

Sky Maps – FITS Format: X-Ray Binaries

- Goals:

- Introduce (again) my generation of sky maps & why
- Update the status of their generation
- Show results of Crab and Mrk 421 & 501
- Show preliminary status of XRB search

Sky Maps – FITS Format: X-Ray Binaries

•Introduction

- Generating full sky maps **to perform search for emission from X-Ray Binaries** (**microquasars**, or XRB)
- Several papers compare XRBs to “mini” AGN
- XRBCAT lists ~ 60 objects within Milagro's field of view
 - with compact companions: white dwarfs, pulsars, blackholes
- Known to be highly variable

Sky Maps – FITS Format: X-Ray Binaries

• Introduction (continued)

- Hourly sky maps from REC data
 - Starting on MJD 1775 (July 2000)
 - +/- 45° in DEC, full RA
 - Hour Angle (HA) $\leq 45^\circ$
 - NFit ≥ 20
 - X2 > 3.0
 - 0.2° pixels, 1800 x 450 pixels
 - Background computed using “**direct integration**”
 - 2 hour acceptance cycle HA x DEC
 - 23 second rate cycle
 - 3 MB files each for sky and background
 - compress down to 100KB and 800KB for sky & background

Sky Maps – FITS Format: X-Ray Binaries

- **Introduction** (continued)

- **Sky maps in FITS file format**

- **What is FITS?**

- Flexible Image Transport System
- Used throughout astronomical community for formatted image files.
- Compatible with many utilities produced and maintained by astronomical community (IRAF, fv, IDL, etc)
- Can contain informative text headers, data tables (ascii and binary) and image extensions.
- My programs use the cfitsio package:
(<http://heasarc.gsfc.nasa.gov/fitsio>)

Sky Maps – FITS Format: X-Ray Binaries

• Update:

- Software
 - Working on **SearchMaps** GUI program to perform:
 - searches from 1 hour to DC
 - combine sky maps into daily, weekly, etc.
 - generate sigma maps and distributions, event density plots, etc.
 - compute upper limits, fluxes, etc.
 - perform statistical checks on maps to check for systematics
 - Working on **DoPhase** GUI program to perform:
 - Orbital phase analysis (including solar system barycentering)
 - Pulsar phase analysis

