CALICE Digital Hadron Calorimeter: Calibration and Response to Pions

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On Behalf of the CALICE Collaboration

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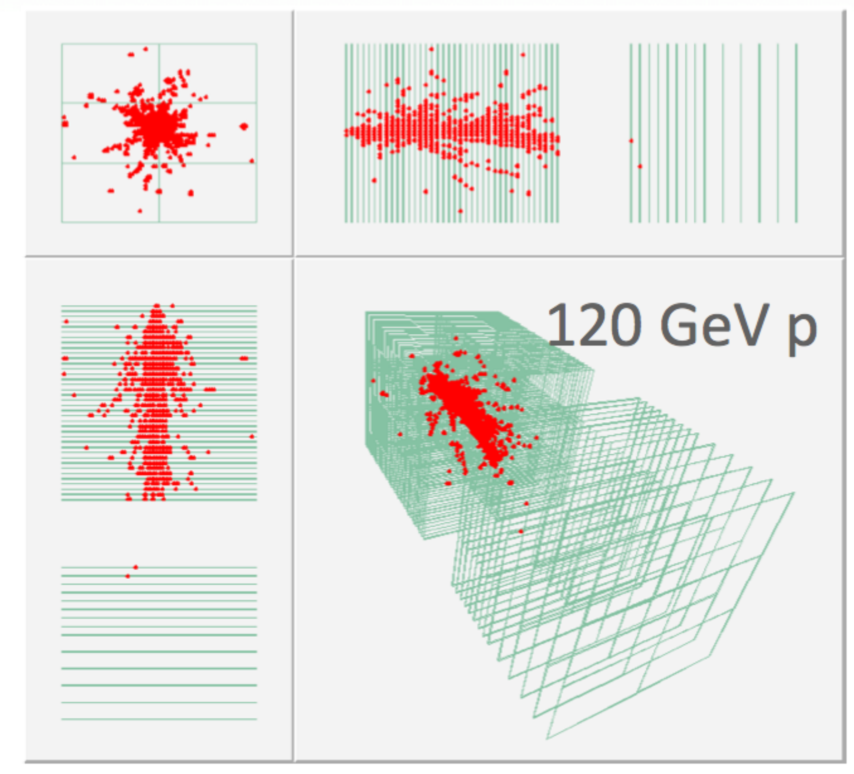
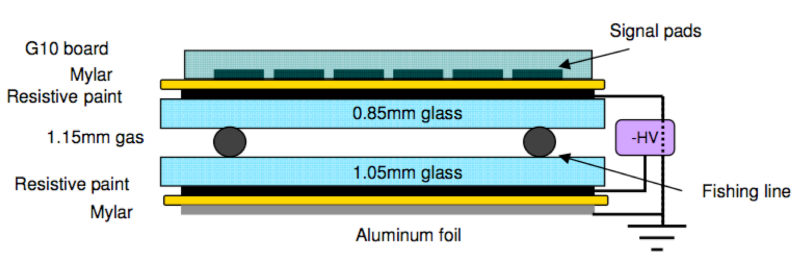
Concept of the DHCAL

- Imaging hadron calorimeter optimized for use with PFAs
- 1-bit (digital) readout
- 1 x 1 cm^2 pads read out individually (embedded into calorimeter!)
- Resistive Plate Chambers (RPCs) as active elements, between steel/tungsten

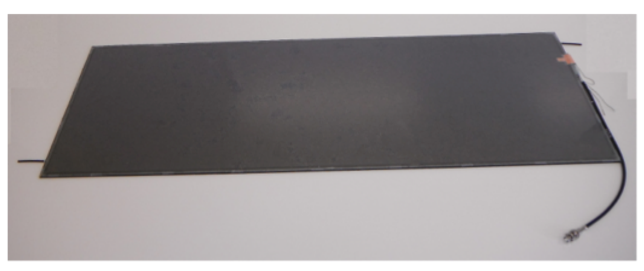
- Each layer with an area of ~ 1 x 1 m^2 is read out by 96 x 96 pads.
- The DHCAL prototype has up to 54 layers including the tail catcher (TCMT) ~ 0.5 M readout channels (world record in calorimetry!)



