p̄-BEAM MONITORING SYSTEM FOR CP LEAR

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Abstract

A monitoring system has been developed for the antiproton beam used in experiments on the CP violating decays of K^0 and $\overline{K}^0$ by the CP LEAR collaboration at LEAR, CERN.

The beam position is measured by means of two small MWPCs. In each MWPC two anode wires, 8 mm apart, provide gas amplification. The position of the beam is obtained from induced current signals on cathode strips.

A small scintillator (Ø7 mm, thickness 1 mm) gives a signal to be included in the trigger. The scintillation light is guided to a PM outside the solenoid by means of 5 m long PMMA (plexiglass) fibers.

The system is mounted on the beam pipe, close to the centre of the experimental setup. The beam position resolution is better than 0.5 mm, the time resolution ≈100 ps.

The Monitor System

The CP LEAR collaboration at CERN is conducting experiments in which the CP violating decay modes of K^0 and $\overline{K}^0$ are studied, with the aim to determine an accurate value for the ε'/ε ratio.

The experimental setup consists of a large solenoid (Ø2.0 x 3.5 m) packed with MWPCs, drift chambers, streamer tubes, scintillators, Čerenkov detectors and an electromagnetic calorimeter. Antiprotons (p̄) from LEAR (200 MeV/c) are stopped in the centre of the setup in a hydrogen (15 bar) target sphere (Ø14 cm). A beam defining detector system is mounted in front of this target on the beam pipe, which ends ≈12 cm from the target centre.

The beam monitoring system is divided into two parts: the beam position system and the beam trigger system. The position of the antiproton beam, which has a diameter of ≈2 mm FWHM at the entrance window of the target, is monitored with 2 small MWPCs, one for the horizontal position (x) and one for the vertical position (y). The x-MWPC has 2 horizontal anode wires (15 μm gold plated tungsten, 8 mm apart) for gas amplification. For field shaping similar wires have been mounted 4 mm further to the outside in the anode plane. The beam is centered between the amplification wires; it is not hitting them.

The x-position is obtained from the induced current signals on vertical cathode strips, which are perpendicular to the anode wires. There are 8 strips (0.1 μm Au on 1 μm Al) with a pitch of 2.54 mm as well on the entrance foil as on the exit foil (12.5 μm kapton). Corresponding strips on both foils are interconnected. The half gap of the chambers is 2.4 mm.

Inherent in the MWPC design is that, as a consequence of the Lorentz force, the beam profile measured in a magnetic field is slightly wider than the real profile. However the optimal beam position , i.e. the centre of the system, stays well defined.

The y-MWPC is identical to the x-MWPC, however rotated over 90° around the beam axis. Fig.1 shows a cross section of the monitor and figs. 2-3 show the system in various stages of assembling.

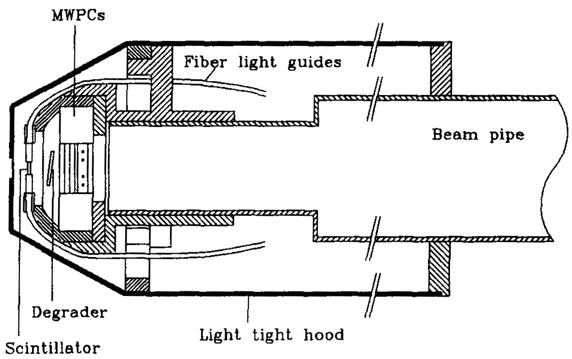

Fig.1: Cross section of the beam monitor, mounted on the beam pipe. The hood (Ø12 cm) is constructed from light tight carbon fiber reinforced epoxy. The light tight exit window (Ø10 mm) consists of several aluminized mylar foils. The design is such that massive structures near the target are avoided. The conical shape ensures a large opening angle for reaction products to the experimental set up.

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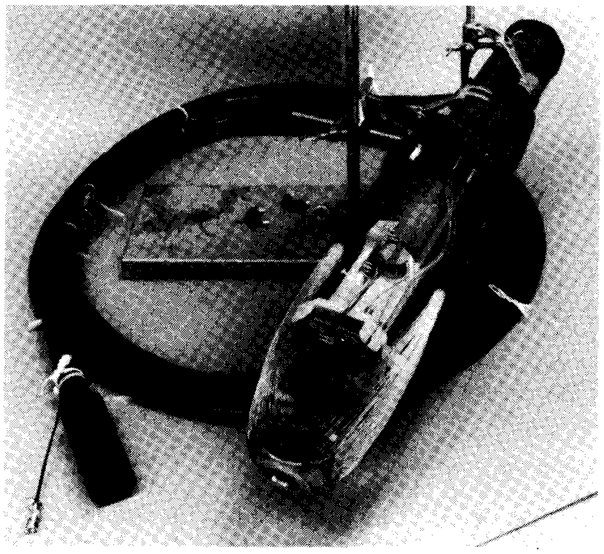

Fig.2: Beam monitor mounted on a dummy beam pipe (beam direction from top-right to bottom-middle). The plexiglass fibers of the light guide are visible. The distance between the scintillator and the MWPCs (square window 25x25 mm) is 20 mm when mounting is completed.

