Depolarization in the ILC Linac-to-Ring positron beamline

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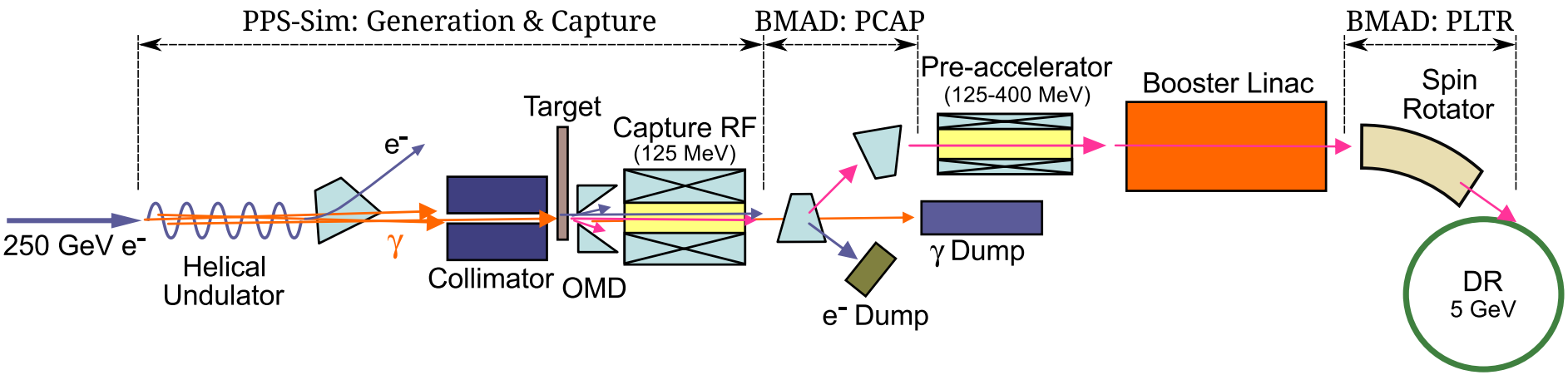
Outline

- Positron source scheme and parameters
- Linac-to-Ring beamline
- Impact of beam energy spread and emittance on polarization
- Summary

Positron Source Scheme



Lattices of e^+ beam lines downstream target and capture section (125 MeV) have been developed by SLAC group (F. Zhou, Y. Batygin, Y. Nosochkov et al.) and ILC2011a version send to us by N. Solyak

Source Parameters

e^- Beam Energy	< 250 GeV
No. of e^+	$3 \cdot 10^{10}$ e^+/bunch
No. of Bunches	2625 or 1312 bunches/train
Repetition Rate	5 Hz
Undulator K-value	< 0.92
Undulator Period	11.5 mm
Undulator-Target Distance	$\sim$ 500 m
Target Material	Ti6Al4V
Target Thickness	0.4 X_0
Target Rotation Speed	100 m/s
OMD	QWT / FC / Li-Lens
DR Acceptance: Energy Spread	1 %
DR Acceptance: Emittance, $\epsilon_{nx} + \epsilon_{ny}$	0.09 rad m
DR Acceptance: Long. Bunch Size	34.6 mm

Spin Rotator at 5 GeV

- Spin precession in bending arc (dipoles)

$$\theta_{spin} = G\,\gamma\,\theta_{bend},$$

where

G is the anomalous magnetic moment of positron, $G = 0.001159652$
γ is the e^+ energy
θ_{bend} is the bending arc angle

