XMM vignetting analysis

Ivan Valtchanov, XMM SOC

XMM CAL OPS 06-07 April 2021

Outline

- Sources with multiple observations in 4XMM-DR10: flux variation with off-axis angle
- Vignetting: observations of 3C58 and G21.5-09 (SNR)
- Some results and future work

The problem

Received December 11, 2018; | Revised –; | Accepted –

DOI: xxx/xxxx

ORIGINAL ARTICLE

The non-linear X-ray/UV relation in active galactic nuclei: contribution of instrumental effects on the X-ray variability

Elisabeta Lusso*

[1]Centre for Extragalactic Astronomy, Durham University, South Road, Durham, DH1 3LE, UK

Correspondence
*Email: elisabeta.lusso@durham.ac.uk

Funding Information
European Union COFUND, Durham Junior Research Fellowship, EU grant agreement no. 609412.

We have recently demonstrated that the non-linear relation between ultraviolet and X-ray luminosity in quasars is very tight (with an intrisic dispersion of ~0.2 dex), once contaminants (e.g. dust reddening, X-ray absorption), variability, and differences in the active galactic nuclei (AGN) physical properties are taken into account. This relation has thus the great potential to advance our understanding in both supermassive black hole accretion physics and observational cosmology, by targeting a single class of objects. Here we focus on the various contributions to the *observed* X-ray variability in a homogenous sample of 791 quasars selected from SDSS–DR7 with X-ray data from the 3XMM–DR7 source catalogue. The 250 quasars in this cleaned data set with at least two X-ray observations typically vary with a standard deviation of fractional variation of 15–30% on timescales of weeks/years. Yet, when the count rates are computed at progressively smaller off-axis values, the same quantity is reduced to roughly 10–25%. This suggests that, when estimating variability indicators, part of the quoted variability amplitude could be due to instrumental/calibration issues rather than *true* variations in the quasar emission.

KEYWORDS:
galaxies: active, quasars: general, X-rays: general, methods: statistical

- off-axis dependent amplitude of the st.dev. of the fractional variation

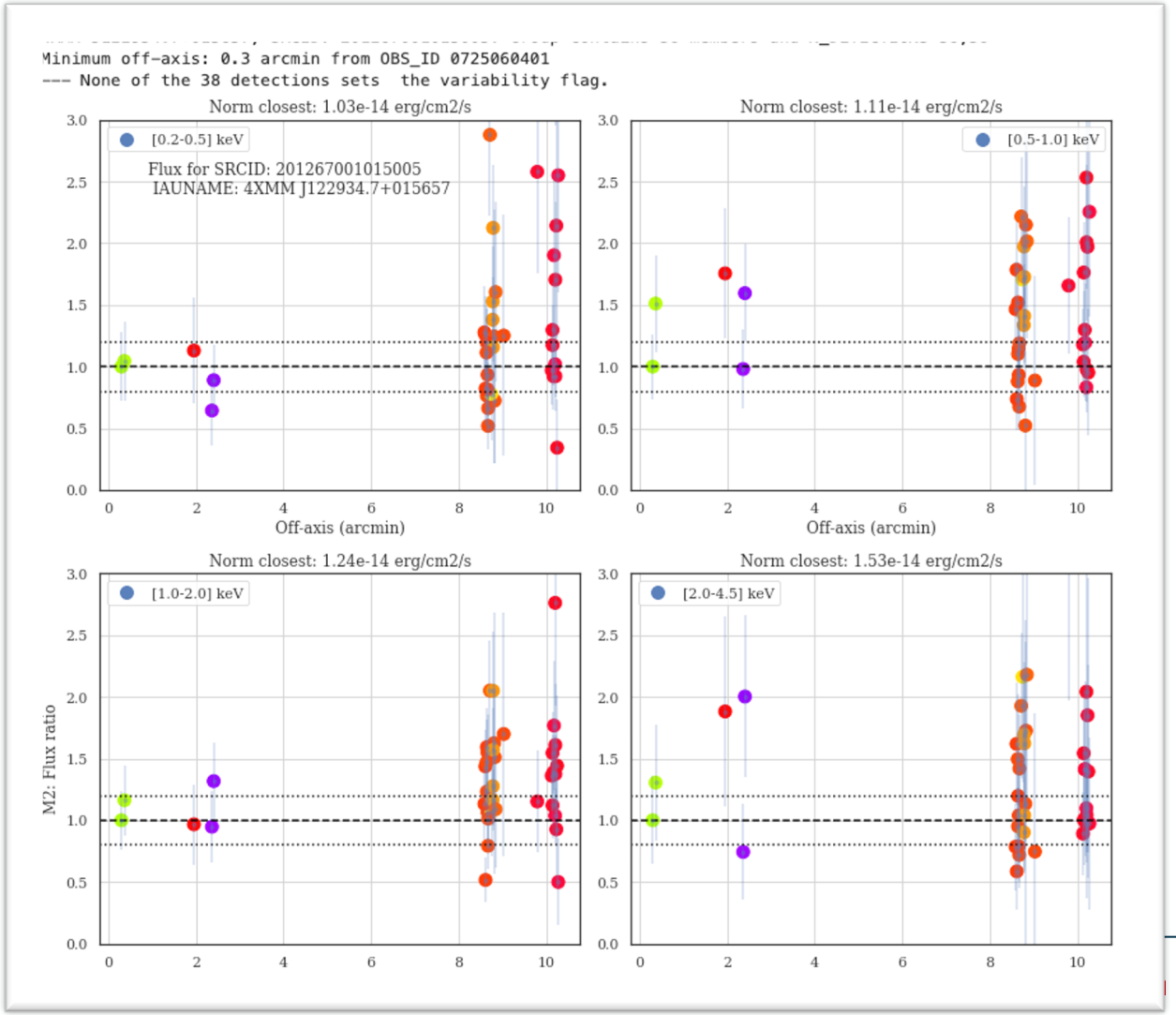
➔ smaller at smaller off-axis

"...variability amplitude could be due to instrumental/calibration issues rather than *true* variations in the quasar emission."

