HADRON CALIBRATION

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JME@HLT MEETING

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Introduction

- PF hadron calibration on run3 120X single pion sample[1] with CMSSW_12_0_1.
  - Configuration wasn't changed compared to previous PFHC, sample was changed.
- I use π^- only.

[1] /Single_Pion_gun_E_*_14TeV_pythia8/Run3Summer21DR-NoPURAWRECO_120X_mcRun3_2021_realistic_v6-v2/GEN-SIM-RAW

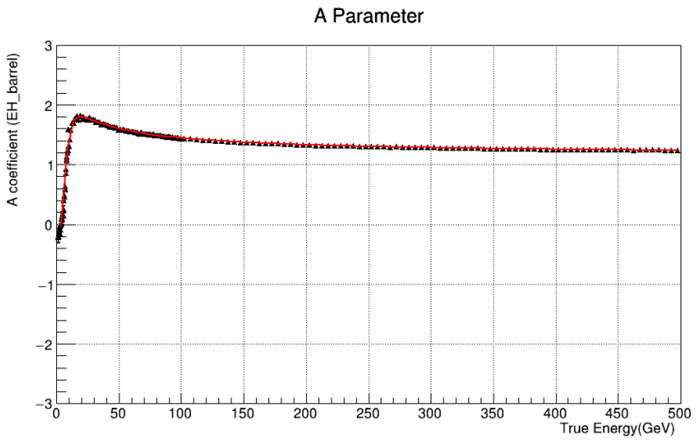
Calibration Coefficients

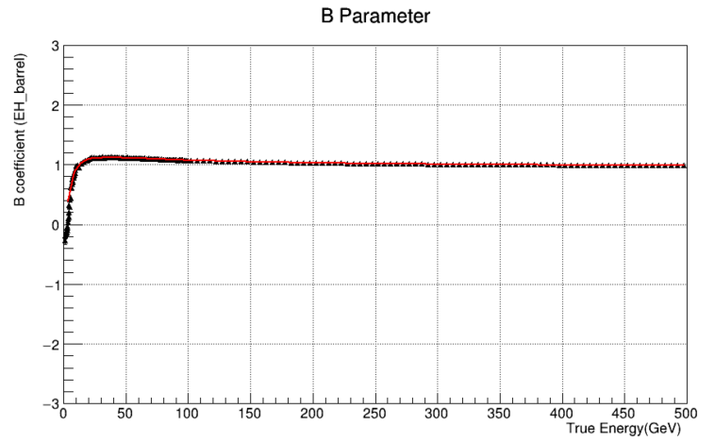
EH hadrons : $E_{corrected} = a(E_t) * E_{rawEcal} + b(E_t)* E_{rawHcal} + o_{EH}$

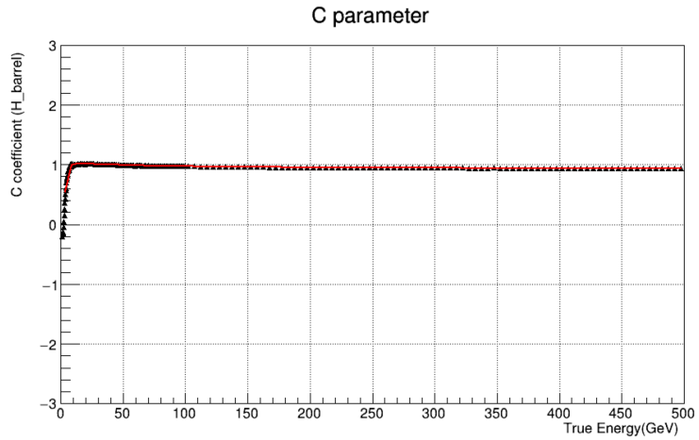
H hadrons : $E_{corrected} = c(E_t)* E_{rawHcal} + o_{H}$

