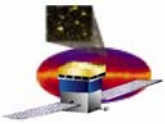


GLAST Large Area Telescope: Tracker Subsystem WBS 4.1.4

Robert P. Johnson
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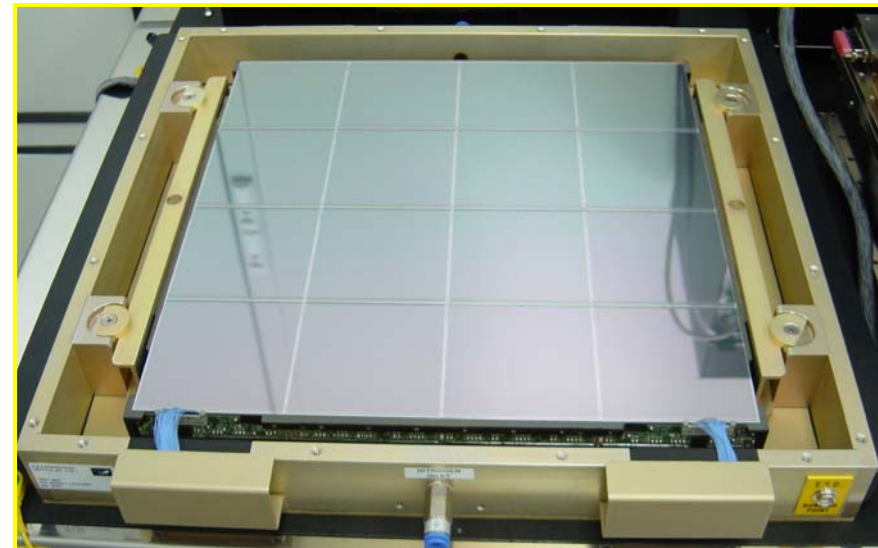
rjohnson@scipp.ucsc.edu
831-459-2125



July Progress

- **Integration of MCMs and Ladders onto Trays**

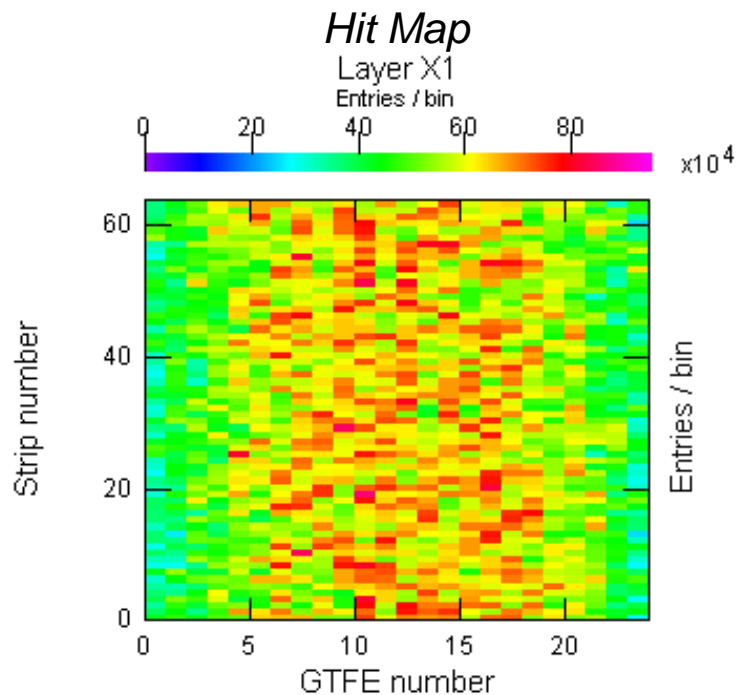
- G&A completed development of the tooling and processes for mounting MCMs onto trays, including alignment, bonding, wire bonding, and encapsulation.
- Two flight trays were completely assembled and tested, including thermal-vacuum at 50C and thermal cycles in air from -30C to $+50\text{C}$.
 - Only 5 out of >6000 channels were lost in the process, and the reasons for those losses were understood and the process corrected.
 - 2 of those channels were lost before encapsulation and subsequently reworked and fixed.
- (These are the only two trays with MCMs not reworked with 75-ohm clock termination resistors.)



