

On-Orbit Operation and Performance of the LAT

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on behalf of the Fermi Large Area Telescope Collaboration



Summary: We summarize the on-orbit operation and performance of the Fermi Large Area Telescope detector. We also summarize the status and performance of the LAT Instrument Science Operations Center at SLAC.

Abstract

The Fermi Large Area Telescope has been operating in orbit almost continuously since its initial turn-on on 24 June 2008. We describe some key events in the operation of the LAT since its activation on orbit, and describe the related status and performance of the ground-based control, monitoring and data processing for the LAT at the Instrument Science Operations Center (ISOC) at the SLAC National Accelerator Laboratory. We also summarize the performance of the LAT sub-systems over almost 3 years in orbit.

ISOC Summary

- The LAT ISOC is organized to:
 - Maintain and safely operate the instrument
 - Process and deliver LAT event data and limited science data
- Main Functions of the ISOC:
 - Command planning and construction
 - Instrument health and safety monitoring
 - Maintain and modify FSW and the LAT Testbed
 - Instrument performance verification and optimization
 - Process and archive LAT data
 - Maintain the software that produces science data
- ISOC supports the *Fermi* mission and the LAT Collaboration
 - ISOC partners with the LAT Collaboration to ensure world-wide monitoring for instrument and science support

LAT Summary

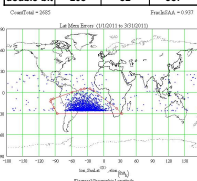
- The LAT is performing well nearly 3 years into the mission
 - Over 179 billion event triggers on the LAT since launch
 - About 20% of LAT event readouts downlinked via the MOC to ISOC
 - Less than 0.05% loss or degradation of active detection elements
- ISOC mission planning and operations have maintained over 99% efficiency for routine data-taking since the start of the science mission
 - Better than 99.9% observing efficiency over the past year
- Almost no data loss: better than 99.99% data recovery from the LAT
 - Due to the efforts of the Flight Operations Team at NASA's MOC

LAT On-board Processors

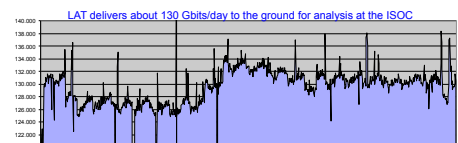
- 13 FSW updates since launch
 - Calibration and Configuration and GRB detection improvements, fix for LAT CPU resets (fixed in 2009), minor bug fixes
- 2 more FSW updates planned for 2011:
 - B3-0-0 (summer 2011): rebuild of FSW under various Linux flavors for easier future maintenance and improved integration into ISOC offline software systems
 - Restructuring of the on-board filter code for offline usage needs
 - Upgrading code and build tools to accommodate RHEL4/RHEL5 32/64 OSes.
- B3-0-1 (summer 2011): Fixes for 2 known remaining minor bugs

LAT CPU Memory Upsets: 94% in SAA

	SIU	EPU0	EPU1
single-bit	11444	4513	12665
double-bit	208	82	387



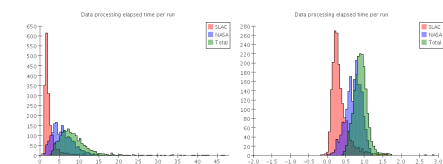
LAT Event and Data Rates



- LAT triggers at about 2kHz
- About 400 Hz of events are delivered to the ground
 - Avg data rate ~ 1.5 Mbps
 - Rate decreases as calibrations or resets (e.g. for new FSW loads)
 - Rate increases typically due to Fermi repoints to GRBs or ToOs
 - Diagnostic data added to downlink in October 2009
- Data rate from the LAT shows orbit-timescale variations due to geomagnetic cutoff of charged particles, plus 53-day timescale variations due to effect of Fermi orbit precession on SAA transit times

