GLAST Large Area Telescope:

ISOC Science Operations

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Science Operations Responsibilities

- Characterize, monitor and optimize LAT Performance at all levels
  - individual LAT detectors
    - calibrations
    - performance and diagnostics
      - » correlate low level characteristics with housekeeping
  - LAT as an integrated particle physics instrument
    - trigger and data flow
    - system wide calibrations
    - overall timing properties
    - performance
      - » efficiencies, alignment, cross-correlation between detectors
  - LAT as a high energy gamma ray detector
    - monitor instrument performance and calibrations with
      - » particle (charged and neutral) background
      - » astrophysical sources
    - identify new operational settings and observing strategies to optimize scientific return
- Coordinate investigation of instrument anomalies
- Coordinate LAT operations scientist program
  - very important at early stages of operations
  - can be phased out as we automate processes
- Science data processing and validation
  - Support of data processing facility (pipeline)
    - automation of some of the L2 data processing
  - Quick look science/alerts
    - Refine parameters of GRBs that were detected onboard by the LAT
    - Search for GRBs not detected onboard by the LAT
    - Detection of flaring sources
    - Monitoring of a predefined set of sources
  - Standard product generation/delivery (to GSSC)

LAT Collaboration and Science Operations

- Participation is needed at many stages
  - Pre- Launch (will show examples later)
    - Development of Data Analysis Software
      - » exercise during LAT integration
    - Development of tools for instrument monitoring and validation of data
    - Development of tools to support anomaly resolution
  - Post-launch
    - Data Analysis using Galactic Cosmic Rays and astronomical sources
    - Instrument Performance Monitoring (include calibrations)
      - » 24/7 coverage to benefit from geographical distribution of Collaborators
    - Coordination and Leading roles within the ISOC
- Interaction of the Collaboration with the ISOC:
  - Optimization of performance, calibrations and science monitoring
    - Science Operations is the point of contact
  - VRVS Meetings and workshops
    - to get the group together and exchange ideas

Main Areas of Science Operations

Below are few examples to illustrate our main responsibilities

- **Quick Look Science**
  - Refine parameters of GRBs that were detected onboard by the LAT
  - Search for GRBs not detected onboard by the LAT
  - Detection of flaring sources
  - Monitoring of a predefined set of sources
  - Study properties of N bright sources
- **Instrument Performance**
  - Verify if deadtime and prescaling have any effect on pulsars and/or GRB science
  - Characterize the SAA location
  - Characterize and monitor
    - background rates
    - on-board filter efficiency
    - trigger performance
    - noise properties
  - Characterize instrument performance as a function of orbital location
- **Calibrations**
  - Calibrate Energy Scales with Galactic Cosmic Rays
  - Verify stability of intertower alignment with Galactic Cosmic Rays
  - Align the LAT with astronomical sources and correct for fish-eye effect
  - Verify calibration dependence on environmental parameters
- **Operations**
  - Investigate on-orbit anomalies
  - Develop new observing strategies to optimize science return
    - Propose and validate optimized operational settings
  - L1 and L2 data processing

All these areas are addressed through data analysis and monitoring tools (more on this later)

Successful partnership with LAT Collaborators

- Data Challenges
  - see Richard Dubois's talk

Mostly data analysis and limited monitoring tool development

- Instrument Analysis Effort
  - Goals
    - uncover hardware problems prior to lunch
    - acquire operational experience with the LAT
    - develop and debug software and data analysis tools
    - Understand how the instrument works
  - Data Analysis results (see next slides)
    - Analyzed data from LAT Integration and Test activities
    - Compared with MC simulations
    - Continuous effort on a weekly basis over the last 20 months
      - » even during LAT construction!
    - Main results were presented in 6 workshops
      - » average of 40 to 60 participants
      - » expect one more workshop with data from final LAT testing

- Strong and continuous support from LAT Collaborators
  - thank you ! (see next slides)

- Future Plans (TBR)
  - Participate in Data Challenge3 to incorporate Instrumental effects
  - Use weekly meeting and workshops to ramp up Science Operations Activities

Calibrations: Tower Alignment

From Michael Kuss (INFN/Pisa Italy)

