GLAST LAT Tracker Anomaly Resolution Team
August 18, 2004
Investigation Outline

1. Charge to the Team

To: Neil Johnson
From: Peter Michelson, GLAST/LAT Principal Investigator
Lowell Klaisner, GLAST/LAT Project Manager
Subject: Tracker Anomaly Resolution Team
Date: August 13, 2004

The tracker subsystem has experienced an anomaly during thermal vacuum testing of trays. The bias circuit delaminates from the tray at temperature under vacuum.

Thank you for agreeing to lead a team to resolve this anomaly. In executing this task:

1. Form a small team of experts from within the tracker organization in Italy and the US supplemented by experts outside of the tracker group.
2. Identify the root cause of the anomaly.
3. Propose a plan to resolve the anomaly, qualify the solution, and restart manufacturing in Italy.
4. This plan will be reviewed by Robert Johnson, Ronaldo Bellazzini and Persis Drell. They will vet this plan and recommend action to the LAT Project Manager.

The team will travel to Italy to work closely with the INFN Tracker staff and their subcontractors. The timeline is for the team to be in Italy before the end of August and have the plan to the Project Manager before September 10, 2004.

2. Anomaly Resolution Team Membership

W. Neil Johnson (chair)	NRL	202.767.6817	neil.johnson@nrl.navy.mil
Ben Rodini	Swales Aerospace	301.902.xxxx	brodini@swales.com
Alessandro Brez	INFN Pisa		alessandro.brez@pi.infn.it
Riccardo Bagagli	INFN Pisa		riccardo.bagagli@pi.infn.it
Jari Drlik	Lockheed Martin	408.756.4173	jari.drlik@lmco.com
Robert Johnson (consultant)	UC Santa Cruz	831.459.2125	rjohnson@scipp.ucsc.edu

3. Supporting Tracker Documentation

The Tracker subsystem documentation can be found at its website home page:
http://www-glast.slac.stanford.edu/Tracker-Hardware

Tracker management has created a link off of this home page for the anomaly investigation with much of the documentation relevant to the bonding anomalies and a few supporting design and analysis reports. The Tiger Team website URL is http://www-glast.slac.stanford.edu/Tracker-Hardware/TigerTeam/TigerTeam.htm.

4. Investigation Outline

The proposed plan consists of

1. Understand the design details and development process and identify key requirements that drive the design – eg. Required temperature range, number of thermal cycles
2. Understand the design test and qualification program. What was learned from early prototypes and what changes have been made to get to flight design? What qualification testing was done at each level?
3. Understand the flight tray manufacturing processes in detail. In this regard I assume we can start with a finished composite structure with face sheets and closeouts attached. Begin at the bonding of the tungsten tiles and follow thru to the completion of the testing after bonding and curing of the bias circuits. If necessary, look also at the bonding of the silicon detectors to the bias circuit.
4. Identify potential issues with the current manufacturing processes and discuss improvements. Develop a list of recommendations and create an action plan in concert with the tracker team and LAT management.
5. Create report and deliver to Peter Michelson and Lowell Klaisner.

The investigation will include a visit to INFN laboratory in Pisa and the manufacturing facility of their contractor, Plyform. To make this visit as productive as possible, I would like to identify critical issues and questions to be presented to the tracker team before the visit. The tracker team in Italy has agreed to provide detailed descriptions of the processes. Due to holidays in Italy, these will not be available until about Aug 25th.

In the sections below I am trying to capture issues and questions to the tracker team. I will update this with input from team members – either the anomaly team or the tracker team.

4.1 Design and Development

4.1.1 Requirements – Environmental

Qualification temperature range?

Number of thermal cycles?
Vacuum issues, if any?

4.1.2 Materials

Composite tray
Tungsten
Bias Circuit – Kapton, Copper
Epoxies

4.1.3 Design margins

There are at least three bonds that are of interest

1. Bonding of tungsten to composite tray
2. Bonding of bias circuit to tungsten
3. Bonding of bias circuit to composite tray

The issues that need to be addressed here include the bonding material properties, bond line thickness requirements and the stresses on the joints from CTE mismatch or other factors.

What are the stresses associated with each bond from CTE mismatch as a function of bondline thickness? I believe the qual temp range is -30C to +55C. This should be checked. I've also been told the the bias circuit to tungsten bond line is around 50 – 100 um thick.

What is the thickness of the bond lines and what variation is seen? How is it controlled?

Since the tungsten is tiled in a 4 x 4 pattern, how big are the gaps and how are they filled? Is filling these gaps important?

What are the planarity requirements? How are they controlled?

