Issues concerning beam direction of Collision IP and Compton IP

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10 Nov 05

anti-DID for intermediate crossing angle

- Normal polarity of Detector Integrated Dipole (DID) allows to compensate locally the effect of crossing the solenoid field for the incoming beam, while the field seen by outgoing beam (and low energy pairs) about doubles
- Reversing polarity of Detector Integrated Dipole (anti-DID) could effectively zero the crossing angle for outgoing beam (and pairs) but would increase it (1.5-1.6 times) for incoming beam
- Increasing the effective crossing angle for incoming beam may create too much synchrotron radiation size growth (which depend as $\Delta\sigma_{SR} \sim \theta^{5/2}$)
- Smaller initial crossing angle (14mrad) ease the use of anti-DID
  - the effective angle with anti-DID is ~21-22mrad
- Compensation of vertical angle possible can be done less locally

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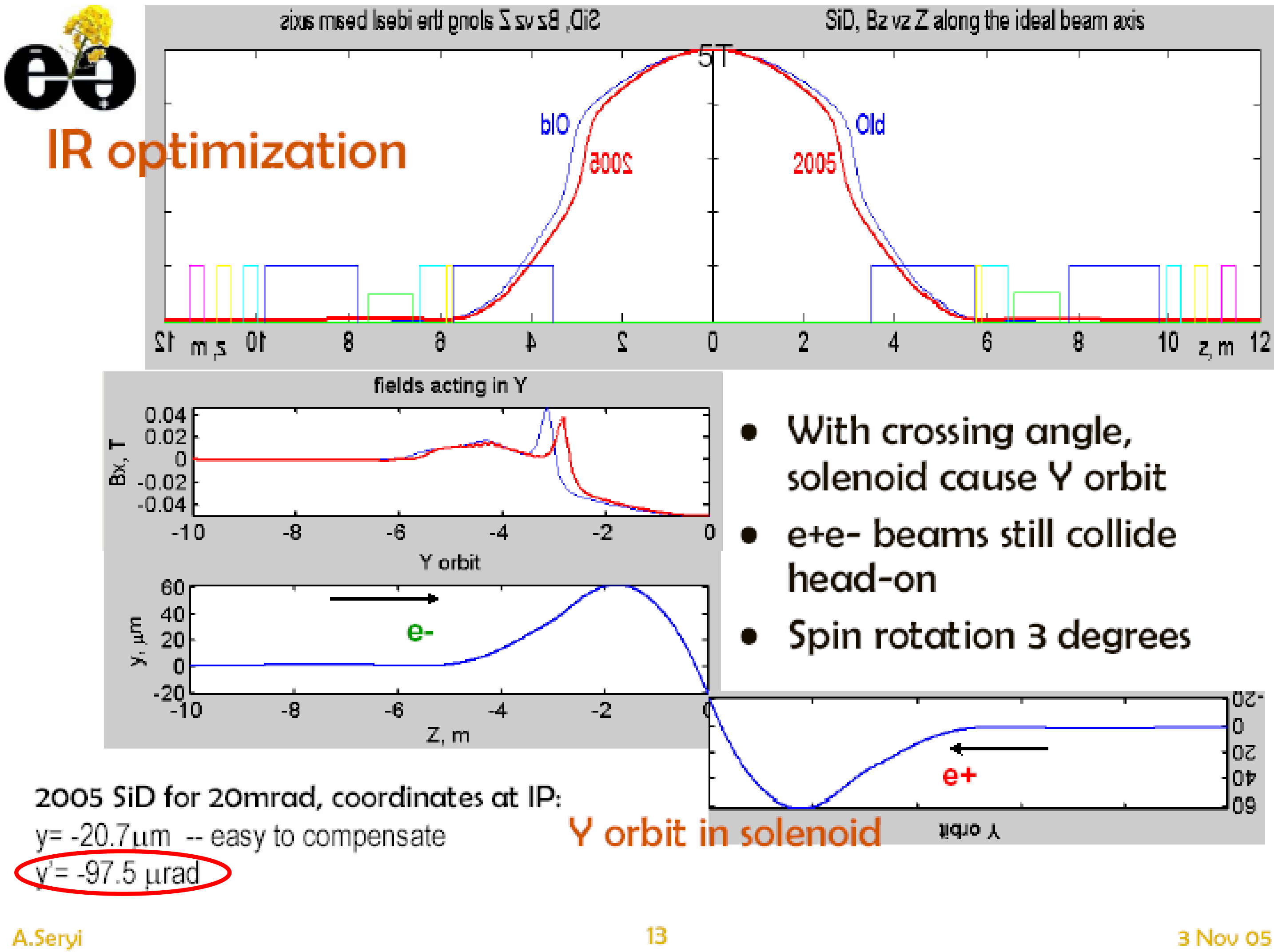
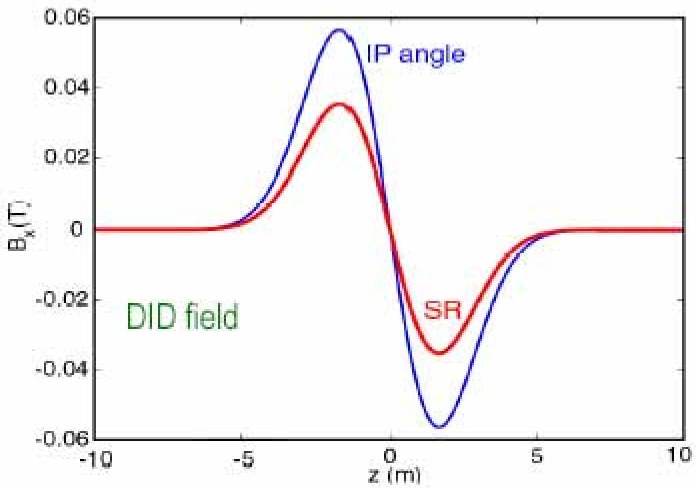
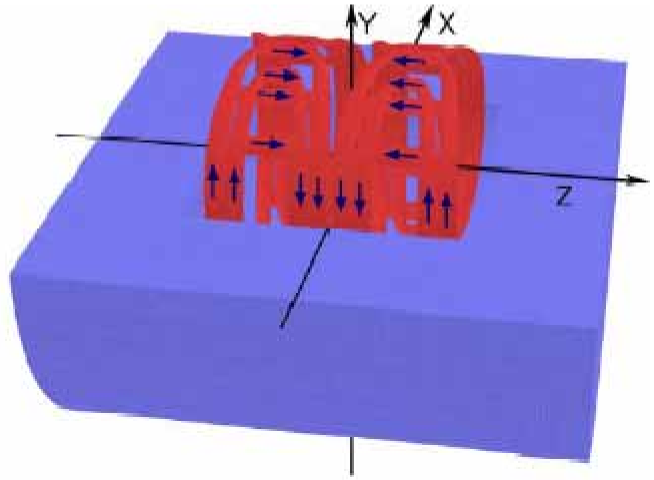
Solenoid field only (NO DID)



