Update on Muons at CalDet

MINOS Collaboration Meeting

January 2002

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Introdction

- Objective is to produce a set of numbers corresponding to energy deposited by a muon for each strip (and each side) for detector calibration
- From test-beam runs, muons are selected and energy deposits are histogrammed for each channel
- Muon energy spectra are fitted to give a value corresponding to peak of Landau for each strip

Data Used

- Previously analysed 2 GeV runs from before HV change to obtain a set of MIP numbers for calibration
- Latest data: 2.5 GeV run from after HV change

Event Selection in Beam Data

Look at each event in turn and apply the following selection criteria:

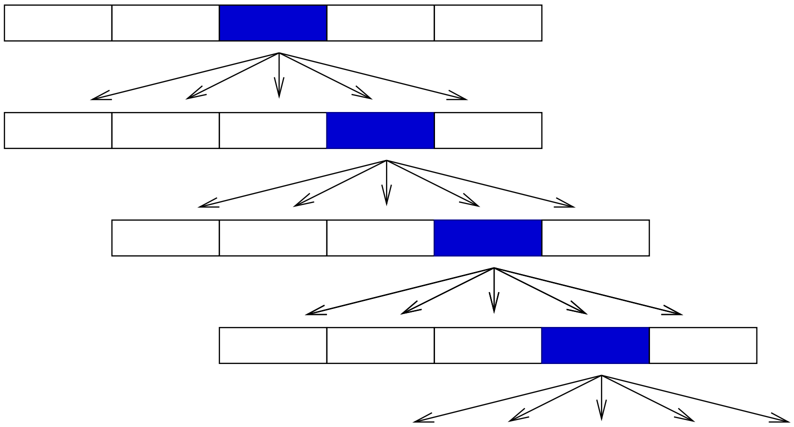
Cuts:

- Total number of hits in an event >= 16
- Number of hits in a “track” >= 4 (in both orientations => minimum track length = 8 planes)
- Along the path of a track, no more than 2 hit strips in 5, per plane
- Angle of track must be < 10 degrees in all 4 views wrt beamline
- Only hits in a track seen on both sides are accepted

To find a “track”:

Find a hit in strip n, look for another hit in the next plane (of same orientation) within n+/-m strips, etc...

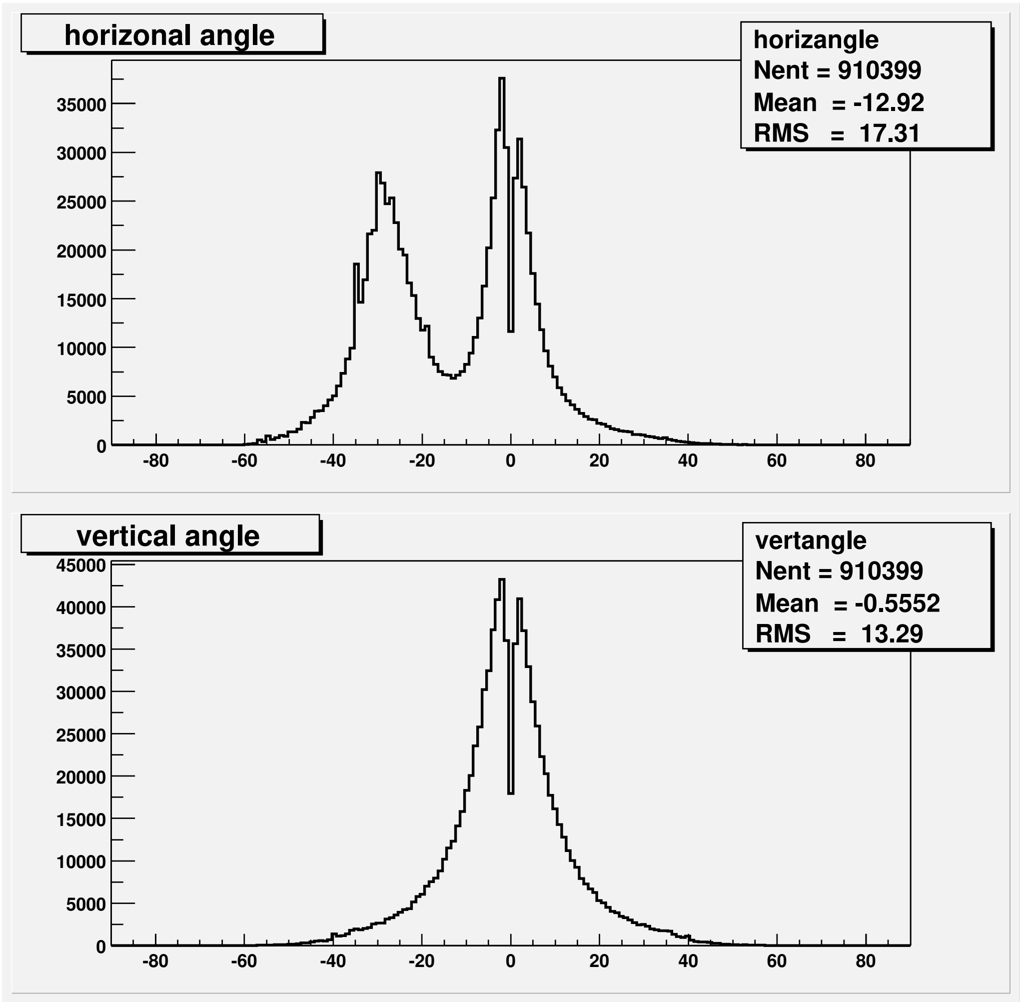
Stop tracking if more than 2 hits are seen in a block of n+/-m strips or if 2 hits within a block occur in 2 consecutive planes



