

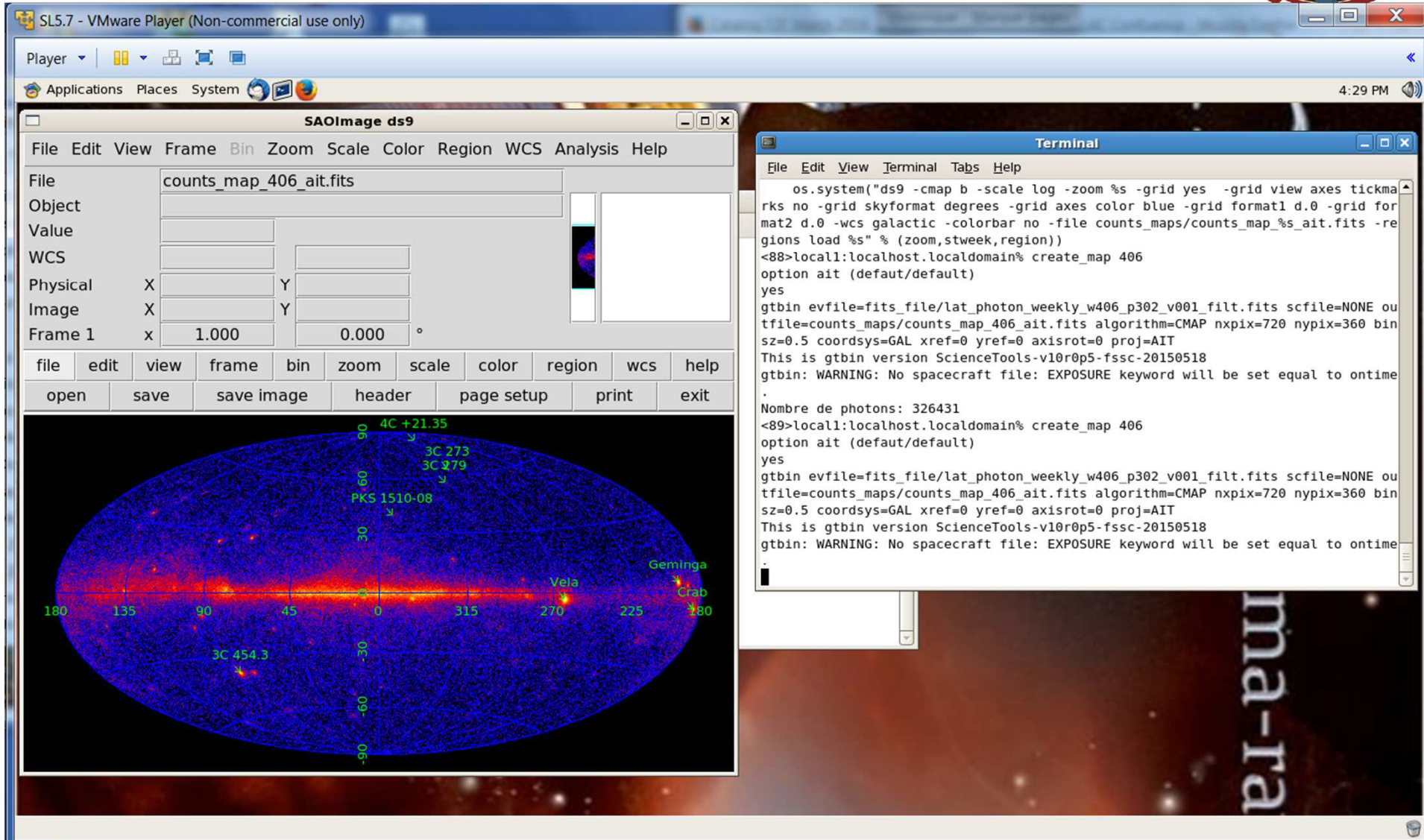
## **Fermi Masterclasses in France**

**Denis Dumora, Benoît Lott  
CEN Bordeaux-Gradignan**

**Eric Nuss  
LUMP, Montpellier**

**Benoît Lott**

# Cosmax (VMWare/Virtual Box/ Linux)

SL5.7 - VMware Player (Non-commercial use only)

Player | Applications Places System | 4:29 PM

**SAOImage ds9**

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

File: counts\_map\_406\_ait.fits

Object: [ ]

Value: [ ]

WCS: [ ]

Physical X: [ ] Y: [ ]

Image X: [ ] Y: [ ]