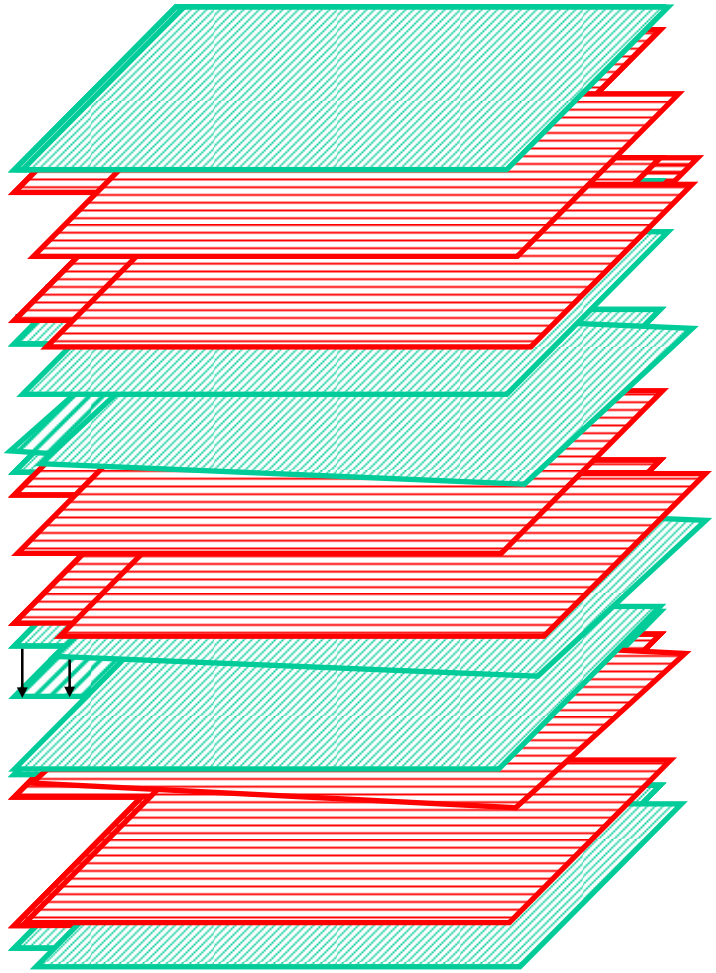
the ideal tower

a horizontal shift

a vertical shift

a rotation

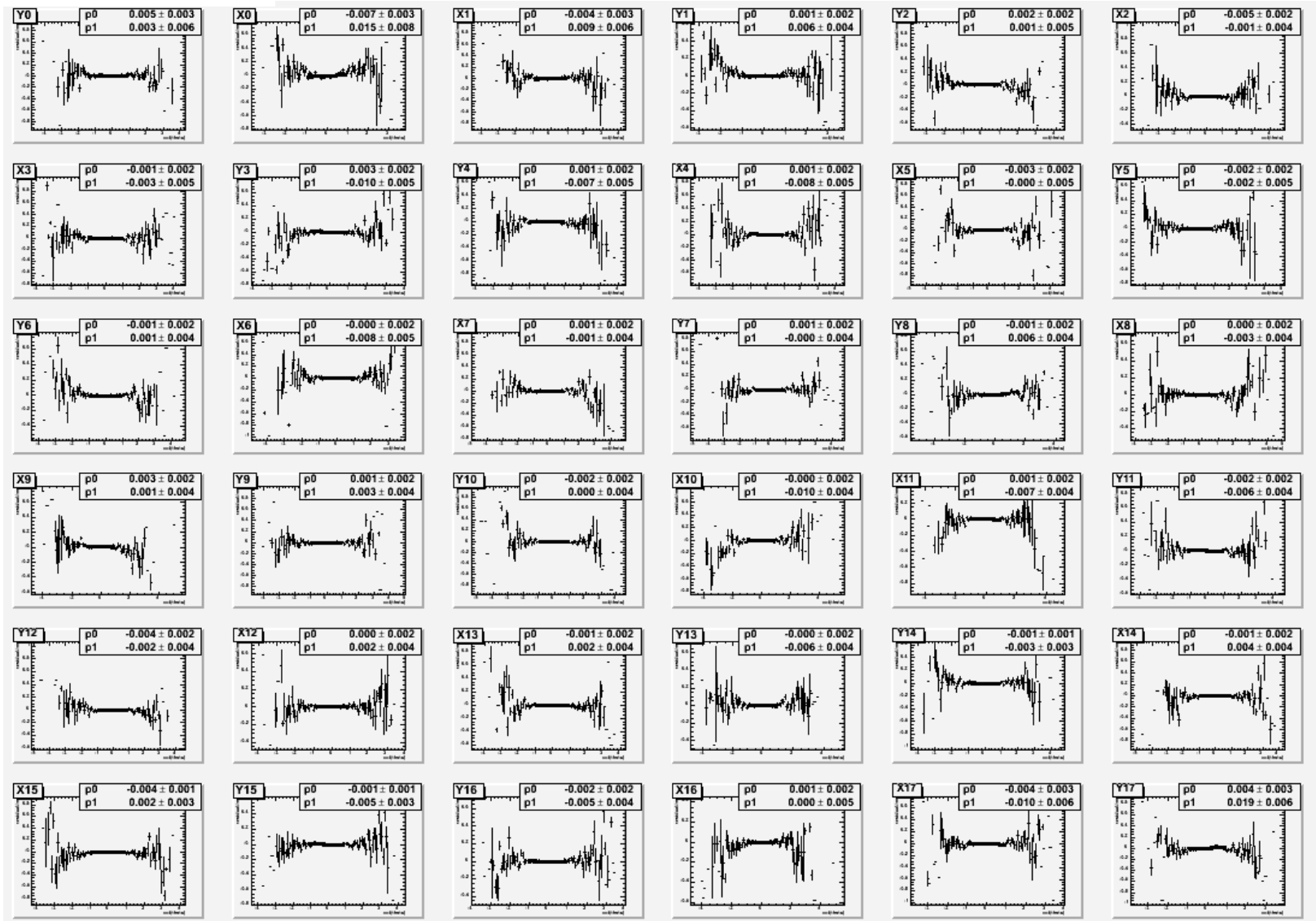
the real tower



Calibration: Tower Residuals vs. slope of track

After Alignment

From Michael Kuss (INFN/Pisa Italy)



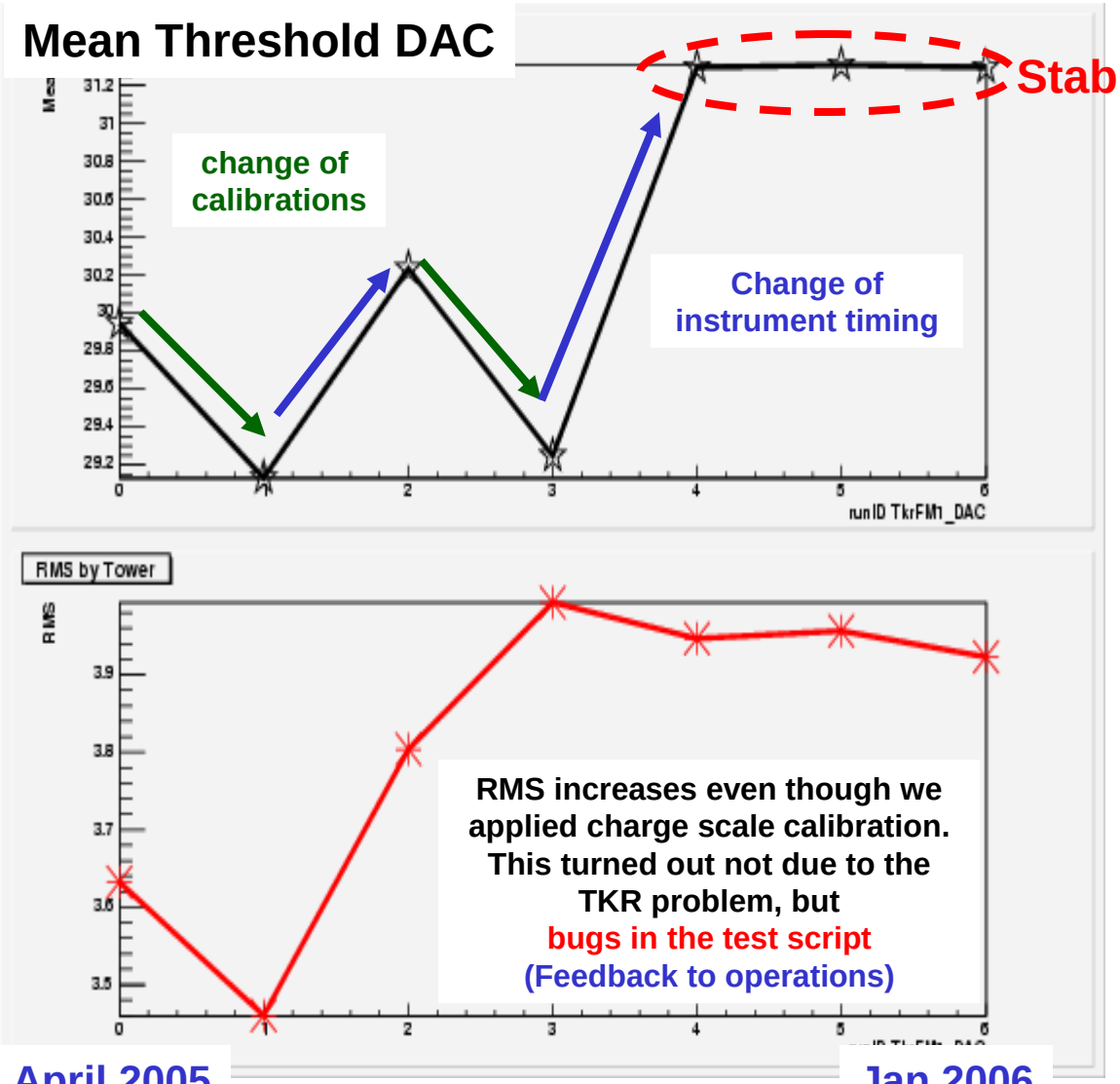
Operations: TKR Threshold vs Instrument Configuration

Flags courtesy of www.theodora.com/flags used with permission

From Takuya Kawamoto
(Hiroshima University/Japan)

Instrument Configuration:
(monitoring changes in time during I&T)

0: arrival at SLAC (April 2005)
1: charge scale calibration
2: Flight TEM installed
3: charge scale test
4: 6 tower test
5: 8 tower test
6: 16 tower test (Jan 2006)



Calibrations: Trending TKR Circuit Gain Monitor

Flags courtesy of www.theodora.com/flags used with permission

From Takuya Kawamoto
(Hiroshima University/Japan)

Circuit Gain:

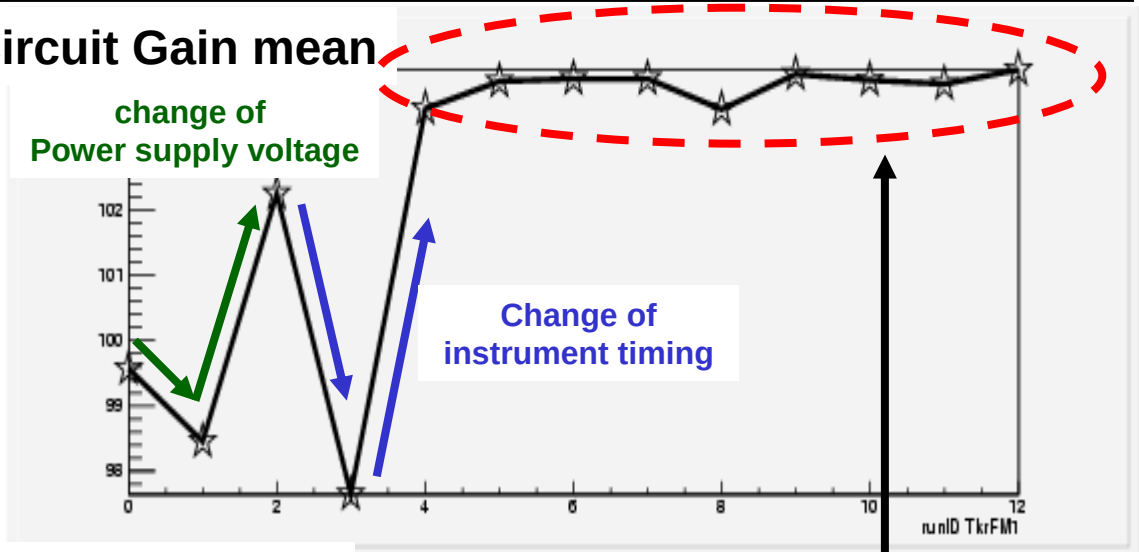
$$\frac{\text{Output Voltage}}{\text{Injected Charge}}$$

Instrument Configuration:

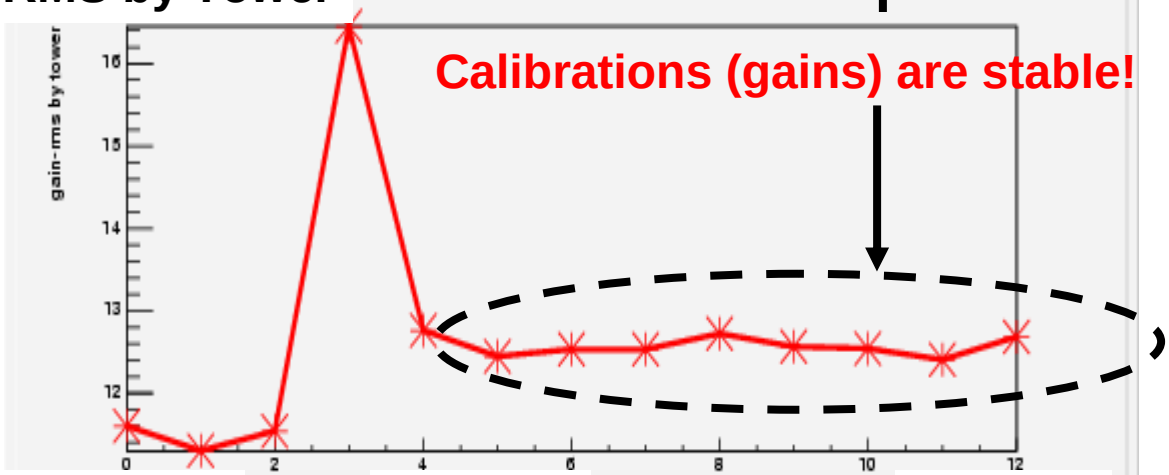
(trending calibrations during I&T)

0 : arrival at SLAC (April 2005)
1 : install in the flight grid
4 : adjust time delays
5-8 : 6 tower tests
9 : 8 tower test
10-11: 10 tower test
12 : 16 tower test (Oct 2005)

Circuit Gain mean



RMS by Tower

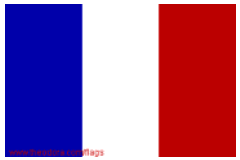


April 2005 Jun 2005 Oct 2005

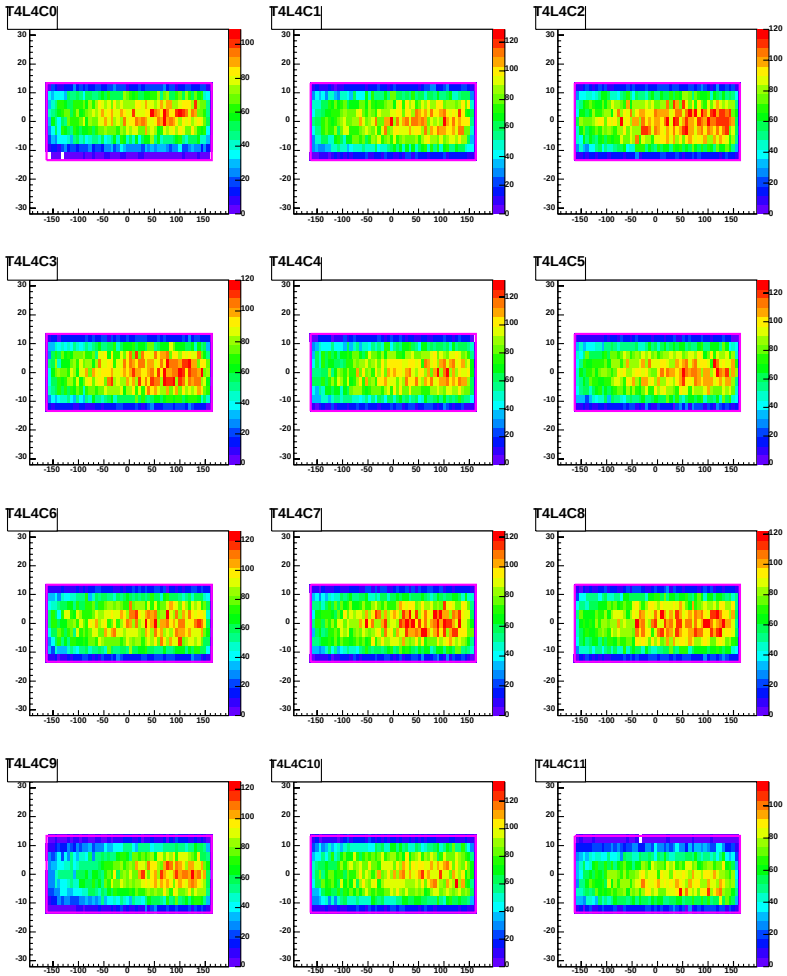
Calibrations: CAL energy scales using TKR extrapolated tracks

From Frederic Piron and Eric Nuss
(Montpellier/France)

