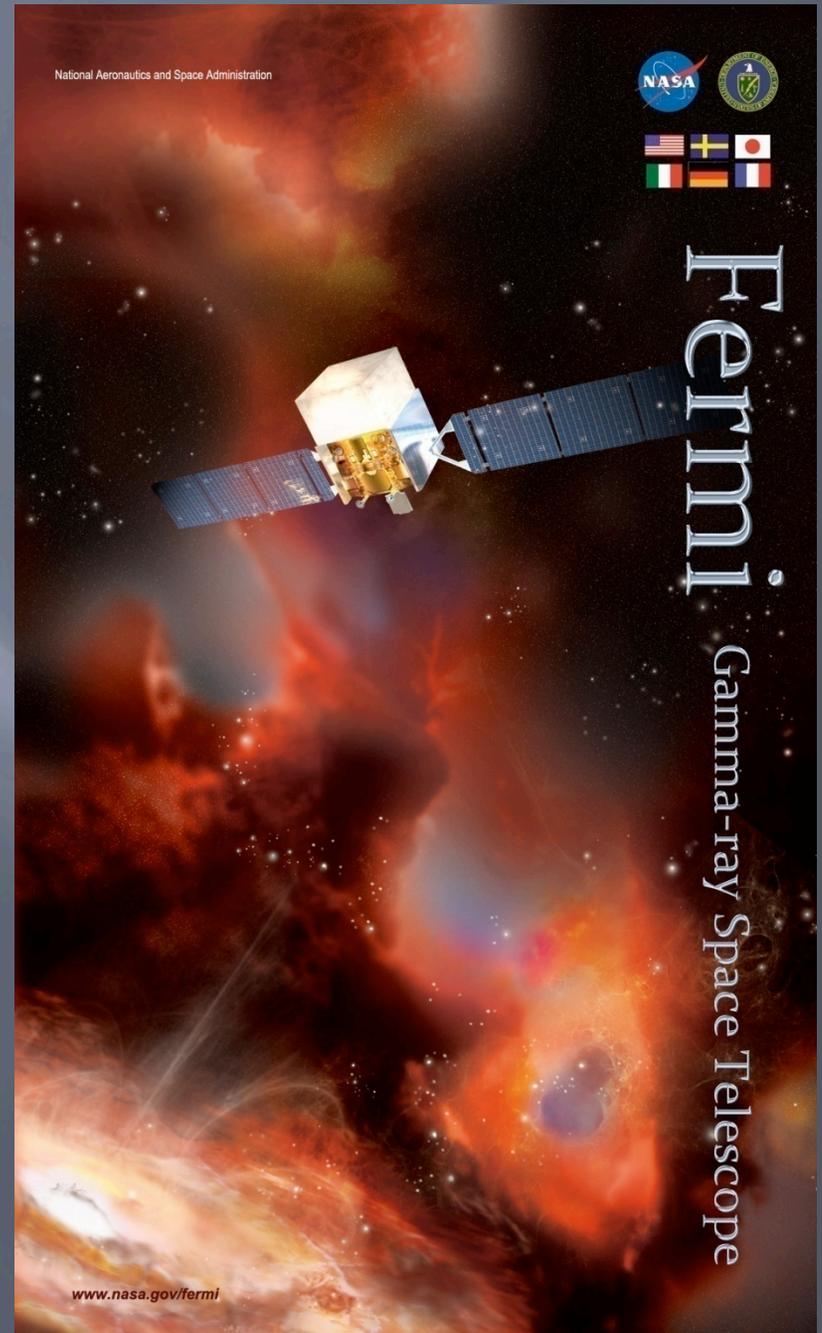


LAT STATUS, PLANS, SCIENCE RESULTS

Peter F. Michelson
LAT Principal Investigator

Fermi User Group Meeting
August 28, 2009



Large Area Telescope status

- LAT continues to perform well;
 - ISOC at Stanford/ SLAC in routine operations mode
 - Data processing pipeline delivering reconstructed event data;
 - LAT collaboration/ISOC continues to refine instrument calibration, event reconstruction, and monitor instrument performance

Year 1 data release

As discussed with the FUG on Feb 6, 2009:

- ▣ LAT 1st year data release is done through the FSSC
 - Year 1 data delivery to FSSC: August 11, 2009
 - Data available from FSSC within one month of delivery

- ▣ Data delivery after initial Year-1 delivery will occur within 72 hours after level-1 processing by ISOC

LAT Public Event Data Release

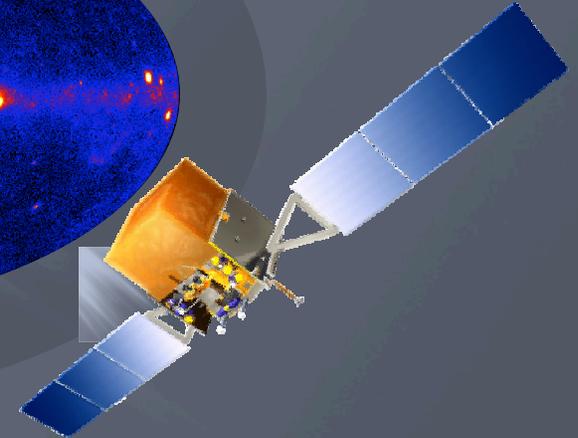
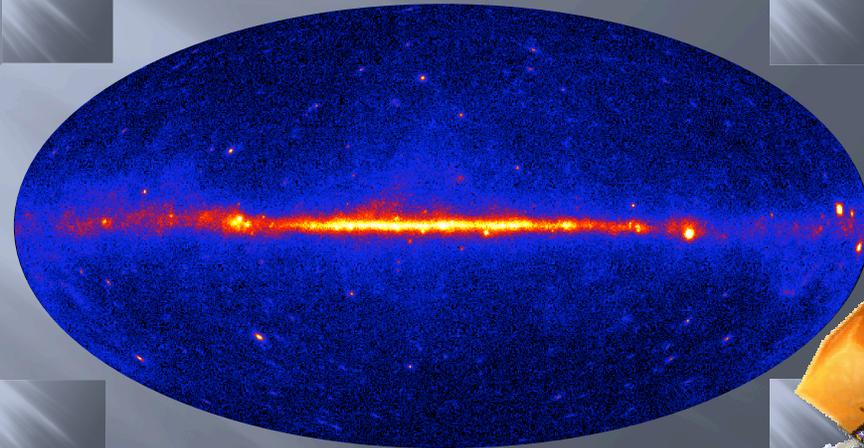
- ▣ all gamma-ray events have well-defined classification, with accompanying instrument performance assessment
 - ▣ if LAT team publishes significant gamma-ray results using a new class, best effort will be made to update public archive with the new classification in a timely manner.
 - ▣ [Note: It takes ~1 month to reprocess, re-deliver and re-ingest 1 year of data]
- ▣ event classes are hierarchical
- ▣ event data for all gamma-ray classes. Event data consist of additional information that is either directly useful in an existing analysis tool or is anticipated to be important enough to include in future tools, along with other information pertinent to a GI analysis.
- ▣ LAT team has provided detailed caveats to guide use of data

LAT Public Event Data: Contents

- ▣ Event data consists primarily of the following (in addition to items in FT1):
 - for systematic checks in instrument coords: **direction, conversion layer,**
 - Covariance error matrix information in slope space. anticipate new tools to transform onto the sky and to use for analyses.
 - Additional variables to enable possible future event class selections without reprocessing

- ▣ Note that event data released do NOT include
 - individual energy estimators
 - ▣ no separate performance parameterizations, difficult to support, no obvious science benefit
 - other event selection variables
 - ▣ standard suite of classes already sufficient for science topics; without ability to run detailed instrument MC (requiring very high level of expertise and significant computing resources), no means to assess performance when changing cuts.
 - detailed track quality information
 - ▣ only meaningful to experts

