Report on Working Group # 2
The MU2E detector: calorimeter

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MUSE Scientific Board meeting
9-July-2019

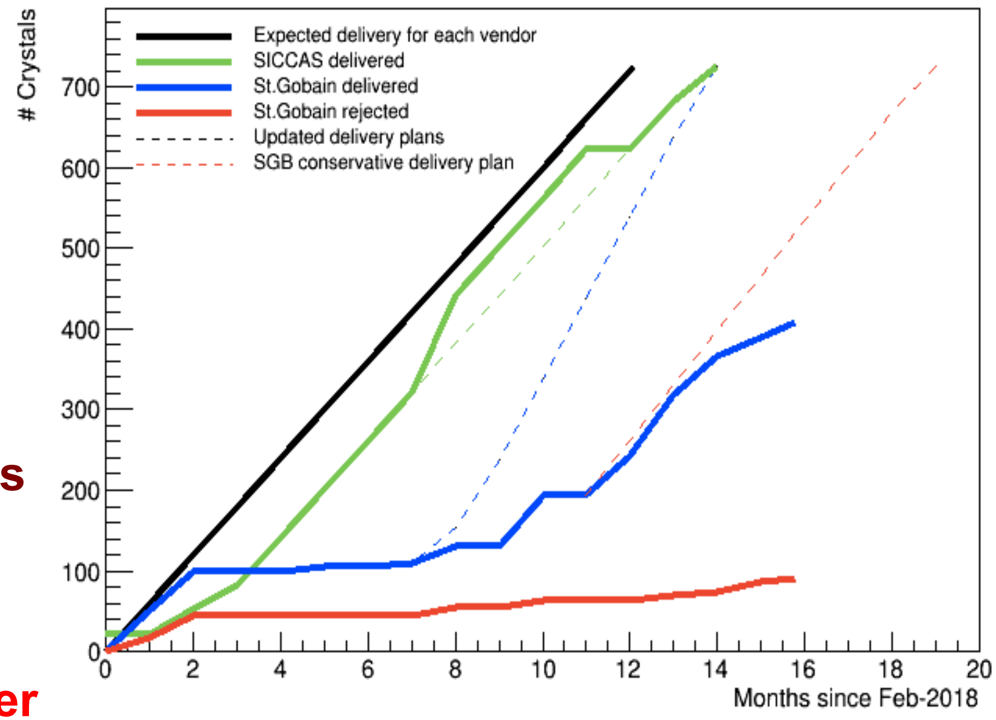
Crystal production

SICCAS

- **725/725 crystals received**
- Last shipment @ FNAL: 4/17/2019
- **Overall # of out-of-specs crystals: 30** → 4% of the production

13 out-of-specs crystals replaced

Replacement of 17 pieces in progress



St.Gobain production still struggling

→ **Reduced production rate and larger out-of-specs fraction since May**

- April: 49 crystals (5 out-of-specs)
- May: 24 crystals (12 out-of-specs)
- June: 19 crystals (4 out-of-specs)
- 21 crystals ready to be shipped

	SICCAS	St.Gobain	Total
Shipped	725/725	409/725	1134/1450
CMM + inspection	725	409	1134
Sent to Caltech	257	116	373
Out-of-specs	30	44+46	120
Irradiation at Caltech	9	3	12

Optical x-talk and Tedlar wrapping

- ✗ Optical cross-talk between adiacent crystals of ~ 2% observed in Module 0 test beam data (Mu2e-doc-20862). Confirmed with laser measurements.
- ✗ **An extra wrapping of 50 μm Tedlar reduces the effect to a negligible level**
- ✗ Tedlar outgassing negligible (<0.08E^{-3} Torr/l×sec) (Mu2e-doc-26775)
- ✗ Thickness precisely measured adding several Tedlar layers
- ✗ Adopted solution for disk crystal assembly: single Tedlar foil between crystal planes + 1 Tedlar foil glued on Tyvek wrapping, on the aluminum taped side
- ✗ Process started two weeks ago. Three step procedure:
  1. Cap mounted on side opposite to the one providing best LY
  2. Crystal ID printed on cap
  3. Tedlar glued on Tyvek

SIPM production COMPLETED (1)

We have concluded also the QA test for the overall 14 batches

- Neutron Irradiation OK with fluence $<10^{12}$ n/cm^2 operating @0℃
- MTTF evaluated > 10^7 hours

A HUGE THANK YOU to the SIPM group for the collaboration shown in the last year and for the high quality of the job done

