Hall C HMS and SHMS Calorimeters

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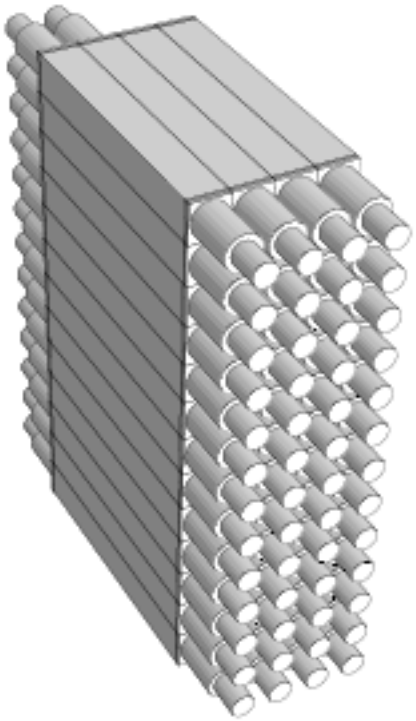
HMS Electromagnetic Calorimeter

Particle flux

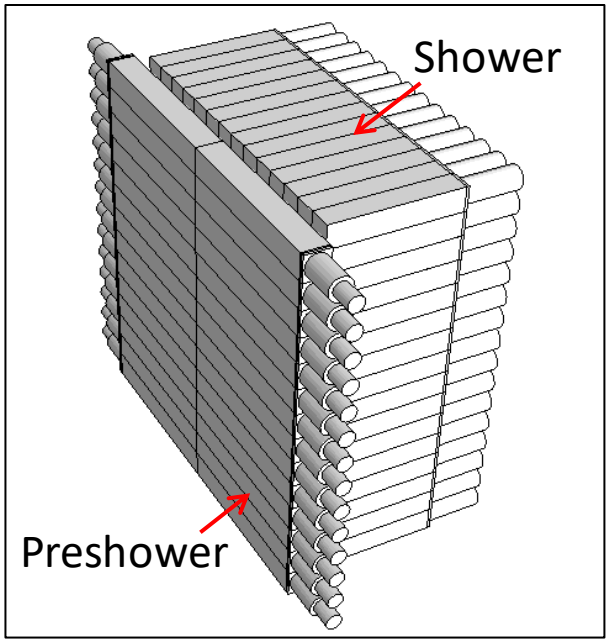


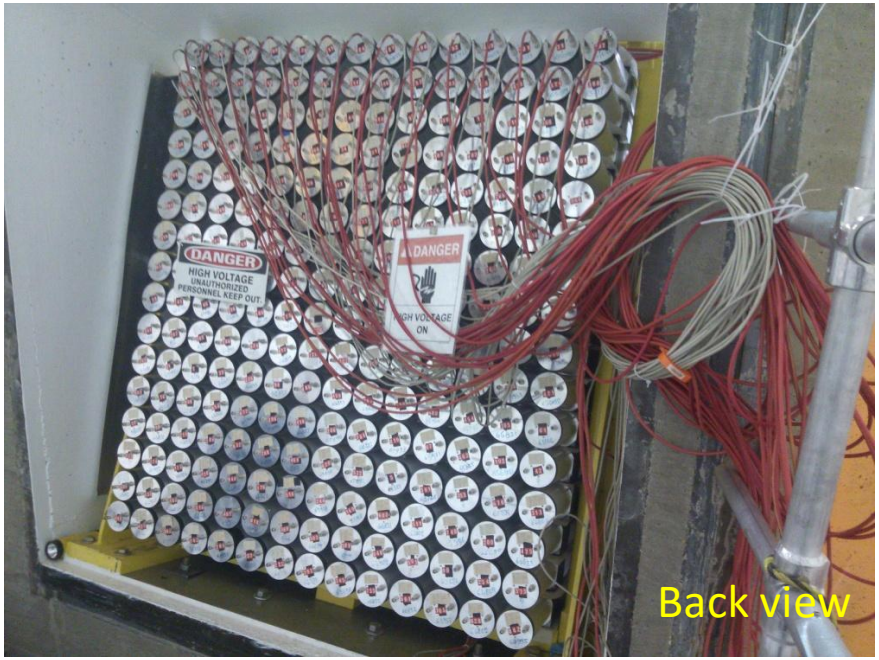
Thickness	40 cm, 14.6 r.l.
Effective area	60×120 cm^2
# of modules	52
# of channels	78
Arrangement	4 col-s, 13 rows
Block sizes	10×10×70 cm^3
Radiator	TF-1 lead glass
PMTs	Photonis XP3462B
In operation	1995 - present

TF-1 lead glass: $\rho = 3.86\ {}^{g}/_{cm^2}$, $X_0 = 2.74\ cm$, $n = 1.65$.

XP3462B PMT: Ø 3", bialcali photocathode, $Max(QE) = 29\%\ @\ 400\ nm$.

