PID Analysis

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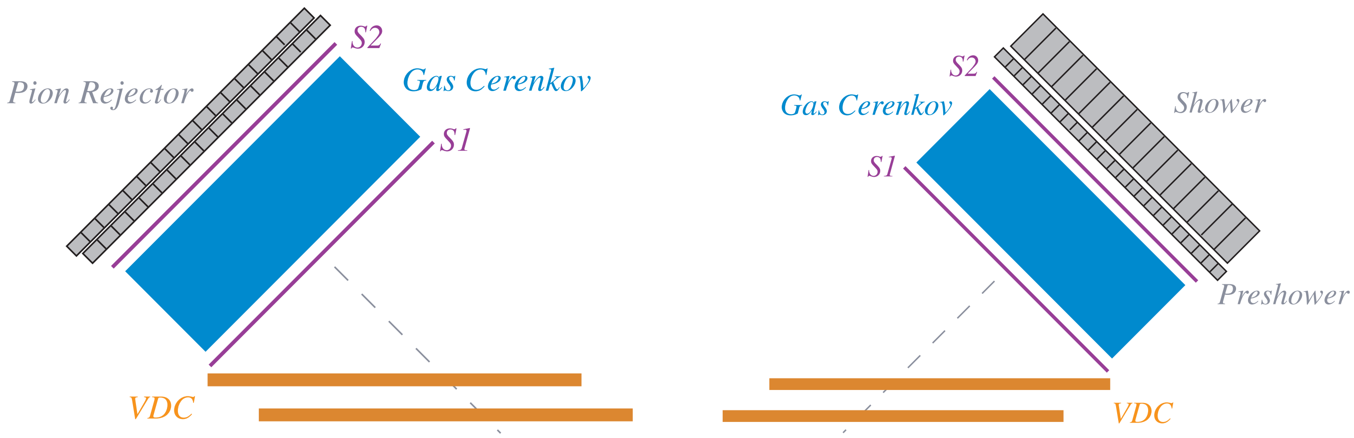
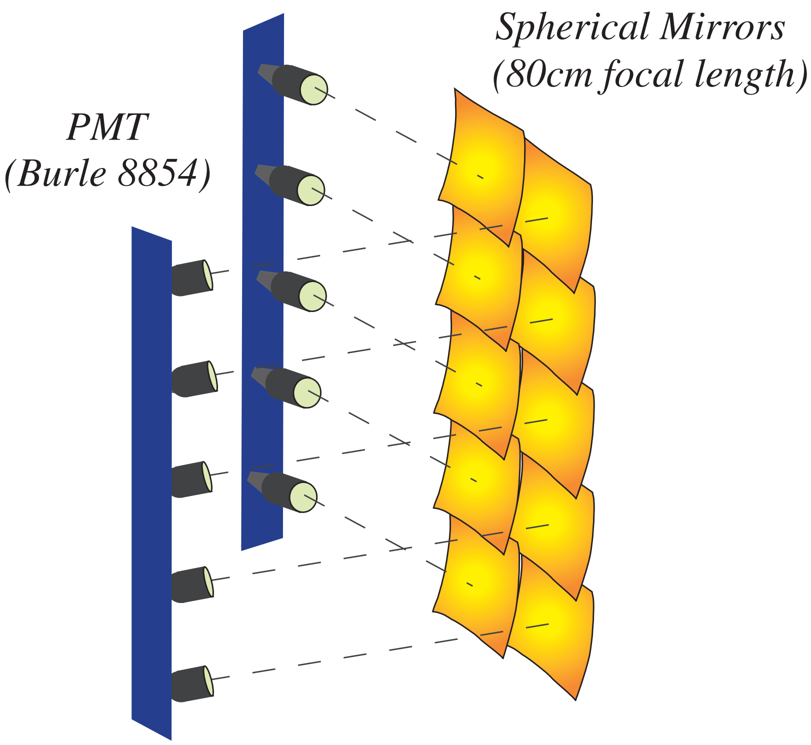
Detectors for Particle Identification



- Gas Cerenkov associated with EM Calorimeter.
- Based on different PID principles.
- Allow discrimination between electrons and pions.