Fermi LAT: 1st year science highlights

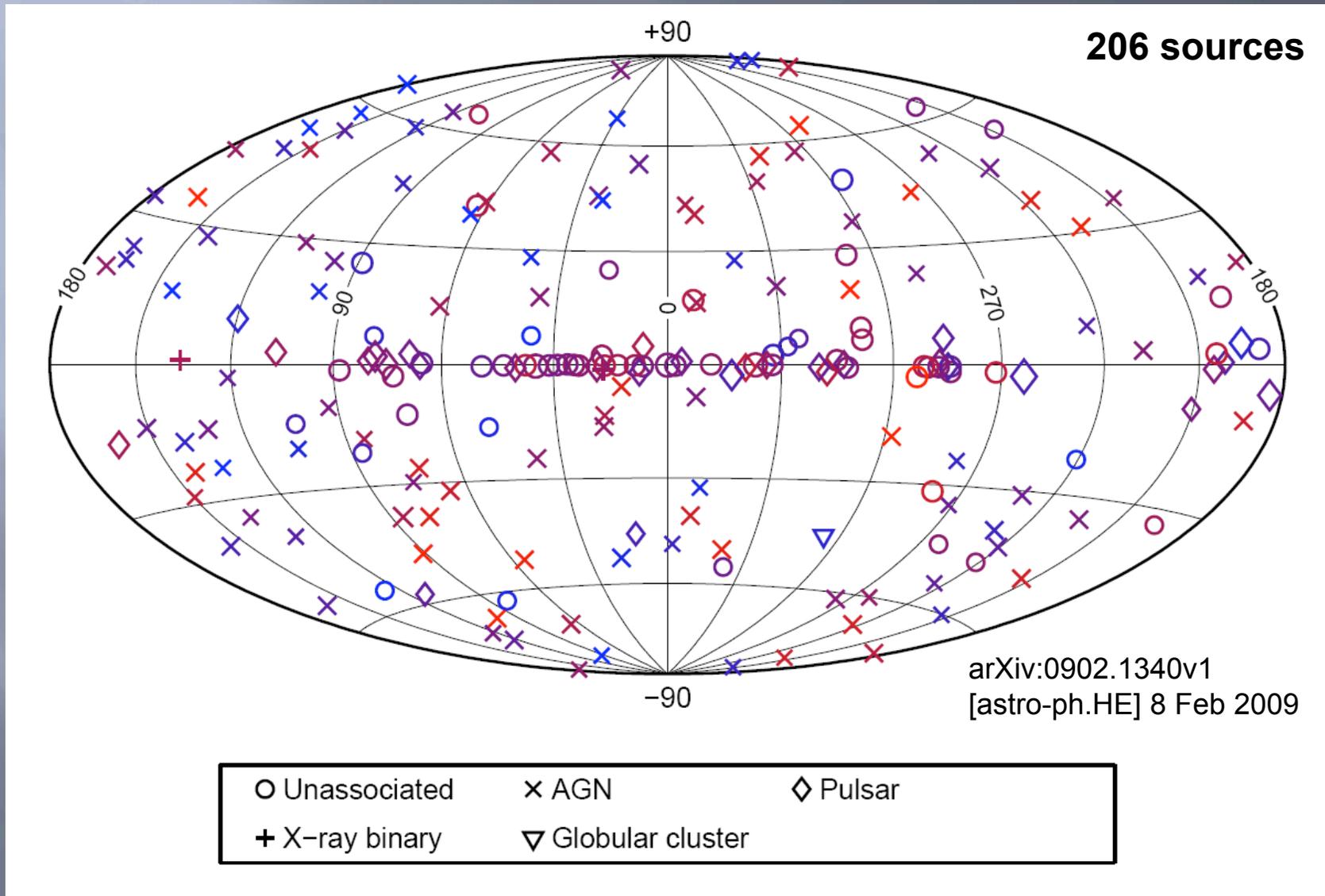


- pulsars, globular clusters, binaries
- active galaxies
- gamma-ray bursts
- diffuse radiation and e^+e^- spectrum

Fermi's wide field of view has been important for facilitating multiwavelength observations

LAT High-Confidence Bright Source List

- released on February 8, 2009; 1st year LAT Catalog by end of October 2009



Science

14 August 2009 | \$10



Fermi
Detecting Gamma-Ray Pulsars

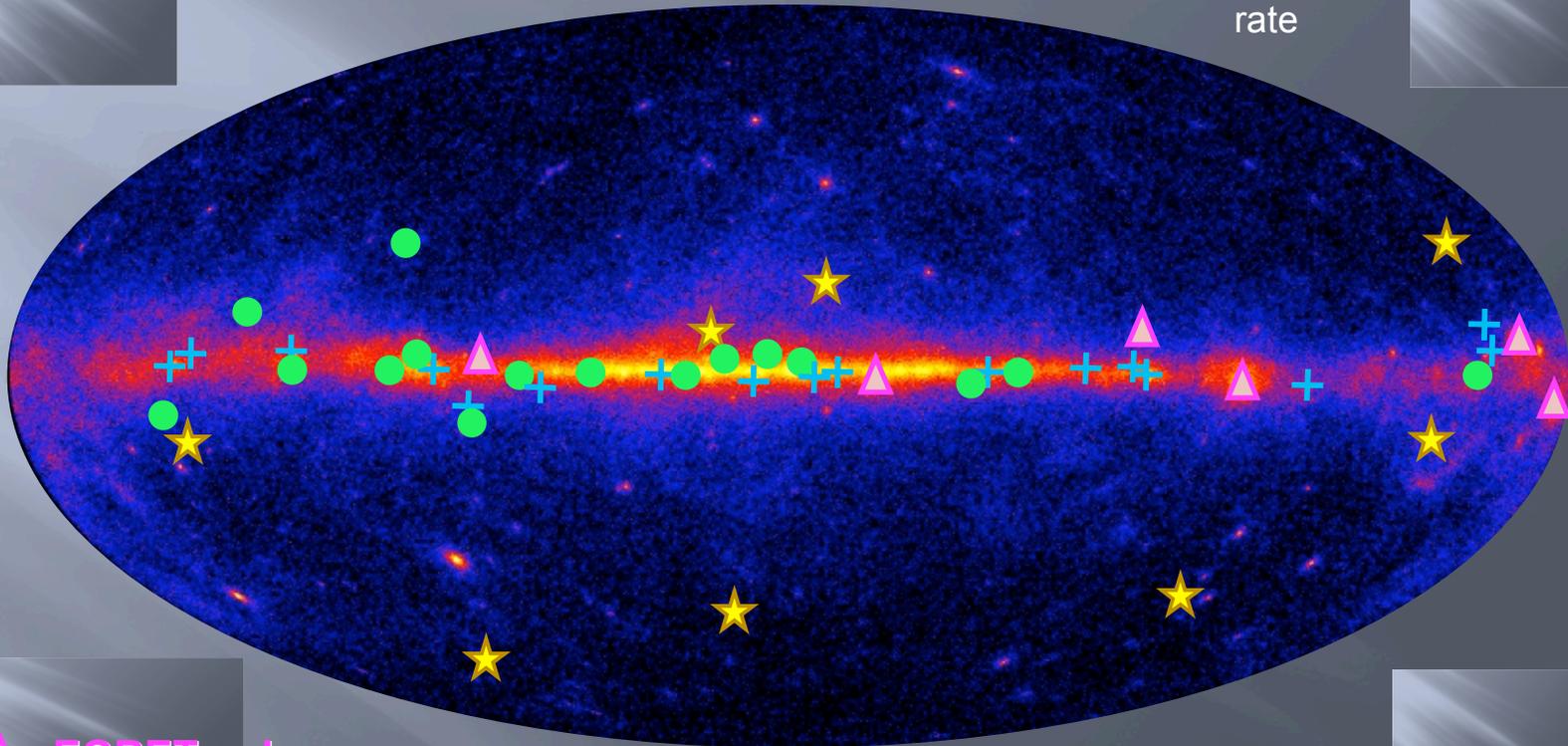
AAAS

Fermi Pulsars

31 gamma-ray and radio pulsars (including 8 ms psrs)

