The LAT tracker performance and first results after launch

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On behalf of GLAST/LAT collaboration

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The GLAST/LAT collaboration

France
- IN2P3
- CEA/Saclay

Italy
- INFN
- ASI
- INAF

Japan
- Hiroshima University
- ISAS/JAXA
- RIKEN
- Tokyo Institute of Technology

Sweden
- Royal Institute of Technology (KTH)
- Stockholm University

United States
- Stanford University (SLAC and HEPL/Physics)
- University of California at Santa Cruz - Santa Cruz Institute for Particle Physics
- Goddard Space Flight Center
- Naval Research Laboratory
- Sonoma State University
- Ohio State University
- University of Washington

Principal Investigator:
Peter Michelson (Stanford University)

~270 Members
(~90 Affiliated Scientists, 37 Postdocs, and 48 Graduate Students)

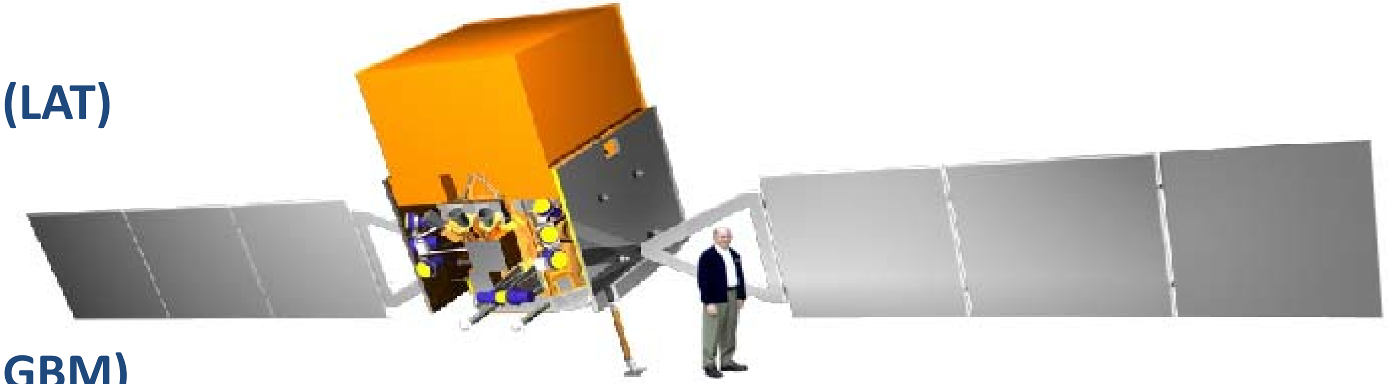
construction managed by Stanford Linear Accelerator Center (SLAC), Stanford University

Outline

- GLAST/LAT
  - Overview
- LAT Tracker performance
  - Flight Data !!!
- Conclusions

The GLAST mission

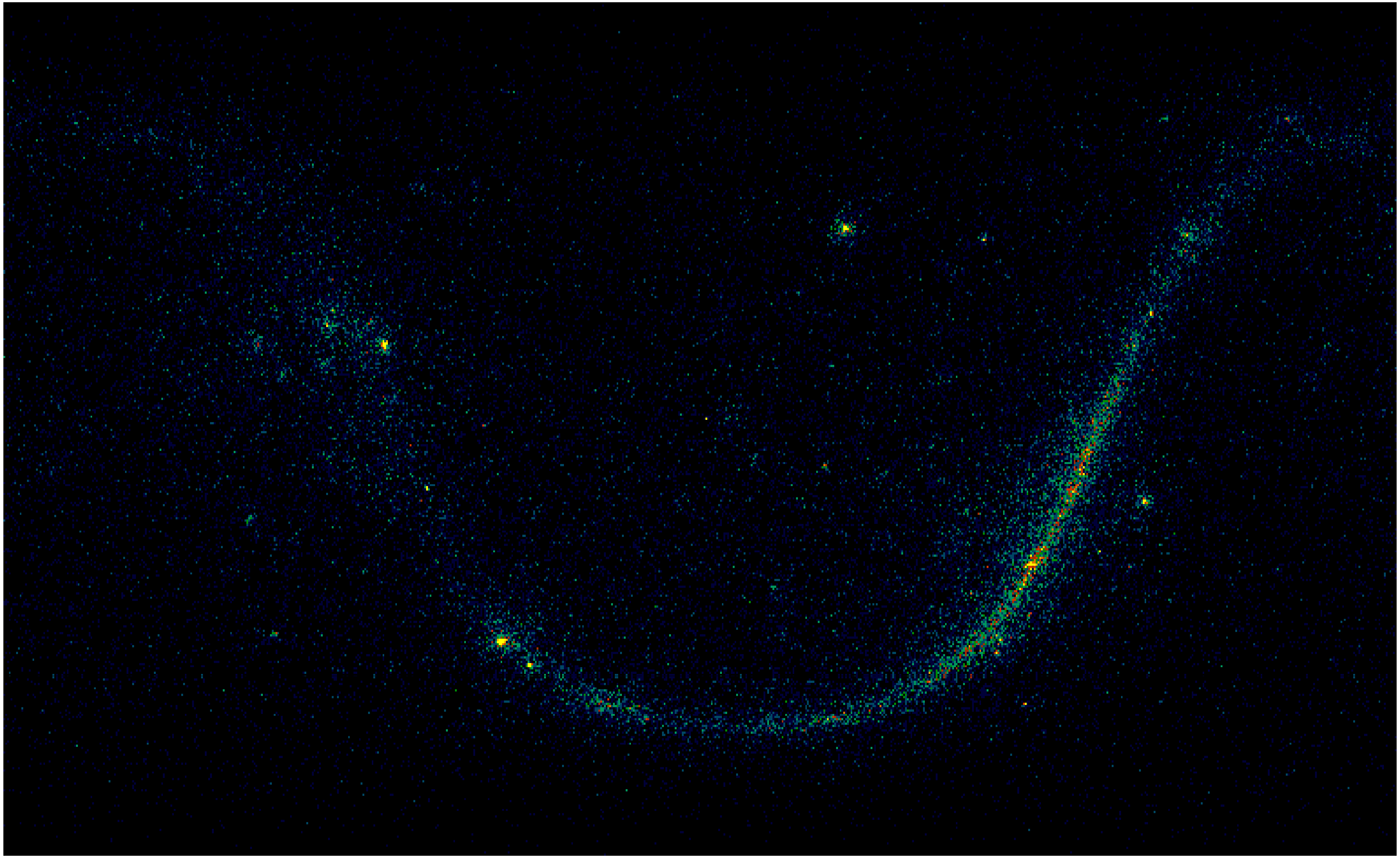
Large Area Telescope (LAT)
20 MeV - 300 GeV
>2.5 sr FoV



GLAST Burst Monitor (GBM)
8 keV – 30 MeV
9 sr FoV

- **Huge field of view (FOV)**
  - LAT: 20% of the sky at any instant; in sky survey mode, expose all parts of sky for ~30 minutes every 3 hours.
  - GBM: whole unocculted sky at any time.
- **Huge energy range**, including largely unexplored band 10 GeV - 100 GeV
- **Will transform the HE gamma-ray catalog:**
  - by more than one order of magnitude in # point sources
  - by more than one order of magnitude in timing resolution
  - spatially extended sources
  - sub-arcmin localizations (source-dependent)

The gamma sky is really variable



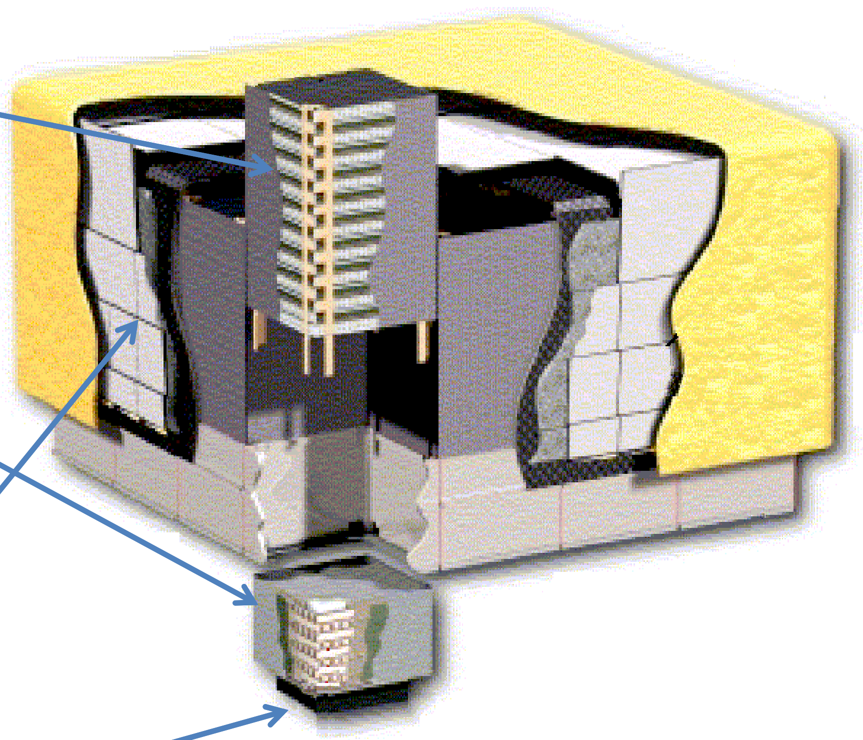
The LAT Instrument
(a pair-conversion gamma telescope)

• **Precision Si-strip Tracker (TKR)** 16 Towers. 18 XY tracking planes. Single-sided silicon strip detectors Measure the photon direction; gamma ID.

