Calorimeter calibration update

calibration based on equation: $E_b = C_e$*EMCAL + C_h*HCAL

where EMCAL and HCAL are raw ADC sum from both calorimeters, C_e and C_h are energy coefficients.

Question: Are C_e and C_h coefficients energy dependent?

initial requirements

beam momentums: 20, 35, 58, 84 and 120 GeV/c

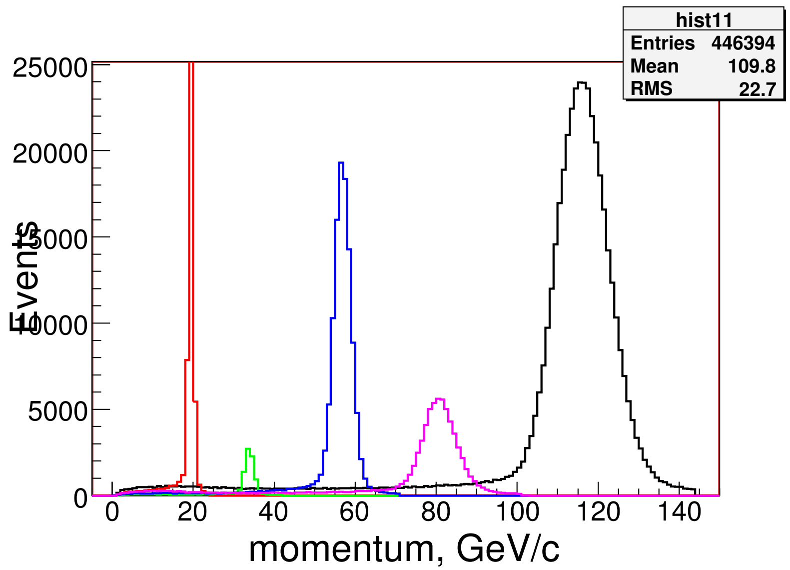
targets: LH2 and thin

trigger: proton beam and proton interactions

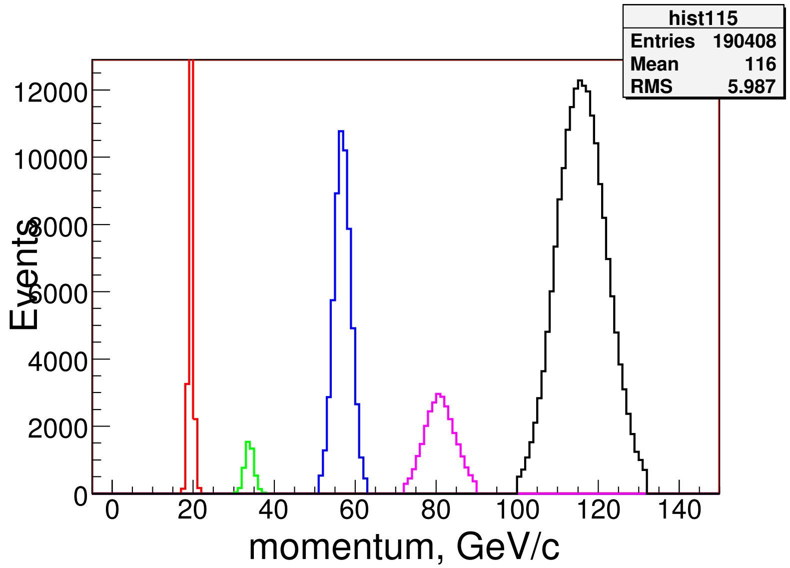
cuts:

- single track events
- tracks within RICH windows
- protons at 20 and 35 GeV: RICH is failed to identify $e^{\pm}$ or $\pi^{\pm}$ or $K^{\pm}$
- protons above 35 GeV: identified by RICH
- track has 2/3 hits in downstream chambers
- track spot size in HCAL $r < 6$ cm
- less than 2 showers in EMCAL
- track - EMCAL match

track momentum

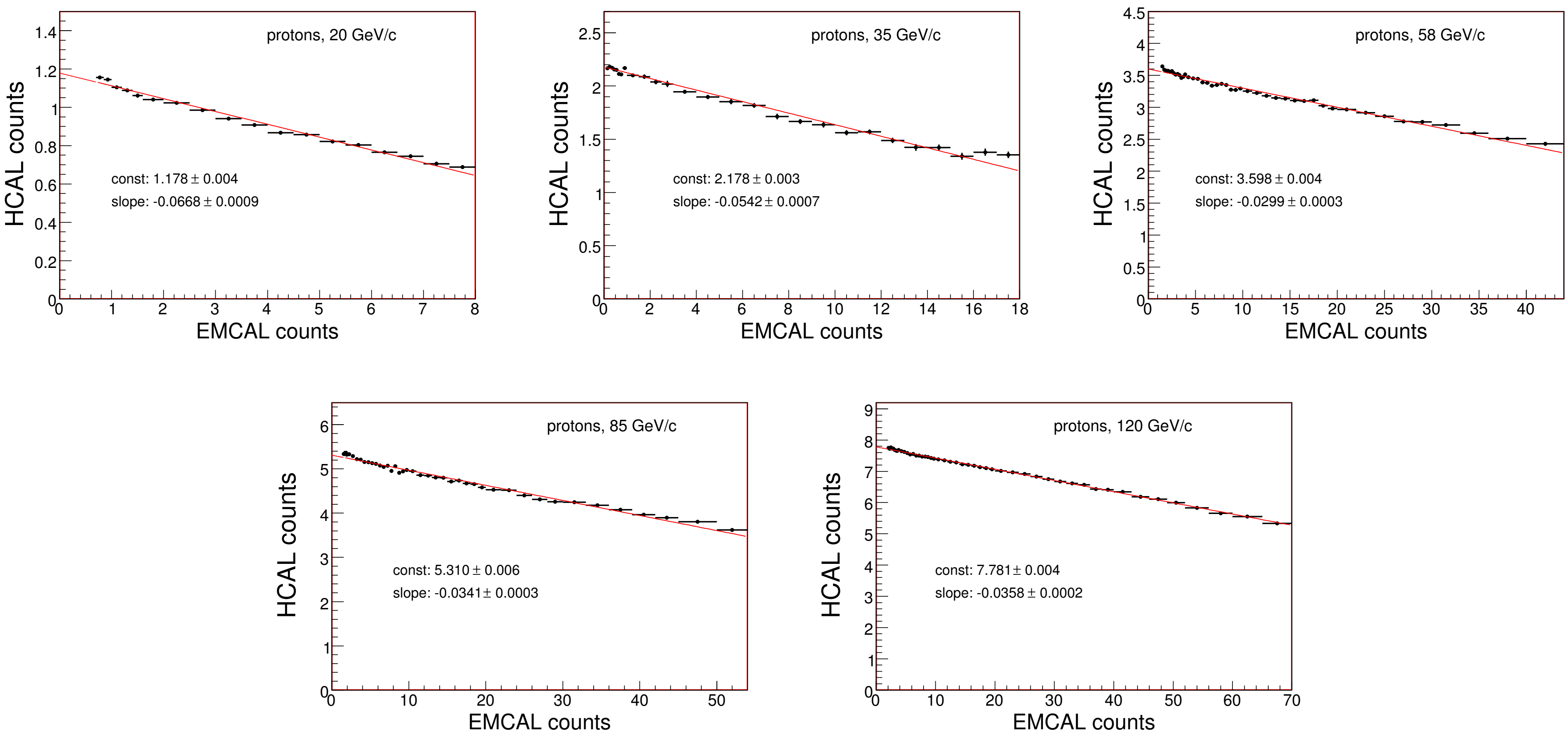


Top plot illustrates the momentum distributions of selected tracks. One can see that they have the long tails.



