Energy reconstruction in the combined SiW/AHCAL/TCMT system

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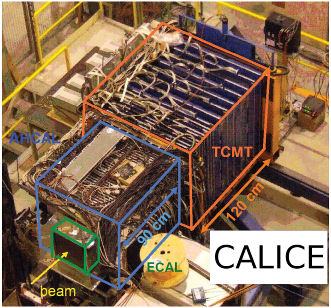
Outline:

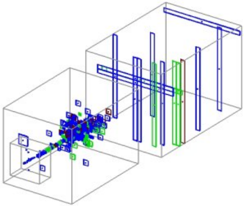


Introduction :

The goal :
Redo the analysis for the complete CALICE prototype from CAN – 15 with up to date calibration and improve further!

The analysis:

- Energy reconstruction for full CALICE setup at Cern in 2007
- SiW ECal+AHCAL+TCMT
  ⇒One weight per Detector("default energy reconstruction")
  ⇒Local software compensation to improve resolution



Individual weights :

Preparation:

- Merge pion TB data of same energy (as done for AHCal paper)
- Cuts: Based on primary track finder and hadron selection processors

Conversion factor MIP $\Rightarrow$ GeV (weights)

Use TMinuit to obtain weights

$$\chi^2 = \sum_{events} \left(\sum_{ECalhits} E_{hit}\omega_{ECal} + \sum_{AHCalhits} E_{hit}\omega_{AHCal} + \sum_{TCMThits} E_{hit}\omega_{TCMT} - E_{beam} \right)^2$$

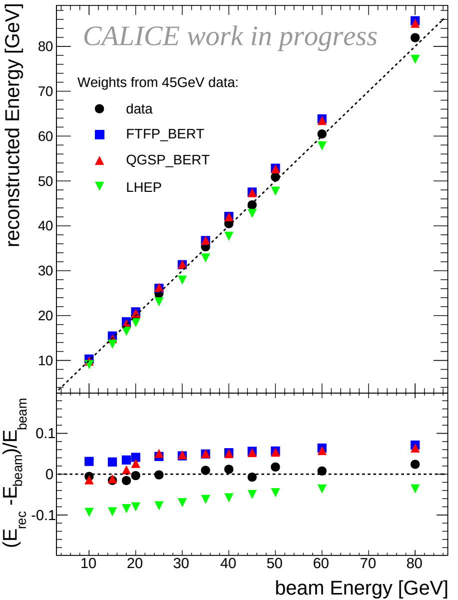
$\rightarrow$ In ECal and TCMT: MIP energy multiplied by absorber Thickness(1,2,3 ECal, 1,5 TCMT)

Individual weights:

- Weights calculated for 45 GeV data

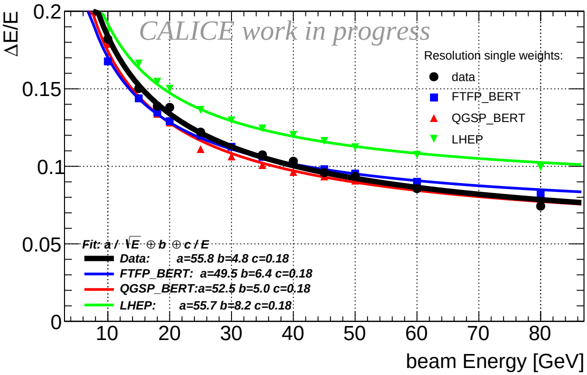
ECal	0.00479	$\frac{GeV}{MIP}$
AHCal	0.0288	$\frac{GeV}{MIP}$
TCMT	0.0267	$\frac{GeV}{MIP}$

- Than applied to full data and MC
- Geant4-9-4p03



Results :

- Very robust
- **Good estimate of the energy**
- CAN-15: a=61.3, b=2.54
- Now: a=55.8, b=4.8

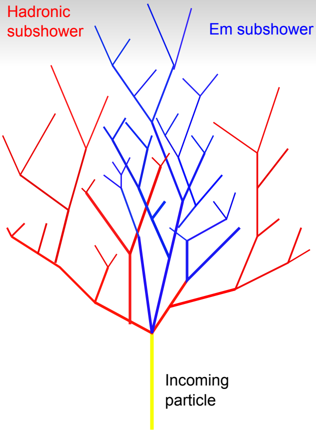


Improve resolution?

