

CENTER FOR

ASTROPHYSICS

HARVARD & SMITHSONIAN

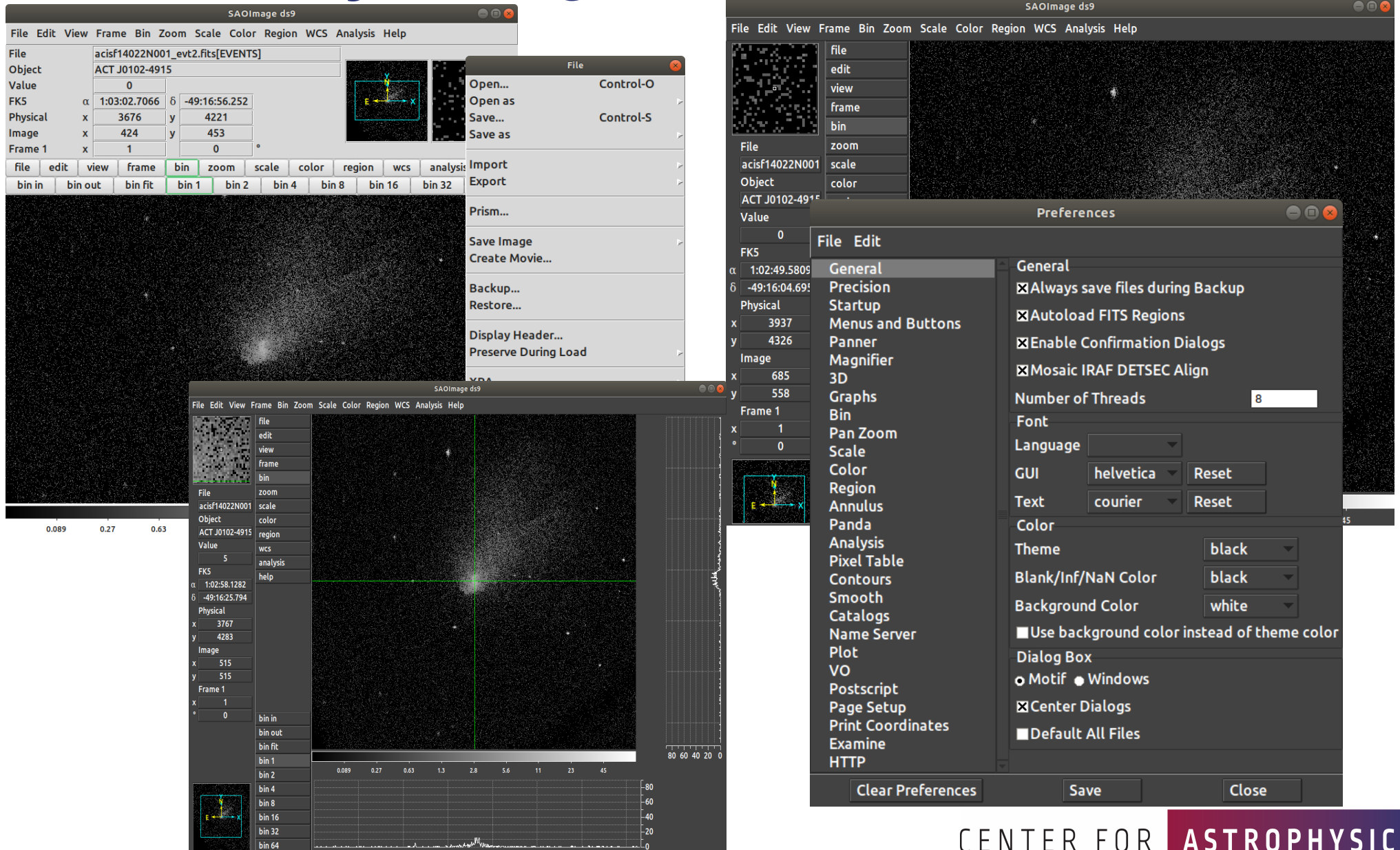
Using SAOImage ds9 and dax

Kenny J. Glotfelty

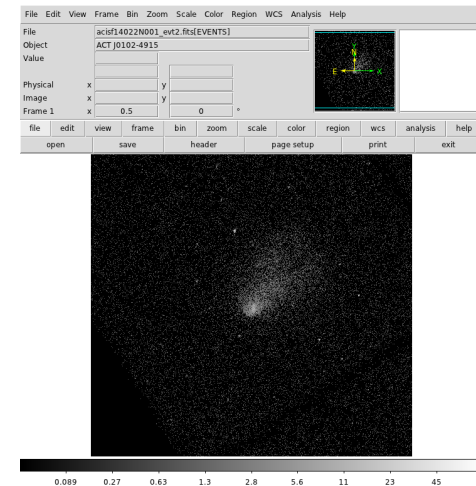
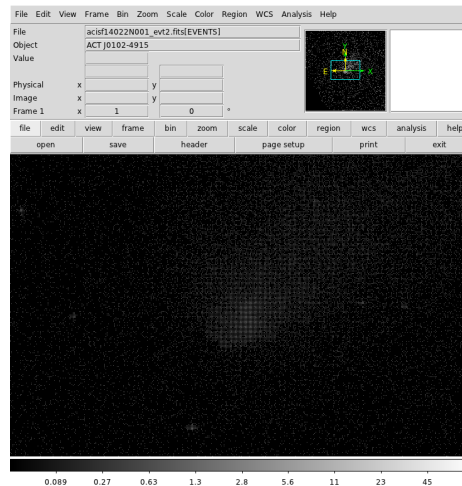
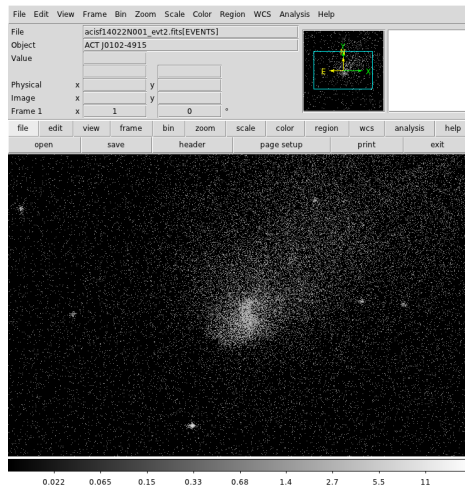
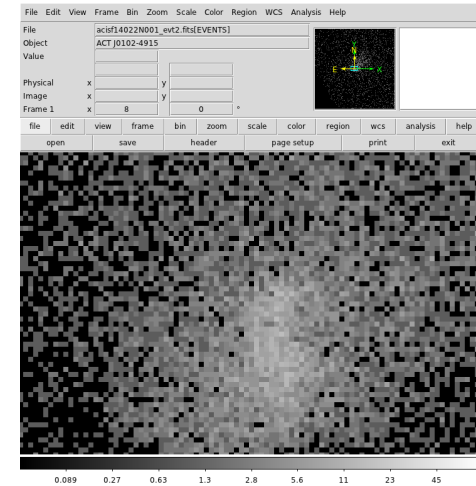
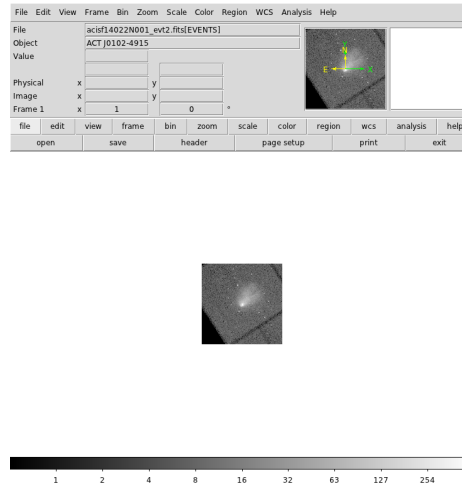
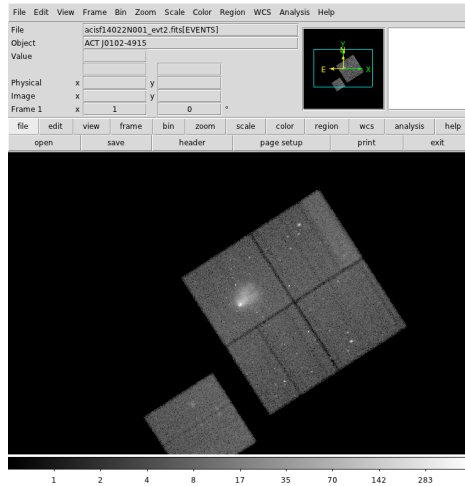
Introduction

- Reference these Jupyter notebooks:
https://github.com/kglotfelty/ds9_dax_demo
- Some basic and advanced ds9 features

ds9 | Adjusting the User Interface



ds9 | Bin, Block, Zoom



ds9 | Filtering

The screenshot displays the ds9 software interface with several windows open. The main window shows a file named 'acisf19004N001_evt2.fits[EVENTS]' with a WCS solution for object '4U 1630-47'. The WCS parameters are: RA = 16:33:24.9042, Dec = -47:20:21.276, X = 4830.5, Y = 4478.5, X pixel = 696, Y pixel = 608, Frame = 1.

