



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Calorimeter Assembly

Stefano Miscetti, LNF INFN, Italy

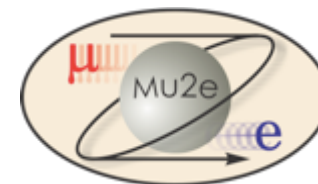
Calorimeter L2 Manager

On behalf of the Mu2e calorimeter group

18 May 2020, Italy

Mu2e-INFN-Calo Assembly meeting

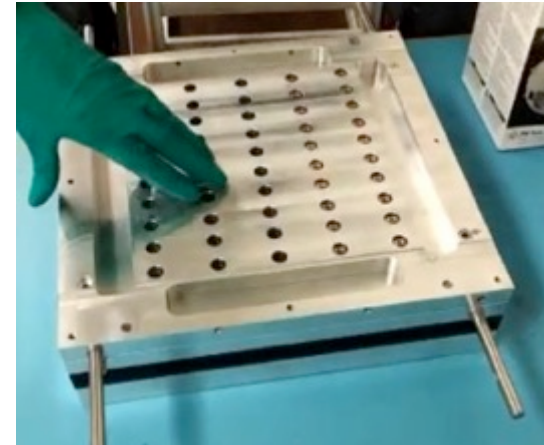
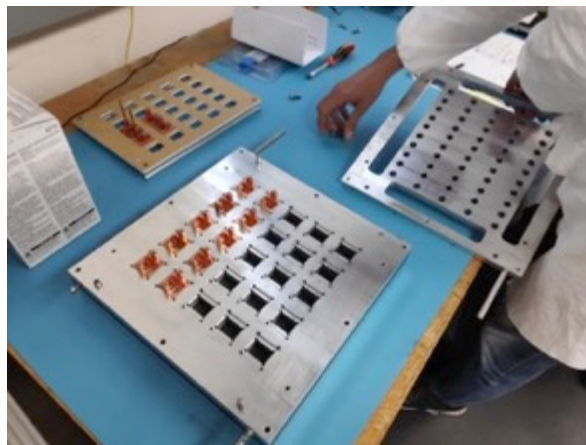
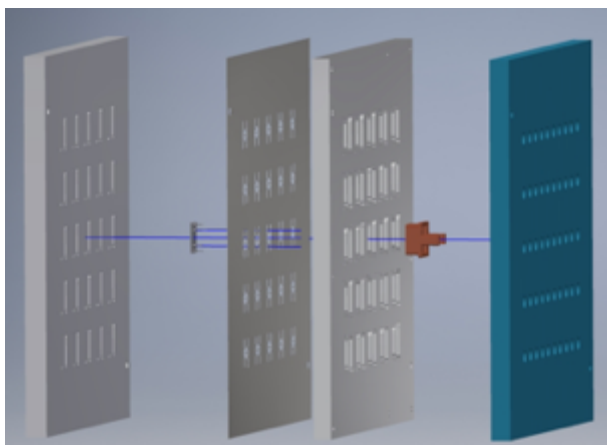
Mu2e



Talk layout

- ◆ Status of Preliminary Preparation Jobs needed
- ◆ Status of electronics + delivery of mechanical components
- ◆ **P6-schedule and COVID-2019**
- ◆ Realistic schedule → need to update
- ◆ Team organization
- ◆ Preparation of documentation, QC and ORCs
- ◆ **Mu2e-Calo-Assembly meetings**

Gluing SiPMs on SiPM holders



SiPM gluing procedure

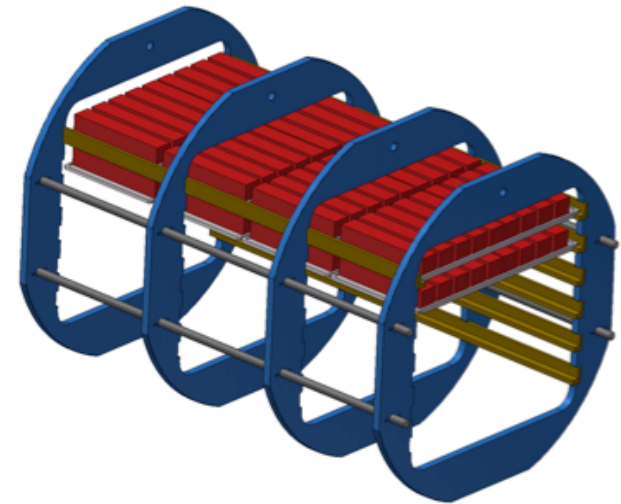
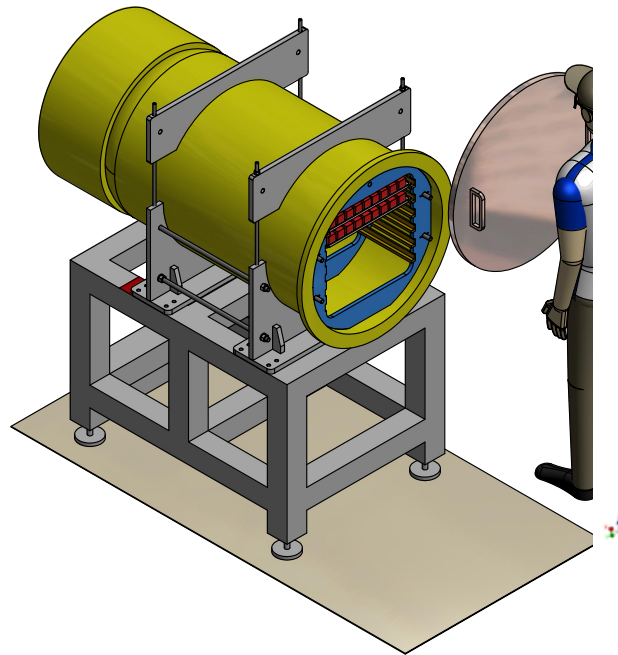
- Insert SiPMs, add glue of fixed quantity
 - Close the device for Holder-SiPM coupling with alignment pins + 5 hours curing
 - 2 gluing tools \rightarrow 25 x 2(tls) x 2 (times) = 100 SiPMs/day \rightarrow
 - ☐ Pre-mixed Epoxy procured \rightarrow 3/10/2020
 - ☐ PRODUCTION Starting in March
- First 14 SiPM-holders prepared in Dec 2019
 \rightarrow being tested at LNF in Module-0



Outgassing Facility in Sidet

To reduce outgassing time for all calorimeter components, we plan to follow the “N2-venting” procedure to : Crystals, FEE/SiPM units, Cables

→ Adapting an existing Vessel to our needs. Vacuum pump from LNF



Outgassing capability:
- 220 crystals/week

- Design of cylinder support, flanges and cover-plug completed
- Design of structure for support of crystals/SiPM trays done
- Procuring under way. Need to agree with space in Assembly Room.

