MICE
PID & trigger Detectors

MICE CM11, LBL Feb 12, 2005

for the PID team
Bonesini, Cremaldi, Gregoire, Kahn, Roberts, Sandstrom, Summers, Tilley, Tonazzo, Tortora, Torun, Wilson and more
Proposal for the PID parallel session at LBL Feb 11, 2:00-5:30 pm

T. Roberts: Update on G4BEAM beam rates, profiles, losses at detector locations

Y. Torun : PID detectors in MICE: overview & steps to evaluation of performance
mu efficiency & pi/mu separation upstream
mu efficiency & e/mu separation downstream

S. Kahn : Implementation of TOF detectors in G4MICE. Comparison with G4BEAM?
Implementation of CKOV I & II

R. Sandstroem Implementation of MuCal in G4MICE
down to fiber geometry? In contact with Roma III

L. Cremaldi : Update & plans on CKOV I

V. Palladino : Short news from TOF and MuCal (*)

G. Gregoire : Mag shield and CKOV II

reports should include status of TRD subchapter

W. Lau : Realistic drawings of PID detectors in the general MICE layout

(*) for M. Bonesini & L. Tortora
in the *PID Summary Talk at CM10 in UK*

the basic conclusion was that we are advancing
well enough on hardware design
not fast enough towards a serious G4MICE re-evaluation of
PID performances

We have had since

- one short meeting *Wed Nov 24*
- a useful meeting of general planning on *Dec 21*
- a meeting of first results on Jan 26
- a meeting with more results on Feb 2
- a parallel session here at LBL Feb 11
In general, no major new progress from CM10 to CM11……
more like a few months of consolidation
striving to

complete another revision of our 8th PID Chapter of the TRD

Striving to eliminate not negligible obsolete information & inconsistencies still remaining
to make it the credible repository of PID detector data.

Geometry files including PID, will be added by Yagmur in Ch. 3 (Simulation)

incorporate realistic drawings of PID detectors in the general MICE layout
general outside dimension of each device
including external cases and supports. Wing Laa& al.

tool up for final design
downstream field maps
files of downstream electron and muons (G4BEAM & G4MICE)
and full re-evaluation of performance
Implementation of TOF, CKOV I & II and MuCal in G4MICE

feed PID detectors requirements to the resuming effort on DAQ & controls
survey questionnaires filled for all detectors
TRD SEPT04 Layout

No change
Apertures

No change. But now implemented throughout.

standard definition of the apertures of the PID devices based on G4BEAM studies

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

Longitudinal coordinates being revised and text, tables, figures updated accordingly.
Updated study on SEP04
watch out ..... we are already waiting for JUN05

Summary of this Simulation

• A significant improvement in realism:
  – First guess of the beamline vacuum, windows, air gaps, etc.
  – More detailed implementation of Tracker1 and Tracker2
    • Vacuum with windows
    • 5 planes, 1.5 mm scintillator each, located as in the TRD (Dec 17 2004)
  – TRD (Dec 17 2004) configurations for everything except a few minor things (absorber and RF window shapes)
Conclusions

• The December 17, 2004 TRD includes minor changes from earlier beamline analyses.
  – The major one is in TOF thicknesses, which costs about 20% in the good mu+ rate
• The PID counter sizes in the TRD miss ~1% of the good mu+. 
Momentum Histograms
(Placed together to facilitate comparisons)
Cherenkov1

TRD
Size 400x400
TOF1

TRD
Size 480x480
Iron Shield (hole)

TRD
Size
r=250

Missed mu+ = 8, Singles=1326 Good mu+=1321
TOF2 - X

Missed $\mu^+ = 5$, Singles=1326 Good $\mu^+ = 1321$

TRD
Size 480x480
TOF2 - Y

TRD Size 480x480

Missed mu+ = 4, Singles=1326 Good mu+=1321
TRD
Size
r=400

Missed mu+ = 3, Singles=1326 Good mu+=1321
Calorimeter - X

TRD Size 1200x1200

Missed mu+ = 1, Singles=1326 Good mu+=1321
Calorimeter - Y

Missed mu+ = 1, Singles=1326 Good mu+=1321
Transit Time for Upstream Tof Planes

- Transit time between Tof0 and Tof1
- Quad fields are currently ignored
- Pions and muons can be distinguished
Cherenkov Systems

- **Upstream Ckov**
  - \( C_6F_{14} \) radiator with \( n=1.25 \)
  - 4 PMTs
    - 2 on top, 2 on bottom.
  - Threshold cherenkov:
    - 0.7 MeV for electrons
    - 140 MeV for muons
    - 190 MeV for pions

- **Downstream Ckov**
  - Aerogel with \( n=1.03 \)
  - 12 PMTs on 12-sided polygon.
  - Typically on electrons visible since pion threshold is > 500 MeV.
  - Requires TOF coincidence.
A warning from Steve

Ckov1 as a Threshold Detector

Note: According to Kevin Tilley’s Talk this morning, we expect the muon beam to have a momentum of ~241 MeV at the Ckov1 radiator!

