Abstract Summary: we describe the tools and methods to monitor the quality of the Fermi-LAT science data.

Science Data Monitoring for the Large Area Telescope

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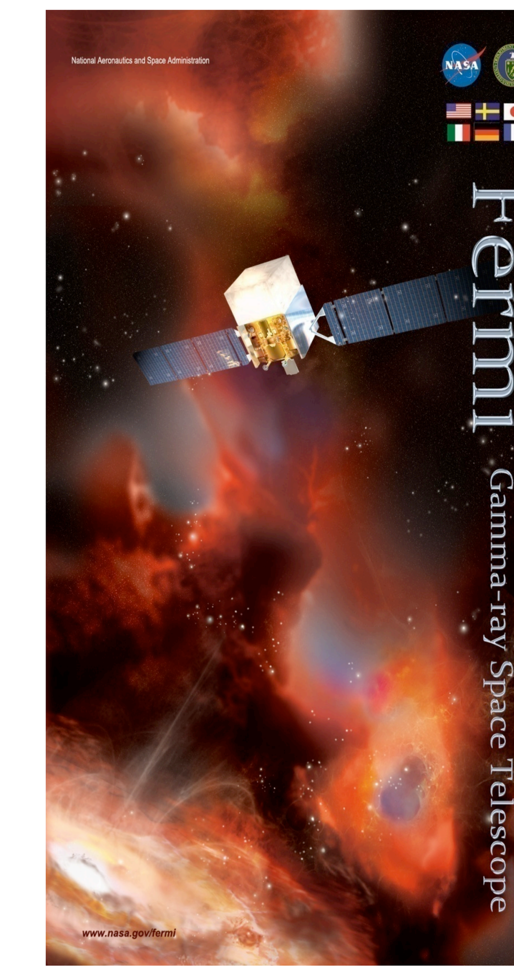
on behalf of the Fermi Large Area Telescope Collaboration



Abstract

The quality of the LAT science data is continuously monitored through a number of web-based tools, to make sure that all the detector subsystem collect data as expected and that the data can be used for physics. We are currently monitoring over a hundred thousand quantities, both at the single-subsystem level and at the overall detector level. Most quantities are checked by an automated alarm system, which can catch problems without human intervention, while a few quantities are inspected every day by duty scientists. The output of the Data Monitoring work includes a Data Quality flag, which assesses the overall quality of the data and is included in the spacecraft data files provided by the Fermi Science Support Center.

Purpose of the system

At any time of the LAT data taking, we want to be able to monitor the quality of the science data, to make sure that the detector is performing as expected and to guarantee that the data can be used for physics analysis.

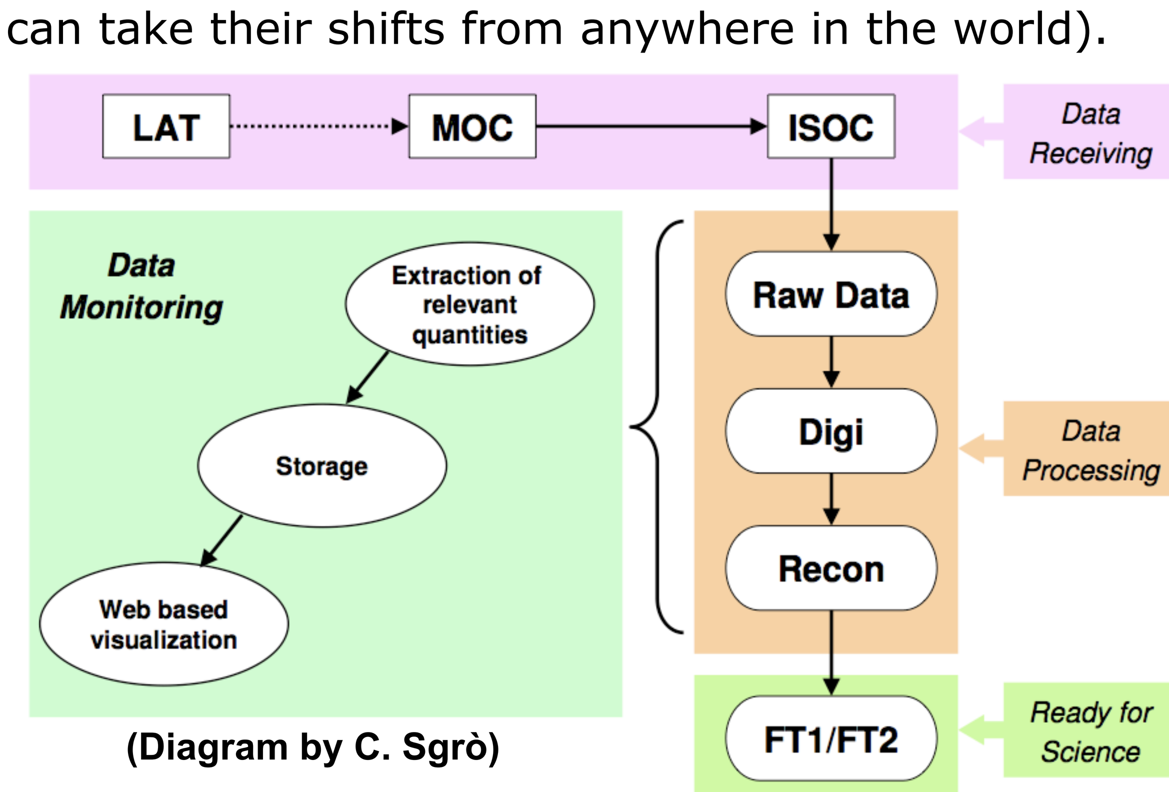
We constantly monitor hardware related quantities (to identify possible anomalies), calibration related quantities (to trend the stability of the instrument performance) and high-level quantities such as physics rates, reconstruction outputs etc.

