GLAST Large Area Telescope:

Status of LAT Instrument

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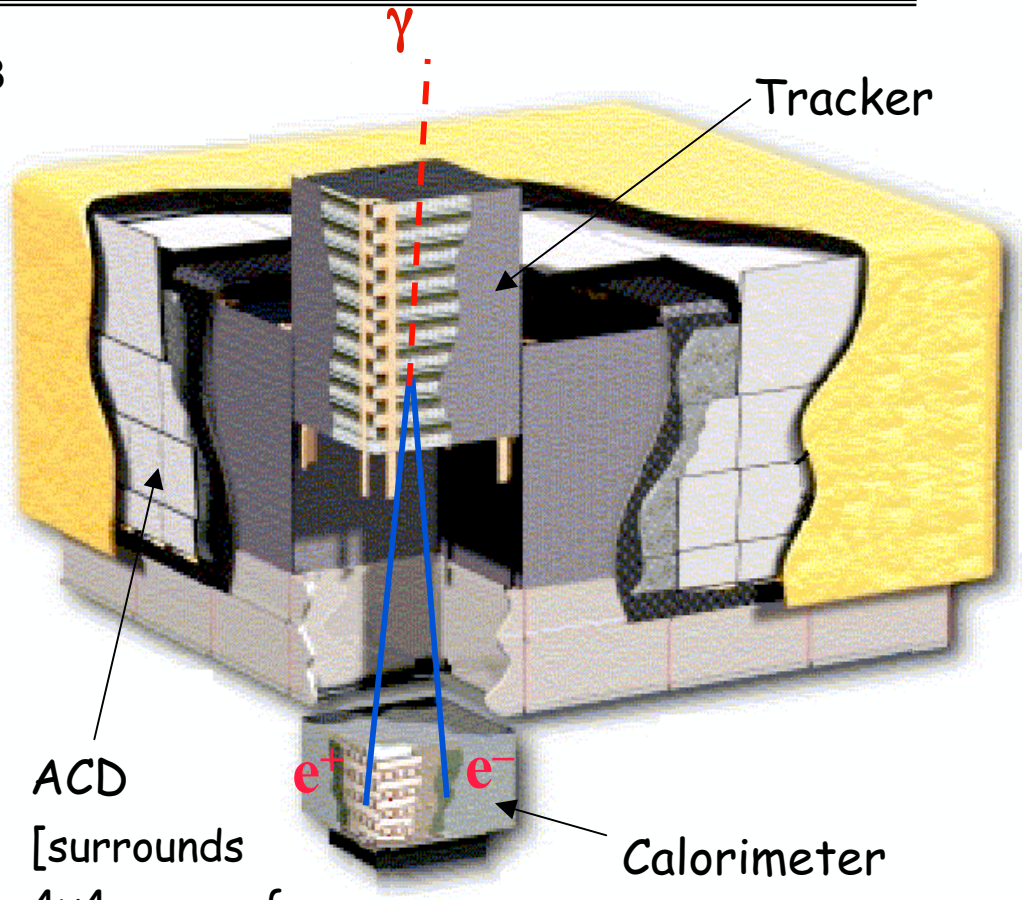
Outline

- Instrument overview, PDR performance expectation
- Overview of technical status
  - Science Analysis Software (SAS)
  - Calorimeter (CAL)
  - Mechanical/Thermal
  - Tracker (TKR)
  - Anti-Coincidence Detector (ACD)
  - Electronics and Flight Software
  - Integration and Test (I&T)
- Work in progress
- Summary

Overview of LAT

- Precision Si-strip Tracker (TKR) 18 XY tracking planes. Single-sided silicon strip detectors (228 μm pitch) Measure the photon direction; gamma ID.
- Hodoscopic CsI Calorimeter(CAL) Array of 1536 CsI(Tl) crystals in 8 layers. 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.



Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV - >300 GeV.

Gamma Conversion Material

TKR tungsten converter thickness profile:

"FRONT": 12 layers of 3% X_0

"BACK": 4 layers of 18% X_0

followed by 2 layers with no converter

- **Large A_{eff} with good PSF and improved aspect ratio for BACK.**
- **Two sections provide measurements in a complementary manner: FRONT has better PSF, BACK greatly enhances photon statistics.**

TKR has ~1.5 X_0 of material.
Combined with ~8.5 X_0 CAL provides 10 X_0 total.

