

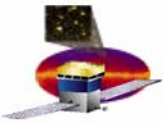
GLAST Large Area Telescope:

Tracker Subsystem WBS 4.1.4

Persis S. Drell
Stanford Linear Accelerator Center
LAT Deputy Project Manager

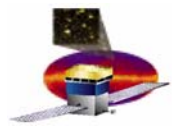
persis@slac.stanford.edu

650-926-8791



Outline

- **Tracker Schedule**
- **Technical Status- last month's accomplishments**
 - **Issues identified and closure plans**
 - **Status of flight hardware**
- **Cost and Schedule Status**



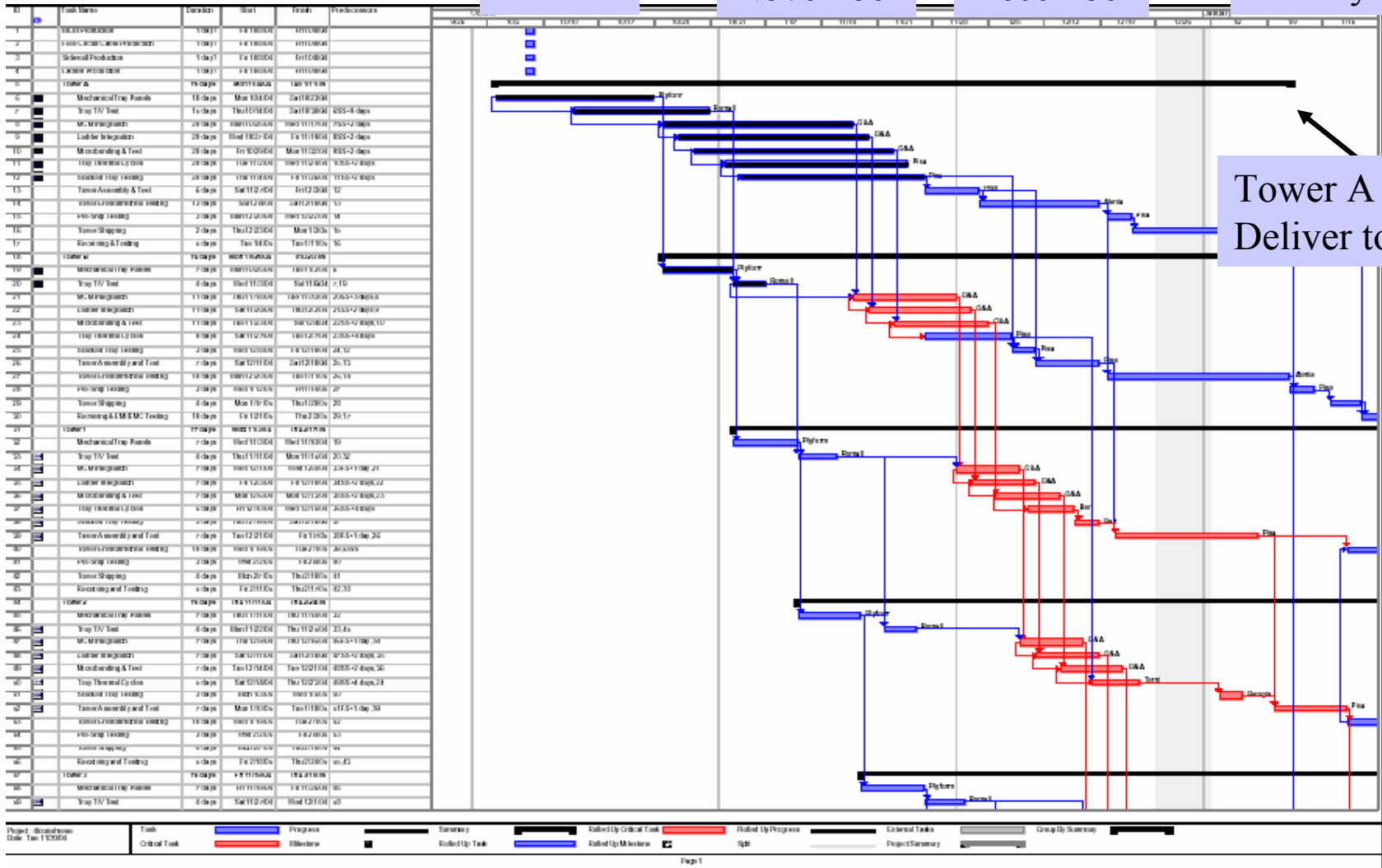
Tracker Fabrication Schedule

October

November

December

January



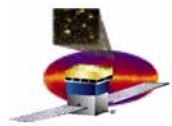
Tower A
Deliver to I&T

Project: Broadband Date: Tue 1/10/05

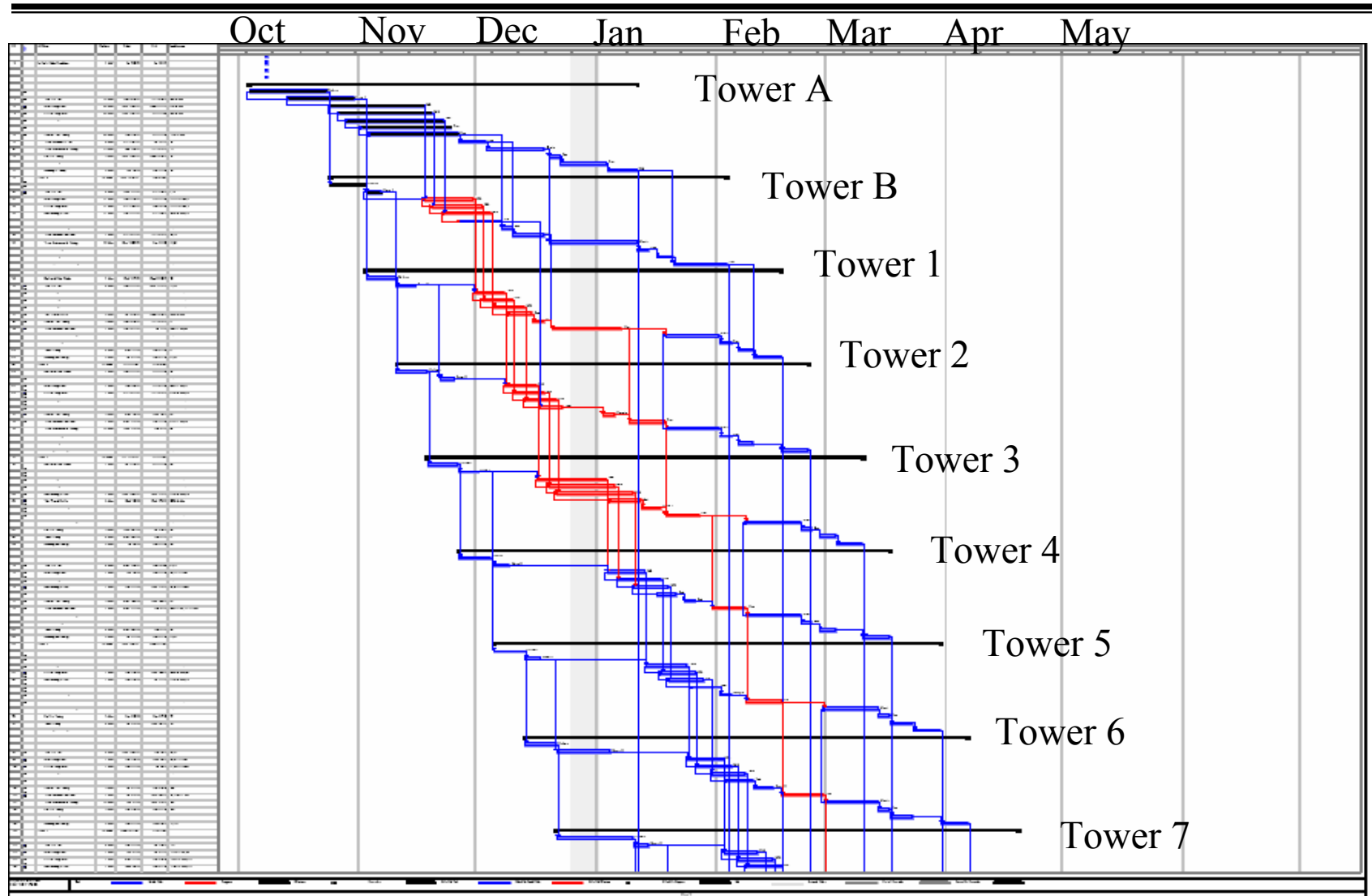
Task: Progress (Blue bar), Critical Task (Red bar), Milestone (Black square)

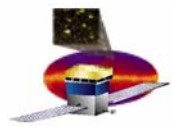
Summary: Rolled Up Critical Task (Black bar), Rolled Up Process (Red bar), Rolled Up Milestone (Black square)

External Tasks: Group Up Summary (Grey bar), Project Summary (Black bar)

