STAR Note #174

Central Trigger Barrel Response for Low Energy Background

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1 Introduction

The STAR trigger is designed to select events based on vertex location, and multiplicity distribution. The components of the trigger system are the Vertex Position Detector (VPD), Veto Calorimeter (VC), Endcap Multi Wire Proportional Chamber (MWPC) and Central Trigger Barrel (CTB). The CTB subsystem is designed to measure charged particle multiplicity in the central $-1 < n < 1$ region.

The CTB (Fig. 1.) consists of scintillation detectors covering the surface of the TPC outer field cage, 207.75 cm in radius and 4.8 meters long. The detectors are housed in 120 trays, divided into two cylinders of 60 trays each. The current design for the CTB consists of 240 BC408 scintillators mounted 2 per tray. The CTB provides a measurement of the through the total light collected in each scintillator. The CTB is susceptible to fluctuations in the signal that reflect the statistical nature of the energy loss in a given scintillator as well as the fluctuations due to delta rays and other background generated in the nearby material. This consists of the TPC field cage in front of the CTB, the Electromagnetic Calorimeter (EMC) behind the CTB and the CTB support structure as shown in Fig. 2.

The purpose of the present measurement is to study the response in a CTB scintillator slat for low energy background including delta rays when 300 and 600 MeV/c pions pass through an adjacent slat. There has been some concern that GEANT calculations may underestimate this background at low energies. Therefore the objective is to compare the experimental yield with the Monte Carlo predictions.

2 Measurement

The measurements were performed using a 300 and 600 MeV/c negative pion beam from the test beam channel at the Los Alamos Meson Physics Facility. The experimental arrangement of the counters is shown in Figs. 3 and 4. The scintillation counters S1 and S2 with dimensions 7.6 cm $\times$ 12.7 cm $\times$ 0.6 cm and 5.1 cm $\times$ 10.2 cm $\times$ 0.6 cm respectively were used to identify the beam. A Pb glass detector S3 with dimension 8.9 cm $\times$ 8.9 cm $\times$ 33 cm was used to veto the electron contamination in the pion beam.

The CTB test scintillator slat A2, 100 cm long by 20 cm wide by 1 cm thick, was mounted just below the beam height and was surrounded by material to mock up the cross section of the STAR detector. This was 1 cm thick each of aluminum and plastic in front, 1 cm thick of plastic behind, the dummy CTB slat A1 (1 cm thick plastic) above and 10 cm thick Pb bricks behind to simulate the STAR EMC. For all counters (S1, S2, S3 and A2), 2 inch diameter Hamamatsu R2490 phototubes were used.

An online S3 spectrum with pions and electrons at 300 MeV/c is shown in Fig. 5. S3 was in anticoincidence with S1$*$S2 with the discriminator threshold set to eliminate any electrons in the beam with pulse height greater than channel 105. This threshold was chosen by placing a Pb brick in front of S1 to eliminate electrons. The beam was defined by the coincidence of S1, S2 and anticoincidence with S3. The timing of S2 was used to determine the trigger for the ADC gate. A LeCroy LRS 2249A ADC was used to record S3 and A2 ADC information. A Macintosh computer based data acquisition system interfaced with a CAMAC crate, and running KMAX software, was used for data recording.

About 55% of the beam at 300 MeV/c and less than 2% of the beam at 600 MeV/c were electrons. The estimated electron background in the beam defined by S1.S2.S3 at 300 MeV/c was 5.5%. This is mainly due to the mismatch of the size of S2 and the Pb glass veto counter. For 600 MeV/c, the electron contamination of the vetoed beam was estimated to be smaller than 0.2%. This is not expected to have a significant effect on the results.

To study the spatial dependence of the background with the beam passing through the dummy slat, data were recorded with the beam being placed at two distances above A2 and at various positions along A1 as shown in Fig. 6. Since the beam profile in the test beam channel was not well known, we considered the area of A1 where beam passed through equal to the area of the scintillator S2 placed behind A1. Data were recorded for six positions (1-6) for both momenta such that Ay=10 cm for position 1,2,3 while Ay=15 cm for 4,5,6 where Ay is the vertical distance between the A2 upper edge and the beam center. The A2 slat was also placed in the beam to calibrate its response to the 2.12 MeV energy loss for 300 MeV/c and to the 2.00 MeV energy loss for 600 MeV/c pion beam.

3 Results

A typical A2 signal for the 300 MeV/c pion beam passing through the dummy CTB slat at position 2 (see Fig. 6) is shown in Fig. 7. The peak around channel 60 is the ADC pedestal. A cut in channel number 161 corresponds to a threshold cut above the pedestal of about 0.96 MeV determined from the calibration run. Any signal beyond channel 161 was attributed to low energy background.

The ratio (R) of the background yield above 0.96 MeV to the pion trigger was measured for different positions (See fig. 6) and for pion momentum of 300 and 600 MeV/c. The yields are shown in Table 1. In addition the percentage of events above 3 MeV for positions 2 and 5 are shown in Table 2.

Position (See Fig. 6)	Yield for 300 MeV/c		Yield for 600 MeV/c	
	Data	MC	Data	MC
1	8.8%		5.6%	
2	9.0%	1.0%	7.0%	2.7%
3	7.4%		4.8%	
4	3.5%		2.9%	
5	3.7%	0.8%	3.1%	1.7%
6	2.8%		2.5%	

Table 1: Measured Low Energy Background Yield Ratio (R) normalized to pion beam. The threshold was set at 0.96 MeV. Also shown are the Monte Carlo predictions.

Position (See Fig. 6)	Yield for 300 MeV/c		Yield for 600 MeV/c	
	Data	MC	Data	MC
2	1.7%	0.3%	1.1%	1.1%
5	0.6%	0.2%	0.7%	0.7%

Table 2: Measured Low Energy Background Yield Ratio (R) normalized to pion beam. The threshold was set at 3.00 MeV. Also shown are the Monte Carlo predictions.

Simulated data were generated for the low energy background using GEANT 3.21. All physical processes were turned on including the production of secondaries. Hadronic showers were generated with GHEISHA. Electron contamination in the pion beam was also included in the simulation. Some of the Monte Carlo default parameters were modified to take into account the lower energy regime of the experimental setup. The particle energy cutoffs were set to 100 KeV for electrons and photons and to 1 MeV for hadrons, neutrons and muons. (A 300 MeV/c run with the default GEANT parameters was made and we found that the yield changed by less than 10The measured and simulated A2 spectra for position 5 are shown in Fig. 8 for 300 MeV/c and Fig. 9 for 600 MeV/c. For position 2, the A2 spectra are shown in Fig. 10 and 11 for 300 MeV/c and 600 MeV/c respectively.