Science Performance Requirements Summary

Parameter	SRD Value	Present Design Value
Peak Effective Area (in range 1-10 GeV)	>8000 cm^2	10,000 cm^2 at 10 GeV
Energy Resolution 100 MeV on-axis	<10%	9%
Energy Resolution 10 GeV on-axis	<10%	8%
Energy Resolution 10-300 GeV on-axis	<20%	<15%
Energy Resolution 10-300 GeV off-axis (>60º)	<6%	<4.5%
PSF 68% 100 MeV on-axis	<3.5°	3.37° (front), 4.64° (total)
PSF 68% 10 GeV on-axis	<0.15°	0.086° (front), 0.115° (total)
PSF 95/68 ratio	<3	2.1 front, 2.6 back (100 MeV)
PSF 55º/normal ratio	<1.7	1.6
Field of View	>2sr	2.4 sr
Background rejection (E>100 MeV)	<10% diffuse	6% diffuse (adjustable)
Point Source Sensitivity(>100MeV)	<6×10^{-9} $cm^{-2}s^{-1}$	3×10^{-9} $cm^{-2}s^{-1}$
Source Location Determination	<0.5 arcmin	<0.4 arcmin (ignoring BACK info)
GRB localization	<10 arcmin	5 arcmin (ignoring BACK info)

Results from January PDR. LAT meets all requirements, and many improvements are underway.

Science Analysis Software Technical Status

New version of the simulation packages: GLEAM
- beta version last June; first user release in October
- Geant4 for particle transport
- revised reconstruction with many improvements underway ➡
  (see talks from yesterday: Dubois, Usher, Atwood, Strickman, Kelly)

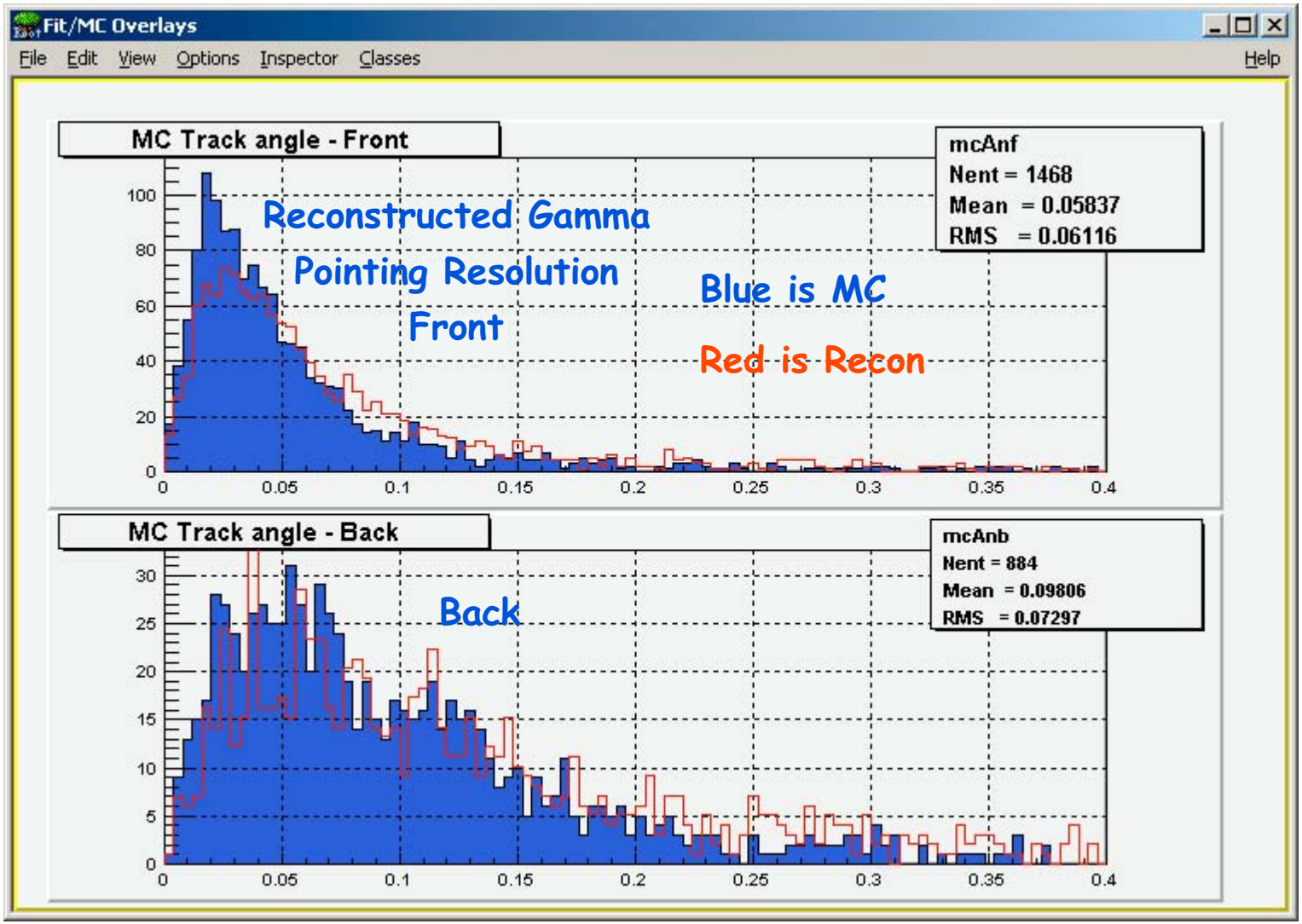
- Support for calibrations planning
  - infrastructure under development
- database implementation underway. TKR hot/dead strip lists being used as first client
- Science tools support
  - joint sit-down working meeting with GLAST Mission Science Support Center (SSC) in June; LAT-SSC working group telecons regularly since February.
  - defining requirements for higher level analysis tools. Review in September (F. Marshall chair), report now complete and submitted. See talks after the break this morning.

