Uncovering the low-energy emission of LAT transients

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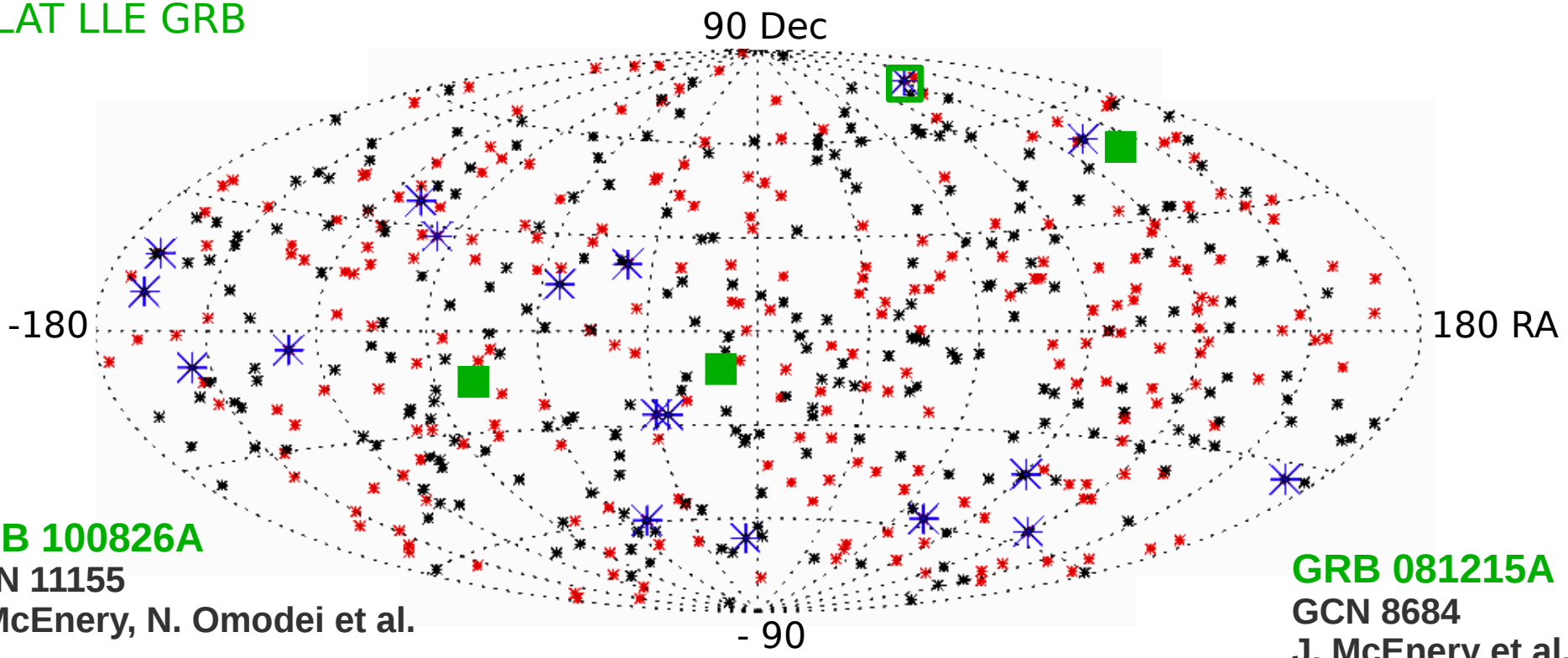
on behalf of Fermi/LAT & GBM collaborations

AMT/PCHE GRB workshop
Toulouse, 23-09-2010

Fermi GRB (as of 100804)

514 GBM GRB
18 LAT GRB (>100 MeV)
3 LAT LLE GRB

In Field-of-view of LAT (264)
Out of Field-of-view of LAT (250)



GRB 100826A
GCN 11155
J. McEnery, N. Omodei et al.

GRB 081215A
GCN 8684
J. McEnery et al.

GRB 100707A
GCN 10945
V. Pelassa, M. Pesce-Rollins et al.

GRB 100724B
GCN 10978
Y. Tanaka, M/ Ohno, H. Takahashi, T. Uehara, N. Omodei, J. Chiang, S. Guiriec et al.

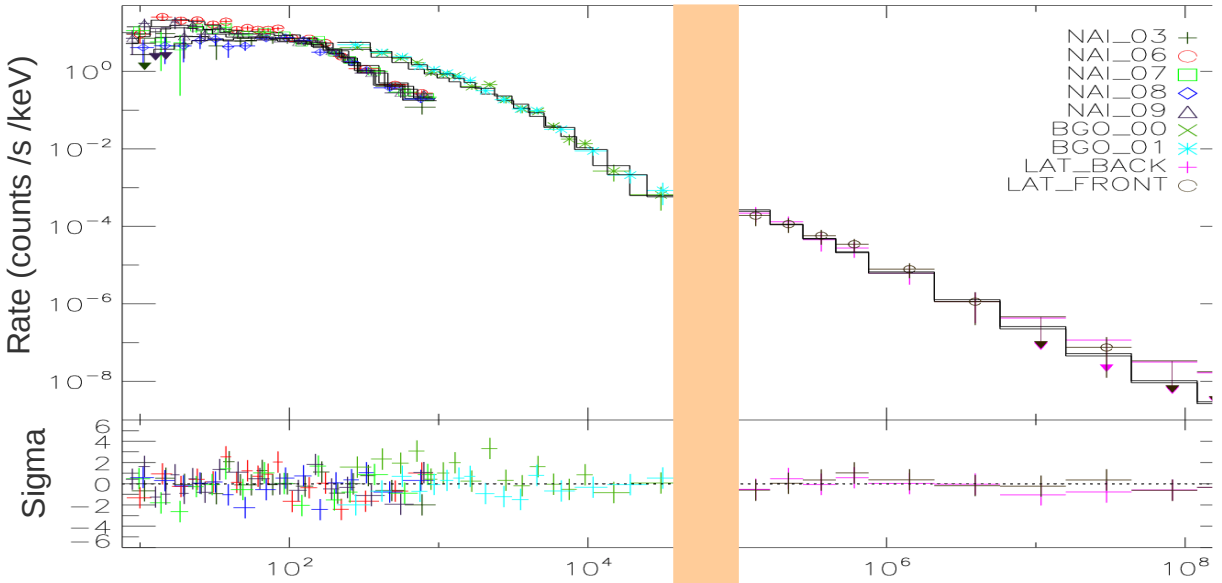
« Using a non-standard selection … »

