A Test of Internal Halo Targets for Heavy Flavour Hadro-Production at the HERA Proton Ring

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Abstract

The main goal of the proposed HERA-B experiment [1] is the detection of CP-violation in the B system by studying the decay $B^0 \to J/\Psi K^0_S$. As a source of the B-mesons an internal halo target in the HERA proton ring will be used. The detection of CP-violation requires interaction rates up to 50 MHZ. This paper discusses the principle of halo targets and the results of several test measurements carried out at the 820 GeV HERA proton ring, which demonstrates the possibility to obtain the required rates parallel to the HERA ep luminosity operation.

1. Introduction

It appears very promising to study the origin of CP violation with decays of neutral B mesons. But there exist only a few decay channels, all of them with small branching ratios, which can exhibit CP asymmetries. HERA-B [1] [2] will measure $\sin(2\beta)$, which is expected to be between 0.2 and 0.9, by comparing the decay rates of B^0 and $\bar{B}^0$ into the CP eigenstate $J/\Psi K^0_S$.

Besides the proposed e^+e^-B factories, internal targets in the halo of a stored proton beam provide a source of B mesons. For the planned HERA-B experiment thin wires or ribbons are positioned around the beam at a distance of 4 – 8 r.m.s. Such a target is mechanically stable and easy to operate, gives a well localized main vertex and with several wires one can distribute the required multiple interactions per bunch on different wires.

At the 820 GeV HERA proton ring, with a center of mass energy ($\sqrt{s} \approx 40$ GeV) not far above the B-threshold, the background dominates B production by six orders of magnitude. Together with branching ratios, tagging and experimental efficiencies one ends up with about $3 \cdot 10^{-12}$ detected $B^0 \to J/\Psi K^0_S$ decays per interaction. Therefore one needs 40 MHz interaction rate assuming 10^7 s running time per year, to get the desired 1000 $B^0 \to J/\Psi K^0_S$ events per year to measure $\sin(2\beta)$ with an accuracy of 0.13. In the last two years several measurements have been carried out to study whether it is possible to achieve the desired rates and not to disturb the other HERA experiments with the parallel operation of an internal halo target at high rates.

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2. Required Target Performance

HERA will operate at a bunch frequency of 10 MHz. Therefore several target interactions per bunch are required to get the desired rates. Assuming the design current of the HERA proton ring (160 mA) and a typical lifetime of 100 h the natural loss rate is 60 MHz. If only using this natural loss, one needs a highly efficient target which absorbs more than 60% of the protons drifting outwards. The protons have to pass the target several hundred times before an interaction takes place. Therefore small drift velocities in the halo are required. Also a large aperture is necessary for efficient competition with scrapers and low β-functions to minimize emittance blow up in the halo due to multiple scattering.

3. Halo Target Test Measurements

For the 1993 measurements a setup with different scintillator counters (Figure 1) and four ribbons as target on two moveable forks surounding the beam (Figure 2) located in the straight west right section of the HERA ring was used. HERA was operating with 90 proton bunches and typical currents of 15 mA. A complete description of these measurements and detailed discussions of the results are given in [3].

Figure 3 shows a typical target scan. If the target leaves the collimator shadow at about 12σ the trigger

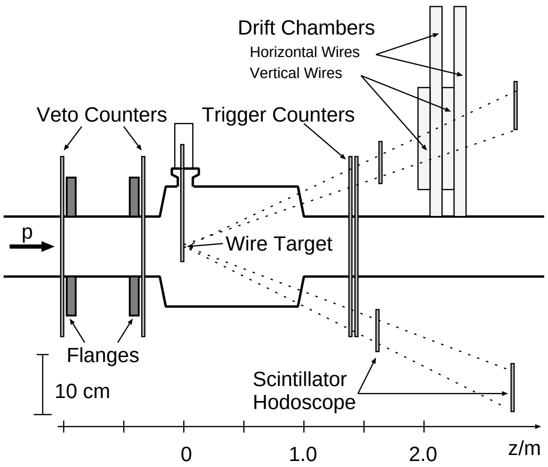

Figure 1. Sketch of the experimental set-up. The trigger counters are nearly full efficient for interactions in the target.

