SXT Calibration Status

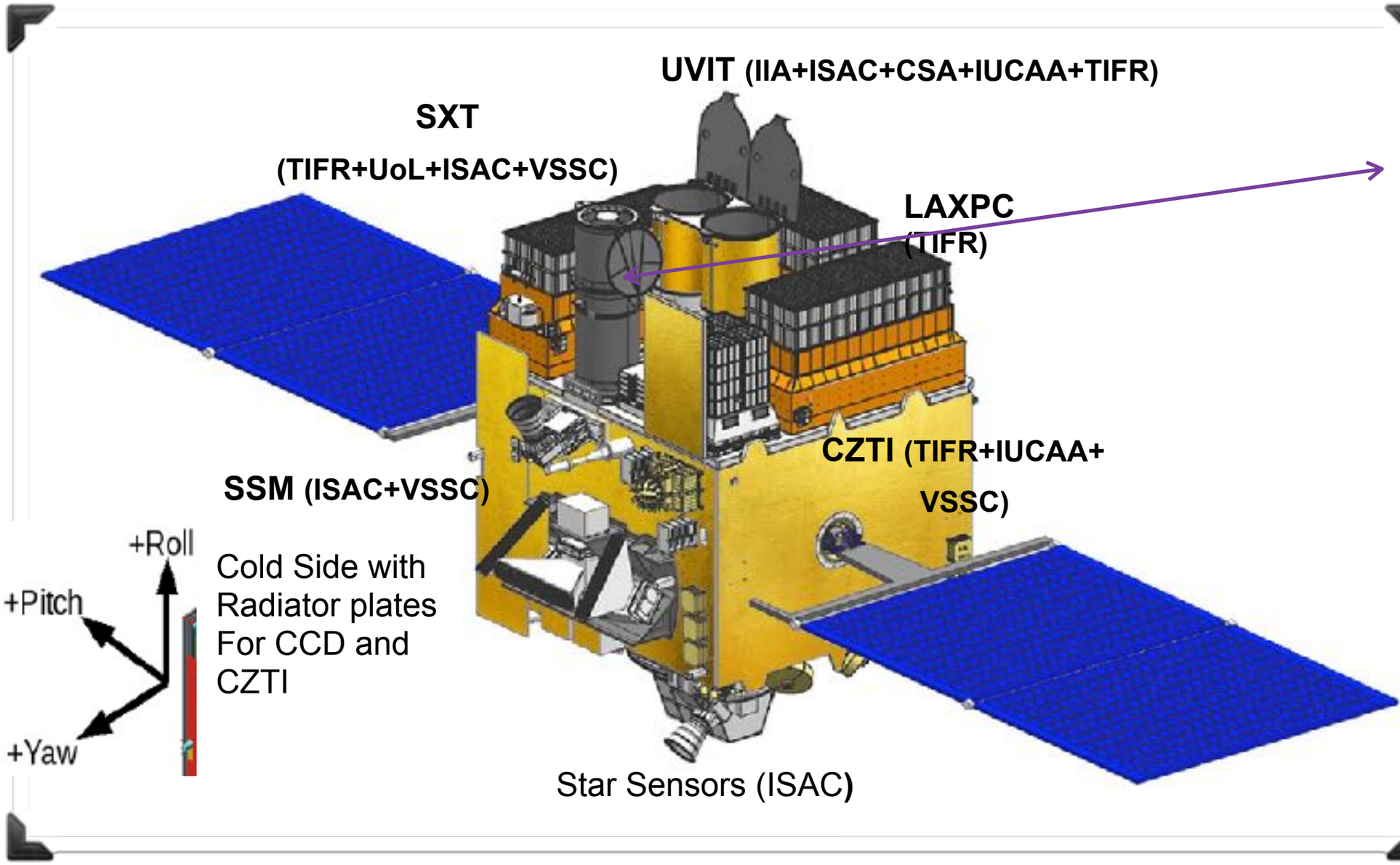
IACHEC 2017

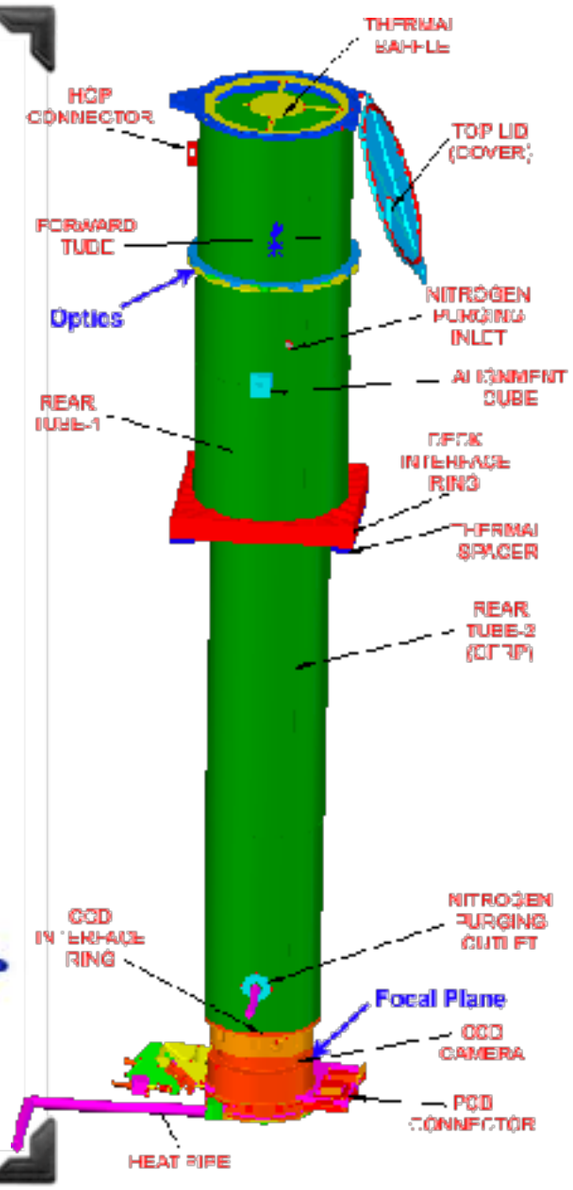
27, March 2017

Sunil Chandra
TIFR, Mumbai
On Behalf of AstroSat-SXT Team

AstroSat and Payloads

Launch date: 28 September 2015





Website : astrosat.iucaa.in

Outline

- Bore sight optical axis determination
- Vignetting function
- Point Spread Function (PSF)
- Spectral calibration
- CTI and Gain

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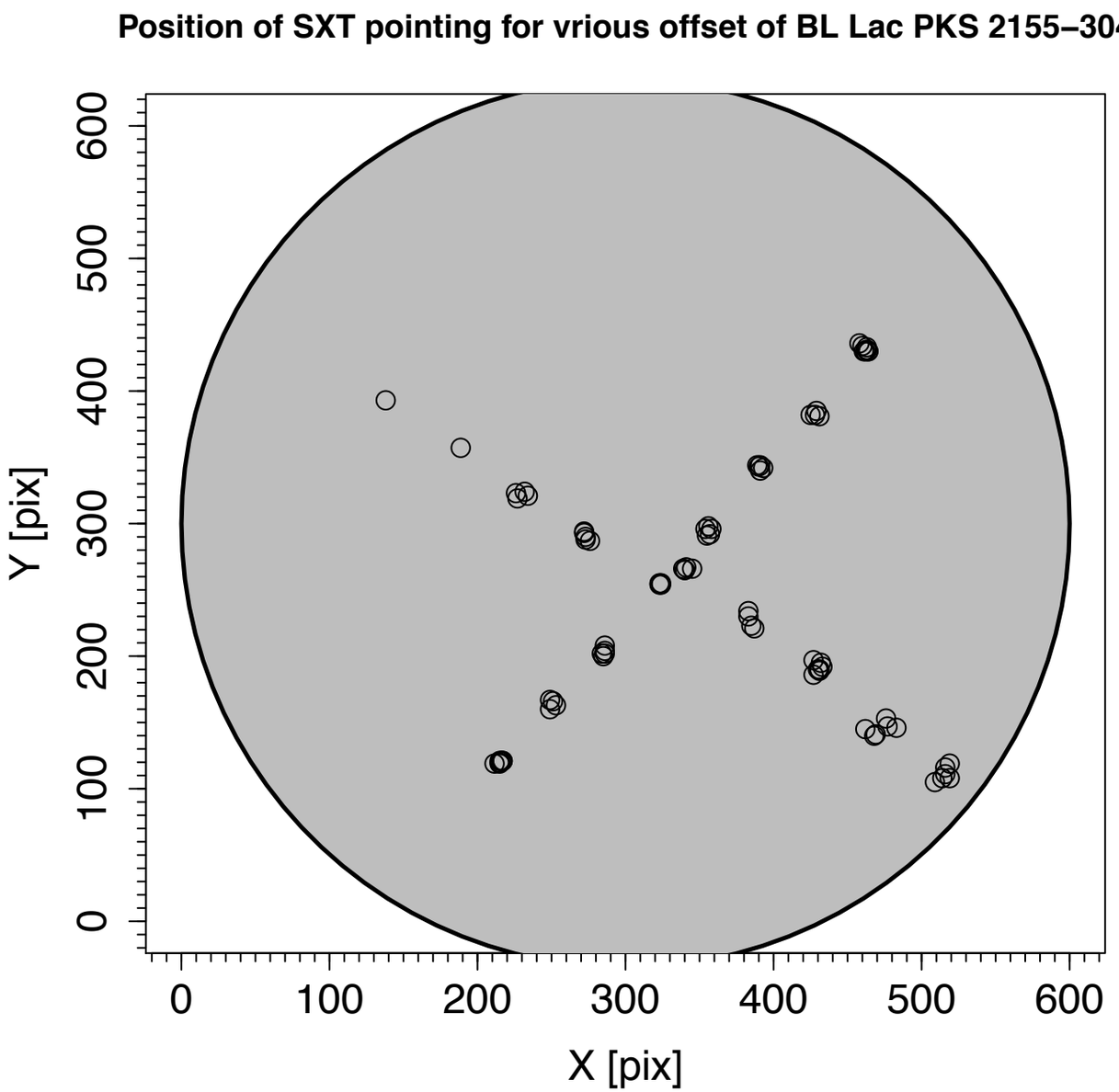
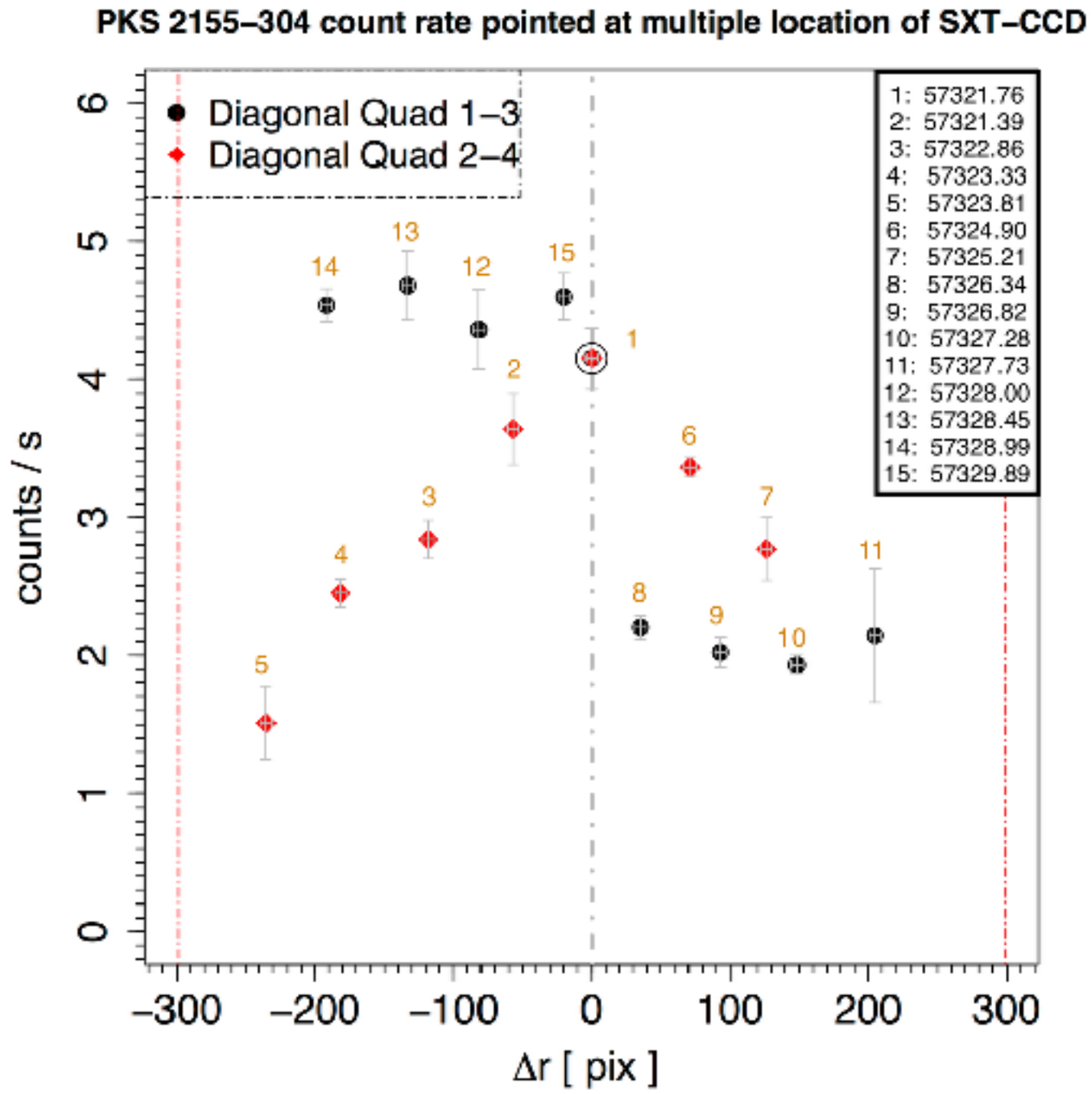
PKS 2155-304, Raster Observations

T ~ 217 ks
Useful Time ~ 58 ks





1E 0102-7217

E0102: Second X-ray brightest source in the SMC

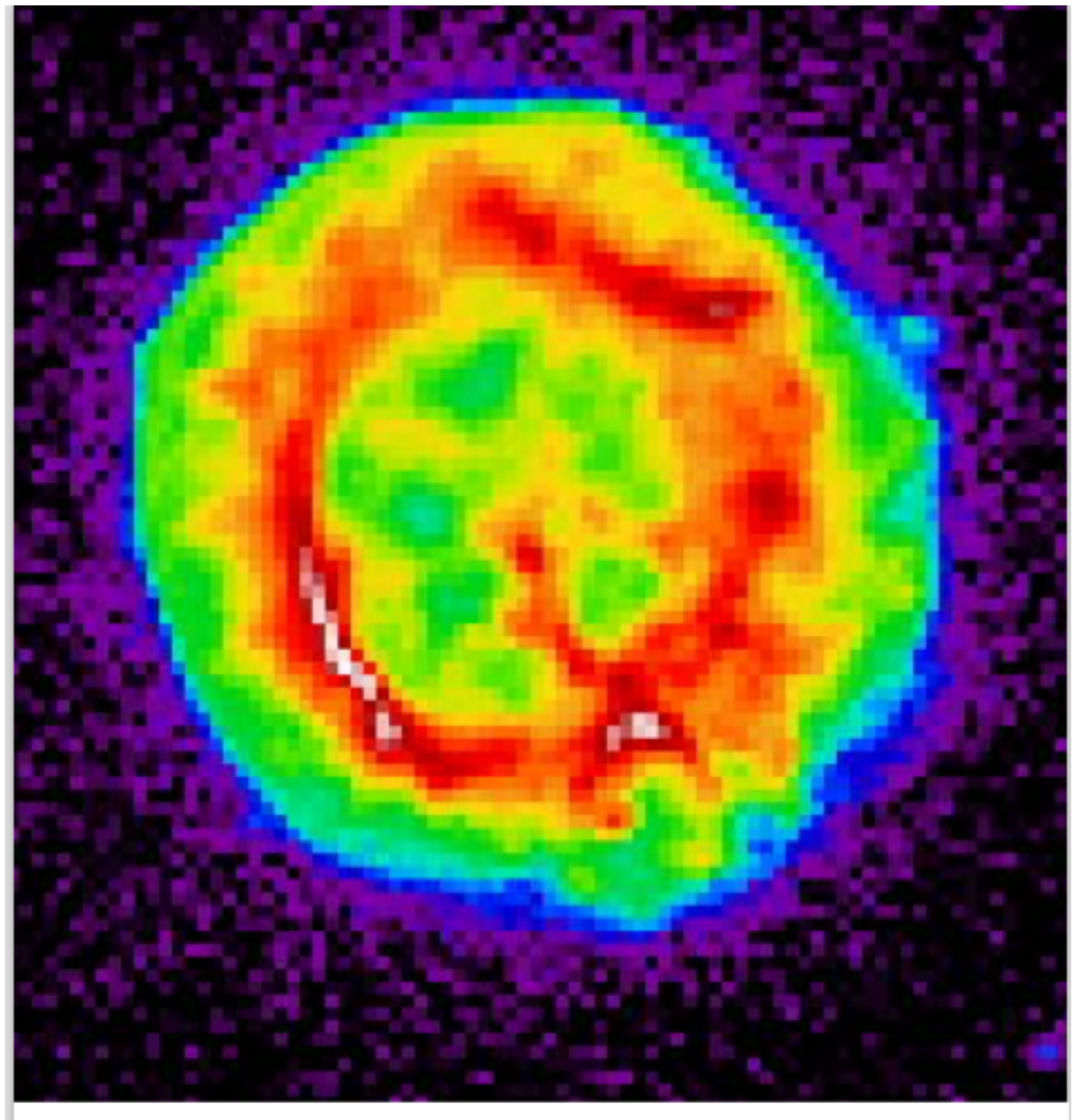
Size: 0.77X0.77 arcmin, 13X13 pc

t ~ 2,000 yr (Finklestein et al. 2006)