SHMS Electromagnetic Calorimeter





Preshower

TF-1 lead glass radiator

$10 \times 10 \times 70\ cm^3$ blocks

XP3462B PMTs

28 modules

3.6 Rad. Length thickness

Shower

F-101 lead glass (simlar to TF-1 but rad. hard)

$9 \times 9 \times 50\ cm^3$ blocks

XP3461 PMTs

224 modules

18 Rad. Length thickness

$116 \times 134\ cm^2$ effective area

Calorimeter PID quantities

etot - total energy deposition in the calorimeter (not associated to any track, hence not corrected for coordinate);

etotnorm - total energy deposition divided by the spectrometer's central momentum (again, not corrected for coordinate);

etrack - energy deposition of the best track, i.e. energy of the hit cluster associated to the best track (corrected for Y coordinate of the track at the calorimeter);

etracknorm - energy deposition of the best track divided by its momentum (Y coordinate corrected);

eprtrack - energy deposition in the Preshower for the best track (i.e. Y coordinate corrected energy deposition of the hit cluster in the first layer of the calorimeter);

eprtracknorm - energy deposition in the Preshower for the best track divided by its momentum (Y coordinate corrected);

etottracknorm - total energy deposition in the calorimeter divided by momentum of the best track (no coordinate correction).

Calorimeter PID quantities

The **tot** quantities correspond to the total energy in the calorimeter, and **track** quantities correspond to the energy in the hit cluster matched to the best track.

The **tot** quantities are not corrected for the track coordinate, the **track** quantities are corrected for the Y coordinate of the track at the calorimeter. A special case is *etottracknorm*, which is not coordinate corrected.

Analysis parameters

In **hallc_replay/PARAM/(S)HMS/CAL** directory.

hcal_geom.param file – geometry of the calorimeter (number of columns and rows, block sizes, positions, coordinate correction constants etc.), rarely need to change.
hcal_slop – the slop parameter, distance between track at the calorimeter and energy deposition clusters, in cm.

hcal_calib.param file – calibration constants in a specific format.

h**cal_cuts.param:**

- hcal_ADCmode = 1 pulse integral – pulse pedestal
  2 sample integral – known pedestal
  3 sample integral – sample pedestal
  Default – raw pulse integral
- FADC Pulse time window cuts
  hcal_adc_tdc_offset= 200.
  hcal_AdcTimeWindowMin = -1000.
  hcal_AdcTimeWindowMax = 1000.
- hcal_AdcNegThreshold = 0. , for selecting good ADC signal by posing cut pedestal + hcal_AdcNegThreshold
- hcal_AdcPosThreshold = 0. – same for positive channels.
- hcal_fv_test = 0 – fiducial volume cut. ← 1 – select tracks within fid. Volume

Now per channel!

Calibration algorithm

- Assume **full energy absorption** of electro-magnetic shower in the calorimeter
- Assume **linear response** to the energy deposition (to the accuracy of coordinate correction)
- Minimize deviation of the reconstructed energy deposition $E_{DEP} = \sum C_i \cdot ADC_i$ relative to measured momentum of incoming electron P.
- With constrain: mean values of E_{DEP} and P are equal.

Developed by Ts.Amatuni in 1990's.

Uses:

- Momentum (deviation), focal plane coordinates and directions from tracking;
- β_{TOF} velocity from hodoscopes;
- Heavy (and Noble) Gas $\check{C}$ signals in *pe* units;
- ADC signals from Preshower and Shower.

Calibration package, updates

Calibration code in **/hallc_replay/CALIBRATION/(s)hms_cal_calib**

- **THcPShHit.h** – calorimeter hit class
- **THcPShTrack.h** – calorimeter track class (spectrometer track param-s and calorimeter hits)
- **THcPShowerCalib.h** – calorimeter calibration class.
- **pcal_calib.cpp** – steering script
- **input.dat** – thresholds used in calibration, initial calibration constants
- **howto.txt** – a short description how to calibrate calorimeters.

Run under hcana:

hcana>.x pcal_calib(string Prefix, int nstop=-1, int nstart=0)

Prefix – prefix of the root file name: ROOTfiles/<Prefix>.root

Output:

pcal.param.<Prefix>_<nstart>_<nstop> -- calibration constants

<Prefix>.pdf – representative plots

<Prefix>.root – representative plots (SHMS only)

Calibration, input data

Input.dat file:

-10 22 Delta range, %
0.5 1.5 Beta range
2. Heavy Gas Cherenkov, threshold on signals in p.e.
0. Noble Gas Cherenkov, threshold on signals in p.e.
20 Minimum number of hits per channel required to be calibrated

