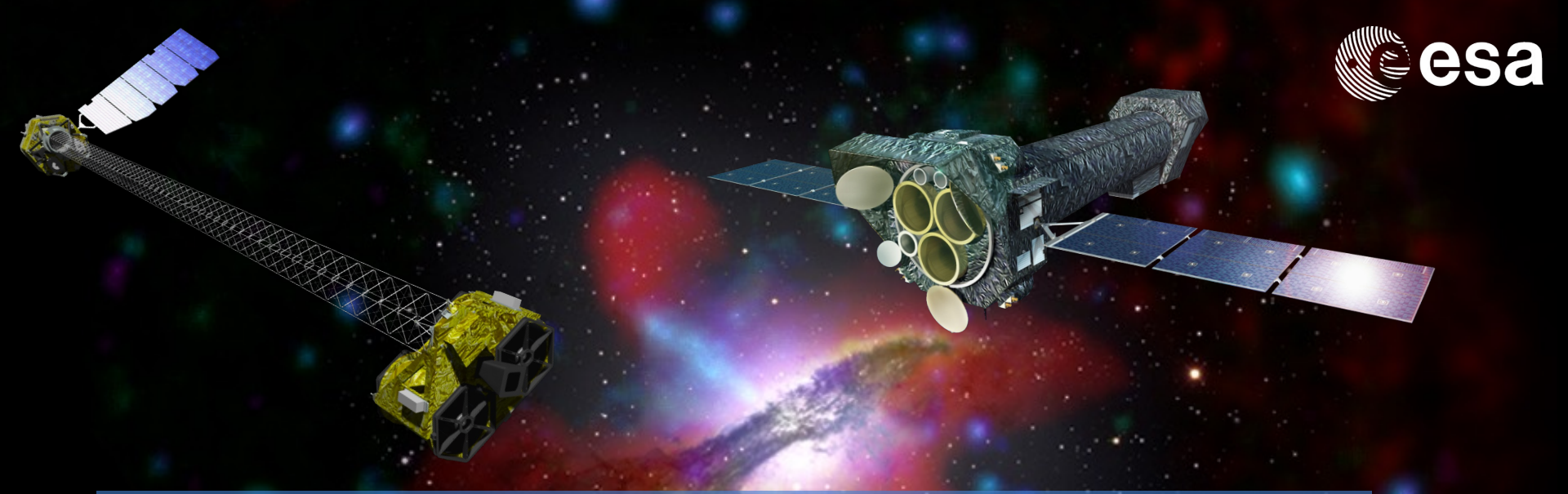


XMM-Newton EPIC-pn vs. *NuSTAR*

Gabriele Matzeu (Quasar SR for ESA)

3rd June 2024

F. Füerst, N. Schartel, M. Smith for the EPIC-pn IDT and SOC USG

Coordinated XMM-NuSTAR & NuSTAR sample

I took over from Felix in mid (and extremely hot) August 2023 at ESAC

Based on previous work by Felix Füerst.

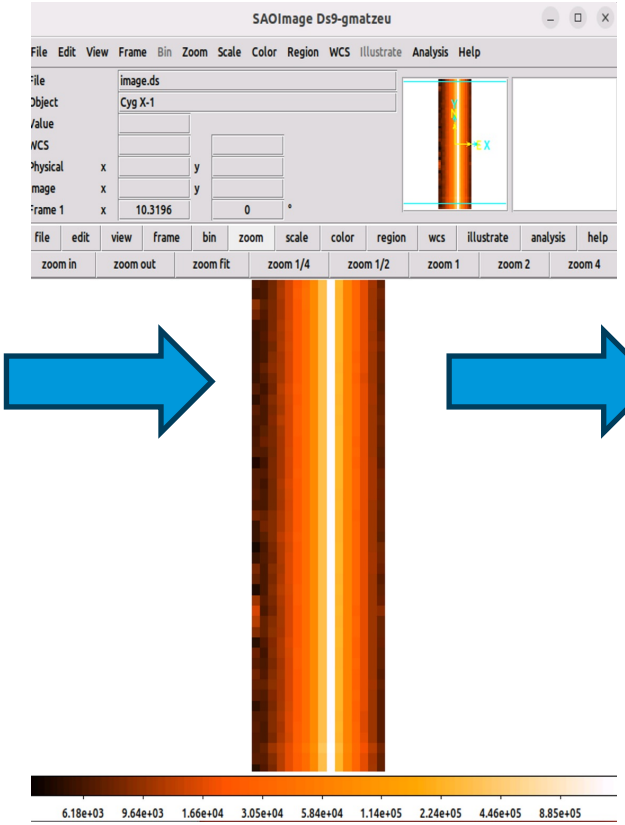
GOAL: Reduce and analyze a large sample of "coordinated XMM-Newton & NuSTAR" targets (**mostly XRBs**) in a semi-automated pipeline for *XMM-Newton* (EPIC-pn in timing mode) and *NuSTAR*

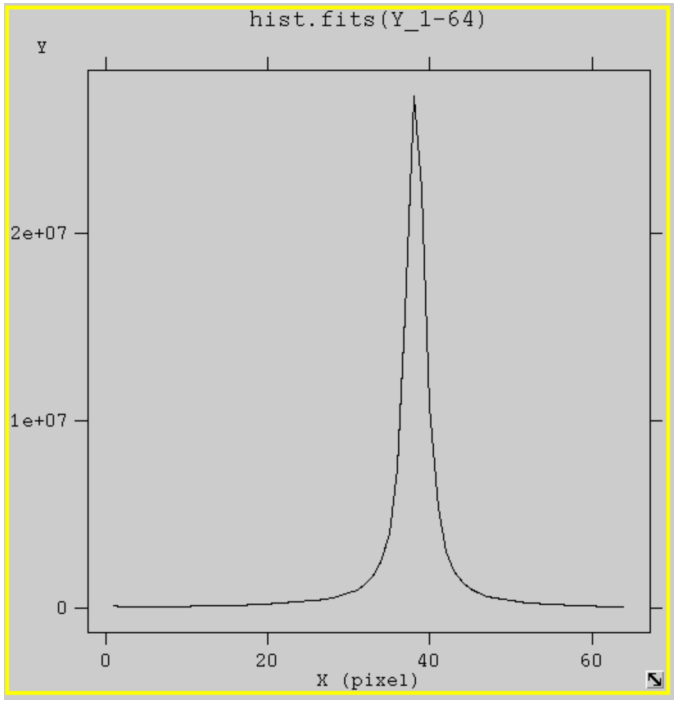
26 obs – Thick Filter
12(10) obs – Medium Filter
30 obs – Thin Filter

Reduction and analysis approach

XMM-Newton
EPIC-pn
Timing mode
RAWX =1-64
Using 3-10 keV

In the Timing mode, spatial information is maintained only in one dimension, along the column (RAWX) axis.

