A synoptic view of the calibration status below 10 keV

Matteo Guainazzi

ESAC-ESA

7th IACHEC – Napa, 27/3/2012

Questions

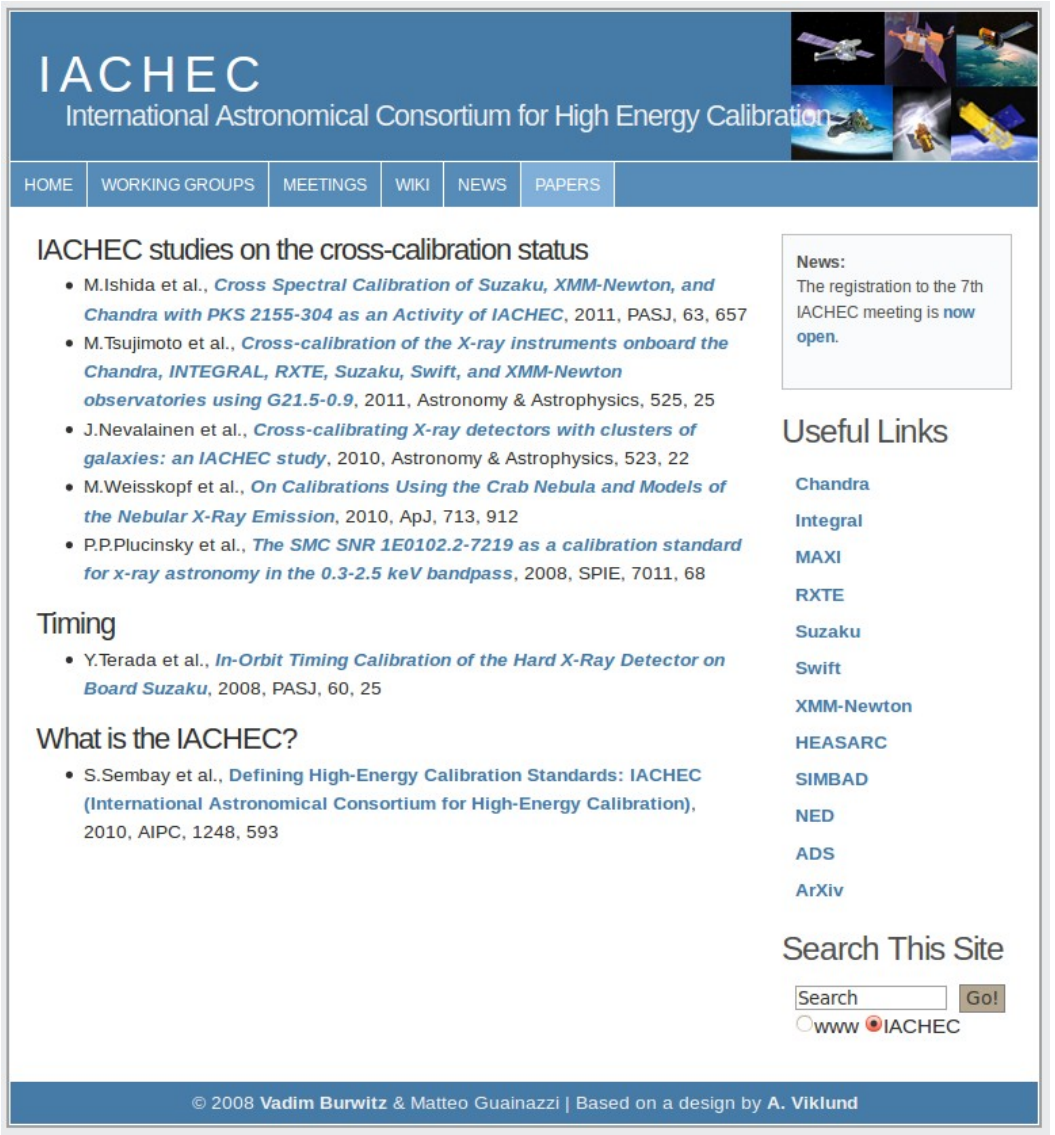
- Do we confront the community with a coherent view of the cross-calibration status?
- Do we transmit the cross-calibration status in the most appropriate way?
- In which direction is the current work on cross-calibration going? A caveat
- How can we make a step forward?