The measured yields above 0.96 MeV were found to be nine times the Monte Carlo prediction for 300 MeV/c at position 2 and five times for position 5. The 600 MeV/c data was three times the Monte Carlo at position 2 and two times at position 5. However, from Fig. 9 and 11 it appears that the 600 MeV/c data and Monte Carlo agree very well except in the region from 1–3 MeV, which corresponds to minimum ionizing particles. From the data in table 1 and 2, one can estimate that this excess is 4.3% for position 2 and 1.4% for position 5. The 300 MeV/c data also appears to have an excess of counts in the 1–3 MeV region, although in this case the data above 3 MeV exceeds the simulation by about a factor of six at position 2 and three at position 5. If we multiply the simulation by the factors just quoted and extrapolate under the minimum ionizing peak, we can crudely estimate that the minimum ionizing excess is about 3% at position 2 and 2% at position 5.

Thus the Monte Carlo underestimates the experimental yields as expected, but at 600 MeV/c it seems to reproduce the data well except for a few percent of single minimum ionizing particles. It is difficult to pinpoint the source of these particles. The beam characteristics were not precisely known; for example we did not have detailed tracking or momentum analysis for the incoming particles. Nor did we have adequate collimation or veto of beam halo caused by interactions of the beam upstream of scintillator S1. Furthermore the complex geometry of the surrounding masses, supporting table, limited and somewhat irregularly shaped lead brick wall, etc, can be approximated only crudely by our GEANT calculations. A similar excess of single minimum ionizing particles is seen in the 300 MeV/c data, although this conclusion is made much less certain since the Monte Carlo clearly underestimates the whole spectrum by factors of at least 3-6. This is probably due to the fact that the energy integrated back angle charged particle cross sections at low energies are not well characterized in GEANT, (or any other code that the authors are aware of). In conclusion we see that if the experimental setup allowed a few per cent of the beam to strike A2 while some process, unaccounted for in GEANT, triggered S1 and S2, then GEANT reproduces the data at 600 MeV/c and falls about a factor of 3–6 below the data at 300 MeV/c. Otherwise we must conclude that GEANT falls about a factor of 5–9 below the data at 300 MeV/c and 2–3 times below the data at 600 MeV/c.

4 Acknowledgement

We would like to thank Dr. J. Donahue and the support staff of LAMPF test beam area for providing us with the beam and all the necessary help during these tests.

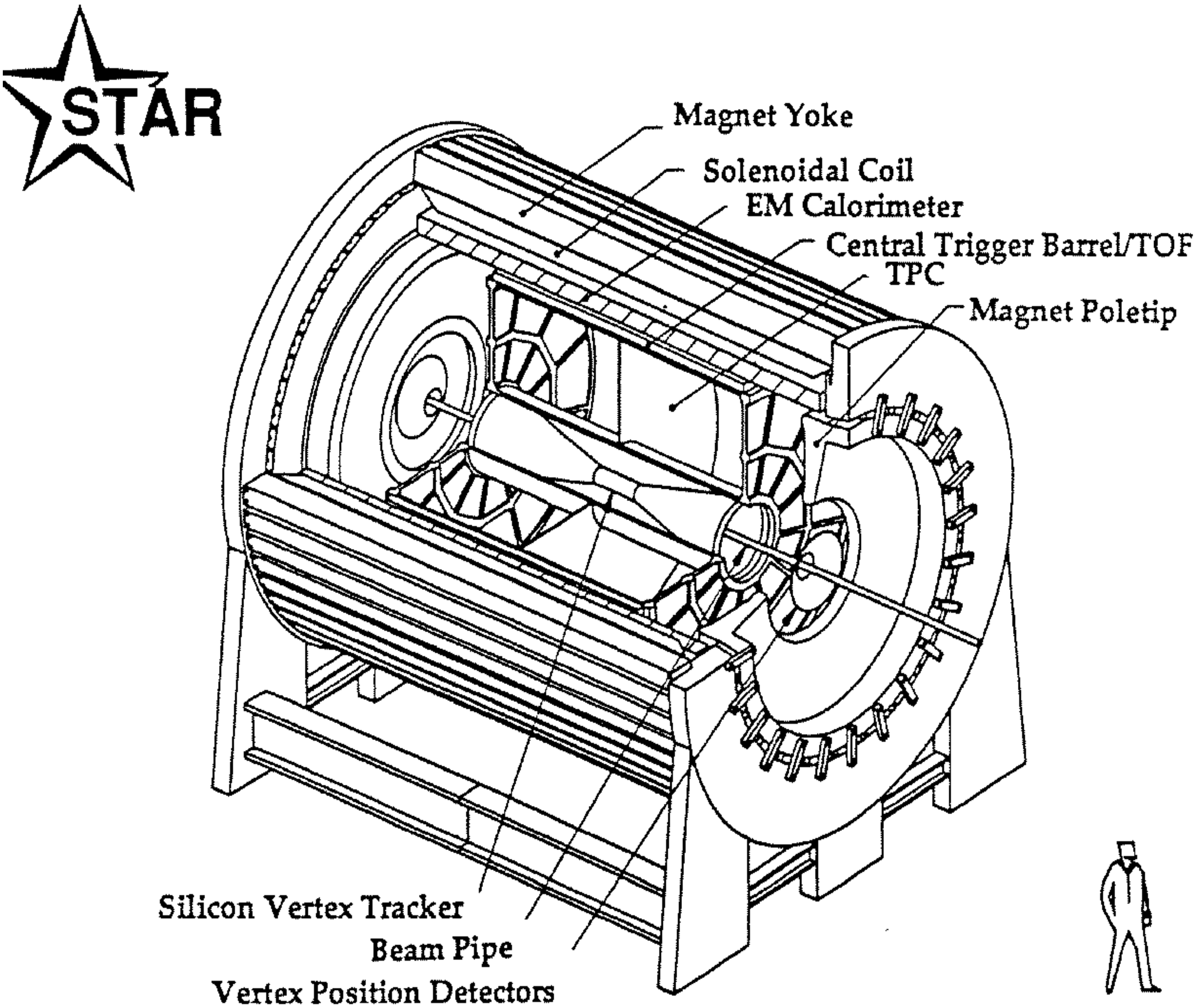


Figure 1: Configuration of the STAR detector.

