

# ***US Module Testing***

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***On behalf of the US TOB testing group***

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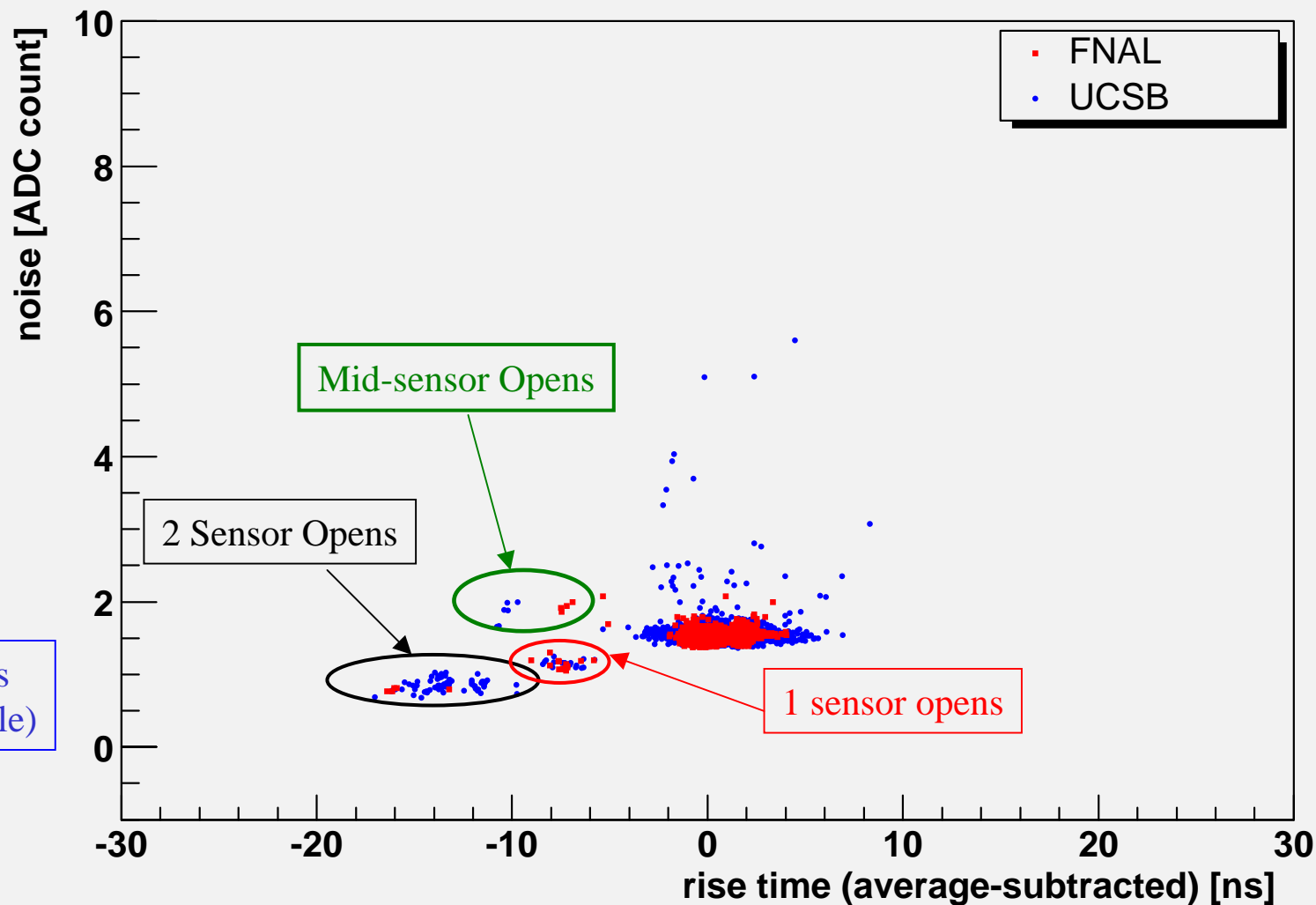