IACHEC papers

PKS2155-304 →

G21.5-0.9 →

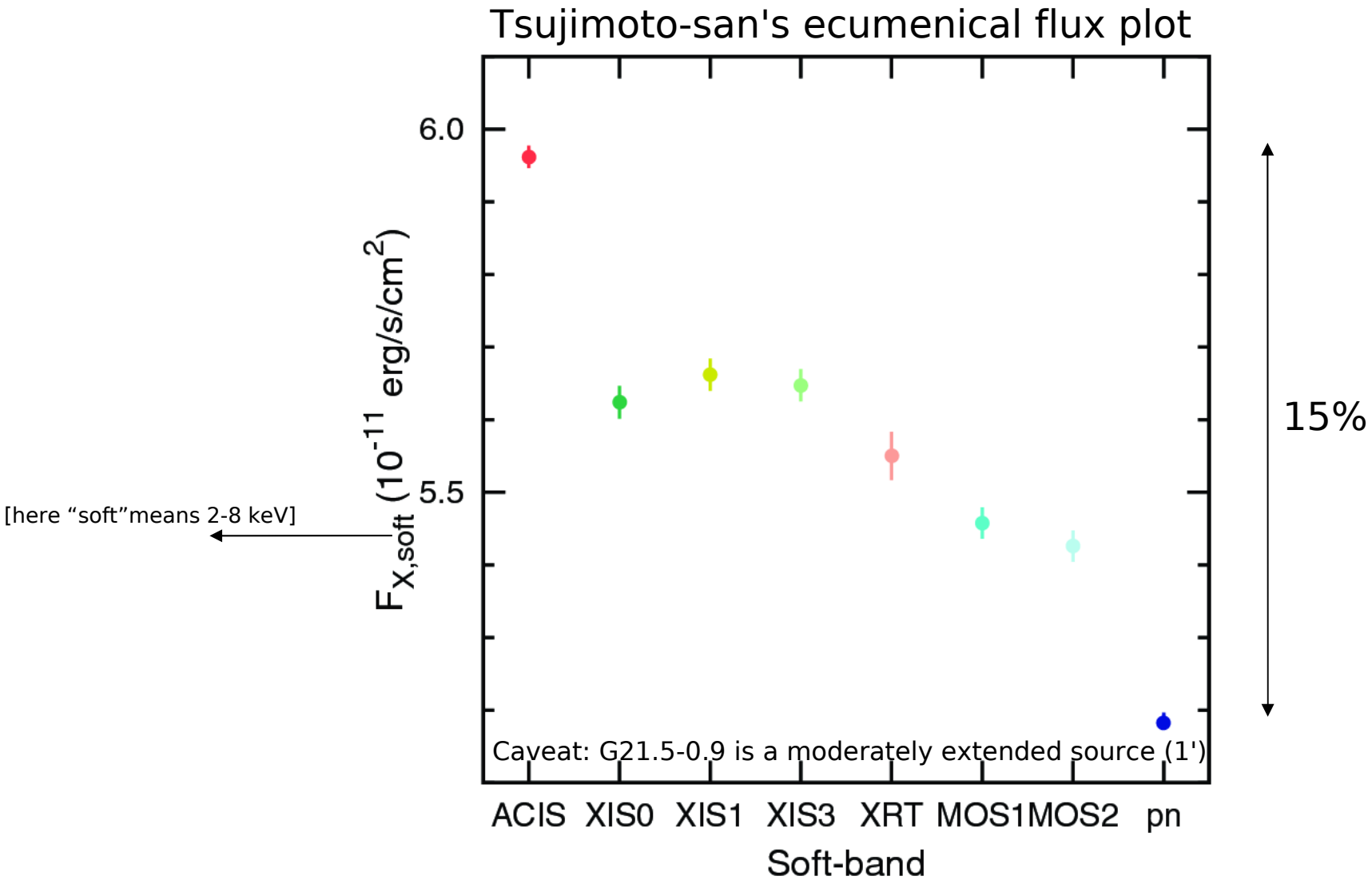
Galaxy clusters →



A synoptic view of the calibration status below 10

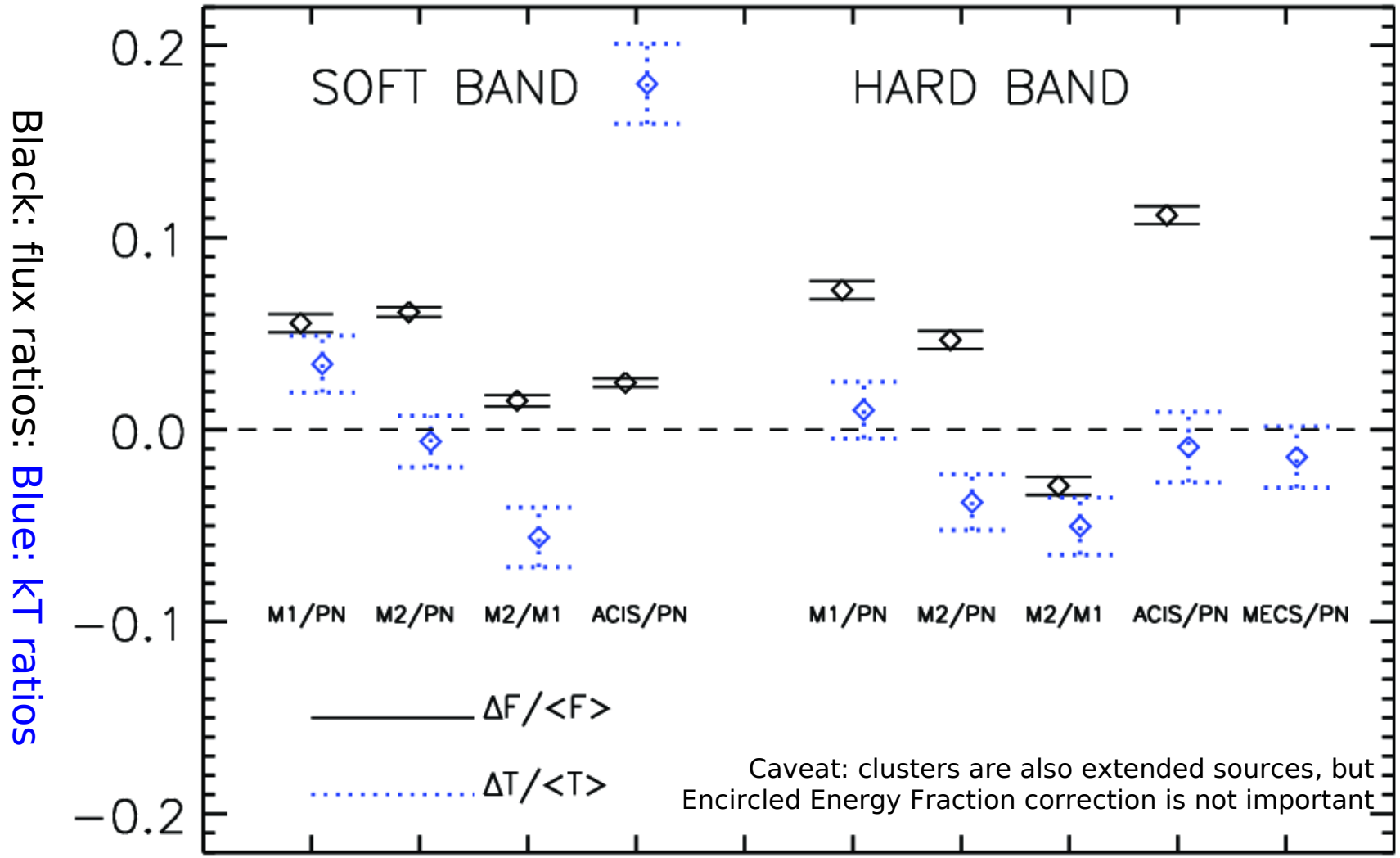
Hard band – fluxes - G21.5-0.9

(Tsujimoto et al., 2011, A&A, 525, 25)



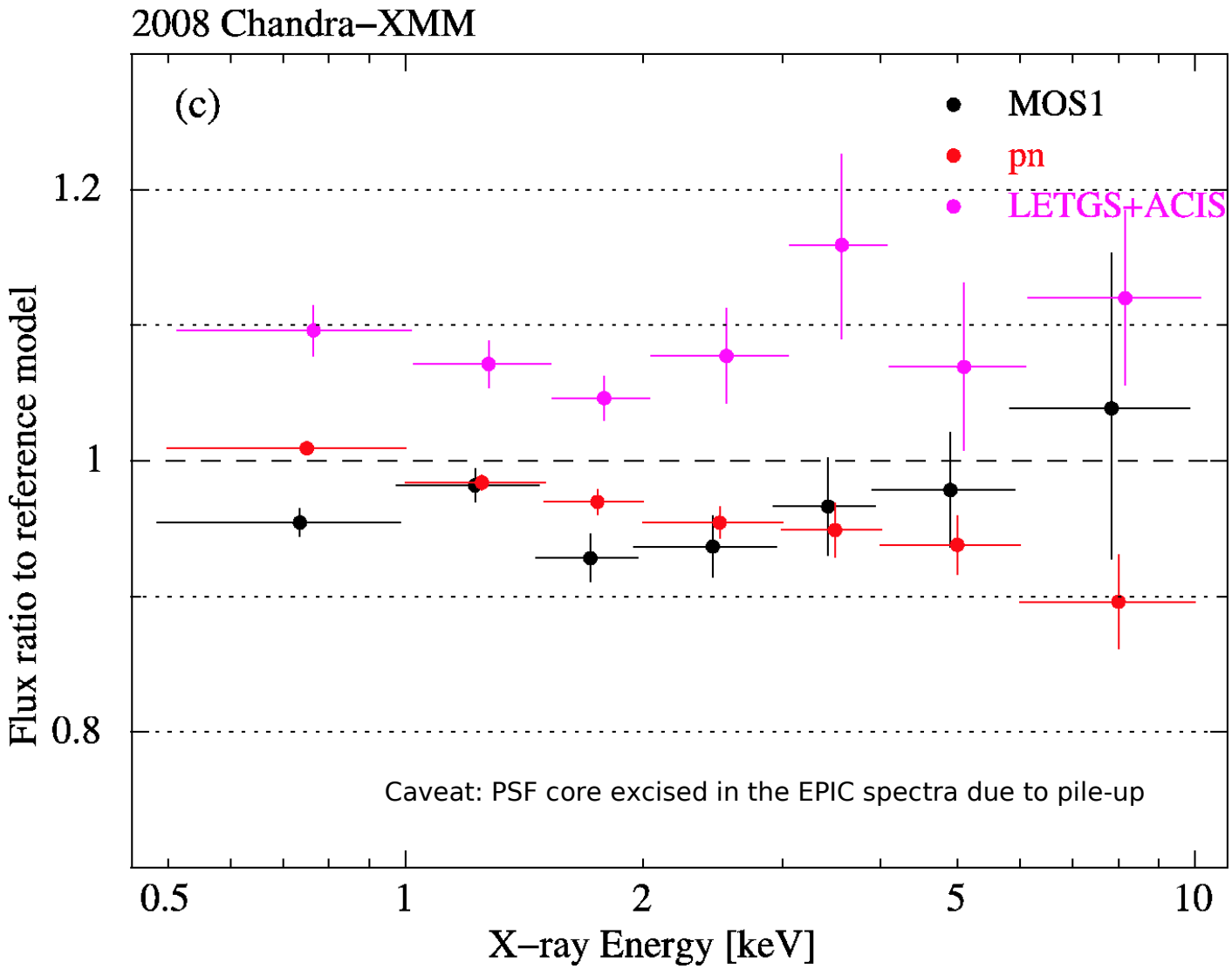
Hard band – fluxes - clusters

(Nevalainen et al., 2010, A&A, 523, 22)

