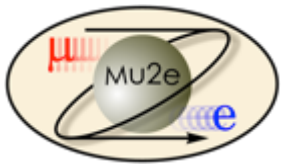
WP4
Calorimeter Software
State of art

R.Donghia, LNF-INFN

SB meeting
April 4, 2018



MUSE

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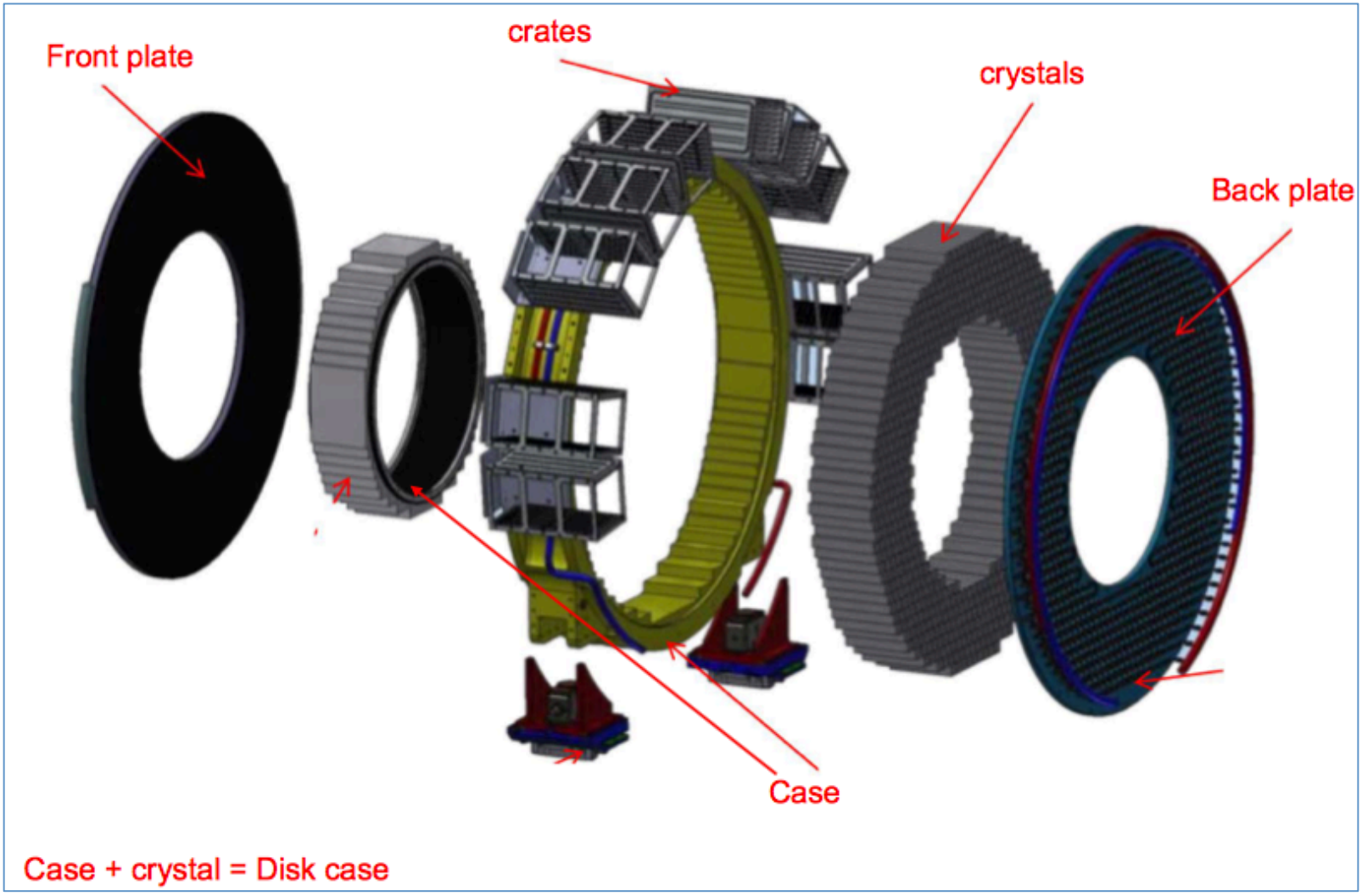
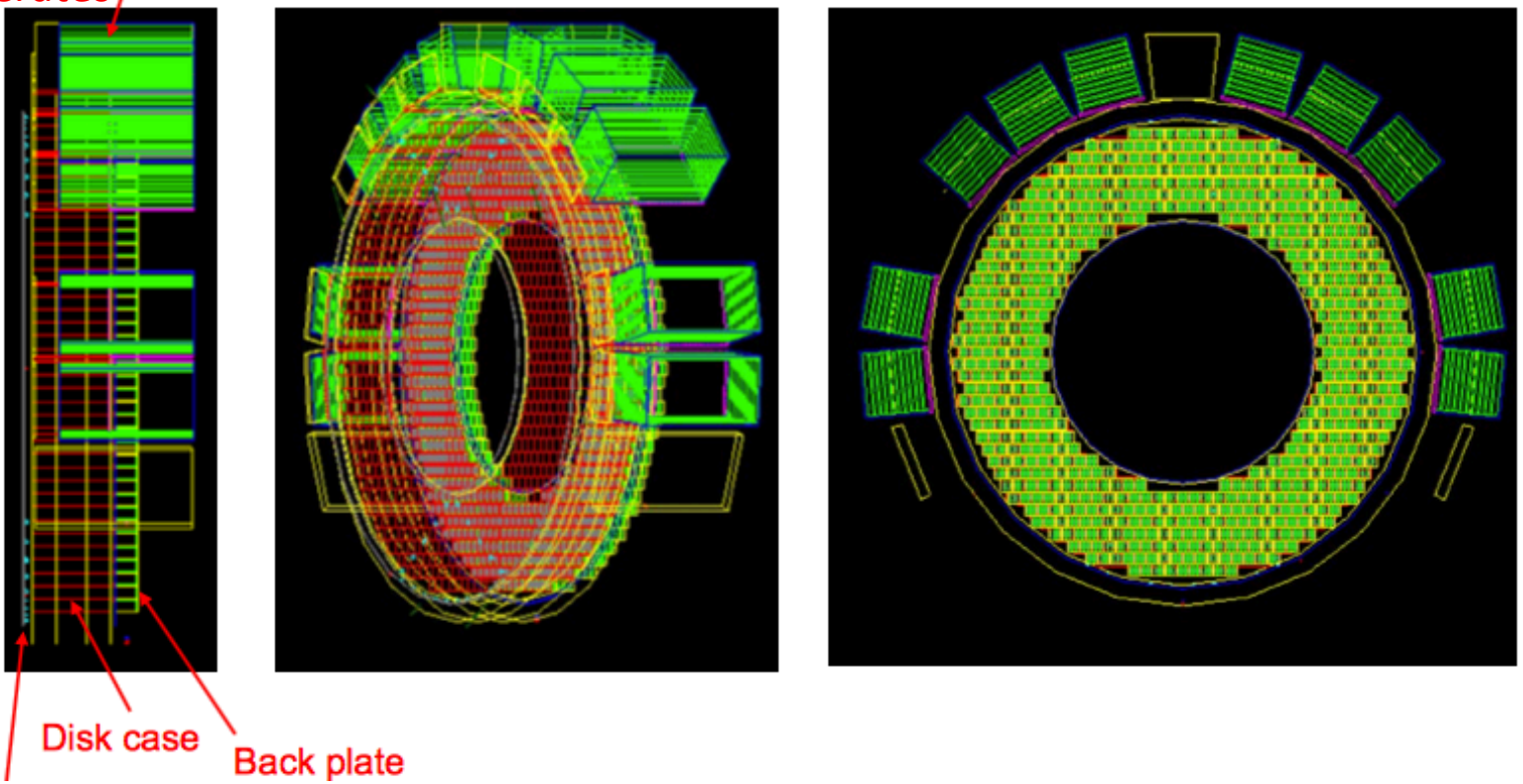
Main tasks

