GLAST Large Area Telescope:

Tracker Subsystem WBS 4.1.4

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Outline

- Summary Status
- Tracker Technical Issues
  - MCM encapsulant delamination
  - MCM production
  - Ladder Breakage on Heavy Trays
  - Flight Cables
- Tower Fabrication Status
  - Tower A
  - Tower B
  - Tower 1
- Cost and Schedule Status

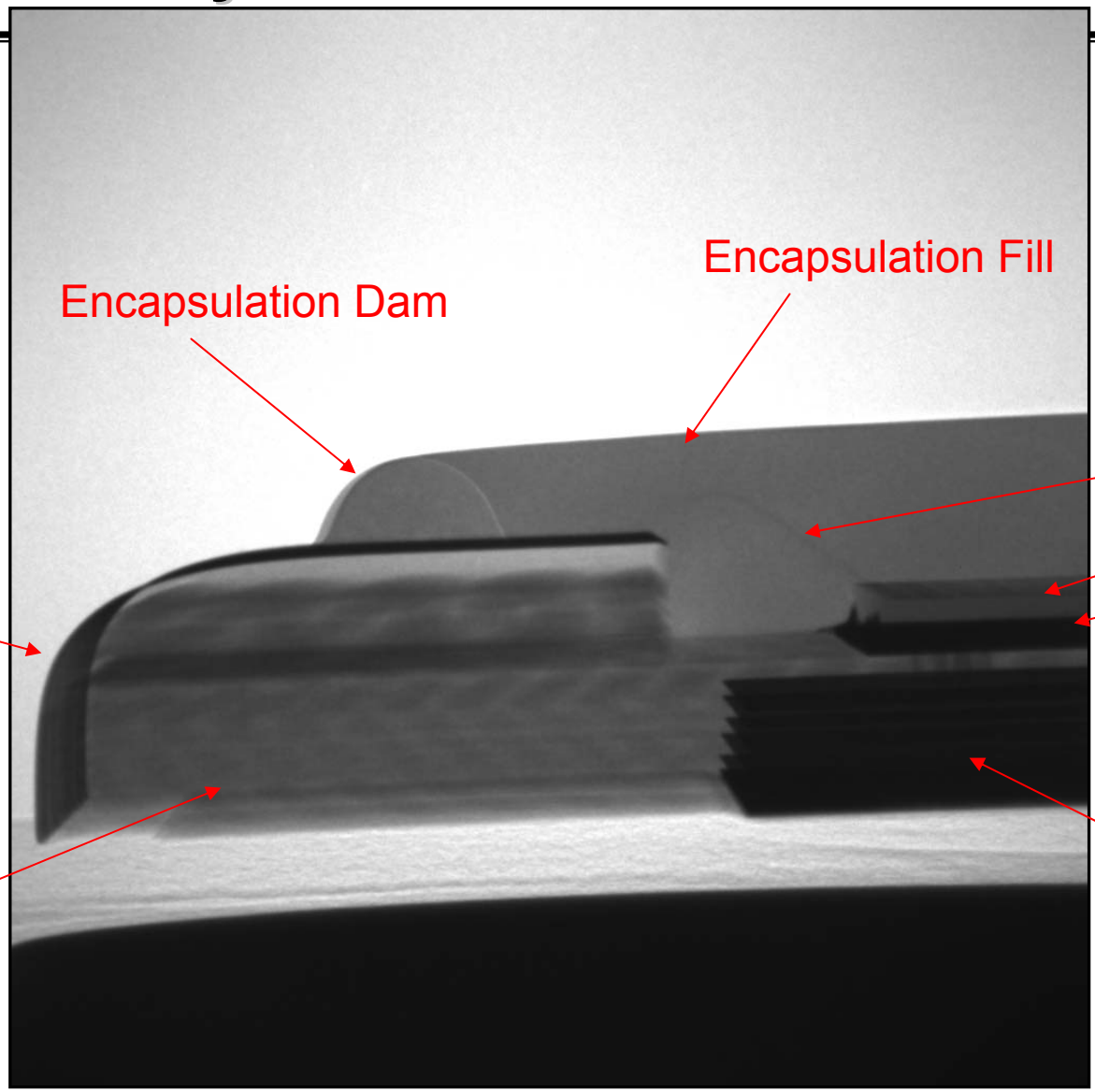
Summary

- Tower A completed environmental testing at Alenia
  - C6 cable anomaly resolved
  - Will arrive at SFO 1/14/05 3:20PM
- Tower B in assembly
  - All trays complete and tested
  - Tower B is being assembled in Pisa
  - Tower B environmental testing starts 1/17/05
- Tower 1 Trays ready for assembly at G&A
- Tower 2 Trays in assembly at Plyform

Tracker Technical Issues: MCM Encapsulant Delamination

- **MCM Anomaly Found During Tower A Tray Assembly at G&A**
  - **First identified in tray production at G&A where MCM on tray found to have 300 disconnected channels**
  - **Subsequently found in MCM's at SLAC before shipping using new (as of November) electrical test fixture**
    - **Large numbers of missing channels seen in ~15% of MCM's screened at SLAC**
    - **Most in August and September MCM production runs**
    - **Delamination occurs mostly during 21 thermal cycles done on MCM's at SLAC (-30C to +85C)**
- **Missing channels due to wire bonds breaking at Pitch Adaptor to ASIC joint under black encapsulation due to delamination of the encapsulation**
  - **Root cause hypothesized to be silicone contamination from masking tape applied to entire surface of pitch adapter prior to reflow soldering**

