Calibration Activities – the MOS perspective

Changing the MOS Quantum Efficiency Calibration:

Motivation and Justification.

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Palermo 12/04/2007

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

Band (keV)	(MOS1-PN)/PN	(MOS2-PN)/PN
0.54-0.85	-5.4%	-1.6%
0.85-1.50	+2.4%	+4.1%
1.50-4.0	+6.8%	+7.3%
4.0-10.0	+11.4%	+7.4%

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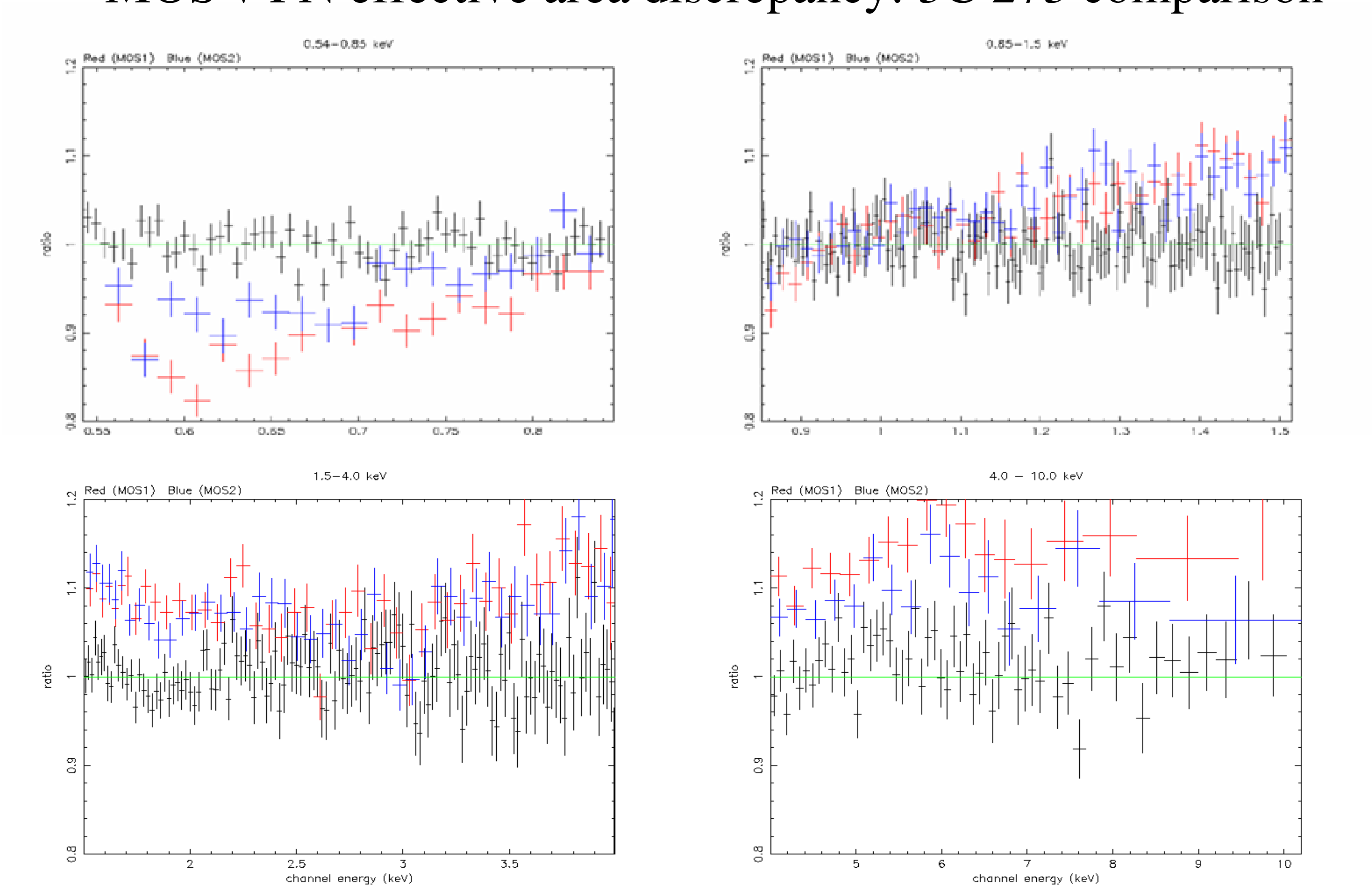
MOS v PN effective area discrepancy: 3C 273 comparison



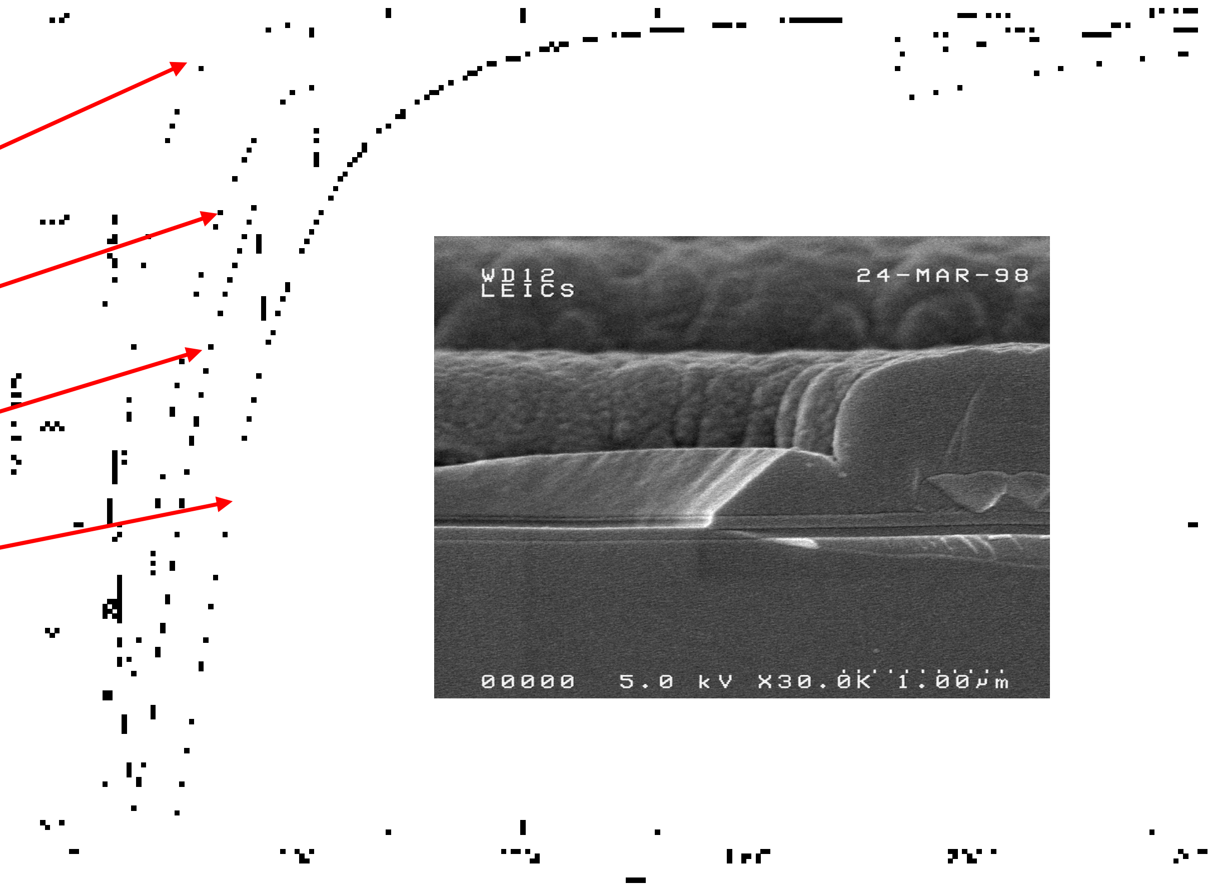
Investigating additional transmission layers

H_2O 0.12 µm

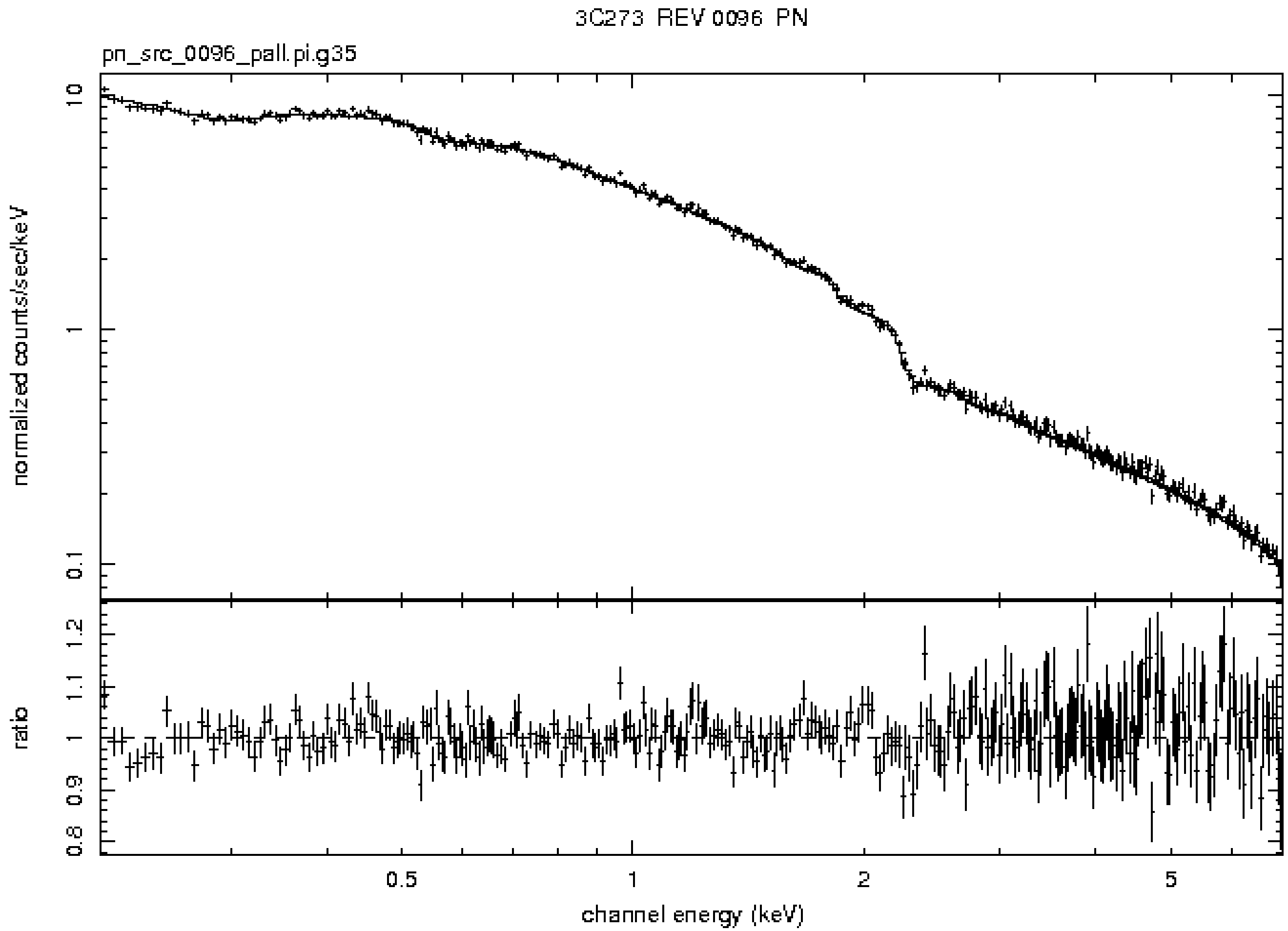
SiO_2 0.068 "

Si_3N_4 0.059 "

Si 0.12 "

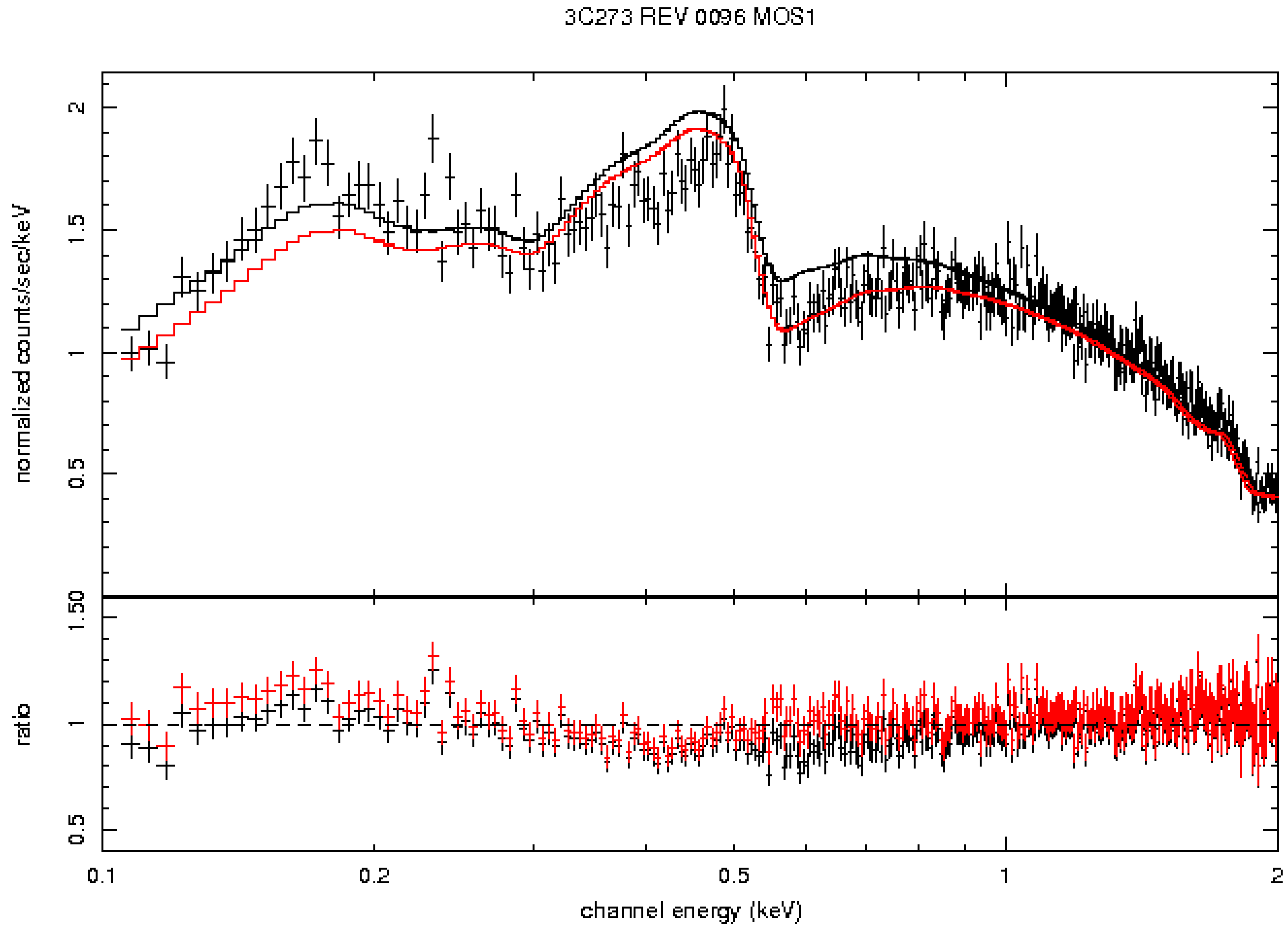


3C 273: What the PN sees



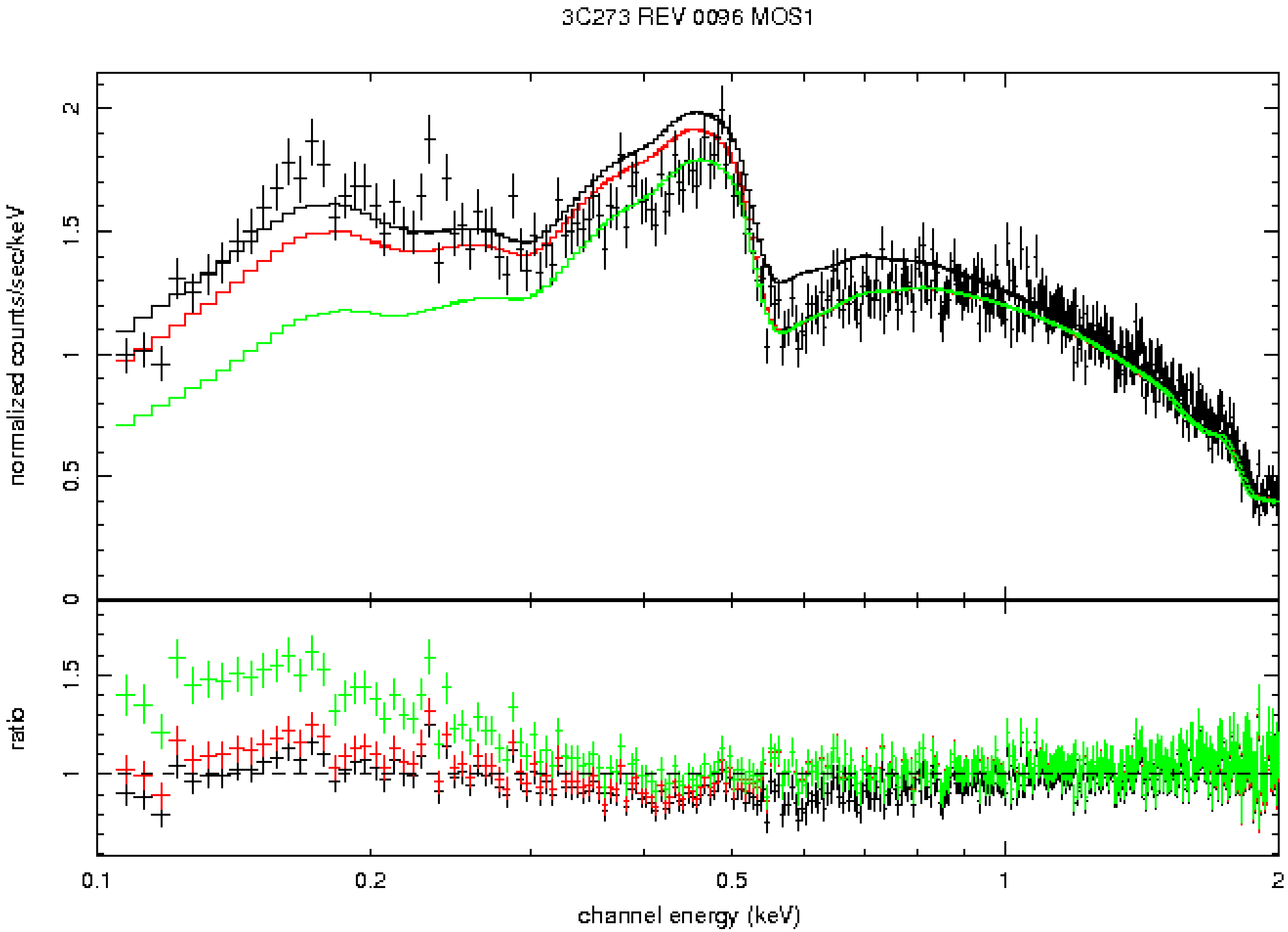
Model: phabs*(po+po) $N_H = 1.79 \times 10^{20} cm^{-2}$ $\chi^2 = 1.08$

