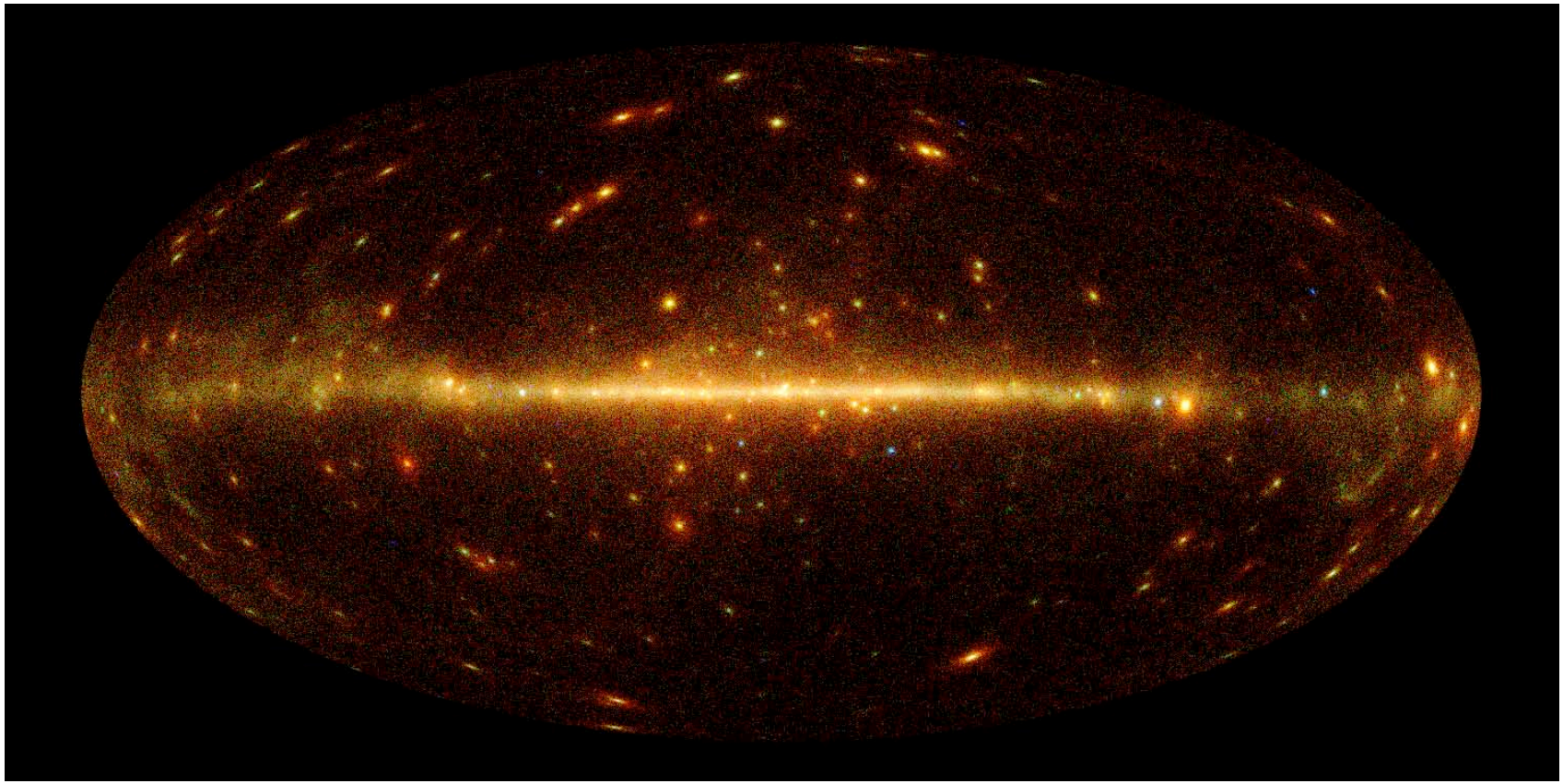
Data Challenge II



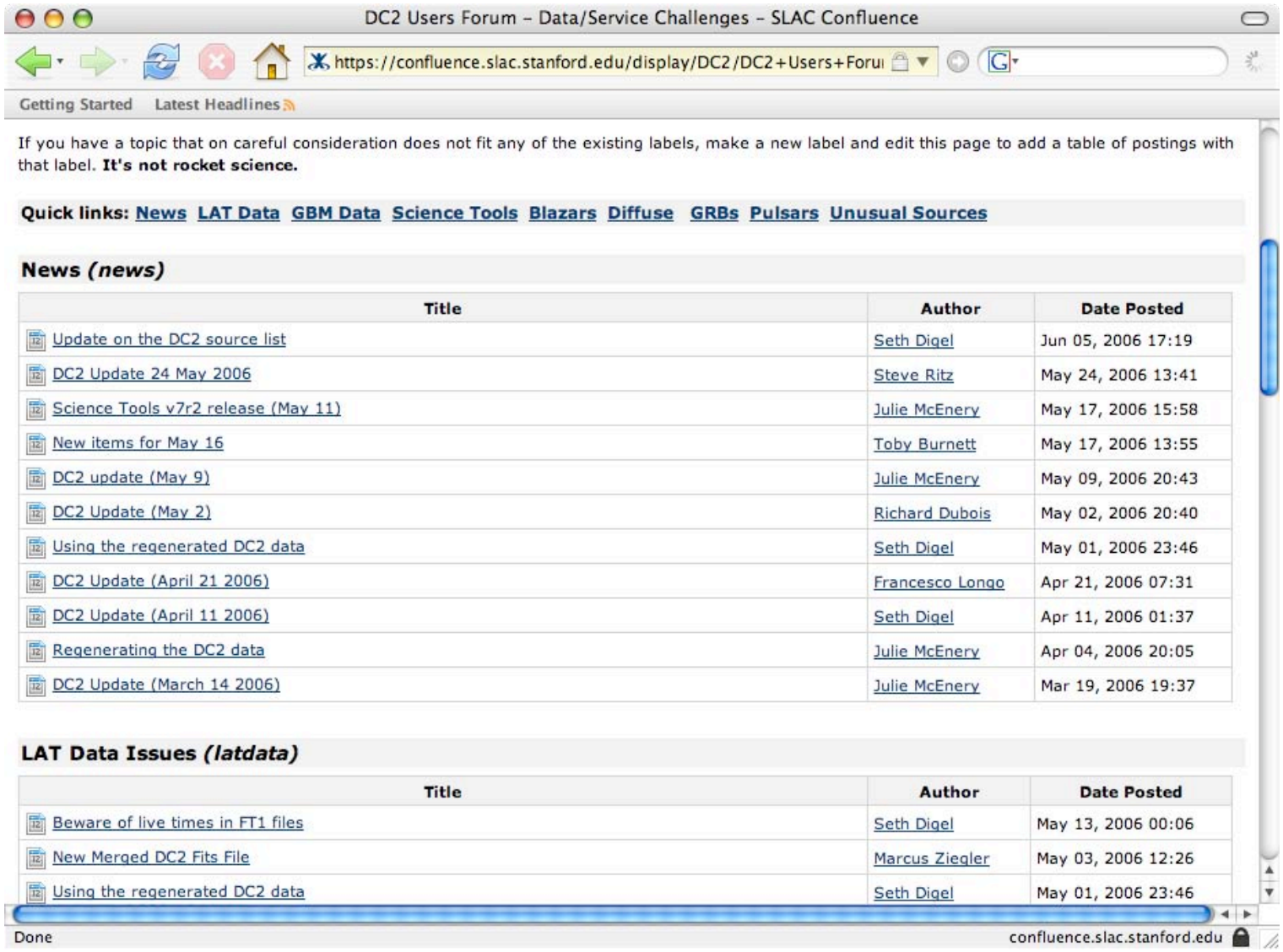
Source Definitions

- *Seth Digel, Diego Torres & Olaf Reimer* on high-latitude molecular clouds, SNRs, XRBs, OB associations, Galaxies and Galaxy clusters
- *Omar Tibolla* on specific models of HESS SNR
- *Max Razzano & Alice Harding* on detailed definitions of pulsars
- *Larry Wai & Ping Wang* - dark matter sources
- *Seth Digel, Igor Moskalenko & Andy Strong* on GALPROP model calculations - diffuse emission of the Milky Way
- Seth Digel - solar flare, moon, EGRET Unids
- Jim Chiang, Gino Tosti, Paolo Giommi, Julie McEnery - AGN
- Nicola Omodei, Valerie Connaughton, David Band, Julie McEnery - GRB
- Luis Reyes - EBL model implementation

DC2 Goals, requirements and purpose

- **55 days of LAT data provide a deeper view of the high energy gamma-ray sky than has previously been achieved.**
  - **Results from previous gamma-ray missions provide, at best, an incomplete guide to the DC2 sky.**
  - **Part of the challenge of DC2 will be to figure out what was included in the sky model.**
  - **DC2 data has a fairly realistic level of detail which will support a wide variety of both science and instrument performance studies.**
  - **Exercise the science tools – but don't feel restricted to them**
  - **Improve the documentation and analysis software from user feedback.**

Internal Communication

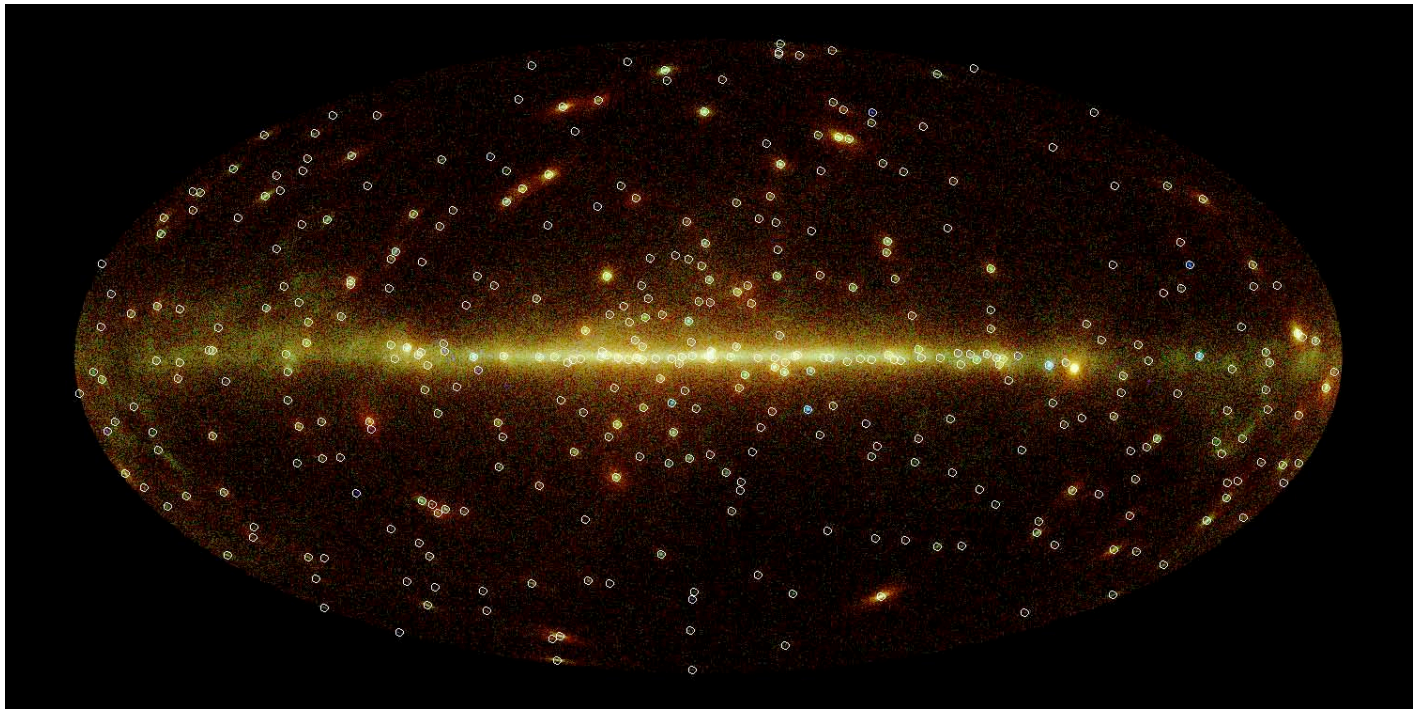


DC2 Point Source Catalog

Catalog analysis pipeline developed by Jean Ballet and collaborators, runs a source detection algorithm and then runs likelihood analysis to produce a table of the basic gamma-ray properties of each source.

