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PID Detector Calibration for E01-012

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Abstract

The PID calibration method and scheme for experiment E01-012 are presented in this report. Due to hardware problems and to a large set of kinematics, different calibrations were needed for the electromagnetic calorimeters.

1 Introduction

To allow separation between electrons and other particles (in our case, mostly pions), a gas Cerenkov detector [1] is associated with a electromagnetic shower counter in each High resolution spectrometer of Hall A. During the experiment E01-012 long tank cerenkov were used (= 1.5m). The right arm contains a total shower detector where the entire energy of the scattered particles can deposit unlike for the left arm where only a part of the particle energy is deposited.

2 Cerenkov

2.1 Properties

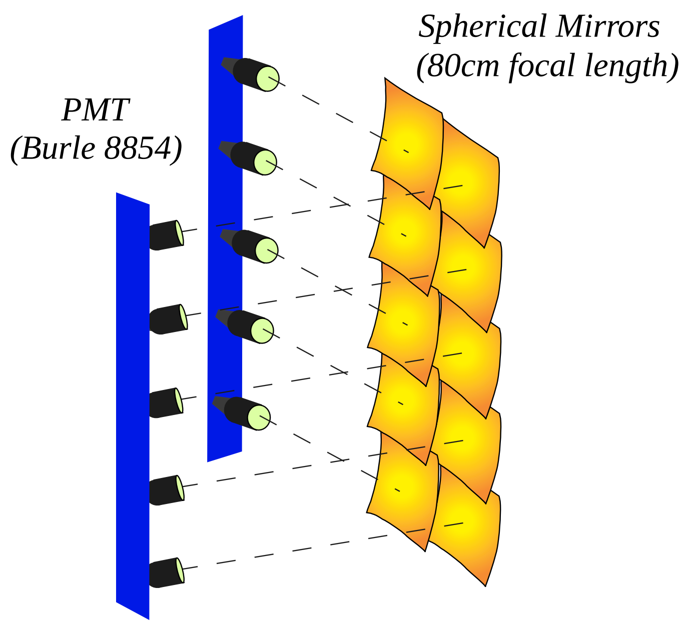

Figure 1: Cerenkov design

Both arm cerenkov detectors are identical. The Cerenkov detectors are filled with CO_2 gas which has an index of refraction $n = 1.00041$ at STP in order to separate electrons from pions. The Cerenkov radiation is received

by ten spherical mirrors and then reflected to 10 PMTs (Fig. 1).
Since Cerenkov radiation is emitted when the velocity of a charged particle is greater than 1/n, the momentum threshold for electron detection is about 18 MeV/c and for pion detection about 4.9 GeV/c from Eq. 1.

$$P = \frac{mc}{\sqrt{n^2 - 1}} \quad (1)$$

So in the momentum range that the HRS will be running (less than 4GeV/c) the CO_2 gas Cerenkov detectors won't be triggered by pions.

2.2 Calibration

The first step in the Cerenkov calibration is to suppress the pedestals by aligning them at channel zero for each adc spectrum. Then the single photo-electron peaks have to be aligned at the same channel (see [2] for more details). In this analysis channel 200 was chosen for both arms and the results are shown on Fig. 2 for the left arm and on Fig. 3 for the right arm.

