# Beam Injection into the Proton EDM Storage Ring

## Overview

The search for a proton EDM currently requires simultaneous injection of two polarized proton bunches of opposite longitudinal polarization in both clockwise and counterclockwise directions of the storage ring in order to better control systematic errors. The proton bunch length is 50 ns and the ring circumference is approximately 240 meters which implies a 1140 ns circuit time for 700 MeV/c protons. If the two bunches were deflected onto the central orbit half the circumference apart by a fast kicker magnet, the required 700 ns flattop would allow for a 400 ns rise plus fall time in order to avoid perturbation of the injected bunches, upon their return, by the decaying magnetic field pulse. This has been achieved in fast beam kicker magnets used at several facilities, some of which are listed in Table I.

**Table I**

Some Existing Fast Beam Kicker Magnets

| | Length | Gap | B Field | Rise Time | Estimated Deflection* |
|---|---|---|---|---|---|
| AGS Extraction | 53.3 cm | 2.2 cm | .830 KG | 160 ns | 39 mr |
| Muon g-2 Injection | 176.0 | 10 | .195 | 200 | 41 |
| RHIC Injection | 112.0 | 5 | .392 | 95 | 43 |
| Fermilab Rebuncher | 241.0 | 5.72 | 1.050 | 395 | 129 |

A list of fast beam kicker magnets. The relevant parameters of the various magnets are presented. All but the muon g-2 kicker are ferrite loaded. * The last column gives the deflection by a one meter long magnet with its magnetic field scaled by the ratio of its gap to the 2 cm gap required for the extracted beam from the AGS.

All of the above magnets provide sufficient deflection but the Fermilab fast kicker would require the two bunches be spaced in time so as to be covered by a flattop of 350 ns.

## Proposed Layout

The one meter length of the proposed injection magnets is constrained by the lattice spacing of 1.5 meters between straight section quadrupoles. It is also necessary to have the incident beam injection lines avoid the polarimeter while reducing the deflection demands on the kicker magnet. Figure 1 indicates a possible arrangement for one injection direction in which a 12 KGauss Lambertson magnet with the field region offset 2.9 cm from the central orbit is located in the adjacent gap between the quadrupoles immediately upstream of the kicker magnet.

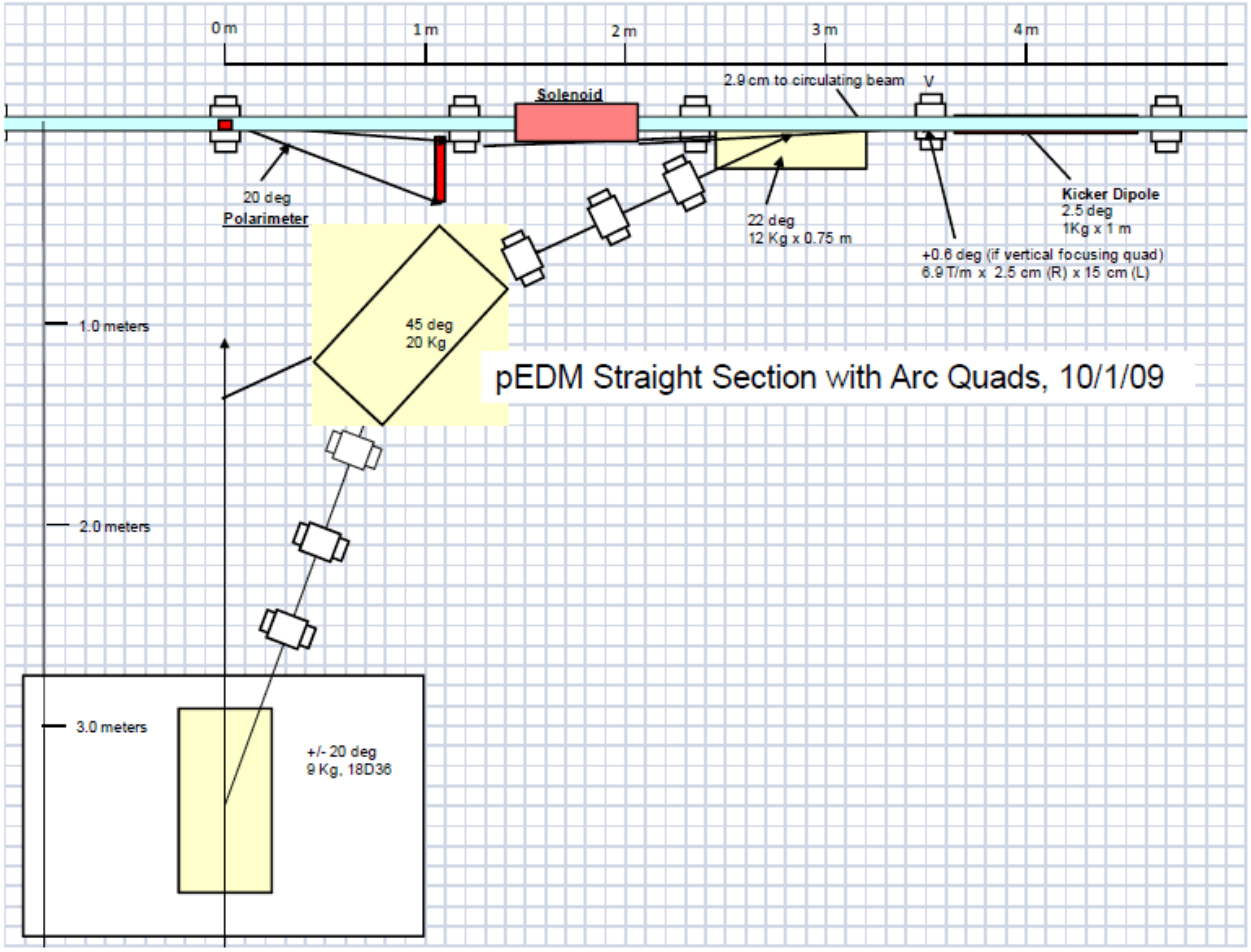

Figure 1. Beam injection arrangement with the Lambertson magnet upstream of the kicker magnet.

The 700 MeV/c polarized proton beam is to be extracted from the AGS in a two 50 ns long bunches of vertical polarization and relatively large horizontal size where it is incident on an electrostatic beam splitter which will separate the two halves of the beam sufficiently to clear the septum of an opposite field septum magnet two meters downstream. The electrostatic septa previously used in the AGS switchyard consisted of three meter long planes of .05 mm thick tungsten rhenium wires.

The magnetic fields on the two sides of the three cm thick central septum are in opposite vertical directions as its name implies. This magnetic septum then deflects the two beams into mirror image identical diverging beam lines which in turn transport them to the Lambertson dipoles. The beam transport lines must match the emittance of the polarized beam to the acceptance of the EDM storage ring. The beam design also should minimize the dispersion at the output of the beam kicker magnets.

### *Reference*

I. Sakai, IEEE Transactions on Applied Superconductivity 12, 242 2002