ATLAS PIXEL SYSTEM FLEX HYBRIDS

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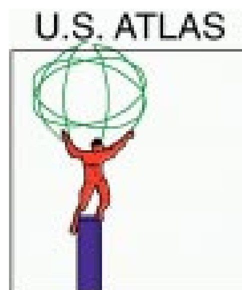
March 12, 1999



Outline

- CLEOIII Si3 Flex Experience
- First Flex Hybrid Prototypes 1.0
- Next Flex Hybrid Prototypes 1.x
- Flex Hybrids - What Is Known
- Flex Hybrids - What is Undetermined
- Second Flex Prototypes and Beyond
- Flex Hybrid/Module Test & Burn In
- Conclusion

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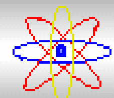

CLEOIII Si3 Flex Experience

- Fabrication is complete (General Electric Corporate Research and Development, Schenectady, NY)
  - 610 flex circuits delivered (6 designs)
  - Yields from 33% to 60 % by design type
  - Extrapolating to current ATLAS design -> 80% yield
- Flex wire bonding studies at Purdue and Cornell
  - 8 gmf typical wire bond strength
  - Only 3 failures in over 80k flex wire bonds so far (pad delamination)
  - All wire bonds are potted
  - Quality of bond can be evaluated visually

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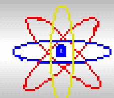
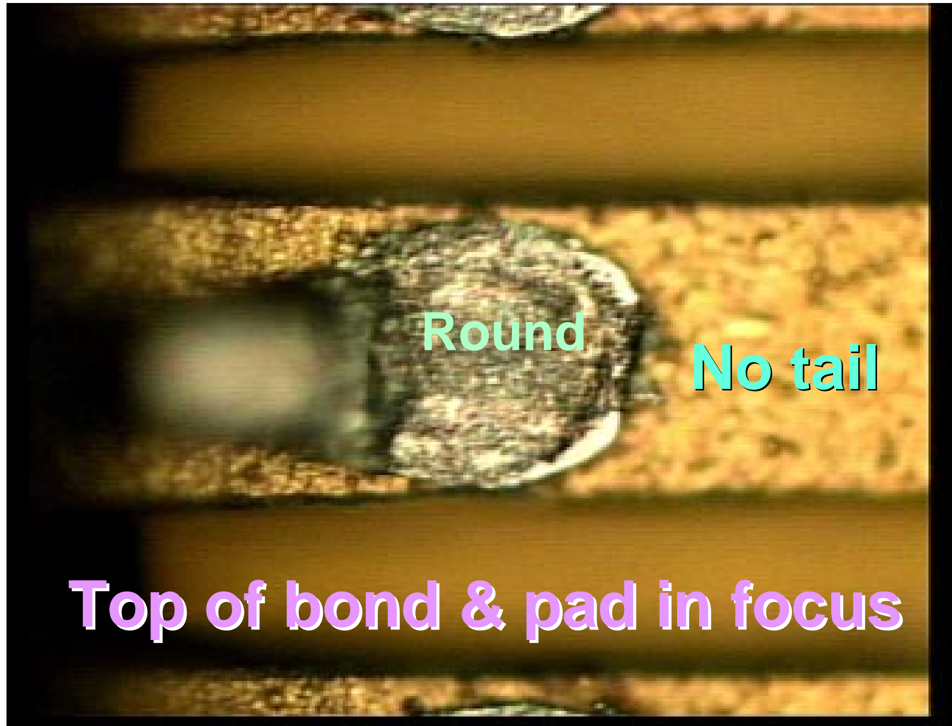


