A MUON STORAGE RING FOR NEUTRINO OSCILLATIONS EXPERIMENTS

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ABSTRACT

$\mu^{\pm}$ decay in a $\mu^{\pm}$ Storage Ring can provide ν_e, ν_μ beams uniquely suitable for the study of ν oscillations. The Fermilab $\bar{p}$ precooler is studied as a possible first μ storage ring.

INTRODUCTION

Recent experimental reports[1,2] of a non-zero ν_e mass and of possible $\bar{\nu}_e$ oscillations reveal the need for more complete study of neutrino properties. Previously, accelerator ν beams have been muon neutrino (ν_μ) beams from $\pi \to \mu\nu_\mu$. In this paper we note that a muon storage ring (see Figure 1) can provide ν_e and $\bar{\nu}_\mu$ beams from $\mu \to e \nu_e \bar{\nu}_\mu$ as earlier suggested by Wojicicki and Collins.[3] We further note that a μ storage ring provides clean ν beams of precisely knowable flux, and therefore an excellent tool for the study of ν_e and ν_μ oscillations.

DESCRIPTION OF A μ STORAGE RING

We also note that the Tevatron $\bar{p}$ precooler (see Figure 2) inescapably functions as a 4.5 GeV/c μ storage ring during the first ms of its cycle, and that its large acceptance designed for $\bar{p}$ acceptance make it a very good storage ring, and therefore a candidate for use in the first experiment of this type.

The 80 GeV proton line, the production target, the transport line and the pre-cooler are shown in Figure 2. Pulses of 1.8×10^{13} protons are focussed on the target producing many secondary particles (π,k,$\bar{p}$, etc.) which follow the transport line to insertion in the ring. The production is dominated by π's which decay ($\pi \to \mu\nu$) and a substantial number of the decay muons will circulate in the ring, a first estimate indicates 10^{10} μ.[4] The decay of these muons in precooler straight sections will provide collimated ν_e and $\bar{\nu}_\mu$ beams with $\sim 8 \times 10^8$ ν per beam per p pulse.

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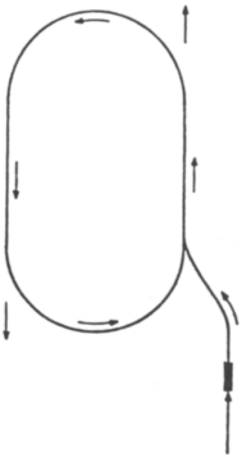

Figure 1: A μ Storage Ring.

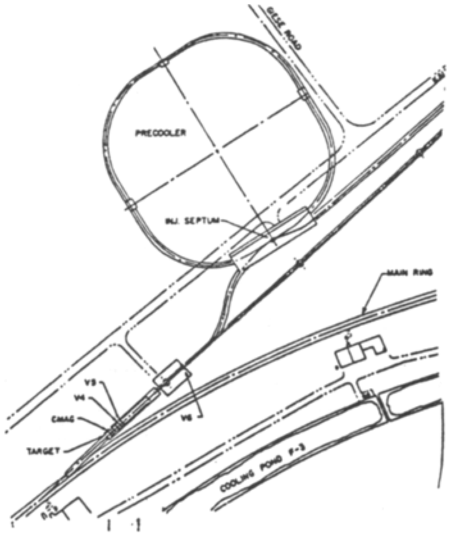

Figure 2: The $\overline{p}$ Precooler/μ Storage Ring.

Modifications of the precooler to increase and acceptance and to increase the decay straight section length could increase this flux by a factor of ∿10 and the proton pulse period of 10 seconds can be reduced from 10 seconds with $\overline{p}$ cooling (parisitic ν beam) to two seconds (dedicated mode). These intensities and designs are discussed in Reference 4, and will be improved in future work.

EXPERIMENTAL COMMENTS

The precooler μ storage ring can provide adequate event rate for a variety of experiments. A 100 ton detector, 0.5 km away will receive ∿4-400 events/day with $5 \times 10^8 - 5 \times 10^9$ $\nu_e \overline{\nu}_\mu$/pulse, 10^4-10^5 pulses/day. The Fermilab 15' bubble chamber could also observe events. A suitable compromise between detector size, sensitivity, and cost is left as a challenge to interested experimenters. Since the ν flux can be precisely known from monitoring the decaying muon current, the μ storage ring can provide a unique tool for future ν experiments.

REFERENCES

1. F.H. Reines, et al., this proceedings.
2. V.A. Lyubimov, et al., ITEP-62, submitted to Yadernaya Fizika (1980).
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4. D. Cline and D. Neuffer, paper contributed to XX International Conference on High Energy Physics (1980).