Muon/Special Detector Studies
Update St. Malo 2002

1. Muon ID - Single muons, single pion rejection.
   TESLA TDR (M. Piccolo)

2. Muon ID $b\bar{b}$ events: μ ID efficiency, hadron punch-through, decays in b-jet environment. TESLA TDR (M. Piccolo)

3. No. American Scintillator-based muon detector

4. R&D Needs

Single muons and pions

Generate single muons and pions at IR center:

uniform in (θ, φ) $45^o < \theta < 135^o$ from 2 – 50 GeV.

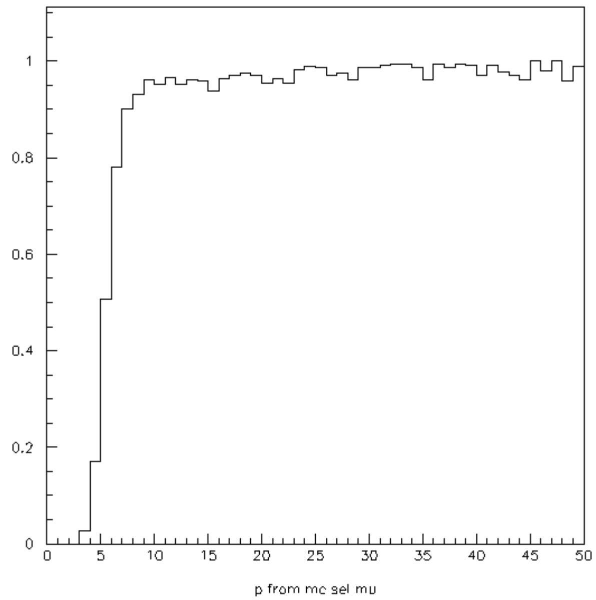
Find:

1. Expected high efficiency for muons when requiring 8 or 9 out of 11 muon chamber hits.

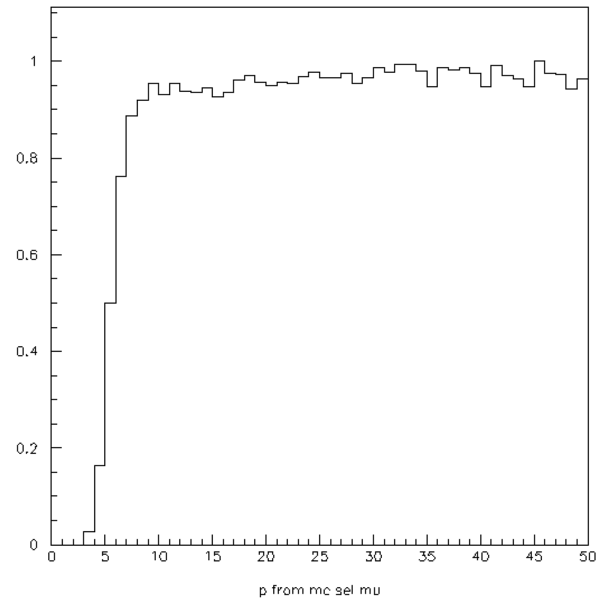
2. Pions are mis-identified as muons 0.3% of the time. So, pion rejection is better than 1%. Will be even better if the proper p-distribution is used. (more events at low momentum)

TDR reminder

8/11 planes



9/11 planes



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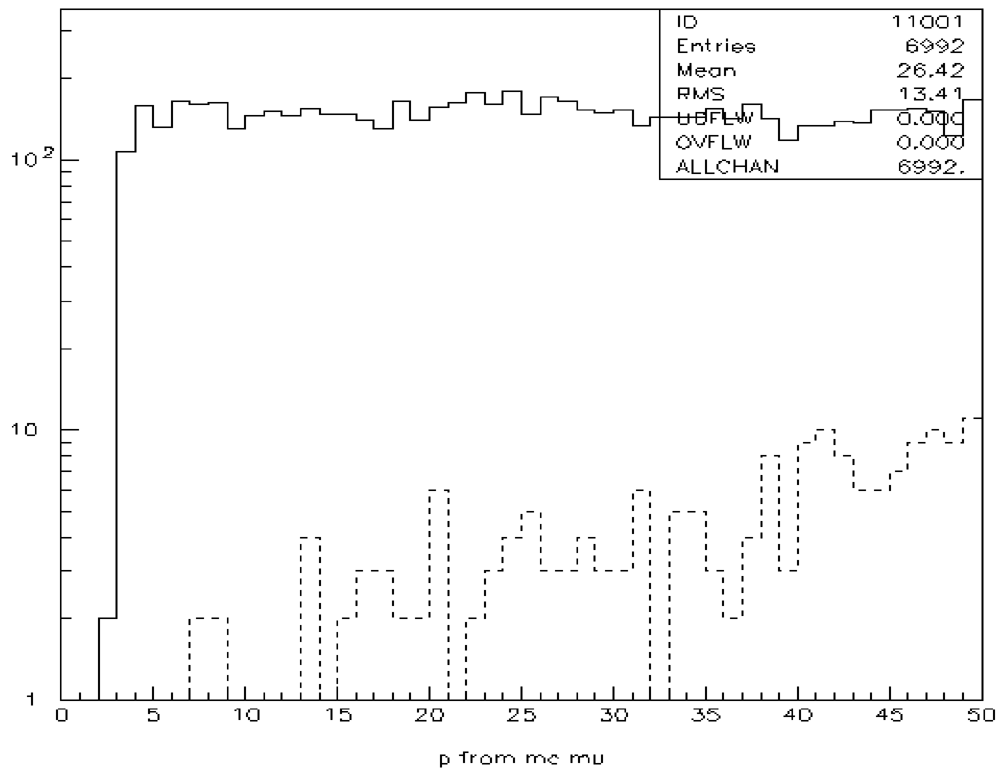
Single particle performances



