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THE HIGH PRESSURE GAS CALORIMETER WITH THE CYLINDRICAL IONIZATION CHAMBERS.

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Introduction

As it has been disussed in the number of papers [1,2,3] the forward hadronic calorimeter in the EAGLE set up has to cover the pseudorapidity range 3 to 5 and can have quite moderate granularity and the energy resolution. It has the starting position at 14 m from the intersection point [4], the transverse dimension up to 160 cm at the beam line and has to operate at the extremely high radiation dose [5]. The calorimeter has to function up to the luminosities L= 2x10**34 1/cm**2sec (on the average 20 events per bunch crossing). Good time response is therefore needed as pile up of events from many bunch crossing will increase the fluctuations in the energy measurements.

As a possible solution for the forward calorimetry we propose to consider a ionization calorimeter filled with a gas (as the active medium) at the modest or intermediate pressures and the lead as the absorber.A possible design concept for this calorimeter we show in the Fig.1 . The idea to build those type forward calorimeter for the collider experiments has been discussed repeatedly [6].

In this note we are presenting the first beam test results of those calorimeter prototype. It has been exposed in the pion beam with the momentum 30.7;43 and 56.2 GeV/c.

2. Description of the prototype.

The prototype consists of seven identical modules of the hexagonal shape with the sizes are shown in the Fig.1. The casing of these modules have been made from the stainless steal. In the used structure the cylindrical sheets of the high pressure gas gaps are oriented parallel to the beam. The main body of the absorber is a lead. The thickness of the gas gaps is 2.5 mm. The electrodes of the cylindrical ioniztion chambers are made from the stainless steal. The inner electrode filled with the lead and has the diameter 8 mm. The electrical isolation inside chambers ensures a few spacers. Aiming for reasonable uniformity,the layout of the tubes shown in the figure with all relevant dimensions. Each module has 19 ionizing tubes. The tubes (one meter long) run through the full length of the calorimeter prototype. Between the tubes and the end walls of the modules there are 30 mm gaps to locate at the back face of the prototype the printed boards, H.V. capacitors and the resistors, output signal connectors.

We paired the inner electrodes at the face of the modules and had 2 m long ionization chambers. One tube has not been used.

The modules have been filled up the gas mixture 95%Ar +5%CF4. The working point on H.V. at the different pressure has been taken from the drift velocity curver (Fig.2) to get the electric field in the chambers with maximum drift velocity (E/P = 4 V/cm*torr).

3. The readout electronics.

The readout electronics include a few components: the units for summing the signals from the tubes outside of the modules; one amplifier for each module and the ADC's.

During beam expose we were testing three summing schemes (Fig.3):

Scheme 1 (Fig.3a) - 18 outputs from a module summing through the impedance-matching transformer;

& Scheme 2 (Fig.3b) - the individual tube output connects with the matching preamplifier. The outputs of the preamps are gathering together and summing result comes to the amplifier.

Scheme 3 (Fig.3c) - the tube outputs come to the common point, the transformer matches the capacitances of the detector and the amplifier.

In the Table 1 we show the electronic noise of the data taken channel for one module and for the complete prototype (7 modules).

We define here the electronic noise as:

$$RMS(noise)=RMS(ped)*E/\langle S\rangle,$$

where RMS(ped) = root mean square a pedestal distribution [ADC counts].

E - energy of the beam [GeV];

<S> - mean signal [ADC counts];

The electronic noise slightly better for the third scheme. The rise time of the signal for these summing schemes shown in the last column of the Table 1.

We have not seen in our set up of seven modules the correlated electronic noise. For example we show in the Table 2 (for summing scheme 1)the dispersion of the pedestals for the individual module and for the system of seven modules ($\Sigma D_1=D_\Sigma$).

In the Fig. 4 one can find the pedestals distribution for the central module and for the whole set up. The distribution of signals from the assembly are presented in the Fig.5a. The typical signal from the central module at 30.7 GeV/c shown in the Fig.5b.

4. Results.

During the beam tests of the prototype we have not found a considerable differenses in the obtained results for three summing schemes and present it below for the scheme one only.

The signal response of the prototype has a linear dependence as a function beam energy (Fig. 6). We show on the same figures also the energy resolution of the testing prototype. The resolution becomes better with the energy increase .Unfortunately due to the small energy interval we are not able to estimate from that behavior the constant term in the energy resolution.

