Absolute effective area of the Chandra telescope

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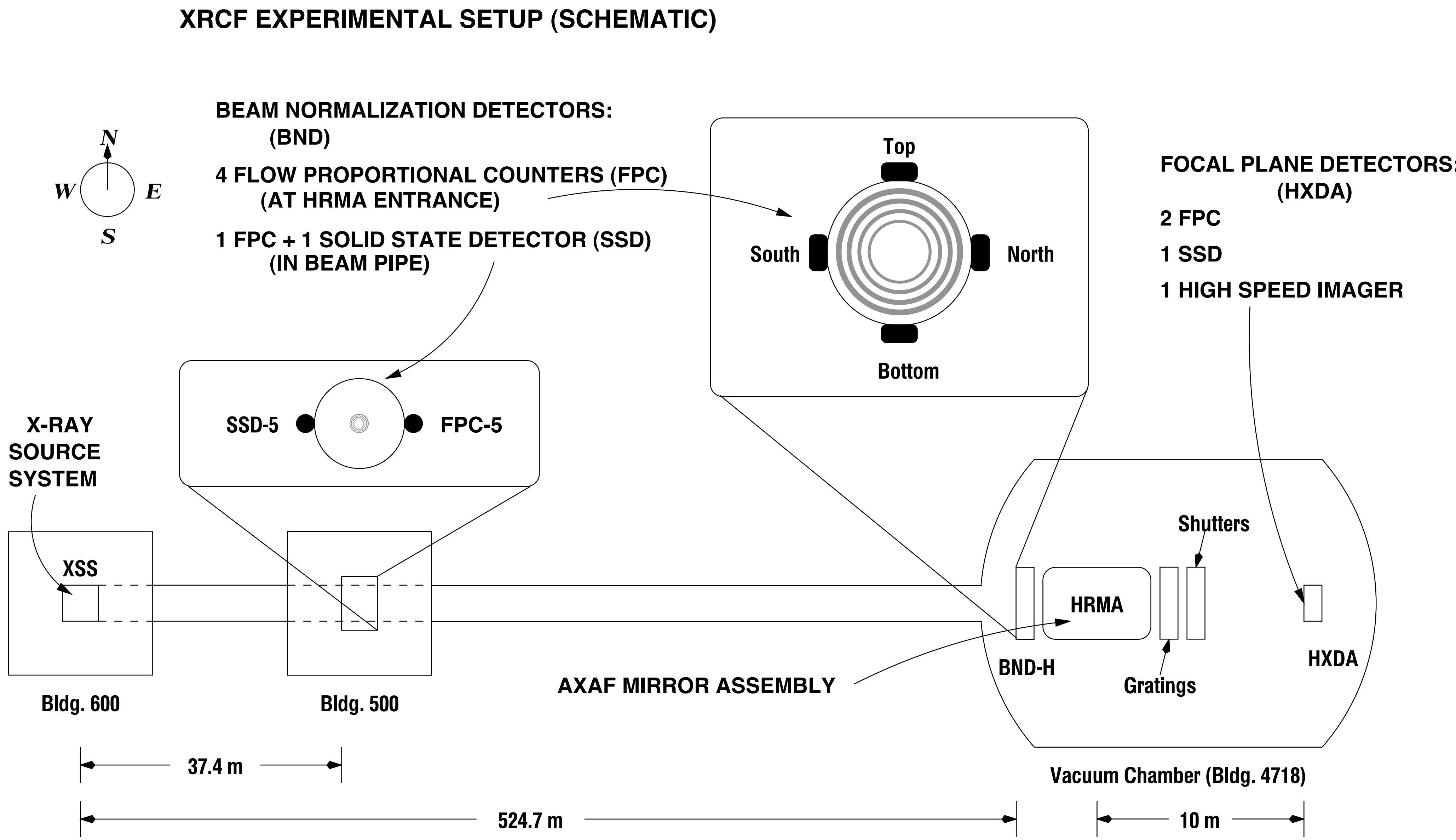
w/D. Jerius, P. Zhao, T. Gaetz, B. Wargelin et al.

IACHEC, Woods Hole, 19 Apr 2010



Schematic of the X-ray Calibration Facility (XRCF)

Effective Area =

$$\frac{\text{Count rate in focal plane detector}}{\text{Average flux in Beam Norm Detectors}}$$

However, comma...

The detectors are not quite identical =>
correct for QE differences

BND count rates are small =>
co-add multiple spectra, and add
in term for time stability error

High-fidelity raytrace SAOTrace apparently overestimates effective areas, for reasons that are not clear.

In 2008 we added a mirror hydrocarbon overlayer to the raytrace model, and adjusted the thicknesses to fit continuum data (taken with SSDs).

Verified overlayer thicknesses with HETG data at Ir M edge near 2 keV

Correction factors of approx 93% (vary by shell) were taken to be gray, and extrapolated to zero energy.

Shell	CH2 thickness	Gray correction
1	28 A	90.1%
3	18 A	94.6%
4	20 A	96.2%
6	27 A	94.7%

2009/2010 Progress

New model of SSD pileup:
small changes continuum Aeff curve.

Re-analysis of spectral line data brings them into better agreement with SSD continuum data

