



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Report on Working Group # 2

The MU2E detector: calorimeter

S.Miscetti

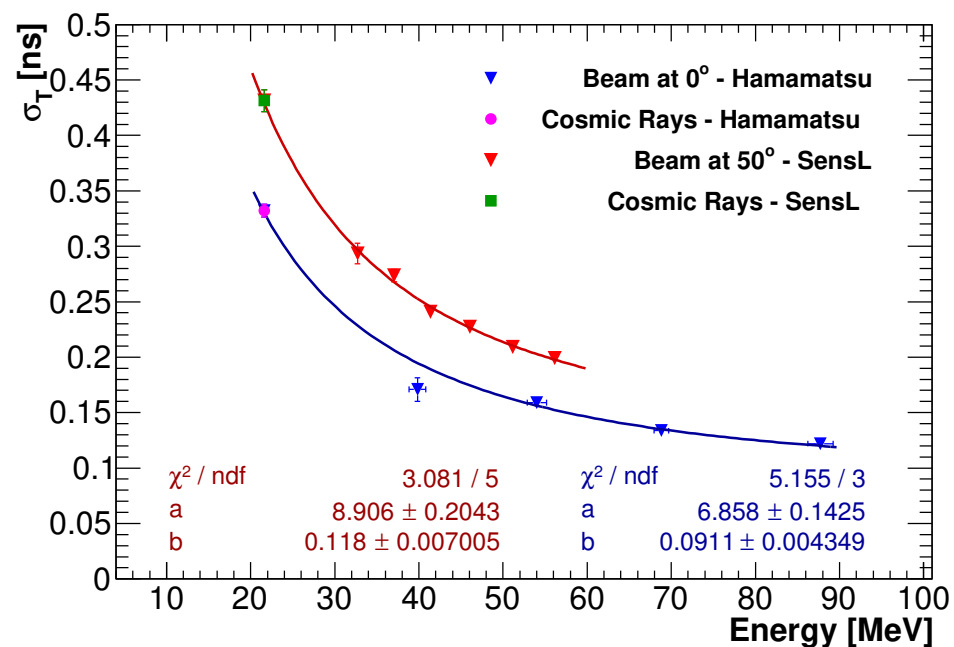
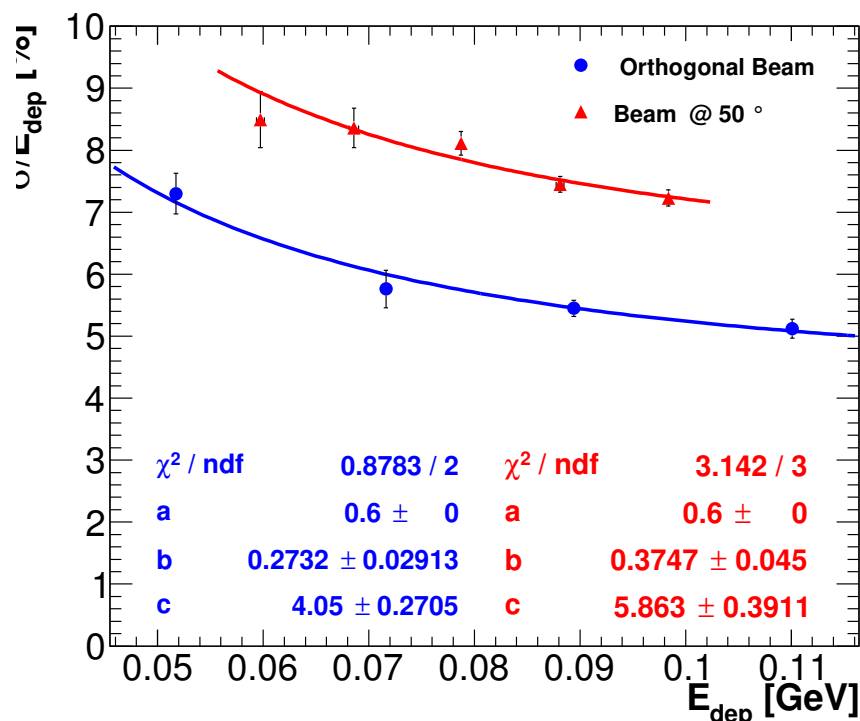
LNF INFN Frascati