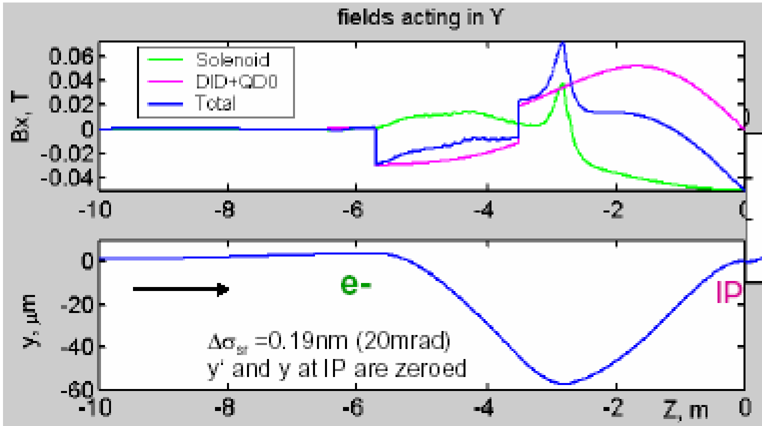
Standard DID

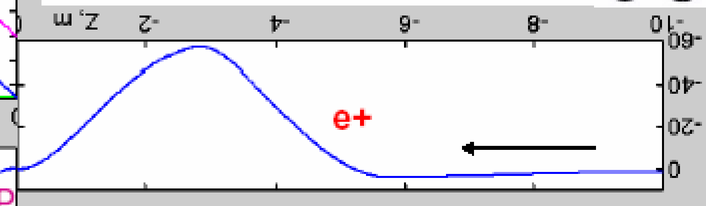




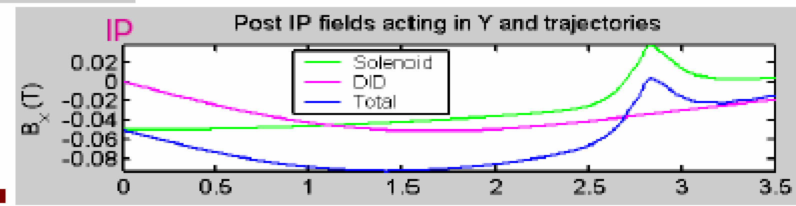
- Coil wound on detector solenoid, giving transverse field, such that the combined field from
  solenoid, Detector Integrated Dipole, and QD0
  would result in zero vertical angle at the IP

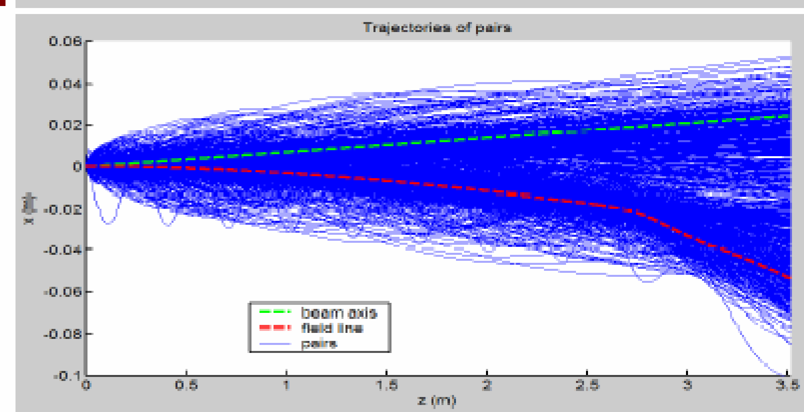
Standard DID





- For standard DID, can zero y and y' at IP
- Correction is local and very effective
- No increase of SR
- But the post IP field is increased by DID => low E pairs directed away from extraction aperture





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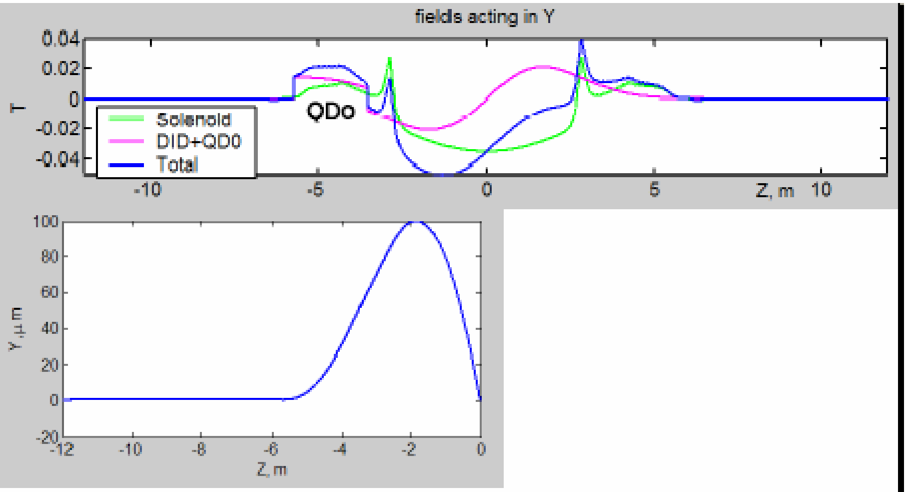
Incoming beam with anti-DID

- Anti-DID increase eff. incoming angle from 14 to ~22mr
- SR increase negligibly for SiD and GLD (0.2-1% of L) and minor for LDC (~2% L)



	IP Y, µm	IP Y', µrad	$\Delta\sigma_{SR}$, nm	Lum, %
SiD L*=3.5m, 14mr, anti-DID	0	-102	0.32	99.8
GLD L*=4.5m, 14mr, anti-DID	0	-96	0.65	> 99