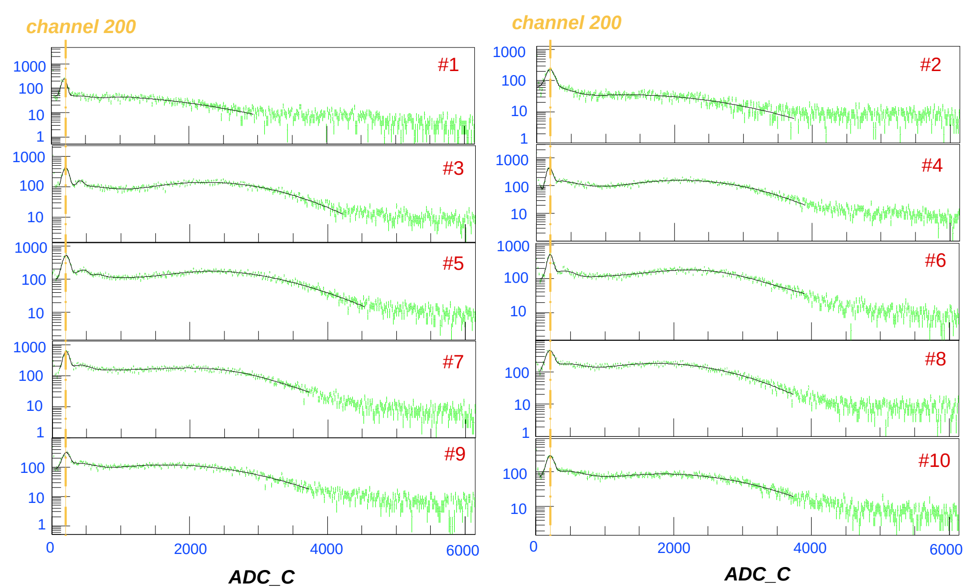

Figure 2: Single photo-electron peaks aligned at channel 200 (left arm)

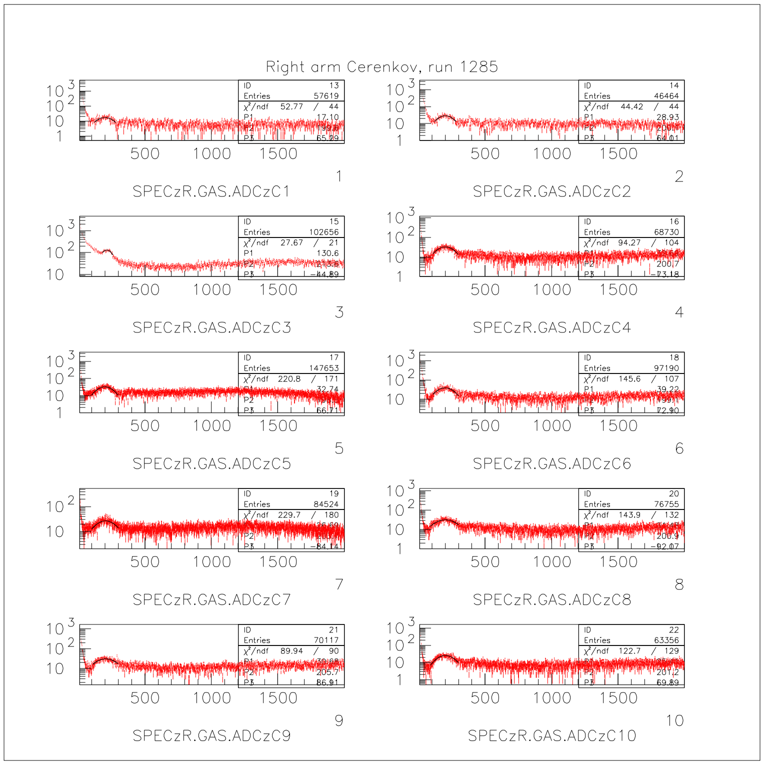

Figure 3: Single photo-electron peaks aligned at channel 200 (right arm)

The database coefficients (first 10 coefficients are the pedestal positions for the 10 adcs and the next 10 are the gains adjusted to have all single photo-electron peaks aligned at the same channel) for the right arm are:

5.200E+02 4.510E+02 3.120E+02 3.250E+02 4.540E+02 5.620E+02 4.470E+02 4.660E+02 4.940E+02 5.590E+02
3.467E+00 3.507E+00 3.206E+00 1.754E+00 1.166E+00 1.821E+00 1.079E+00 1.495E+00 2.024E+00 1.633E+00

and for the left arm:

5.710E+02 5.510E+02 5.490E+02 5.250E+02 6.250E+02 6.110E+02 6.490E+02 6.620E+02 5.570E+02 5.580E+02
2.418E+00 1.407E+00 2.439E+00 1.929E+00 2.504E+00 2.787E+00 2.886E+00

2.463E+00 3.313E+00 2.664E+00

For E01-012 it was required that the average number of photo-electrons for each PMT would be minimum seven. To check the performance of each PMT [4], a cut in our analysis is applied to select the central region of each mirror and then the corrected ADC spectra are fitted as in Fig. 4 for the right arm and in Fig. 5 for the left arm. The performance of both left and right arms cerenkov detectors is summarized in Table 1.

Table 1: Cerenkov detectors performance

MIRROR	RIGHT ARM			LEFT ARM		
	s.p.e	main peak	$n_{p.e.}$	s.p.e	main peak	$n_{p.e.}$
1	200	1708	8.5	200	1452	7.3
2	200	1556	7.8	200	2006	10.0
3	213	1724	8.1	200	2430	12.1
4	200	2233	11.2	200	2380	11.9
5	199	1303	6.5	202	2450	12.1
6	200	2155	10.8	202	2348	11.6
7	200	1472	7.4	200	2084	10.4
8	200	2254	11.3	200	2094	10.5
9	205	2116	10.3	200	1974	9.9
10	201	2086	10.4	199	2228	11.2

