Design of the Spin rotator/flipper section for the ILC

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Outline

- Motivation

- Spin rotation for the ILC

  - PLTR section

  - PLTR modification

- Design of positron spin-flipper

  - Requirements and constrains

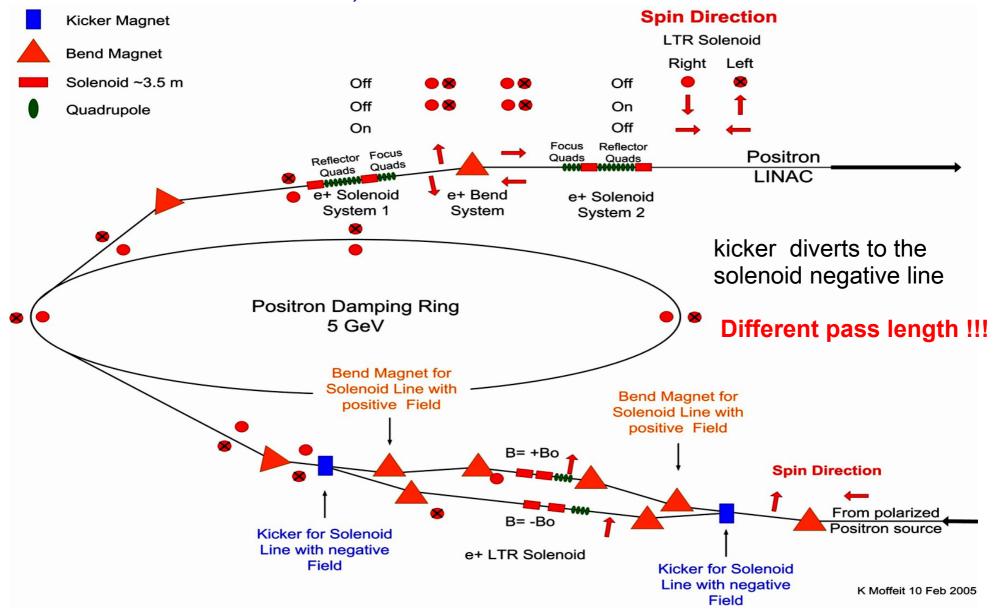 - optic files examples (MAD8)

- Results

Motivation I

- The use of the polarised beam enhance possibility of the precision measurement at the ILC (see G. Moortgat-Pick talk)

- Increase of effective luminosity using (- +) and (+ -) helicity pattern of e+ and e- beams

- Production and transport of e^+/e^- were already investigated in great details

- The e^+/e^- beam produced longitudinally polarised

- At the IP longitudinal polarisation is expected

- In Damping Ring only the vertical component of polarisation is preserve, thus the spin rotators are necessary and were already included in TDR
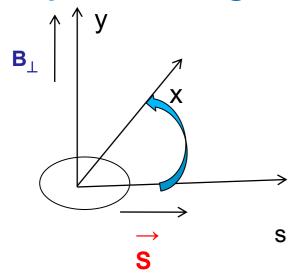
Motivation II

- The suitable combination of e^+/e^- polarised beams enhance signal rates and supress unwanted background

- fast helicity reversal is required :for e^- : change the polarity of laser beam

- for e^+ : helicity of undulator cannot be changed

- The solution is a dedicated helicity flipper

- BUT… a properly designed spin rotator section can be used for this purpose

- Some examples of possible layout were investigated at DESY (Hamburg) in 2012

- Fully matched lattice files for various configurations are available

An Example of SPIN-FLIPPER with helicity rotation
From K. Moffeit et al.,SLAC-TN-05-045
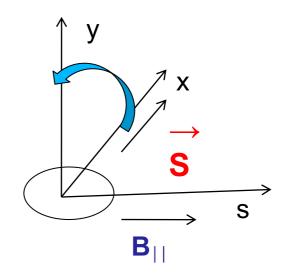
Spin Rotation for the ILC

