MOS Pn cross calibration
with a sample of Galaxy
Clusters

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The Exercise

- Sample of 21 high gal latitude, hot, intermediate redshift Galaxy Clusters observed with XMM-Newton.
- About 80 high quality spectra (bkg is not an issue)
- All reduced with SAS 6.0 (rerun with 6.1 to begin soon)
- Emission & Epchain correction for OOT applied
- Effective areas generated using arfgen with extended source options
- Rmfs generated using rmfgen
- MOS1, MOS2 (pattern 0-12) and pn (0-4)
- flag==0 for MOS and pn
The Exercise

MOS1 image of A1689

Spectral accumulated in concentric annuli (from 5 to 8 depending on source SB). Important for testing full FOV.
hich ban

- esting spectral caliration it t ermal spectra is some at different t an it po er la s.
- For ig ( eV) t e scientific alua le information is all in t e ard and o e er for (I) and man ot er ra e periments most of t e statistics is in t e softer and.
- (erforming spectral fits using a cumulati e statistics suc as $^2$ on a road and ill put lots of eig t on t e insensiti e soft part of t e spectrum and relati el less on t e ard scientificall important part.
Two possible points of view

**Observer:** forget the soft band, it only complicates things!

**Calibrator:** if I can get the right temperature fitting the broad band than my calibration must really be good!

Spectral fits in

0.5-10 keV 1.5-10 keV 2-10 keV
Spectral fits in
.5 . .5 . . for OS and OS
.5 . .5 . . for pn

1. For each band comparison btwn detectors.
2. For each detector comparison btwn T measures in different bands
typical case
T measured in 2–10 keV band

mean = -0.064
MOS vs MOS

T measured in 1.5–10 keV band

mean = -0.054
\textbf{MOS vs MOS}

T measured in 0.5–10 keV band

\begin{equation}
\text{mean} = -0.075
\end{equation}
MOS s pn

T measured in 2–10 keV band

\( \text{mean} = 0.063 \)
MOS s pn

T measured in 1.5–10 keV band

mean = -0.007
MOS s pn

T measured in 0.5–10 keV band

mean = -0.18
Summary MOS s pn

1. For hard bands reasonable agreement btwn all instruments.
2. Broad band MOS and PN are clearly discrepant
1. For each band comparison between detectors.
2. For each detector comparison between $T$ measures in different bands.
\[
\frac{(T_{2-10} - T_{1.5-10})}{T_{1.5-10}}
\]

N of obj

MOS1 0.081
MOS2 0.089
pn 0.157
0.5-10 keV vs 1.5-10 keV

\( \frac{(T_{0.5-10} - T_{1.5-10})}{T_{1.5-10}} \)
Summary

1. ... drops as you include softer parts of the spectrum at least part of this is not due to calibration.

2. The $P_n$ temperatures vary considerably more than the MOS.

* Bigest problem is 2. $P_n$ variation when going from 1. 1 e to 1 e.
For one object 5 eV compared old and newer 5 eV empty circles
Table 2. Comparison between percentual differences in PN temperature profiles obtained with version 6.0 and 6.1 of the SAS analysis package.

<table>
<thead>
<tr>
<th>ring</th>
<th>SAS6.0</th>
<th>SAS6.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0’-0.5’</td>
<td>15.2%</td>
<td>10.8%</td>
</tr>
<tr>
<td>0.5’-1’</td>
<td>12.1%</td>
<td>11.7%</td>
</tr>
<tr>
<td>1’-2’</td>
<td>14.7%</td>
<td>10.6%</td>
</tr>
<tr>
<td>2’-3’</td>
<td>9.5%</td>
<td>6.7%</td>
</tr>
<tr>
<td>3’-4’</td>
<td>13.4%</td>
<td>10.4%</td>
</tr>
<tr>
<td>4’-5’</td>
<td>14.8%</td>
<td>9.9%</td>
</tr>
<tr>
<td>5’-7’</td>
<td>21.1%</td>
<td>17.4%</td>
</tr>
<tr>
<td>7’-9’</td>
<td>27.2%</td>
<td>25.4%</td>
</tr>
<tr>
<td>mean values</td>
<td>13.3±2.2%</td>
<td>10.5±0.7%</td>
</tr>
</tbody>
</table>
Summary

1. In the hard bands we have reasonable agreement between instruments better than 1.

2. In the soft band there is a large discrepancy between MOS and PN; the fact that PN in 1.1 is e and PN in ... that the problem is a PN rather than a MOS problem.

PN changes in S and S.1 solve only part of the problem.