A SPECTRO-SPATIAL MODEL FOR THE XMM BACKGROUND

FABIO GASTALDELLO

INAF, IASF-Milano

M. MARELLI, D. ECKERT (U. Geneva), S. MOLENDI, C. E. GRANT (MIT), P. KUHL (U. Kiel), I. BARTALUCCI, M. ROSSETTI, A. TIENGO (IUS Pavia), S. GHIZZARDI, A. DE LUCA

APPROACH

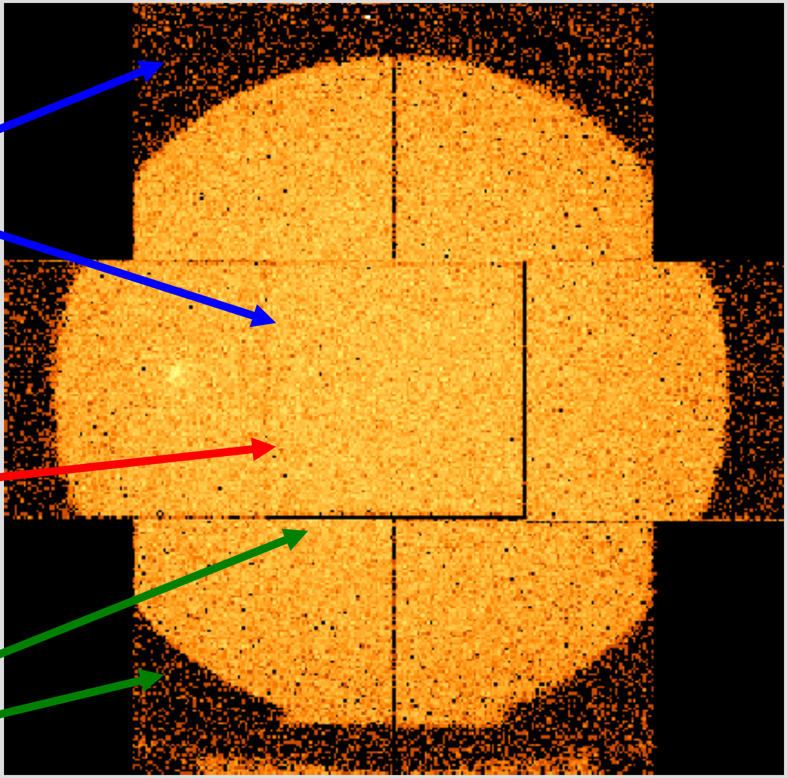
Goal: **provide multi-dimensional spectro-imaging model of the bkg components (energy, time, position in the detector), understanding their physical origin**

The components of the EPIC bkg are:

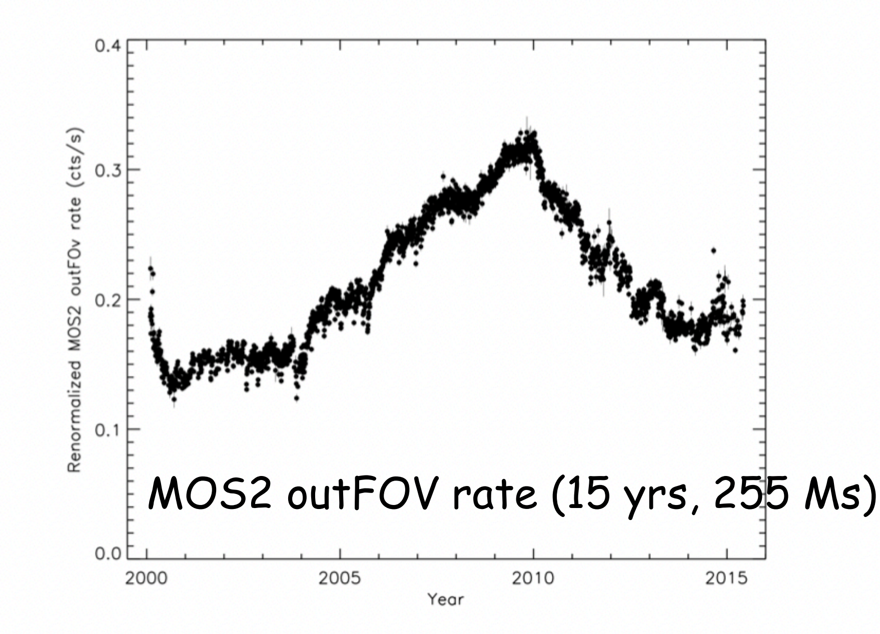
1) GCR bkg (i.e. GCR induced particle bkg, secondaries caused by protons in 0.3-1 GeV)
2) SP (those should be ideally filtered out (is there any SP quiescent component ?)
3) Compton bkg (induced by hard photons of the CXB)
4) Sky components (Galactic foregrounds + CXB)
5) Solar Wind Charge eXchange (SWCX)

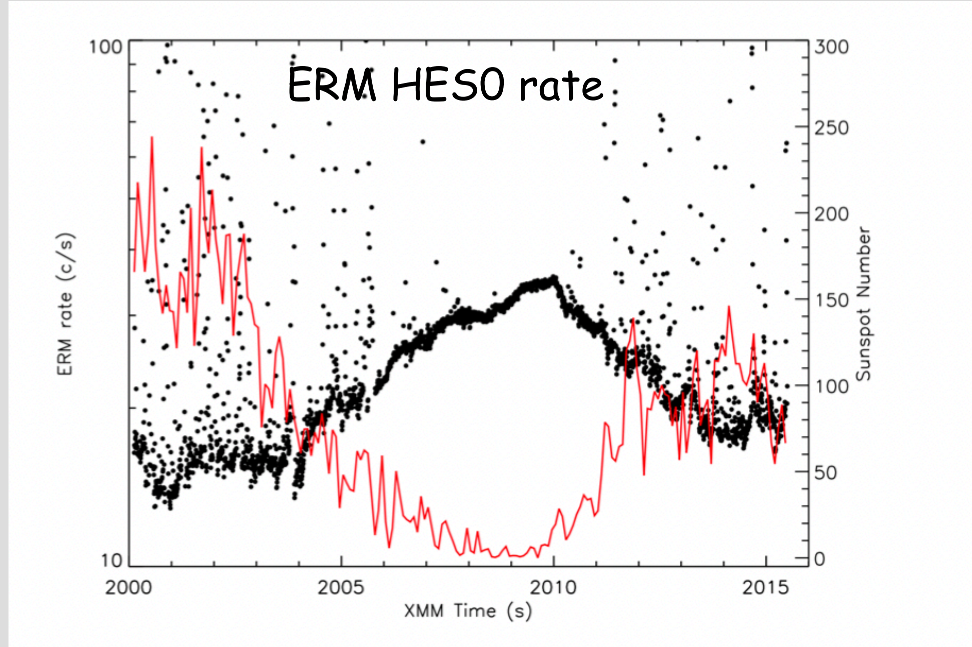
INSTRUMENTAL BACKGROUND

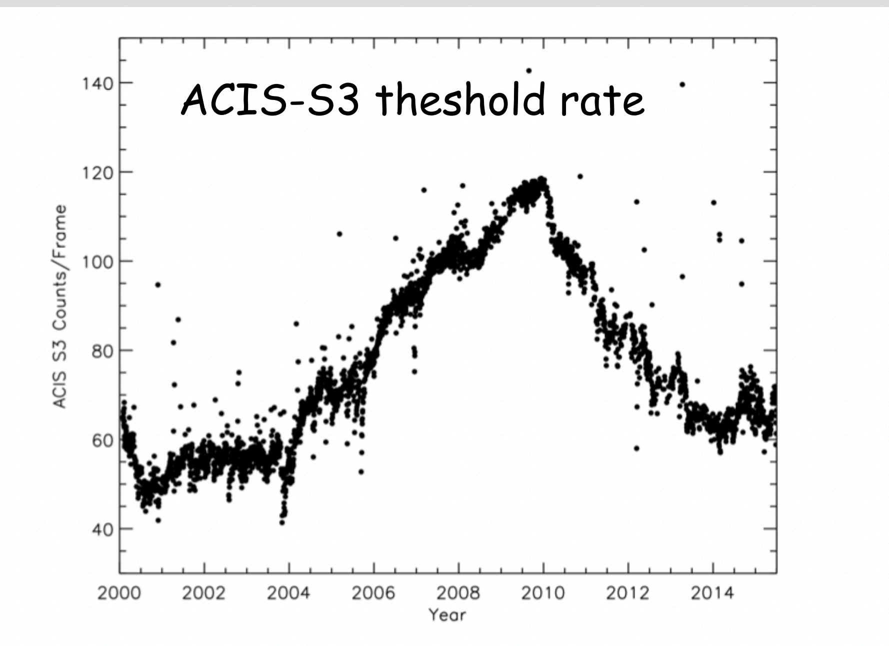
- Secondaries generated by high energy particle (E>100 MeV) mostly Cosmic Rays p+ (unfocused)
- Low energy ions (E<100 KeV) concentrated by mirrors (focused)
- Compton component

