XMM-NEWTON VS. XRISM CROSS-CALIBRATION STATUS

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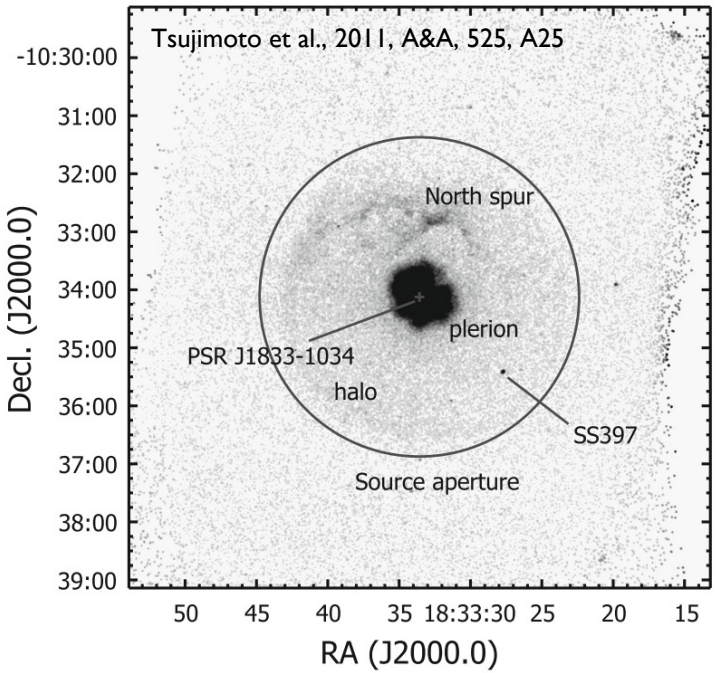
XRISM IN-FLIGHT CALIBRATION TEAM

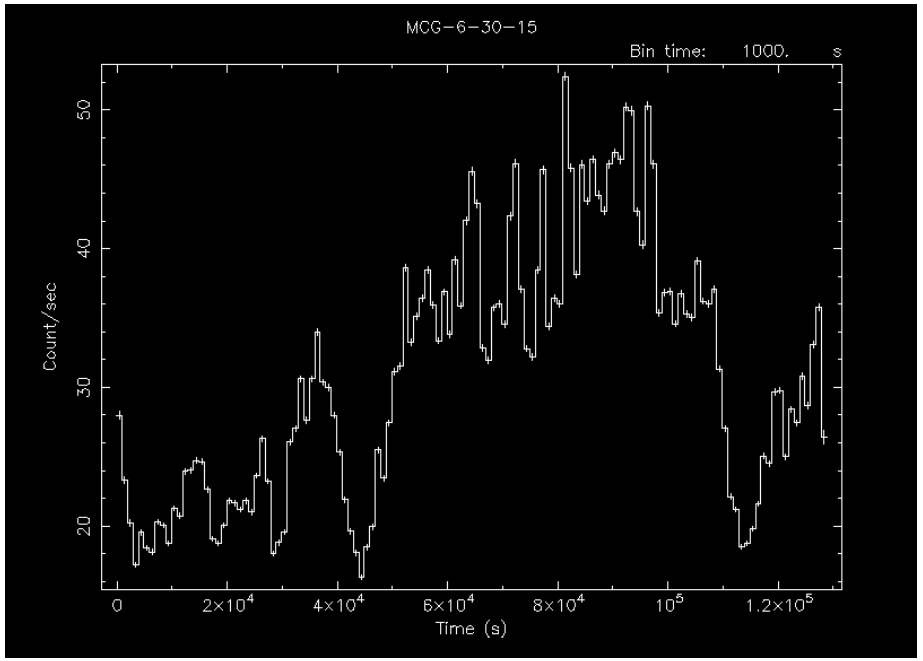
SOURCES

G21.5-0.9



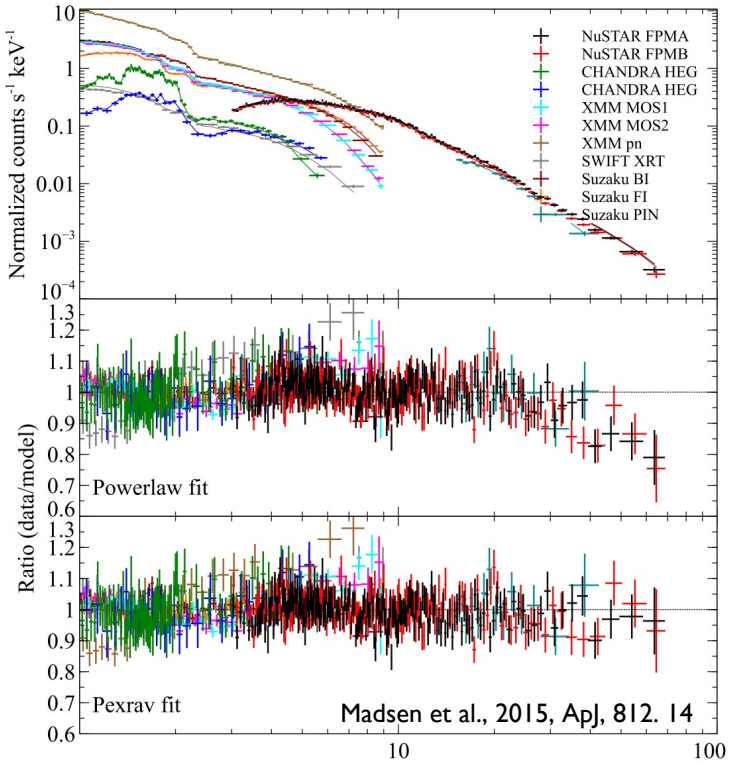
- Pulsar Wind Nebula
- Hard not-thermal spectrum
- Absorbed (~3×10^{22} cm^{-2})
- Extended (~5' diameter)
- 2000 & 2021 XMM-Newton

MCG-6-30-15
NGC3783



- Seyfert Galaxies (AGN)
- Multi-component not-thermal spectrum
- Point-like, variable
- Long contemporaneous observations during the XRISM PV phase

3C273



- Quasar (AGN)
- Hard not-thermal spectrum
- Point-like, moderately variable
- IACHEC yearly cross-calibration campaign