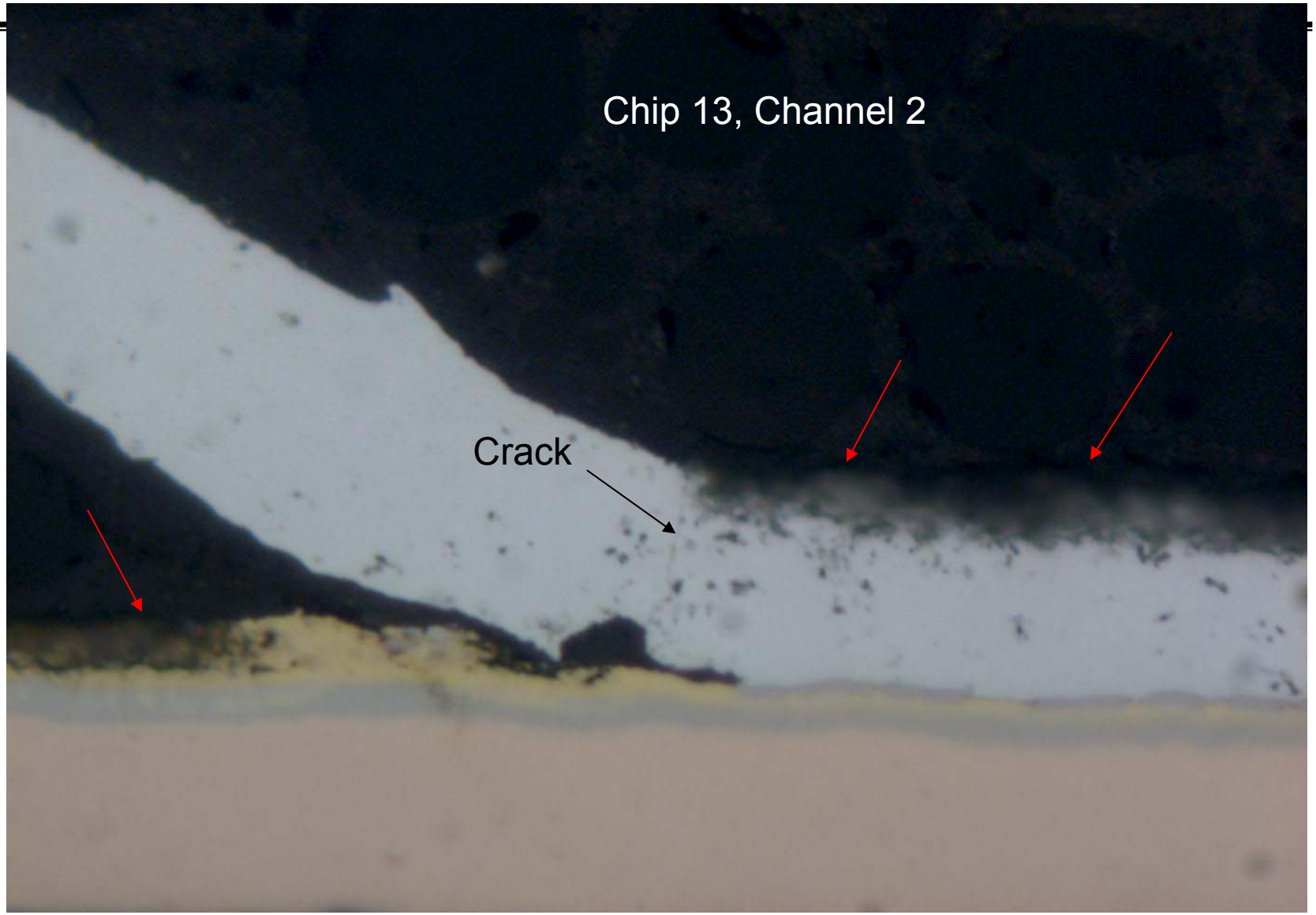
X-Ray Cross Section of an MCM



DPA of MCM

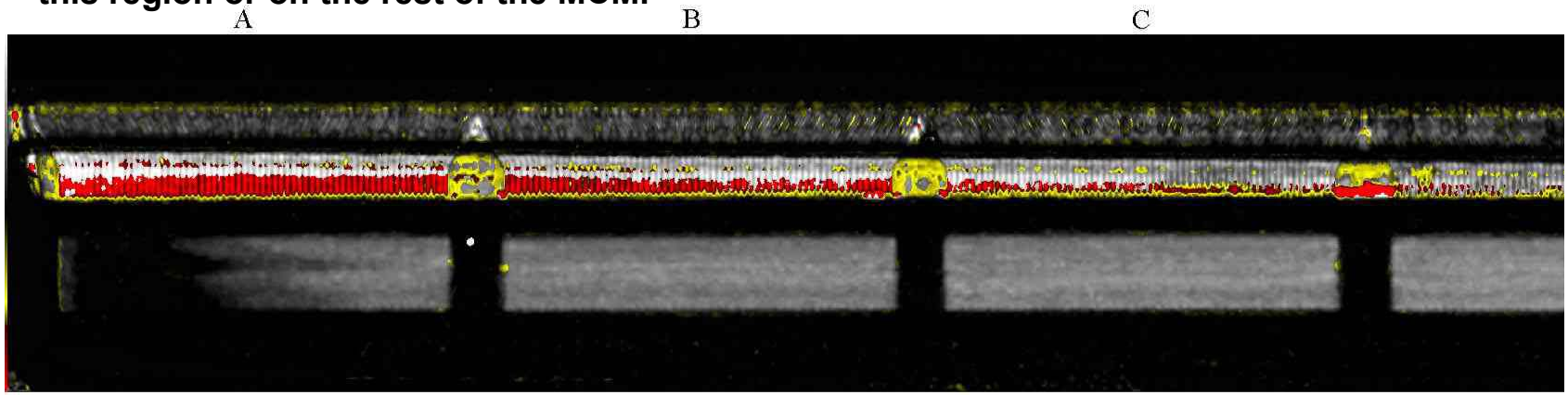
- Done by Diane Kolos and Bruno Munoz at GSFC.
  - X-ray results
  - sectioning and polishing
- C-SAM sonar images of MCM's confirm delamination
  - some delamination likely in all MCM's but in most cases not enough to break wire bonds

Example Wire Bond Crack

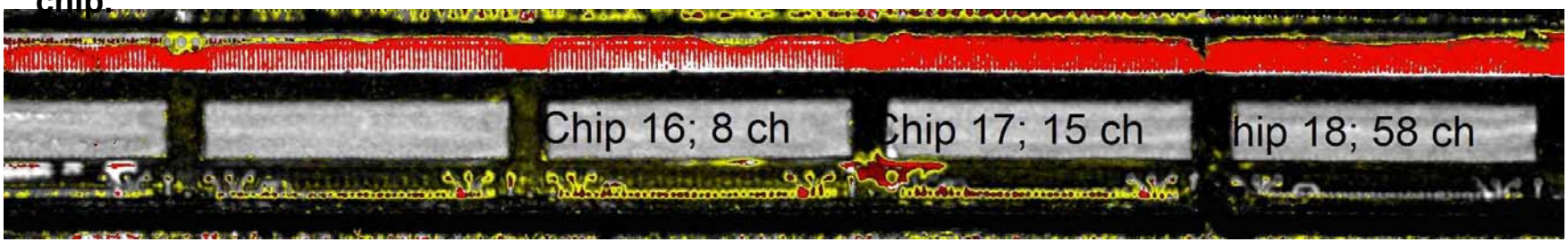


C-SAM Analysis of MCM Encapsulation Delamination Anomaly

C-SAM sonar image of the left-hand end of MCM S/N 600. The red areas are where the encapsulation has delaminated from the pitch adapter. There are no broken wire bonds in this region or on the rest of the MCM.



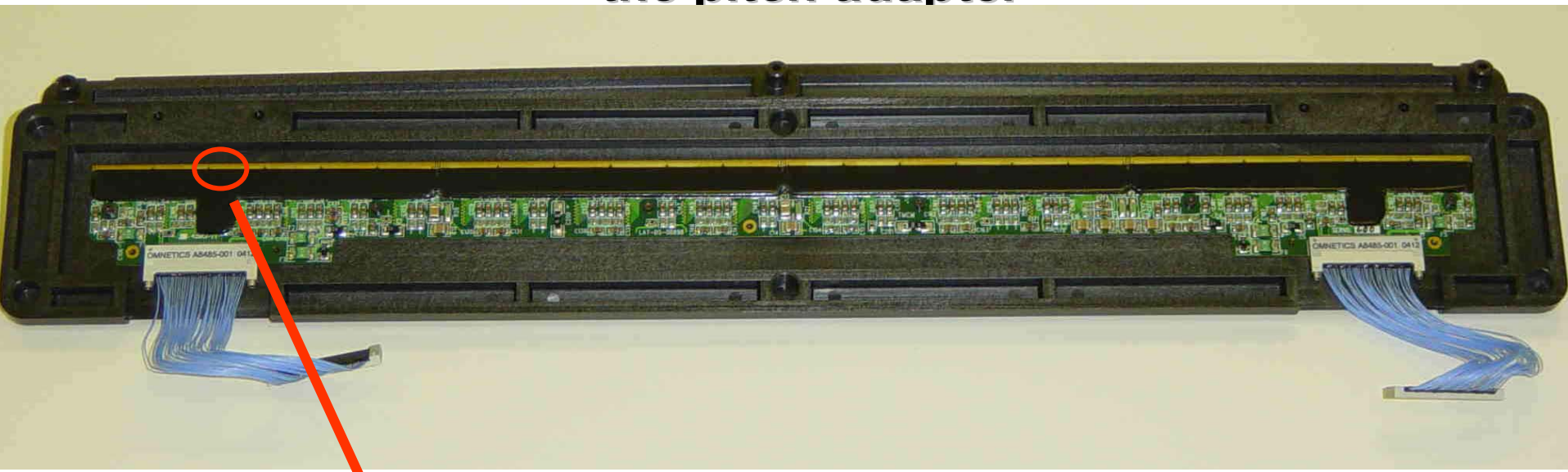
C-SAM sonar image of the region of MCM S/N 11046 were we find a transition from the left-hand 2/3 of the board, where no wire bonds are broken, to the right-hand 1/3, where nearly all the wire bonds are broken. The text indicates the number of broken wires for each chip.