Most quantities are highly orbit dependent, so their behavior is always evaluated towards the detector environment (particle fluxes, geomagnetic variables).

We are currently monitoring approximately 120,000 quantities, both at the single channel/subsystem level and for the entire detector. The LAT duty scientists are requested to visually inspect only a small subset of these quantities: everything else is monitored through a series of automated alarms. The resulting workload is very light (2-3 hours per day are usually enough to inspect all the data for that day and to ensure that all data is good for physics).

How it works

The path of the LAT data is shown below: at each step of the data processing in the Level1 Pipeline, the relevant data quality information is stored and made available via web-based interface (the Duty Scientists can take their shifts from anywhere in the world).



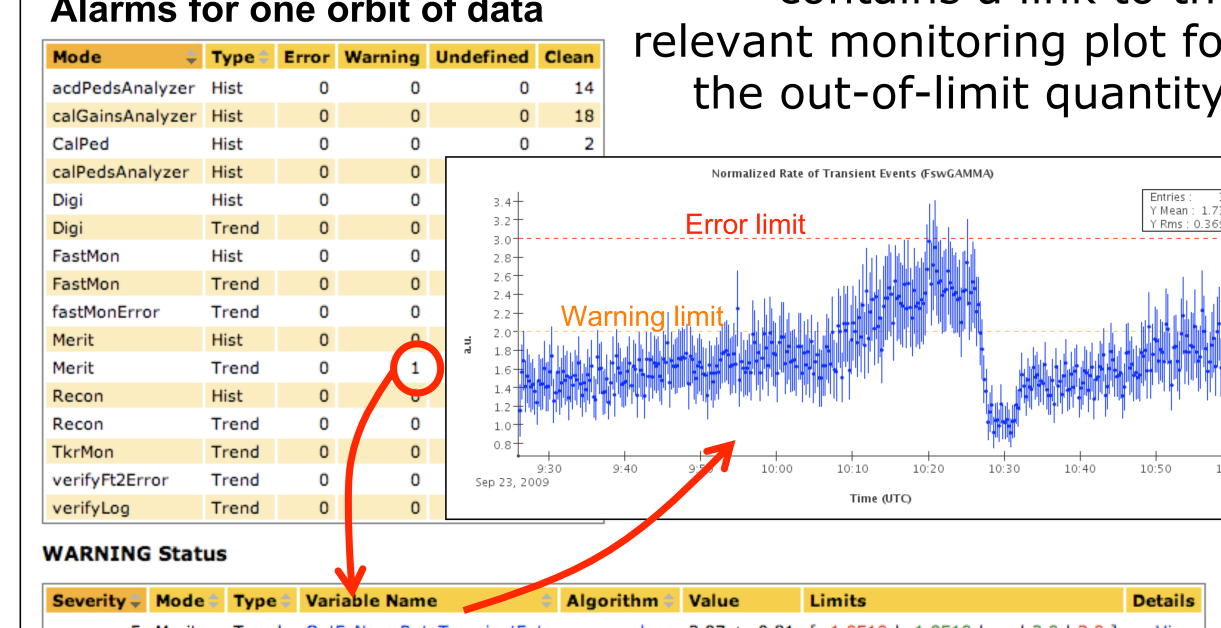
(Diagram by C. Sgrò)