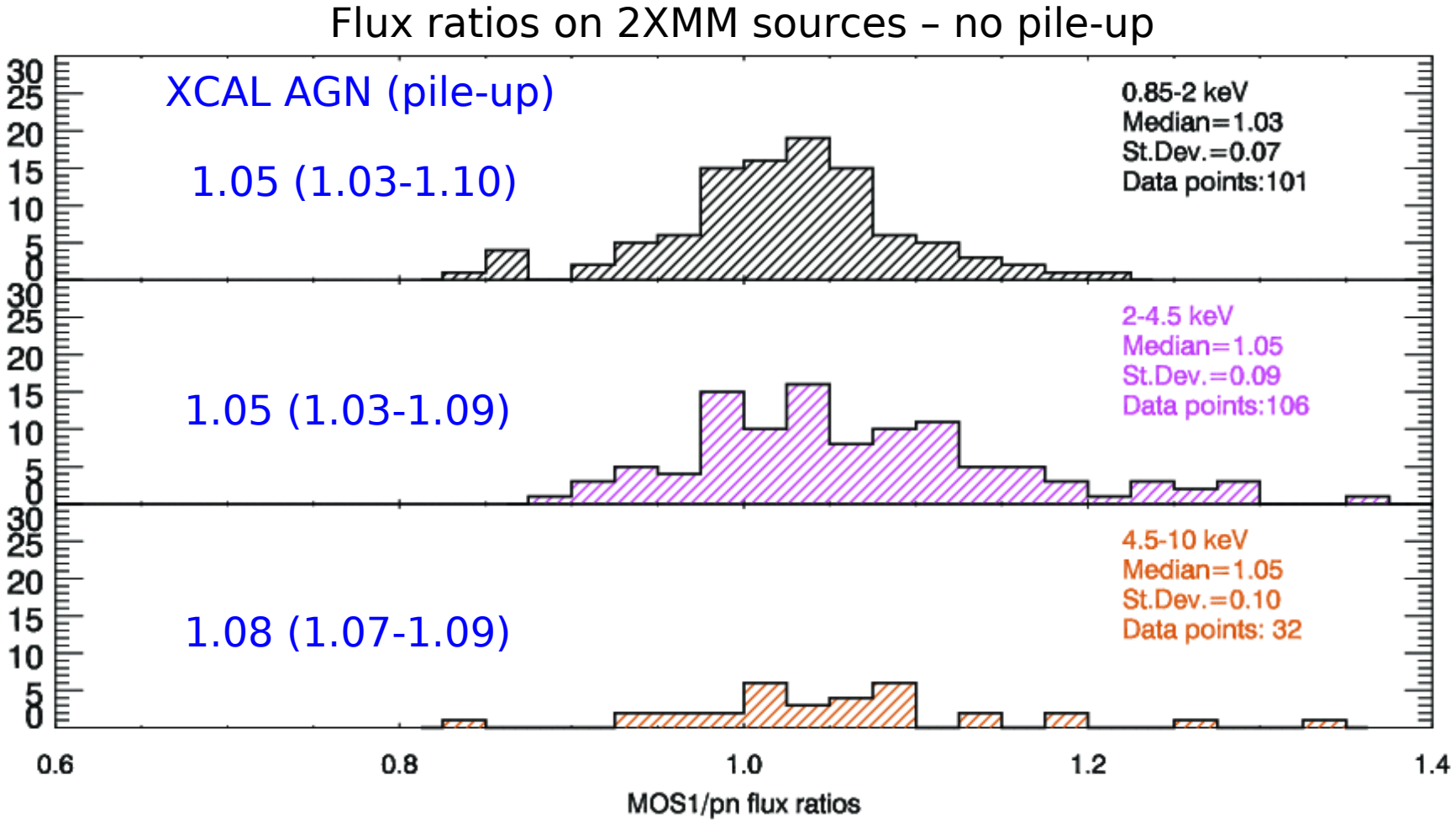


Hard+soft band – fluxes - PKS2155-304

(Ishida et al., 2011, PASJ, 63, 657)



Hard fluxes – inter EPIC cross-calibration



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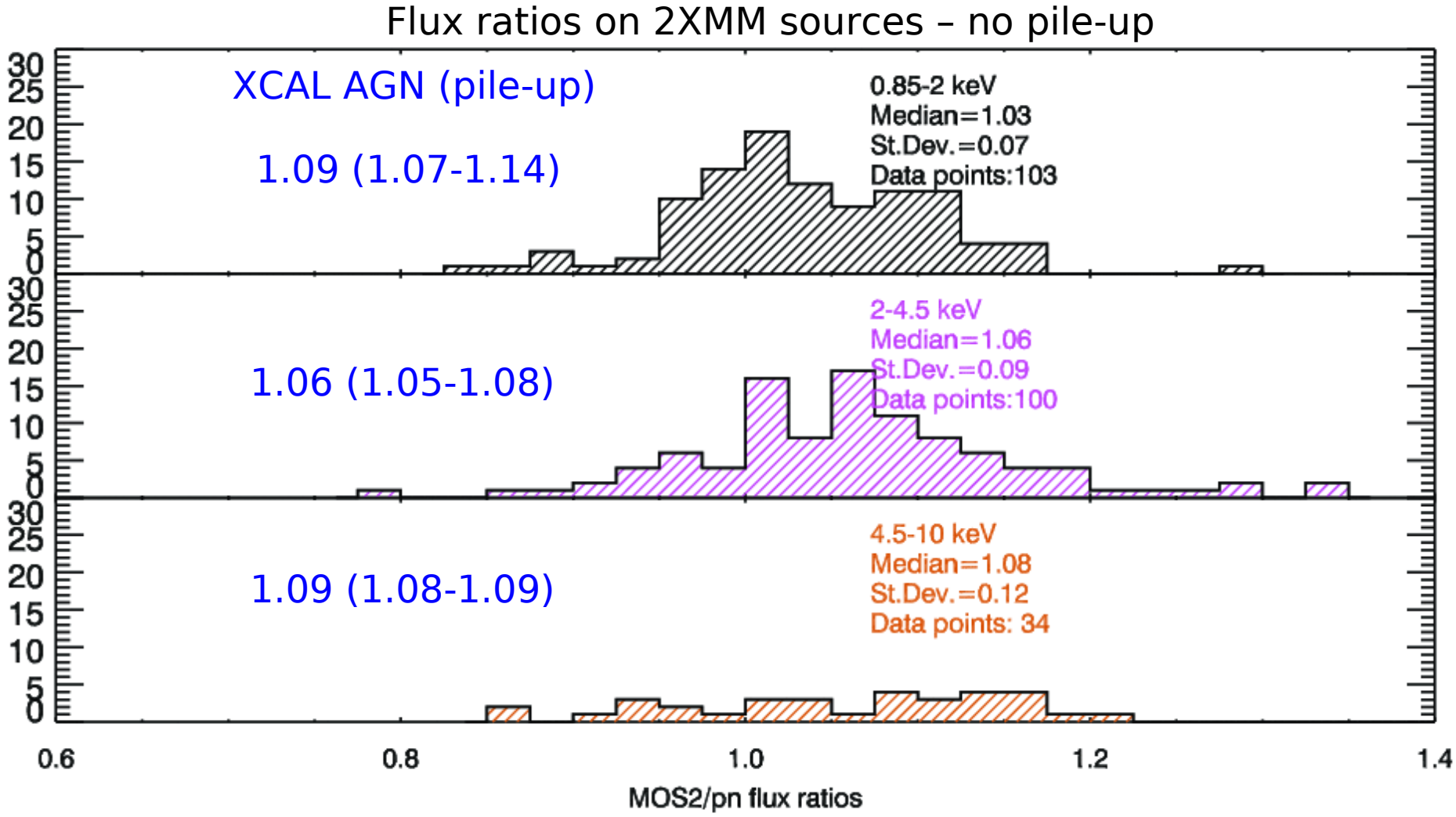
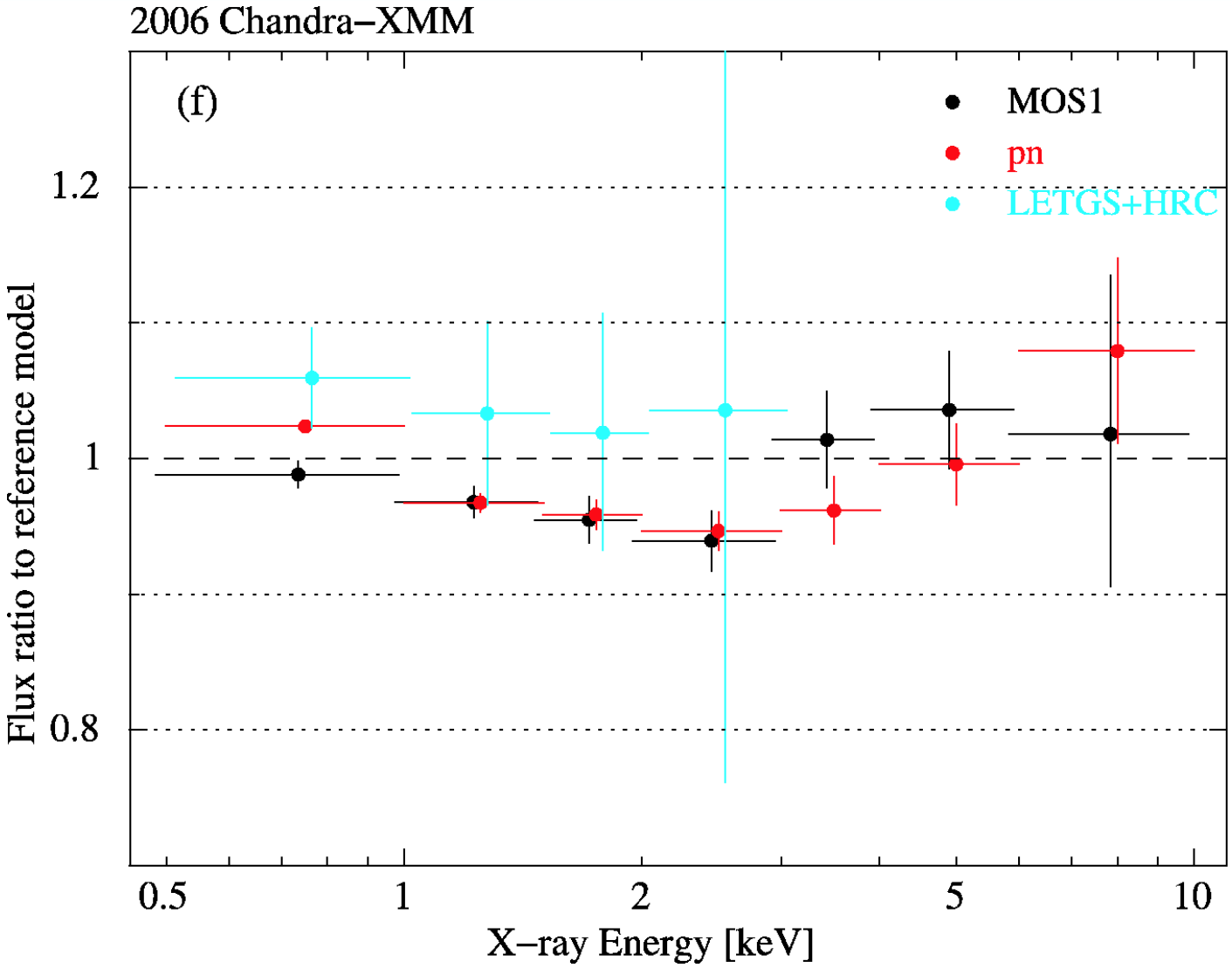