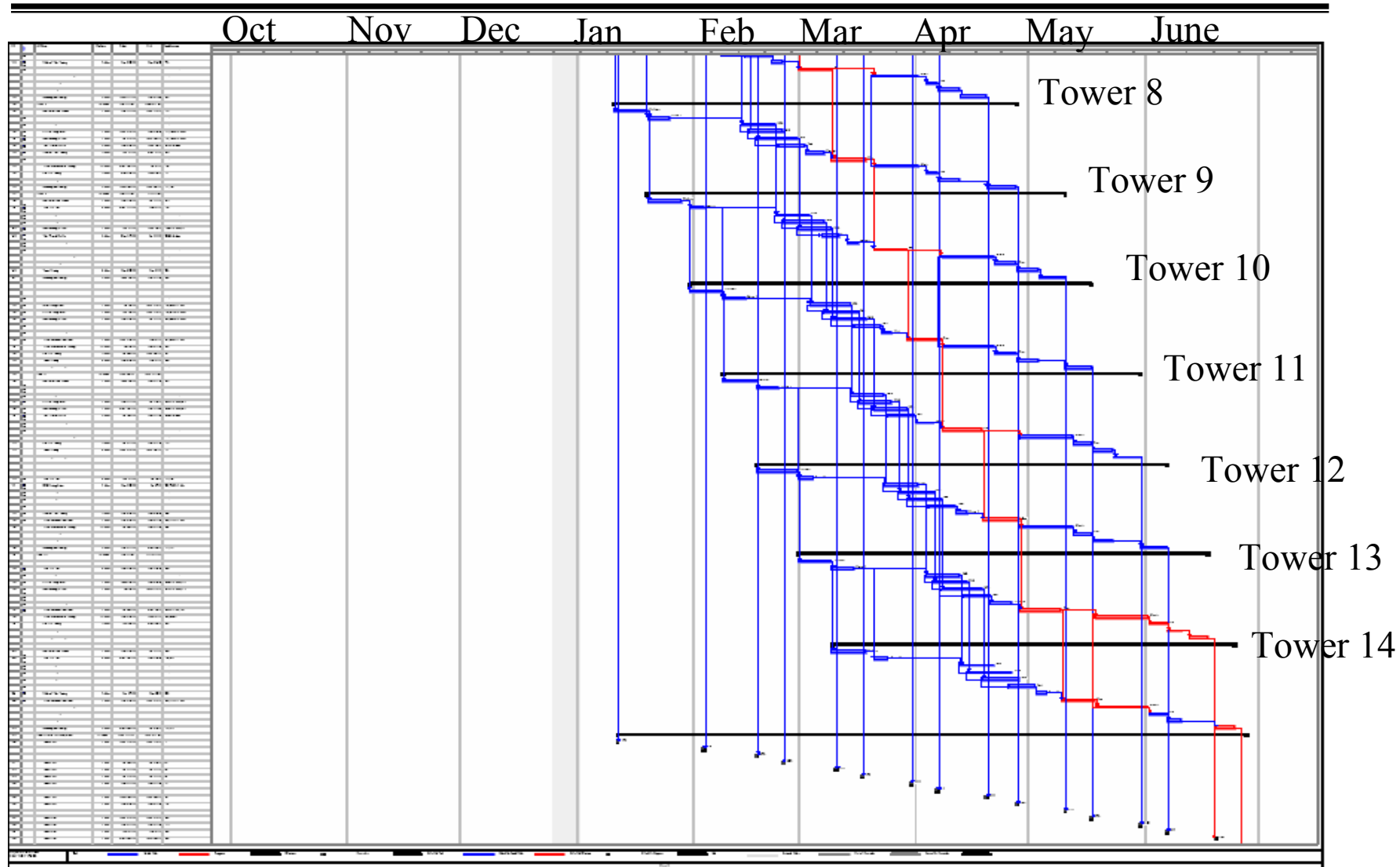


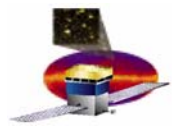
Tracker Fabrication Schedule





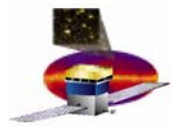
Tracker Fabrication Schedule





Accomplishments and Issues Identified in Tower A Fabrication

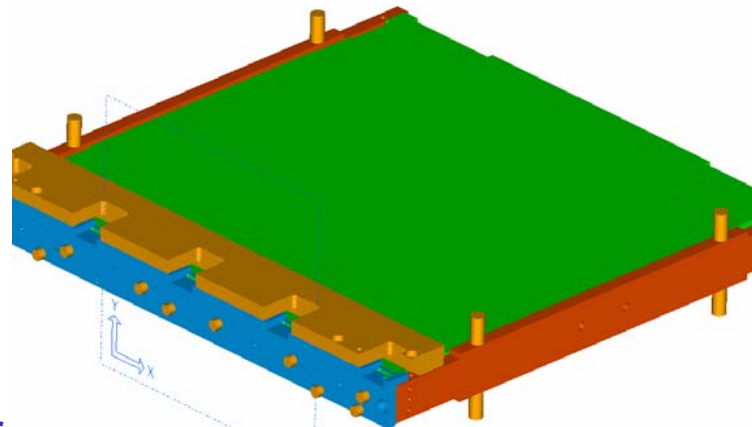
- **Tracker Tray Fabrication**
 - **Flight tray production restarted 10/4/04**
 - **Flight trays for Tower A completed**
 - **Flight trays for Tower B in production**
- **Tower A Assembled and being aligned today**
 - **Environmental Testing on Tower A begins next week**
- **Tray Production Status (Plyform + INFN) as of 11/26/04**
 - **140 bare trays (no converter or bias circuits) produced**
 - **36 trays completed with converter and bias circuit through T/V**
 - **1 failure due to bias circuit delamination early in production**
 - **81 ready for delivery requiring MCM pocket rework**
 - **Trapped air in bias circuit lamination continues to be a problem**



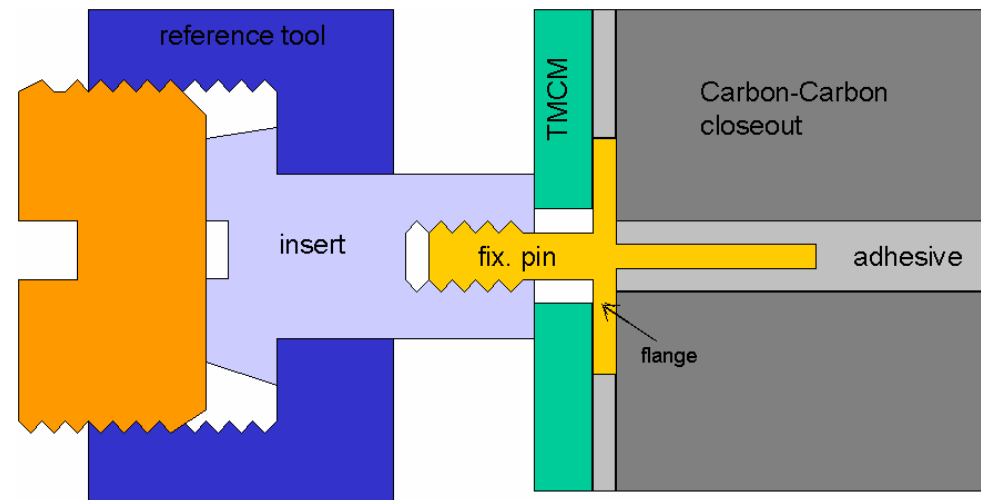
MCM Connector Stick-out and Pocket Rework

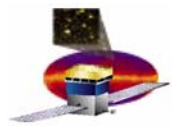
- In Tower 0, identified interference between connector on MCM and sidewall on many trays
 - Tolerance on placement of MCM Connector very tight
 - Critical dependence on:
 - Pocket depth on closeout
 - MCM connector height
 - New MCM bonding procedures finalized to ensure connector stay clear

The tray with the TMCM assembly jig.



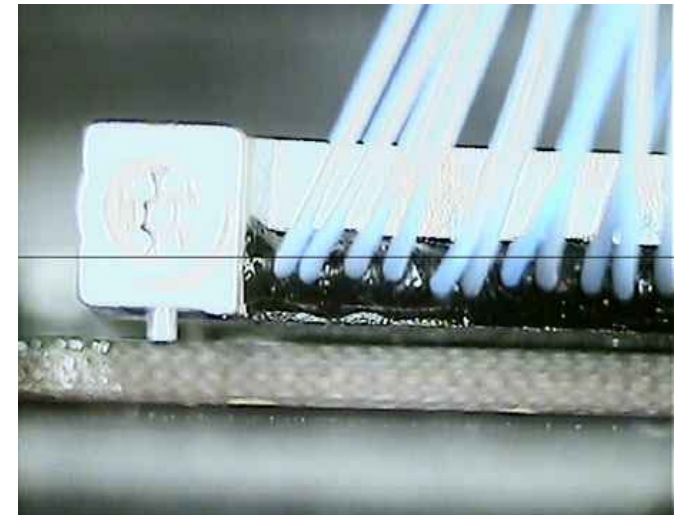
Fixation pin assembly scheme.