Fig.7 shows a dependence of the mean signal as a function of the pressure.After the subtraction the electronic noise we see slow improve of the energy resolution with the pressure. The contribution the fluctuation of the ionization in the gas mixture to the energy resolution is small (<5%) at the pressure grater 20 atm.

The intrinsic hadron energy resolution for the prototype has been estimated by using the GEANT3.14 simulation program. The results are in good coincidence with the experimental data (Fig. 7), taken into accounta possible constant term contribution to the energy resolution.

Using the results of the simulation paper [7] we may expect to have the intrinsic hadron energy resolution for our type gas calorimeter by factor 3-4 better, if we will construct it with the proper structure.This goal we will try to achieve in the next new prototypes.

We can decrease the signal/noise ratio in 3-5 times also to use the gas mixture with higher response amplitude (using,for example, Xe in the gas mixture),to operate at higher pressure, to make better the match between the ionizing chambers and front end electronics. These ideas need further examination.

During the beam tests we have achieved the time length of the signal from the modules ~60 ns (the full width at the base). The charge collection time was ~30 ns in our case. We hope to decrease this value in 1.5-2 times to make smaller the gas gap (1.5 mm) and to use a gas mixture with a higher drift velocity. The better matching impedances will also to make the time duration of the signal in 1.5-2 times less. So, we hope to build the detector with a time response ~20-30 ns.

References.

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[4] J.Chwastowski et al,EAGLE detector layout for simulations towards the L.O.I.,EAGLE Internal note: TECH-NO-003, 11 May 1992.

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Table 1

The electronic noise and the signal rise time
P_{beam}=56 GeV/c, P=30 atm

Scheme	The central module [GeV]	Seven modules [GeV]	The rise time [ns]
1	4.9	13	6
2	5.4	14.5	12
3	4.5	12	12

Table 2

The first and the second momentums of the pedestals distribution

Modules	1	2	3	4	5	6	7	Assembly
RMS	21.9	17.4	18.0	15.4	16.2	20.3	24.1	51.0
D	479.61	302.76	324.0	237.16	262.44	412.09	580.81	