LETGS is innocent

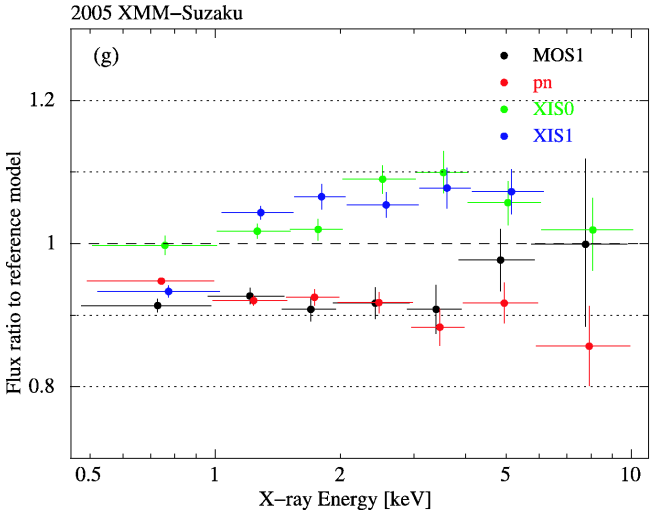
(Ishida et al., 2011, PASJ, 63, 657)

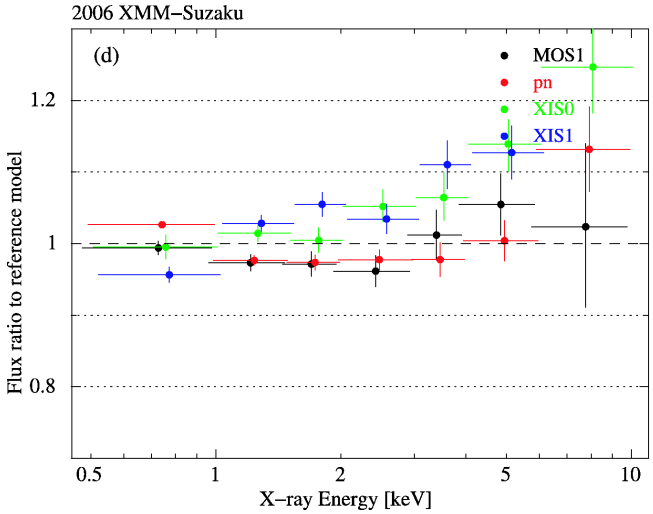


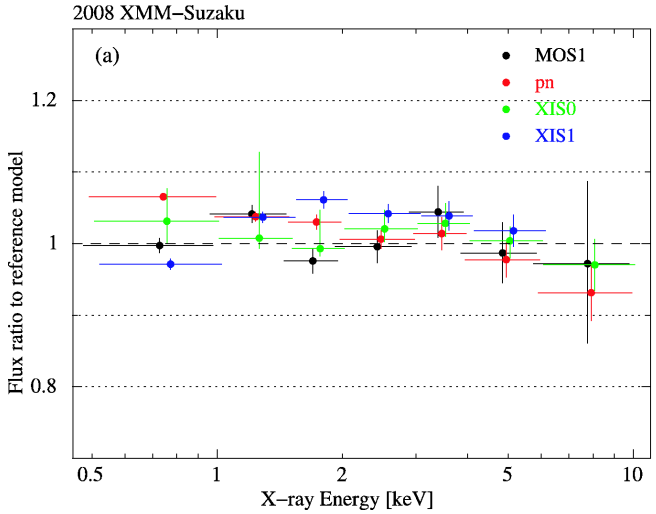
Hard+soft band - flux – PKS2155-304 (EPIC vs. XIS)

(Ishida et al., 2011, PASJ, 63, 657)

Strong time-variability when comparing the XIS (as a whole) against the EPIC (as a whole)



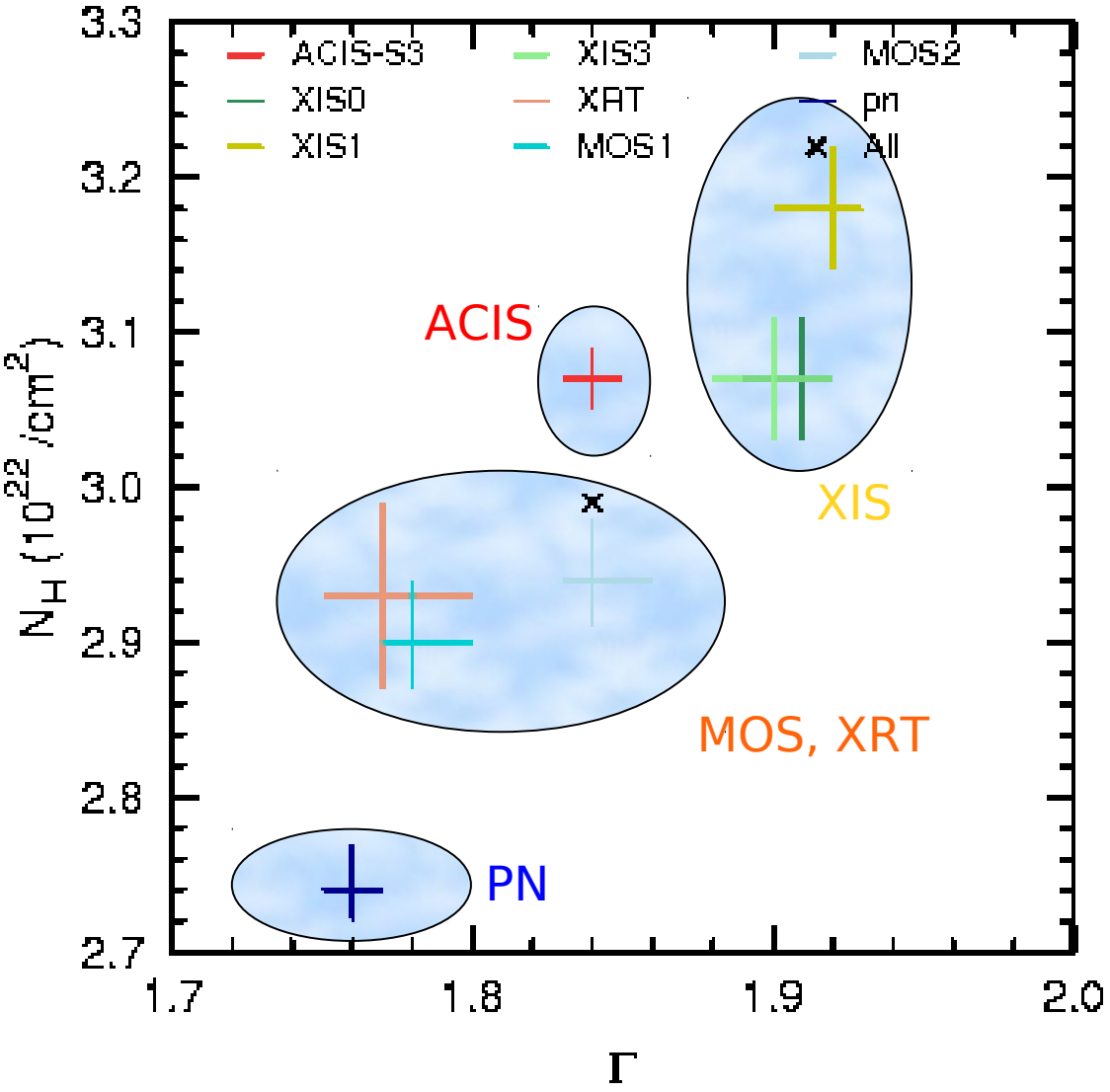




Energy-dependence rules out simple explanation in terms of XIS contamination

Hard band – shape - G21.5-0.9

(Tsujimoto et al., 2011, A&A, 525, 25)

