



# US Hybrid/Module Testing Update

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For the US CMS tracker group

Current Hybrid/Module Testing Results  
LT Testing Results  
Expect Testing Throughput  
Potential Bottlenecks



# Hybrid Testing Results

Two major changes made to hybrid thermal cycling systems

- Both sites updated computer to industrial PC
  - Testing time reduced from 45 to 35 minutes
- FNAL has replaced Peltier element
  - Now constantly monitoring the peltier status

19 of the 81 failures are due to scratches in the PA which should be repairable

|              | Cumulative  |           | % Pass        |
|--------------|-------------|-----------|---------------|
|              | Pass        | Fail      |               |
| L12su        | 270         | 1         | 99.63%        |
| L12sd        | 143         | 1         | 99.31%        |
| L12pd        | 333         | 3         | 99.11%        |
| L34p+L12pu   | 1369        | 19        | 98.63%        |
| L56p         | 1735        | 24        | 98.64%        |
| R2N          | 103         | 2         | 98.10%        |
| R2S          | 158         | 6         | 96.34%        |
| R5N          | 317         | 3         | 99.06%        |
| R5S          | 440         | 11        | 97.56%        |
| R6           | 506         | 10        | 98.06%        |
| R7           | 243         | 1         | 99.59%        |
| <b>Total</b> | <b>5617</b> | <b>81</b> | <b>98.58%</b> |



# ARCS Testing Results

ARCS testing is proceeding very smoothly at both sites

Tests take ~20 minutes and are completely automated

- 1 technician can run 3 stands simultaneously
  - Not sustainable for an extended period of time

**We are over halfway through module production in US!!!**

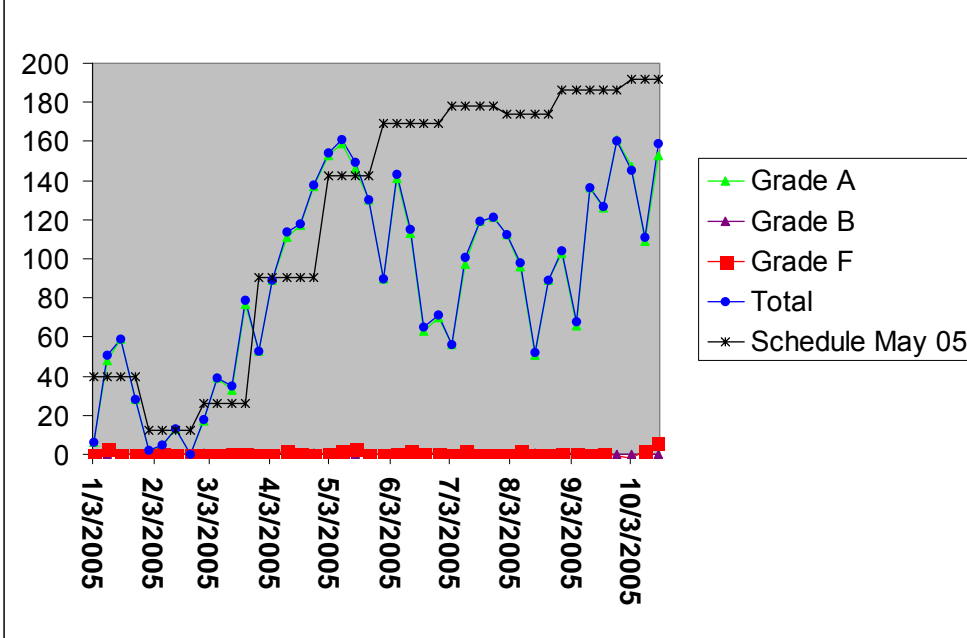
- 55% of TOB finished
- 41% of US TEC finished

|              | Cumulative  |           |           | % A or B      |
|--------------|-------------|-----------|-----------|---------------|
|              | A           | B         | F         |               |
| L12pu        | 180         | 0         | 1         | 99.45%        |
| L12pd        | 297         | 0         | 0         | 100.00%       |
| L12su        | 128         | 1         | 3         | 97.73%        |
| L12sd        | 75          | 0         | 0         | 100.00%       |
| L34p         | 789         | 4         | 9         | 98.88%        |
| L56p         | 1371        | 5         | 13        | 99.06%        |
| R5N          | 155         | 1         | 4         | 97.50%        |
| R5S          | 172         | 0         | 1         | 99.42%        |
| R6           | 309         | 0         | 0         | 100.00%       |
| R7           | 165         | 0         | 1         | 99.40%        |
| <b>Total</b> | <b>3641</b> | <b>11</b> | <b>32</b> | <b>99.13%</b> |