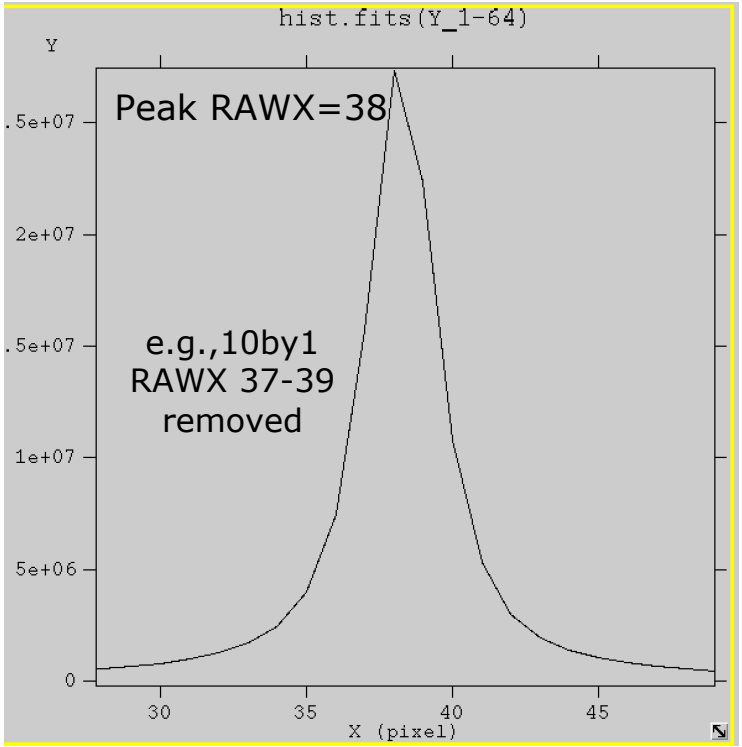




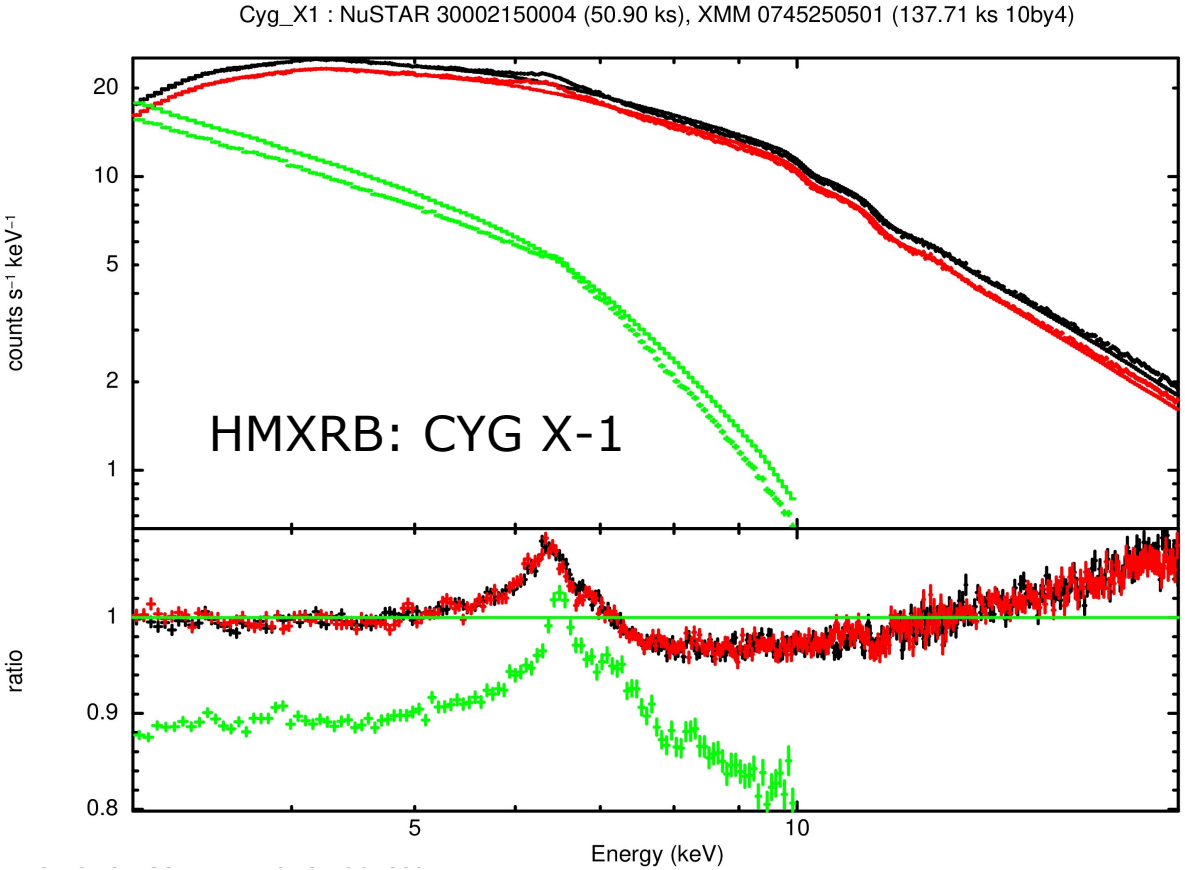
Reduction and analysis approach

XMM-Newton EPIC-pn
Timing mode
RAWX by (central RAWX excl)
10by0 … 10by4 depending on pileup
Using 3-10 keV
Mincount=25 and oversample=3
arfgen applyabsfluxcorr=yes

