Spin Rotation before the Damping Ring

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Presented at the LCWS-08
16-20 November 2008
Chicago

K. Moffeit, D. Walz, M. Woods, *Spin Rotation at lower energy than the damping ring,* ILC-NOTE-2008-040, February 2008

K. Moffeit, *Spin Rotation before the Damping Ring*, Workshop on Polarization and Energy measurements at the ILC
9-11 April 2008, IPBI TN-2008-3, April 2008

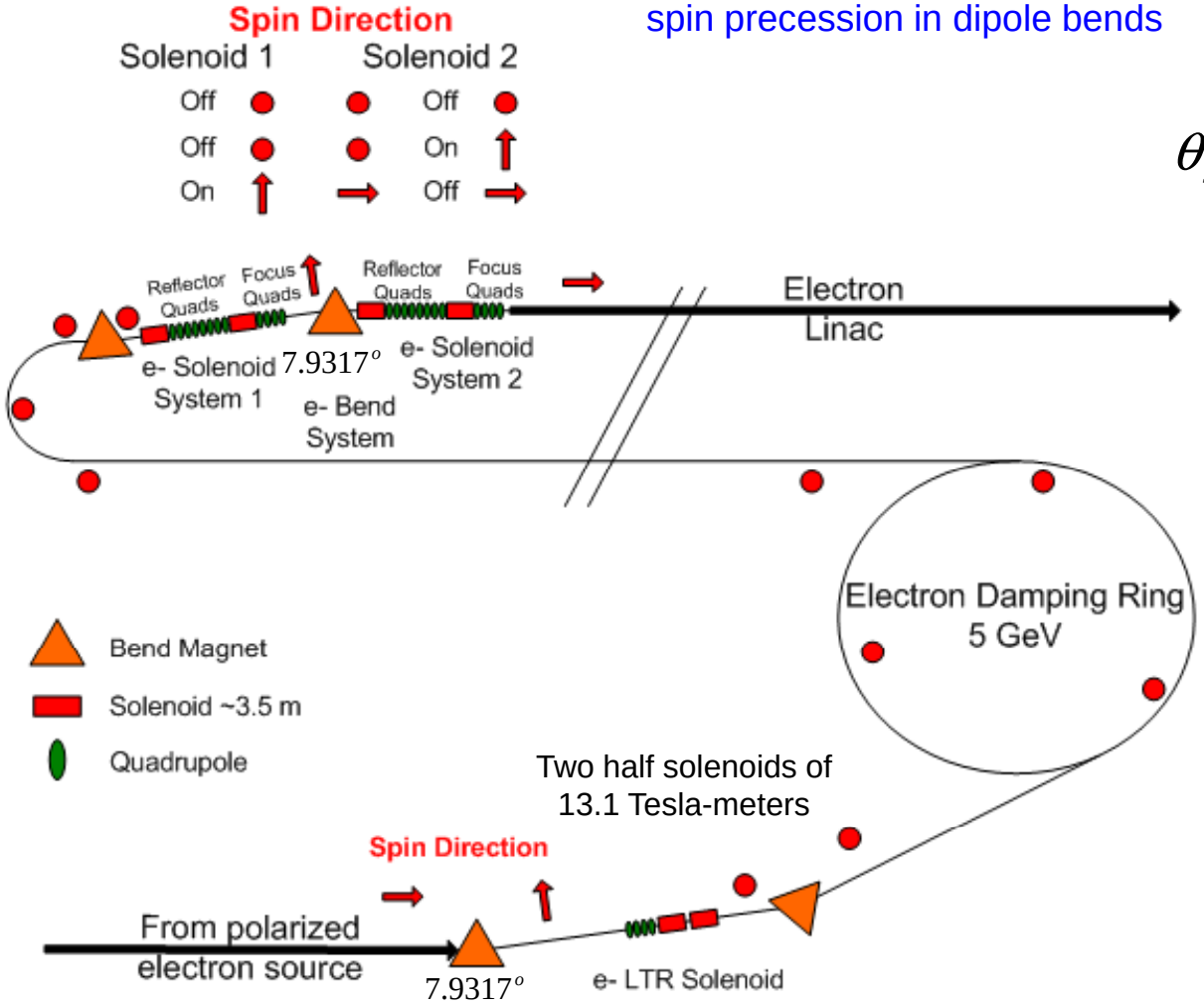
Reference Design Report Damping Ring and Spin Rotation Systems