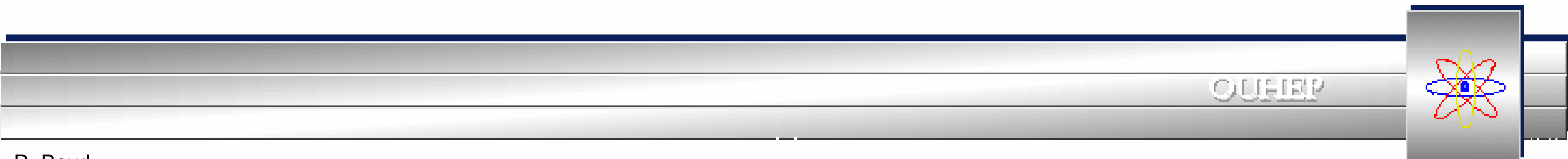
CLEOIII Si3 Flex Experience *(cont.)*

U.S. ATLAS



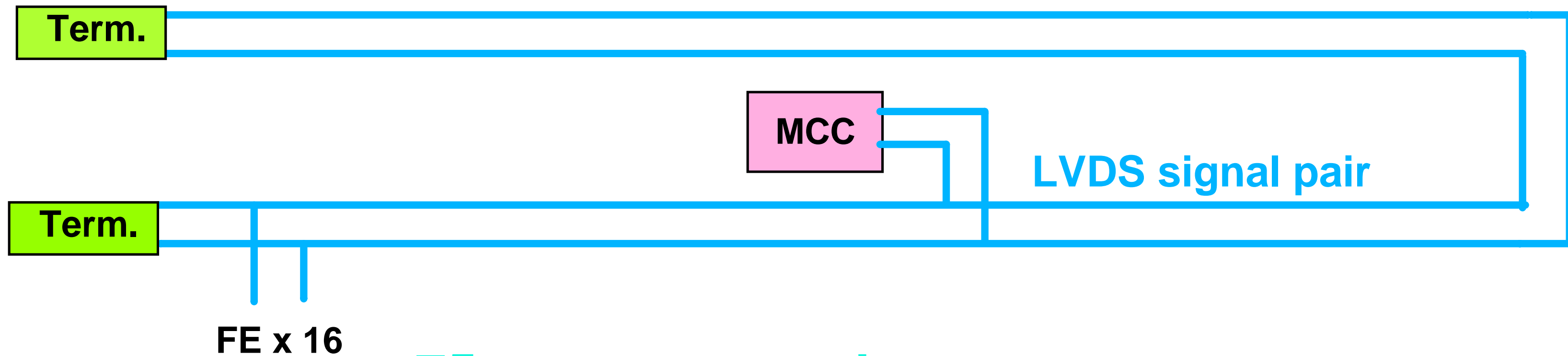
Smashed bond

Good bond



First Flex Hybrid Prototypes 1.0

- "U" buss signal layout



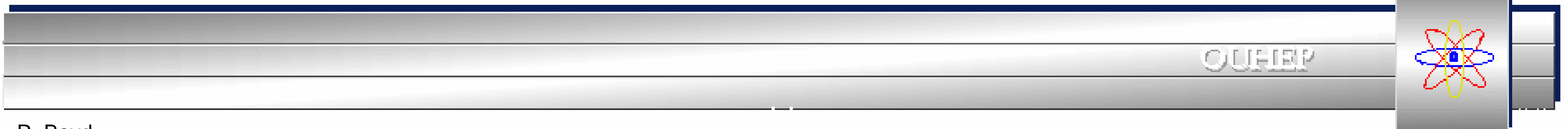
75 μm traces and spaces

90 μm via holes

130 μm cover pad

7 μm Cu, 2 μm Ni, 0.2 μm Au

Approx. 200 Ω LVDS impedance (unconfirmed)



First Flex Hybrid Prototypes 1.0 *(cont.)*

- Other features
  - **51 0402 capacitors for power decoupling**
  - 3 EIA "A" tantalum capacitors for power cable filtering
  - 14 0402 LVDS termination resistors
  - 16 solder pads at one end for signal I/O
  - 5 solder pads at opposite end for power
  - Supports MCC or MCC replacement chip
  - Hole for bias connection to back side of sensor under flex
  - Flex overhangs sensor by 0.5 mm on each side to provide protection from shorting and arcing to high voltage bias supply
  - **Fabricated at CERN**