• **Hodoscopic CsI Calorimeter(CAL)** Array of 1536 CsI(Tl) crystals in 8 layers (8.6 X0). Total mass 1.5 tons. Measure the photon energy; image the shower.

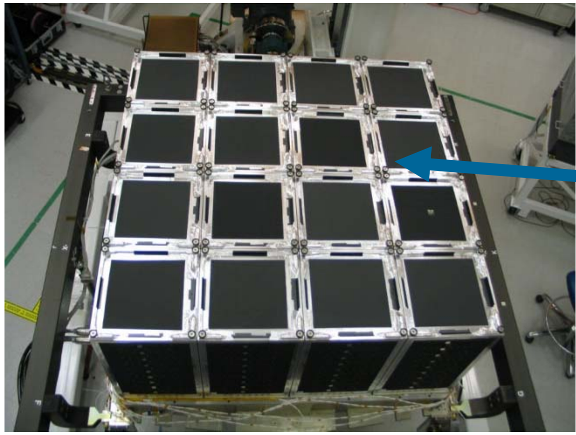
• **Segmented Anticoincidence Detector (ACD)** 89 plastic scintillator tiles. Reject background of charged cosmic rays; segmentation removes self-veto effects at high energy.

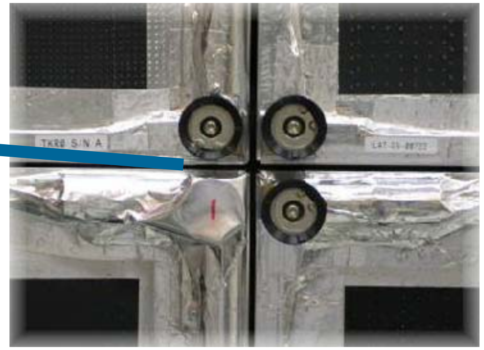
• **Electronics System** Includes flexible, robust hardware trigger and software filters.

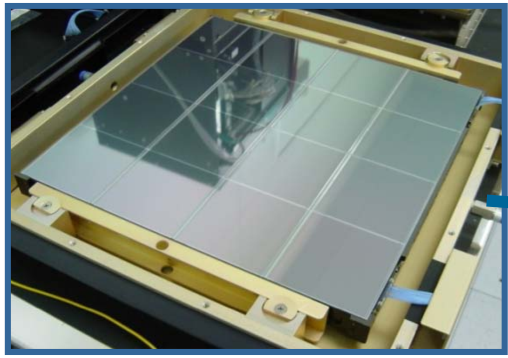


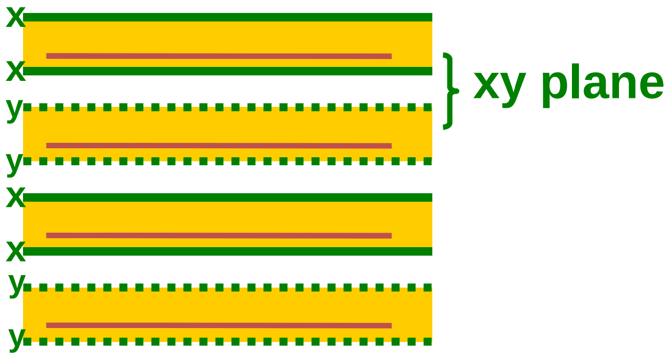
Tracker Design Overview

- **16 tower modules**
  - 37 × 37cm² active cross section/layer
  - 2 mm inter-tower separation in order to minimize the inactive area
  - **70m² of Si** (in space!!!)
  - 11500 SSD 8.95X8.95 cm²,
  - 384 strips - 880,000 channels
  - 440 μm thick
  - 228 μm strip pitch:
- **18 *xy* layers per tower**
  - 19 "trays" structure
    - 12 with 2.7% X_0 W
    - 4 with 18% X_0 W
    - 3 with no converter foils
  - every tray is rotated by 90°
  - W foils are followed by
    - *x,y* plane of detectors
    - 2mm gap between
- **Electronics on sides of trays:**
  - Minimize gap between towers









Readout Electronics Architecture

This a **space experiment**: Emphasis on compactness, minimum of wiring, redundancy, very low power consumption:

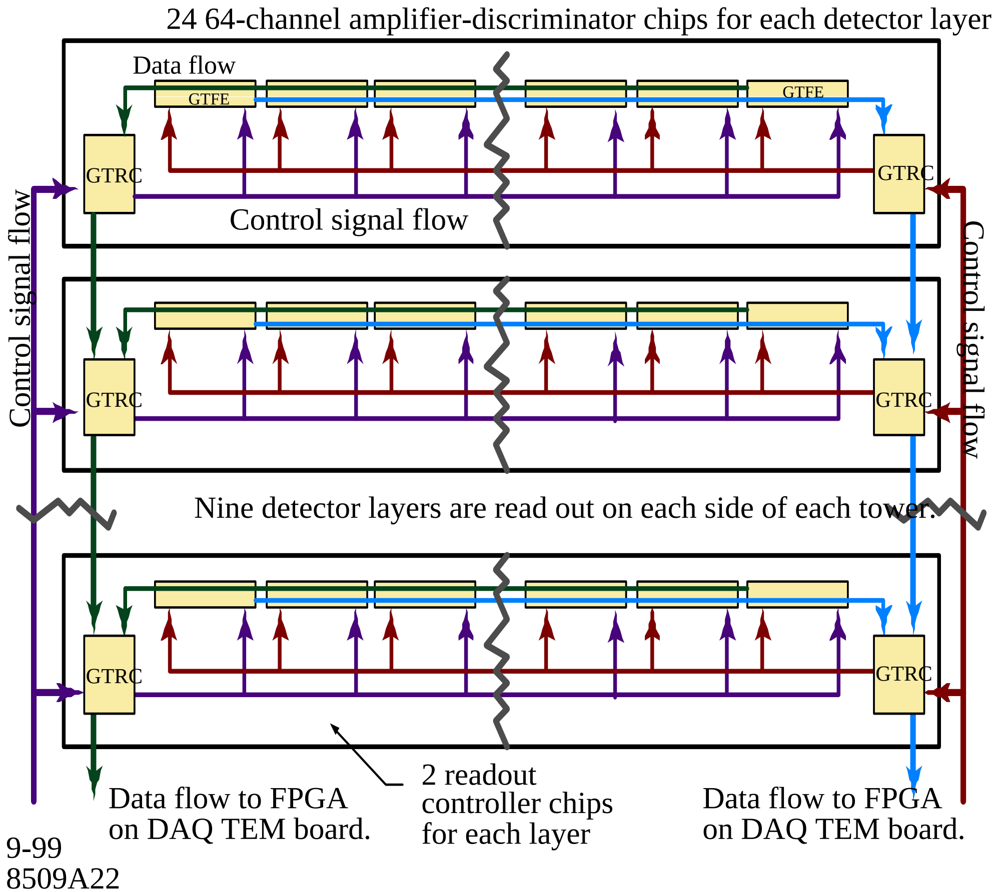
Any single component (GTFE, GTRC, cable) can fail without affecting the other.

GTFE (GLAST Tracker Front-end Electronics) ASIC

- Preamplifier - shaper - discriminator
- One threshold DAC and one calibration DAC per chip.
- 64 channels per chip, 24 chips per MCM.
- Noise: ~1500 e for 4 SSD ladder.
- Gain: ~100 mV/fC.
- Peaking time: 1.5 µs.
- 0.1 mW/channel.