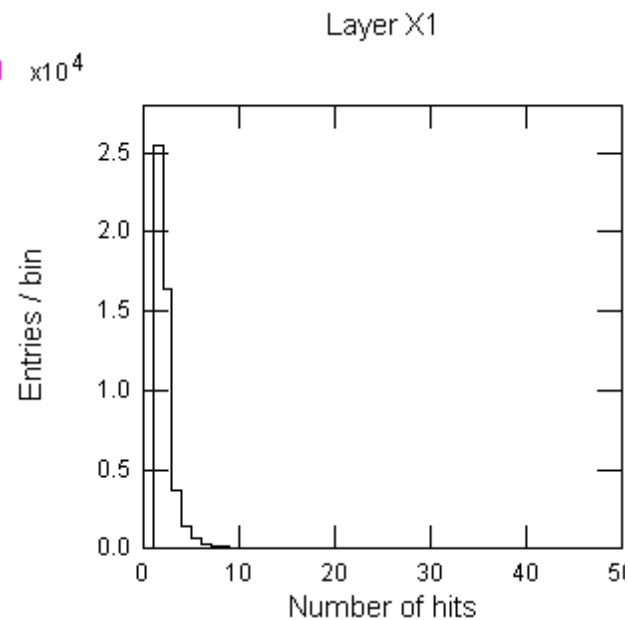


July Progress

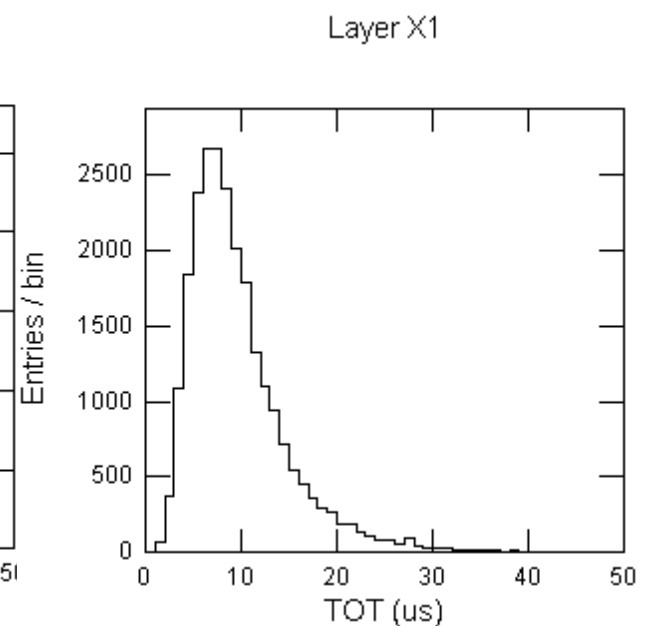
- **Stacked tray testing of the first 2 trays (4 layers of silicon)**
 - Self triggering on cosmic rays
 - Data look very clean, with little noise and few dead channels
- **Example plots from one of the 4 layers:**



Hit Multiplicity



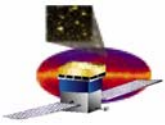
Time Over Threshold





July Progress

- **MCM Production at Teledyne (end-of-July status)**
 - Teledyne had shipped 223 flight units as of July 30.
 - First 6 flight units are still in MRB storage, although 100% functional.
 - 3 units had test issues at SLAC requiring more investigation but are probably okay.
 - 10 units failed environmental and burn-in testing at SLAC and have to be considered non-flight (some are still useful for EGSE purposes).
 - This leave 204 flight MCMs available (>5 towers), of which
 - 131 have been burned-in (behind schedule because of the rework). 25(+2) more are in the thermal chamber now.
 - 96 have been reworked.
 - More than enough MCMs with reworked clock termination are in Italy to equip all of Tower A.

