GEM TN-93-466

Spatial Resolution of 3x0.3 m^2 Dubna Prototype CSC (Preliminary Results)

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Abstract:

The Dubna CSC prototype has been constructed in the framework of the R&D program for the development of the Muon System for GEM. This four-layer prototype has a "full-scale" length of the chamber, about 3 m, but the width of the prototype is only 16 read-out channels with two interpolating strips each. For the strip cathodes two FR-4 plates 1.5m x 1m made in FNAL are used. In this note we report preliminary results of the CSC module test at Dubna in the cosmic rays. Spatial resolution of the order of 80 microns has been achieved using BNL read-out system.

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THE SPATIAL RESOLUTION OF 3x0.3 m^2 DUBNA PROTOTYPE CSC (preliminary results)

The Dubna CSC prototype has been constructed in the framework of the R&D program for the development of the Muon System for GEM. This four-layer prototype has a "full-scale" length of the chamber, about 3 m, but the width of the prototype is only 16 read-out channels with two interpolating strips each. For the strip cathodes two FR-4 plates 1.5m x 1m made in FNAL are used. In this note we report preliminary results of the CSC module test at Dubna in the cosmic rays. Spatial resolution of the order of 80 microns has been achieved using BNL read-out system.

1 DESIGN

The prototype is built as a four gap module. The module cross-section is shown in Fig.1. The four gaps are formed by five flat rigid panels made of 20mm thick nomex honeycomb and two 0.8mm thick copper-clad FR-4 laminates. The 1 oz/sq.ft copper forms the cathodes of four proportional chambers. The position sensing cathode strips are made by precise mechanical milling of the copper-clad FR-4 laminates. Due to short length of FR-4 laminates (1.5m) each cathode consists of two parts of such plates. The cathodes are precisely positioned with respects to each other with the aid of locating pins. The strip to strip connection of each single cathode is made with soldering. The readout pitch is 0.3" (7.62mm) and the gap between the strips is 32mils (0.8mm). All the strips are of the same width. The anode planes are made of 1044 gold plated tungsten wires of 30 microns diameter, and 2.5mm wire spacing. The wire tension is less than 100g. All the wires are connected in groups of 16 wires, so that each anode plane has 64 read-out channels.

2 PERFORMANCE

The prototype has been tested in cosmic rays at Dubna Test Rig (DTR). The general layout of DTR is shown in Fig.2, and the geometric parameters are shown in Fig.3. In order to minimize the plane alignment errors, only one half of the prototype was used in coincidence with the trigger. For this purpose the small SC (PM5-PM8) is included in PM telescope. The trigger set-up, shown in Fig.4, is built using standard CAMAC logic units in two CAMAC crates. The BNL read-out card [1] was used for strip read-out. A CAMAC module had been designed and built to provide all the necessary control signals for the BNL card. The read-out card was connected to the strips via 64 round shielded cables soldered directly to the strips. 16 strips from each of the four planes were connected to one BNL card. Analog information from the BNL card was digitized with 10-bits ADC CAMAC module located in the crate. The data acquisition software provided all the necessary monitoring and calibrating features as well as automatic modes for data taking with IBM-PC. The test inputs of the BNL card were used to calibrate each electronic channel. A typical (third order polynomial) calibrating curve is shown in Fig.5. The distribution of the number of clusters, Landau distribution, the charge distribution, and the Q_r/Q_{max} vs Q_l/Q_{max} ratio are shown in Fig.6 a,b,c,d, respectively.

According to the ratio method [2] we used

$$\alpha = \frac{(Q_r - Q_l)}{(2Q_m - Q_r - Q_l)}$$

as the base combination for the coordinate calculation. Fig.7 presents distribution of α for the cases when Q_m belongs to channels 6 and 11 of the 2nd plane. Assuming uniform distribution of x-coordinate we got x=x(α) as integral of α distribution normalized to strip width (Fig.8). One can see that these distributions: (1) differ for different channels and (2) are asymmetric. As a result, the functions gotten this way have systematical errors, depending on x-coordinate. This is illustrated by Fig.9a. To exclude the errors of this kind function correction has been made to provide minimal residuals. Fig.9b shows the result of the corrections. Using y-coordinate (along strips) which has been measured by trigger counters we could make corrections due to geometrical factors. Fig.10a shows that plane 1 is rotated and its strips are curved in respect to planes 2-4. To compensate these factors we used transformation x=x+P(y) with P(y)-polynomial of 3rd power. Fig.10b shows that dependence of x-residual on y disappeared after such a correction.

For estimation of spatial resolution we used 4-points tracks with residuals less than 0.35mm for external planes(1,4) and 0.5 mm for internal ones(2,3). Fig.11,12 present distributions of residuals in planes 3,4 with results of fitting these distributions by Gauss + parabola. Gaussian parts have standard deviations S1=0.048mm and S2=0.068mm. Besides, the chamber multiple scattering (MS) contributes to widths of these distributions. Neglecting M.S. one can get chamber resolution as

$$S = \sqrt{(S1^2 + S2^2)} = 0.08mm$$

To eliminate the influence of M.S. and estimate chamber spatial resolution we used distributions of two combinations: D1=(x1-x4)/3 - (x2-x3) and D2=(x1-x2) - (x3-x4) with different relative contributions of M.S. (Fig.12,13). Briefly saying, MS between planes 2 and 3 is included to D2 but is eliminated from D1 so M.S. contribution to D2 is a few times as much as to D1. Gaussian parts of distributions of D1 and D2 have standard deviations 0.125mm and 0.185mm respectively. Comparison of these values shows practically negligible influence of M.S. on D1 and leads to chamber spatial resolution 0.08mm.

SUMMARY

The data presented here is a preliminary result which shows that a single CSC plane with the strip length about 3m can achieve the spatial resolution of the order of 80 microns. The geometry of the Dubna CSC prototype is very close to that of the Middle Superlayer CSC of the Barrel. The resolution of 80 microns is consistent with the GEM requirements for the single plane resolution of the Muon system.