16 gamma-ray only pulsars

Pulses at 1/10th real rate



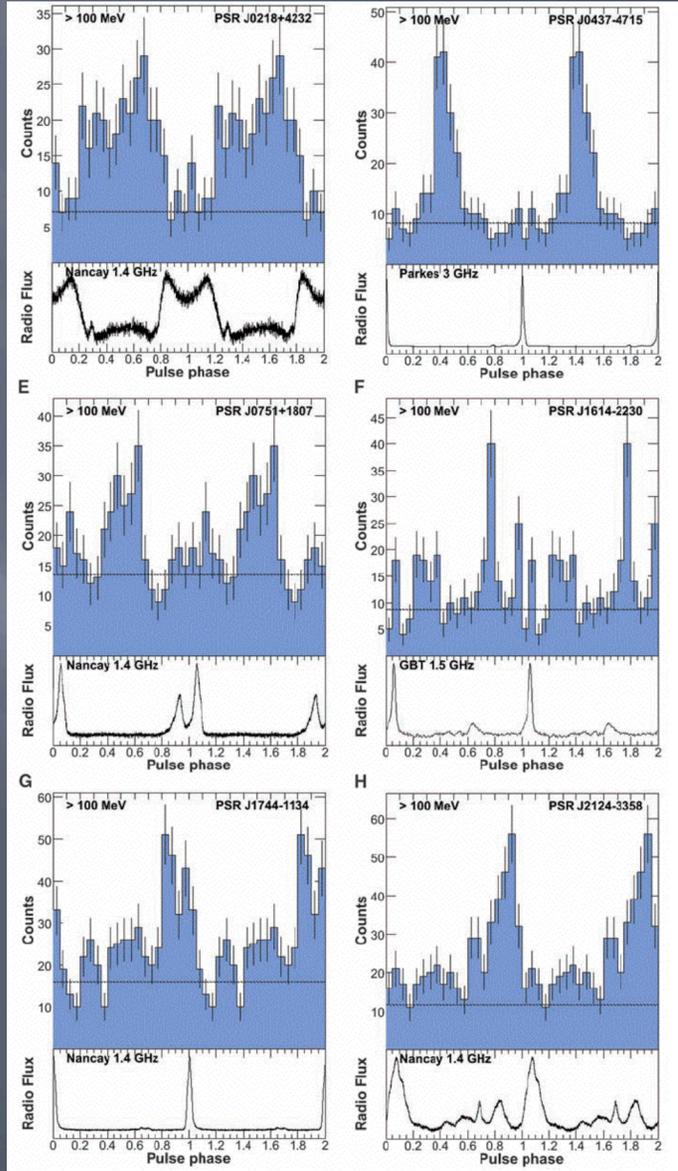
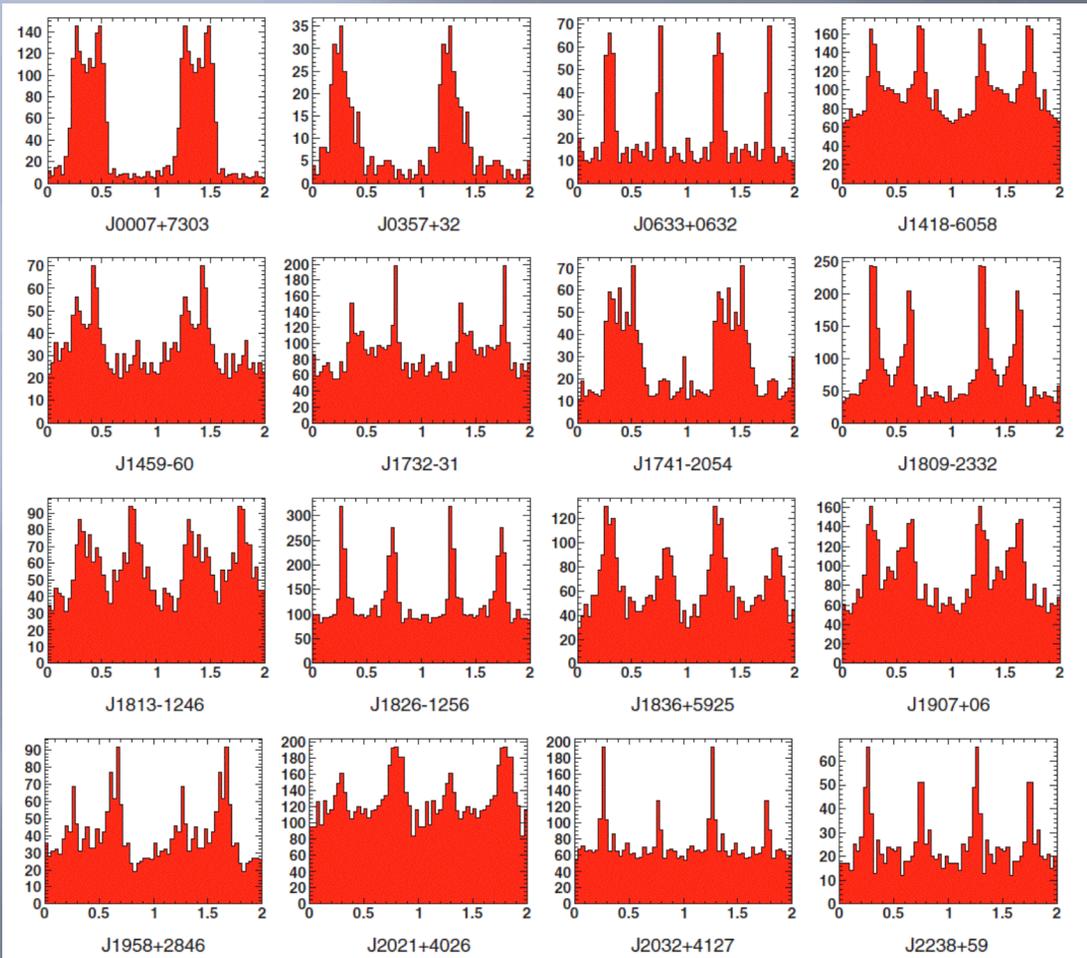
▲ EGRET pulsars

