
# GLAST Large Area Telescope:

## Pitch Adapter Trace Cracking Issues

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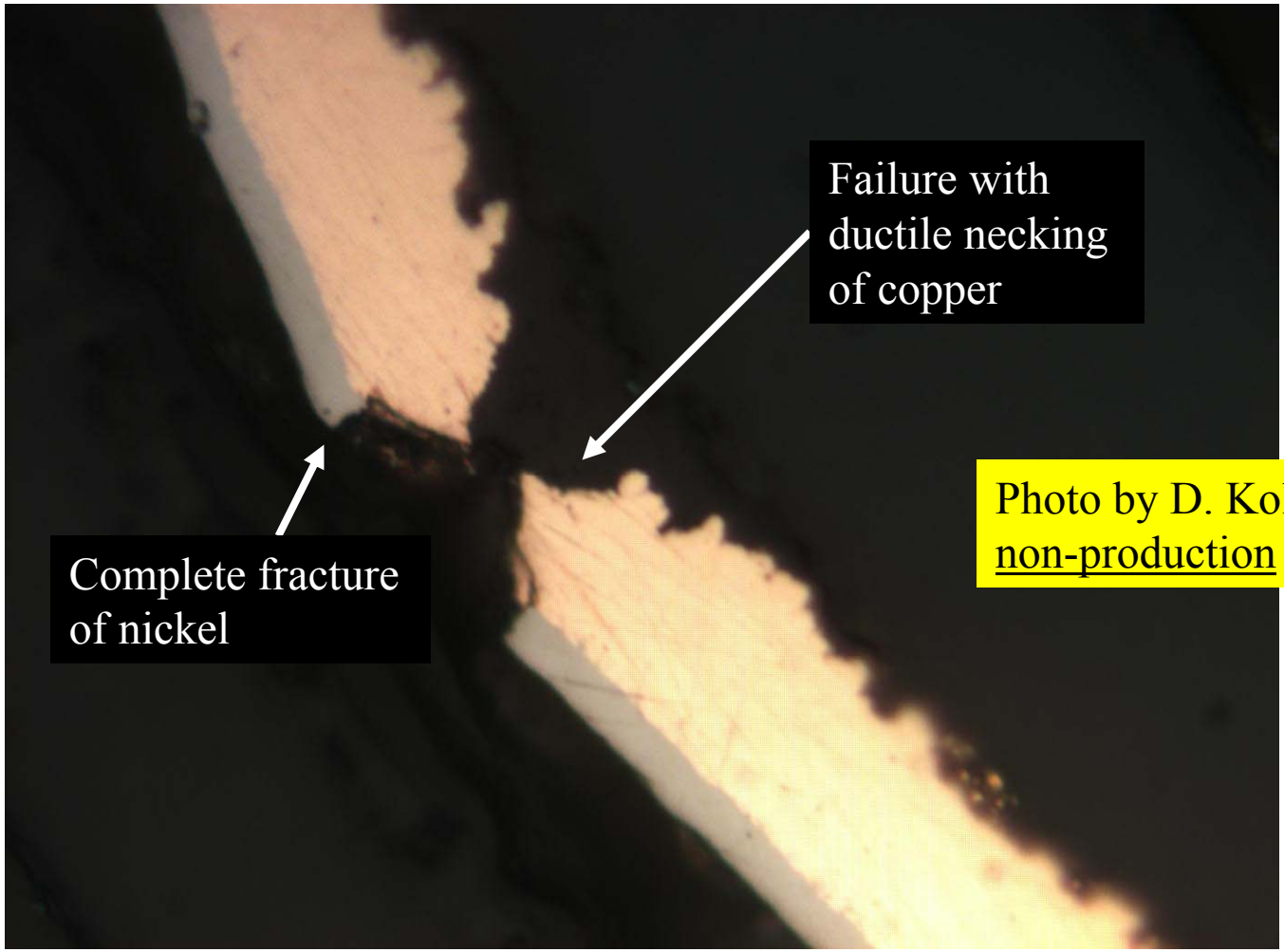
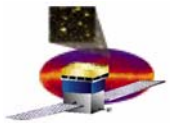
# Picture of Cracked Trace





# Several Types of Pitch Adapter

- Parlex “Apr 04”.
  - Used successfully in MCM production.
    - ~80% yield.
    - No more than 8 cracked traces.
- Parlex “Sep 04” and “Nov 04”.
  - Used in MCM production restart in Dec 04.
  - Massive failure with every trace cracked.
- Dyconex.
  - Test PA.
  - Better than “Sep 04” & “Nov 04” but not acceptable.
- Parlex “Jan 05”.
  - Test PA. Delivered 10:00 yesterday.
- Titan.
  - Test PA. Delivered 17:00 yesterday.