$\theta_{bend} = \mathbf{7.93}^\circ \Longrightarrow \theta_{spin} = 90^\circ$

- Spin precession in solenoid

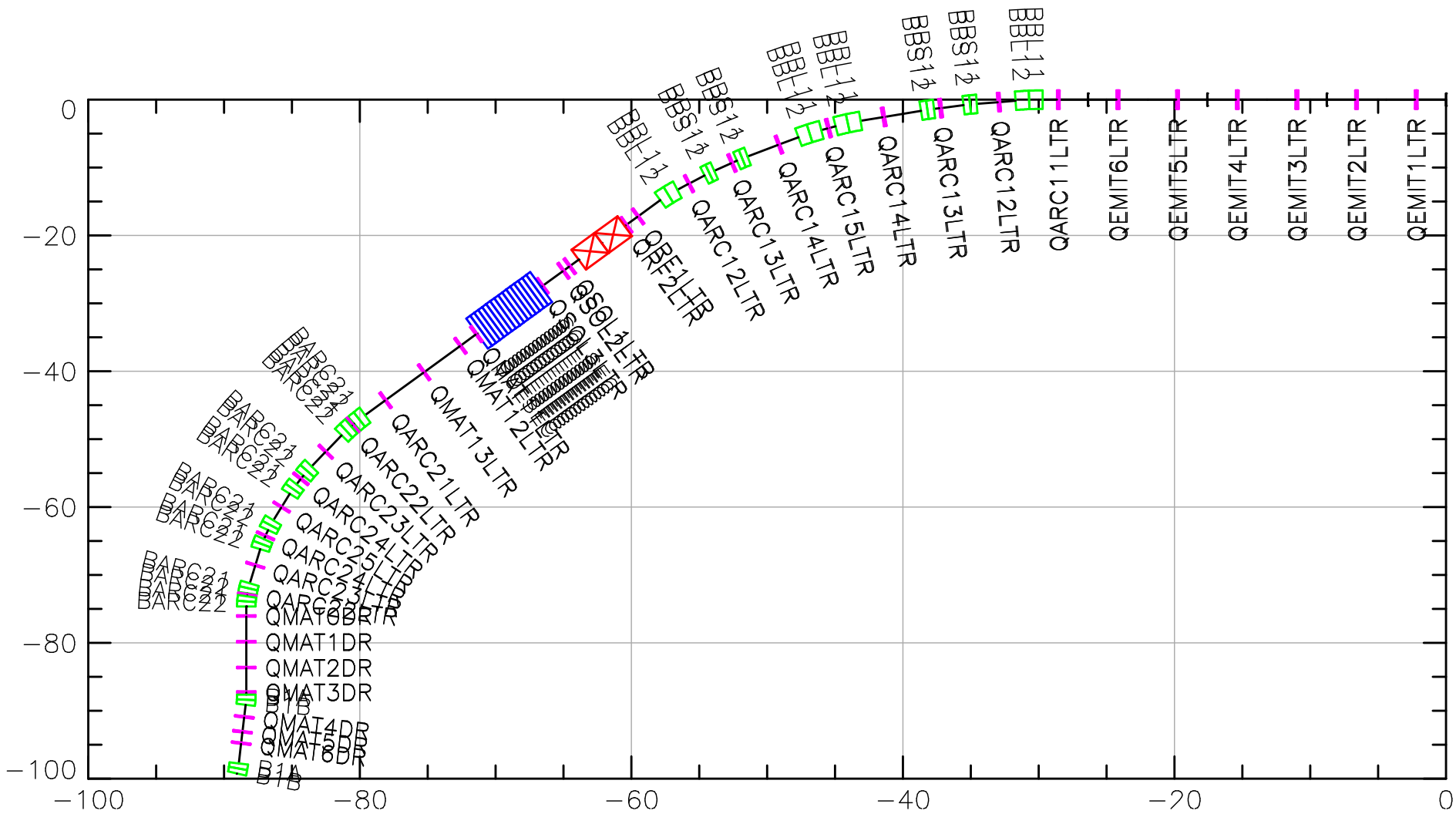
$$\varphi_{spin} \approx 2\,\varphi_{orbit} = \frac{\int B_z\,dl}{B_0\,\rho},$$

