Jem-X Source Extraction

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- ***What it does***
- ***Parameters***
- ***Method***
- ***Properties, Limitations, Testing***
- ***Timing and spectral analysis***
- ***And then what? (OSA5.0 or so…)***

Jem-X Source Extraction
What it does

Need input from imaging and source finding (NJWs presentation)

Source light curve extraction (j_src_lc)

Source list -> Source LC Energy band i=1,2,3… (background subtracted)

Source background LC Energy band i=1,2,3…

LC -> XRONOS etc.

Source spectrum extraction (j_src_spectra)

Source list -> Source Spectrum (background subtracted)

Source background spectrum

Source response (ARF)

SPE + ARF + RMF -> XSPEC

Jem-X Source Extraction
Parameter examples

- timeStart=-1 timeStop=-1 timeStep=100.0

  (IJD) (IJD) (sec)
- useRaDec=y (use source sky coord instead of instrument coord)
- vignCorr=y -> flux per 100 cm^2 (always for spectra)

Lightcurve parameters

- nChanBins=2 chanLow="5 101" chanHigh="100 200"
  Energy Band 1 = channel 5-100, Band 2 = channel 101-200

You will maybe not use (but might like to know about)

precisionLevel=20 (Default, should be ok.
Although, if spectra look strange you could try 25)

diagnosticMode=0 or 1-4

Folding: nPhaseBins=-10 (not really in OSA4.0)

(negative for equal size bins or specify with parameter phaseBins)

Jem-X
Instrument model

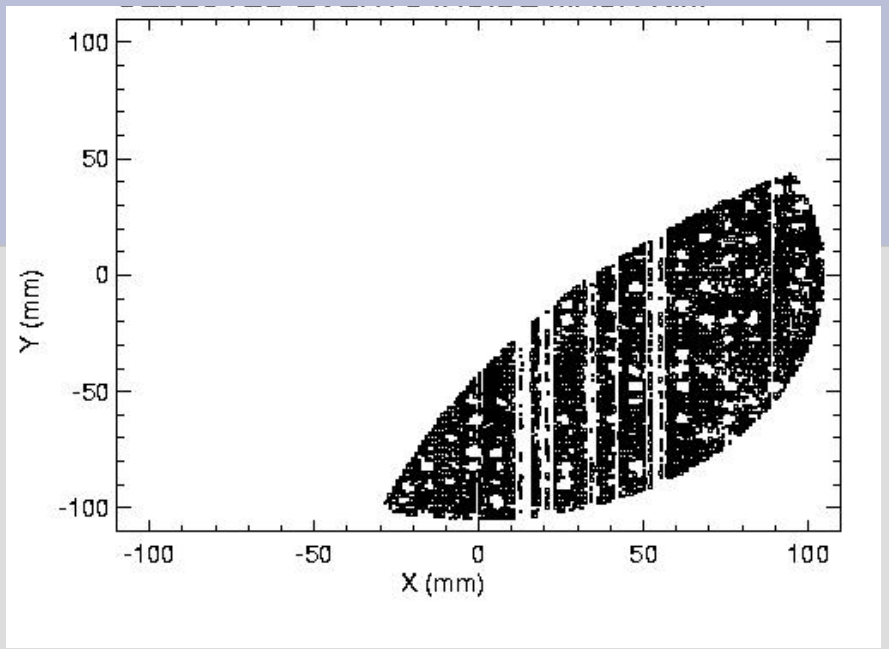
MASK

COLLIMATOR

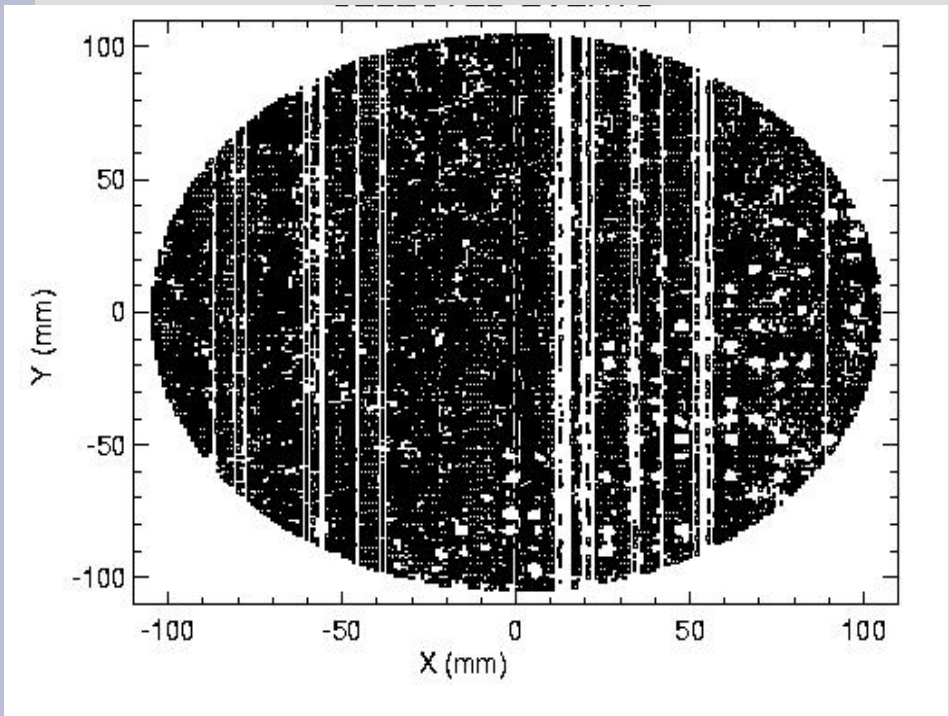
DETECTOR

ILLUMINATION PATTERN

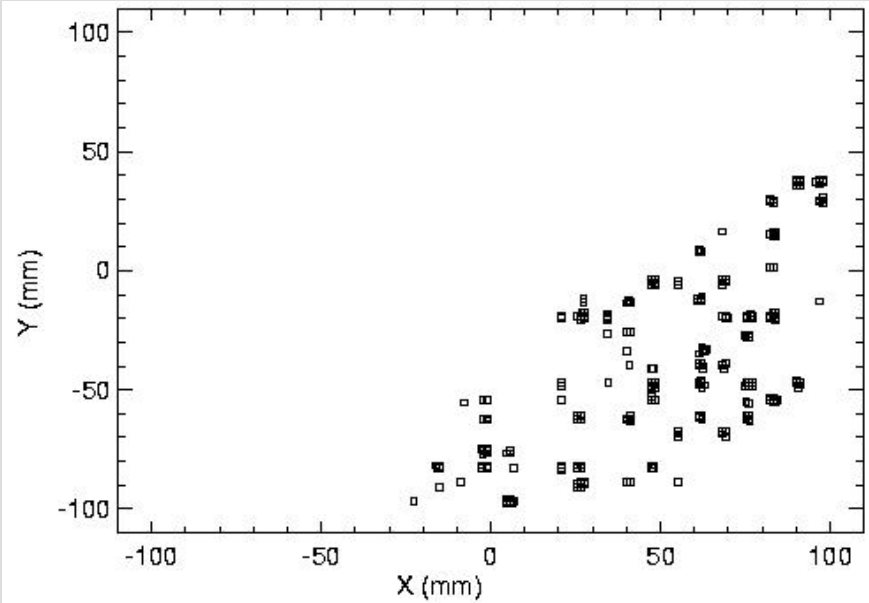
Non-illuminated pixels inside mask rim



Source non-illuminated pixels



Source illuminated pixels



Jem-X source extraction

- Calculate PIFs (Pixel Illumination Fraction)
- Sum events in open/closed area fluxes

