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FIRST W DECAYS OBSERVED WITH THE DØ DETECTOR*

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Abstract

We have observed the first few W decays into electrons at the Tevatron, using the newly commissioned DØ detector. Preliminary results are presented. The number of observed decays as well as the transverse momentum of the electron, the neutrino and their transverse mass distributions, are consistent with expectations.

The DØ project is a second generation detector designed to operate at the Fermilab 2 TeV Tevatron. This project was proposed in 1984 and the first data were recorded this June at the start of the present 1992 Tevatron running period.

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†The D0 collaboration includes: Universidad de los Andes (Colombia), University of Arizona, Brookhaven National Laboratory, Brown University, University of California at Riverside, CBPF (Brasil), CINVESTAV (Mexico), Columbia University, Delhi University (India), Fermilab, Florida State University, University of Hawaii, University of Illinois at Chicago, Indiana University, Iowa State University, Lawrence Berkeley Laboratory, University of Maryland, University of Michigan, Michigan State University, Moscow State University (Russia), New York University, Northeastern University, Northern Illinois University, Northwestern University, University of Notre Dame, Panjab University (India), IHEP-Protvino (Russia), Purdue University, Rice University, University of Rochester, CEN-Saclay (France), SUNY at Stony Brook, Superconducting Supercollider Laboratory, Tata Institute of Fundamental Research (India), University of Texas at Arlington, Texas A & M University.

The detector includes three main components: the Central Tracking system (CD, described in some detail in this paper), the Calorimetry and the Muon system. Figure 1 shows an isometric view of the detector. The Calorimeter is a liquid argon-uranium system with an electromagnetic section followed by two hadronic sections.[1] The information is read out according to a tower geometry. The muon spectrometer includes magnetized

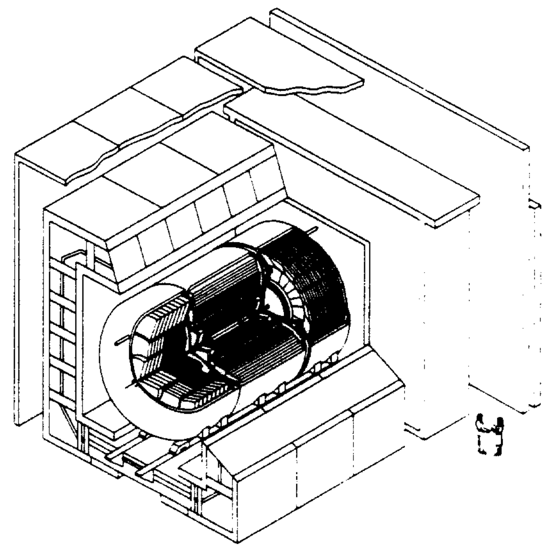

Figure 1. Isometric view of the DØ detector.

toroids and three layers of drift chambers.[2] The total number of electronics channels is 117,000. The main features of the DØ detector are the large solid angle coverage extending down to theta of 2 degrees and the excellent identification of leptons and jets. The detector is compact and does not have a central magnetic field.

All accepted events have a vertex defined by three or more tracks. Electrons are identified first in the electromagnetic section of the calorimeter and then in the transition radiation detector. Also present must be a single minimum ionizing track originating from the interaction vertex and pointing to the electromagnetic shower. Muons are recognized by a track in the muon spectrometer that extrapolates through the central tracking to the vertex. Neutrinos are considered whenever there is missing energy in the calorimeter. Jets are detected in the calorimeter.

THE DØ TRACKING SYSTEM

The DØ Tracking system includes three units of drift chambers.[3] A fourth component, the Transition Radiation Detector (TRD), is also considered to be part of the tracking. Figure 2 shows a cross section of the DØ central tracking. Two of the drift chambers, the Vertex (VTX) and the Central (CDC) are cylindrical units with a jet geometry. They measure tracks in a range of (pseudorapidity) $|\eta| < 1$. The Forward Drift Chambers (FDC), made with Theta- and Phi-modules, extend the coverage to $|\eta| = 3.0$.

