Snowmass and R&D for Mu2e-II

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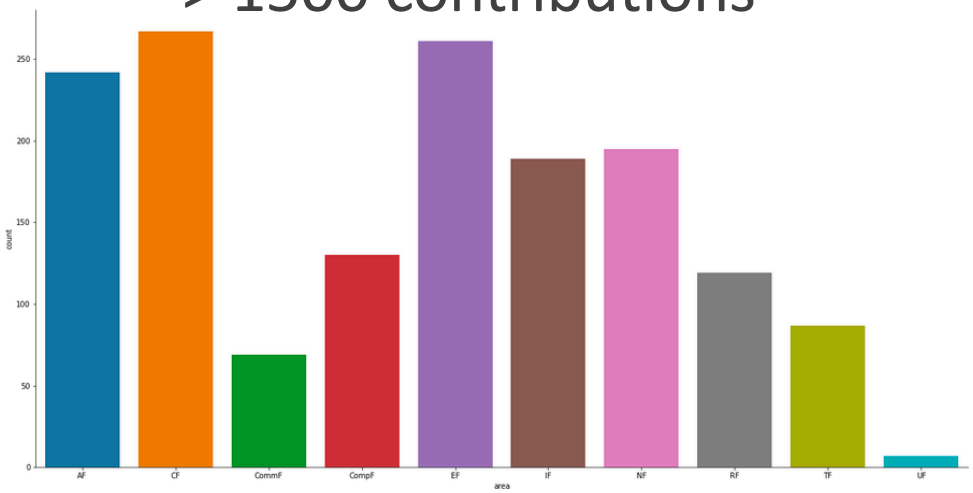
Summary for the Mu2e INFN referees

Other items: Snowmass

- Snowmass (Particle Physics Community Planning Exercise) is organized by DPF e APS. It is a scientific study to provide an opportunity for the Pphysics Community to identify a vision for the future of PP in US and in the world (similarly to the EP strategy).

→ Snowmass kick-OFF, Apr 18 2020
→ Community Planning Oct 2020
→ Snowmass mid-term Apr. 2021
→ Snowmass Summer Study July 2021
➔ Snowmass Output will be used by P5 (somewhere in 2022-2023) to develop a Strategic US planning for 10 year timescale with a 20 year timescale vision (similar to EP strategy)

> 1500 contributions



- Mu2e et al. partecipate to the Rare and Precision frontier

- Upgrades at the Muon Campus (CLFV searches) or at the foreseen BRU (Booster Replacement Upgrade) are dominated by Mu2e upgrade related work.
- Mu2e-II has submitted 12 contributions how of which at least five (Calorimeter, tracker, TDAQs) have signatures from INFN people.
- Upgrades are being considered for intensity increase of > x 10 posing serious issues on: Detector systems and Readouts

Other items: Snowmass

- 4 working group conveners from INFN
  Calorimetry (L.Morescalchi, I.Sarra)
  Tracker (G.Tassielli)
  TDAQ (A.Gioiosa)

- Few explorative R&D items identified to clear up our upgrade ideas and startup a slow activity in parallel with the Mu2e construction, O(40 kEuro) in 2021
- If Snowmass goes well the R&D plan will be finalized to prepare a realistic proposal for the far future (> 2027)

- Main Mu2e-II LOI
  - Mu2e-II
- Mu2e-II topical LOIs
  - Beam delivery for Mu2e-II
  - Calorimeter
  - Cosmic Ray Veto
  - Production target
  - Stopping target monitor
  - Theory
  - Tracker
  - Trigger/DAQ, 2 level, FPGA, scheme A
  - Trigger/DAQ, 2 level, FPGA, scheme B
  - Trigger/DAQ, 2 level, GPU
  - Trigger/DAQ, software trigger

For calorimetry we need to have a better radiation hard crystal, faster and with a faster electronics than CsI → from 200 ns width to < O(30) ns
For TDAQ make propostal for an intermediate trigger level not only in software.
For tracker → new ideas with respect to a ”thinner” straw-tracker

Calorimeter R&D - summary

- Requirements are kept the same: Eres <10%, St < 500 ps
- Unfortunately we know that:

→ Intensity increases by a factor of 3 (Pileup increase)

→ Duty cycle increases by a factor of 4 (from 25% to 100%)

→ Overall Dose and Neutron flux increases X 10 (1 Mrad, 10^13 n/cm^2)

Since we know that CsI deteriorates at 1 Mrad and that our resolution depends on the neutron flux we need to:

→ get a better radiation hard crystal (BaF2 or Lyso)

→ Improves the SiPM kind (pixel size, new generation) or change sensors (MCP?)

