Clusters WG report

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Activities since Woodshole 2010 meeting

- Our paper on Chandra/XMM-Newton T and flux comparison accepted Aug 2010 (Nevalainen et al., 2010, A&A, 523, 22)
- A&A 2010 results checked with March 31 2011 calibration
- Suzaku extension of the cluster sample
- XMM-Newton gain calibration using cluster Fe XXV Kα line

A&A 2010 paper

- No major changes in the refereeing stage
- No change from the results presented in Woodshole meeting, repeated in the following

Sample

- 11 clusters: A1795, A2029, A2052, A2199, A262, A3112, A3571, A85, Coma, HydraA, MKW3S
- Nearby ($z < 0.08$), bright (10^{-12}-10^{-11} erg s^{-1} cm^{-2}) $\rightarrow$ good statistics
- Most have a cool core, no major merger signatures, spectra extracted within the ~isothermal region 0.1-0.3 r_{500} $\rightarrow$ single-T modeling
- Observed with ACIS/Chandra, EPIC/XMM-Newton

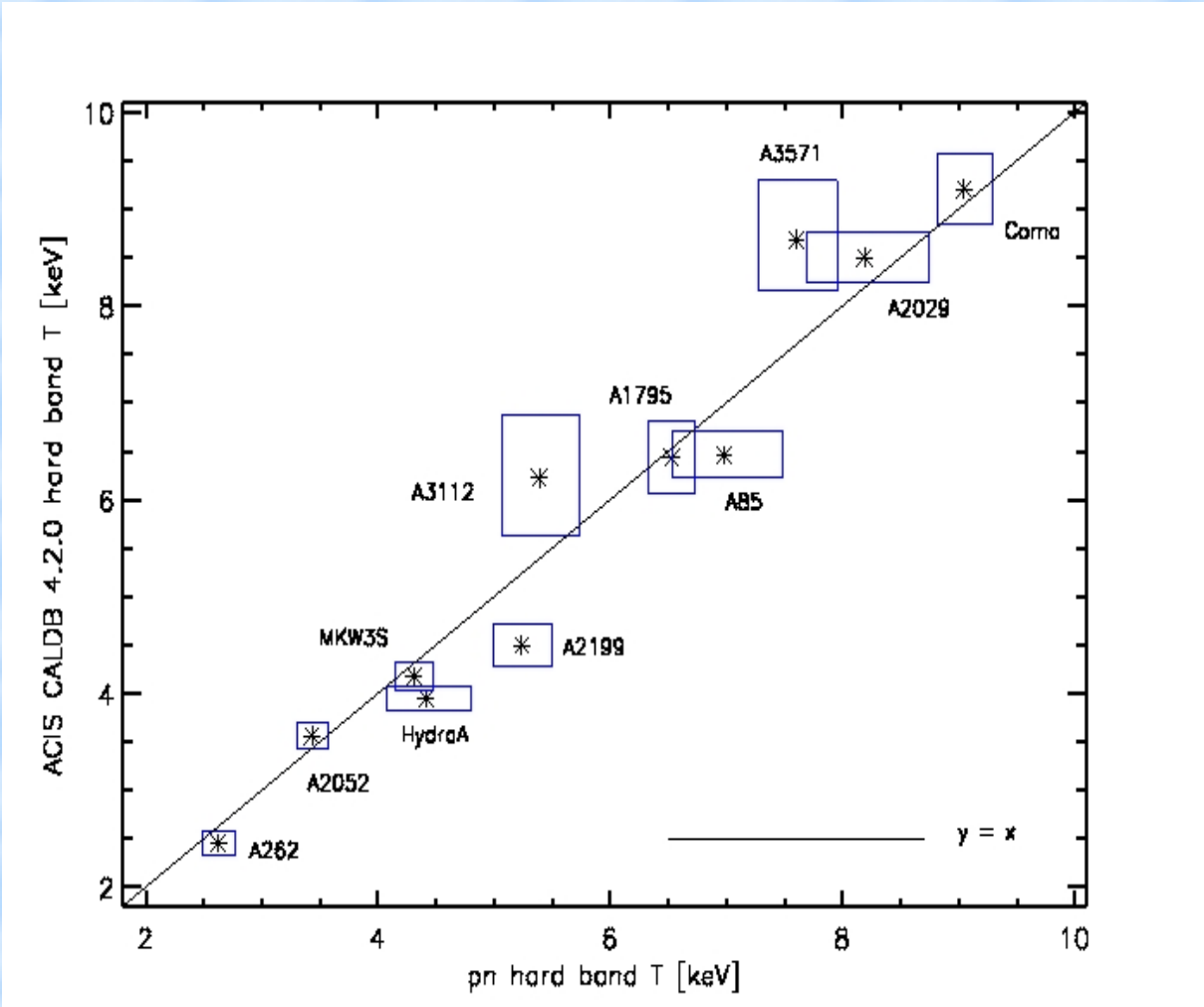
Method

- Spectral fits with 1-T MEKAL model to hard (2-7 keV), soft (0.5-2.0 keV) and wide (0.5-7.0 keV) band
- Data for different instruments extracted from the same annular sky region for a given cluster
- Compare T for a given cluster obtained with different instruments $\rightarrow$ cross-calibration of the shape of the effective area ($\equiv$ telescope effective area $\times$ filter transmission $\times$ quantum efficiency)
- Compare fluxes $\rightarrow$ cross-calibration of the normalisation of the effective area
- Fe XXV/XXVI line ratio T measurement for the hottest clusters as an additional tool

