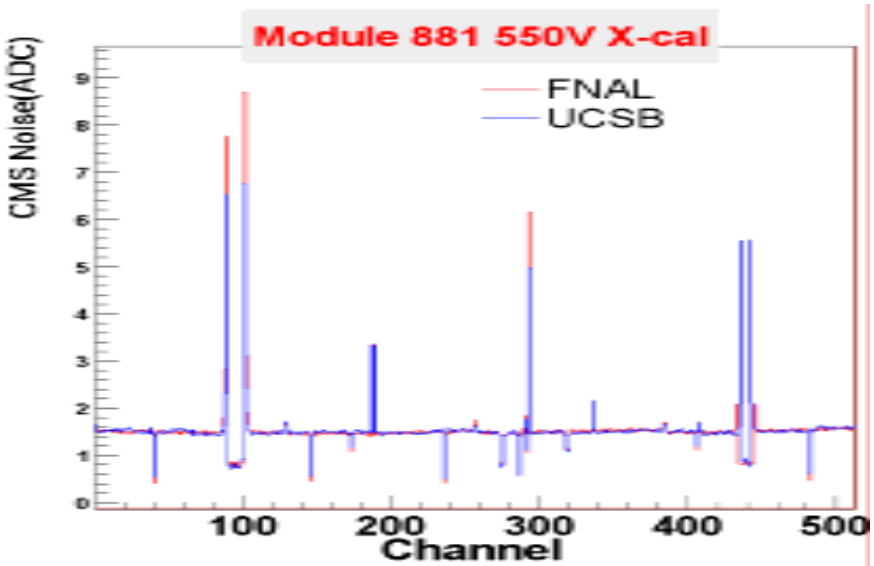
Report on Module Test Progress

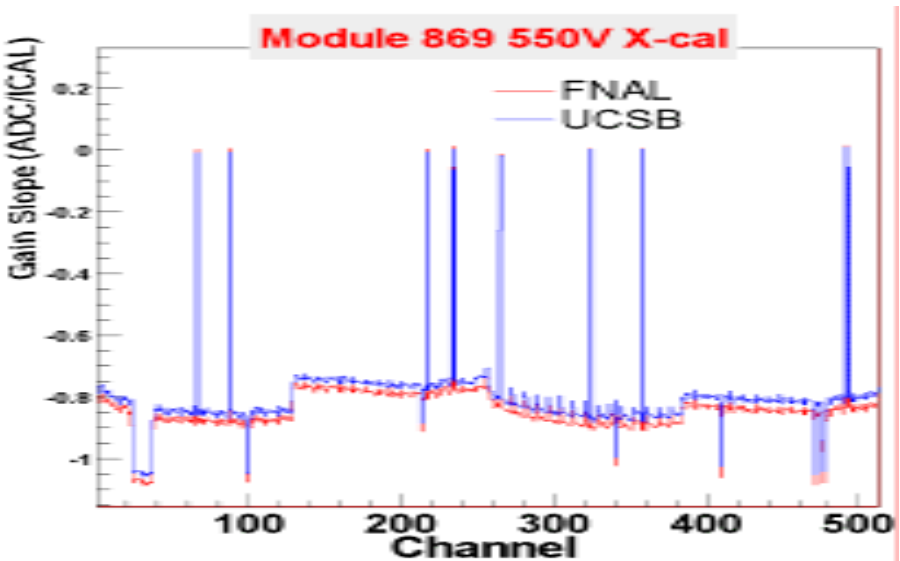
Hybrid/Module Testing in US

- 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

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 for details





US Long Term Test Stands

- 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

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 μA 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

- See R. Demina talk in sensor meeting for more details

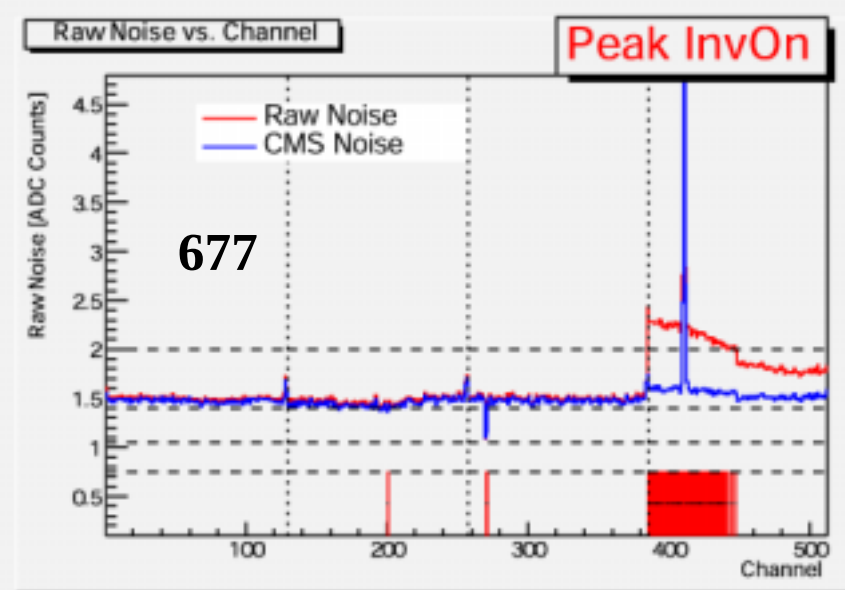
Module	Sensor Bad Channels	Bonding Bad Channels	Testing Bad Channels	% Bad Channels	Grade
876	1.5+2	3	1	1.4%	B
865	1.5	0	5.5	1.4%	F
866	1.5	0	9.5	2.1%	F
867	4.5	0	1.5	1.2%	F
868	2+3+1??	0	0	1.0%	A
869	1+13	1	0	2.9%	F
877	0 +1??	0	0	0.0%	A
878	0+2??	0	0	0.0%	A
879	0	0	0	0.0%	A
880	2+2??	0	0	0.3%	A
881	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		

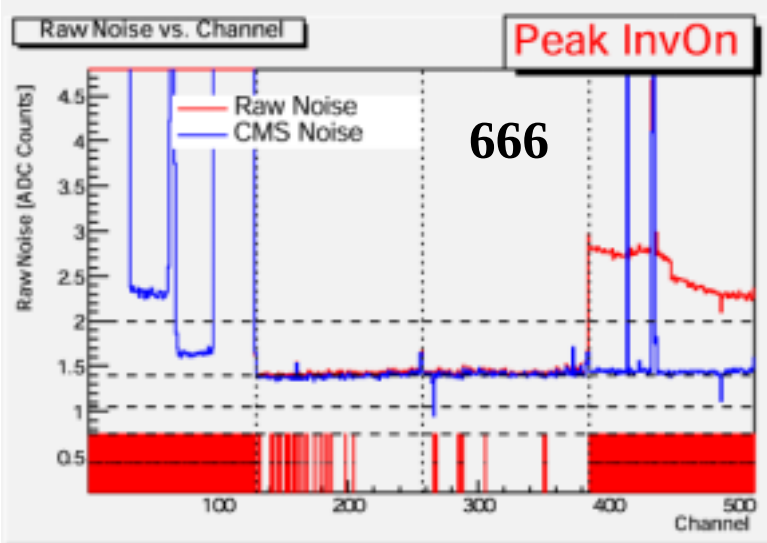
FNAL Module Testing Summary

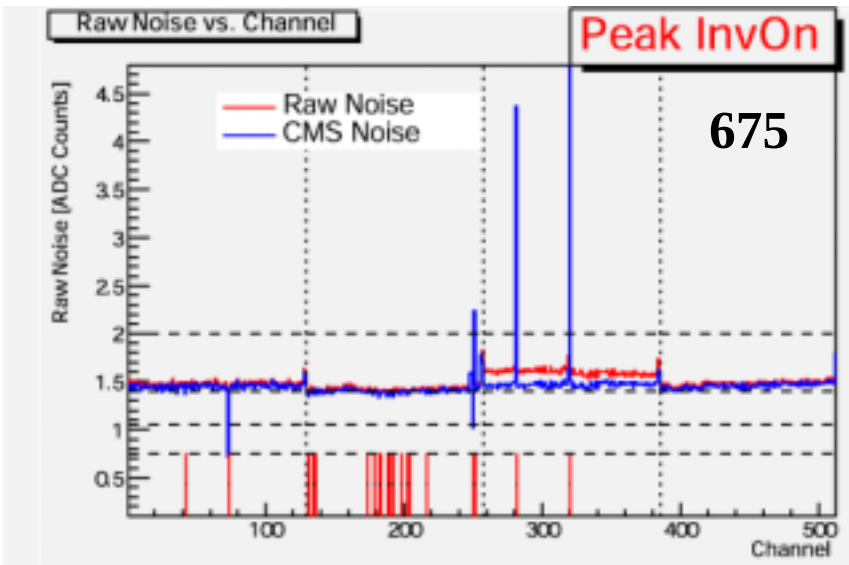
- In May-June
  - Tested 40 hybrids
  - Tested 20 modules
- All hybrids good
  - Some problems seen:
    - Touching bonds, broken bonds, PA cleaning necessary to improve bonding
- 6 really bad module (micro discharge effect)
- Identified several unbonded channels in first 2 modules due to dirty PA
  - 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

Micro-discharge(1)