Threshold Gas Cerenkov Counters



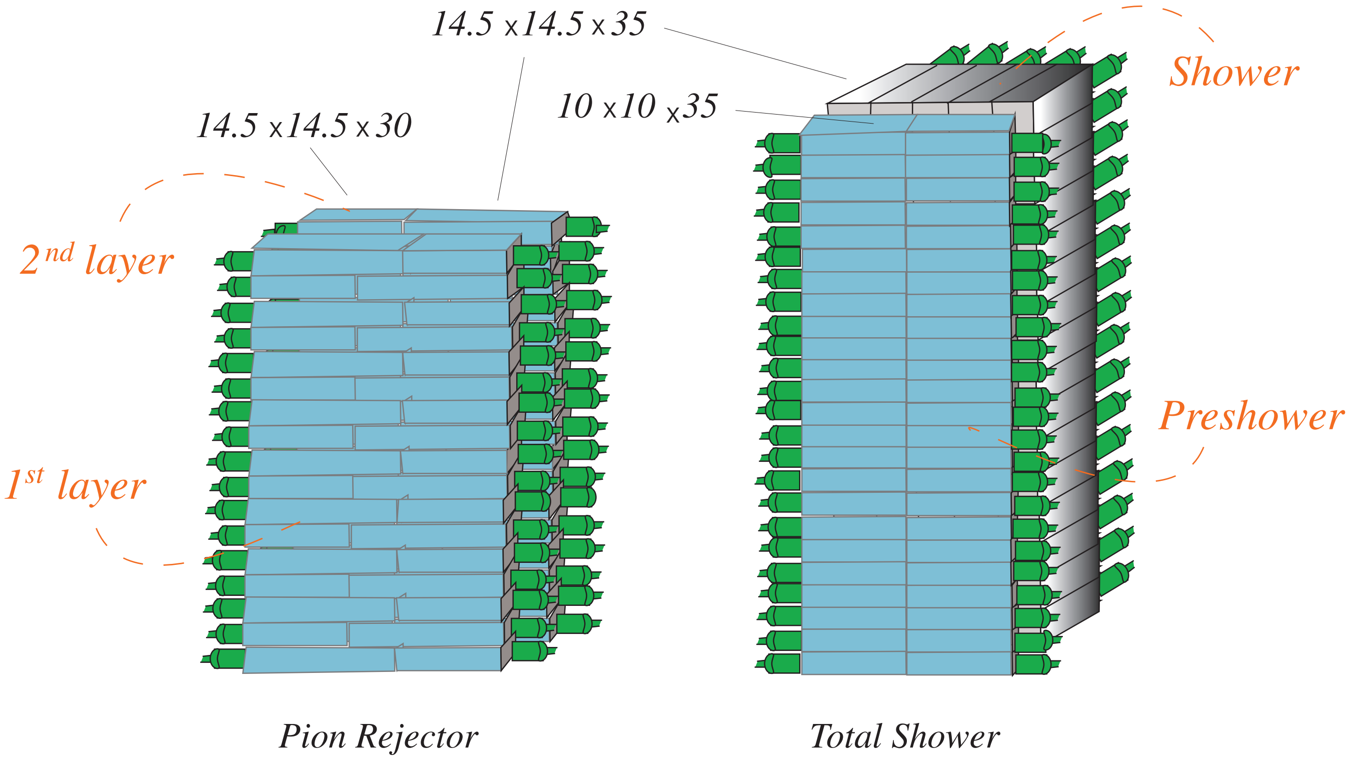
- Composed of 10 mirrors to collect the light then focussed on 10 PMTs.
- Filled with CO_2: $n = 1.00041$.
- Allows a good separation between electrons and pions.

$$P_{thres} = \frac{m}{\sqrt{n^2 - 1}}$$

$\rightarrow$ for electron: $P_{thres} \sim 0.017$ GeV/c

$\rightarrow$ for pion: $P_{thres} \sim 4.8$ GeV/c ($> P_{max}$ of HRS)

