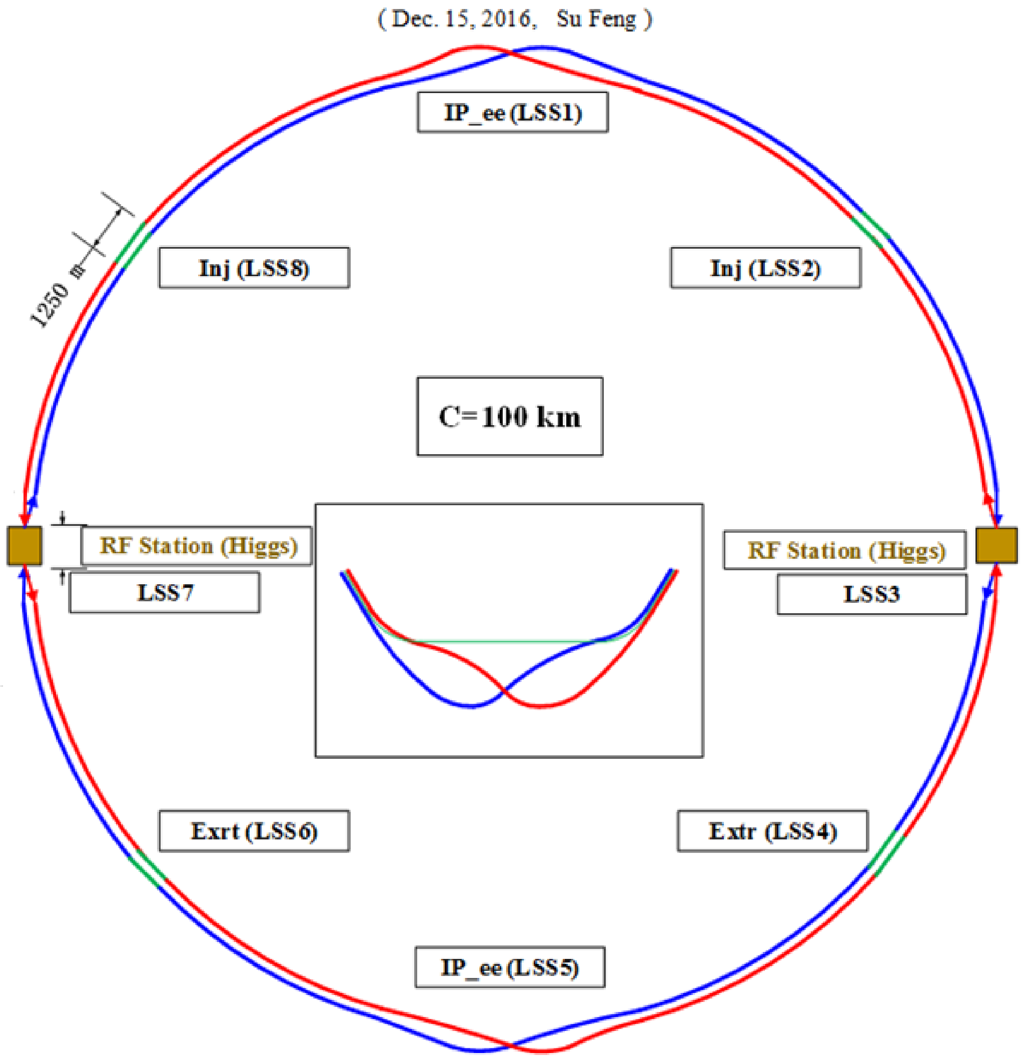
MDI Status Report

Hongbo Zhu

20 March 2017

Full Partial Double Ring



Focal length:
L* 1.5m →2.2 m

Crossing angle: 33 mrad

Common RF stations for H/Z at LSS3/7 (IP 3/4)

