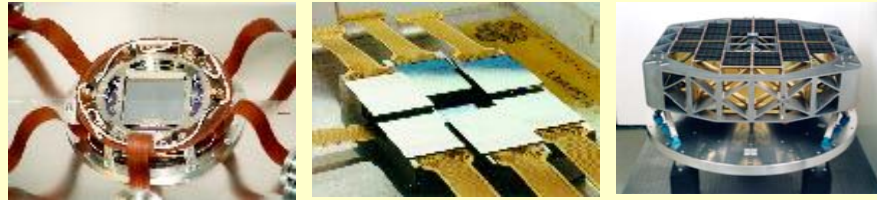


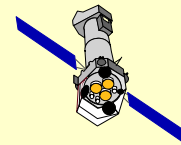
# Status of the XMM-Newton Calibration



M.G.F. Kirsch

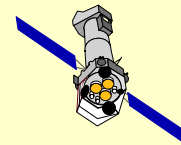
EPIC consortium

VILSPA EPIC & RGS IDT

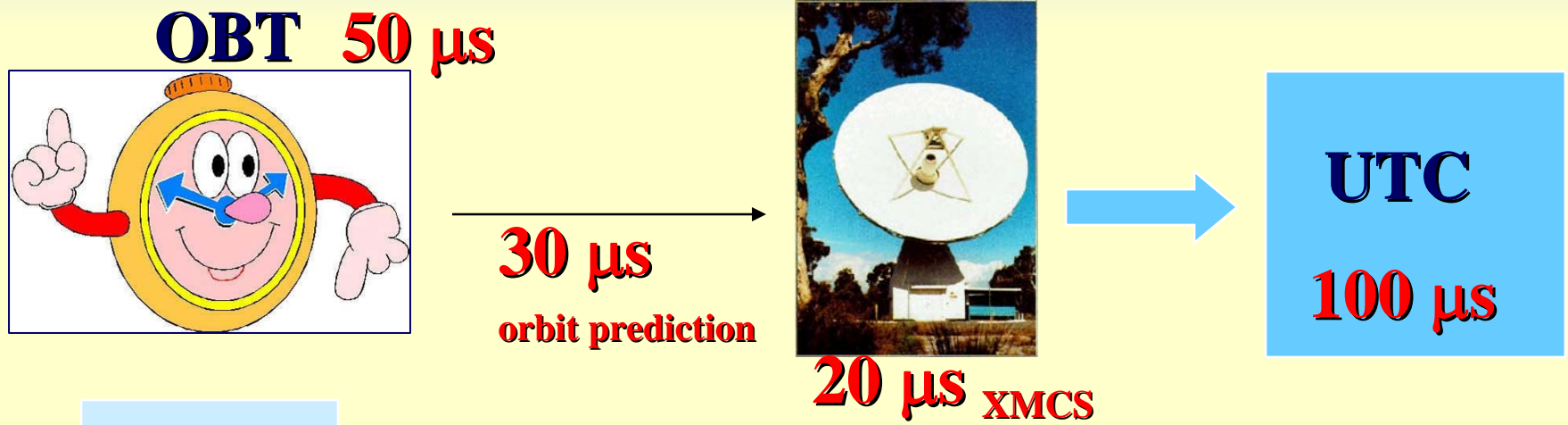


# menu

- status of calibration
  - general: timing, Vignetting, PSF: re-calibration
  - MOS: QE, RMF, cooling
  - pn: QE, RMF
  - long term stability
  - RGS: see talk by A. Pollock
  
- cross calibration campaign



# th. absolute accuracy

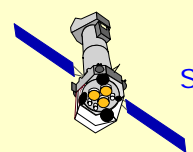


EPIC-pn

$\pm 10 \mu\text{s}$

quadrant  
clocks

- theoretical upper limit for absolute time uncertainties is  $< 100 \mu\text{s}$
- the limited number of analyses conducted so far indicated in the past that the actual error is larger ( $\sim 1\text{ms}$ )



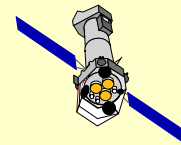
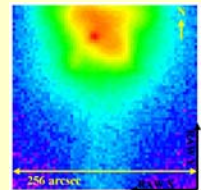
# a. accuracy: the bug

(for details see Kirsch et al. Proc. SPIE 5165)

- wrongly corrected CDMU delay (626.17  $\mu\text{s}$ )
- delay was erroneously subtracted instead of added  
--> shift of 1252.34  $\mu\text{s}$ .
- correction will be implemented in new time correlation

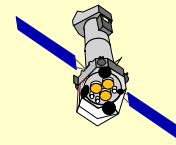
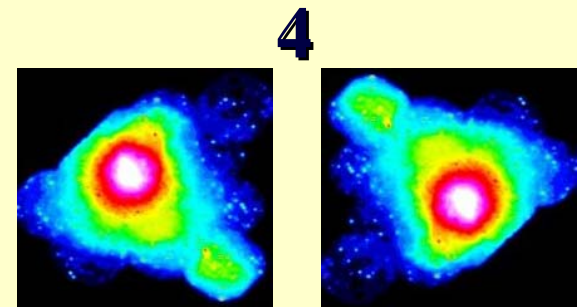
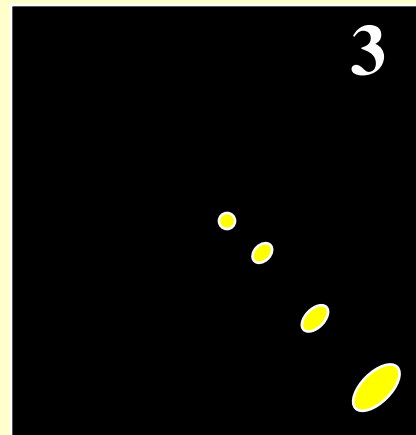
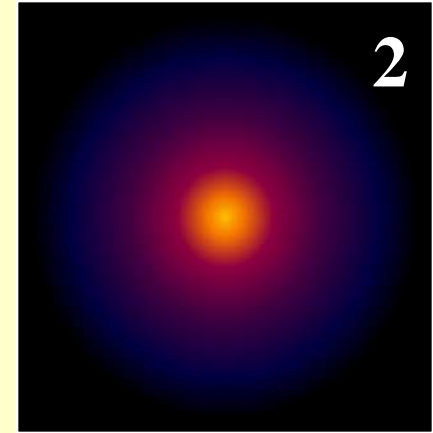
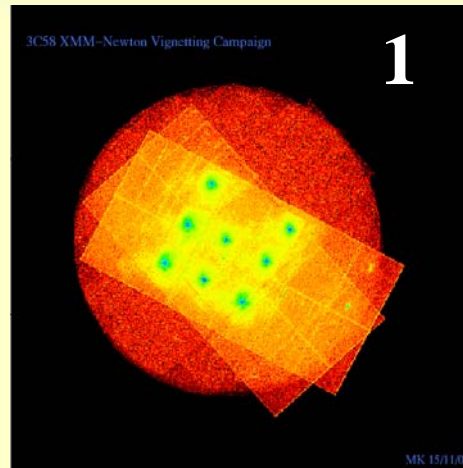
$$\text{UTC(OBT)} = \text{ERT} + \delta(\text{CDMU}) - \delta(\text{Flight}) - \delta(\text{G/S})$$

- absolute timing accuracy now:  $\sim 300\text{-}600 \mu\text{s}$
- in agreement with Crab observations performed by RXTE and Chandra
- **Crab observation with Chandra, XMM and in the optical** using an MPE developed fast photometer to get a radio-ephemeris independent phase solution between the optical and X-ray pulses performed, to be analysed



# Vignetting: the 4 methods

- source at different position
- diffuse background
- source elongation
- coma cluster



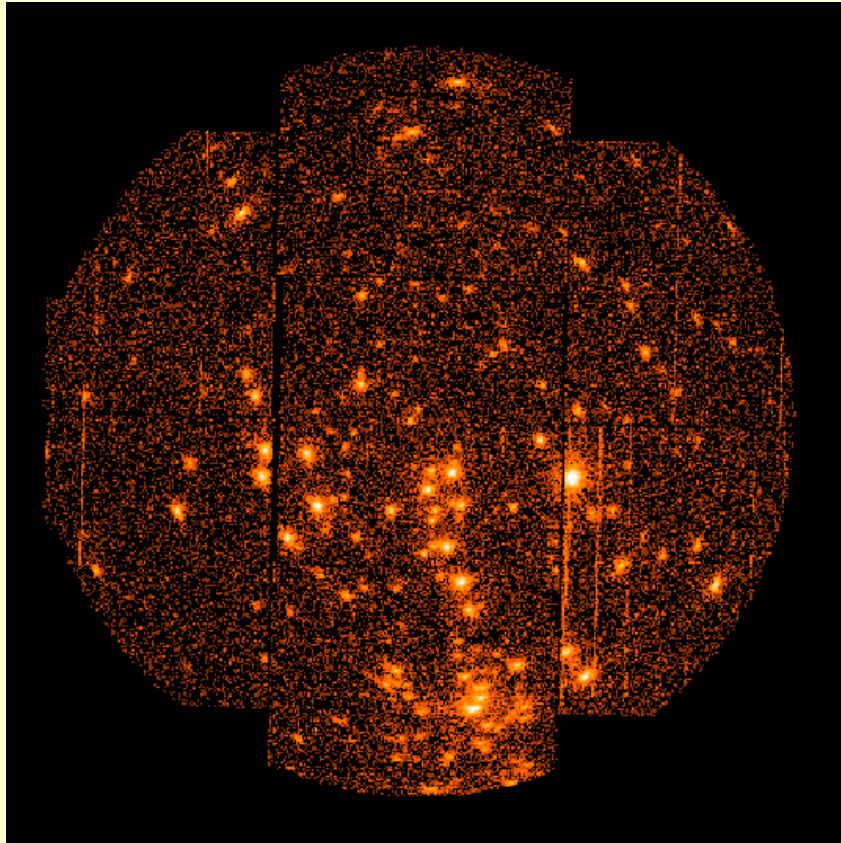
# position of optical axis

| method                | MOS1 X        | MOS1 Y          | MOS2 X        | MOS2 Y            | PN X           | PN Y          |
|-----------------------|---------------|-----------------|---------------|-------------------|----------------|---------------|
| Coma Cluster          | 110<br>+/-40  | (-)200<br>+/-70 | 550<br>+/-60  | (-)1255<br>+/-30  | 1243<br>+/-30  | 402<br>+/-30  |
| 3C58 + G21.5 - 09     | 200<br>+/-200 | (-)50<br>+/-200 | 340<br>+/-200 | (-)1300<br>+/-200 | 1300<br>+/-500 | 450<br>+/-500 |
| optics_X/Y (PIXCOORD) | 305           | 291             | 325           | 243               | 23             | 183           |
| optics_X/Y MISC_0019  | 300           | 300             | 300           | 300               | 39             | 188           |
| difference in pixel   | -5            | 9               | -25           | 57                | 16             | 5             |
| difference in arcsec  | -5.5          | 9.9             | -27.5         | 62.7              | 65.6           | 20.5          |