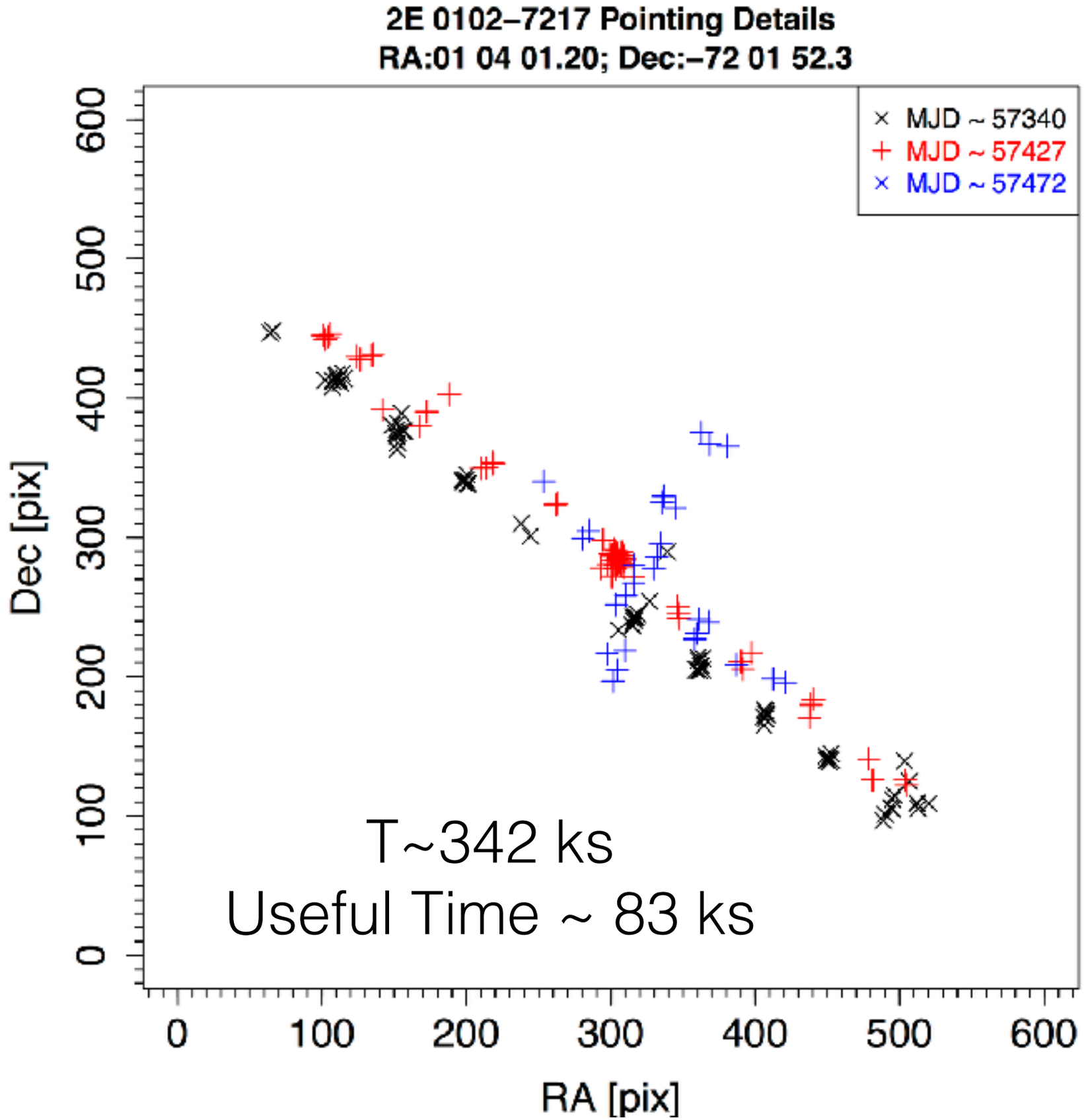
L_X(0.3-10.0 kev) = 2.5x10^{37} ergs s^{-1} no compact object