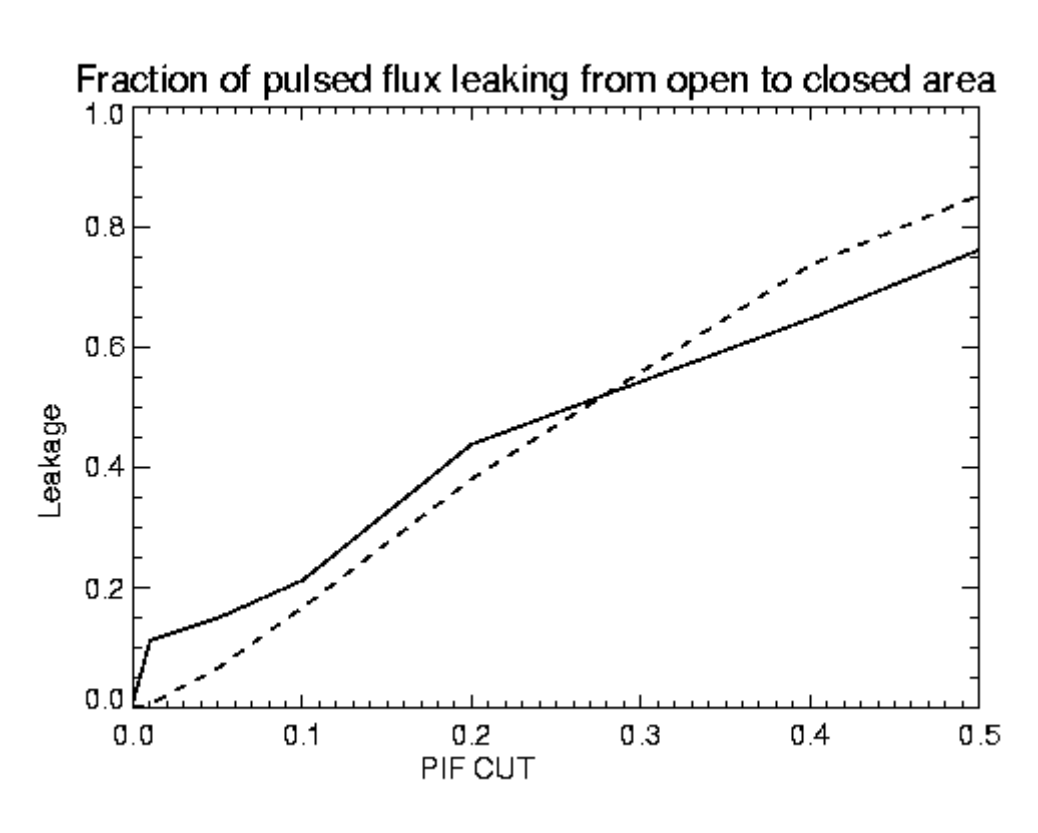
  (apply greyfilter and dead time corrections)
- Solve for source fluxes

  (Not just open-closed flux since the finite detector resolution smear out the shadow pattern and some open area photons end up as closed area events. This "leakage" is computed and corrected for.)

Calibrating detector resolution using a pulsating source

Vela X-1 2.8 degrees off axis

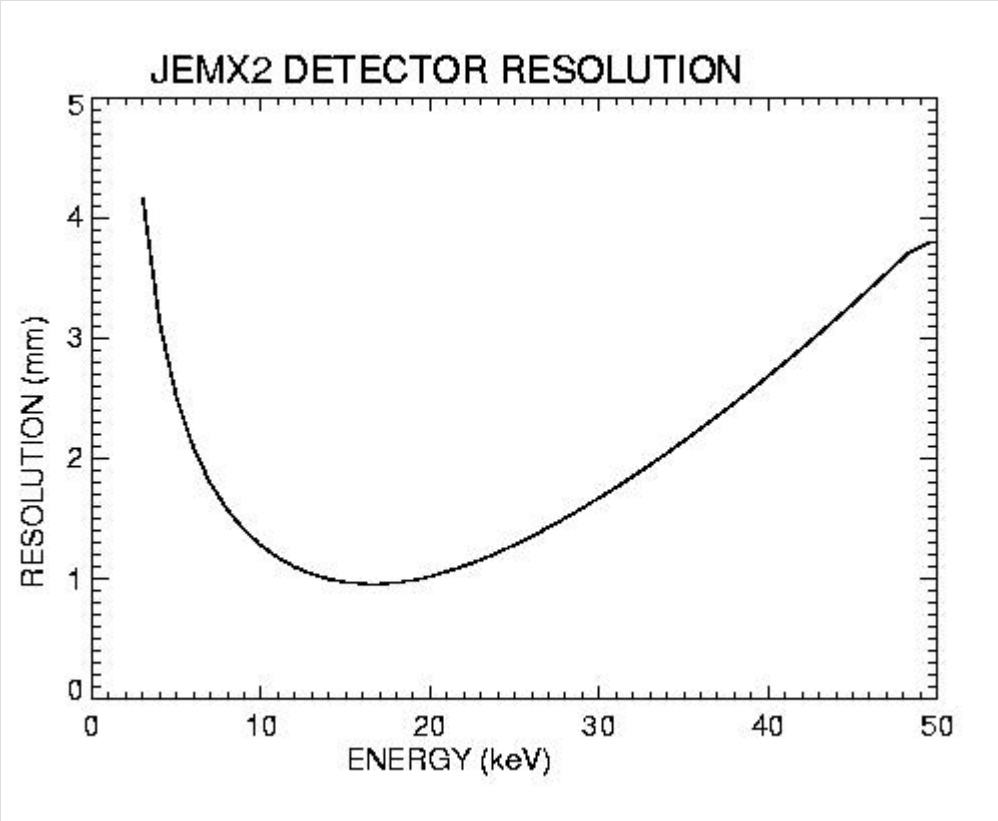
Observed (solid line) vs predicted (dashed line) pulsed flux



Detector resolution as function of energy.

At low and high energy the resolution is worse and the PIF is smeared.

For spectroscopy a correction for this is essential.



Calculation of Pixel Illumination Fraction (PIF)

For each source compute PIF map at energy
E = 3, 4, 7.5, 15, 25, 34.5, 34.6, 45 keV

Position independent response
- Intrinsic PSF (function of energy and direction)
- Map to pixel distribution function

Position dependent response
- Ray tracing towards source & add to PIF
- Screen out bad detector areas

Pixel Illumination Fraction (PIF)

