Preliminary model of the solenoidal fields in FCC-ee

(one quarter of the ring IR: v. 6-14-2, arc: v14)

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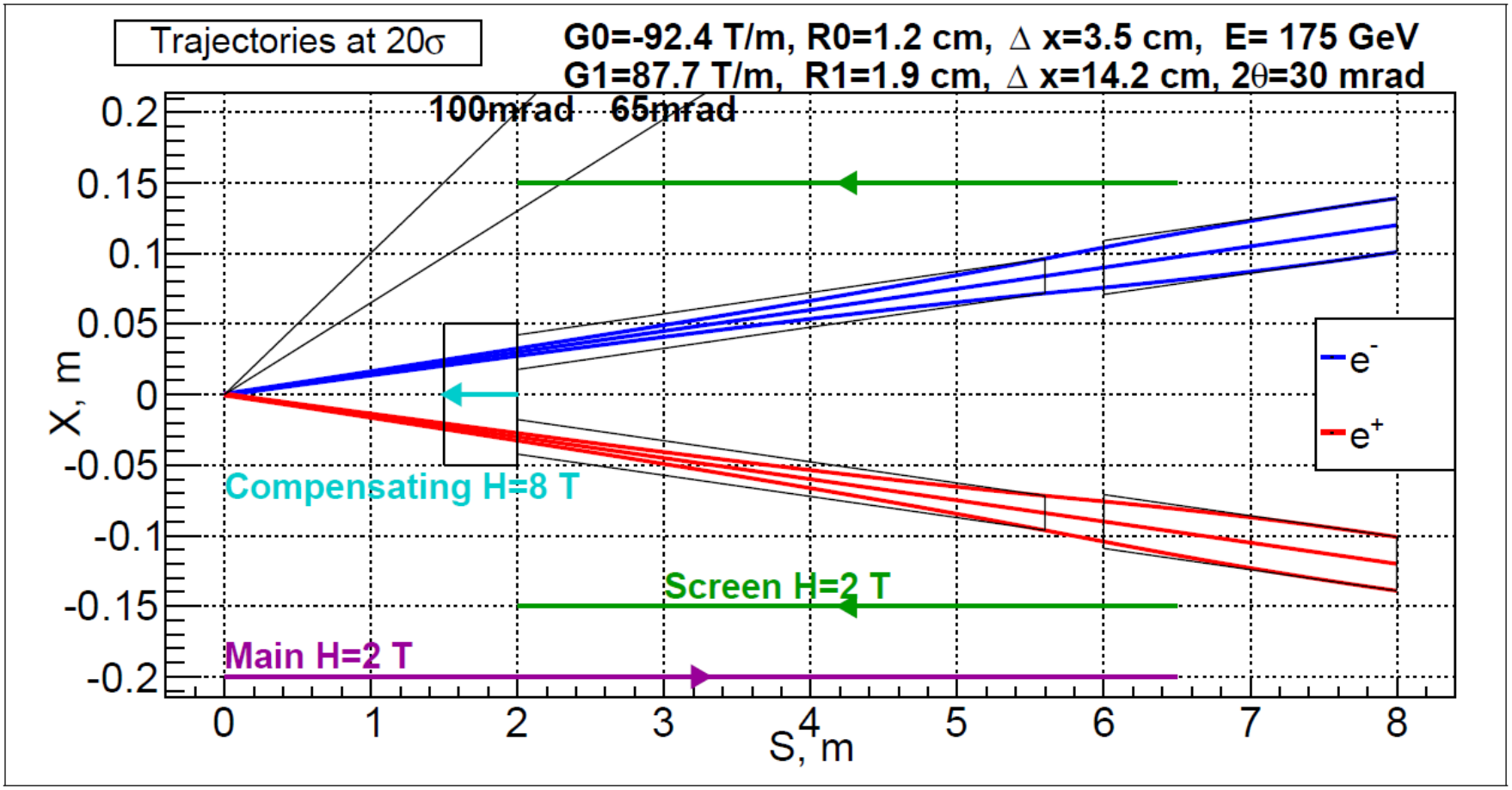
Final Focus layout: sketch of solenoids