TkrRecon / Monte Carlo Comparisons

Examples of Monte Carlo prediction vs Recon output

100 MeV Gammas generated into the cone –0.8 < cos(theta) < -1.0

From Tracy Usher's talk yesterday

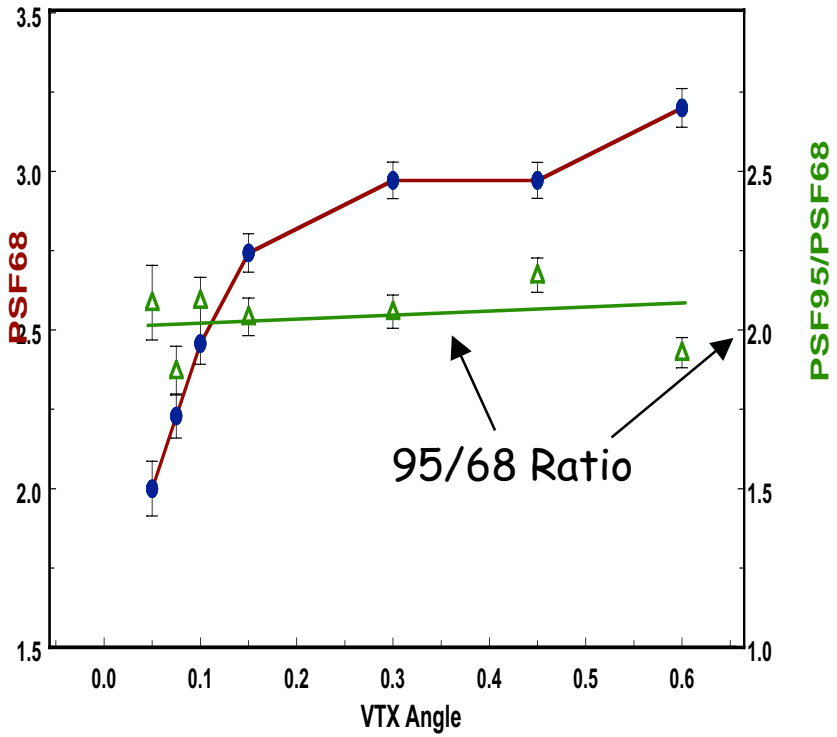


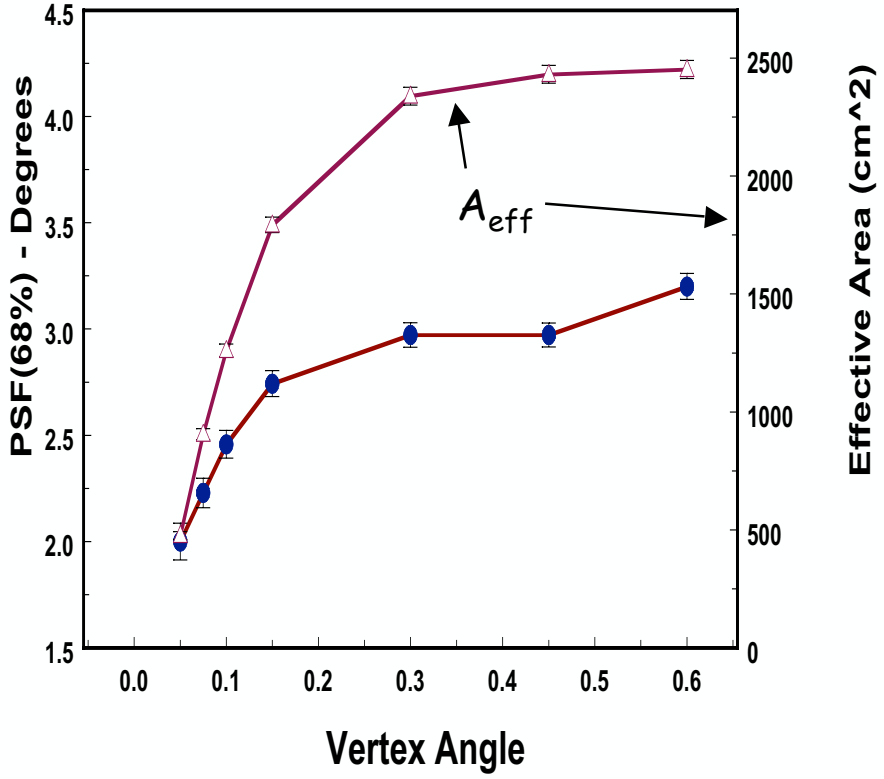
