SXT calibration status & UV/X-ray spectroscopy with AstroSat

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On Behalf of

AstroSat Science Support Cell (ASSC), IUCAA
(http://astrosat-ssc.iucaa.in)

SXT-Payload Operation Centre, TIFR
(http://www.tifr.res.in/~astrosat_sxt/index.html)

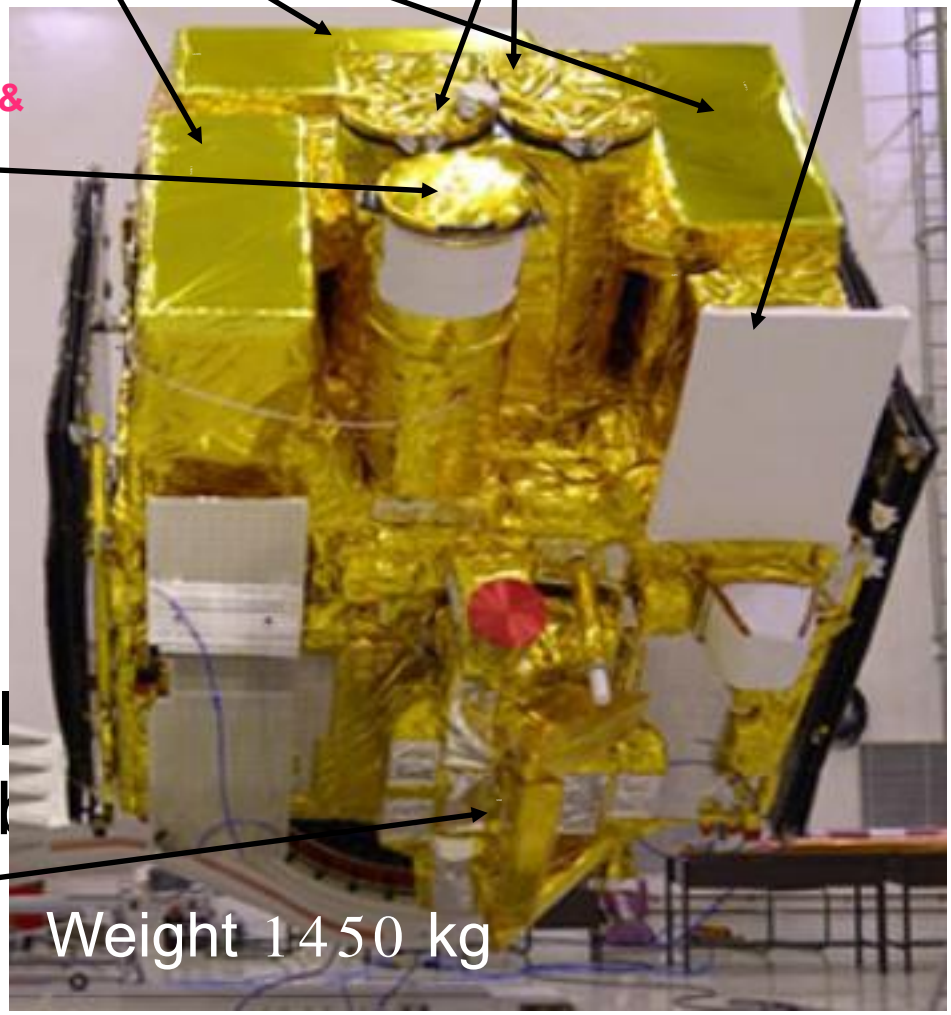
AstroSat

LAXPC
3-100 keV X-ray Timing, broadband spectroscopy

UVIT
1.4" UV imaging
1200 - 3000 A

CZTI
10-250 keV hard X-ray imaging, timing, spectroscopy

SXT
0.2-8 keV imaging & line spectroscopy



SSM
rotating 2-10 keV monitor

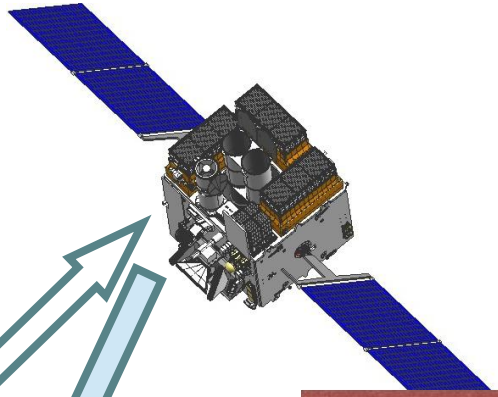
PI: S. Seetha (ISRO)
PMs: S.N. Tandon (UVIT),
H. M. Antia (LAXPC),
S. Bhattacharyya (SXT)
A.R. Rao (CZTI)
M.C. Ramadevi (SSM)

LAXPC: TIFR, RRI
SXT: TIFR, ISRO, UoL
CZTI: TIFR, ISRO, IUCAA, RRI, PRL
SSM: ISRO, IUCAA, RRI
UVIT: IIA, ISRO, IUCAA, CSA

Spacecraft: ISRO
Operations: ISRO
Ground software: ISAC, SAC, TIFR, RRI, IIA, IUCAA, NCRA, PRL

Launched 30 September 2015,
Orbit 650 km altitude circular 6deg inclination

AstroSat – Proposal driven Operation



USER COMMUNITY

DATA ANALYSIS & MODELING

PROPOSALS (APPS)

REVIEW &TIME ALLOCATION (ATAC, ATC)

ISTRAC (ISRO) SCHEDULING OBSERVATIONS

commands

data

ISSDC (ISRO)

raw data

Processed data

Payload Operation Centres (POCs)

LAXPC: TIFR, RRI
UVIT: IIA
SXT: TIFR
CZTI: IUCAA
SSM: ISAC, IUCAA

ASTROSAT DATA ARCHIVE

ASTROSAT SCIENCE SUPPORT CELL (IUCAA)

AstroSat mission status

Nearly 3.5 years in orbit, ~20000 revolutions, 1449 individual pointings, ToOs being executed more frequently now

UVIT: NUV control electronics failure

- recurring noise issues, monthly reset executed
- In hibernation for more than a year now
- Recovery attempts have failed.

FUV and VIS channels functioning normally

LAXPC: Unit 3 had gas leak. Switched off on 8 March 2018

Unit 1 showed anomalous counts since 26 March 2018

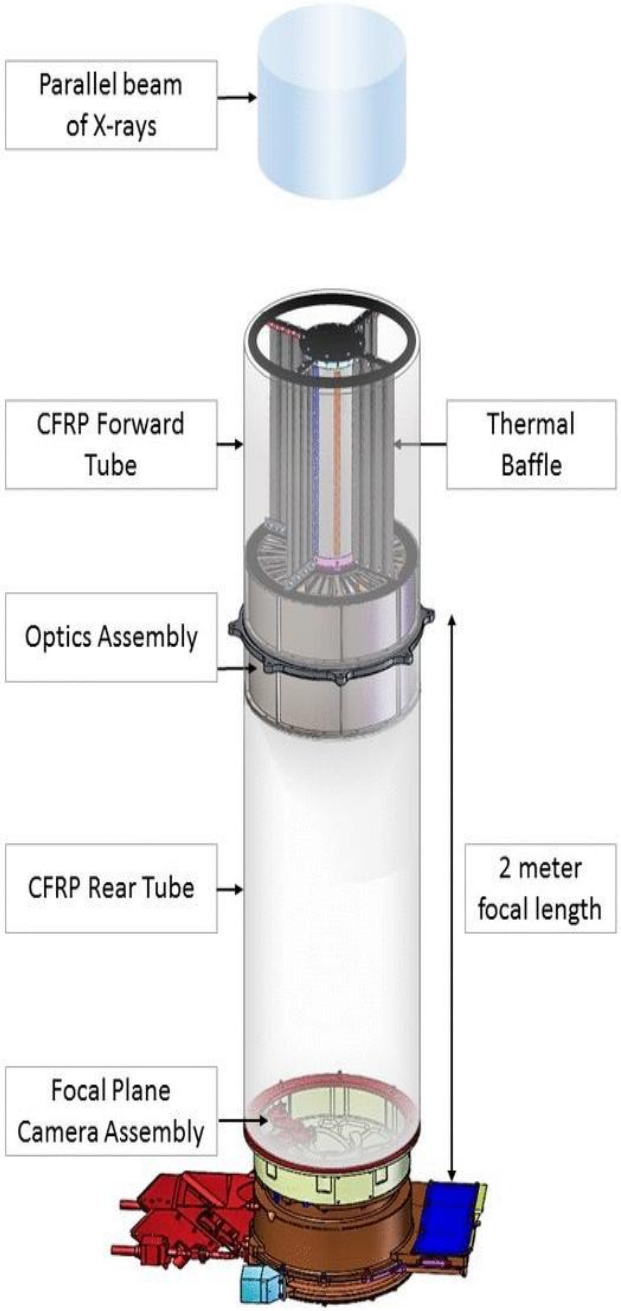
- Operated with reduced HV since 29 March 2018
- Erratic behavour again started on 9 April 2019
- HV was further lowered on 17 April 2019, data not usable.

Unit 2 functioning normally

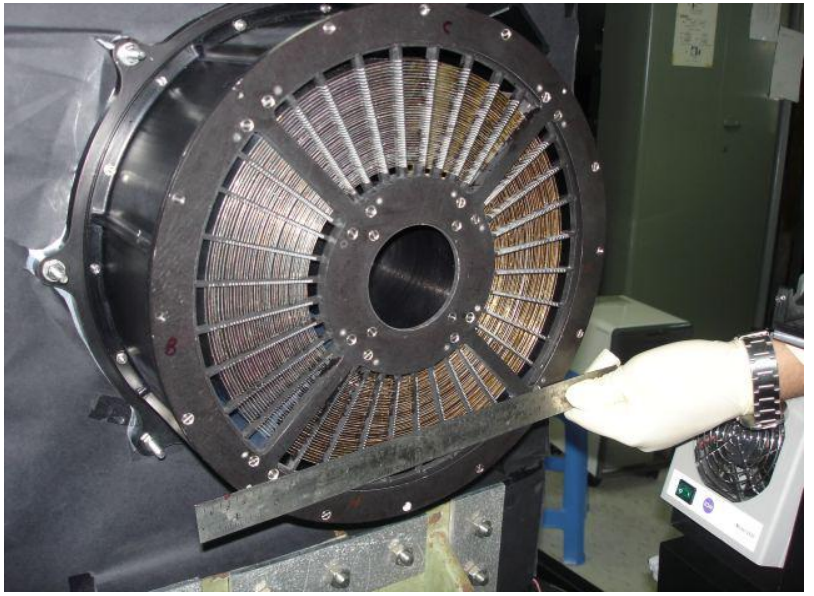
SSM: Operating with two cameras, the third had gas leak

SXT and CZTI functioning normally.

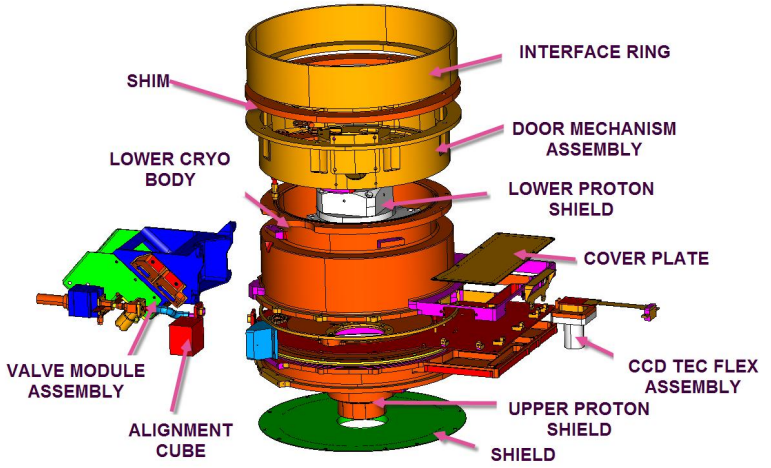
Soft X-ray Telescope



- Thin Optical Blocking Filter
- CCD Assy. including TEC
- PCB with front-end electronics
- Four Fe-55 corner sources for calibration