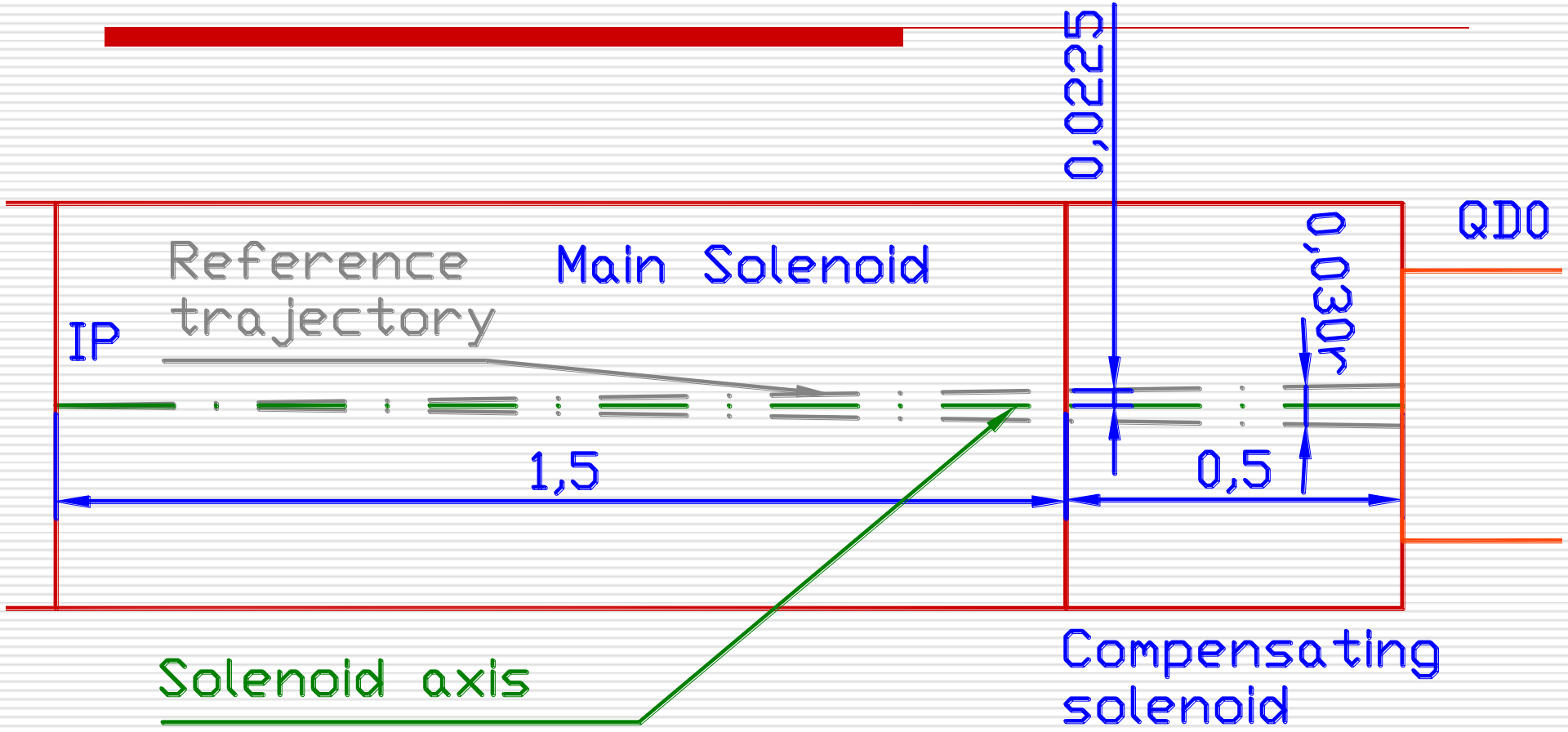
Parameters of Final Focus layout

- Main solenoid: L = 3 m, Bsol = 2 T
- 2 compensating solenoids: L = 0.5 m, Basol = - 6 T (Full magnetic field of compensating solenoid 8 T)
- Angle between beam reference trajectory and axis of solenoid ±15 mrad
- Shift of compensating solenoids entry with respect to beam trajectory: $1500 \cdot \sin(\pm 0.015) \approx \pm 22.5$ mm

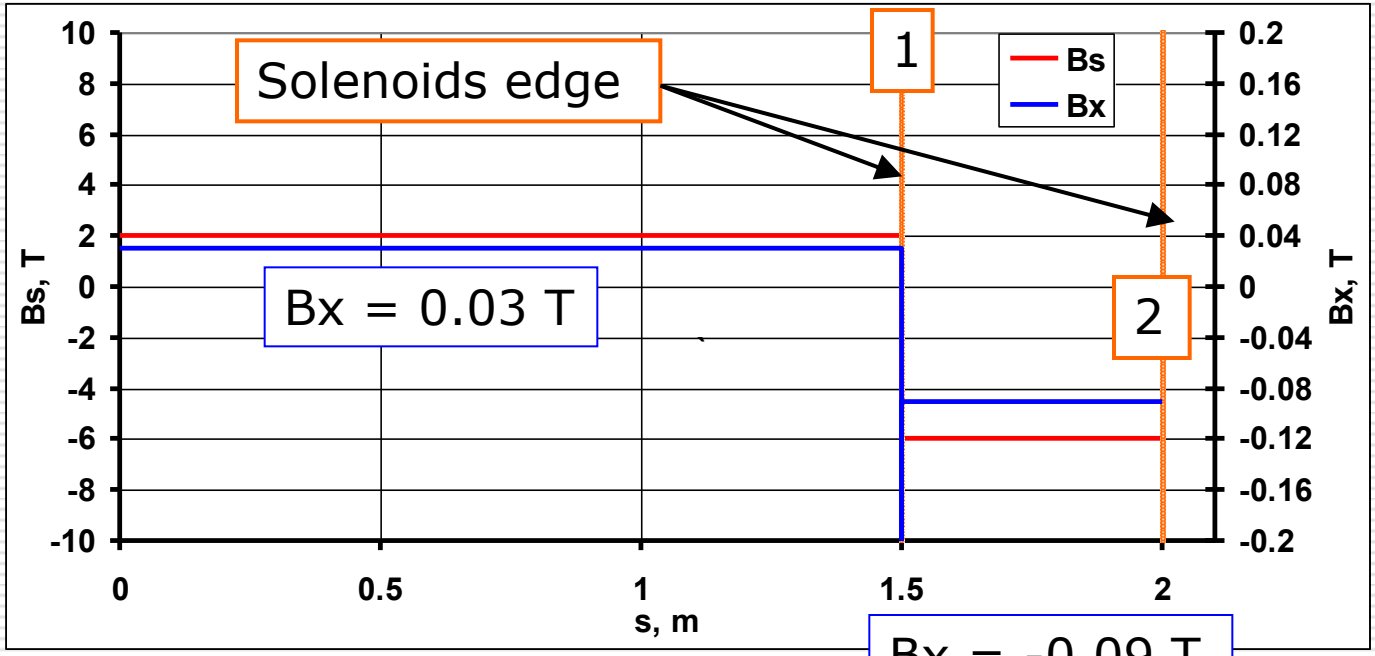
Method of solution

- Insertion of misalignments in MAD-X model (rotation of solenoids and horizontal shift)
- Magnetic field decomposition on new reference trajectory and creation of MAD-X model

Layout


0,025
QD0
Reference trajectory
Main Solenoid
IP
0,030
1,5
0,5
Solenoid axis
Compensating solenoid