- Finalizing geometry – adding support for realistic disk description
- Improving timing description (big item)
- Adding support for realistic energy resolution and improving hit extraction
- Calibration
- Include Module-0 TB results in the Mu2e official software

Calorimeter geometry



Actual software geometry (1)



- Situation basically unchanged from last meeting.
- Geometry contains all the important pieces, except cables. Should be easy to add new parts or refine model if needed.
- Run dose estimate in crate / readout card underway

Realistic geometry (1)

- Prototype code for realistic geometry under the following assumptions:
  - The crystal is described as a perfect rectangle.
    A volume defined by a set of non-parallel planes is much slower to simulate, and it is much more annoying to deal with in the reconstruction
- The crystal size is taken to be that of the smallest envelope containing the measured crystal edges
- The crystal position is taken as center of the envelope, as measured from the position survey in the disk
- In case of overlaps, the crystal size is slightly reduced to avoid overlaps

Each crystal will be placed at its surveyed position. Its shape is idealized as a rectangle whose dimensions are slightly bigger than the physical ones (O(100 μm)). These small approximations will have a negligible impact on physics.

Realistic geometry (2)

- Need “realistic geometry” to meet the **summer data challenge milestone**
- “Mock-up database” (i.e. text file) → allowing to define the position and size of crystals
- Need to finalize the chimes and clean up the code, but this should be ready soon for (extensive) testing

Future work

- **Realistic timing simulation (**next big issue**)**
  - understand a bit better the readout chain performance → efficient strategy to implement in the simulation
- **Realistic energy simulation:**
  - Most of the corrections are already implemented
  - database “mock-up” is needed to load the various calibration constants.
  - Need to add support for dead channels as well
  - Improve the accuracy/speed of the hit extraction procedure
- **Source calibration simulation:**
  - crude simulation, we need to refine it and improve the spectrum fitting procedure
- **Hit compression:**
  - This has been just tested works well, fixed last bugs

We’re in good shape for the summer data challenge milestone, though we need to get started on finalizing the geometry description and improving the timing simulation / extraction.

