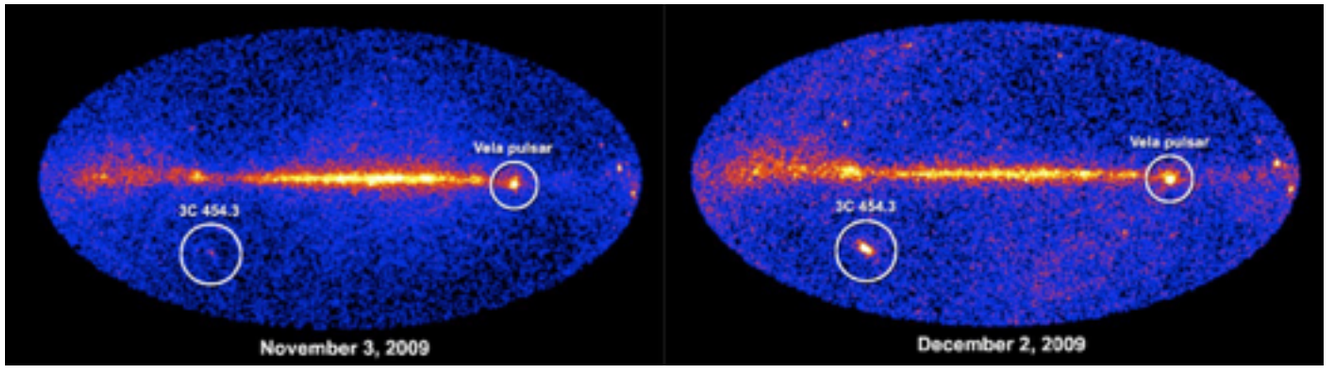
Fermi Data Analysis

3C 454.3 Light Curve and Counts Map

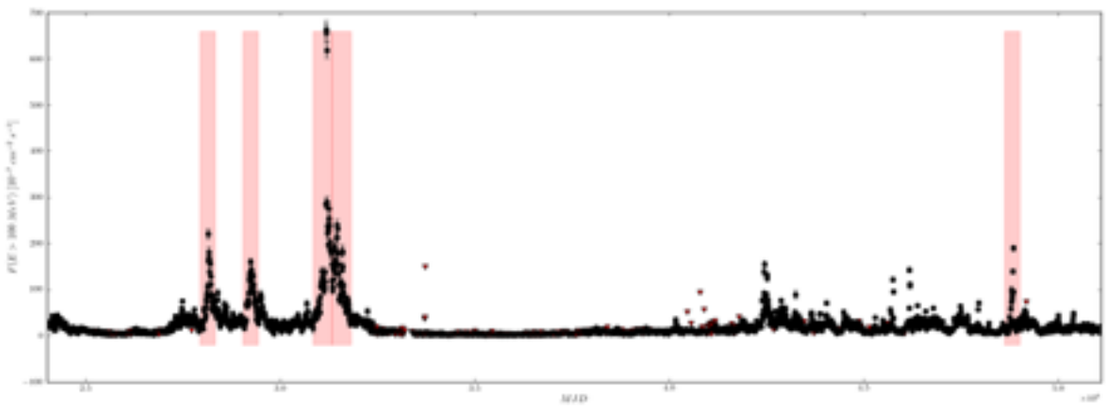
Fermi
Gamma-ray
Space Telescope

what are we going to do?

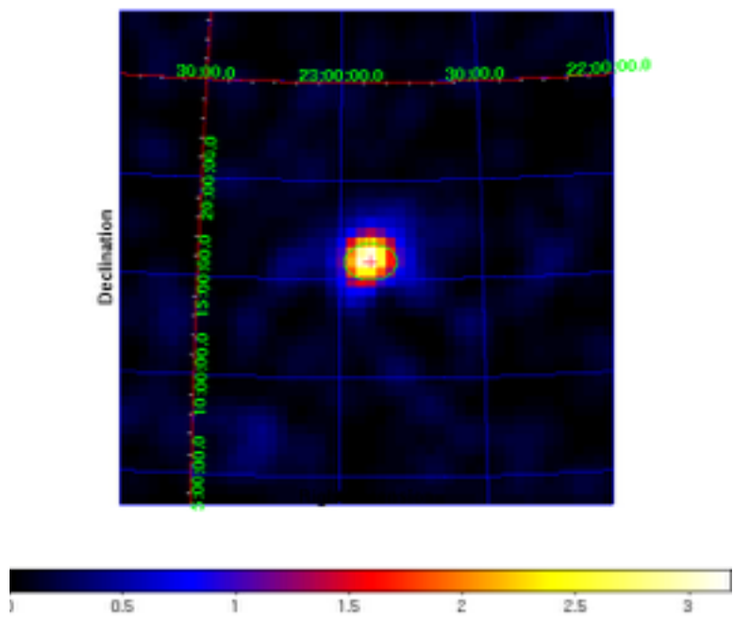
select the Region of Interest (ROI) and...



1) extract Light curve



2) produce Counts map



what do we need to know?

