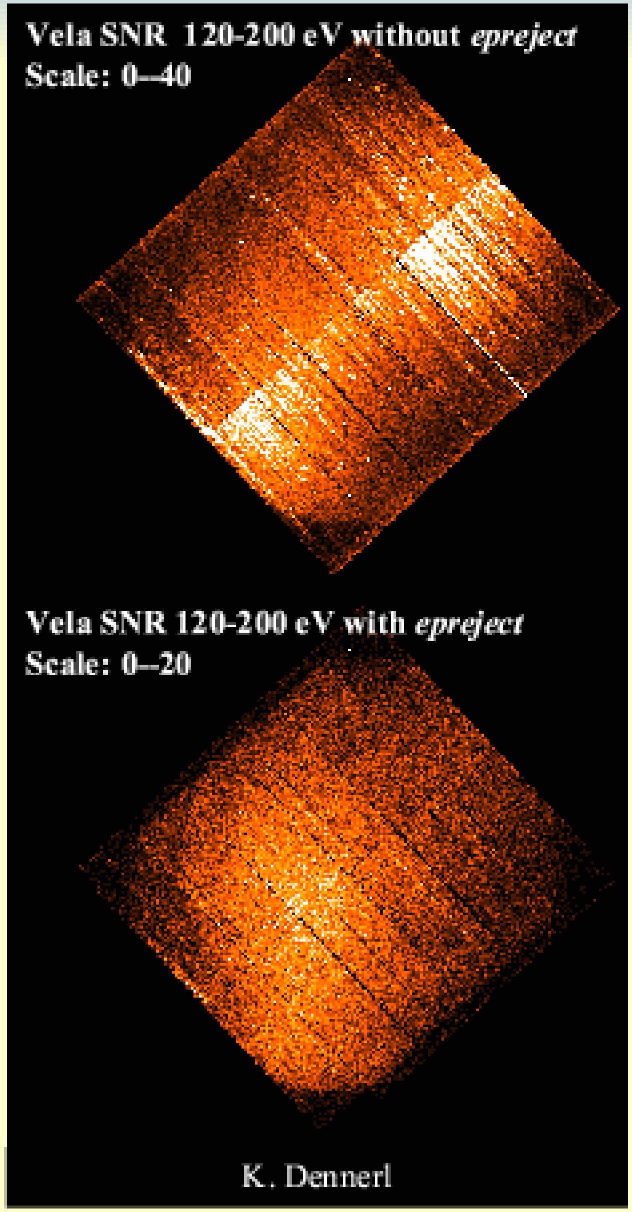
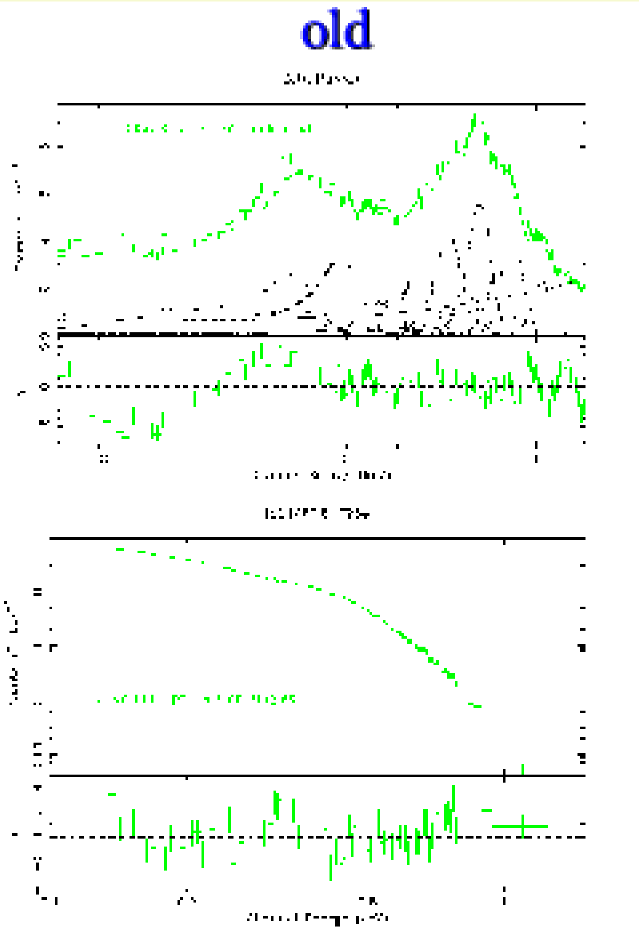
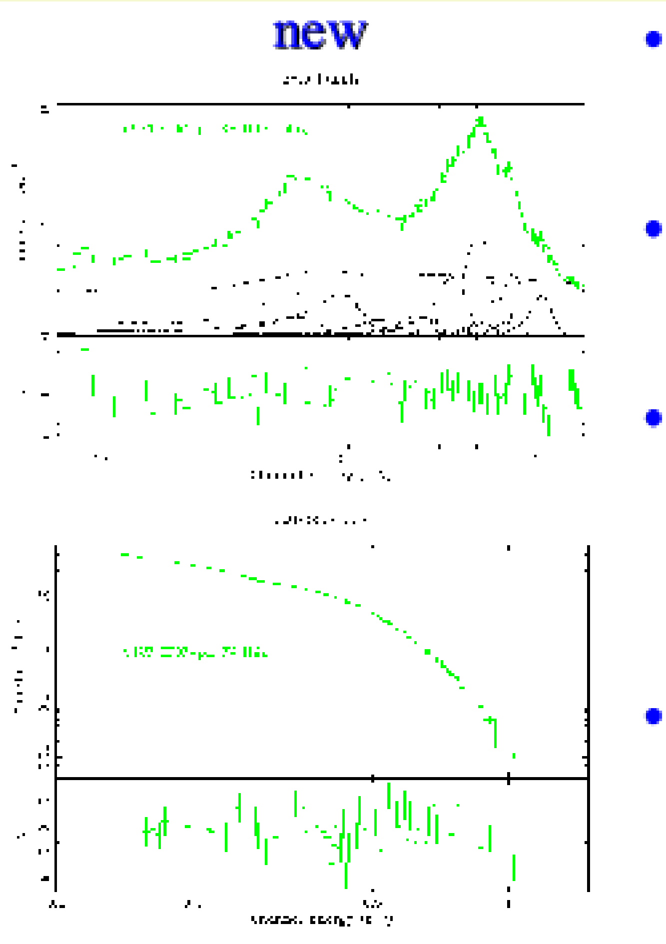
pn: low energy noise reduction