Comparison: PN Model with MOS1 data and various QEs



ICE 0.12 µm

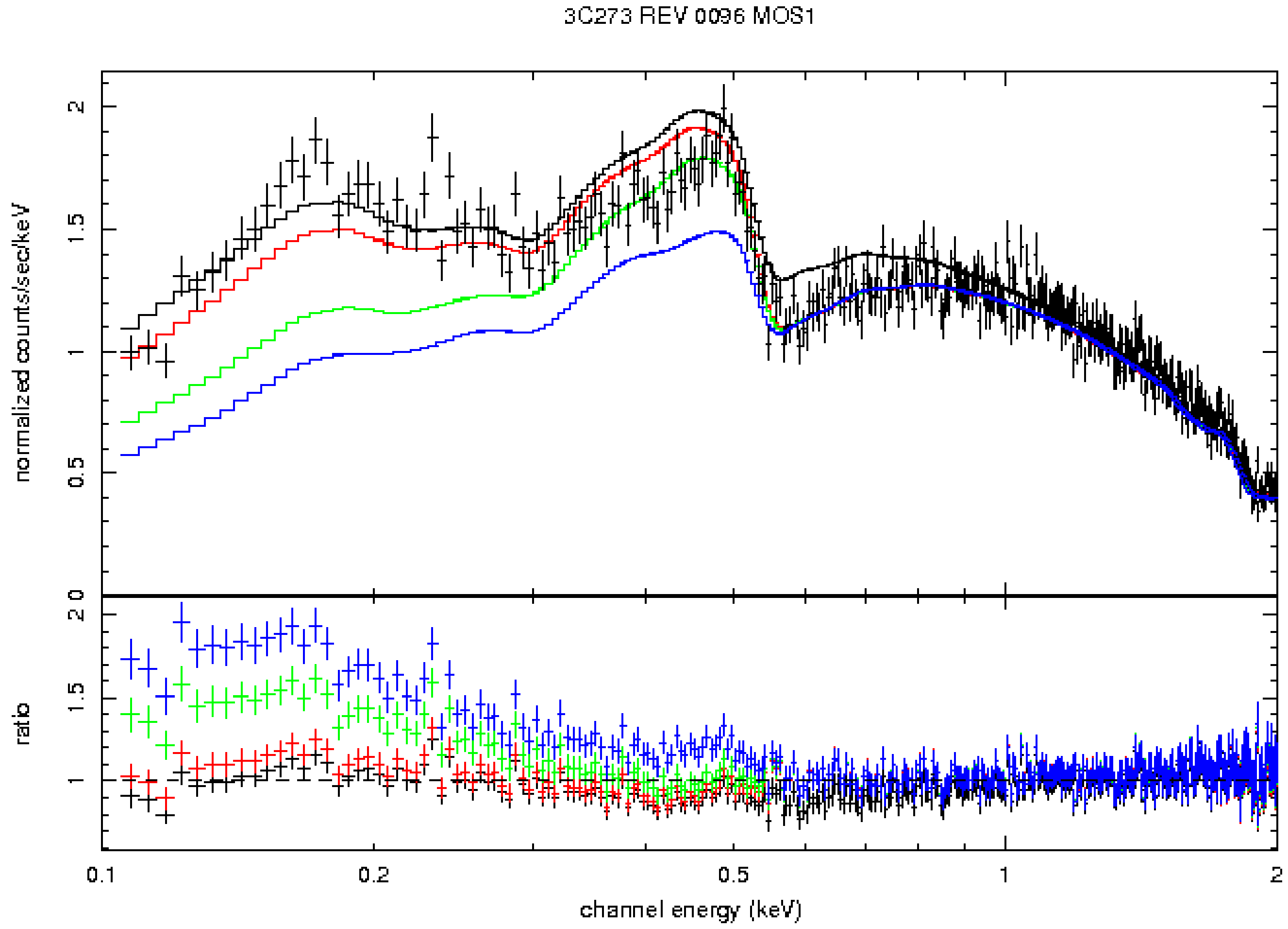
Comparison: PN Model with MOS1 data and various QEs



