Hadron Calorimeter Calibration

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Hadron Calorimeter Introduction

The hadron calorimeter used in E907 is an 8 cell sampling calorimeter, originally used for beam line triggering in HyperCP (FNAL E871).

- The calorimeter is positioned to be beam left/right symmetric
- There are 4 detection planes along the z-axis of roughly equal sampling fractions
- Each cell is readout by a single phototube and digitized by custom 14bit ADCs
- Two scintillator paddles are positioned after the last beam left/right cells to allow for “muon” detection and calibration

Hadron Calorimeter

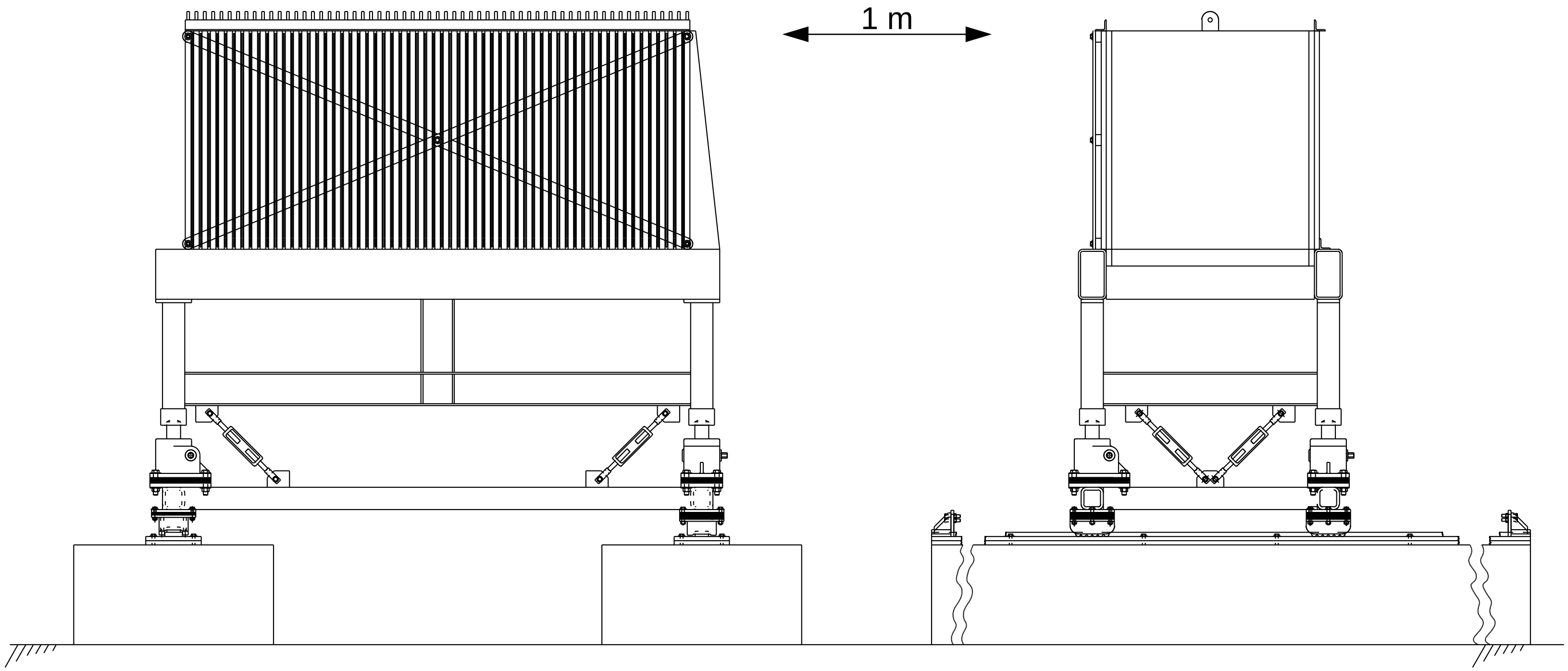
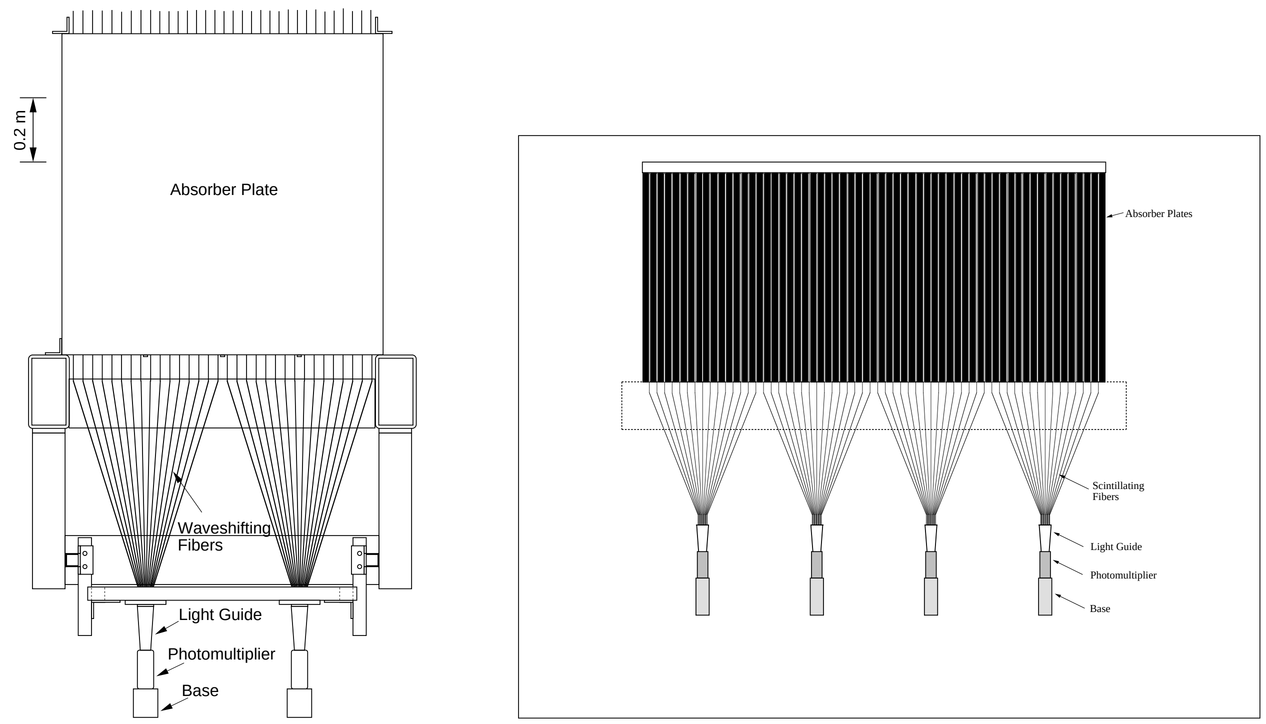