Requirements:

•Rotate spin to the vertical before damping ring so polarization is not destroyed during damping.

•Rotate spin after the damping ring to have the desired polarization at the e^+e^- IP, e.g. longitudinal polarization at IP. To avoids spin diffusion depolarization effects locate RTL spin rotation system after transport to beginning of main linac.

Spin rotation is done with a combination of spin rotation solenoids and spin precession in dipole bends



θ_{spin} Is rotated 90° in a solenoid field of 26.2 Tesla-meters at 5 GeV

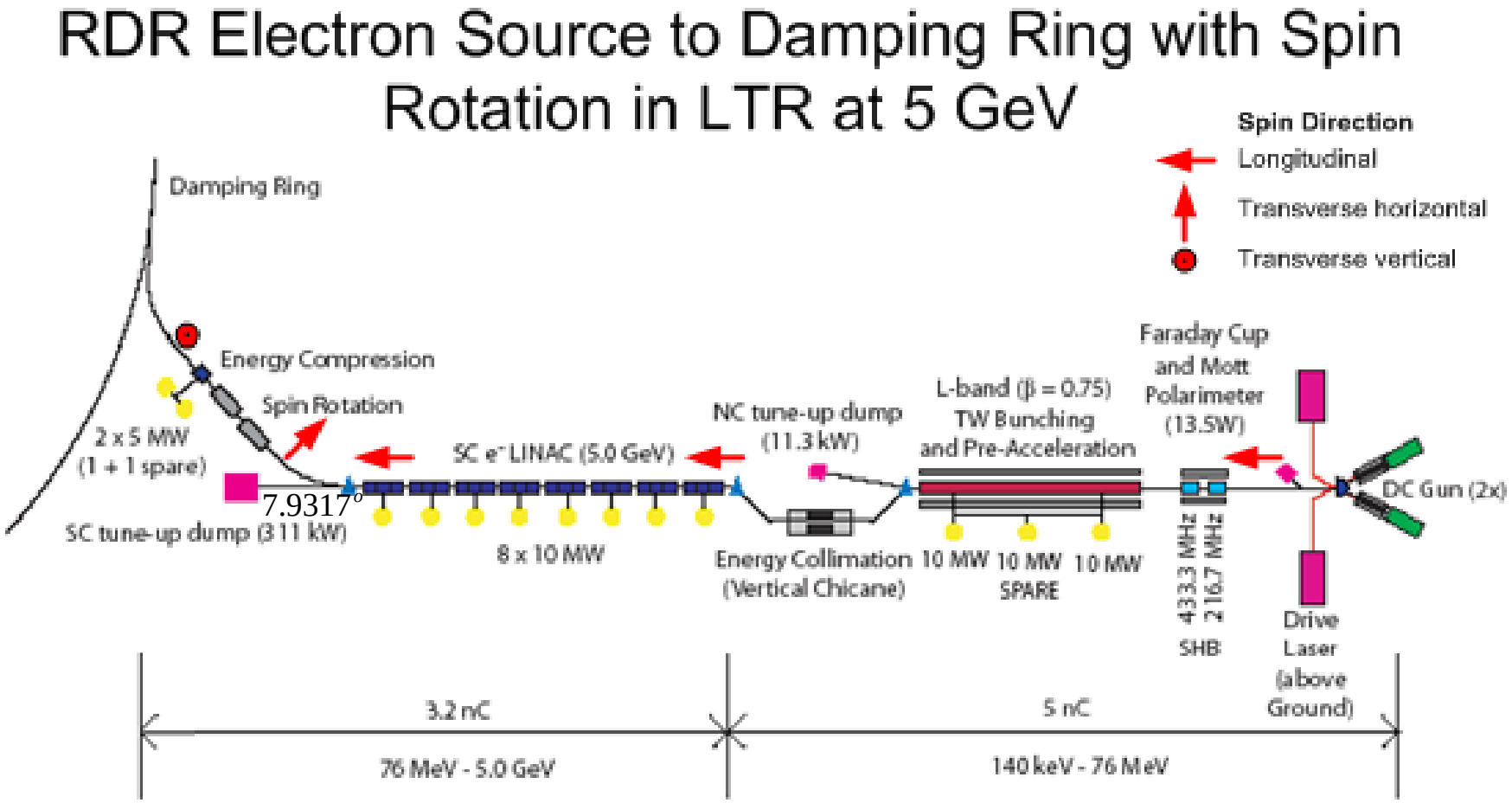
Spin Precession ahead of momentum direction change