Trigger status/updates

Substantial improvements in the pure track and track-calo triggers:

- **Track trigger**: substantial modifications to the hit making algorithm, resulting in a processing around 3 ms.

- **Dual track – calo trigger**: working for a processing time < 3 ms

- **Calorimeter trigger**: algorithm running ~1 ms with ~90% efficiency (consolidation phase to build full trigger sequence and try merging some sequence)

Dual Calo TRG Quick review

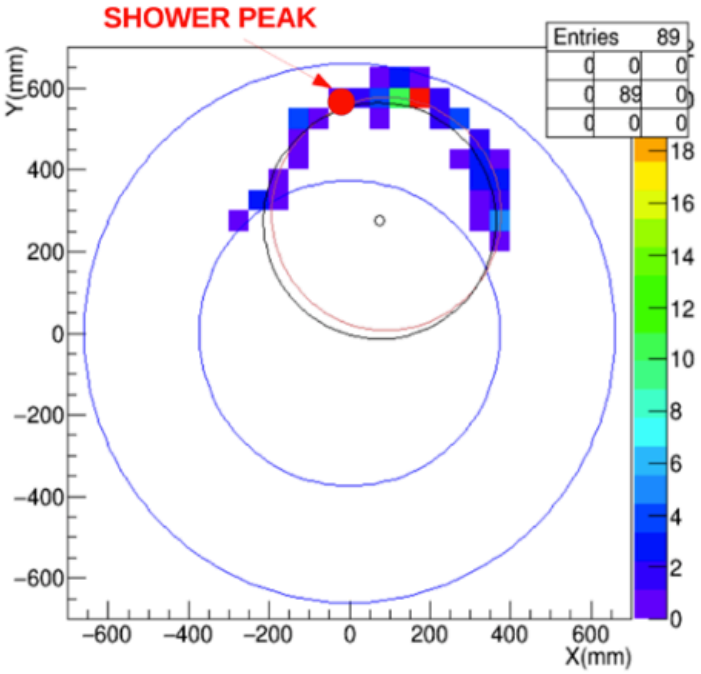
Select tracker hit based on the calorimeter cluster time / position and try to reconstruct the track using a semi-analytical model

CE MIXED TRACKER-CALORIMETER TRIGGER PROPOSAL (doc-db 15369)

QUICK REVIEW:

8) Select the hits on the circle (distance<50 mm)

Doc-db 15962



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CE MIXED TRACKER-CALORIMETER EFFICIENCY vs REJECTION

preselection	CE efficiency	BKG rejection
Good tracks	90.9±0.1%	102±2
Good tracks matching a cluster with E>50 MeV	96.2±0.1% 95.3±0.1%	570±30 1030±70

TIME PERFORMANCE

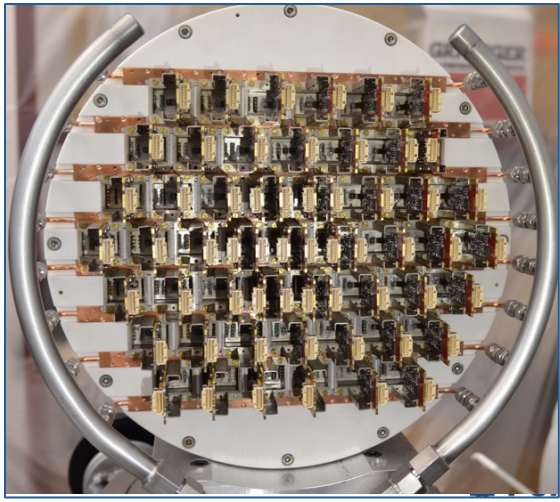
TimeTracker printout (ms)	Min	Avg	Max
makeSH:StrawHitReco	0.4	1.3	2.3
FilterEcalMixedTrigger	1.0	2.1	5.7