Dipole bending magnet

Solenoid field

Rotation in (x,s) plane

Rotation in (x,y) plane

$B_{||}$

at 5 GeV :
orbital rotation of   7.9316°
Spin rotation of   90°

orbital rotation of   45°

Spin **rotation** of   90°

$$\delta\theta_{spin} \propto \frac{(g-2)}{2}\gamma\delta\theta_{orbit}$$

$$\delta\theta_{spin} = [1+\frac{g-2}{2}]\frac{B_s L_s}{B_0 \rho} \approx 2\theta_{rot}$$

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PLTR : Positron Linac To Ring system (2011)

E	Arc length=27.769m	Angle =0.415
D	**Length=123.595m**	
C	Arc length=14.258m	0.168
B	Length=123.590m	

B

C

D

9.643^{0}

Section B is a transport line
Vertical separation of positrons for 2 DR
1.3*2=2.6 m   spin direction is not affected here

23.795^{0}

E

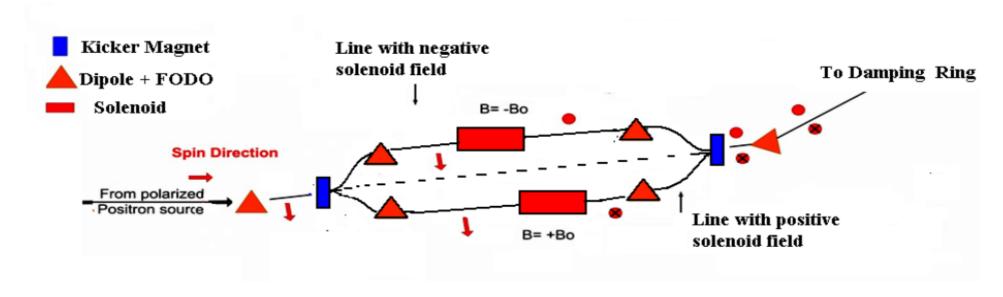**(2n+1)*7.9316˚ orbital rotation**

- **Extract positrons from Positron Booster Linac (PBSTR) at the beginning of PLTR**
- **Rotate spin to the vertical direction (D)**
- **Match the longitudinal beam size to the DR acceptance (Energy compressor) (D)**
- **Inject to DR at the end of PLTR**

Modification of the section E (bend) and D(straight section)

- New arc (23.795^0 orbital =3x90^0 spin)
- Length of D is increased 123.595 m
- Space between the energy compressor and spin rotator
- 2 parallel lines with opposite polarities with 2m separation
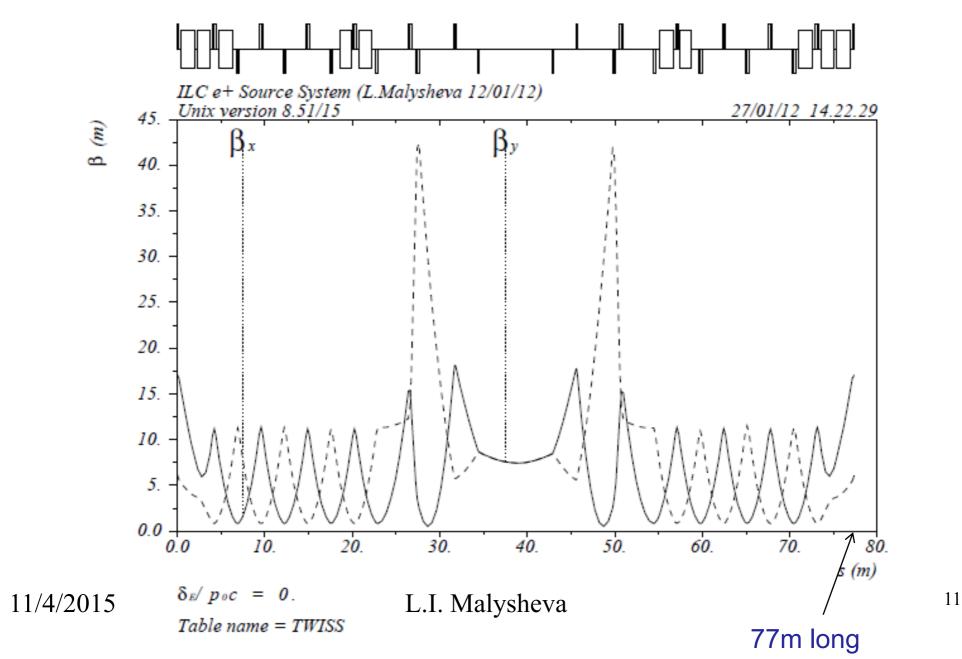- spin rotator section(s) with opposite solenoid field
- merger line to recombine

