Fermi Data Analysis

Gamma Ray Burst

Fermi
Gamma-ray
Space Telescope

What are we going to do?

Analyze two different GRB:

Torino

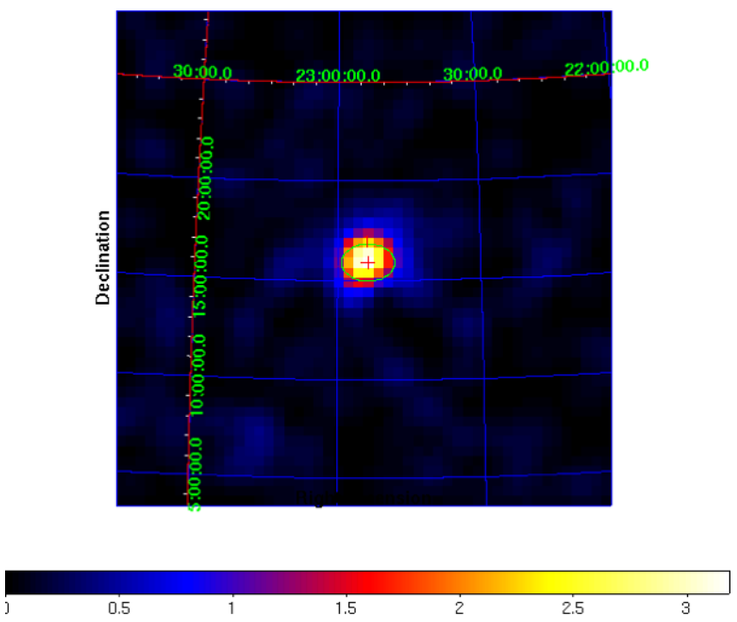
Equatorial coordinates (degrees)	(353.401,-66.3239)
Time range (MET)	(270777602,278726401)
Time range (Gregorian)	(2009-08-01 00:00:00,2009-10-31 23:59:59)
Energy range (MeV)	(50,500000)
Search radius (degrees)	60

GRB090510

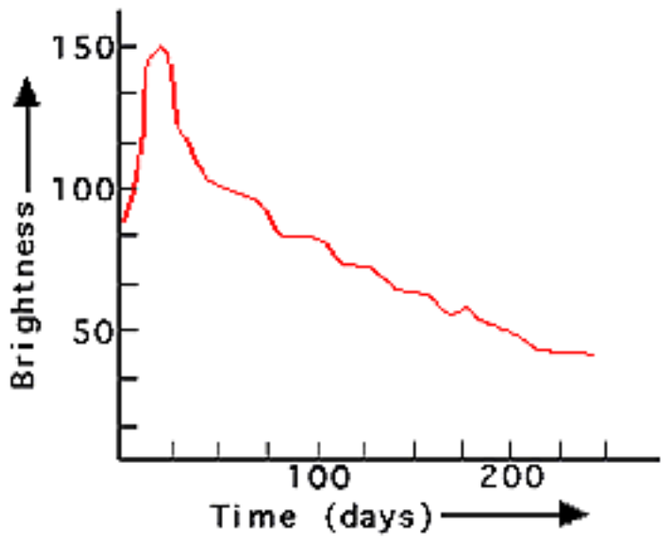
Equatorial coordinates (degrees)	(333.553,-26.5975)
Time range (MET)	(263433602,263779201)
Time range (Gregorian)	(2009-05-08 00:00:00,2009-05-11 23:59:59)
Energy range (MeV)	(50,500000)
Search radius (degrees)	30

by producing...

1) counts map



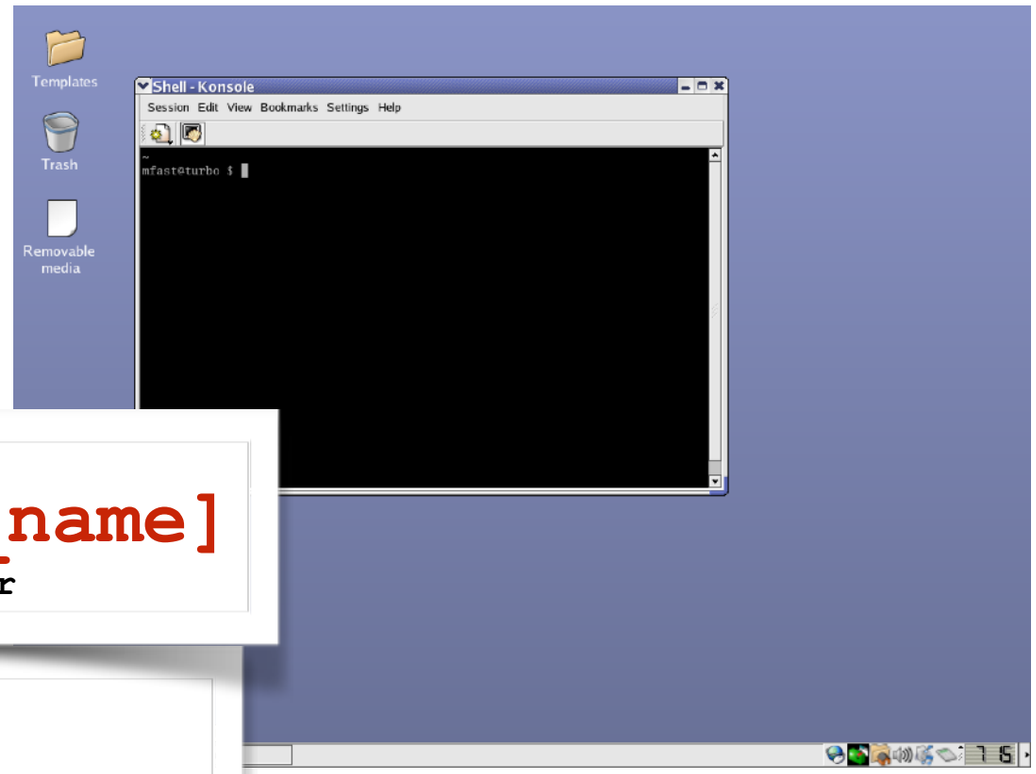
2) light curve



First of all, check your data!

Open a terminal

you are in your 'HOME'!



pwd
check the current path

mkdir [folder_name]
create a new folder

cd [folder]
go to another folder

ls
check the content of a folder

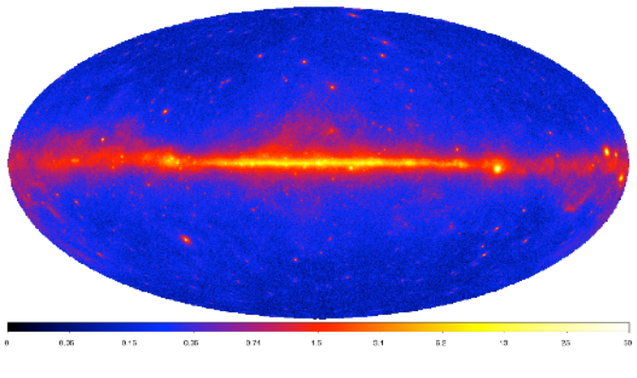
cp [path/files] [new_path/.]
copy files from a folder to another folder

```
$ pwd
$ ls
$ cd FERMI/data/
$ ls
```

What's the data format?