Bottom plot illustrates what happens after cut-out the tails and proton identification and EMCAL requirements. These tracks used for the calorimeter calibration purpose.

HCAL vs EMCAL profiles



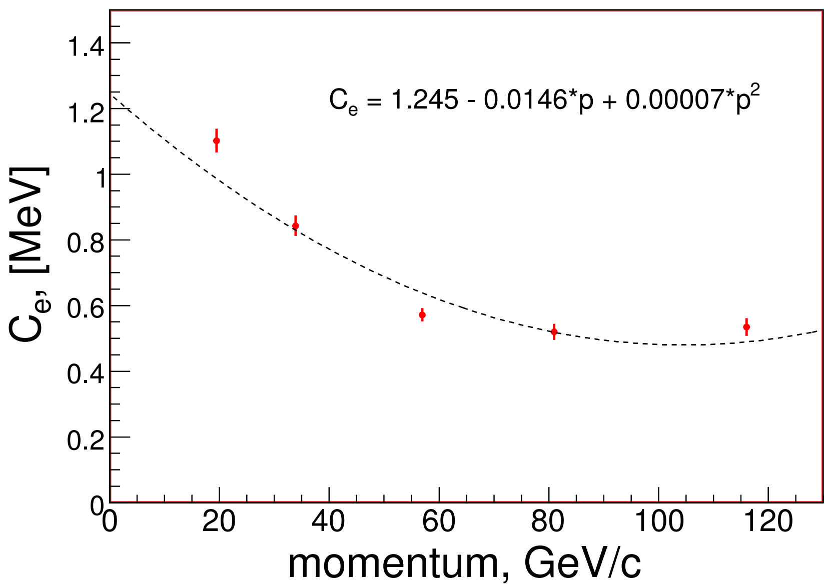
HCAL vs EMCAL profiles for 20, 35, 58, 85 and 120 GeV/c protons. The fitted straight line parameters allows to extract the C_e and C_h coefficients.

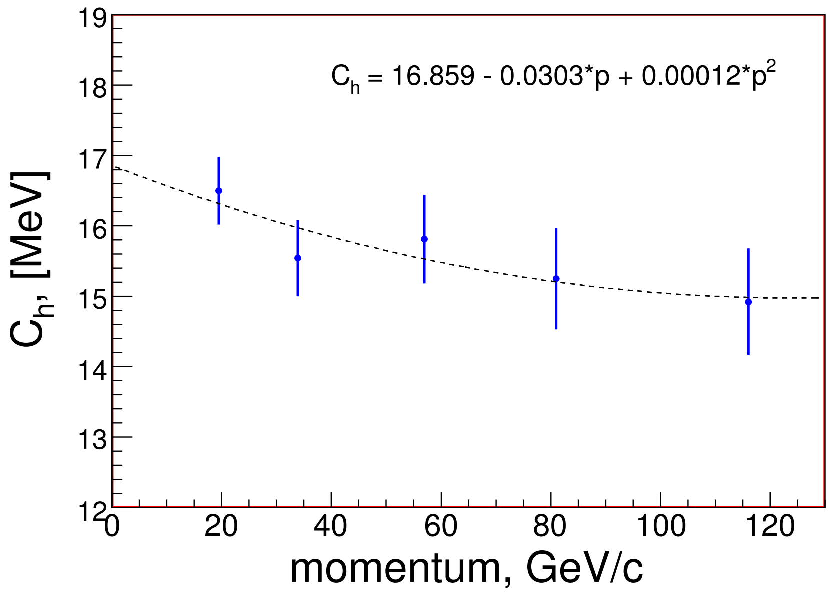
C_e and C_h coefficients

	C_e (MeV)	C_h (MeV)
20 GeV	1.102±0.036	16.50±0.48
35 GeV	0.843±0.031	15.54±0.54
58 GeV	0.472±0.020	15.81±0.63
85 GeV	0.520±0.025	15.25±0.72
120 GeV	0.534±0.027	14.92±0.76

Table 1: The resulting C_e and C_h coefficients for 20, 35, 58, 85 and 120 GeV/c proton momentums. From now we need to implement the variable coefficients into analysis. I will start to use it for neutrons.