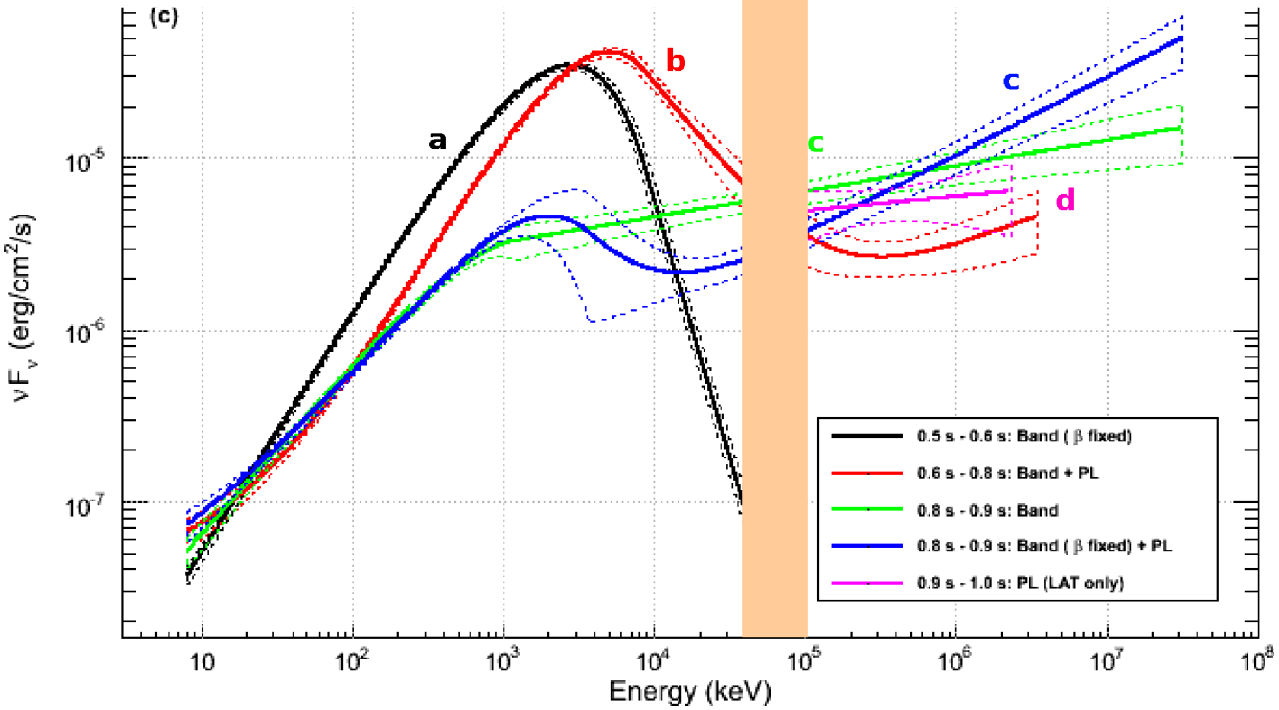
Outline

- Motivation
- Detection
  - Loosened selection efficiency
  - GRB light curves
- Direction measurement
  - Definition
  - MC vs data agreement
  - Impact of ROI selection
- Spectral analysis
  - Technique
  - Energy resolution
  - Performance for spectral analyses
  - Preliminary results
- Perspectives

All unpublished results shown are preliminary

Motivation





Standard analyses:
BGO <40 MeV
LAT >100MeV
We want to fill the gap and recover photon statistics
- Apply a loosened cut

Expectations for bright GRB:
- improve the analyses
- better measurement of spectral features

For soft/faint GBM bursts:
- recover LAT signal

GRB 090510 (Ackermann, M. et al. ApJ, 716, 1178, 2010)

Loosened event selection

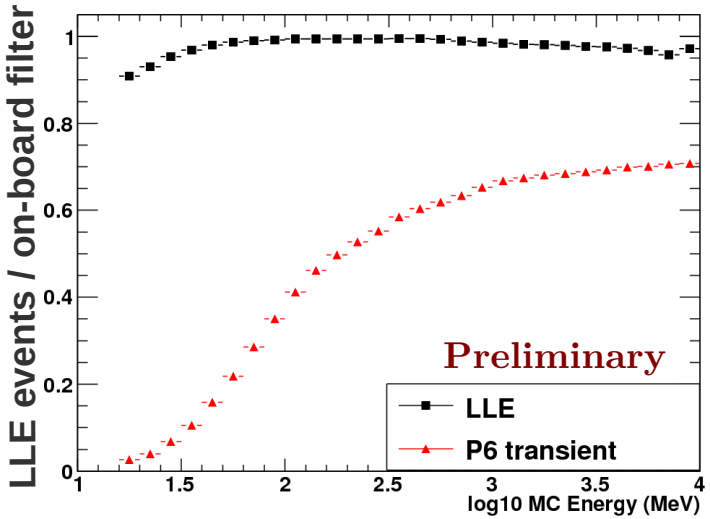
Basic event selection:
LAT **L**ow **E**nergy