10000 events on mu2ebuild01
Average Total: 3.5 ms

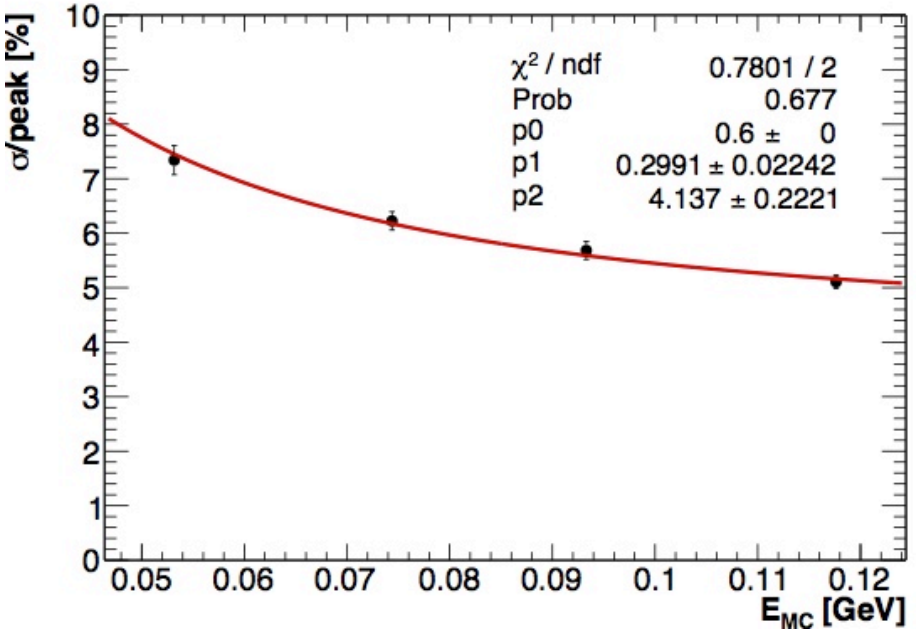
Subtracting
Straw Hit position reconstruction (1.3 ms) and ECAL waveform peaks search (1.4 ms)
We should able to reach ~0.7 ms

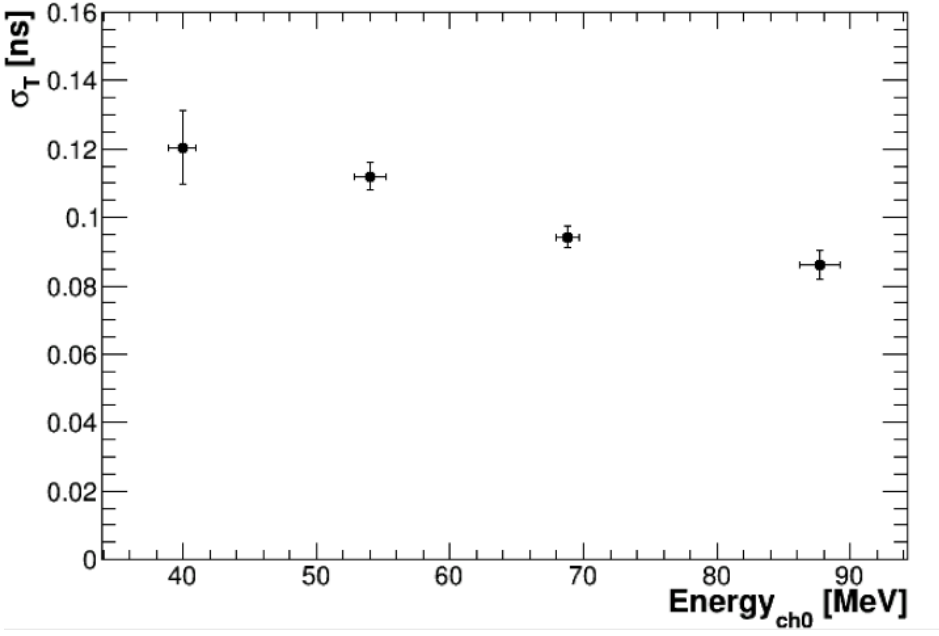
Module-0 TB data analysis

- Calorimeter prototype has been assembled and tested at the LNF-BTF:
  - 51 crystals
  - 102 SiPM (58 radout)
  - Test with an electron beam with an energy rom 60 up to 120 MeV
  - No final readout digitizer!



Module-0 TB data analysis Status





At 100 MeV energy beam we achived satisfying results w.r.t. Mu2e requirements:
Energy resolution ~ 5.6%
Time resolution ~ 96 ps