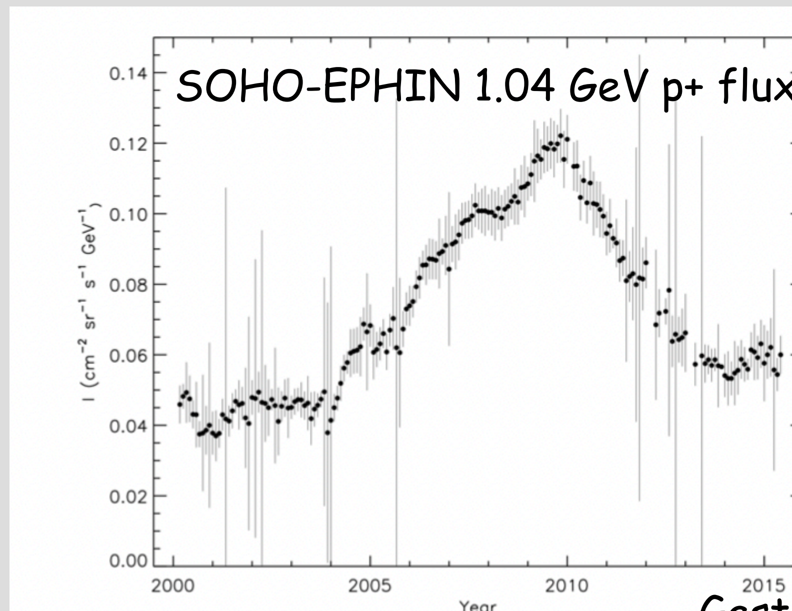


GCR-INDUCED BACKGROUND



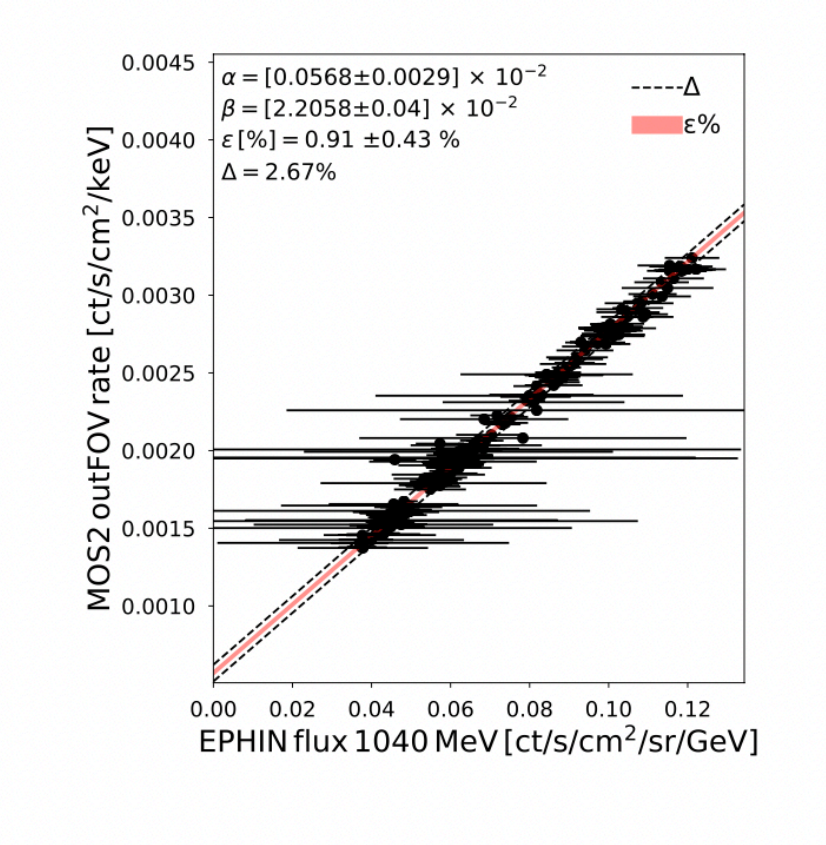


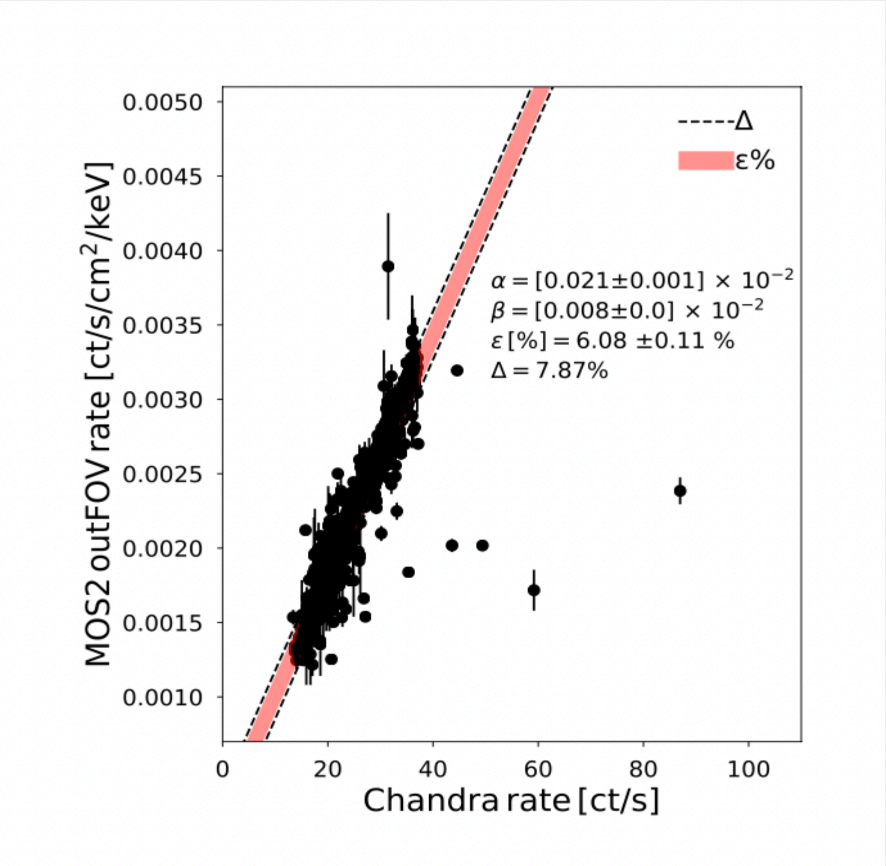




Gastaldello+22

GCR-INDUCED BACKGRUND

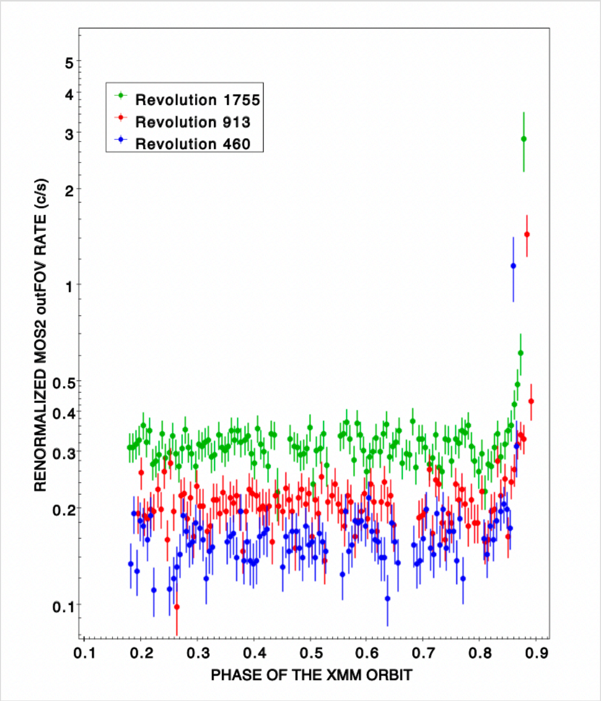


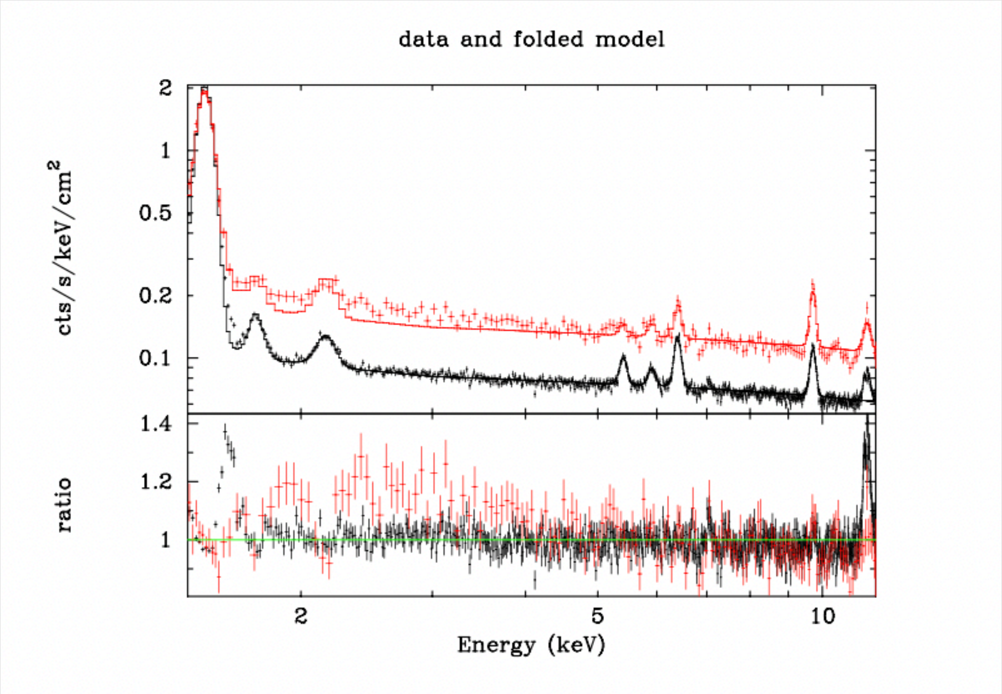


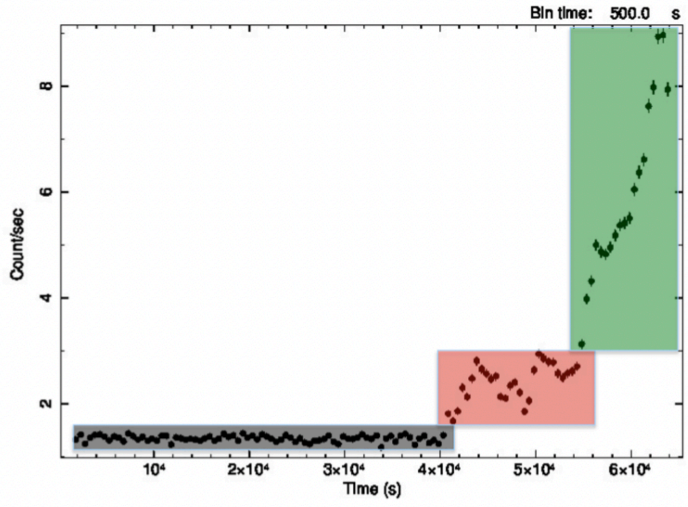
Tight correlation (2.7% total scatter) between MOS2 unfocused background rate and EPHIN proton flux strongly suggests that the bulk of the MOS2 background is generated by GCR protons (as shown by Geant4 simulations)

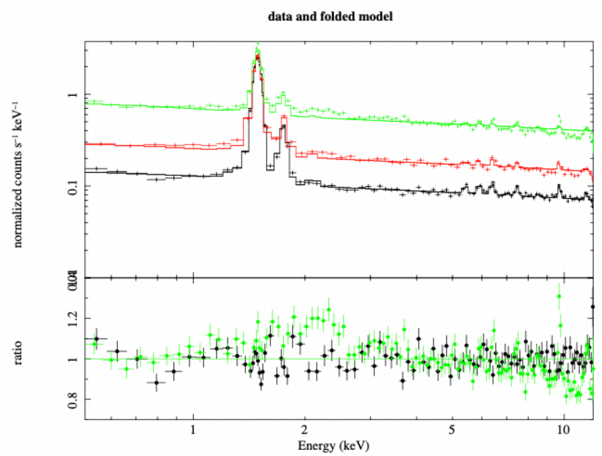
Tight correlation with Chandra bkg rate reinforces the common GCR origin for CCDs in similar orbits.

ELECTRON CONTRIBUTION





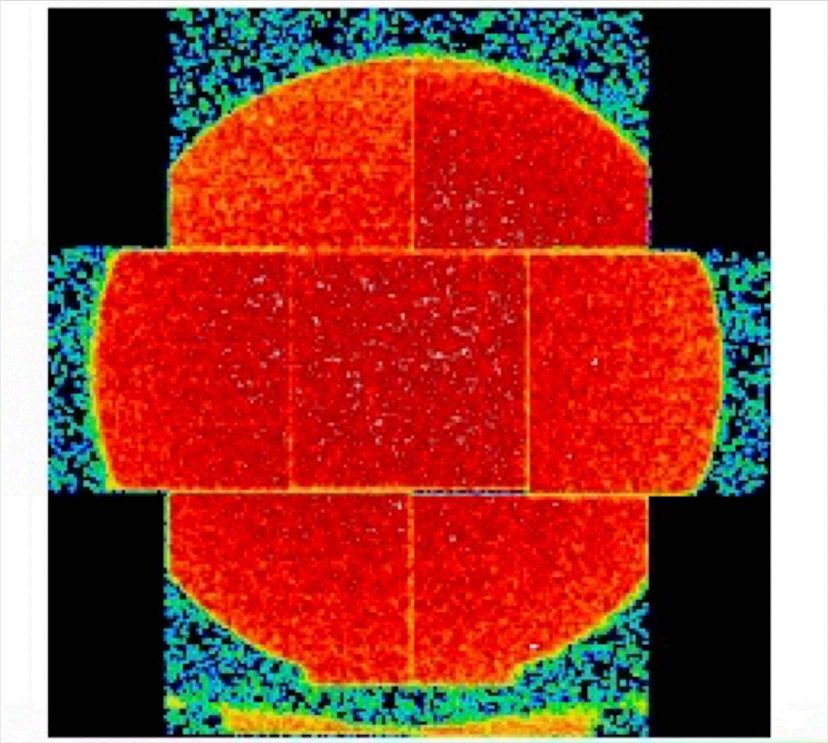