Grey is beautiful!
New data are in close agreement with released curve

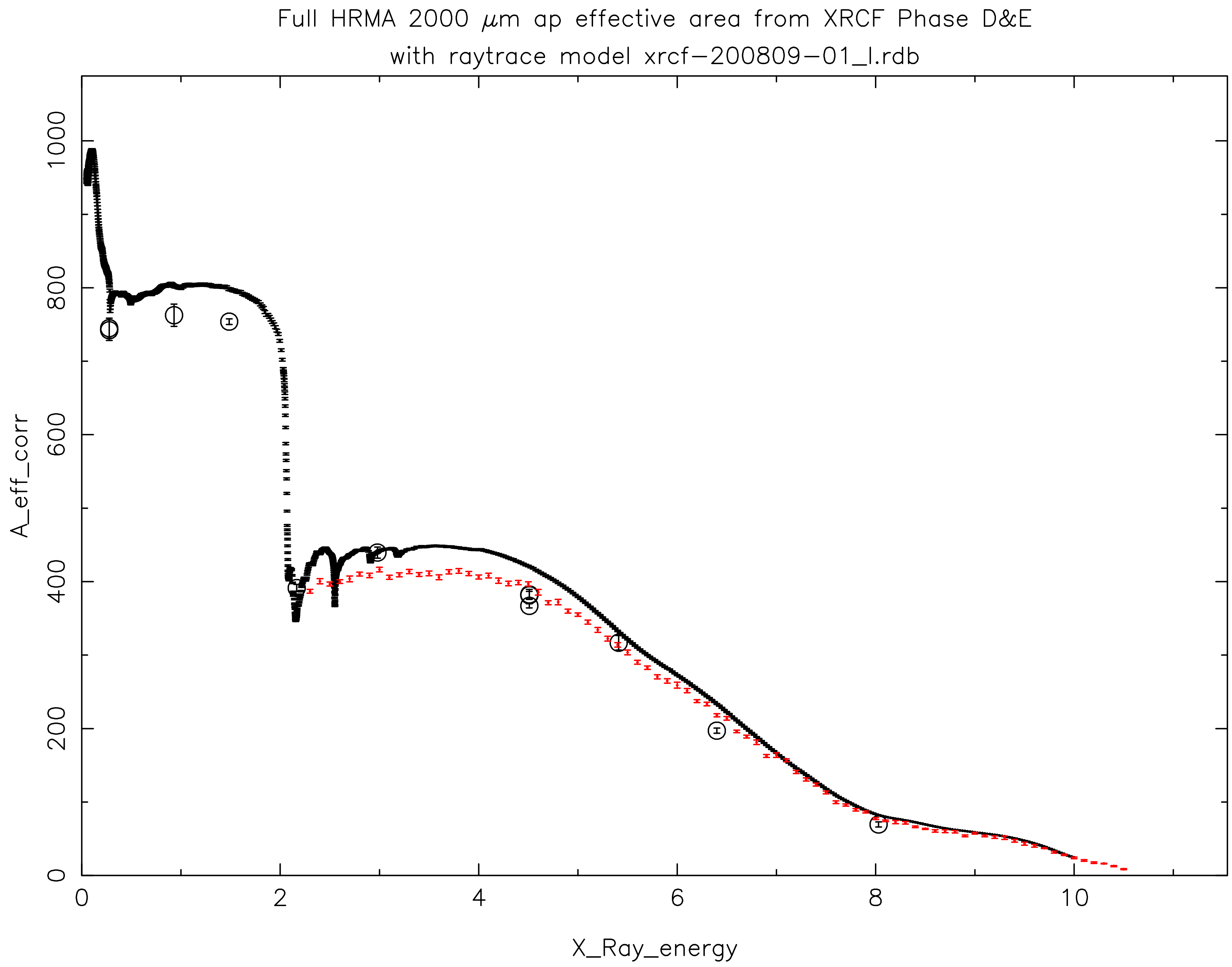
Legend for the plots that follow

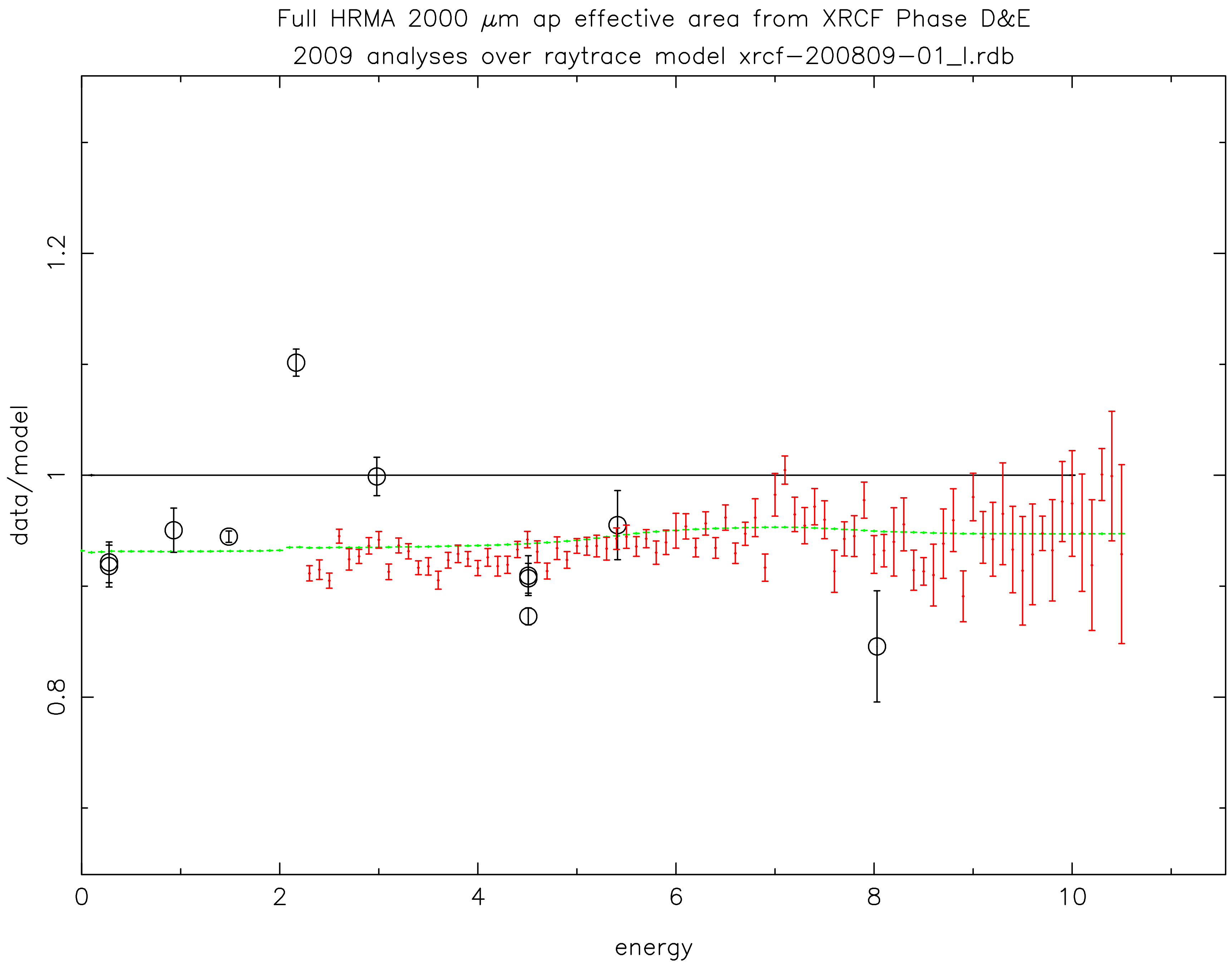
Heavy line--Raytrace model

Circles--Spectral line data

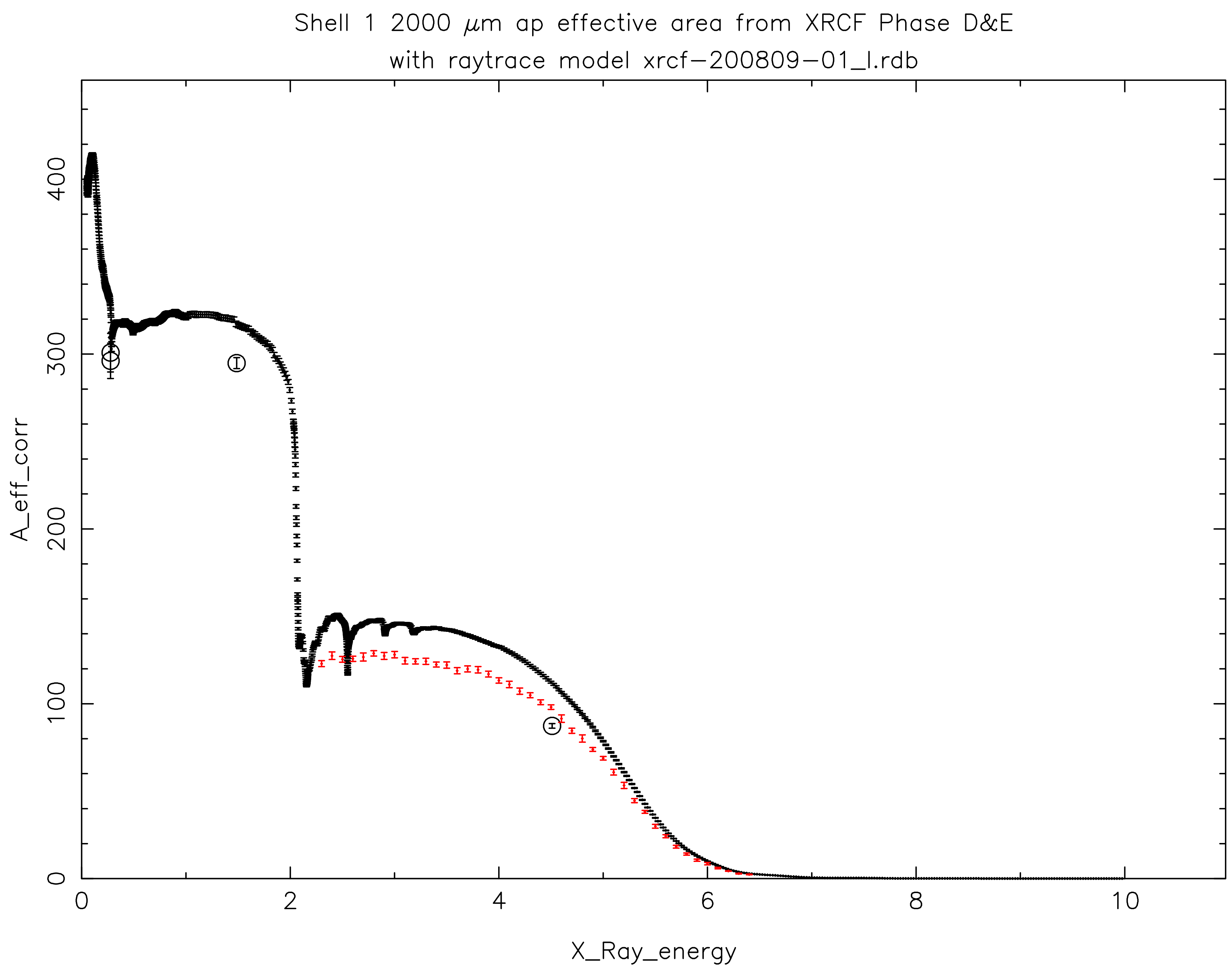
Red--SSD continuum data

Green--Raytrace correction factors
(as released)


Full HRMA 2000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf−200809−01_l.rdb
A_eff_corr
X_Ray_energy
0
200
400
600
800
1000
0
2
4
6
8
10



Full HRMA 2000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
energy
0.8
1
1.2
0
2
4
6
8
10