Electromagnetic calorimeters



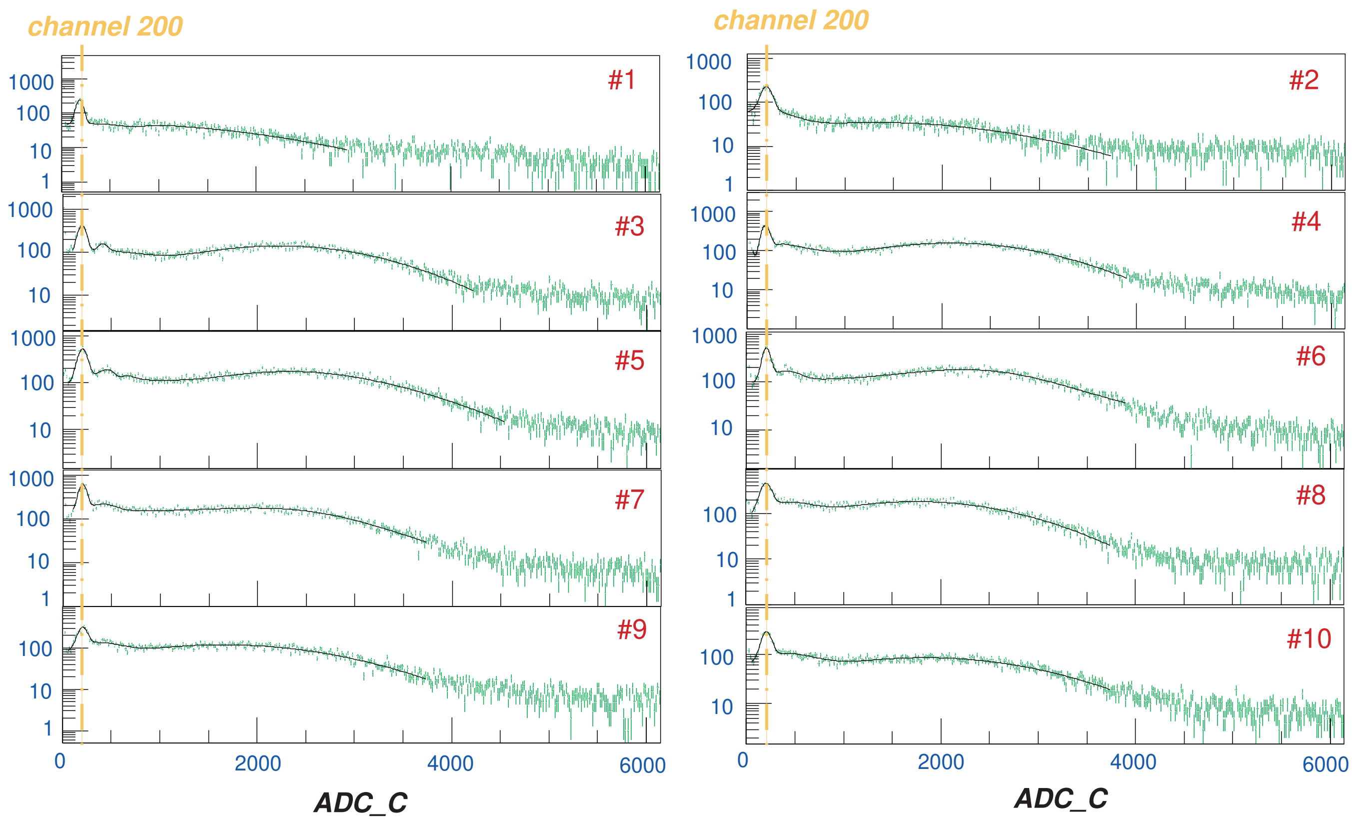
Lead glass blocks of radiation length 1.68cm.

- Total absorption shower counter in the right arm
  $\Longrightarrow$ good energy resolution and PID detector.
- reduced thickness for the pion rejector
  $\Longrightarrow$ energy resolution and PID properties not as good.

PID calibration procedure

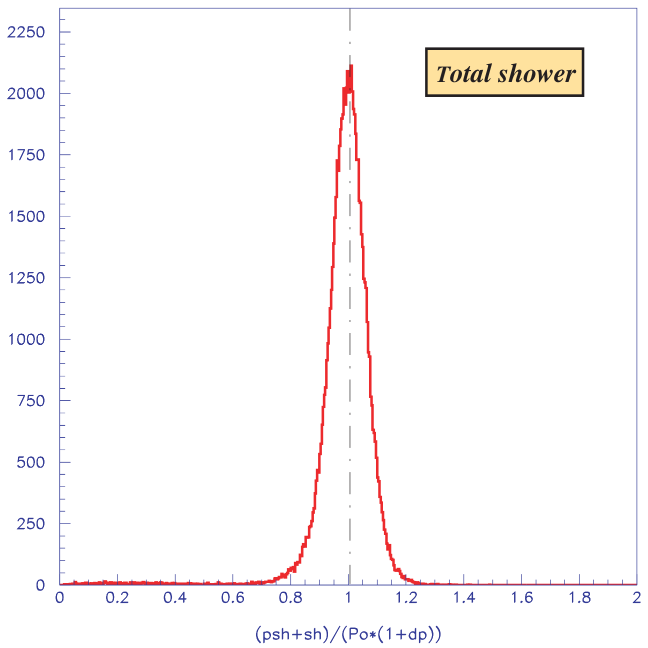
Cerenkov calibration

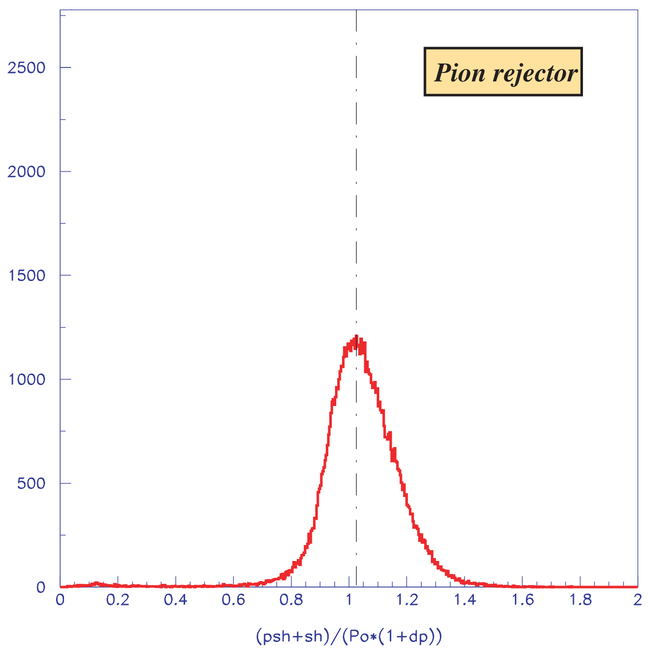
- Align the pedestal at zero by looking at the ADC channel of the first non-zero signal.
- Adjust the software gain by aligning the single photo-electron peaks for each ADCs.
- Pedestal and gain values can be changed in the database.