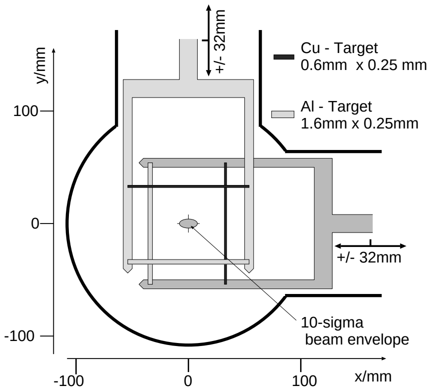

Figure 2. Arrangement of target ribbons on moveable forks.

rate suddenly starts to rise. With each step towards the beam center the target scrapes away a part of the beam halo. This leads to a sharp rise in the rate which decays then within a few minutes to a new steady state. At a distance of about 8σ the rate remained at 200–300 kHz for about one hour. After retracting the target the rate drops suddenly and rises again until the halo is refilled.

In Figure 4 the target efficiency ϵ_{tar}, which is defined by the ratio of the interaction rate in the target to the proton loss rate, is shown for two different wire scans. ϵ_{tar} rises after the wire has left the collimator shadow at 12σ and becomes the dominating absorber if the target is moved closer into the beam. Efficiencies well above 50% have been reached.

At only 30% of the nominal bunch current already more than 2.5 interactions per bunch crossing were observed without any disturbance of the ep luminosity operation. The track direction reconstructed in the small drift chambers gives clear evidence that the observed interactions come from the halo target. Variations and fluctuations of the rate on several time scales have been studied. Only the bunch to bunch variations, caused by timing problems at the injection,

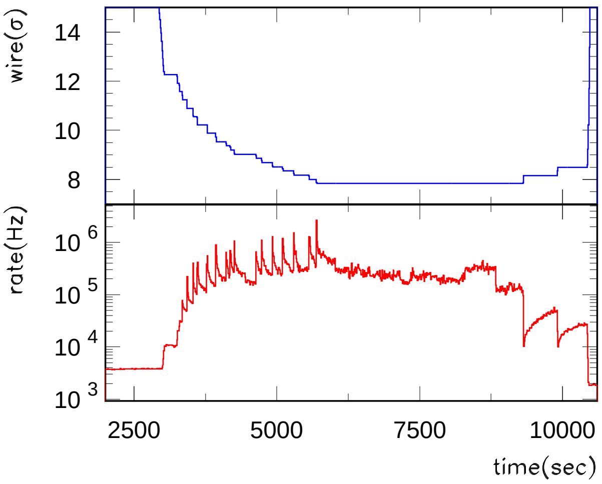

Figure 3. Target distance to beam center (measured in r.m.s. beam widths) and trigger rate as function of time.

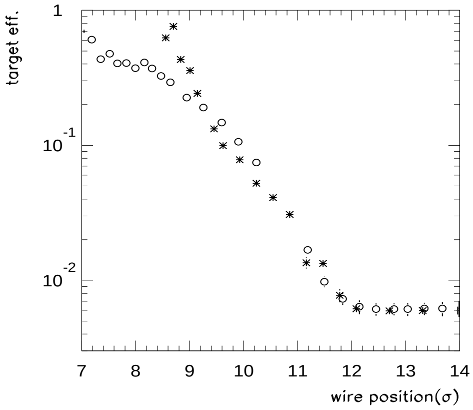

Figure 4. Target efficiency ϵ_{tar} as function of the distance to the beam center (measured in r.m.s. beam widths).

are large for some fills. However solutions to improve the injection are still under study.

4. Conclusion

The measurements demonstrate the feasibility of internal halo target at the HERA proton ring, and indicate that the required rates for a dedicated B Experiment can be achieved in parallel running to ep luminosity operation. The measurements will continue with an improved setup to study more in detail, e.g., event topology and vertex distributions along the target.

References

[1] T. Lohse *et al.*, *HERA-B An Experiment to Study CP Violation in the B System Using an Internal Target at the HERA Proton Ring*, Proposal: DESY-PRC 94/02 (1994).

[2] W. Hofmann, *CP violation using an internal Halo target at HERA-B* , this conference.

[3] C. Hast *et al.*, *Test of Internal Halo Target in the HERA Proton Ring*, DESY 94-119 (1994).