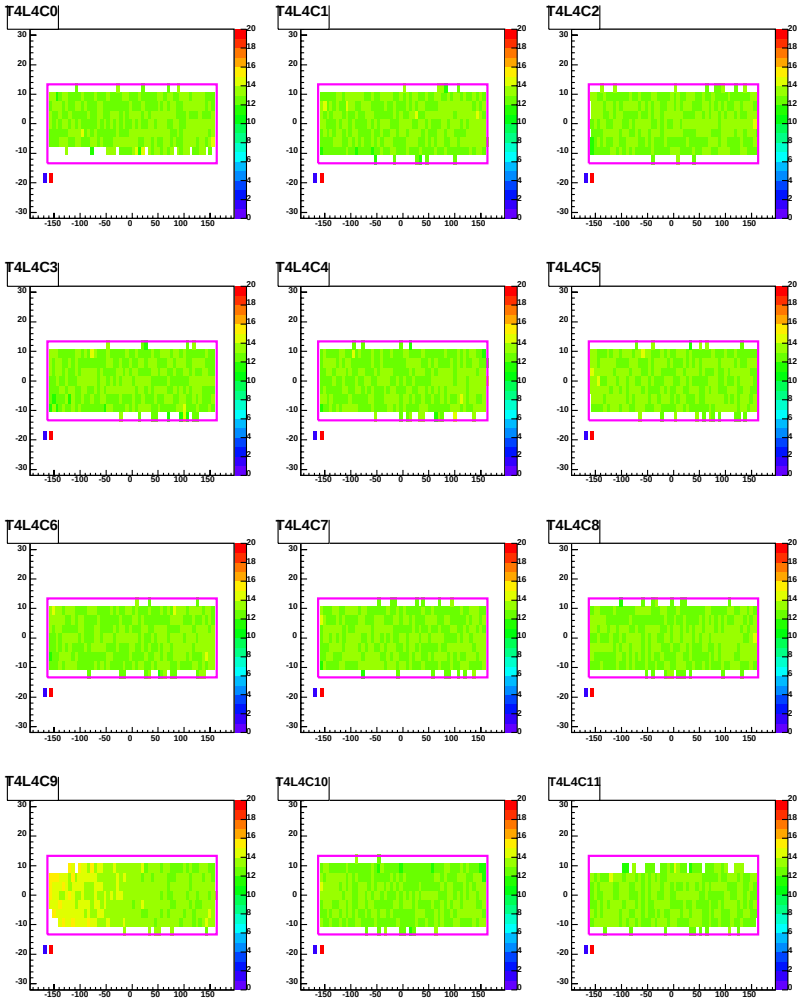
Flags courtesy of www.theodora.com/flags used with permission



Number of hits along the crystal

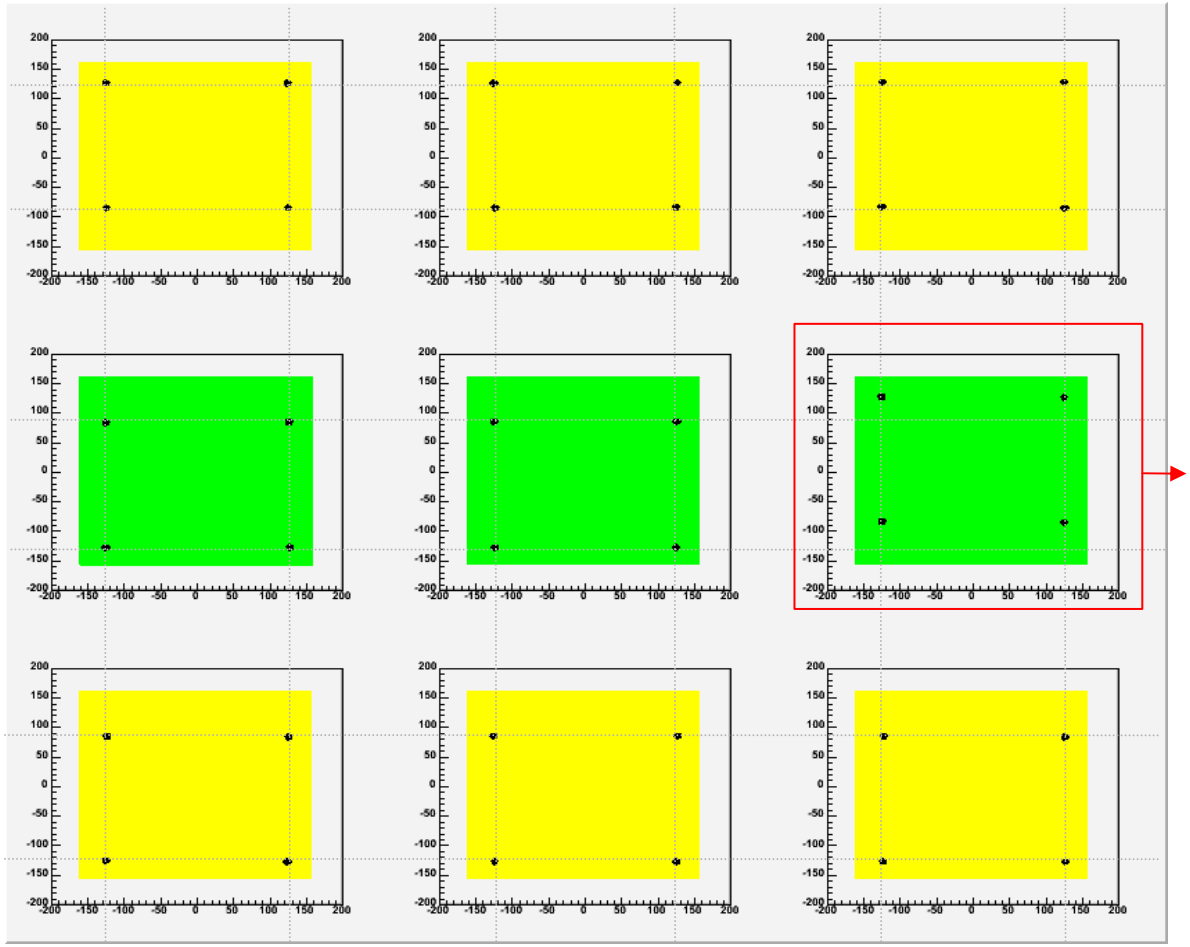


Calibrated Mean energy along the crystal



Instrument Performance: Find ACD screws using TKR extrapolated tracks

From Luis Reyes
(University of Maryland/GSFC/USA)