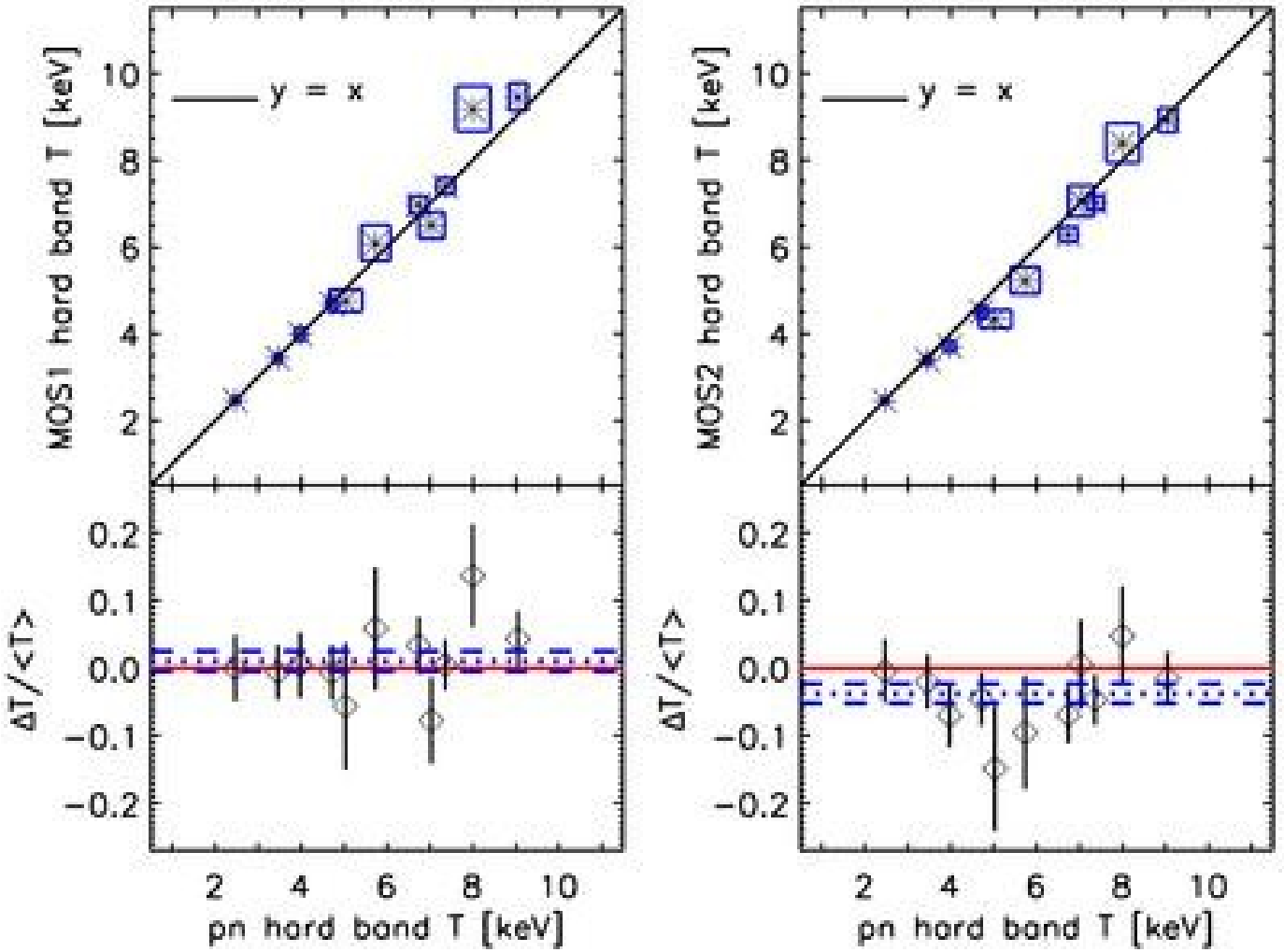


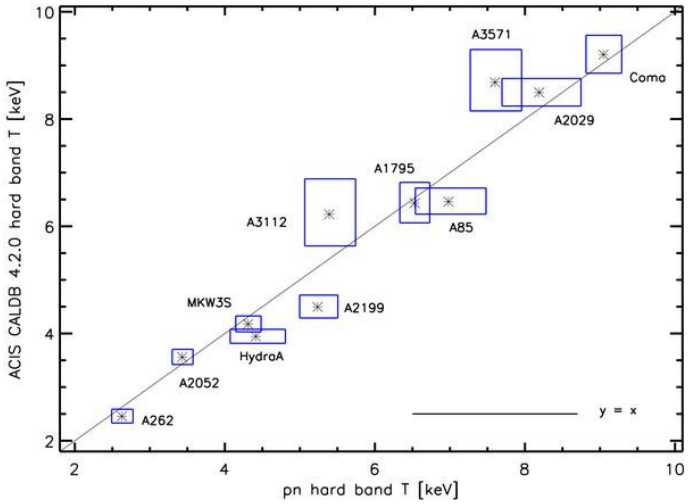
In PKS2155-304 similar results (on the whole band), except:

- MOS1+2 *flatter* then PN by 0.1
- XIS0+2+3 occasionally flatter then XIS by 0.1

Hard band – shape - clusters

(Nevalainen et al., 2010, A&A, 523, 22)





pn vs. ACIS: agreement at the 1% (0.6σ) level

As far as the soft band is concerned ...

Non chiederci la parola che squadri da ogni lato
l'animo nostro informe, e a lettere di fuoco
lo dichiari e risplenda come un croco
perduto in mezzo a un polveroso prato.

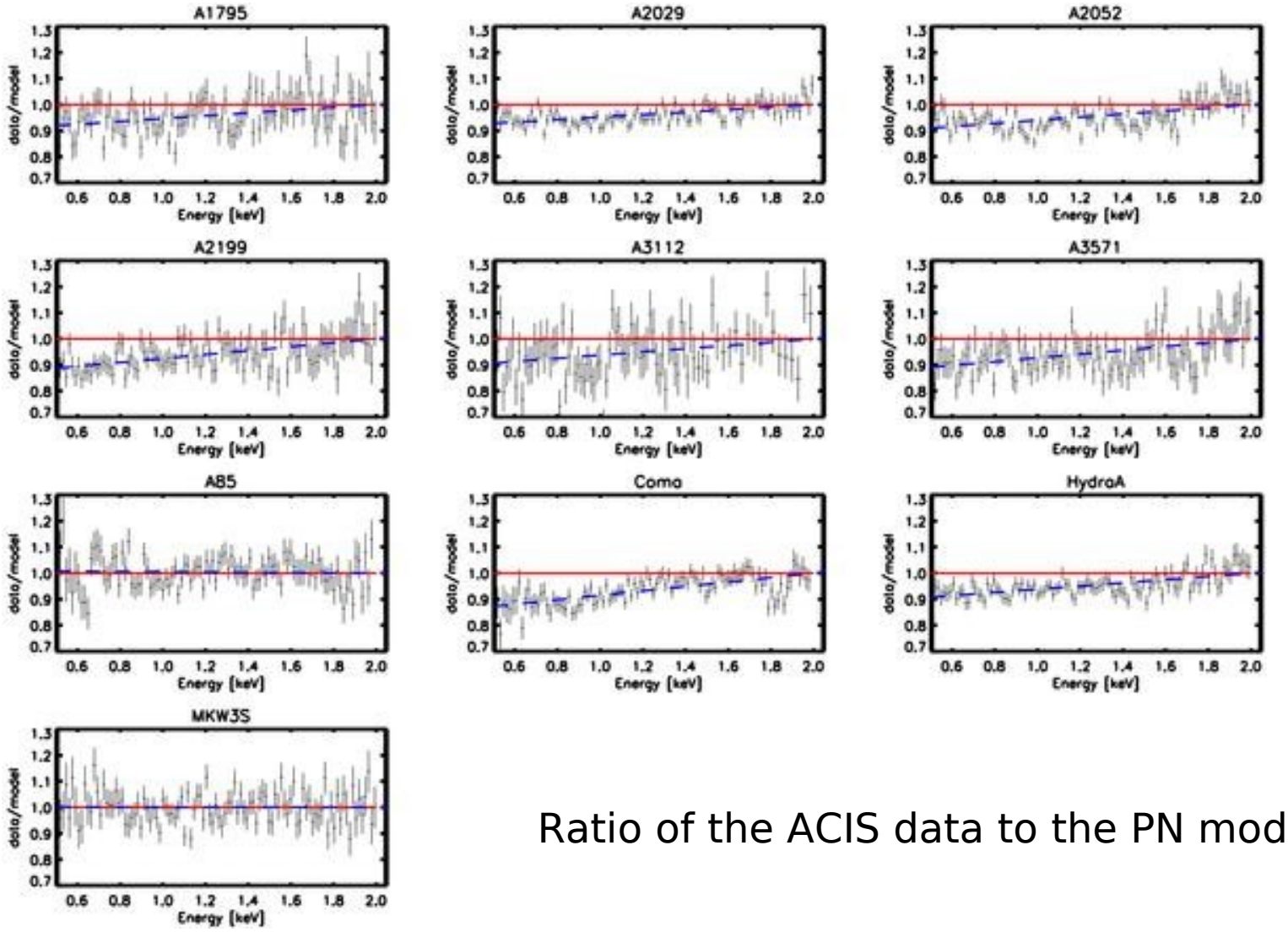
Ah l'uomo che se ne va sicuro,
agli altri ed a se stesso amico,
e l'ombra sua non cura che la canicola
stampa sopra uno scalcinato muro!