- Here is the response to muon (full) and pions (dashed)
- The overall normalization for the input spectra differs by a factor of 5.
  - 5 times more pions than muons.
- The vertical axis is logaritmic.
- The overal rejection is better than 0.3%.

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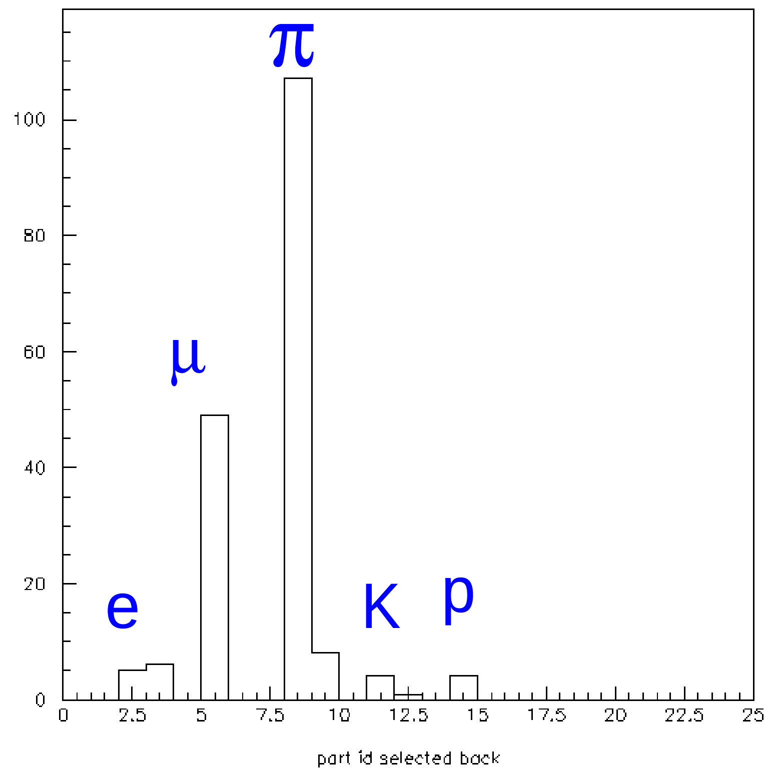
Single particle performance (cont.)



- In order to assess the overall goodness of the design, one should see if the misidentified pions come from punch through or from decay,
- The optimized confguration obviously calls for a 50-50 mix of the two components.
- Here is the truth table for misidenfied pions propagating in the calorimetric part of the Tesla detector
- These results come from a particles generated with a flat momentum and angle spectra.

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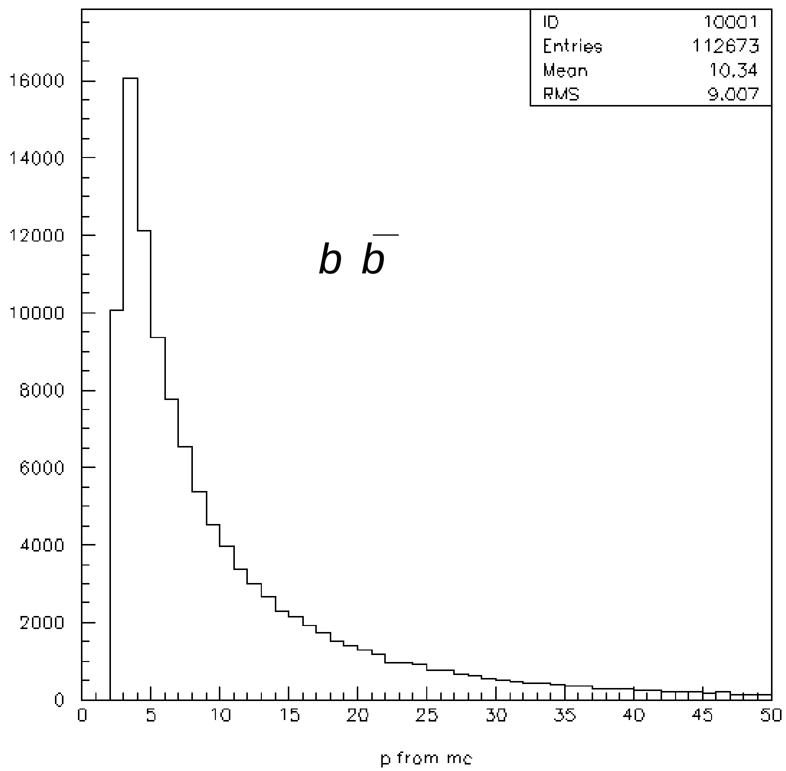
Moving to a jetty environment