Dialing in Your PSF!

From Bill Atwood's talk yesterday

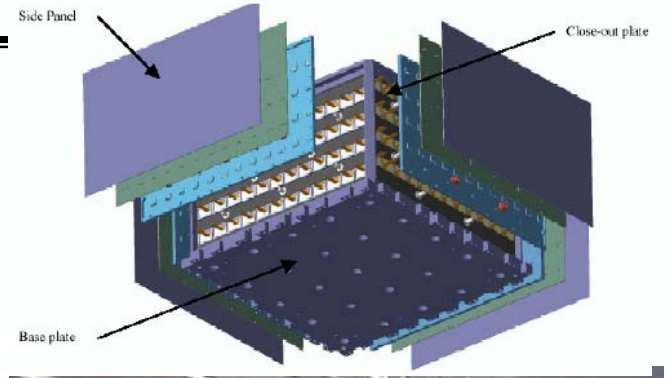
The PSF for γ's turn out to depend on the Opening Angle between the 2 Tracks

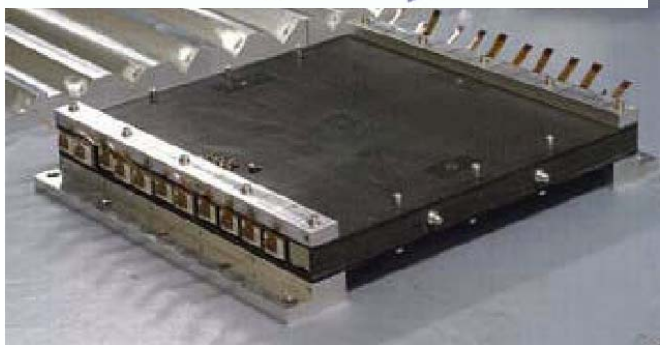
In retrospect this is now Obvious! - Parallel Tracks ➡ minimal MS!