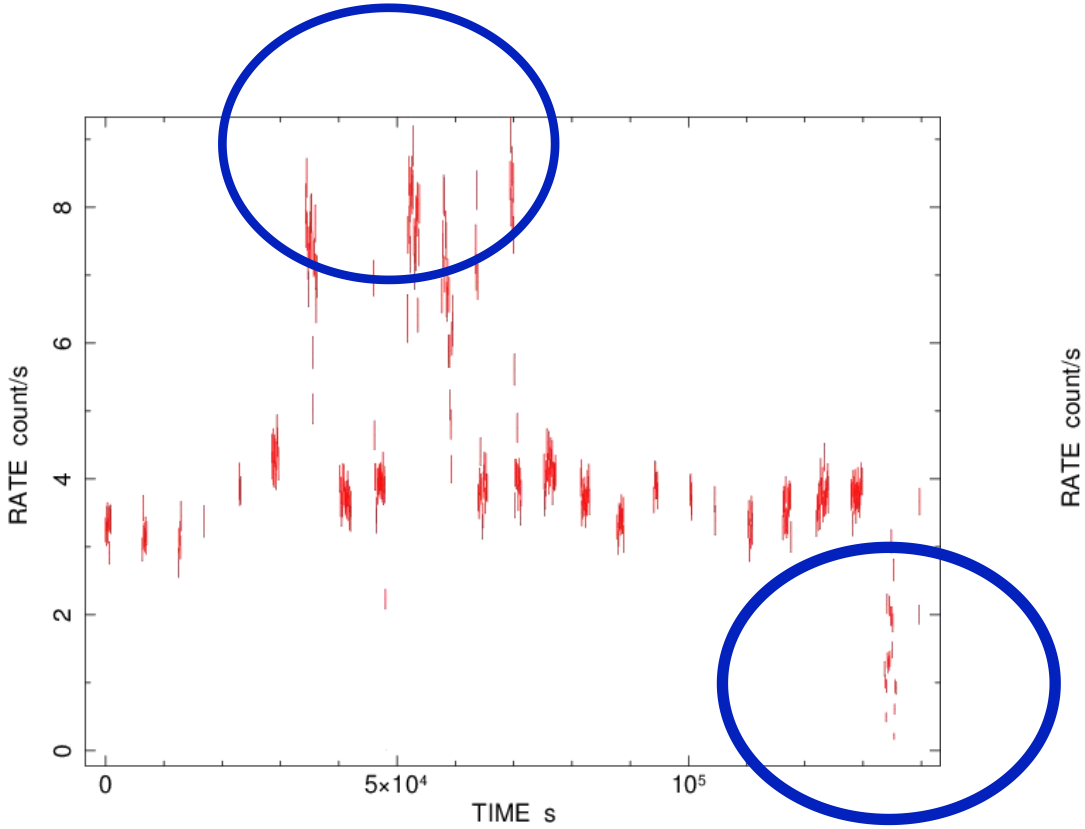


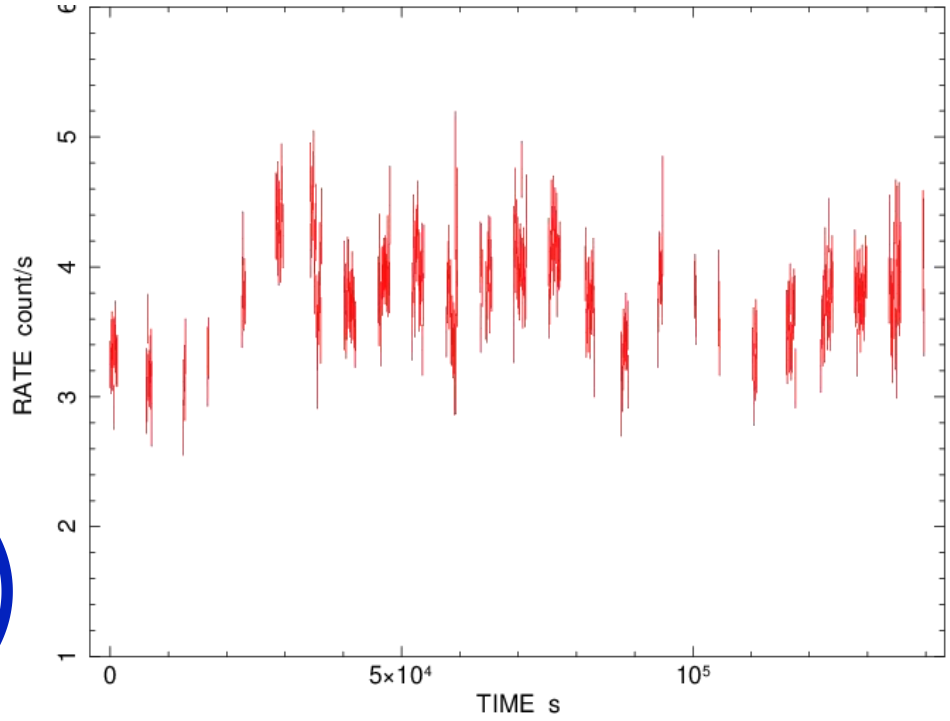
SXT- Focal Plane Camera Assy



SXT : Issues & Calibration Status

Data Issues





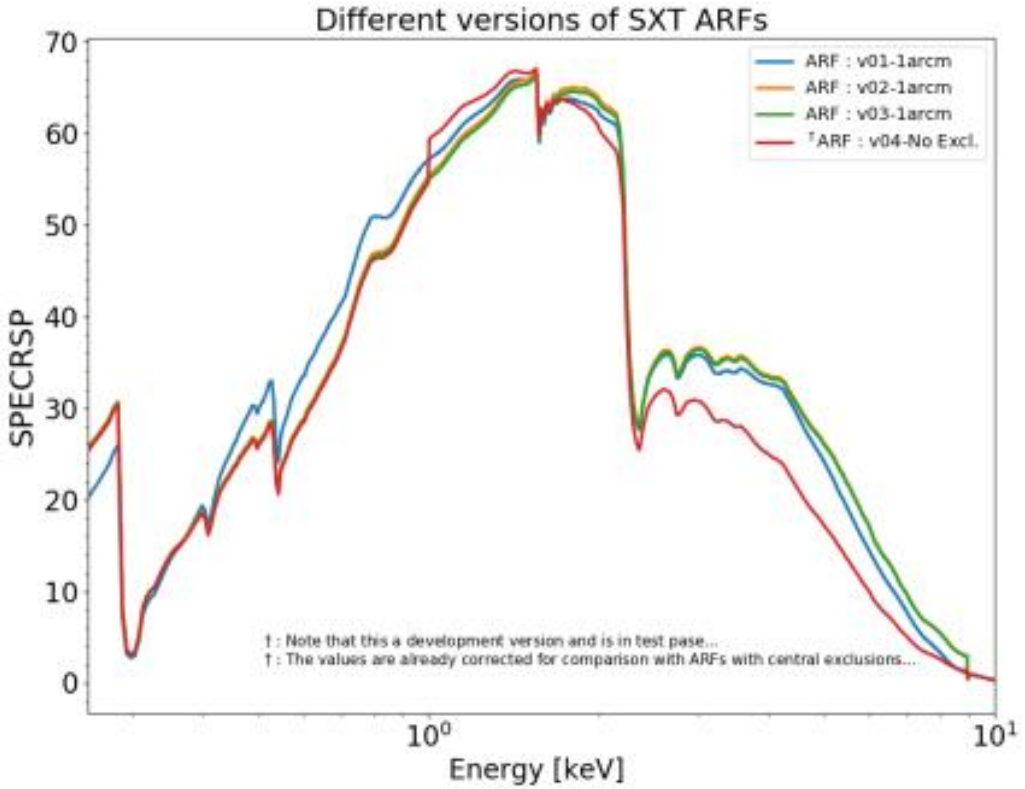
Double counting of events

(A new merger tool developed, **sxt_l2evtlist_merge.jl**)

Noisy data packets (a new algorithm implemented, **sxtpipeline 1.4b).**

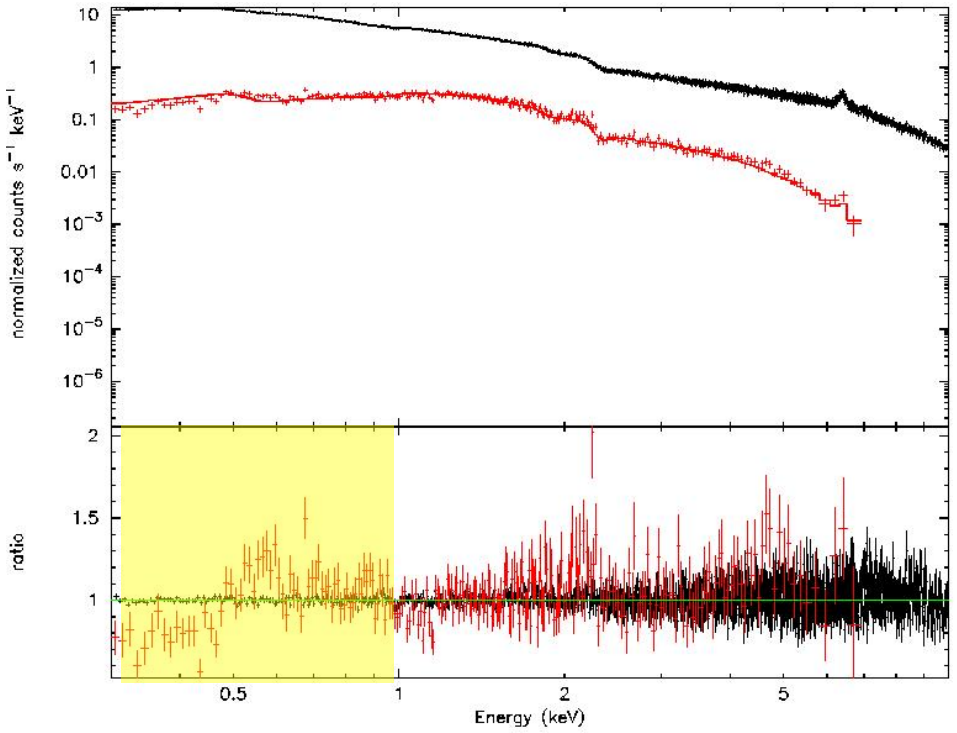
SXT ARF

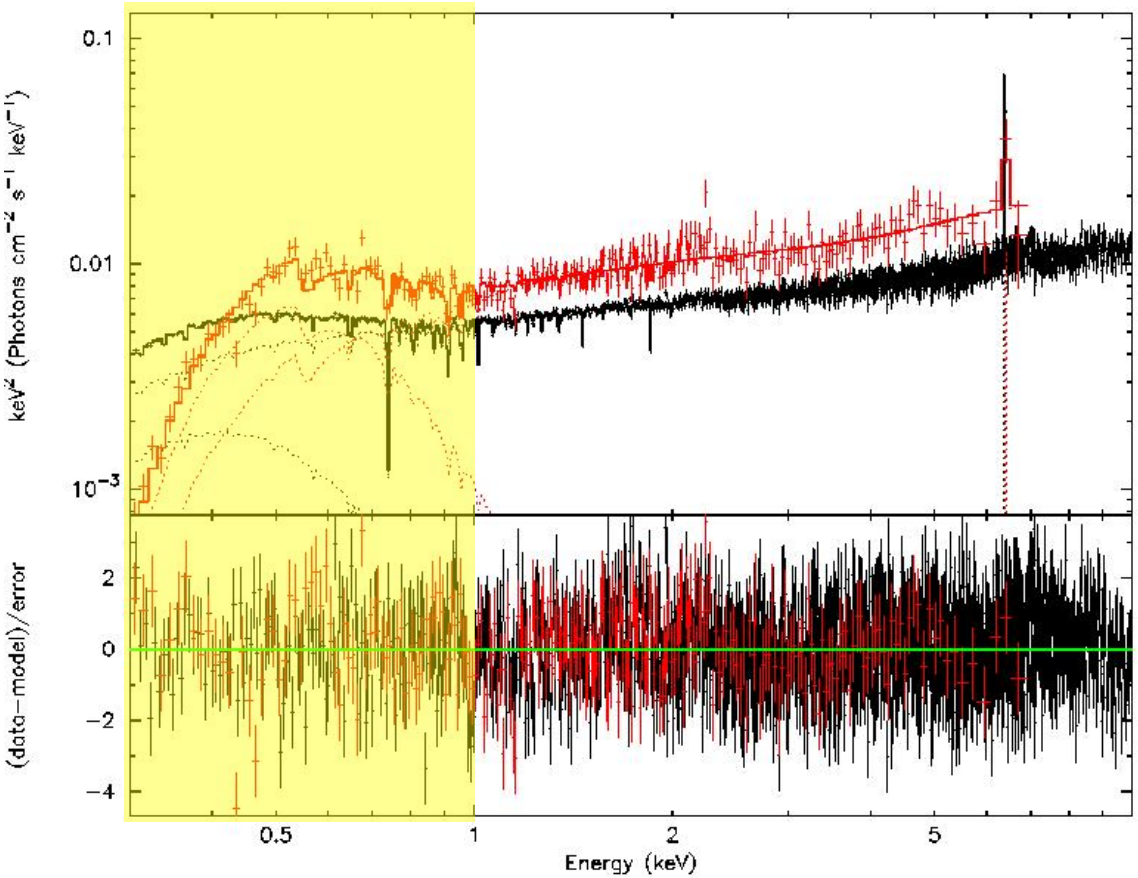
- ARF: recalibrated using Crab observations (Feb 2017)
  - Softer spectral shape, Issues at low energy < 1keV
- Recalibrated using simultaneous SXT/Swift data (May 2019)
  - Improved above 1keV but still issues at low energies



SXT : low energy response

- NGC4593 : Simultaneous observations on 2016-07-14 by SXT (446.7 ks) and XMM-Newton EPIC-pn (140.5 ks).

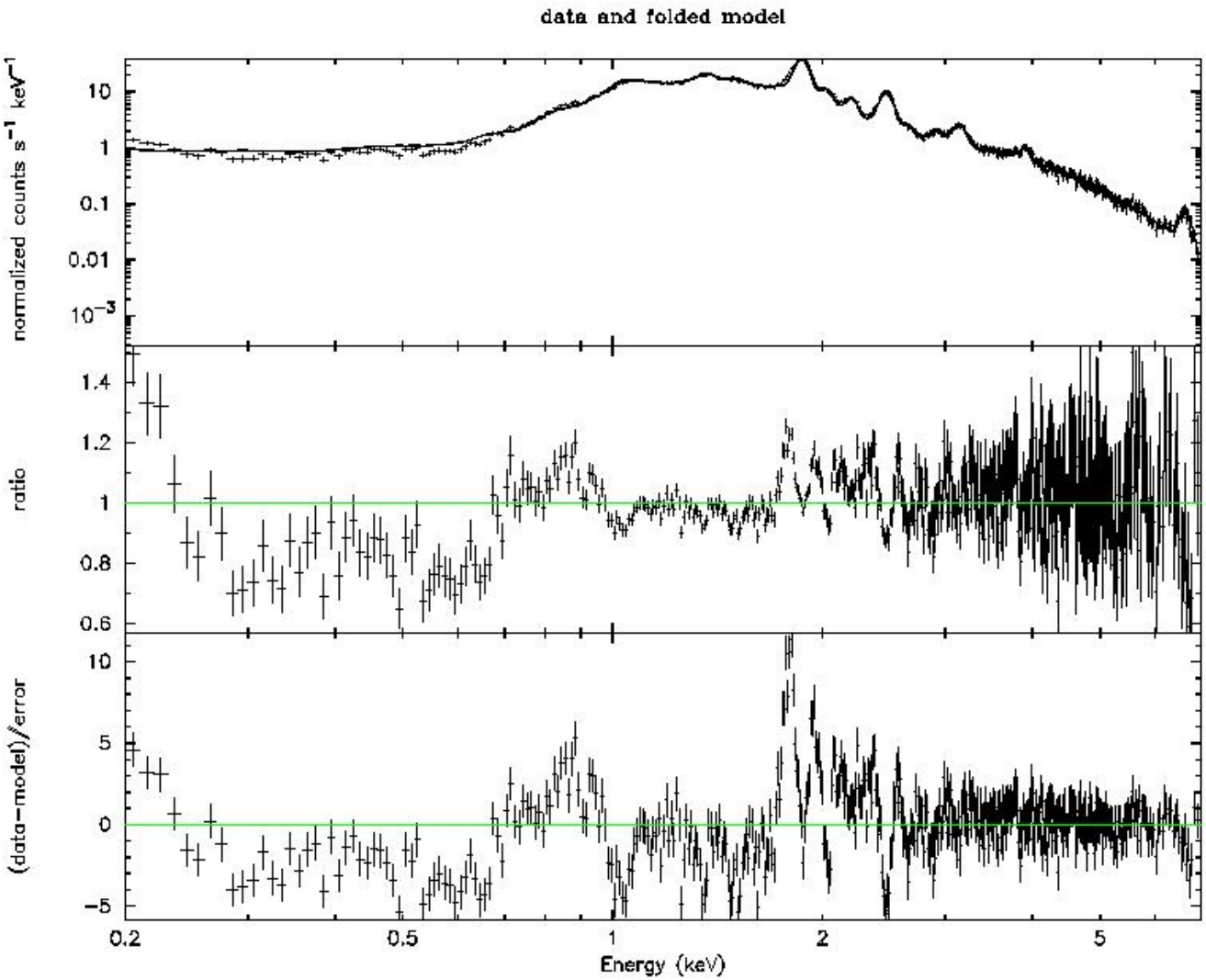




Tweaking ARF does not solve. Likely due to bias / CTI / gain changes?