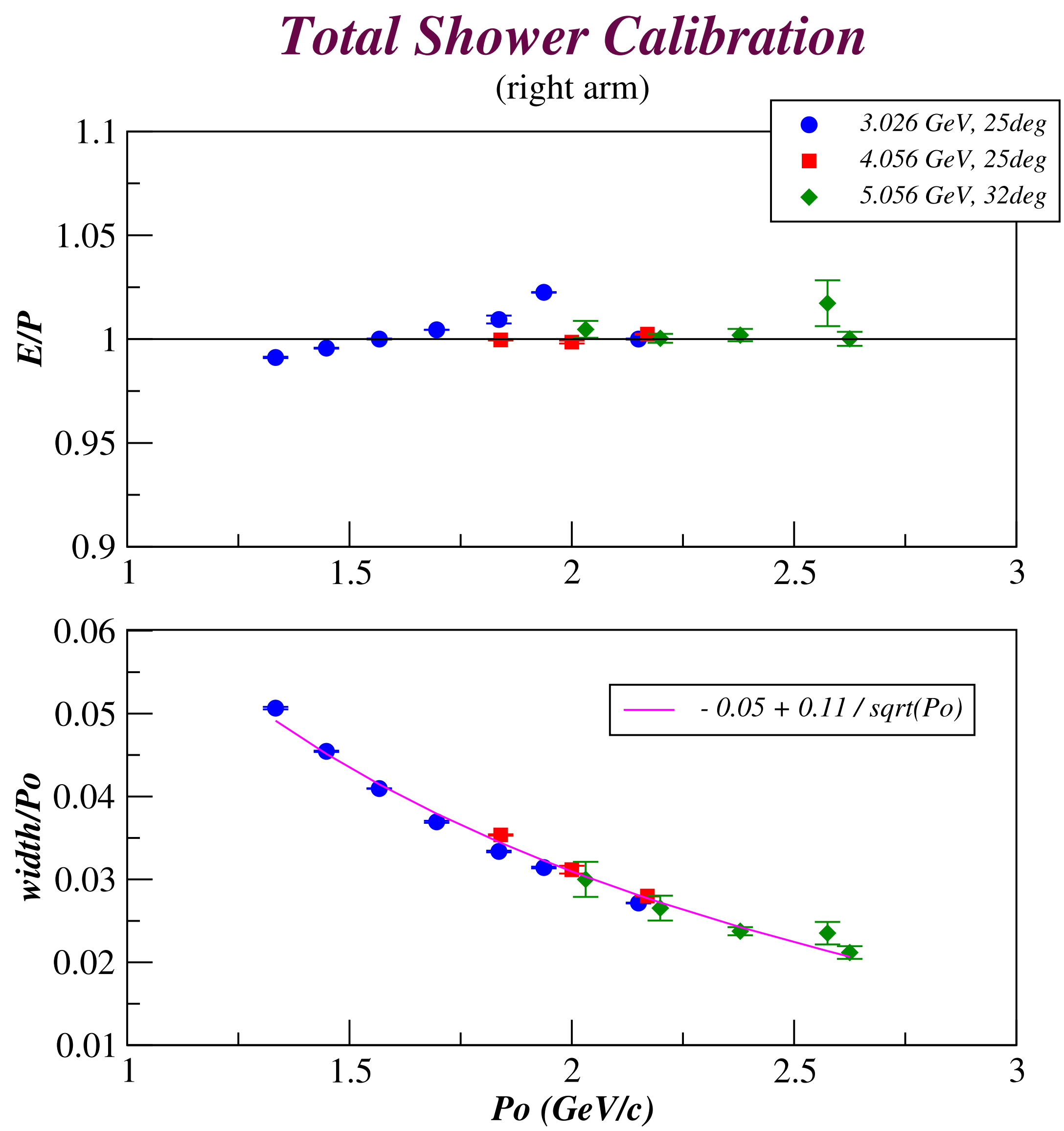


shower calibration

- Record pedestal position for each ADC.
- Total shower: gains adjusted *by software* in ESPACE
  $\rightarrow$ based on Cluster reconstruction and minimization of
  $\chi^2 = \sum_{n=1}^{N} \left[\sum_{i \in M^n} C_i (A_i^n - P_i) - E_e^n \right]^2$
- Pion rejector: gains adjusted *by hand*
  $\rightarrow$ goal: good separation of electron and pion peaks.
- Pedestal and gain values should be updated in *shower-calib.dat* and *pr-calib.dat*.