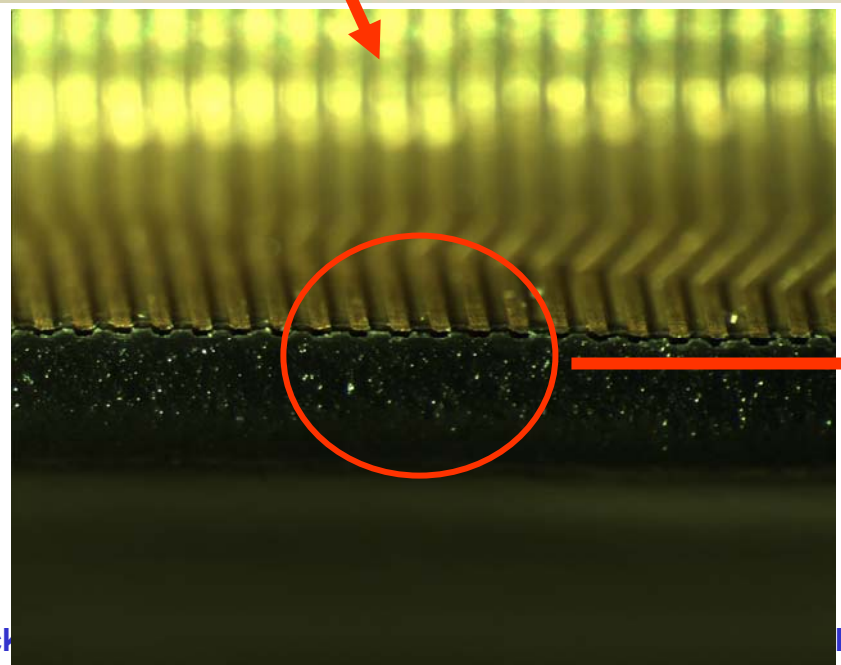


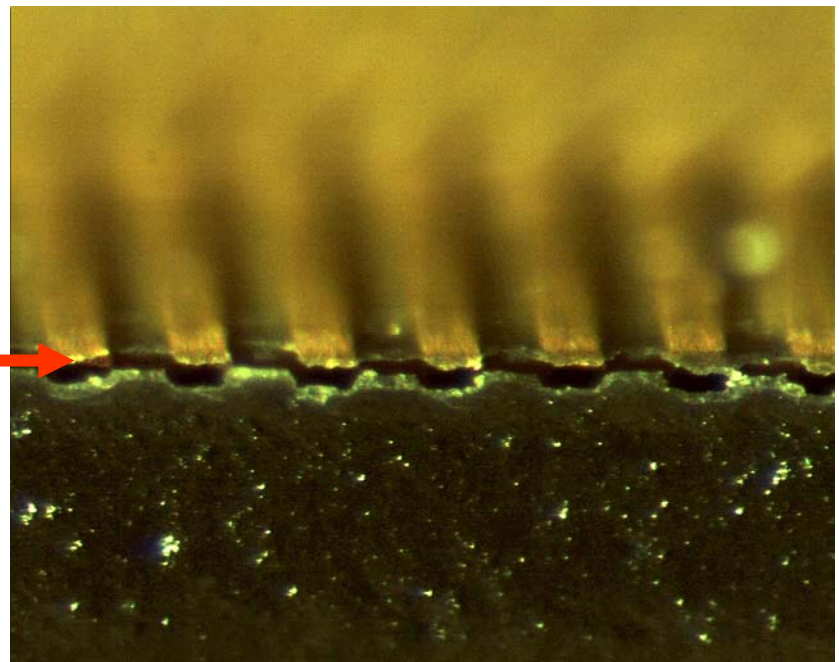
Tracker Technical Issues: MCM Encapsulant Delamination

- **Electrical Test Procedure at SLAC effectively eliminates all MCMs with more than 15 broken signal wire bonds following thermal cycles.**
  - **Concern is additional delamination and breaking of bonds during tray and tower assembly and test**
- **In Tower A tray assembly, problems were seen**
  - **2 MCMs screened at SLAC developed significant delaminations in tray assembly (>125 consecutive wire bonds broken)**
  - **Different signature**
    - **Location of delamination**
      - **Near MCM ends rather than MCM center**
    - **Visible gap between encapsulant and pitch adaptor**
    - **Early MCM delivery**

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







Impact on Tower Production

- Tower A
  - Two trays in Tower A have large numbers of missing channels (~150 each)
    - Accepted trays to keep Tower production on schedule
- Tower B
  - Continue to put MCM's on trays with modified procedures to avoid encapsulation delamination
    - Modify procedure for mounting MCM to tray
    - Reduce amount of adhesive
    - Visual inspection to look for debonding of encapsulant before silicon installed
- Tower 1
  - MRB before proceeding (1/3/05)
  - Disposition to continue to use existing MCMs on Tower 1 trays
    - Including full electrical screening at SLAC
    - Modified procedures and visual screening at G&A

Summary of Tower A and Tower B experience

Tower	Layer	SLAC	G&A	T-Cycle	Vibe	T/V
A	X1	0	156	174	177	178
A	X3	4	21	22	22	22
A	Y3	2	128	138	140	128
A	Y6	0	34	36	36	51
A	X0	1	4	6	6	9
B	X5	7	13	17	--	--
B	X0	15	17	28	--	--
B	Y3	7	8	9	--	--

Plan Forward: MCM Encapsulant Delamination

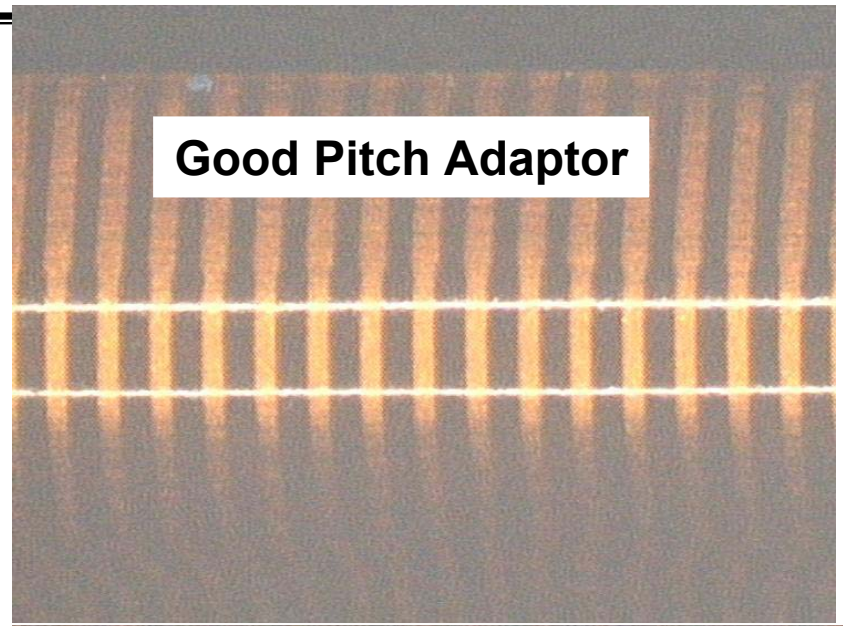
Plan	Status	Who	Date
1. 100% electrical screening of MCM's at SLAC	1. Done		
2. Process changes during MCM assembly on trays	2. Done		
3. 1/3/05 MRB	3. Done	RPJ	1/3/2005
4. Proceed to put existing MCM's on Tower 1,2,3	4. Recommendation of 1/3/05 MRB	Pisa	1/10/2005
5. Monitor bad channel rate during assembly and call an MRB if the number is greater than 20 or the change in any assembly or testing step is greater than 25%	5. Needs procedure	CCY	1/10/2005

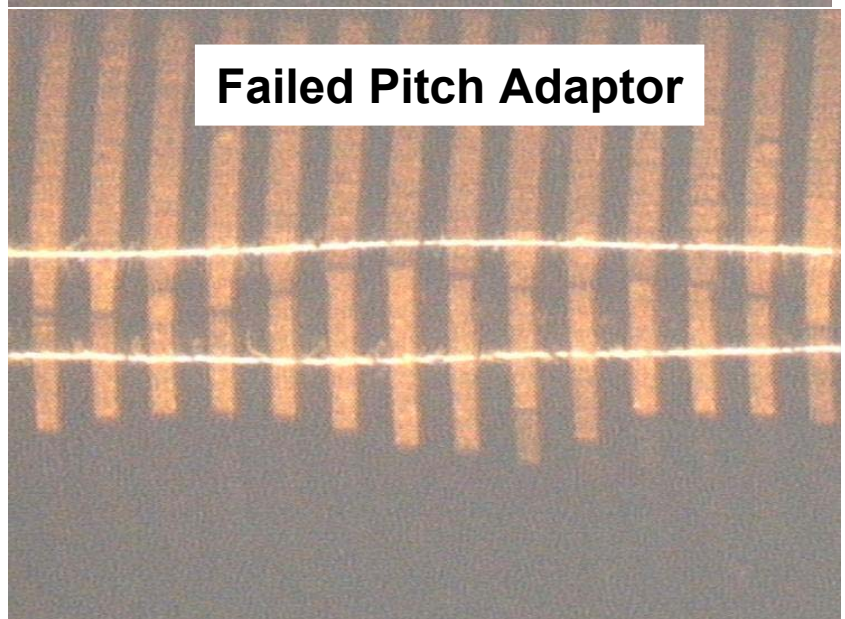
Tracker Technical Issues: MCM Production

- MCM Production at Teledyne was halted 10/1/04
  - Implement PWB bake out
  - ESD Controls
  - Variety of workmanship issues
- Teledyne restarted production 12/20/04
  - Up to but not including encapsulation
  - Immediately started having trouble with cracking of pitch adaptors
- Pitch Adaptor Cracking
  - In 3 batches of first 18 boards failed inspection after bonding the PA
  - every board had a large number of cracked and open traces, spanning more than half the length of the board in some cases.
  - qualitatively different from earlier runs.

Tracker Technical Issues: Pitch Adaptors

- For good PA, bright lines straight and parallel
- For bad PA, bright lines are wavy and non-parallel.
  - traces do not fade away at the same rate.
  - interpreted to mean that the radiused corner has variations along its length.
  - Note cracks in many traces, and sometimes multiple cracks in each trace.