"O-rich" core-collapse

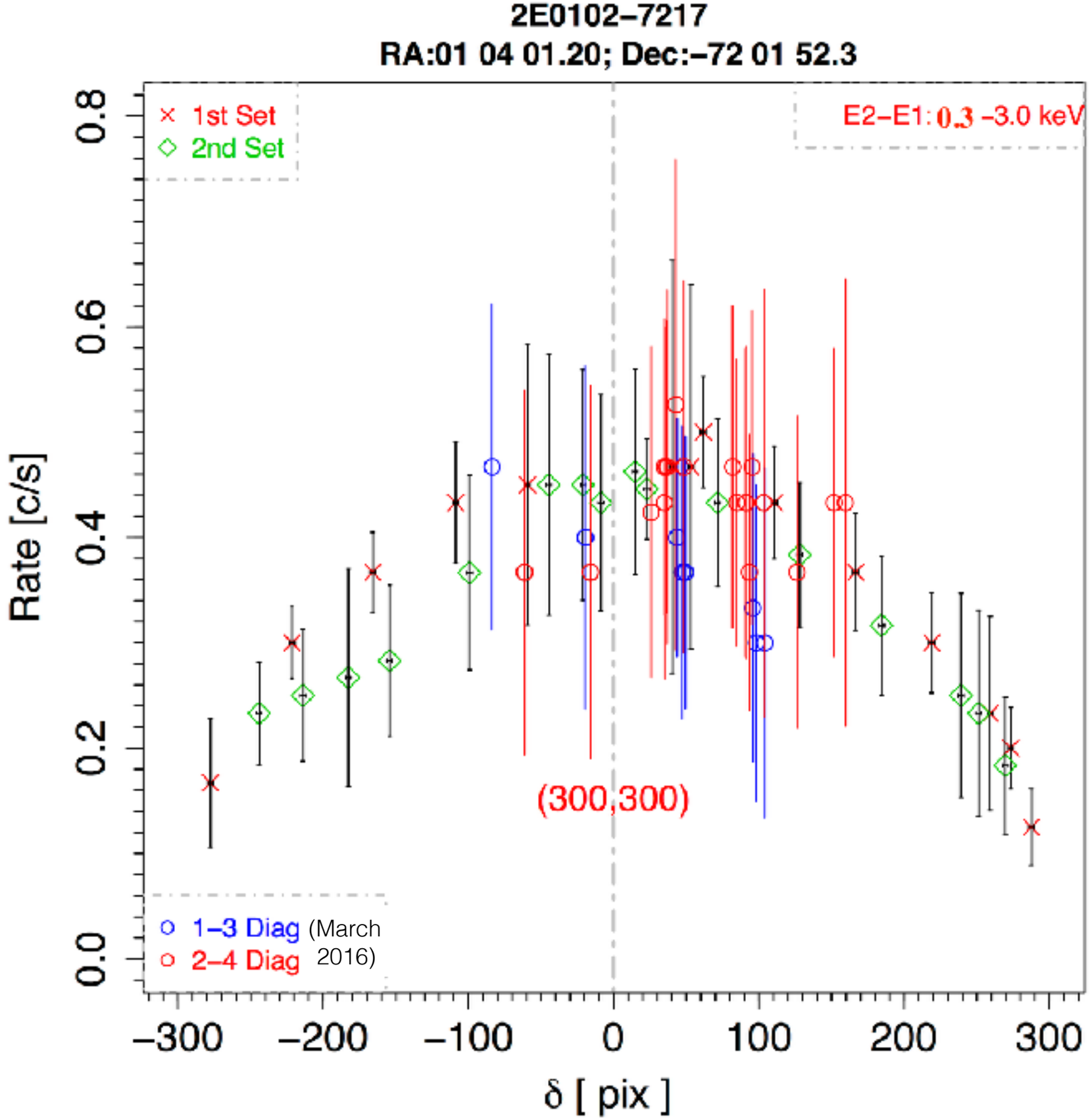
No compact object



1E 0102-7217 & ASTROSAT Calibration



1E 0102-7217 & ASTROSAT Calibration



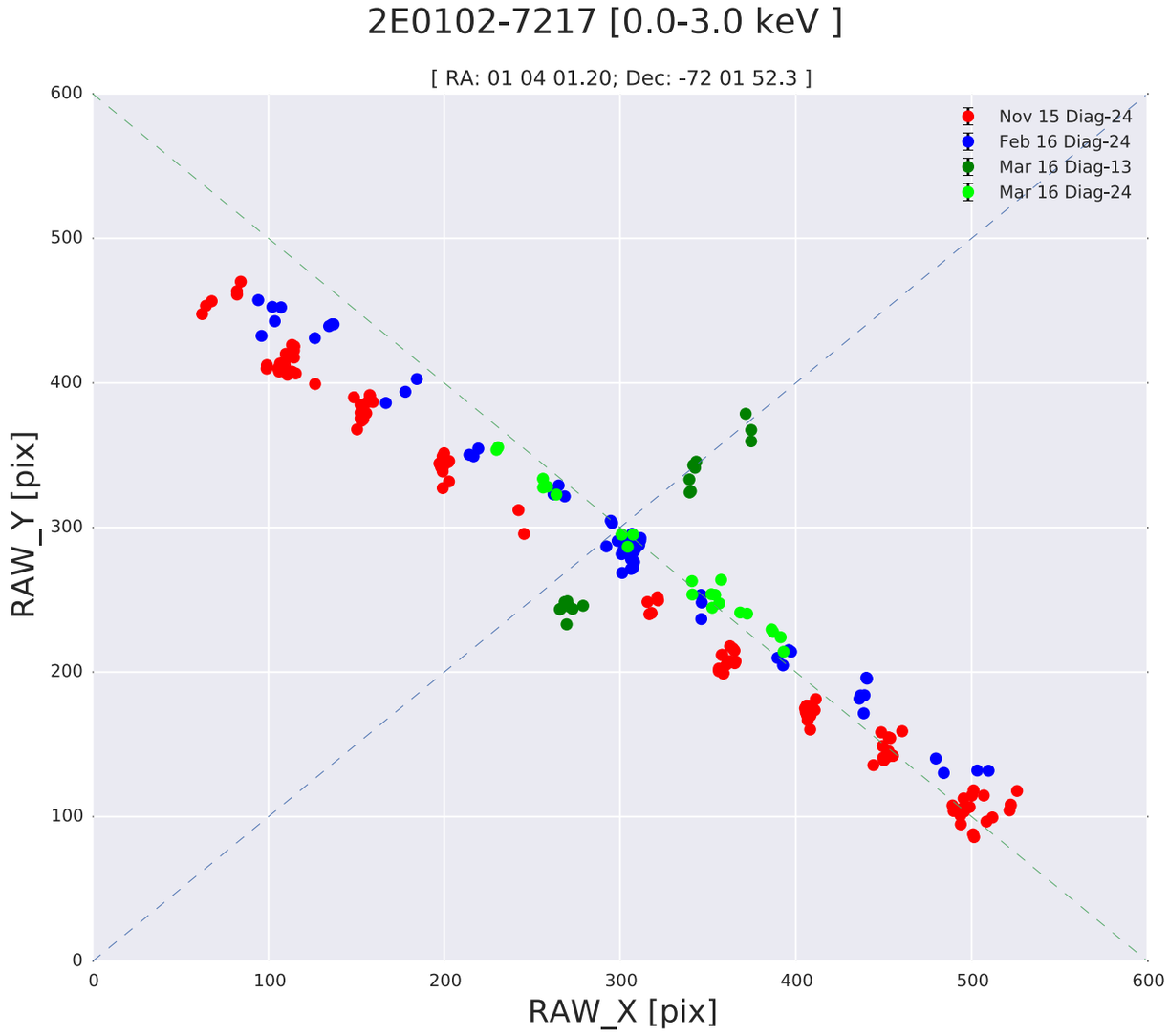
Bore-sight of SXT Using SNR 2E0102-7217

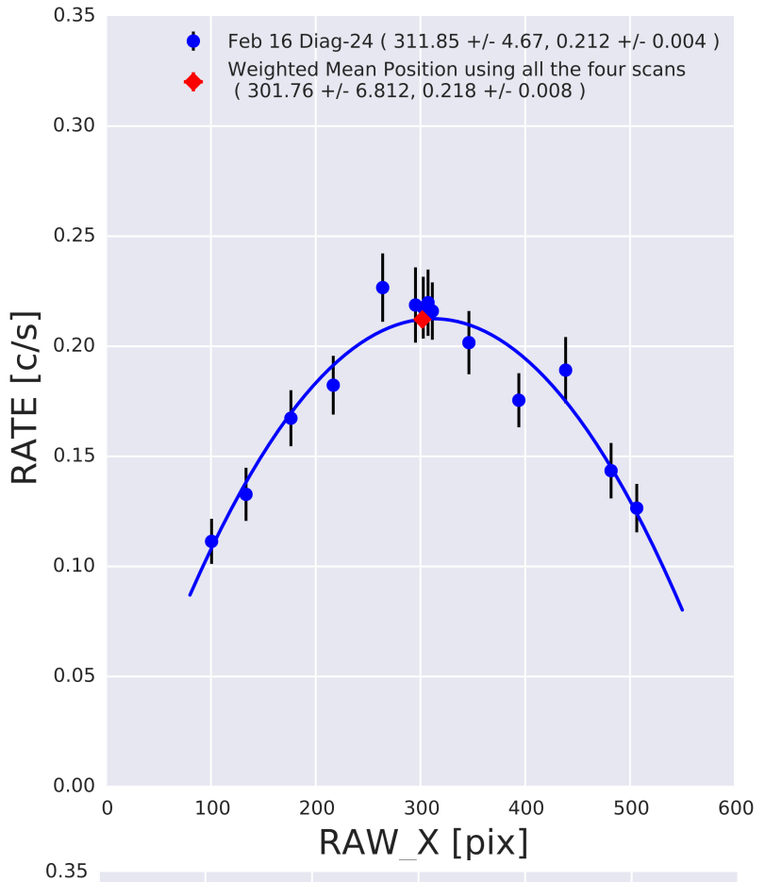
Special Mode of data analysis required

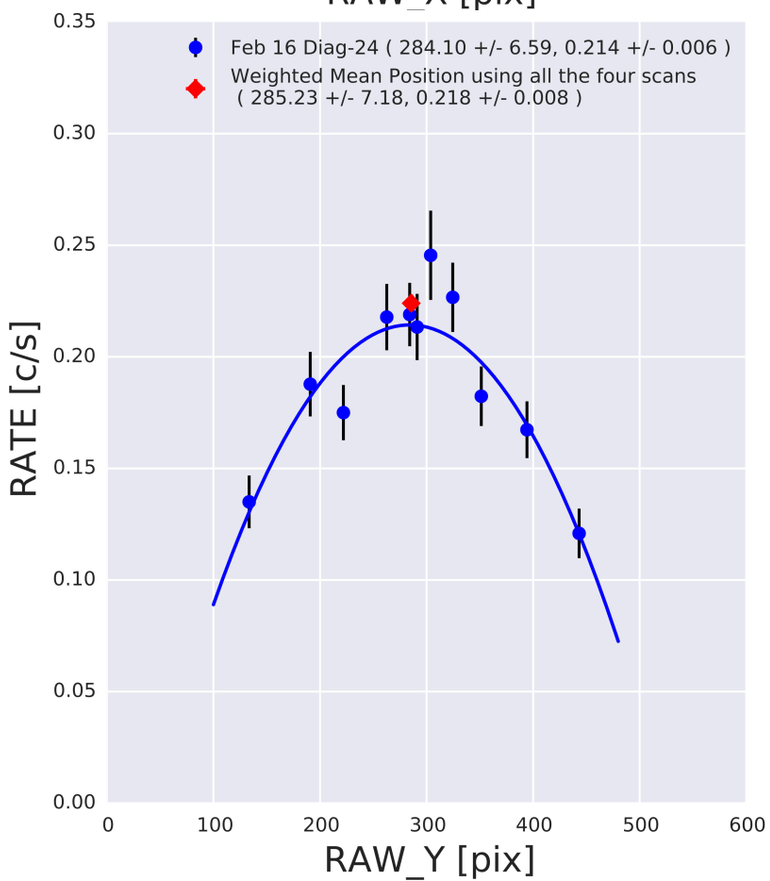
190 Useful Orbits = 326 ks

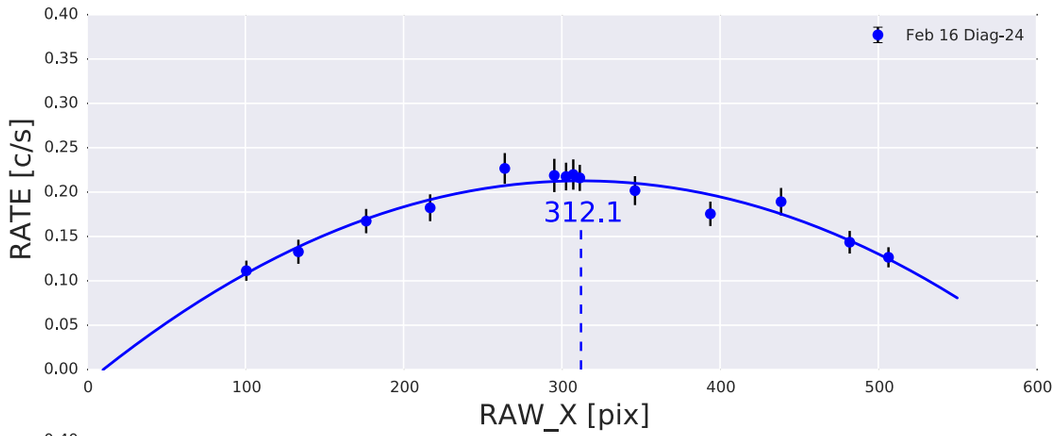
$$y = -a(x-h)^2 + k$$

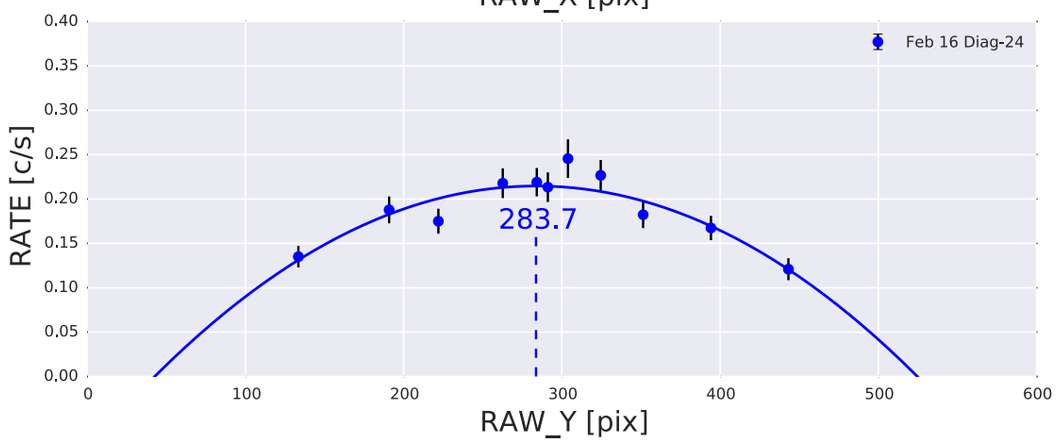
Singh et al. 2017, (Telescope Description and Calibration Status), In preparation

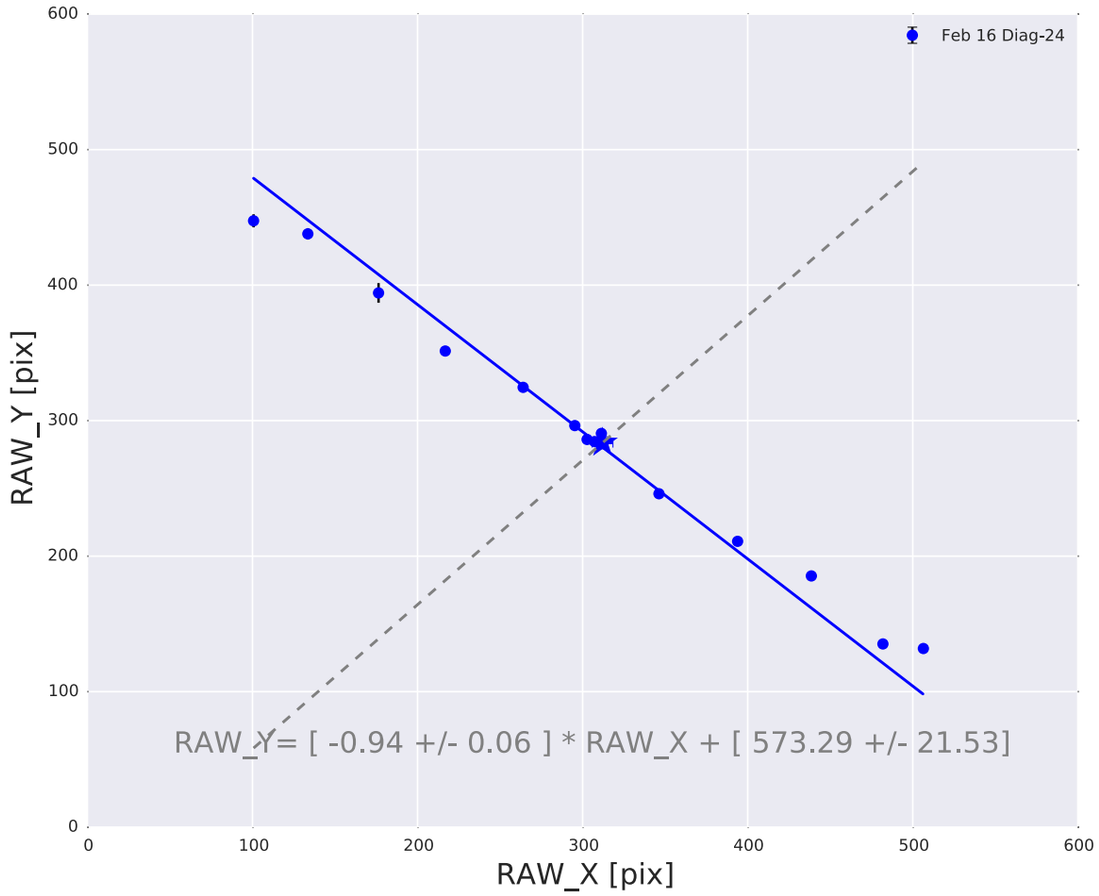


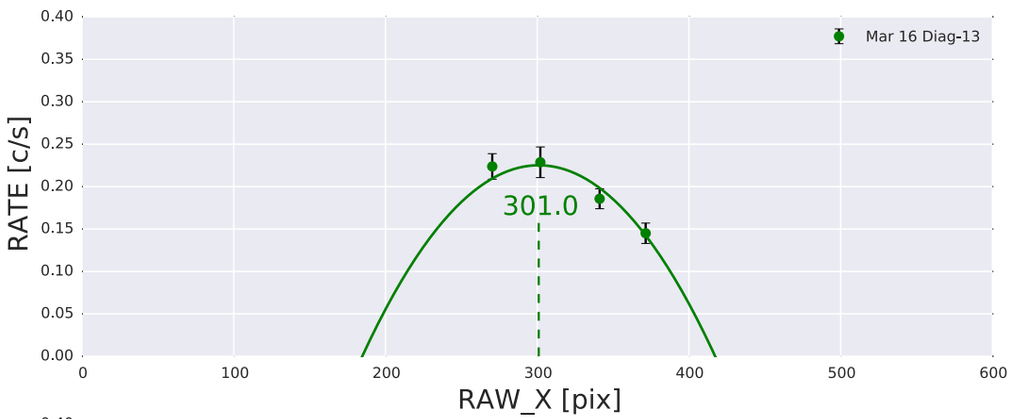


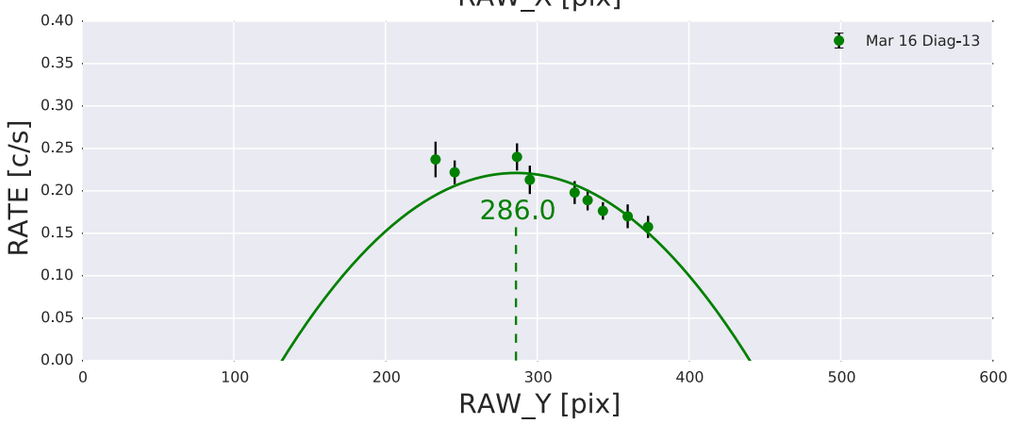


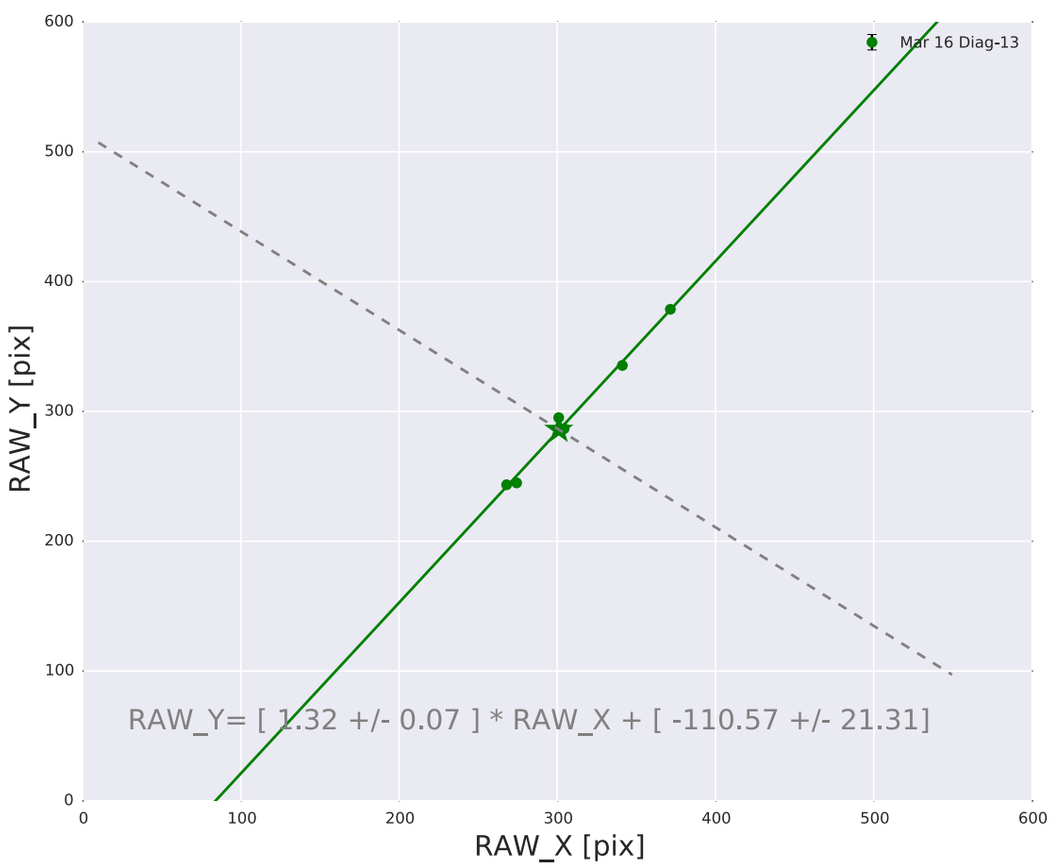

2E0102-7217 [0.3-3.0 keV]
Feb 16 Diag-24
RATE [c/s]
RAW_X [pix]
312.1


Feb 16 Diag-24
RATE [c/s]
RAW_Y [pix]
283.7

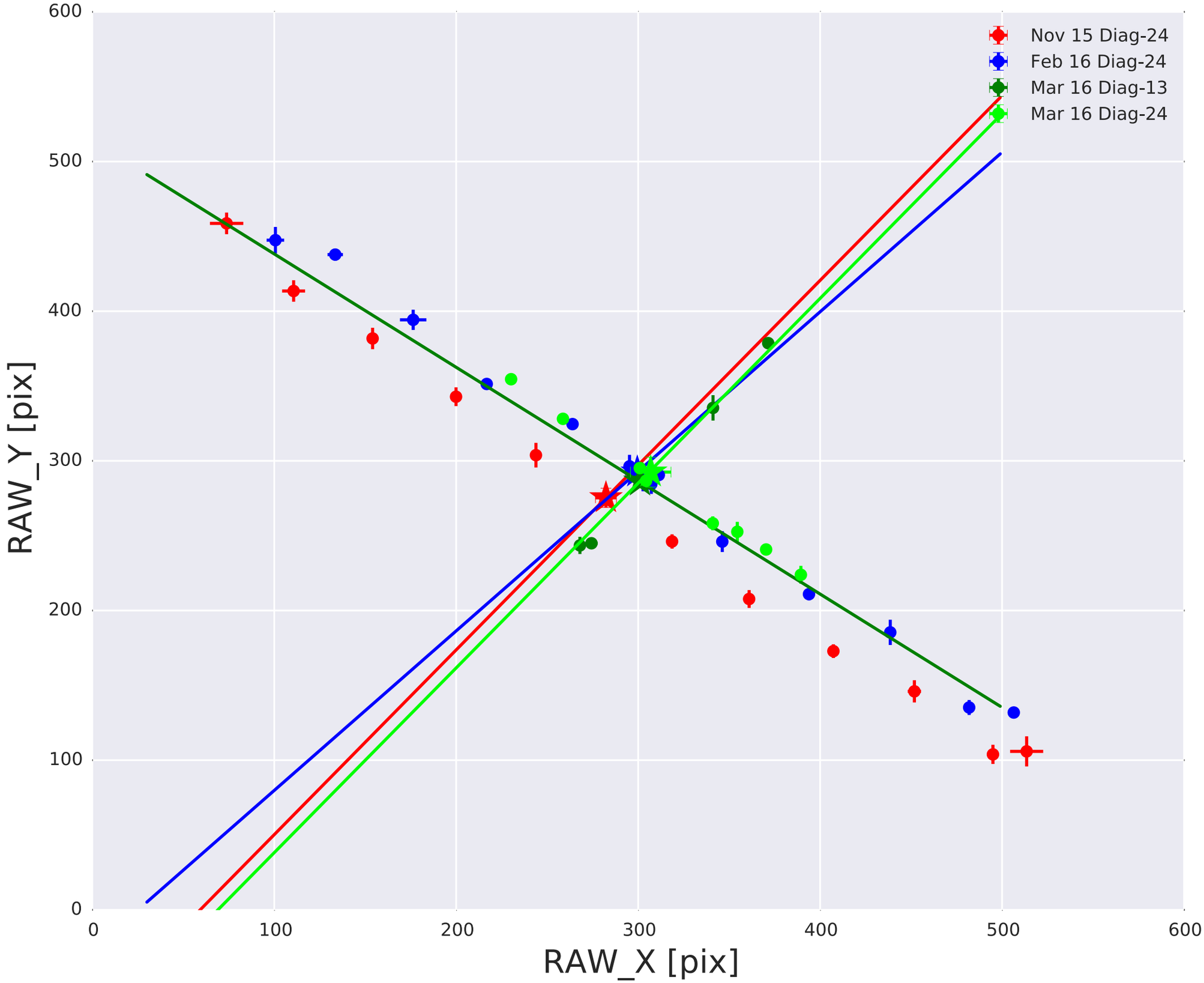

2E0102-7217 [0.3-3.0 keV]
Feb 16 Diag-24
RAW_Y [pix]
RAW_X [pix]
RAW_Y= [-0.94 +/- 0.06] * RAW_X + [573.29 +/- 21.53]