The 'Prism' window shows the 'EVENTS' extension selected, with the following header keywords:

Keyword	Value	Description
XTENSION	'BINTABLE'	binary table extension
BITPIX	8	8-bit bytes
NAXIS	2	2-dimensional binary table
NAXIS1	64	width of table in bytes
NAXIS2	445631	number of rows in table
PCOUNT	0	size of special data area
GCOUNT	1	one data group (required keyword)
TFIELDS	19	number of fields in each row
EXTNAME	'EVENTS'	name of this binary table extension
HDUNAME	'EVENTS'	ASCDM block name
TTYPE1	'time'	S/C TT corresponding to mid-exposure
TFORM1	'1D'	format of field

The 'Binning Parameters' window is open, showing the following settings:

Column	Bin	Min	Max
x	4	0.5	8192.5
y	4	0.5	8192.5

Bin Center: 4096.5 (checked), or center of data (unchecked)

Bin Filter: energy=2000:7000

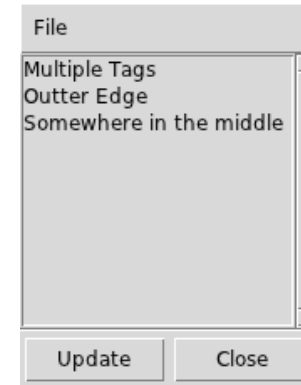
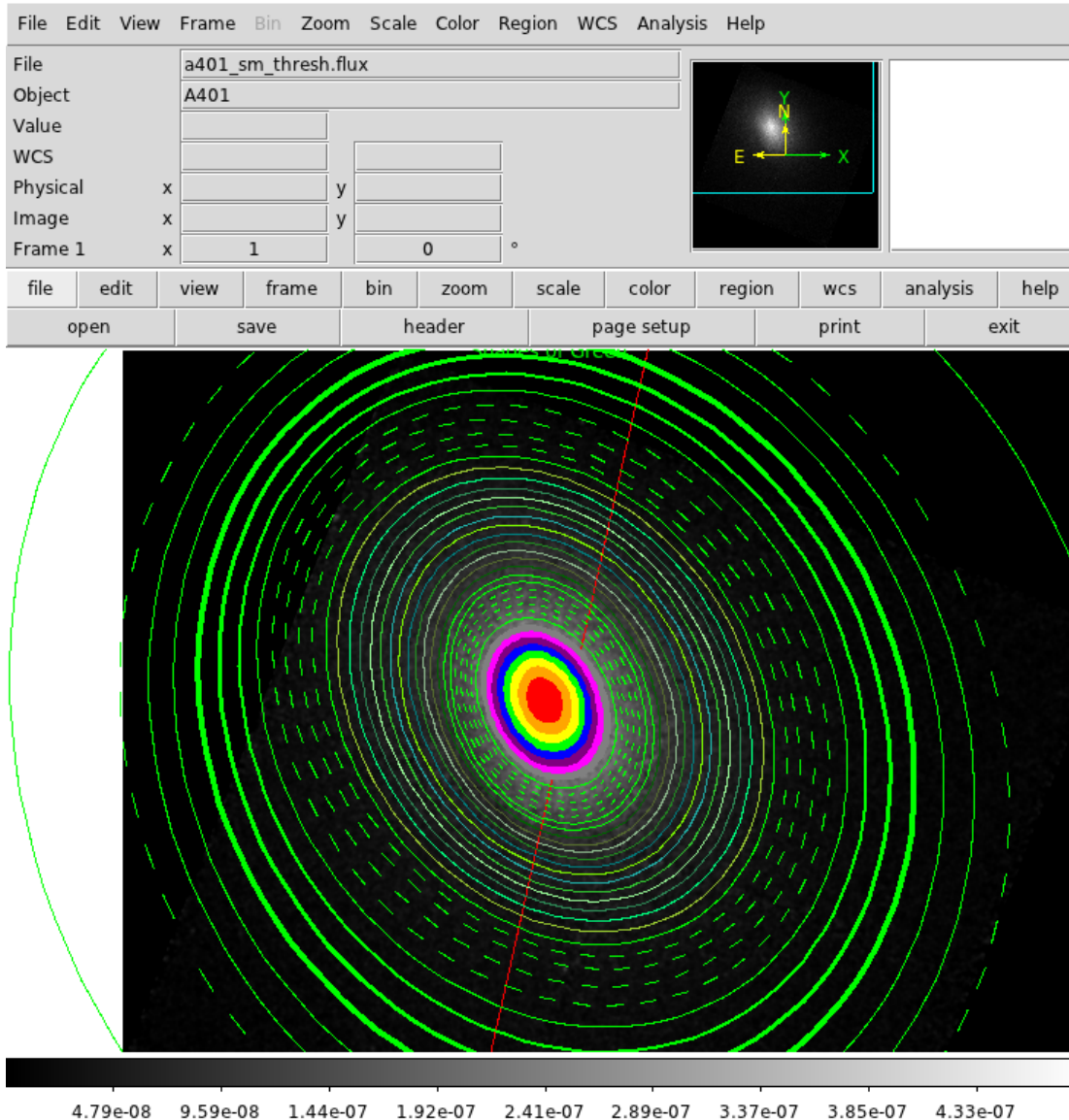
Bin 3rd Column: Column 1, Depth 0, Min 0, Max 0

Buttons: Apply, Update Filter, Clear Filter, Close

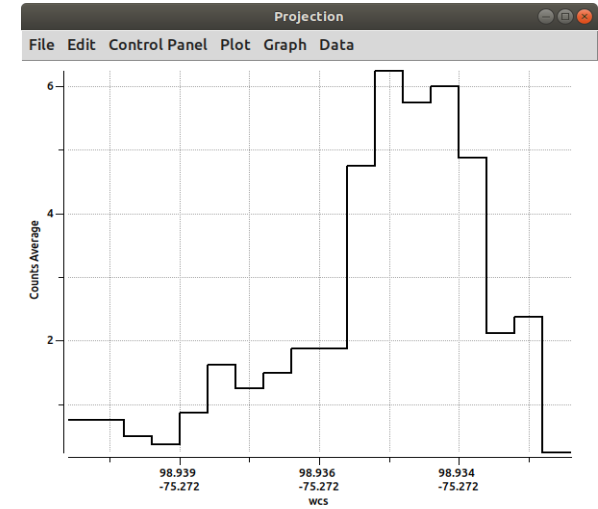
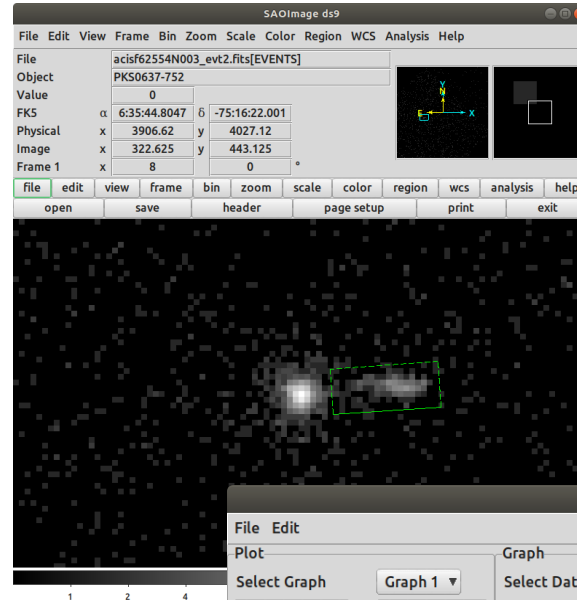
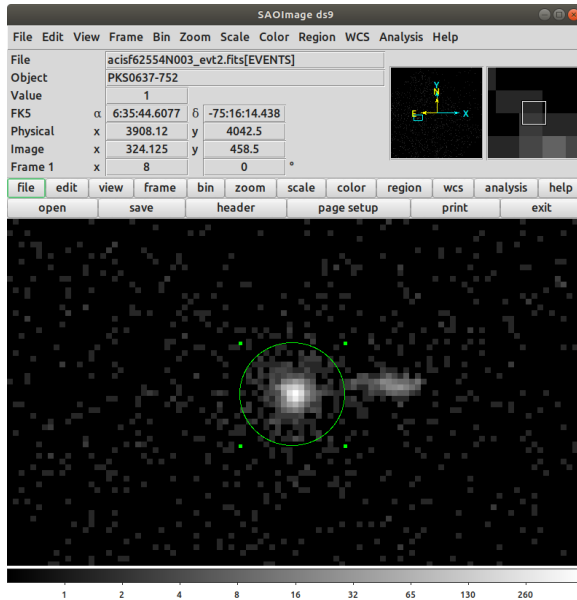
The main window shows a list of event data with columns: Row, detx pixel, dety pixel, x pixel, y pixel, pha adu, pha_ro adu, energy eV, pi chan, and fltgrade. The first 11 rows of data are visible.

