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(I)

Performance of the SLD Barrel CRID During the 1992 Physics Data Run*

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Abstract

The SLD Barrel Cherenkov Ring Imaging Detector was fully operational in the 1992 physics data run. The electron drift velocity and magnetic field deflection of electron trajectories have been measured. Cherenkov rings have been observed from both the liquid and gas radiators. The number and the resolution of the angle of Cherenkov photons have been measured to be approximately equal to design specifications.

I. INTRODUCTION

The SLD is an e^+e^- spectrometer designed for Z^0 physics[1]. The SLD Cherenkov Ring Imaging Detector (CRID)[1-10] has been designed to provide charged particle identification that allows π/K/p separation up to 30 GeV/c and e/π separation up to 6 GeV/c. This is accomplished by the use of liquid and gaseous fluorocarbon radiators. The Cherenkov photons from the gaseous radiator are focused on the drift boxes with spherical mirrors; see Figure 1. The Cherenkov photons created in a layer of liquid radiator 1 cm thick do not require mirror focusing. The drift boxes are constructed with fused silica quartz windows. Inside the drift box is ethane gas with an admixture of 0.1% TMAE which absorbs a Cherenkov photon and liberates an electron. The photoelectron drifts in a uniform electric field to a multiwire proportional chamber. The three coordinates of the point of absorption of the Cherenkov photon are provided by the drift time of the photoelectron, the hit wire number and the ratio of the pulseheights at the two ends of the high resistance carbon fiber anode wire.

II. STATUS OF CRID DURING THE 1992 PHYSICS RUN

The operational experience with the CRID to date is discussed in detail elsewhere[2,10]. The radiator vessel was filled with a mixture of 70% C_5F_{12} and 30% N_2. Good UV transmission was maintained in the radiator gas. The O_2 and H_2O levels were kept below 5 and 50 ppm respectively[10].

The drift boxes were filled with high purity ethane with an admixture of 0.1% TMAE. The O_2 and H_2O levels were kept below 0.5 and 5 ppm respectively. The ethane gas contained

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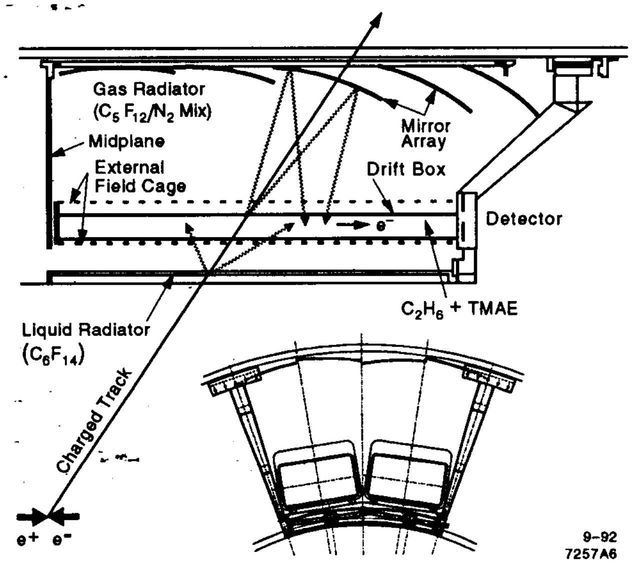

Figure 1. Schematic of the SLD barrel CRID.

small amounts of sulfur (3 ppm) which was removed by a nickel based absorber.

All of the liquid radiator trays were filled with C_6F_{14}. Excellent liquid transparency was maintained during the run.

III. UV FIBER STUDIES

The fiber-optic calibration system injects UV light into the drift boxes at various points which serve as fiducial marks. It was designed to provide drift velocity monitoring and measurements of the electron trajectories in the x, y plane using the vertical fibers, see Figure 2. The 45° inclined fibers nearest the detector are used for charge division calibration. The three 45° inclined fibers in the middle are used for trajectory measurements in the y, z plane; a right handed coordinate system is used.

The light is generated by a flashlamp[11] filled with xenon and triggered every beam crossing at 120 Hz. The trigger circuit shown in Figure 3 consists of a silicon controlled rectifier (SCR) that fires the auxiliary electrode of the flashlamp which initiates the discharge of a capacitor through the main electrodes. The discharge capacitor was chosen to be 1 nF which results in a pulse width of 70 ns. The jitter intrinsic to the lamp is 200 ns. The lamp has been operating under these conditions for 4000 hours without noticeable decrease in intensity. The light is transported over an average distance of about 12 m to the drift boxes by fused silica UV transmitting optical fibers[12] having 600 µm core diameter. At each drift box the 600 µm fiber illuminates a bundle of 19 silica fibers having 200 µm core diameter which in turn route the light to the appropriate position on the drift box.

The full angle of the cone of light emerging from the fibers is limited to 2° by a collimator. The collimators shown in Figure 4 were designed with a cavity in the middle because otherwise light would reflect at a grazing angle on the inside walls and widen the emerging light cone.