2E0102-7217 [0.3-3.0 keV]
Mar 16 Diag-13
RATE [c/s]
RAW_X [pix]
301.0

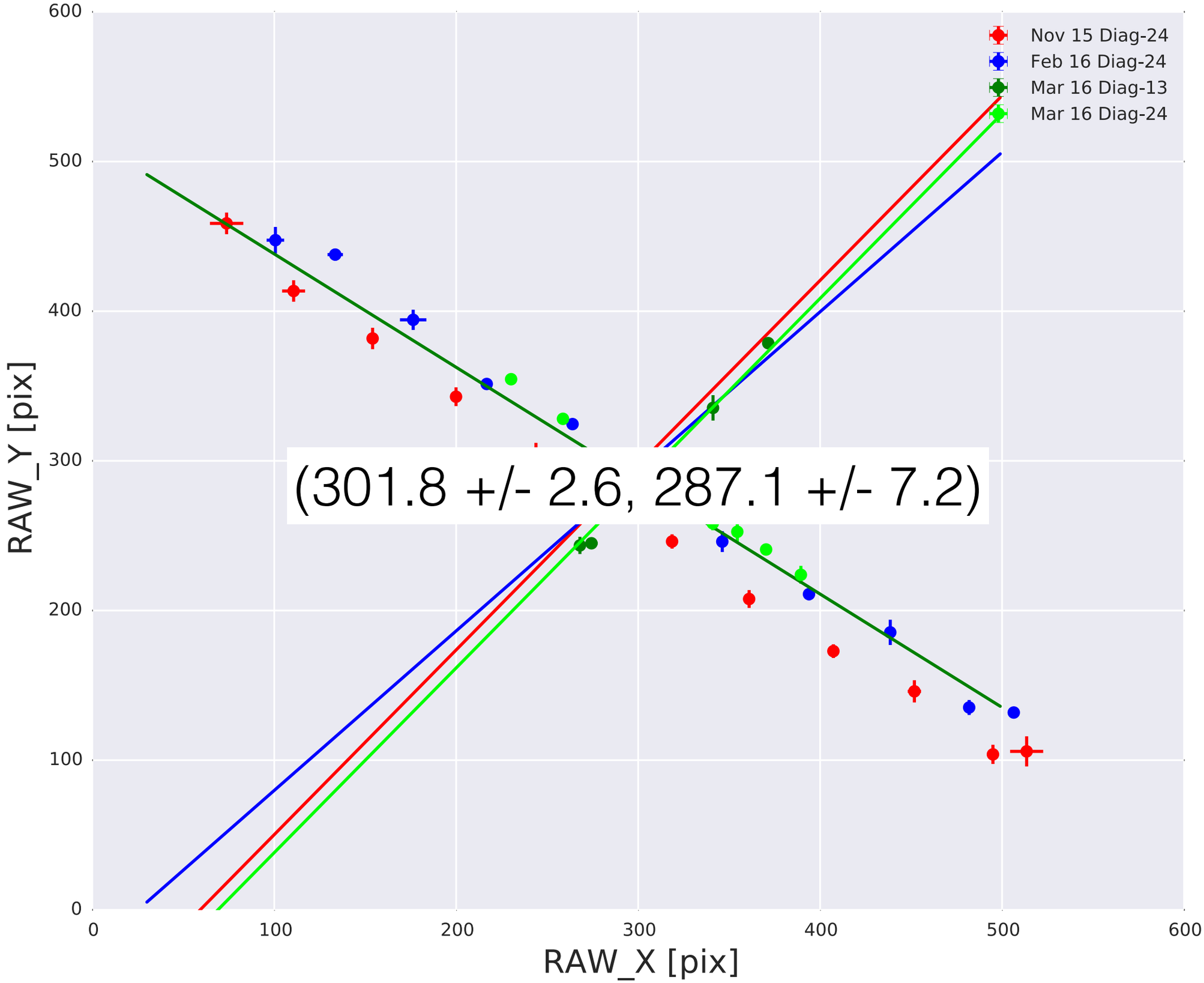

Mar 16 Diag-13
RATE [c/s]
RAW_Y [pix]
286.0


2E0102-7217 [0.3-3.0 keV]
Mar 16 Diag-13
RAW_Y [pix]
RAW_X [pix]
RAW_Y= [1.32 +/- 0.07] * RAW_X + [-110.57 +/- 21.31]

2E0102-7217 [0.3-3.0 keV]



2E0102-7217 [0.3-3.0 keV]



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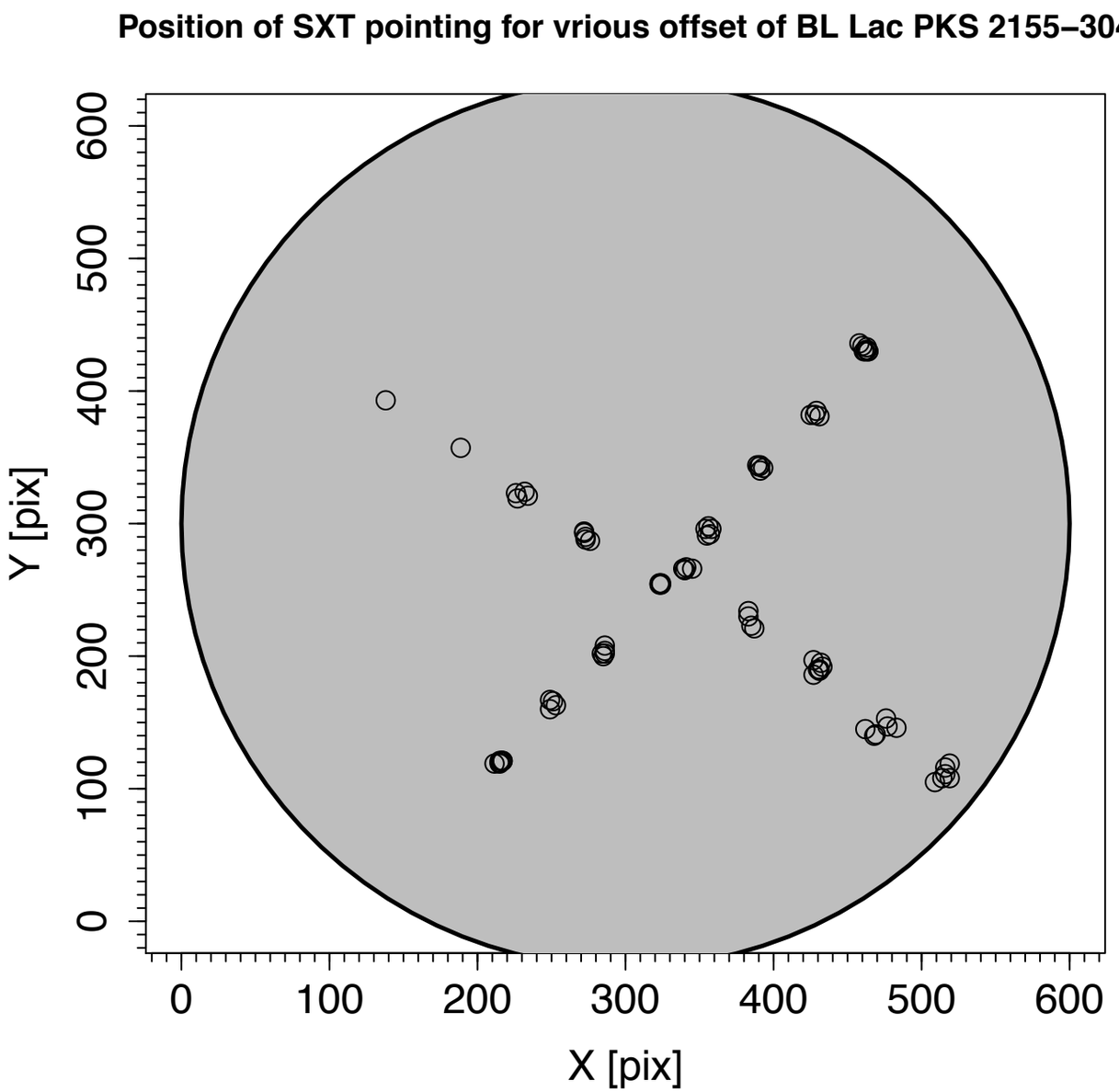
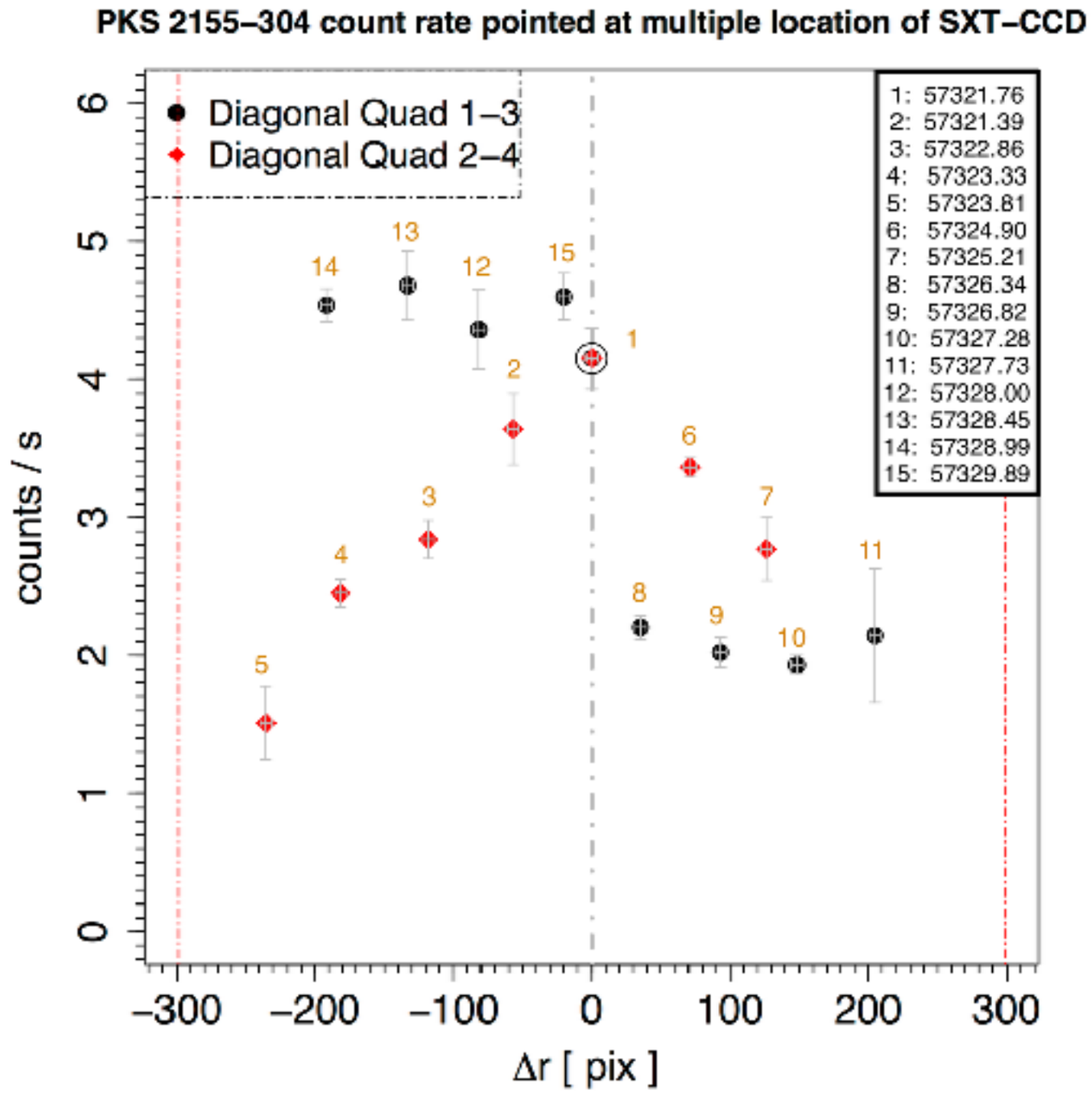