+ young pulsars discovered using radio ephemeris

● pulsars discovered in blind search

★ millisecond pulsars discovered using radio ephemeris

A selection of γ -ray pulsar light curves



Blind search pulsars

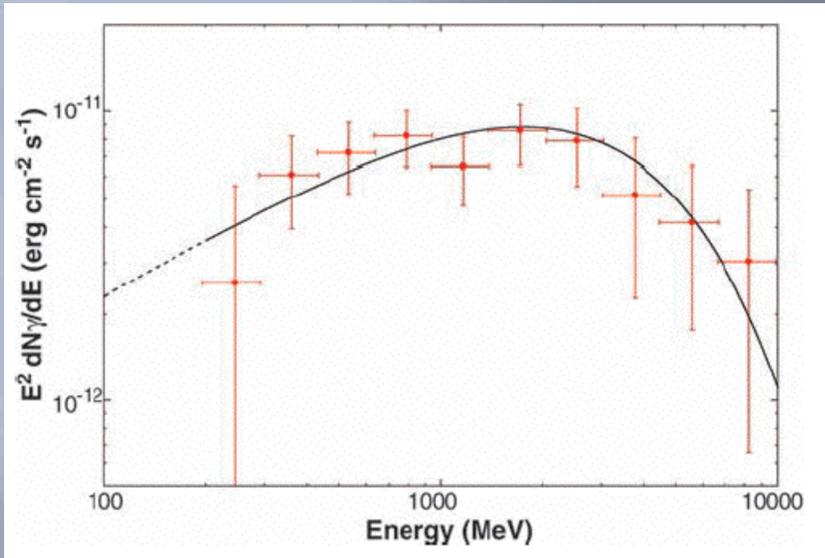
Abdo et al 2009 Science 325 840

Millisecond pulsars

Abdo et al 2009 Science 325 848

Globular Clusters: detection of 47 Tucanae

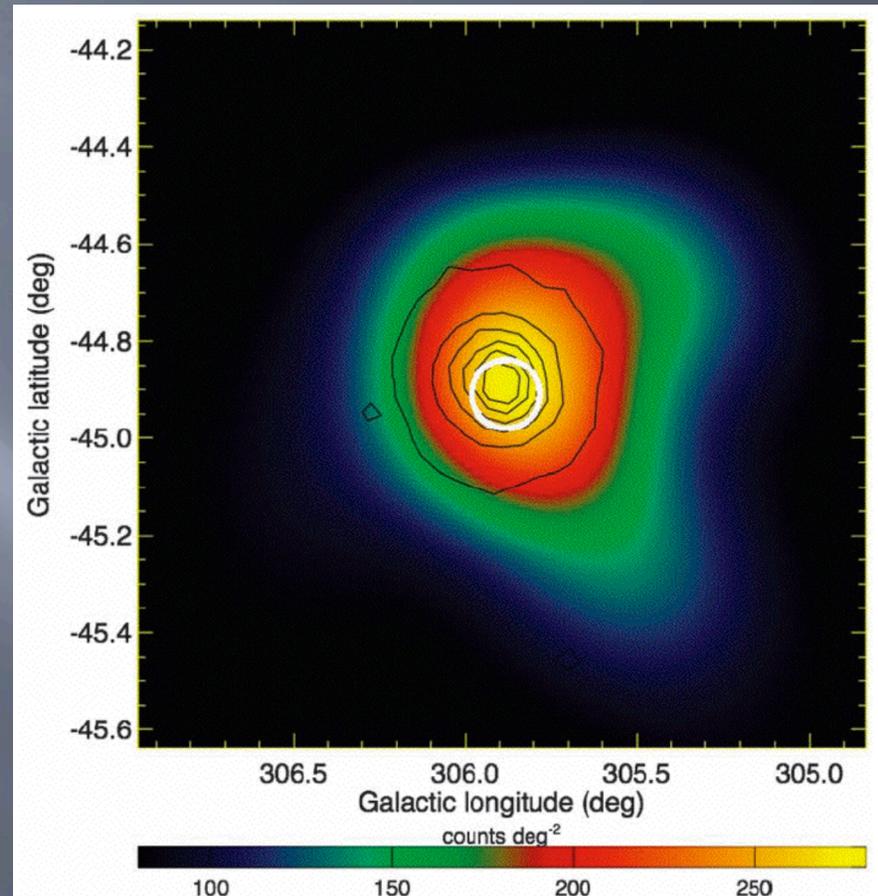
Abdo, et al 2009 Science 325 845



energy spectrum well fitted by
power law with exponential cutoff

$$\Gamma = 1.3 \pm 0.3; E_c = 2.5_{-0.8}^{+1.6} \text{ GeV}$$

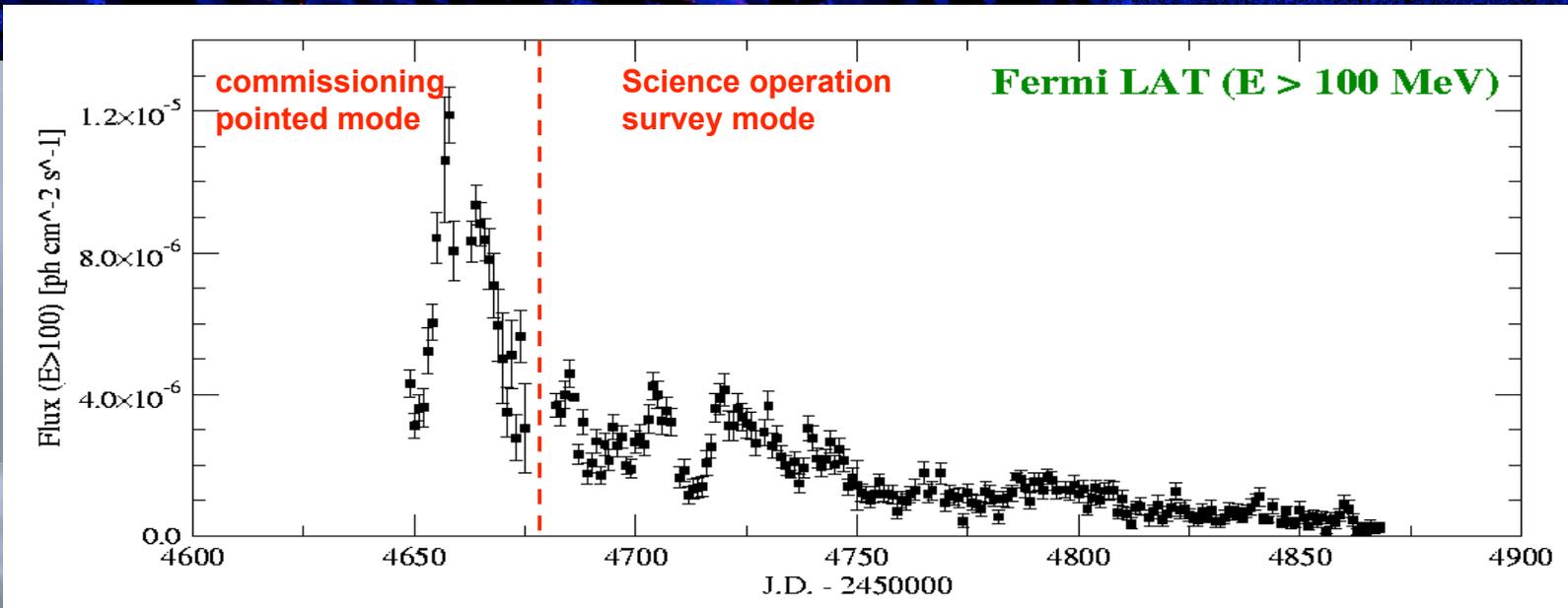
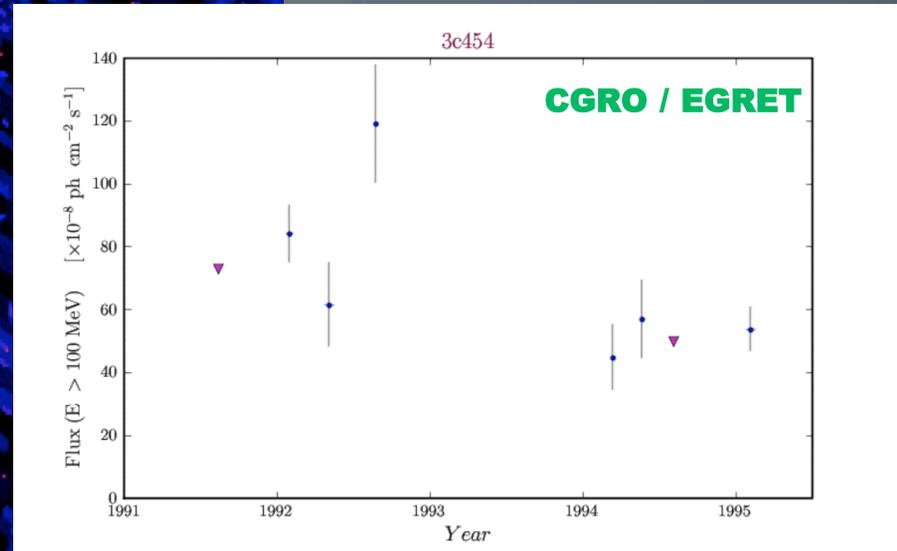
Spectral shape and lack of observed
time variability consistent with γ -ray
emission from population of
millisecond pulsars



LAT γ -ray image (200 MeV – 10 GeV) of
region centered on 47 Tuc.

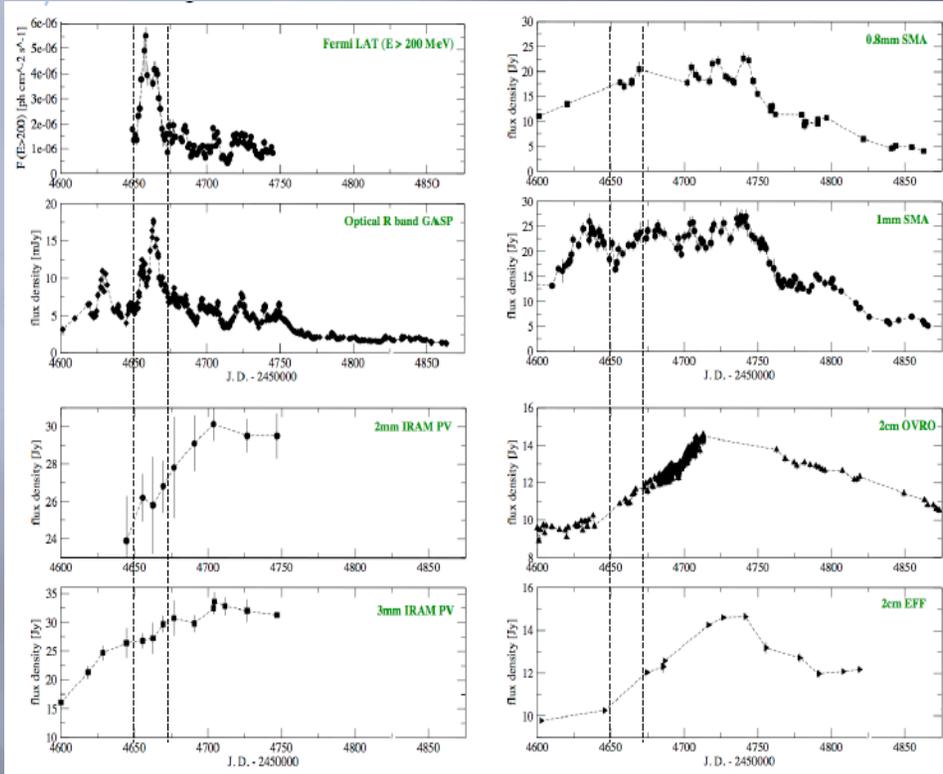
black contours: stellar density
white circle: 95% confidence region
for location of γ -ray source