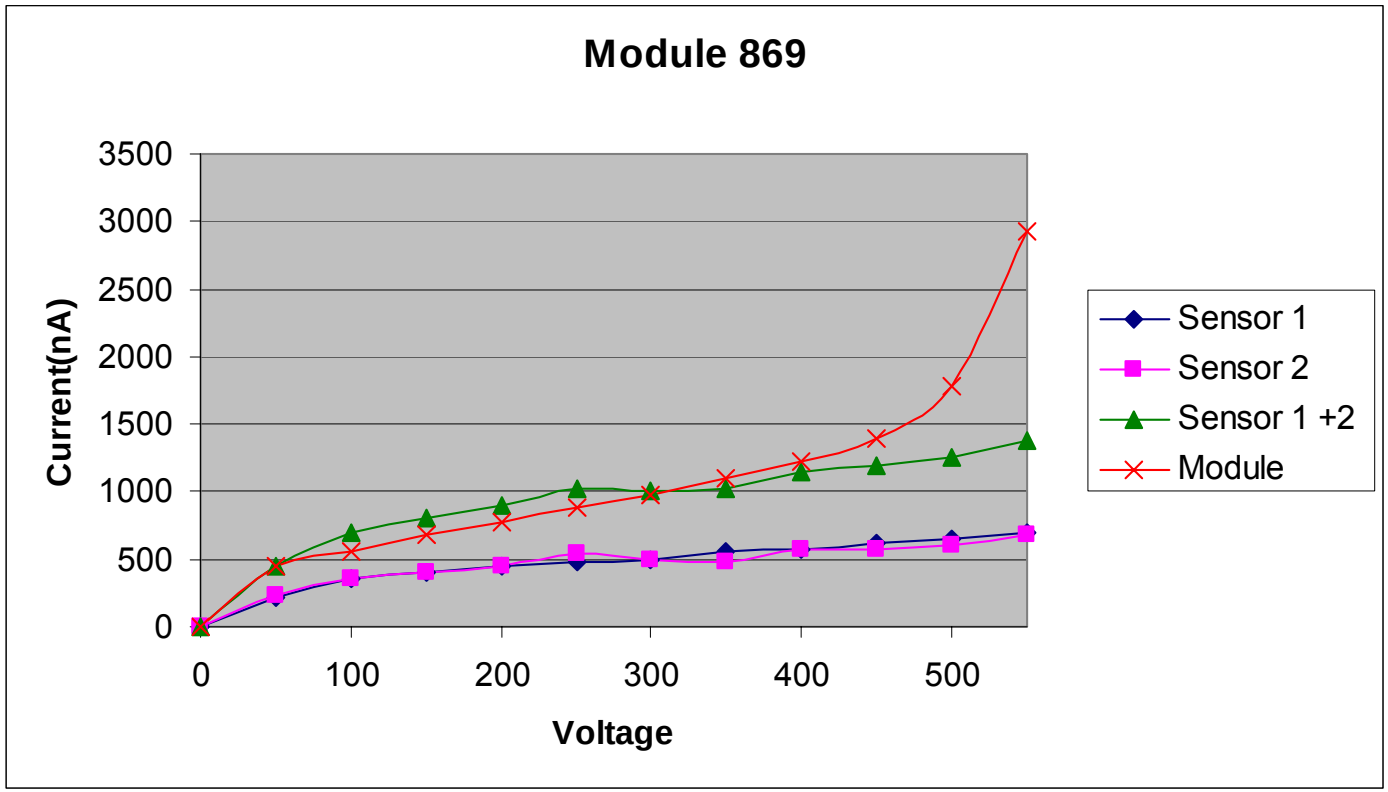




Small Micro-discharge effects (675)

Large Micro-discharge effects (666, 677)

Micro-discharge (2)

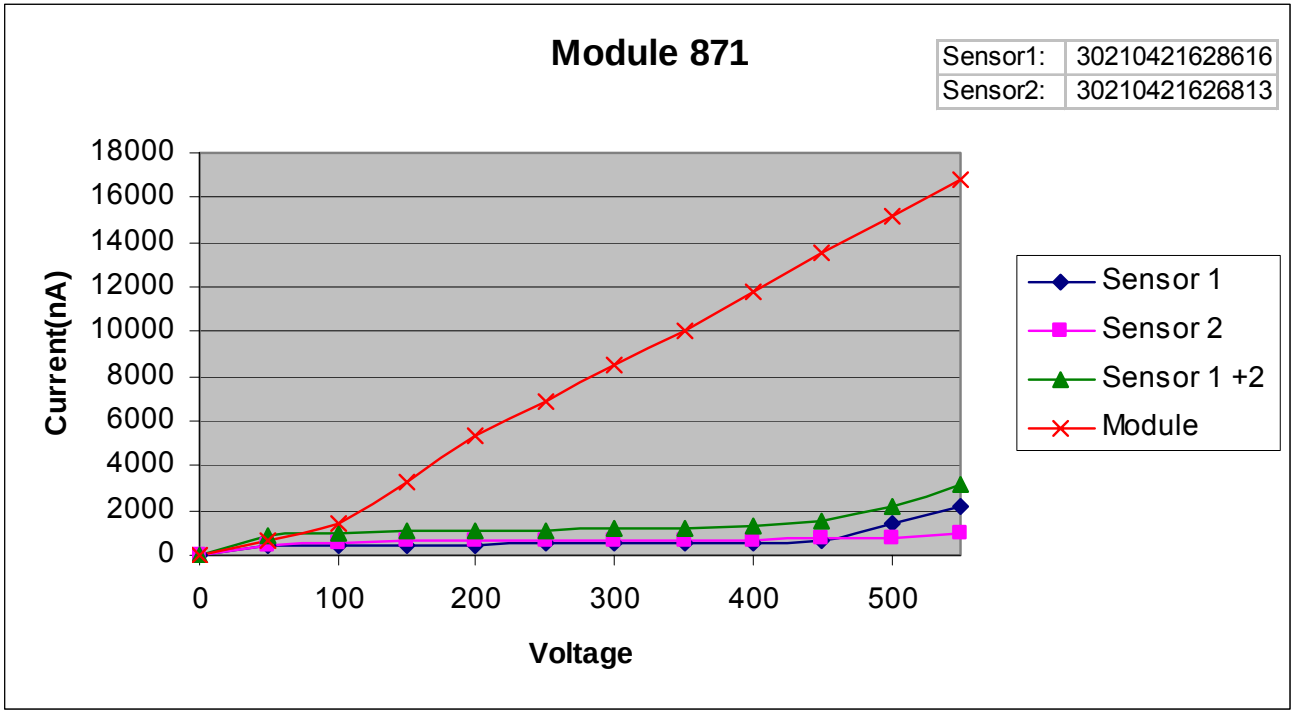


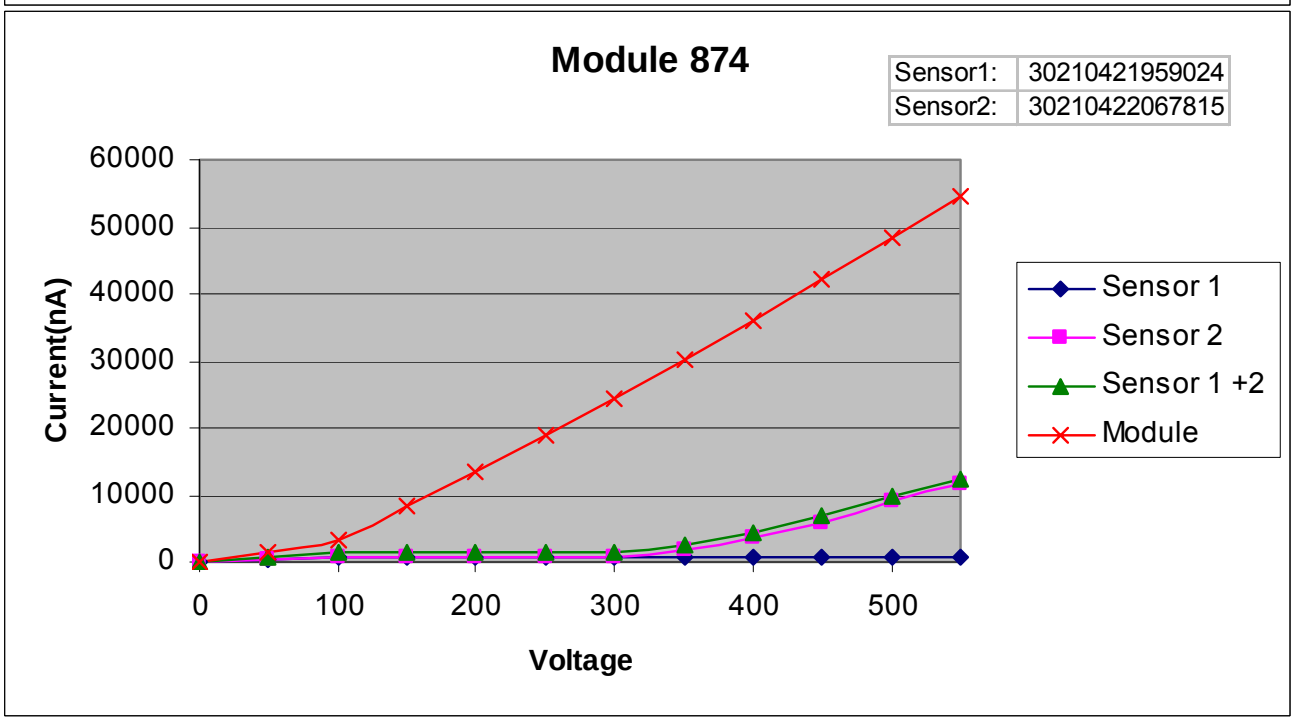
Modules with as little as 2 μA extra bias current relative to sensor probing data has shown to exhibit high common mode noise due to micro-discharge effects

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

10 Grade F modules due to this micro-discharge effects

TOB Weird I-V


Module 871
Sensor1: 30210421628616
Sensor2: 30210421626813
Current(nA)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
100
200
300
400
500
Voltage
Sensor 1
Sensor 2
Sensor 1 +2
Module


Module 874
Sensor1: 30210421959024
Sensor2: 30210422067815
Current(nA)
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
Voltage
Sensor 1
Sensor 2
Sensor 1 +2
Module

