Leading Baryon Production in ed Interactions at HERA

G. Levman
University of Toronto, Toronto, Canada

Abstract: With a Forward Neutron Calorimeter and a Leading Proton Spectrometer, experiments at HERA have the possibility of detecting both the scattered and spectator baryons in *ed* collisions. The deuteron stripping channels $ed \to eX(p)(n)$, $eX(n)(n)$, $eX(p)(p)$ have been studied by modifying the HERWIG Monte Carlo program. For double tagged events most ambiguities are broken; however, an essential ambiguity remains between diffractive proton scattering with a neutron spectator, and diffractive neutron scattering with a proton spectator.

1 Introduction

Both the ZEUS and the H1 collaborations possess a Leading Proton Spectrometer (LPS)[1] and a Forward Neutron Calorimeter (FNC)[2] for the detection of energetic, low transverse momentum baryons produced in *ep* collisions. This note contains some remarks on the use of these detectors, especially the FNC, in the study of *ed* stripping channels, where one or both of the spectator/produced baryons can be detected.

The FNCs for both experiments are similar. They are compensating, transversely segmented, lead-scintillator calorimeters with excellent energy and position resolution, located approximately 100 m downstream of the main detector at a scattering angle of $\theta = 0$. The scattering angle covered, from 0 to 7 μr, is determined by the aperture of the proton machine beam line elements. The acceptance covers only a portion of the azimuth and is a complicated function of θ[3]. The transverse momentum measurement is limited by the intrinsic p_T of the beam.

2 Double Tagged Stripping Reactions

In this note it is assumed that the HERA machine will be essentially unchanged for *ed* running and that the beam energy will be 820 GeV for deuterons. The HERWIG[4] Monte Carlo program was modified to allow the generation of *ed* stripping reactions. In addition, diffractive baryon production was introduced[5][6]; non-diffractive baryon production through mechanisms such as reggeon or meson exchange, or excited baryon production and decay, was represented by one pion exchange[7][8]. The reaction types are shown in Table 1.

	Target nucleon	$ed \to$	Process	Signature
1		$enXp_s$	$\mathbb{P}$ exchange	fast n/fast p
2	n	$enXp_s$	0 exchange	slow n/fast p
3		$epXp_s$	- exchange	slow p/fast p
4		$epXn_s$	$\mathbb{P}$ exchange	fast p/fast n
5	p	$epXn_s$	0 exchange	slow p/fast n
6		$enXn_s$	+ exchange	superfast n

Table 1: Double tagged leading baryon reactions in *ed* collisions. Generic diffractive scattering is represented by $\mathbb{P}$ exchange; non-diffractive scattering, +/0/- charge exchange, by π exchange.

The distribution of momentum p of the spectator baryons was modeled with the Hulthen distribution[9]: in the rest frame of the deuteron,

$$H(p) \propto p^2 \left[\frac{1}{p^2 + a^2} - \frac{1}{p^2 + b^2} \right]^2, \tag{1}$$

where $a = 46$ MeV and $b = 260$ MeV. In the HERA frame the energy distribution is strongly peaked at E=413 GeV with an RMS width of 23 GeV (Fig. 1). Because the average p_T of the spectator is only 63 MeV, 87% of the spectators are detected in the FNC.

Figure 1 shows that the energy spectrum of spectator neutrons is not separated from that of diffractively produced neutrons whose distribution peaks at 395 GeV with a width of 26 GeV; however because the p_T distribution is much broader only 22% of diffractive neutrons are detected. In contrast, the energy distribution for non-diffractive neutrons is clearly separated although the acceptance for these is only about 10%. Note that reactions 3 and 6 in Table 1 produce either two protons or two neutrons. In the LPS the protons will appear as two separate tracks; in the FNC the energies will add and reaction 6 will have an energy distribution like π exchange of Fig. 1, but on a 'pedestal' of 410 GeV.

3 Conclusions

The FNC and the LPS will be essential for sorting out the stripping channels in *ed* collisions at HERA; however, an important ambiguity will remain between diffractive proton and neutron production when the struck nucleon cannot be distinguished from the spectator, although the difference in their p_T spectra might be helpful.

Acknowledgments

I thank M. Arneodo, W. Krasny, and T. Massam for fruitful discussions.

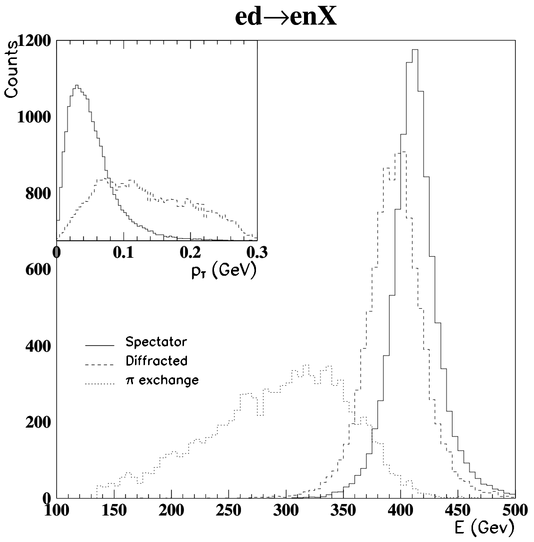

Figure 1: The energy spectrum of FNC neutrons detected in the FNC in *ed* reactions. Resolution effects have not been folded in (10k events of each type are plotted). The spectra for leading protons will be similar. The inset shows the p_T distribution for tagged spectator and diffractive neutrons.

References

[1] T. Massam, *these proceedings.*

[2] S. Bhadra et al., Nucl. Instr. and Meth. **A354** (1995) 479.

[3] ZEUS Coll., M. Derrick et al., *Observation of events with an energetic forward neutron in deep inelastic scattering at HERA*, DESY report 96-093, to be published in Phys. Lett. **B** (1996) .

[4] G. Marchesini et al., Comput. Phys. Commun. **67** (1992) 465.

[5] G. Ingelman and P. Schlein, Phys. Lett. **152B** (1985) 256.

[6] A. Donnachie and P. V. Landshoff, Phys. Lett. **191B** (1987) 309, and Nucl. Phys. **B303** (1988) 634.

[7] M. Bishari, Phys. Lett. **38B** (1972) 510.

[8] G. Levman and K. Furutani, *Virtual pion scattering at HERA*, DESY Report 95-142 (1995).

[9] Gross, Franz, *Relativistic Quantum Mechanics and Field Theory* (Wiley, 1993).