$$\theta_{spin} = \gamma \frac{g-2}{2} \cdot \theta_{bend} = \frac{E(GeV)}{0.44065} \cdot \theta_{bend}$$

$$\theta_{spin} = 90^o = \frac{5.0}{0.44065} \cdot 7.9317^o$$

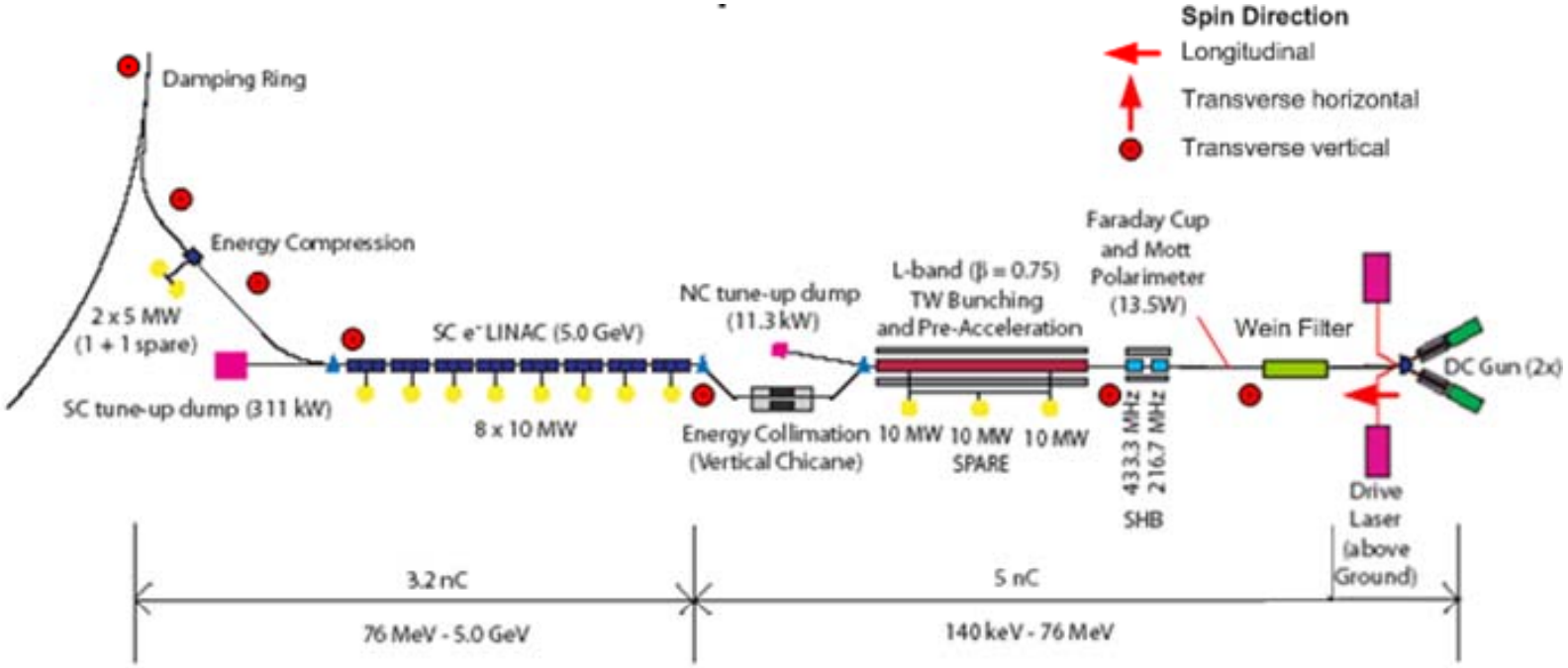
Current plans for electron Beam Spin Rotation before the damping ring