ICE 0.12 μm

SiO2 0.068 μm

Comparison: PN Model with MOS1 data and various QEs

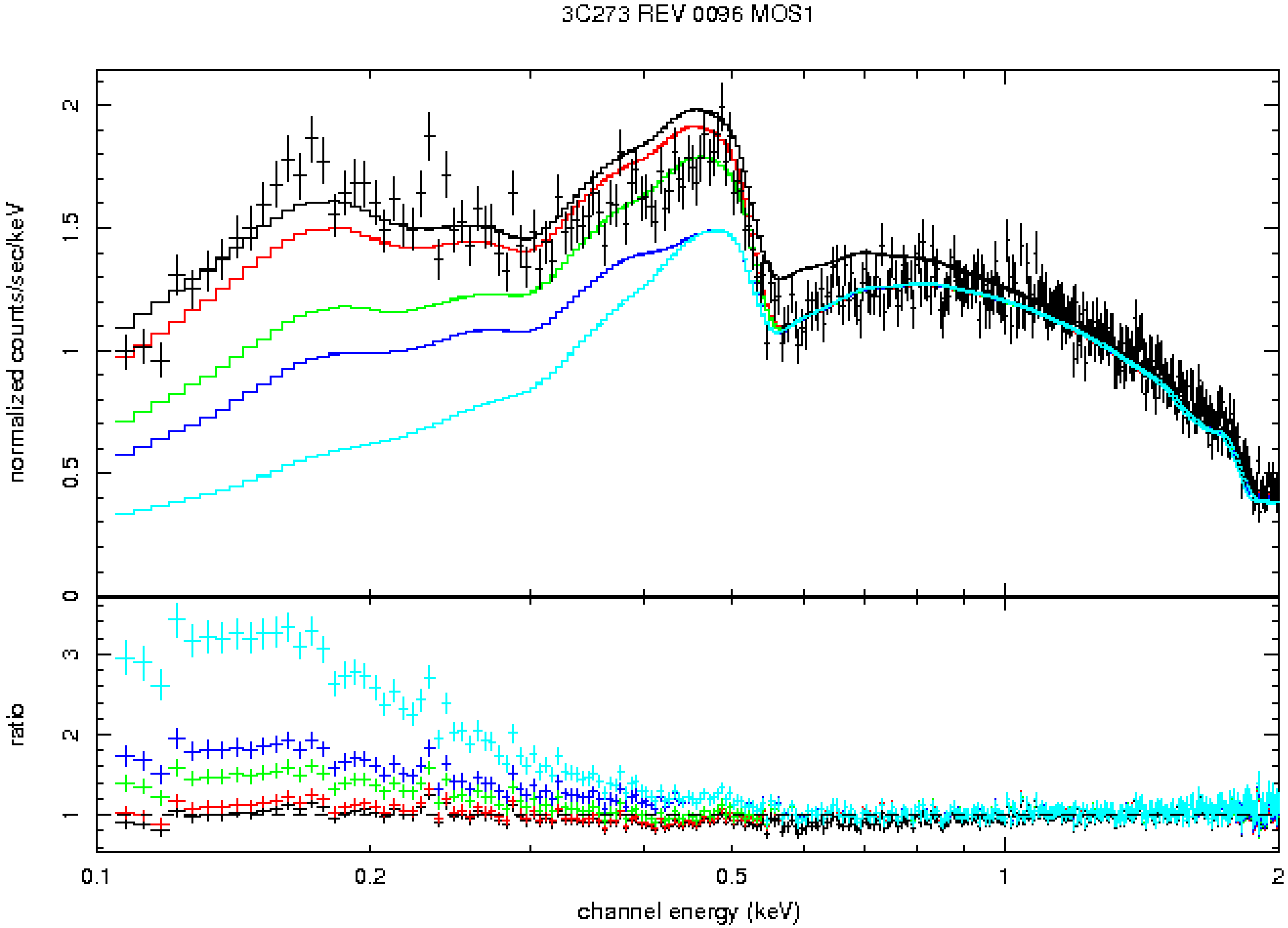


ICE 0.12 µm

SiO2 0.068 µm

Si3N4 0.059 µm

Comparison: PN Model with MOS1 data and various QEs



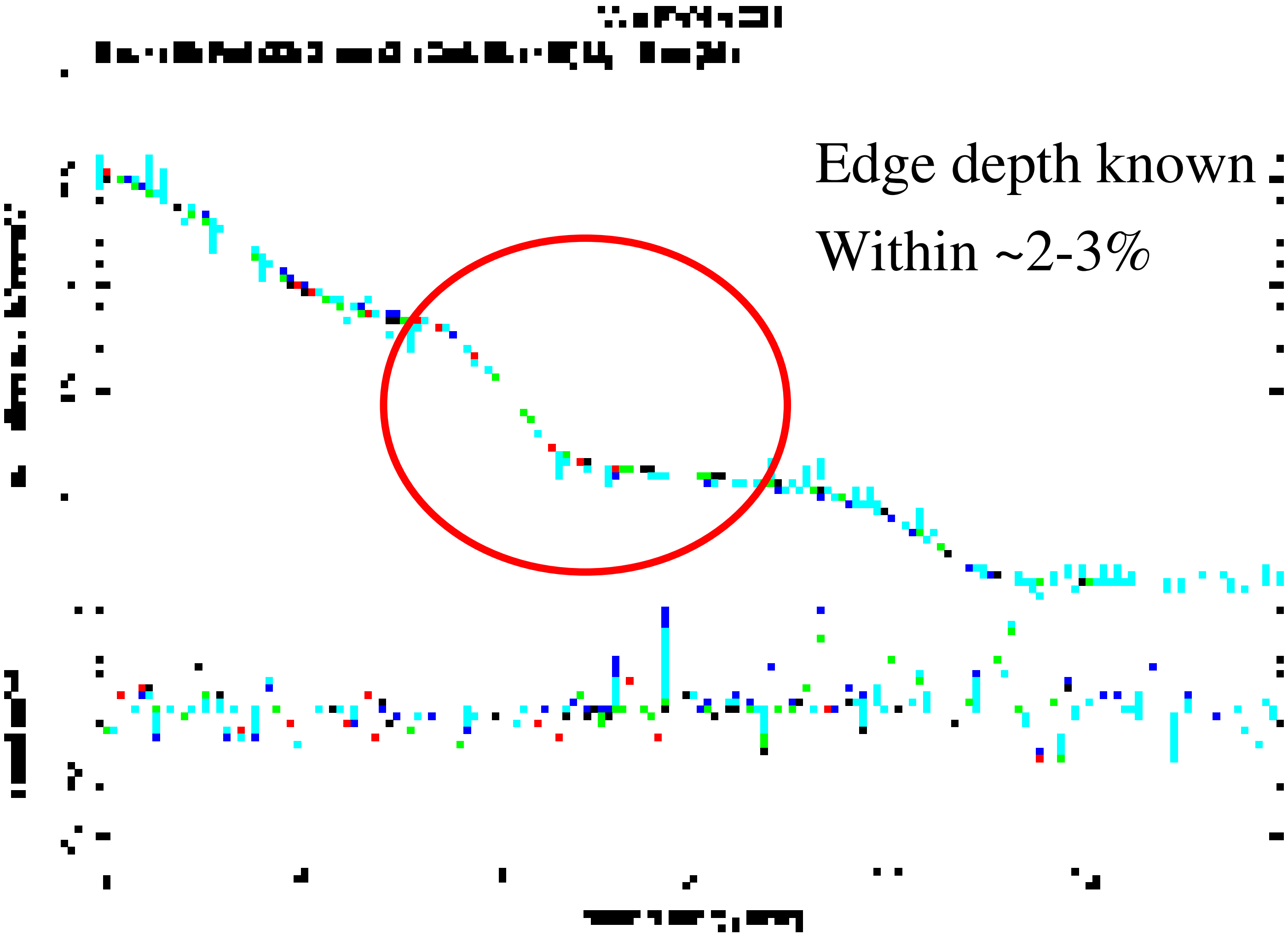
ICE 0.12 μm

SiO2 0.068 μm

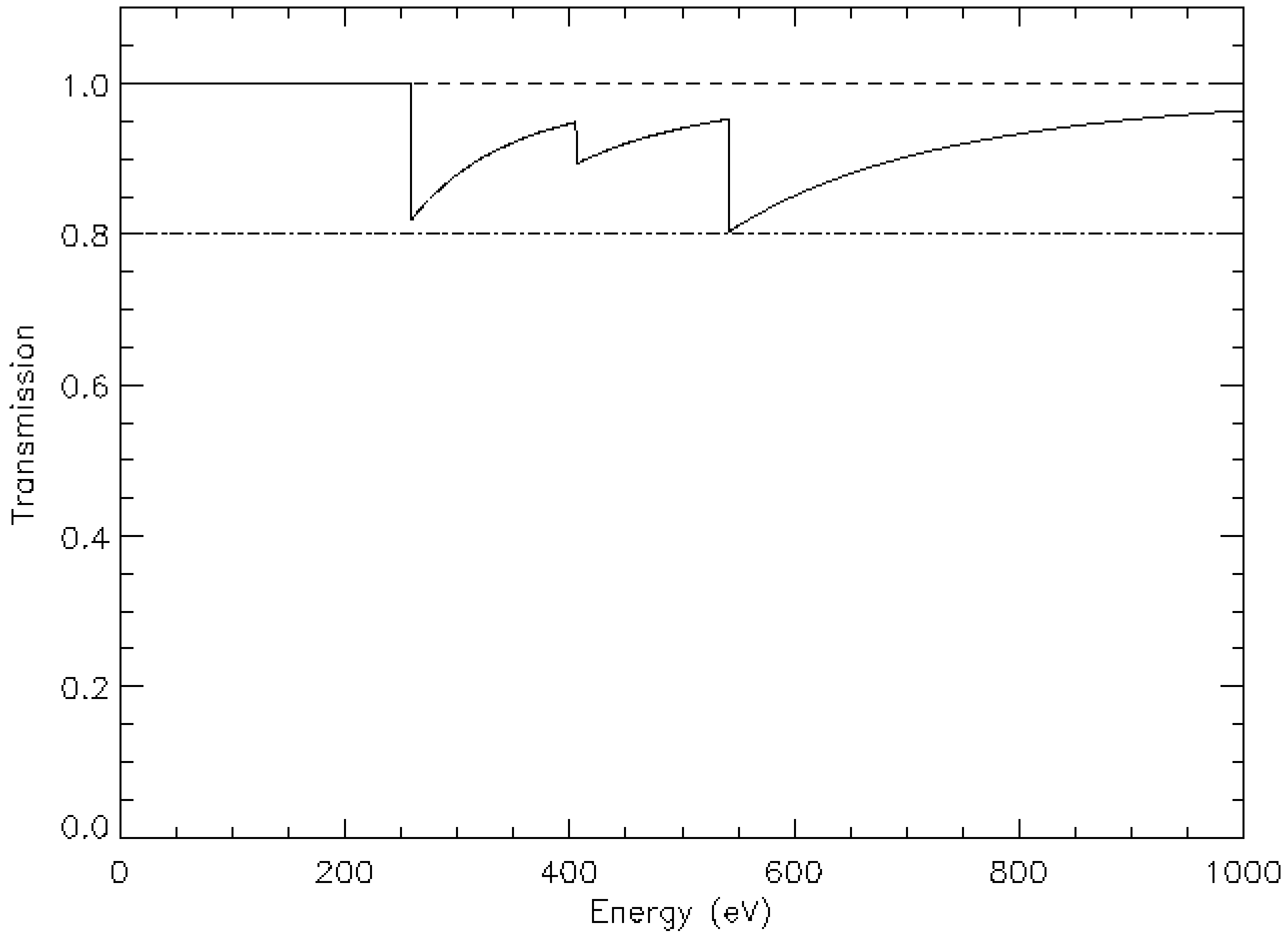
Si3N4 0.059 μm

Si 0.12 μm

Constraint on Si edge also precludes strong "Si" absorber

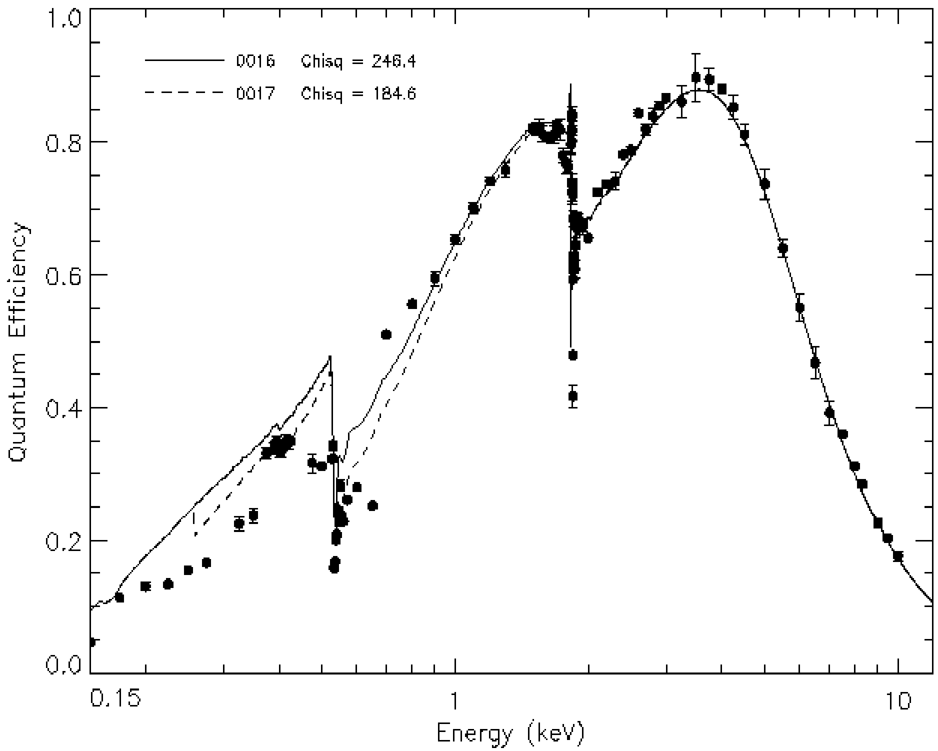


QE17 – Adjustment of edges at C, N, O, only

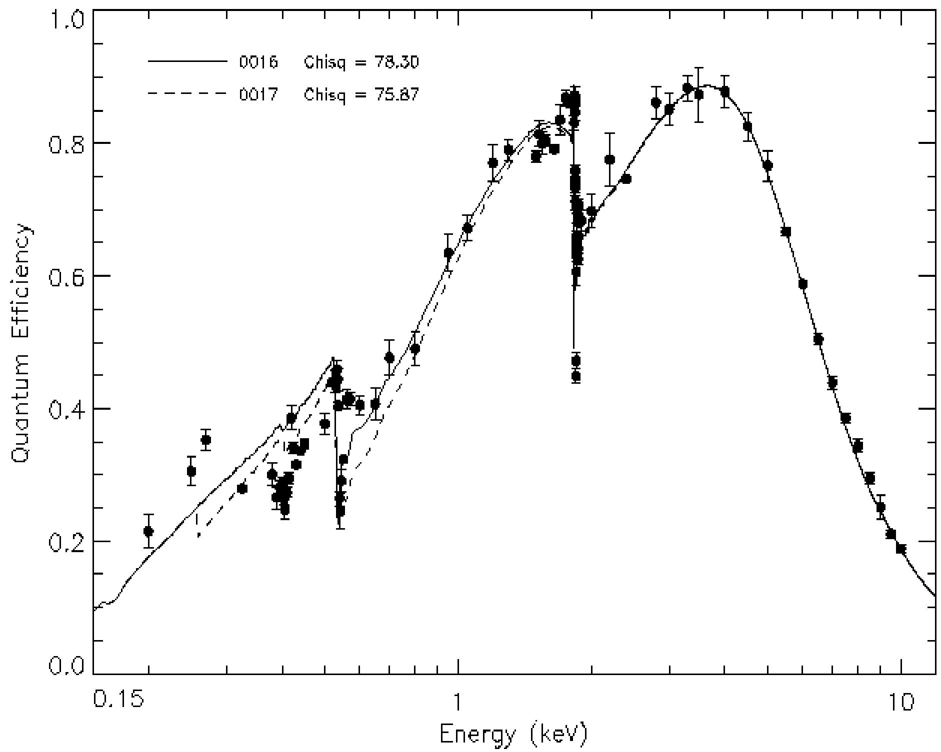


Comparison with Orsay

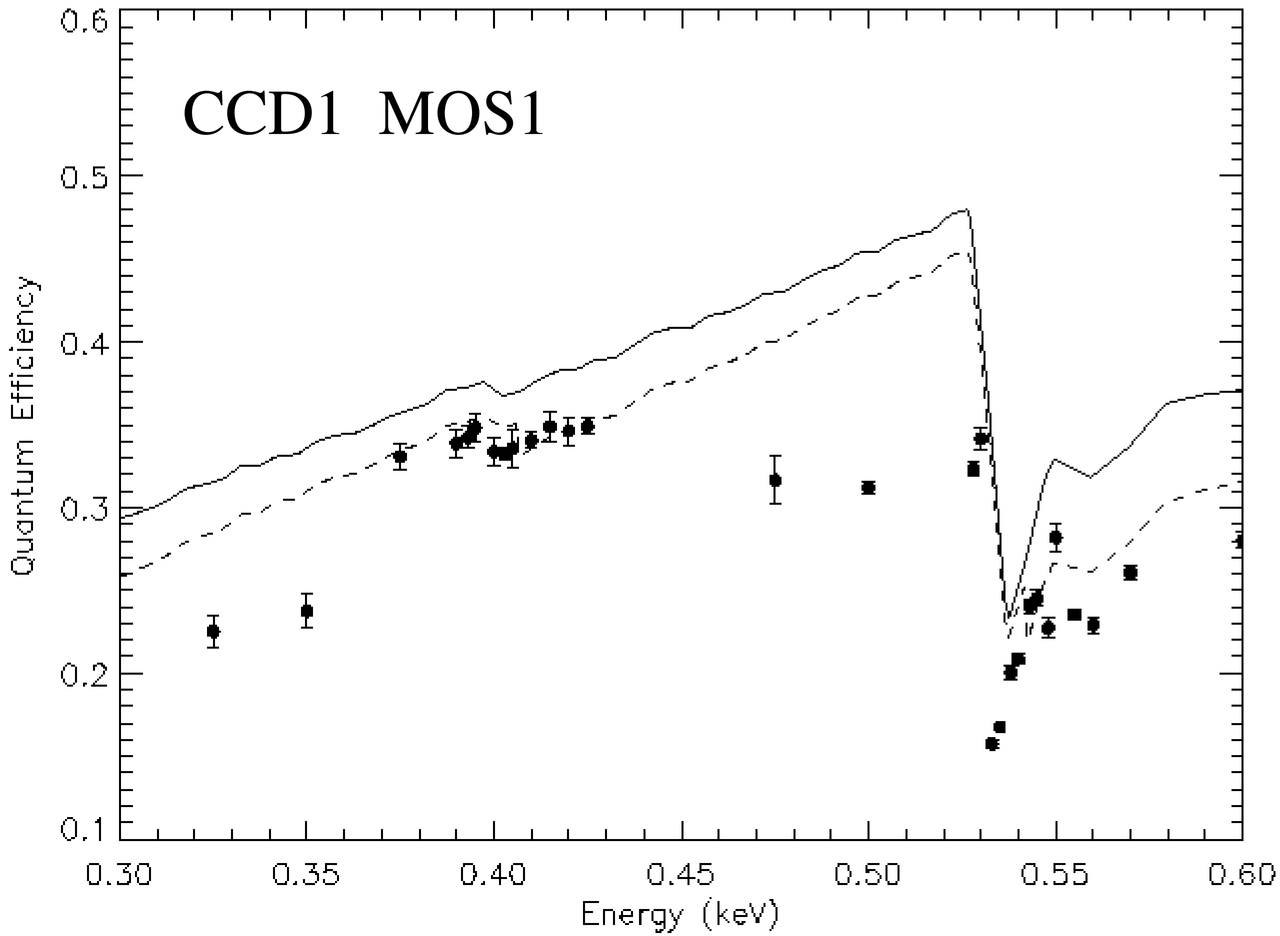
CCD1 MOS1

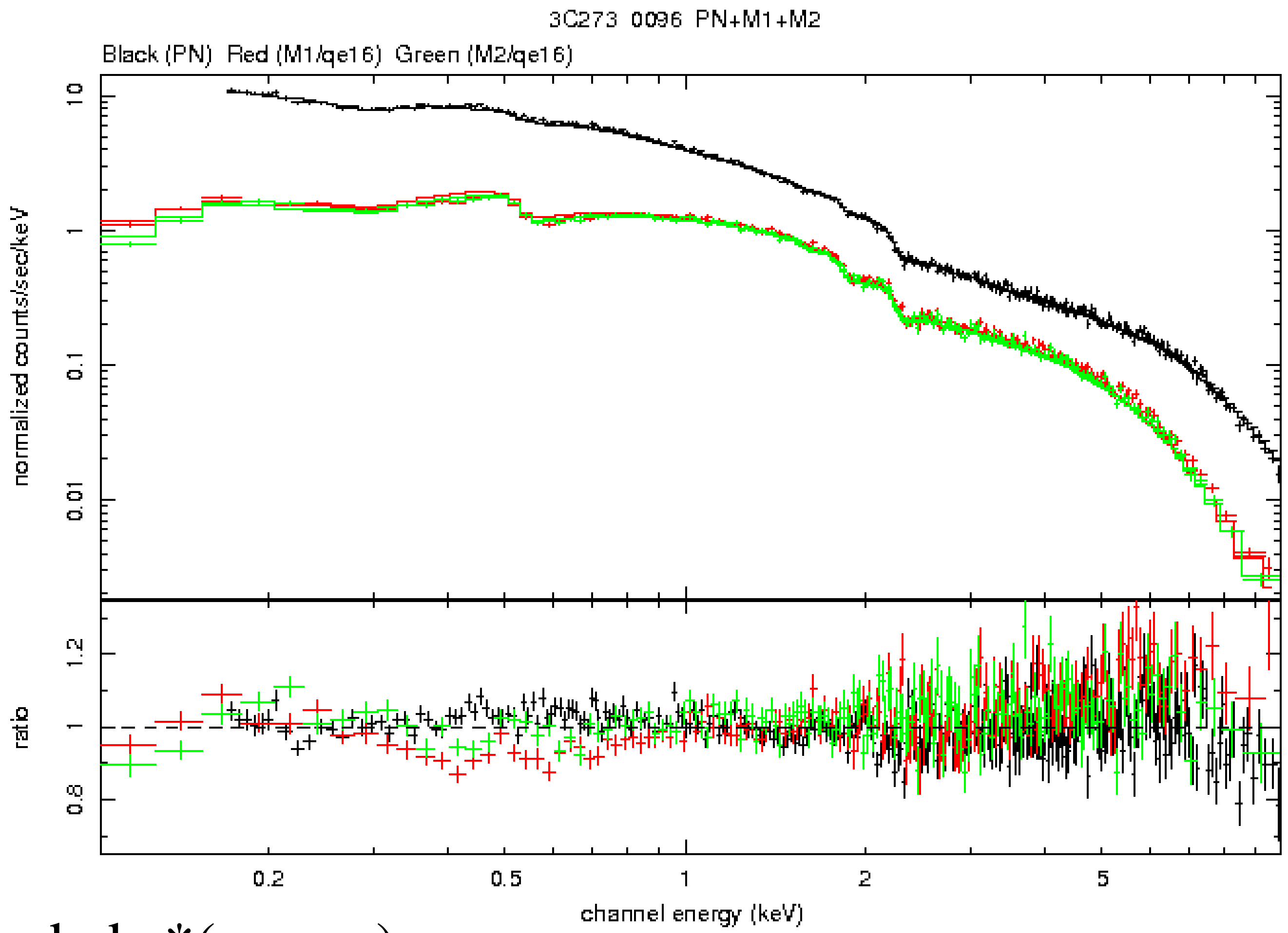


CCD1 MOS2



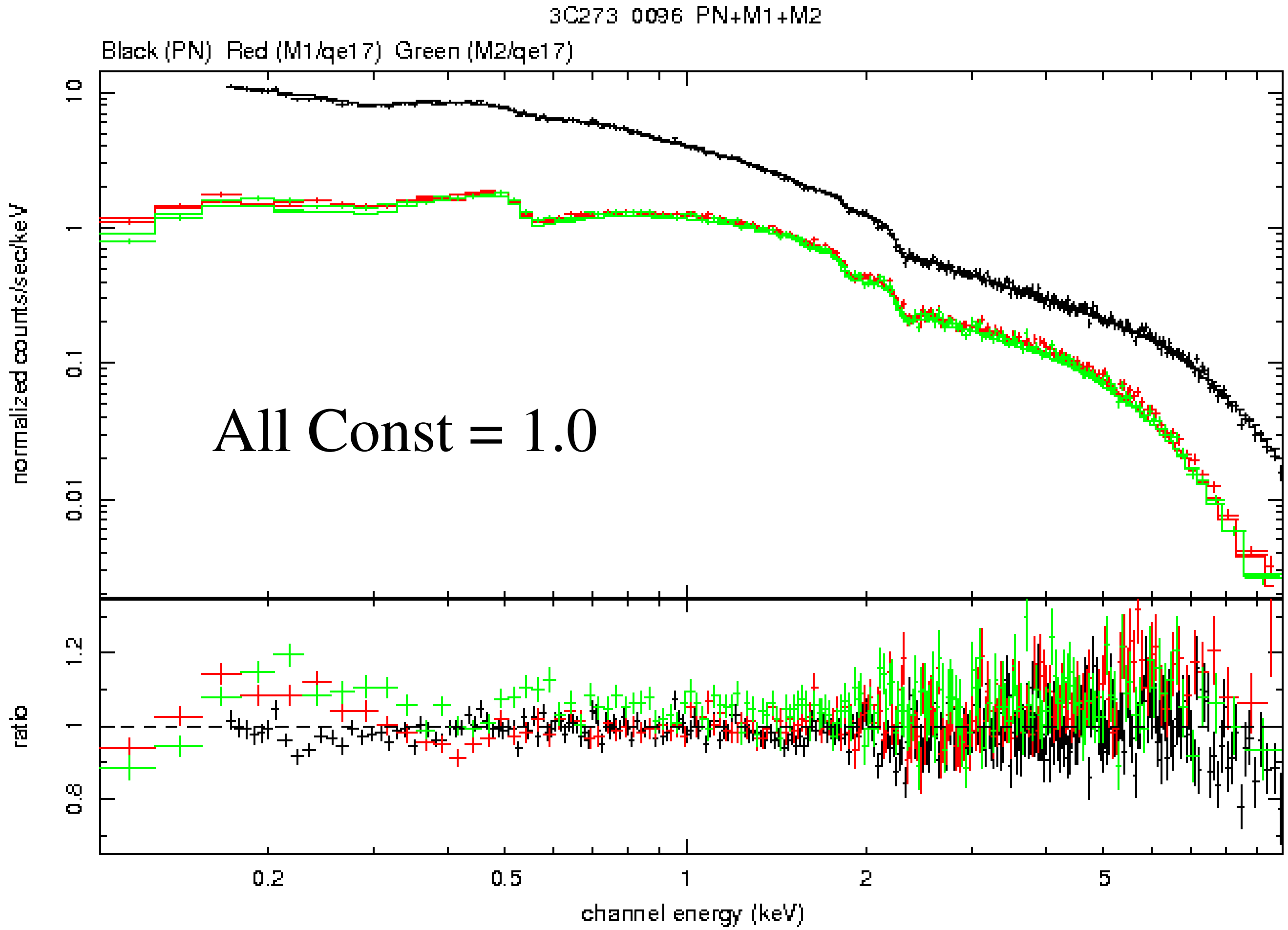
Comparison with Orsay





Model: phabs*(po+po)