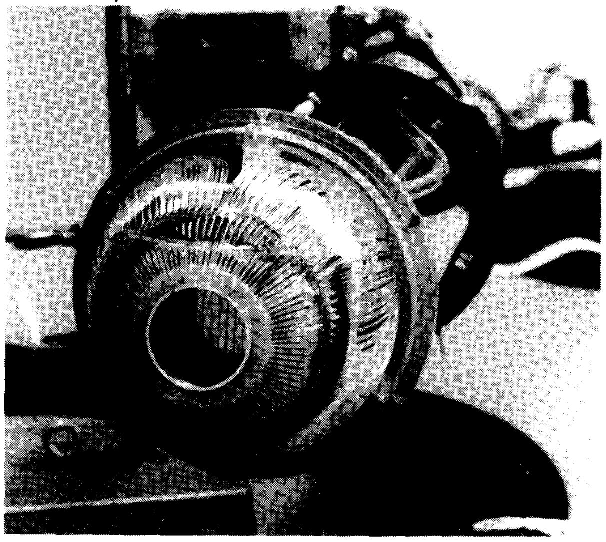

Fig.3: Detail of the beam monitor. The scintillator (Ø7 mm) is visible in the centre of the circular light guide (Ø30 mm). Behind the scintillator and light guide the cathode strips on the exit foil of the x-MWPC are visible. The beryllium degrader is not mounted yet.

The strip-currents are fed to 8 x- and 8 y-electrometer amplifiers. The output voltages are averaged with a time constant of 0.12 s and sampled and digitized (8 bit). One scan over all strips is made every 20 ms (scanning frequency is locked to the 50 Herz line frequency). With a beam intensity of up to 2x10^6 $\bar{p}$ per second the gas amplification can be low (< 100) and the data of one scan can directly be used to produce histograms to show the beam profile projected onto the x- and y-axis.

A second pair of MWPCs can be mounted at some distance behind the monitor system to measure the $\bar{p}$ stopping distribution. Cathode strips are read out by the same system and a second set of histograms is generated in the same scan.

The read-out of the scans is made by using the MAC 64 system [1]. The 8-bit data and the 5-bit strip address are read simultaneously using a parallel digital input device (PIAx2,56040) [2]. The x- and y-projections of the beam profile are displayed on a video monitor (see Fig.4) using a video-drive interface (SPS 6607 10, Monochrome Monitor Interface). The quality of the beam is checked by determining the mean values and the FWHM of the two projections. The positioning of the beam is better than 0.5 mm.

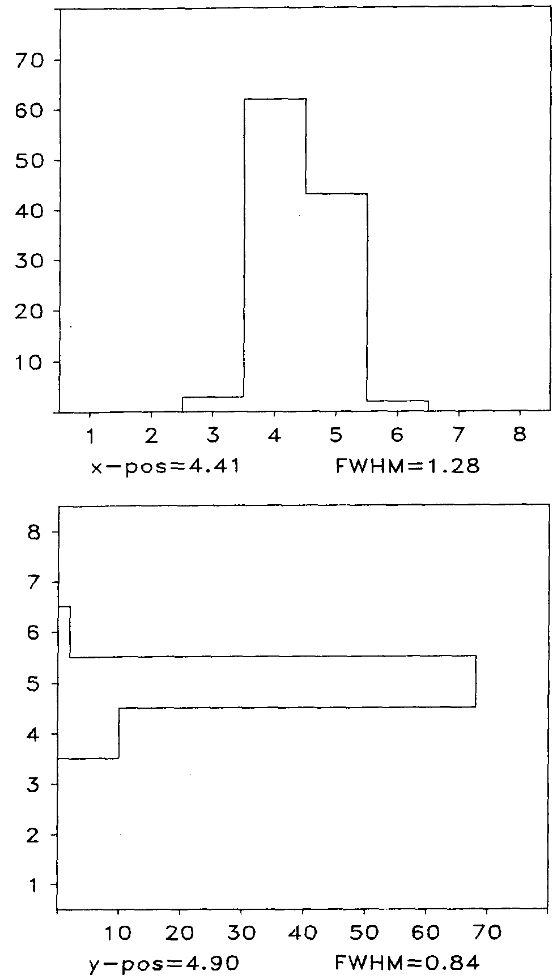

Fig.4: Example of measured histograms. Top: horizontal projection of $\bar{p}$-beam profile. The intensity is divided over two adjacent cathode strips to demonstrate centering (3.2 mm FWHM = 1.3 strip pitch). Bottom: vertical projection. The full intensity is on one cathode strip to demonstrate the beam diameter (2.0 mm FWHM).

The beam trigger system consists of a tiny scintillator (Ø7 mm, thickness 1 mm, Nuclear Enterprise NE102A), mounted between the MWPCs and the target sphere (see Fig. 1,3). The scintillation light is guided to a PM outside the magnetic field of the solenoid by means of 192 plexiglass (PMMA) fibers (Ø1 mm, length 5.00 m, Mitshubishi Rayon Co. Ltd; attenuation of 300 dB/km at 420 nm). The fibers are all of the same length and bundled to form one light guide. The guide ends in a circular (Ø4 cm) coupling piece with a flat end to match the PM. The signal from an antiproton passing the scintillator ($\Delta E = 6$ MeV) is of a well defined height and much larger than the single electron signal from the PM (see Fig.5). There is an obvious reflection at the receiving end of the cable. The time resolution is ≈ 100 ps.

Fig.5: Output signal of the XP2020 PM, generated by heavily degraded 200 MeV/c antiprotons. Horizontal: 10 ns/div.; vertical: 0.5 V/div.

It is not only important that the beam is well centered in the x- and y-direction but also that the stopping distribution of the antiprotons is centered in the target sphere along the beam (z-)direction. For this purpose a beryllium degrader (thickness 1.8 mm) has been mounted between the MWPCs and the scintillator (see Fig.1) which can be tilted by remote control. Thus a thickness variation of 60 μm of beryllium can be introduced in the beam, which is sufficient for z-centering of the stopping distribution.

Acknowledgements

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References

1 A.E. Ball, Monitoring and Control 64. G-64 based system, EF-NEU Controls (1985), CERN Report.

2 User Manual COR-PIAx2,56040, Corylus, Geneva.