Shell 1 2000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf-200809-01_l.rdb
A_eff_corr
X_Ray_energy
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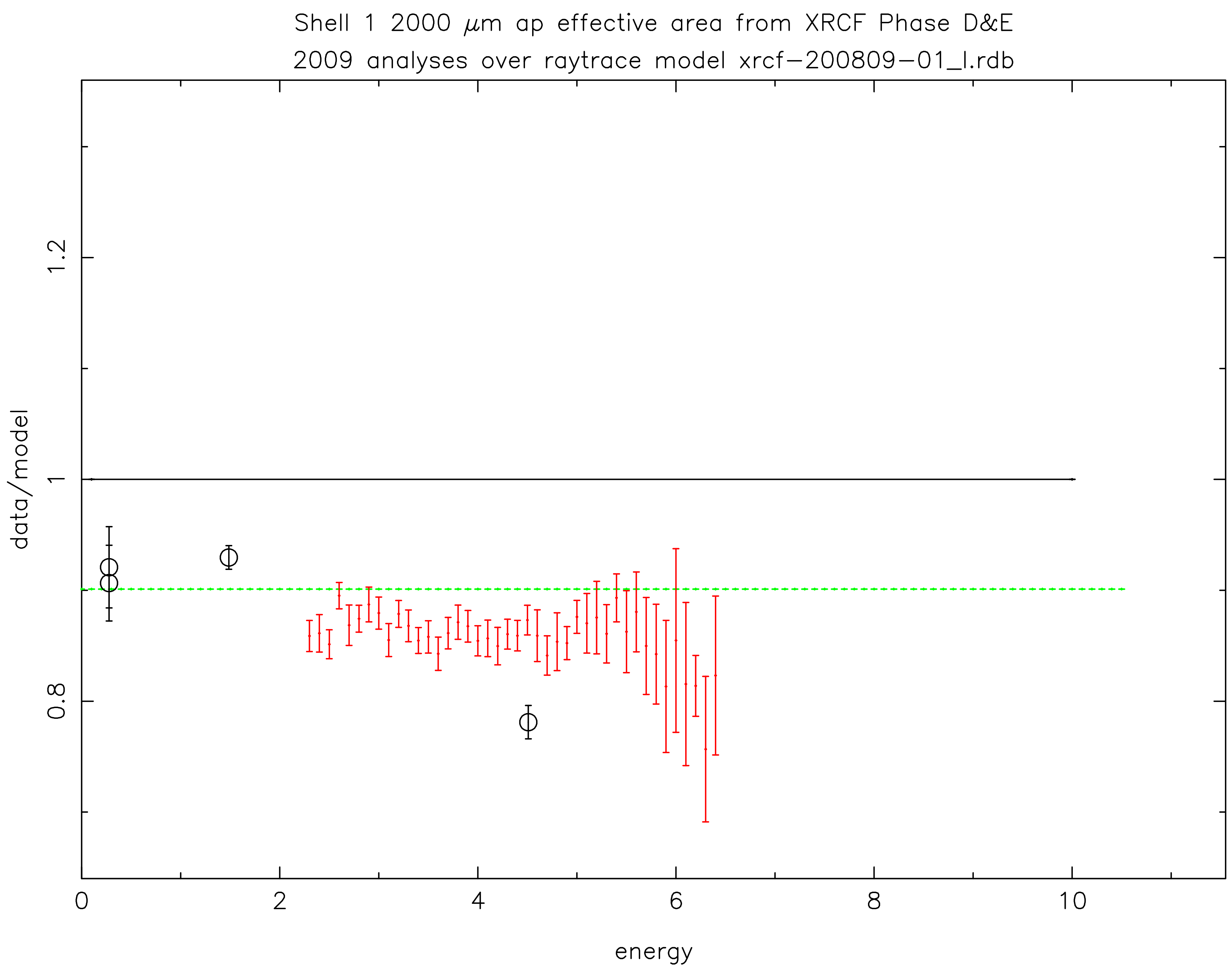
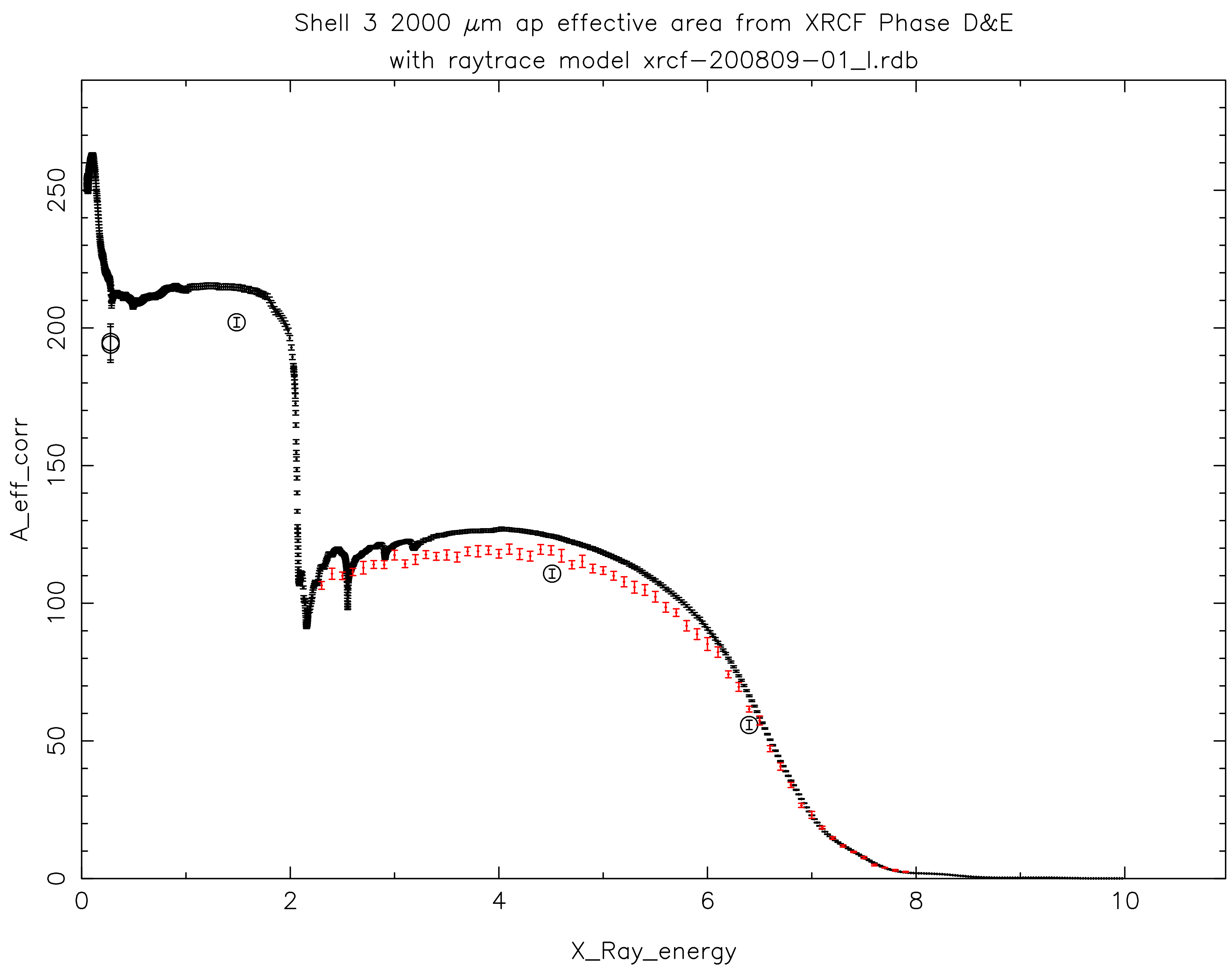
100
200
300
400
0
2
4
6
8
10


Shell 1 2000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
1.2
1
0.8
0
2
4
6
8
10
energy