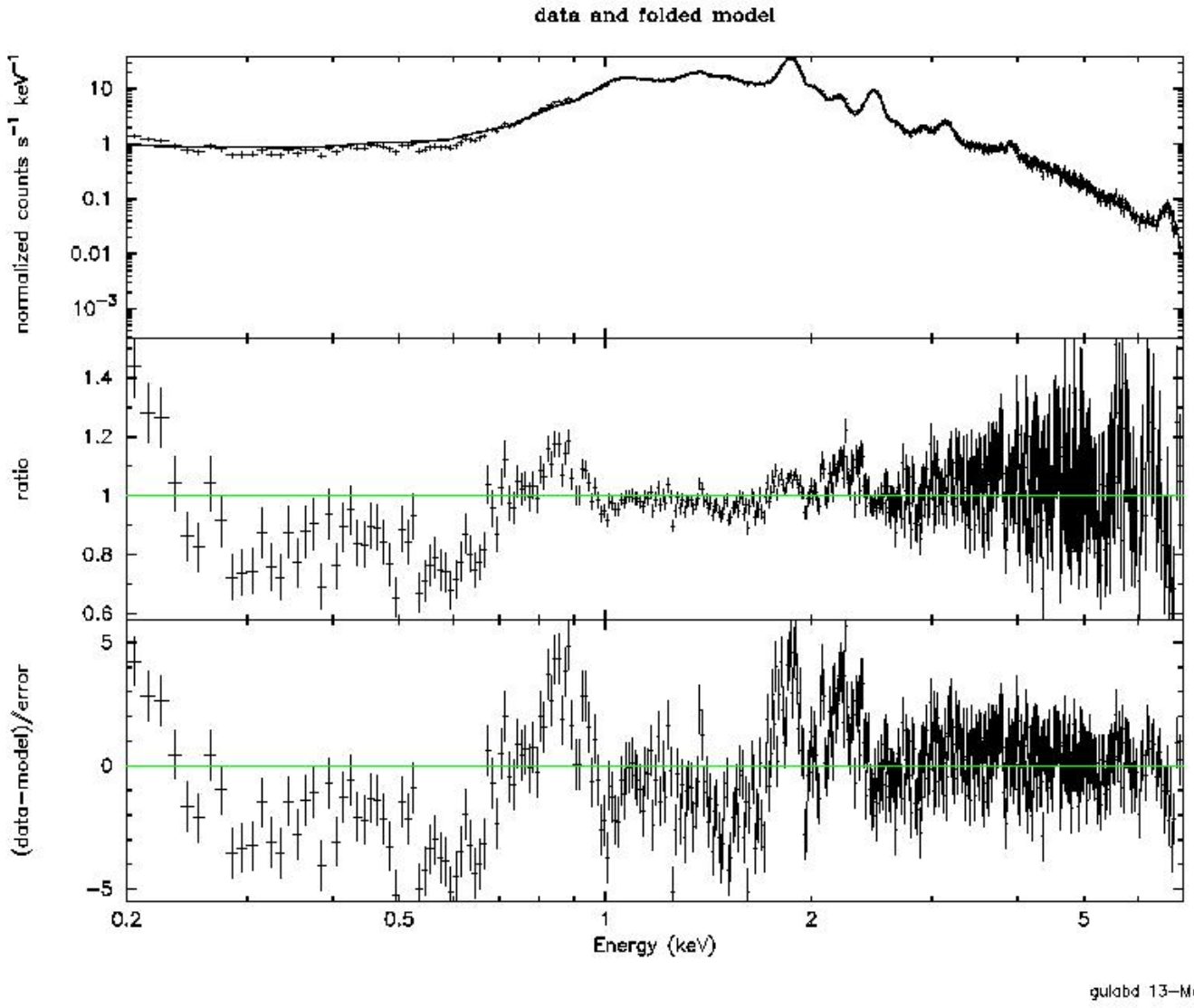
SXT: Spectral response

Cas A : XMM MOS1 model (provided by Andy Beardmore)



Possible change in the response and/or CTI effects

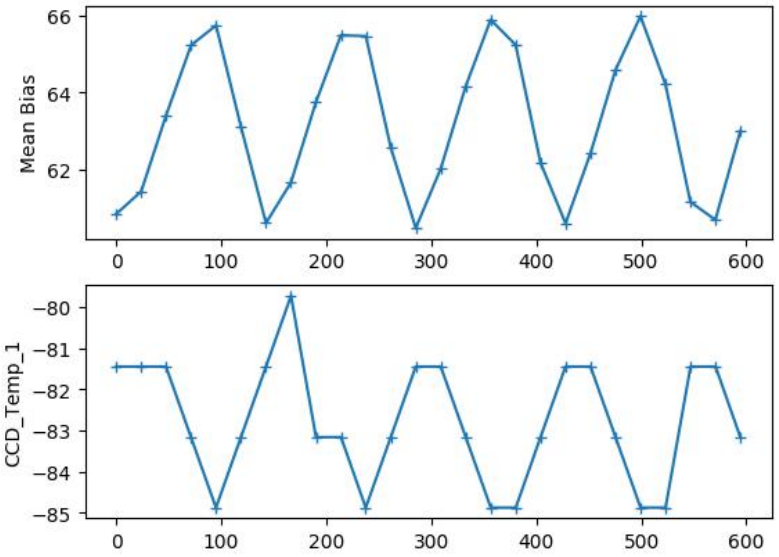
Cas A : XMM MOS model (smoothed)

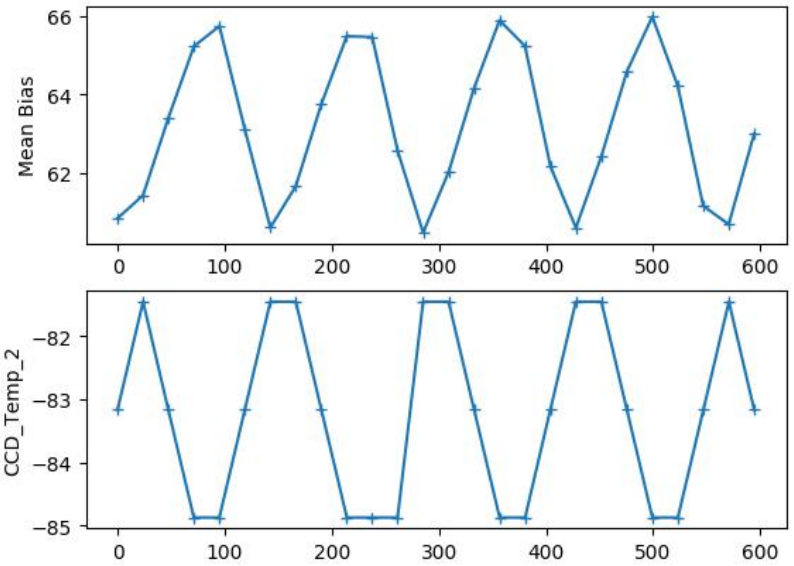


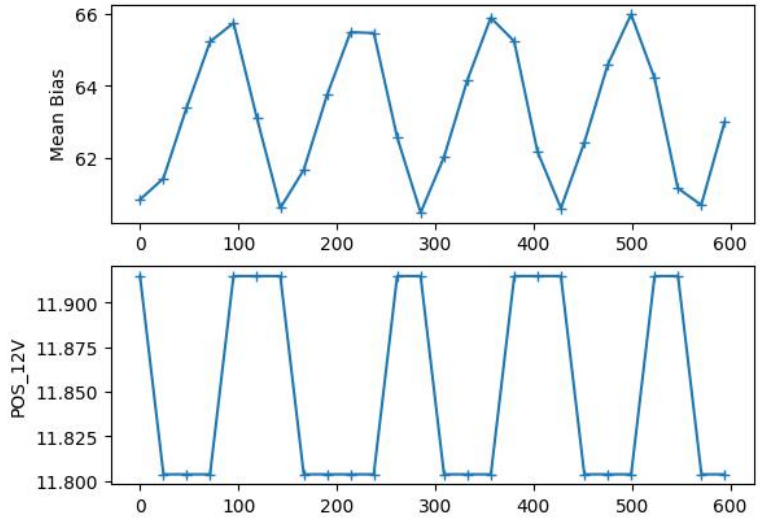
Indicate degradation of spectral resolution and/or CTI effects

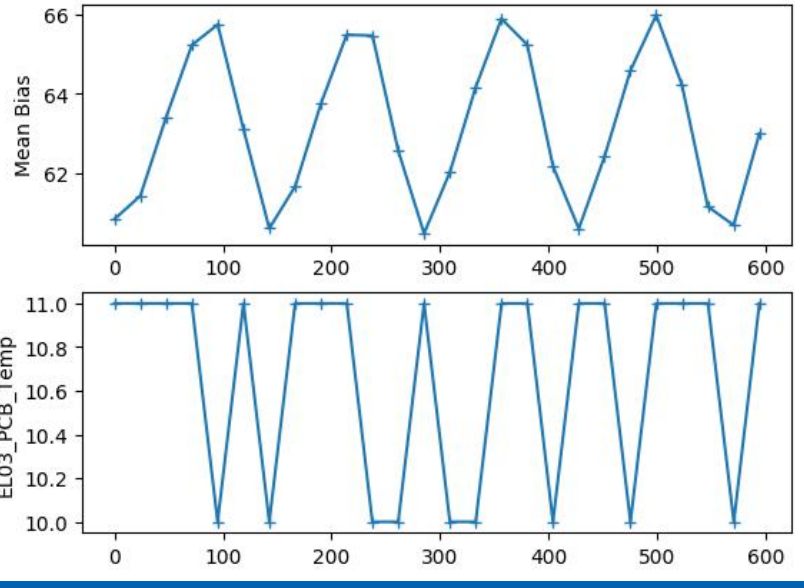
ARF fine > 1 keV

SXT : Bias variations

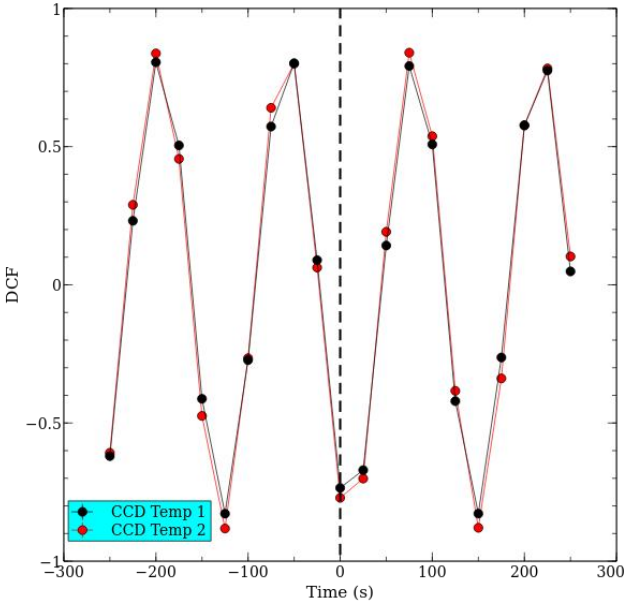


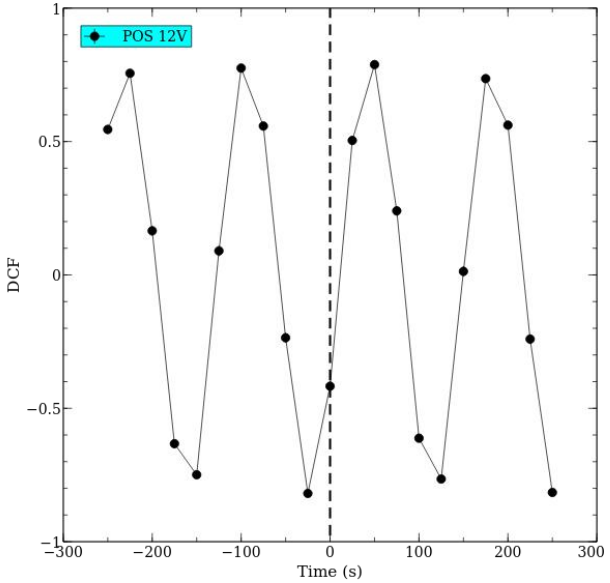


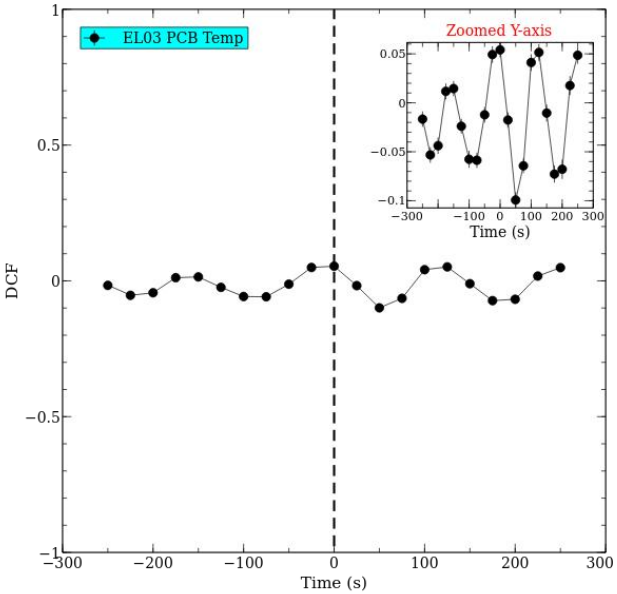


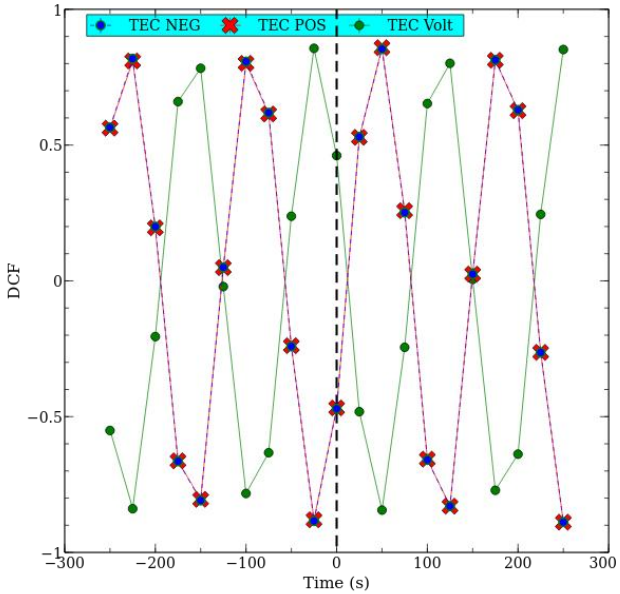


What is driving the bias variations?