ACIS/EPIC hard band agreement

pn / ACIS hard band T

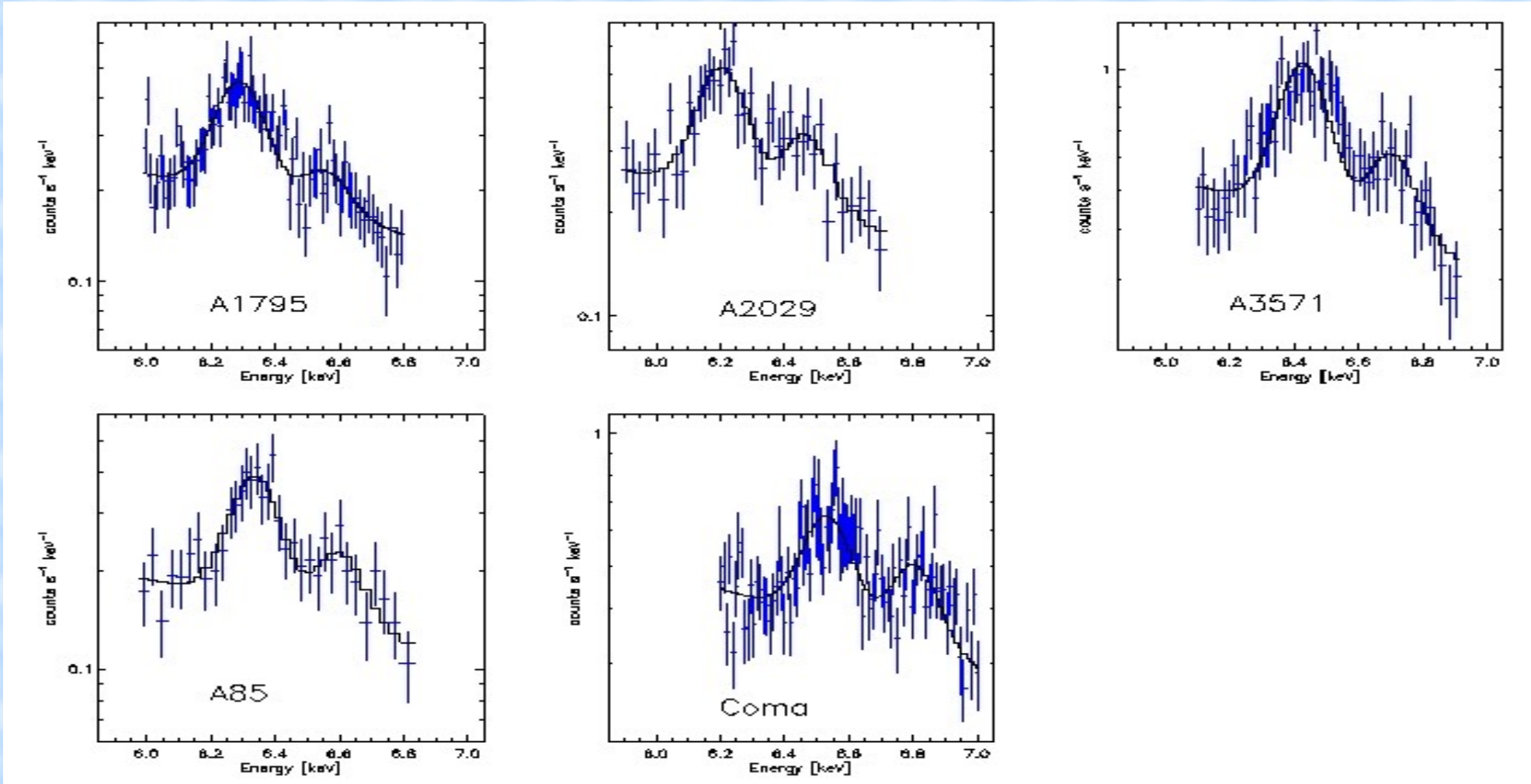
- < ACIS - pn > 1%, no systematic difference btw. the instruments $\longrightarrow$
- The shape of the effective area is accurately calibrated for ACIS, pn and MOS in the hard band