Status of FEE production

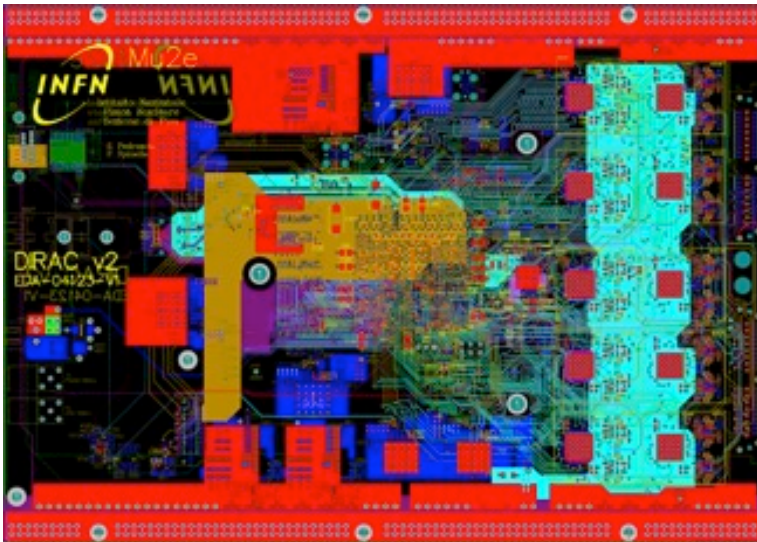
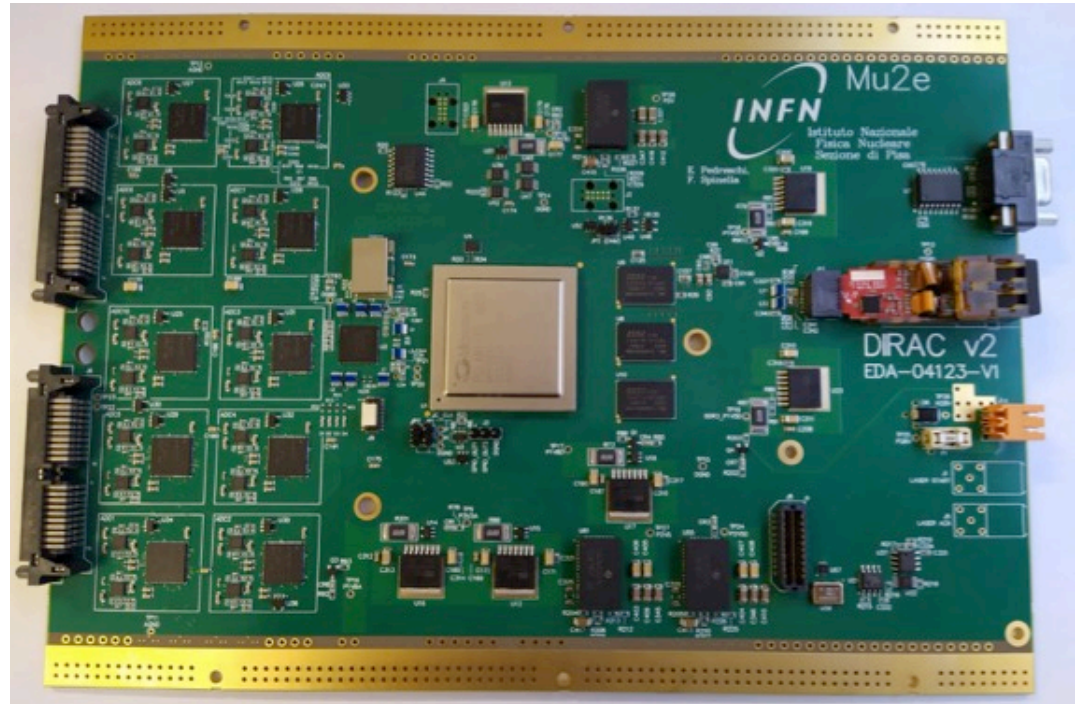
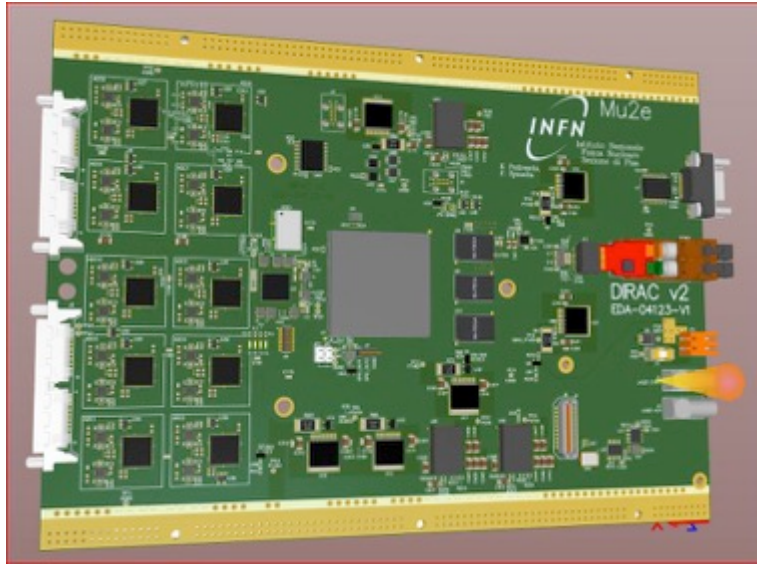
Tender for 3100 pieces completed 16 December

- After new TID on the first sample, it will take 4 weeks for the first 350 pieces, then 1000 pieces/month
- from Italy to DUBNA for QC test then shipped to SIDET
- ❑ First 10 prototypes for TENDER production received at LNF first week of February
- ❑ Produced with the same LOT for ADC/DAC/MOSFET, OK on the bench
- ❑ Shipping of 10 old FEE V3 pieces toward JINR to test custom procedure underway → they arrived at JINR after two weeks “only” -☺
Lost Contact after COVID-19
- ❑ Boards for current test of FEE QA under production
- ❑ MB firmware modified for calibration of ADC scale in six different points
- ❑ **Preparation for Radiation Hardness test at Calliope under way.**
→ **Planned for middle of March → NOW JUNE ?**

- **This starts up production 350 pieces in 1 month, 1000/Month later**
Then we need to integrate on SIPM holder and test all of them

Status of DIRAC production

- 5 assembled boards V2 under test in Pisa



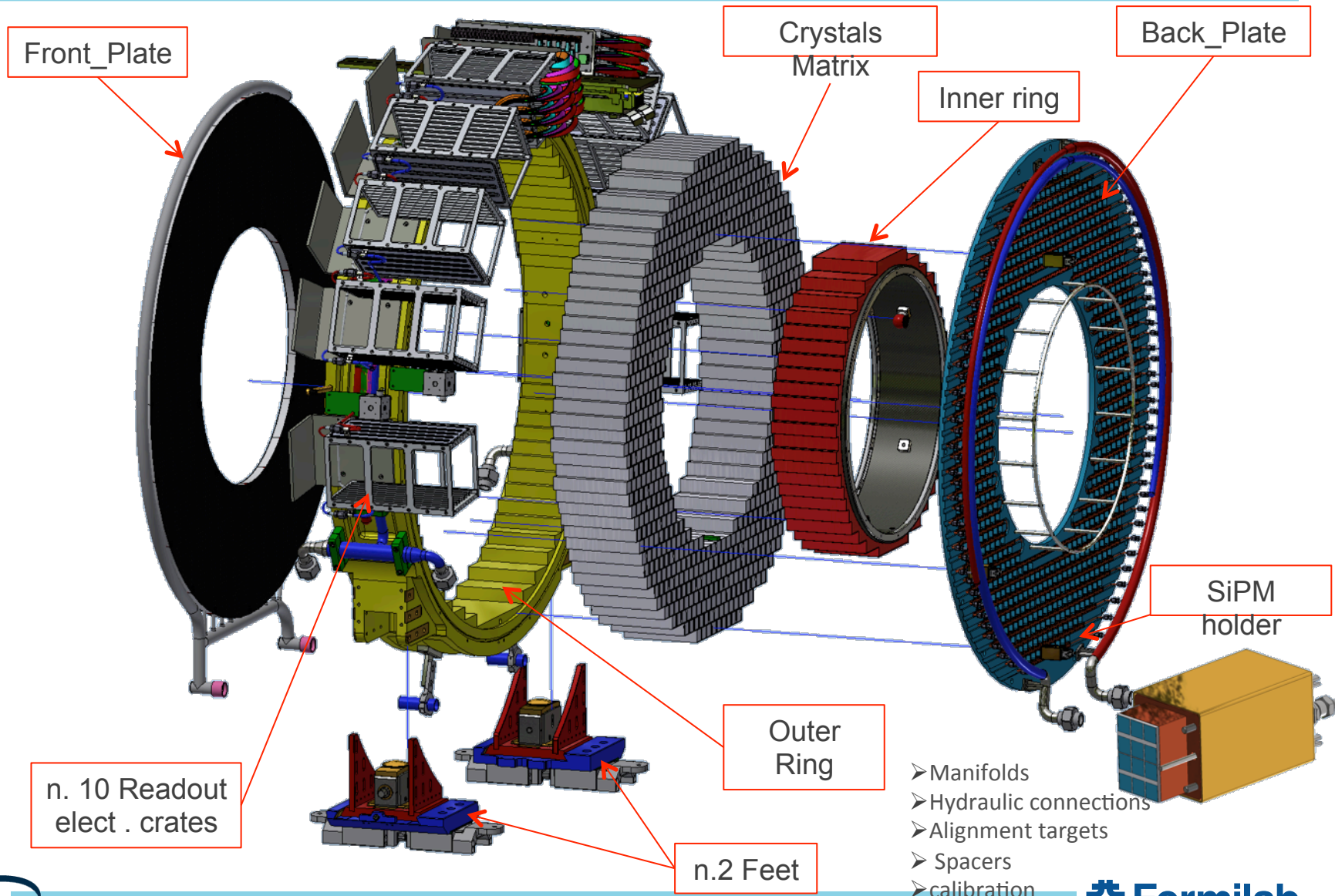
- Work on firmware proceeds
- Need to integrate again with MB mechanical test and DCS
- Module-0 readout is a good task
- Irradiation test at Board level needed
- Production ready to go ... CRR?