✔ On-board photon
✔ One track required

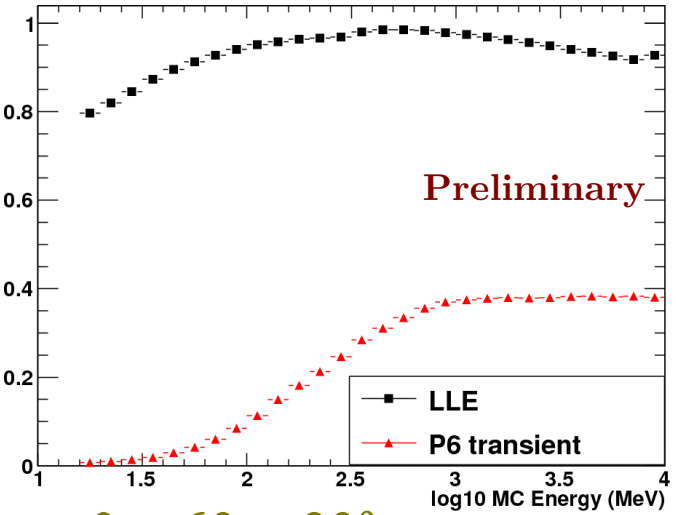
➢ Energy and direction

Study of MC photons
efficiency on source signal

norm. to on-board filter



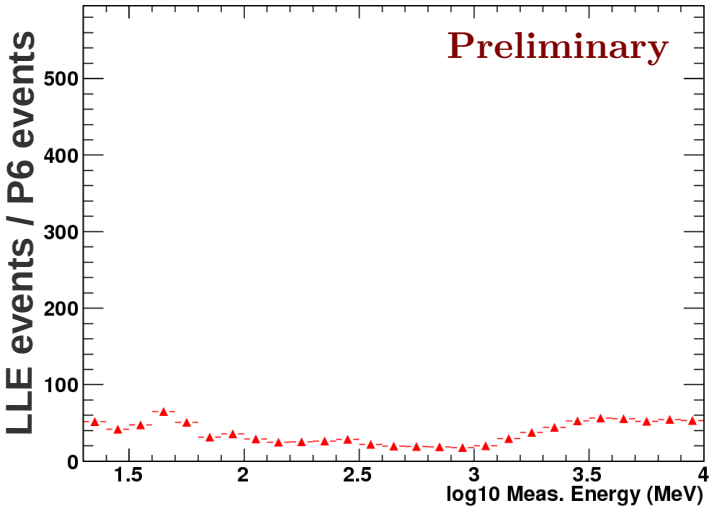
θ = 0 – 30°

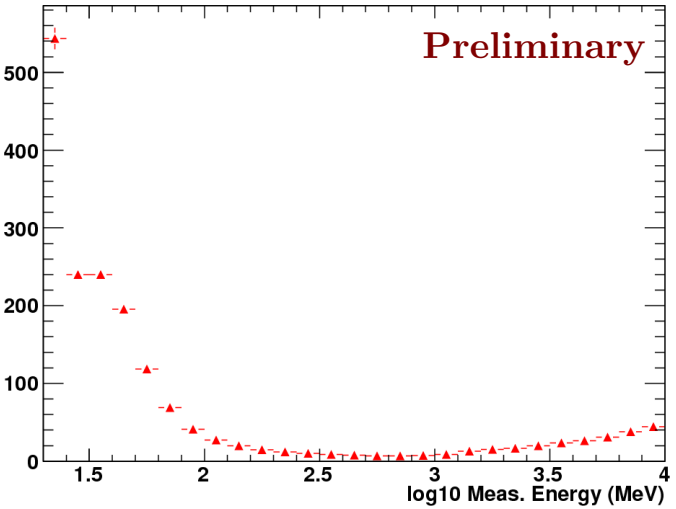


θ = 60 – 80°

Study of Data
efficiency on background

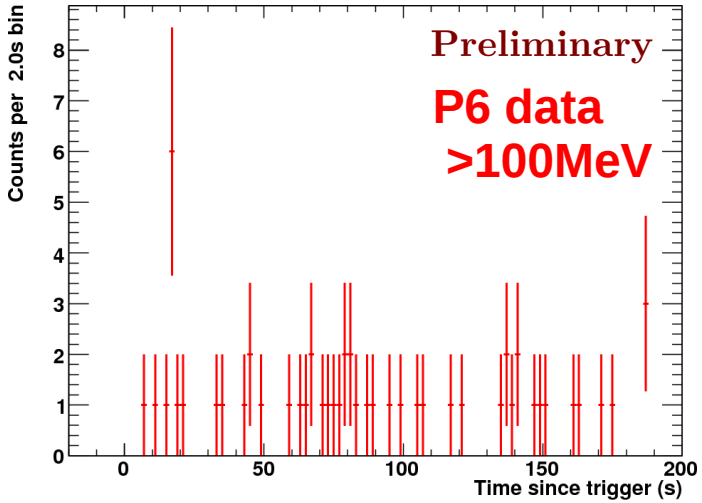
efficiency ratio :
LLE/ P6 transient

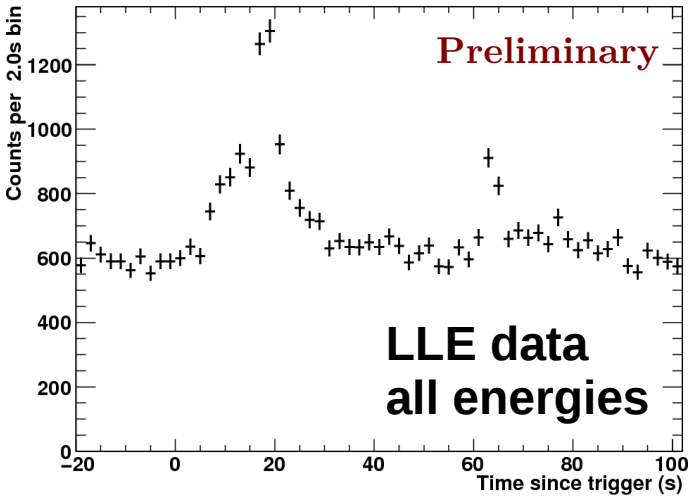




GRB light curves

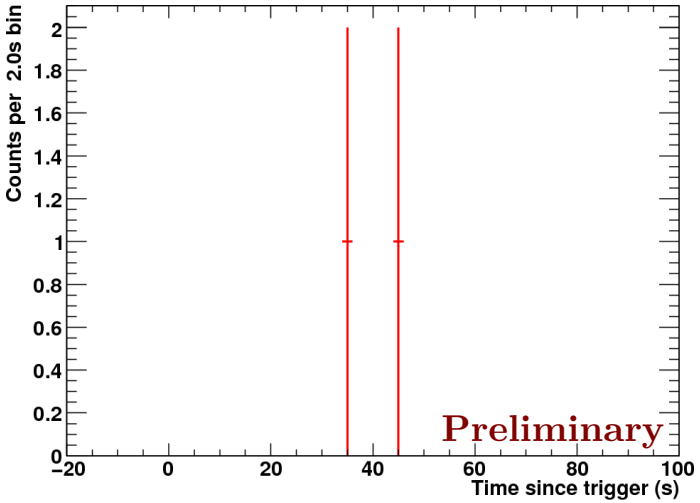
GRB 100724B (θ=49º)

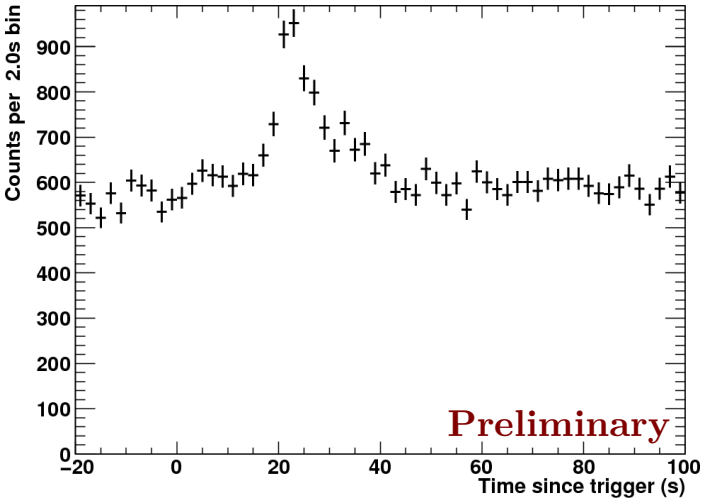




- Higher statistics

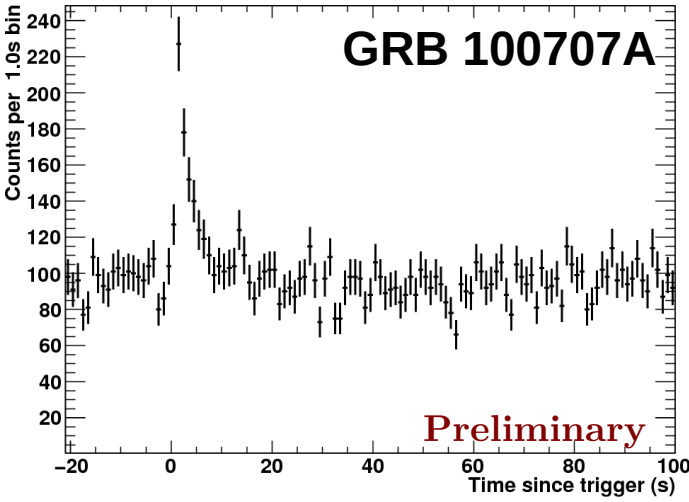
GRB 100826A (θ=70º)

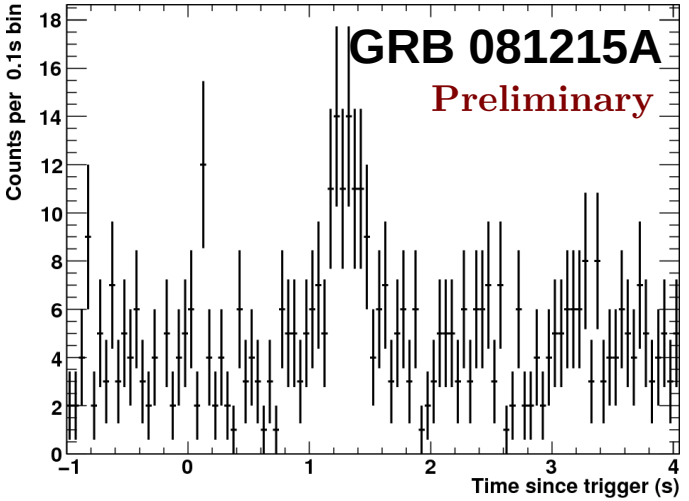




Far off-axis bursts (θ > 80º)