FIG. 1: Hadron Calorimeter



(a) Front (b) Side

FIG. 2: Hadron Calorimeter fiber optic readouts

Calorimeter Notes

There are a few things to remember about the calorimeter

- The calorimeter was originally designed for high speed triggering, not precise energy resolution
- The E&M calorimeter constitutes ≈ 1 radiation length and acts as a converter/pre-shower for electromagnetic and hadronic particles
- The calorimeter is not hermetic and can not be considered to fully contain the showers in X or Y
- The calorimeter is not finely segmented, so there is no localized showering for detection of multiple neutrals etc...

Pedestal Calibrations

The 14-bit ADCs used for the digitization of the calorimeter signals exhibit standard, narrow pedestals.

- The pedestals do exhibit drift over time.
- The pedestal drift is primarily temperature related and has been correlated with cooling failures, seasonal variations, and daily variations
- Pedestal data is obtained through the out of spill calibration triggers, and as such can be determined on a run by run, subrun by subrun and even a spill by spill basis

HCal Calibration Software

Analysis routines for the Hadron calorimeter are available in multiple forms

- A small fast analysis package Hcal_Analysis runs off raw data and produces Hbook style histograms and Ntuples. This is a stand alone package dating back to Feb ’04 and includes KUMACs for pedestals fits, gain calibrations etc...
- Calorimeter pedestals and energy sums are calculated real time as part of the standard online software (see the HCal online monitor page)
- For the official offline software there is the HCalReco package which extracts standard pedestals, performs inter-run pedestal drift calculations, and stores all the pedestal information in the standard database tables.