where

$B_0\,\rho$ is the magnetic rigidity

$\int B_z\,dl = \mathbf{26.18\ Tm} \Longrightarrow \varphi_{spin} = 90^\circ$

Positron Linac-to-Ring Beamline: Floor Plan

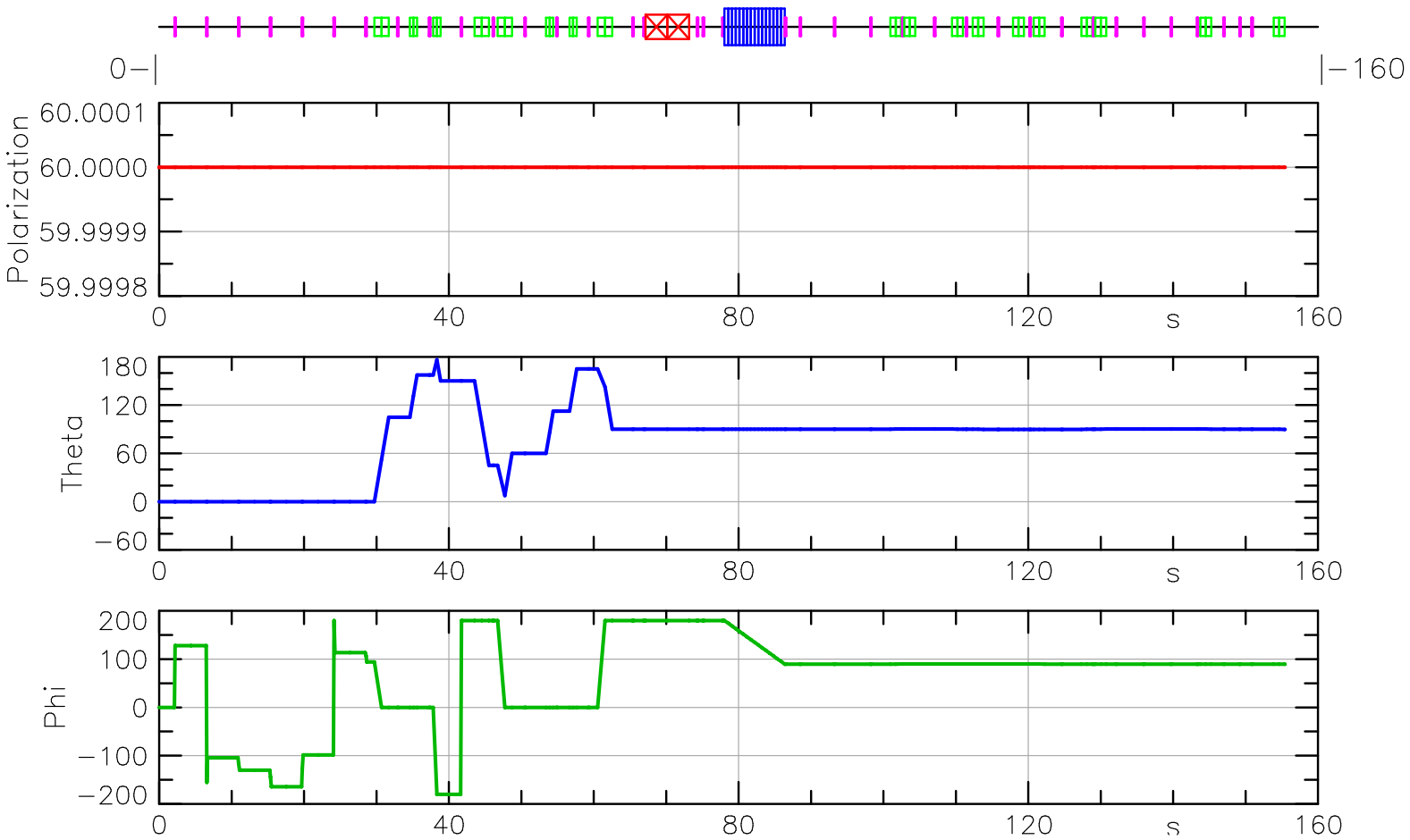


Lattice released by F. Zhou on 01/08/2007

Spin Tracking of Ideal Beam

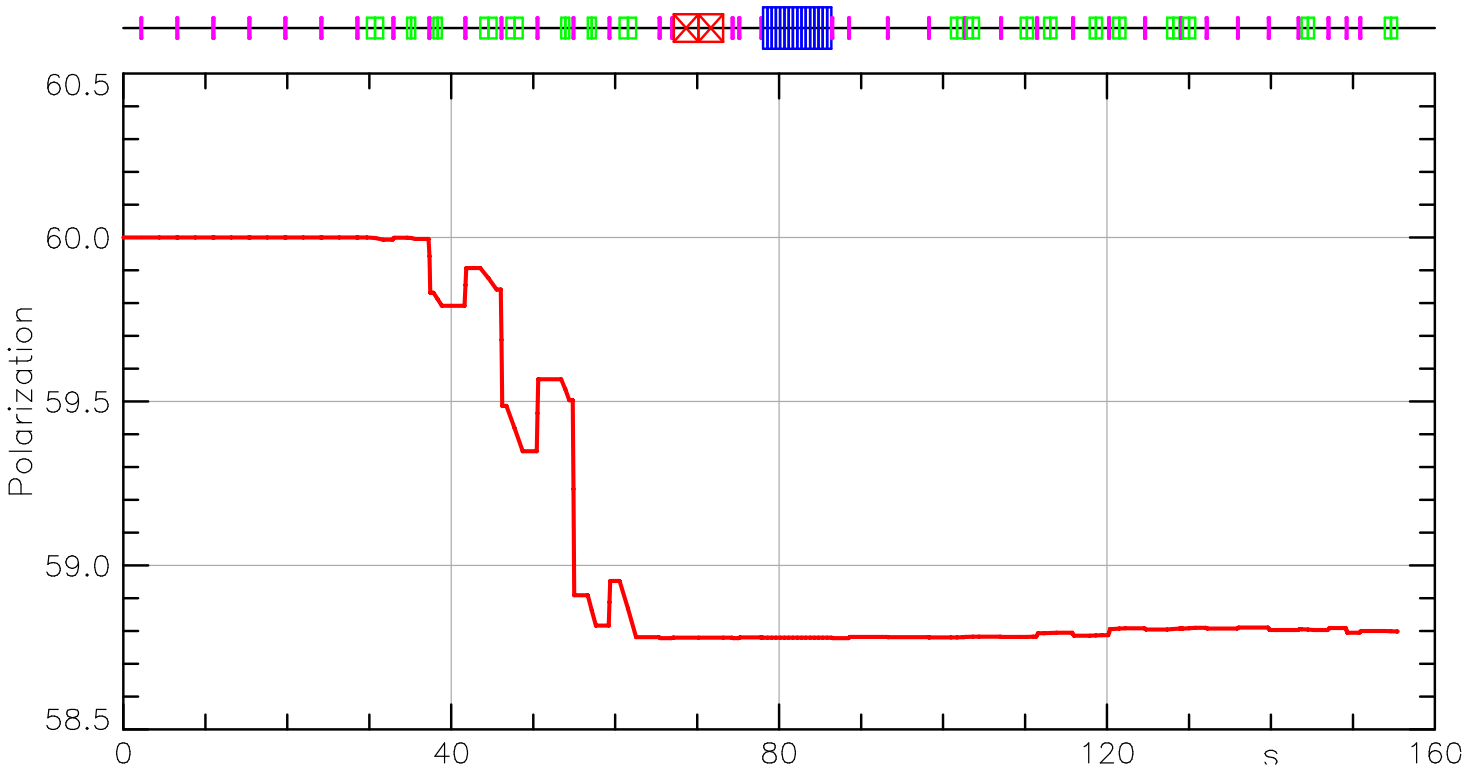
Ideal Beam: emittance, bunch size, energy spread are very small
(10 orders less as expected in reality)

