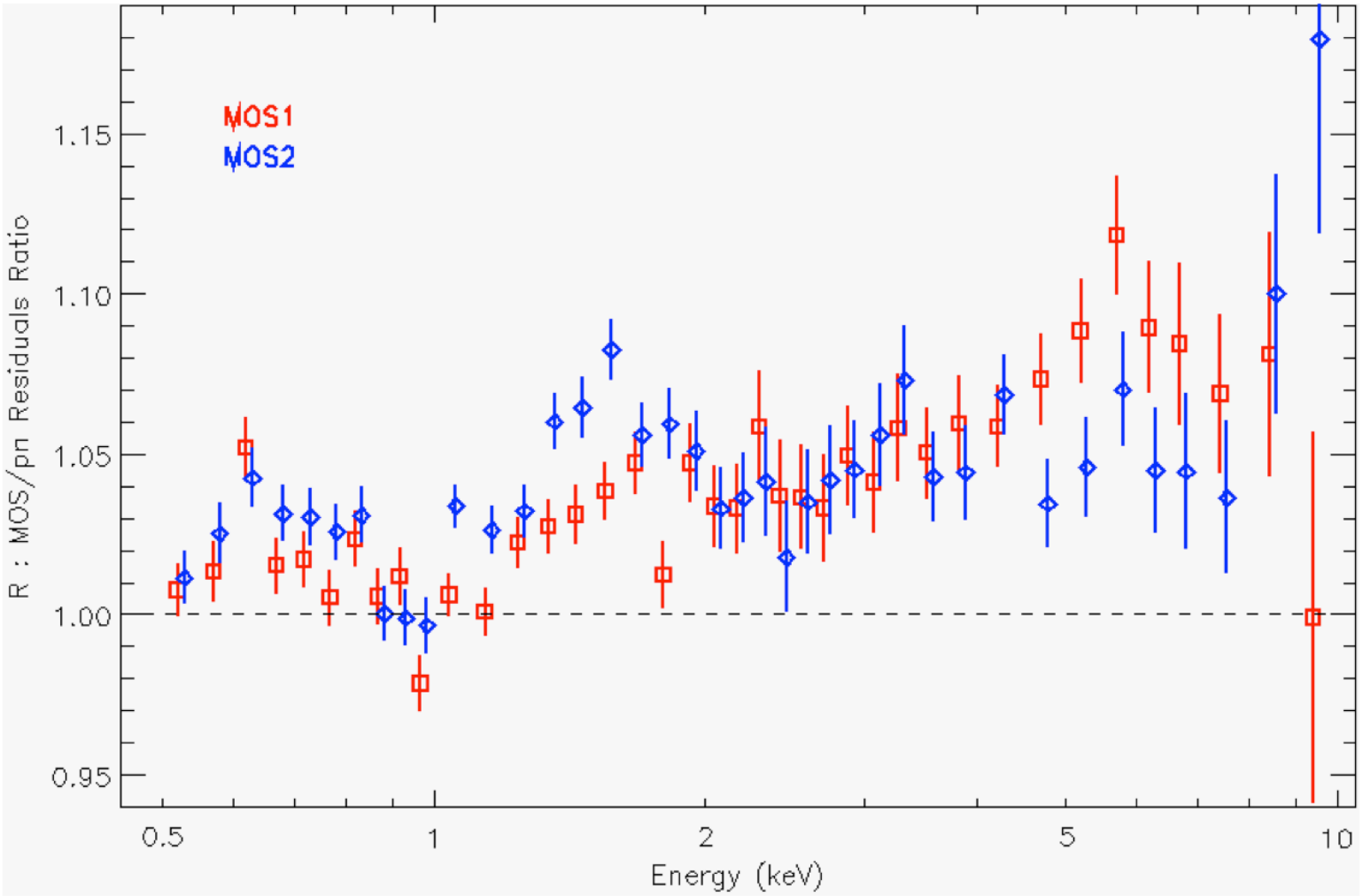
Calibration of the XMM-Newton telescopes' area revisited

David Lumb (ESA-ESTEC) & Matteo Guainazzi (ESA-ESAC)

EPIC cross-calibration status in 2012 (SASv12)



(Read et al., 2014, A&A

The former Calibration Scientist comes to rescue

XMM Mirror Calibrations - Revisited

David Lumb, 26 March 2014

EPIC XCAL Meeting #6, MPE

[Work is **ongoing**. Results are **preliminary**]

Scope

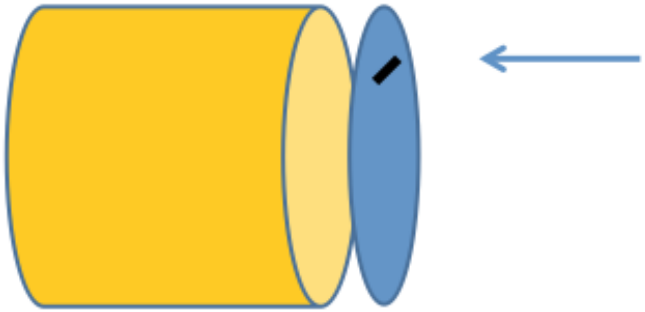
- History lesson
- Mirror Module variable parameters
- Ray trace comparisons
- Latitude for "arbitrary" modifications ?
- Vignetting