DATA REDUCTION

XMM-Newton

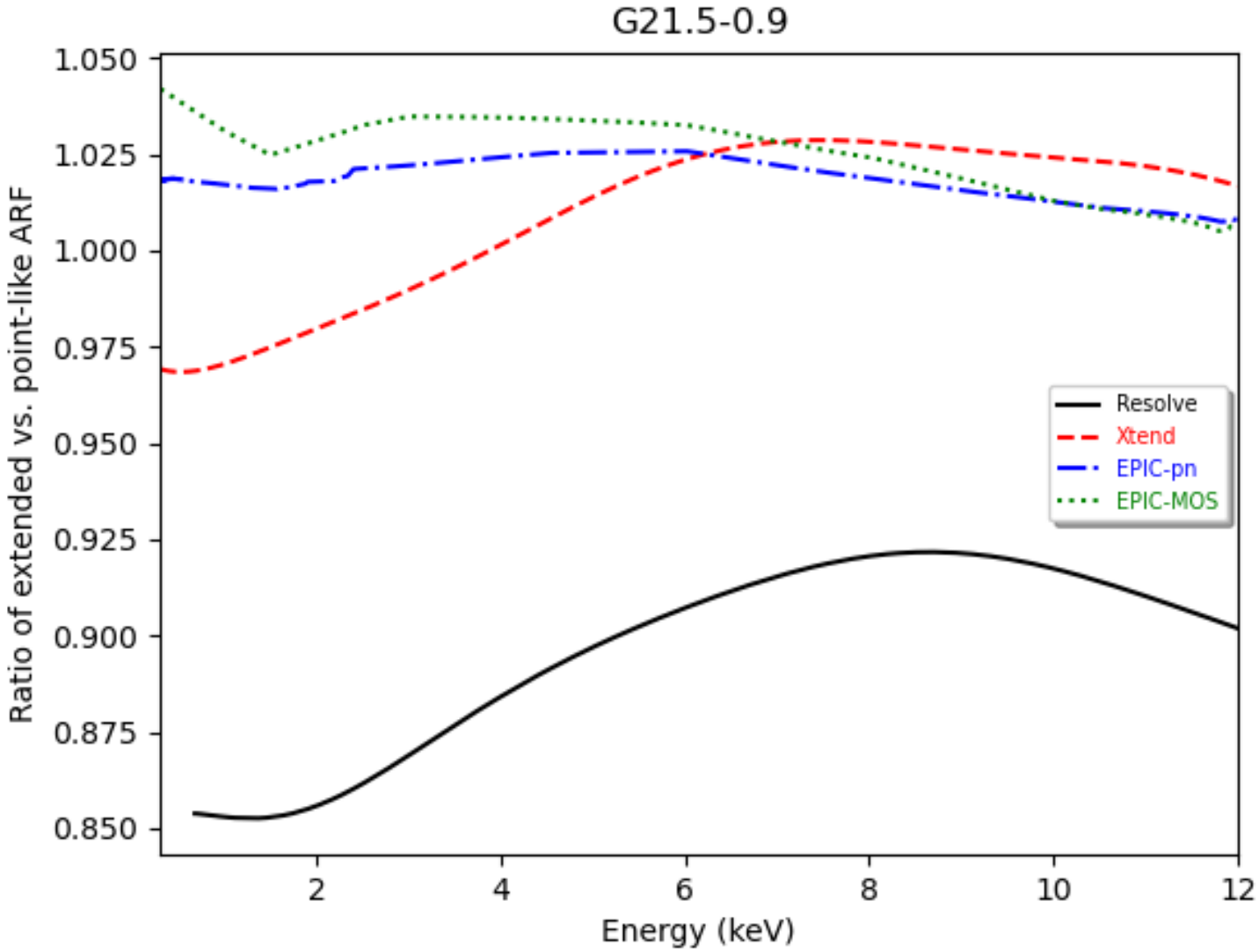
- SAS v21.0
- CCF as of April 2025
- No EPIC-pn ARF rectification to NuSTAR
- No RGS rectification to EPIC-pn
- No EPIC-MOS rectification to EPIC-pn
- [I will show the impact of the EPIC-MOS to EPIC-pn correction presented by Michael Smith on the first day]

XRISM

- HEASOFT v6.34
- CALDB as of ~15 March 2025
- Resolve spectra extracted from the whole field-of-view (expept pixel #27)
- Xtend spectra with standard bad pixel removal (after visual inspection)
- Extended ARF for G21.5-0.9 using the EPIC-MOS image as input

G21.5-0.9 EFFECTIVE AREA DETERMINATION

- ARFs calculated assuming an extended source, using the EPIC-MOS1 image as an input
- Moderate (~±3%) correction for CCD cameras
- Important (8-15%) correction for *Resolve* (as expected)
- We show later also results assuming a point-like source ARF for *Resolve*



CROSS-CALIBRATION COMPARISON TECHNIQUES

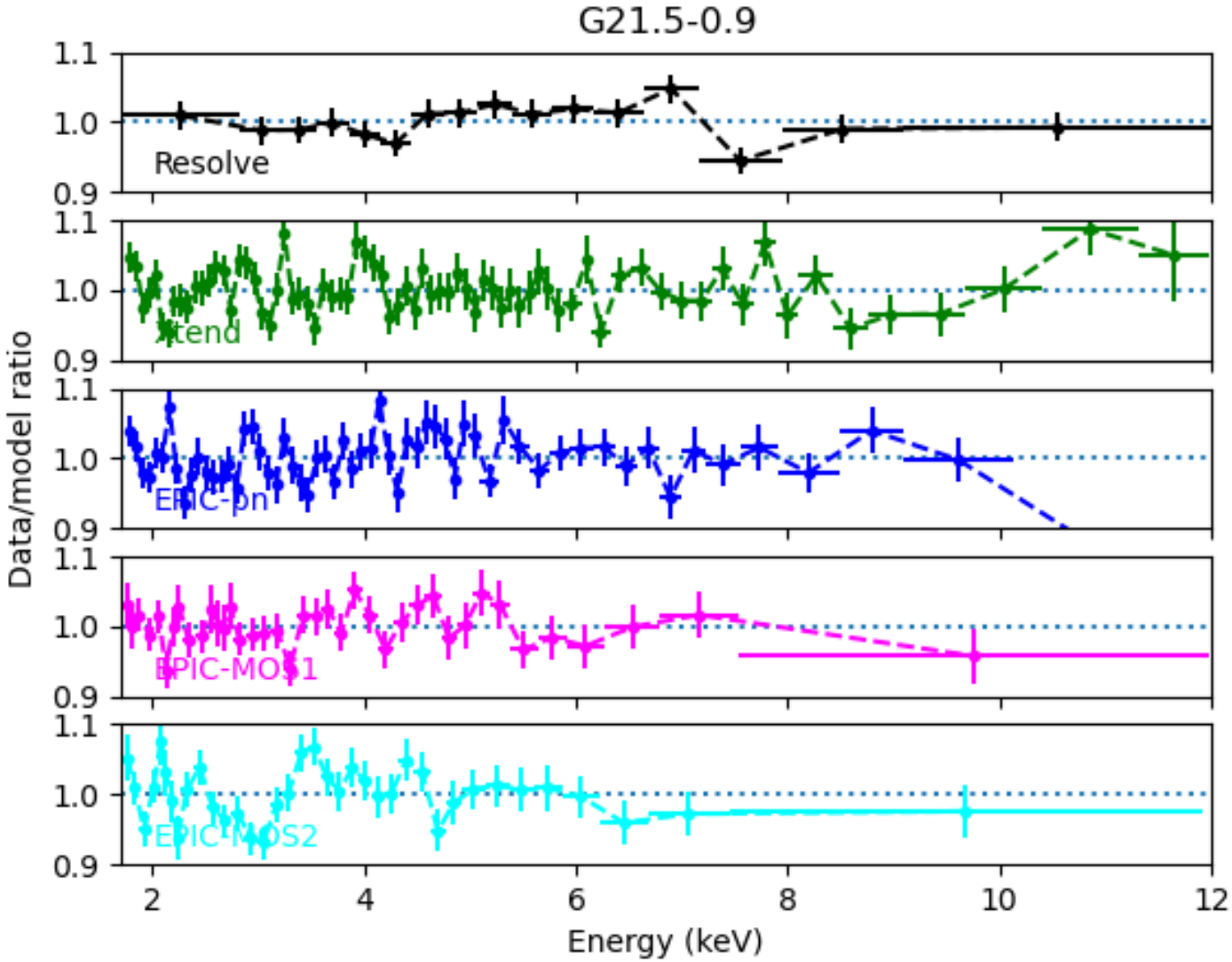
1. Comparison of best-fit spectral parameters **(Method 1)**
   - The most directly applicable information to spectral analysis
   - *Requires* a simple *and* good spectral model