Using 3XMM-DR7
- and combined fluxes of the 3 instruments?

Checking with 4XMM-DR10

- Selecting sources with multiple observations at different off-axis angles
- Filtering for good detections and not too bright (pile-up) or too faint sources

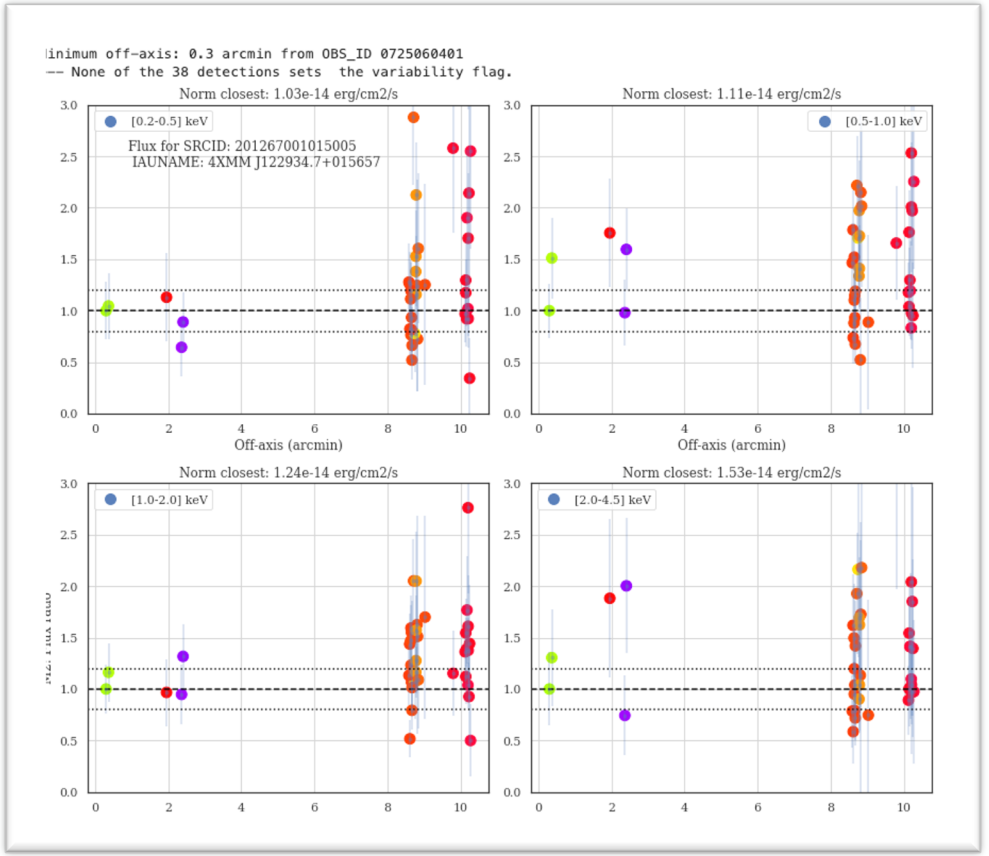


MOS2

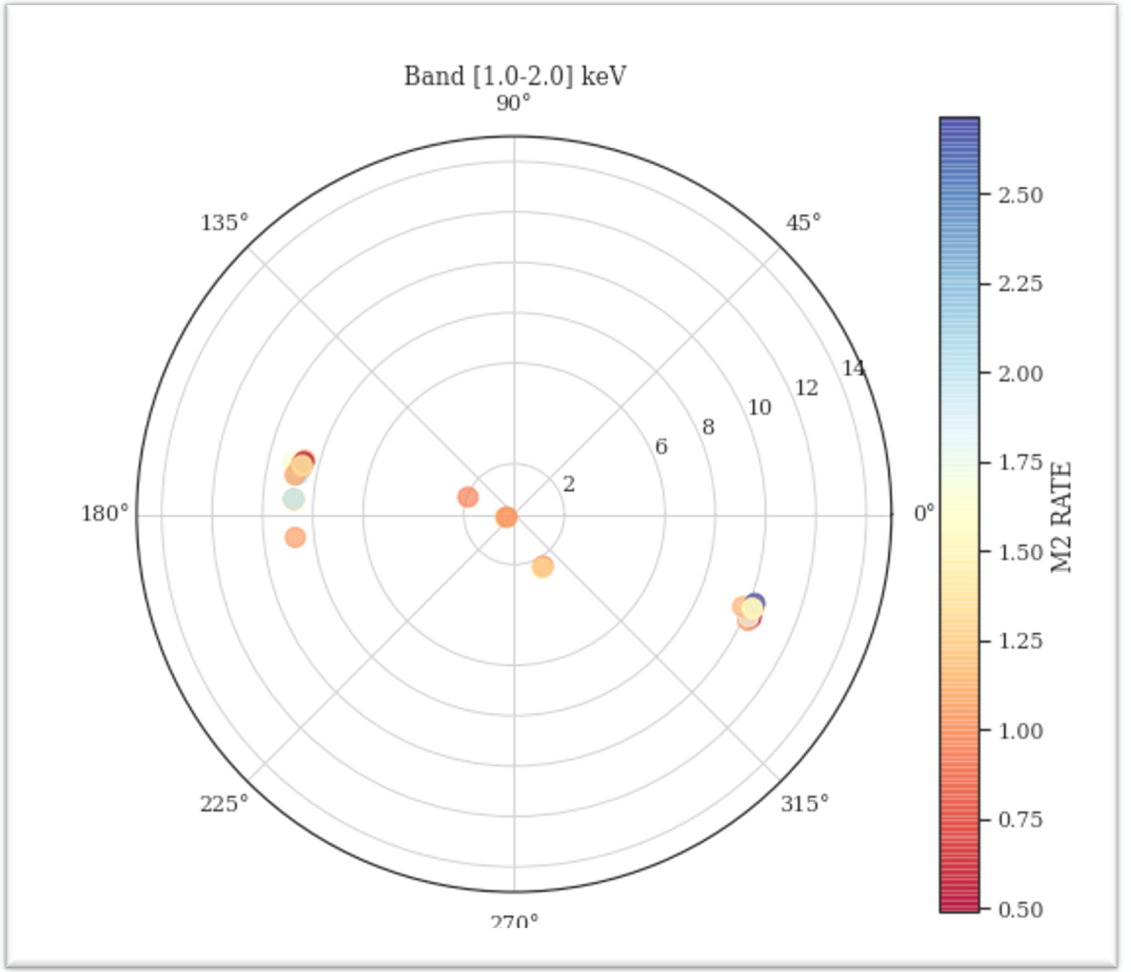
Source with 38 detections

- None has variability flag