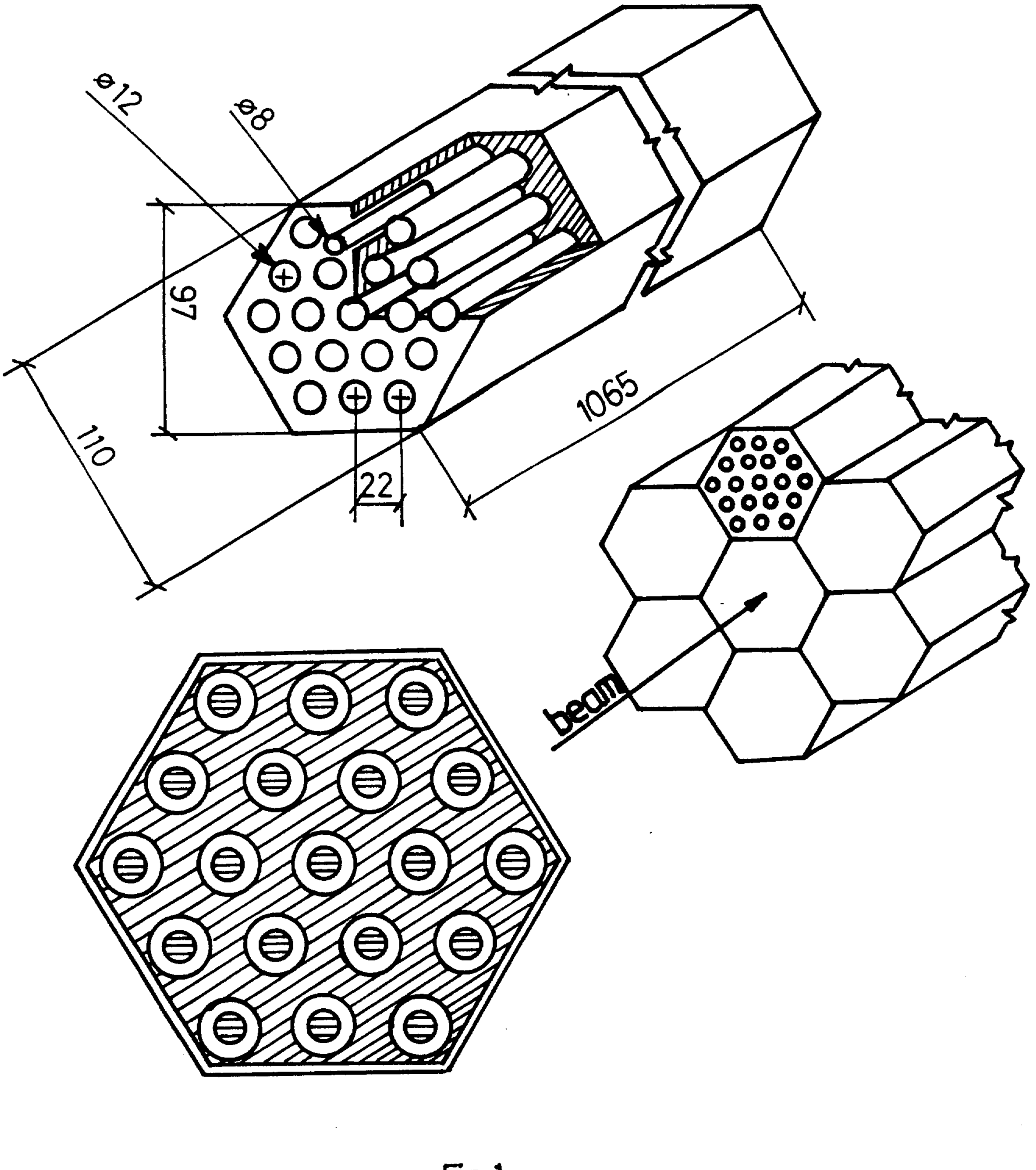
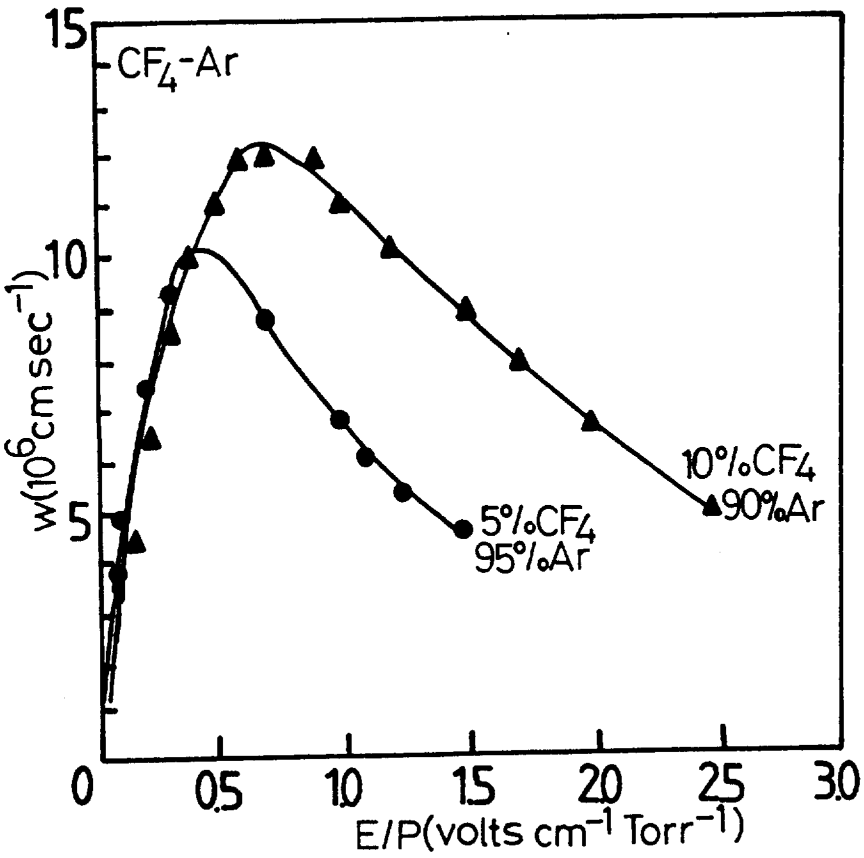


Fig.1



15
10
5
0
CF4-Ar
w(10^6 cm sec^-1)
0.5
1.0
1.5
2.0
2.5
3.0
E/P(volts cm^-1 Torr^-1)
10%CF4
90%Ar
5%CF4
95%Ar