Cut	Approx. No. of events	% of total	% of previous
None	3,700,000	100	100
>=16 hits	3,250,000	87.8	87.8
4 Hit Track (even planes)	1,114,000	30.1	34.3
4 Hit Track (odd planes)	1,215,000	32.8	37.4
Track in both even and odd	761,000	20.6	65.3
<10 degrees	350,000	9.5	46.0

Table 1: Selection Statistics from a 2 GByte Beam Run. Typically $\sim$ 9-10% of events pass all cuts.

Angles of Muon Events from Beam

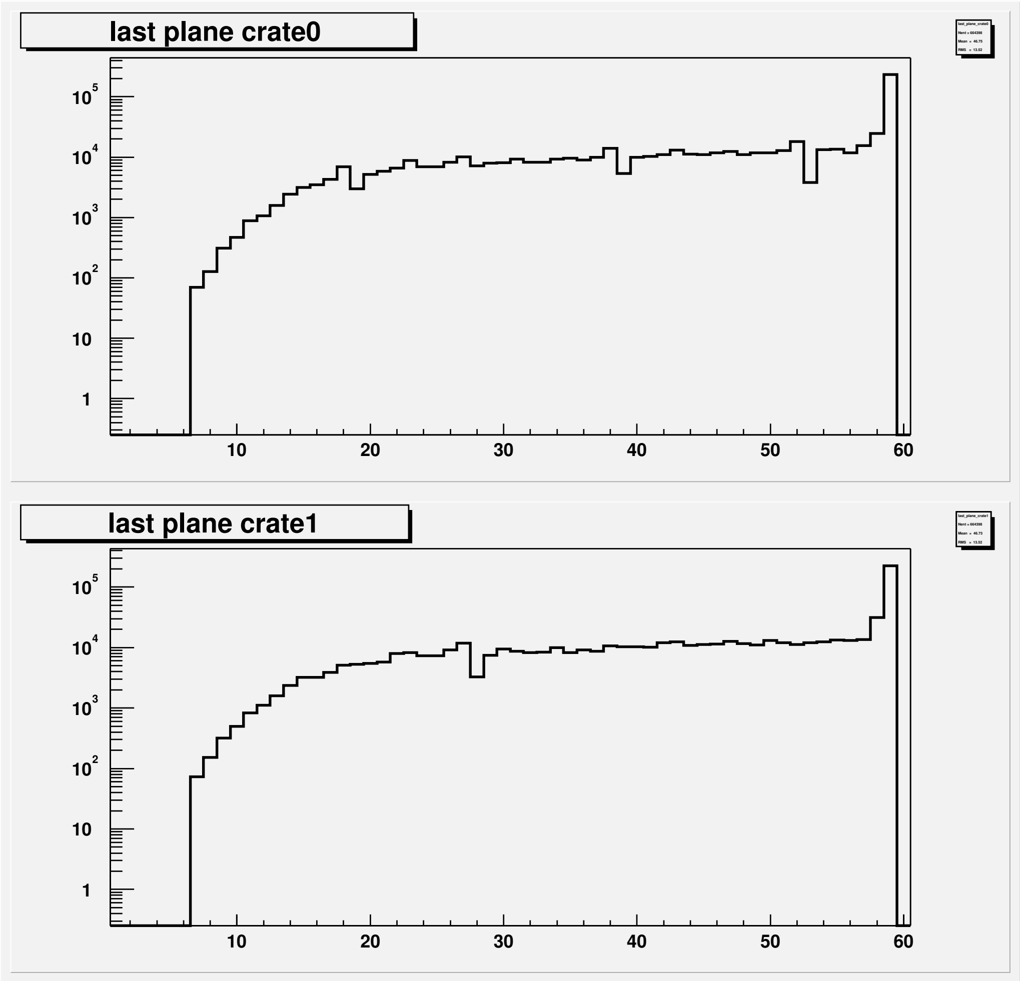


Peaks around 0 as expected in both horizontal and vertical angle.

Secondary peak in horizontal angle corresponding to muons from PS

Last Plane Hit/Track Length

Looking at the last plane hit in each selected event:



Stopping distance for 2.5 GeV muons peaks at > plane 60

(Compare with 2 GeV muons: last plane distribution peaks at plane 55)

Fitting Function

Want to Approximate:

$$L \otimes P = \int L(\lambda, \mu, \sigma).P(n, \lambda)d\lambda$$

- Use the ROOT adapted CERNLIB routine for Landau
- Simulate integral with summation:

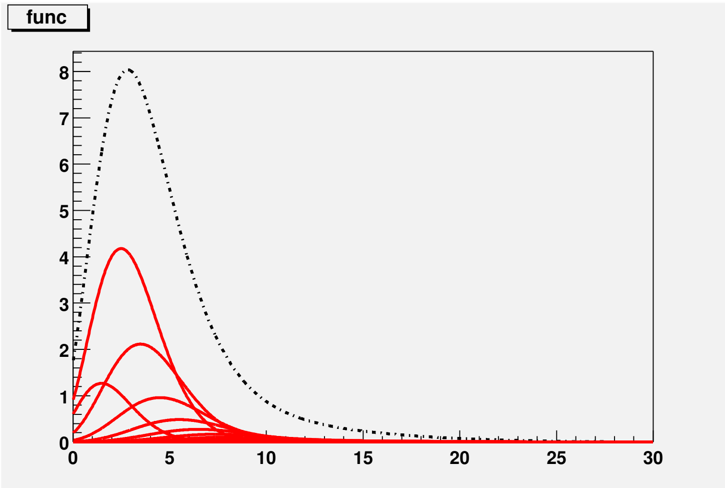
$$L \otimes P \approx N \sum_{\lambda=1}^{20} L(\lambda.s, \mu, \sigma).P(n, \lambda.s)$$

  Where the basic units used are NPEs and s is a scale factor which depends on the range of the histogram

- Therefore need 3 fit parameters: μ and σ in NPEs from Landau, and a normalisation constant, N

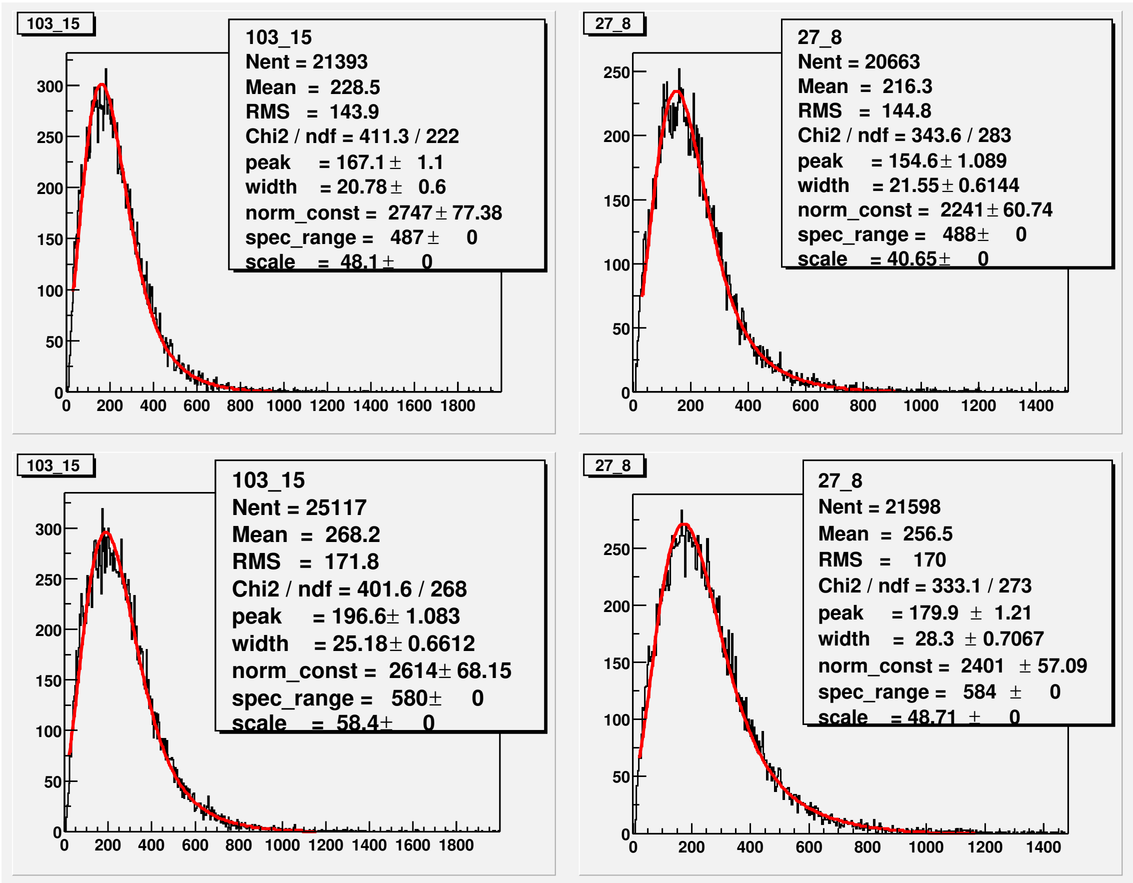
Example with:

$\mu = 3$
$\sigma = 0.5$
$N = 100$
$s = 20$



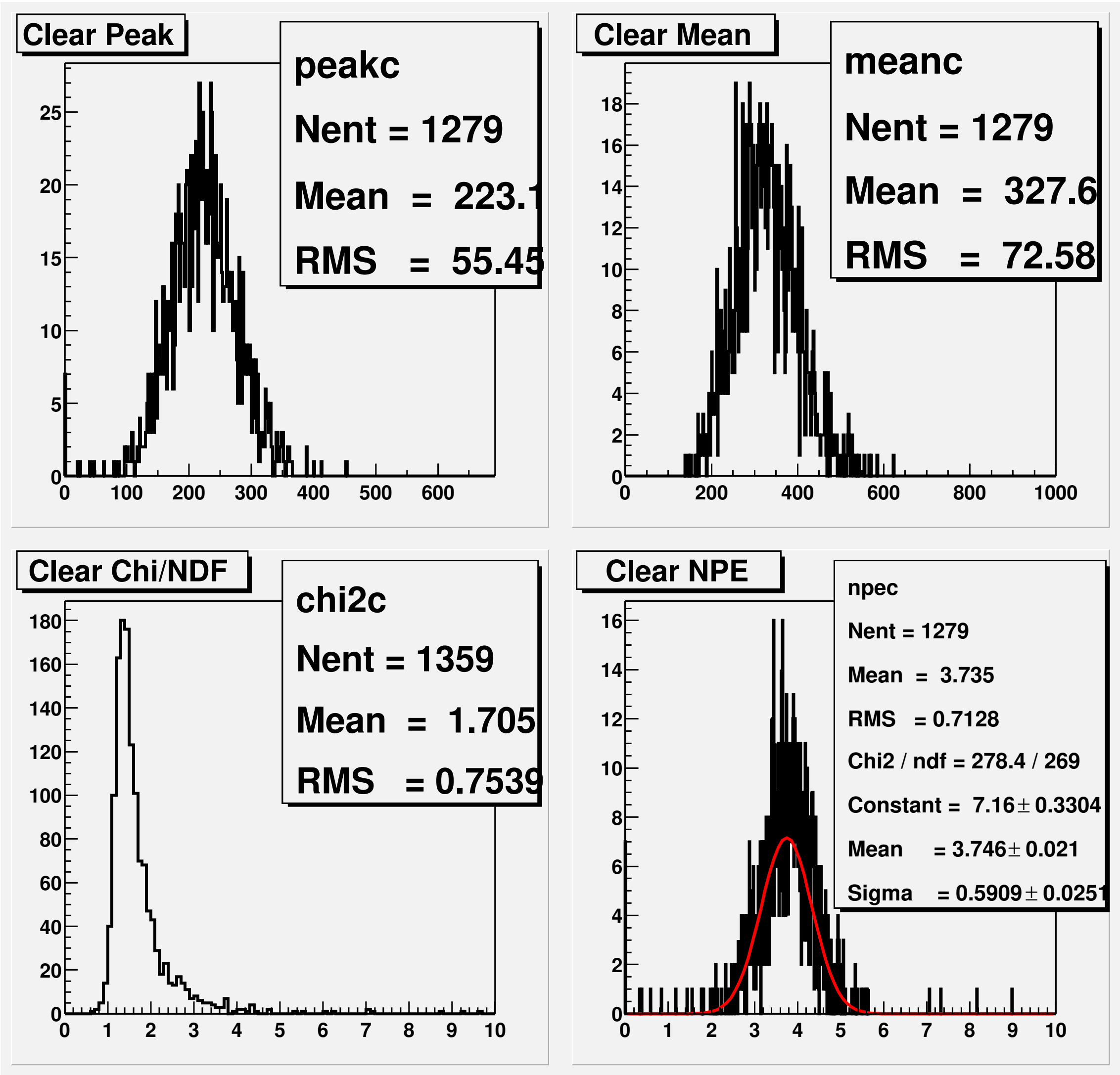
Examples of Fits

Histograms are rebinned and fit using the function above. Examples:



Fit Summaries

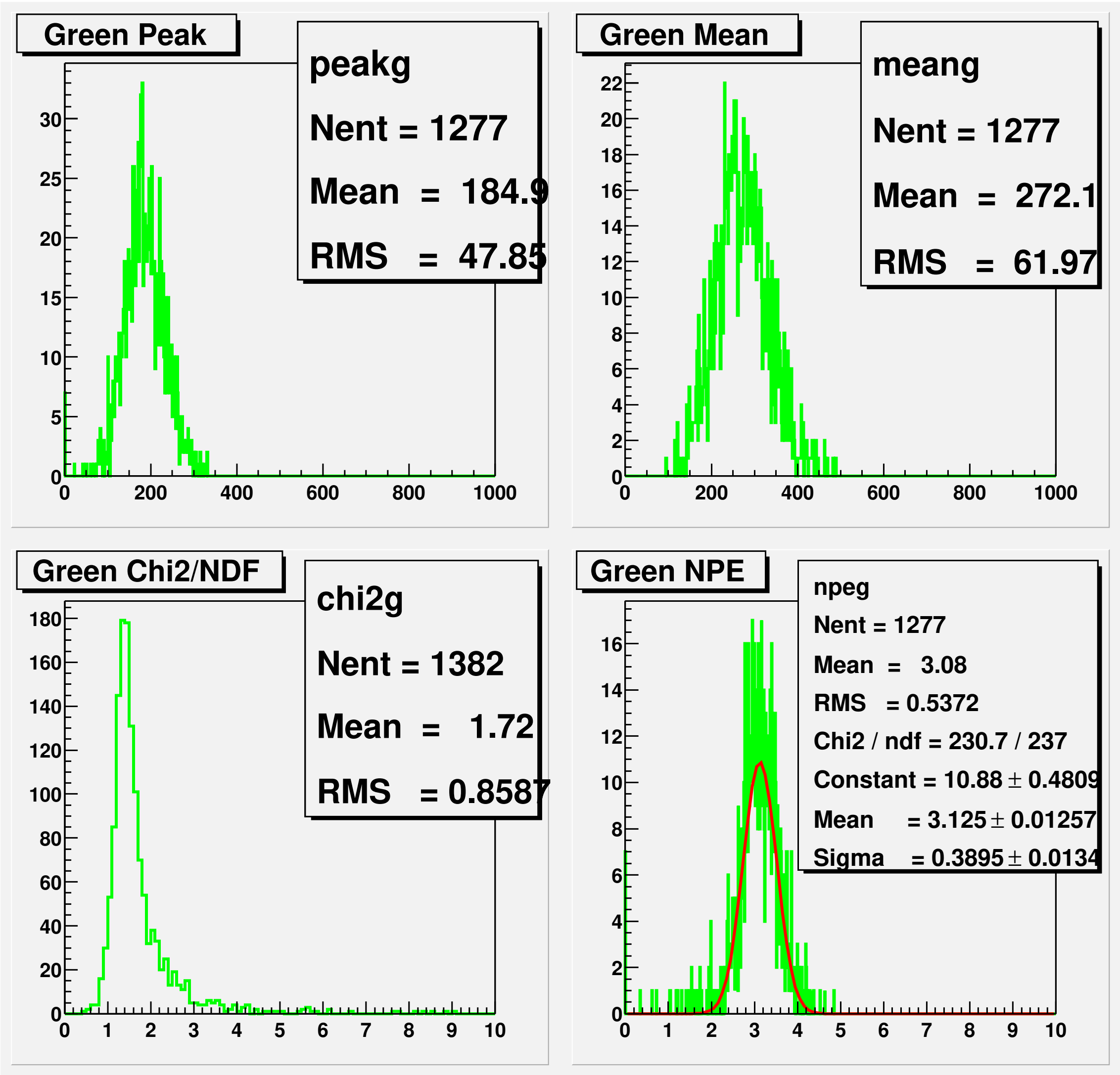
For Clear Fibre Readout:



Mean MIP value = 3.75 +/- 0.02

Fit Summaries

For Green Fibre Readout:



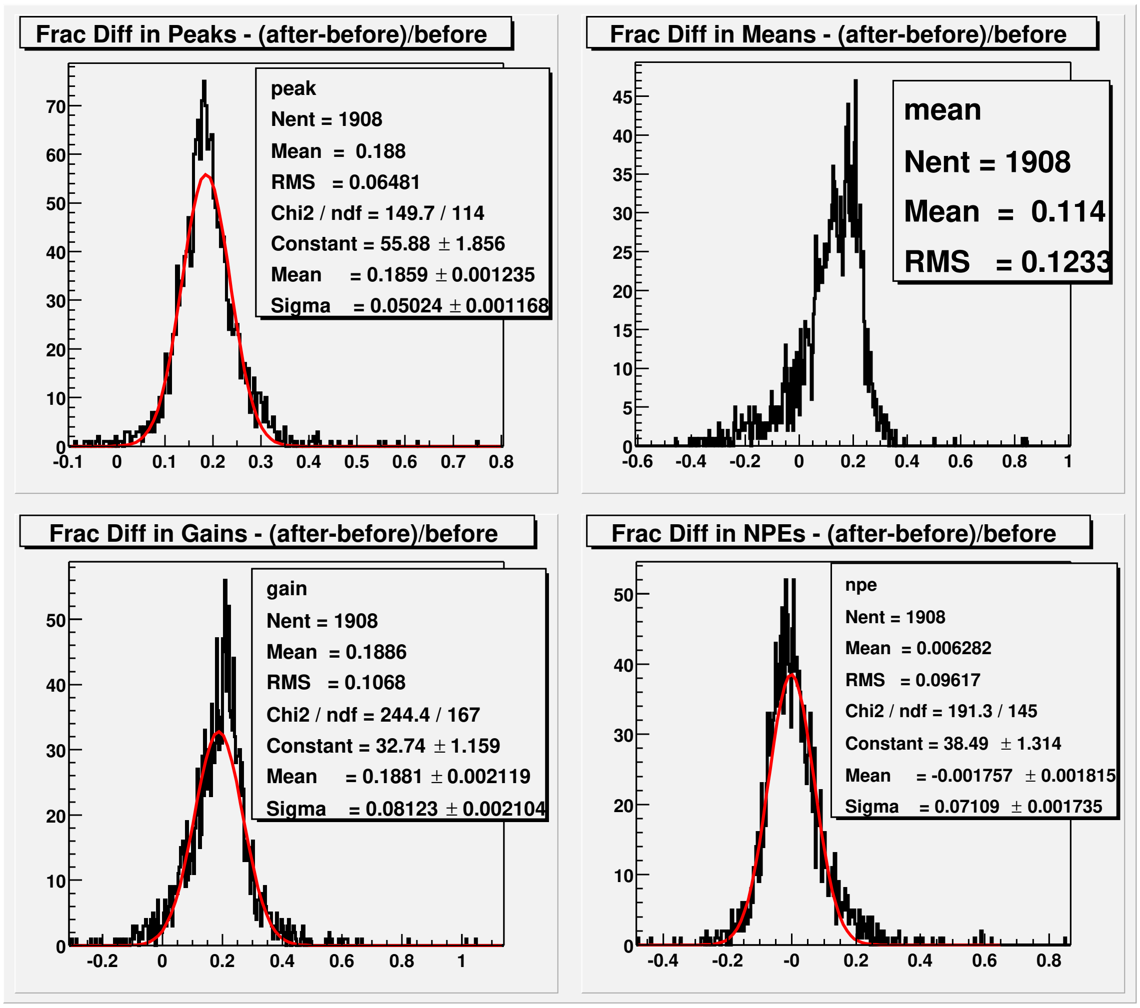
Mean MIP value = 3.13 +/- 0.01

Stability of MIPs with HV Change

Compare MIP values from before and after HV change

Only compare values for plane<50 (for 2 GeV muons, stopping plane = 55)

Expect the MIP values, in terms of NPEs, to be independent of HV



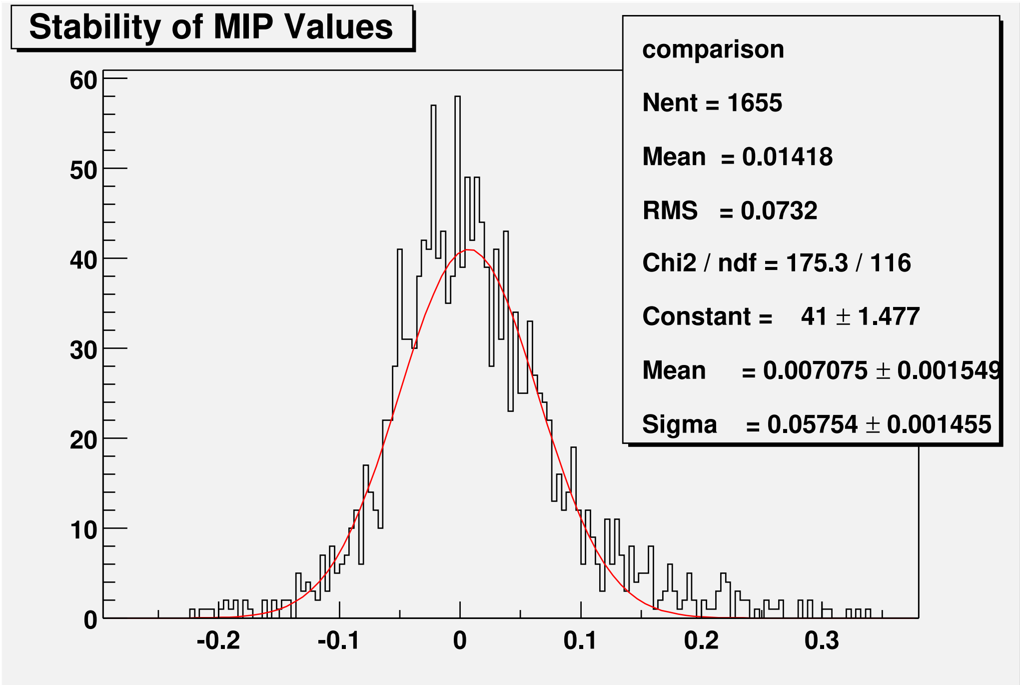
Looking at peaks and gains: ∼19% increase after HV change

Looking at MIP values: mean is at zero, width ∼7%

Stability of MIP Values Over Time

Comparing two runs collected a month apart

Look at fractional difference in peak positions for all (possible) channels:



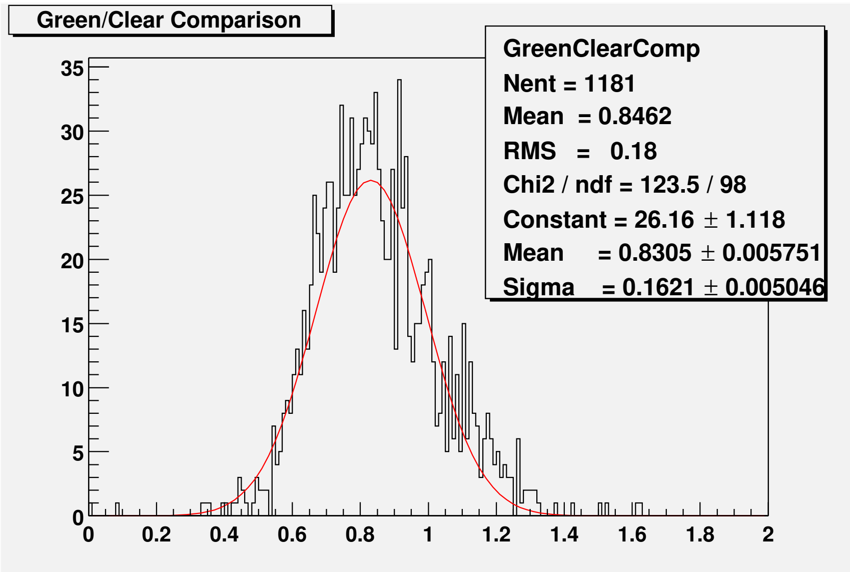
Peak is at zero, width ∼6%

Green/Clear Comparison

Green Fibre: Mean MIP value = 3.13 +/- 0.01

Clear Fibre: Mean MIP value = 3.75 +/- 0.02

From means: 3.13/3.75 = 0.83 +/- 0.01



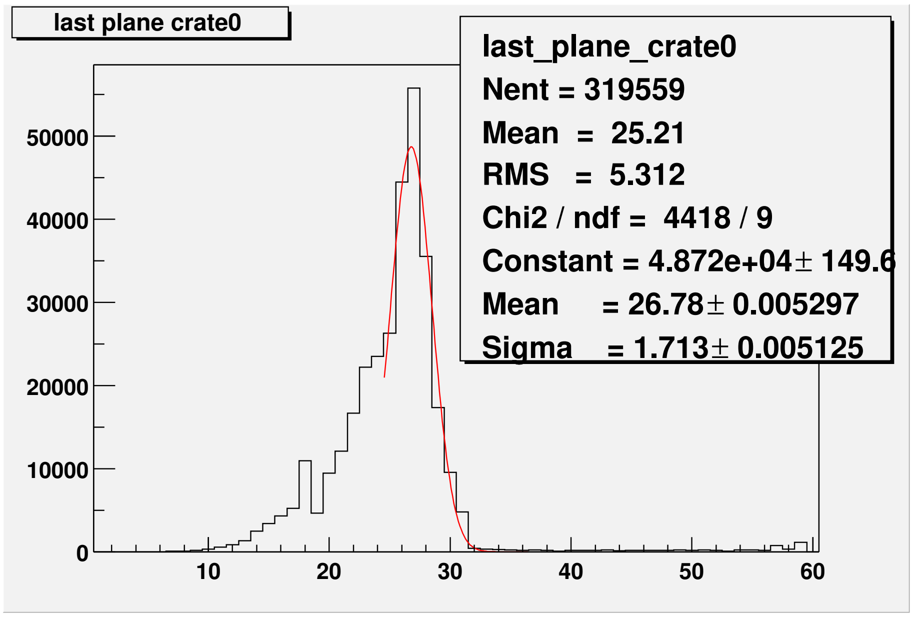
From histogram of ratios by strip: 0.83 +/- 0.01

Given a clear attenuation length of 10m, this value predicts 5.1m for green fibre

Stopping Muons

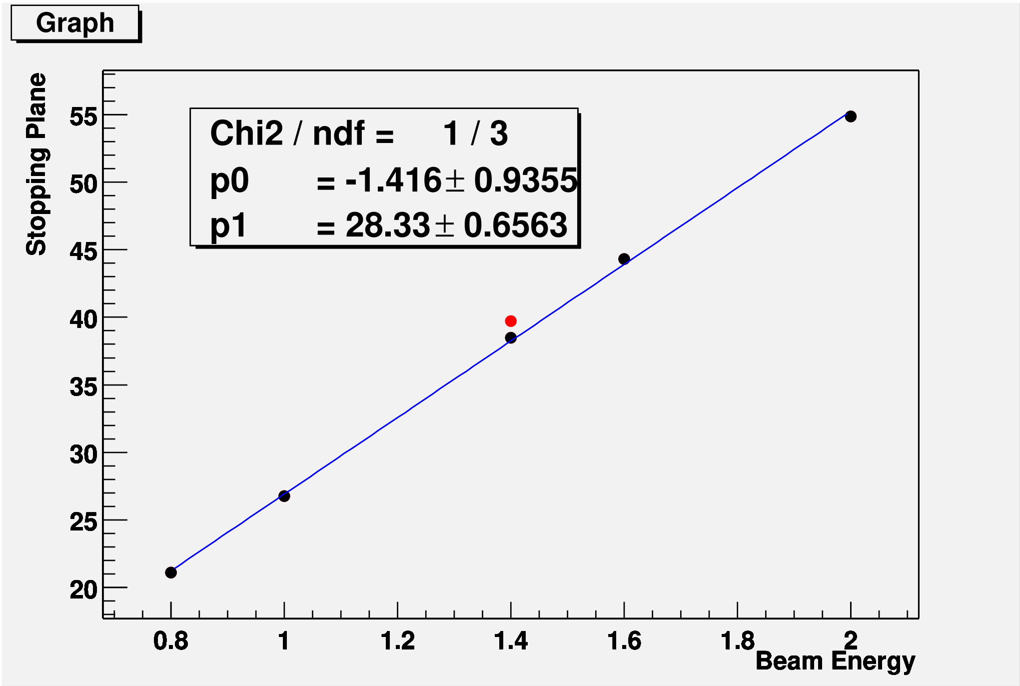
- To understand energy loss as a function of muon energy, look at 5 runs with beam energies 0.8, 1, 1.4, 1.6 and 2 GeV
- Know that the most energetic muons in a run have the beam energy. Need to select these muons for this measurement
- Look at stopping muons: histogram last plane hit in all muon events for each run

For 1 Gev Run:



Stopping Muons

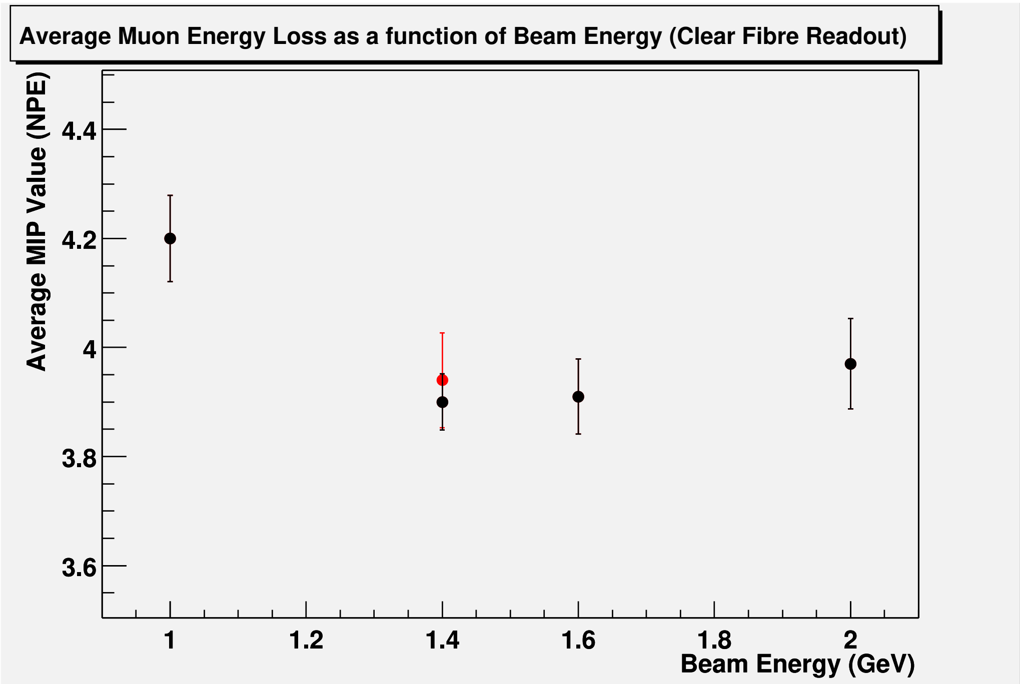
Fit the peaks with Gaussian for each of the 5 beam energies and plot:



Stopping Muons

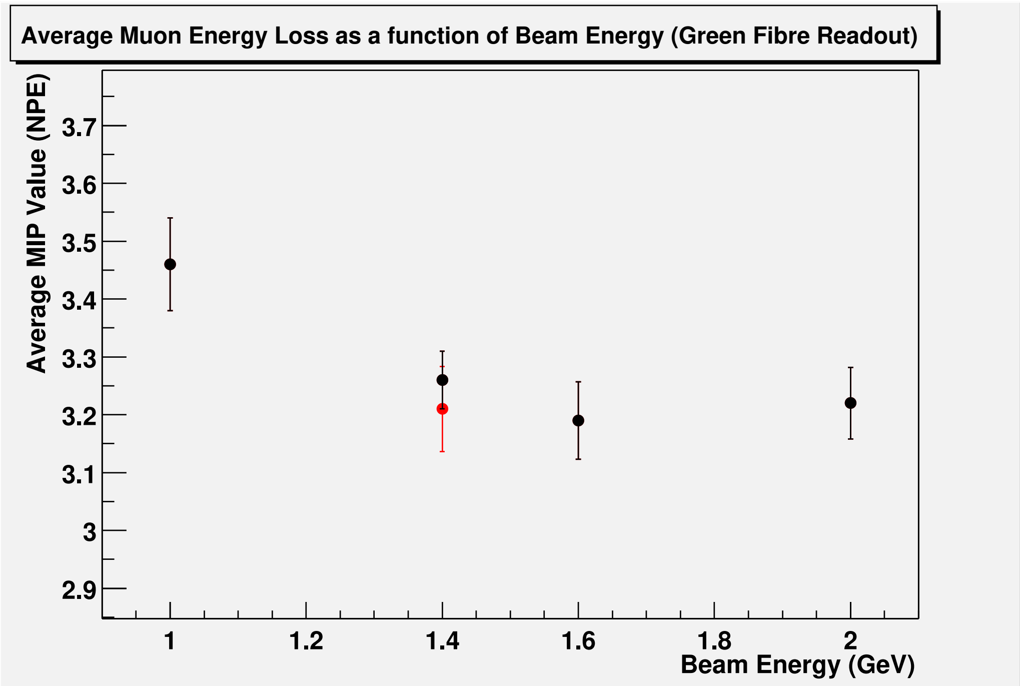
- Muons with maximum beam energy correspond to those in the peak
- Select only muons stopping in peak plane (+/- 1 plane) then fill and fit energy spectra as before
- Look at a strip in front 10 planes of the detector to find energy loss as a function of muon energy

Clear Fibre Readout:



Stopping Muons

Green Fibre Readout:



Summary

- At 2.5 GeV, after HV change, mean MIP values are

  for clear: 3.75 pes

  for green: 3.13 pes

- MIP values are stable to $\sim$7% after HV Change (observed stability of MIP values over period of a month $\sim$6%)
- Possible to distinguish differences in muon energy loss at different beam energies