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Spin Dynamics in the Interaction Region

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Abstract

I have studied the movement of the spin vector in various situations near the interaction point. Special emphasis is put on the required tolerance on the magnets involved in order not to limit the envisaged measurements.

1 Introduction

When a polarized electron or positron bunch crosses the magnets at the interaction region (the experimental solenoid) of a linear collider the electromagnetic fields exert forces on the spin which alter the spin direction. These effects are investigated in a number of magnet configurations with and without a crossing angle.

The spin precession is calculated by numerical integration of the Thomas-BMT equation

$$\frac{d\vec{S}}{dt} = \vec{\Omega}_{\mathrm{BMT}} \times \vec{S}$$
with
$$\vec{\Omega}_{\mathrm{BMT}} = -\frac{e}{\gamma m}\left[(1+a\gamma)\,\vec{B}_{\perp} + (1+a)\,\vec{B}_{\parallel} + f\left(\vec{E}\right)\right] \tag{1}$$

(a is the anomalous magnetic moment of the electron (g-2)/2). The magnetic field $\vec{B}$ is separated into a component $\vec{B}_{\perp}$ perpendicular to the direction of motion and one parallel $\vec{B}_{\parallel}$. There are no electric fields at the interaction region. The term $f\left(\vec{E}\right)$ does not contribute. Likewise the equation of motion

$$\frac{d\vec{p}}{dt} = e\left(\vec{v} \times \vec{B}\right) \tag{2}$$

is integrated numerically. A bunch is treated as a single particle with no spacial extent. Technically speaking a loop is executed with the following steps

1. Calculate magnetic field at position $\vec{r}$.
2. Calculate an infinitesimal step $\Delta\vec{S} = d\vec{S}/dt\ \Delta t$ and $\Delta\vec{p} = d\vec{p}/dt\ \Delta t$ from the equations above and derive $\Delta\vec{r}$ from $\Delta\vec{p}$.
3. Calculate the new spin vector, momentum and position ($\vec{S}' = \vec{S} + \Delta\vec{S}$)
4. Back to 1.

2 Experimental Setups

Two principal configurations are discussed:

- Head-on collisions as envisaged for TESLA. The polarimeter is located down-stream of the detector. It is assumed that the spin direction is manipulated until the polarimeter shows a maximal polarization in the longitudinal or transverse direction. It is then assumed that this polarization is transported without further modifications to a point 10 meters before the interaction point where the tracking starts.

  The bunches pass through the two quadrupoles of the final focus and into the solenoidal field of the detector to the IP where the final spin direction is recorded. All spin rotations and depolarizations are taken between the IP and the point 10 meters in front of the IP where the tracking started.

- Collisions under a half-crossing angle of 10 mrad. Such a crossing angle is mandatory for a warm linear collider and is also an option for TESLA. The polarimeter is now down-stream of the IP and the spin will be manipulated to maximize the polarization in this down-stream location. For simplicity it is assumed that the polarimeter is located 10 meters down-stream of the IP. The magnetic chicane at the polarimeter is not included in the simulation.

  In this situation the bunch has to be tracked from the IP to the polarimeter, but to simplify the calculations the bunch is tracked backwards from the polarimeter to the IP as above. The bunch will leave the solenoidal field on its way to the polarimeter. It will not pass through the quadrupoles. There is one more magnet between the IP and the polarimeter. This is a dipole compensating the bend in the horizontal plane introduced by the solenoidal field and the crossing angle. The bending angle can be calculated to

  $$\sin\frac{\theta}{2} = \frac{\sin\alpha\,\ell_0 B_0}{2\,B\rho} \tag{3}$$

  where $\alpha = 10$ mrad is half the crossing angle, $\ell_0 B_0 = 30$ Tm is the length and strength of the solenoid and $B\rho = p/e$ is the magnetic rigidity of the beam. For an ideal solenoid the corrector magnet must have a field integral of

  $$\ell_C B_C = \sin\alpha\,\ell_0 B_0. \tag{4}$$

  The fringe field of a real solenoid will reduce the bend substantially. I have chosen the field integral of the compensator dipole such that not net bend appears.

Each of the two configurations is calculated in three different variations.

- An ideal solenoid is used with a perfectly homogeneous field inside the coil and no field outside (no fringe field). Neither the quadrupoles for the head-on scheme nor the corrector dipole in the case of crossing angle are taken into account. This unrealistic situation indicates the magnitude of the potential effects on the spin.

- The solenoid is simulated as a real magnet with field inhomogeneities and its fringe field. A field map calculated for the Large Detector concept for the NLC is used. Figures 1 and 2 show the longitudinal field on axis of the magnet and the radial field 1 cm away from the axis. The magnetic field at a certain point is derived from the longitudinal field on axis by the method described in [1]. As above quadrupoles and the corrector dipole are not taken into account.

- In the third variation the same solenoid is used, but now the quadrupoles are included for head-on and the corrector dipole for the crossing angle situation. This corresponds to a possible realistic situation.

3 Results

In the appendix tables with the results are presented. Each table gives the polar angle θ and the azimuth ϕ of the spin vector at the interaction point. The depolarization is calculated as $1 - \cos\alpha$ where α is the angle to the z-direction in the case of longitudinal polarization and the angle to the x-y plane in the case of transverse polarization.

The first line gives the spin rotation in a situation where all magnets and the beam are perfectly aligned and the magnets produce their nominal fields. Then a number of misadjustments are considered. They are listed below. The line labeled 'real beam' gives the spin rotation and its spread if all parameters are randomly misaligned. In order to determine the spread the bunch is tracked 100 times with randomly distributed misadjustments and the average is taken. For the following block of lines superscribed 'single parameter effects' all parameters were kept at their nominal value except for the one parameter listed in each line. This gives an indication on the contribution of each parameter to the real beam situation. But one can clearly see, that the depolarizations introduced by all single parameter effects do not add up to the depolarization of the real beam. This can be understood, if one calculates the depolarization (longitudinal polarization) as

$$\text{depol} = 1 - \cos(\theta_0 + \theta_i) \approx \theta_0\theta_i + \frac{1}{2}\theta_i^2 \tag{5}$$

where θ_i is the spin rotation angle introduced by the parameter considered and θ_0 is the rotation angle with this parameter at its nominal value. In the case of single parameter variations θ_0 vanishes in the case of head-on collisions and the sensitivity of the depolarization is reduced to a quadratic dependence on the (hopefully) small angles θ_i. In the case of a crossing angle and in the real beam situation for both configurations θ_0 does not vanish and we get a higher sensitivity to misadjustments.

The second block of entries in the tables, superscribed by 'cumulative effects' tries to estimate the contributions of a single parameter in the real beam situation. All parameters are varied except for the one parameter listed in each line. The spread is calculated as the quadratic difference between the real beam situation and the situation where this one parameter is at its nominal value. This should give an estimate of its contribution in the real beam situation.

The acronyms of the parameters and the amount of variations are explained in Appendix A. The adjustment tolerances of each parameter are a rough estimate of what should be achievable without extraordinary effort.

4 Conclusions

All results are given in tables in the appendix.

For each configuration the spin has been tracked for 45 GeV and for 250 GeV. There is hardly any visible dependence on the beam energy at all. This can be readily understood from the Thomas-BMT equation (eqn. 1). The leading term in Ω_{BMT} is independent of γ. The momentum of the particles only enters as a second order effect. There is a small dependence in the beam energy for head-on collisions where the bunch transverses the quadrupoles between the polarimeter and the IP. If the beam is off-axis in a quadrupole, it sees a net bending field. For proper focusing, the strength of the quadrupole k scales linear with the beam energy. Spin rotations are therefore smaller at smaller energies.

For the first configuration with an ideal solenoid an no further magnet there is no effect on a longitudinal spin in head-on collisions at all. The spin is aligned to the longitudinal direction at the IP with the same precision as it started in the polarimeter. This is different in the case of a crossing angle. First of all, there is a spin rotation between the IP and the downstream polarimeter of roughly 80 mrad, corresponding to a depolarization of 0.33 %. This effect is not severe and could be compensated with a polarimeter that would have to align the spin direction to a preset value of -80 mrad. Second, there is a small sensitivity to alignments, mainly to the alignment of the solenoid axis and the beam in the plane of the crossing angle. The cumulative effect of the misalignments adds up to almost 0.1 %.

In the second configuration the ideal solenoid is replaced by a realistic solenoid with fringe fields. Nothing changes for head-on collisions. There is neither a spin rotation nor a depolarization by the solenoid. In the case of the crossing angle the fringe field reduces the spin rotation between the IP and the down-stream polarimeter by about a factor of 3 and it reduces the sensitivity to misalignments correspondingly. The simulation indicates a non-negligible sensitivity to the fringe field itself, but this is exaggerated. It was assumed that it is only know to 10 %. If the fringe field is measured properly before the magnet is installed this effect will become negligible.