Tracker Technical Issues: Pitch Adaptors

- Known process changes
  - PWB boards are radiused with custom tool bit.
    - Small irregularities were observed, and a step was added in early November where SLAC manually "deburred" the bare boards before shipping them to Teledyne
- Other possibilities
  - PA may be from different production run (exploring with Parlex)
    - Test data
    - Plating verification
  - PWB radius may be incorrectly put on
  - Change in tension put on PA during bonding
  - PA from 2nd vendor being evaluated
- Intensive effort to determine root cause and get Teledyne production re-started

Plan Forward: PA Trace Cracking

Issue	Plan	Status	Who	Date
Pitch Adaptor Cracking	1. Assess impact of PWB edge debur	1. In process	CCY	1/5/2005
	2. Evaluate PA from 2nd vendor	2. In process	CCY	1/5/2005
	3. Evaluate process changes at Parlex	3. In process	RGobin	1/5/2005
	4. Evaluate process changes at Teledyne	4. In process	CCY/RG	1/7/2005

Tracker Technical Issues: MCM Production

- To stay on current Tracker fabrication schedule, MCM production must ramp up to:
  - Deliver 25 MCMs/week by 2/2/05
  - Working to increase production beyond that
    - Teledyne supports production increase
- To complete MCM's for 18 Towers, need to order more ASIC's
  - 1 order of 20 wafers—will barely make 16 towers
  - 2 orders of 20 wafers– will make 18 towers with spares
    - To date 15% loss of chips at Teledyne (under investigation)
    - Loss of 3 towers worth of MCM's from Tower 0, encapsulant delamination and other MCM problems (cracked traces, short circuits in PWB, PA delamination, etc.)
  - Order needs to be placed immediately

Plan Forward: MCM Production

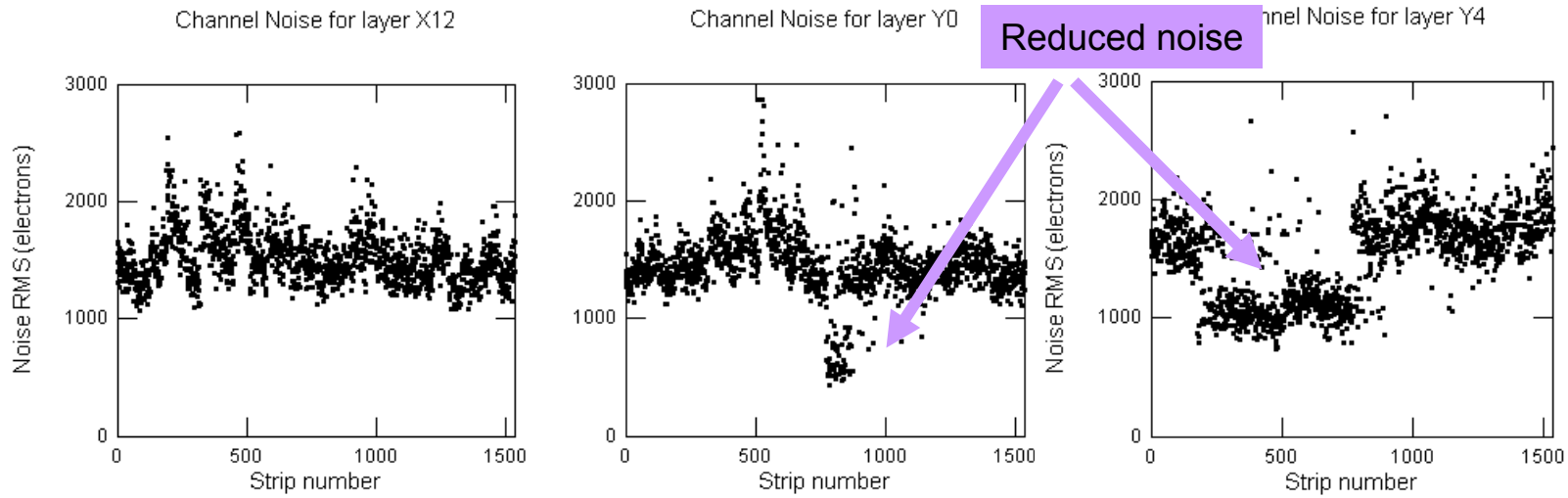
Issue	Plan	Status	Who	Date
MCM Production Line @ Teledyne	1. Make plan for pitch adaptor cracking	1. Evolving	CCY/RPJ	1/5/2005
	2. Order parts to ensure full flight MCM production, esp ASICs	2. Purchase req. submitted	CCY/RPJ	1/10/2005
	3. Restart full production 25/week with goal of getting to 35/week	3. Needs PA MRB	CCY/RPJ	
	4. Sonagram a sample of new production MCM's; thermal cycle, 100% electrical test to evaluate delamination and validate process changes	4. Procedure and criteria needed	CCY/RPJ	
	5. Extended qual program for at least 2 MCMs	5. Procedure needed	CCY/RPJ	
	6. Increase production to 30/week	6. Plan needed	CCY/RPJ	

Tracker Technical Issues: Ladder Breakage on Heavy Trays

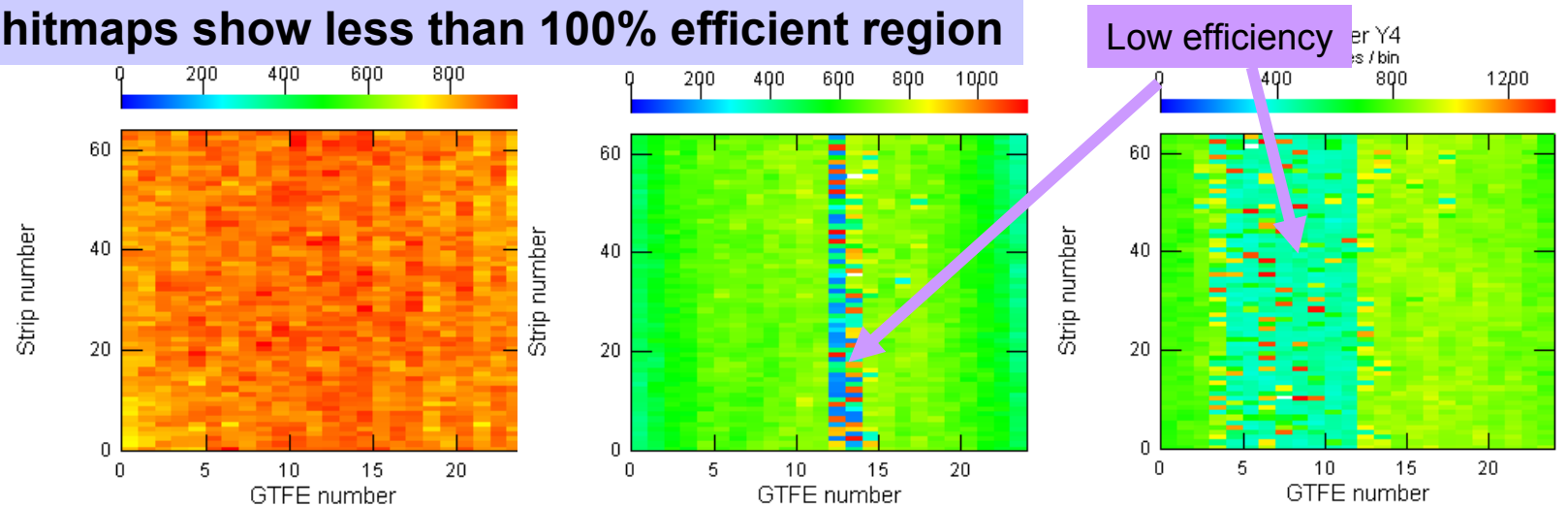
- **Description**
  - 3 different ladders belonging to 2 tower A trays showed signal strips interrupted at half their length
    - inferred from noise measurements (compatible with half strip capacitance)
    - seen in hitmap occupancy
  - trays could not be visually inspected as they were already assembled into tower A
- **Root cause**
  - from comparison with measurements taken during acceptance test at G&A and after thermal cycle we could identify thermal cycle as the origin of the break

Ladder Breakage on Heavy Trays: Online Analysis

Noise profile shows a group of channels with lower noise.



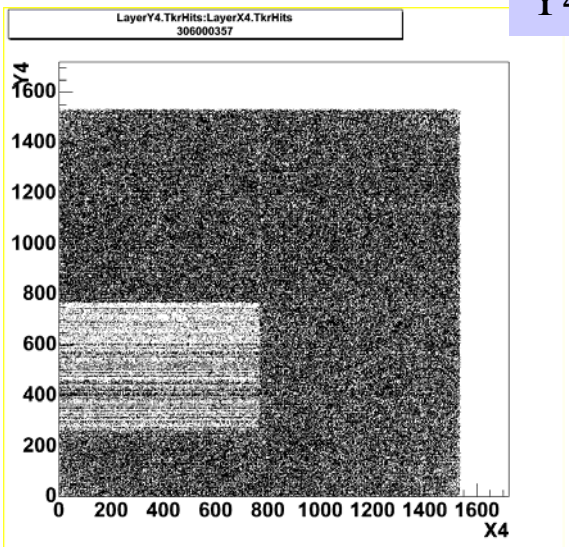
CR hitmaps show less than 100% efficient region