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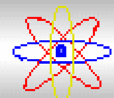


First Flex Hybrid Prototypes 1.0 *(cont.)*

Signal I/O pads

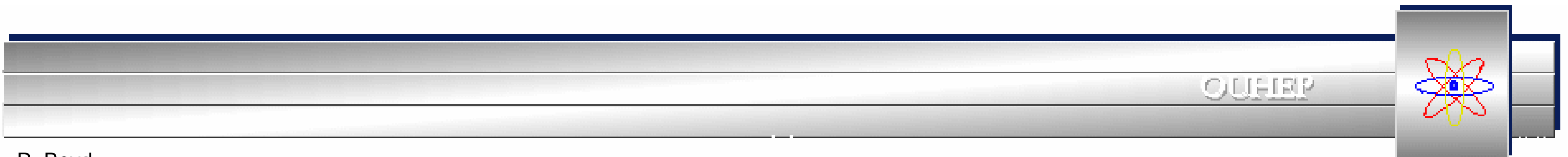
Power pads

MCC

Resistors

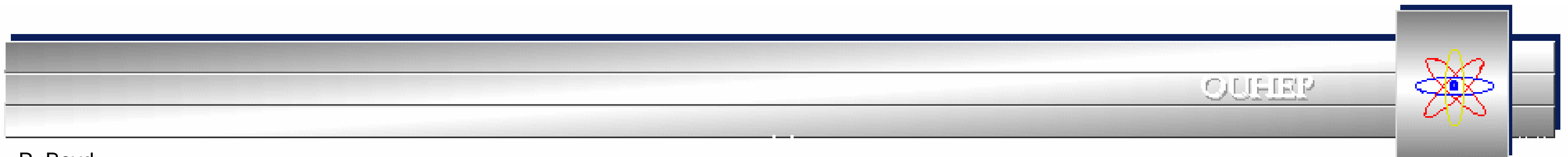
Tantalum capacitors

Flex Hybrid on Full Module



First Flex Hybrid Prototypes 1.0 *(cont.)*

- **Performance**
  - It works! Nothing found to date that indicates problems with the flex hybrid
  - Maximum voltage drop in power traces approx. 100 mV
  - Waveforms look good
- **Yield - of 28 delivered, know of two flex NOT zero defect**
- Surface mount component attachment
  - Solder (LBNL, Genoa)
  - Conductive adhesive (UOK)
  - Both seem to work acceptably
- 60 mm Kapton cover layer and adhesive on 1/2 of fabricated circuits