Spin direction must be normal the damping ring plane to preserve polarization while the beam is being damped, i.e. rotate longitudinal spin produced at the source into the vertical direction



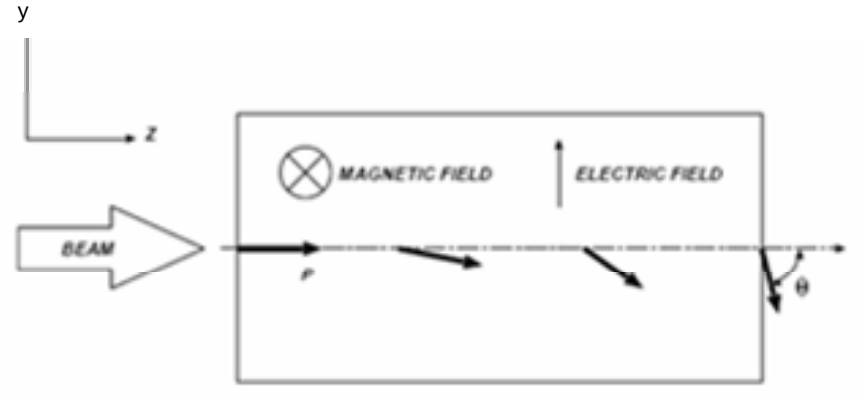
Requires two 13.1 tesla-meter superconducting solenoids after a bend of 7.9317^{o}

Proposal to rotate spin direction to the vertical near polarized electron Source



Wien Filter

E < 5 MeV



This was done at the Jefferson Lab for their polarized electron scattering experiments.

The Wein filter for the e- source Mott polarimeter is already costed in the RDR. It's location needs to be moved into the main beam line.

Space charge effects need study.

Positron Beam Spin Rotation and Helicity Selection before the positron damping ring