Fig.2

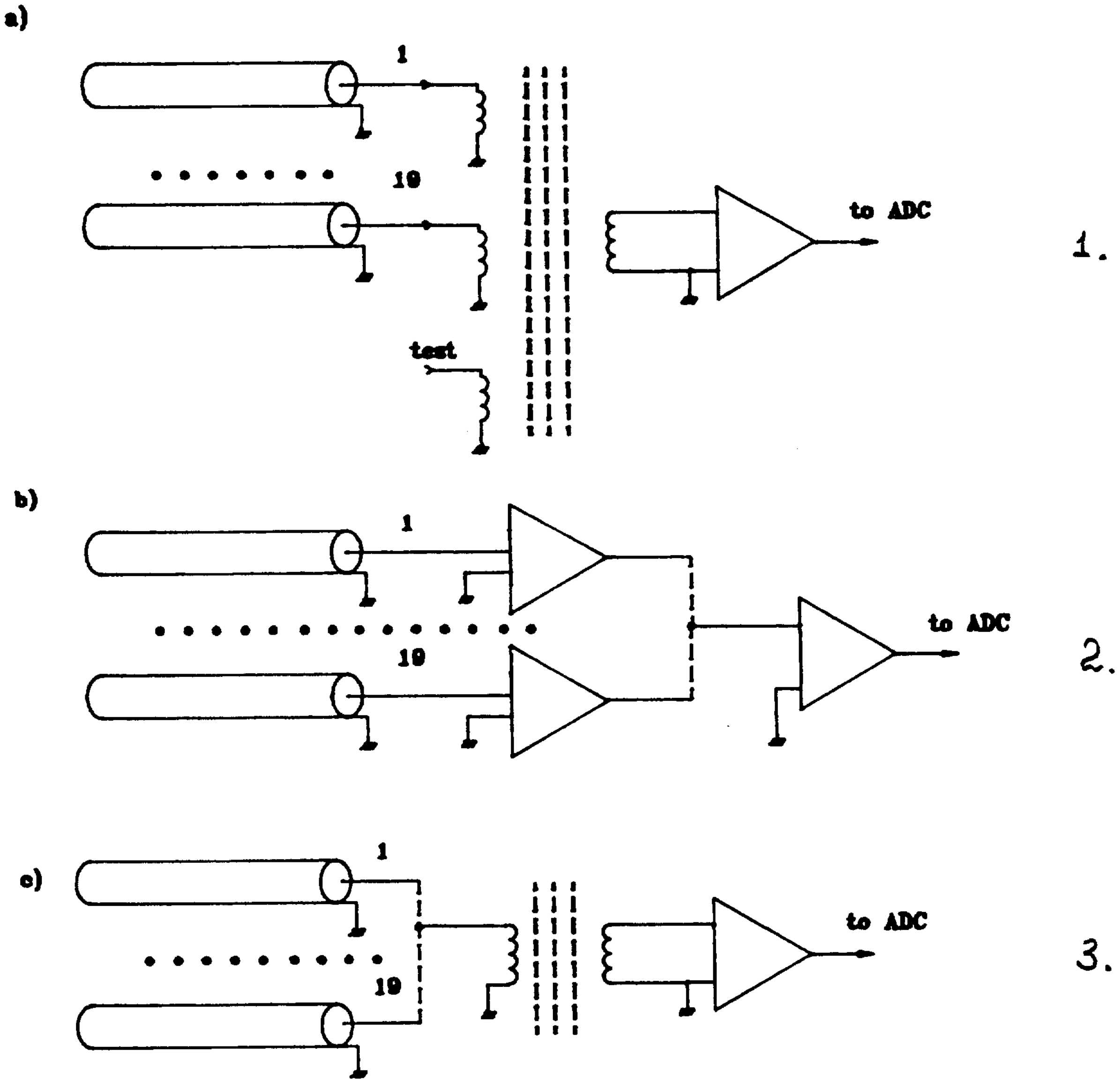


Fig.3

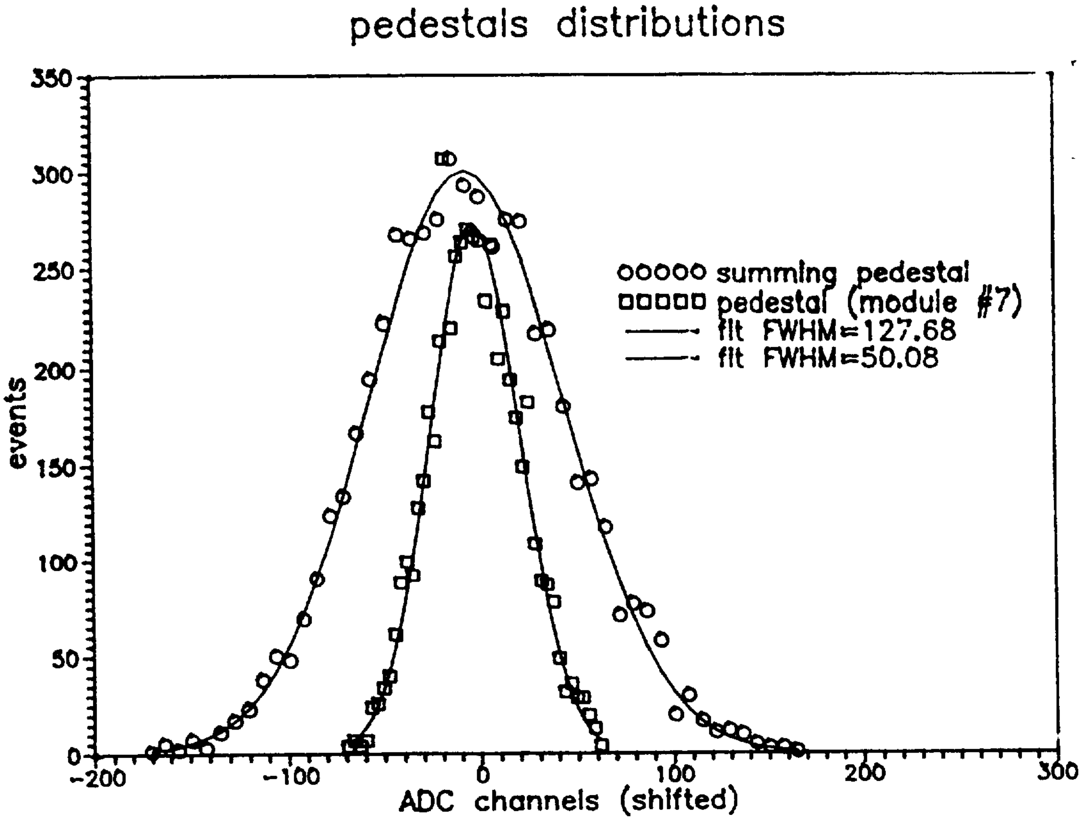

pedestals distributions
events
350
300
250
200
150
100
50
0
-200
-100
0
100
200
300
ADC channels (shifted)
ooooo summing pedestal
□□□□□ pedestal (module #7)
fit FWHM=127.68
fit FWHM=50.08