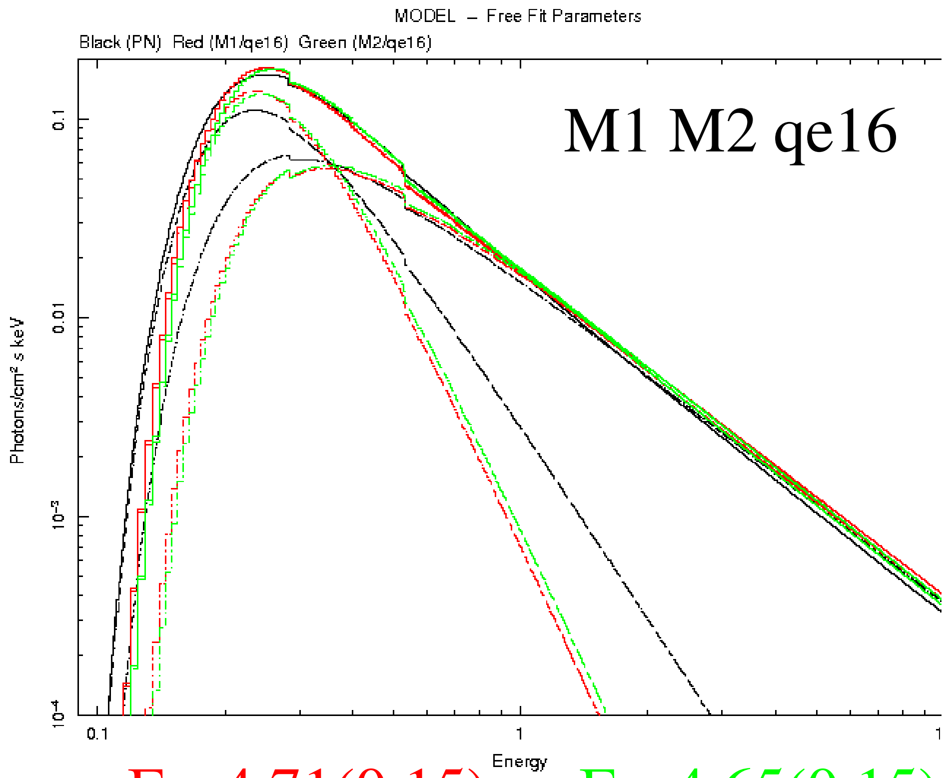
$\chi^2 = 1.19$

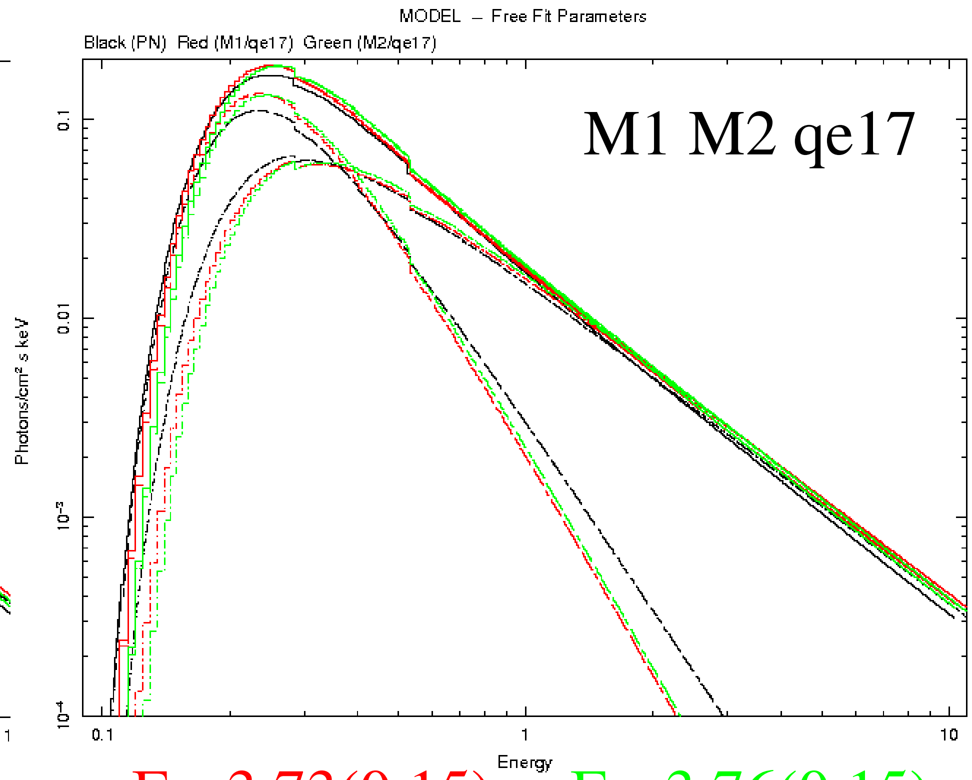


Model: const*phabs*(po+po): const(M1) = 1.03 const(M2) =1.06

χ^2 = 1.11 (with global renormalisation, c.f. 1.19 before without)

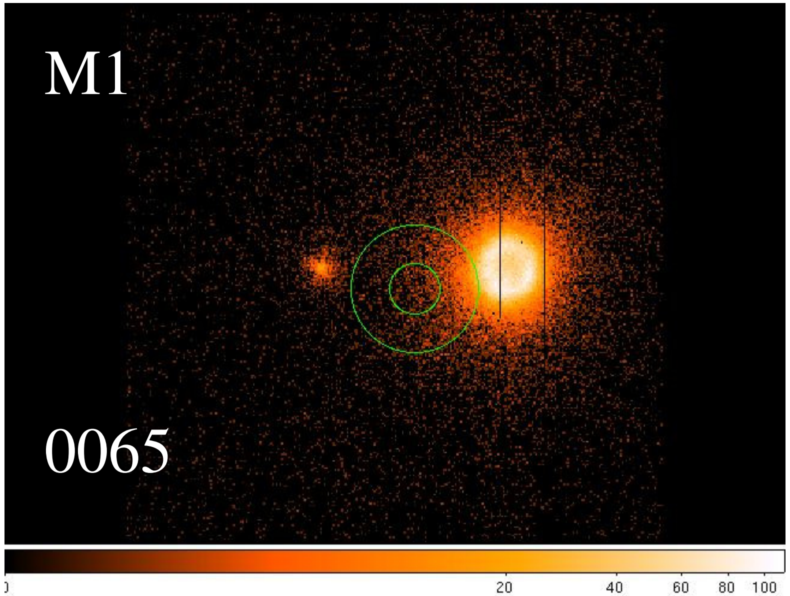
PN soft/hard slopes: Γ_1=3.20(0.11)
Γ_2=1.63(0.01)

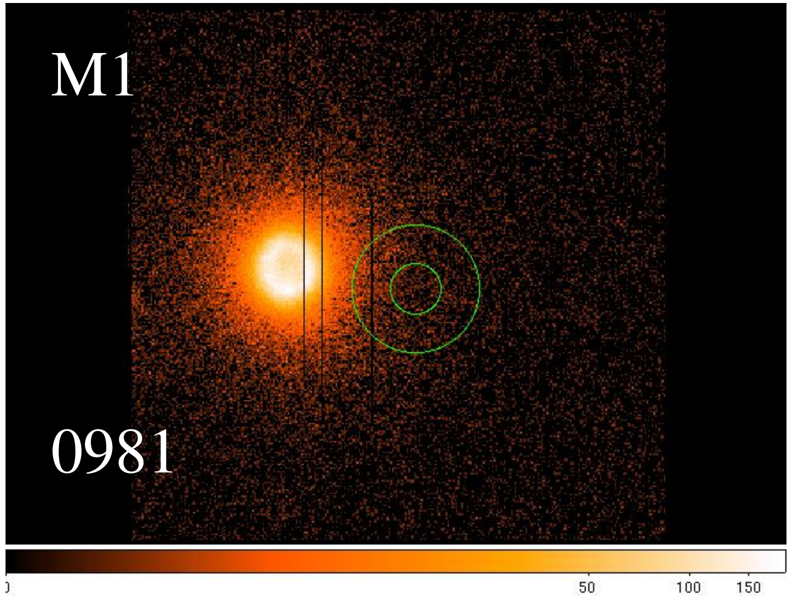




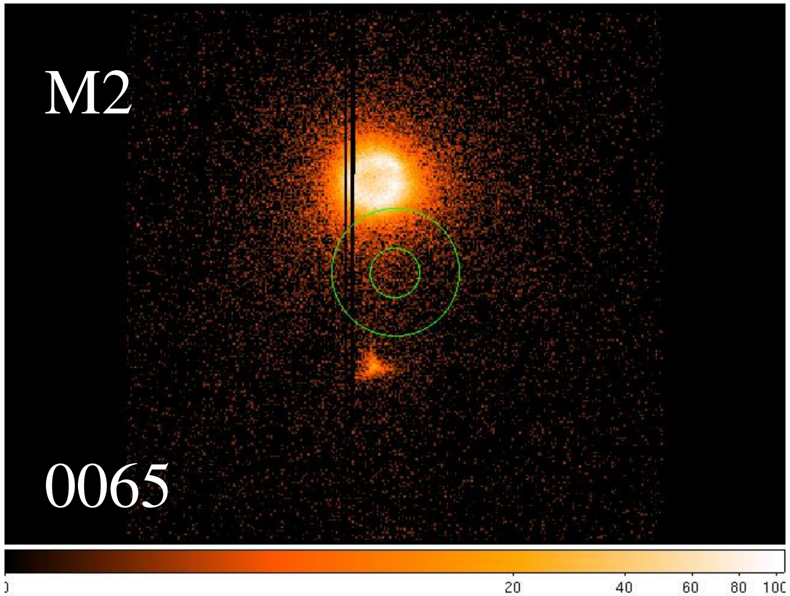
Γ_1=4.71(0.15) Γ_1=4.65(0.15) Γ_1=3.73(0.15) Γ_1=3.76(0.15)

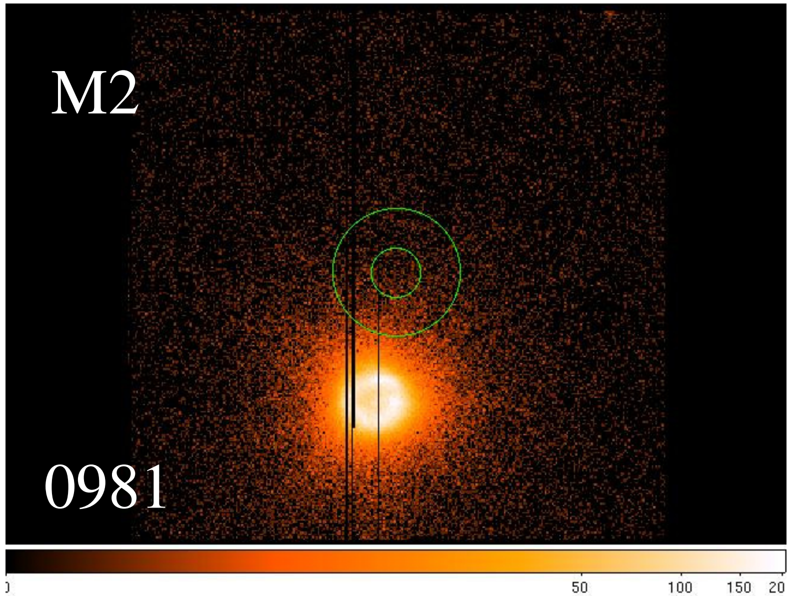
Γ_2=1.64(0.02) Γ_2=1.69(0.02) Γ_2=1.61(0.02) Γ_2=1.65(0.02)





1ES0102





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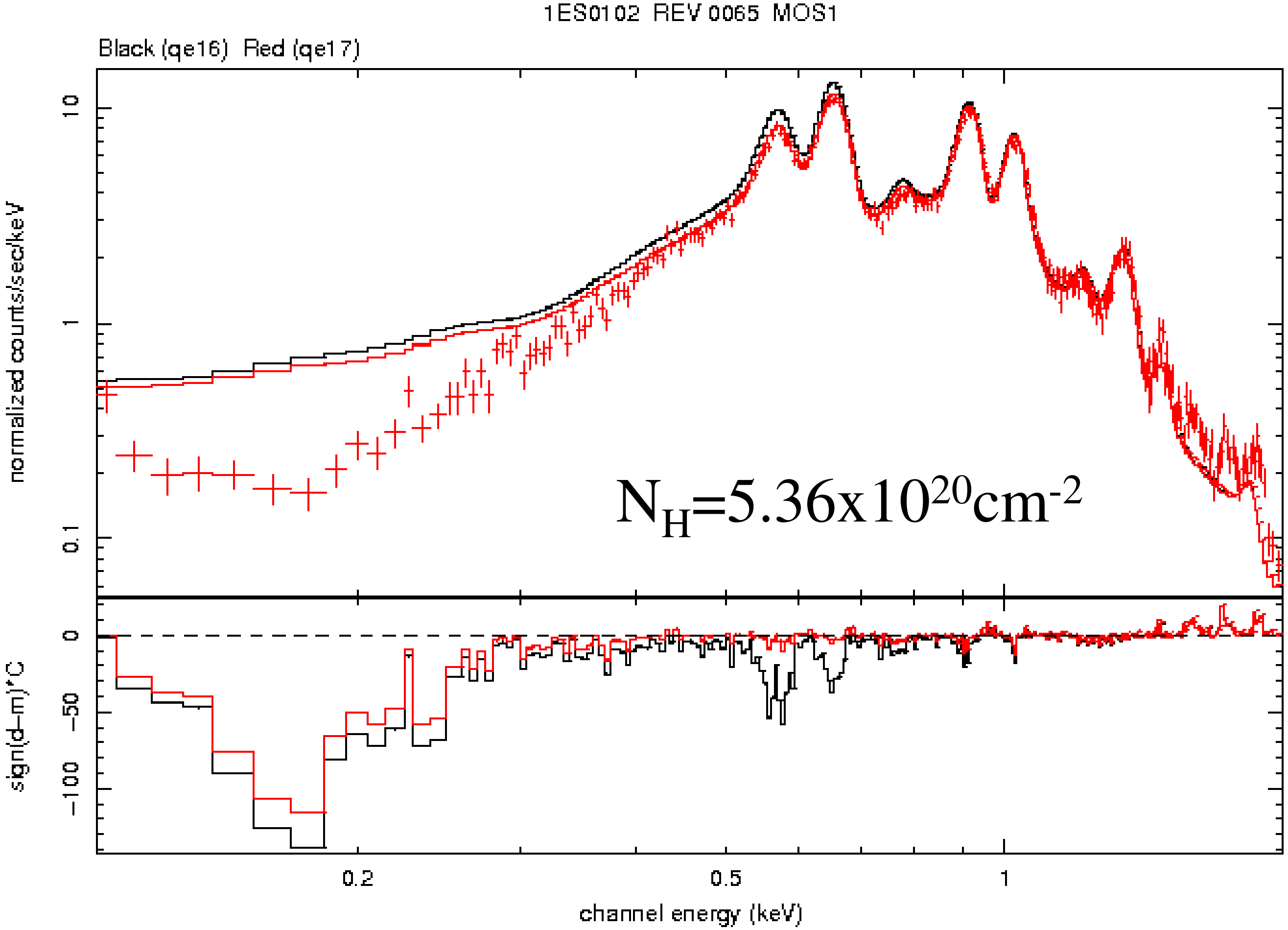
MOS1 v RGS model, 1ES0102 – Rev 0065



Const x (RGS model)

0.3-1.5 keV

MOS1

χ^2 = 3.65 -> 1.78

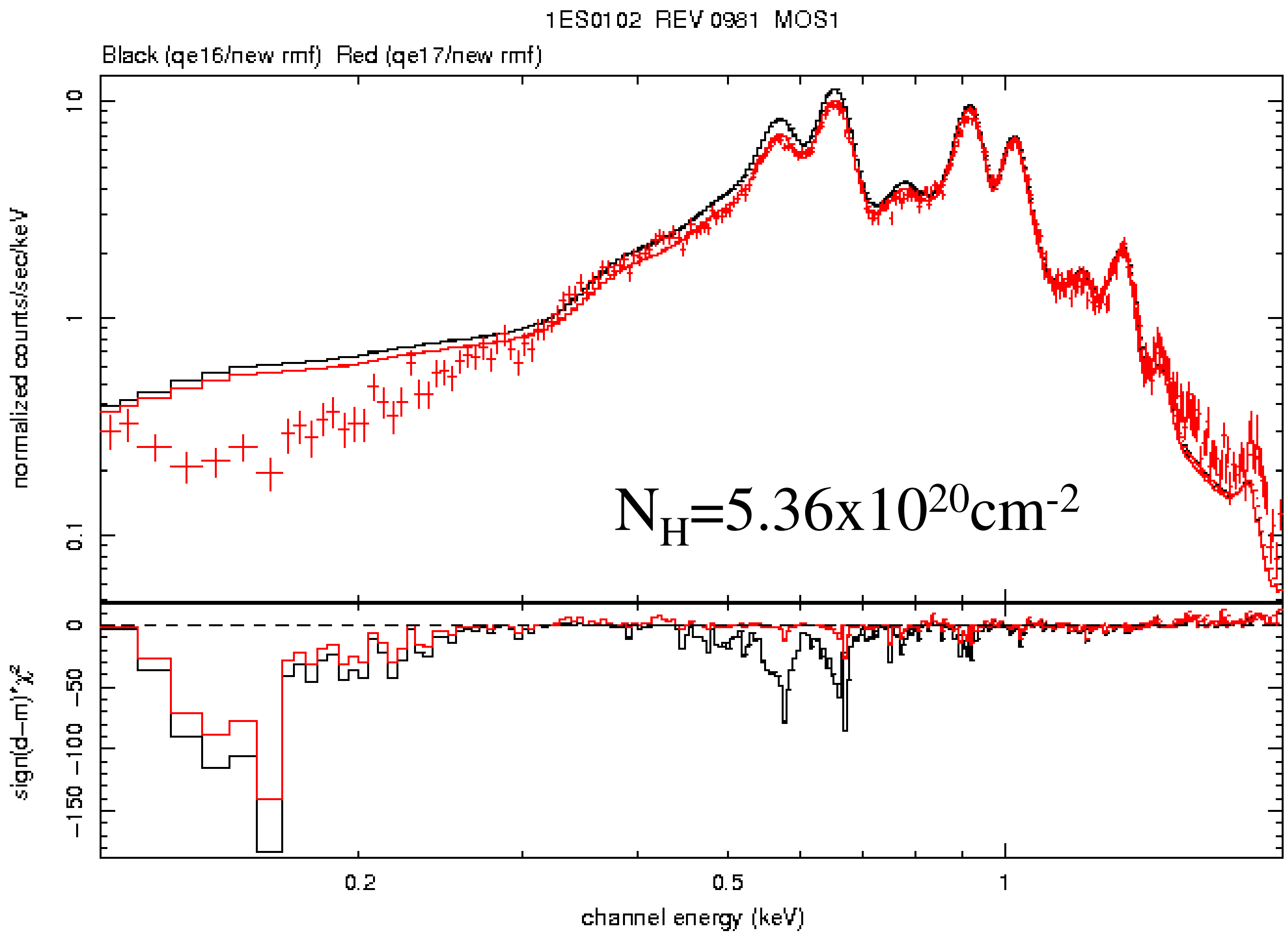
Const. 0.51 -> 0.80

MOS2

χ^2 = 3.70 -> 2.30

Const. 0.58 -> 0.90

MOS1 v RGS model, 1ES0102 – Rev 0981



Const x (RGS model)