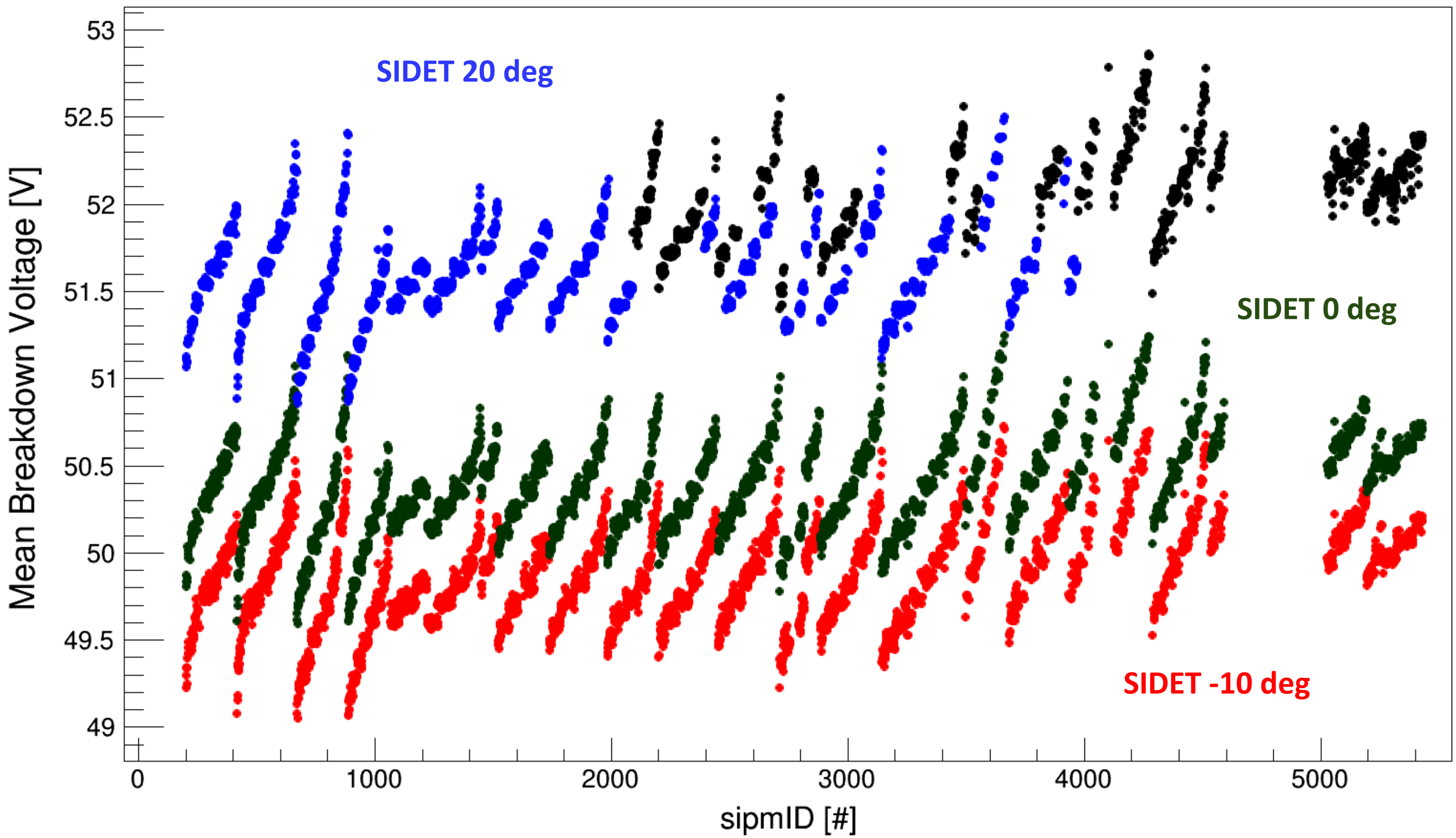
Details:
3950 SiPM arrived
3902 SiPM accepted

- 5 SiPMs of batch 1 used as reference in the QA station
- 35 SiPMs irradiated (first 7 batches) + 20 must be irradiated = 55 SiPMs
- 180 SiPMs tested in the MTTF station → **MTTF > 12 million hours**

48 SiPM rejected → 1.2% of the total

SiPM Vbr as a function of SiPM ID#

- Results from the 5 tested batches confirmed the sipmID dependance of Vbr:



Where are we now … after big RAD detour? (1)

After June 2018 TID test, we have revised most of FEE electronics while completing the design of rad-hard DIRAC (V2)

- FEE V1→ V2 Shaping adjusted (NIM-MB controlled)
- FEE V2 → V3 better cable controlled by MB-V1
- FEE V3 → V4 (RAD-HARD) final cabling vs MB-V2

V4 design has been completed

➔ **SEU test for MB-V1 needed for ARM processor → done in May**
➔ **DIRAC-V1 SEU test under planning probably this July**
➔ **First slice test with few channels done up to DIRAC V1**

➔ 25 channels of V3 produced in May, being prepared for Module0
➔ Module-0 will be ready to be readout with DIRAC V1
➔ Then proceed for slice test with V4-MB2 and DIRAC-V2 (Fall 2019)

Development of RAD-Hard electronics

Long irradiation campaign carried out:

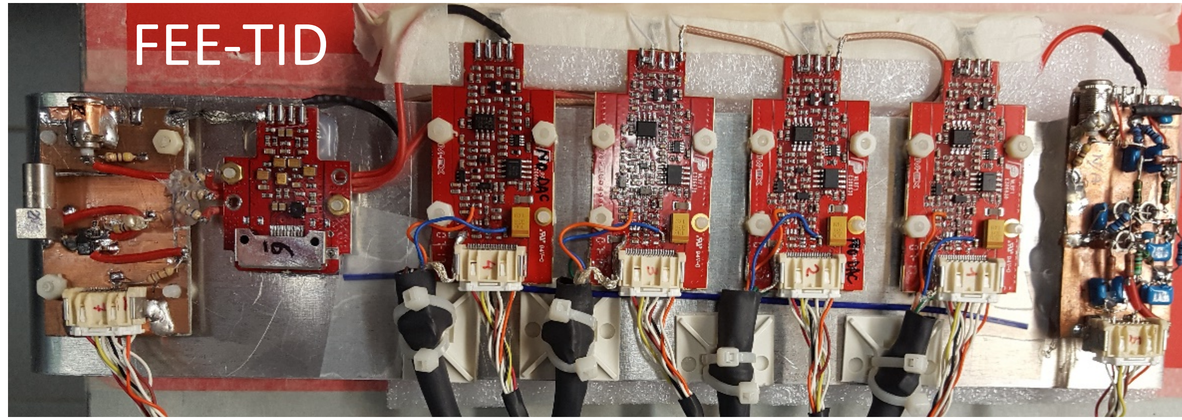
- ➔ Neutrons in FNG(Italy) HZDR(Germany)
- ➔ Dose in Calliope (Italy) HZDR (Germany)
- ➔ SEU in Warrenville (USA)

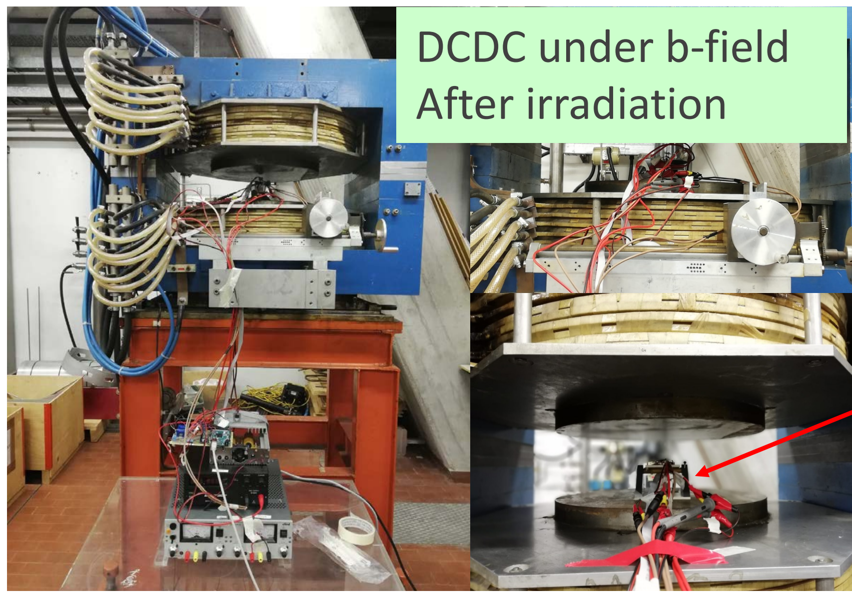
Results:

1) Final rad-hard components selected
2) FEE v4 OK
3) DC-DC converter OK
4) FPGA/ADC/DDR sections of DIRAC tested

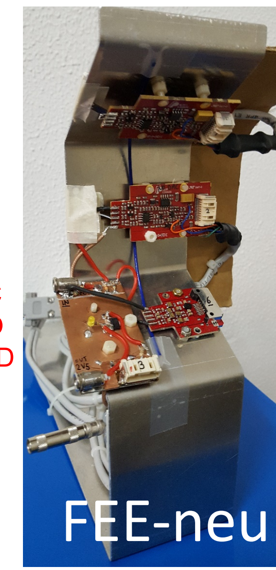
→ SEU test almost completed

→ Dirac V2 design completed





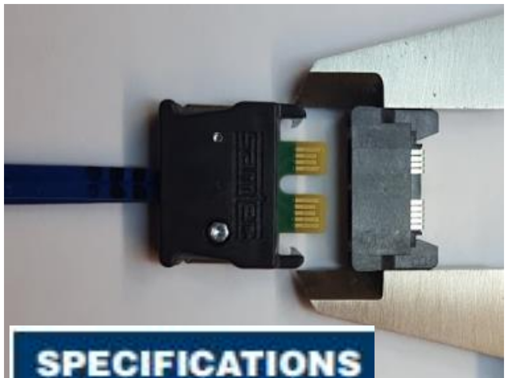
DCDC
DEMO
BOARD



FEE v3 → v4 (different ADC .. Different cable)

