Clusters WG report

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Frascati 2011
Activities since Woodshole 2010 meeting


• 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$^{-2}$) → good statistics
- Most have a cool core, no major merger signatures, spectra extracted within the ~isothermal region 0.1-0.3 r$_{500}$ → 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

- \langle \text{ACIS} - \text{pn} \rangle < 1\%, \text{ no systematic difference btw. the instruments} →

- 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

- $<\text{MOS / pn}> \sim -3\%$, values agree within 1

- Fe XXV/XXVI based $T$ agrees with 2-6 keV continuum fit
  - hard band effective area shape calibration OK
  - no significant deviations from ionisation equilibrium state and Maxwellian electron velocity distribution in the sample $\rightarrow$ Fe XXV/XXVI useful for calibration
ACIS/EPIC soft band T disagreement
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 → 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

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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<td>XMM-CCF-REL-273</td>
<td>EPIC MOS response</td>
<td>24-Mar-2011</td>
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<td>EPIC MOS Fixed Offset Tables</td>
<td>11-Sep-2010</td>
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<td>Refinement of pn redistribution</td>
<td>17-Jun-2010</td>
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<td>RAWY-dependent calibration of the PATTERN fraction in EPIC-pn Timing Mode</td>
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<td>Spectral quality-related CCF XMM_SPECQUAL</td>
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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 $11 \pm 1$ 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