Polarization and Average Spin Direction along Beamline



Impact of Energy Spread

$\sigma_E = 0.875\%$, $\sigma_z = 34.6$ mm*, $\epsilon \approx 0$

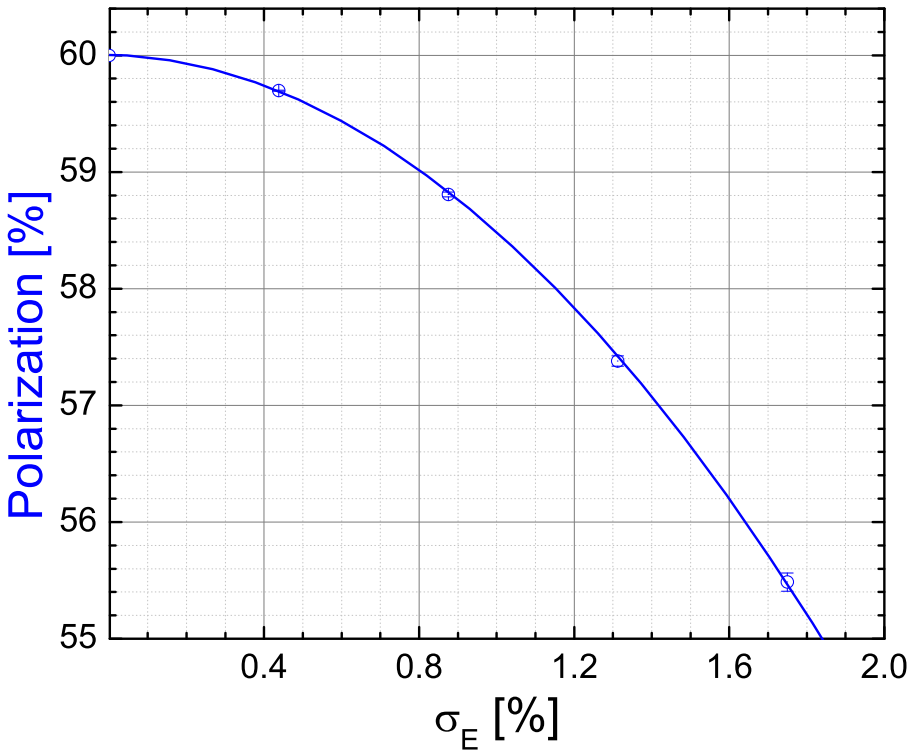


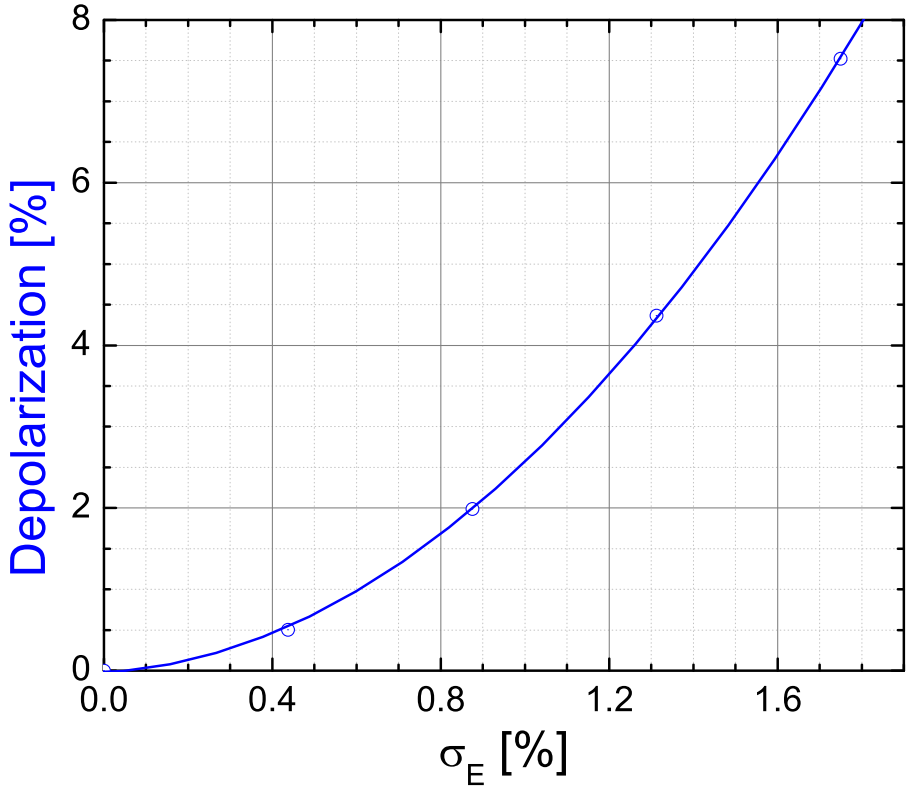
Polarization [%]	θ [deg]	φ [deg]
58.81 ± 0.01	88.99 ± 0.06	89.00 ± 0.05