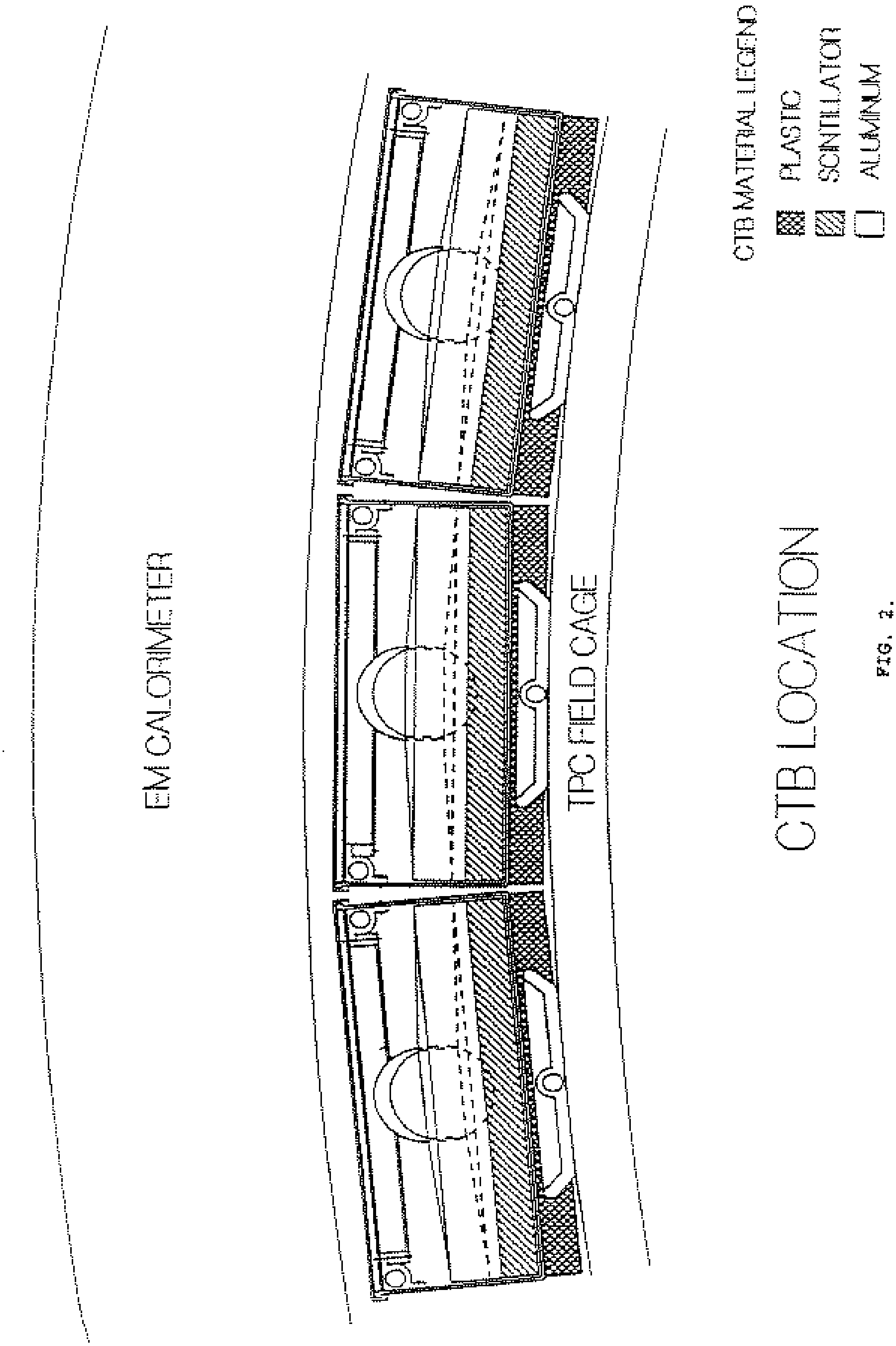


Figure 2: CTB supprot structure.