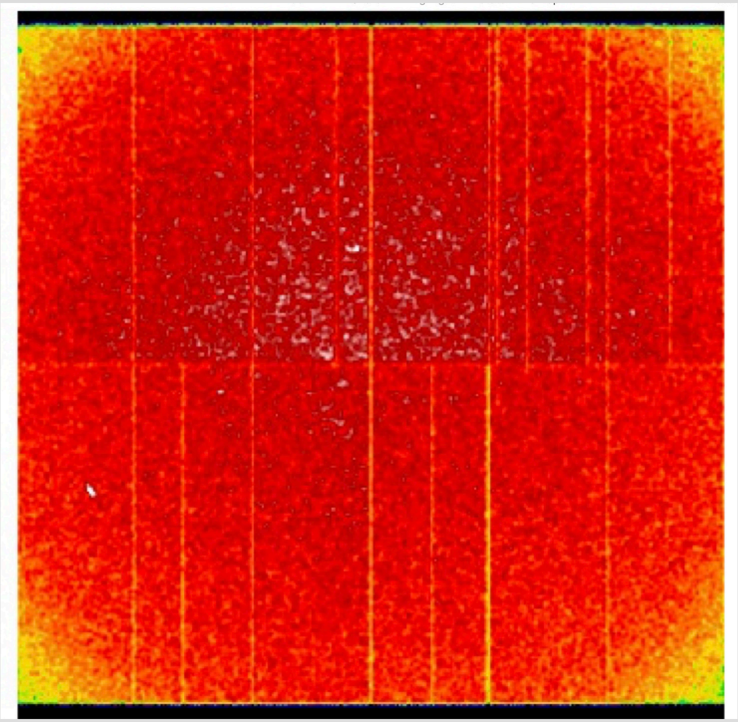


ELECTRON CONTRIBUTION

First evidence of a spectral change in the high energy band in the unfocused MOS2 background (slope going from 0.18 to 0.35-0.39) connected to the entrance to the outer electron belts and to an increase by order of magnitudes of the primary electrons flux. Limited use for XMM but important validation of Geant4 simulation of future missions (e.g. von Keinlin+18)

NO PN CORNERS

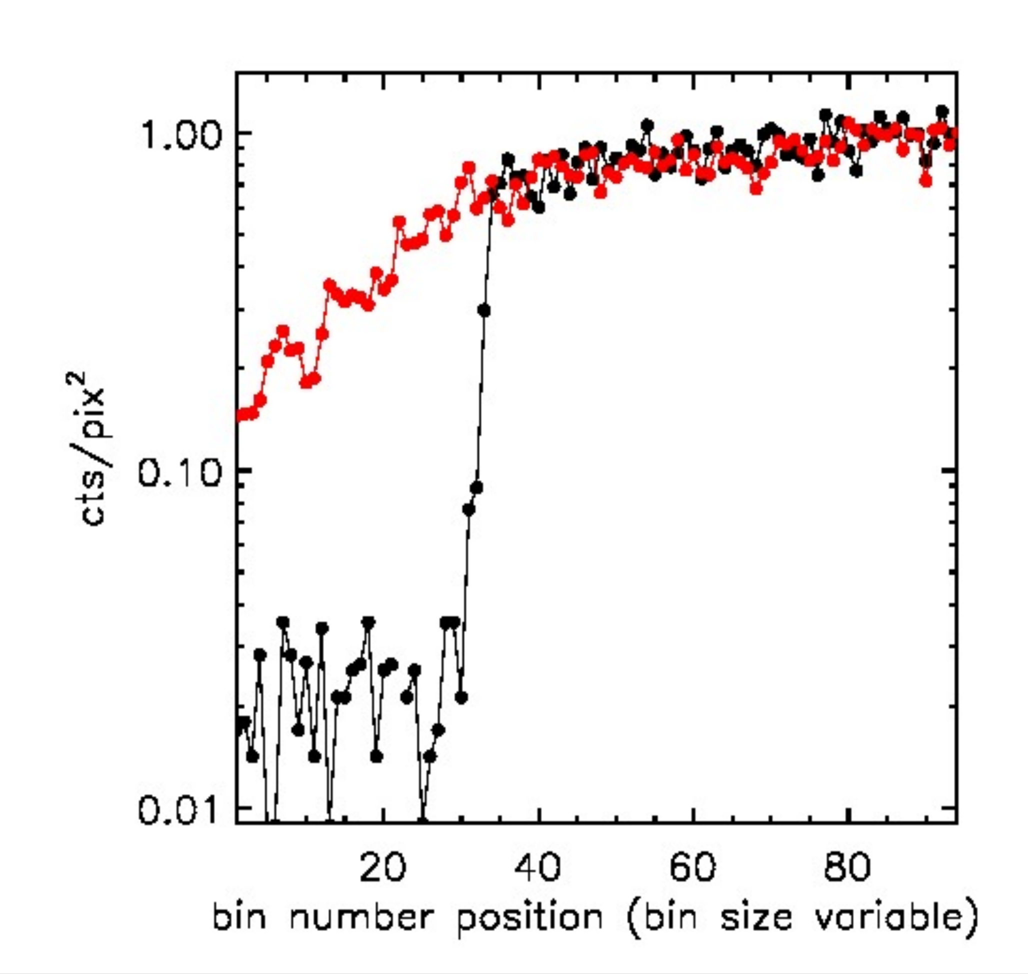




The pn instrument does not behave like MOS. Even when correcting for the ooT contribution significant contamination of the corner data by soft protons (and photons) as strikingly shown for example by a flared Lockman Hole observation.