Released at the beginning of DC2, it provided a starting point for a large fraction of the more detailed source analysis and was a reference for people doing population/source detection type studies.

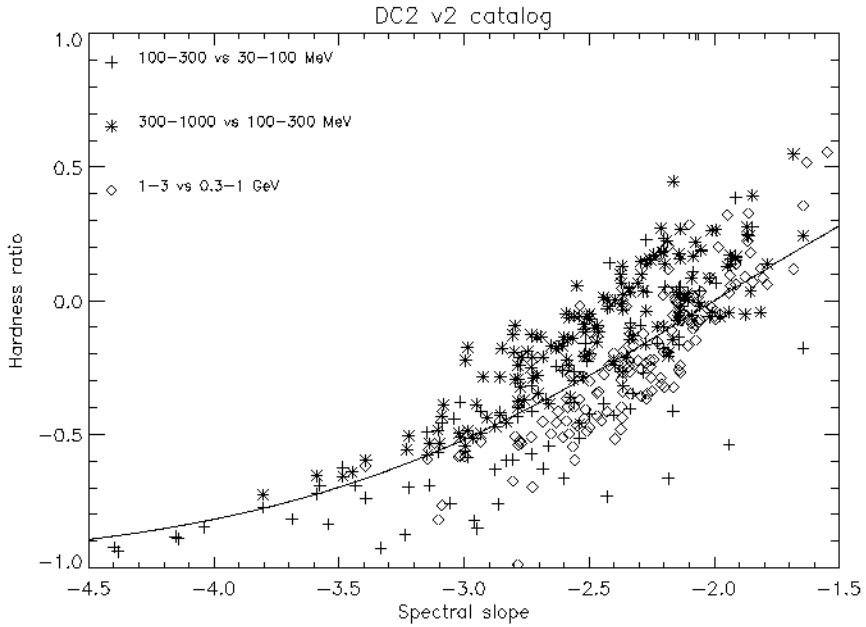
380 sources



Produce LAT point source catalog

- **Requirement: Spectral index and flux (with associated uncertainties), location with 68% and 95% confidence ranges, flux in discrete energy bands.**
- **Goal: Variability index, flux history,** peak flux, measure of whether a source is extended.

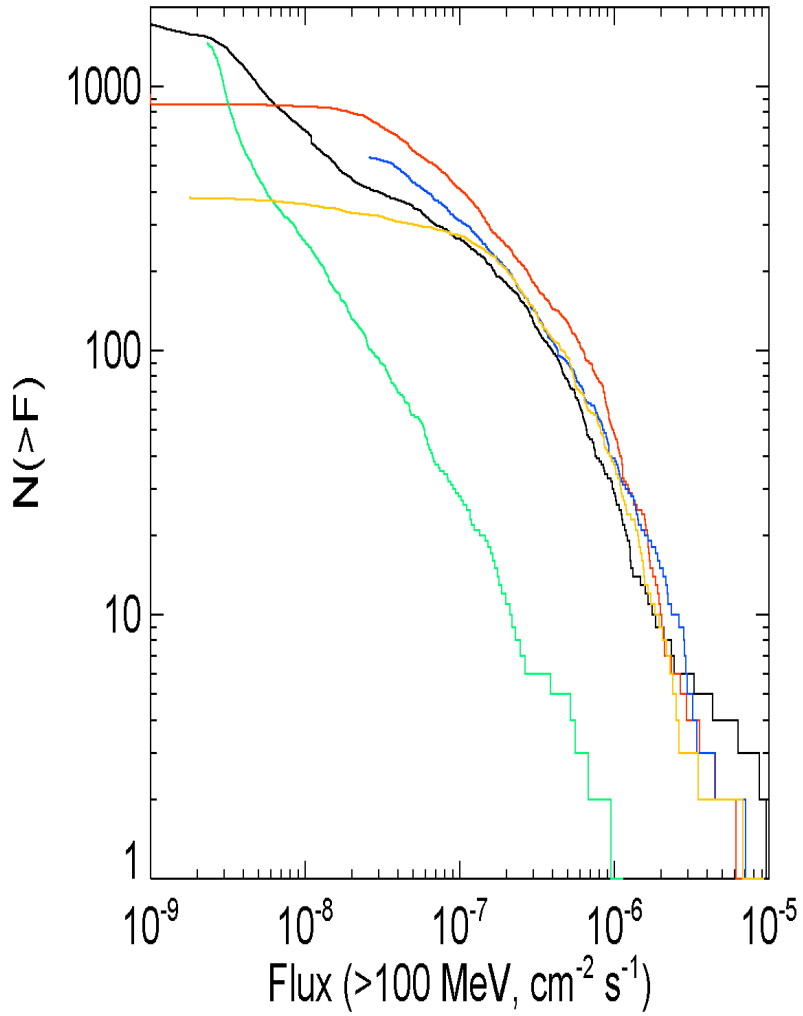
Hardness ratio vs global slope



- ✓$HR_i = (F_{i+1}-F_i)/(F_{i+1}+F_i)$
- ✓The full line is the theoretical value for a power law spectrum with 2 bands per decade
- ✓HR2 (stars) looks systematically larger than HR3 (diamonds)

Develop and test source detection algorithms

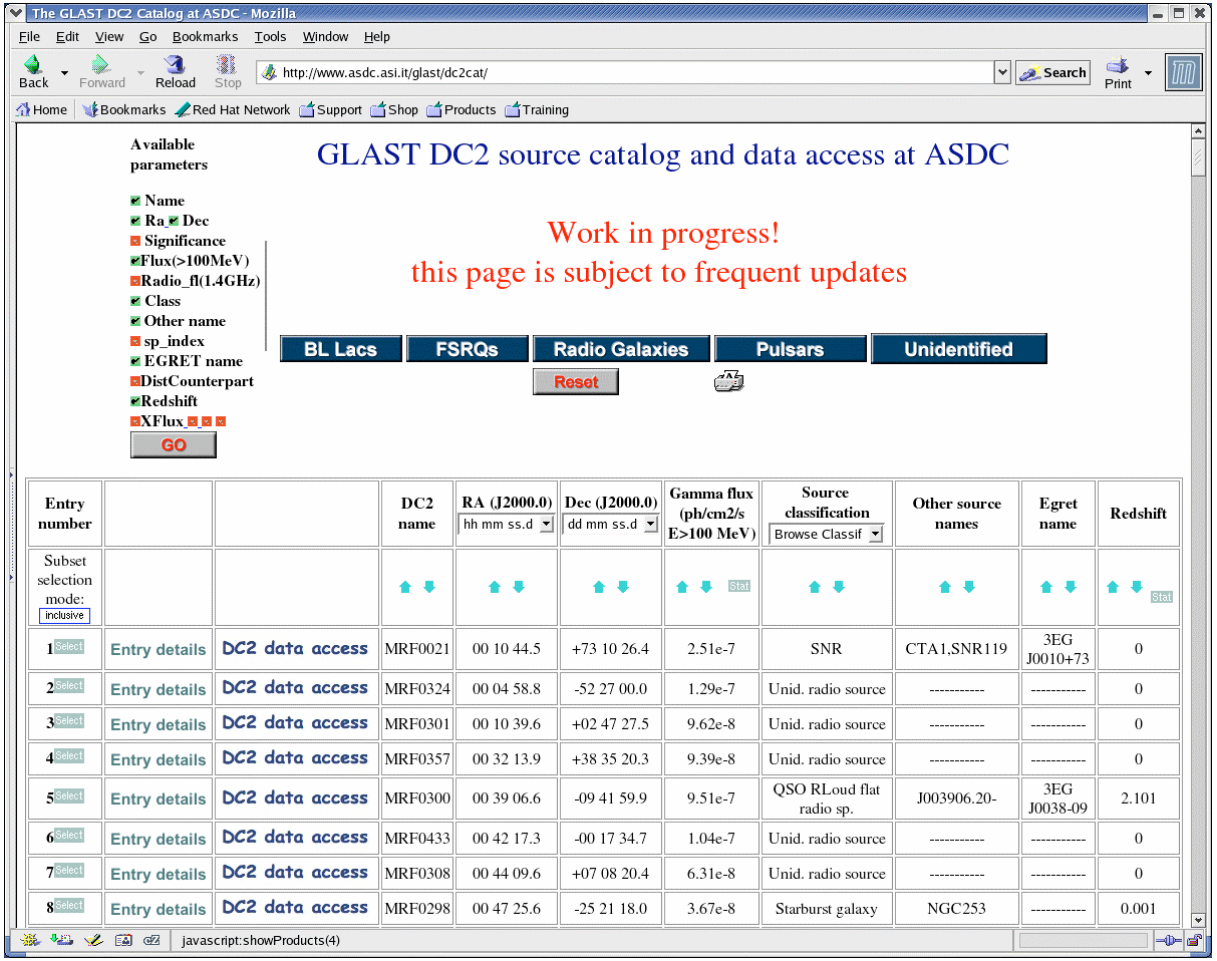
- **Requirement: That these algorithms are tested and compared with one another in a systematic way using the DC2 data.**
  - **Many source detection methods developed – Stephens, Tosti, Burnett, Casandjian, Ballet, Romeo/Cillis**
  - **Compared with one another by Seth Digel**



More on Catalogs

Cross reference the catalog sources against other catalogs to produce identifications.

Displays the catalog data in an interactive way and links in data from other wavelengths.

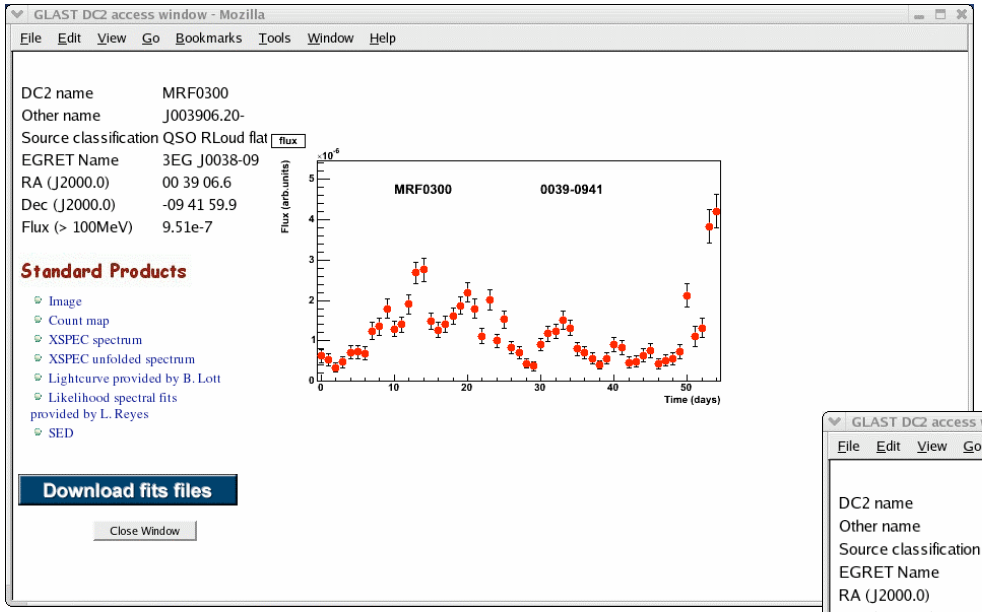


Entry number			DC2 name	RA (J2000.0) hh mm ss.d	Dec (J2000.0) dd mm ss.d	Gamma flux (ph/cm2/s E>100 MeV)	Source classification Browse Classif	Other source names	Egret name	Redshift
Subset selection mode: inclusive										
1 Select	Entry details	DC2 data access	MRF0021	00 10 44.5	+73 10 26.4	2.51e-7	SNR	CTA1,SNR119	3EG J0010+73	0
2 Select	Entry details	DC2 data access	MRF0324	00 04 58.8	-52 27 00.0	1.29e-7	Unid. radio source	----------	----------	0
3 Select	Entry details	DC2 data access	MRF0301	00 10 39.6	+02 47 27.5	9.62e-8	Unid. radio source	----------	----------	0
4 Select	Entry details	DC2 data access	MRF0357	00 32 13.9	+38 35 20.3	9.39e-8	Unid. radio source	----------	----------	0
5 Select	Entry details	DC2 data access	MRF0300	00 39 06.6	-09 41 59.9	9.51e-7	QSO RLoud flat radio sp.	J003906.20-	3EG J0038-09	2.101
6 Select	Entry details	DC2 data access	MRF0433	00 42 17.3	-00 17 34.7	1.04e-7	Unid. radio source	----------	----------	0
7 Select	Entry details	DC2 data access	MRF0308	00 44 09.6	+07 08 20.4	6.31e-8	Unid. radio source	----------	----------	0
8 Select	Entry details	DC2 data access	MRF0298	00 47 25.6	-25 21 18.0	3.67e-8	Starburst galaxy	NGC253	----------	0.001