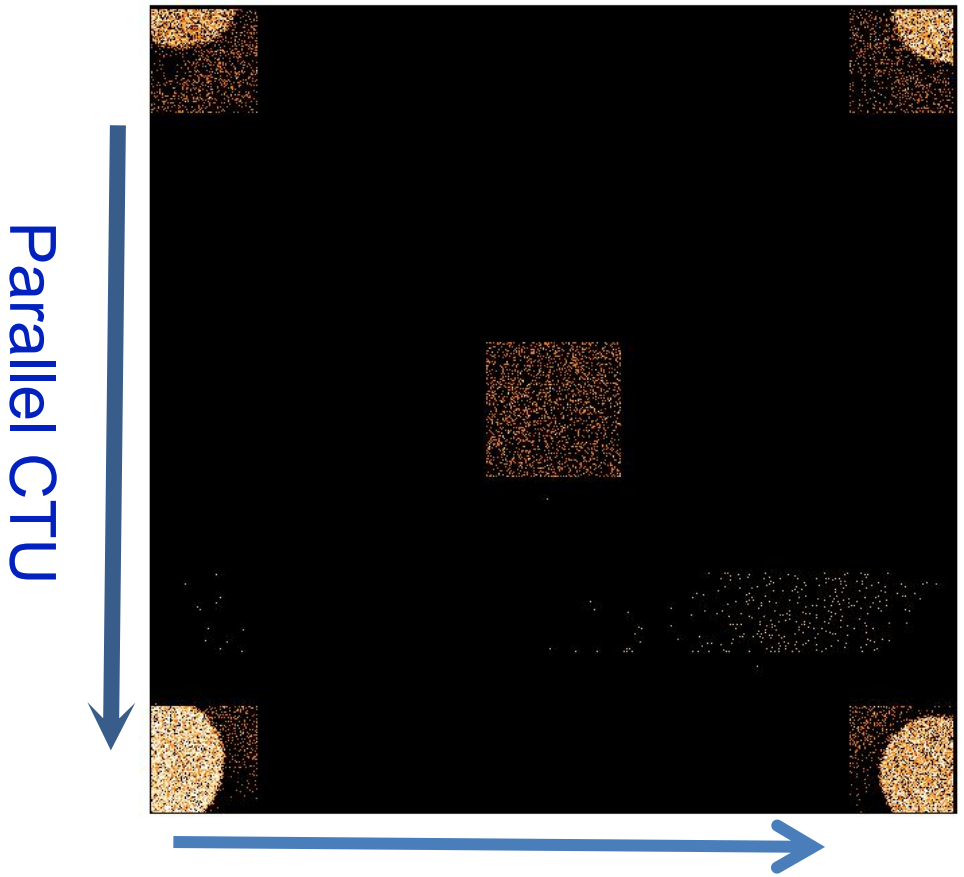


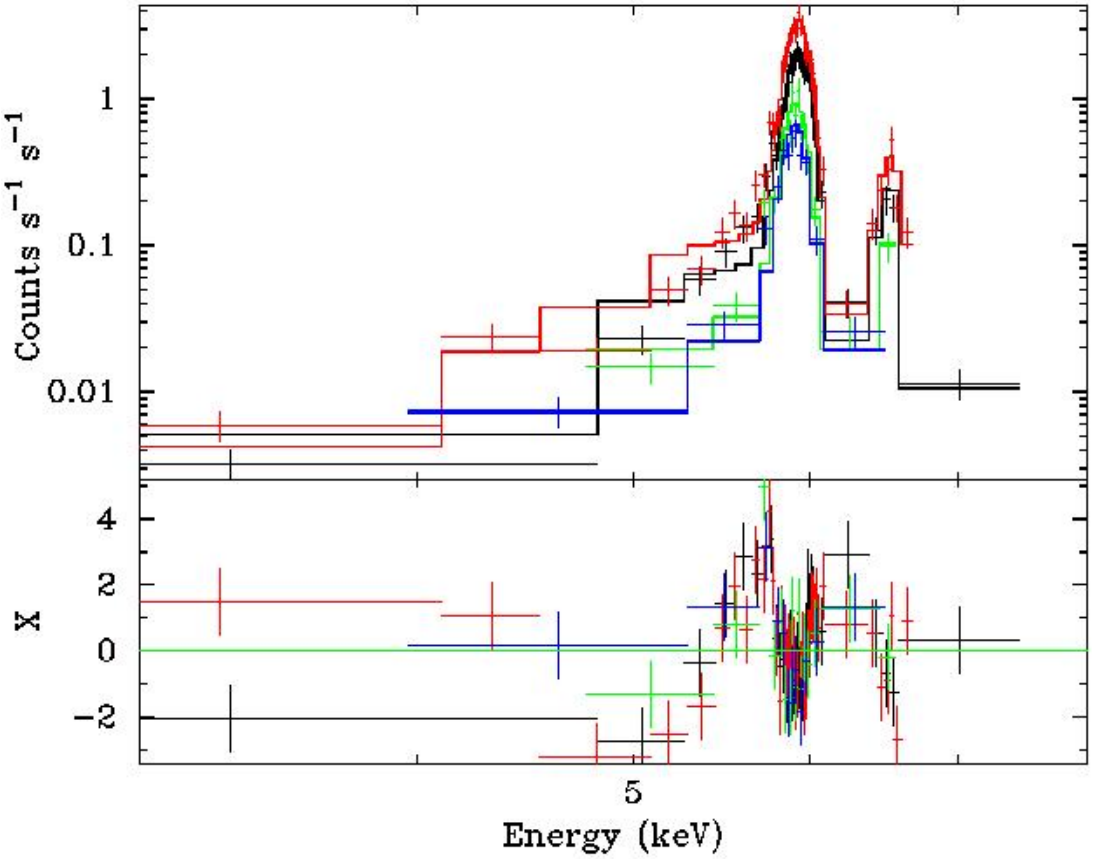
Predict the bias level based on one of the HK parameter

Correct for the predicted bias instead of constant bias level

Ongoing work!

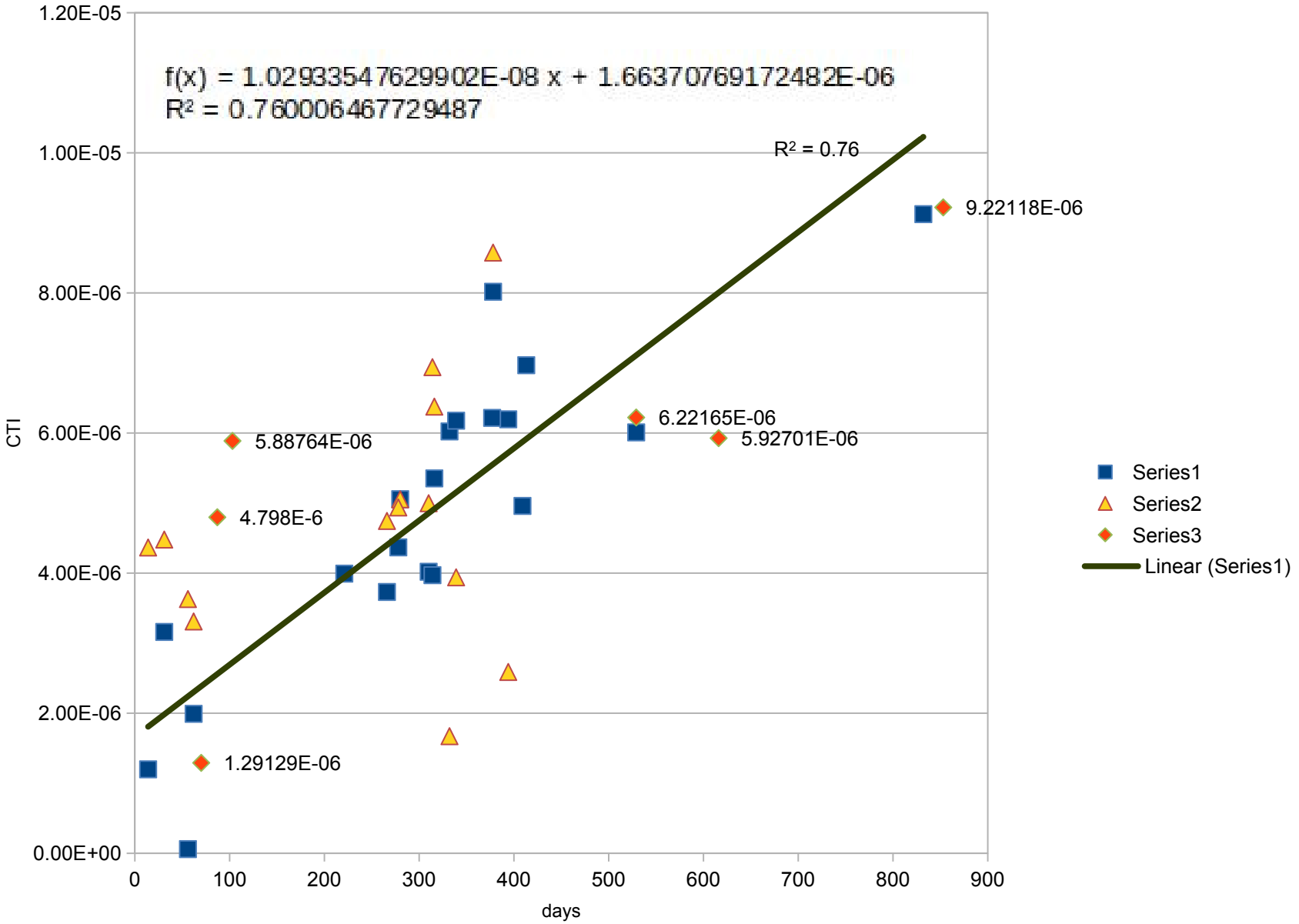
SXT : CTI Variations (Corner source analysis)





Simultaneous fit to four corner sources with the same offset and specific set of gain fit parameters to determine additional parallel CTI.

Additional Parallel CTI



Days from 25/04/2016

Ongoing SXT Calibration activities

- Correction for bias variation
- Correction for CTI variation
- New ARF appropriate in the 1-7 keV band to be released soon.
- ARF and RMF will be re-examined after BIAS/CTI corrections.

UV/X-ray Spectoscopy with AstroSat

UVIT: MW spectroscopy requires specialized tools/products, calibration of gratings

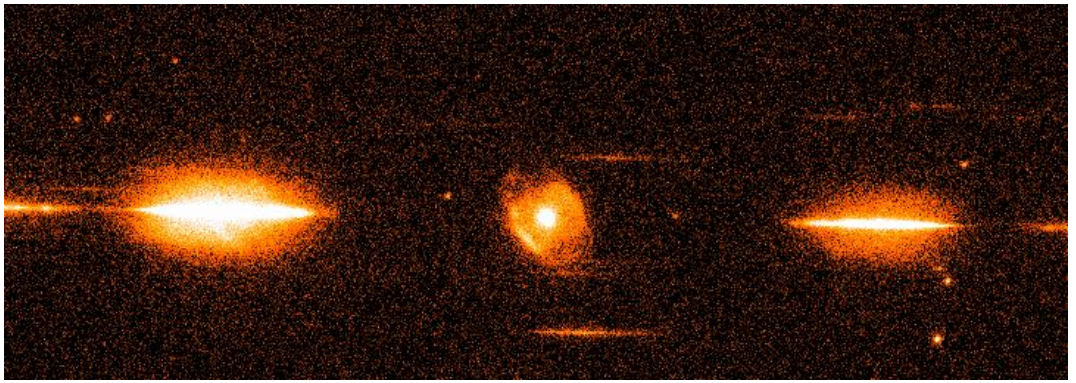
UVIT analysis tools for MW science (UVITTools in Julia language)

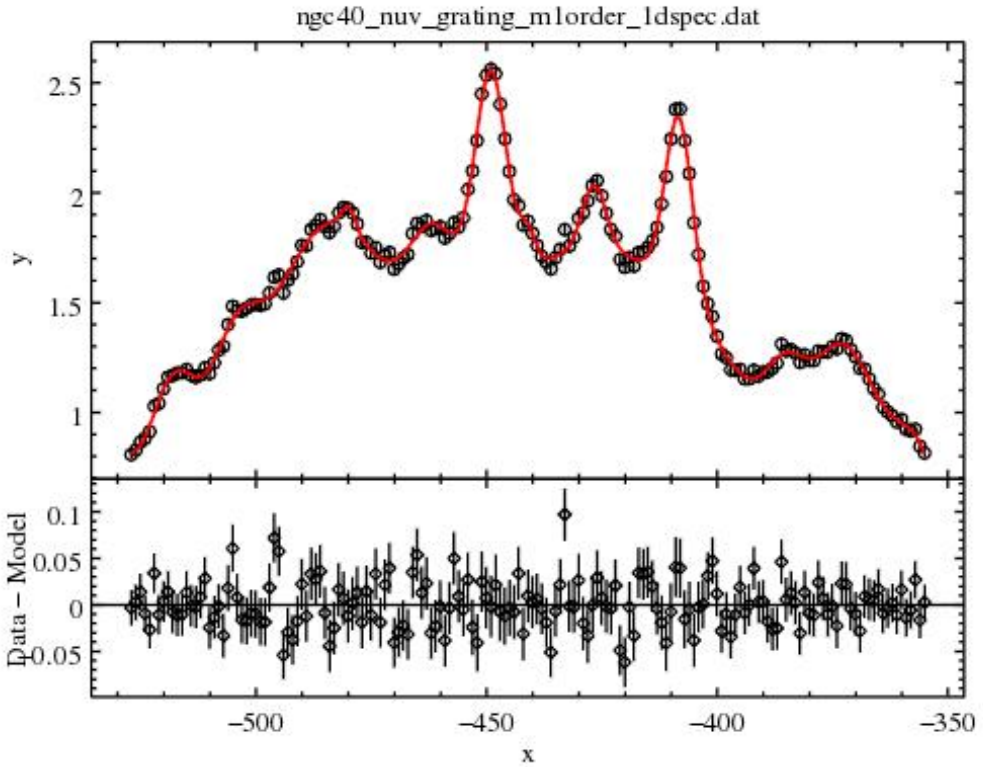
- Photometry (based on Tandon et al. 2017 calibration)
- PHA spectral and response files for all flters (total 10) for MW analysis
- Grating Spectral calibration for 2 FUV and 1 NUV grating
  - 1d spectral extraction,
  - wavelength calibration
  - flux calibration
  - Effective Area
- Fluxed as well as Grating PHA spectral and response generation for MW analysis