Fig.4

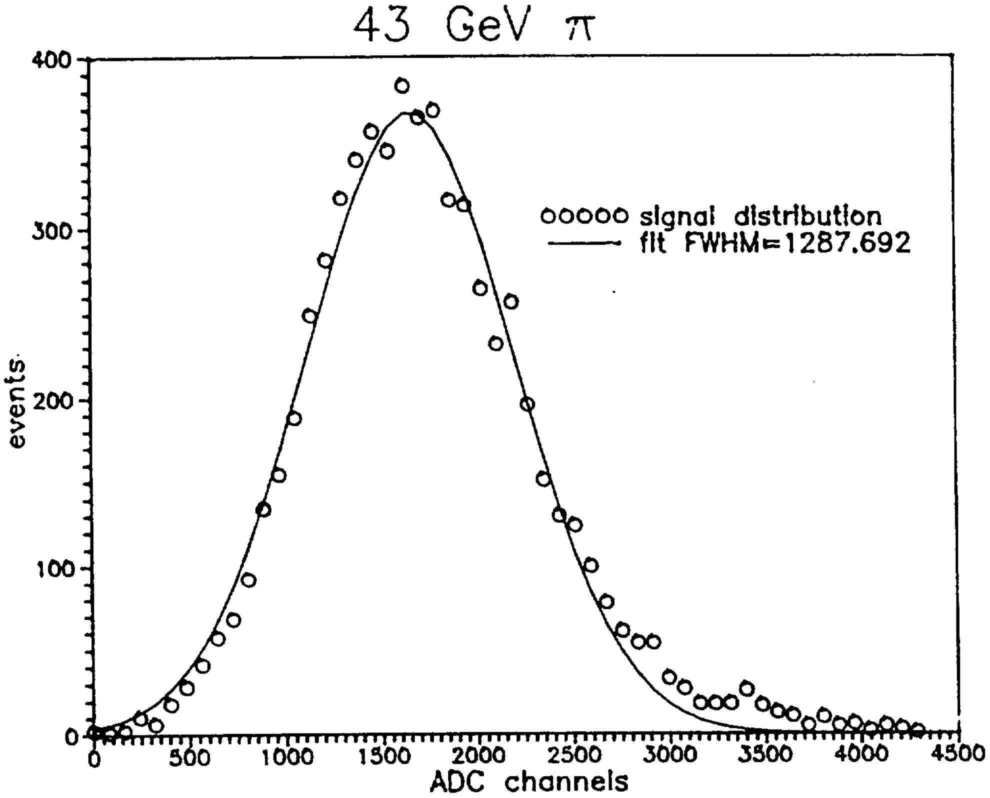

43 GeV π
events
ADC channels
0
100
200
300
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
ooooo signal distribution
fit FWHM=1287.692