[1] "The Spatial Resolution of the Interpolating Cathode Strip Chamber" GEM/CSC 7-92, October, 1992

[2] J.Chiba et al. Nucl. Instr. and Meth. 206(1983)451

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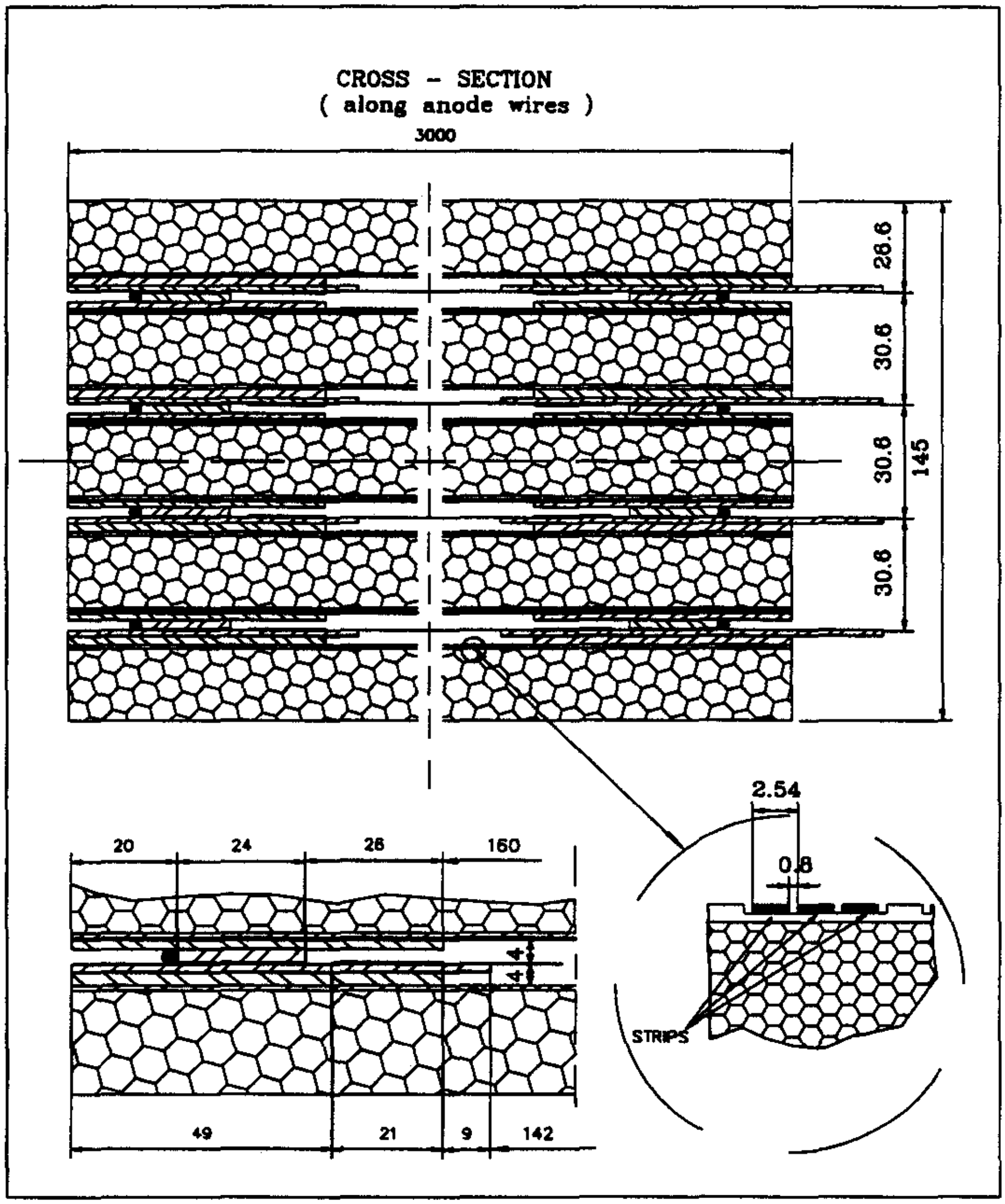


Fig.1 Cross section of the Dubna long CSC prototype.

Figure 1: Cross-section of the Dubna long CSC prototype.

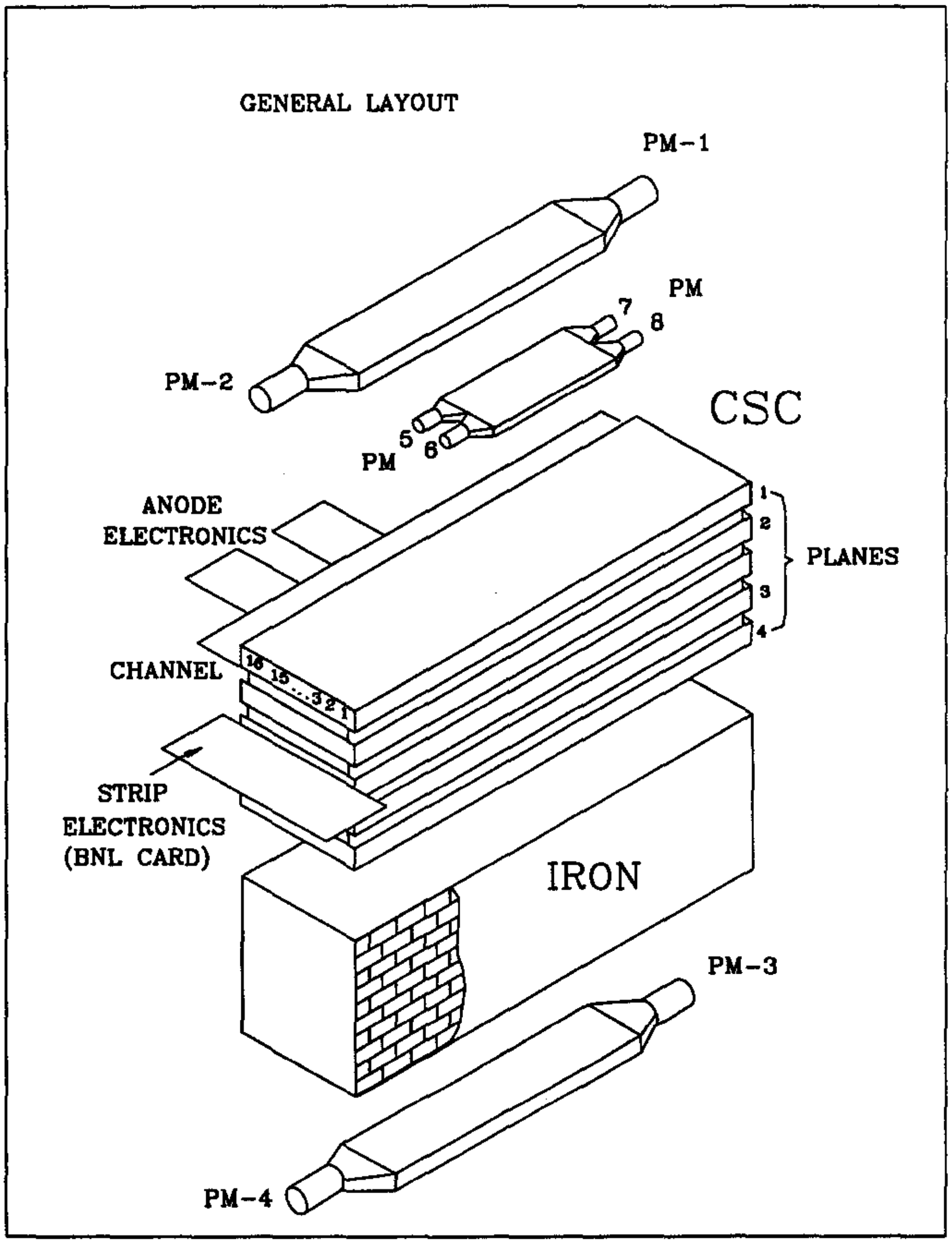


Fig.2 DTR general layout.