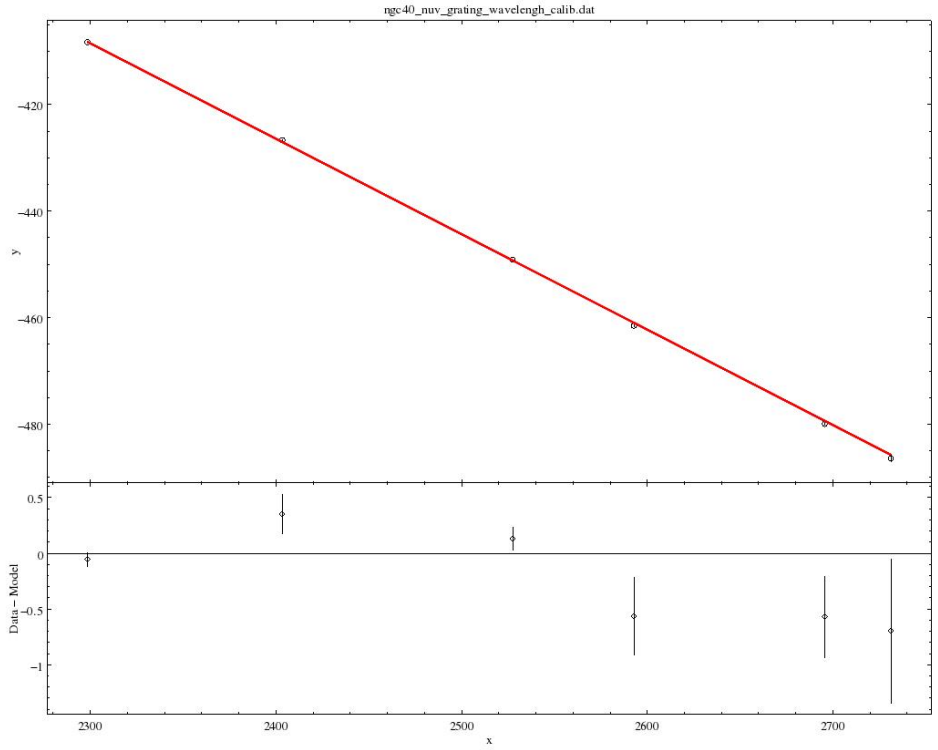
UVIT Grating Calibration

Wavelength Calibration

Planetary nebula NGC40
with a number of lines



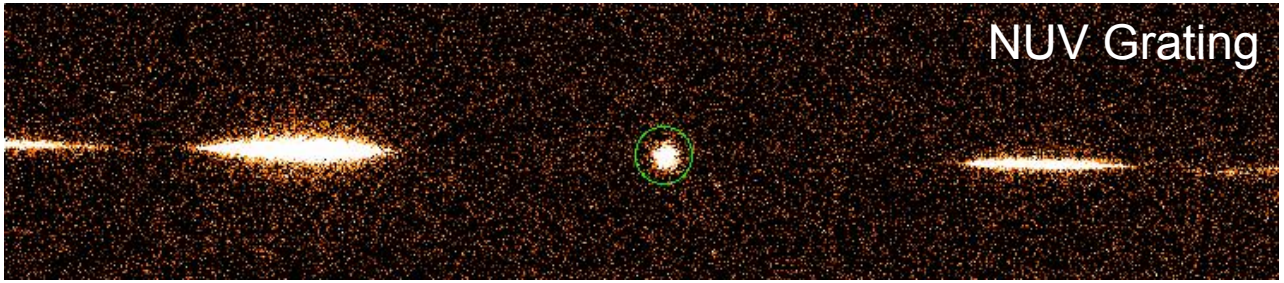


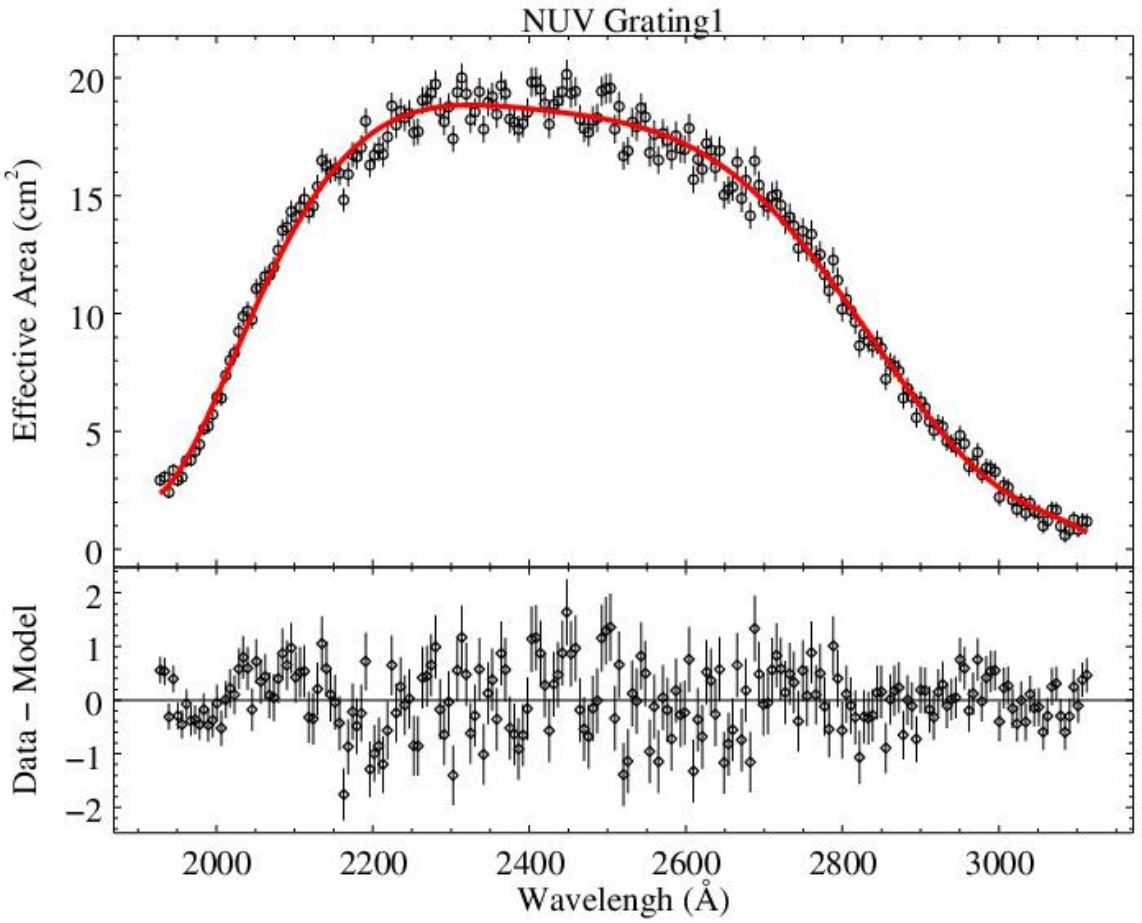


Flux calibration / effective area (NUV)

Spectrophotometric standard HZ4 (a white dwarf)

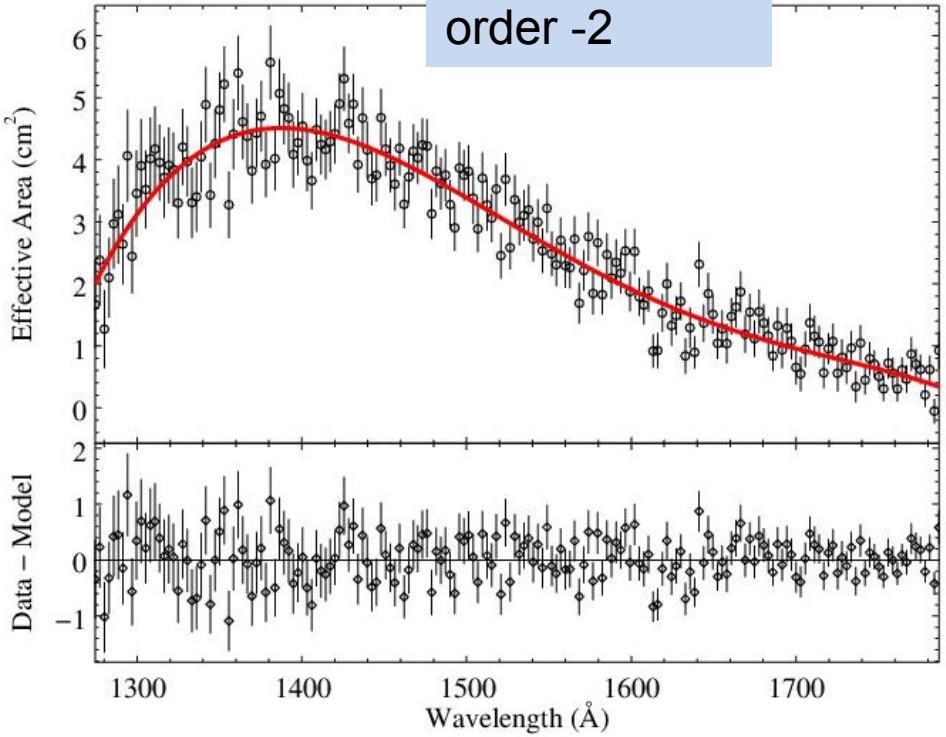
Effective Area : Using standard spectrum of HZ 4 measured with IUE/HST



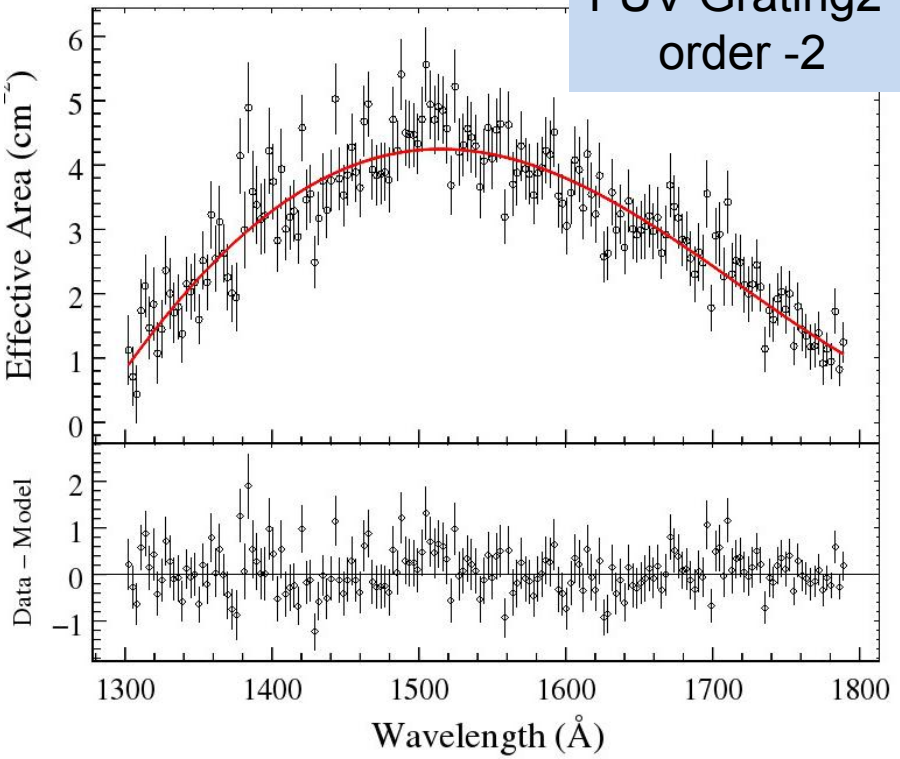


FUV Grating 1,2 effective area

FUV Grating1
order -2



FUV Grating2
order -2



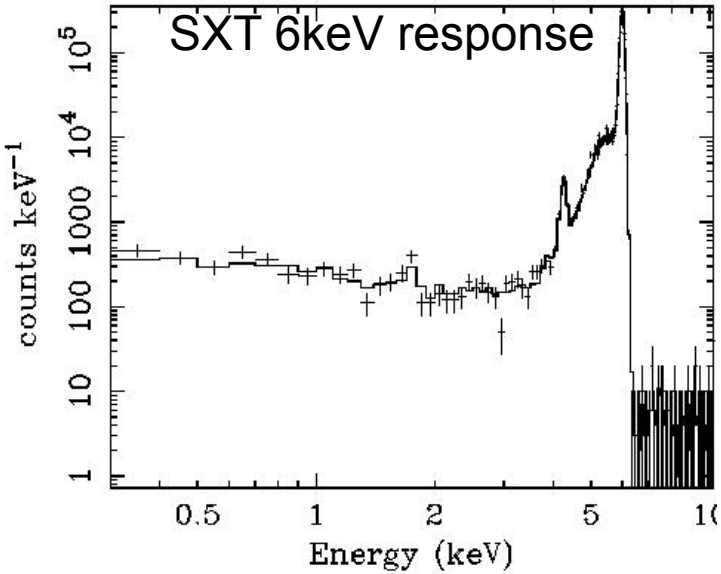
Peak effective area ~ 5 cm^2

FWHM: 38.4A (NUV-grating), 16A(FUV-grating1), 14A(FUV-grating2)

MW spectral analysis

X-ray Spectral Analysis

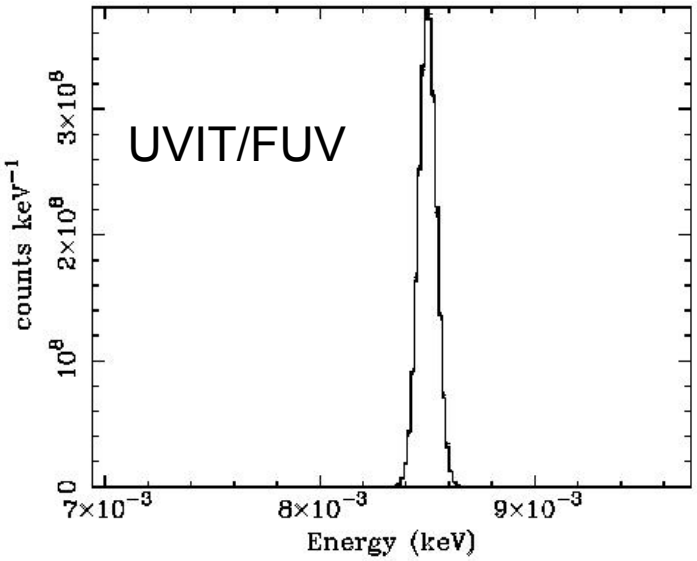
$$D(I) = T \int R(I,E)A(E)f(E)dE + B(I)$$



UVIT Grating response R(I,E)
(pixel no. along the dispersion direction => channel I)