- Normalised to the most central one
- Different energy bands as in 4XMM

Azimuth distribution



Azimuthal distribution



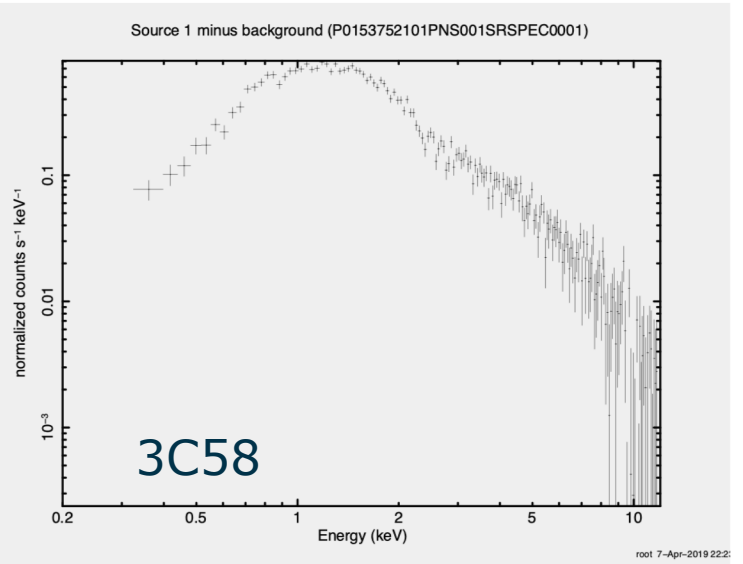
Non-conclusive results

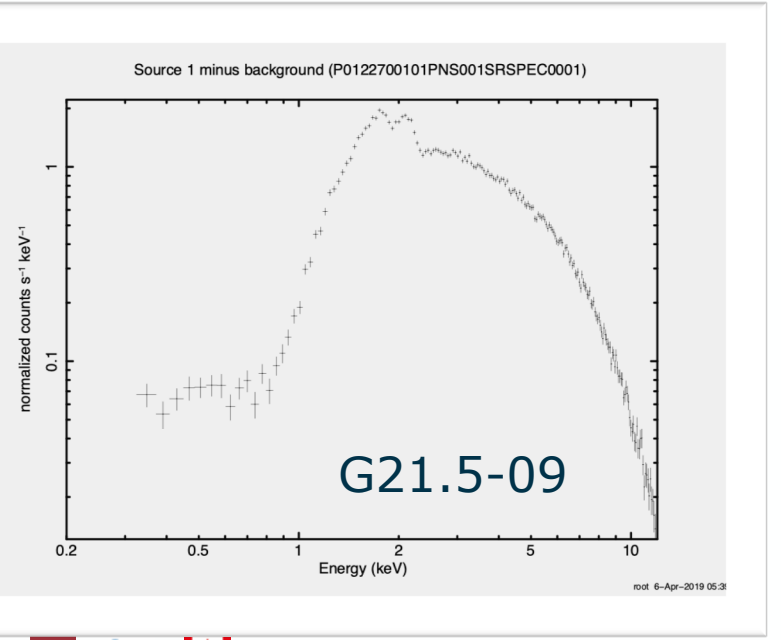
We obtain similar results to Lusso (2018) using 4XMM-DR10

➔ Not easy to interpret the results as due to instrumental calibration: vignetting.