In the third configuration the quadrupoles are included for head-on collisions. Alignment tolerances between the beam and the quadrupole on the 0.1 mm level create a depolarization of 0.3 % with an error of the same size which is barely acceptable. The alignment of the beam through the quadrupole has to be understood at least at that level.

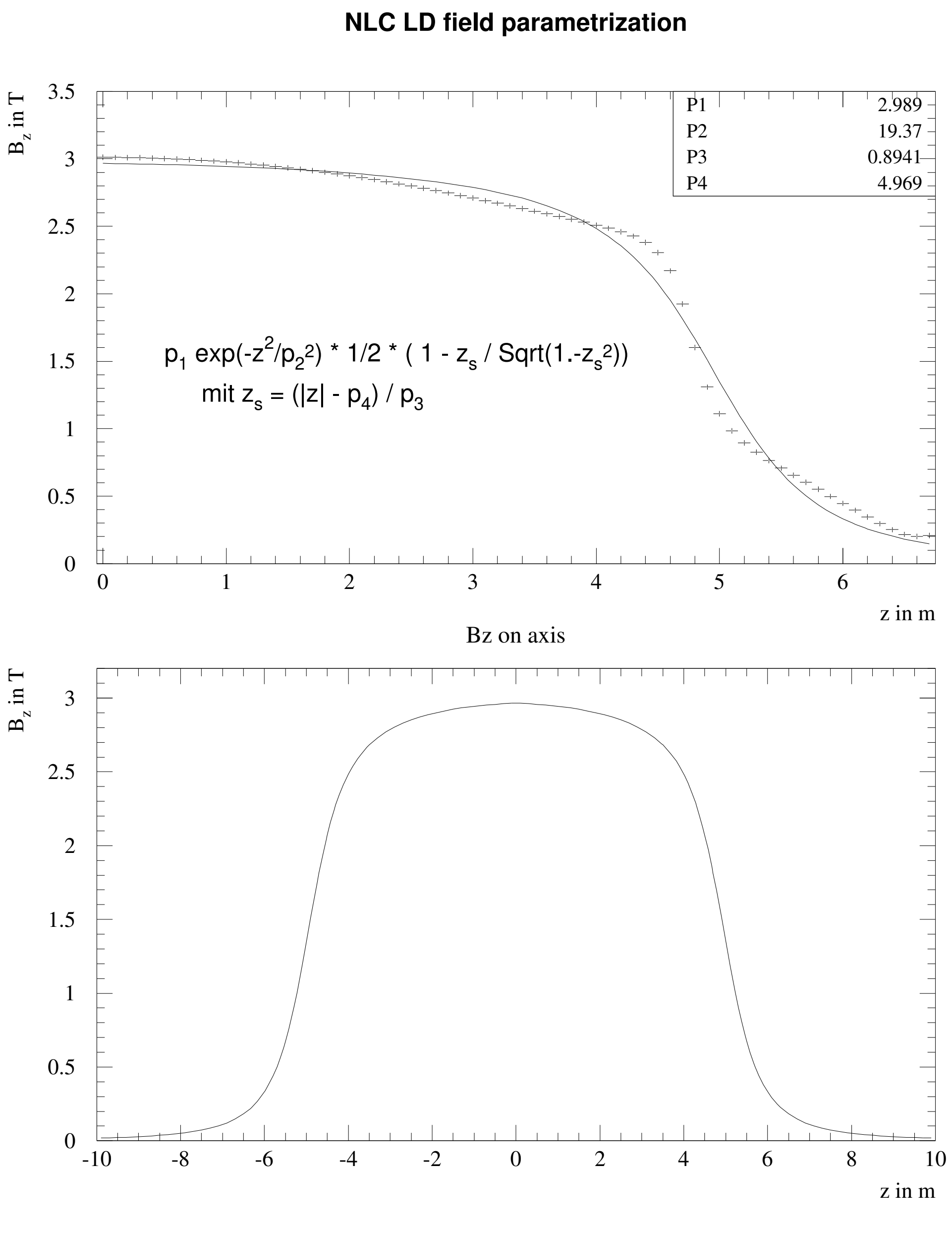

Figure 1: Longitudinal field on axis of the NLC Large Detector solenoid. The upper plot shows the calculated field (crosses) together with the parameterization used in this note. The lower plot shows just the parameterization in a wider range.

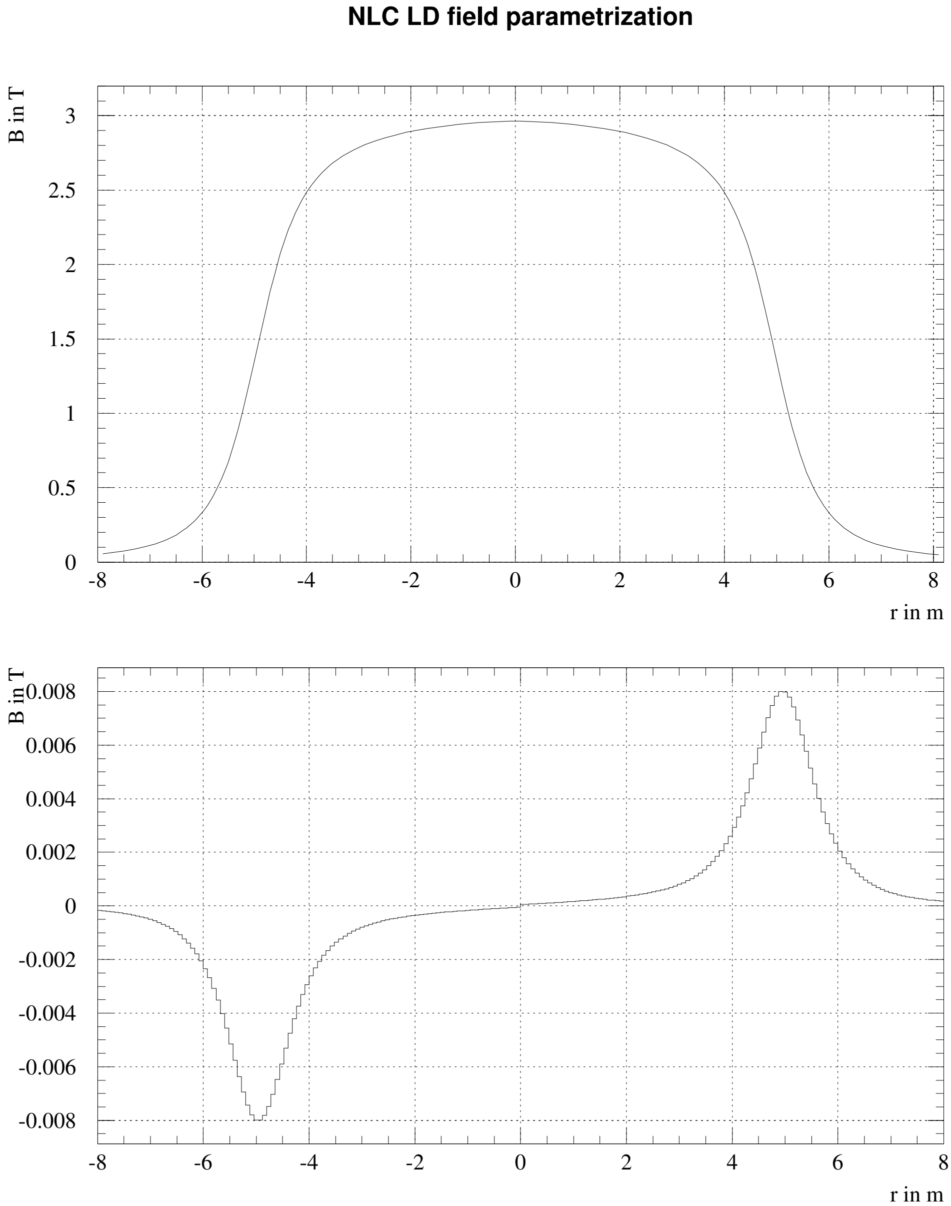

Figure 2: The upper plot shows once more the longitudinal field on the axis of the NLC LD solenoid. The lower plot shows the radial field 1cm away from the magnet's axis.

References

[1] E. Freytag und G. Ripken, *Nichtlineare Störungen im Speicherring durch das longitudinale, rotationssymmetrische Magnetfeld einer Detektoranordnung*, DESY E3/R1-73/1.