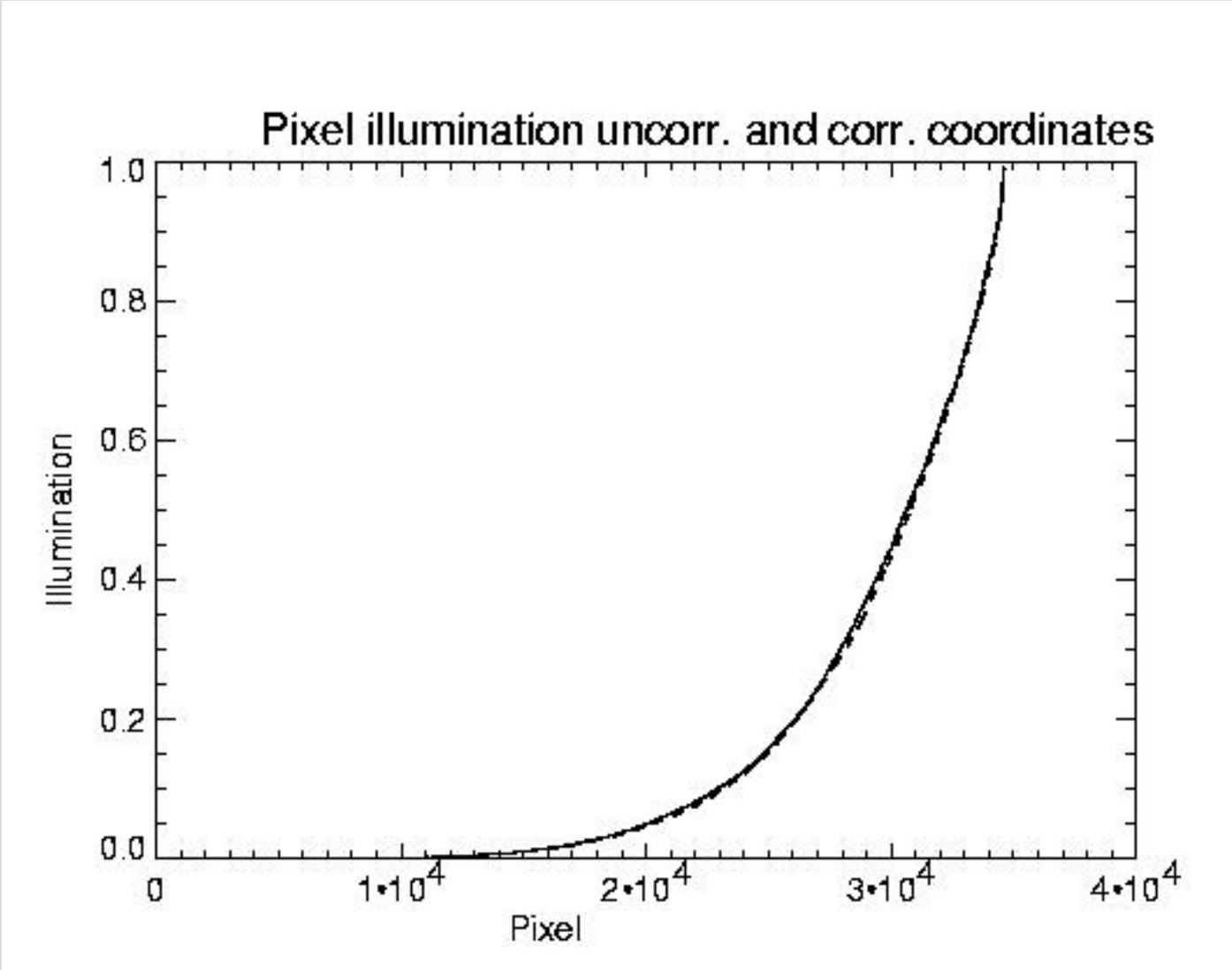
Define open/closed area

- Sort PIFs

- Define PIF cut level such that “open area” contains 75% of the flux, i.e leakage is 25%.
  [PIF cut level is energy dependent]

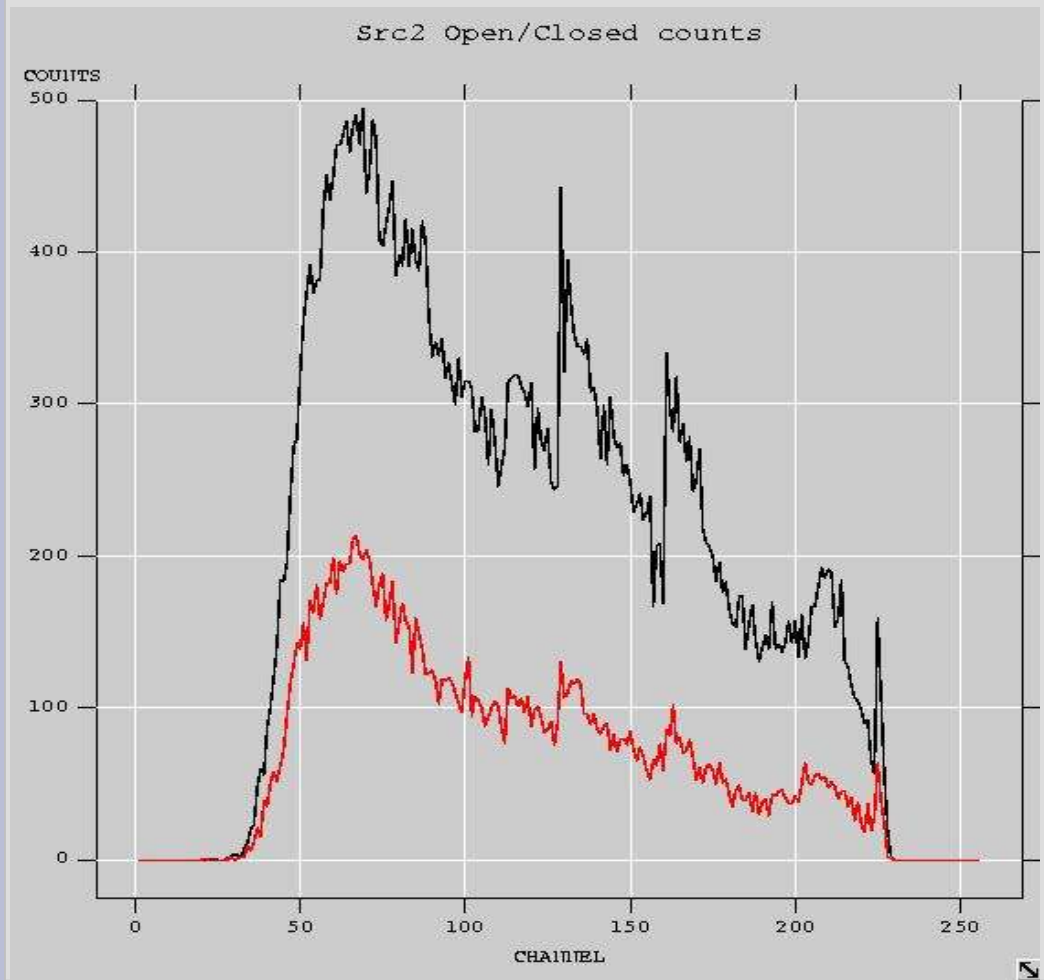
Open area: Pixels with PIF > $PIF_{OpenCut}$

Closed area: Pixels with PIF < $PIF_{ClosedCut}$

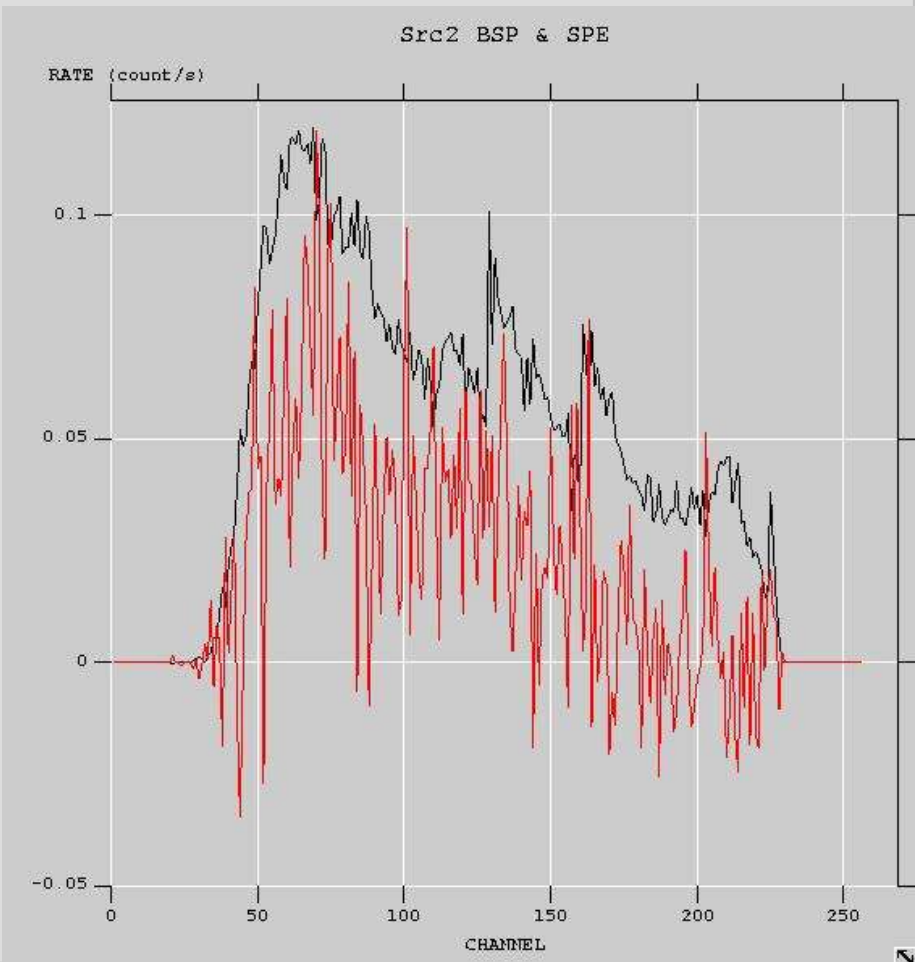

Pixel illumination uncorr. and corr. coordinates
1.0
0.8
0.6
0.4
0.2
0.0
Illumination
0
1•10^4
2•10^4
3•10^4
4•10^4
Pixel