ISOC Data Processing

- SLAC resources
 - CPU: 1600 cores
 - Storage: 1.06 PB disk + 1.25 PB tape
 - 6 TB/week used for Level1 data products
- Lyon resources
 - 1200 cores, used for Monte-Carlo simulations
- Simulations (during 2011)
 - 2800-4000 cores running simulations
 - ~5M CPU hours
 - 1 TB of event tuple files
- Level1 data processing + Automated science processing
 - 546 million reconstructed events delivered to NASA and the LAT Collaboration
 - Up to 800 cores to process downlinked raw data promptly, after ~10 data deliveries/day
 - Event reconstruction, monitoring etc.
 - 10 CPU-years/month
 - Recent buffering changes now allows faster processing; processing at ISOC is a minor contributor to data latency
 - LAT Collaboration members provide 24-hour coverage for Data Quality Monitoring
 - Over 100,000 data quality measurements, with alarm limits on ~5000 measurements
 - Automated blind search for GRB candidates and variable flux sources
- Recent and future improvements
 - Changes to data buffering now allows faster processing; the processing time at the ISOC is a minor contributor to latency between LAT data collection and availability
 - Added data quality monitoring for solar flares as Solar Maximum approaches
 - Updates to quality flagging of LAT photons, to provide additional quality flags for solar flares and GRBs
 - Pass 7 event reprocessing in place; Pass 8 processing should be in ISOC in 2012

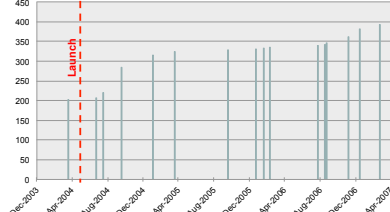


Level 1 Processing at the ISOC adds little delay to the time between data collection and delivery of reconstructed photon data to NASA's Fermi Science Support Center

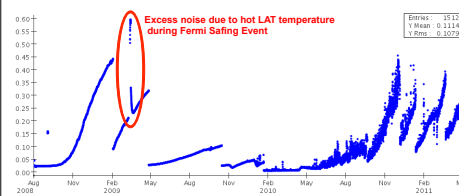
LAT Tracker

- LAT Tracker Towers are generally very stable
- Slow increase in leakage current observed, due to cumulative radiation dose
- Each Tracker has 36 Si layers, each containing 1536 Si detector strips
- Strips which become noisy or dead can be electronically masked off
- 203 strips were masked before launch
- 191 strips have been masked since launch; mostly in Tower 0 (early mission) and Tower 3 (since 2010)
- Total number of masked strips = 394 of 884,736 = 0.045% of Collecting Area

History of LAT Tracker Masked Strip Count



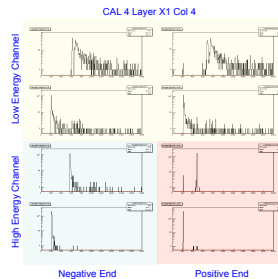
- Noise Occupancy for Layer 35 of Tracker Tower 3 shows early mission noise due to a few very noisy Si strips, followed by increasing noise since 2010
- Noise is restricted to half of one ladder of Si wafers = 1/8th of the Layer
- Noisy strip masking shown by reductions in occupancy curve below; 62 strips masked in this layer since launch



LAT Calorimeter and ACD

Calorimeter

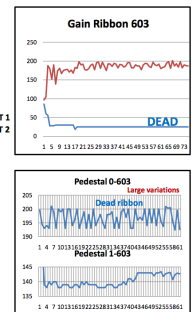
- 1536 CsI crystal logs, with 6144 CAL channels
- Small gain change since launch
- 1 channel failure, July 2010. CAL Tower 4, Layer X1, Column 4, +Face, HE diode
- 3 channels showing noise
- Bad channels masked out in ISOC Data Monitoring



Anti-Coincidence Detector

- All 89 ACD tiles are well behaved
- No PMT bias change since launch
- One ACD ribbon end (of 8 ACD ribbons between tiles) is non-responsive since 2008

- Most likely a de-coupling of the ribbon and PMT after many thermal cycles
- The opposite end of the ribbon works well, and compensates for the dead end



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More information available at the LAT ISOC website: <http://glast-isoc.slac.stanford.edu>