Shell 3 2000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf–200809–01_l.rdb
A_eff_corr
X_Ray_energy
0
50
100
150
200
250
0
2
4
6
8
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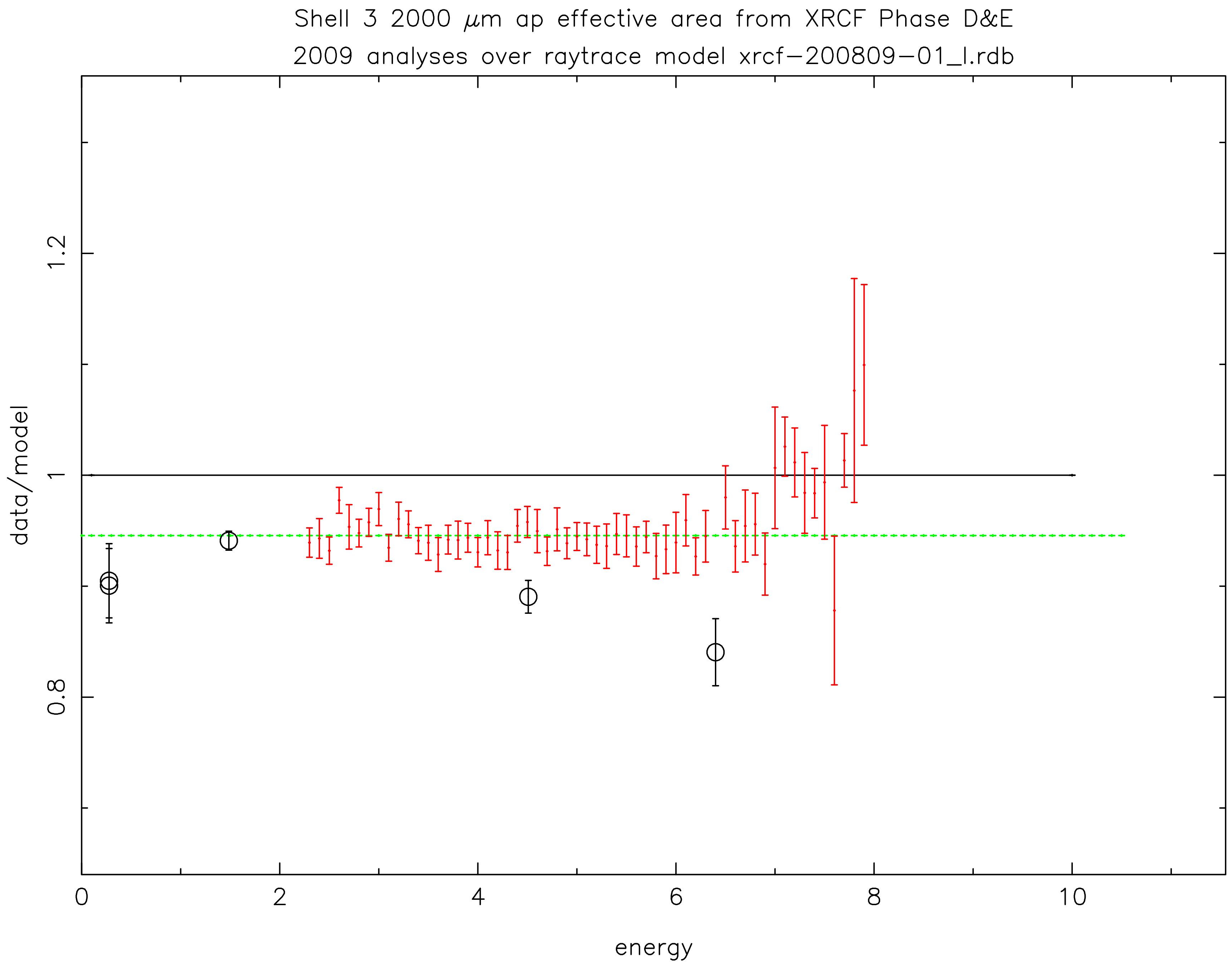
Shell 3 2000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
energy
0.8
1
1.2
0
2
4
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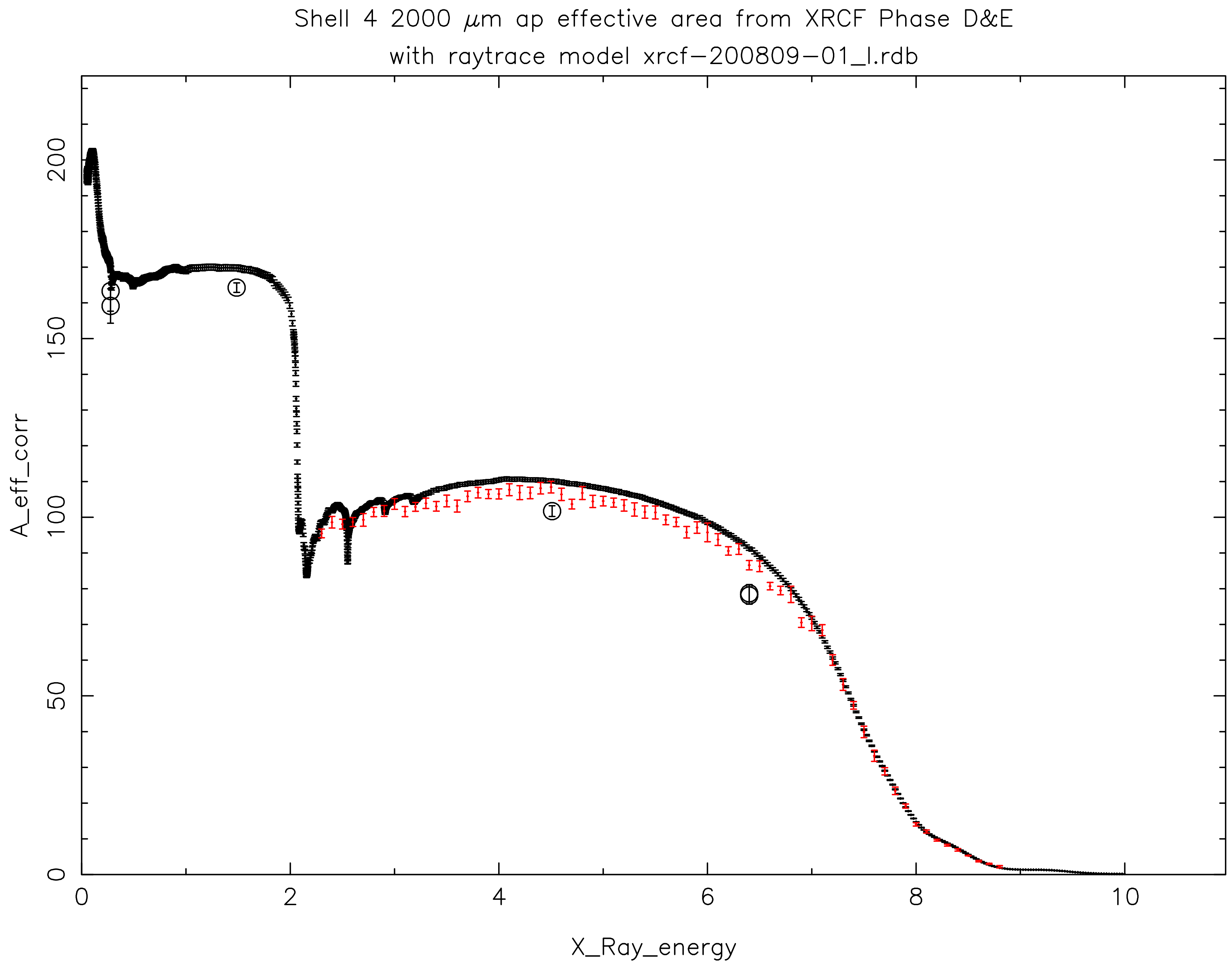
Shell 4 2000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf−200809−01_l.rdb
A_eff_corr
X_Ray_energy
0
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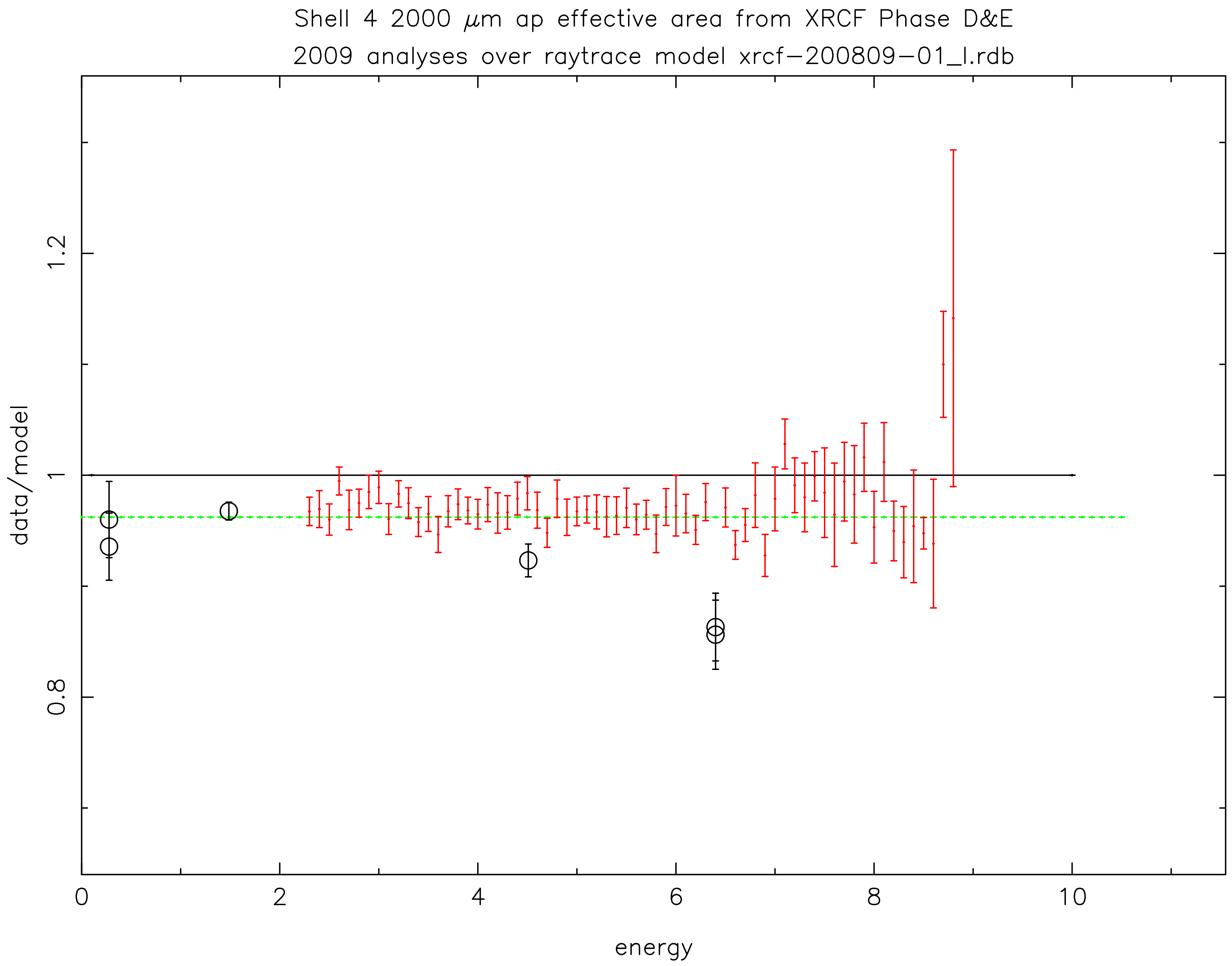
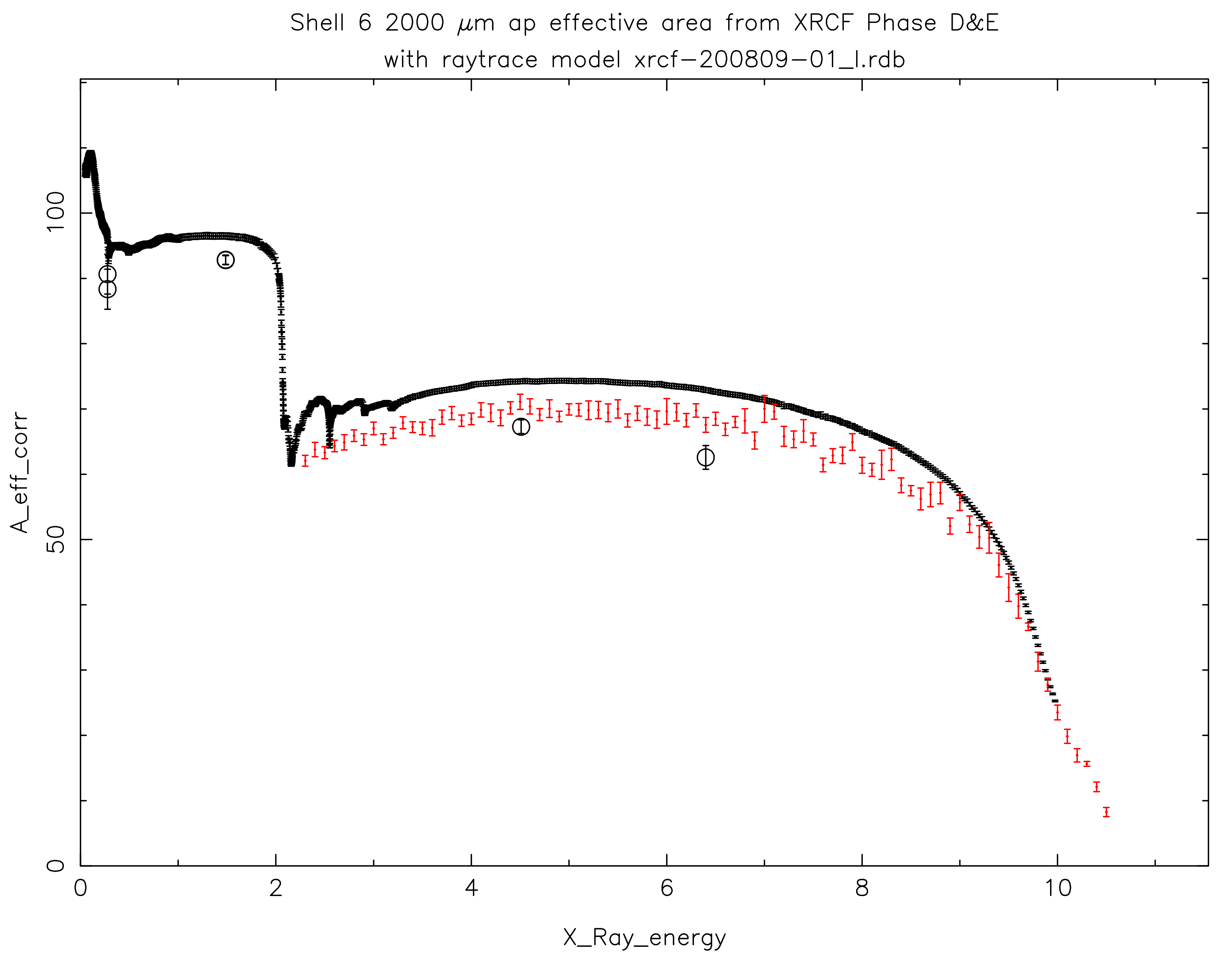
2
4
6
8
10