Pedestal Examples

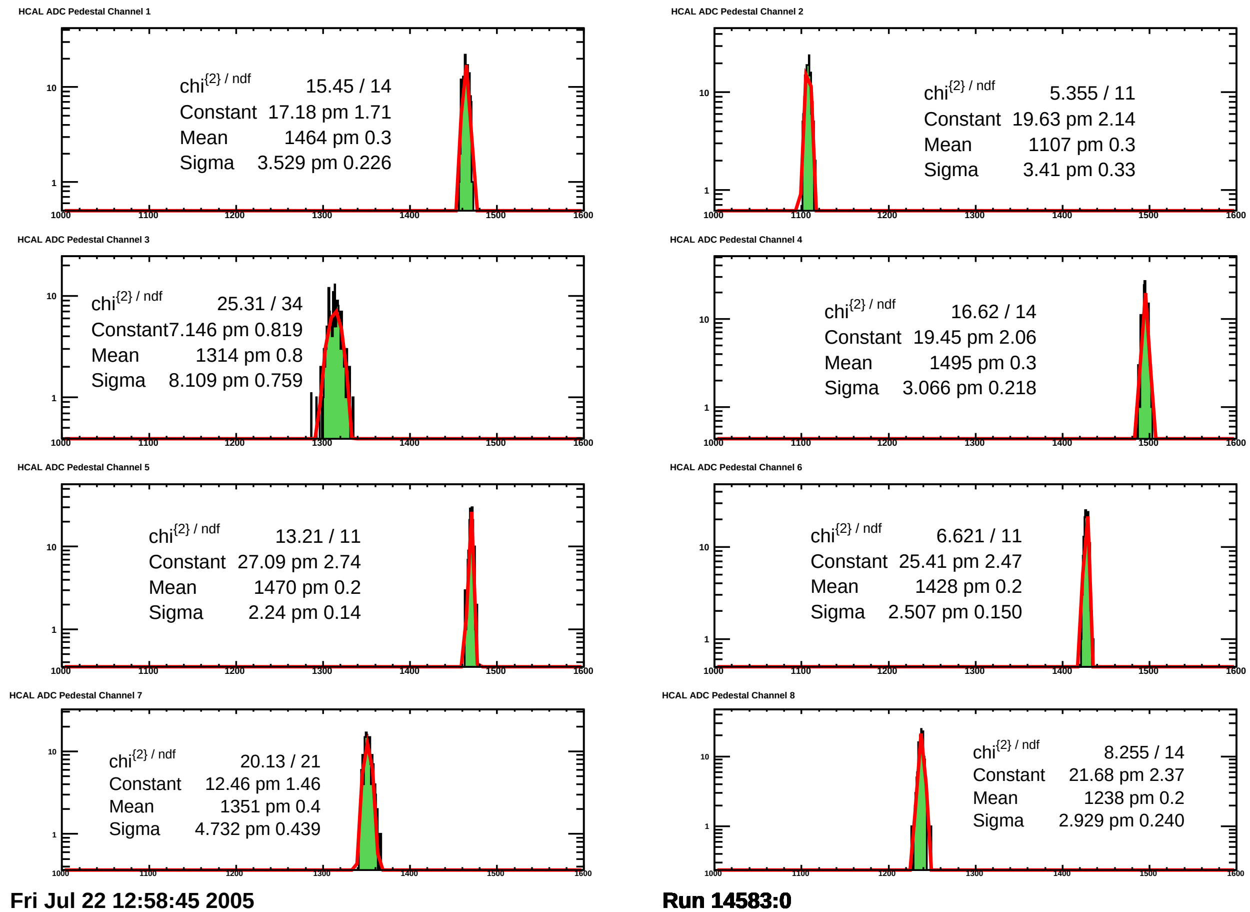


FIG. 3: Example Calorimeter Pedestals (Run 14583-1)

Gain Calibrations

Channel to channel gain variations were examined using various forms of muon identification.

- Muon paddles are latched and included in the diagnostics latch word (which includes the spill gate information) and are available at all energy scales
- Incident tagged muons were recorded in special runs – 13916, 13919, 13205 (5GeV/c)
- Channel to channel gains were optimized and equalized to place the minimum ionizing peaks from the tagged muons at roughly 80 channels over pedestal on each channel.
- Fine tuning of the channel to channel gain calibration is done in software over the muon samples and separately by minimizing the widths of the ADC sum from the PID beam tracks across the available running momenta.