0.3-1.5 keV

MOS1

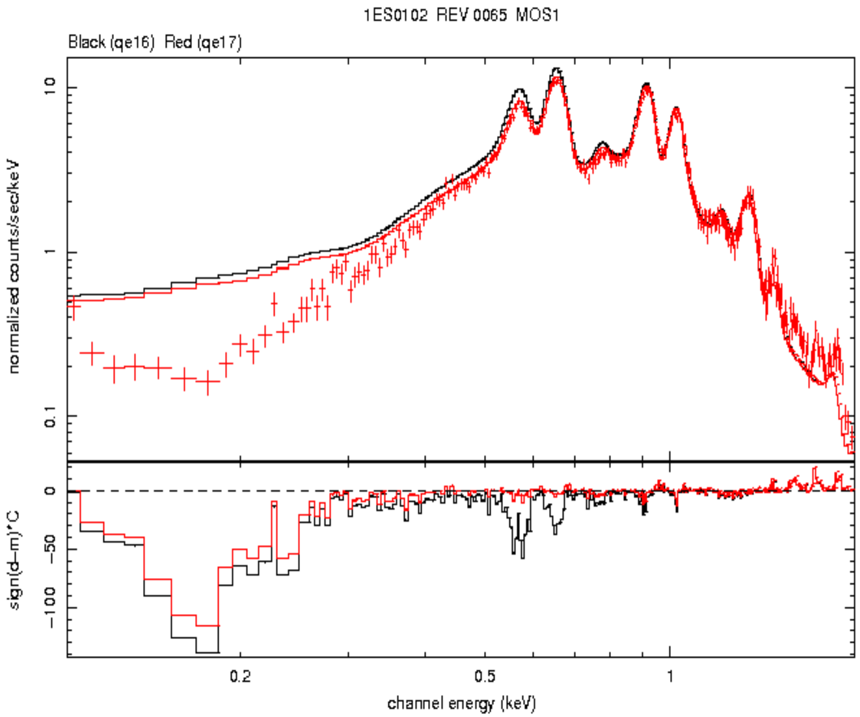
χ^2 = 5.47 -> 2.16

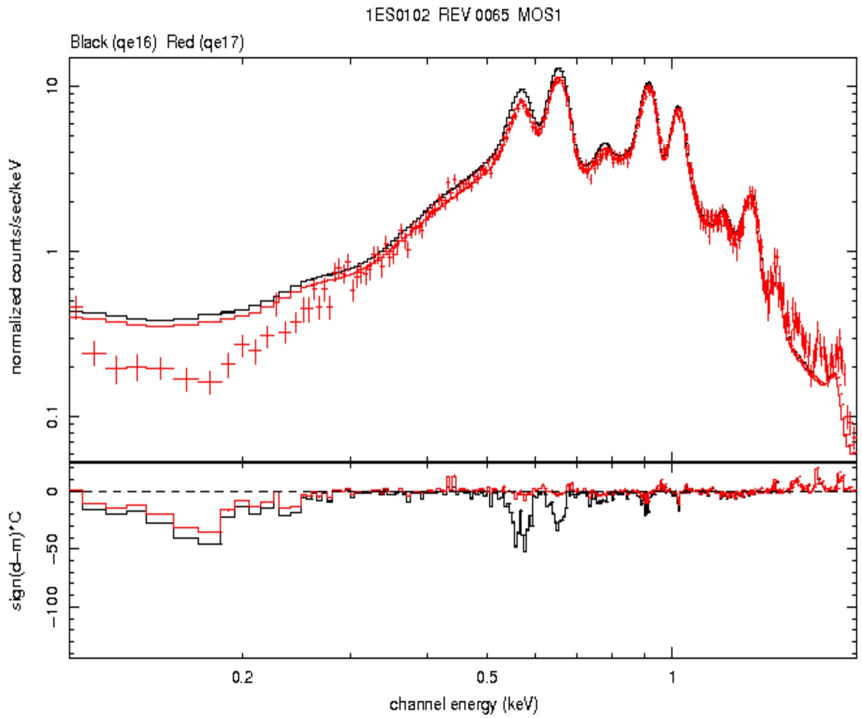
Const. 0.39 -> 0.74

MOS2

χ^2 = 7.46 -> 2.62

Const. 0.33 -> 0.70

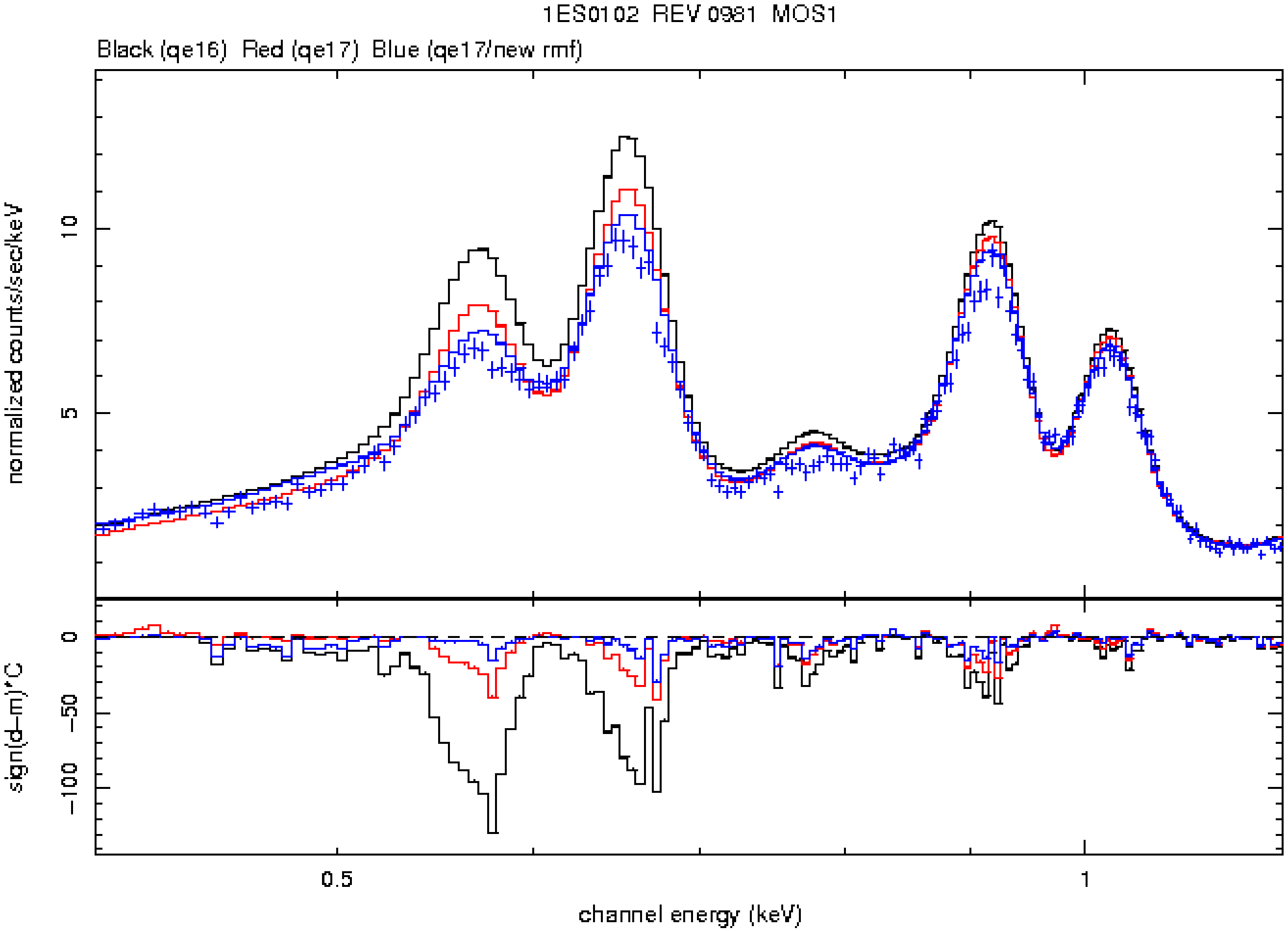




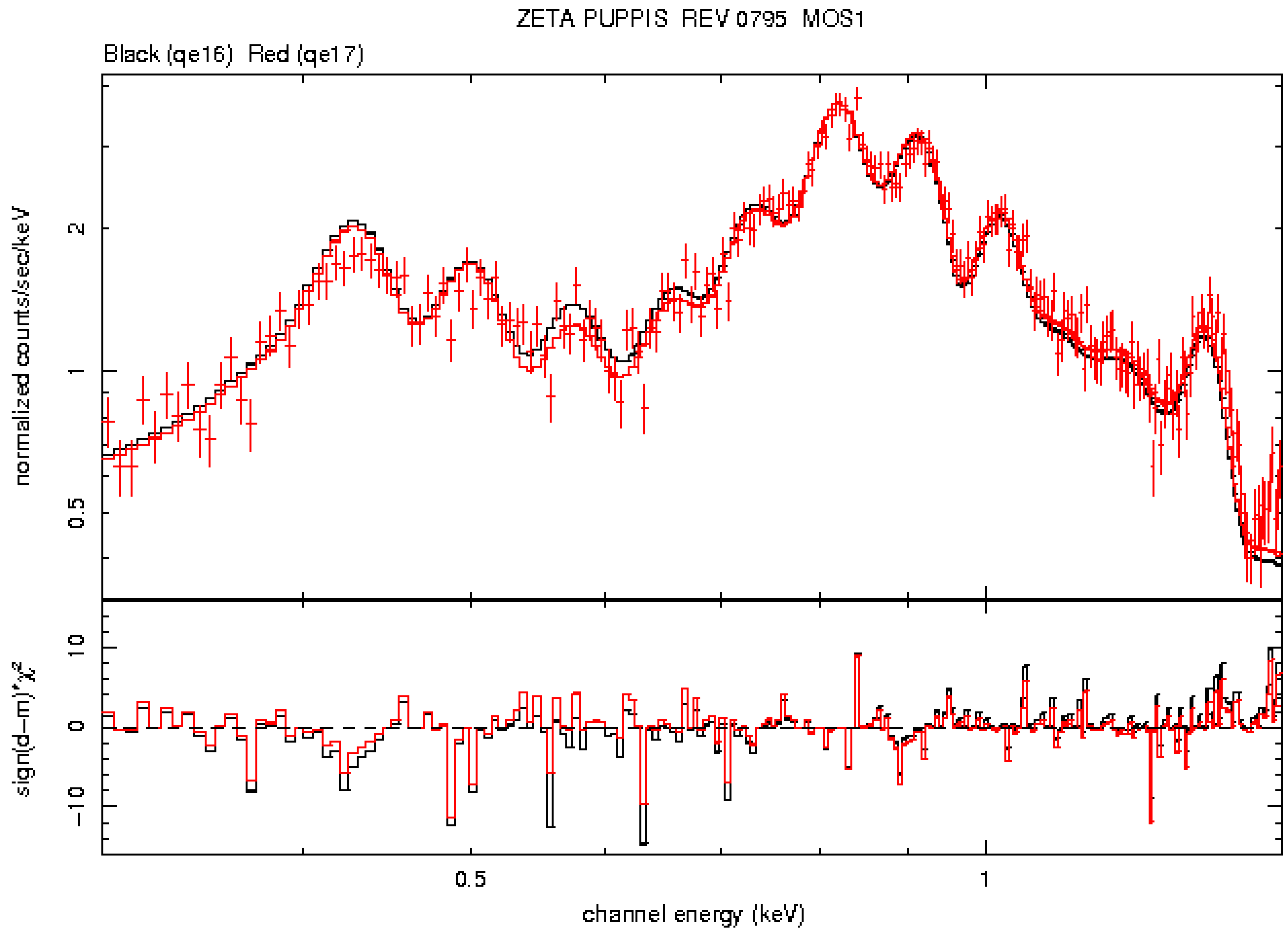
N_H=5.36x10^{20}cm^{-2}

N_H=8.00x10^{20}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

χ^2 = 1.69 -> 1.49

Const. 1.05 -> 1.12

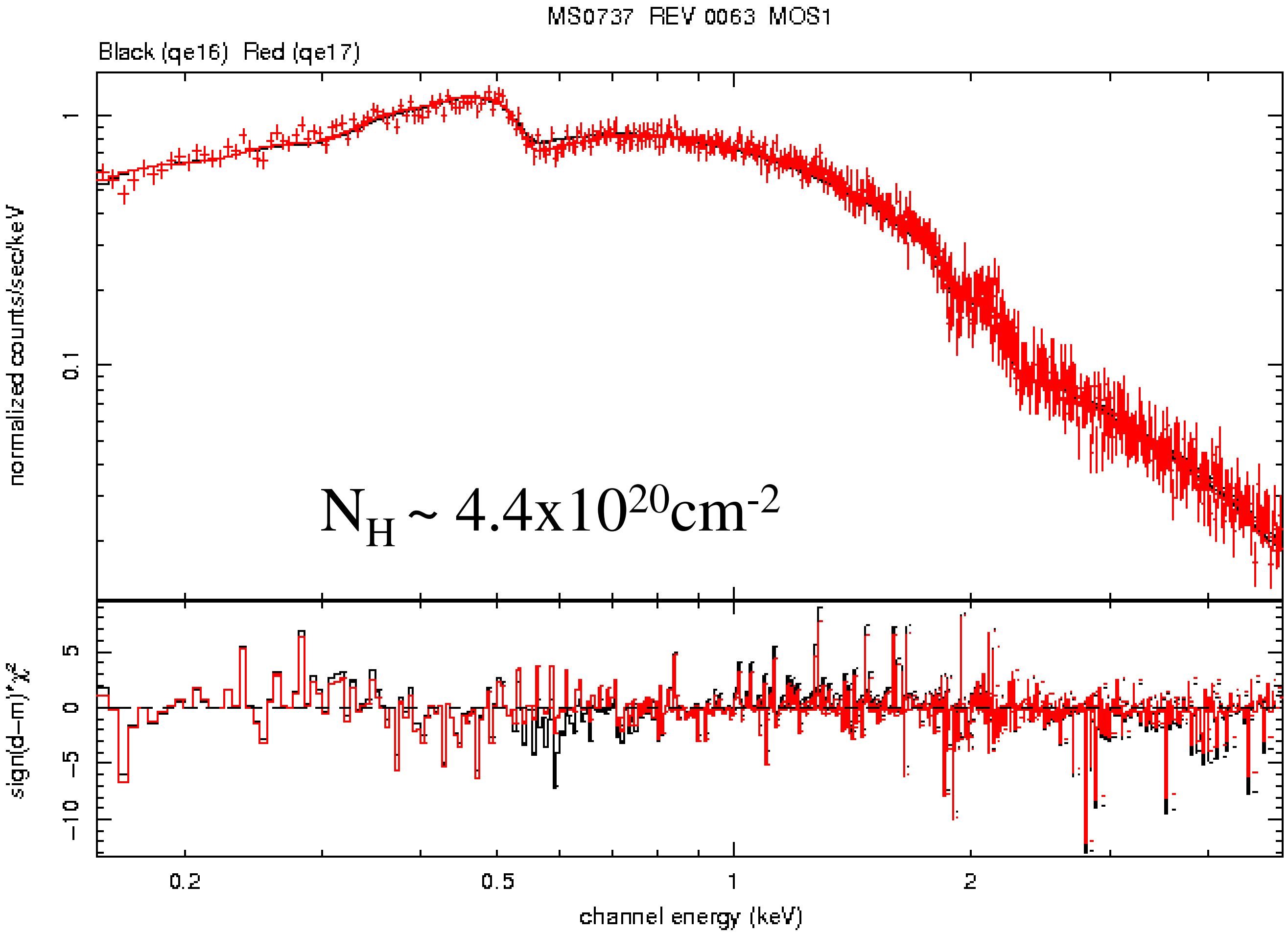
MOS2

χ^2 = 1.76 -> 1.51

Const. 1.07 -> 1.15

Independent astrophysical evidence ?