Mu2e

Fermilab

MAIN MECHANICAL COMPONENTS

Each disk consist of:

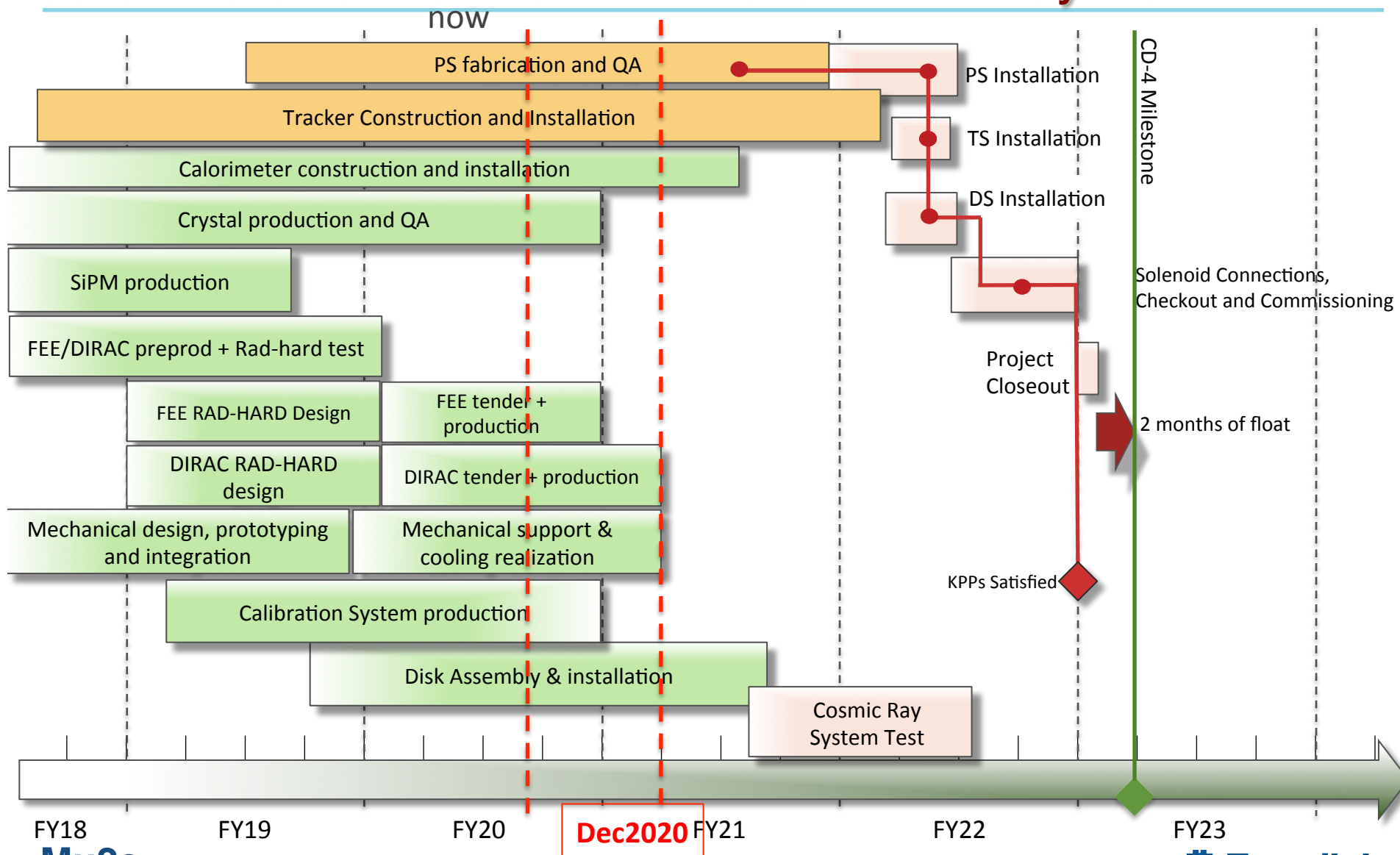


Mechanical tenders/expected delivery (to be updated)

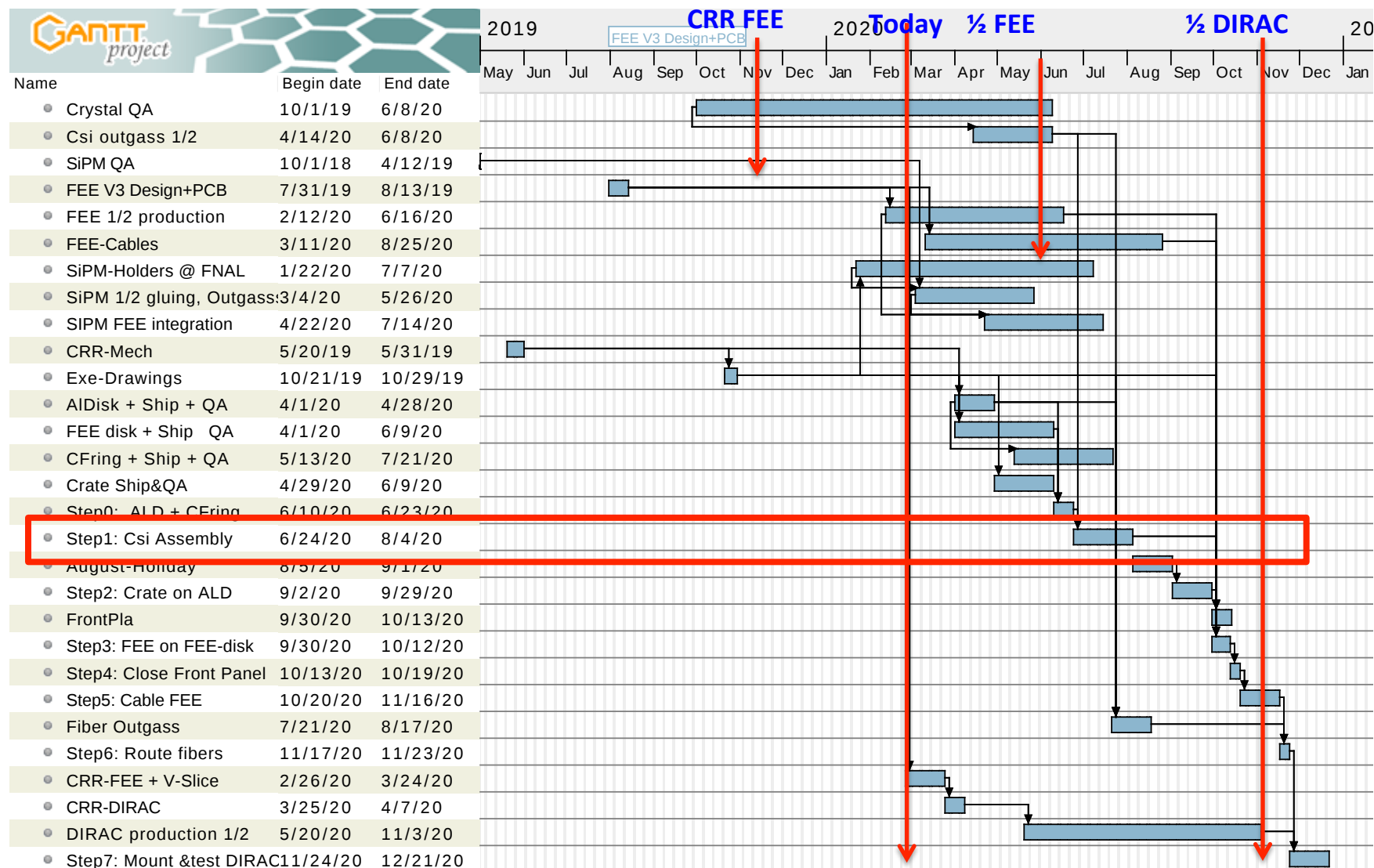
- ✓ Outer Al cylinder → **completed April 2020, now QC → OK**
 - ✓ FEE plate – Tender Out → **July 2020, Critical #1, OK ??**
 - ✓ Inner CF cylinder – Tender Out → **Steps agreed → August 2020, OK ?**
 - ✓ Source Plate – Tender Out → **Send to CETMA July 2020, Not critical**
 - ✓ Crates – Tender Out → **Sep. 2020 → Less critical**
 - ✓ **SiPM Holder – Tender Out → April 2020 → OK**
-
- ✓ Faraday cage – tender in progress → **it is not yet critical**
 - ✓ **Fiber guide line – tender in progress → it is critical to produce fibers**
 - ✓ Cable trays – finalizing design → **Not yet critical but we should do it**
 - ✓ Assembly stand – design finalized → **Under construction. ~ OK**
 - ✓ **Patch Panel – not yet critical .. But it should be done**
 - ✓ **Lifting tool – Conceptual design being engineered**

