MOS/pn cross-calibration in hard X-ray band

• Comparison between MOS and pn in 3-10 keV band (no instrumental edges)
• Bright source with hard spectrum

<table>
<thead>
<tr>
<th>Source</th>
<th>Rev.</th>
<th>Obsid</th>
<th>Mode</th>
<th>Exp (ks)</th>
<th>Region (arcsec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C273 (a)</td>
<td>0277</td>
<td>0136550101</td>
<td>SW</td>
<td>43</td>
<td>5-40</td>
</tr>
<tr>
<td>3C273 (b)</td>
<td>0277</td>
<td>0136550101</td>
<td>SW</td>
<td>45</td>
<td>5-40</td>
</tr>
</tbody>
</table>

• Aim is to compare MOS and pn spectra with all corrections taken into account (CTI, EEF and vignetting effects etc.)
All encircled energy corrections have been made using data in CCF

\text{pn} \quad \text{latest CTI correction} \rightarrow \text{SAS 5.3} \\
\text{response matrices} \rightarrow \text{version 6.2}

\text{MOS} \quad \text{CTI correction} \rightarrow \text{SAS 5.2 (latest is SAS 5.3, } \Delta \Gamma \sim -0.03) \\
\text{response matrices} \rightarrow \text{q20 and q21}

Simple power-law model used
MOS effective area issues

Current matrices: \( m^{1/2}_{<\text{filter}>} v9q20t5r6\_all\_15\).rsp

=> MOS1 and MOS2 QE identical

Proposed QE for SAS 5.3 (q21)
Proposed QE for SAS 5.3 (q21)

MOS2

Energy (eV)

0 0.2 0.4 0.6 0.8
GEO

100 1000 10^4
Recently Dave Lumb suggested vignetting corrections required for “on-axis” observations of MOS2 and pn
Blue  – (DETX,DETY) = (0,0)
Black  – MOS1 optical axis, Red – MOS2 optical axis, Green – pn optical axis
<table>
<thead>
<tr>
<th>Response MOS/pn</th>
<th>Correction</th>
<th>Source</th>
<th>MOS1</th>
<th>MOS2</th>
<th>pn</th>
</tr>
</thead>
<tbody>
<tr>
<td>q20/6.2</td>
<td>none</td>
<td>3C273 (a)</td>
<td>1.58</td>
<td>1.53</td>
<td>1.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3C273 (b)</td>
<td>1.59</td>
<td>1.57</td>
<td>1.74</td>
</tr>
<tr>
<td>q20/6.2</td>
<td>EEF only</td>
<td>3C273 (a)</td>
<td>1.45</td>
<td>1.41</td>
<td>1.71</td>
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<td>3C273 (b)</td>
<td>1.46</td>
<td>1.45</td>
<td>1.74</td>
</tr>
<tr>
<td>q21/6.2</td>
<td>none</td>
<td>3C273 (a)</td>
<td>1.60</td>
<td>1.63</td>
<td>1.71</td>
</tr>
<tr>
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<td>3C273 (b)</td>
<td>1.61</td>
<td>1.67</td>
<td>1.74</td>
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<tr>
<td>q21/6.2</td>
<td>EEF + vignetting</td>
<td>3C273 (a)</td>
<td>1.47</td>
<td>1.50</td>
<td>1.67</td>
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<tr>
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<td>3C273 (b)</td>
<td>1.48</td>
<td>1.54</td>
<td>1.70</td>
</tr>
</tbody>
</table>

MOS1 $\Delta \Gamma \sim -0.13$  MOS2 $\Delta \Gamma \sim -0.12$  pn $\Delta \Gamma \sim 0.0$
MOS1 $\Delta \Gamma \sim +0.02$  MOS2 $\Delta \Gamma \sim +0.10$  pn $\Delta \Gamma \sim 0.0$
MOS1 $\Delta \Gamma \sim -0.11$  MOS2 $\Delta \Gamma \sim -0.03$  pn $\Delta \Gamma \sim -0.04$
3C273 (a) MOS1 – black, MOS2 – red, pn - blue

q20, no correction

PhIndex

norm

0.014

0.012

0.01

1.5  1.55  1.6  1.65  1.7  1.75
3C273 (a)  MOS1 – black, MOS2 – red, pn - blue

q20, EEF correction only

PhIndex

norm

0.016

0.018

0.02

0.022

0.024

0.024
3C273 (a) MOS1 – black, MOS2 – red, pn - blue

q21, EEF + vignetting correction
3C273 (b)        MOS1 – black, MOS2 – red, pn - blue

q20, no correction
3C273 (b)  MOS1 – black, MOS2 – red, pn - blue

q20, EEF correction only
3C273 (b)  MOS1 – black, MOS2 – red, pn - blue

q21, EEF + vignetting correction
Summary

• When all corrections made to best of current knowledge, there is still a large discrepancy between MOS and pn spectra in the 3-10 keV band

• Difference must be due to QE or mirror area

• Assumption is mirrors have been calibrated very well

⇒ Which QE should we trust, MOS or pn (or neither)?