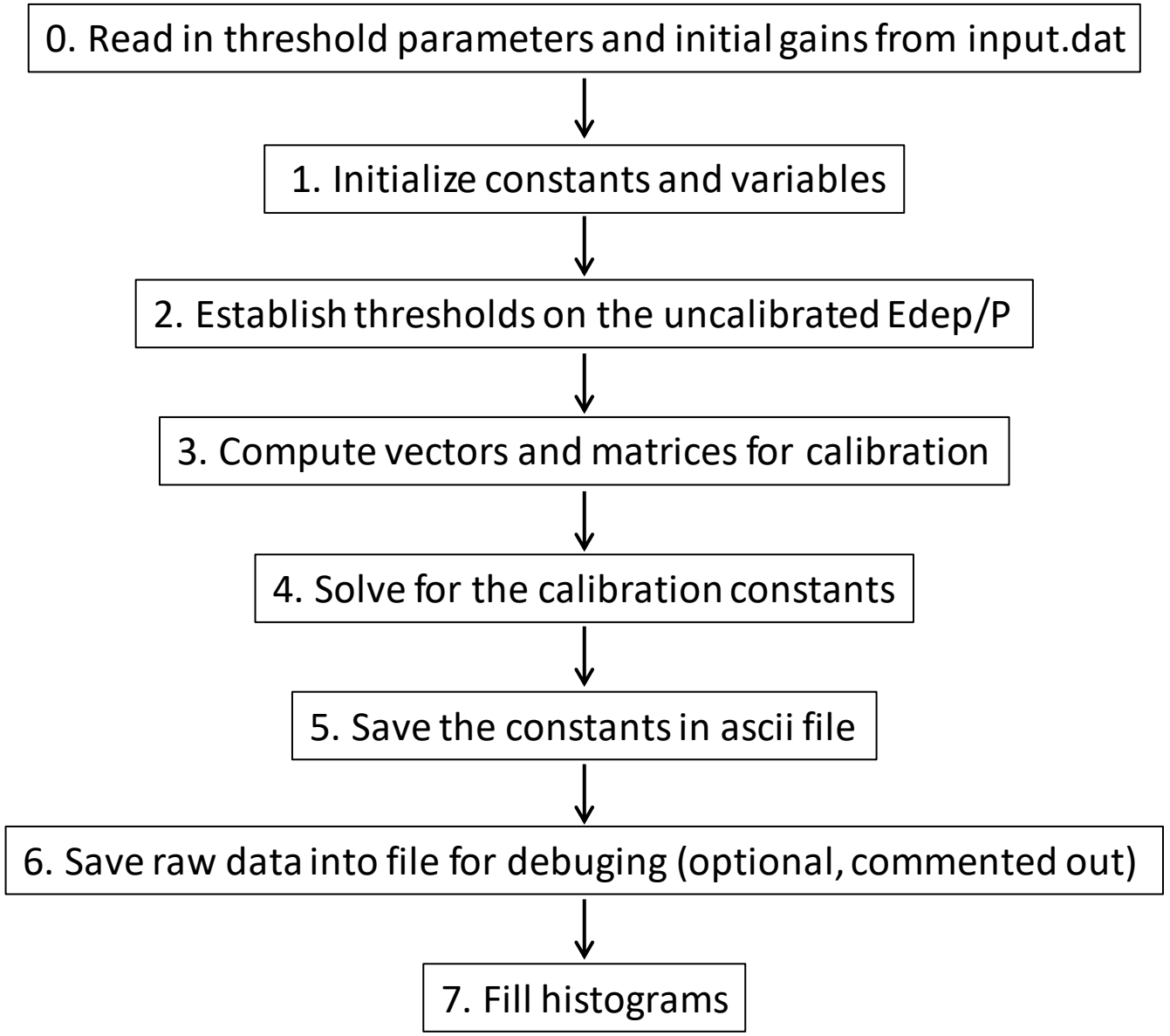
SHMS only

; Calibration constants for run 1791_300000, 38067 events processed (dec. 17 defocused run)

pcal_neg_gain_cor = 31.20, 28.28, 28.19, 29.18, 31.57, 27.67, 30.21, 32.54, 31.59, 28.61, …,
pcal_pos_gain_cor = 29.91, 27.86, 27.42, 28.18, 31.90, 34.08, 29.00, 24.00, 27.65, 27.75, …,
pcal_arr_gain_cor = 0.00, 0.00, 0.00, 37.46, 24.21, 25.41, 14.60, 32.73, 40.66, 9.56, …,
49.52, 28.39, 57.17, 43.51, 44.38, 36.14, 42.24, 25.59, 22.50, 37.73, 72.10, …,
54.73, 39.81, 37.85, 33.96, 58.96, 62.49, 41.46, 60.29, 32.42, 50.27, 39.06, …,
57.37, 46.09, 36.74, 46.87, 41.02, 31.42, 80.19, 63.10, 55.60, 56.74, 60.95, …,
41.31, 34.24, 30.86, 29.89, 65.71, 58.52, 47.87, 32.37, 34.76, 47.78, 41.52, ….,
…

SHMS Initial gain constants from a commissioning de-focused run.
HMS initial gain constants: 10 for double PMT modules, 20 for single PMT modules.
Note: the gain constants are not iterated, used only to get un-calibrated Edep spectra.