Estimates are done for the first ½ parts to complete Disk-0

Calorimeter Schedule in Mu2e GANTT May-2020



Calorimeter GANTT updated in February



Mu2e

We need to align it with updated delivery dates .. See later

Fermilab

COVID-2019
and work
organization

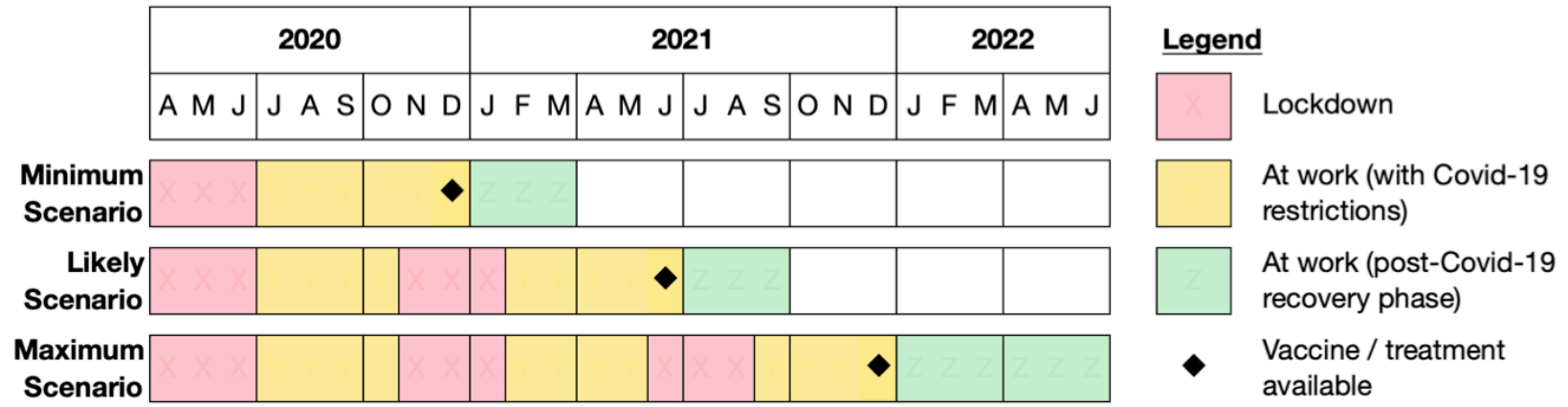
Covid-19 Scenarios – Assumptions

In defining our Covid-19 scenarios, we make the following assumptions and approximations:

- Covid-19 is major crisis that cannot be managed internally by the projects. This necessitates a coordinated approach involving the projects, the Lab, the DOE, other partners, and vendors.
- There may be Covid-19 resurgences, necessitating more than one stay-at-home lockdowns.
- During the crisis, project work will continue but at reduced efficiency, particularly during lockdowns when access to facilities is restricted.
- When lockdowns are *not* in force, efficiency is still reduced due to ES&H considerations (e.g. physical distancing, increased PPE, and enhanced cleaning), additional work at the start and end of lockdowns (e.g. switching labs into and out of a safe state), vendor disruptions, and other effects.
- External domestic and international partners will suffer from Covid-19 problems that are similar to the projects. In this initial assessment, is assumed that the project and partner schedules are similarly delayed and do not become significantly unsynchronized.
- It is assumed that external partners will fulfill their commitments, albeit with delays.

Covid-19 Scenarios – Estimated Schedules

Based on the qualitative Covid-19 scenarios characterized above, we estimate the following straw man schedules, as shown below.



Each schedule is divided into phases:

1. **Lockdown** with teleworking from home where possible;
2. **At work (with Covid-19 restrictions)**, e.g. Covid-19-safe working procedures; and
3. **At work (post-Covid-19 recovery phase)**.

The milestones indicate the assumed date in each scenario at which an effective Covid-19 vaccine or treatment has been made widely available.

The durations and timings of the lockdown(s) will be refined as we learn more about the effectiveness of the current lockdowns in the USA and other countries.

Consideration on Covid “likely-scenario” (1)

- ❑ Milestones are being pushed by the COVID-19 existing scenario and are already impacting us independently from what will happen next !!!
- ❑ However, assuming to be in the likely scenario, a window of opportunity **to go back to assembly work at FNAL it is located btw August and October**

However, this does not take into consideration:

- if INFN will allow (or not) us to go
- if people are happy (or scared) to go
- If Italians are allowed to cross-border in US
- If FNAL will really re-open to external users in July

For the moment, the June flights (Fabio) have been canceled.

Hope that at beginning of June we will know what to do next!

Consideration on Covid “likely-scenario” (2)

As a consequence:

- I was forced to move ahead of another month the installation of the crystals **on P6 schedule and I “made it “ (on the schedule) as fully due to COVID-19 (we know that this is only partially true!)**
- In the coming weeks, we should really discuss if there is or not an option to start operations in August, **or it is better to back-up and plan for September.**
- In order to do so we should however:
 1. complete most of the preparatory jobs that are behind and investigate if we have any possibility to do something more in Italy;
 2. Update the Assembly document Docdb # 26076 and complete the writing of additional documentation for QC and operation steps for each component;
 3. Update GANTT from “simplified” to “fully blown” → V0 done with Daniele
 4. Get prepared for the many ORCs we are going to do (as we did for the QA room)

Update of P6 schedule in Mu2e

Activity Name	Shift of +1 month	Planned Duration	Total Float	Baseline Start	Working Start	Days work behind Base
Calorimeter Installation		163	394	7/13/20	7/13/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 16-18		5	287	7/13/20	7/13/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 19-21		5	287	7/20/20	7/20/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 22-24		5	287	7/27/20	7/27/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 25-27		5	287	8/3/20	8/3/20	
Issue PO for Procurement of remaining material for installation on Mu2e (Obligation)		1	394	8/3/20	8/3/20	
Procurement of remaining material for installation on Mu2e		146	394	8/4/20	8/4/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 28-30		5	287	8/10/20	8/10/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 31-33		5	287	8/17/20	8/17/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 34-37		5	287	8/24/20	8/24/20	
Install crystal assemblies & FEE assembly into support structure for Disk 1: Row 38-40		5	287	8/31/20	8/31/20	
Installation of source tubing and manifolds on disk 1 support - Caltech		5	287	9/8/20	11/12/20	
Installation of source tubing and manifolds on disk 1 support - Fermi		5	287	9/8/20	11/12/20	
Install laser distribution box on Disk 1 support		5	287	9/15/20	11/19/20	
Connect LV, HV and signal cables for Disk 1		10	287	9/22/20	11/30/20	
Test LV, HV and signal cables for Disk 1		10	287	9/22/20	11/30/20	
Issue Statement of Work to INFN for FY21 (Obligation)		1	394	9/30/20	10/1/20	
Coordination of Assembly & Installation - FY21 to Cosmic Ray Test LOE		106	394	10/1/20	10/2/20	
Installation of laser fiber on Disk 1 crystals		15	287	10/6/20	12/14/20	
Insert digital boards in crates for Disk 1		10	287	10/13/20	1/15/21	
Insert TDAQ fibers and test Calorimeter readout for Disk 1		15	287	10/27/20	2/1/21	
Install crystal assemblies & FEE assembly into support structure for Disk 2: Rows 1-3		5	181	11/12/20	2/19/21	
Prepare disk 1 for move		5	287	11/17/20	2/22/21	
Install crystal assemblies & FEE assembly into support structure for Disk 2: Rows 4-6		5	181	11/19/20	2/26/21	
T5 - DISK 1 is completed and ready to move to rails		0	287			
Calorimeter Installation		145	355	8/13/20	8/13/20	

Next CRR's and ORC

☐ PCB review/CRR for digital electronics **(End of April) → June by remote**

This is needed to provide green light for production.

☐ Calibration CRR (Source and Laser) .. June .. → **July by remote?**

This looks reasonable to me and is not a show-stopper

☐ **Cooling station**

This is not a show-stopper, at the moment, assuming interfaces fixed.
However, it is remaining behind. To be updated

- pre-ORC for HV/LV crates, service cables and cooling flow inside the TDAQ crate
- ORC for gluing SiPMs under Mechanical group
- ORC for mounting and surveying the disk in SIDET assembly room +
organize requests to Survey team of J. Barker
- ORC for outgassing vessel then we wait for rest of components to appear

Organization of Assembly work and team@ SIDET (Doc# 26076)

Overall Coordination: S. Miscetti (LNF)

Technical coordination of P1-P7
F. Happacher, F. Raffaelli, A. Saputi,

Technical coordination of P8-P14
I. Sarra, E. Pedreschi, F. Spinella

Responsible of QC, logistic and control of schedule: D. Pasciuto

Assembly.
Test and
Commiss.
operations

1. Installation/survey of Al. Disks (F. Happacher, A. Saputi)
2. Installation/survey of FEE plate and CF ring (F. Happacher, F. Raffaelli)
3. Insertion/survey of Csl crystals (S. Giovannella, F. Happacher)
4. Installation of Source Front plate (A. Saputi, F. Porter)
5. Mounting of DIRAC crates (F. Raffaelli)
6. Connection and test of manifolds (F. Raffaelli, A. Saputi)
7. Insertion of SiPM/FEE holders (I. Sarra, E. Diociaiuti)
8. Routing of FEE-MB cable and single channel test (D. Pasciuto, R. Donghia)
9. Routing of Laser optical fibers (C. Ferrari, S. Miscetti)
10. Installation of Patch panels and local services (I. Sarra, F. Spinella)
11. Final assembly/test of Digitizer boards (L. Morescalchi, E. Pedreschi)
12. Cosmic test stations assembling (F. Happacher, M. Martini)
13. Calorimeter test with Noise/Cosmic runs (S. DiFalco, S. Giovannella)
14. Calorimeter test with Laser runs (R. Donghia, L. Morescalchi)

Organization of work and team: Pre-assembly works

**Assuming FEE and DIRAC are
blessed for production
i.e. Dose Test and B-Test completed
CRR done**

- PW-0: Preamplifier test (N. Atanov, @ JINR)
- PW-1: Gluing of SiPM on Holders (M.Martini, B.Ponzio) ?**FNAL? WhatIfLNF?**
- PW-2: FEE on Holders and test of SiPM/FEE (I. Sarra, E. Diociaiuti)
- PW-3: MB production test (G. Corradi, R. Donghia) @ LNF
- PW-4: DIRAC production test (L. Morescalchi, E. Pedreschi) @ Pisa ? @ FNAL?
- PW-5: Outgassing of “components” (S. Bini, A.Zanetti) @ FNAL
- PW-6: Integration test FEE-MB-DIRAC (G. Corradi, F.Spinella) @ LNF-Module-0
- PW-7: Preparation and routing of Service Cables (I. Sarra, D. Pasciuto) @ FNAL
- PW-8: test of secondary optical bundles (S. Miscetti, C. Ferrari) @ FNAL

Next steps ...