US Labs Conclusions

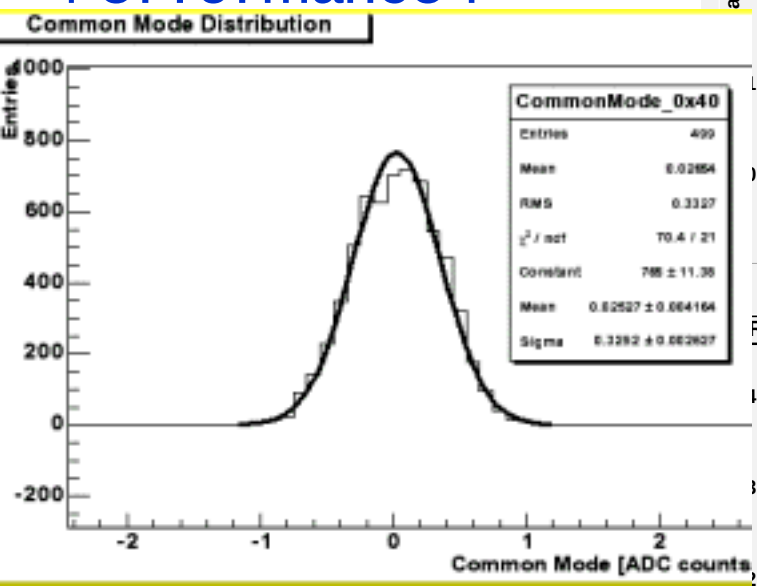
- Hybrid/module testing nearly ready for production
  - Hybrid thermal cycler needs to be commissioned
- Sensor related problems need to be understood to improve module yield to acceptable levels
- Module burn-in capabilities steadily increasing
  - More study needed to understand long term performance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

Results from TIB

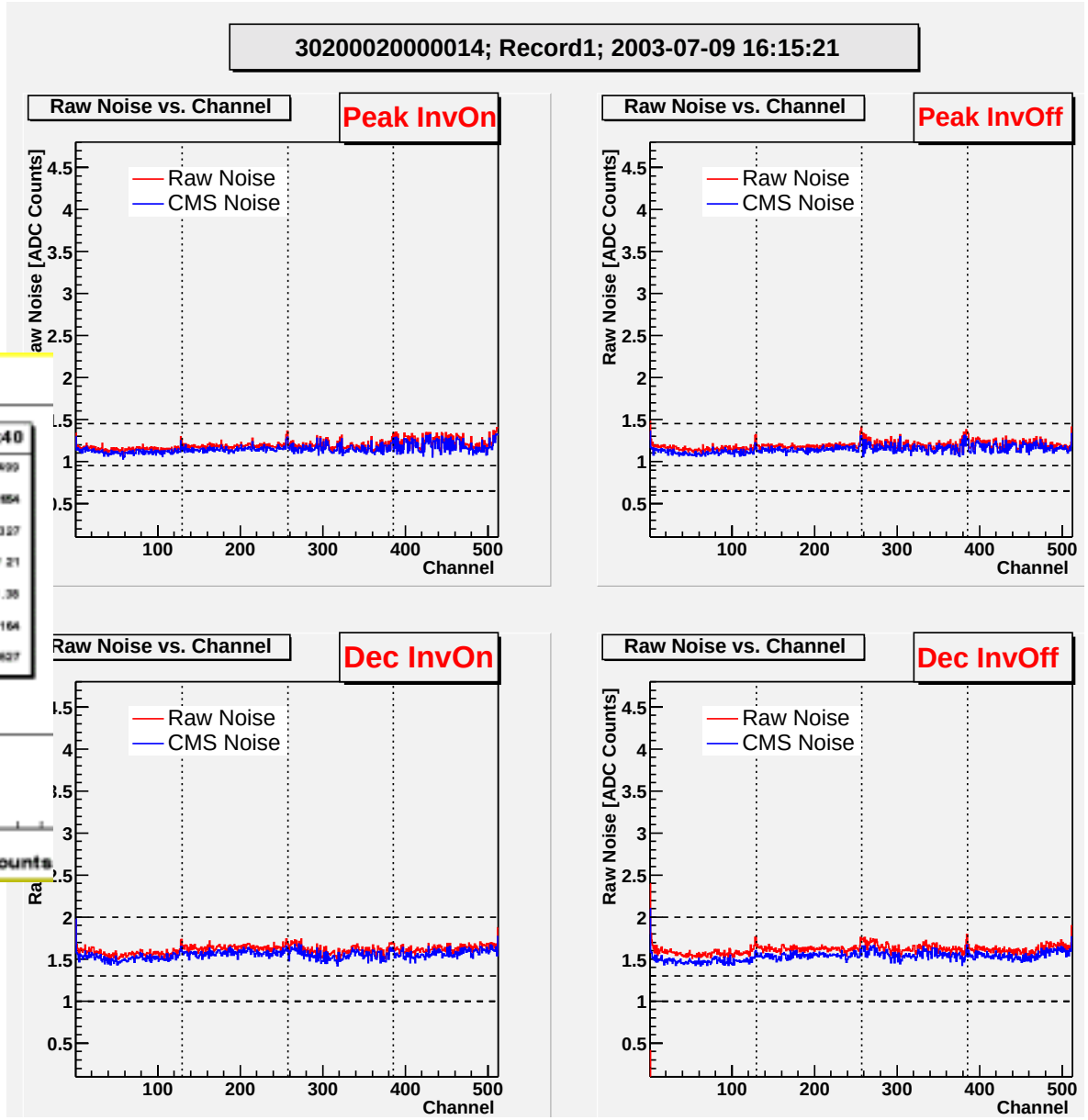
- 2 Final version modules built and tested (Bari, Firenze), 5 more under bonding next week.
- No major problem during production and testing
- Minor problems in bonding on some lateral PA pads, but anyway possible to make good bonds
- Both have been tested with ARC 6.1 and Tony's macros
- Firenze has also taken data with single module LT

The New Module from Bari

Analyzed with new macros: Beautiful Noise Performance !