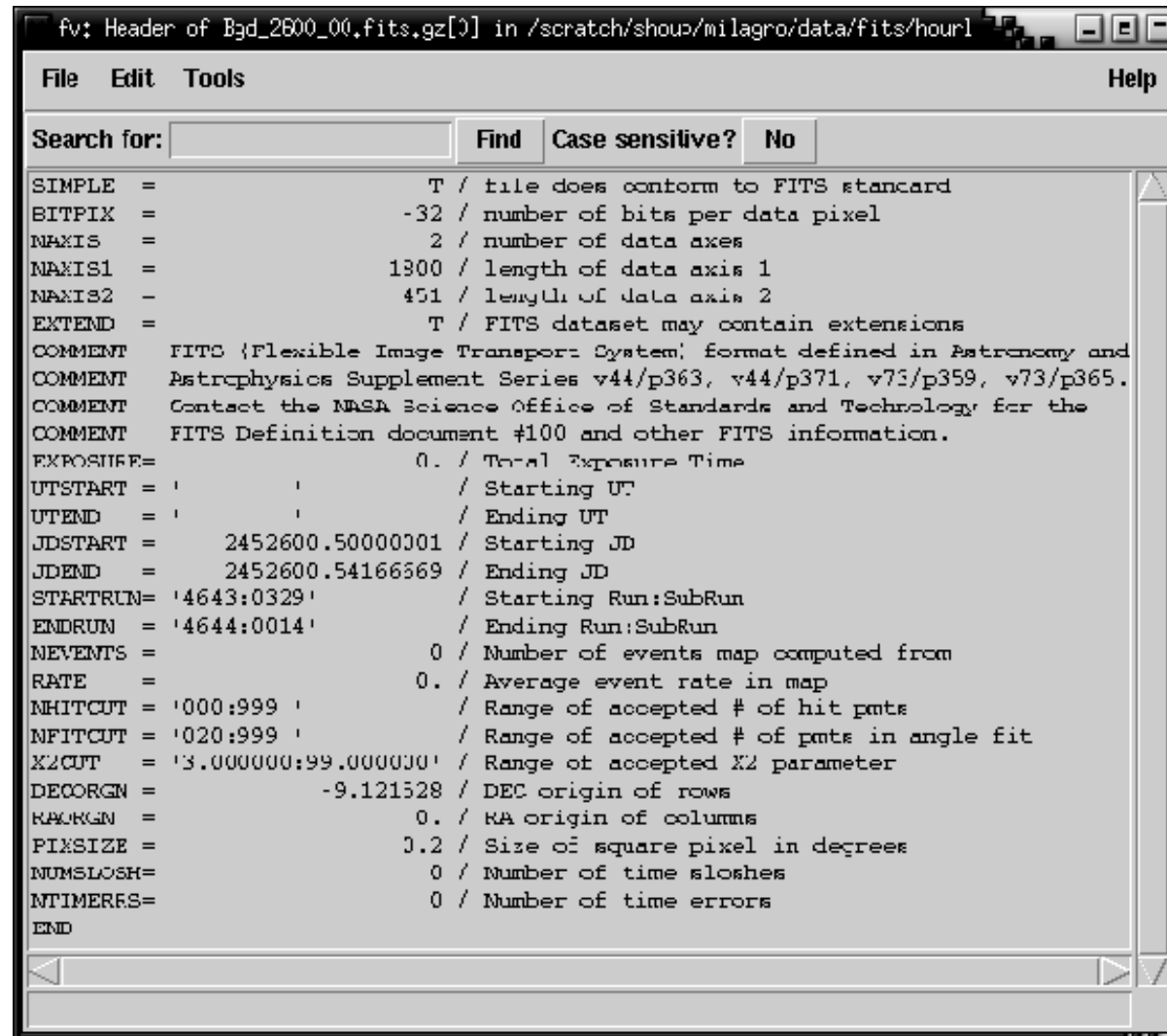
Sky Maps – FITS Format: X-Ray Binaries

• Update:

- Map generation
 - generated hourly maps from MJD 1775 to 2693
 - Combined these into daily maps
 - Example hourly maps:

Sky Maps – FITS Format: X-Ray Binaries

- FITS Header
 - using fv
 - Fits viewer

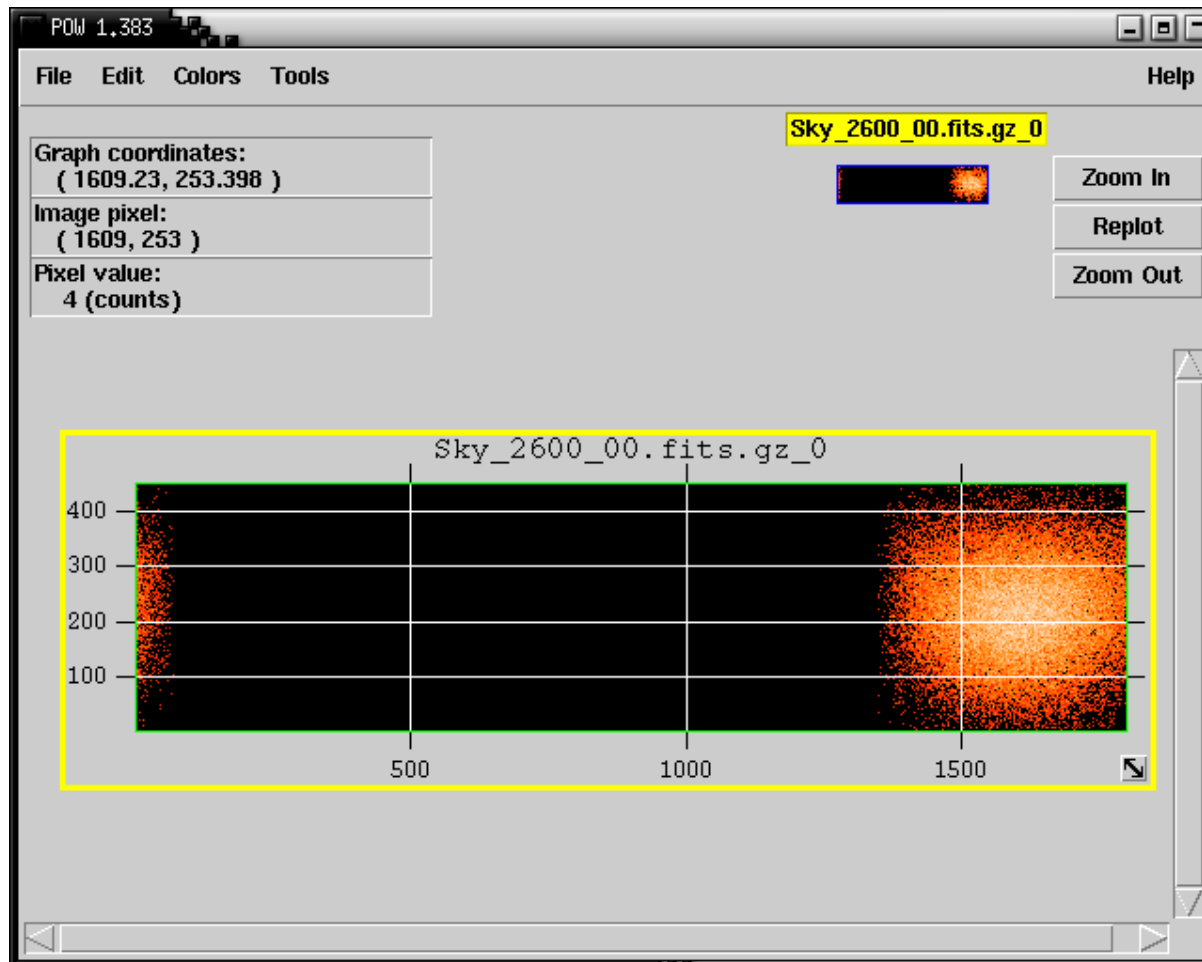


The screenshot shows a window titled "fv: Header of Bgd_2600_00.fits.gz[0] in /scratch/shoup/milagro/data/fits/hour1". The window has a menu bar with "File", "Edit", "Tools", and "Help". Below the menu bar is a search bar with "Search for:" and "Find" buttons, and a "Case sensitive?" checkbox set to "No". The main area displays the FITS header information in a monospaced font:

```
SIMPLE = T / file does conform to FITS standard
BITPIX = -32 / number of bits per data pixel
NAXIS = 2 / number of data axes
NAXIS1 = 1300 / length of data axis 1
NAXIS2 = 451 / length of data axis 2
EXTEND = T / FITS dataset may contain extensions
COMMENT FITS (Flexible Image Transport System) format defined in Astronomy and
COMMENT Astrophysics Supplement Series v44/p363, v44/p371, v75/p359, v73/p365.
COMMENT Contact the NASA Science Office of Standards and Technology for the
COMMENT FITS Definition document #100 and other FITS information.
EXPOSURE= 0. / Total Exposure Time
UTSTART = ' ' / Starting UT
UTEND = ' ' / Ending UT
JDSTART = 2452600.50000001 / Starting JD
JDEND = 2452600.54166569 / Ending JD
STARTRUN= '4643:0329' / Starting Run:SubRun
ENDRUN = '4644:0014' / Ending Run:SubRun
NEVENTS = 0 / Number of events map computed from
RATE = 0. / Average event rate in map
NHITCUT = '000:999 ' / Range of accepted # of hit pnts
NFITCUT = '020:999 ' / Range of accepted # of pnts in angle fit
X2CUT = '3.000000:99.000000' / Range of accepted X2 parameter
DECORGN = -9.121528 / DEC origin of rows
RAORGN = 0. / RA origin of columns
PIXSIZE = 3.2 / Size of square pixel in degrees
NUMSLOSH= 0 / Number of time slashes
NTIMERS= 0 / Number of time errors
END
```