GTRC (GLAST Tracker Readout Controller)

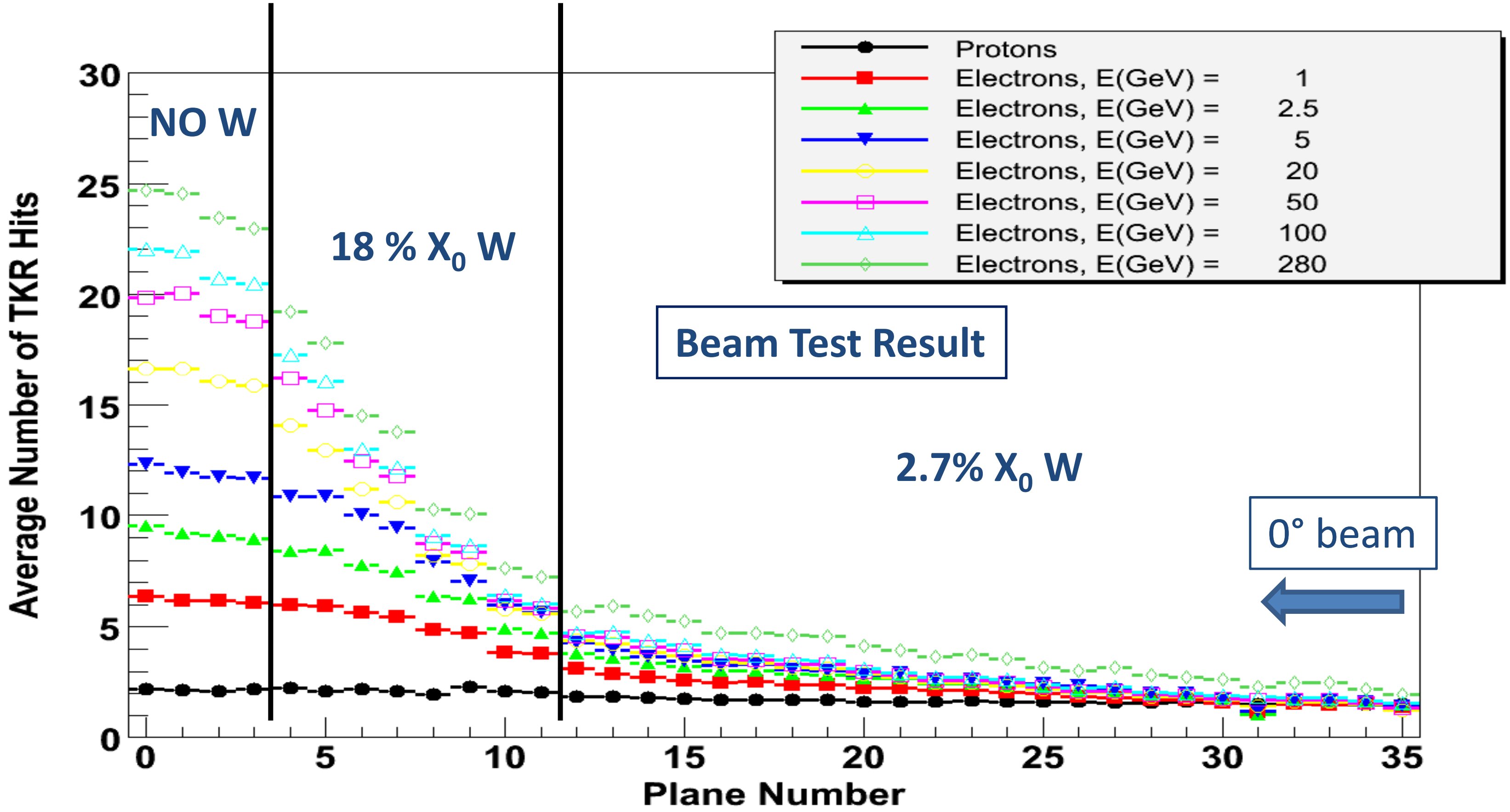
- 9 GTRC per cable.
- Communication between 24 GTFE and back-end electronics.
- TOT measurement from layer-OR trigger signal



The tracker isn't light….

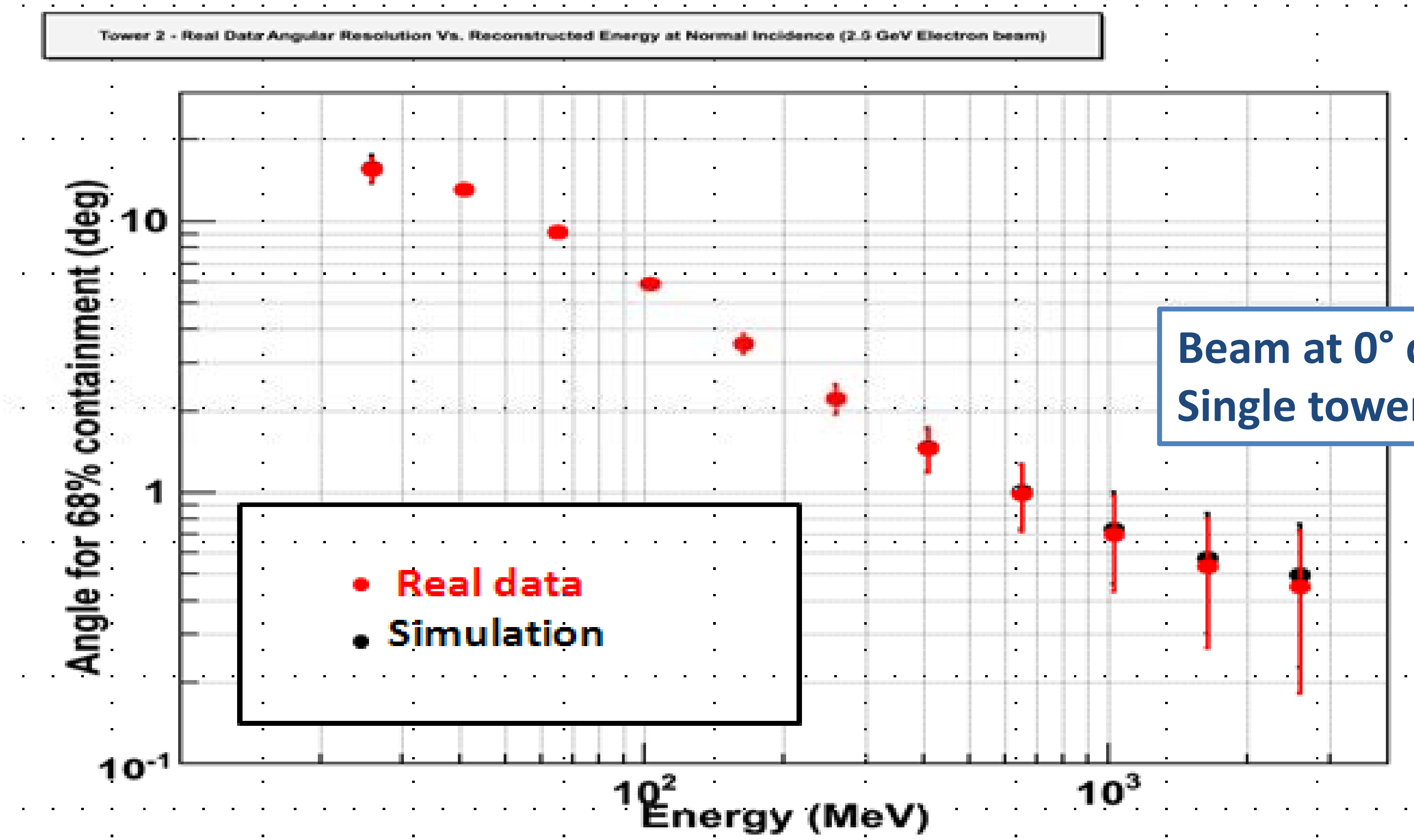
• The tracker-converter design is a compromise between very thin converter foils, good for **angular resolution**, versus thick foils, good for **effective area.**

• The hits multiplicity increases as the incident particle crosses the tracker. The main increase is (for normal incidence) in the bottom x-y planes where the thick W converters are located . The data are from beam test campaign in summer 2006



…but has a good angular resolution for gammas

- The Angular Resolution shown has been evaluated from Beam Test Data (gammas produced by bremsstrahlung between beam electrons and the upstream materials)
- It has been evaluated with respect to the nominal electron beam direction



Beam at 0° degree
Single tower events

LAUNCH!!!

