THE DØ DETECTOR UPGRADE FOR RUN II

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The DØ detector at Fermilab is being upgraded to meet the demands imposed by high luminosity Tevatron running expected during Run II. A solenoidal field, silicon vertex detector, scintillating fiber tracker and preshower detectors will make up the new inner tracking system. Scintillation counters will be added to the central muon system. Plastic mini-drift tubes, pixel scintillation counters and thick shielding will make up the new forward muon system. A three level trigger will provide a rejection factor of approximately 10^6.

1 Introduction

In 1999 Fermilab will begin Run II, the first run with the Main Injector. Because the Main Injector will improve the $\bar{p}$ production rate by a factor of three and more efficiently transfer $\bar{p}$'s to the Tevatron, Run II will see an order of magnitude increase in the instantaneous and integrated luminosities to $2\text{x}10^{32}$ $\text{cm}^{-2}\ \text{s}^{-1}$ and 2 fb^{-1}. This is accompanied by an increase in the number of proton and antiproton bunches to 36 (108) and a decrease in the bunch spacing to 396 (132) ns. With these bunch spacings, the average number of interactions per crossing is 5.2 (1.7) at this luminosity.

As a result of physics opportunities created by improvements planned for the accelerator, DØ is in the process of enhancing its detector capability. This upgrade builds on the strengths of the existing detector by enhancing the tracking and triggering capabilities to exploit the expected high luminosity. This report outlines the DØ upgrade design[1,2] (see Fig. 1) and presents recent progress in construction.

The key element of the upgrade is replacement of the inner tracking systems with a solenoid magnet, silicon vertex detector, and scintillating fiber tracker. Central and forward preshower detectors improve the electron and photon identification. The muon system is augmented by the addition of scintillation counters to the central and forward regions, the replacement of the forward pdts by plastic mini-drift tube planes, and thick forward shielding. New front-end electronics for the calorimeter and those muon detectors which are retained is required because of the decreased bunch spacing. A fully pipelined trigger provides high rate capability.

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1.1 Inner Tracking

A 2 Tesla field is provided by a 2.8m long superconducting solenoidal magnet built by the Toshiba Corp. Inside the tracking volume the value of $\sin\theta \times \int B_z dl$ along the trajectory of any particle reaching the solenoid is uniform to within 0.5%, despite the absence of a field-shaping iron return yoke. The magnet winding was recently completed.

The silicon vertex detector is to be constructed of interleaved barrels and disks providing 3D tracking information to $|\eta| \leq 3$. The barrel design presently has 4 overlapping layers, two single-sided with axial strips and two double-sided with axial and 2 deg stereo strips. The inner layer begins at a radius of 2.77 cm and the outer layer ends at a radius of 9.99 cm. The full length of the barrel is 84 cm. The $r\phi$ silicon strips have a 50μm pitch providing a spatial resolution of approximately 10μm. There will be 16 disks, 12 (4) disks with an inner radius of 2.57 (9.5) cm and an outer radius of 9.96 (26) cm. The larger disks are located farthest from the interaction point. The silicon strips are AC-coupled (each strip has an integrated coupling capacitor and polysilicon bias resistor) for rad-hardness. A portion of the detectors have been received. The readout is via SVX II chips developed at Fermilab and LBL. The rad-hard SVX II chips were recently delivered for testing.

The silicon vertex detector enables tagging of displaced vertices from heavy quark decay and separation of multiple interactions. The small angle stereo design provides $r - z$ resolution at the vertex of 0.5 mm allowing separation of primary vertices from multiple interactions.

The Scintillating Fiber Tracker (SFT) surrounds the silicon detector and covers the central pseudorapidity region. It performs two main functions. First, with the silicon detector, the SFT enables track reconstruction and momentum measurement for all charged particles within $|\eta| \leq 1.7$. Second, it provides a list of track candidates above preset momentum thresholds for the Level 1 (hardware) trigger. A total of about 74,000 multiclad scintillating fibers are arrayed in 8 doublet layers, each with axial and small angle stereo doublets, with radii from 20 to 50 cm. Eight meter clear multiclad fiber conducts the light to the Visible Light Photon Counter (VLPC) readout on the platform. The readout is also via SVX II. At $\eta = 0$, the resolution is approximately $\delta p_T/p_T = 8\%$ for $p_T = 50$ GeV/c.

The Central and Forward Preshower Detectors (CPS and FPS) will augment triggering on electrons in the regions $|\eta| \leq 1.3$ and $1.4 \leq |\eta| \leq 2.6$. The detectors will consist of several layers of axial and stereo scintillator strips with wavelength-shifting (WLS) fiber readout and a lead radiator to provide a constant $2X_0$. The fine segmentation aids in offline electron and photon ID.