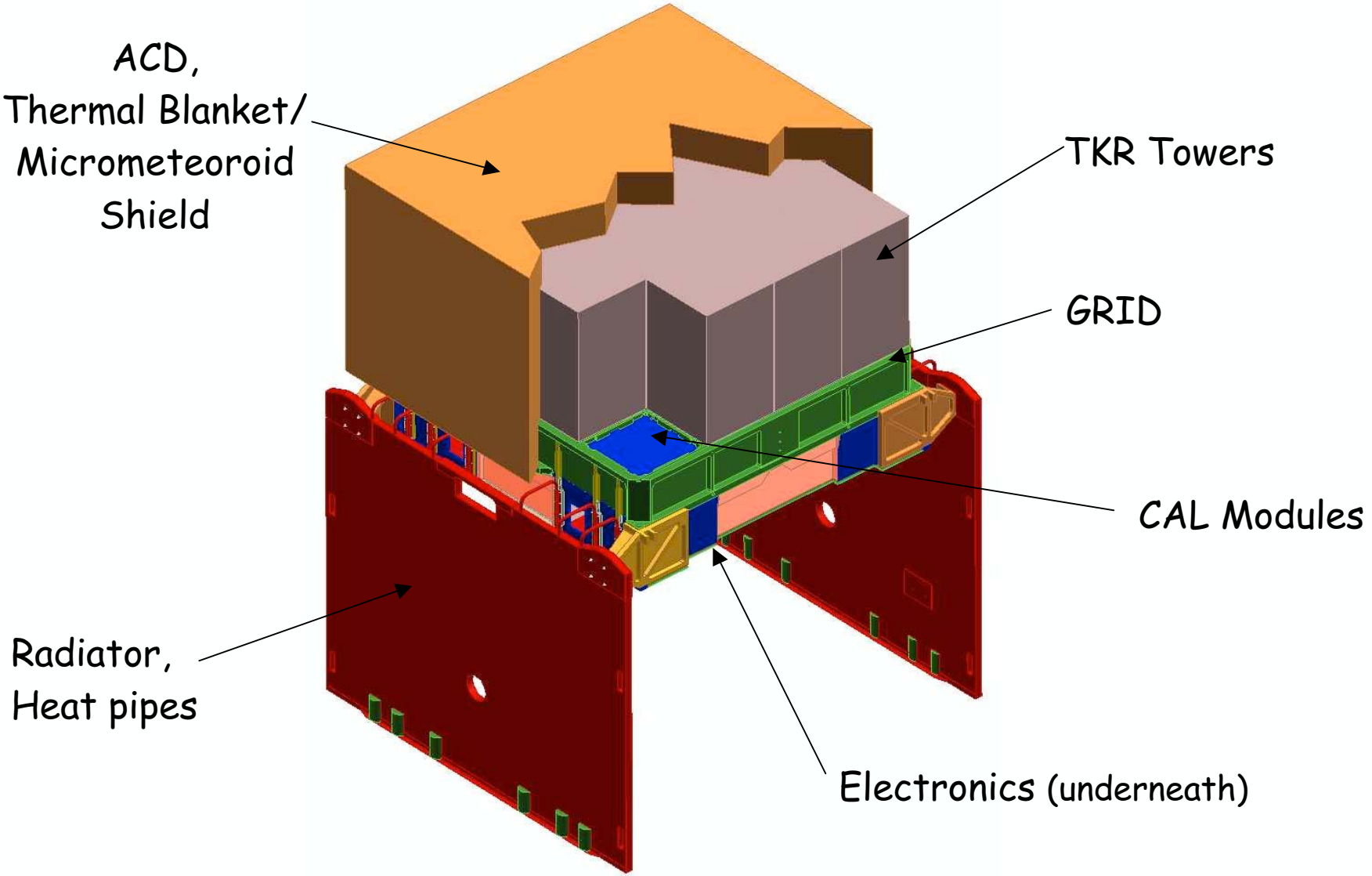
Calorimeter Technical Status





- Environmental testing (vibe and thermal) of CAL module prototypes successfully completed (LAT-TD-00850).
- Crystal Detector Element (CDE) development program initiated at NRL
  - support French program in developing manufacturing process
  - provide alternate source of CDE for the Engineering Model
- Modifications to CsI crystal, PIN diode and mechanical structure dimension specs.
- Qualification testing of PIN diodes
- PIN diode-crystal bonding procedure developed and tested (LAT-PS-00385).
- Prototype ASICs, front-end boards fabricated, tested, used for interface testing.

LAT Mechanical Design Overview



Mechanical/Thermal Technical Status

- January review: mechanical designs technically ready; thermal subsystem design judged not ready *"due to a recently directed change to repackage the radiators to allow…the maximum number of potential spacecraft vendors to bid for the spacecraft contract."*
- Action items from the review
  - Re-evaluate thermal interface requirements — DONE
  - Investigate alternate design implementations — DONE
  - Add specific items to test plans — DONE
  - Conduct delta review — PASSED
- Mechanical/Thermal Design changes summary:
  - Observatory accommodations in radiator layout
  - Thermal management (improved radiator emissivity, added heat pipes, change TKR sidewall material for better conductivity)

TKR Technical Status

- Mechanical prototype construction and testing ⟹
- ASICs:
  - Second run of the readout controller and front end chips had design rule error. Fixed, verified, and resubmitted.
  - Resubmitted chips came back in August. Baseline schedule: one more submission for flight parts. August chips have all functionality for flight.
- Electronics testing facilities set up. New results ⟹
- Parts qualification in progress.
- Engineering Model tooling and production facilities setup and running.
- Flight unit construction (300 flight ladders) underway in Italy. 3,600 flight SSDs received and tested in Italy.
- Setup for tray production in Italy (4 trays/week). Producing 30 EM trays.