Field distribution on reference trajectory

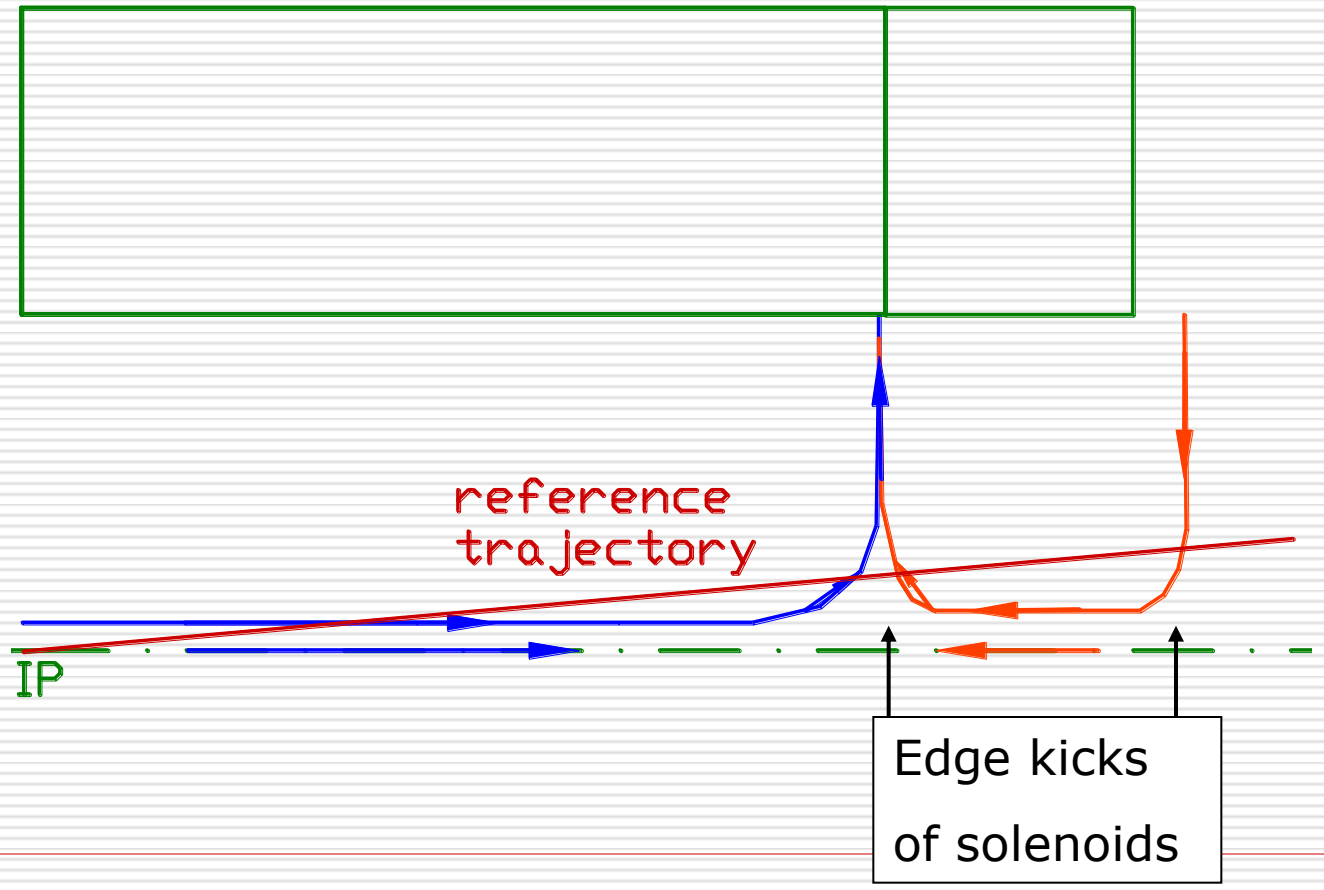


Solenoid Edge:

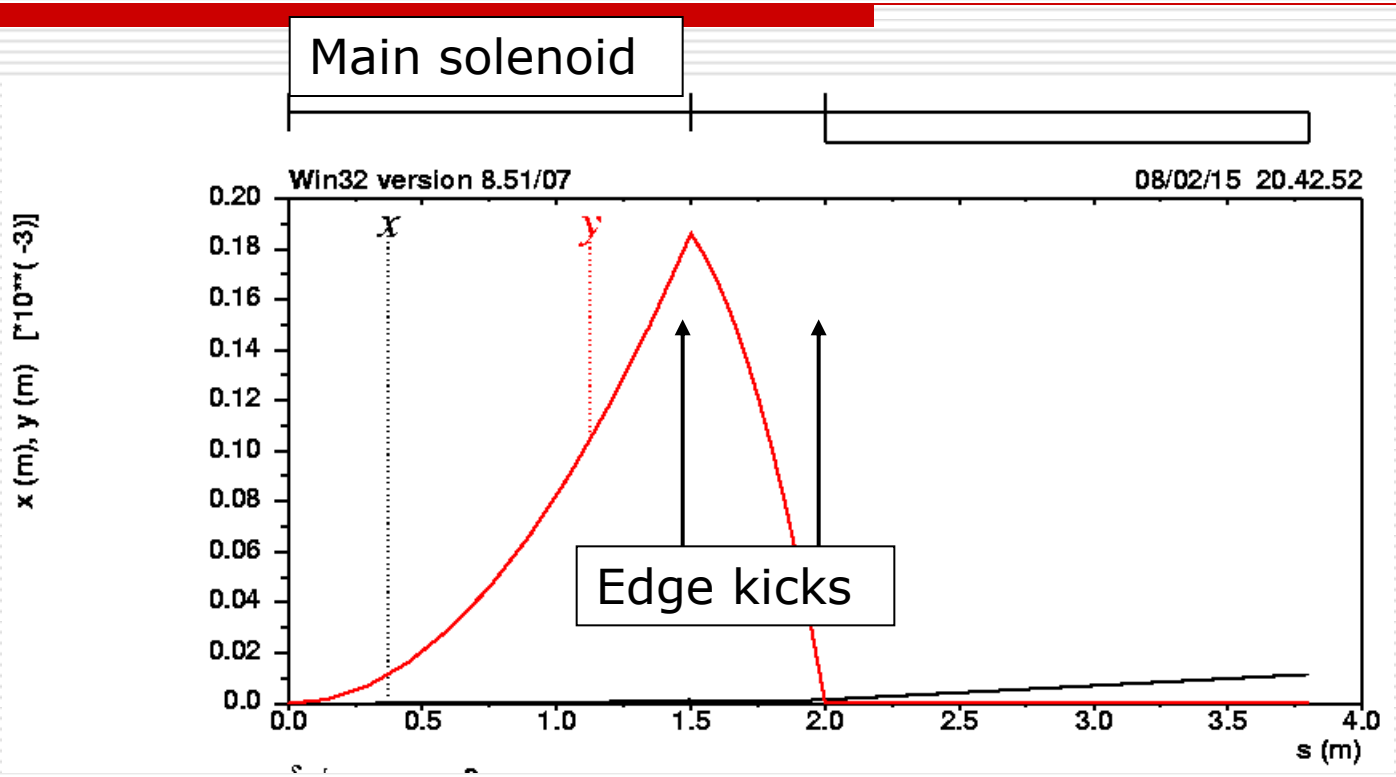
1 Vert. Kick $\Delta y' \approx (B_{com\_sol} - B_{sol}) \cdot \Delta x / (2 \cdot BR) = (-6 - 2) \cdot 0.0225 / (2 \cdot 45 / 0.3) = -6 \cdot 10^{-4}\ rad$