Now add up the events according to thereOpen area: Pixels with PIF > $PIF_{OpenCut}$
Closed area: Pixels with PIF < $PIF_{ClosedCut}$

Open (red) and Closed area flux

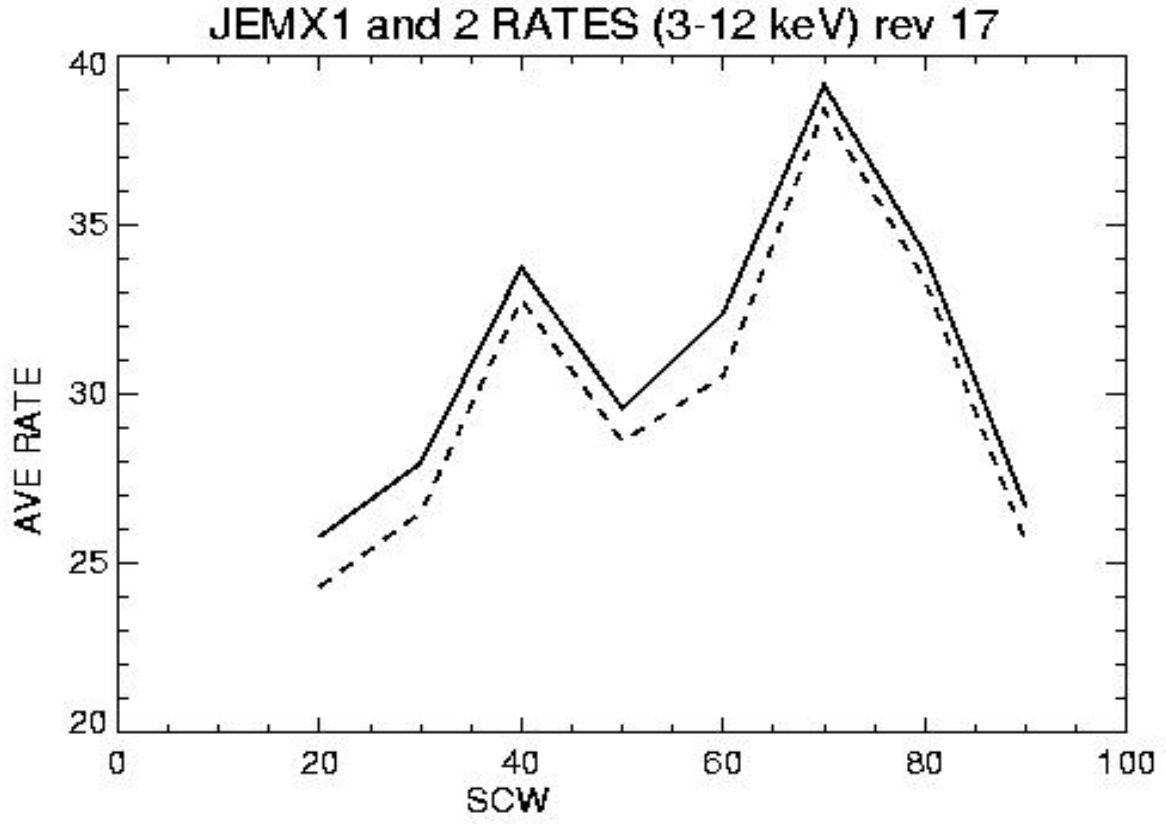


Background scaled to open area and net extracted source flux (red)



Jem-X1 vs Jem-X2

Cyg X-1 on-axis obs in rev 0017



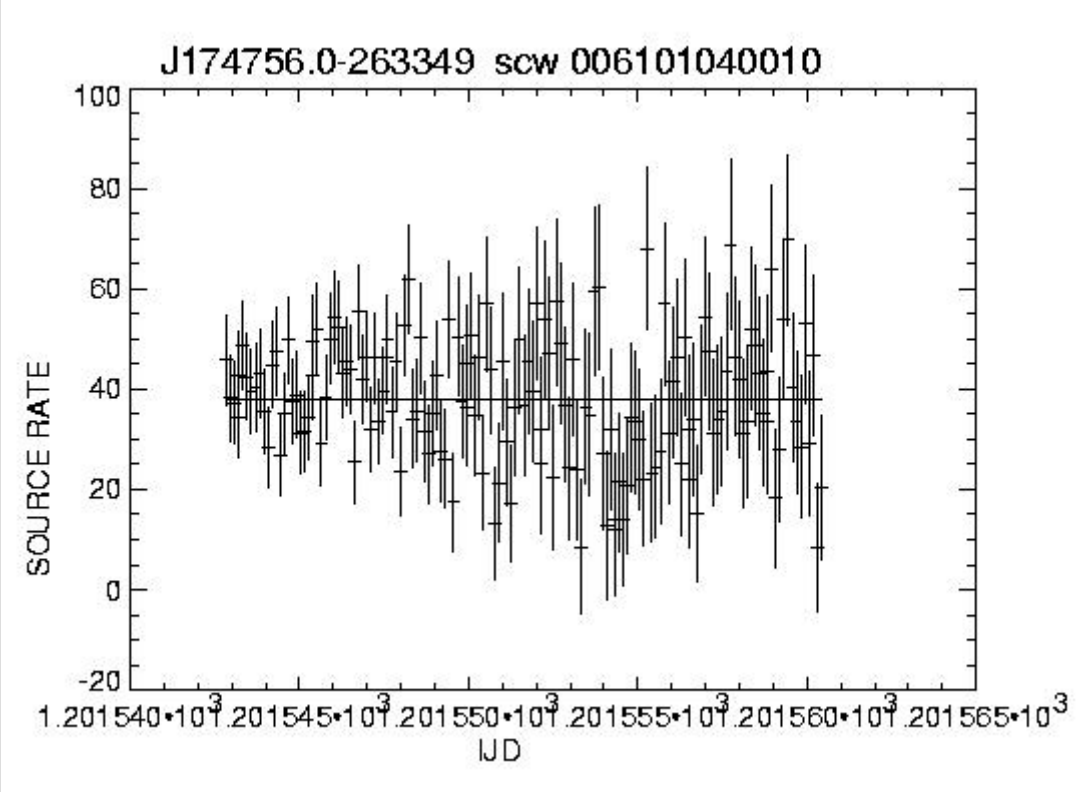
ERROR ESTIMATES: Lightcurve of bright source

Extracted source light curve src2

A chi-square fit (constant level) gave chi-sq=152.5 for 152 d.o.f.