- This is the first discussion to introduce the plan
- Next week I will invite all team to read it in order to get feedback and optimize it
- We will organize weekly/bi-weekly meetings to focus the discussion on specific arguments
- **For the moment, we need to assure that we are all OK with the room usage.** Daniele has prepared a “breakdown” of the area related to the different activities to be sure we at least complete the procurement of outgassing vessel ..

Let's discuss now this but then:

- Make your homework, read docdb# 26076 and correct tasks when wrong;
- Update tasks when needed and write expanded/“separated” documentation;
- Send me updated dates and guess for delivery of components or length of tasks

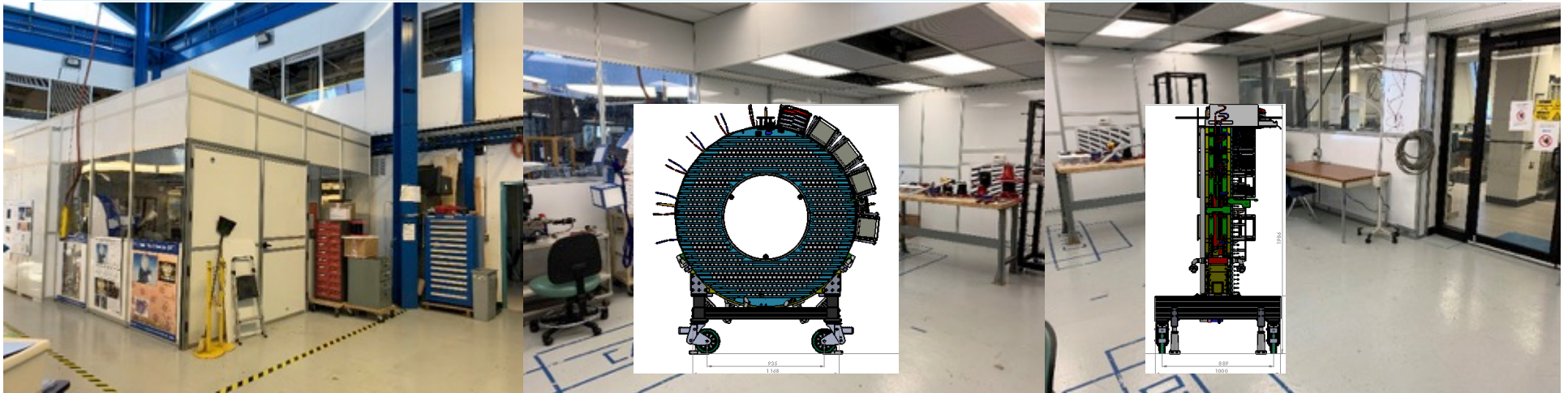
I will work with Daniele to make a revised schedule and circulate it

- Let's discuss about ORC

In this way we will circulate a revised an expanded version of the plan that will help us in: (a) allowing everybody to have a clear idea of what to do and (b) complete the needed documentation for the tasks.

Additional
Documentation

Progress 11: Calo Assembly Room @ SIDET



- Structure completed
- Access with crane for Calo truck loading
- Temperature and Humidity controlled and monitored
- Portable crane inside for components
- One mechanical assembling region
- One electrical and data acquisition region
- Testing of half disk a time

- **Nitrogen and compressed air installed**
- **Electrical implant finished**
- **fire alarms done**
- **calibrating HEPA and HVAC system**
 - **sealing small openings**
 - **cleanroom class verification in progress**
 - **stand for calorimeter support under construction**

Back disk drawings and tender

1. Tender assigned to CINEL in November 2019
2. Tender includes two back planes, cooling lines, manifolds, test, proper packaging and transportation to Fermilab

Status of construction

- Materials for the back plate, cooling lines and manifolds, arrived.
- The manifold fitting are on hold expecting the qualification tests.
- **CINEL received the Peek for the back plate:**
 - **Two plates 1500x1000 mm² and two plates 500x1000 mm², 20 mm thick.**
- Those plates need to be joined with glue to obtain the right dimension.

Time construction schedule

- ☐ The delivery is set by the contract: **6 months** from the approval of the construction drawings.
- ☐ We will separate the shipment of the first back plane before the date set on the contract.

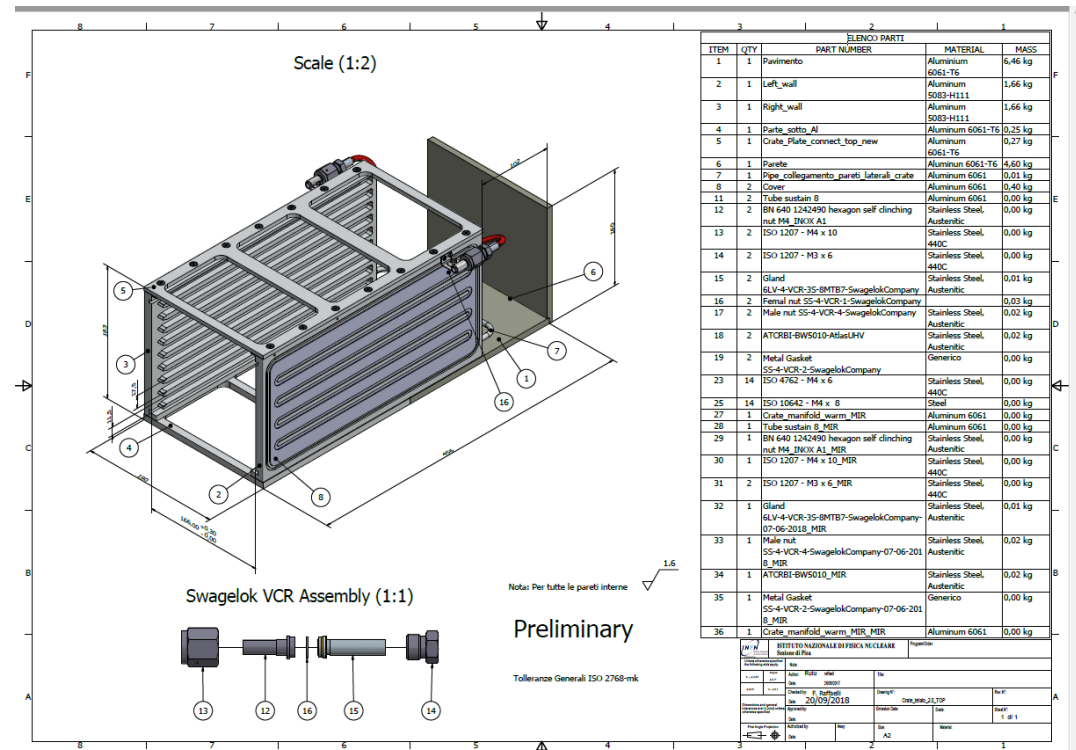
crate drawings and tender

Tecno Alarm won the tender.

Order issued in middle of November 2019.

Executive crates drawings

All drawings of the crates and manifolds have been released.



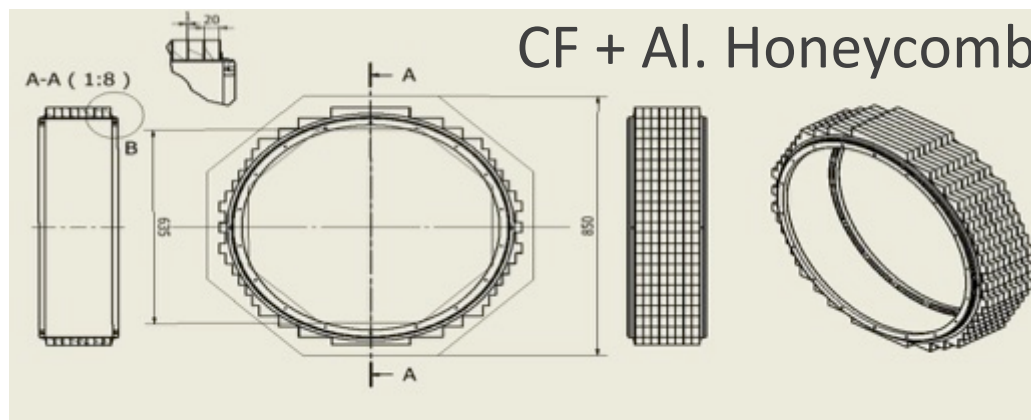
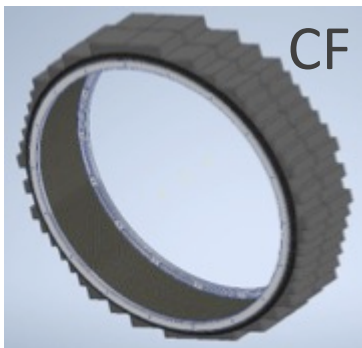
Time construction schedule.