Row	detx pixel	dety pixel	x pixel	y pixel	pha adu	pha_ro adu	energy eV	pi chan	fltgrade
1	4849.641113281	4454.910644531	4401.794433594	3339.560791016	2737	2678	12179.44042969	835	64
2	4007.398681641	4279.83203125	4276.217773438	4190.592285156	2042	1988	9118.171875	625	72
3	4014.947021484	4141.910644531	4138.090820312	4191.114257812	2612	2552	11660.93359375	799	208
4	3911.082275391	3773.486572266	3776.363525391	4316.32421875	2767	2686	12387.02636719	849	104
5	4405.150390625	3757.171875	3731.21411328	3824.052978516	2640	2565	12372.17480469	848	208
6	4528.110839844	3586.076904297	3553.227783203	3711.297607422	2695	1754	12463.453125	854	11
7	4316.772460938	3579.469482422	3558.977783203	3922.660888672	2566	2467	12003.12011719	823	64
8	2773.639648438	4453.215332031	4521.379394531	5412.115722656	1750	1691	7644.037109375	524	208
9	2394.340332031	4399.654296875	4490.067871094	5793.895996094	2460	2379	10964.82128906	752	104
10	2803.528076172	4390.033691406	4456.559570312	5385.969238281	2972	2890	12993.328125	890	22
11	1986.205200195	4334.126953125	4448.495117188	6205.162597656	2924	2809	12218.77441406	837	64

ds9 | Regions | Decorations



ds9 | Regions | Analysis



Circle

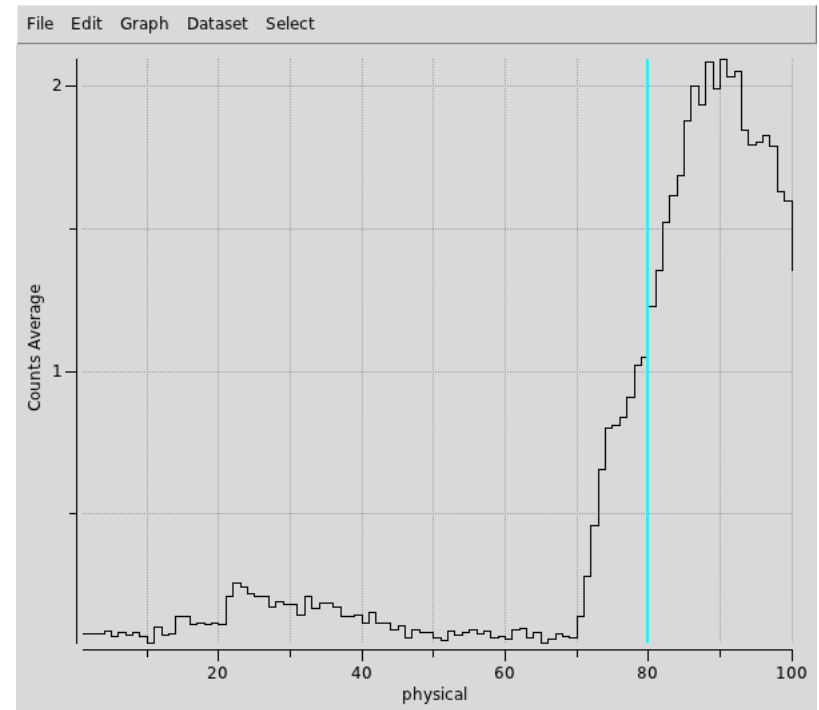
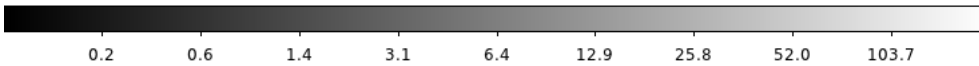
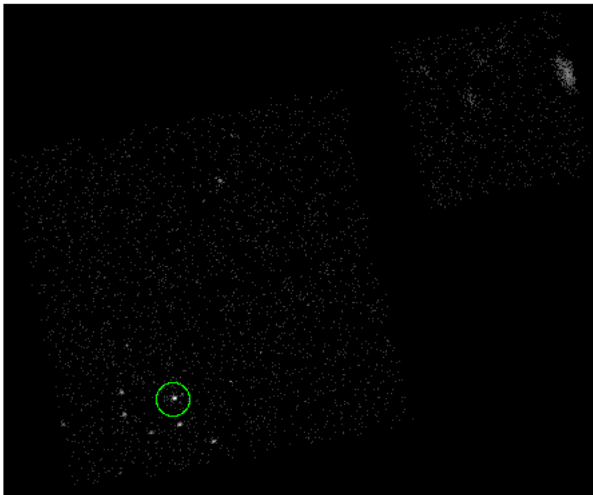
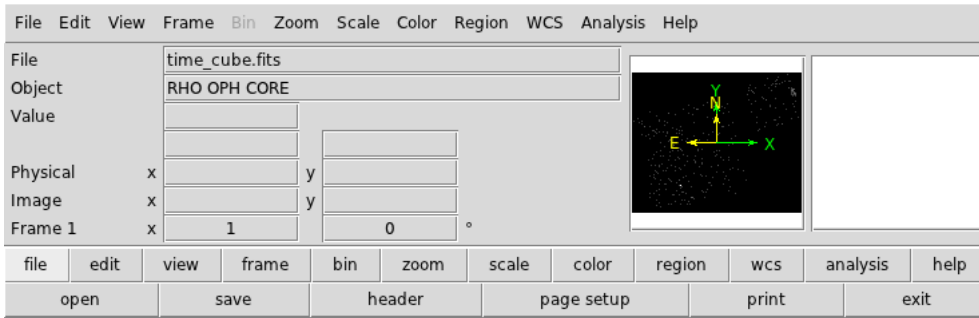
```
File Edit Font
center=98.944269 -75.27134
fk5
1 pixel = 0.49200001 arcsec
```

reg	sum	error	area	surf_bri	surf_err
---	---	---	(arcsec**2)	(sum/arcsec**2)	(sum/arcsec**2)
1	2645	51.4296	61.9684	42.6831	0.829932

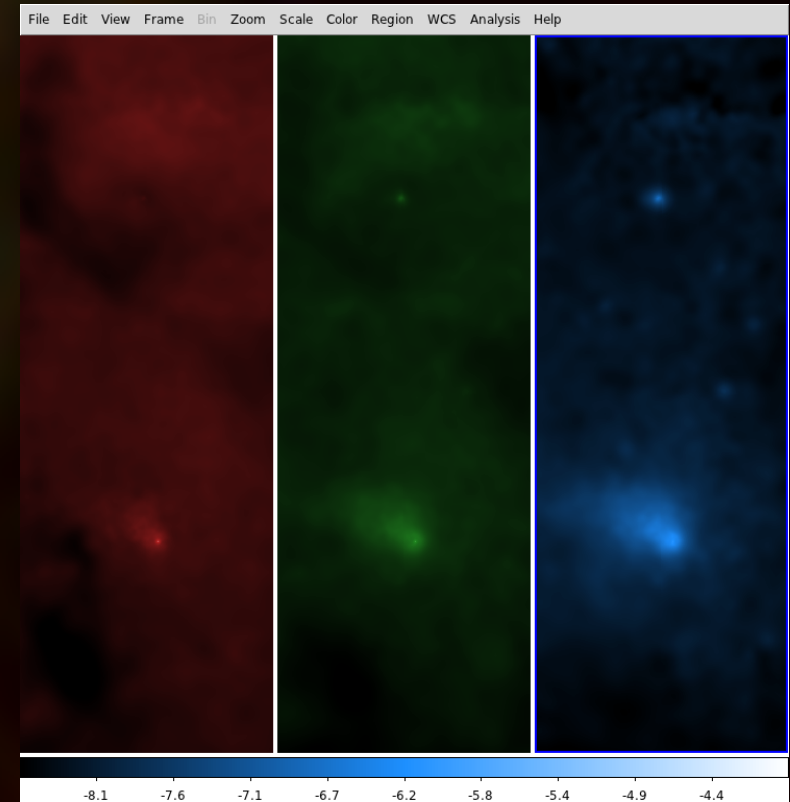
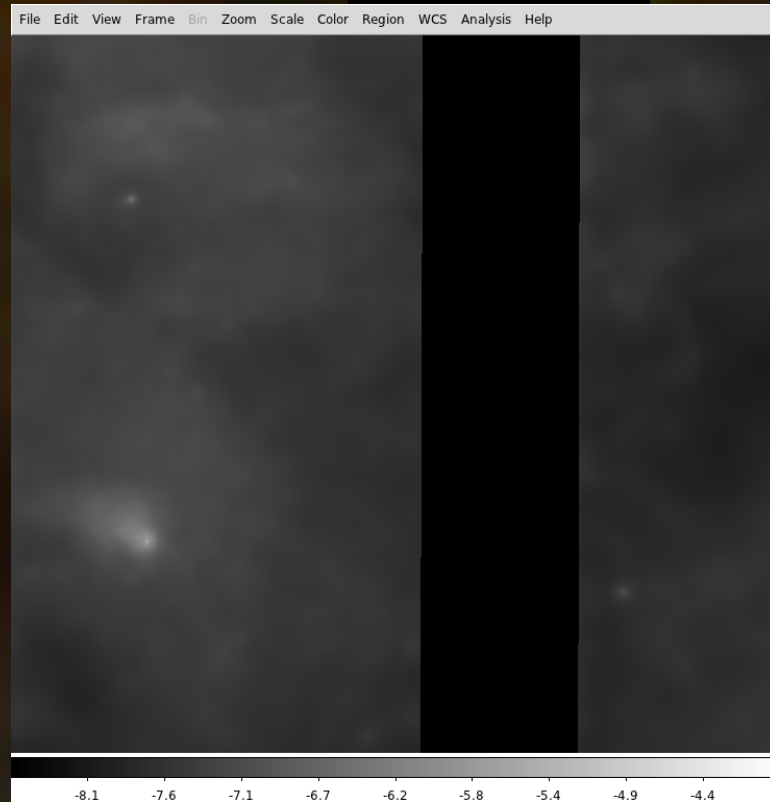
reg	sum	npix	mean	median	min	max	var	stddev	rms
---	---	---	---	---	---	---	---	---	---
1	2645	256	10.332	1	0	519	2068.1	45.4763	46.6353