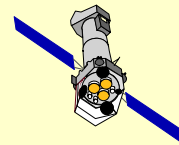
currently under testing in DT SAS



# calculate new BS angles

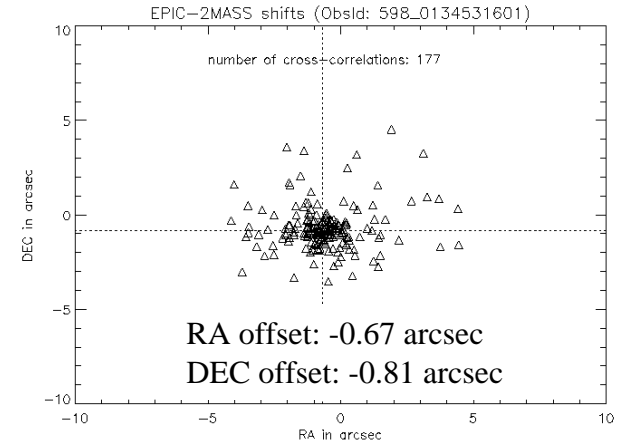
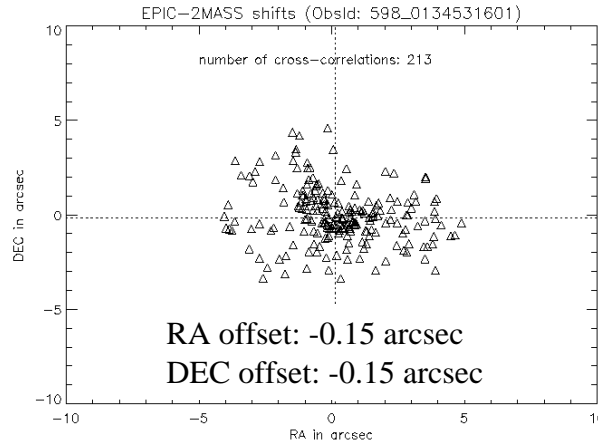
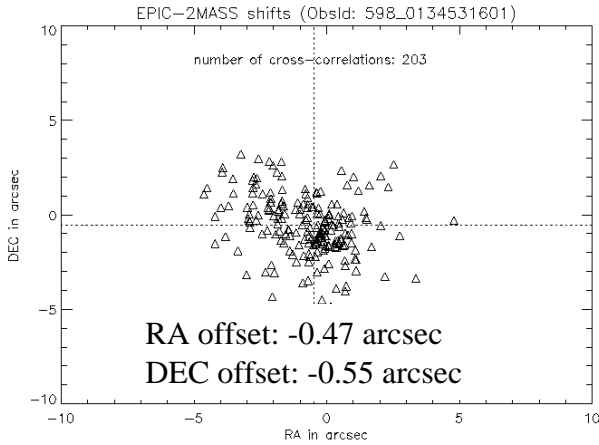


- the new optical axis position required a set of new Boresight CCFs which hold for each instrument a triple of three angles describing the misalignment of the respective instrument boresight with respect to the satellite coordinate frame
- using the OMC2/3 field new BS misalignment angles for all the three cameras have been calculated
- goal: astrometry should not change!!!!!!!!!!!!

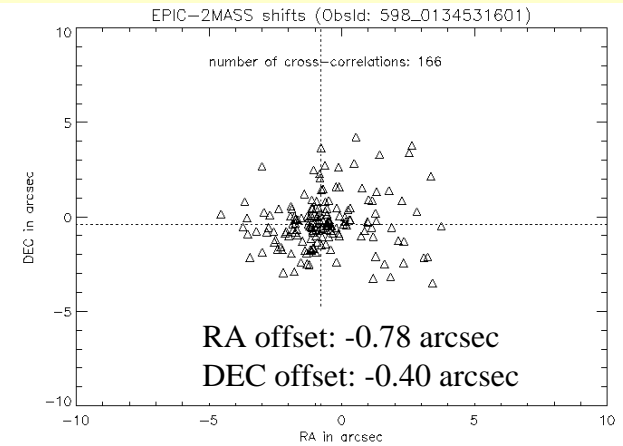
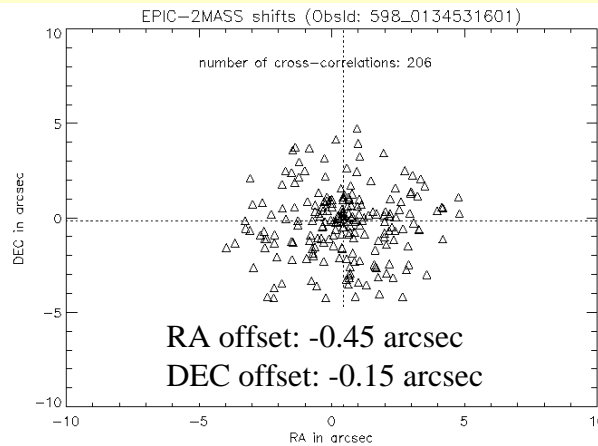
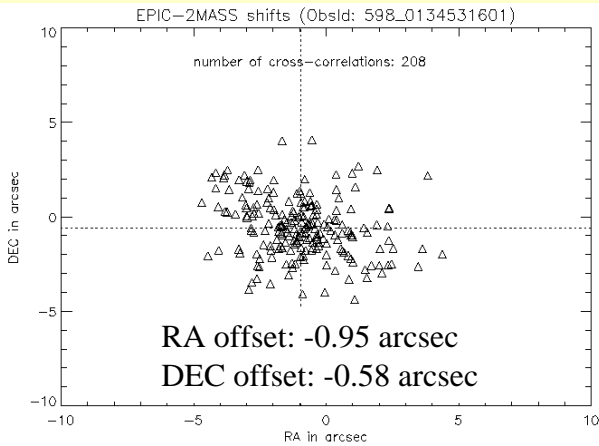


# astrometry: EPIC-2MASS

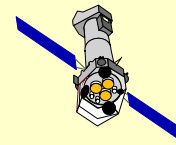
## old optical axis and BS:



## new optical axis and BS:

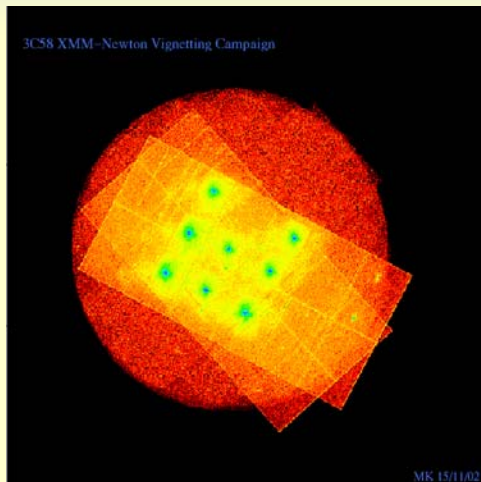


B. Altieri

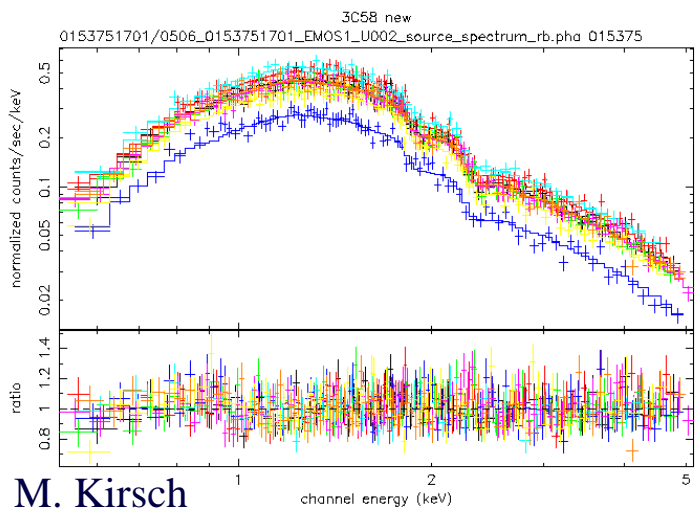
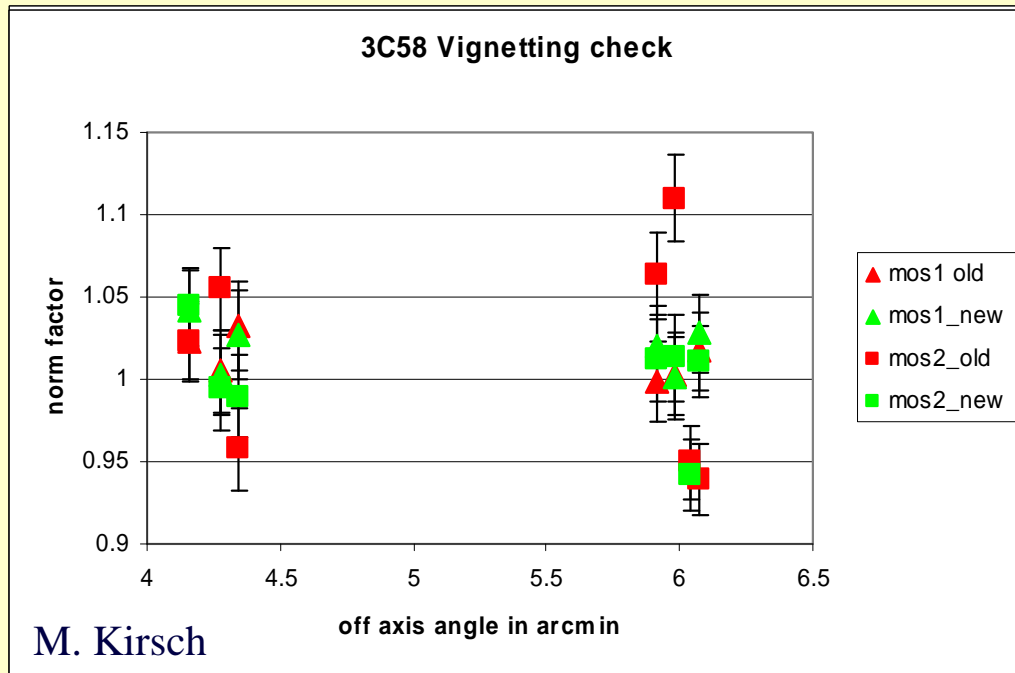