We support two main types of monitoring tools: the End-Of-Run histograms (computed once for each orbit) and the trending quantities (computed every 15 seconds and stored in a time-ordered fashion).

The automated alarms

All relevant quantities are automatically checked against limits (or reference histograms), producing a summary report on the status of all the alarms and a table with the all the alarm details. The detailed table contains a link to the relevant monitoring plot for the out-of-limit quantity.

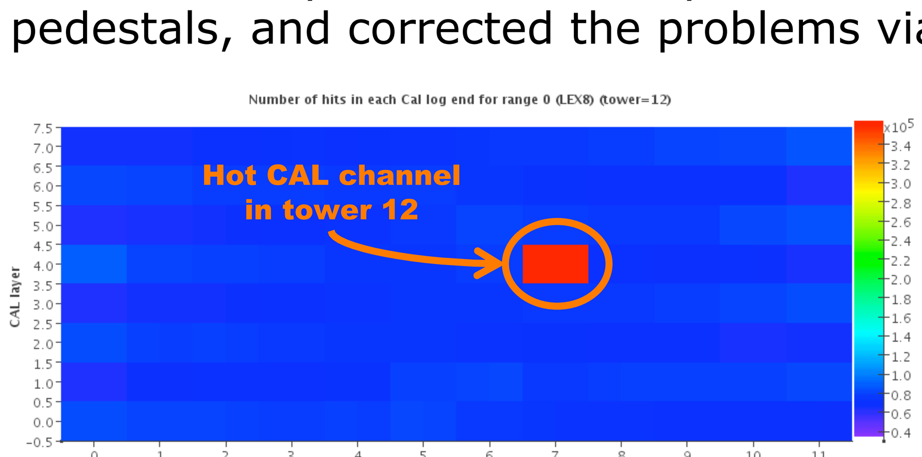
Alarms for one orbit of data

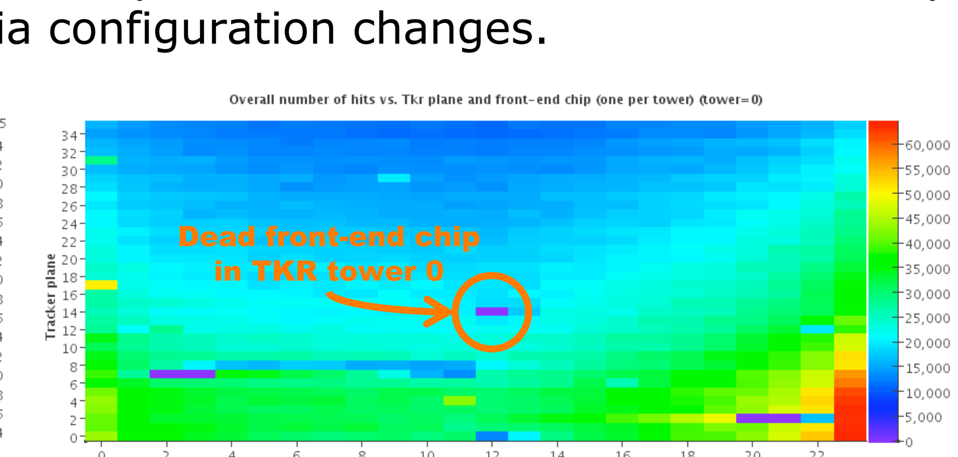


Alarm levels are evaluated for each orbit, on End-Of-Run and trending quantities. We implemented some 20 different alarm algorithms, to check all possible pathological behaviors. Whenever an anomaly is detected, a detailed report is generated and the duty scientists are informed via email.