New TKR Noise Measurements

LAT-TD-01060 Noise Trigger Rates Page 6 of 8

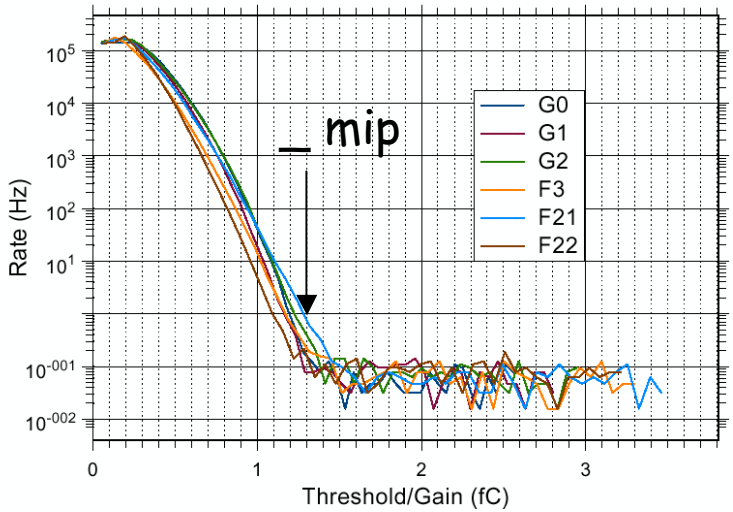


Figure 4. The trigger rate per channel measured in each of the 6 chips connected to the ladder, in each case averaged over the 64 channels in the chip. The horizontal scale is normalized to the average gain measurement of the chip, as measured in LAT-TD-1023.

Engineering Model system tests next.

Table 1. Summary of noise occupancy measurements, averaged over all 64 channels per chip. Note that Chip 0 has several dead detector strips, so its result is artificially low.

	G Chip 0	G Chip 1	G Chip 2	F Chip 3	F Chip 21	F Chip 22
Threshold	24	22	21	19	18	19
Occupancy times 10^6	0.47	0.72	0.83	1.06	1.39	0.93

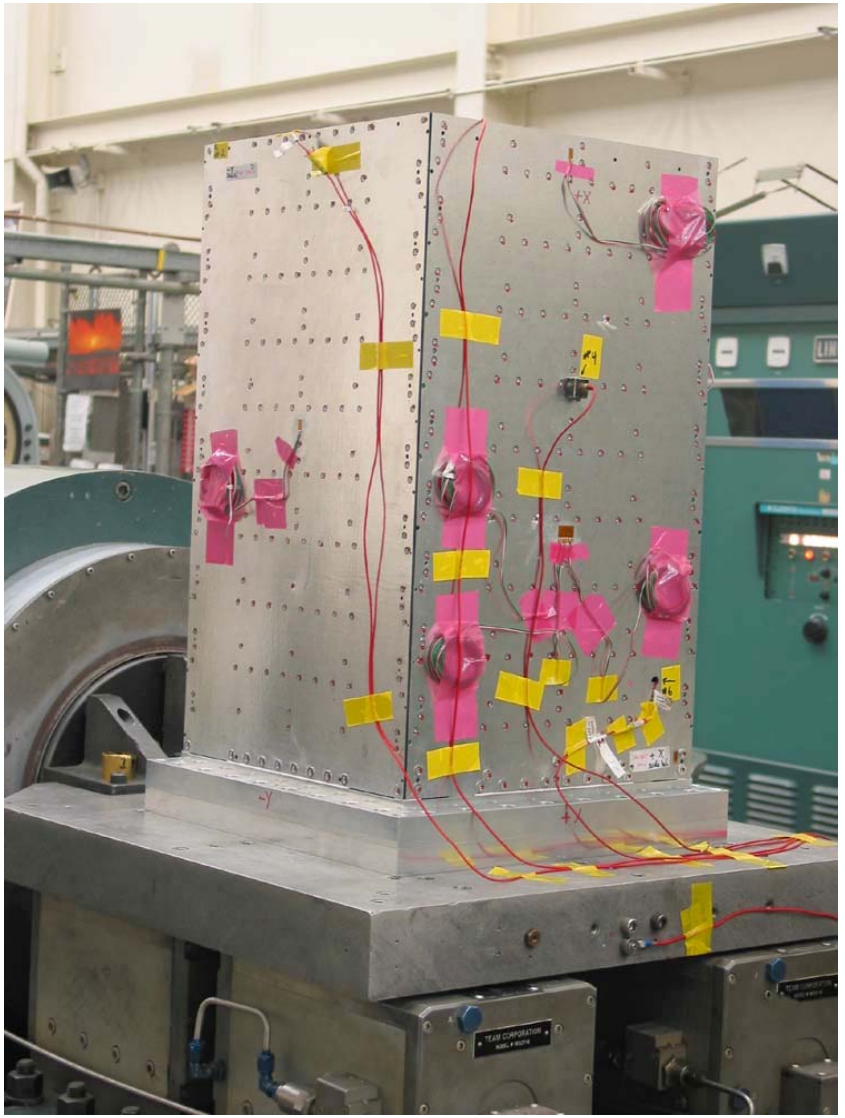
TKR Mechanical Prototype

Mechanical prototype program conducted to reduce risk in the engineering model development.