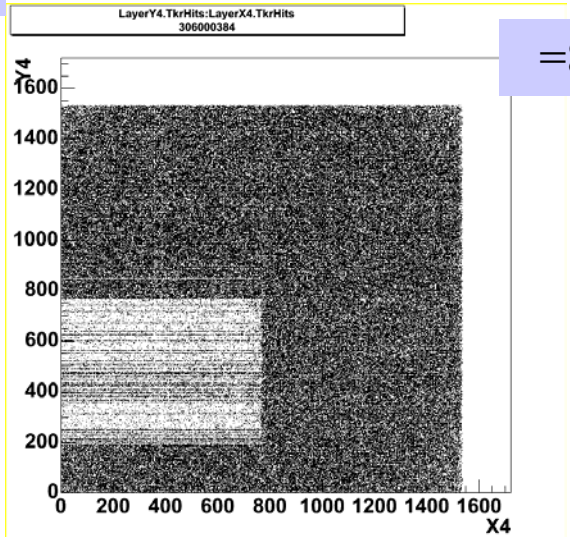
Ladder Breakage on Heavy Trays: Offline Analysis

Y4 Heavy 20

12/1 without sidewalls

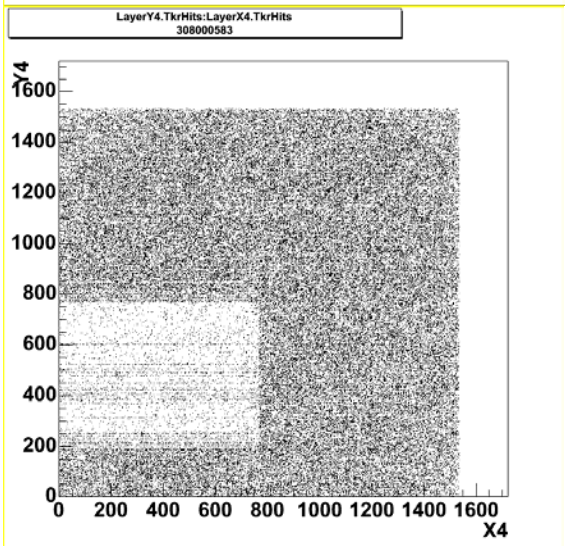


12/5 assembly complete

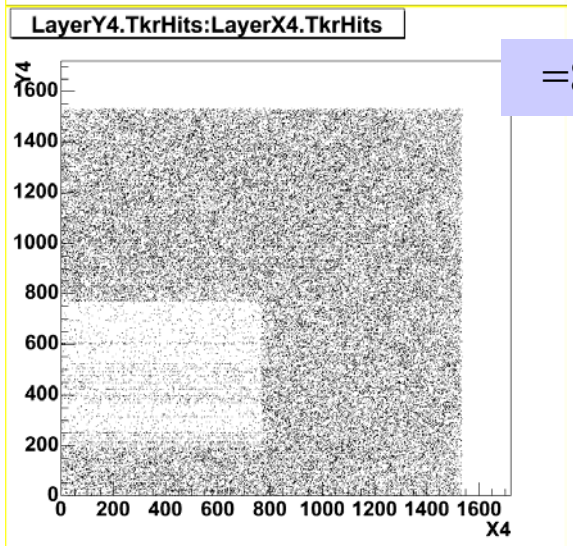


=86.4%

12/18 50C Plateau



12/27 Preship run



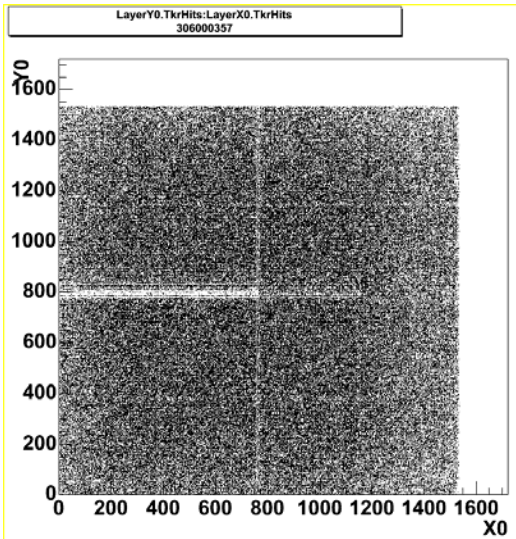
=85.3%

Offline analysis **2D scatter plot X0 vs Y0**

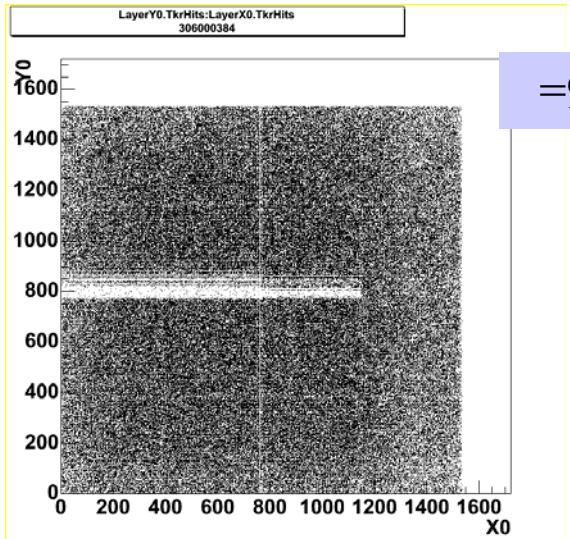
Ladder Breakage on Heavy Trays: Offline Analysis

Y0 Bot 003

12/1 without sidewalls

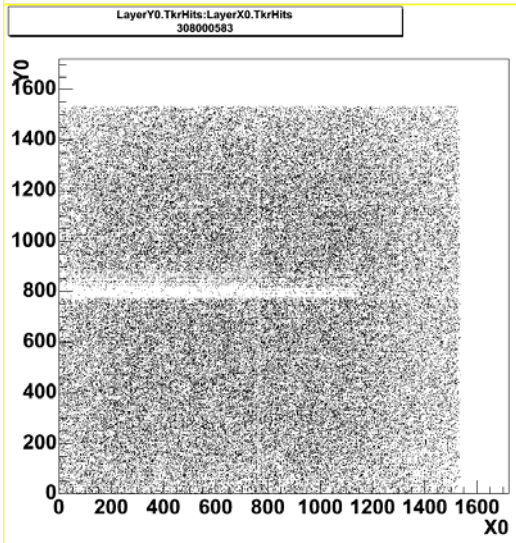


12/5 Assembly complet

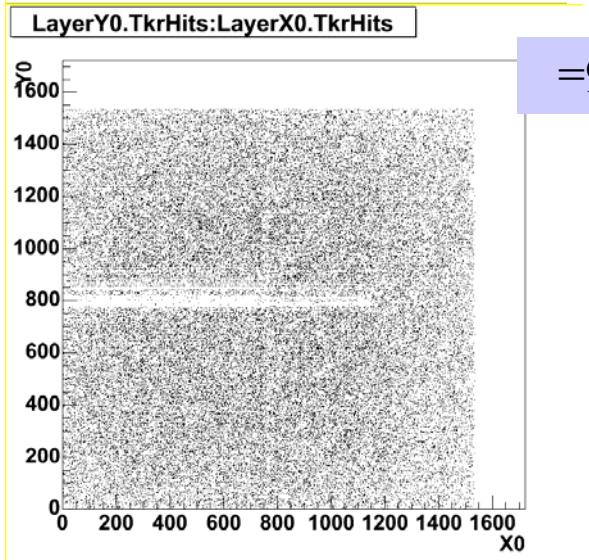


=96.1%

12/18 50C Plateau



12/27 Preship run



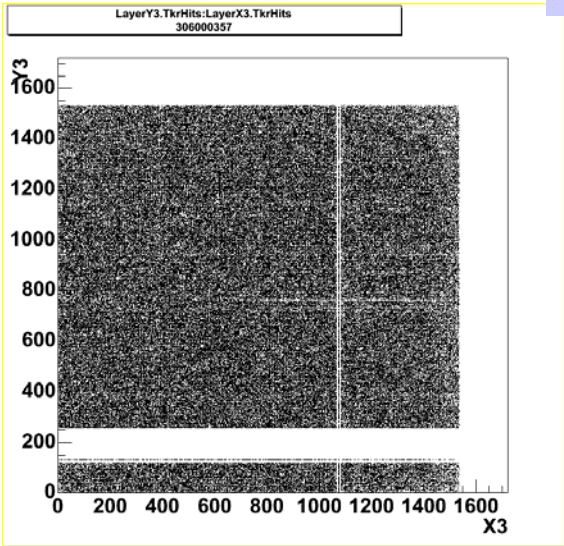
=96.1%

Offline analysis **2D scatter plot X0 vs Y0**

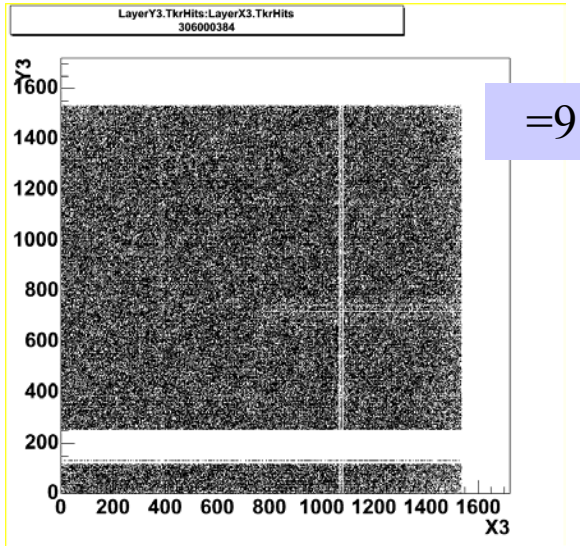
Ladder Breakage on Heavy Trays: Offline Analysis