P from MC

A first analysis has been performed on bb events in the barrel region.
Here is the momentum spectrum for particles ending up in an angular region between 0.81 and 2.35 rad. (polar angle).

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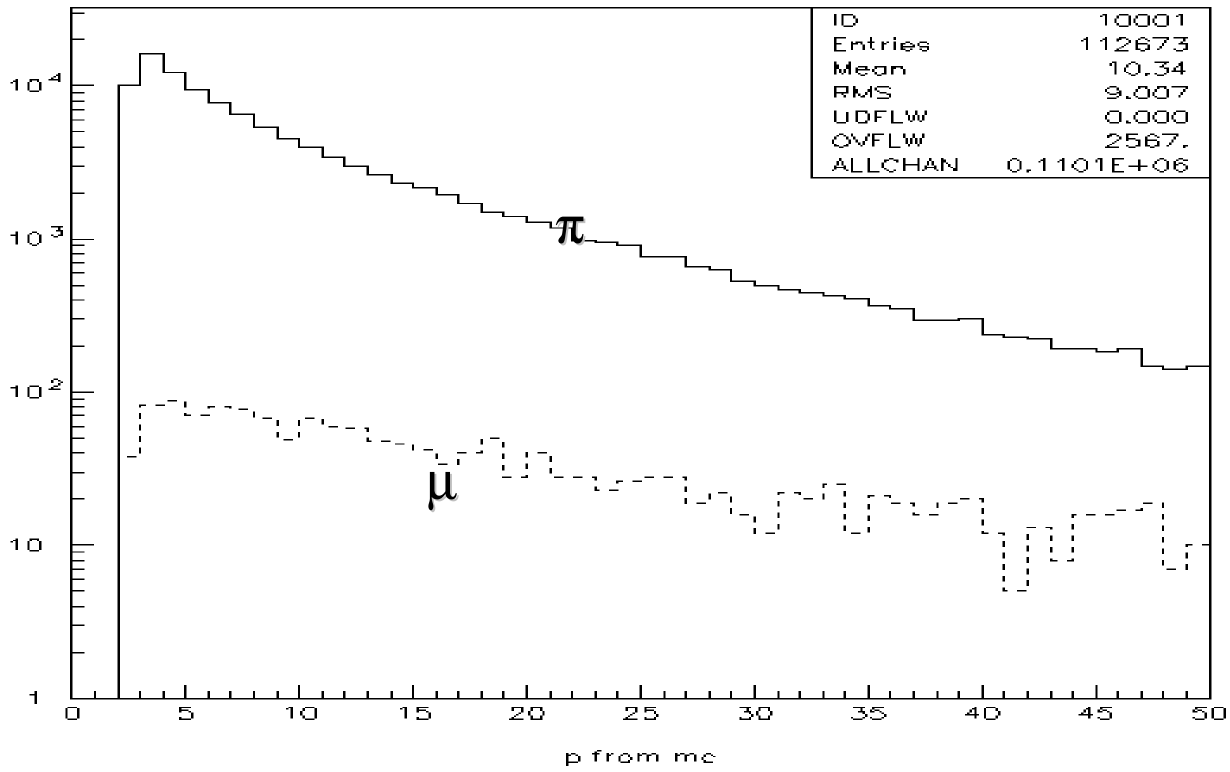
And comparing to muons