Very recent developments.

Evolving rapidly.

Some real-time results.

# Trace Cracking Status by PA Type

| | Vendor | Nickel Plating | Date | Usage | Status |
|---|---|---|---|---|---|
| A | Parlex | Electrolytic? | Apr 04 | Prod | OK in prod. |
| B | Parlex | Electroless | Sep 04 | Prod | Failed. |
| C | Parlex | Electroless | Nov 04 | Prod | Failed. |
| D | Dyconex | Electroless | Dec 04 | Test | Better but not good enough. |
| E1 | Parlex | Electrolytic (thin) | Jan 05 | Test | Testing now. |
| E2 | Parlex | Electrolytic (nominal) | Jan 05 | Test | Testing now. |
| F | Titan | Electrolytic | Jan 05 | Test | Testing now. |

Problem in Dec 04

Focus of current work

# Top Two Issues

- **Nickel plating process.**
  - **Electrolytic preferred over electroless plating.**
  - **We suspect Parlex switched process between Apr 04 and Sep 04.**

- **Stretching of PA by gluing fixture.**
  - **No change in process.**
  - **Bad practice all along.**

# Nickel Plating Process

- **Identified as the most important issue.**

- **Technical note from Merix Corp.**
  - **"Intrinsic to the electroless process is a significant amount of phosphorus (~8 to 11%) that is co-deposited with the nickel, which reduces the nickel ductility to < 1% elongation (i.e. it becomes much more brittle than pure nickel)."**
- **Similar advice from many other sources.**

- ***Know*** **"Sep 04" and "Nov 04" Parlex PA's are electroless.**
- ***Believe*** **"Apr 04" Parlex PA is electrolytic.**
- **Trying to confirm in two ways.**
  - **Traveler information.**
  - **Material analysis at GFSC.**

# Analysis at GFSC

- **SEM analysis of Dyconex PA.**
  - **Not Parlex for historical reasons.**

- **“It is clear, the electroless Ni, which is brittle and stiff, cracked first. The local stiffness decreased substantially due the cracking and cause the deformation of the copper layer to be localized around the cracked area and caused necking and fracture.”**