Evaluated manufacturing, tooling, finite element model, environmental testing.

Systematic progression:

- early test articles (tray concept) √
- beam test/balloon flight tower √
- mechanical prototype ⬅
- engineering model
- qual towers
- flight towers



TKR Mechanical Prototype Testing Results

- Thermal and vibration testing of prototype trays successful (LAT-TD-00793).
- Two tower-level vibration tests were performed. Improvements in TKR tower mount design required (primarily affects bottom tray):
  - Formal review team commissioned by LAT project management
  - Underlying problems identified and corrective actions defined.
  - Two alternative design improvements under development.

INVAR Bottom Tray

Corner Gussets

ACD Technical Status

- Technical action items from the January review:
  - Finalize tile and fiber layout, build mock-up √
  - Test light yield of full optical system √
  - Demonstrate electronic noise is low
    - underway
  - Thermal cycle tile assemblies √
  - Plan for calibration of ACD system √
    - draft complete
  - Improve ASIC schedule margin √

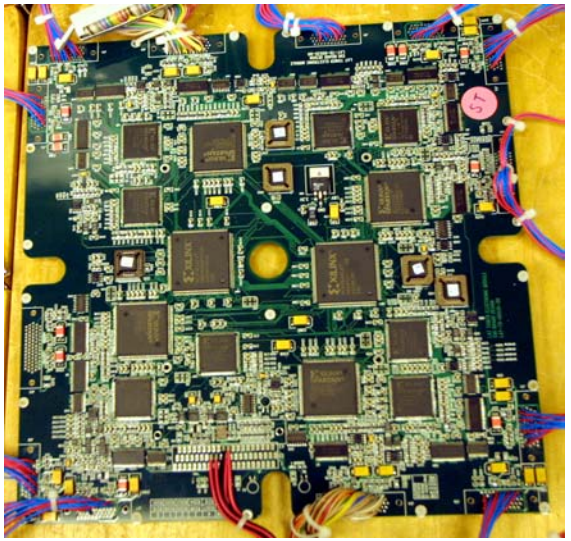
Full-scale mock-up of ACD being used for tile placement and fiber routing

- ACD Electronics Module: EM1 version designed, built, and tested; EM2 version (interfaces, functions, and components as flight-version) in design.
- Issues of pulse pileup being worked now.

Electronics/Flight Software Technical Status

- Tower Electronics Module (TEM)
  - Built and tested EM1 version
  - EM2 version [all functions, components, interfaces as flight model] under development.
- Flight-Processors
  - Received cPCI BAe750 processor board, being evaluated
- Global trigger system design (see JJ's talk from yesterday)
- Power supplies
  - Prototype of most challenging converter (1.5V for TKR) built and tested. Evaluated with TKR electronics to verify no observable impact on noise.
- Designed TEM enclosure and mounting system
- Interface functionality tests (hardware and flight software)
  - TEM/AEM used to control and readout subsystem front-end electronics.

EM1 version of TEM



Electronics/Flight Software Technical Status (II)

See yesterday's talk by JJ Russell

- Event format from front-end electronics decided.
  - demonstrated readout on the bench using prototype hardware from subsystems.
  - new format improves event size, event access time
  - software written to transform Monte Carlo event data to this format. Used to study filtering process.
- Event filtering code approaching production quality
  - processing time optimized (currently <15 μs/event)
  - rejection rate currently 98%
- Finer estimate of CPU requirements
  - benchmark BAE 750 board, matches earlier estimates
  - major pieces of filter algorithm coded
  - generous amount of CPU cycles left for processing final 2% of background.