ECDP-04-L2

- 1 connector per SiPM/Channel



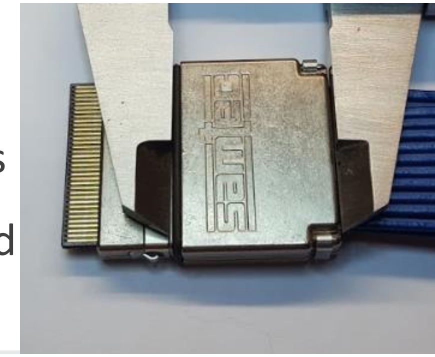
SPECIFICATIONS

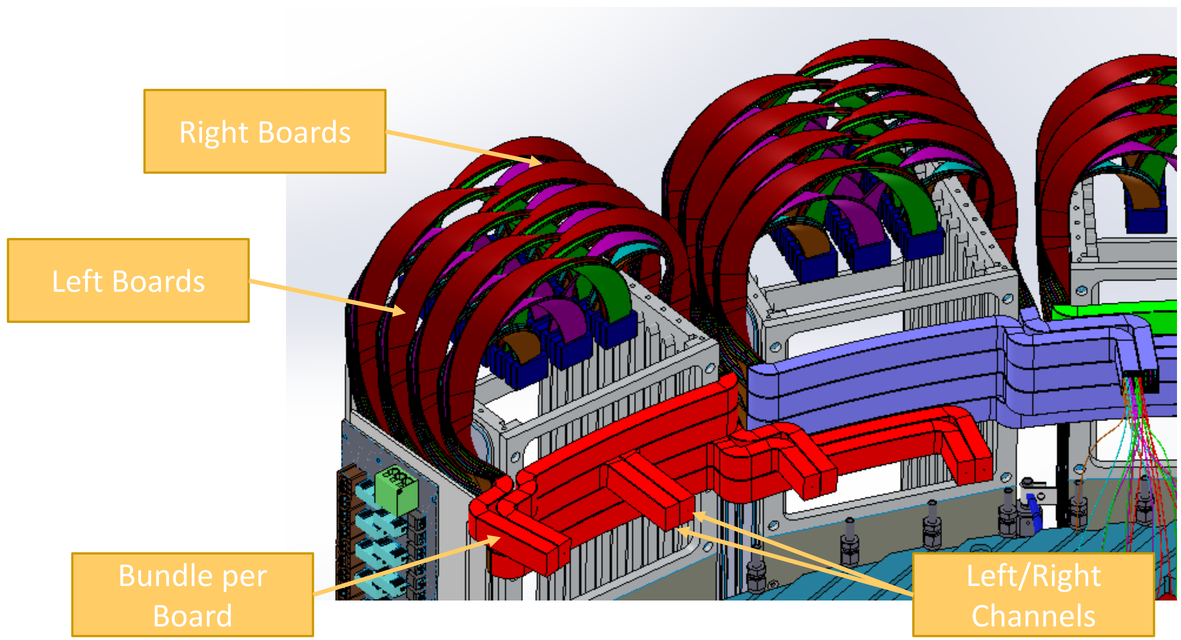
For complete specifications see www.samtec.com?ECDP

Cable: 30 AWG twinax cable
Plating: Edge Card = ENIG, 3-10 microinches
Operating Temp Range: -25 °C to +105 °C
Current Rating: 2.3 A per pin (2 adjacent pins powered)
Impedance: 100 Ω Differential
Bend Radius: (3.18 mm) .125"
Pinout Map: See web address above
RoHS Compliant: Yes

HDLSP

- 1 connector per 4 SiPMs/channels
- 5 connectors per Mezzanine board
- 2 x 12 TTF





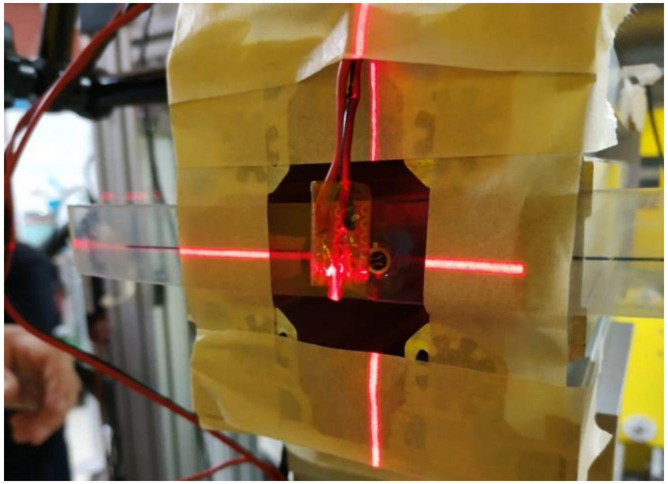
Electronics: digital electronis test up to 50 krad

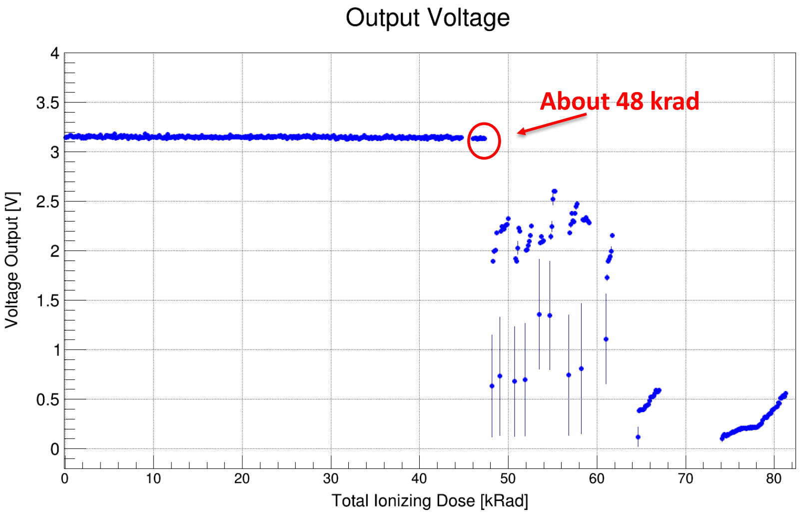
In 2018 /2019 a long set of TID/B-field measurements for DIRAC/its components done:

- ENEA Calliope TID - 12/2018
- INFN LASA B - 12/2018
- ENEA Calliope TID - 4/2019
- HZDR TID (locale) - 5/2019

❑ **All components needed for DIRAC V2 well qualified up to 32 krad (12 krad is our requirement with a SF=60)**

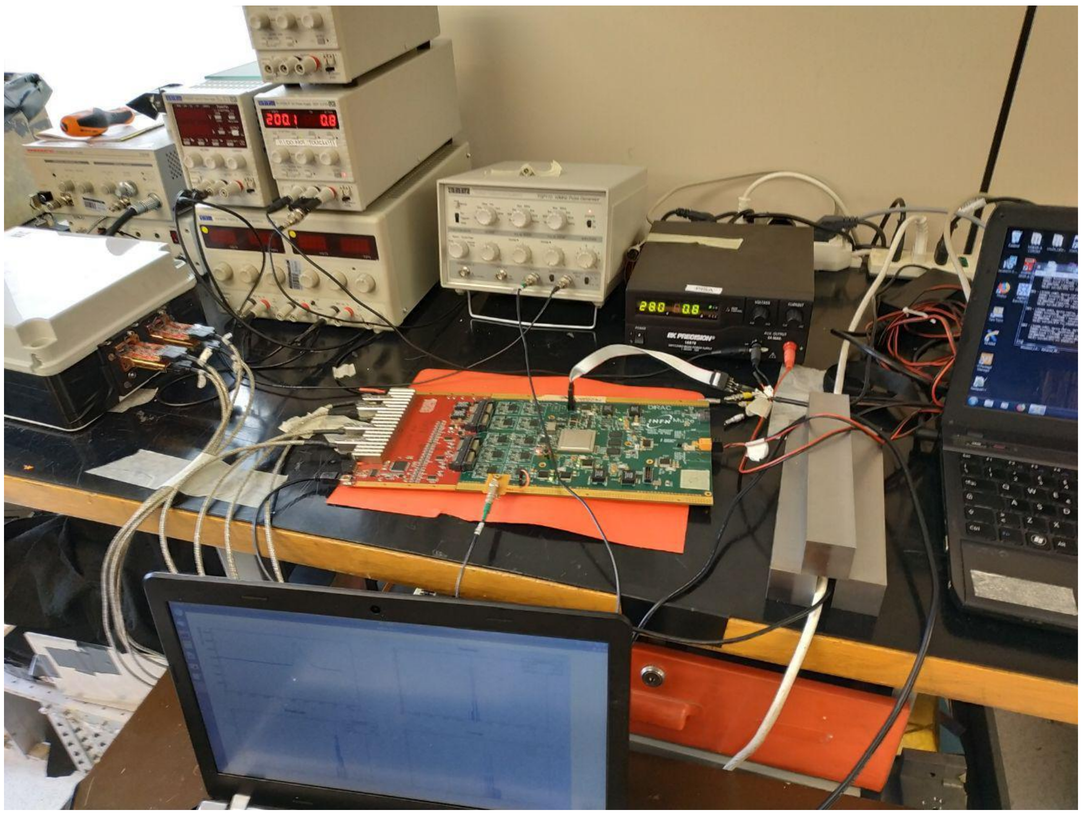
❑ Latest measurement @ HZDR (GELBE) certified again and selected DC-DC converter (docdb # 26781): **DCDC LMZM33606**





