Electrical Testing at UCSB: Hybrids & Modules

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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)
  - Tariel 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)
Module Testing Cycle

- Gantry makes modules (30/day)
- Wire bond modules (30/day)
- Thermal cycle modules (20/day)
- Module ARCS test (30/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

Can We Fix It? Yes

Repairs

Needs Repair Shelf in Bonding Room

If Failed

Bad Thermal Cycle, Needs Retest Shelf

Chosen for LT Test?

Yes

TEC Thermal Cycled Ready For Shipping Shelf

TEC or TOB?

No

TOB Thermal Cycled Ready For Rod Assembly

LT Testing

If Passed

Good ARCS Tested Modules Shelf

TEC or TOB?

If Failed

Repairs

Repaired Modules Shelf

Can We Fix It? No

Is the Problem Understood?

Yes

Failed Modules Shelf

No

Undiagnosed Modules Shelf

ARCS Testing

Modules Enter

Bonded, Untested Modules Shelf

TEC Thermal Cycled Ready For Shipping Shelf

TEC or TOB?

TOB Thermal Cycled Ready For Rod Assembly

TEC

TOB
• 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**
Major Accomplishments/Milestones

- 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