3C454.3
Supermassive black hole
8 billion light-years from us

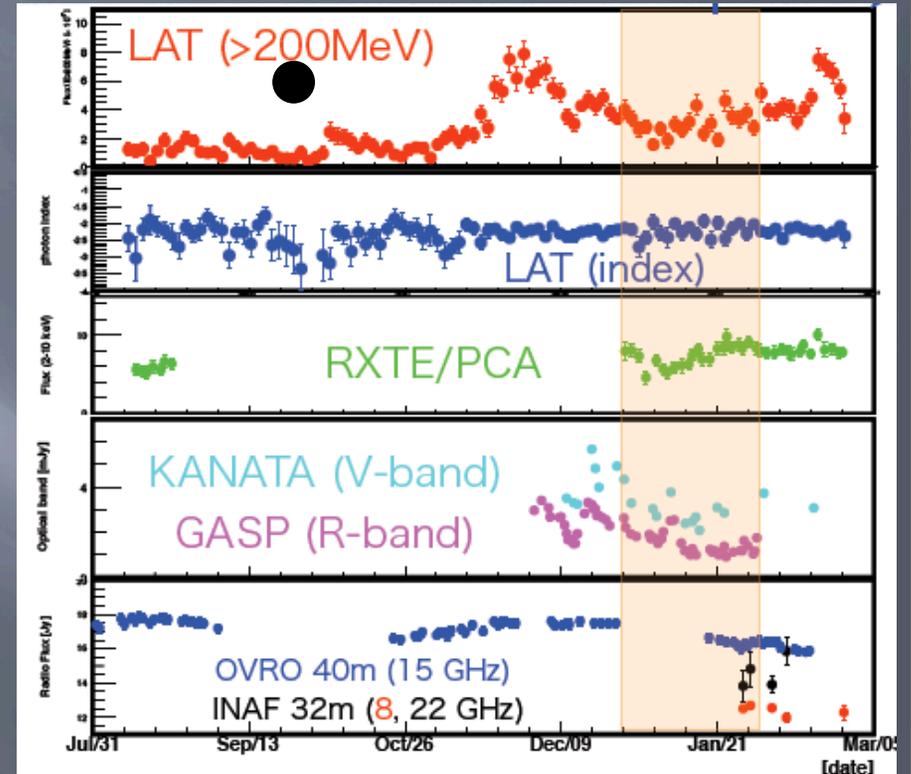


MW campaigns

3C 454.3 (Lars Fuhrmann)



3C 279 (Masaaki Hayashida)



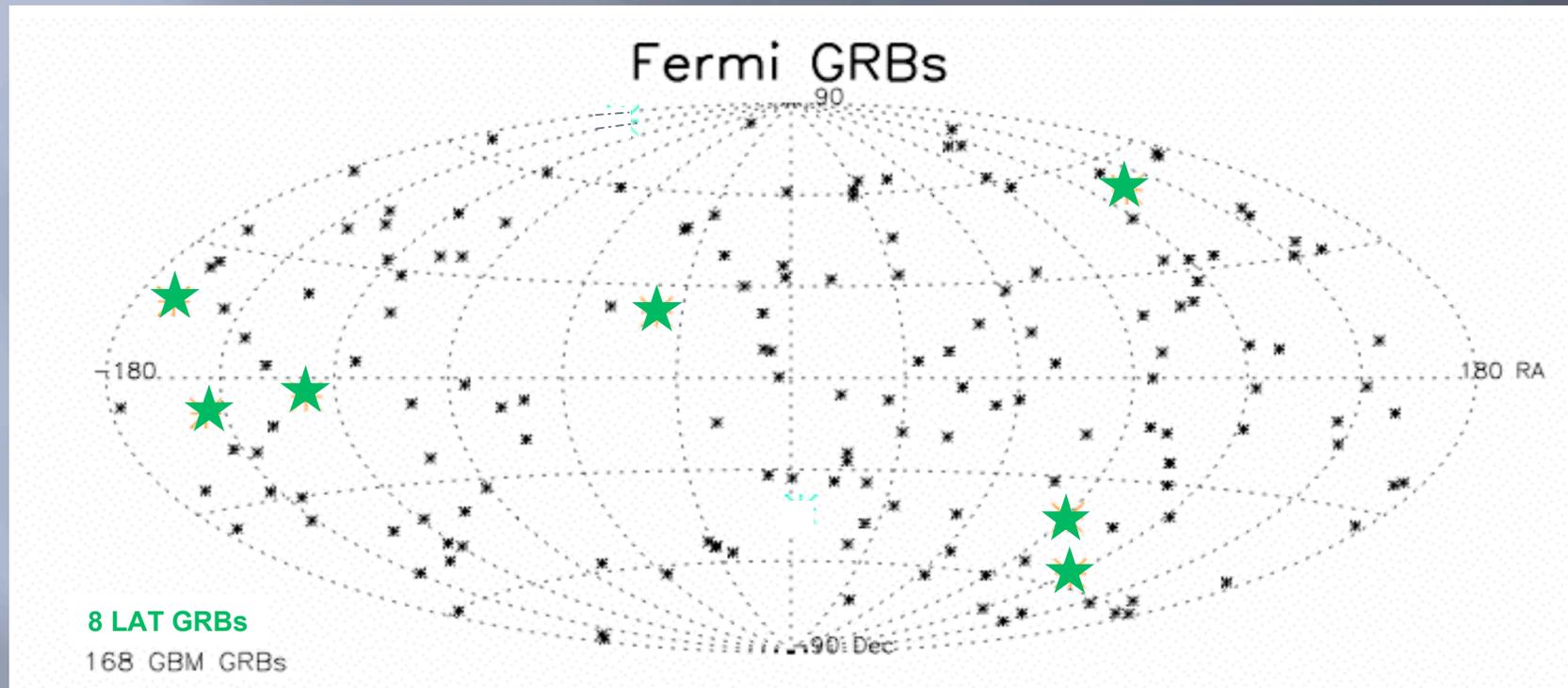
Interband timing correlation

Time resolved SEDs: dynamics of emitting particles

_ Location, environment of emitting zone, acceleration vs cooling

Other campaigns: Mrk421, Mrk501, 1ES1959+650, 3C66A...