Panter

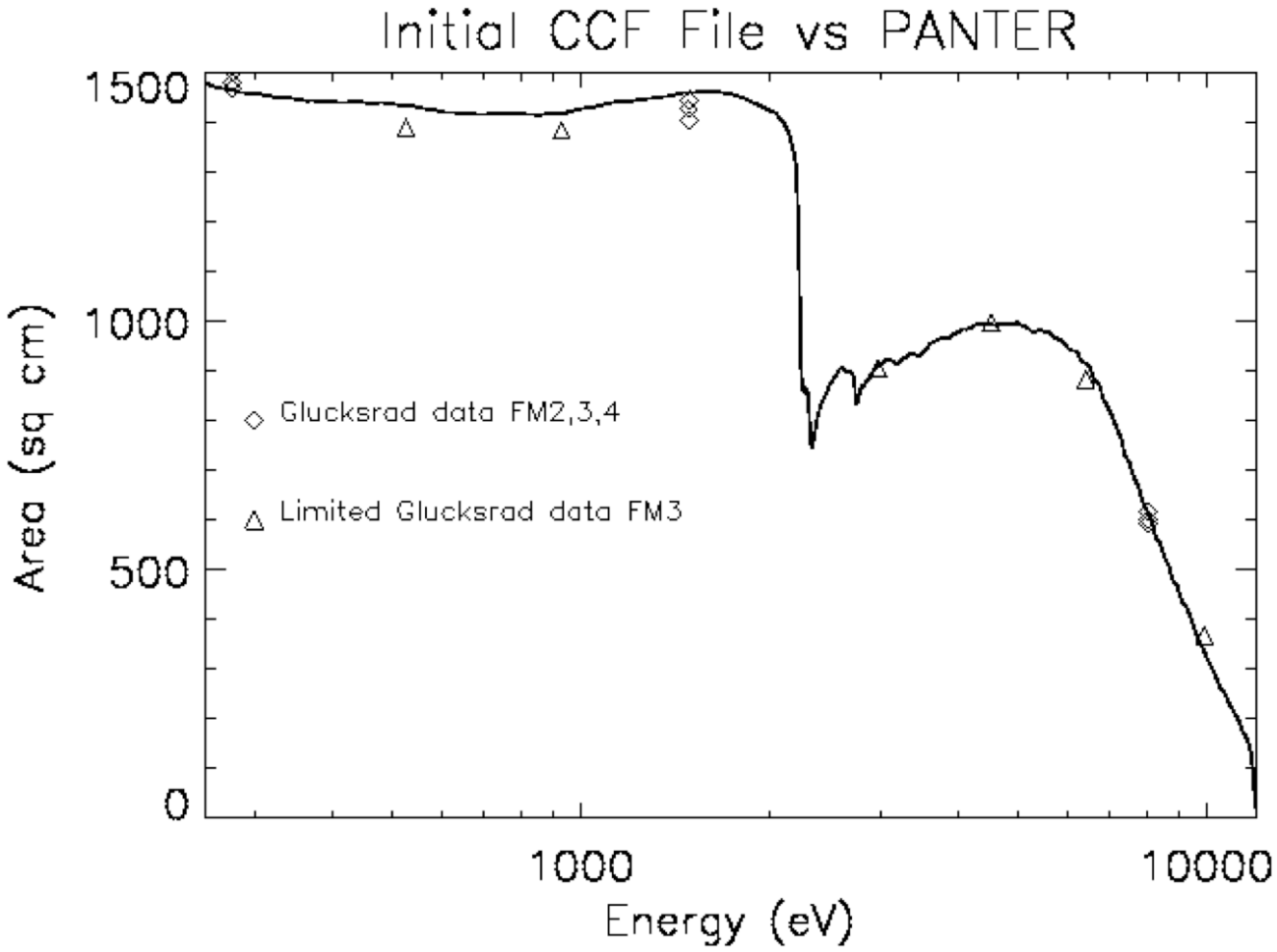
- ~128m beam – not parallel
- Shell distortions – partial blocking and 30% not illuminated
- Persistent 15 % area deficit – reflectivity or geometry?