MCM Connector Stick Out

- Even with new bonding procedures continued difficulty meeting tolerance
- Root Causes:
 - (1) Most of the MCM connectors are not fully torqued, and some have a visible gap between the connector and PWB.
 - The clearance between MCM and Tracker sidewall is very small, such that we can tolerate only a 100-micron excess in thickness beyond the 3.81mm nominal
 - On most MCMs at SLAC we can turn the screws about $\frac{1}{4}$ turn before reaching 10 inch-oz. This pulls them to within the thickness spec.
 - (2) Pockets on Closeouts too shallow
 - Rework and process change at Plyform
- For the few extreme cases, where the MCM+Connector thickness is greater than 4.0mm, we have not tried to pull it snug, for fear of damaging the connector or solder pins. These will require rework.



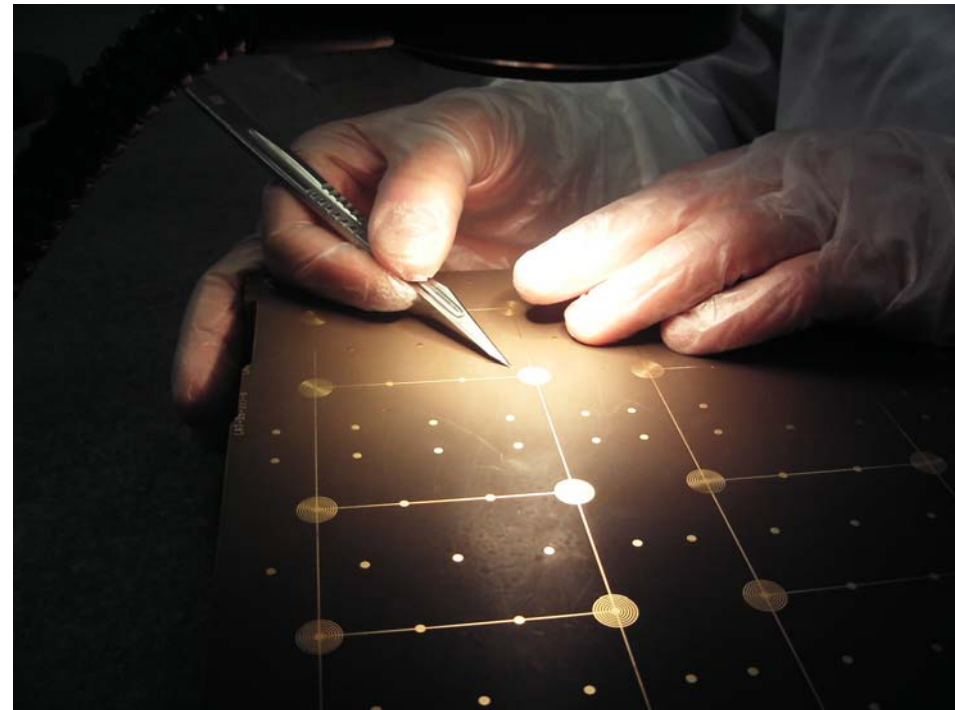
This photo is an extreme example.



Bias Circuit Air Trapping

- **Process of laminating bias circuit traps air**
 - Preferentially at center of tray
 - Process improvements continue
 - MRB 11-12-04
 - Size of bubble limited (< 4 dots)
 - Disposition: For bubbles >~1.8cm
 - Small (<2mm) cut far from bias lines (>1mm) using an edged scalpel
 - Perform Insulation test with an ohm-meter between tray and shield plane
 - Affects ~30% of trays produced so far
 - Recent production shows significant improvement
- Procedure has never resulted in electrical short

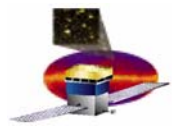
TRAY MAP			
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16





New MCM Issues Identified in Tower A Fabrication

- **343 units delivered to SLAC**
 - through burn in and final test
 - Need 686 for 18 towers + electronics group
 - Production at Teledyne currently stopped
- **MCM Anomalies Found During Tower A Tray Assembly at G&A**
 - Issue (1): Pitch Adaptor delamination from PWB (cannot wire bond in delamination areas)
 - Typically affecting a handful (~20) channels
 - Affecting up to about 20% of boards
 - Issue (2) Missing connections on MCM
 - sometimes resulting in hundreds of missing channels
- **Resolution of Issue 1:**
 - Inspection
 - Rework (successful at G&A)
 - Will do before shipping for existing boards
 - Process improvements at Teledyne



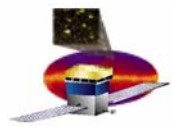
Missing Connections on MCM's

- Issue 2 is a much bigger problem!
 - First identified in tray production at G&A where MCM on tray found to have 300 disconnected channels
 - Visual scan shows no evidence of broken or cracked traces
 - Subsequently found in MCM's at SLAC before shipping using new electrical test fixture
 - Problem affects ~11% of MCM's screened
 - Most in August and September MCM production runs
 - Note this is a *new* issue, distinguished from ongoing 'cracked PA trace' problem which results in ~15% fall out after burn in.
- *All evidence points to wire bonds breaking at Pitch Adaptor to ASIC joint under black encapsulation due to delamination of the encapsulation*

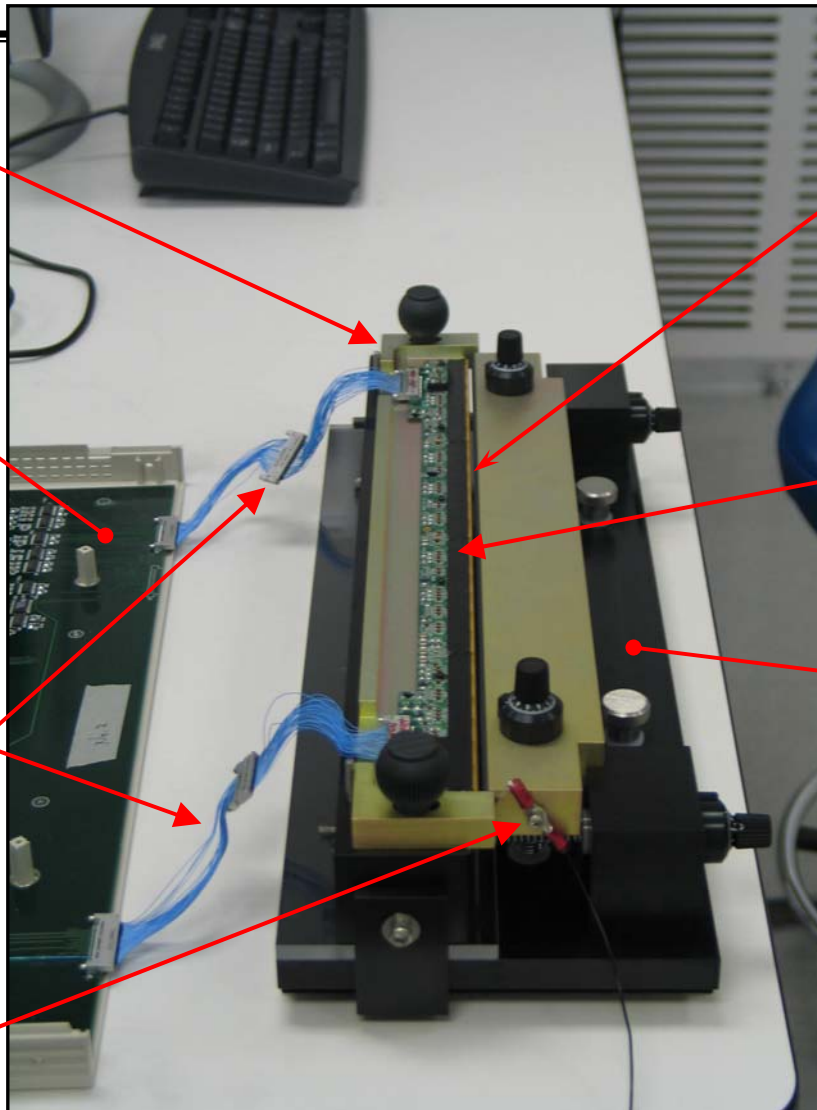


MCM Investigations Helped by New MCM Electrical Test Method

- **Can now electrically test every MCM connection**
 - **Use a conductive, flexible strip (zebra strip) to short circuit 100% of the pitch-adapter traces to ground.**
 - **Run a charge-injection scan and measure the response of each channel.**
 - **Channels with inputs shorted to ground will look dead.**
 - **Channels not connected to the pitch adapter will look alive, unless the amplifier is already dead for some other reason.**
- **So, if a channel measures good in the normal electrical test, with the input floating, AND it measures dead with the zebra strip applied, then we are certain that it is a good, connected channel.**
- **If a channel measures good with the zebra strip applied, then either**
 - **it is disconnected from the pitch adapter, or**
 - **the zebra strip did not make contact with the pitch adapter (false negative).**