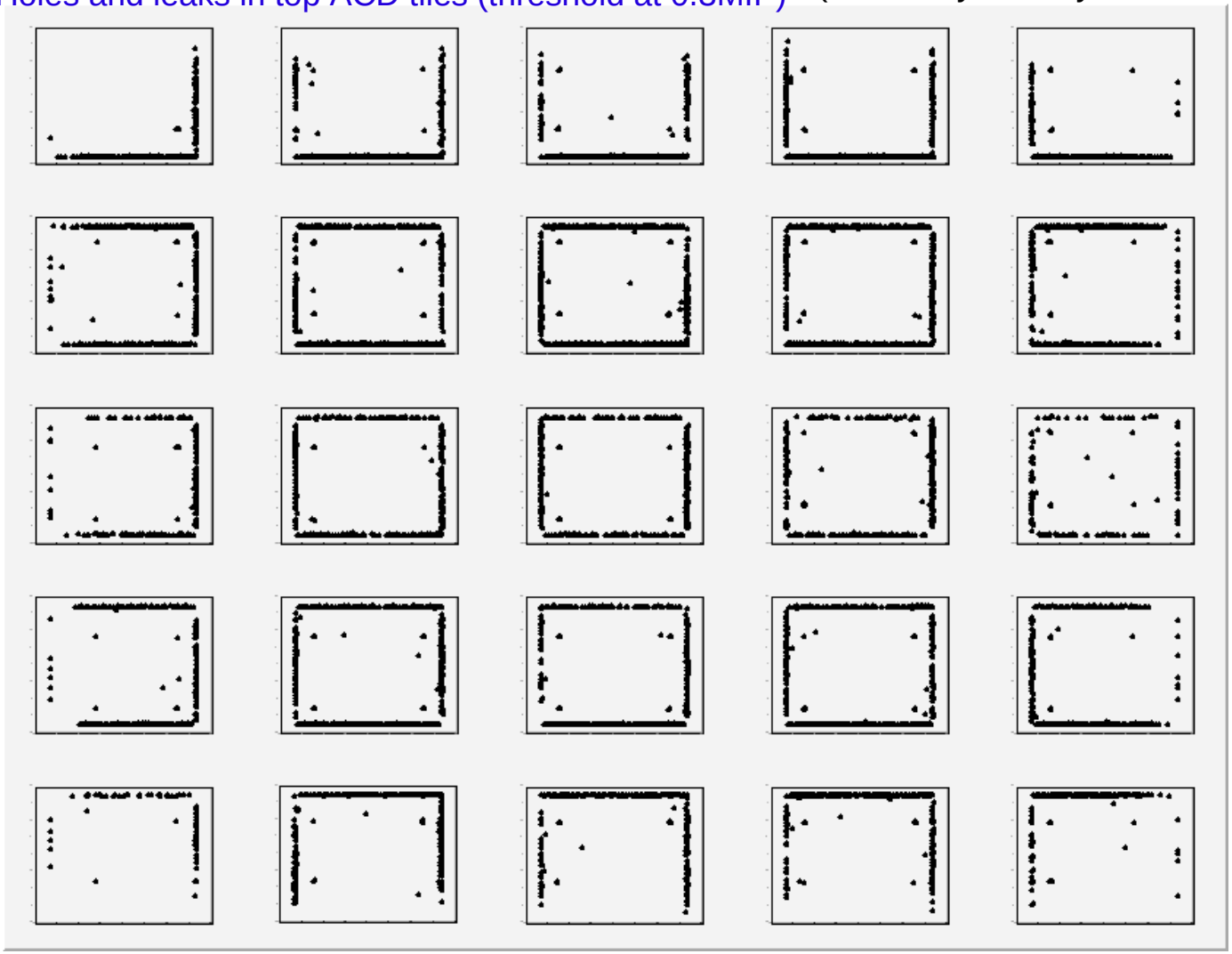


This tile is flipped along x axis because cables go in +y direction.

Operations: ACD maps diagnose performance with different thresholds

From Luis Reyes
(University of Maryland/GSFC/USA)

Holes and leaks in top ACD tiles (threshold at 0.3MIP)



Current Usage of Resources from LAT Collaboration

- **Instrument Performance and Calibrations**
  - **Italy**
    - **~ 2 FTE**
  - **France**
    - **~ 1.5 FTE**
  - **Japan**
    - **~ 0.5 FTE**

- **Number of FTE are difficult to quantify for the following reasons**
  - **Collaborators were occupied with LAT construction**
  - **participation occur in phases (sometimes on weekly basis) and increases due to workshop meetings**
  - **Collaborators will in the near future be also occupied with the Beam test**
    - **see talk from Benoit Lott**

Science Operations: Tool Development

- **Data Retrieval Interface**
  - allow access of L1 data using a flexible query system
  - provide multiple outputs tailored to data analysis needs
- **Data Quality Monitoring**
  - verify integrity of L1 data
  - coarse monitoring
    - instrument performance
    - calibrations

As we transition from instrument analysis, science operations will need substantial help from the collaboration

- **Configuration Monitoring**
  - allows visualization of instrument configuration used during data taking
  - essential for investigating instrument anomalies
- **Trending and Operations tools**
  - allows trending of science, calibrations and also housekeeping data

The goal is to have as much as possible web based to facilitate access all over the world

Science Operations: Current Data Analysis Web Portal

LAT Instrument Analysis Group

Meetings	Finding Data	Data Analysis
Weekly Friday Meetings	Runs Database Trigger runs	Data Analysis Primer (html) (pdf)
Workshops 1, 2, 3, 4, 5, 6	How to get data - End2End runs:1 , 2, 4, 6, 8 towers - LAT Jan '06 (B2 runs as muons) - Rates	How to Look at Data
SVAC JIRA CCB	Register Configuration	Merit Ntuple Description
Contact info	Data quality reports	SVAC Ntuple Description
Databases and GUIs, December 1 2005	Housekeeping data	Digi variables Recon variables NEW!
	Hardware Information with ACD map	How to filter events
	Tower/Bay location info (pdf)	Using the Event Display
	EM versions in the pipeline	Mapping from physical space to electronic space
	MC Simulated Data	Run NtupleCompare
	Useful things to know about the data quality	Data Analysis Examples
	ACD data @ SLAC (temp link)	

Data Analysis Software	Calibrations	Other Links
Event Display SAS	rdbGui	I&T: SVAC, Online, IFCT
HippoDraw	Calibration Files Directory Structure	ACD, CAL TKR and Trigger
ROOT Installation	Calibration Flavors and Instrument Names	ISOC, SAS (Offline Workbook)
Unix setup	SAS calibration page	LAT Analysis Group
	Calibration meeting March 18 2005 (minutes)	LAT: @ SLAC , @ GSFC
	Calibration meeting April 15 2005	NEW! Test Beam 2006
	How to run calibGenCAL - Handbook	Movies!
	Calibration constants	

Science Operations: Data Retrieval Interface

LAT Instrument Analysis Group

Meetings	Finding Data	Data Analysis
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	Calibration constants	

Data Retrieval Interface

GLAST Shift Logbook
Shift Run Info

GLAST Home | Help | Shift Index | List Runs

Run Range: (e.g. 2500-2550 2567)
Run Date Range: taken from to (use format YYYY-MM-DD)'
Duration (s): (e.g. > 1000) No. of events: (e.g. > 1000)
Completion status: Any Particle Type: Any
Instrument Type: Any Orientation: Any
I&T Test ID/Config ID: LAT/701 (e.g. 0/1) example No. of towers: (e.g. 1)
TKR Serial No.: example CAL Serial No.: example
Script Name: (e.g. calf_mu*) Schema file: (e.g. em2cal*)
Suite Name: (e.g. LPT)
Suite Date Range: taken from to (use format YYYY-MM-DD)'
FITS file: (e.g. *2805*)
Site: Any Phase: Any
list runs | list root files | list run ids

600001188 Shift Summary	PASSED	LAT/701	(TkrFMA,FM104,0) (TkrFM10,FM113,14) (TkrFM14,FM117,2) (TkrFM12,FM115,6) (TkrFMB,FM105,4) (TkrFM4,FM108,13) (TkrFM2,FM103,1) (TkrFM13,FM116,7) (TkrFM6,FM110,12) (TkrFM11,FM114,15) (TkrFM5,FM107,8) (TkrFM1,FM102,5) (TkrFM15,FM118,3) (TkrFM9,FM112,11) (TkrFM3,FM106,9) (TkrFM7,FM111,10)	end2end	Report Dir	digi recon config	482830/47	901	digi recon merit svac cal	2006-02-23 03:22:06	Cosmics	Vertical

Developed with the online group
(used existing infrastructure from the BaBar experiment @ SLAC)

Flexible query system to support operations AND data analysis

Needs to be tailored for on-orbit operations and to include L2 data (need LAT collaboration support)

L1 data quality reports (automated)

L1 Data files

Instrument configuration report

comments from operators

Serial Number of flight module and bay location

L1 Data Quality Report (1)