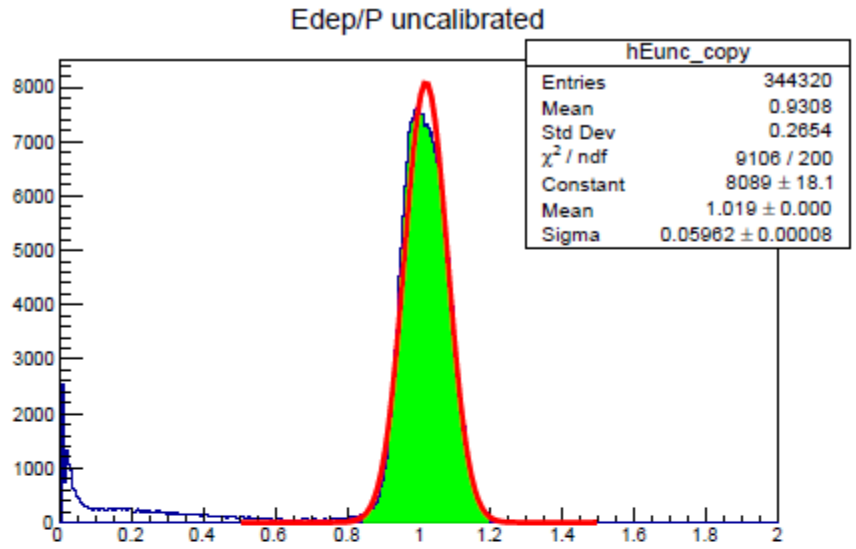
Calibration flow

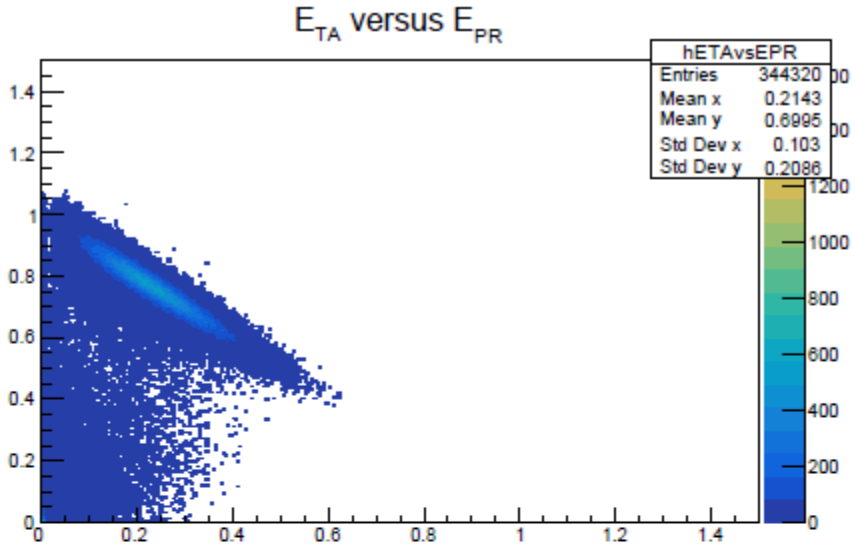


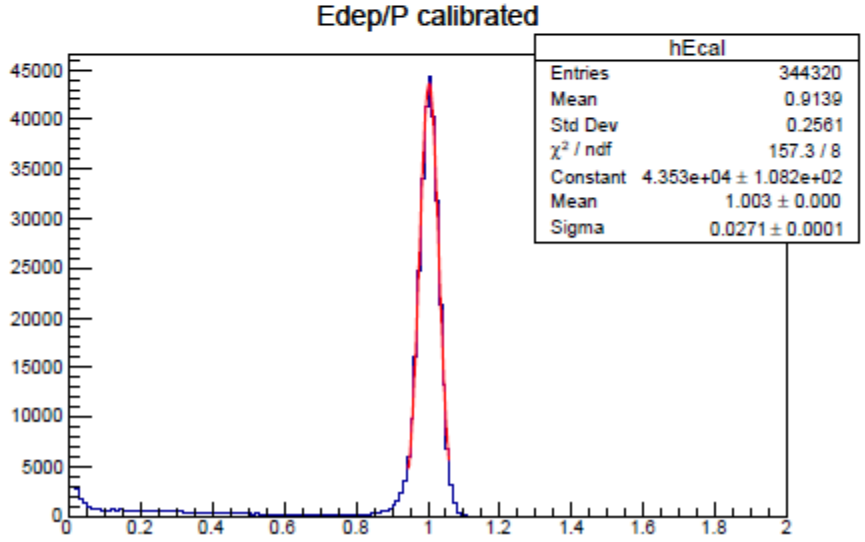
Note: steps 2, 3, 6, 7 evolve loop over events.