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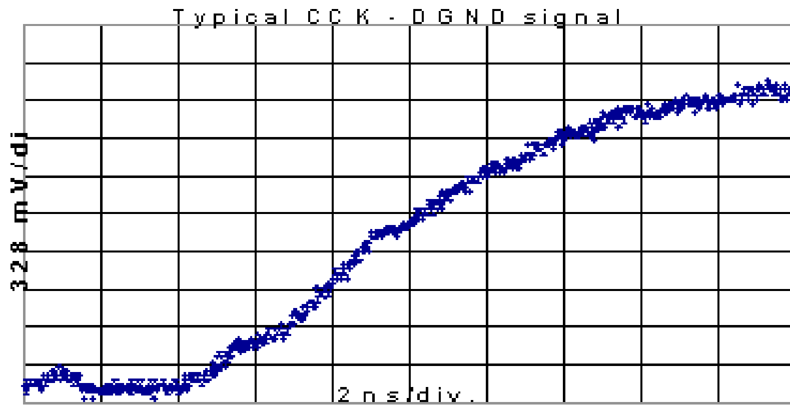
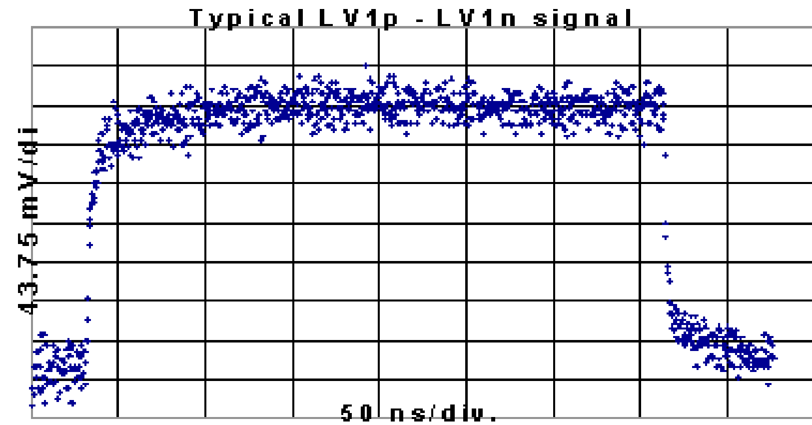
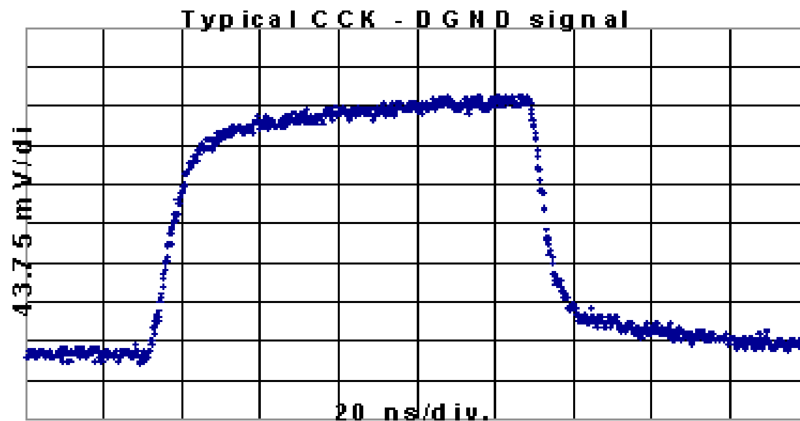
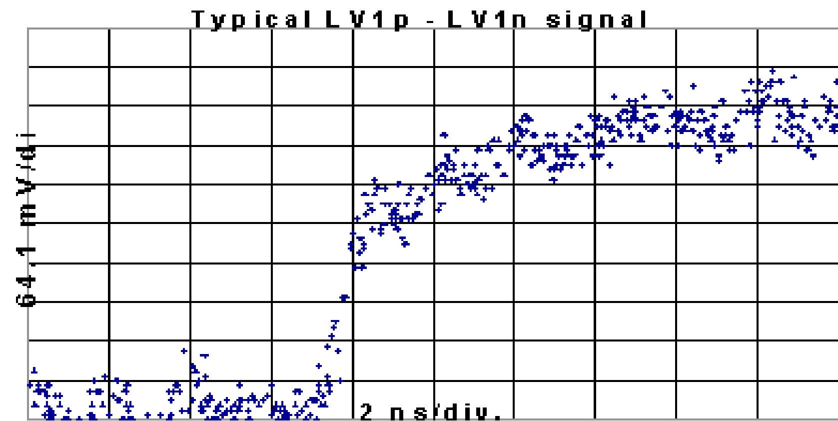
First Flex Hybrid Prototypes 1.0 *(cont.)*









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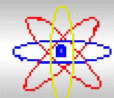
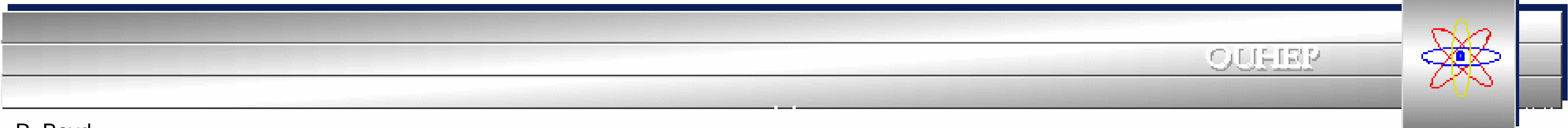