Pitch-Adapter Electrical Test Fixture



STORAGE CASE BASE

ZEBRA CONNECTOR

SOFTWARE/
ELECTRICAL FIXTURE

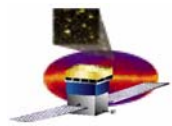
MCM WITH
PITCH ADAPTER

TEST FIXTURE

CONNECTOR SAVER

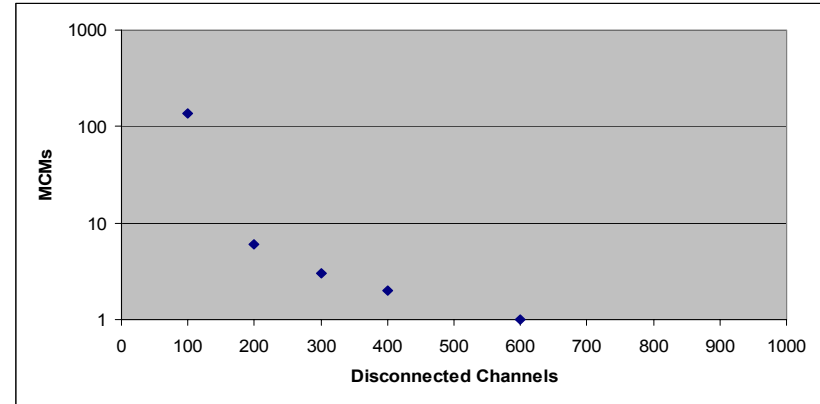
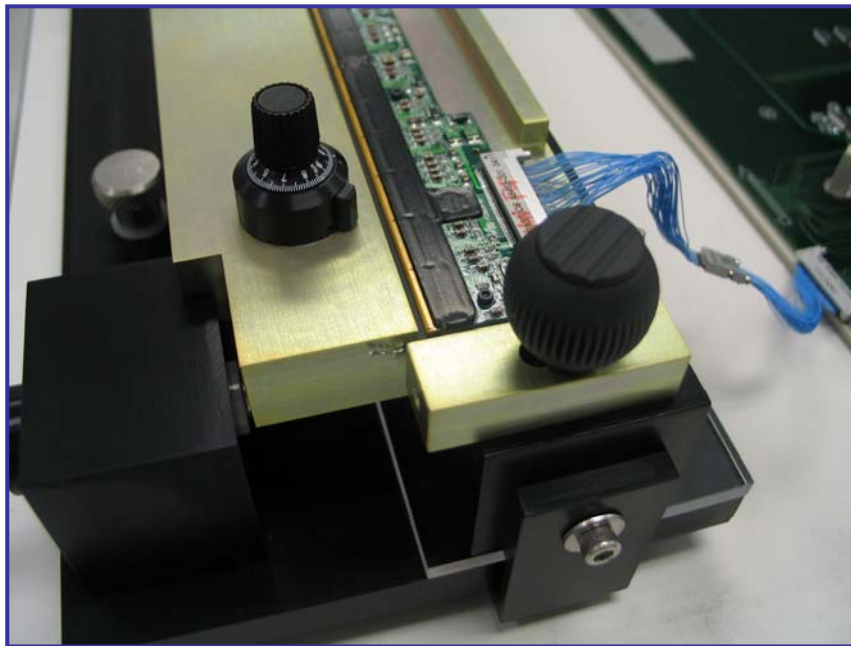
*Provides a quick,
positive test of pitch-
adapter connections
to all 1536 input
channels.*

GROUND LEAD

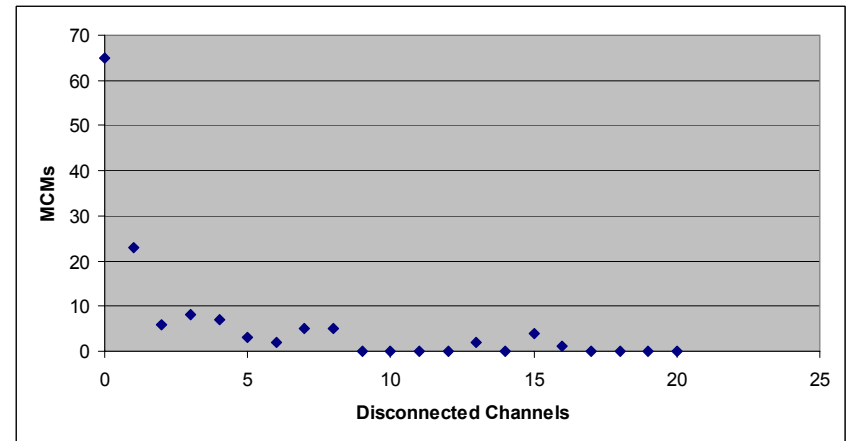


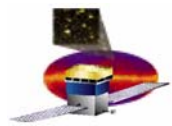
Pitch-Adapter Testing

The new test fixture and software enables us to test 100% of the channels on every MCM very quickly, at a price of only a very few false negative readings.

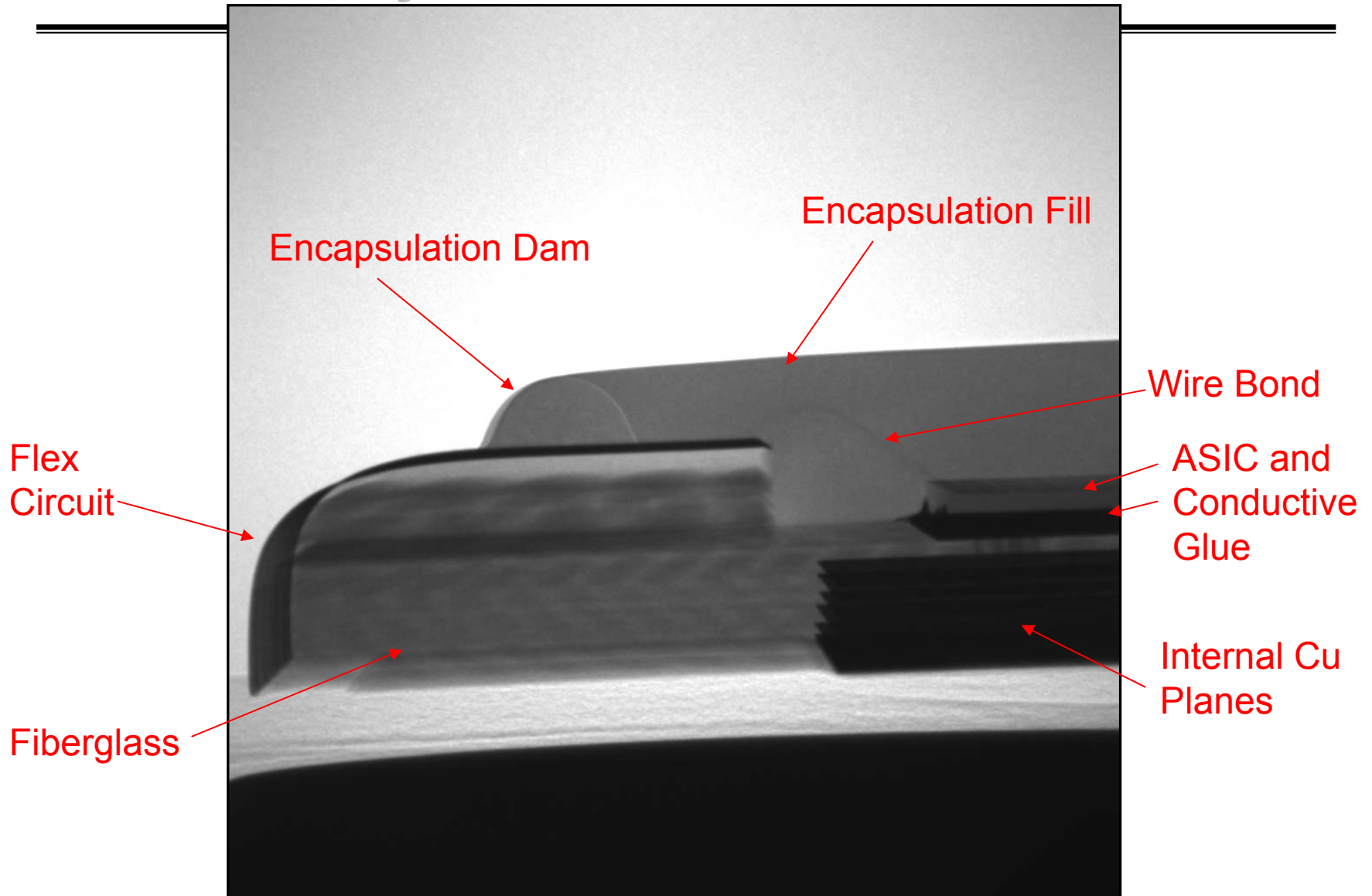


11% of the MCMs have >15 bad connections.
Average number of broken connections/MCM after rejecting those 11% is only 2.





