Central Outer Z-chamber of the H1 Detector

T. Kurča et al.

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Abstract

The Central Outer Z-chamber (COZ) of the H1 detector is used for the precise measurement of the z-coordinates of the charged particles tracks. It's construction, performance and operation experience at HERA conditions are given here.

1 Introduction

The H1 central tracking system [?] operates in a magnetic field of 1.15 T. It consists of a set of concentric multiwire drift and proportional chambers. Two large jet chambers (CJC1,CJC2), the central inner and outer z-chambers (CIZ,COZ) are used for triggering and the track parameters measurements. For triggering also the central inner and outer proportional chambers (CIP,COP) are used. The system is completed by two layers of silicon detectors (CST).

Jet chambers wires are strung parallel to the beam axis arranged in a configuration with radially tilted cells to compensate for the Lorentz angle. There are no stereo wires layers. CJC1 and CJC2 provide precise measurement $\sigma_{r,\phi} = 120\ \mu m$ in the $r-\phi$-plane but only insufficient $\sigma_z \sim 3-5\ cm$ from the charge division.

The complementary precise $z-$measurement is performed by the z-drift chambers.

2 COZ Construction

2.1 Mechanical

The COZ (Fig.x) has a cylindrical shape with an active length of 2160 mm, an inner and outer diameter of 920 resp. 970 mm, and covers a polar angle range $25^\circ < \theta < 125^\circ$. The chamber is in z divided into 24 identical rings, each 9 cm wide, and subdivided in ϕ by the wire supporting rods into 24 drift cells. Each ring has 4 sense wires and 3 pairs of potential wires strung perpendicular to the beam line. The sense wires are not staggered since mirror tracks could be removed by the software as they do not point to the vertex.

The chamber was erected on a 24 fold Rohacell polygon, which covers a cylinder of carbon fiber reinforced plastics. Kapton foil with field shaping copper strips was glued on the Rohacell surface. This foil is also used to isolate the drift cell from the Rohacell body. Guided by a mechanical positioning device the wire supporting rods from G10 with Cu strips from both sides were placed and soldered to the polygon edges. The copper strips on the foil and on the rods were connected to each other. The holes for the wire feedthroughs were drilled in their nominal positions with a precision of about $\sigma \sim 30\ \mu m$. The gold plated brass feedthroughs themselves are pressed into the the wire supporting rods with a special tool. The drift cells were created by introducing cathode planes made of 1 mm thick G10 with copper strips on both sides. Holes in the cathode planes allow for a gas flow along the chamber (Fig. cell).

The chamber was wired on a device, where it could be rotated around the z-axis. The 96 sense wires (48 μm Stablohm) and the 6×24 potential wires (127 μm gold plated brass) were guided through the feedthroughs, soldered and crimped to the end rods at the readout zones. Due to the short unsupported distance of $12 - 13\ cm$ between two rods, the wire tension of 140 p and 800 p for the sense and potential wires respectively, is not a critical issue (parameter). Before closing the chamber the sense wires positions on each feedthrough were measured with a precision of $\sigma \sim 100\ \mu m$. These coordinate corrections are used for the transformation of the measured drift times into the global coordinate system.

The drift cell cover of the COZ made of a Kapton-Rohacell sandwich is fixed on (at) the cathode planes. The field forming copper strips on the bottom side were connected with the strips on the 2 endrods. Therefore all field forming strips of 1 ring with the same high voltage are connected. On average, the chamber represents a material thickness of 1.5 % X_0 for perpendicular crossing tracks. More mechanical details, design consideration and test results can be found in earlier reports [?], [?], [?].