MUSE Scientific Board meeting

6-July-2018

Mu2e

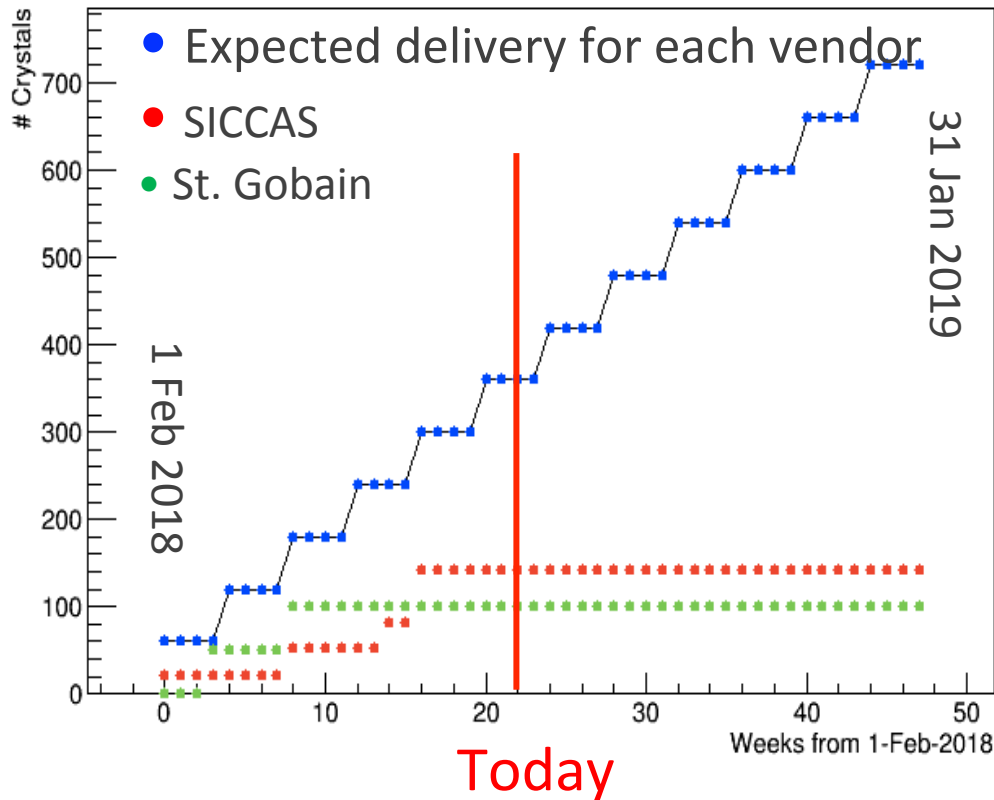
TB results



Test beam results are becoming final:

- Discovered not-linearity of amplification, correlated noise and small optical x-talk
- Resolution at 50 degrees larger at 0 degrees → increase of front leakage fluctuation
- Timing resolution for 1 sensor only ...

Crystal production status



SICCAS:

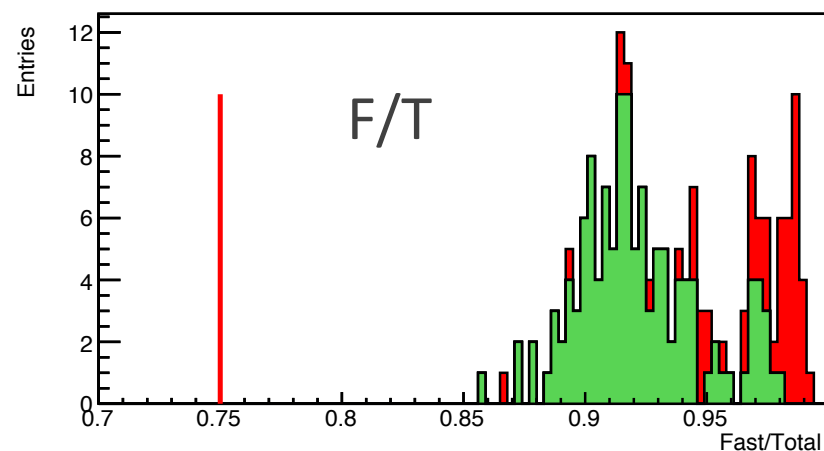
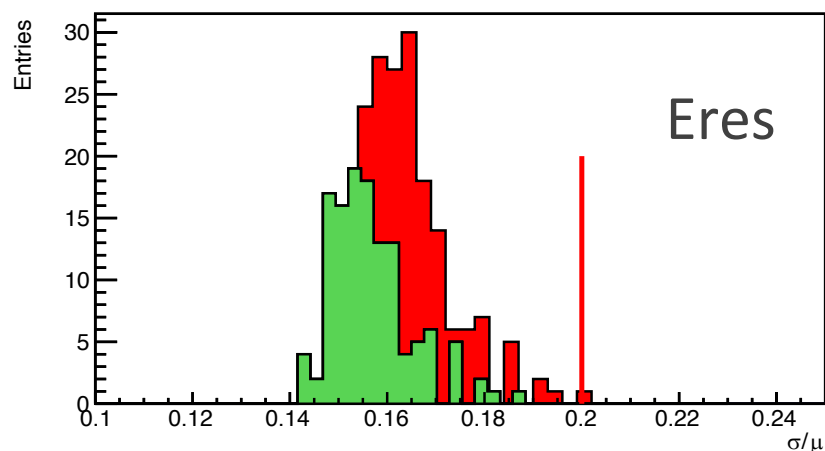
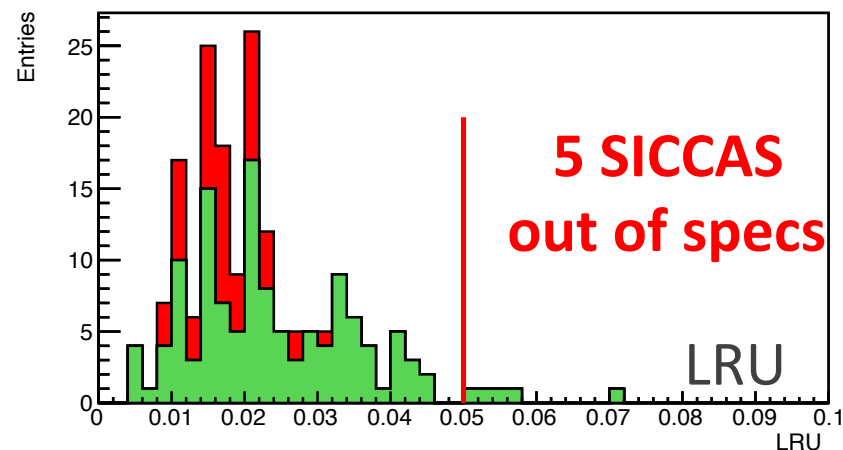
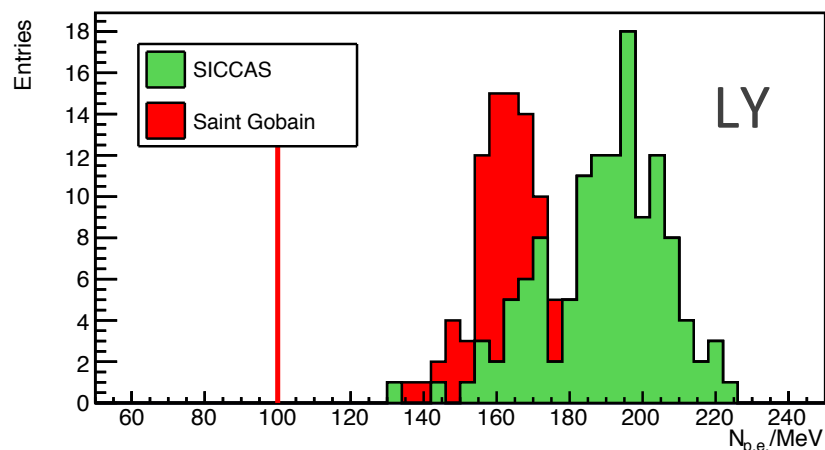
- ✗ 12 pre-series crystals delivered on Dec 2017 → **Marked/Visible dents in most of the crystals**, due to the packaging procedure
- ✗ 10 pre-series crystals delivered on Jan 2018 → Improved packaging method, no visible crystal damages
- ✗ **30+30+60 production crystals delivered on Mar/May/Jun 2018**
- ✗ Next shipping of 60 crystals arriving end of this month

Saint Gobain:

- ✗ 50 crystals delivered on Feb 2018
- ✗ 50 crystals delivered on Mar 2018

- All crystals tested with the FNAL CMM machine
- QA optical properties tested @ FNAL
- 16+3(16) SIC(SGB) crystals sent to Caltech for QA and irradiation tests

QA of optical properties @ SIDET



230 (180) crystals tested (accepted). Excellent optical properties for both vendors
Only 5 SICCAS crystals with LRU exceeding acceptance cut