# Hybrid/Module Testing



- **Hybrid/module testing using ARCS stands in a fairly mature state**
  - ➔ 60+ hybrids and 39 modules tested
  - ➔ Full compliment of ARCS hardware
    - Same power supplies, grounding, and testing fixtures at both sites
  - ➔ High uniformity of testing results between FNAL/UCSB (See x-cal slide)
    - Allows for combination of testing results to increase bad channel statistics
    - Same bad channel requirements can be used at both sites
    - New root-tuple of each channel's testing results developed
      - Quick feedback to modify bad channel requirements, see new fault types
  - ➔ ARCS analysis root macro efficiently finding majority (>95%) of faults in modules
    - Uses correlations in test results to define fault type
    - Any unexpected problem channel is studied extensively (optically/electrically)
- **DAQ module testing still under-study**
  - ➔ Grounding issues/multiplexing issues still need to be resolved

Noise versus rise time (peak inversion on)

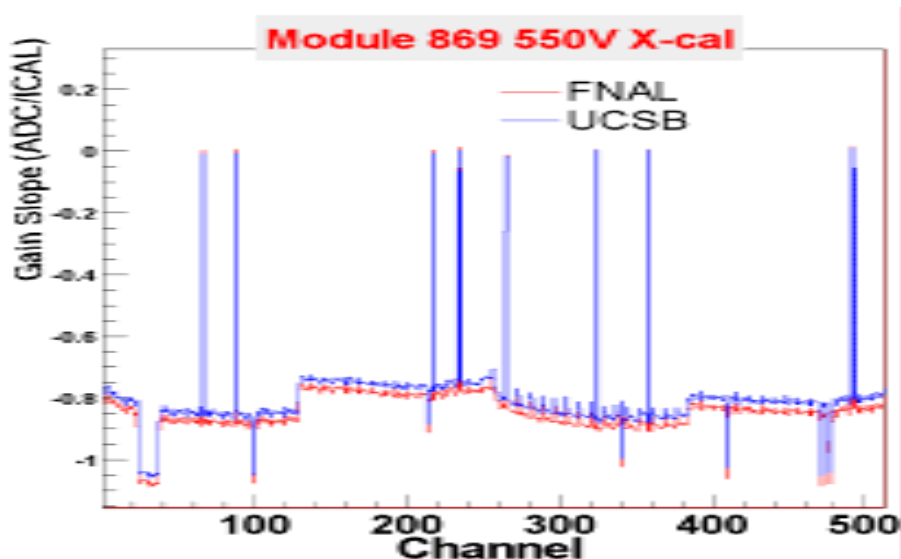
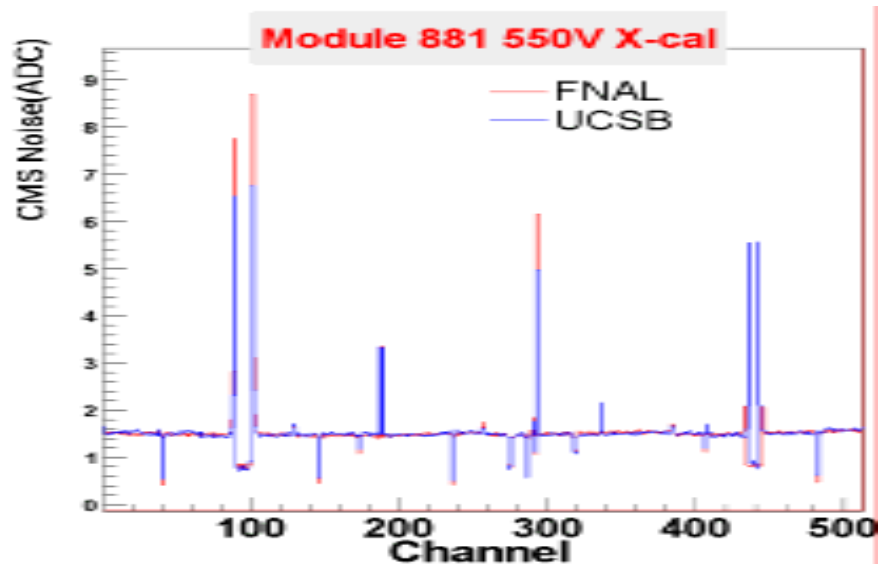




