FTC DETECTOR IN L3 EXPERIMENT (CERN)

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In 1989—1990 the endcap Forward Tracking Chamber (FTC) is designed and produced for L3 experiment at CERN. This detector is located on the two sides of the cetral TEC detector (fig.1) and provides the data about particles coordinates at the angles $10^{\circ} - 35^{\circ}$ to the beam axis. The need for this detector is caused firstly by insufficient resolution of the TEC detector for particles at the mentioned above angles — $\sigma = 0.8 — 1$ *mm*. Secondly, the TEC's thick external flange ($13\ g/cm^2$) rescattered particles and it necessitates to define more exactly the entrance angle and coordinates for BGO passing particles. According to the estimations the FTC detector should have the following parameters:

1. Space resolution — $200\ \mu m$;
2. Angle resolution — 10 *mrad;*
3. Simultaneous registration of the two coordinates (X,Y) for each of 5—7 particles passing FTC;
4. The thickness of the detector along beam axis not more than 72 *mm*.

The design of the endcaps is made of two symmetrical parts, with two disks each of lm diameter. The two disks (fig.1) rotated by 90° relatively to one another make orthogonal coordinate system. Each disk has 26 drift chambers — modules with 4 sense wires (SW) and 5 field wires (FW) in the middle anode plane. The distance between neighbouring wires is 3 *mm*, that between FM edge and the wall is — 2 *mm*. So, module contains two symmetrical drift spaces H = 22 *mm* restricted by foiled fiberglass cathodes of 0.5 *mm* thickness. The thickness of the foiled fiberglass walls is 1.5 *mm*. The inner side surface of the walls is copper-clad with 0.5 *mm* strips milled 2.0 *mm* apart. These copper strips provide the voltage grading steps necessary for a uniform drift field. These voltage steps are provided with a specially designed high voltage divider. It is produced with application of high resistive thick film technology and has both small dimensions and high stability: temperature stability is not worse than 5×10^{-4}; resistors accuracy is 1×10^{-3}. The cathode, strips and FW are held at negative high voltage potential, SWs are set at zero potential.

Particles passing through the detector see an average of 0.06 radiation length. Arrangement of the modules of the disk provides situation for any particle to pass the detector at the angle to the anode plane. That permits to solve left-right ambiguity on the level of one drift module and simplifies the operation of readout electronics. Two modules on each disk were equiped with drift time monitoring systems to control stability of high voltage supply, gas mixture and electronics. To control the temperature of the detector's surface 8 thermal sensors were located on each FTC endcap. Each module has a system of reference marks related to anode plane disposition in order to adjust FTC coordinates and global L3 coordinates. According to the measurements FTC detector producing technology ensures mechanical accuracy of the particles coordinates determination not worse than $\sigma \leq 50\ \mu m$ for any disk.

The endcap gas mixture is Ar + 38.5% C_2H_6. Potential on FW is set U = 1.9 *kV*, on cathode $U_c = -3.85$ *kV*, which corresponds to electrical field intensity in drift space $E = 1.2\ kV/cm$. The measurements show that FTC works reliably with gain up to 2.2×10^5, gain 8×10^4 was chosen as a work point.

Readout electronics was designed so that information from each SW provides a possibility to determine two coordinates simultaneously: the first by drift time registration and the second by charge division method. The second coordinate is used as a target designation to second FTC disk, which simplifies multitrack analysis. The total number of the analog channels of readout electronics is 832. Data from FTC are transmitted to the specialized amplitude shaper and after that to the FASTBUS TDC, ADC and VAX station. Fast-acting preamps with low input resistivity (25 Ωm) and amplitude shapers were designed and produced at LNPI. Charge division method obtains space resolution of about 1—2% of the wire length.