Figure 2: DTR general layout

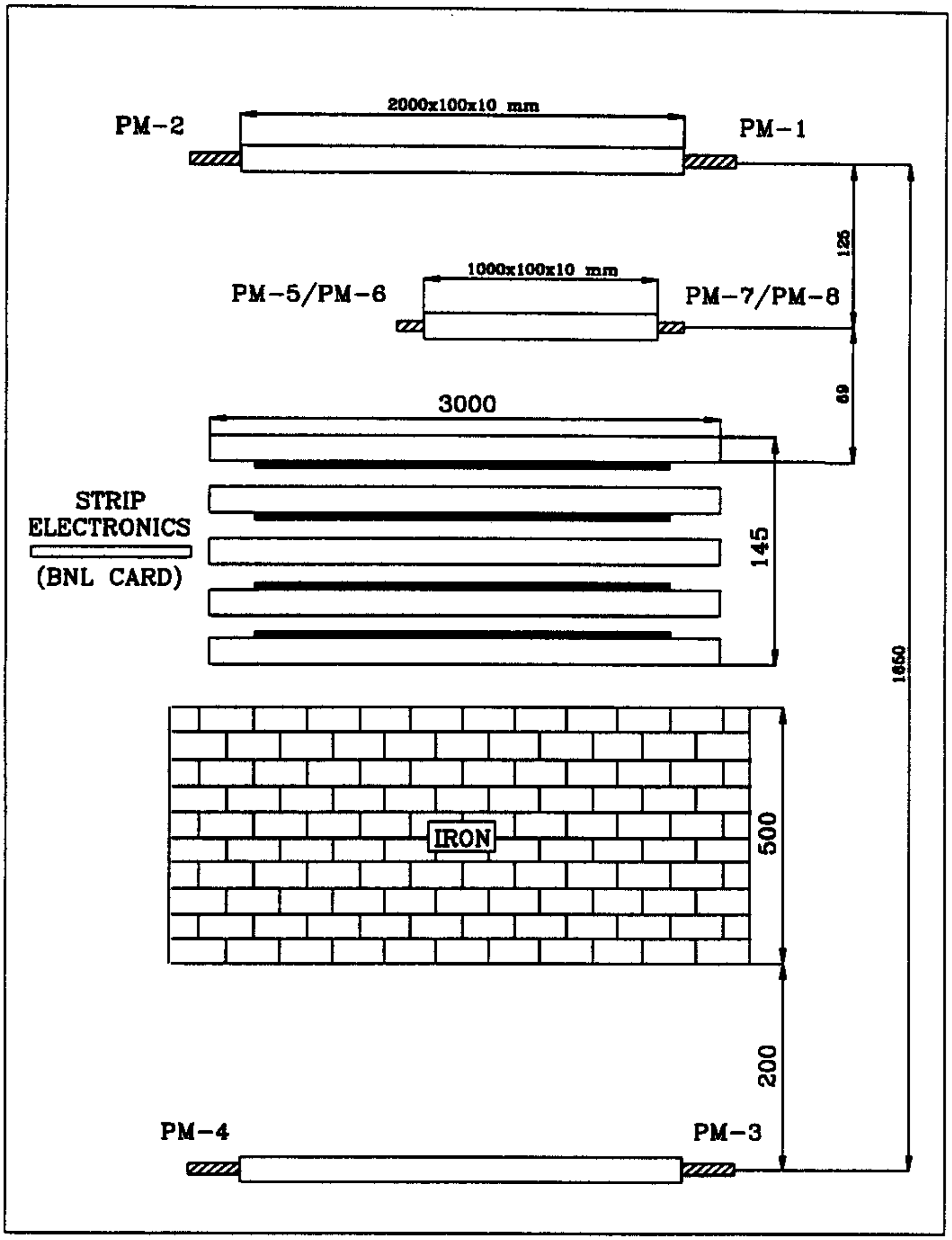


Fig.3 DTR geometric parameters.

Figure 3: DTR geometric parameters.

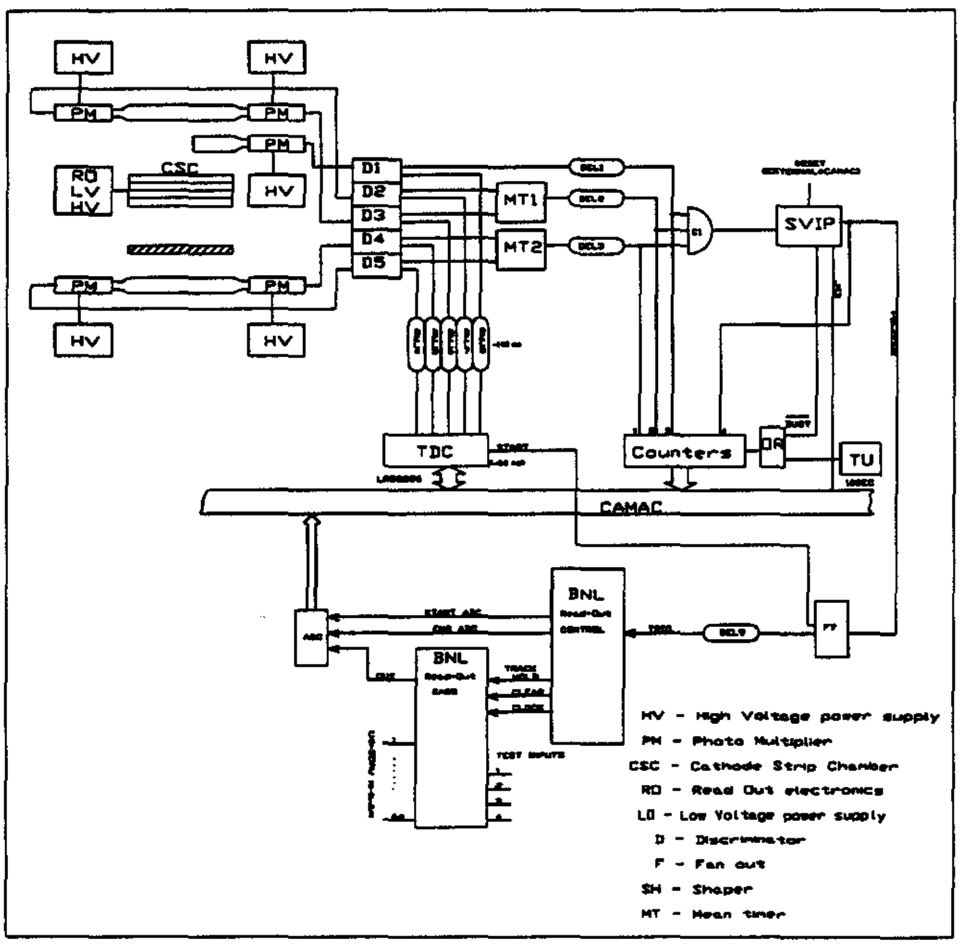


Fig 4. DTR Trigger and readout functional diagram.

