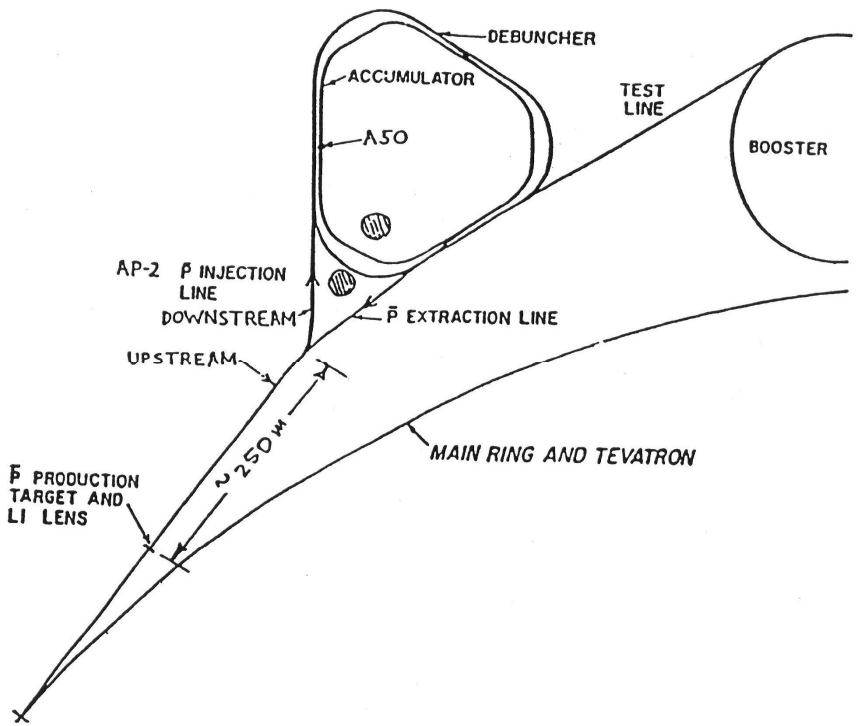
Why test beam?

- We want to build a detector to detect a small admixture of ν_e CC events in a sample of NC and ν_μ CC events
- Need to evaluate ν_e CC detection efficiency
- Need to evaluate NC rejection capability
- It would be nice to have flavor separated beam of ν_e/ν_μ/anti ν_e/anti ν_μ at 1-4 GeV

Neutrino test beam exists at Fermilab

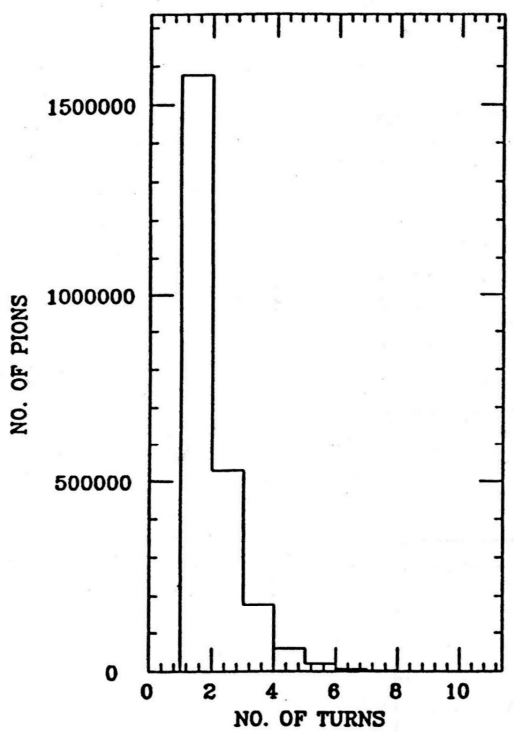
- It is called 'antiproton source' – W.Y. Lee proposal P860
- It is, in fact, a prototype of a muon storage ring ☺

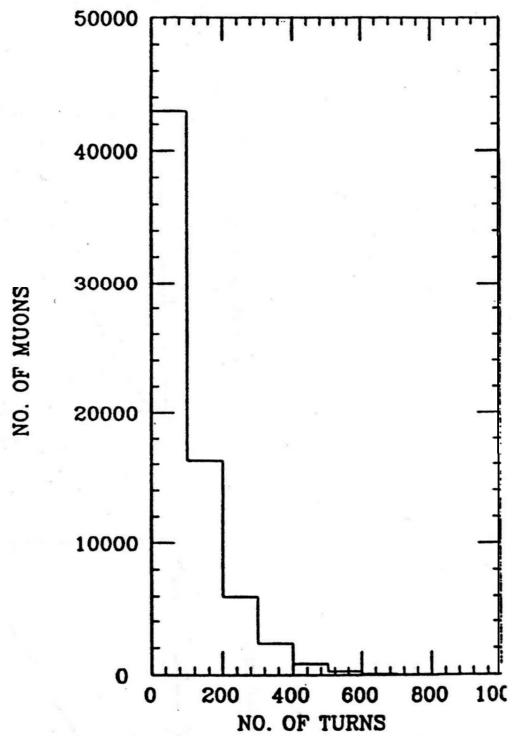


Antiproton Debuncher

- Central momentum 8.9 GeV
- Momentum acceptance 2%
- Circumference 500 m
- Straight section length 65 m
- $N_{\mu}^{-}/N_{antiproton}$ = 1 +- 0.2
- Production rate:
  - 1×10^{11} pbar/hour (now)
  - $3\text{-}5 \times 10^{11}$ pbar/hour (goal)
- $\gamma\tau_{\pi}$ ~ 1 turn
- $\gamma\tau_{\mu}$ ~ 117 turns
- ω_{μ} (spin precession period) ~ 20 turns