Plot Control Panel showing various settings for the histogram. The plot is titled 'Graph 1' and shows 'Dataset 1'. The y-axis is labeled 'Counts Average' and the x-axis is labeled 'wcs'. The plot is a step histogram. The control panel includes options for layout (Grid, Row, Column, Strip), font (helvetica), color (black, white, gray64), and axis titles (Title, X Axis Title, Y Axis Title, Legend Title). The 'Line Dataset' section shows 'Dataset 1' with 'Show' checked, 'Color' set to black, 'Width' set to 2, 'Shadow' set to black, 'Shape' set to none, 'Color' set to red, and 'Fill' checked. The 'Errorbar' section shows 'Show' checked, 'Cap' unchecked, 'Color' set to red, and 'Width' set to 1. The 'Titles' section shows 'Title' set to 'wcs', 'X Axis Title' set to 'wcs', 'Y Axis Title' set to 'Counts Average', and 'Legend Title' set to 'Legend'.

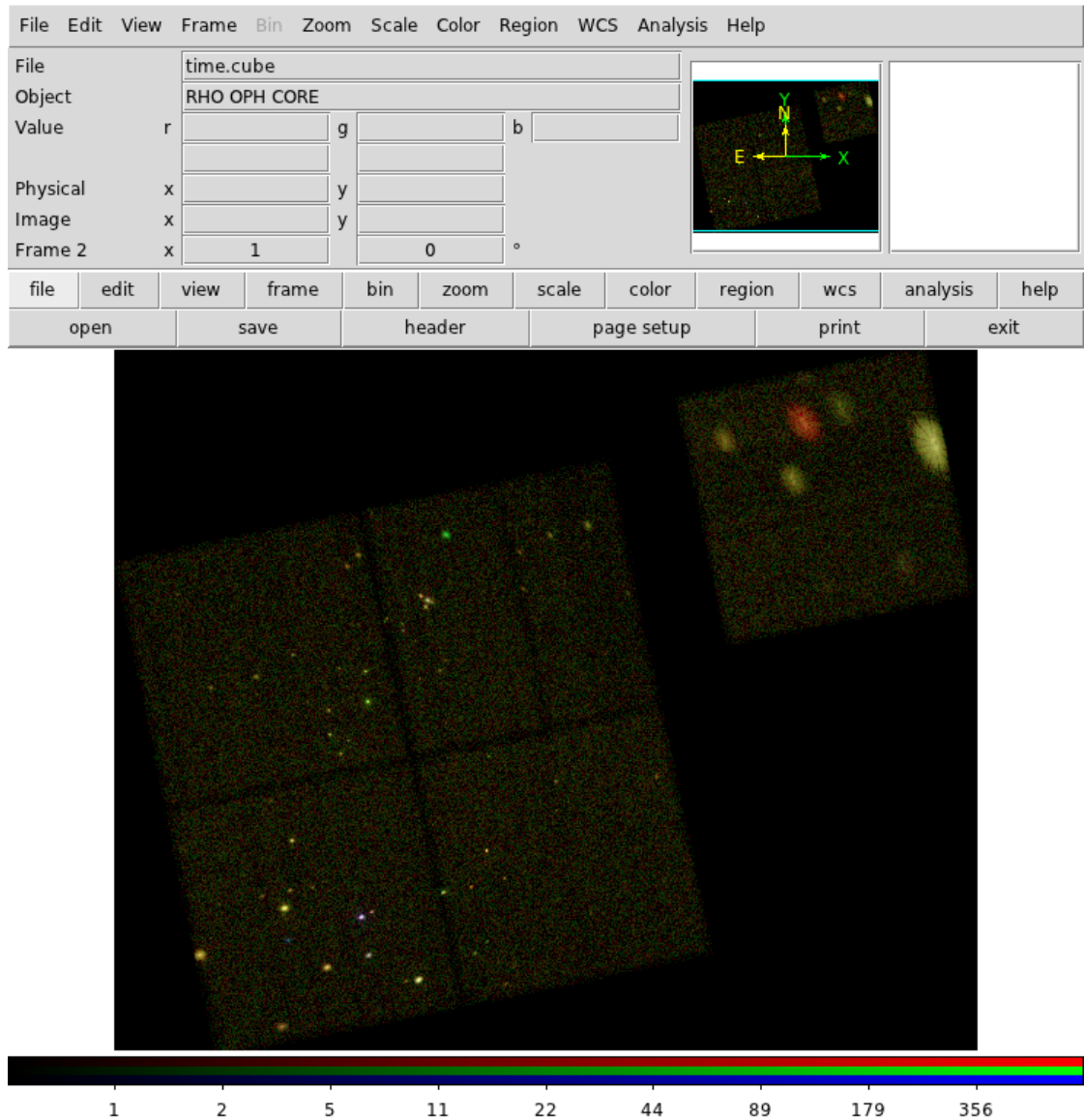
ds9 | Regions | Cubes



ds9 | RGB | Multi-Wavelength



ds9 | RGB | Time

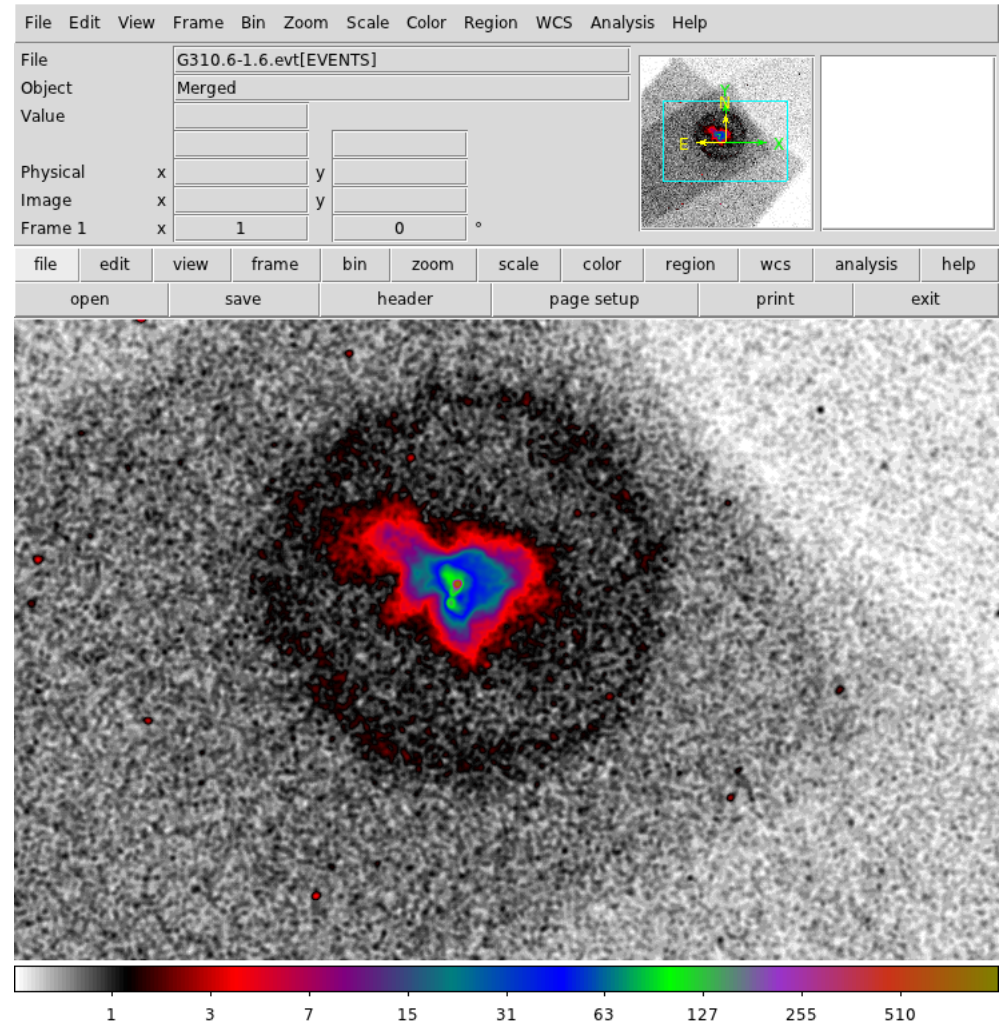
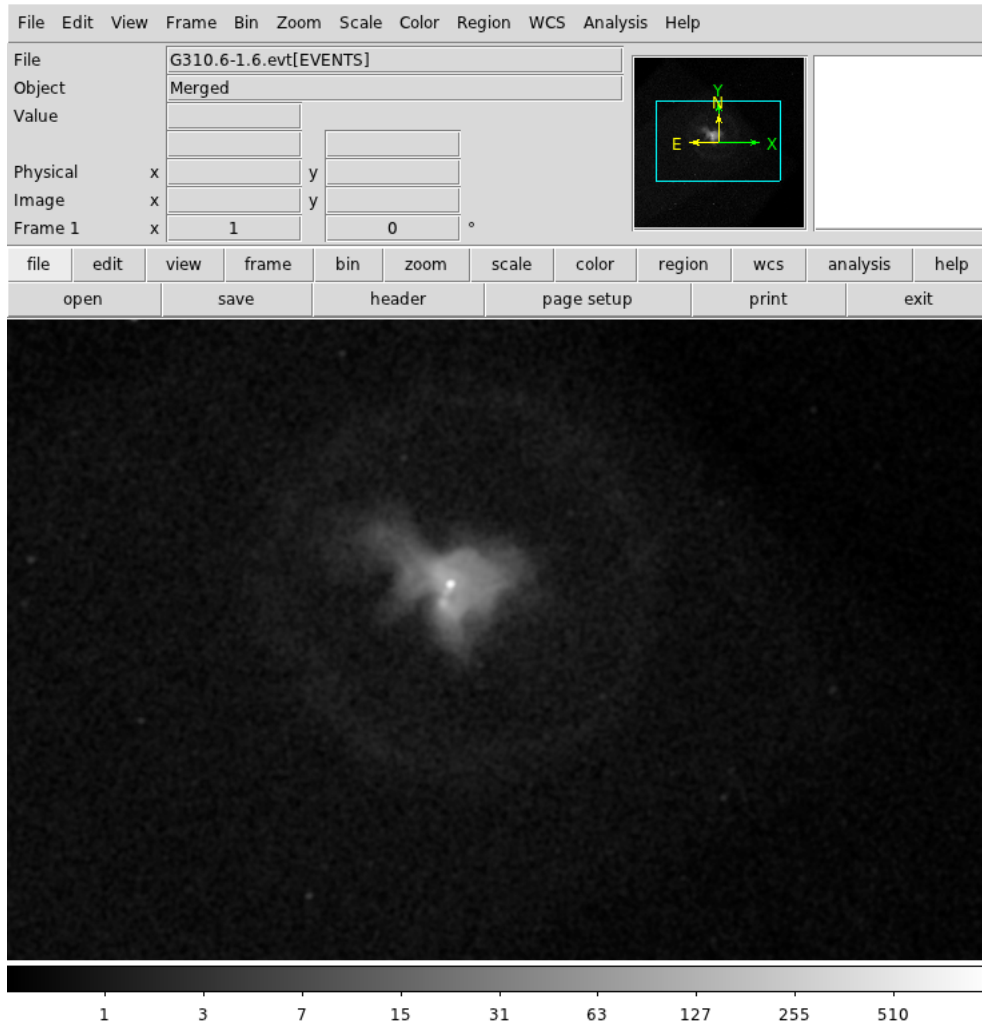


CENTER FOR

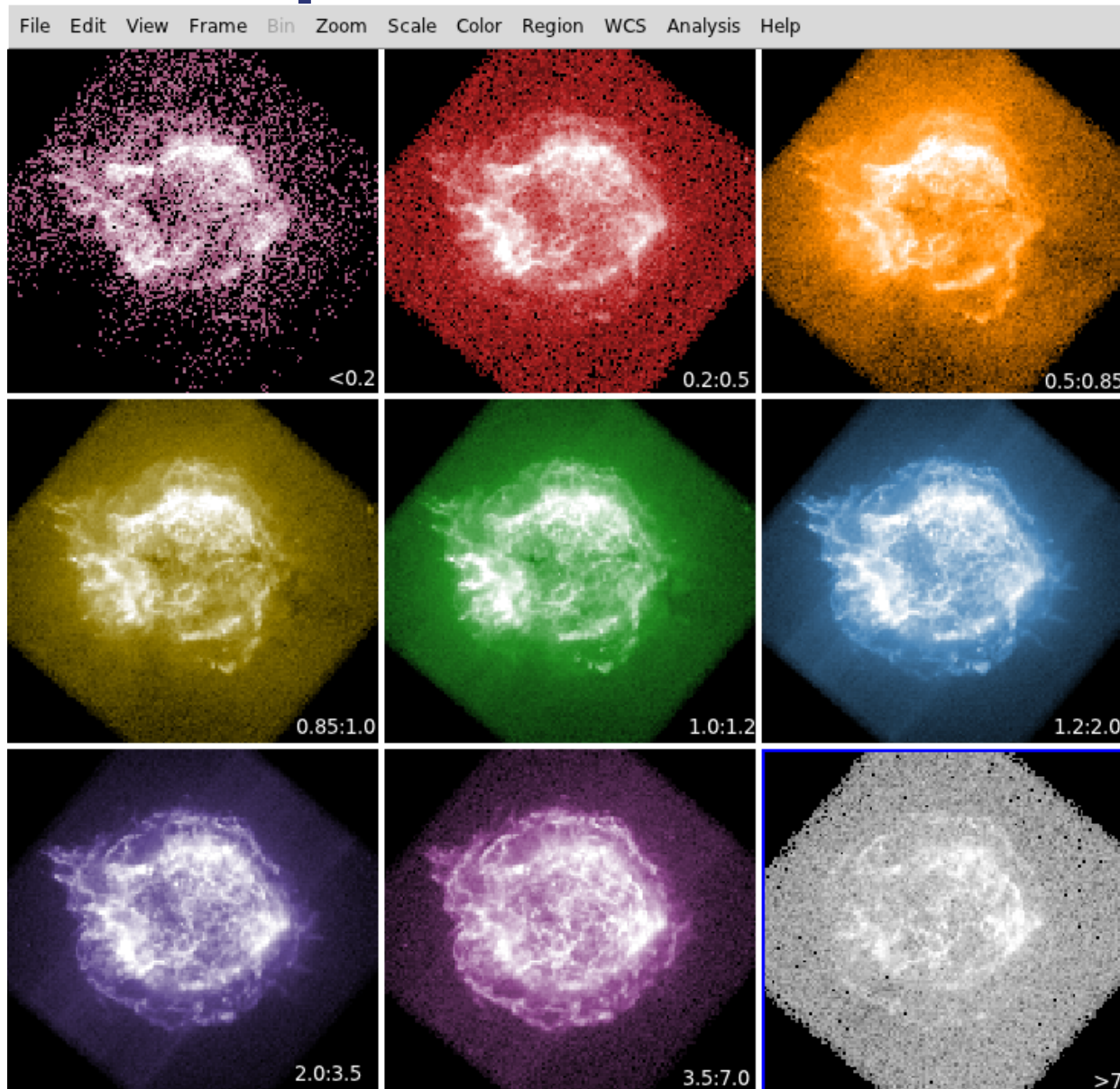
ASTROPHYSICS

HARVARD & SMITHSONIAN

ds9 | Color Look Up Tables



ds9 | Backup & Restore



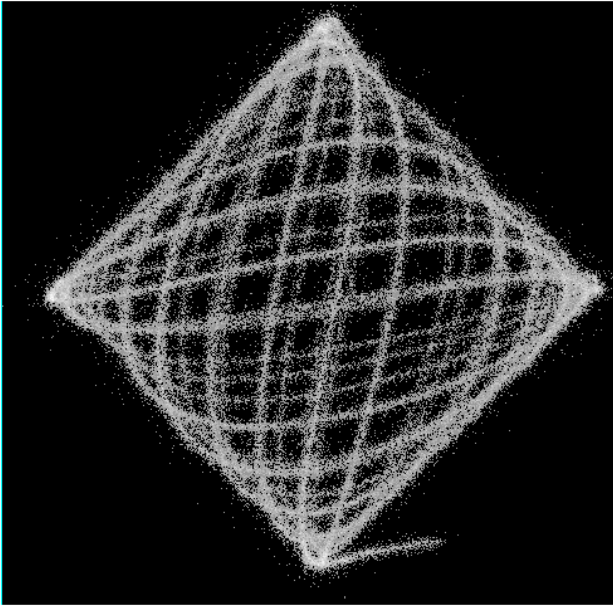
ds9 | 3D Rendering

File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help

File: ar_lac.cube
Object: ArLac
Value:

Physical: x y z
Image: x y z
Frame 2: x 1 y 0 z °

file edit view frame bin zoom scale color region wcs analysis help
open save header page setup print exit



0.016 0.047 0.11 0.24 0.49 0.99 2 4 8

File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help

file
edit
view
frame
bin
zoom
scale
color
region
wcs
analysis
help

File: ar_lac.cube
Object: ArLac
Value:

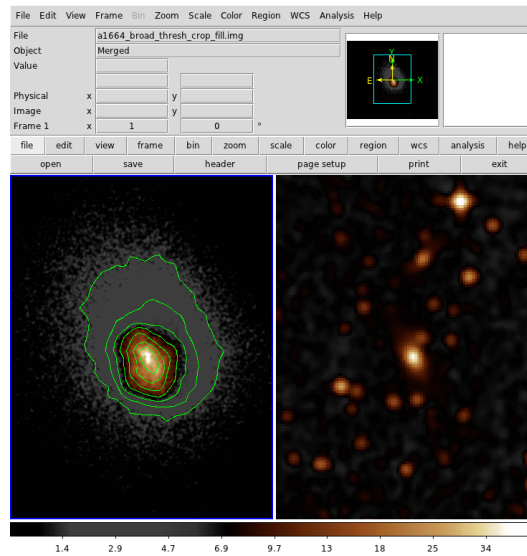
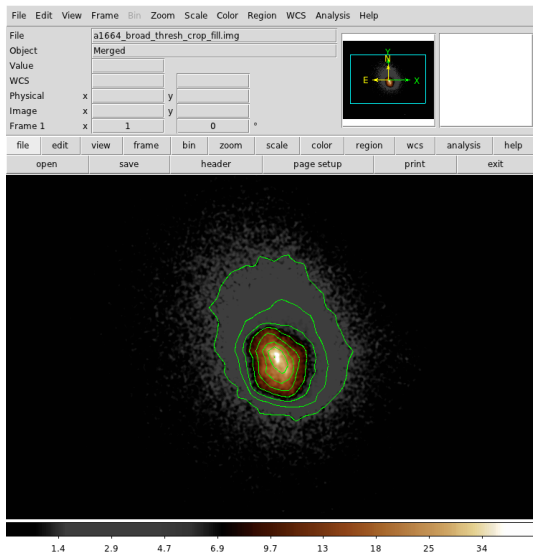
Physical: x y z
Image: x y z
Frame 2: x 1 y 0 z °

open
save
header
page setup
print
exit

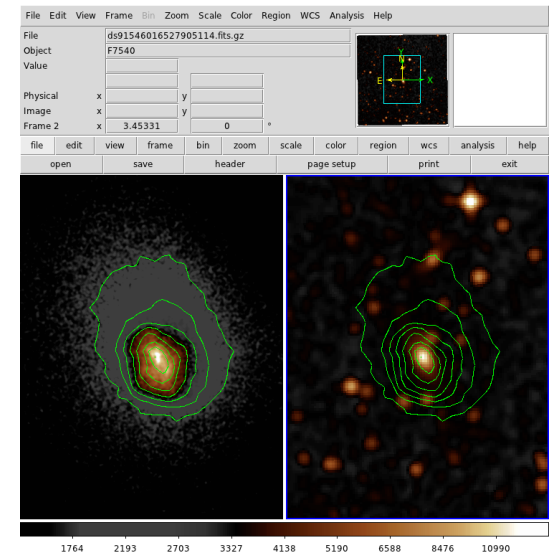
A 3D point cloud rendering of a diamond-shaped object, similar to the wireframe view. The object is composed of many individual points forming a diamond shape. The background is black, and the object is rendered in a light gray color. The object is tilted and rotated, showing a different perspective.

0.016 0.047 0.11 0.24 0.49 0.99 2 4 8

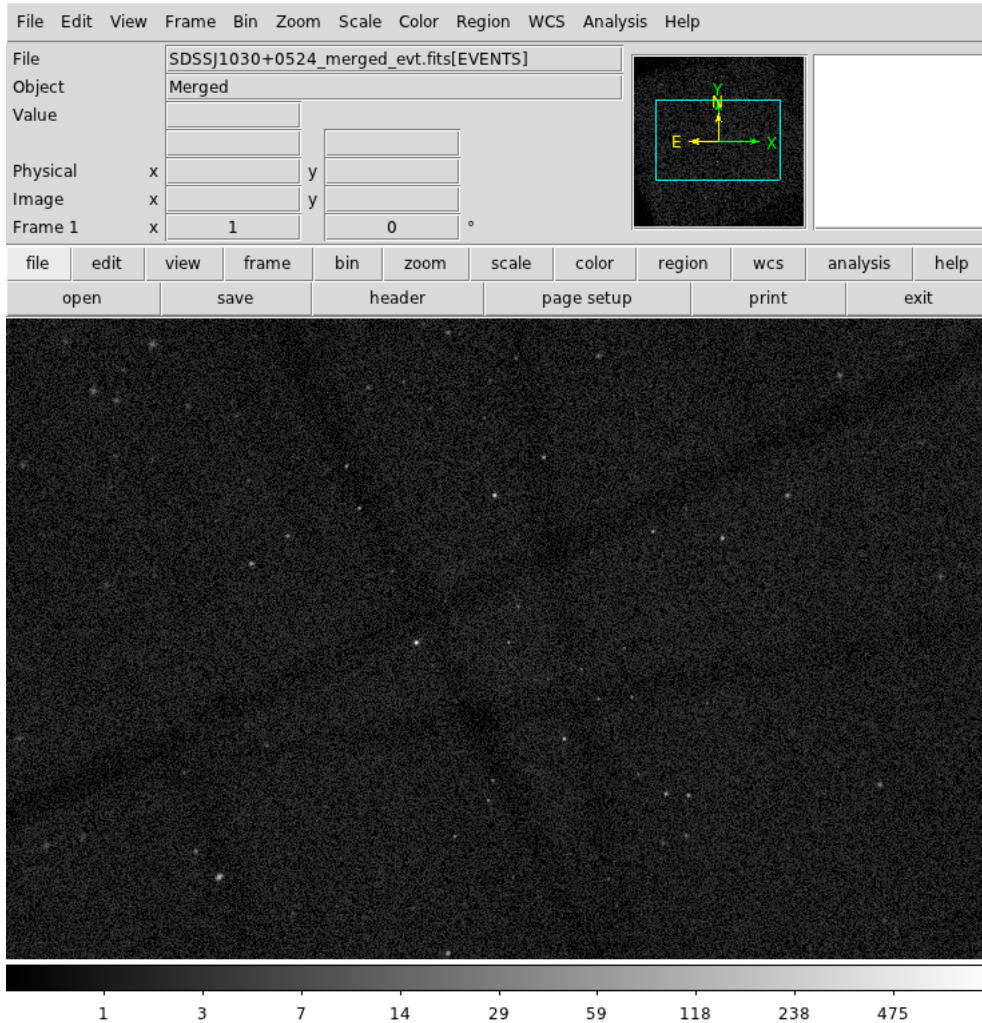
ds9 | Contours



- Apply
- Generate
- Clear
- Copy Contours
- Paste Contours...
- Load Contours...
- Save Contours...
- Load Contour Levels...
- Save Contour Levels...
- Convert to Polygons
- Close



