Calibration flight data sets for the Fermi-LAT data analysis

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Summary: After almost three years on-orbit, the Fermi-LAT has collected a huge amount of flight data from which many useful calibration data sets can be extracted.

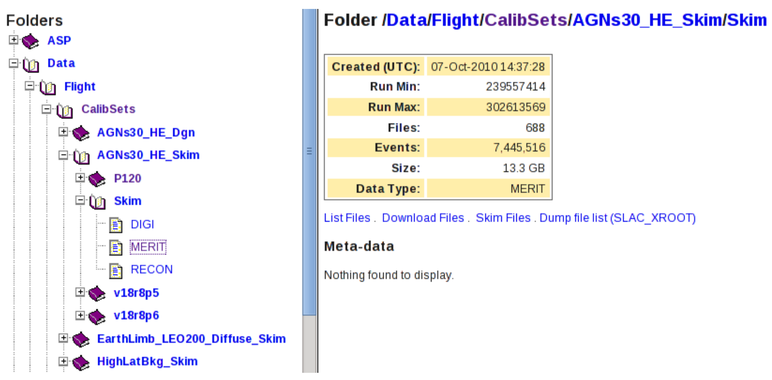
From the detector design to the event analysis scheme, the Fermi-LAT has relied heavily on Monte-Carlo simulations. The high–quality data produced since launch have validated this choice. However, two and a half years of flight data now allow us to better understand the instrument response over a very large phase space. Many specific calibration data sets can be extracted from the data collected so far, and may be used to constrain systematic uncertainties, validate Monte-Carlo simulations and develop a new and improved low-level event reconstruction. This poster describes the calibration data sets used within the LAT collaboration and gives an overview about the methodology developed to extract relevant figures of merit. We encourage scientists both within and outside the LAT collaboration to reproduce our calibrations data sets to constrain the systematic uncertainties specific to their analysis.

Introduction

- Pre–flight event analysis was based on simulations [1], and validated with beam–test data taken with the LAT Calibration Unit.
- In 2.5 years of data taking, Fermi has released half a billion events to the public.
- Calibration data sets can be used to explore the instrument response, some of them can be extracted from public data such as Earth limb photons, pulsed photons from Vela or high energy events from AGNs.

How we build calibration datasets

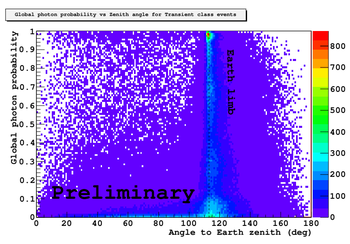
- Define and extract a coherent set of data
- Postprocessing: calculate new quantities (e.g. phase for pulsar photons or distance from a specific source. . .)
- Store and document all the data products to make them easily accessible to the collaboration
- Reprocessing: reconstruct events using new algorithms for the improvement of the low level event reconstruction



Earth limb photons

- The Earth limb is a bright source of γ-rays, that usually is in the LAT field of view
- Pure γ source with a well known spectrum: check the systematics of a spectral analysis

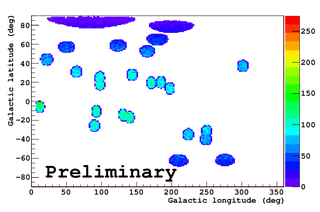
- The Earth limb is at 113° from the Earth zenith
- Its spectrum follows a smooth power law above $\sim$3 GeV



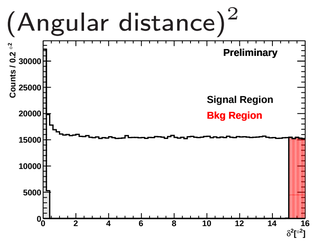
Active Galactic Nuclei

- 25 brightest AGNs from the first Fermi source catalog (1FGL) [2]
- Select `Transient` class events within a circular 6.5° region of interest
- Point sources: test the tracker angular resolution at high energy