⇒ **Local Software Compensation**

Local software compensation:

- Em and hadronic subshowers have different energy densities
- Classify hit by energy density

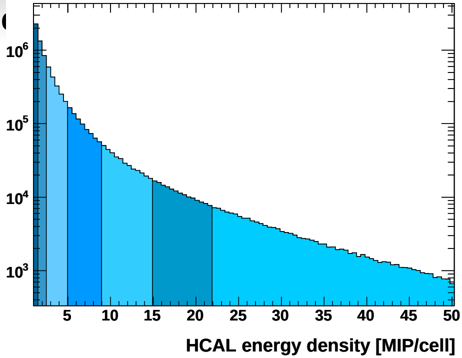


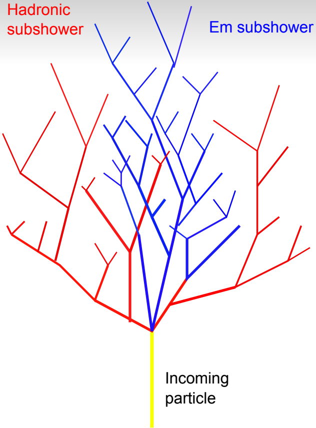
Use TMinuit to obtain weights

$$\chi^2 = \sum_{events} \left(\sum_{hits} E_{hit}\omega_j - E_{beam} \right)^2$$

j=Density bin index

L





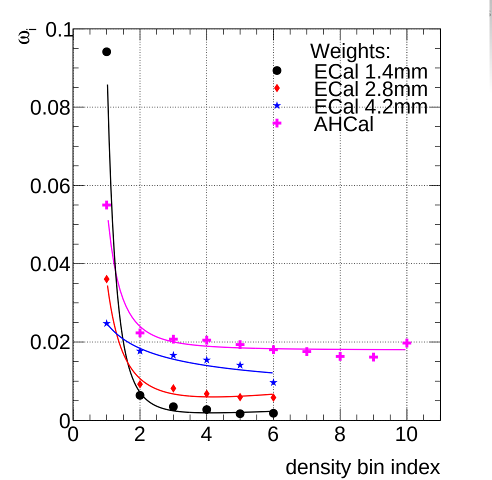
Use TMinuit to obtain weights

$$\chi^2 = \sum_{events} \left(\sum_{hits} E_{hit}\omega_j - E_{beam} \right)^2$$

j=Density bin index

Local software compens

- TCMT energy calculated with constant weight
- Low energy density
  ⇒ More likely hadronic
  ⇒ Higher weight!
- Smooth curve



Change to

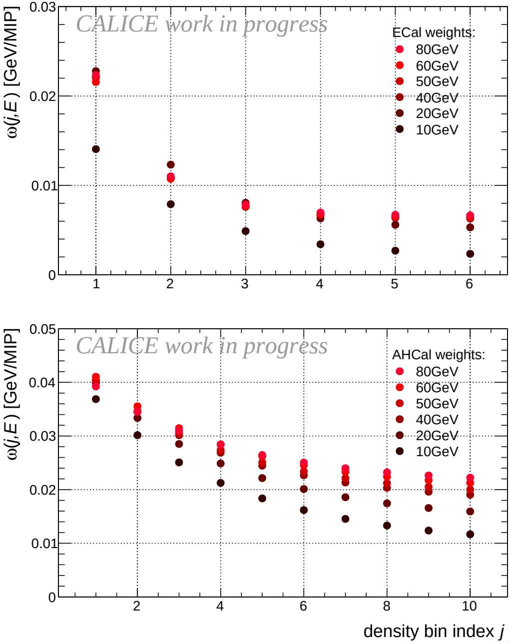
$$\chi^2 = \sum_{events} \left(\sum_{hits} E_{hit} (p_1 Exp^{(p_2 * j)} + p_3) - E_{beam} \right)^2$$

j=Density bin index

Weights:

- **Weights change with beam energy**
- $\omega(j, E) = p_1(E)Exp^{(p_2(\mathbf{E})*\mathbf{j})} + p_3(E)$

Parameterization needed!



Parameterization:

Iterative procedure :

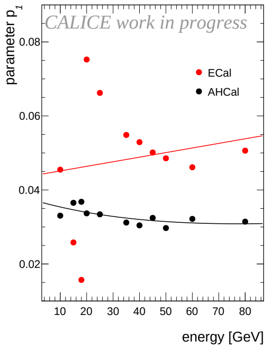
1. Minimize
2. Fix parameter 3
3. Minimize
4. Fix parameter 2
5. Minimize

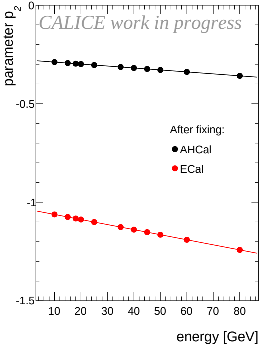
For now :

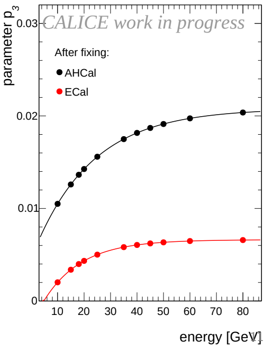
- $p_1(E) = c_1 + E * c_2 + c_3 * Exp^{c_4 * E}$
- $p_2(E) = b_1 * E + b_2$
- $p_3(E) = a_1 * (1 - Exp^{a_2 * E}) + a_3$