NuSTAR
Fitting FPMA and FPMB
90” extraction radius both src and bkg
Using 3-20keV
Mincount=50



Example 1:



Find best-fit continuum model to *NuSTAR* data only
(in this case: constant*pow)

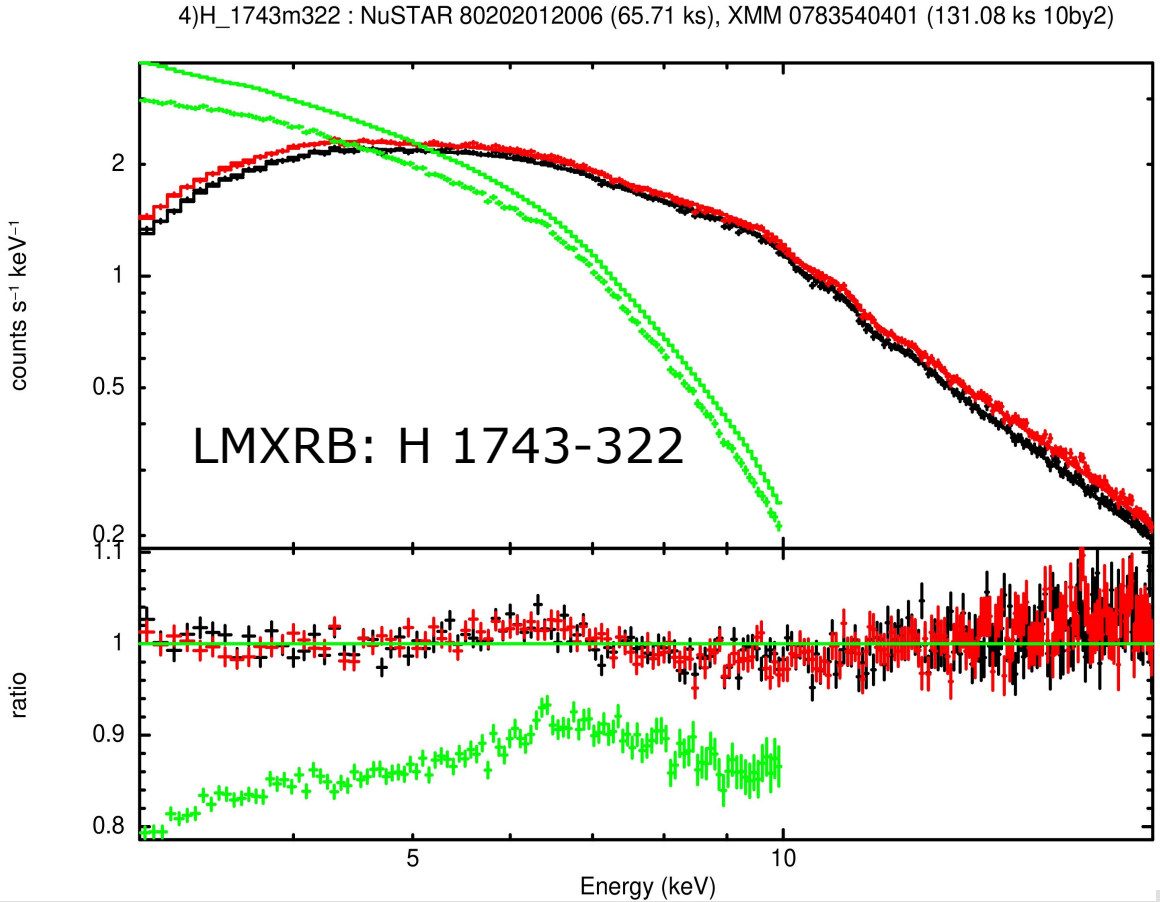
(*XMM* EPIC-pn not fitted)

EPIC-pn photo-index wrt *NuSTAR*: harder

(*XMM* EPIC-pn not fitted)

arfgen applyabsfluxcorr=yes

Example 2 :



Find best-fit continuum model to *NuSTAR* data only (model:constant*Tbabs*pow)

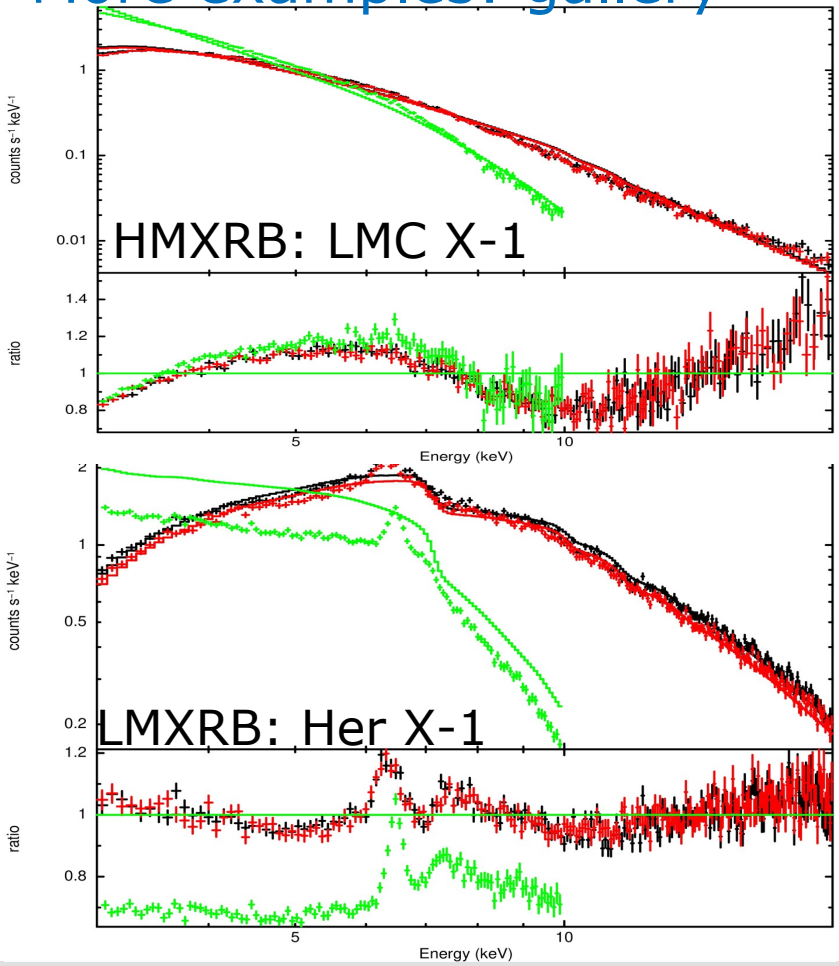
(*XMM* EPIC-pn not fitted)