EPIC bremsstrahlung/ ionisation T agreement

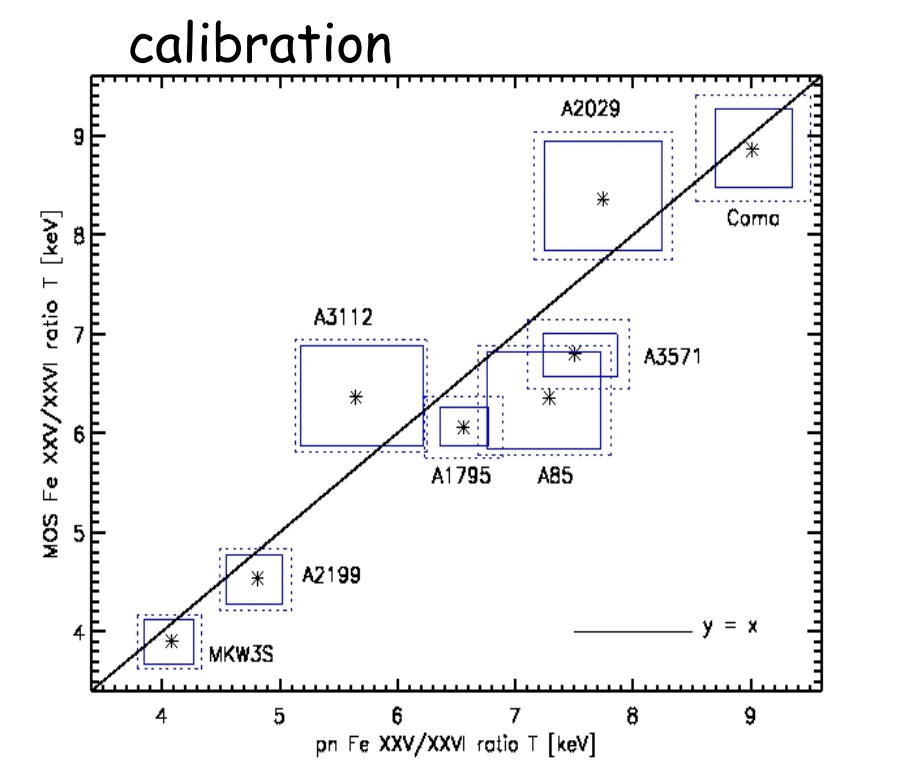
FeXXV/XXVI based T measurement

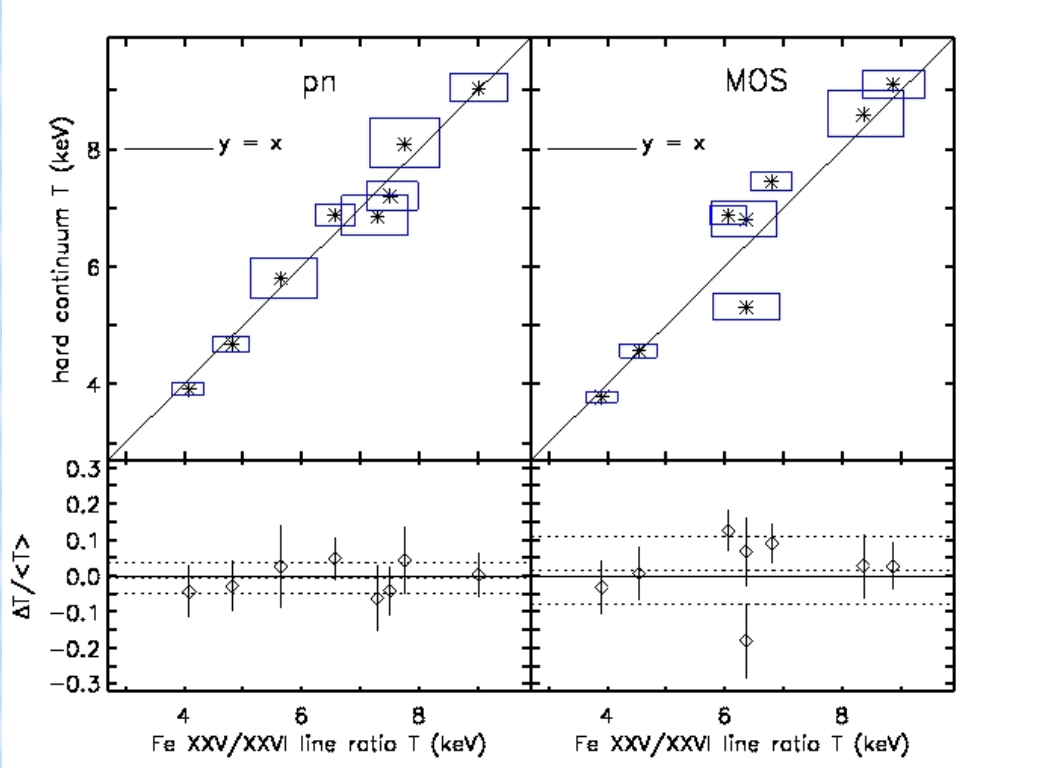
- Fe XXV/XXVI line ratio decreases with higher ionization temperature
- Fe XXVI is measurable for the hottest clusters with EPIC and ACIS resolution
- T measurement : MEKAL fit to [6.45-7.25]/(1+z) keV band