A Parameters

solenoid offset	Offset of the center of the detector solenoid with respect to the interaction point simulated as a gaussian distribution sigma in x: 1 mm sigma in y: 1 mm sigma in z: 2 mm
solenoid rotation	Rotations of the solenoid with respect to the beam reference frame (gaussian distributions). The rotations are applied subsequently. 1.st Euler Angle, rot. around vertical axis: 0.25 mrad 2.nd Euler Angle, rot. around detector axis: 0.25 mrad 3.rd Euler Angle, rot. around vertical axis: 0.25 mrad
solenoid strength	Variation of the overall strength of the solenoidal field by 0.1 %.
solenoid correction	The steepness of the drop-off of the field at the end of the magnet is varied by gaussian smearing of the parameter p_3 in the field parameterization by 0.5 %.
solenoid fringe-range	The shape of the fringe-field is modified by smearing the parameter p_4 in the field parameterization by 10 .
QUAD offset	The position of the quadrupoles is varied by 0.1 mm in x and y and 2 mm in z.
QUAD orientation	The orientation of the quadrupoles is modified by three Euler rotations as described for the solenoid. The sigmas of the rotations are 0.1 mrad each.
QUAD gradient	The gradient of the two quadrupoles is simultaneously varied by 0.1 %
CORR offset	The position of the corrector dipole is varied by 1 mm in x and y and 2 mm in z.
CORR orientation	The orientation of the corrector dipole is modified by three Euler rotations as described for the solenoid. The sigmas of the rotations are 0.5 mrad each.
CORR strength	The strength of the corrector dipole field is varied by 0.1 %.

spin azimuth	This corresponds to the azimuthal angle of the spin vector when it is aligned in the polarimeter. In case of transverse polarization it is assumed to be aligned with an accuracy of 25 mrad into an upright vertical direction in the x-y plane. In the case of longitudinal polarization the azimuth is uniformly distributed between 0 and 2 π.
Spin alignment	Alignment of the spin vector in the z-direction. For longitudinal polarization the polar angle of the spin is aligned to the z-direction such that the polarimeter gives a maximum reading within an error of 10^{-4}. In the case of transverse polarization the spin is assumed to be perfectly aligned perpendicular to the z-direction.
beam energy	The beam energy is smeared by a gaussian distribution of 1 % width to simulate the energy loss of the particles at the IP due to beam strahlung. Only half of the gaussian distribution is used always reducing the energy from the nominal beam energy. This is only applied to the crossing angle scenario where the polarimeter follows the interaction.
beam offset	The beam is offset at the start of the tracking (i.e. in the polarimeter) with respect to its nominal position is varied by 0.1 mm in x and y.
beam angle	The beam direction at the start of the tracking (i.e. in the polarimeter) with respect to its nominal direction is varied by 0.1 mrad in the x-z and y-z planes.

B Ideal Solenoid — No Fringe Fields

B.1 Longitudinal Polarization

B.1.1 Head-On Collisions, 45 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	0.0±0.0	0.0± 0.0	0.00± 0.00
real beam	11.7±4.6	59.9±1726.5	0.01± 0.01
single parameter effects	±	±	±
solenoid offset in x	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid offset in y	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid offset in z	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 1	1.5±1.1	-93.8±1575.9	0.00± 0.00
solenoid rotation 2	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 3	1.7±1.3	-31.0±1578.4	0.00± 0.00
solenoid strength	0.0±0.0	0.0± 0.0	0.00± 0.00
spin azimuthal ang.	0.0±0.0	0.0± 0.0	0.00± 0.00
Spin alignment	11.1±4.5	80.1± 0.1	0.01± 0.01
Beam energy	0.0±0.0	0.0± 0.0	0.00± 0.00
beam offset in x	0.0±0.0	0.0± 0.0	0.00± 0.00
beam offset in y	0.0±0.0	0.0± 0.0	0.00± 0.00
beam angle in x-z	0.7±0.5	-31.4±1578.4	0.00± 0.00
beam angle in y-z	0.7±0.5	-1602.2±1578.4	0.00± 0.00
cummulative effects	±	±	±
solenoid offset in x	12.3±0.0	-21.4± 186.6	0.01± 0.00
solenoid offset in y	12.8±0.0	-61.2± 0.0	0.01± 0.00
solenoid offset in z	12.0±0.0	303.5± 0.0	0.01± 0.00
solenoid rotation 1	11.6±0.7	42.1± 0.0	0.01± 0.00
solenoid rotation 2	12.1±0.0	-207.6± 0.0	0.01± 0.00
solenoid rotation 3	11.5±0.0	30.0± 673.2	0.01± 0.00
solenoid strength	11.6±0.0	-236.7± 0.0	0.01± 0.00
spin azimuthal ang.	11.3±1.0	81.5±1692.3	0.01± 0.00
Spin alignment	2.7±4.2	-124.0± 269.5	0.00± 0.01
Beam energy	11.6±0.0	170.1± 0.0	0.01± 0.00
beam offset in x	12.0±0.0	36.6± 0.0	0.01± 0.00
beam offset in y	11.7±0.0	-93.3± 110.4	0.01± 0.00
beam angle in x-z	12.1±0.0	-46.0± 0.0	0.01± 0.00
beam angle in y-z	12.2±0.0	63.8± 321.0	0.01± 0.00

B.1.2 Head-On Collisions, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	0.0±0.0	0.0± 0.0	0.00± 0.00
real beam	11.7±4.6	-4.9±1728.2	0.01± 0.01
single parameter effects	±	±	±
solenoid offset in x	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid offset in y	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid offset in z	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 1	1.5±1.1	-94.2±1575.9	0.00± 0.00
solenoid rotation 2	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 3	1.7±1.3	-31.4±1578.4	0.00± 0.00
solenoid strength	0.0±0.0	0.0± 0.0	0.00± 0.00
spin azimuthal ang.	0.0±0.0	0.0± 0.0	0.00± 0.00
Spin alignment	11.1±4.5	14.4± 0.0	0.01± 0.01
Beam energy	0.0±0.0	0.0± 0.0	0.00± 0.00
beam offset in x	0.0±0.0	0.0± 0.0	0.00± 0.00
beam offset in y	0.0±0.0	0.0± 0.0	0.00± 0.00
beam angle in x-z	0.7±0.5	-31.4±1578.4	0.00± 0.00
beam angle in y-z	0.7±0.5	-1602.2±1578.4	0.00± 0.00
cummulative effects	±	±	±
solenoid offset in x	12.3±0.0	-26.6± 221.1	0.01± 0.00
solenoid offset in y	12.7±0.0	-123.5± 0.0	0.01± 0.00
solenoid offset in z	12.0±0.0	240.7± 0.0	0.01± 0.00
solenoid rotation 1	11.6±0.7	104.0± 0.0	0.01± 0.00
solenoid rotation 2	12.1±0.0	-144.3± 0.0	0.01± 0.00
solenoid rotation 3	11.5±0.0	29.9± 679.3	0.01± 0.00
solenoid strength	11.6±0.0	-299.8± 0.0	0.01± 0.00
spin azimuthal ang.	11.3±1.0	20.5±1694.2	0.01± 0.00
Spin alignment	2.7±4.2	-124.0± 275.2	0.00± 0.01
Beam energy	11.6±0.0	168.6± 0.0	0.01± 0.00
beam offset in x	12.0±0.0	95.8± 0.0	0.01± 0.00
beam offset in y	11.7±0.0	-160.7± 196.8	0.01± 0.00
beam angle in x-z	12.1±0.0	-46.1± 0.0	0.01± 0.00
beam angle in y-z	12.2±0.0	0.9± 339.2	0.01± 0.00

B.1.3 Crossing Angle, 45 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	81.5±0.0	1571.3± 0.0	0.33± 0.00
real beam	82.6±9.5	1564.9±102.2	0.34± 0.08
single parameter effects	±	±	±
solenoid offset in x	81.5±0.0	1571.3± 0.0	0.33± 0.00
solenoid offset in y	81.5±0.0	1571.3± 0.0	0.33± 0.00
solenoid offset in z	81.6±0.0	1571.3± 0.0	0.33± 0.00
solenoid rotation 1	81.5±1.9	1571.3± 0.4	0.33± 0.02
solenoid rotation 2	81.5±0.0	1571.3± 0.0	0.33± 0.00
solenoid rotation 3	81.6±2.1	1571.3± 0.7	0.33± 0.02
solenoid strength	81.5±0.1	1571.3± 0.0	0.33± 0.00
spin azimuthal ang.	81.5±0.0	1571.3± 0.0	0.33± 0.00
Spin alignment	83.3±1.0	1438.1± 52.5	0.35± 0.01
Beam energy	81.5±0.0	1571.3± 1.0	0.33± 0.00
beam offset in x	81.5±0.0	1571.3± 0.0	0.33± 0.00
beam offset in y	81.5±0.0	1571.3± 0.0	0.33± 0.00
beam angle in x-z	81.5±0.8	1571.3± 0.4	0.33± 0.01
beam angle in y-z	81.6±0.0	1571.1± 10.2	0.33± 0.00
cummulative effects	±	±	±
solenoid offset in x	82.7±0.0	1567.5± 21.7	0.35± 0.00
solenoid offset in y	81.6±0.0	1570.7± 0.0	0.34± 0.00
solenoid offset in z	84.1±0.5	1587.6± 0.0	0.36± 0.00
solenoid rotation 1	83.3±2.3	1572.5± 12.5	0.35± 0.02
solenoid rotation 2	81.6±3.8	1576.0± 0.0	0.34± 0.03
solenoid rotation 3	81.7±2.9	1543.6± 0.0	0.34± 0.02
solenoid strength	80.4±1.7	1570.5± 0.0	0.33± 0.02
spin azimuthal ang.	83.4±9.0	1441.0± 86.4	0.35± 0.07
Spin alignment	81.1±8.9	1571.4±101.6	0.33± 0.07
Beam energy	82.7±0.0	1570.3± 39.7	0.35± 0.00
beam offset in x	81.9±0.0	1568.1± 0.0	0.34± 0.00
beam offset in y	82.3±3.3	1552.0± 0.0	0.34± 0.03
beam angle in x-z	80.8±0.7	1573.3± 0.0	0.33± 0.02
beam angle in y-z	83.0±3.0	1556.5± 0.0	0.35± 0.02