I&T Technical Status

- Planning for Engineering Model I&T testbed
- Technical Plan Documents:
  - LAT Performance Verification Plan (LAT- MD-00408)
  - Science Verification and Calibration Plan (LAT-MD-00446)
  - I&T Contamination Control Implementation Plan draft complete [contained in the LAT Contamination Control Plan (LAT-MD-00404)].
  - Particle Test Plan (LAT-TD-00440) draft complete.
  - Airplane Cosmic Ray End-to-End Test Plan (LAT-TD-00550) draft complete. Under review.
- Test support equipment (EM1 EGSE Release 1) has been delivered to subsystems.

Some Items for This Week

- Along with the work in the science groups, would like to see progress on these items:
  - onboard science (bursts, AGN flare detections) algorithm concepts. see Jay's talk from yesterday.
  - quicklook ground-based analysis concepts. Opportunities for AGN flare detection:
    - ~minutes to hours: onboard
    - ~day: ground-based **quicklook** analysis can run along with daily LAT data processing. Methods, criteria, and alerting mechanisms all TBD.
    - >day (or weak): ground-based full analysis
  - operations during intense solar flares
  - data analysis platform(s)

Summary

- PDR/Baseline hurdles behind us. (CDR is directly in front of us.)
- Great progress on all fronts, due to hard work by many people across institutions/countries:
  - **subsystems working on their Engineering Models and CDRs; planning for flight production and testing.**
  - **software tools shaping up well**
- Many technical issues being worked (only some of them mentioned here): TKR bottom tray, ASICs and related electronics issues, CAL photodiodes, alignment, calibration and test plans & procedures, backplane layout and access, backgrounds (see Tune Kamae's talk from yesterday), onboard event filters, test executive,

EM Deliverables to I&T

- **ACD** – none
- **TKR** - one full size mechanical module and a four-tray module fully instrumented (1 with W, 2 No-W and 1 bottom tray) with cables and electronic readout (mini-tower), TKR lift fixture, preliminary functional test scripts
- **CAL** – fully instrumented module, preliminary functional test scripts
- **ELX/I&T** - EGSE – EM1 version
- **ME/I&T** - 1 x 4 support grid
- **SAS/I&T** - GLEAM Monte Carlo, calibration algorithms

EM Delivery Schedule

Subsystem/Hardware	Delivery to I&T (baseline dates)	Delivery back to subsystem
ME – EM/CU Grid	December 2, 2002	Not required
TKR – EM Mechanical Model	December 9, 2002	Not required
TKR – EM live mini-tower	February , 2003 (not in baseline)	Not required
ELX – EGSE Hardware	February 2003	Not required
CAL – EM Calorimeter	April 25, 2003	June 6, 2003

Backup slides

Analysis Group Formed

- Initial purposes and tasks:
  - grow the base of people using the simulation and reconstruction
  - as organized users, important interactions with SAS: quick feedback on functionality, documentation, usability, etc.
  - evaluate, improve, parameterize instrument performance
  - background rejection analysis improvements
  - calibration/verification tasks simulations
  - GLEAM higher-level checkout
  - onboard filtering studies support
  - instrument issues as they arise

- Participation from across LAT team. Meets regularly.
- See http://www-glast.slac.stanford.edu/software/AnaGroup/

Reminder: Burst-related Requirements on LAT

- SRD 17: GRB location accuracy on-board
  - Must specify burst characteristics to set requirement:
    - For burst of <20 sec duration with >100 photons with E>1 GeV
  - Requirement: < 10 arcmin (Goal <3 arcmin)
- SRD 18: GRB notification time to spacecraft
  - Requirement: <5 sec (Goal <2 sec)
- SRD 14: Instrument time accuracy (relative to s/c time)
  - Requirement: <10 μs (Goal < 2 μs)
- SRD 16: Dead time
  - Requirement: <100 μs/event (Goal < 20 μs/event)

we could do better – the requirements set the minimum performance

On-board Longer-Timescale (AGN Flare) Detection

- Background rate after basic selections on-board <30 Hz. Additional rudimentary selections possible and necessary to improve signal:background.
- Current LAT PS Goals for AGN flare detection:

  AGN Location Accuracy On-Board

  The goal is to achieve AGN location accuracy on-board of better than 2 degrees (68% confidence radius) for transients occurring within the LAT FOV, for flares at high galactic latitude with change in flux greater than 2×10^{-6} ph cm^{-2} s^{-1} (E>100 MeV) for more than 1000 seconds.

  AGN Notification Time to Spacecraft

  The goal is to achieve AGN notification time of less than 1 minute after recognition for transients occurring within the LAT FOV, and flares at high galactic latitude with change in flux greater than 2×10^{-6} ph cm^{-2} s^{-1} (E>100 MeV) for more than 1000 seconds.

these goals are not easy to meet