# 3C58 results for MOSs



Model:  $\text{constant}[1] * \text{wabs}[2] (\text{powerlaw}[3])$

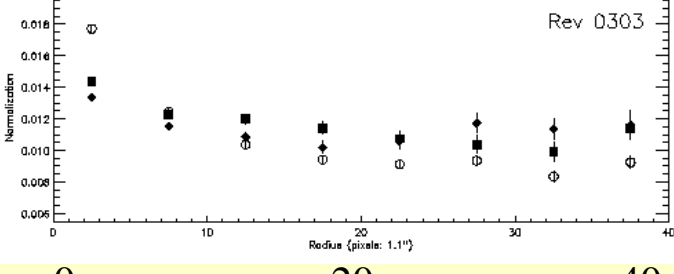
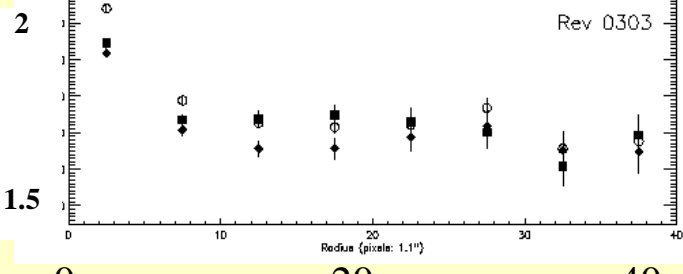
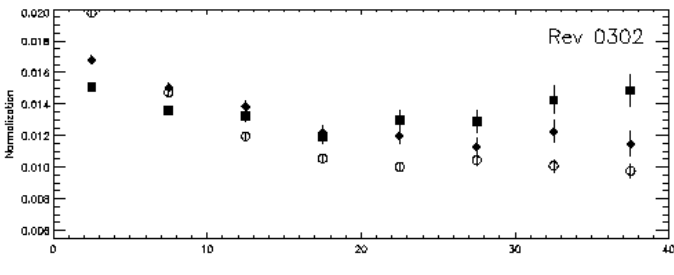
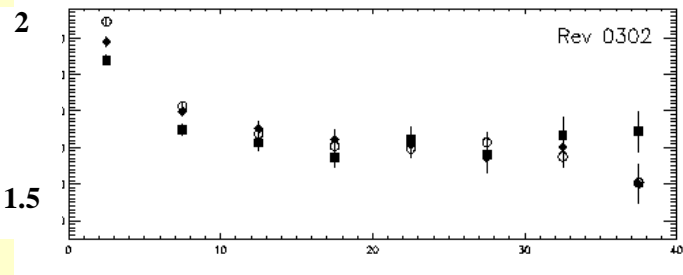
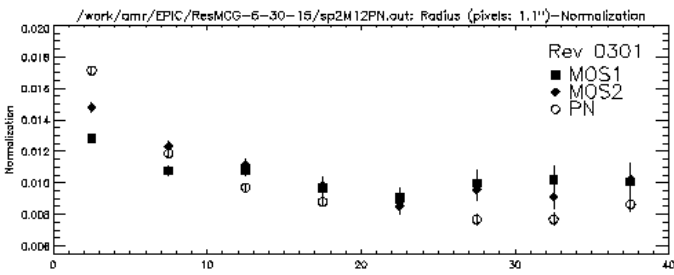
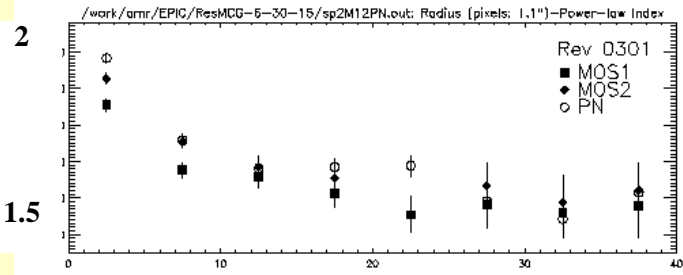


- flux variation off axis reduced from  $\pm 10\%$  down to  $\pm 2-3\%$  for both MOSs
- pn to be checked with Coma/G21.5-09 observations

# PSF: re-calibration

photon index

normalisation

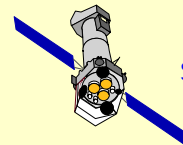


- spectra from annuli at 0, 5, 10, 15, ... 40 pixels of MCG-6-30-15
- created appropriate RSPs and ARFs
- fit (power-law modelling) on the 2-10 keV single events.
- derived spectral slope for non-piled-up point sources is not independent of the extraction radius