According the contract six months. We should received them in June. We do have some concern on the delivery date. The company does not have enough man power to produce 22 crates in that time. **The real delivery time is more 8-10 months →**

Required the firm to provide a first shipment after producing 10 crates!

Final solution for Inner Ring → yes

- CRR for mechanics (May 2019) recommended to avoiding Al-foam for the Inner-Stepped ring (outgassing and virtual leaks). We are still facing some difficulties to define and agree on the final construction method
- **3 techniques envisioned to be agreed with assigned firm (CETMA) + tested**
 - ~~Full carbon Fiber option: looks practically rejected~~
 - Carbon-Al honeycomb with multiple longitudinal sandwich
Simple and robust. Al-honeycomb tested at LNF resulted not good for outgassing
→ **New version being outgassed in these days ..**
 - Milled support structure similar to the PVC one done for the full-size Mockup → **replacing PVC with Peek. ~~Alternative with 3D printing also being considered~~**
- Production of CF ring, Al stiffening rings and Front Plate are starting



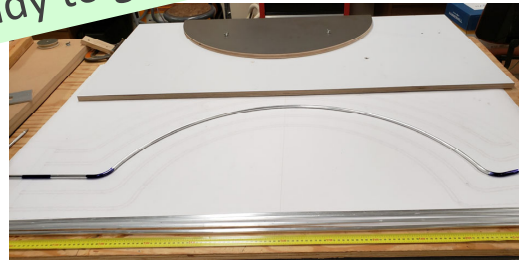
Tubing for the source ...

Thin-wall tubing carries activated FC-770 in front of crystals

- 20 tubes, 6 different shapes
- 3/8 inch OD, 0.020 inch wall
- Aluminum 3003-H112
- Fabrication completed at Caltech, shipped to FNAL
- Awaiting arrival of manifolds at FNAL



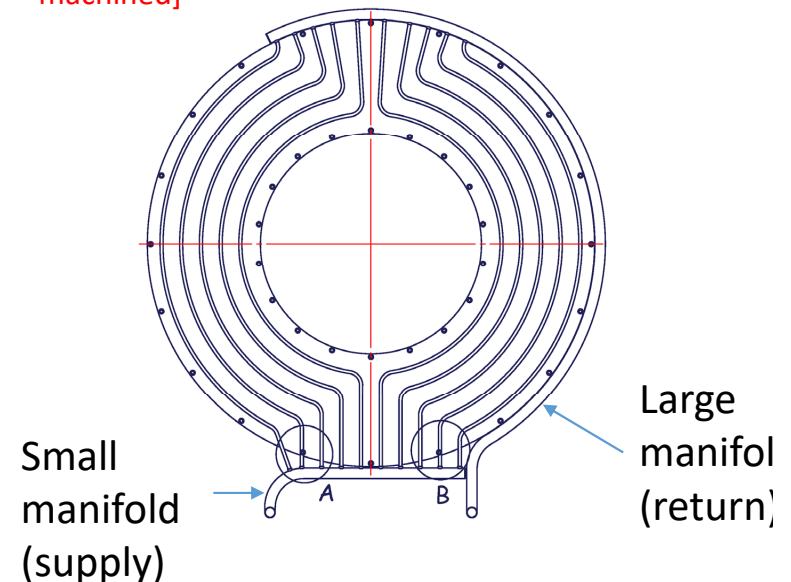
Making a small radius bend



QC

Thin-wall tubing connects to Al manifolds

- Aluminum 6061-T6
- 1.25 inch diameter tubing by 0.065" wall
- Large manifolds will be made in three pieces; small manifolds in single piece
- Vendor welding certification not sufficient for FNAL, so three pieces will be welded in-house
- Delivery estimate 5-6 weeks (Mar 11-18) [Maybe sooner, material has been rolled and is being machined]

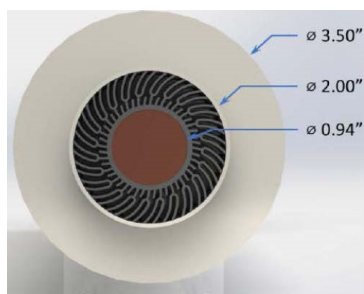


Trying to push welding at FNAL (w.r.t. ANL) to prepare tubing
Shipment to CETMA for final integration: e-mail to Bob.T last week

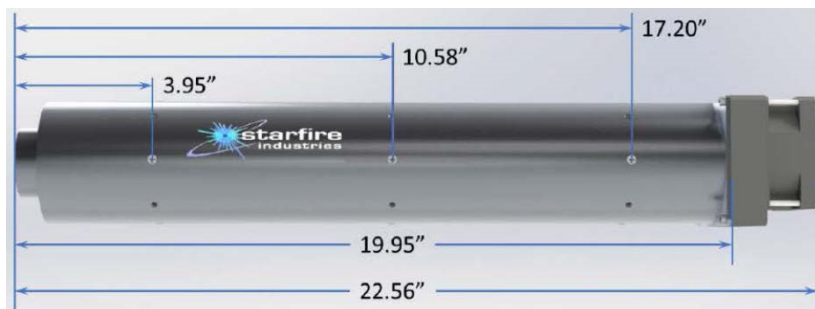
Progress 11: Source status

- PO transmitted to vendor
- Starfire nGen-310 with Tritium fill
 - 1.5e9 n/s, 14 MeV
- Delivery anticipated April-June 2020

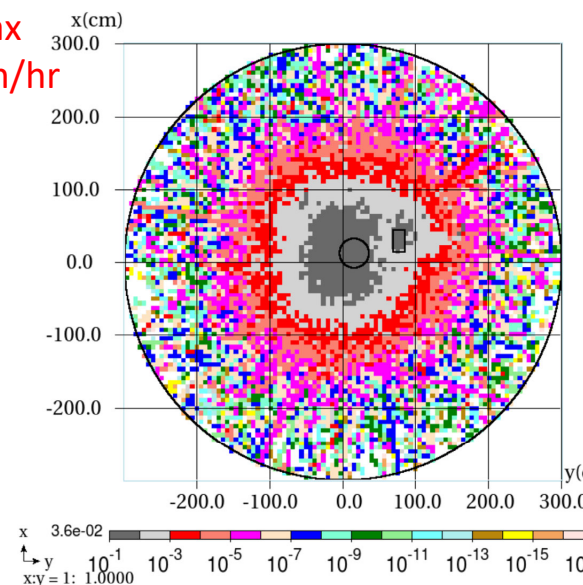
- Acceptance test
 - Plan to do in Mu2e hall
 - FNAL radiation physics will measure neutron rate using activation of Al foil, neutron Rossi sphere