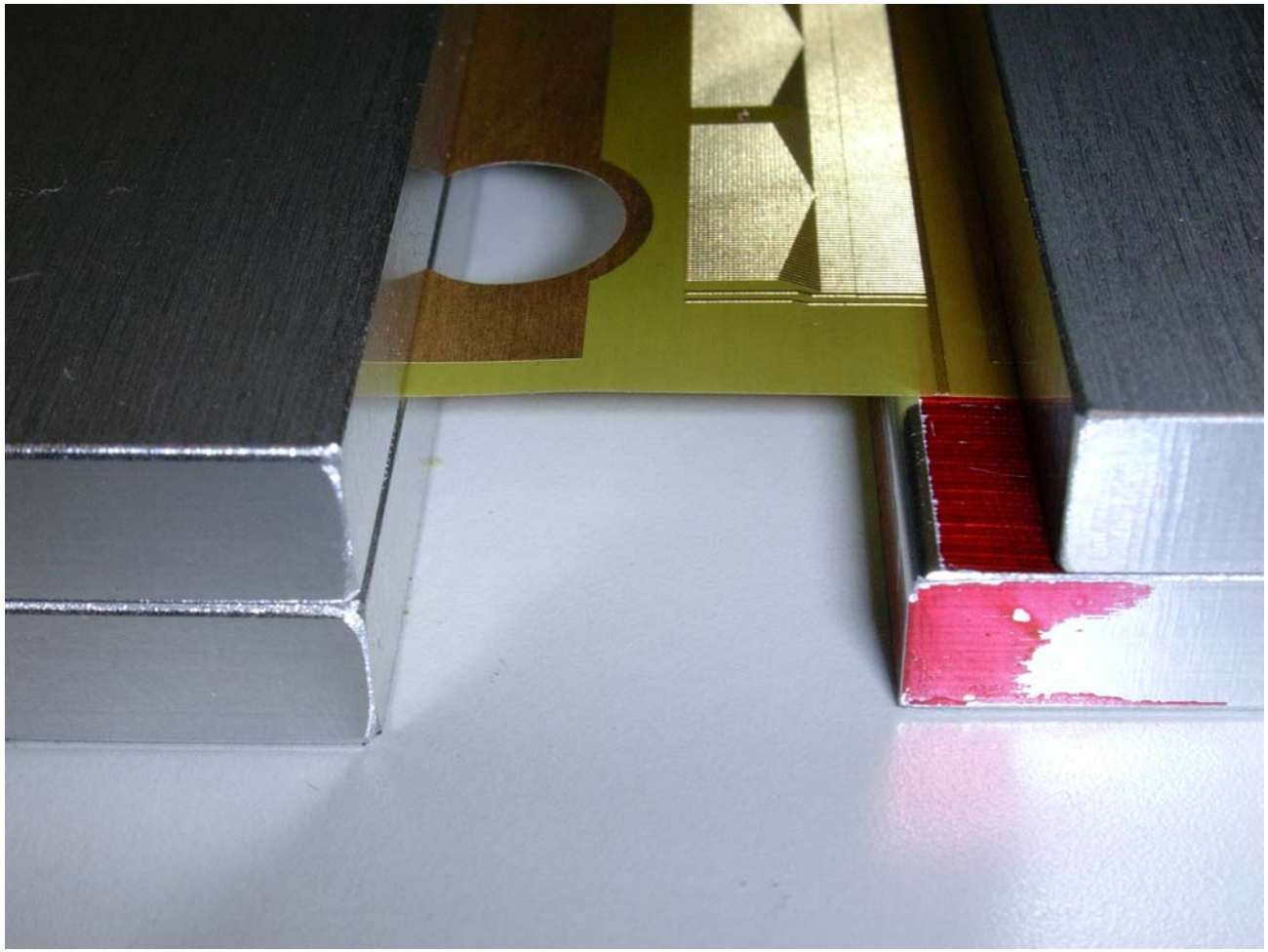
# Planned Nickel Plating Tests

- All comparisons so far used different vendors and/or batches.
  - Cannot exclude other changes.
- Get directly comparable parts.
  - Same run from one vendor.
  - Compare ability to conform to 1-mm radius.
  - Compare performance in bonding PA's to PWB's.
- New PA's from Parlex using both processes.
  - Electroplated version available since yesterday.
  - Electroless version next week.
  - Direct comparison not ready for this report.

# Tests of Nickel Plating

- Test electroplated PA's using 1-mm radius mandrel.
  - All electroless samples failed with massive cracking.
    - Parlex "Sep 04".
    - Parlex "Nov 04".
  - Tested 3 Parlex "Jan 05" electroplated samples.
    - One thin: 54 μin nickel.
    - Two thick: 129 and 158 μin nickel.
  - All 3 samples passed with no cracked traces.
- Two thick PA's also tested on 0.5-mm radius.
  - Pulled as hard as possible by hand.
  - Both samples passed with no cracked traces.
- Bonding test at Teledyne right now.
  - This is the acid test.