Gain Calibrations

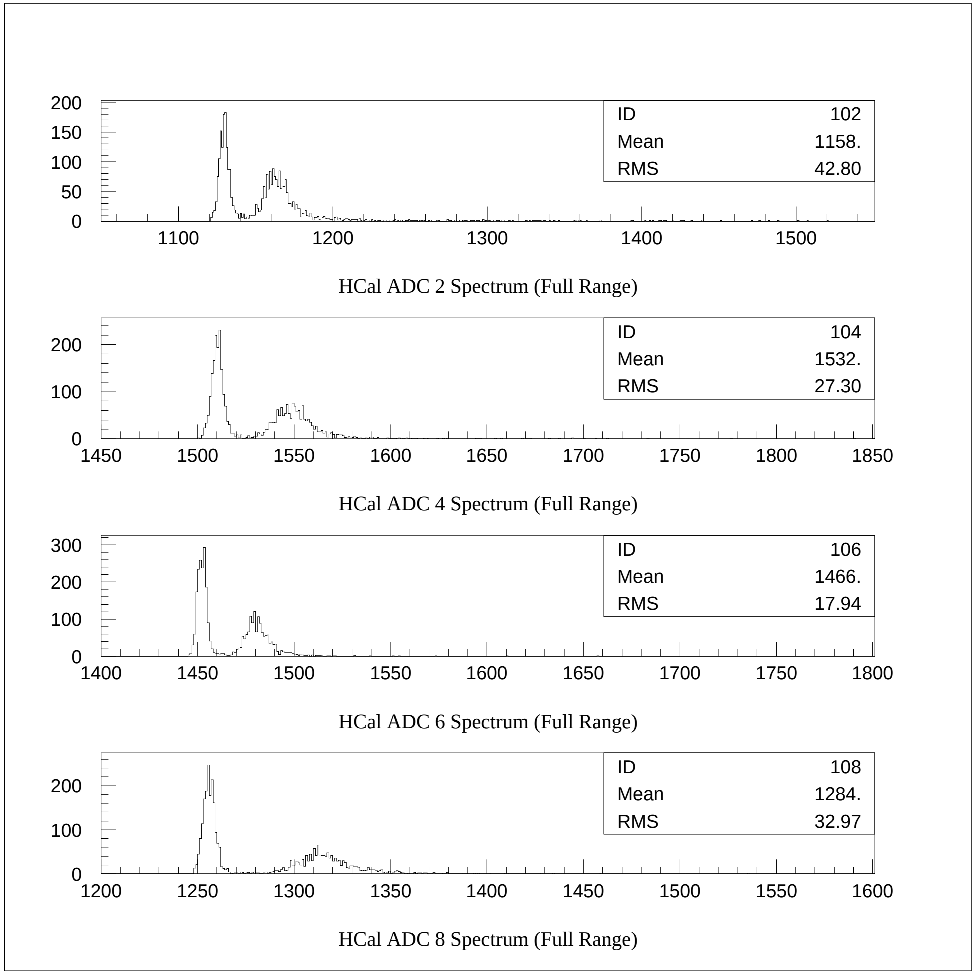


FIG. 4: Beam Left 5 GeV/c muon peak

Energy Scale

Determination of the absolute energy scale in the calorimeters requires calibration of the momenta scale of tracks in the spectrometer. Once this has been determined real calibration of the detector response can be performed.

- Calibration of the energy resolution will be performed using the beam track sample
- Momentum dependent detector response to known tagged species (π,K,p) will be determined from the beam samples.
- Full iterative calibration will be performed according various methods that include the E&M calorimeter.

Future and PID

- The Hadron calorimeter due to it's design will be more suitable in E907 for use as a PID detector in combination with the E&M calorimeter to distinguish electromagnetic tracks from hadronics.
- The calorimeter will most likely not be useful for neutrals detection due to shower leakage out of the active detector volume.
- The plan is to treat the calorimeters together to form a "Converter" and a "Back" section, and train the fractional energy deposition of a track/event to identify distinct E&M regions and hadronic.

Analog to a Lead Glass Array

Example: A shallow PbG array (shower leakage in Z)