- Events hitting only tracker

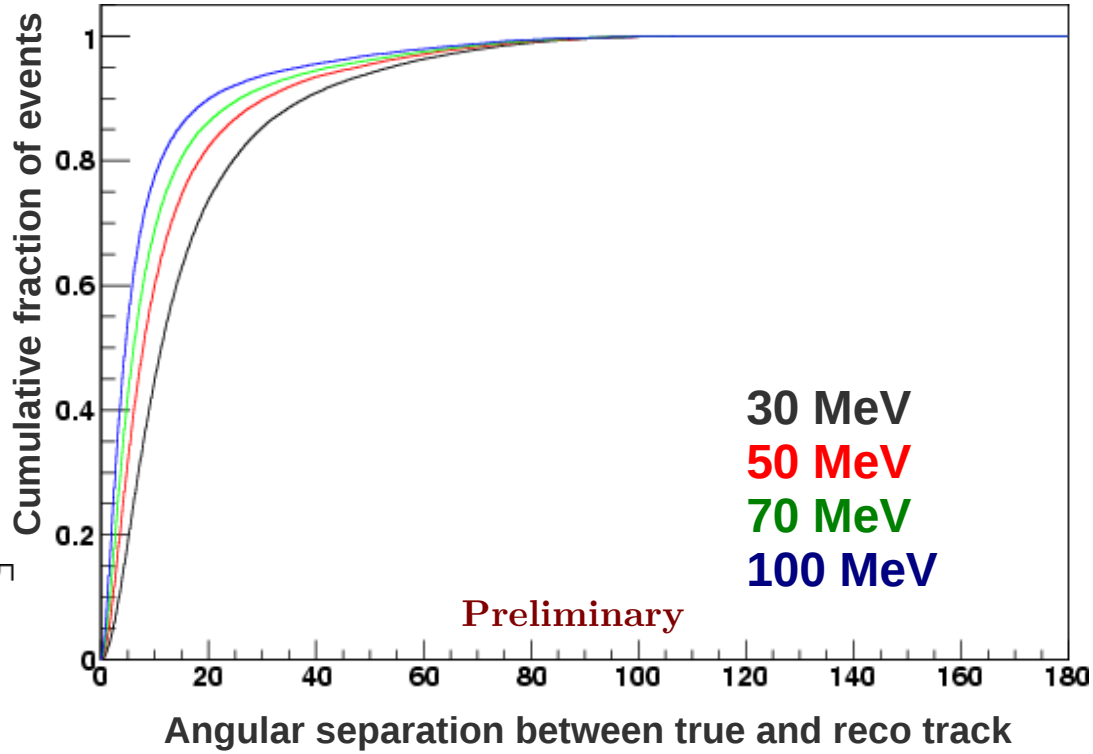


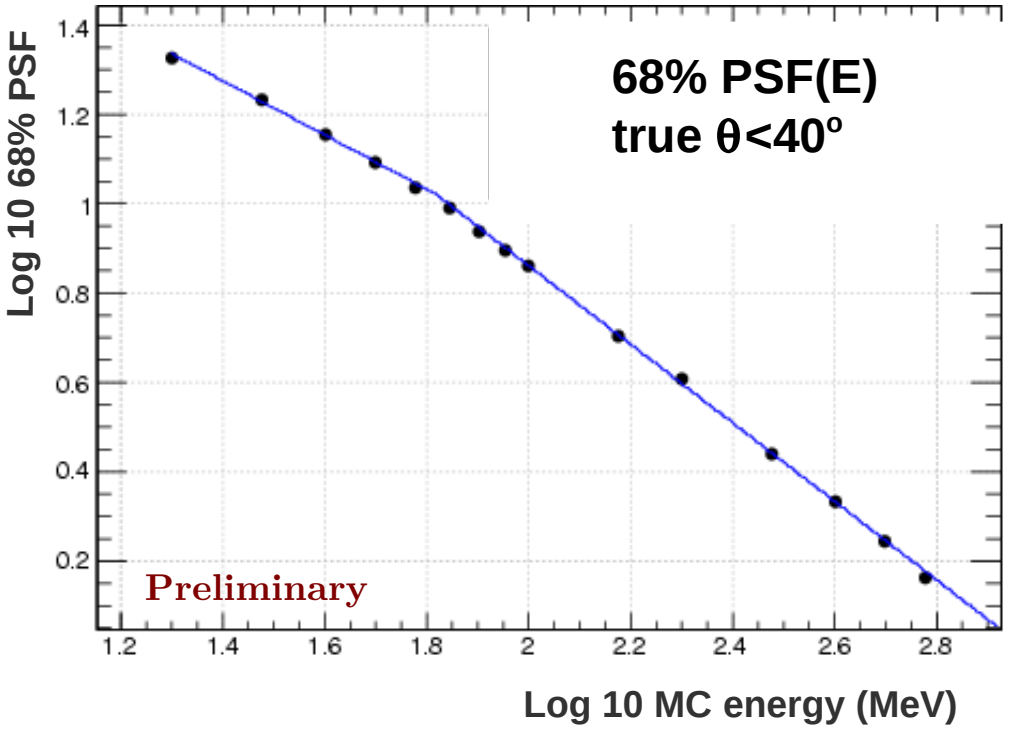


- new detections

Direction measurement

MC photons :
True energy lines
(+\- 2 MeV, 20 MeV - 10 GeV)