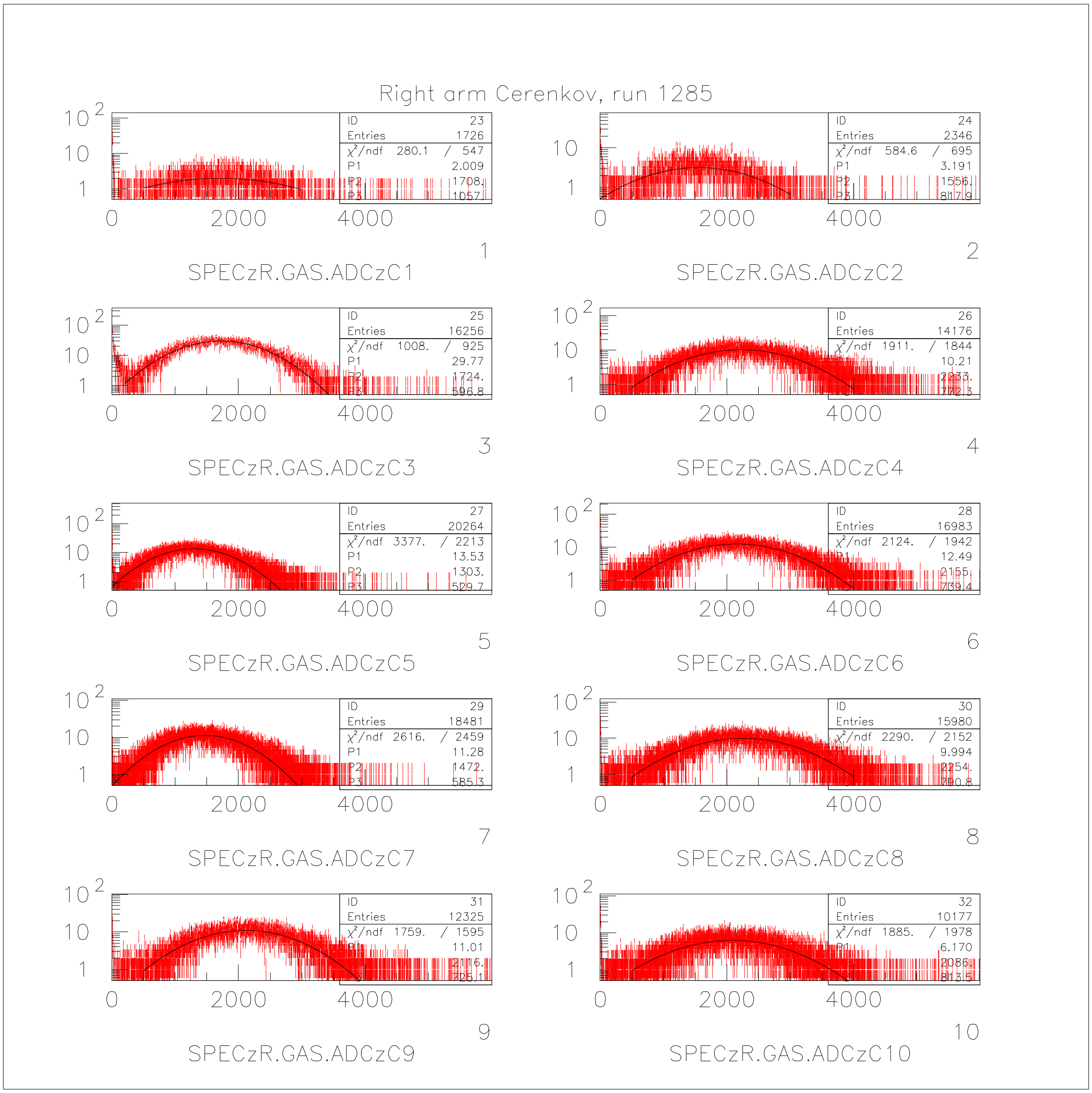

Figure 4: fit of main peak (left arm)