ds9 | Analysis Menu



ds9 | Catalog

File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help

File: acisf03750N003_evt2.fits[EVENTS]
 Object: ROSETTE NEBULA / NGC 2244

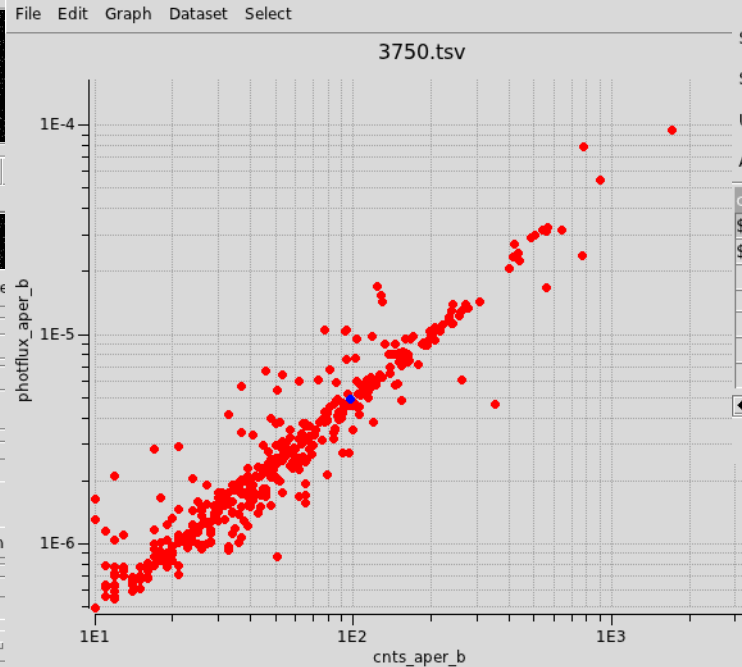
Physical Image Frame 1: x, y, x, y, x, y, x, y

File Edit View Frame Bin Zoom Scale Color
 open save header page setup

File Edit Catalog Server Name Selection
 Catalog Name: 3750.tsv
 Identification: tool
 Object Name: α , δ
 Radius: arcmin
 Table Filter: Sort: Max Rows: 5000 Found: 411
 α : ra δ : dec fk5

name	ra	dec	instrument	obsid	obi	region_id	m...
CXO J063120	97.83474	4.84090	ACIS	3750	0	495	u
CXO J063120	97.83684	4.83460	ACIS	3750	0	478	u
CXO J063121	97.84108	4.81201	ACIS	3750	0	496	u
CXO J063122	97.84565	4.82249	ACIS	3750	0	493	u
CXO J063123	97.84818	4.86180	ACIS	3750	0	387	u
CXO J063125	97.85515	4.94484	ACIS	3750	0	380	u
CXO J063125	97.85617	4.82539	ACIS	3750	0	185	u
CXO J063125	97.85626	4.88125	ACIS	3750	0	472	u
CXO J063125	97.85751	4.97069	ACIS	3750	0	154	u
CXO J063126	97.86073	4.98583	ACIS	3750	0	358	u
CXO J063127	97.86445	4.89609	ACIS	3750	0	344	u
CXO J063127	97.86481	4.86460	ACIS	3750	0	506	u
CXO J063127	97.86519	4.90085	ACIS	3750	0	228	u
CXO J063128	97.86843	4.91401	ACIS	3750	0	238	u
CXO J063128	97.87008	4.87038	ACIS	3750	0	333	u

Status Done
 Retrieve Cancel Filter Clear SAMP Plot Close



File Edit

If: $\$ks_prob_b > 0.9$ Edit

Then

Shape: circle point

Color: green

Width: 1

Font: helvetica

Text: \$name Edit

Size/Radius: Edit

Size/Radius 2: Edit

Units: physical

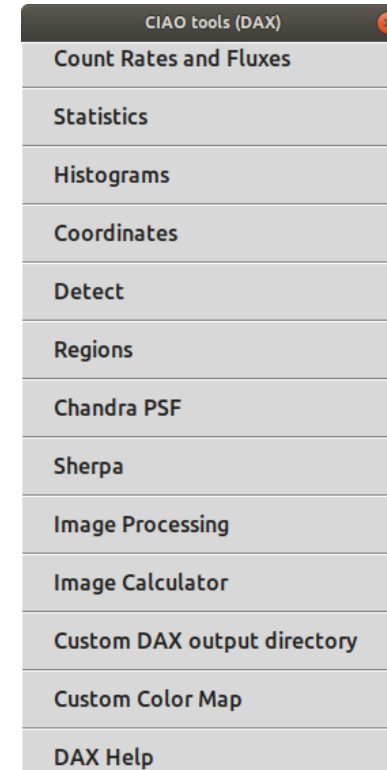
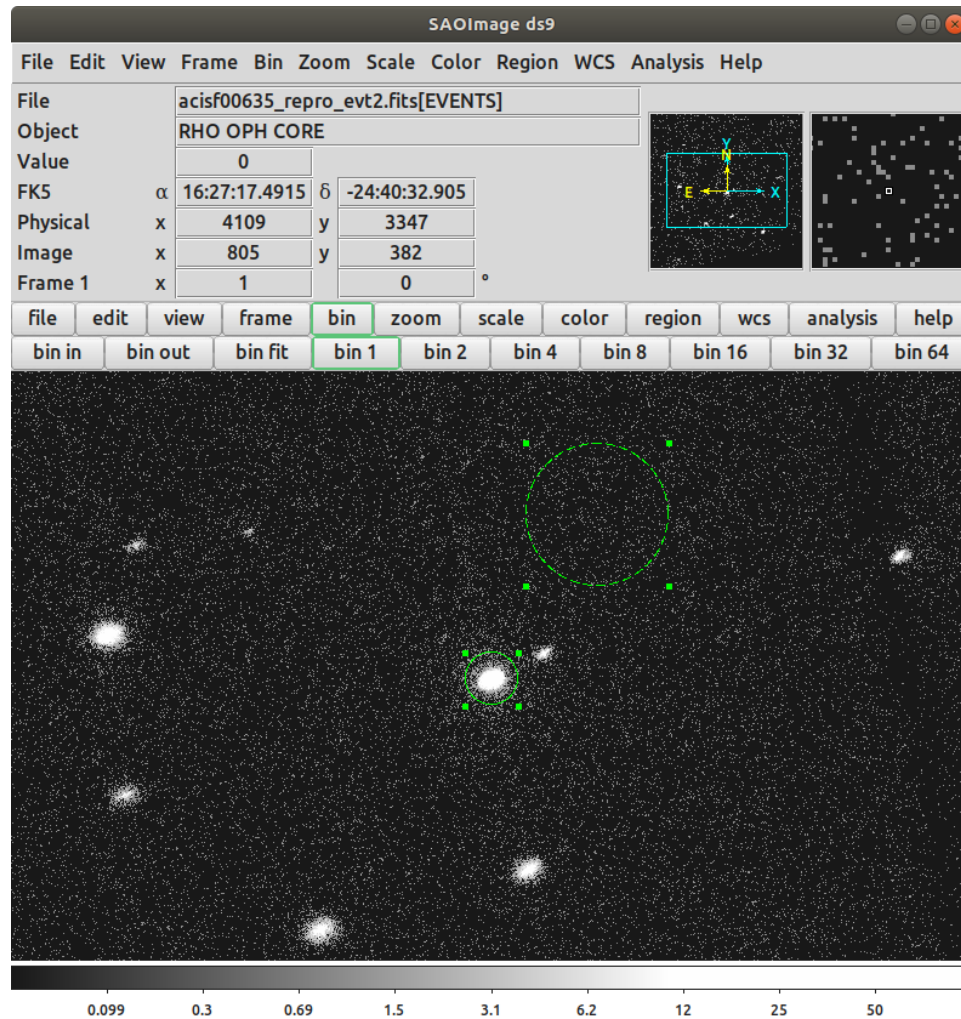
Angle: Edit

condition	shape	color	width	dash	font	font size
$\$ks_prob_b > 0.9$	circle point	green	1	0	helvetica	10
$\$ks_prob_b \leq 0.9$	box point	yellow	1	0	helvetica	10