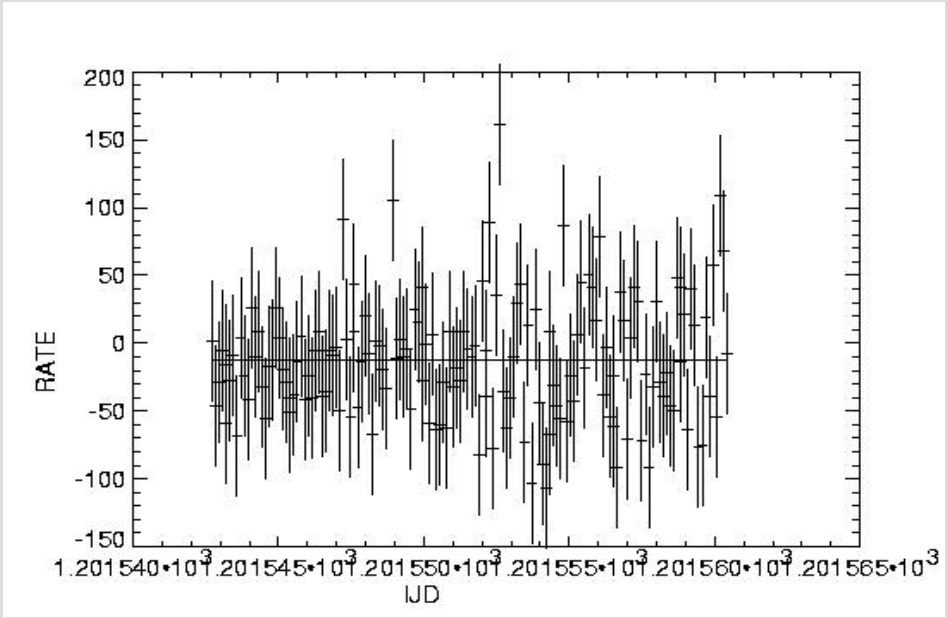
Mean = 38.0640 +/- 0.92

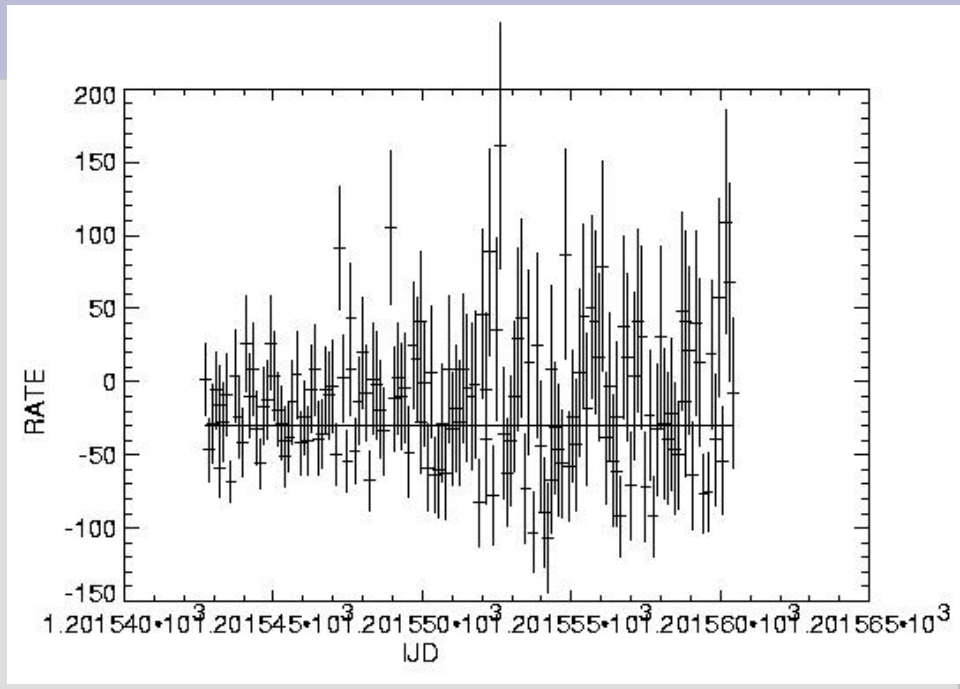
j_src_lc: 38.0537 +/- 1.02



ERROR ESTIMATES AT LOW COUNT RATES:
Faint and/or far off-axis sources, small time bins.
A lesson in statistics

Chi-square fit to empty sky position
(errors from single time bin) =>





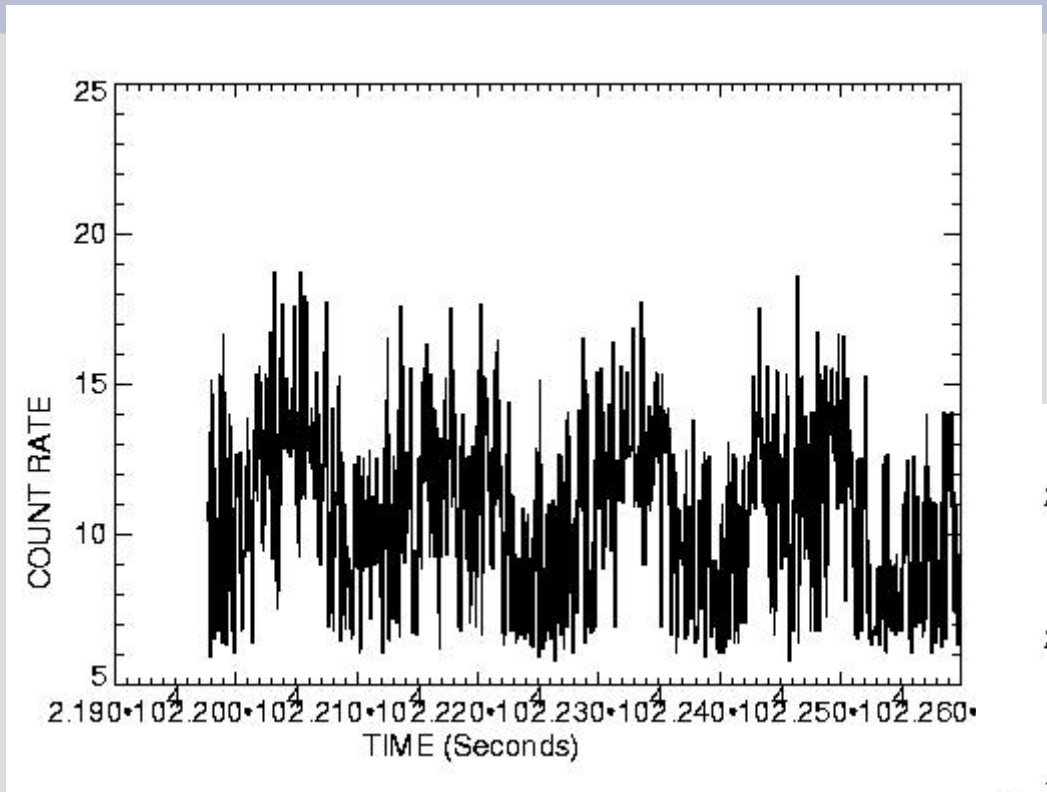
<= Chi-square fit to empty sky position
(equal size errors from mean rate)

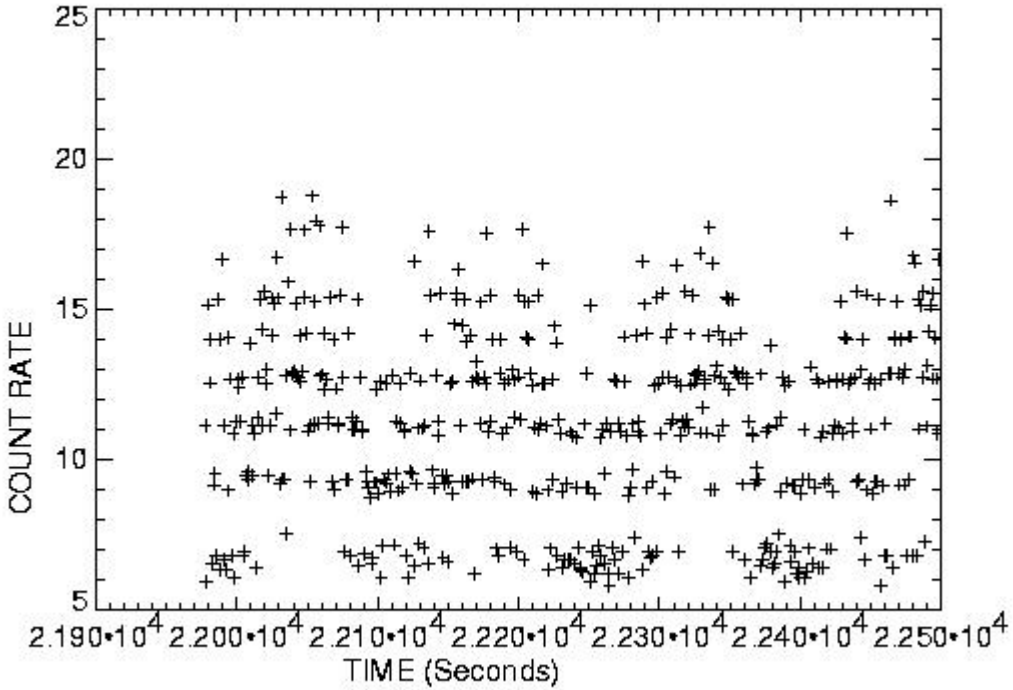
NOTE: Error bars are estimated from counts in a single time/energy bin. So dont use higher time resolution than necessary!
REMEMBER: Rate= ~ Open-0.25*Closed counts

Statistics at low countrates.