Frame 1 x: 1.000 y: 0.000 °

file edit view frame bin zoom scale color region wcs help

open save save image header page setup print exit

4C +21.35  
3C 273  
3C 179  
PKS 1510-08  
Vela  
Geminga  
Crab  
3C 454.3

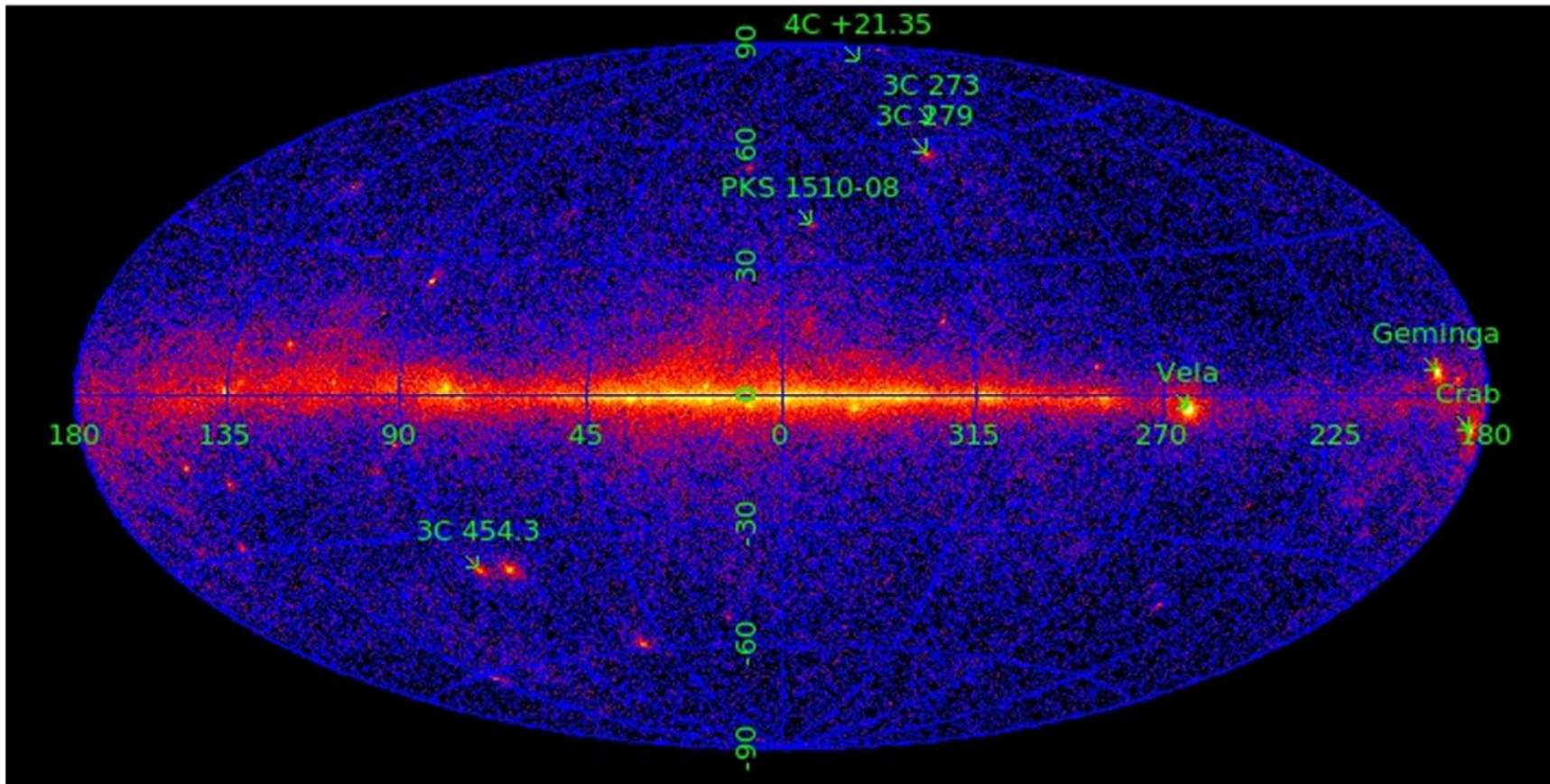
**Terminal**

File Edit View Terminal Tabs Help

```
os.system("ds9 -cmap b -scale log -zoom %s -grid yes -grid view axes tickmarks no -grid skyformat degrees -grid axes color blue -grid format1 d.0 -grid format2 d.0 -wcs galactic -colorbar no -file counts_maps/counts_map_%s_ait.fits -regions load %s" % (zoom,stweek,region))
<88>local1:localhost.localdomain% create_map 406
option ait (defaut/default)
yes
gtbin evfile=fits_file/lat_photon_weekly_w406_p302_v001_filt.fits scfile=NONE outfile=counts_maps/counts_map_406_ait.fits algorithm=CMAP nxpix=720 ny pix=360 bin sz=0.5 coordsys=GAL xref=0 yref=0 axisrot=0 proj=AIT
This is gtbin version ScienceTools-v10r0p5-fssc-20150518
gtbin: WARNING: No spacecraft file: EXPOSURE keyword will be set equal to ontime
.
Nombre de photons: 326431
<89>local1:localhost.localdomain% create_map 406
option ait (defaut/default)
yes
gtbin evfile=fits_file/lat_photon_weekly_w406_p302_v001_filt.fits scfile=NONE outfile=counts_maps/counts_map_406_ait.fits algorithm=CMAP nxpix=720 ny pix=360 bin sz=0.5 coordsys=GAL xref=0 yref=0 axisrot=0 proj=AIT
This is gtbin version ScienceTools-v10r0p5-fssc-20150518
gtbin: WARNING: No spacecraft file: EXPOSURE keyword will be set equal to ontime
.
```



# The current sky (week 460)



# Cosmax: contributed software



https://fermi.gsfc.nasa.gov/ssc/data/analysis/user/ 80 % Bayesian Information Criterion

NASA National Aeronautics and Space Administration  
Goddard Space Flight Center

Fermi Science Support Center

Home Observations **Data** Proposals Library HEASARC Help Site Map

**Data**

- ▶ Data Policy
- ▶ Data Access
- ▶ Data Analysis
  - + System Overview
  - + Software Download
  - + Documentation
  - + Cicerone
  - + Analysis Threads
  - + User Contributions
- ▶ Caveats
- ▶ Newsletters
- ▶ FAQ

## User Contributions

The FSSC welcomes contributions to the Fermi Science Tools from the scientific community. If you have developed an extension to the science tools or any other tool useful for Fermi data analysis, please let us know and we will post it on this website. While the FSSC will work with the developer to resolve any issues with the software the contribution is provided "as is" and may not work after a software or data upgrade (e.g. to pass 8 data), updating the tool or script remains the responsibility of the developer. For the moment, please direct any communication to the [Help Desk](#).