Produced by ASDC group – Giommi and collaborators

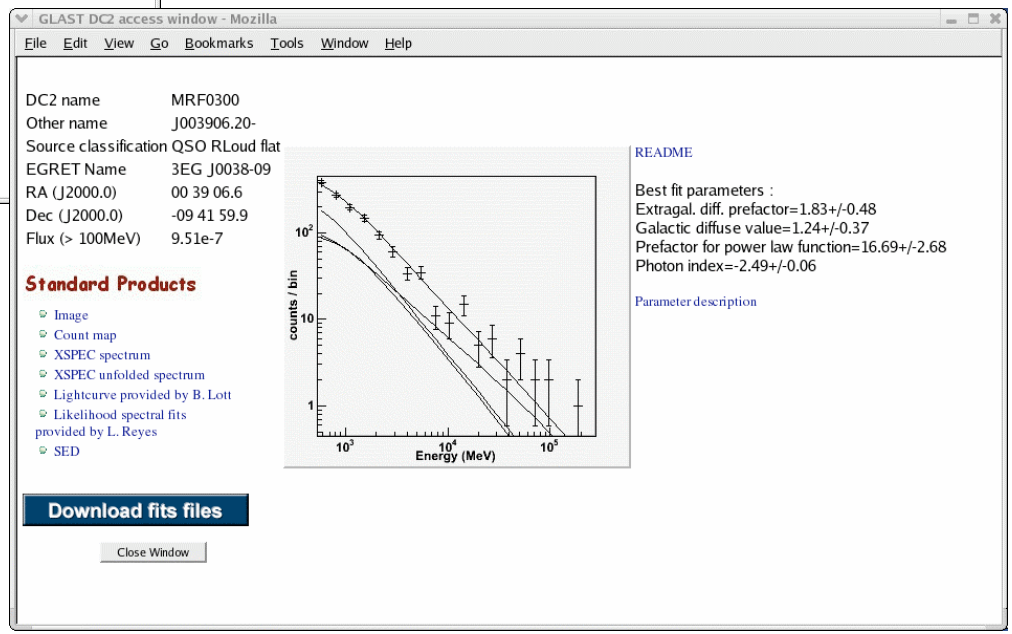
Lightcurves and Spectra

From the catalog at ASDC, there are links from each source to DC2 data products



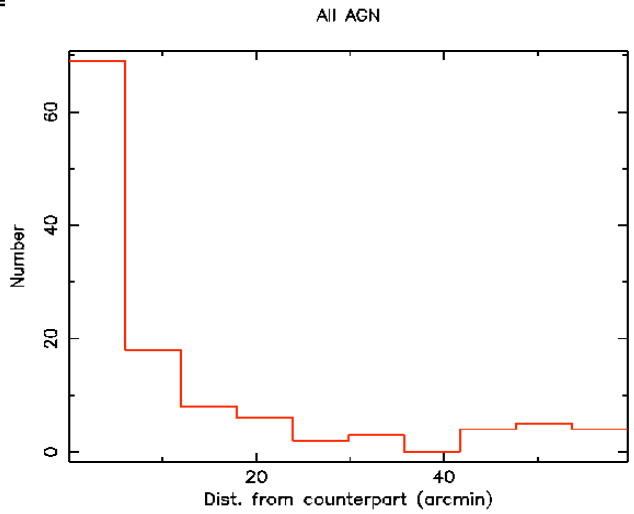
lightcurves produced by Benoit Lott for bright sources in the catalog. These are corrected for exposure variations and are background subtracted

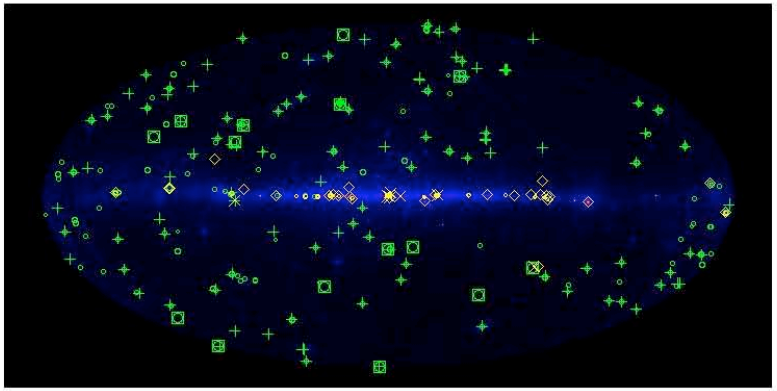
Spectral fits for each source were produced by Luis Reyes. These are simple power-law fits, but provide a plot which can guide users to different models if needed.



Source Identification

- This was not identified as either a requirement or a goal, but there was some significant work in this area by Lonjou and Pittori.
- ASDC catalog webpage was a big hit with DC2 users, very convenient way for people to browse high-level DC2 results.





Extra-galactic sources
169

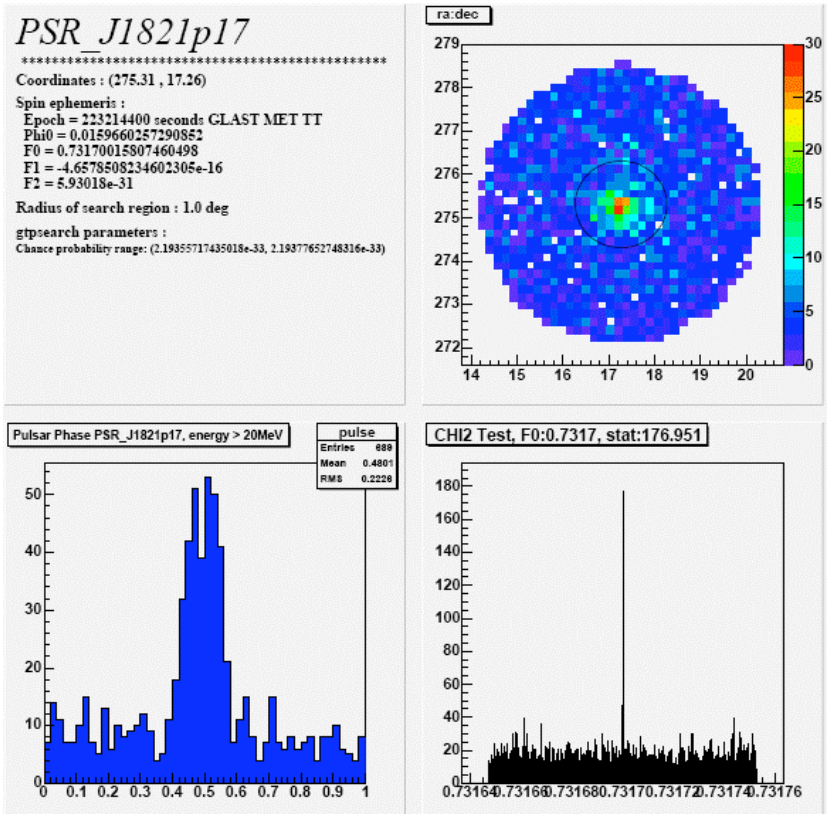
Galactic sources
39

Identified sources
55 %
= f (probability threshold)

Pulsars

- **Requirement: Determine the gamma-ray lightcurves for at least 6 pulsars which have an exact ephemeris.**
- **Requirement: Determine timing properties of pulsars and produce gamma-ray lightcurves for at least one pulsar with an approximate ephemeris.**
- **Goal: Determine lightcurves for more of the fainter pulsars in the DC2 data.**
- **Results for all the pulsars in the ephemerides were produced by Smith et al, Max Razzano and Andrea Caliandro.**

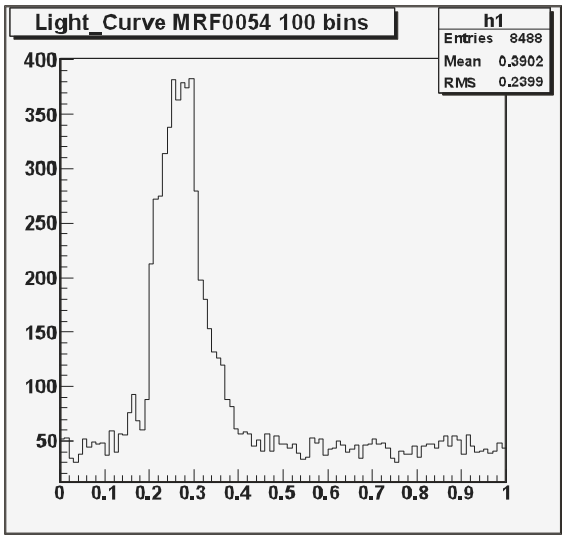
From David Smith's talk



Pulsars

– **Goal: blind periodicity searches on candidate DC2 pulsars**

Marcus Ziegler – lightcurves of pulsars withut radio data.

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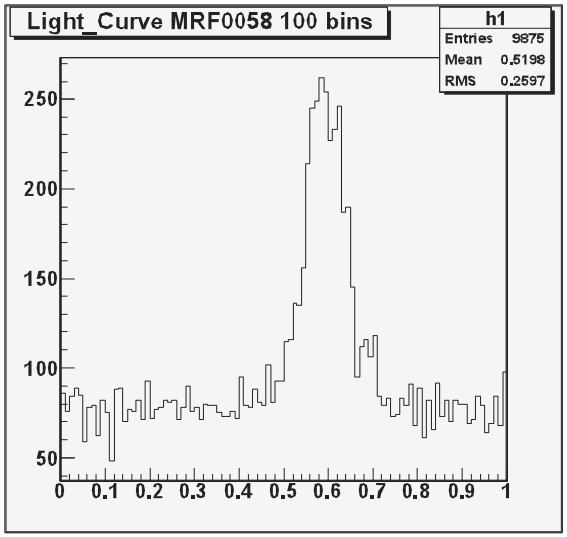
Epoch_MET =  220838550
F0=  5.885928323969
F1= -1.306230        e-012
F2=  1.0             e-021
```

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F1 = -1.936137       e-013
F2 =  6.0            e-022
```
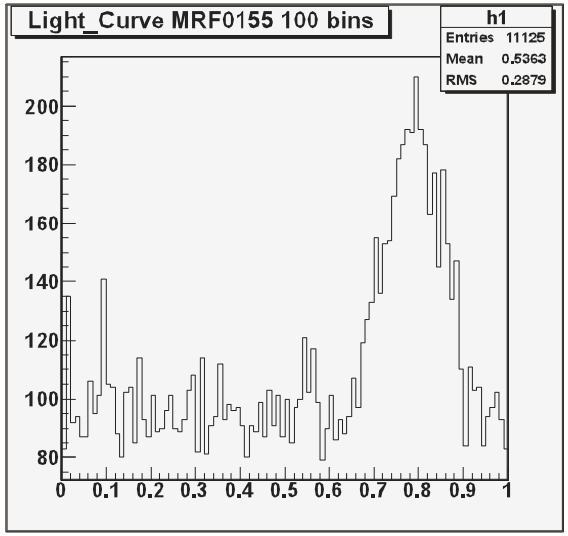
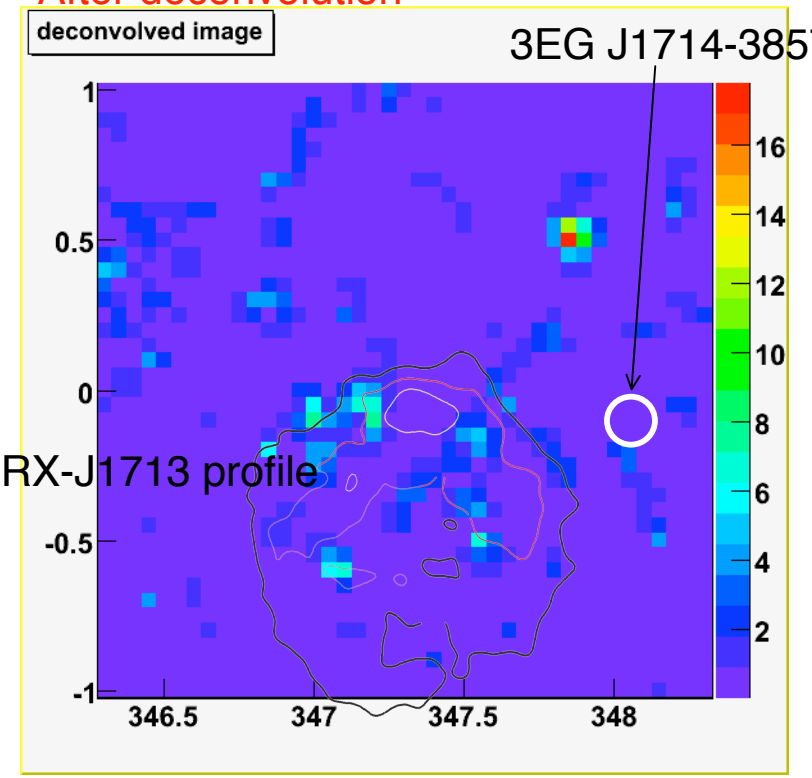




```
Epoch_MET =  220838550
F0 =  3.766282209980
F1 = -3.677283       e-013
F2 = -3.3            e-021
```