Summary

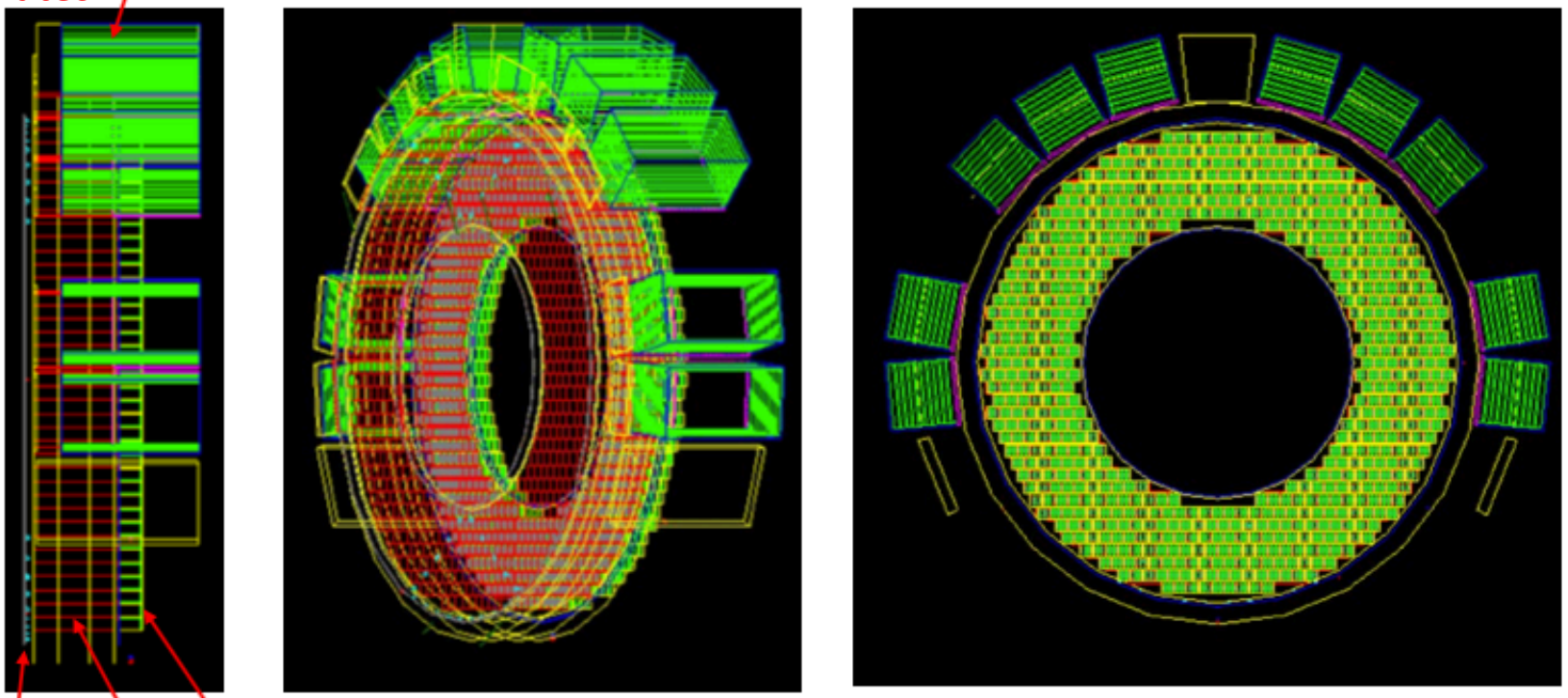
- Calorimeter geometry description inserted in simulation is already in good agreement with the final realistic configuration. Still to do:
  - include source calibration
  - Mock-up design, final position and dimensions of crystals

- Fast and efficient Trigger method have been developed
  - 96.2% of good tracks reconstructed in ~2.1 ns. We should be able to reach 0.7 ns!

- Module-0 data analysis almost terminated.
  - Results optimization underway.
  - Next studies:
    - Data − MC agreement
    - Cosmic rays

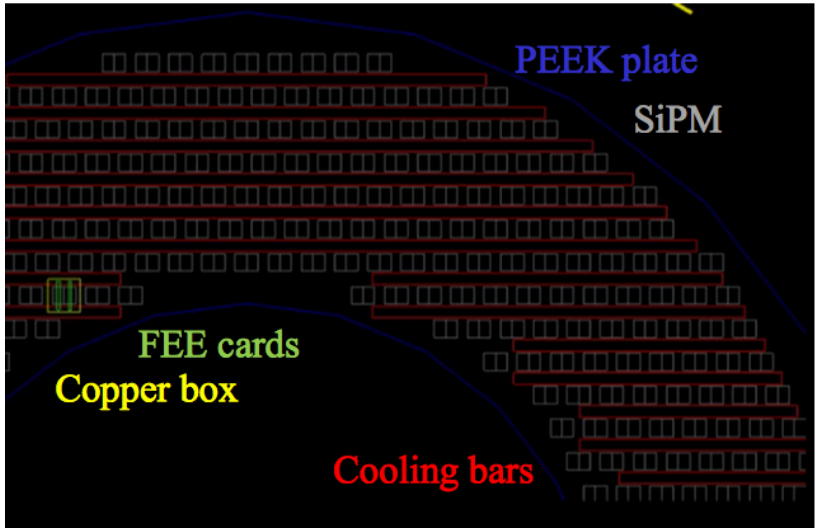
Backup

Actual software geometry (1)



