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ISABELLE Project

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Informal Report

INTERSECTING STORAGE ACCELERATOR NOTES

Neutrons from Isabelle

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If ISABELLE is operated with deuterons, a substantial fraction of the total beam energy will go into tightly collimated neutron beams from stripping reactions. Provision should be made to protect machine components from concentrated radiation of this type. The beams will be largely mono-energetic at one-half the deuteron beam energy. It is possible that useful physics experiments could be performed in such a beam, and some of its parameters are computed here.

Assumptions

In order to make the calculation definite, we make the following assumptions:

1. Deuterons on protons -- both beams at 200 GeV/c momentum.
2. Transverse momentum distribution of the spectator neutron

$$p + p(n) \rightarrow X + (n)$$

is typically $0.14 \text{ GeV/c} = p_f$. We use

$$\frac{d\sigma_n}{dt} = \frac{d\sigma_n}{dt} \Big|_0 e^{t/p_f^2}$$

$$p_f^2 = 0.02 (\text{GeV/c})^2$$

$$\frac{d\sigma_n}{dt} \Big|_0 = 2 \times 10^{-24} \text{ cm}^2/(\text{GeV/c})^2$$

This gives a total cross section of $\sigma_n \approx 40 \text{ mb}$ for forward neutrons.

3. Luminosity = $L = 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$.

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These assumptions can be varied as appropriate. For example, d on d will double the intensity in a single beam and give a second beam. Beams from lower luminosity intersections can be scaled appropriately.

Neutron Beam Characteristics

Roughly 63% of the spectator neutron emerge within an angle

$$\theta_f = p_f/p_o \quad (p_o = 100 \text{ GeV}/c)$$

$$= 0.0015 \text{ radians.}$$

The intensity of the beam within this angle is

$$I_f = 0.63 \times \sigma_n \times L = 2.5 \times 10^7/\text{sec}.$$

At 10 meters from the intersection this beam would be 3 cm diameter. If one wished to collimate at 100 meters distance, a typical set of parameters might be

$$\begin{aligned} \text{Beam diameter} &= 3 \text{ cm} \\ \text{Beam divergence} &= 0.15 \text{ mrad (half-width)} \\ \text{Beam intensity} &= 2.5 \times 10^5/\text{sec.} \end{aligned}$$

Intersection Design

We represent the area downstream of an intersection region below,

(CRISP 72-5 Fig. 6).

We assume the circulating beam pipes to be 10 cm diameter for the first 40 m after the intersection, thereafter expanding to 20 cm. The main consideration from the point of view of machine design, is to keep this area clear for experiments. Any experiments, on the other hand, will have to keep their apparatus out of the horizontal plane. Sketched in is a crude setup for total cross sections of neutrons on protons at 100 GeV.

Comments

It is possible that a mono-energetic neutron facility, such as that described here, will be unique. NAL or CERN II would have to accelerate deuterons to match it. On the other hand, calorimetric techniques improve with high energy, and it is possible that all the 100 GeV neutron physics will be performed in broad spectrum beams at NAL before ISABELLE can become operational. However, the option should be kept open in case important experiments arise which require the mono-energetic property.

Beam Dump Considerations

If the principal mechanism for beam decay is beam-beam interactions, then a substantial fraction of the energy in a deuteron beam will go into a neutron beam such as the one described here. In such a case, some thought should be given to providing beam dump facilities to protect machine components from these neutrons. If one examines Fig. 4 of CRISP 72-5 it can be seen that the main ring dewars will be struck by all of the neutrons created in the intersection region (30 cm diameter at 100 m distance). In addition, there are long (40 m) sections of coasting beam which could give further neutrons if beam-gas interactions are the principal source of losses.

Neutron-Proton Colliding Beams

One might consider putting a stripping target (foil or gas jet) in the deuteron beam upstream of an intersection region. This might provide 200 GeV on 100 GeV pn collisions for experimental study.

The first thing to note is that there is an immediate loss of a large factor because each neutron makes only one pass, whereas protons in p-p interaction make 1.5×10^5 passes/sec. The highest average luminosity for np would be achieved by filling the deuteron ring, accelerating to 200 GeV, (120 seconds), dumping on the stripping target in a few seconds, and recycling (120 seconds). Assume 250 seconds. During this time a p-p beam would make 3.8×10^7 passes. The transverse dimension of the neutron beam would be about $30 \times 30 \text{ (mm)}^2$ instead of $0.7 \times 0.22 \text{ (mm)}^2$ giving 6×10^3 for 10 m distance from stripping to interaction. The net loss from these two items here is 2×10^{11} , yielding a luminosity of the order of 5×10^{22} . Several other factors could be considered, but it seems pointless at this level.

Another scheme might be assymetric operation. Keep one ring at 30 GeV and inject deuterons every AGS cycle. This might gain a factor 10^2 in luminosity, but the smaller longitudinal momentum loses a factor 36 in emittance from the stripping target. The net gain is far from enough.

Unless some bright technical trick can save this, it appears that n-p colliding beams are not practical.