Program	Purpose	Read Me	Last Update	Author
<a href="#">GBM_TTE_TGF_SW.v1c.tar.gz</a>	Provides TGF analysis tools for the GBM TTE data products. The version v1c is an update for the Dec 31 2016 leap second and includes update files for longitude calculations.	<a href="#">PDF</a>	Feb 9, 2016	G. Fitzpatrick, M. Briggs
<a href="#">cosmax</a>	This is an outreach-oriented suite of simple tools enabling non-experts to create sky maps, animations, etc, with the Fermi-LaT data.	<a href="#">ReadMe</a>	May 13, 2016	B. Lott and D. Dumora

<http://www.cenbg.in2p3.fr/COSMAX-Cosmic-accelerators-at-home>

[ftp://www.cenbg.in2p3.fr/astropart/VM/cosmax\\_english.pdf](ftp://www.cenbg.in2p3.fr/astropart/VM/cosmax_english.pdf)



# Fermi masterclasses

<https://confluence.slac.stanford.edu/display/SCIGRPS/Masterclass+with+the+Fermi-LAT+data>



# Fermi Masterclasses in France

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- **2015: Three high-school classes, two in the Bordeaux area, one in the Montpellier area (~70 students)**
- **2016: Two high-schools classes, in the Bordeaux and Montpellier area (60 students) in November.**
- **Theme: « Black holes » (as seen by the Fermi-LAT)**
- **Study of the bright flare of 3C454.3 in Nov. 2010 and GRB 080916C (maps, lightcurves, computation of luminosity or fluence), Some published results/figures were replicated.**
- **Very positive experience according to all parties**
- **Thanks to Roopesh Ojah for devoting some his time to answering questions!**

# Agenda



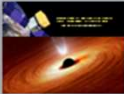



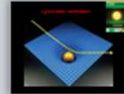


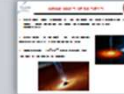



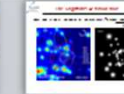


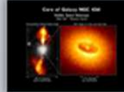
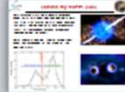









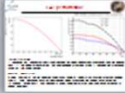



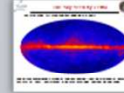
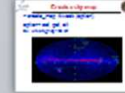

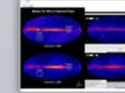

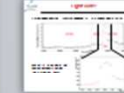
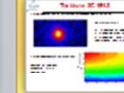
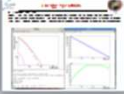



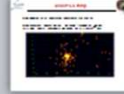


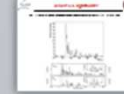
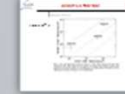