Figure 4: DTR trigger and readout functional diagram.

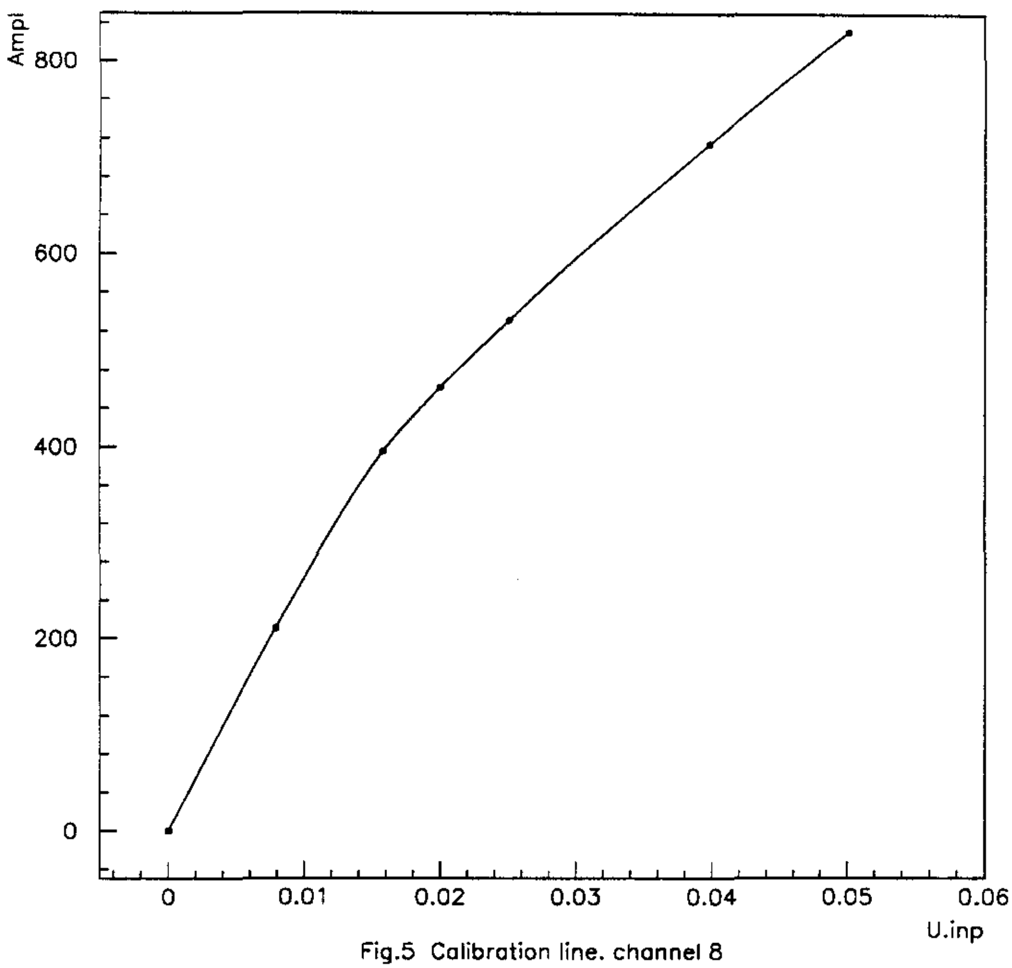
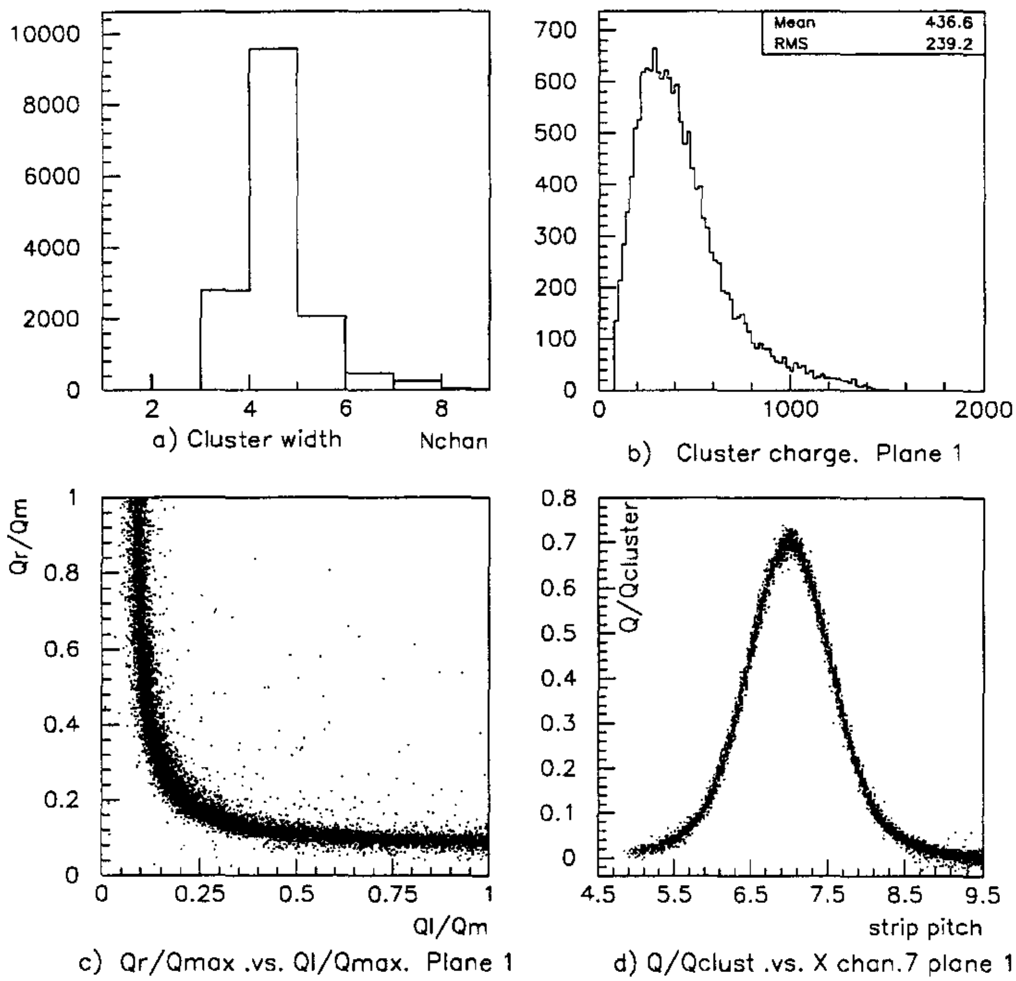


Figure 5: Calibrating curve of one single electronics channel of the BNL card.