B.1.4 Crossing Angle, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	81.6±0.0	1571.2± 0.0	0.33± 0.00
real beam	82.6±9.4	1564.6±102.1	0.35± 0.08
single parameter effects	±	±	±
solenoid offset in x	81.6±0.1	1571.2± 0.0	0.33± 0.00
solenoid offset in y	81.6±0.1	1571.2± 0.0	0.33± 0.00
solenoid offset in z	81.6±0.0	1571.2± 0.0	0.33± 0.00
solenoid rotation 1	81.6±1.9	1571.2± 1.4	0.33± 0.02
solenoid rotation 2	81.6±0.1	1571.2± 0.0	0.33± 0.00
solenoid rotation 3	81.7±2.1	1571.2± 0.0	0.33± 0.02
solenoid strength	81.6±0.1	1571.2± 0.0	0.33± 0.00
spin azimuthal ang.	81.6±0.1	1571.2± 0.0	0.33± 0.00
Spin alignment	82.7±0.7	1436.4± 53.5	0.34± 0.01
Beam energy	81.6±0.1	1571.2± 0.0	0.33± 0.00
beam offset in x	81.6±0.1	1571.2± 0.0	0.33± 0.00
beam offset in y	81.6±0.1	1571.2± 0.0	0.33± 0.00
beam angle in x-z	81.6±0.8	1571.2± 0.7	0.33± 0.01
beam angle in y-z	81.6±0.0	1571.1± 10.2	0.33± 0.00
cummulative effects	±	±	±
solenoid offset in x	82.7±0.0	1567.1± 10.4	0.35± 0.00
solenoid offset in y	81.7±0.0	1571.2± 0.0	0.34± 0.00
solenoid offset in z	84.3±0.7	1585.7± 0.0	0.36± 0.00
solenoid rotation 1	83.4±2.5	1571.7± 0.0	0.35± 0.02
solenoid rotation 2	81.7±3.7	1576.0± 0.0	0.34± 0.03
solenoid rotation 3	81.6±2.6	1543.8± 0.0	0.34± 0.02
solenoid strength	80.5±1.8	1571.9± 0.0	0.33± 0.02
spin azimuthal ang.	82.8±9.0	1439.4± 85.7	0.34± 0.07
Spin alignment	81.2±8.9	1571.3±101.6	0.33± 0.07
Beam energy	82.7±0.0	1570.2± 41.1	0.35± 0.00
beam offset in x	82.0±0.0	1568.4± 0.0	0.34± 0.00
beam offset in y	82.2±3.3	1551.4± 0.0	0.34± 0.03
beam angle in x-z	80.9±0.9	1574.3± 0.0	0.33± 0.02
beam angle in y-z	83.0±2.8	1555.5± 0.0	0.35± 0.02

B.2 Transverse Polarization

B.2.1 Head-On Collisions, 45 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	1570.8±0.0	1650.9± 0.0	0.00± 0.00
real beam	1571.1±3.3	1649.8±21.4	0.00± 0.00
single parameter effects	±	±	±
solenoid offset in x	1570.8±1.9	1650.9± 0.0	0.00± 0.00
solenoid offset in y	1570.8±1.9	1650.9± 0.0	0.00± 0.00
solenoid offset in z	1570.8±1.9	1650.8± 1.2	0.00± 0.00
solenoid rotation 1	1570.8±1.7	1650.9± 0.0	0.00± 0.00
solenoid rotation 2	1570.8±1.9	1650.9± 0.0	0.00± 0.00
solenoid rotation 3	1571.0±2.1	1650.9± 0.5	0.00± 0.00
solenoid strength	1570.8±1.9	1650.8± 0.6	0.00± 0.00
spin azimuthal ang.	1570.8±1.9	1650.6±21.9	0.00± 0.00
Beam energy	1570.8±1.9	1650.9± 0.0	0.00± 0.00
beam offset in x	1570.8±1.9	1650.9± 0.0	0.00± 0.00
beam offset in y	1570.8±1.9	1650.9± 0.0	0.00± 0.00
beam angle in x-z	1570.8±1.2	1650.9± 0.0	0.00± 0.00
beam angle in y-z	1570.8±0.6	1650.9± 0.0	0.00± 0.00
cummulative effects	±	±	±
solenoid offset in x	1571.2±1.3	1653.4± 0.0	0.00± 0.00
solenoid offset in y	1570.3±2.0	1651.0± 0.0	0.00± 0.00
solenoid offset in z	1570.6±1.6	1651.8± 0.0	0.00± 0.00
solenoid rotation 1	1570.5±2.6	1649.6± 0.0	0.00± 0.00
solenoid rotation 2	1570.6±0.2	1655.3± 0.0	0.00± 0.00
solenoid rotation 3	1570.8±2.3	1648.7± 0.0	0.00± 0.00
solenoid strength	1571.1±1.7	1648.6± 0.0	0.00± 0.00
spin azimuthal ang.	1570.6±0.9	1650.8±21.4	0.00± 0.00
Beam energy	1571.0±1.7	1651.4± 0.0	0.00± 0.00
beam offset in x	1570.7±1.3	1647.8± 0.0	0.00± 0.00
beam offset in y	1571.4±1.1	1652.3± 0.0	0.00± 0.00
beam angle in x-z	1570.4±0.0	1652.0± 0.0	0.00± 0.00
beam angle in y-z	1570.7±1.3	1653.1± 0.0	0.00± 0.00

B.2.2 Head-On Collisions, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	1570.8±0.0	1585.2± 0.0	0.00± 0.00
real beam	1571.1±3.2	1584.2±21.4	0.00± 0.00
single parameter effects	±	±	±
solenoid offset in x	1570.8±1.9	1585.2± 1.6	0.00± 0.00
solenoid offset in y	1570.8±1.9	1585.2± 1.6	0.00± 0.00
solenoid offset in z	1570.8±1.9	1585.2± 0.0	0.00± 0.00
solenoid rotation 1	1570.8±1.8	1585.2± 1.6	0.00± 0.00
solenoid rotation 2	1570.8±1.9	1585.2± 1.6	0.00± 0.00
solenoid rotation 3	1571.0±2.0	1585.2± 1.6	0.00± 0.00
solenoid strength	1570.8±1.9	1585.2± 0.0	0.00± 0.00
spin azimuthal ang.	1570.8±1.9	1584.9±21.9	0.00± 0.00
Beam energy	1570.8±1.9	1585.2± 1.6	0.00± 0.00
beam offset in x	1570.8±1.9	1585.2± 1.6	0.00± 0.00
beam offset in y	1570.8±1.9	1585.2± 1.6	0.00± 0.00
beam angle in x-z	1570.8±0.9	1585.2± 1.6	0.00± 0.00
beam angle in y-z	1570.8±1.2	1585.2± 1.6	0.00± 0.00
cummulative effects	±	±	±
solenoid offset in x	1571.2±0.0	1587.8± 0.0	0.00± 0.00
solenoid offset in y	1570.3±1.7	1585.3± 0.0	0.00± 0.00
solenoid offset in z	1570.6±1.4	1586.2± 0.0	0.00± 0.00
solenoid rotation 1	1570.5±2.4	1583.9± 0.0	0.00± 0.00
solenoid rotation 2	1570.6±0.0	1589.6± 0.0	0.00± 0.00
solenoid rotation 3	1570.7±2.4	1583.0± 0.0	0.00± 0.00
solenoid strength	1571.1±0.7	1583.0± 0.0	0.00± 0.00
spin azimuthal ang.	1570.6±1.0	1585.2±21.4	0.00± 0.00
Beam energy	1571.0±1.1	1585.7± 0.0	0.00± 0.00
beam offset in x	1570.7±0.4	1582.1± 0.0	0.00± 0.00
beam offset in y	1571.4±1.3	1586.6± 0.0	0.00± 0.00
beam angle in x-z	1570.4±0.0	1586.4± 0.0	0.00± 0.00
beam angle in y-z	1570.7±0.4	1587.5± 0.0	0.00± 0.00