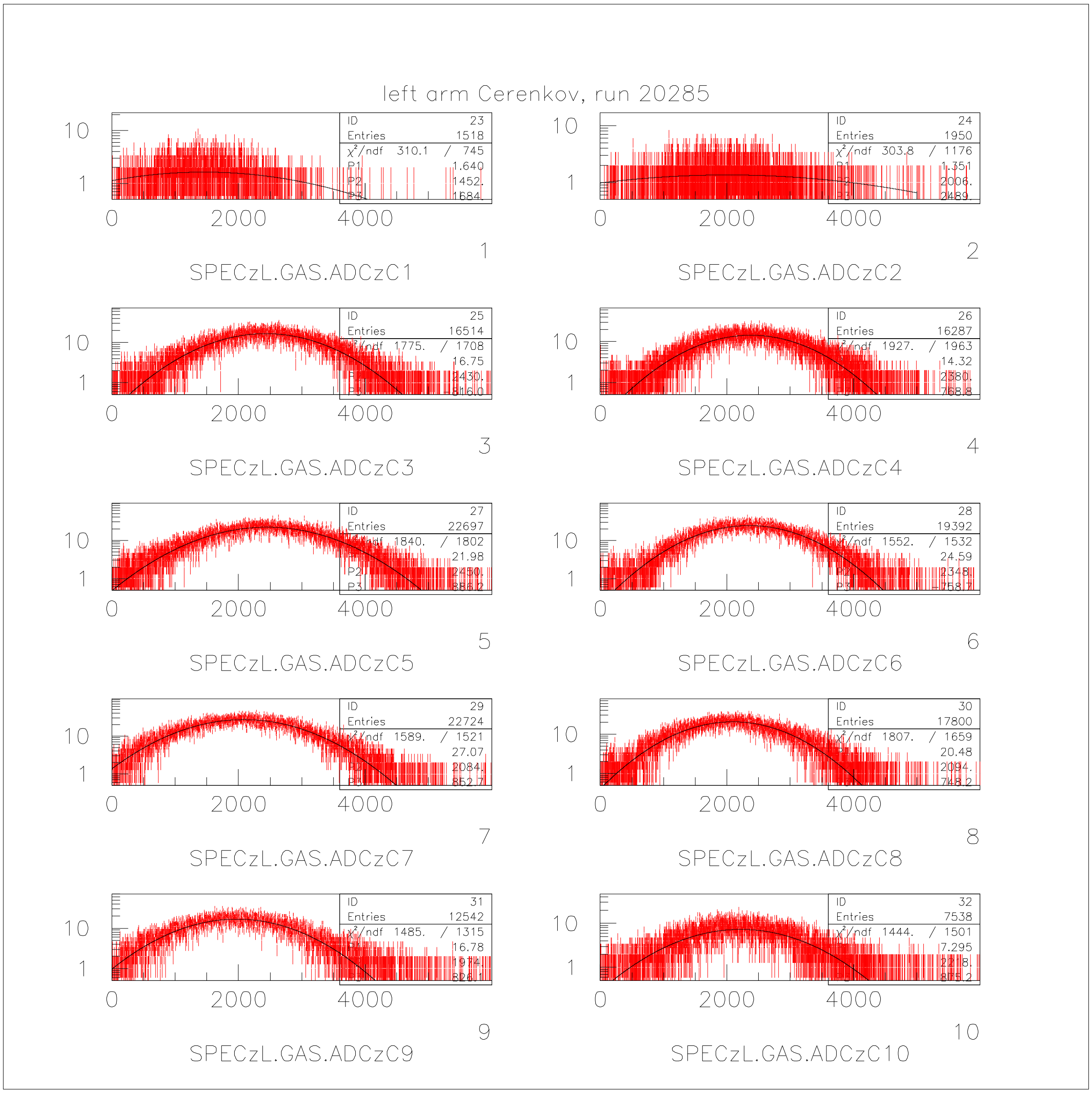

Figure 5: fit of main peak (right arm)

2.3 Comments

PMT3 of the right arm cerenkov was noisy and got worse during the experiment with the pedestal tail leaking into the single photo-electron peak and even higher. That will be taken into account in the PID cut analysis [5].

3 Electromagnetic calorimeter

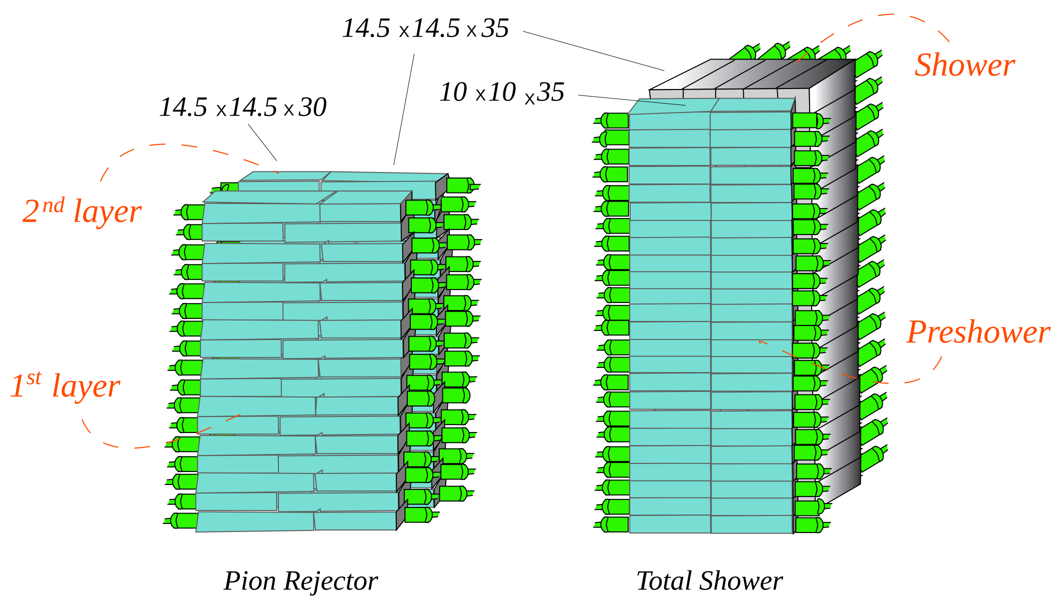

Figure 6: Configuration of the electromagnetic calorimeters in left (pion rejector) and right (total shower) arm.