Apply Add Delete Close help

none region cross colorbar pan zoom rotate crop cat exam

dax | Introduction



dax | Statistics

```
File Edit Font
#==== 2018-12-28 12:08:57 =====
#File: acisf00635_repro_evt2.fits[EVENTS]

#Background subtracted data

#COMPONENT    NET_COUNTS    NET_ERR    NET_RATE    CEL_AREA    CEL_BRI    CEL_BRI_ERR
#              count          count      count/s     arcsec**2   count/arcsec**2 count/arcsec**2
1              22893         151.304    0.227383    1539.94     14.8661    0.0982531

#source region(s):
#circle(3814,3466,45)

#COMPONENT    COUNTS        COUNT_RATE    AREA
#              count          count/s       pixel**2
1              22893         0.227383     6361.73
```

```
File Edit Font
Adding net rates to output
Appending flux results onto output
Appending photflux results onto output
Computing Net fluxes
Adding model fluxes to output
Scaling model flux confidence limits

Summary of source fluxes

Position                                0.5 - 7.0 keV
Value          90% Conf Interval
#0001|16 27 28.02 -24 39 33.6 Rate      0.209 c/s (0.206,0.211)
Flux           5.15E-12 erg/cm2/s (5.09E-12,5.21E-12)
Mod.Flux       2.06E-12 erg/cm2/s (2.04E-12,2.09E-12)
Unabs Mod.Flux 2.54E-12 erg/cm2/s (2.51E-12,2.57E-12)

Output files are located in /tmp/ds9aper.kjg/4162/
```

```
File Edit Font

#source region(s):
#circle(3814,3466,45)

#COMPONENT    COUNTS        COUNT_RATE    AREA
#              count          count/s       pixel**2
1              22893         0.227383     6361.73

#==== 2018-12-28 12:09:14 =====
#File: acisf00635_repro_evt2.fits[EVENTS]

#Background subtracted data

#COMPONENT    NET_COUNTS    NET_ERR    NET_RATE    CEL_AREA    CEL_BRI    CEL_BRI_ERR    BGREG_COUNTS    BGREG_ERR
#              count          count      count/s     arcsec**2   count/arcsec**2 count/arcsec**2 count          count
1              22457.3       151.759    0.223055    1539.94     14.5832    0.0985485     435.691         11.7412

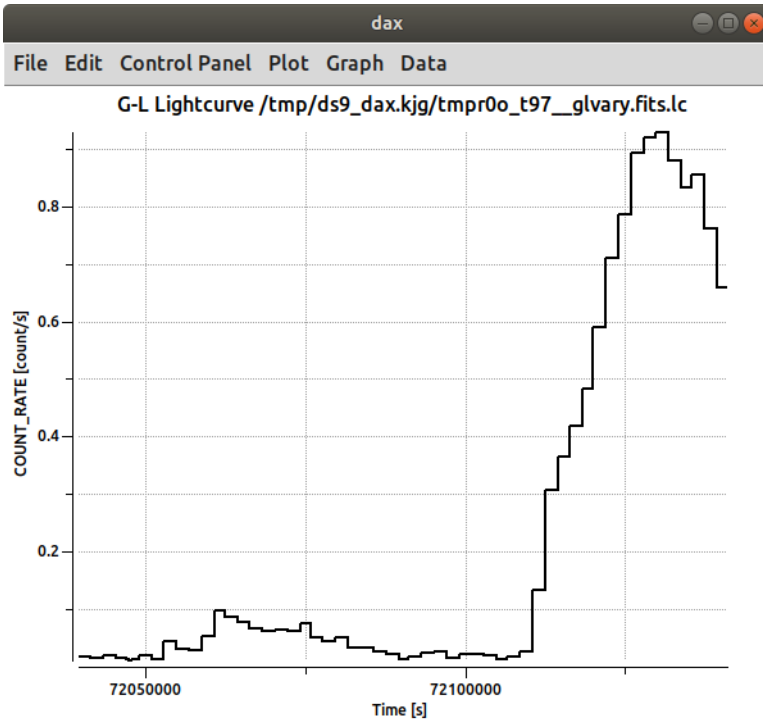
#source region(s):
#circle(3814,3466,45)

#COMPONENT    COUNTS        COUNT_RATE    AREA
#              count          count/s       pixel**2
1              22893         0.227383     6361.73

#background region(s):
#circle(3878,3742,80)

#BG_COUNTS    BG_RATE    BG_AREA
#count        count/s    pixel**2
1377          0.0136769 20106.2
```

dax | Histograms



The screenshot shows a window titled "Gregory-Loredo Lightcurve" with a menu bar containing "File", "Edit", and "Font". The window displays the following parameters:

```
Required parameters:
  infile = acisf00635_repro_evt2.fits[EVENTS][(x,y)=circle(3816.9653
  outfile = /tmp/ds9_dax.kjg/tmp00_t97_glvary.fits Output: probabi
  lcfile = /tmp/ds9_dax.kjg/tmp00_t97_glvary.fits.lc Output: resu
  efffile = Input file efficiency factors

Optional parameters:
  probfile = NONE Input probability file for background
  frac = 1.0 Fraction of events to be included in sub
  seed = 1 Seed for random subsample selection
  mmax = None Maximum number of model bins
  mmin = None Minimum number of model bins
  nbin = 0 Number of bins to use in light curve
  mintime = 50 Range of binnings, maximum resolution in
  clobber = True Overwrite output files if they exist?
  verbose = 0 Tool chatter level

Output file: /tmp/ds9_dax.kjg/tmp00_t97_glvary.fits
```

dax | Sherpa

DAX Sherpa Model Editor

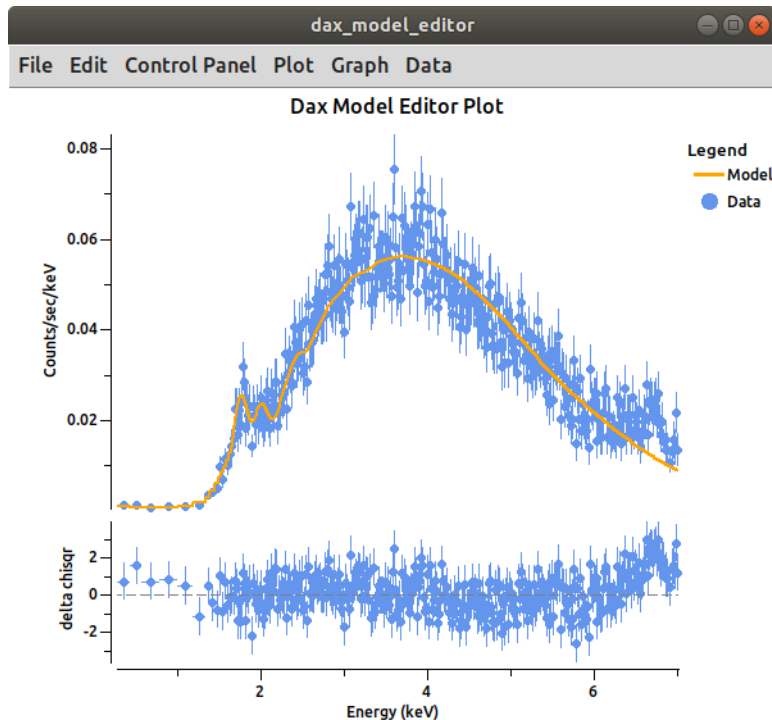
powlaw1d.mdl1

Parameter	Value	Frozen?	Min	Max	Units
gamma	1	<input type="checkbox"/>	-10	10	
ref	1	<input checked="" type="checkbox"/>	-3.4028e+38	3.4028e+38	
ampl	2.8727e-06	<input type="checkbox"/>	2.8727e-09	0.0028727	

xswabs.abs1

Parameter	Value	Frozen?	Min	Max	Units
nH	0.1399	<input type="checkbox"/>	0	1e+05	10 ²² atoms / cm ²

Fit Exit Plot Reset Cancel



Spectral Fit

File Edit Font

```

Method = levmar
Statistic = chi2gehrels
Initial fit statistic = 15168.5
Final fit statistic = 383.858 at function evaluation 100
Data points = 377
Degrees of freedom = 374
Probability [Q-value] = 0.351366
Reduced statistic = 1.02636
Change in statistic = 14784.6
  mdl1.gamma 1.41932 +/- 0.0550164
  mdl1.ampl 0.00162575 +/- 0.000143771
  abs1.nH 5.03945 +/- 0.137954
abs1.nH lower bound: -0.135506
abs1.nH upper bound: 0.139637
mdl1.gamma lower bound: -0.0558893
mdl1.gamma upper bound: 0.0565797
mdl1.ampl lower bound: -0.000139559
mdl1.ampl upper bound: 0.000153514
Dataset = 1
Confidence Method = confidence
Iterative Fit Method = None
Fitting Method = levmar
Statistic = chi2gehrels
confidence 1-sigma (68.2689%) bounds:
  Param Best-Fit Lower Bound Upper Bound
  -----
  mdl1.gamma 1.41932 -0.0558893 0.0565797
  mdl1.ampl 0.00162575 -0.000139559 0.000153514
  abs1.nH 5.03945 -0.135506 0.139637

(powlaw1d.mdl1 * xswabs.abs1)
  Param Type Value Min Max Units
  -----
  mdl1.gamma thawed 1.41932 -10 10
  mdl1.ref frozen 1 -3.40282e+38 3.40282e+38
  mdl1.ampl thawed 0.00162575 2.87273e-09 0.00287273
  abs1.nH thawed 5.03945 0 100000 10^22 atoms / cm^2

Photon Flux = 0.0009727712681029657 photon/cm^2/s
Energy Flux = 8.694503934719166e-12 ergs/cm^2/s

To restore session, start sherpa and type
restore('/tmp/ds9_dax.kjg/specfit/12be334b5557b2e6dfe258945083f52b/sav')
    
```

Summary

- **Some interesting topics not covered**
 - **Mosaics**
 - **SAMP**
 - **Masks**
 - **Composite and Template Regions**