DHCAL Construction

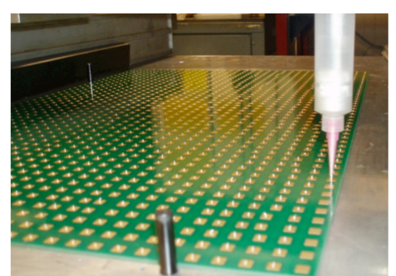


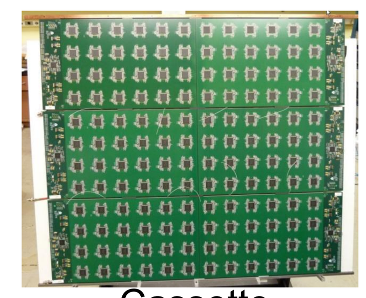
Sketch of the 2-glass RPC

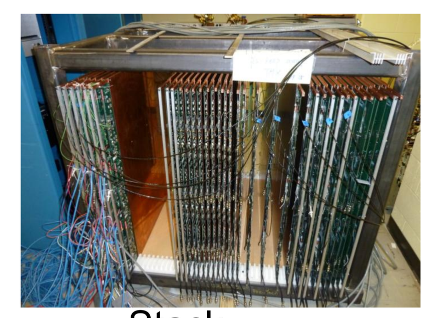

Assembled RPC

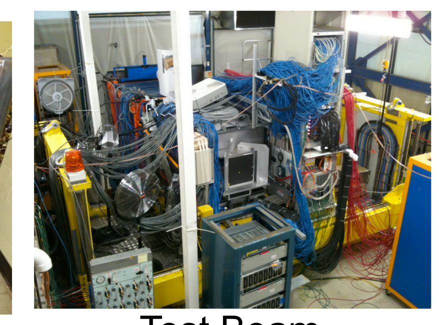

Pad Board

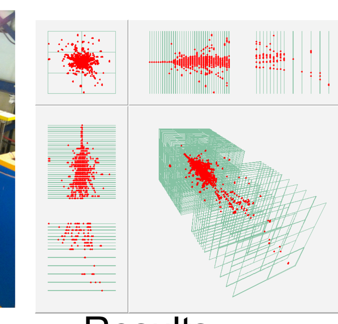

Readout Board


Gluing Machine


Cassette


Stack


Test Beam


Results

Calibration/Performance Parameters

DHCAL Data

Event:
Time stamp, Čerenkov/muon tagger bits

Hit:
x, y, z, time stamp

Cluster:
Nearest neighbor clustering
Combine hits with a common edge

Efficiency (ε) and pad multiplicity (μ)

Track Fits:
- specifically for muon calibration runs
- Identify a muon track that traverse the stack with no identified interaction
- Measure all layers

Track Segment Fits:
- for online calibration
- Identify a track segment of four layers with aligned clusters within 3 cm
- Measure only one layer (if possible)

- Fit to the parametric line: $x=x_0+a_xt$; $y=y_0+a_yt$; z=t

A cluster is found in the measurement layer within 2 cm of the fit point?