X-Ray Cross Section of an MCM

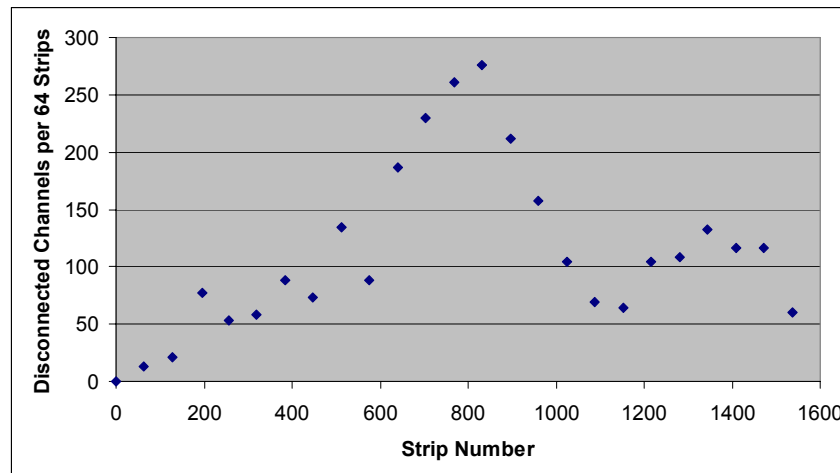


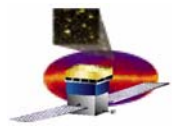


Broken Wire Bonds

- **Observations:**

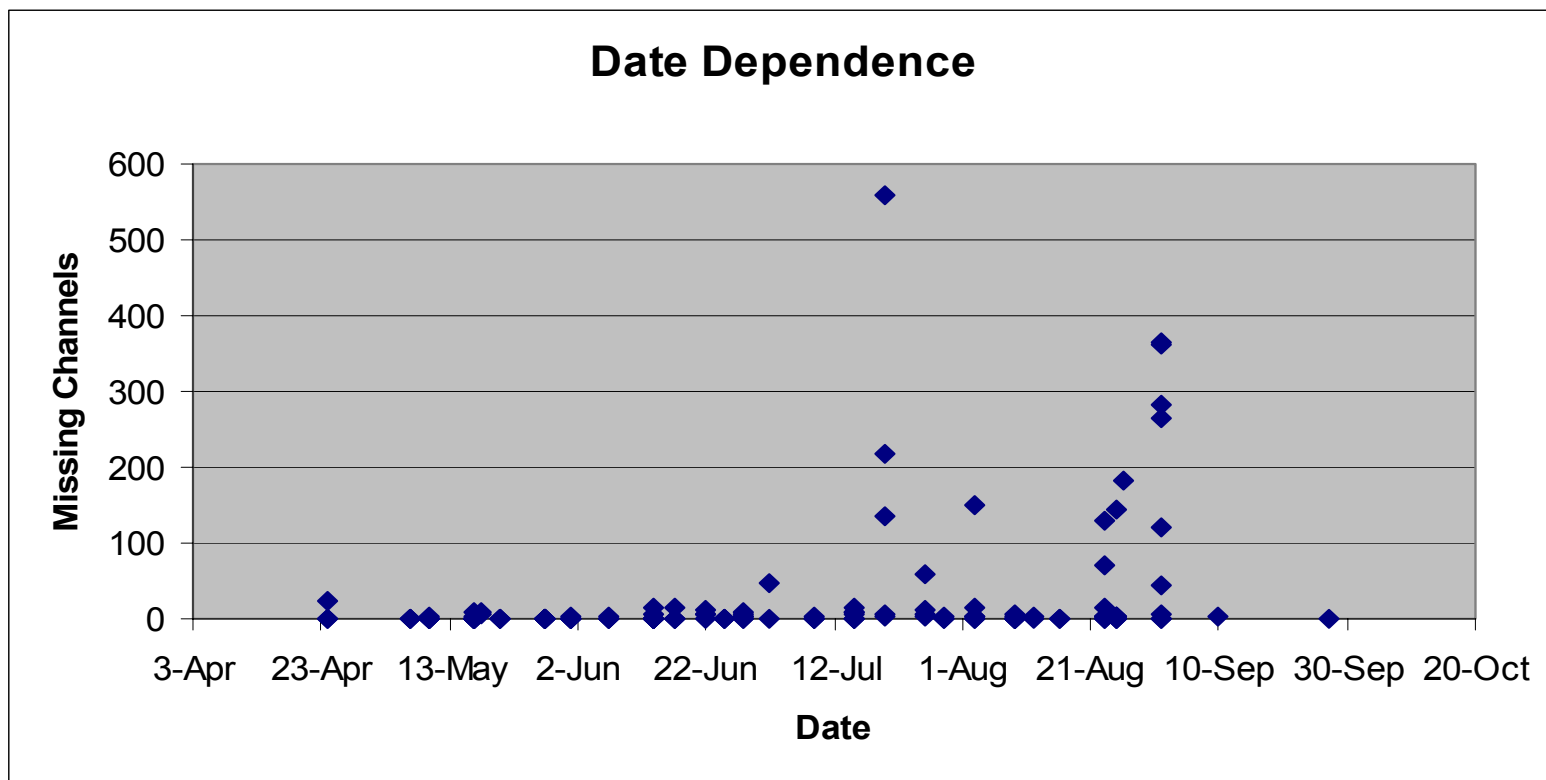
- Open channels can be intermittent and sensitive to pressure indicating that the break occurred after curing of the encapsulation, and the two pieces are still very close to each other.
- We do not see any broken bonds on the PWB side of the ASICs indicating the break is almost certainly at the pitch-adaptor end of the wire bond
- The highest probability of breakage is toward the center of the MCM.

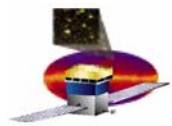




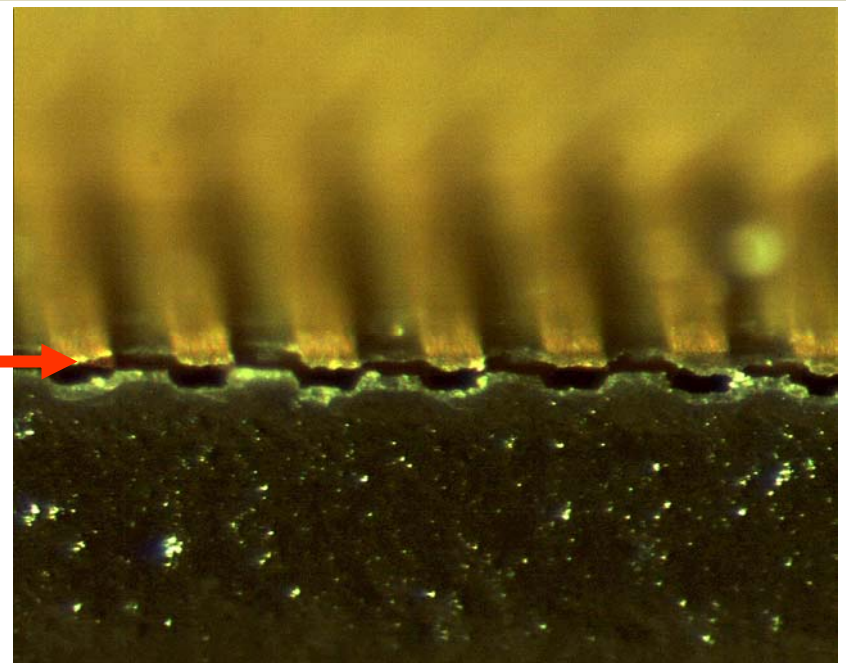
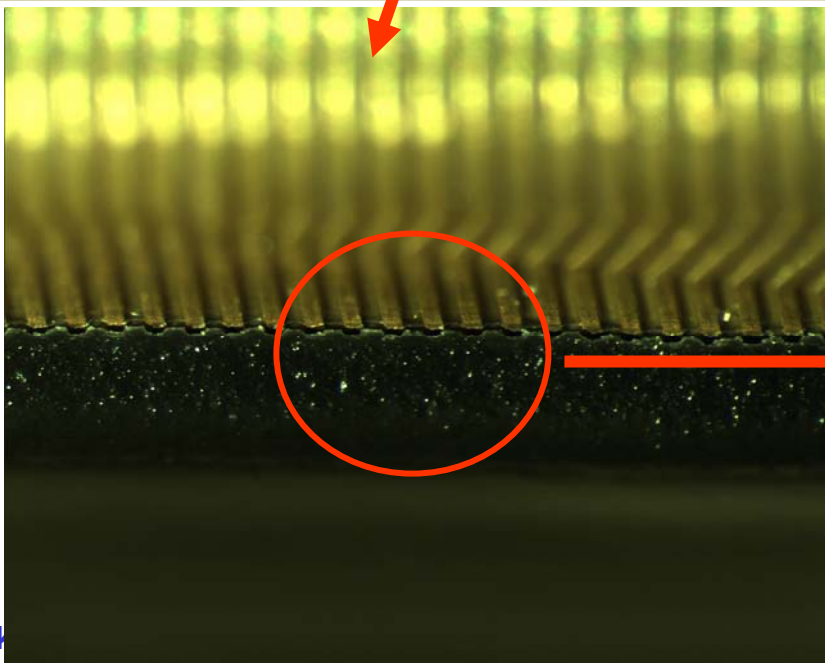
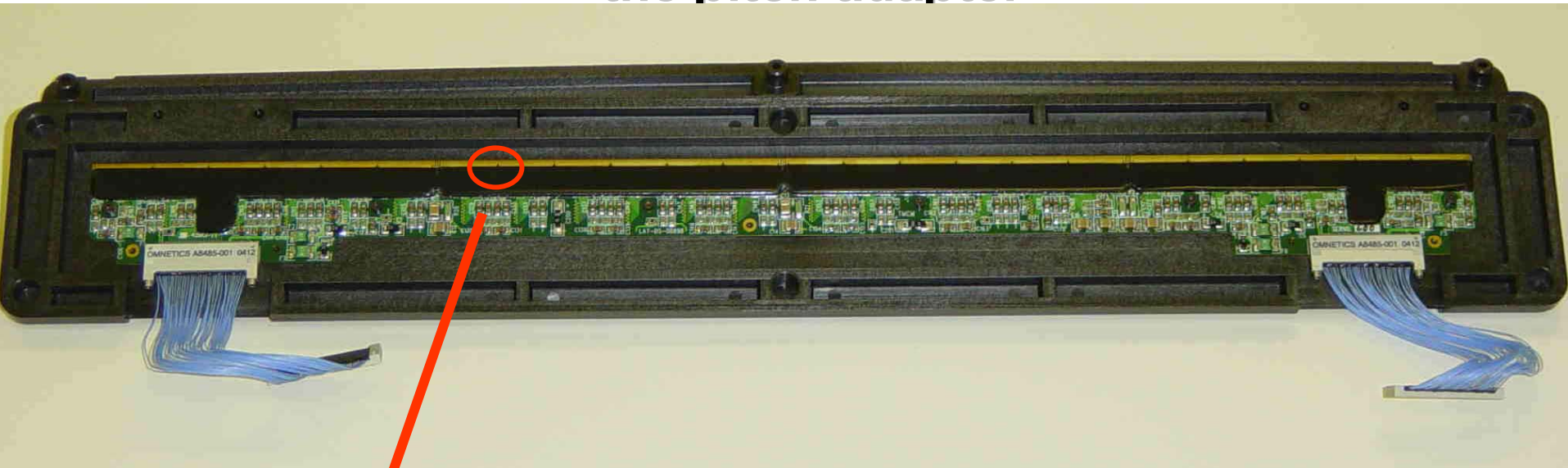
Broken Wire Bond Date Dependence