B.2.3 Crossing Angle, 45 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	1652.1±0.0	1652.0± 0.0	0.33± 0.00
real beam	1652.4±3.1	1651.6±21.5	0.33± 0.03
single parameter effects	±	±	±
solenoid offset in x	1652.1±1.4	1652.0± 0.0	0.33± 0.00
solenoid offset in y	1652.1±1.4	1652.0± 0.0	0.33± 0.00
solenoid offset in z	1652.1±0.0	1652.0± 0.4	0.33± 0.00
solenoid rotation 1	1652.1±2.1	1652.0± 0.0	0.33± 0.02
solenoid rotation 2	1652.1±1.4	1652.0± 0.0	0.33± 0.00
solenoid rotation 3	1652.3±2.2	1652.0± 0.0	0.33± 0.02
solenoid strength	1652.1±1.2	1652.0± 0.0	0.33± 0.00
spin azimuthal ang.	1652.1±0.0	1651.7±21.9	0.33± 0.00
Beam energy	1652.1±1.0	1652.6± 0.7	0.33± 0.00
beam offset in x	1652.1±1.7	1652.0± 0.0	0.33± 0.00
beam offset in y	1652.1±1.4	1652.0± 0.0	0.33± 0.00
beam angle in x-z	1652.0±1.6	1652.0± 0.0	0.33± 0.01
beam angle in y-z	1652.1±0.6	1652.0± 1.4	0.33± 0.00
cummulative effects	±	±	±
solenoid offset in x	1652.5±0.0	1655.3± 0.0	0.33± 0.00
solenoid offset in y	1651.5±1.1	1652.9± 0.0	0.33± 0.01
solenoid offset in z	1651.8±1.0	1653.6± 0.0	0.33± 0.01
solenoid rotation 1	1651.8±2.2	1651.3± 0.0	0.33± 0.02
solenoid rotation 2	1651.8±0.0	1657.1± 0.0	0.33± 0.00
solenoid rotation 3	1652.0±2.2	1650.5± 0.0	0.33± 0.02
solenoid strength	1652.3±1.7	1650.4± 0.0	0.33± 0.01
spin azimuthal ang.	1651.9±0.2	1652.7±21.5	0.33± 0.01
Beam energy	1652.3±1.4	1652.6± 0.0	0.33± 0.01
beam offset in x	1652.0±1.2	1649.6± 0.0	0.33± 0.01
beam offset in y	1652.6±0.0	1654.1± 0.0	0.34± 0.01
beam angle in x-z	1651.7±0.8	1653.8± 0.0	0.33± 0.00
beam angle in y-z	1652.0±0.0	1654.9± 0.0	0.33± 0.00

B.2.4 Crossing Angle, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	1652.4±0.0	1586.1± 0.0	0.33± 0.00
real beam	1652.7±3.3	1585.2±21.5	0.34± 0.03
single parameter effects	±	±	±
solenoid offset in x	1652.4±0.0	1586.1± 1.8	0.33± 0.00
solenoid offset in y	1652.4±0.0	1586.1± 1.8	0.33± 0.00
solenoid offset in z	1652.4±0.0	1586.1± 1.1	0.33± 0.00
solenoid rotation 1	1652.5±2.4	1586.1± 0.7	0.33± 0.02
solenoid rotation 2	1652.4±0.0	1586.1± 1.8	0.33± 0.00
solenoid rotation 3	1652.6±2.5	1586.1± 0.9	0.34± 0.02
solenoid strength	1652.4±0.2	1586.1± 0.0	0.33± 0.00
spin azimuthal ang.	1652.4±0.0	1585.8±22.0	0.33± 0.00
Beam energy	1652.4±0.0	1586.2± 0.0	0.33± 0.00
beam offset in x	1652.4±0.0	1586.1± 1.9	0.33± 0.00
beam offset in y	1652.4±0.0	1586.1± 1.8	0.33± 0.00
beam angle in x-z	1652.4±0.0	1586.1± 0.5	0.33± 0.01
beam angle in y-z	1652.4±0.7	1586.1± 1.0	0.33± 0.00
cummulative effects	±	±	±
solenoid offset in x	1652.8±0.0	1588.8± 0.0	0.34± 0.00
solenoid offset in y	1651.9±1.0	1586.4± 0.0	0.33± 0.01
solenoid offset in z	1652.2±1.9	1587.2± 0.0	0.33± 0.01
solenoid rotation 1	1652.1±2.8	1584.9± 0.0	0.33± 0.02
solenoid rotation 2	1652.2±0.9	1590.6± 0.0	0.33± 0.00
solenoid rotation 3	1652.4±2.6	1584.0± 0.0	0.33± 0.02
solenoid strength	1652.7±1.2	1584.0± 0.0	0.34± 0.01
spin azimuthal ang.	1652.3±0.8	1586.2±21.5	0.33± 0.01
Beam energy	1652.6±1.7	1586.6± 0.0	0.33± 0.01
beam offset in x	1652.3±1.7	1583.1± 0.0	0.33± 0.01
beam offset in y	1653.0±1.2	1587.6± 0.0	0.34± 0.01
beam angle in x-z	1652.0±0.0	1587.4± 0.0	0.33± 0.00
beam angle in y-z	1652.3±0.5	1588.5± 0.0	0.33± 0.00

C Real Solenoid

C.1 Longitudinal Polarization

C.1.1 Head-On Collisions, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	0.0±0.0	0.0± 0.0	0.00± 0.00
real beam	11.7±5.7	-98.7±1809.0	0.01± 0.01
single parameter effects	±	±	±
solenoid offset in x	0.8±0.6	124.6±1573.7	0.00± 0.00
solenoid offset in y	0.7±0.6	1224.2±1540.0	0.00± 0.00
solenoid offset in z	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 1	1.9±1.5	62.6±1577.4	0.00± 0.00
solenoid rotation 2	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 3	1.7±1.1	94.0±1575.9	0.00± 0.00
solenoid strength	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid correction	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid fringe rnge	0.0±0.0	0.0± 0.0	0.00± 0.00
spin azimuthal ang.	0.0±0.0	0.0± 0.0	0.00± 0.00
Spin alignment	11.3±5.3	17.4± 0.0	0.01± 0.01
Beam energy	0.0±0.0	0.0± 0.0	0.00± 0.00
beam offset in x	0.1±0.1	-158.1±1570.8	0.00± 0.00
beam offset in y	0.1±0.1	1632.6±1577.4	0.00± 0.00
beam angle in x-z	1.2±0.9	-94.7±1575.9	0.00± 0.00
beam angle in y-z	1.3±1.0	1538.9±1578.4	0.00± 0.00
cummulative effects	±	±	±
solenoid offset in x	11.7±3.1	-361.2± 0.0	0.01± 0.00
solenoid offset in y	11.9±1.3	24.9± 0.0	0.01± 0.00
solenoid offset in z	11.5±0.0	-29.4± 0.0	0.01± 0.00
solenoid rotation 1	12.0±2.8	-36.1± 397.9	0.01± 0.00
solenoid rotation 2	11.9±1.4	-55.8± 0.0	0.01± 0.00
solenoid rotation 3	12.0±1.8	29.1± 366.9	0.01± 0.00
solenoid strength	12.0±2.4	-49.9± 0.0	0.01± 0.00
solenoid correction	12.9±1.4	-158.4± 0.0	0.01± 0.00
solenoid fringe rnge	11.4±2.5	-0.2± 0.0	0.01± 0.00
spin azimuthal ang.	11.8±2.4	-6.7±1758.3	0.01± 0.00
Spin alignment	3.6±5.3	103.8± 784.9	0.00± 0.01
Beam energy	12.2±0.0	-89.5± 0.0	0.01± 0.00
beam offset in x	11.7±3.2	-46.9± 389.3	0.01± 0.00
beam offset in y	11.1±2.3	68.5± 608.1	0.01± 0.00
beam angle in x-z	11.7±2.5	117.8± 283.5	0.01± 0.00
beam angle in y-z	11.7±3.3	258.8± 0.0	0.01± 0.00

