Hadronic Energy Resolution: AHCAL & Complete CALICE Setup

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Idea to improve energy resolution

Hadronic showers:

- Electromagetic and hadronic components
- Fraction of electromagnetic and hadronic subshowers varies from event to event
- Higher signal of electromagentic subshower: $\frac{e}{\pi} > 1$

Idea to improve energy resolution:

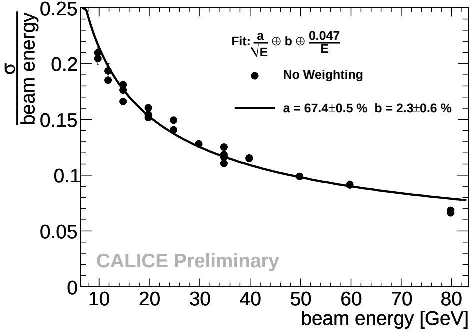
- Different weights for electromagnetic and hadronic shower components

How to distinguish:

- Electromagetic showers have higher energy density
  energy density $= \frac{MIPamplitude}{volume}$
- Stronger weighting of hadronic shower components

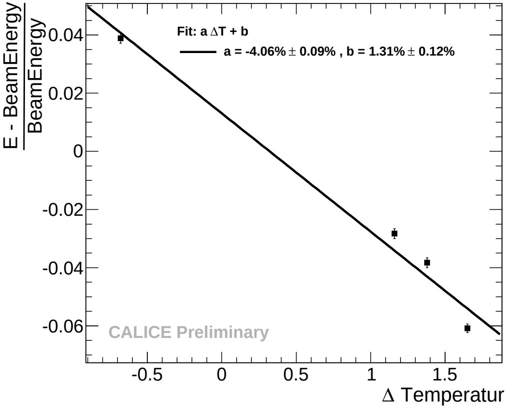
AHCAL only: energy resolution without weighting

- CERN beam time 2007
- only in AHCAL contained showers
  $ECAL_{MIP} < 200$
  $TCMT_{MIP} < 5$
- No weighting method:
  Use conversion factor of 0.03 to determine reconstructed energy in GeV and energy resolution



Temperature correction

- Response of SiPM changes for different temperatures
- Mean temperature differences of up to a few degrees

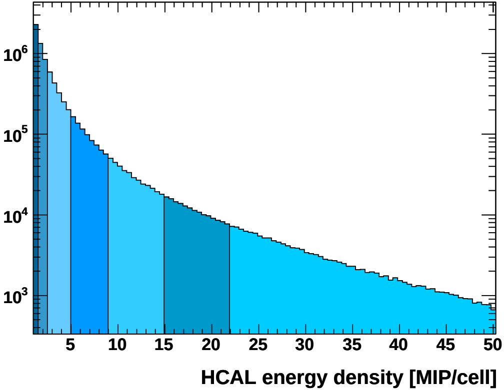


- Value of mean temperature slope also found in other measurements of temperature dependency studies
- Take mean temperature for all cells
- MIP amplitude correction for all cells due to mean temperature

Energy density - define weighting borders

Choose weighting sections:

- Calculate density for each cell
- Devide density spectrum in sections
- Each section gets one weighting parameter ω_i
- Every cell hit corresponds to one energy density $\rightarrow$ to one weight



Weighted energy:

- $E_{weighted} = \sum E_i \omega_i$

Individual weights

- Use MINUIT to find weights ω_i for each run with best χ^2
  $\chi^2 = \frac{1}{n_{events}} \sum_{events} \left(\sum_i E_i \cdot \omega_i - E_{deposited}\right)^2$
- Input: beam energy = $E_{deposited}$

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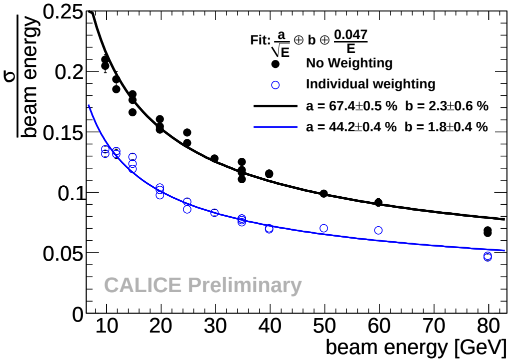