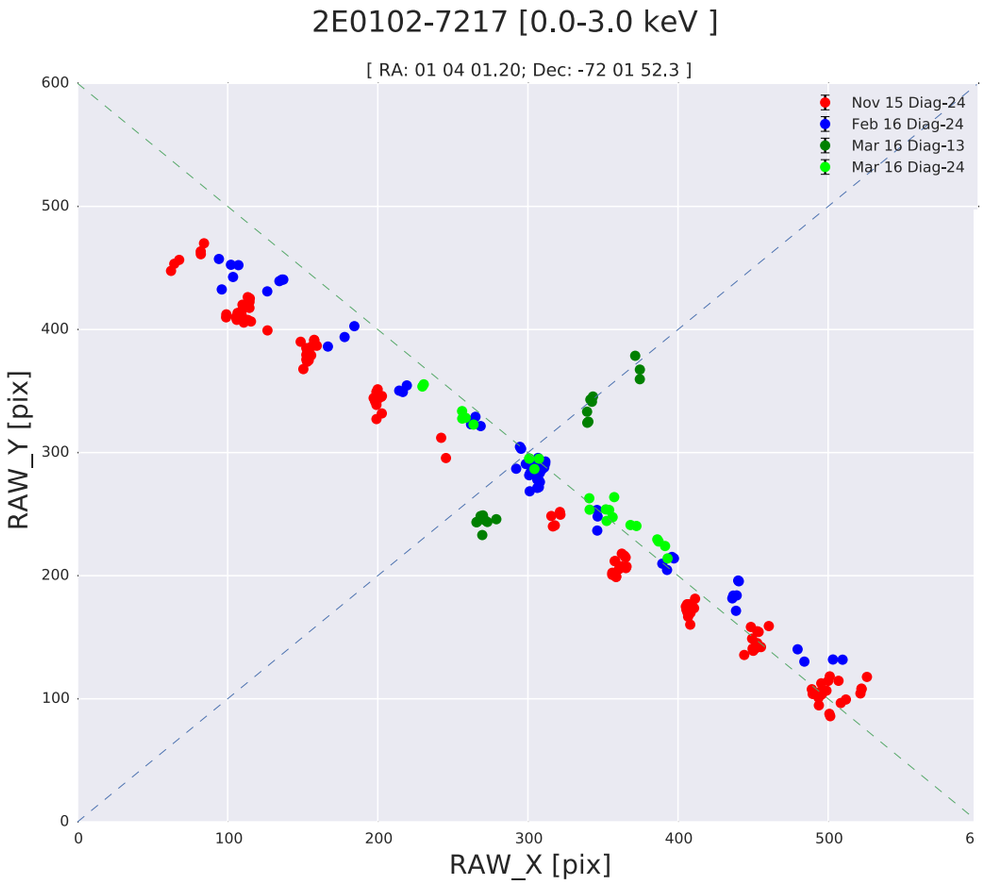


Vignetting function Using SNR 2E0102-7217

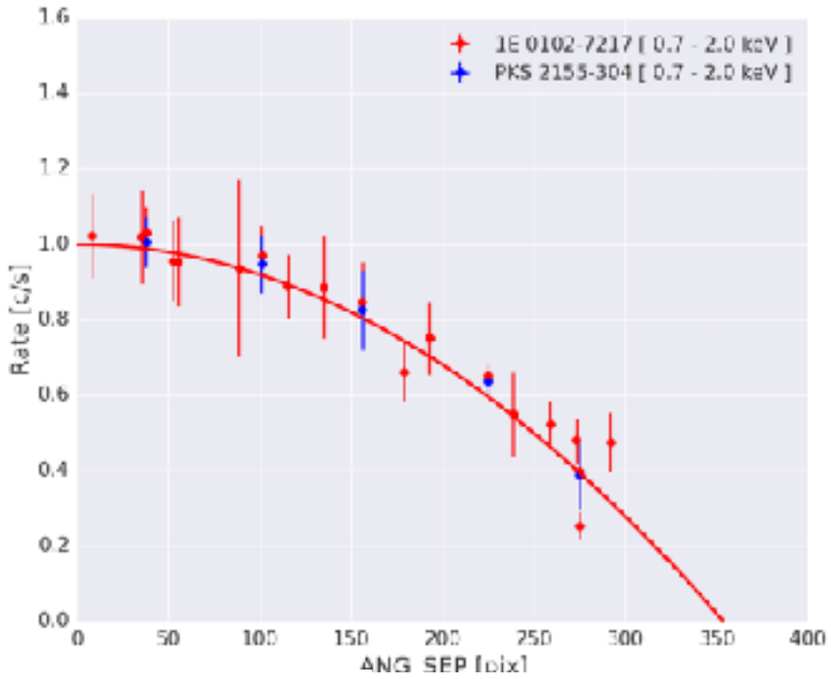
$$V(\theta) = 1 - C\theta^2$$

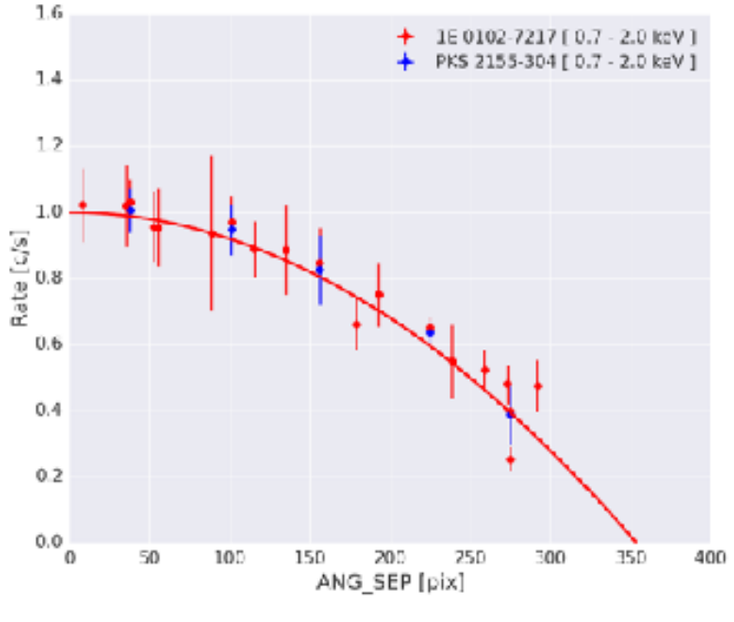
θ is the off-axis angle, and the coefficient C is a function of energy (in keV),

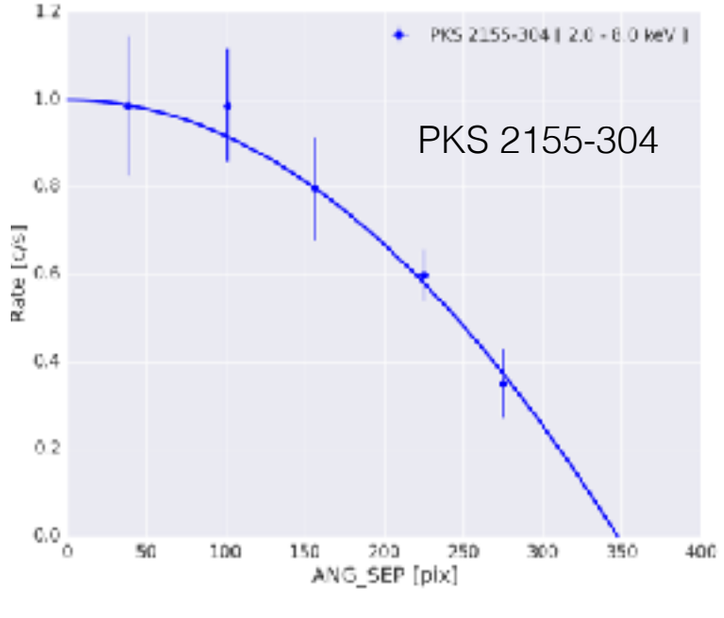
$$C(E) = P_0 \times E^{P_1} + P_2$$



P_0 = -2.492e-06
P_1 = 0.9996
P_2 = 9.6120e-06







Singh et al. 2017, (Telescope Description and Calibration Status), In preparation

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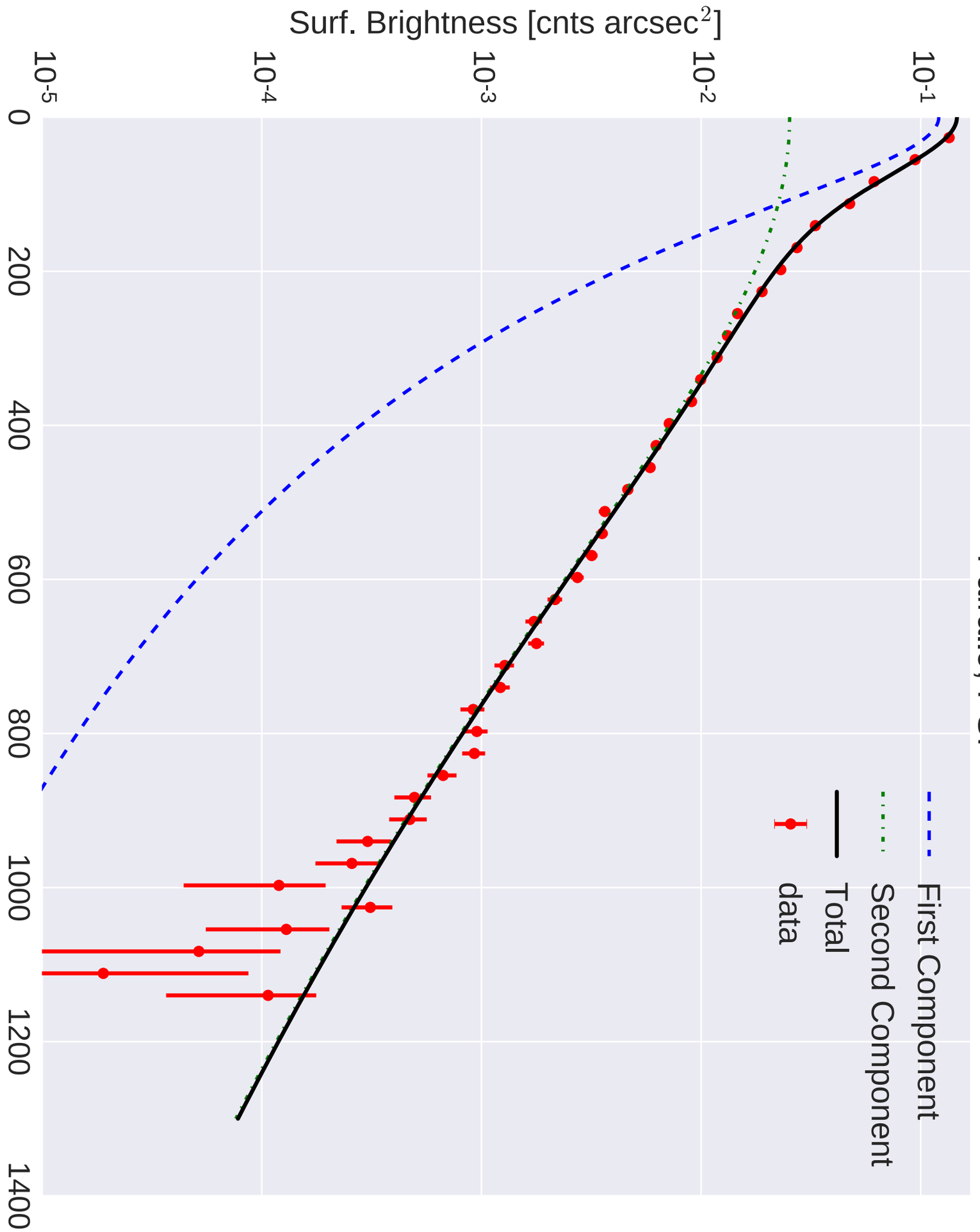
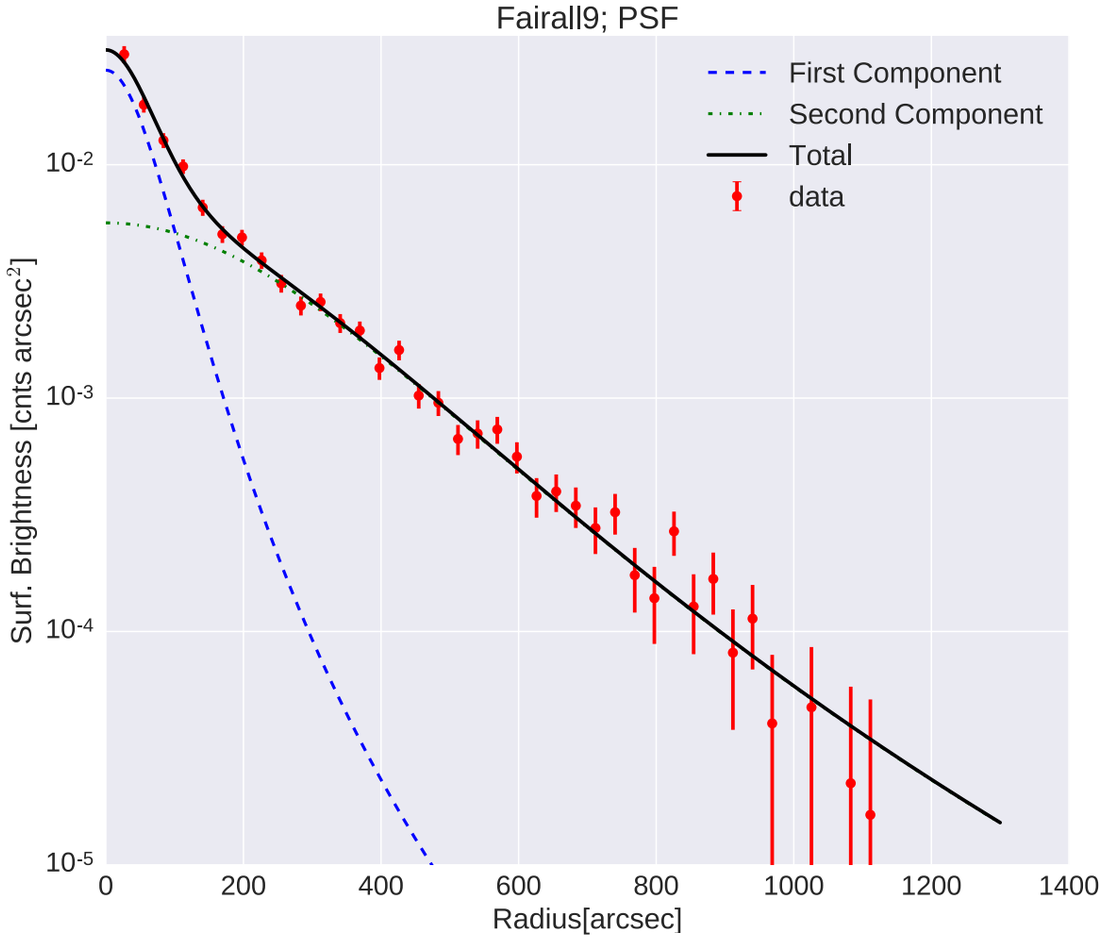
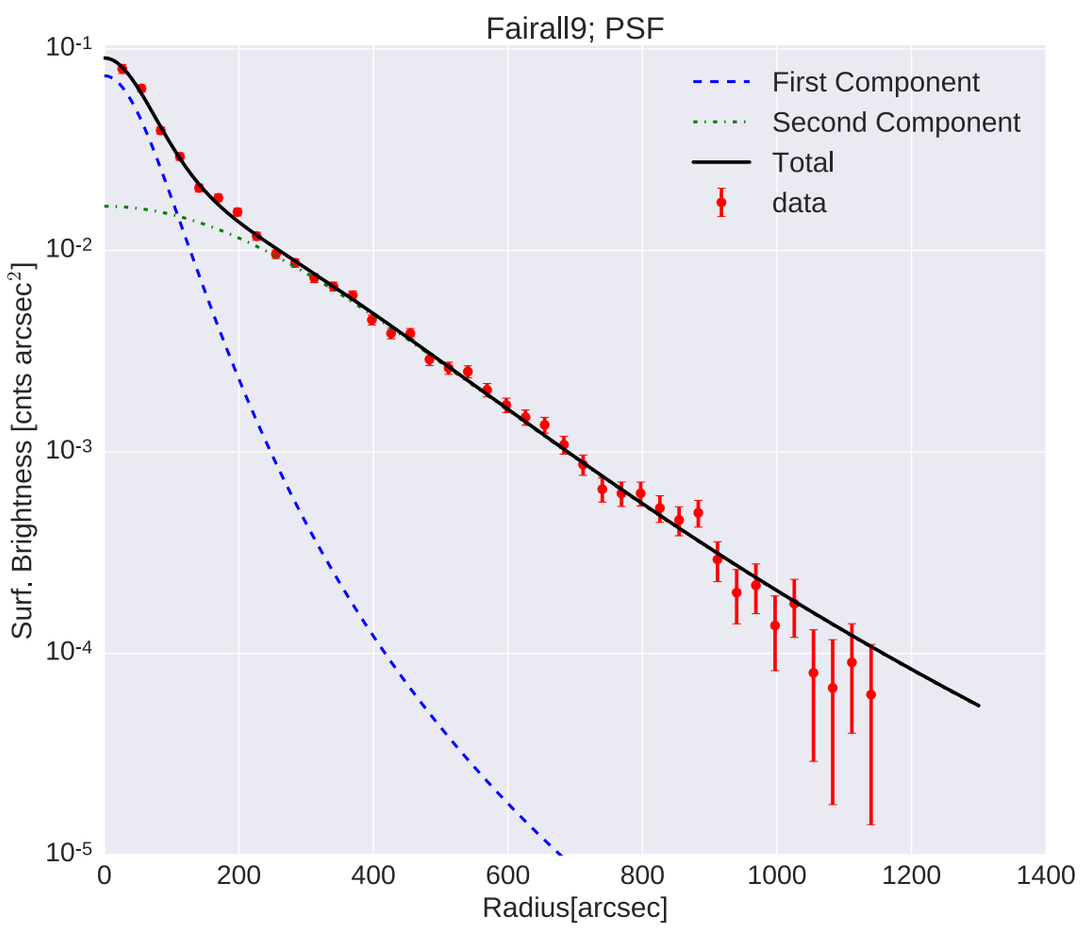
$$S(r) = i_{01} \times [1 + (\frac{r}{r_{c1}})^2]^{\alpha 1} + i_{02} \times [1 + (\frac{r}{r_{c2}})^2]^{\alpha 2}$$

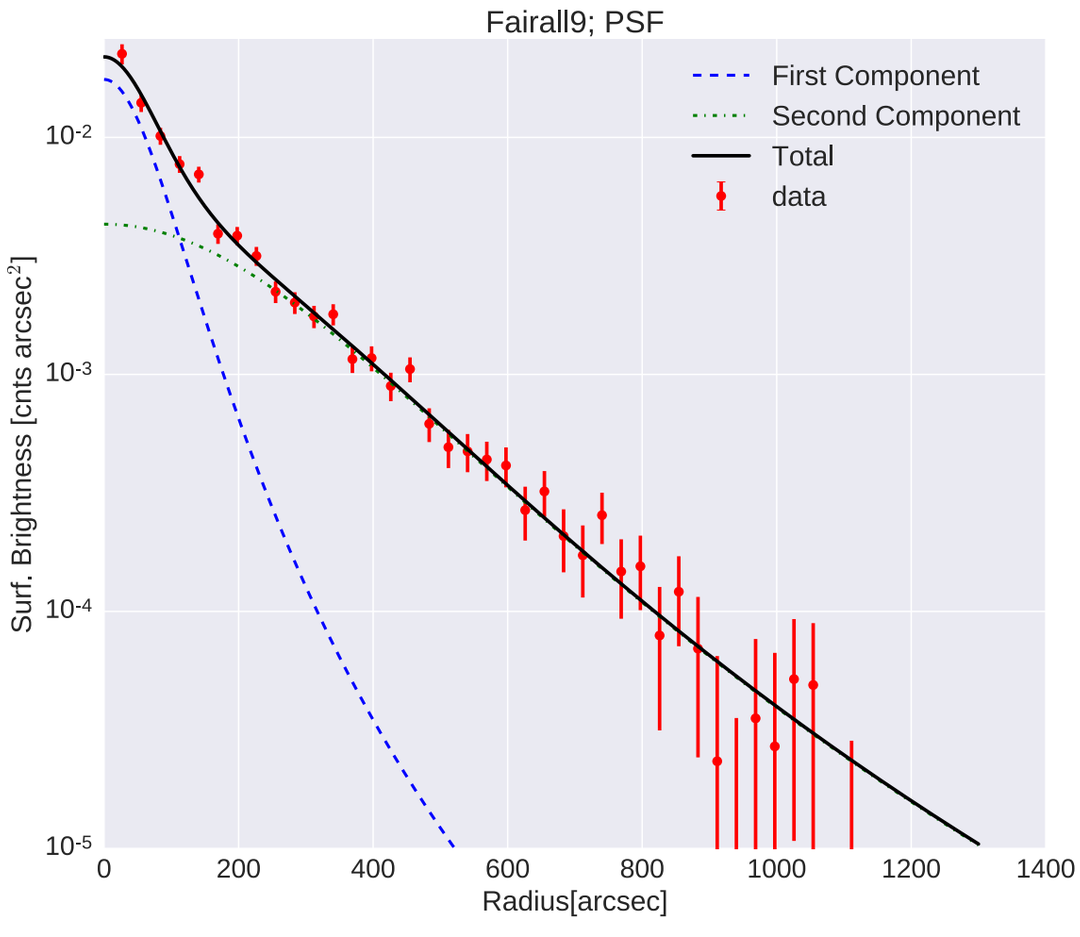
where S(r) is the surface brightness of the image corresponding to the particular energy band.