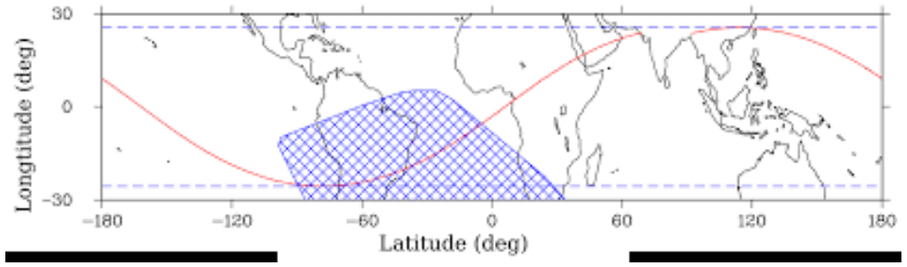
Torino_events.fits

recorded data



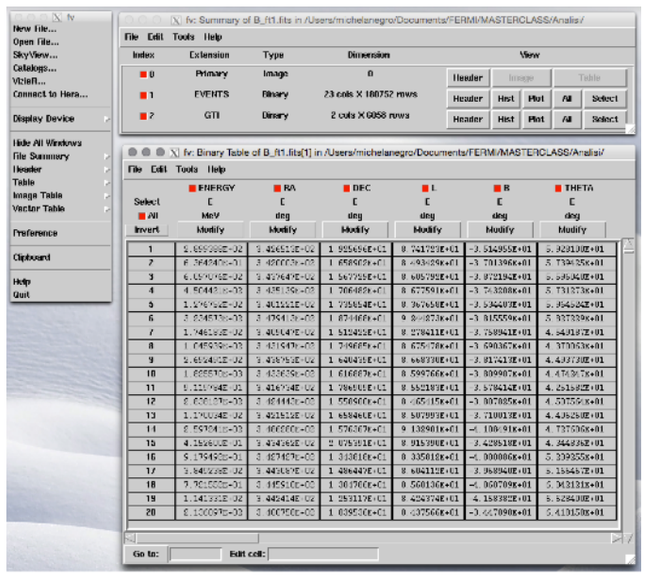
Torino_spacecraft.fits

spacecraft hystory

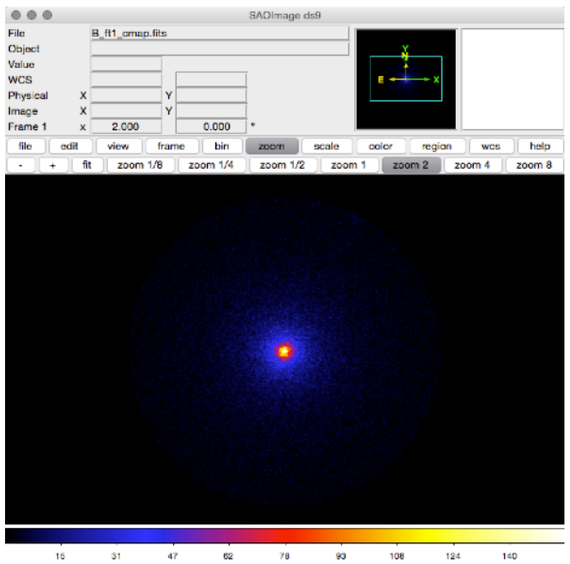


- fits files are tables of data
- can be opened by fv (fits view) or ds9

`fv ft1.fits`

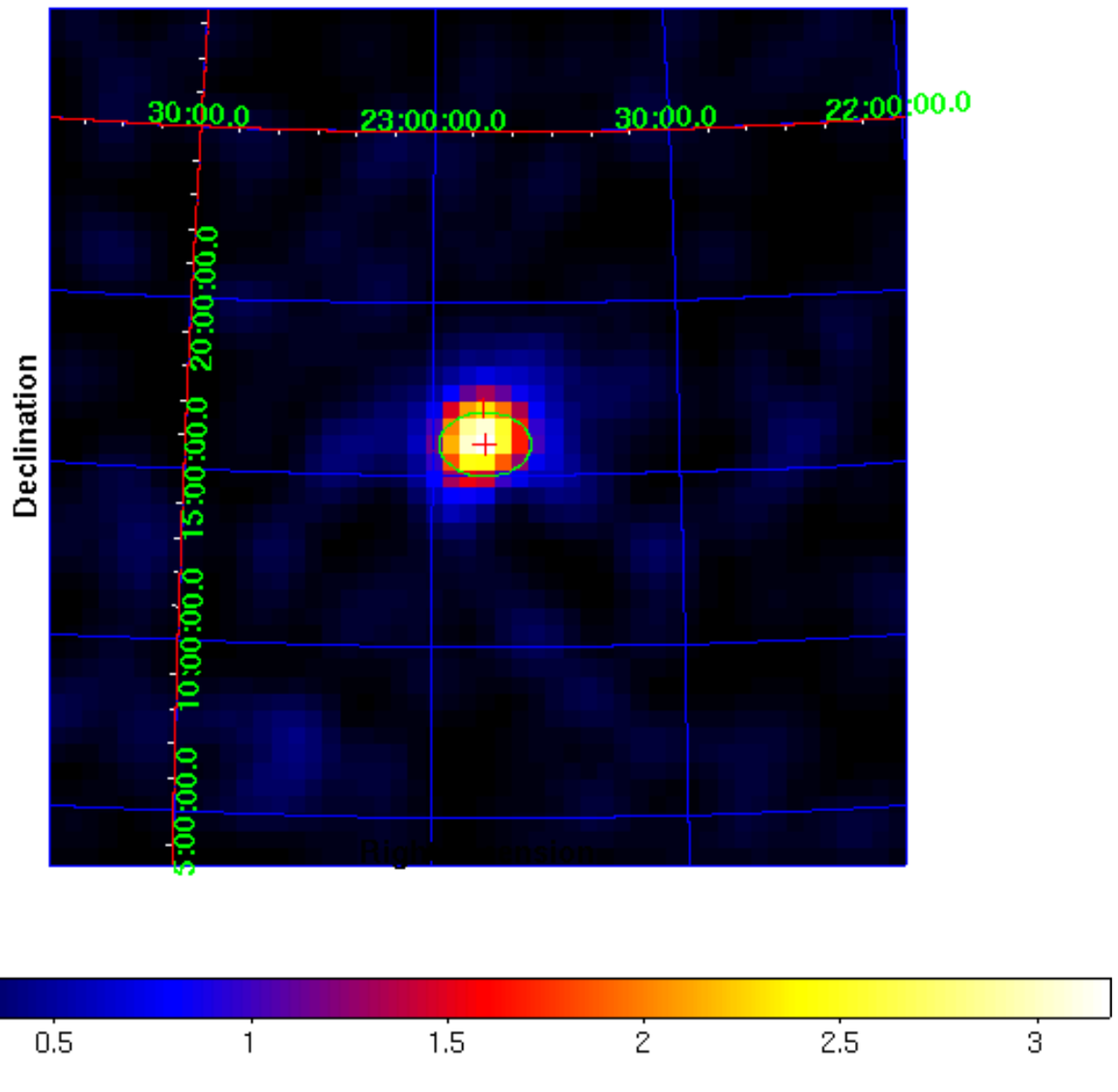


`ds9 ft1.fits`



TASK 1

GRB Counts Map



Select the desired events

gtselect

```
Input FT1 file[] Torino_events.fits
Output FT1 file[] #cmap_gtselect.fits
RA for new search center (degrees) (0:360) [] 353.401
Dec for new search center (degrees) (-90:90) [] -66.324
radius of new search region (degrees) (0:180) [INDEF]
start time (MET in s) (0:) [] #start_time
end time (MET in s) (0:) [] #end_time
lower energy limit (MeV) (0:) [] 50
upper energy limit (MeV) (0:) [] 500000
maximum zenith angle value (degrees) (0:180) [90] 100
Done.
```

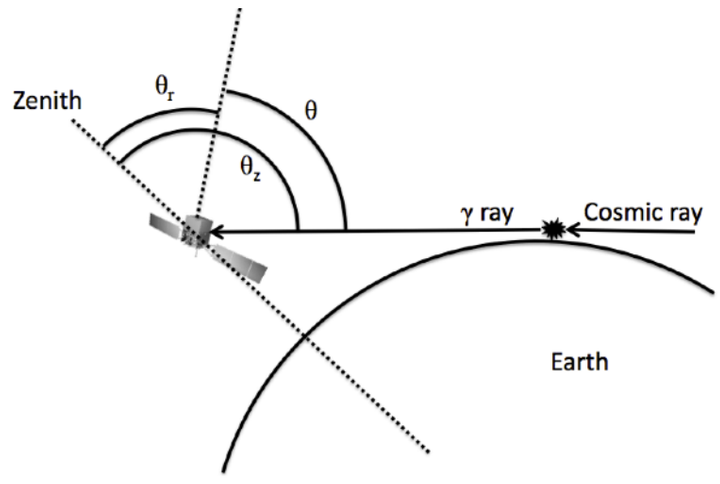
GRB coordinates

MET = Mission Elapsed Time

ls

a new file should have been appeared:

#cmap_gtselect.fits



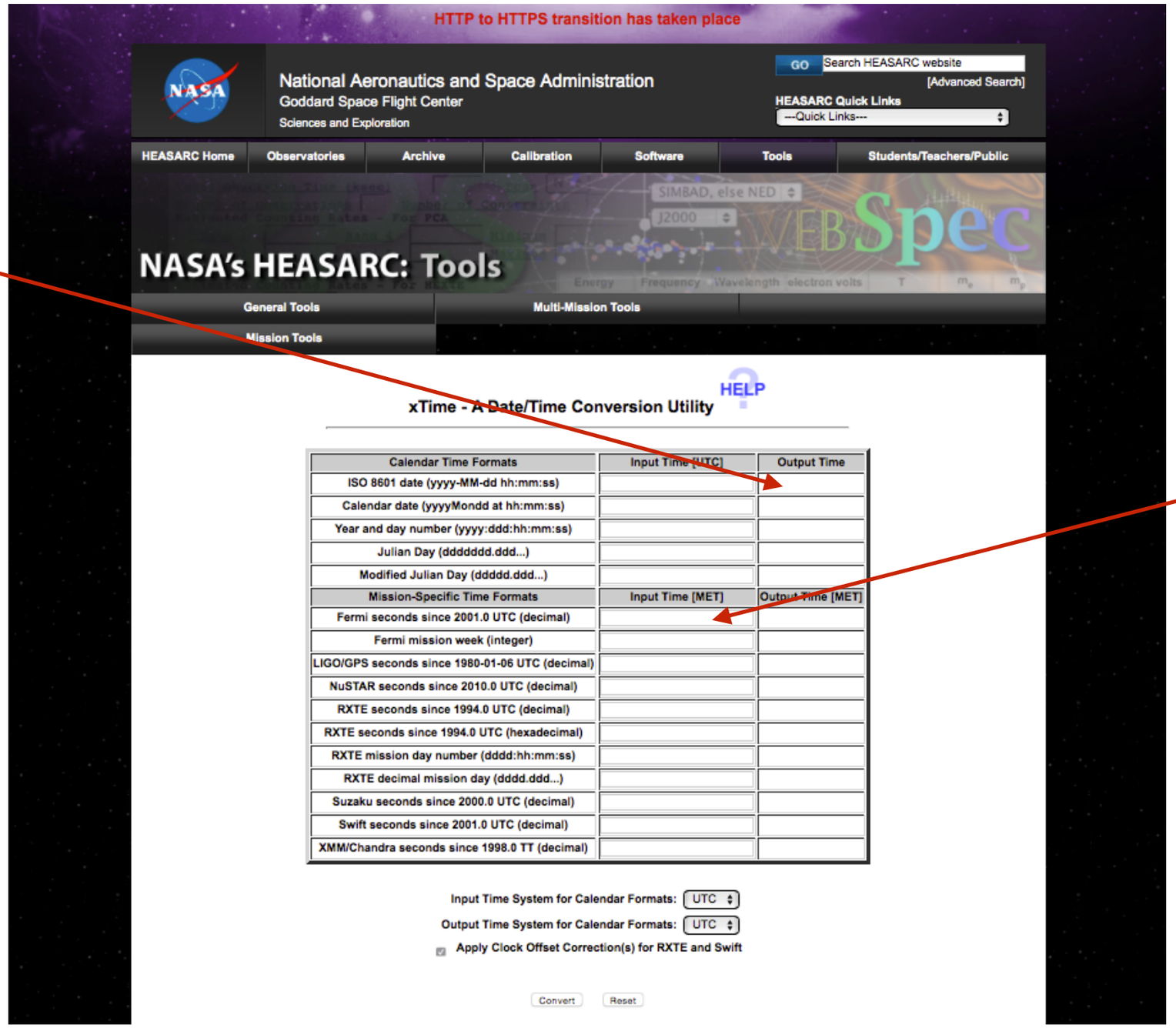
ATT: each of you will have a different time range!