Fermi detected GRBs



8 LAT-detected high-energy bursts

GRB 080825C

GRB 080916C $z = 4.35 \pm 0.15$ (GROND/photometric)

GRB 081024B short-duration burst

GRB 081215A

GRB 090217

GRB 090323 $z = 3.6$ (Gemini/spectroscopic)

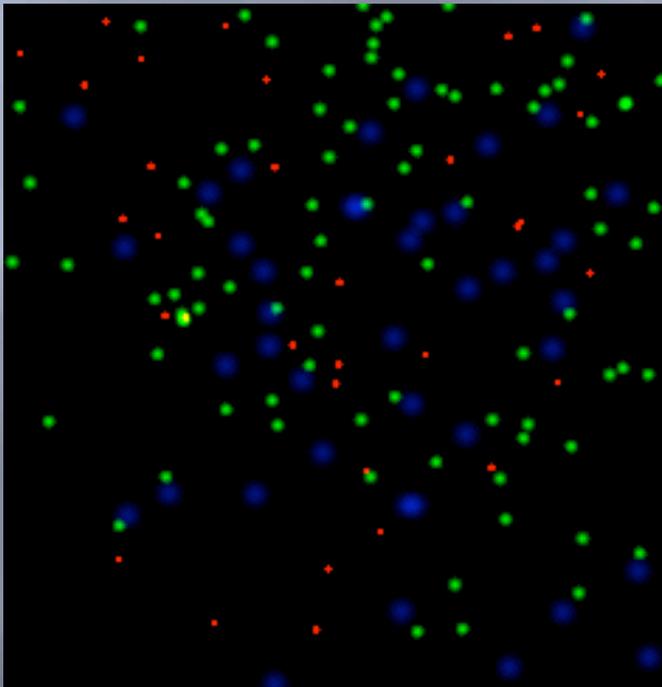
GRB 090328 $z = 0.736$ (Gemini/spectroscopic)

GRB 090510 short-duration burst $z = 0.9$ (VLT)

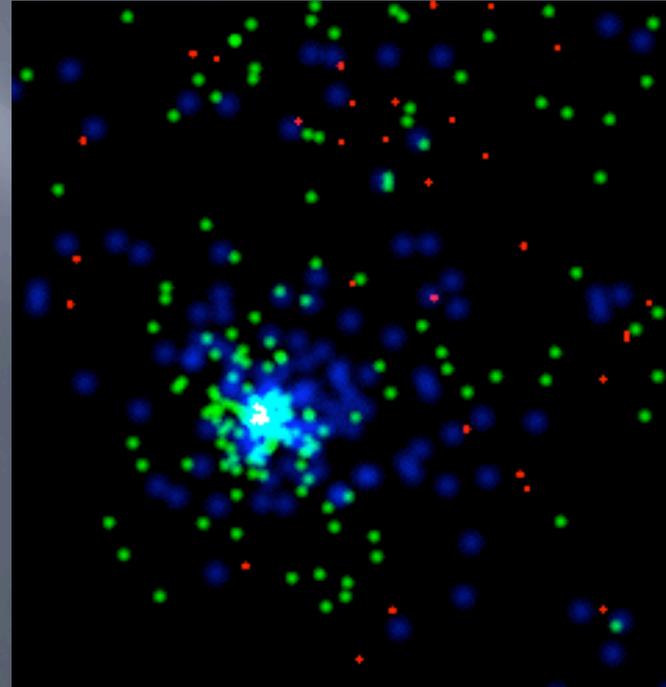
GRB 080916C

- $\pm 25^\circ$ region around GRB 080916C
 - GRB at 48° from the LAT boresight at T_0
- **RGB** = **<100 MeV**, **100 MeV - 1 GeV**, **>1 GeV**

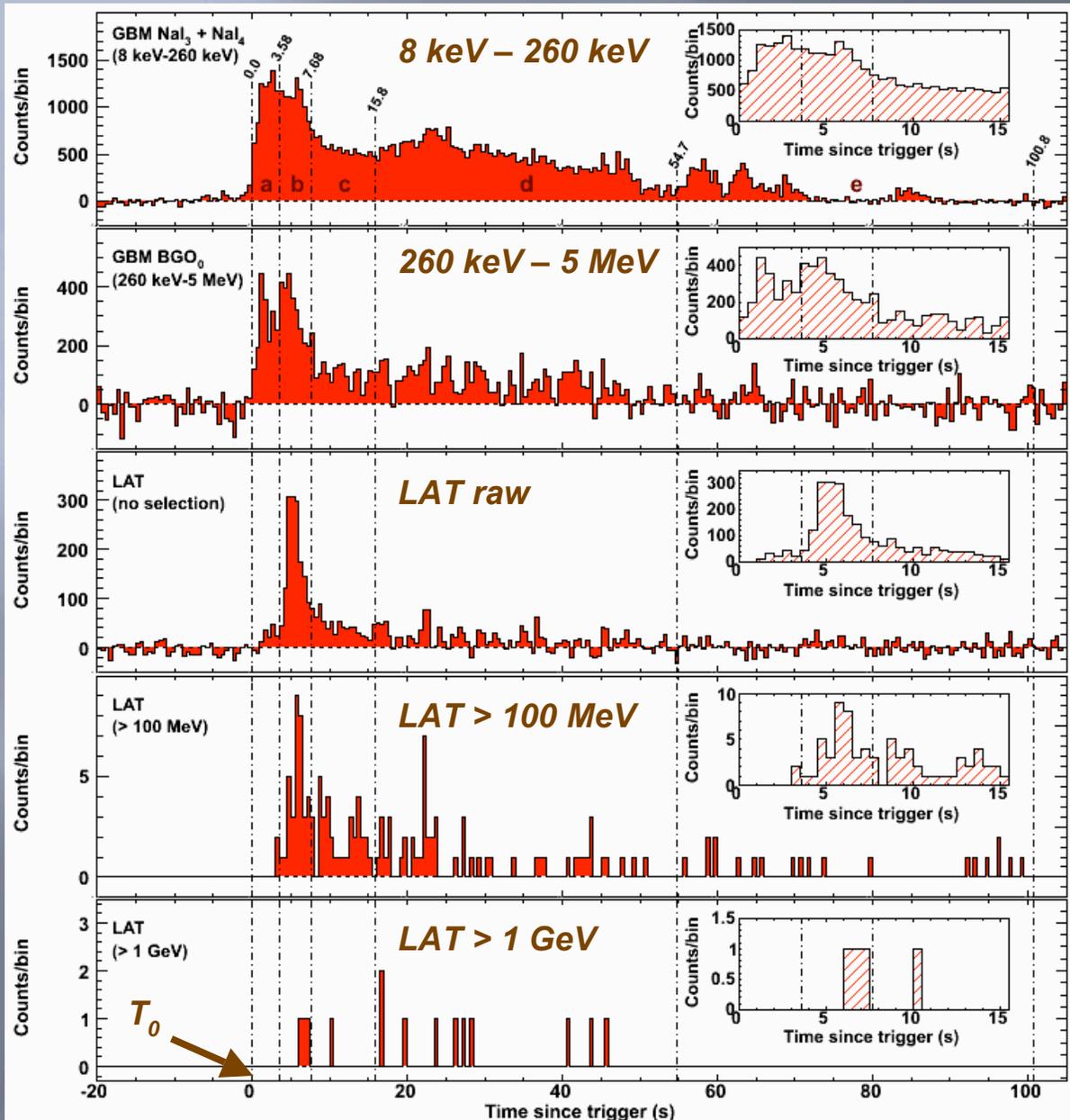
Before the burst ($T_0 - 100$ s to T_0)



During the burst (T_0 to $T_0 + 100$ s)