Spectral fitting to relatively high column density BL Lac



TBABS * PO

Wilms abund

0.15-5.0 keV

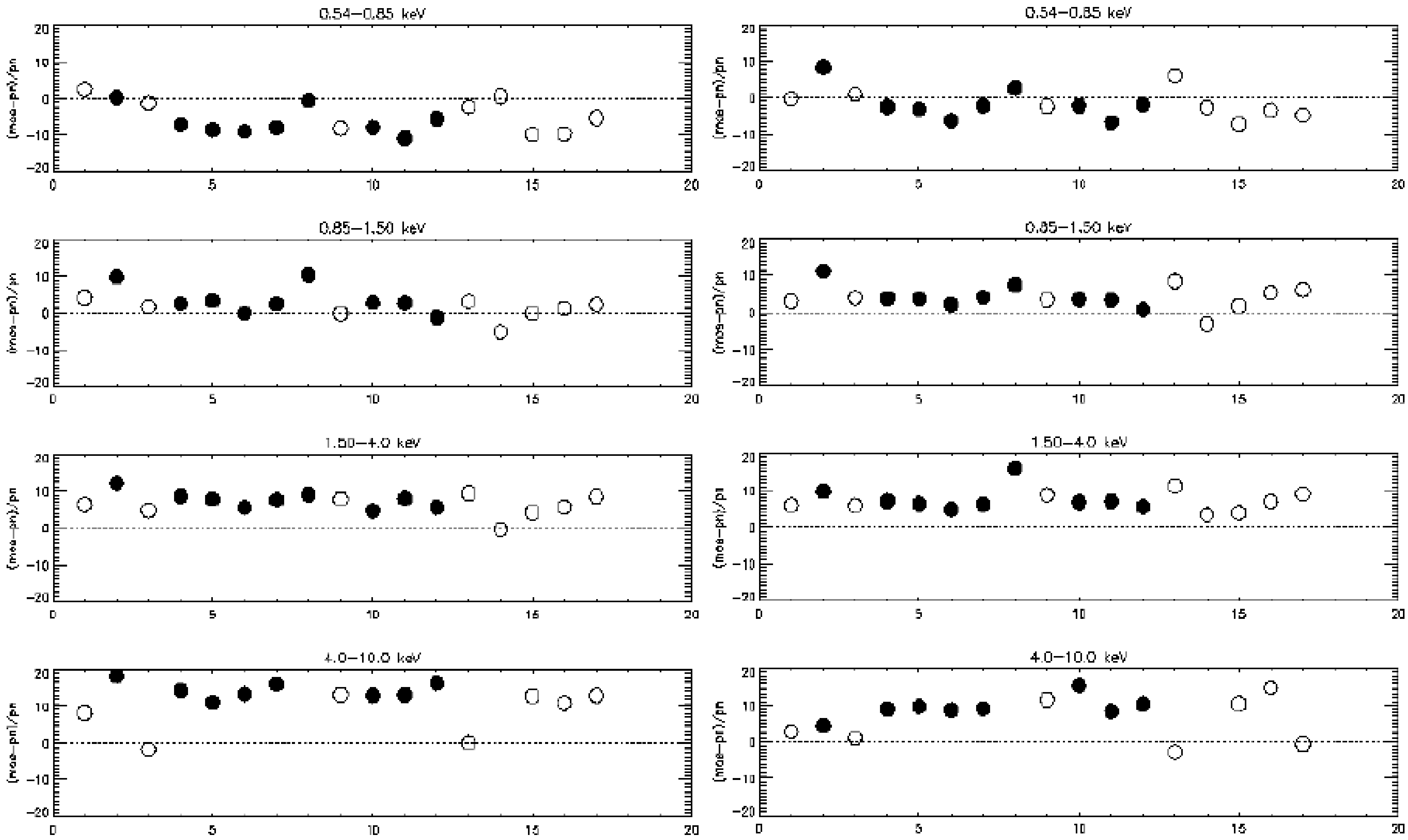
MOS1

$\chi^2 = 1.13 \rightarrow 1.06$

MOS2

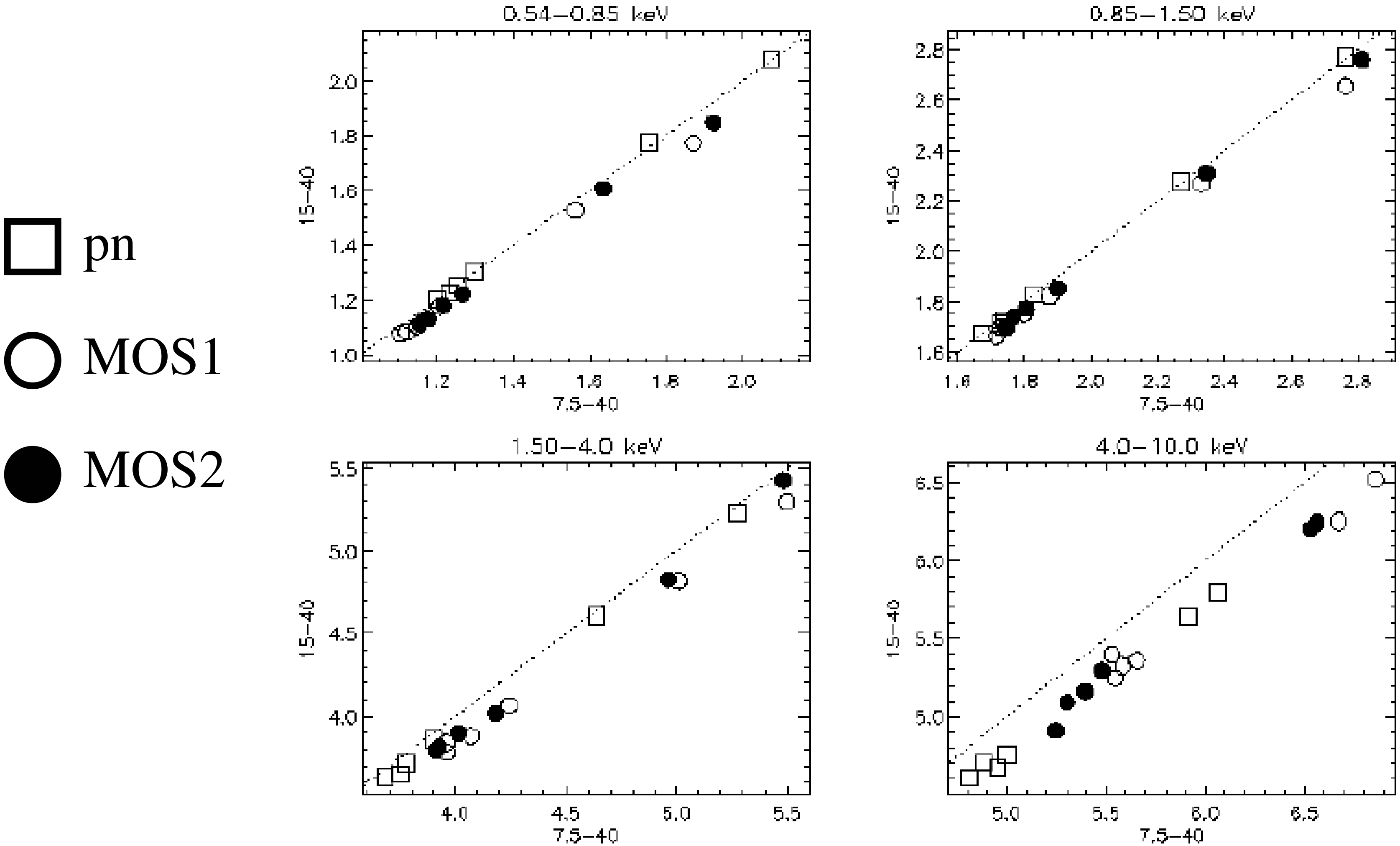
$\chi^2 = 1.16 \rightarrow 1.08$

(MOS1-PN)/PN ○ Thin ● Medium (MOS2-PN)/PN



Problem with the psf? – See talk by Andy later

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



XMM
EPIC
MOS

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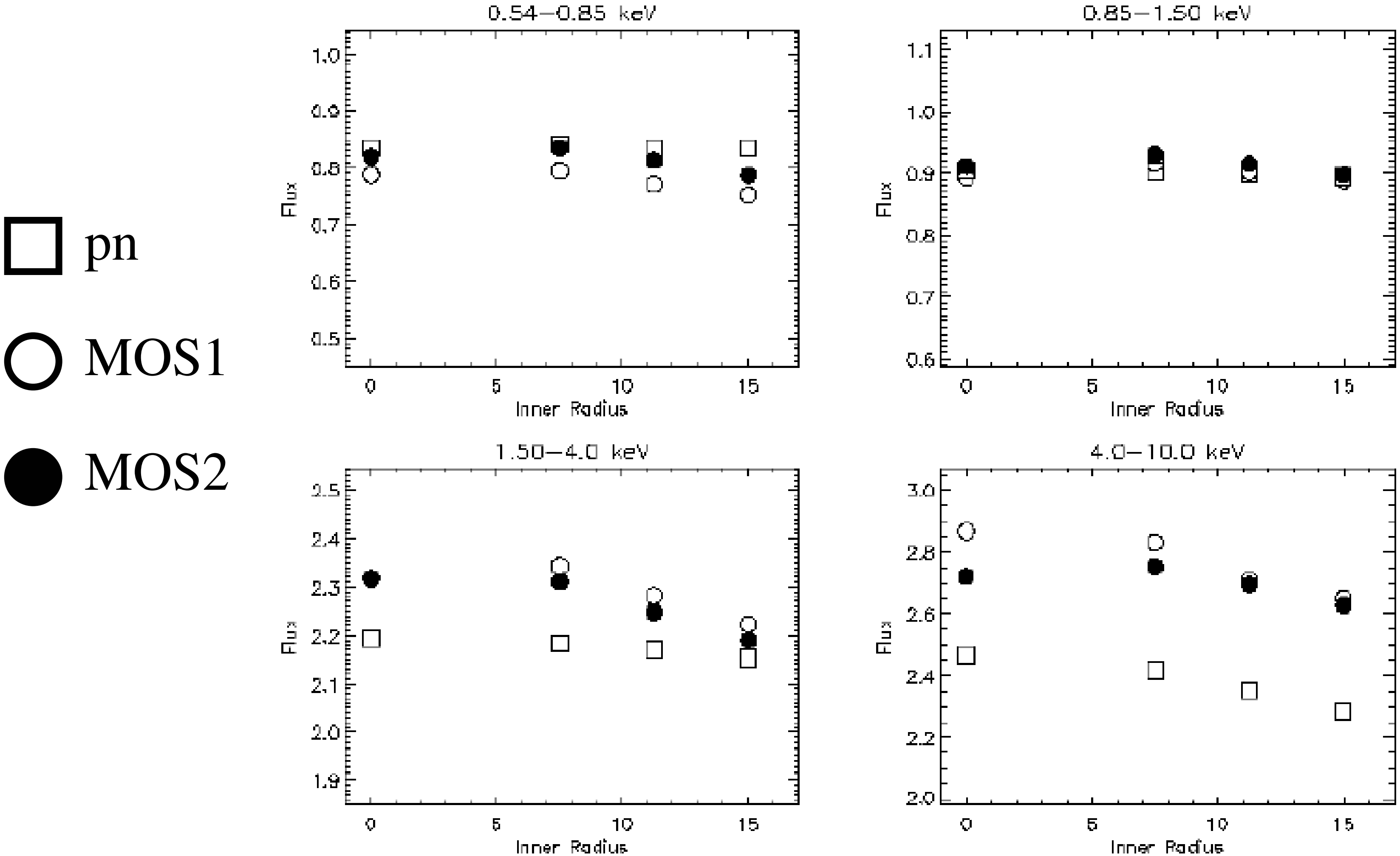
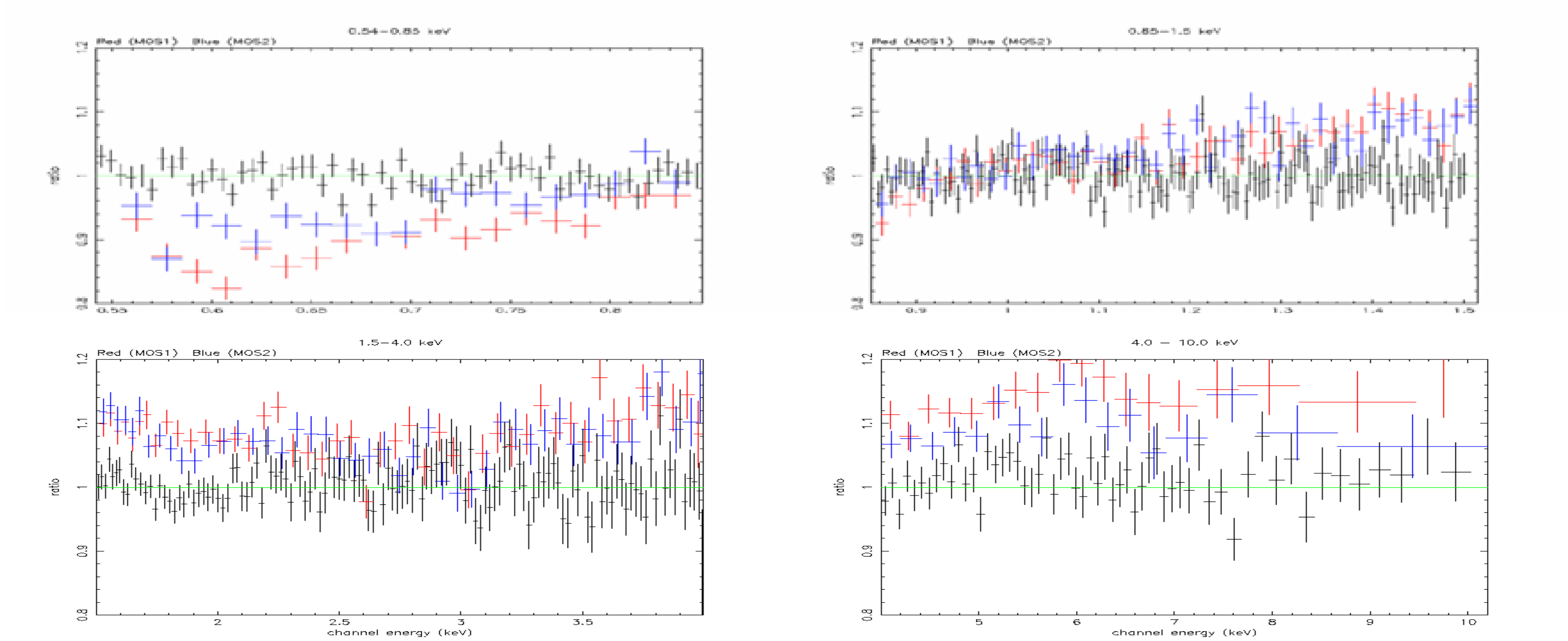
Problem with the psf? – See talk by Andy later

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





Band (keV)	(MOS1-PN)/PN	(MOS2-PN)/PN
0.54-0.85	-5.4%	-1.6%
0.85-1.50	+2.4%	+4.1%
1.50-4.0	+6.8%	+7.3%
4.0-10.0	+11.4%	+7.4%