New plot from Don soon
Adjust n?
Steve’s effort ... in contact Lucien & Ghislain

Photon Generation in the Cherenkov Detectors

- For each track that crosses the radiator with a velocity above threshold a number of photons are generated proportional to the deposited energy.
- We currently do not use the Cherenkov photon facility in Geant4.
  - There is some question as to how well it works with reflective surfaces.
- Imaginary photons are generated in a cone (at the ĉ angle) around the particle direction.
- Since all mirrors are at 45° w.r.t. the beam direction, we can position the PMTs on an imaginary plane.
  - The ĉ photons that intercept the PMT circles are “seen”. 
**Geometry in G4MICE**

- Calorimeter modeled on a fiber by fiber basis, grouped in cells. There are four sheets of cells along z.
- Cells: lead, 4x4x120 cm. 30 cells per layer.
- Fibers: scintillator, 120 cm long, 1 mm diameter.
- The default fiber spacing is 1.35 mm, center to center.
- Fibers are organized in hexagonal pattern. A cell is filled with as many fibers as dimensions allow.
- All cells parallel.
Energy loss per hit, mu+ beam
Energy loss per hit, e- beam

\[ edep(p), \text{ not mu+} \]

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Performance – e/mu separation

- Previous results from Alessandra Tonazzo showed electron-muon separation capability.
- Trying to do the same.
- A few problems to be solved
  - Barycenter calculation requires event by event information.
  - So does $dE_1$ vs $dE_1/dE_{\text{tot}}$.
  - Information is there in G4MICE, but not easily accessible.
  - We already have a new interface design, which will simplify things.

... dubious … Rikard’s fresh look welcome
CKOV I ............ Cremaldi & Summers reaparecidos

DESIGN

• Based on Tom Roberts beam spread plots at CKOV1 we are sizing the radiator aperture at 20”=+-250mm.

• This is oversized, but will allow some flexibility in understanding the incoming beam. A small cost in fluorocarbon and quartz.

• The window will be fused silica 1/8-1/4 inch.

• We will test a thin clear mylar window 20mil, believing a small UV absorption and some light dispersion issues.

• Light collection by 4 flat triangular mirrors + 4 8” PMTs (+ cones??)
CKOV I light collection …. to be improved
A sample of mechanics drawing

12 * 4 cm
both views

TOF0 mechanics
support structure
TOFI/TOFII support structure

8 * 6 cm
both views
Measurement campaign in the spring
R49998       TOF0
fine mesh R7761TOF I & II

Remaining problems

- Finalize PMT choice (tests foreseen)
- QADC/TDC choice to cope with rate (no clear ideas ... Emilio’s help foreseen)
- Updated physics performances from G4MICE to revise detector layout, parameters
Single block iron disk

- External diameter = 150 cm
- Central hole diam. = 50 cm
- Thickness = 10 cm
- Total mass = 1.3 ton

Support frame: welded H-shape profiles (normal steel/SS?)

Seen from upstream
The support frame is not longitudinally thicker than CKOV2.
Energy distributions

New files (T. Roberts)

- Lower 11 momentum allows to increase the index of refraction of the radiator.

- The very low energy electrons have disappeared (all electrons are now fully relativistic).

Proposal and present TRD (P. Janot)
1. The *entrance* aperture of CKOV2 as proposed in the TRD is adequate to cover the whole beam spot of muons.

2. The lower muon momenta allow to use an aerogel of a higher index (up to 1.05):
   - Larger nr of photoelectrons
   - Larger Cherenkov angles
   - Improved mechanical strength
   - Cheaper material
   \[\rightarrow\]  Higher detection efficiency
   \[\rightarrow\]  Lower cost

3. I would need similar electron and muon files at the *exit* of CKOV2 (or at Emcal entrance)

   (For Tom ...
Side view of EmCal layout

Readout:
- **Now 30** PMTs per layer at both ends (18)
- cell size 4x4 cm²

Thickness unchanged

CM 30 Mars 2004
**EmCAL bar**
(see MICE drawings gallery)

Diagram showing:
- **BEAM**
- **LIGTH GUIDE**
- **VOLTAGE DIVIDER**
- **CONNECTORS**
- **GROOVED LEAD FOIL**
  - thickness 0.3 mm
- **FIBERS**
- **PM**

Diagram indicates the structure and components of the EmCAL bar, including beam path, light guide, voltage divider, connectors, and grooved lead foil.
Side view of EmCal layout

Side view: still 4 layers of 120x120x4 cm³

Still 16 cm

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)

No length limitation for lead grooving
PID @ CM11: slowly lifting CM-10 bad marks

*Upstream*

- TOF-0... find a final site with moderate rates ....... < 3.8 MHz
  - validate PMT choice (Ham 4498)
  - (almost) no news, evaluate performance

*Downstream*

- TOF-I... find a final site, with moderate B-field, < K-gauss
  - validate PMT choice (Ham 7791 fine mesh)
  - (almost) no news, evaluate performance

*Refine evaluation of performance*

If modified layout and/or thickness, re-evaluate

- not necessary, so far

*Try to progress on digitization and controls*

- TOF-II... establish consensus on B-shielding and active area
  - validate PMT choice (Ham 7791 fine mesh)

- Ckov-II... establish consensus on active area
  - implement simulation

- Mucal... establish consensus on active area
  - debug simulation

- define size, evaluate performance

- in progress
- progress too slow
- in progress
- progress too slow

- in progress
- progress not fast enough

- resuming, new DAQ czar needed
The end