- ***epreject*** corrects shifts in the energy scale of specific pixels due to high-energy particles hitting the EPIC PN detector during offset map calculation
- suppresses the detector noise at low energies by statistically flagging events based on the known noise properties of the lowest energy channels
- The offset correction recovers errors of up to several 10 eV for point sources that happen to fall on a bright patch caused by a wrong offset value.
- The reduction of the detector noise allows to extend the useful energy range down to an instrumental energy of ~120 eV.
- In the case of timing mode data, flagging of soft flare events may be performed. (V. Burwitz)

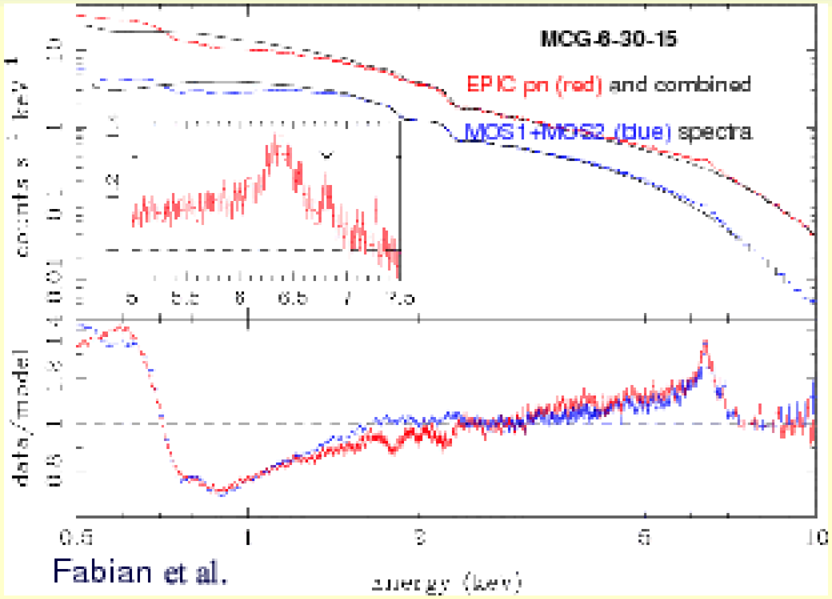
pn: redistribution



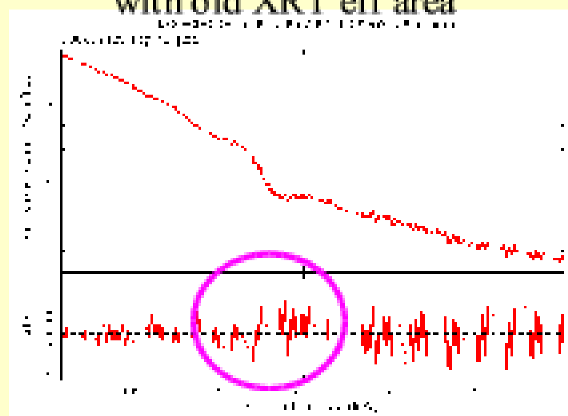


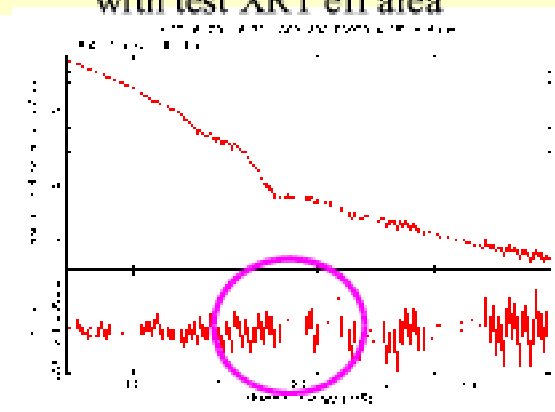
- spectral response below about 400 eV might not yet be correctly reproduced
- in particular the re-distribution as modelled in SAS 6.0.0 is higher than seen in the data
- this can lead to large (30%) systematic errors in the absolute flux of very soft spectral components (kT<100 eV)
- currently new response matrices are tested

pn: XRT effective area

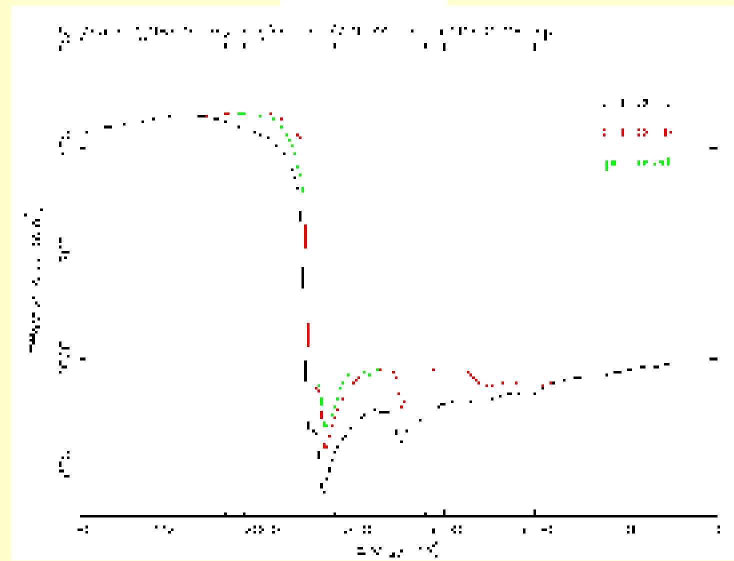


Fabian et al.