Yes	ε=1 μ=size of the found cluster
No	ε=0 No μ measurement

Calibration Procedures

0. RPC performance

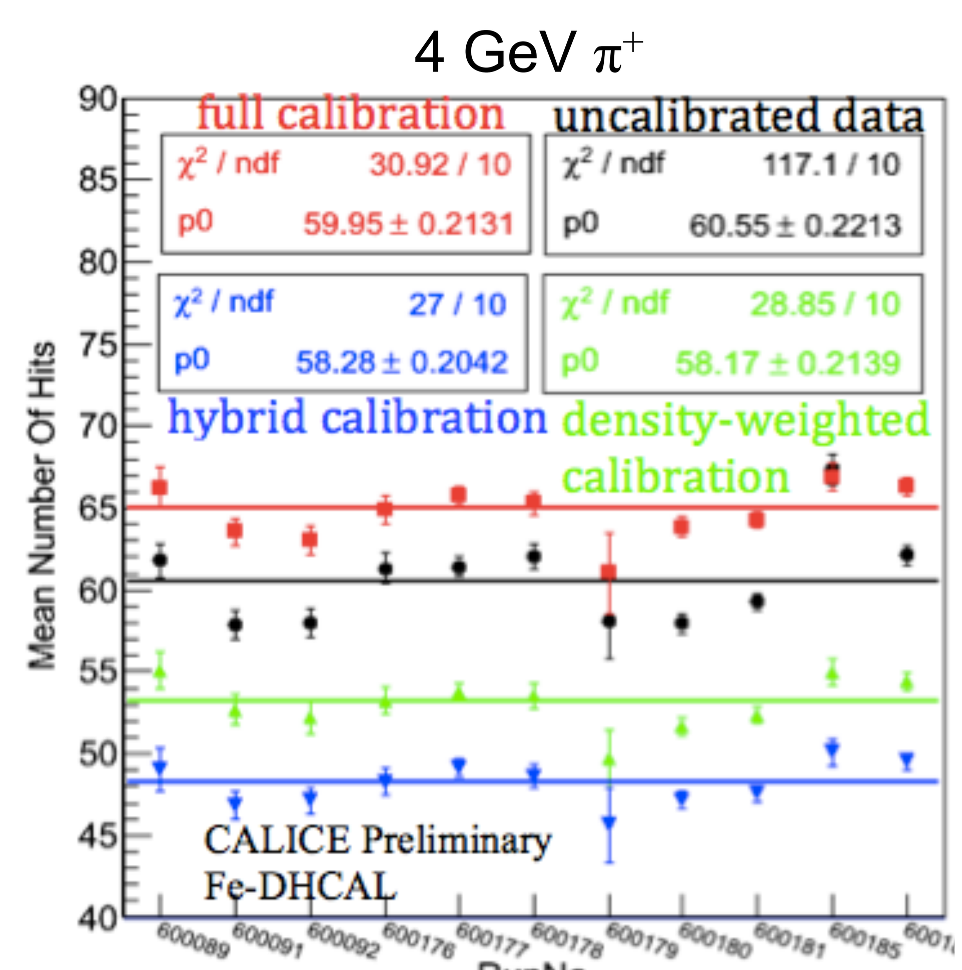
Average efficiency to detect MIP: $\varepsilon_0 \sim 96\%$