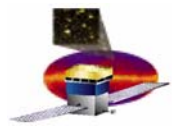
- The problem seems to have started in July and gotten worse in August and September.
- These data are incomplete, however, as we are continuing with testing of the existing MCM stock.





Failure of the wire bonds where they connect to the pitch adapter

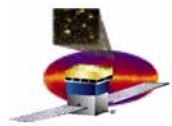




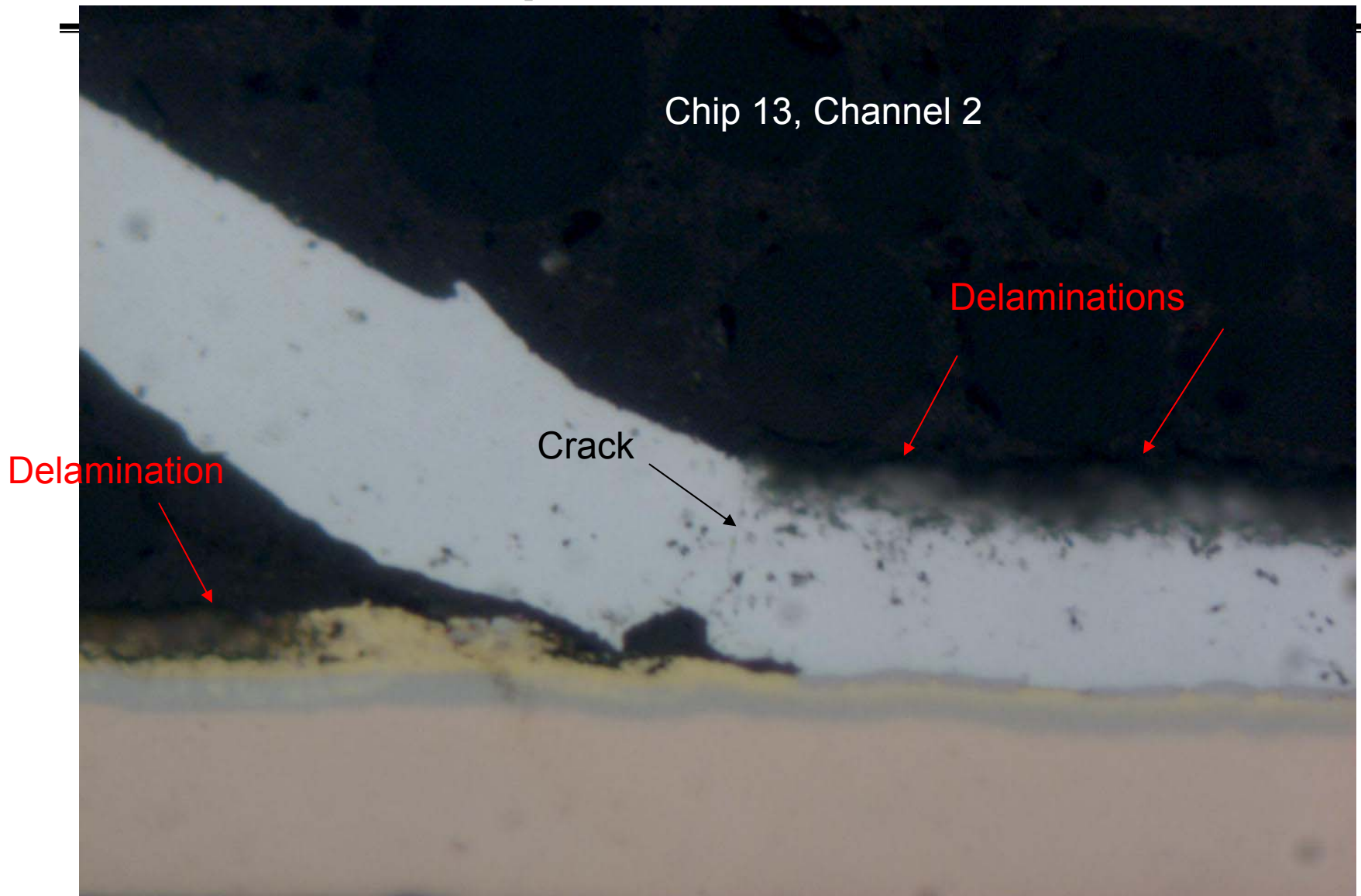
DPA

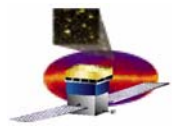
- **Done by Diane Kolos and Bruno Munoz at GSFC.**
- **MCM SN 775, with ~180 missing connections.**
- **Diane sectioned the MCM at the location of a few of the known bad connections.**
- **Bruno x-rayed the MCM.**

- **The results verify that the wire bonds are broken at the pitch-adapter end, at the “ankle”.**
- **The results also indicate debonding of the encapsulant from the substrates in the affected regions.**