Fig.5a

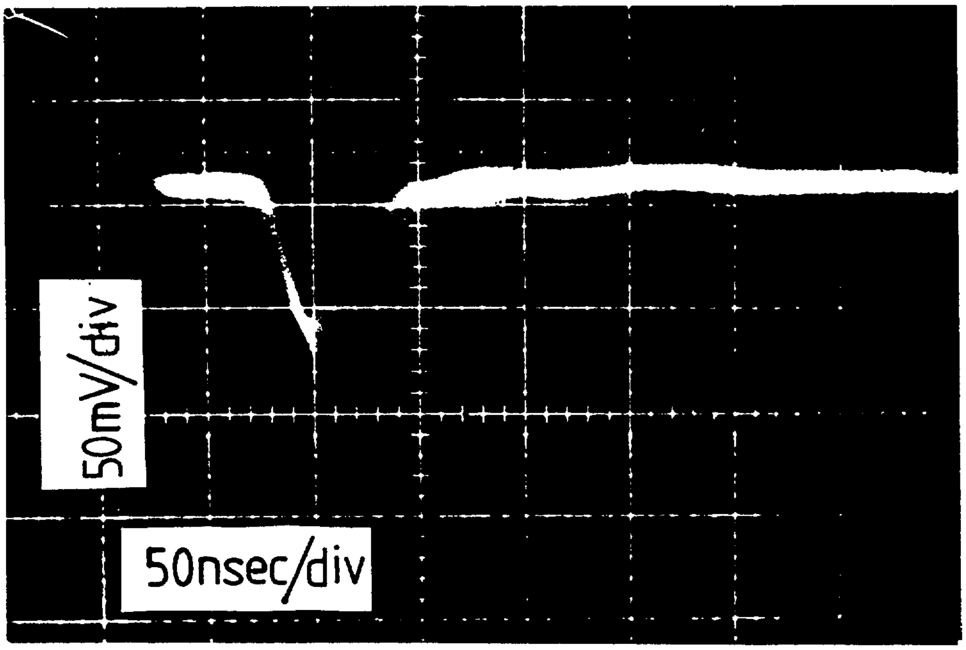

50mV/div
50nsec/div

Fig.5b

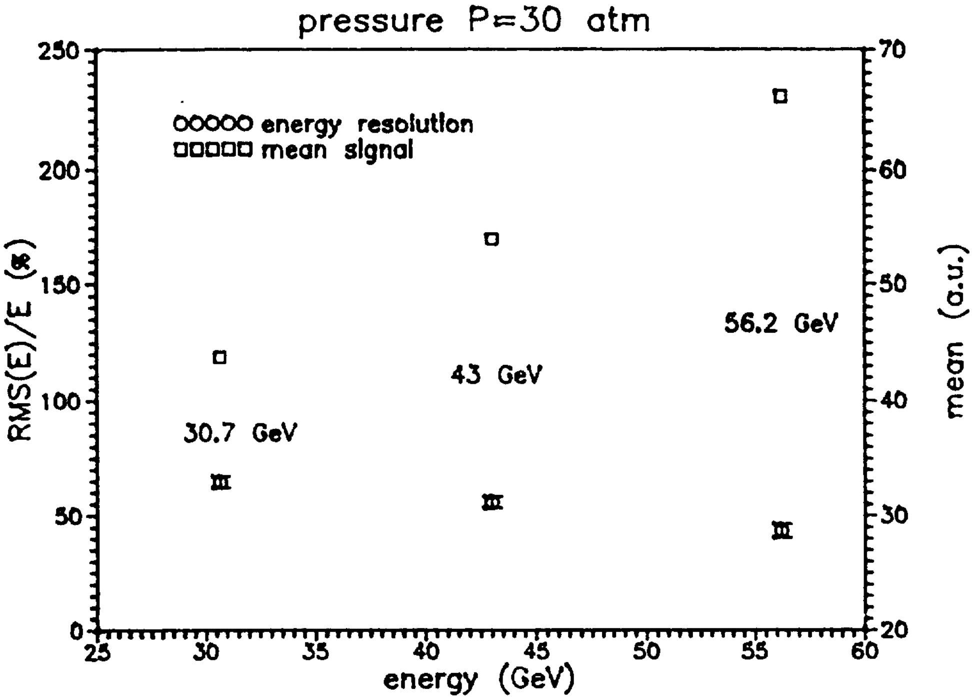
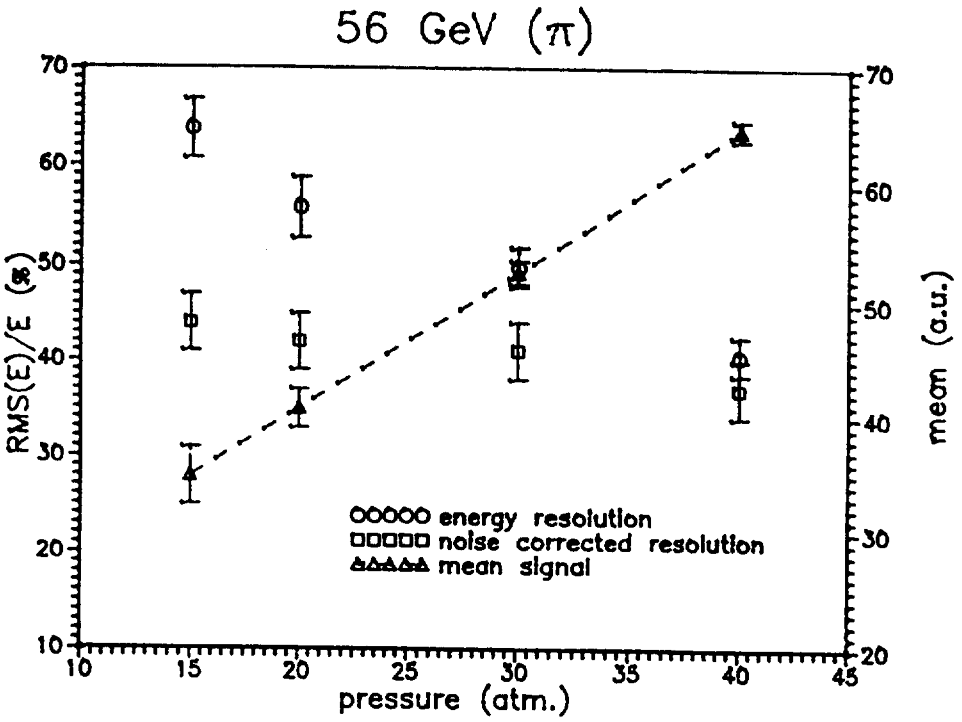

pressure P=30 atm
ooooo energy resolution
□□□□□ mean signal
RMS(E)/E (%)
mean (a.u.)
energy (GeV)
0
50
100
150
200
250
20
30
40
50
60
70
25
30
35
40
45
50
55
60
30.7 GeV
43 GeV
56.2 GeV

Fig.6



56 GeV (π)

70
60
50
40
30
20
10
RMS(E)/E (%)
70
60
50
40
30
20
mean (a.u.)
10
15
20
25
30
35
40
45
pressure (atm.)
○○○○○ energy resolution
□□□□□ noise corrected resolution
△△△△△ mean signal

Fig.7