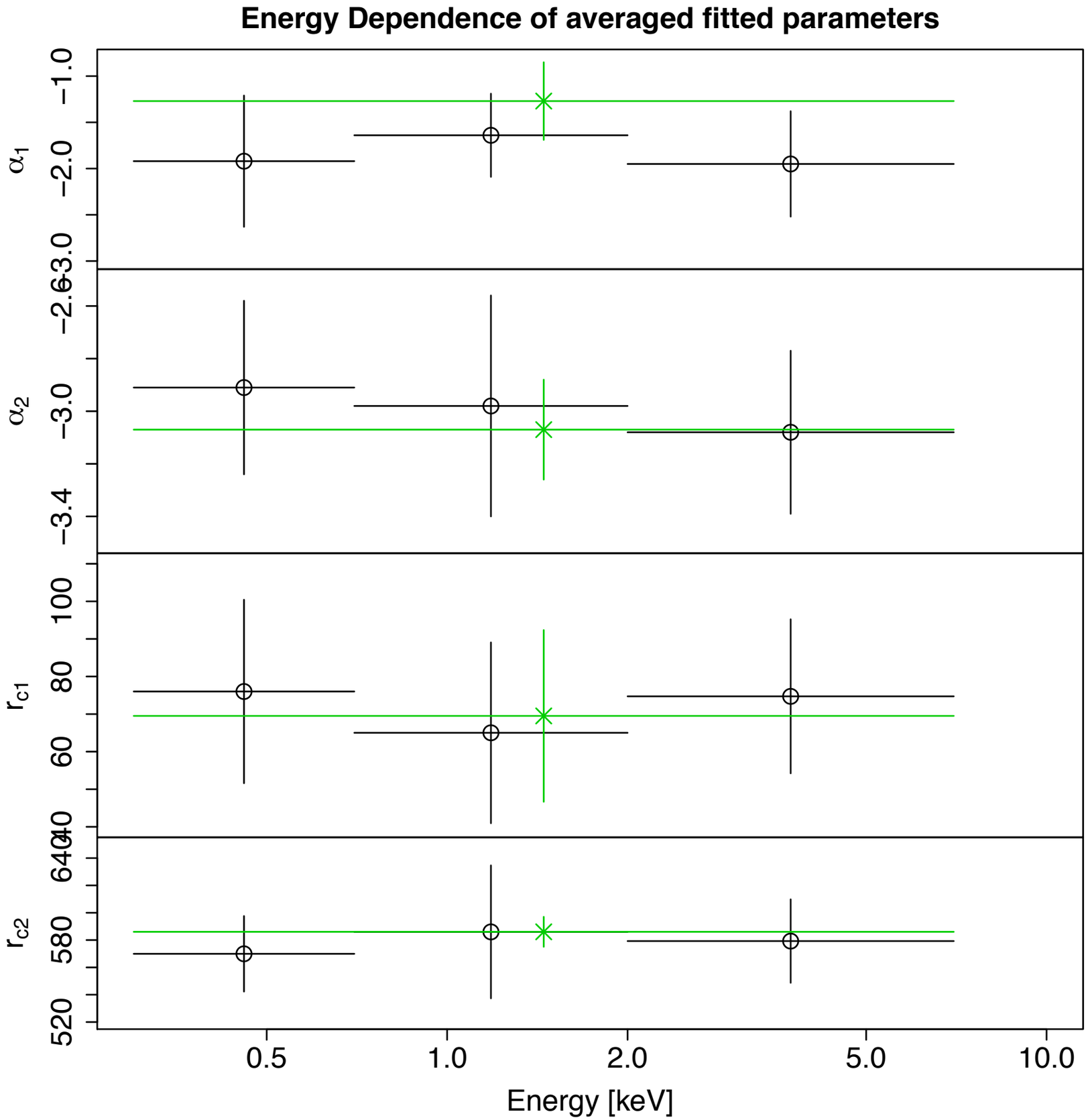
$$S(r) = i_{01} \times [1 + (\frac{r}{r_{c1}})^2]^{\alpha 1} + i_{02} \times [1 + (\frac{r}{r_{c2}})^2]^{\alpha 2}$$

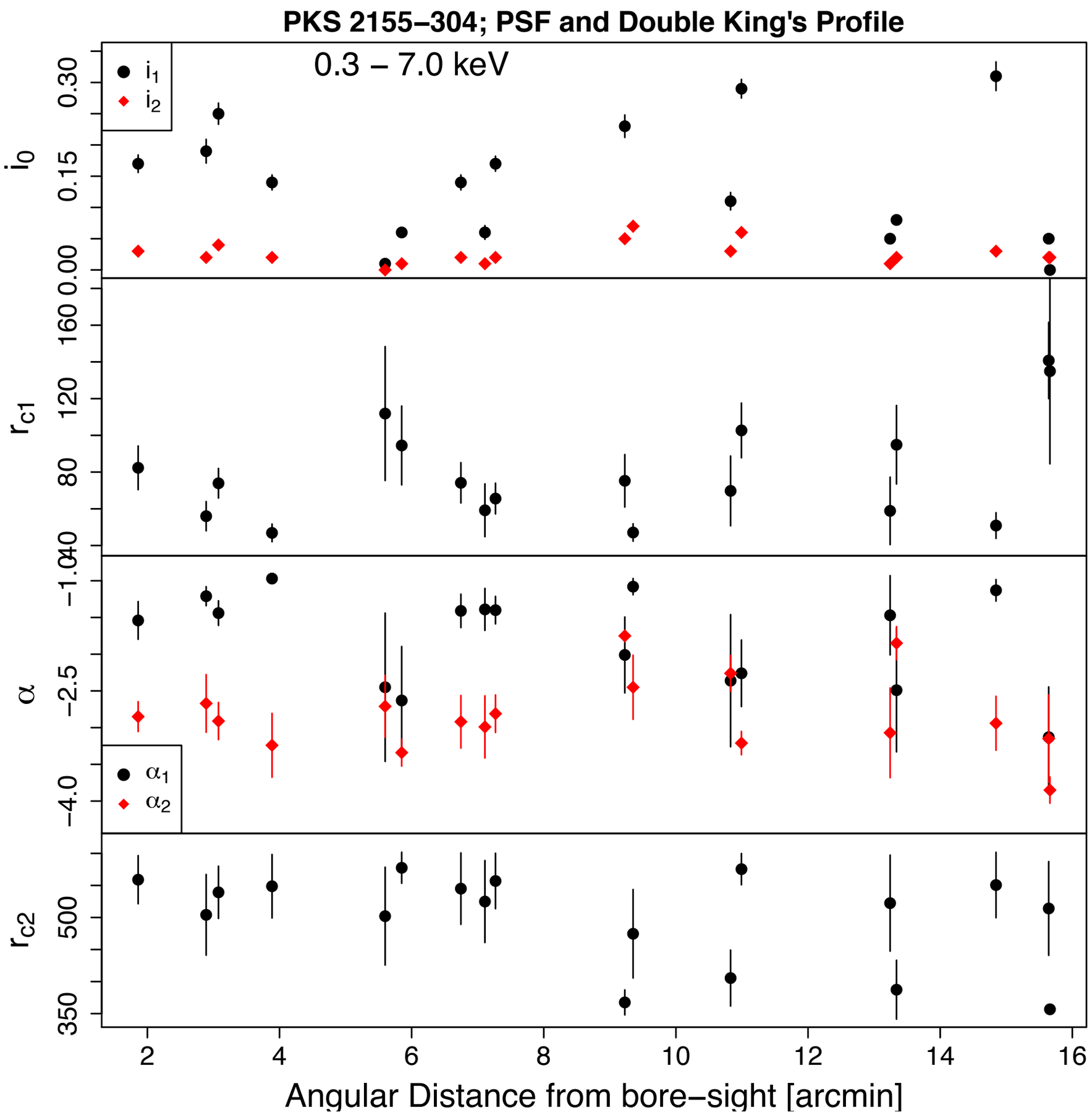






Source Name	Coordinate (pix,pix)	Mode	max_radius (pix)	Number of cells
1ES 1959+650	(298.56201,291.64582)	A02a	280	40
	(300.50042,293.53624)	A02b	280	40
	(298.42818,290.5263)	G06	280	40
Faiall 9	(302.42527,278.3769)	G06	280	40
GX13+1	(142.38307,169.47535)	G05	120	40
IGRJ17091-3624	(204.66133,203.52306)	T01	200	40
LMCX-2	(265.62066,167.51322)	G05	170	35
Mrk 110	(301.4574,294.72462)	G05	280	40
Mrk 421	(267.53592,185.48931)	G05	180	40
Mrk 501	(301.54029,294.61479)	G05	280	40
PKS 2155-304	(270.50215,287.71113)	PV01	280	40
4U 1728-34	(268.34081,171.5014)	G05	170	40
Cyg X-3	(259.56974,189.50537)	G05	200	40
	(262.40972,187.35579)	G05	200	40
NGC 4051	(303.628,293.519)	G05	280	40


Energy Dependence of averaged fitted parameters
α1
−1.0
−2.0
−3.0
α2
−2.6
−3.0
−3.4
rc1
100
80
60
40
rc2
640
580
520
0.5
1.0
2.0
5.0
10.0
Energy [keV]


PKS 2155−304; PSF and Double King's Profile
0.3 – 7.0 keV
i1
i2
i0
0.30
0.15
0.00
rc1
160
120
80
1.040
α
−2.5
−4.0
α1
α2
rc2
500
350
2
4
6
8
10
12
14
16
Angular Distance from bore−sight [arcmin]

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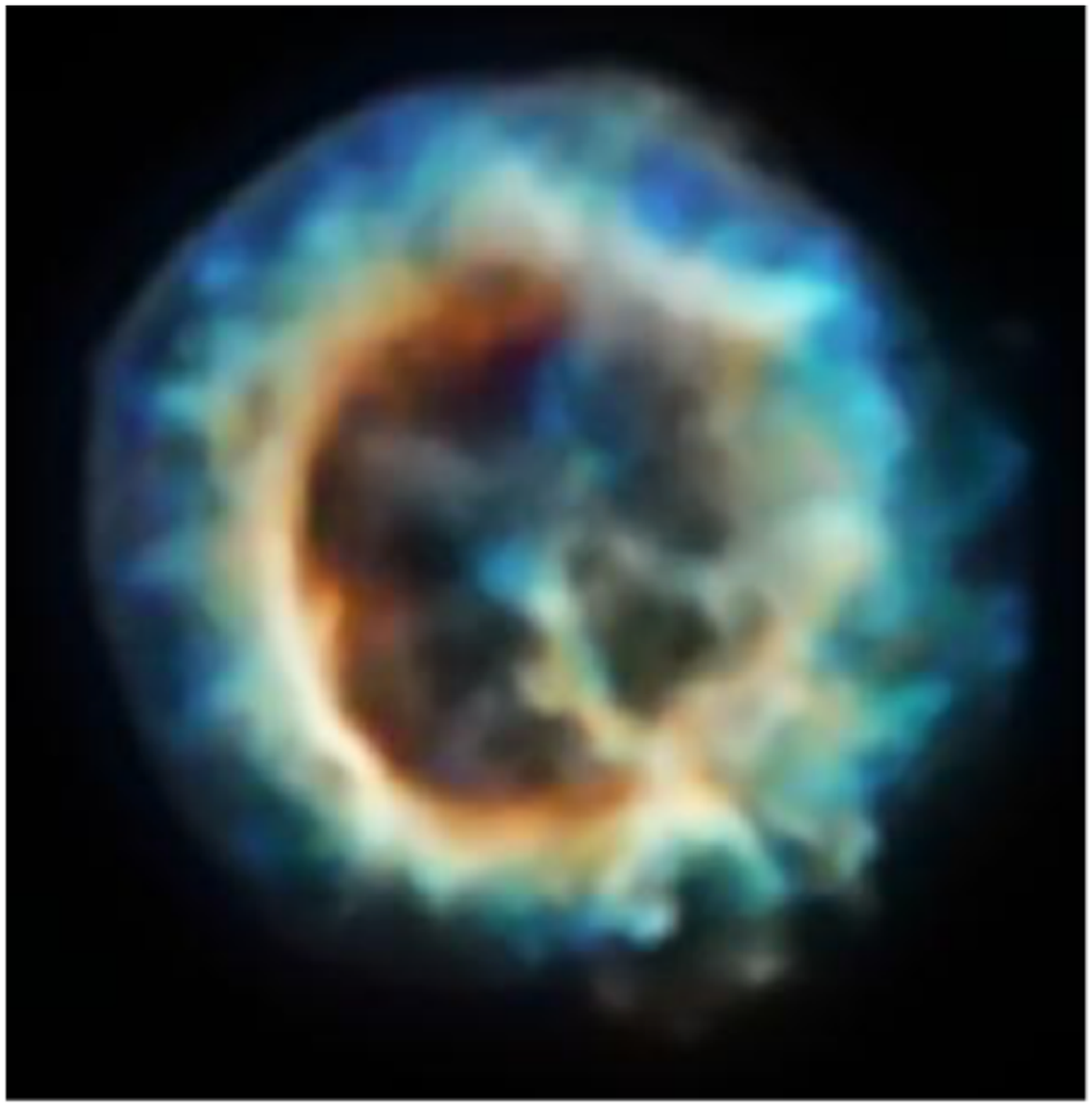
1E 0102-7217

Fantastic Spectral Calibration for low energy side (0.3-2.0 keV)

Effective Area Calibration using Raster Scanning mode observations

Celebrated IACHEC SNR for low energy spectral calibrations



Red (0.3-0.5 keV), Green (0.5-0.75 keV)
Blue (0.75 – 7.0 keV)