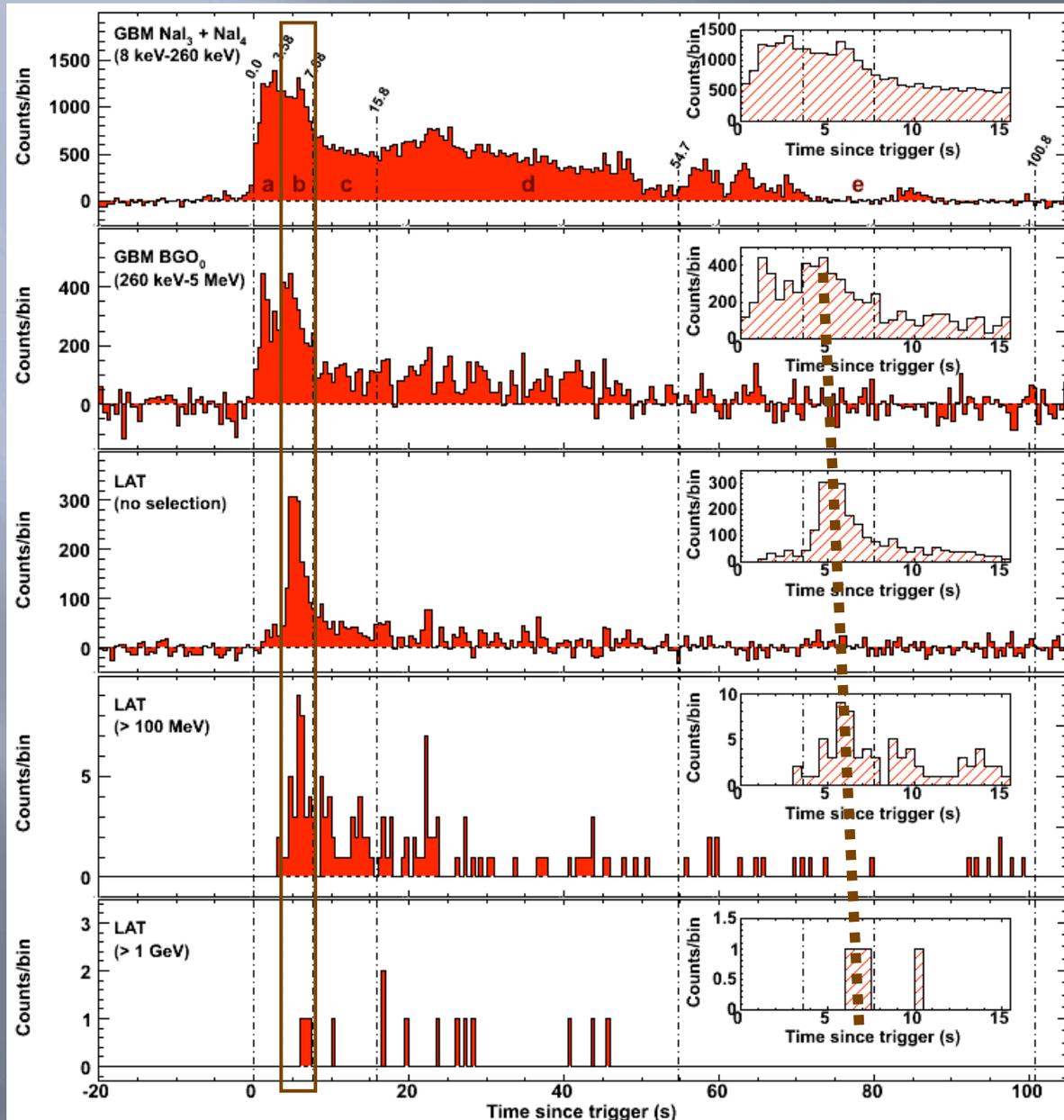
GRB 080916C: GBM & LAT light curves



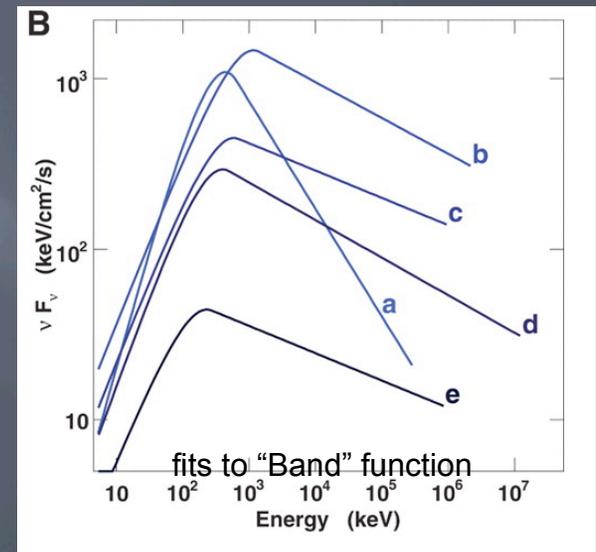
- For the first time, can study time structure > tens of MeV, 14 events above 1 GeV
- First low-energy GBM peak is not observed at LAT energies
- $z = 4.35 \pm 0.15$

$\gamma\gamma$ absorption arguments and redshift impose a lower limit of $\Gamma_{\min} = 860$

GRB 080916C: GBM & LAT light curves



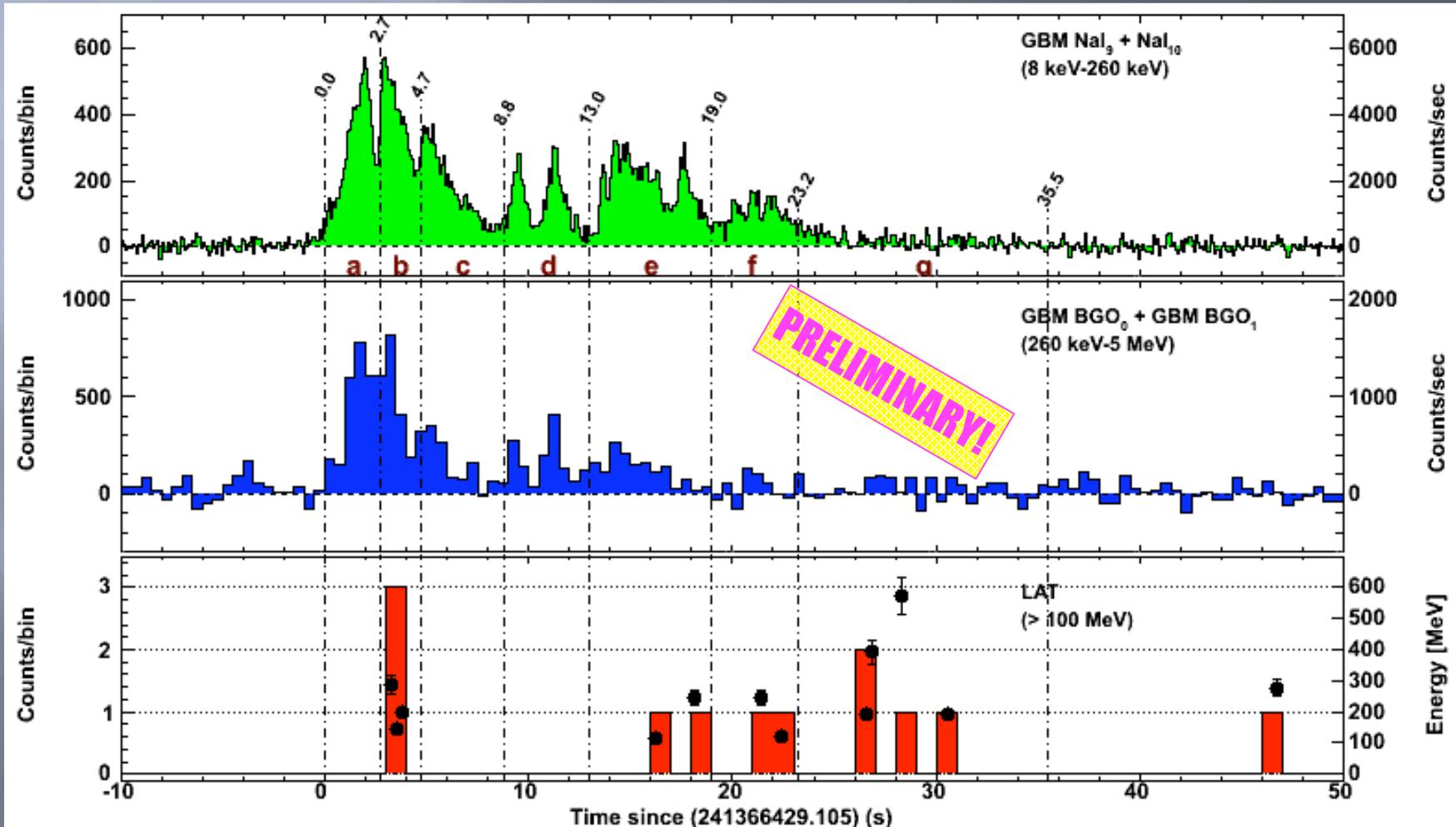
- The bulk of the emission of the 2nd peak is moving toward later times as the energy increases
- Clear signature of spectral evolution



