EmCal Design

- Revision
- Alternative

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EmCal update (memo)

Results of the simulation work
(by T.J.R. : 21.VII. 04 and 22.IX. 04)

on:

a) softer pulse spectrum of beam imposes a “lighter” calorimeter

b) particles transverse profile imposes a “larger” calorimeter
Comparison 0.5 mm vs 0.3 mm lead foils

MICE EmCal TRD Update
Fiber – Lead Composite (sketch)

- ≈ 0.9 mm pitch \( \perp \) to the beam
- 1.35 mm pitch of lead foil grooving
- 0.3 mm Lead + 1 mm Fiber

- ≈ 1.2 mm pitch \( \perp \) to the beam
- 1.35 mm pitch of lead foil grooving
- 0.5 mm Lead + 1 mm Fiber
Beam spot and Losses on EmCal (reminder)

<table>
<thead>
<tr>
<th>Counter</th>
<th>TRD (Sept 04) Size</th>
<th>Lost Good mu+ per 2353 Good mu+</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOF0</td>
<td>480 by 480</td>
<td>0</td>
</tr>
<tr>
<td>Cherenkov1</td>
<td>400 by 400</td>
<td>0</td>
</tr>
<tr>
<td>TOF1</td>
<td>480 by 480</td>
<td>0</td>
</tr>
<tr>
<td>Downstream IronShield</td>
<td>r = 250</td>
<td>1</td>
</tr>
<tr>
<td>TOF2</td>
<td>480 by 480</td>
<td>8</td>
</tr>
<tr>
<td>Cherenkov2</td>
<td>r = 425 *</td>
<td>0</td>
</tr>
<tr>
<td>Calorimeter</td>
<td>1200 by 1200</td>
<td>2</td>
</tr>
</tbody>
</table>

(Roberts 22.IX.04)

( Remember the relaxed Trigger considers Mu P -> e decays to be “Good mu+”.)
... three times bigger EmCal

120 x 120 cm²
Active Area

30 x 4
Light Guides per Side

MICE EmCal TRD Update
EmCal overall dimensions

No change in shape wrt previous
MICE_EmCal_TRD
Side view of EmCal layout

Now 120 cm

(72 cm)

Readout:
Now 30 PMTs per layer
at both ends (18)
cell size 4x4cm²

CM 30 Mars 2004

Now 120 cm

(72 cm)

16 cm

Thickness unchanged

Beam

X

Y

Z

fibers
Does the EmCal fulfill its duties?

✓ Reject low energy electrons (see Cherenkov inefficiency)
  ⇒ easy job: it contains electron showers in the first layer

✓ Reject high energy electrons
  ⇒ 90% of the electron showers have to be contained in the first two layers, so look at $E_{\text{FIRST}}/E_{\text{TOT}}$ vs $E_{\text{TOT}}$ and barycenter

✓ Full efficiency in muons tagging
  ⇒ ALL muons in the momentum range of MICE interest have to cross the EmCal, so look at $E_i/E_{\text{TOT}}$ vs $E_{\text{TOT}}$ and barycenter

✗ Still need to play with lead thickness and cell dimension?
**e/µ separation algorithm (memo from Alessandra)**

Apply cuts on

- **Barycenter coordinate**
- **E1 vs E1/Etot**

**Problems:**
- muons barycenter
- anomalous electrons propagation
EmCal Separation of electrons from muons

(memo from KAHN 21.VII. 04)
My baricenter coordinate distribution looks similar to Alessandra’s, however my E1 vs E1/E_{tot} fraction plot shows a wider muon region.

This needs to be understood.

(KAHN 21.VII. 04)

We may have to rely almost exclusively on the downstream Cherenkov2 and calorimeter for muon decay rejection.

(Roberts 21.VII.04)
Separation of “µ” from “e” using Barycentric variable in EM Calorimeter

Flat \( \mu \) \( E_{\text{dep}} \) should give Barycenter \( \approx 80 \) mm

EmCal still too heavy?

(G4MICE and/or REALITY)? to Rikard

KAHN
21.VII. 04
Rikard is taking over the work previously done by Alessandra for the EmCal simulation in G4MICE (Version 0.9.1).

According to the layout quoted on the MICE_TRD_update, he has generated, with a more recent version of G4MICE, a new EmCal picture.

The internal structure, no longer simulated by alternate layers of scintillator and lead, reproduces the scintillating fibers embedded and glued between thin grooved lead plates with a pitch of 1mm.
Downstream PID picture by Rikard Sandström

- PhotoMultiplier side B
- PhotoMultiplier side A
- Fibers
- Single cell
- 4 x 4 cm²
- 120 cm
- Beam
- TOF
- Ckov
Alternative Design desirable?

To take into account of:

1) un-predicted (for time being) “lightness” of EmCal (to guarantee appropriate response to electrons and muons)

2) active area still growing ....

3) availability of raw material (CHORUS, HARP, ....)

4) flexibility

Why not? TOF LIKE STRUCTURE

(small swaging machine needed for thinner lead foils previously used for end caps of KLOE EmCal)
Basic EmCal Bar

- Scintillating fibers embedded in grooved lead foils

- Ingot Size: \((4 \times 8 \times 120) \text{ cm}^3\) (thick \times wide \times long)

- Four PMs Hamamatsu 1355 and as many voltage dividers 2624 type (two per side)

- Four Winston cone light concentrators (two per side) [from cell \((4 \times 4) \text{ cm}^2\) to \((\pi \times 1,3 \times 1,3) \text{ cm}^2\) cathode surface]

- Two mechanical housing boxes (one per side as CHORUS) with 2 mu-metal shielding each.
EmCAL bar

- Beam
- Light guide
- PM
- Voltage divider
- Connectors
- Grooved lead foil
  - Thickness 0.3 mm
Single plane made of 15 bars
4 x 8 x 120 cm³ each
readout by 2 pm per side
TOF-like of EmCal assembling
Side view of EmCal layout

Side view: still 4 layers of 120x120x4 cm³

Still 120 cm

Readout: still 240 PMTs
30 per layer at each end
(almost max available)

Optimized cell size: still 4x4 cm²
(max area as best compromise
between cathode surface of PMT
and acceptable light concentration factor)

Still 16 cm

fibers

Beams

X

Y

Z

no length limitation
for lead grooving
Pattern of visible energy

It’s possible to distinguish electrons from muons by means of:

⇒ path reconstruction based on the energy released inside the calorimeter’s elements
⇒ combination of cluster length, total energy, energy per plane ...
⇒ $E_{\text{FIRST}}$ vs $E_{\text{FIRST}}/E_{\text{TOT}}$
⇒ Barycenter of Energy deposition
EmCal support for TOF-like mounting
Conclusions

- Calorimeter size: still 120 x 120 x 16 cm³

- Still 4 layers
  each read out by 30 PMTs per side
  (240 total out of 256 inherited by CHORUS/HARP)