F. Haberl



- the old fellows for RGS and EPIC: Si-(no news) and Au-edge
- using obtained in-orbit data on continuum sources (flat around the edges) is the best way to calibrate the effective mirror areas across the edges.
- spectra with very high statistics from several sources justify change in mirror effective area around Au-edge

RGS: background

- shape of the RGS background spectrum is dependent only on its total intensity
- long-exposure blank fields used to accumulate intensity-dependent background templates
- individual background estimate synthesised from background light curve-weighted combination of templates
- perfect for extended sources in particular

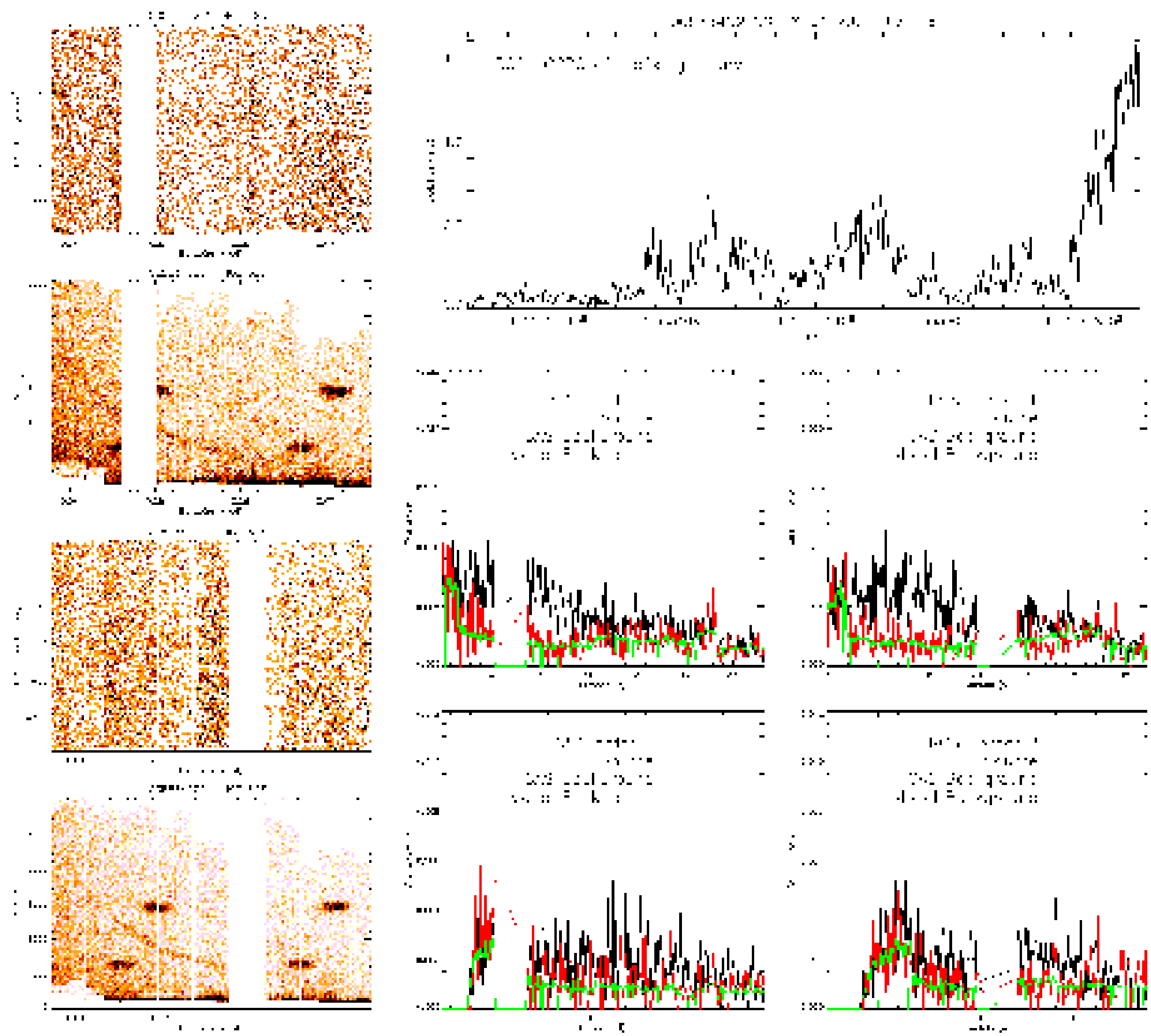
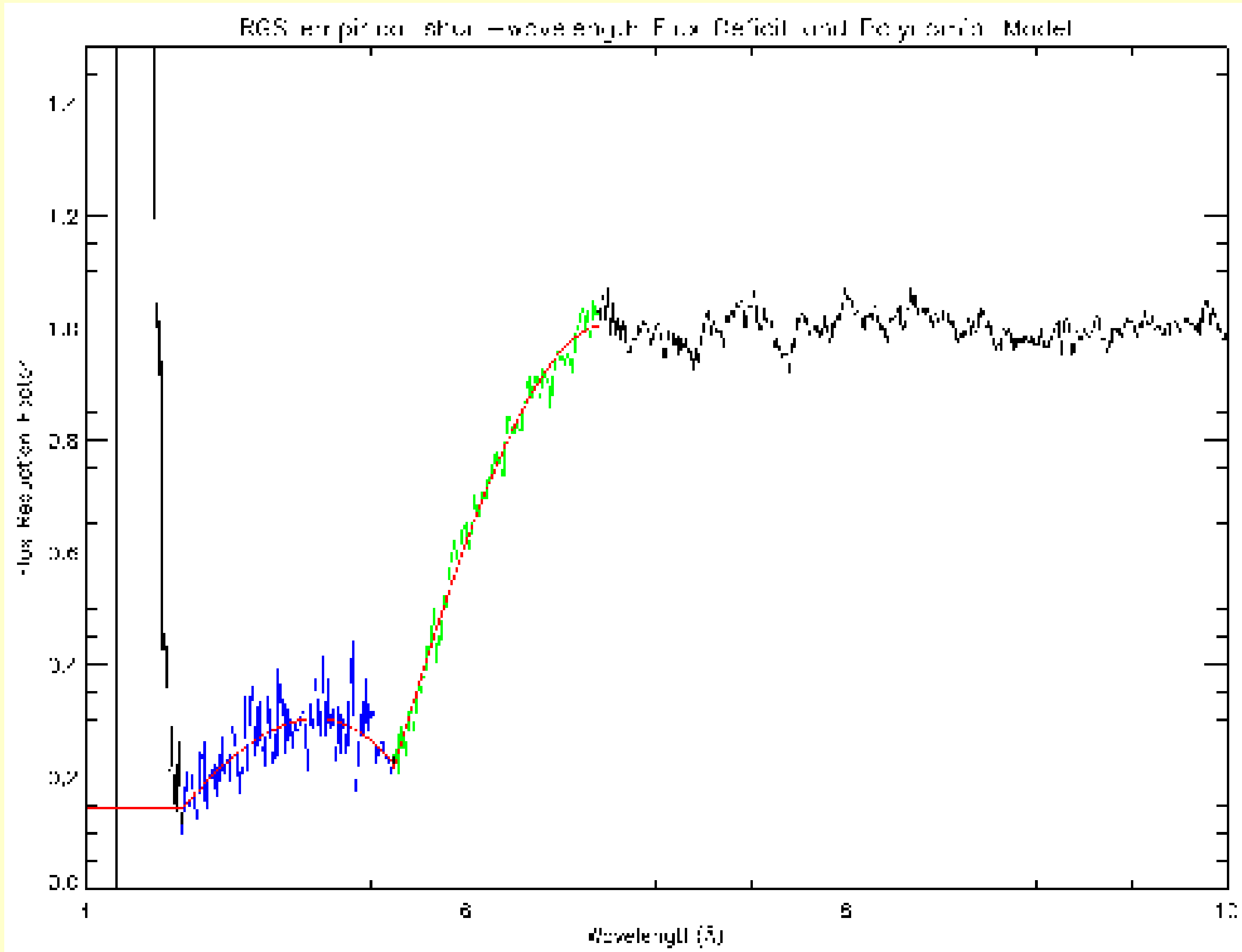