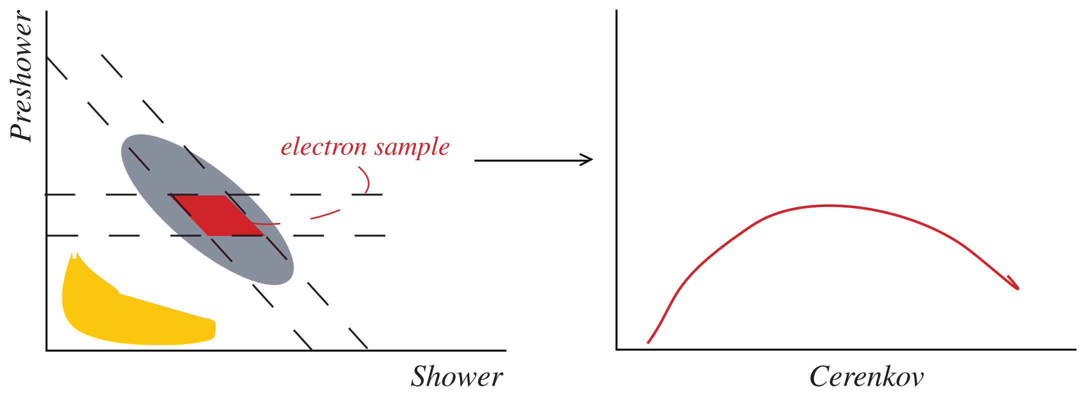



Total Shower Calibration
(right arm)
3.026 GeV, 25deg
4.056 GeV, 25deg
5.056 GeV, 32deg
E/P
1.1
1.05
1
0.95
0.9
1
1.5
2
2.5
3
width/Po
0.06
0.05
0.04
0.03
0.02
0.01
- 0.05 + 0.11 / sqrt(Po)
Po (GeV/c)

PID efficiencies

Cerenkov detector

- Detection efficiency determination:
  - use low pions run.