Extended sources

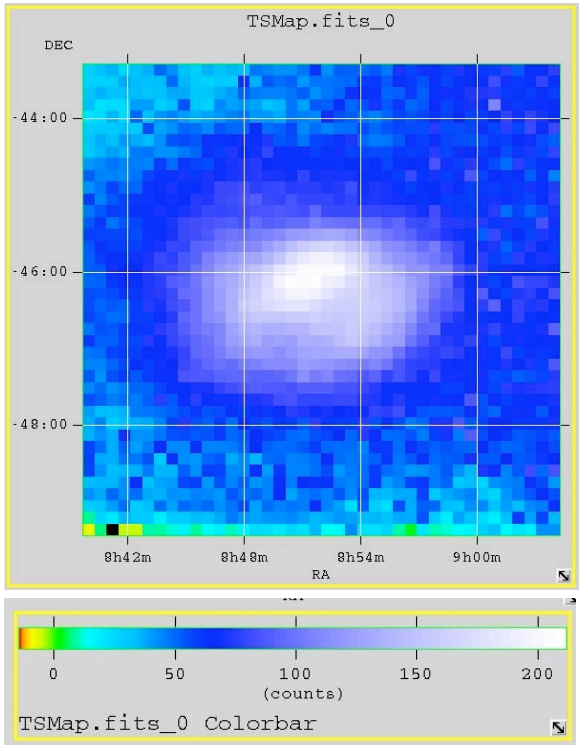
- Goal: To identify extended sources in the DC2 data (there are some…)
- Goal: Perform spatially resolved spectroscopy.

After deconvolution



Hiro Tajima

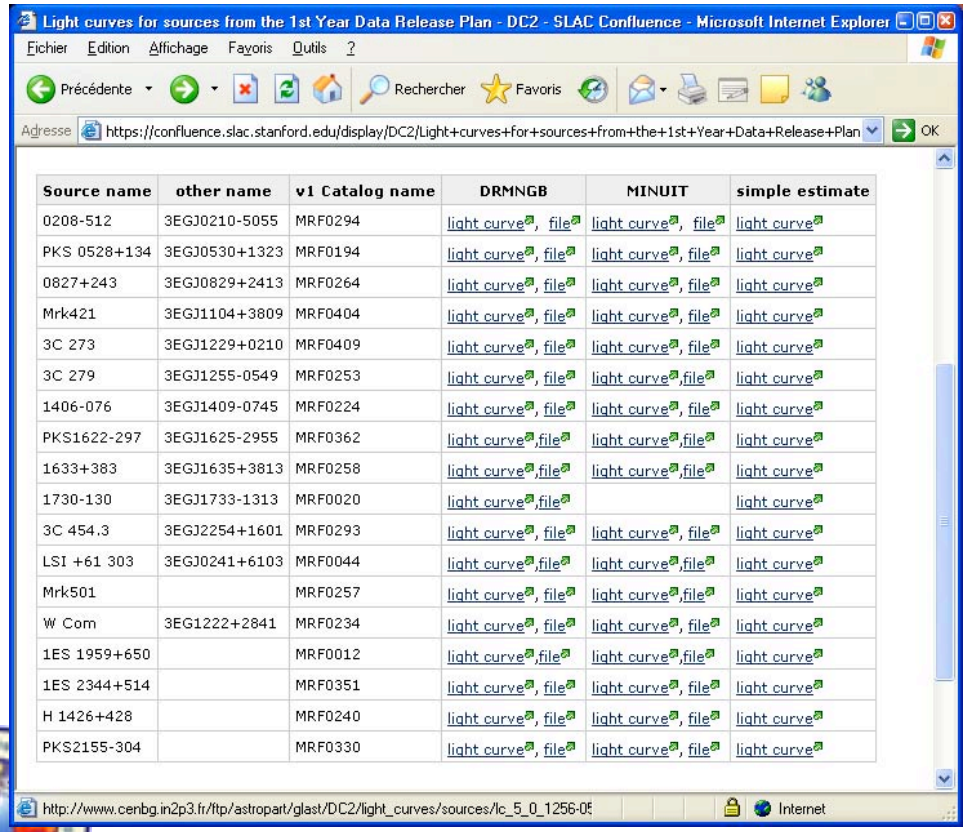
Vela Jr



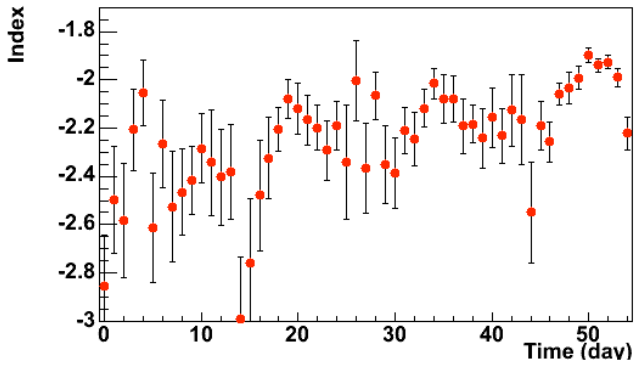
Omar Tibolla

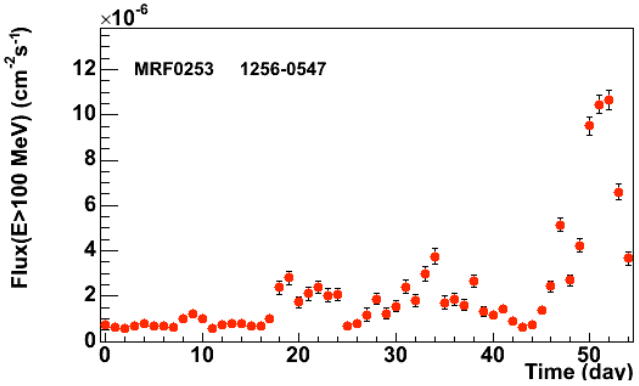
Variable sources

- Requirement: Produce lightcurves for at least 20 bright sources (from the data release plan, these are the sources we will release high level data from in year 1)
- Goal: look at lightcurves for many more sources



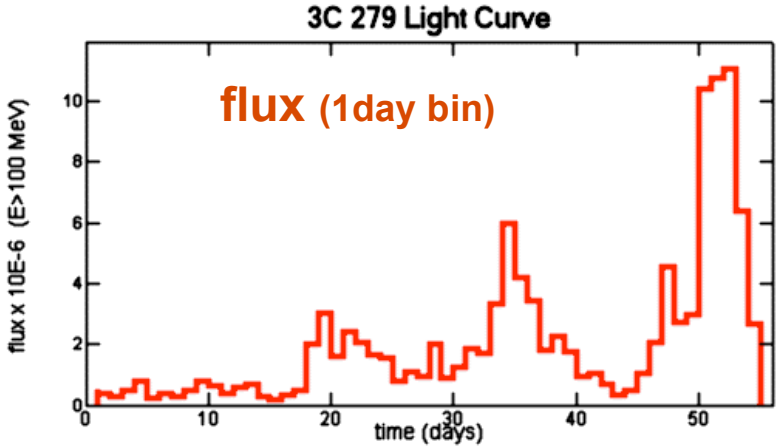
Source name	other name	v1 Catalog name	DRMNGB	MINUIT	simple estimate
0208-512	3EGJ0210-5055	MRF0294	light curve, file	light curve, file	light curve
PKS 0528+134	3EGJ0530+1323	MRF0194	light curve, file	light curve, file	light curve
0827+243	3EGJ0829+2413	MRF0264	light curve, file	light curve, file	light curve
Mrk421	3EGJ1104+3809	MRF0404	light curve, file	light curve, file	light curve
3C 273	3EGJ1229+0210	MRF0409	light curve, file	light curve, file	light curve
3C 279	3EGJ1255-0549	MRF0253	light curve, file	light curve,file	light curve
1406-076	3EGJ1409-0745	MRF0224	light curve, file	light curve, file	light curve
PKS1622-297	3EGJ1625-2955	MRF0362	light curve,file	light curve,file	light curve
1633+383	3EGJ1635+3813	MRF0258	light curve,file	light curve,file	light curve
1730-130	3EGJ1733-1313	MRF0020	light curve,file		light curve
3C 454.3	3EGJ2254+1601	MRF0293	light curve, file	light curve, file	light curve
LSI +61 303	3EGJ0241+6103	MRF0044	light curve,file	light curve,file	light curve
Mrk501		MRF0257	light curve, file	light curve,file	light curve
W Com	3EG1222+2841	MRF0234	light curve, file	light curve, file	light curve
1ES 1959+650		MRF0012	light curve,file	light curve,file	light curve
1ES 2344+514		MRF0351	light curve, file	light curve, file	light curve
H 1426+428		MRF0240	light curve, file	light curve, file	light curve
PKS2155-304		MRF0330	light curve, file	light curve, file	light curve