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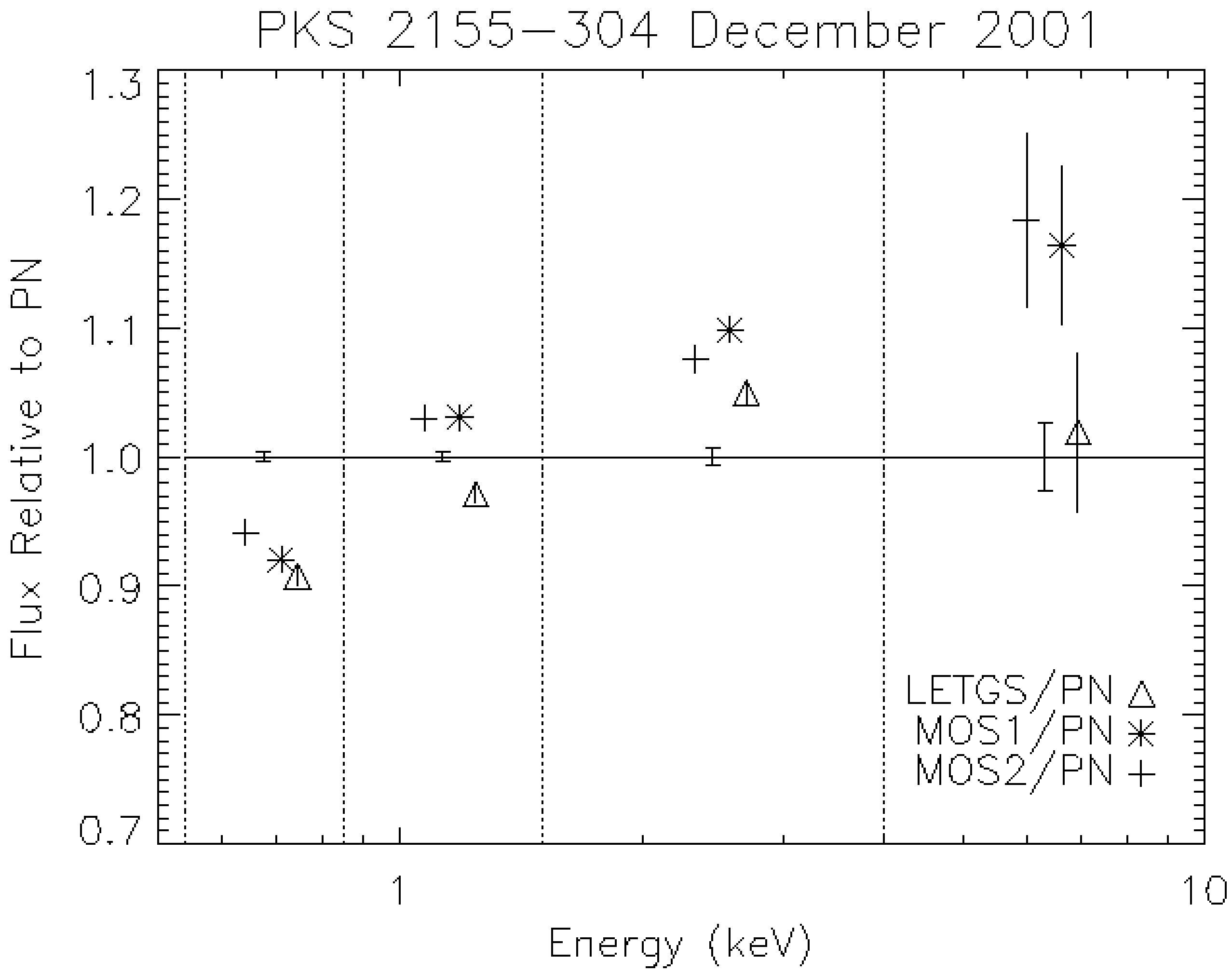
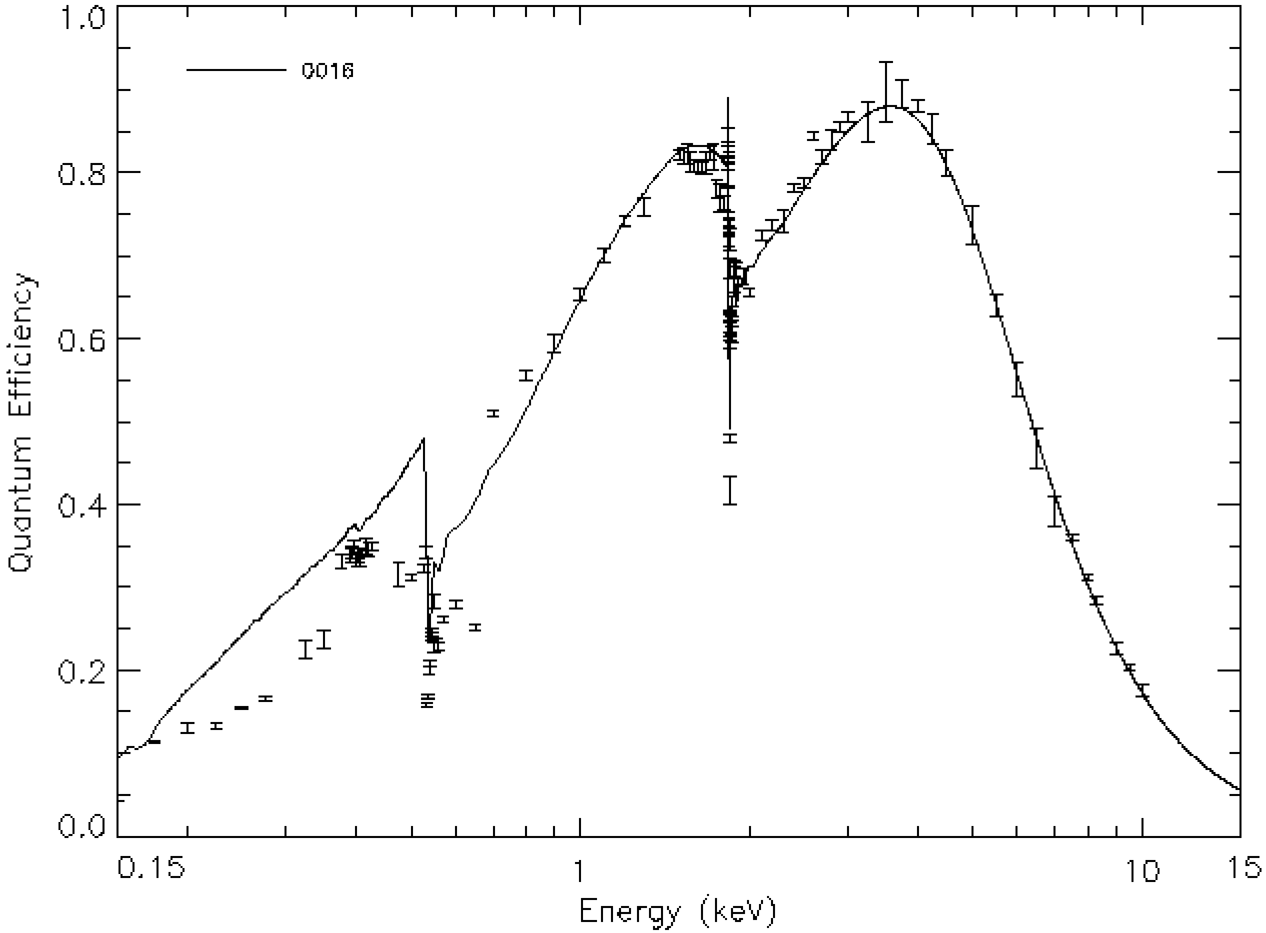
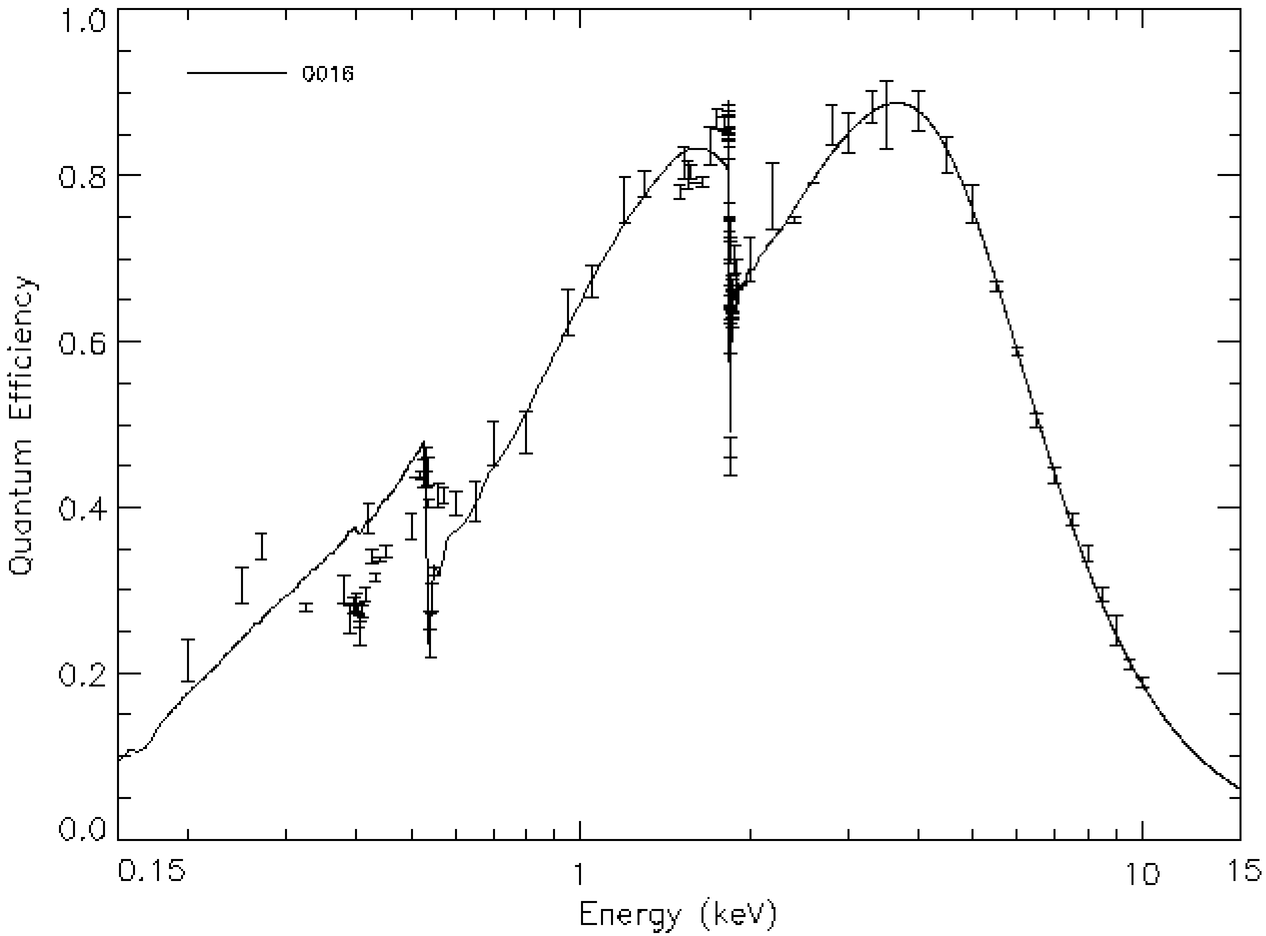

PKS 2155−304 December 2001
Flux Relative to PN
Energy (keV)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
1
10
LETGS/PN
MOS1/PN
MOS2/PN

Quantum Efficiency measurements from Orsay
MOS1 – Central CCD

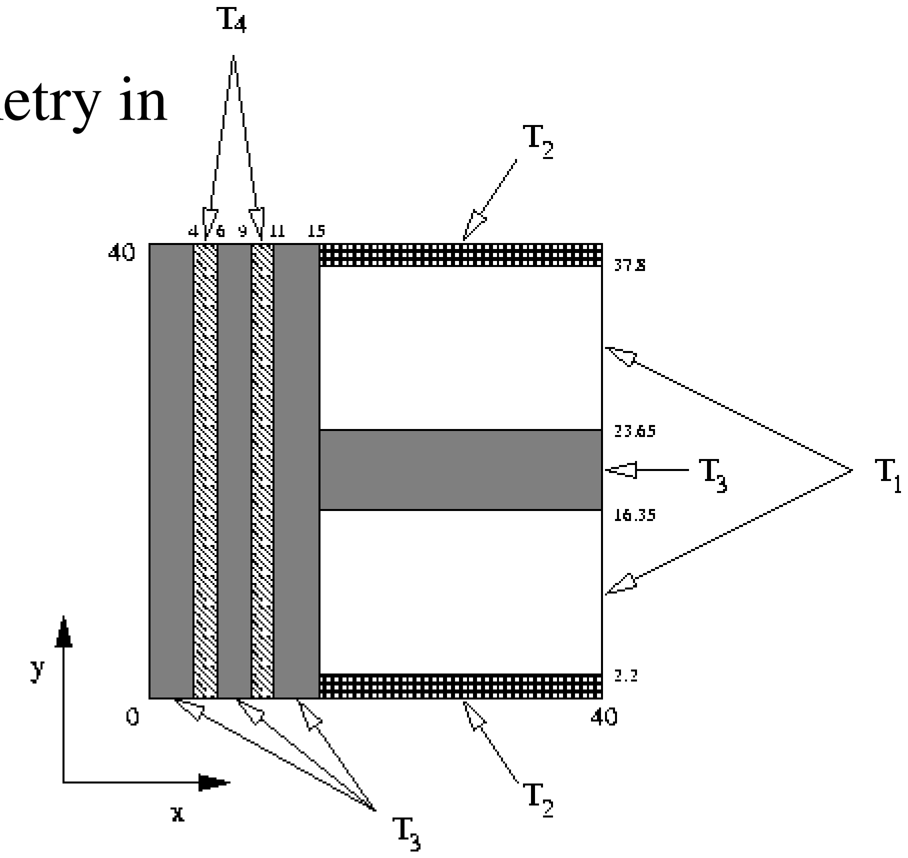


Quantum Efficiency measurements from Orsay

MOS2 – Central CCD

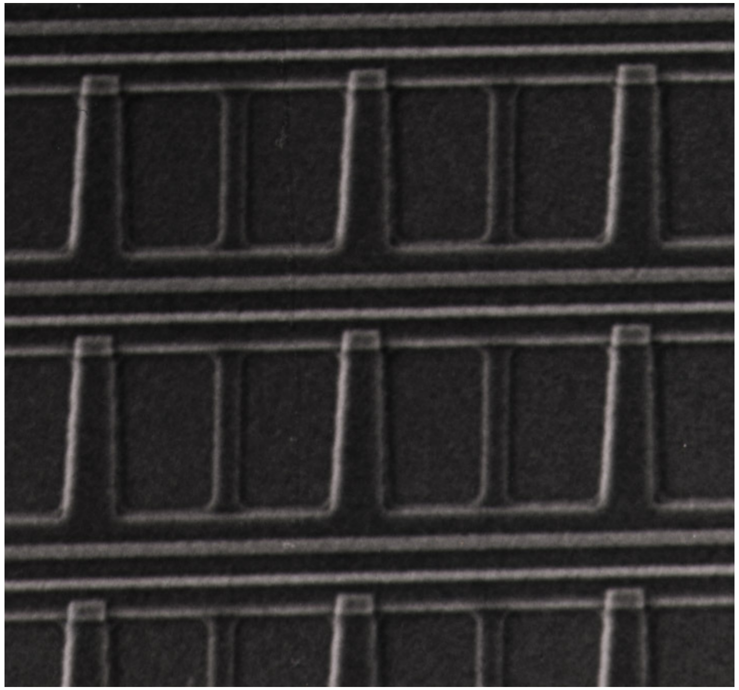


Surface Pixel Geometry in Monte Carlo model



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

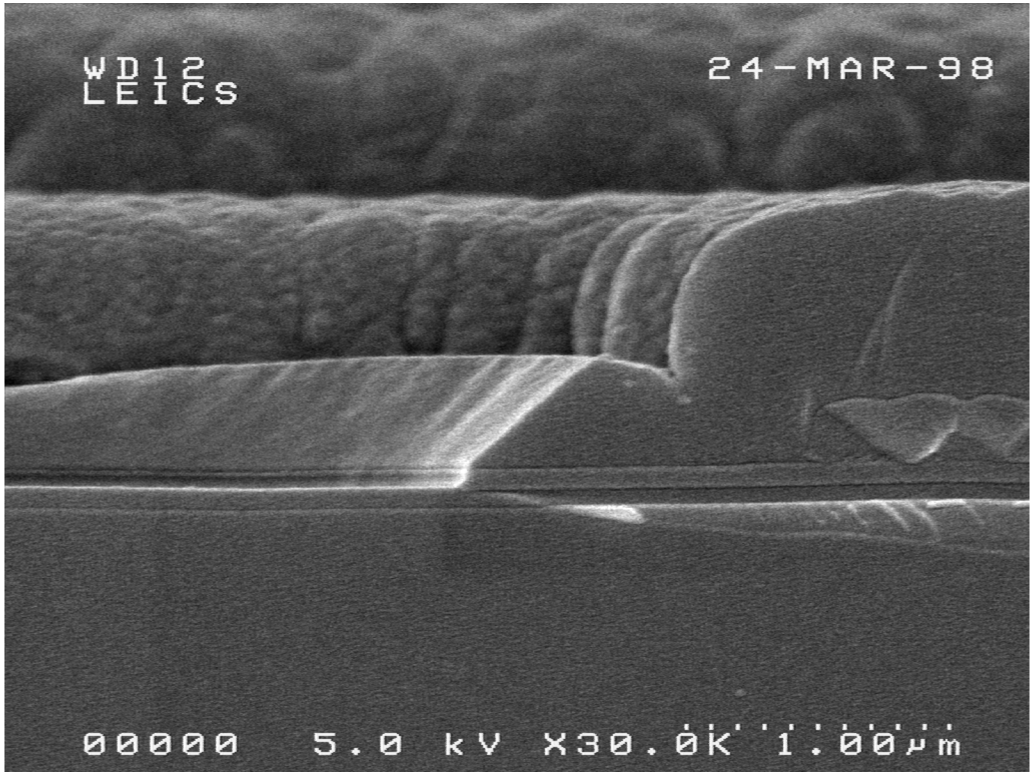
$$
\begin{aligned}
T_1 &= \exp(-0.1\,\mu_{SiO_2}) \\
T_2 &= T_1 \exp(-0.1\,\mu_{Si_3N_4}) \exp(-0.4\,\mu_{SiO_2}) \\
T_3 &= T_2 \exp(-0.25\,\mu_{Si}) \exp(-0.3\,\mu_{SiO_2}) \\
T_4 &= T_3 \exp(-0.25\,\mu_{Si}) \exp(-0.4\,\mu_{SiO_2})
\end{aligned}
$$