Translate a MET into a date

https://heasarc.gsfc.nasa.gov/cgi-bin/Tools/xTime/xTime.pl

read your date here

put your MET here



Create the Counts Map

gtbin

```
This is gtbin version ScienceTools-v10r0p5-fssc-20150819
Type of output file (CCUBE|CMAP|LC|PHA1|PHA2|HEALPIX) [] CMAP
Event data file name[] #cmap_gtselect.fits
Output file name[] #cmap_gtbin.fits
Size of the X axis in pixels[] 240
Size of the Y axis in pixels[] 240
Image scale (in degrees/pixel)[] 0.5
Coordinate system (CEL - celestial, GAL -galactic) (CEL|GAL) [] CEL
First coordinate of image center in degrees (RA or galactic l)[] 353.401
Second coordinate of image center in degrees (DEC or galactic b)[]-66.324
Rotation angle of image axis, in degrees[0] 0
Projection method e.g. AIT|ARC|CAR|GLS|MER|NCP|SIN|STG|TAN:[] AIT
```

Counts Map

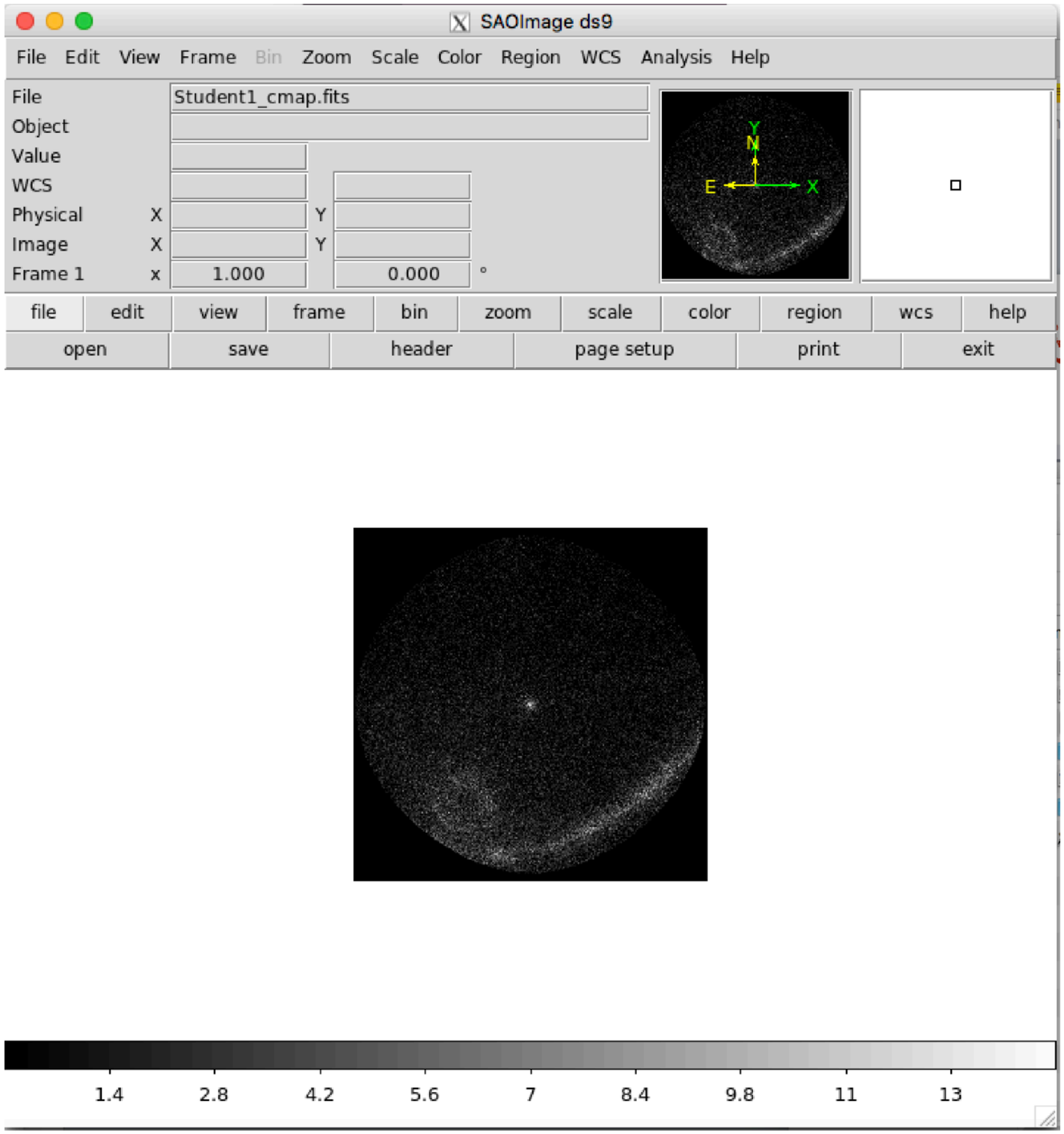
ls

a new file should have been appeared:

#cmap_gtbin.fits

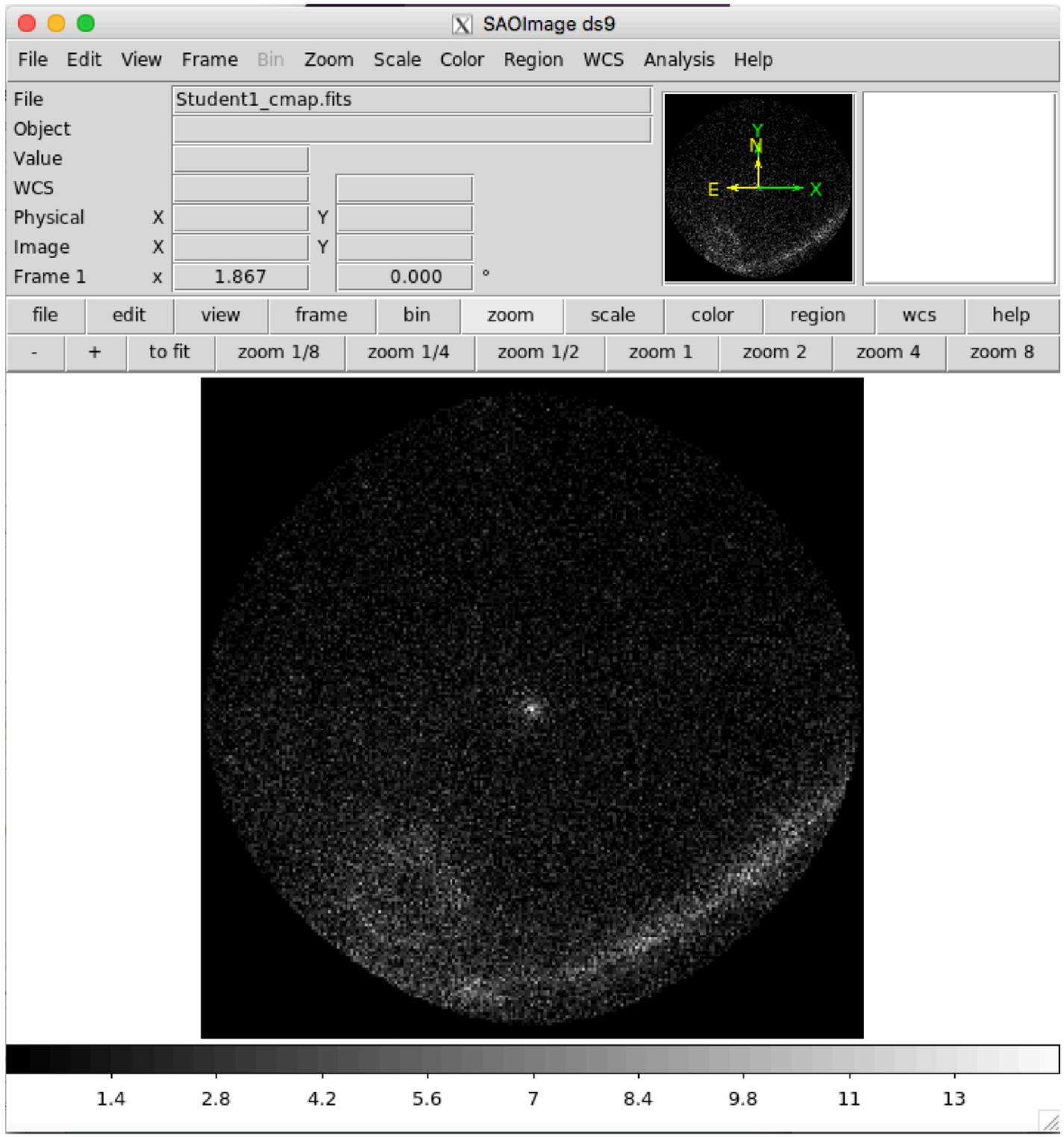
Let's take a look to the result!

ds9 #cmap_gtbin.fits &



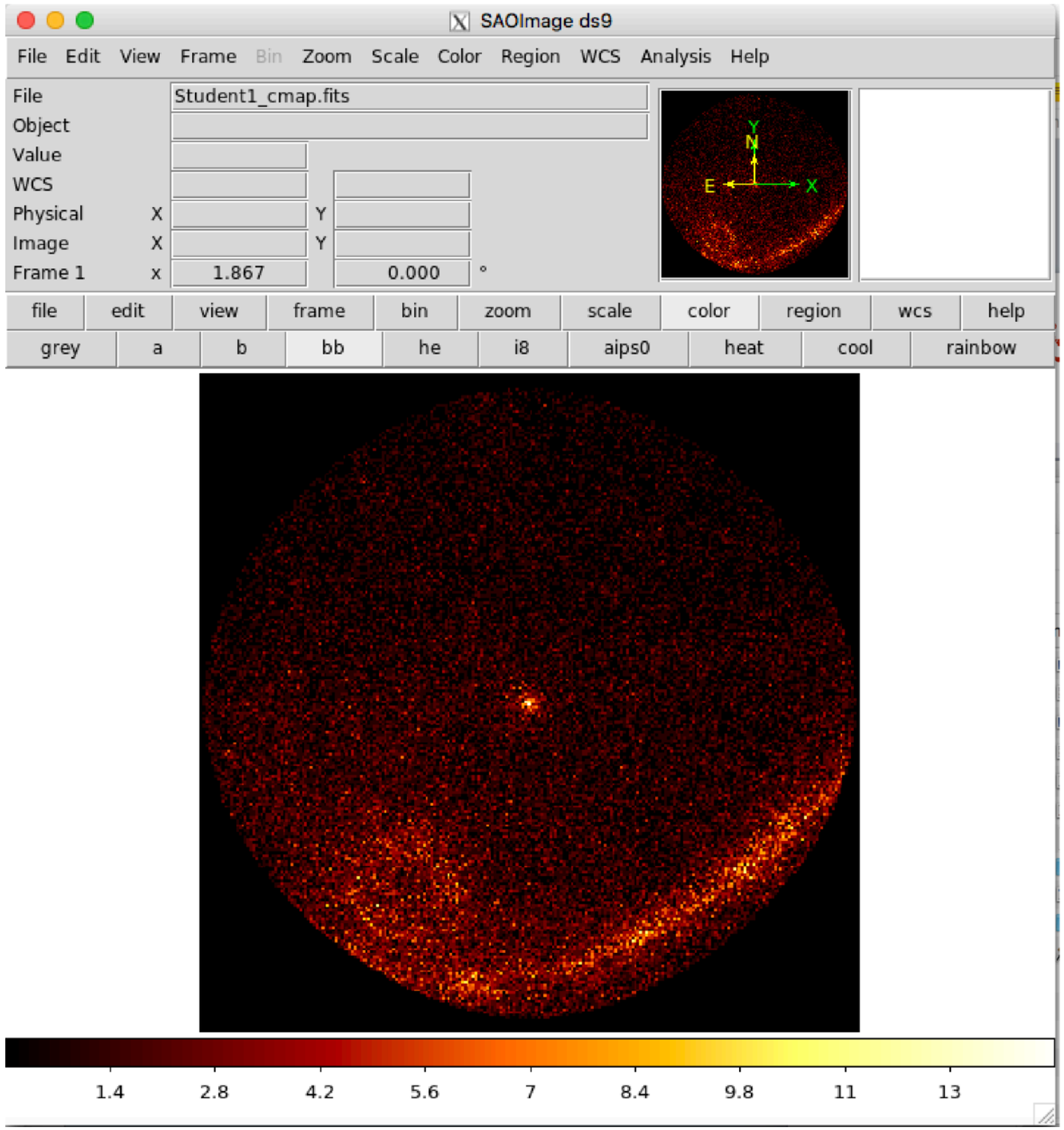
Let's take a look to the result!