Updated Machine Parameters

D. Wang

	Pre-CDR	*Higgs*	*W*	*Z*
Number of IPs	2	2	2	2
Energy (GeV)	120	120	80	45.5
Circumference (km)	54	100	100	100
SR loss/turn (GeV)	3.1	1.67	0.33	0.034
Half crossing angle (mrad)	0	16.5	16.5	16.5
Piwinski angle	0	3.19	5.26	4.29
N_e/bunch (10^{11})	3.79	0.968	0.365	0.455
Bunch number	50	644 (412)	5534	21300
Beam current (mA)	16.6	29.97 (19.2)	97.1	465.8
SR power /beam (MW)	51.7	**50 (32)**	**32**	**16.1**
Bending radius (km)	6.1	11	11	11
Momentum compaction (10^{-5})	3.4	1.14	1.14	4.49
β_{IP} x/y (m)	0.8/0.0012	0.171/0.002	0.2 /0.002	0.16/0.002
Emittance x/y (nm)	6.12/0.018	1.31/0.004	0.57/0.0017	1.48/0.0078
Transverse σ_{IP} (um)	69.97/0.15	15.0/0.089	10.7/0.059	15.4/0.125
ξ_x/ξ_y/IP	0.118/0.083	0.013/0.083	0.0064/0.062	0.008/0.054
RF Phase (degree)	153.0	128	126.8	165.3
V_{RF} (GV)	6.87	**2.1**	**0.41**	**0.14**
f_{RF} (MHz) (harmonic)	650	650	650 (217800)	650 (217800)
Nature σ_z (mm)	2.14	**2.72**	**3.37**	**3.97**
Total σ_z (mm)	2.65	2.9	3.4	4.0
HOM power/cavity (kw)	3.6 (5cell)	0.64(2cell) (0.41)	0.72(2cell)	1.99(2cell)
Energy spread (%)	0.13	0.098	0.065	0.037
Energy acceptance (%)	2	1.5		
Energy acceptance by RF (%)	6	2.1	1.1	1.1
n_γ	0.23	0.26	0.14	0.12
Life time due to beamstrahlung_cal (minute)	47	52		
F (hour glass)	0.68	0.96	0.98	0.96
L_{max}/IP (10^{34}cm^{-2}s^{-1})	2.04	3.13 (2.0)	5.12	11.9

Preliminary Lattice Design

Y. Wang

- *To ease the magnet design*

L*= 2.2m

βx*= 0.171mm

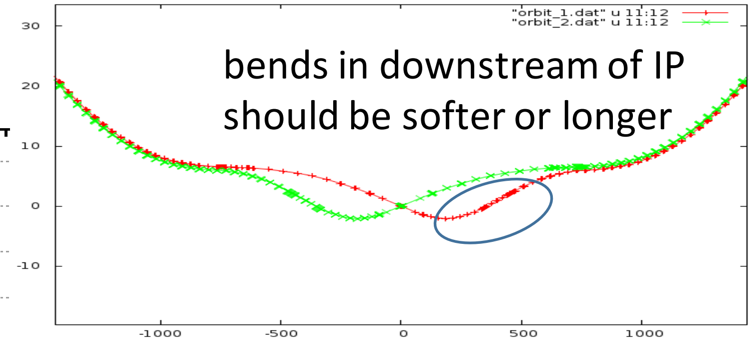
βy*= 2mm

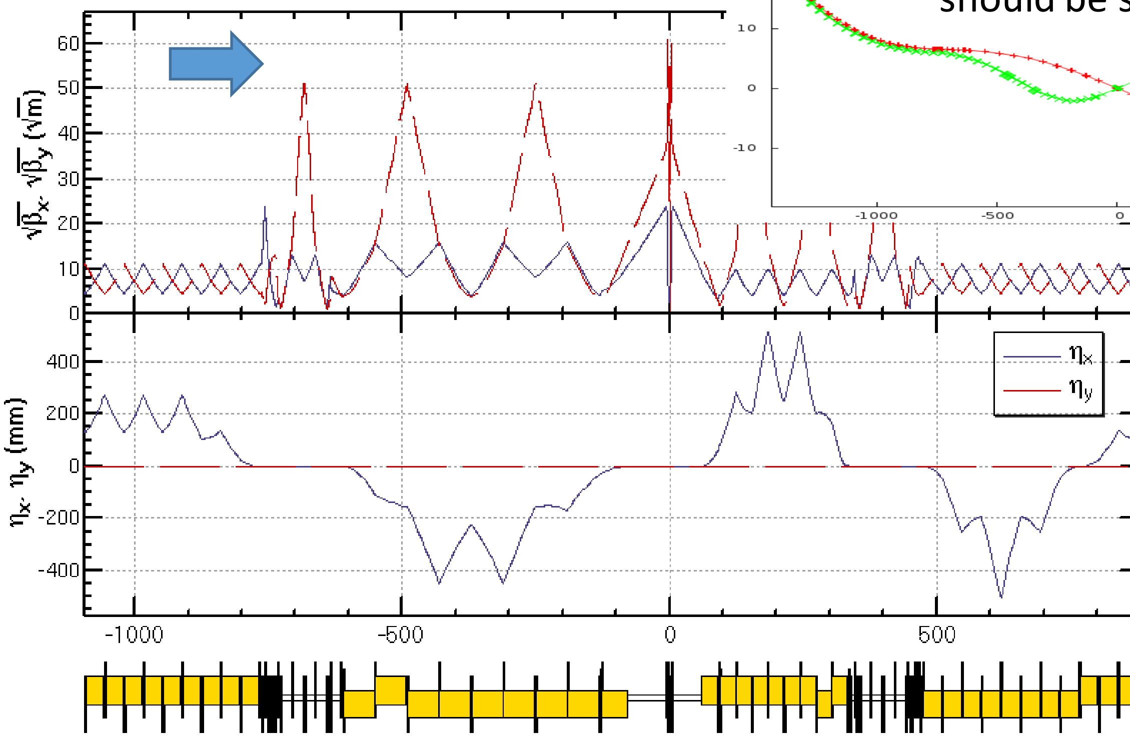
GQD0~ -150T/m

GQF1~100T/m

LQD0=1.73m

LQF1=1.48m





IP upstream *Ec < 100 keV within 250m*

IP downstream *Ec < 500 keV within 150m*

- *Much improved from previous design (Ec ~ 1MeV), may have to bring down the Ec further*