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Spin flipper section requirements

- an achromat bend: FODO structure ("0" dispersion)

- Dogleg design (to cancel all the extra rotation)

- total length including rotator section <80m

- Min length- max phase advance.

- the first cell is irregular FODO cell which should include fast kickers and separate the branches horizontally

- At the parallel section the branch separation is about 2 m.

- It is also good to have an "asymmetric design" which gives smaller horizontal separation about 1m

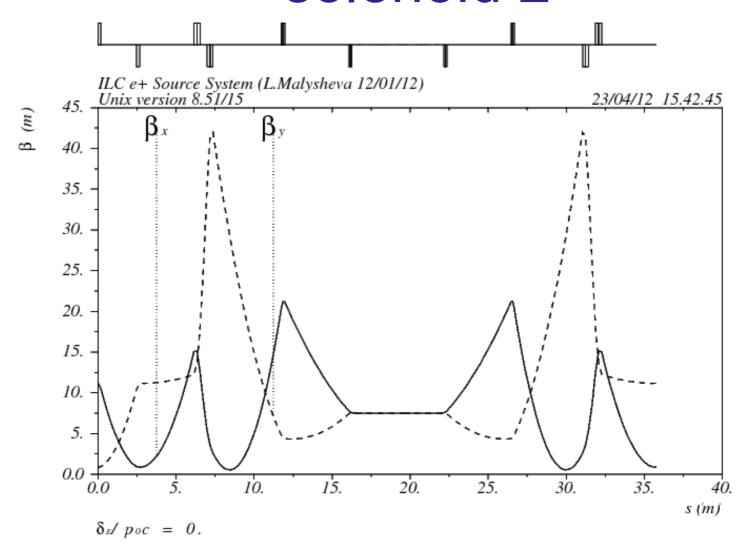- The region must be dispersion free to minimize emittance growths

Spin flipper/spin rotator section solenoids

- Solenoid 1: 8.32 m long solenoid consists of 16 short sections . Field=3.16 T-m , 26.18 T-m integrated field from (Nosochkov/Zhou) . The same solenoid was used in W.Liu PLRT design (now in TDR)

- In April 2012 second version of solenoid was suggested by V. Kashikhin: Solenoid 2: Field = 5.24 T, Length =2.5 m ,Integrated field/solenoid = 13.1 T-m, for both 26.2 T-m.

- NOW solenoid specs in TDR are different from the solenoid used in the lattice for PLRT (W. Liu)(Please, correct me, if I'm wrong)

- Our versions of PLTR lattices are done for BOTH solenoids

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Example of Lattice with solenoid 1

ILC e+ Source System (L.Malysheva 12/01/12)
Unix version 8.51/15   27/01/12 14.22.29

β_x β_y

β (m)

$\delta_E/ p_0c = 0$.