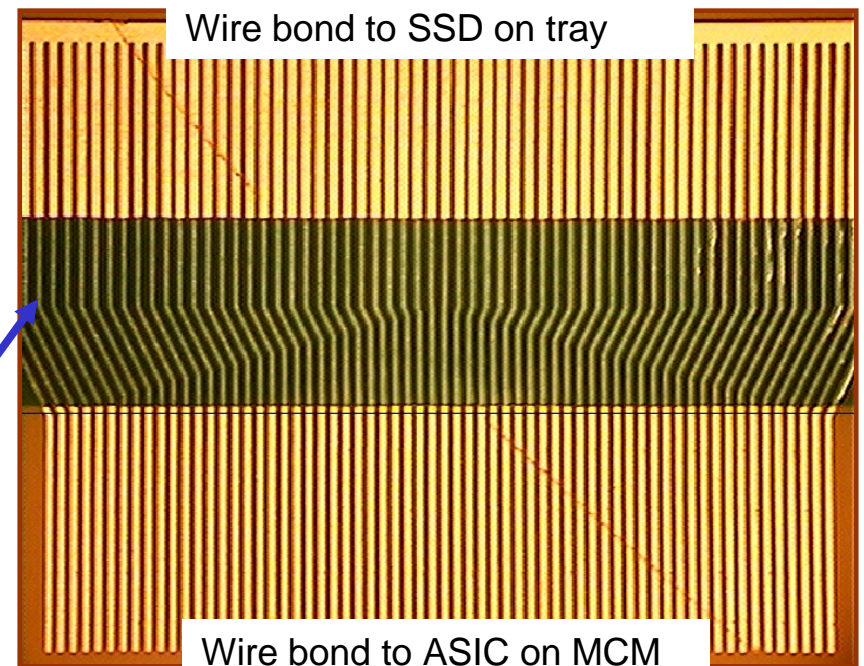


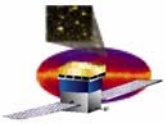
July Progress

- Procurement of new pitch adapters
 - Needed to avoid low yield in pitch-adapter bonding at Teledyne due to cracking of traces in the bend region.
 - Procurement was delayed in purchasing and at Parlex, making the schedule now critical with respect to keeping production at Teledyne going.
 - Finally, in the last week of July we had >25 circuits in hand and inspected, and Teledyne is starting the qualification testing this week.

Example of a new pitch adapter (photo, courtesy of QA, taken because of the scratch).

Bend region, covered with solder mask, with no nickel and gold plating.





July Progress

- **Tray Panel Fabrication**

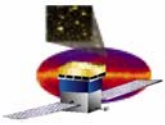
- Some weeks were lost due to problems with bonding the Kapton bias circuit to the tungsten converter foils, but Plyform and G&A are working overtime and delaying vacations to complete Tower-A trays.
- By the end of July all Tower-A bare panels were fabricated and ESPI tested, including the top and bottom tray panels.
- Also, all but the top tray had tungsten and bias circuits bonded, although 2 needed the bias circuits reworked.
- By the end of this week all Tower-A panels should be completely assembled and vibration tested, with completion of thermal-vacuum testing over the weekend.

- **Ladder Assembly**

- 1198 good ladders are assembled.
- This is enough for >8 towers.

- **Sidewall Fabrication**

- The Tower-A sidewalls have been fabricated.
- Coupons are made and under test.



July Progress

- **Tower Alignment**
 - The alignment procedure was successfully executed on the tower mockup in Pisa using the INFN CMM.
 - Experimentation showed that the eccentric cones can be accurately positioned without difficulty.
- **Tower Assembly**
 - Work continued on detailing the assembly and test procedures and developing the test scripts.
 - INFN fabricated the tower inversion fixture and is making preparations to test it and proof load it.
- **Cables and Corner Brackets**
 - The last Tracker flight hardware design, the cable-restraining corner brackets, was completed, and the parts are in fab.
 - Two sets of flight flex-circuit cables are in hand, and the remainder are scheduled (another set arriving this week).
- **GSE**
 - Lots of work and progress on GSE. See the following chart.