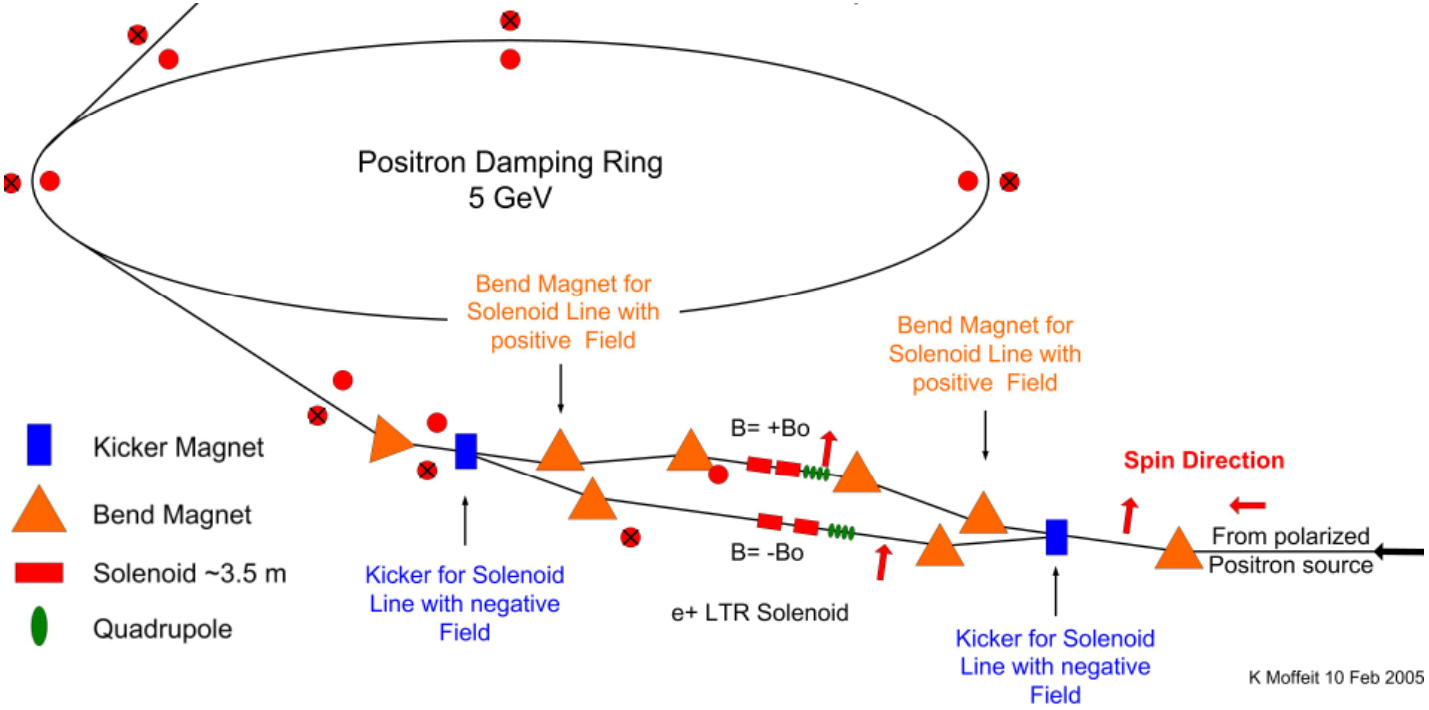
Requirements:

- Rotate longitudinal polarization from positron source to the vertical
- Select the helicity of the positron beam for each pulse train.

In the current baseline design the positron helicity can only be slowly reversed by changing the polarity of the superconducting solenoids. Slowly means every few days or weeks. This does not satisfy the demands of the precision physics program, which needs positron helicity reversals train-to-train as it is done for electrons.