Bright AGNs sky map

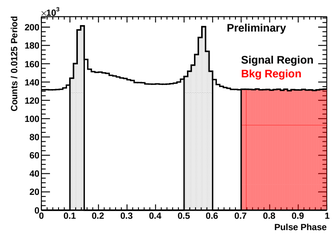


(Angular distance)^2



The Vela pulsar

- Brightest persistent γ-ray point source
- Select `Transient` class events within a 15° region of interest
- Use *off–pulse* to statistically subtract background from *on–pulse* distributions



Vela phase histogram:

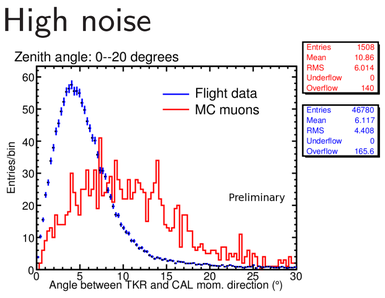
- *on-pulse* (gray) signal: $\Phi \in [0.1 - 0.15]$ or $\Phi \in [0.5 - 0.6]$
- *off-pulse* (red) background: $\Phi \in [0.7 - 1.0]$

Calibration data sets for the improvement of the event reconstruction

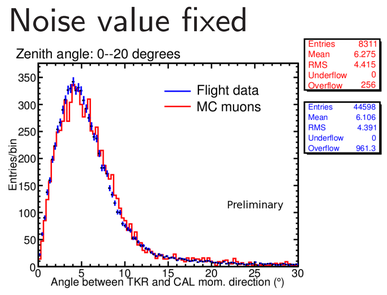
Study the electronic noise in the simulation

- We used a calibration data set of flight minimum ionizing particles (mostly protons)
- We looked at the difference in the reconstructed directions between the tracker and the calorimeter moment analysis
- Fine tune the noise value in the simulation

High noise

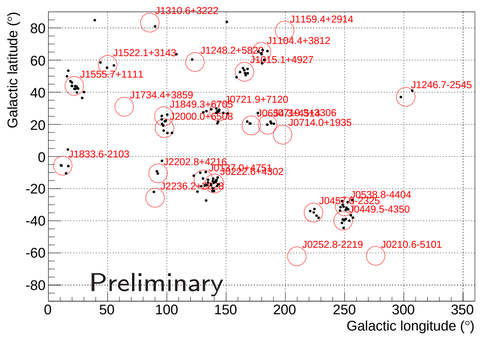


Noise value fixed



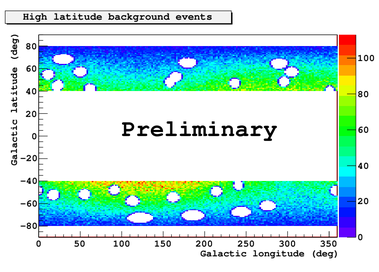
Study calorimeter moment analysis performance

- The bright AGNs sample is a good source of high energy events from a known direction (as measured in the tracker)
- Sky map of the AGNs sample as seen by the calorimeter: study the calorimeter angular resolution



Study background events

- High latitude events with no special selections
- Remove the bright galactic plane, the Earth limb and 1FGL [2] bright sources
- Validate simulations, especially when designing quantities for new reconstruction algorithms
- Test or develop background rejection on real on–orbit data



- Select events passing through the GAMMA filter
- Keep 1/100 events to sample 55 days of orbits
- 3.7 M events total
- Reprocessed with the new reconstruction algorithms

Conclusions

- The Fermi-LAT collaboration uses flight data to validate science analysis and develop new event reconstruction algorithms.
- Many calibration data sets can be extracted from public data: Earth limb photons, Vela pulsed photons, high energy events from AGNs

References

[1] Atwood, W. B. et al., *The Large Area Telescope on the Fermi Gamma-ray Space Telescope Mission*, ApJ, 697, 1071 (2009).

[2] Abdo, A. A. et al., *Fermi Large Area Telescope First Source Catalog*, ApJS, 188, 405 (2010).