# Mandrel Test

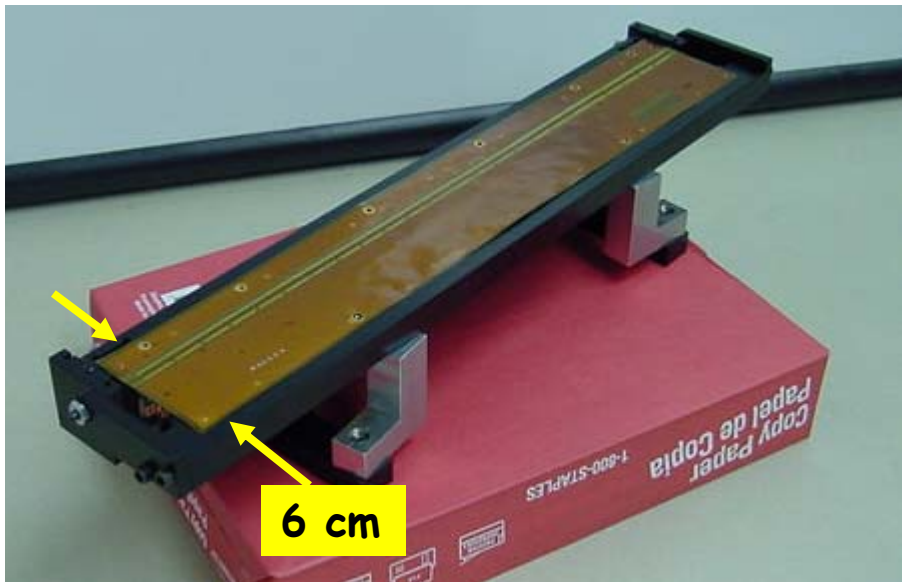


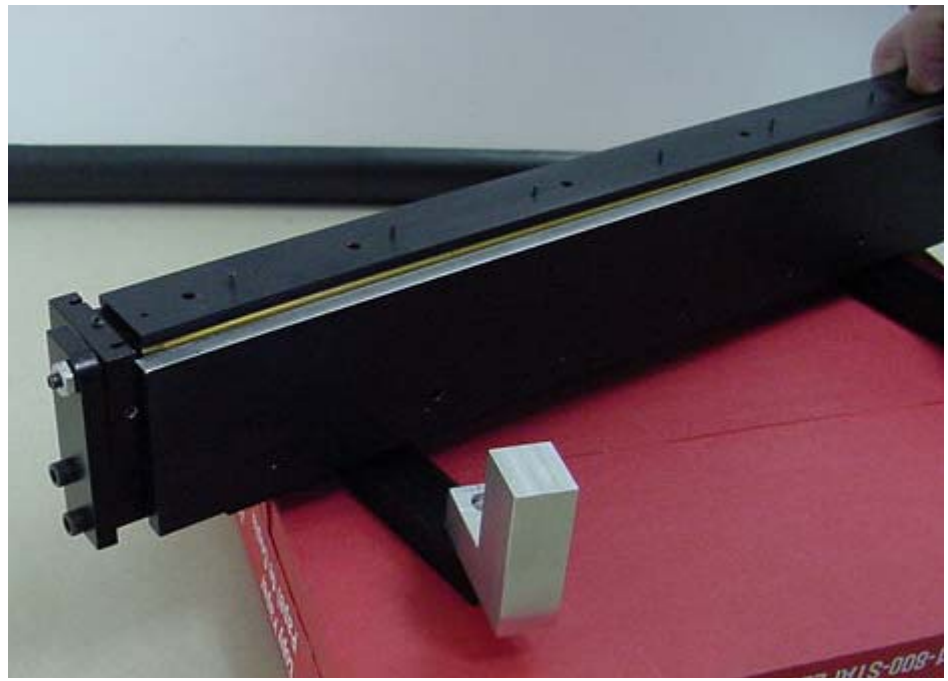
# Stretching of PA

- Identified as second in importance.

- Production fixture at Teledyne stretches PA by ~1.5 mm.
  - Consequence of fixture design.
  - Confirmed stretch in tests.
- Rejection rate ~O(20%) in early 2004 implies it is not an absolute killer.

# Teledyne Gluing Fixture



# Alternate Fixture

- Prototype G&A fixture does not stretch PA.
  - PA held in a mold.
  - Works well in tests.
  - But fixture has its own problems.
    - Alignment holes drilled through middle of PWB.
- Modified design.
  - Contract engineer.
  - Design review with Teledyne this morning.
  - Production drawings this week.
  - Fabricate and test fixture.