- errors are non-gaussian
- they are non-symetric
- Variance = # bin counts is a POOR estimate.

Vela X-1: Part of a scw.





For timing analysis: XRONOS
For Jem-X lightcurves you may also try DES7:

ftp.astro.su.se/pub/des/des7intel_linux.tar.gz

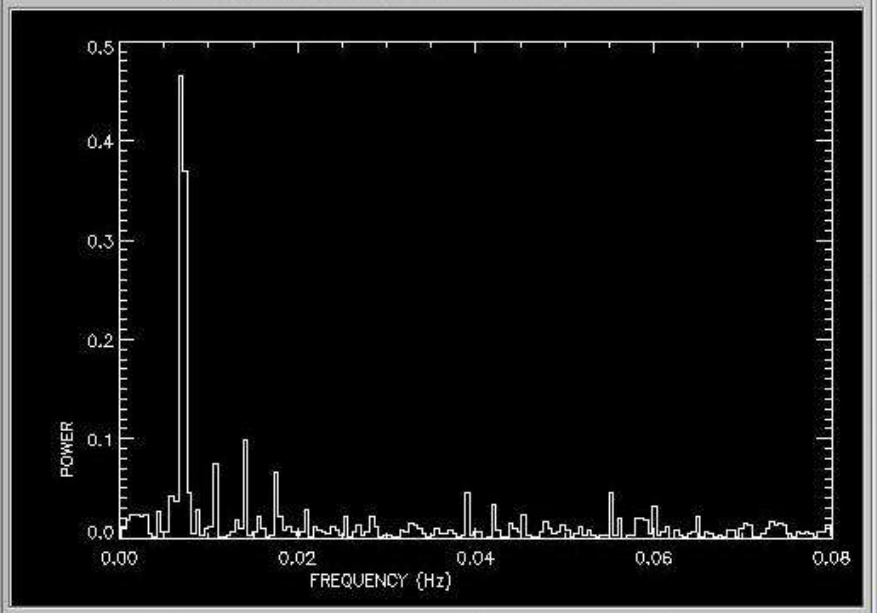
0. Active data array: 2 Points: 2248
1. READ FILE 2. STATISTICS 3. DETREND 4. SELECT PART
5. BIN 6. SMOOTH 7. WRITE FILE 8. VIEW ARRAY
9. PARAMETERS 10. FFT 11. UNEVEN DFT 12. UNEVEN ACF
13. UNEVEN PS 14. UNEVEN CCF 15. CROSS SPEC 16. POWER SPEC.
17. ACF 18. CCF 19. FIT 20. STATUS
21. TRANSF. 22. RESET 24. FOLD 25. EPHEMERIS
26. NOISE 27. ANALYSE PS 28. FLARES 29. AUTOPLOT
30. PLOT 31. COPY ARRAY 32. PHOTOMETRY 33. AUTOSIM.
34. SIMULATION 35. SIM-LOOP 76. AUTOBACKUP 77. BACKUP
90. INFO 99. EXIT

Programs Favorites Settings Desktop

D.E.S. PLOT

DONE

Press the left mouse button to see cursor coordinates.



PRINT
PRINT THICK
PLOT
REPLOT
RESET POINTS

Y-scale
1
Y-scroll
1

8
X-scale
1
X-scroll
1
PRINTER

functionality of this product contact your sales representative or
Research Systems (303-786-9900, info@ResearchSystems.com).

```
IDL> desdraw
% Compiled module: DESDRAW.
% Compiled module: XMANAGER.
% Compiled module: GAPCOUNT.
fgap =       0.00000
fgap =       0.00000
```

stefan-n620c:~> []

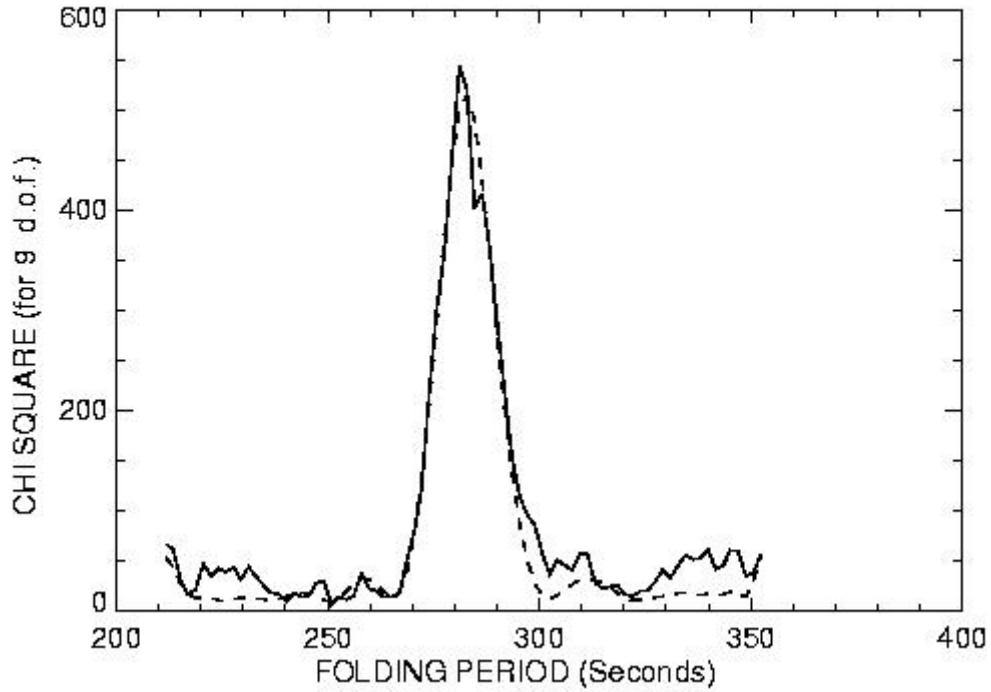
Xtefan

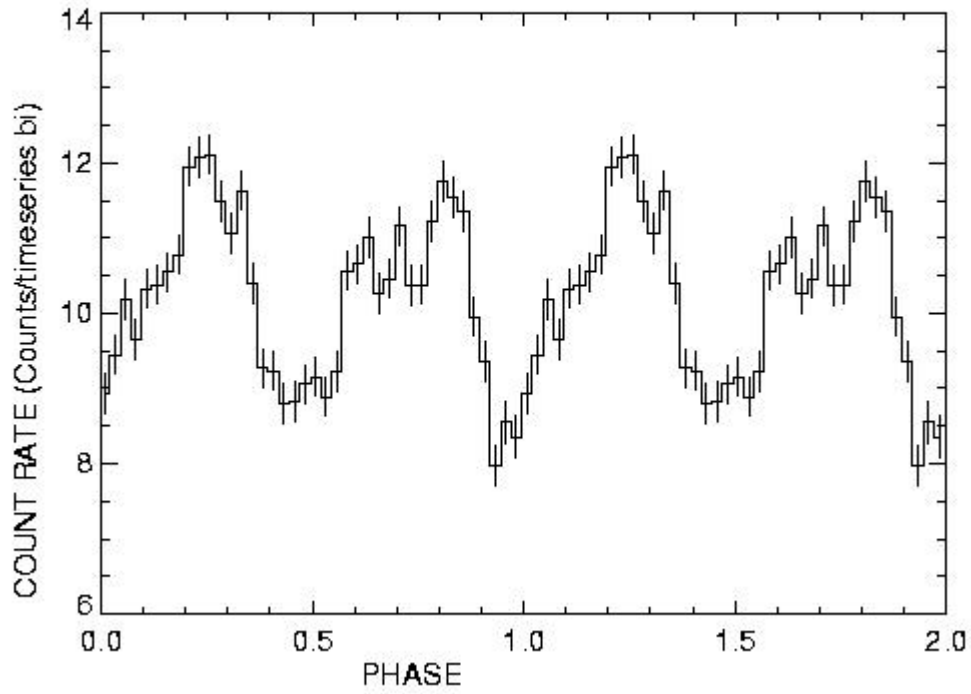
```
-rw-rw-r--    1 stefan   stefan     206119 Oct  6 02:59 root.jpeg
stefan-n620c:~> xv root.jpeg &
[1] 2071
```