# US X-calibration



- US ARCS stands recently cross-calibrated using two modules that have micro-discharge problems
  - ➔ Added multiple examples of common problems
    - Shorts (neighbors & next-to-neighbors)
    - Opens (sensor-sensor & PA-sensor)
    - Pinholes
- Results nearly identical
  - ➔ All faults found at both sites
    - [hep.ucsb.edu/cms/xcal\\_data.html](http://hep.ucsb.edu/cms/xcal_data.html) for details



- **Hybrid pitch adaptor pulsing/thermal cycling test**

- Acts as short-term burn-in (20 minutes)
- Hybrid/pitch adaptor/wire bonds tested at operational temperature

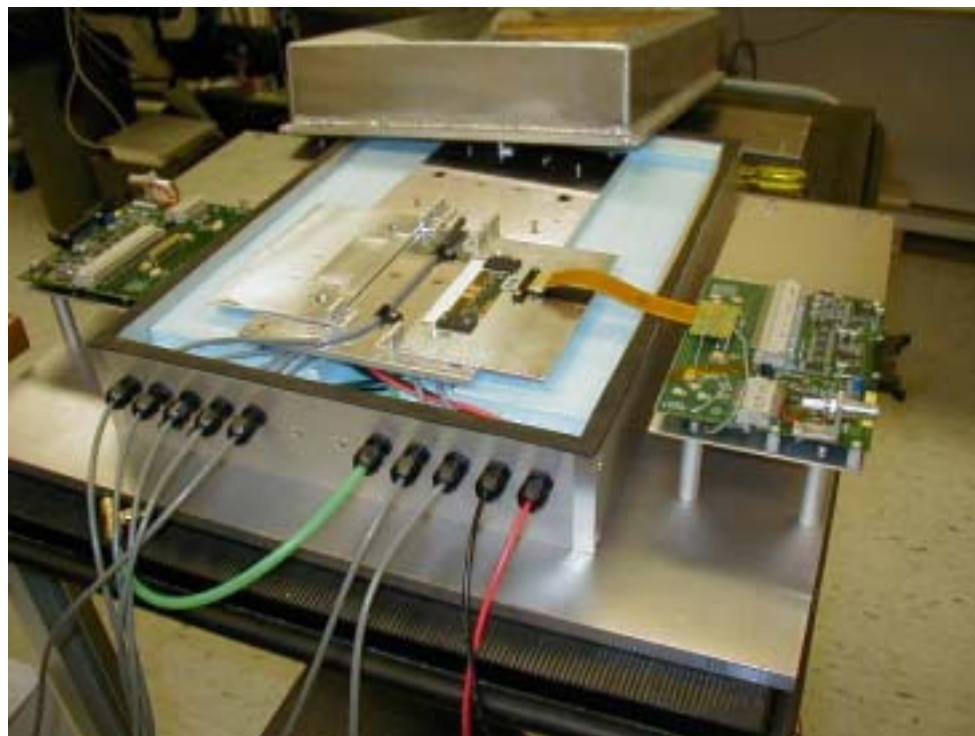
- **Construction almost finished**

- Basic functionality tested
  - Temperature/RH electronics
  - Coolie Box
  - Peltier element
  - Labview software

- ARCS hardware/software ready

- **System will be fully operational by end of July**

- Ready for beginning of APV-PA wire bonding at UCSB



If failure rate determined to be low after first 200-300 hybrids, will only sample test hybrids

- **Two fully functional Vienna box test stands**
  - LV currents read-out by PAACB
  - HV current read-out by electrometer
    - Both still need calibration
  - MUX readout operational
    - 4 module readout demonstrated
    - More FED-MUX cables needed for larger test
    - MUX crate + 3 MUX boards needs for FNAL test stand

**UC Santa Barbara**



**Fermilab**





# Rod Assembly/Testing



- First rod + assembly tools shipped from CERN to UCSB
- First rod DAQ stand currently being commissioned
- Rod test box design underway
- Beginning of rod electrical testing awaiting power supply from CERN
- More DAQ boards needed in order to begin construction of second rod assembly test stand