Shell 4 2000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
1.2
1
0.8
0
2
4
6
8
10
energy


Shell 6 2000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf−200809−01_l.rdb
A_eff_corr
X_Ray_energy
0
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100
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2
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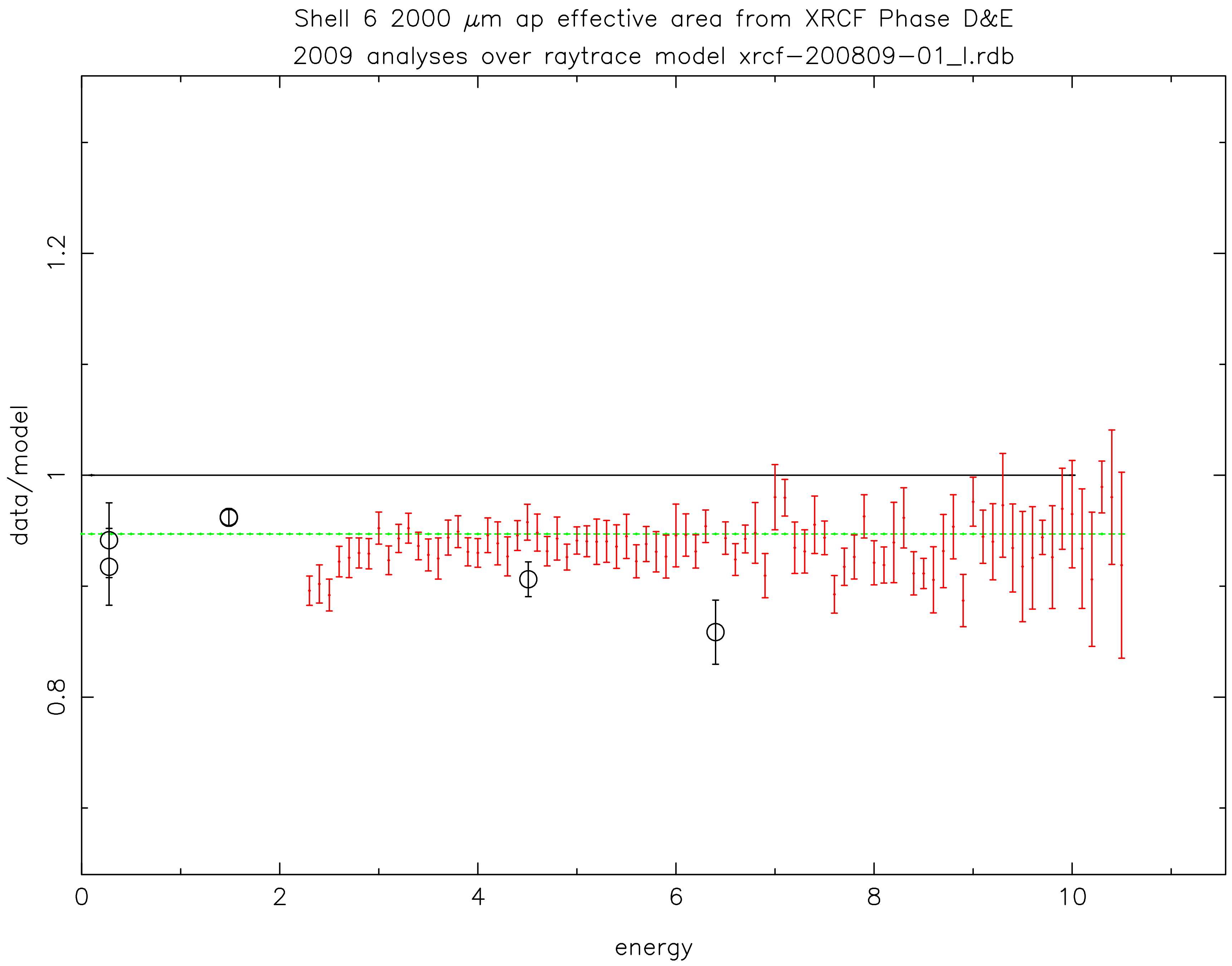
Shell 6 2000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
0.8
1
1.2
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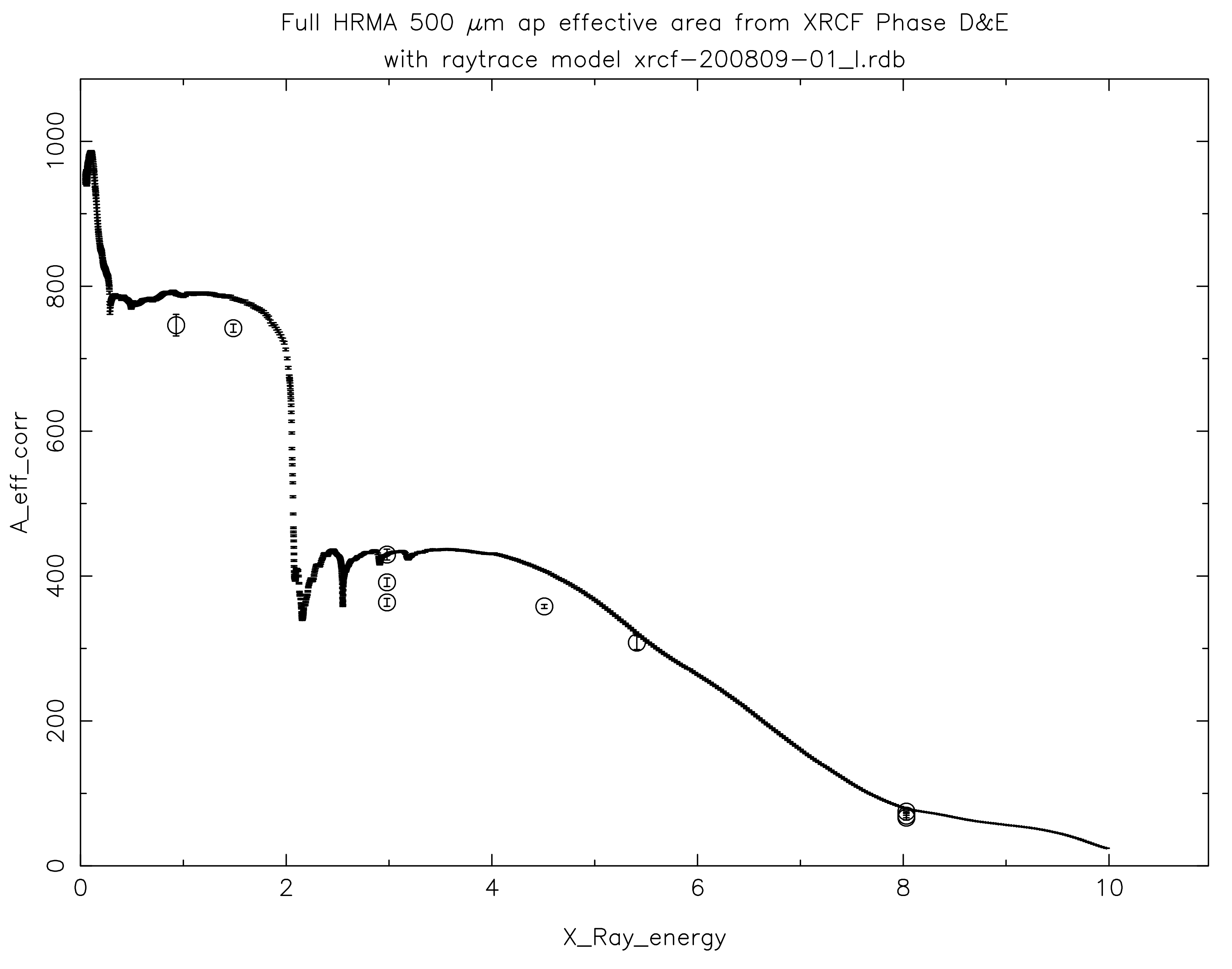
energy