Panter

- Glücksrad – sector (16) and radius (4) selector to make illumination much more parallel
- But reduced S:N per unit time and only used on FM3 (= XRT1 = MOS1) for all energies
- Still ~4% total loss, and some azimuthal variations



CCF vs. PANTER

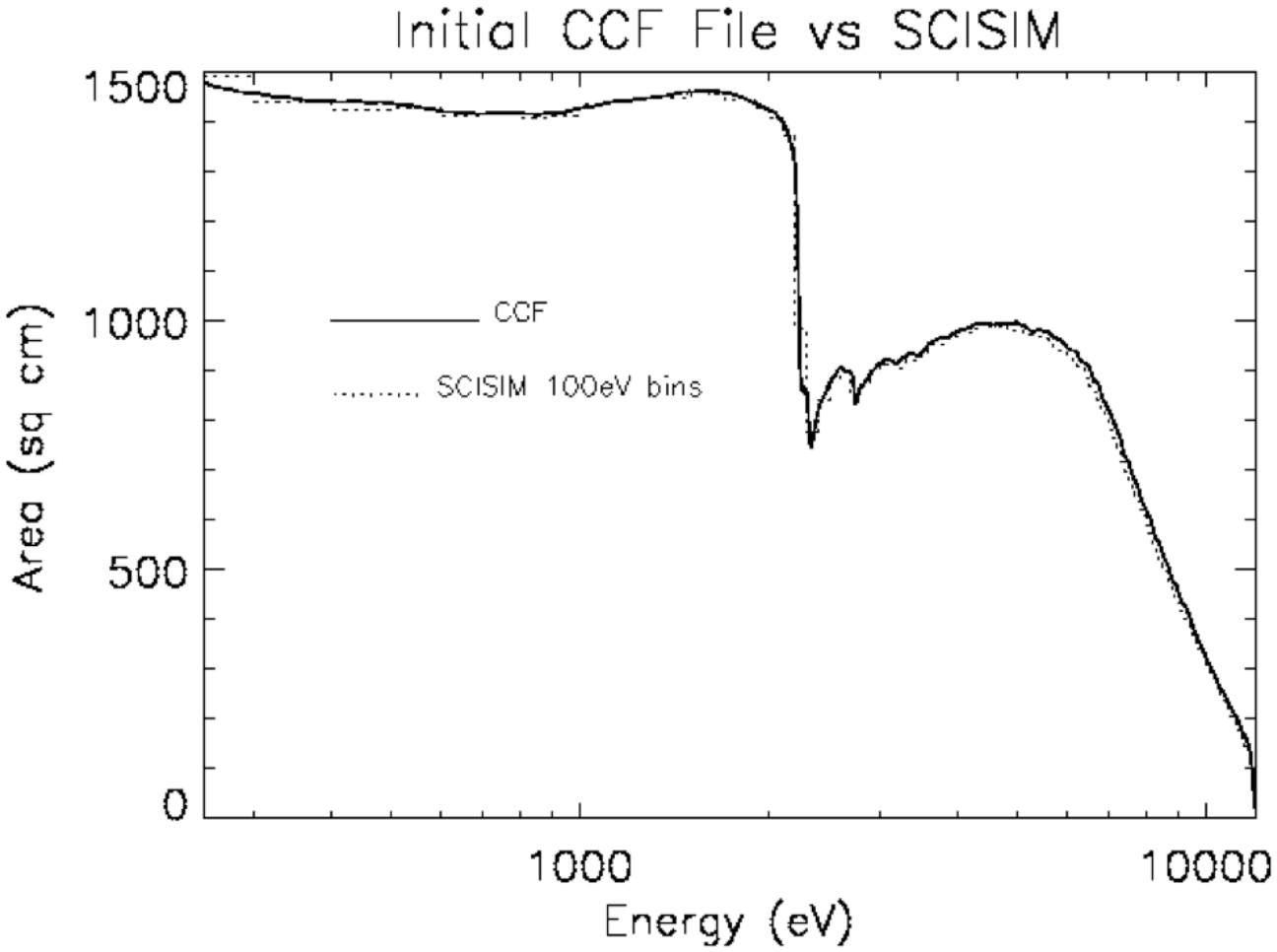


PANTER measurements confirmed at the EUV beam at CSL

CCF

- Adopted an effective area assuming a gold density, dust contamination and mirror surface roughness consistent with all the calibration data
- No statistically significant trend between mirrors so all three XRT data files set identical
- Subsequently, minor changes resulting from in-orbit calibration programme (spectral residuals not attributed to CCDs)

CCF vs. `SciSim` (XMM-Newton ray-tracing)