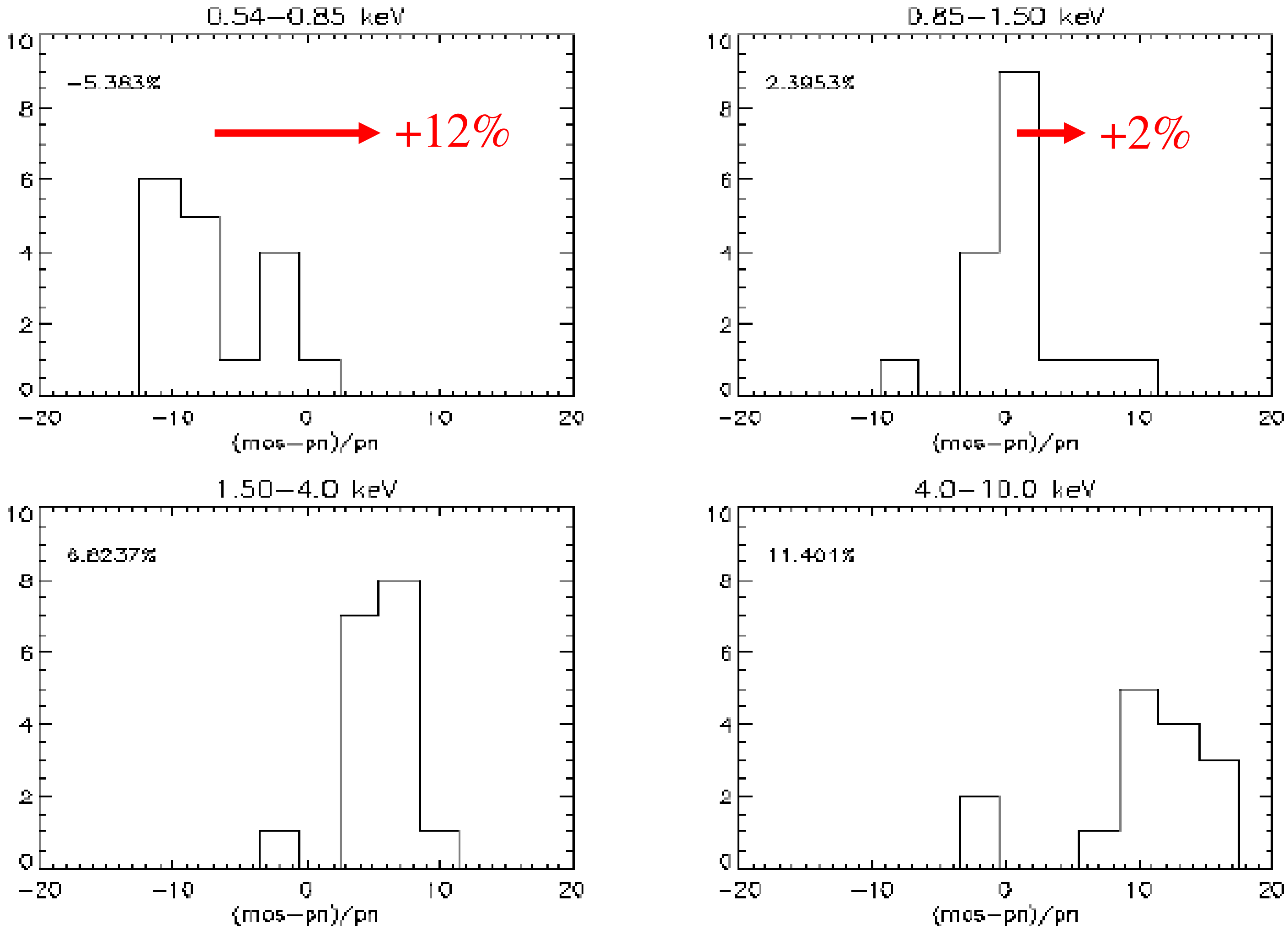
Top View

SEM Pictures

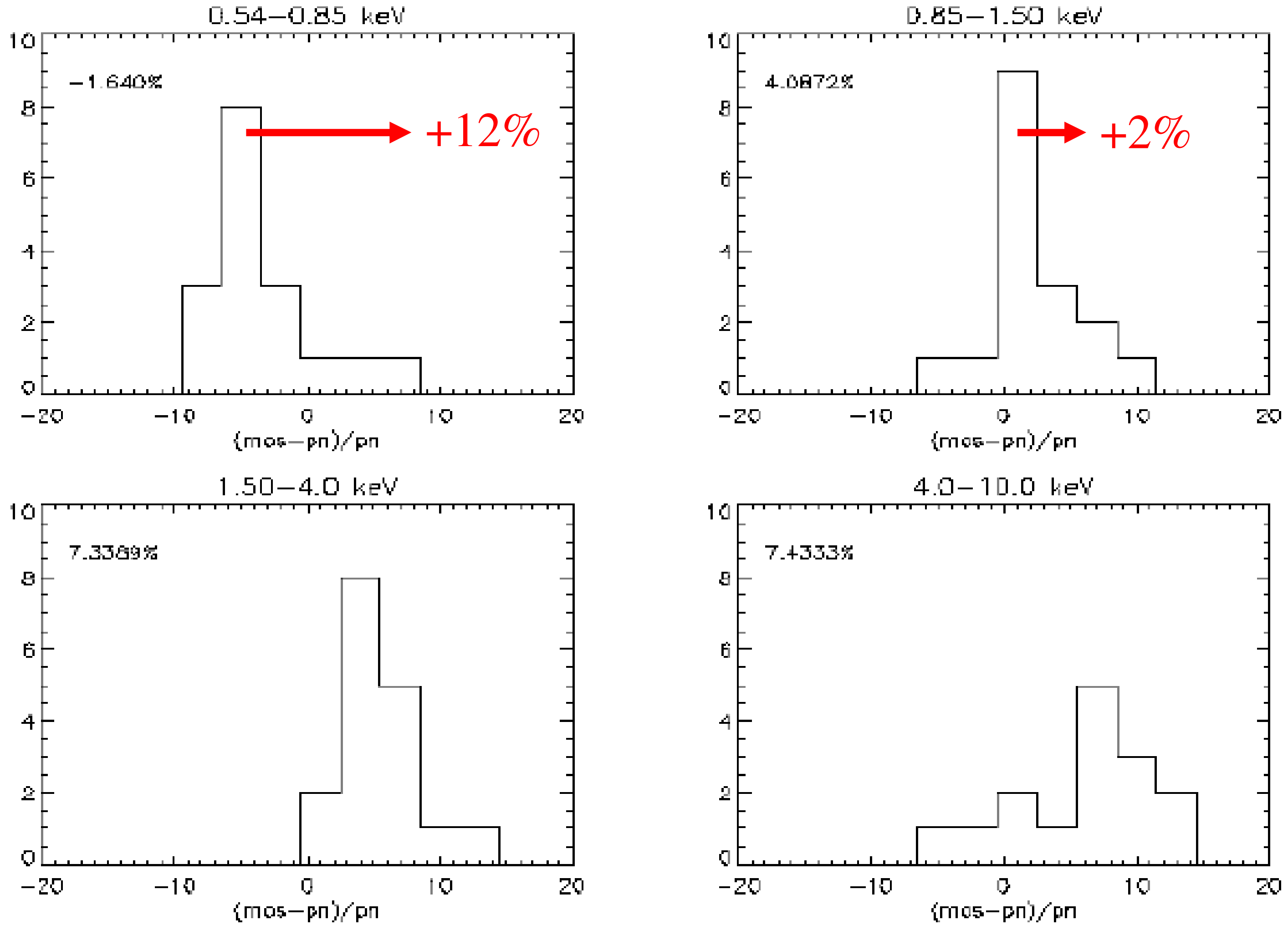
Side View



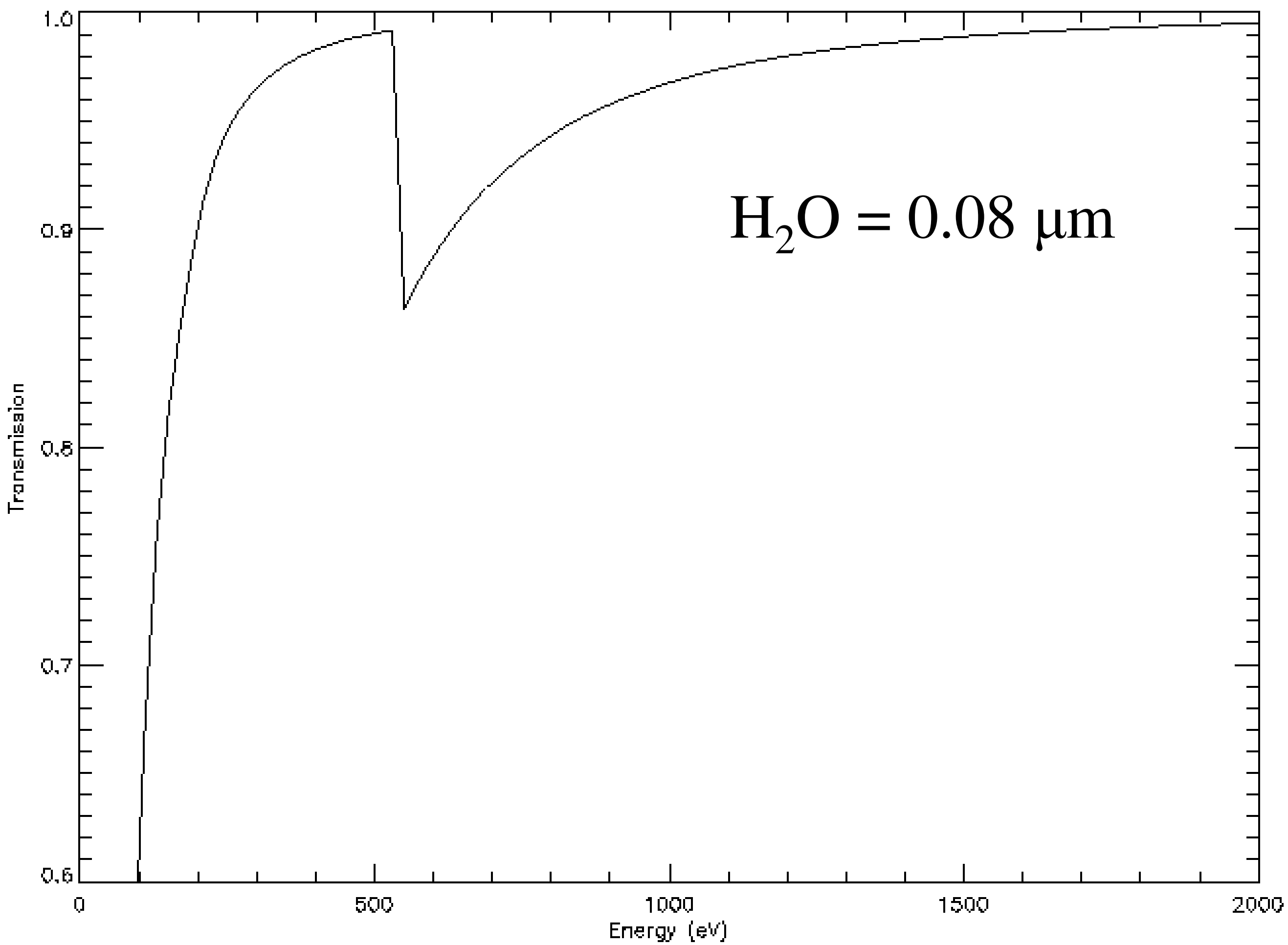
(MOS1-PN)/PN


0.54–0.85 keV
-5.383%
+12%
0.85–1.50 keV
2.3953%
+2%
1.50–4.0 keV
6.8237%
4.0–10.0 keV
11.401%
(mos–pn)/pn

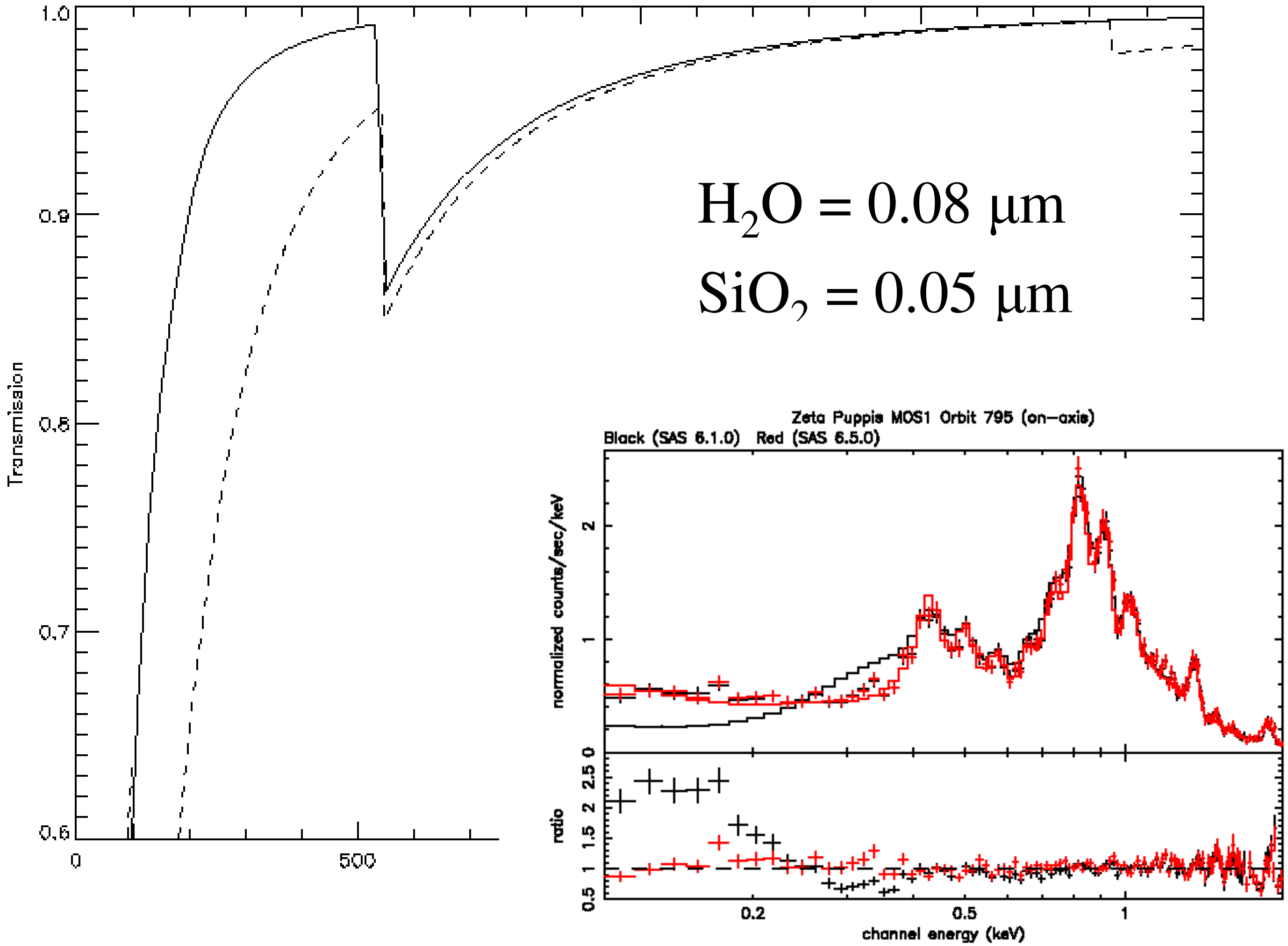
(MOS2-PN)/PN



0.54–0.85 keV
-1.640%
+12%
0.85–1.50 keV
4.0872%
+2%
1.50–4.0 keV
7.3389%
4.0–10.0 keV
7.4333%
(mos–pn)/pn

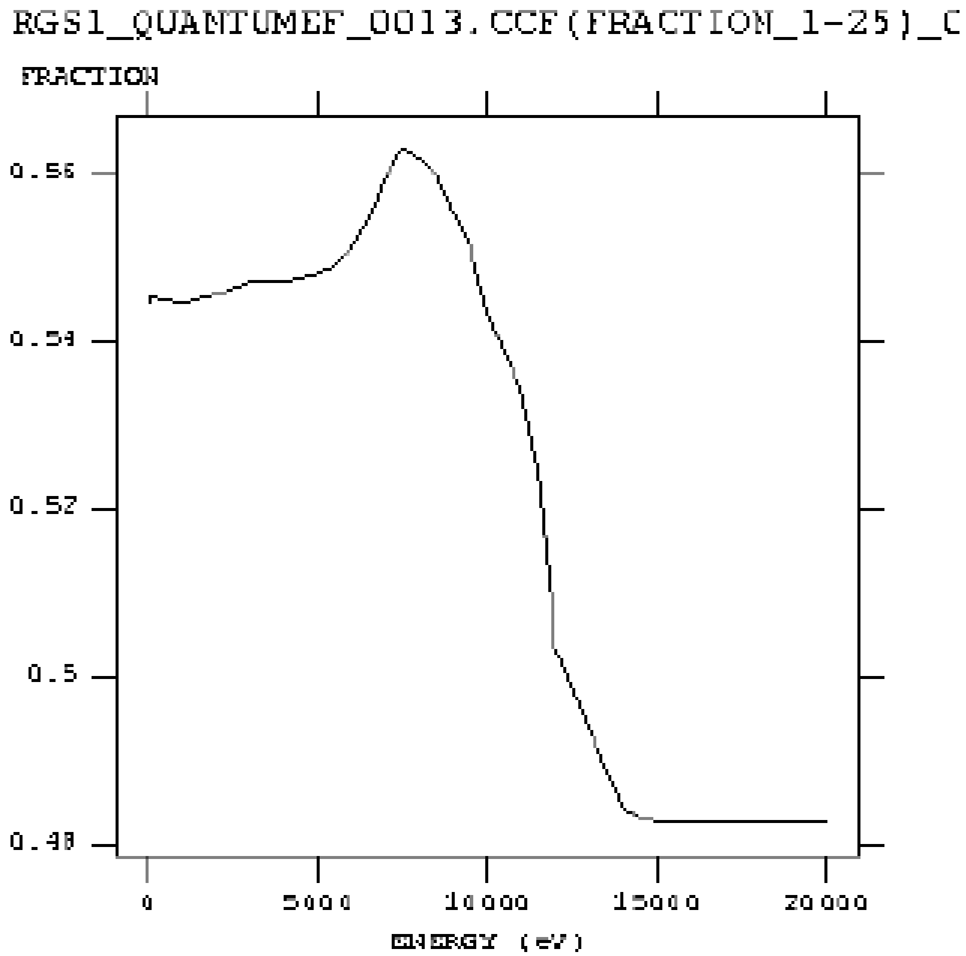


1.0
0.9
0.8
0.7
0.6
Transmission
0
500
1000
1500
2000
Energy (eV)
H2O = 0.08 µm



$H_2O = 0.08$ µm

$SiO_2 = 0.05$ µm


RGS1_QUANTUMEF_0013.CCF(FRACTION_1-25)_C
FRACTION
0.56
0.54
0.52
0.5
0.48
0
5000
10000
15000
20000
ENERGY (eV)

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