



Electrical Testing at UCSB: Hybrids & Modules

Anthony Affolder

On behalf of the UCSB testing group

- Description of Testing Procedure
- Achieving Required Testing Capacity
- Major Accomplishments/Milestones
- Outstanding Issues



Testing personnel at UCSB

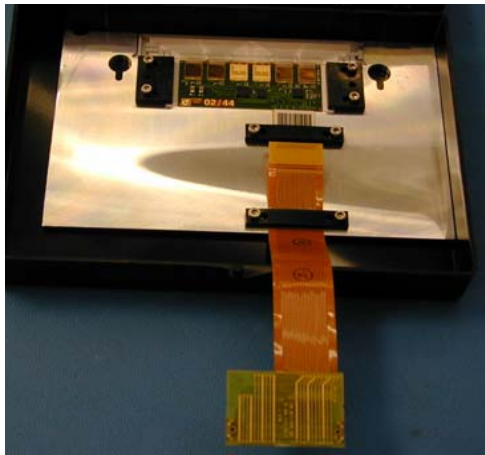


- **Professors**
 - ➔ Joe Incandela
 - ➔ Claudio Campagnari
- **Post-docs**
 - ➔ Anthony Affolder
 - ➔ Patrick Gartung (UC-Riverside)
(now post-doc @ Northwestern University)
- **Graduate Students**
 - ➔ Ford Garberson
- **Electrical Engineering Support**
 - ➔ Sam Burke
- **Mechanical Engineering Support**
 - ➔ David Hale
(retired)
 - ➔ Dean White
- **Undergraduates**
 - ➔ Derek Barge (B.S. Physics)
 - ➔ Chris McGuinness (B.S. Physics)
 - ➔ Lance Simms (B.S. Physics)
(now grad. stud. at Stanford University)
 - ➔ Adam Crook (EE major)
 - ➔ Julia Lundy (Physics major)
 - ➔ Taniel Naxon (Physics major)
 - ➔ Milan Nikolic (Physics major)
 - ➔ Jingtian Yu (Physics major)

Joined group since January, 2004

Left group since January, 2004

Hybrid Testing Cycle



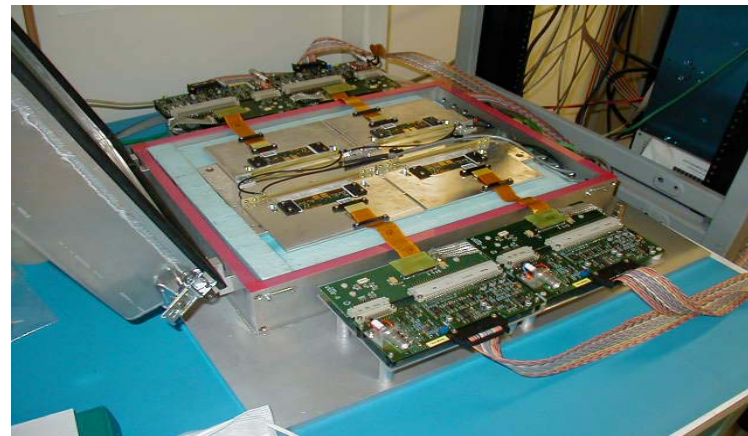
Mount/Inspect hybrids (30/day)



Wire bond PA (30/day)



Assemble into modules (30/day)



Thermal cycle hybrids (30/day)