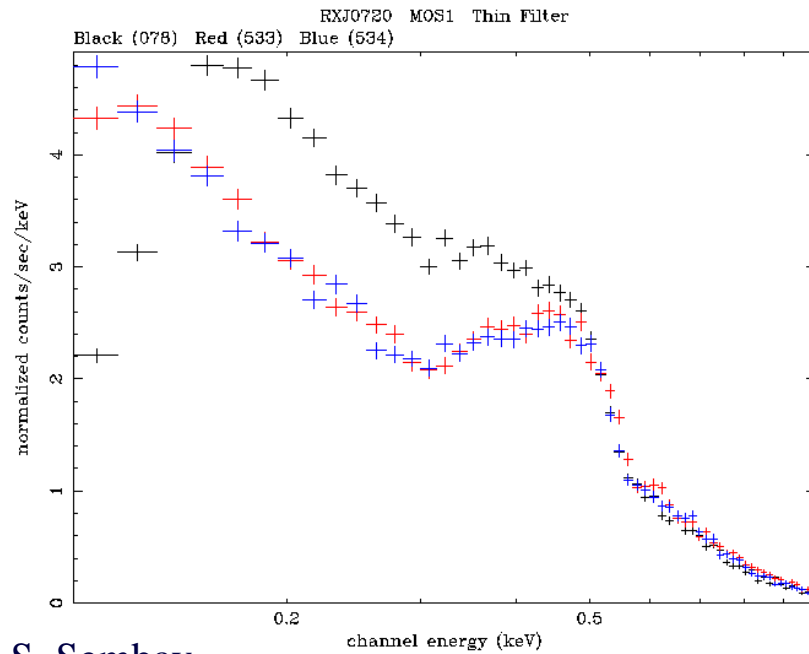
extraction radius in pixels

extraction radius in pixels

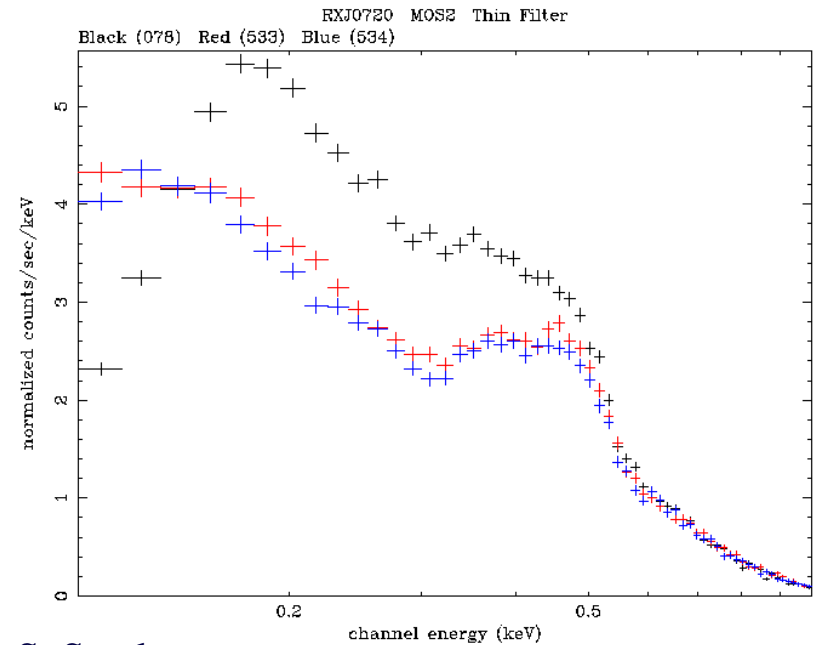
A. Read



# MOS: Low Energy Epoch Dependent Response Variation

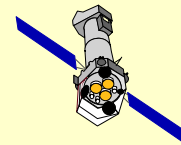


S. Sembay

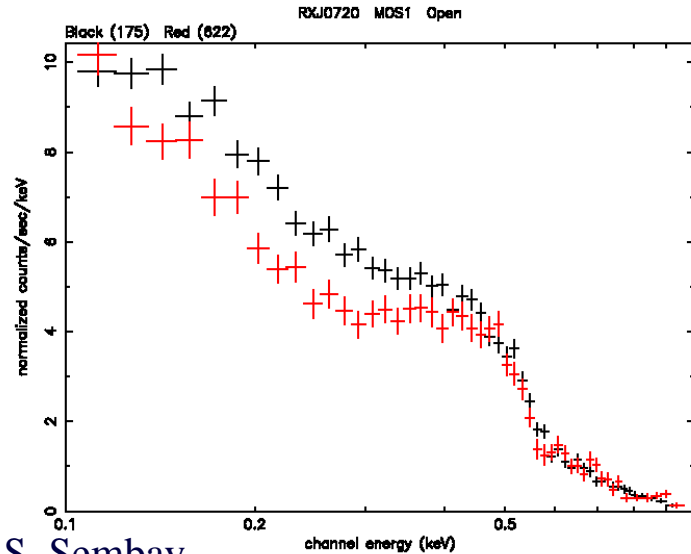


S. Sembay

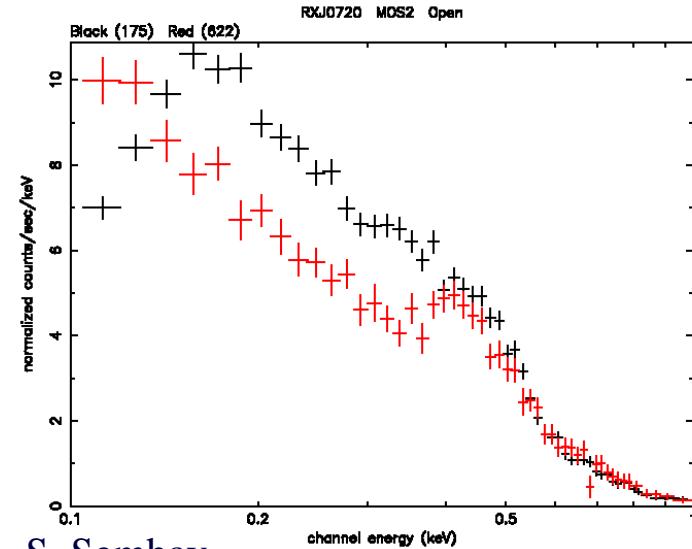
➔ Significant change in spectrum between  
Rev 78 and 533/534



# what happened?



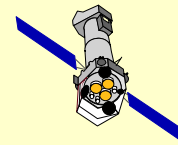
S. Sembay



S. Sembay

RXJ0720.4-3125, mos1 and mos2, in OPEN between Revolutions 175 and 622

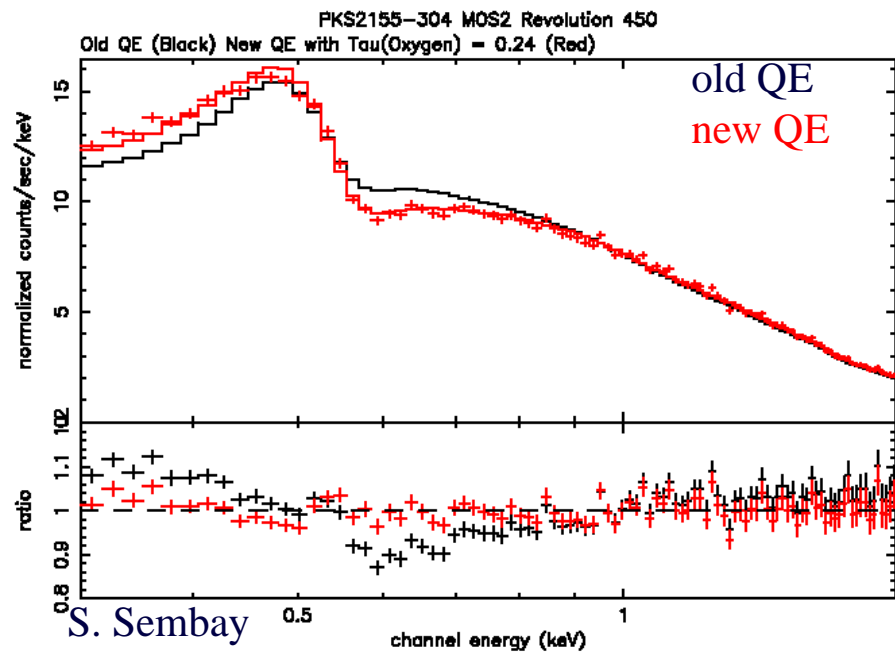
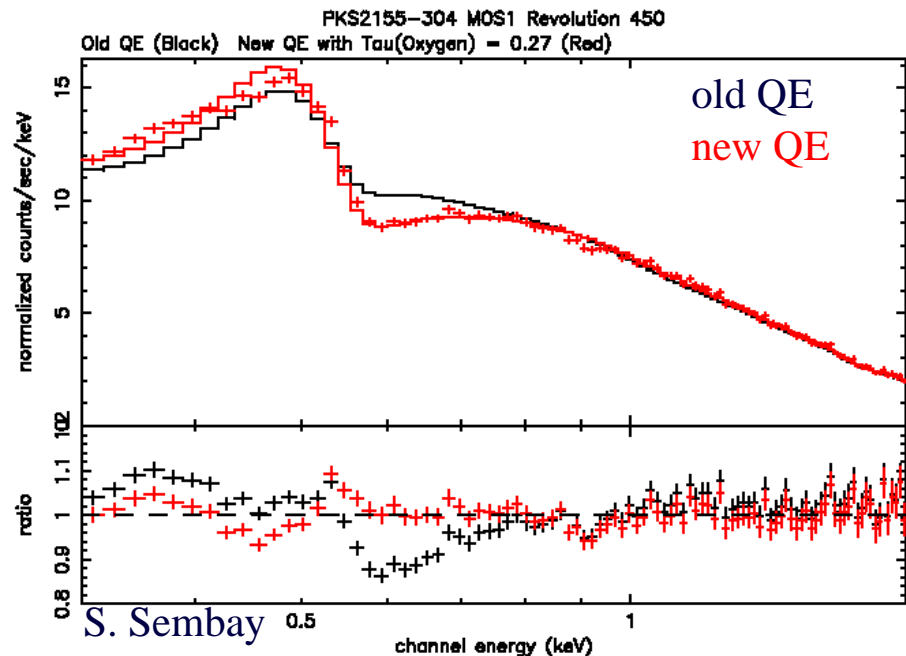
- no filters, so the CCDs have changed
  - difference in the change in the spectrum below 200 eV for MOS1 and MOS2
- ↻
- combination of **time dependent QE and rmf change** which has affected both cameras, but not exactly at the same times



# MOS: oxygen absorption

MOS1

MOS2



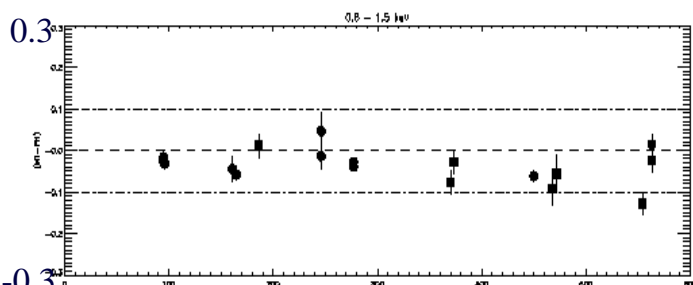
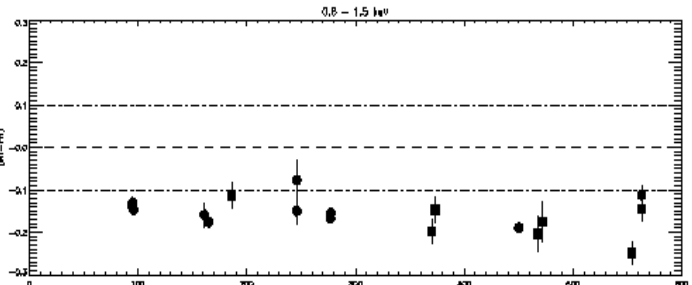
- PKS2155-304 MOS1 and MOS2 from Rev 450 showing the difference at oxygen of the old and new QE
- MOS2 fits pretty well, but MOS1 still has some residuals, probably due to inaccuracy in the new test rmf