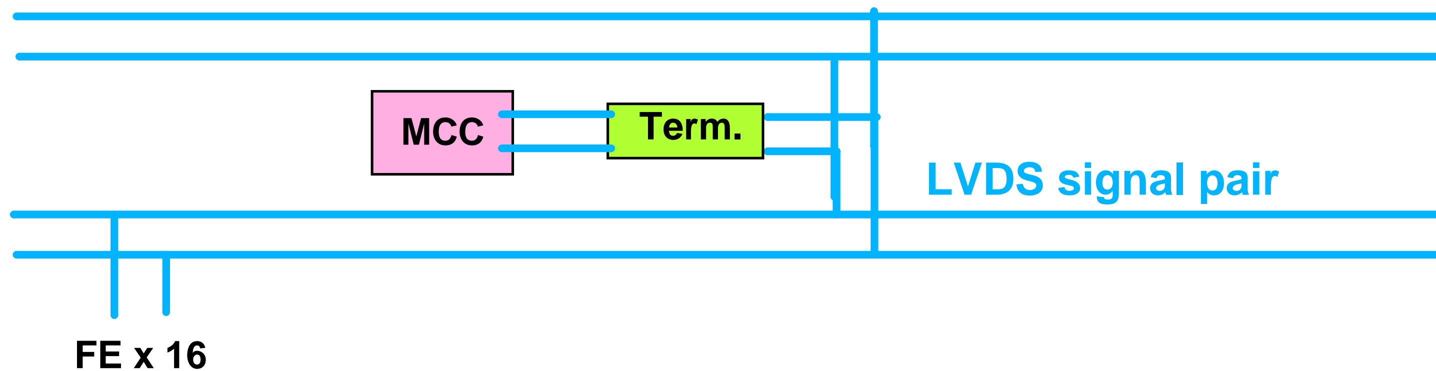
Next Flex Hybrid Prototypes 1.x

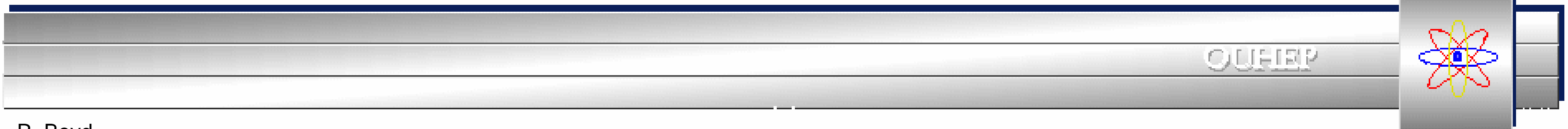
- Basic goals- enhance usability, performance & functionality
  - Improve usability
    - *Add Vcal buss*
    - *Modify sensor back side bias access*
    - *Route to allow wire bond rework*
    - *Min. 1.5 mm between MCC pads and corresponding pads on flex hybrid*
  - Improve power trace performance and enable tests with realistic power supplies and cables
    - *Use of space outside of bond pads for routing leaves space for wider traces*
    - *Addition of separate sensor bias return*
    - *Separate return pads for AVCC and AVDD*



Next Flex Hybrid Prototypes 1.x *(cont.)*

- Basic goals (*cont.*)
  - Make room for Optical Link
    - *Move 6 MCC LVDS terminating resistors to support card*
    - *Route with "H" buss topology - eliminate 4 LVDS terminating resistors (empirical tests show this should be possible, simulations in progress)*





Next Flex Hybrid Prototypes 1.x (*cont.*)

- Basic goals (*cont.*)
  - More flexibility to allow experimentation to optimize number of decoupling capacitors and their values
    - *Increase decoupling capacitor physical size to 0603*
    - *Modify tantalum capacitor pads to accept sizes down to 0603*
  - Include 1206 pads for Pt1000 and sensor bias decoupling capacitor
  - Add ground plane under MCC
  - Provide sighting holes through flex for fiducial markers on sensor
  - Add multiple vias for power busses