- Launch from Cape Canaveral Air Station 11th June 2008 at 12:05PM EDT
- Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination

Commissioning | 1st year of observation

11th June
Launch

23rd June
LAT Turn On

30th June
First light
Whole Sky

11th August
End of commissioning

We are here

Tracker milestones

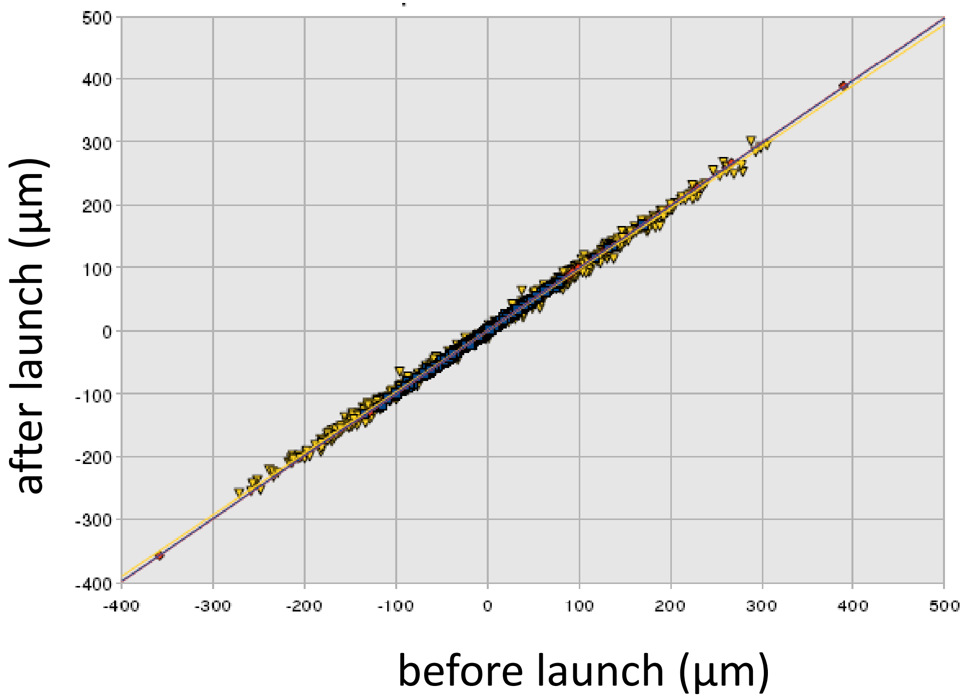
- **23rd June LAT Turn On**
  - Conservative SSD voltage (80 V)
  - Nominal threshold loaded (0.28MIP)
  - Everything was fine. The noise occupancy was very low . The trigger rate was as expected

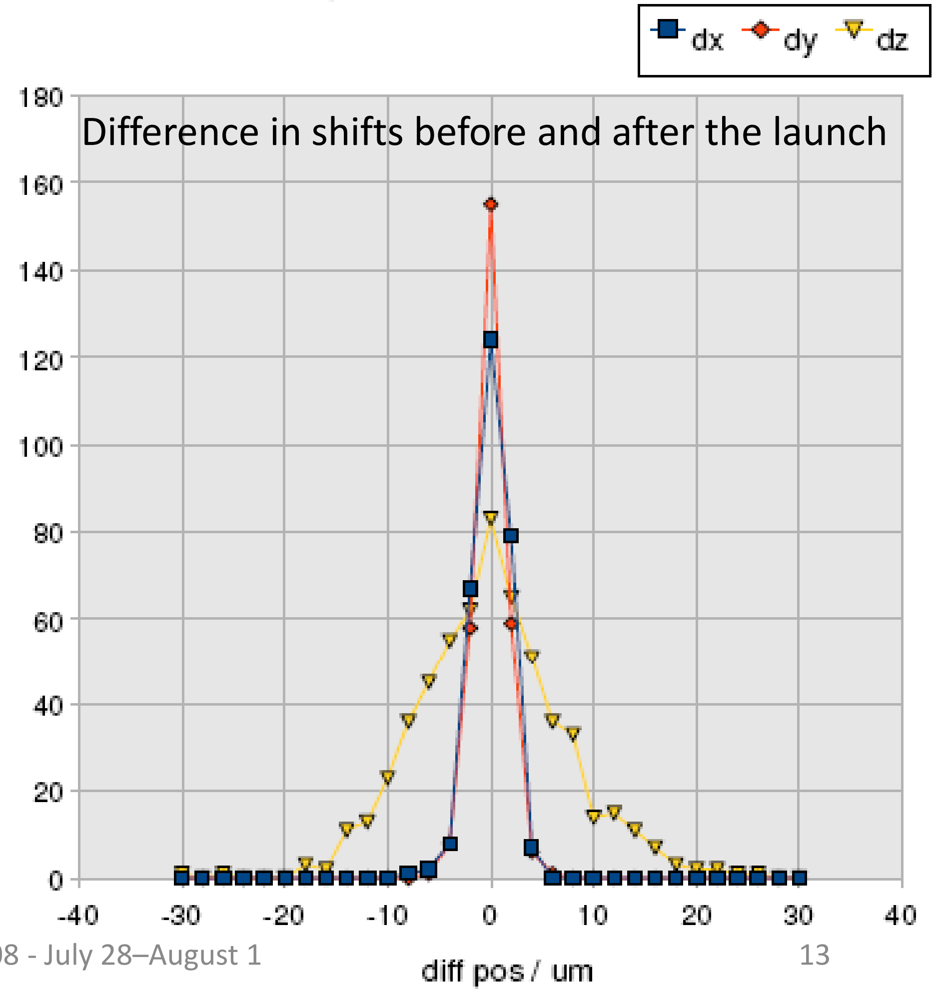
- **30th June Tracker at nominal values**
  - SSD voltage raised to 105V (nominal value). An increase of 0.16% in hit efficiency as been observed
  - No need to load new threshold (the on orbit calibration gave the same result of ground calibration)

- **After 7 days from the Turn ON (and only 23 after the launch) we work in space with the nominal configurations !!!!**

Well aligned after the launch
Translations

- GLAST underwent **4g acceleration** during the launch.
- We have verified the alignment of the planes in a tower before and after the launch using crossing particles
- No major shifts one respect to the other