FEE-V3 – MB-V1 – DIRAC-V1 (1) docdb 26514-26778

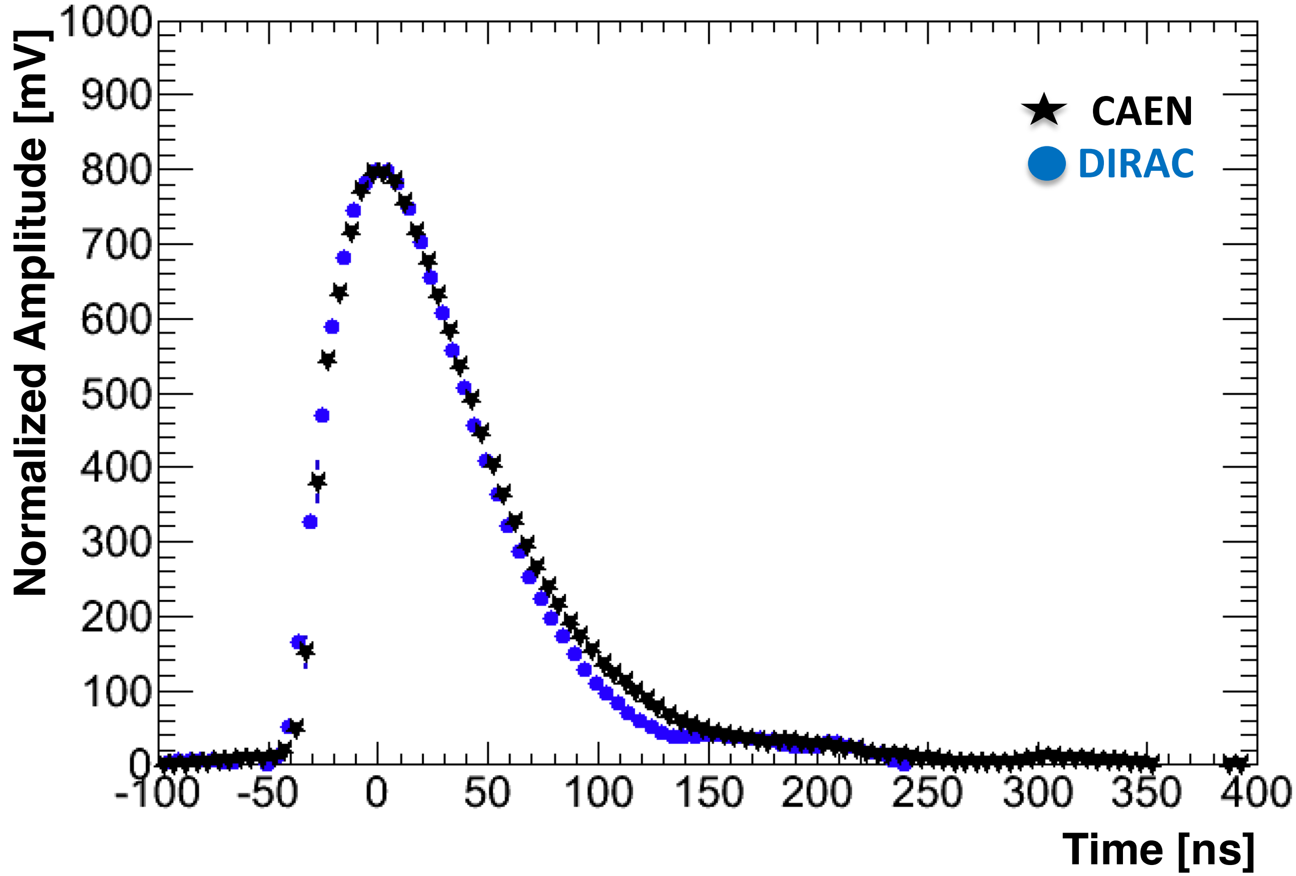
- Second Step: we plugged the Dirac into the LNF SiPM + FEE test station described in **docdb-26514**
- Test of the linearity over the full dynamic range



Station characteristics:

- Automatized Filter wheel to filter LED light (9 different positions)
- Possibility to test up to 4 channels (4 SiPMs, 4 FEE modules)
- Possibility to set the HV individually for each SiPM

FEE-V3 – MB-V1 – DIRAC-V1 slice test (3)



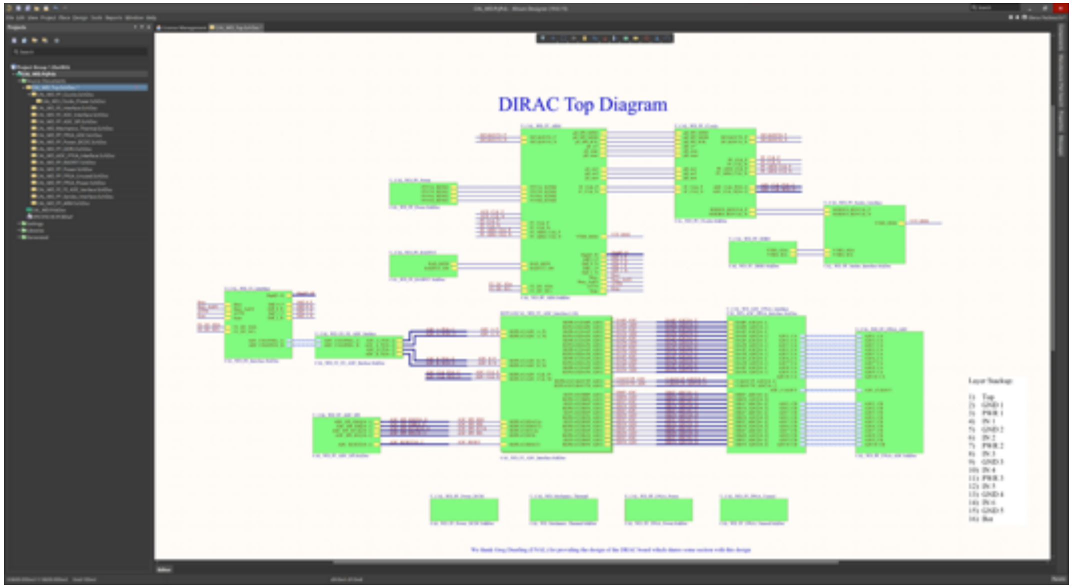
A long CRs run with 16 Module-0 channels is planned for the first week of July
FEE_v3 + Mezzanina + Dirac

DIRAC vs CAEN digitizer comparison very successful

Status of rad-hard DIRAC (V2)