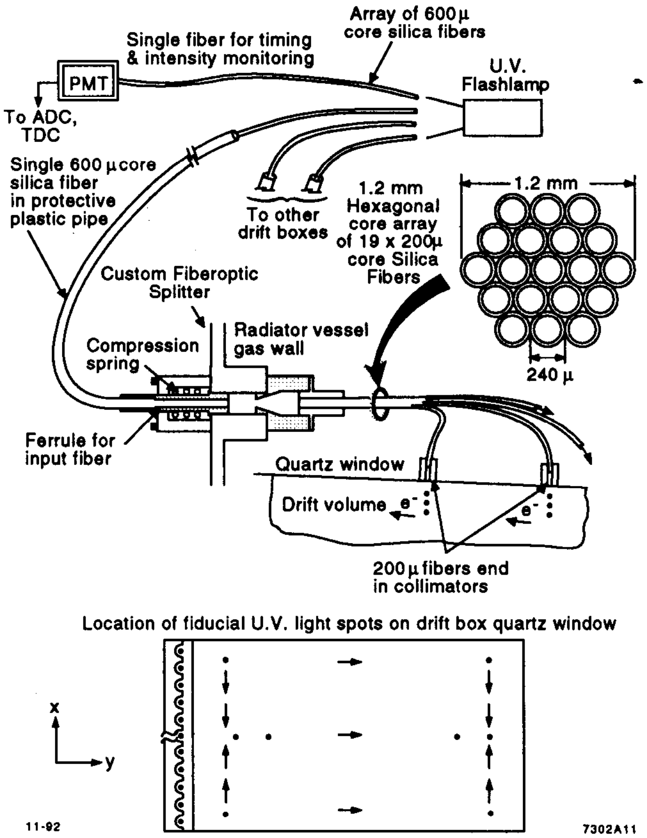

Figure 2. The fiber-optic calibration system. Dots indicate vertical fibers; arrows indicate the plane and direction of the 45° inclined fibers.

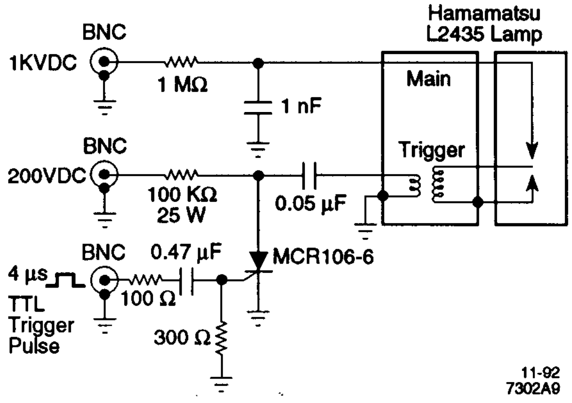

Figure 3. Flashlamp trigger circuit.

The extreme variation in light intensity between the fibers is a factor of 10 due to the routing of each fiber, which causes different amounts of bending, and the transmission non-uniformity of short segments of optical fibers.

The fiber data are logged during the run together with the rest of the CRID data. The intensity of the flashlamp is adjusted so that the probability for a photoelectron to be generated at each fiducial point is approximately 10%. They account for 5% of the data in an event caused by colliding beams. The continuous logging of the fiber data was deemed necessary because large variations of the drift velocity were observed; see Figure 5. If uncorrected, these variations would cause an error in position measurement of about 2 cm, whereas the design specifications call for an error of 1 mm.

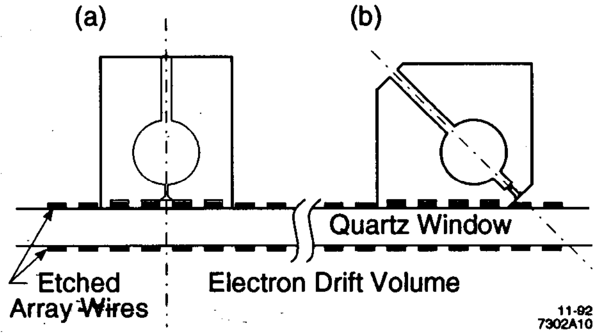

Figure 4. Cross section of collimators (a) vertical, (b) inclined 45°.

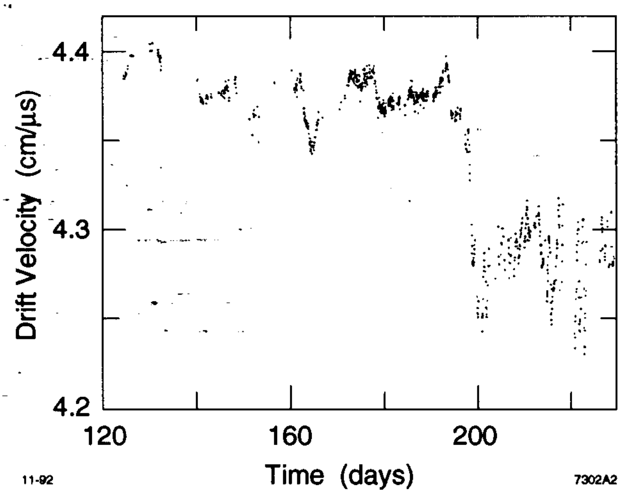

Figure 5. Variation of the drift velocity over the entire run.