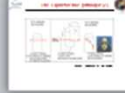
- Introduction
- Background on black holes (blazars, gamma-ray bursts)
- Background on gamma-ray astronomy
- Notions of flux and luminosity
- The Fermi-LAT telescope
- The Fermi-LAT data
- Creation of sky maps
- Study of a blazar outburst
- Study of a gamma-ray burst
- Video connection with D.J. Thompson/R. Ojha (NASA)



*Full presentation:*

[https://confluence.slac.stanford.edu/download/attachments/209365302/Masterclasse\\_2015\\_eng.pptx](https://confluence.slac.stanford.edu/download/attachments/209365302/Masterclasse_2015_eng.pptx)



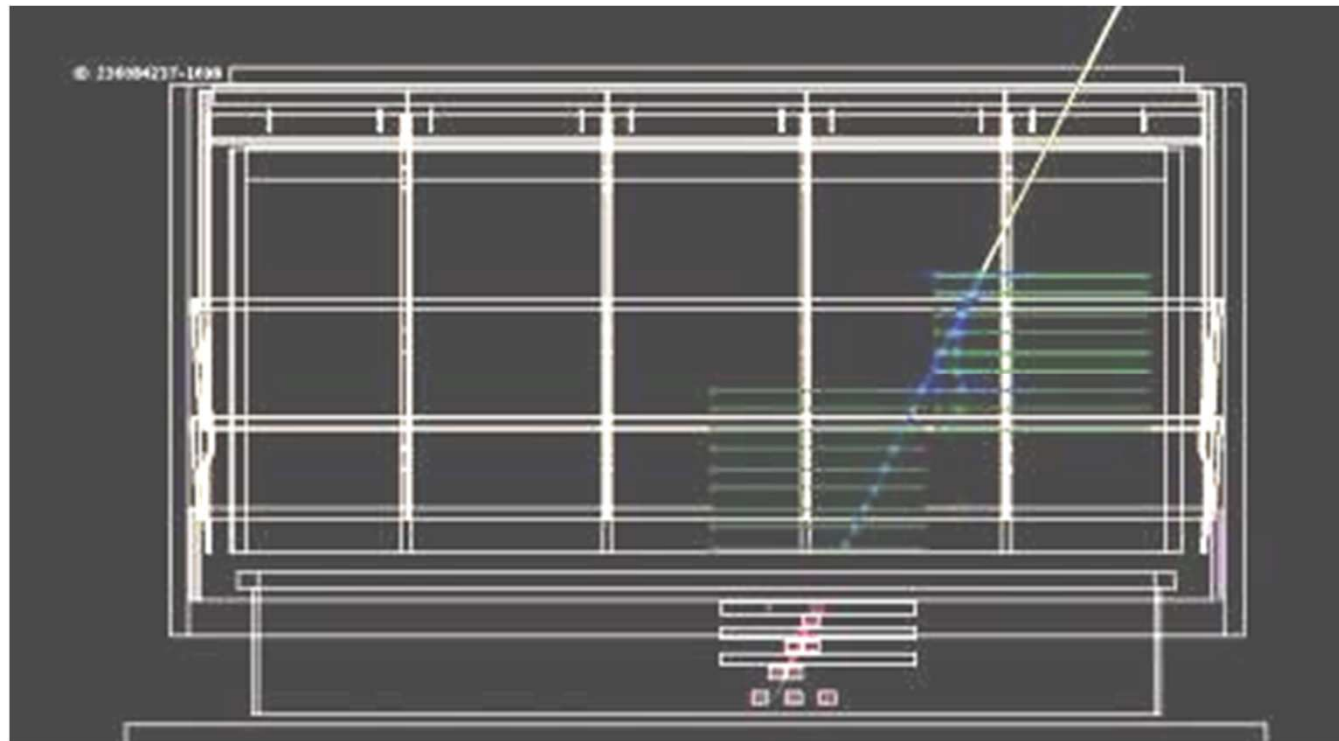
											
1	2	3	4	5	6	7	8	9	10	11	12
											
13	14	15	16	17	18	19	20	21	22	23	24
											
25	26	27	28	29	30	31	32	33	34	35	36
											
37	38	39	40	41	42	43	44	45	46	47	48
											
49	50	51	52								




## Background rejection (project)



**Goal:** After a quick training, try to tell from the event displays whether the primary particles are most likely photons or charged cosmic rays.  
Guess the energy: low, medium, high?  
( Do it for 20 events. What is your score?)