Table name = TWISS

77m long

Example of Lattice section with solenoid 2

ILC e+ Source System (L.Malysheva 12/01/12)
Unix version 8.51/15   23/04/12 15.42.45

$\delta \varepsilon / p_0 c = 0.$

Example of lattice with Solenoid 1 with matching to RF section(from the left)

Beam parameters sent by W.Liu on entrance to section
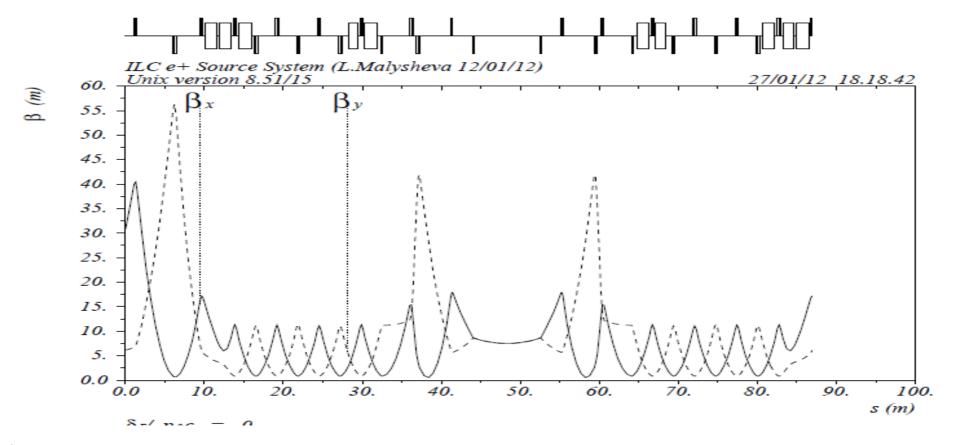
β_x =30.87888 α_x =−3.8976 D_x =0.0039859 DP_x =0.0005205
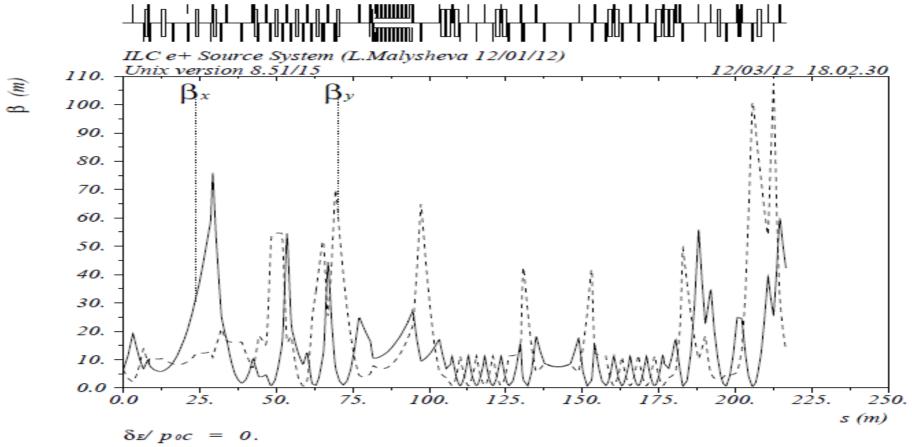
β_y =6.165833 α_y =-0.160898 D_y =0 Dp_y =0

ILC e+ Source System (L.Malysheva 12/01/12)
Unix version 8.51/15   27/01/12 18.18.42

PLTR1 matched section with solenoid 1

ILC e+ Source System (L.Malysheva 12/01/12)
Unix version 8.51/15   12/03/12 18.02.30

β_x β_y

$\delta_E / p_0 c = 0.$

Beam parameters obtained by MAD8 at the Matching point (left)