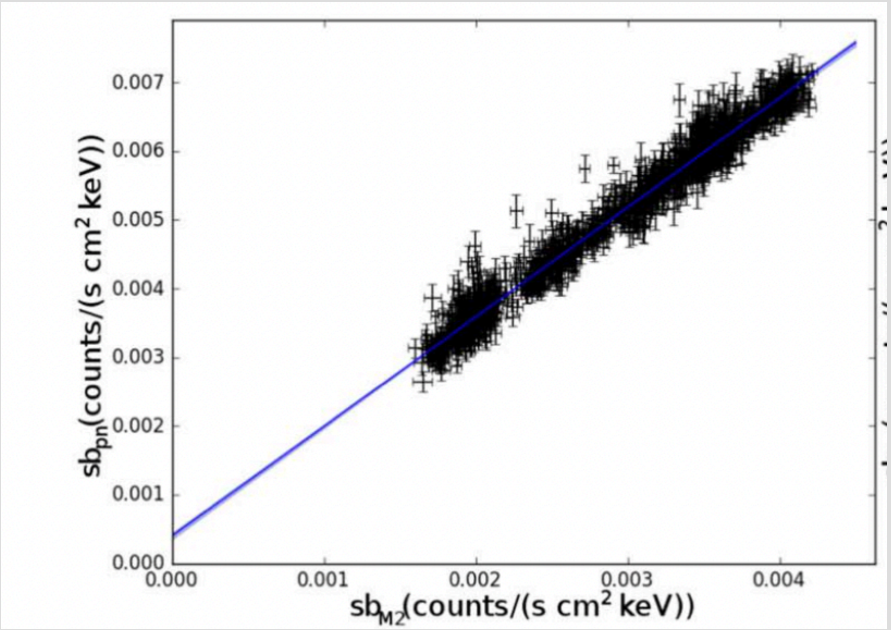
Marelli+21

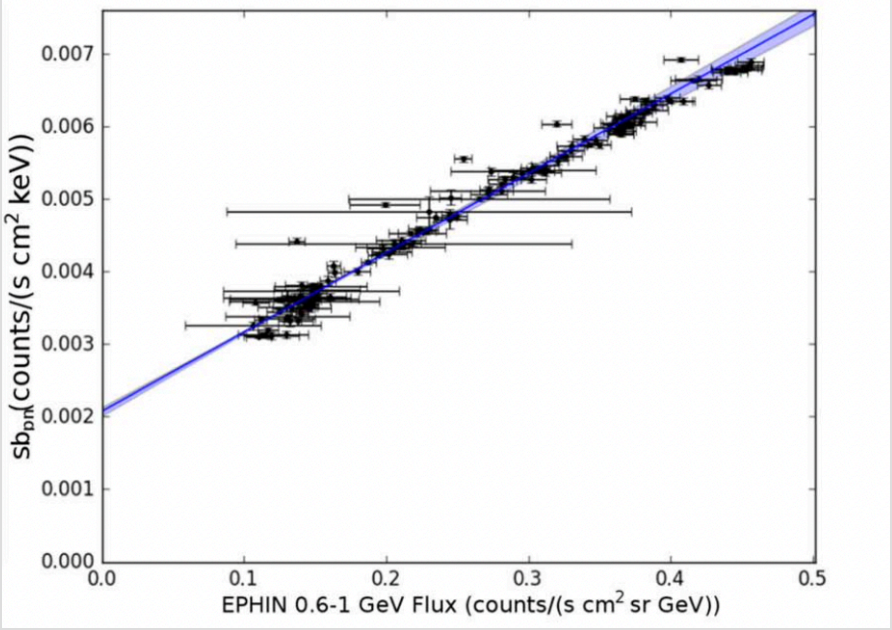
NO PN CORNERS



Comparison of pn and MOS profiles, renormalized, to show the different behavior in the outFOV.

PN GCR-INDUCED BACKGROUND

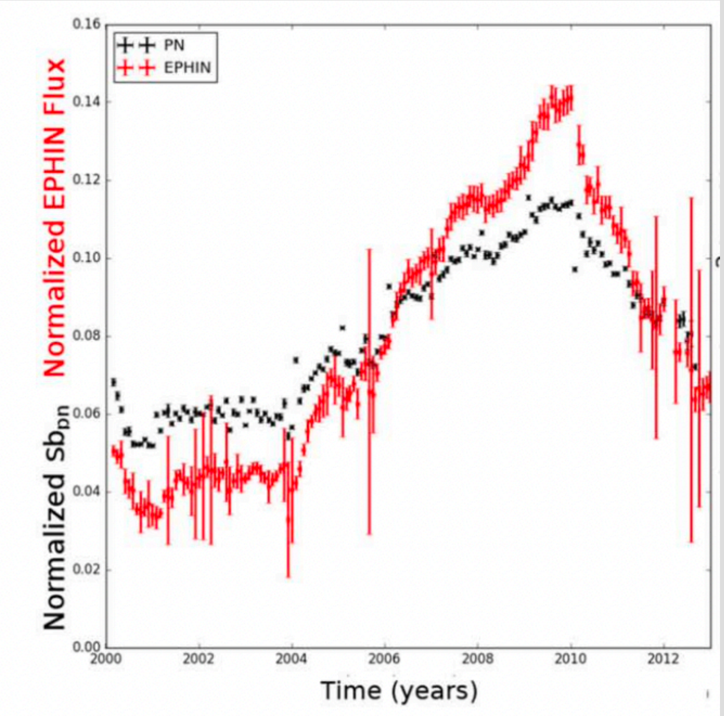




Filtering in time (excluding SP flares) , space (avoiding regions close to the edge of the FOV) and energy band (10-14 keV to minimize photons) can allow to use the pn OUT area as a monitor of the unfocused background.

Only after this cleaning we do see tight correlations with the MOS2 outFOV rate (2.3% scatter) and the EPHIN 0.6-1 GeV flux (3.5% total scatter)