* Longitudinal bunch size does not change polarization

Depolarization due to Energy Spread

$\sigma_z = 34.6$ mm, $\epsilon \approx 0$





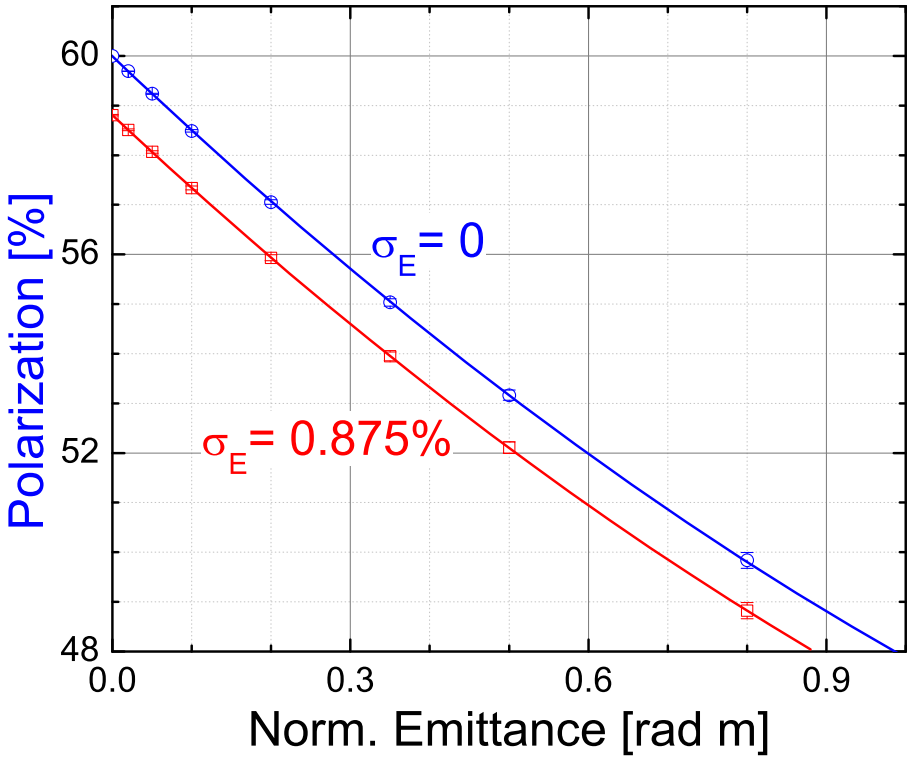
Depolarization of Beams with Different Initial Polarization