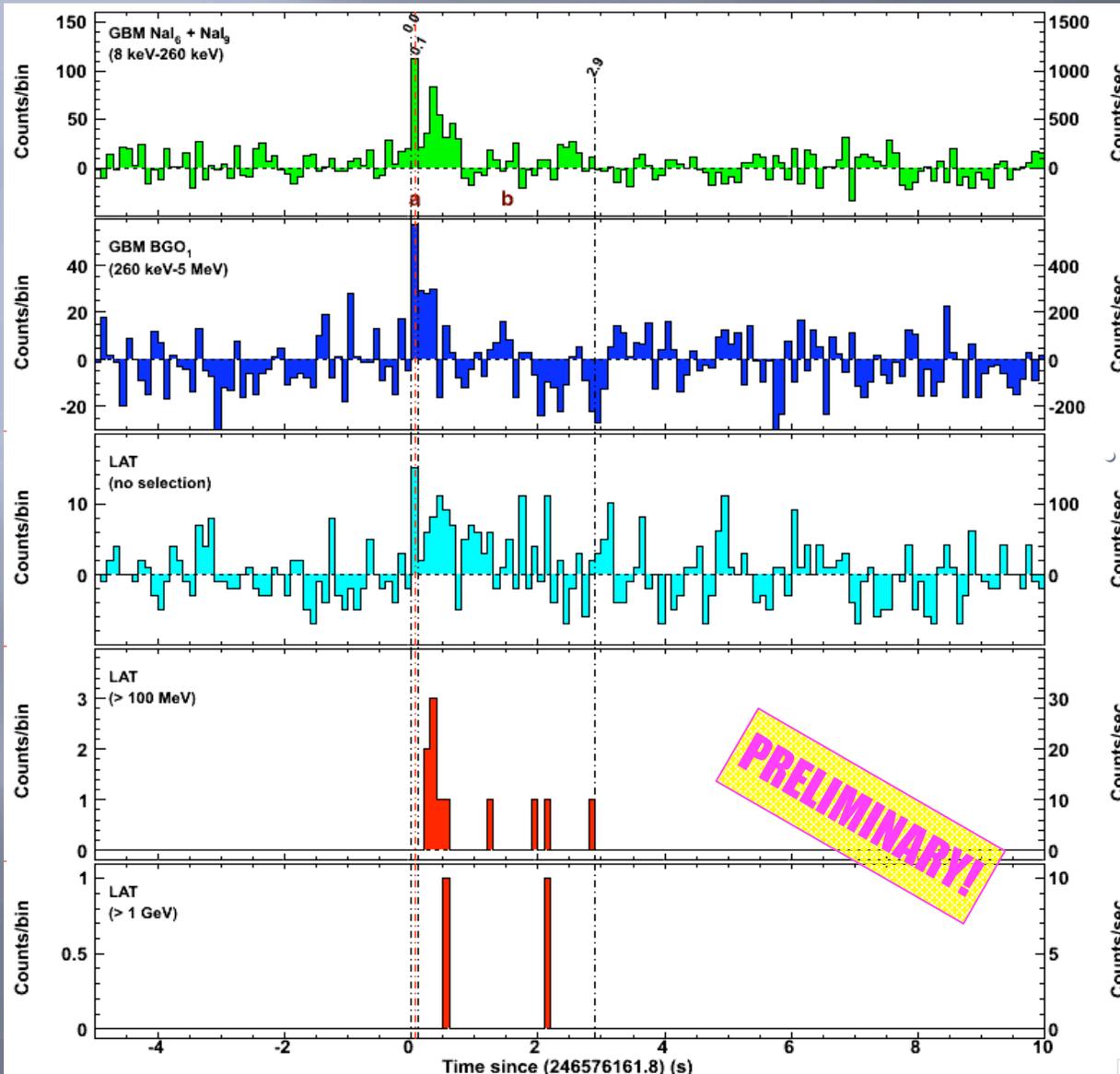
Soft-to-hard, then hard-to-soft evolution

GRB 080825C

- First LAT events are detected in coincidence with the 2nd GBM peak
- Highest energy event is detected when GBM low energy emission is very weak



GRB 081024B

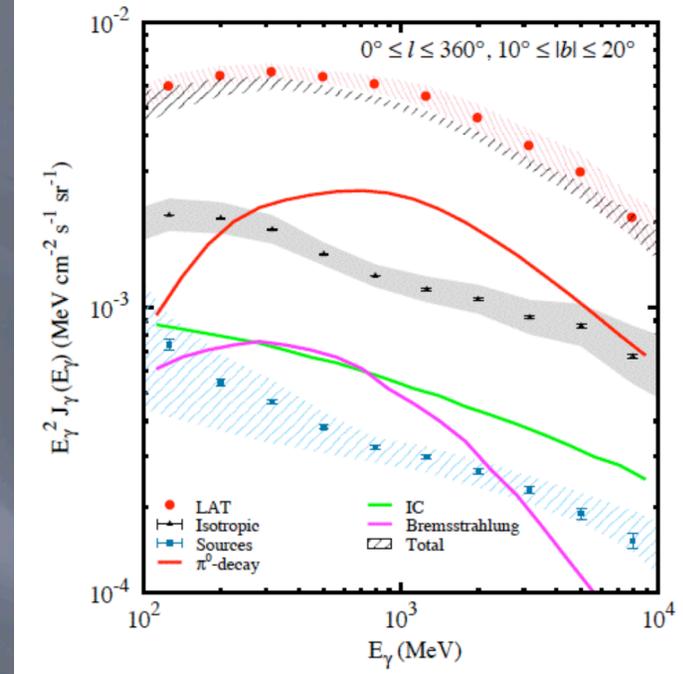
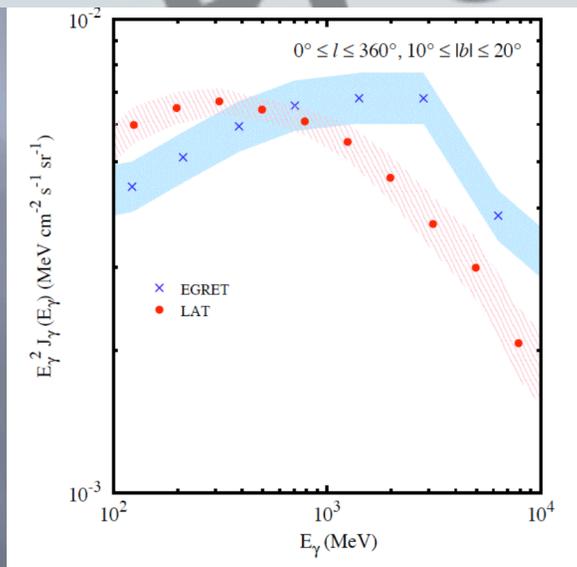
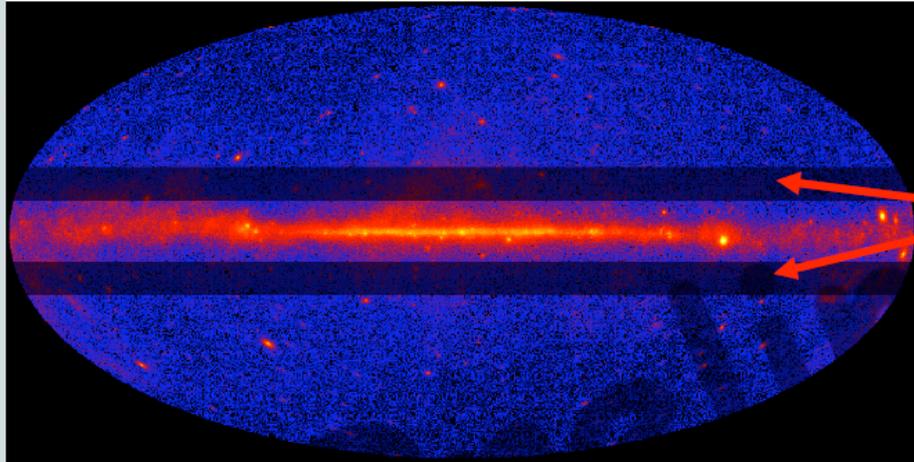


First LAT events are again delayed with respect to GBM onset and seem to arrive in coincidence with GBM 2nd pulse.

LAT emission extends few seconds beyond the duration of the typical keV-MeV emission (~0.8 sec).

First short GRB with >1 GeV photons detected

Diffuse bkgnd “GeV excess”



Fermi LAT: e^+e^- spectrum

- no prominent spectral features between 20 GeV and 1 TeV;
significantly harder spectrum than inferred from previous measurements

- events for e^+e^- analysis required to fail ACD vetoes for selecting γ events; resulting γ contamination $< 1\%$

- further cuts distinguish EM and hadron events; rejection $1:10^3$ up to 200 GeV; $\sim 1:10^4$ at 1 TeV

- energy reconstruction aided by shower imaging capability of calorimeter

- more than 4×10^6 e^-e^+ events in selected sample