english

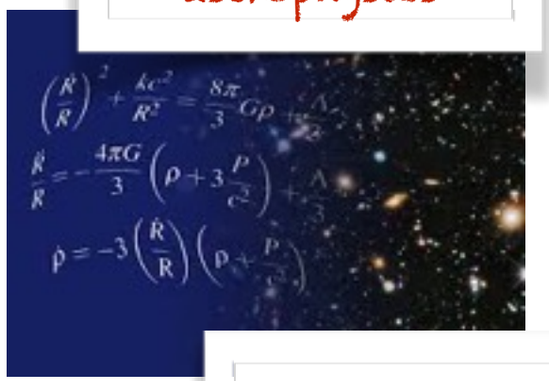
use of the terminal

Comunicate your results

extract data and results

programming language

fundamental astrophysics

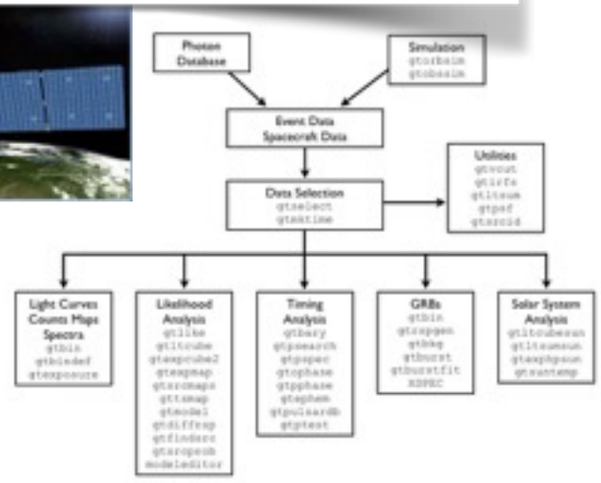


to interpret results

instrument tools and characteristics

cosmology

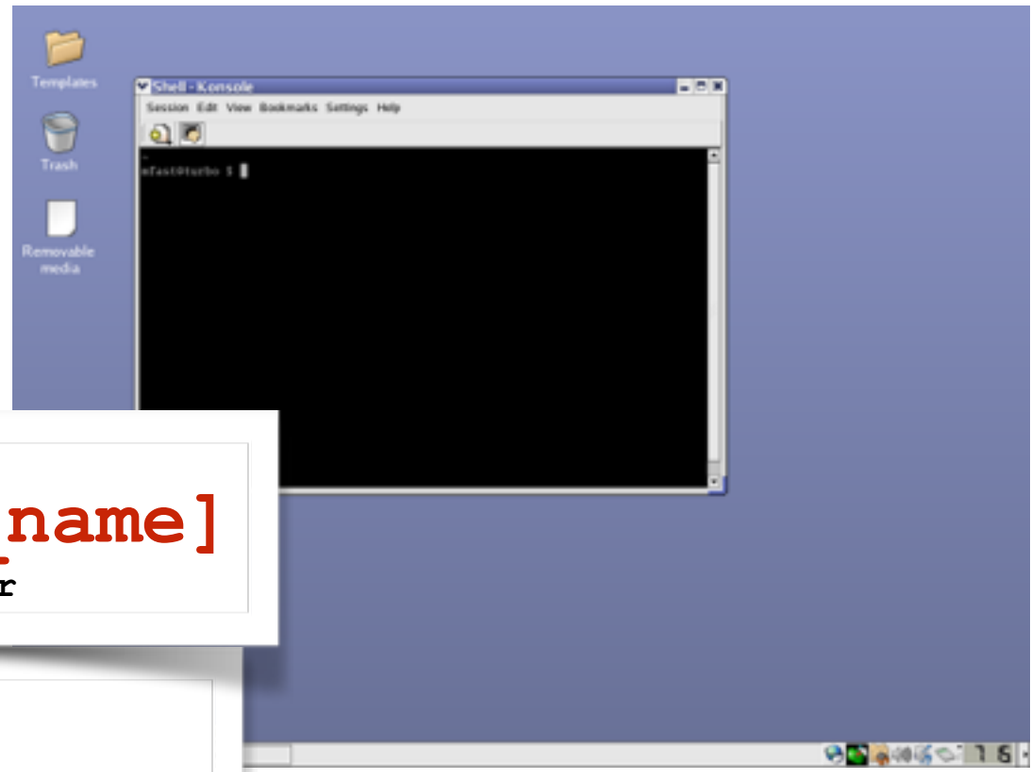
special and general relativity



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

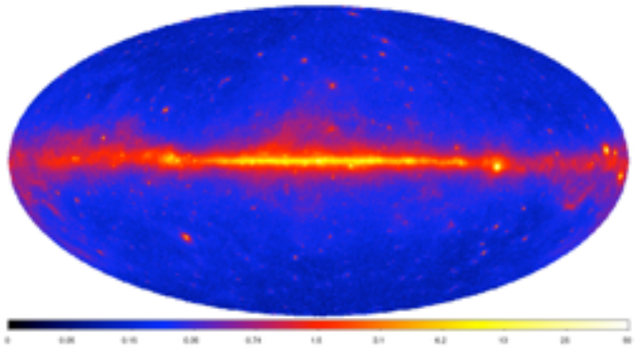
cp [path/files] [new_path/.]
copy files from a folder to another folder

```
pwd
mkdir masterclass2017
cd masterclass2017
ls
cp /usr/users/st00/maldera/FERMI/data/ft1.fits .
ls
```

what's the data format?