NASA Home >

Missions

Missions High

Current Missi

Current Missio

Fermi Gamm

Telescope

Science

Launch

Multimedia

Spacecraft and Instruments

Team

News and I

Past Missions

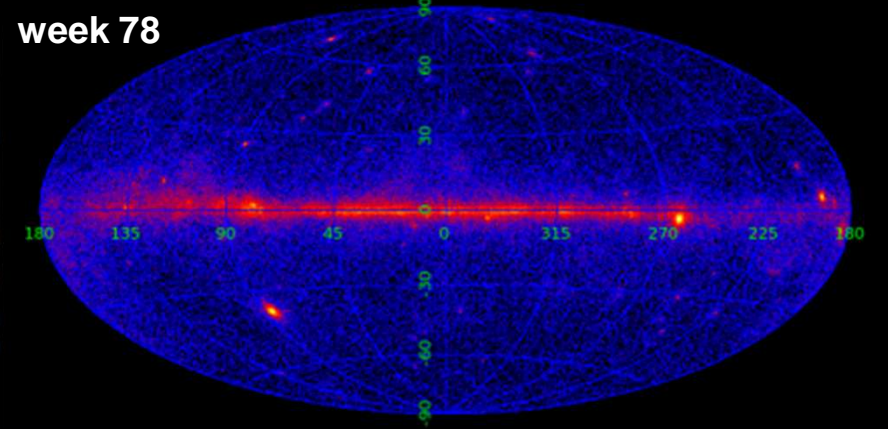
Future Missio

Launch Sched

Mission Calen

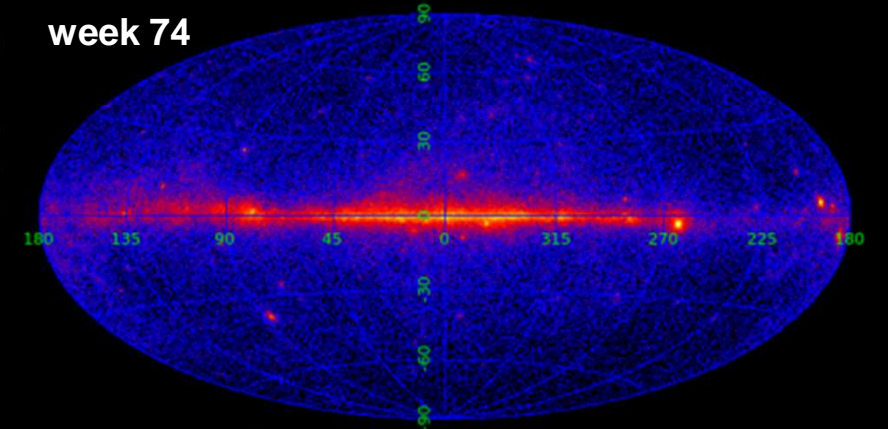
NEWS  
News, features & press
MISSIONS  
Current, future, past
MULTIMEDIA  
Images, videos,
CONNECT  
Social media channels  
NASA apps
ABOUT NASA  
Leadership, organization,  
budget, careers & more

**week 78**



**Fermi Sees Brightest-Ever Blazar Flare**


**week 74**



**Blazars, like many active galaxies, emit oppositely directed jets of particles traveling near the speed of light when matter falls toward their central supermassive black holes. What makes a blazar so bright in gamma rays is its orientation: One of the jets happens to be aimed straight at us.**

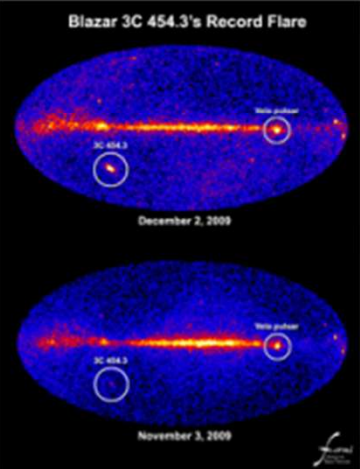
Search

Send Print Share



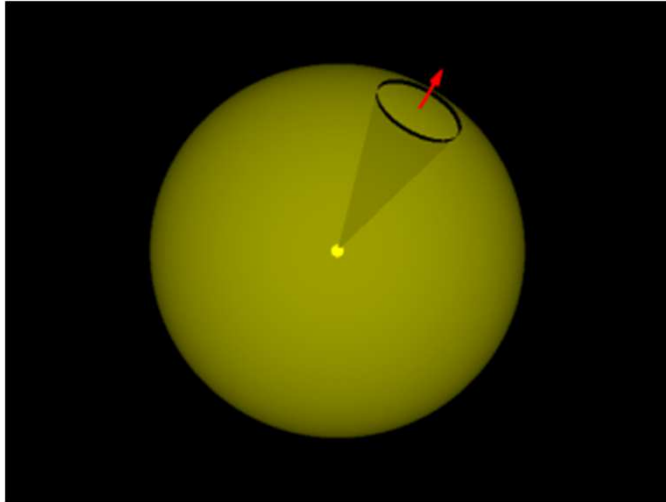
12.08.09

**Blazar 3C 454.3's Record Flare**



Unprecedented flares from the blazar 3C 454.3 in the constellation Pegasus now make it the brightest persistent