Floor level, max dose 3.6 mrem/hr



MARS shielding study



Acceptance test plan discussion in DocDB-31583

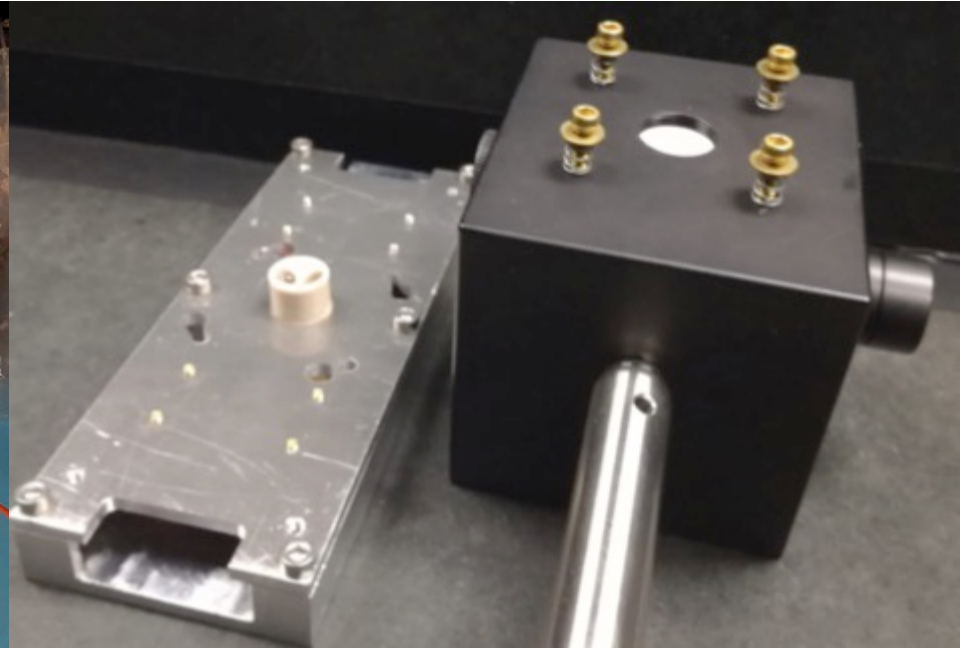
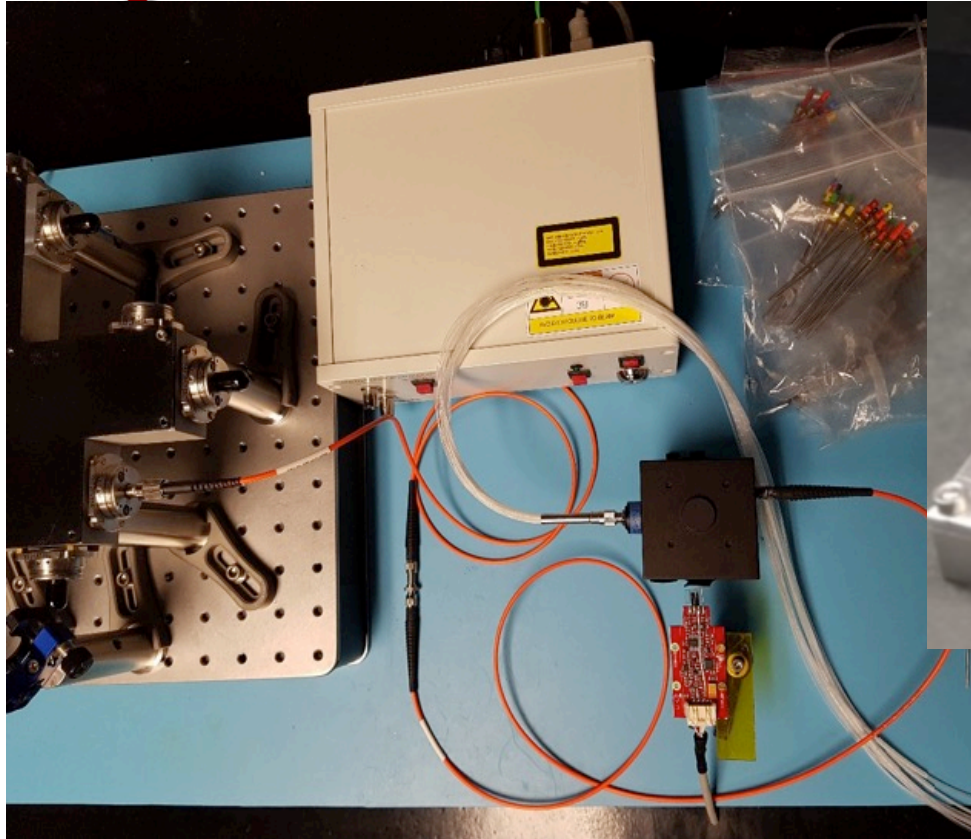
<https://mu2e-docdb.fnal.gov/cgi-bin/sso/ShowDocument?docid=31583>

- Preparation of DT generator pit advanced, lead blocks +HDPE OK
- Getting ready for real acceptance test

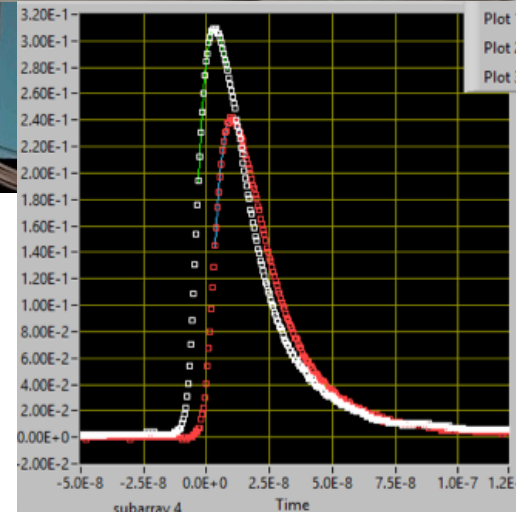
Mu2e

Fermilab

Progress 12: Laser status



- Monitor system inside DS frozen
- PIN diodes procured
- FEE being modified with real gain



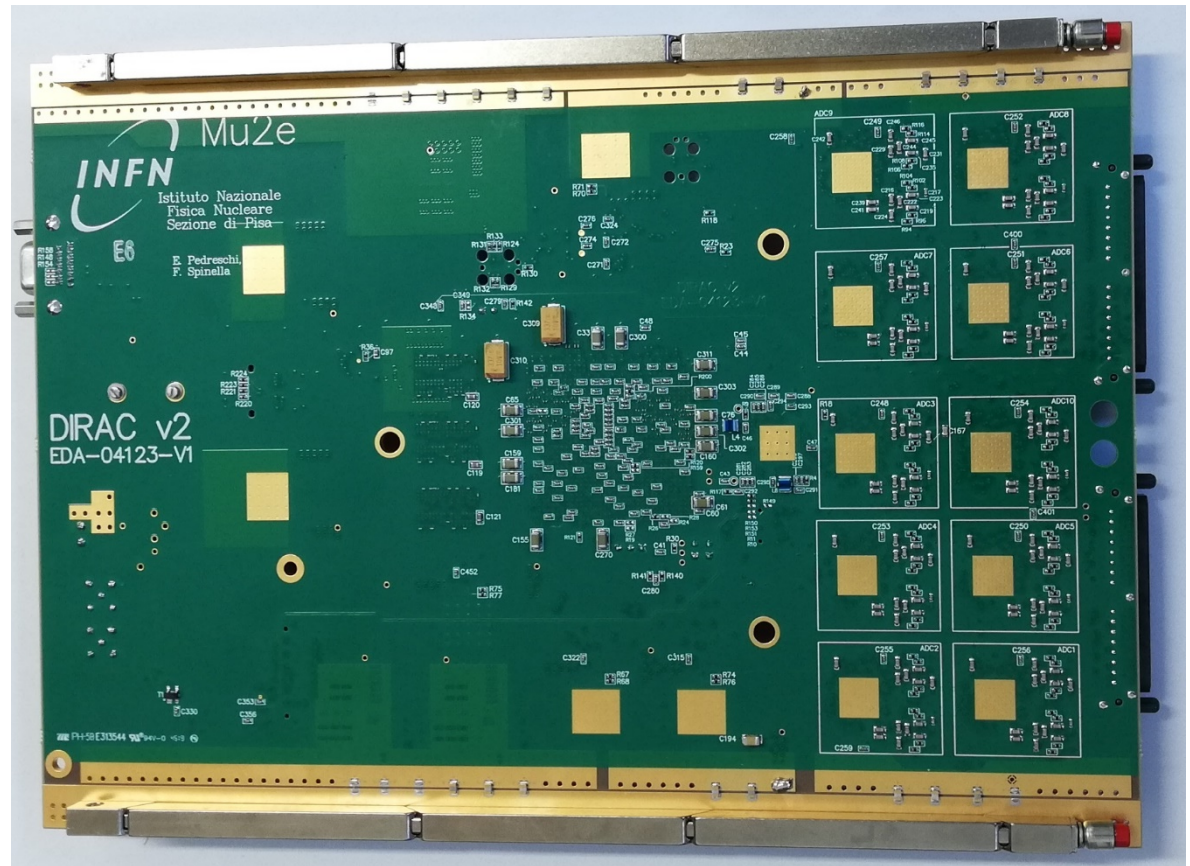
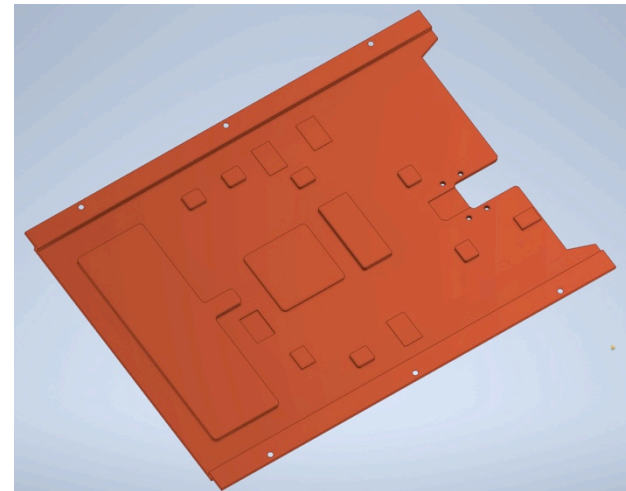
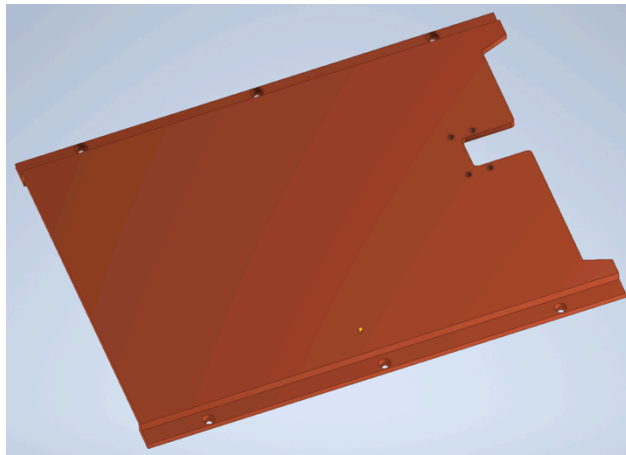
Next step
TDAQ
integration