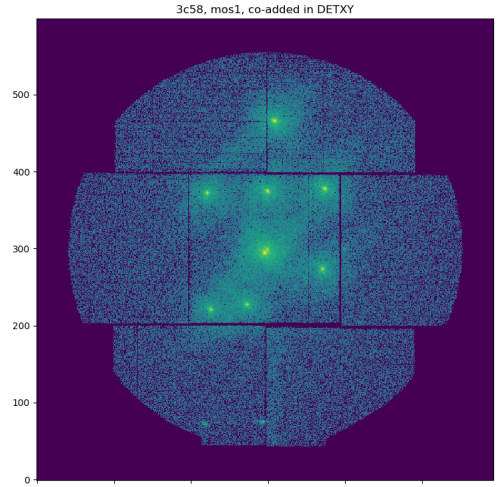
Re-analysis of SNRs used for vignetting

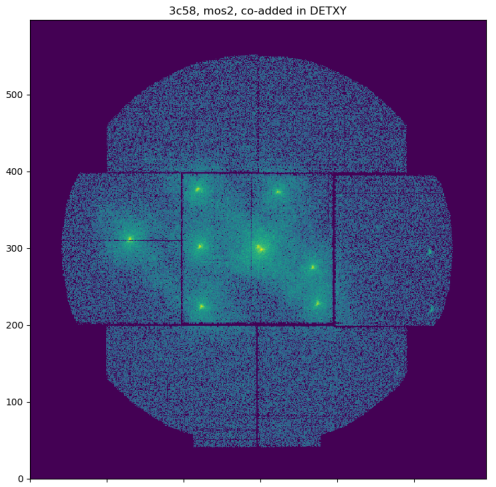
- Based on Lumb et al.
  - 3C58 and G21.5-09 were used as suitable SNR candidates
  - Relatively compact
  - Not too bright (no pile-up)
  - Non-variable
  - Emission at energies above 2 keV.
- Analysis parameters
  - Spectral extraction in 25 or 40 arcsec region centred on SNR
  - Background from annulus in [3,4] arcmin from source
  - XSPEC rate for soft [0.2,2] keV and hard [2.0,10.0] keV bands + uncertainties