- **The DIRAC V2 design includes:** 1) Microsemi® PolarFire FPGA MPF300TS
  2) CERN VTRx Optical Transceiver 3) Texas Instruments® DC-DC LMZM33606
  4) Monitoring: 4 currents, 2 temp, 1 RadFet, VTRx mirrored photo current)
  5) CAN BUS interface for secondary slow control interface
- **The design is finalized**

- PCB is under design (CERN), Components for 5 prototypes already in Pisa
- 5 prototypes foreseen in Pisa end of Summer/September
- The bid for 160 cards production is under INFN approval



Outcome of CRR for mechanics (21-22 May)

- ❑ CRR closeout was positive and the reviewers acknowledged the maturity of the Calorimeter Mechanics Design
- ❑ CRR findings, comments and recommendations in Doc# 26511

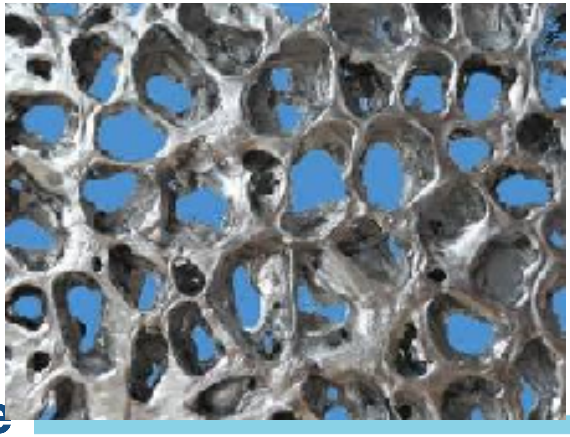
→ Findings address the charges. Not full YES but many ALMOST

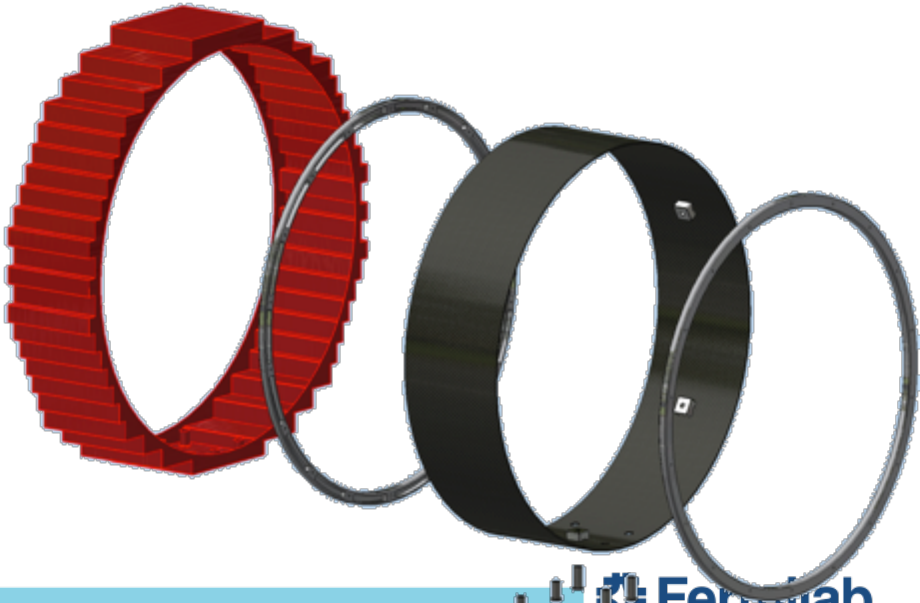
→ Main concerns:

1) **Complete detailed fabrication drawings → IN progress**
2) **Develop block diagram for grounding and insert all needed grounding connections on related drawings → Done**
3) **Carry out further outgassing tests + CF Inner Ring → In progress**
4) **Develop formal guidelines for cleaning/assembly & maintenance procedures → In progress**

CF Inner Ring

- In the current design the Inner ring is composed of:
  - A CF cylinder
  - 2 Al supports
  - A stepped margin made of CF skins embedding structural Al foam. This Foam has holes for outgassing, but concerns of its vacuum compatibility after it is machined/glued





CF Inner Ring Construction

- We are negotiating with CETMA company the possibility to avoid Al foam that, when shaped/machine, could loose its quality in terms of vacuum compatibility.