C.1.2 Crossing Angle, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	49.8± 0.0	1571.8± 0.0	0.12± 0.00
real beam	50.5±11.4	1575.8±189.1	0.13± 0.06
single parameter effects	±	±	±
solenoid offset in x	49.7± 1.0	1571.8± 0.0	0.12± 0.01
solenoid offset in y	49.8± 0.0	1574.9± 18.5	0.12± 0.00
solenoid offset in z	49.8± 0.0	1571.8± 0.0	0.12± 0.00
solenoid rotation 1	49.9± 2.5	1571.8± 0.9	0.12± 0.01
solenoid rotation 2	49.8± 0.0	1571.7± 0.6	0.12± 0.00
solenoid rotation 3	49.9± 2.1	1571.8± 0.5	0.12± 0.01
solenoid strength	49.8± 0.1	1571.8± 1.4	0.12± 0.00
solenoid correction	49.8± 0.0	1571.8± 0.0	0.12± 0.00
solenoid fringe rnge	50.1± 5.1	1571.8± 0.0	0.13± 0.03
spin azimuthal ang.	49.8± 0.0	1571.8± 0.0	0.12± 0.00
Spin alignment	51.5± 1.3	1351.7± 99.9	0.13± 0.01
Beam energy	49.8± 0.0	1571.8± 0.0	0.12± 0.00
beam offset in x	49.8± 0.1	1571.8± 0.4	0.12± 0.00
beam offset in y	49.8± 0.0	1571.8± 1.9	0.12± 0.00
beam angle in x-z	49.9± 1.5	1571.8± 0.0	0.12± 0.01
beam angle in y-z	49.8± 0.0	1571.3± 33.1	0.12± 0.00
cummulative effects	±	±	±
solenoid offset in x	48.7± 6.6	1610.4± 47.0	0.12± 0.04
solenoid offset in y	50.2± 3.3	1566.0± 27.2	0.13± 0.02
solenoid offset in z	51.3± 5.2	1581.4± 0.0	0.14± 0.02
solenoid rotation 1	50.1± 4.6	1572.7± 0.0	0.13± 0.03
solenoid rotation 2	51.0± 6.9	1563.2± 0.0	0.13± 0.03
solenoid rotation 3	51.0± 5.5	1562.1± 0.0	0.14± 0.03
solenoid strength	50.4± 3.2	1593.4± 0.0	0.13± 0.01
solenoid correction	49.2± 5.3	1625.3± 0.0	0.13± 0.03
solenoid fringe rnge	50.6± 7.9	1584.9± 0.0	0.13± 0.04
spin azimuthal ang.	52.1± 9.1	1354.4±160.3	0.14± 0.04
Spin alignment	49.0± 9.9	1566.4±185.4	0.12± 0.05
Beam energy	49.4± 0.0	1568.8± 0.0	0.13± 0.00
beam offset in x	51.4± 6.1	1561.5± 44.6	0.14± 0.03
beam offset in y	50.3± 2.0	1567.9±104.9	0.13± 0.02
beam angle in x-z	52.2± 6.0	1564.0± 62.2	0.14± 0.03
beam angle in y-z	51.6± 4.5	1591.7± 0.0	0.14± 0.02

D Full Configuration

D.1 Longitudinal Polarization

D.1.1 Head-On Collisions, 45 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	0.0±0.0	0.0± 0.0	0.00± 0.00
real beam	16.5±9.4	354.5±1811.7	0.02± 0.02
single parameter effects	±	±	±
solenoid offset in x	1.0±0.7	-132.1±1573.7	0.00± 0.00
solenoid offset in y	1.1±0.9	1470.1±1575.9	0.00± 0.00
solenoid offset in z	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 1	2.1±1.6	-95.8±1575.9	0.00± 0.00
solenoid rotation 2	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 3	2.4±1.8	29.9±1578.4	0.00± 0.00
solenoid strength	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid correction	0.0±0.0	0.0± 0.0	0.00± 0.00
solenoid fringe rnge	0.0±0.0	0.0± 0.0	0.00± 0.00
QUAD offset in x	0.3±0.2	-1869.7±1532.6	0.00± 0.00
QUAD offset in y	0.3±0.2	78.1±1578.7	0.00± 0.00
QUAD offset in z	0.0±0.0	0.0± 0.0	0.00± 0.00
QUAD rotation 1	0.0±0.0	0.0± 0.0	0.00± 0.00
QUAD rotation 2	0.0±0.0	0.0± 0.0	0.00± 0.00
QUAD rotation 3	0.0±0.0	0.0± 0.0	0.00± 0.00
QUAD strength	0.0±0.0	0.0± 0.0	0.00± 0.00
spin azimuthal ang.	0.0±0.0	0.0± 0.0	0.00± 0.00
Spin alignment	11.7±5.4	96.6± 0.1	0.01± 0.01
Beam energy	0.0±0.0	0.0± 0.0	0.00± 0.00
beam offset in x	0.3±0.2	1228.4±1577.4	0.00± 0.00
beam offset in y	0.3±0.3	-216.7±1577.4	0.00± 0.00
beam angle in x-z	6.1±4.5	1465.4±1575.9	0.00± 0.00
beam angle in y-z	6.2±4.7	-168.3±1578.4	0.00± 0.00

cummulative effects	$\pm$	$\pm$	$\pm$
solenoid offset in x	17.0±3.5	4.1± 834.8	0.02±0.01
solenoid offset in y	14.6±7.0	147.8± 388.3	0.01±0.02
solenoid offset in z	17.0±2.7	-63.6± 0.0	0.02±0.00
solenoid rotation 1	14.8±5.9	15.8± 495.4	0.01±0.01
solenoid rotation 2	14.1±6.3	-286.3± 306.8	0.01±0.02
solenoid rotation 3	14.7±6.4	-131.3± 397.4	0.01±0.02
solenoid strength	15.6±5.9	257.3± 0.0	0.01±0.01
solenoid correction	15.1±3.2	-29.9± 240.6	0.02±0.01
solenoid fringe rnge	15.9±4.2	-167.8± 97.7	0.02±0.01
QUAD offset in x	15.5±5.5	92.1± 0.0	0.01±0.01
QUAD offset in y	16.0±4.9	207.0± 0.0	0.02±0.01
QUAD offset in z	16.7±5.0	-130.3± 0.0	0.02±0.01
QUAD rotation 1	15.2±4.0	-374.5± 0.0	0.02±0.01
QUAD rotation 2	17.3±2.2	141.9± 0.0	0.02±0.00
QUAD rotation 3	15.0±5.4	3.1± 220.5	0.01±0.01
QUAD strength	16.4±4.0	-266.7± 442.2	0.02±0.01
spin azimuthal ang.	15.8±4.8	13.8±1526.3	0.02±0.01
Spin alignment	11.4±7.7	-349.4± 589.5	0.01±0.02
Beam energy	14.6±7.2	316.0± 0.0	0.01±0.02
beam offset in x	15.6±5.0	-174.7± 363.9	0.02±0.01
beam offset in y	15.7±5.5	57.7± 127.7	0.02±0.01
beam angle in x-z	13.2±7.1	63.0± 150.0	0.01±0.02
beam angle in y-z	13.5±7.0	-20.1± 401.7	0.01±0.02

D.1.2 Head-On Collisions, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	0.0± 0.0	0.0± 0.0	0.00± 0.00
real beam	60.3±31.2	320.4±1887.7	0.23± 0.23
single parameter effects	±	±	±
solenoid offset in x	1.0± 0.7	-126.9±1573.7	0.00± 0.00
solenoid offset in y	1.0± 0.9	1475.3±1575.9	0.00± 0.00
solenoid offset in z	0.0± 0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 1	2.1± 1.6	-94.6±1575.9	0.00± 0.00
solenoid rotation 2	0.0± 0.0	0.0± 0.0	0.00± 0.00
solenoid rotation 3	2.4± 1.8	31.1±1578.4	0.00± 0.00
solenoid strength	0.0± 0.0	0.0± 0.0	0.00± 0.00
solenoid correction	0.0± 0.0	0.0± 0.0	0.00± 0.00
solenoid fringe rnge	0.0± 0.0	0.0± 0.0	0.00± 0.00
QUAD offset in x	1.7± 1.3	-1933.6±1532.6	0.00± 0.00
QUAD offset in y	1.8± 1.3	14.2±1578.7	0.00± 0.00
QUAD offset in z	0.0± 0.0	0.0± 0.0	0.00± 0.00
QUAD rotation 1	0.0± 0.0	0.0± 0.0	0.00± 0.00
QUAD rotation 2	0.0± 0.0	0.0± 0.0	0.00± 0.00
QUAD rotation 3	0.0± 0.0	0.0± 0.0	0.00± 0.00
QUAD strength	0.0± 0.0	0.0± 0.0	0.00± 0.00
spin azimuthal ang.	0.0± 0.0	0.0± 0.0	0.00± 0.00
Spin alignment	11.7± 5.4	17.4± 0.0	0.01± 0.01
Beam energy	0.0± 0.0	0.0± 0.0	0.00± 0.00
beam offset in x	1.7± 1.3	1456.0±1577.4	0.00± 0.00
beam offset in y	1.6± 1.4	10.9±1577.4	0.00± 0.00
beam angle in x-z	33.1±24.4	1628.4±1575.9	0.08± 0.11
beam angle in y-z	33.6±25.4	-5.3±1578.4	0.09± 0.14

cummulative effects	±	±	±
solenoid offset in x	62.7± 0.0	-144.2± 913.8	0.25±0.05
solenoid offset in y	55.0±18.9	499.3± 460.2	0.18±0.18
solenoid offset in z	61.4± 0.0	-24.4± 640.4	0.24±0.08
solenoid rotation 1	52.6±15.7	-245.4± 896.1	0.17±0.16
solenoid rotation 2	53.2±12.2	-116.4± 404.6	0.18±0.15
solenoid rotation 3	55.8±15.1	-166.0± 933.1	0.19±0.15
solenoid strength	53.2± 8.9	-220.3± 800.1	0.19±0.14
solenoid correction	55.3±15.7	-65.6± 587.7	0.19±0.17
solenoid fringe rnge	60.0± 0.0	3.0± 0.0	0.23±0.00
QUAD offset in x	58.6±14.8	-150.8± 0.0	0.21±0.16
QUAD offset in y	58.8± 0.0	-45.8± 256.8	0.22±0.06
QUAD offset in z	56.4± 0.0	-279.3± 192.3	0.21±0.05
QUAD rotation 1	55.2±13.3	-296.0± 72.8	0.19±0.13
QUAD rotation 2	60.7± 0.0	-103.0± 643.5	0.23±0.05
QUAD rotation 3	54.9±14.9	-43.6± 905.9	0.19±0.15
QUAD strength	59.6±11.1	28.8± 639.3	0.22±0.09
spin azimuthal ang.	53.2±12.2	-60.6±1122.0	0.18±0.15
Spin alignment	57.2±14.3	-311.8± 823.6	0.20±0.16
Beam energy	52.7±17.0	232.4± 0.0	0.17±0.16
beam offset in x	55.4± 0.0	-133.2± 681.5	0.20±0.11
beam offset in y	57.2±12.1	-59.6± 547.2	0.20±0.13
beam angle in x-z	35.7±21.6	-162.9± 946.2	0.09±0.21
beam angle in y-z	31.8±22.0	201.9± 268.7	0.07±0.21