THE COMPTON COMPONENT



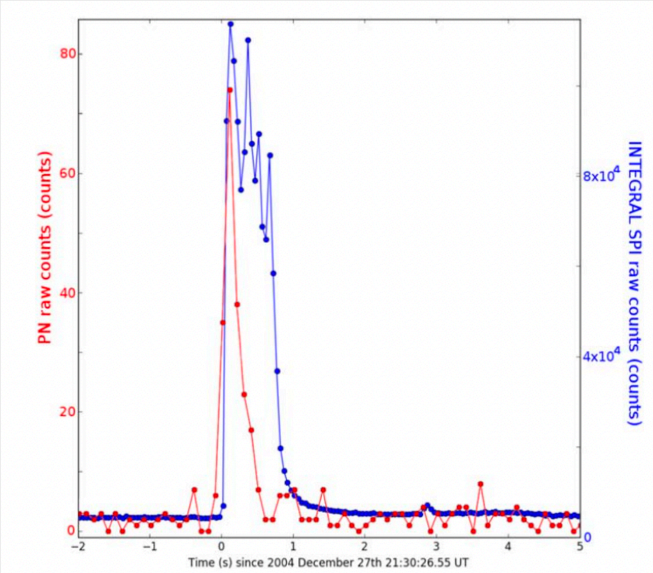
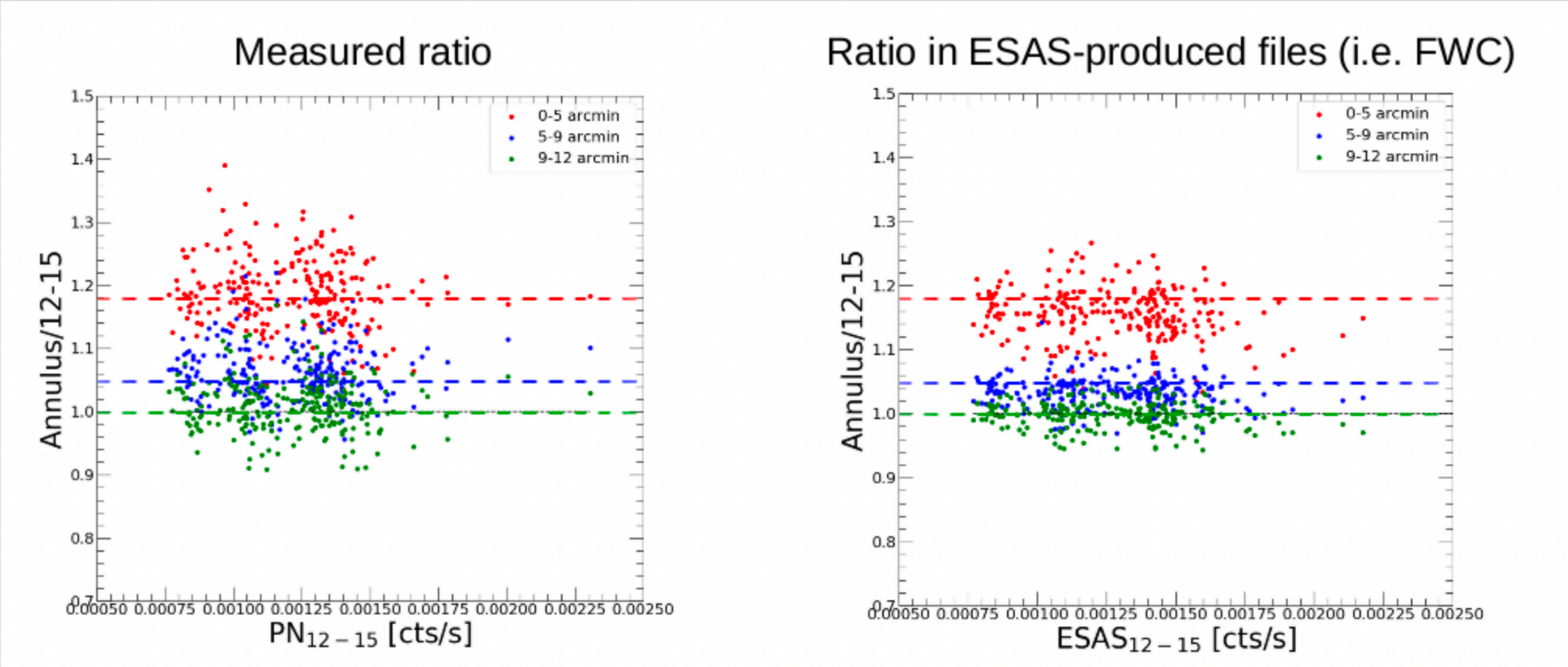


Figure 9. Light curve of the giant flare from SGR 1806–20, as seen by INTEGRAL/SPI (18 keV–8 MeV, time bin size 0.05 s, and the peak is saturated; Mereghetti et al. 2005) and XMM-Newton/pn (0.2–14 keV, time bin size 0.1 s). Time zero has been chosen following Mereghetti et al. (2005). Contemporaneous flares have also been registered by the MOS1 and MOS2 cameras, although their time resolution is worse (2.6 s). Flare events are registered throughout the entire pn detector (both inFOV and outFOV), and its spectrum is consistent with a power law with $\Gamma \sim 0.2$.

Presence of a constant component in the relationships of MOS/pn with EPHIN, no dependence on the solar cycle or time variation and roughly isotropic (very low scatter). The likely source are hard X-ray photons from the CXB. Similar in spectral shape to the GCR-induced background (Gastaldello+22).

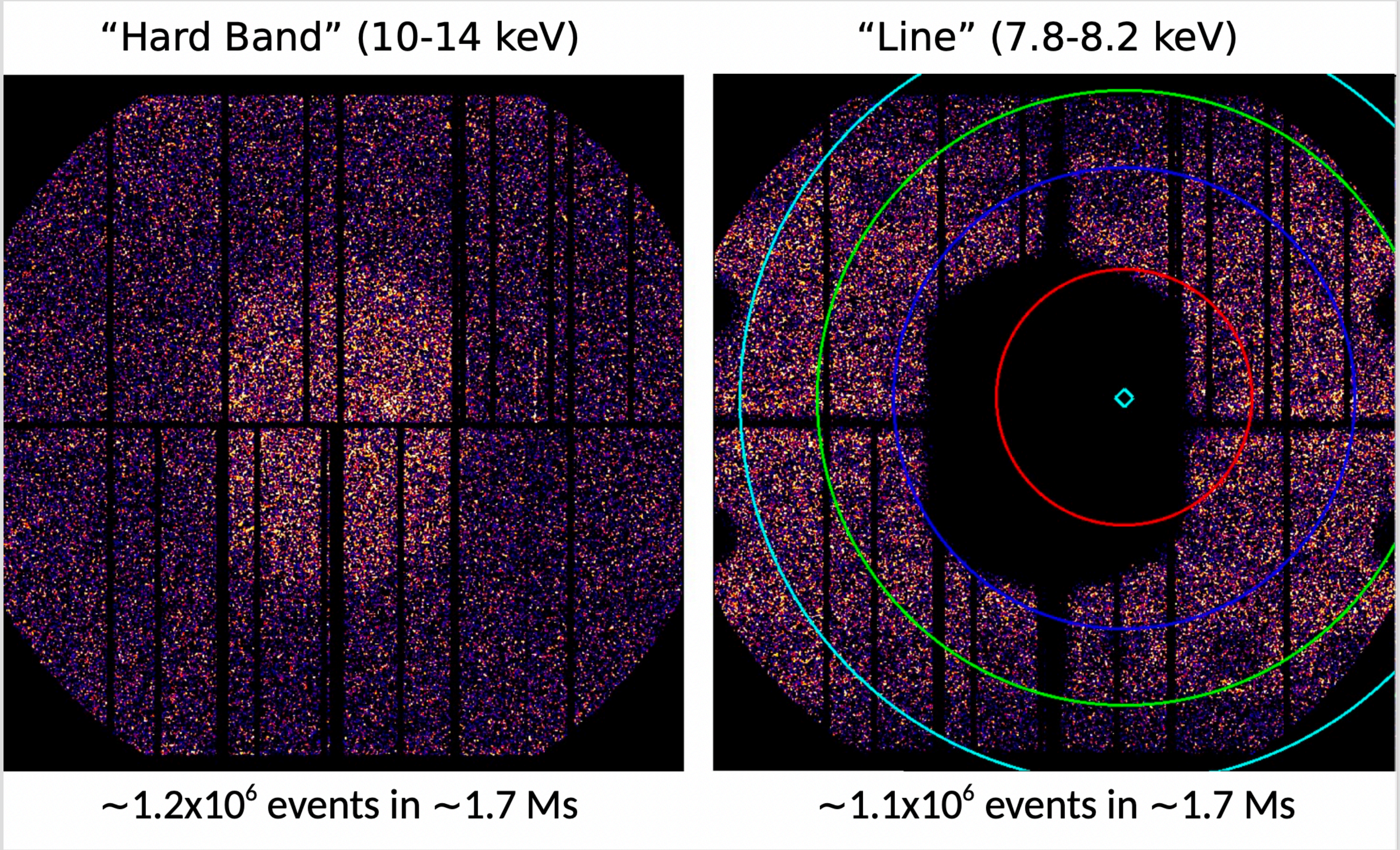
Other support comes from the giant flare of SGR 1806-20 (seen at 90 degrees by XMM).

PN SPATIAL VARIATION



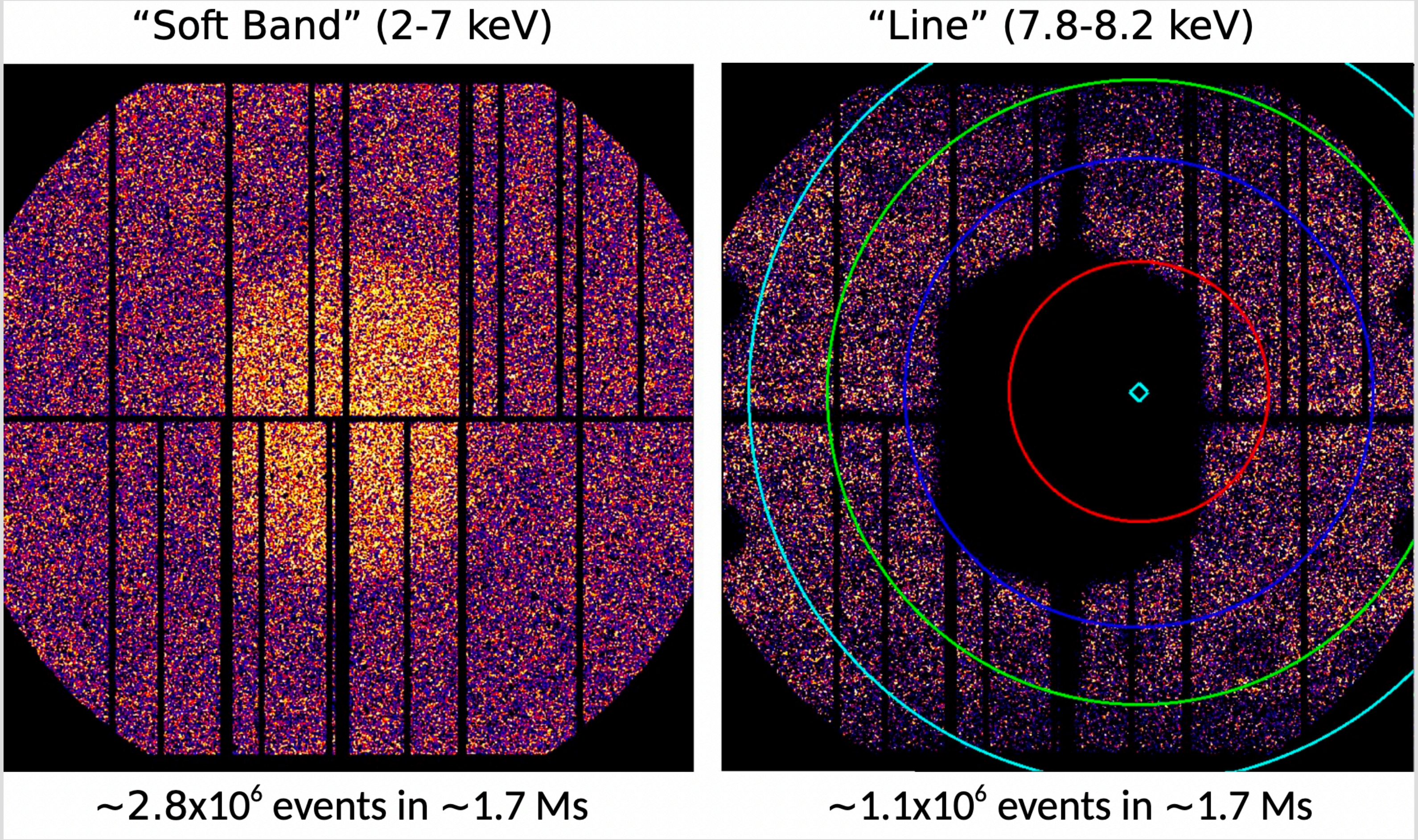
Safely use pn “cleaned” outFOV rates and the correlation with MOS2 outFOV rates and you are sensitive to spatial variations.