# Hardware Needs (Near Term)



- ARCS hardware fully supplied
  - ➔ Just need a few DEPP boards
- Much more DAQ hardware needed to meet short term goals (Next Months)
  - ➔ 4 Vienna slots equipped for module cold testing at both UCSB/FNAL
  - ➔ 1 Stand-alone testing/debugging stand at FNAL
  - ➔ 1 SS4 rod assembly test stand at both UCSB/FNAL
  - ➔ Maybe a few spares
- To meet these goals we need:
  - ➔ 2 TSC
  - ➔ 3 FED
  - ➔ 3 MUX crates with 3 boards each
    - Or 30 FED-VUTRI data cables
  - ➔ 2 Rod LV power supply
  - ➔ 4 Electrometers
    - Without them, only  $\mu\text{A}$  resolution HV current measurements possible during rod assembly
- This list does not include any spares
  - ➔ We need one extra board of each type in the US in case of failure during production



# UCSB Module Testing Summary



- 19 modules tested
  - Few bad channels introduced in production
    - < 0.3% of channels
  - Many sensor issues
    - 4 modules have micro-discharge problems which cause large common mode noise in one chip
      - Requires 9-13 pulled wire bonds to remove noise from chip
    - 7 modules have channels with increasing noise with bias voltage
      - Lithographic errors
- See [hep.ucsb.edu/cms/noise\\_vs\\_voltage.html](http://hep.ucsb.edu/cms/noise_vs_voltage.html)
- See R. Demina talk in sensor meeting for more details

Module	Sensor Bad Channels	Bonding Bad Channels	Testing Bad Channels	% Bad Channels	Grade
876	1.5+2	3	1	1.4%	B
865	1.5	0	5.5	1.4%	F
866	1.5	0	9.5	2.1%	F
867	4.5	0	1.5	1.2%	F
868	2+3+1??	0	0	1.0%	A
869	1+13	1	0	2.9%	F
877	0+1??	0	0	0.0%	A
878	0+2??	0	0	0.0%	A
879	0	0	0	0.0%	A
880	2+2??	0	0	0.3%	A
881	1.5+22	0	0	4.6%	F
882	2+1??	1	0	0.6%	A
883	0+3	1	0	0.8%	A
870	2	0	0	0.4%	A
871	1+13	0	0	2.7%	F
872	1+1??	1	0	0.4%	A
873	0.5+9	0	0	1.9%	F
874	0.5+4.5	1	0	1.2%	B
875	1.5+4	0	0	1.1%	B
AVE	1.2+4.2	0.42	0.89		