ds9 #cmap_gtbin.fits &



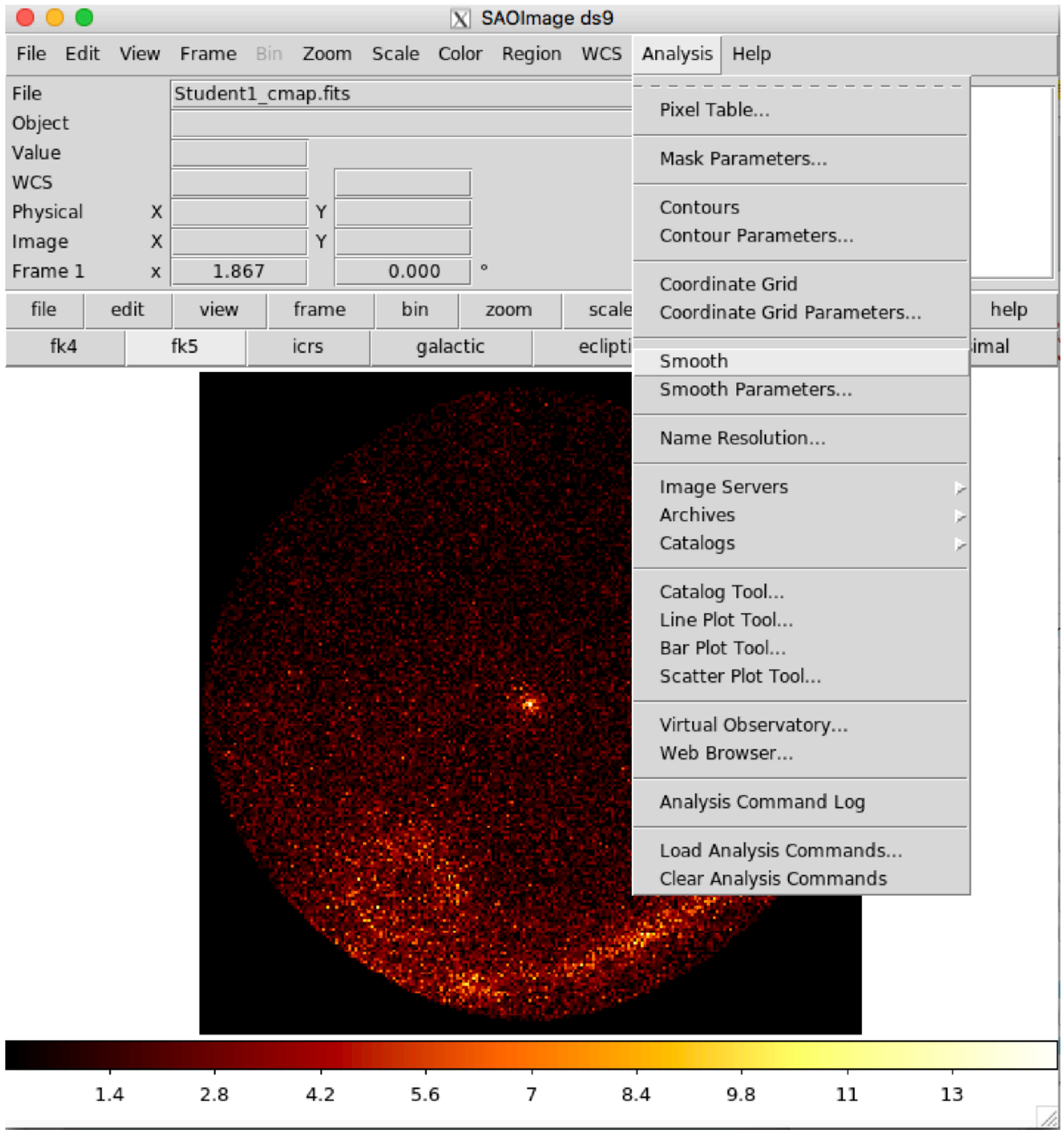
Let's take a look to the result!

ds9 #cmap_gtbin.fits &



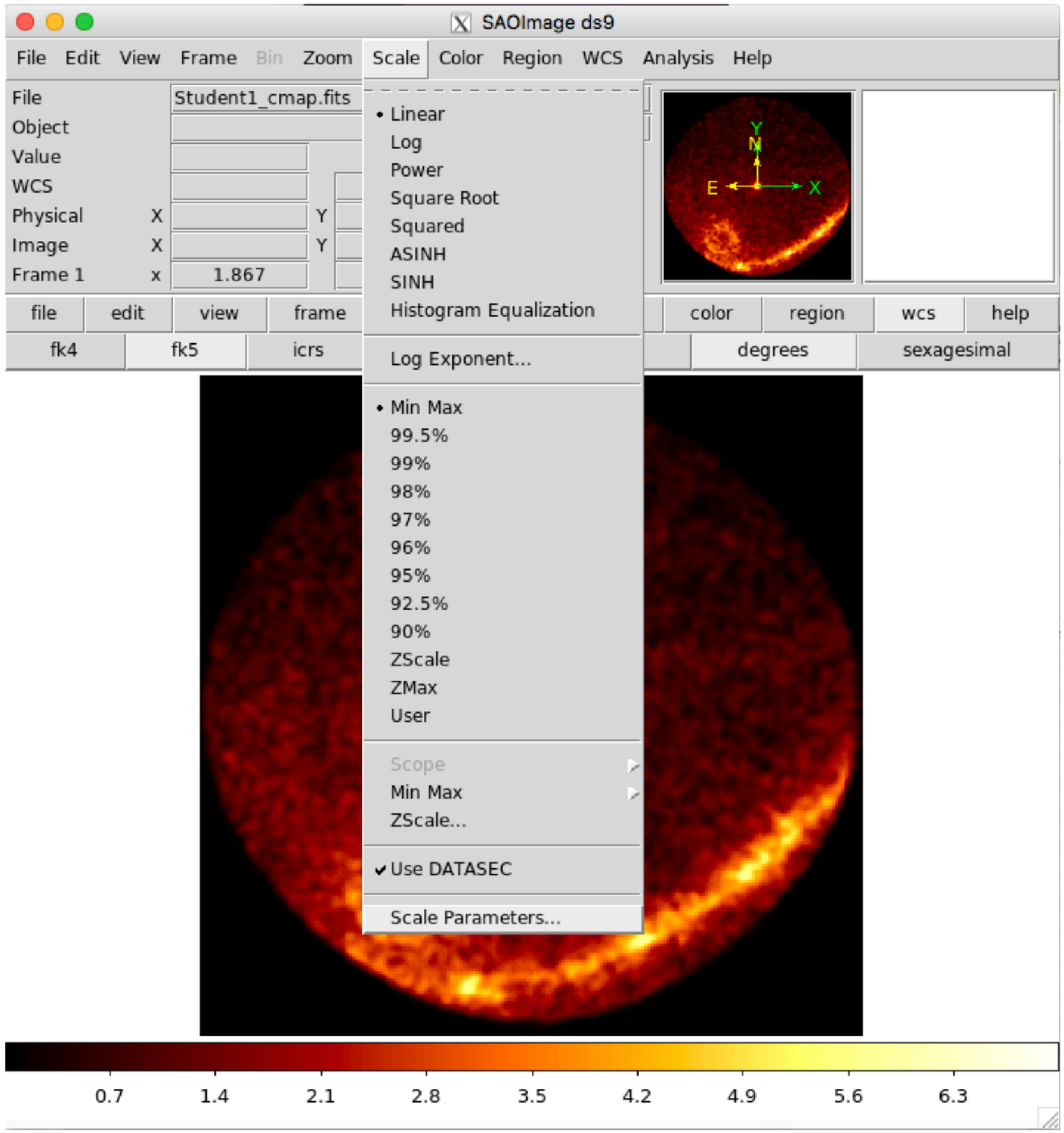
Let's take a look to the result!

ds9 #cmap_gtbin.fits &



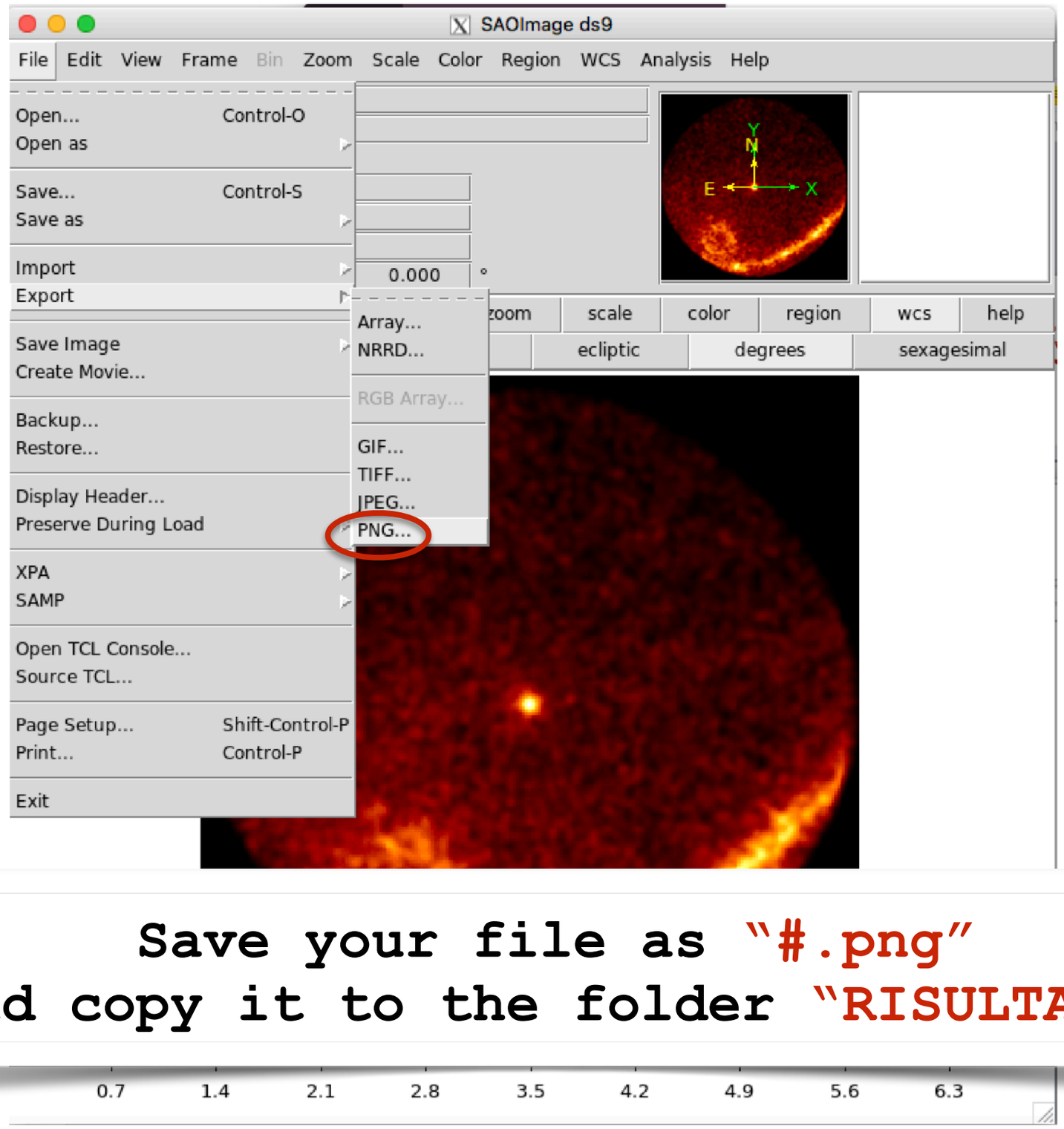
Let's take a look to the result!

ds9 #cmap_gtbin.fits &



Let's take a look to the result!