PN SPATIAL VARIATION



We investigated and stacked the available pn closed data. The circuit board causing fluorescence is also affecting the continuum.

PN SPATIAL VARIATION



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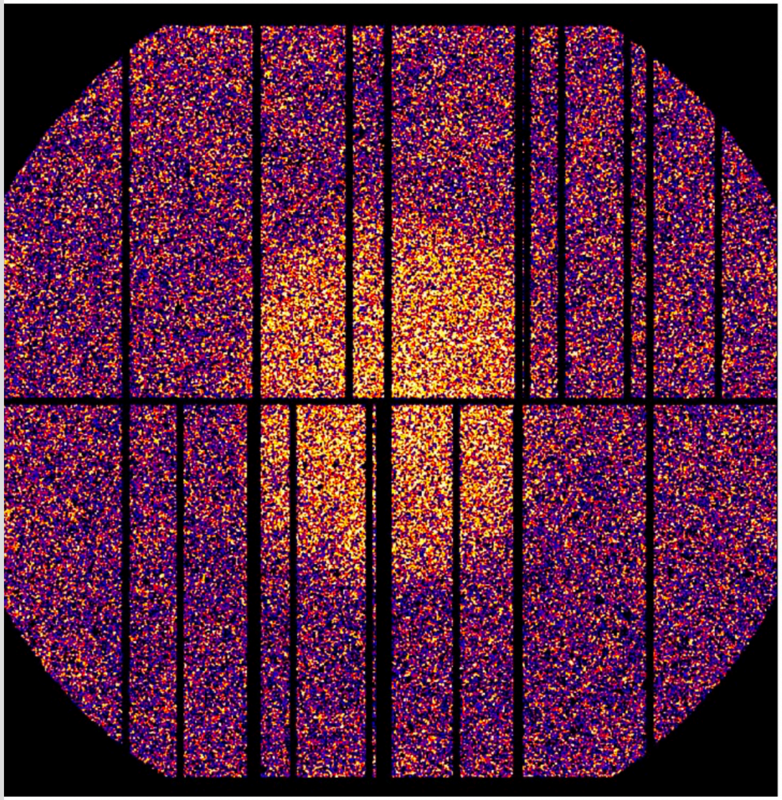
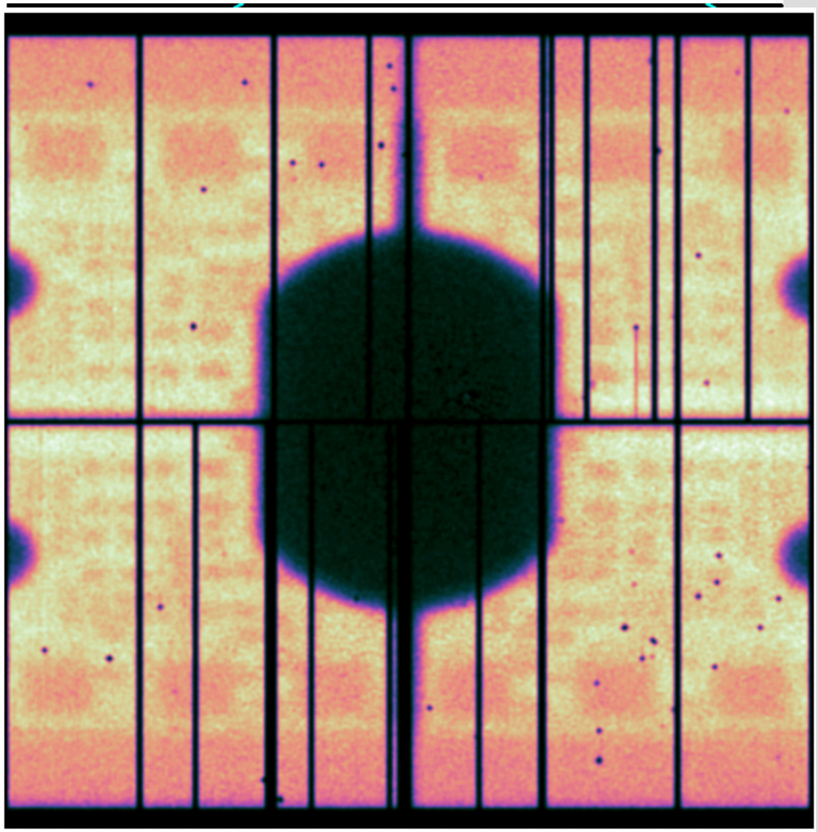
PN SPATIAL VARIATION

"Soft Band" (2-7 keV)



~2.8×10^6 events in ~1.7 Ms

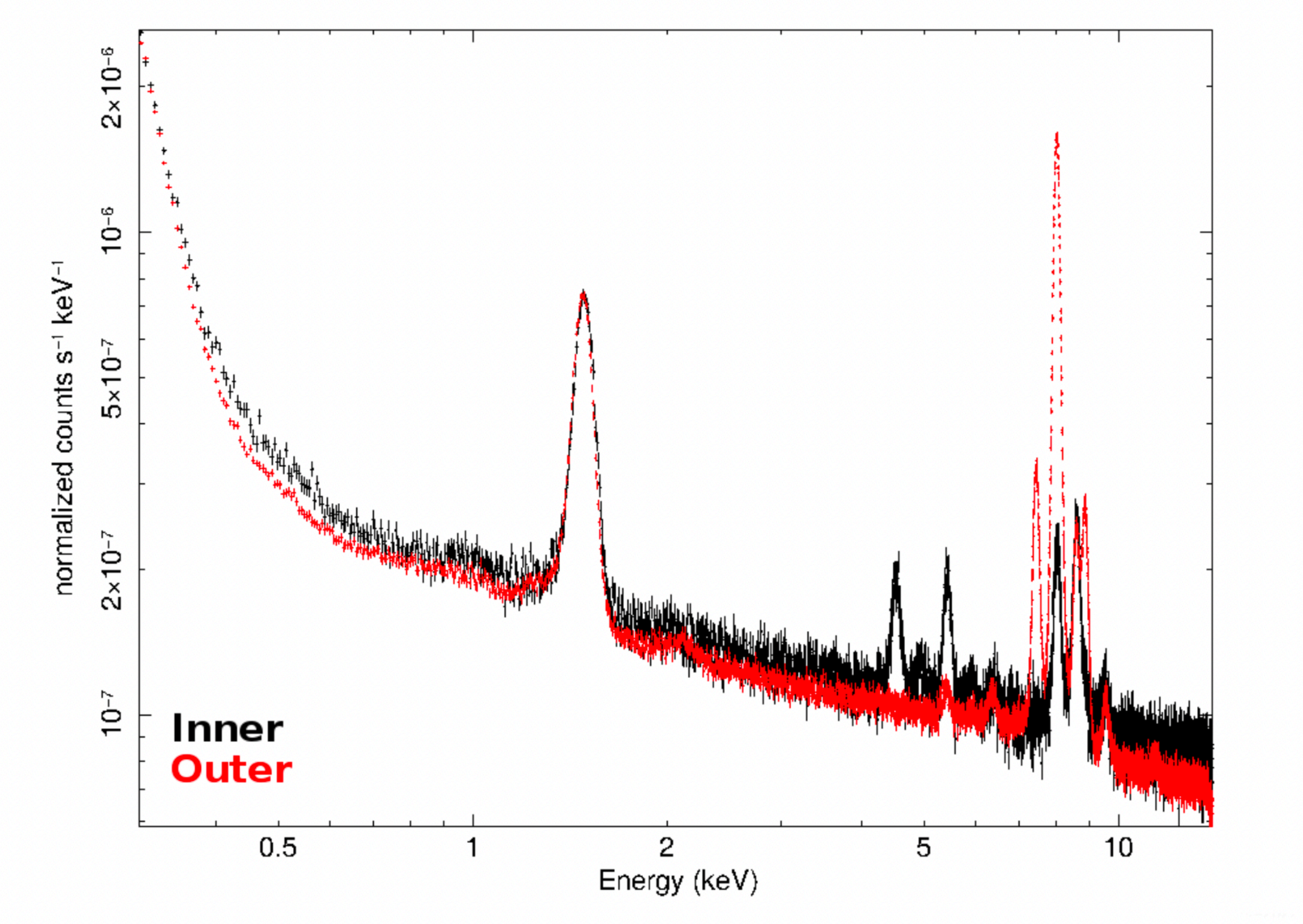
"Line" (7.8-8.2 keV)