o_{EH} = 3.5 GeV
o_{H} = 2.5 GeV

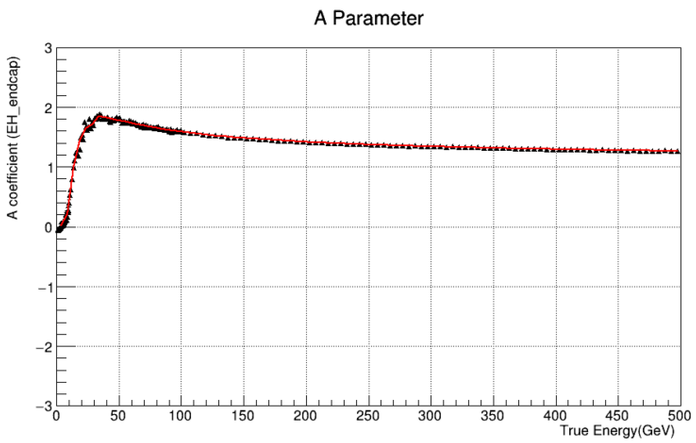
Barrel

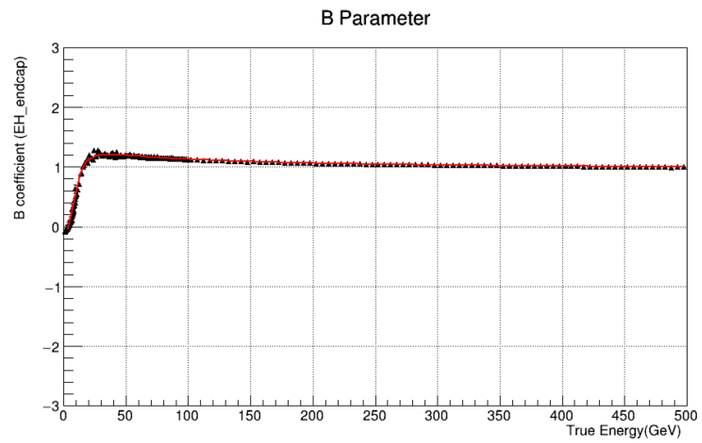


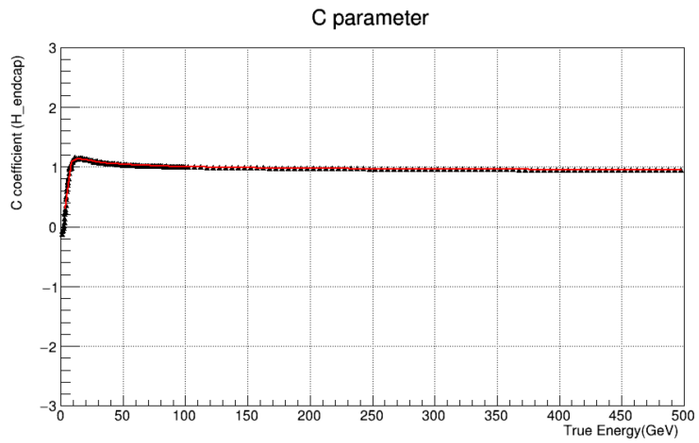




Endcap



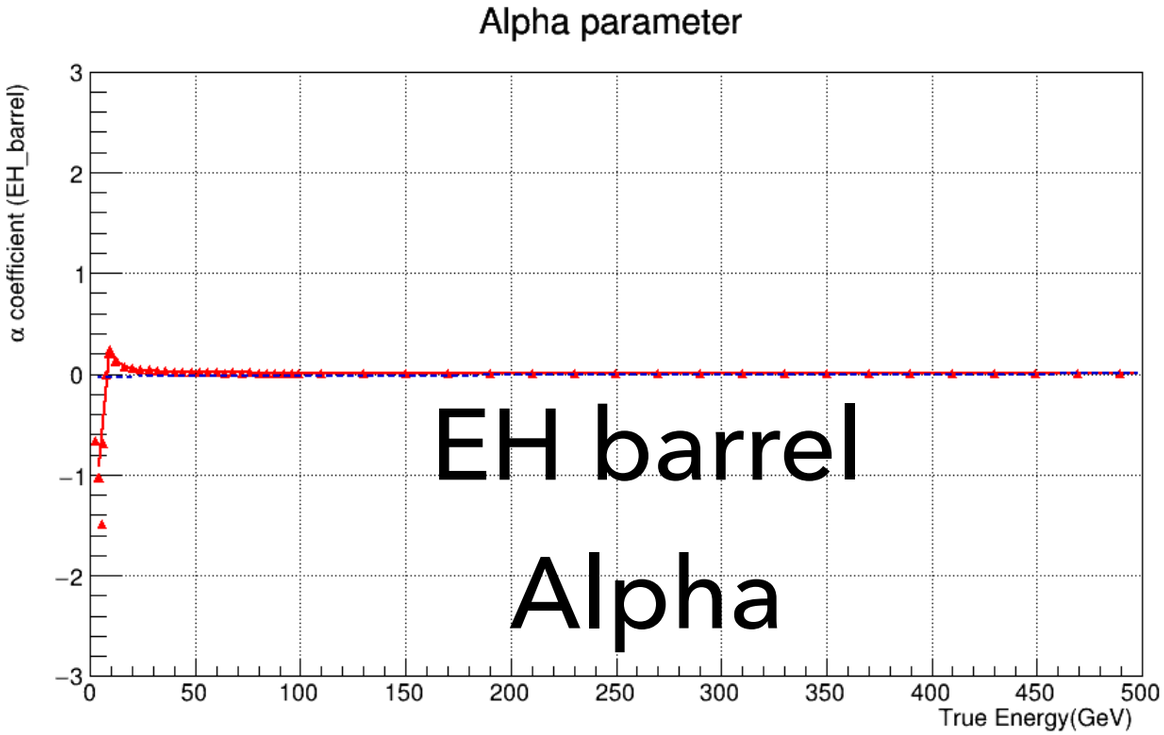


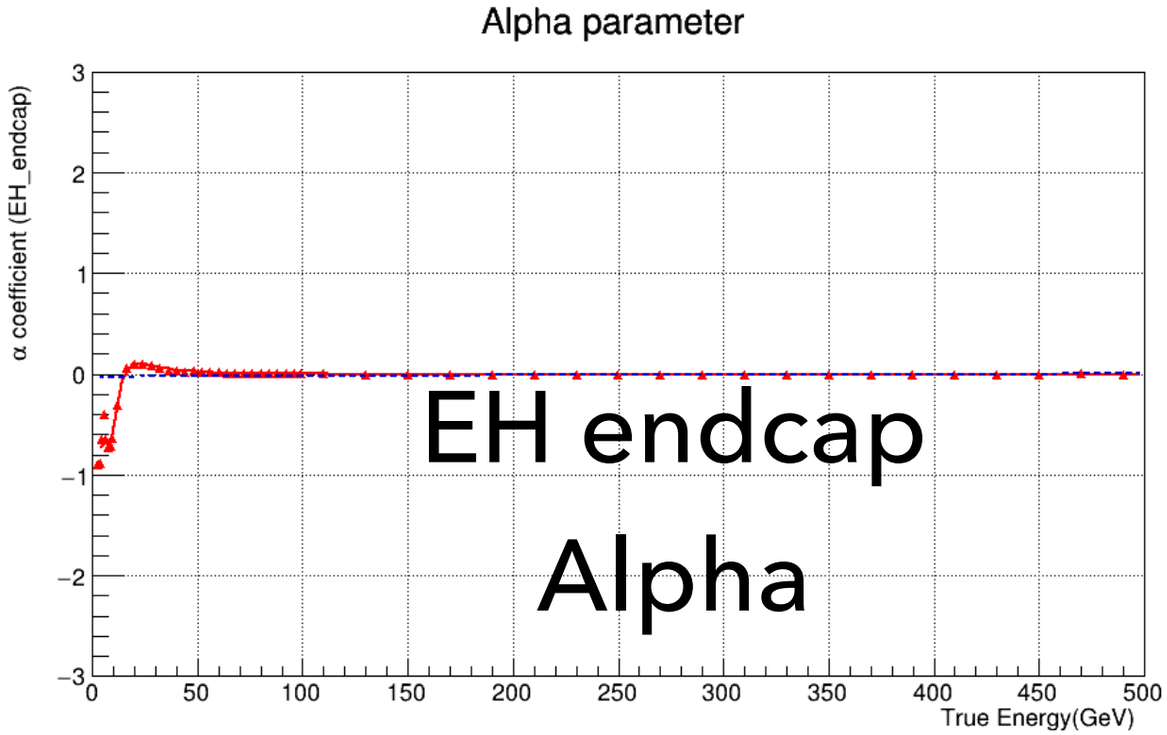


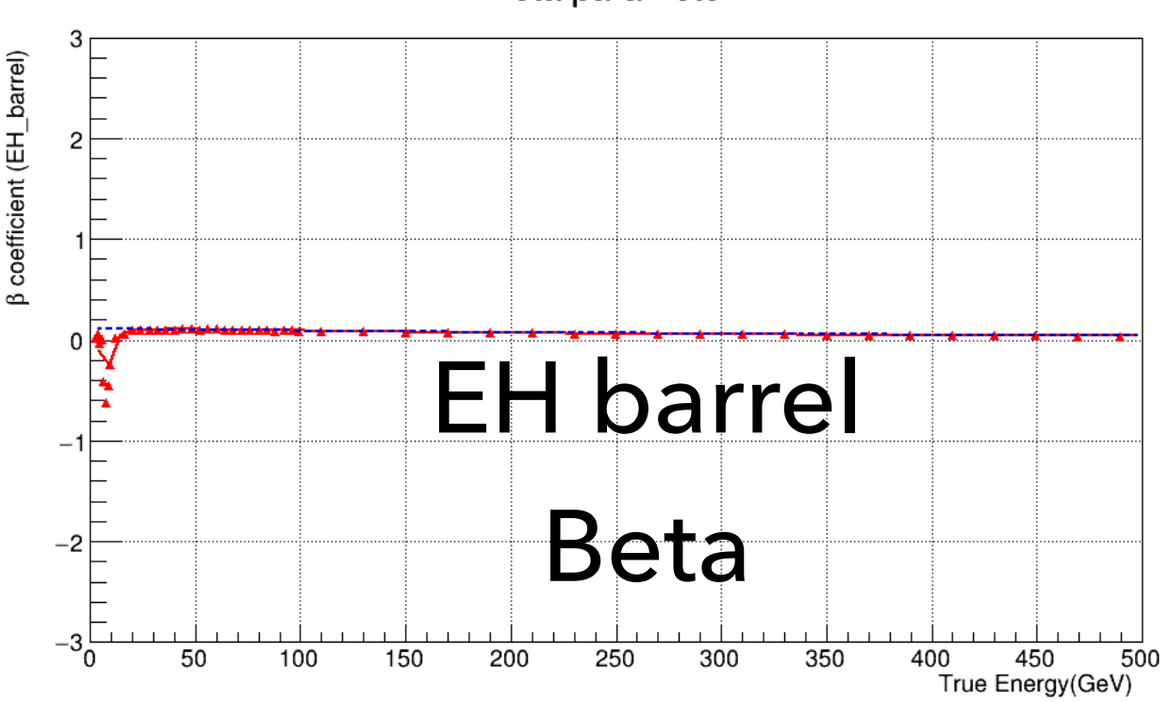
Calibration Coefficients

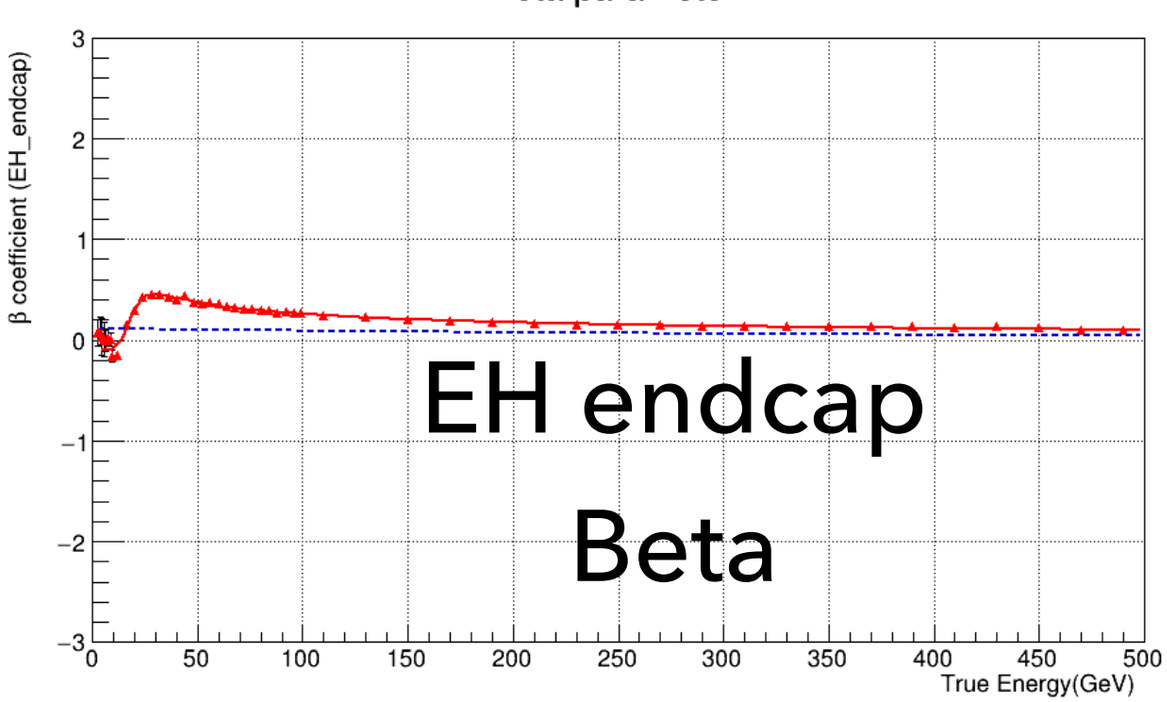
For EH Hadrons (start their shower in ECAL):

- Barrel : $E_{corr} = (1 + \alpha(E_t) + 1.3*\beta(E_t)*|\eta|^2) *E'_{ecal} + E'_{hcal}$
- EndCap($1.5 < |\eta| < 2.5$): $E_{corr} = (1 + \alpha(E_t)) * E'_{ecal} + E'_{hcal}$
- EndCap($|\eta| > 2.5$): $E_{corr} = (1 + \alpha(E_t) + 1.3*\beta(E_t)*((|\eta| - 1.5)^2 + 0.6)) * E'_{ecal} + E'_{hcal}$