→ Work on optical filter for slow components for the BaF2
Nanotechnology ? ALD filters ? External optical filters

→ Work on the cooling
(factor of 10 increase corresponds to additional 30 degree lower running, -40 C)

→ Work on the FEE readout (shape the signals at O(30 ns))

→ Work on the digital readout (pico-TDC or others)

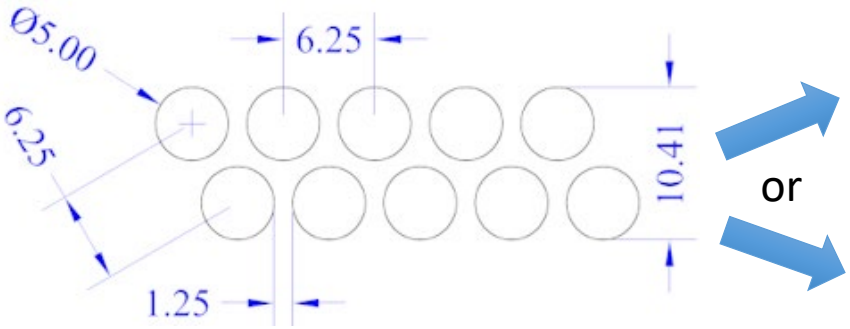
→ Requests done are in line to make the minimum effort to start addressing options

Tracker R&D - summary

A tracker option for Mu2e-II - panel

Instead of using straws for the cathodes use:

- all thin wires (conf. 1)
- thin metalized Maylar foils and thin wires (conf. 2/3)

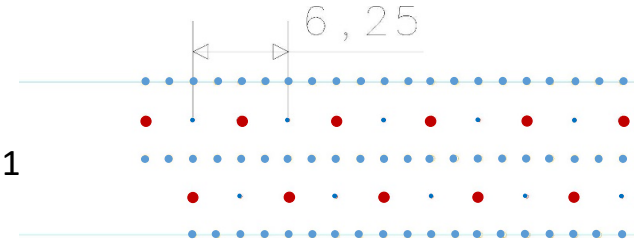


or

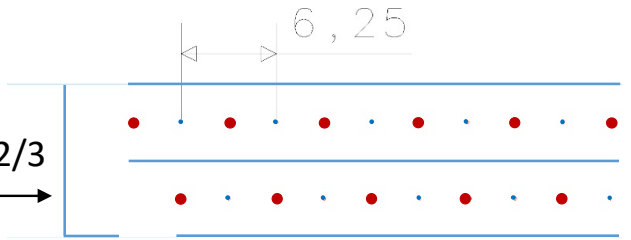
Assumption:

- 20 µm W wires
- 50 µm Al wires
- 40 µm Al wires
- 2.5 µm Mylar with 500 Å Al

conf. 1



conf. 2/3



Option: use unique foil to be gas-tight

Simple construction (as used for MEG-II drift chamber):

- with a wiring robot, build 3 layers of cathode wires (or use 3 foils)
- build 2 layers of anode and cathode wires
- machine 4 planar spacer layers
- stack the wire layers and the spacer layers (in the right sequence) on a support frame.
- use dowel pins and screws to align and to lock (no glue, apart from conf. 3).

Caphri R&D

- Increases of a factor of 10 the background will reduce the capability of a LYSO based crystal to monitor the 1.8 MeV line.

- We need to study a more performant crystal for energy resolution.
- Solution is at hand looking at the one used for the STM LaBR.

Resolution expected to be a factor of 2 better than LYSO, from 60 keV to < 30 keV line.

- PRO: we are going to match the LaBr with our own SiPMs and test it. This should be feasible. A small 3" LaBR costs around 7-9 kEuro.

- Contra: we do not know how to make it work on vacuum.
- Need to work with St.Gobain and test it. Make our own R&D here.

- If working (and after the experience of the first Mu2e run) this will be a solid replacement for an upgraded STM and a fast monitor along running.