Non domandarci la formula che mondi possa aprirti,
sì qualche storta sillaba e secca come un ramo.
Codesto solo oggi possiamo dirti,
ciò che non siamo, ciò che non vogliamo.

Eugenio Montale, “Non Chiederci la Parola”

Soft band – shape - clusters

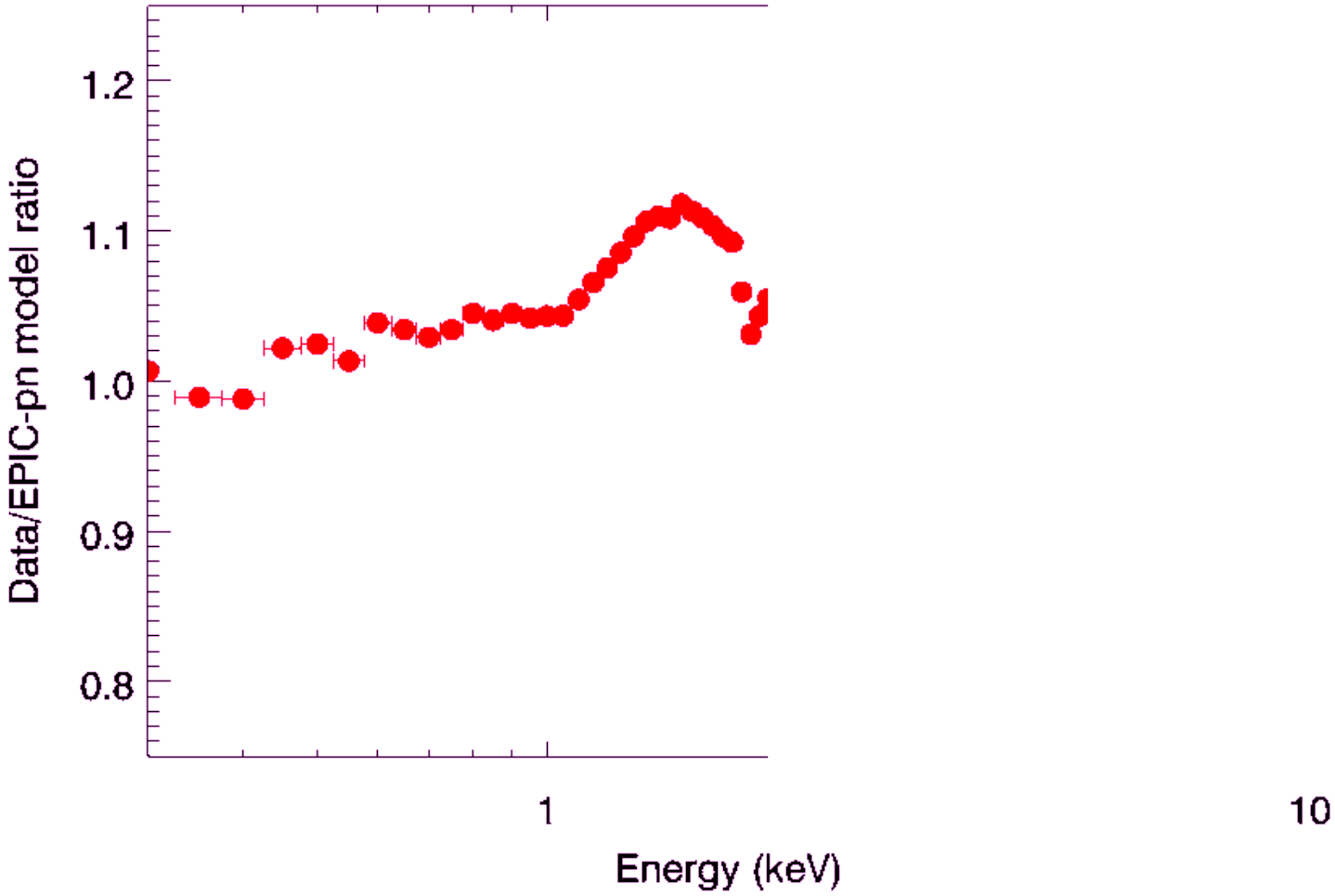
(Nevalainen et al., 2010, A&A, 523, 22)



Ratio of the ACIS data to the PN model

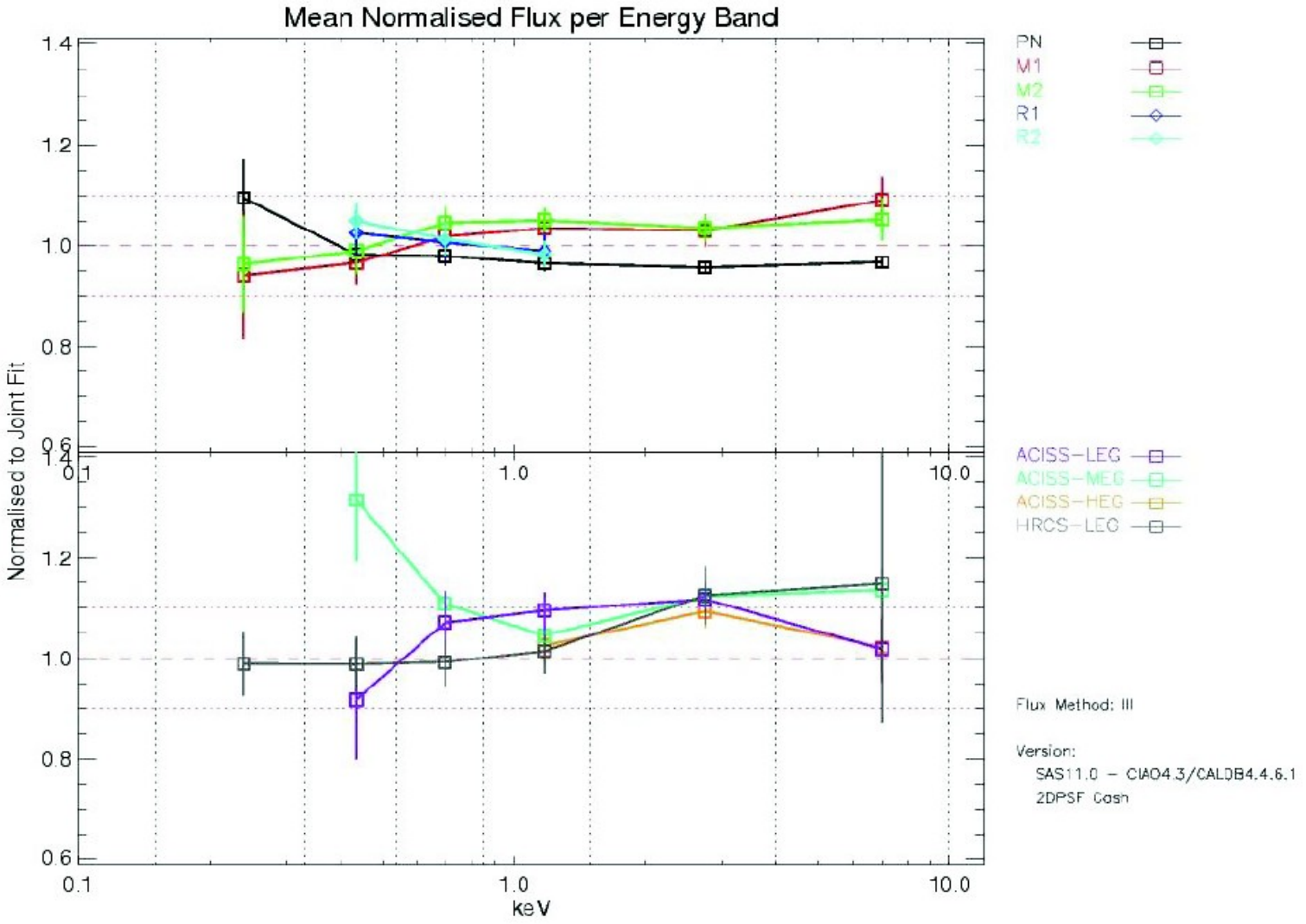
Soft band – shape - blazars

Ratio of MOS data against the PN model



XMM-Newton versus Chandra gratings

(Courtesy of M.SMith)