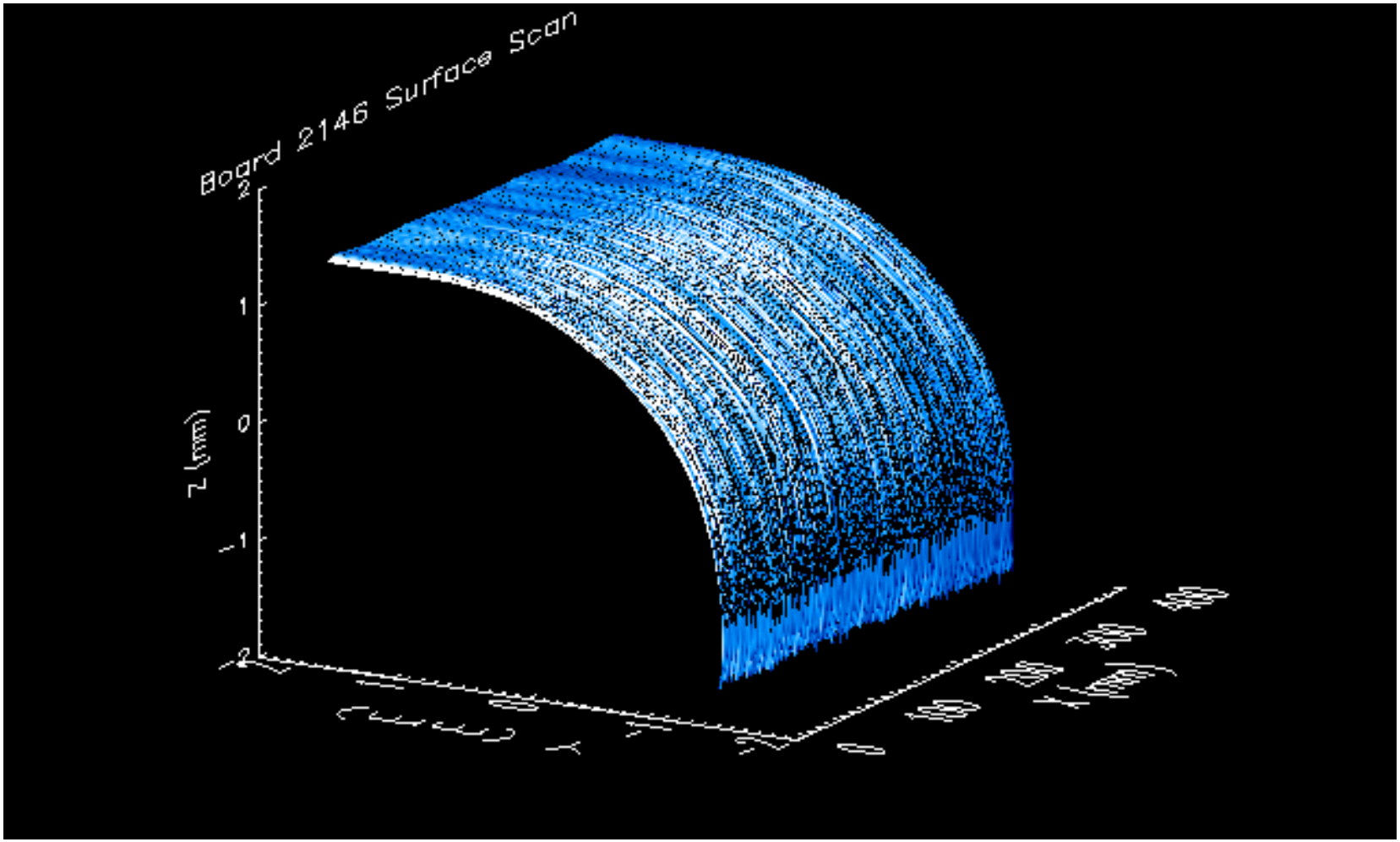
# Other Issues

- Investigated other potential causes of trace cracking.
- Excluded as reason for massive failures in MCM restart.
- Some may help improve yield after getting back to “Apr 04”.
  - Radius on PWB.
  - Plating on flexed part of circuit.
  - Slower plating speed.
  - Coverlay.
  - Grain direction in rolled annealed (RA) copper.