LDC, L*=4.5m, 14mrad	IP Y, µm	IP Y', µrad	$\Delta\sigma_{SR}$, nm	Lum, %	Pairs to extr. hole, %
anti-DID at 0.023 T	0	-122	1.01	98	49
anti-DID at 0.035 T	0	-138	1.67	95	62

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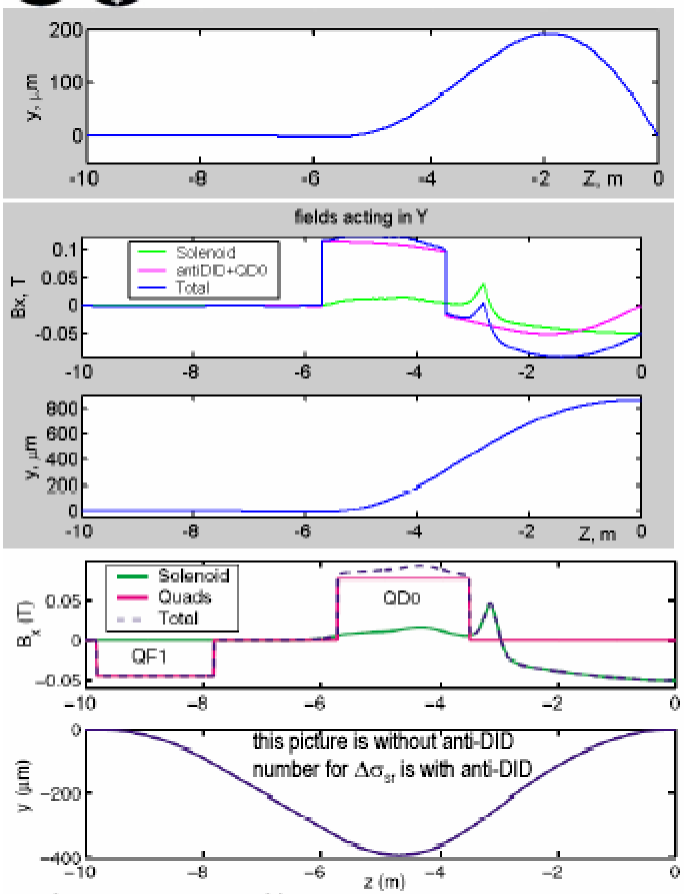
Incoming beam with anti-DID, example for SiD



(Orbits shown are for 20mrad and for anti-DID larger than optimal)

- Only y at IP compensated with QD0 dipole corrector:

$\Delta\sigma_{sr}$ ~0.37nm (14mrad) => $\Delta L/L$ ~ 0.27 %

- Angle y' zeroed w QD0, y is free

$\Delta\sigma_{sr}$ ~1.2nm (14mrad) => $\Delta L/L$ ~ 2.8 %

- Both y' and y zeroed with QD0 and QF1 correctors (difficult)

$\Delta\sigma_{sr}$ ~6.6nm (14mrad) => $\Delta L/L$ ~ 40 %

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Y-angle at IP & polarization measurements

- Options with 14mrad and anti-DID
  - Zero IP Y-angle with dipole coils in FD (~2.8% Lumi impact in SiD)
    or decrease it to < 50μrad (negligible Lumi impact)
    - IP position offset can be easily handled
  - Leave IP angle not corrected, but create Y angle at downstream diagnostics, exactly as at the IP

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Spin Precession

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

Change in Bend Angle	Change in Spin Direction at 250 GeV	Longitudinal Polarization Projection
1 mrad	32.5 ^{o}	84.3%
275 μrad	8.9 ^{o}	98.8%
100 μrad	3.25 ^{o} $^{=}$56mrad	99.8%

Change in spin direction for various bend angles and the projection of the longitudinal polarization. Electron beam energy is 250 GeV.

