2005 INTERNATIONAL
LINEAR COLLIDER WORKSHOP

Stanford, California, USA 18-22 March, 2005

Highlights from the MDI workshop
Spin Rotation System for 2 IR's
Downstream polarimetry

Ken Moffeit

SLAC

Polarimetry
MDI workshop SLAC, January 2005

- Physics motivation and polarization measurements from annihilation data,
  Klaus Moenig, DESY/LAL-Orsay

- Overview on Compton polarimetry at the ILC,
  Peter Schuler, DESY

- Spin transport and depolarization,
  Kaoru Yokoya, KEK

- Detector analyzing powers for upstream and downstream polarimeters,
  William Oliver, Tufts U.

- Design issues and measurement strategy,
  Ken Moffeit, SLAC

http://www-conf.slac.stanford.edu/mdi/sessions/polarimetry.htm

Summary of MDI Workshop Polarization Session

Polarimetry
MDI workshop SLAC, January 2005
Klaus Moenig

- Three ways to measure polarization: upstream, downstream, data
- Issues to Understand:
  - Difference of incoming, outgoing and luminosity weighted polarization.
  - Correlations between electron and positron polarization.
  - Polarimeter corrections for data methods.
- More concrete questions:
  - Is downstream polarimetry with 2 mrad crossing angle possible?
  - If no, is upstream polarimetry enough?
  - Can we believe CAIN for depolarization?
  - Do we understand the polarization transport well enough?
  - Backgrounds.
  - Light sources for different polarimeters (backgrounds, correlations)
  - Switching between IRs, how, how often?
  - Real Designs
  - Common issues with beam energy/luminosity spectrum: correlations between beams, momentum-polarization correlations.

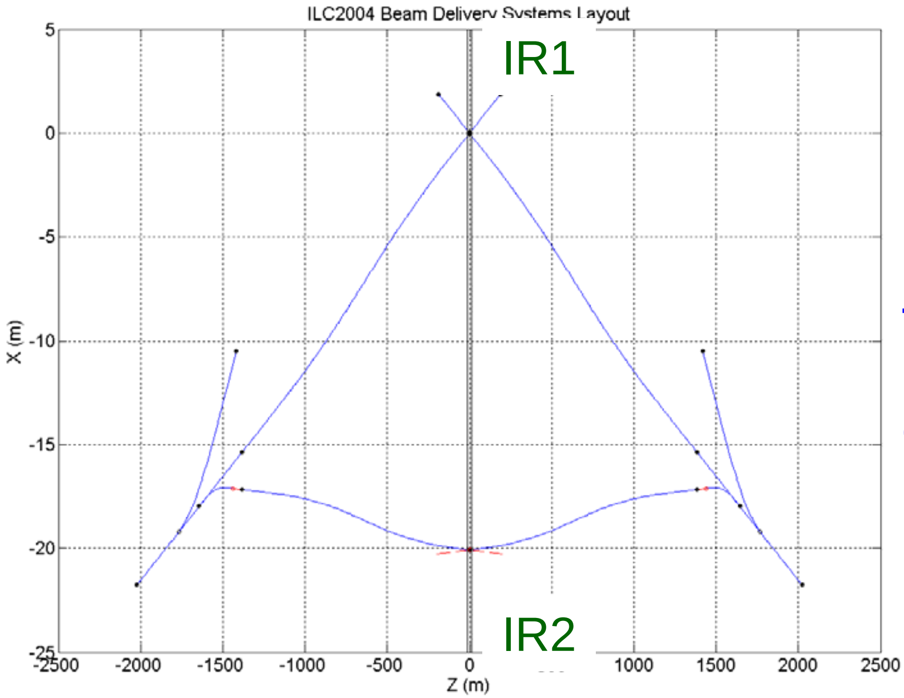
Spin Rotation schemes at the ILC for Two IRs and Positron Polarization with Both Helicities

Moffeit & Woods (SLAC), Schuler & Moenig (DESY), Bambade (LAL-Orsay)

SLAC-TN-05-045, Feb 2005

20 mrad crossing angle

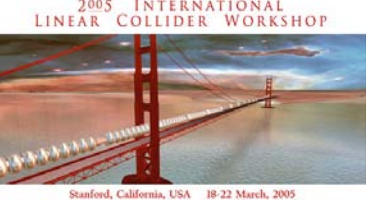
2 mrad crossing angle



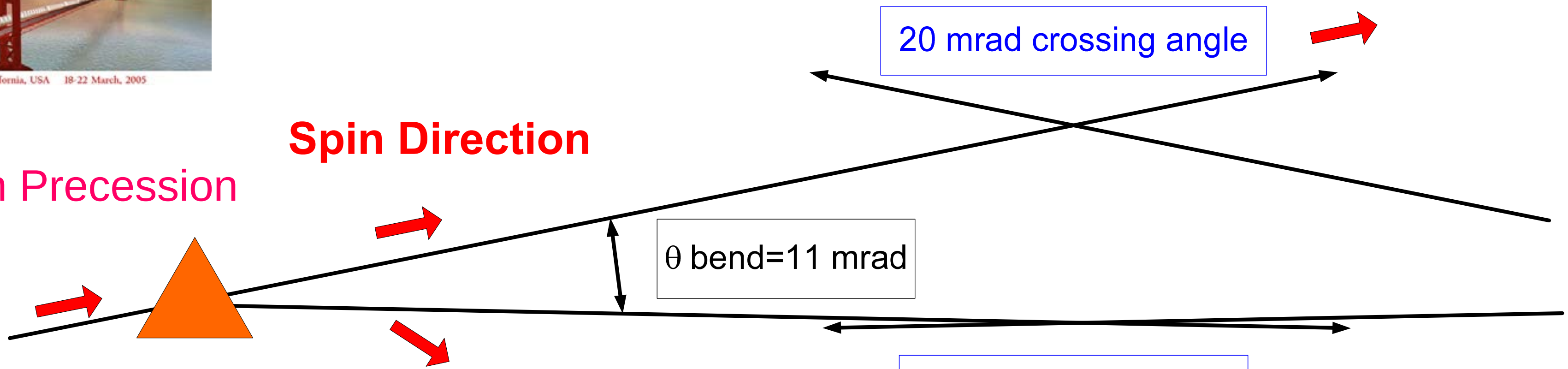
Layout of the Beam Delivery System to two Interaction Regions with Crossing Angles

- Polarization important at ILC
- Simultaneously running at both IRs
  by alternating each pulse train.
- Beams at two IRs are not parallel.
  so spin direction will be different at the two IRs

Beam Delivery Systems
Layout from Mark Woodley



Two Interaction Regions



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

K Moffeit 20 Mar 2005

Simultaneous running of 2 IRs and have longitudinal spin orientation at both.