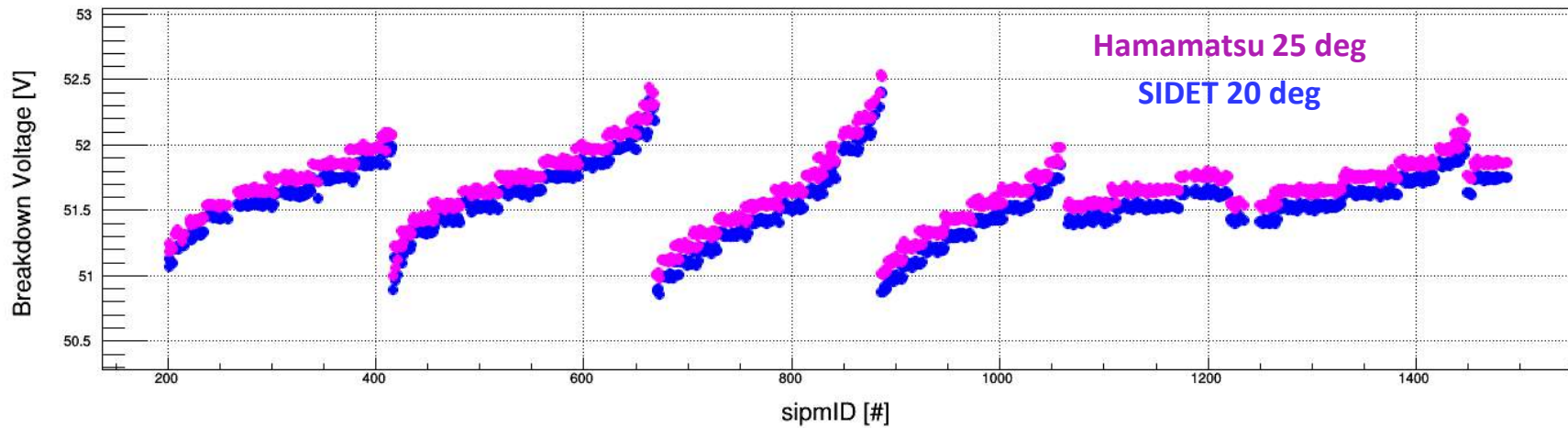
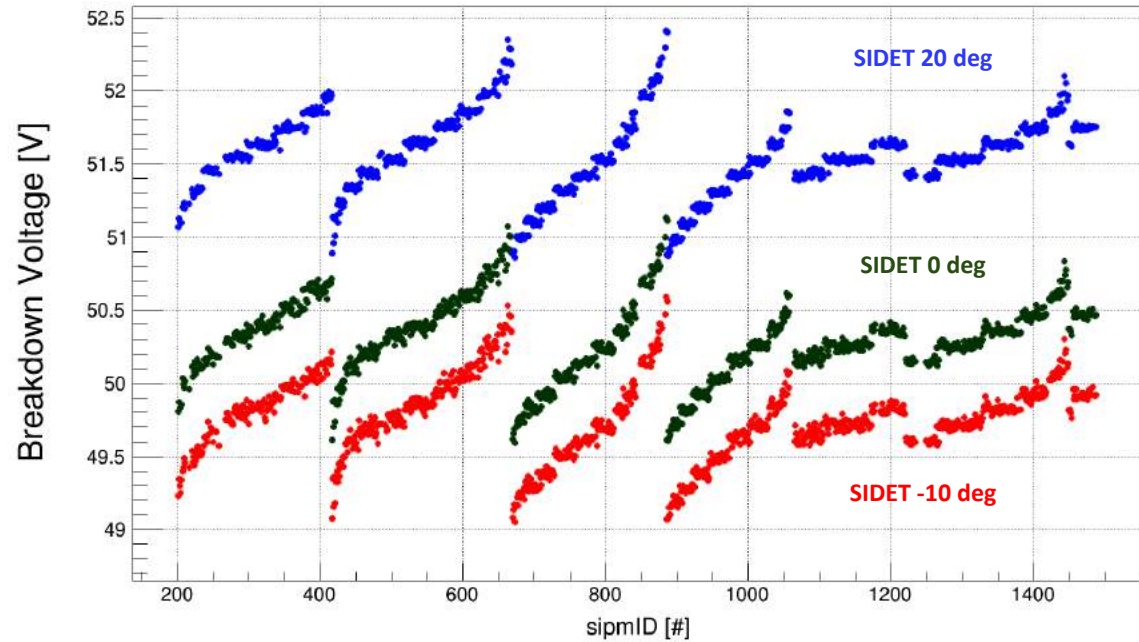
SiPM: summary of status of production