(based on AHCal SC paper)

$\Rightarrow$ obvious problem in ECal







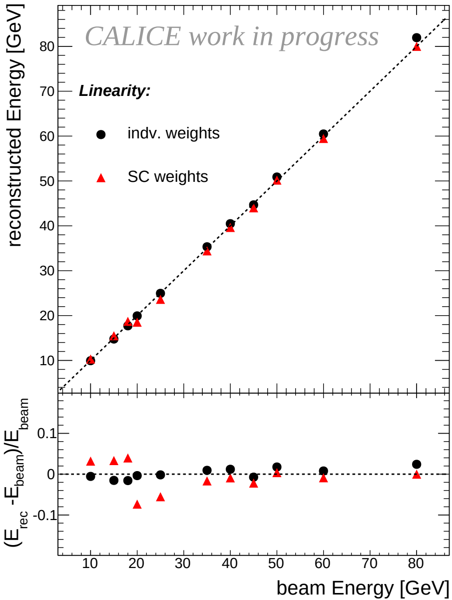
Reconstruced Energy :

Ind.weights + SC :

- Reconstruct event using ind. weights
  $\rightarrow$ Energy
- Use to choose SC weights
  $\rightarrow$ Resolution
- Reconstruct event!

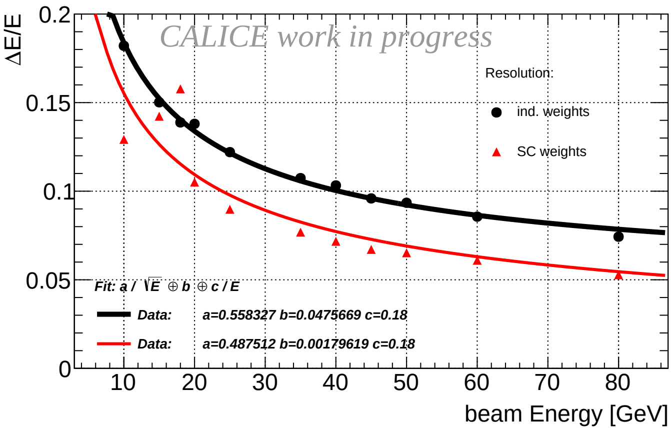
Minimization instability

- Minuit messes up
- Highly dependent on right starting values
- For parameters clean fit in every iteration needed



Resolution :

- SC improve resolution
- Problems for certain energies(15,18)

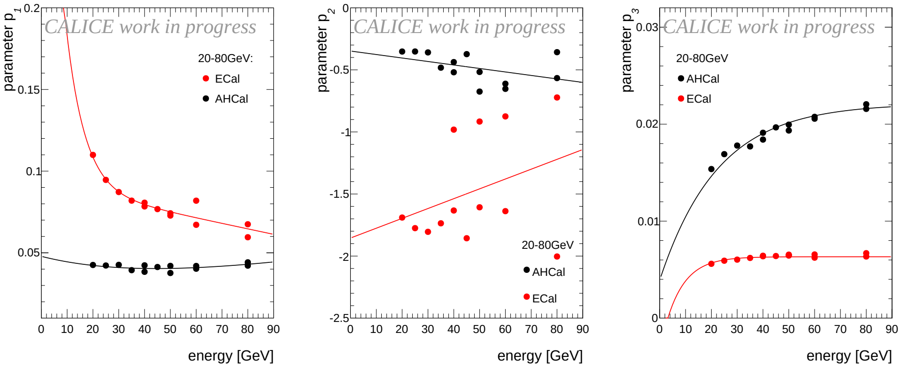


Increased stability needed!

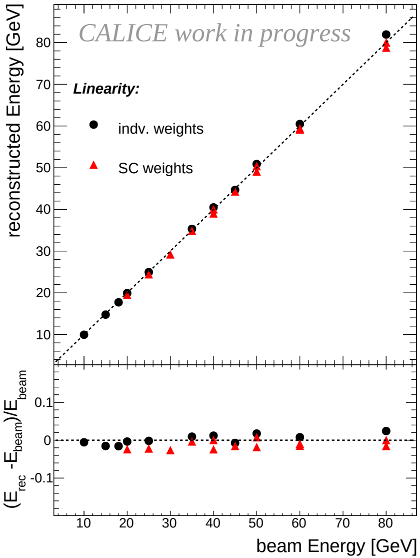
20-80GeV:

Here parameters before fixing:

- Good behavior
- Reasonable fits

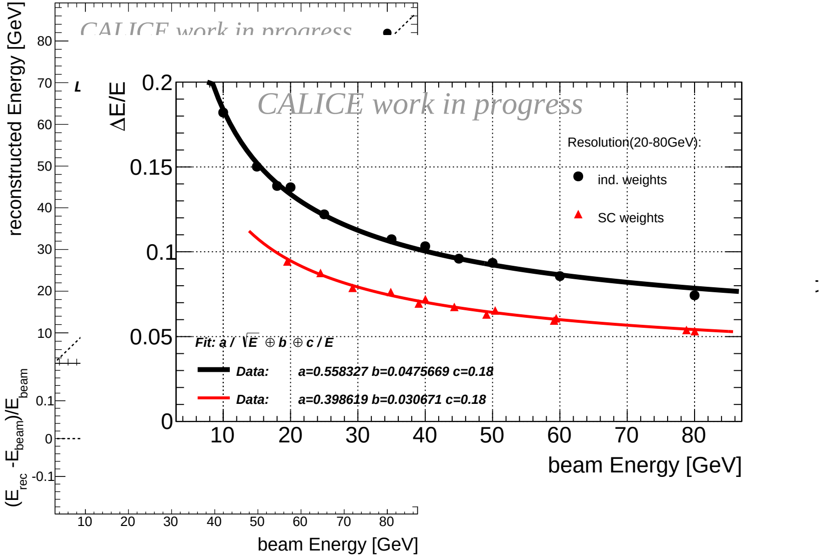


20-80GeV:



- Good linearity
- At high energies improvement over individual weights

20-80GeV:


CALICE work in progress
reconstructed Energy [GeV]
$(E_{rec}-E_{beam})/E_{beam}$
beam Energy [GeV]
ΔE/E
CALICE work in progress
Resolution(20-80GeV):
ind. weights
SC weights
Fit: a / √E ⊕ b ⊕ c / E
Data: a=0.558327 b=0.0475669 c=0.18
Data: a=0.398619 b=0.030671 c=0.18
beam Energy [GeV]

Summary :

- Individual weights as a robust energy independent reconstruction
- Utilization of SC compensation enhances resolution
- Major source of problems for SC is Minuit minimization

To do :

- Investigate behavior of weights in more detail
- Increase stability
- Investigate extension to TCMT, study potential improvements
- SC for MCs

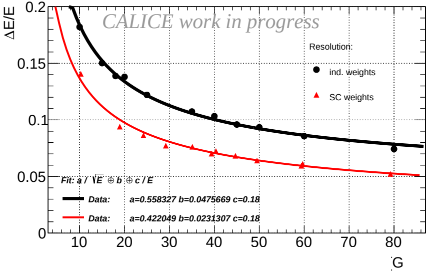
Backup

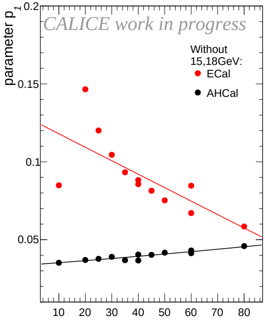
Run list from CAN-35:

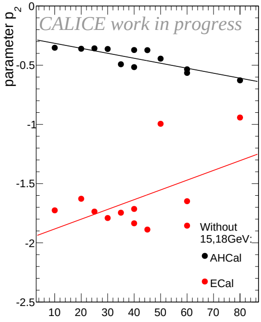
Table : List of used data runs.

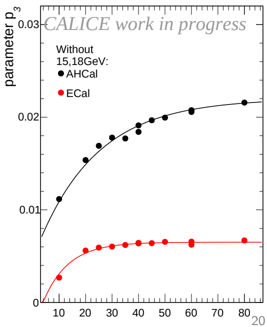
run number	particle type	beam energy, GeV	run number	particle type	beam energy, GeV
330332	π^-	10	330550	π^-	45
330643	π^-	10	330559	π^-	45
330777	π^-	10	330961	π^-	45
330850	π^-	10	330391	π^-	50
330328	π^-	15	330558	π^-	50
330327	π^-	18	331335	π^+	50
330649	π^-	20	331282	π^+	60
330771	π^-	20	331333	π^+	60
330325	π^-	25	331334	π^+	60
330650	π^-	25	331556	π^-	60
331298	π^+	30	331568	π^-	60
331340	π^+	30	331655	π^-	60
330551	π^-	35	331664	π^-	60
330960	π^-	35	330392	π^-	80
330390	π^-	40	330962	π^-	80
330412	π^-	40	331280	π^+	80
330560	π^-	40	331324	π^+	80
331338	π^+	40	331554	π^-	80
331339	π^+	40	331567	π^-	80
			331654	π^-	80

Results without 15GeV, 18GeV:









Results(10-30GeV):