XTEFAN

```
  1. READ FILE    2. STATISTICS   3. DETREND      4. SELECT PART
  5. BIN          6. SMOOTH       7. WRITE FILE   8. VIEW ARRAY
  9. PARAMETERS  10. FFT         11. UNEVEN DFT  12. UNEVEN ACF
 13. UNEVEN PS   14. UNEVEN CCF  15. CROSS SPEC  16. POWER SPEC.
 17. ACF         18. CCF         19. FIT         20. STATUS
 21. TRANSF.     22. RESET       24. FOLD        25. EPHEMERIS
 26. NOISE       27. ANALYSE PS  28. FLARES      29. AUTOPLOT
 30. PLOT        31. COPY ARRAY  32. PHOTOMETRY  33. AUTOSIM.
 34. SIMULATION  35. SIM-LOOP    76. AUTOBACKUP  77. BACKUP
 90. INFO        99. EXIT
1

Which input file?[
jmx2_src_lc.fits[3]
]:

 TYPE OF FILE?
 (0. Return)
 1. TEXT-FILE    2. DES-FILE    3. NOT Photopolarimeter
 4. WATCH
 5. JEM-X Light curve (fits file)


 READ OPTIONS:
 9. Range to read: Points   1  to   131072
 10. Time values: From file
     Sampling time: Calculated from the data
 11. Previous array content: DELETE
 12. Error bar storage: INTERNAL
 13. Time series type: SAMPLED
5
  naxis =           32      2248
  tstart =       0.128125434106E+04
  mjdref =     0.5154400E+05

  0. Active data array:   2   Points:   2248
  1. READ FILE    2. STATISTICS   3. DETREND      4. SELECT PART
  5. BIN          6. SMOOTH       7. WRITE FILE   8. VIEW ARRAY
  9. PARAMETERS  10. FFT         11. UNEVEN DFT  12. UNEVEN ACF
 13. UNEVEN PS   14. UNEVEN CCF  15. CROSS SPEC  16. POWER SPEC.
 17. ACF         18. CCF         19. FIT         20. STATUS
 21. TRANSF.     22. RESET       24. FOLD        25. EPHEMERIS
 26. NOISE       27. ANALYSE PS  28. FLARES      29. AUTOPLOT
 30. PLOT        31. COPY ARRAY  32. PHOTOMETRY  33. AUTOSIM.
 34. SIMULATION  35. SIM-LOOP    76. AUTOBACKUP  77. BACKUP
```

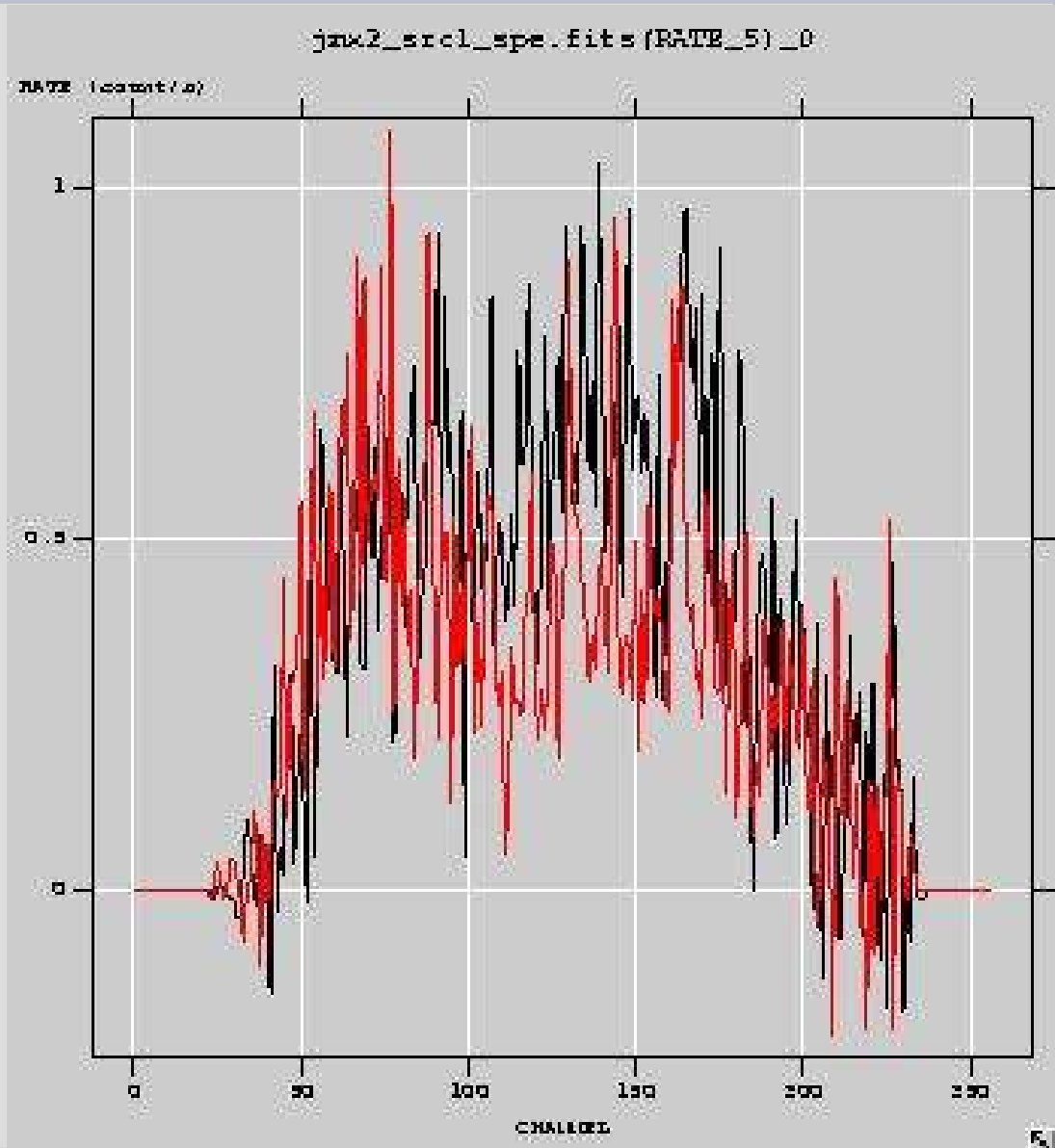
Vela X-1: Epoch folding of data from 1 scw





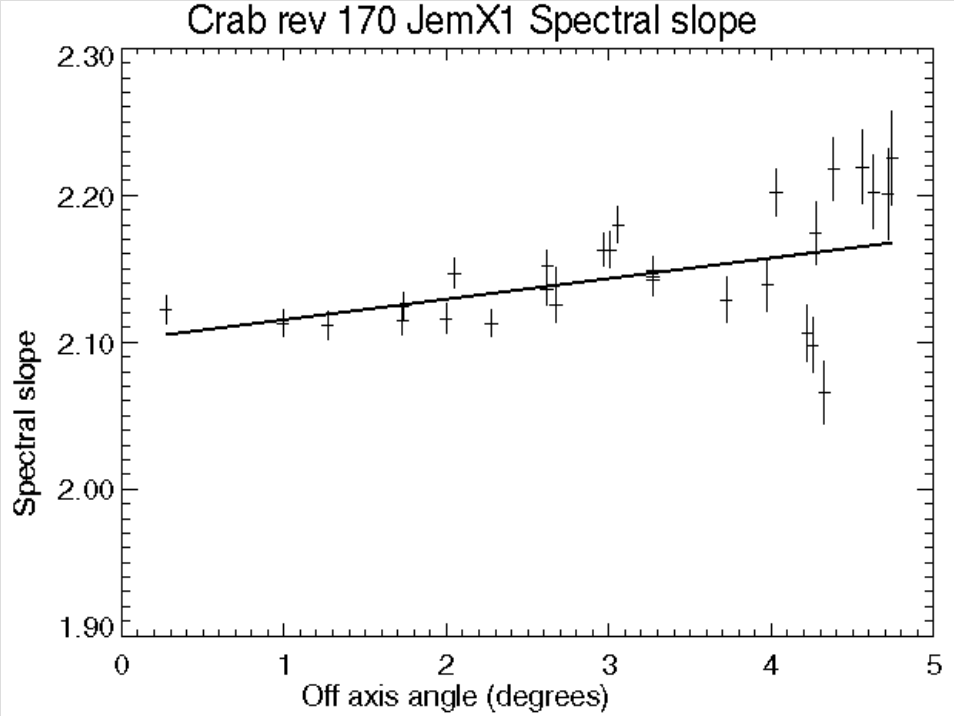
Phase folded lightcurves and spectra (to make Peter happy)

