ITEP Beam chambers

ITEP group, BPC Note1, 14-Sep2003

1. The chamber design

The ITEP BPC is a three-electrode multi-wire proportional chamber with a cathode delay line readout. The anode plane has 25 wires of 20 µm in diameter, with 6 mm wire spacing. The cathode planes are placed at both sides of the anode plane, forming two sensitive gaps of 5 mm. The cathode planes have 31 wires of 100 µm in diameter, with 4 mm wire spacing, perpendicular to anode wires.

The total working area of the chamber is 120×120 mm^2.

The corresponding wires of the two cathode planes are connected together at one end and the combined signals are routed to the nodes of a lumped delay line. Each of the two ends of the delay line (further referred to as *right* and *left* channels) is connected to a separate amplifier-shaper.

All anode wires are joined together and connected to an *anode* amplifier.

Two such chambers ("planes"), rotated by 90^0 to each other, are mounted in a common housing, and make a unit to measure two independent coordinates (X and Y) . The distance between the anode planes is 26 mm. The housing, with the external windows of aluminized mylar, also serves as an electromagnetic shield. A grounded wire plane similar to the cathode planes is placed between the chambers, to prevent cross-talks.

The working gas is Ar-CO_2 mixture (80% Ar :20% CO_2 in our case). The working HV is about 2250 V, with the detection efficiency of practically 100%.

For electronic calibration purposes, an external pulser signal is sequentially applied to the delay line nodes of wires 7, 16 and 25 in each chamber.

The chambers are used with general-purpose external electronics: LeCroy 623A NIM discriminators, LeCroy 2228A CAMAC TDCs (11 bit range, 250 ps resolution), LeCroy 2249A CAMAC ADC (for anode signals).

The layout of the BPCs in the H6 beam-line is sketched in Fig. 1.

2. Comments on the BPC data analysis

To determine the BPC resolution, the following algorithm is used:

- A system of three chambers is considered: two monitor chambers (M1 and M2) and the chamber under study (I).[1]
- The beam particle coordinates in each plane are computed as follows:

$$xMeas = G\_scale \cdot fCal(tLeft - G\_LR \cdot tRight),\ \text{where}$$

tLeft, tRight are the measured times from the left and right channels, fixated by discriminators;

[1] In the note chambers 1 and 4 are used as a monitor, and the chamber 3 is the one we studied.

fCal – is a calibration function, which transforms the *(tLeft-G_LR*tRight)* value into the coordinate. This function is determined, separately for each BPC plane, from the BPC calibration pulser events taken at the start of each run. For online monitoring purposes, a simple linear function, with *G_LR=G_scale=1,* is sufficient. For high precision applications, a parabolic function is more appropriate.[2] The parameters *G_scale* and *G_LR* are determined for all the chambers in a common fit, aimed at minimizing the residuals for a large sample of beam tracks.

- The residual *dX* is the difference between the measured coordinate in the chamber under study and the prediction by the monitor chambers:

$$dX = xMeas(I) - xPred\ ,$$

$$xPred = xMeas(M1) + (xMeas(M2) - xMeas(M1)) \cdot \frac{Z_I - Z_1}{Z_2 - Z_1}\ ,$$

where Z are coordinates of the chambers.

- From the Gaussian fit to the final *dX* distribution one obtains the (Gaussian) space resolution of the system – σ(dX). The resolution of the studied chamber, for our geometry, is σ(I)=σ(dX)/√2.

3. The results

- *dX* distribution are shown in Fig.2a. For the beam spot of 70×70 mm^2 , σ(dX)=160 µm, σ(I)≈115µm. A MC simulation shows that the tails of this distribution are, basically, due to δ-electrons off the tracks crossing the chambers (Fig.2a, MC with and without δ-electrons). Fig. 2b shows the efficiency of the *dX*-cut, for real events. 97% of events have *dX* of less than 1 mm.
- Fig.3 illustrates the resolution over the surface of a BPC plane.
- The BPC arrangement used in the FCAL beam tests, with pairs of BPCs installed next to each other, is advantageous, because it permits to apply the *dX*-cut to raw measurements. One can compare the coordinates measured in one or both projections by the two adjacent chambers and reject the events with large discrepancies. A clean sample of beam particles can be thus obtained without performing any fit, thereby simplifying a lot the BPC alignment procedure.

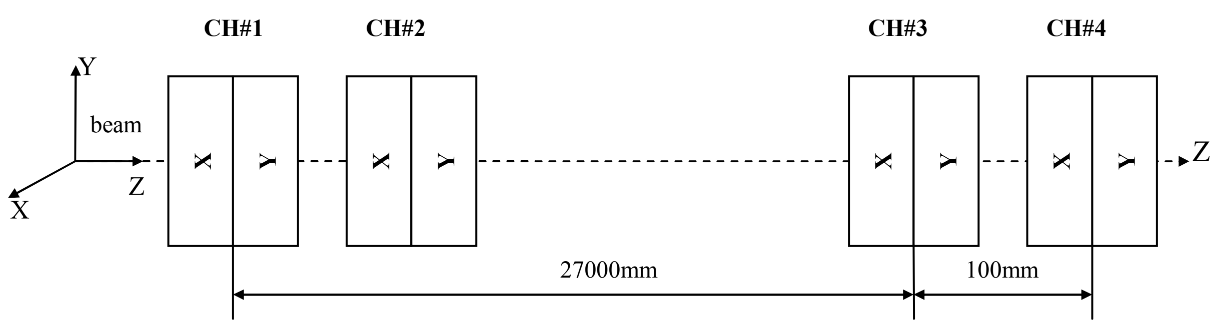

Fig.1. Chambers setup on the beam line.
X- and Y- chambers measure, respectively, X and Y coordinates.

