



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

## Report on Working Group # 2

# The MU2E detector: calorimeter

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S.Miscetti

LNF INFN Frascati

MUSE Scientific Board meeting

13-Sep-2019

**Mu2e**

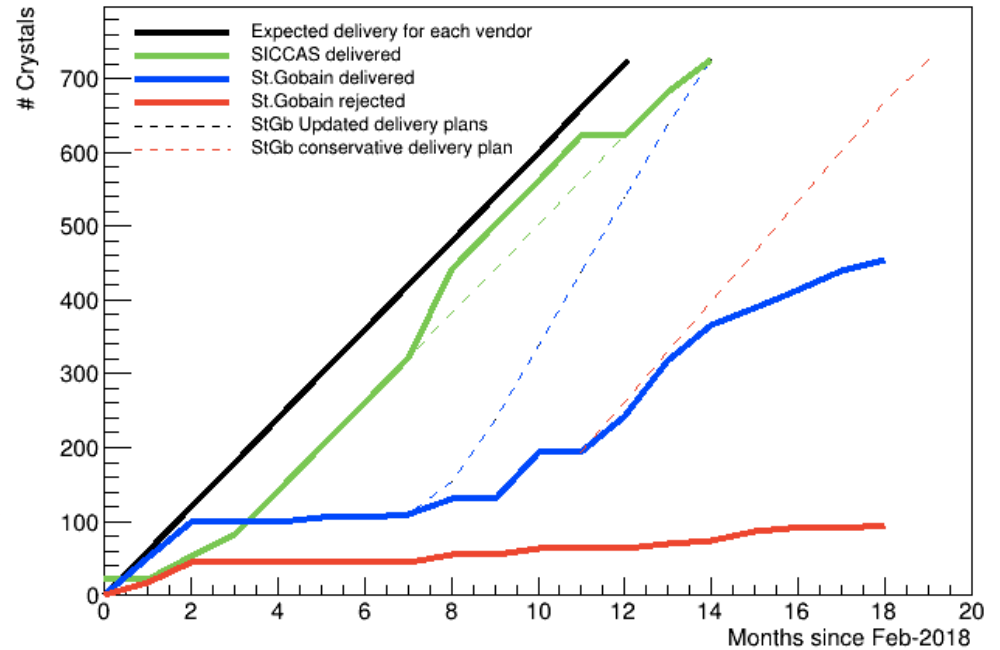
# Crystal production

## SICCAS

- **725/725 crystals received**
- **# out-of-specs crystals: 30**  
→ 4% of the production

## St.Gobain problems persisting

Proposal of closing the contract & swapping SICCAS for the rest of production in progre



Plan is to re-start production with SICCAS in 1 month from now. REQ being prepared

	SICCAS	St.Gobain	Total
Shipped	725/725	460/725	1185/1450
CMM + inspection	725	454	1179
Sent to Caltech	257	146	403
Out-of-specs	30	94	124
Irradiation at Caltech	9	3	12

# SiPMs production – neutrons

- Estimated neutron flux by simulation is  $(4-5) \times 10^{10}$  n/cm<sup>2</sup> per year:
  - 5 years of run →  $\sim 2 \times 10^{11}$  n/cm<sup>2</sup>
  - including a factor 3 of safety →  $\sim 6 \times 10^{11}$  n/cm<sup>2</sup>

Tests on the irradiated SiPMs @ DRESDEN demonstrated that:

- We can operate at 0°C keeping the leakage current < 2 mA up to  $1 \times 10^{12}$  n/cm<sup>2</sup>: → Reducing the V<sub>bias</sub> of 3 V and loosing 15% of PDE and a factor of 2 of Gain

A fine tuning of the leakage current vs integrated flux has been done, testing:

- 9 SiPMs @  $5 \times 10^{10}$  n/cm<sup>2</sup>
- 9 SiPMs @  $1 \times 10^{11}$  n/cm<sup>2</sup>
- 9 SiPMs @  $5 \times 10^{11}$  n/cm<sup>2</sup>
- 9 SiPMs @  $1 \times 10^{12}$  n/cm<sup>2</sup>

@ FNG Frascati with a 14 MeV n source.

We have inserted 8 SiPMs of group B and 8 SiPMs of group C inside Module-0 for testing their response and timing resolution. Analysis in progress.

However we have observed a x2 I<sub>dark</sub> with respect to EPOS (Dresden). **Investigating.**

# Electronics production ...

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- Realization of the FEE Boards is the most critical path in the schedule
  - PCB review for FEE and MB-V2 boards carried out in July
  - Recommendation received end-of-July (see next slide)
  - getting ready for a PCB review for DIRAC V2 in coming weeks
  
- Planning a joined PCB and CRR for MB-V2 and DIRAC V2 in the fall 2019 after a final vertical slice test with the first DIRAC V2 proto

In the meanwhile:

- **preparing the tenders in Italy**
  - **Plan is to submit production end 2019/beginning 2020**
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- **Tender for the FEE-MB cables also in preparation**

# Recommendations from FEE-PCB review

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## □ Recommendations from FEE-PCB review received:

- We are pleased for findings and for comments.
- 17 recommendations were received.
  - All suggestions will be replied and applied in the final version of the PCBs.
  - The last one required us to make more work:

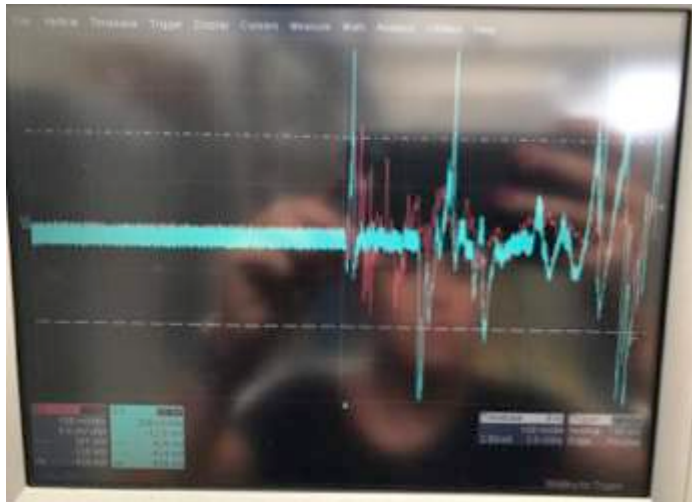
17. Operation in vacuum: The committee recommends that the design team review the routing of high voltage traces, vias, and parts placement, for proper operation (i.e. the absence of breakdown) as a function of vacuum.

- The team should either determine this analytically,
- or measure the corona of the existing boards under bias as a function of vacuum.
- An allowance for safety factor headroom is recommended.

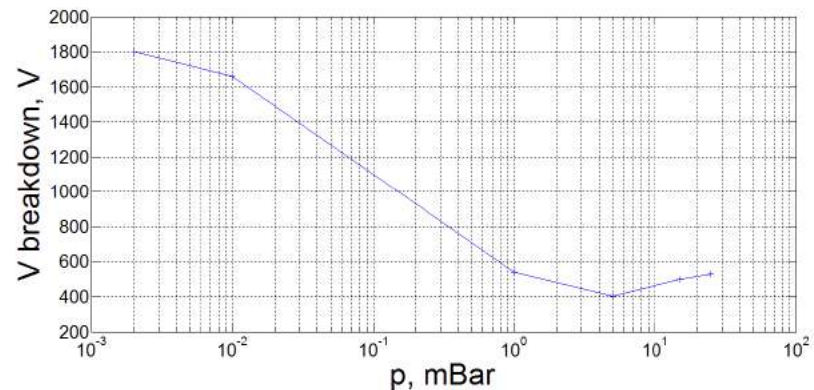
1. We made an analytical calculation of  $V_{\text{breakdown}}$
2. We performed a series of test with FEE in Vacuum
3. We searched for Corona's effect looking at noise

# FEE @Pachen Min: Results (Docdb 27933)

Example of breakdown startup



HV [V]	25 mbar	15 mbar	5 mbar	1 mbar	10 <sup>-2</sup> mbar	2x10 <sup>-3</sup> mbar
300	ok	ok	ok	ok	ok	ok
350	ok	ok	ok	ok	ok	ok
400	ok	ok	bd @ 405 V	ok	ok	ok
450	ok	ok		ok	ok	ok
500	ok	bd		ok	ok	ok
530	breakdown			ok	ok	ok
540				bd	ok	ok
600					ok	ok
900					ok	ok
1200					ok	ok
1600					ok	ok
					Bd @ 1660	Bd @ 1800



- @ Paschen minimum ,  $V_{br} > 405$  V (larger than 327 from flat electrodes), x 2.2 times  $V_{max} < 200$  V
- @ 10<sup>-2</sup> Torr ,  $V_{br} > 1650$  V , factor of 8 safety granted

# Answer to FEE recommendation:

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→ The highest level recommendation of operation in vacuum has been deeply studied. These are our conclusions:

1. Calorimeter operations between  $10^{-2}$  to  $10^{-4}$  Torr have a safety factor  $> 8$
2. Operation at Paschen minimum for the 300 um distance electrodes in the PCB have been calculated and tested:
  - **We estimated  $V_{br} > 600$  V , we measured  $V_{br} = 405$ .** This is a safety factor  $> 2.2$
  - This status is going to be just a transient. We do not need to work there.  
Procedure will be to turn-OFF HV anyhow when changing pressure.
3. **We have run 3 SiPM+FEE boards in vacuum at  $10^{-2}$  Torr and 50 Torr.**
  - No differences in the noise observed
  - No corona spikes observed
4. SiPM+FEE boards were run also in the past showing no problems either in the considered operation regions or in proximity of the Paschen minimum

# LV-HV-TDAQ services + Readout

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- We are getting very close to 100% complete also for the services.  
LV and HV PS crates selected.
- Kind, numbering and prototypes of all LV/HV cables prepared.
- Mockup of LV/HV cable under way
- Feed-throughs have also been selected (and most of them procured)
- Test of routing on IFB mockup could be organized

**THE ACTUAL ROUTING OF THESE CABLES SHOULD HAPPEN BEFORE HAVING THE SUPPORT FOR THE RAILS INSTALLED .. (SUMMER 2020). This is mandatory for installation in the pit.**

- Full Slice test being prepared. DIRAC V2 prototypes are arriving**
- DIRAC V2 PCB review planned for this month**
- LASER system is going fine**



# Status of deliverables & Milestones

- D2.1 (TDR) Month 12
- D3.3 (Design Laser system) Month 18
- D4.2 (Development of Simulation Code) Month 32
- D2.2 (Production DB for Crystals and sensors) Month 36
- MS2 (Assembly of the first calorimeter disk) Month 42

## Calorimeter disk assembly delayed of more than 6 months

- CRR of mechanics done for May 20
- PCB review for FEE/DIRAC done in July / plan for September
- Disk mechanics expected for winter 2019
- FEE delivery expected for winter 2019

- Tight schedule to get delivery of components for end of 2019.
- Assembly start now planned for February 2020
- it will be a great results to have large components for Jan 2020