# MOS: oxygen absorption

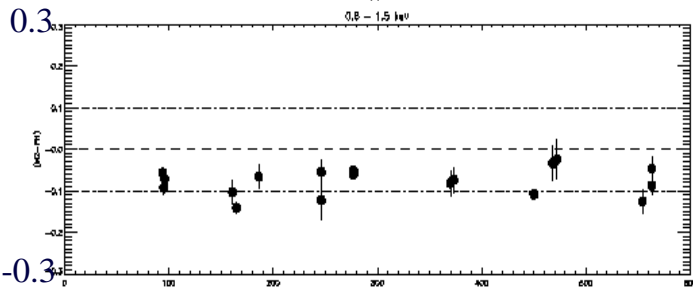
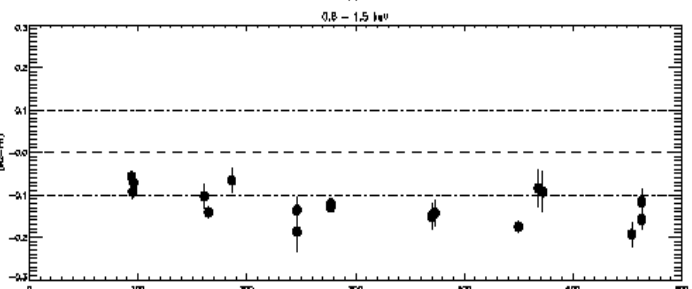
old QE and rmf

new QE and test rmf

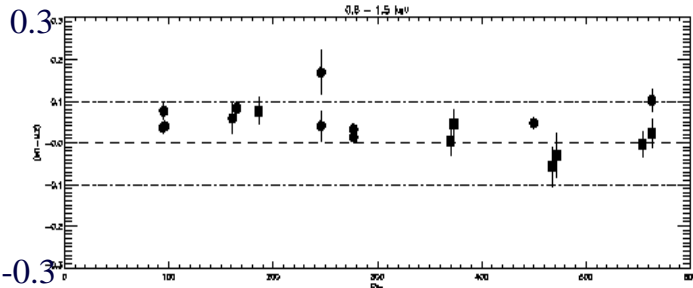
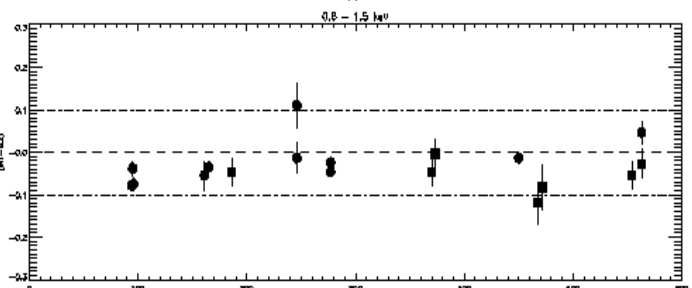
M1-pn



M2-pn



M1-M2



- differences in fitted spectral slope to a group of AGN in the band 0.6-1.5 keV
- all cameras now agree to within 0.05 in slope whereas the difference before between MOS and pn was ~0.15

S. Sembay

300  
Rev

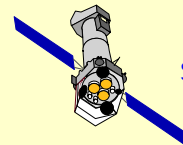
600

0

300

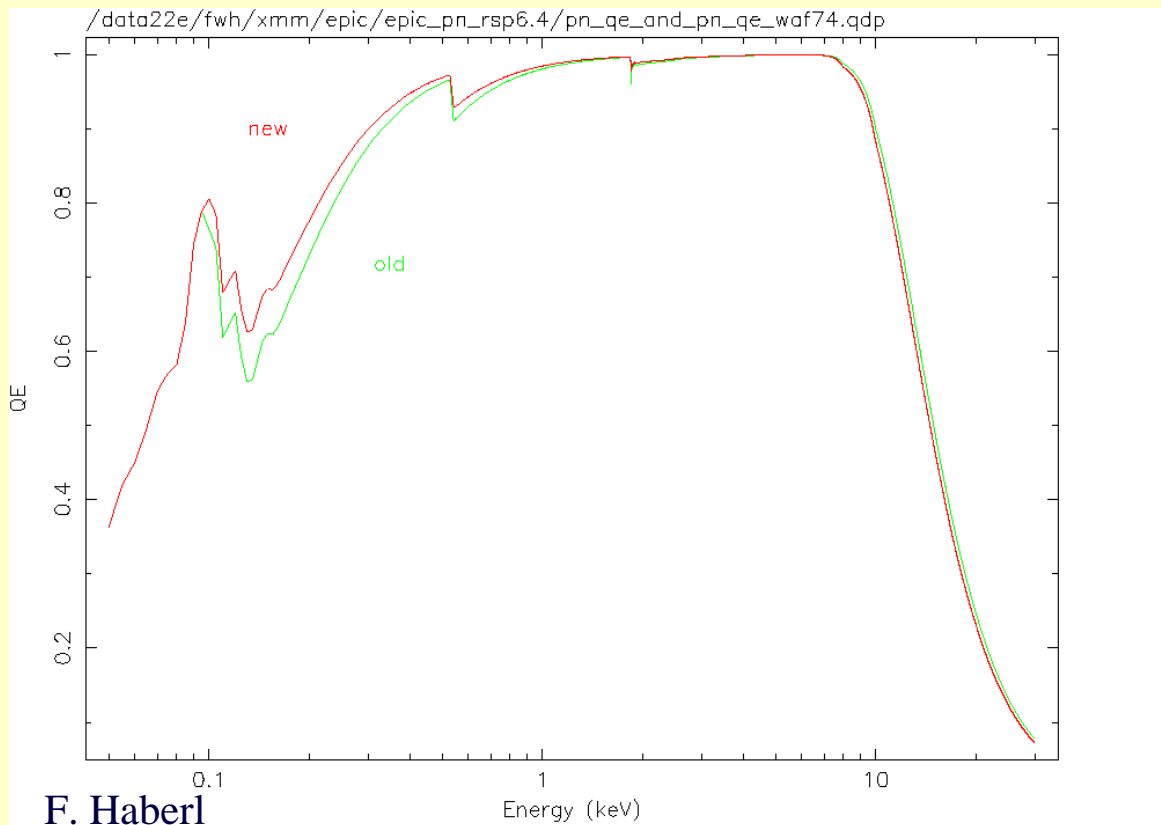
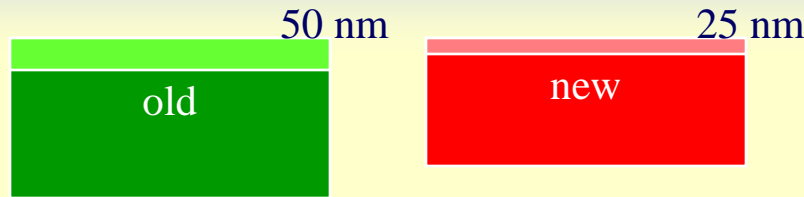
600

Rev





# pn: spectral response in SAS5.4.1

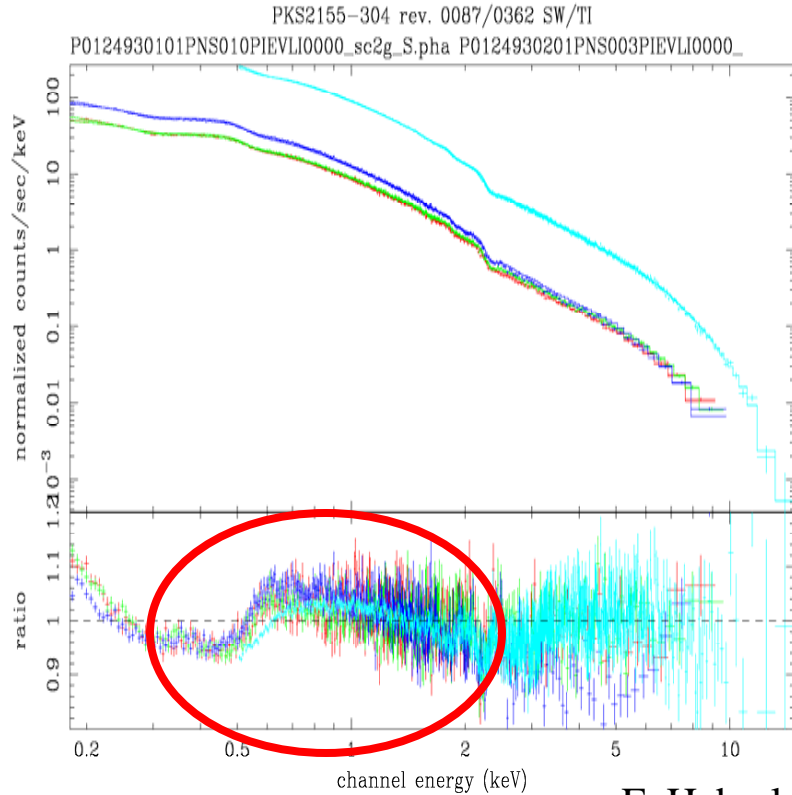


fwh 29-Jan-2003 11:21

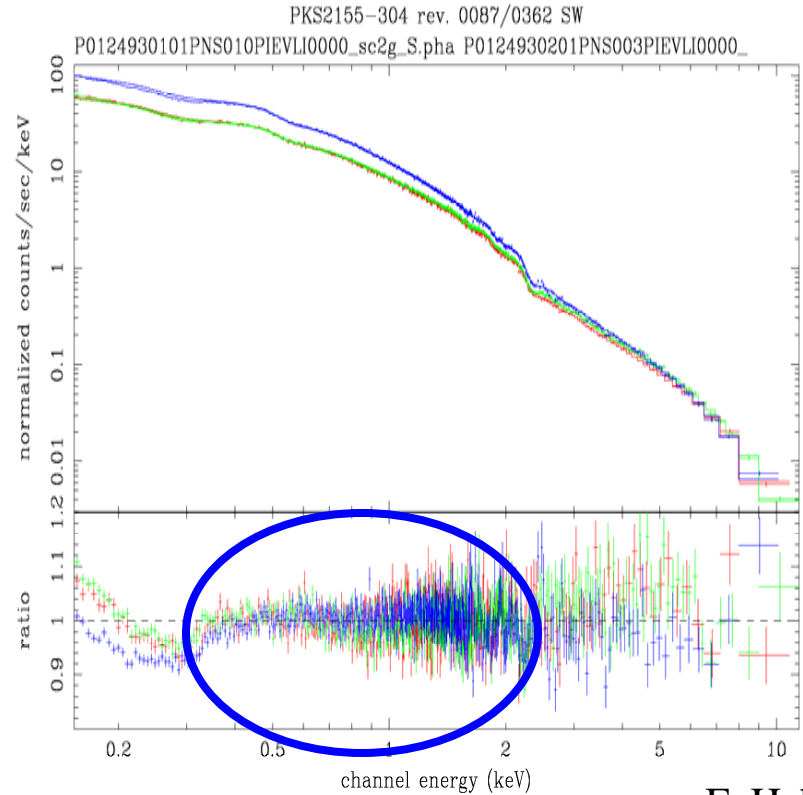
- Now implemented (SAS5.4.1)
  - newly determined thickness of the SiO<sub>2</sub> entrance window
  - New Quantum Efficiency curve
  - RX J1856.5-3754: Redistribution re-adjustment