The VTX includes three shells made by cylinders of carbon fibers. The inner unit is segmented in 16 cells and the outer two in 32 cells. Cells in the same layer are separated by planes of cathode wires (163 μm gold plated Al). Each cell has 8 radial sense wires (25 μm $NiCoTin$) in the middle, 0.457 cm apart. They are staggered by $\pm 100\,\mu$m. Pairs of guard wires at ground separate adjacent sense wires. Depending on the VTX-layer, the electrons are drifted over a distance of 1.1 to 1.6 cm. All VTX sense wires are read out at both ends. Charge division is used to measure the coordinate along the beam. The chamber uses a mixture of 95.5% CO_2 and C_2H_6 at atmospheric pressure. The drift velocity is 7.4 μm/ns at the operating voltage of 1.0 kV/cm.

The CDC includes four cylindrical layers of drift chambers.[4] Each chamber is built with cells made with panels of Rohacell foam, wrapped in Kevlar and covered with Kapton. Field shaping electrodes are located on the walls of these cells. Each center plane of a cell has seven sense wires (30 μm gold-plated W) separated by 0.6 cm and staggered by 200 μm. Pairs of guard wires (163 μm gold plated Al) separate adjacent sense wires. The maximum drift distance is 7 cm. Each cell also includes two delay lines (drift velocity 0.24 cm/ns) which measure the track position along the beam direction. Cells from adjacent layers are staggered by a half-cell. The sense wire information is read out at one end of the wire only.

The FDC units, figure 3, include two types of modules. The PHI units, of cylindrical shape, have radial wires. There are 36 cells in each PHI unit. Cells are separated by a divider and have 16 sense wires (30 μm gold plate W). 0.8 cm apart and staggered by 200 μm. One guard wire (163 μm goldplated Al) separates two adjacent sense wires. The THETA units are made with four quadrants of 6 cells each accomodating 8 sense wires, 0.8 cm apart and staggered by 200μm. Two guard wires separate sequential sense wires. Each cell has a rectangular cross section and is made with light materials. The three cells near the beam are half cells. Each cell contains one delay line. CDC and FDC are operated at atmospheric pressure with $Ar/CO_2/CH_4$ (93/3/4%), and

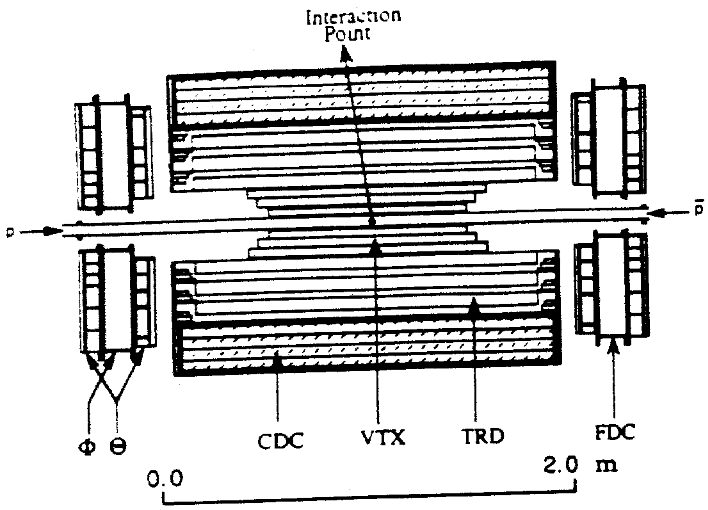

Figure 2. The DØ central tracking system.

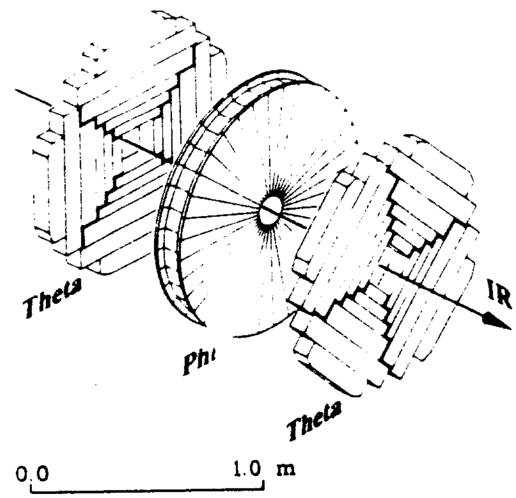

Figure 3. Isometric view of one FDC.

the drift velocity is 35 μm/ns.