Fe XXV/XXVI EPIC results

- <MOS / pn> ~-3% , values agree within 1
- Fe XXV/XXVI based T agrees with 2-6 keV continuum fit $\longrightarrow$
  - hard band effective area shape calibration OK
  - no significant deviations from ionisation equilibrium state and Maxwellian electron velocity distribution in the sample $\longrightarrow$ Fe XXV/XXVI useful for calibration

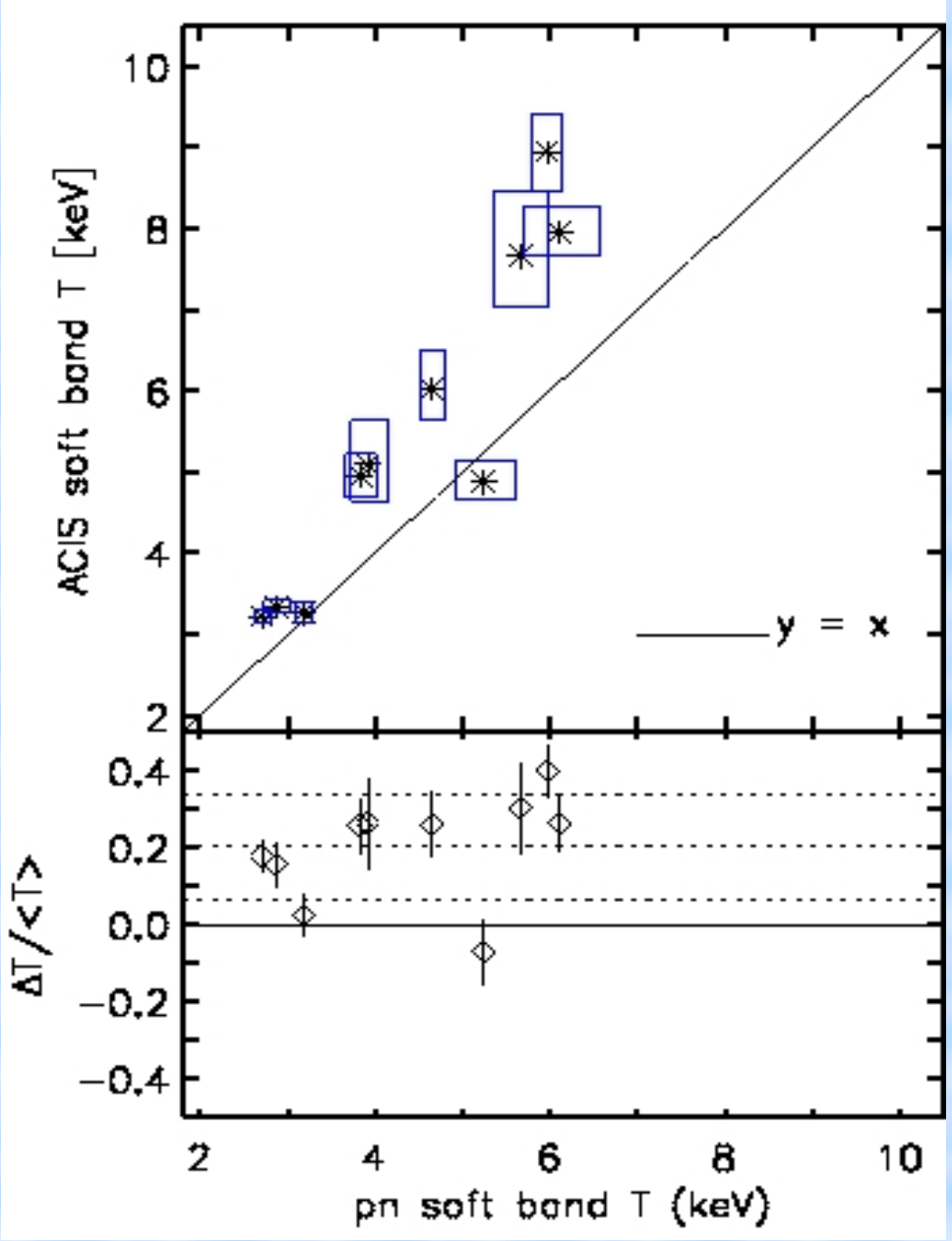




ACIS/EPIC soft band T disagreement

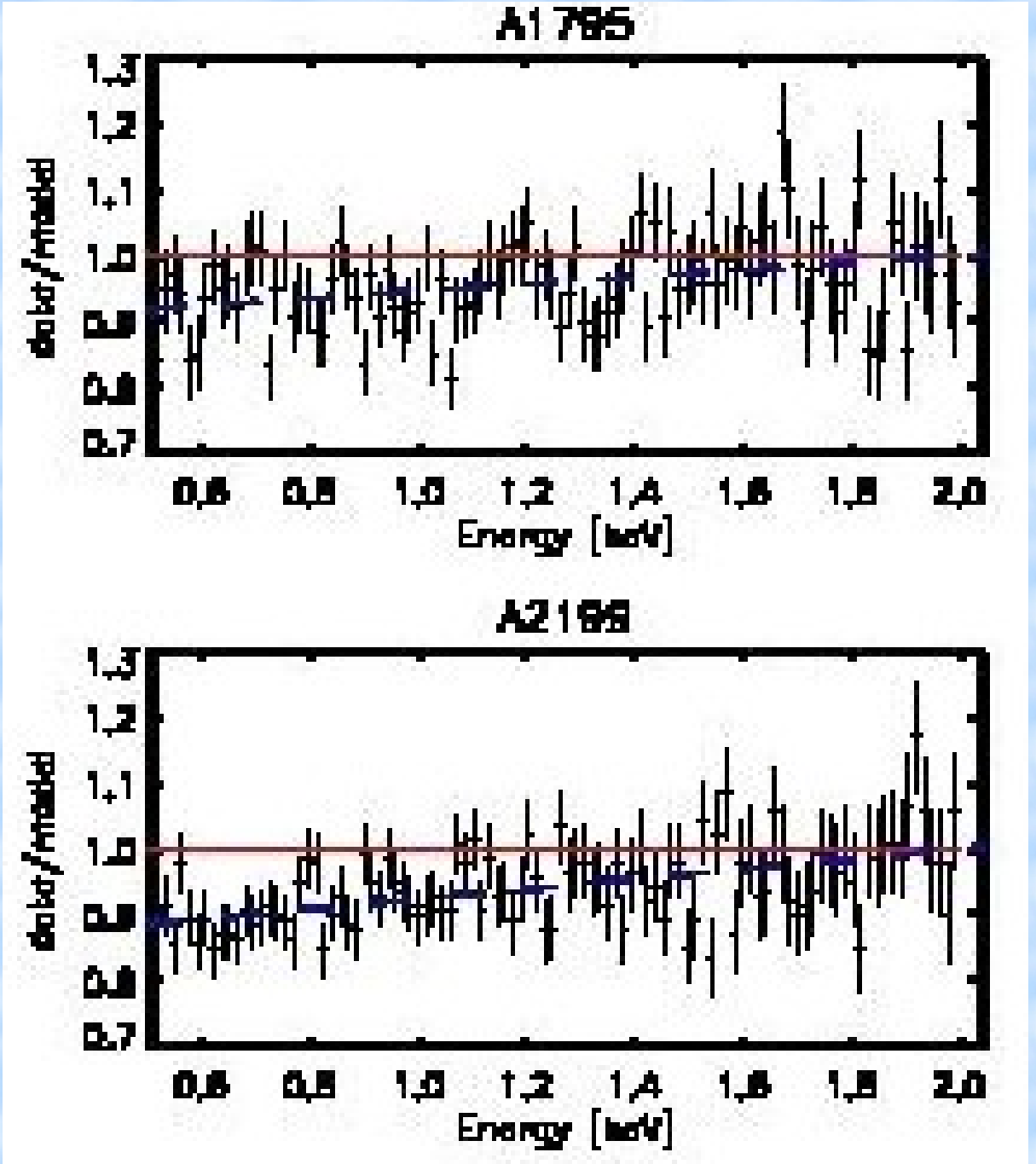
ACIS / pn soft band T

- In the soft band, ACIS temperatures exceed those of pn by 20% →
- cross-calibration uncertainty at this level