[2] The results presented here are obtained with a parabolic *fCal.*

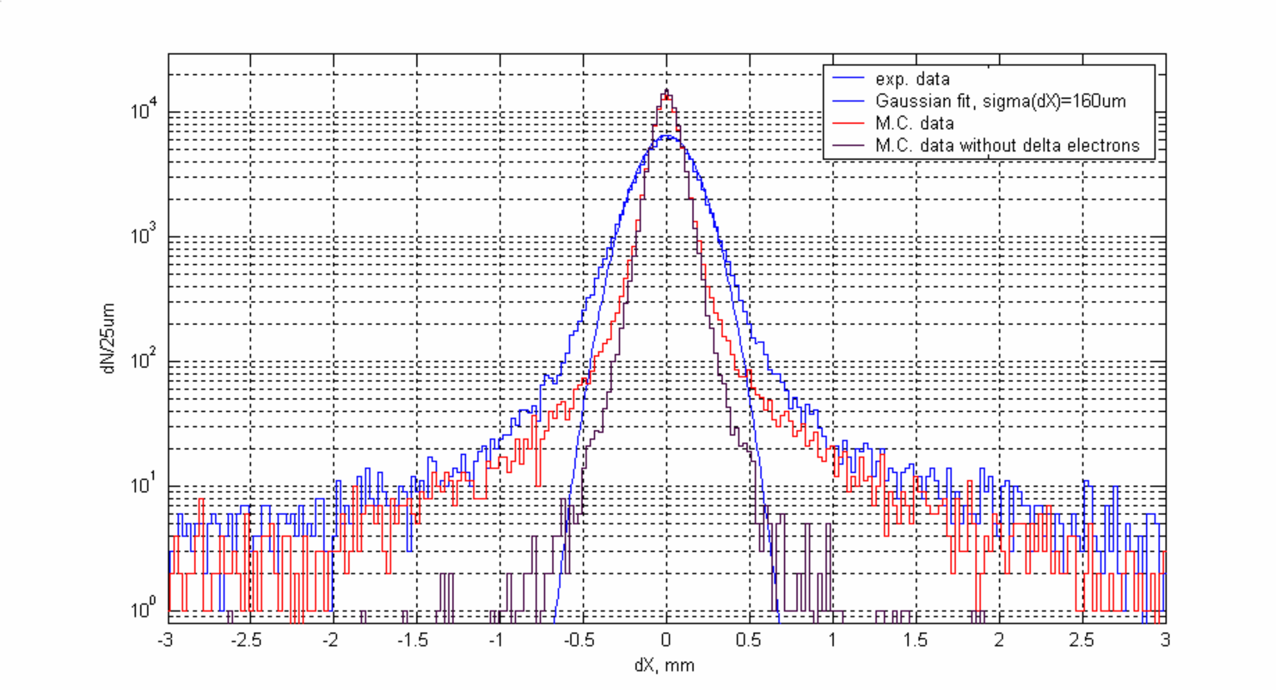

Fig.2a. Distributions of residuals dX, for 110000 events.