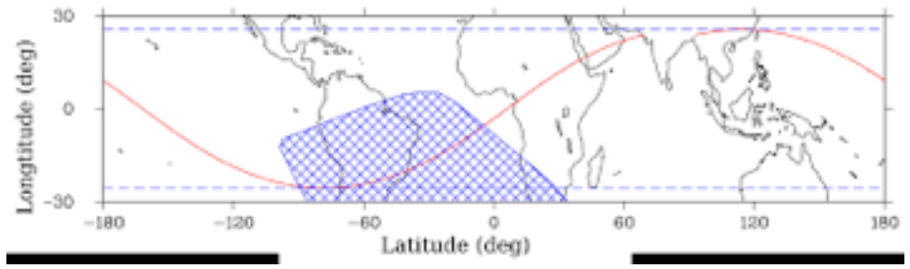
ft1.fits

recorded data



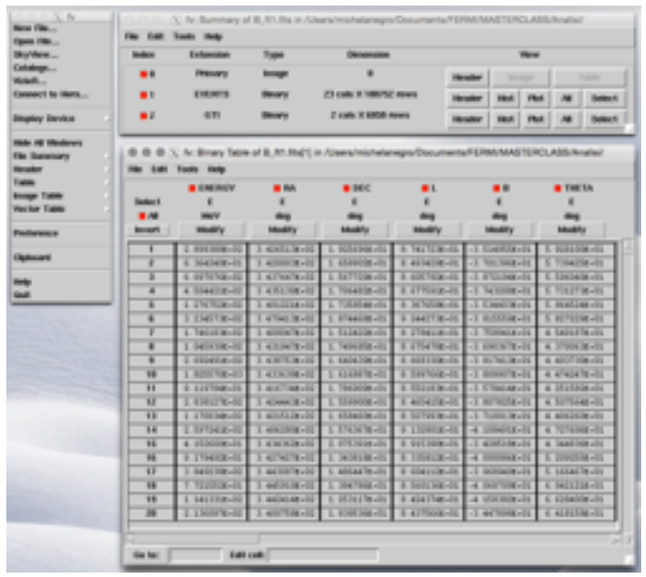
ft2.fits

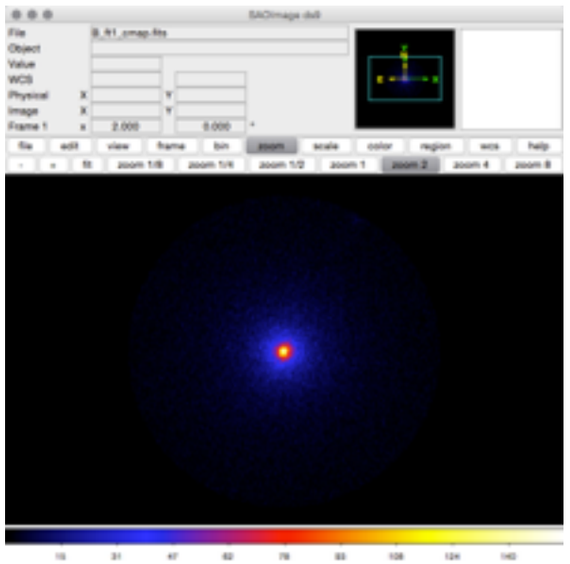
spacecraft hystory



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

`fv ft1.fits`



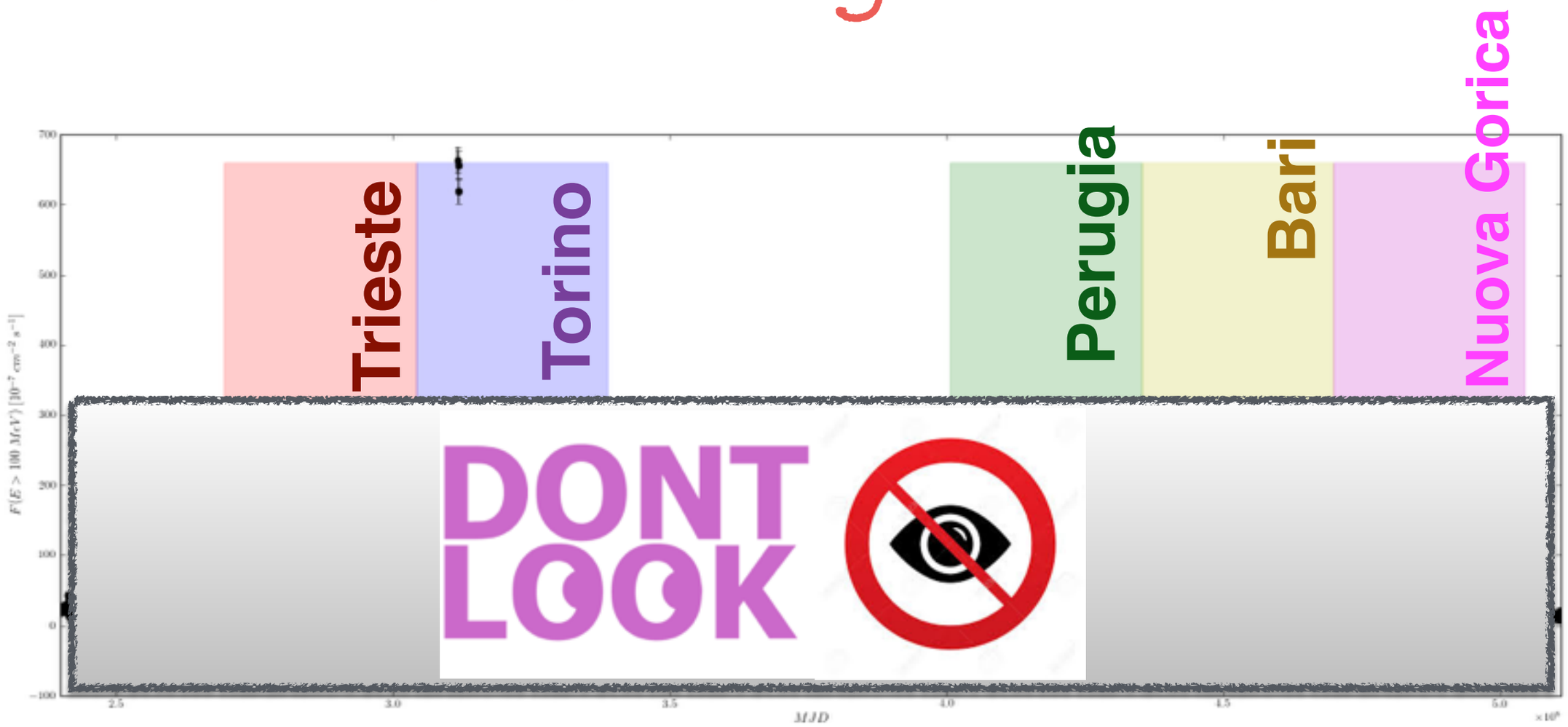


`ds9 ft1.fits`

now... let's start!

task 1

3C 454.3 Light Curve

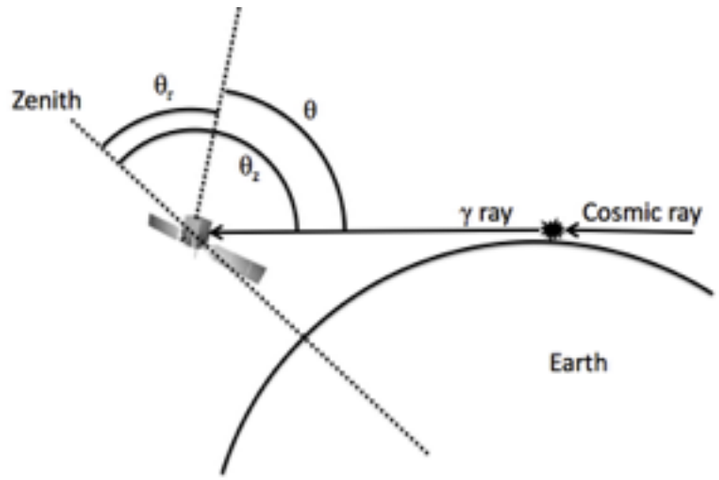


Select the desired events

```
gtselect evclass=128
Input FT1 file[] ft1.fits
Output FT1 file[] lc_ft1_gtselect.fits
RA for new search center (degrees) (0:360) [] 343.49
Dec for new search center (degrees) (-90:90) [] 16.148
radius of new search region (degrees) (0:180) [] 1
start time (MET in s) (0:) [] 312768002
end time (MET in s) (0:) [] 314496002
lower energy limit (MeV) (0:) [] 100
upper energy limit (MeV) (0:) [] 200000
maximum zenith angle value (degrees) (0:180) [90] 90
Done.
```