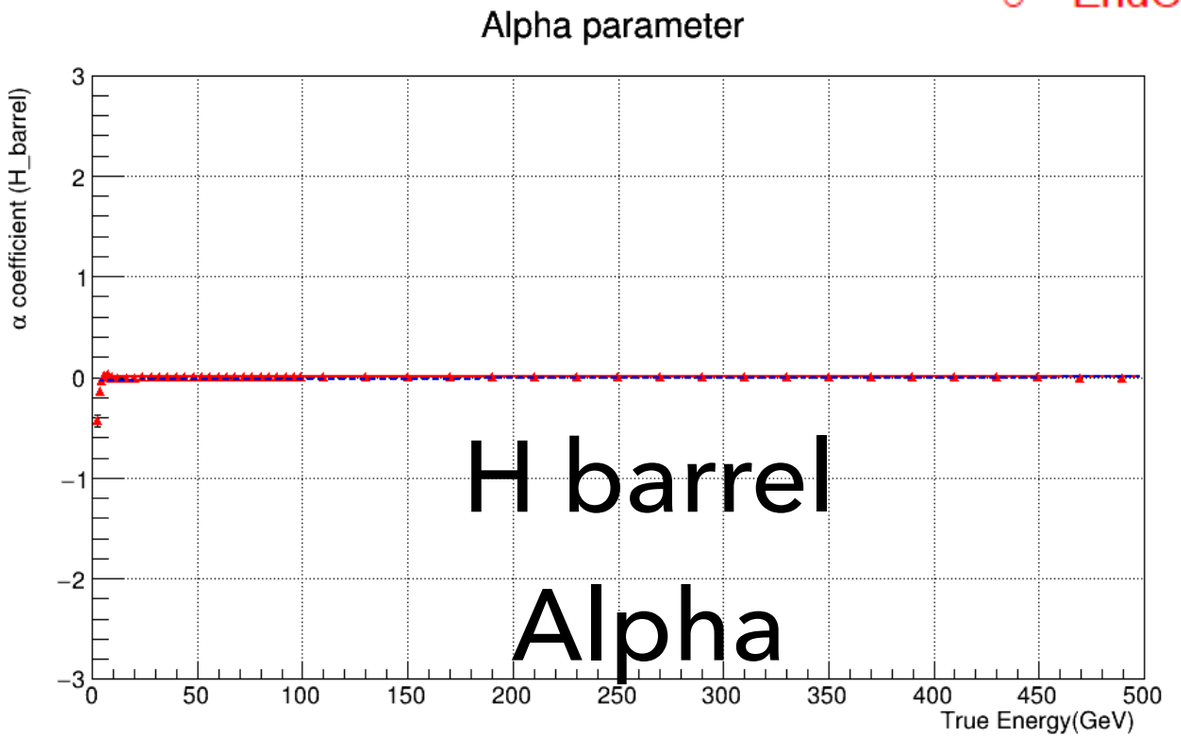


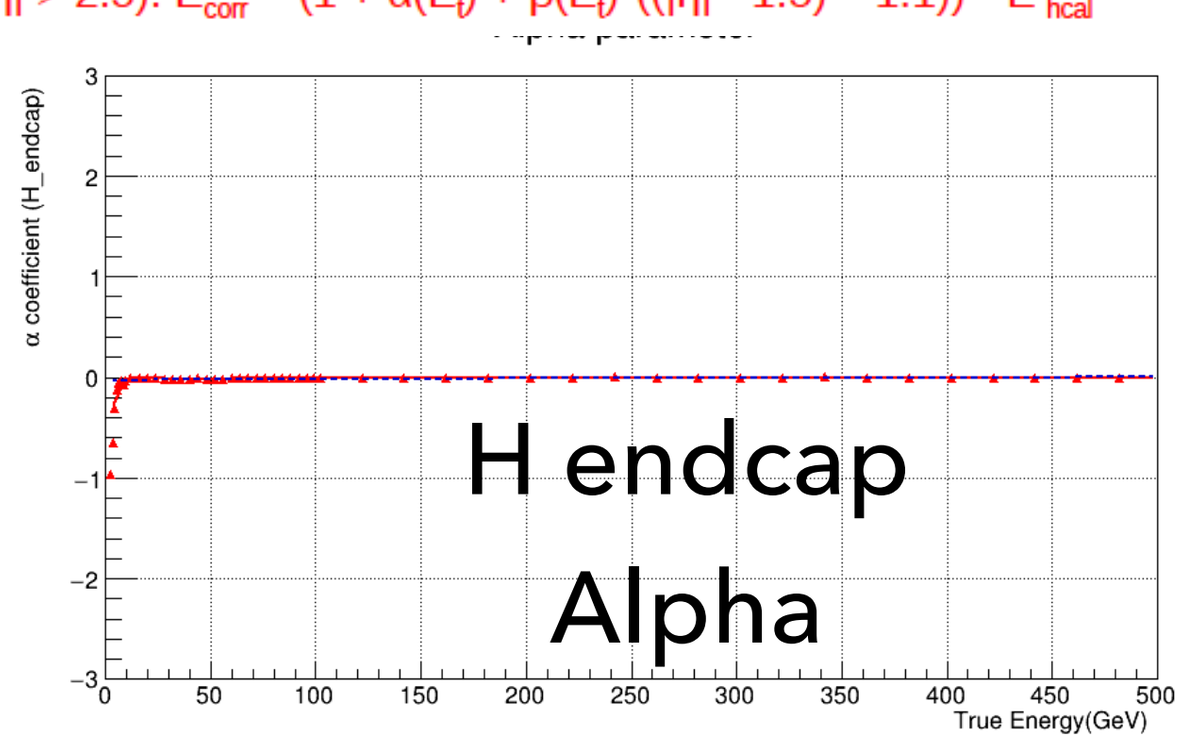


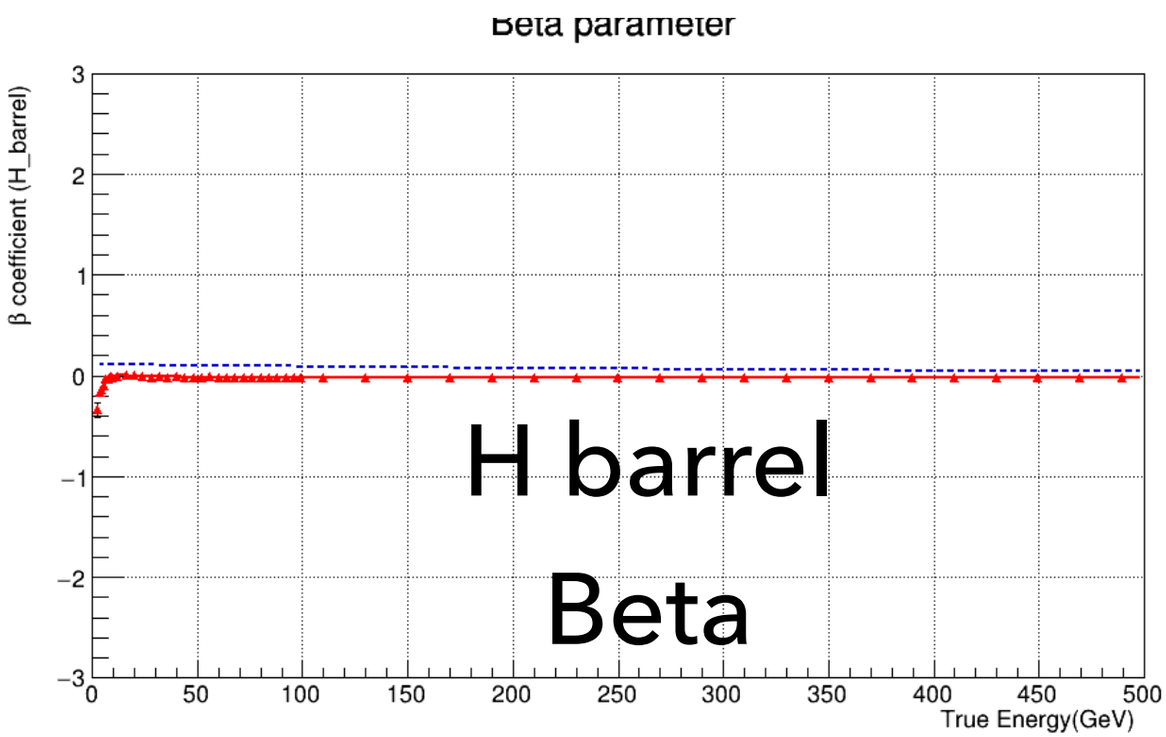
Calibration Coefficients

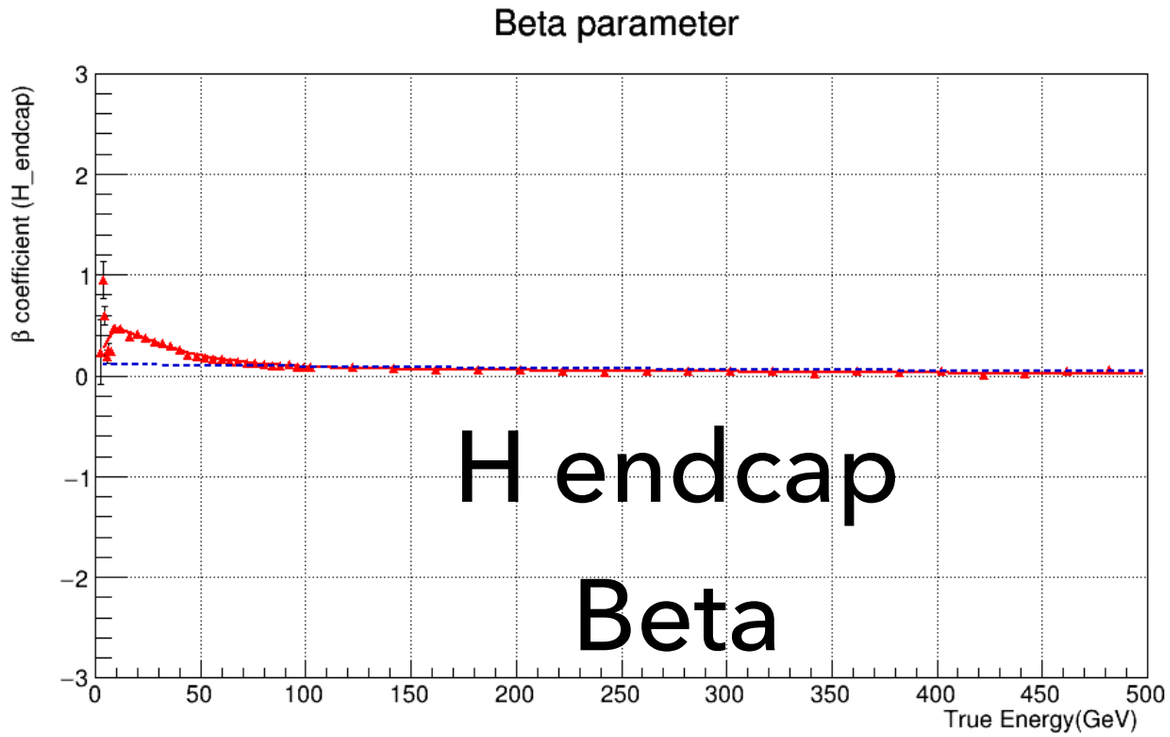
For H Hadrons (start their shower in HCAL):

- Barrel : $E_{corr} = (1 + \alpha(E_t) + \beta(E_t)*|\eta|^2) * E'_{hcal}$
- EndCap ($1.5 < |\eta| < 2.5$): $E_{corr} = (1 + \alpha(E_t) + \beta(E_t)* 0.05) * E'_{hcal}$
- EndCap ($|\eta| > 2.5$): $E_{corr} = (1 + \alpha(E_t) + \beta(E_t)*((|\eta| - 1.5)^4 - 1.1)) * E'_{hcal}$

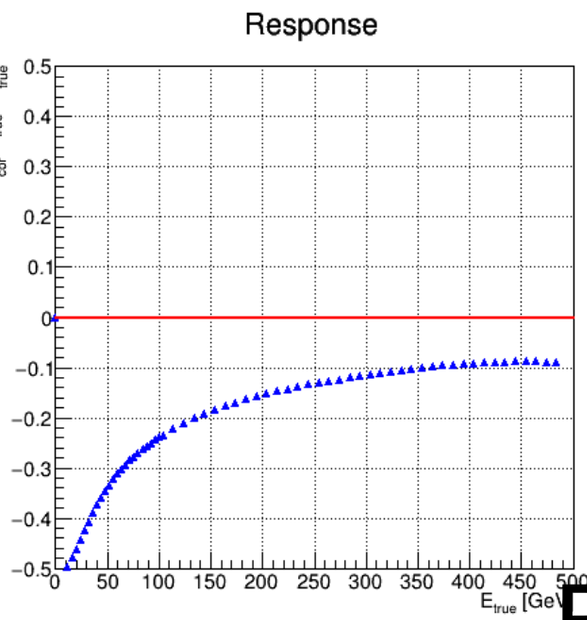


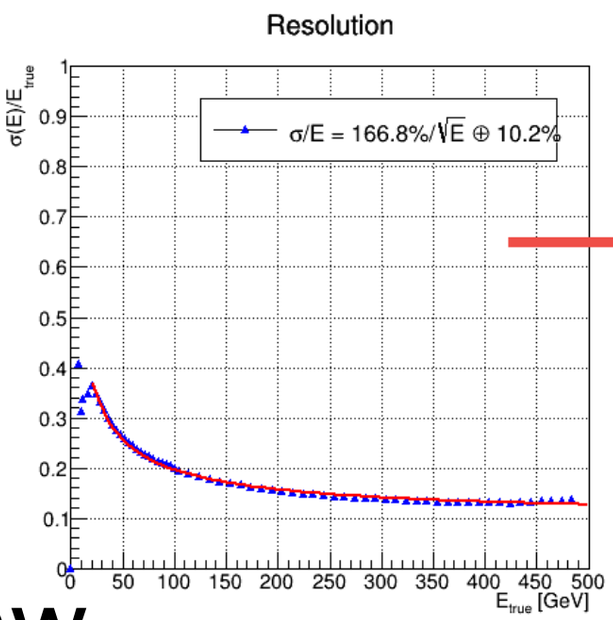






EH Barrel





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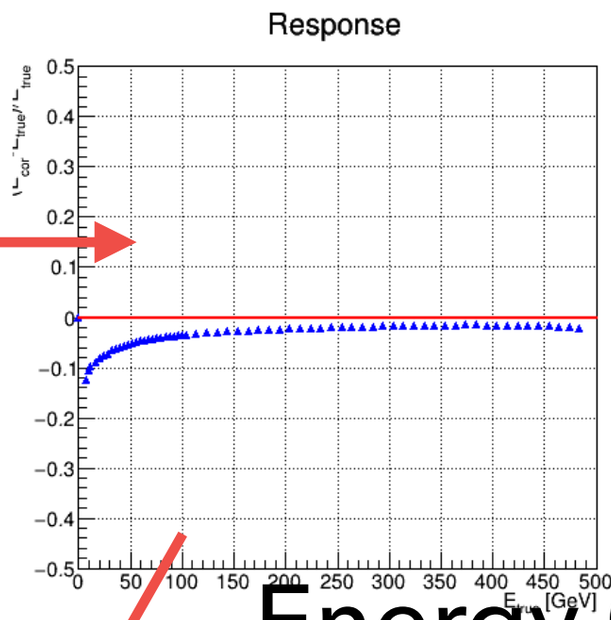
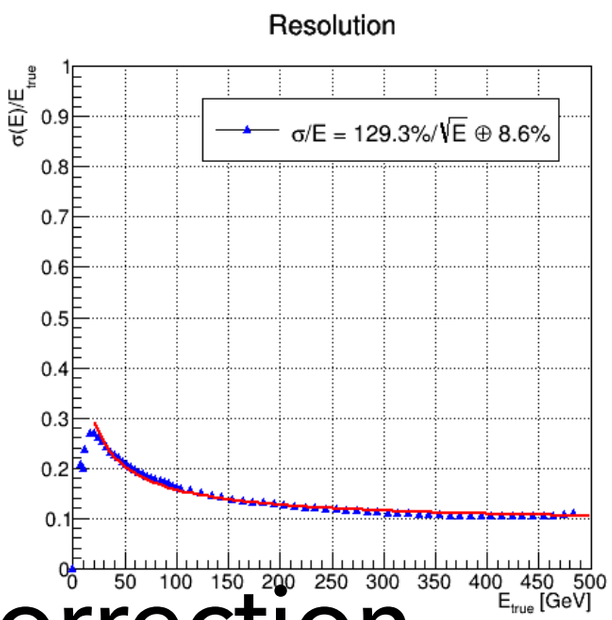
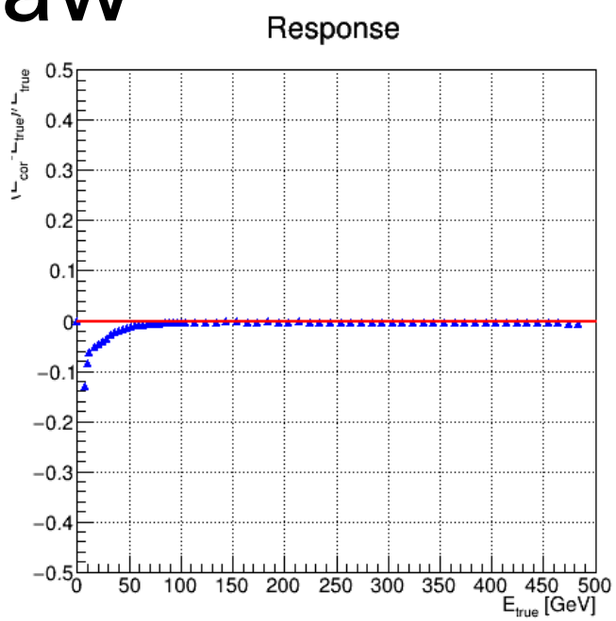
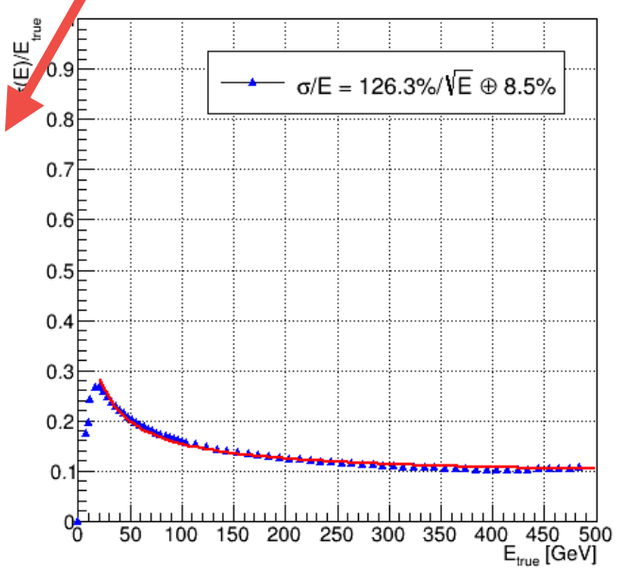