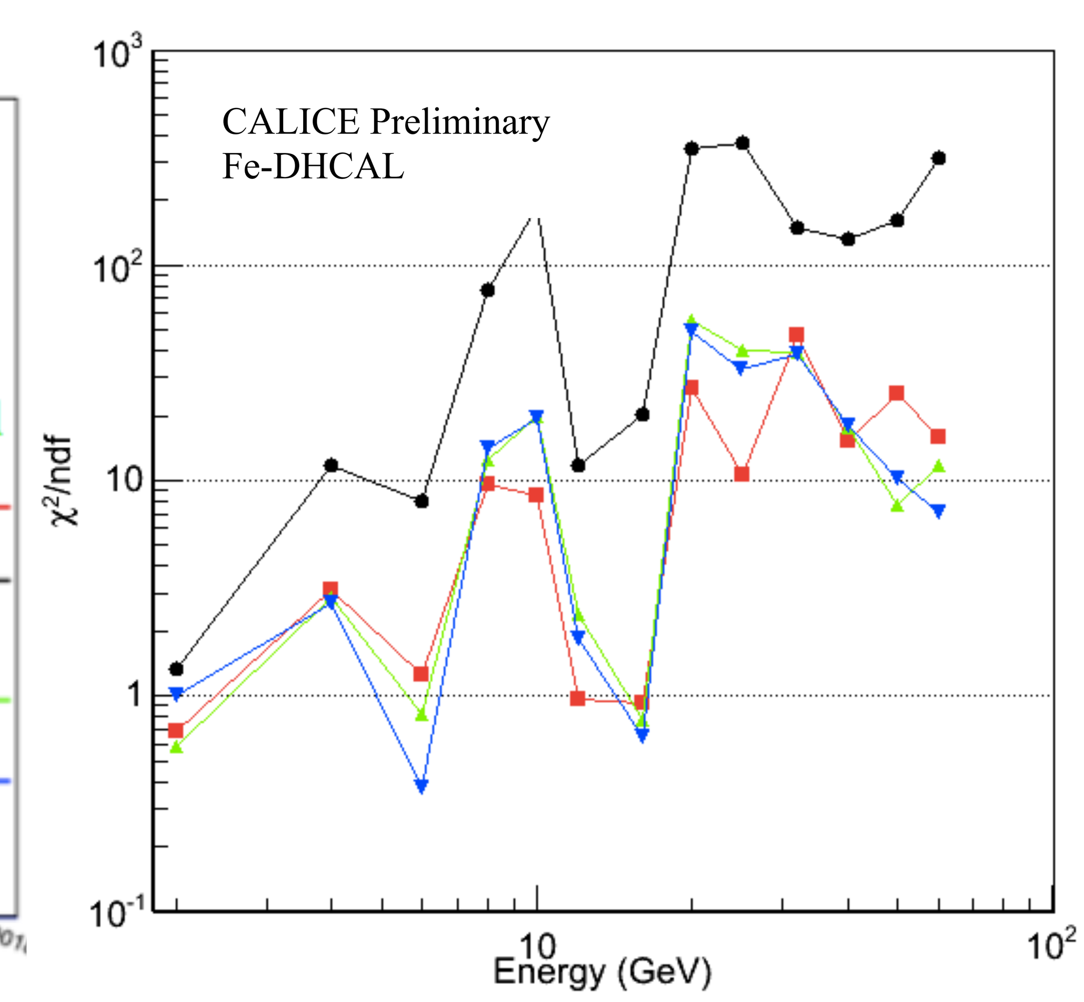
Average pad multiplicity: $\mu_0 \sim 1.6$

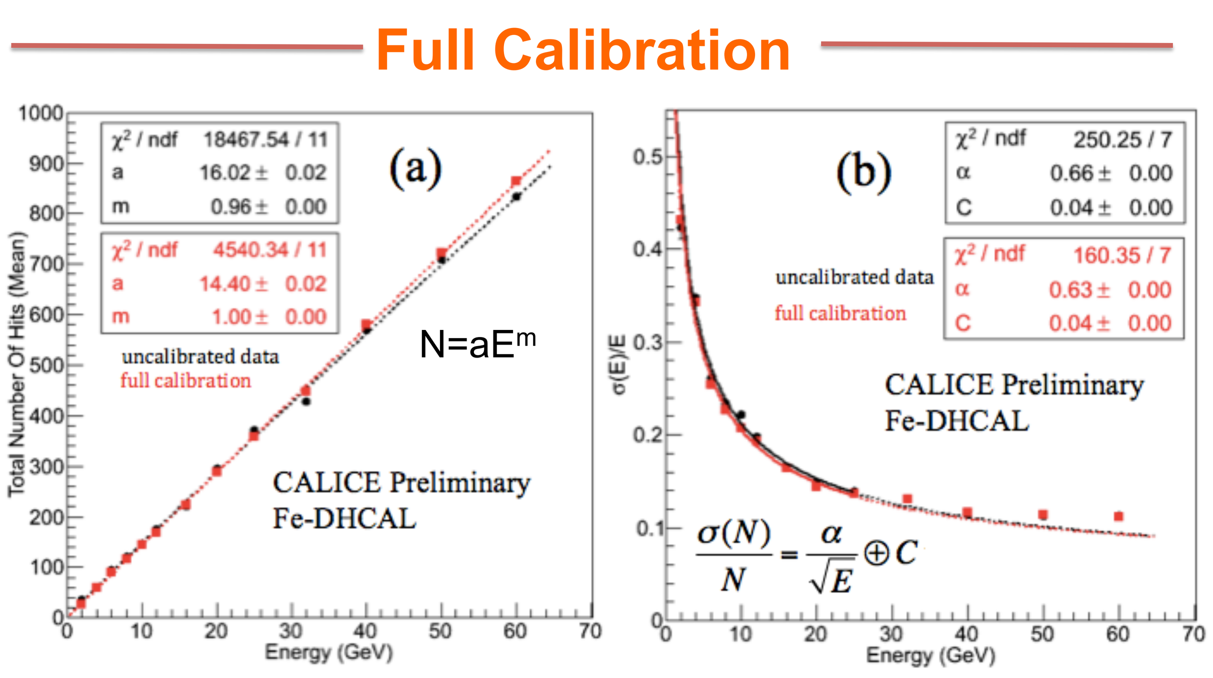
1. Full Calibration: $H_{calibrated} = \sum_{i=RPC_0}^{RPC_n} \frac{\varepsilon_0 \mu_0}{\varepsilon_i \mu_i} H_i$ H_i: Number of hits in layer i