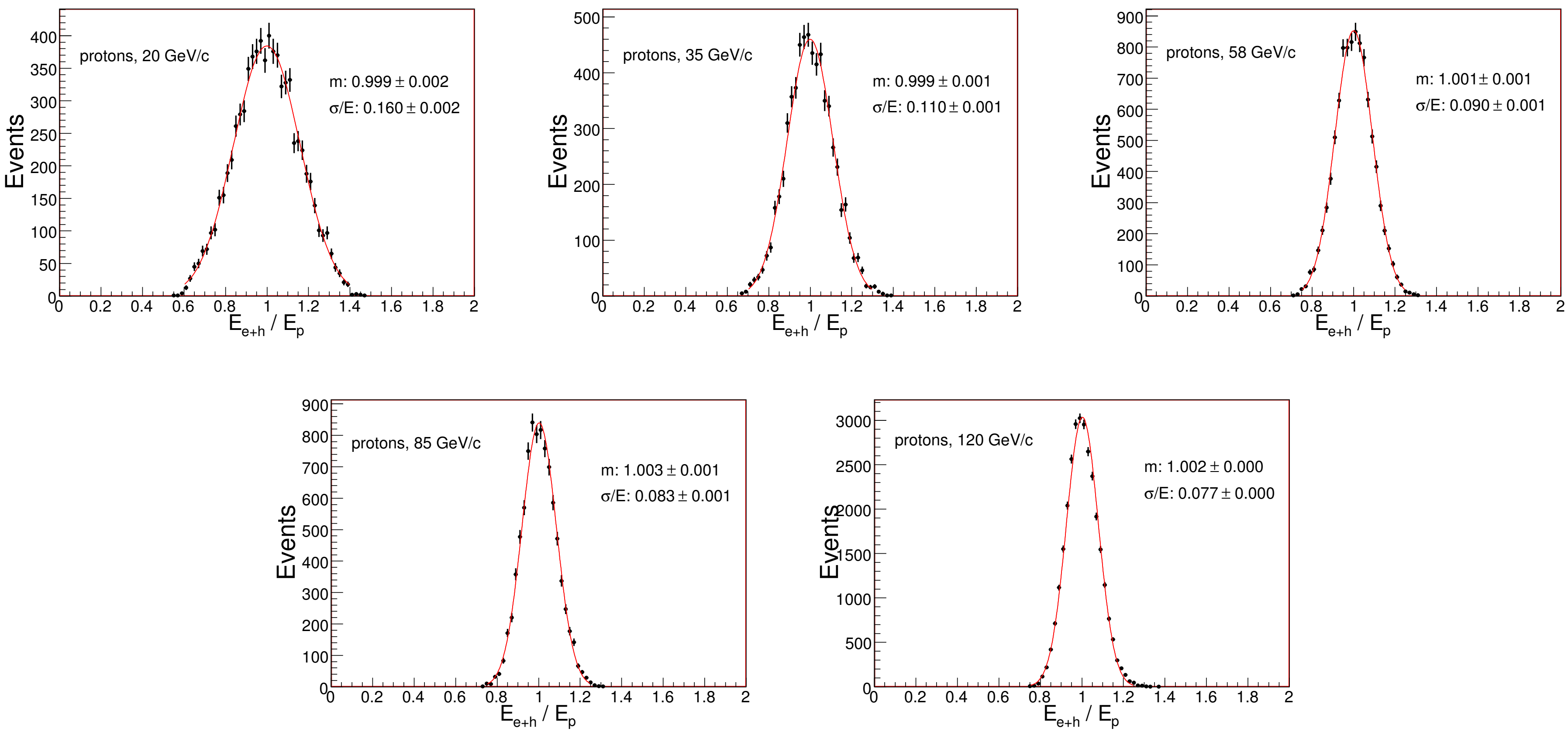
C_e and C_h, cont





An analytical formula is more correct way to use the energy coefficients.