β_x =26.9175 α_x =−1.268 D_x =0 D_{Px} =0
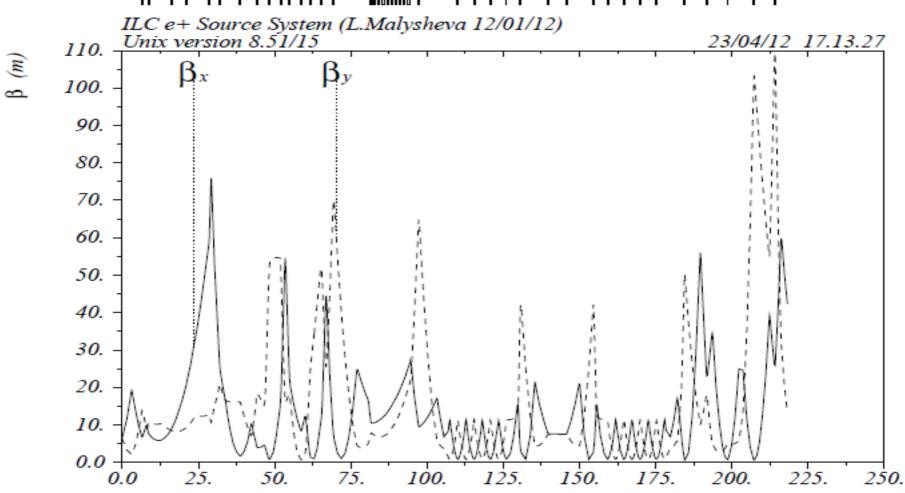β_y =21.7363 α_y =-1.4879 D_y =0 Dp_y =0

PLTR +Solenoid 2 (example)

ILC e+ Source System (L.Malysheva 12/01/12)
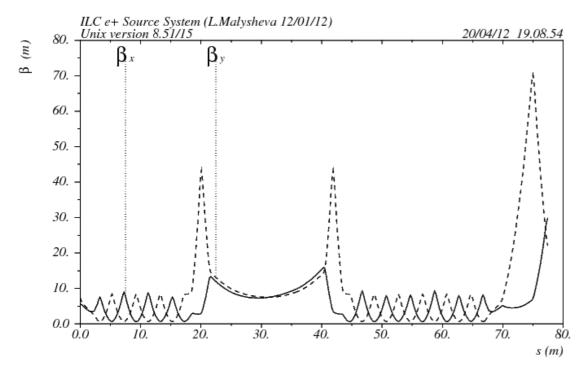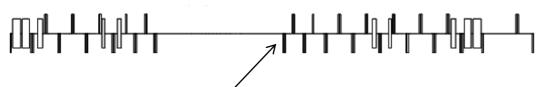Unix version 8.51/15   23/04/12 17.13.27
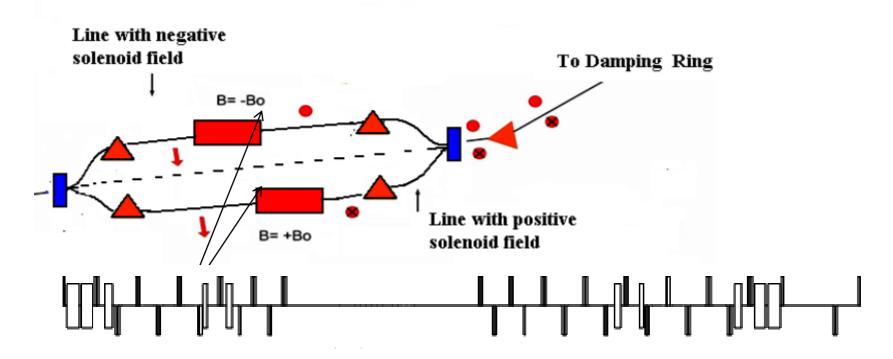
Asymmetric design

- Save transverse space: shift solenoids sections by 6-11 m
- The horizontal offset of 0.54m
- Adding one or two extra FODO cells in one branch before solenoid and after solenoid in second branch
- New optics
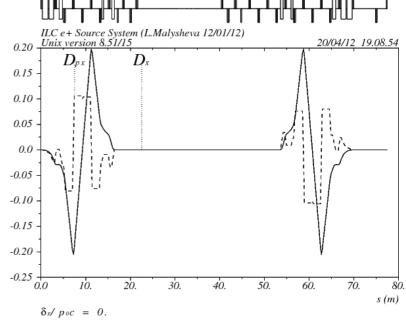- Length of D is fixed, new matching of section was done (123.595 m for D section)