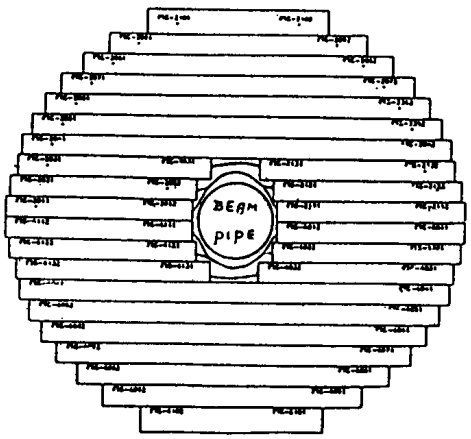

Fig.1a.

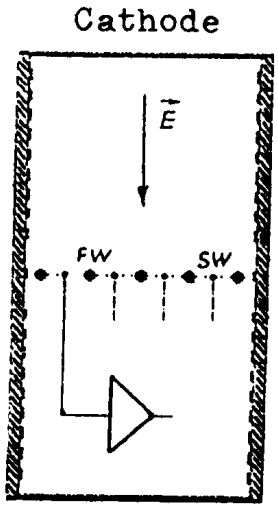

Fig.1b.

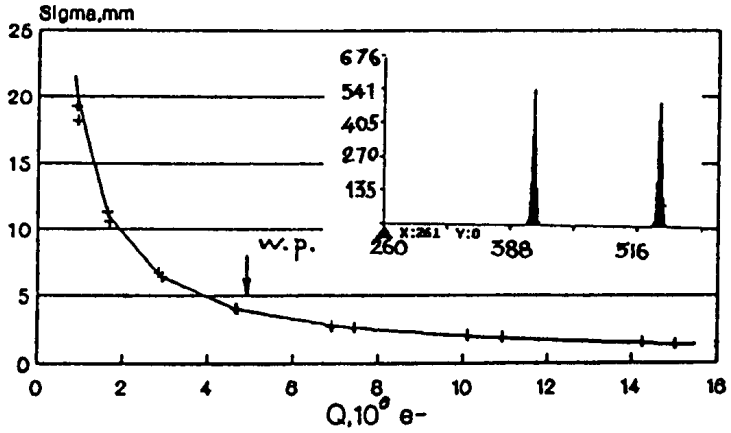

Fig.2.

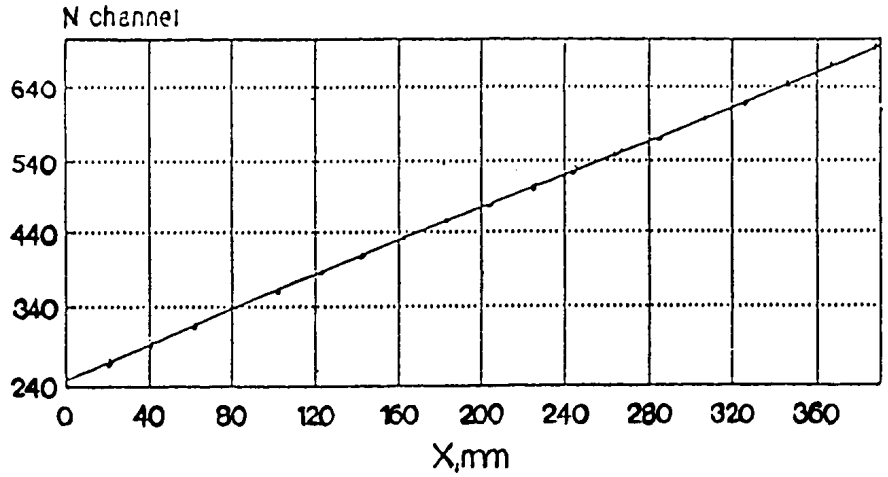

Fig.3.