2. Comparison of flux calculated over a small energy range **(Method 2)**
   - Calculated based on the best-fit simple spectral model
   - Not entirely model independent
   - [Not shown here: al alternativa approach based on power-law fits of spectral on small energy ranges]

3. New: spectral ratio against a spline model of the spectrum with the highest resolution (*Resolve*/RGS)
   - Applicable to sources with an arbitrarly complicated astrophysical model
   - Adequate to provide the cross-calibration status over relatively broad energy ranges (comparable to #2)
   - Implemented in SPEX

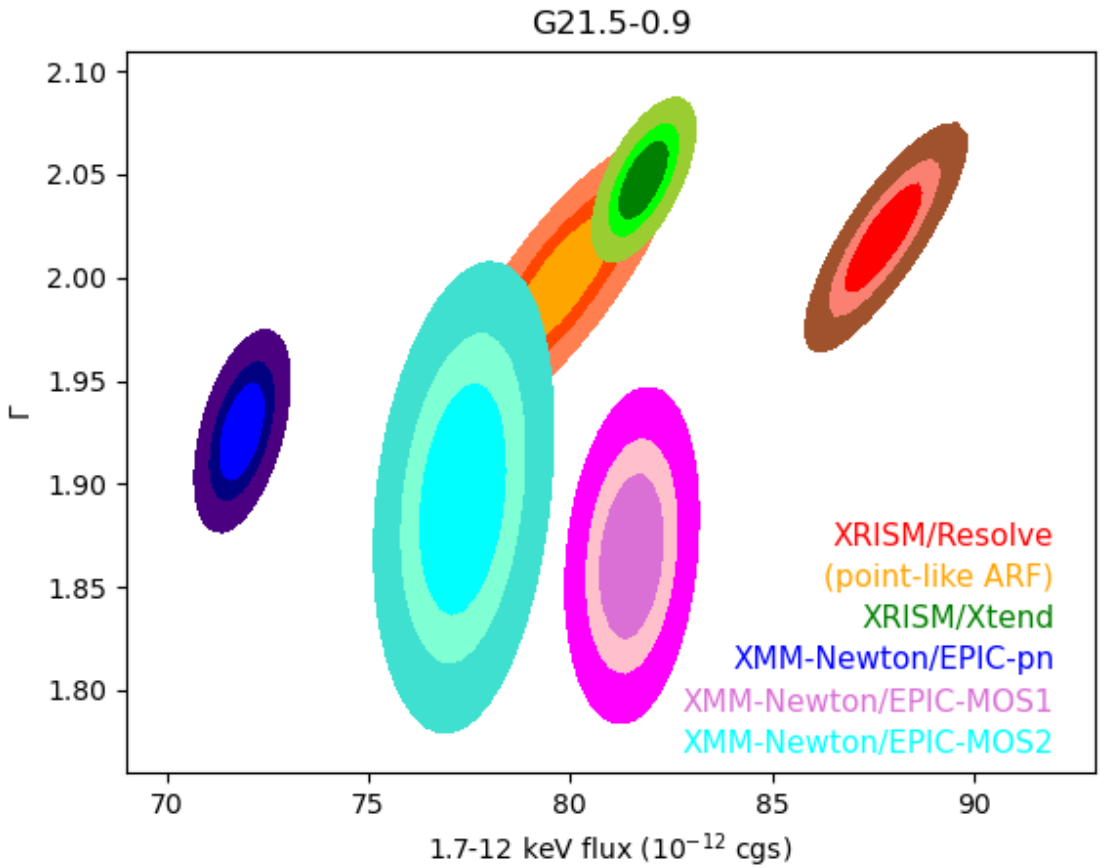
QUALITY OF SPECTRAL FITTING (G21.5-0.9 EXAMPLE)