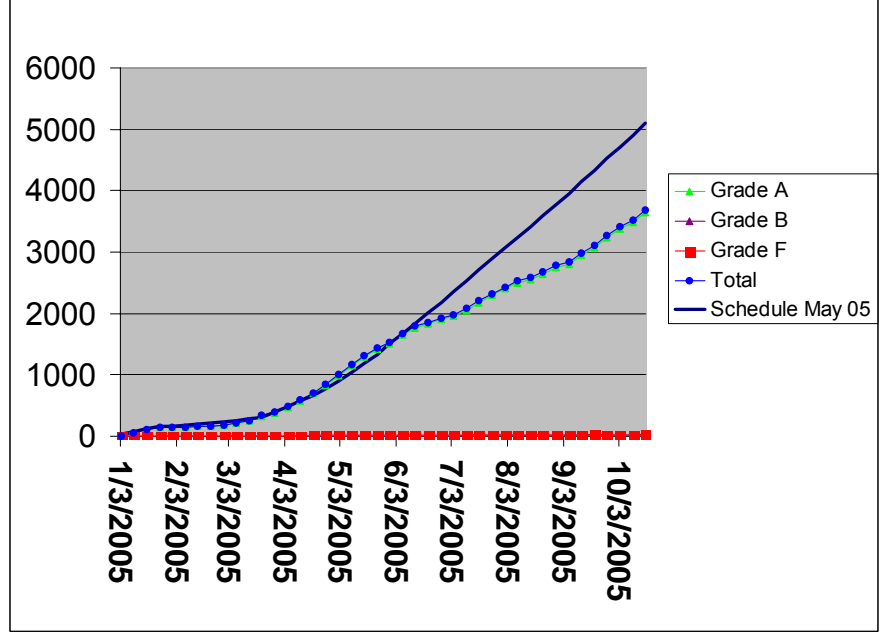


# US ARCS Testing Rates

Weekly US HPK Modules Tested



Total US HPK Modules Tested



3684 Total Tested

- 3641 Grade A
- 11 Grade B
- 32 Grade F



# US Backplane Bias Repair Testing

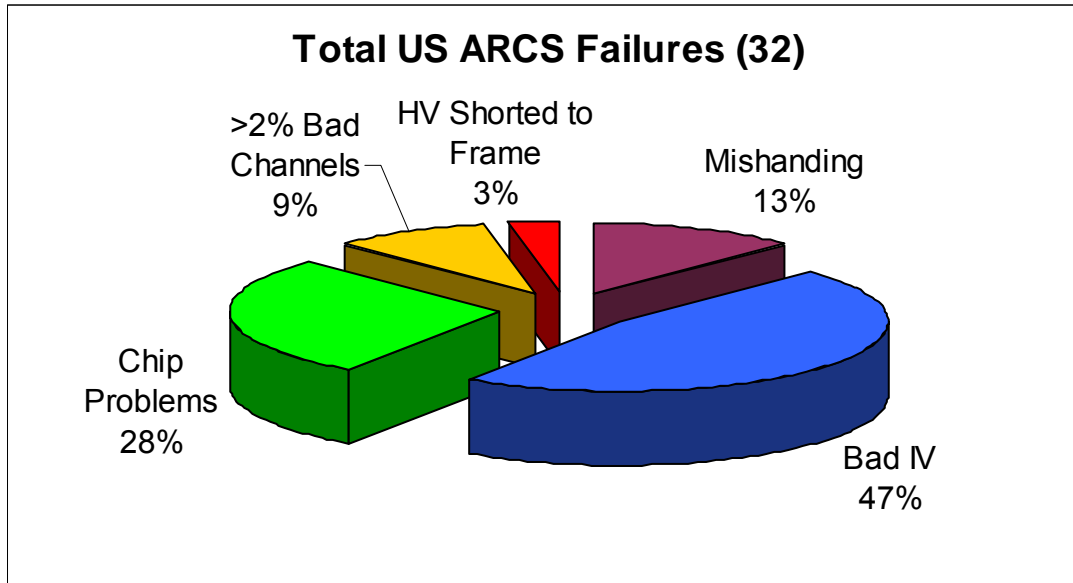
To improve the reliability of the backplane bias connection modules have been modified