SVAC Report

v3r4p9

PS file PDF file

Author:
{automatically generated}

Purpose

This report is used in offline data analyses to identify apparent problems in cosmic ray muon and VDG data. **Warning! Results from other tests (such as charge injection) should be interpreted with care.**

Software Version

- EngineeringModel: **v5r070305p4**
- TestReport: **v3r4p9**

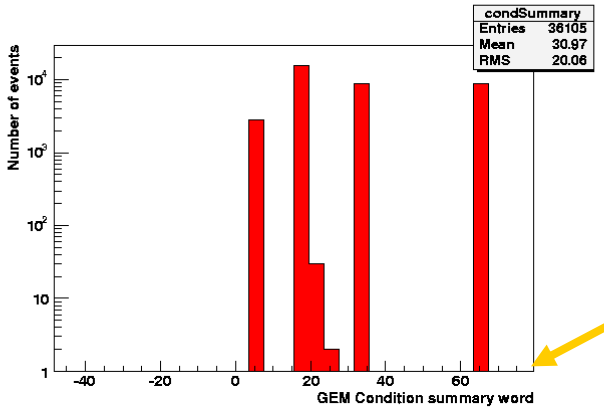
Summary

In the digi file */nfs/farm/g/glast/u25/Integration/rootData/600001188/v5r070305p4/grRoot/digiReport-v3r4p9_600001188_digi_DIGI*.root

- There are **36105** triggers. There should be 36107 events recorded in the eLog database since LATTE adds two additional events in the process which are not triggered events.
- There are **37** bad events
- There are **0** events with Trigger Parity errors
- There are **0** events with Packet errors
- There are **37** events with TEM errors
- There are **0** events with ACD Odd Parity errors

Trigger

GEM condition summary word. The word is deduced by combining bit patterns from the table shown below. For example, an event with both the TKR trigger bit and the CAL low trigger bit set in GEM has the condition summary word of $2^2 + 2^1 = 6$



GEM Condition summary word

Trigger bit	0	1	2	3	4	5	6	7
Summary	ROI	TKR	CAL Low	CAL High	CNO	Periodic	Solicited	External
Number of events	4083	4298	2819	2	15691	8898	8727	0

Needs to be tailored for charge injection tests and on-orbit operations and to include L2 data (need LAT collaboration support)

SAS Software version

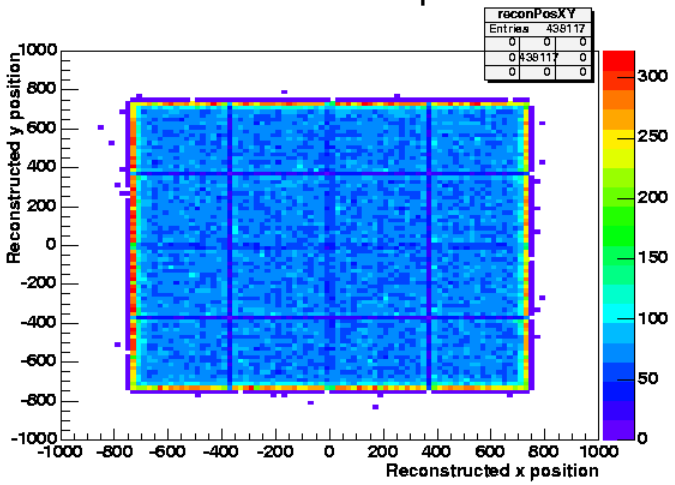
Summary results for L1 Data and location of archived data

Trigger information graphical and tables

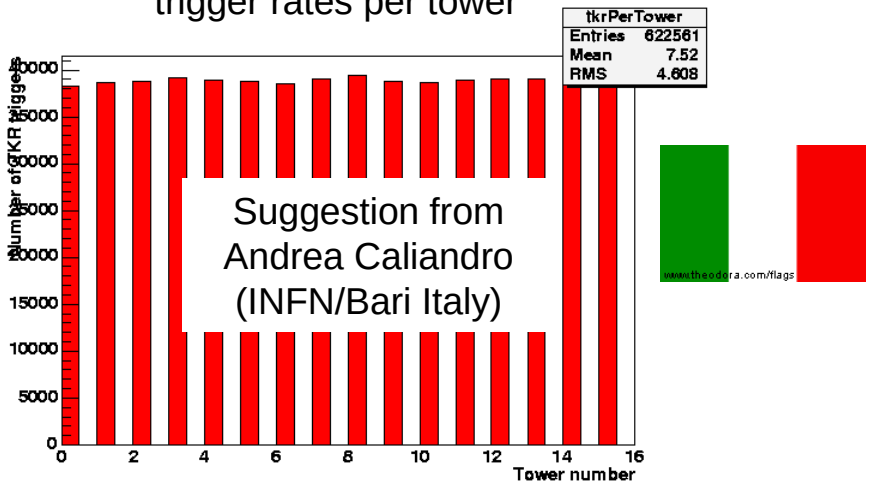
Plots from L1 Data Quality Report (2)