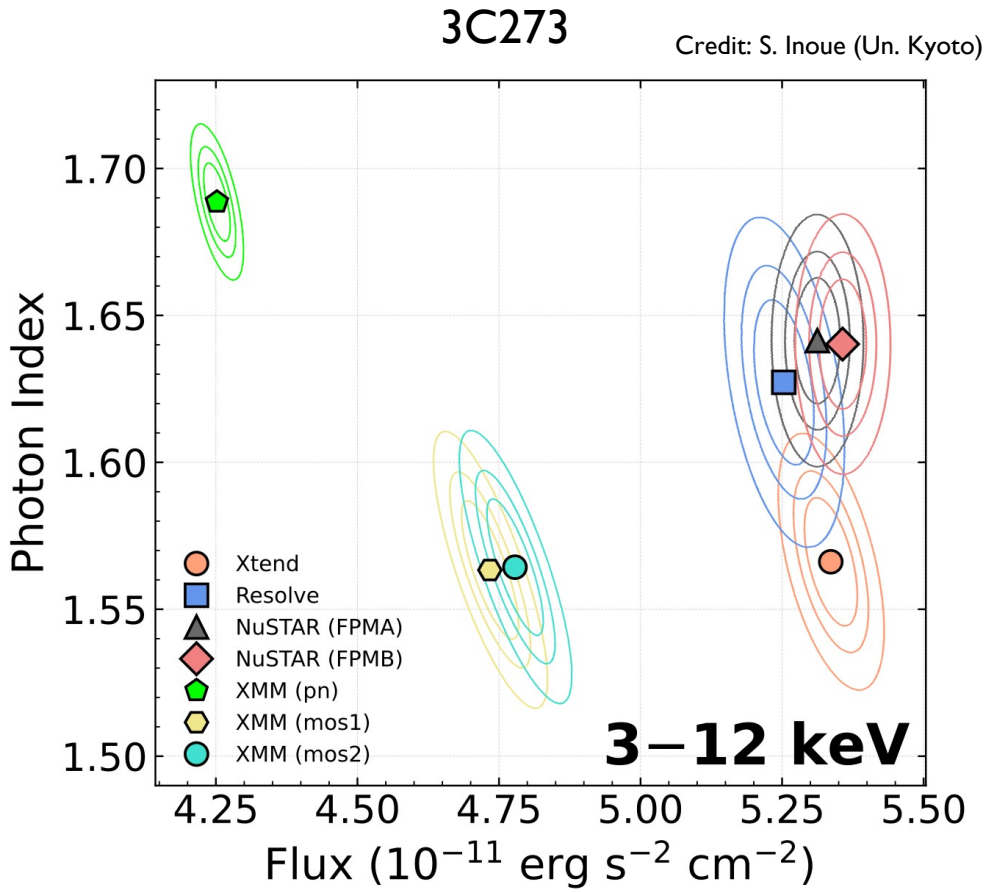
- Spectral fit with a photoelectrically absorbed (`tabs`) power-law over the *Resolve* energy band (1.7-12 keV)
- Good fits, no evidence for an additional energy break



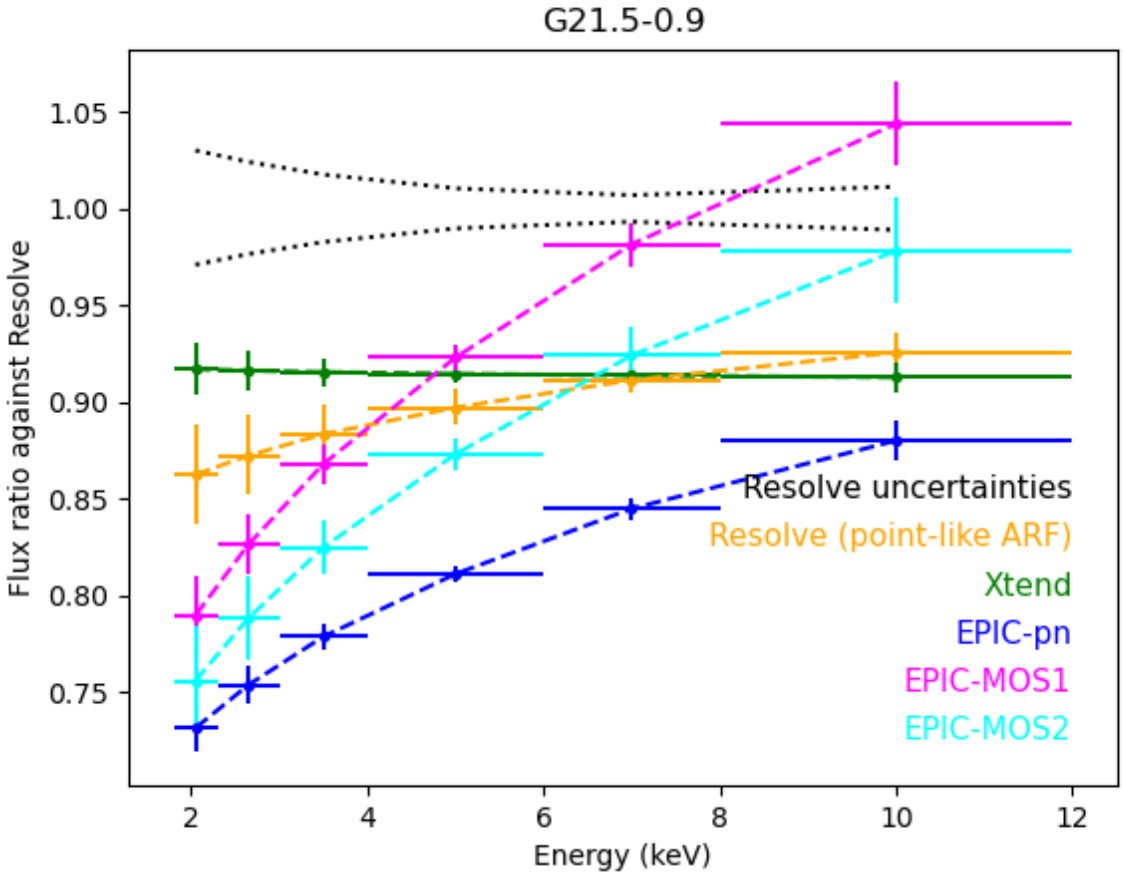
E>1.7 KEV CROSS-CALIBRATION RESULTS (METHOD 1)

Photon index vs. flux contours (68%, 90%, 99%)