- Use spin precession to find energies for π spin rotation with 11 mrad between beam direction at two IRs

  For θ=11mrad spin direction changes by π every 125.85 GeV

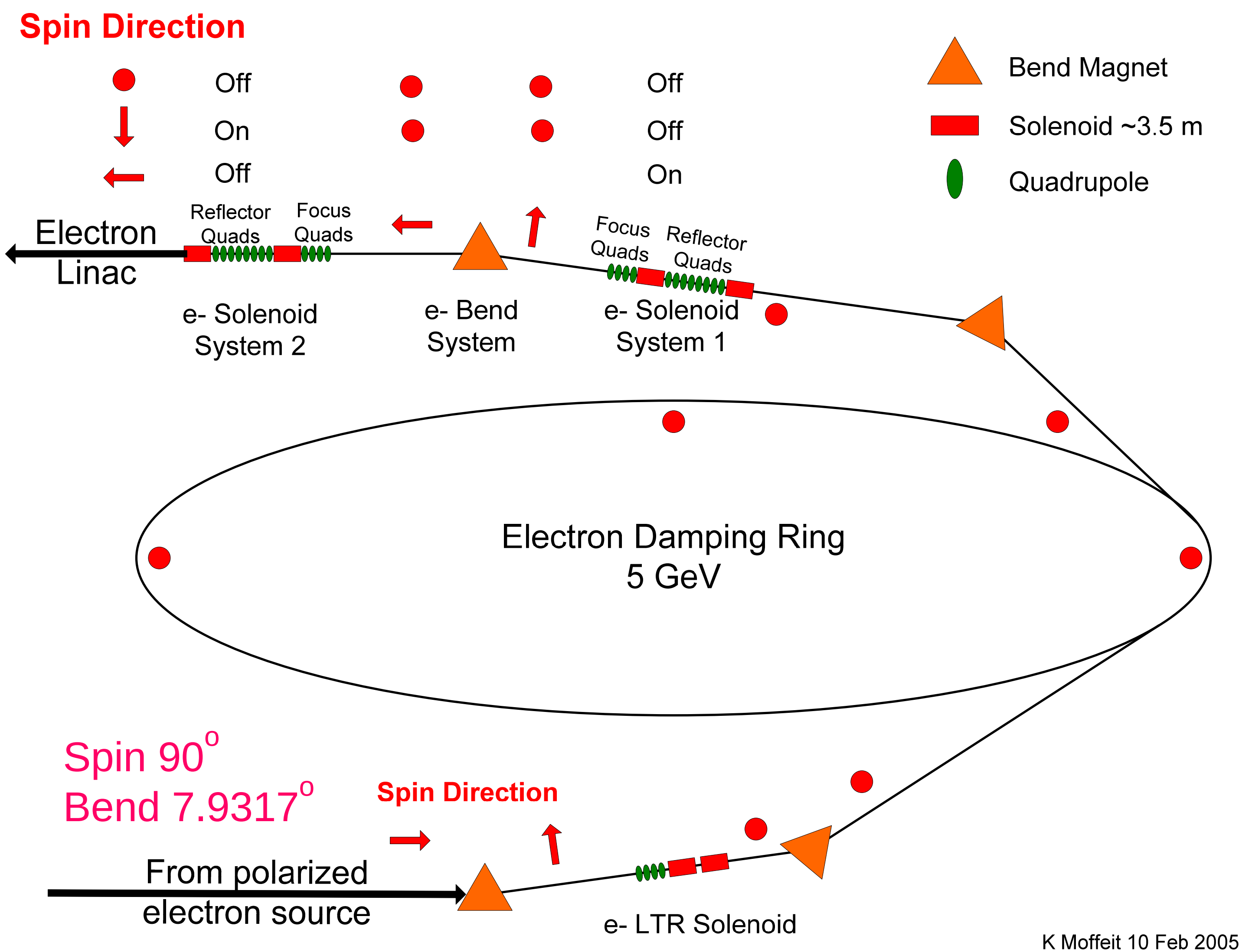
  Both IR 1 and IR 2 will have longitudinal polarization at beam energies:
  251.7 GeV, 377.55 GeV and 503.4 GeV

At these energies you can switch beams train to train between the two IRs and have longitudinal polarization at both.

Spin Rotation Scheme at the ILC for two Interaction Regions

- Tune polarization direction at IR1 and IR2 independently
- Switch pulse train to IR1 or IR2 between pulse trains:
  - 5 Hertz
  - Beam pulse length = 0.95 msec
  - Time between bunch trains = ~199 msec
- Switch Spin Rotation Setup between pulse trains?
- Changing current in Superconducting Solenoids between pulses is ruled out because of high inductance and a long time constants ~minutes
- The scheme described in the following uses parallel spin rotation beam lines and kicker magnets to switch between them. The spin rotation beam lines are located between the damping ring and the linac. The beam energy in the damping ring is 5 GeV

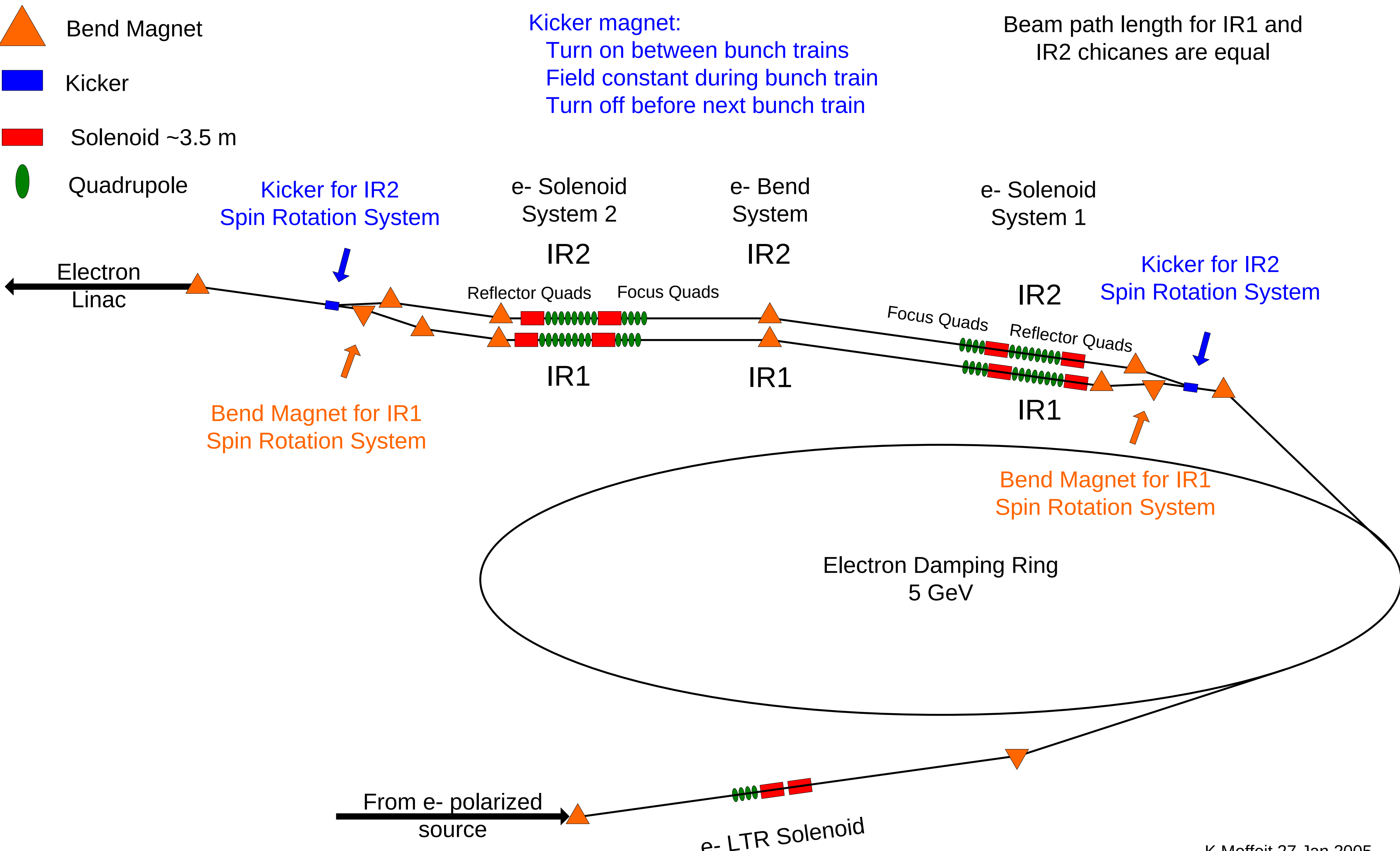
Electron Spin Rotation for Single Interaction Region