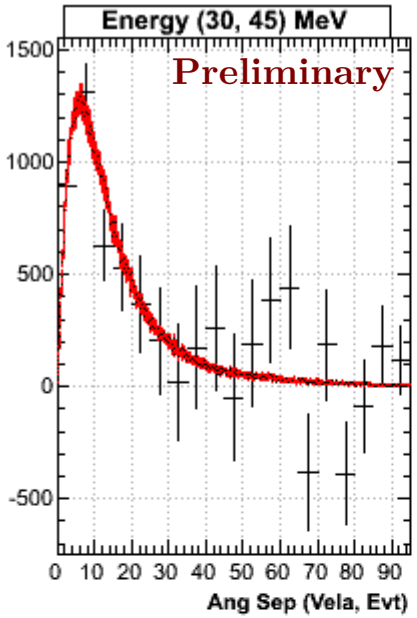


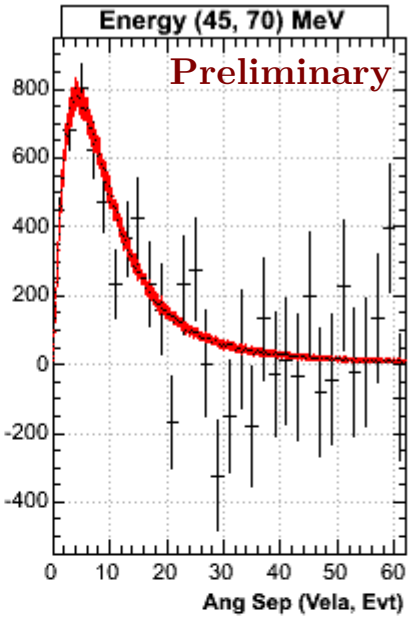


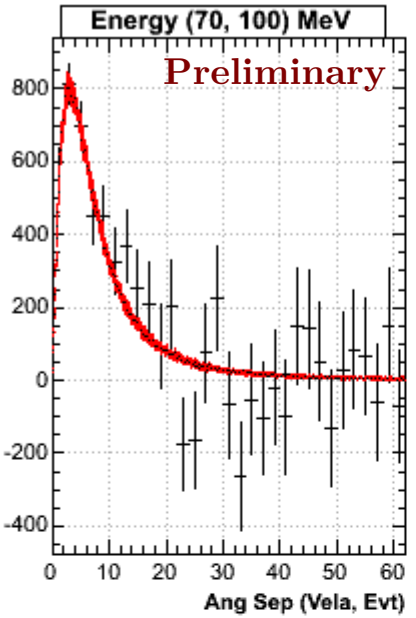
- PSF(E) can be defined
- ROI selection can be used

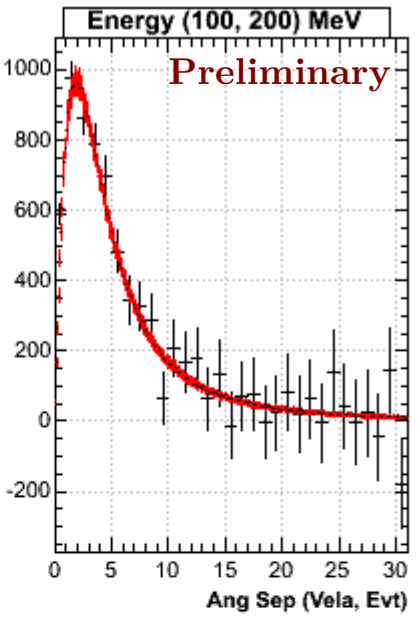
Data/MC agreement

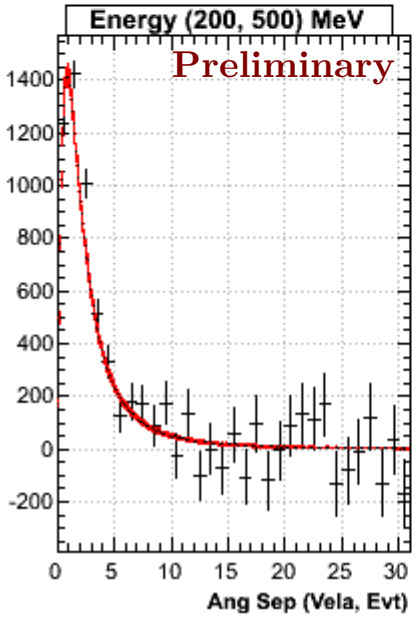
Vela pulsar: brightest steady point source in LAT's sky

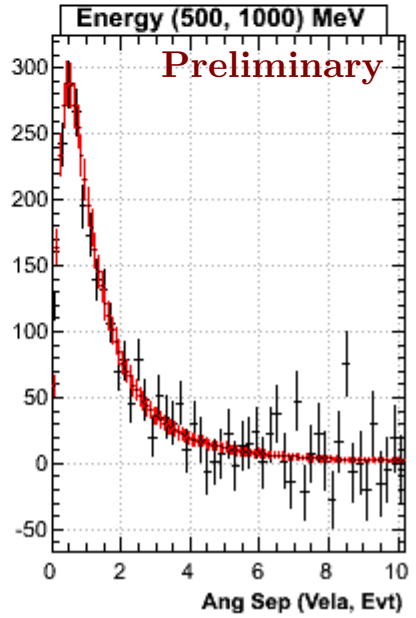


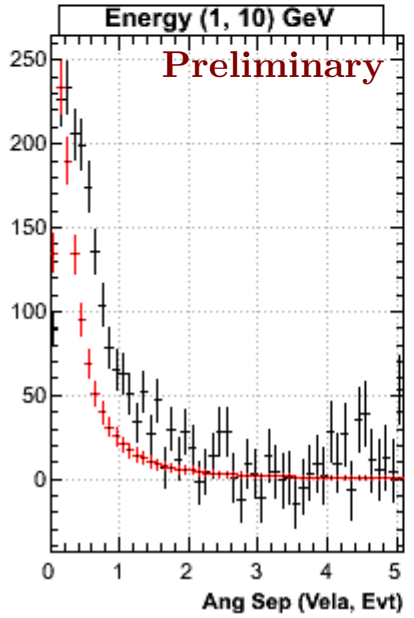


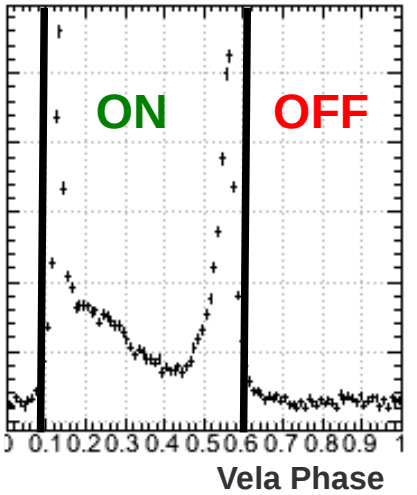










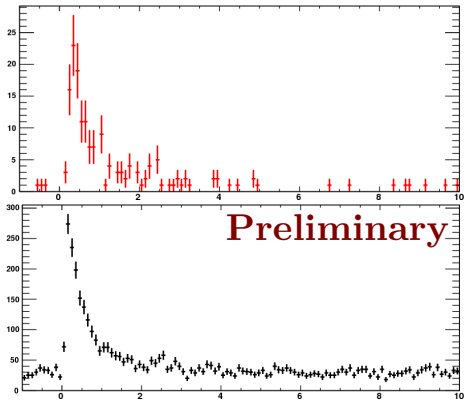


+ Vela ON – OFF

+ MC photons

Back to GRB light curves

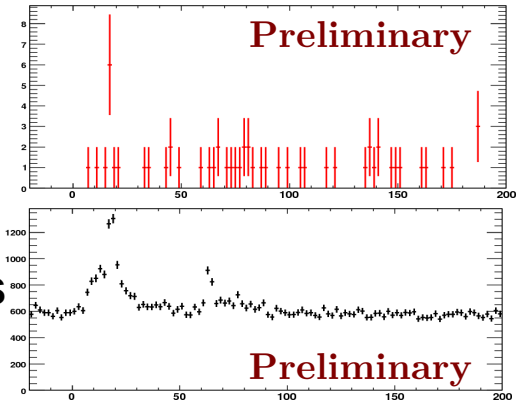
GRB 090510 (θ = 15°)