| Batch # | 1 | 2 | 3 | 4 | 5 | Total |
|--------------|----------------------|---------------------|---------------------|----------------------|------------|------------------|
| N.SiPMs | 292 | 280 | 280 | 280 | 280 | 1412/1132 |
| Date In | 28/2/18 | 28/3/18 | 25/4/18 | 24/5/18 | 15/6/18 | |
| Qa Date | 26/3/18 - 18/4/18 | 18/4/18 - 5/5/18 | 5/5/18 - 18/5/18 | 24/5/18 - 12/6/18 | 20/6/18 | |
| MTTF date | 10/4/18 | 22/5/18 | 10/6/18 | 28/6/18 | ... | |
| N. Acc | 284 | 269 | 269 | 272 | | 1094 |
| N.Reject | 8 | 11 | 11 | 8 | | 38 (3.4%) |

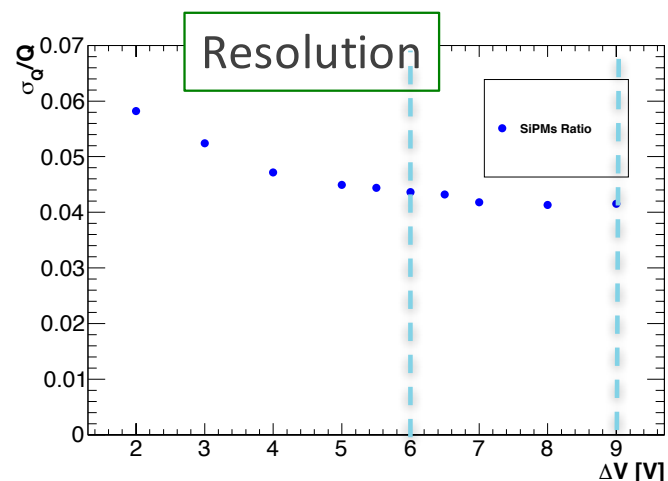
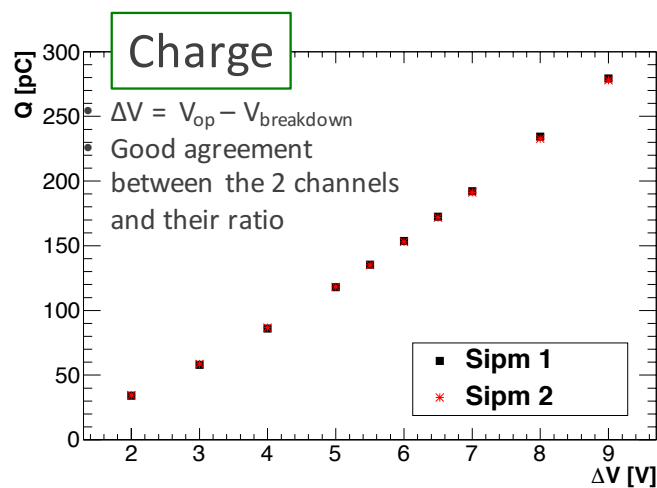
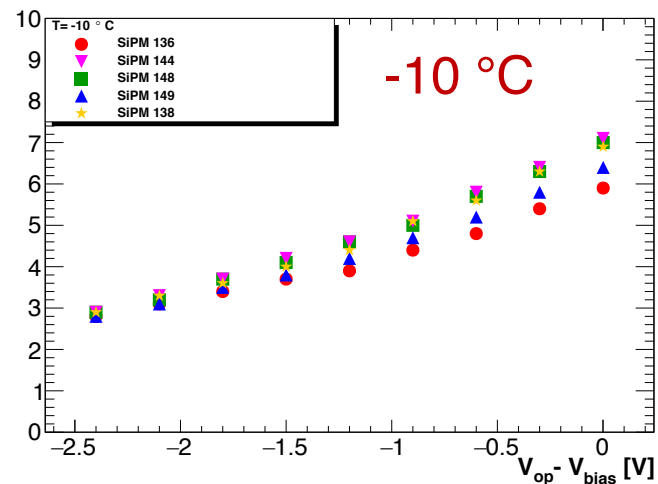
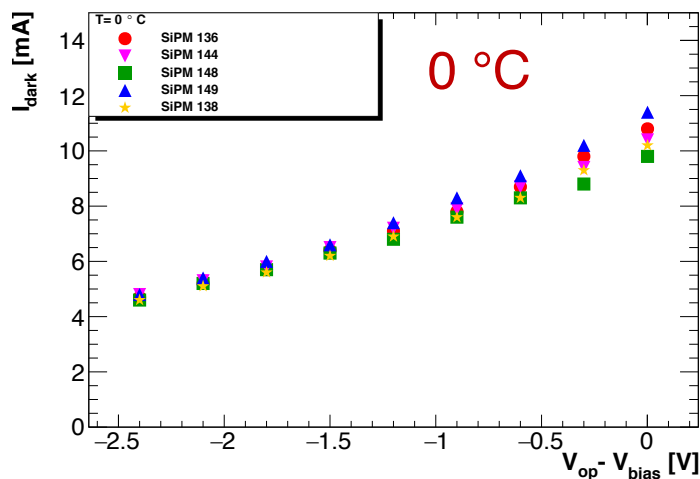
- 1132 out of 3350 of standard production (1/3)
- Additional 650 spares to be handled at the end of prod