2.2 Electronics

The given arrangement of the COZ inside the central tracker suggested high voltage (HV) supply from the endflanges to the individual rings and the signal readout vice-versa. This ensures also access to the preamplifiers and the HV supply after installing the COZ into the central tracker. To improve the reliability of the HV supply cathodes, wires and strips are fed at both ends. All electronics components (feeding resistors, decoupling capacitors for the sense wires etc.) are located outside the chamber gas volume at the endflanges. The given Φ symmetric arrangement of the preamplifiers at the endflages and the requirement of minimizing the cable length led us to distribute the readout zones in the same way. Thus the chamber pulses are transmitted over distances ranging from 20 cm to 120 cm before entering the preamplifiers. The design considerations, manufacturing and test of the strip lines are described in [?]. The impedance of the strip lines has to correspond to the chamber impedance of about 200 Ω. To achieve this we had to utilize a stripline arrangement without an electric shielding because cables covered from both sides have typical impedances of about 20 Ω, i.e. one order of magnitude below the required value. The lack of shielding of the cable is partially compensated for by the differential input of the preamplifiers [?] which suppress common mode pickup of any two parallel transmission lines up to a certain frequency. RF pickup is attenuated by the Faraday cage of the COZ. Particular attention was paid to minimize the cross talk. The cross talk within a cable from one signal core to the next one across the interleaving ground has been measured to be 2.2 %. This adds to the cross talk between adjacent sense wires. The cross talk is crucial to the chamber resolution in the case of inclined tracks since the cross coupled charge affects the leading edge of the pulses and generates a time shift of the reconstructed position. This time shift depends on both the Q_t algorithm and the time difference between the pulses. As expected, the biggest effect occurs for a time difference of about 30 ns which is roughly half of the FWHM of the COZ pulses. Even in the worst case the maximum position error of about 30 μm is negligible compared to the chamber resolution of a few 100 μm. With the full size prototype also the charge asymmetry from the charge division measurement for different sense wire materials had been studied (Fig.5). The Elgiloy resistance is obviously too high, the asymmetry reaches ± 1 values before the ends of the wire ($\Phi = \pm 180°$). Finally Stablohm was chosen, since it has a smoother surface and is mechanically more stable than the W/Rh wire. The last point is important since the wire has to be guided through 24 feedthroughs. the charge asymmetry for different

3 COZ Operation

3.1 Drift Cell

The COZ is in Φ and z-direction through the wire supports and through the cathodes resp. divided into 24×24 drift cells. Figure 6 shows rz-view of one cell with electric field lines and isochrones. The electric field inside this cell is a function of four different HV parameters: U_{SW}, U_{CS}, U_{FS} and U_{CA} are applied to the sense wires, the central and first fieldforming strip and the cathode respectively. The CA plane and the last strip are connected to each other. The potential wires are grounded. These four voltages fulfill different functions and a careful chice (tuning) of these parameters is needed for an efficient and optimal performance of the chamber. The gas gain is mainly determined by the sense wire voltage U_{SW}. The field homogeneity in the sense wire region and the ratio of the gas gains of inner and outer wires is defined by the central strip voltage U_{CS}. The HV difference between the first strip and cathode determines the field gradient in the drift region and therefore the drift velocity. Typical values in the first years of COZ operation typical values used were $2350/350/300/-3500\ V$ for $U_{SW}/U_{CS}/U_{FS}/U_{CA}$ resp. Later for different gas mixture the setting used was $2350/300/250/3900\,V$.

Garfield (Wircha) program [?] is used to calculate the electrostatic field configuration and the isochrones as a function of the reduced electric field (E/p) and the gas mixture (Fig.6). The dashed curve in Fig.7 indicates the calculated local drift velocity v_d as a function of the distance to the sense wire along a 90° isochrone line. The average drift velocity is calculated by summing the drift times from the distance d to the sense wire (solid curve) and is used for the transformation of drift times into drift distances. This curve is fixed at the end of the drift cell by the internal calibration (solid point). For details of the calibration methods see chapter 6. The progress of the drift velocity curve is verified by an external calibration (open points). The general COZ performance is monitored by online histograms like wire hit map, signal pulse amplitudes spectrum and drift times distribution. These allow for fast performance check of the chamber.

3.2 Gas Mixture

3.3 Chamber Performance

References

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