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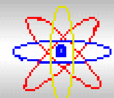
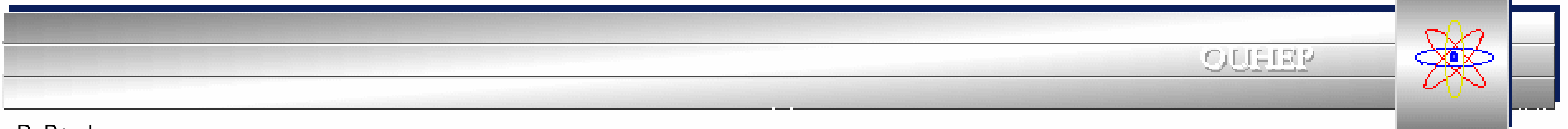


Next Flex Hybrid Prototypes 1.x (cont.)

- Still designed for board supported module
- Explore cover layer options with vendors
  - ★ Strenthens Flex Hybrid, protects traces
  - ★ Provides barrier for solder and conductive adhesive to nearby traces
  - ► 12 mm thickness top and bottom
  - ► Patterned bottom cover layer (hole for sensor bias pad on bottom)
  - ► Top pattern must be placed with ± 50 mm accuracy



Next Flex Hybrid Prototypes 1.x *(cont.)*

- Fabrication possibilities
  - **CERN**
  - **General Electric Corporate Research and Development (NY)**
  - **Dyconex (Zurich) - D0 experience**
  - **R & D Circuits (NJ)**
    - In house testing - deliver fully functional parts only
    - Can do component mounting?
    - Meets component side cover layer specs
    - Dual Au plating thickness' to optimize solder and bond pads
    - High purity Au plating -> 15 gmf wire bond pull strength
    - In house laser cutting (die cutting?)

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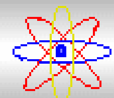

Flex Hybrids - What Is Understood

- "U" buss layout topology works well, but consumes too much space
- Preliminary tests indicate that change to "H" buss topology will not have an adverse affect on signal quality
- Design can be fabricated with less dense routing than CLEOIII required -> more vendors, lower cost
- Consistent, successful wire bonding to flex is possible
- Construction of working Flex Hybrid Modules is possible

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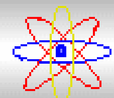

Flex Hybrids - What is Undetermined

- **Final size of first prototype Optical Link (Summer 99)**
- **Size of second generation MCC (late 99)**
- **Optimal decoupling strategy/power supply interface**
  - ***Electronics, especially FE-D (probably 1.x)***
  - ***Full length power cable (1.x)***
  - ***Realistic power supply (?)***
- Radiation studies (waiting at LBNL)
  - ***Conductive adhesive***
  - ***Passive components***
  - ***Thermaphase***
  - ***Coverlay materials (e.g., Pyralux)***

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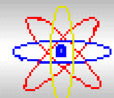
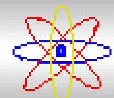


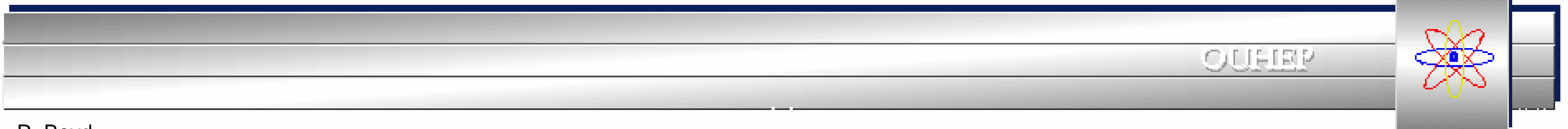
Flex Hybrids - What is Undetermined

- Mechanical studies - expansion and contraction on module (1999)
  - **Effects of humidity**
  - **Thermal properties**