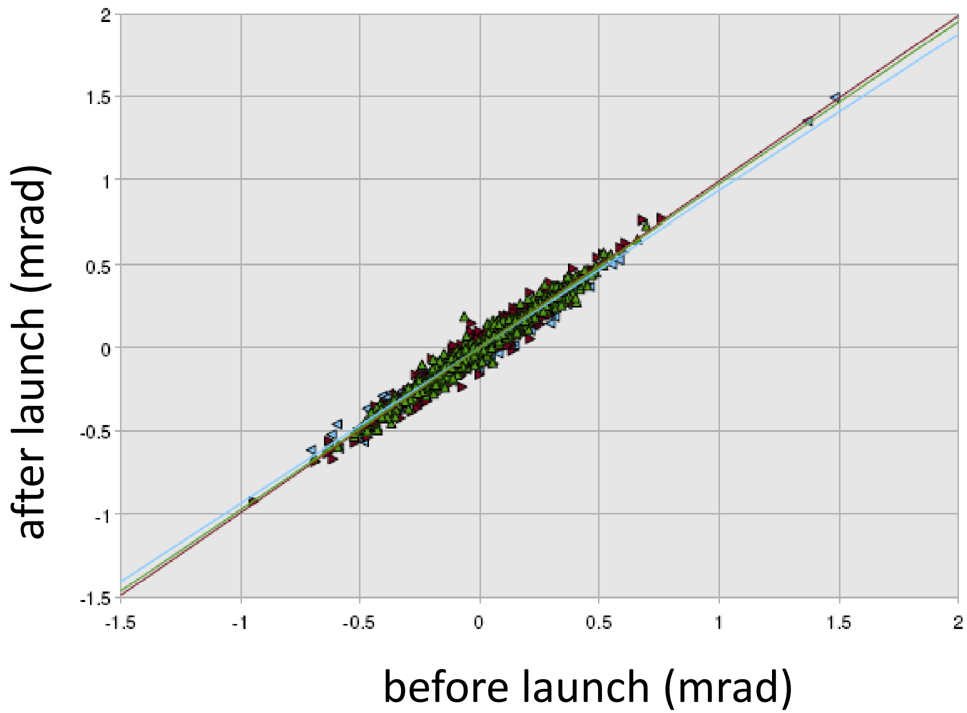


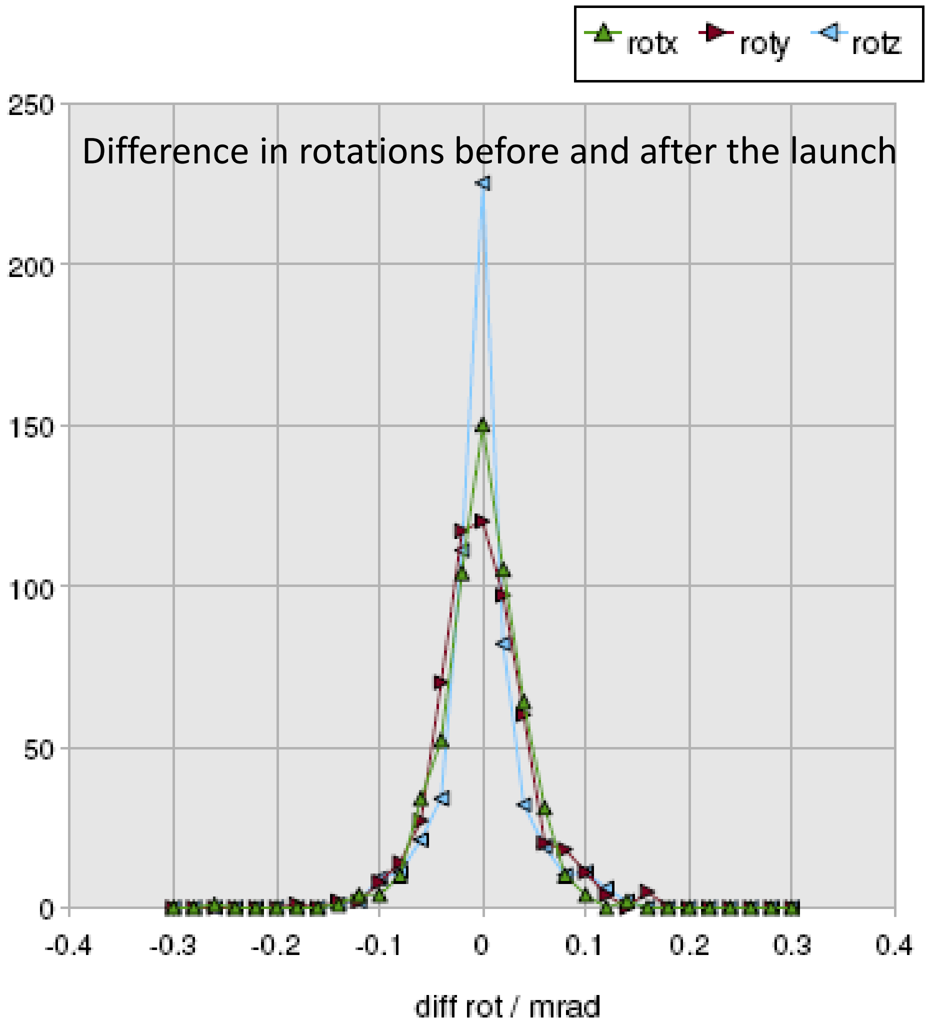


Thanks: M.Kuss (INFN-Pi)

… and Rotations

•No mayor rotations of the planes one respect to the other



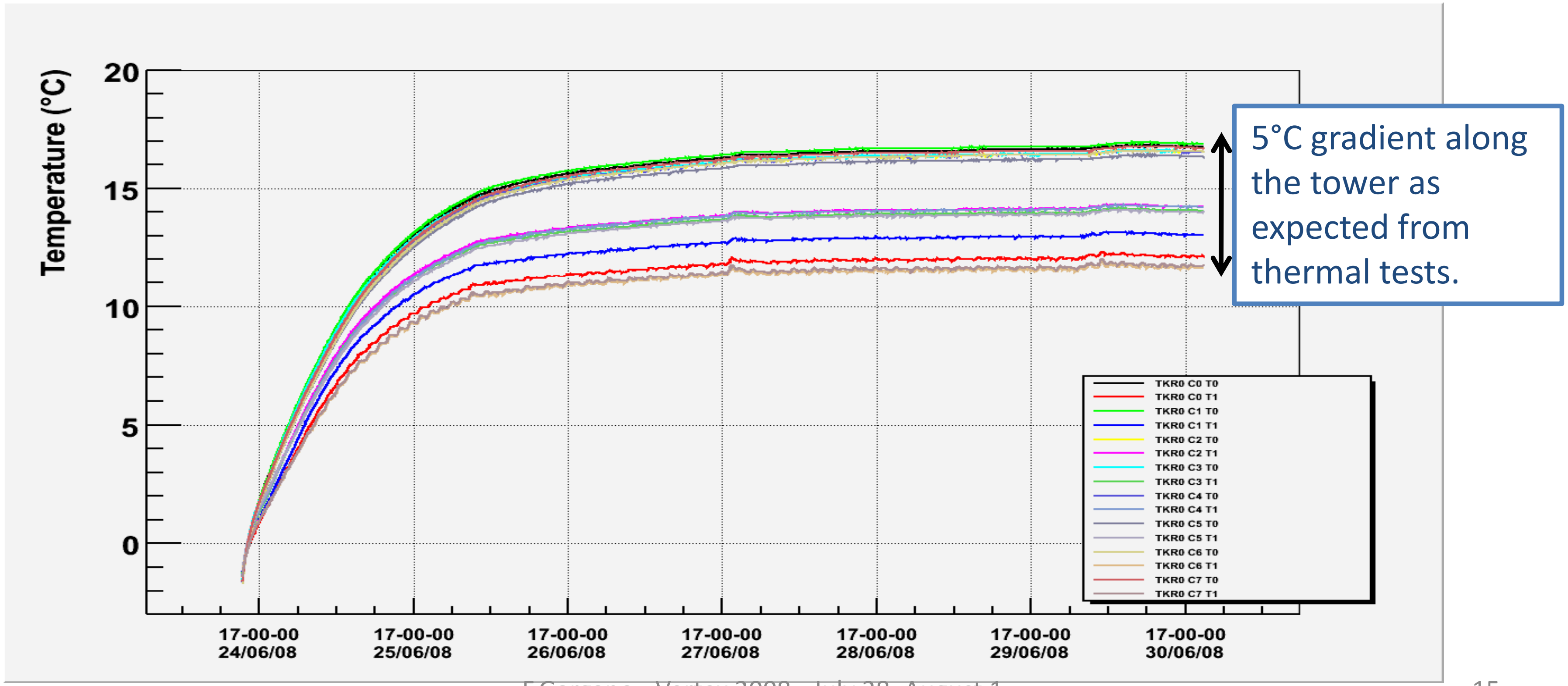


We have also checked the inter tower alignment and verified that we are well aligned

Thanks: M.Kuss (INFN-Pi)

Temperature is under control

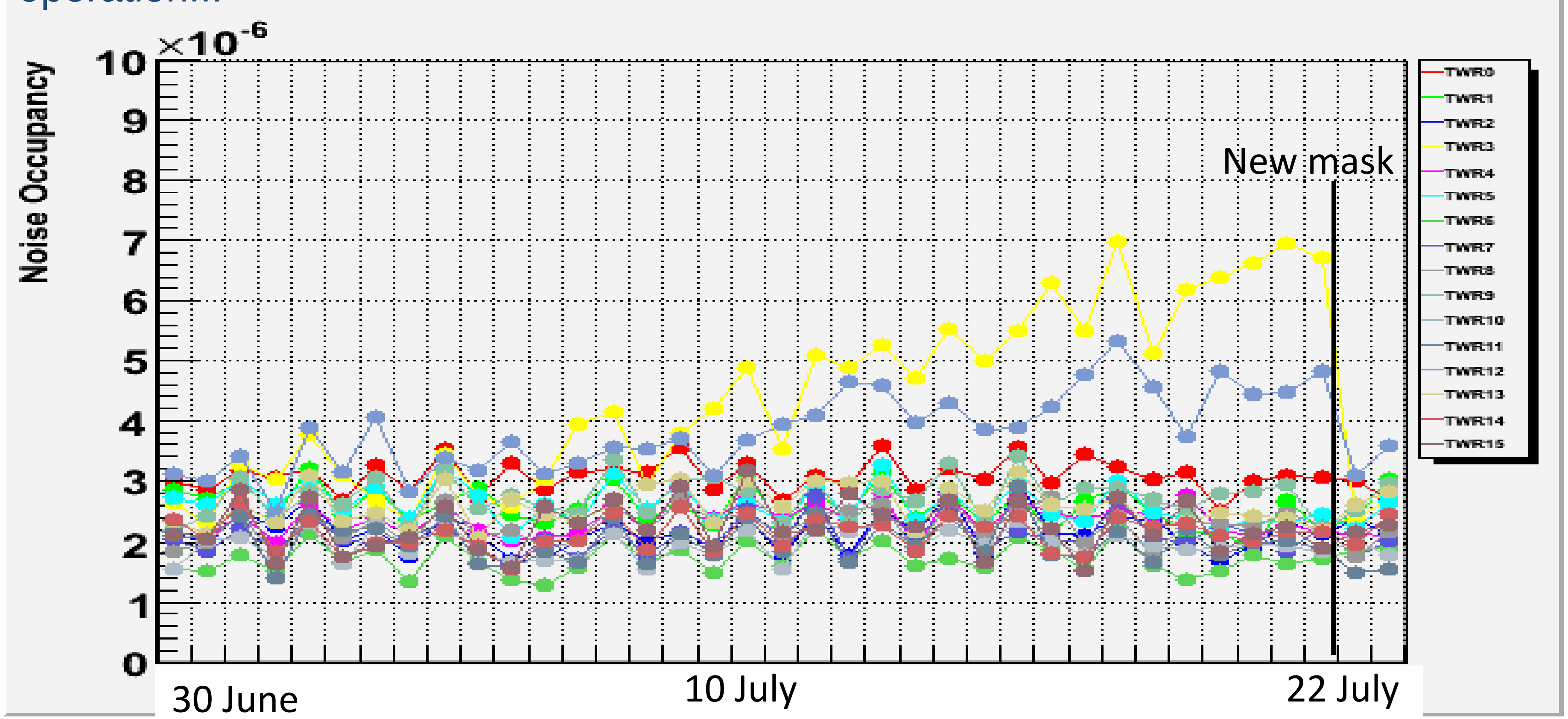
- The spacecraft temperatures are under tight control by an efficient thermal system
- The TKR temperature reach a steady value in a week from turn on
- In sky survey mode only small fluctuations are observed (<0.5°C). In pointed mode there is an overall increase of 2°C.
- The tracker is completely insensitive to this kind of variations (no effect on noise)
- The only temperature requirement is to keep the temperature < 25°C to avoid some strips to flare (0.05% on average)