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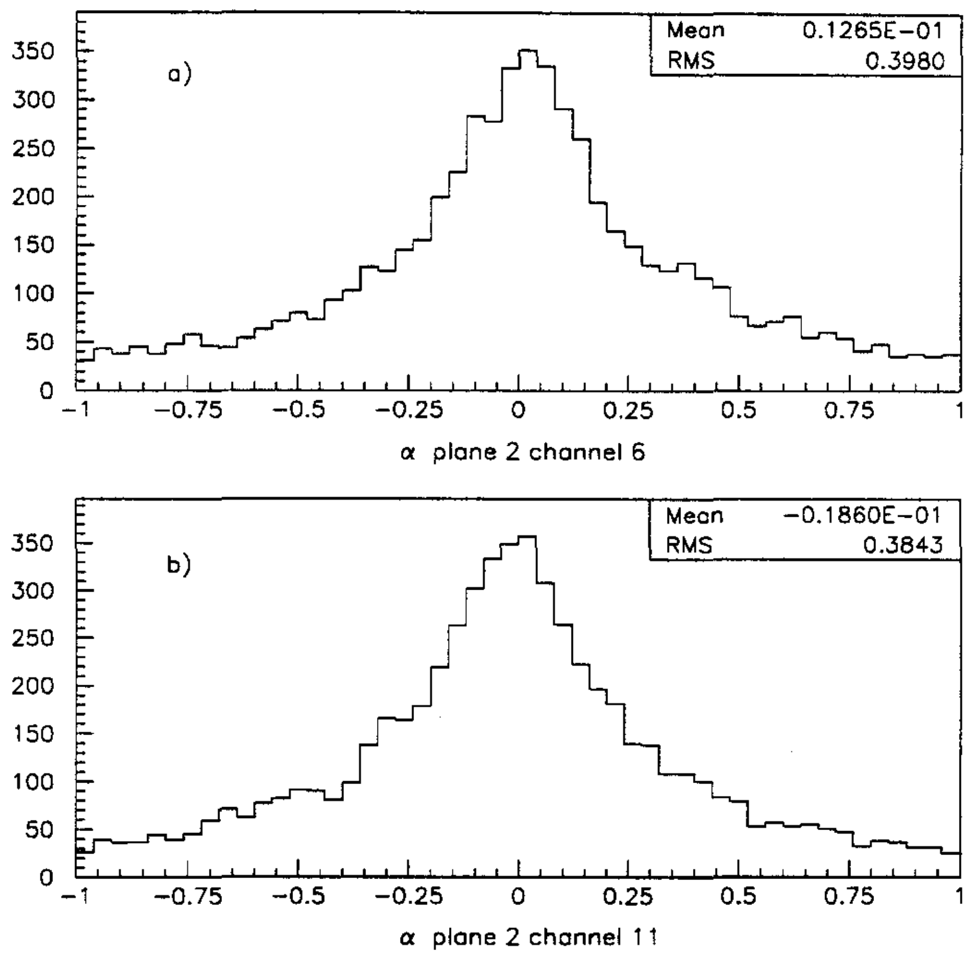

Figure 7: α distribution for the channels 6 and 11 of the second plane.

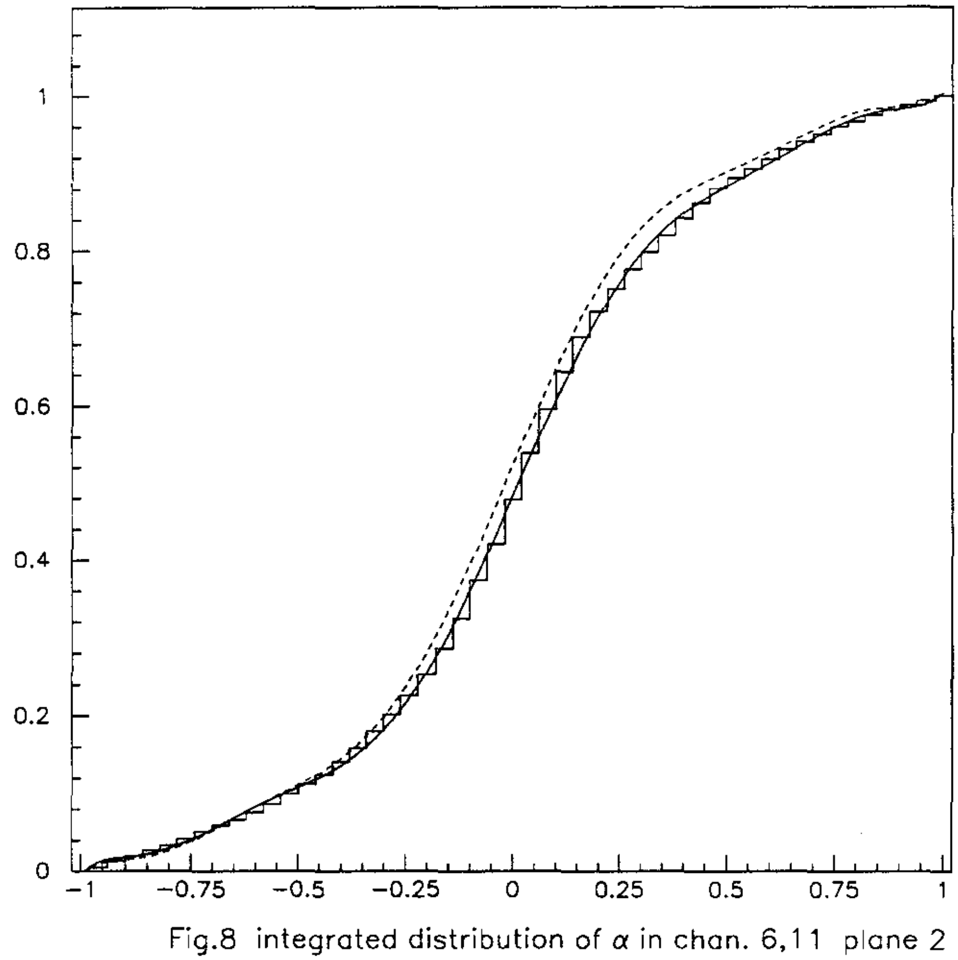

Figure 8: Integral of α distribution.