# pn: PKS2155-304

without and with new QE and redistribution for pn

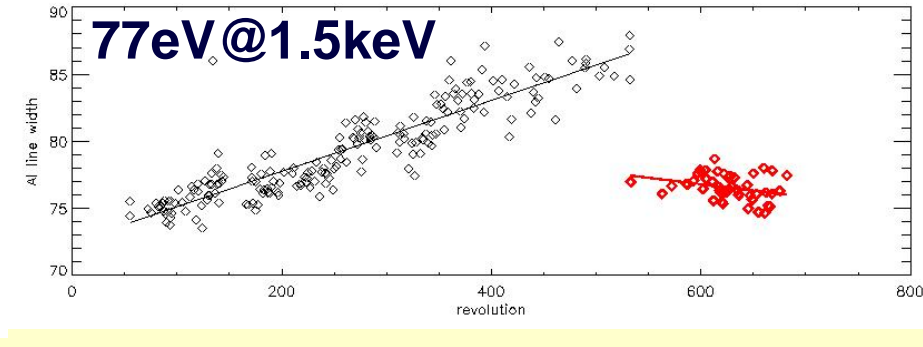
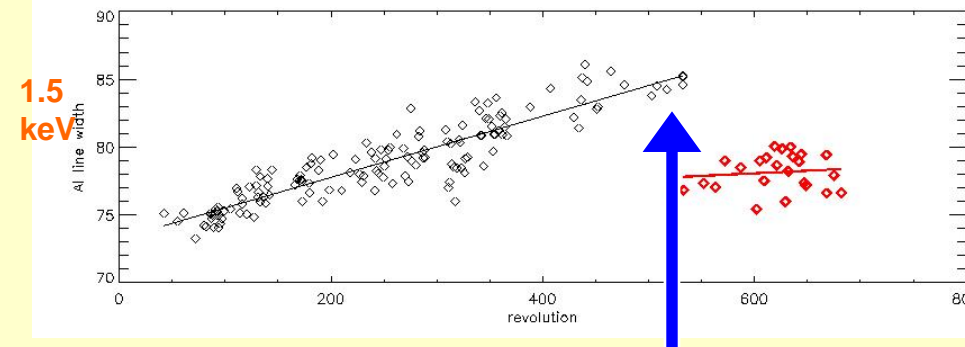
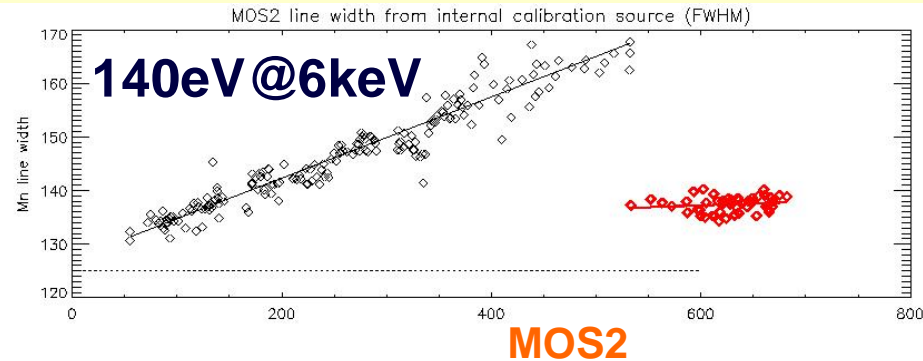
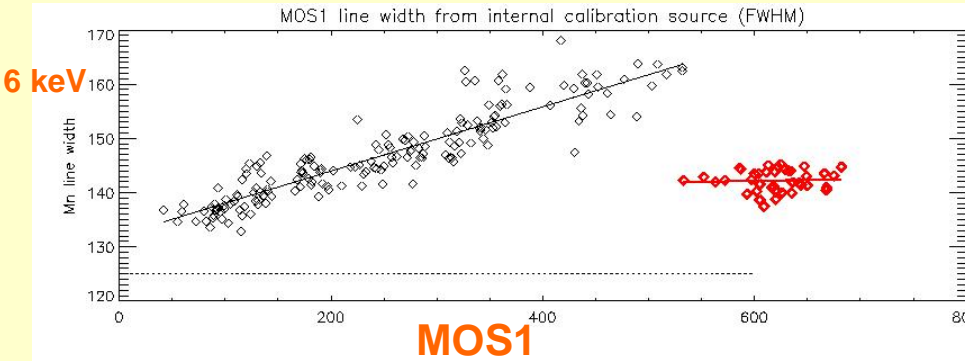


F. Haberl



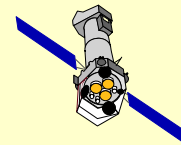
F. Haberl

# MOS: long term trends

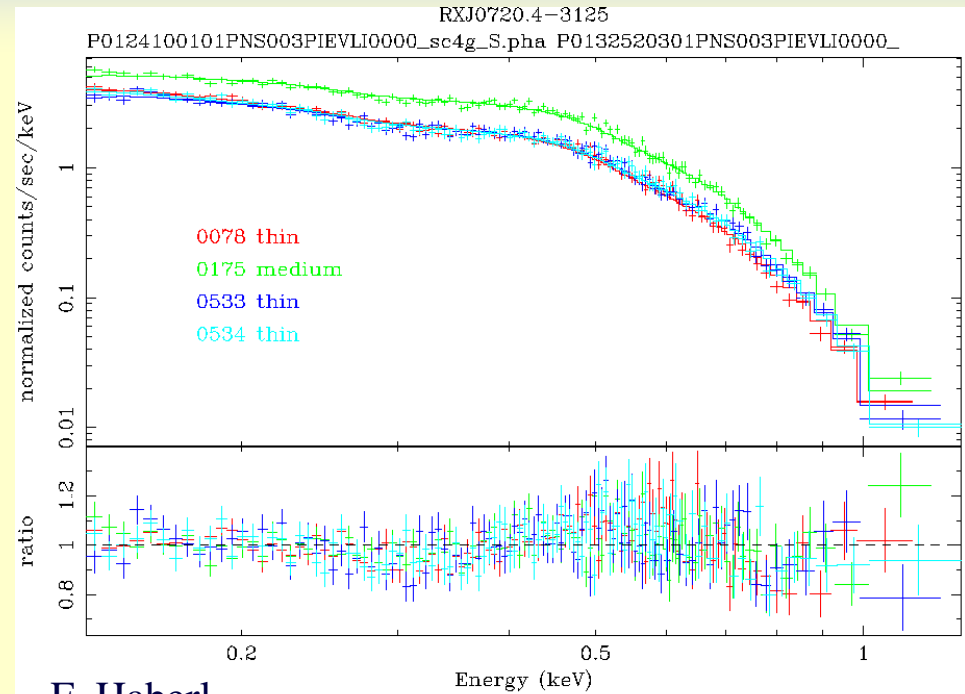
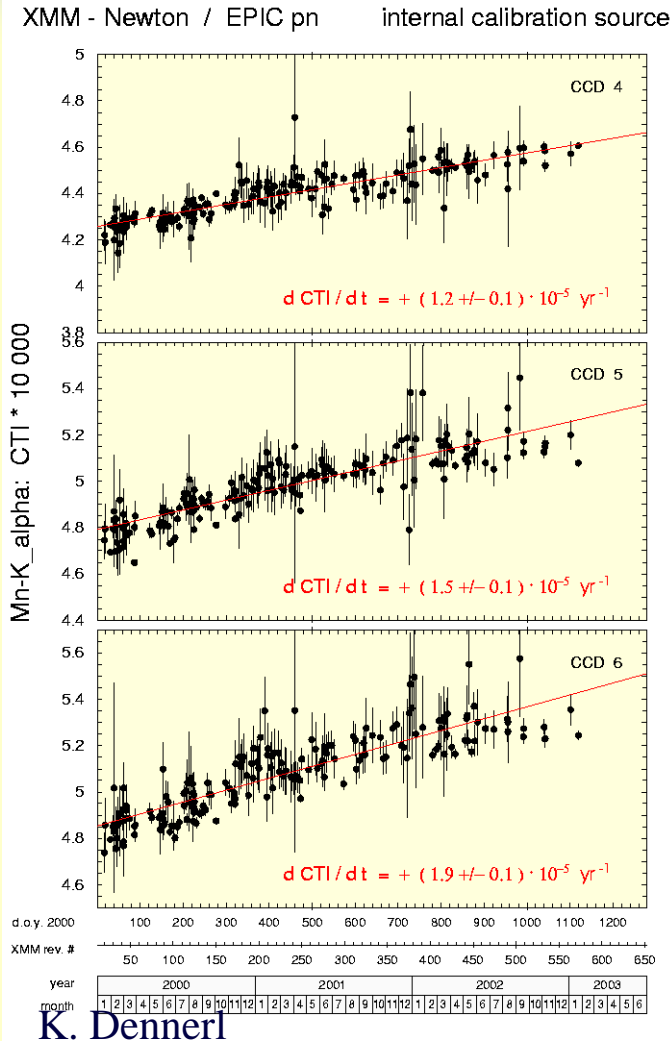