The drift velocity is calculated from fits to the middle row of four vertical fibers. The velocity is averaged over an interval of one hour. This corresponds to 3500 triggers and a statistical accuracy on the drift velocity determination of 0.05%.

The position of the photoelectrons needs to be known with an accuracy of 1 mm at all points in the drift box. The trajectory of the drifting electrons is affected by the radial component of the magnetic field of the SLD solenoid, imperfectly aligned electric field and space charge in drift volume. Figure 6 shows the 1 cm shift of the fiber pattern along the wire number direction caused by the radial component of the magnetic field. The spacing between the wires is 3.175 mm. Figure 7 shows the images of the fiber fiducial points in the middle row with the magnetic field off and on. The fiducial points with the field on are fitted to a parabola.

The fiber fiducial points farthest from the detector end show variations from box to box with a standard deviation of 1 mm. The fiducial positions are stable to within 0.5 mm. The fiducial points do not depend on whether the gating system is on or off. This implies that space charge effects due to positive ions streaming back into the drift region from the amplification region of the detector are small, if present at all.

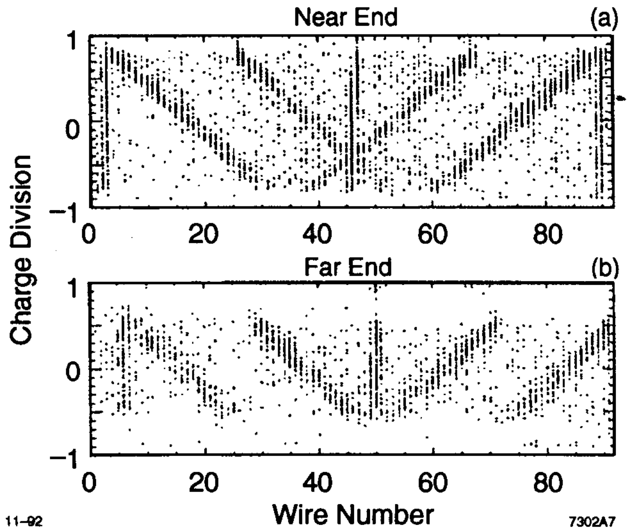

Figure 6. (a) Fiber pattern near the detector end, (b) fiber pattern near the high voltage end of the drift box; the abscissa is the wire number and the ordinate is the charge asymmetry at the two ends of the anode wire.

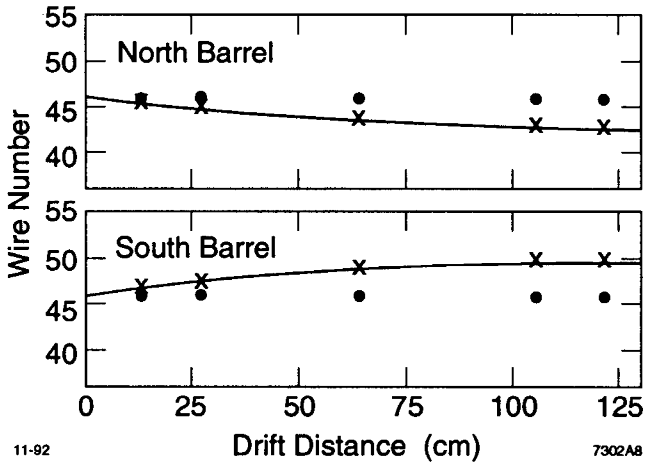

Figure 7. Top view of drift box, circles are the measured positions of fibers with the magnetic field off; the points marked by x are the measured positions with the magnetic field on.

IV. RECONSTRUCTION OF CHERENKOV RINGS

Cherenkov rings are reconstructed by taking all relevant hits in the CRID for each track in the central drift chamber and transforming that data into Cherenkov angle emission space. Because the detailed alignment and trajectory studies have yet to be performed, the search for gas radiator rings was done in an alignment independent way. Points that are found to lie within 150 mrad in Cherenkov space are fitted to a circle and the center is determined. At least five hits with a good circle fit are required. Because of the small size of the gas ring, with a typical diameter of 5 cm, the resolution of gas rings is sensitive to local shifts of electron trajectories only. The resolution of the Cherenkov angle is 4 mrad and the mean number of photoelectrons is 10. This is consistent with expectations from Monte Carlo studies.

Liquid radiator rings extend over two, three or four drift boxes with a typical radius of 17 cm. The resolution of the liquid rings is more sensitive to drift velocity variation, drift box alignment and trajectory distortion. Because the corrections due to these effects have not yet been implemented, the resolution of the Cherenkov angle of the liquid radiator rings is twice as big as Monte Carlo simulations predict.

V. CONCLUSIONS

The observed Cherenkov rings prove that the CRID works and all the technical problems have been solved successfully. In order for the CRID to be useful as a particle identification device, work on the electron trajectories, on the alignment of the drift boxes to the central drift chamber and on the alignment of the mirrors has to be completed. The fiber-optic calibration system is indispensable in achieving the required 1 mm resolution in the position measurement of the photoelectrons.

VI. REFERENCES

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