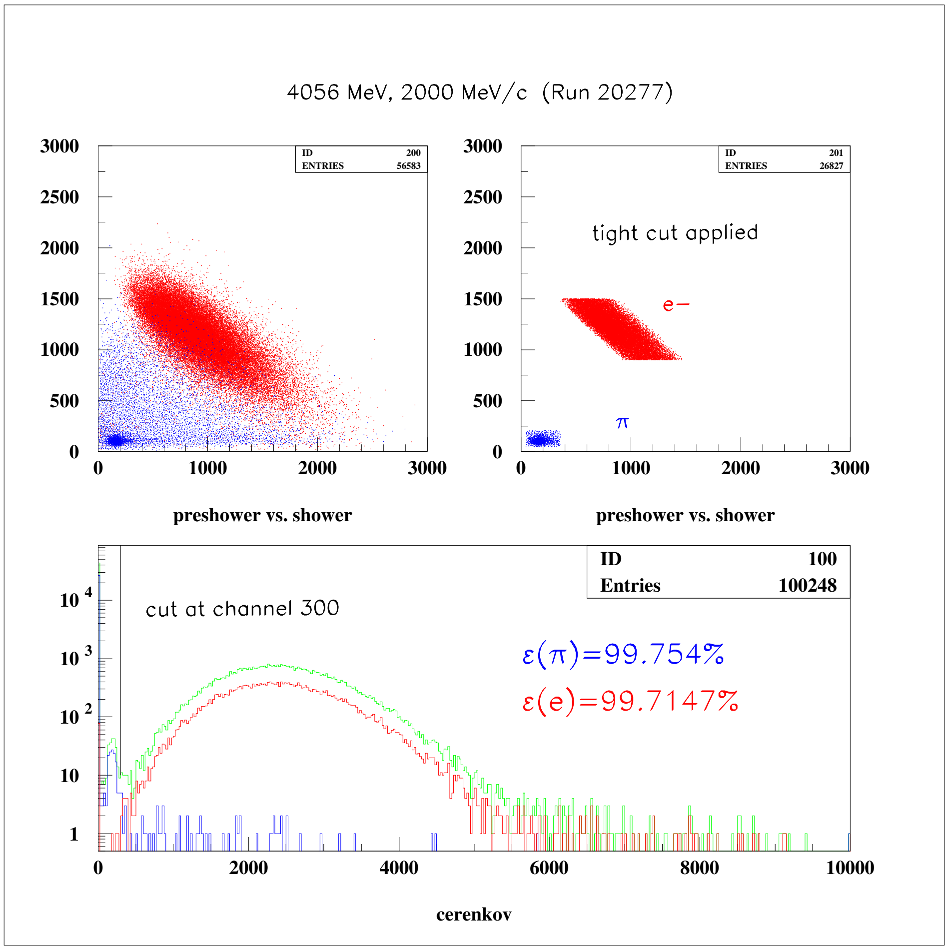


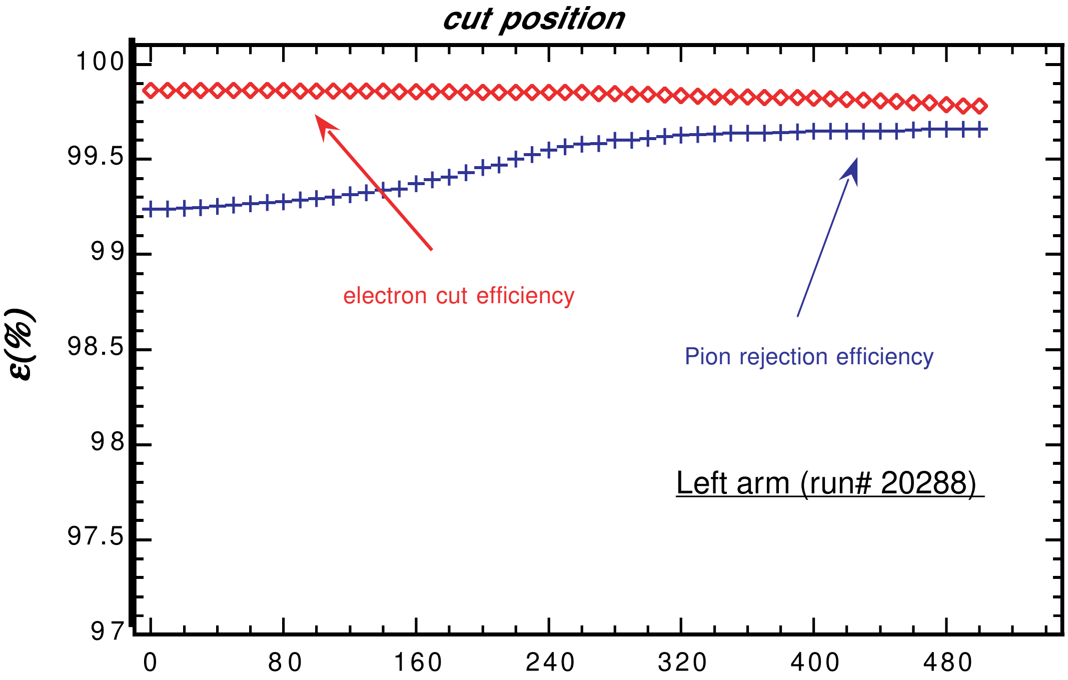
  - take electron “sample” in the shower detector.
  - count how many triggered the Cerenkov detector.

$$\epsilon = \frac{n_{cer}}{n_{sample}}$$

For E01-012: $\epsilon > 99.9\%$

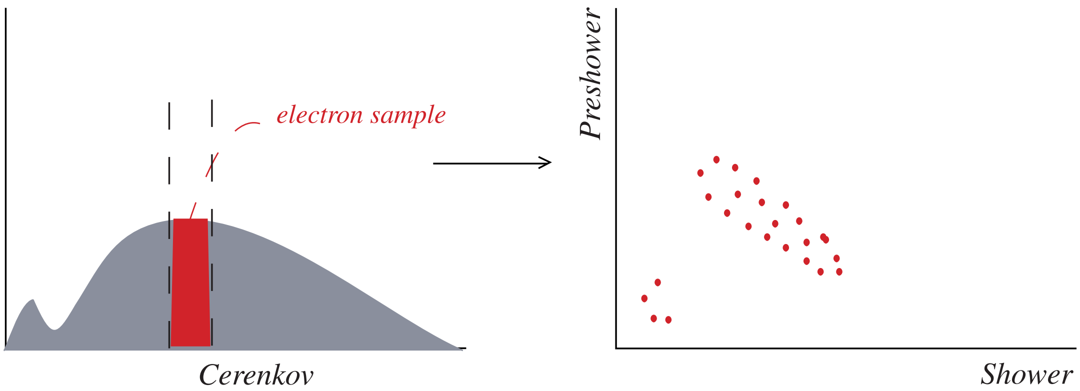
- cut optimization:
  - goal: remove π while keeping e^- efficiency high.
  - single photo-electron peak = mostly π (δ-electrons).


4056 MeV, 2000 MeV/c (Run 20277)
ID 200
ENTRIES 56583
preshower vs. shower
ID 201
ENTRIES 26827
tight cut applied
e−
π
preshower vs. shower
ID 100
Entries 100248
cut at channel 300
ε(π)=99.754%
ε(e)=99.7147%
cerenkov


cut position
ε(%)
electron cut efficiency
Pion rejection efficiency
Left arm (run# 20288)

Shower detector

- Detection efficiency determination:
  - take electron “sample” in the Cerenkov detector.