Figure 11: Results for NGC 6251

RGS: QE

- RGS QE at the shortest wavelengths (λ < 7 Å) of its 6-38 Å range was poorly calibrated
- smooth extrapolation of Mkn421's spectrum from 7 Å < λ < 10 Å used as basis for empirical correction factor
- RGS spectra between 6 and 7 Å now useful for SiXIII and SiXIV line measurements, for example



cross-calibration:

In 2003 significant manpower was added to the cross-calibration efforts of the PI instrument teams by the XMM-Newton Science Operations Centre (SOC).

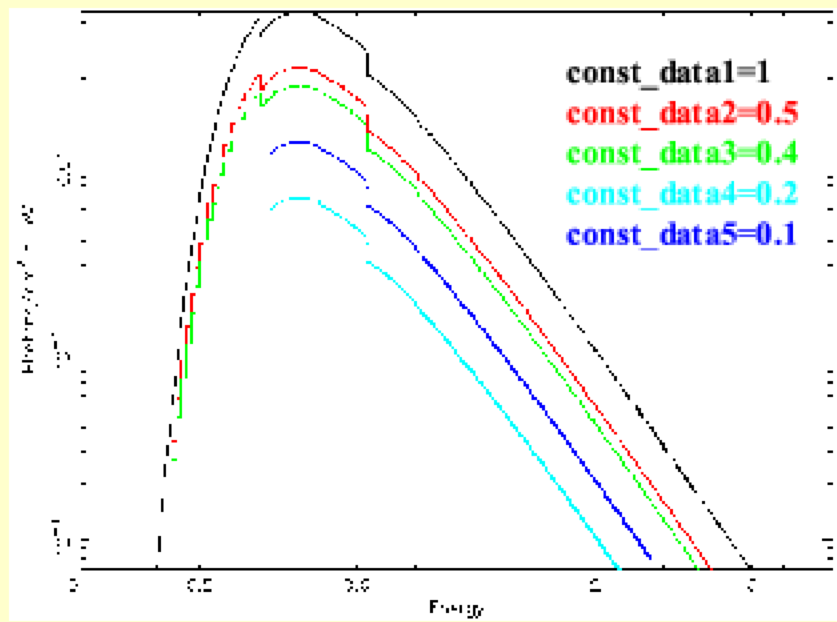
assessment using SAS 5.4.1

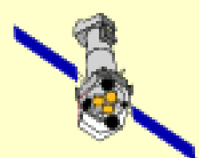
- take various kinds of sources (AGN, SNR, Hot stars, Neutron stars, Galaxy clusters, Coronal sources, White Dwarves

methods:

1. fit: const*(model) where: $const_{pn}$=1, others free, and model parameters linked
2. fit: simultaneous model without allowing for instrument normalization
   - continuum sources: EPIC spectra as start for simultaneous fits
   - line-rich sources: RGS model
   - compare absolute normalization constants
     - Global
     - In some energy bands
   4. compare relative spectral features