Flags courtesy of www.theodora.com/flags used with permission

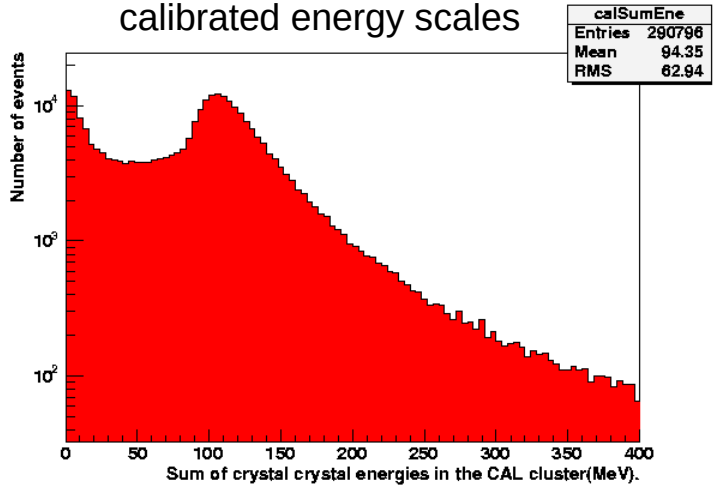
reconstructed track positions



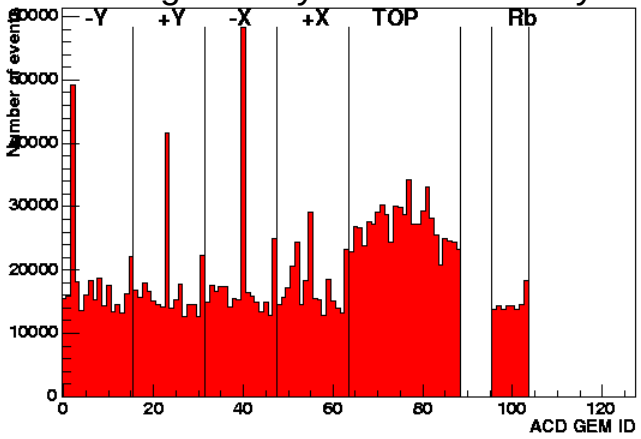
trigger rates per tower



calibrated energy scales

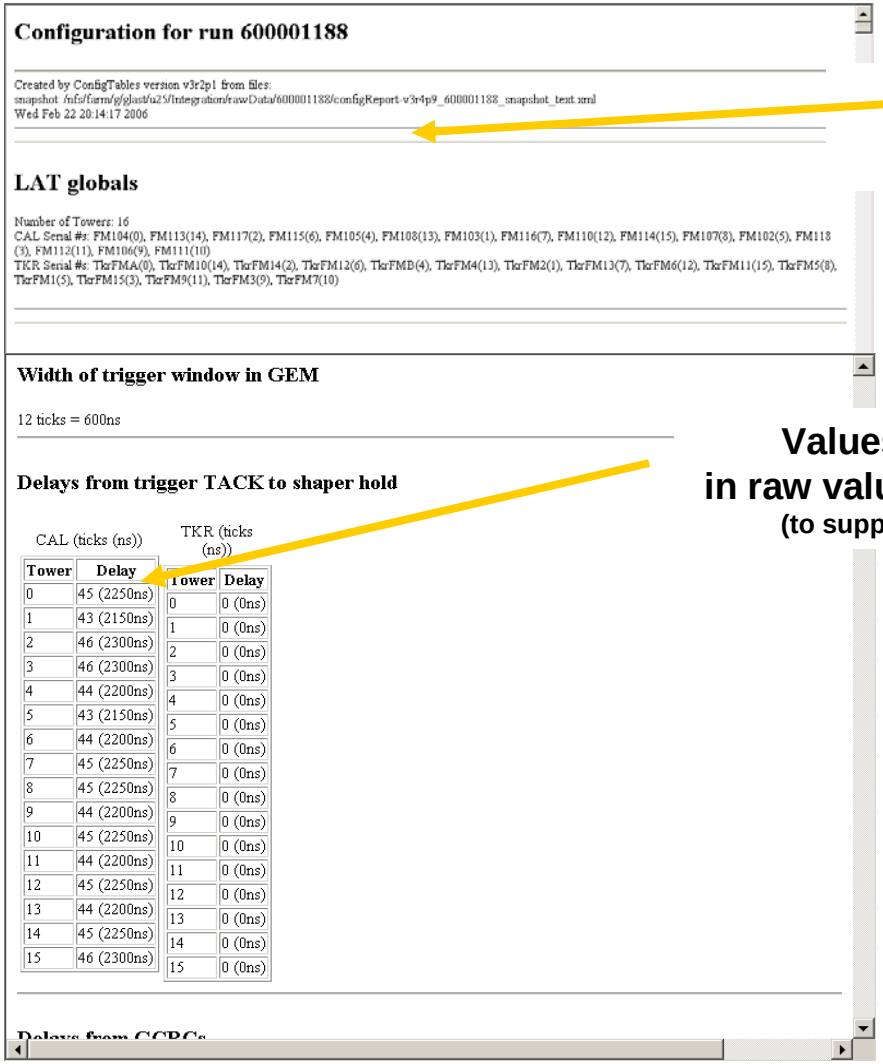


ACD geometry and functionality



Needs input from LAT Collaborators to define distributions for on orbit operations

Configuration Reports



Configuration for run 600001188

Created by ConfigTables version v3r2p1 from files:
snapshot: /nfs/farm/g/glast/u25/Integration/rawData/600001188/configReport-v3r4p9_600001188_snapshot_text.xml
Wed Feb 22 20:14:17 2006

LAT globals

Number of Towers: 16
CAL Serial #s: FM104(0), FM113(14), FM117(2), FM115(6), FM105(4), FM108(13), FM103(1), FM116(7), FM110(12), FM114(15), FM107(8), FM102(5), FM118(3), FM112(11), FM106(9), FM111(10)
TKR Serial #s: TkrFMA(0), TkrFM10(14), TkrFM14(2), TkrFM12(6), TkrFMB(4), TkrFM4(13), TkrFM2(1), TkrFM13(7), TkrFM6(12), TkrFM11(15), TkrFM5(8), TkrFM1(5), TkrFM15(3), TkrFM9(11), TkrFM3(9), TkrFM7(10)

Width of trigger window in GEM

12 ticks = 600ns

Delays from trigger TACK to shaper hold

CAL (ticks (ns))

Tower	Delay
0	45 (2250ns)
1	43 (2150ns)
2	46 (2300ns)
3	46 (2300ns)
4	44 (2200ns)
5	43 (2150ns)
6	44 (2200ns)
7	45 (2250ns)
8	45 (2250ns)
9	44 (2200ns)
10	45 (2250ns)
11	44 (2200ns)
12	45 (2250ns)
13	44 (2200ns)
14	45 (2250ns)
15	46 (2300ns)

TKR (ticks (ns))

Tower	Delay
0	0 (0ns)
1	0 (0ns)
2	0 (0ns)
3	0 (0ns)
4	0 (0ns)
5	0 (0ns)
6	0 (0ns)
7	0 (0ns)
8	0 (0ns)
9	0 (0ns)
10	0 (0ns)
11	0 (0ns)
12	0 (0ns)
13	0 (0ns)
14	0 (0ns)
15	0 (0ns)

Delays from GCRCs

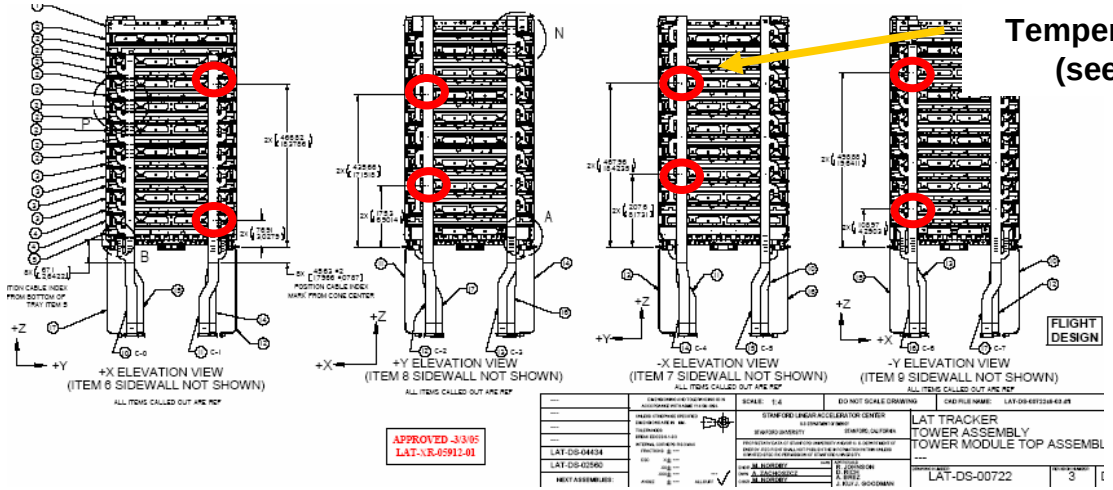
input configuration file
(to be replaced by a more robust database system for on-orbit operations)

Values of timing registers in raw value and engineering units
(to support resolution of anomalies)

Needs to be tailored for on-orbit operations and linked to more complete database system that includes all register values (need LAT collaboration support)