3C 454.3 coordinates

MET = Mission Elapsed Time

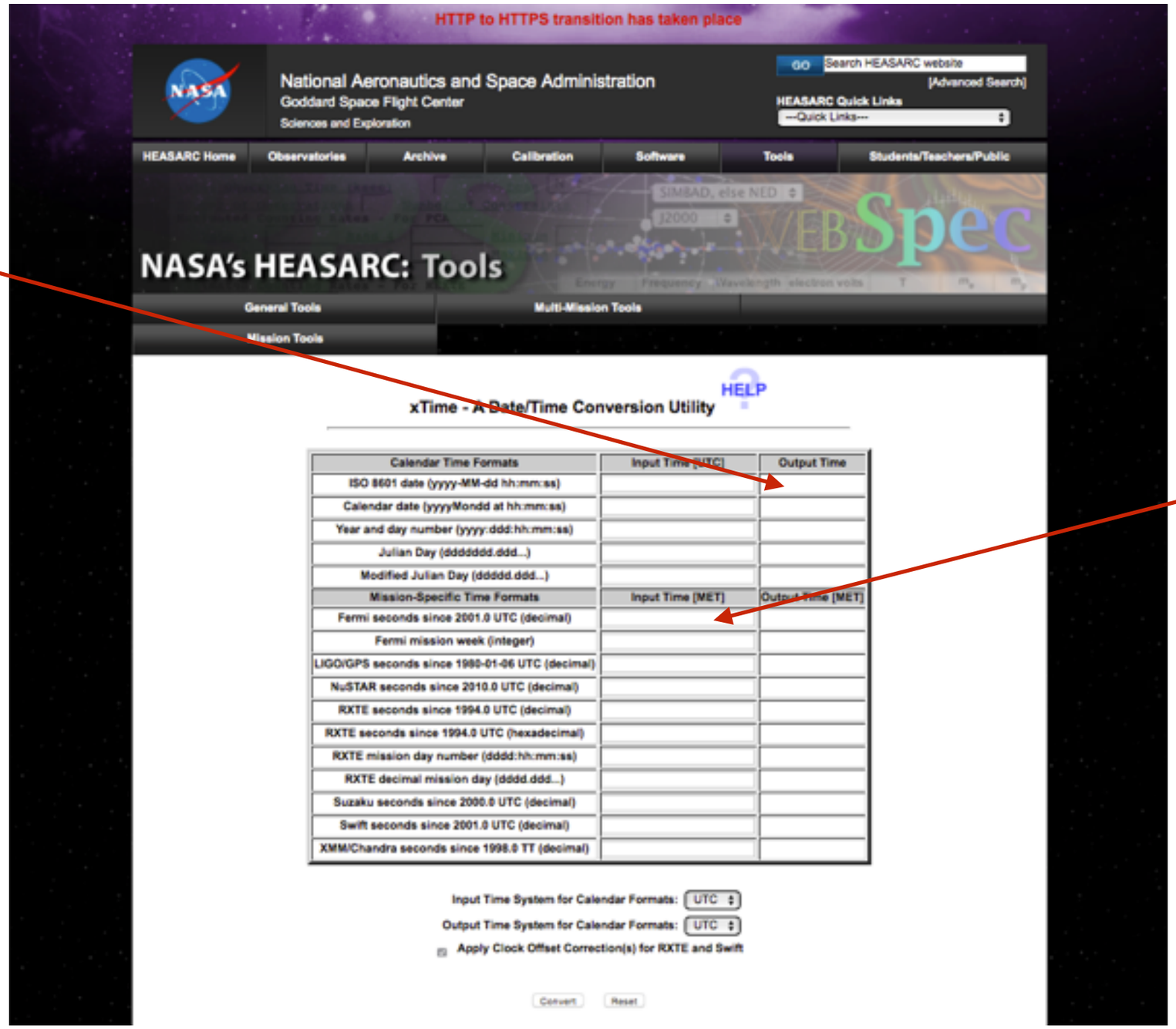


ATT: each of you will have a different time range!

to which date does a MET correspond?

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

read your date here



put your MET here

Select the desired events

gtmktime

Spacecraft data file[] **ft2.fits**

Filter expression[]

(DATA_QUAL==1) && ABS(ROCK_ANGLE)<90 && (LAT_CONFIG==1) &&
(angsep(RA_ZENITH,DEC_ZENITH,343.49,16.148)+1<105) &&
(angsep(343.49,16.148,RA_SUN,DEC_SUN)>5+1)
&&(angsep(343.49,16.148,RA_SCZ,DEC_SCZ)<180)

Apply ROI-based zenith angle cut[] **yes**

Event data file[] **lc_ft1_gtselect.fits**

Output event file name[] **lc_ft1_gtmktime.fits**

ls

new files should have been appeared:

lc_ft1_gtselect.fits

lc_ft1_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_ft1_gtmktime.fits
Output file name[] lc_ft1_gtbin.fits
Spacecraft data file name[] ft2.fits
Algorithm for defining time bins (FILE|LIN|SNR) [] LIN
Start value for first time bin in MET[] 312768002
Stop value for last time bin in MET[] 314496002
Width of linearly uniform time bins in seconds[] 86400
```

Light Curve

ls

a new file should have been appeared:

lc_ft1_gtbin.fits

Create the Light Curve

gtexposure

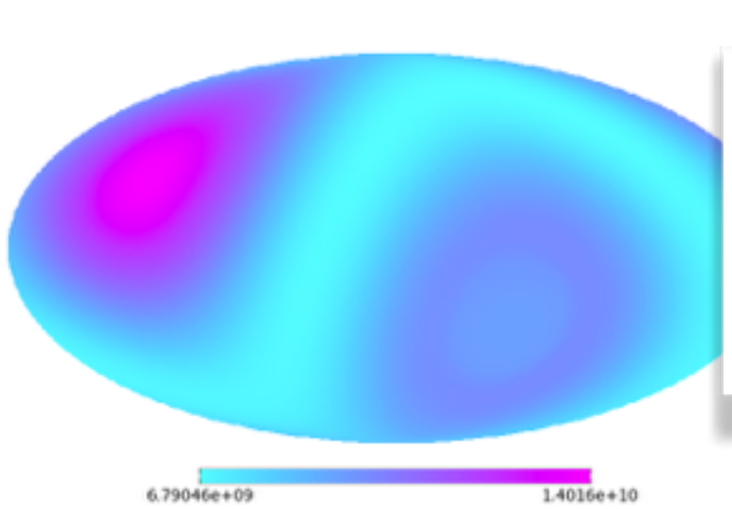