Energy Correction

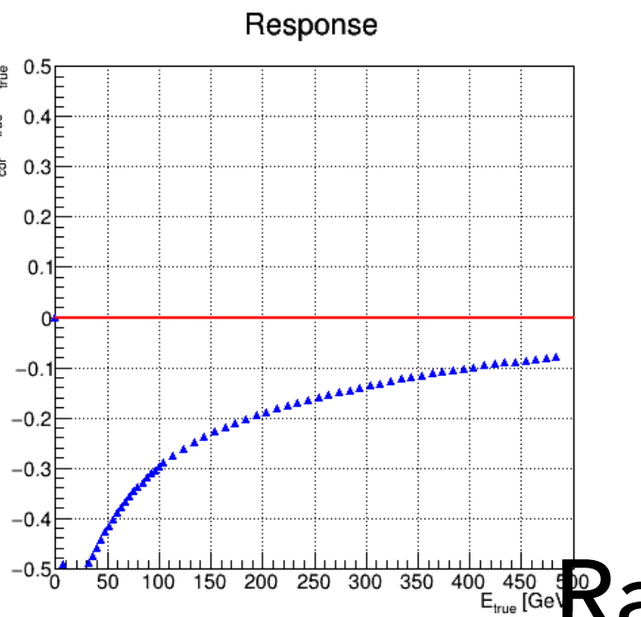


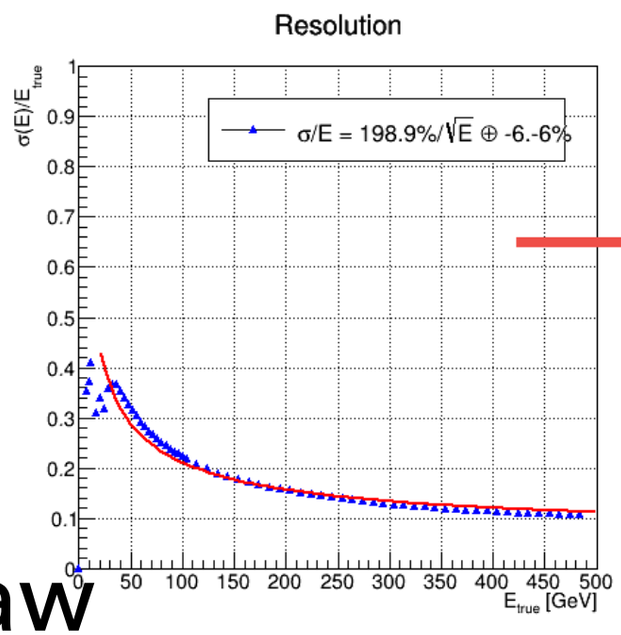


Energy and Eta dependence Correction

The response is improved after eta correction

EH Endcap





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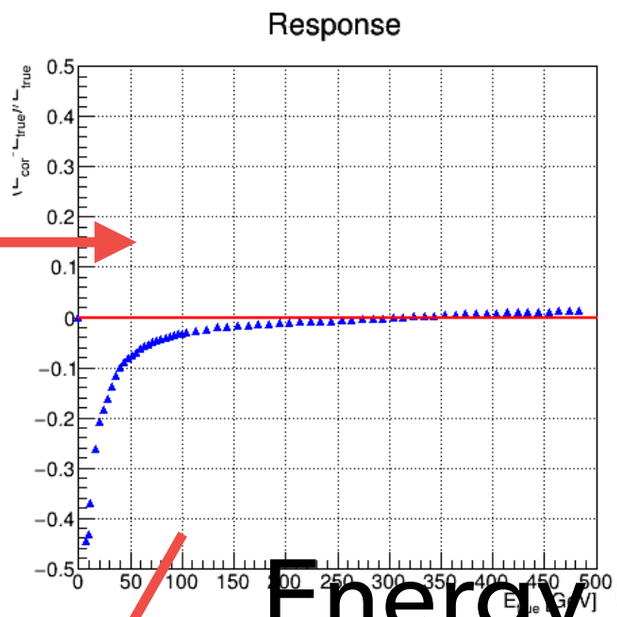
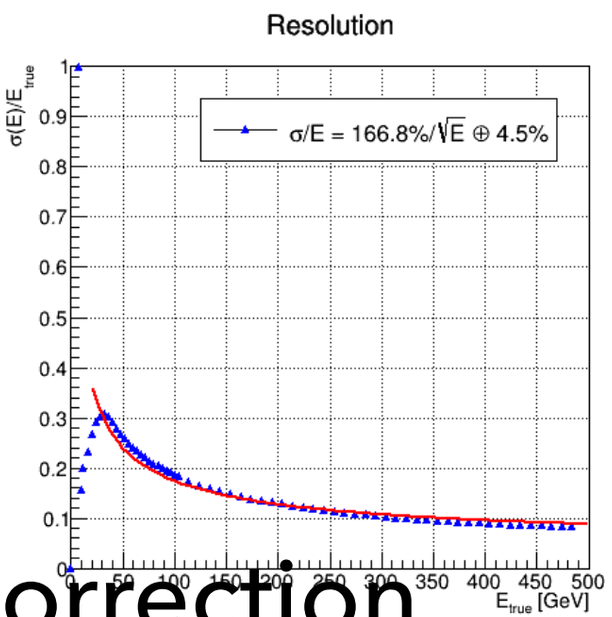
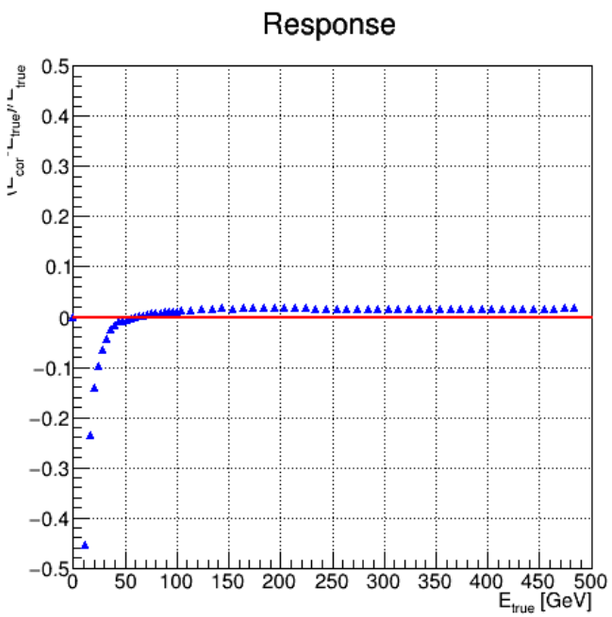
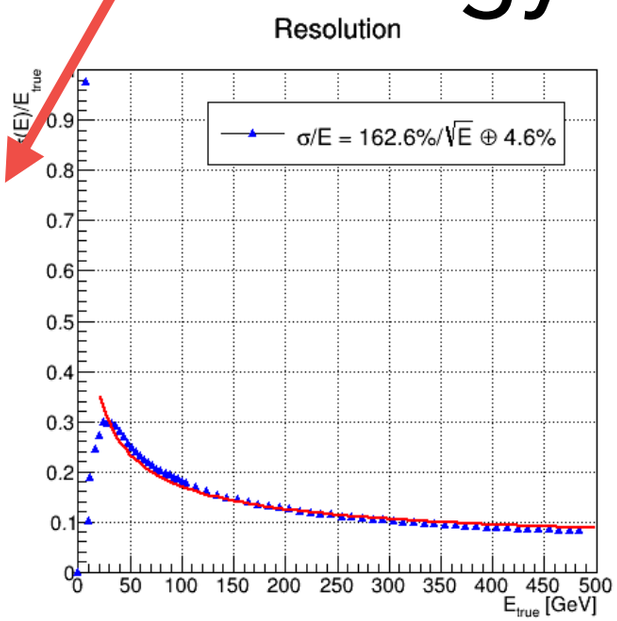


Energy Correction



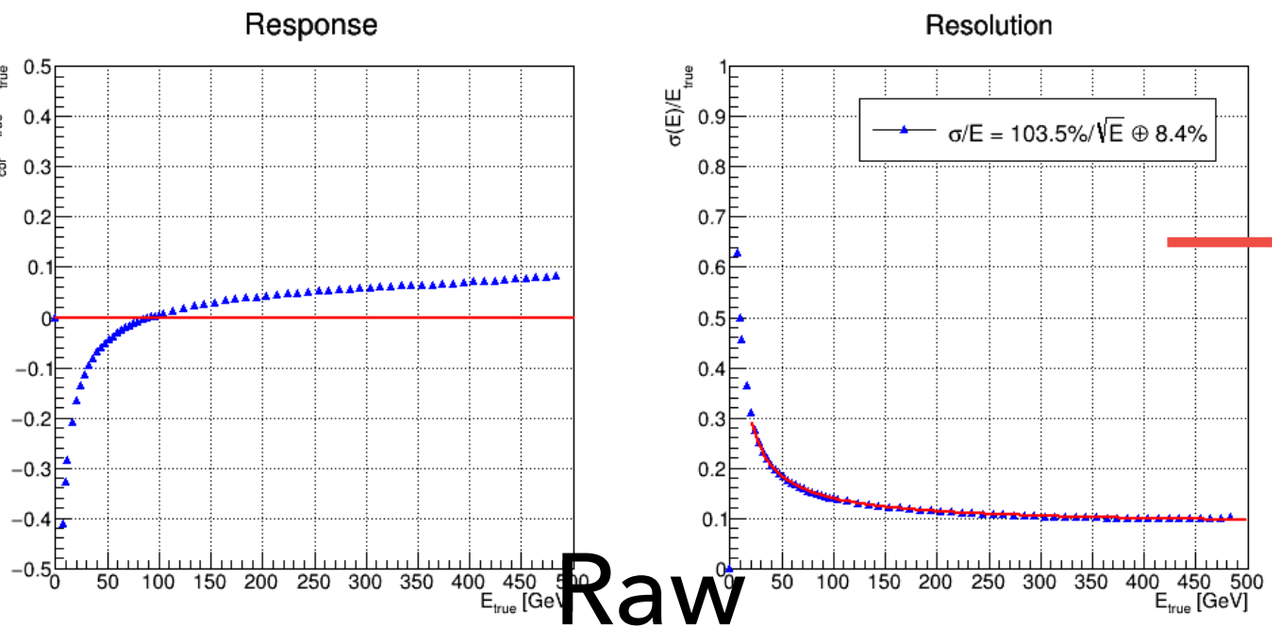




Energy and Eta dependence Correction

The Response is improved after eta correction.