Second Flex Prototypes and Beyond

- Prototype 2.0
  - Should not require board support
    - *Actual size*
    - *Optical link communication*
    - *Power cable configuration*
    - *Second generation MCC support*
- For prototype 2.x add:
  - Refinements from 2.0 experience
  - Support for second generation Optical Link & MCC
- Prototype 3.0 (preproduction)
  - Final positions for "tall" components (MCC, Optical Link)
  - Support for final electronics and Optical Link
  - Decoupling requirements finalized



Flex Hybrid/Module Test & Burn In

- Have identified 4 vendors who (claim they can*) test Flex Hybrids
  - *Microcontact (Berne) - tested first prototypes before NI/AU plating step*
  - *Zero Defects (CA)**
  - *Printed Circuit Technology (CA)**
  - *R & D Circuits (NJ)**
- Working with Albany to develop testing program for verification/QA of vendor testing
  - *Have completed (successfully) testing of CLEOIII flex*
  - *Began testing 1.0 this month*

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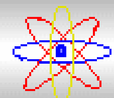
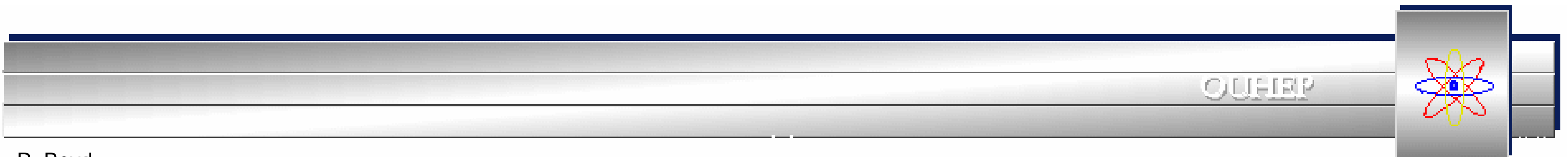
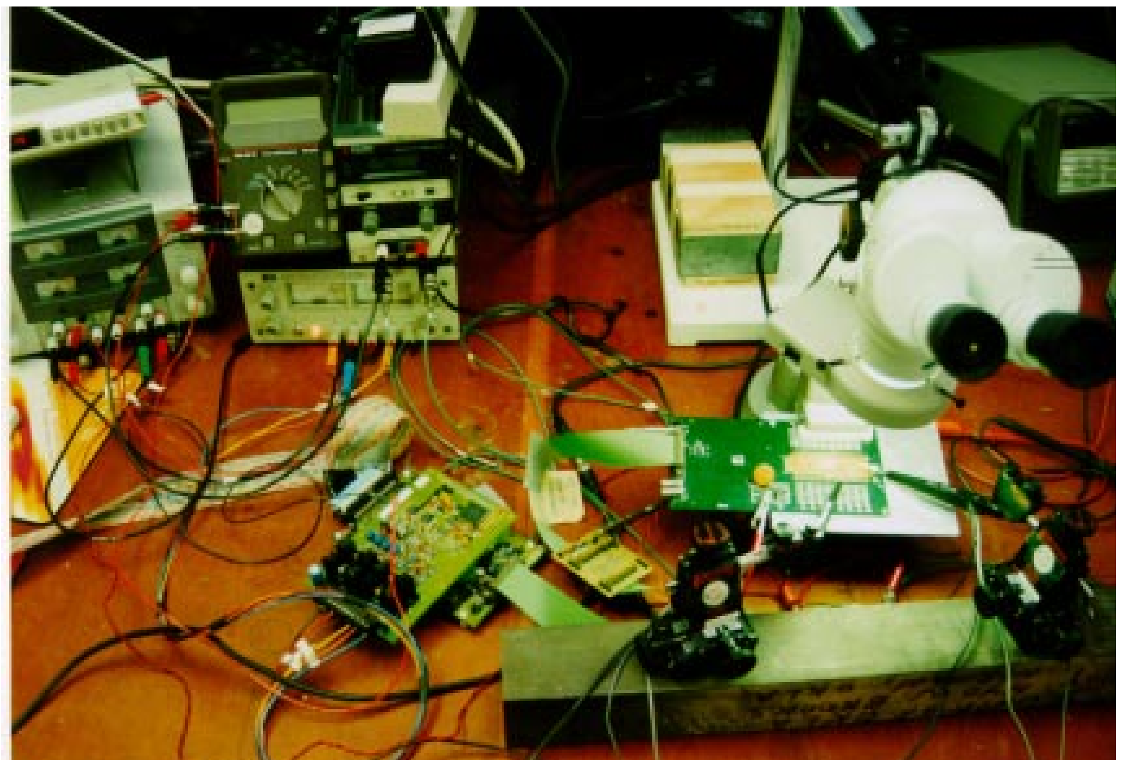
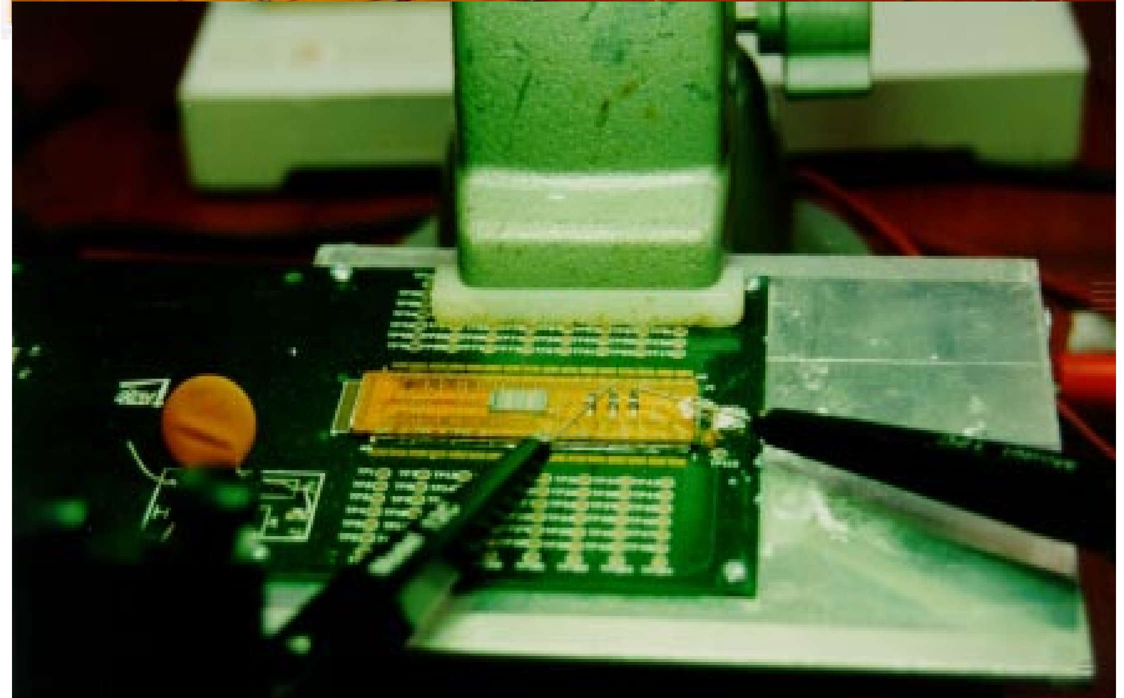


Flex Hybrid/Module Test & Burn In (cont.)

- Have set up and been using PixelDAQ test system at UOK since Oct. 98
    - *Windows NT PC*
    - *VXI crate*
    - *GPIB interface*
    - *PLL (LBNL) and PCC (Seigen)*
  - Langston lacks only PLL
  - Albany needs PLL and PCC
- **Module test, burn in and QA system design to begin after prototype 1.x design**







Conclusion

- First Flex Hybrid prototypes successful
- Design requirements within capabilities of more vendors - their numbers should continue to increase, costs going down
- Prototype 1.x design underway
- Reliable wire bonding to flex is possible
- Flex Hybrids appear to be an appropriate solution to module hybridization

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