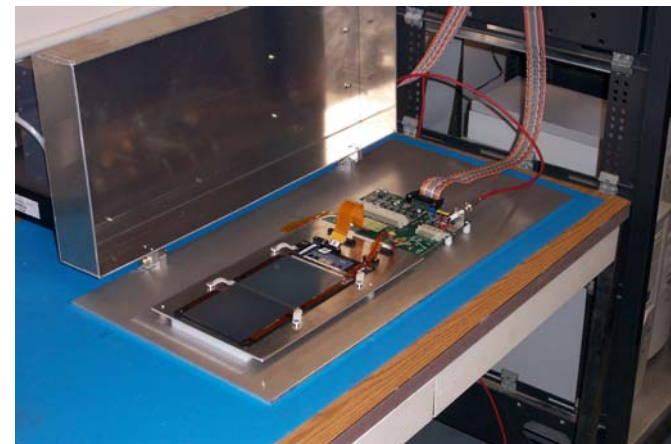




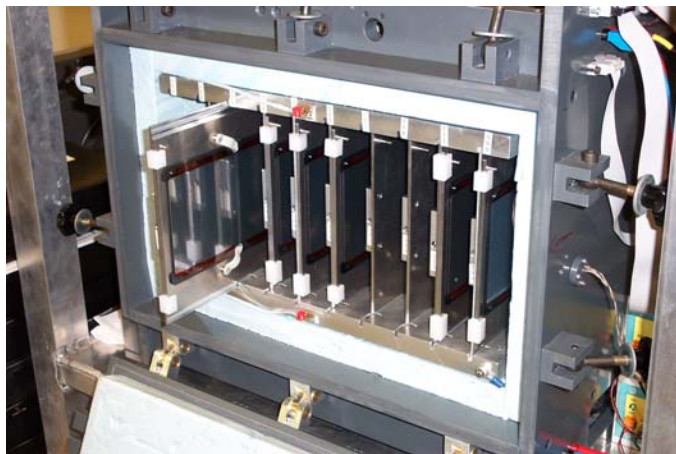
Gantry makes modules (30/day)



Wire bond modules (30/day)



Module ARCS test (30/day)



Thermal cycle modules (20/day)





Achieving Testing Capacity Needs



- Over the last year, the required peak production rate at UCSB has increased from 15 to 30 modules/day
- In order to achieve and to sustain this level of production, we have done the following:
 - ➡ Increased uniformity of testing
 - ➡ Increased testing efficiency
 - ➡ Improved clean room logistics
 - ➡ Decreased test stand downtime
 - ➡ Prepared for quick recoveries from failures



Increased Uniformity



- Detailed procedures have been written for all aspects of testing
 - 7 different procedures
 - Ultimately streamlined the testing process
- Training of new personnel
 - Only one person per procedure is qualified to train others, for consistency and to establish a clear line of authority and responsibility
 - Because of this uniformity, new problems are quickly identified
- The procedures incorporate the integrated experience of 2 years of testing
 - Continuously updated with new knowledge
 - Quicker diagnosis of problems



Increased Efficiency (1)



- Increased the speed and automation of testing
 - ⇒ Can match new production rates with existing test equipment
- Hybrid Testing
 - ⇒ Reduced time from 50 to 30 minutes for 4 hybrids
 - Streamlined testing and data handling
- Module ARCS testing
 - ⇒ Reduced testing time from 45 minutes to 20 minutes
 - Streamlined queries for module component information
 - Integrated HV supply into the system
 - Beta tested of the ARCS software