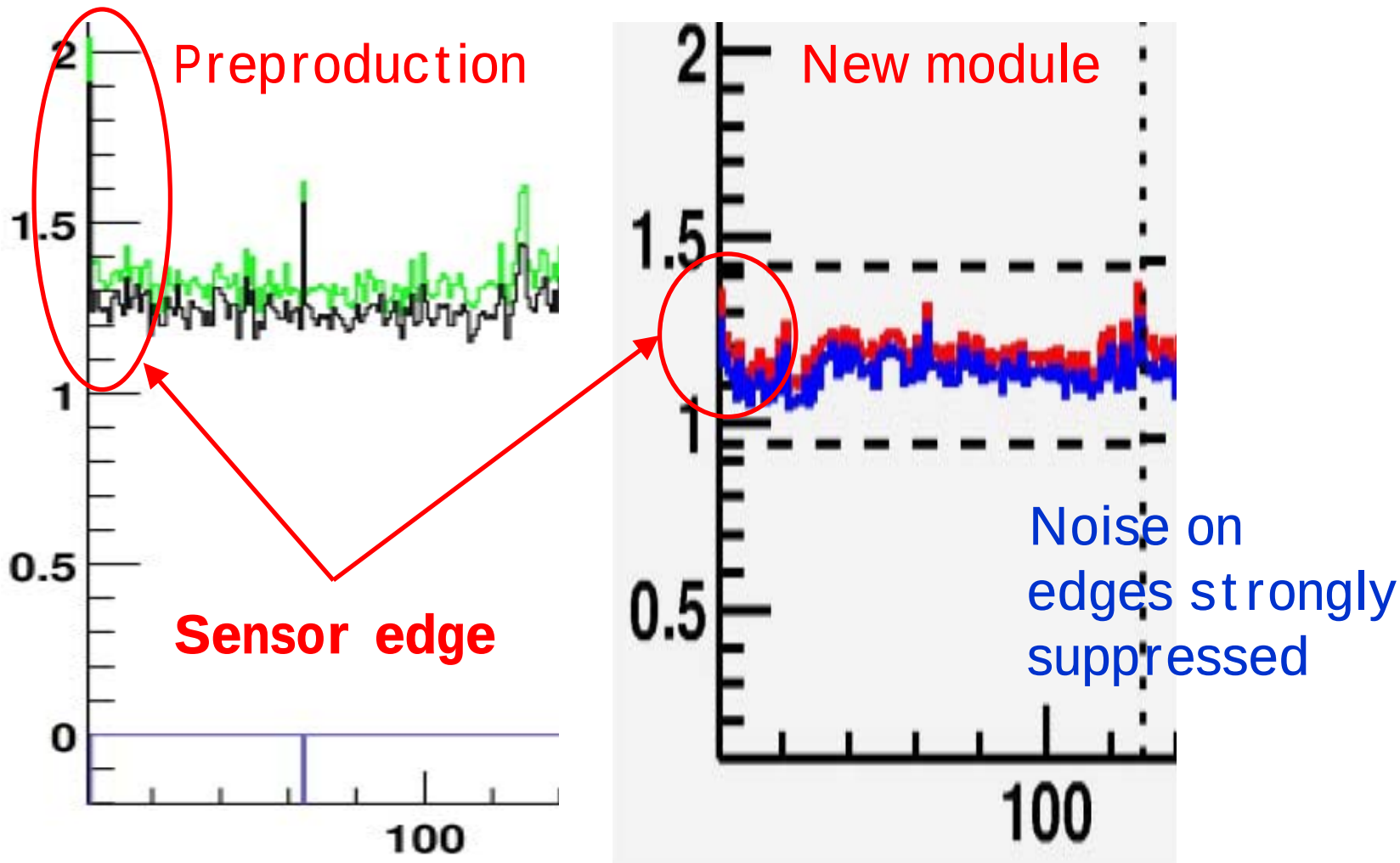
CMN=0.33 ADC



Mod Production 17/7/2003

Marco Meschini, INFN Firenze

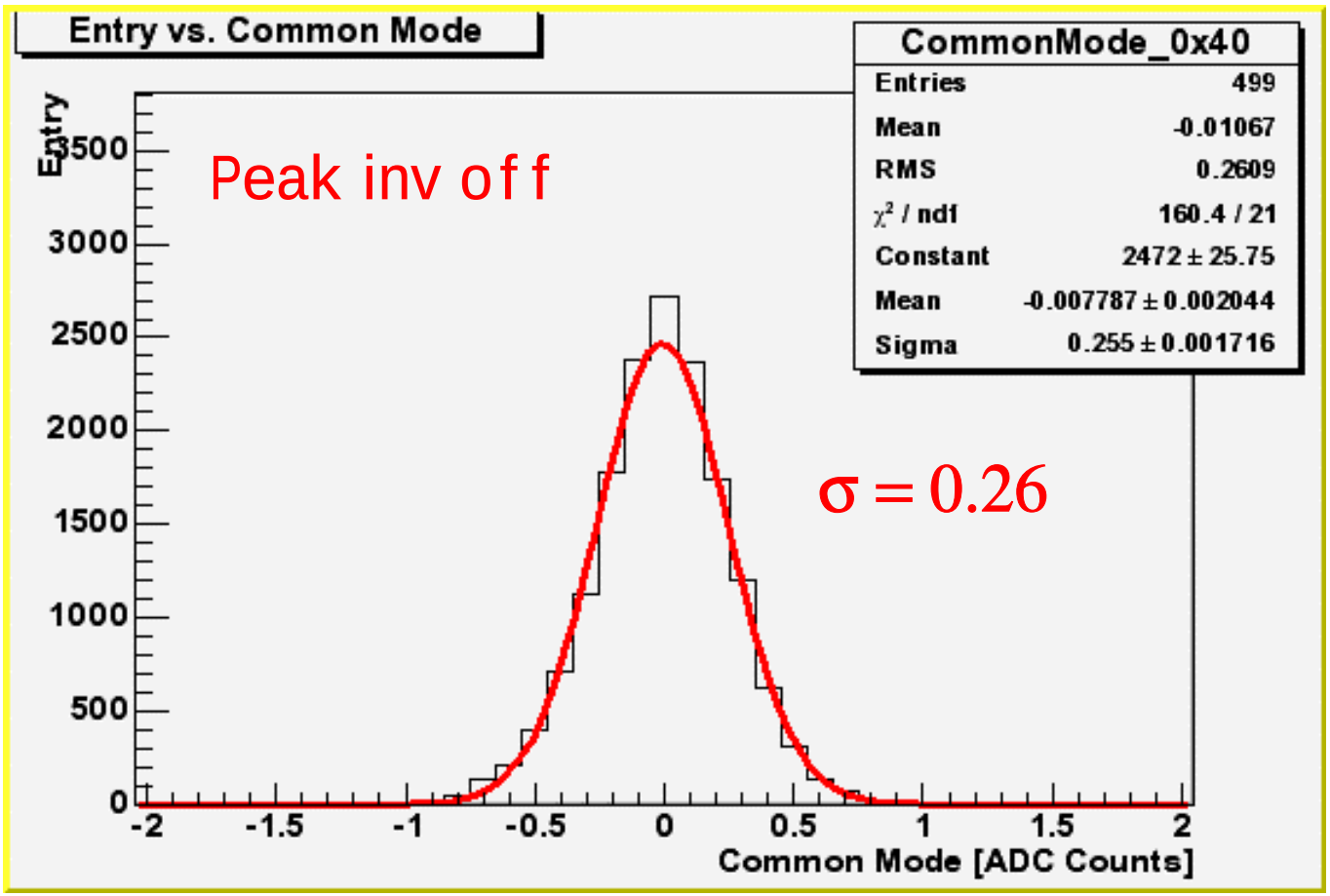
Comparison with preproduction (Firenze)



First chip – peak inv off

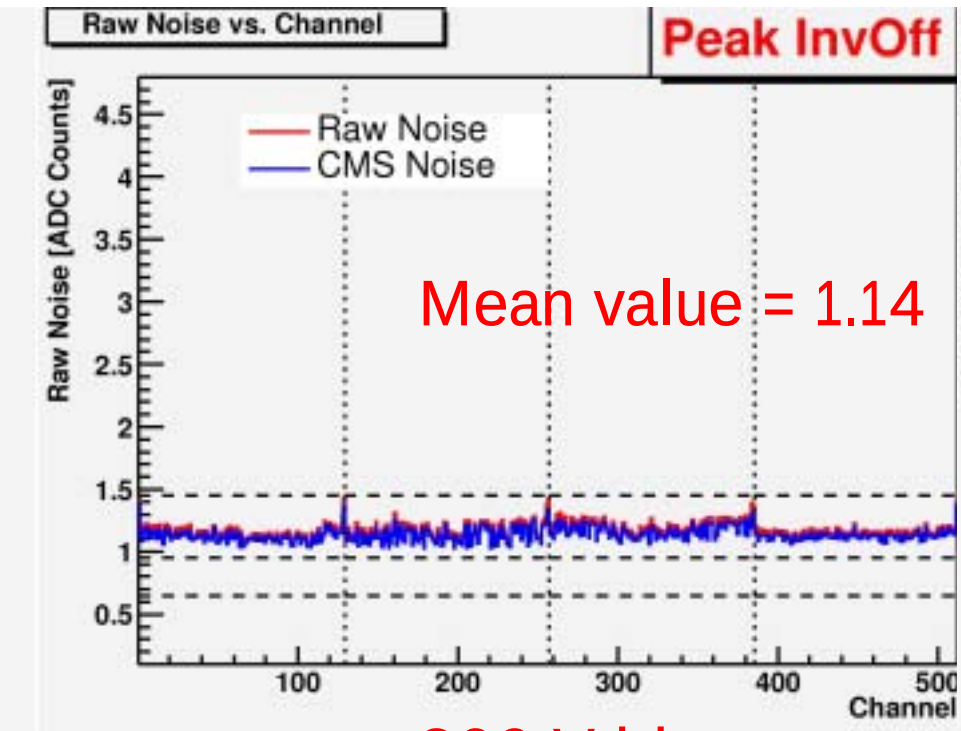
Common Mode Noise

- The CMN meets the specifications
- Below 0.4 ADC channels in peak inv off

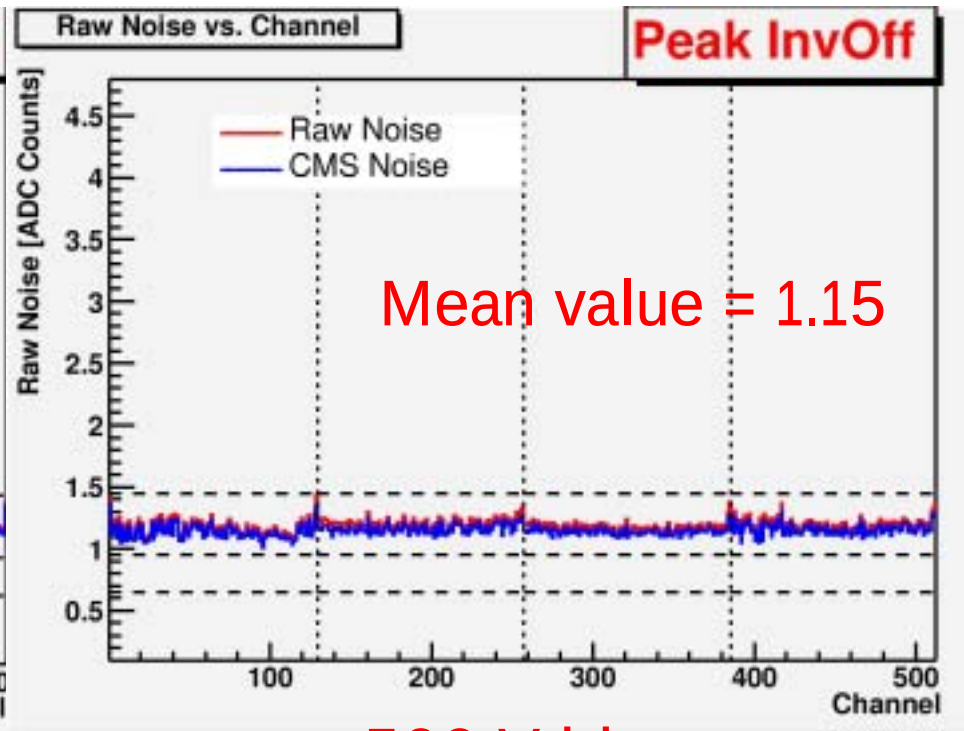


Differences between 300 V and 500 V bias

- Measurements taken at different voltages don't show any significant difference in the strip behaviour