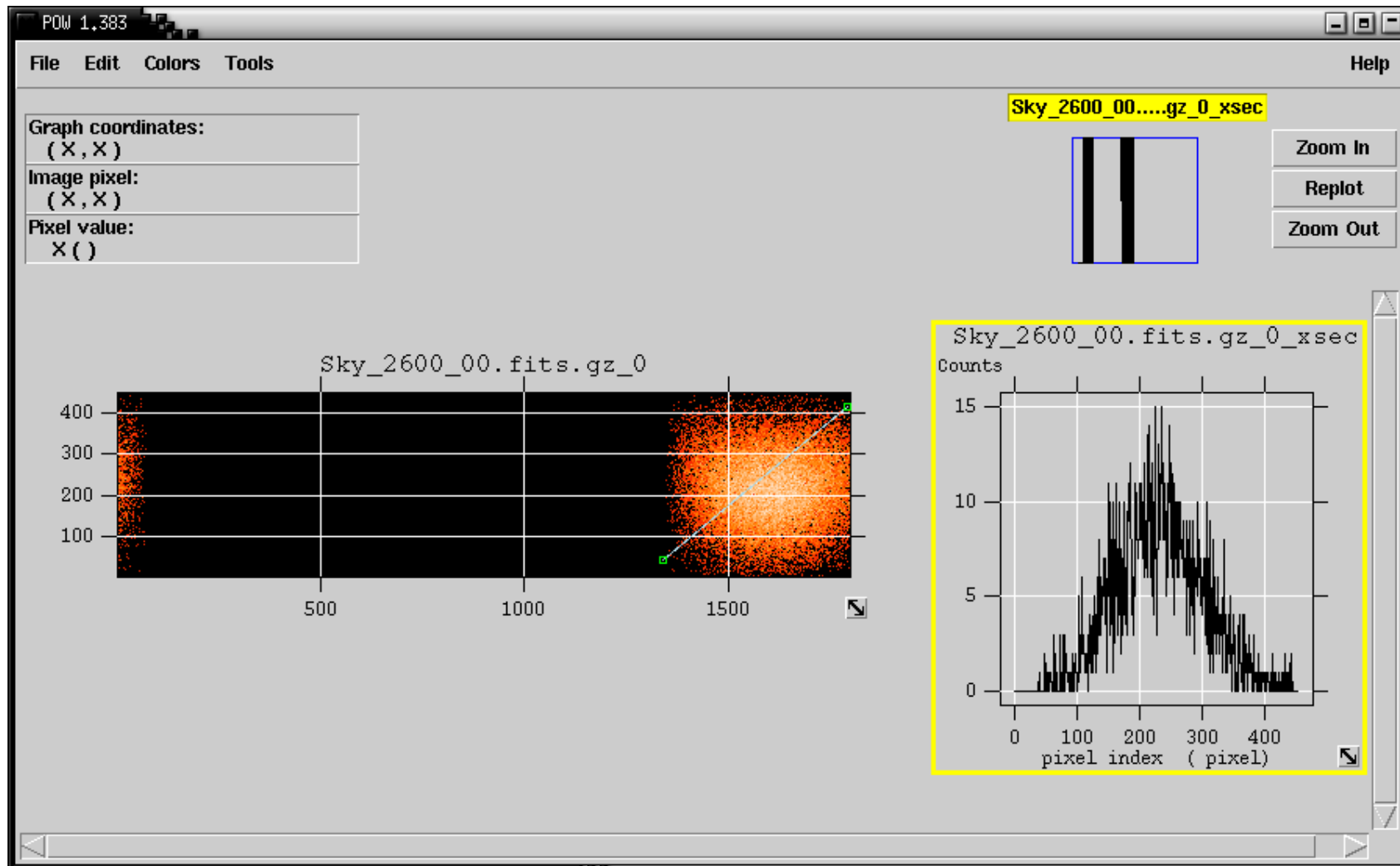
Sky Maps – FITS Format: X-Ray Binaries

- FITS Image (hourly map):