- **Module Thermal Cycling**

- ➔ Efficiency improved by ~20%

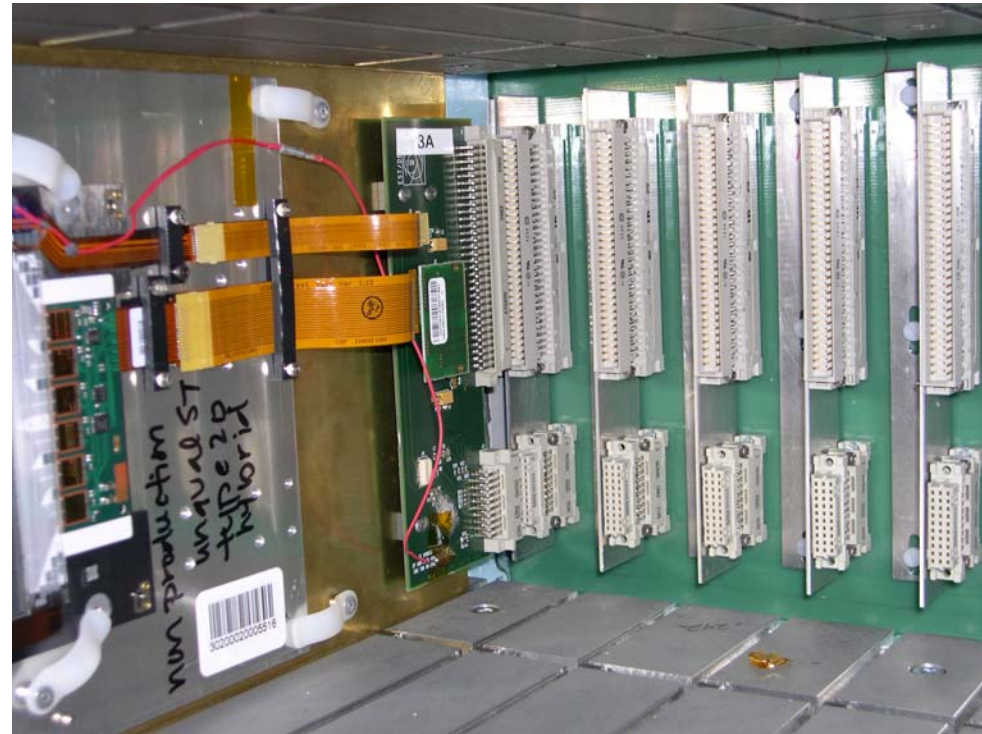
- Mechanical improvements

- ➔ Data handling improved

- Automatic data qualification
 - Analysis scripts written to generate database files and plots

- ➔ Work is still in progress

- Increasing capacity of stand from 16 to 20 modules/day
 - Reducing the rate of false bad channel flags





