Commissioning of the HERA-B Internal Target: Using the HERA Proton Ring as a B-Factory

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Abstract

HERA-B is a fixed target experiment using the 920 GeV HERA proton storage ring to produce B-mesons. The internal target consists out of eight thin ribbons, which are positioned around the beam, and operates in the beam halo. An interaction rate of 40 MHz is required to achieve the primary goal - a significant CP measurement in the gold plated B decay mode $B^0 \rightarrow J/\psi K_S^0$ within one year of data taking.

The performance of the internal target has been studied in detail for several years. During the last two years the main effort was spent for a successful transition from a test setup to a continuous operational device and into the improvement of the efficiency. This paper reviews the requirements, the impacts and the performance of the HERA-B target.

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1 Introduction and Overview

The measurement of CP violation in the B-system provides a well defined and fundamental test of the standard model. It's one of the very interesting questions in high energy physics, aiming to explain the creation of matter and antimatter. Decay channels which can exhibit CP asymmetry are extremely rare and suppressed by 4 to 5 orders of magnitude. A clean signature and an expected large asymmetry characterize the so called "gold plated" decay $B^0/\bar{B}^0 \rightarrow J/\psi K_S^0$ [1, 2, 3, 4], which has a branching ratio of $5 \cdot 10^{-4}$. Cuts to select the events and to identify the b flavour reduce the useful rate further. To study CP violation one needs therefore a high luminosity B source, i.e. a B-factory producing at least $\mathcal{O}(10)$ B's per second. Two different ways are followed by the dedicated CP experiments which are recently built and commissioned. On the one side there are e^+e^-B factories [5, 6] working on the $Y(4S)$ resonance with the advantage of clean events but the challenge to reach this high luminosity region with a new kind of an asymmetric storage ring and with the arising challenge to keep the high radiation background in the vicinity of the sensitive interaction regions under control.

HERA-B followed another way [1]. It uses the existing HERA proton ring (Fig. 1) to produce a large number of B mesons in a fixed target experiment. The B mesons are generated in proton nucleus interaction of the 920 GeV HERA protons on a fixed target which is operated in the beam halo at typical distances of around five beam standard deviations. The center of mass energy $\sqrt{s} \approx 40$ GeV is not very far above the b threshold, therefore the $b\bar{b}$ cross section is suppressed by six orders of magnitudes compared to the total inelastic cross section. At these energies the gluon fusion process $gg \rightarrow b\bar{b}$ dominates the heavy quark production, and only a small fraction is produced by quark annihilation $q\bar{q} \rightarrow b\bar{b}$. Figure 2 shows the result of QCD calculations up to α_s^3 [7]; they predict for 920 GeV protons a cross section $\sigma_{b\bar{b}} \approx 17$ nb but with large uncertainties.

To achieve a significant CP measurement within one year of data taking a very high interaction rate of several 10 MHz is required. The resulting high rate environment implies on the one side a lot of challenges to the HERA-B detector and its trigger[2]. The effort and challenge in connection with the target system, on the other side, was to establish and commission this new

[2] This is discussed in detail in various contributions to this conference.