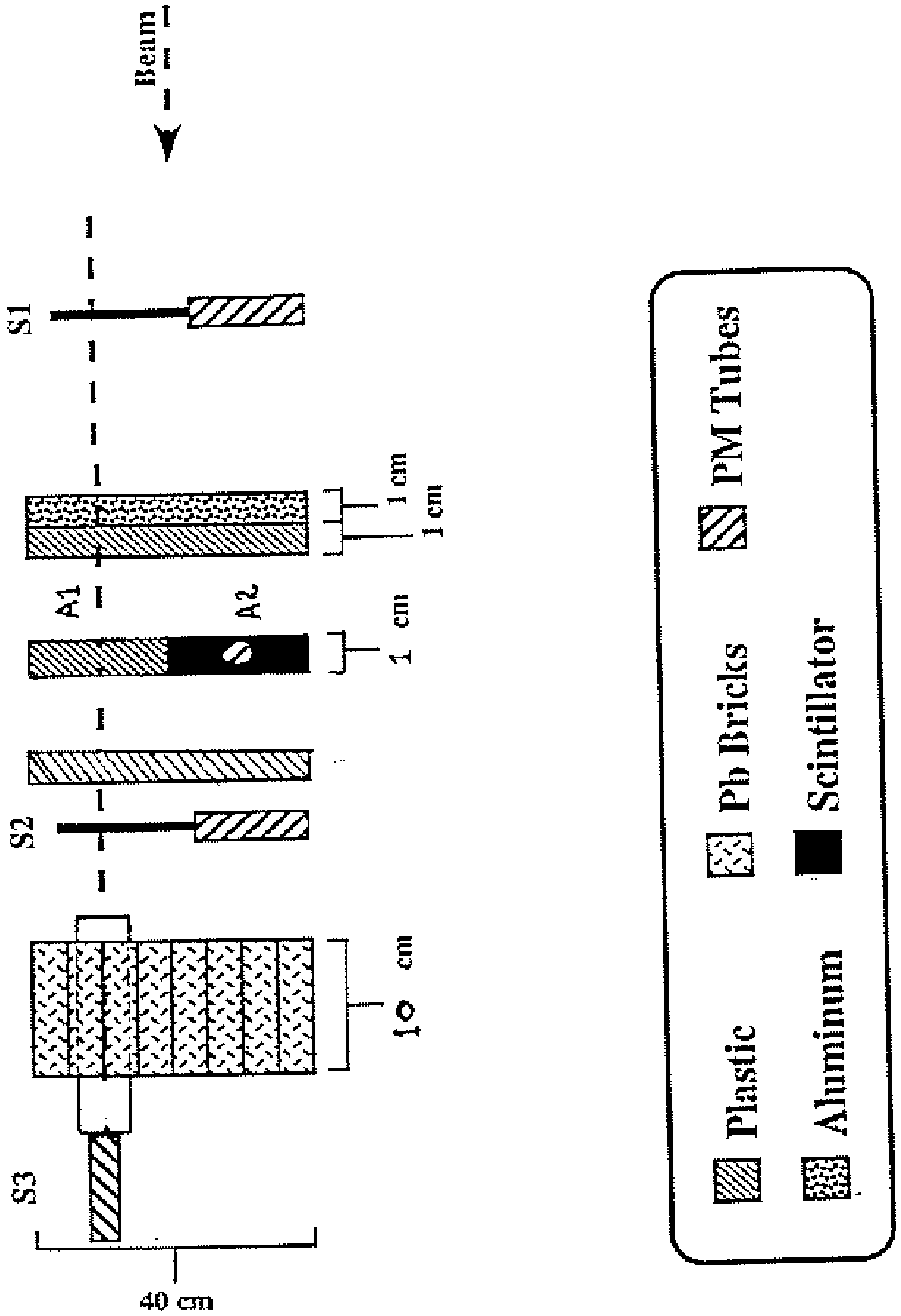
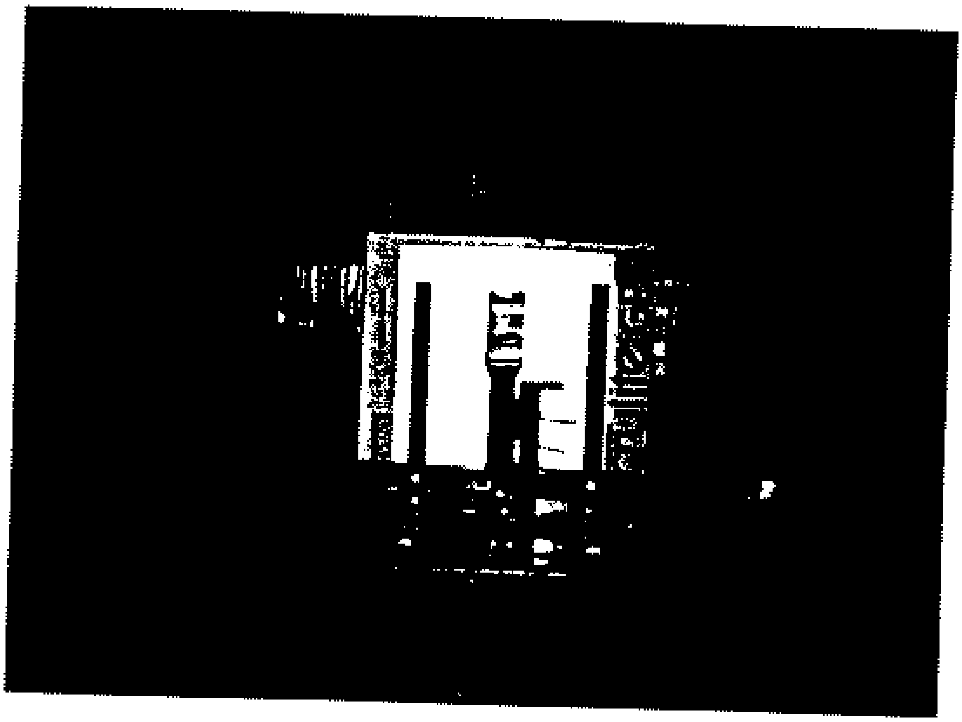
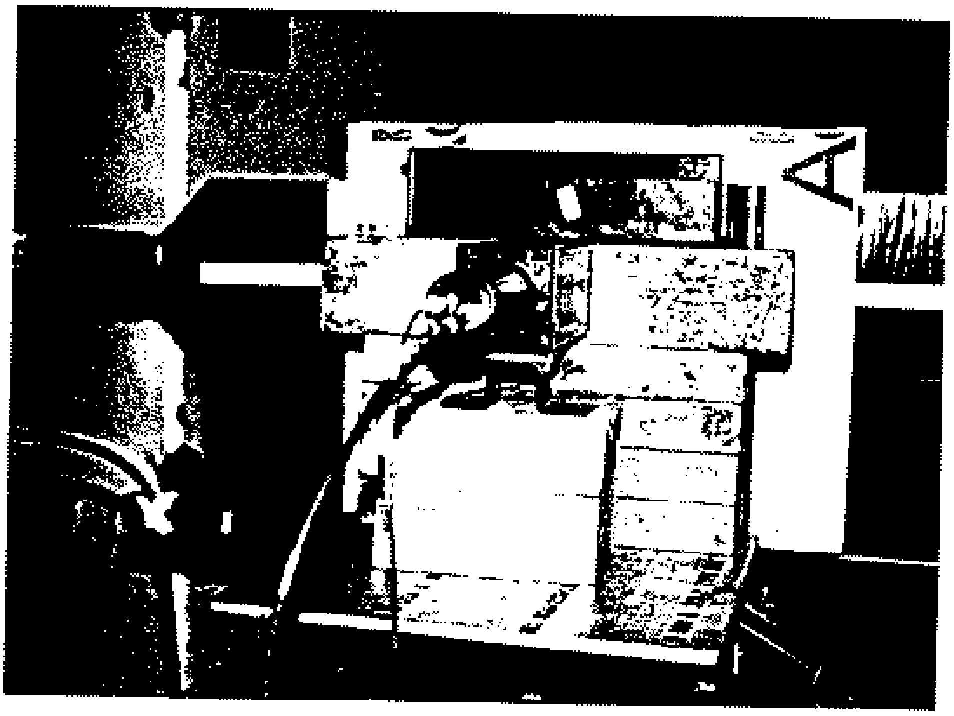


Figure 3: Experimental arrangement (S1=7.6 cm $\times$ 12.7 cm $\times$ 0.6 cm, S2=5.1 cm $\times$ 10.2 cm $\times$ 0.6 cm, S3=8.9 cm $\times$ 8.9 cm $\times$ 33 cm. A1 and A2 were 100 cm $\times$ 20 cm $\times$ 1 cm. Aluminum and plastic sheets were 1 cm $\times$ 46 cm $\times$ 46 cm. The Pb brick wall was 10 cm $\times$ 40 cm $\times$ 40 cm.)



FRONT
VIEW



END
VIEW

Figure 4: Front and End view of the arrangement. The setup is for a calibration run where A2 was placed in the beam.