10,000 evts;
500 GeV

~ 2000 muons

$b\,\bar{b}$ events

Generated spectra

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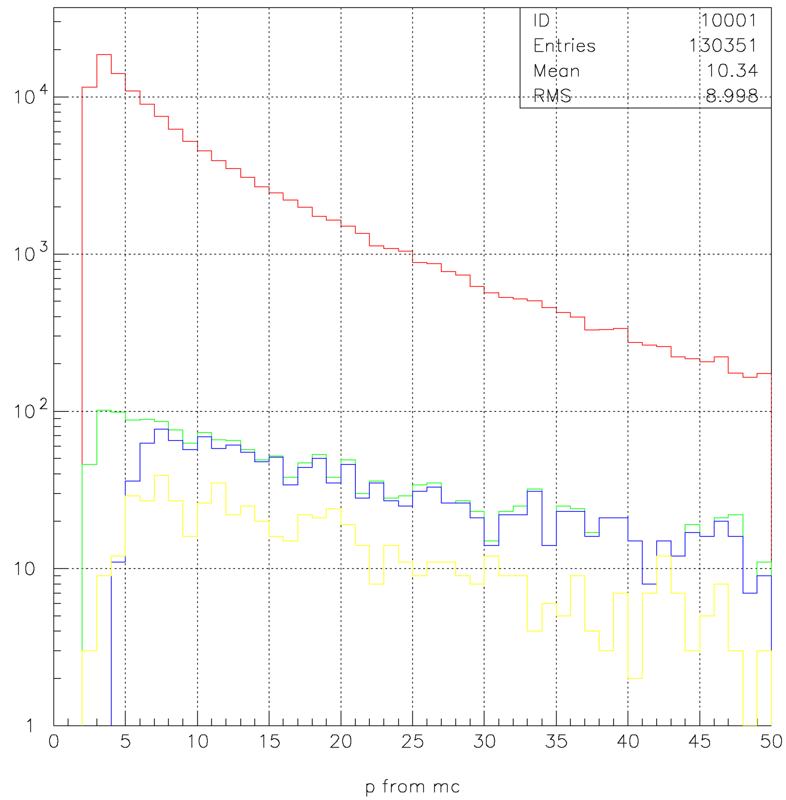
Here are the overall results



μ ID:

8/11 planes,
Angular consistency of hits,
Track angle match at entrance
to first muon hit.

The four spectra refer to:

RED : generated primary particles
GREEN : generated m
BLUE : identified m
YELLOW : misidentified p

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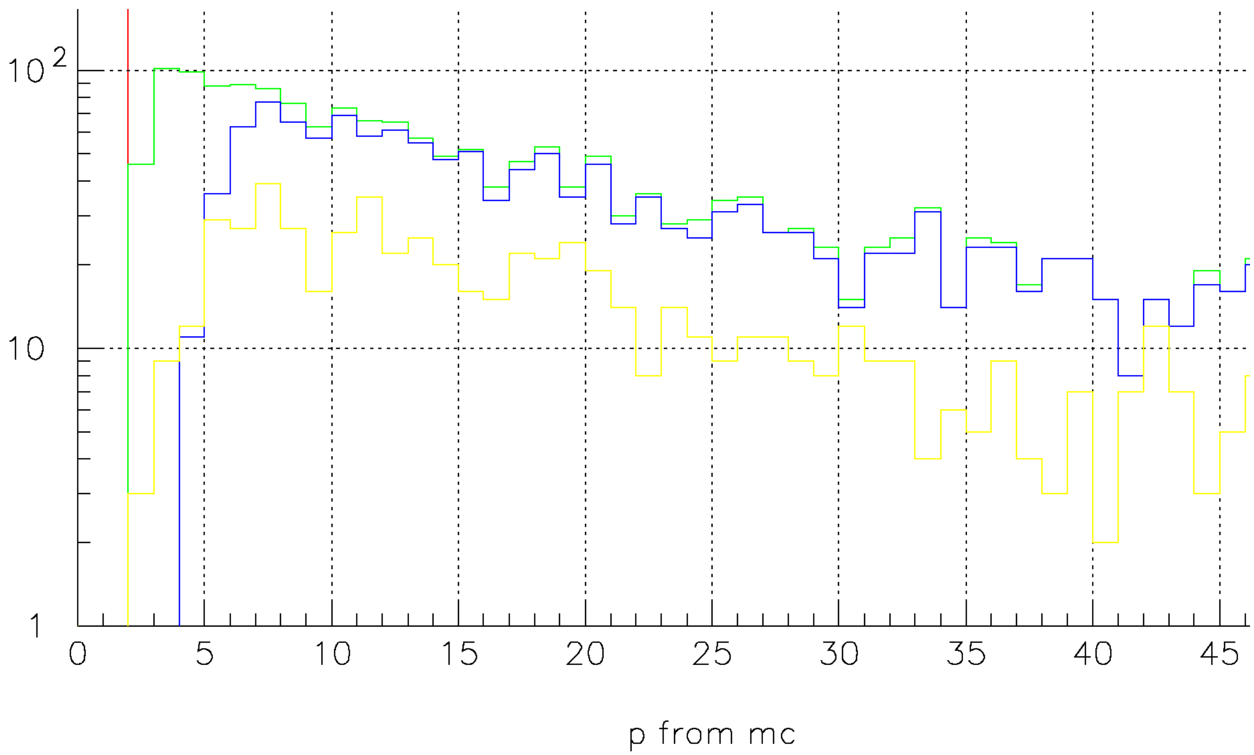
Slightly more visible?