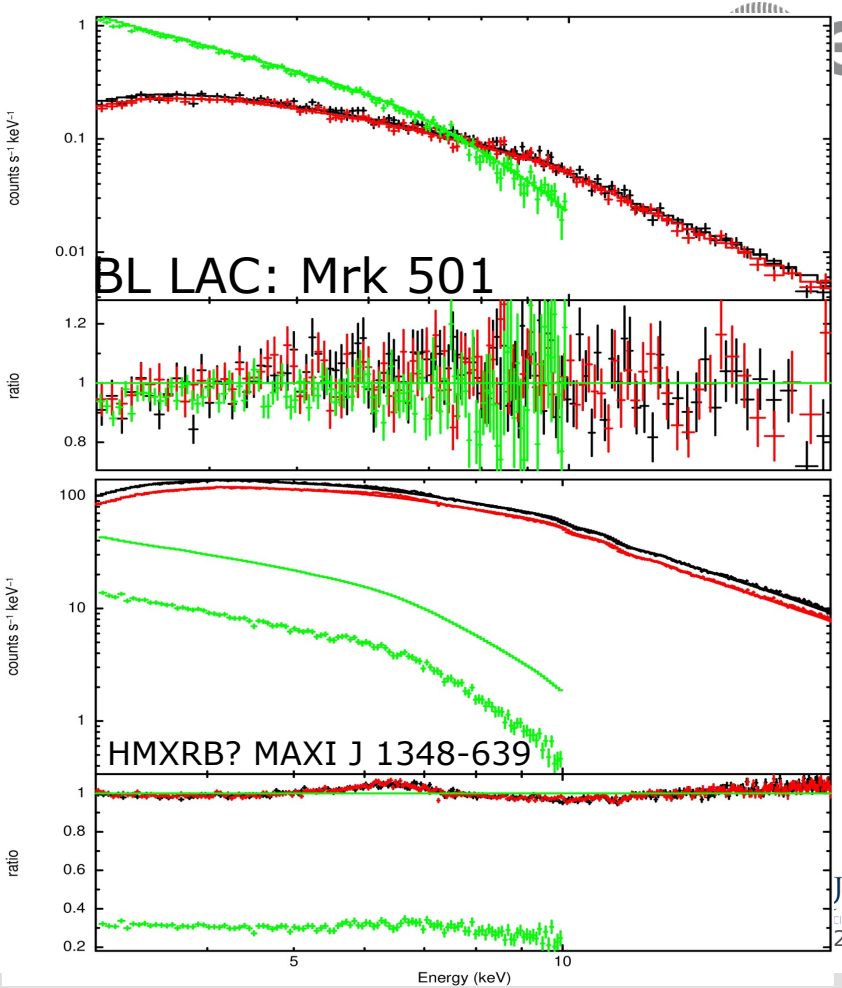
EPIC-pn photo-index wrt *NuSTAR*: harder

(*XMM* EPIC-pn not fitted)

arfgen applyabsfluxcorr=yes

More examples: gallery





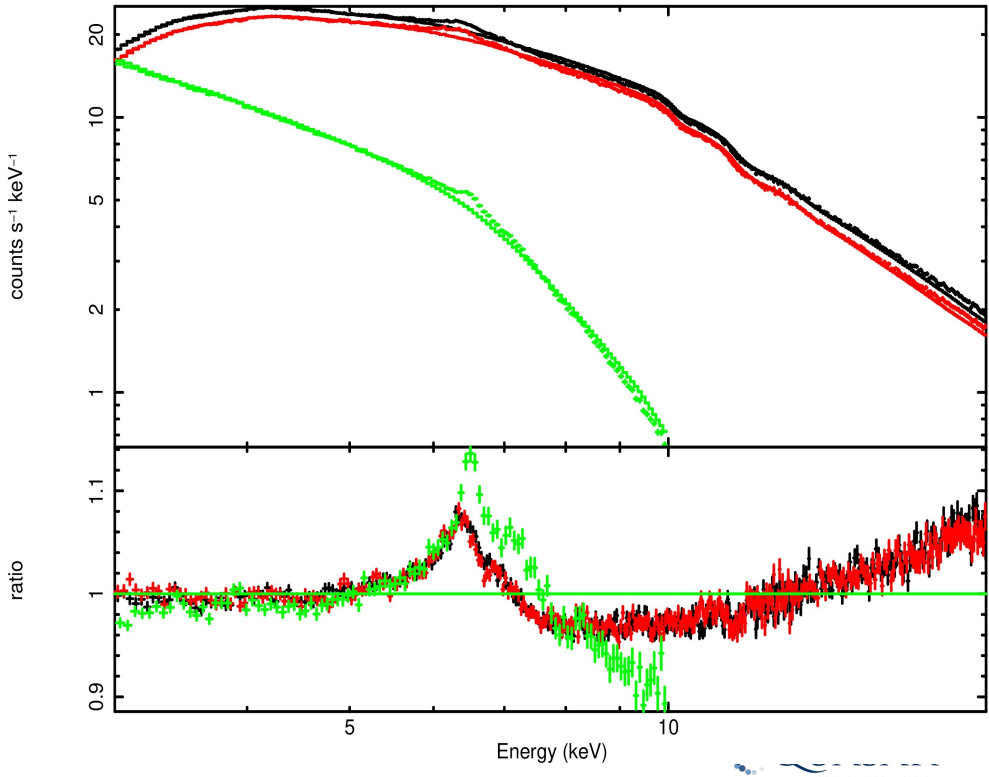
TEST 1 example – EPIC-pn VARIABLE CONSTANT

CYG X-1; An accreting high mass X-ray binary with strong iron Kα line.