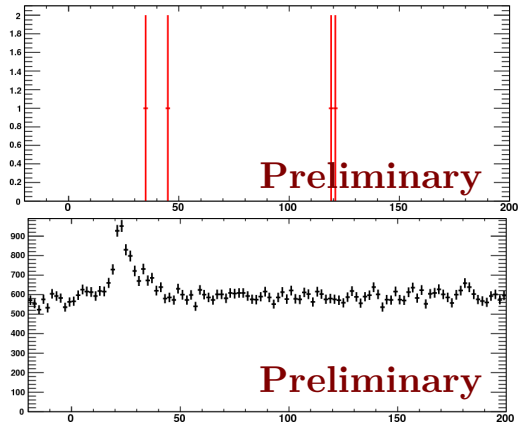
P6 data >100MeV

LLE data all energies

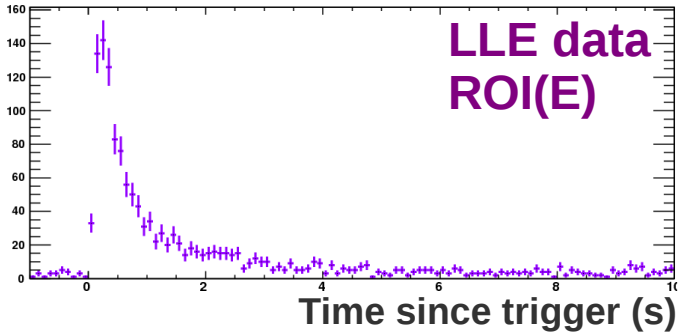
GRB 100724B (θ = 49°)

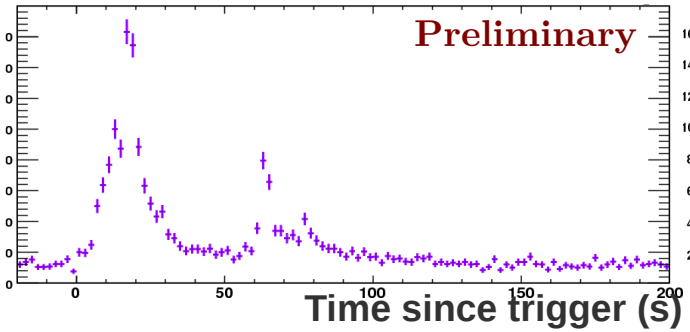


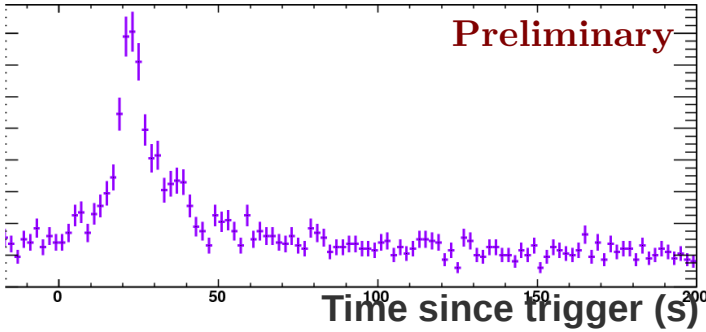
GRB 100826A (θ = 70°)



LLE data ROI(E)







Quality factor ratios : $Q = eff_{\gamma} / \sqrt{eff_{Bkg}}$

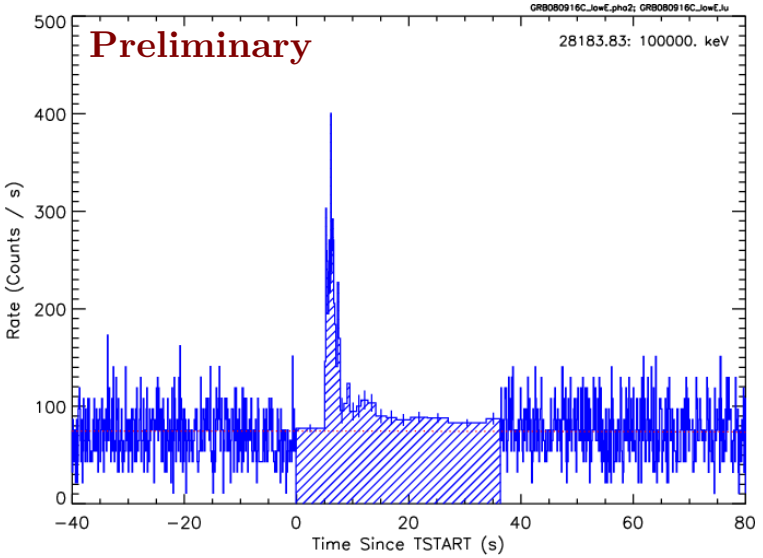
(for source spectrum E^-1.5)

	θ = 0 - 40°	θ = 40 - 60°	θ = 60 - 80°
LLE / P6	0.08	0.08	0.12
LLE ROI / P6	0.42	0.36	0.39

LLE+ROI selection has :

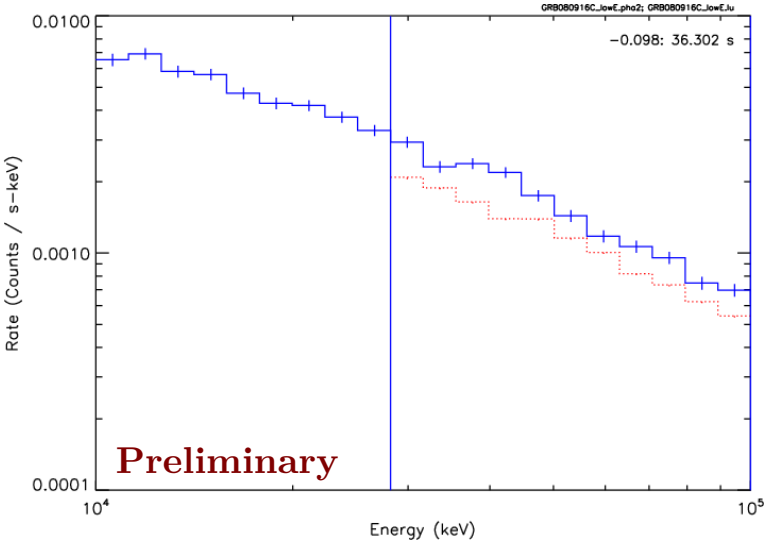
- ✔ LLE high statistics
- ✔ Higher S/N ratio than LLE
- ➢ Better detection significance
- ➢ Time history analysis possible