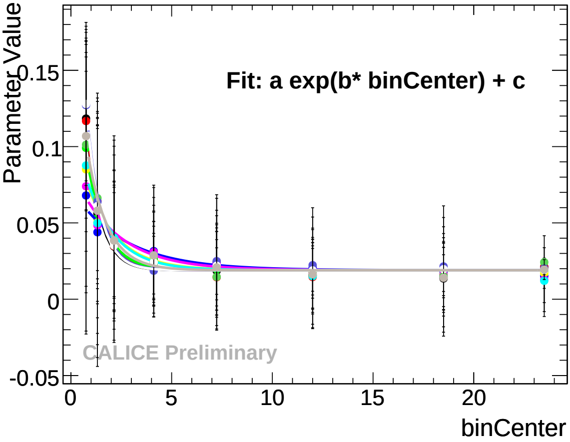
- In experiment the deposited energy is not known → cannot use this method
- Weights need to be energy dependent to fullfill linearity of reconstructed energy

Energy dependent weights

Weighting parametrisation: $\omega_i(x, E) = a(E) \cdot \exp\left(b(E) \cdot x_i\right) + c(E)$

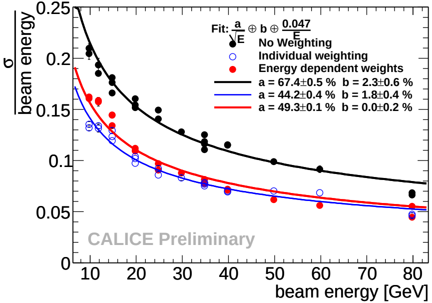
x_i center of energy density section i

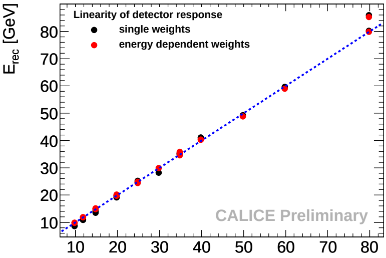
Input: reconstructed energies of not weighted method.

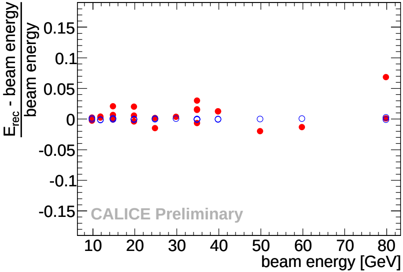


Energy dependent weights

Input: reconstructed energies of not weighted method (black points).

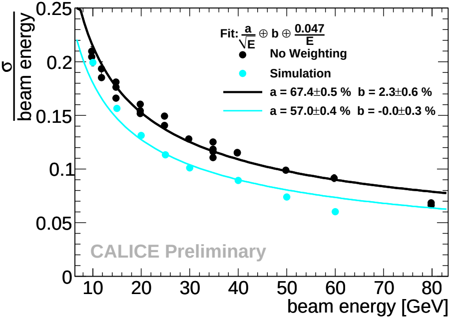


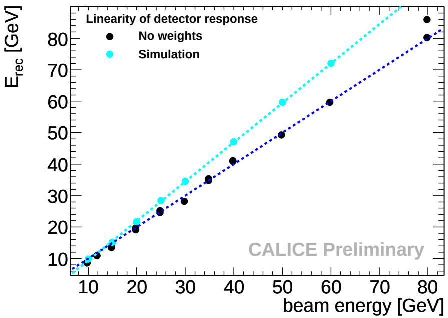




Simulation

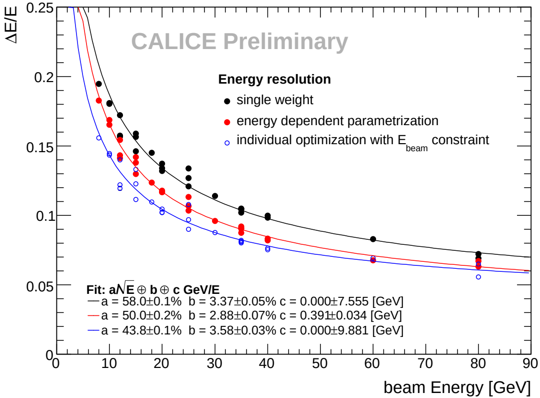
- No ECAL and TCMT information in digitization → different cuts for AHCAL contained showers
- No weighting applied for E_{rec} of simulation