Assumptions: 100ppm dust, 97% bulk Au density, 0.45nm roughness

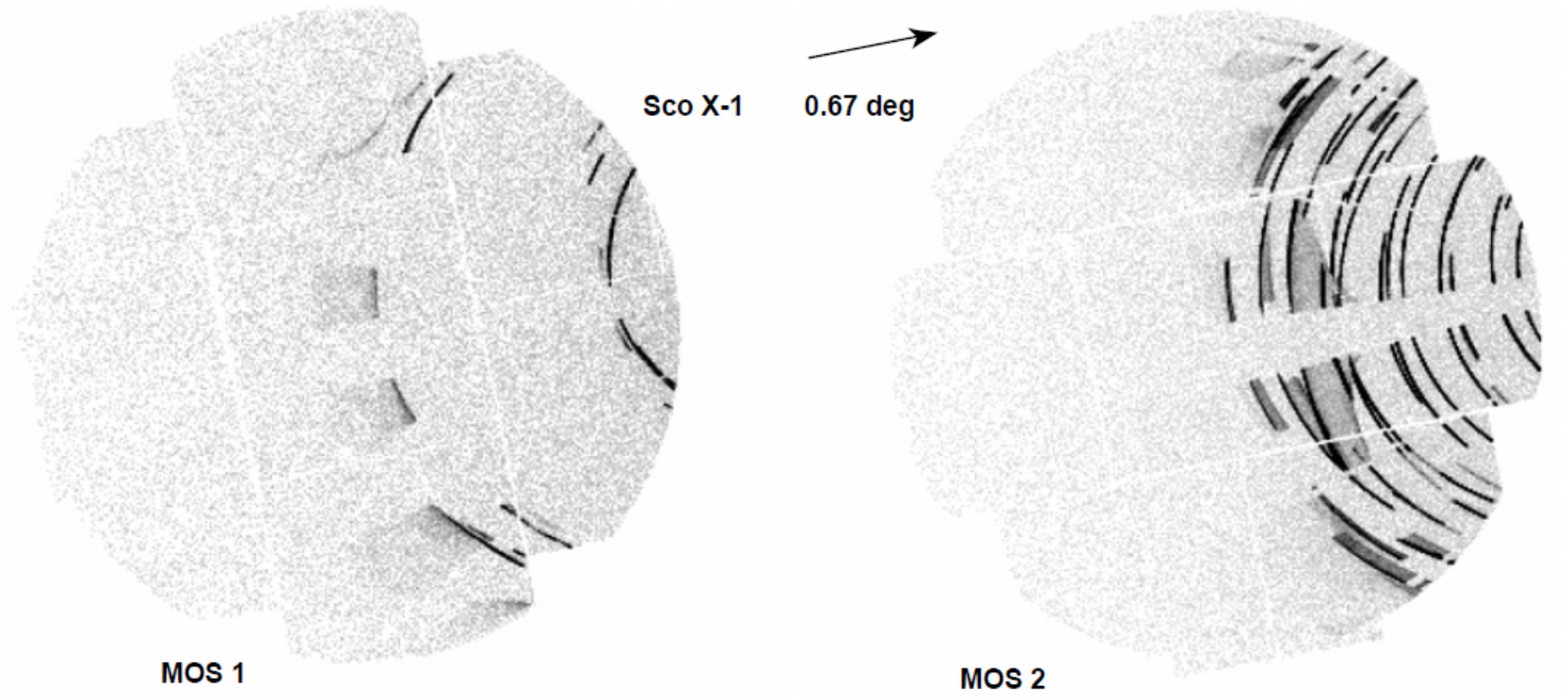
However ...

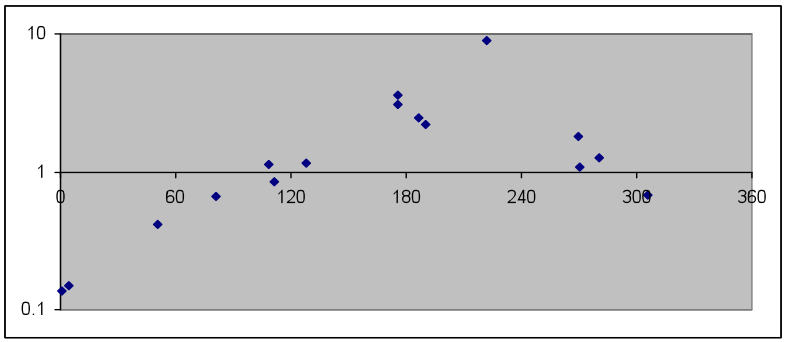
- The metrology is not the same for the Flight Modules
- The Gold reflectivity constants have been updated in the meantime
- Metrology measurements suggested a range of roughness between 3.5 and 6 Å
- The (XMM-Newton) Contamination Working Group suggested that a dust layer up to 140 ppm should be taken into account
- The level of contamination by hydrocarbons revised between on-ground calibration and in-flight operations to 1.5×10^{-7} g cm^{-3}
  - Ad hoc assumptions on thickness and density
  - Phthallate plasticiers from cables, esters from Carbon fibre tube ~(CH_2 CH_2 CH_2 ..) 1 g cm^{-3}
- Evidence for gross mis-alignment in the geometry of stray-light baffles (see later)
- [Telescope tilt determination accuracy no better than ~10 arcseconds. This should have been calibrated by in-flight calibration of the vignetting. However, evidence for strong different in the fluxes yielded by the EPIC camera off-axis; Mateos et al., A&A, 2009]
- `SciSim` mimics the PANTER configuration using the same radius in the focal plane as the PSPC (38 mm). `arfgen` assumes an extraction region of 5 arcminutes

Baffles

- Sieve plates installed in front of mirrors (after calibrations) to minimise off-axis stray light from single reflections
- Budgeted ~50 microns ring-to-ring alignment and 100 microns centring error for fabrication.
- CSL measurements indicated no gross misalignment on installation
- Ray trace can implement selectable randomised misalignments
- However – in orbit data suggest GROSS misalignment problem – probably could act as a "gray " filter even for on-axis sources …..