Questions

- Do we confront the community with a coherent view of the cross-calibration status? Yes
  - Tsujimoto et al. ecumenical flux plot (G21.5-0.9) is a resonable description of the flux behaviour in the hard band
  - General agreement in the hard band spectral shapes within $\Delta\Gamma=\pm0.1$ (or 1-3% in kT)
  - In the soft band ACIS and MOS exhibit a ~10% deficit with respect to PN at 0.5 keV with respect to 2 keV
  - *[preliminary: different MOS/PN behaviour between clusters and blazars between 2-4 keV]*
  - When *Chandra* gratings are in use, the energy-dependent flux ratios are consistent with this picture (within statistics)
  - RGS/PN agrees well (±2%) blue-wards the OI edge, currently ~7% *above* the PN red-wards the OI edge
  - Time matters → all these results require the most recent contamination calibration
- Do we transmit the cross-calibration status in the most appropriate way?
- In which direction is the current work on cross-calibration going?
- Can we make a step forward?

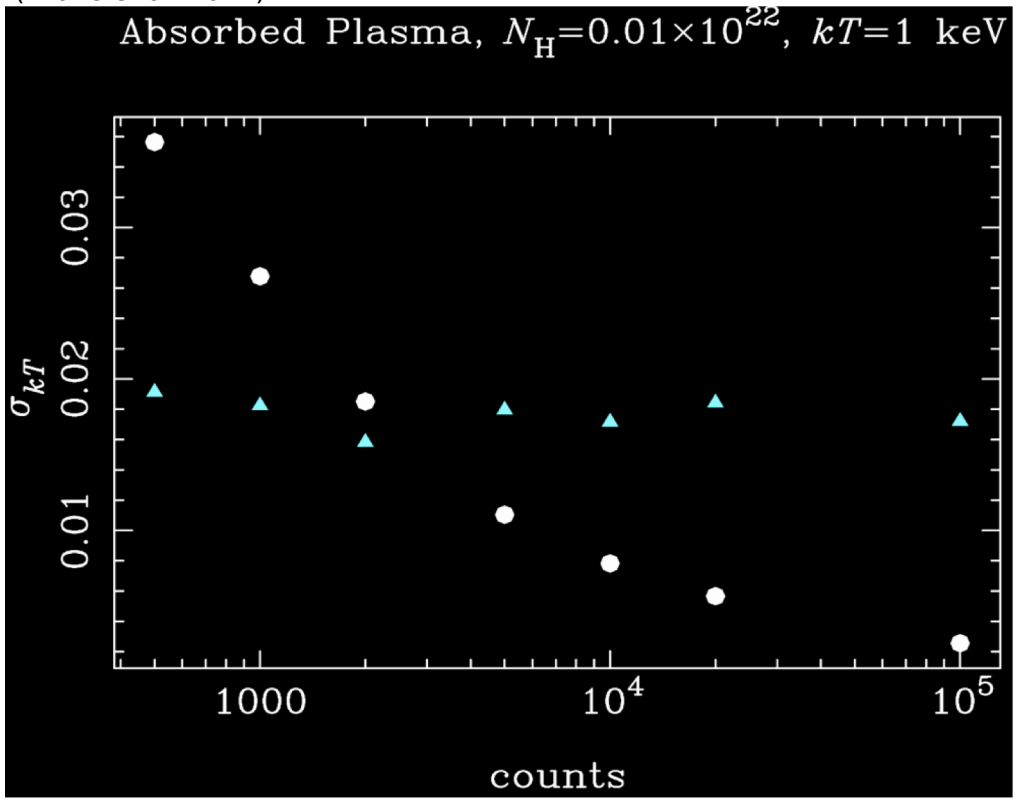
What the community wants

- The answer to the question: “If I measure an astrophysical parameter (luminosity, spectral index, temperature), which is the *systematic error* on it”
- This answer does not depend too strongly on the source nature
- This answer *does* depend on time, in two ways:
  - Because the cross-calibration status is time-dependent (due to the time-dependent accuracy of our calibration)
  - Because the cross-calibration status evolves with time
  - Because the instrument evolves with time
- The Kashyap's et al. approach to this problem: create a dynamical system which calculates the *systematic errors* on-the-fly. Brilliant idea, but in the real world:
  - The system is extremely calculation-intensive (i.e.: hours to find a solution on a simple phenomenological model)
  - Extension to the whole range of X-ray instrument (beyond ACIS-S3) is lagging behind – unlikely to happen soon, unless somebody finds extraordinary resources

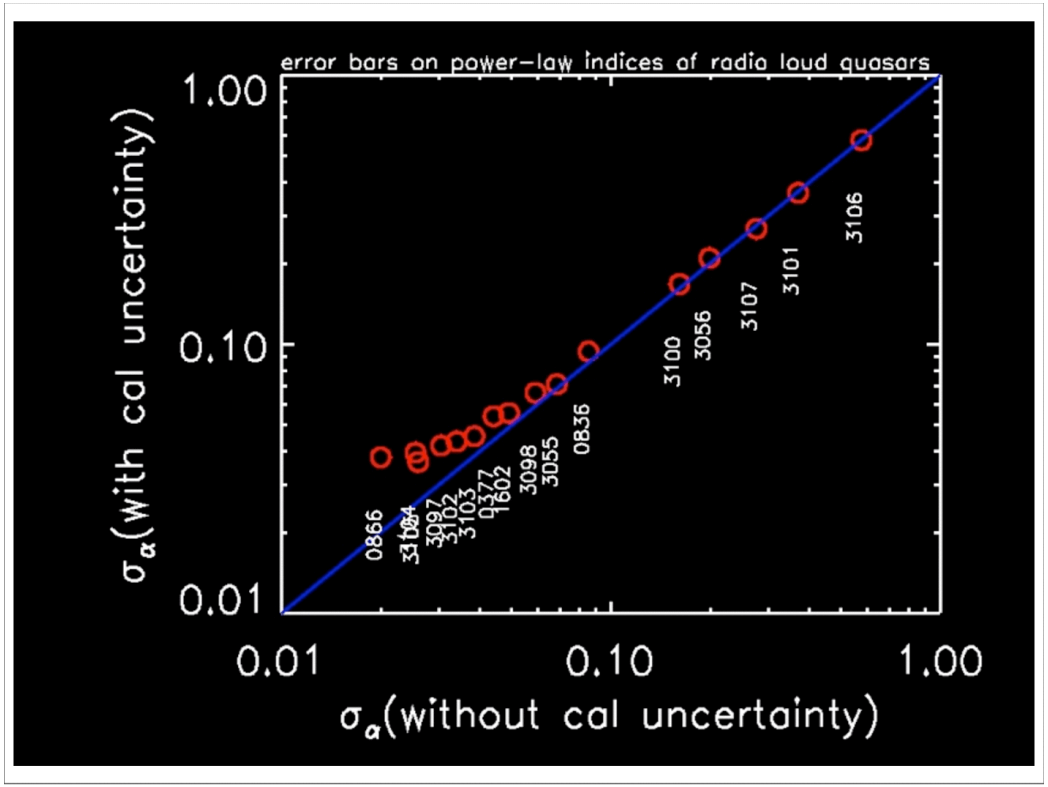
What we can offer – best scenario

In the minimum it would be already a success if each mission could post on the IACHEC web page plots like these for each instrument – is this going to happen?

(Drake et al. 2011)



(Posson-Brown, 7th IACHEC)



What we can offer – realistic scenario

Data - IACHEC - MIT Wiki Service - Mozilla Firefox

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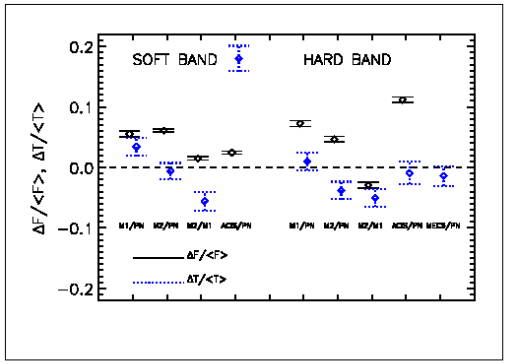
35 Added by Jukka Nevalainen, last edited by Jukka Nevalainen on Jun 22, 2011 09:14 (view change)

In the bottom of this page you find the spectra, responses and background files necessary to reproduce the spectral analysis in Nevalainen et al., 2010 (A&A, 523, 22) which yielded results summarised in Fig 1.