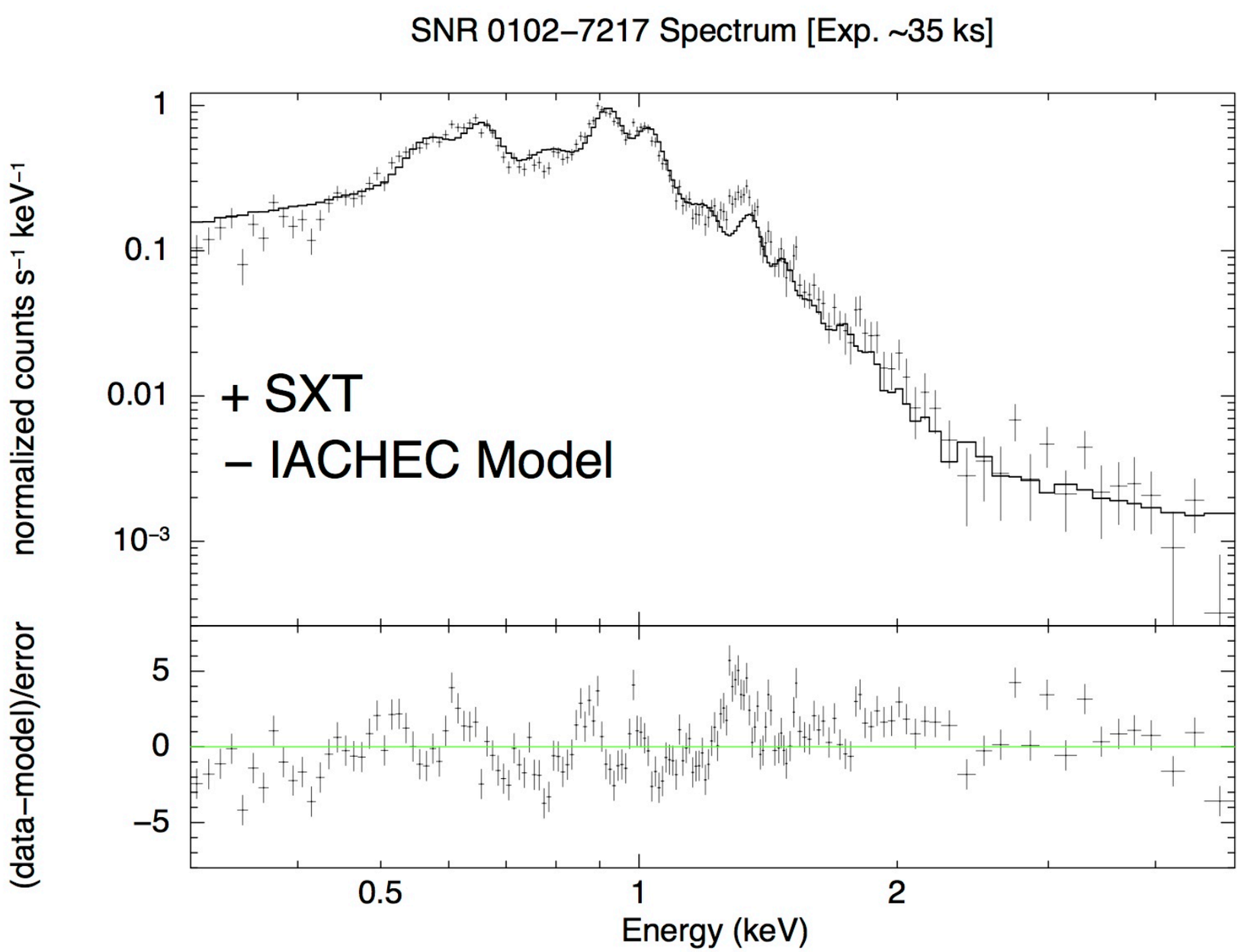


Figure 9. The X-ray spectrum of 1E0102-72.3 as fitted with the IACHEC model derived from several X-ray observatories carrying a CCD camera in the focal plane of a telescope. The SXT spectrum was extracted from a radius of 10 arcmin.

SXT March 2016 & Dec 2015 (reg. 8'; black); SXT Oct 2016 (reg. 18'; red); SXT (reg 13'; green)

normalized counts s^{-1} keV^{-1}

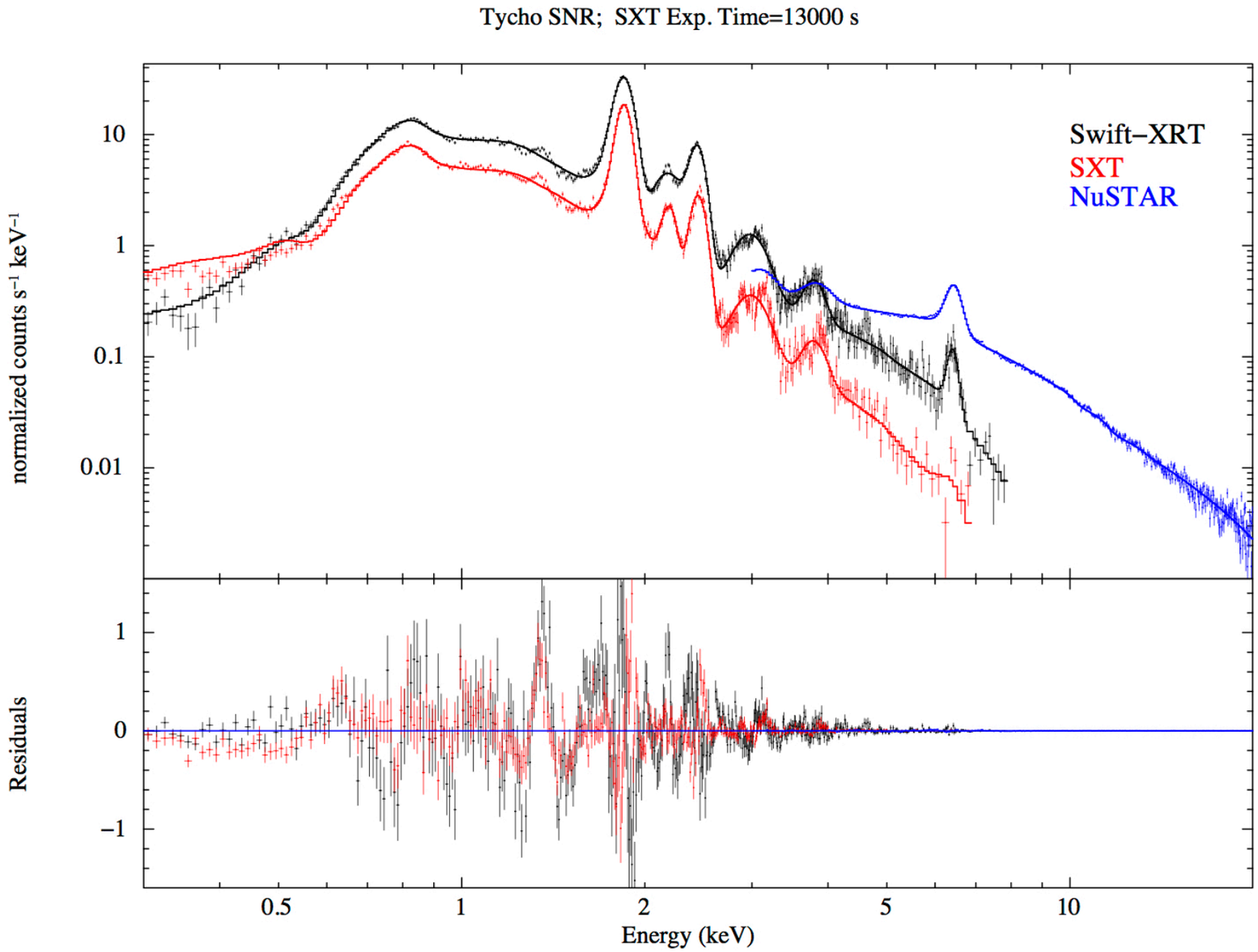
1
0.5
0.2
0.1

(data−model)/error

4
2
0
−2
−4

0.5
1

Energy (keV)



The X-ray spectrum of Tycho SNR as obtained with the SXT, Swift XRT and the NuStar. The SXT spectrum was extracted from a radius of 18 arcmin for this bright source

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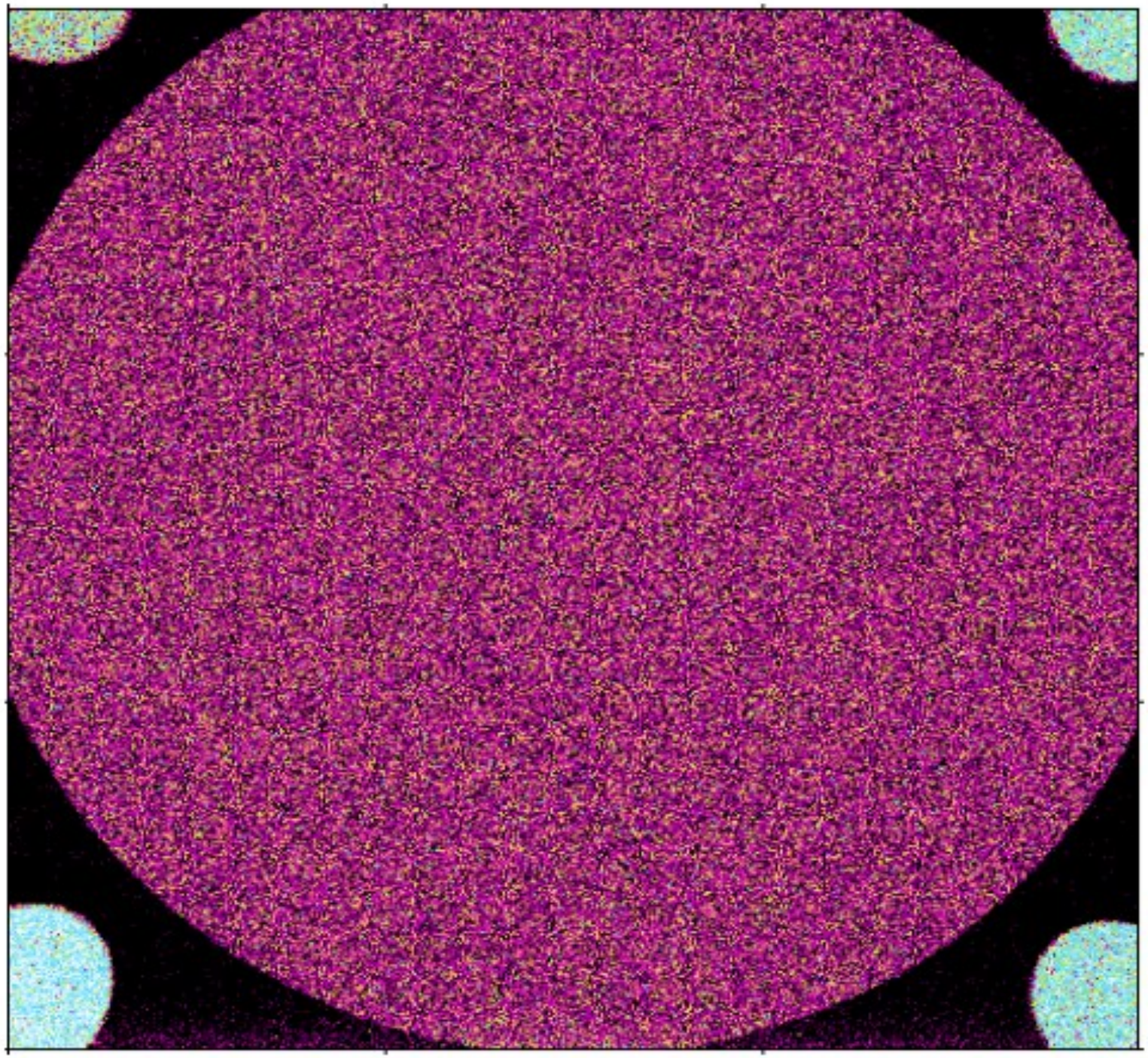
(599,599)

CS4



CS3

CS2

CS1

(0,0)

Corner Source Spectrum; # = CS1

Counts Channel^{-1}

Channel [#]

Guass. Start
Loren. Start
Gaussian
Lorentzian
data

Corner Source Spectrum; # = CS2

Counts Channel^{-1}

Channel [#]

Guass. Start
Loren. Start
Gaussian
Lorentzian
data

Corner Source Spectrum; # = CS3

Counts Channel^{-1}

Channel [#]

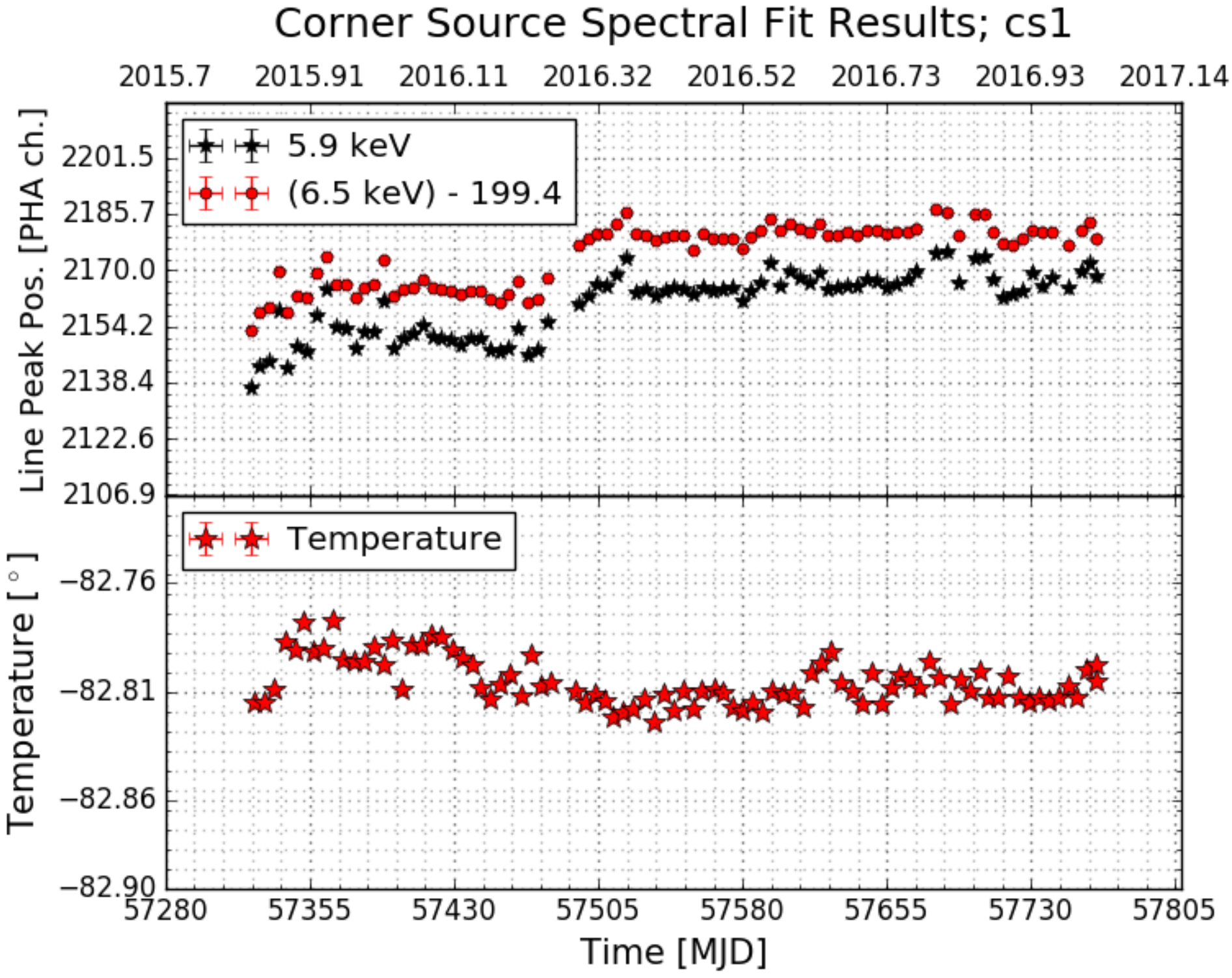
Guass. Start
Loren. Start
Gaussian
Lorentzian
data