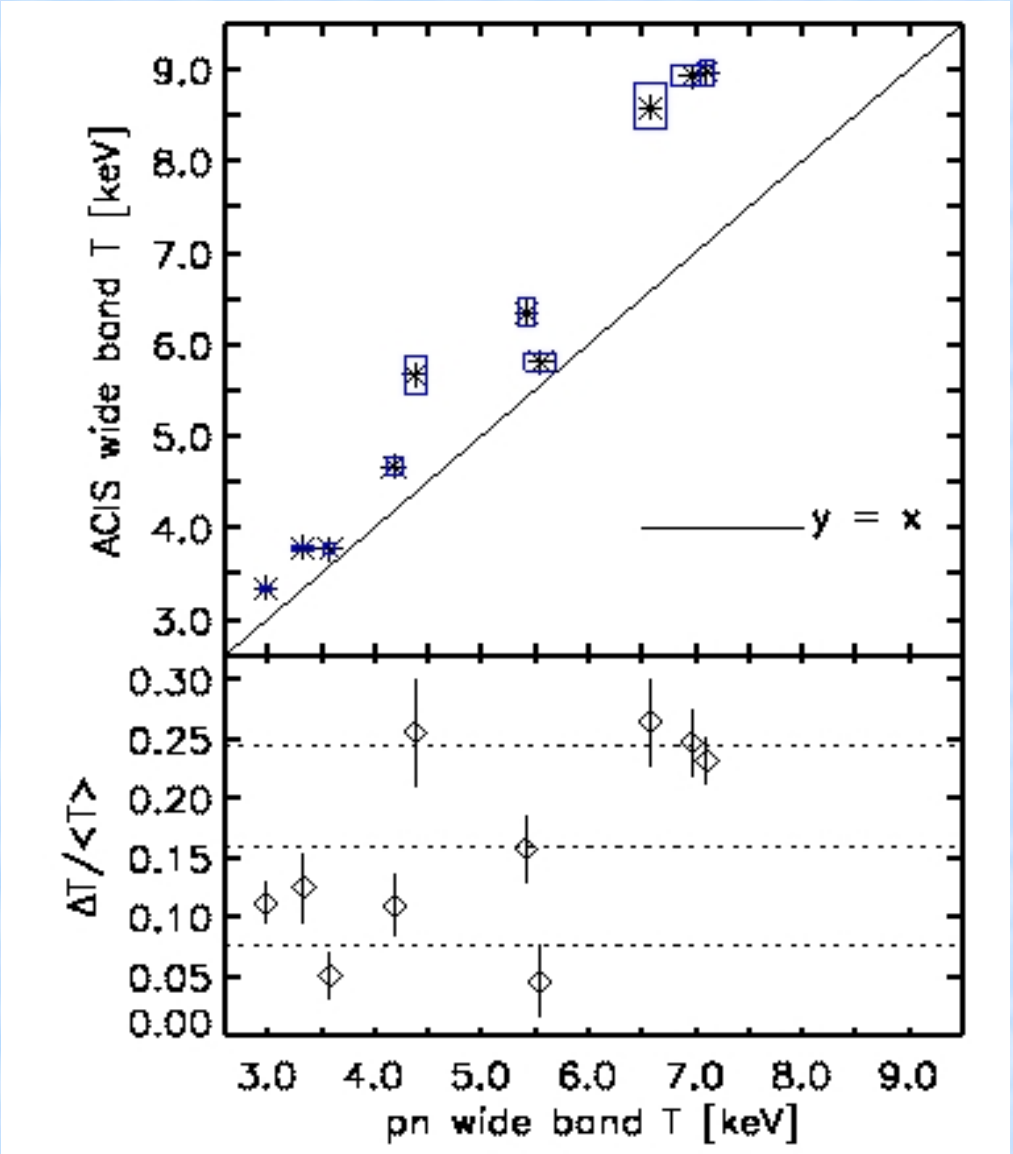
ACIS / pn soft band T

- Quantification of the cross-calibration problem: pn soft band best-fit model folded through ACIS responses, compared to ACIS data →
- 10% difference at 0.5 keV (pn effective area underestimated or ACIS effective area overestimated)



ACIS / pn wide band T