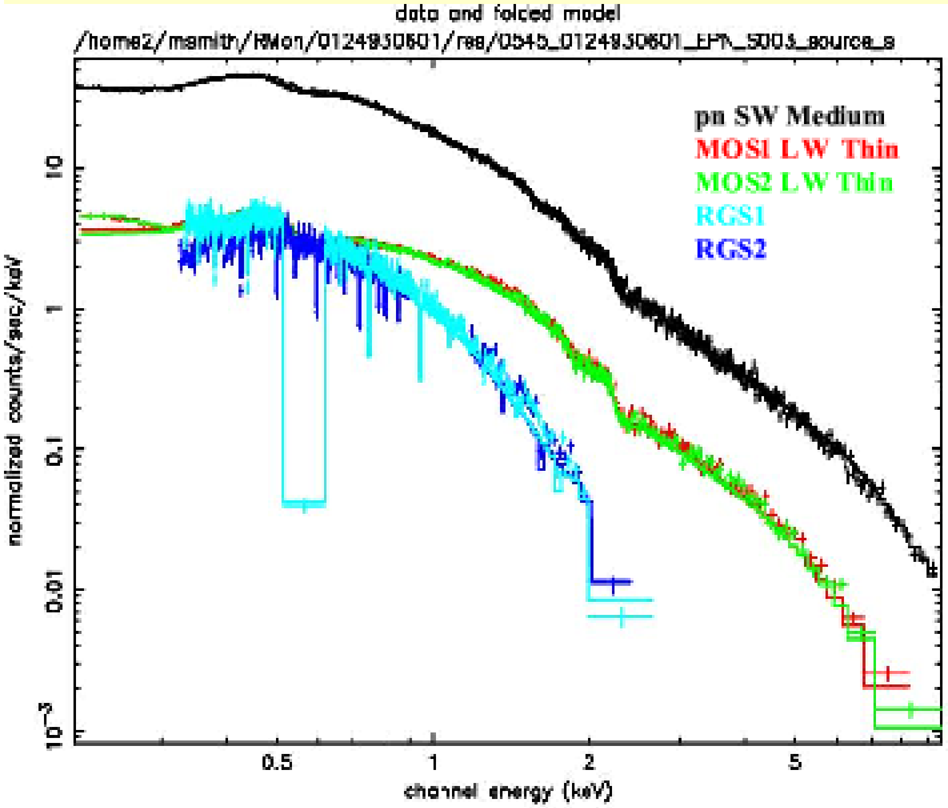
- fold RGS fluxed spectra through epic DRMs

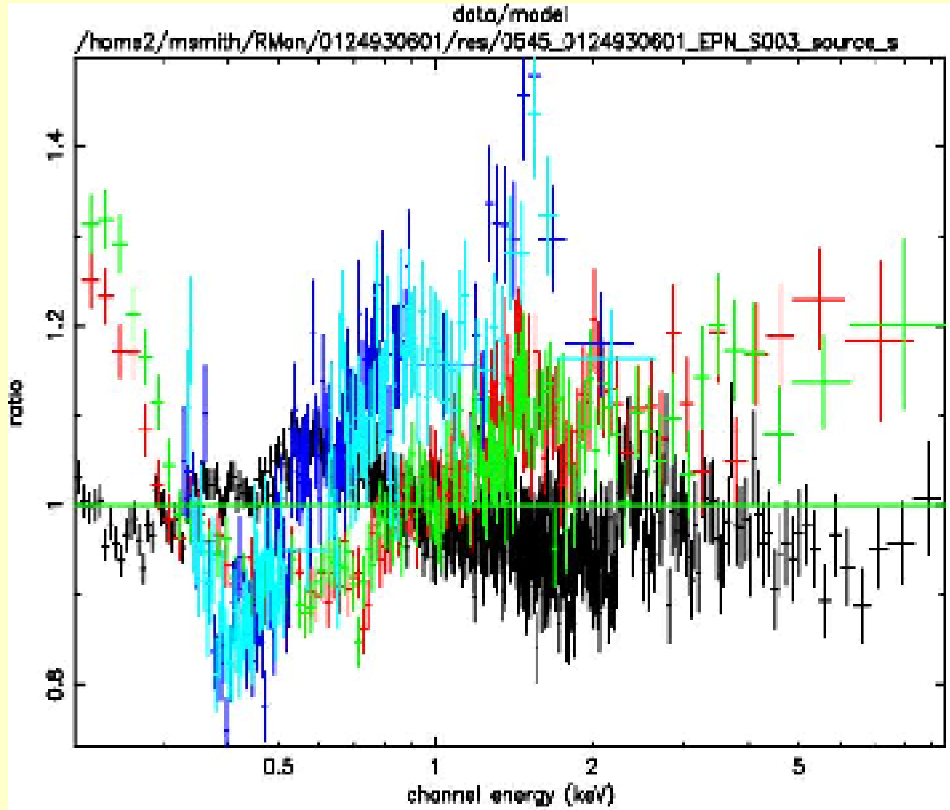




BL Lac's

PKS2155-304





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Normalisation factors in energy bands for AGNs