- For TEC modules, wire bonds are added to gold pads that are available on the frame
  - All TEC modules in US have been backplane bonded with no additional failures
- For new TOB modules, we have soldered a gold-plated mylar tab to the frame
  - Fault rate has not increased
- For old TOB modules, we must make a modification
  - See module production talk
  - About 2300 modules still need retrofit

|              | Cumulative  |          |          | % A or B      |
|--------------|-------------|----------|----------|---------------|
|              | A           | B        | F        |               |
| L12pu        | 168         | 0        | 1        | 99.41%        |
| L12pd        | 152         | 0        | 0        | 100.00%       |
| L12su        | 99          | 0        | 2        | 98.02%        |
| L12sd        | 39          | 0        | 0        | 100.00%       |
| L34p         | 7           | 0        | 0        | 100.00%       |
| L56p         | 99          | 0        | 1        | 99.00%        |
| R5N          | 93          | 0        | 1        | 98.94%        |
| R5S          | 132         | 0        | 1        | 99.25%        |
| R6           | 188         | 0        | 0        | 100.00%       |
| R7           | 114         | 0        | 0        | 100.00%       |
| <b>Total</b> | <b>1091</b> | <b>0</b> | <b>6</b> | <b>99.45%</b> |



# Module Failure Sources



Chip Problems (9)-Various DCU and APV failures. Most missed in hybrid testing

Bad IV (15)-Most show damage to sensor-not clear when it occurred

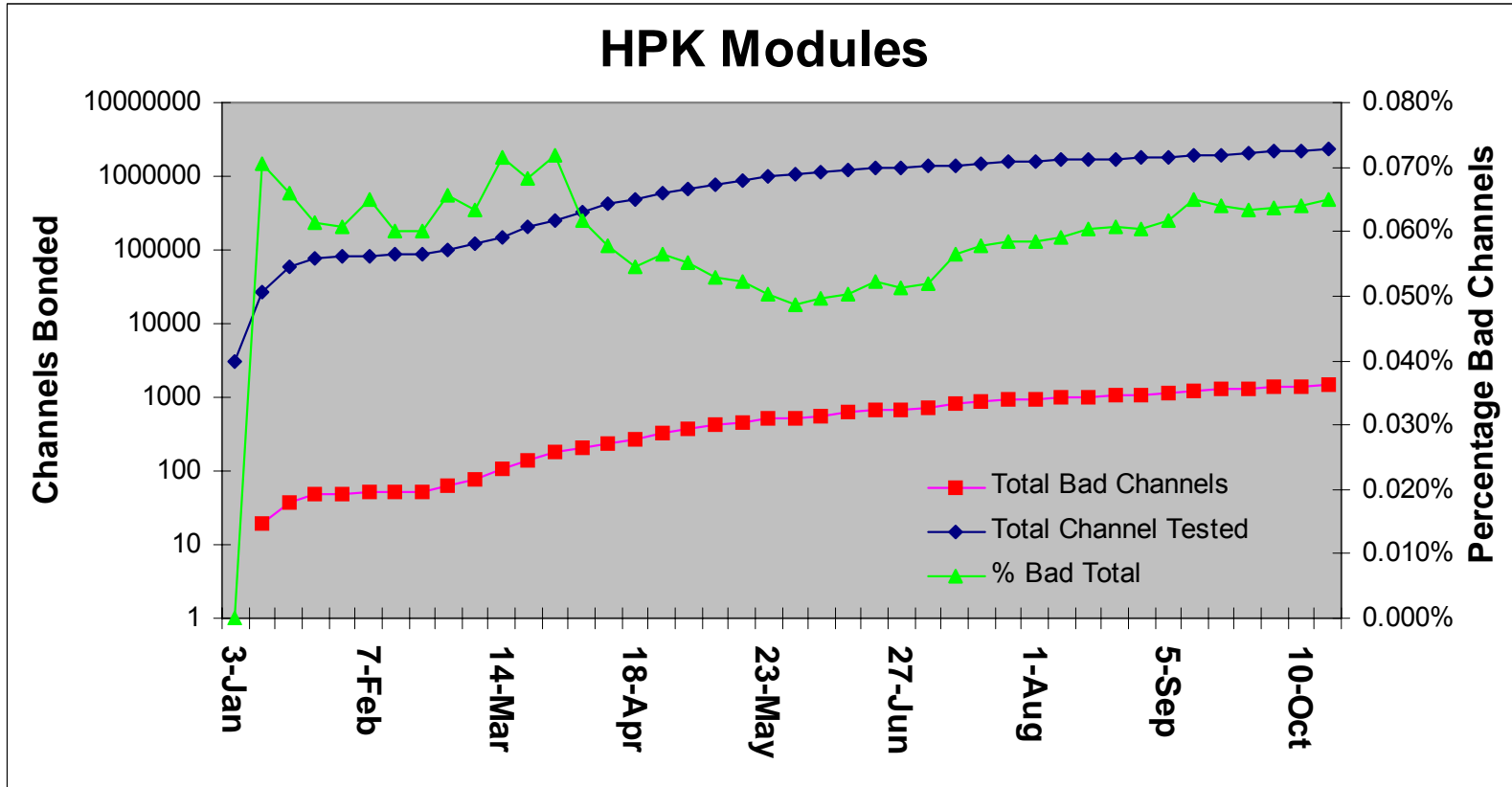
HV Shorted to Frame (1)-Not repairable

>2% Bad Channels (3)-All due to wire bonding errors

Mishandling (4)-Both occurred early in production



# Module Quality



A total of 1488 bad channels in the 2292728 bonded (0.065%)

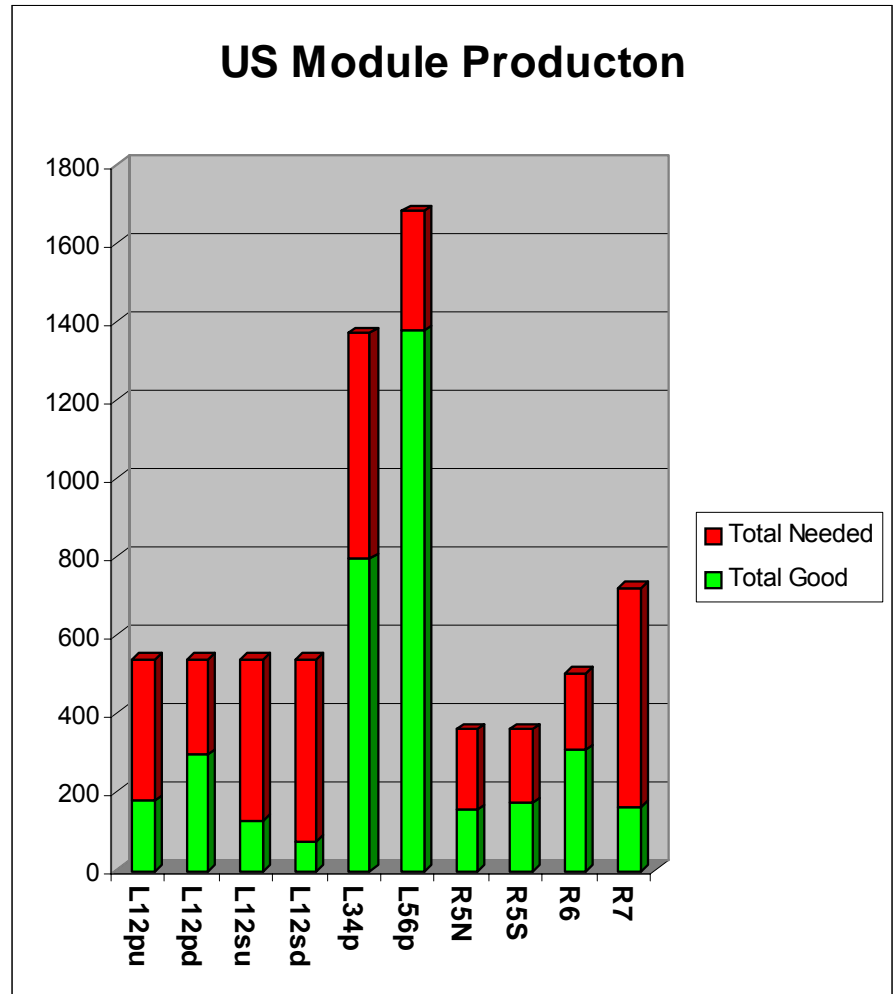
- Most failures introduced caused by either the wire bonder losing wire or during channel repairs