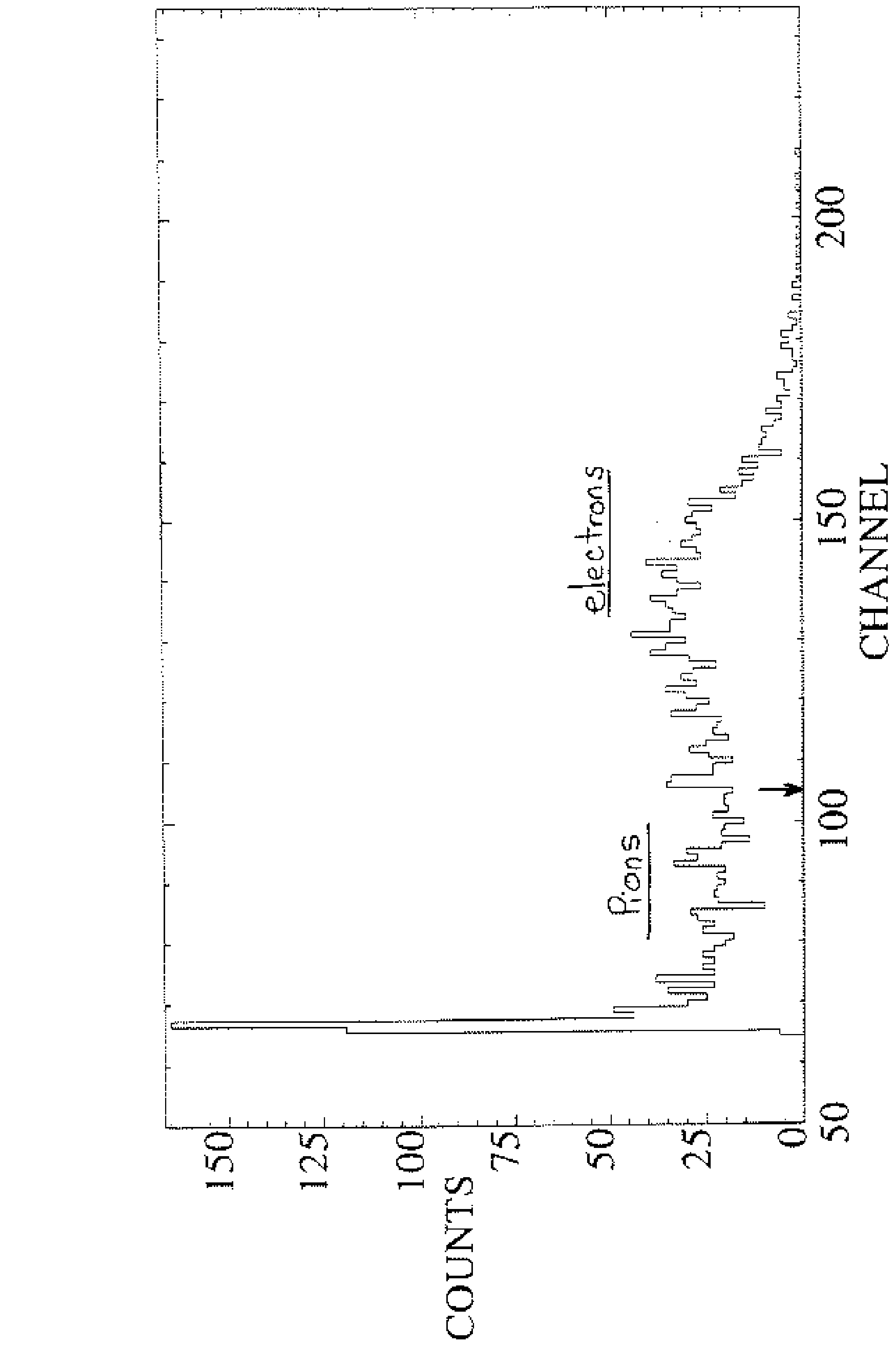


Figure 5: A typical online Pb glass spectrum showing pions and electrons from the 300 MeV/c beam. Electrons in the beam were eliminated by a threshold cut at channel 105.

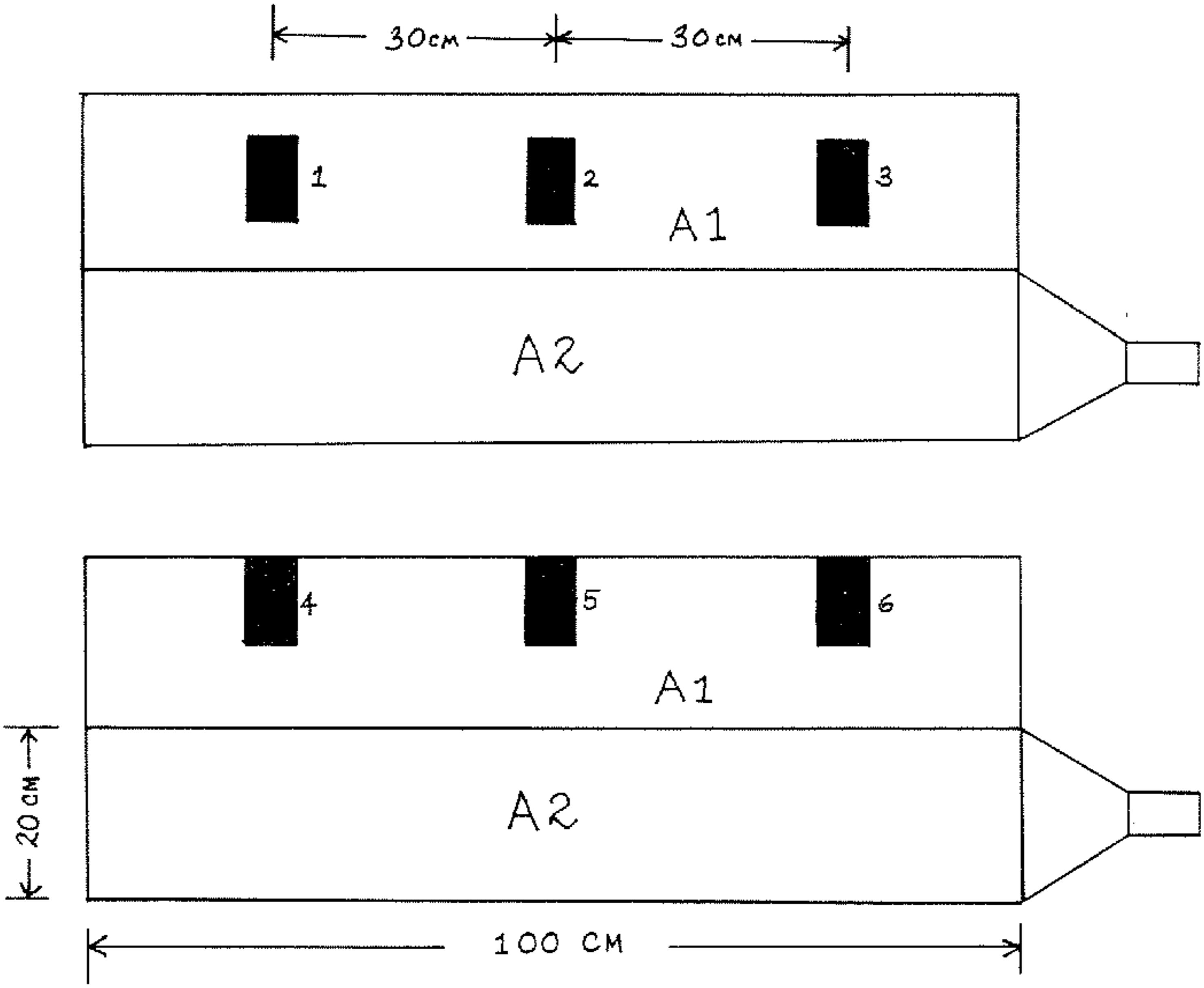


Figure 6: Six spatial positions (1,2...6) of the beam. The dark area indicates the size of S2 projected on A1.