H Barrel



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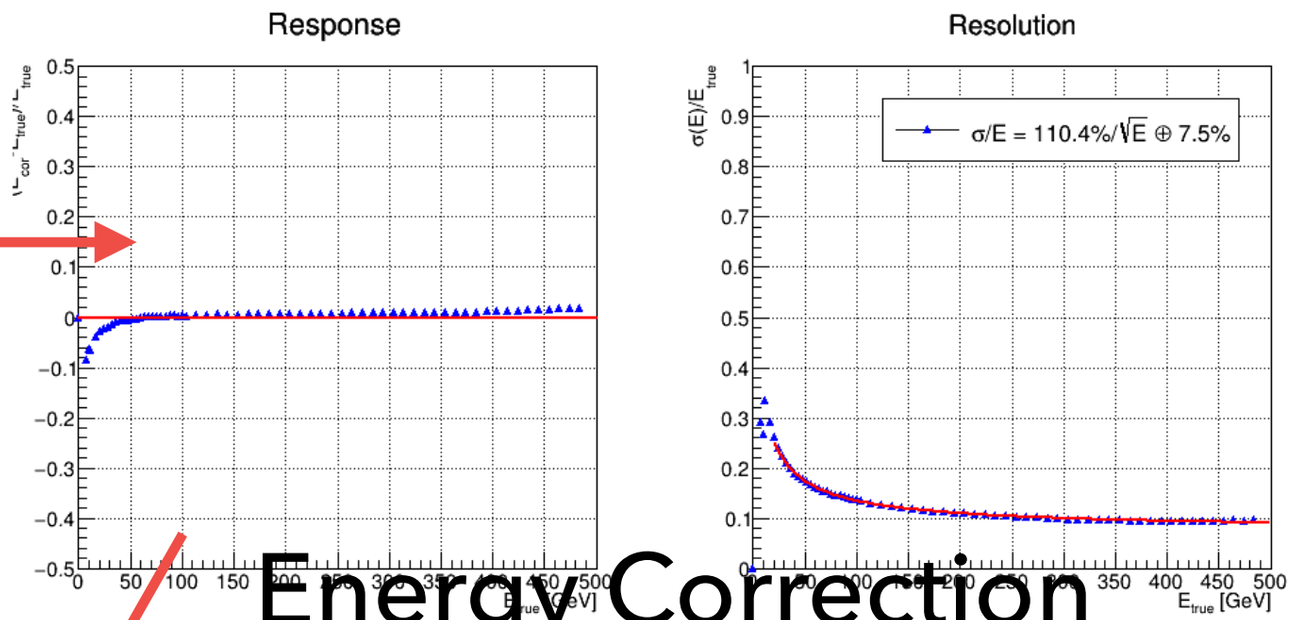
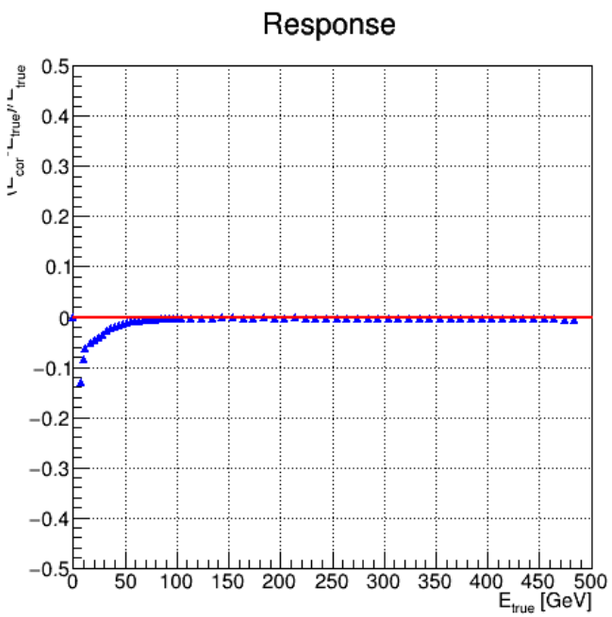
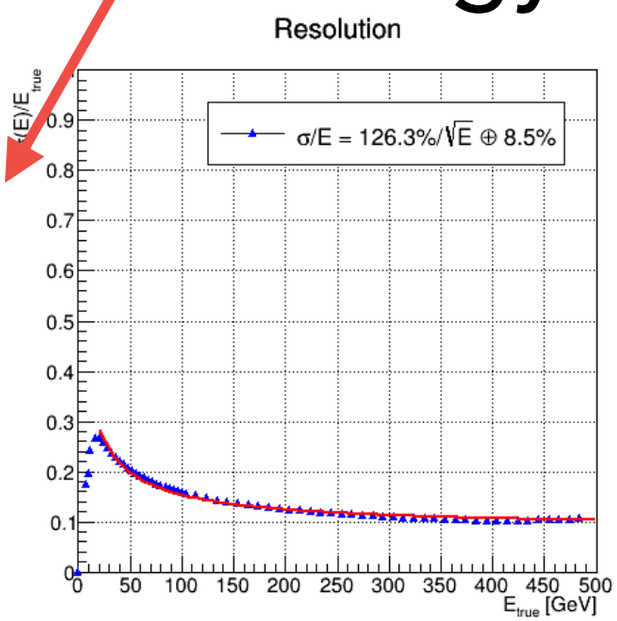


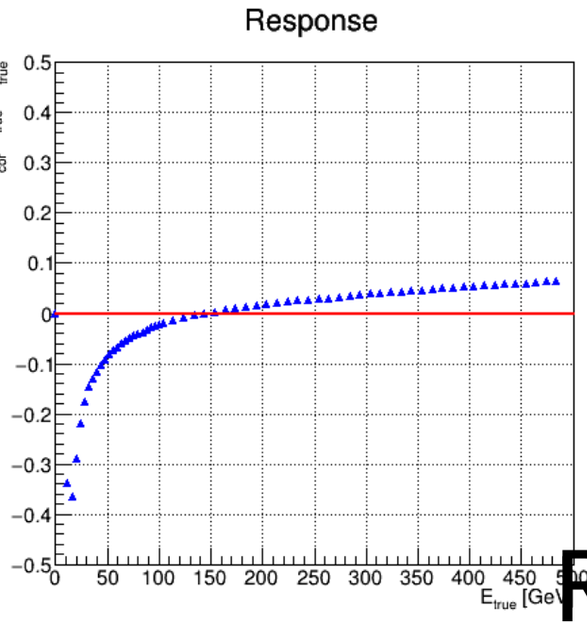
Energy Correction

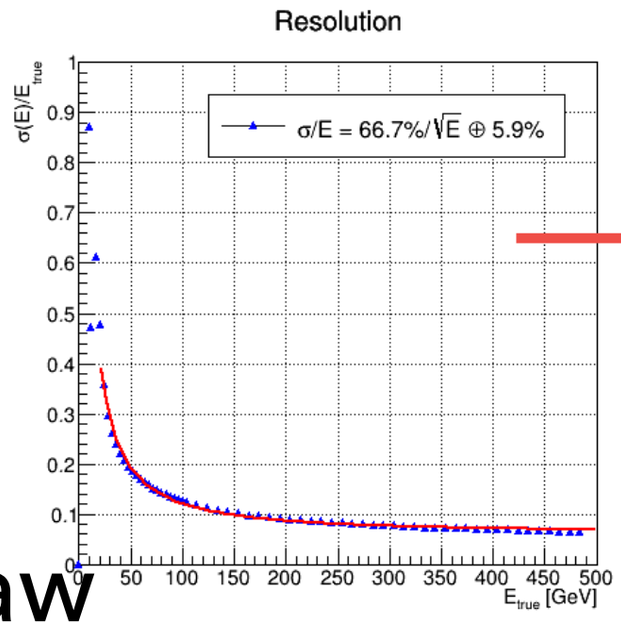




Energy and Eta dependence Correction

H Endcap





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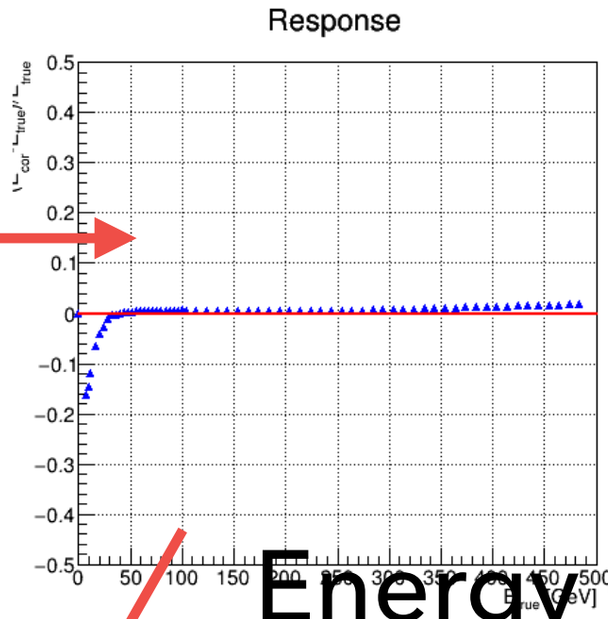
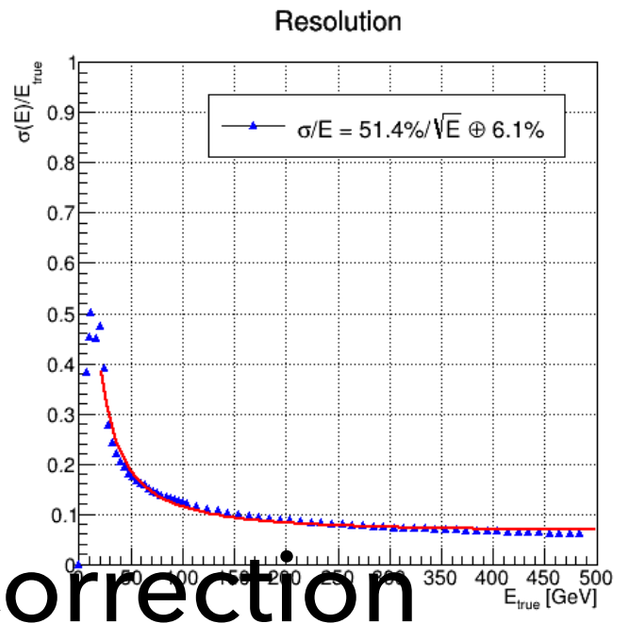
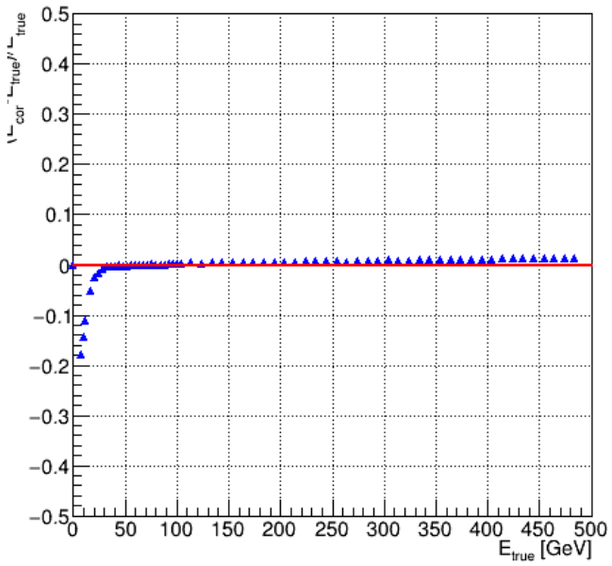
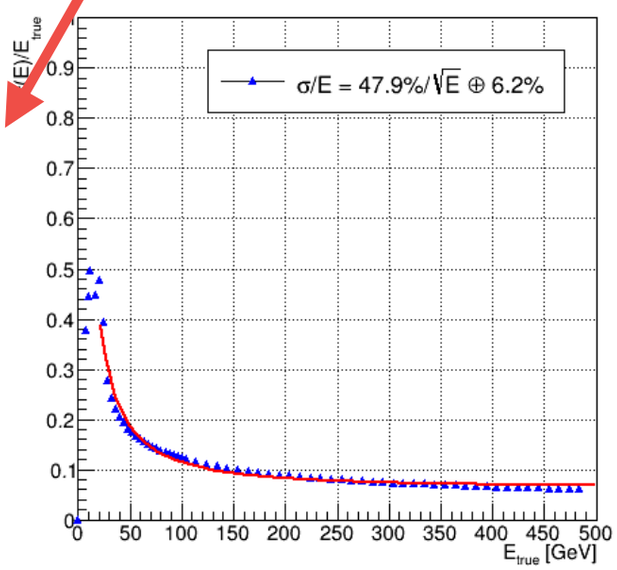