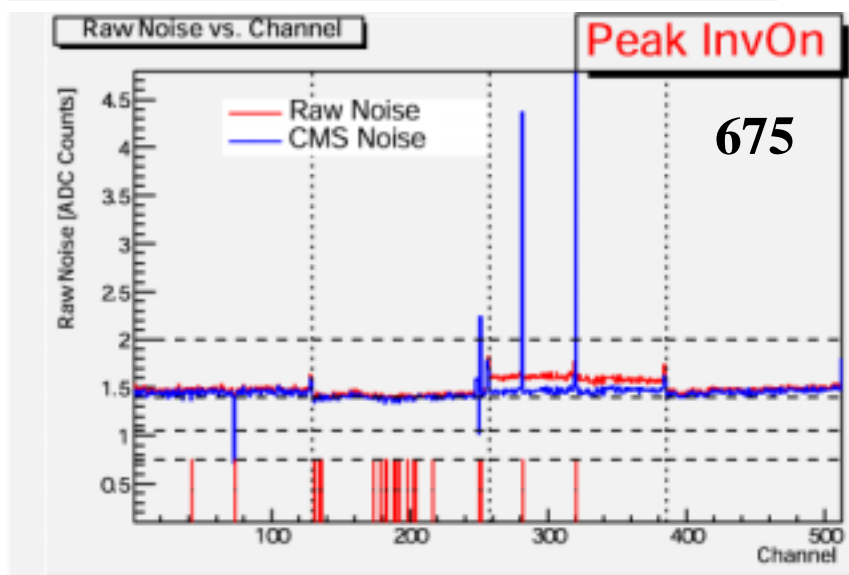
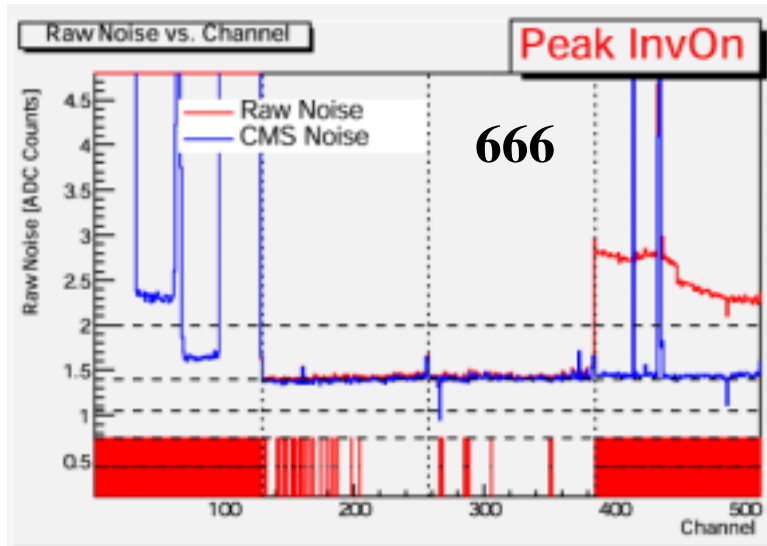
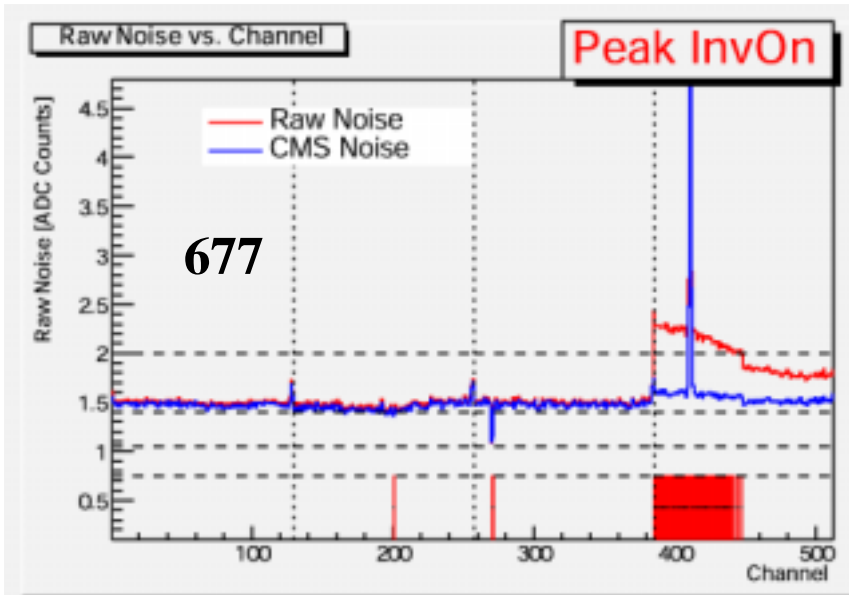