Fe Ka centroid energy lines is shifted by ~10 eV

Δconst = 1 (FPMA) – constant (EPIC-pn) = 0.09

-> work in progress.



TEST 2 example – EPIC-pn VARIABLE Γ

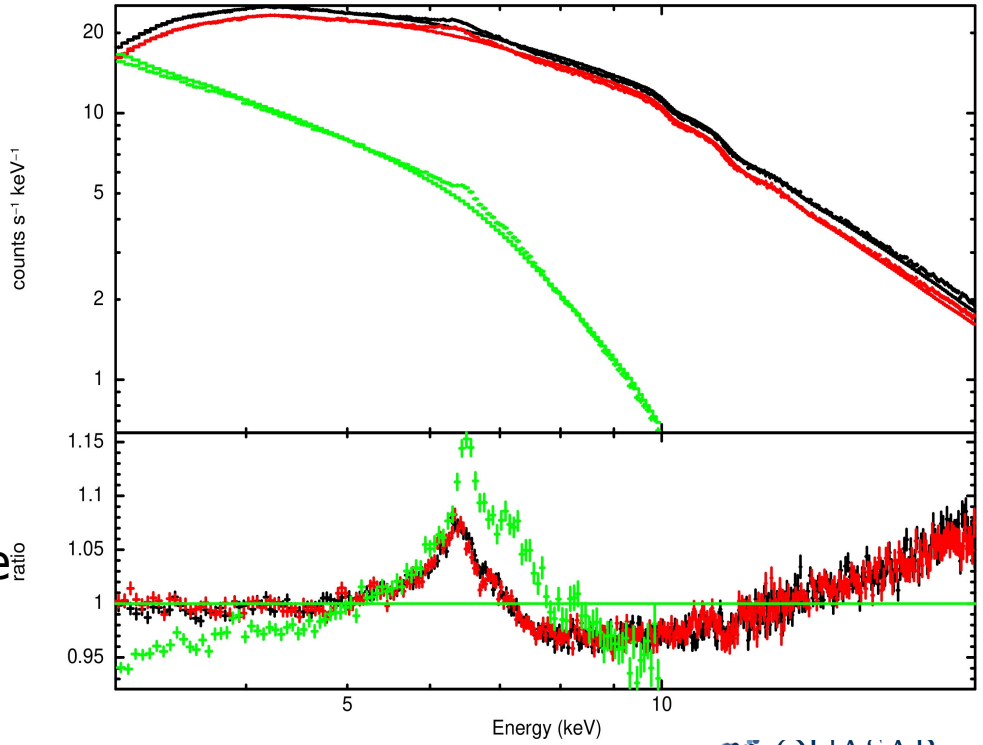
CYG X-1; An accreting high mass X-ray binary with strong iron Kα line.

Fe Ka centroid energy lines is shifted by ~10 eV

ΔΓ = Γ (FMPA) - Γ (pn) = 0.06

The majority of EPIC-pn slopes are softer w.r.t. *NuSTAR FPMA/B*

-> work in progress.



QUASAR SCIENCE RESOURCES, S.L.

Results

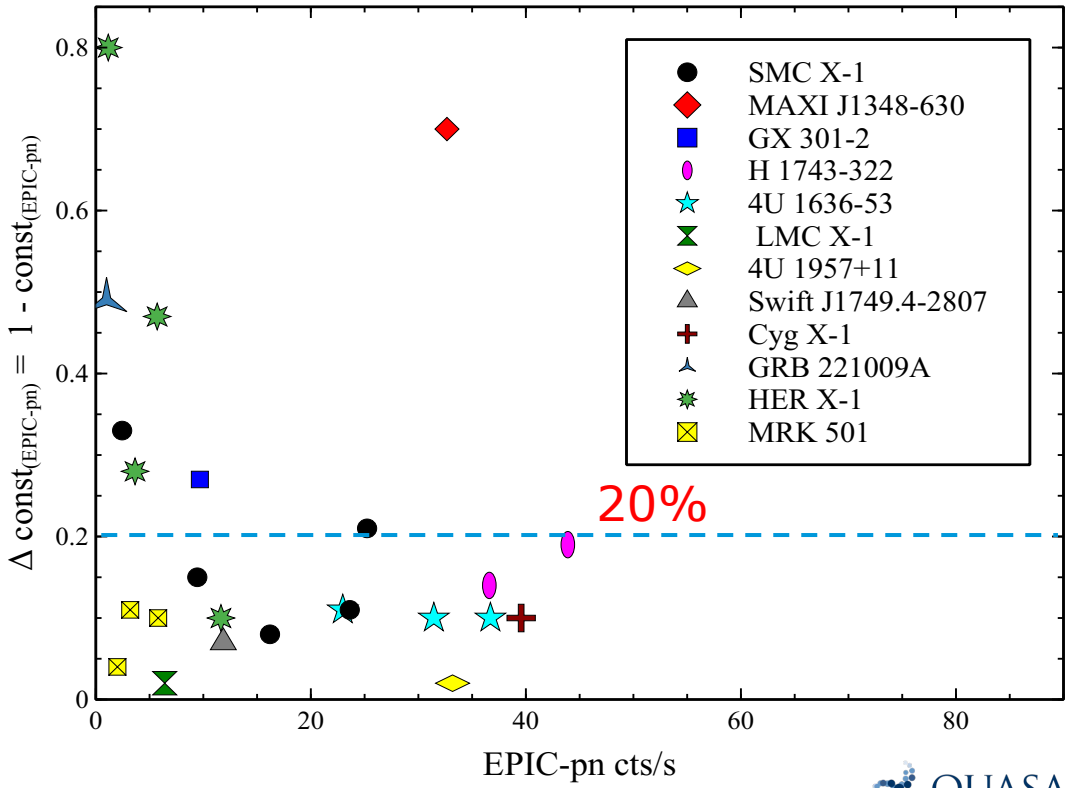
Counts/s vs Δconstant (THICK)

High S/N so 1-3% error

There is a considerable scatter without any recognizable correlation

Work in progress!