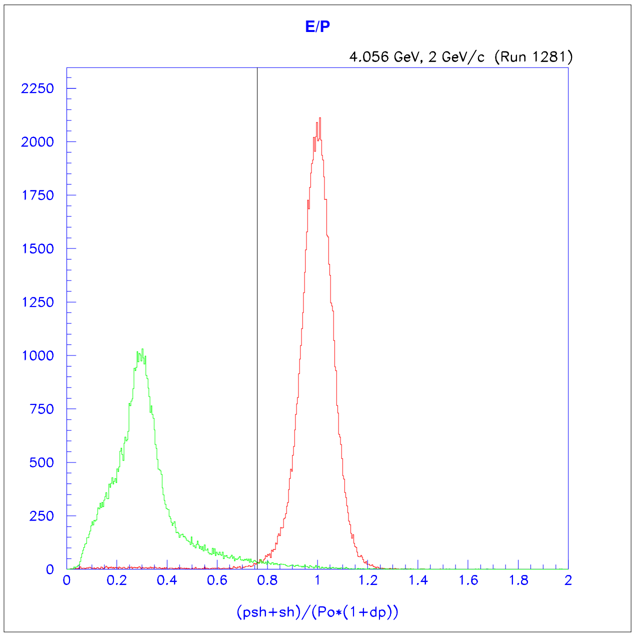
  - count how many triggered preshower and shower (or PRL1-PRL2).

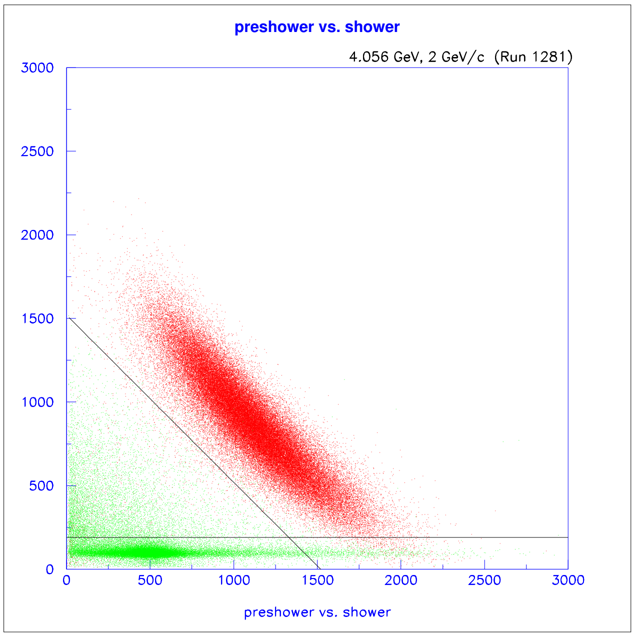
$$\epsilon = \frac{n_{sh}}{n_{sample}}$$

For E01-012: $\epsilon \sim 99.7\%$

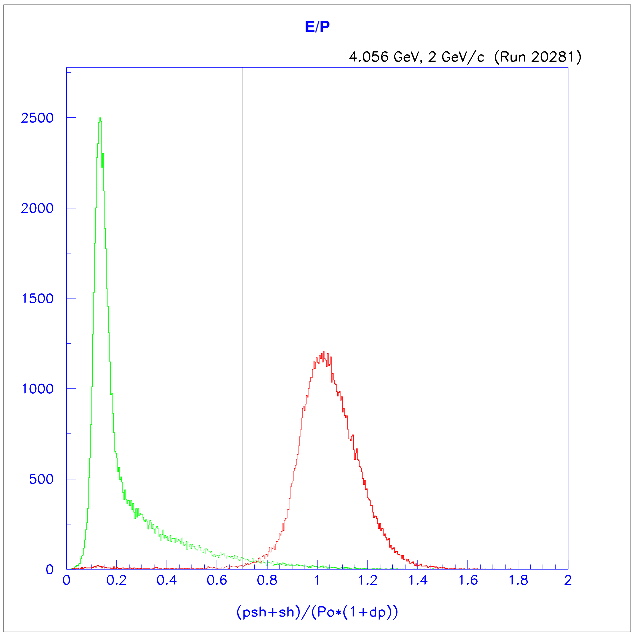
- cut optimization:
  - goal: remove π while keeping e^- efficiency high.
  - Fit electron and pion tails to simulate the loss after cut on E/P.
  - Apply a cut on preshower (or PRL1).