# FNAL Module Testing Summary



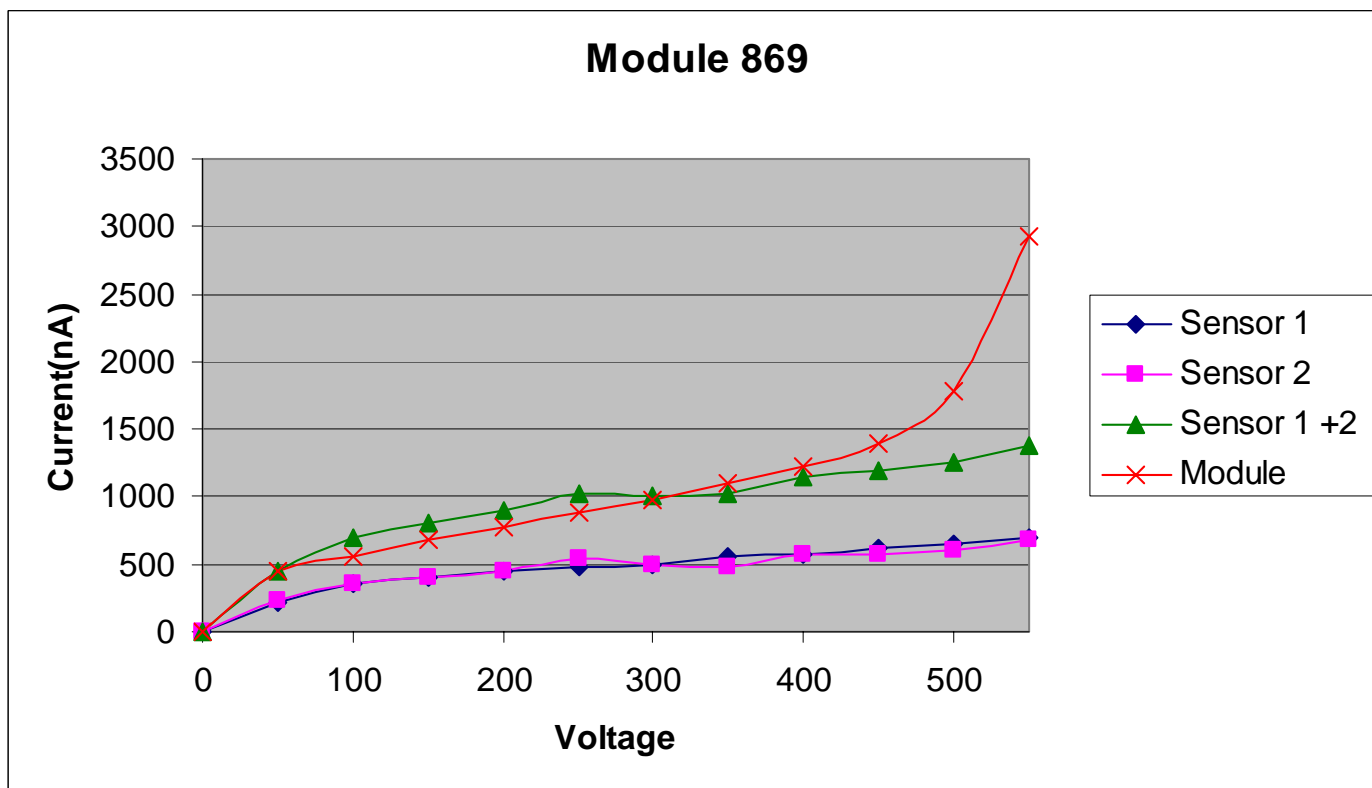
- **In May-June**
  - ➔ Tested 40 hybrids
  - ➔ Tested 20 modules
- **All hybrids good**
  - ➔ Some problems seen:
    - Touching bonds, broken bonds, PA cleaning necessary to improve bonding
- **6 really bad module (micro discharge effect)**
- **Identified several unbonded channels in first 2 modules due to dirty PA**
  - ➔ Problem is eliminated after PA cleaning
- **Some noisy channels are seen in addition to known defects – about 1-4 per module**

Module	Pulled bonds		Additional defects found in testing	Grade
	sensor-sensor	pA-sensor		
664	364	23,259,468	Channels 32-33 PA short	B
665	150,160,418,489	352,396	No	A
666	270,271	-	Micro-discharge	F
667	-	181	Channels with increasing noise	A
668	-	-	193,411 – noisy channels	A
669	97	-	No	A
670	251	-	176-179,182 mid-sensor opens	A
671	122	-	Micro-discharge	F
672	3,247	446	Micro- discharge effect in chip 3, pulled channels 263-274 to decrease CMN	F
673	185-187	-	No	A
674	-	-	No	A
675	249,250	73	Small Micro-discharge	F
676	4,219,220	173	Small Micro-discharge	F
677	111,487	266	Micro-discharge	F
678	292-295		Channels with increasing noise	A



Small Micro-discharge effects  
(675)

Large Micro-discharge effects  
(666, 677)