0.35-0.7 keV
later split in
- 0.35-0.55 keV
- 0.55-0.7 keV

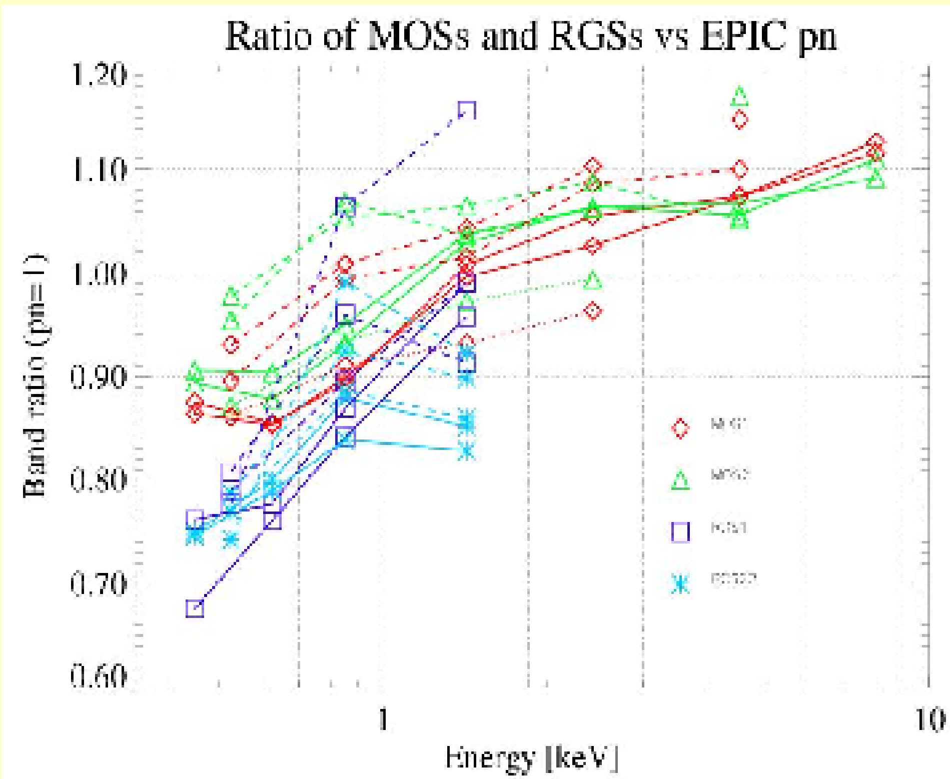
0.7-0.972 keV

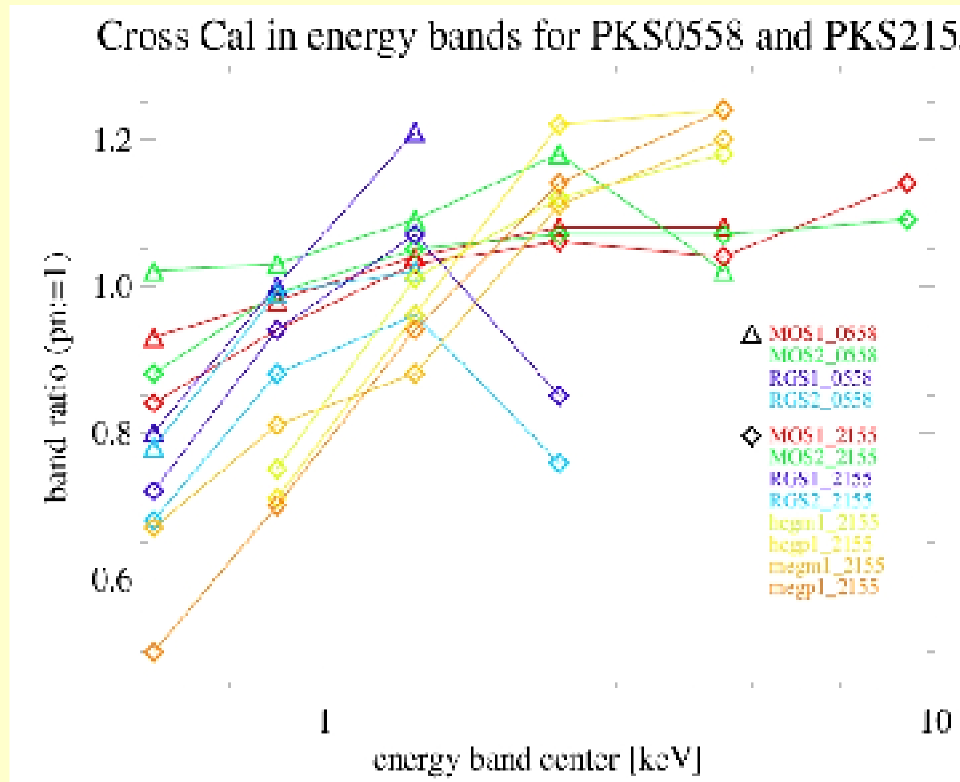
0.972-1.84 keV

1.84-3 keV

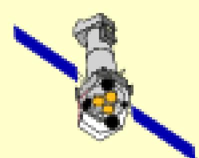
3-6 keV

6-12 keV

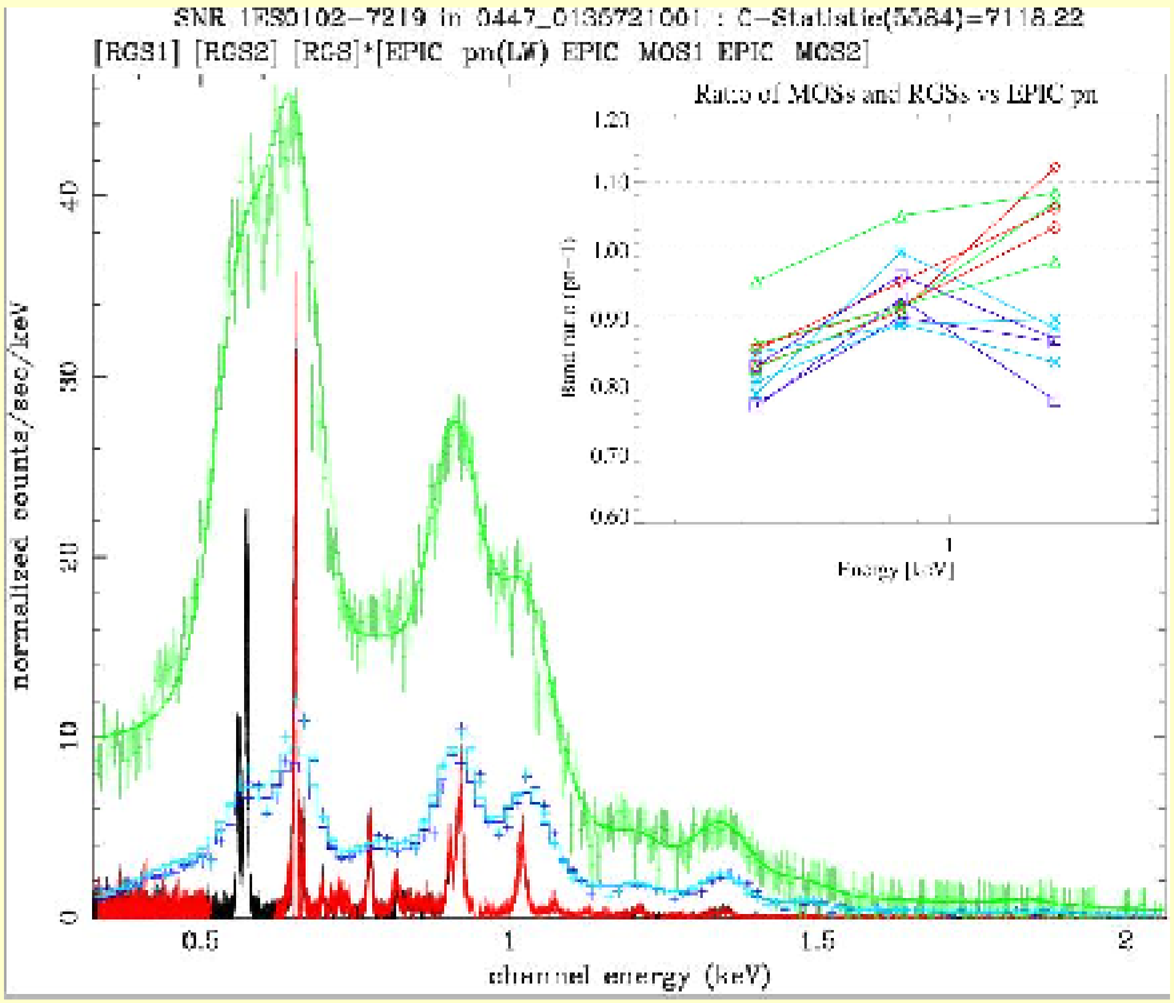




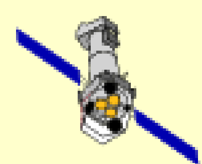
EPIC-pn flux higher than RGS by 20-30% in 0.35-0.7 keV



The SNR picture: a slightly different view



- Method: fold RGS model through EPIC responses. Same extraction region.