2 Vert. Kick $\Delta y' \approx (0 - B_{comp\_sol}) \cdot \Delta x / (2 \cdot BR) = (0 - -6) \cdot 0.03 / (2 \cdot 45 / 0.3) = 6 \cdot 10^{-4}\ rad$

Schematic plot of solenoid edge field



Distortion of orbit (E= 45 GeV)

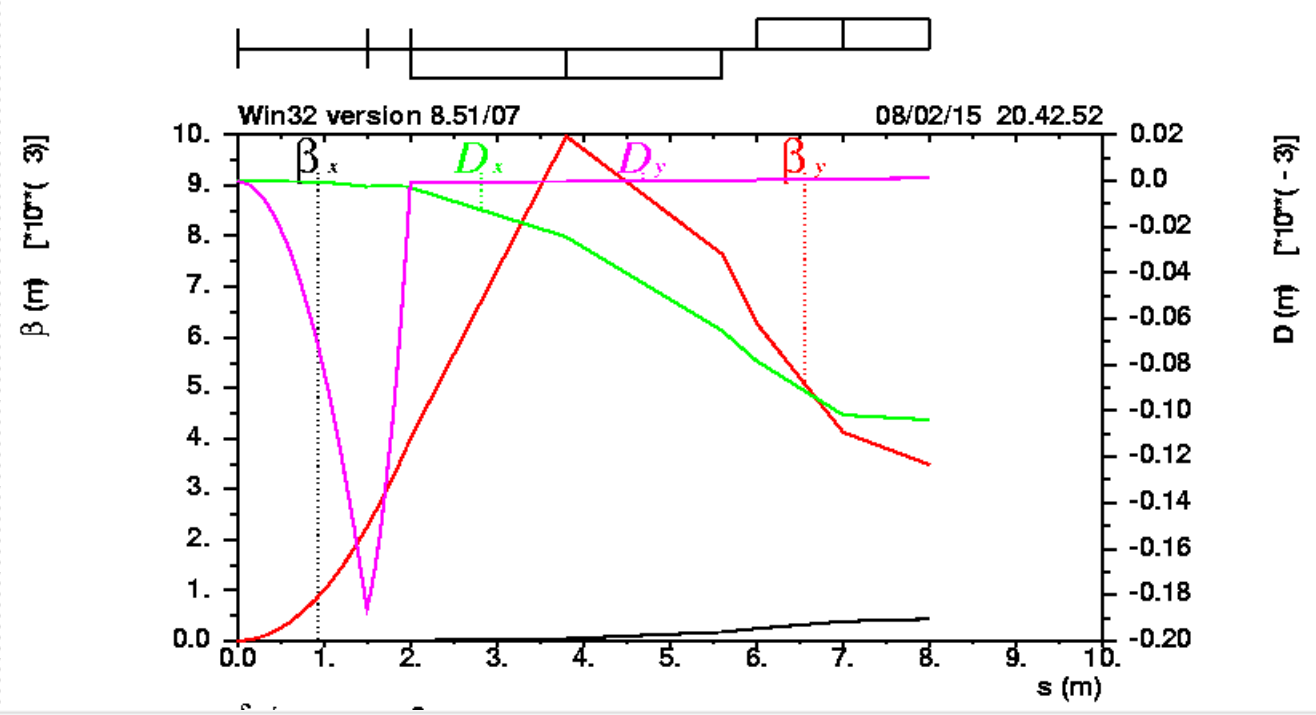


Orbit after solenoids:

X= 1.5 mkm

Y=0 mkm

Change of dispersion functions (E= 45 GeV)