$\mathbf{E}_{e+h}$ / $\mathbf{E}_p$



The calorimeter to proton energy ratio distributions for 20, 35, 58, 85 and 120 GeV/c track momentums. These plots allow us to extract the $\sigma_{(e+h)}$/E values. As next step I need to subtract the tracking Δp/p contribution.

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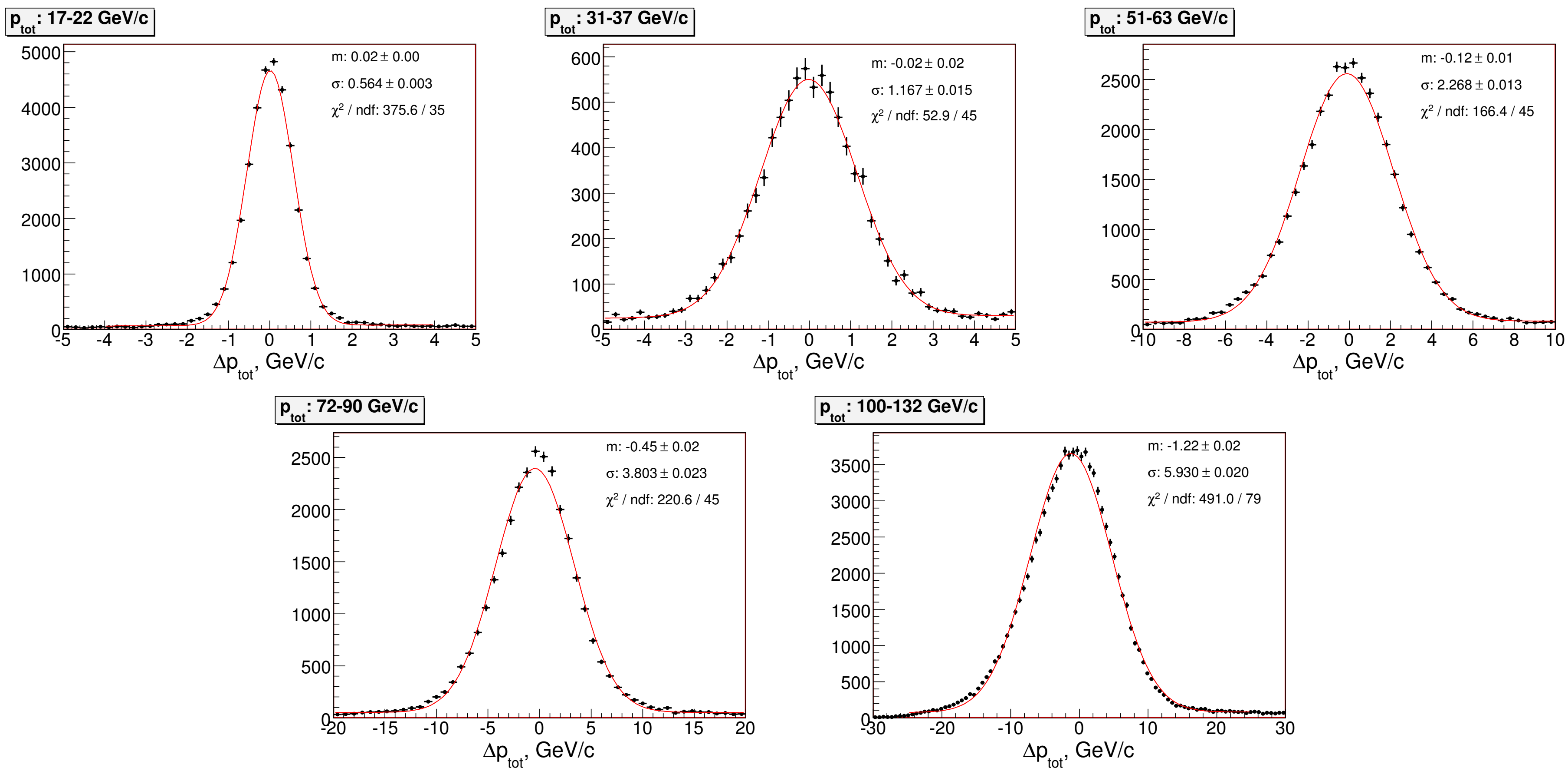
Δp = p$_{mc}$ - p$_{reco}$