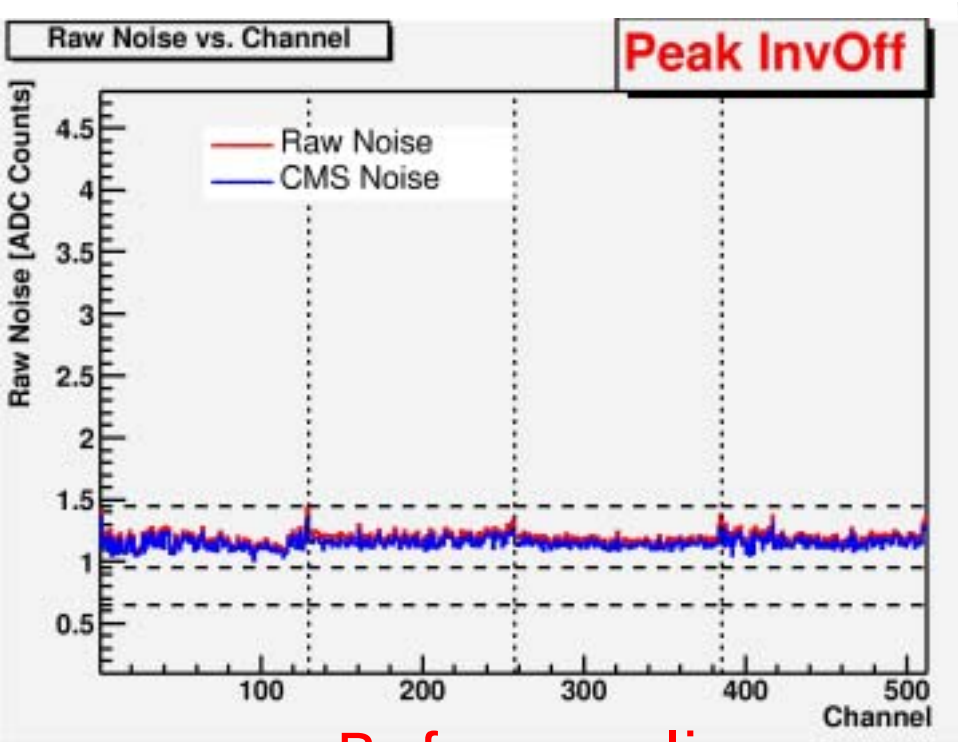
300 V bias



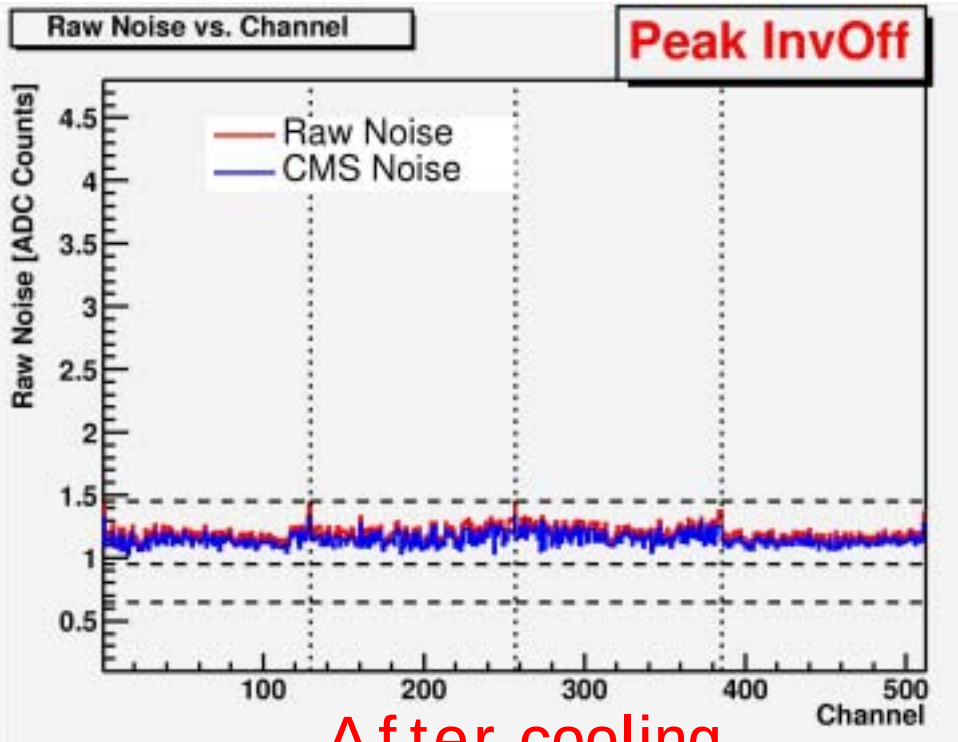
500 V bias

ARCS test results

- Cooled down (passive) to –15 C for 30 min
- Data taken at 500V bias
- No new bad strip appeared after cooling

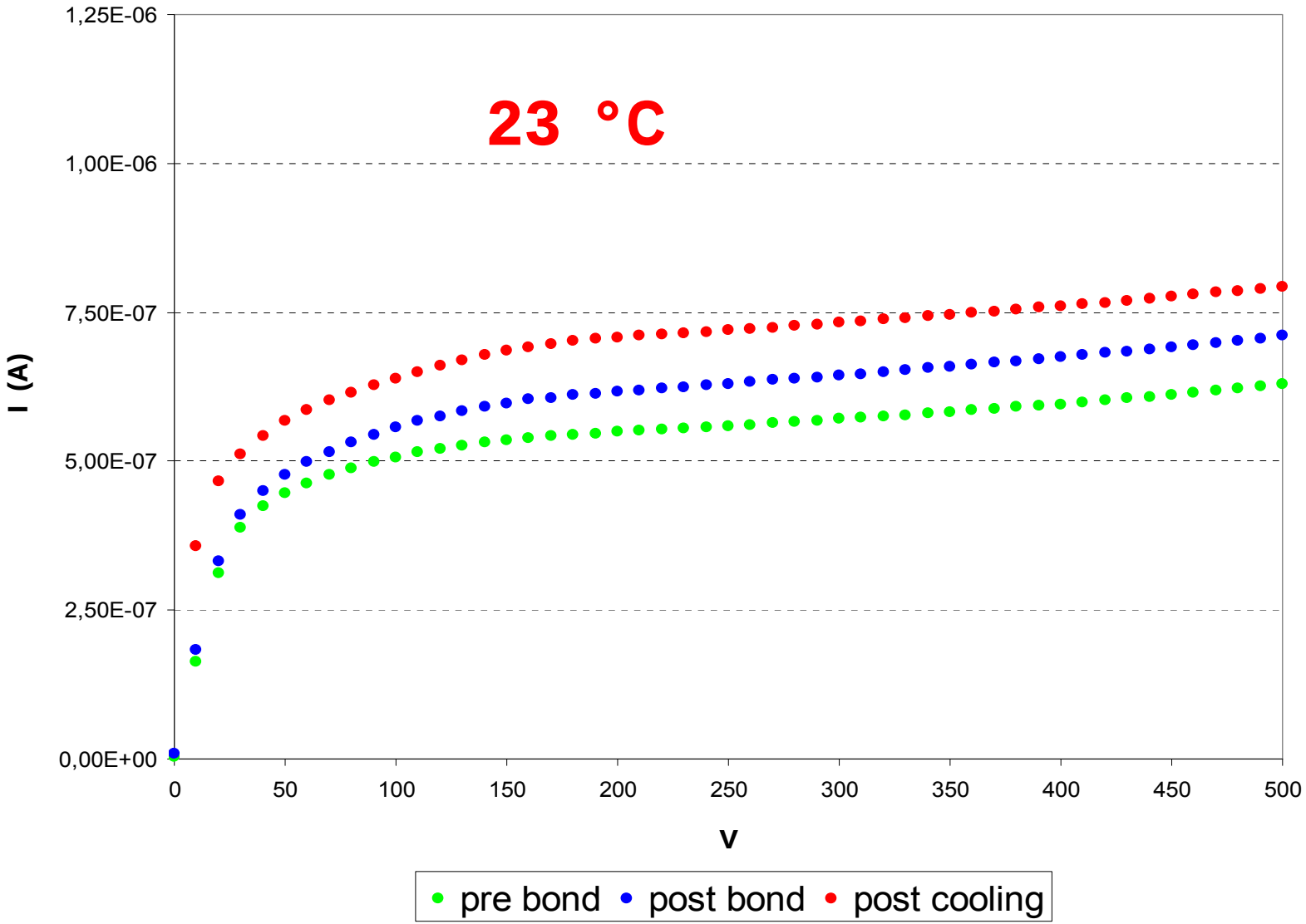


Before cooling



After cooling

IV plots with T compensation



Torino Workshop 7-12 July 2003

- The task force, plus some additions, met in Torino last week (after 2 VRVS meetings, email discussions, homework):
  - T. Affolder, L. Demaria, V. Zhukov, T. Franke, M. Meschini, C. Marchettini
- Goals of the workshop:
  - Tune the best cuts to find defects in tracker modules;
  - Identify the type of defect in automatic way;
  - Advance in verification of compatibility of results obtained using ARC and LT setups
- The compatibility of ARC and LT sw had been discussed previously and it is now taken for granted
- Modules shipped to Torino to be crosschecked:
  - 2 TOB modules from UCSB (by express courier from US), 2 TEC from Karlsruhe (by car), 1 TIB from Firenze (by car), 2 TIB already in Torino
  - Other tests were done on the spot on root data files taken on different modules in home labs to verify the selection criteria

Strategies from the Task Force

- Overall Strategy for cuts:
  - Find all defects, minimizing the probability of missing any of them
  - Identify them: short, open 1 or 2 sensors, pinhole, other
- Optimal Cuts have been found using present module statistics:
  - looking at normalized cumulative distributions of noise, calibration peaking time etc.
  - Fine tuning on module with known defects

The Result

- 1 set of cuts for TOB and TEC modules, higher capacitance detectors
- 1 set of cuts for TIB modules, for lower capacitances detectors
- All cuts act in OR
  - Exceptions: first and last strip of the module are not marked bad if they are ONLY failing noise cuts