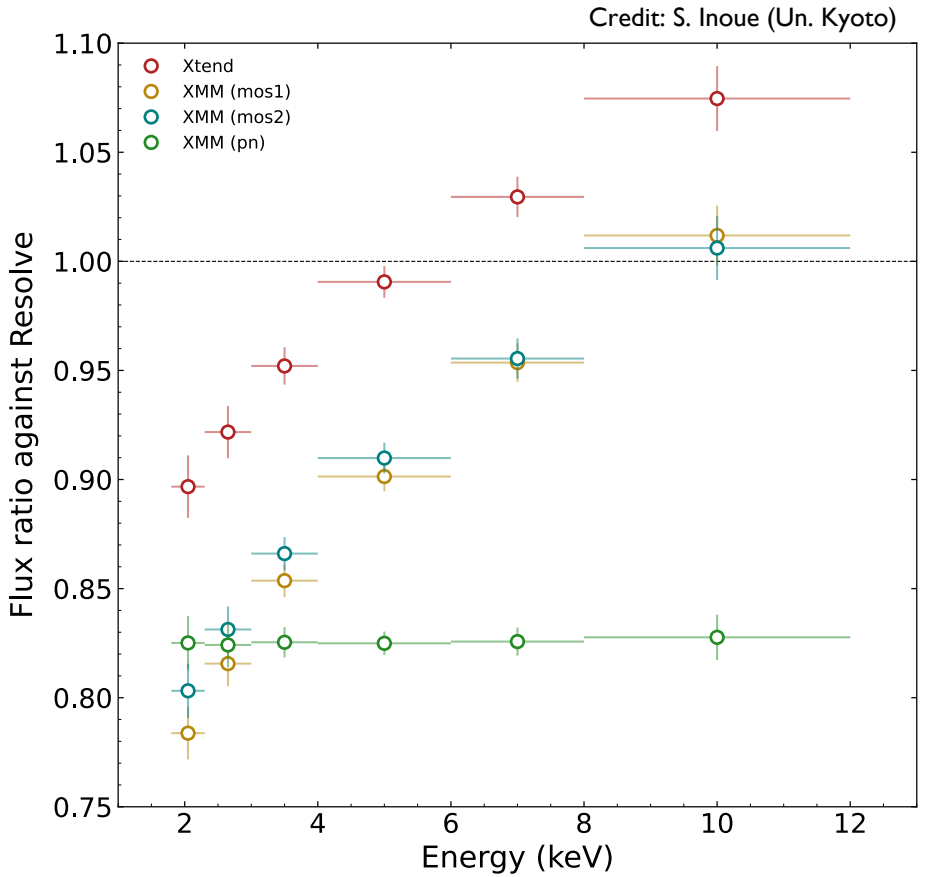




E>1.7 KEV CROSS-CALIBRATION RESULTS (METHOD 2)



- *Xtend*: ~0.92
- EPIC-MOS1: ~0.8-1.05, -MOS2 -0.75-1.0
- EPIC-pn: ~0.75-0.85



- *Xtend*: ~0.90-1.08
- EPIC-MOS: ~0.80-1.0
- EPIC-pn: ~0.82

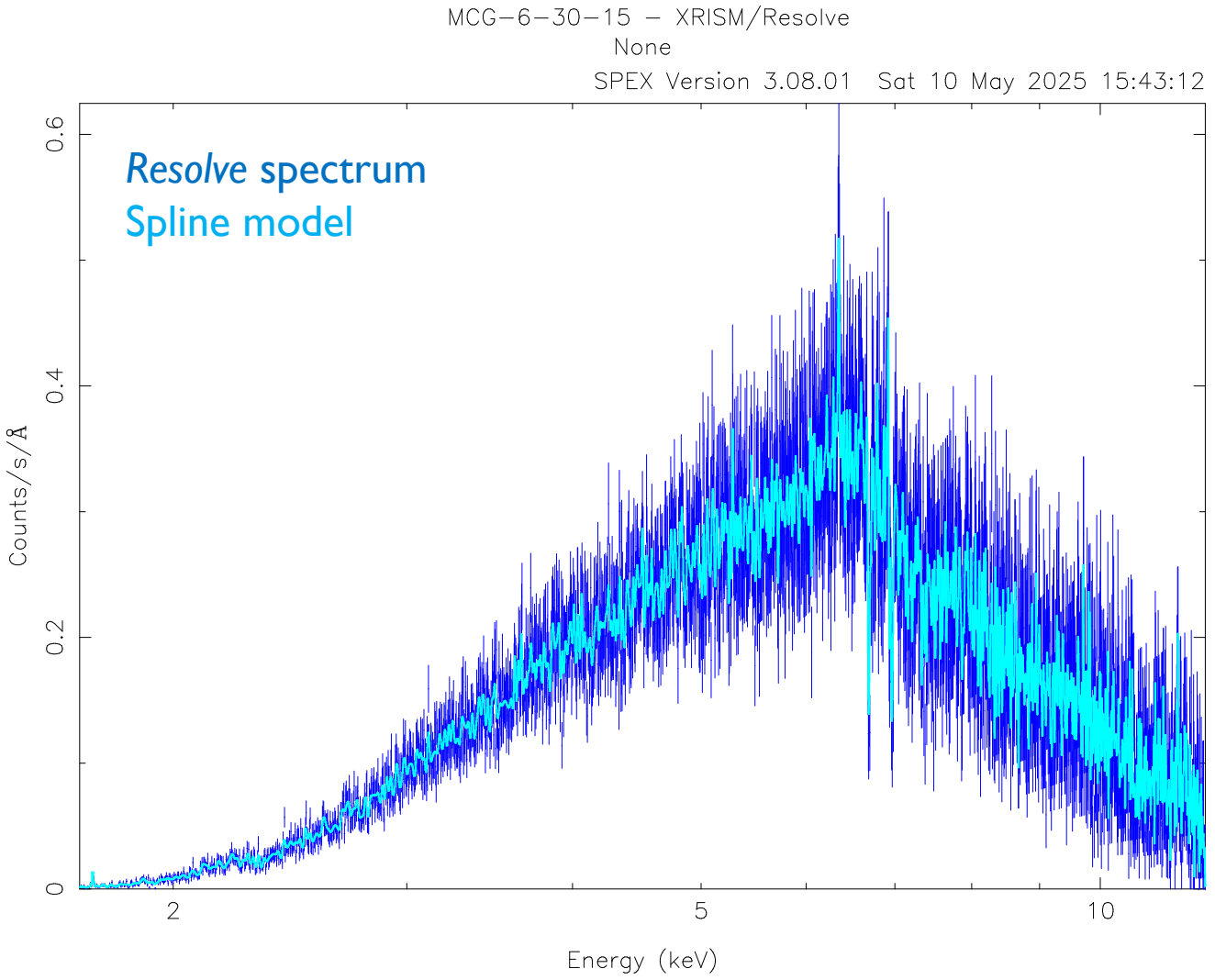
SPLINE APPROACH: APPLICATION TO SEYFERTS

- Studies based on Seyfert (astro)physical models are hampered by their complexity

- Alternative approach
  1. fit the spectrum at the highest energy resolution (*Resolve*) with a spline
  2. Plot highly binned ratios against the best-fit *Resolve* spline