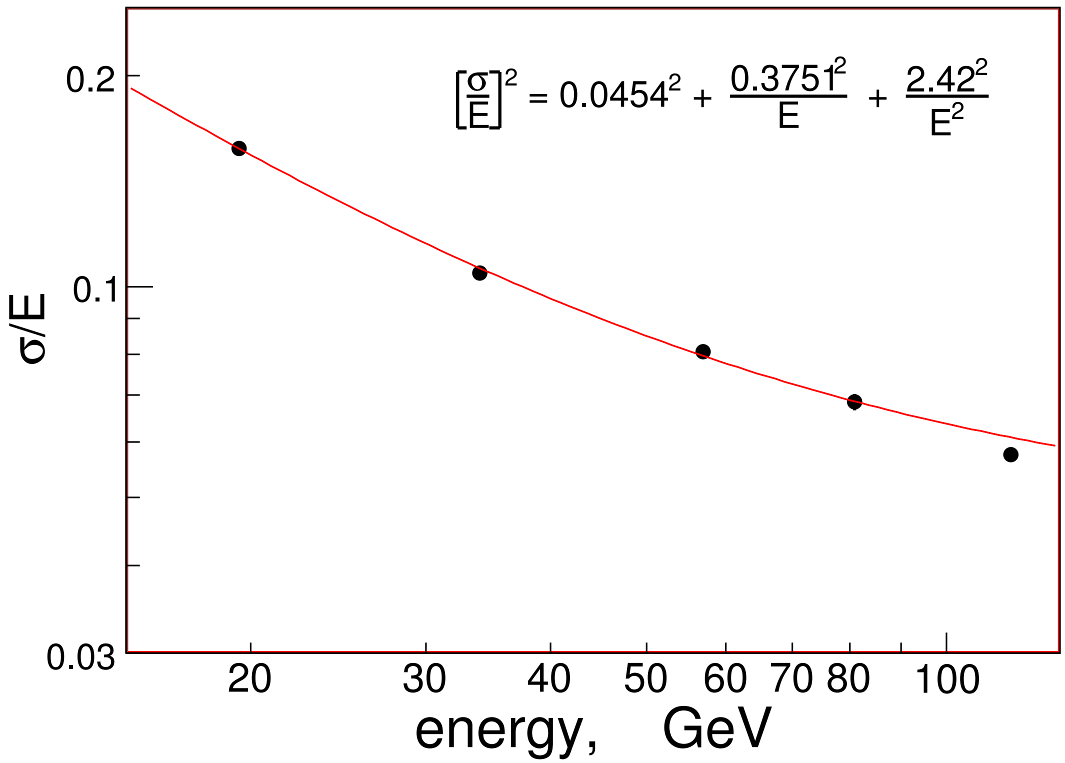


The Δp distributions for 20, 35, 58, 85 and 120 GeV/c track momentums from Monte Carlo pC interactions at 120 GeV. For 20 GeV data I used pions and protons, above 25 GeV - protons only. These plots allow us to extract the Δp/p values. Momentum ranges: same as for the calorimeter calibration.

