Intercalibration of Supermodules with cosmic rays??

Q Ingram, ECAL Week, April 2004

- Obviously not of Test beam reliability, but a 200 MeV signal maybe better than a source.
- Open question whether really worth it if D Futyan's scheme with jet data works
- Tests every channel individually before installation in CMS in a way firing the laser into all channels simultaneously doesn't

Set-up

SM lying horizontally (*) with trigger scintillators and wire chambers above and below.

5-10 cm absorber above lower scintillator to suppress high de/dx tail(?).

Trigger scintillators divided into broad hodoscopes to limit angular divergence of trigger particles.

Wire chambers used to require tracks to pass through crystal end faces.

(*) tilting in eta (even 10 deg) would help the rate at large eta, but is mechanically risky

Rate, signal

Rate: Vertical (0 degrees), hard component:

80 per (m^2 sec sr)

==> 300/week through a crystal

Trigger rate: Raw rate through SM without geometrical constraint ca 300/sec - I.e. this is upper limit

Signal: 210 Mev for minimum ionising muon

Noise: 50 MeV rms.

APD Gain: Set to ca 250 (then noise negligible) -> 1 GeV signal

Track gain of each APD with monitoring system

Signal, accuracy

Accuracy: Precision is sigma(peak)/Sqrt(counts)

Width of peak:	From Landau broadening	10% (???)
	From variation of dE/dx	10% (???)
	From statistics	3.3 * Sqrt (F) %
	F (Excess Noise factor)	*= 3.5 at M=250*
	Noise	5%
	Total	**15% rms**

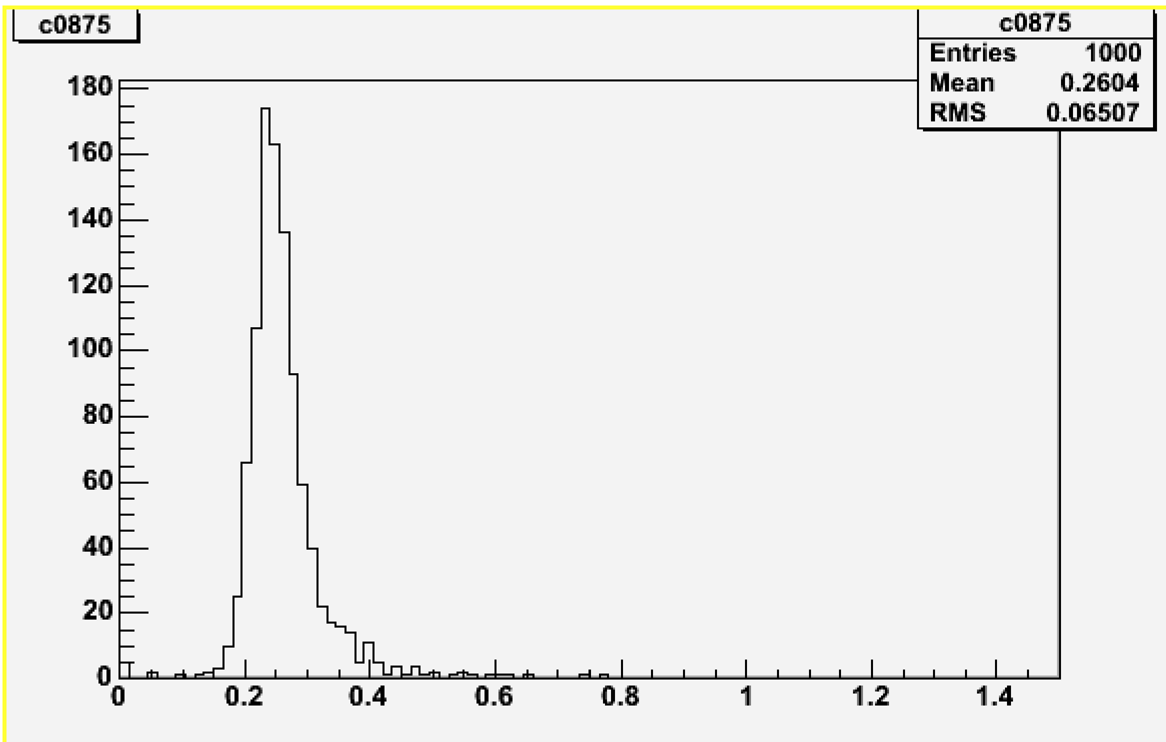
but biggest uncertainties are main components

15%/Sqrt(300) = 0.9% accuracy in 1 week for intercalibration, at 100% efficeincy

Nuclear Counter effect: doubles pulse height => 10% loss in rate

GEANT simulation with 4 GeV Muons

(Alain Givernaud)