Generated muons

Identified muons

Mis-identified

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Performances... good enough?

- Identification efficiencies seem O.K.
- Pion rejection is 100 to 1.
- If anything, one would ask a better pion rejection: an identified muon, in this class of events, has a 30% chance of being a misidentified pion.
- Why this deterioration with respect to the single particle figure ?
- Fake associations are the first bet
- First ID cut using 40 mr => 1 to few mr

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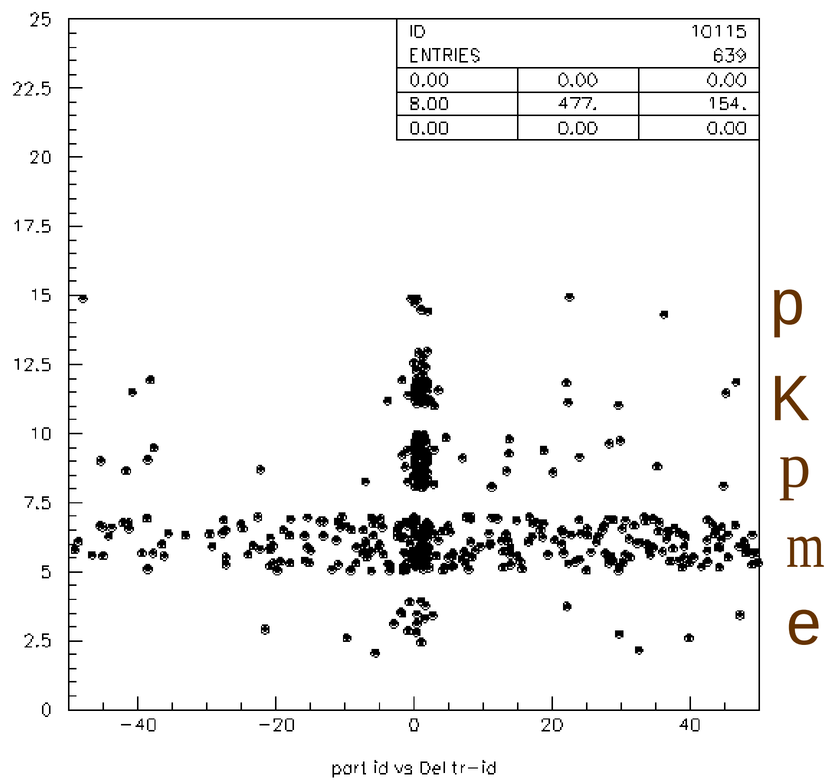
Performances in bb jets



Track id difference

Truth Table :

the relation between the hits in the first layer and the associated track (for misidentified hadrons) .

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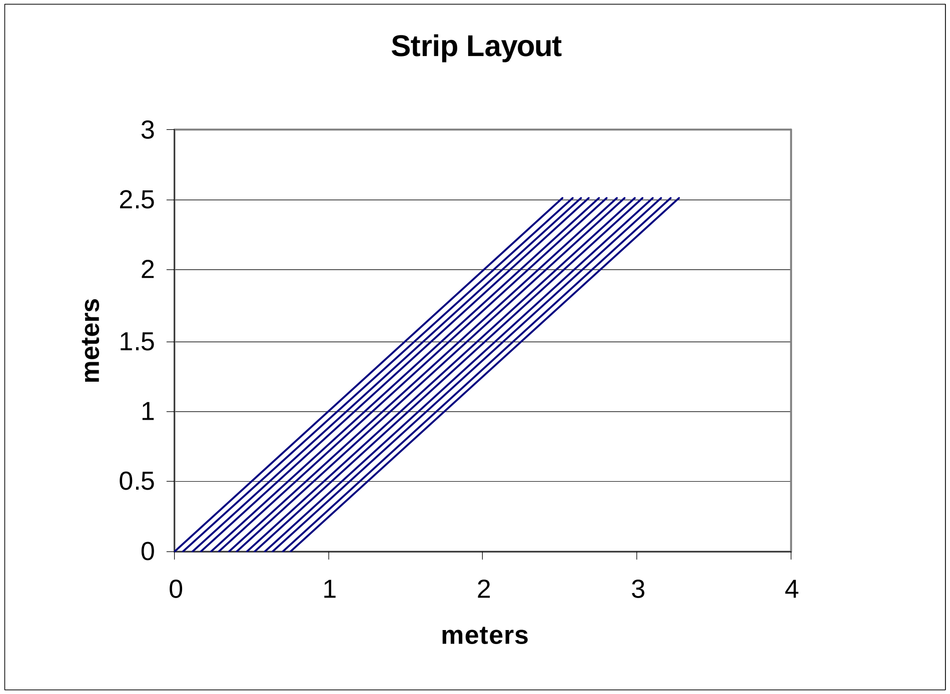
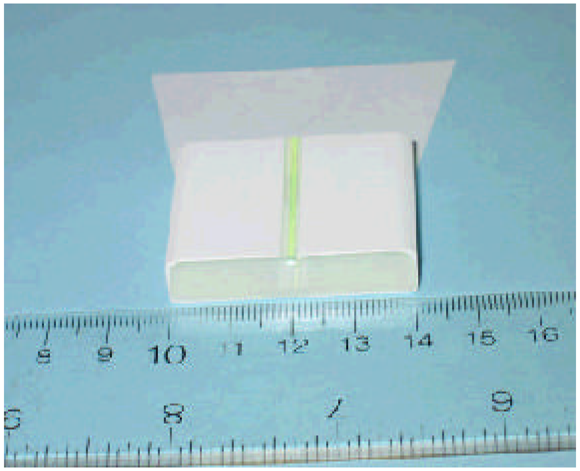
Scintillator Based Muon System