# US Production Status

Significant fraction of modules of all types built:

- L12pu: 33% finished
- L12pd: 55% finished
- L12su: 24% finished
- L12sd: 14% finished
- L34p: 58% finished
- L56p: 82% finished
- R5N: 43% finished
- R5S: 48% finished
- R6: 61% finished
- R7: 23% finished





# Hybrid Testing Throughput and Potential Bottlenecks

With the recent computer upgrades of the hybrid thermal cycler, we can test 40-48 hybrids/site/day

- Last week FNAL tested 171 hybrids (48 on Friday alone)
  - Mexico City has not yet begun any hybrid work

These rates easily outpace the needs of high rate module production

Equipment failure is the only potential bottleneck for hybrid testing

- We have already acquired spares of all long lead time items: computers, peltier elements, chillers, etc.
- We do not have ARCS equipment spares
  - If there was a failure, we would take the needed part from one of our ARCS module testing stations, and request a replacement component from Aachen. In past, we have always received the replacement within 1-2 weeks



# ARC Module Testing Throughput and Potential Bottlenecks

With current equipment, UCSB can test 50-60 modules per day and FNAL can test 60-70 modules per day

- UCSB has tested 150 modules in one week (45 in one day)

These rates easily exceed the needs of high rate module production even with the additional testing needed for retro-fitting TOB modules

Equipment failure is the only potential bottleneck for module testing

- Again, we do not have spare ARCS equipment
  - If there was a failure, we would still be able to keep up with production.



# LT Testing

We have LT tested almost all of the modules produced in the US

With about half of the total production tested, we find only a 0.09% failure rate during LT tests

We want to go to sampling LT testing of modules (10 modules/day/site)

- modules will be thermal tested during rod and petal testing
- We will target modules that have faults already or have had bonding repairs
- Going to sampling frees valuable manpower for other tasks, providing much needed help for rod production.

|              | Cumulative  |          | % Pass        |
|--------------|-------------|----------|---------------|
|              | Pass        | Fail     |               |
| L12pu        | 127         | 0        | 100.00%       |
| L12pd        | 213         | 0        | 100.00%       |
| L12su        | 92          | 0        | 100.00%       |
| L12sd        | 68          | 0        | 100.00%       |
| L34p         | 785         | 2        | 99.75%        |
| L56p         | 1356        | 1        | 99.93%        |
| R5N          | 153         | 0        | 100.00%       |
| R5S          | 143         | 0        | 100.00%       |
| R6           | 226         | 0        | 100.00%       |
| R7           | 129         | 0        | 100.00%       |
| <b>Total</b> | <b>3292</b> | <b>3</b> | <b>99.91%</b> |



# LT Module Testing Potential Bottlenecks

Equipment failure is the only potential bottleneck for LT modules testing

- We have obtained spare infrastructure like chillers, power supplies, etc...

But we are still waiting for valuable DAQ spares. This lack of spares is a potential bottleneck for both module and rod LT testing

Spares we still need:

- 2 TSC spares
- 3 TPO (1 for UCR, 2 spares)
- 2 FEC spares sent back for repairs
- About 20 TEC hybrid-to-utri adaptor boards (only needed when FNAL goes into production)



# LT Module Sampling Proposal

At high rate production neither FNAL or UCSB can match the production rates

- Only 20 modules/site/day can be tested

...But as stated earlier, modules only have a 0.09% failure rate during module LT

We therefore propose to go to sampling:

10 modules/day/site, which we can easily maintain