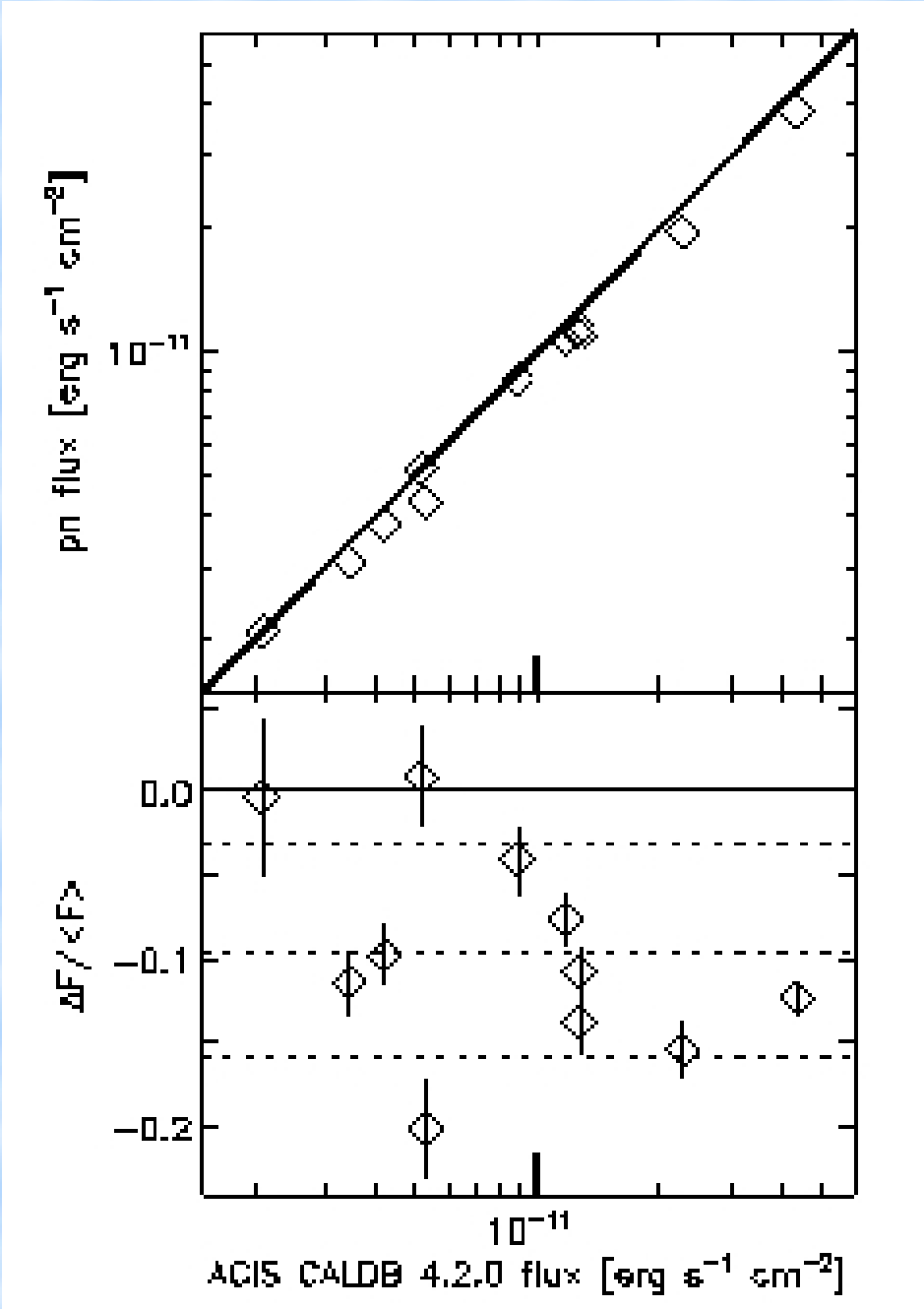
- Hard band accurately calibrated, but most of the photons are in the soft band where calibration more uncertain →
- ACIS wide band temperatures exceed those of PN by ~15%
- Scientific analysis of cluster wide band (0.5-7 keV) problematic:
- The absolute cluster models (T and flux) uncertain by 10-15% at the moment