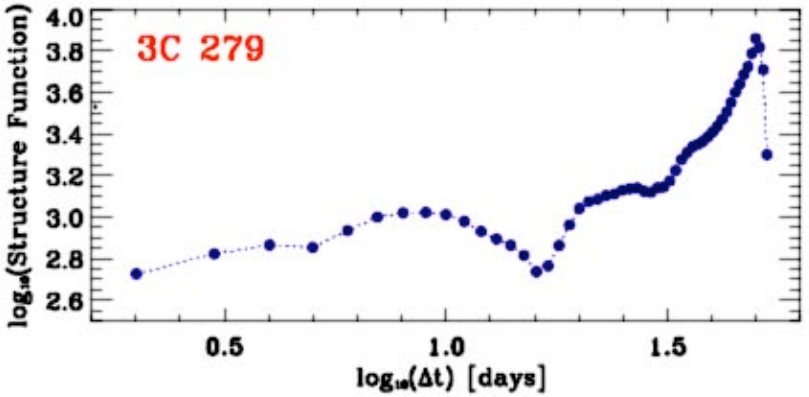


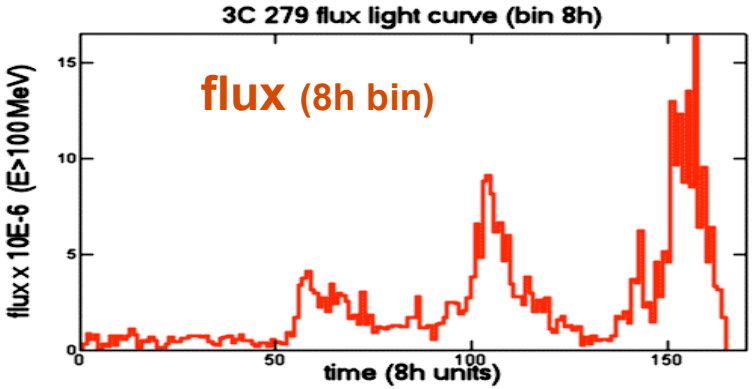


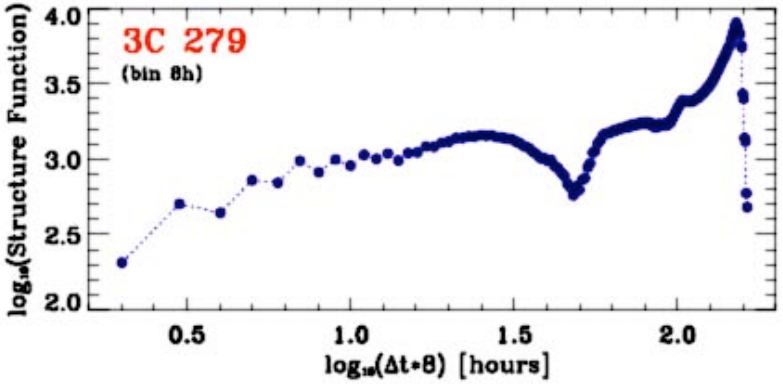
By Benoit Lott

Variable Sources





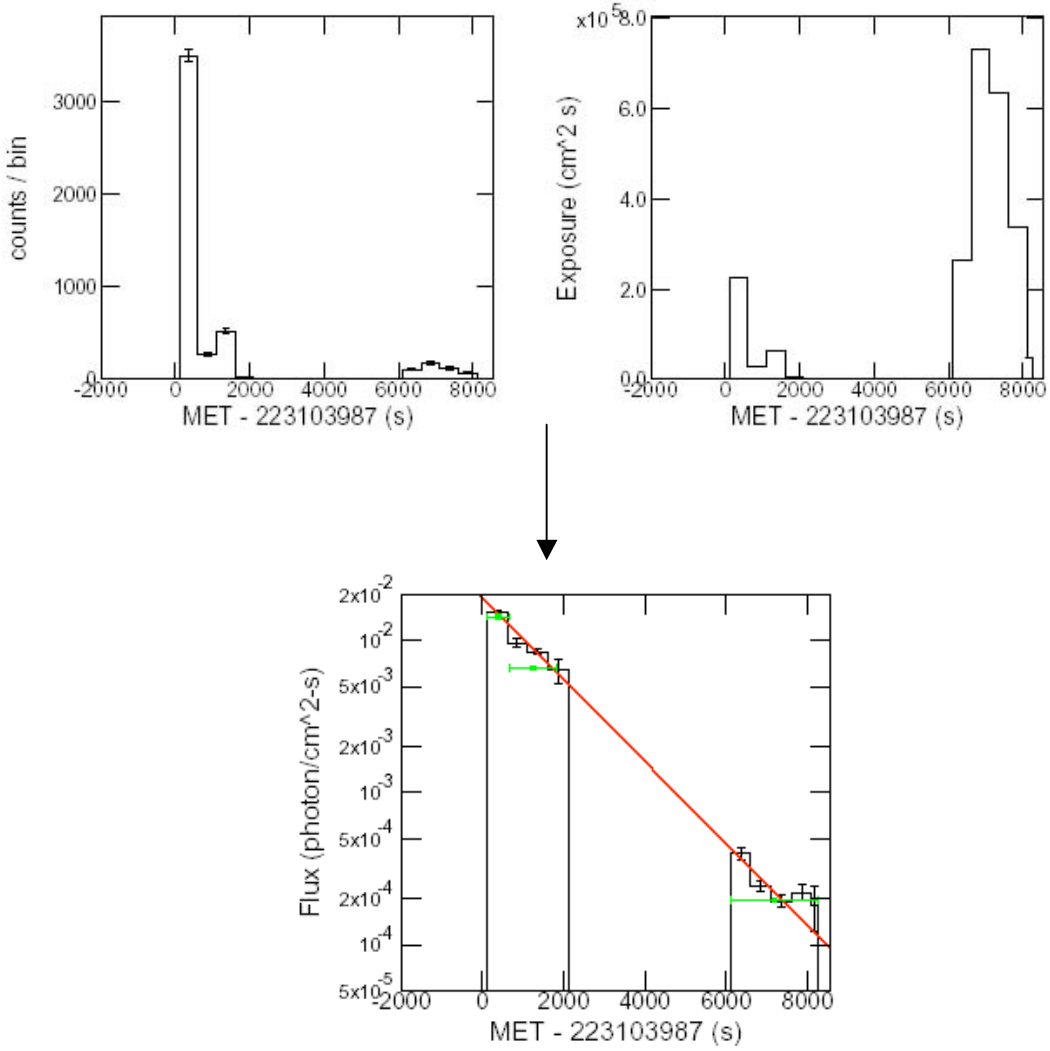




Gino Tosti – Taking lightcurves to the next level…

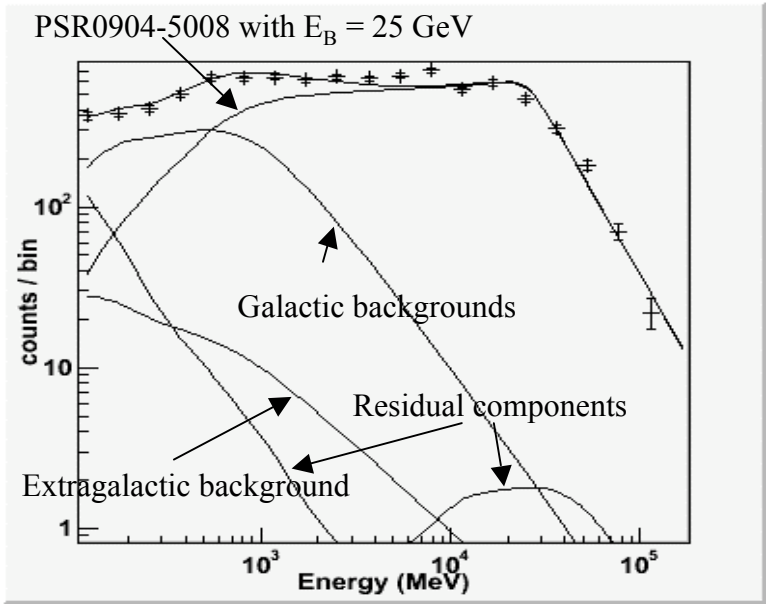
Variable sources

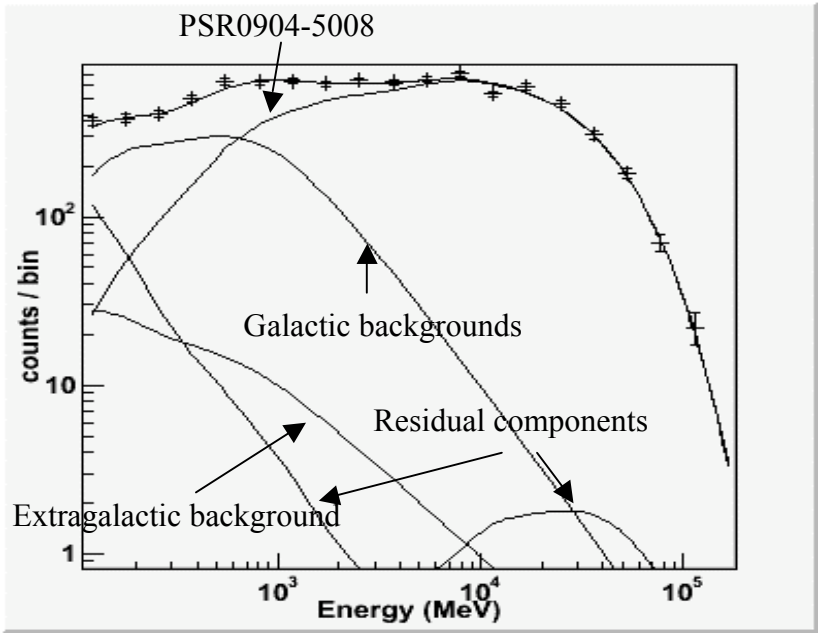
- **Goal: To find and study variable sources that might not be blazars (i.e. the AGN folk do not get to have all the fun)**
- **An example of this was a study of the solar flare by Jim Chiang.**



Spectral Studies

- **Goal: Study spectra of pulsars to determine the shape of spectral cutoffs**
- **Goal: EBL attenuation studies (redshift dependent cutoffs)**
- **Goal: Search for spectral signatures of dark matter**





Omar Tibolla

Spectral Studies

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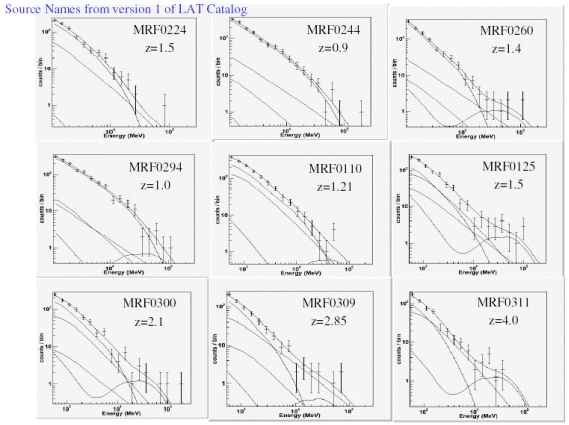
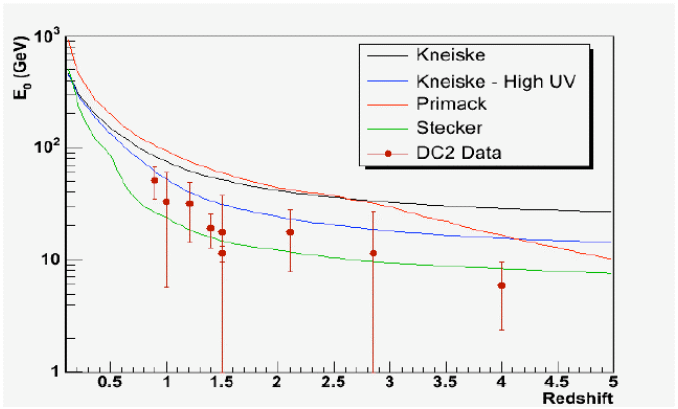
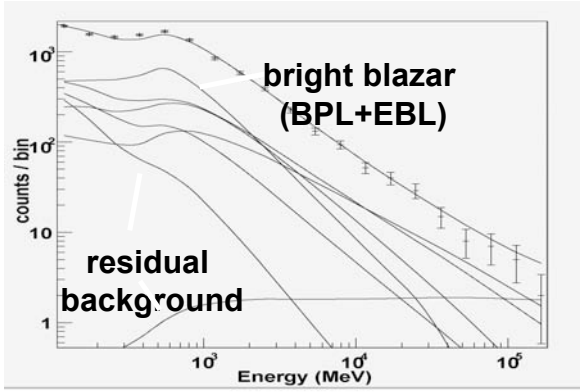
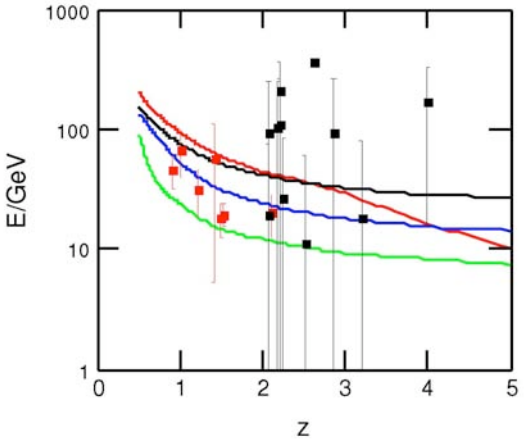
- Goal: Search for spectral signatures of dark matter





