7. The Drift Chamber Spectrometer

Drift Chambers

Proceeding from downstream mirror plate of the ROSIE magnet the along the beam direction (toward the north), one encounters 3 vertex (or jet) drift chambers (VDC1,VDC2 and VDC3) near the upstream pole face. Immediately downstream of the ROSIE magnet are 3 prodigious drift chambers (DC1, DC2 and DC3) of conventional type.

The large downstream chambers are used with the analysis magnet for momentum measurement of charged particle tracks and to match upstream tracks to hits in the muon identification system and in the lead glass calorimeter. The VDCs are used for additional tracking and to supplement the scintillating fiber system in track discrimination.

Physical Layout of the VDCs

The The most downstream of the VDCs (VDC3) is located approximately 44 cm from the upstream face of the upstream mirror plate of ROSIE. The wires inside this VDC are slanted at a 4.2° angle from the vertical, (defined as the u' plane. The middle VDC (VDC2) has wires slanted at -4.2° with respect to the vertical (defined as the v' plane). The most upstream of the VDCs (VDC1) has wires oriented along the vertical direction (x plane). The active area of theVDCs is 100 cm × 70 cm. The chamber windows are centered 1.24 mm west of beam center.

Each VDC has 16 cells each 7 cm wide (perpendicular to beam) and 9 cm in depth. Each cell has 6 sense wires spaced in .95 cm increments along the z direction. The cell geometry is shown in Figure 1.

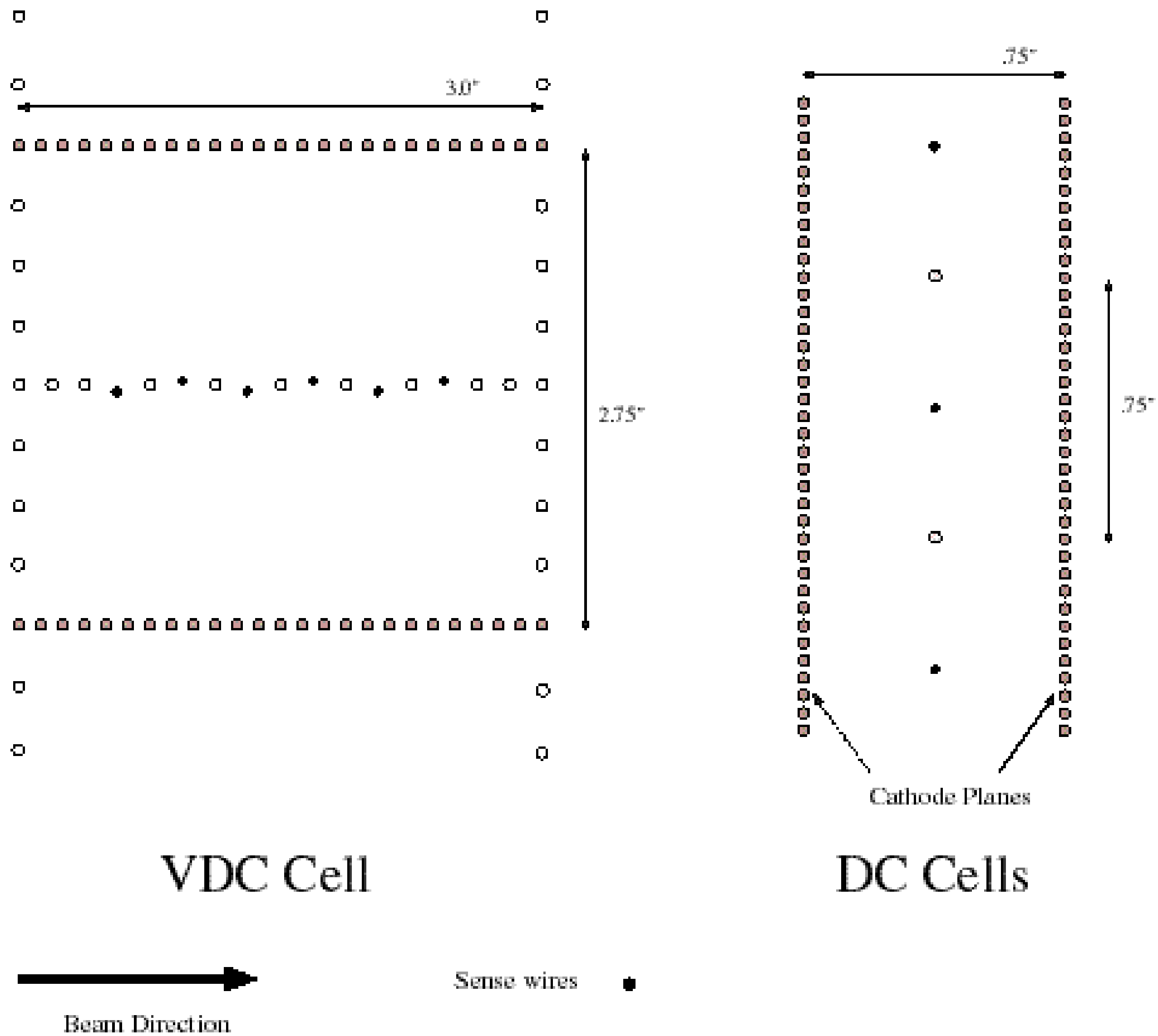

Figure 1. Cell geometry of the vertex (jet) drift chambers and of the large downstream drift chambers.