EPIC-pn and *NuSTAR* differences not always that large but mostly within 20%



Results

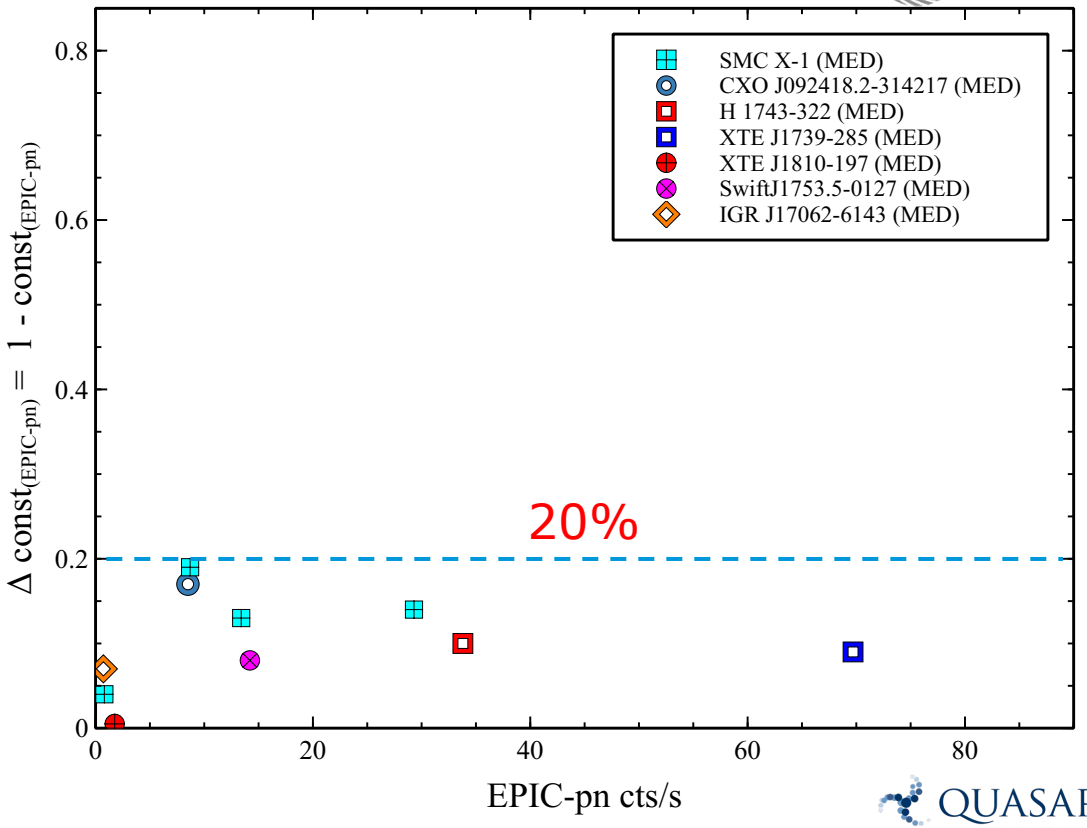
Counts/s vs Δconstant (MEDIUM)

High S/N so 1-3% error

There is a considerable scatter without any recognizable correlation

Work in progress!

EPIC-pn and *NuSTAR* differences not always that large but mostly within 20%



Results

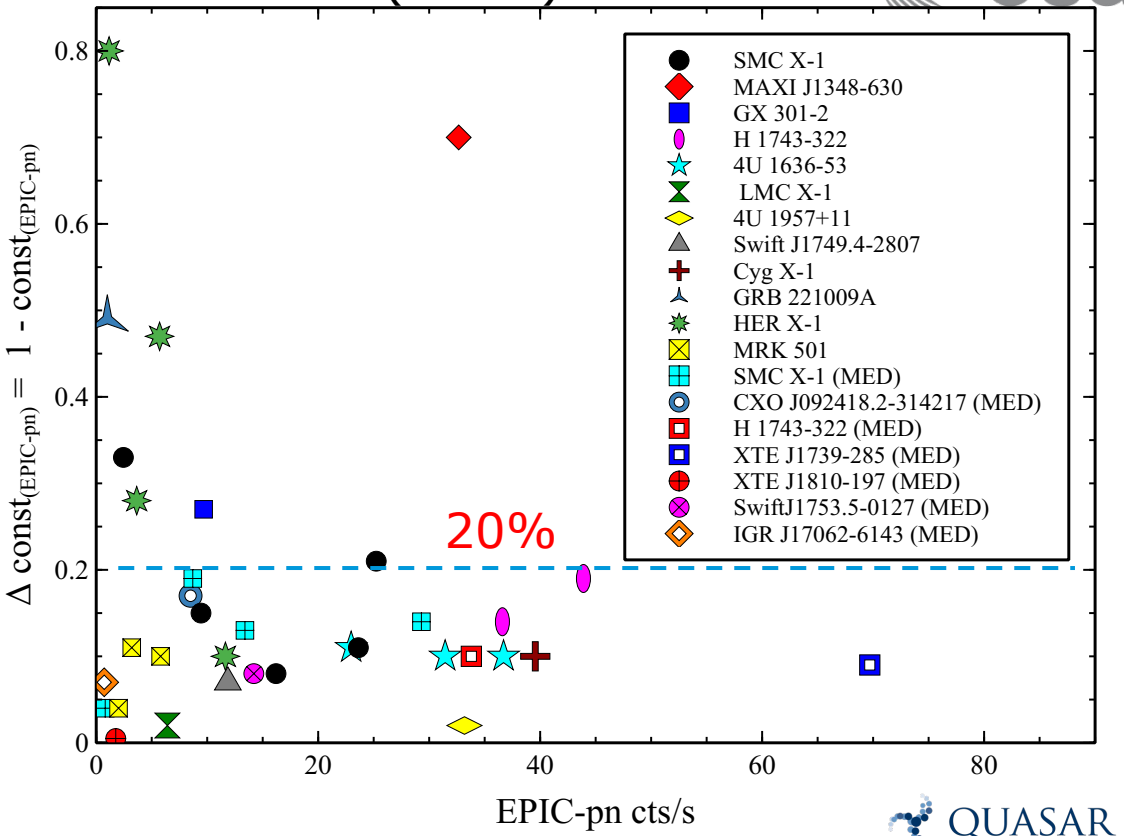
Counts/s vs Δconstant (BOTH)