cooling

- Energy resolution rather constant since cooling



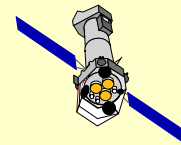
# pn: long term trends



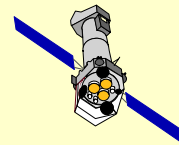
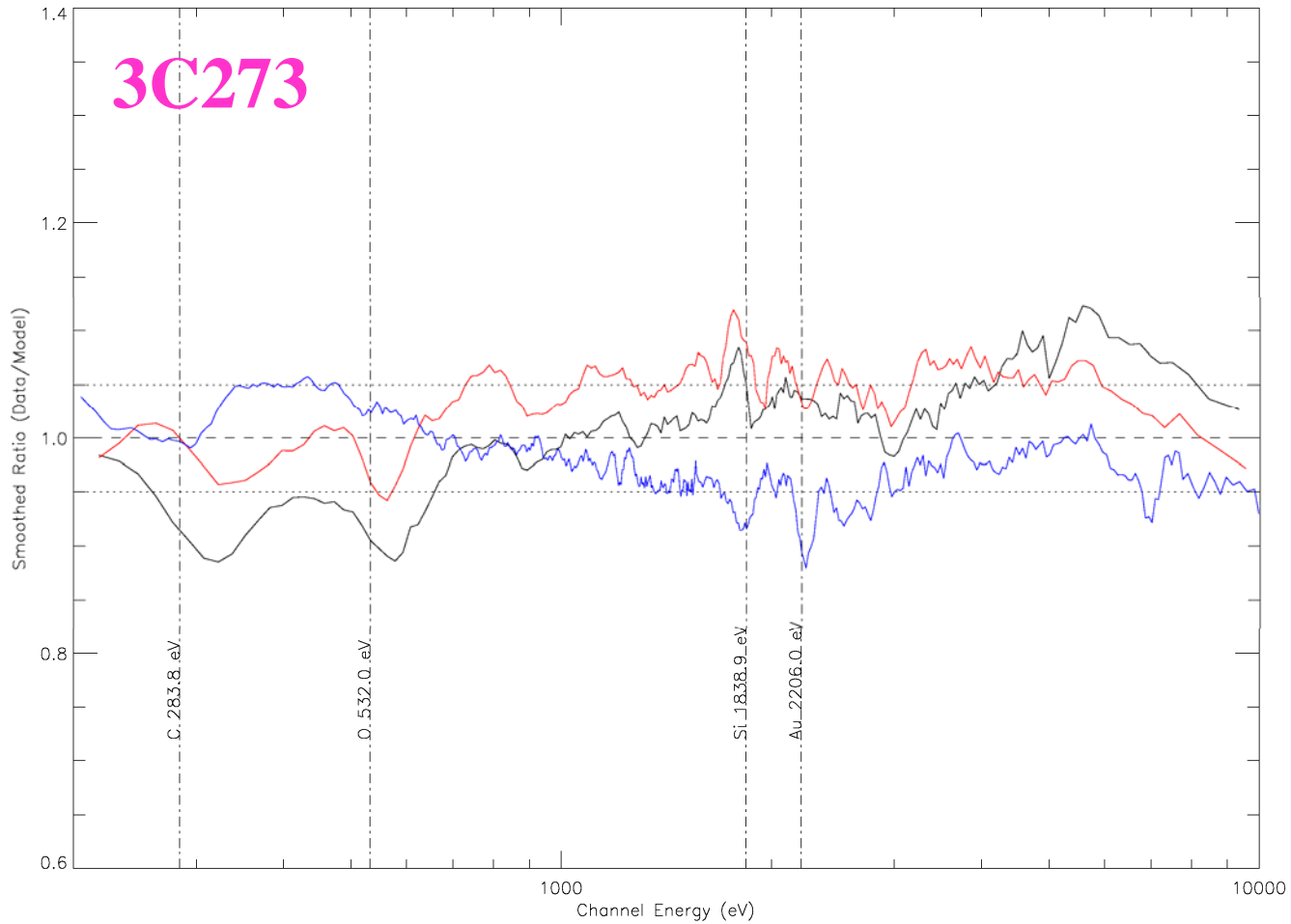
F. Haberl

fw 23-Jan-2003 14:07

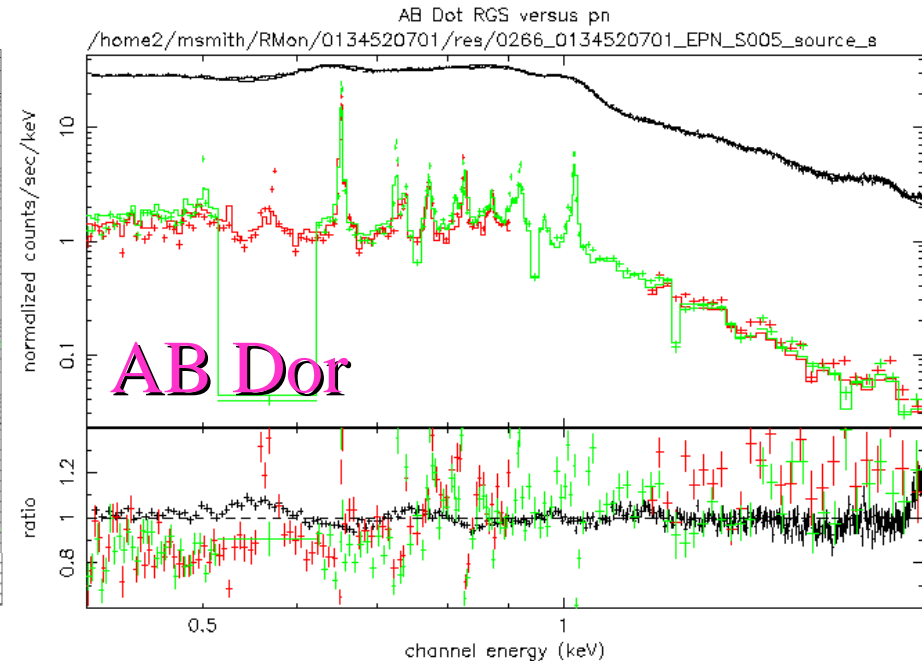
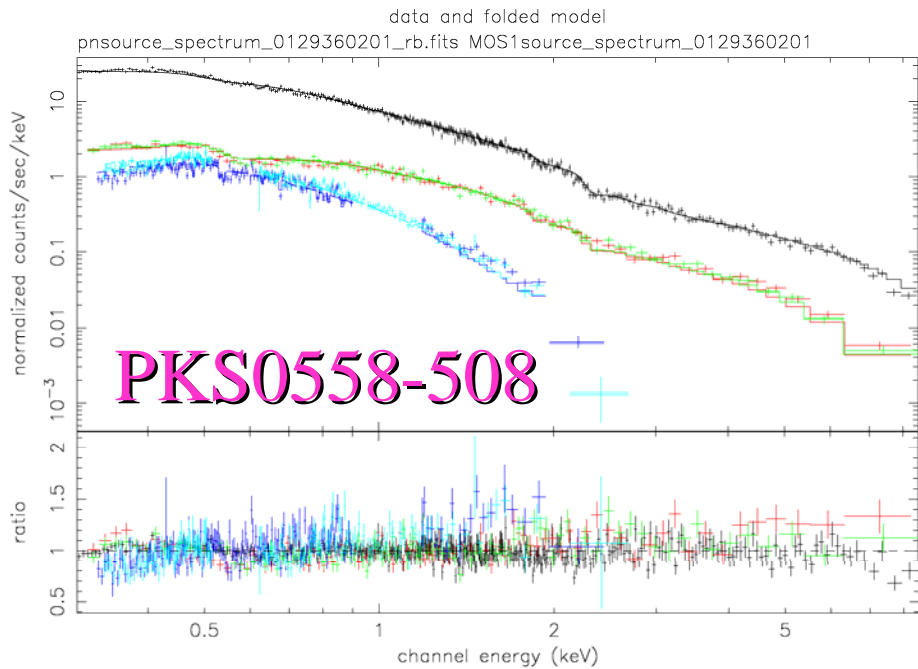
- no change in soft response
- CTE degradation seems to slow down (some further monitoring before action)



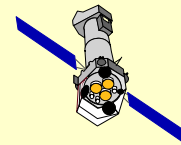
# cross calibration: EPIC



# cross calibration: EPIC-RGS

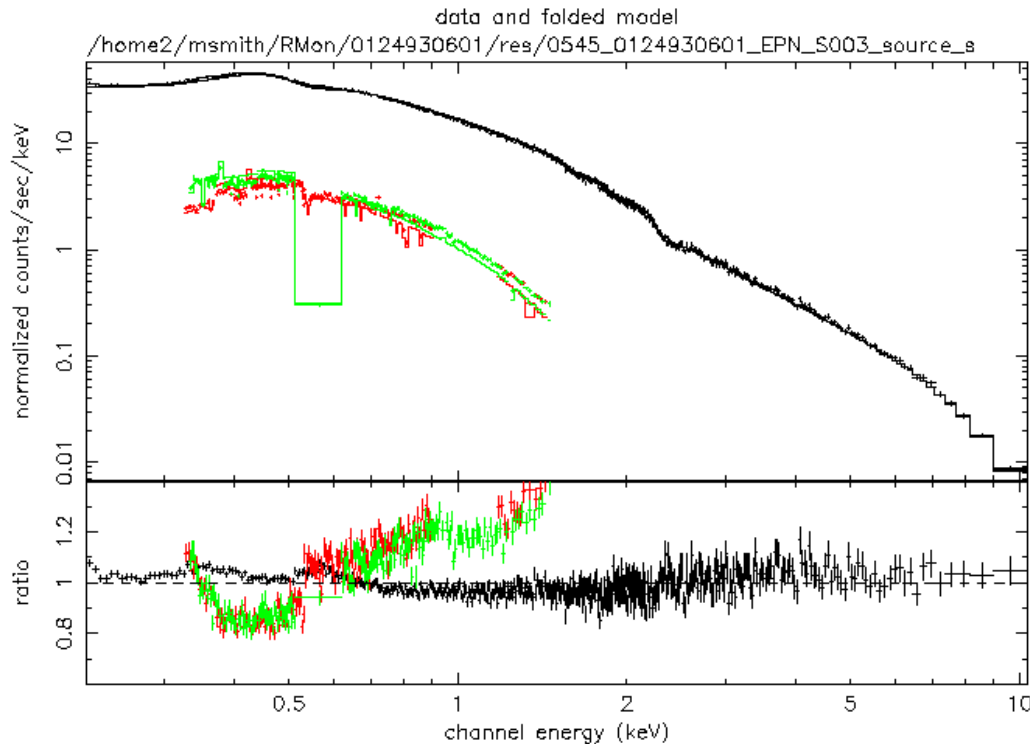


- systematic cross calibration for 25 targets, 200 observations underway
- understand the up to  $\pm 20\%$  differences in flux between EPIC and RGS
- line-rich spectra RGS  $\Rightarrow$  EPIC
- continuum spectra EPIC  $\Rightarrow$  RGS