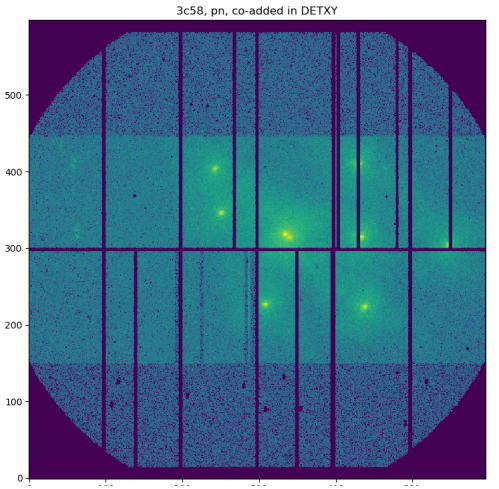




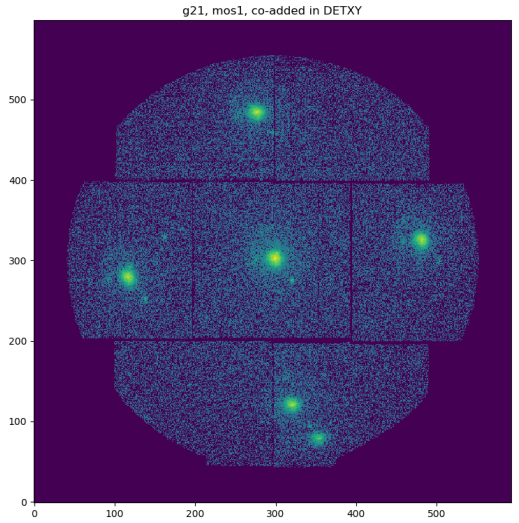
Results for the 2001-2002 observations

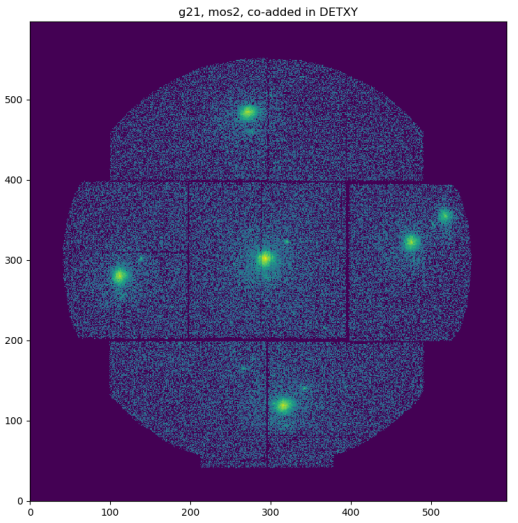


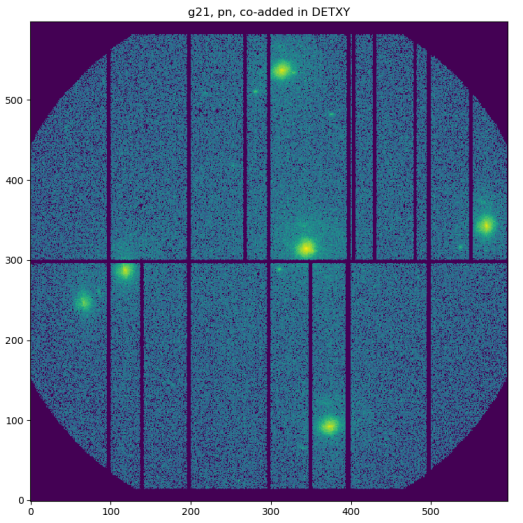




3C58 mosaic

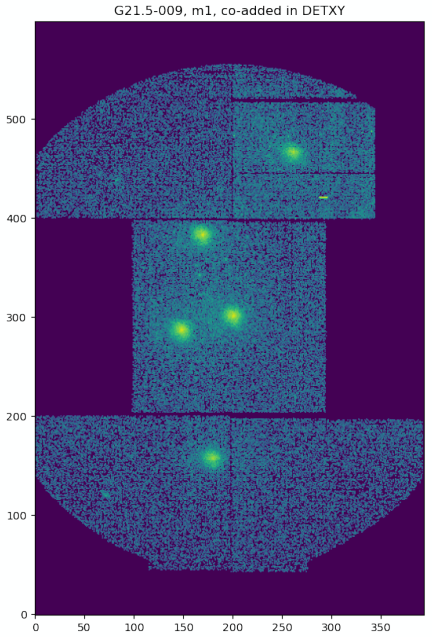


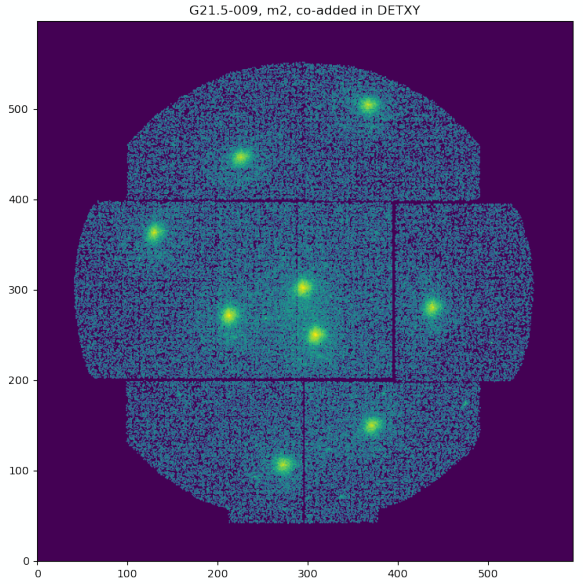


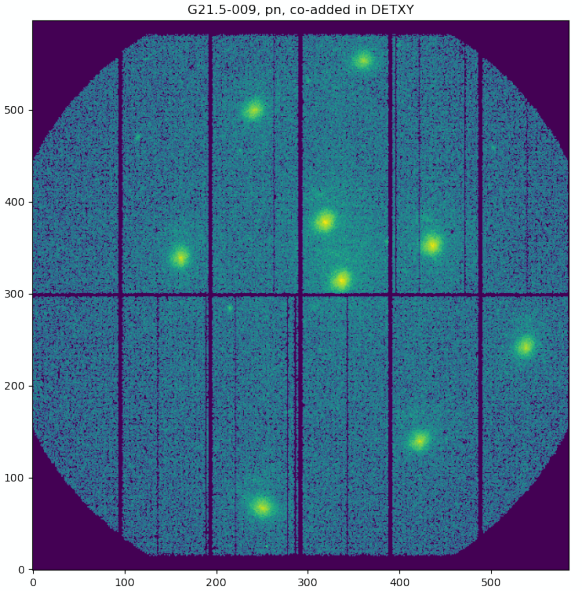


G21.5-09 mosaic