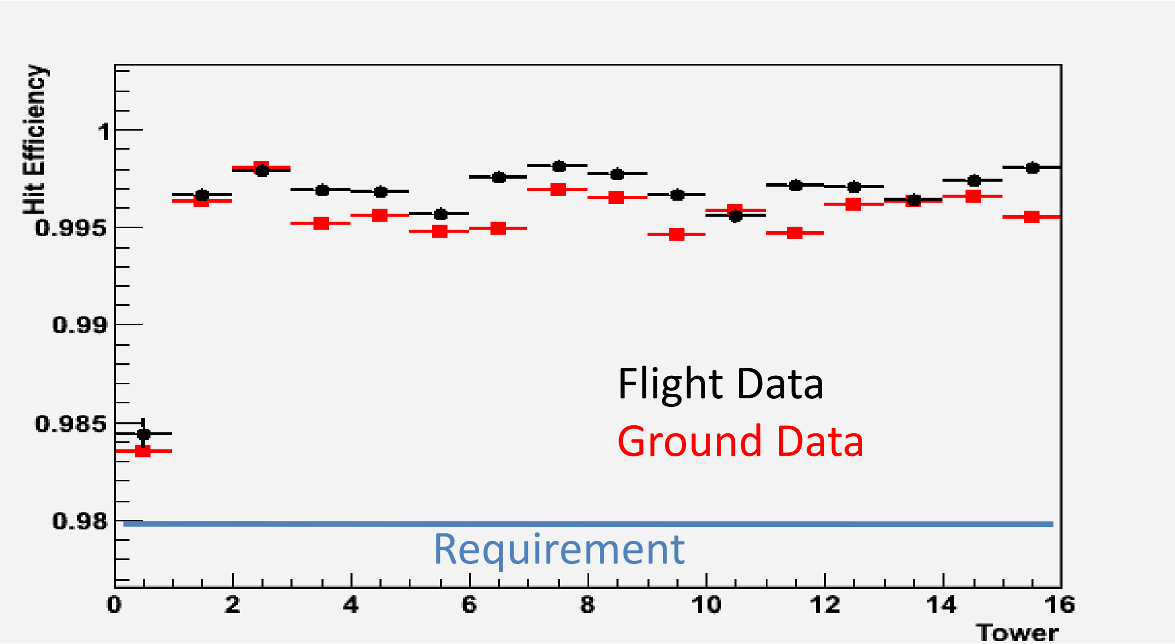
Very low Noise Occupancy

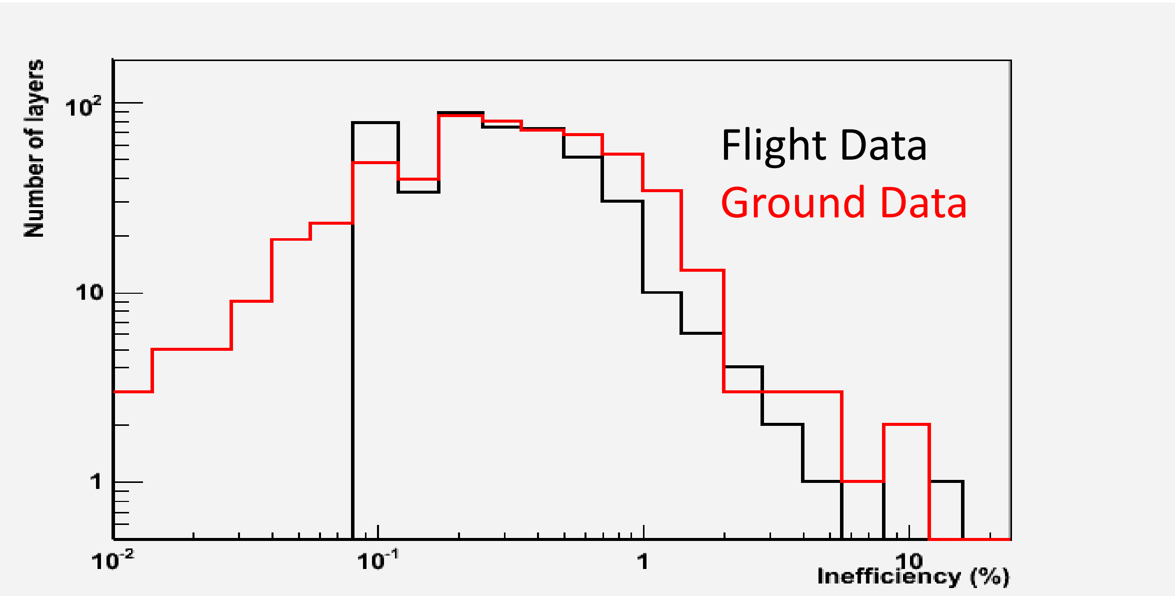
•The **Noise Occupancy** is defined as the average fraction of channels above threshold at any snapshot in time. We have evaluated it using the on board periodic trigger.

•The on orbit noise occupancy is almost an **order of magnitude lower** than the requirement 5x10^{-5} (averaged over all towers). It is very good for long term operation!!!



Few hits missed !!!





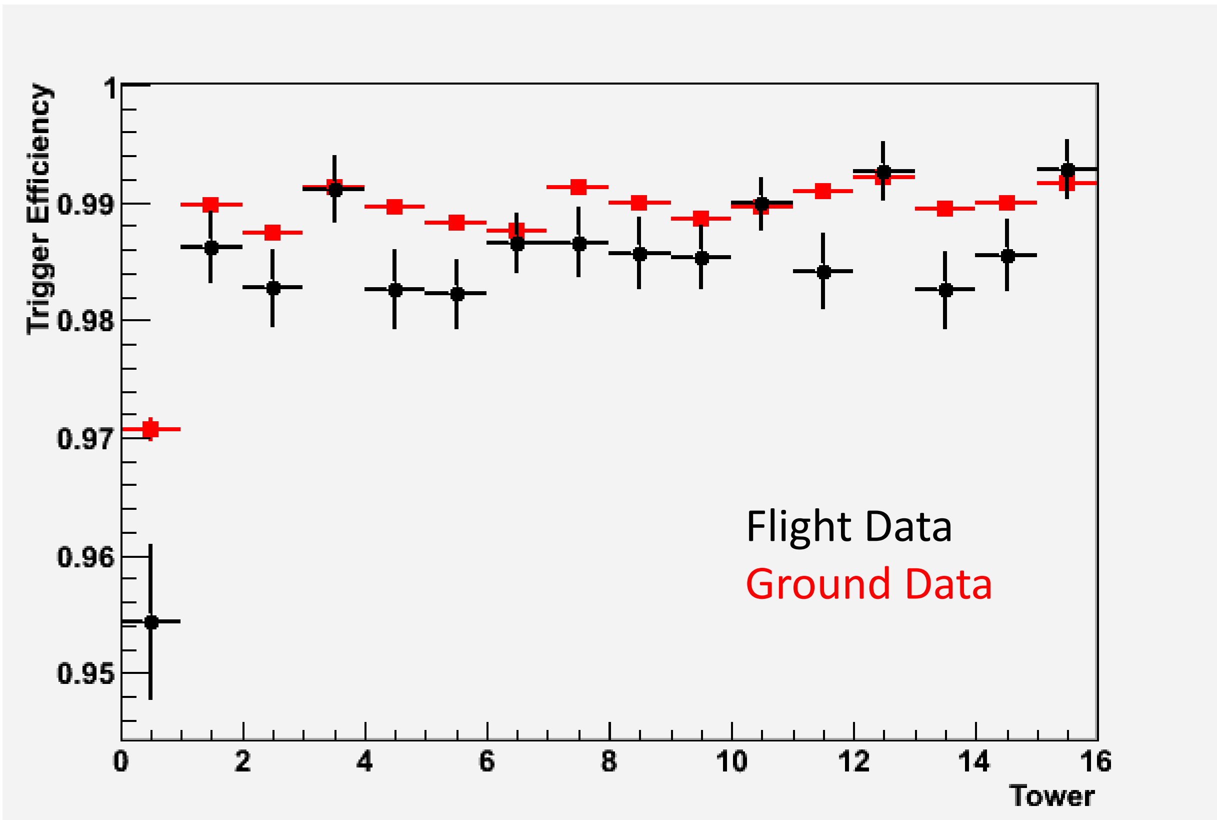
- An high **hit efficiency** is crucial for photon direction especially al low energy in order to measure the first two points after the conversion The requirements is > 98%
- The hit efficiency is evaluated looking for missing hits along the reconstructed track (±3.0mm confidential zone)
- The dead zone are taken into account in this procedure (geometrical inefficiency ≈4%). The hit inefficiency is mainly due to dead strips.
- The overall efficiency is very high > 99% for 15 towers
- Only 24 layers (4% of the total) show an hit inefficiency > 1%
- Due to the low statistic at the moment we cannot measure inefficiency < 0.1%