High S/N so 1-3% error

There is a considerable scatter without any recognizable correlation

Work in progress!

EPIC-pn and *NuSTAR* differences not always that large but mostly within 20%



Results

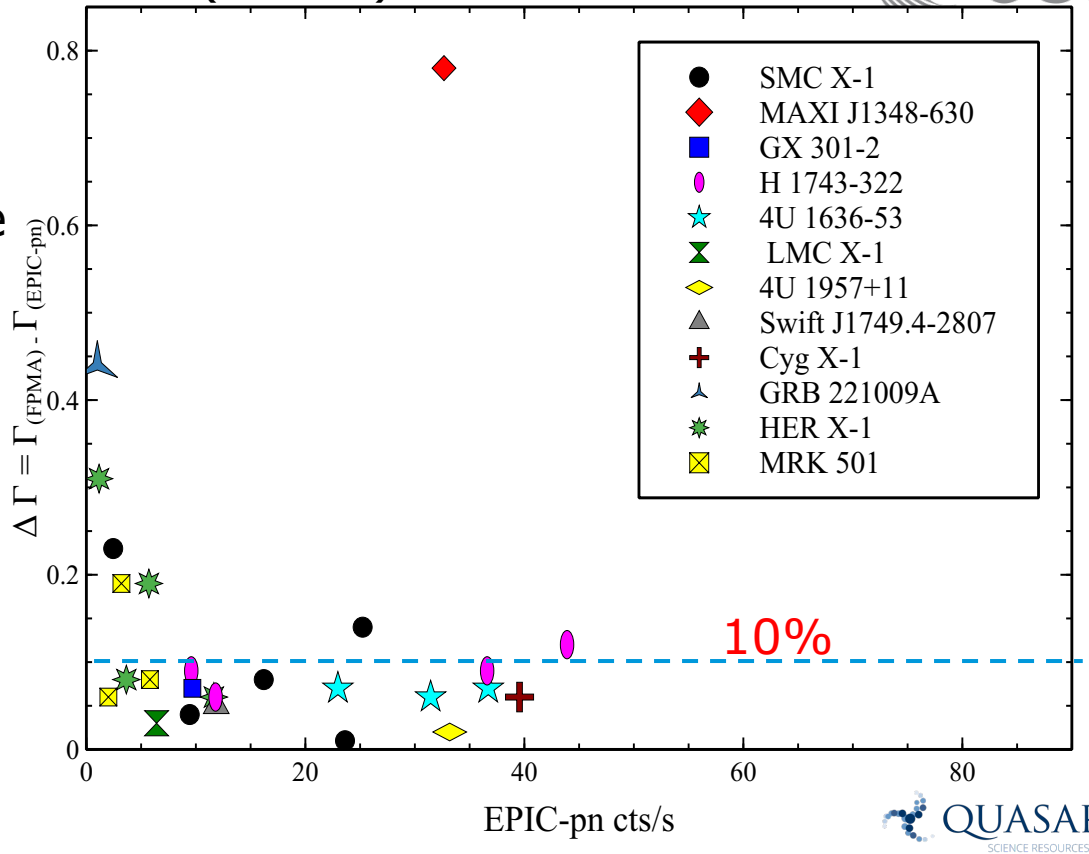
Counts/s vs ΔΓ (THICK)

High S/N so 1-3% error

There is also a considerable scatter without any recognizable correlation

Work in progress!

EPIC-pn and *NuSTAR* differences not always that large, see GRS 1739-278



Results

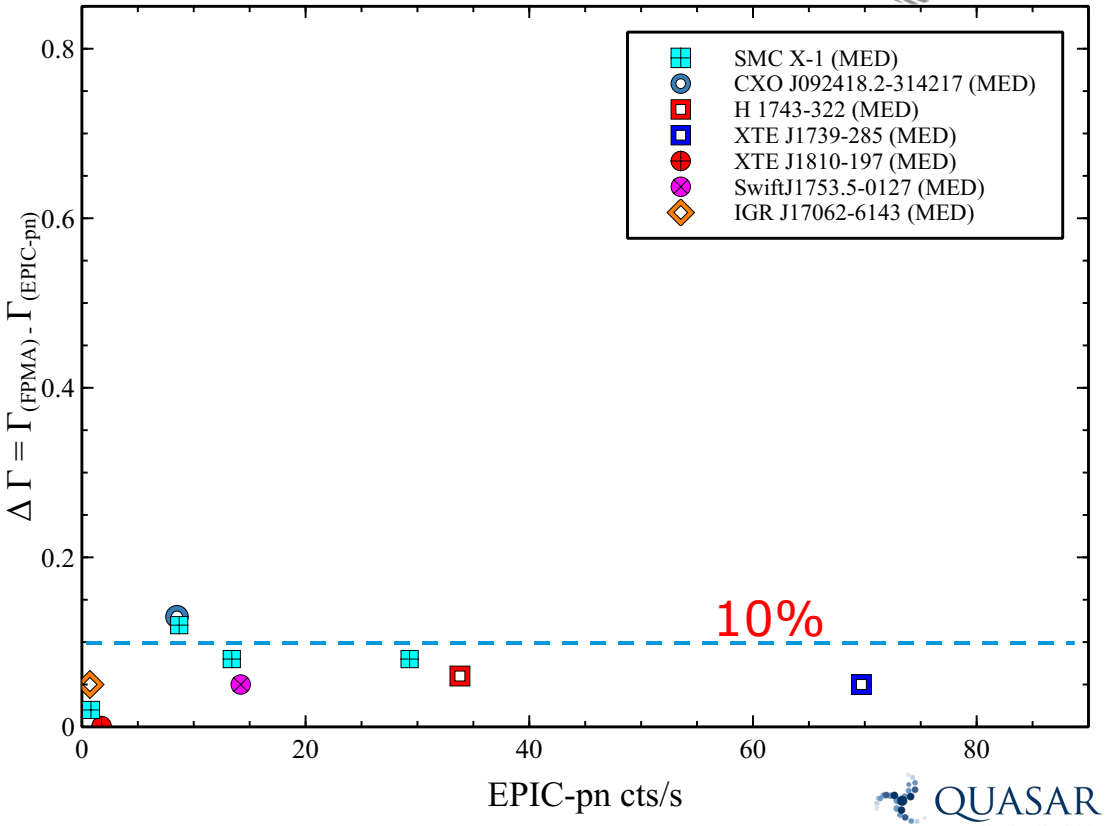
Counts/s vs ΔΓ (MEDIUM)