SiPM: QA-station results

- Production trend for V_{op}
- Good comparison btw our measurement and Hamamatsu one



SiPM: Radiation hardness test

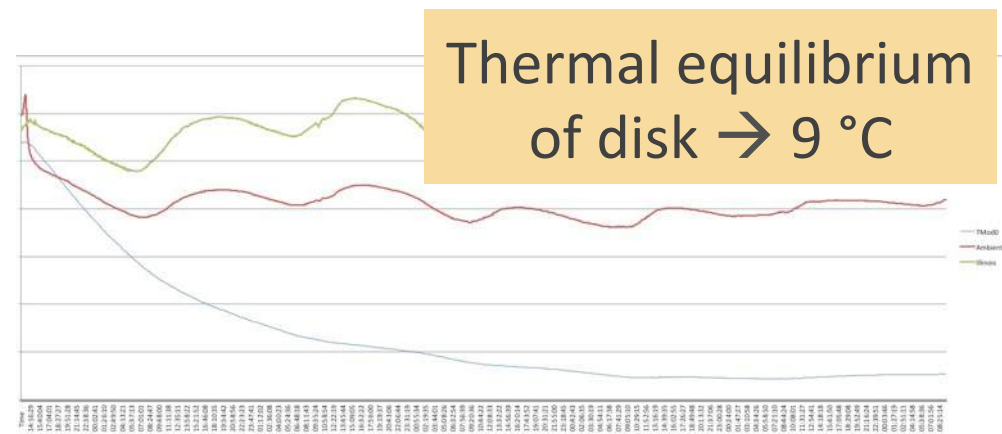
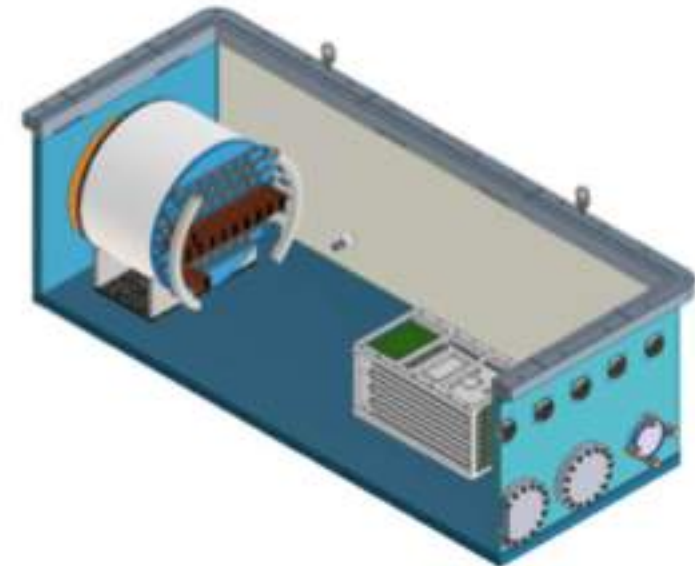
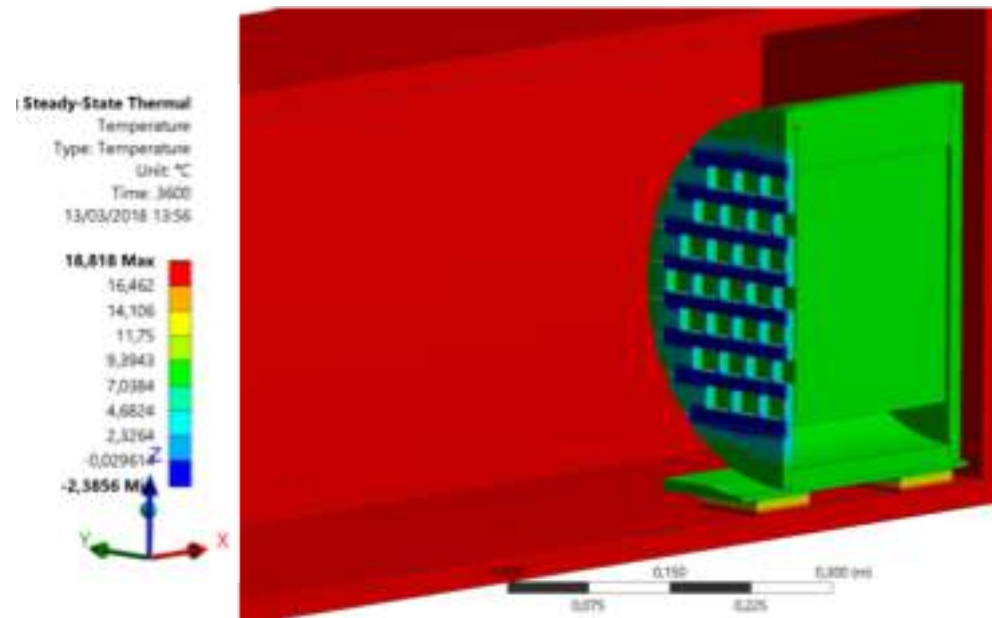