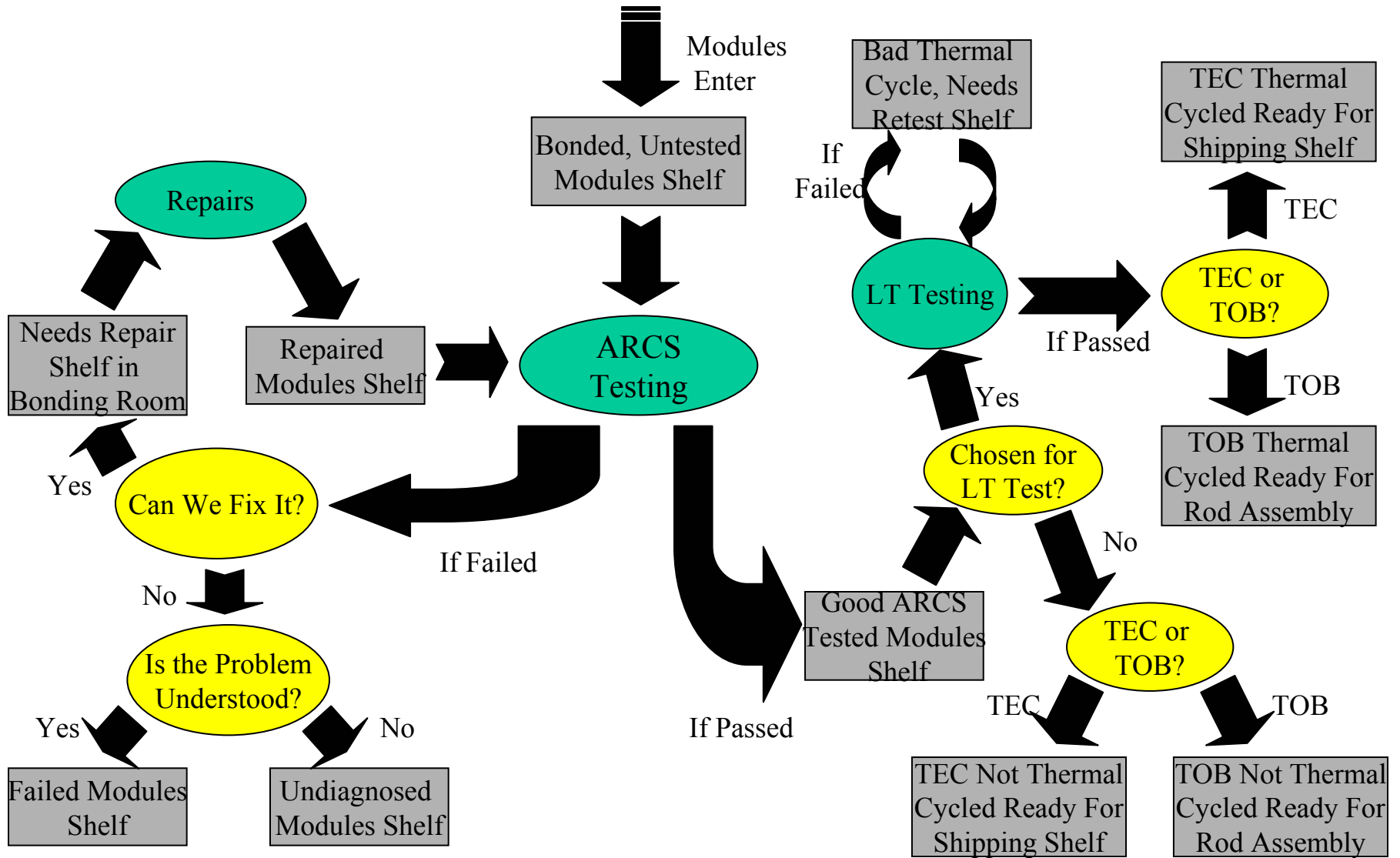
Improved Clean Room Logistics



- Testing room layout changed significantly to handle higher rates
 - ➡ Storage capacity has more than doubled
 - Each testing step has storage for at least 2 days of production
 - ➡ Stands moved to improve part flow in/out the testing room
- Plan made for increased flow of parts
- Programs to track the progress of the components have been strengthened to handle the increased load
 - ➡ An automated report of the test results per week is being developed for each test type.



Module Testing Flowchart





Decreased Test Stand Downtime



- **Identified all potential failure modes for our stands**
 - DAQ equipment, cables, Vienna box, chillers, HV, etc.
 - Contacted the sources of these components to get all the spares we need
- **Wrote a testing operations/failure analysis document**
 - Available at “Testing Operations and Maintenance” under “Documents” on the UCSB CMS website
 - Exercise extremely useful; greatly reduced the chance of major downtime
 - The failure analysis exercise was very highly regarded by CERN management and now all major production groups have since been asked to carry out similar exercises