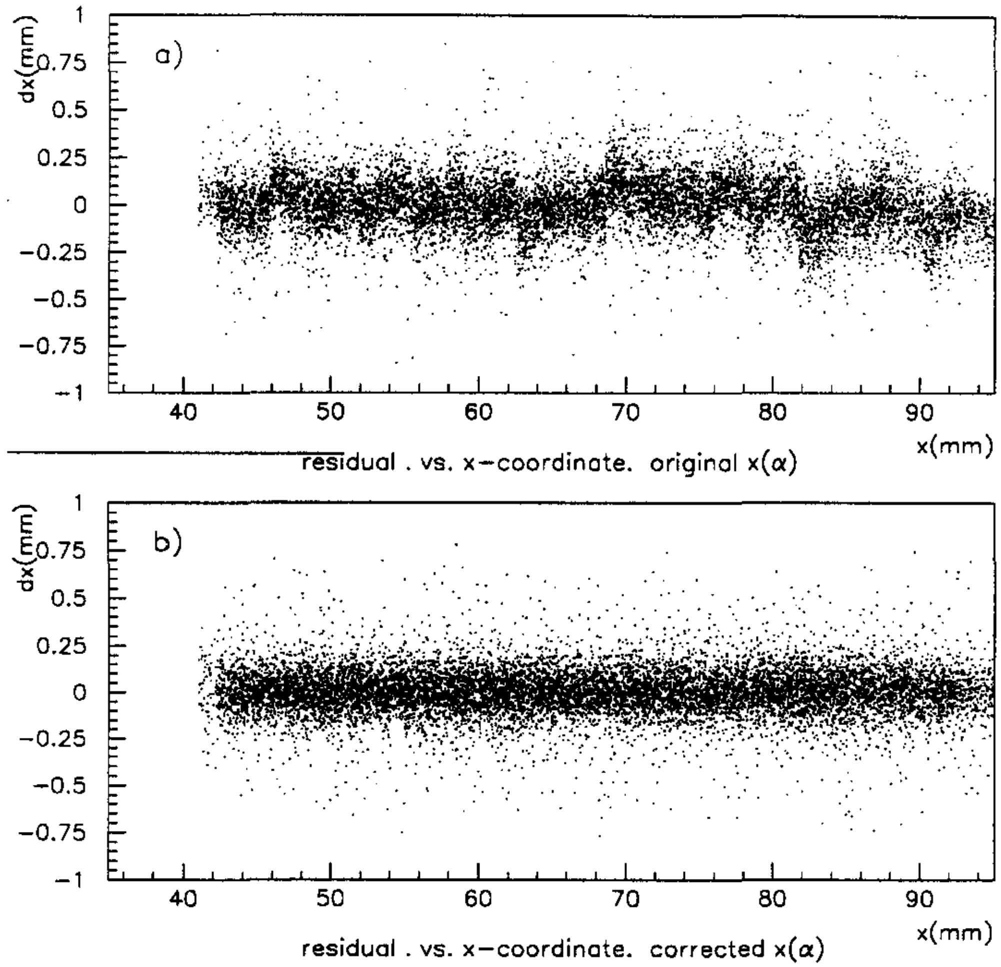

Figure 9: Systematical errors distribution along the X-coordinate.

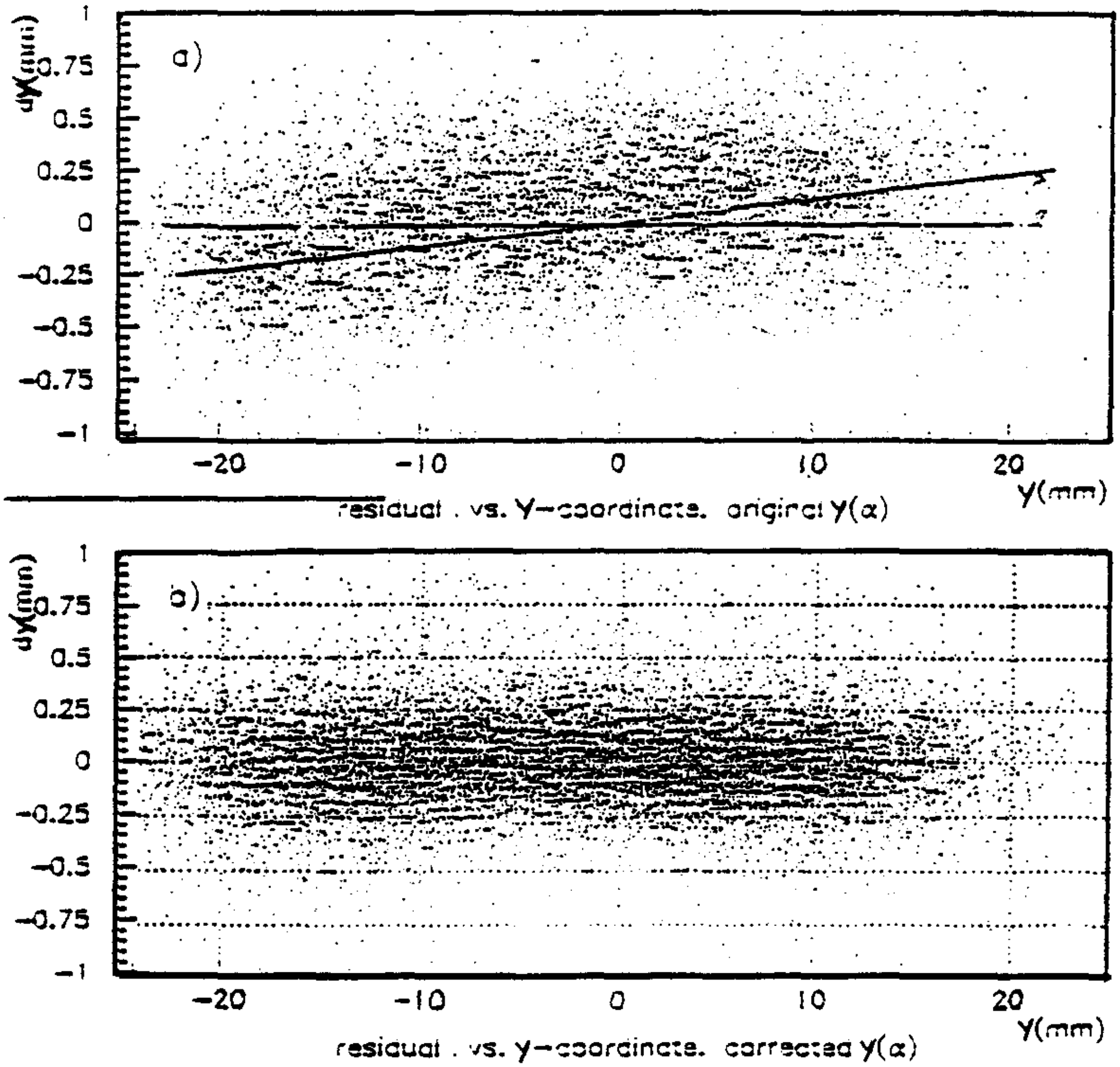

Figure 10: Systematical errors distribution along the Y-coordinate.