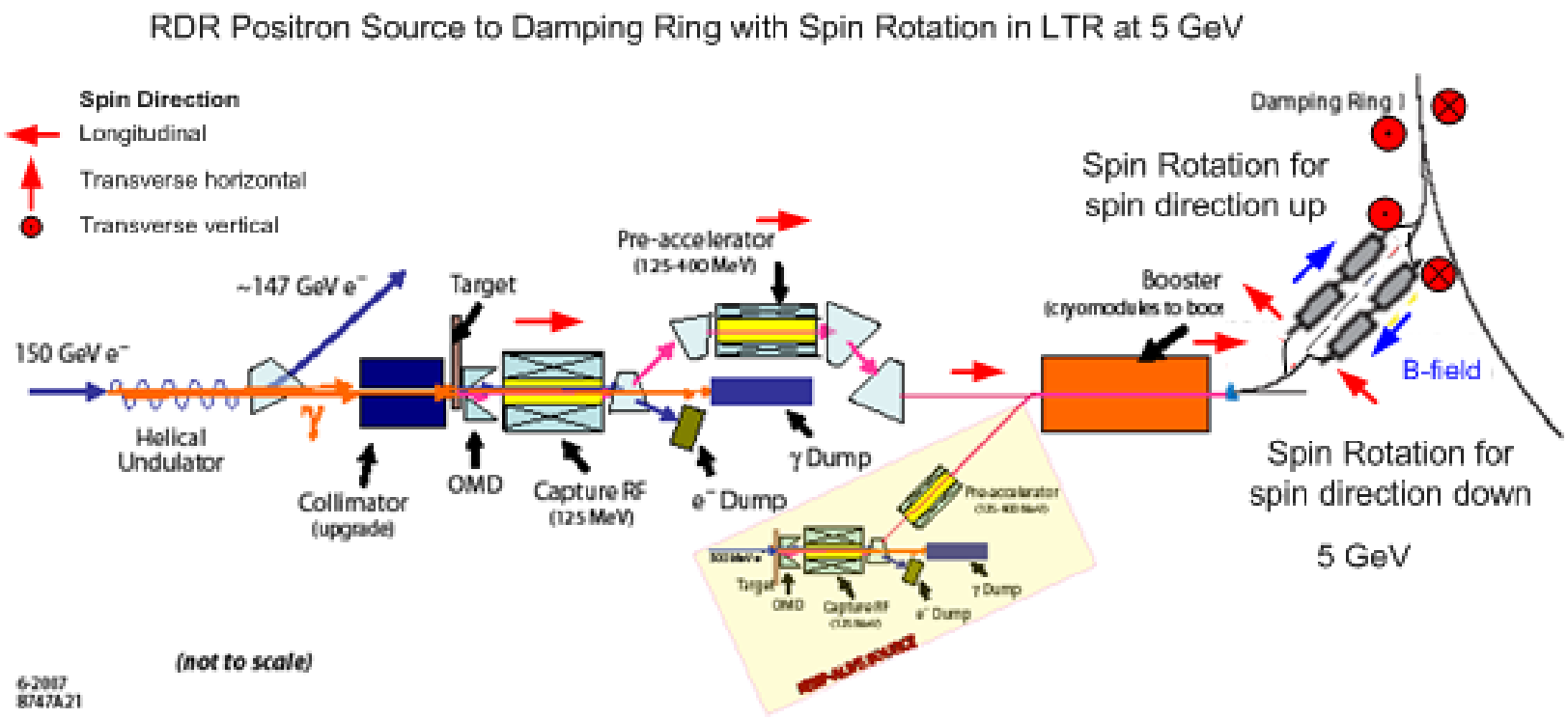
Helicity Flipping

Parallel beams lines have + and - solenoid magnetic field.
Kicker magnets select the beam line with the opposite solenoid magnetic field.



K. Moffeit, P. Bambade, K. Moenig, P. Schuler, M. Woods, “Spin Rotation Schemes at the ILC for Two Interaction Regions and Positron Polarization with both Helicities", LCC-159, SLAC-TN-05-045, February 2005.