Sanders+20

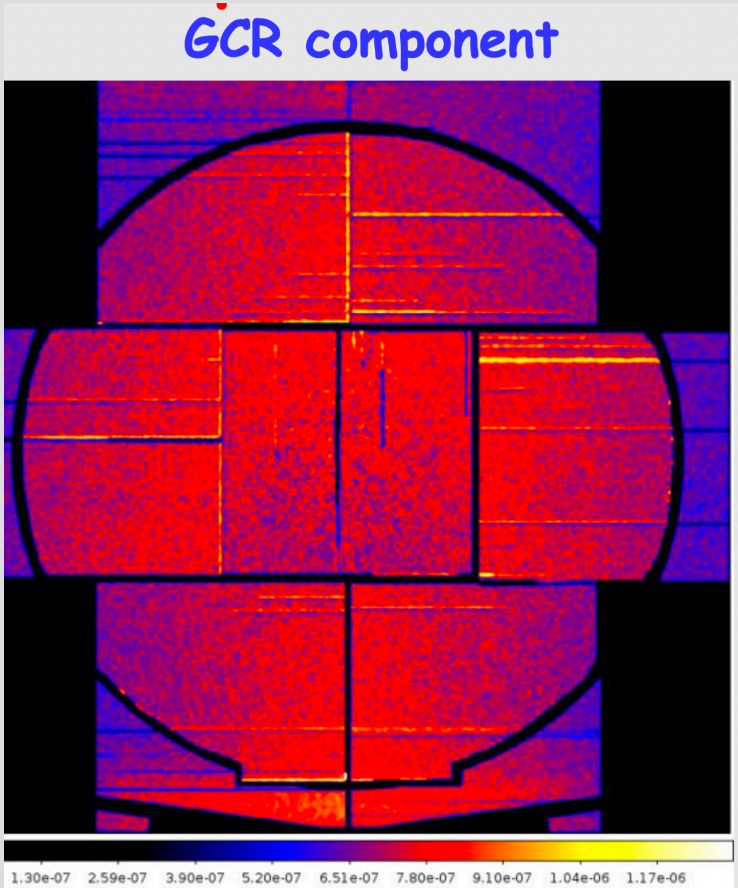
We investigated and stacked the available pn closed data. The circuit board causing fluorescence is also affecting the continuum.

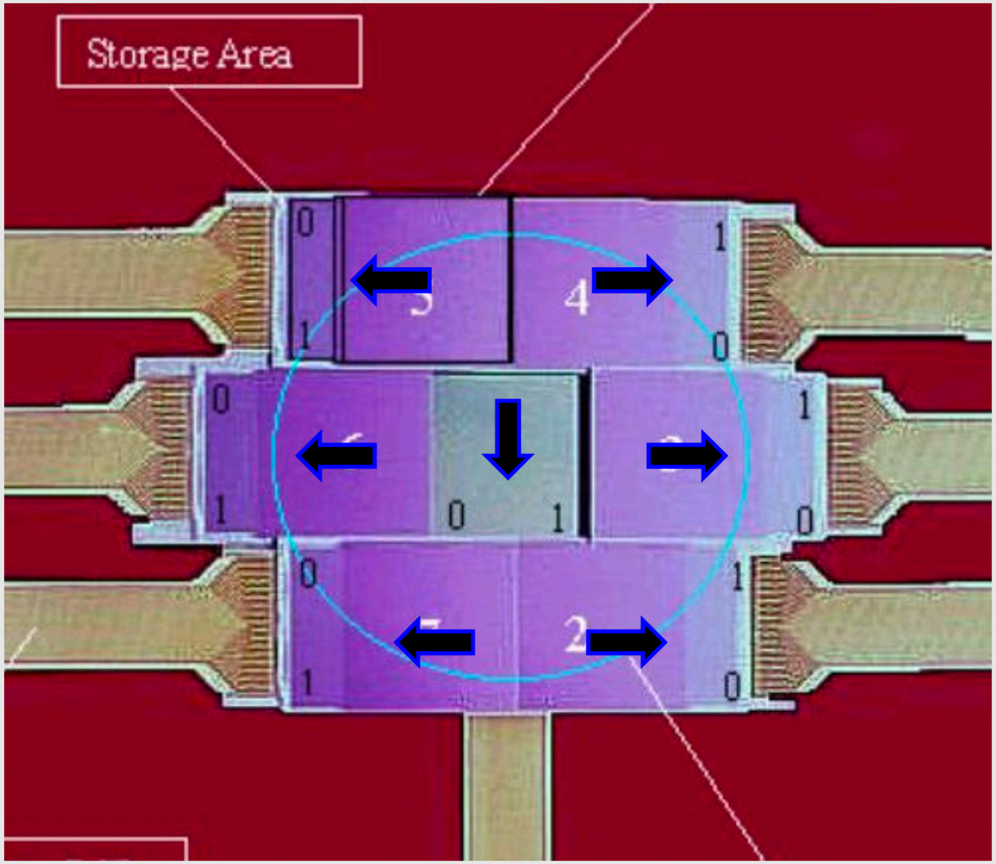
PN SPATIAL VARIATION



Spectral difference: brighter harder spectrum in the inner region: are we seeing the unperturbed spectrum of the secondaries ?

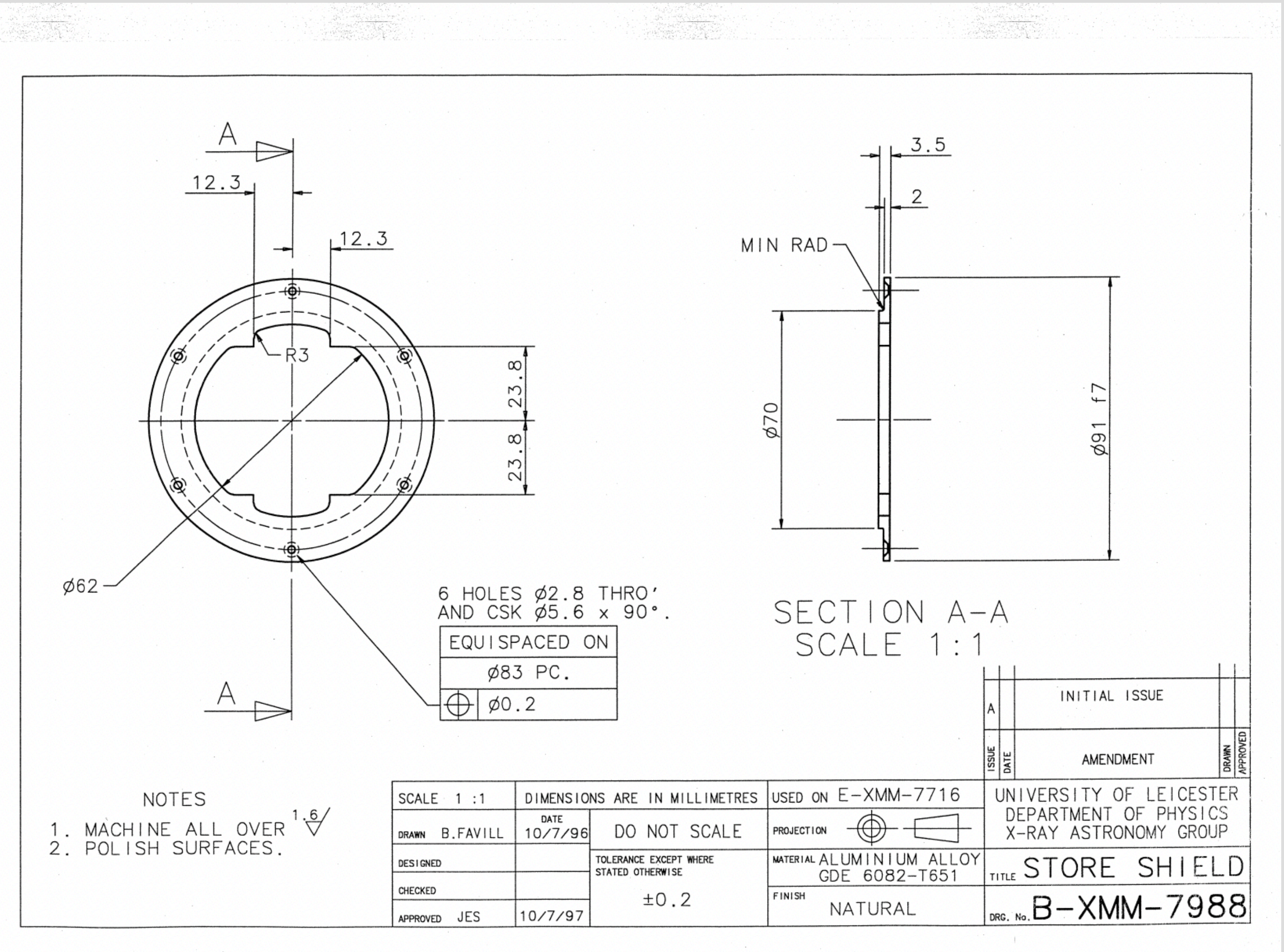
MOS SPATIAL VARIATION





We are investigating gradients due to the increased amount of time spent in the storage frame. A gradient was already seen in the MOS on board Swift (Moretti+09), see also eROSITA (Freyberg+20)