Status of Parts & Materials from SLAC

Item	Status	Issues
MCMs	~40 in Italy and 30 in transit	HV capacitor uncertainty Clock duty factor sensitivity (NCR 107)
Flex-Circuit Cables	Two flight sets are in hand	
Ti Corner Brackets & Flexures	Flight order complete	
Bottom-tray closeouts	Flight order complete	
Interface cones & studs	The Tower-A set is ready and the remainder is in fab	
Hex nut	In hand	
Shims	Enough in hand for Tower A, but working on Ni plating	



Status of Parts & Materials from SLAC

Item	Status	Issues
Cable Tie-Down Brackets	In fabrication	Installation procedure needs quick practice, e.g. on the EM tower
Sidewall Prepreg	Italy purchased enough already for at least 2 or 3 towers. SLAC has a PO for the rest.	
Ti Sidewall washers	Sufficient quantities are in Italy	
Sidewall Fasteners	All are in hand and verified	
Cytec BR-127 Primer	A large quantity was shipped last week and arrived okay	
Bias Circuits	Plenty in Italy for tray mass production to begin	Waiver of coupon via plating thickness



Status of Parts & Materials from SLAC

Item	Status	Issues
Heat straps	Tower A set plus spares are in Italy	
Locktite 401 for heat straps	Being shipped to Italy	
Solithane (for locking screws)	Being shipped to Italy	
Nusil silicone adhesives	Sufficient quantities now in Italy	Need to be notified well in advance if these run low
Aeroglaze paint and primer	Sufficient quantities now in Italy	Need to be notified well in advance if these run low
Honeycomb	In Italy except for the remaining bottom-tray cores (shipping this week)	
Carbon Carbon for Tray Closeouts	Full flight order is in Italy	



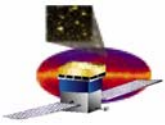
Status of GSE from SLAC

Item	Status	Issues
Vibration Fixture (Grid Simulator)	First deliveries from Humboldt this week, so SLAC-built fixture used for the EM vibe will not be used for Tower A	
Inner Shipping Container	Tower-A container is hand and is being proof tested	
Cable Holding Plate	In hand and being proof tested this week	
Static Test Grid Simulator	In Italy, already used for Tower A	
Lifting Fixture	One is in hand and proof tested. 2 more will also be made for use in Italy.	
Outer Shipping Container	Drawings and specs for a new container are being signed off and are nearly ready for procurement	Tight schedule. Existing container can be used but is too tall and lacks tie-down features



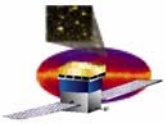
Status of GSE from SLAC

Item	Status	Issues
Cable Bending Tool	Second try at a first article is ready this week	Cable assembly needs to be tested quickly on a mockup, in work at SLAC
Tools for Cone Alignment and Extraction	Enough tools are in hand for Tower A assembly in Italy	
EGSE Sets	4 sets are in Italy. One more for T/V testing is under test at SLAC prior to shipping.	
Long EGSE Cables for T/V Test	1 set delivered to Italy. 2 more are in work	
C0 Cables for Stacked Tray Tests	Enough in hand for Tower A	Need to equip 3 more test sets in Italy with a less expensive version, in work
Breakout Boxes for Tray Testing	2 are in Italy	



Flight Hardware Drawings Status

- **Top/Bottom Tray Panels (including flexures)**
 - All drawings complete and released.
- **Interface Hardware**
 - All complete and released.
- **Mid Tray Panels**
 - Some rework and improvements of the drawings to reflect as-built condition are still in work.
- **Tray Assembly (Bonding MCMs + Ladders to tray panels)**
 - 5 drawings (tray types) all complete and signed off.
- **Sidewall Drawings**
 - All complete and released.
- **Heat Straps**
 - Complete and released, except that the tie-down bar is being modified to facilitate assembly (simple change)



Flight Hardware Drawings Status

- **Flex-Circuit Cables**
 - All complete and released, but Parlex is working to some redlines that need to go back into the released drafts.
- **Top Mount Cable Retainer and Alignment Hardware**
 - Complete and released.
- **Electronics, including SSDs, Ladders, MCMs, Bias Circuits, ASICs, etc.:**
 - All complete and released.
- **Tower Assembly Drawing**
 - In work at SLAC, with the second iteration out for review.