- MOS and RGS agree rather well below 1keV
- EPIC-pn redistribution seems OK down to ~0.6 keV. The new redistribution was introduced only below 530eV in SAS 5.4.1 to bring up the N_H of RXJ1856.
- Some MOS redistribution too much



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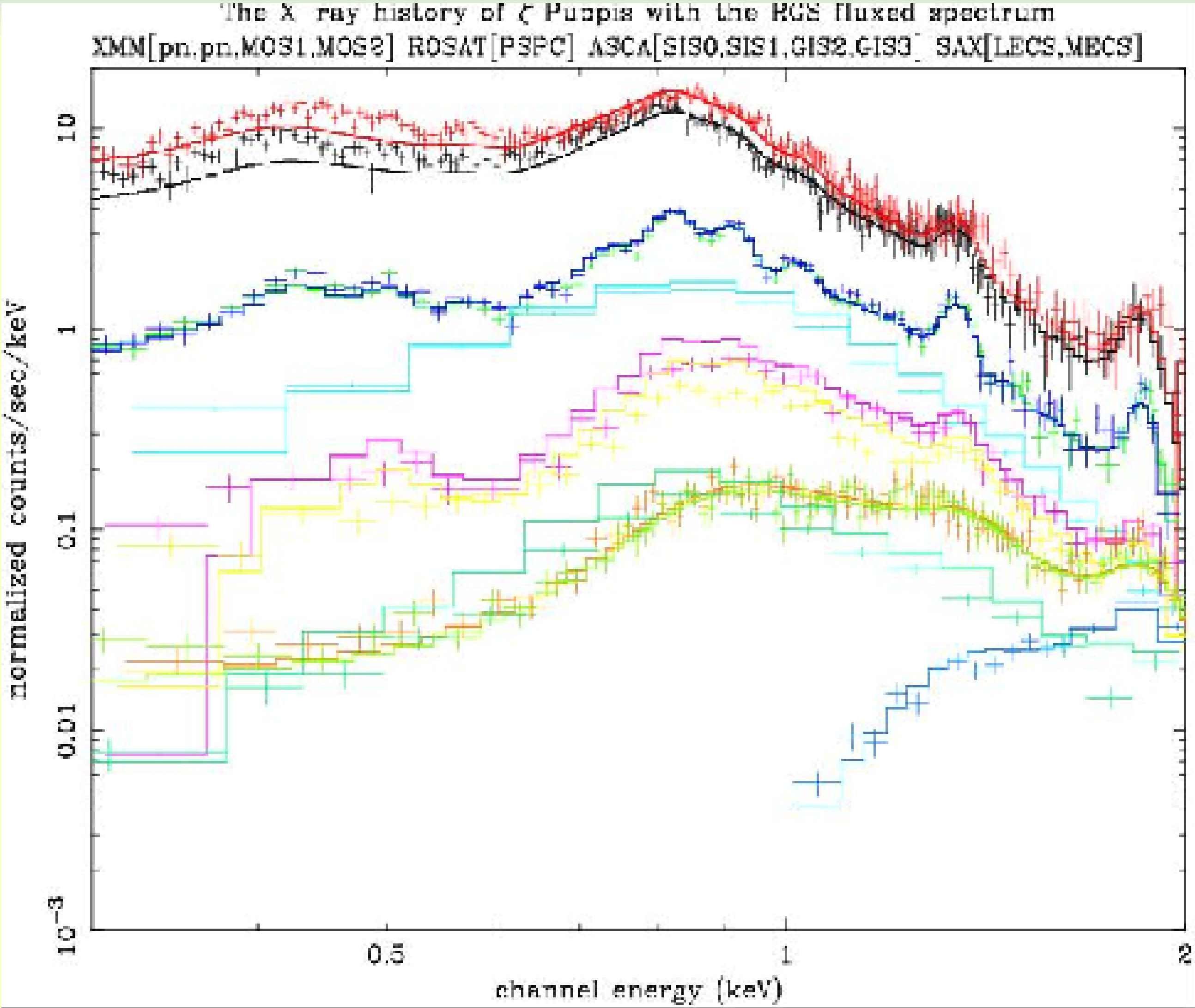
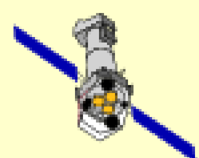
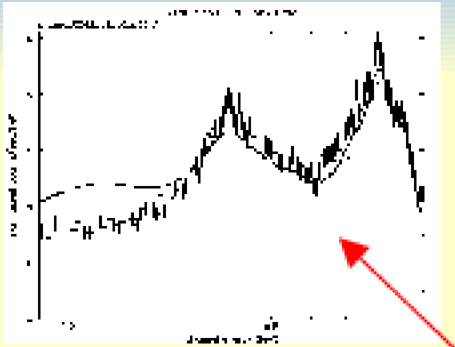
zeta Puppis wide cross-correlation