error calculation for σ/E

	initial σ/E	Δp/p	final σ/E
20 GeV	0.160	0.029	0.157
35 GeV	0.110	0.034	0.105
58 GeV	0.090	0.040	0.081
85 GeV	0.083	0.047	0.068
120 GeV	0.077	0.051	0.058

σ/E vs E_p



The calorimeters resolution, σ/E, vs the proton energy. The red curve shows the fit result according to formula (suggested by Raja):

$$\left[\frac{\sigma}{E}\right]^2 = C^2 + \frac{S^2}{E} + \frac{N^2}{E^2}$$

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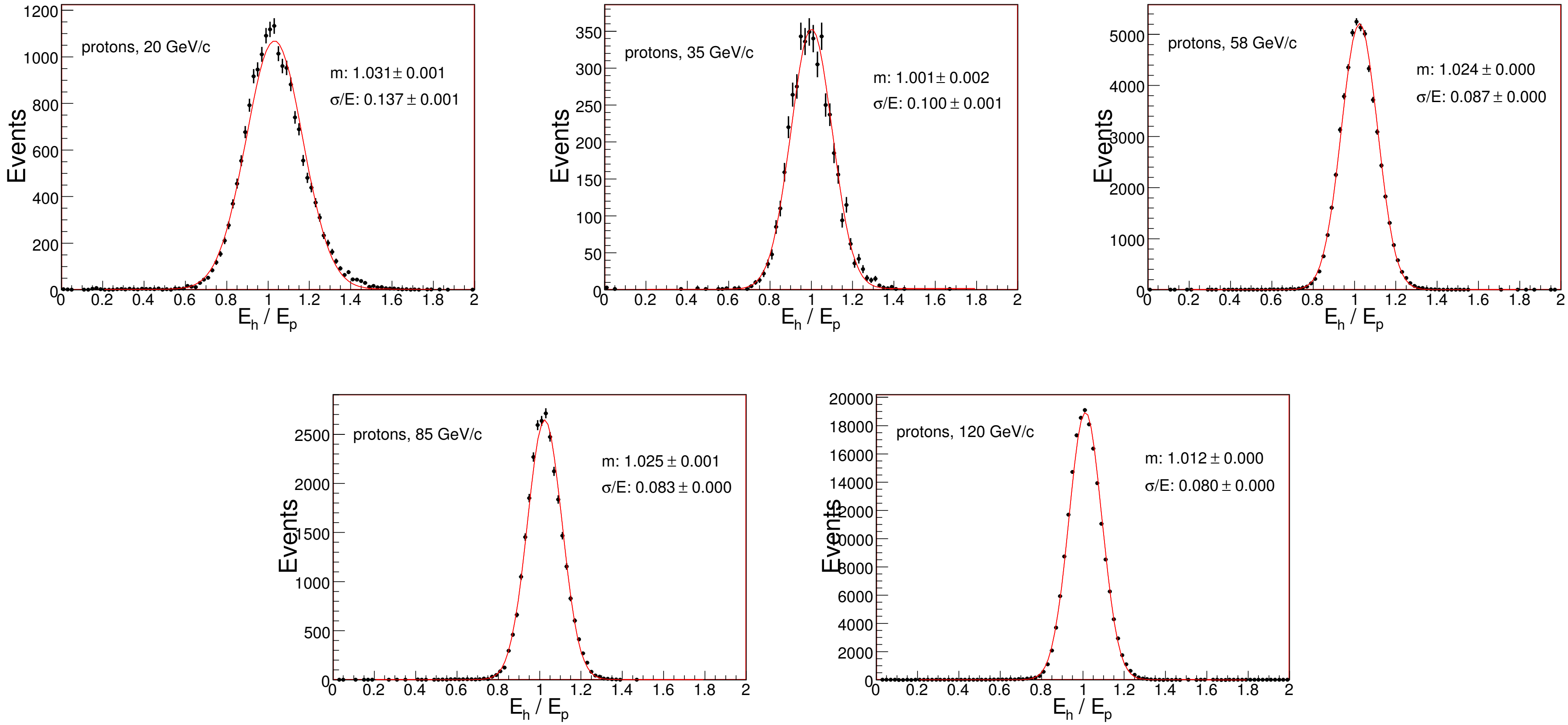
For energy calibration I used $E_{ecal} >> 1$ GeV events

For neutrons $E_{ecal} \approx 200$ MeV or less.