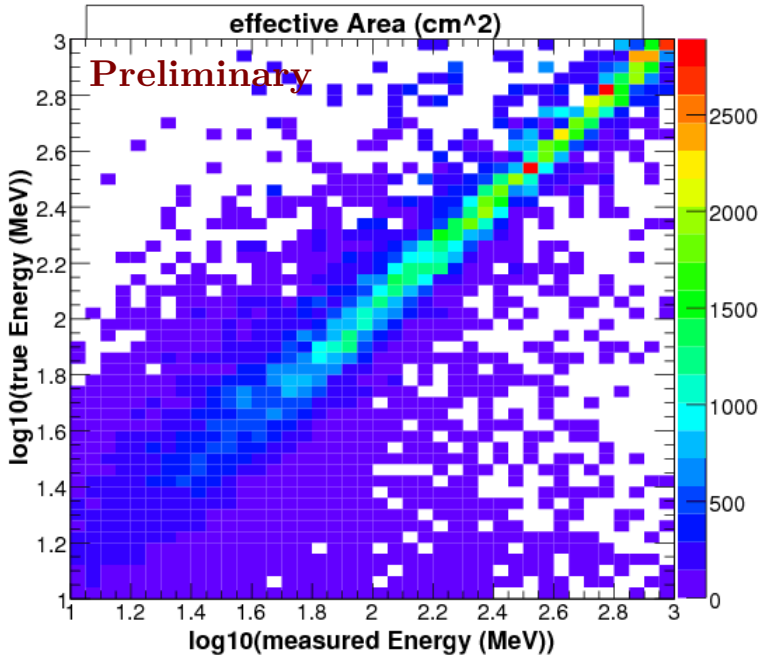
Spectral analysis method



“ON-OFF” :
time intervals

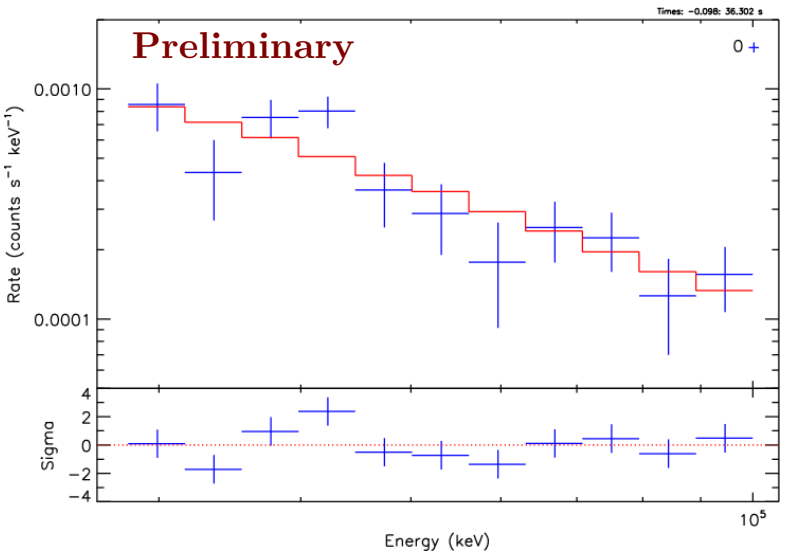
(GRB080916C)



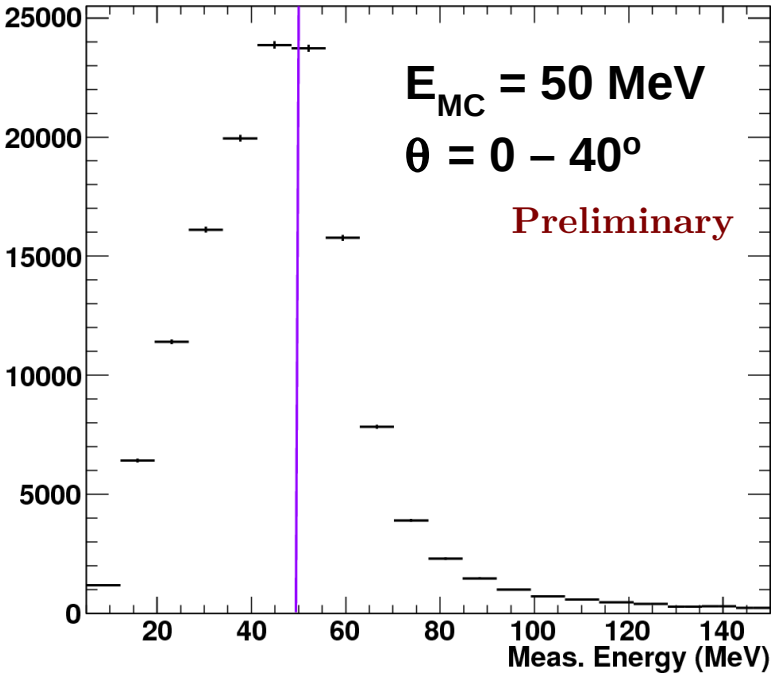


Response Matrix :
GLEAM dedicated simulation

Spectral fit:
(RMfit, R. Preece)



Energy resolution



- Distributions very asymmetric for E_{MC} < 30 MeV
- bias: small
- energy resolution:
  - reasonable above 50 MeV
  - larger than in standard IRF
- ΔE increases with θ
- θ >80° : geometrical constraints

θ = 0 - 40°

E_{MC} (+/- 2 Mev)	Measure (MeV)	<E> / E_{MC}	ΔE/<E>
30	27 +/- 10	0.90	0.33
50	45 +/- 16	0.90	0.32
100	90 +/- 27	0.90	0.27
500	490 +/- 70	0.98	0.14

θ = 40 - 80°

E_{MC} (+/- 2 Mev)	Measure (MeV)	<E> / E_{MC}	ΔE/<E>
30	30 +/- 14	1.0	0.50
50	44 +/- 18	0.88	0.36
100	85 +/- 34	0.85	0.34
500	470 +/- 80	0.94	0.16

Performance for spectral analysis

Simulated GRB080916C-like PL spectrum :

$N(E) = N_0 (E/E_0)^{\gamma}$

N_0 = 1.19 e-09 ph/cm2/s/keV

E_0 = 1 GeV

γ = -2.1

LAT-only, no background

P6 >100MeV only :

N_0 = 1.36 +/- 0.13 e-09

γ = -2.21 +/- 0.06

- ok to <2 σ

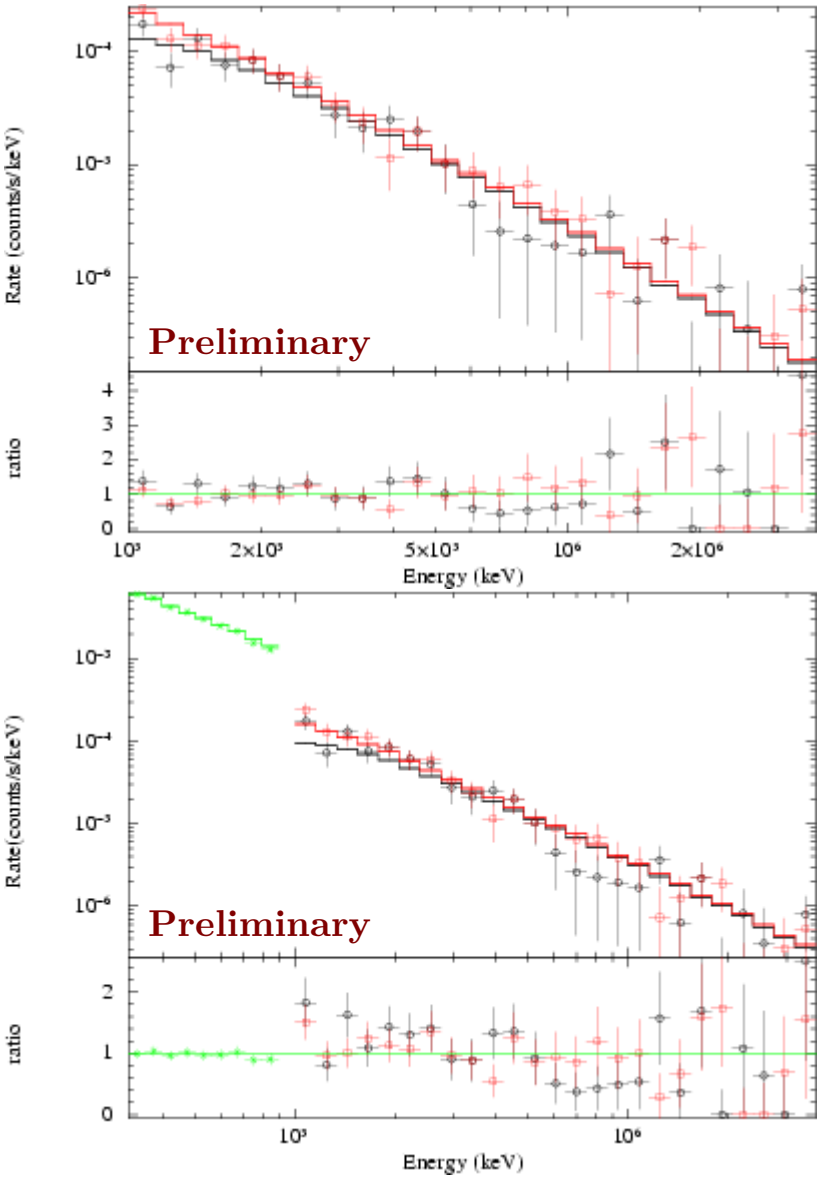
P6 >100MeV + LLE <100MeV :