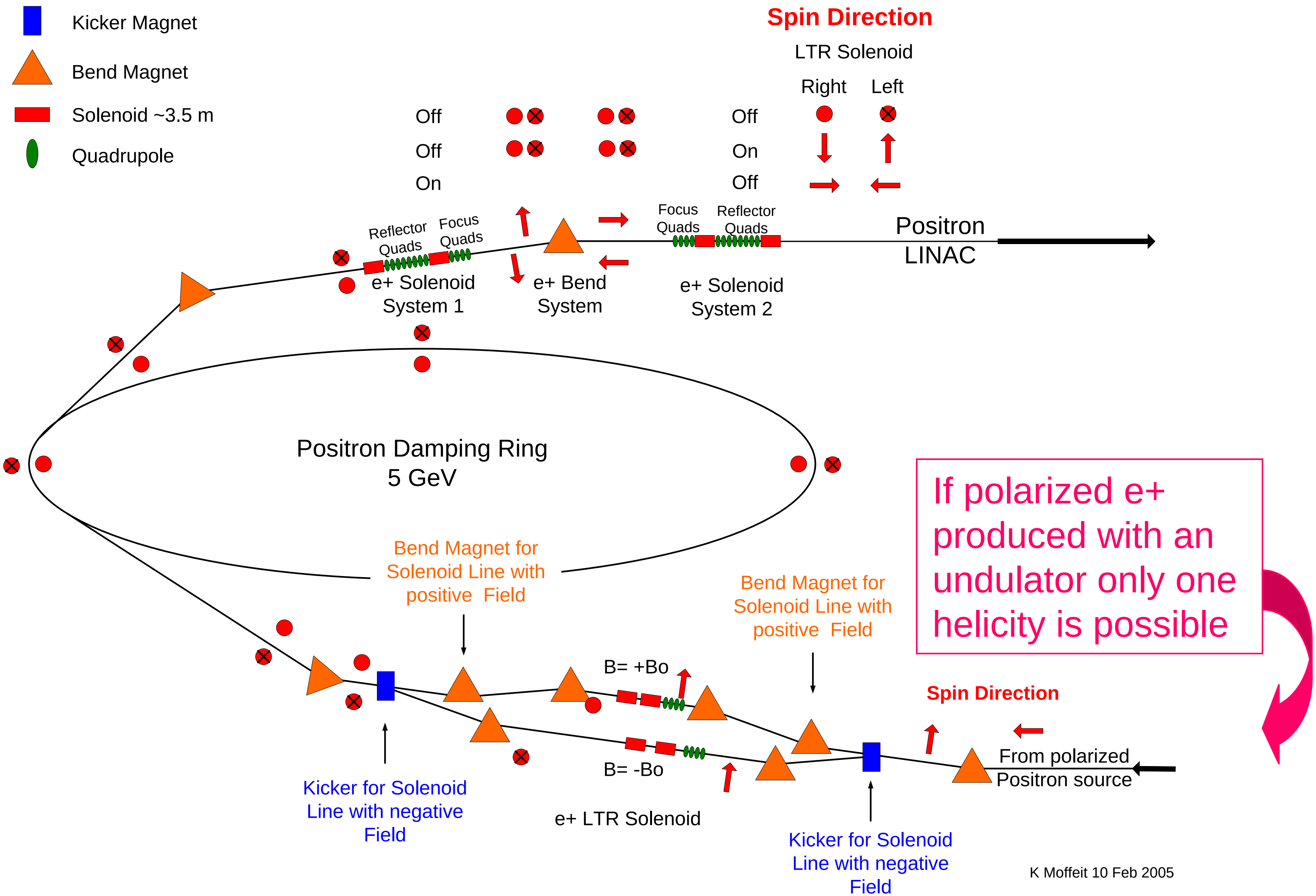
Electron Spin Rotation for 2-IRs

Kicker magnet:
- Turn on between bunch trains
- Field constant during bunch train
- Turn off before next bunch train

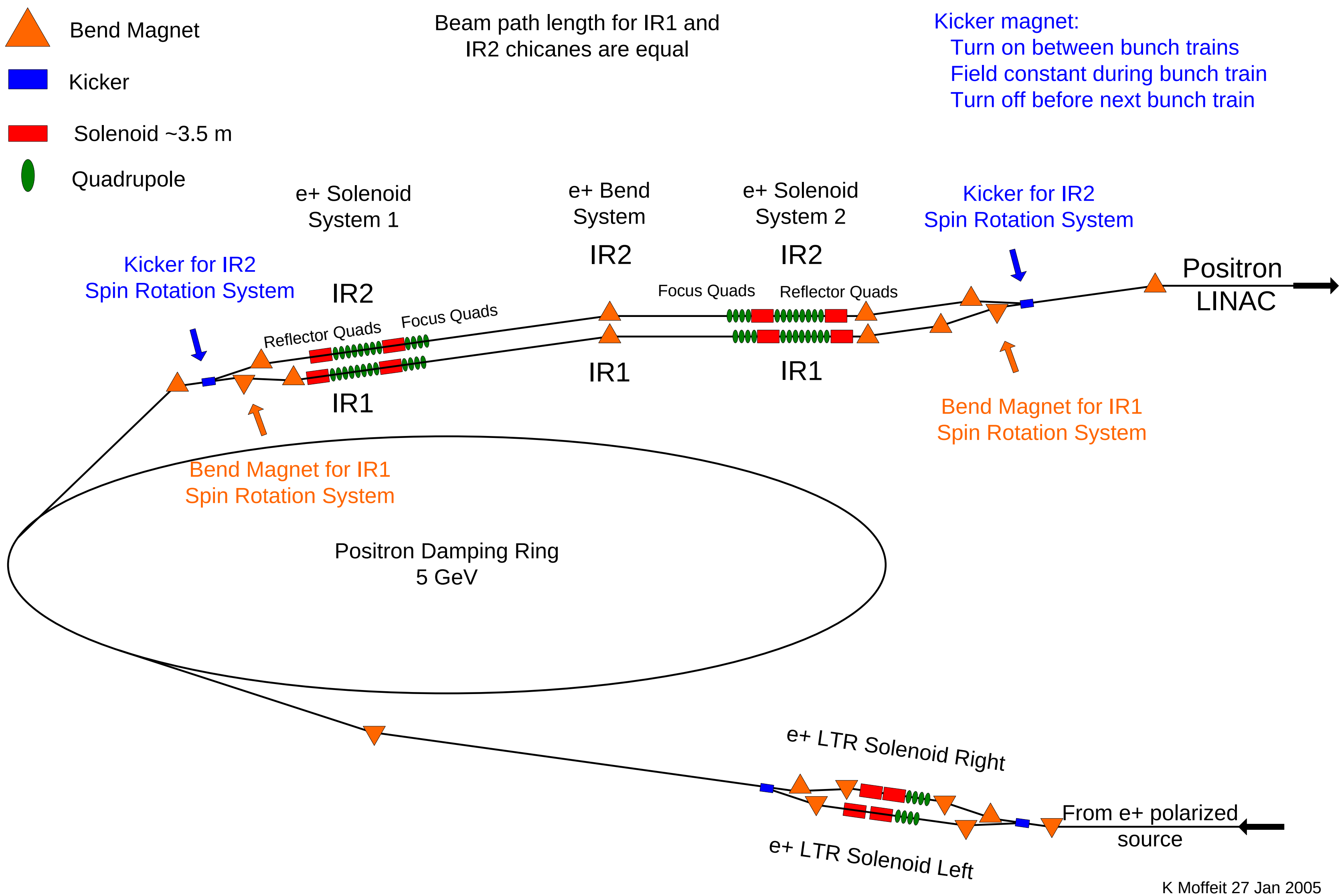
Beam path length for IR1 and IR2 chicanes are equal



Positron Spin Rotation for Single Interaction Region



Positron Spin Rotation 2-IRs



Comments for parallel beam lines

- The chicanes for the parallel beam lines are in the horizontal plane so there are no bends in the vertical plane since the beam emittance is critical in that dimension. Beam energy is 5 GeV in the parallel beam lines.