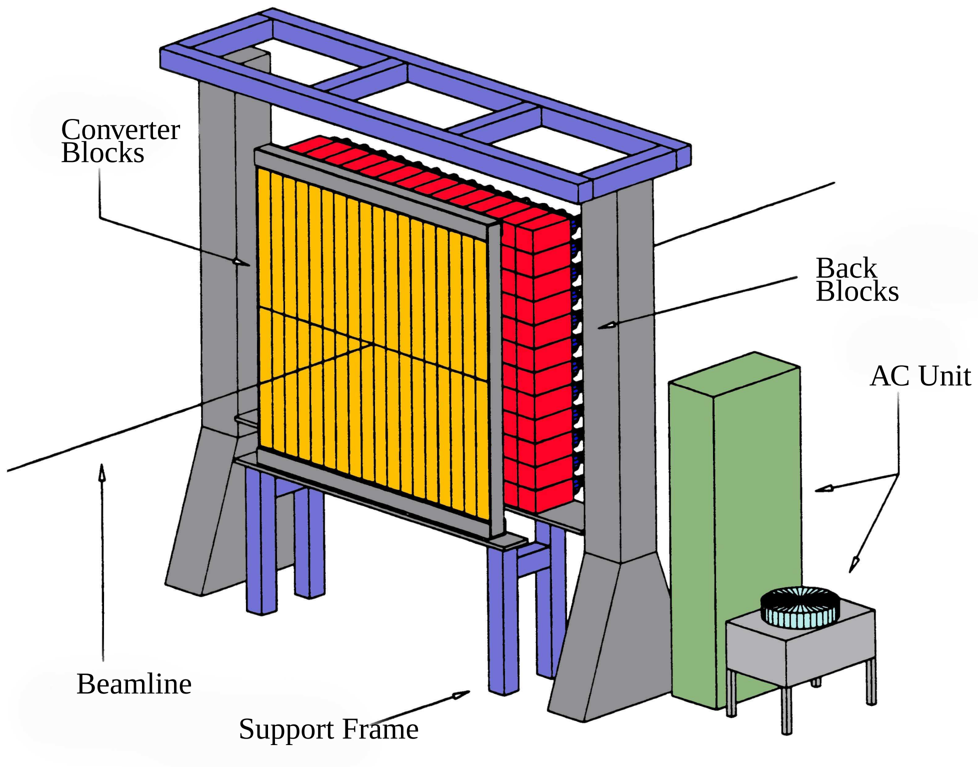


FIG. 5: BNL E871 lead glass array

Analog to a Lead Glass Array

PID through Fractional energy deposition regions:

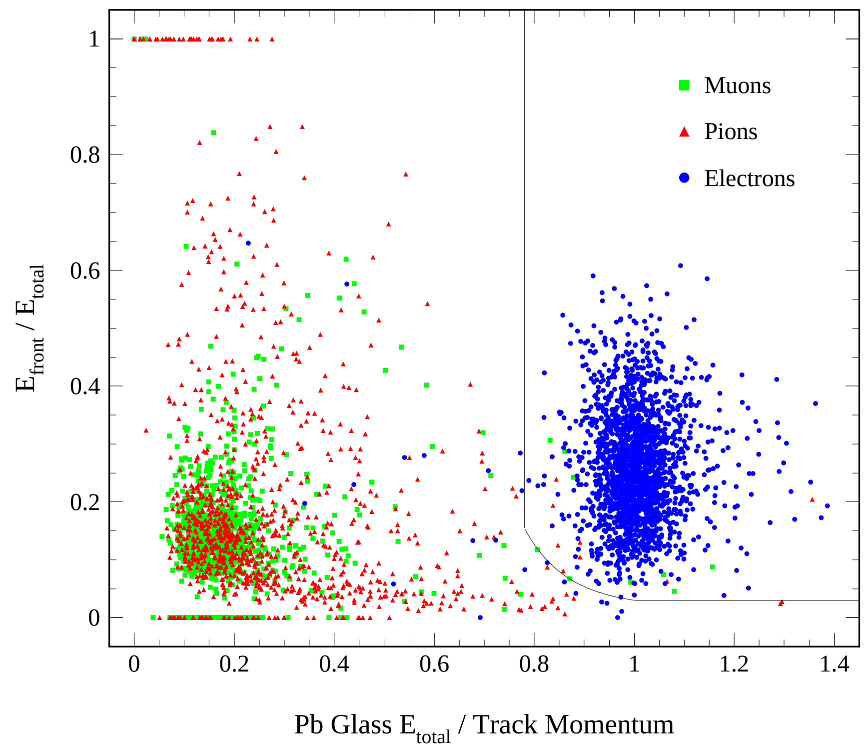


FIG. 6: Lead glass array electron/pion separation contour

Conclusions

- Pedestal calibrations are available and ready for inclusion in standard software
- Channel to channel gain calibrations were done in hardware, and are fine tuned in the offline
- Energy scale calibrations do require more spectrometer information, but rough calibrations are ready
- PID should be possible using fractional energy deposition. Packages for this will be available shortly