N_0 = 1.60 +/- 0.12 e-09

γ = -2.02 +/- 0.02

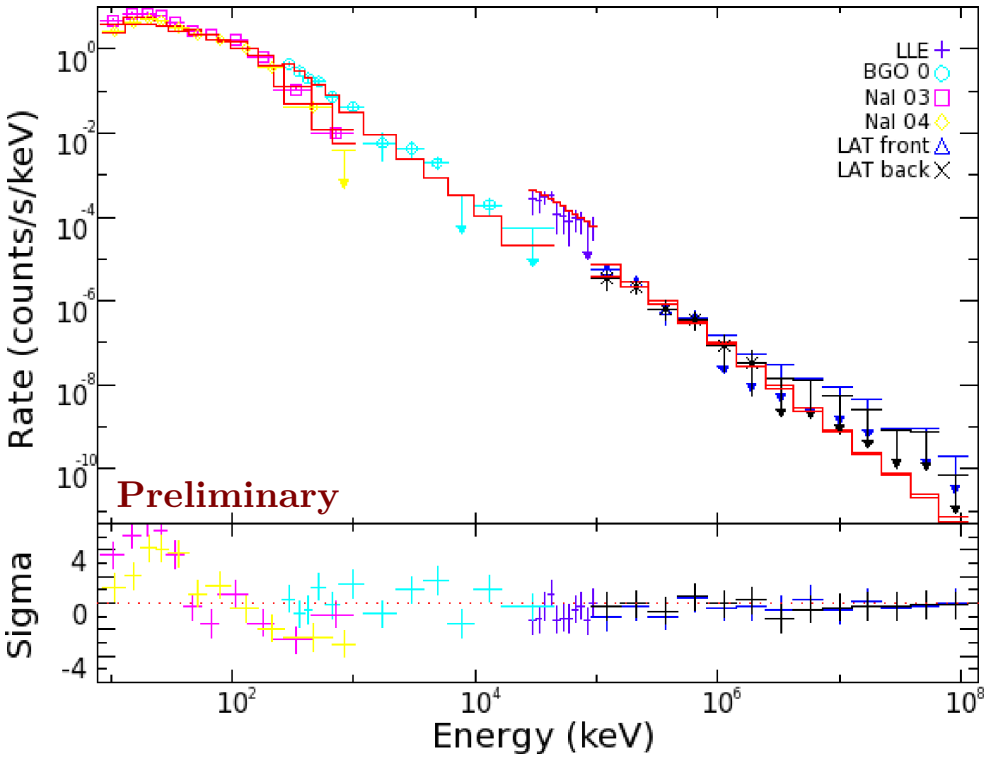
- statistical errors smaller
- possible systematic bias (>3 σ difference)

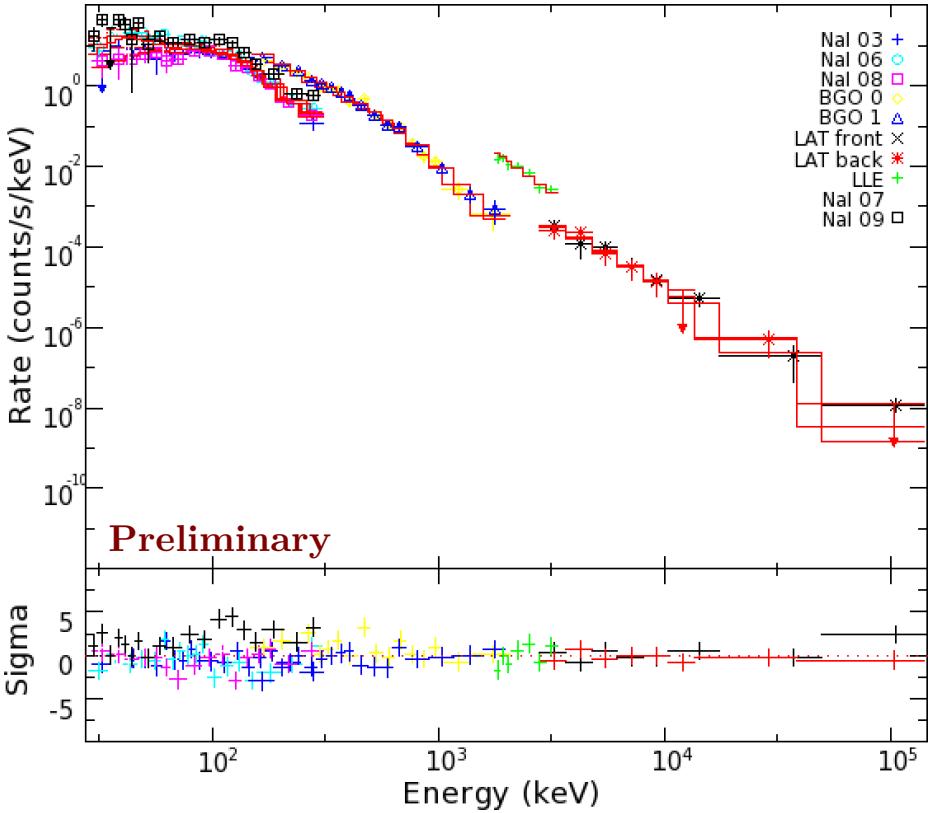
(Count spectra)



Preliminary spectral re-analyses

Integrated spectra of bright GRB 080916C & GRB 090510 :
(no ROI cut here for the moment)





Band function fit :
GBM + LAT transient >100MeV
LLE data superimposed
- good residuals

(Nicola O.)

Band + PL fit :
GBM + LLE<100MeV + transient>100MeV
- increased significance of the additional PL : 8.9 sigma (instead of 5.6)

(Sylvain G.)

Conclusions & perspectives

LLE selection:

✔ Allows to recover GRB emission statistics
✔ Enlarges LAT field-of-view
➢ Brought new LAT GRB detections
➢ Enables time history analysis (w/ ROI cut)
➢ Improves spectral analysis accuracy

Ongoing work:

Validate instrument's responses for this selection
Check associated systematic effects

Future studies:

Light curves analyses
LAT GRB re-analyses
- ➢ Time-resolved spectral analysis
- ➢ Additional spectral components e.g. GRB 090510
- ➢ Spectral cutoffs e.g. GRB 090926A

Extensive search for new detections