

H2020-MSCA-RISE-2015 — Grant Agreement N° 690835

Highlights of the MU2E Calorimeter 2018

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Mu2e

MUSE General Meeting Fermilab – 22-Oct-2018





Results from Module-0

CsI and SiPM production

Electronics and Vertical slice test

Calibration systems

◆ Mechanics ….





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Module-0 at last GM ····

@ last Muse GM in May 2017, we had just finished to assemble module-0 and done Tbeam





A large size prototype of the disk with final components.

• 51 crystals, 102 sensors,

 102 FEE chips, cooling lines and readout





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11 May 2017

Final results of TB data-MC comparison: Eres

- ✓ Version 0 of a note (for a full blown up NIM) is ready and available for comments to the calorimeter group
- Few plots are being adjusted in the note \checkmark
 - → Distributions data-MC at angles
 - → Distributions of the shower shape

The Data-MC agreement is excellent



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Final results of TB data-MC comparison: Eres

- Energy resolution data-MC OK
 Disentangle of the components from MC reasonable behaviour
 - Leading term is "leakage"

Recovery of split-off applied in MC is relevant





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Timing resolution: Module-0 with CR



- Data taking with Module-0 with CAEN digitizer 250 Msps
- Module-0 tested in vacuum and at low temperature
- □ Scintillator triggering for CR selection
- Differently from Test Beam data now boards can be synchronized
- Timing resolution evaluated both by the differences of two SiPMs/crystal and by time differences between different crystals









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Status of crystal production

SICCAS

- X 4 batches, 60 crystals each, delivered:
 - Batch 8: 12 Jul 2018
 - Batch 10: 31 Jul 2018
 - Batch 11: 6 Sep 2018
 - Batch 13: 3 Oct 2018
 - Next shipment planned for October 19

Saint Gobain

- X test crystals with improved manufacturing technique:
 - 5 crystals: 13 Jul 2018
 - 4 crystals: 19 Sep 2018
- **x** production crystals:
 - 8 crystals: 11 Oct 2018
 - 8 crystals: 16 Oct 2018



	Siccas	St.Gobain	Total
Shipped	382	131	513
Arrived	382	125	507
CMM + inspection	382	113	495
Sent to Caltech	74	16	90
Back to Vendor		44	44
@ FNAL	308	65	373
Wrapped @ FNAL	299	67	366
Source scan	293	71	364
RIN @ FNAL	282	62	344
		<	MIS

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St Gobain mechanical specifications



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Summary of crystals QC at SiDet



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SiPM QC

Mu2e SiPMs undergo 4 specific QC tests: (1) dimensional control, (2) QC of operational Working parameters (I-V, Vop, G*PDE, RMS), (3) MTTF and (4) neutron rad-hard test



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SiPM : improvement of QC



- Improvement on rejection factors reached in September by moving the test temperature from 20 to 25 °C to better compare with Hamamatsu QC
- Batch 7 also completed in September for a total of 1962 i.e. around ½ production.
- □ Rejection factor is now @ < 1 % level



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SiPM: summary of status of production

At the end of September 1972 SiPMs tested (corresponding to 7 batches)

- SiPMs available to be installed in the calorimeter: 1820
- Rejected SiPM: 12 (0.6%)

(Used for the MTTF 105 and Irradiated 35)

•The results of the tests are available on google drive (in the future database format) and they will be insert in the database asap