Current plans for positron spin rotation before the Damping Ring

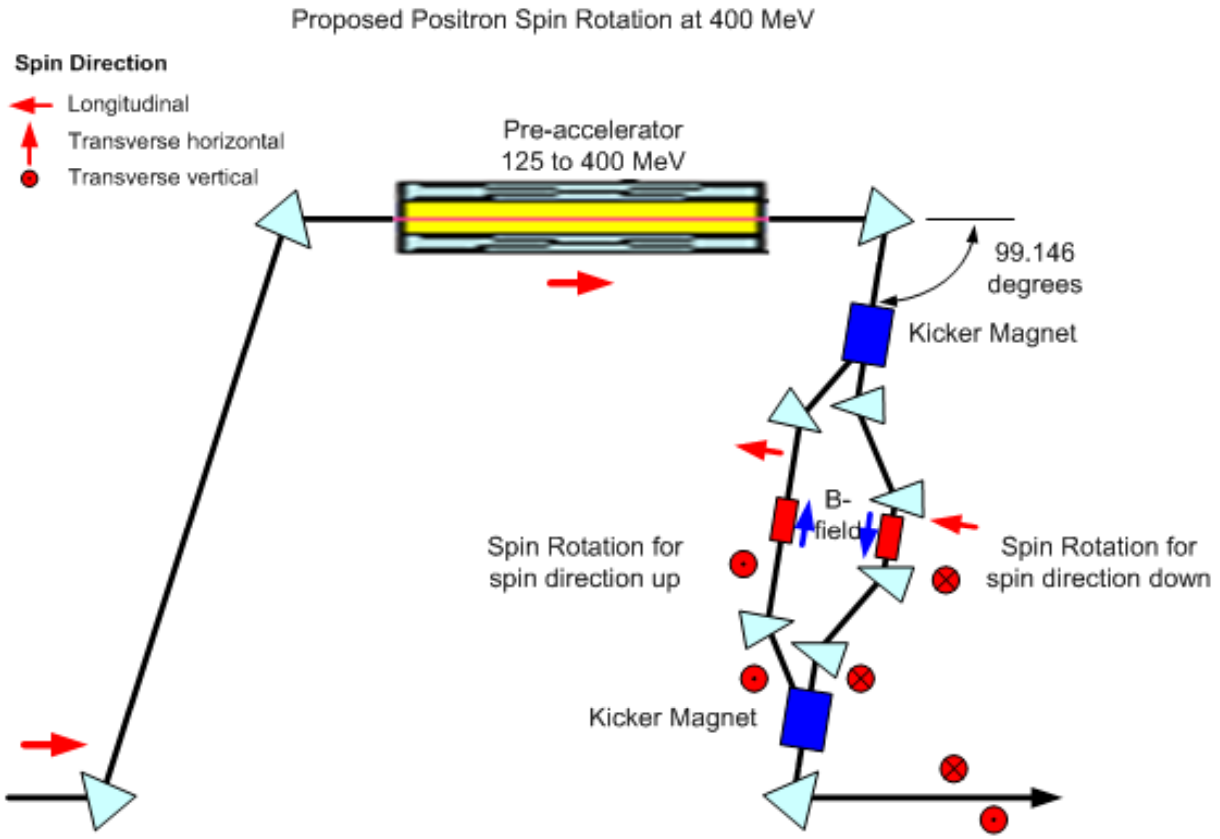


At 5 GeV 4 superconducting solenoids each with 13.1 Tesla meters are required for spin rotation to the up or down spin direction.

Helicity Selection

Damping Ring type kicker magnets needed to do helicity selection before the damping ring into parallel beam lines. Tunnel length and width to obtain separation of parallel beam paths at solenoid positions will be needed.

Proposal is to do positron spin rotation at 400 MeV directly following pre-accelerator where beam energy is 400 MeV



After a bend of 99.146^{o} two parallel beam lines with copper wound solenoids of +/- 2.096 Tesla meters (2.2 meters long with axial field of 9.53 Kilogauss in 2” bore) will rotate the spin from the transverse horizontal direction to the vertical.