Energy Correction

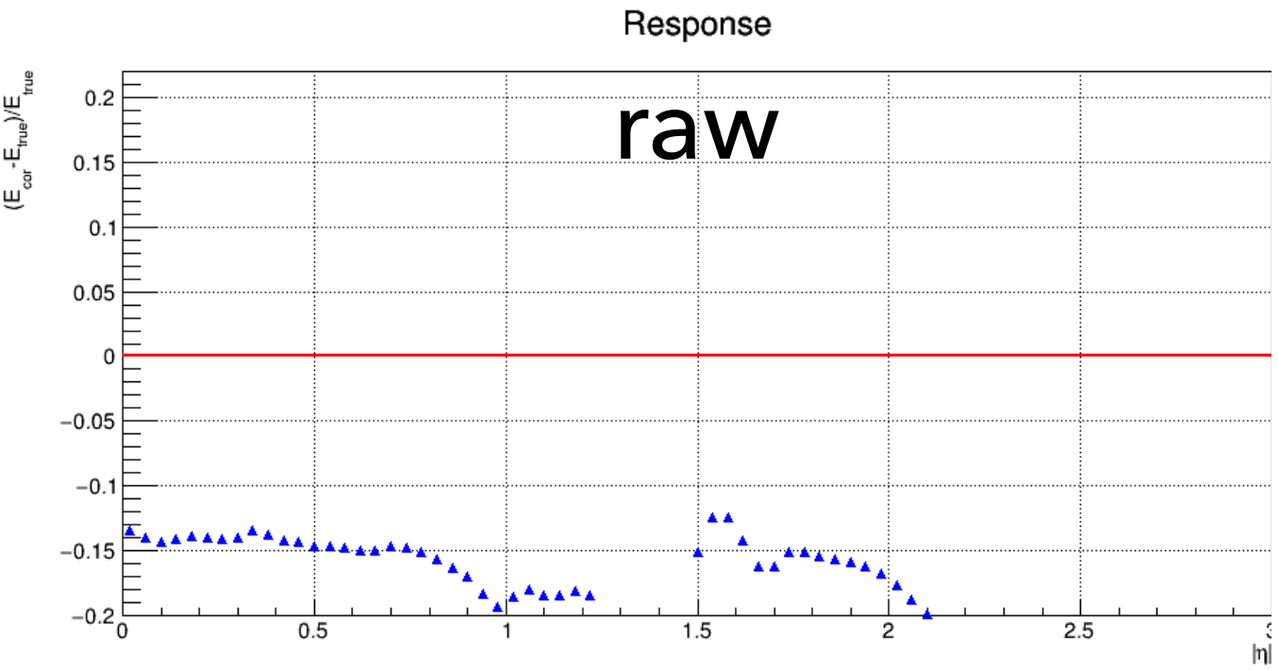


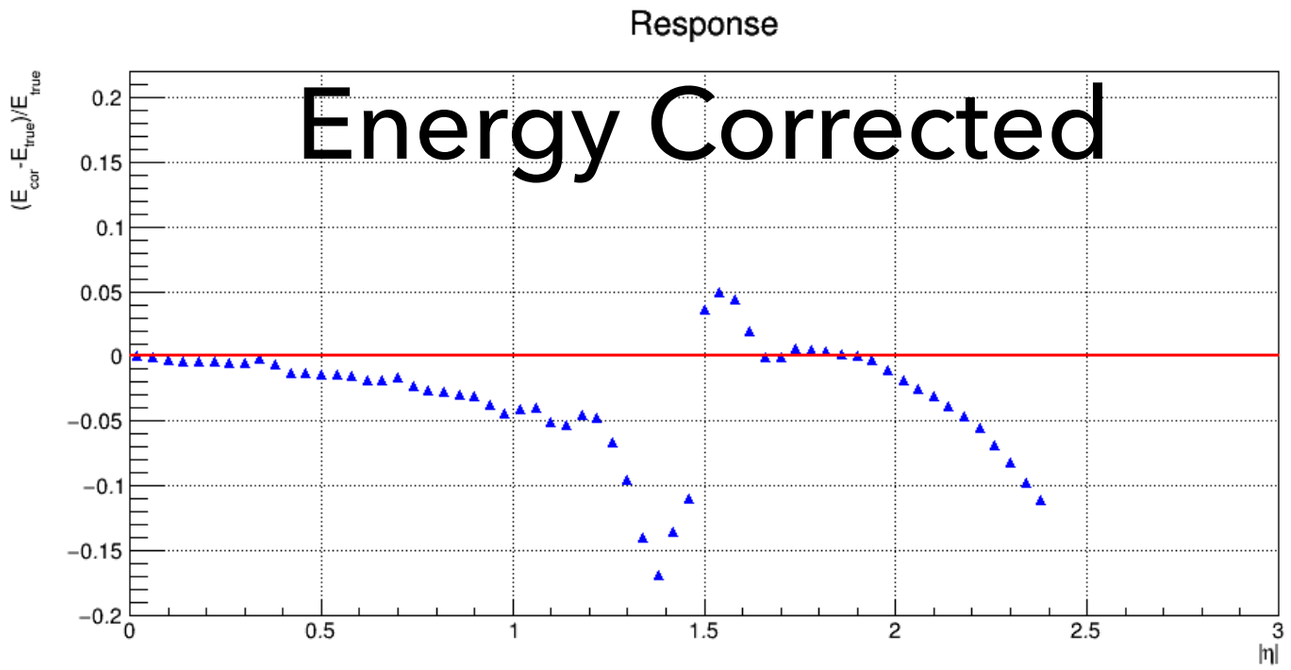


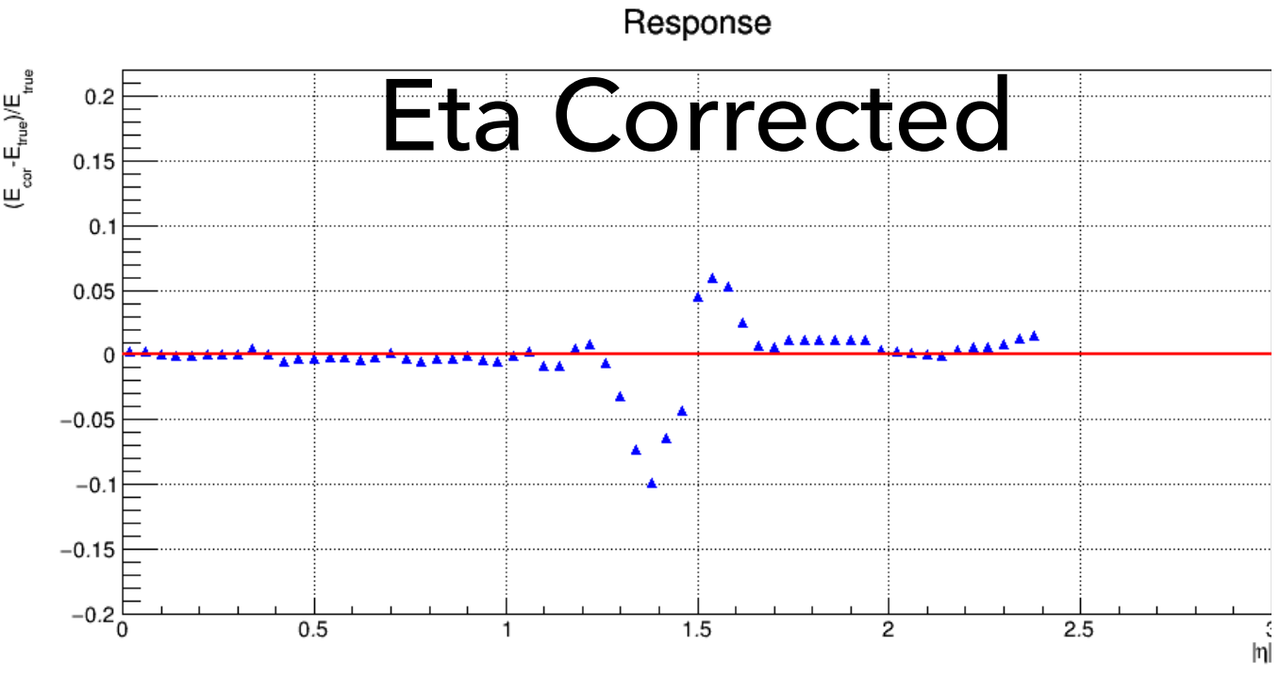
Energy and Eta dependence Correction

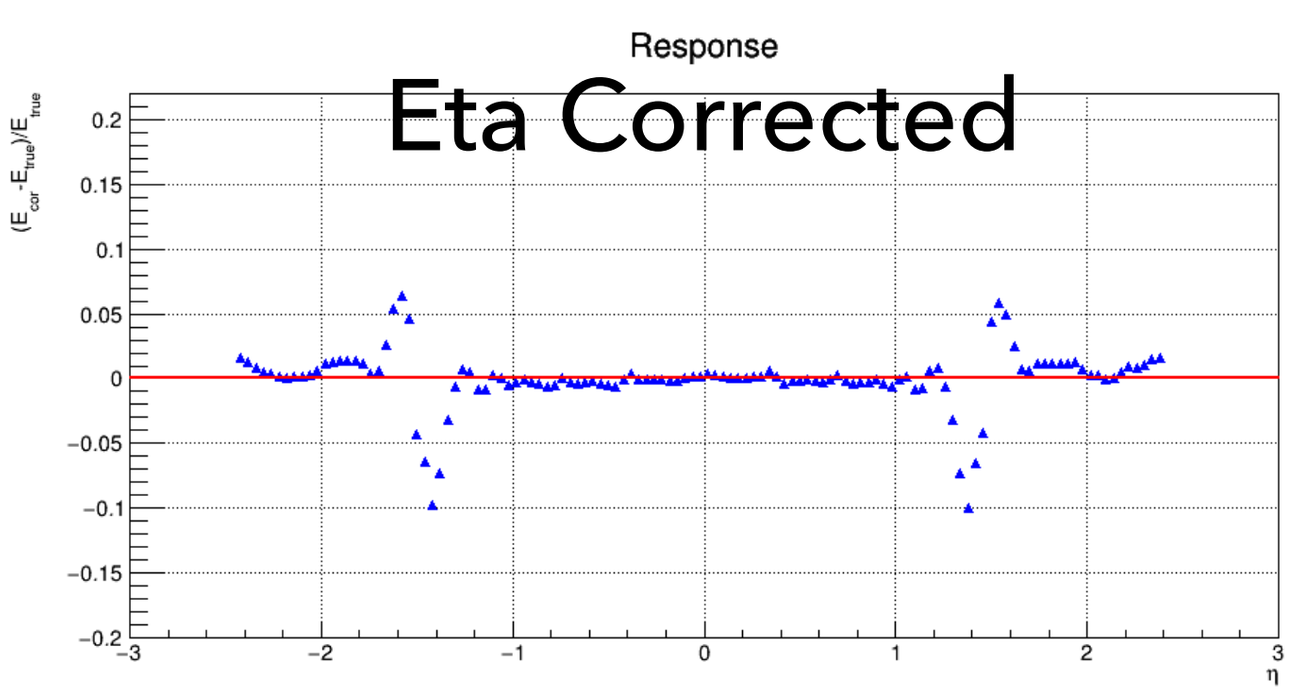
Response vs eta, EH hadron

The response is improved after eta correction.