2019 last sanity checks before procurement

1. Checked light tightness of SiPM holders
 2. Checked light tightness of Fiber bundles
 3. Controlled outgassing of new cables and materials
 4. Controlling magnetic permeability of components
 5. Checked rad-hardness of cables
 6. Checked rad-hardness of Pin-Diodes and fibers
 7. Checked electronics in Vacuum from 10^{-2} to 10^{-4} Torr and Paschen minimum region (few mBar)
 8. Check in progress of outgassing and permeability of SiPM holders screws
 9. Tested cabling scheme of LV and HV supplies
 10. Checked Interlock capability of HV supplies with DS Pressure
- other smaller details not needed to be mentioned here ----

Thermal interface: cardlocks and copper plate

- Cardlocks fits well
- V2 Thermal copper plate designed, prototype is coming



Coolant choice for Chiller Station @ -20 °C

- ❑ Due to the 7 °C drop from chiller to SiPMs to get -10 °C on SiPM surface required to have a coolant different from Water Glycol
- ❑ Preliminary analysis of a different coolant carried out:
 - Best candidate already used in **CMS/LHCb** is **3M PF-5060**
i.e. the **Perfluoro-hexane (C6F14)**.
 - A novel “improved” eco-friendly coolant is **3M Novec 649 (radiation hardness?)**
- ❑ These coolants have a freezing temperature @ -90 °C so leaving a lot of flexibility
- ❑ Temperature drop along the line is larger → needs additional -3 °C from Chiller to SiPM, so coolant should be kept below -20 °C

Property	C6F14 (a -20°C)	Monopropylene glycol 35%, water (a -10°C)
Density [Kg/m ³]	1000	1040
Specific heat [J/(Kg K)]	982	3759
Kinematic viscosity [m ² /s]	3.8 10 ⁻⁷	4,16 × 10 ⁻⁶
Absolute viscosity [Kg /m s]	6.4 10 ⁻⁴	4,33 × 10 ⁻³
Thermal conductivity [W/mK]	0,057	0,429
Freezing temperature [°C]	-90	-17

Can we use
it @ SIDET ?

Outgassing status

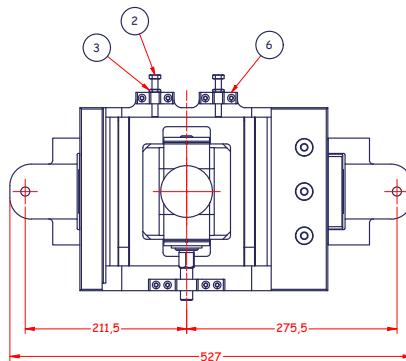
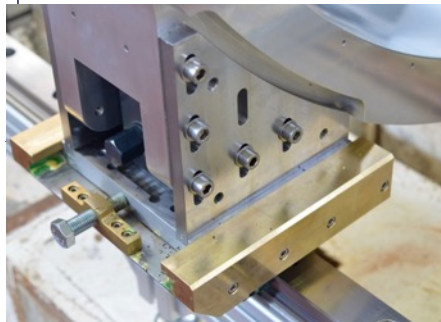
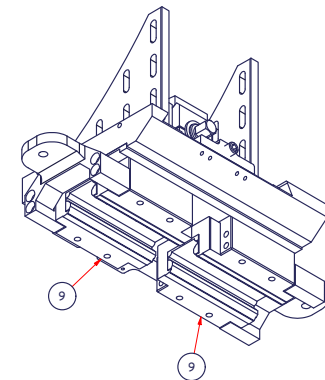
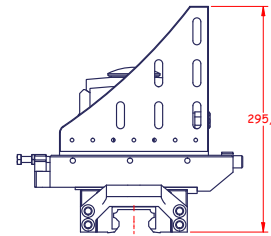
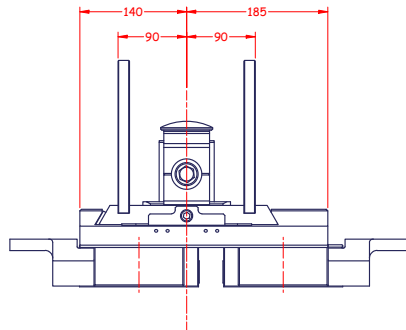
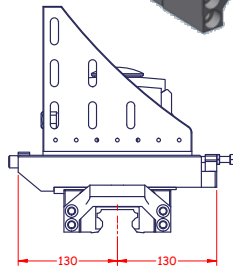
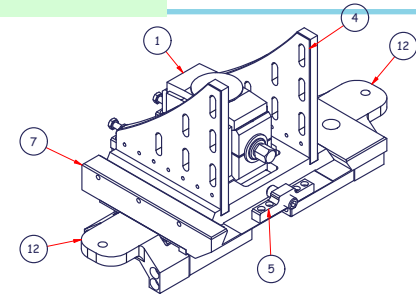
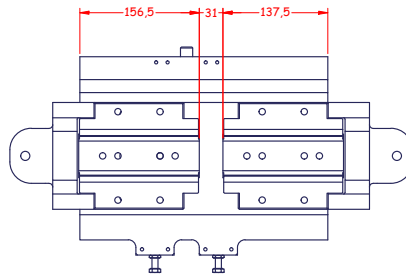
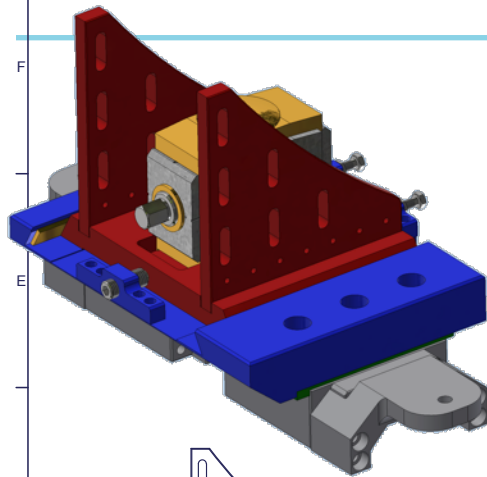
Updated as DOCDB# 31811

Component	Q (Torr x liters/sec)
Crystal-Tyvek	$2,40 \times 10^{-3}$
SiPM+FEE+holders (updated)	$1,30 \times 10^{-3}$
Diffusive Spheres	$0,12 \times 10^{-3}$
Laser Optical Fibers (updated)	$0,36 \times 10^{-3}$
Patch-Panel-IFB Service Cables	$0,10 \times 10^{-3}$
New FEE-MB Cables+connectors	$0,6 \times 10^{-3}$
V1 Dirac Boards + CU +Aprizon	2×10^{-3}
Other materials	-----
Total	$< 6,86 \times 10^{-3}$

Requirement: $Q < 8 \times 10^{-3}$ Torr*liters/sec

Feet

Main parts in Al. 316 LN



PRELIMINARY
- for information only -

Elenco parti				
ELEM	QTA	NUMERO PARTE	DESCRIZIONE	NOTE
1	1	Mu2e 05 00 00 - 00	Y-ADJ	
2	2	ISO 4017 - M8 x 50	Vite a testa esagonale	
3	2	ISO 4035 - M8	Dado esagonale	
4	1	Mu2e 02 03 00 - 00	Skid	
5	1	Mu2e 02 00 00 - 01	Nut	
6	2	Mu2e 02 00 00 - 02	Nut	
7	1	Mu2e 02 01 00 - 00	Base	
8	1	ISO 4062 - M8 x 25	Hexagon Socket Head Cap Screw	
9	2	F10089 - short	Plain washers - Normal series - Product grade A	
10	2	F10089 - 10	Wedge	
11	2	F10089 - 10	Wedge	
12	1	DT 10089 - 10	Wedge	
3	1	DT 10089 - 10	Vite di arresto con esagono incassato e punta a coppa	

Mu2e 05 00 00 - 00		1	
Mu2e 02 00 00 - 00		1	
NEXT ASSY DWG		QUANTITY	NOTE
Date	Material	Quantity	Weight
18/07/2016	Various	2	N/A
DESIGNER	Alessandro Saputi		
ENGINEER	Alessandro Saputi		
APPROVAL			

ISTITUTO NAZIONALE DI FISICA NUCLEARE Laboratori Nazionali di Frascati Via E. Fermi, 40 - Frascati (Rome)	
Mu2e Experiment Calorimeter	
Foot	
Scale	1:4 A2