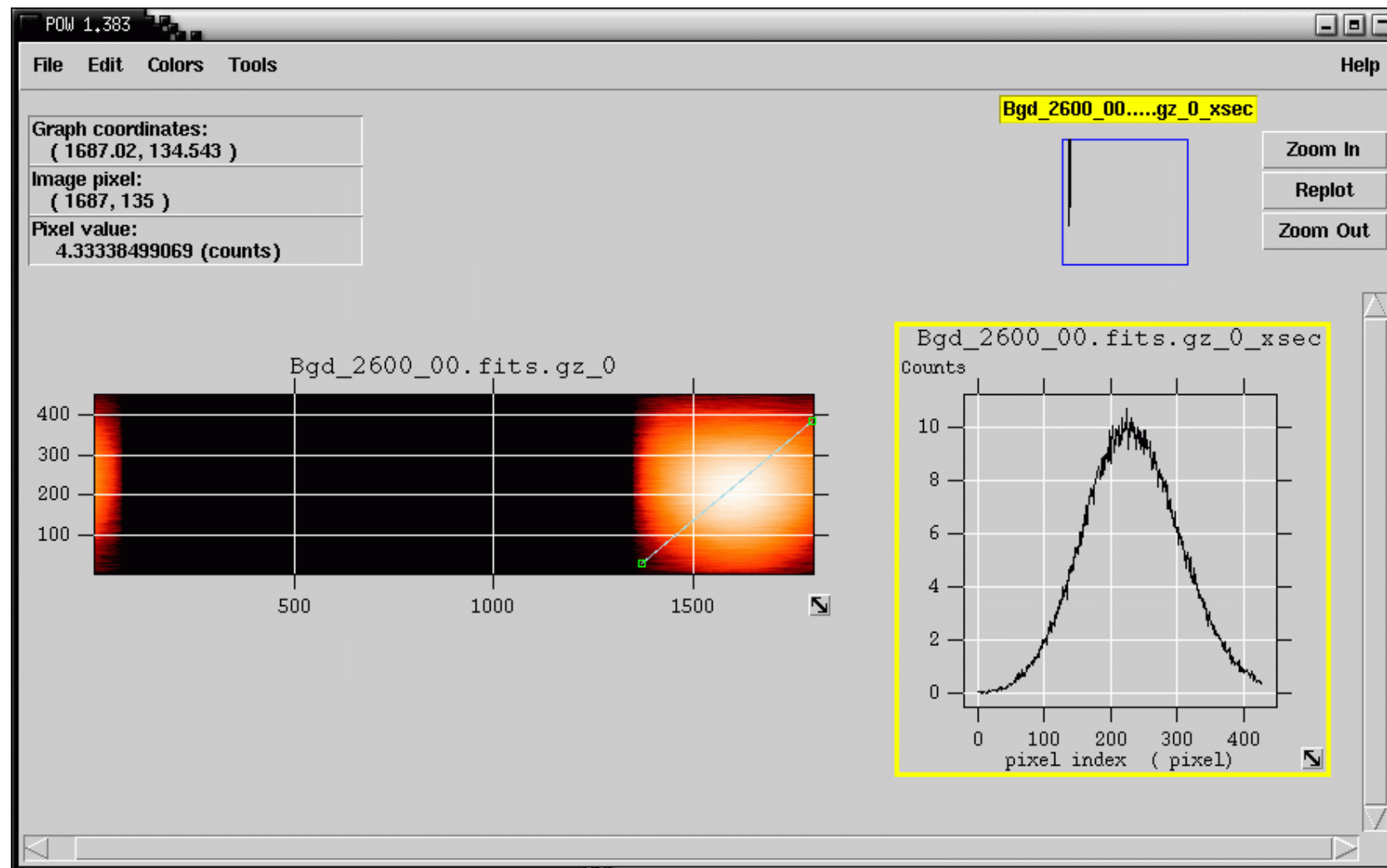
Sky Maps – FITS Format: X-Ray Binaries

- Probing FITS Image (hourly map):