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286	04/05/10	FNAL	0.1	01	0507	1	20.00	51,575	0.216	401329.75	0.00	50.333	0.024	450635.38	-10.00	49.734	0.009	436273.53	0	0	08.	wk-imprescalchi01	1.
387	04/05/1	E FNAL	0.1	01	0507	2	20.00	\$1.510	0.188	404836.44	0.00	50.307	0.025	467728.31	+10.00	40.707	0.008	453864.75	0	0	CR.	ek-imorescalchi01	1-
110	04/05/14	FNAL	0.1	01	0507	3	20.00	51,555	0.214	482381.10	0.00	50.300	0.024	470857.28	-10.00	49.666	0.009	446367.03	0	0	CR.	wk-imprescalch/01	1.
310	04/05/10	5 FNAL	0.1	01	0507	4	20.00	51.512	0.237	491955.94	0.00	50.267	0.028	480190.06	-10.00	48.681	0.011	470312.00	0	0	OR.	wk-imprescalchi01	1.
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741	04/06/1	FINAL	0.1	01	0507	6	20.00	51.482	0.198	406732.62	0.00	50.287	0.023	473510.72	-10.00	49,691	0.009	460940.09	0	0	ok.	ex.imorescalchi01	1.
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101	04/05/1	5 FNAL	0.1	01	0513	2	20.00	01.577	0.172	400848.12	0.00	50.343	0.018	405141.31	-10.00	49.727	100.0	430045.62	0	0	CR.	wik-impresoalchi01	٩.
14	04/05/1	5 FNAL	0.1	01	0513	3	20.00	51,480	0.174	455600.62	0.00	50.235	0.018	451088.47	-10.00	40.044	0.007	430021.59	0	0	CR.	wk-imprescalchi01	1.
111	04/05/1	FNAL	0.1	01	0513	4	20.00	51.532	0.185	445433.62	0.00	50.283	0.020	435144.88	-10.00	49.702	800.0	424288.56	0	0	CR.	w8-impressalch01	1-
140	04/05/1	5 FNAL	0.1	01	0513	6	20.00	51.826	0.175	451674.06	0.00	50.274	0.017	446268.91	-10.00	49.058	0.007	435871.16	0	0	CR.	wk-imprescalchi01	1.
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Deliverable D2.2 (Month 36)

- Mu2e HWDB developed in collaboration with the Fermilab Scientific Computing Division
- 14 tables to store crystal QA ٠ parameters





- Production data are being collected for Crystals and SiPMs -
- Code and loading of DB for crystals completed
- Work is in progress for the SiPM side









FEE status: TID problems with V2

✓ FEE v2 with good
 linearity and signal shape
 tested with TID up to 80 krad
 ✓ MB up to 30 krad
 ✓ Problems found during
 test on HV regulation side

 New version rad-harder under way



A posteriori observations after TID test:

- The V-ref section was the one to die first;
- The HV-read ADCs were still functioning after irradiation while the DAC section for HV-setting died
- □ The T-sensor died
- The irradiated amplifier looked still functioning when biased correctly but it was difficult to check if the gain got modified

□ The Mezzanine Board was still working after 20 krad



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DIRAC V1 (SF2) .. Integration + Thermal

- Mechanical integration
 With MB V1 done
- Test of crate OK
- Work on Thermal
 Simulation and thermal
 Test OK





For details about the status of DIRAC digitizer (V1, V2) and slice test .. See ELENA's talk





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Getting ready for the Mechanical CRR

- □ A lot of work is on-going to get ready for the Mechanical CRR
- □ The list of pre-CRR requirements in our hands is getting fulfilled
- Meeting next week to see integration drawings and try to agree on a final date (hopefully before the end of the year)

The plan is to limit this review to the mechanics and integration inside the DS

- ➔ Not final rad-hard FEE has implications on mechanical design on two aspects: length of SiPM holders and cooling requirement on crates
- → Separate CRR for electronics expected in spring 2019
- → Separate CRR for infrastructure is expected lately in 2019 (Cooling/Power)
- ✓ Drawings are being modified to fulfill known interfaces
- Conceptual design of Installation Procedure "successfully" shown to Integration meeting during this workshop
- ✓ Keep working on improving details and tests on full size Mockups

SEE FABIO's presentation for details



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Calibration triggers for calo commissioning

♦ Source trigger
 → Weekly, 10' calibration, standalone. Energy requirement

- Laser trigger
 → Off-spill low rate running based on number of fired cell
 → special runs at high rate
- ◆ "Golden" Cosmic ray trigger
 → Selection of CR tracks i.e. clusters with > 4 fired crystals (thr=6 MeV)
 → Off-spill rate of O(5 Hz)
- "Pulse Trigger"
 Not decided yet
- ♦ Noise runs
 → un-biased trigger





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Data taking with Module-0 for T0 equalization ...

- Simulated method of TO calibration (already presented) tested with real data.
- The 16 channels of module-0 used for this calibration procedure
- Straight CR tracks selected inside calorimeter
- "light"-speed imposed btw timings of crystals/track
- Insert faverage timing value as first T0 estimate .. then iterate





Conclusions

□ Calorimeter construction is in full swing

□ Production of CsI and SiPM is proceeding well

- → St.Gobain problems being solved (Csl prod O(30%))
- → SiPM production > 50% with extremely good Rejection factors
- Calibration systems and study/tests of calibration IN-SITU are progressing well

□ FEE and WFD

- → Design of Dirac V2 under way to improve rad-hardness
- → TID RadHardness for FEE remains the largest concerned
- → FEE V3 under way

□ Aiming for a CRR of the mechanical system before end of the year.





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