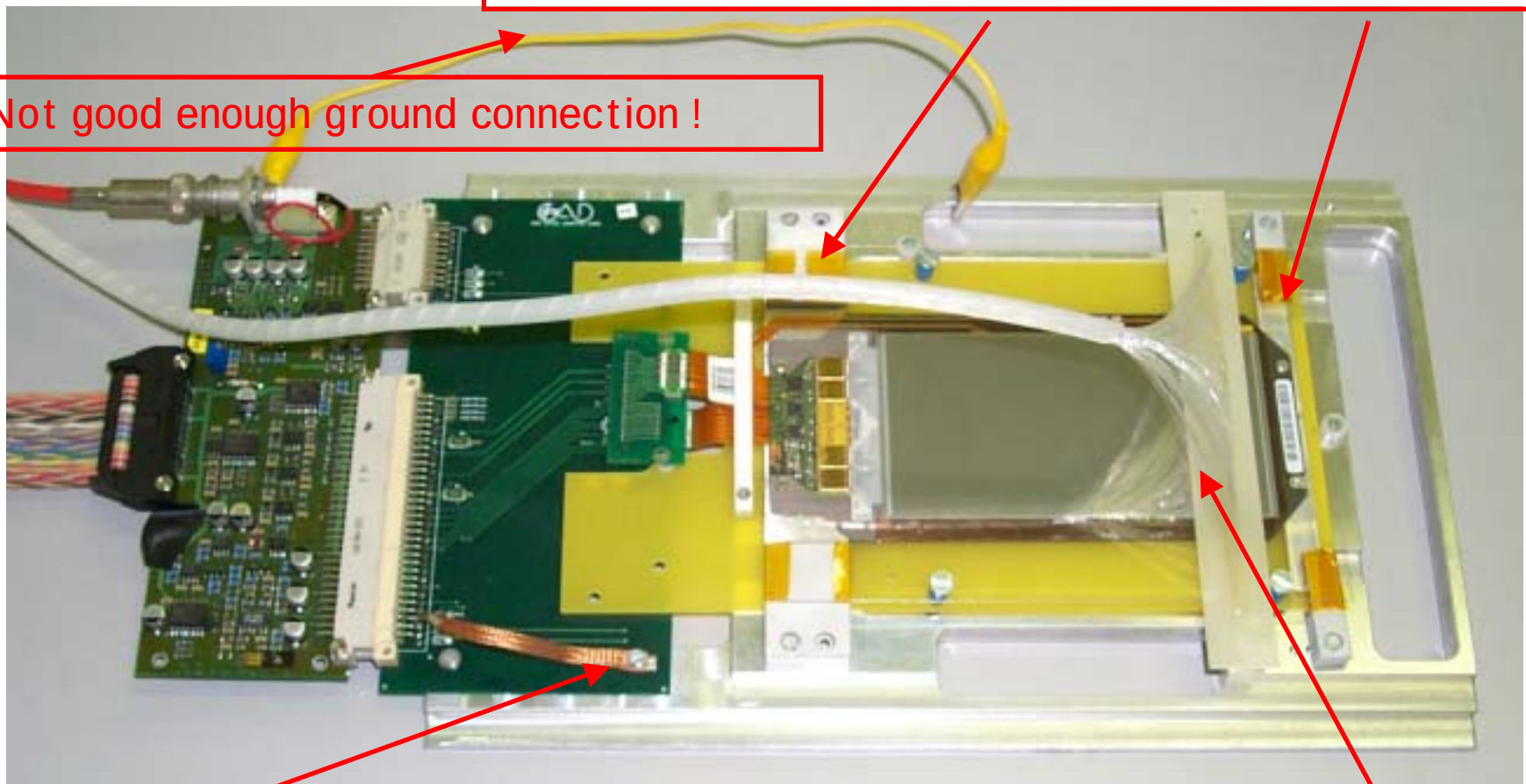
The Macros

- Tony Affolder (UCSB) wrote macros to be used on root files for defects identification.
- Cuts can be given in a configuration file; there are both absolute and percentage cuts, following the outcome of the task force studies
- Different cut thresholds are used to distinguish among different failures.
- The macros are presently working on ARC root files; the LT root output will be soon modified by Valery to be fully compatible with macros
- Macros are already on web, presently in Torino website www.to.infn.it/cms/Tracker/ModuleTest/Proposal/Tony/

Before Starting 1

- The basic requirements (in PEAK INV OFF):
  - **CMN < 0.5 ADC in TEC and TOB**
  - **CMN < 0.4 ADC in TIB**
  - VERY stringent requirements, but they demonstrated to be NECESSARY and within our reach
  - Every test centre has to do a careful grounding of test setup

Connections for Noise Minimization on a TIB module



Before Starting 2

- **A new request**: all module tests must be done at **500 V bias** (except for Pinhole test which can be relaxed to 300 V). This is due to possible high current/noisy strips which show up only at high bias (see Affolder's talk)
- With present sw all data should be taken in one go, without repeating the same measurement: needed to have everything in the root file in the same record

Changed to 400 V after discussions during TK meetings: compliant with sensors test specs

The Tests you must use

In order to speed up the module qualification, the task force tried to minimize the number of tests needed

In all 4 modes

- Noise and pedestals
  - Pedestals: not used for cutting, but useful as "fingerprint" in case of unforeseen module identification problems
- Calibration and related measurement (Pulse shape, Peaking time, Amplitude)

In selected modes only

- Pinhole at max intensity (300 uA) default ARC peak inv off
- LED default ARC peak inv on
- Pipeline in peak inv on

Can be skipped

- Gain test

An Example

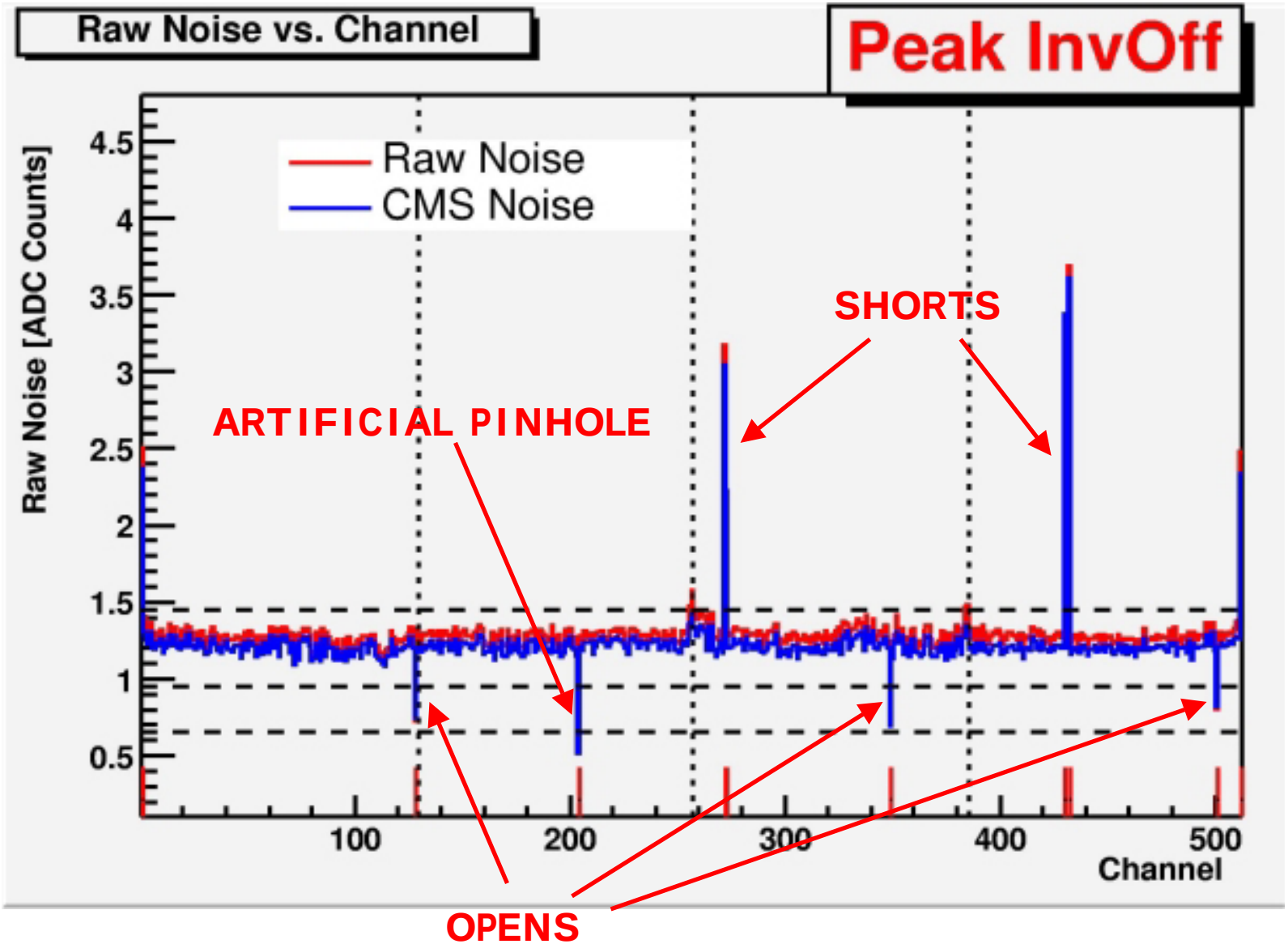
- In Firenze we prepared and tested module TIB000 with a few artificial defects:
  - # 128 open
  - # 204 'artificial' pinhole
  - # 272-273 short neighbouring strips
  - # 349 open
  - # 430-432 short on even row (simulating an error on PA to APV bonds)
  - # 501 open
- In Torino we tested TIB-000 with ARC and Tony's macros with final cuts: we identified all and only the induced defects
- TIB-000 was tested again back in Firenze, without any change in results