Full HRMA 500 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf-200809-01_l.rdb
A_eff_corr
0
200
400
600
800
1000
X_Ray_energy
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4
6
8
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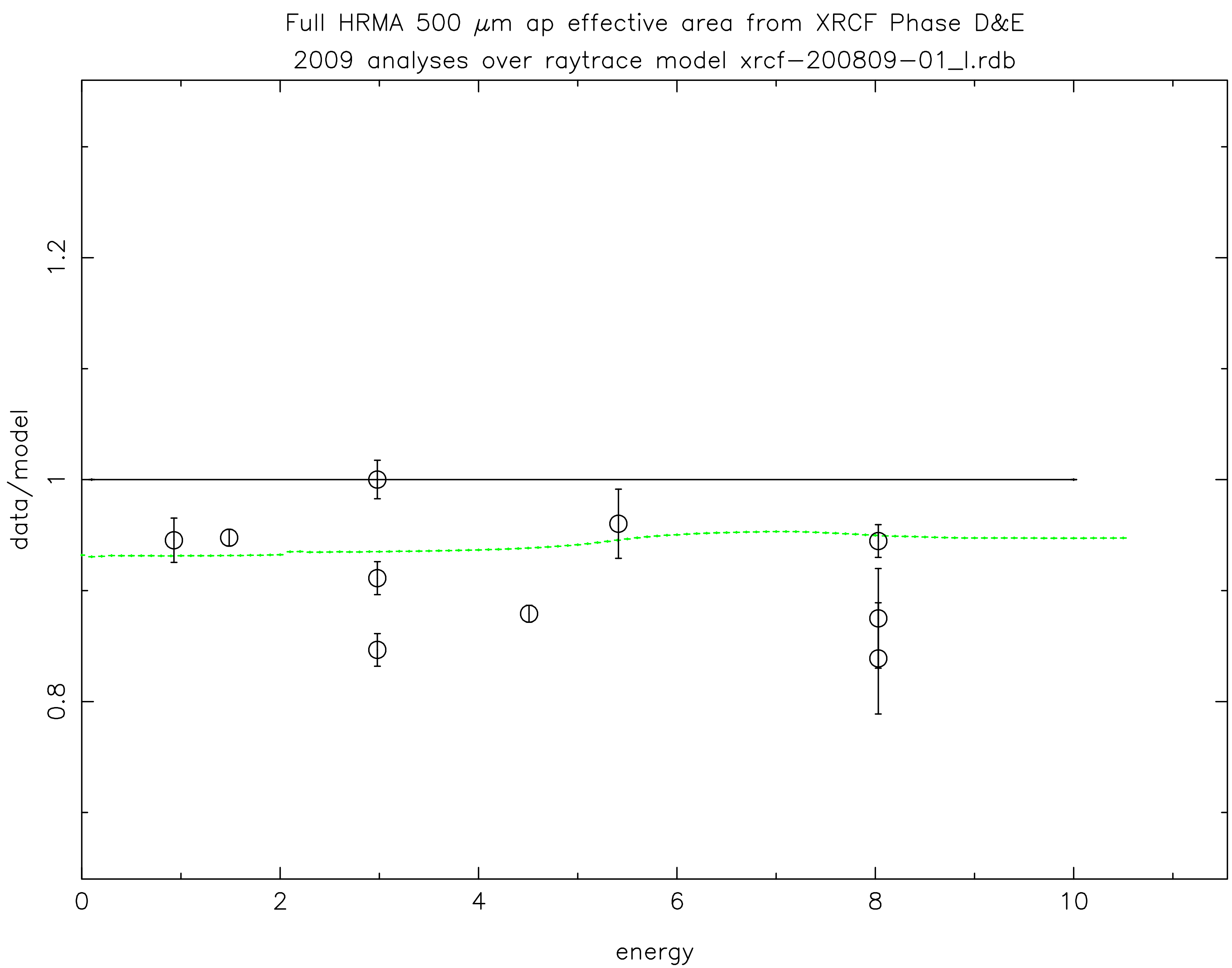
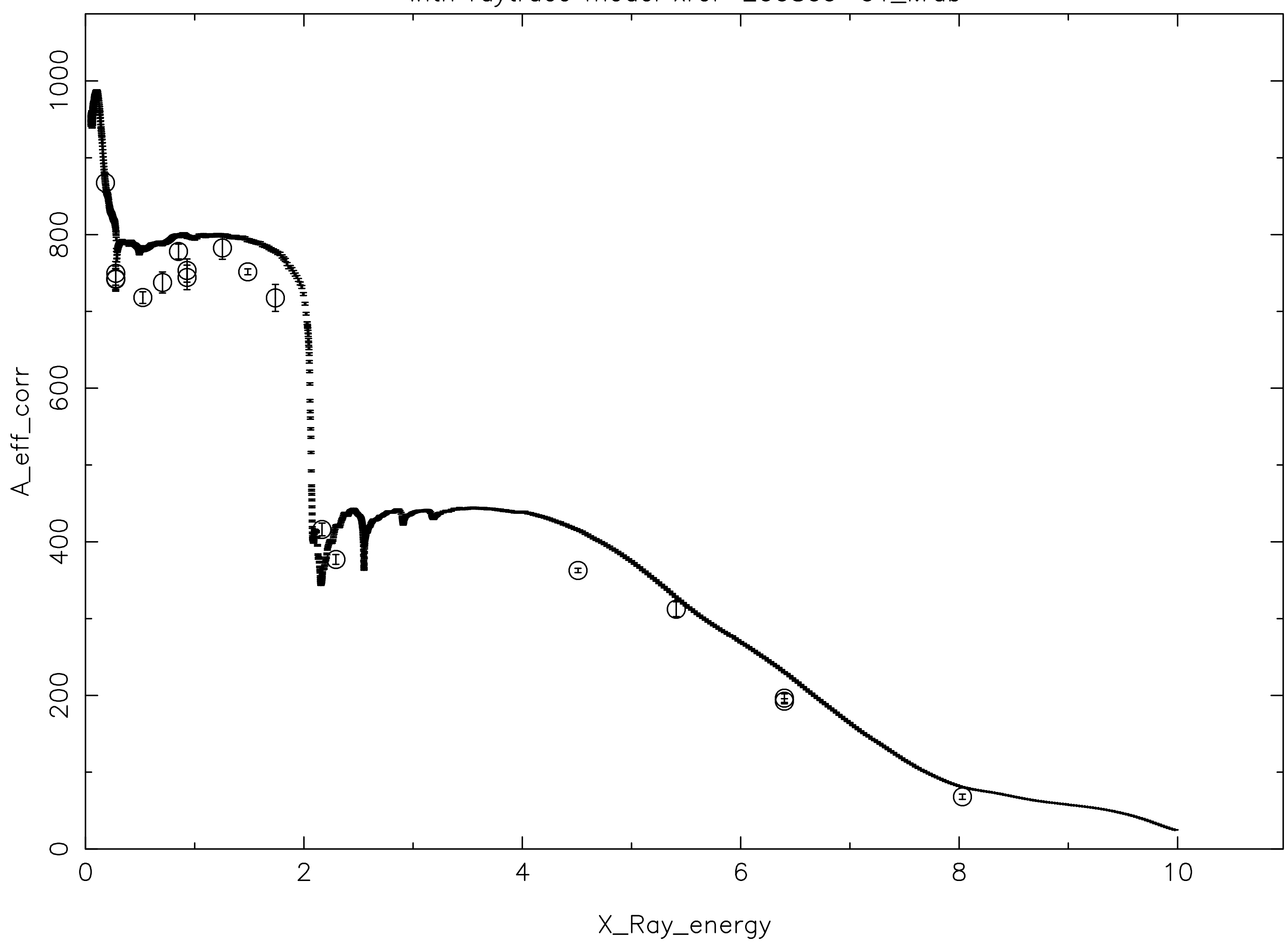
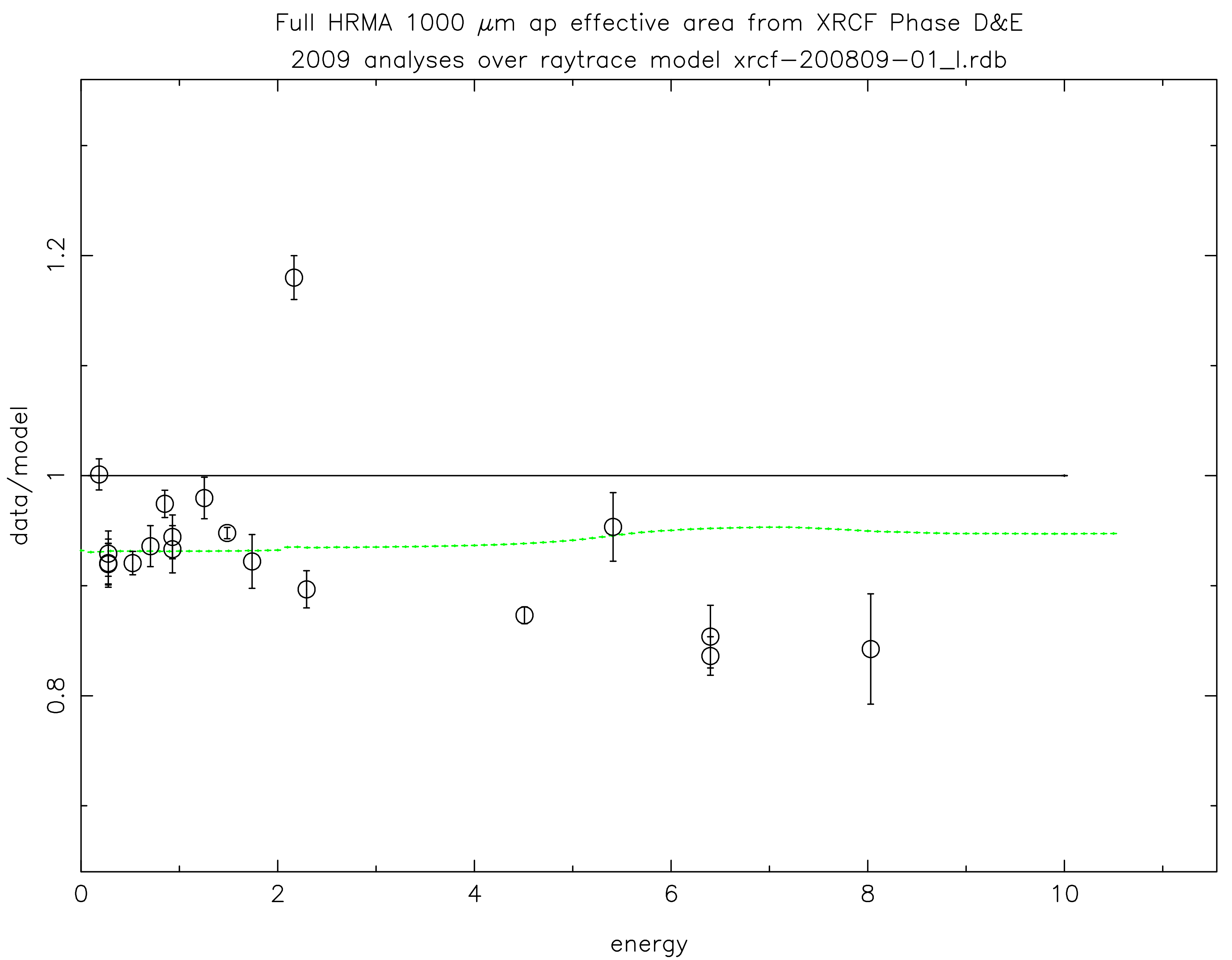


Full HRMA 500 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
energy
0
2
4
6
8
10
0.8
1
1.2

Full HRMA 1000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf-200809-01_l.rdb