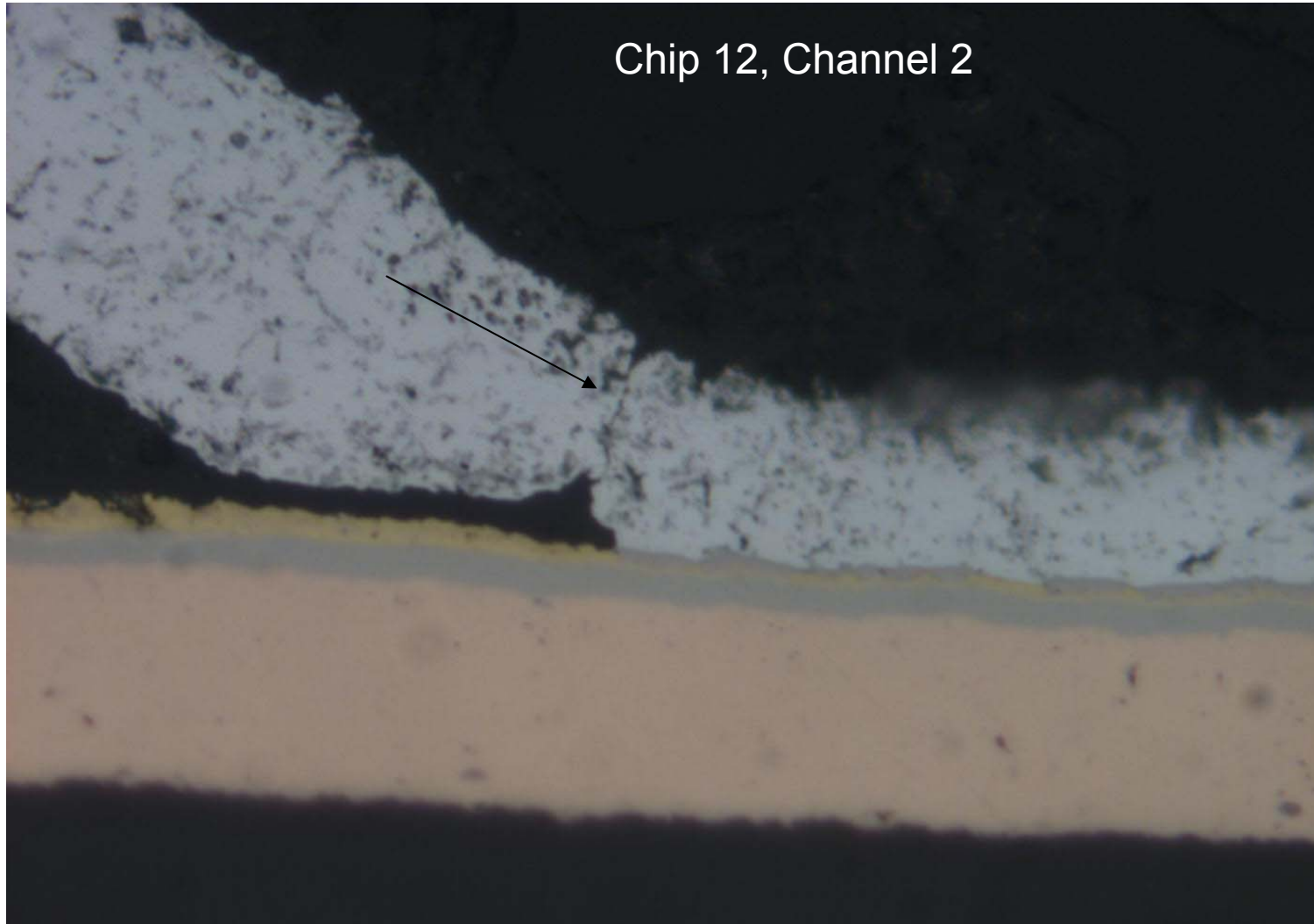


Example Wire Bond Crack





Another Example Crack

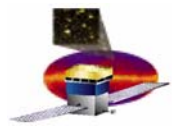


Chip 12, Channel 2



Tentative Conclusions

- **Source of the disconnected channels**
 - **Small numbers are from the cracked traces, verified by visual scans**
 - **Most are from broken wire bonds.**
- **The cause of the broken wire bonds is movement of the encapsulant relative to the pitch adapter.**
 - **This motion would not occur if the encapsulant remained well adhered.**
 - **This problem never occurs on the PWB side of the ASICs.**
- **The root cause of the encapsulation debonding needs to be better understood. Note that it does *not* happen on *all* MCMs.**
 - **Surface contamination?**
 - **Inadequate surface preparation?**
 - **Too much temperature range (+125C cure vs 30C test)?**



Impact on Tower Production

- **Tower A**
 - Two trays in Tower A have large numbers of missing channels (~150 each)
 - “Soft Descope” to keep Tower production on schedule
 - Open NCR
 - MRB Friday 9AM
 - In thermal cycling number of disconnected channels increased ~10%
- **Tower B – Tower 2**
 - Continuing to put MCM’s on trays
 - Additional steps
 - Visual inspection to look for debonding of encapsulant before silicon installed



GSFC Review Team Input

- Review team met at SLAC yesterday
- Briefed on this issues (and cables)
 - Team at Teledyne today
 - Developing plan to mitigate this problem as restart Teledyne production
- Root Cause Must be understood before we can restart MCM production



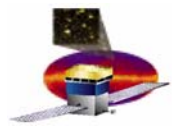
Other Issues Identified in MCM Production

- **Pitch adaptor cracking**
 - Treated as yield problem
 - Alternate designs dropped
 - New electrical test fixture detects broken traces
- **MCM Leakage Current Problem**
 - Short circuits between HV and Bias plane of PWB
 - 10 MCMs from 7 panels clustered tightly in time
 - We rejected all good MCMs from the same panels
 - All shorts occurred either before burn-in or in the first day of the 7-day burn-in, except one case where the short occurred about 2/3 of the way through the burn-in.
 - Root cause appears to be metallic contamination of the prepreg, based on DPA done at GSFC.
- **Data readback errors**
 - Some MCMs are too sensitive to clock duty factor during burn-in
 - Problem mitigated by changing termination resistor on cables
- **MCM Conformal Coating Problems**
 - Issues identified in QA with peeling, contamination and bubbles
 - A full inspection of all units has been completed.
 - MRB 11/3/04
 - Reworks in process



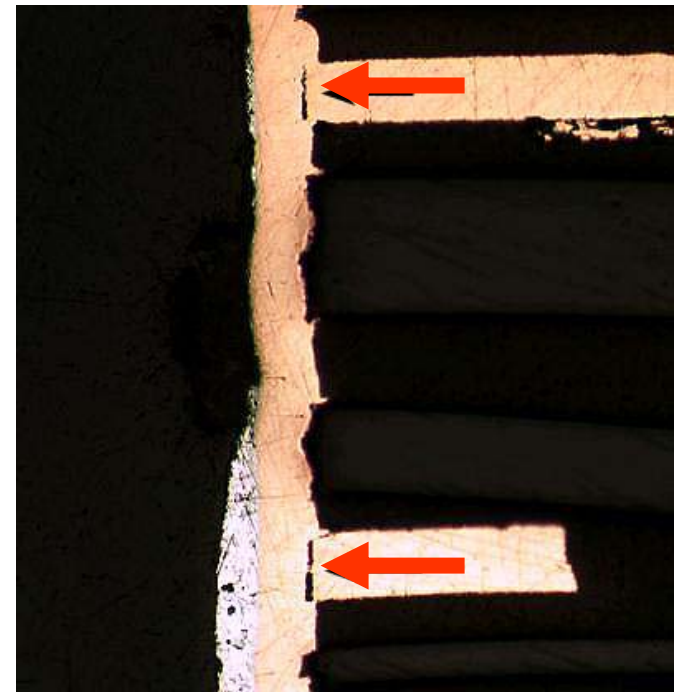
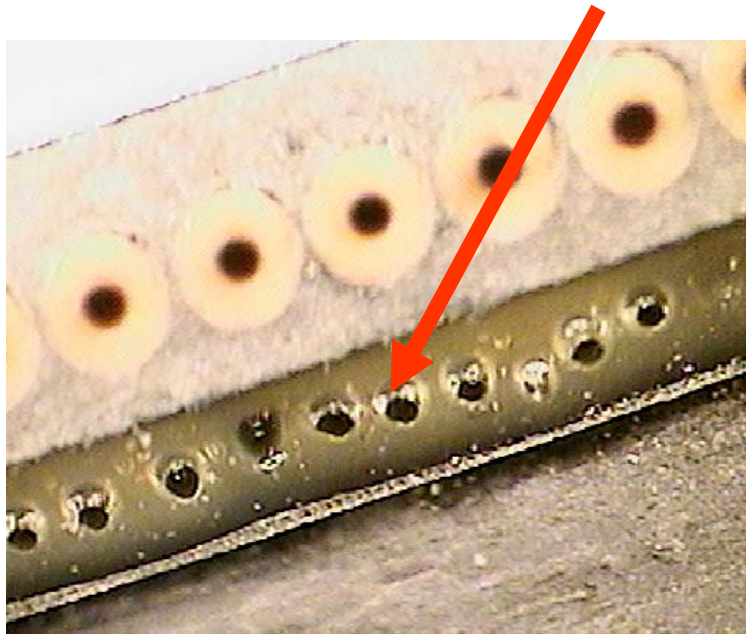
MCM Schedule Issues

- All of the MCMs currently at SLAC need to be delivered to Italy before Christmas to support production of the first 5 towers.
- MCM production needs to resume *next week* in order to have any chance of delivering more MCMs to Italy to continue tray production after Christmas.
- The tower production plan was increased from 2 towers per month to 3 per month in order to complete by end of June 2005.
 - 25 MCMs/week production will not support 3 towers per month.
 - It would have to be increased to at least 30/week.
 - Burn-in, test, and inspection at SLAC can in principle barely keep up with 3 towers per month, but it will fall behind if we have to keep doing so much rework.