1 Day Time Trial



- **Goal**

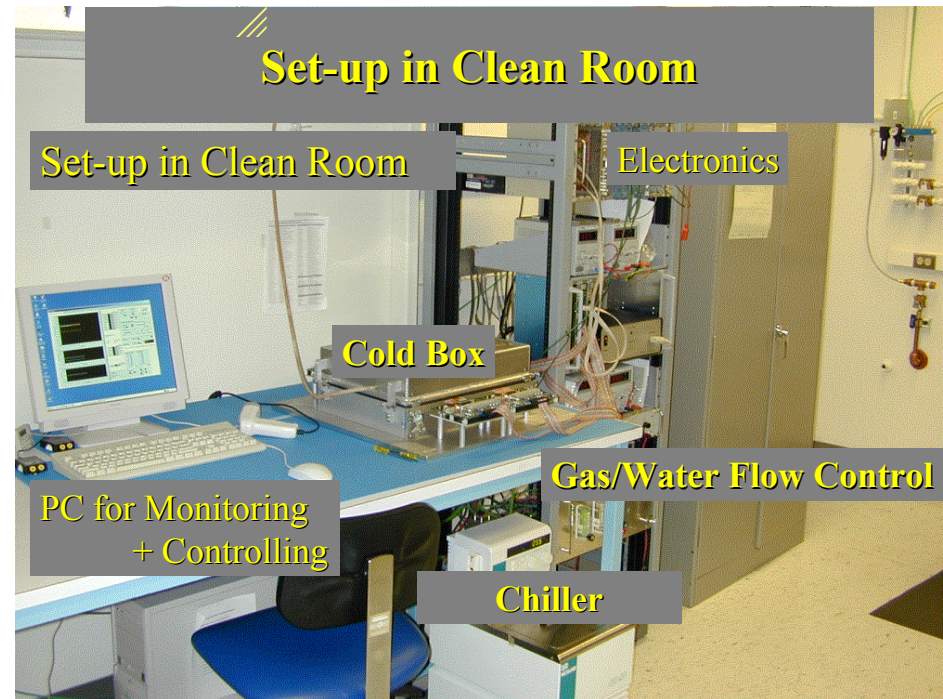
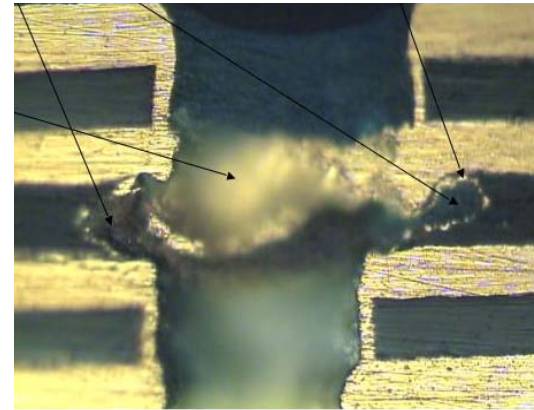
- To see if a testing rate of 30 hybrids/modules per day can be comfortably sustained at UCSB

- **Results**

- All hybrids and modules completely tested in a standard 8 hour day
 - Only used 2 of 3 module test stands available
 - Further reductions of testing times have been accomplished since the trial
- Found that having full complement of testers in the room at one time actually improved efficiency and communication
 - We were able to solve problems faster by shifting manpower and using the integrated experience of all the testers

REQUIRED TESTING THROUGHPUT IS SUSTAINABLE

- Over 1200 hybrids and 400 modules tested
- Played an important role in the ST silicon decision
- Discovered hybrid via problem
- Leading the encapsulation study
- Qualification of new hybrids and HPK silicon
- Built/qualified/shipped hybrid thermal cyclers to FNAL and Mexico City





Module Quality



- Goal of less than 1% faulty channels per module
 - ST Sensor Modules
 - 0.55% Faulty Channels Per Module
 - Production introduced faults at less than 0.1% rate
 - With HPK Sensors, <0.1% Faulty Channels
 - Only 21 Modules Tested So Far
- Over 400 modules produced with industrial methods with historically low rate of faulty channels
 - Made possible by the design of the modules which emphasizes robustness and simplicity



Outstanding Issues



- Qualifying modules built with new HPK sensors
- Qualifying the new testing protocol of the 4 hybrid thermal cycler, which reduces test times by 20 minutes
- Increase the capacity (16 to 20/day) and increase the automation of the Vienna Box
- Finish acquiring spares in order to reduce potential test stand down-time



Summary



- **Very eventful year with a great deal accomplished!!!**
 - Through careful testing, we discovered a potentially serious problem with hybrids
 - Produced a failure analysis study
 - Reduces potential downtime of test stands
 - Added manpower for increased production rates
 - Increased testing throughput of parts from 15 to 30 units/day

We are ready for production