Full HRMA 1000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
energy
0.8
1
1.2
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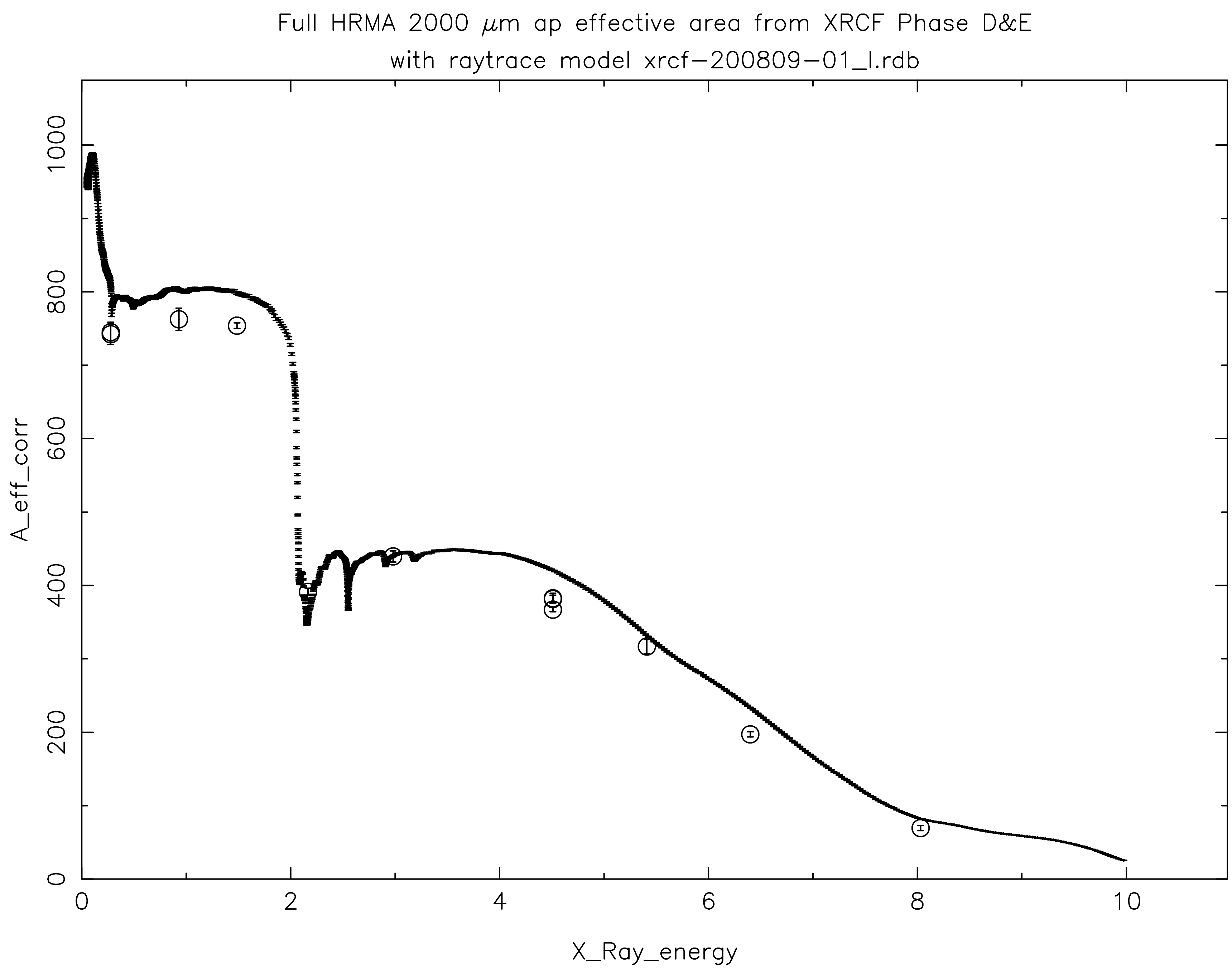
Full HRMA 2000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf-200809-01_l.rdb
A_eff_corr
X_Ray_energy
0
200
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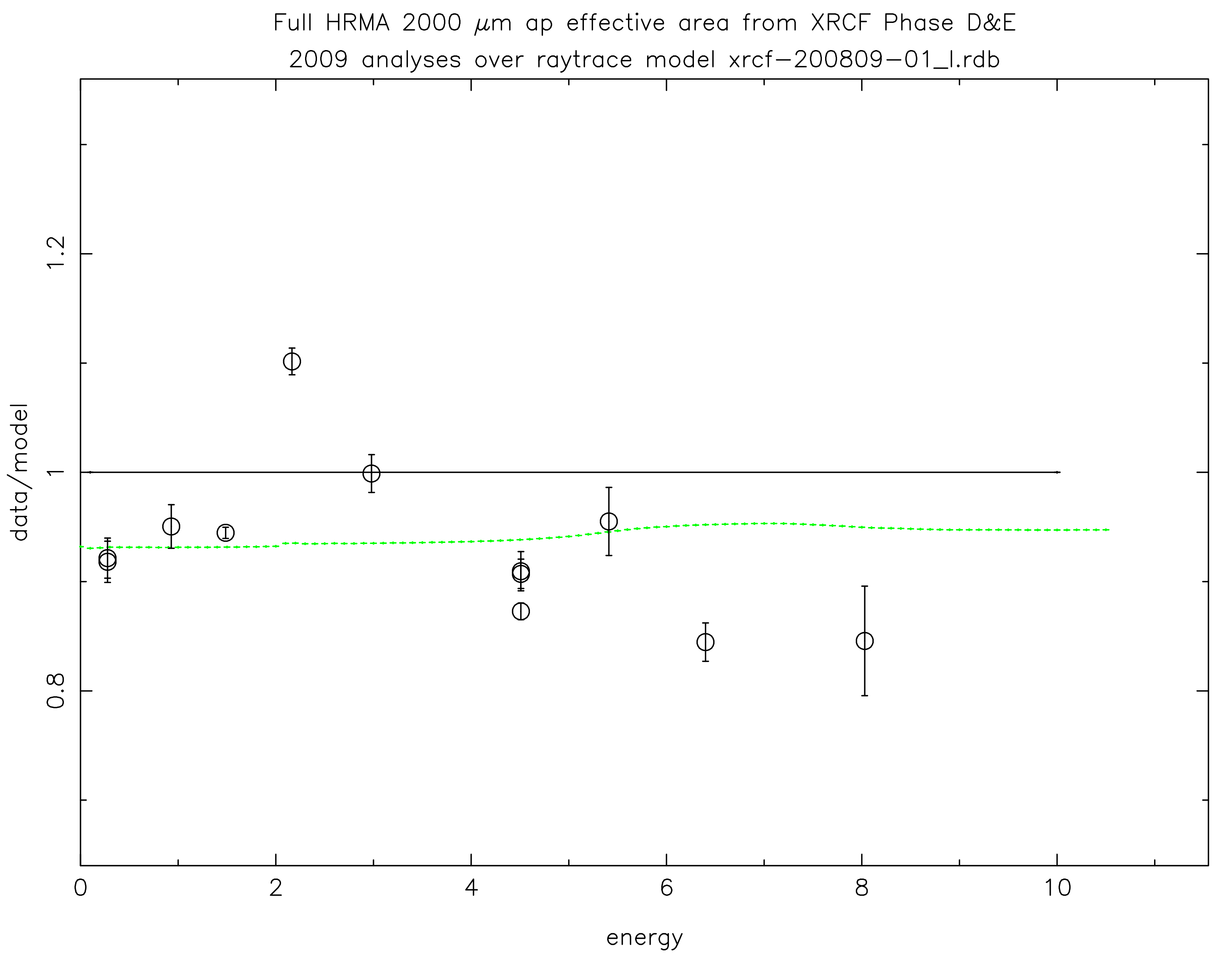
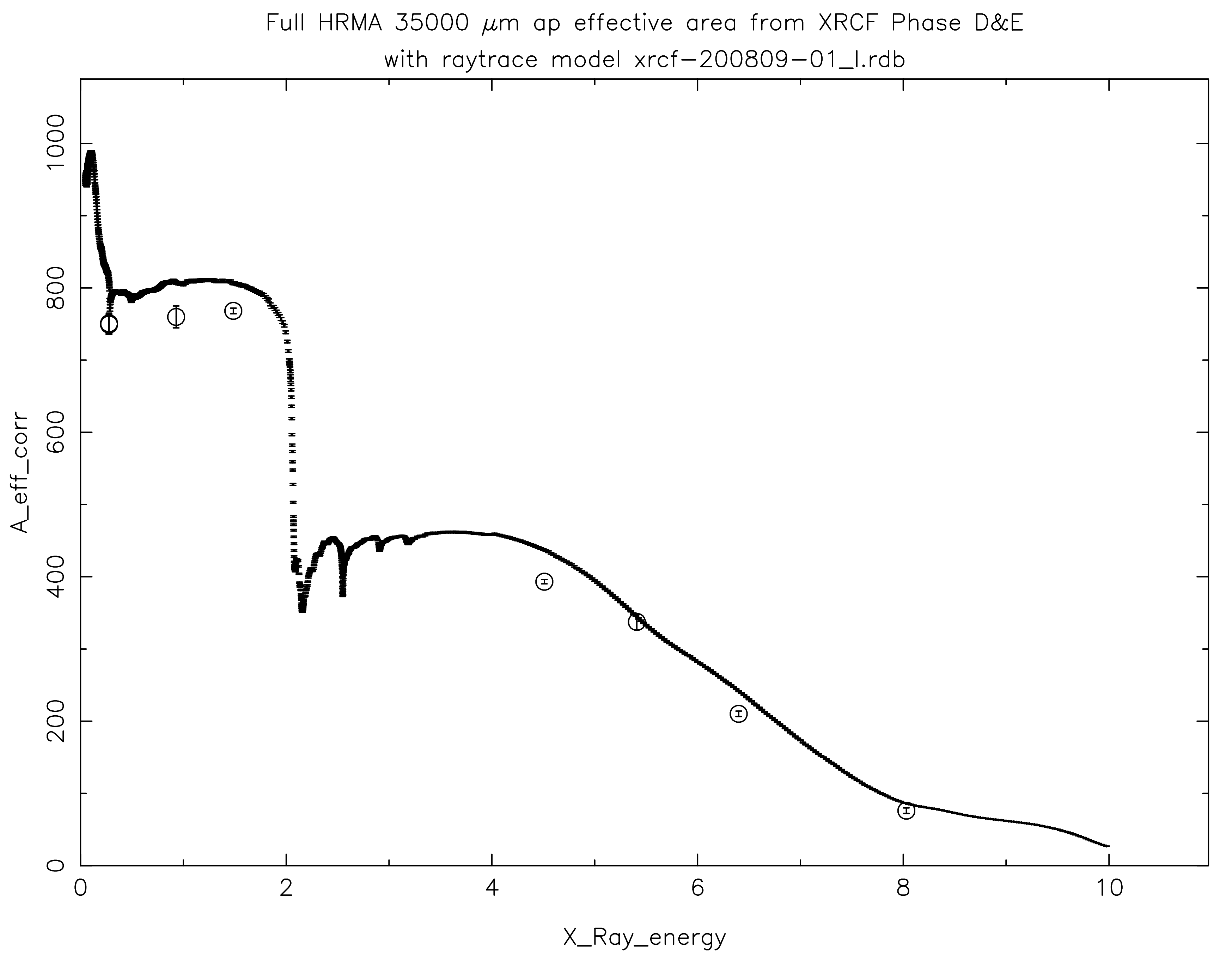