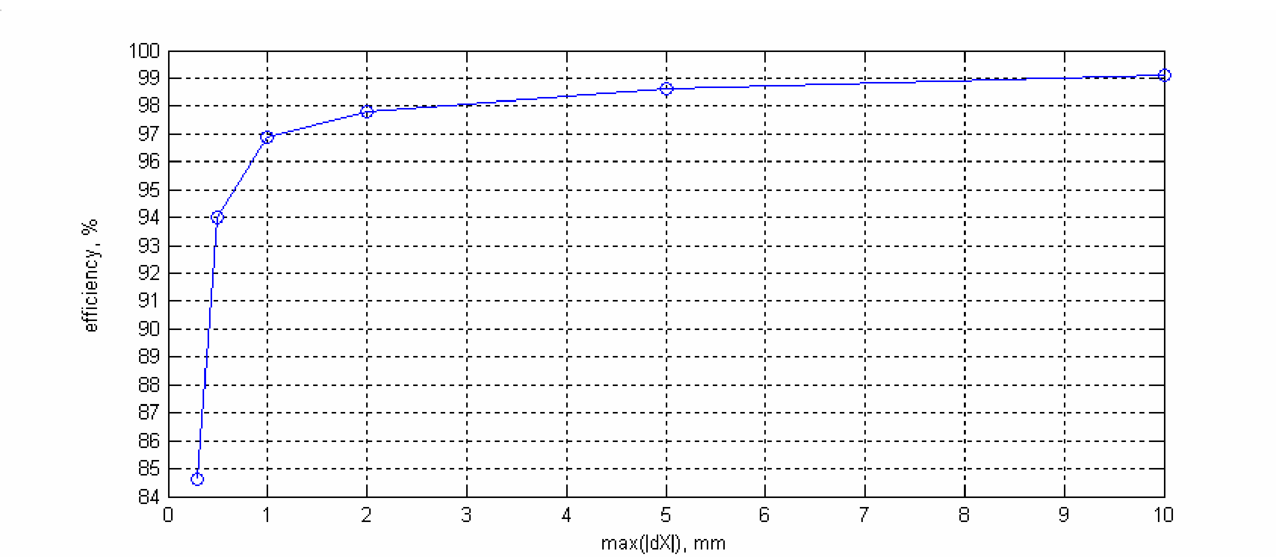

Fig. 2b. The dX cut efficiency.

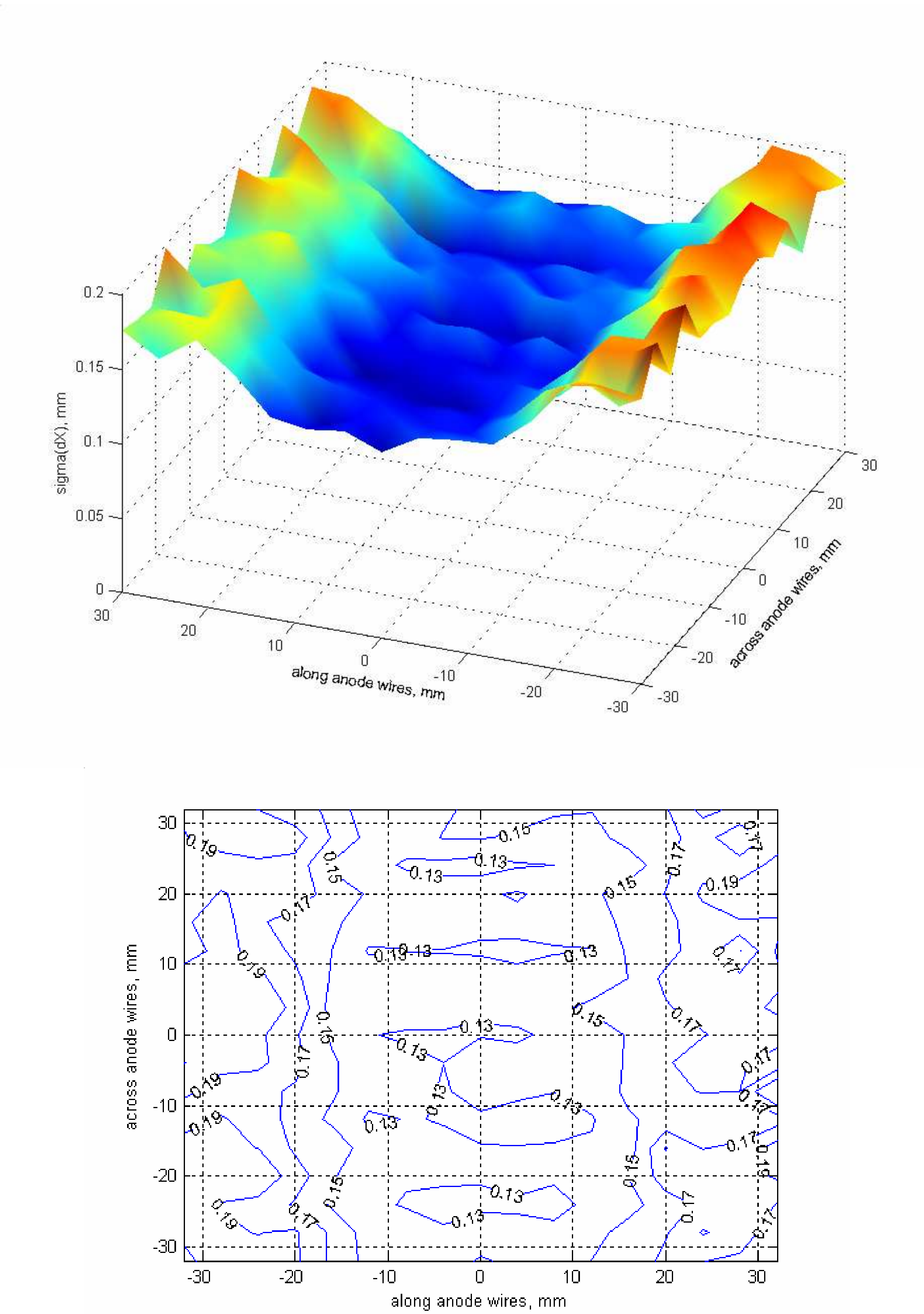

Fig.3. The BPC-system resolution, $\sigma(dX)$, over the chamber surface.