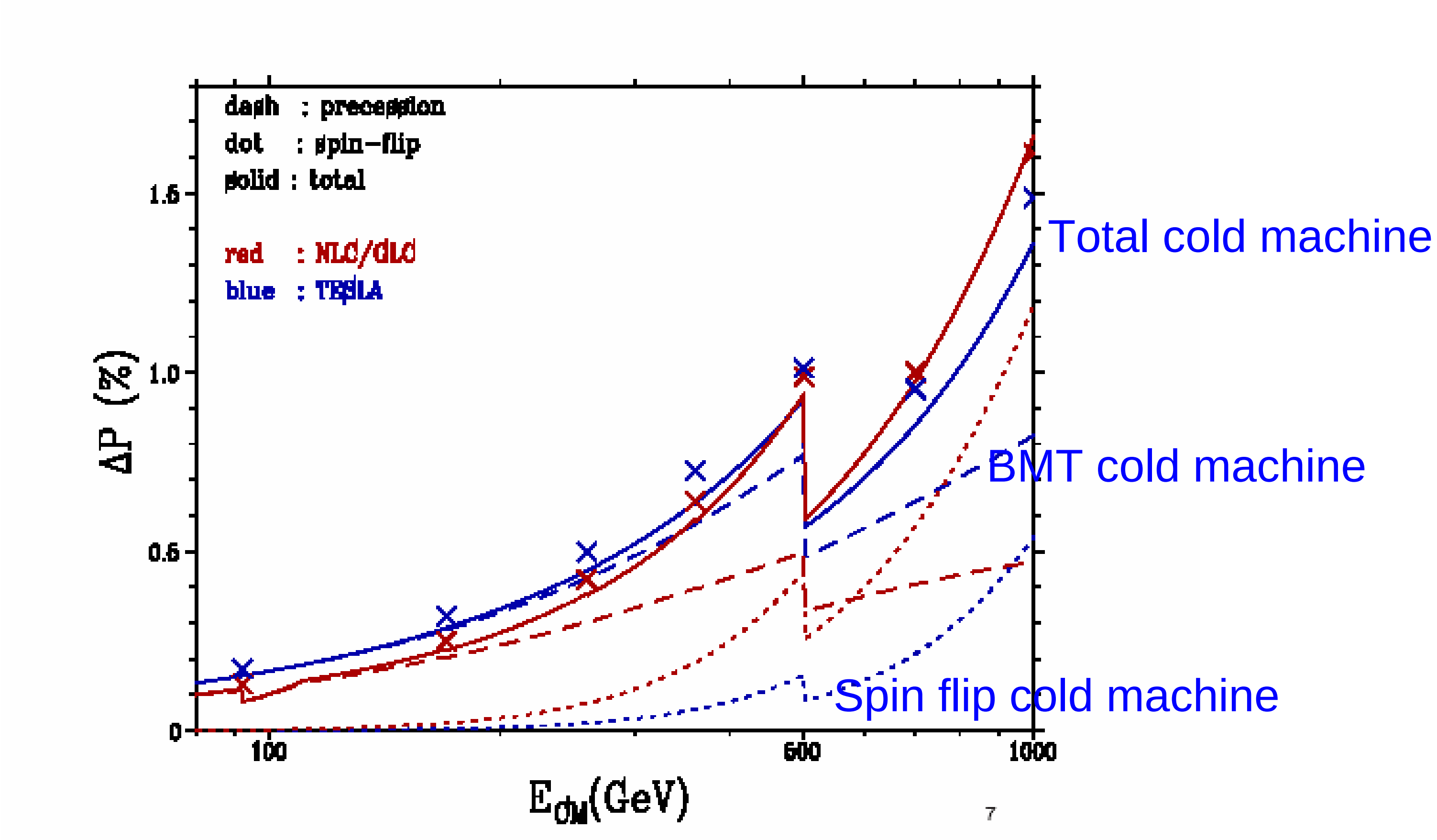
Beam Properties

Parameter	e^+e^-
$\sigma(\theta_x)^{in}$	35 μrad
$\sigma(\theta_y)^{in}$	10 μrad
$\sigma(\theta_x)^{out}$	275 μrad
$\sigma(\theta_y)^{out}$	55 μrad
$(\Delta P^{BMT})_{IP\text{-}Lum\ wt}$	0.3 %

Angular divergences of the incoming and outgoing disrupted beams for ILC collision parameters.

BMT depolarization due to the angular divergences.