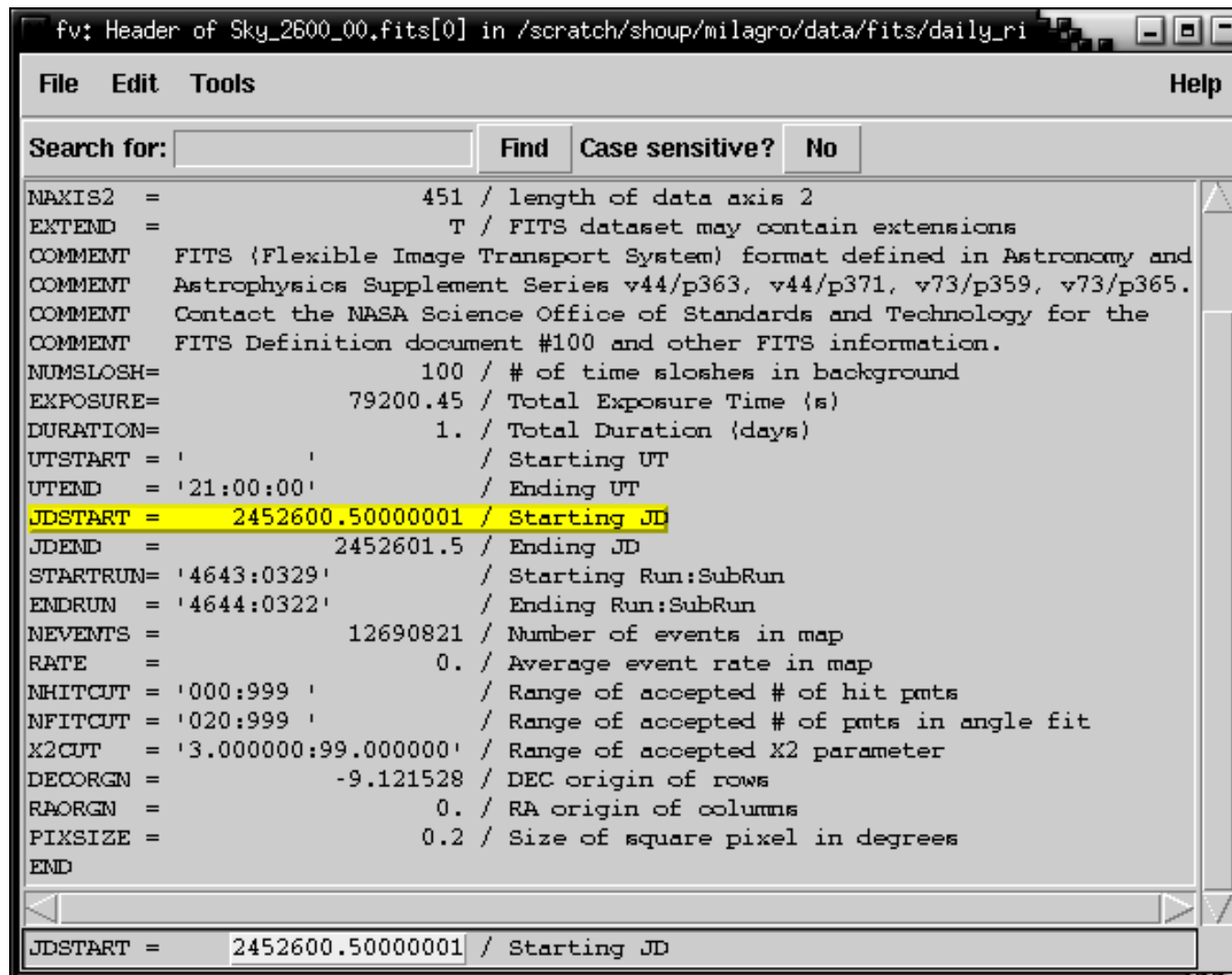
Sky Maps – FITS Format: X-Ray Binaries

- Background FITS Image (hourly map):



Sky Maps – FITS Format: X-Ray Binaries

- FITS Header (daily map):