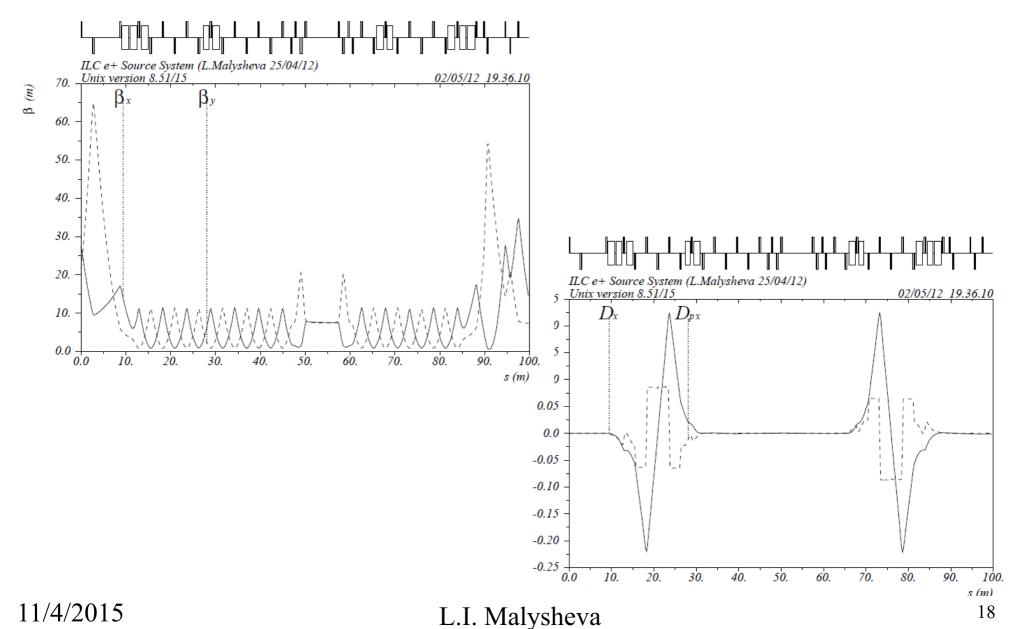# Asymmetric design with solenoid 1

extra FODO cells are placed after solenoid

For the second branch extra FODO cells are placed before solenoid

Asymmetric design with solenoid 2

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More examples of lattices are available and still there at DESY

```
-rw-r--r-- 1 malyshev lc 14546 Mar 11  2012 PLTR.xsif
-rw-r--r-- 1 malyshev lc 18237 Mar 12  2012 my+PLTR.xsif
-rw-r--r-- 1 malyshev lc 18269 Mar 14  2012 Larisa_PLTR.xsif
-rw-r--r-- 1 malyshev lc 18237 Apr 10  2012 Larisa_PLTR1.ele
-rw-r--r-- 1 malyshev lc 18310 Apr 16  2012 Larisa_PLTR1.xsif
-rw-r--r-- 1 malyshev lc  9360 Apr 19  2012 my_assym_0.75_good.xsif
-rw-r--r-- 1 malyshev lc  9529 Apr 19  2012 my_assym_0.75_alldata.xsif
-rw-r--r-- 1 malyshev lc  9134 Apr 19  2012 my_assym_0.75_best.xsif
-rw-r--r-- 1 malyshev lc  9312 Apr 20  2012 my_assym_0.75.xsif
-rw-r--r-- 1 malyshev lc  2354 Apr 23  2012 Short_sol.xsif
-rw-r--r-- 1 malyshev lc 18997 Apr 23  2012 Larisa_PLTR1_New_sol.xsif
-rw-r--r-- 1 malyshev lc 10488 Apr 26  2012 My_assym.xsif~
-rw-r--r-- 1 malyshev lc  6276 Apr 26  2012 My_assym.xsif
-rw-r--r-- 1 malyshev lc  8002 May  2  2012 My_assym_2.xsif~
-rw-r--r-- 1 malyshev lc  8869 May  3  2012 My_assym_2.xsif
```
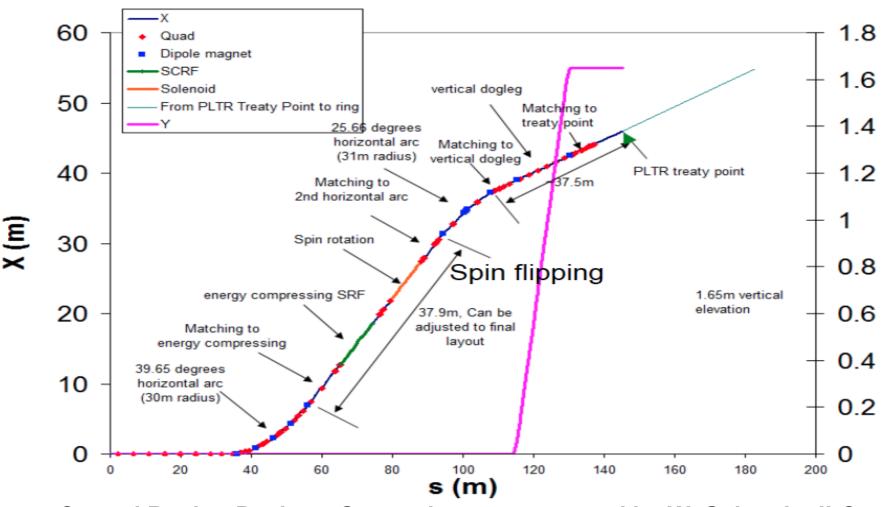
See also:
L.I. Malysheva et al., The Spin rotator with a possibility of helicity switching for polarized positrons at the ILC, Helmholtz Alliance Linear Collider Forum, Proceedings of the Workshops, Hamburg, Munich, Hamburg 2010-2012, p.570, http://www-library.desy.de/confprocs.html