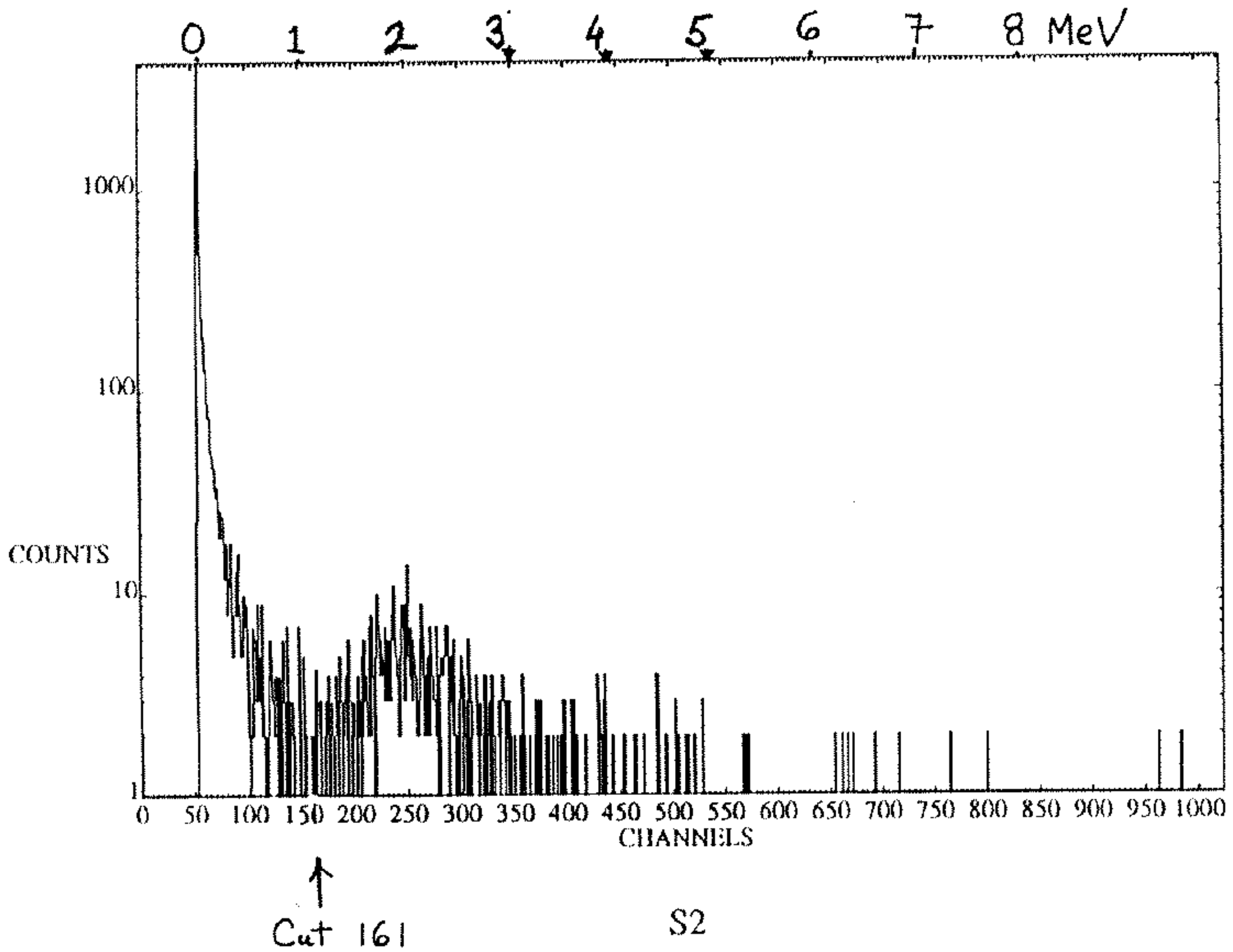


Figure 7: A typical A2 spectrum obtained from 300 MeV/c pion passing through position 2 of the CTB dummy slat.