MOS FRAME STORAGE SHIELD



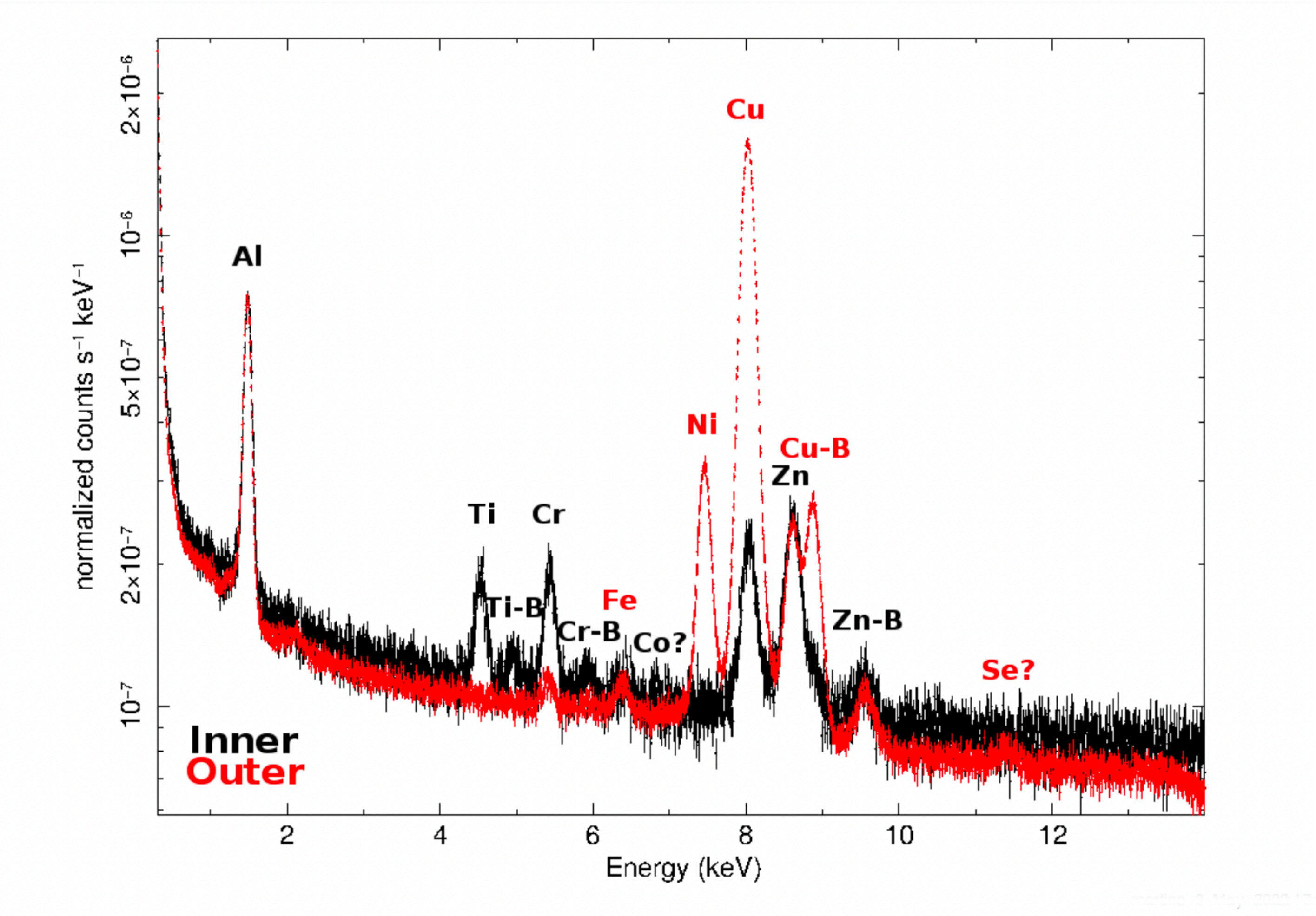
Courtesy T. Abbey and D. Ross: 3.2 mm thick Al alloy

SUMMARY

Goal: **provide multi-dimensional spectro-imaging model of the bkg components (energy, time, position in the detector), understanding their physical origin**

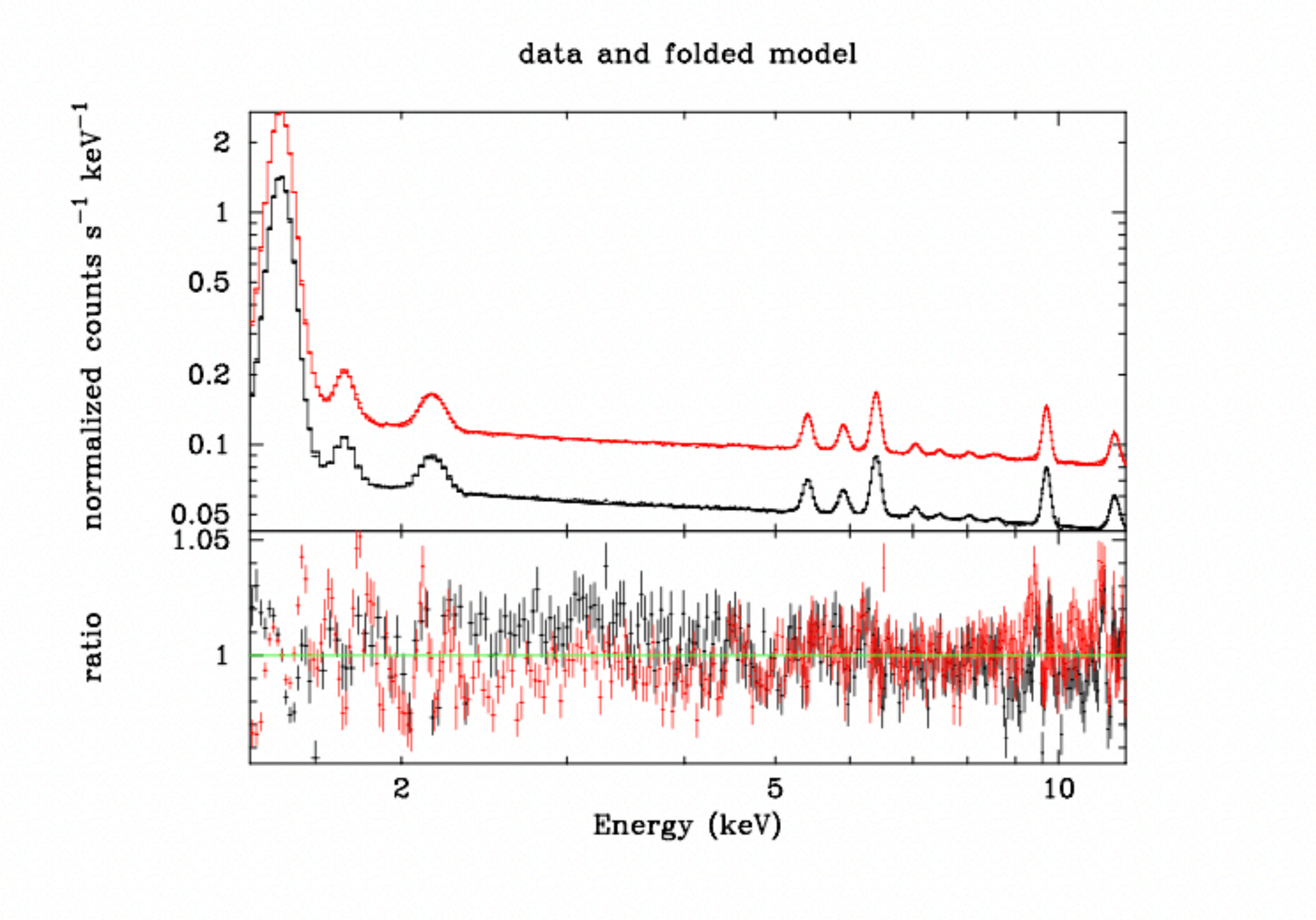
We are not there yet but progress has been made: more than 20 years of data are there to mine. Probably one of the major limitations will be the lack a detailed view of the mass model of XMM for the purpose of Geant4 simulations.

PN SPATIAL VARIATION



Spectral difference: brighter harder spectrum in the inner region: are we seeing the unperturbed spectrum of the secondaries ?

COMPTON NO SPECTRAL VARIATION



No spectral difference between spectra at solar maximum and minimum in the MOS2