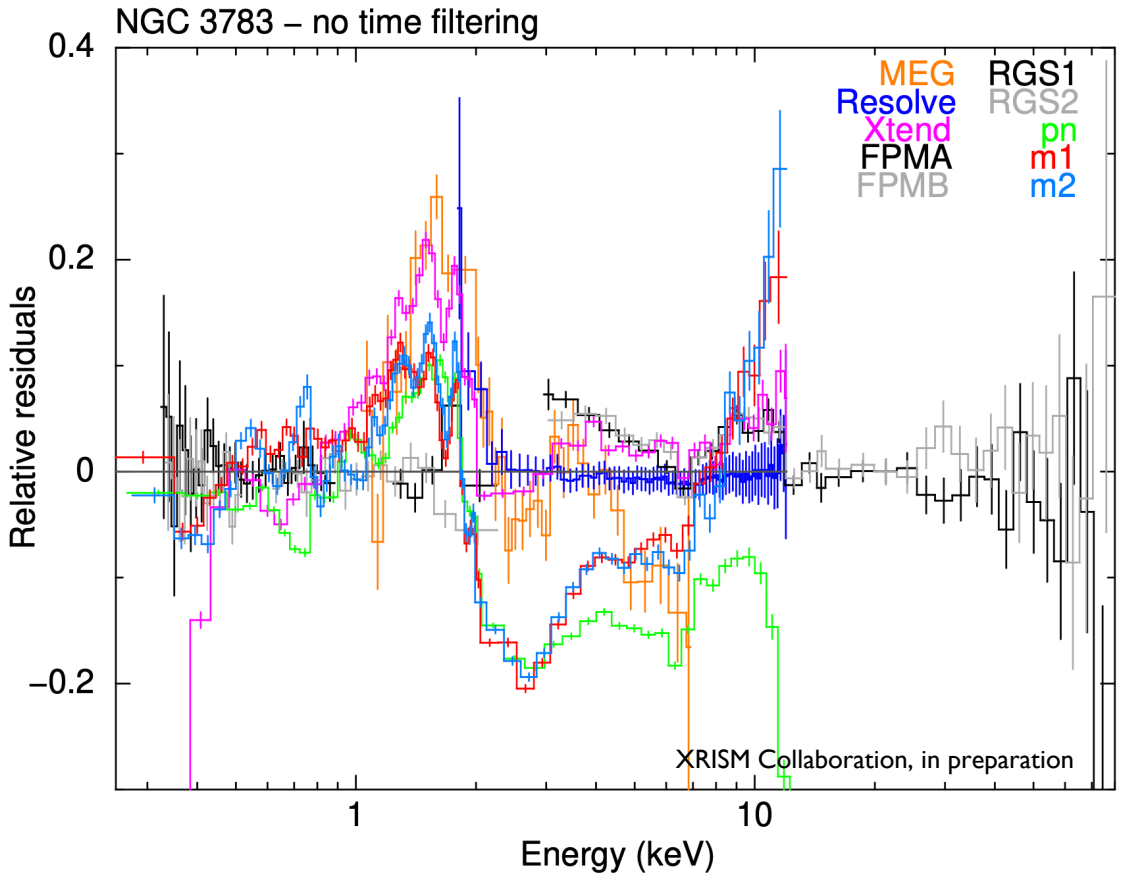
- Implemented by J. Kaastra in XSPEC

- Beware high frequency features (in energy space)!

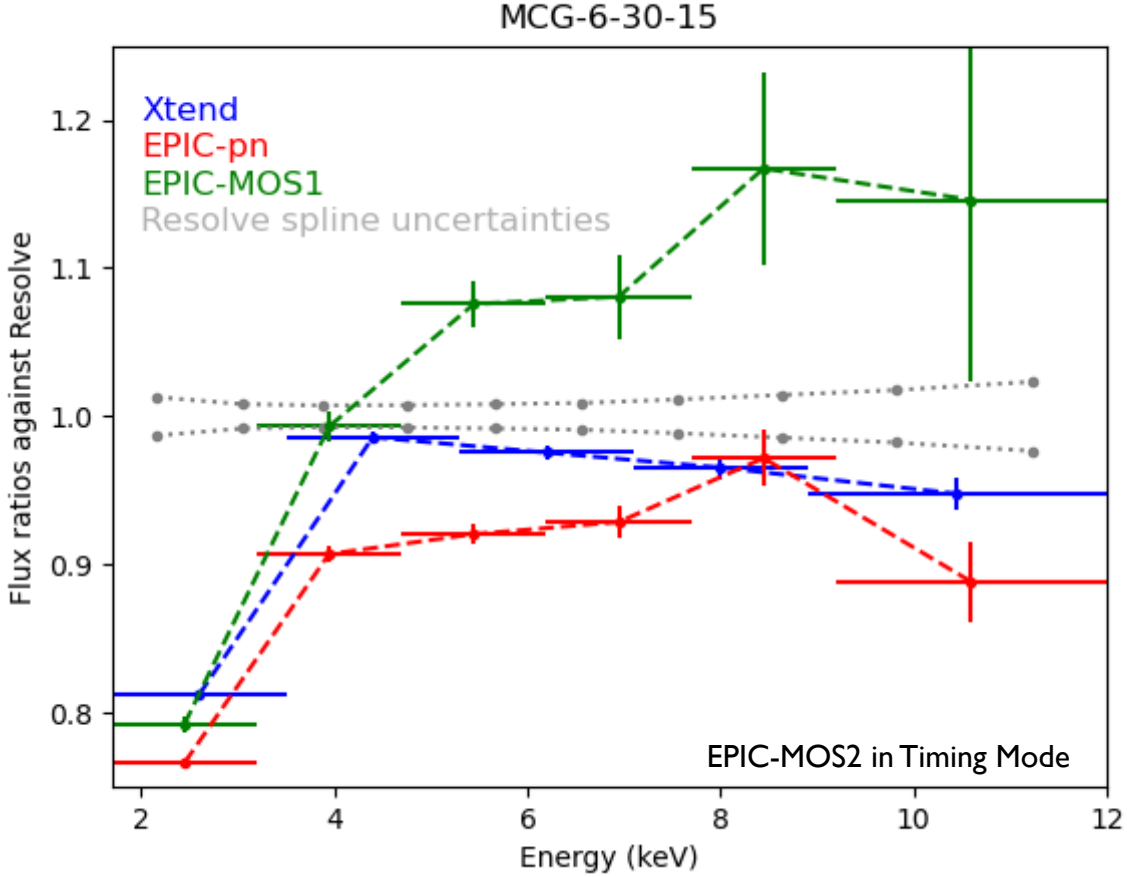


E>1.7 KEV CROSS-CALIBRATION RESULTS (METHOD 3)