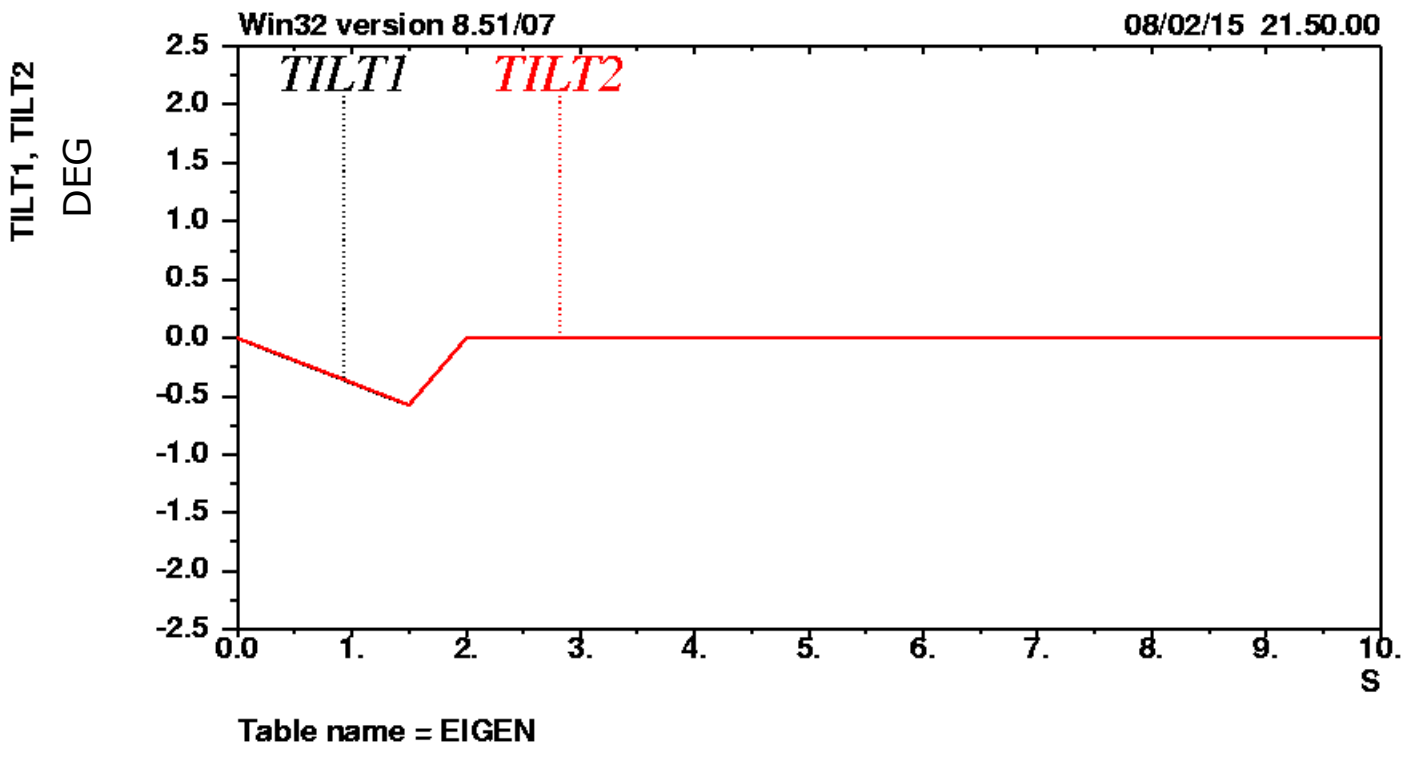


Orbit after solenoids:

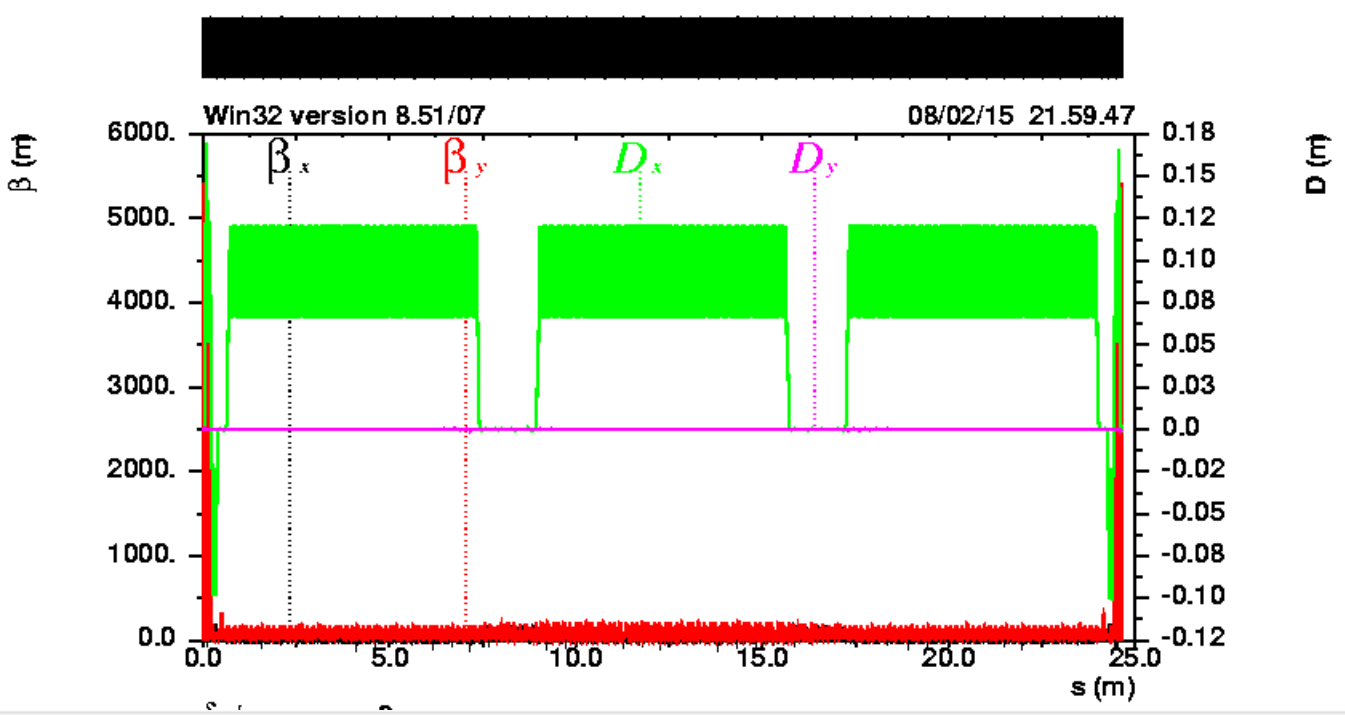
D_X= 0.04 mm

D_Y=0 mm

Change of normal mode angles (E= 45 GeV)