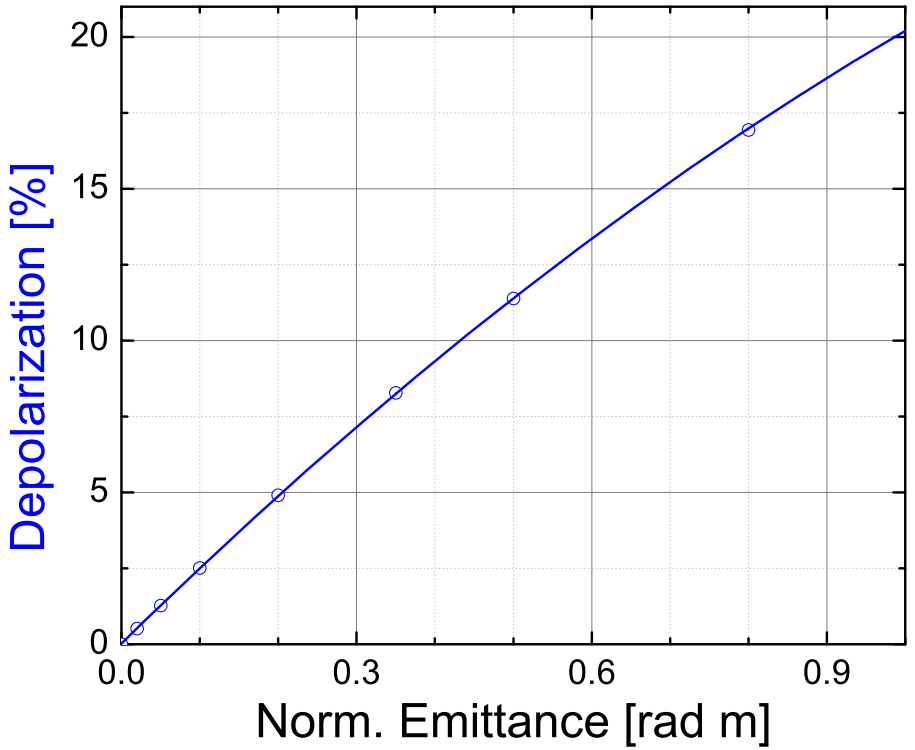
$\sigma_z = 34.6$ mm, $\epsilon \approx 0$

Ini Polarization [%]	End Polarization [%]	Depolarization [%]
100	98.06	1.94
60	58.81	1.99
30	29.43	1.91