4.1.3.1 Bond line thickness

4.1.3.2 Stresses

4.1.3.3 Flatness

4.2 Qualification Program

A brief understanding of the development of the design and how it evolved into the flight design and manufacturing process. The emphasis is on what design components were verified with each prototype and how/why the design evolved.

Issues:

What thermal cycling (temp range and number of cycles) were performed on prototypes or EM to qualify design?

I have heard that bias circuit design changed during the development – how and why?

I understand that bubbles have always been a problem in bonding bias circuit to tray. Is the problem the same for the side with tungsten as the side bonded directly to the composite face plate?

What are the requirements relative to bubbles? None? Are bubbles and the "wave" delamination thought to be manifestations of the same problem?

4.2.1 Prototypes and Testing

4.2.2 Engineering Model Testing

4.2.3 Flight Model Design Changes

4.2.4 Chronology of Design Evolution and Problems

4.2.4.1 Bubbles

4.2.4.2 Delamination "Waves"

4.2.4.3 Delamination "Blisters"

4.2.4.4 Incomplete curing

4.3 Flight Manufacturing Process

Process flow from preparing to bond Tungsten to a composite tray thru the completion of bonding and curing the bias circuits to both faces of the tray.
What is the sequence of steps? What is the timeline? How are the components handled and/or stored between steps?

Process issues to be addressed:
Facility:

- Contaminants? Silicones are bad
- Humidity Control?
- Mold release agents in general area?

Material Control:

- What cleaning is done with what solvents? What gloves and wipes?
- What bags are used for storage and transportation? Mold release contamination issue.
- Adhesive preparation. Accuracy of mix ratio? Witness samples from each batch? Out gassing process? Pot life monitoring?
- Adhesive application. Material of containers? Material of rollers or applicators? Is adhesive applied to both surfaces to be bonded?

4.3.1 Tungsten bonding

How is the tungsten roughened? Cleaned after roughening? Stored during transportation?

Have you done a water break test on a tile before bonding to verify cleanliness?

How do you provide an electrical ground of the tungsten tile to the composite tray? (This may be a new issue/requirement.)

4.3.1.1 Preparation

4.3.1.2 Cleaning / Storage

4.3.1.3 Bonding Material

4.3.1.4 Process

4.3.2 Bias Circuit Bonding – Both sides of tray

How is the kapton of the bias circuit roughened?

What is the bake out of the bias circuit to remove moisture?

How is the bond line thickness controlled?

How do you check for and remove voids or bubbles?

How do you control flatness and/or achieve uniform bond thickness?

What is the curing process? Temperature – vacuum profile? Limitations?

What bond strengths are you achieving in test samples? Are they consistent with the literature and requirements from stress analysis?

What other adhesives have been considered? Issues relating to primer use?

What are the issues relative to use of sheet adhesive?

4.3.2.1 Preparation

4.3.2.2 Cleaning / Storage

4.3.2.3 Bonding Material

4.3.2.4 Process

5. Findings

To be entered

6. Recommendations

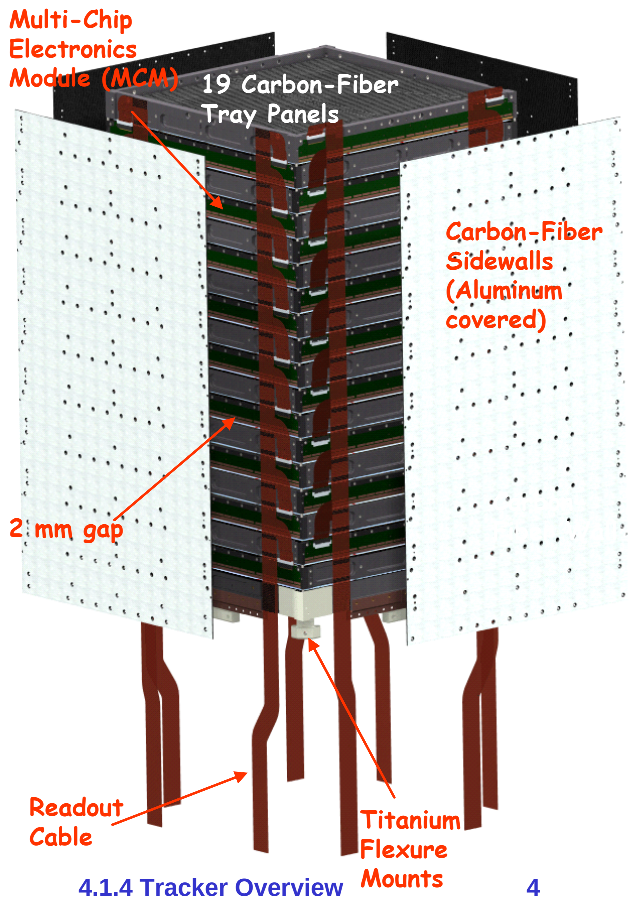
To be entered.