Fig.1: The average relative difference (diamonds) +- the error of the mean of the fluxes (solid line) and temperatures (dotted line) for different instrument pairs in the soft band (left side of the plot) and in the hard band (right side of the plot)



SASv9.0 was used for processing the XMM-Newton data with calibration information from December 2009.

XMM-Newton MOS1 and MOS2 spectra and responses are combined and referred to as MOS instrument.

Chandra data are processed with CIAO 4.2. (see details)

For most clusters the Chandra data are obtained with ACIS-S, but for some ACIS-I is used, and marked accordingly.

The script files **bestfit....xcm** will set up the best fit. In more detail:

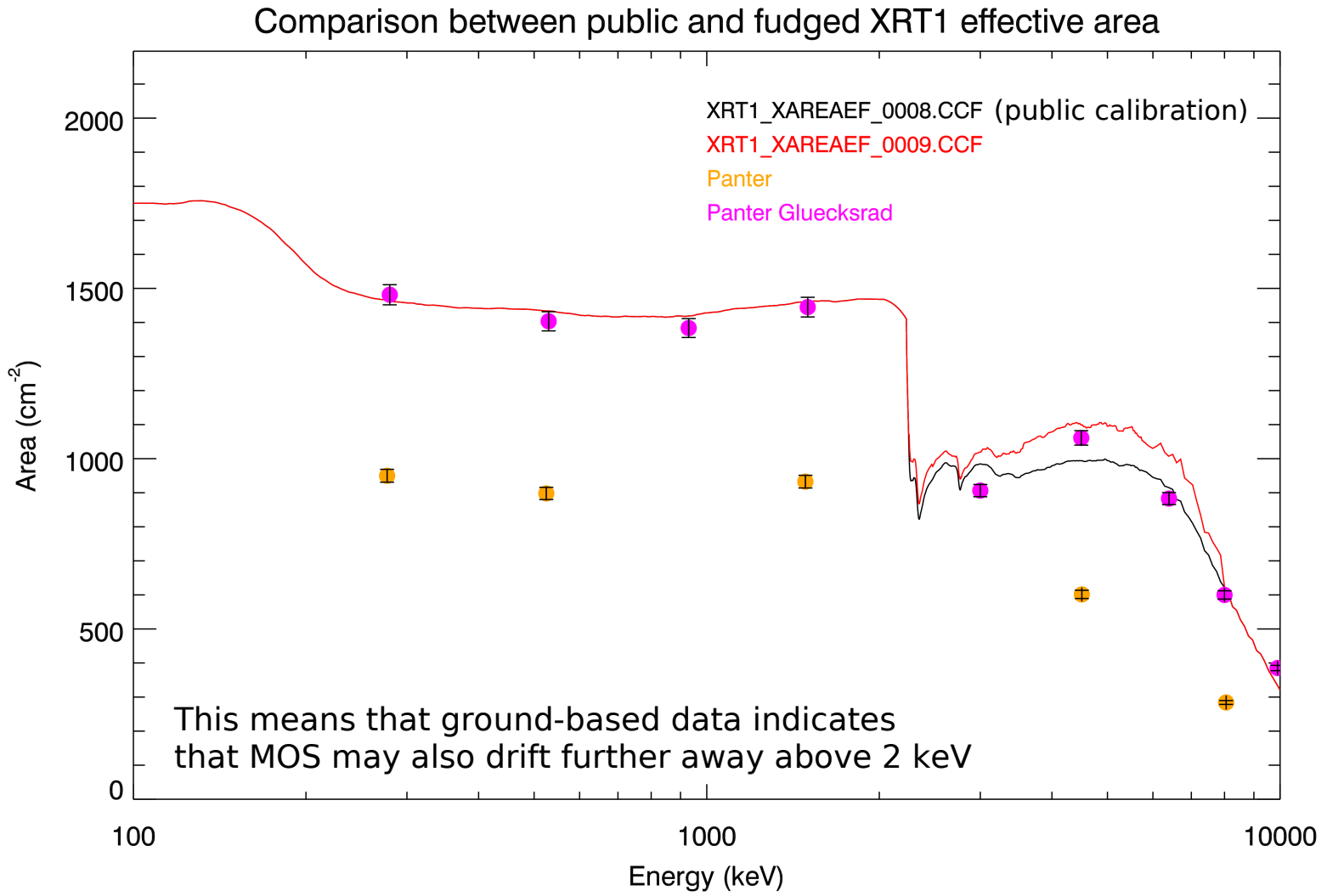
- The scripts use a 1-temperature phabs x mekal model.
- The column density is from Kalberla et al. (2005) and the absorption cross-sections are from Balucinska-Church & McCammon (1992).
- The scripts use the metal abundance table from Grevesse & Sauval (1998).
- 2. and 3. term in the script file name are the inner and outer radii of the spectrum extraction annulus in arcmin.
- ***hard***, ***soft*** and ***wide*** refer to the fits done in 2.0-7.0 keV, 0.5-2.0 keV and 0.5-7.0 keV bands, respectively.
- ***fe*** refers to the Fe XXV/XXVI "constr." fit in [6.45 - 7.25]/(1+z) band, i.e. with a prior for the emission measure.

For flux comparison, scale the measured fluxes to the full annulus by dividing with the fraction of the covered full annulus

Questions

- Do we confront the community with coherent view of the cross-calibration status? Yes
- Do we transmit the cross-calibration status in the most appropriate way?
  - We are forced by circumstances to take more seriously the information maintainance on the IACHEC Wiki
  - **Proposal: MG will ask all WGs to identify a member, who is responsible for the WG Wiki. They will form a novel "Wiki Editorial Board". This WEB will discuss the form we publish and maintain the data of the IACHEC published papers to ensure homogeneity, and accuracy**
- In which direction is the current work on cross-calibration going?
- Can we make a step forward?

Which instrument is “right”, eventually?



Calibration updates in the pipeline

- ACIS
  - Contamination model ➔ ?
- EPIC
  - 2-D PSF ➔ fall 2011
  - EPIC-pn redistribution time dependency ➔ fall 2011
- HETG
  - Higher order efficiency ➔ ?
- HRC
  - HRC-S QE below C-K edge ➔ ?
- RGS
  - Wavelength scale ➔ fall 2011
  - Line Spread Function ➔ fall 2011
- XIS
  - Optical Blocking Filter contamination ➔ April 2011
  - RMF – Si edge ➔ ?
- XRT
  - Trap correction ➔ ready to be released
  - New V_{ss}=6 V RMF ➔ ready to be released

Status at the IACHEC

- ACIS
  - Contamination model
- EPIC
  - 2-D PSF
  - EPIC-pn redistribution time dependency
  - *MOS effective area*
- HETG
  - Higher order efficiency
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- XRT
  - Trap correction
  - New V_{ss}=6 V RMF

Released or scheduled
Dropped
No schedule for release

What we said we would do (IACHEC 2011)

- We wait for these calibration changes to be implemented
- We use Drake's perturbation approach to see what we should change in the calibration to improve the cross-calibration agreement
  - This will also yield as a by-product an estimate of the systematic uncertainties on astrophysical parameters associated to our calibration uncertainties
- This has not happened, because
  - Many instruments were (are?) not ready for a genuine cross-calibration exercise
  - The approach is very (too?) ambitious:
    - We need to do extraordinary calibration work, while ...
    - ... we need to learn a new complex algorithm and software implementation

Alternative proposal for a common exercise

- We select one or two sources with a broad-band spectrum
- Each of us contributes to the common exercise with:
  - Spectra and responses
  - A working hypothesis on a small number of calibration items which mostly affect the effective area
- We fit together the astrophysics and the calibration working hypothesis
- We evaluate whether the required modification to the calibration element makes sense
- If not, we change the working hypothesis, and iterate

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- **Why should such a proposal work, if the previous similar one did not?**

Alternative proposal for a common exercise

» **Because it requires a smaller delta effort with respect to what we are already doing**

- Contamination studies (HETG, XIS) fit together the contamination N_H/τ and the astrophysics
- MOS algorithm by S.Sembay fits together astrophysics and redistribution/effective area
  - Work to extend it to the EPIC-pn ongoing (by M.Smith)

» **Open to discussion (this afternoon).**

» If you believe this proposal (or another) makes sense, I would love seeing as an outcome:

- When we start
- Which Working Group (or a combination thereof) takes the lead (and therefore who is the PI of this exercise)
- Which goals we set for IACHEC 2013

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… unless you believe that times are not mature yet to undertake this exercise. In this case, **we may change the way IACHEC works** (less frequent plenary meetings, presentinal WG meetings etc. etc.)