High S/N so 1-3% error

There is also a considerable scatter without any recognizable correlation

Work in progress!

EPIC-pn and *NuSTAR* differences not always that large, see GRS 1739-278



Results

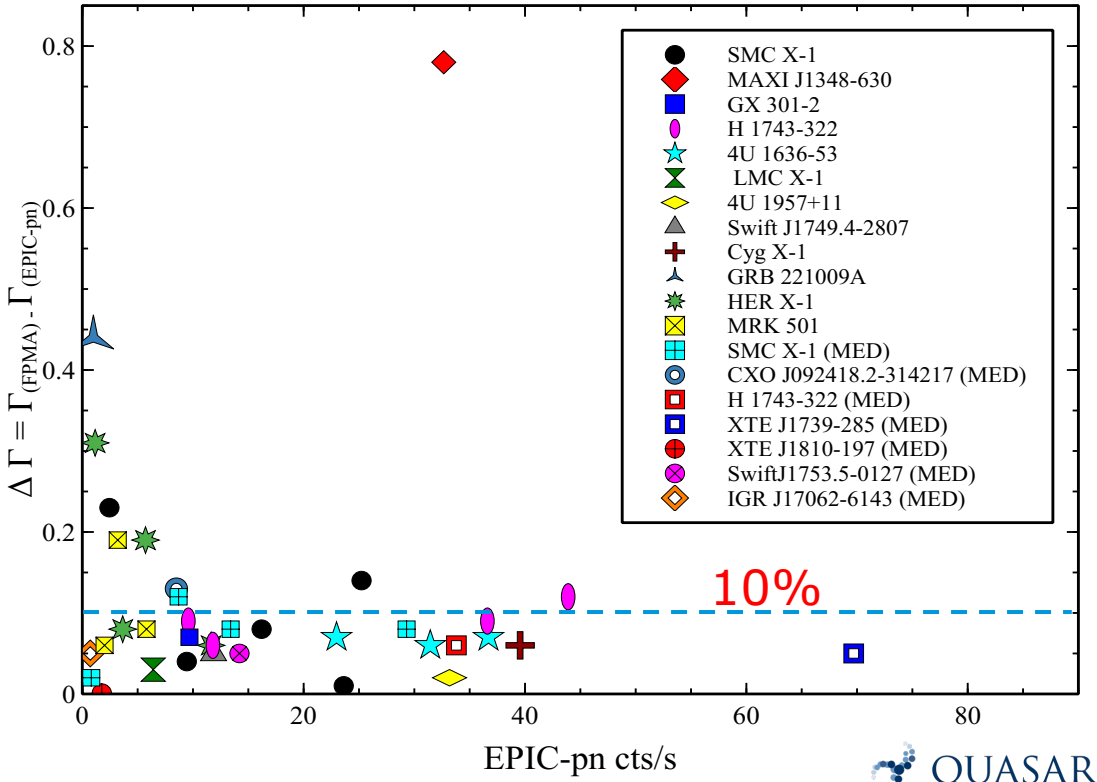
Counts/s vs ΔΓ (BOTH)

High S/N so 1-3% error

There is also a considerable scatter without any recognizable correlation

Work in progress!

EPIC-pn and *NuSTAR* differences not always that large, see GRS 1739-278



Current status and outlook

Flux difference of ~20% obvious in most of the 36 sources with some outliers

Slope difference of ~10% for most of the 36 targets with some pronounced outliers

As this is in working progress we still have to find some form of correlation (if any!).

Outliers like MAXI J1348-630, HER X-1, 4U1636-53 will make my life even more complicated

w.r.t. *NuSTAR*
XMM flux typically lower by ~ 20%
XMM spectrum softer ($\Delta\Gamma \sim 0.1$)

Work is ongoing to create automated pipeline, add more sources. Any change to calibration can be immediately checked.

Conclusion

IACHEC cross-calibration observations and XRBs provide a good set to measure and test the cross-calibration between EPIC-pn in timing mode and *NuSTAR.*

Project only recently started (but based on lots of previous work done by Felix and IDT team).

Current cross-calibration is far from perfect, but **hopefully** stable and can be characterized well in the short-term.

Short-term goal: Optimize the analysis by considering COMMON GTIs (when possible).

Investigate the Δconst, ΔΓ (and ΔNH) behavior w.t.r. to the **number of columns removed** for pileup sources (most of them!)

Mid-term goal: Increase the sample by adding the XMM-Newton EPIC-pn in timing mode observed with Thin filter.

Long-term goal: Also investigate the change in centroid energy of FeKα emission line.