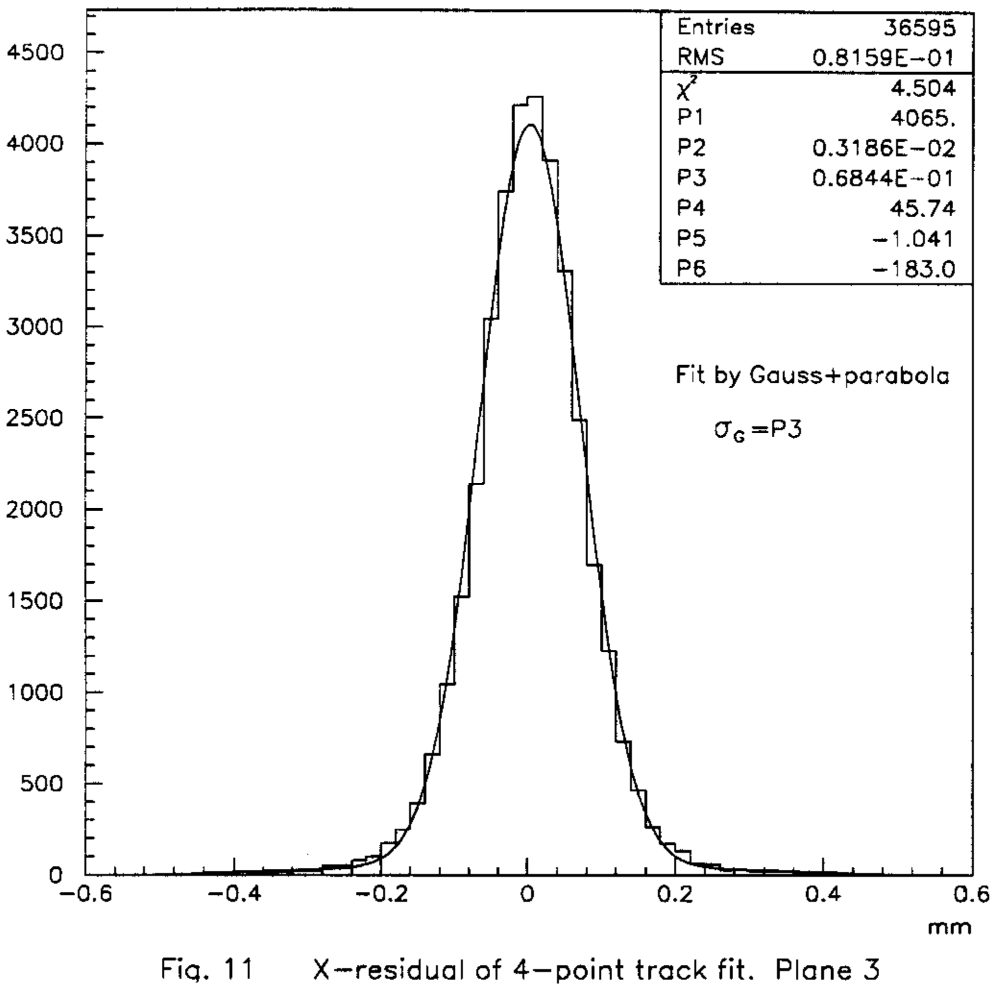

Figure 11: Residuals distribution in plane 3.

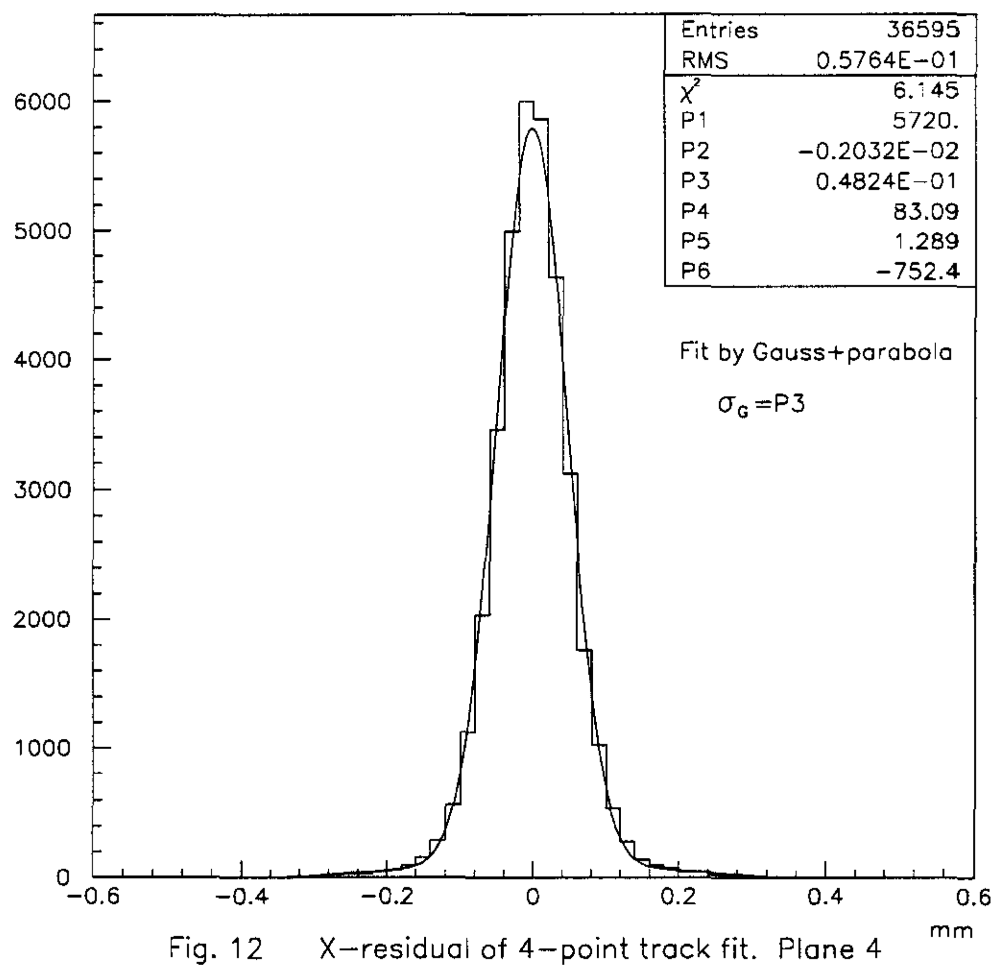

Figure 12: Residuals distribution in plane 4.