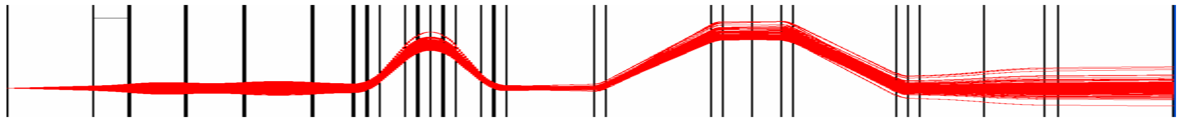
- Path lengths for the parallel beams need to be almost equal with any difference small compared to the bunch length. Path length correction chicanes can be added to the parallel beam lines if necessary.

- The pair of kicker magnet can be powered in series from the same current source to minimize beam jitter entering the linac.

- The double-solenoid spin rotator system is a small energy band-pass system. It must be located upstream of the RF used to compress the bunch length. The beam at the damping ring extraction has an rms relative energy spread of about 0.1% rather than the 1-2% rms level in the bunch compressor.

20 mrad Extraction Line

Energy Chicane   Polarimeter Chicane



Considerations for Polarimetry ***(Woods, Moffeit, Schuler, Monig, Nosochkov)***

The R-Transport matrix from the collider IP to the extraction line Compton IP allows one to compare the beam parameter phase space between the two locations,

$$\left| x \right\rangle_{chicane} = R \left| x \right\rangle_{IP} \qquad \text{for beam parameters} \qquad (x, x', y, y', z, {}^{dE}\!/_{E})$$

R22 and R44 give the angular magnification from collider IP to Compton IP.

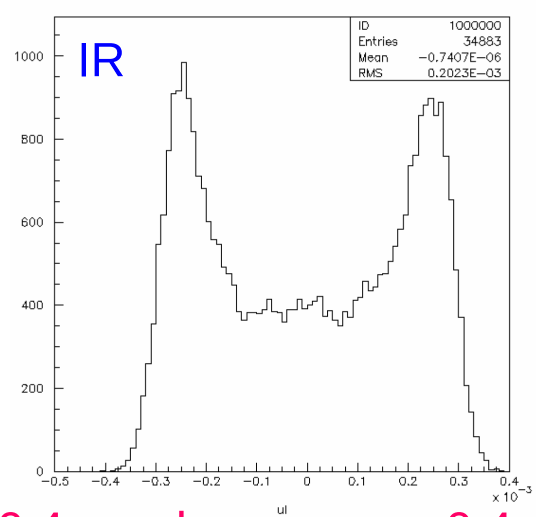
- R22 most important for e+e-, since horizontal angles dominate.
- R22 close to -0.5, polarimeter measurement close to lum-weighted P
  sensitive to both BMT and spin flip depolarization
- R22 close to 0, polarimeter will only measure spin flip depolarization.

Previous design: R22 = -0.595, R44 = -0.443 Sensitive BMT & Spin Flip Good

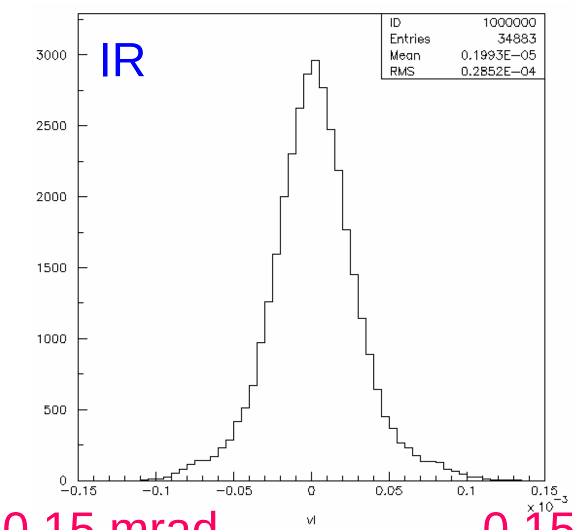
Recent designs for 20-mrad IR that also include energy spectrometer:

L*(ext)=4m,	R22 = -0.144,	R44 = -0.275	Only Spin Flip	Poor
L*(ext)=15m,	R22 = -0.326,	R44 = -0.419	BMT? Spin Flip ok	Marginal

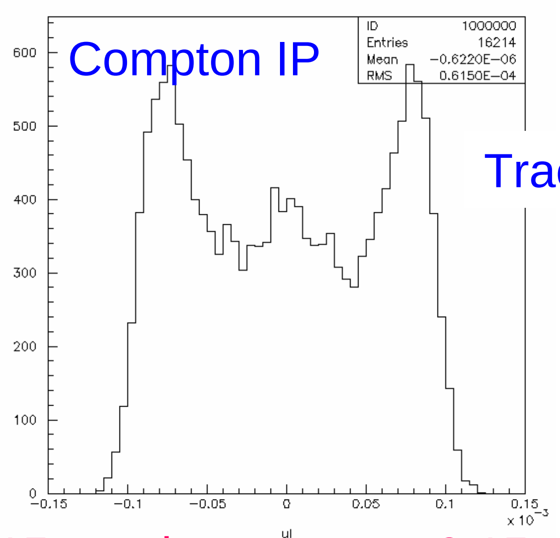
L*= 15 m optics R22 = -0.326 R44 = -0.419