# Flux and luminosity



- *The number of photons emitted in a cone per second remains constant and thus is independent of the distance to the source.*
- *At a given distance, the area of a sphere intercepting the cone scales as the square of the distance.*
- *So the number of photons per square cm and second (= the flux) is inversely proportional to the distance squared ("inverse-square law").*

CERN 03/2017

**Flux**  $F_p = N / S T$

$F_p$  = Flux (ph cm<sup>-2</sup> s<sup>-1</sup>)

$N$  = Number of collected photons

$S$  = Collecting area (cm<sup>2</sup>)

$T$  = Collecting time (s)

**Energy flux**  $F_E = F_p E$

$F_E$  = Energy flux (W cm<sup>-2</sup>)

$E$  = Mean photon energy (MeV)

1 MeV = 1.6 10<sup>-13</sup> J

**Fluence**  $F = N E / S$

$F$  = Fluence (J cm<sup>-2</sup>)

$N$  = Number of collected photons

$S$  = Collecting area (cm<sup>2</sup>)

**Luminosity**  $L = 4 \pi d^2 F_E$

$L$  = Luminosity (W)

$d$  = distance (cm)

Luminosity of the Sun: 4 10<sup>26</sup> W

Luminosity of the Milky Way: 5 10<sup>36</sup> W

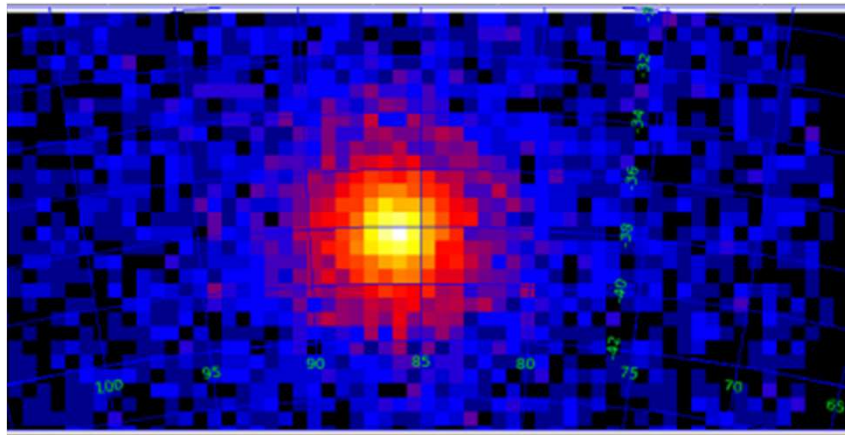
Benoit Lott



# The blazar 3C 454.3



```
> create_map 129 ait 311731200 311990400 343.5 16.15 15
```



$$F_p = N / (S \times T)$$

$N$  = Number of collected photons

$S$  = Collecting area (cm<sup>2</sup>)

$T$  = Collection time (s)

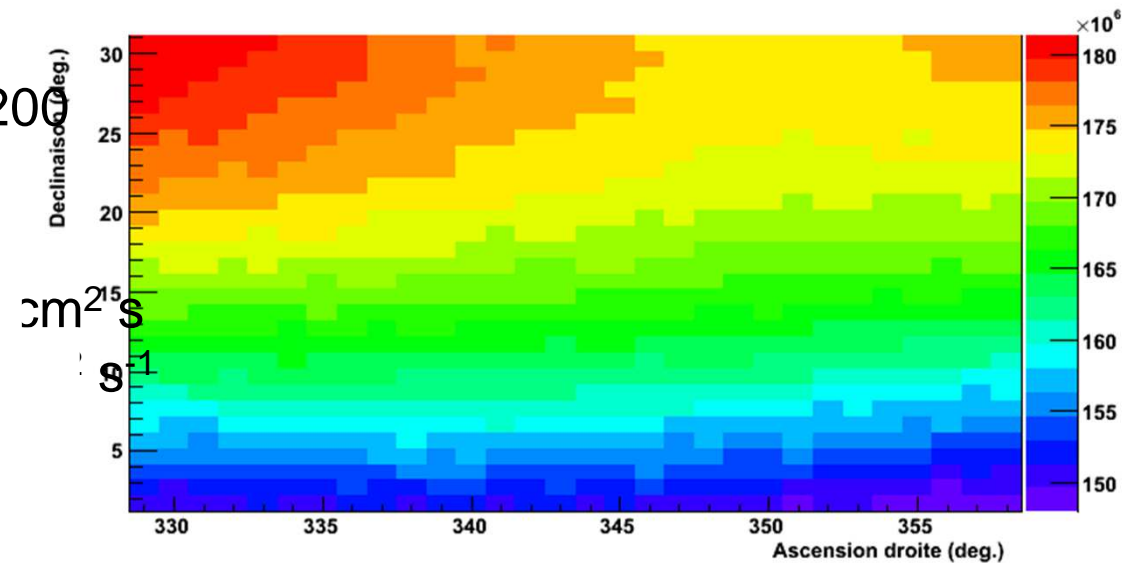
The product  $S \times T$  is called *exposure*.

```
> create_exposure 129 map 200
```

