MUCAL updates
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• Calorimeter design updates
  – Transverse size (beam profile)
  – Optimization of sampling fraction (beam spectrum)

• $e/\mu$ separation algorithm
  – Efficiency vs momentum with G4MICE

• Hardware activity
Beam profile at calorimeter

The beam is contained within ~30 cm radius

⇒ Calorimeter transverse size 72x72 cm²
Calorimeter layout

Scintillating fibers embedded in grooved lead layers

Side view:
2 blocks of
72x36x16 cm³

Beam

72 cm
(72 cm (no limitation))

16 cm

Readout:
18 PMTs per layer at both ends

Minimum cell size 4x4 cm² due to PMT support
Fine Grained Calorimeter Option for Muon Identifier

The construction technique consists in embedding 1 mm diameter polystyrene based blue scintillating fibers between thin grooved lead plates, obtained by plastic deformation of **0.3 mm thick lead foil**.

Fibers are glued to the lead plates and run parallel to each other with a pitch of 1.35 mm and are mostly orthogonal to the entering particles.

**Same Construction Technique as KLOE EmCal**

Density \( \approx 3.7 \text{ g/cm}^3 \)
Radiation length \( \approx 2.1 \text{ cm} \)
Moliere radius \( \approx 3.4 \text{ cm} \)

(estimate without glue)
Momentum distributions at calorimeter

G4MICE datacards used:
\(<E_{\text{kin}}>=120.5 \text{ MeV, } \Delta E/E=0.1\)

Muon spectrum softer than in MICE proposal!
Consider thinner absorber
Fiber-Lead composite

0,3 mm Lead + 1 mm Fiber

0,5 mm Lead + 1 mm Fiber
Optimization of lead absorber thickness

Eff. for signal>threshold in 3rd or 2nd layer vs momentum
(useful mainly for trigger purposes)

- 1 Layer = 4 cm depth
- 0.5mm Pb cause too large loss on 3rd layer
- Eff. on 2nd layer is close to 100% even for softer muons (small sample…)

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e/µ separation algorithm

Apply cuts on
Baricenter coordinate

and

E1 vs E1/Etot

$$Z_B = \frac{\sum_{i=1}^{N\text{layers}} Z_i \times PH_i}{\sum_{i=1}^{N\text{layers}} PH_i}$$

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e/µ separation algorithm

Muon efficiency vs momentum and angle

- Comparable efficiency with all the sampling options
- Fraction of electrons surviving the cuts is ~10% for $P_e > 120$ MeV (larger with very thin Pb layers) - but there might be some problems in the simulation... we are checking

Our favourite choice at the moment: Pb layer thickness 0.3mm
Lead foil grooving

Comparison 0.5 mm vs 0.3 mm lead foils
Test at LNF Metrology Lab

Lead grooved foil

Enlarged view

Microscope

Measurement
Basic elements for calorimeter construction

Lead spool

Big lead shaping machine

The grooving rollers
Big swaying machine at RomaIII
Calorimeter design

[Diagram of calorimeter design with labeled parts: Beam, [9 x 2] Light guides, Cell 40x40 mm²]

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PMTs and Winston-cone light guides

PMTs recovered from the HARP experiment
- Hamamatsu 1355 PhotoMultiplier and 2624 Voltage Divider
- Box with mu-metal shielding for mechanical housing of two complete readout channels (to be modified)

Some exemplary of Winston come light guides with different length an section
Light guide and PMT support structure
MUCAL seen from outside
Conclusions (PRELIMINARY)

- Fine grained calorimeter: scintillating fibers embedded in grooved lead foils
- Calorimeter size: 72 x 72 x 16 cm$^3$
- Lead layer thickness 0.3 mm
- Read-out: 4 Layers, each read out by 18 PMTs at both ends (cell size 4x4 cm$^2$)

- Muon identification efficiency studied with G4MICE: close to 100% for momentum above 150 MeV/c

- Electron contamination $<10^{-3}$
  - Checks on correctness of simulation still needed