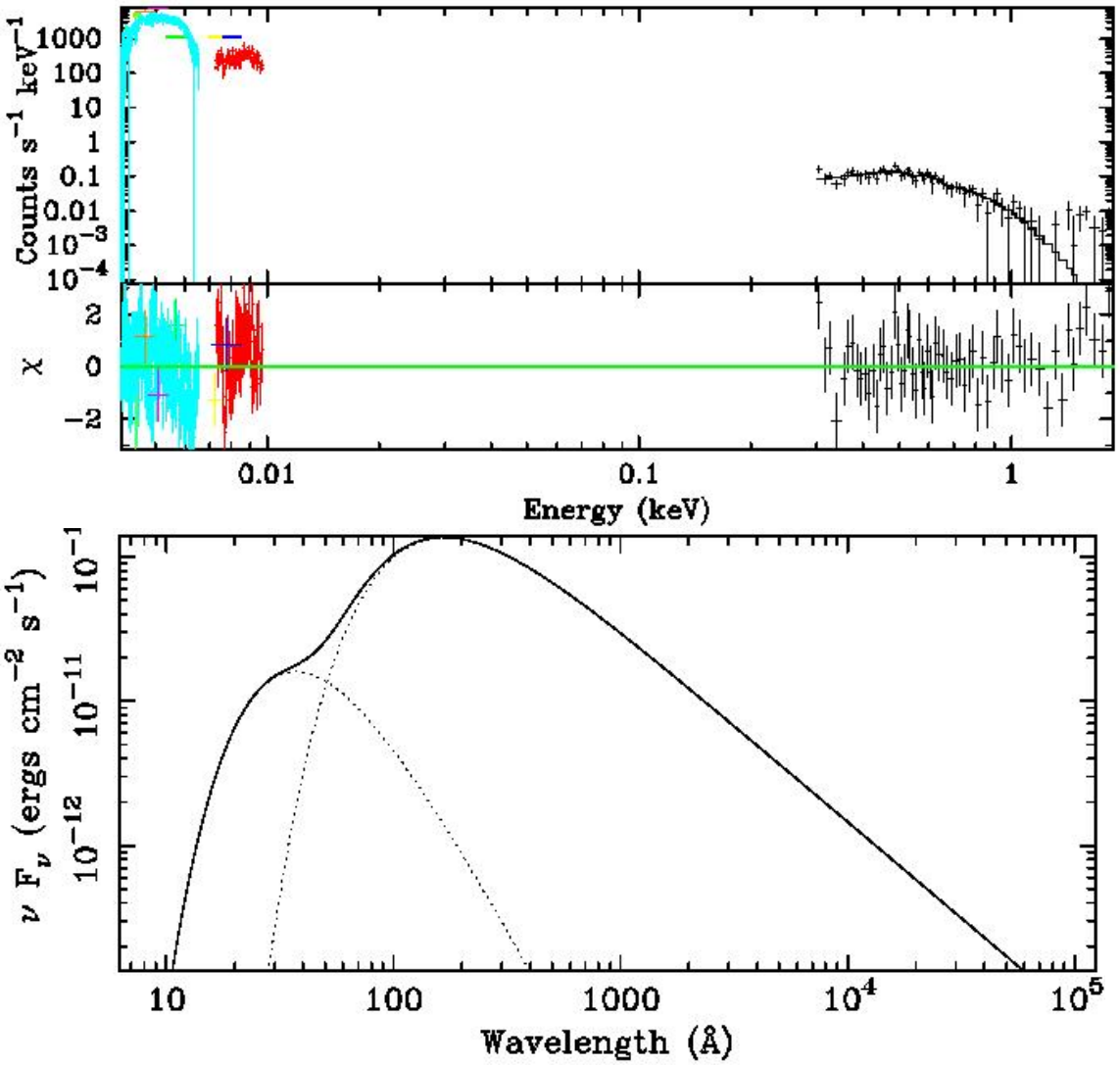
UVIT gratings - Gaussian response to delta function
FWHM: 38.4A (NUV-grating), 16A(FUV-grating1), 14A(FUV-grating2)

A(E) : Effective area curves derived for the gratings



ASASSN-16oh : A transient supersoft X-ray source

AstroSat ToO observations



UVIT FUV/NUV gratings, filters + SXT data

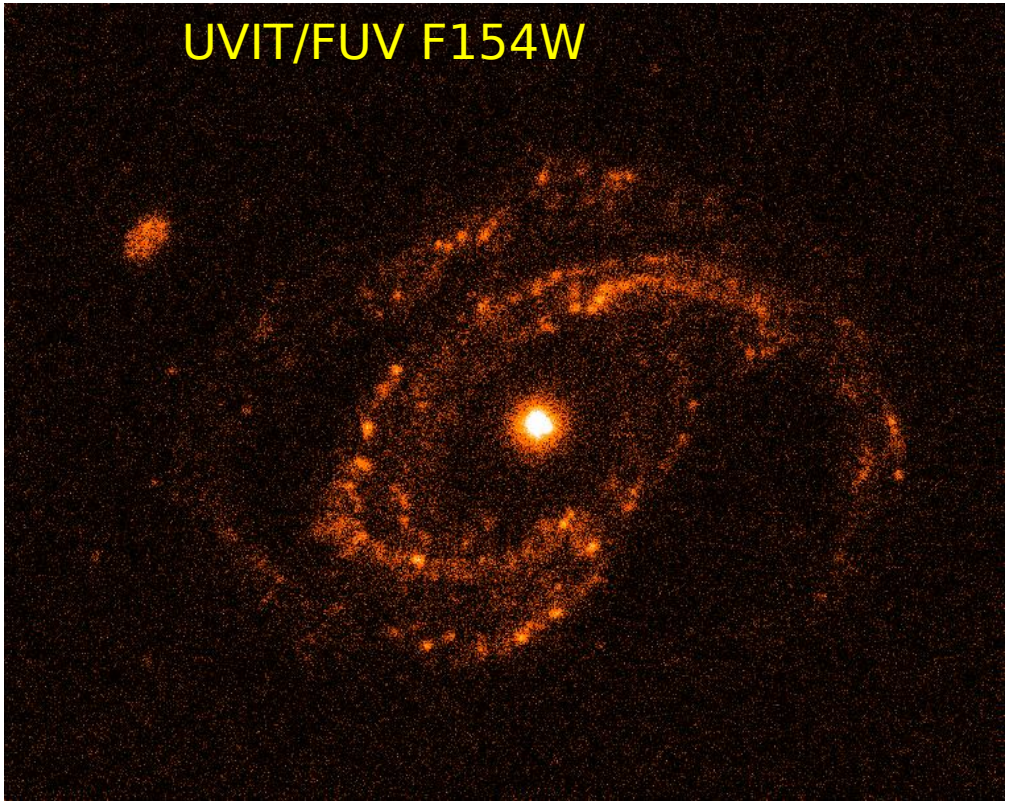
Blackbody from WD (kT~90eV),

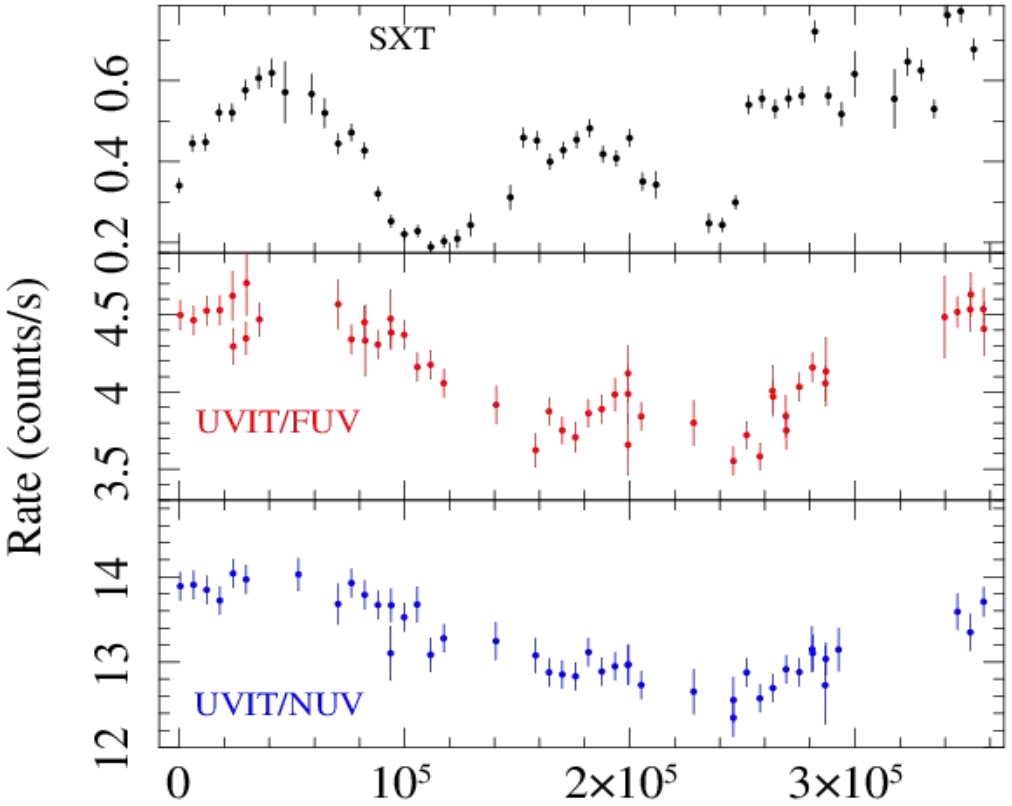
Accretion disk emission with kT_in ~30eV

Possible discovery of an accretion disk in a supersoft X-ray source?