Y3 Heavy 20

12/1 without sidewalls

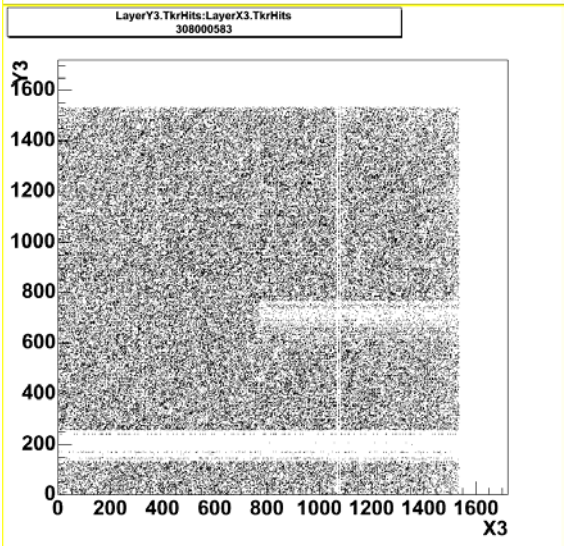


12/5 Assembly complete

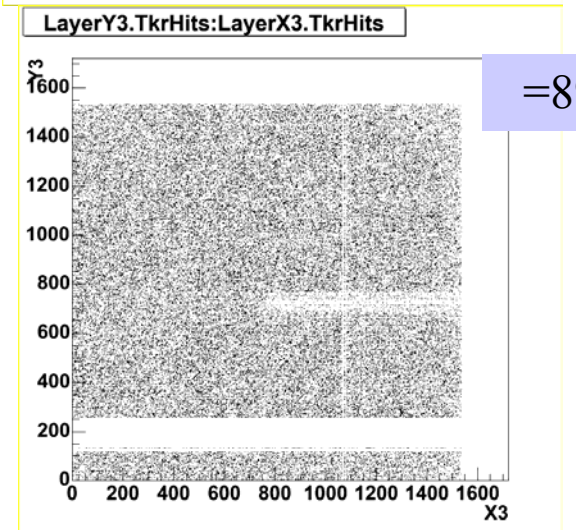


=91.2%

12/18 50C Plateau



12/27 Preship run



=89.9%

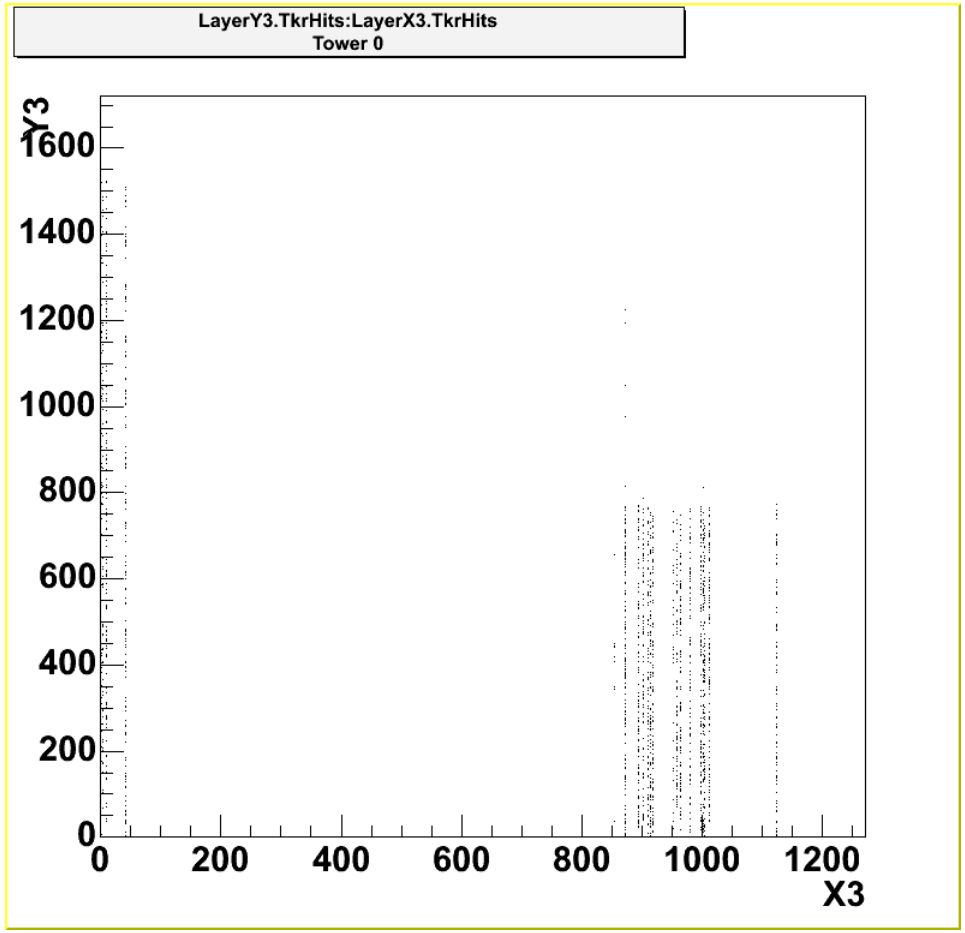
Offline analysis **2D scatter plot X0 vs Y0**

Tracker Technical Issues: Ladder Breakage on Heavy Trays

- **Conclusions**
  - Wirebonds connecting different SSDs inside a ladder broke in 4 ladders attached to 3 different trays of 'heavy' type (heavy and bottom)
  - Break tends to appear at the centre of tray
  - Root cause is very likely the same effect that broke wirebonds between strips and PA and led us to remove encapsulation of those wirebonds
  - We cannot remove encapsulation on ladders
- **Plans forward**
  - use trays as they are for tower A
  - Review temperature ranges for thermal cycles and thermal-vacuum tests:
    - Cycle Tower B trays at tower acceptance level of -15C to +45C
  - For Tower 1 heavy and bottom trays, fabricate ladders without encapsulation

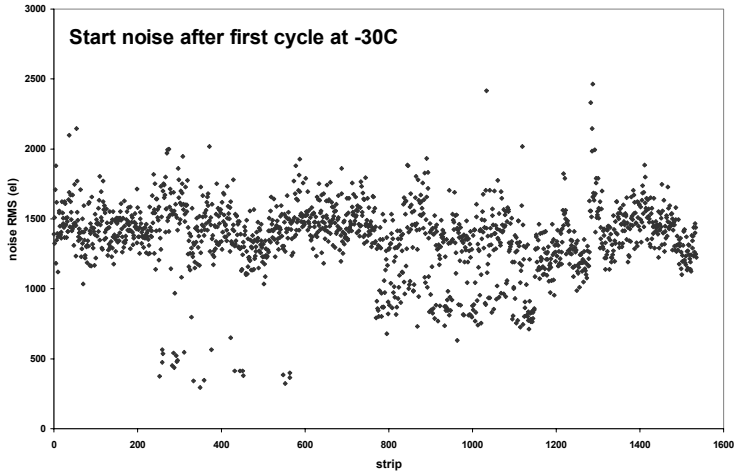
Ladder Breakage on Heavy Trays: Offline Analysis from Tower 0

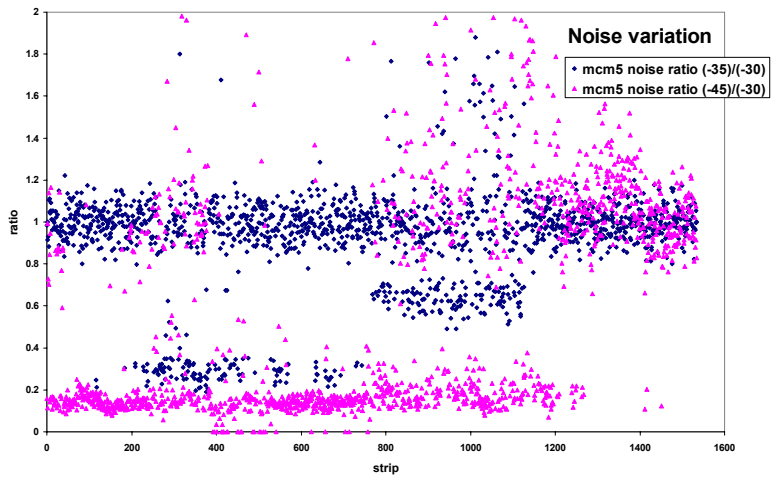
- Went back to tower 0 data
- Recall tower 0 heavy trays lost large numbers of channels due to encapsulation between silicon and MCM (removed for Tower A and beyond)
- For Tower 0, the only tray showing interrupted strips had very few live channels (NCR INFN/PI-92)
  - The problem was there in Tower 0
- Have taken Tower 0 heavy trays and thermally cycled them in Perugia
  - Decrease lower temperature
  - See continued breakage of ladders