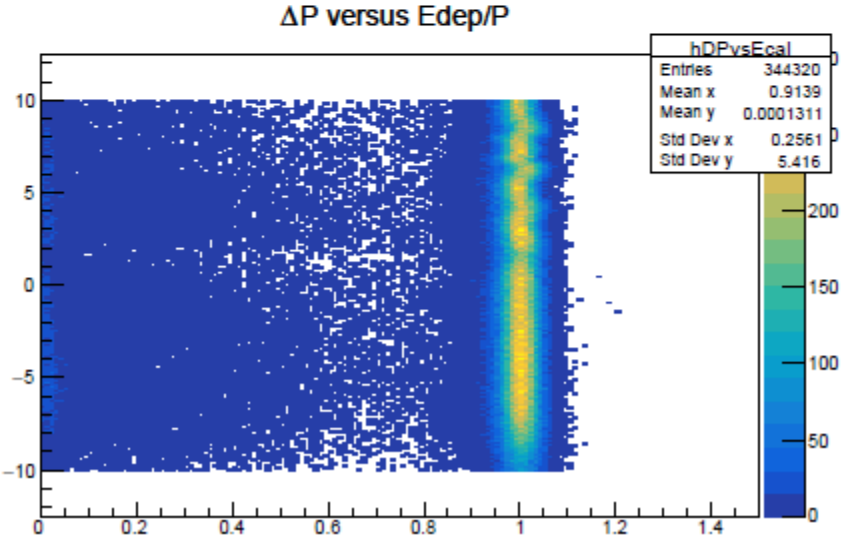
Calibration, representative plots

HMS run 4301



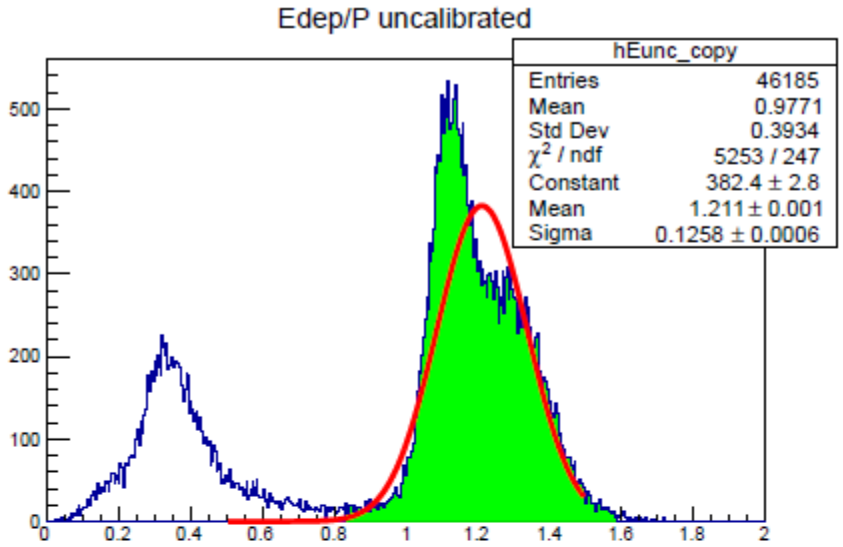


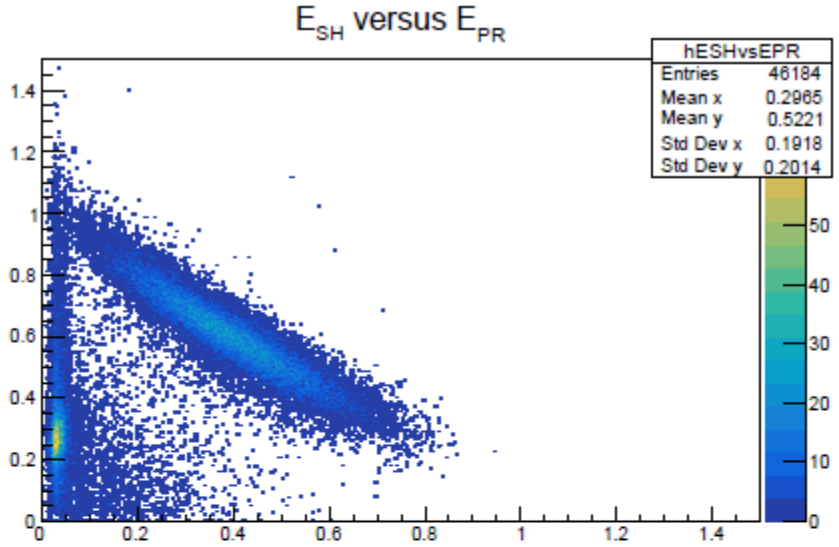


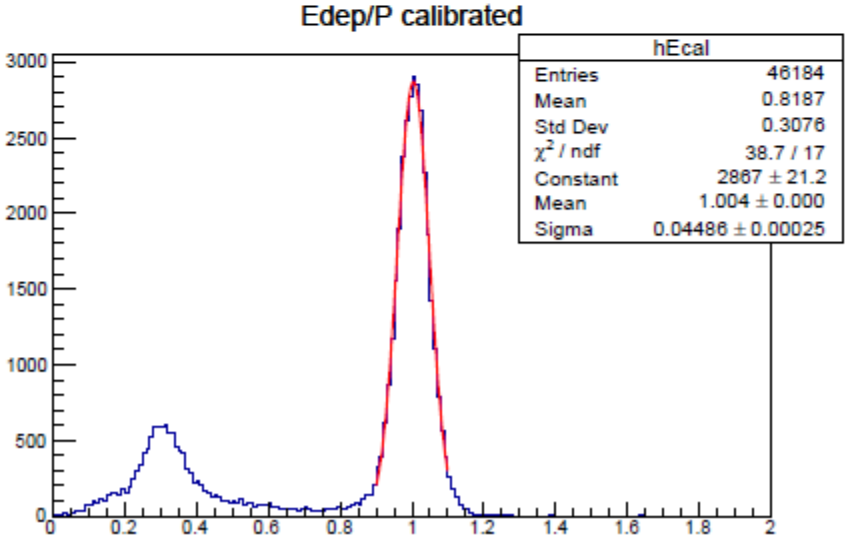