Fermilab/NIU

- Proposed Parameters
  - 16 – 5cm gaps between 10cm thick Fe plates.
  - Module sizes: 940(L)X(174 to 252)(W)X1.5 cm^3.
  - 4.1 cm X 1 cm extruded scintillator: 8u & 8v planes.
  - Light output from both ends: 11(n) + 6(f) p.e.s.
  - Multianode PM; 94K fibers X 2 clear fibers.
  - Expect ~ 1/vE for calorimetry.

Scintillator Layout and Strips

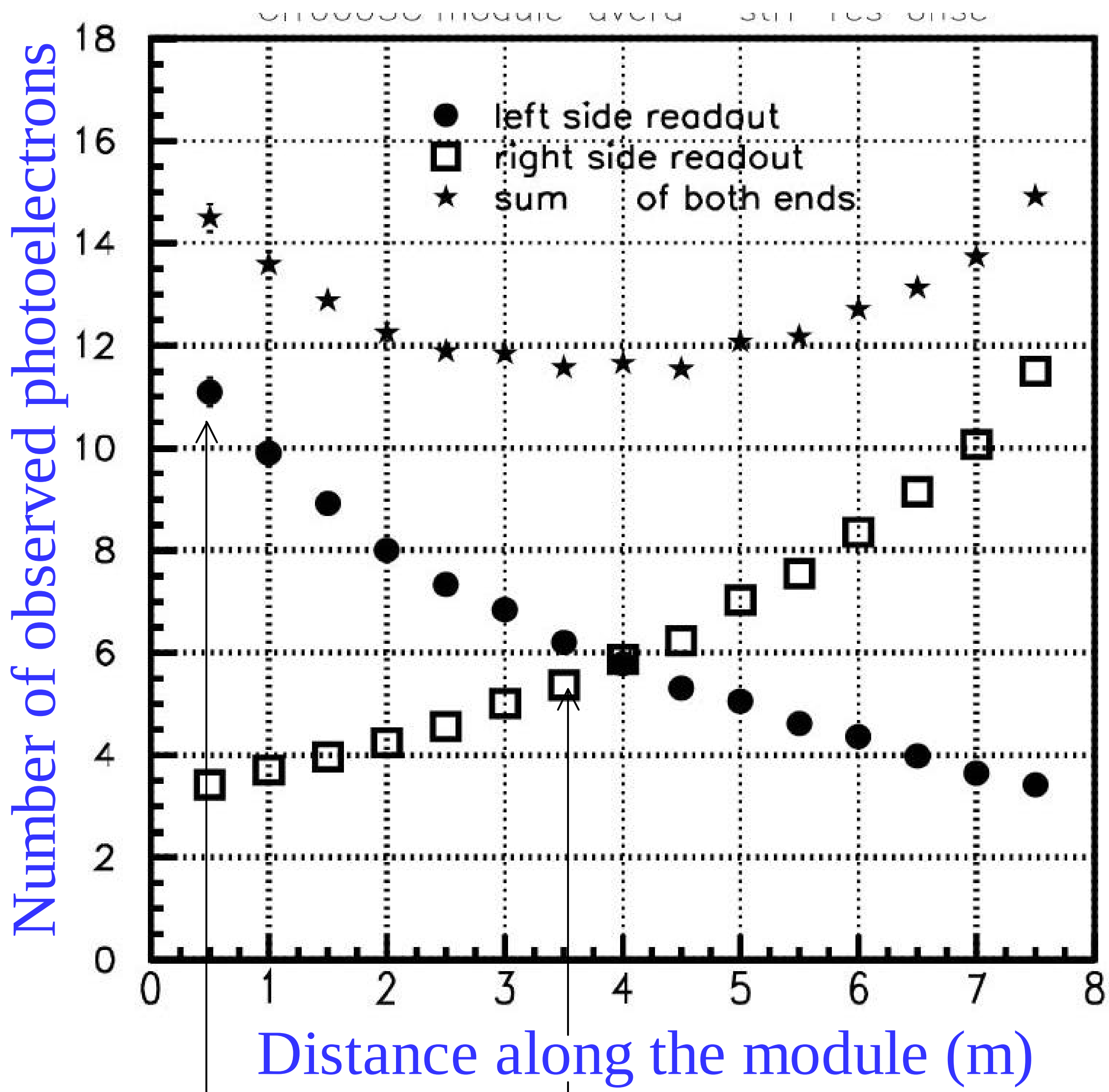




U/V strips with wls shifted light exiting both ends. Add left/right signals from clear fibers to provide the pulse height sum.

Scintillator: 4.1 X 1 cm^2 co-extruded strips with 1 mm dia. WLS fiber and outer reflector of TiO_2.

MINOS Scintillator



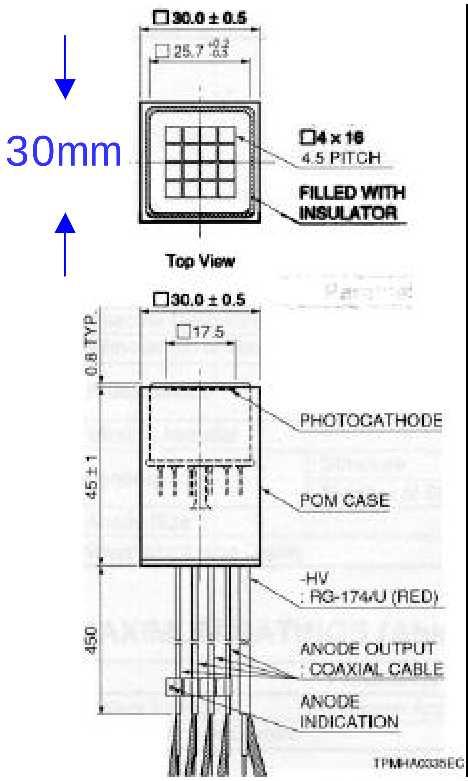
Measured light output using the complete MINOS optical system: Connectors, clear fibers, multi-anode PMT's

Near
11±3 p.e.

Far (3.6 m for the proposed layout)
6±2 p.e.

PM, Channel Count

16 channel
multi-anode PM



Hamamatsu H6568

	Barrel	Ends	Total
WLS Fibers	51,200	42,766	93,966
Clear Fibers			187,932
Scintillator			
Area (m^2)	7,174	4,353	9,527
Vol. (m^3)			95.3
M (ρ=1.2g/cm^3)			114.3T

Some Selected Costs

Extruded scintillator: ~ $13/kg => $1.5M

WLS fiber: $1 - $3/m => $2.5M

Clear fibers: $1 - $3/m => ?

Multi-anode PM $600 ea. (16 anodes)

1600 PM's * $600/PM => $1.0M

1500 channels of signal processing …

Calibration system … … …

Looks possible, but too early to quote real costs!

Further Muon/Special Detector Studies/R&D

1. Hadron ID – Cerenkov detector: Is it needed? Very important in BaBar, but the physics case has not been made for the LC. It could be important for flavor dependent physics – low energy. Physics groups need to study/comment. Other omissions?
2. Essentially no work has been done for a Z-pole muon detector. Are there unique features for a Giga-Z muon detector? e.g. Hadron identification?
3. Integration of the muon detector design and analysis with the calorimeters: punch-through, energy flow, tracking, etc.

Thanks to our European colleagues and French hosts!

The previous slide was the last

- Backup transparencies follow

So, performances could be improved

- Fake association do account for a sizeable part of fake muons… .
  – Better software might get rid of a good part of them .
- Better extrapolation of charged tracks should be used : a first step can be the GEANE package.
- As of now the matching is pretty crude: an angle cut both in polar and azimuthal view.