Tony's Macro Result Summary

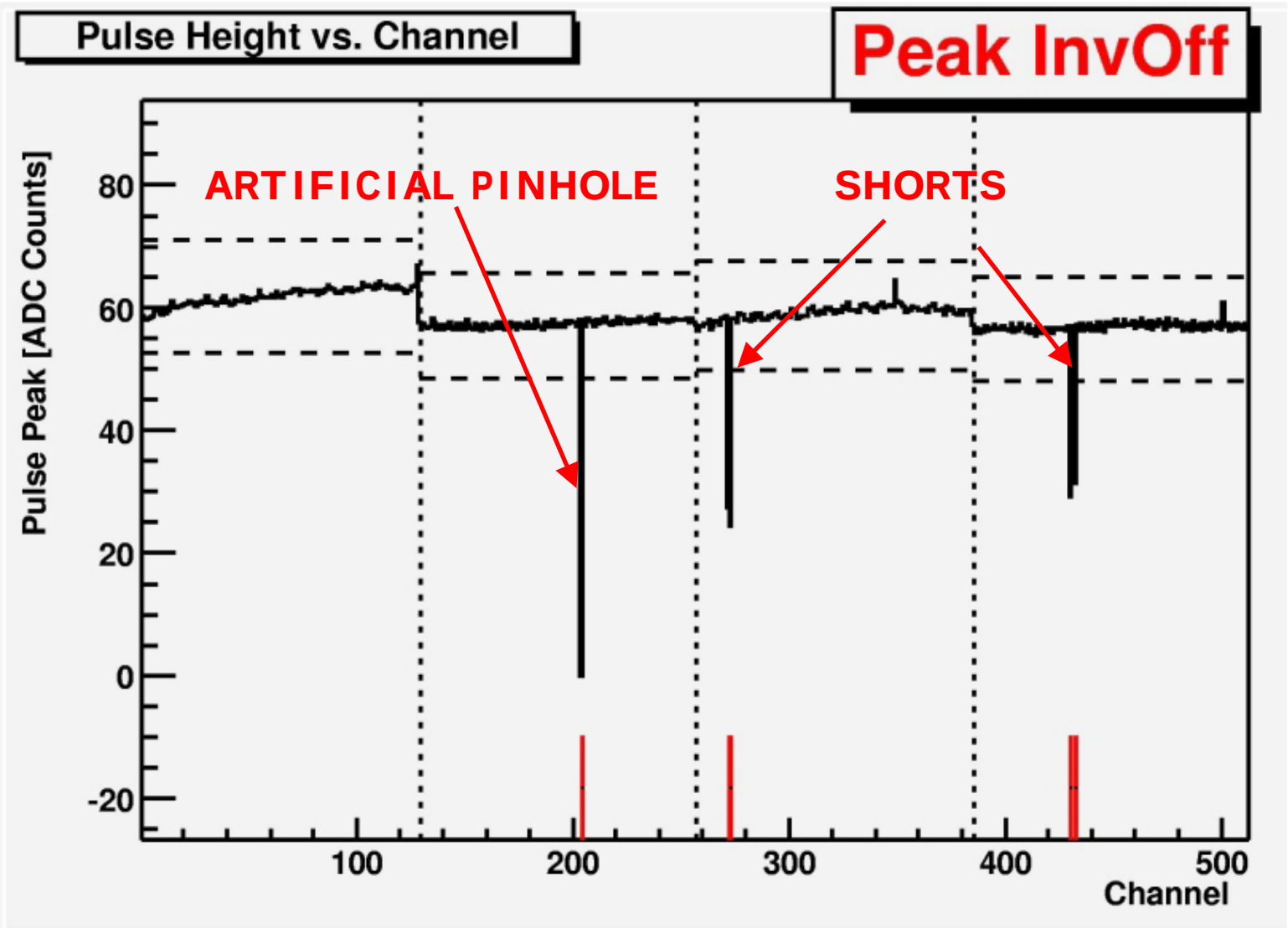
```
Bad Channel Summary for module 30200020000000; Record 6
   configFile: optimumCut_TIB_6_1.dat
         Date: 2003-07-07 18:02:28
   TestCenter: Torino
      Version: 6.0
     Operator: Lino
```

Chan#	Peak Off	Peak On	Dec Off	Dec On
2	NOIS	NOIS	NOIS	NOIS
3			NOIS	NOIS
128	OSO-	OSO-	OSO-	OSO-
204	PHL+	PHL+	PHL+	PHL+
256	NOIS	NOIS		
272	SHT+	SHT+	SHT+	SHT+
273	SHT+	SHT+	SHT+	SHT+
349	OSO-	OSO-	OSO-	MSO-
430	SHT+	SHT+	SHT+	SHT+
432	SHT+	SHT+	SHT+	SHT+
501	OSO-	OSO-	OSO-	MSO-
510			NOIS	NOIS
511	NOIS	NOIS	NOIS	NOIS