ACIS/PN/MOS flux problems

ACIS/pn hard band flux

- ACIS flux exceeds that of pn by ~10% (ACIS/MOS ~5%) → relative effective area normalisation uncertain by this amount



Conclusions

- The calibration of the shape of the effective area of ACIS, pn and MOS accurate within a few % in the hard band (2-7 keV)
- No significant deviations from ionisation equilibrium state and Maxwellian electron velocity distribution in the sample

  in the hard band $\longrightarrow$ standard candle
- Relative normalisation of the ACIS/pn hard band effective area uncertain at ~10% level
- Relative ACIS/pn effective area off by 10% at 0.5 keV (if assumed equal at 2 keV)
- Cluster absolute temperatures and fluxes in the 0.5-7.0 keV uncertain by ~10% at the moment

A&A 2010 results checked with March 30 2011 calibration

- A&A 2010 paper (SAS9.0, calibration info in Dec 2009) v.s. SAS 11.0.0, calibration info March 2011
- Cluster data in 0.5-7.0 keV band, mostly continuum, observations 2000-2002

EPIC CCF release

Reference	Title	date	effect to clusters
XMM-CCF-REL-273	EPIC MOS response	24-Mar-2011	None
XMM-CCF-REL-272	EPIC MOS response	31-Jan-2011	None
XMM-CCF-REL-271	EPIC-pn Long-Term CTI	21-Dec-2010	Fe line centroid
XMM-CCF-REL-270	EPIC MOS Fixed Offset Tables	11-Sep-2010	?
XMM-CCF-REL-267	EPIC MOS response	29-Jul-2010	None
XMM-CCF-REL-266	Refinement of pn redistribution	17-Jun-2010	Fe line width
XMM-CCF-REL-265	RAWY-dependent calibration of the PATTERN fraction in EPIC-pn Timing Mode	17-Jun-2010	None
XMM-CCF-REL-264	2-D PSF Gaussian parameterization	06-May-2010	None
XMM-CCF-REL-263	2-D PSF parametrisation	07-May-2010	None
XMM-CCF-REL-260	EPIC MOS Quantum Efficiency	15-Jan-2010	None
XMM-CCF-REL-259	Spectral quality-related CCF XMM_SPECQUAL	13-Apr-2010	None

Results

- No significant changes in the best-fit XMM-Newton temperatures or fluxes in any band
- No change in Chandra results either (L. David)
- Hard band agreement remains as published
- Problems with flux and soft band remain as published

Suzaku extension

Suzaku extension

- Motivation: see if Suzaku soft band temperatures agree with XMM-Newton or Chandra
- Work in progress (see Kimmo Kettula's presentation):
  - XIS0 disagrees with XIS1 and XIS3
  - Should decrease the XIS0 contamination or increase XIS1 and XIS3 by few 10^{17} cm^{-2}
  - At the moment XIS1 and XIS3 roughly agree with ACIS

➔ Chandra/XMM problems probably not solved this way. Should study directly the Chandra/XMM calibration modeling.