NGC4593 : UVIT / SXT Timing

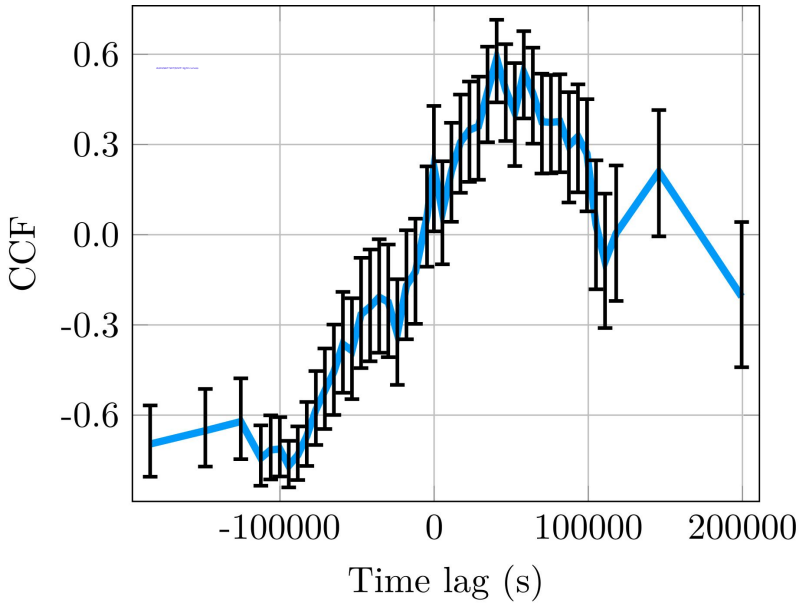
4 day long AstroSat observation



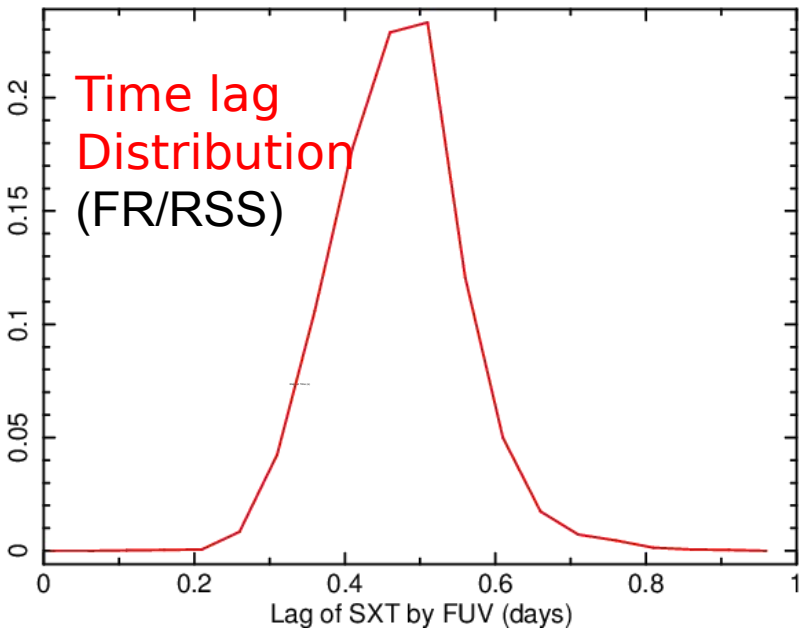


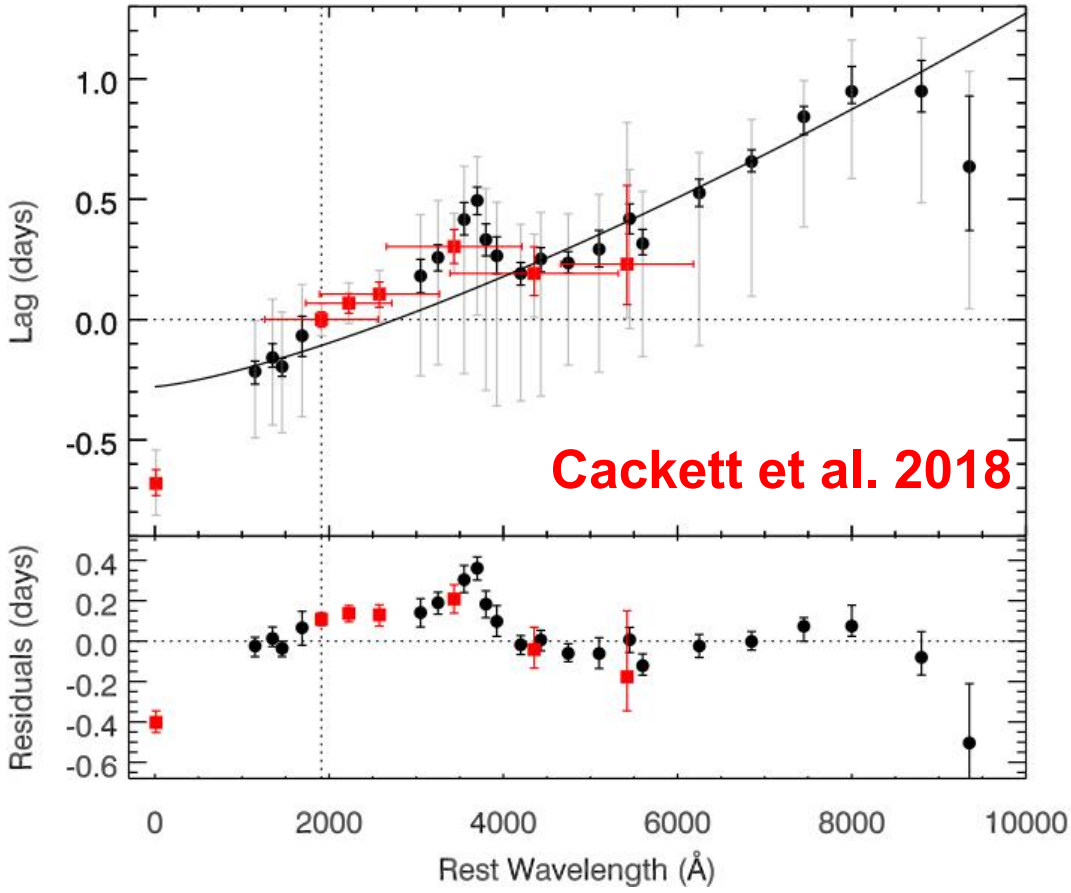
NGC4593: UV/X-ray variability

$$\tau = 0.475 \pm 0.086 \text{ days}$$

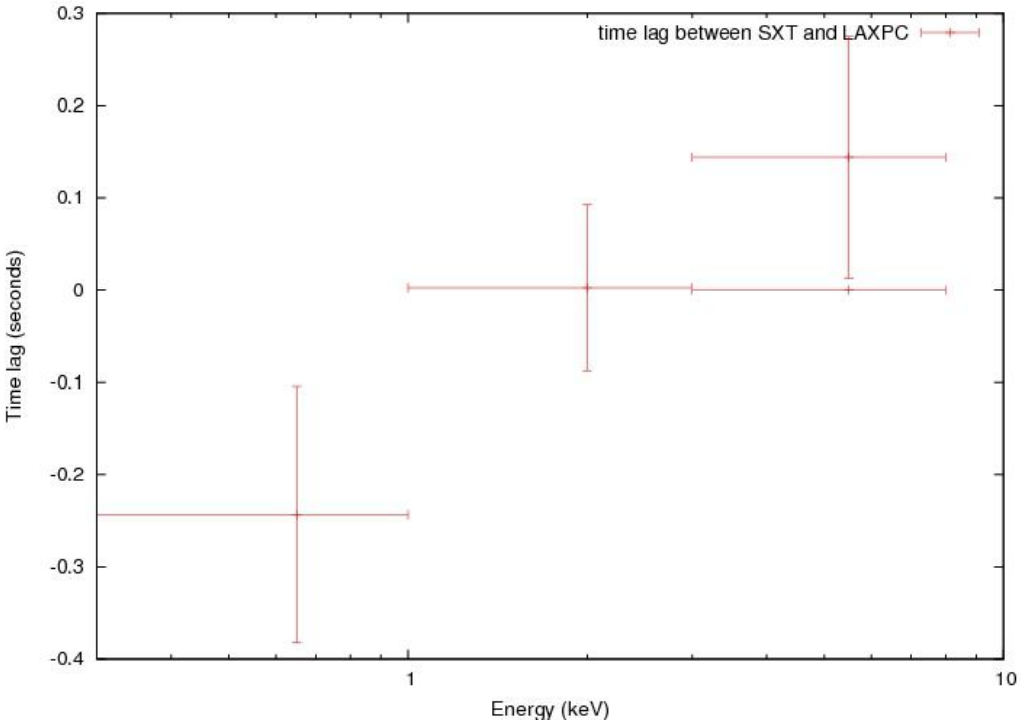


X-ray processing in accretion disk into UV



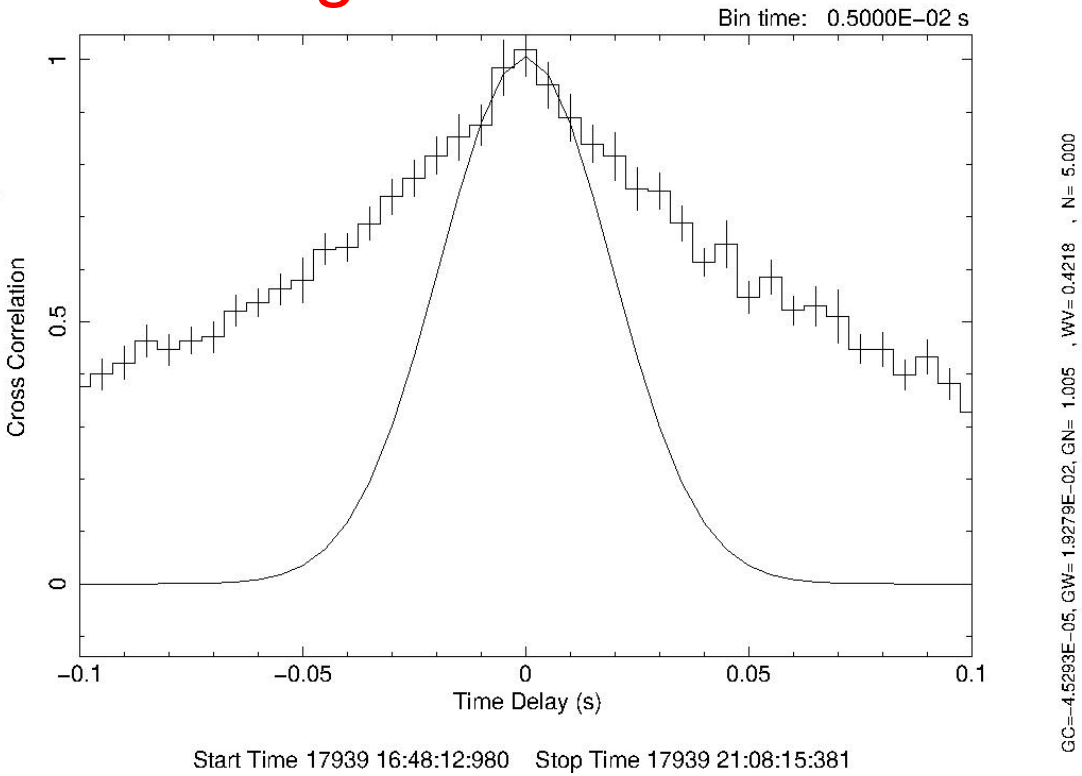


SXT/LAXPC time lag Vs Energy



LAXPC/NICER

time lag in the 3-10keV band



R. Misra

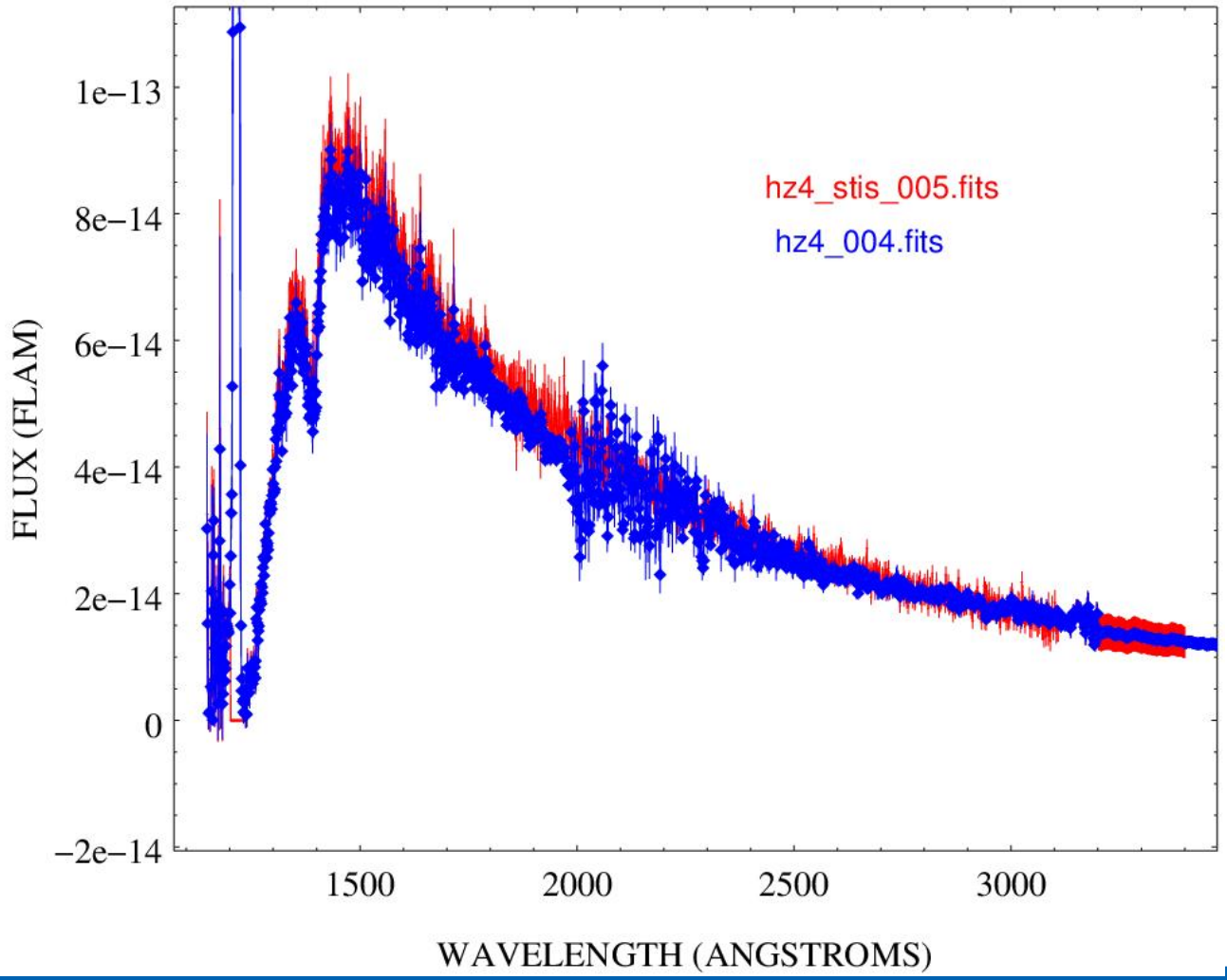
Thank You

UVIT Grating: Flux Calibration / Effective Area

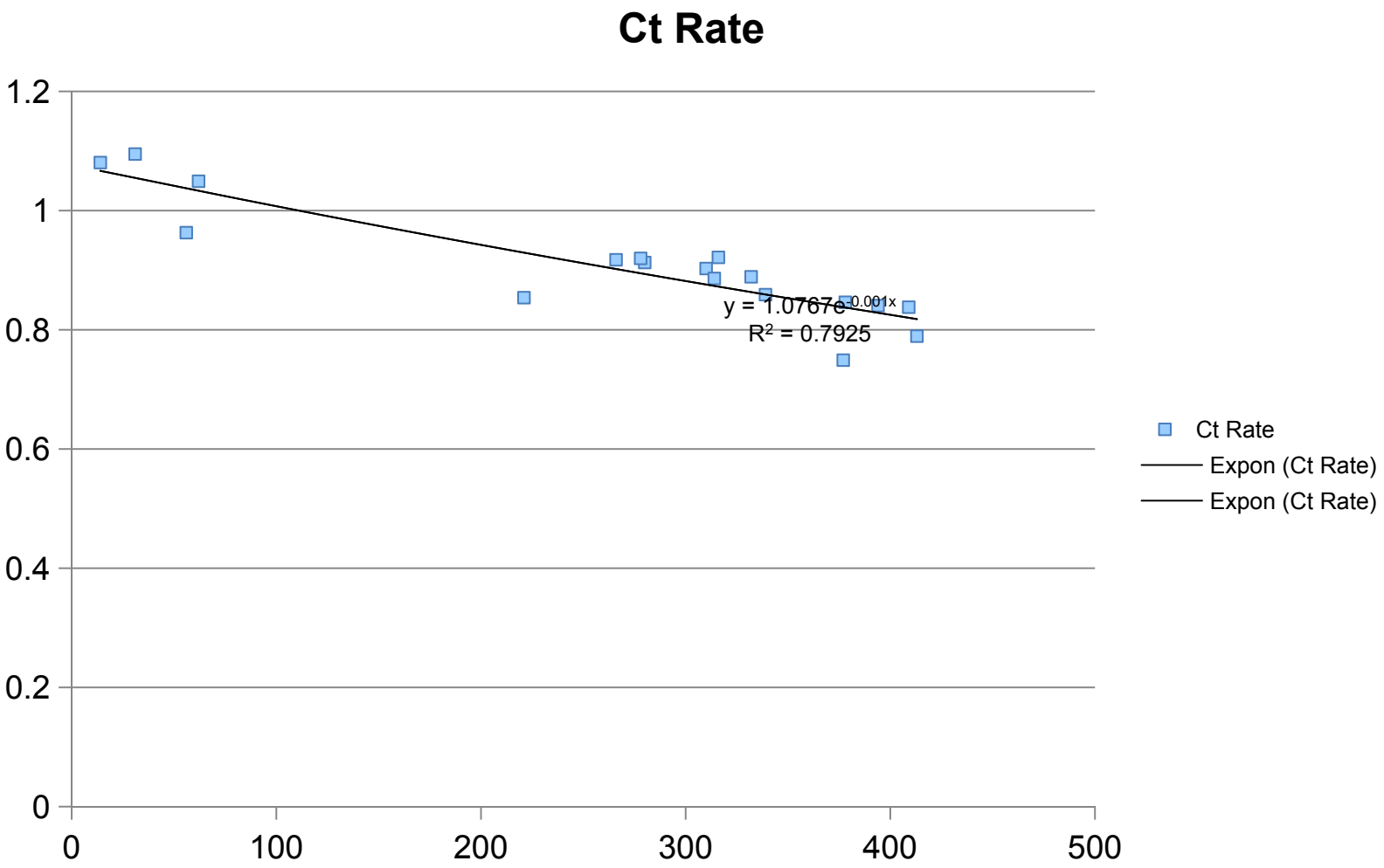
Spectrophotometric standard

HZ4 - A white dwarf with well measured spectrum

(relatively smooth spectrum)