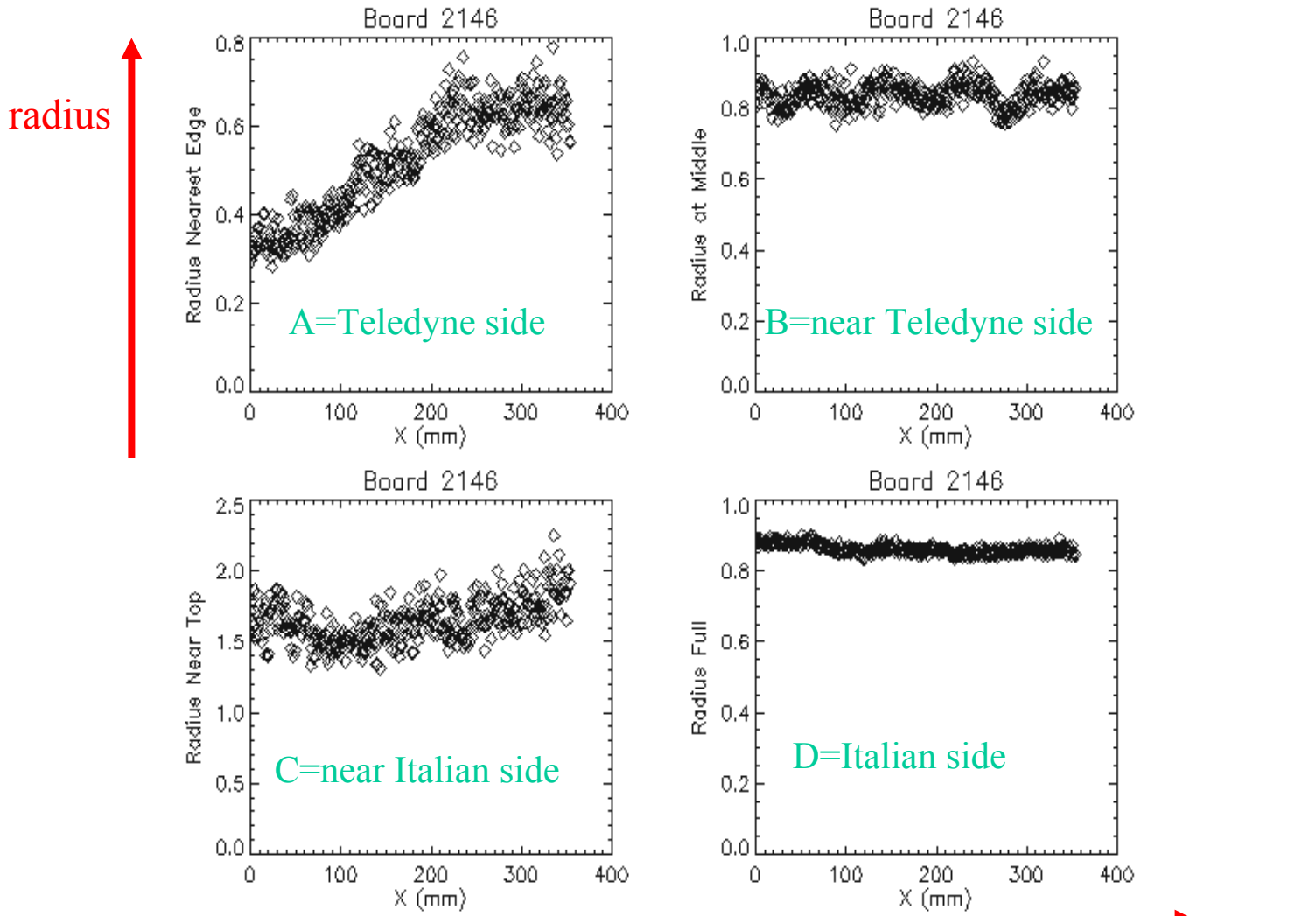
# Radius on PWB

- PWB cut to nominal 1-mm radius.
  - Some visual imperfections led to manual “deburring”.
  - Did we make them worse and hence break traces?
- Empirical test of deburred and undeburred PWB.
  - Same results from both.
- Detailed CMM measurements of ~10 boards.
  - Not perfectly 1-mm radius.
  - However, defects are small and not expected to be an issue.
- Stopped deburring.
- Will QC all flight parts prior to bonding.