New NRCO for G21.5-09

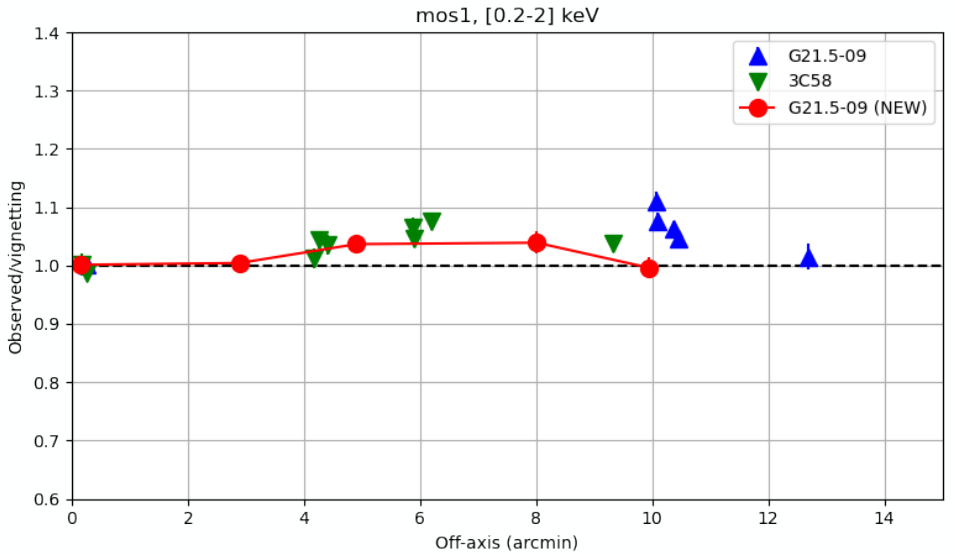


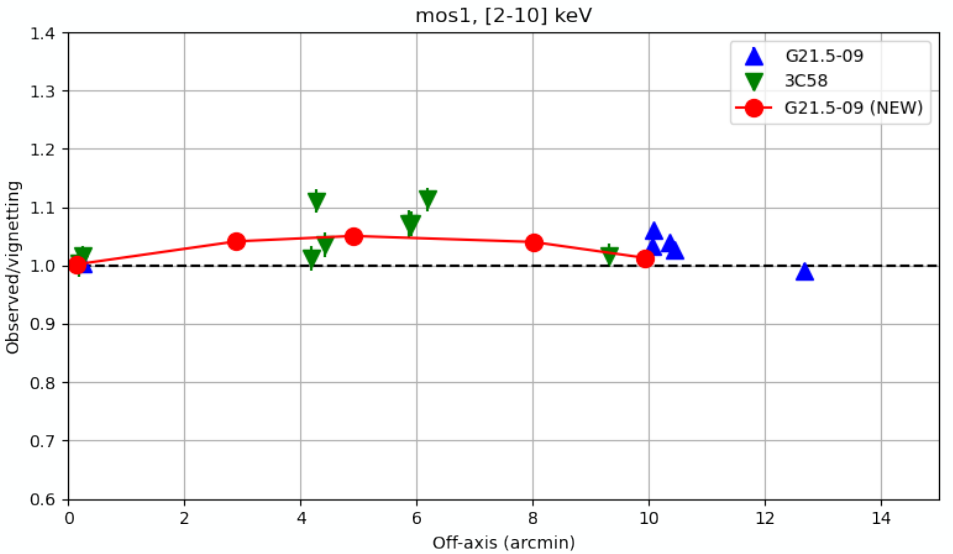




G21.5-09, observations on 13 March 2021, 9 locations

Adding to the previous results

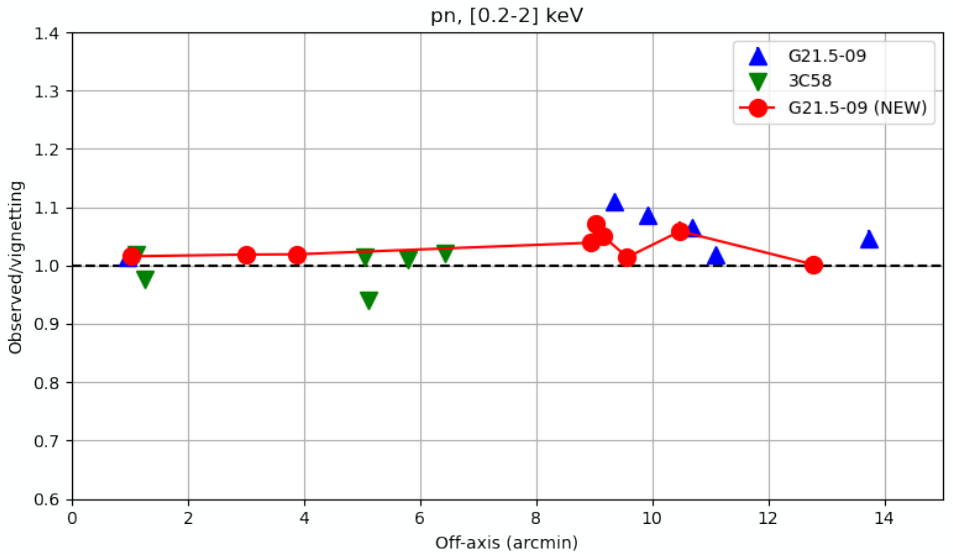


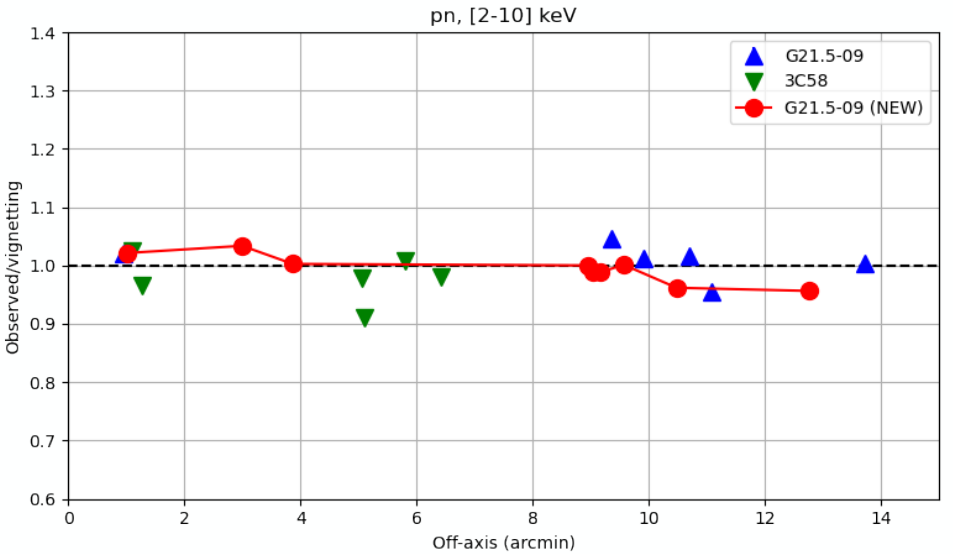


MOS1

Normalised to centre and divided by the empirical vignetting, including azimuthal dependence.