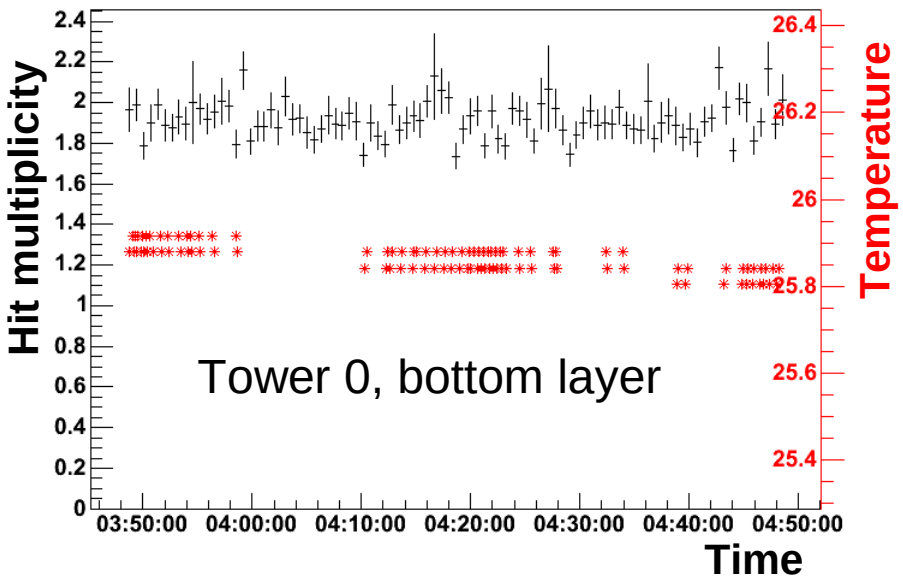
Calibration and other operational settings are not shown but are also present (the report is too long to fit in this slide)

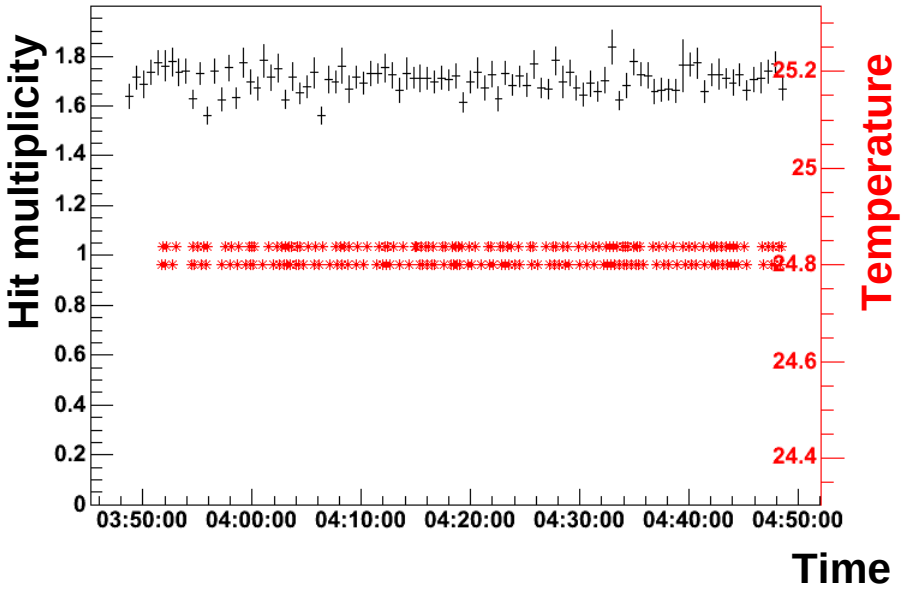
Operations Tools: Correlate Science and Housekeeping



Temperatures are accessible via Web based interface (see Flight Operations talk from Rob Cameron)

Needs to be tailored for on-orbit operations and linked to more complete database system (need LAT collaboration support)





Operations Scientist/Shift Takers

- **What for?**
  - **to monitor quick-look products**
  - **to monitor instrument performance**
  - **to assist in anomaly resolutions with ISOC leads**
- **Coverage**
  - **24/7 to benefit from geographical distribution of LAT Collaborators**
    - **need 3 FTEs**
      - » **3-5 persons for checking data quality for each of 8 the contacts /day**
      - » **needs to be distributed around the Collaboration**
- **On-going discussions within the LAT Collaboration to define details**

Resources Needed from the LAT Collaboration

- Need ~ 8-10 FTEs (until first year after launch) to support science Operations group to perform the following tasks
  - data analysis
    - quick look science
    - instrument performance
    - calibrations
    - operations
  - Tool development and/or tailoring
    - data retrieval
    - Data quality monitoring
    - Configuration reports
    - Operation tools (e.g correlate housekeeping and science)
    - data processing
- Need ~ 3 FTEs (3 persons) to support science Operations group to perform monitoring
  - few hours of work during the ~ 8 daily contacts but we need continuous coverage
- Currently we have the following support for data analysis and monitoring
  - Italy
    - 9-10 persons ~ 2 FTE?
  - France
    - 5 persons ~ 1.5 FTE ?
  - Japan
    - 2 persons ~ 0.5 FTE?

Back up slides

Science Operations Tasks(1)

- **Science Monitoring (Quick look)**
  - **Development Phase**
    - Define distributions for Monitoring pages
      - » code to extract indices and spectra needs to be developed
    - Develop of algorithms
  - **Operational Phase**
    - Refine parameters of GRBs that were detected onboard by the LAT
    - Search for GRBs not detected onboard by the LAT
    - Detection of flaring sources
    - Monitoring of a predefined set of sources
    - Refining parameters of solar flares

Preliminary

- **Performance Monitoring**
  - **Development Phase**
    - Update/develop offline timing analysis for on orbit operations
    - GRB algorithm to improve localization on orbit (use GBM info and get 3D)
  - **Operational Phase**
    - Extract of properties of bright pulsars (e.g Crab)
    - Extract Properties of N bright sources
    - Verify effects from deadtime and prescaling for different instrument configurations
      - » investigate if it has any effect on pulsars and/or GRBs
    - Characterize the SAA
    - Study detector properties entering/exiting SAA
    - Characterize background rates
    - Characterize on-board filter efficiency
    - Verify trigger performance (arrival times, rates, etc, with unbiased samples)
    - Characterize trigger rates per trigger type and per engine
    - Characterize noise properties
    - Characterize Environmental effects (correlations with housekeeping)
    - Characterize Orbital effects (take SAA into account)
    - Verify cross correlation/calibration between LAT detectors using gamma ray sources
    - Characterize energy resolution (low and high energy)

Science Operations Tasks(2)

Preliminary

- **Development Phase**
  - **Planning**
    - Develop Requirements documents, validation plans and provide inputs to activation plan
  - **Monitoring**
    - Define distributions to be monitored and the layout of the monitoring pages for instrument performance and calibrations and develop code to address
      - » correlations between subsystems
      - » correlations between science data and housekeeping
  - **Calibrations**
    - develop and implement plan to validate calibrations (e.g. energy scales and energy resolution)
      - » algorithms, software and database interface developments may be needed
    - develop and test algorithms (MC) to verify orbital effects (if any), stability of alignment, fish-eye effect
    - define constants to be trended and corresponding time scale for trending
      - » develop tools and displays needed to perform trending
  - **Operations**
    - define and develop tools and displays to identify and diagnose problems
      - » test with MC if possible
    - define list of on-orbit anomalies and prioritize workload to prepare for them using MC
      - » anomalies could also be expected instrument degradation
      - » document expected environmental effects and produce a graphical interface of location of thermistors
    - develop code for the analysis
- **Operational Phase**
  - **Instrument Performance**
    - Revisit distributions for monitoring
    - develop code for data analysis
  - **Calibrations**
    - Calibrate Energy Scale with Galactic Cosmic Ray Calibrations with the CAL
    - align towers with star tracker and correct for fish-eye effect
    - Revisit trending
  - **Operations**
    - Investigate on-orbit anomalies
    - Implement, test and validate optimized operational settings
    - Revisit frequency and accuracy of calibrations
    - Develop new observing strategies to optimize science return
  - **Note :**
    - Critical tasks (TBD) need to be covered by more than one person to create redundancy and minimize risks