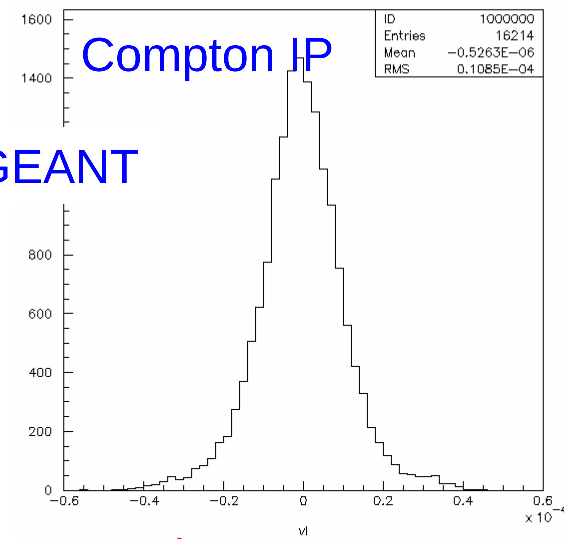
-0.4 mrad 0.4 mrad



-0.15 mrad 0.15 mrad



Tracking using GEANT



-0.15 mrad 0.15 mrad

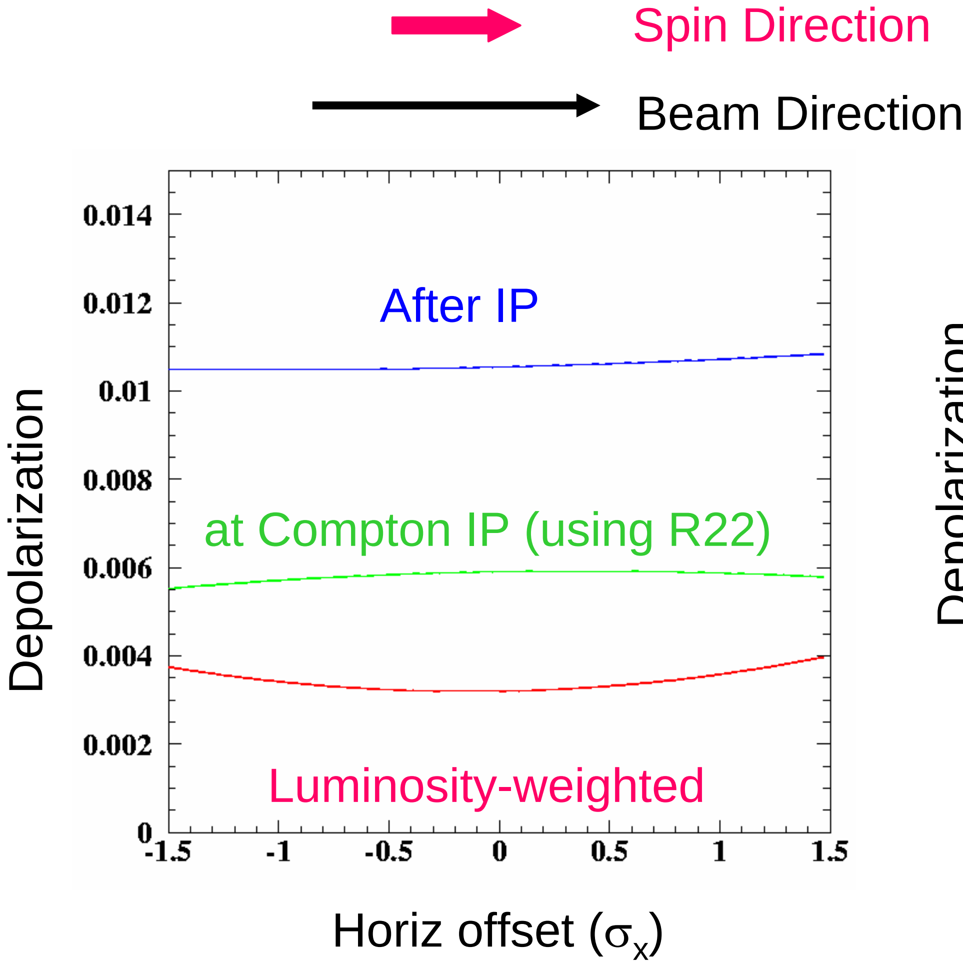
X-angle

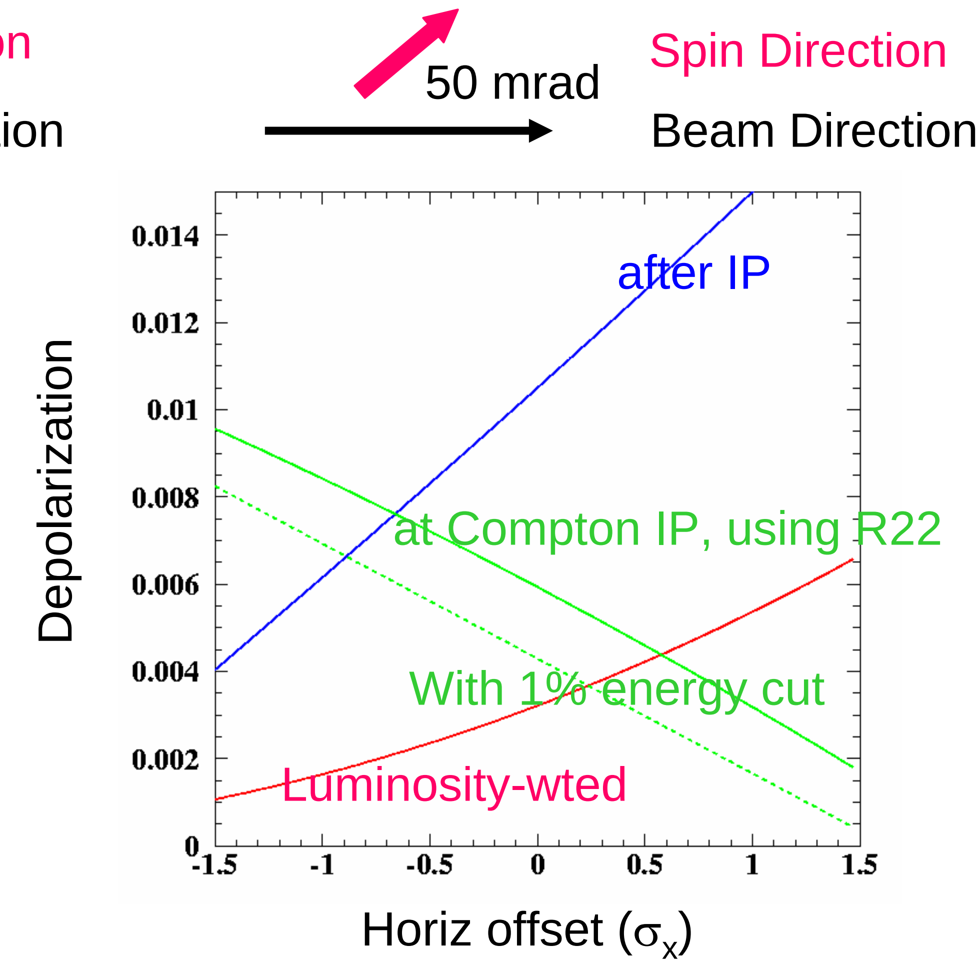
-0.06 mrad 0.06 mrad

y-angle

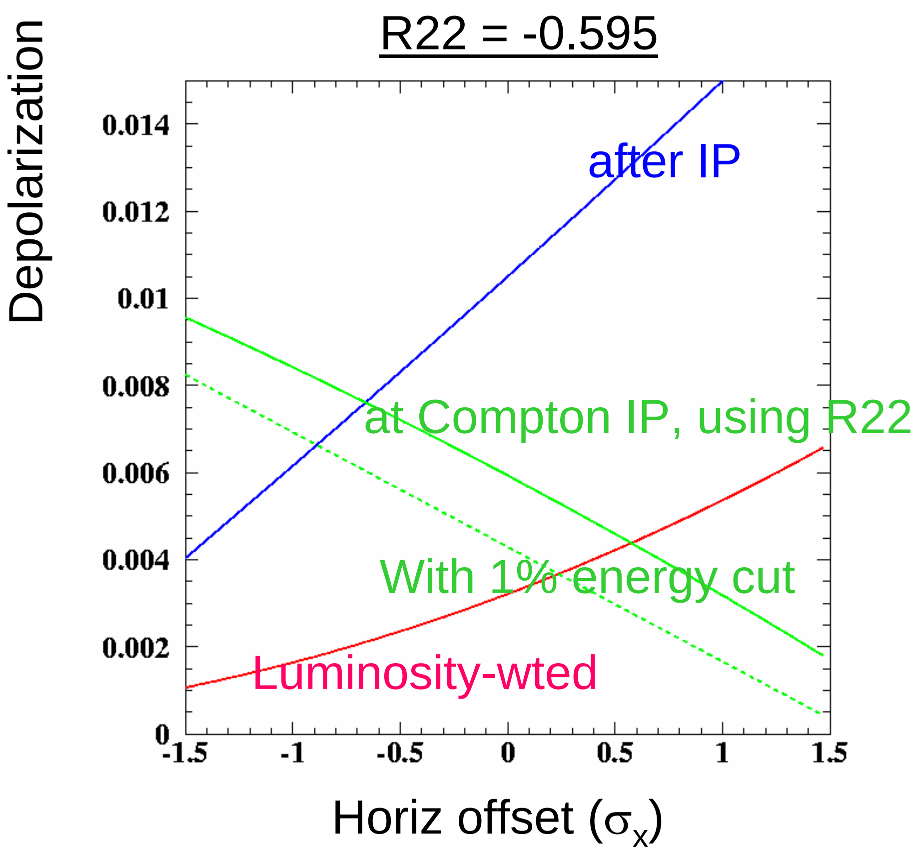
Klaus Monig has been looking at sensitivity to misalignment of longitudinal Polarization at the Collider IP for the extraction line polarimeter measurements.