Appendix - Tracker Overview

The following slides, taken from Robert Johnson's LAT Critical Design Review presentation provide an overview of the Tracker subsystem. The subsystem consists of 16 identical Towers. A tower consists of 18 trays of various configurations.

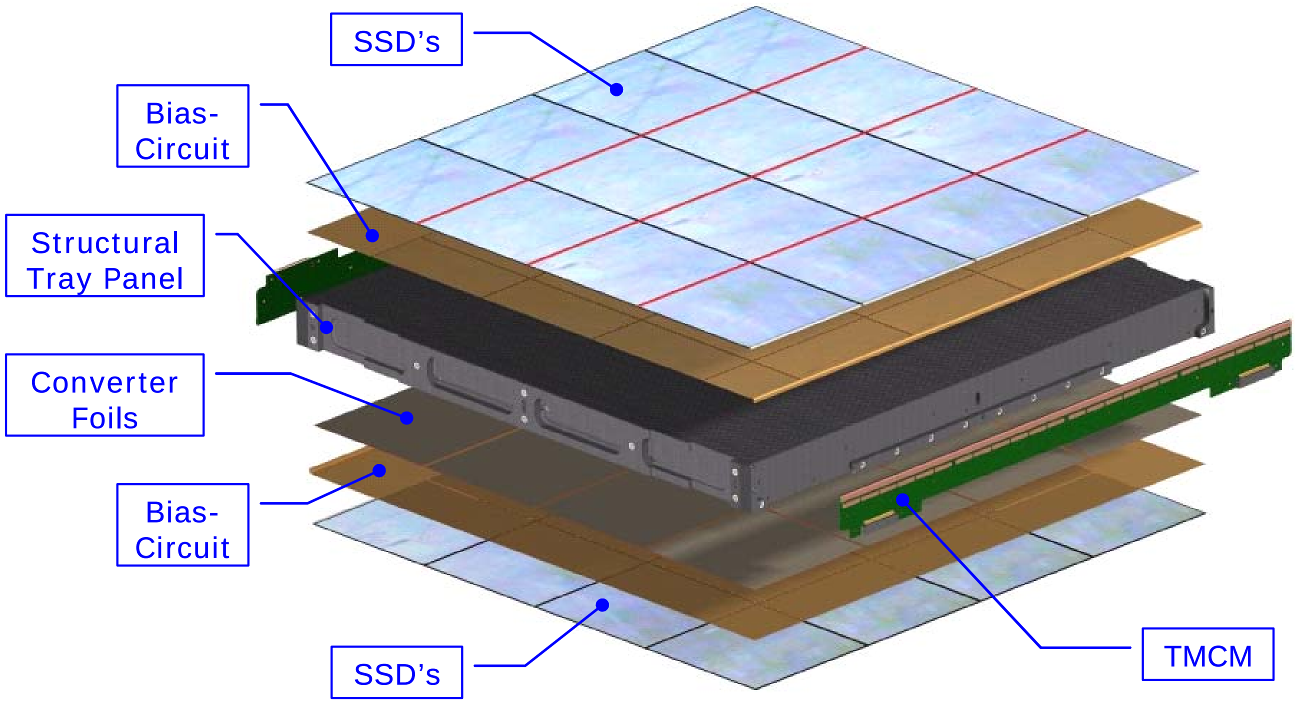
Tracker Design Overview

- Stiff composite panels (>500 Hz)
  - Allows small gap between x-y SSD layers
- Tungsten foils on panel bottom
- SSDs on top & bottom faces
- Electronics on panel edges
  - Minimizes the gap between towers (1.59 cm Si to Si)
- Carbon-fiber walls for vertical support
  - Very stiff box structure
  - Passive cooling to tower base
- Flexure attachment to Grid
  - Decouple from thermal expansion
  - Lowest frequency >150 Hz
  - Greatly reinforced attachment to the bottom tray.
  - Thermal straps couple sidewalls to the Grid (not shown)



Tracker Tray with Payload

- The tray "payload" is bonded to the sandwich structure using epoxy, with the exception of the SSD bonding, which is done with silicone.
  - Silicone decouples the thermal/mechanical effects from the tray



Tray Sandwich Structure

- Lightweight 4 piece machined closeout frame, bonded to face sheets and core to form a sandwich structure