The transition radiation detector (TRD)[5] is located between the VTX and the CDC. It consists of three cylindrical modules and its function is to identify electrons in a range of $|\eta| < 1$. The radiator, at small radius, is made of 382 foils of polypropylene, 18 μm thick and 150 μm apart. Outside the radiator there is a shell filled with a mixture of $Xe/CH_4/C_2H_6$ (91/7/2%). A grid of cathode wires at 0 V separates this gas volume into a drift region and, at larger radius, a cylindrical PWC. The 256 wires of the PWC run parallel to the beam direction and measure, in addition to the dE/dx of the tracks, the ionization of the electrons photoproduced by the transition radiation in the Xe of the drift region.

Read-Out Electronics of the CD

All four components of the central tracking are read out by the same electronics. The charge collected by a wire is first amplified then shaped and amplified again. The analog signals are then digitized by a 106 MHz wave form digitizer FADC and zero suppressed. The information of the 5,700 channels is processed in parallel in VME crates. The digitization of the FADC starts synchronously with each beam crossing. The resultant data is stored in a buffer and then either goes through the suppression cycle or is dumped depending on the decision of the level-1 trigger frame. The retained events are transfered to the level-2 microvax farm. Two pieces of information are extracted from the FADCs' data: the position of the hits and the ionization of the tracks. The hit finding algorithm makes use of the pulse shape to determine the track position. The area under each pulse is a measure of the dE/dx. This is used by the TRDs to identify e and by the drift chambers to identify γ that convert into e^+e^-.

Test Beam Results of the CD

All the central detector chambers have been tested in test beams. The position resolution measured with the VTX, in the R-Φ plane, for a single track, is between 40 and 60 μm for drift distances larger than 0.2 mm. This resolution has been determined using the triple time difference technique.[6] The position resolution along the wire obtained from the charge division is 1.5 cm. Both CDC and FDC measure the position of a single track along the drift distance with a sigma of 180 μm. This result is obtained by fitting straight lines

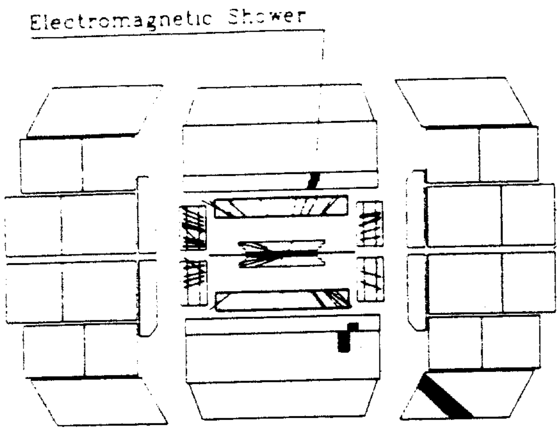

Figure 4. R-z view of a $W \rightarrow e$ decay.

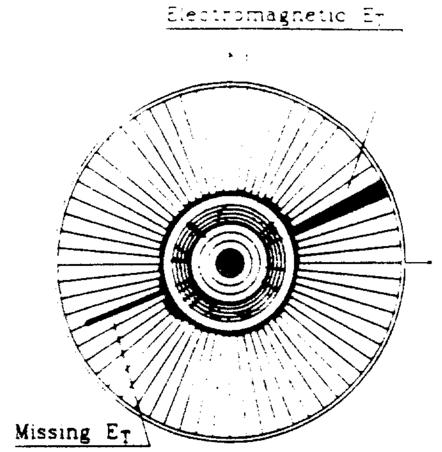

Figure 5. Same event seen along the beam.

through the chamber. This precision remains the same within 10% over the entire drift distance of 7 cm. A single delay line measures the z coordinate in the CDC with a sigma of 3 mm.[7] The two track separation, measured using e^+e^- from converted gammas (1.5 m upstream), is 0.5 cm with 90 % efficiency for identifying the tracks.[8] (The same quantity calculated by displacing individual tracks relative to each other is 0.2 cm). The dE/dx resolution is 13 % when retaining 75 % of the hits in the CDC or FDC. This gives a rejection factor of 50 for 2 mip (e^+e^-) for a 90 % probability of identifying a one mip particle.[9] The efficiency for identifying tracks with the resolution quoted is above 98 %. The test results of the TRD predict that the three modules will have a pion rejection factor of 50 for a 90 % probability of identifying the electron.