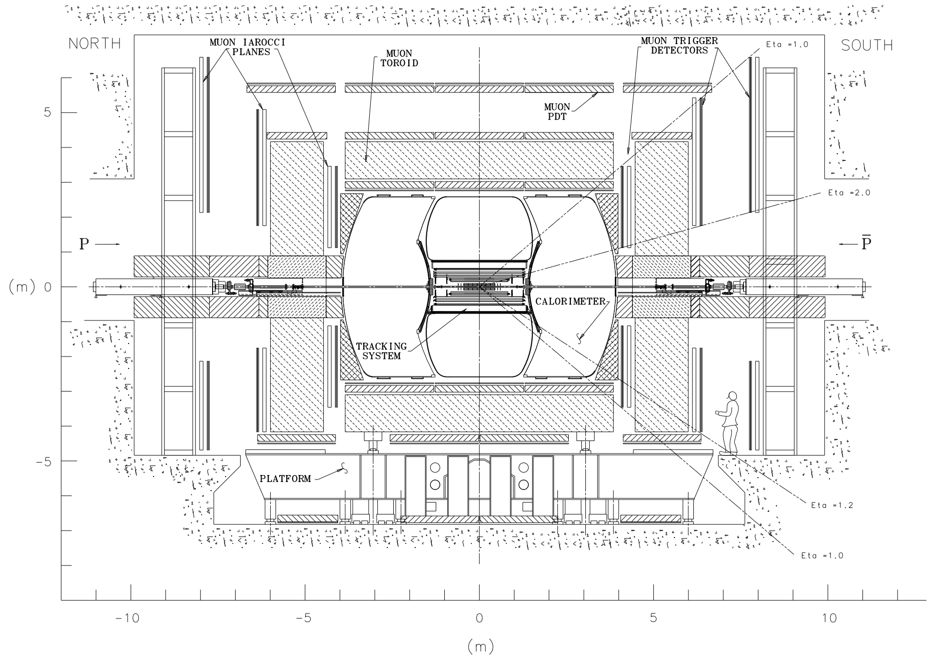

Figure 1: The DØ detector upgrade for Run II.

1.2 The Calorimeter

The liquid argon calorimeter front-end electronics will be replaced to accomodate the smaller bunch spacing. The peak sampling time will be reduced to 400 ns from 2200 ns. An analog pipeline provides the trigger latency.

1.3 The Muon System

In the central region, defined approximately as $|\eta| \leq 1$, the WAMUS drift chambers and "Cosmic Cap" scintillation counters will be retained with replacement of their electronics to accomodate the small bunch spacing. The coverage of the Cosmic Cap will be extended to the underside of the detector. In addition, 630 scintillation counters will be added to the space between the calorimeter and first layer of WAMUS pdts, to reject out-of-time backgrounds and to provide a ϕ match to SFT track candidates at the trigger level.

The forward muon system, defined approximately as $1 \leq |\eta| \leq 2$, has undergone a major revision. Due to aging, the forward region WAMUS pdts will be replaced with plastic mini-drift tubes in an $r\phi$ geometry. The cells are square in cross section with a width of one cm. There will be three planes (A,B,C) on each end of the detector with (4,3,3) decks of tubes per layer. Three layers (A,B,C) of scintillation counters in an $R-\phi$ geometry, with $\Delta\eta \times \Delta\phi = 0.1 \times 4.5\,\mathrm{deg}$, reject out-of-time background hits. A coincidence of hits in the three layers in conjunction with a track in the SFT forms the forward muon trigger. Lastly, the large flux of non-muon background particles, originating from collisions and scattered from the beampipe and low-β quadrupole magnets, has compelled the addition of a thick iron (50 cm) and polyethylene (15 cm) shield with a lead skin (5 cm) around the forward accelerator elements in the collision hall. This shield will reduce the background flux by a factor of 20-50.

1.4 The Trigger System and Data Acquisition

The upgrade trigger has three levels. Level 1 (L1) is a deadtimeless hardware trigger with inputs from the calorimeter (+ SFT), preshower, muon system (+SFT). L2 provides capability to combine information from the L1 triggers and L3 is a computer farm for running more sophisticated software algorithms. The L1 trigger must reduce the event rate to less than 10 khz. L2 reduces the rate to less than one khz. L3 has a limit of 10-20 hz. The combined effect is to reduce the raw inelastic event rate by a factor of about a 10^6.

2 Conclusions

The upgrade of the DØ detector for Run II is underway. Conceptual designs for all subsystems have been completed and approved. Construction of many components is underway and is planned to be completed in 1999, in time for the first Main Injector run.

I thank my colleagues for their help and useful discussions. In particular, I thank C. Boswell, A. Bross, J. Ellison, R. Lipton, J. Thompson, and M. Tuts.

References

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2. S. Choi, "Characterization of VLPCs"; K. Davis, " DØ Muon Trigger Upgrade"; M. Wayne, "Test of a fiber tracker using VLPC readout"; C. Boswell, "Prospects for CP violation", all in these Proceedings.