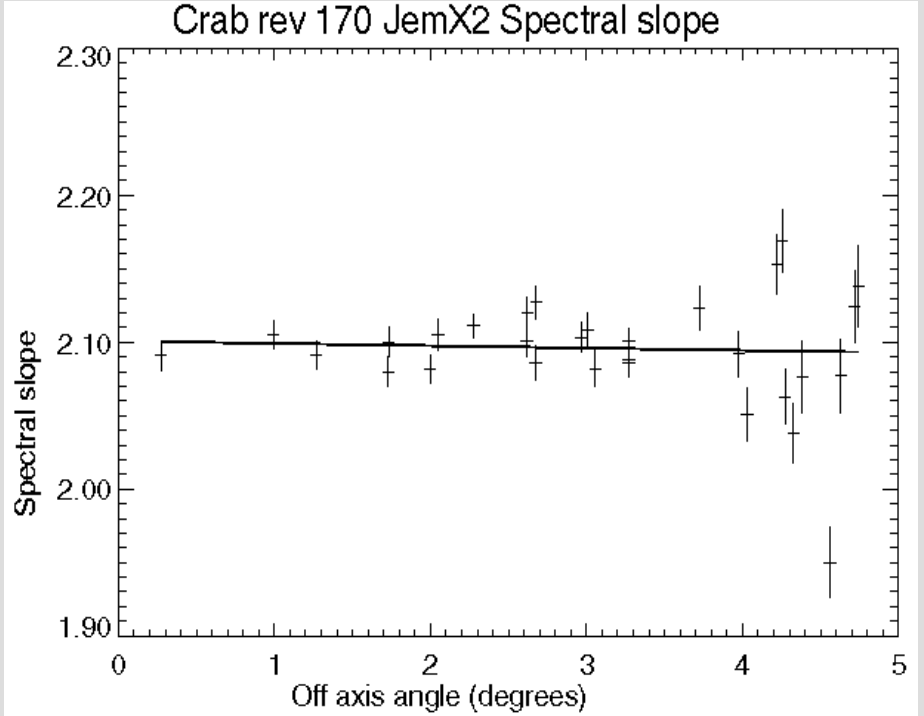
Vela X-1 example
nPhaseBins=-6 and
timeStep=141.5
1 Scw.
Folding spectra in 6 phase bins.
Black: Pulse max spectrum
Red: Pulse min spectrum



Jem-X1 vs Jem-X2

Crab obs in rev 0170. Spectral slopes.





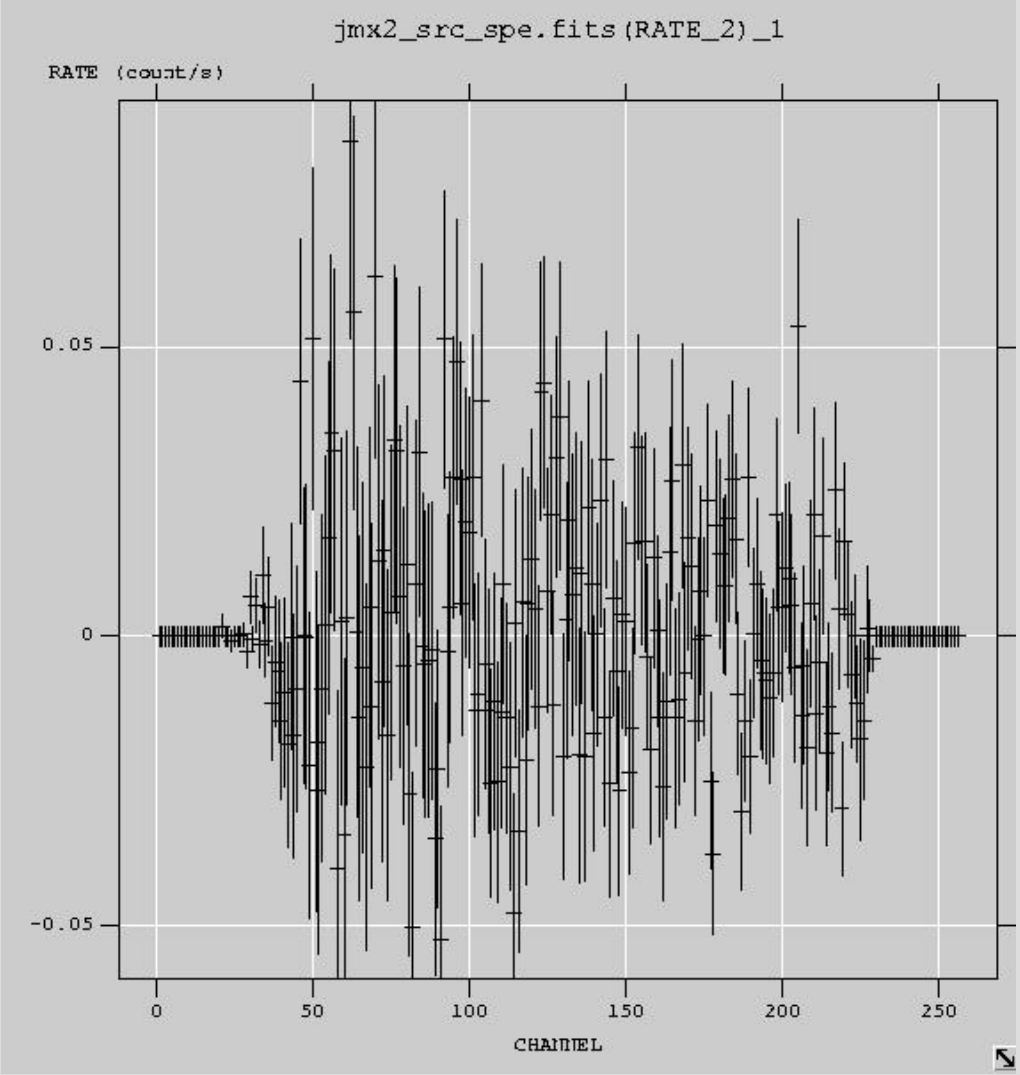
On-axis result is good but a vignetting dependent effect (instrument dependent) is still present.

Diagnostic Mode

diagnosticMode =

1 = Open area counts in src-lc/spe and
closed area counts in backgr lc/spe
(3 = Position mapping)
4 = Randomized event positions
diagnosticMode=4
diagnosticParam=11 [rand. Seed]

Diagnostic Mode 4. Example
Randomized event positions



Jem-X Source extraction
The good and the bad

GOOD:

Time variability on timescales < SCW
And over identical pointings

Spectral shapes are quite good < 3-3.5 degrees off axis

BAD:

Flux normalization varies across the field of view,
due to unmodelled vignetting. Increasing to ~20%
At 3-4 degrees off axis.

Development for OSA 5.0

1. Improved vignetting/collimator model
   (under development at DSRI)
2. Support structure of mask in ray tracing.
3. Including non-flat background models
4. REST mode light curves.
5. "*IROS* function" (using correlation between PIF maps)