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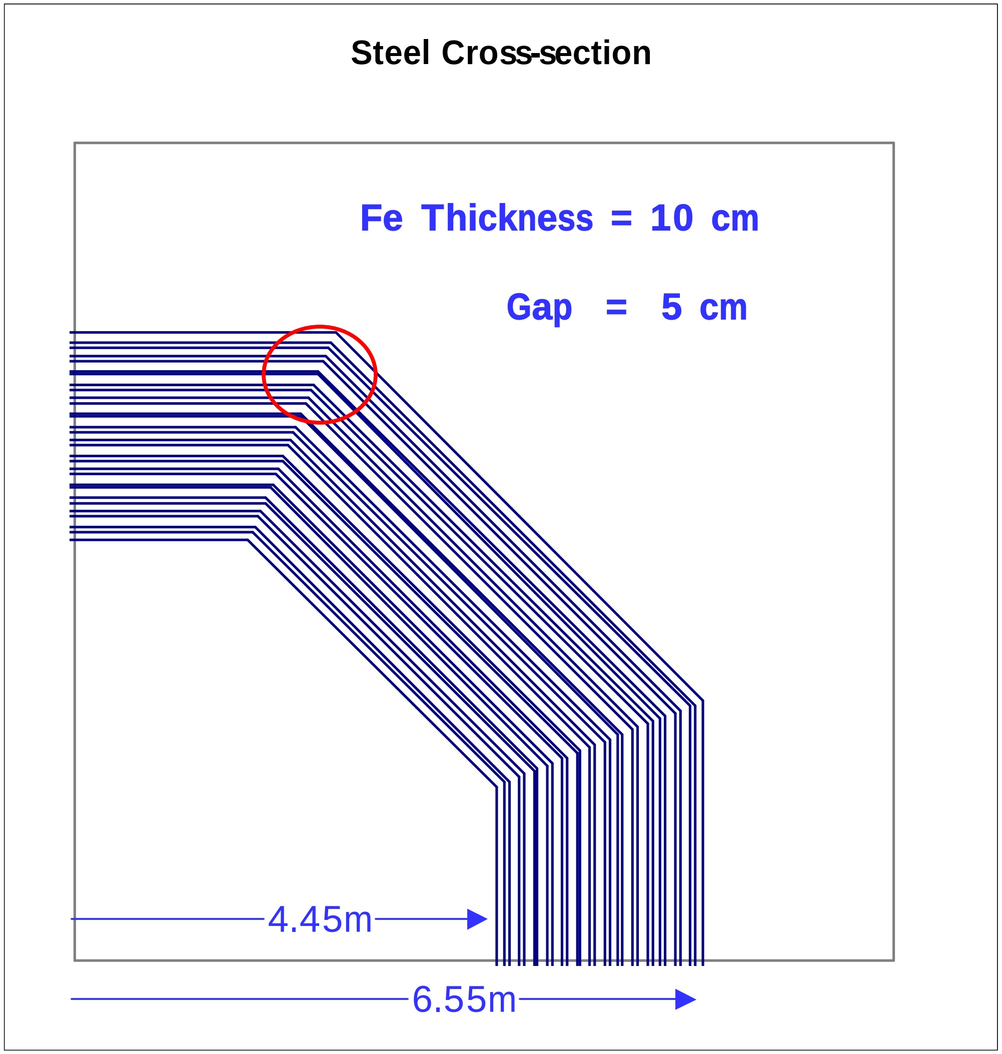
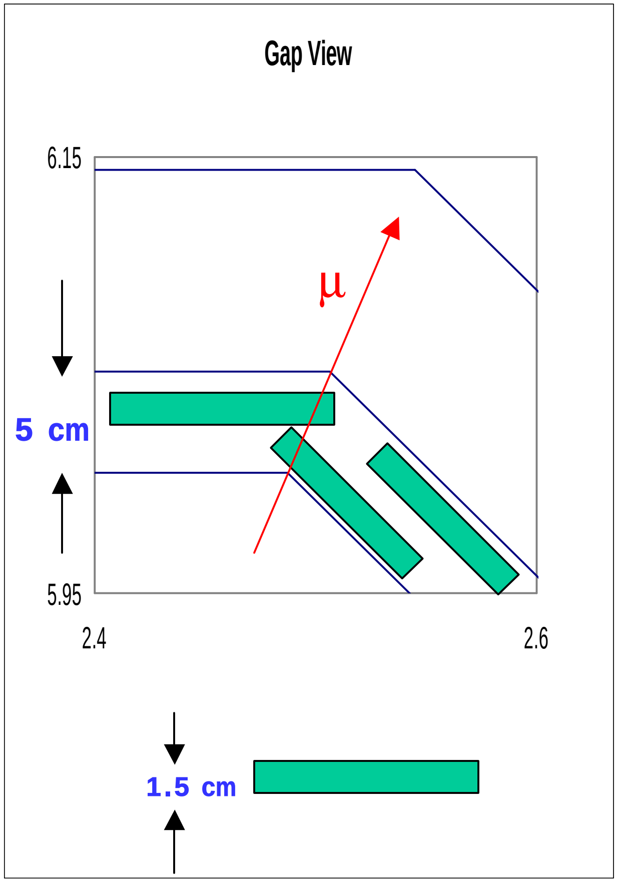
Fe Cross Section





Left/Right Summed Output