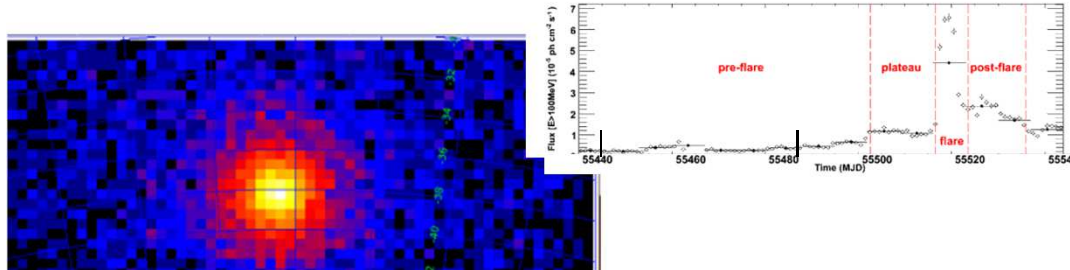
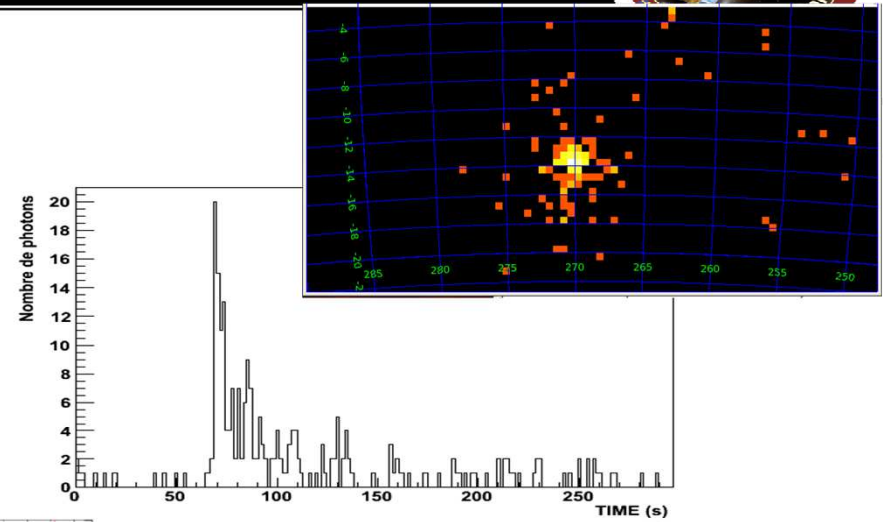
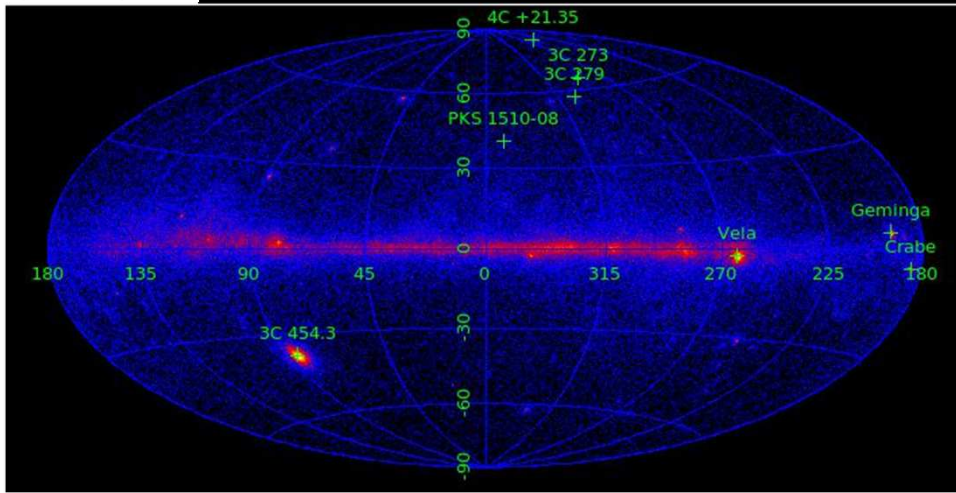
Number of photons: 5