From K. Yokoya talk at MDI workshop



Note for cold machine depolarization dominated by BMT

R- Transport matrix

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,

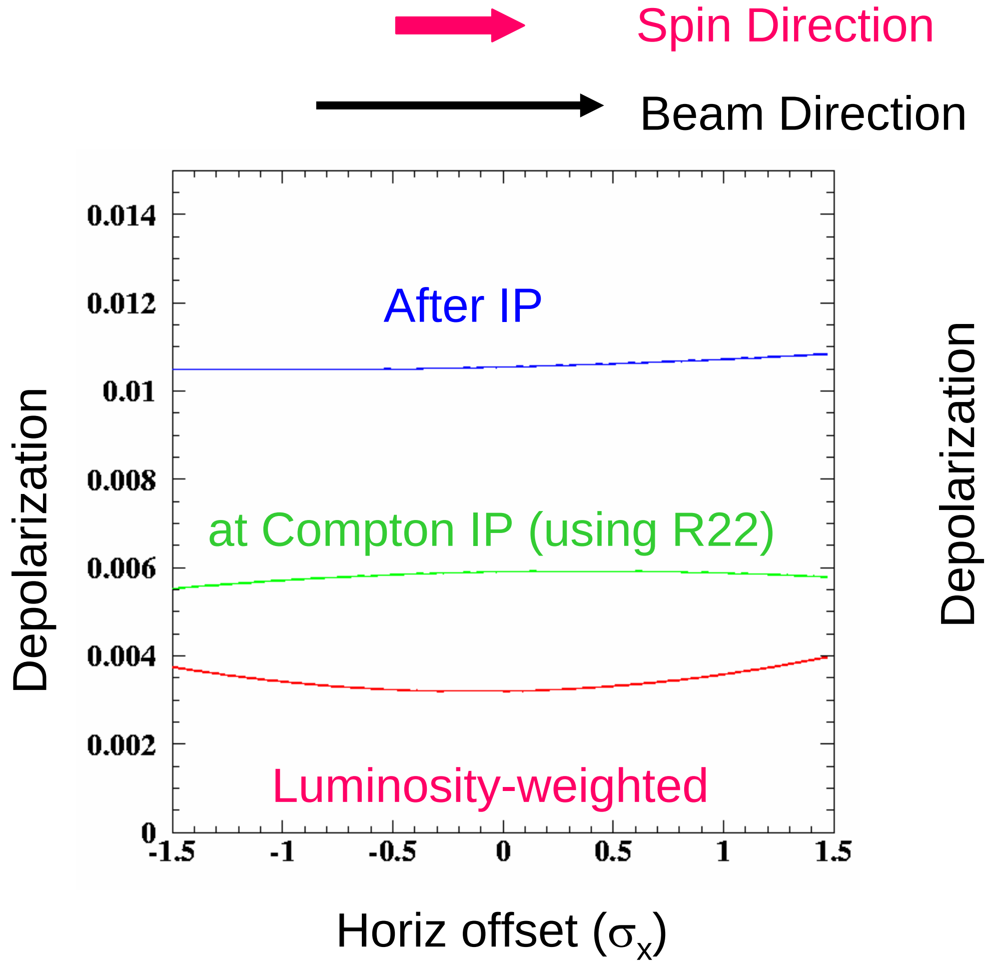
$$|x\rangle_{chicane} = R|x\rangle_{IP} \quad \text{for beam parameters} \quad (x, x', y, y', z, {dE}/{E})$$