DØ TRIGGERING SYSTEM

The triggering system of the DØ detector requires first the coincidence between particles produced at small angle and on both sides of the interaction (level-0). A hardware trigger processor selects events based on the information in the calorimeter as well as in the muon spectrometer (level-1). An additional selection is achieved by analysis done on a farm of microprocessors (level-2). Data can be collected simultaneously for up to 30 different combinations (triggers) of requirements of level-1 and level-2. The events satisfying the required 'trigger' criterias are then stored for further analysis.[10]

The present 'trigger' for $W \rightarrow e\nu$ demands first a minimum bias interaction (level-0). Second, it requires from the level-1 an $E_T > 15$ GeV in the electromagnetic section of the calorimeter. Events are anlysed in the level-2 and they are retained whenever clusters of electromagnetic energy with $E_T > 25$ GeV are identified. A test on the shape of the shower is also performed. The offline analysis, in addition to fully reconstructing clusters of electromagnetic energy, compares the longitudinal shape of the shower to that measured in a test beam with an identical calorimeter module. A one mip track must also connect the event's vertex with the centroid of the electromagnetic cluster.

FIRST $W \rightarrow e\nu$ DECAYS

In the 1992 Tevatron running period, prior to this conference, about 100 nb^{-1} have been delivered. Half of this luminosity has been used to debug and calibrate the detector. A fraction of the remaining luminosity has been dedicated to the study of Ws decays.

The present preliminary analysis of this

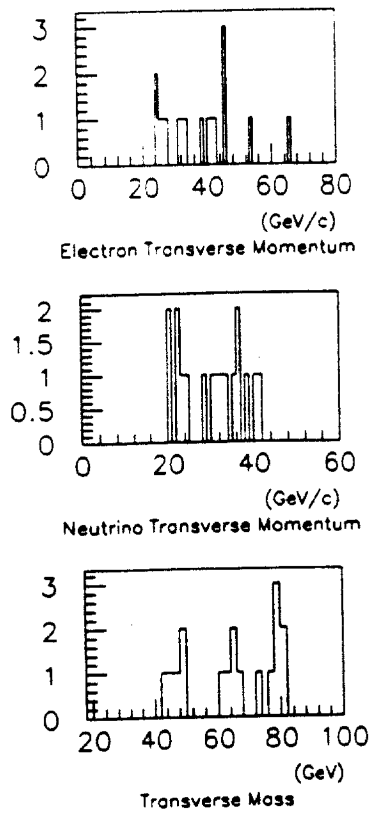

Figure 6. Results.

data has identified 17 candidates of W decaying into $e\nu$ with the p_T of the electron and of the neutrino larger than 20 GeV/c. An analysis of IVBs decaying into muon has produced 10 candidates. Two Z decays into e^+e^- have also been identified. The number of events observed is consistent with our expectations. Figure 4 displays the information recorded in the calorimeter and part of the drift chambers for a W candidate decaying into $e\nu$. The tracks associated with the interaction vertex are visible. Cells of the calorimeter with more than 1 GeV are also shown for the entire azimuthal angle. A cluster of energy deposited in the electromagnetic section of the central calorimeter is clearly shown. In figure 5 the same candidate is seen along the beams' direction. The detector has measured 39.5 GeV of electromagnetic energy in one direction and an almost equally large amount of missing energy in the exact opposite direction.

The transverse momentum of the electron and neutrino are plotted in figure 6. The two electrons with a $p_T > 40$ GeV correspond to events where the electron is produced together with a jet. Figure 5 shows the transverse mass distribution of the 17 candidates. The distributions of these three plots are consistent with what is expected for the decay of a W with a mass of about 80 GeV into $e\nu$.

The goal of DØ towards the study of the IVBs for the 1992 Tevatron running period is to measure the mass of the W with a precision of 160 MeV. This will be achievable with the expected luminosity of 25 pb^{-1}. This measurement together with the prediction of the Standard Model will set new limits on the mass of the top quark.

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