Full HRMA 2000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
1.2
1
0.8
0
2
4
6
8
10
energy


Full HRMA 35000 μm ap effective area from XRCF Phase D&E
with raytrace model xrcf-200809-01_l.rdb
A_eff_corr
X_Ray_energy
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200
400
600
800
1000
0
2
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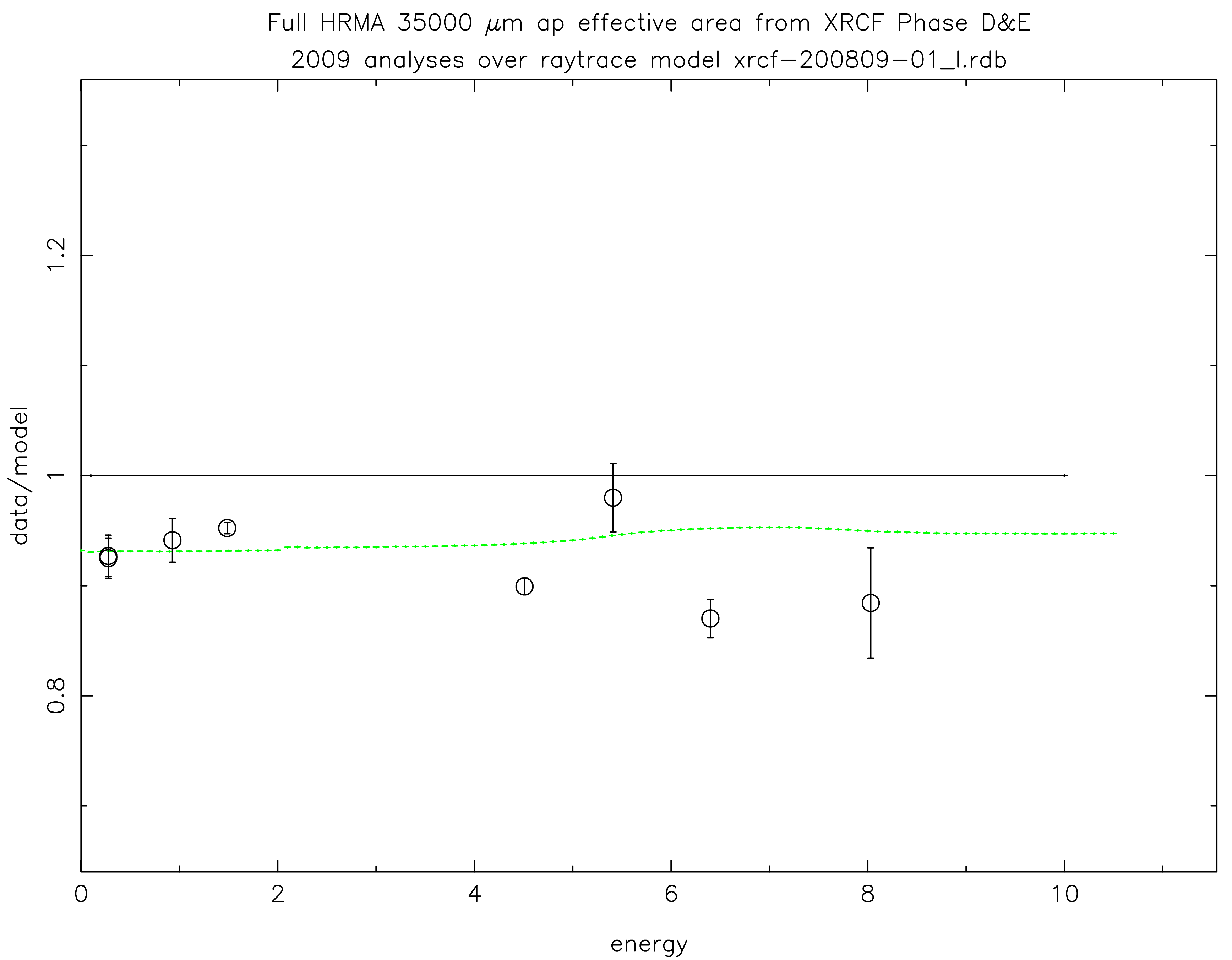

Full HRMA 35000 μm ap effective area from XRCF Phase D&E
2009 analyses over raytrace model xrcf−200809−01_l.rdb
data/model
1.2
1
0.8
0
2
4
6
8
10
energy

2009/2010 Progress

New model of SSD pileup:
small changes continuum Aeff curve.

Re-analysis of spectral line data brings them into better agreement with SSD continuum data

Grey is beautiful!
New data are in close agreement with released curve

Comments

Nb-L data at 2.166 keV are still above the raytrace

(really at "same" energy as Ir M-V edge?)

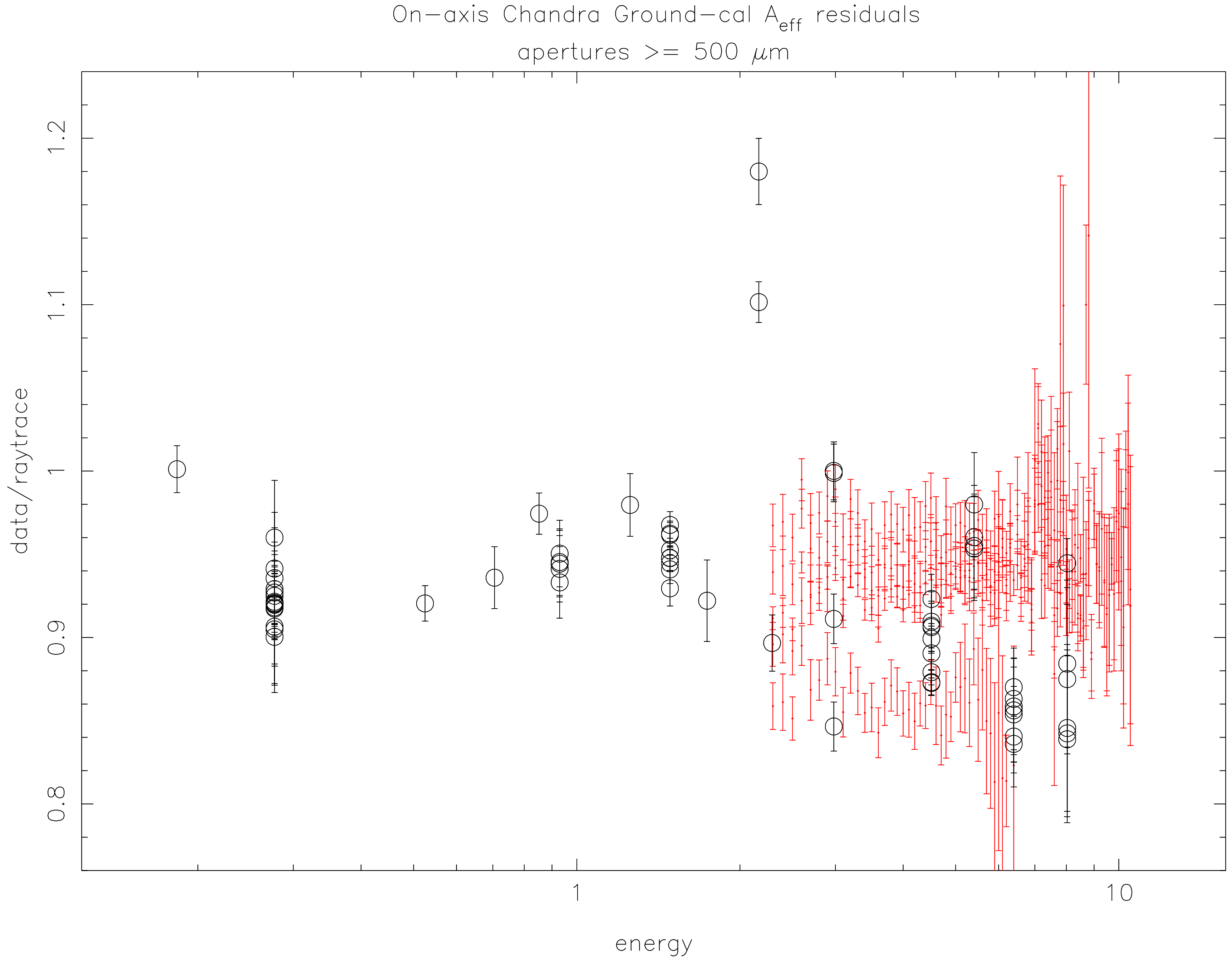
B-K data at 0.183 keV are on the line

(QEs are very different--Window thickness)

Ag-L data around 3 keV are really hard to fit

(And Ar K edge doesn't help)

4%-ish scatter in residuals may indicate the size of (some) systematic errors



On-axis Chandra Ground-cal A_{eff} residuals
apertures >= 500 μm
data/raytrace
energy
0.8
0.9
1
1.1
1.2
1
10