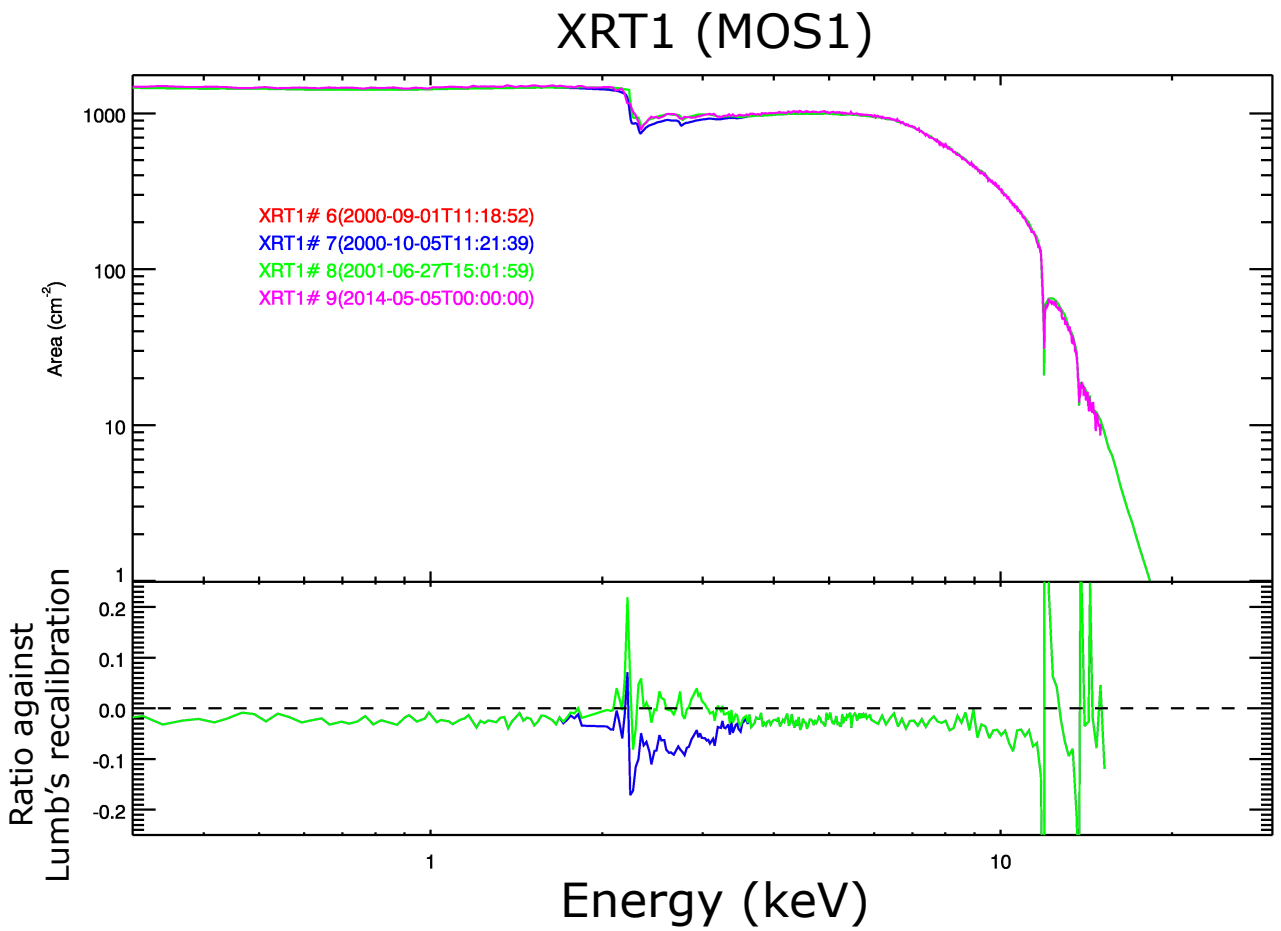
Straylight differences



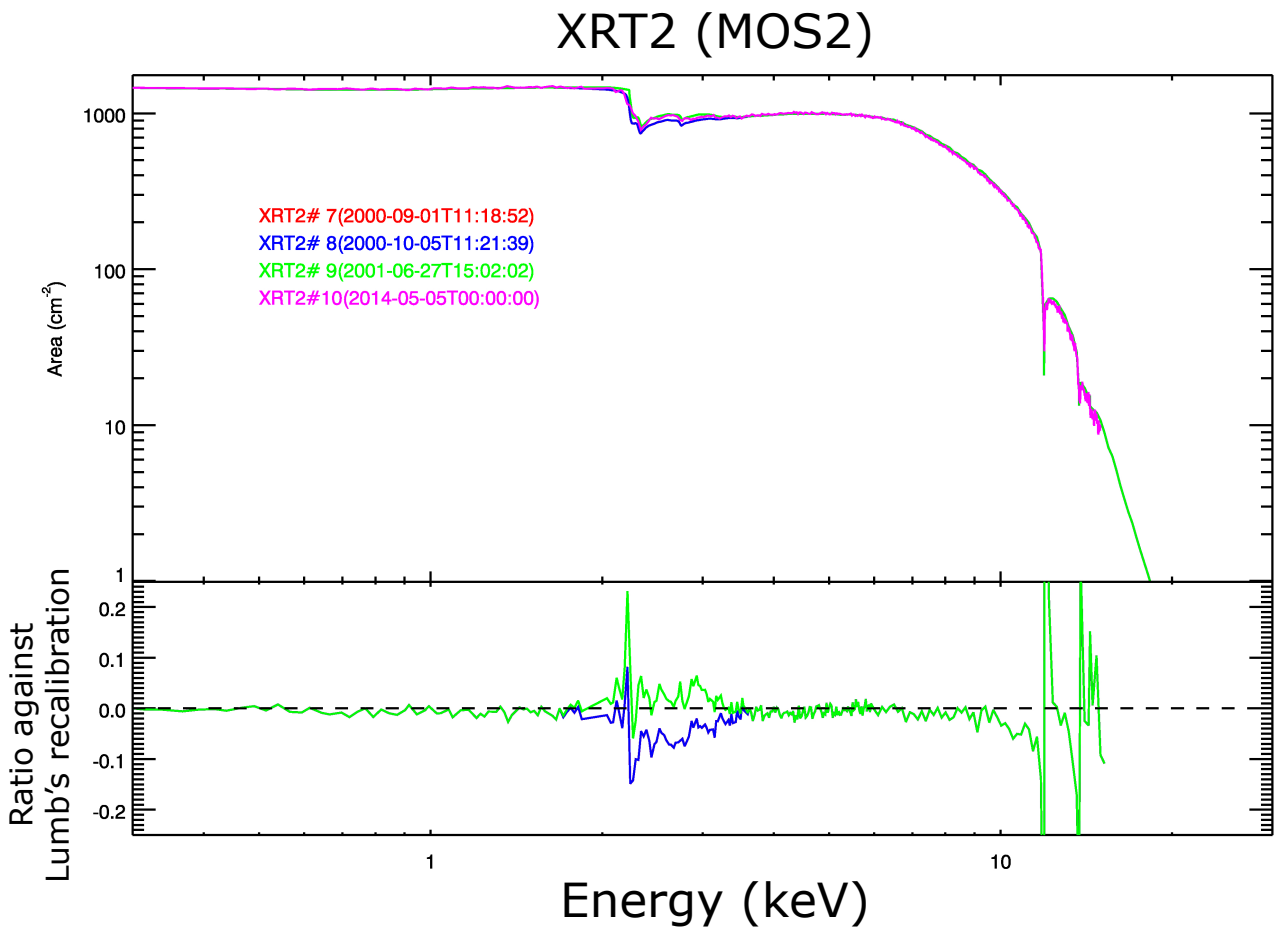


MOS1/MOS1 ratio
as a function of azimuth

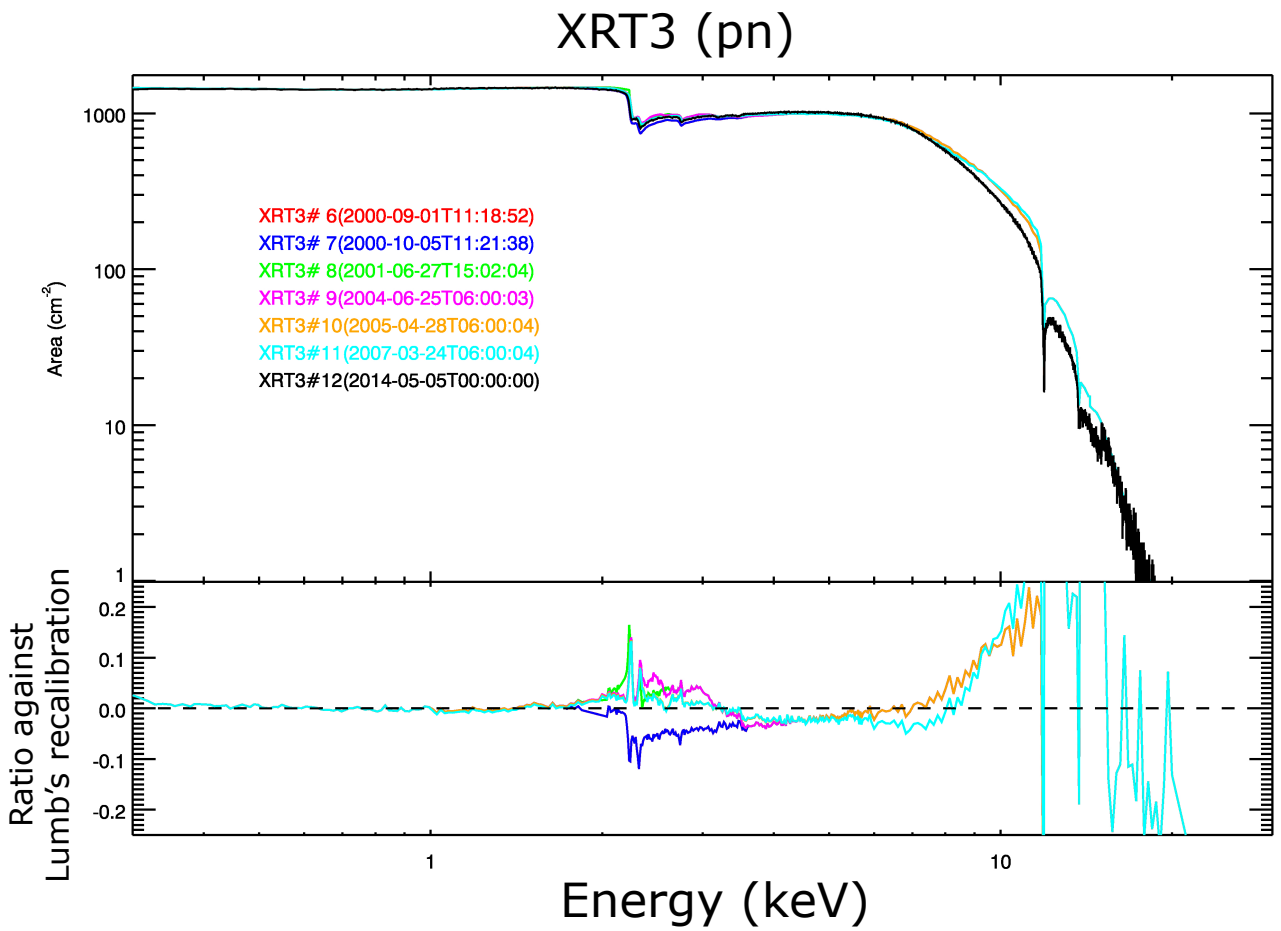
XRT1 area history