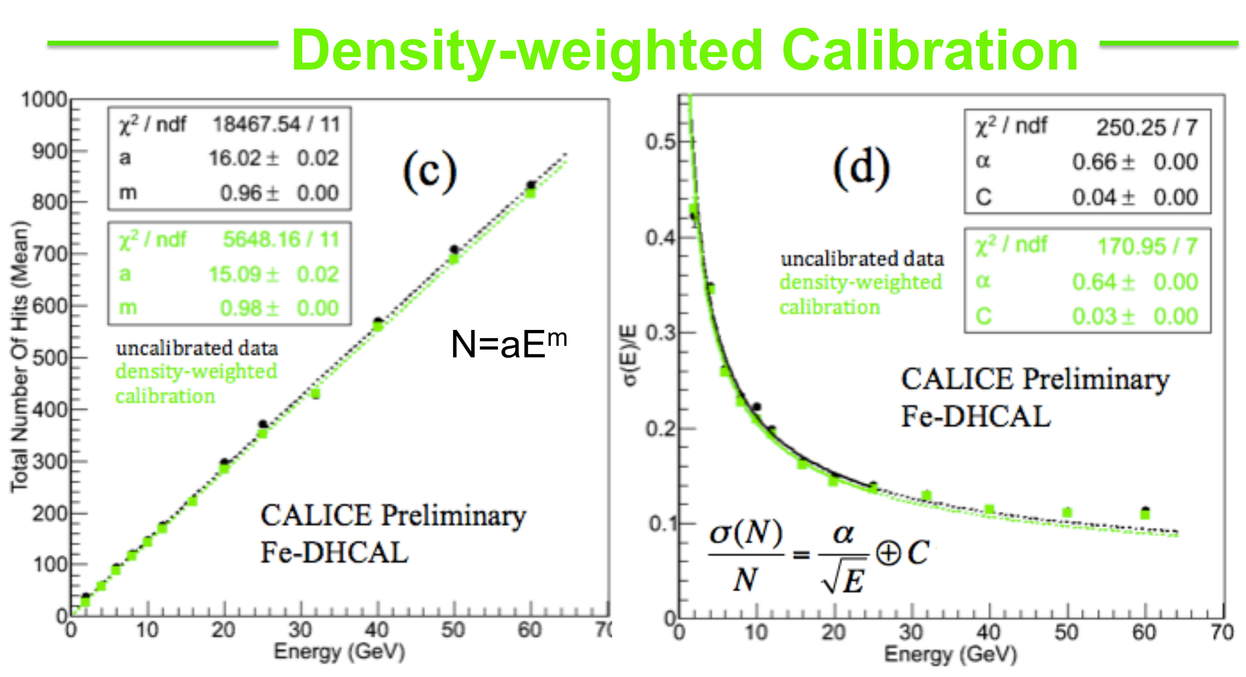
2. Density-weighted Calibration: Developed due to the fact that a pad will fire if it gets contribution from multiple traversing particles regardless of the efficiency of this RPC. Hence, the full calibration will overcorrect. Classifies hits in density bins (number of neighbors in a 3 x 3 array).