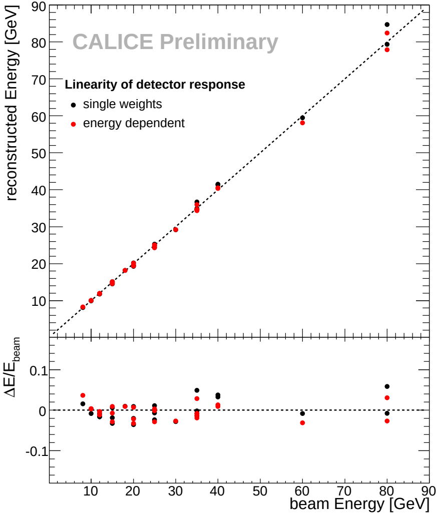


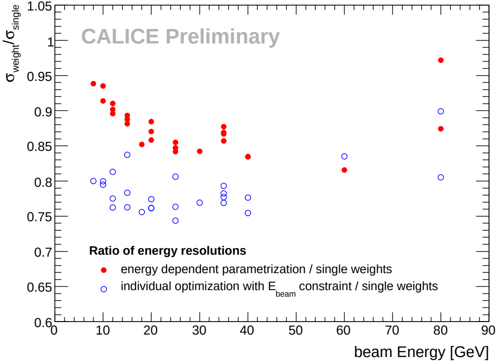
Complete Detector Setup

- Same method as with AHCAL only, without temperature correction
- Single weights/conversion factors:
  $\mathrm{ECAL} = 0.0083 \cdot (1; 1.12; 1.63)$, $\mathrm{AHCAL} = 0.029$,
  $\mathrm{TCMT} = 0.034 \cdot (1; 4.55)$



Complete Detector Setup





Summary / Outlook

Summary

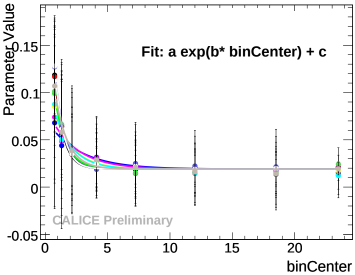
- Weighting methods works well for Analog HCAL and Complete Setup
- Linearity of reconstructed energy is given

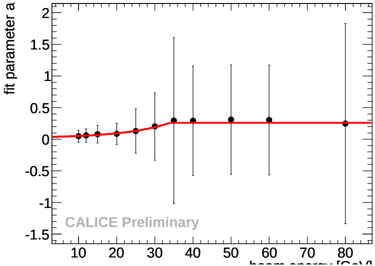
Outlook

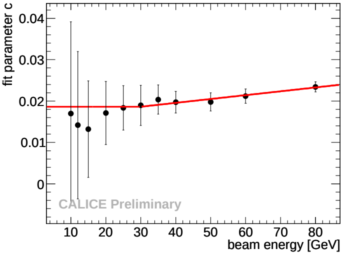
- Further comparsion with simulation
- Extend method on clusters in CALICE setup
- Try to apply method in full ILC detector, also at energies above 1TeV
- Analysis note in preparation for presentation of results at TIPP

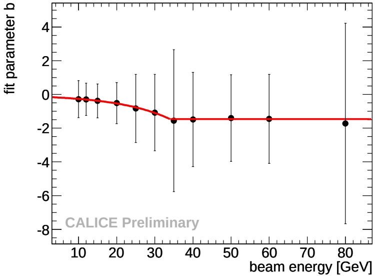
Backup slides

Energy dependent weights HCAL

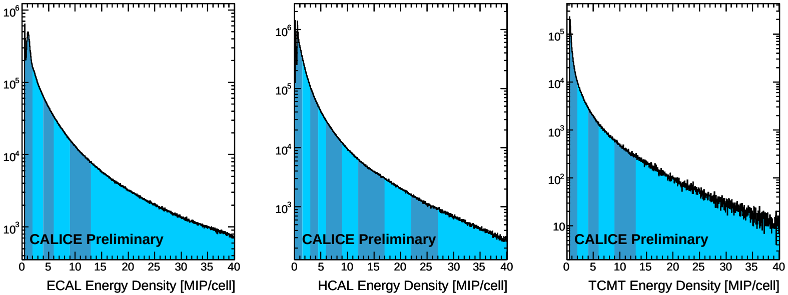




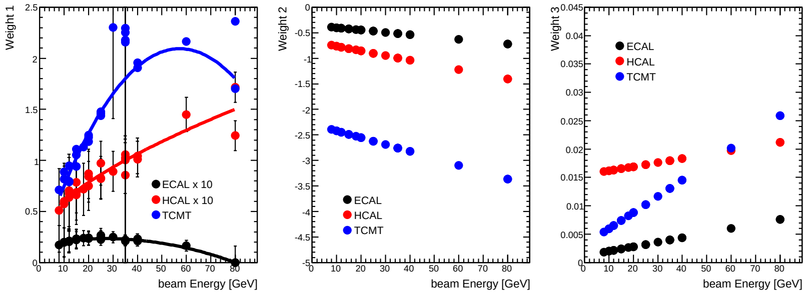




Energy Density - Complete Setup



Energy dependent weights - Complete Setup



Energy Distributions - Complete Setup