Tower A Schedule

Below is a rough representation of the detailed schedule that INFN is working to in order to complete Tower A. The pre-ship review will take place the week of September 27.

ID	Task Name	Start	Finish	Duration	Jul 2004				Aug 2004				Sep 2004			
					7/4	7/11	7/18	7/25	8/1	8/8	8/15	8/22	8/29	9/5	9/12	9/19
1	Bare panel fabrication	7/1/2004	7/30/2004	22d	█											
2	Tungster & Kapton bonding	7/15/2004	8/3/2004	14d					█							
3	Vibration and TV testing	7/19/2004	8/6/2004	15d					█							
4	MCM integration	7/21/2004	8/9/2004	14d					█							
5	Ladder integration	7/22/2004	8/10/2004	14d					█							
6	Wire bonding & encapsulation	7/26/2004	8/11/2004	13d					█							
7	Tray functional testing	7/26/2004	8/16/2004	16d					█							
8	Tray thermal cycles	7/30/2004	8/20/2004	16d					█							
9	Stacked tray testing	8/2/2004	8/24/2004	17d					█							
10	Tower assembly	8/26/2004	9/1/2004	5d									█			
11	Tower test and burn-in	9/2/2004	9/3/2004	2d									█			
12	Tower vibration testing	9/6/2004	9/10/2004	5d									█			
13	Tower thermal-vacuum testing	9/13/2004	9/17/2004	5d									█			
14	Tower final test & measurement	9/20/2004	9/24/2004	5d									█			

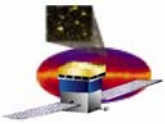


Tracker Schedule

Rough view of the INFN schedule for tower assembly.

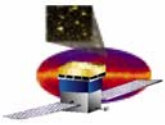
The delivery rate ramps up to 3 towers per month toward the end, which will require production of additional assembly tooling.

ID	Task Name	Start	Finish	Duration	Q3 04			Q4 04			Q1 05			Q2 05		
					Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
1	Tower A	7/1/2004	9/23/2004	61d	█											
2	Tower B	9/1/2004	10/29/2004	43d				█								
3	Tower 1	9/1/2004	11/30/2004	65d				█								
4	Tower 2	10/1/2004	12/31/2004	66d				█								
5	Tower 3	10/1/2004	12/31/2004	66d				█								
6	Tower 4	10/1/2004	1/31/2005	87d				█								
7	Tower 5	11/1/2004	1/31/2005	66d				█								
8	Tower 6	11/1/2004	2/15/2005	77d				█								
9	Tower 7	11/1/2004	2/25/2005	85d				█								
10	Tower 8	12/1/2004	2/25/2005	63d				█								
11	Tower 9	12/1/2004	3/15/2005	75d				█								
12	Tower 10	12/1/2004	3/31/2005	87d				█								
13	Tower 11	1/3/2005	3/31/2005	64d							█					
14	Tower 12	1/3/2005	4/15/2005	75d							█					
15	Tower 13	2/1/2005	4/29/2005	64d							█					
16	Tower 14	2/1/2005	4/29/2005	64d							█					
17	Tower 15	2/1/2005	5/30/2005	85d							█					
18	Tower 16	3/1/2005	5/30/2005	65d										█		