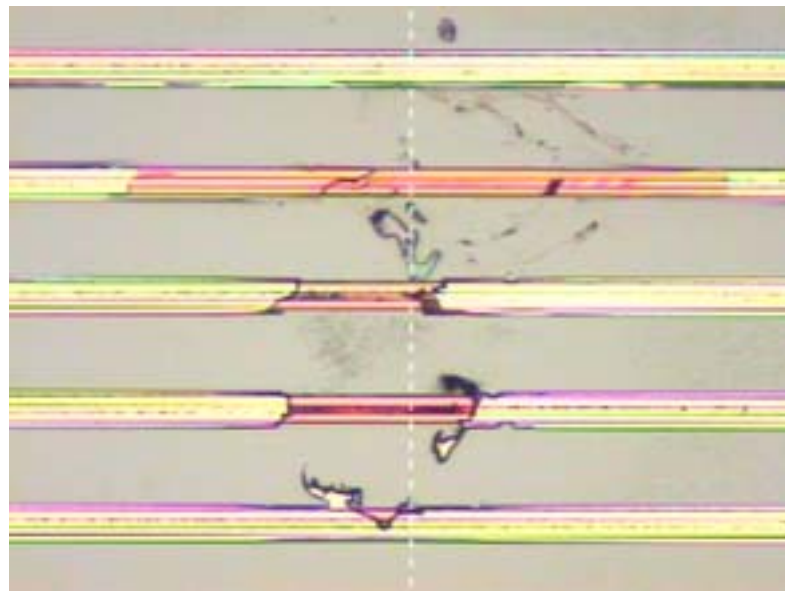
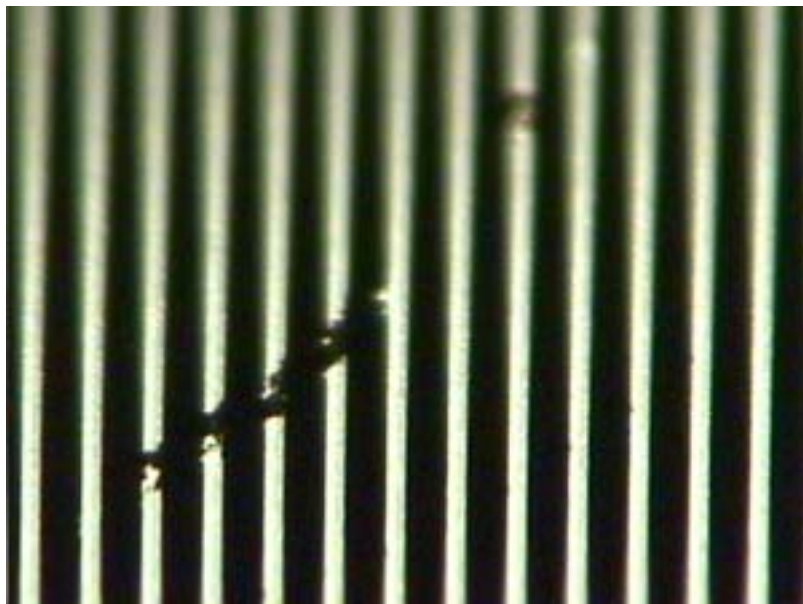


Modules with as little as 2  $\mu\text{A}$  extra bias current relative to sensor probing data has shown to exhibit high common mode noise due to micro-discharge effects

Not clear how to treat channels increasing noise (Pull wirebond?)

***10 Grade F modules due to this micro-discharge effects***

Both FNAL and UCSB production lines seen micro-discharge effects, mid-sensor opens, and channels with increasing noise (current) with HV  
*(Not seen in sensor probing)*



Sensor opens, along with channels with increasing noise with bias voltage, have resulted in Grade B modules



# Conclusions



- **Hybrid/module testing nearly ready for production**
  - ➡ Hybrid thermal cycler needs to be commissioned
- **Sensor related problems need to be understood to improve module yield to acceptable levels**
- **Module burn-in capabilities steadily increasing**
  - ➡ More study needed to understand long term performance of modules
- **Rod assembly test stand beginning construction**
  - ➡ Much more DAQ components needed to have assembly test stands at both FNAL & UCSB