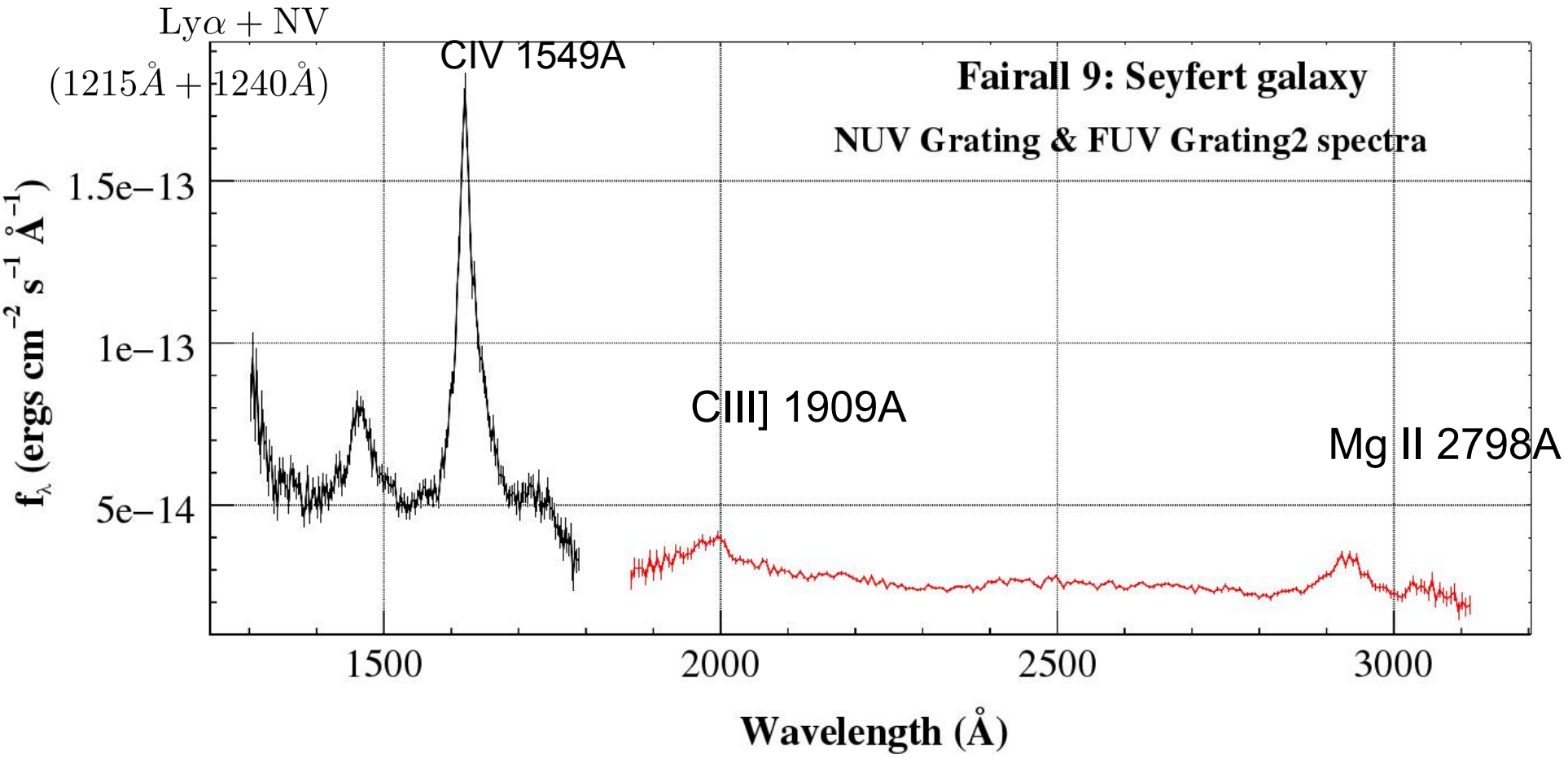


Calibration Source Analysis

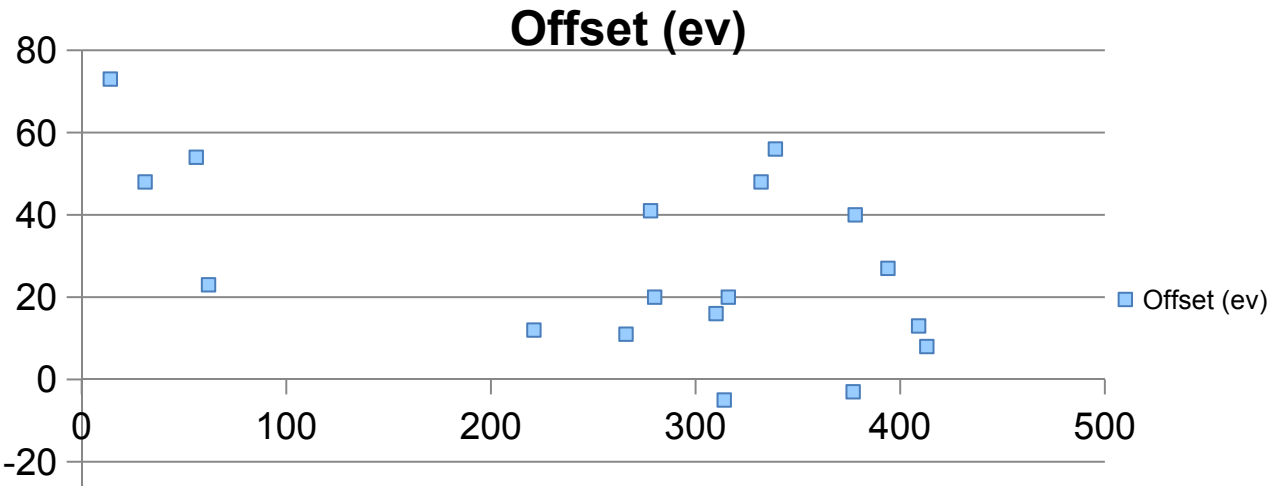


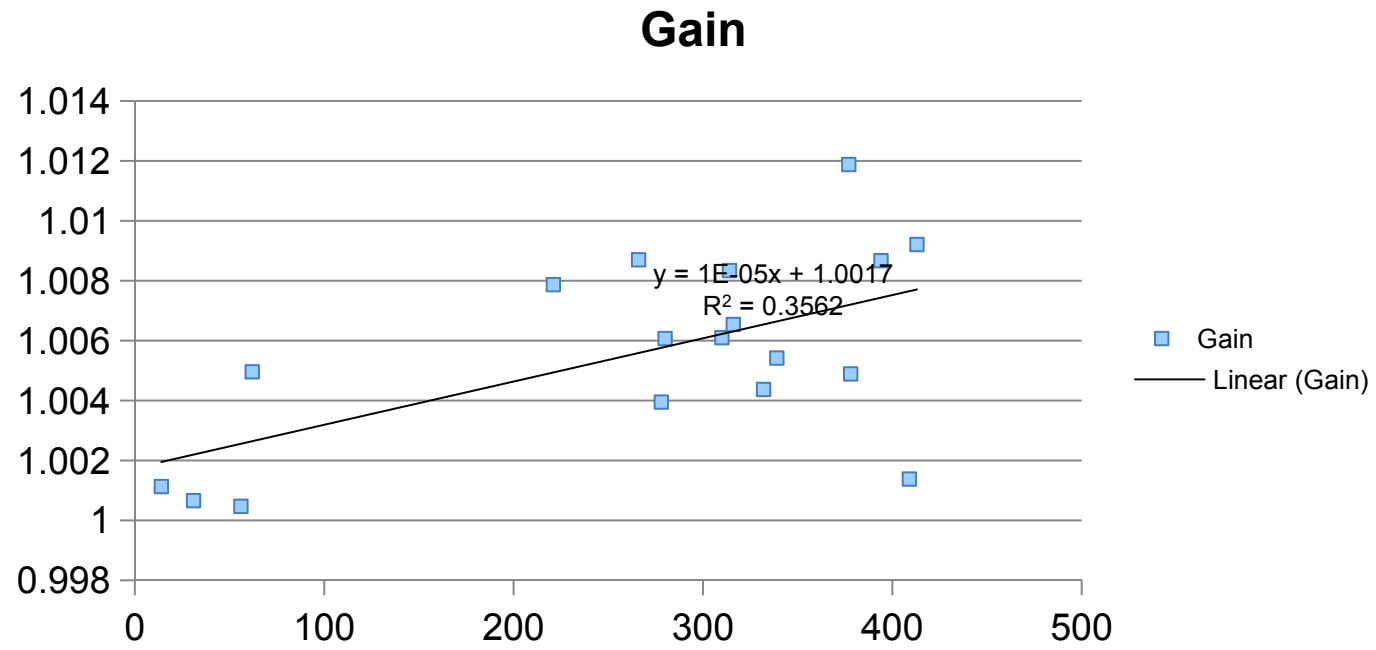
Fairall 9: UVIT Grating Spectra

A Bare Seyfert 1



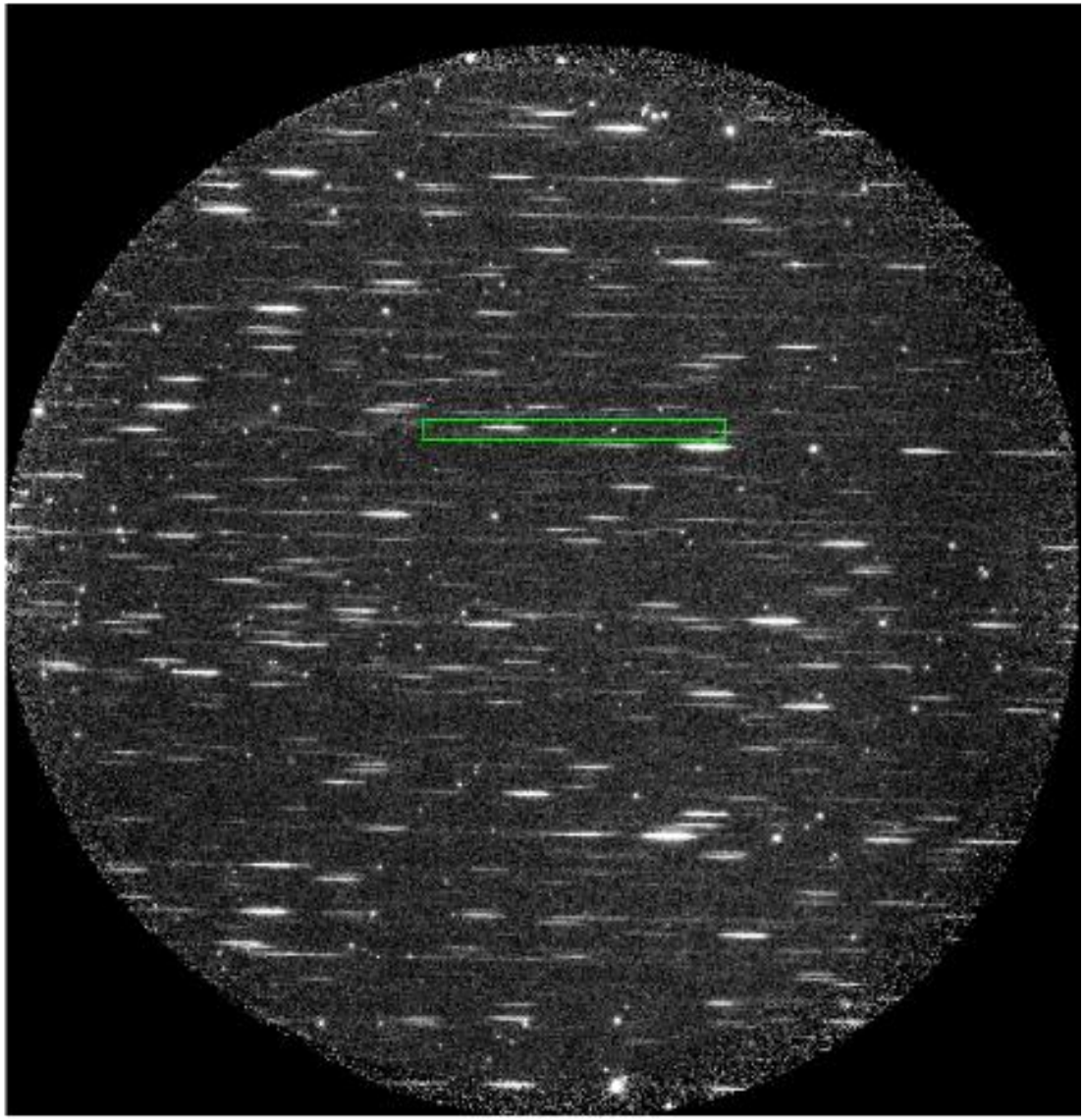
Offset & Gain Variations





UVIT Grating Data Analysis

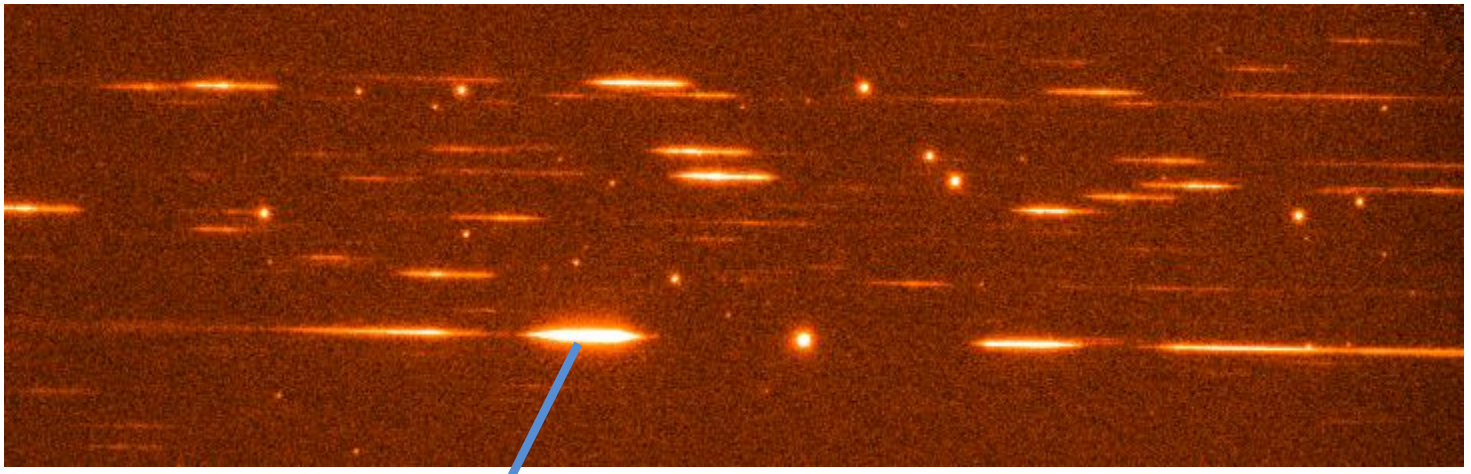
- Merged Level2 image (CCDLAB or your favorite pipeline)
- Identify 0, -1, -2 orders spectra of the target of interest
- Extract 1d spectrum (Dispersion axis slightly tilted wrt to X-axis (NUV-grating, FUV-grating1) or Y-axis (FUV-grating2)
- Counts Vs pixel numbers

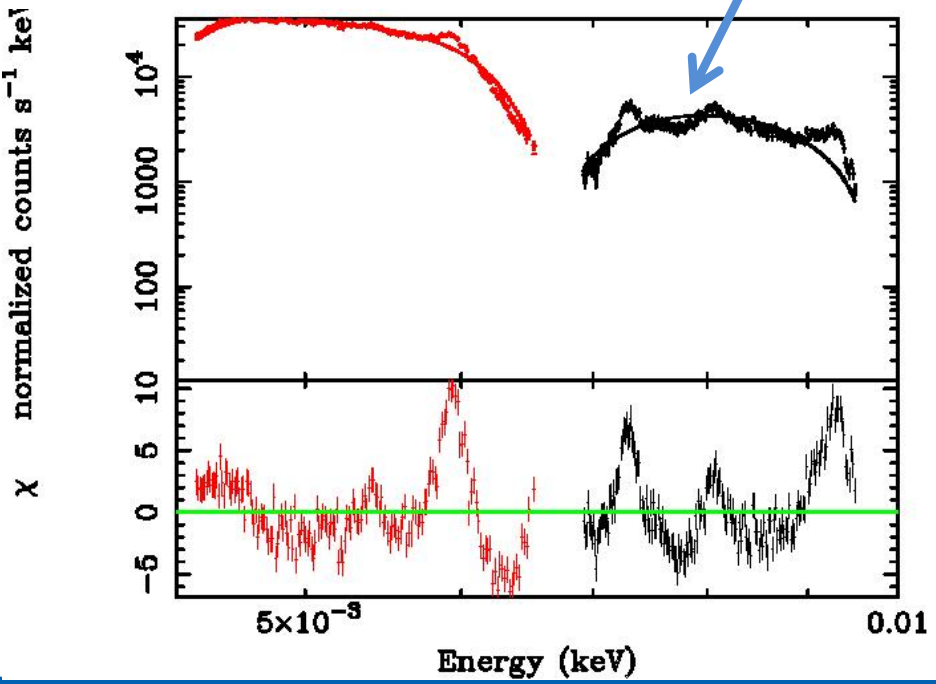


ASASSN-16oh

PG0804+761 : AstroSat view

A bright RQ quasar (V=14.7 mag) at z=0.1, $M_{BH} = 5.4 \times 10^8 M_\odot$





FUV & NUV Grating
Exposure : 4ks