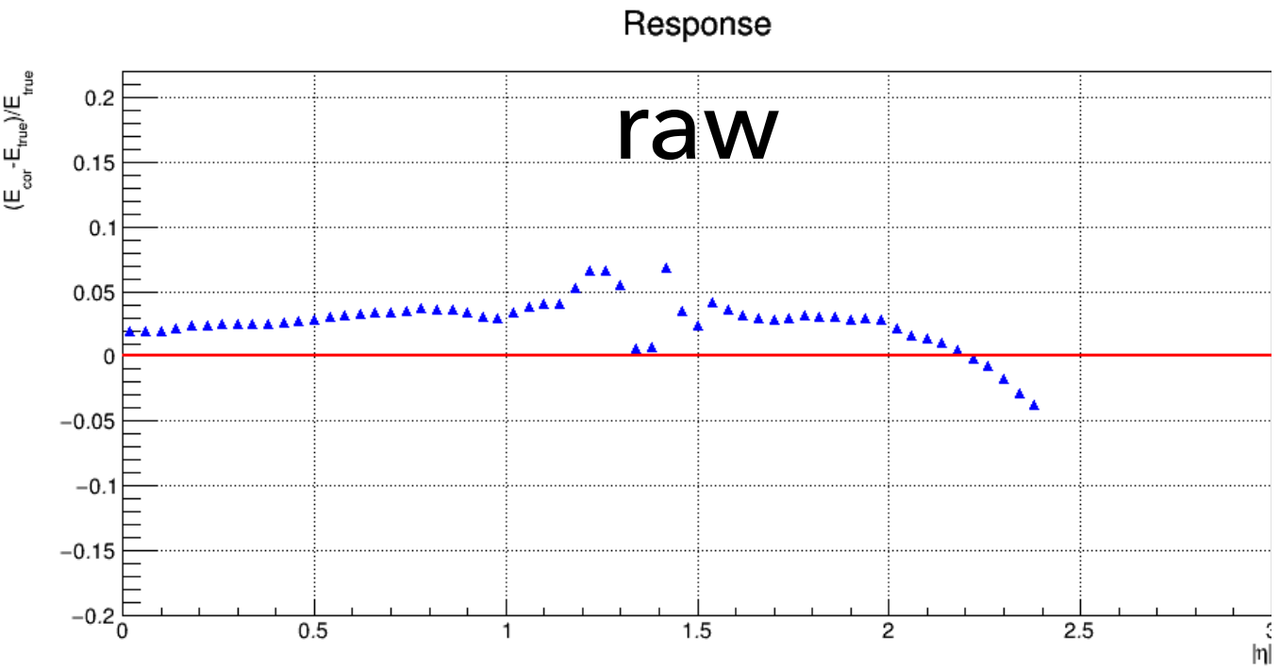


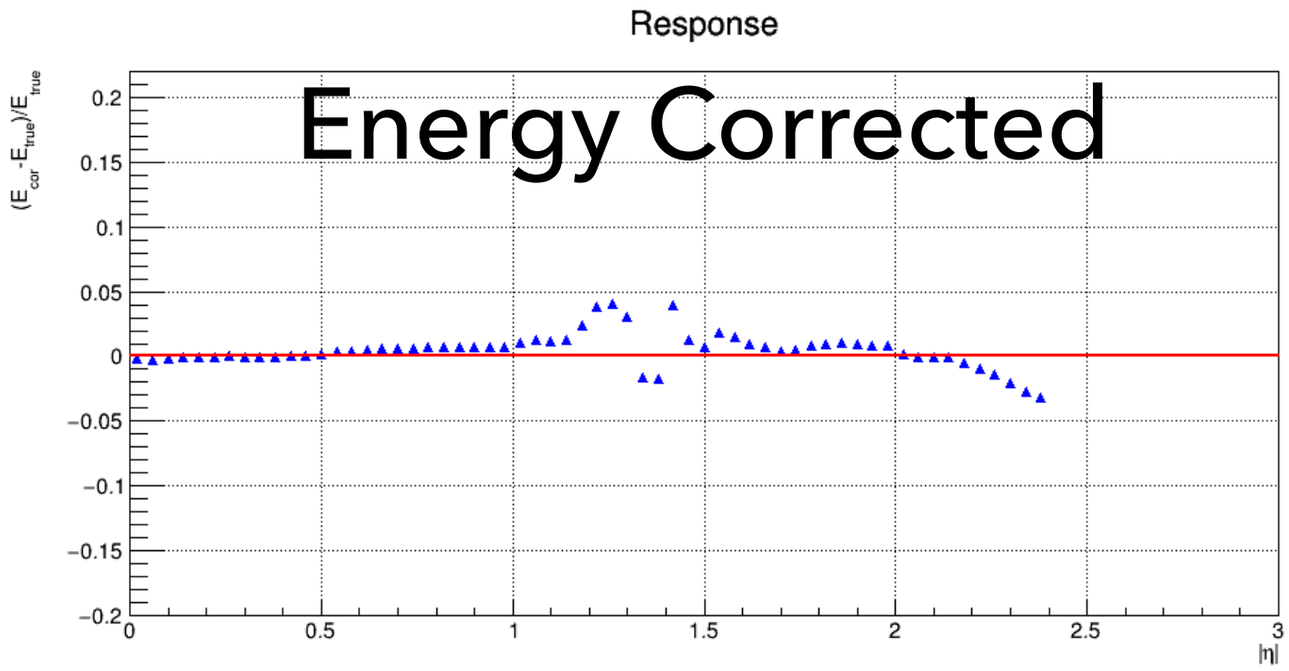


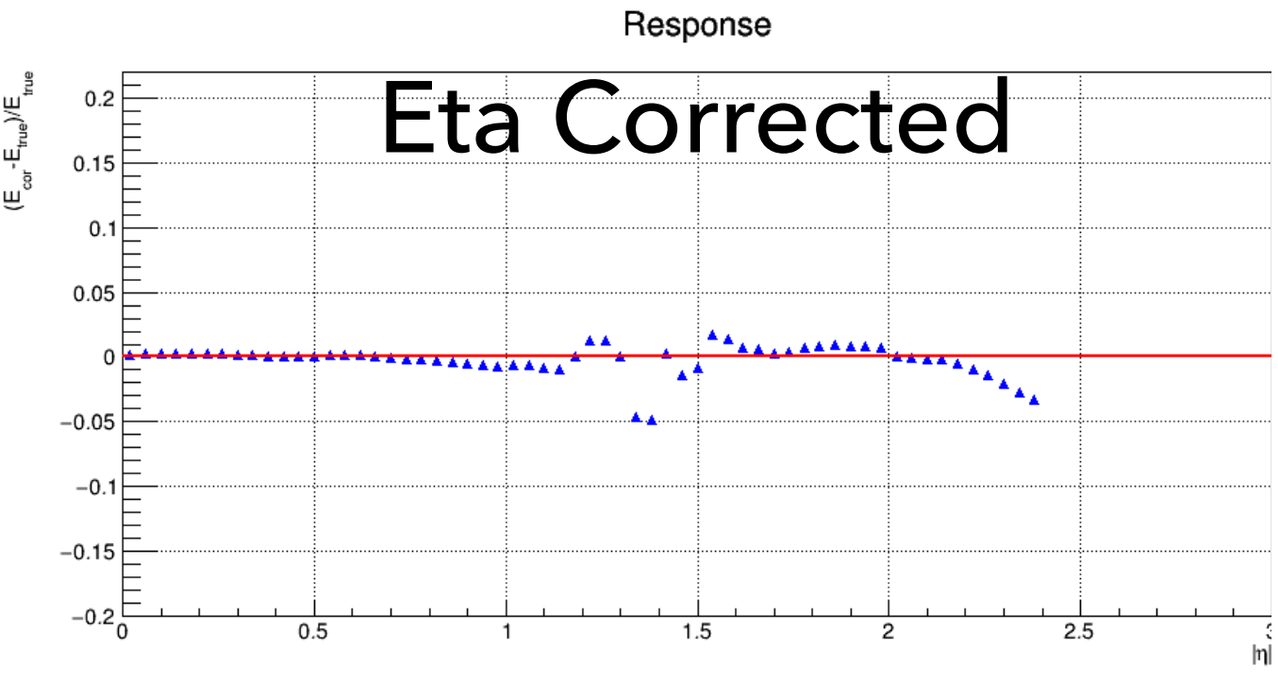


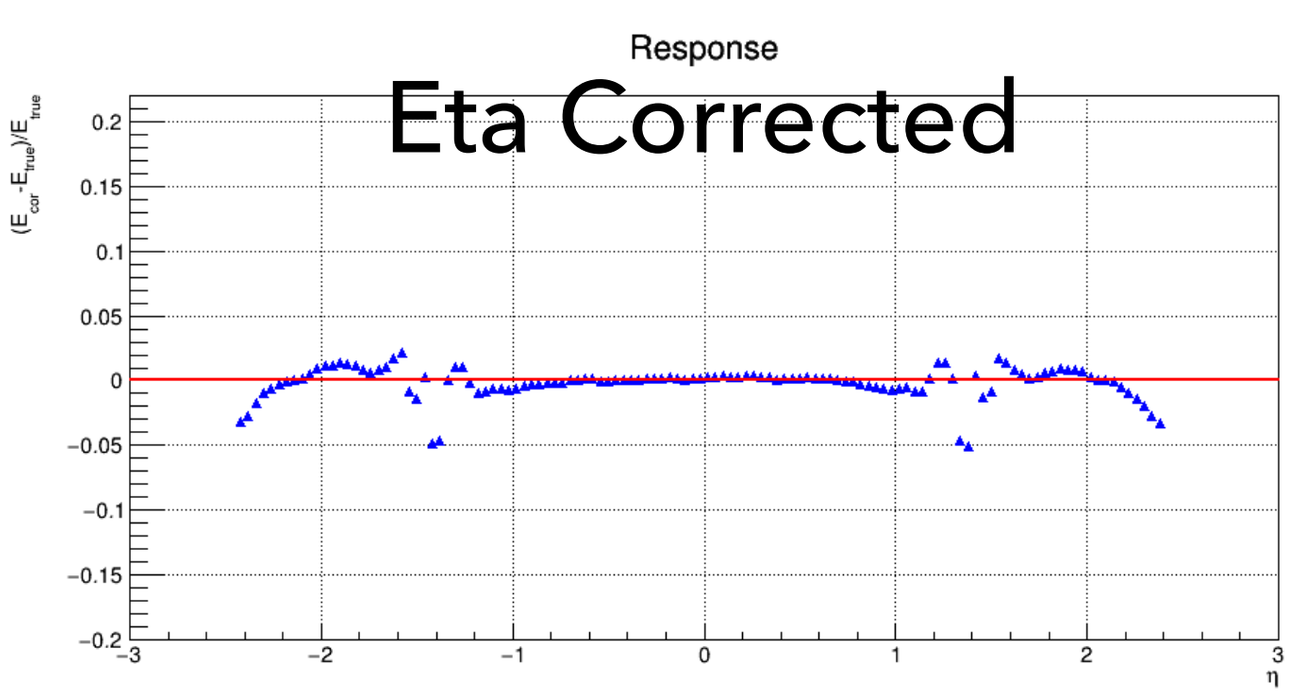


Response vs eta, H hadron









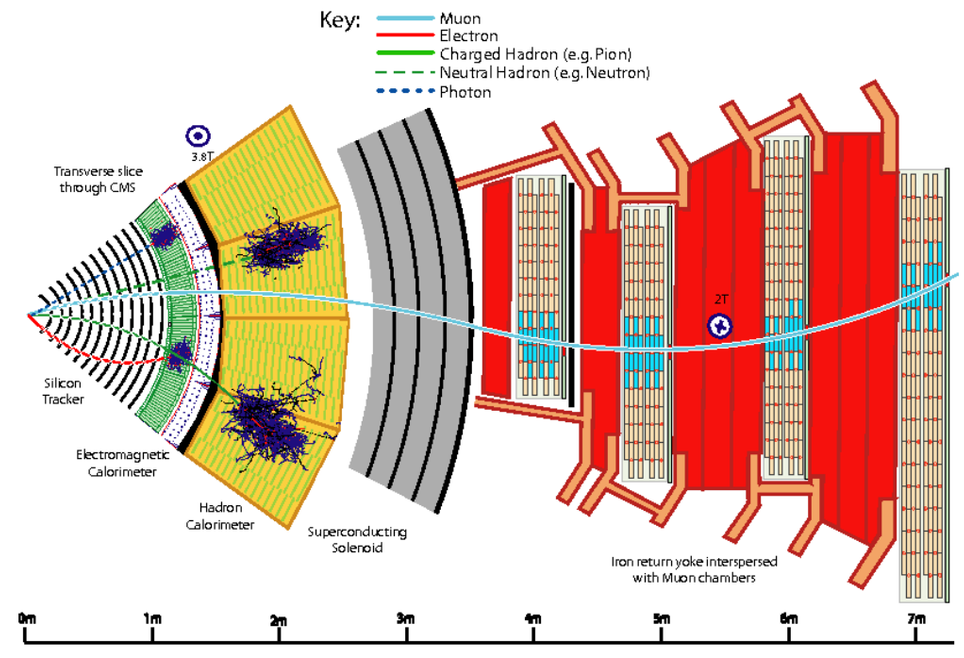
Summary

- PF hadron calibration on run3 120X single pion sample with CMSSW_12_0_1.
- The response is improved after energy and energy-eta correction.

BACKUP

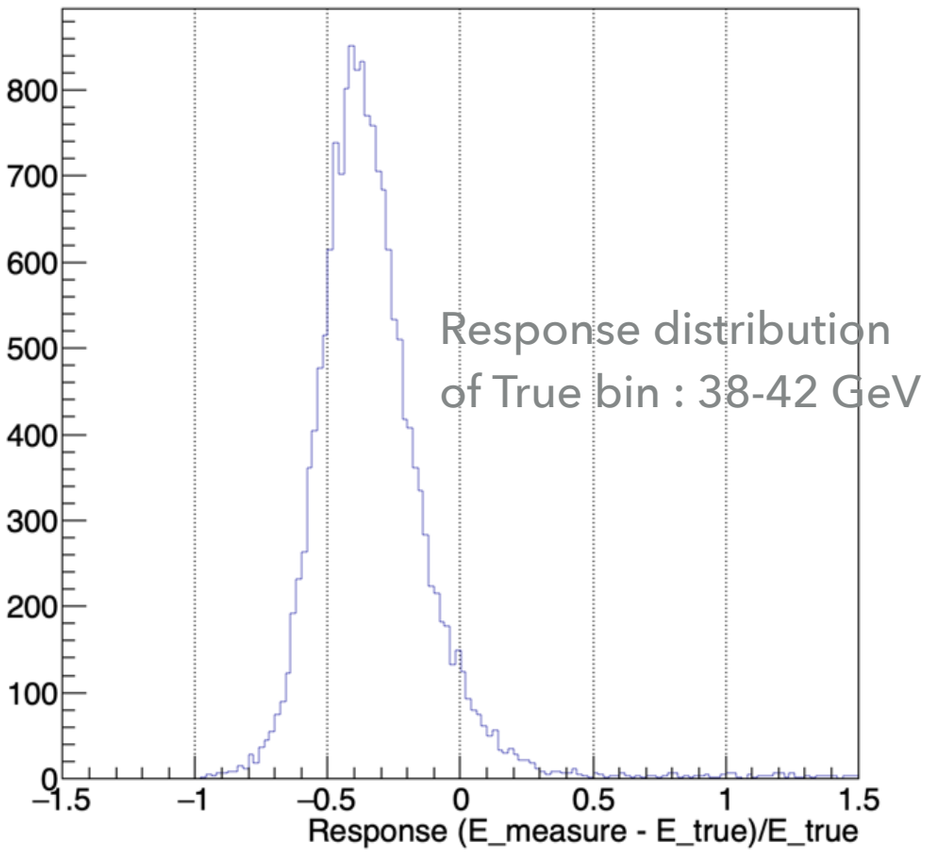
Introduction to the calibration procedure

- We privately generate π- sample in the energy range 0-200 GeV.
- Here, η and ϕ of the pions are the position at the ECAL entrance surface propagated through the tracker.
- Particles which do not start a nuclear interaction in ECAL, i.e., do not start a hadronic shower in ECAL are categorized as H hadrons.
- Those starting a shower in ECAL are called EH hadrons.
- Online(HLT) and offline(Reco) Jets use the same method.