I need to select those events when whole energy goes into HCAL.

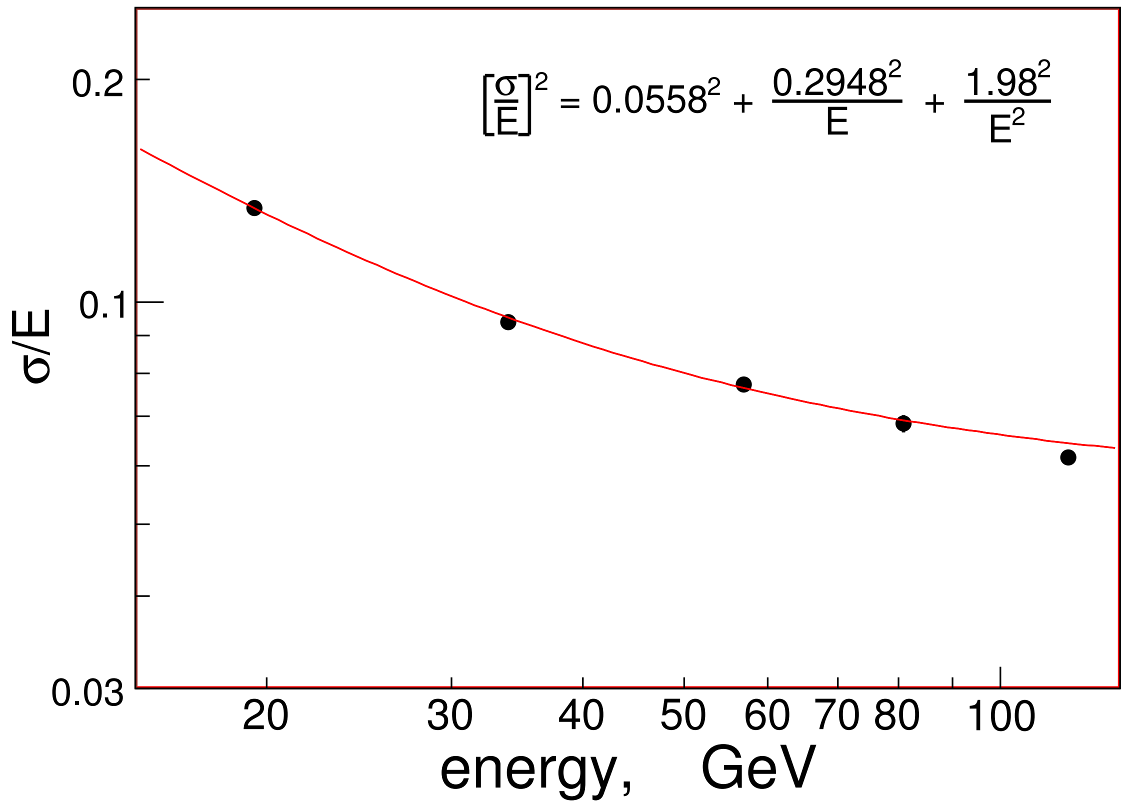
Fraction of such events is about 80$\%$

E_h / E_p



The HCAL calorimeter to proton energy ratio distributions for 20, 35, 58, 85 and 120 GeV/c track momentums. These plots allow us to extract the $\sigma_{(h)}$/E values which going to be in use for the neutron analysis.

σ/E vs E_p for HCAL



The HCAL calorimeters resolution, σ_h/E, vs the proton energy. HCAL itself in low momentums has less the width than the combined case. The fit parameters will be used for the neutron smearing.