INTERSECTING STORAGE ACCELERATOR NOTES

MASTER

PRELIMINARY DESIGN OF LARGE ANGLE PROTON-PROTON ELASTIC
SCATTERING FOR ISABELLE

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Theoretical Motivation

What is the energy dependence of large angle elastic scattering? At lower energies (up to 30-GeV protons), $d\sigma/dt$ goes as s^{-2} for fixed momentum transfer. Many theorists have speculated that $d\sigma/dt$ cannot drop faster than the fourth power of the e-p form factor. This happens to correspond to the measured $d\sigma/dt$ for p-p at 30 GeV/c. Hence the prediction is that above 30 GeV $d\sigma/dt$ is independent of energy. For example, at $-t = 7 \text{ GeV}^2$, $d\sigma/dt \approx 10^{-33} \text{ cm}^2/\text{GeV}^2$ for 30-GeV protons. An s^{-2} dependence would give a cross section 3000 times smaller. The predicted cross section is shown in Fig. 1. Another question concerns dips in the angular distribution. Is the dip at $t = 1.4 \text{ GeV}^2$ still there, and will new dips appear at "infinite" energy?

Experimental Layout

Collinear crossing is used to maximize reaction rate and allow the scattered protons to clear the primary beams more easily. The preferred crossing option used the four dipoles in the order (-++-), i.e., polarities of the two upper half circles are the same.

Solid angle is limited by the momentum transfer region corresponding to measurable cross sections. $d\sigma/d\omega$ for $p_{\perp} > 5 \text{ GeV/c}$ will be too small to give detectable rates. Hence $1 < p_{\perp} < 5 \text{ GeV/c}$ is the region proposed. For $p_{\perp} = 2.5 + 0.1 \text{ GeV/c}$ a solid angle $\Delta\Omega = 10^{-5} \text{ sr}$ is obtained. The four dipoles used to give beam crossing can also be used to deflect the scattered particles

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away from the beams (see Fig. 2). Only secondaries of $p_{\perp} > 1$ GeV/c would reach the detectors shown in Fig. 2, hence the singles rates will be low enough. Parallel rays from the interaction region are focused to a point on the proportional chamber detectors. Each value of momentum transfer is at a different point on the detector.

Counting Rates

We assume with bunching a luminosity $\mathcal{L} = 5 \times 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$. We assume an interaction region $\ell = 10$ m, and a solid angle $\Delta\omega = 10^{-5}$ sr. At $p_{\perp} = 2.5$ GeV/c the 30-GeV cross section is $d\sigma/dt \approx 1.7 \times 10^{-33} \text{ cm}^2/\text{GeV}^2$. The number of elastic scatters per second is then

$$\begin{aligned} N_{pp} &= \mathcal{L} \frac{d\sigma}{d\omega} \Delta\omega & \frac{d\sigma}{d\omega} &= \frac{p^2}{\pi} \frac{d\sigma}{dt} = 2 \times 10^{-29} \text{ cm}^2/\text{sr} \\ &= 5 \times 10^{33} \times (2 \times 10^{-29}) \times 10^{-5} \\ &= 1 \text{ event/sec} . \end{aligned}$$

At 10^{-11} mm pressure, beam-gas interactions would be ~ 1 collision/sec. The probability that secondaries from such an interaction reach PC1 and PC4 simultaneously is $\sim 10^{-15}$.

For $t = 25 \text{ GeV}^2$ ($p_{\perp} = 5$), $d\sigma/d\omega$ would be $6 \times 10^{-34} \text{ cm}^2/\text{sr}$ and $\Delta\omega = 4 \times 10^{-5}$ sr could be achieved. Then

$$N_{pp} = 5 \times 10^{33} \times 6 \times 10^{-34} \times 4 \times 10^{-5} = 0.43 \text{ events/h.}$$

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Fig. 1

10^5 GeV P-P SCATTERING AT $\sqrt{s} = 6 \text{ GeV}^2$

REGION COVERED IS $1 < \sqrt{s} < 10 \text{ GeV}^2$

SIDE VIEW

Fig. 2