Issues: HV Capacitors

- **Many Novacap HV capacitors fail the mil-spec leakage-current requirement**
 - Testing of this issue should conclude at GSFC in a few days.
 - Tower-A is being built with the Novacap capacitors as-is.
 - Tower-B MCM integration is on hold pending MRB.
 - If we are required to use new Novacap capacitors (in production), then Tower-B and succeeding towers will be delayed by months.
- **Tracker viewpoint:**
 - The magnitude of the leakage current is in itself not an issue (the SSD leakage is much greater, by a factor of 20 or more).
 - The MCM leakage current drops by about a factor of 2 during burn-in.
 - The MCM leakage current does appear to be stable and uniform following burn-in (e.g. throughout the rework and re-test process).
 - We designed-in failure protection by putting 2 capacitors in series in all cases. Each is 250V rated, while we do not use more than 120V total in operation (we test MCMs to 200V).
 - Each series pair is also protected by a series 270k Ω resistor, so a failure of the pair would knock out only a single SSD ladder.
 - No completed MCMs to date have ever had a bias-circuit failure due to failing capacitors.



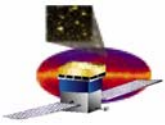
Issues: MCM Test Errors

- **NCR 104 (register readback errors)**
 - All but 4 MCMs will be reworked or built using 75-ohm clock termination resistors. Teledyne started using 75-ohm resistors this week.
 - Up to now this has been a 100% cure, with ~100 MCMs reworked and tested thus far.
- **NCR 107 (strip data read errors)**
 - We lose up to 5% of MCMs from this error when we test at +60C.
 - The symptom is that the data from every other event are corrupted, always for event tags 0 and 2.
 - All MCMs eventually exhibit the same symptom if the frequency is pushed up, the voltage decreased, or the clock duty factor increased.
 - We isolated the error to be internal to the GTRC chip. We believe that one of the two memory buffers is at fault (only the memory access uses both clock edges, and the error always coincides only with event tags 0 and 2, which correspond to one specific hardware buffer).
 - Risk: if the duty factor of the clock in the flight system is much greater than that which we see in the EGSE, this error could occur.
 - Control carefully the clock distribution, or lower the frequency?
 - Use only a single GTRC buffer? What is the deadtime impact?



Issues: Bias-Circuit Bonding

- **Bias Circuit bonding onto tungsten**
 - Vacuum bake at 55C caused some delamination of the Kapton from the tungsten foils.
 - INFN bead blasted all of the foils on both sides, with about a 1-micron roughness. This gave much better uniformity to the bond, with about a factor of 2 increase in peel strength.
 - The Kapton surface preparation was also improved.
 - Small bubbles appear to be impossible to eliminate completely:
 - An NCR is filled out in each case.
 - Generally the bubble is cut with a sharp blade to prevent air pressure from increasing the delamination.
 - Additional thermal-vacuum testing is carried out on the completed tray in these cases, to verify that the bubble does not cause any harm.



PMCS Schedule & Cost Variance

- **June: only a +45k change in schedule variance since May**
- **Cumulative: schedule variance of $-\$659\text{k}$ from $\$13,772\text{k}$ budgeted cost of work scheduled.**
 - Most of the cumulative variance is due to the delays in TMCM production, which started up slowly but in the last couple of months has been going at close to the planned rate.
 - Keep in mind that most of the Tracker assembly work is to be done in Italy and is therefore not tracked by this schedule variance calculation.
- **Cumulative Cost Variance: $-\$216\text{k}$**
 - This improved significantly since last month, largely as a result of approved change requests.
 - A significant set of Tracker budget liens is queued up for CCB action (some today).



Tracker Budget Liens (k\$)

Item	2004	2005	Sum
Add'l Engineering/Design Support	160		160
Aluminum Cores	13		13
Continued TKR Manpower Increase		564	564
Flex Circuit Cables (flight)	498		498
Flex Circuit Cables (non-flight)	47		47
GTFE Chips	50		50
Prepreg from COI	229		229
Shipping Container	25		25
Tracker MGSE	50		50
Tracker-Grid Interface Hardware	248		248
MCM Rework	73		73
Data Entry Support	4	20	24
Procurement Overruns	135		135
TOTAL	1532	584	2116