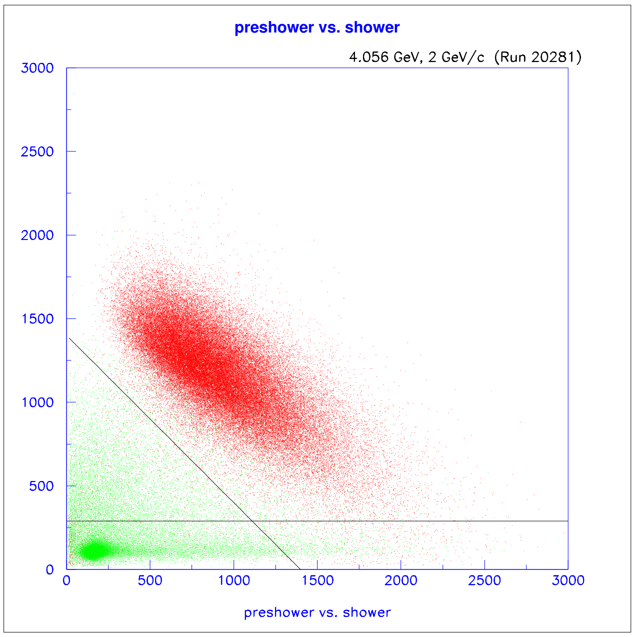
Total shower





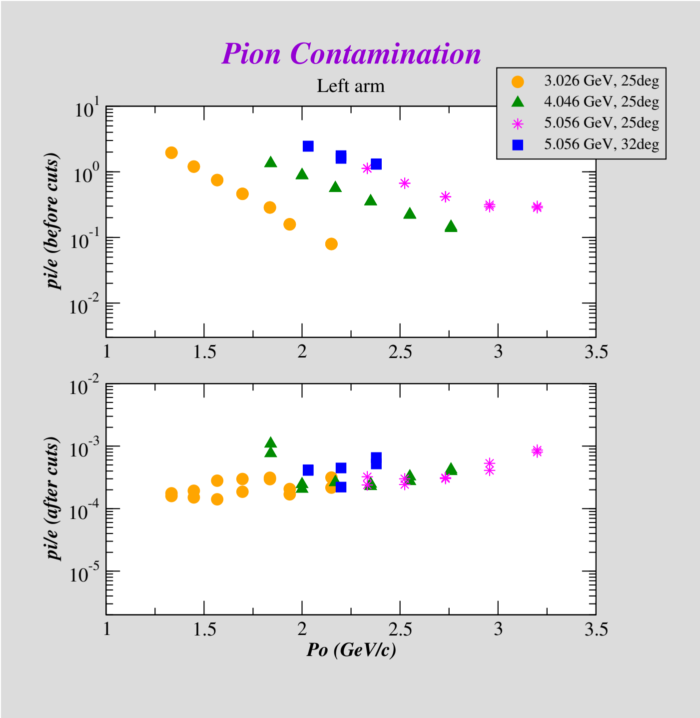
Pion rejector

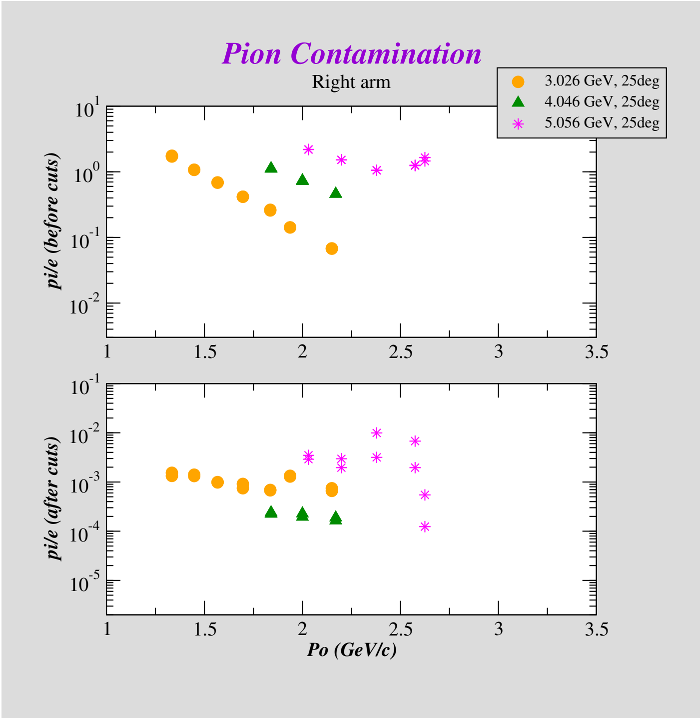




Pion contamination

- π/e ratio decreased by three order of magnitude (at least) after PID cut optimization.
- Detector electron efficiencies were keeping above 99%.





Summary

- Threshold Gas Cerenkov: very good for discrimination between π and e^-.
- Shower counters help us to improve the selection.
- Cerenkov combined with EM calorimeter:
  - electron efficiency above 98%
  - pion rejection better than 10^3.

Some references

→ A. Ketikyan et al, "*About Shower Detector Software*", http://www.jlab.org/~armen/sh web page/general.html.

→ M. Iodice et al, "*The CO_2 Cherenkov Detectors for the Jefferson Lab Hall-A Spectrometers*", Elsevier preprint (1998).

→ K. Slifer, "*Analysis of the Hall A HRS Cerenkov Detectors for E94010*", E94010 Technical Note (2000).

→ K. Slifer, "*Shower Detector Calibration and Cut Optimization for E94010*", E94010 Technical Note (2000).

→ X. Zheng, "*Gas Cherenkov Performance*", http://hallaweb.jlab.org/physics/experiments/he3/A1n/pid/memo12 (2001).