Twiss functions (E= 45 GeV)



IP:

β_x = 0.5 m

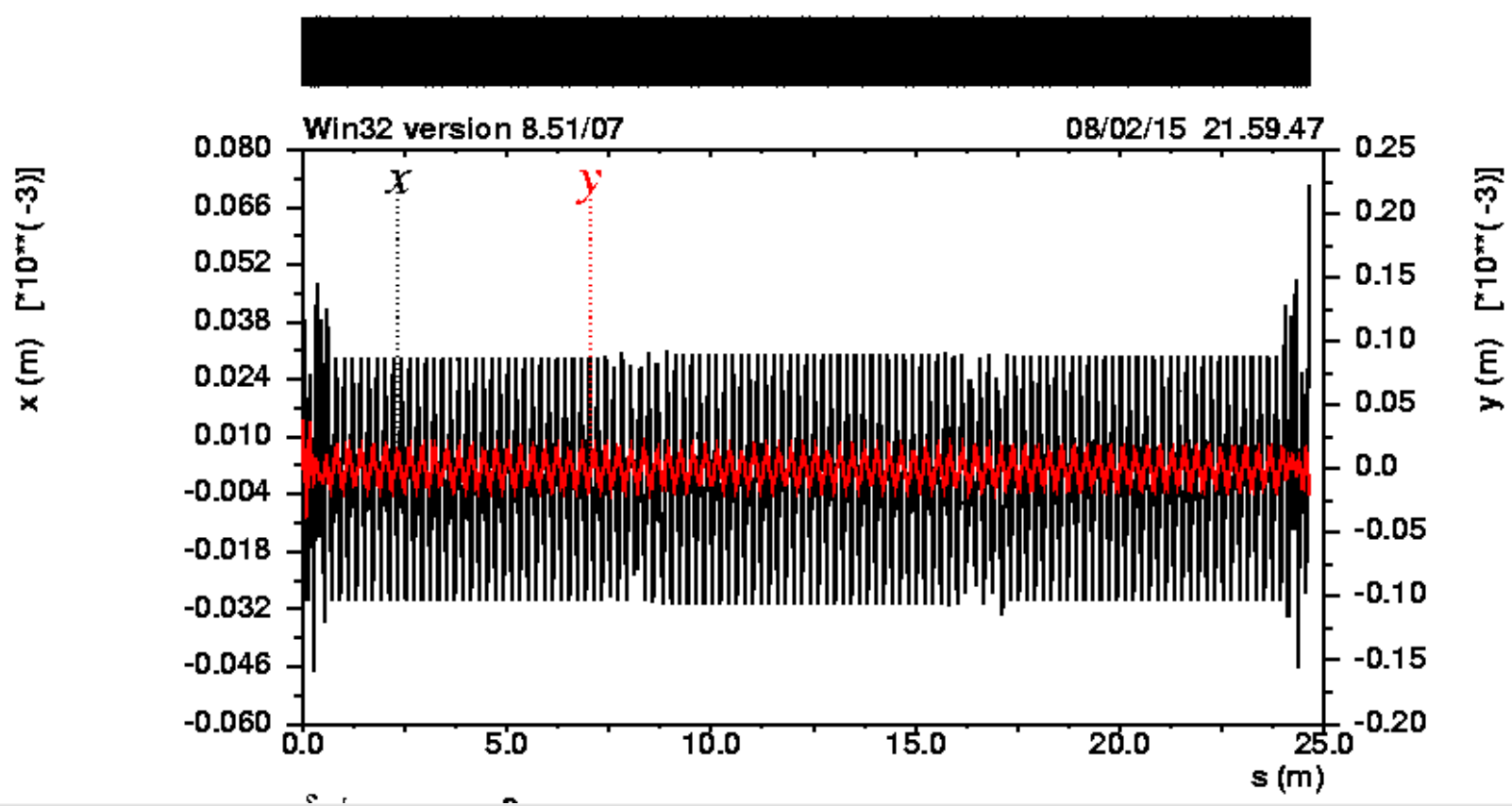
β_y = 1.84 mm

Maximum value :