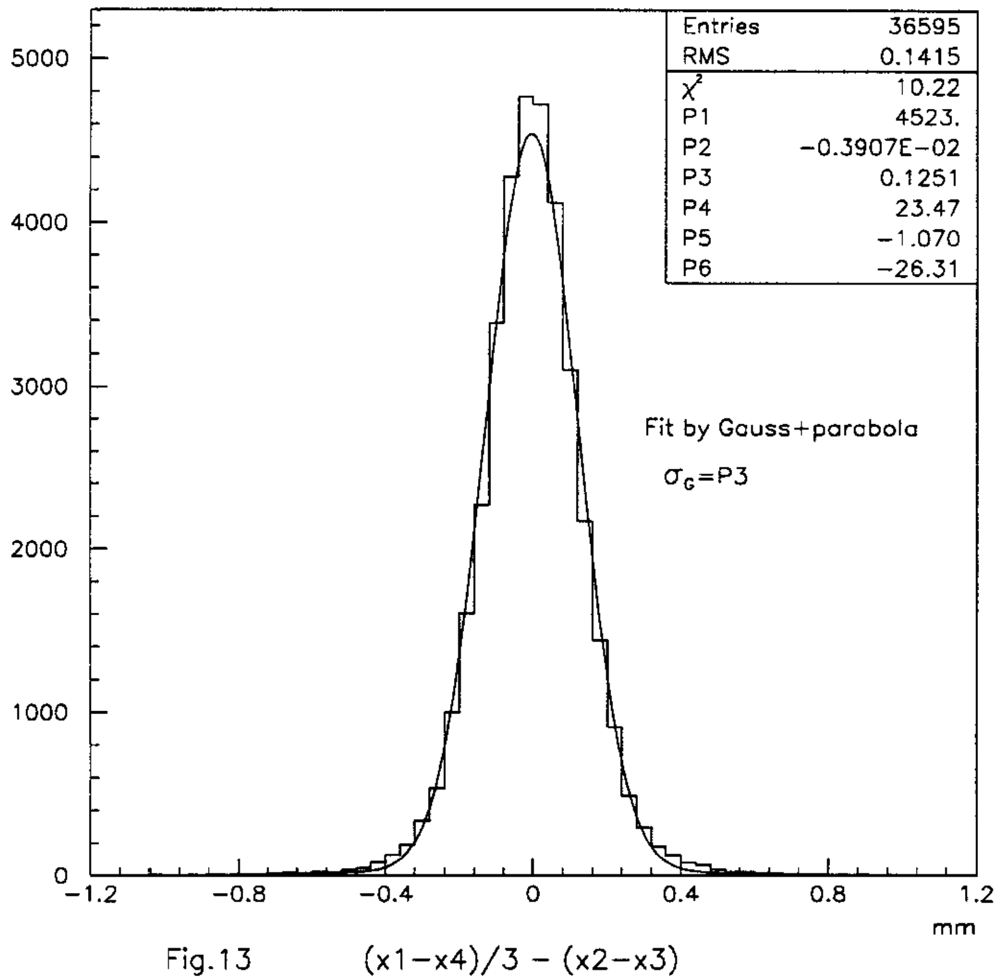

Figure 13: D1=(X1-X4)/3-(X2-X3) distribution.

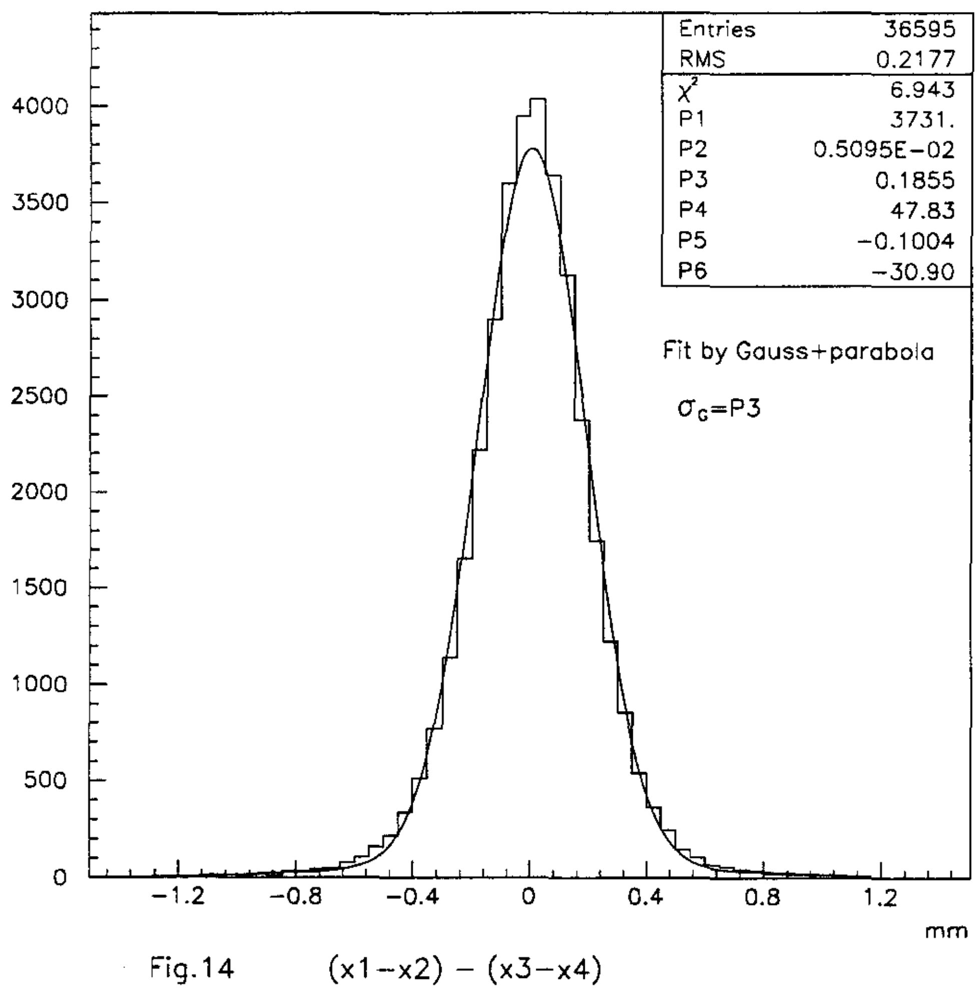

Figure 14: D2=(X1-X2)-(X3-X4) distribution.