Note that in both cases the **PSF core is excised due to pile-up**



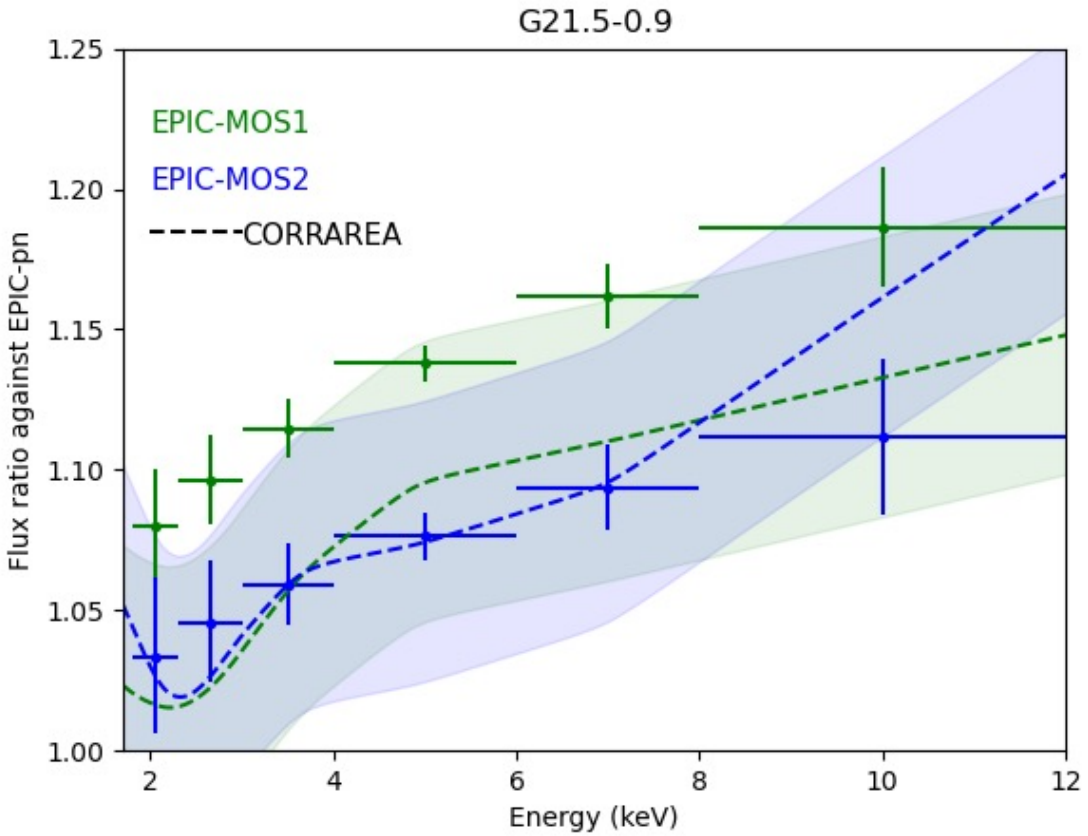
- *Xtend*: ~1.03-1.07
- EPIC-MOS: ~0.8-1.2
- EPIC-pn: ~0.8-0.9

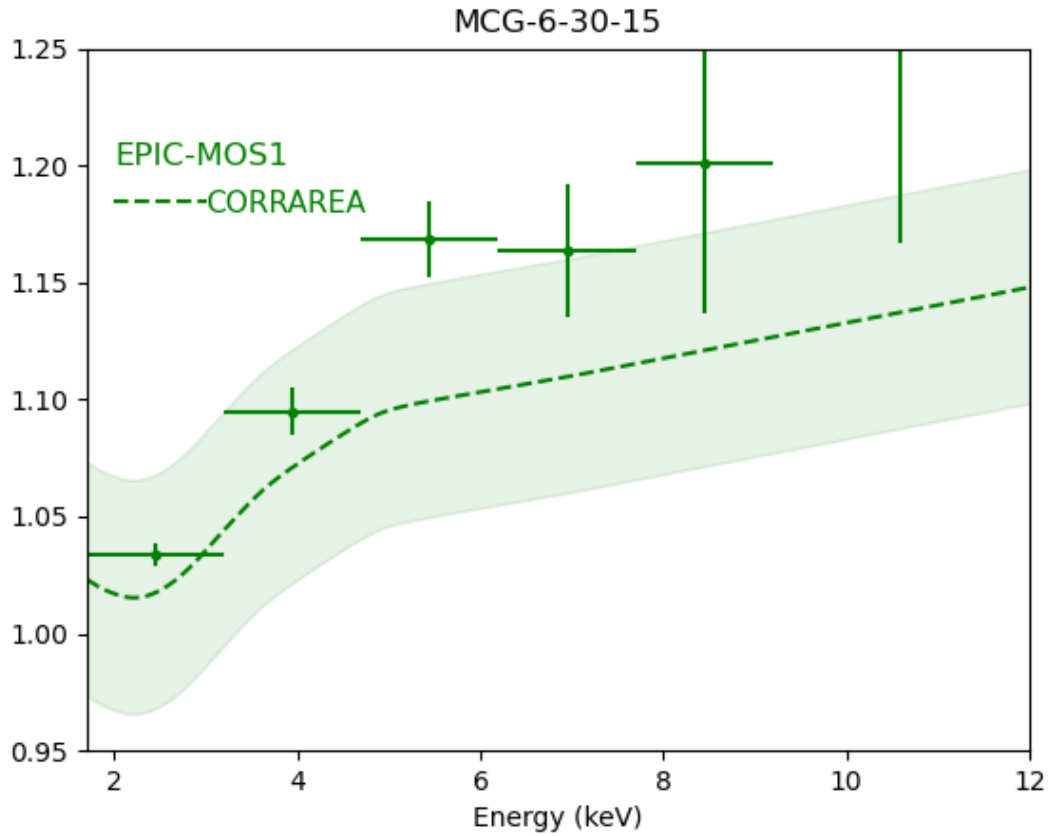


- *Xtend*: ~0.92-1.00
- EPIC-MOS1: ~0.78-1.12
- EPIC-pn: ~0.78-0.90

INTERLUDE ON THE INTRA-EPIC CALIBRATION

The cross-calibration among the EPIC cameras is ~consistent with `CORRAREA` (cf. M. Smith presentation)

