Dynamic Alignment of FP420 Detectors

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We propose a method of dynamically aligning the detectors of the Roman Pot Spectrometers (RPS) of the RP420 project at the Large Hadron Collider (LHC) by seeking a maximum of the $d\sigma/dt$ distribution at $t = 0$ for Double Pomeron Exchange (DPE) events selected by a coincidence between the RPS trigger counters on the two sides of the Interaction Point (IP). This method has been successfully used in the Run II diffractive program of the Collider Detector at Fermilab (CDF), which is equipped with a single RPS downstream in the outgoing $\bar{p}$ direction (Fig. 1) [1].

At CDF, the $\bar{p}$ fractional momentum loss, ξ, and four-momentum transfer squared, t, of Single Diffractive (SD) events are determined from the event vertex at the Interaction Point (IP) and the $\bar{p}$ track reconstructed in the tracking detectors of the RPS using the beam transport matrix between the IP and RPS. Crucial for this measurement is the determination of the RPS detector alignment relative to the actual beam position. The standard alignment method is to survey the detector position relative to the center of the beam pipe and use beam position monitors to determine the beam position and angle relative to the center-line of the beam pipe. This method, however, was limited at CDF by the non-availability of beam position monitors near the RPS detectors and, most importantly, by the uncertainties in re-positioning the detectors after they were moved away from the beam during injection and back to their position close to the beam for data taking.

In the dynamic alignment method the actual detector position during data taking is determined from the recorded data. The method is based on the expectation that the t-distribution of the recoil protons (recoil antiprotons in the case of CDF) will have a maximum at $|t| = 0$ only if the detectors are correctly aligned (Fig. 2). In the CDF diffractive data analysis, offsets in both the X and Y coordinates of the RPS detectors with respect to the beam are iteratively adjusted until a maximum for $|d\sigma/dt|$ is found at $t = 0$ when the RPS fiber tracker is correctly aligned. This innovative method is very precise and is limited only by the statistics of the event sample, the size of the beam, and the jitter in beam position during data taking of the particular data sample used. The method has been successfully applied to Run II data of CDF yielding an accuracy of ± 30 μm in beam position determination [2], but is quite general and can equally well be used to accurately calibrate the position of the FP420 detectors at the LHC. In principle, the offsets could be determined from small data samples and dynamically applied during data taking to enritch the data sample written on tape in useful events.

References

[1] H. Nakada, Ph.D. thesis, University of Tsukuba, January 2001.

[2] Michele Gallinaro, DIS-2006, arXiv:hep-ex/0606024.

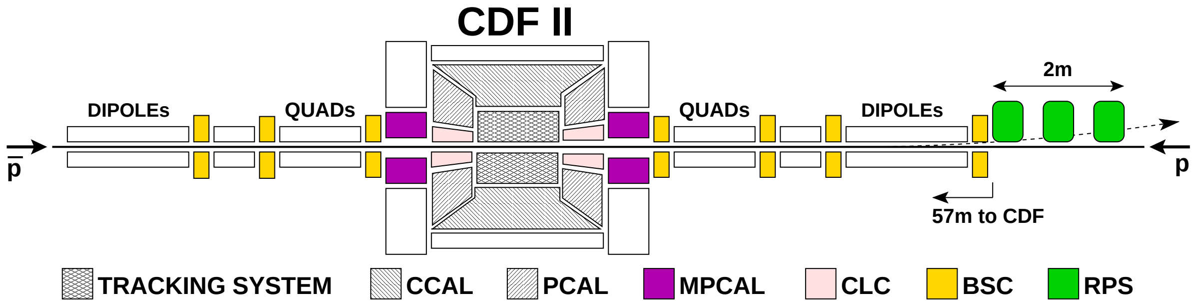

Figure 1: Schematic drawing of the CDF II detector (not to scale)