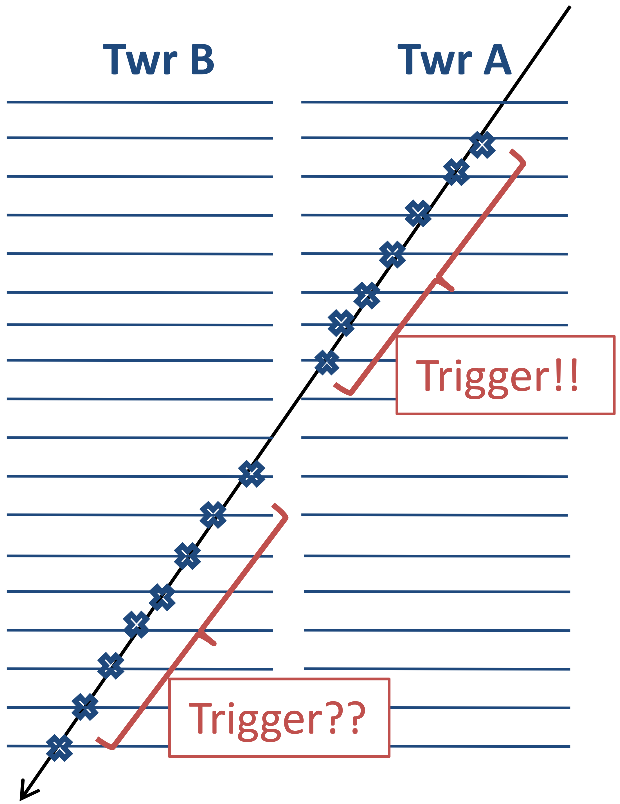
Thanks: Hiro Tajima (SLAC)

High Trigger Efficiency

- A tower trigger is set when there are 6 consecutive hits (3x + 3y)
- To evaluate the trigger efficiency we select events with a particle crossing two neighbor towers. The first (TwrA) is the one the that fires the trigger. We then search in TwrB if there are 3x+3y hits and, if it is the case, we search for a trigger request from TwrB.

The required hit efficiency is 90%

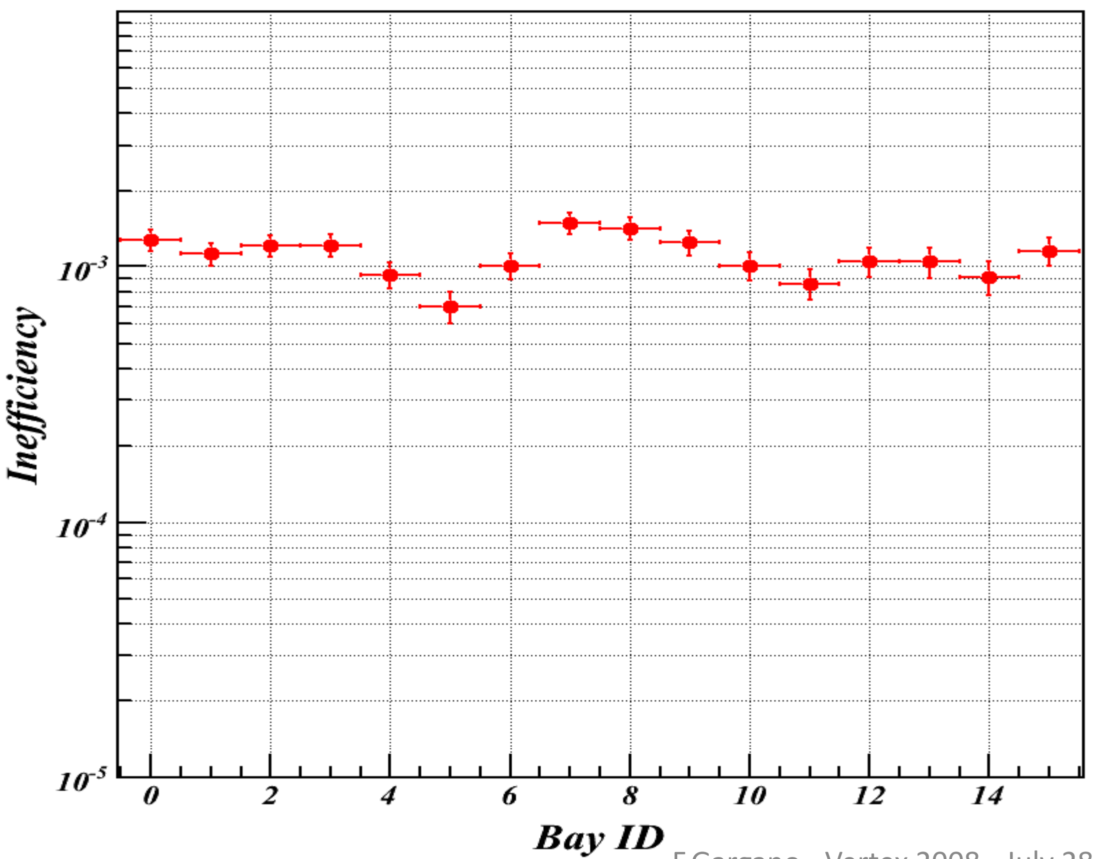


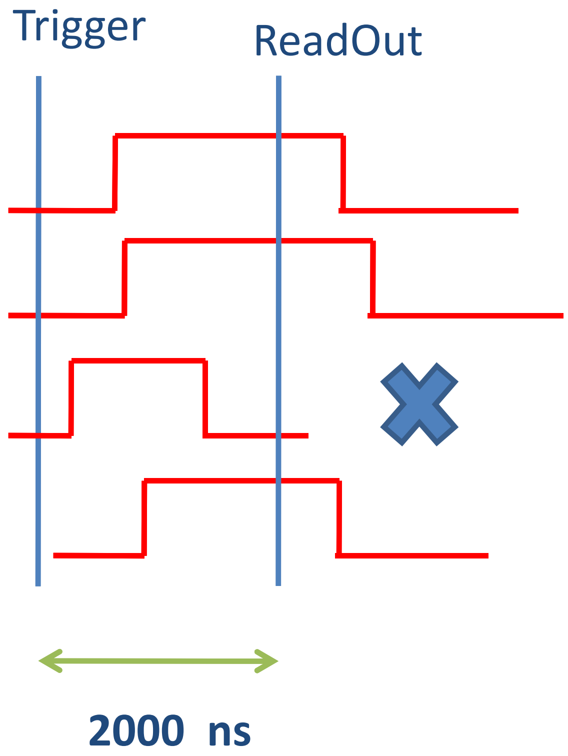


Thanks: Hiro Tajima (SLAC)