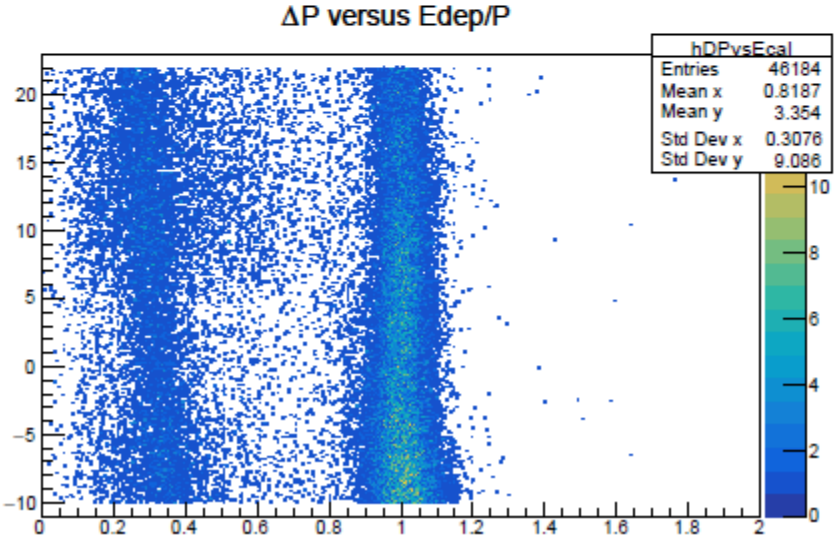
Calibration, representative plots

SHMS run 3665





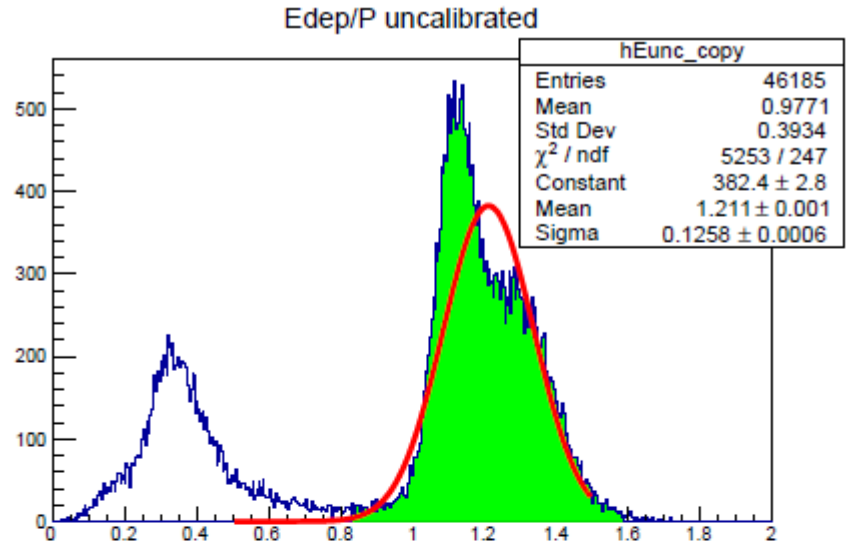


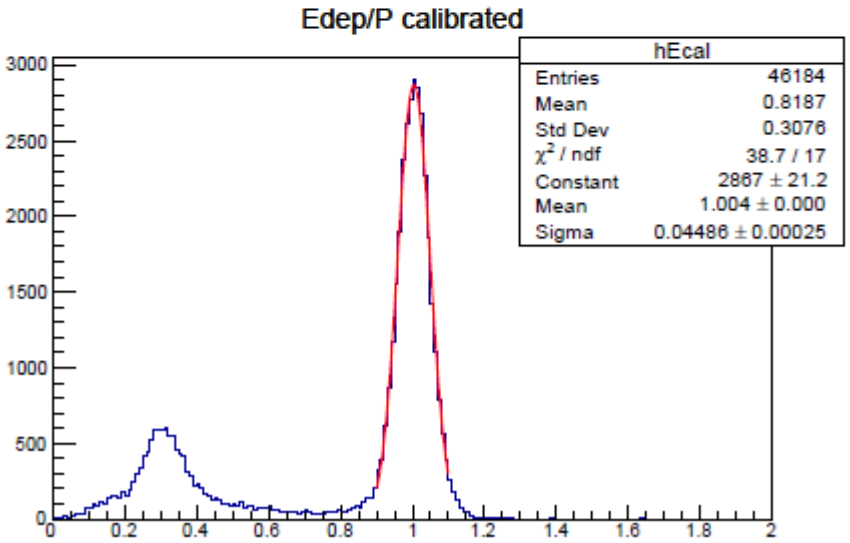


Use Preshower & Shower to boost PID!