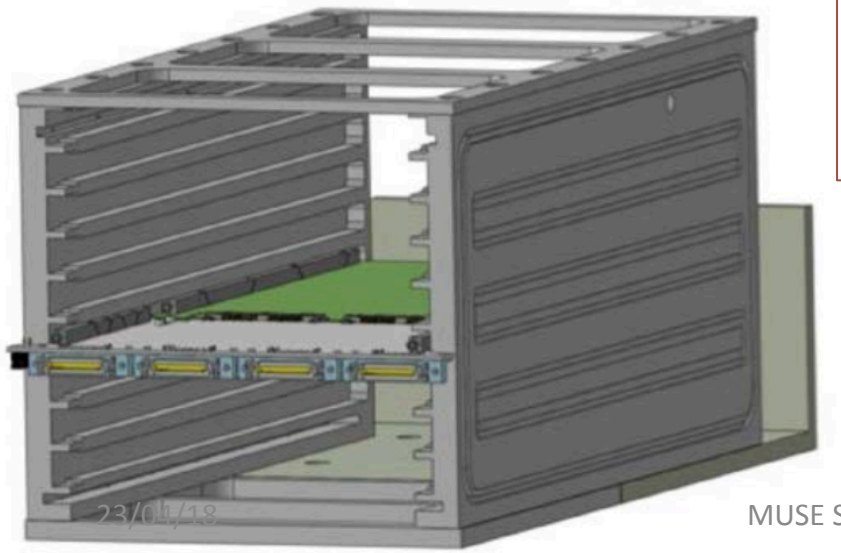
- **Front plate**: sandwich of 2 carbon fiber plates+ PET-like material
  - ❑ Pipe servicing not included
  - ❑ Need to verify dimensions and placement
- **Disk case**: inner ring, inner steps?, crystals, outer ring
  - ❑ Feet, check dimension and placement of inner and outer ring and step

Actual software geometry (2) back plate



- **Back/FEE plate**:SiPM, PEEK plate, simplified cooling bars, FEE,copper boc, manifolds
  - ❑ Cooling parts, SiPM holder…
    More pieaces = slower simulation
  - ❑ Need to verify dimensions and placement

- **Crates**: Crates panels, shielding, cards, cable services

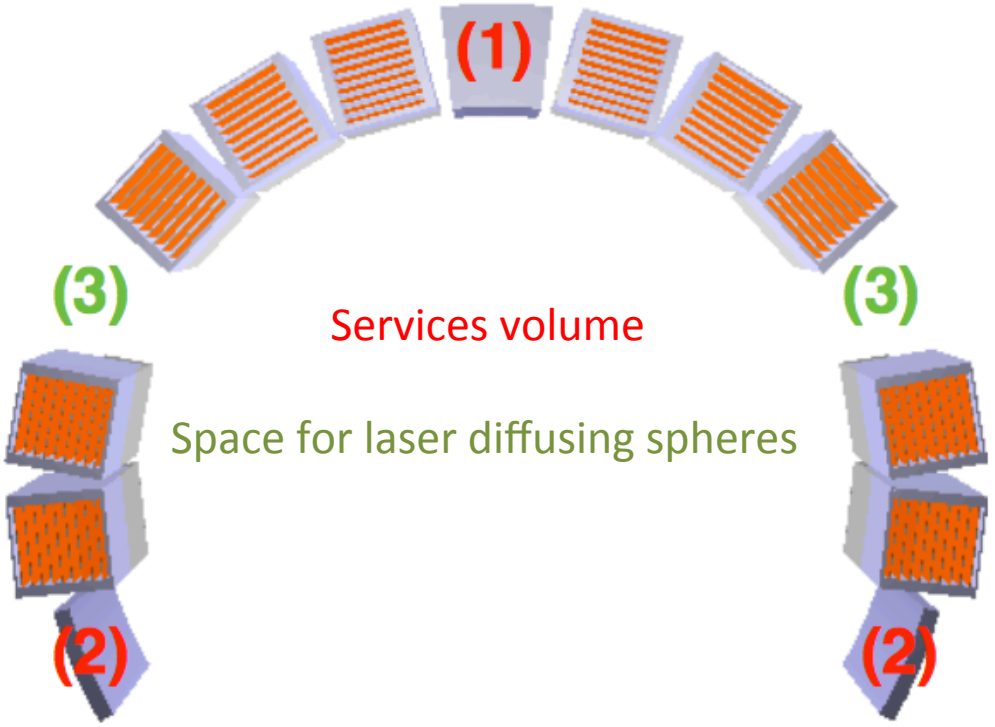


All main components included in the geometry!