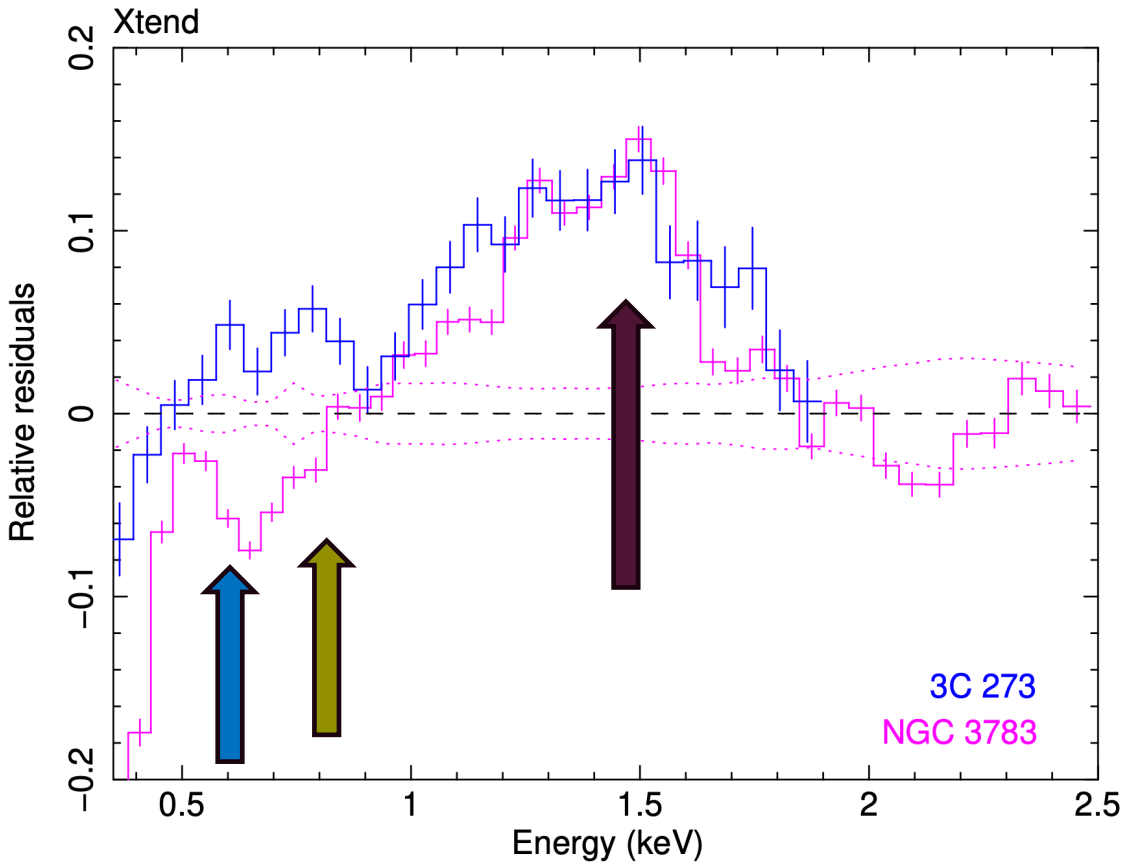


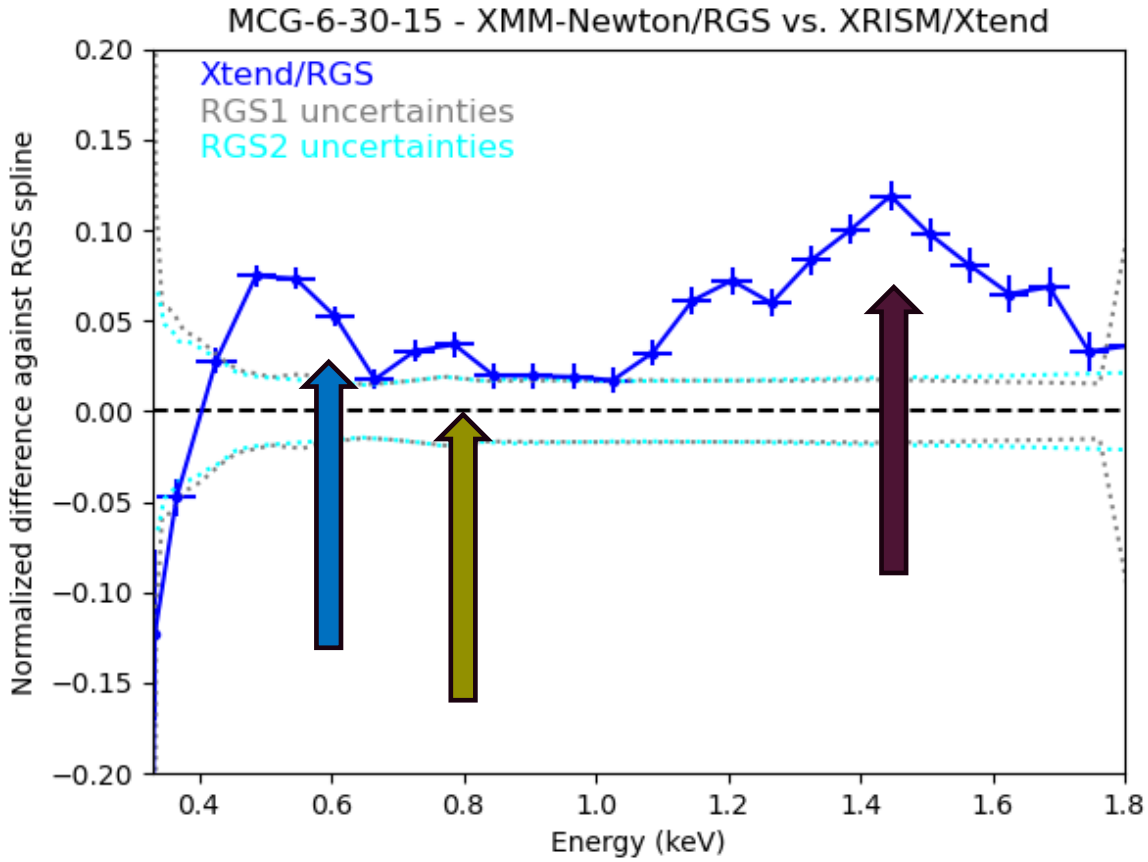


[The colored band is the estimated uncertainty on the effective area correction]

XTEND VS. RGS

XRISM Collaboration, in prep





Note about the method: these are the *Xtend* ratios versus the best-fit RGS spline models

SUMMARY

- *Xtend* vs. *Resolve*:
  - Generally, good agreement in flux (±5%) and spectral shape for E≥3 keV (exception: 3C273)
  - Flux decrease for E<3 keV (feature occasionally seen in the ratio against other instruments)

- EPIC-pn vs. *Resolve*
  - Flux deficit between 10% and 20%
  - Moderate energy dependency in a given source

- EPIC-MOS vs. *Resolve*
  - Trend of monotonically increasing flux ratio from ~0.8 (~2 keV) to ~1.1 (~10 keV)

- *Xtend* vs. RGS
  - Average excess flux ~7%
  - Energy dependent with clear "peaks" at ~1.4 keV and (maybe) ~0.6 keV and 0.8 keV

- Lots of work needed to understand the systematics