Light curve file[] **lc_ft1_gtbin.fits**

Spacecraft file[] **ft2.fits**

Response functions[] **P8R2_SOURCE_V6**

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_ft1_gtbin.fits**

Name of output FITS file[lc_ft1_flux.fits] **lc_ft1_flux.fits**

Resultant column name[] **flux**

Arithmetic expression[] **counts/exposure**

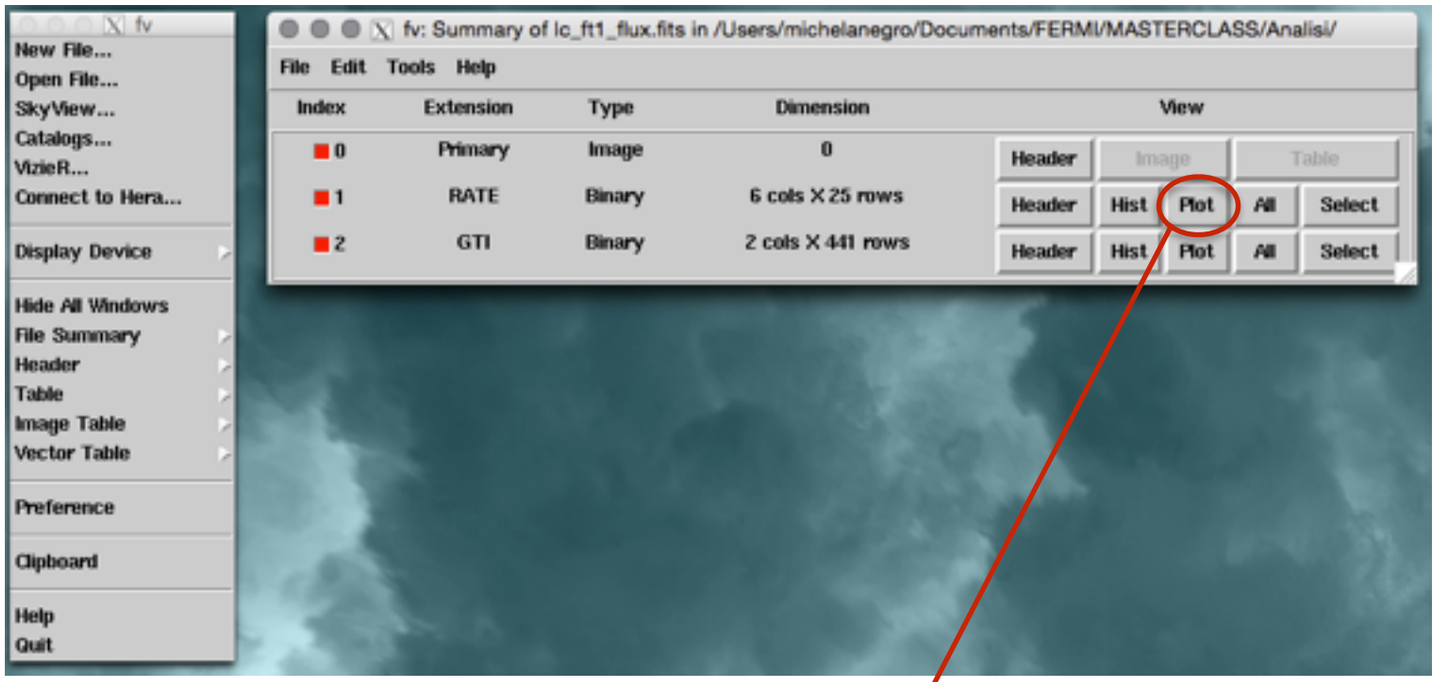
ls

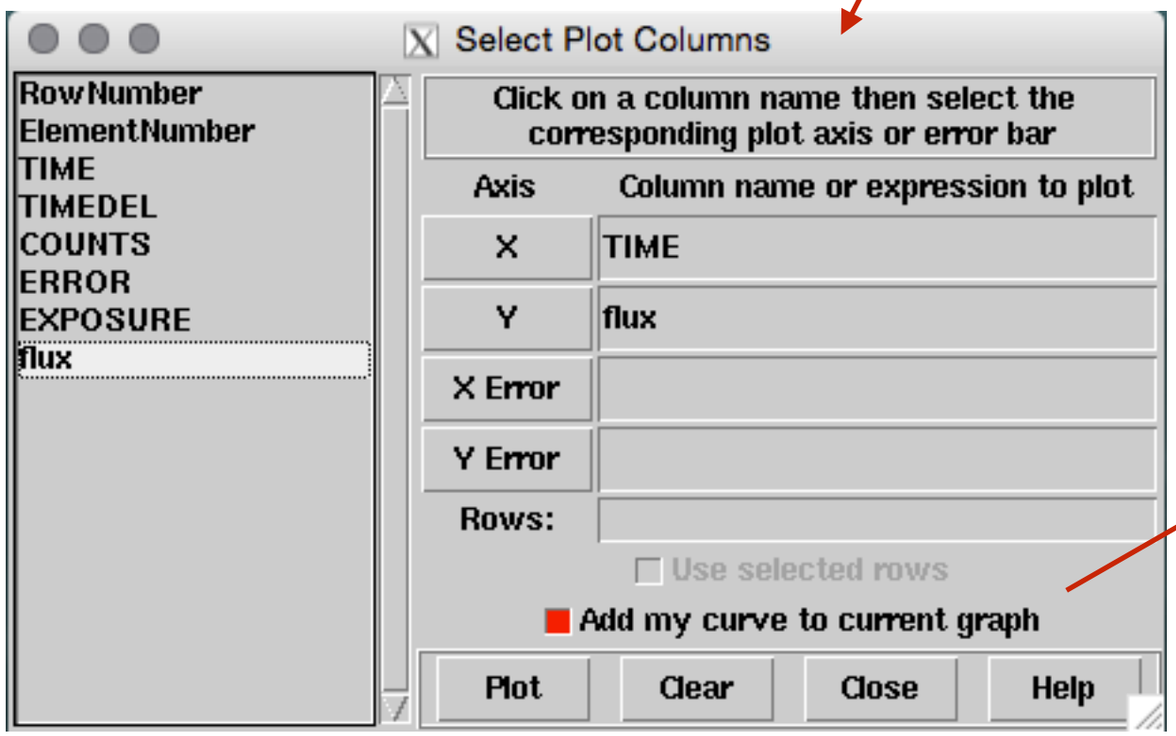
new files should have been appeared:

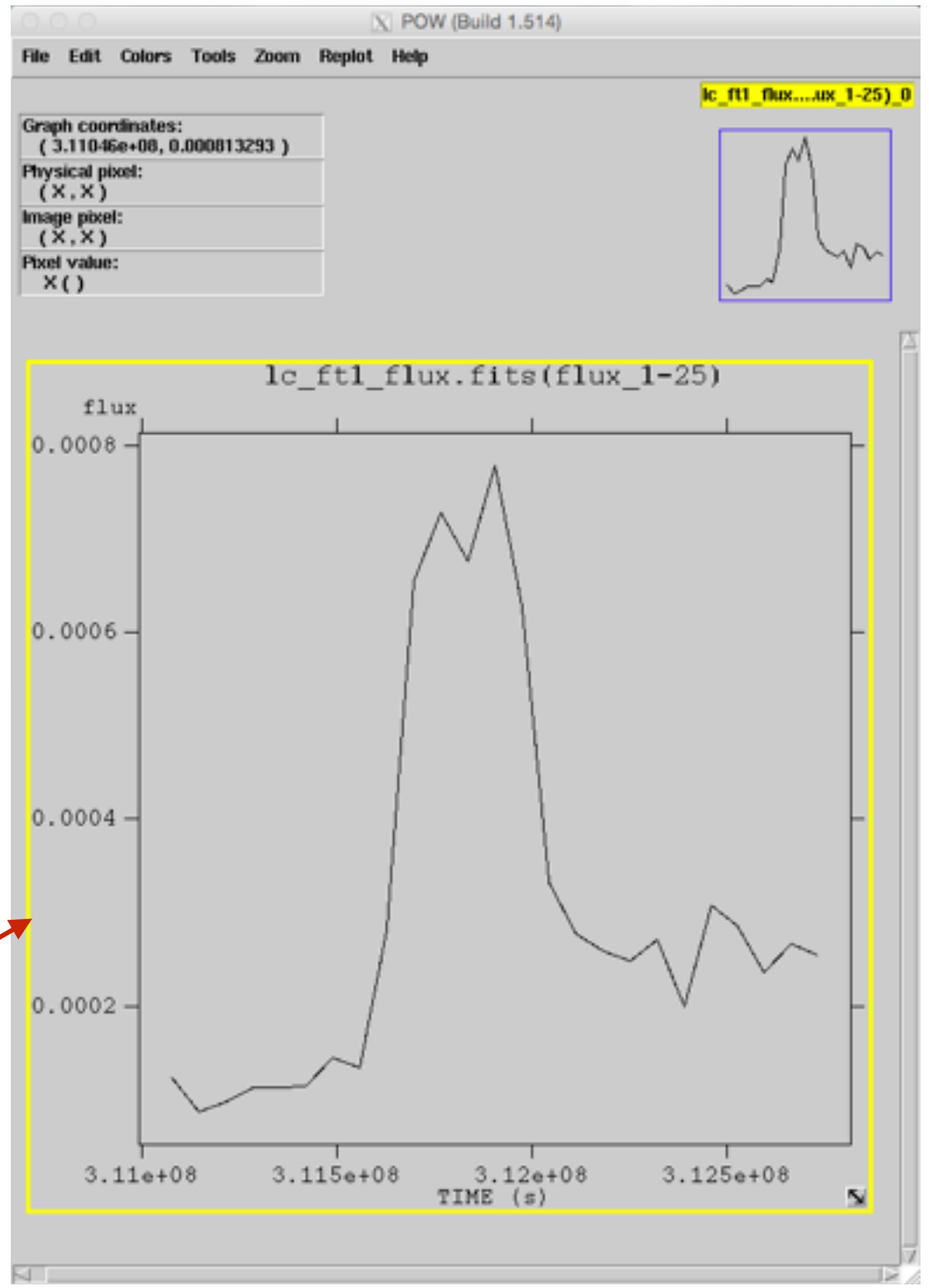
lc_ft1_flux.fits

Let's take a look to the result!