Ladder Breakage on Heavy Trays: Thermal Cycling at Perugia

- Perugia testing of Tower 0 heavy trays:
  - -30 C
  - -35 C
  - -45 C
- New Tray level thermal cycling lower limit for Tower B and beyond
  - -15 C



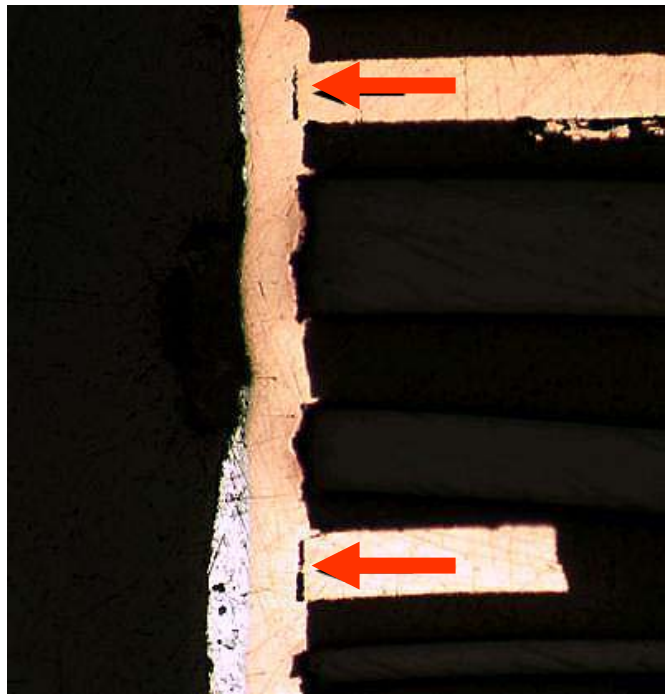


Plan Forward: Ladder Breakage on Heavy Trays

Issue	Plan	Status	Who	Date
Ladder Breakage	1. Mine Perugia and Twr B data, including visual inspection of broken ladders from Perugia trays		Pisa	1/12/2005
	2. Assemble existing analysis to understand root cause for heavy tray problems and margin for mid-trays		Ku	1/12/2005
	3. 1/12/05 MRB	INFN/PI_318 /319	Pisa	1/12/2005
	4. Proceed to make heavy trays for Tower 1 using ladders without encapsulation		Pisa	1/17/2005
	5. Use analysis and prototype ladders without encapsulation to retire risk		Pisa/Ku	

Tracker Technical Issues: Flight Cables

- Technical, workmanship and schedule performance issues identified at Parlex
  - Technical Issue:
    - Bad coupon tests indicating separations between barrel plating and internal layers



Tracker Technical Issues: Flight Cables

- Parlex
  - CAP developed for assembly process
    - Assembly is going forward
  - Production of new flex circuits restarting under engineering control
    - Water blast step after drilling seems to improve plating
      - Awaiting coupon test results
    - High level of interaction with Parlex
      - Daily telecons
      - Biweekly visits from QA and tracker personnel
      - GSFC team visit
- Currently installing cables in hand (with original plating process)
  - Tower A has 1 cable with bad coupon (NCR closed)
  - Tower B delayed so that can install cable set with all good coupons (cables arrive 1/7/05)
  - If Tower 1 tray fabrication proceeds on schedule we will face decision on installing cable with bad coupons or delaying Tower assembly
  - Tower 2 and beyond there is the potential Parlex will deliver new process cables

Current Flex Cable Inventory

Cable Assy P/N Flex Ckt P/N	DS-02377 DS-00584 C0 (4X)	DS-02378 DS-00723 C1 (4X)	DS-02379 DS-00724 C2 (1X)	DS-02380 DS-00725 C3 (1X)	DS-02381 DS-00726 C4 (1X)	DS-02382 DS-00727 C5 (1X)	DS-02383 DS-00728 C6 (3X)	DS-02384 DS-00729 C7 (3X)
ASSY S/N	011	001	001	001	001	001	001	001
FLEX S/N	0019	0038	0014	0012	0011	0013	0031	0079
ASSY S/N	12	002	002	003	003	002	002	002
FLEX S/N	0031	0026	0010	0013	0016	0011	0038	0078
ASSY S/N	16	003	004	004	006	003	004	003
FLEX S/N	0044	0053	0044	0019	0033/35	0020	0050*	0105
ASSY S/N	17	004	005	005	007	004	005	004
FLEX S/N	0040	0051	0042	0017	0044	0027	0051*	0100
ASSY S/N		005	003	006	008	005	006	005
FLEX S/N		0052	0043	0022	0046	0024	0049*	0102
ASSY S/N		006	tbd cnr	007	009	007	007	006
FLEX S/N		0049	0045	0028	0045	0035	0043*	0103
ASSY S/N		007	004		007	008	008	007
FLEX S/N		0055	0044		0044	0037	0048	092
ASSY S/N		008	005		008	007	009	008
FLEX S/N		0043	0042		0046	0035	0044*	093
ASSY S/N		009	003		009	008	010	009
FLEX S/N		0042	0043		0045	0037	0052	099
ASSY S/N		010	tbd cnr				011	010
FLEX S/N		0054	0045				0064	108
ASSY S/N							012	
FLEX S/N							0059	
ASSY S/N							013	
FLEX S/N							0057	
ASSY S/N							011	
FLEX S/N							0064	
ASSY S/N							012	
FLEX S/N							0059	
ASSY S/N							013	
FLEX S/N							0057	

Tracker Technical Issues: Flight Cables

- All cables are fully functionally tested before installation in the Tower
  - Concern is that cable will fail in Tower or Instrument level environmental testing
  - Validate cables with thermal cycling of 2 test cables
    - Test 1: Thermal Cycle Testing of pre-water blast cable (good coupon)
      - Thermal cycles 1 – 21: -50 C to 125 C
      - Thermal cycles 22- 100: -35 C to 55 C
    - Test 1 results
      - No change in cable performance
    - Test 2: Thermal Cycle Testing of pre-water blast cable (bad coupon)
      - Thermal cycles 1 – 21: -50 C to 125 C
      - Thermal cycles 22- 41: -35 C to 55 C
    - Test 2 results
      - Single via broke between cycle 16 and 21
      - No change in cable performance cycles 22-41

Path Forward: Flight Cables

Issue	Plan	Status	Who	Date
Flight Cables	1. MRB to disposition cables for Tower A and B	1. Done	DN/PSD	1/4/2005
	2. Complete test program for cables with bad coupons for Twr 1	2. In process	HT	1/7/2005
	3. Fully restart Parlex	3. Waiting coupon results	DN/DK	1/7/2005
	4. For Twr 1 and beyond use new cables/good coupons as much as possible depending on production schedule	4. Needs MRB	DN/DR	1/18/2005
	5. Evaluate options for second sources that have been developed and develop a plan to mitigate downstream risk with Parlex	5. Needs LAT IPO approval	HS/DN	
	6. Order parts to ensure full flight cable production	6. In process	DN/DR	1/15/2005