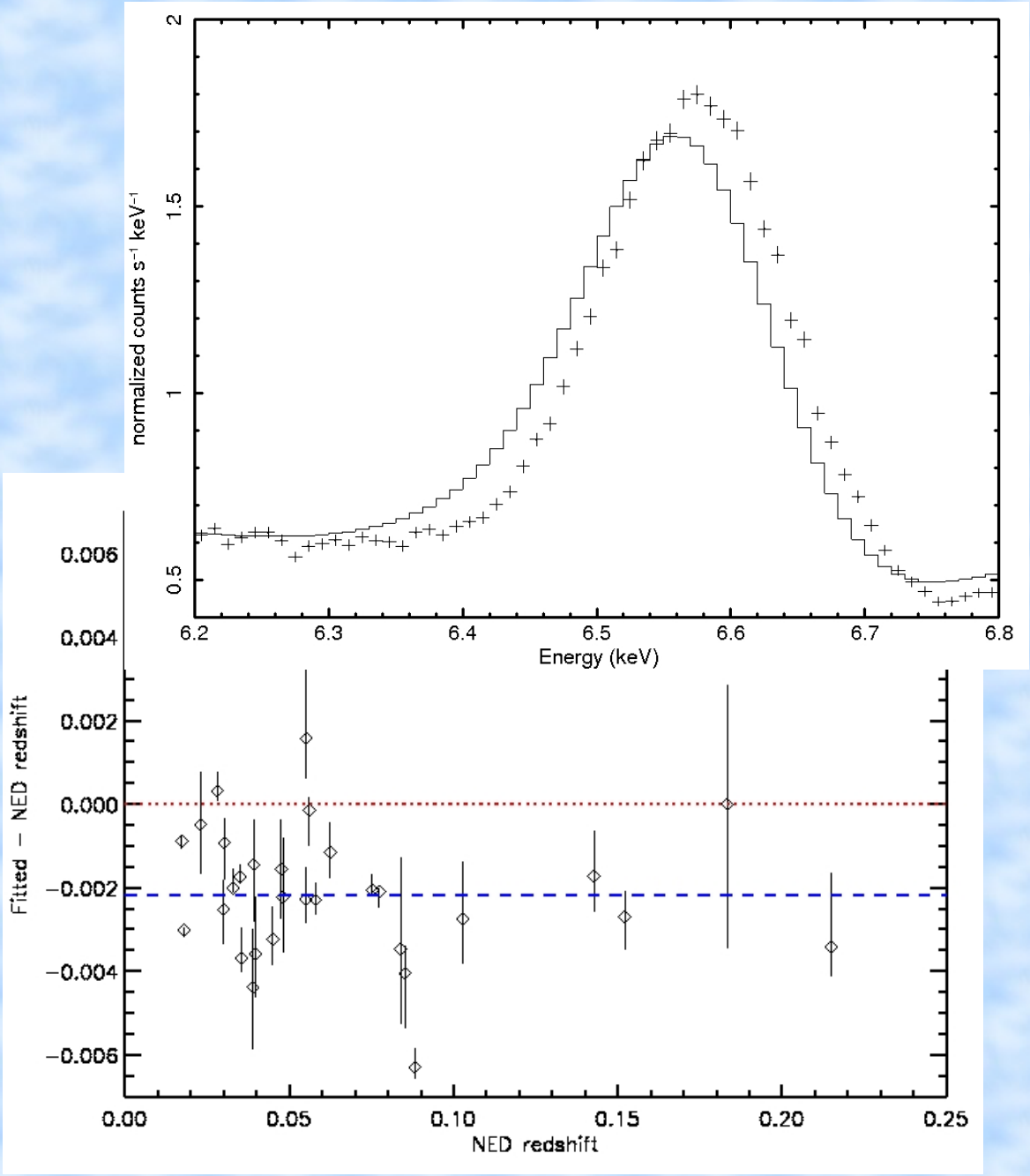
Chandra/XMM soft band problems

- Refereed paper on Chandra/XMM flux and soft band temperature problems has not been enough to create action to solve the cross-calibration problems
- What to do?
  - Propagate more aggressively the Chandra/XMM problems with flux and soft band T to get action?
  - Confirm the systematic effects with different objects?
  - Give up and conclude that we never get the calibration better than 10-15%?

XMM gain calibration using cluster FeXXV K alpha line

XMM gain calibration

- ~30 cool core clusters from HIFLUGCS (J. Nevalainen et al. in prep.)
- Calibration info in Aug 2010, SAS 10.0.0
- MOS data yields free redshift systematically lower than optical (NASA Extragalactic Database)
- Average redshift difference ~0.002 → free gain offset parameter obtains a value 11±1 eV



TBD

1) Data to IACHEC WIKI page

2) Suzaku extension/soft band problems

3) Flux problems

4) How to propagate the Chandra/XMM problems with flux and soft band T to get action?

5) Extend the XMM/Chandra comparison to contain all useful HIFLUGCS clusters and pointings available in 2011

6) Deeper observations of the hottest clusters for better statistics of the FeXXV/XXVI line ratio measurement

7) Swift extension

8) XMM gain calibration using cluster FeXXV K alpha line