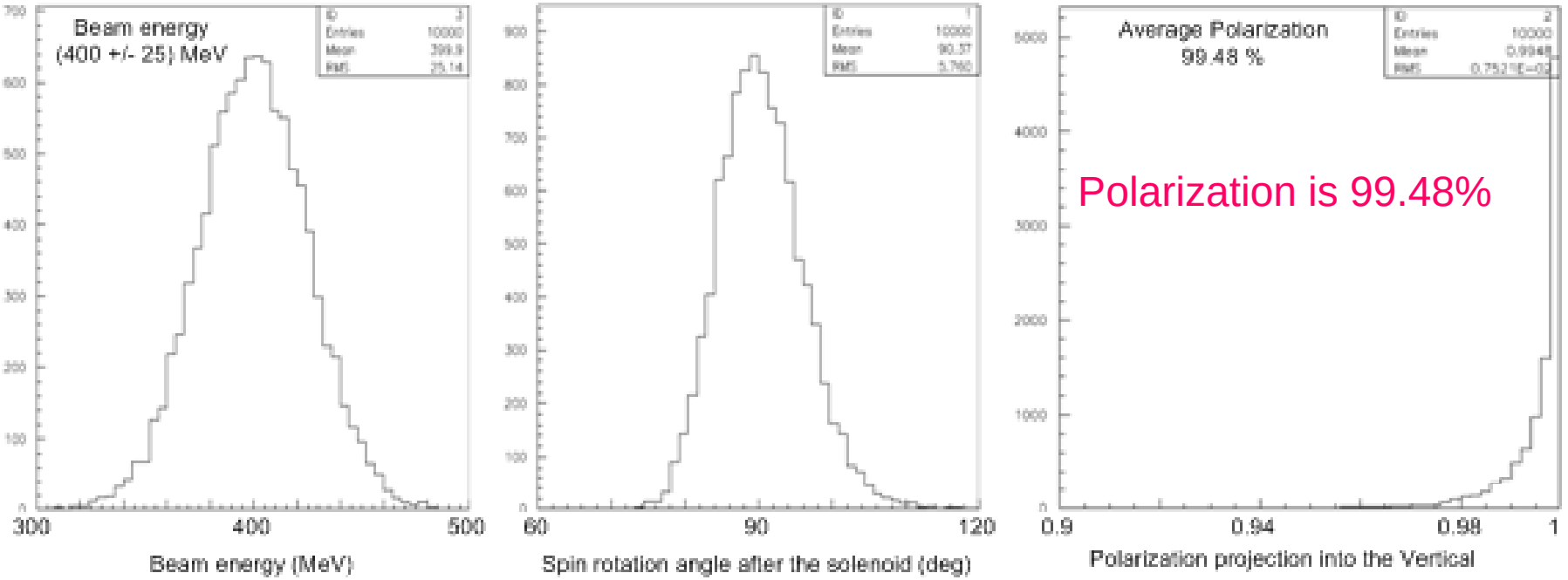
Criteria for the kicker magnets for helicity flip and tunnel space is much less demanding at 400 MeV than at 5 GeV.

Spin Diffusion due to positron energy spread at 400 MeV

Concerns:
Energy spread at 400 MeV may be large and depolarize the beam in the first 99.146^{o} bend and 2.096 tesla-meter solenoid:

- Negligible spin diffusion for energy spreads less than 3%
- However, the energy spread could be as large as 6% or +/- 25 MeV at 400 MeV, and would give a 0.5% loss in polarization for the bend and 0.5% polarization loss in the solenoid.

Spin Rotation in 1st 99.146^{o} bend with energy spread +/- 6% at 400 MeV



Positron Beam Losses:
Another concern is to transport the beam through the two bends and the optics of the parallel beam lines without significant positron beam losses.

Conclusions

The costs and performance requirements for the spin rotation systems before the damping ring will be less demanding at lower energy than at the damping ring energy of 5 GeV.

Positron Beam Spin Rotation and Fast Helicity Selection

• Copper-wound solenoids for the spin rotation solenoids 2.2 meters long with a bore of 2” can be used for the positron beam at 400 MeV.

• The angle the beam leaves the spin rotation system is required to be in the plane of the damping ring. The tolerance on the angle alignments is ~ 3 degrees resulting in a depolarization of 0.1%.

• A system to randomly select the helicity of the positrons at the e+e- IR is given. Such a scheme is important to minimize systematic errors in the measurement of polarization asymmetries. At 400 MeV the parallel beam lines and kicker magnets will be much simpler than at 5 GeV.

Electron Beam Spin Rotation

Rotate the spin vector to the vertical at very low energy for the electrons near the polarized gun using a Wein filter.

•The spin rotations systems presented here are conceptual designs. A more detailed optics design, including simulating performance and overall operation, will be needed.