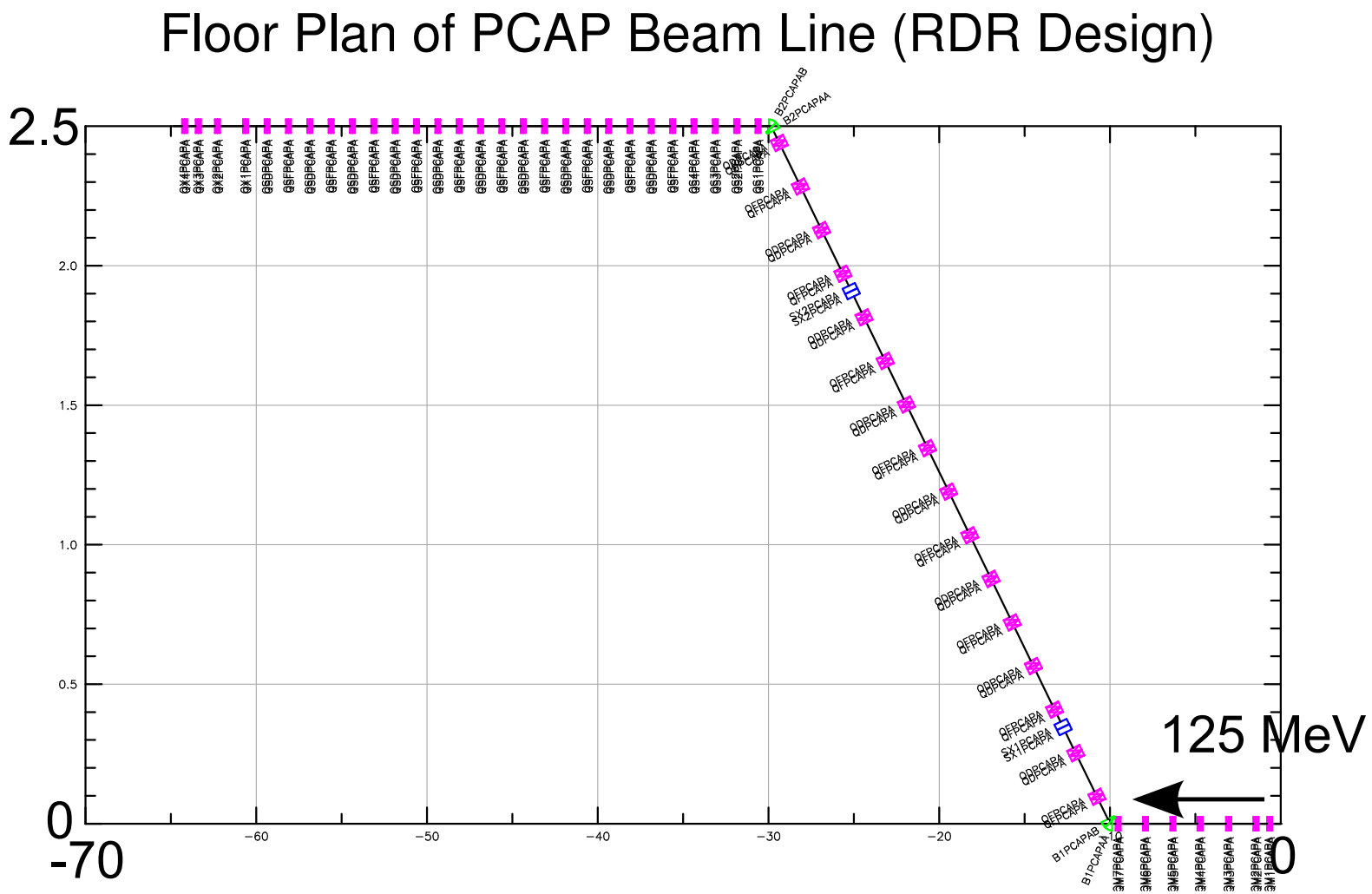
Impact of Emittance on Polarization

$\sigma_z = 34.6$ mm





PCAP Beamline

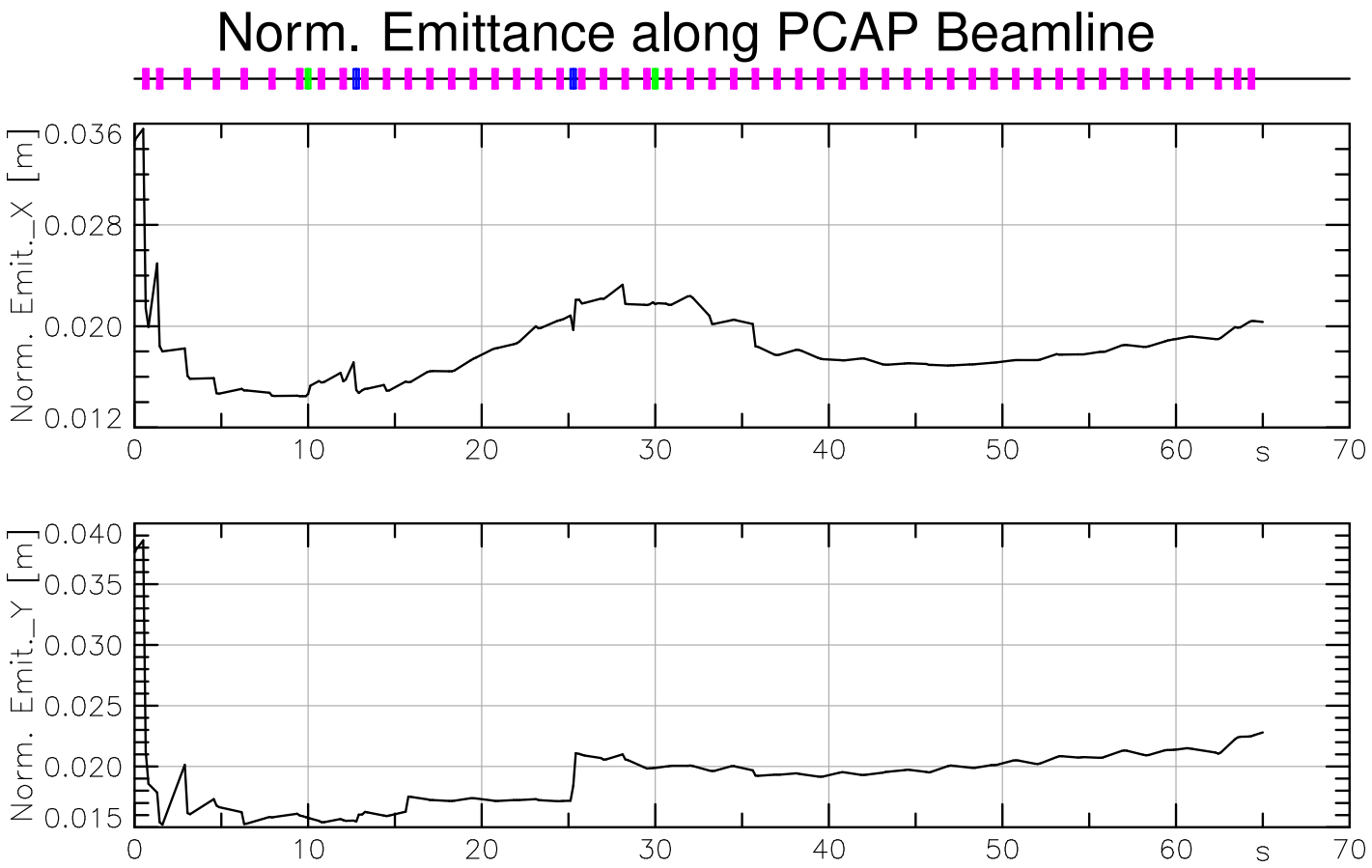


PCAP: beamline that separates the positrons from the electrons and photons
Lattice released by Y.Nosochkov on 01/08/2007