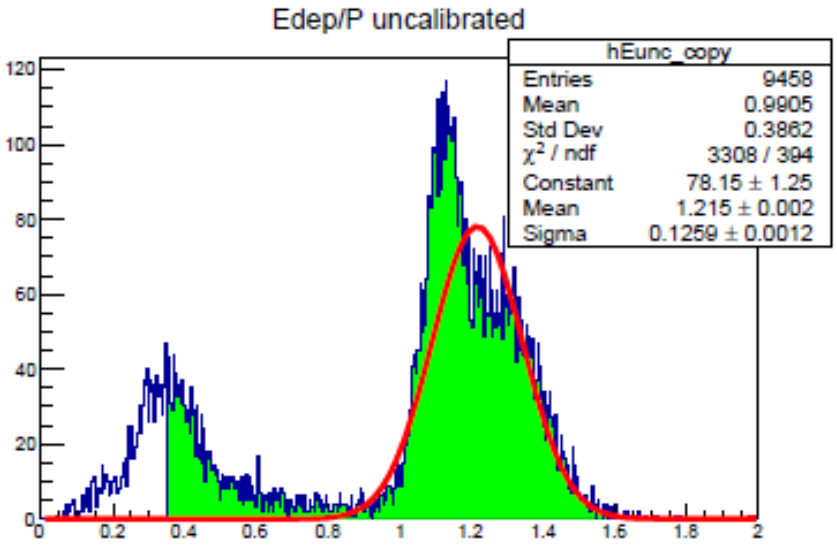
Calibration, good versus bad

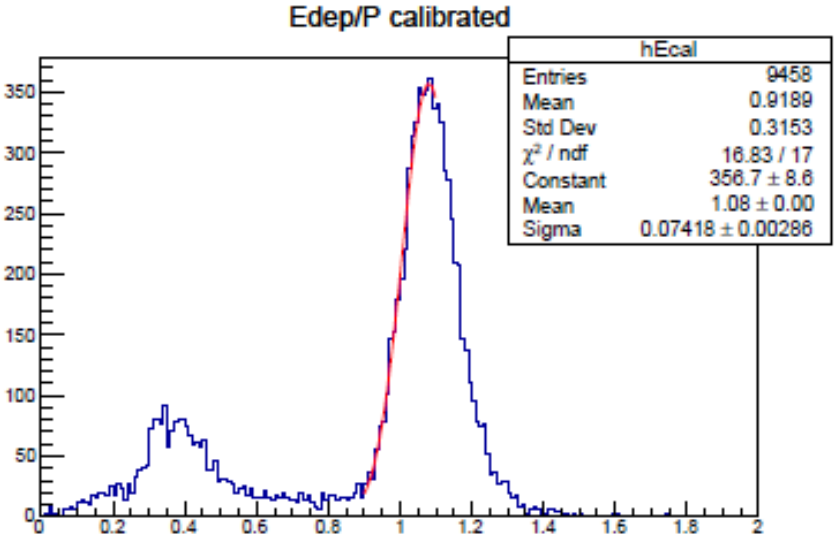
Efficient e- selection



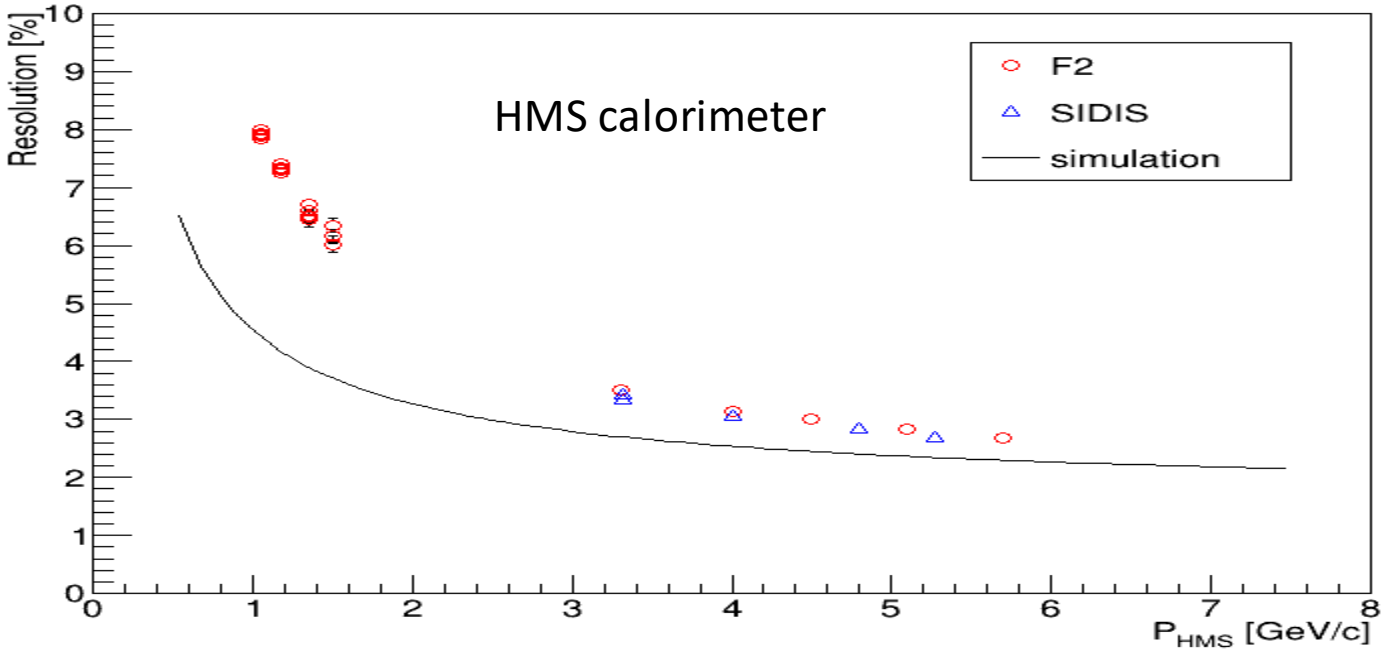