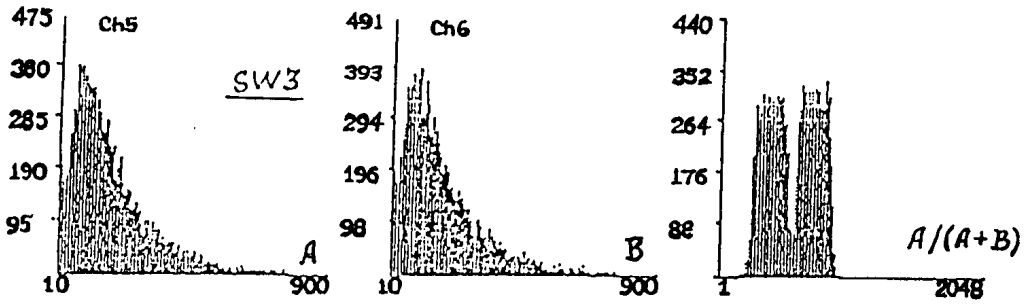

Fig.4.

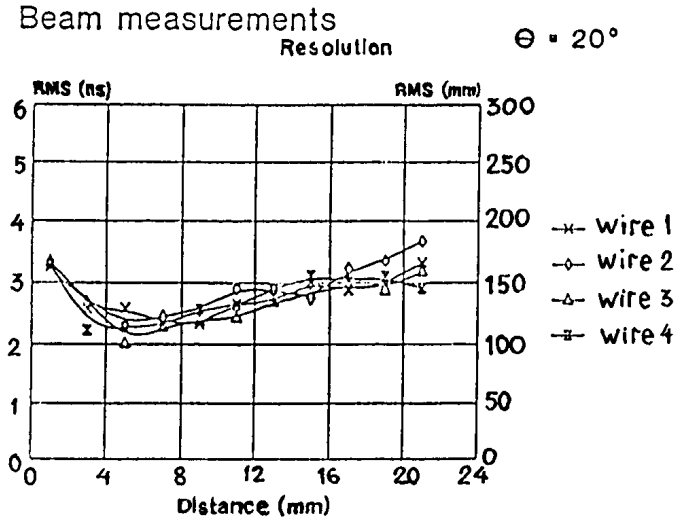

Fig.5.

Usually a special highresistive wire (2.5 $k\Omega m/m$ and more) is used for this purpose. But as it is known such kind of a wire stimulates ageing processes in a chamber. To avoid this problem a special readout electronics which permits to use obvious golden plated tungsten wires 25 μm, 100 Ω m/m) with the similar resolution was designed at LNPI. Fig.2 shows dependence of the space resolution upon the value of the collected charge. One can see that to the wire with length $l = 400\ mm$ in the work point ($Q = 5 \times 10^6$ electrons, that corresponds to the gain $M = 8 \times 10^4$) $\sigma = 4\ mm$ is obtained. Fig.3 shows dependence of the measured coordinates upon the real disposition of the source along the wire. It is seen that the method has a good linearity. Deviation from linearity does not exceed 2 channels. Fig.4 shows spectra illustrating the method which were obtained by cosmic — rays FTC-module exposition. The amplitude spectra from the both sides of single SW wire are presented in fig.4*a* and fig.4*b*. Fig.4*b* shows the spectrum of ratio A/(A+B) that is a distribution of particles along the wire. The downfall in the center is caused by the cable joint of the modules which are disposed symmetrically relatively to the beam tube (fig.1a). For the space resolution and drift time measurements of FTC the 1 *GeV* proton beam was used at the LNPI synchrocyclotron. It was shown that space resolution for single wire depended upon drift length and did not exceed $\sigma = 180\ \mu m$ in the angles range $\Theta = 0^\circ — 30^\circ$ (fig.5). Taking into account that each module contains 4 sense wires, FTC provides accuracy of particles space localization at the level $\sigma = 100\ \mu m$.

In the end of 90-th and beginning of 1991 FTC was assembled and incorporated in the existing L3 readout system. During 1991 the detector took part in data acquisition and proved to be reliable in use. FTC parameters measured in real situation perfectly correspond to the initial demands.