Emittance Change in PCAP

e^+ source wo photon collimator

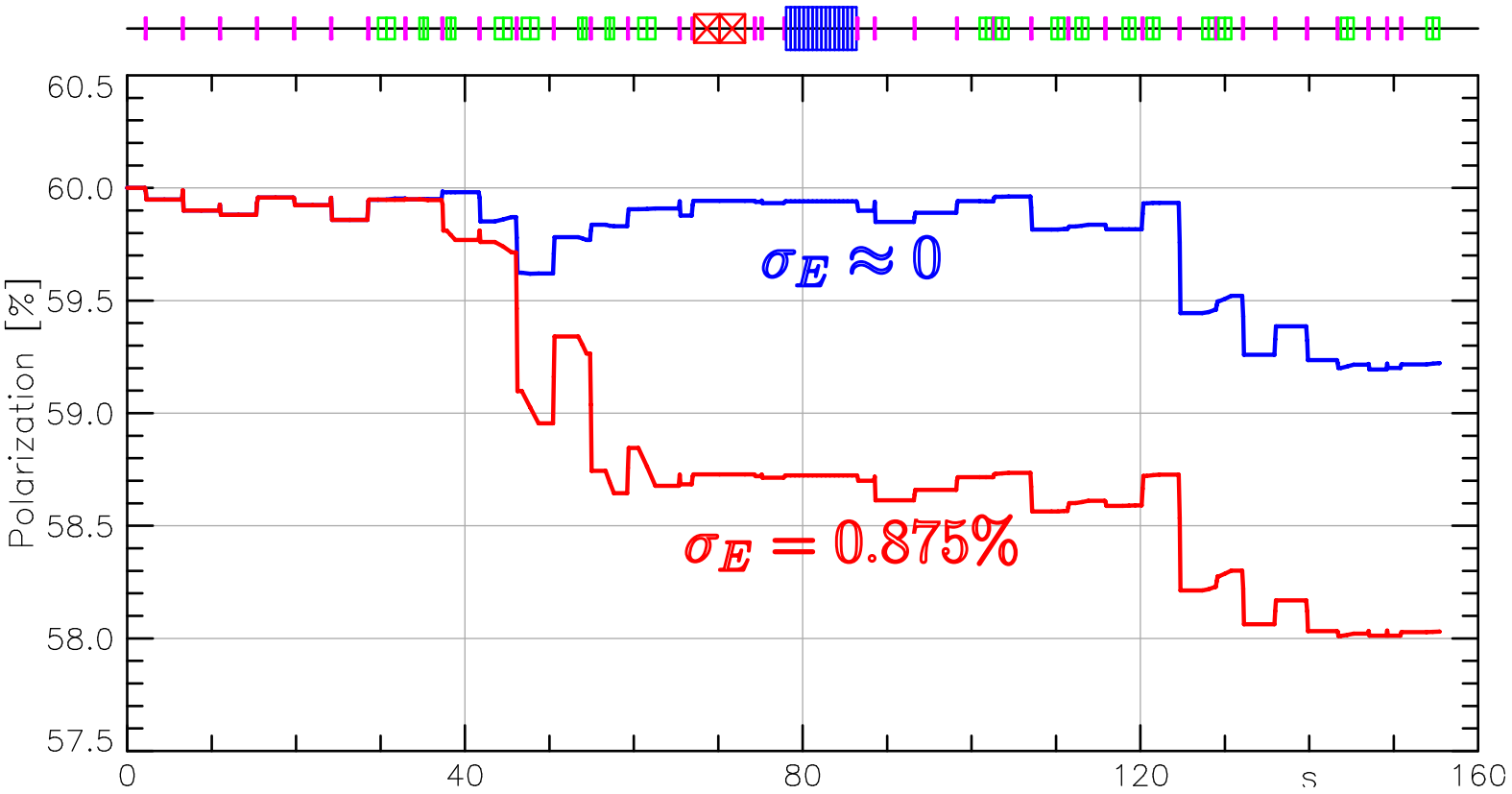
- Emittance after Target: $\epsilon_n \approx 0.13$ m



- DR Acceptance: $\epsilon_{nx} + \epsilon_{ny} < 0.09$ m

Polarization Change along LTR Beamline

$\epsilon_{nx} = \epsilon_{ny} = 0.05$ rad m, $\sigma_z = 34.6$ mm



Depolarization of Beams with Different Initial Polarization

$\epsilon_{nx} = \epsilon_{ny} = 0.05$ rad m, $\sigma_E = 0.875\%$

Ini Polarization [%]	End Polarization [%]	Depolarization [%]
100	96.82 ± 0.01	3.18 ± 0.01
60	58.07 ± 0.03	3.22 ± 0.04
30	29.09 ± 0.02	3.03 ± 0.08

Random up to 10 μm misalignment of PLTR beamline magnets does not change polarization (less then statistic errors)

Summary

- Estimated depolarization in PLTR is about $2 \div 3\%$ due to beam energy spread and relatively big emittance
- Reduction of beam energy spread upstream to spin rotator helps to reduce depolarization in PLTR

- To calculate more accurately the change of polarization in PLTR more realistic beam parameters at beginning of PLTR is necessary
- Update/development of e^+ source lattice for SB2009 is needed