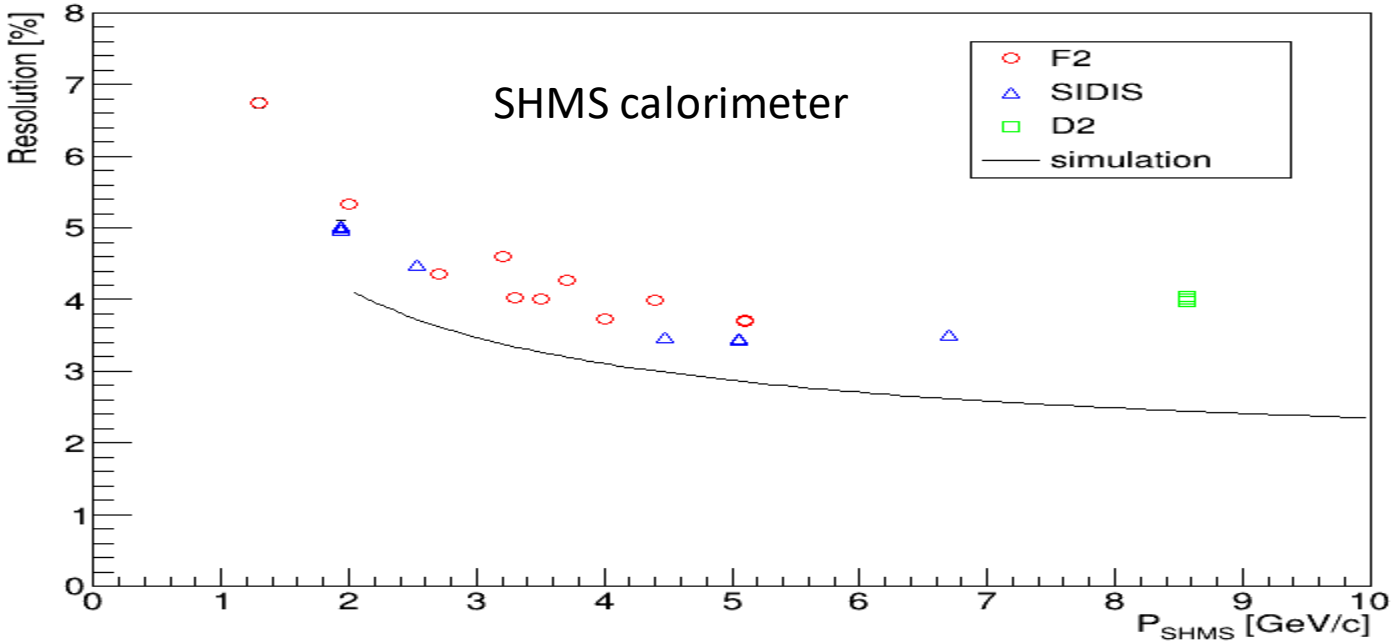
Inefficient e- selection





Resolutions





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