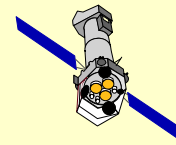


# results: PKS2155-304

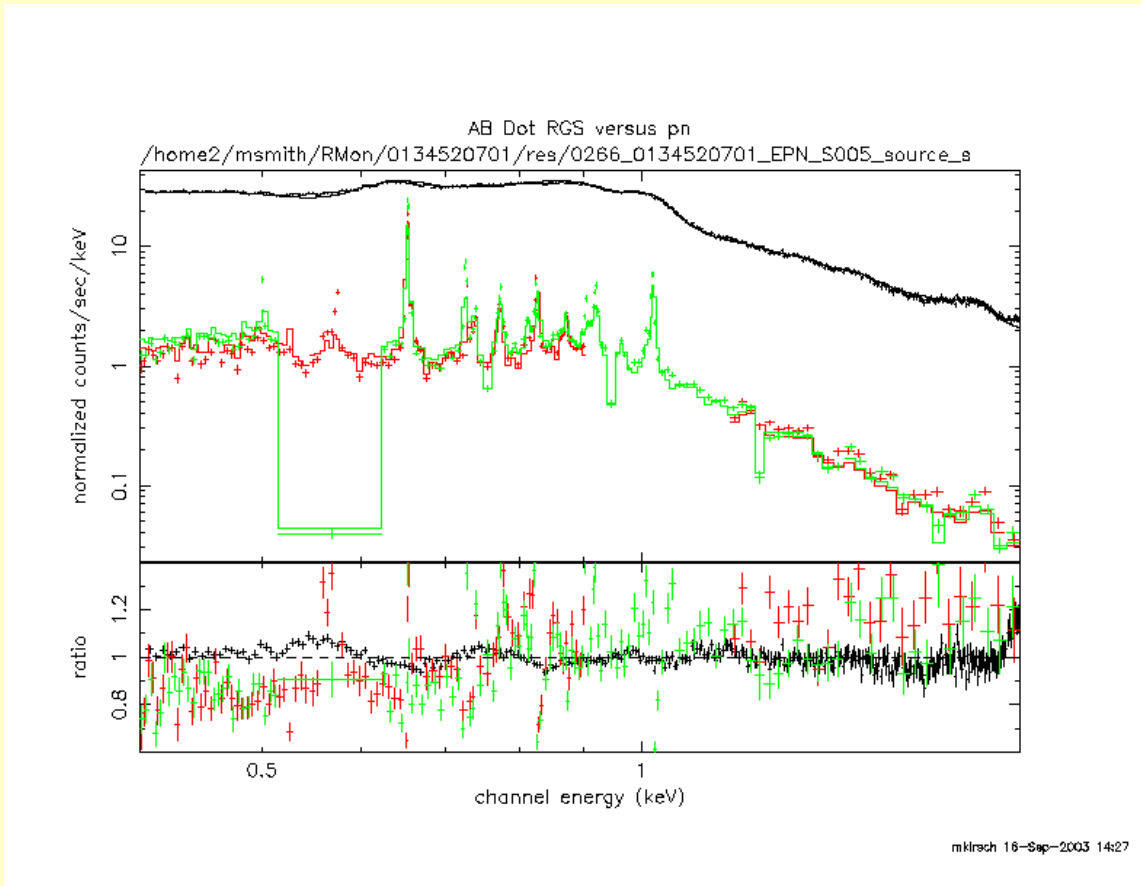


m.kirsch 16-Sep-2003 15:36

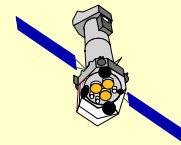
- Model:  
constant  
\*wabs  
\*powerlaw  
where constants for RGS are free (0.91,0.89), all other parameters are fitted simultaneously
- up to  $\pm 20\%$  differences in flux
- same trend also observed for PKS0558-504



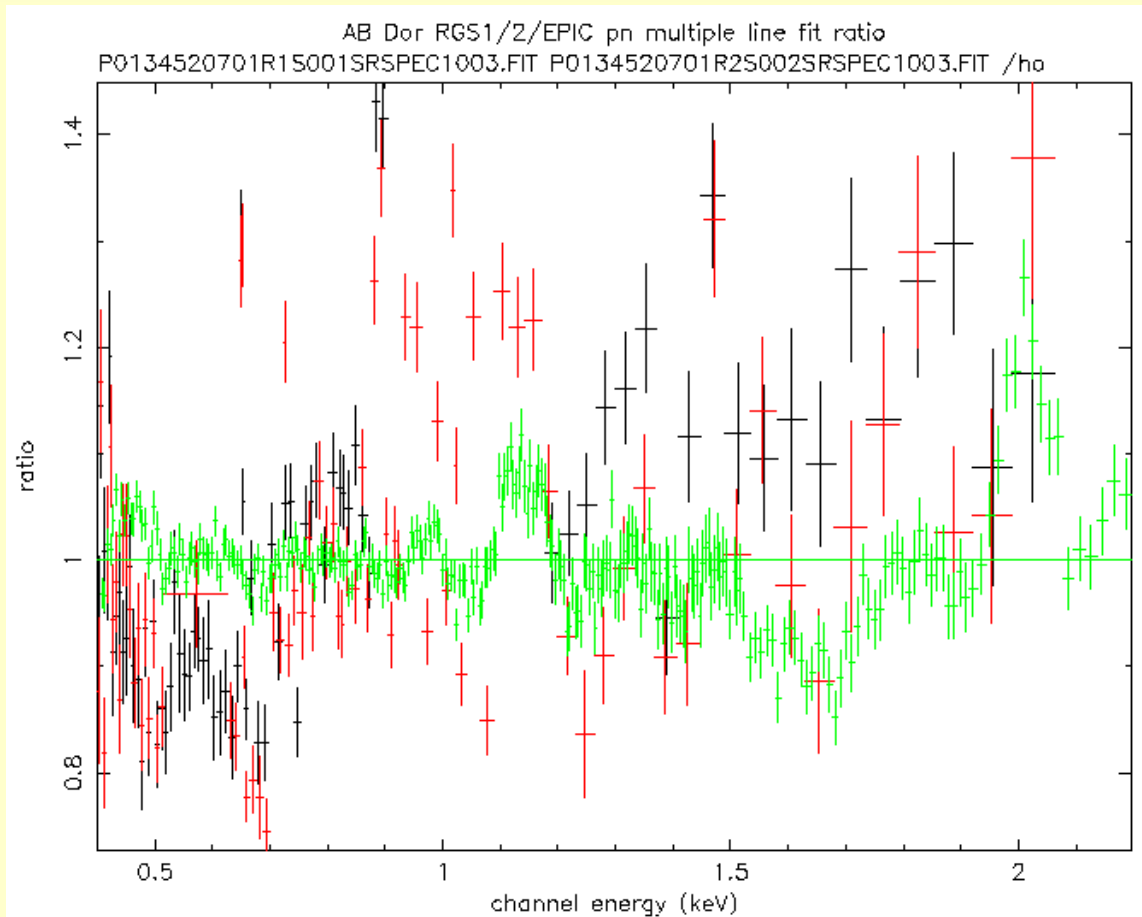
# results: AB Dor



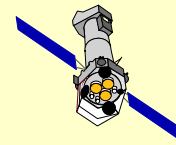
- Model:  
constant  
\*wabs  
\*(vmekal+bremss)  
where constants for RGS are free (0.85,0.87), all other parameters are fitted simultaneously
- the spectrum's many lines are not perfectly fit but the model is good enough for this comparison
- up to  $\pm 20\%$  differences in flux



# results: AB Dor

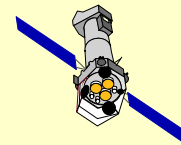


- Model:  
 constant  
 \*wabs \*brems+  
 (some gaussians)  
 where constants for  
 RGS are free
- up to  $\pm 20\%$   
 differences in flux



# EPIC calibration summary

| Effect                  | Max. Error             | Energy dependent | Off axis angle dependent |
|-------------------------|------------------------|------------------|--------------------------|
| Relative Astrometry     | 1''(r.m.s.)            | NO               | YES                      |
| Absolute Astrometry     | 2'' (r.m.s.)           | NO               | YES                      |
| PSF                     | 2 %                    | YES              | YES                      |
| Relative Effective Area | ± 5 %                  | YES              | YES                      |
| Absolute Effective Area | ± 10 %                 | YES              | YES                      |
| Line Energies           | ± 10 eV                | YES              | YES                      |
| Relative Timing         | $\Delta P/P < 10^{-8}$ | NO               | NO                       |
| Absolute Timing         | 300-600 $\mu$ s        | NO               | NO                       |



# for detailed information

## XMM-Newton Calibration Portal

[http://xmm.vilspa.esa.es/external/xmm\\_sw\\_cal/calib/index.shtml](http://xmm.vilspa.esa.es/external/xmm_sw_cal/calib/index.shtml)

- ➔ Updated: EPIC Calibration Status Version 2.2 for new SAS release
- ➔ Release notes for every new CCF
- ➔ General Calibration Documentation



**we keep on calibrating**