Status

- The lattices for spin-flipper /spin rotator section of PLTR are available

- Matching was done for both options of superconducting solenoid

- The results for PLRT (solenoid 1) were cross-checked with ELEGANT

- Spin tracking with BMAD(V. Kovalenko) confirms that no problem with spin

- Asymmetric designs are available for   both solenoid strengths but some extra matching may be necessary

- Variation in cell distribution with asymmetric design was investigated for solenoid 1

Back-up slides

PLTR system (October 2011)

Central Region Positron Source layout presented by W. Gai at the ILC Baseline Technical Review Meeting held at DESY, Oct 24-27, 2011.

Superconducting solenoid

"So, the e+/e- PLTR specified solenoid parameters are:
- Field - 5.24 T > Length - 2.5 m
- > Current 8692 A
- > Superconducting cable - SSC inner
- Integrated field/solenoid - 13.1 T-m for both 26.2 T-m.
- > The conceptual design based on SSC type SC cable and experience of building such solenoids for INP(Troizk) Meson Facility.
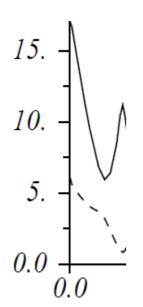> SSC inner cable capable carry 9660 A at 7 T field."

Vladimir Kashikhin about the spin rotator solenoids (21 April 2012!!)

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First cell

B1: SBEND, L=1.6, angle=0.005
B2: SBEND, L=1.4, angle=0.024, K1=-0.4714

At the combined function magnet :

β_x /β_y approx 8m/1m

beam size: $\sigma = \sqrt{\beta\varepsilon}$

$$\sigma_x = \sqrt{8*4.5*10^{-6}} = 6*10^{-3} m$$

$$\sigma_y = 2.12*10^{-3}$$

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