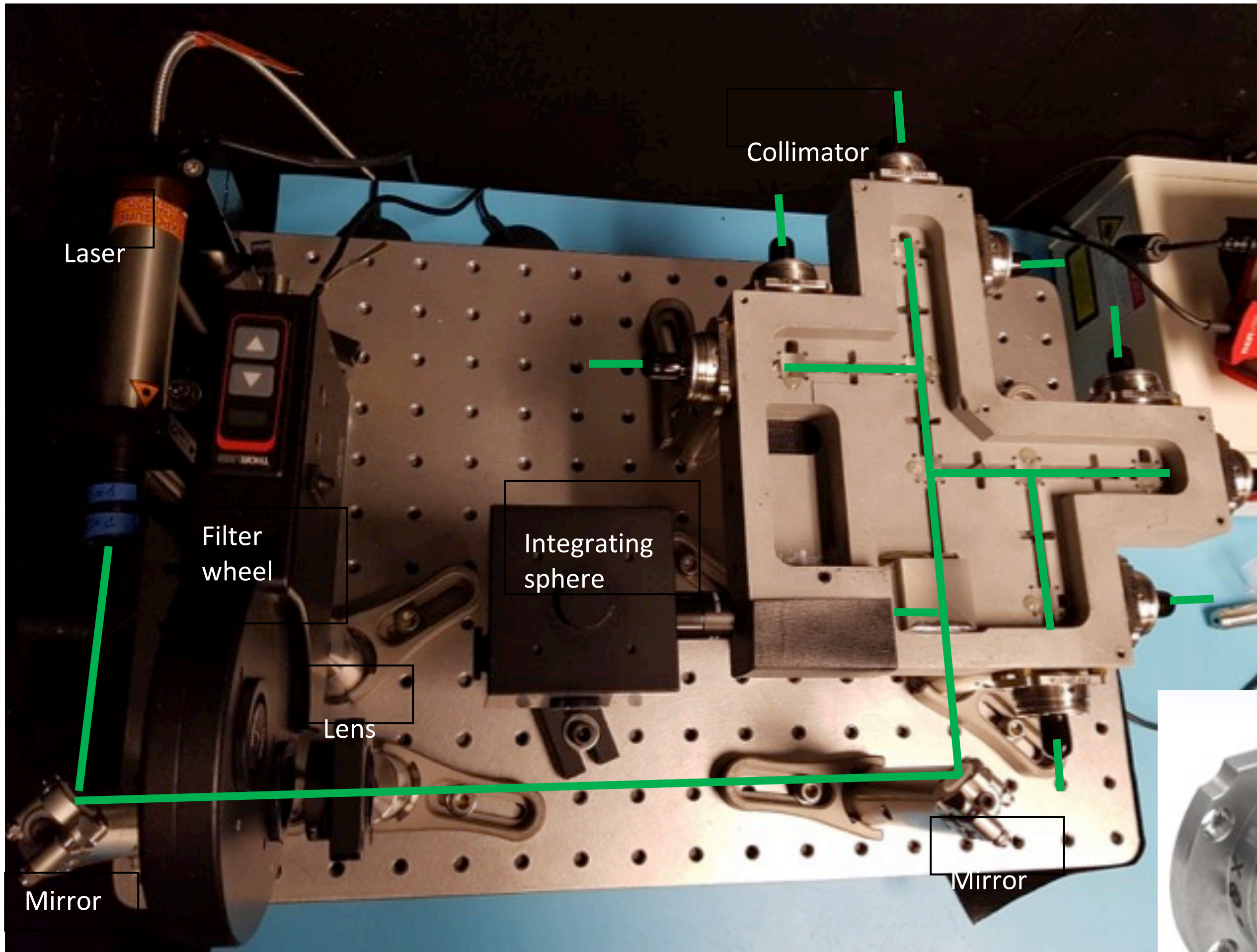
  The manufacturing in this case is more complicated.

- F. Raffaelli has defined a QC procedure for the manufacturing and polishing of the CF parts.

- If we keep the Al foam, the company will provide us with a sample of assembled parts, glued/machined, and we will perform an outgassing test before hand.

Laser: Primary distribution system @ Fermilab

24th March 2019 @ Laser Hut in SIDET



Final assembly **(but lens, filter and photodiodes)**

Laser: Secondary Light distribution system

ThorLab-IS200 Sphere
- 1 input, 4 output ports
- 3 Bundles of fibers with SMA connector in the port and final ferrule needle on each fiber.

One sphere has been purchased (over eight)

MM 200 μm fiber:
- NA = 0.22 → Silica/Fluorine-Doped Silica cladding (FIP Optical Fiber from Molex)

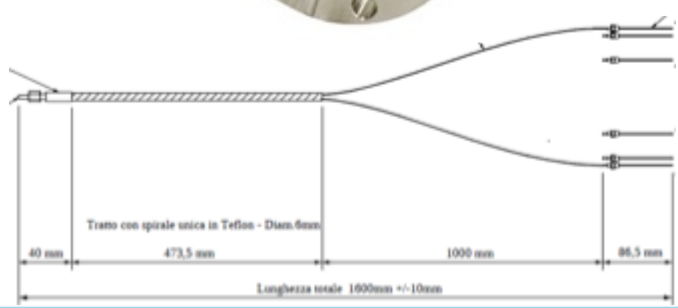
RadHard test on 80 krad

- Test with ^{60}Co: no effect detected
- Two 10 m long fibers has been purchased (over ten)

Vacuum optical feedthrough
- ConFlats 2.75"
- Feedthrough with Multifiber
- From Kurt J. Lesker

Mod. FIBM3–IR00–02–S–3 has been purchased (one over four)

Fibers bundle
- 110 fibers
- Length 1600mm +/- 10mm



One bundle has been purchased (over 21)

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 will not be ready for June

→ CRR of mechanics done for May 20
→ PCB review for FEE/DIRAC done in July / plan for August
→ Disk mechanics expected for the fall 2019
→ FEE delivery expected for the fall 2019

→Very tight schedule to match delivery end of the year