Very good read out timing

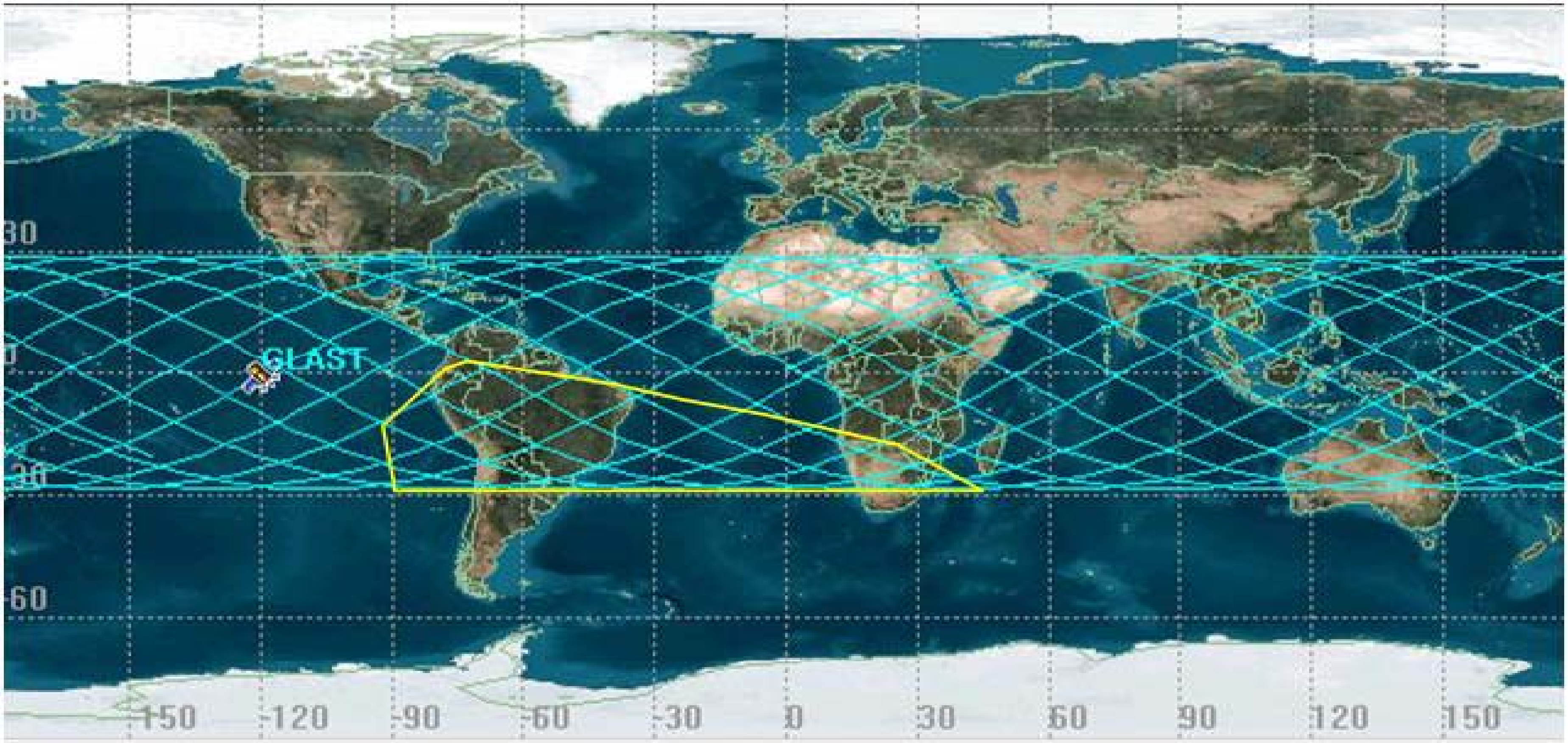
- The **hit capture inefficiency** is evaluated counting all the events in which we miss a ToT in a plane that belongs to a triggering tower
- The hit capture inefficiency is ≈ 0.1%
- The read out timing is really good and we miss very few hits !!!!





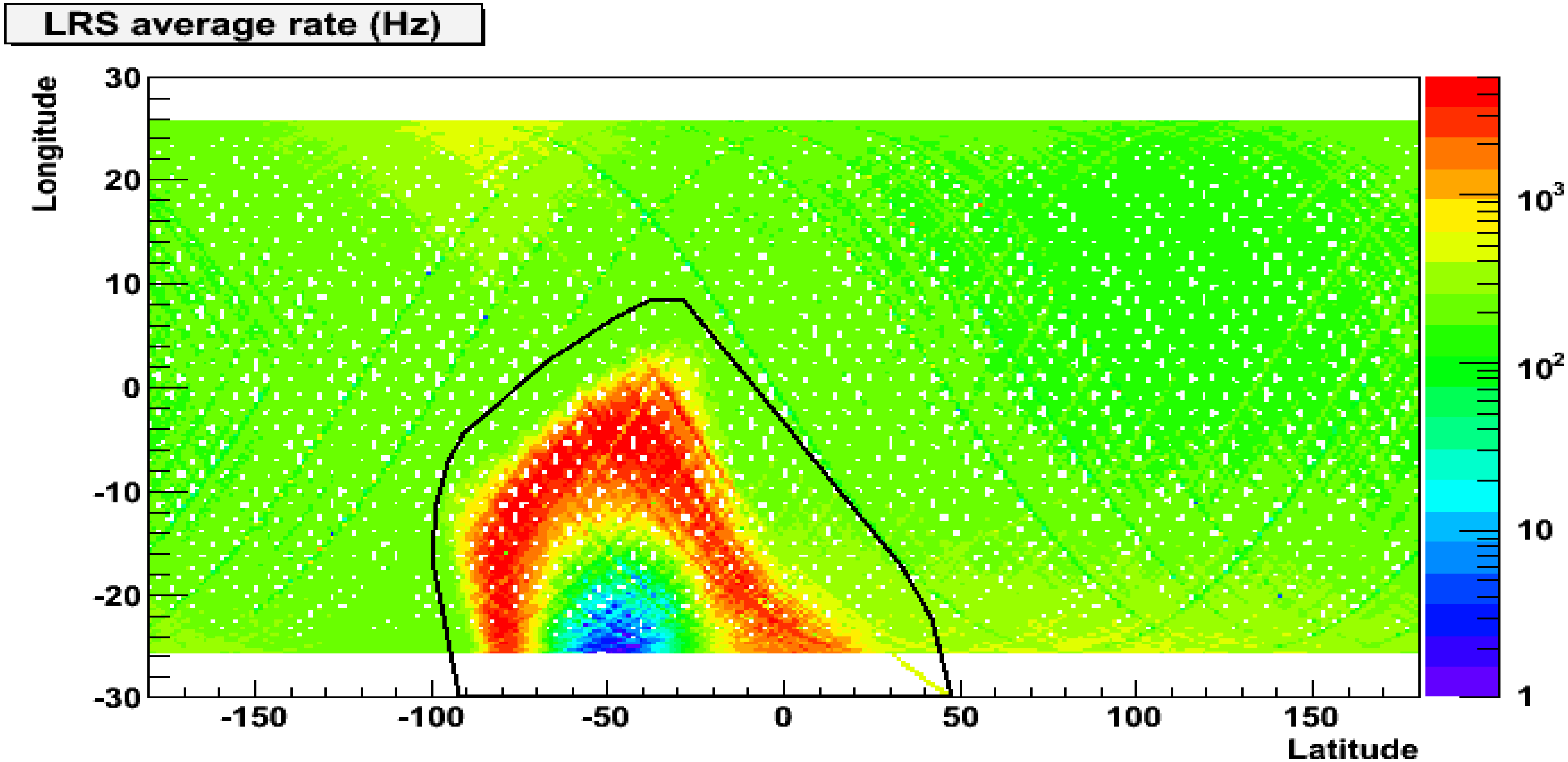
GLAST in the SAA

•The **South Atlantic Anomaly** (or SAA) is the region where Earth's inner van Allen radiation belt makes its closest approach to the planet's surface. Thus, for a given altitude, the radiation intensity is greater within this region than elsewhere.
•When GLAST in the SAA we don't take physics data. The rate of charged particle is too high to be efficiently filtered out, moreover the high rate can cause saturation effects in the readout electronics.
•With the actual SSA definition GLAST spend ≈18% of the time in it.



The SAA as seen by the tracker

- There are 4 counters for each towers that register the triggers inside the SAA .They are use to build a map of the SAA in order to study its boundary
- The map is averaged over all towers and all counters.
- The hole right in the middle of the SAA for the Tracker LRS counters is due to the saturation of the GTFE preamplifier
- We are working to **reduce the boundary** in order to increase the total live time. The goal is to reduce the time in the SAA to 13% of the total



Thanks: L.Baldini (INFN-Pi)

Conclusion

- GLAST has been on orbit for 47 days now!!! (29th July)
- The TKR performance are being monitored and everything behaves as expected
  - It underwent 4g acceleration during the launch
  - It is operating in vacuum (thermosphere P< 10^{-5} Torr) at ≈15°C
  - It has worked fine since the turn on without any problem **!!!**
- We are still in the commissioning phase (-12 days)
  - We are working on fine tuning calibrations
  - We are looking in more details at the TKR performance
- **Stay tuned for the first science results**