3.1 Properties

Both total shower and pion rejector are made of two layers of leadglass blocks. Two types of leadglass are used: TF-1 and SF-5. Their main components are PbO and SiO_2, plus some additional compounds. The characteristics of each detector are listed below:

- right arm thickness:

  - preshower: leadglass type TF-1 ($X_0 = 2.74$ cm), the blocks thickness is 10cm = 3.6 radiation length.
  - shower: leadglass type SF-5 ($X_0 = 2.55$ cm), the blocks thickness is 35cm = 13.7 radiation length.

- left arm thickness:
  - first layer: leadglass type SF-5 ($X_0 = 2.55$ cm), the blocks thickness is 14.5cm = 5.7 radiation length.
  - second layer: same as first layer.

3.2 calibration

Due to the high voltage changes during the experiment and some hardware problems too, several calibrations were necessary. Here the calibration scheme for E01-012:

- run < 1510: shower_calib_r1281.dat
- 1511 < run < 1531: shower_calib_r1525.dat
- 1532 < run < 1537: shower_calib_r1537.dat
- 1538 < run < 1547: shower_calib_r1539.dat
- 1548 < run < 1800: shower_calib_r1908.dat
- 1828 < run < 1883: shower_calib_r1858.dat
- 1884 < run < 1987: shower_calib_r1908.dat
- 20000 < run < 20254: pr_calib_test4.dat
- 20270 < run < 20996: pr_calib1.dat

The high voltage in preshower blocks 8 and 16 were changed several times by mistake (due to a wrong detector map) between runs 1511 and 1548 and resulted in a saturation of these blocks that made them largely inefficient. Several calibrations were needed for this period each time the HV were increased.
Two calibrations are needed for the pion rejector due to a base problem on

block 4 of the second layer (problem fixed after run 20254).
All the other calibrations were generated when the E/P peak positions and widths deviated too much from the expected value (see Fig. 8 and Fig. 9).

E/P plots for the right (total shower) and the left (pion rejector) arm are shown in Fig. 7 (E is here the sum of the particule energy deposited in the 2 layers of the EM calorimeters). Both spectra were produced at the same kinematic setting: the total shower shows a much better energy resolution (12%, see fig. 8) than the pion rejector (17%, see fig. 9). Thus the right arm is a better particule discriminator.