Luis Reyes





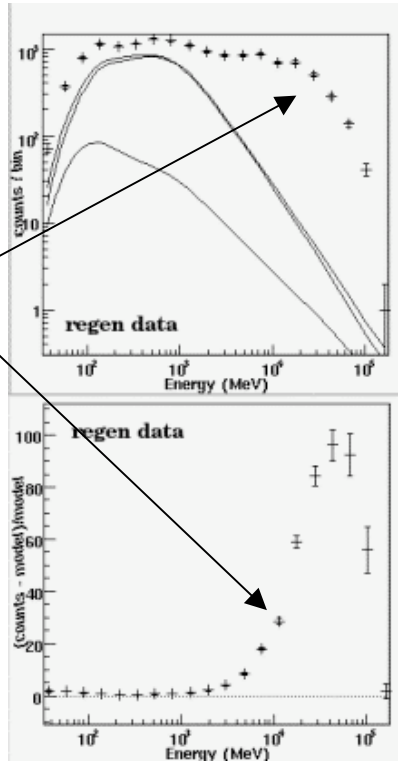
Jennifer Carson

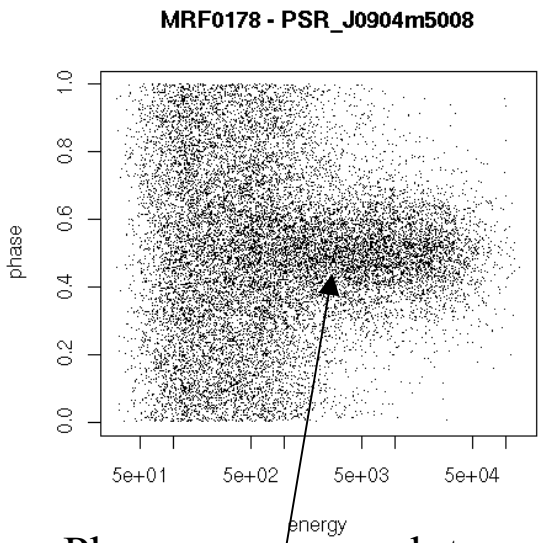
Julie McEnery

Spectral Studies

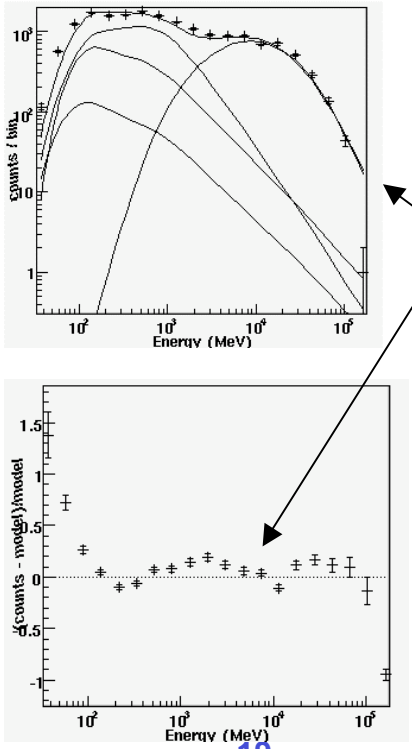
- **Riccardo Rando found a source that appeared to consist of two components, a pulsed hard component and a soft, steady component.**

Power-law point source + background model is a very poor fit to the data





Phase vs energy plot shows that the pulsed emission dominates above 1 GeV

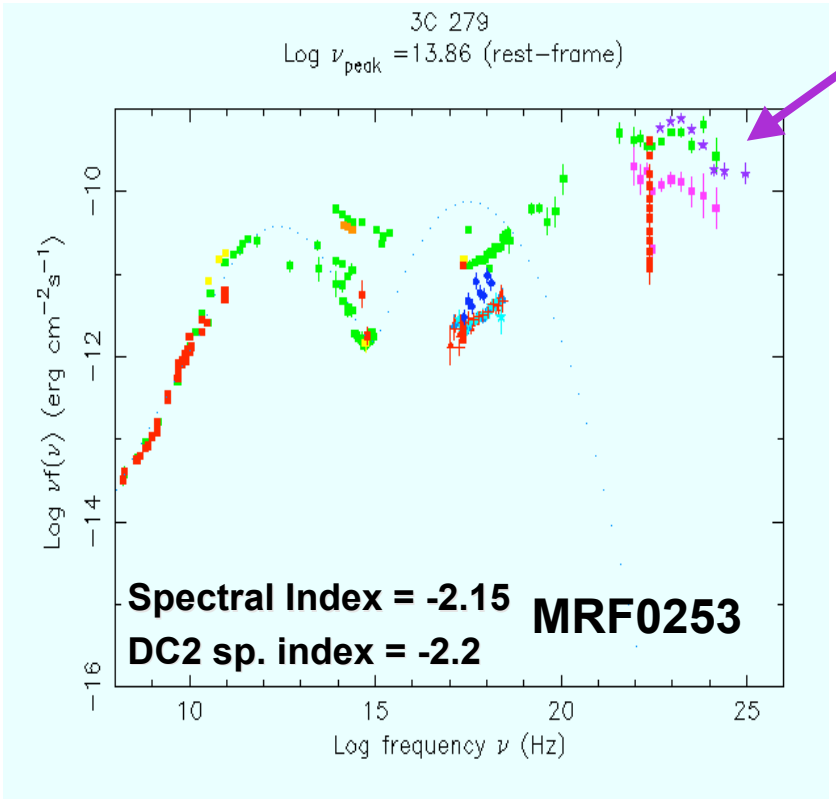


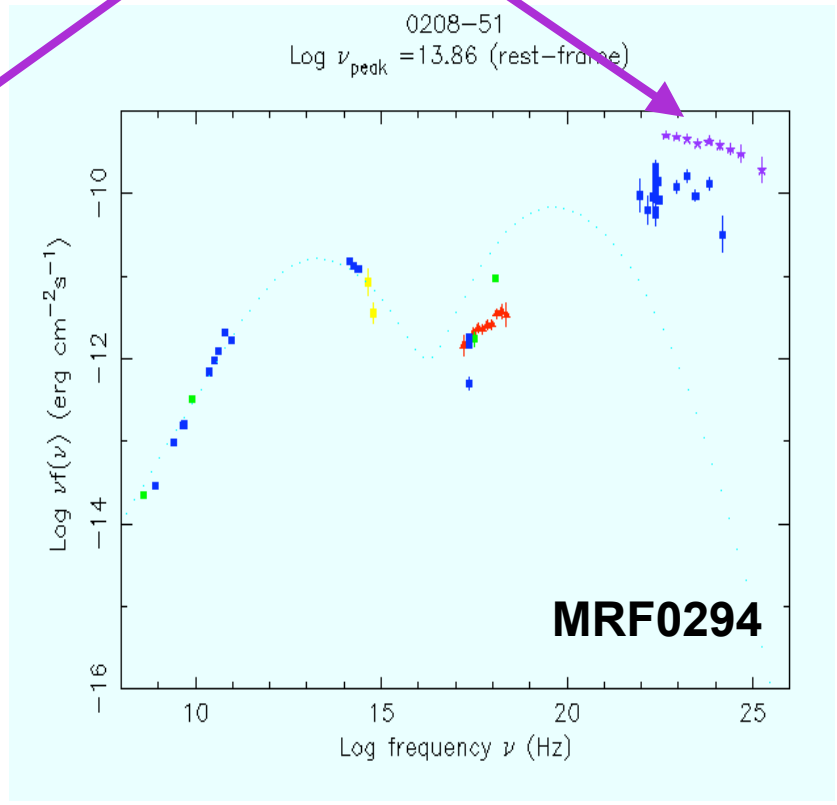
Refit with a composite source consisting of a power-law and a log normal component

Spectral Studies

Sara Cutini and Dario Gasparini presented spectral studies of a sample of blazars using xspec.

Purple stars DC2 data



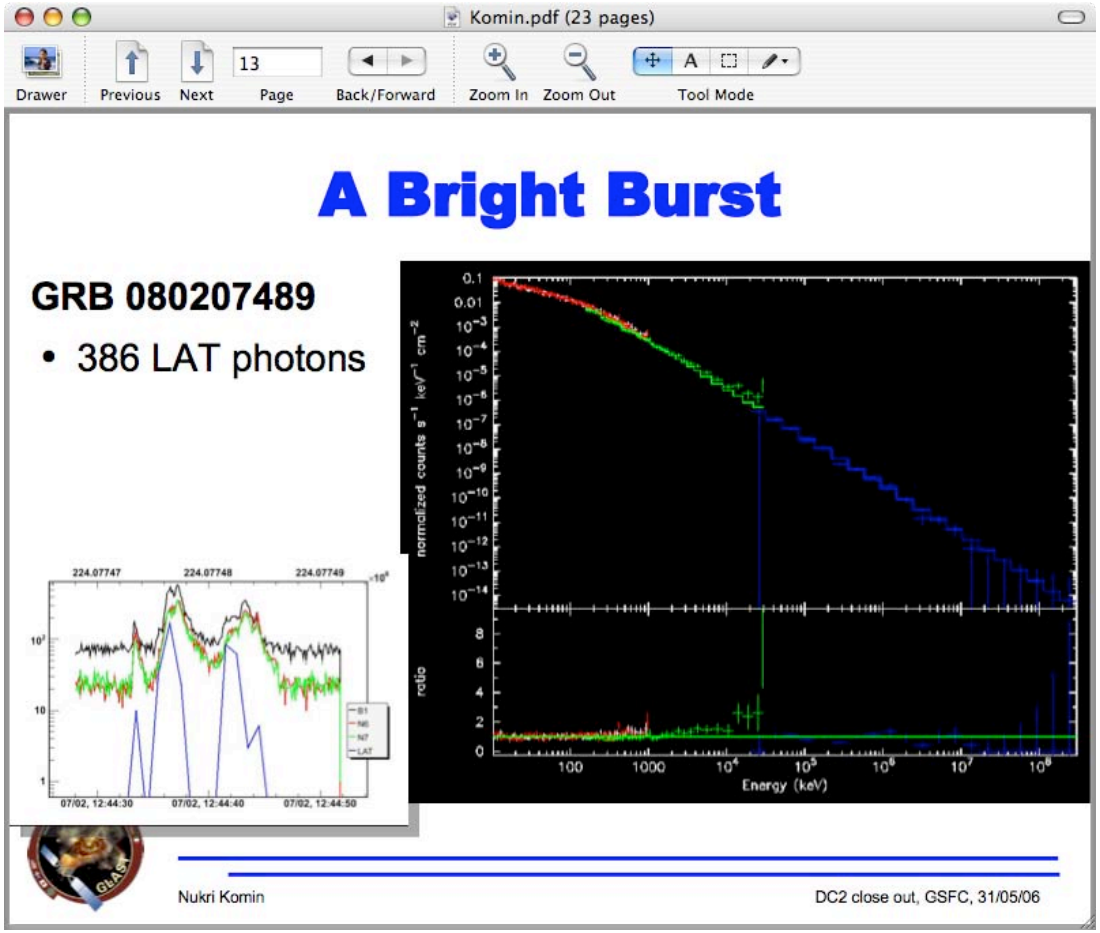


GLAST/MaxEGRET = 0.9

GLAST/MaxEGRET = 1.9

Gamma-ray bursts

– **Requirement: Perform joint spectral fits of at least one burst using both LAT and GBM data. (gtbin, rspgen, xspec)**