End-Of-Run monitoring

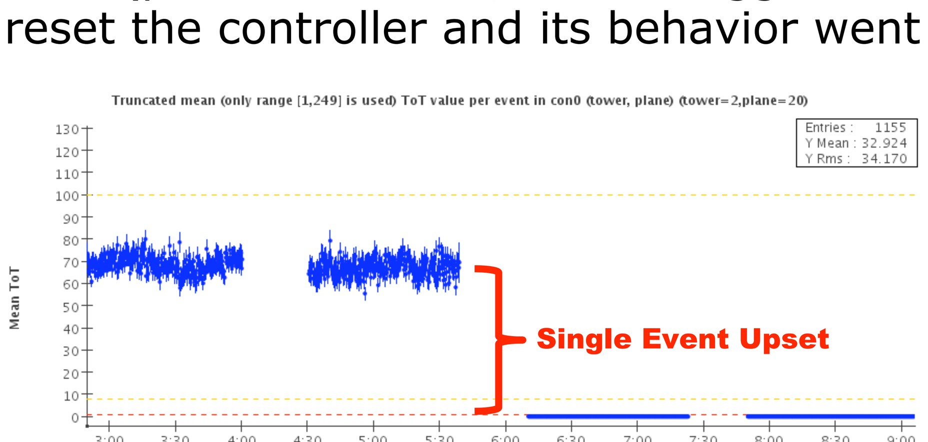
The typical application of the End-Of-Run histograms are the occupancy plots, that are filled for every subsystem (tower, TKR plane, CAL crystal, ACD tile, etc.). These plots are especially apt at identifying hardware problems such as hot and dead channels. In the plots below, we can see the identification of a noisy TKR strip (which will be subsequently masked out from the trigger configuration) and of a number of dead TKR strips (which unfortunately can't be replaced on orbit). In the same way, we successfully identified noisy CAL channels and/or out-of-family pedestals, and corrected the problems via configuration changes.