Tested up to $1.4 \times 10^{12} \text{ n/cm}^2$ @ HZDR $\rightarrow T = (-5/-10) \text{ }^\circ\text{C}$, $\Delta V = -3\text{V}$

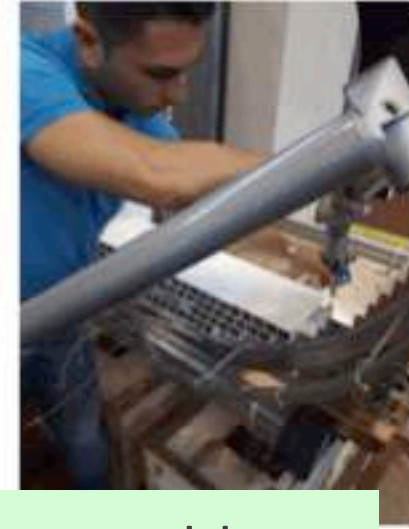
Engineering design and tenders

- ❑ The engineering proceeds well with all parts fully engineered and prototyped.
- ❑ In Italy most of the tenders are in preparation or ready to go but waiting for the last step of integration and overall blessing. We are tuning the work to **have a CRR for mechanics at end of September** to be sure to start with the solid parts first (i.e. disks)
- ❑ Study of tolerances for stacking and integration of crates and services are important to complete the drawings and make them final
- ❑ Integration of the source and final version of PEEK-plate and SiPM/FEE holders are also needed to freeze the drawings.
- ❑ A continuous turn around of tests and comparison with thermal/mechanical simulation are being carried out @ **Module0, full size mockup, small size tests**
- ❑ Work is continuing in designing and planning assembly area at SIDET