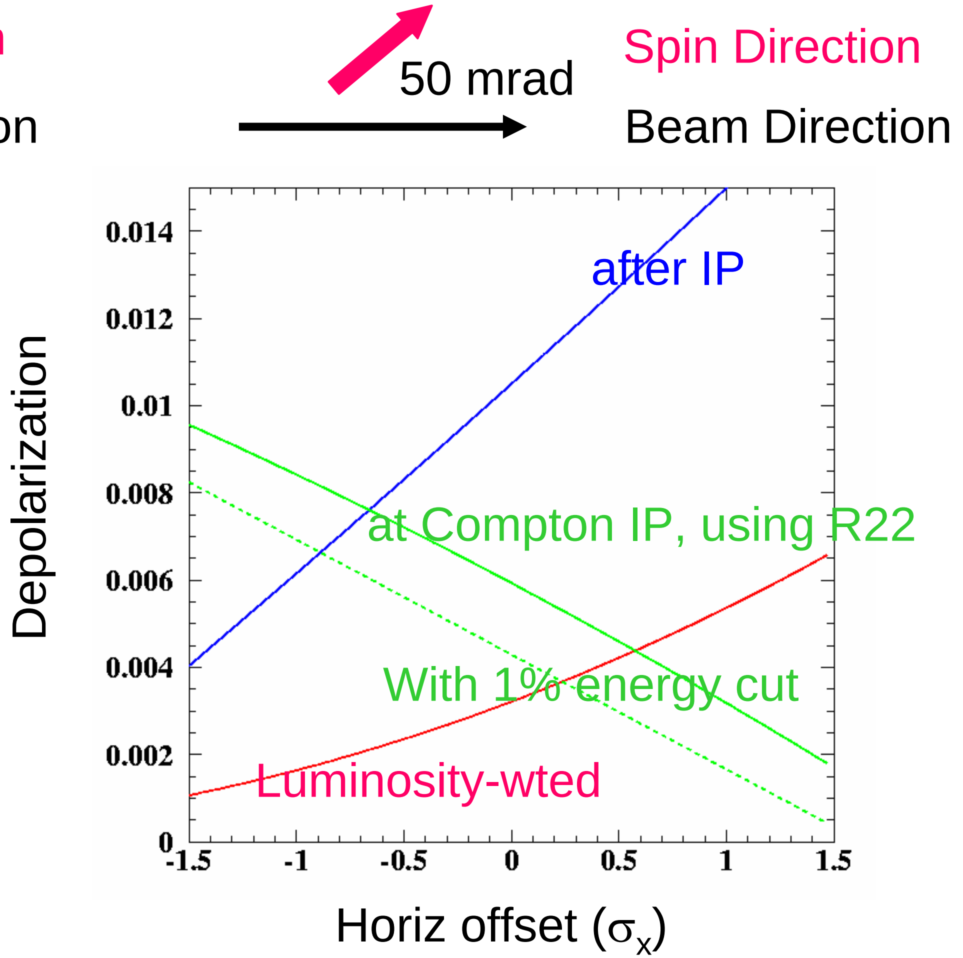
R22 and R44 give the angular magnification from collider IP to Compton IP.

- 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.

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):