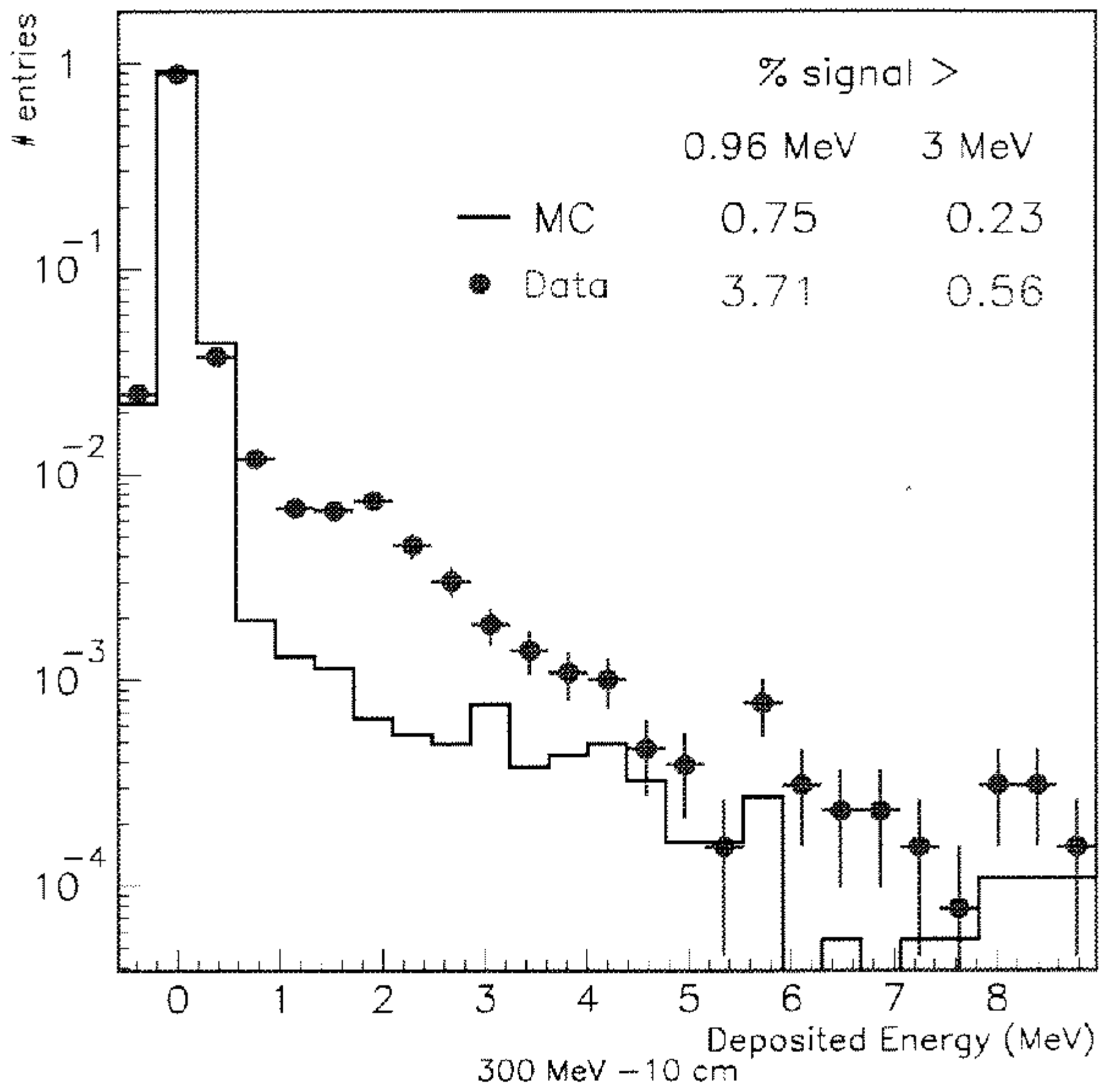


Figure 8: Simulated and measured pedestal subtracted A2 spectrum for position 5 and momentum 300 MeV/c. The peak below 1 MeV is due to the ADC pedestal. The data in table 1 and 2 are the integral of the counts above 0.96 MeV and 3 MeV respectively.

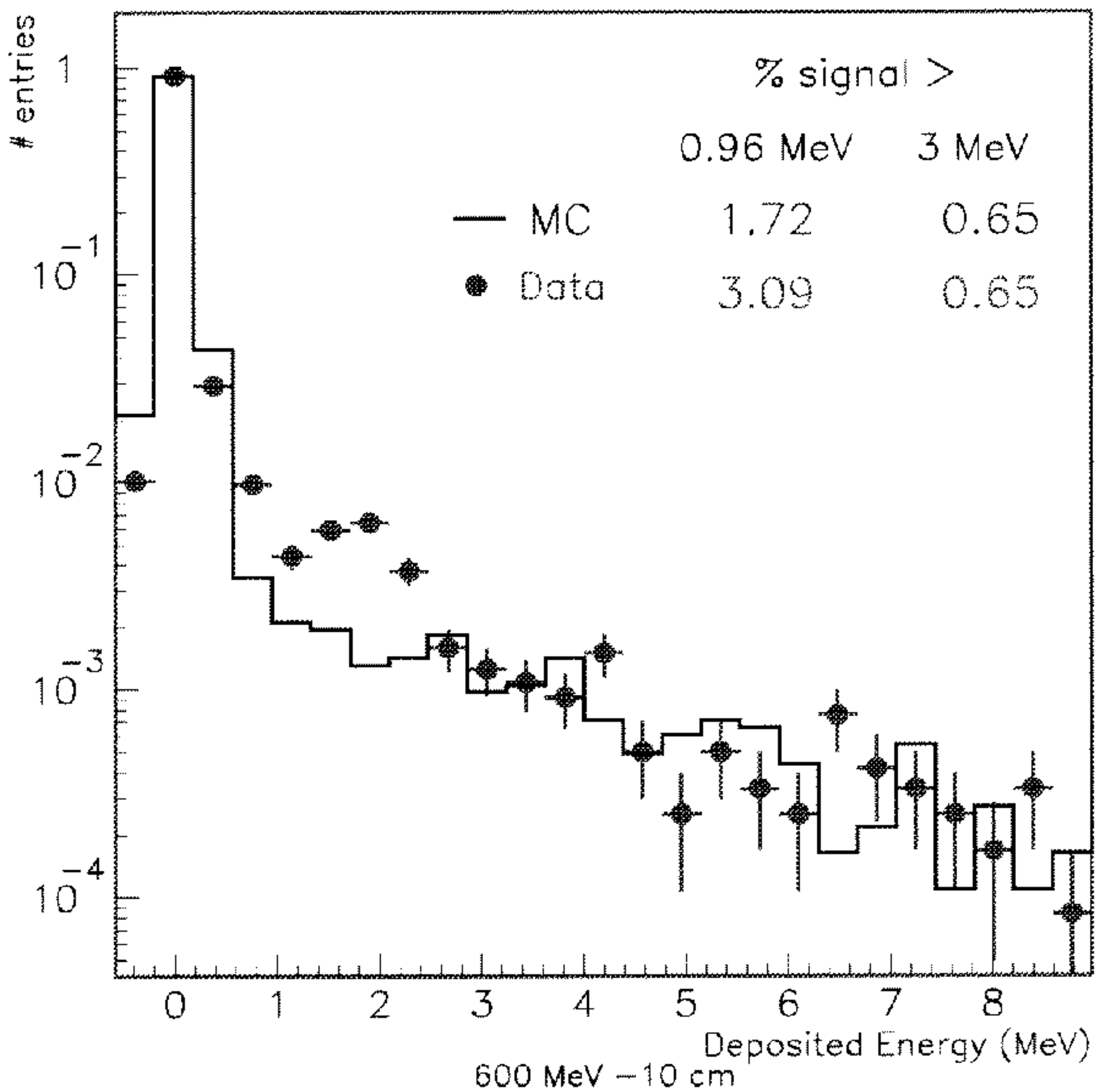


Figure 9: Simulated and measured pedestal subtracted A2 spectrum for position 5 and momentum 600 MeV/c. The peak below 1 MeV is due to the ADC pedestal. The data in table 1 and 2 are the integral of the counts above 0.96 MeV and 3 MeV respectively.