β_x = 432 m

β_y = 5420 m

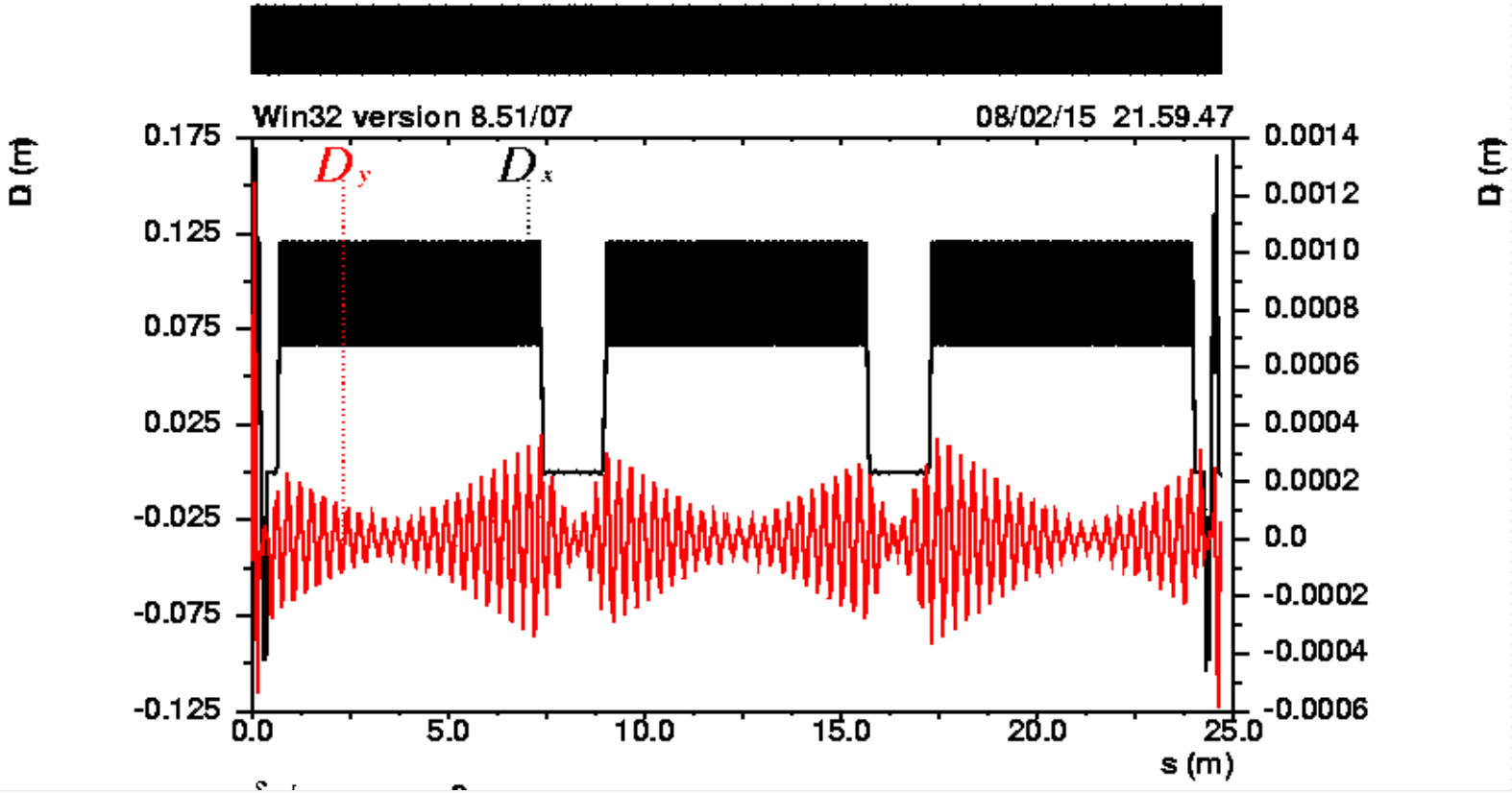
Orbit Distortion (E= 45 GeV)



X < 70 mkm

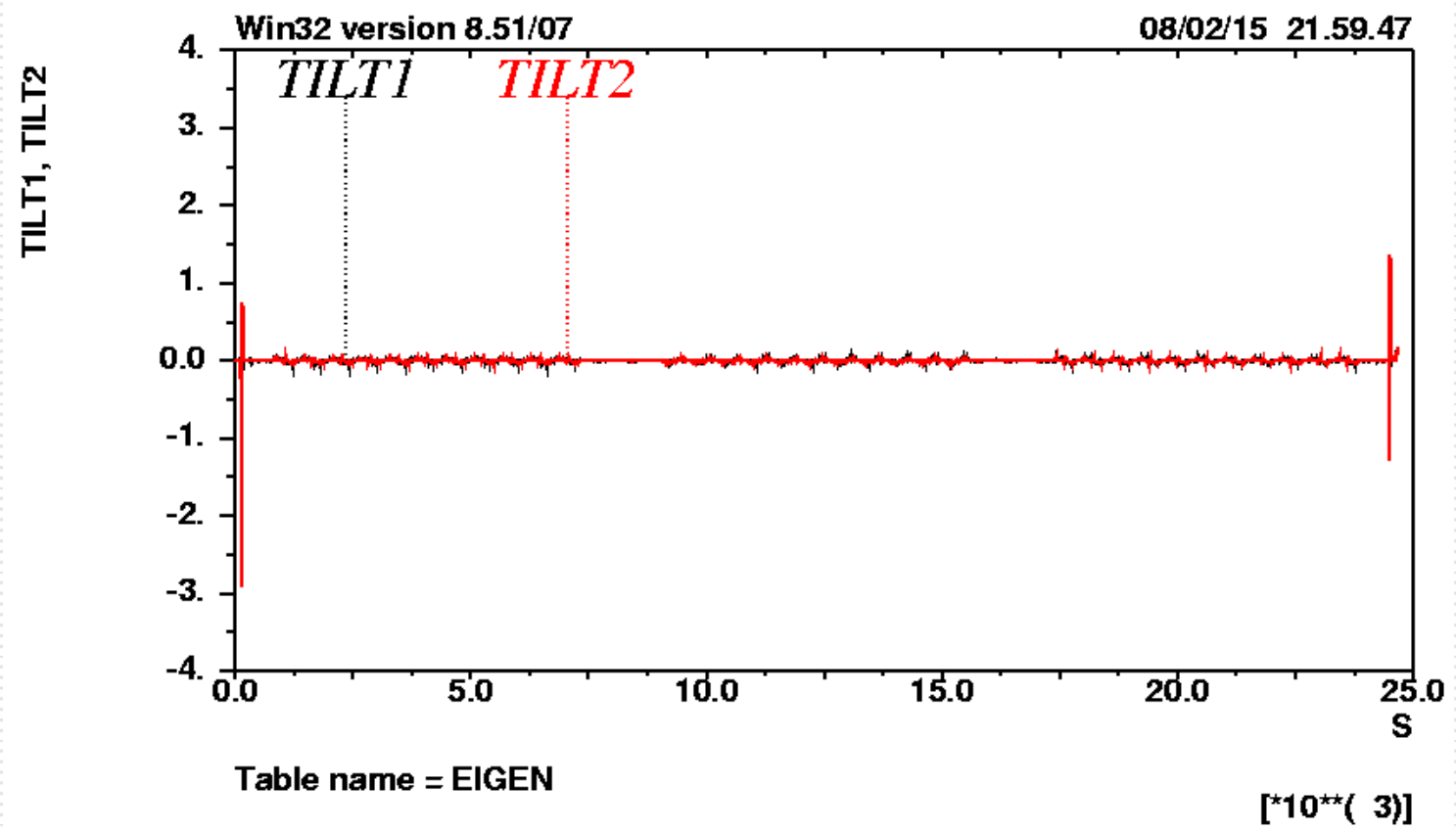
Y < 25 mkm

Distortion of dispersion (E= 45 GeV)