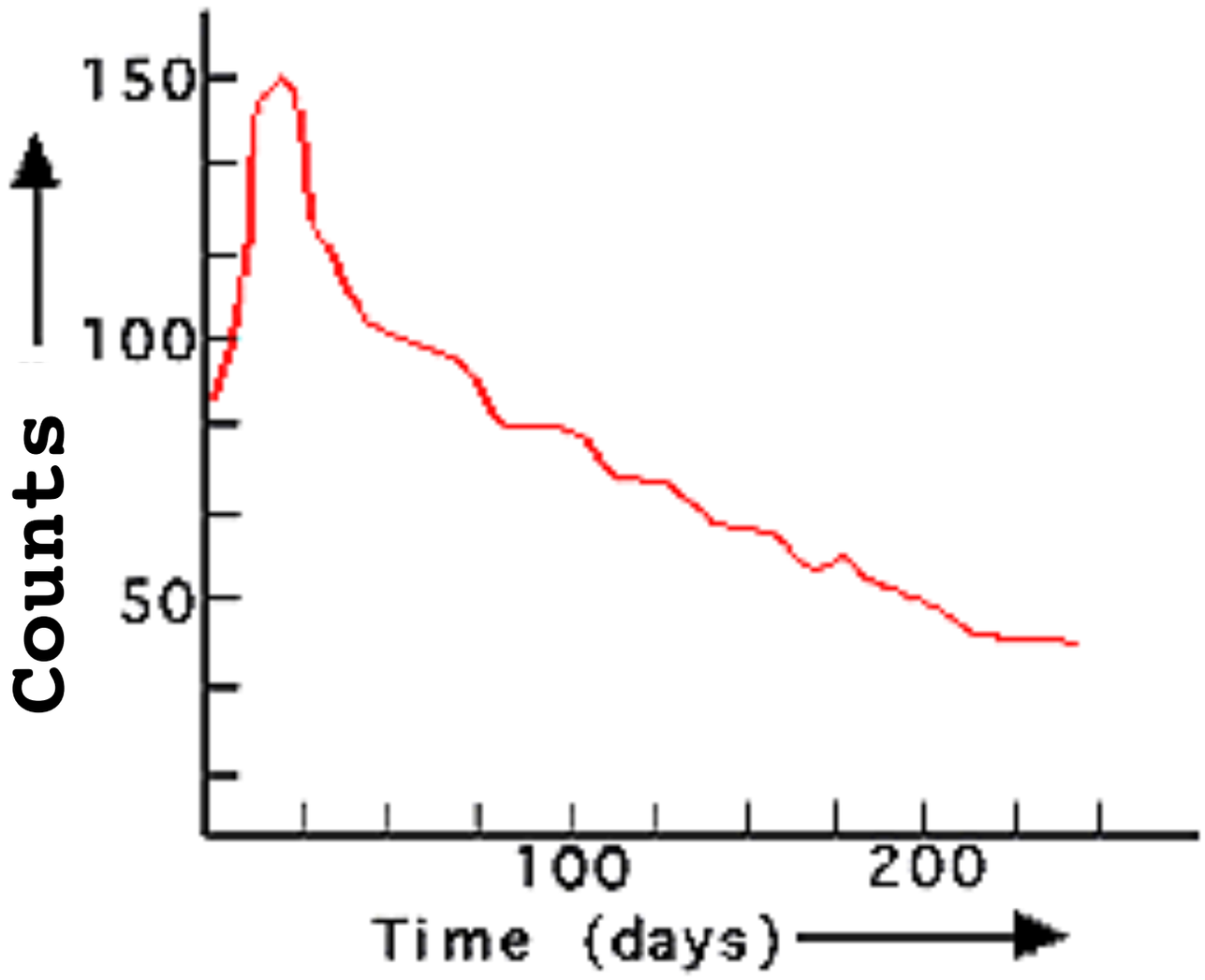
ds9 #cmap_gtbin.fits &



Save your file as "#.png"
and copy it to the folder "RISULTATI"

TASK 2

GRB Light Curve



Select the desired events

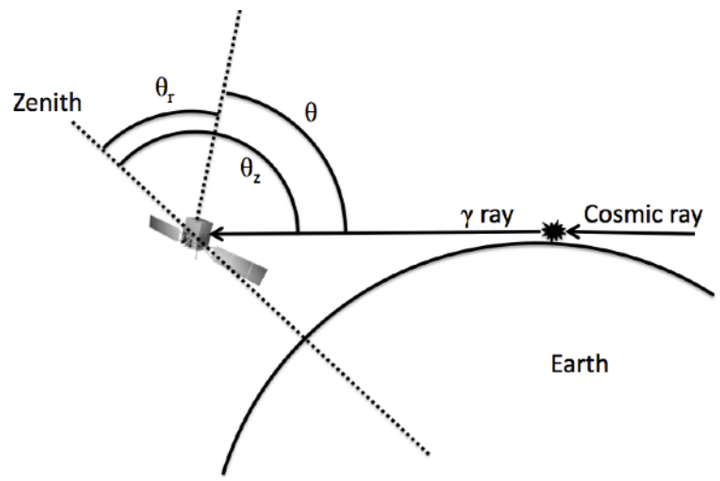
gtselect

```
Input FT1 file[] Torino_events.fits
Output FT1 file[] #lc_gtselect.fits
RA for new search center (degrees) (0:360) [] 353.401
Dec for new search center (degrees) (-90:90) [] -66.324
radius of new search region (degrees) (0:180) 10?
start time (MET in s) (0:) [] start_time
end time (MET in s) (0:) [] end_time
lower energy limit (MeV) (0:) [] 50
upper energy limit (MeV) (0:) [] 500000
maximum zenith angle value (degrees) (0:180) [90] 100
Done.
```

ls

a new file should have been appeared:

#lc_gtselect.fits



Select the desired events

gtmktime

Spacecraft data file[] **Torino_spacecraft.fits**
Filter expression[]
(DATA_QUAL==1) && ABS(ROCK_ANGLE)<90 && (LAT_CONFIG==1) && (angsep(RA_ZENITH,DEC_ZENITH,353.401,-66.324)+10<105) && (angsep(353.401,-66.324,RA_SUN,DEC_SUN)>10) &&(angsep(353.401,-66.324,RA_SCZ,DEC_SCZ)<180)
Apply ROI-based zenith angle cut[] **yes**
Event data file[] **#lc_gtselect.fits**
Output event file name[] **#lc_gtmktime.fits**

ls

new files should have been appeared:

#lc_gtselect.fits

#lc_gtmktime.fits

Create the Light Curve

gtbin

```
This is gtbin version ScienceTools-v10r0p5-fssc-20150819
Type of output file (CCUBE|CMAP|LC|PHA1|PHA2|HEALPIX) [] LC
Event data file name[] #lc_gtmktime.fits
Output file name[] #lc_gtbin.fits
Spacecraft data file name[] Torino_spacecraft.fits
Algorithm for defining time bins (FILE|LIN|SNR) [] LIN
Start value for first time bin in MET[] start_time
Stop value for last time bin in MET[] end_time
Width of linearly uniform time bins in seconds[] 10
```

Light Curve

ls

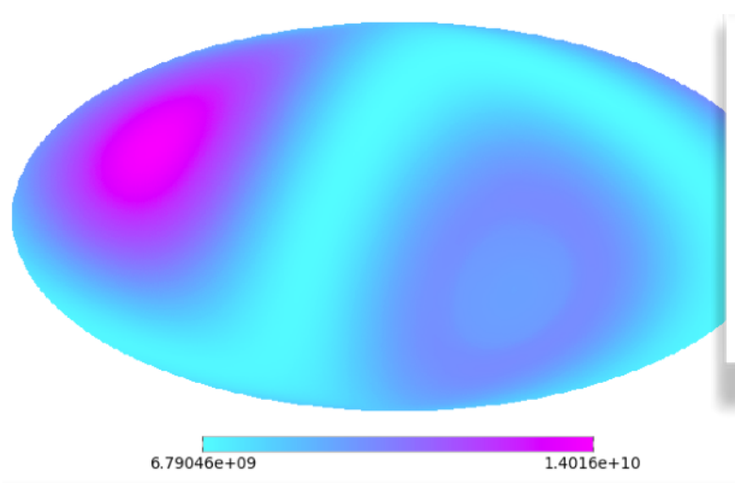
a new file should have been appeared:

#lc_gtbin.fits

Create the Light Curve

gtexposure

```
Light curve file[] #lc_gtbin.fits
Spacecraft file[] Torino_spacecraft.fits
Response functions[CALDB]
Source model XML file[none]
Photon index for spectral weighting[-2.1]
```



Exposure map

- cm^2 s
- not uniform

ATT: this step will not produce a new file, but will modify your light curve file!