`fv lc_ft1_flux.fits &`

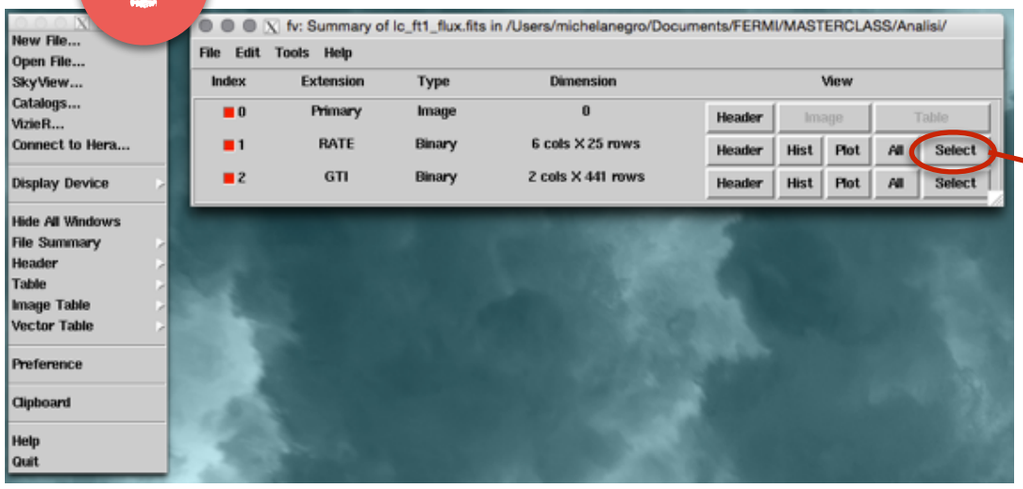




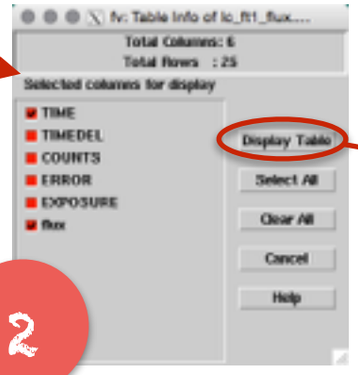


take and share data

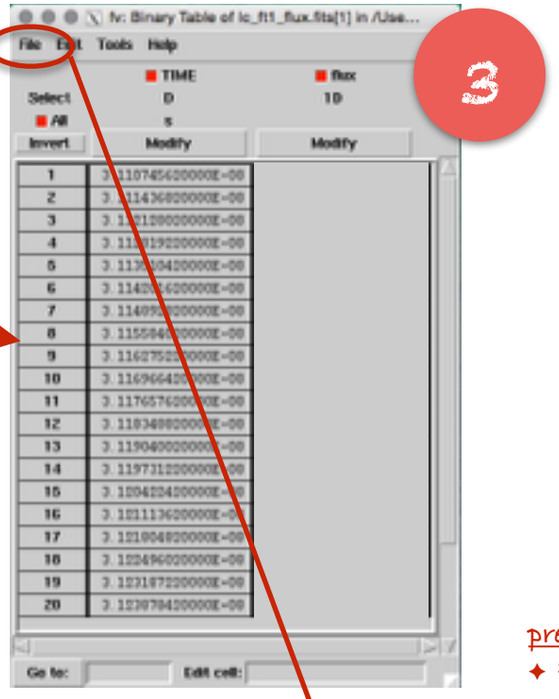
1



select only TIME column

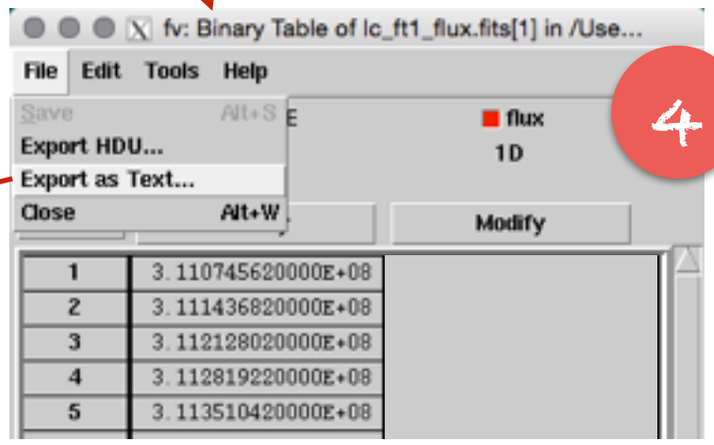


2

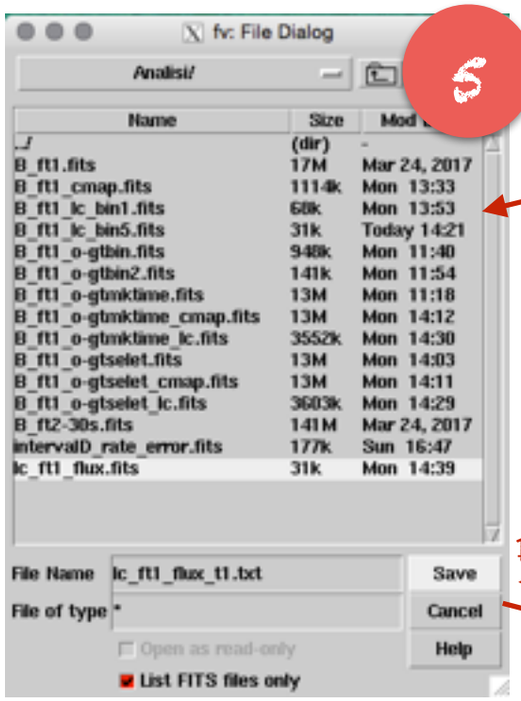


3

press:
- File
- Export as Text...

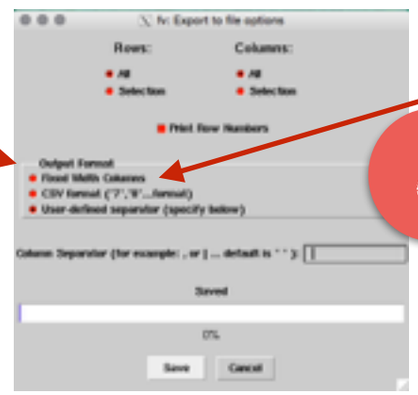


4



5

press:
- Save



6

select:
'Fixed Width Column'

press (again):
- Save

7

type on terminal:
more lc_ft1_flux_t1.txt

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
```

