Calibration Activities – the MOS perspective

Changing the MOS Quantum Efficiency Calibration:

Motivation and Justification.
Flux comparison using a sample (17) of AGN observations: as presented at MPE (May 2006)

<table>
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<th>(MOS1-PN)/PN</th>
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MOS v PN effective area discrepancy: 3C 273 comparison

Steve Sembay (sfs5@star.le.ac.uk)
Palermo 12/04/2007
Investigating additional transmission layers

H2O  0.12 µm
SiO2  0.068 “
Si3N4  0.059 “
Si    0.12 “
3C 273: What the PN sees

Model: phabs*(po+po) \[ N_H = 1.79 \times 10^{20} \text{cm}^{-2} \quad \chi^2 = 1.08 \]

Steve Sembay (sfs5@star.le.ac.uk)
Palermo 12/04/2007
Comparison: PN Model with MOS1 data and various QEs

ICE 0.12 µm
Comparison: PN Model with MOS1 data and various QEs

ICE 0.12 µm
SiO2 0.068 µm
Comparison: PN Model with MOS1 data and various QEs

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ICE 0.12 µm
SiO2 0.068 µm
Si3N4 0.059 µm
Si 0.12 µm

Steve Sembay (sfs5@star.le.ac.uk)
Palermo 12/04/2007
Constraint on Si edge also precludes strong “Si” absorber

Edge depth known Within ~2-3%
QE17 – Adjustment of edges at C, N, O, only

Adjustment of edges at C, N, O, only
Comparison with Orsay

CCD1  MOS1

CCD1  MOS2

Steve Sembay (sfs5@star.le.ac.uk)
Palermo 12/04/2007
Comparison with Orsay

[Graph showing the comparison between CCD1 and MOS1 quantum efficiency with energy (keV) on the x-axis and quantum efficiency on the y-axis.]

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Palermo 12/04/2007
Model: $\text{phabs}^* (\text{po}+\text{po})$

$\chi^2 = 1.19$

Steve Sembay (sfs5@star.le.ac.uk)
Palermo 12/04/2007
Model: \( \text{const} \times \text{phabs} \times (\text{po} + \text{po}) \): \( \text{const}(M1) = 1.03 \) \( \text{const}(M2) = 1.06 \)
\[ \chi^2 = 1.11 \] (with global renormalisation, c.f. 1.19 before without)
PN soft/hard slopes:

\[ \Gamma_1 = 3.20(0.11) \]
\[ \Gamma_2 = 1.63(0.01) \]

\[ \Gamma_1 = 4.71(0.15) \]
\[ \Gamma_2 = 1.64(0.02) \]

\[ \Gamma_1 = 4.65(0.15) \]
\[ \Gamma_2 = 1.69(0.02) \]

\[ \Gamma_1 = 3.73(0.15) \]
\[ \Gamma_2 = 1.61(0.02) \]

\[ \Gamma_1 = 3.76(0.15) \]
\[ \Gamma_2 = 1.65(0.02) \]
MOS1 v RGS model, 1ES0102 – Rev 0065

Const x (RGS model)
0.3-1.5 keV
MOS1
χ² = 3.65 -> 1.78
Const. 0.51 -> 0.80

MOS2
χ² = 3.70 -> 2.30
Const. 0.58 -> 0.90

N_H = 5.36 x 10^{20} cm^{-2}
MOS1 v RGS model, 1ES0102 – Rev 0981

Const x (RGS model)
0.3-1.5 keV
MOS1
\(\chi^2 = 5.47 \rightarrow 2.16\)
Const. 0.39 \rightarrow 0.74

MOS2
\(\chi^2 = 7.46 \rightarrow 2.62\)
Const. 0.33 \rightarrow 0.70

\(N_H = 5.36 \times 10^{20} \text{ cm}^{-2}\)
\[N_H=5.36 \times 10^{20}\text{cm}^{-2}\]  \[N_H=8.00 \times 10^{20}\text{cm}^{-2}\]
Zoom showing resolution adjustment required for later Revs
Comparison with Zeta Puppis – On-axis Point Source

Const x (RGS model)
0.3-1.5 keV
MOS1
$\chi^2 = 1.69 \rightarrow 1.49$
Const. 1.05 -> 1.12

MOS2
$\chi^2 = 1.76 \rightarrow 1.51$
Const. 1.07 -> 1.15

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Independent astrophysical evidence?

Spectral fitting to relatively high column density BL Lac

\[ N_H \sim 4.4 \times 10^{20} \text{cm}^{-2} \]

TBABS * PO

Wilms abund

0.15-5.0 keV

MOS1

\[ \chi^2 = 1.13 \rightarrow 1.06 \]

MOS2

\[ \chi^2 = 1.16 \rightarrow 1.08 \]
Problem with the psf? – See talk by Andy later

3c 273: Flux Comparison, 7.5”-40” v 15”-40” extraction radii

☐ pn

☐ MOS1

● MOS2
Problem with the psf? – See talk by Andy later

MCG-6-30-15: 0", 7.5", 11.25", 15" inner extraction radii, 40" outer

☐ pn
☐ MOS1
● MOS2
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PKS 2155–304 December 2001

Flux Relative to PN

Energy (keV)

LETGS/PN △
MOS1/PN ★
MOS2/PN +
Quantum Efficiency measurements from Orsay

MOS2 – Central CCD

Steve Sembay (sfs5@star.le.ac.uk)
Palermo 12/04/2007
Surface Pixel Geometry in Monte Carlo model

Transmission functions for the various regions (dimensions in microns):

\[ T_1 = \exp(-0.1 \mu m) \]
\[ T_2 = T_1 \exp(-0.1 \mu m) \exp(-0.4 \mu m) \]
\[ T_3 = T_2 \exp(-0.25 \mu m) \exp(-0.3 \mu m) \]
\[ T_4 = T_3 \exp(-0.25 \mu m) \exp(-0.4 \mu m) \]
(MOS1-PN)/PN

0.54–0.85 keV

0.85–1.50 keV

1.50–4.0 keV

4.0–10.0 keV

+12%

+2%
(MOS2-PN)/PN

- 0.54–0.85 keV: +12%
- 0.85–1.50 keV: +2%
- 1.50–4.0 keV: 7.3389%
- 4.0–10.0 keV: 7.4333%

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Palermo 12/04/2007
H$_2$O = 0.08 μm
$H_2O = 0.08 \, \mu m$

$SiO_2 = 0.05 \, \mu m$
Steve Sembay (sfs5@star.le.ac.uk)
Palermo 12/04/2007
Summary:

Shape of the MOS/PN discrepancy suggests problem lies with the quantum efficiency

Adjustment of the MOS QE would be consistent with Orsay measurements and probable uncertainties in model

Adjusting the QE would leave a residual normalisation offset of about 5-7% between MOS and PN

Would need to increase MOS global effective area or decrease PN global effective area to achieve absolute consistency

MOS low energy rmf would need re-calibration for consistency with any change in the QE
Comparison of high energy portion of the spectra from 795 and 903

Rate down 8%
Flux down 5%
Eff. Area down 3%