Create the Light Curve

fcalc

```
Name of FITS file and [ext#][] #lc_gtbin.fits
Name of output FITS file[lc_ft1_flux.fits] #lc_flux.fits
Resultant column name[] flux
Arithmetic expression[] counts/exposure
```

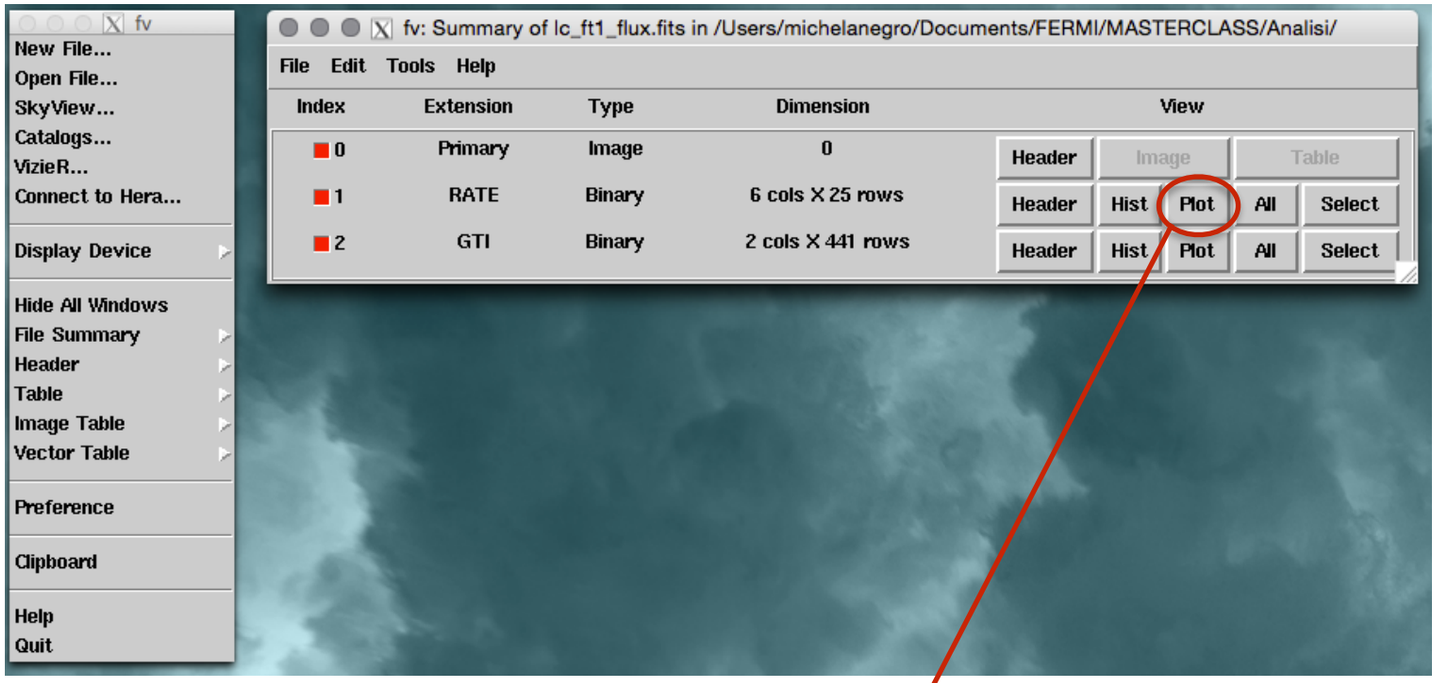
ls

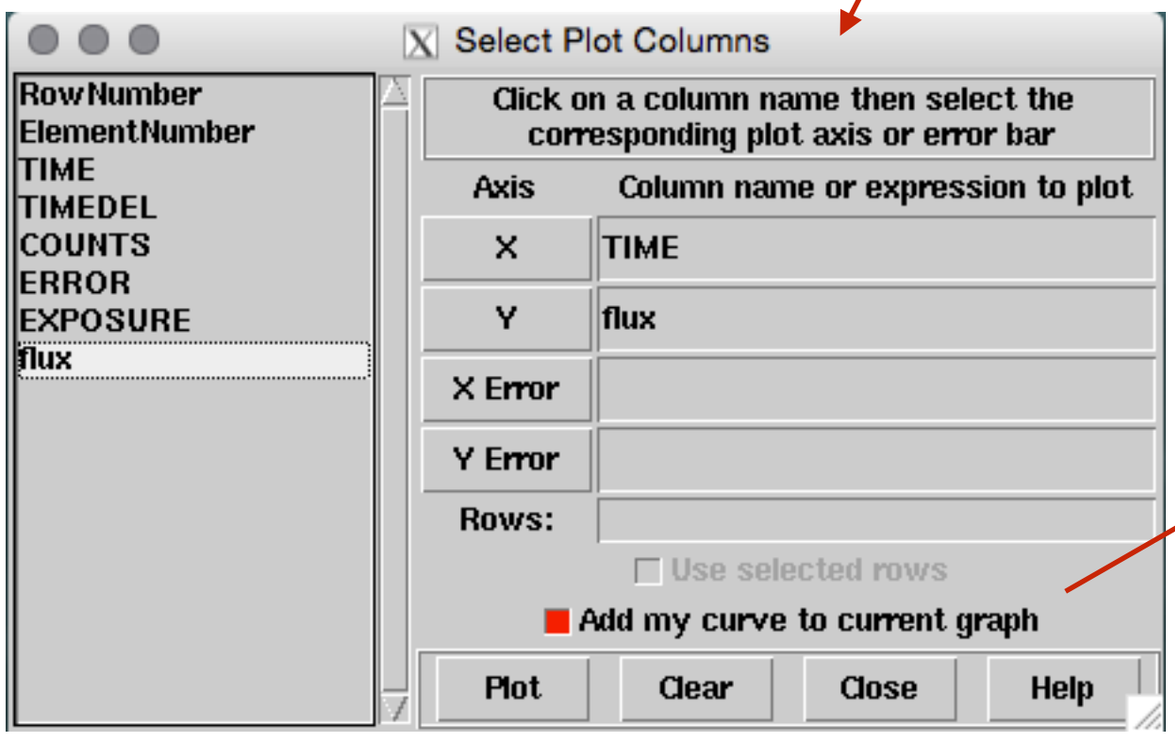
new files should have been appeared:

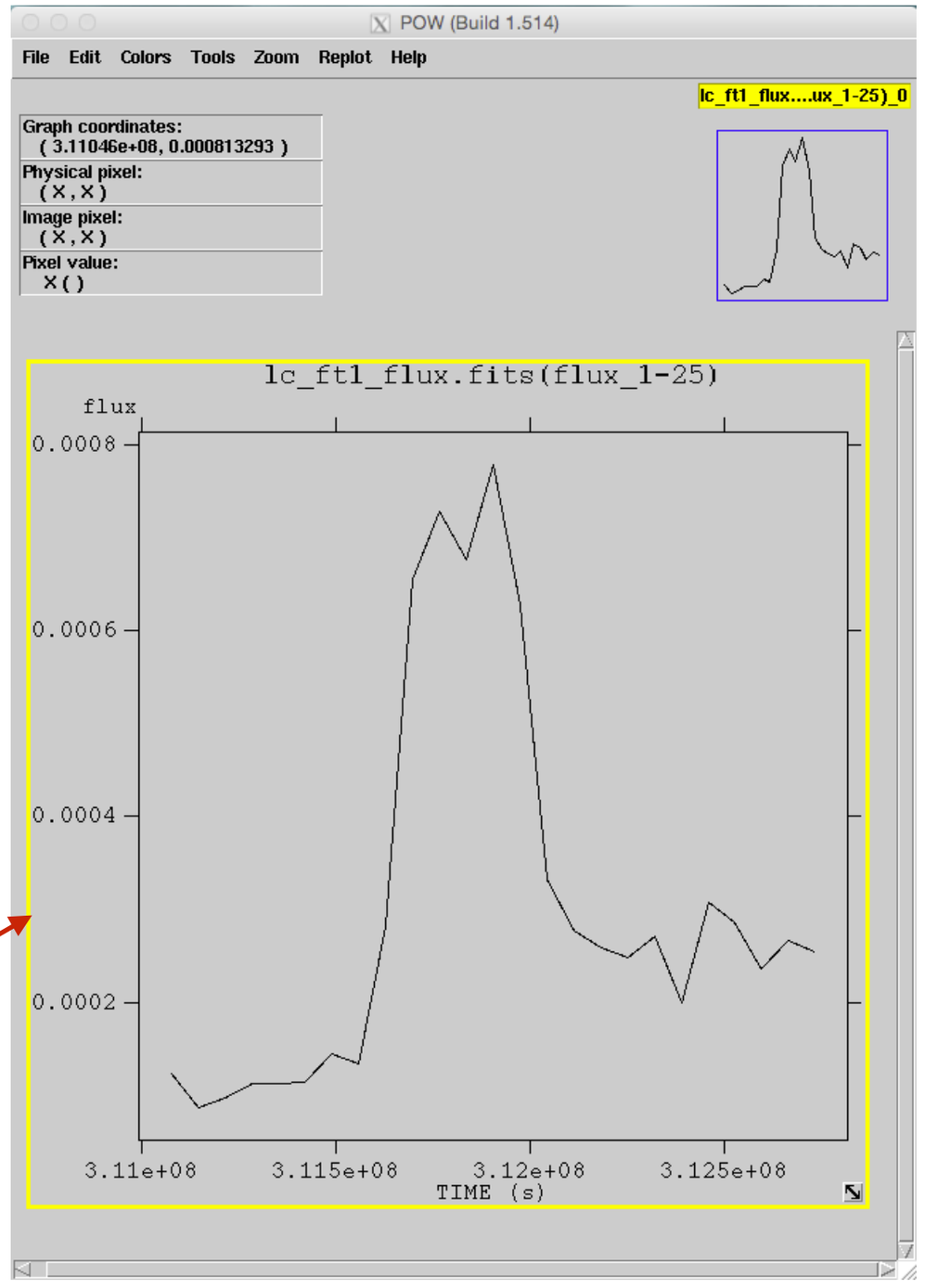
#lc_flux.fits

Let's take a look to the result!