Time structure of particles (ignoring pbars)





- pions (➔ anti ν_μ) for firrst 2-3 turns
- Muons (ν_μ and anti-ν_e for 150-200 turns
- Similar to Karmen, but much longer time scales

Neutrino spectra

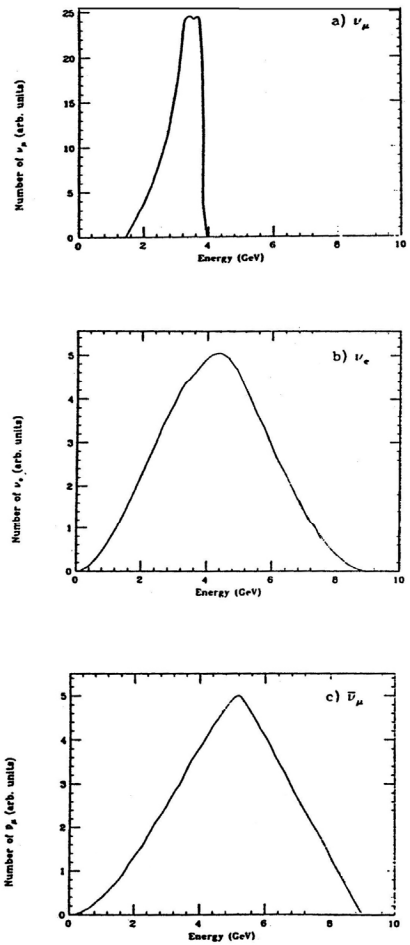


Fig. IV.1: ν_e energy spectra from the Debuncher with a 10 mrad cut. The Debuncher energy is 9 GeV.

- Beam divergence ~ 10 mrad
- Beam spot radius ~ 1 m

Event rates (from P860)

- 100t detector
- 15 m downstream the straight section
- Now (I.e. 10^{11} pbars/hour)
- 1 year

See also S. Geer, Fermilab-TN

Anti ν_e	~400
ν_μ	~ 900
Anti ν_μ	~11000

Consider post-run II scenario:

•run debuncher for positive particles?

•Flip the flavor of neuyrinos

Muon polarization

- Muons are 100% polarized (V-A decay)
- Muon spin precession in the magnetic field
- Neutrino /antineutrino direction and energy correlated with the spin of the muon (remember g-2 experiment?)

Time separation of ν_μ and anti ν_e !

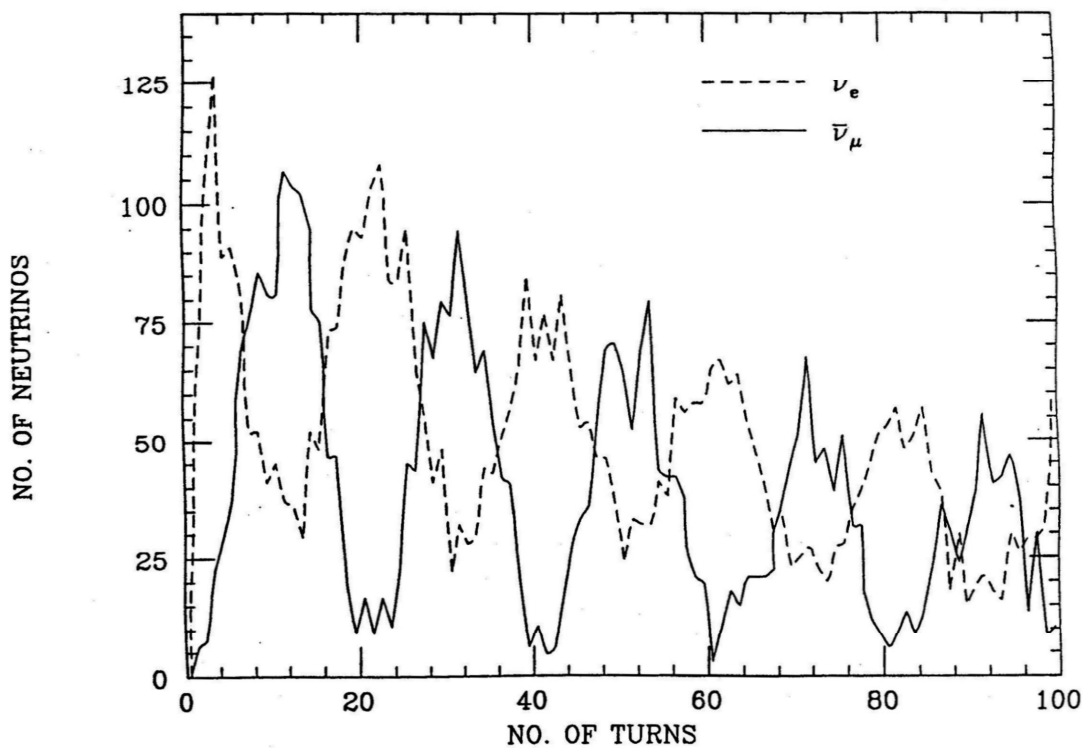


Fig. IV.3: The number of high energy ν_e and $\bar{\nu}_\mu$ accepted by the detector as a function of number of turns. A 10 mrad, 6 GeV energy cut is applied.

- Not a flavor-separated neutrino beam, but pretty close!