Crates Dose study

Dose on the calorimeter boards was updated using the latest geometry

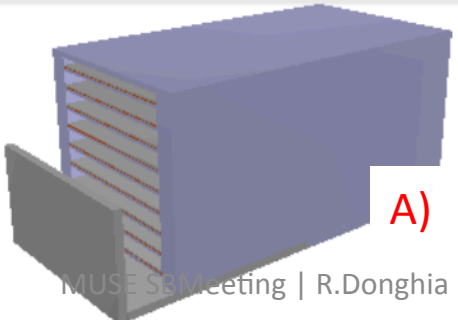
- 9 boards/crate:
  - ➡ 8 DIRAC + mezzanine
  - ➡ 1 clock distributor

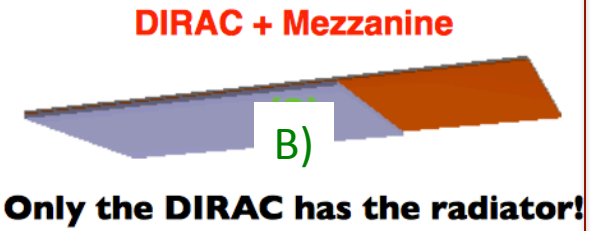


Shielding option

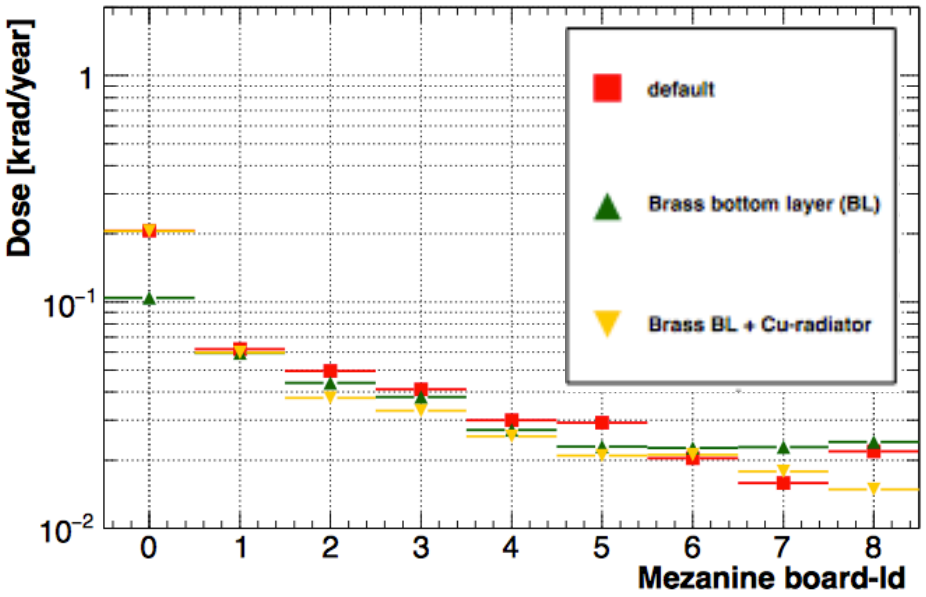
A) Brassfor the bottom layer

B) Cu radiator instead of Al

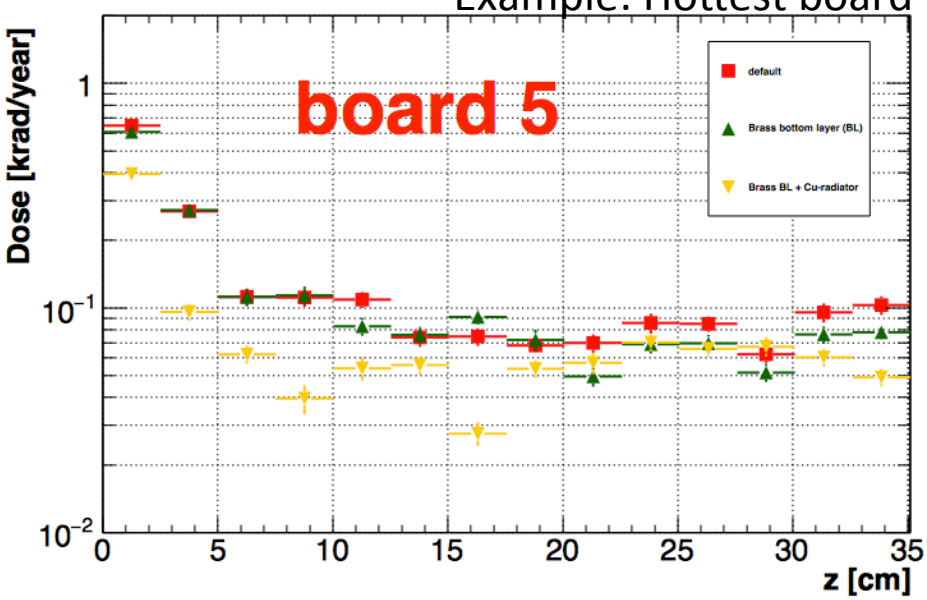




Boards dose – Disk 0



Example: Hottest board



- board-Id = 0 is the closest to the crystal volume
- Mean dose is below 0.2 krad/year
- Dose along the board can vary by a large factor (>2)
- Disk-1 mean dose < 0.3 krad/year (more photons on disk-1 from simulation)