D.1.3 Crossing Angle, 45 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	1.8± 0.0	-2458.0± 0.0	0.00± 0.00
real beam	293.3±11.2	-1595.6±35.3	4.28± 0.32
single parameter effects	±	±	±
solenoid offset in x	292.5± 0.9	-1596.2± 0.0	4.25± 0.03
solenoid offset in y	292.5± 0.0	-1596.4± 3.6	4.25± 0.00
solenoid offset in z	292.5± 0.0	-1596.2± 0.0	4.25± 0.00
solenoid rotation 1	292.4± 2.5	-1596.2± 0.8	4.25± 0.07
solenoid rotation 2	292.5± 0.2	-1596.2± 1.5	4.25± 0.00
solenoid rotation 3	292.0± 2.8	-1596.3± 1.0	4.23± 0.08
solenoid strength	292.5± 0.2	-1596.2± 0.0	4.25± 0.00
solenoid correction	292.5± 0.0	-1596.2± 0.0	4.25± 0.00
solenoid fringe rnge	292.8± 4.6	-1596.5± 4.5	4.26± 0.13
CORR offset in x	292.5± 0.0	-1596.2± 0.5	4.25± 0.00
CORR offset in y	292.5± 0.0	-1596.2± 0.5	4.25± 0.00
CORR offset in z	292.5± 0.0	-1596.2± 0.0	4.25± 0.00
CORR rotation 1	292.5± 0.1	-1596.2± 0.5	4.25± 0.00
CORR rotation 2	292.5± 0.1	-1596.3± 0.5	4.25± 0.00
CORR rotation 3	292.5± 0.2	-1596.2± 0.4	4.25± 0.00
CORR strength	292.5± 0.3	-1596.2± 0.8	4.25± 0.01
spin azimuthal ang.	292.5± 0.0	-1596.2± 0.5	4.25± 0.00
Spin alignment	291.3± 0.5	-1555.8±18.7	4.21± 0.01
Beam energy	292.5± 0.0	-1596.4± 0.0	4.25± 0.00
beam offset in x	292.5± 0.0	-1596.2± 0.0	4.25± 0.00
beam offset in y	292.5± 0.2	-1596.2± 0.0	4.25± 0.00
beam angle in x-z	292.4± 1.4	-1596.2± 0.4	4.24± 0.04
beam angle in y-z	292.5± 0.2	-1596.0± 4.8	4.25± 0.00

cummulative effects	±	±	±
solenoid offset in x	292.2±0.0	-1590.9±12.3	4.25±0.02
solenoid offset in y	292.8±4.9	-1591.1±17.6	4.26±0.14
solenoid offset in z	294.4±0.0	-1599.0±12.0	4.31±0.00
solenoid rotation 1	293.2±0.0	-1601.6±19.2	4.27±0.00
solenoid rotation 2	293.2±1.6	-1593.9±20.5	4.27±0.03
solenoid rotation 3	292.5±5.6	-1593.1±17.6	4.25±0.16
solenoid strength	291.4±4.2	-1599.3± 0.0	4.22±0.13
solenoid correction	294.8±1.2	-1596.1±15.5	4.32±0.02
solenoid fringe rnge	293.9±5.2	-1596.3±16.3	4.29±0.15
CORR offset in x	291.2±0.0	-1599.4±16.5	4.22±0.02
CORR offset in y	293.4±3.1	-1601.8±10.7	4.28±0.08
CORR offset in z	292.9±0.0	-1597.3±20.0	4.27±0.00
CORR rotation 1	295.0±0.0	-1597.7±17.4	4.32±0.00
CORR rotation 2	292.0±3.9	-1597.8± 9.0	4.24±0.11
CORR rotation 3	292.9±2.0	-1602.2±16.3	4.26±0.05
CORR strength	293.2±0.0	-1597.4± 0.0	4.27±0.00
spin azimuthal ang.	290.2±9.3	-1555.9±31.0	4.18±0.27
Spin alignment	293.5±9.0	-1597.6±34.5	4.28±0.26
Beam energy	291.8±2.7	-1598.3±20.2	4.23±0.08
beam offset in x	292.4±0.0	-1594.6±16.9	4.25±0.00
beam offset in y	291.7±3.3	-1593.1±17.7	4.23±0.09
beam angle in x-z	292.5±5.1	-1595.0±13.8	4.25±0.15
beam angle in y-z	292.8±0.8	-1597.1±17.8	4.26±0.03

D.1.4 Crossing Angle, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	0.7± 0.0	-1959.0± 0.0	0.00± 0.00
real beam	291.7±11.2	-1575.2±35.1	4.23± 0.32
single parameter effects	±	±	±
solenoid offset in x	291.0± 0.9	-1576.8± 0.0	4.20± 0.03
solenoid offset in y	290.9± 0.1	-1577.0± 3.4	4.20± 0.00
solenoid offset in z	290.9± 0.1	-1576.8± 1.1	4.20± 0.00
solenoid rotation 1	290.9± 2.5	-1576.8± 0.0	4.20± 0.07
solenoid rotation 2	290.9± 0.0	-1576.8± 0.4	4.20± 0.00
solenoid rotation 3	290.5± 2.8	-1576.8± 0.0	4.19± 0.08
solenoid strength	290.9± 0.0	-1576.8± 0.0	4.20± 0.00
solenoid correction	290.9± 0.2	-1576.8± 0.0	4.20± 0.00
solenoid fringe rnge	291.2± 4.3	-1576.8± 1.0	4.21± 0.12
CORR offset in x	290.9± 0.0	-1576.8± 0.0	4.20± 0.00
CORR offset in y	290.9± 0.0	-1576.8± 0.0	4.20± 0.00
CORR offset in z	290.9± 0.0	-1576.8± 0.5	4.20± 0.00
CORR rotation 1	290.9± 0.0	-1576.8± 0.0	4.20± 0.00
CORR rotation 2	290.9± 0.0	-1576.9± 1.1	4.20± 0.00
CORR rotation 3	290.9± 0.0	-1576.8± 0.0	4.20± 0.00
CORR strength	290.9± 0.4	-1576.8± 0.0	4.20± 0.01
spin azimuthal ang.	290.9± 0.0	-1576.8± 0.0	4.20± 0.00
Spin alignment	291.0± 0.1	-1536.0±18.9	4.20± 0.00
Beam energy	290.9± 0.1	-1576.8± 0.6	4.20± 0.00
beam offset in x	290.9± 0.2	-1576.8± 0.0	4.20± 0.00
beam offset in y	290.9± 0.2	-1576.8± 0.6	4.20± 0.00
beam angle in x-z	290.8± 1.4	-1576.8± 0.0	4.20± 0.04
beam angle in y-z	290.9± 0.0	-1576.6± 4.7	4.20± 0.00

cummulative effects	±	±	±
solenoid offset in x	290.8±1.1	-1570.3±10.9	4.20±0.04
solenoid offset in y	291.3±5.3	-1571.3±15.7	4.22±0.15
solenoid offset in z	292.7±0.0	-1579.7± 9.2	4.26±0.00
solenoid rotation 1	291.4±2.2	-1581.6±19.3	4.22±0.07
solenoid rotation 2	291.8±2.1	-1574.4±21.3	4.23±0.05
solenoid rotation 3	291.1±5.8	-1574.0±16.6	4.21±0.17
solenoid strength	289.8±4.2	-1579.6± 4.5	4.17±0.13
solenoid correction	293.2±2.2	-1576.3±16.6	4.27±0.06
solenoid fringe rnge	292.3±5.1	-1577.2±15.4	4.25±0.15
CORR offset in x	289.5±1.4	-1579.6±17.2	4.17±0.06
CORR offset in y	291.6±3.9	-1581.7±11.4	4.23±0.11
CORR offset in z	291.3±0.0	-1578.6±18.4	4.22±0.00
CORR rotation 1	293.3±0.9	-1577.7±18.6	4.28±0.00
CORR rotation 2	290.4±4.3	-1577.9± 6.5	4.19±0.12
CORR rotation 3	291.1±2.6	-1582.5±16.5	4.21±0.07
CORR strength	291.6±0.0	-1577.4± 0.0	4.23±0.00
spin azimuthal ang.	289.9±9.5	-1536.4±31.3	4.17±0.27
Spin alignment	291.9±9.2	-1577.7±34.6	4.23±0.26
Beam energy	290.2±3.1	-1578.4±20.8	4.19±0.09
beam offset in x	290.9±2.4	-1574.3±17.3	4.21±0.06
beam offset in y	290.2±3.3	-1574.0±18.5	4.19±0.09
beam angle in x-z	291.0±4.7	-1574.9±13.5	4.21±0.13
beam angle in y-z	291.2±1.5	-1576.8±17.9	4.22±0.05