Tower Fabrication Status

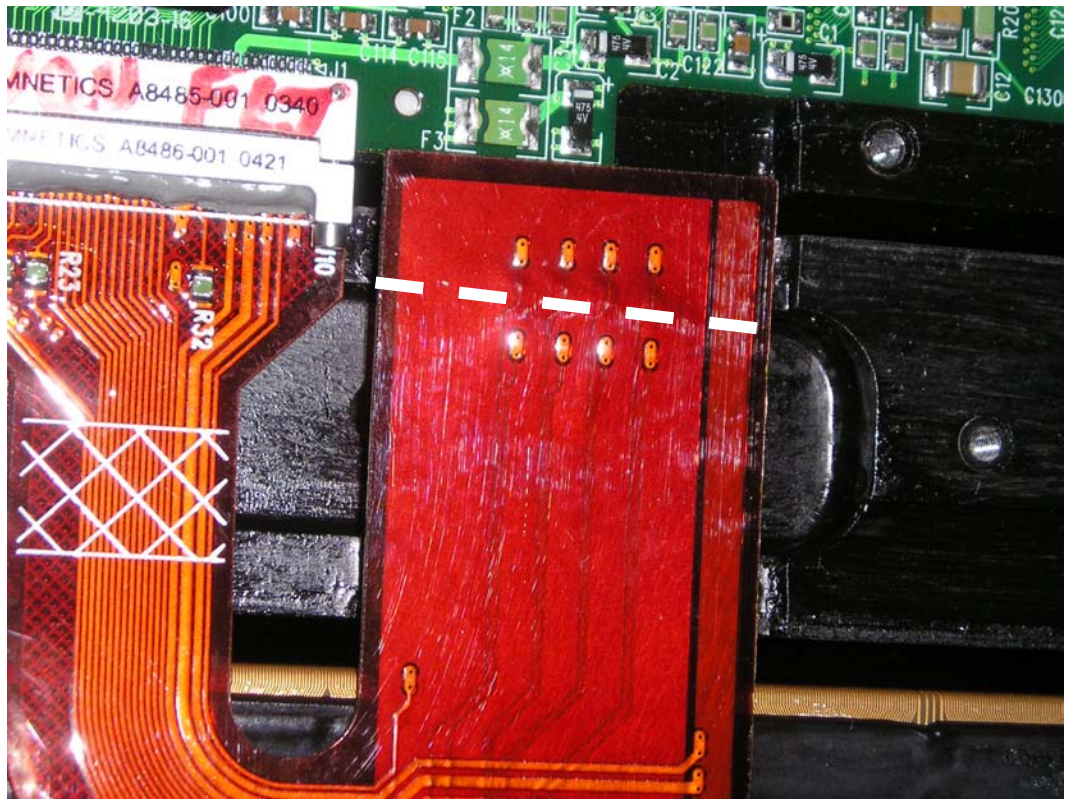
- **Tray Production Status (Plyform + INFN) as of 11/26/04**
  - 151 bare trays (no converter or bias circuits) produced
  - 66 trays completed with converter and bias circuit
    - Trapped air in bias circuit lamination is no longer a problem
- **Tracker Tray Fabrication**
  - Flight tray production restarted 10/4/04
  - Flight trays for Tower A completed
  - Flight trays for Tower B completed
  - Flight trays for Tower 1 ready for fabrication at G&A
  - Flight trays for Tower 2 in fabrication at Plyform
- **Tracker Tower Assembly**
  - Environmental Testing on Tower A completed
    - Tower A will ship 1/11/05
    - Tower A PSR schedule 1/10/05 8AM PST
  - Tower B is being assembled now
    - Environmental Testing on Tower B starts 1/17/05
    - Ship date for Tower B 2/4/05

Tower A C6 Anomaly

- Tower A Environmental test went very smoothly
  - The tower went through vibe perfectly
- Half way through thermal cycling, the C6 readout line failed.
  - Diagnostic capability was limited
    - Initial prejudice was a TEM problem
    - When the T/V chamber was opened, the TEM was exonerated
    - Tests were then done to determine if we are seeing a cable or MCM problem.
  - Failure traced to short on C6 CKLM trace
- Root cause analysis by Robert Johnson led to the hypothesis that the C6 termination resistor was shorting against a closeout due to a design flaw.

Tower A C6 Anomaly

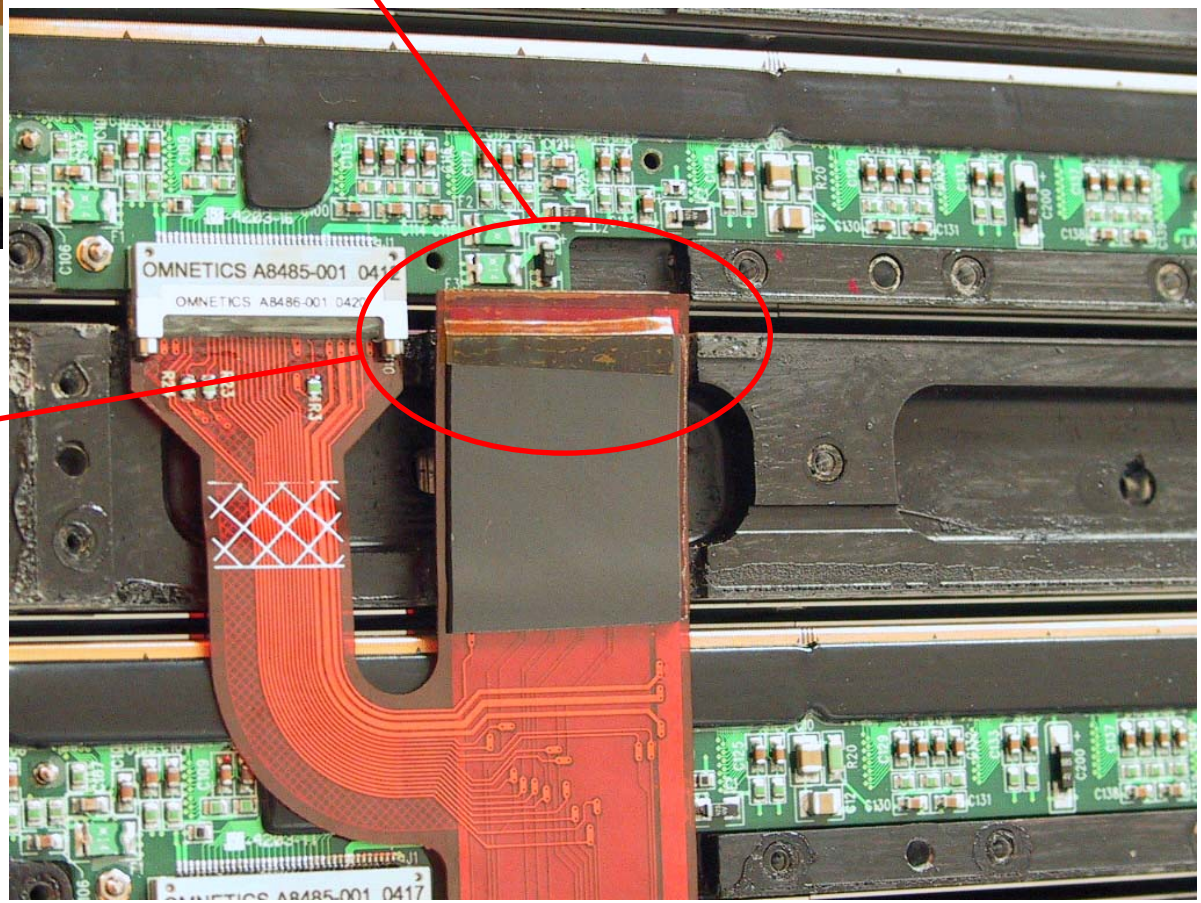
- Fit check of flex cable C6 on tower 0
  - white dashed line is the actual edge of the cavity in the closeout.

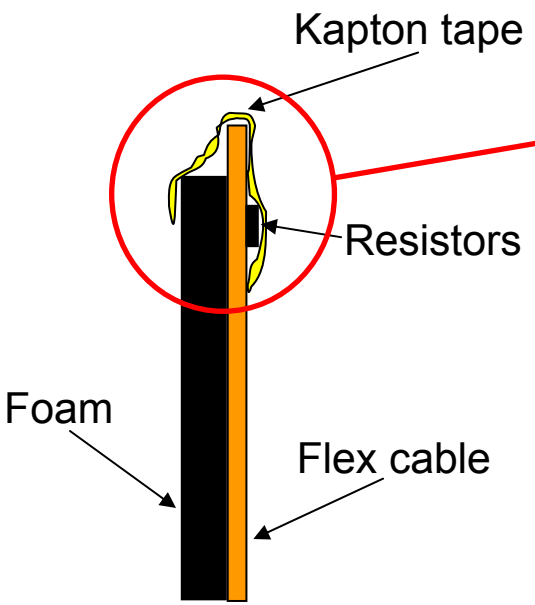


Tower A C6 Anomaly

Anomaly Resolved

Kapton tape is applied *without* disconnecting the cable.





Tower A C6 Cable Anomaly Resolved

- **MRB 1/4/2005**
  - **Closed C6 NCR on Tower A**
  - **Use kapton tape on C6 cables for subsequent towers**
  - **Will review feasibility of change in cable design for downstream cable fabrication**

Tracker Fabrication Schedule

- Schedule currently shows Tracker 14 RFI 7/25/05
  - This is a slip of 3 weeks from end of November schedule
    - Due to anomalies in production
    - Capacity of production steps evaluated to be at 3 tower/month level (Plyform, G&A)
- Near term threats to the current schedule
  - This schedule assumes no delays at G&A and Plyform due to funding issues
    - Delay in assembly of Tower 1 trays will start to impact schedule 1/10/2005
  - This schedule assumes no delays due to MCM's
    - Within days will start to incur day for day slip on this schedule due to MCM supply drying up after Tower 3 if we cannot solve PA problem and get Teledyne restarted

Tracker Thermal Cycle Ranges

		Cycle		Number
		Low	High	
MCM		-30	85	21
Bare Panel			60	4
Tray		-30	55	4
Tower Qual		-30	50	4
Tower Acc	Old	-20	50	4
Tray		-15	55	4
Tower Qual		-20	50	4
Tower ACC	New	-15	50	4