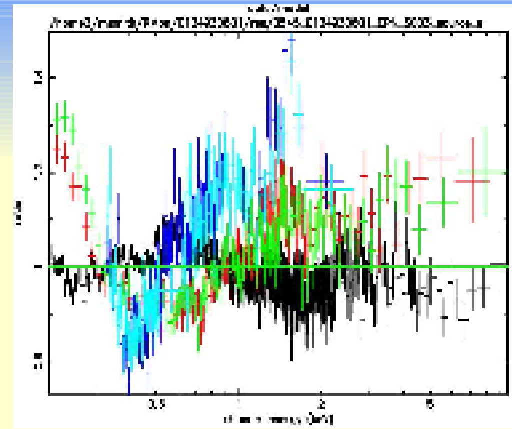


- Assuming zeta Puppis is a stable source…
- All measurement agree except pn.

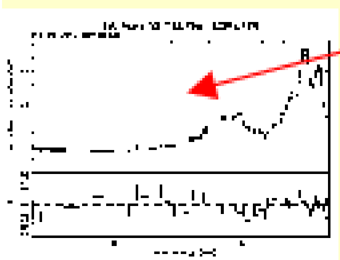


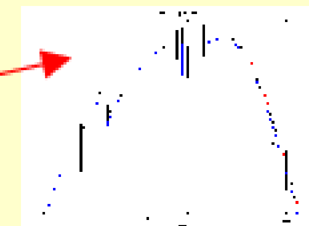
Current investigations

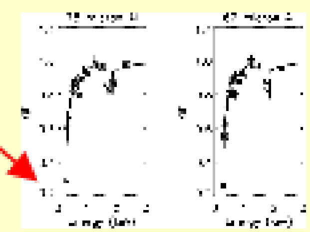




TOPIC	pn	MOS1	MOS2	RGS1	RGS2
CTI					
gain					
redistribution					
mirror A_{eff}					
QE	?				
PSF					
vignetting					
filter					
exposure time		?	?		
contamination					
SAS					







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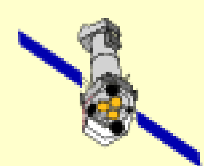
main plans for the future

- **general:**
  - **PSF:** core of the PSF is very slightly underestimated. This effects the MOS more than the pn. This can produce an error in the enclosed energy of at most ~2 %, depending on instrument, energy and extraction radius. → model the PSF as a combination of a King function plus a Gaussian function
  - **Astrometry:** possible residual in the position angle rotation (Euler ψ angle) of the order of 0.1 deg. This could lead to an uncertainty of up to 1.5'' at the edge of the XMM-Newton field of view.
  - **Cross-Calibration:** Extension of the ESAC cross cal archive building up also Chandra data base
- **MOS:**
  - **refinement of redistribution:** uncertainties remain, spectral fitting can be performed down to 150 eV, but in these cases it is recommended that a systematic error of 2 % is applied (XMM-SOC-CAL-SRN-169)
  - **column dependent CTI correction**
- **pn:**
  - **pn redistribution:** EPIC-pn spectra from zeta puppis have shown that the spectral response below about 400 eV might not yet be correctly reproduced. In particular the re-distribution as modelled in SAS 6.0.0 seems to be higher than seen in the data. This can lead to large (30%) systematic errors in the absolute flux of very soft spectral components (kT<100 eV).
  - **pn CTI:** The internal calibration source shows an over correction of up to 15 eV at Mn-K in pn Extended Full Frame mode, that is related to imperfect Gain/CTI correction. This is currently under investigation with special calibration observations.
- **RGS:**
  - **low energy QE refinement**



calibration workshops

XMM-Newton Calibration Meetings & Workshops

- meetings: 2 per year
  - next 01-03/02/2005
- workshops: 2 per year
  - last took place 13-15.10.2004 (ESAC)
    → seen as very effective and fruitful meeting from RGS and EPIC
  - next one 16-18/03/2005 (ESAC)

why not having one together with Chandra ???