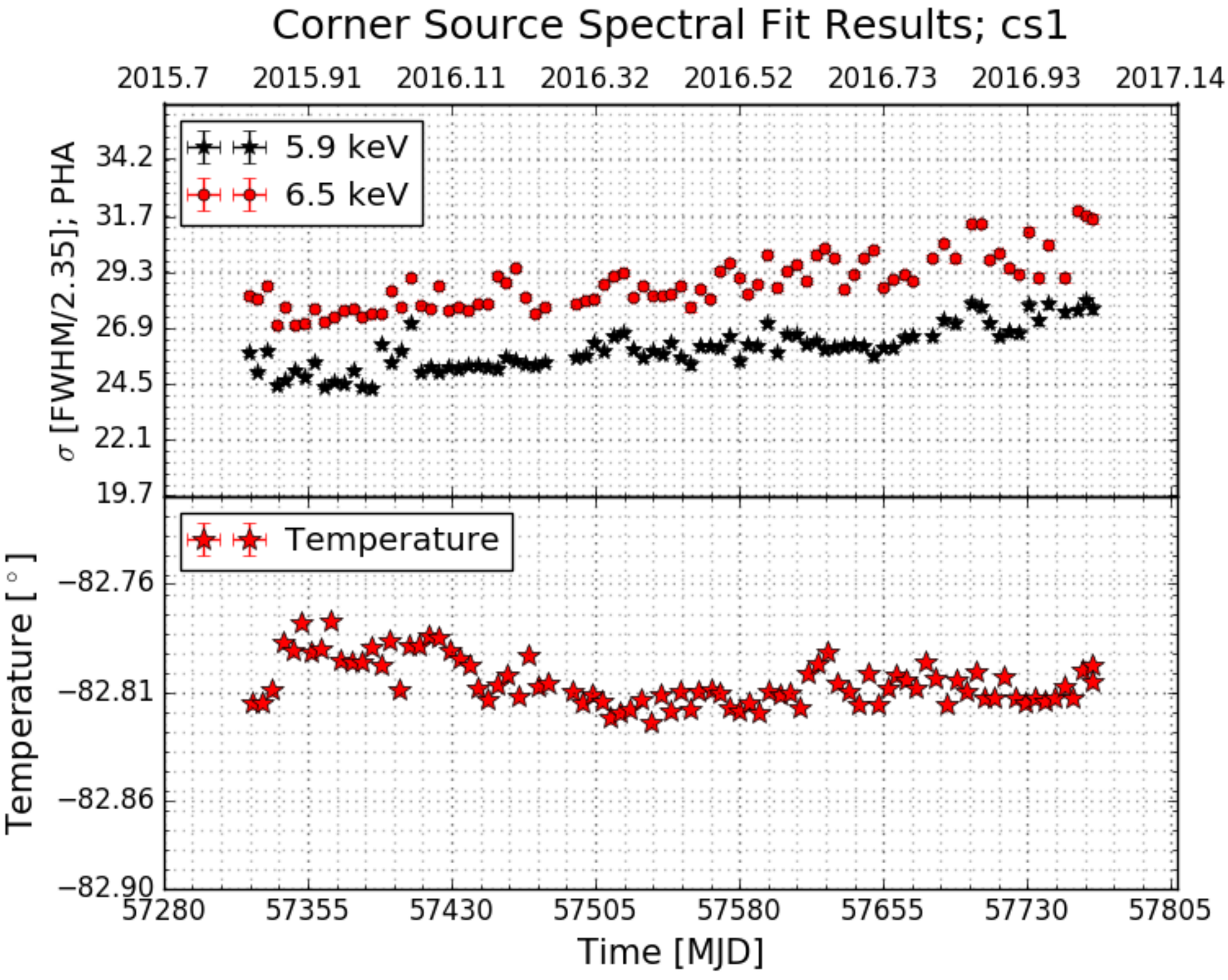
Corner Source Spectrum; # = CS4

Counts Channel^{-1}

Channel [#]

Guass. Start
Loren. Start
Gaussian
Lorentzian
data


Corner Source Spectral Fit Results; cs1
2015.7
2015.91
2016.11
2016.32
2016.52
2016.73
2016.93
2017.14
Line Peak Pos. [PHA ch.]
2201.5
2185.7
2170.0
2154.2
2138.4
2122.6
2106.9
5.9 keV
(6.5 keV) - 199.4
Temperature [°]
−82.76
−82.81
−82.86
−82.90
Temperature
57280
57355
57430
57505
57580
57655
57730
57805
Time [MJD]


Corner Source Spectral Fit Results; cs1
2015.7
2015.91
2016.11
2016.32
2016.52
2016.73
2016.93
2017.14
5.9 keV
6.5 keV
σ [FWHM/2.35]; PHA
34.2
31.7
29.3
26.9
24.5
22.1
19.7
Temperature
Temperature [°]
−82.76
−82.81
−82.86
−82.90
57280
57355
57430
57505
57580
57655
57730
57805
Time [MJD]

Summary

- The optical axis of SXT, determined, is approximately along the detector axis

- The energy dependent vignetting functions are generated and are updated in CALB

- The PSF determinations is almost done and are updated in CALDB

- The spectral comparison with the IACHEC model shows that the area and response matrix are constrained within satisfactory limits…a refinement is going on and soon will be updated with CALDB

- A gain shift of around 30 eV has been noted since the launch of AstroSat

1ES 1959+650 (SXT+LAXPC)

normalized counts s^{-1} keV^{-1}

10
1
0.1
0.01
10^{-3}

Preliminary

T1 (Black), T2 (Red), T3 (Green), T4 (Blue)

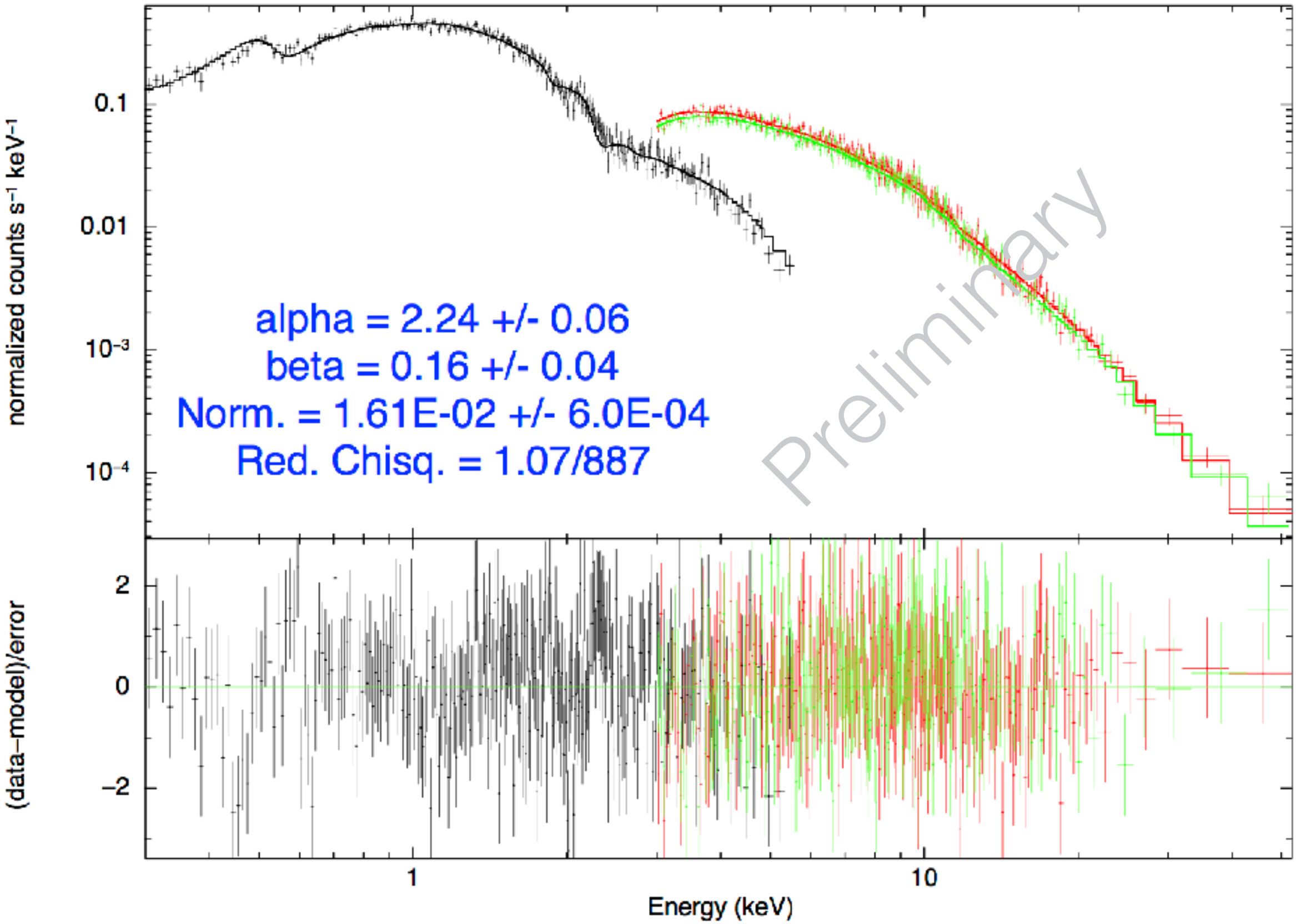
(data−model)/error

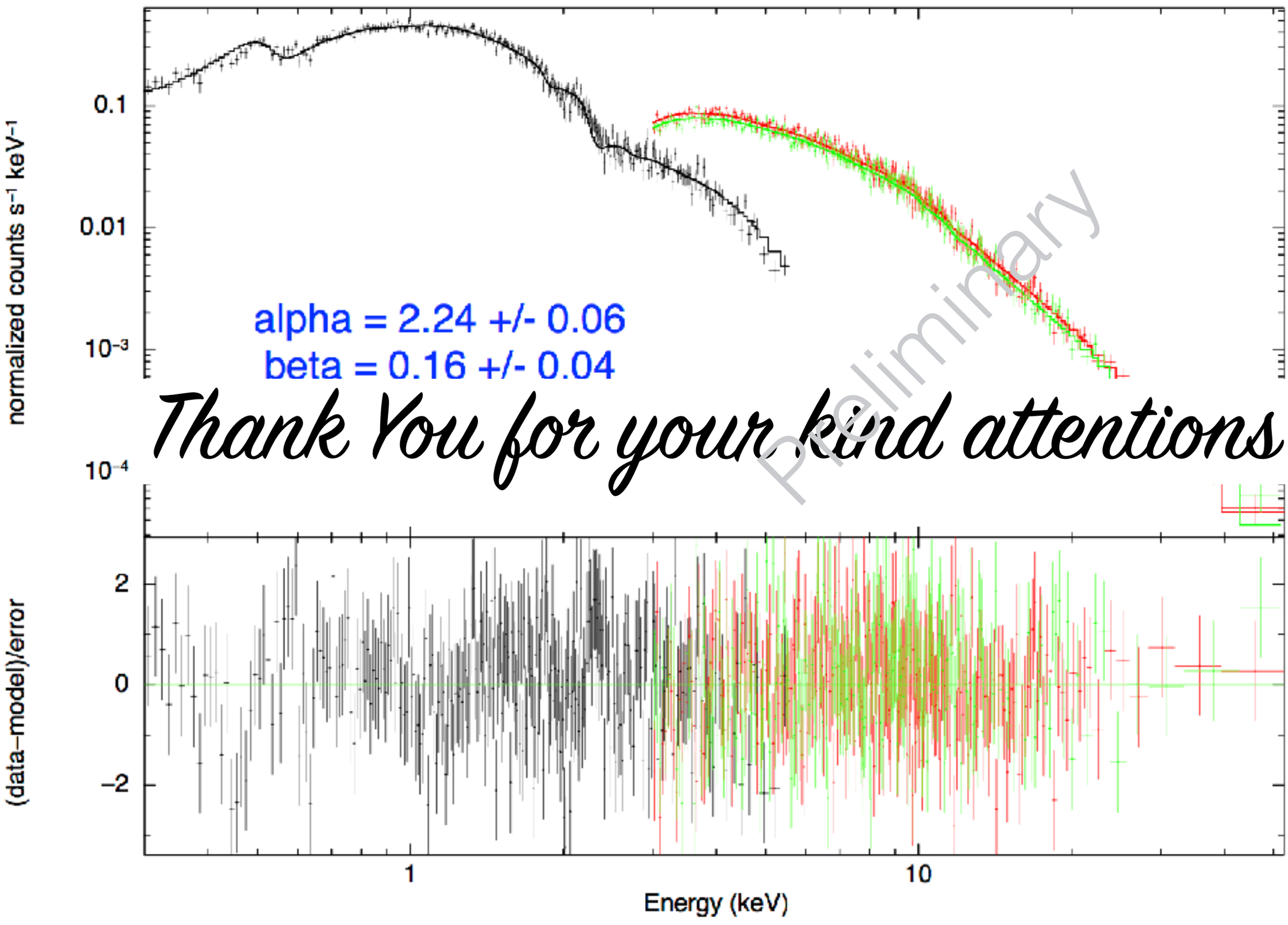
5
0
−5

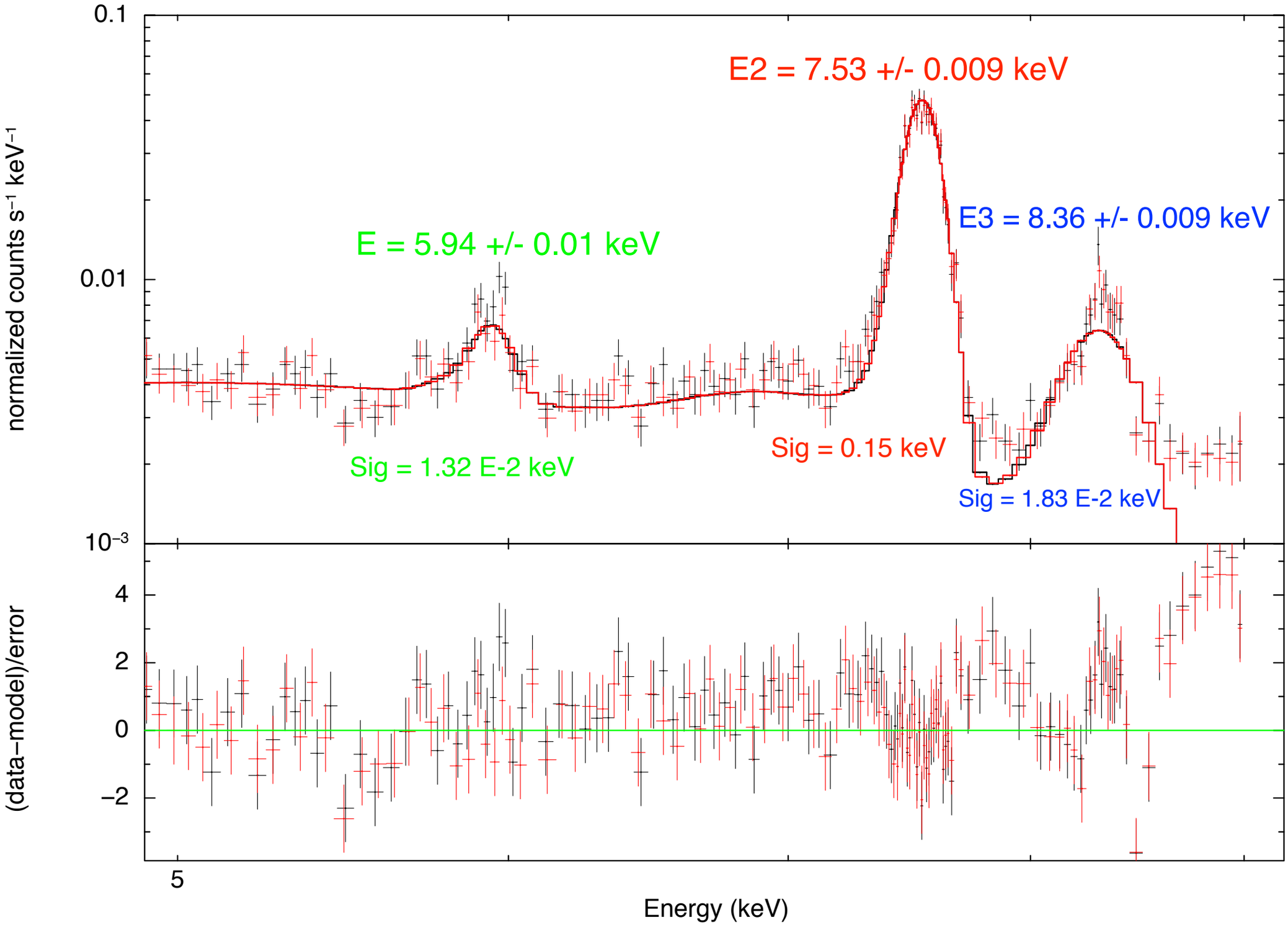
0.5
1
2
5
10
20

Energy (keV)

1ES 1101−232 X−ray Spectrum; SXT (black), NuSTAR(red & green)





Thank You for your kind attentions

Combined Sky Bkg. Spectrum; including (red)/excluding(black) sky2a & sky2b