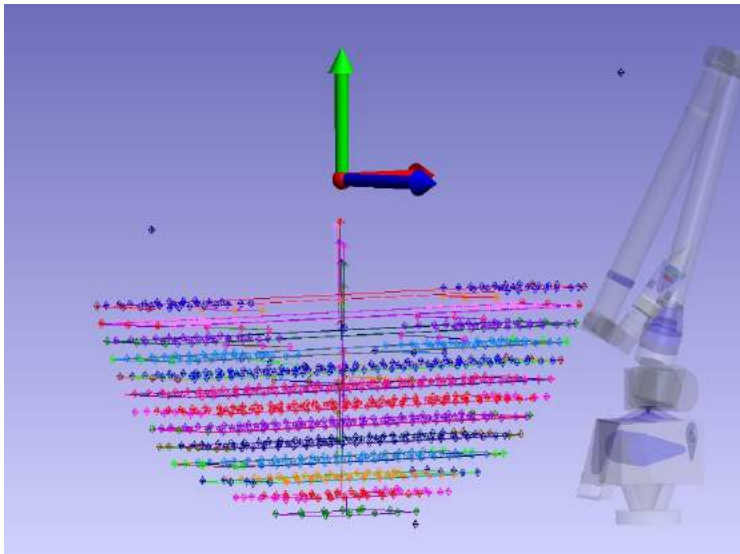
Tests of Module-0 inside large Dewar



Surveying the full size Mockup



DAΦNE LNF alignment team



| plane AI | x-xi | cristals planes | |
|----------|----------|-----------------|-------|
| 635,14 | | | |
| 600,79 | 34,35000 | 600,91 | 34,23 |
| 566,34 | 34,45000 | 566,51 | 34,40 |
| 531,92 | 34,42000 | 532,13 | 34,38 |
| 497,53 | 34,39000 | 497,75 | 34,38 |
| 463,19 | 34,34000 | 463,29 | 34,46 |
| 429,00 | 34,19000 | 428,92 | 34,37 |
| 394,79 | 34,21000 | 394,56 | 34,36 |
| 360,51 | 34,28000 | 360,25 | 34,31 |
| 326,21 | 34,30000 | 325,84 | 34,41 |
| 291,90 | 34,31000 | 291,5 | 34,34 |
| 257,59 | 34,31000 | 257,21 | 34,29 |
| 223,27 | 34,32000 | 222,86 | 34,35 |

| PIANI | RMS |
|--------------------|------|
| PIANO_0 | 0.03 |
| PIANO_1 | 0.04 |
| PIANO_2 | 0.04 |
| PIANO_3 | 0.04 |
| PIANO_4 | 0.04 |
| PIANO_5 | 0.01 |
| PIANO_6 | 0.07 |
| PIANO_7 | 0.03 |
| PIANO_8 | 0.03 |
| PIANO_9 | 0.03 |
| PIANO_10 | 0.03 |
| PIANO_11 | 0.02 |
| PIANO_12 | 0.03 |
| PIANO_1 CRISTALLI | 0.05 |
| PIANO_2 CRISTALLI | 0.06 |
| PIANO_3 CRISTALLI | 0.08 |
| PIANO_4 CRISTALLI | 0.10 |
| PIANO_5 CRISTALLI | 0.12 |
| PIANO_6 CRISTALLI | 0.14 |
| PIANO_7 CRISTALLI | 0.14 |
| PIANO_8 CRISTALLI | 0.16 |
| PIANO_9 CRISTALLI | 0.17 |
| PIANO_10 CRISTALLI | 0.21 |
| PIANO_11 CRISTALLI | 0.25 |
| PIANO_12 CRISTALLI | 0.27 |

Test with dose @ Calliope

(1) Irradiate SiPM/FEE in different conditions @ 5Gy/h for 6-7 days.

Max Dose reach: 125 hours x 6-7 → 70 krad.

- The MB driving the components in bullet (1) is protected behind a LEAD shielding and at 1.8 m distance (cables' length)
- To the components in (1) we added also a HV regulator board set at 100 V to monitor continuously its working value.

(2) Irradiate a MB @ 2Gy/h → Max Dose = 30 krad.

- The SiPM driven by the MB in (2) are shielded behind few LEAD blocks.
- ❖ For all components we store Vread, Idark, T each 1' with Labview program MU2E_CALO-0
- ❖ 4 channels will be acquired with RUNDAQ_calliope firing a Laser at 0.5 Hz. We also add noise data taking at 0.2 Hz.

(3) Irradiate HV/LV service Cables up to 25, 250 krad

SIPM OK, Preamplifier OK, HV-regulator problems on LDO, ADC/DAC

DIRAC V1 → DIRAC V2 and next plans

Design of V2 board started, many components need to be replaced:

- Fiber receiver VTRX (outgassing OK, procurement done, pieces OK)
- FPGA Polarfire
- DCDC converters LTM8053

→ **Design of new version ready for Nov-Dec 2018**

Next Steps on testing V1

1. radiation tests at HZDR to spot precise regions/component in the board
2. Radiation hardness test with dose in Italy to test behavior of jitter cleaner
3. Test the extraction of the ADC data to evaluate ADC performance
4. Setup a full chain in Pisa (crystal + FEE) to evaluate ADC performance and analog filter on the digitizer

Test with dose of DIRAC V1

- From latest simulation: Dirac DOSE = 0.2 krad/y
- Applying safety factors: 60 = 5(years) x 12 (SIM,Rate,Prod)
→ looking for O(12 krad)



Calliope: Co60



DIRAC



DIRAC



HZDR: g-elbe

Laser

Polyammide
Ø 7mm, 10mm, 13mm, 16

- Calliope: test of full board up to 30 krad
→ No problem or broken components
- HZDR : test of single components up to 80-150 krad
→ ADS, DCDC-converter, LDO, Jitter cleaner ..