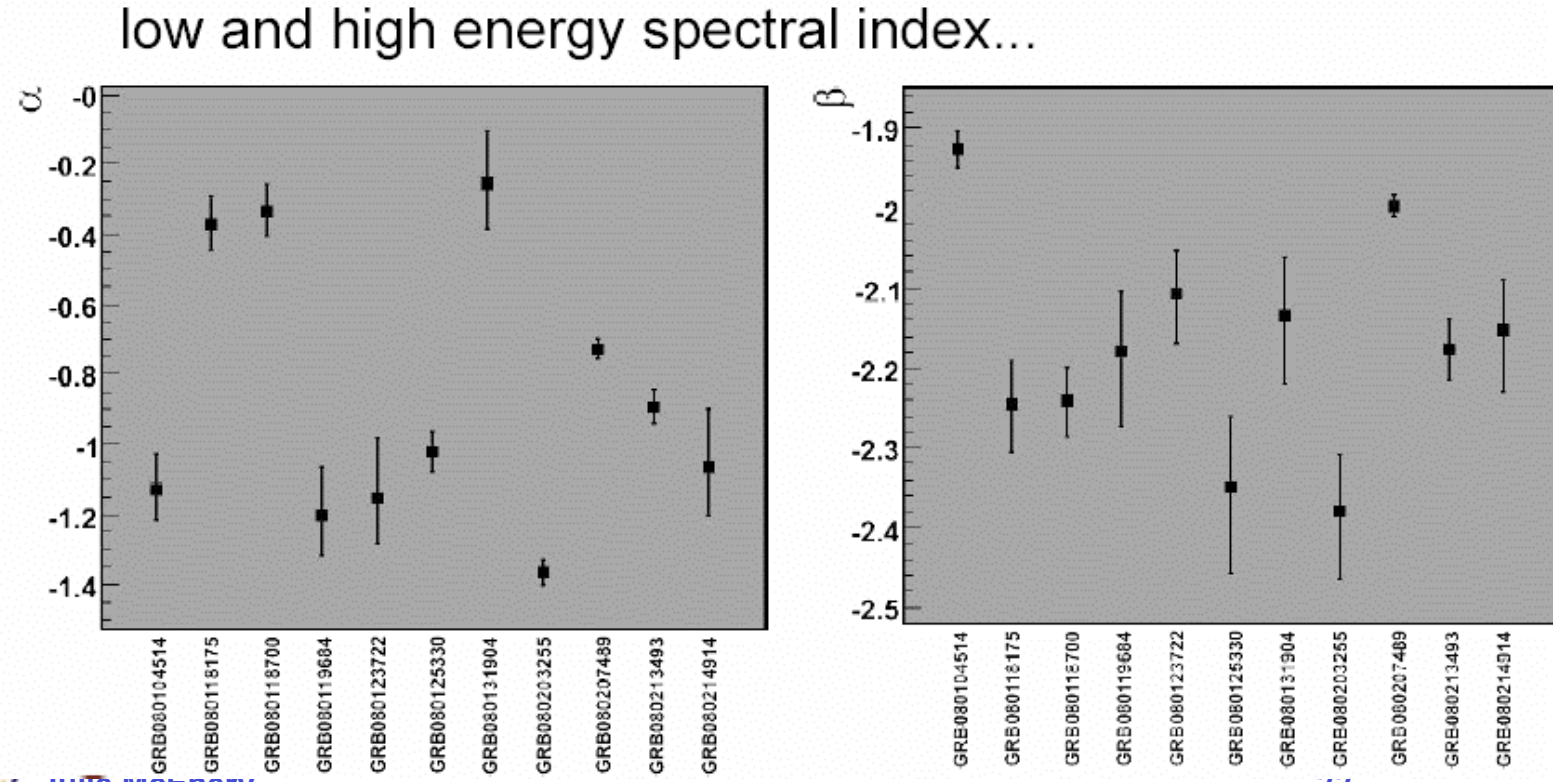


Nukri Komin

Gamma-ray bursts

– **Requirement: Produce preliminary GRB catalog, this should include GBM + LAT properties (goal: include LAT upper limits for GRB with no LAT detection).**

Nukri Komin – fit all GRB with more than 4 LAT photons, also compared xspec with likelihood fits

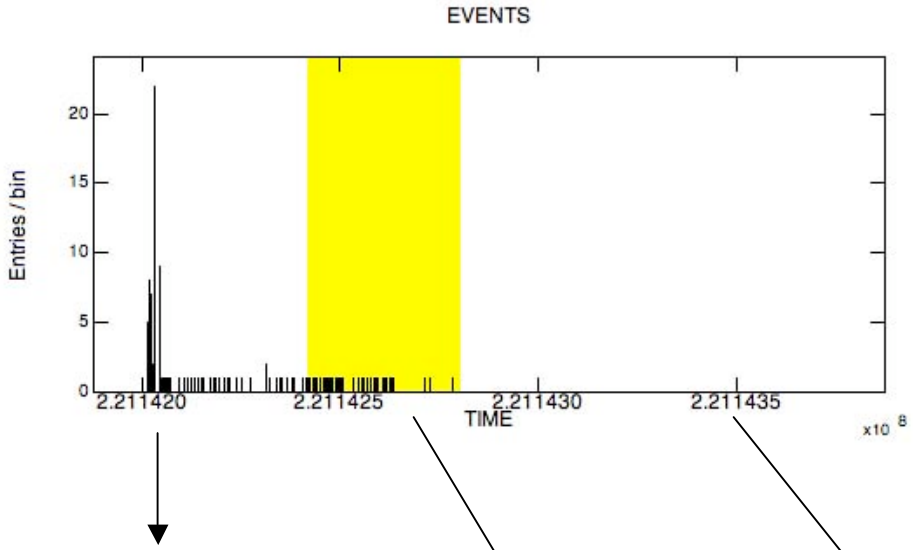


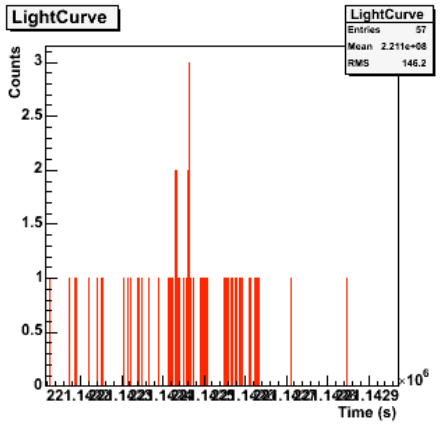
Gamma-Ray Bursts

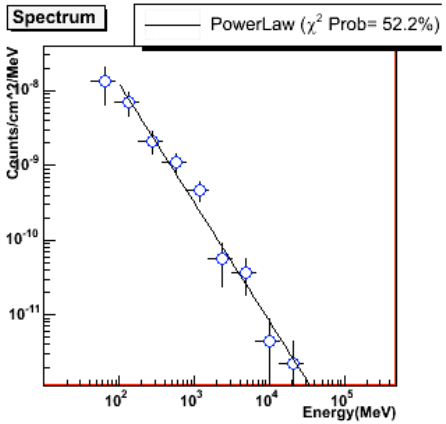
- Goal: Search for LAT only GRB
- Searches by Nukri Komin, David Band and Jerry Bonnell
- There were several “lat-only” GRB to find. All the lat only GRB discoveries posted were “real” transient events (i.e. no false positives).

Gamma-Ray Bursts

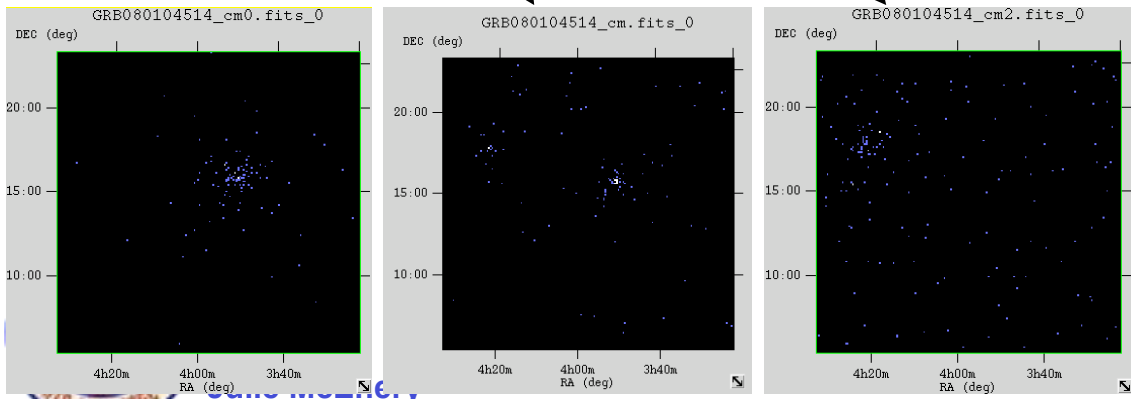
– **Goal: Search for additional high energy components and/or afterglows**







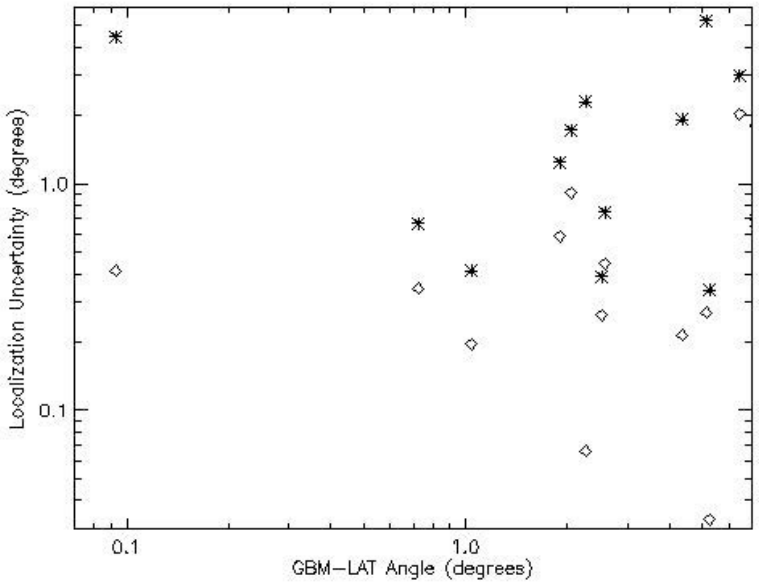
Spectral analysis: spectral index=
(FT1Viewer*): 1.53 +/- 0.07 (52%)
(Xspec): 1.64 +/- .09 (75%)



Omodei: GRB08010514 – Delayed emission beginning ~400s after the GRB trigger.

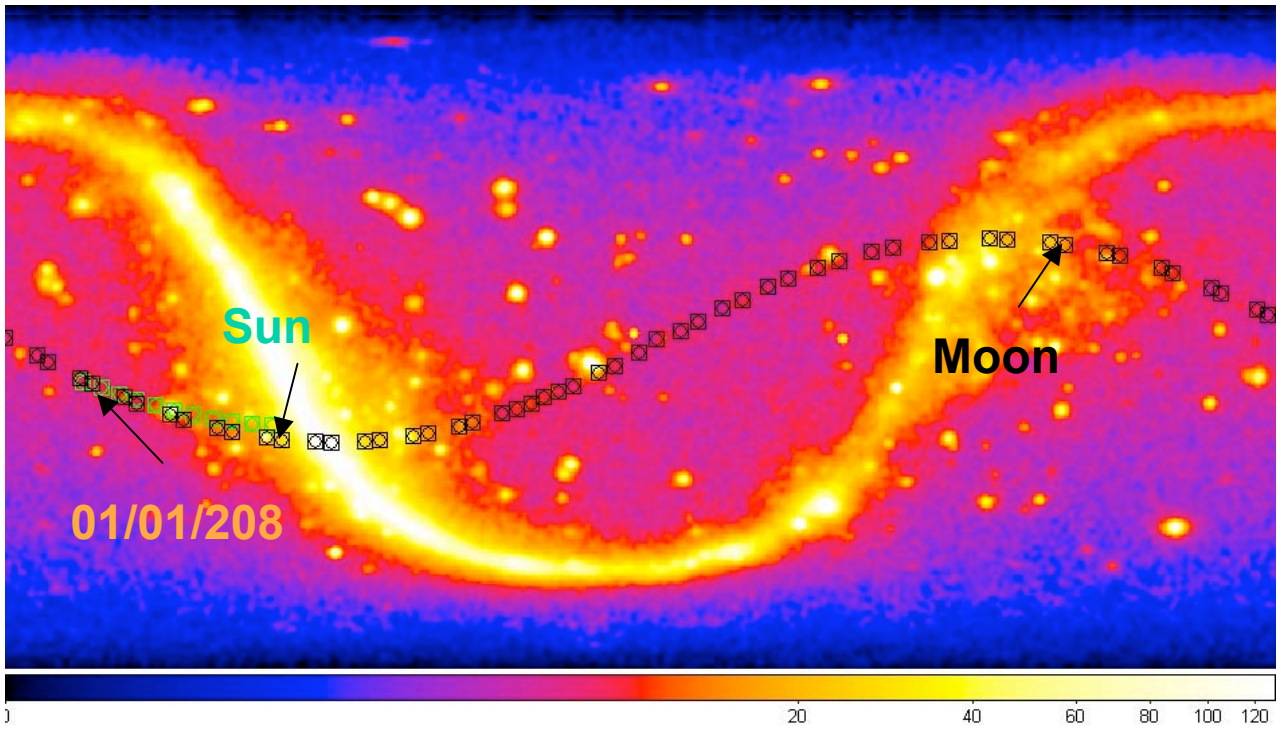
Gamma-Ray Bursts

- Goal: Compare the LAT and GRB locations and quoted statistical uncertainties to study the systematic GBM localisation uncertainty.
- Localisations by David Band, GBM systematic uncertainty analysis by Michael Briggs.