Issues Identified in Flight Cable Production

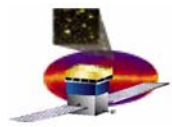
- **Two technical issues identified:**
 - **Bad coupon tests indicating separations between barrel plating and internal layers.**
 - **Bubbles in adhesive holding connector to cable**





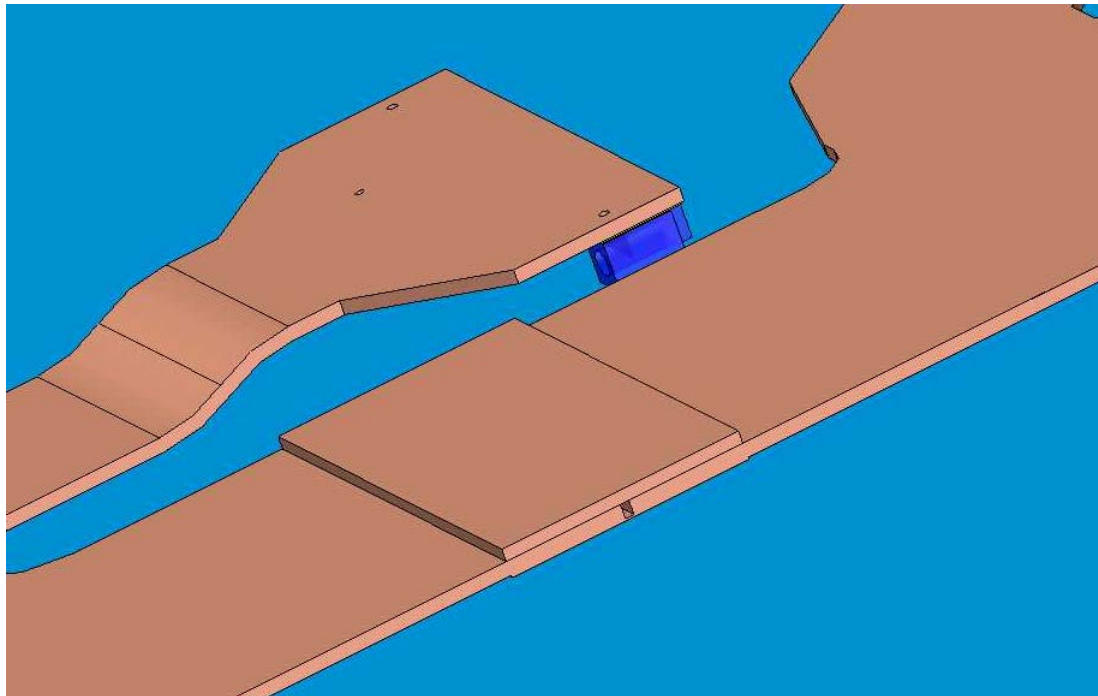
Path forward with Tracker Flex Cables

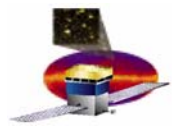
- **Parlex**
 - **CAP developed for assembly process**
 - **Bubbles not a problem**
 - **Assembly is going forward**
 - **Production of new flex circuits still stopped**
 - **Root cause of bad coupons still not understood**
 - **Delivery schedule continues to be unreliable**
 - **Daily telecons**
 - **Biweekly visits from QA and tracker personnel**
 - **GSFC team to visit Parlex next week**
- **Currently installing cables in hand (with original plating process) to stay on schedule for Tower A assembly**
 - **Tower A will have lien to be resolved at a later time**
 - **Plan to also do for Tower B and beyond**



Alternate sources for tracker flex cables

- **Developing alternate source for full length cables**
 - **12/6 delivery from Flexible Circuits to produce 5 C4 cables**
 - **QA source inspection next week**
 - **New RFP for full length flight cables going out for bid this week**
- **Developing option of 2 short cables with 'rigid-flex' joint**
 - **Need to validate design**
 - **New drawings in process**
- **Will place flight order with alternate source by 12/17**

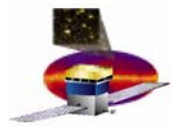




Flight Hardware Drawings Status

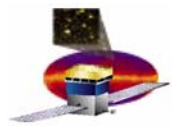
- **Mid Tray Panels**
 - In final approval. Rework and improvements of the drawings to reflect as-built condition.

- **Flex-Circuit Cables**
 - One piece design
 - C0 thru C7 in check. Provided to Parlex for review.
 - Splice
 - C0 PWB Master, Flat Assy., Bent Assy. Ready for release.
 - C4 PWB Master in design check
 - Six other PWB Masters in work (ECD 12/8).



Status of Parts & Materials from SLAC

Item	Status	Issues
MCMs	88 in Italy, delivering approx. 35 per week	Significant technical issues
Flex-Circuit Cables	-Tower A Cables installed (Lien pending) -Tower B & Tower 1 cables being reworked with 75 ohm resistors	Production problem at Parlex In discussion with alternate vendors
Ti Corner Brackets & Flexures	Full flight order complete, delivered to Italy	
Bottom-tray closeouts	Flight order complete	Some spares to be ordered.
Interface cones & studs	Two tower sets in Italy. Tower 1,2,3 being kitted for shipment.	
Hex nut	Two tower sets at INFN Tower 1,2,3 being kitted for shipment.	



Status of Parts & Materials from SLAC

Item	Status	Issues
Shims	Enough in hand for Tower A, Ship balance late December	
Top Tray Corner Brackets	Two tower sets at INFN. Ship balance late December.	
Sidewall Prepreg	COI orders shipped to Italy. Plyform has full order.	
Ti Sidewall washers	Sufficient quantities are in Italy. Ship balance late December.	
Sidewall Fasteners	Replacement M2.5 x 100 deg. received. Two tower sets at INFN.	Cam-out torque improved, but margin is low
Cytec BR-127 Primer	Large quantity on-hand in Italy. Small re-order for Mar. 05.	
Bias Circuits	Plenty in Italy for tray mass production	PR placed for final buy qty. 75.



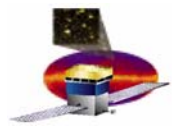
Status of Parts & Materials from SLAC

Item	Status	Issues
Heat straps	Tower A & B sets plus spares are in Italy. Balance at SLAC. CMM and ship to INFN.	
Locktite 401 for heat straps	At INFN.	
Solithane (for locking screws)	At INFN.	
Nusil silicone adhesives	At INFN.	
Aeroglaze paint and primer	Sufficient quantities now in Italy. Small re-order for Mar. 05.	
Honeycomb	Full flight order is in Italy. Small re-order for Mar. 05 (tbr)	
Carbon Carbon for Tray Closeouts	Full flight order is in Italy Re-order PR in process.	
Flex Cable Foam Compression Pads	Sufficient quantities now in Italy.	INFN directed to install on Tower A. Drawings need update to reflect build.



Status of GSE from SLAC

Item	Status	Issues
Vibration Fixture (Grid Simulator)	Three units at INFN. Ten units received and CMM inspected.	
Inner Shipping Container	Tower-A container at INFN. Balance due 1 st wk Jan. 05.	
Cable Holding Plate	Tower-A container at INFN. Balance due 1 st wk Jan. 05.	
Lifting Fixture	One is in hand and proof tested. 2 more will also be made for use in Italy.	
Outer Shipping Container	Tower A container on-hand in Italy. Balance due 1 st wk Jan. 05.	Drop test qual by similarity to original container.



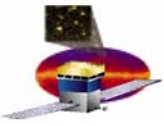
Status of GSE from SLAC

Item	Status	Issues
Transport Environmental monitors	Pisa has nine units.	
ESD wrap for inner container	At INFN.	
Desiccant pads (for inner container)	Sufficient quantities now in Italy. Ship balance late December.	



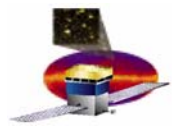
Status of GSE from SLAC

Item	Status	Issues
Cable Bending Tool	Cable bending tools in Italy	Minor improvements needed to reduce cycle time.
Tools for Cone Alignment and Extraction	Enough tools are in hand for Tower A assembly in Italy. Improved stud socket sent to INFN.	
EGSE Sets	7 sets are in Italy.	
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	Still exploring options on how to equip remaining test sets
Breakout Boxes for Tray Testing	2 are in Italy	~10 more in fab at SLAC



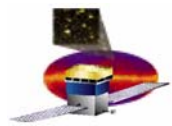
Material for Tower Production

- **In process of inventory of supplies for production in Italy and US**
 - **Placing orders to ensure parts availability for 18 Towers + spares**
 - **Bias Circuits**
 - **C-C Closeouts**
 - **Tungsten**
 - **Others in work**
 - **Connectors**
 - **Resistors**
 - **....**



PMCS Schedule & Cost Variance

- **October: Schedule variance decreased from -\$575k to -\$621k on total \$15,948 BCWS**
 - **Schedule has continued to degrade due to work stoppage at Teledyne and problems making flex cables at Parlex**
 - **Keep in mind most of Tracker assembly work is in Italy and not tracked by this schedule variance calculation**
- **Cumulative Cost Variance: -\$621k**
 - **The biggest contribution to the increase in cost variance is the machining of tower support system components.**



Schedule Status: Tower A Campaign

- The Tracker team is focused on delivery of Tower A to I&T
 - Updated plan: Tower A ships ~~12/16/04~~ 12/29/04