XRT2 area history



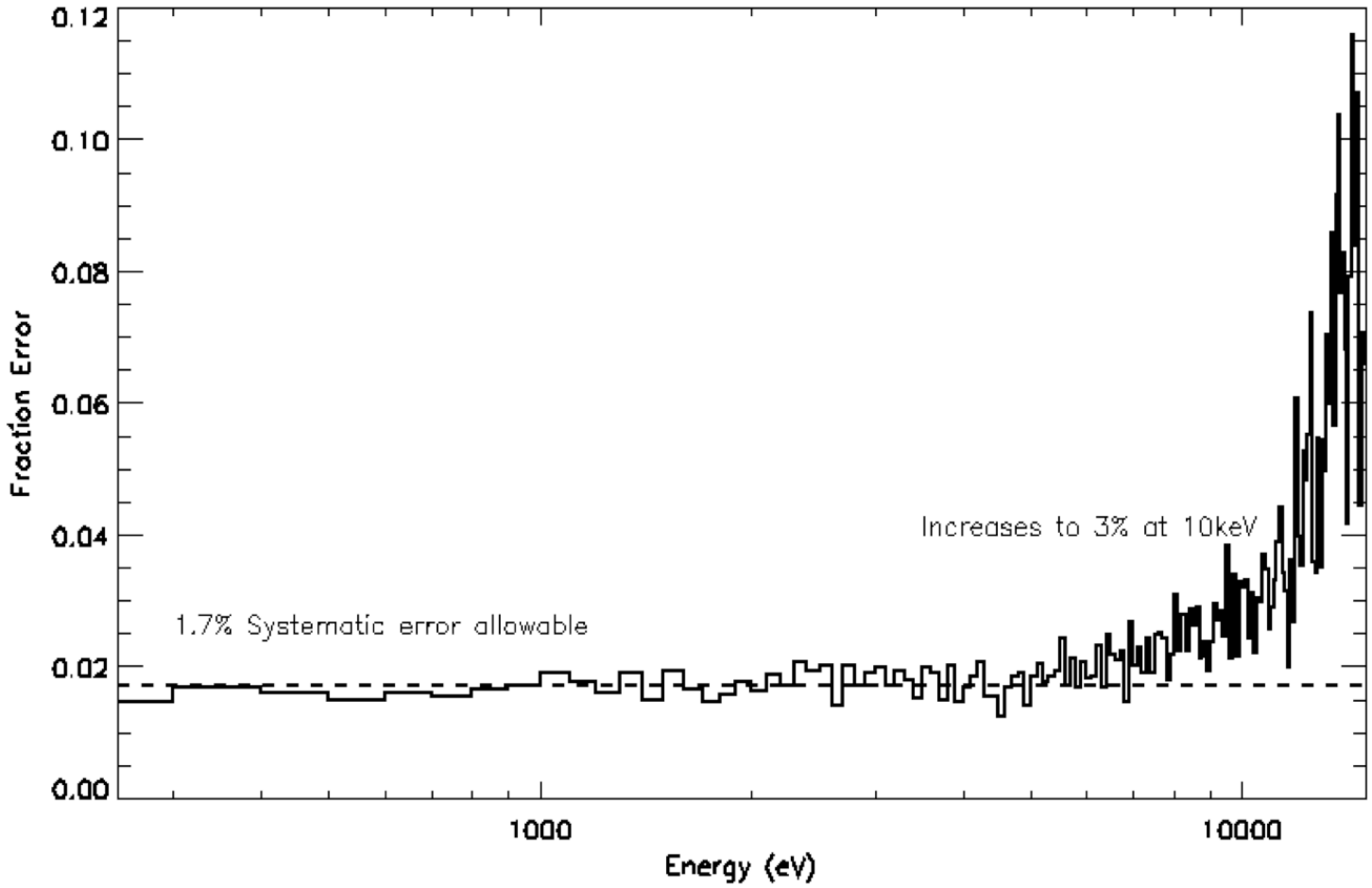
XRT3 area history



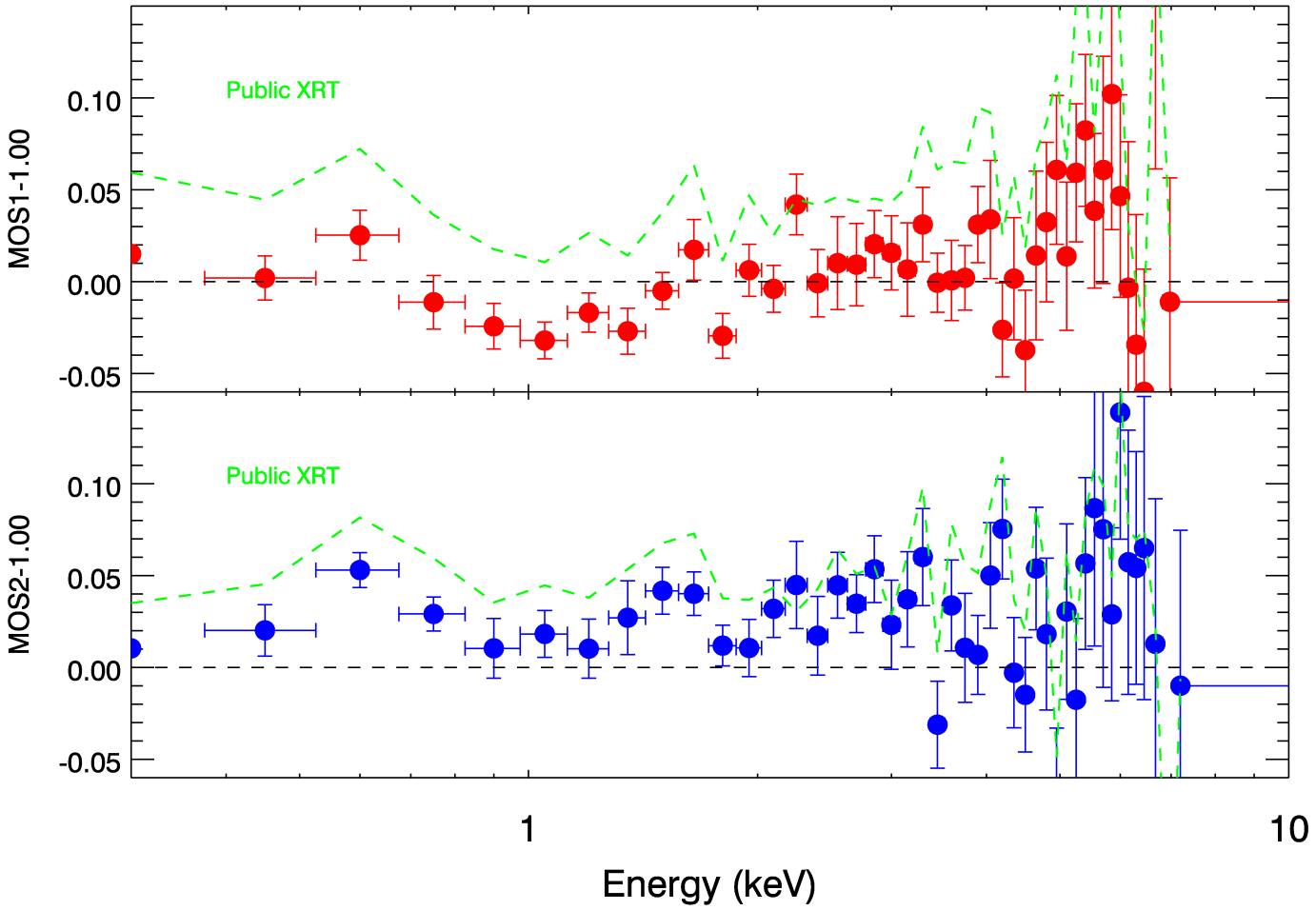
What is the allowable error from these parameters?

- Density < 0.5% absolute (*averaging ?)*
- Roughness – 0.05nm rms (*averaging ?)*
- Dust 30% variation – max due to exposures?
- 30 μ rms within the baffle structure and 150 μ centring baffle to telescope
- Axis – 10 arcsec at calibration and 10 arcsec in orbit vignetting calibration method
- Sum the errors r.s.s. as 1 σ?

Systematic errors estimate



Impact on EPIC cross-calibration



The IACHEC Galaxy Cluster WG is participating in the testing