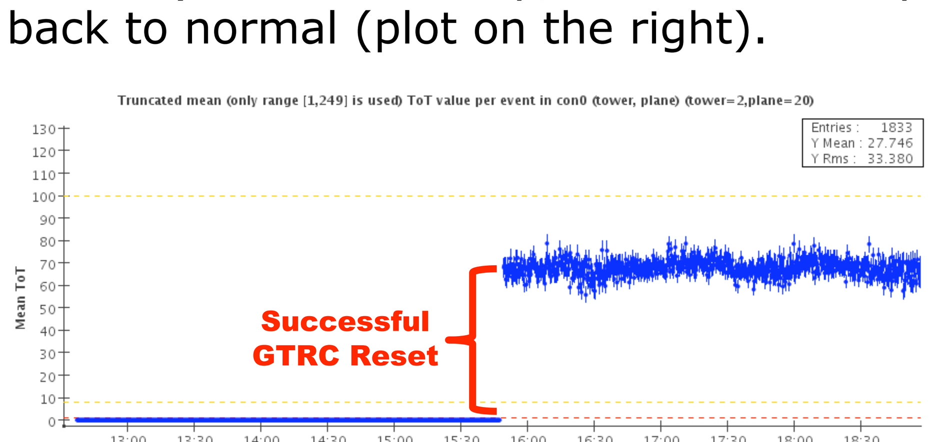




Trending

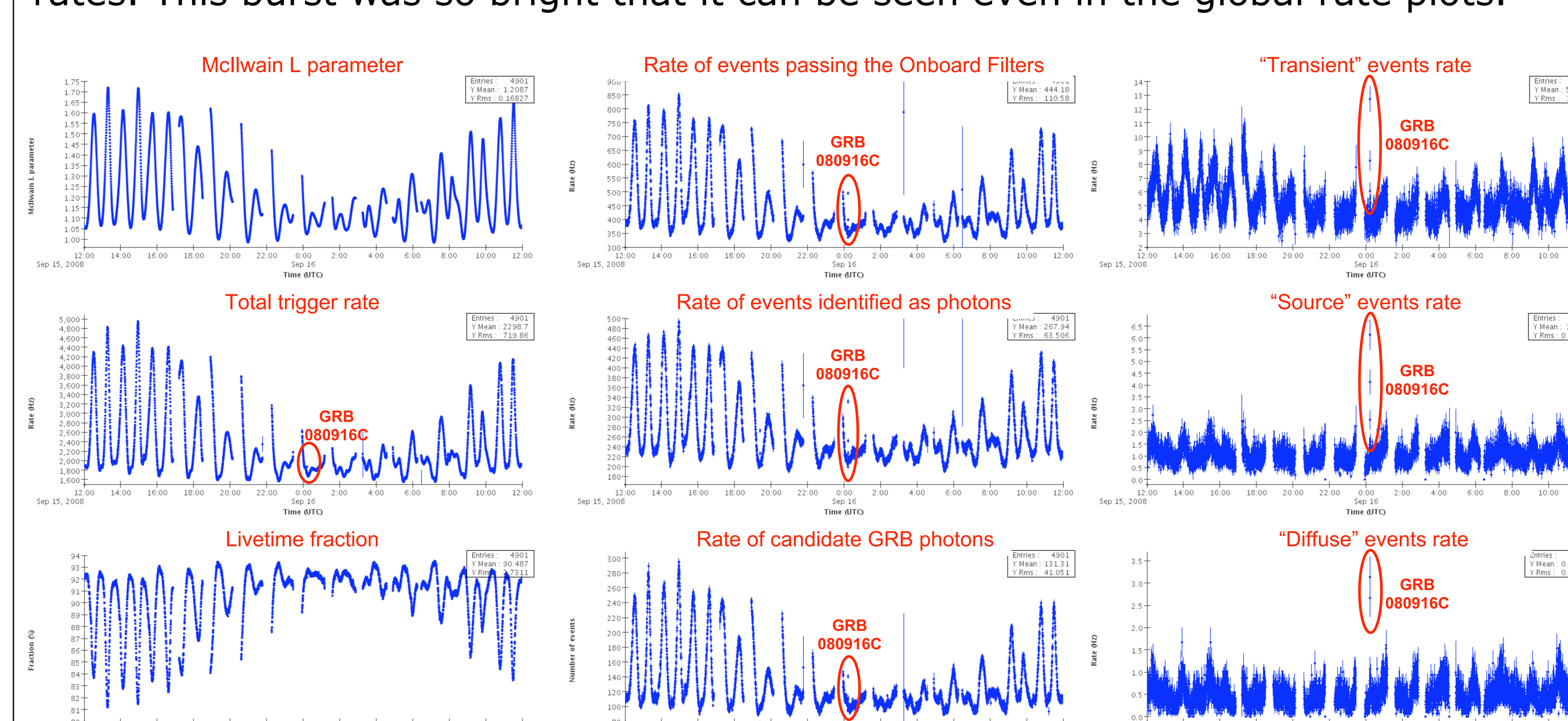
The trending plots are particularly sensitive to possible changes in the detector conditions, both on long time scales (pedestal drifts, calibration changes), and on shorter time scales (errors that suddenly manifest from one orbit to the next). The plots below show an interesting application of the trending alarms: on September 10, 2009, during a South Atlantic Anomaly passage, one of the TKR readout controllers (GTRC) was hit by a charged particle and its readout value got stuck at zero (plot on the left, which triggered an alarm). The next day, we successfully reset the controller and its behavior went back to normal (plot on the right).





Data Quality and the Environment

Correlating the high level detector variables (global and subsystem rates) to the external environment (geomagnetic location, etc.) is one of the most delicate issues in the implementation of this Data Quality Monitoring system (measured rates can vary over a factor of three according to the position of the spacecraft). The trending graphs below show some rate summary plots for the 24 hours around GRB 080916C (the brightest burst detected in the LAT so far). We can observe the correlations between Fermi's McIlwain L geomagnetic coordinate and the different rates. This burst was so bright that it can be seen even in the global rate plots.



Acknowledgements

The LAT Data Quality Monitoring system was designed and implemented by: Anders Borgland, Eric Charles, Warren Focke, Martin Kocian, Maria Elena Monzani, David Paneque, Massimiliano Turri (SLAC National Accelerator Laboratory), Luca Baldini, Johan Bregeon, Melissa Pesce-Rollins and Carmelo Sgrò (INFN and University of Pisa). We thank all the Duty Scientists that have taken Data Monitoring shifts since launch: their contribution was fundamental to ensure the high quality of the LAT data and hence the success of the entire mission.