Dy < 0.3 mm - in arcs cells

Change of normal mode angles along azimuth (E= 45 GeV)



Change of parameters by solenoid fields

Energy, GeV	45	45	175	175
Solenoids	off	on	off	on
Betatron tunes:				
qx	124.540	124.540	124.540	124.540
qy	84.570	84.643	84.570	84.577
Betafunction IP:				
Betx, m	0.50	0.50	0.50	0.50
Bety, mm	1.00	1.84	1.00	1.09
Emittance, nm*rad:				
horizontal	0.084	0.084	1.26	1.26
vertical	**0**	**3.71E-05**	**0**	**3.13E-05**
Betatron coupling	0.00E+00	4.45E-04	0.00E+00	2.48E-05

Summary

- Misalignment of solenoids are inserted in MAD-X model
- Some correction of MAD-X representation are made
- It is necessary to insert compensation of betatron tunes
- Optics must be rematch
- For more correct calculation of betatron coupling the superperiod of ring must be used (the optics should contain arcs with small and big radius).
- To control betatron coupling the skew quadrupoles are necessary to insert into MAD-X model
- Decomposition of a real field on a trajectory of a beam is necessary to make

Several questions on MAD-X & MAD-8 (Question 1)

- Rotation of solenoids is 15 mrad with respect to reference trajectory
- Solenoid fields is switched off

- Why are betatron tunes changes?
- Qx = 124.540 - > 124.540
- Qy = 84.570 - > 84.549

- To correct this effect the distance between IP and QD0 is necessary to increase: dL=L*(1-cos(0.015))

Several questions on MAD-X & MAD-8 (Question 2)

- Rotation of solenoids is 15 mrad with respect to reference trajectory
- Solenoid fields is switched off

- Why are horizontal orbit distortion?

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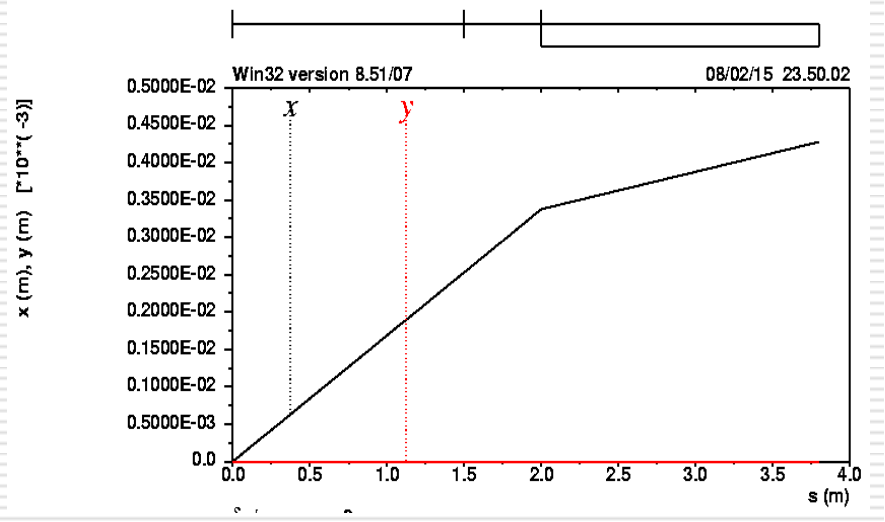

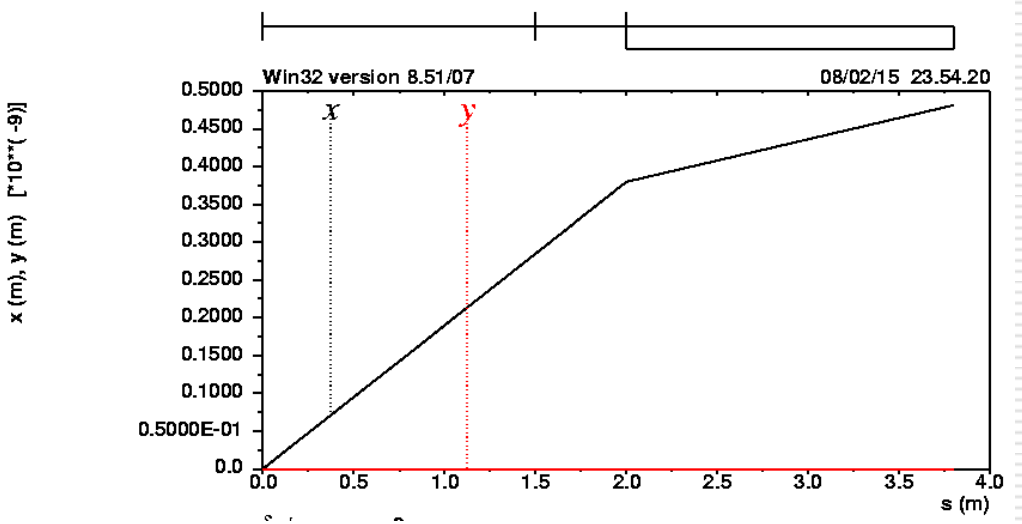

Before correction

Xout solenoid = 3.5 mkm

After correction

Xout solenoid = 0.37 nm

Insert additional elements: YROTATION before and after solenoids

YR in_sol : yrotation,angle=-(0.015-asin(tan(0.015)));

YR out_sol : yrotation,angle= (0.015-asin(tan(0.015)));