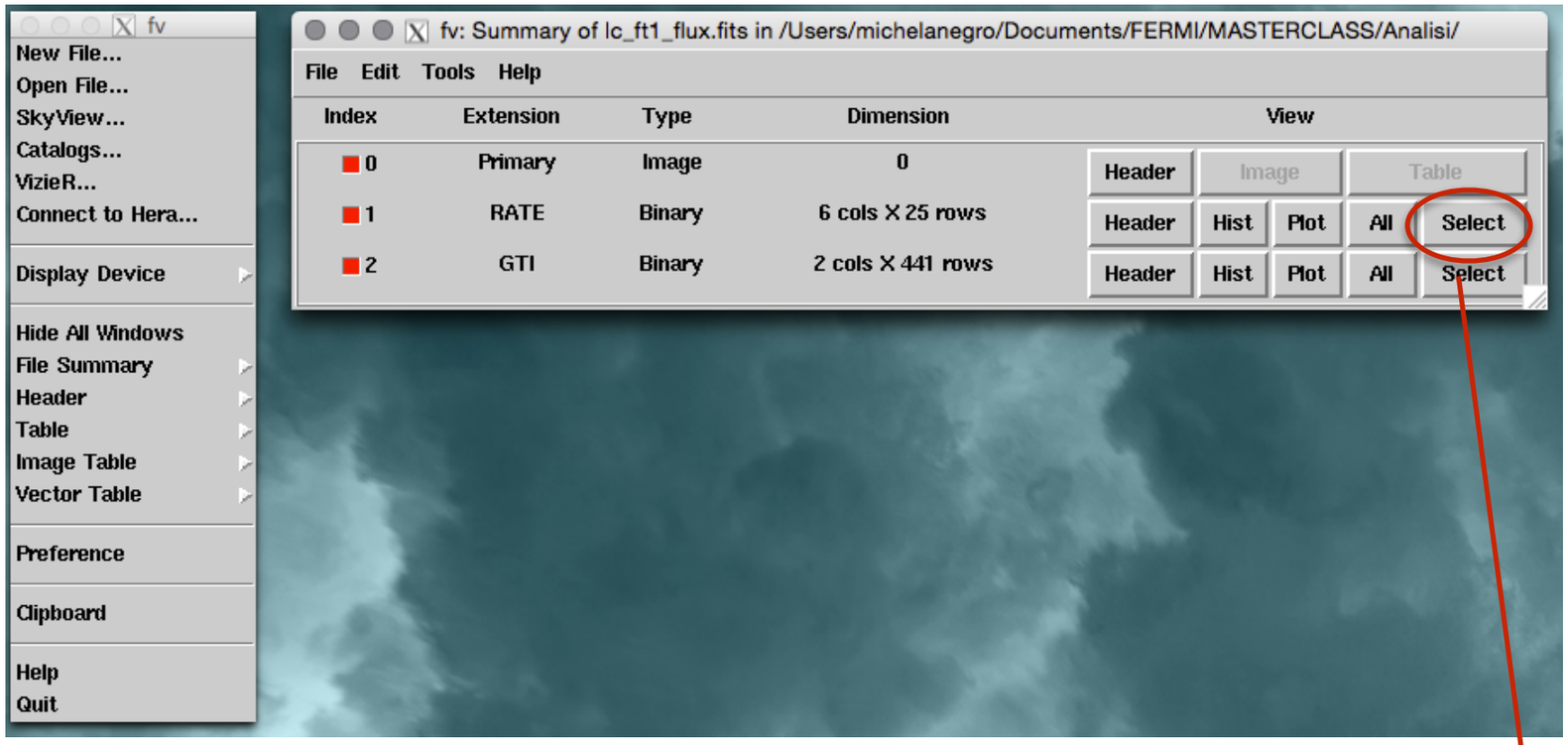
fv lc_ft1_flux.fits &

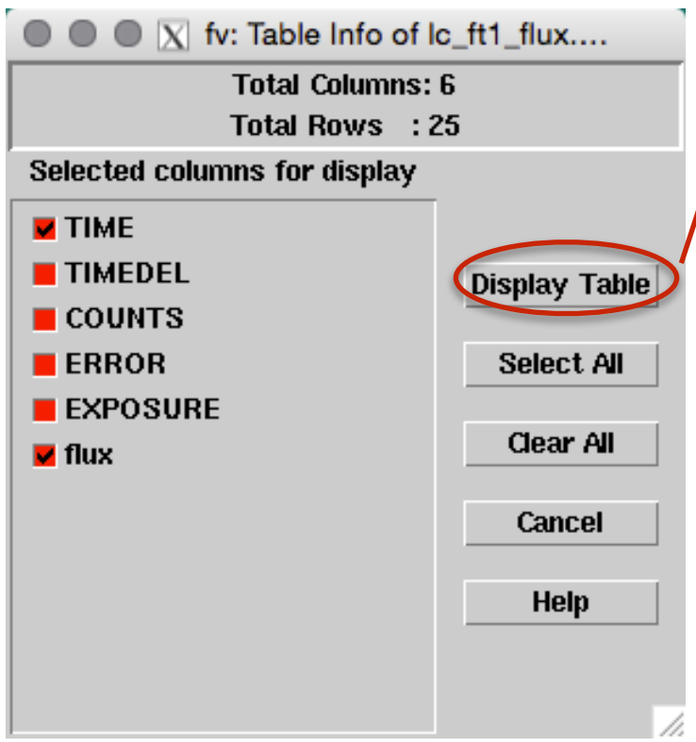


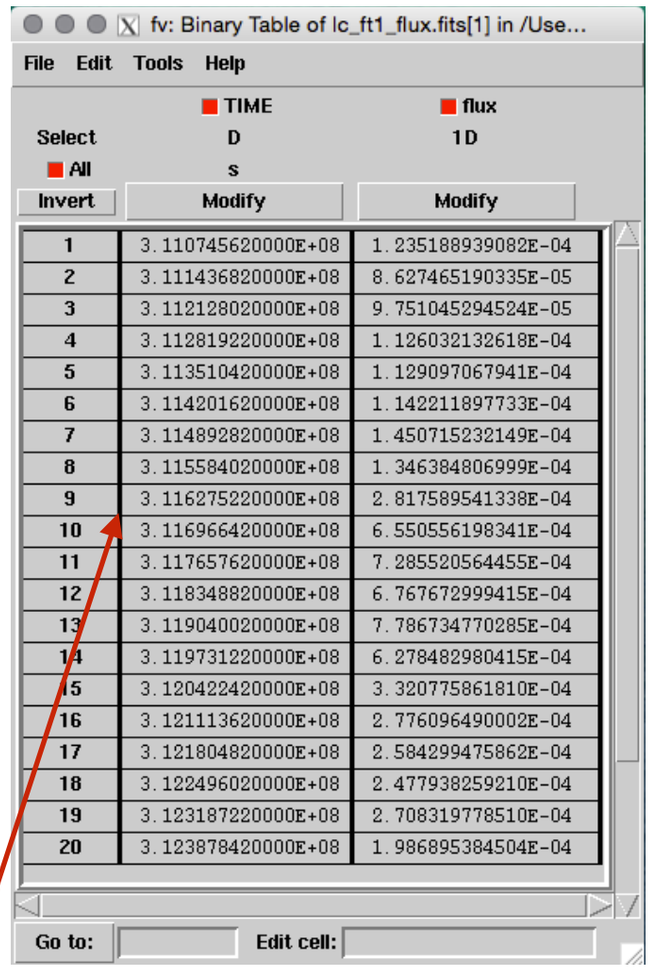




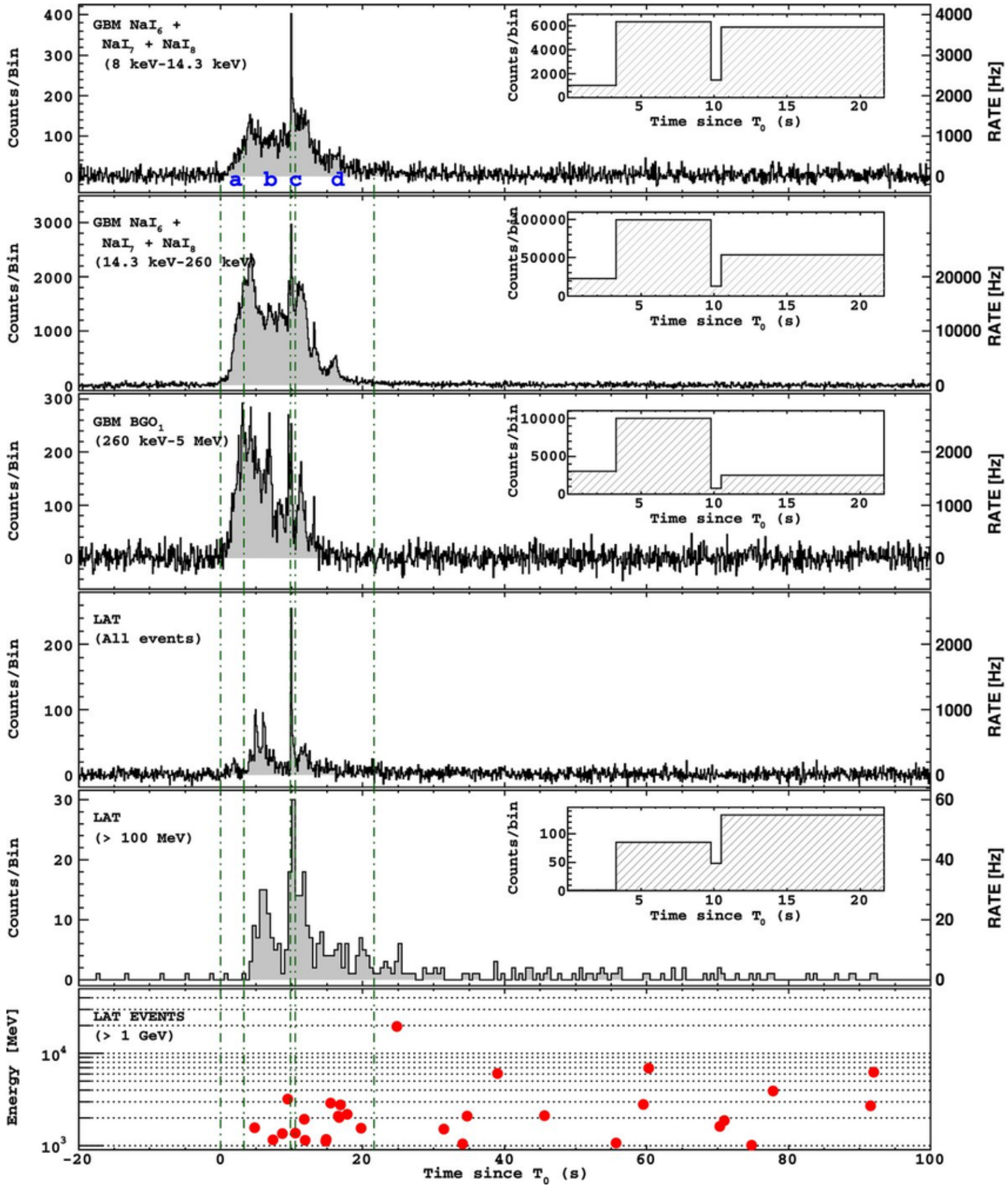
Let's take a look to the result!





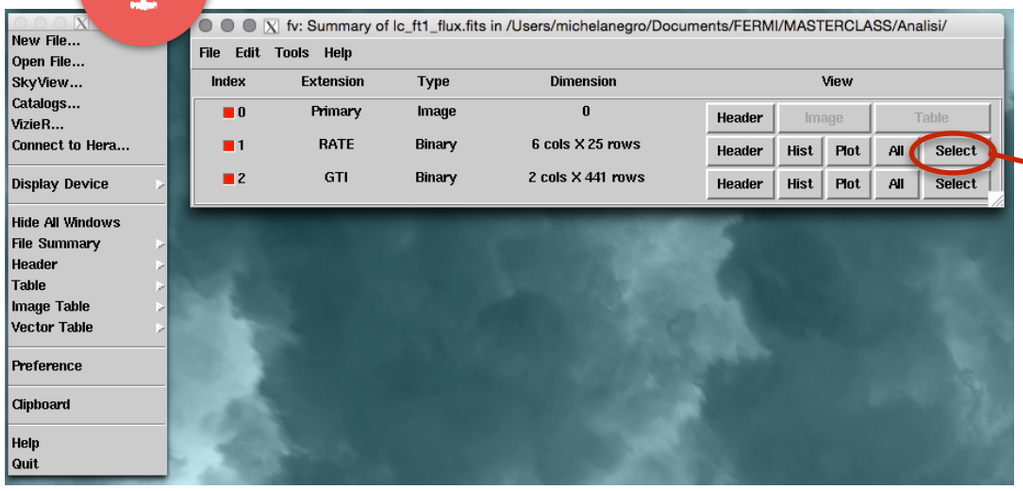


... and that's it!!