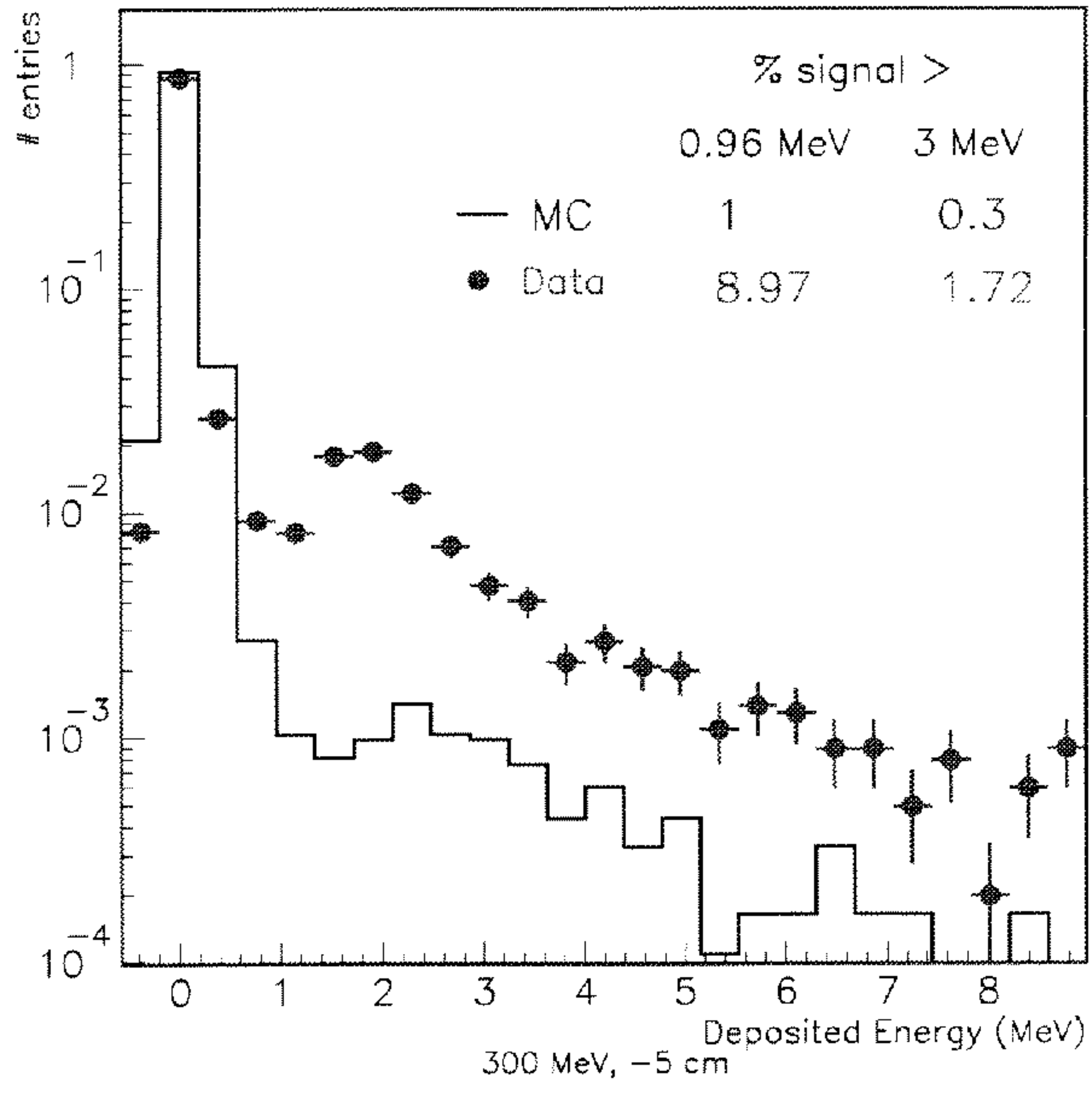


Figure 10: Simulated and measured pedestal subtracted A2 spectrum for position 2 and momentum 300 MeV/c. The peak below 1 MeV is due to the ADC pedestal. The data in table 1 and 2 are the integral of the counts above 0.96 MeV and 3 MeV respectively.

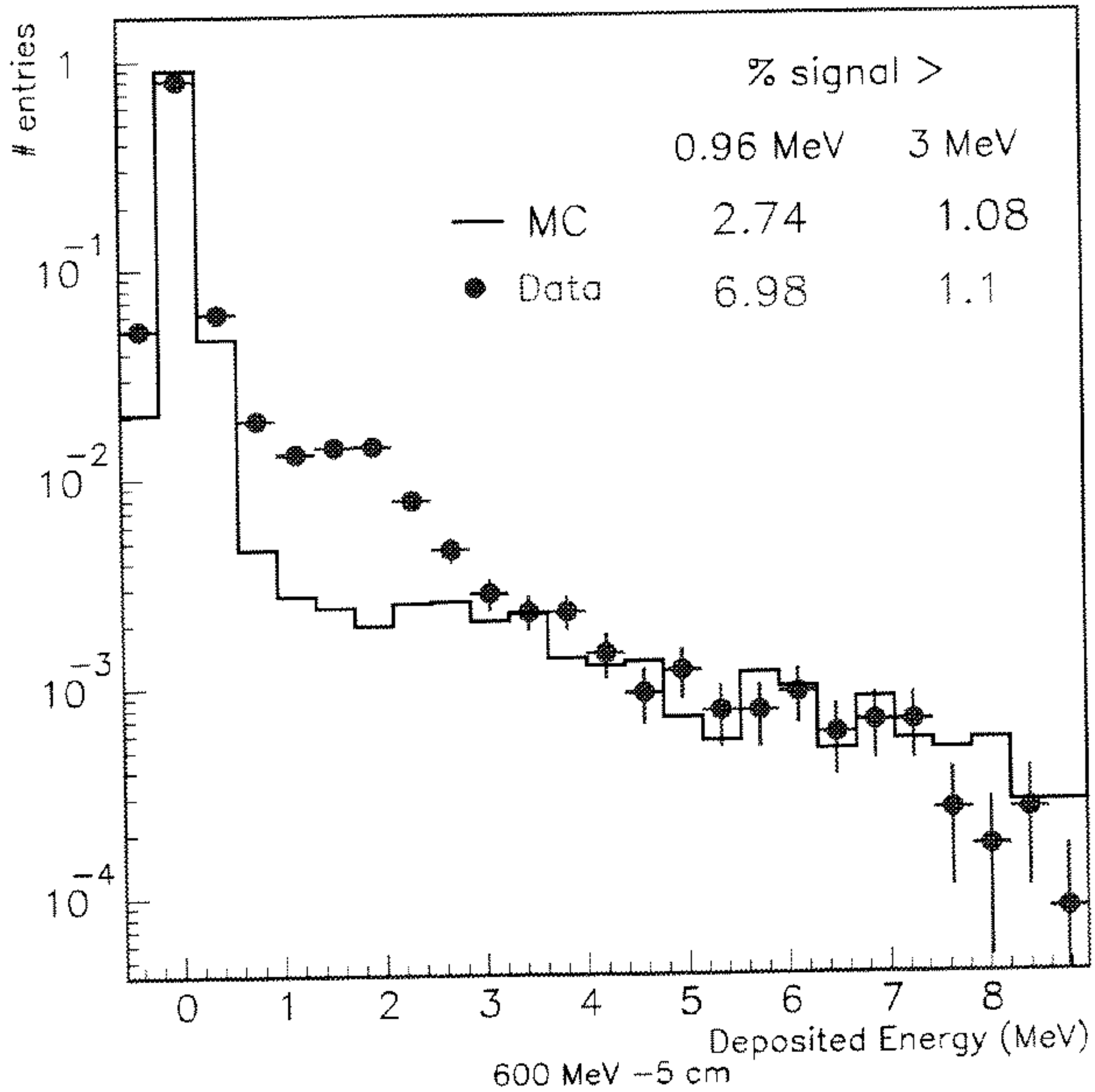


Figure 11: Simulated and measured pedestal subtracted A2 spectrum for position 2 and momentum 600 MeV/c. The peak below 1 MeV is due to the ADC pedestal. The data in table 1 and 2 are the integral of the counts above 0.96 MeV and 3 MeV respectively.