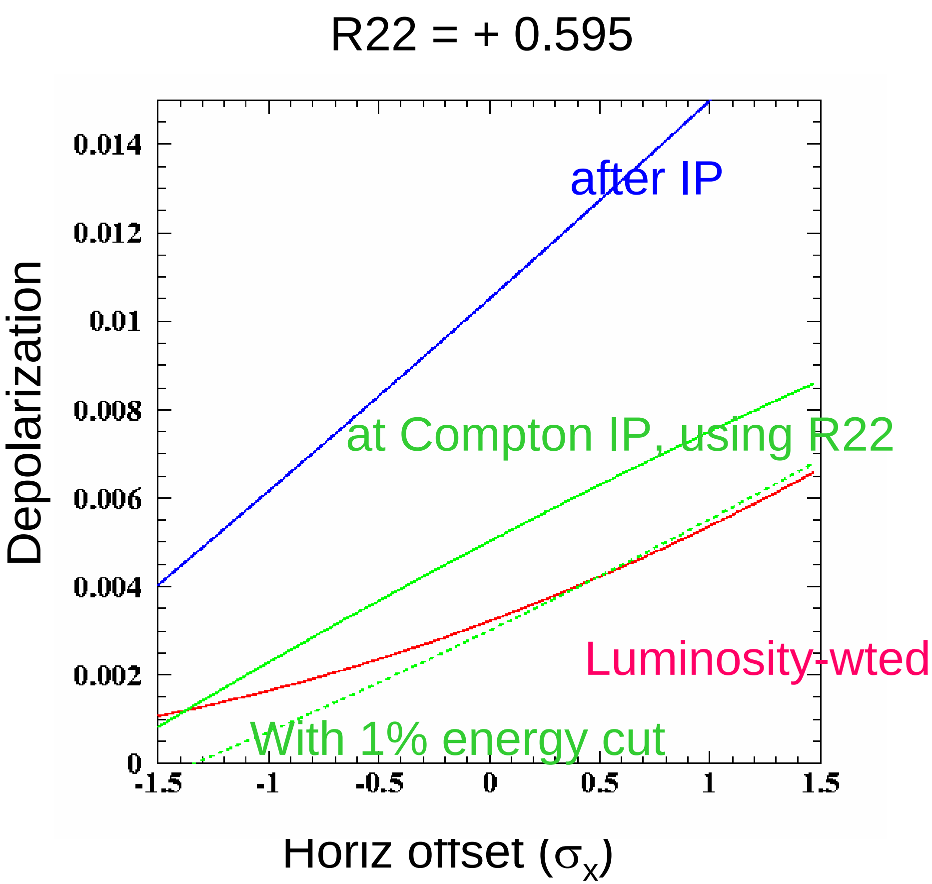
Results using old optics R22 = -0.595 (from collider IP to Compton IP):





Comparison of negative and positive R22

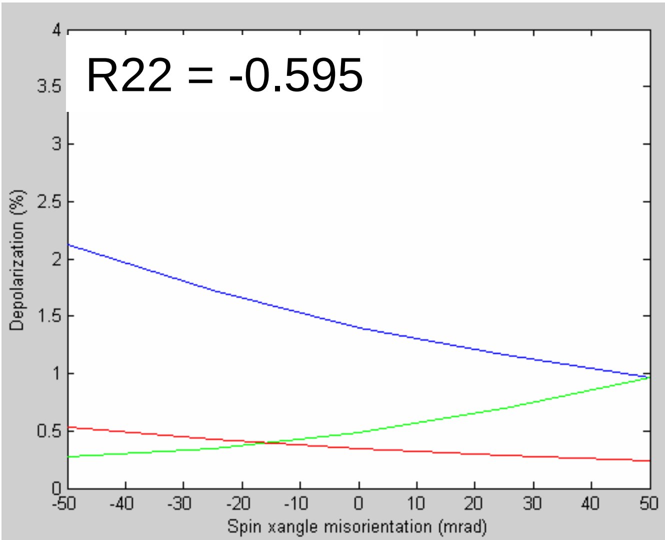


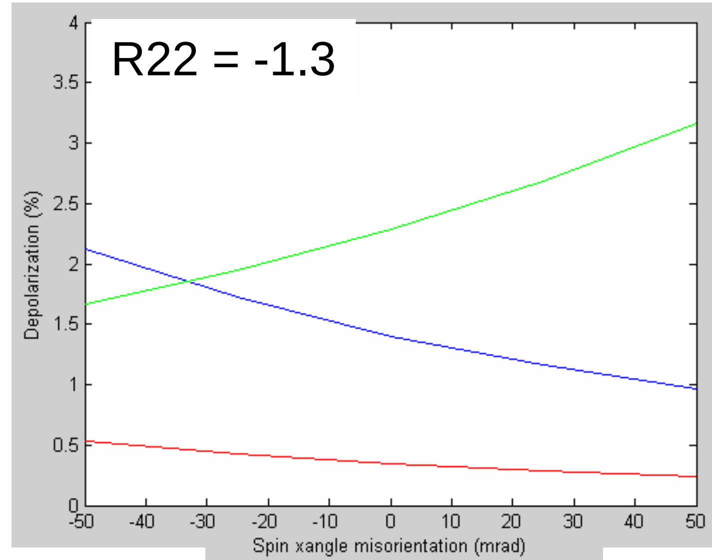


Uses one of the TESLA TRC files, Guinea-PIG simulation

500nm horizontal offset

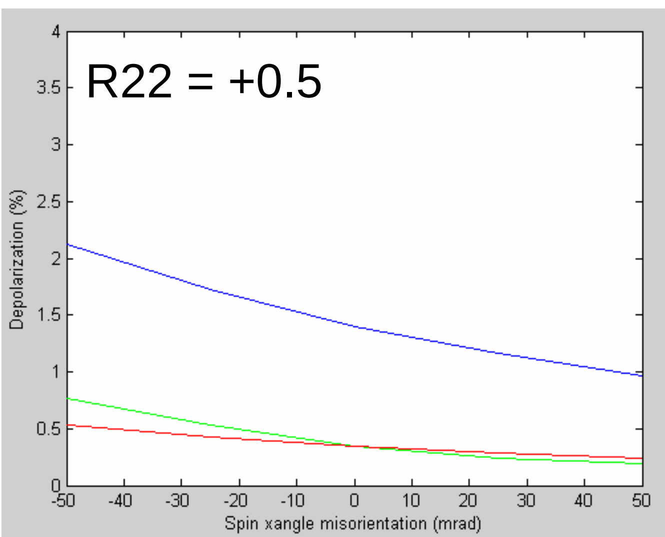
Depolarization (%)