Other sources

- **Requirement: Identify at least one source that is not a pulsar, AGN or GRB (there are some that can be identified from the gamma-ray data)**
- **Moon (Tosti, Rando)**
- **Sun (Tosti, Chiang)**

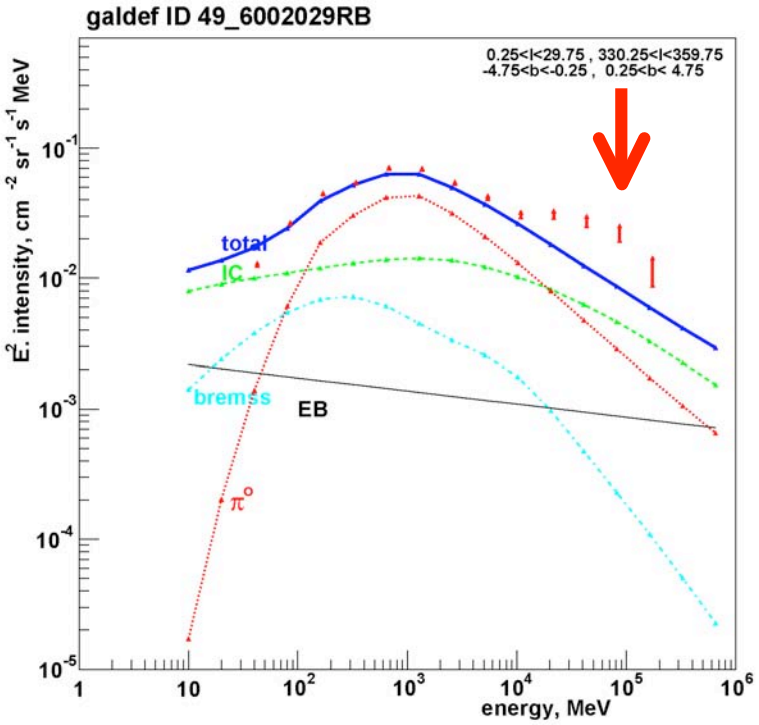


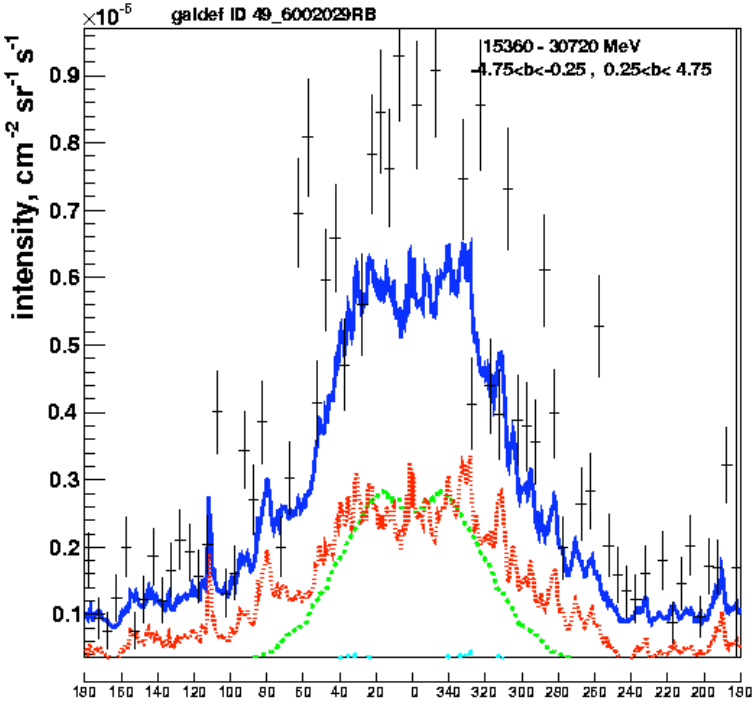
The Moon

- Several people “found” the moon, generally as an irritant that got in the way of the analysis that they set out to do
  - Spurious sources – Tosti, Ballet
  - Modulating the lightcurve of sources along the moons path – Rando
- It is clear that the moon is something that we are going to have to learn how to deal with.

Diffuse sources

- **Goal: Study flux, spectra and spatial distribution of the galactic diffuse and compare with the diffuse model provided for source analysis.**
- **Studied by Jean Marc Casanjian, Andy Strong and Larry Wai**

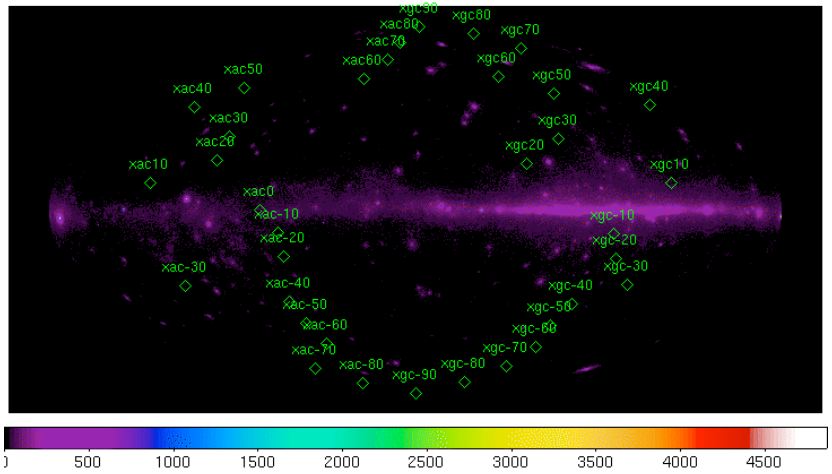


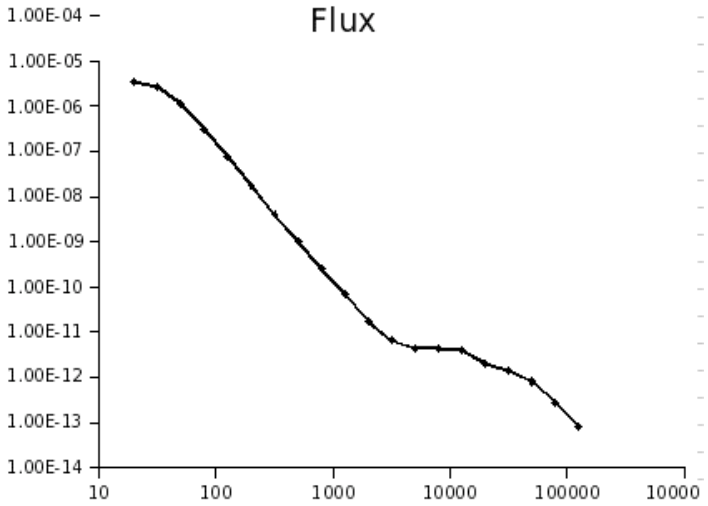


Excess due to residual cosmic-ray background

Diffuse sources

- **Goal: Study flux and spectral properties of the extragalactic background. This will include a study of the effect of residual background, contribution from galactic diffuse and resolving the point sources.**
- **Riccardo Rando performed an analysis of the extragalactic diffuse spectrum. He produced a mapcube fits file which described the residual background which was subsequently used by several people in source analyses.**

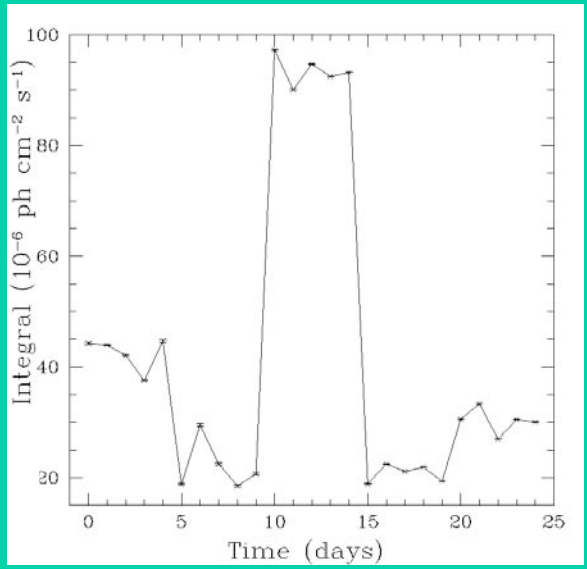




Likelihood accuracy/stabiliy

- **Several people examined the effect of residual background (Reyes, Carson, Cutini/Gasparini)**
- **Rita Sambruna presented a systematic study of the behaviour of the likelihood analysis in the presence of neighbouring sources and then took a closer look at the 3C279 region.**

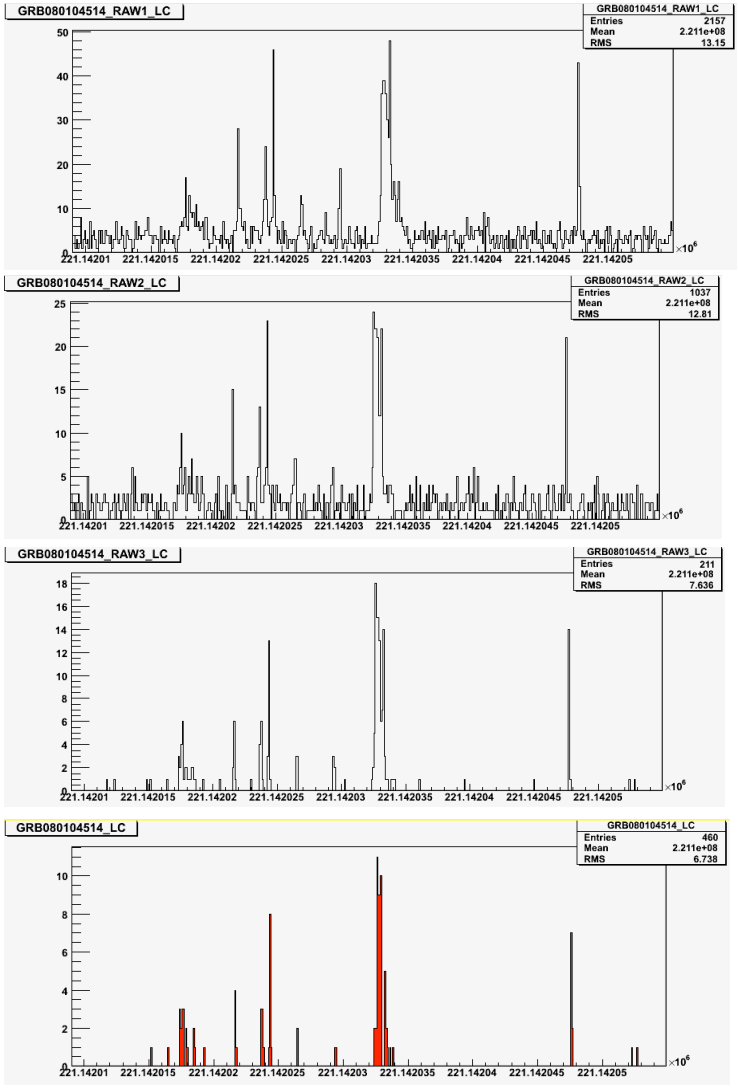
	DRMNGB	MINUIT
1	*0-60%*	*5-60%*
2	*10-120%*	
3	*0-110%*	
4	*20-100%*	*30-500%*
5	*20-50%*	
6	*30-80%*	



The wrong model overestimates the flux

Cuts/IRFs and analysis methods

- Several people discussed the details of the impacts of choices made at the higher analysis levels – photon selection region etc. A systematic study was performed by Andrea Caliandro to investigate and optimise analysis selections for pulsar studies.
- Nicola Omodei presented an analysis of GRB detection sensitivity for looser sets of event selection cuts.
- There are many more things that could be done in this area!



Summary

- Coordination and interaction across the collaboration
  - Results of some analyses were used to refine studies in other areas
    - Catalog
    - Riccardo's mapcube
  - Verifies that we are able to communicate results and ideas with one another and also that we have developed our standard data formats and software interfaces sufficiently that people can case their results in a shareable way.
- The range and details of the analyses performed on the DC2 data exceeded our expections.