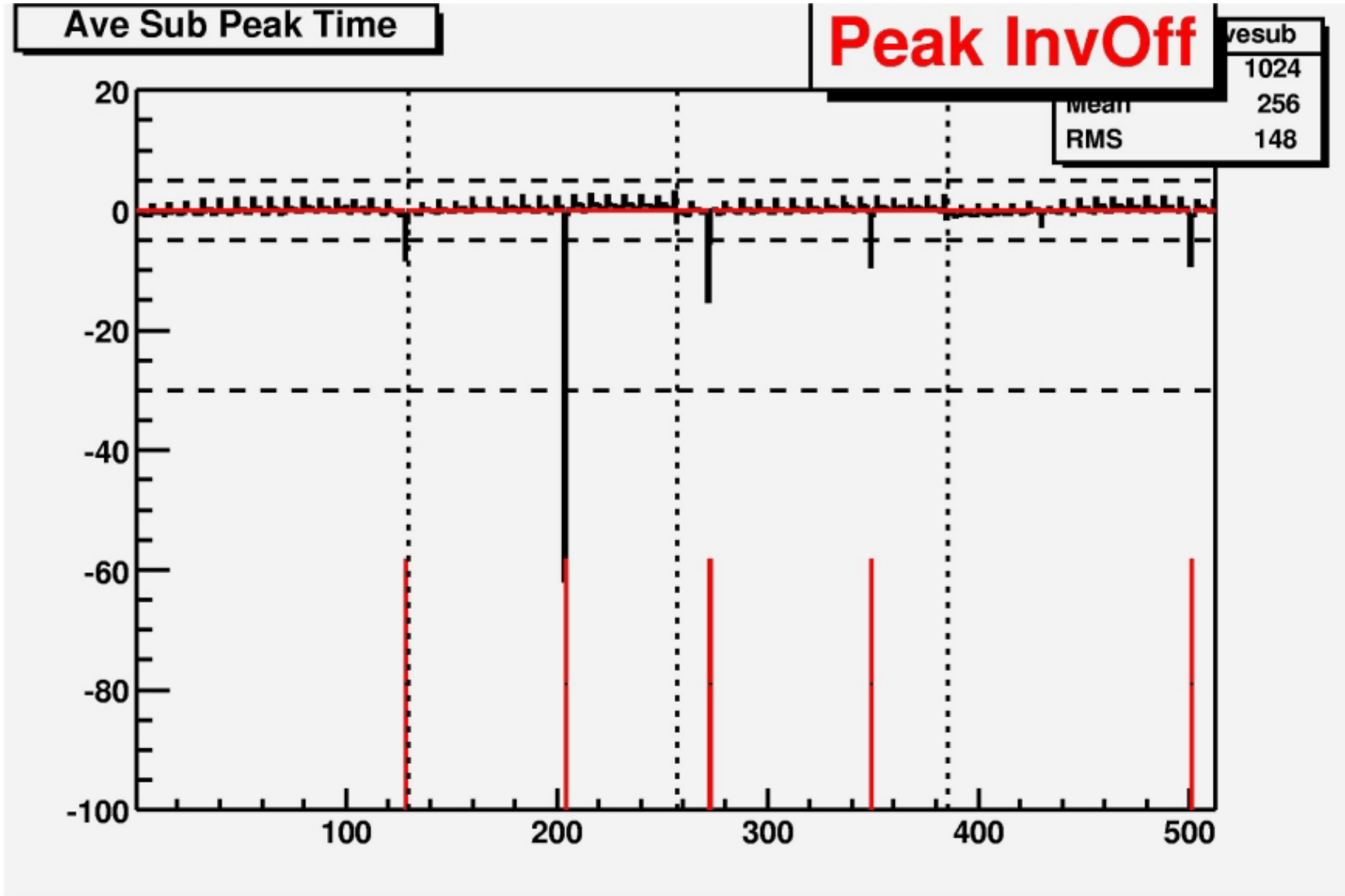
Defect Identification



Calibration Amplitude

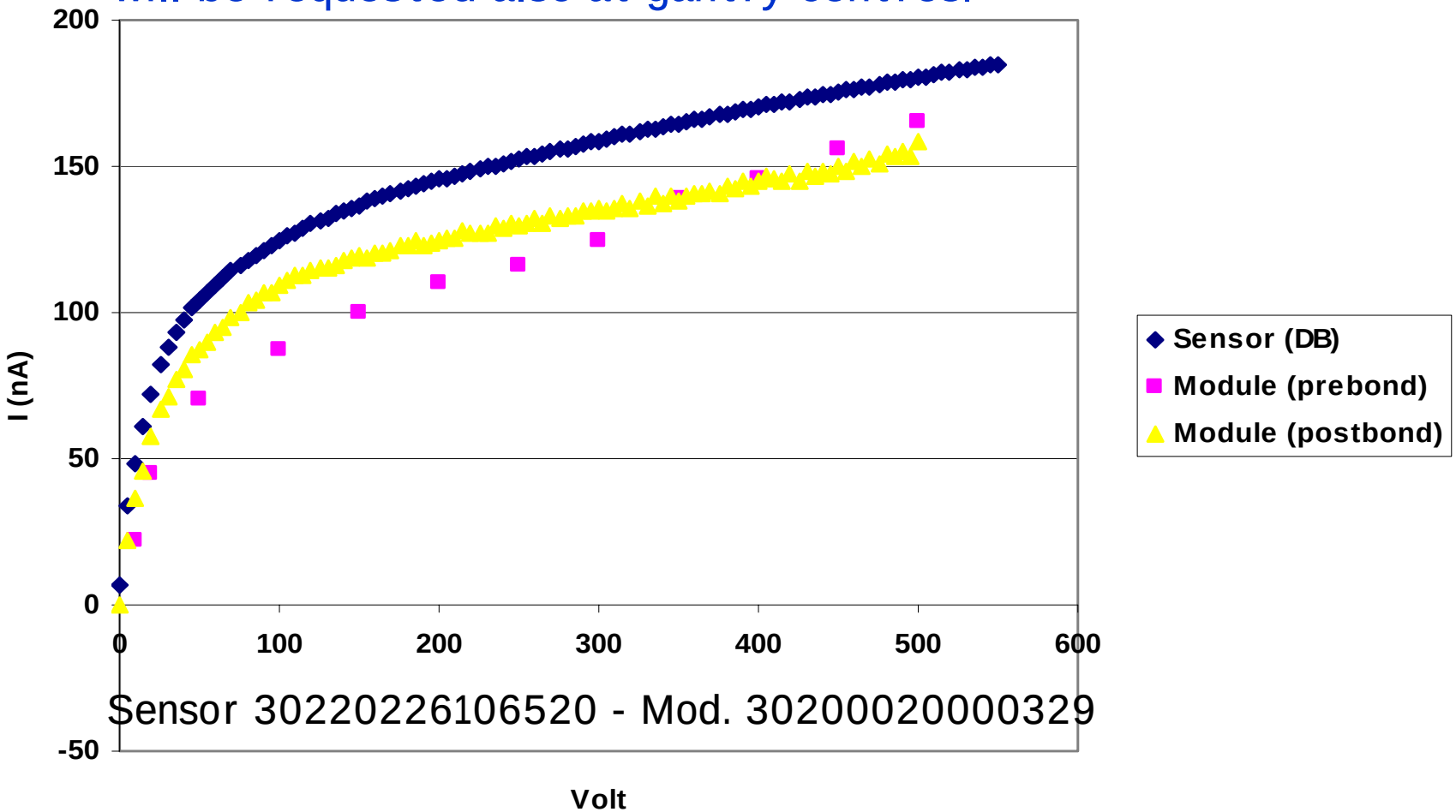


Peaking Time



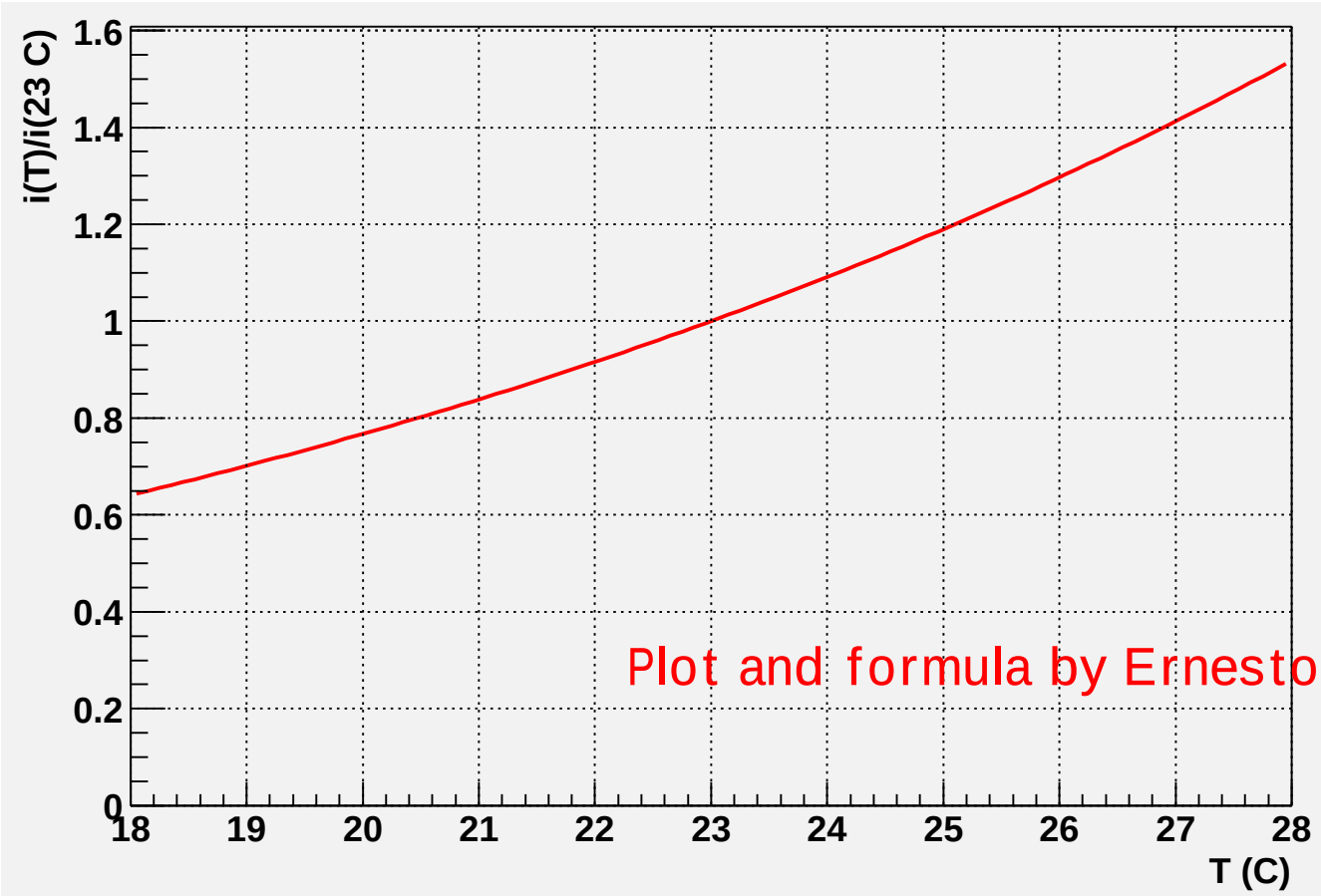
I-V tests

- IV must be done before and after PA-sensor bond, up to 500 V. This strategy will allow to trace back where IV deterioration, if any, will happen. It has been already adopted by TIB centres. In case of unforeseen problems IV will be requested also at gantry centres.



I-V Temperature Compensation

- Temperature compensation is needed to compare IV at different sites and/or tests
- i(T) = i(T0) * (T/T0)^2 * exp[-7100*(1/T-1/T0)]



Plot and formula by Ernesto Migliore

More on I-V

We cut on I500, I300: currents measured at 300V and 500V

IV criteria for cuts

Rejected if:

fail sensor specs: I500 > 20uA/sensor OR
I300 > 5uA/sensor OR

I450>10uA/sensor (for compatibility with QTC)

TOB + TEC (r4 to r7) [thick sensors]

I500(measured) > 2 x I500(expected) OR
I300(measured) > 2 x I300(expected)

TIB + TID + TEC (r1 to r3) [thin sensors]

I500(measured) > 1.5 x I500(expected) OR
I300(measured) > 1.5 x I500(expected)

WARNING: Thresholds subject to change after agreement with sensors w.g.

PLEASE SEE UPDATES IN MOD TEST PAGE http://hep.fi.infn.it/CMS/modultest/wg.html

Other issues

- Cuts for hybrids with Pitch Adaptor ready by end of TK week
- ARCS 6.1 working since 3 weeks, heavily used in Torino workshop with very satisfactory results
  - Fast test gives good feedback on overall module behaviour as it was intended for (currents, asics, I2C)
- A new ARCS release is in preparation with the implementations requested during workshop:
  - input of IV text files
  - direct evaluation of CMN rms online
  - module type via ID barcode and consequent automatic choice of appropriate cuts. Also valid for hybrid test at gantry centres and at bonding centres upon module reception
- As soon as possible all cuts will be integrated in the ARCS as they are now in Tony's macros

TEC status: (from a V. Zhukov's mail)

1) Test with ARC system after bonding (Karlsruhe, Strasbourg) are out of specs (0.5 cmn) yet.

   Box for the ARC to meet specs needed?

2) ARC (acceptance) also should have such box compatible with TEC transportation plates

3) Cross calibration for ARC system in TEC community is needed

4) Same concepts apply to CMSlike system:

   the setup are not yet in specs (if we accept same as for ARC), then again Xcal needed

We need modules to advance!

5) CMS software. We have to implement analysis algorithms.

Considerations on Test Conditions

- We are now going to apply 400 V bias voltage during tests
- Are we taking any risk ?
- We must be extremely careful during all operations! (Was it the case until now ?)
- Does it make sense to speak about operating detectors after 10 LHC years at 550V if we do not care how they do perform NOW, when they are not even irradiated ?

LT module qualification test

- Release lt_1_00 is used in different labs. Not much feed back. So not so much problems.
- Rarely the acquisition doesn't start the first time one has to restart. Not easy to reproduce.
- In special cases the bias voltage and current is not stored correctly. Still under investigation.
- **Data base file: no problems reported** → My personal comment: does this mean really we have no problems on DB ?
- Analyzing results: No major problems reported. Further standardization with ARC results is under discussion

F-MUX version

- tag with lt_1_10 is stable working in Antwerpen, UCSB, Karlsruhe but not as official release
- **Need lastest version** of FEC (tag stable0703) and basic DAQ (tag stable0703).
- upgrade only if you need it now !
- After implementation of final cuts a more detailed file structure will be used. This can give "difficulties" during a cvs update (developers !!!) . Therefore best is to do a fresh checkout (tag > lt_1_14) . Release tag will be lt_1_20

Documentation

At http://hep.uia.ac.be/cms/testing

- installation instruction
- version overview
- calibration issues
- faq , bugs reported
- etc.

features to be added

- Hard to implement request as more temperature in the GUI

LT planning

- beta version lt_1_1x F-MUX .
- Version lt_1_20 for production of long term test when cuts and analyzing details are fixed.