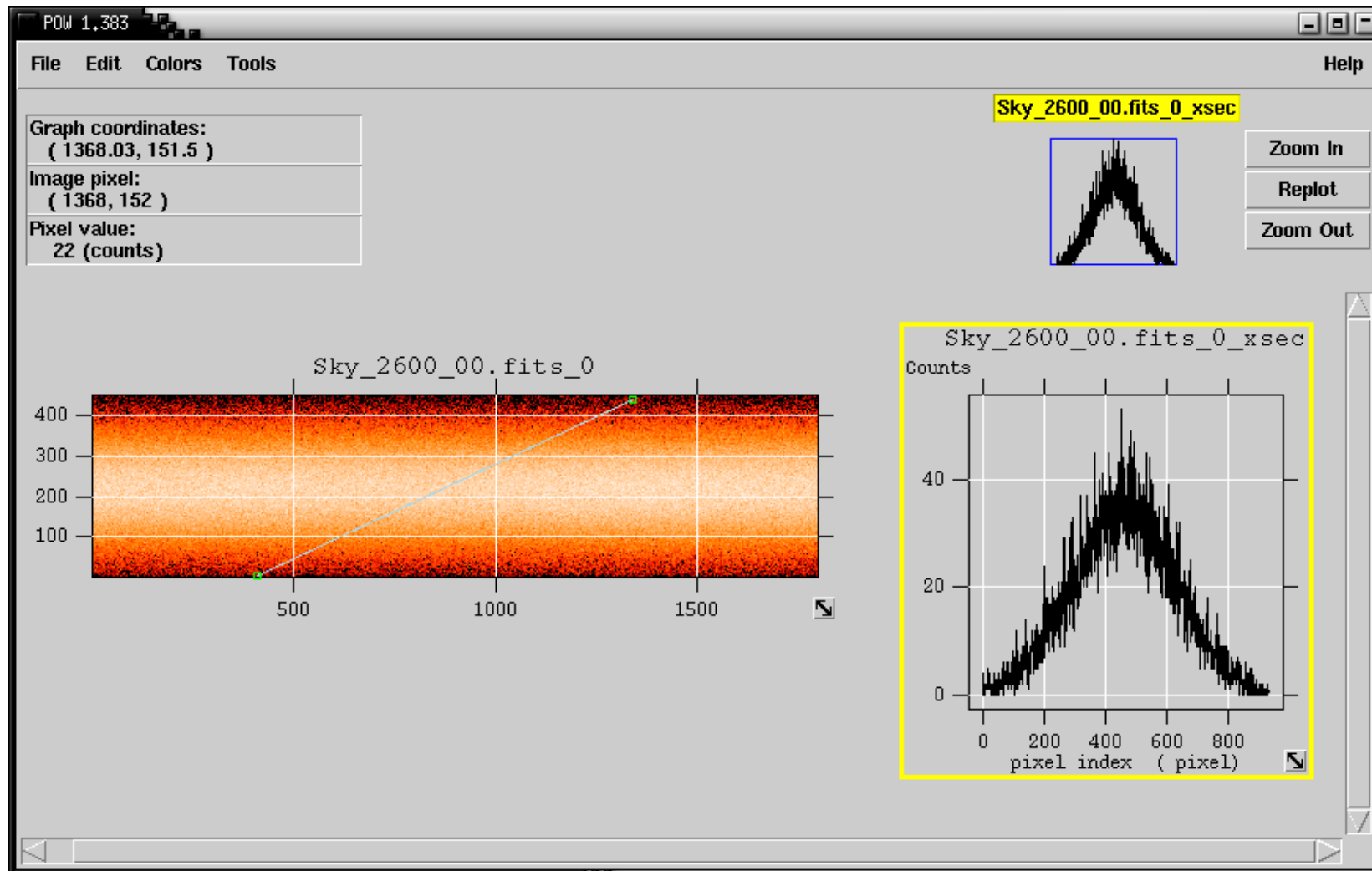


The image shows a screenshot of a text editor window displaying the header of a FITS file. The window title is "fv: Header of Sky_2600_00.fits[0] in /scratch/shoup/milagro/data/fits/daily_ri". The editor has a menu bar with "File", "Edit", "Tools", and "Help". Below the menu bar is a search bar with "Search for:" and buttons for "Find", "Case sensitive?", and "No". The main text area contains the FITS header information, which is a list of parameters and their values. The line "JDSTART = 2452600.50000001 / Starting JD" is highlighted in yellow. The header ends with "END".

```
fv: Header of Sky_2600_00.fits[0] in /scratch/shoup/milagro/data/fits/daily_ri
File Edit Tools Help
Search for: Find Case sensitive? No
NAXIS2 = 451 / length of data axis 2
EXTEND = T / FITS dataset may contain extensions
COMMENT FITS (Flexible Image Transport System) format defined in Astronomy and
COMMENT Astrophysics Supplement Series v44/p363, v44/p371, v73/p359, v73/p365.
COMMENT Contact the NASA Science Office of Standards and Technology for the
COMMENT FITS Definition document #100 and other FITS information.
NUMSLOSH= 100 / # of time slashes in background
EXPOSURE= 79200.45 / Total Exposure Time (s)
DURATION= 1. / Total Duration (days)
UTSTART = ' ' / Starting UT
UTEND = '21:00:00' / Ending UT
JDSTART = 2452600.50000001 / Starting JD
JDEND = 2452601.5 / Ending JD
STARTRUN= '4643:0329' / Starting Run:SubRun
ENDRUN = '4644:0322' / Ending Run:SubRun
NEVENTS = 12690821 / Number of events in map
RATE = 0. / Average event rate in map
NHITCUT = '000:999 ' / Range of accepted # of hit pmts
NFITCUT = '020:999 ' / Range of accepted # of pmts in angle fit
K2CUT = '3.000000:99.000000' / Range of accepted K2 parameter
DECORGN = -9.121528 / DEC origin of rows
RAORGN = 0. / RA origin of columns
PIXSIZE = 0.2 / Size of square pixel in degrees
END
JDSTART = 2452600.50000001 / Starting JD
```

