Hard Diffraction at Run I and Run II in the DØ Experiment

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Recent results on hard diffraction from DØ Run I data are mentioned. The new Forward Proton Detector which is being installed in the DØ experiment to improve diffractive measurements for Run II is presented.

1 Hard Diffraction at DØ Run I

At Tevatron Run I was observed the existence of large rapidity gaps in events with a hard scattering. CDF and DØ published many new results on events with a central rapidity gap between jets [1,2], diffractive production of jets [3,4], W and Z bosons [5,6], and b quarks [7]. To improve the diffractive measurements and to reconstruct more precisely the kinematical variables requires new detectors for tagging and measuring scattered protons and antiprotons, which are being installed now in the DØ experiment.

2 The Forward Proton Detector

The DØ Forward Proton Detector (FPD) [8] consists of momentum spectrometers which allow to measure the energies and angles of the scattered proton and antiprotons in the beam pipe. Tracks are measured using scintillating fiber detectors located in vacuum chambers positioned in the Tevatron tunnel 20–60 meters upstream and downstream of the central DØ detector.

Figure 1 shows the FPD layout. For reference, the DØ detector is drawn schematically in the center of the figure. We notice that we have six different locations for our roman pot detectors. The dipole detectors (named A_{D_1} and A_{D_2} in the figure) are located at 57 and 59 m in the direction of the outgoing antiprotons respectively. In addition, four quadrupoles have been installed (named A_{2S}, A_{2Q}, P_{2S} and P_{2Q} in the figure) have been installed in Summer 2000 at ± 23 and ± 33 m both in the direction of outgoing protons and antiprotons. The dipole spectrometer consists of two scintillating fiber detectors located after the Tevatron dipole magnets (D) and measures anti-protons that have lost a few per cent of the beam momentum (and are thus deflected out of the beam envelope and into the detector located on the radial inside of the Tevatron ring). These detectors have a very good acceptance at low t ($|t| < 1$

GeV^2) and high values of ξ, the momentum fraction of the pomeron carried by the proton (ξ >0.02). The quadrupole detectors are located adjacent to the electrostatic beam separators (S) and use the low beta quadrupole magnets (Q) as the primary analyzing magnets. They show a very good acceptance at medium t ($0.5 < t < 2$ GeV^2), and low ξ ($\xi < 0.04$). Each quadrupole show four independant detectors, above, below, to the right, or to the left of the beam. This maximizes the acceptance for protons and anti-protons given the available space for locating the detectors. Particles traverse thin steel windows at the entrance and exit of each Roman pot (the stainless steel vessel that houses the detector). Taking into account both the dipoles and quadrupole detectors, this gives us a total of 18 independant detectors.

The pot motion can be controlled remotely and the detectors can be moved close to the beam during stable beam conditions. They remain retracted otherwise. Each quadupole or dipole detector is made of 7 detectors, composed of six planes of 800 μm scintillator fibers (the planes show an offset by 2/3 of a fiber). The theoretical resolution of the detector is about 80 μm. The scintillating fiber detectors are read out by multi-anode photomultiplier tubes and are incorporated in the standard DØ trigger and data acquisition system.

The FPD project is now well advanced, and all the castles (quadrupoles and dipoles) have been installed in the Tevatron. In Fig. 2, you can see a quadrupole equipped with the TOP detector installed inside the Tevatron tunnel. You can clearly notice the motors which allow the pot motion close to the beam. With the start of Run II, the FPD is now in a test phase with two detectors fully installed, and 8 additional ones with a trigger scintillator only. We expect to get 10 detectors fully installed by the end of October 2002 (namely both dipoles, and all UP and DOWN quadrupoles), and the remaining 8 detectors later on. This will allow us to get already some new interesting physics results probably by Summer 2002.