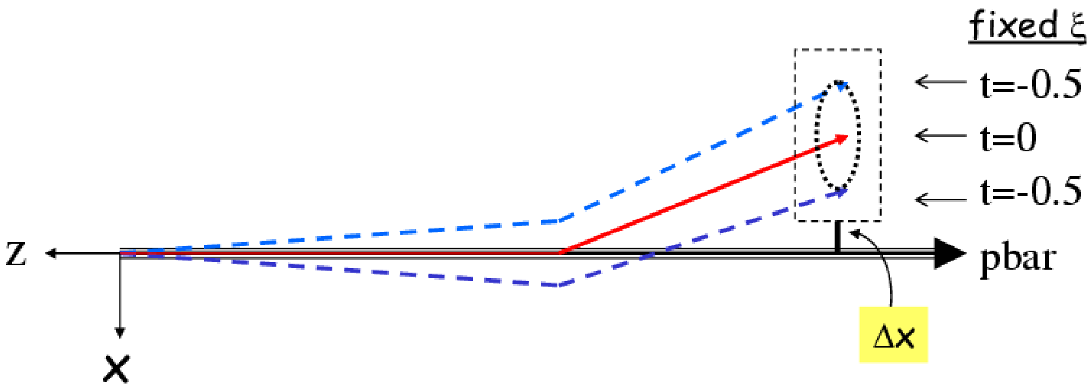

Figure 2: Schematic representation of a track detected by the RPS.

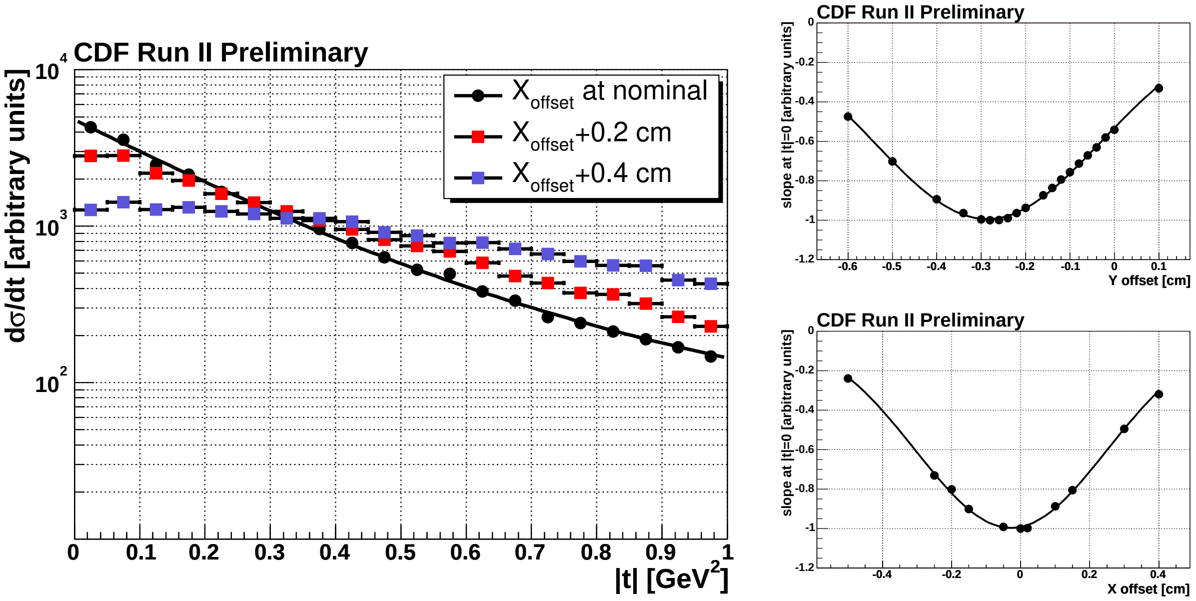

Figure 3: *Left*: t-distribution of reconstructed RPS tracks for positive X_{offset} shifts; *Right*: $|b|$ slope versus Y (*top*) and X (*bottom*) offsets.