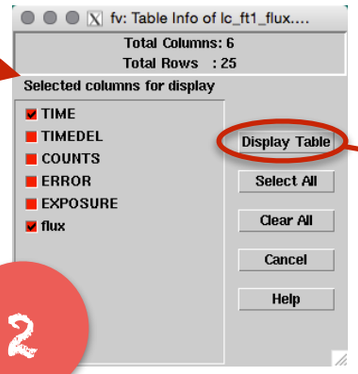

GBM NaI6 + NaI7 + NaI8 (8 keV-14.3 keV)
Counts/Bin
RATE [Hz]
Counts/bin
Time since T0 (s)
a
b
c
d
GBM NaI6 + NaI7 + NaI8 (14.3 keV-260 keV)
GBM BGO1 (260 keV-5 MeV)
LAT (All events)
LAT (> 100 MeV)
LAT EVENTS (> 1 GeV)
Energy [MeV]

take and share data

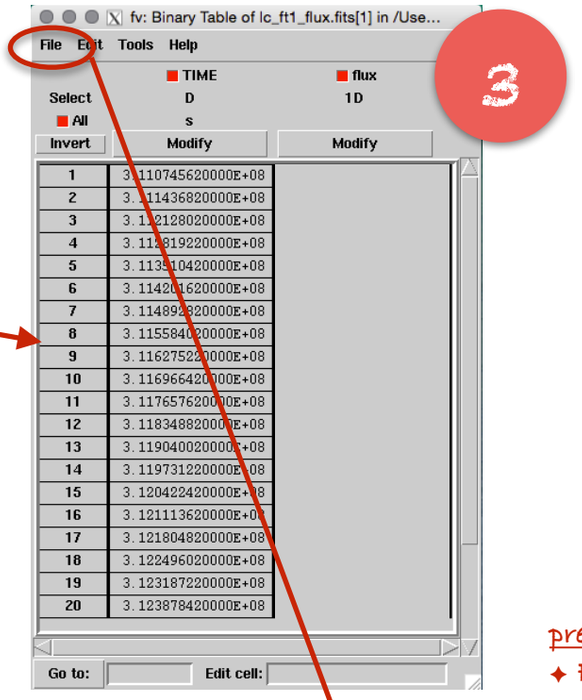
1



select only TIME column

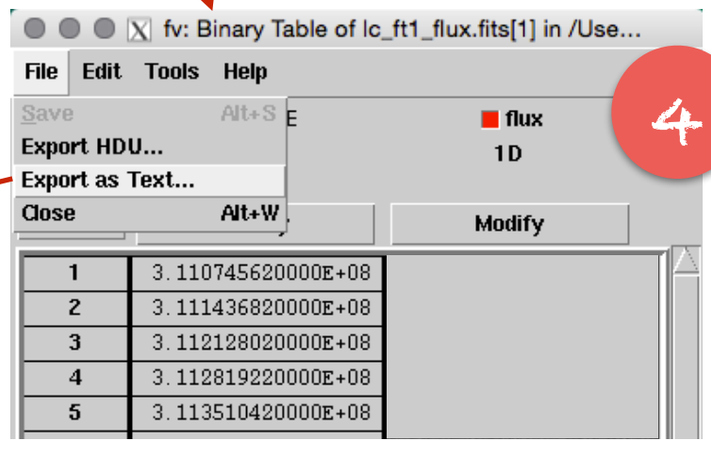


2

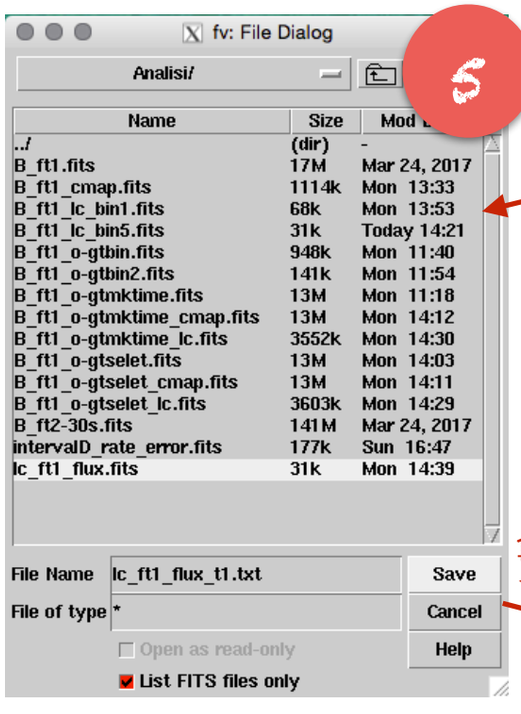


3

press:
- File
- Export as Text...

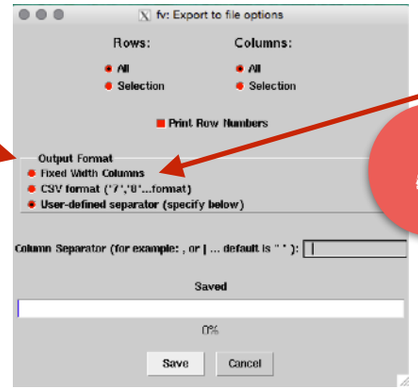


4



5

press:
- Save



6

select:
'Fixed Width Column'

press (again):
- Save

type on terminal:
more lc_ft1_flux_t1.txt

7

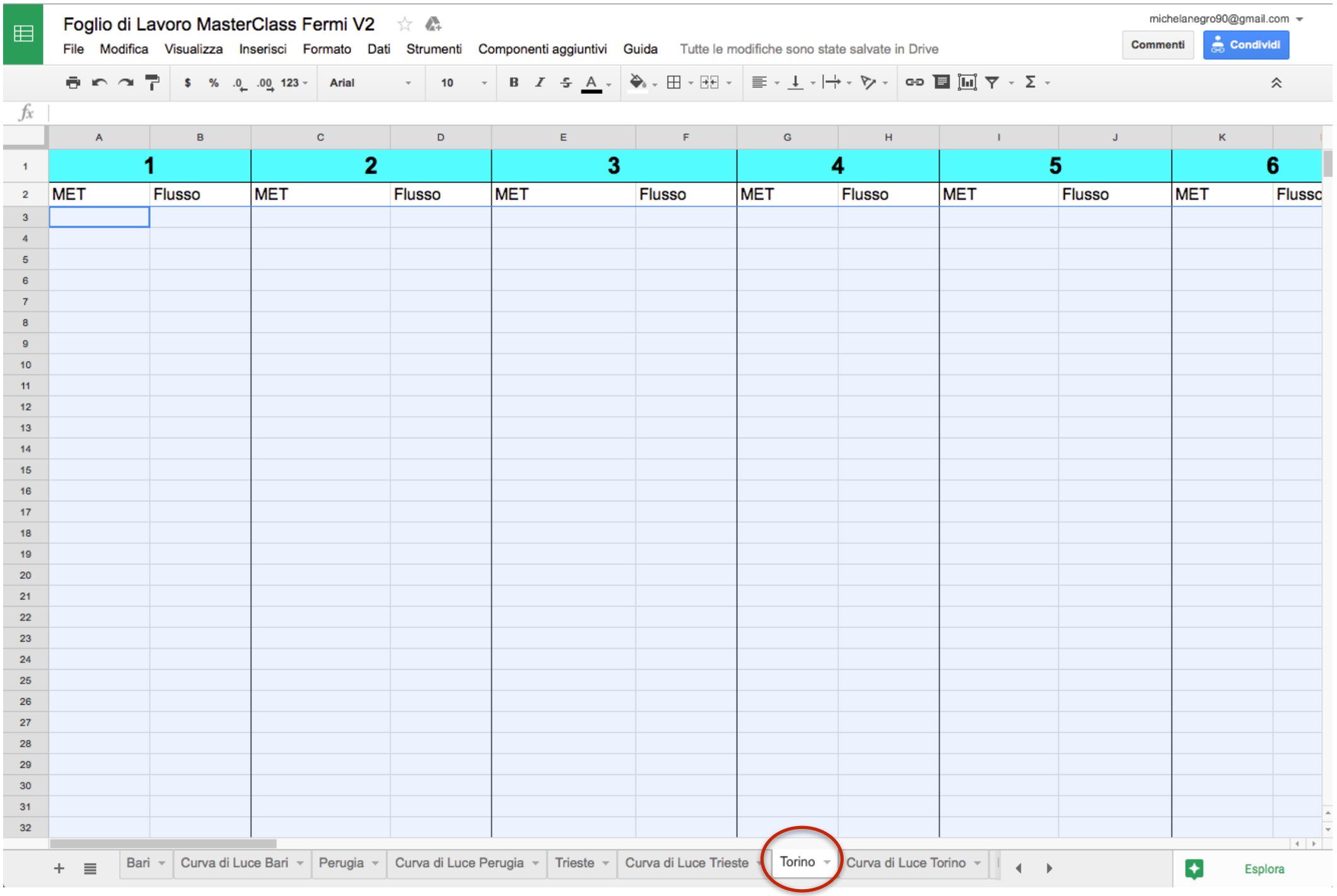
press:
- Copy 'TIME' column
- go to the google spreadsheet
- select the right cell
- Paste

```
more lc_ft1_flux_t1.txt
                    TIME
                       D
                       s
    3.110745620000E+08
    3.111436820000E+08
    3.112128020000E+08
    3.112819220000E+08
    3.113510420000E+08
    3.114201620000E+08
    3.114892820000E+08
    3.115584020000E+08
    3.116275220000E+08
    3.116966420000E+08
    3.117657620000E+08
    3.118348820000E+08
    3.119040020000E+08
    3.119731220000E+08
    3.120422420000E+08
    3.121113620000E+08
    3.121804820000E+08
    3.122496020000E+08
    3.123187220000E+08
    3.123878420000E+08
    3.124569620000E+08
    3.125260820000E+08
    3.125952020000E+08
    3.126643220000E+08
    3.127334420000E+08
```

8

Repeat from step 1 for 'flux' column

ATT: change output file name!!!

google spreadsheet

https://docs.google.com/spreadsheets/d/1x7VwoeaIoAxODU3pW_6B7rwFOjujz5jnyc634zTZnK4/edit#gid=83196820