The FPD will allow us to trigger directly on events with a scattered proton, anti-proton, or both, along with activity in the DØ detector. We will use elastic events for alignment and calibration. Concerning data taking, the FPD will be read out for all events taken by DØ and in addition we will get a few triggers dedicated to diffraction, namely diffractive jets, double pomeron exchange... For 1 fb^{-1} (namely after a bit more than one year of data), we expect to get about 1000 diffractive W bosons, 3000 hard double pomeron events, and about 500 000 diffractive dijet events. In the case of double pomeron exchange, we can tag both the scattered proton and antiproton, and a massive central system with a mass of more than 150 GeV could be produced. The addition of the FPD makes possible to study these very interesting events in detail since the kinematics of the event would be fully determined by the detection of both

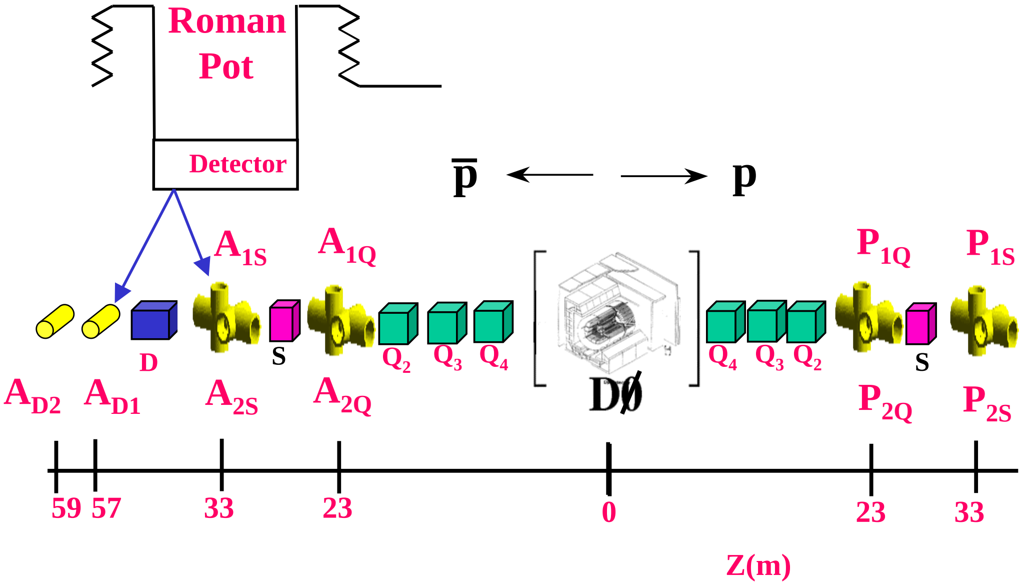

Figure 1: Layout of the Roman pot stations and Tevatron components comprising the Forward Proton Detector (see text).

the proton and the antiproton. This process has been proposed as a trigger for Higgs production [10,9]. It might be possible to observe a handful of Higgs events via this mechanism during Tevatron Run II. Finally, the FPD will also a more precise measurement of the luminosity which is of course fundamental for all DØ analyses.

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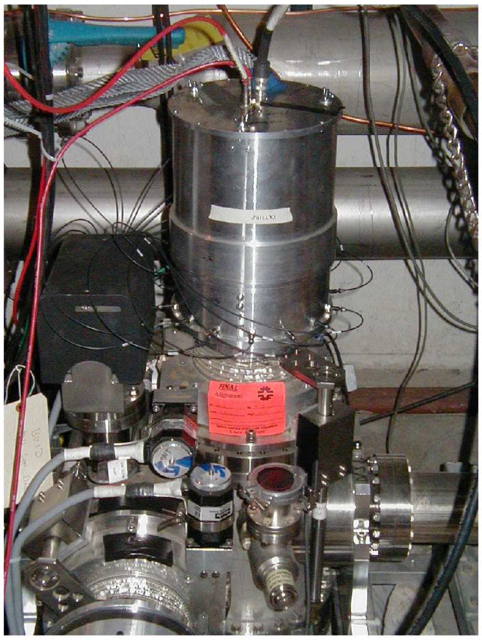

Figure 2: Picture of a quadrupole spectrometer installed inside the Tevatron. The TOP detector is fully equipped.

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