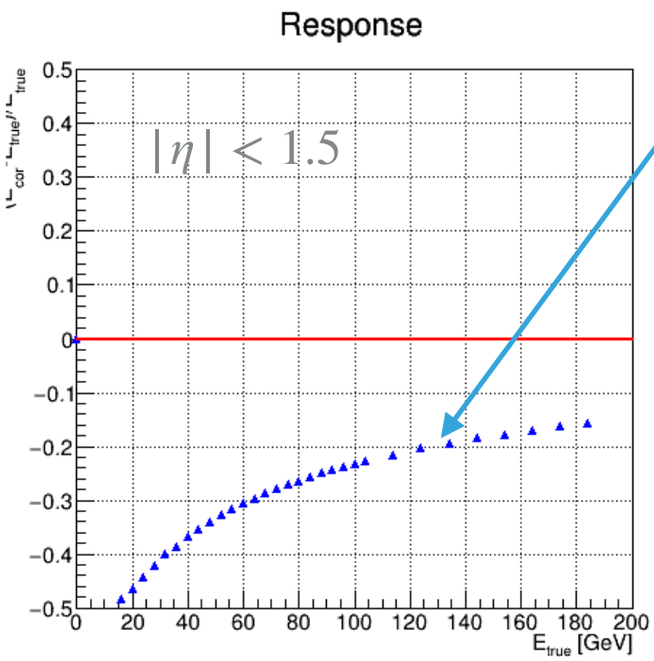


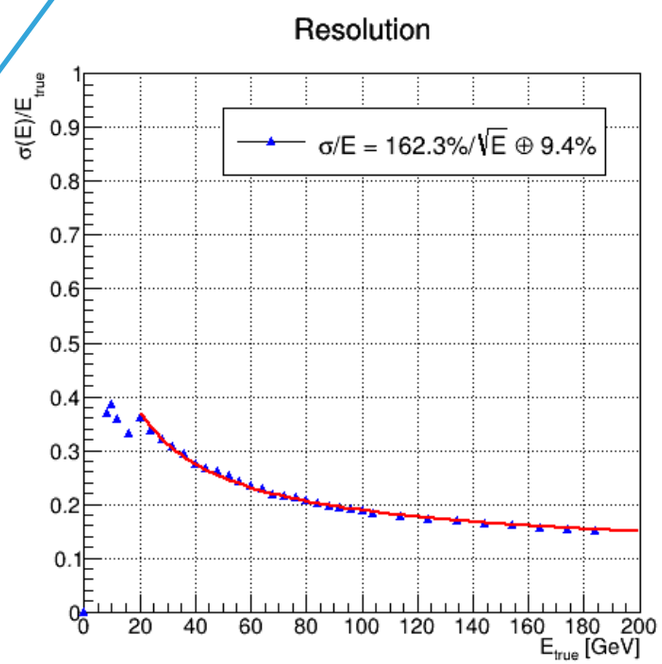
Calibration method

- Check the raw response distribution in the various E_{true} bins.
  - Response = $(E_{measure}-E_{true})/E_{true}$, $E_{measure} = E_{rawEcal} + E_{rawHcal}$
- Fit a gaussian function.
  - Gaussian mean and sigma ⇨ response(mean) and resolution(sigma/mean)



Response is non linear





Energy dependent correction

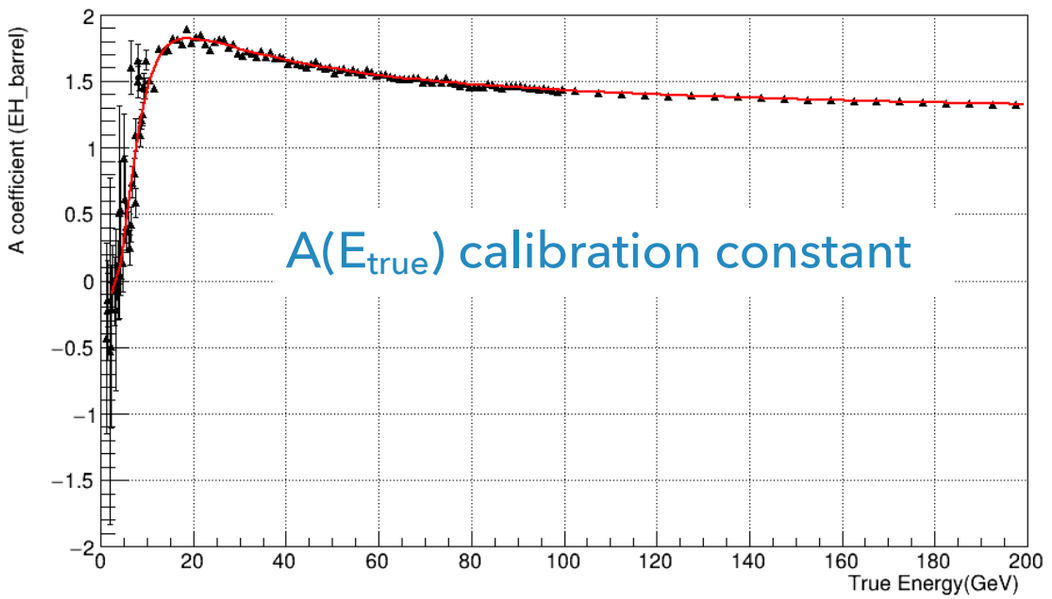
- Divide hadron into two categories:
  - EH: start their shower in ECAL
  - H: start their shower in HCAL
- For EH Hadrons:
  - $E_{corrected} = A(E_{true}) * E_{rawEcal} + B(E_{true}) * E_{rawHcal} + O_{EH}$; $O_{EH} = 3.5$ GeV
- For H Hadrons:
  - $E_{corrected} = C(E_{true}) * E_{rawHcal} + O_H$; $O_H = 2.5$ GeV
- These parameters are derived separately for Barrel region ($|\eta| < 1.5$), and EndCap region($1.5 < |\eta| < 3.0$)
- Apply these corrections on the raw ECAL & HCAL energies

To get A and B parameters, minimize χ^2 : defined as, for EH hadrons

$$\chi^2_{EH} = \sum_{hadrons} \left[\frac{E_{true} - E_{corr}}{\sigma\left(E_e + E_h\right)} \right]^2$$

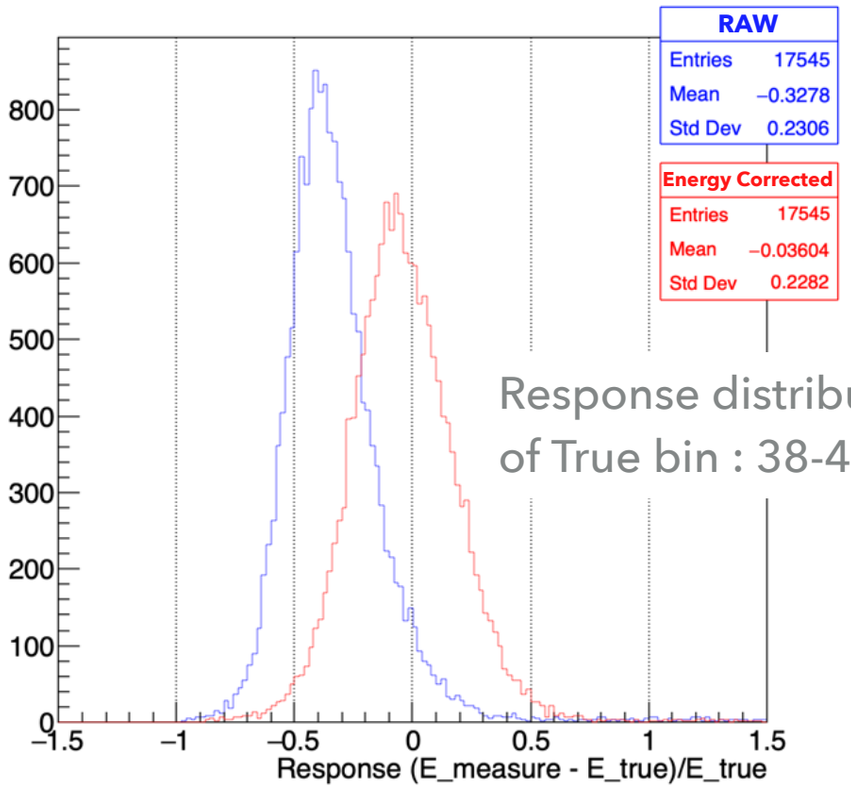
To get C parameters, minimize χ^2 : defined as, for H hadrons

$$\chi^2_{H} = \sum_{hadrons} \left[\frac{E_{true} - E_{corr}}{\sigma\left(E_h\right)} \right]^2$$



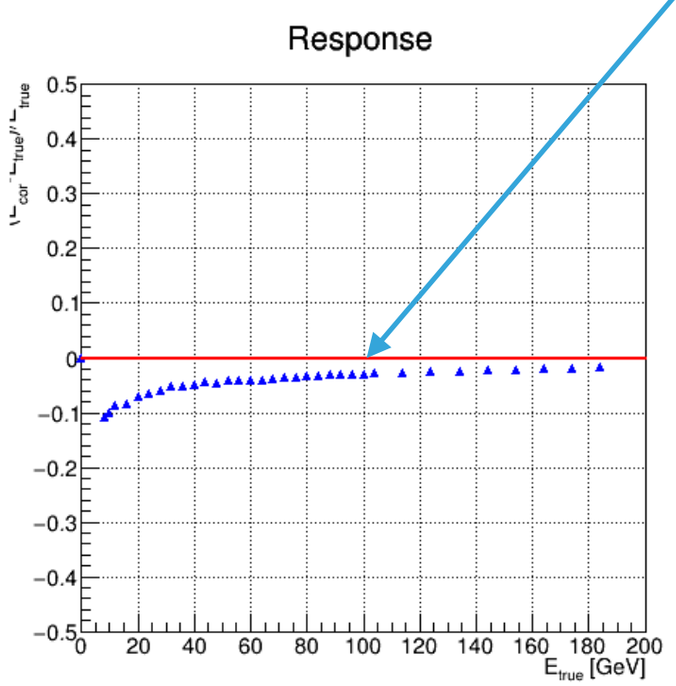
Energy dependent calibration in a nutshell

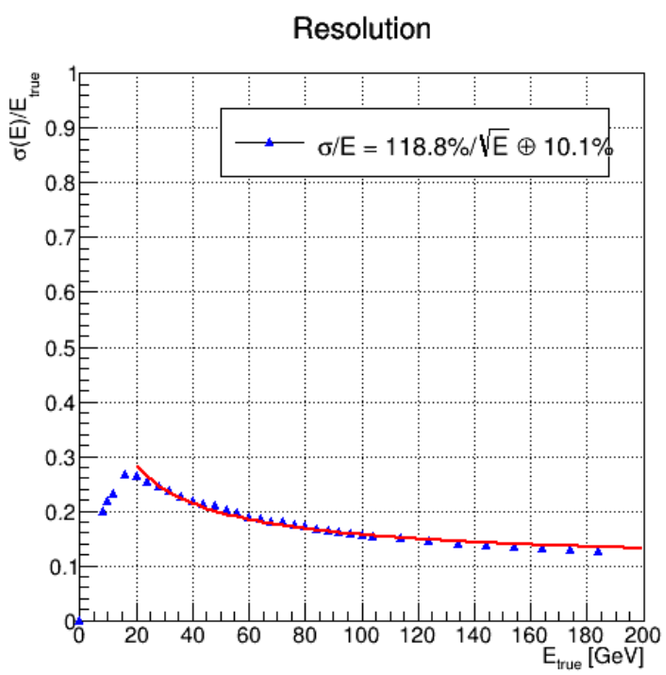
- Check the **Raw response ($E_{raw} = E_{rawEcal} + E_{rawHcal}$)** in the various E_{true} bins.
- And then define "**corrected response**" for each E_{true} bins
  - **EH hadrons** : $E_{corrected} = A(E_{true}) * E_{rawEcal} + B(E_{true}) * E_{rawHcal} + O_{EH}$
  - **H hadrons** : $E_{corrected} = C(E_{true}) * E_{rawHcal} + O_{H}$



Response distribution of True bin : 38-42 GeV

Restored response linearity but incomplete closure





Pseudorapidity dependent calibration in a nutshell

- After energy correction, look at the response as a function of η.
- Parametrize the η dependence.
- For EH hadrons in barrel, we use
  - $E^{\eta}_{corr} = \left(1 + \alpha\left(E_{true}\right) + \beta\left(E_{true}\right) * \left|\eta\right|^{2}\right) * E^{Energy-corrected}_{ecal} + E^{Energy-corrected}_{hcal}$
- Make eta dependent correction
  - using χ^2 minimization
  - Apply on top of Energy correction