Dose shield

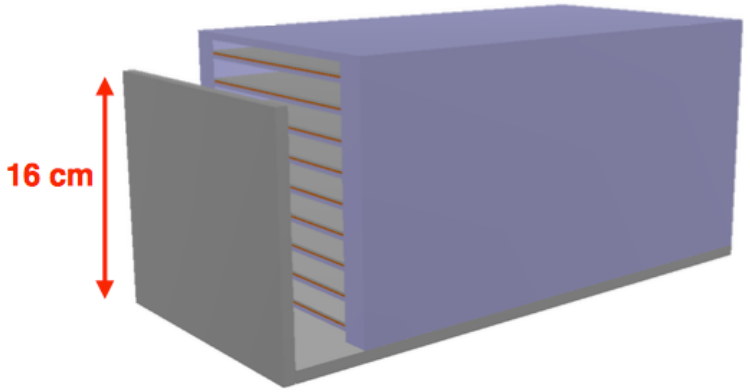
Study with CuW

Disk-0

- Edge effects on DIRAC boards disappeared
- Mezzanine dose doesn't show any change

Disk-1

- Edge effects on DIRAC board disappeared
- Mezzanine dose doesn't show any change



Summary

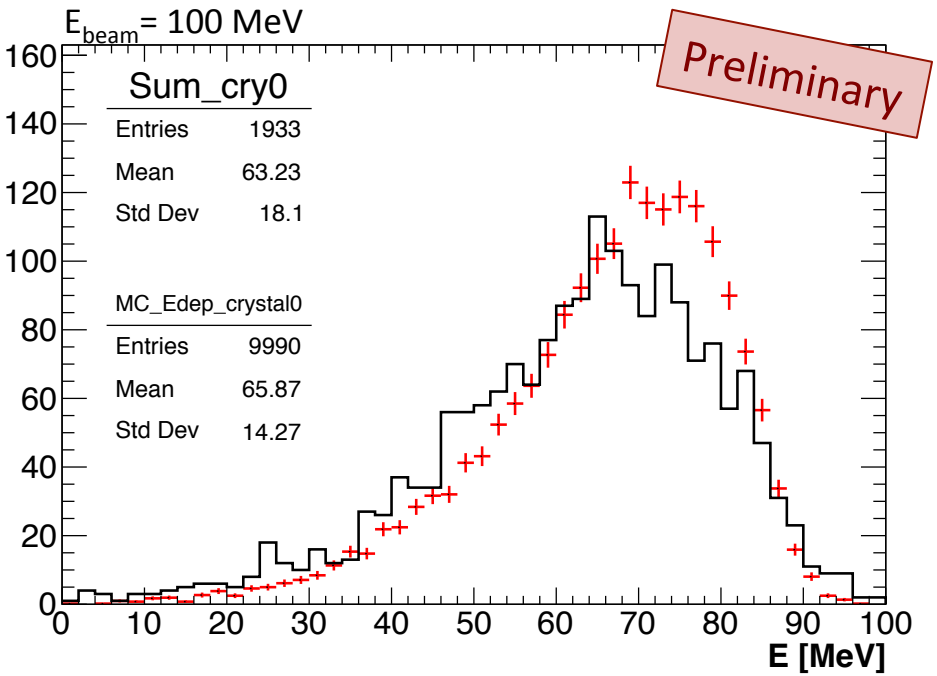
Dose on the calorimeter boards was updated using the latest geometry

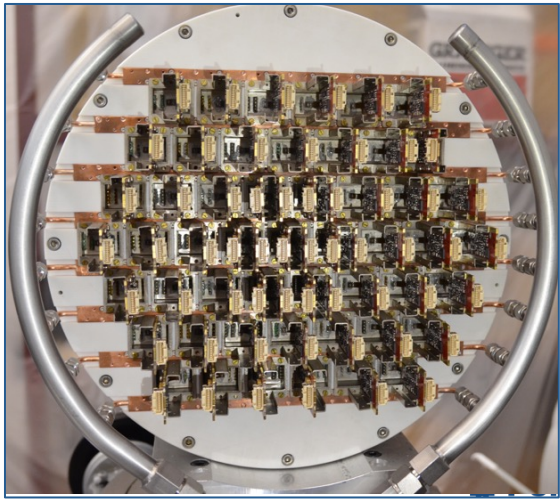
- 16 cm tall shield provides dose below 0.2 krad/year on disk 0: uniform
- the boards on disk 1 show regions with dose ~ 1 krad/year
- Mechanical engineer already started thinking of ways to implement 16 tall shield without interfering with board access
- Now we are focusing the attention to the crates on the second disk

Module-0 TB

Mu2e Offline is also used to simulate the expected response of calorimeter prototypes

→ Module-0 tested @ BTF facility with e- beam (60-120 MeV)





- At the end of data analysis, the developed procedure will be integrated in the official Mu2e offline