D.2 Transverse Polarization

D.2.1 Head-On Collisions, 250 GeV

	angles at IP in mrad		depolarization at IP in %
	anlge θ	anlge ϕ	
ideal beam	1570.8± 0.0	1588.2± 0.0	0.00± 0.00
real beam	1566.0±45.3	1590.7±26.8	0.10± 0.17
single parameter effects	±	±	±
solenoid offset in x	1571.0± 1.6	1588.2± 0.0	0.00± 0.00
solenoid offset in y	1570.8± 0.5	1588.2± 0.0	0.00± 0.00
solenoid offset in z	1570.8± 1.9	1588.2± 0.2	0.00± 0.00
solenoid rotation 1	1570.8± 2.9	1588.2± 0.0	0.00± 0.00
solenoid rotation 2	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
solenoid rotation 3	1571.3± 2.7	1588.2± 0.0	0.00± 0.00
solenoid strength	1570.8± 1.9	1588.2± 0.8	0.00± 0.00
solenoid correction	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
solenoid fringe rnge	1570.8± 1.9	1588.2± 2.0	0.00± 0.00
QUAD offset in x	1570.8± 1.4	1588.2± 0.0	0.00± 0.00
QUAD offset in y	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
QUAD offset in z	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
QUAD rotation 1	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
QUAD rotation 2	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
QUAD rotation 3	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
QUAD strength	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
spin azimuthal ang.	1570.8± 1.9	1589.5±20.1	0.00± 0.00
Beam energy	1570.8± 1.9	1588.2± 0.0	0.00± 0.00
beam offset in x	1570.8± 0.0	1588.2± 0.0	0.00± 0.00
beam offset in y	1570.8± 2.2	1588.2± 0.0	0.00± 0.00
beam angle in x-z	1570.8± 2.5	1588.1± 0.0	0.00± 0.00
beam angle in y-z	1571.0±40.0	1588.2± 0.8	0.08± 0.09

cummulative effects	±	±	±
solenoid offset in x	1567.5± 0.0	1588.1±13.5	0.12±0.00
solenoid offset in y	1570.8± 0.0	1586.9± 6.6	0.11±0.11
solenoid offset in z	1576.0±11.7	1588.8±10.7	0.10±0.11
solenoid rotation 1	1571.3±16.0	1589.8± 6.7	0.09±0.12
solenoid rotation 2	1567.5±11.3	1586.0±10.1	0.10±0.08
solenoid rotation 3	1570.6±14.2	1587.4±10.4	0.09±0.12
solenoid strength	1573.3±14.8	1587.8±13.5	0.09±0.12
solenoid correction	1575.0± 5.8	1587.2± 5.9	0.10±0.07
solenoid fringe rnge	1574.8±17.6	1585.1±15.1	0.09±0.13
QUAD offset in x	1569.0±18.4	1583.5±11.0	0.09±0.13
QUAD offset in y	1569.8± 8.8	1589.3± 7.0	0.10±0.09
QUAD offset in z	1567.1± 7.2	1589.5± 9.2	0.10±0.10
QUAD rotation 1	1571.7± 0.0	1581.2±16.9	0.10±0.08
QUAD rotation 2	1570.5±27.7	1591.8± 8.3	0.06±0.15
QUAD rotation 3	1569.6± 6.4	1588.0± 5.8	0.10±0.10
QUAD strength	1573.8± 0.0	1588.9±10.3	0.10±0.09
spin azimuthal ang.	1567.7±15.8	1588.1±26.7	0.09±0.13
Beam energy	1573.6±11.4	1588.1± 6.9	0.10±0.12
beam offset in x	1575.0± 0.0	1587.3± 0.0	0.11±0.09
beam offset in y	1568.6±16.7	1583.2± 0.0	0.09±0.12
beam angle in x-z	1578.2±22.9	1585.3±13.4	0.08±0.14
beam angle in y-z	1570.5±45.0	1588.9± 6.2	0.00±0.17

D.2.2 Crossing Angle, 250 GeV

	angles at IP in mrad		depolarization at IP in %	
	anlge θ	anlge ϕ		
ideal beam	1570.1±0.0	1588.2± 0.0	0.00±	0.00
real beam	1279.6±5.5	1590.6±28.1	4.21±	0.16
single parameter effects	±	±	±	
solenoid offset in x	1279.8±0.7	1587.5± 0.0	4.20±	0.03
solenoid offset in y	1279.9±0.4	1587.6± 0.8	4.20±	0.00
solenoid offset in z	1279.9±0.4	1587.5± 0.0	4.20±	0.00
solenoid rotation 1	1280.0±2.5	1587.5± 0.0	4.20±	0.07
solenoid rotation 2	1279.9±1.9	1587.5± 0.0	4.20±	0.00
solenoid rotation 3	1280.4±2.8	1587.5± 0.7	4.19±	0.08
solenoid strength	1279.9±0.7	1587.5± 1.0	4.20±	0.00
solenoid correction	1279.9±0.0	1587.5± 0.0	4.20±	0.00
solenoid fringe rnge	1280.0±5.0	1587.5± 2.1	4.20±	0.14
CORR offset in x	1279.9±2.0	1587.5± 0.0	4.20±	0.01
CORR offset in y	1279.9±2.0	1587.5± 0.0	4.20±	0.01
CORR offset in z	1279.9±1.9	1587.5± 0.0	4.20±	0.01
CORR rotation 1	1279.9±0.9	1587.5± 0.0	4.20±	0.00
CORR rotation 2	1279.9±0.0	1587.5± 0.0	4.20±	0.00
CORR rotation 3	1279.9±1.2	1587.5± 0.0	4.20±	0.00
CORR strength	1279.9±0.0	1587.5± 0.0	4.20±	0.01
spin azimuthal ang.	1280.0±1.0	1588.9±20.9	4.20±	0.01
Beam energy	1279.9±1.0	1587.7± 0.7	4.20±	0.00
beam offset in x	1279.9±0.0	1587.5± 0.0	4.20±	0.00
beam offset in y	1279.9±0.6	1587.5± 0.0	4.20±	0.00
beam angle in x-z	1280.0±1.5	1587.5± 0.0	4.20±	0.04
beam angle in y-z	1279.9±0.7	1587.5± 1.3	4.20±	0.00

cummulative effects	±	±	±
solenoid offset in x	1279.8±0.0	1587.6±14.4	4.20±0.00
solenoid offset in y	1280.8±0.0	1586.3± 7.4	4.18±0.00
solenoid offset in z	1280.3±0.0	1588.4±11.3	4.19±0.00
solenoid rotation 1	1279.4±1.4	1589.3± 7.5	4.22±0.04
solenoid rotation 2	1279.7±0.0	1585.5±11.0	4.21±0.00
solenoid rotation 3	1280.3±1.5	1586.7±11.7	4.19±0.03
solenoid strength	1279.9±0.0	1587.4±14.3	4.20±0.00
solenoid correction	1280.0±0.8	1586.7± 6.5	4.20±0.02
solenoid fringe rnge	1280.1±4.1	1584.4±15.9	4.20±0.12
CORR offset in x	1279.6±0.0	1583.0±11.8	4.21±0.00
CORR offset in y	1281.3±0.0	1588.9± 8.2	4.16±0.00
CORR offset in z	1279.8±0.0	1589.1±10.4	4.20±0.00
CORR rotation 1	1279.5±0.0	1580.4±17.9	4.22±0.00
CORR rotation 2	1280.2±0.0	1591.7± 9.5	4.20±0.00
CORR rotation 3	1280.4±0.0	1587.6± 7.7	4.19±0.00
CORR strength	1280.3±0.0	1588.3±11.1	4.19±0.00
spin azimuthal ang.	1279.7±0.0	1587.7±28.1	4.21±0.00
Beam energy	1280.7±0.0	1587.4± 7.9	4.18±0.00
beam offset in x	1281.1±0.0	1586.9± 0.0	4.17±0.00
beam offset in y	1279.5±0.0	1582.4± 0.0	4.21±0.00
beam angle in x-z	1280.3±0.0	1584.6±14.3	4.19±0.00
beam angle in y-z	1279.5±0.0	1588.6± 6.8	4.22±0.00