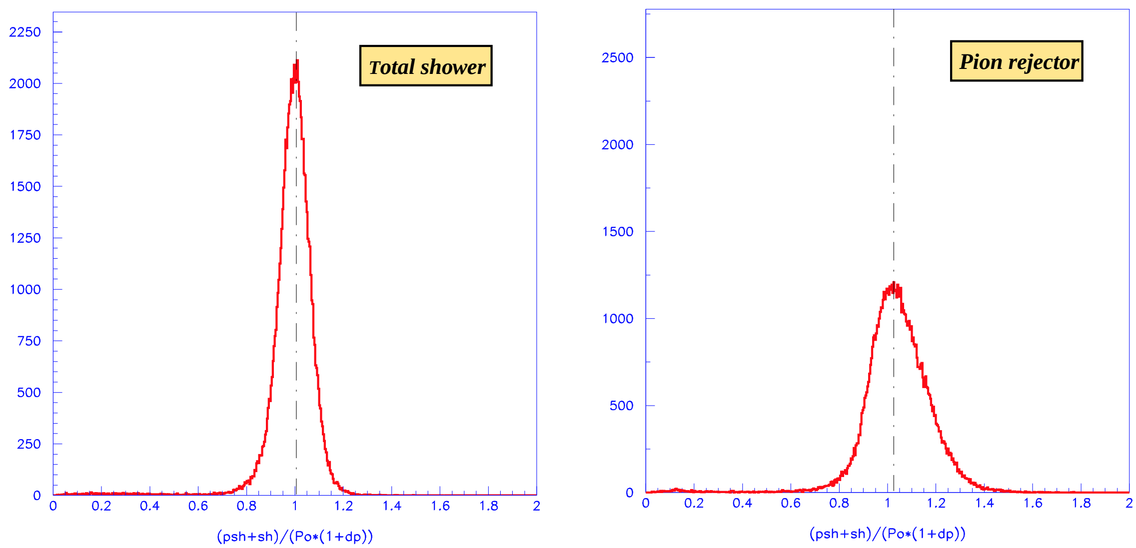

Figure 7: E/P peaks for right (total shower) and left (pion rejector) arm after a cut on cerenkov to remove most of the pions.

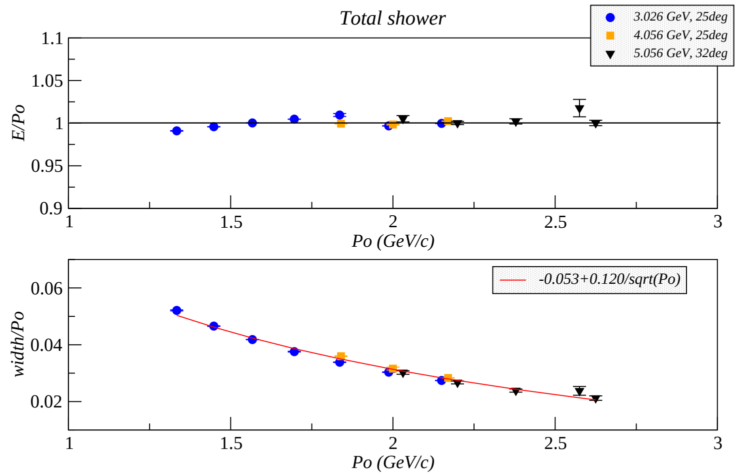

Figure 8: Total shower calibration: peak position and width from the gaussian fit of the E/P plot for each kinematic setting.

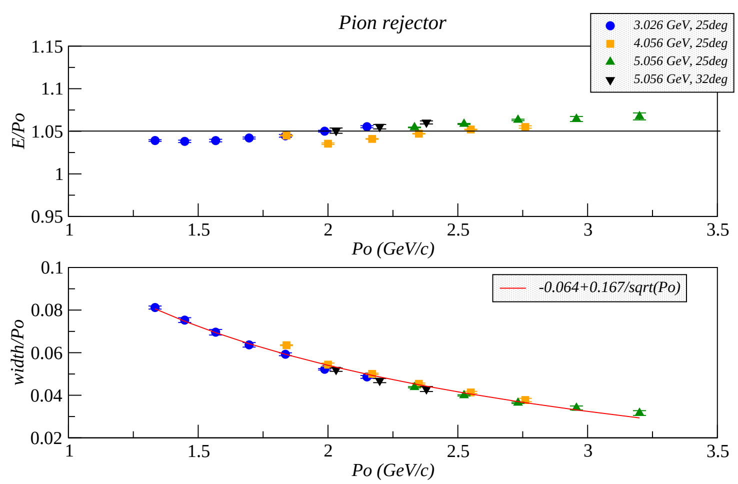

Figure 9: Pion rejector calibartion: peak position and width from the gaussian fit of the E/P plot for each kinematic setting.

Acknowledgments

I would like to thank Jian-Ping Chen and Karl Slifer for their precious advices.

References

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[2] K. Slifer,"*Analysis of the Hall A HRS Cerenkov Detectors for E94010*", E94010 Technical Note 32 (2000).

[3] K. Slifer,"*Shower Detector Calibration and Cut Optimization for E94010*", E94010 Technical Note 31 (2000).

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

[5] P. Solvignon,"*PID Efficiency for E01-012*", E01-012 Analysis Report 02 (2004).