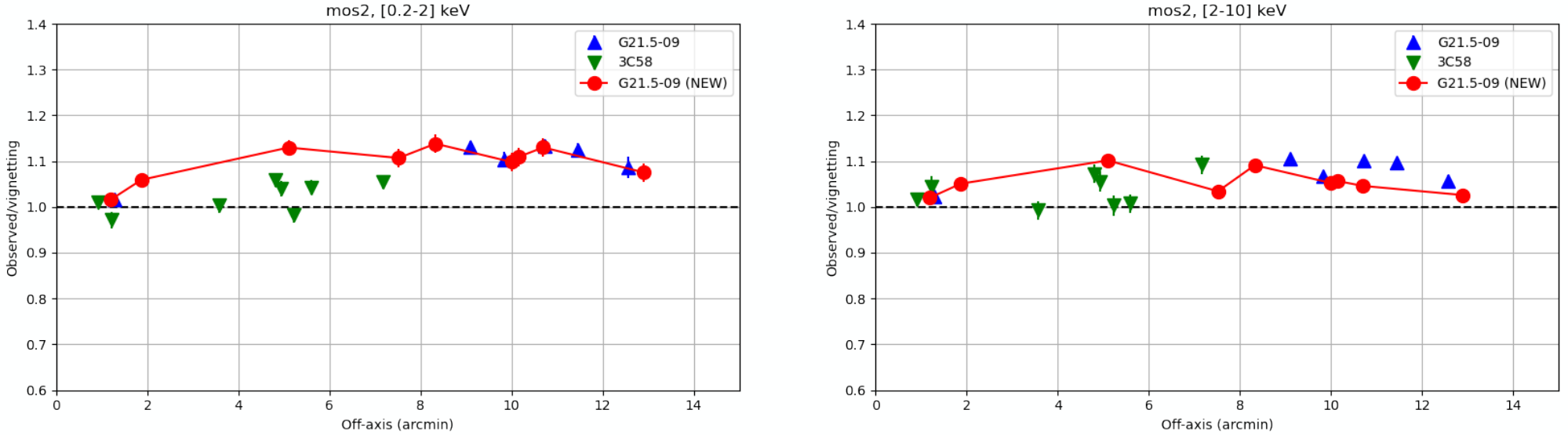
Adding to the previous results





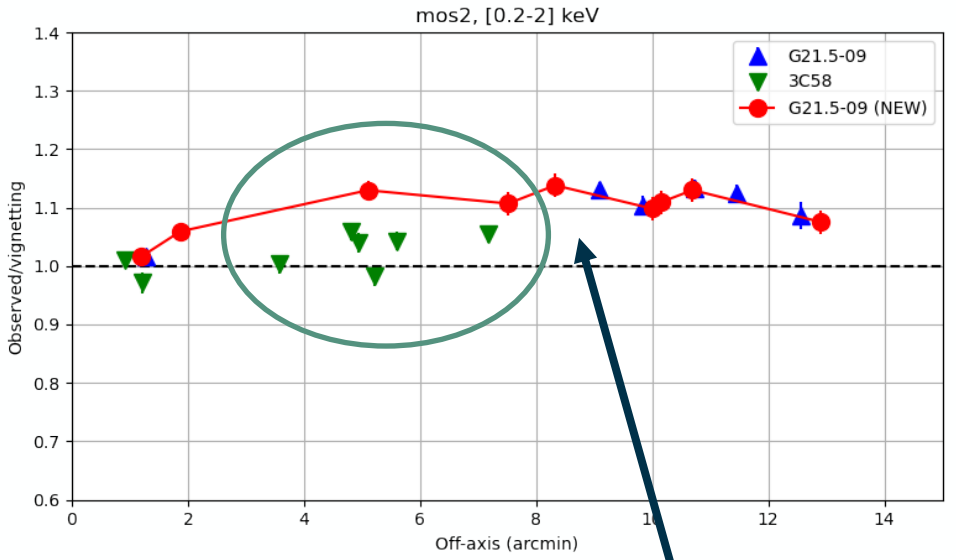
PN

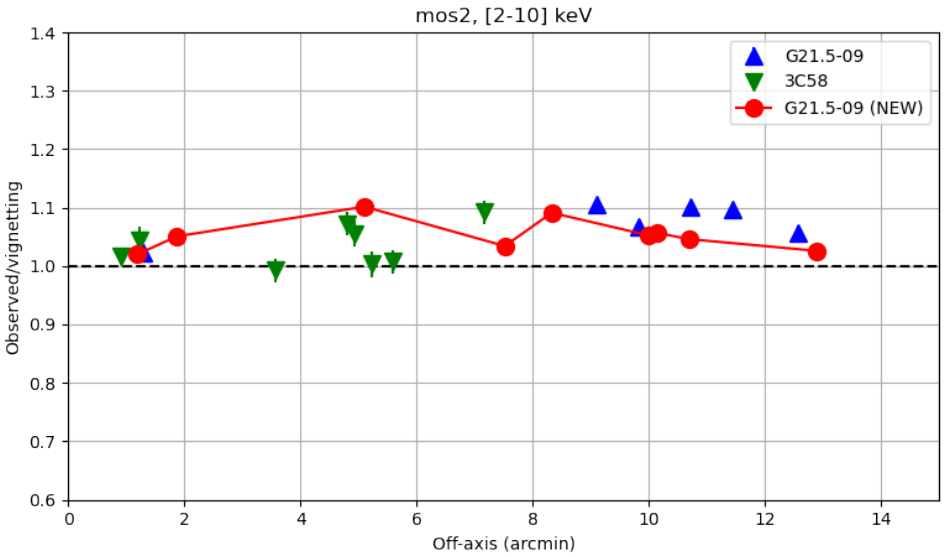
Adding to the previous results



MOS2

Adding to the previous results





MOS2

Systematic at >10%, confirm 2001 results
Discrepancy with 3C58 at off < 6 arcmin

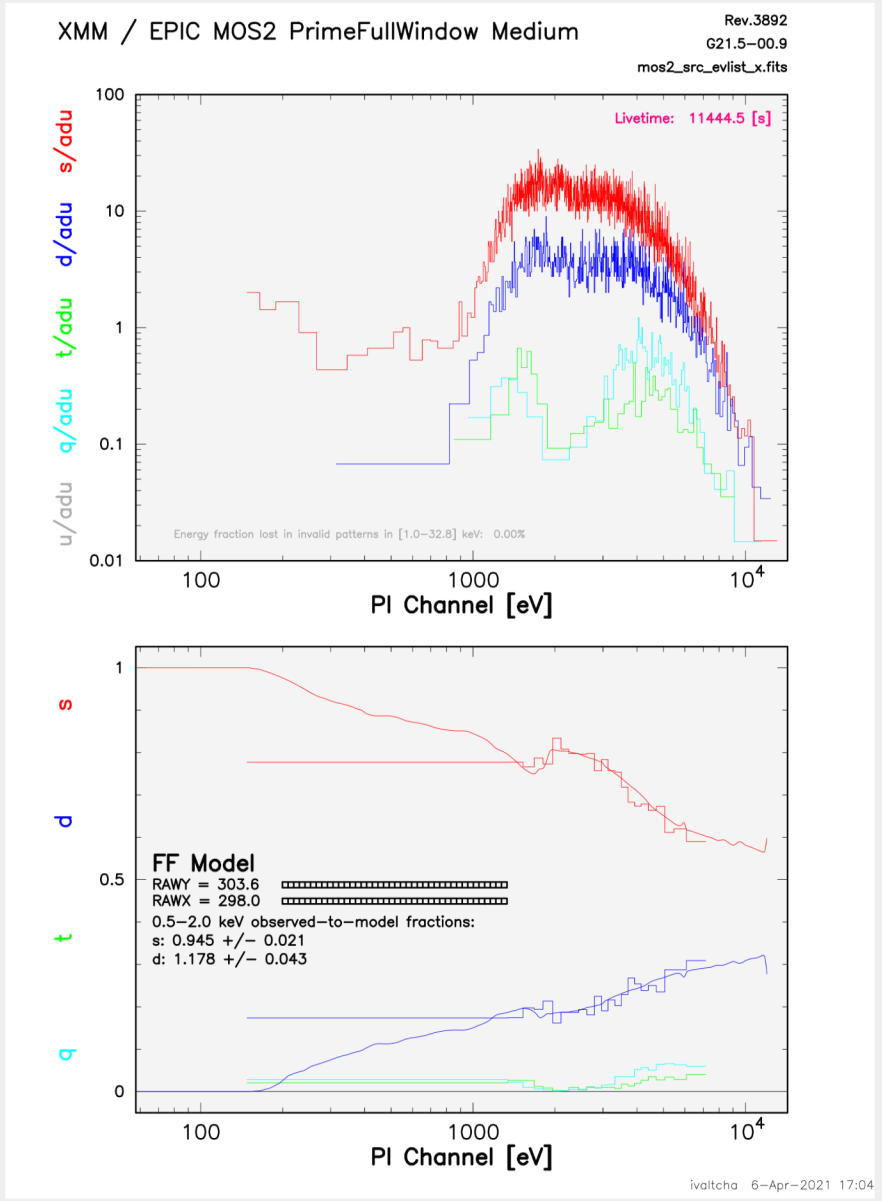
Further steps

- Reconfirm the results for G21.5-09 and MOS2:
  - Reprocess with different source region outside the central source.
  - Spectral dependency? Try with [0.5,2] keV band as source is heavily absorbed below 0.5 keV.

- Find an alternative non-variable source (or sources) to replace 3C58 (poor visibility) and observe over the same parameter space as G21.5-09.
  - Ideas on potential targets?

Conclusions

- Using 4XMM sources with multiple observations:
  - not easy to interpret the observed spread at large off-axis as calibration issue (vignetting)
- Using the two SNRs, 3C58 and G21.5-09
  - Earlier observations did not cover the same parameter space (off-axis)
  - New NRCO of G21.5-09 (preliminary!):
    - Carefully planned XMM pointings to avoid chip gaps and bad columns for MOS2 and PN
    - Fills the gaps on off-axis and azimuth
    - Confirms the agreement for MOS1 and PN with the empirical vignetting function for two energy bands: soft [0.2,2] keV and hard [2.0,10.0] keV
    - Confirms the deviations for MOS2 for G21.5-09 seen in previous observations, systematically higher count-rate at ~10% for the soft band.



MOS2 pile-up check with epatplot