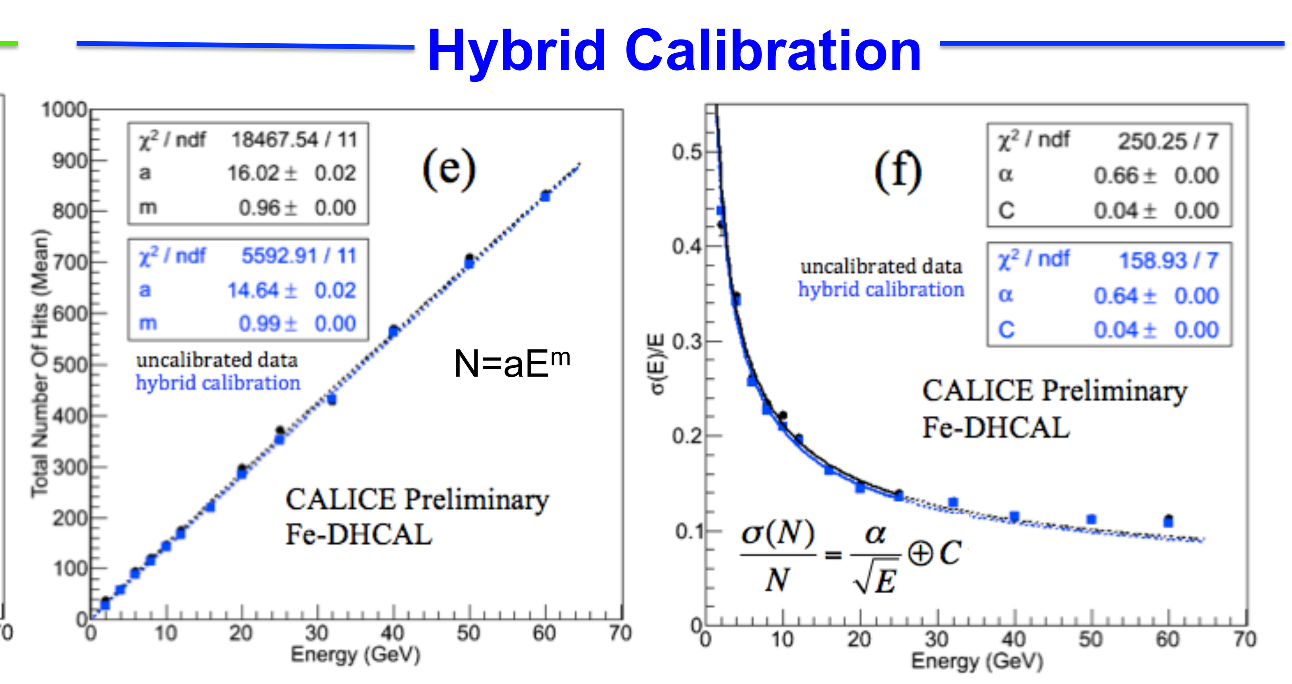
3. Hybrid Calibration: Density bins 0 and 1 receive full calibration.











Uncalibrated response: 4% saturation

Full calibration: Perfectly linear up to 60 GeV (in contradiction to MC predictions)

Density- weighted calibration/Hybrid calibration: 1 – 2% saturation (in agreement with predictions)

Calibration: Improves results

Monte Carlo prediction: Around 58%/√E with negligible constant term

Saturation at higher energies: → Leveling off of resolution

DHCAL concept is validated both technically and from the physics point of view!

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