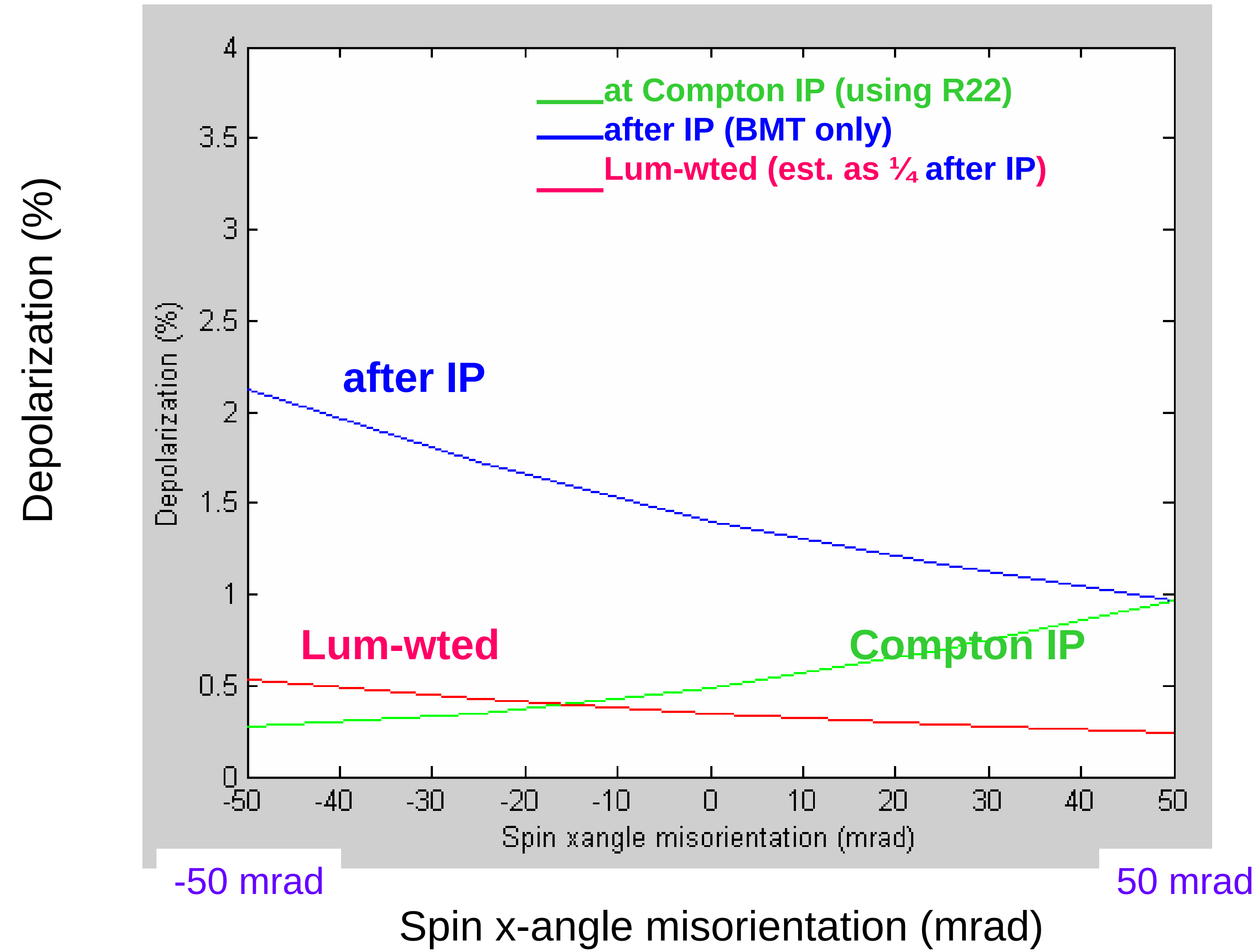




Uses one of the TESLA TRC files, Guinea-PIG simulation

R22 = -0.595

500nm horizontal offset (~1 sigma)



From Mike Woods

Comments

- Polarimeter measures "green" results at Compton IP. We want "red" = Lum-wted P.
- Prefer R22 close to -0.5 so good sensitivity to BMT and spin flip.
- Important to limit
  1. Spin angle misalignment <25mrad (corresponds to angular alignment ~50 μrad at 250GeV)
  2. Horizontal offsets (<250nm).

Use depolarization vs beam offset determined from IP BPMs as diagnostic for spin miss-orientation at IP.

Spin Alignment Procedures

The procedure for setting the spin direction so the electrons are longitudinally polarized at the IP is as follows:

Accurate beamline and quad alignment is needed to achieve <~10μrad orbit tolerance between the IP and either upstream or downstream polarimeter locations.

Obtain reference orbit through the extraction line with solenoid off and with electron-beam only (no collisions).

Optimize spin rotator settings with solenoid off. Perform a "3-state measurement" with each of *x, y* and *z* spin orientation in the Linac: measure the longitudinal spin component at each of the upstream/downstream polarimeters for each of the 3 spin orientations. The z-component of the spin transport matrix, S, between the Linac and the polarimeter can then be determined using

$$P_z^{polarimeter} = S_{zx} \cdot P_x^{Linac} + S_{zy} \cdot P_y^{Linac} + S_{zz} \cdot P_z^{Linac}$$

This determines the (unitary) spin transport matrix. It can be inverted to determine the optimal RTL and LINAC spin rotator settings to achieve longitudinal spin at the polarimeter.

Spin Alignment Procedures con't

Scan each individual spin rotator about optimal to check or fine tune the settings.

Turn on the solenoid and serpentine/dipole compensation and reproduce the extraction line orbit. Then repeat the spin rotator optimization procedure described in steps above.

Analysis of this data should verify the relative alignment of the upstream and downstream polarimeters and determine the uncertainties in orbit and spin alignment between the polarimeters and the IP.

We expect to achieve 25 mrad tolerances for the orientation of the spin at either the upstream or downstream polarimeters via the procedure described above. Additionally, we expect to achieve a tolerance of 50 μrad for the orbit between the IP and either polarimeter, with the IR solenoid off; the largest uncertainty comes from the orbit through the Interaction Region. Lastly, we expect to compensate the crossing angle/solenoid steering effects to better than 10%.

Other Spin Transport Studies Needed

- Spin transport studies of electron beam through helical undulator
  - Spin diffusion
  - Spin rotation
  - Spin flip
- Positron polarization spin transport
  - Optimum energy and energy spread of positrons in return line to positron damping ring.