The cathode and field-shaping wires in the VDCs are 150 microns in diameter. The sense wires are and have a 25-micron diameter. The spacing between sense and field wires is ___, with the sense wires staggered on each side of the plane formed by the field wires. This staggering helps to resolve ambiguities in determining which side of the cell the particle actually traversed. The spacing between the field plane and one cathode plane is 3.5 cm. The cathode wires are spaced by ___ cm. The guard wires are used to step the voltage down smoothly from the cathode to ground.

The VDCs have pre-amplifier cards on-board which output a differential analog signal. This feeds into a shaper/discriminator card whose purpose is to take groups of six signals (the number of pre-amp outputs) and regroup them in sets of eight signals so that no TDC channels will be wasted. The cards put out differential ECL signals which are routed to a crate of LeCroy 4291 TDCs, operating in MOD 500 mode, with a dynamic range of 1024 nanoseconds. The TDCs are run in common stop mode so that hits closest to the wires will give the largest TDC values. The power racks and shaper/discriminator electronics sit in a relay rack approximately 2 m east of the VDCs.

Supplemental VDCs

To improve the tracking inside the magnet volume, additional jet chambers were added during the summer of 1997. The first chamber, KSY, was in place for about 2/3 of the data run. This chamber has 17 cells of 6.6 cm which measure position in *y* with four samples along the beam direction. The second chamber, KSX, has a total of 22 cells and measures position in *x* with four samples along the beam direction. KSX was in position for approximately 1/3 of the data run.

Both chambers are read out through LeCroy 3377 TDCs. KSY has a total of 68 channels and KSX has a total of 88 channels.

Physical Layout of the DCs

The three large DCs are situated between the ROSIE magnet and the lead glass house and we have labeled the most upstream of these DC1 (with DC3 being farthest downstream). Each of the DCs have chamber windows that are on both sides of aluminum frames. Each DC is approximately 30 cm deep. The first lies about 1 m downstream of the geometrical center of the analysis magnet. The second is positioned 75 cm downstream of the first and the third is 75 cm downstream of the second. The ordering of the planes in DC1 and DC2 from upstream to downstream is: ground plane, cathode plane, x' sense plane (with wires oriented vertically), cathode plane, x sense plane (with wires oriented vertically, but shifted by 9.5 mm from the previous vertical plane), cathode plane, u'' sense plane (with wires slanted from the vertical by 16.7 degrees--a slope of 0.3--with the top of the wires closest to the east wall), cathode plane, V sense plane (with wires slanted from the vertical by 16.7 degrees, with the top of the wires closest to the west wall), cathode plane and ground plan. Similarly, for chamber DC3 (previously used in Fermilab experiment E771),[1] the ordering from upstream to downstream is: ground plane, cathode plane, x' sense plane, cathode plane, u'' sense plane, cathode plane, x sense plane, cathode plane, v'' sense plane, cathode plane, ground plane.

Each sense plane has alternate sense and field-shaping wires spaced 9.5 mm apart. Each cathode plane has cathode wires spaced 2.1 mm apart. Alternating cathode/sense/cathode planes every 9.5 mm along the beam direction create drift cells which are ___ square. The cell geometry of the DCs can be seen in Figure 1.

Each of the DCs was contructed to have 176 cells of one sense wire each. For DC1 only the center 112 cells of the x and x' planes and the center 144 cells of the u'' and v'' planes are used. This is an active width of 223 cm. For DC2 and DC3 all 176 cell of the x and x' cells are used. The center 176 cells are used for the u'' and v'' planes of DC2 and the u'' plane of DC3. The v'' plane of DC3 uses only its central 144 cells.

The drift chambers use a gas mixture of 50% Ar and 50% ethane. A customized system in the gas shed precisely controls the mixture of the two gases. The gas is routed to the chambers through a system of bundle tubing, with the option of bubbling the gas through ethanol at 0°C for suppression of corona discharges. A solenoid at the gas inlet to the chamber and a second solenoid at the outlet regulate each chamber's pressure.

DC1 and DC2 were constructed as identical chambers and employ exactly the same signal amplification electronics. The geometry of DC3 is the same as for DC1 and DC2, but its field wires have a larger diameter and its amplifier cards are entirely different. All three DCs output differential ECL signals (via their amplifier cards) to LeCroy 4291 TDC modules.

Drift Chamber Resolution

Resolution for both the VDCs and the DCs were measured with muons from the PW5 dump. Single, unambiguous muon tracks (as identified in the muon identification system) were fitted and the residual distance to the hit position on the sense wires was calculated. Histograms of the residuals for the VDCs and DCs are shown in Figure 2 and Figure 3, respectively.

Figure 2. Gaussian fits to residuals (difference of track and hit positions) used to determine the resolution of the VDCs.

Figure 3. Gaussian fits to residuals (difference of track and hit positions) used to determine the resolution of the large DCs.

Drift Chamber Efficiencies

The efficiency of a drift chamber was found by using muons from the PW5 dump. The efficiency is taken to be the fraction of the time that a sense wire did not give a signal for a clearly defined muon track, subtracted from unity. For the VDCs the combined efficiency of the all the 1st, 2nd, etc. sense wires in all the cells is shown in Figure 4. The efficiency for entire planes of sense wires in the DCs are shown in Figure 4 as well.

Figure 4. Drift chamber efficiencies for the VDCs (top) and large drift chambers (bottom).

[1] T. Alexopoulos, et al., E771 Collaboration, Nucl. Inst. and Meth. A 376 (1996) 375.