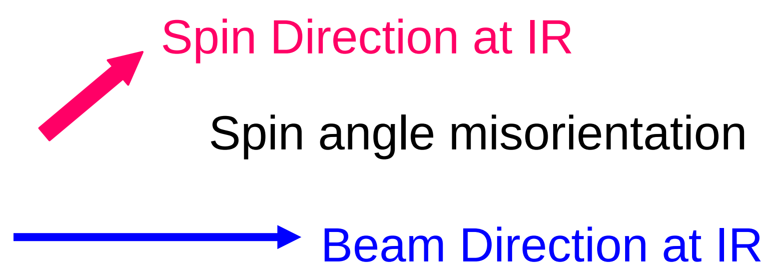




-50 mrad 50 mrad

at Compton IP (using R22)
after IP (BMT only)
Lum-wted (est. as ¼ after IP)

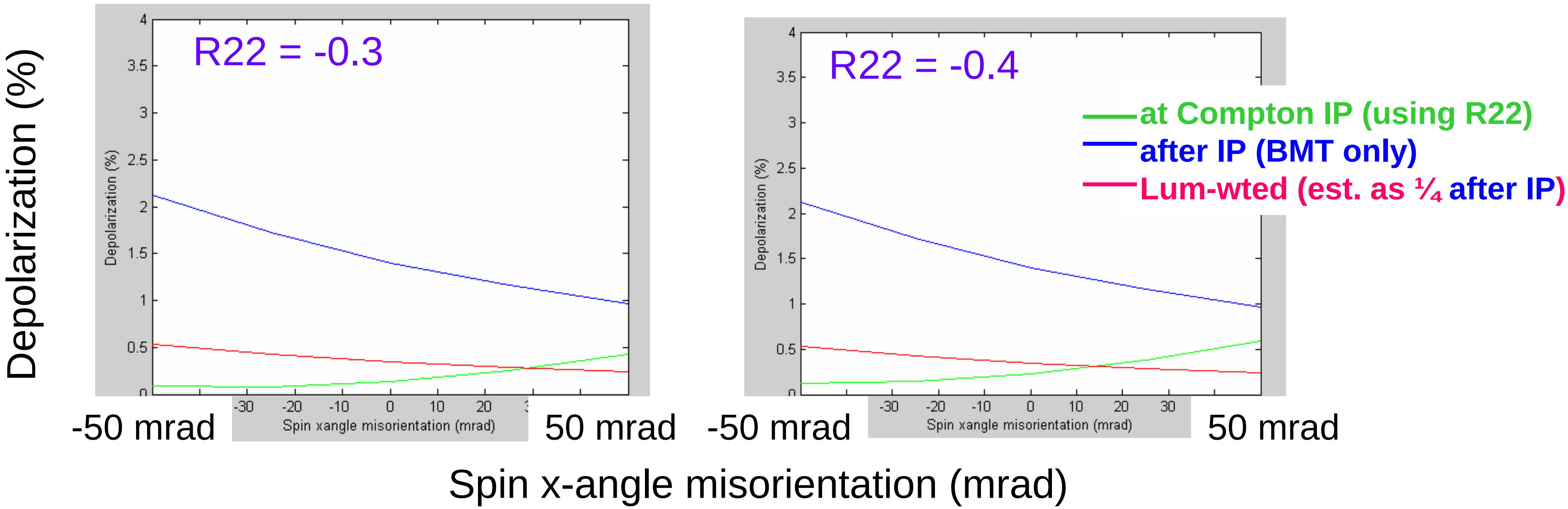




Spin x-angle misorientation (mrad)

Uses one of the TESLA TRC files, Guinea-PIG simulation

500nm horizontal offset



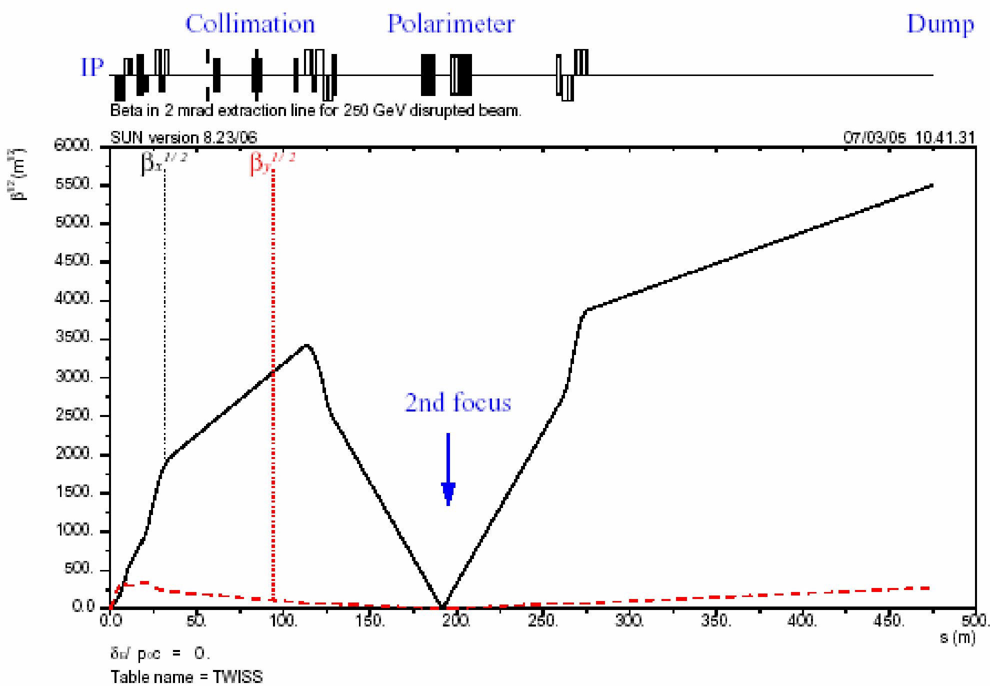
Comments:

1. Polarimeter measures "green" results at Compton IP. We want "red" = Lum-wted P.
2. Prefer R22 close to -0.5 so good sensitivity to BMT and spin flip.
   - Add a 3rd focus to decouple more polarimetry from energy spectrometer?
   - Change polarity of quads so R22 larger?
   - Is R22 +0.5 possible?
3. If R22 close to 0 can we determine BMT depolarization from data?
4. Important to limit spin angle misalignment and horizontal offsets.
   - Use depolarization vs beam offset as diagnostic for spin miss-orientation at IP.