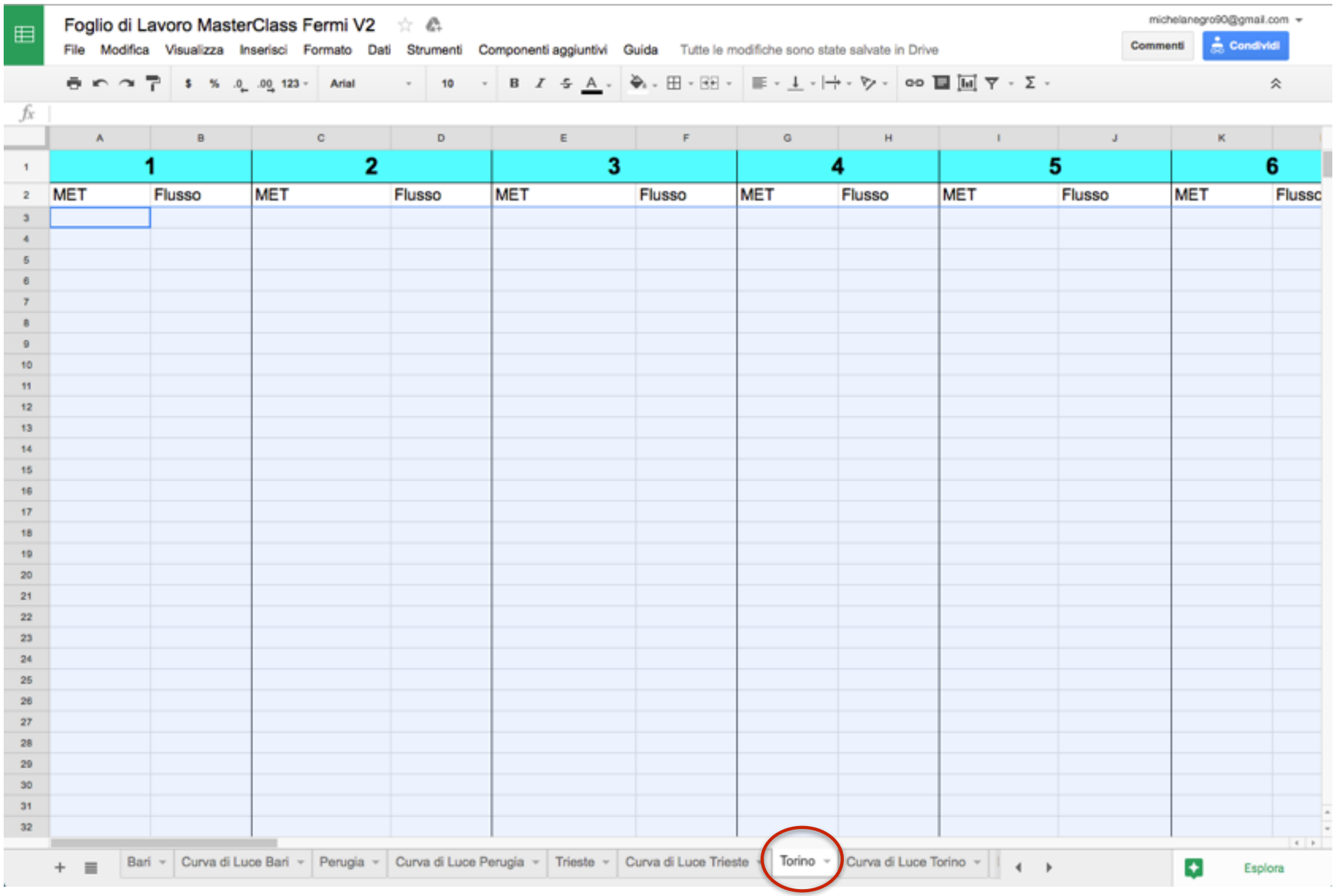
8

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



task 2

3C 454.3 Counts Map

Select the desired events

```
gtselect evclass=128
Input FT1 file[] ft1.fits
Output FT1 file[] map_ft1_gtselect.fits
RA for new search center (degrees) (0:360) [] 343.49
Dec for new search center (degrees) (-90:90) [] 16.148
radius of new search region (degrees) (0:180) [] 5
start time (MET in s) (0:) [] 312768002
end time (MET in s) (0:) [] 314496002
lower energy limit (MeV) (0:) [] 100
upper energy limit (MeV) (0:) [] 200000
maximum zenith angle value (degrees) (0:180) [90] 90
Done.
```

Select the desired events

gtmktime

Spacecraft data file[] **ft2.fits**

Filter expression[]

(DATA_QUAL==1) && ABS(ROCK_ANGLE)<90 && (LAT_CONFIG==1) &&
(angsep(RA_ZENITH,DEC_ZENITH,343.49,16.148)+1<105) &&
(angsep(343.49,16.148,RA_SUN,DEC_SUN)>5+1)
&&(angsep(343.49,16.148,RA_SCZ,DEC_SCZ)<180)

Apply ROI-based zenith angle cut[] **yes**

Event data file[] **map_ft1_gtselect.fits**

Output event file name[] **map_ft1_gtmktime.fits**

ls

new files should have been appeared:

map_ft1_gtselect.fits

map_ft1_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) [] CMAP
Event data file name[] map_ft1_gtmktime.fits
Output file name[] map_ft1_gtbin.fits
Size of the X axis in pixels[] 100
Size of the Y axis in pixels[] 100
Image scale (in degrees/pixel)[] 0.1
Coordinate system (CEL - celestial, GAL -galactic) (CEL|GAL) [] CEL
First coordinate of image center in degrees (RA or galactic l)[] 343.49
Second coordinate of image center in degrees (DEC or galactic b)[] 16.148
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

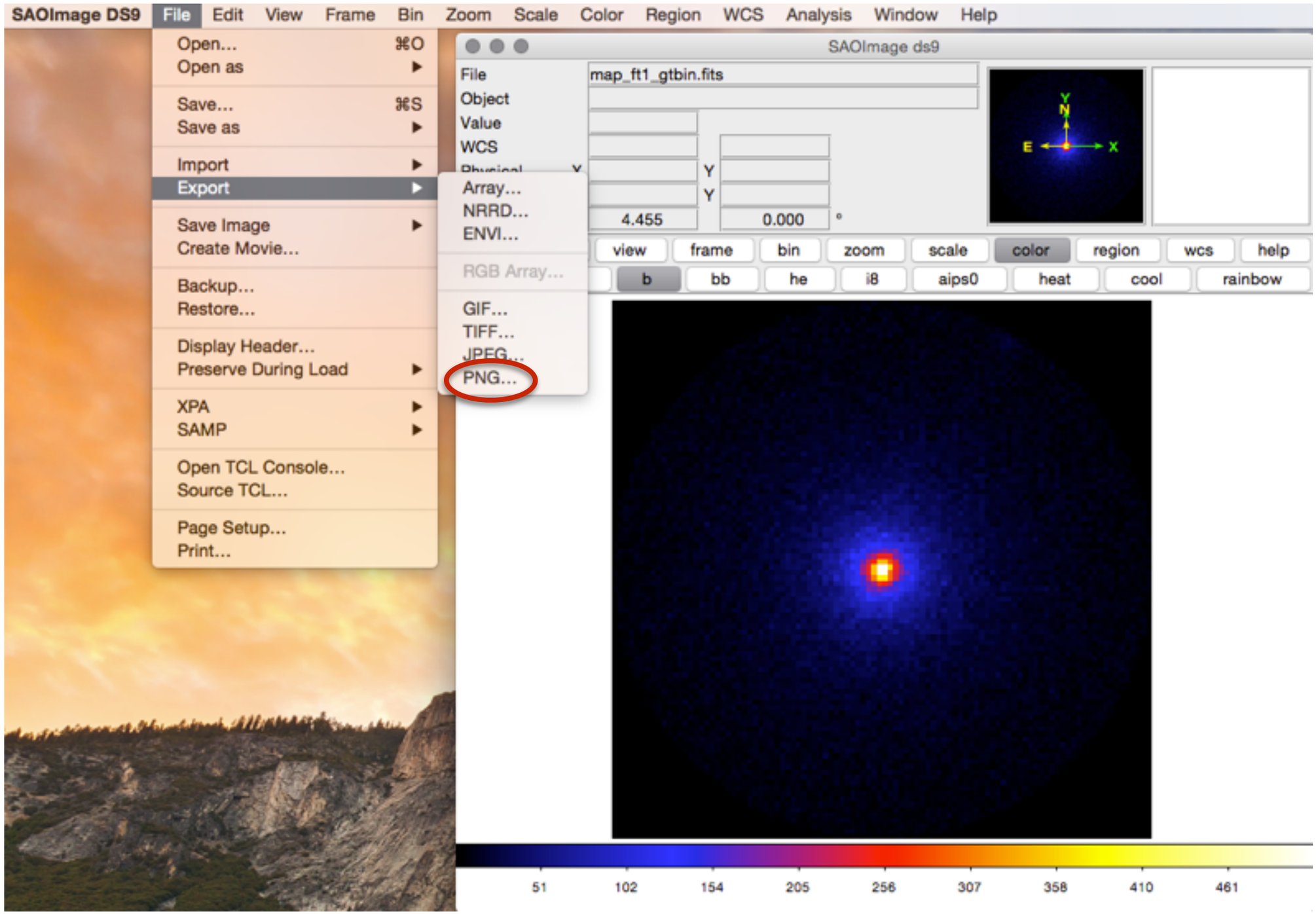
ls

a new file should have been appeared:

map_ft1_gtbin.fits

Let's take a look to the result!

```
ds9 map_ft1_gtbin.fits &
```



... and that's it!!

find your partner

check the dates behind your badge

during the lunch,
find the one who has the same dates

Congratulations!
you will work together!!!