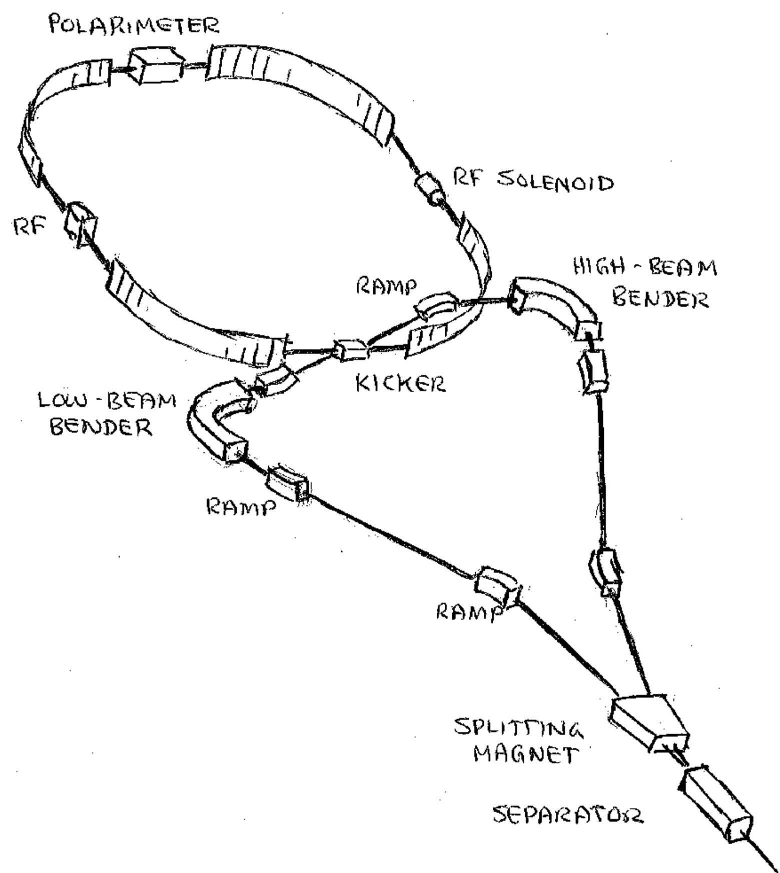
Note on EDM ring injection

Ed Stephenson, 11/18/09

After hearing discussions of a septum to split the beam coming from the AGS and concerns about the space needed for kicker magnets, I offer the following suggestion as a starting point for further thought.



Pictured here are the ring (much too small relative to other beam lines) and two injection lines. I thought that the kicker could work for both beams at the same time. We only needed to deliver them from opposite directions. One way to do that is to inject vertically, bringing in one beam from above and the other from below. The horizontal equivalent would require one beam inside the ring, something that sounds as if it would create other complications. So the injection lines in the drawing go up on the right side and down on the left. For spin purposes, you just have to be careful to do the larger bends in a horizontal plane. (IUCF used vertical extraction and injection.)

Following injection, the beam can be allowed to coast and it will quickly (<1 s) fill the ring uniformly. Then you turn on $h = 2$ bunching. An RF cavity will accelerate beam going in either direction, so it will introduce a situation where the bunches from the counter-rotating beams cross at four places, each 90° away in phase from the RF cavity. To emphasize this feature, I drew the EDM ring above with four straight sections.

The RF solenoid should act on both beams at the same time, and so should be located at one of the four intersection points relative to the RF cavity. The system at COSY had a strength of 10^{-5}, which is the angle through which it rotated a deuteron beam during one pass. The same system for a proton will be about 10 times more effective, so assume 10^{-4}. The solenoid will operate at the cyclotron frequency, or about f_{cyc} = 1 MHz, so that it precesses one of the two bunches in one direction and the other bunch in the opposite direction for each beam. If the bunch is reasonably well localized, then the time required to do this when the spin tune is zero (frozen spin) is $(\pi/2)/(f_{cyc}*10^{-4})$ = 16 ms. To avoid having different protons experience rather different precession histories, there should be "many" synchrotron oscillations during this time. One reasonable solution is to have the synchrotron tune be about 10^{-3}, which sets the scale of the RF voltage. Where this falls will have some effect on the time required for full precession. This effect is equivalent to using bunching to lengthen the polarization coherence time.

This scheme will be less complicated if the *g*−*2* precession during the RF solenoid precession process Is less than about 30°. A calculation using the formula for the precession of the polarization in an external field would then require that the momentum be correct to about 2.5 parts per million. One way to confirm that this is correct would be to look for a large and steady horizontal polarization following precession with the RF solenoid. Fourier analysis of the subsequent measurement could help make corrections.

The difficulty at first with using the RF solenoid is knowing the ring circumference to this level of precision. A calibration carried out at IUCF at a nearby energy used the $p+d \rightarrow \pi^0+{}^3He$ reaction just above threshold where the momentum can be determined by measuring the size of the ${}^3He$ cone in the polarimeter detector. This has been done at IUCF to a precision of 5 parts per million. One could use a skimmer target with a thin CD_2 foil.