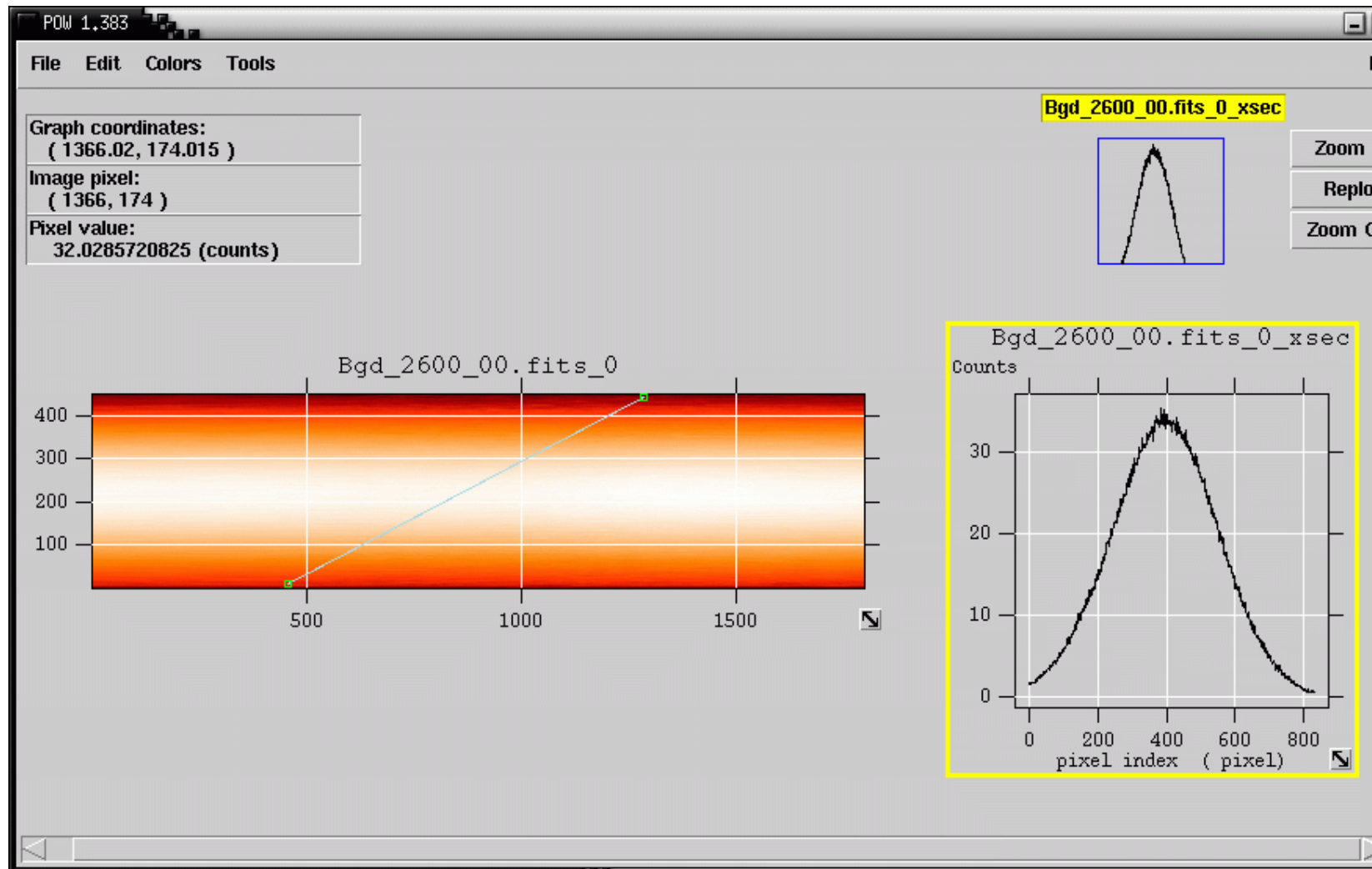
Sky Maps – FITS Format: X-Ray Binaries

- FITS Image (daily map):



Sky Maps – FITS Format: X-Ray Binaries

- Background FITS Image (daily map):



Sky Maps – FITS Format: X-Ray Binaries

- **Crab results from these sky maps:**

- MJD 1775 to 2693 (minus about 60 days, MJD 2060-2099, 2280-2299)
- 1111196 events on source 1105970 events off source
- Diff: 5226, **4.94 sigma**
- Sigma map:

Sky Maps – FITS Format: X-Ray Binaries

- **Mrk 421 results from these sky maps:**

- MJD 1775 to 2693 (minus about 60 days, MJD 2060-2099, 2280-2299)
- 1587547 events on source 1583850 events off source
- Diff: 3697, **2.9 sigma**
- Sigma map:

Sky Maps – FITS Format: X-Ray Binaries

- Preliminary results on XRBs