# Radius Profile for S/N 2146



# S/N 2146 Radial Profile



# Nickel Plating Flex Portion

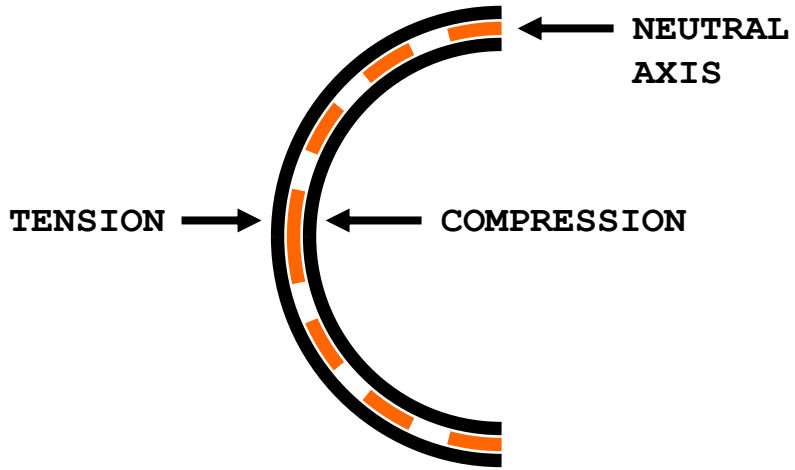
- Don't do it.
  - IPC 2223: "Nickel plating over the flexible section is not recommended due to its brittle nature."
  - Driven to it by manufacturability.
    - Nickel needed for wire bonding.
    - Bend area close by.
- Electrolytic process instead of electroless.
  - Yes!
- Keep it thin.
  - Requirements on nickel thickness from wire bonding.
  - Will test different nickel thickness after back to "Apr 04".
- Continue with electroplated nickel.

# Plating Speed

- Plating speed affects nickel ductility.
  - Faster => more brittle.
  - Slower => more ductile.
- Investigate manufacturing implications.
  - How slow is slow?
  - Is it within operating range of typical plating machine?
  - How controllable is it at this setting?

# Cover Layer

- Kapton-metal-Kapton structure.
  - Two Kapton layers under tension and compression.
  - Metal on neutral axis.
    - Minimize strain.
- Cannot cover entire circuit.
  - Need room for wire bonding.
- Difficult to cover just the flex region.
  - Manufacturability issues from alignment.
- Continue without coverlay.



# Copper Grain Direction

- Rolled annealed copper with parallel grain direction.
  - Handbook of Flexible Circuits: "RA copper is extremely directional, and maximum flexural fatigue resistance is achieved when circuits are layed out so that the copper grain structure is parallel to the bending direction."
- Parlex PA laid out perpendicular.
  - Better utilization of sheet material.
- Evidence that nickel initiated the crack.
- Will test parallel direction.
  - After getting back to "Apr 04".
- Continue with perpendicular grain direction for now.

# Priorities

- Top priority: get back to “Apr 04” as soon as possible.
  - Prove electrolytic nickel plating is root cause.
    - Bonding many PA’s at Teledyne right now.
  - Produce flight PA’s to restart MCM production.
  - In parallel, demonstrate no other problems.
    - Run through entire MCM production using test PA’s.
  - Restart PA and MCM production.
    - Parlex has raw material ready.
- Ensure it does not get worse again.
  - Document current processes, including plating.
  - Rigorous oversight of production process.
  - Other PA vendors as insurance policy.

# Priorities

- Improve yield at Teledyne.
  - Additional operational margin, e.g. new gluing fixture.
- Increase production rate.
  - Parlex plans to produce 50 per week.
  - Dyconex is similar.
    - Must first demonstrate good performance with electrolytic nickel plating.
  - Work with Teledyne on rate.

# Plan Forward: PA Trace Cracking

| PA Trace Cracking | Status | Who | Date |
|---|---|---|---|
| 1. Bond new Parlex PA to PWB | 1. In progress | RPJ/CCY | 1/28/2005 |
| 2. Document current process | 2. In progress | RG | 2/4/2005 |
| 3. Restart PA production | 3. Plan needed | RPJ/CCY | |
| 4. Oversight of PA production | 4. In progress | RG | On-going |
| 5. Demonstrate entire MCM production chain | 5. Plan needed | RPJ/CCY | 2/11/2005 |
| 6. Design new gluing fixture | 6. In progress | RPJ/CCY | 2/4/2005 |
| 7. Fab and test new fixture | 7. Need design | RPJ/CCY | 2/18/2005 |
| 8. PA from another source | 8. In progress | RPJ/CCY | 2/15/2005 |
| 9. Parallel copper grain direction | 9. In progress | RPJ/CCY | 2/11/2005 |