Peak 230 MeV

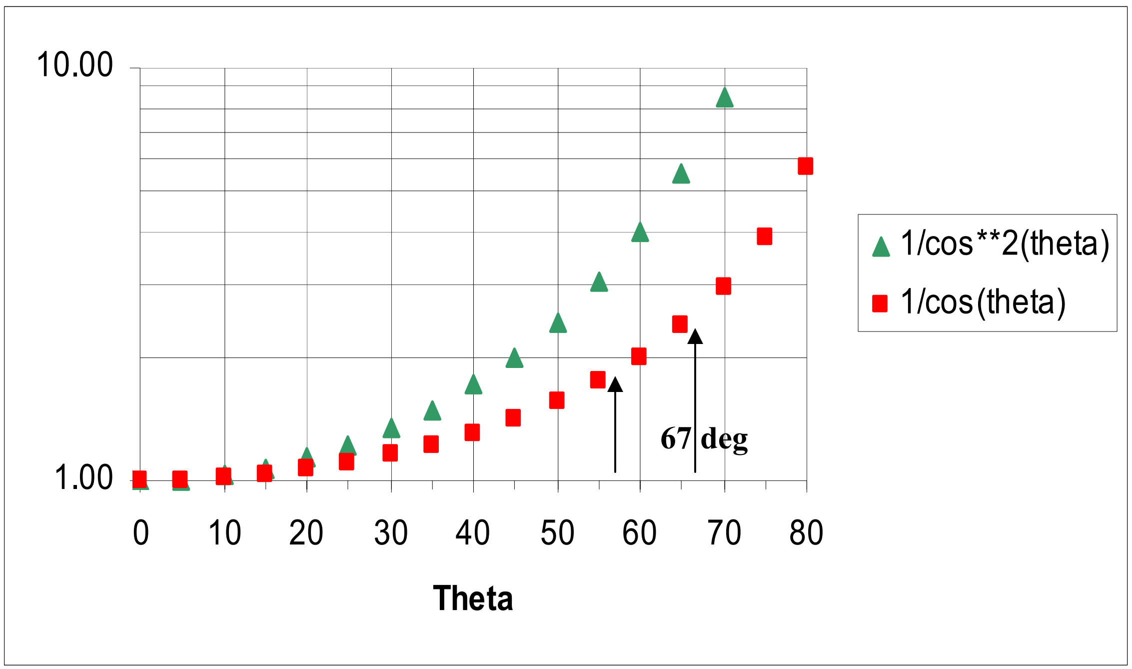
Width 67 MeV FWHM

ca 12.5 % rms

Angular dependence (1)

Range: With SM horizontal, the 4 modules have crystals at 0 - 28 deg; 28 - 40 deg; 40 - 57 deg; 57 - 67 deg

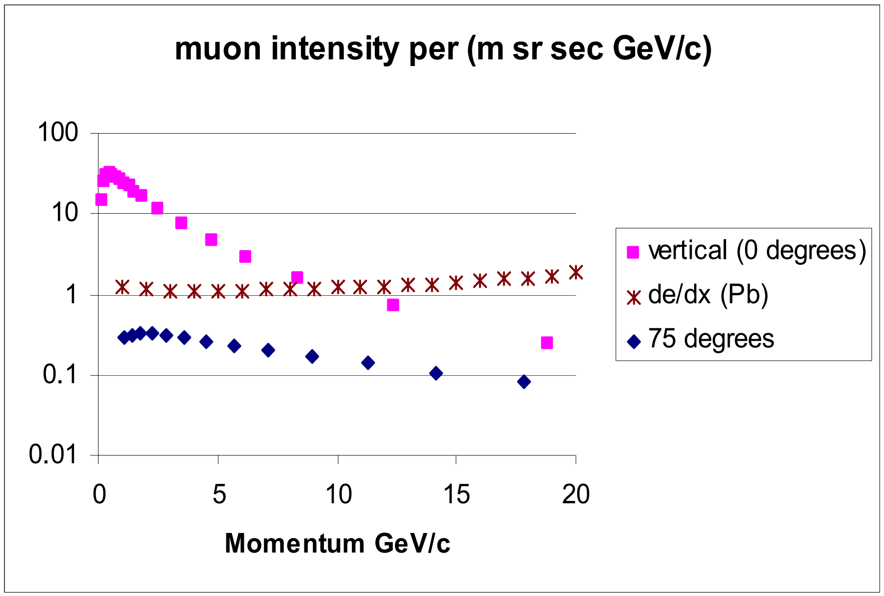
Cosmic flux: Overall rate ~ $\cos^2$ ==> accuracy ~ cos



Angle	1/cos2	1/cos
67	6.6	2.6
57	3.4	1.8

Angular dependence (2)

But the overall rate is not all: the spectrum changes too:



spectrum at 0 deg, 75 deg

and de/dx vs momentum

==> the signal size will increase with eta, by of order 20%, due to increased de/dx, *Calibrate with rotated single crystal*

The spectrum here at 75 deg *looks* like half expected by $\cos^2$ rule
(but the paper gives the rate per cm not cm^2)

Angular dependence (3)

Depending on the detailed set-up, there may be an additional tail in the spectrum at higher de/dx due to low energy muons.

The absorber thickness will probably change with angle and so this tail would vary.

There may be some small contribution from hadrons, although I think these will be negligible: if significant this would also be angle dependent.

All these effects should be included in a calibration with a single crystal rotated through the 67 degrees.

Any residual eta dependence would be a smooth function

Conclusions

1. Looks plausible at ca 2% level from rate point of view

2. Line width estimate needs verification

3. Angular dependence of signal would need correcting for

4. APD gain must be tracked by monitoring system

5. Quite a lot of work to set-up and run

6. Final check of method by checking result with test beam calibration of that SM

7. Would ensure that every channel was tested individually for ca 1 week before final installation

Set-up

Original idea was to use all adjacent crystals as veto to ensure that track enters and exits through front and back faces – to make the set-up “simple”, not requiring wire chambers.

Noise seems to make it difficult to set a low enough veto threshold, so I have assumed there will be wire chambers.

However, this could possibly be reviewed if it is considered a big plus to see if it is feasible.