Extraction line Polarimeter for 2mrad IR

Yuri Nosochkov (SLAC-BNL-UK-France task group)

Beta functions for disrupted beam at 250 GeV



Undisrupted beam size $\sigma = \sqrt{\beta\varepsilon + (\eta\sigma_E)^2}$ for $\sigma_E = 0.1\%$

- At 2nd focus: $\sigma_x = 69$ µm, $\sigma_y = 0.3$ µm
- At $Z\text{-}Z_{IP} = 475$ m: $\sigma_x = 6.7$ mm, $\sigma_y = 0.053$ mm

At 2nd focus

Compton IP

- $Z\text{-}Z_{IP} = 191.66$ m
- 2 mrad horiz. angle
- 10 m space
- $\eta_x = -6.9$ cm
- $R_{11} = -0.767$
- $R_{22} = -1.305$
- $R_{33} = -61.87$
- $R_{44} = -0.016$

R22 = -1.305

R44 = -0.016

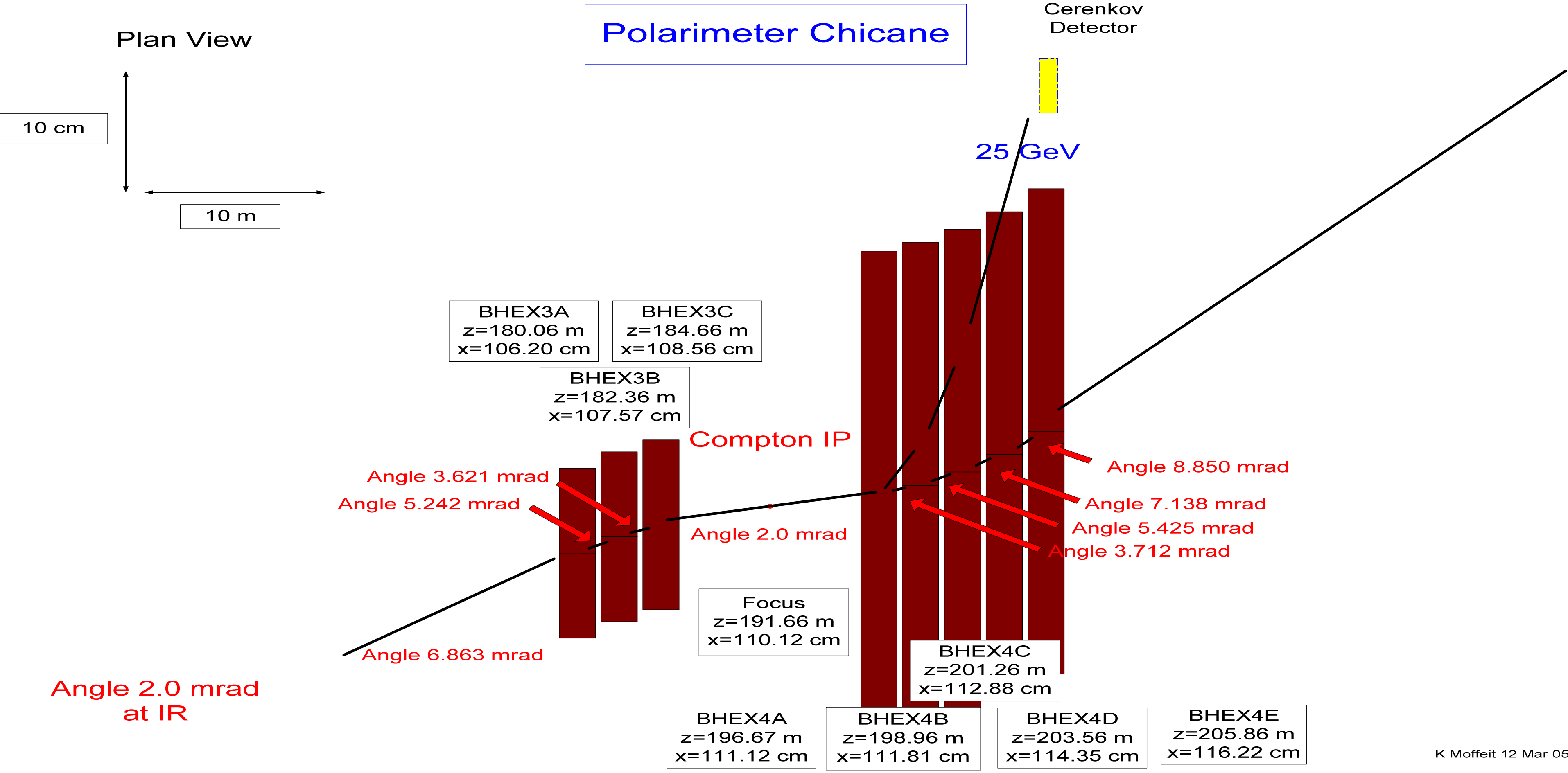
At $Z\text{-}Z_{IP} = 475$ m

- $X\text{-}X_{IP} = 3.57$ m
- 8.56 mrad horiz. angle

R44~0 means no sensitivity to BMT in Vertical

R22>1 means very sensitivity to spin misalignment and horizontal offsets and large correction from measured polarization to Lum-weighted Pol

Polarimeter Chicane



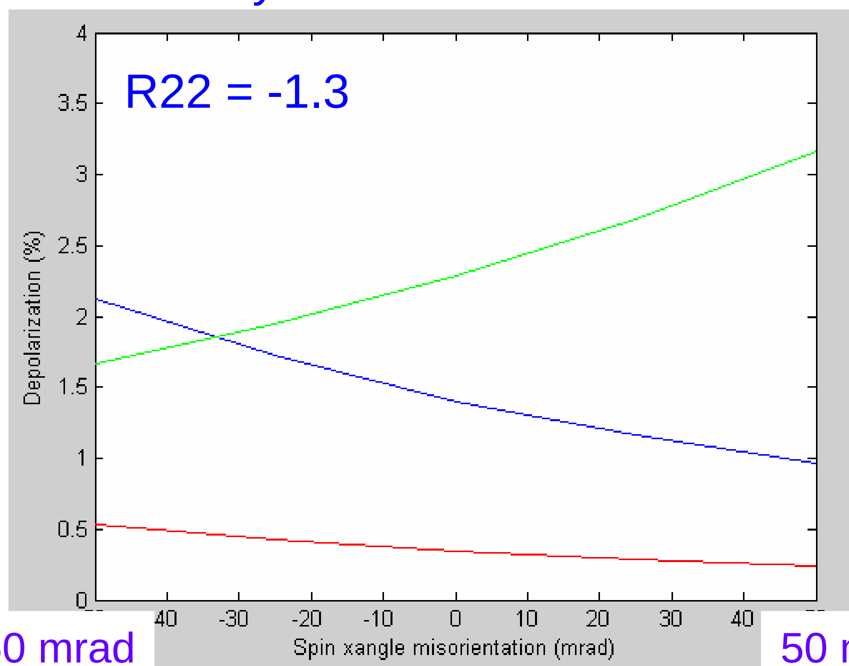
- Current design requires changing magnet current with beam energy.
- Need drift space (~20 m) to get Compton e- to detector.
- Incorporate a four magnet polarimeter chicane along the 2 mrad line between BHEX3 and BHEX4. Requires ~50 meters for chicane. Should the chicane be in the vertical or horizontal plane?

Polarimetry for 2mrad IR

- Beam size at Compton IP: probably ok for 100 μm laser spot - needs study
- Backgrounds at Compton Detector: needs study
- Spin diffusion and loss between IR and Compton IP: R22 = -1.3 not good
- Study effects of beam jitter on the Polarization measurement.

Presently R22 = -1.305 R44 = -0.016

Depolarization (%)



-50 mrad 50 mrad

Spin x-angle misorientation (mrad)

500nm horizontal offset

at Compton IP (using R22)
after IP (BMT only)
Lum-wted (est. as ¼ after IP)

Summary

Between the damping ring at 5 GeV and the linac two parallel spin rotation beam lines allow the spin to be tuned separately for IR1 and IR2. A set of kicker magnets activated between pulse trains is used to direct the beam into the appropriate spin rotation beam line.

Flip helicity of positron beam in input line to e+ damping ring.

Optimize 20 mrad extraction line optics for reducing systematic errors on polarization measurement.

Can polarization measurement be accomplished in extraction line for 2mrad Interaction region?

- Backgrounds at Cerenkov detector need study.
- Can we insert chicane along 2 mrad beam line?
- Optimize optics.