Exposure (S x

Photon flux

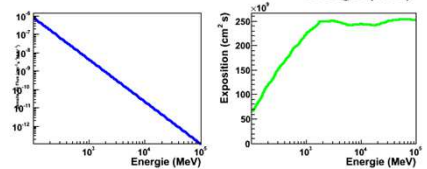
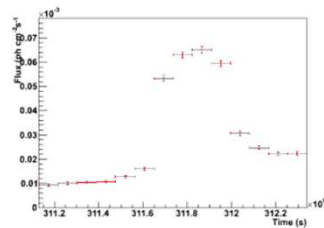
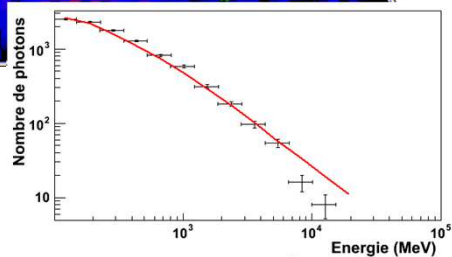


# Some highlights



Fv: Summary of lat\_photon\_weekly\_wd15\_p130\_v001\_fit.fits in /home/local1/fits\_file/

Index	Extension	Type	Dimension	View
0	Primary	Image	0	Header Image Table
1	EVENTS	Binary	22 cols X 262496 rows	Header Hist Plot All Select
2	GTI	Binary	2 cols X 108 rows	Header Hist Plot All Select



Fv: Binary Table of lat\_photon\_weekly\_wd15\_p130\_v001\_fit.fits[1] in /home/local1/fits\_f

Select	ENERGY	RA	DEC	L	B	THETA
Invert	MeV	deg	deg	deg	deg	deg
	Modify	Modify	Modify	Modify	Modify	Modify
1	5.948376E+02	3.190671E+02	-3.705634E+01	6.410967E+00	-4.397406E+01	7.043832E+01
2	3.559989E+02	5.263270E+01	2.587974E+01	1.622107E+02	-2.460732E+01	4.078584E+01
3	4.959988E+02	3.013696E+02	3.537136E+01	7.224776E+01	1.923292E+00	6.550476E+01
4	2.561439E+02	4.725511E+00	6.717814E+01	1.197768E+02	4.506552E+00	5.332901E+01
5	3.140352E+02	3.761794E+01	4.568155E+01	2.628327E+02	-6.298319E+01	6.428506E+01
6	4.192114E+02	5.025957E+01	5.157824E+01	1.451875E+02	-4.710841E+00	4.850282E+01
7	2.660367E+02	7.625768E+01	3.367800E+00	1.969225E+02	-2.178014E+01	6.450130E+01
8	7.746436E+02	4.434700E+01	2.130900E+01	1.582946E+01	-3.277552E+01	3.153118E+01
9	4.046572E+02	6.938319E+01	3.018223E+01	1.702534E+02	-1.125100E+01	5.469625E+01
10	1.369719E+02	5.213140E+01	3.194742E+01	1.578145E+02	-2.008077E+01	4.040837E+01
11	3.997244E+02	3.530521E+02	1.868325E+01	9.797916E+01	-4.041833E+01	1.891041E+01
12	1.658488E+02	3.066959E+02	4.506220E+01	8.256982E+01	3.941032E+00	6.277695E+01
13	4.585629E+03	1.083242E+01	3.266071E+01	1.209584E+02	-3.017991E+01	1.832021E+01
14	3.793775E+02	4.164798E+01	1.037430E+01	1.634978E+01	-4.324523E+01	2.875199E+01
15	1.526924E+02	3.383994E+02	3.378288E+01	7.933768E+01	-3.716058E+01	3.307420E+01
16	1.013430E+02	3.353424E+02	1.529149E+01	7.774402E+01	-3.410194E+01	3.591610E+01
17	1.856867E+02	3.167148E+01	2.925471E+01	1.420531E+02	-3.080777E+01	2.286978E+01
18	2.878818E+02	3.101717E+02	3.919566E+01	7.939149E+01	-1.622287E+00	5.984022E+01
19	5.396586E+02	3.551581E+02	5.789342E+01	1.136128E+02	-3.691428E+00	4.532473E+01
20	2.429480E+02	5.011462E+01	5.818341E+01	1.415458E+02	8.026558E-01	5.125824E+01

# Conclusions

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- **Interested in using cosmax?  
Feedback, suggestions welcome.**
- **We are promoting the masterclasses at the  
local and national levels.**



# The COSMIX kit