Revised Magnet Designs

Y. Zhu

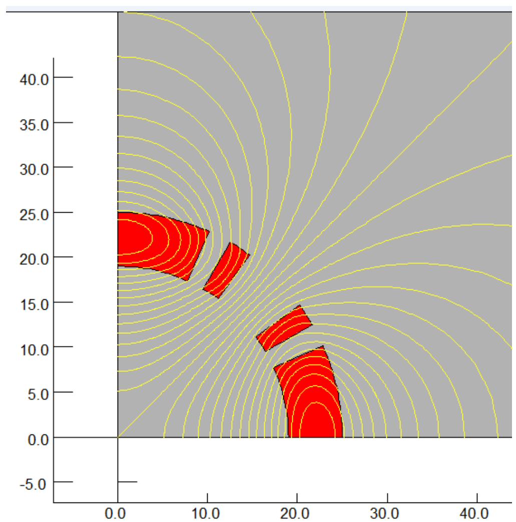
- Updated parameters of the magnets based on the new L* = 2.2 m and lower detector solenoid of B=3 T

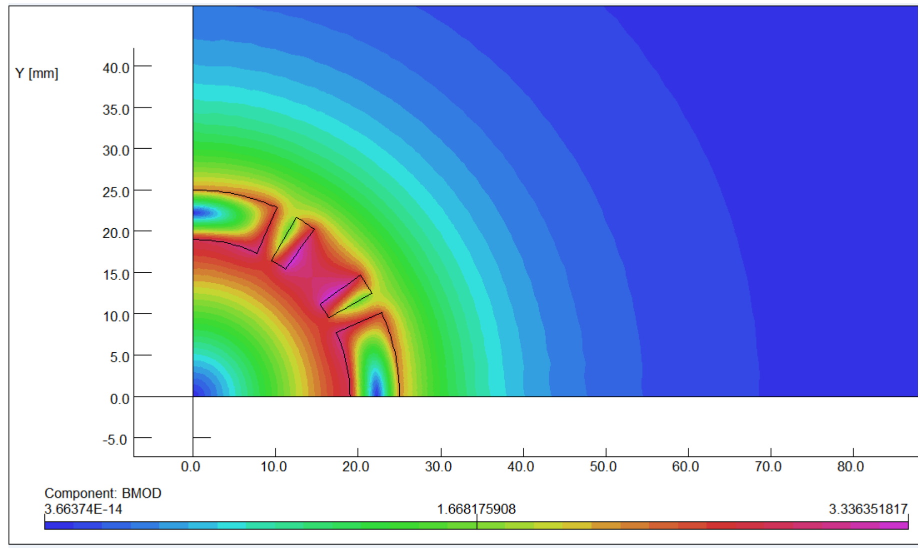
Magnet	Field Strength	Length (m)	Inner Radius (mm)
QD0	150 T/m	1.7489	19
QF1	106 T/m	1.4636	26
Compensating solenoid	6.6 T	1.0	90
Screening solenoid	2.5 T	1.7489	100

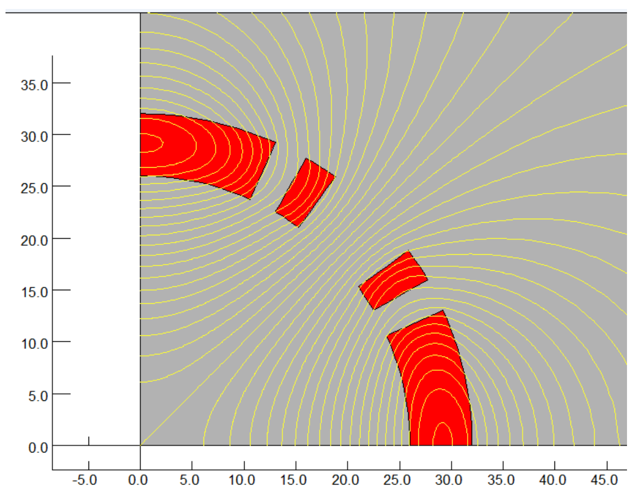
- Weaker QD0/QF1 field strengths would introduce less harder SR photons in the IR → easier collimation and less backgrounds
- Lower compensating solenoid makes it possible to construct the magnet with the cutting-edge superconducting magnet technology → motivation to increase L* (+ clearance between electron/positron beam pipes)

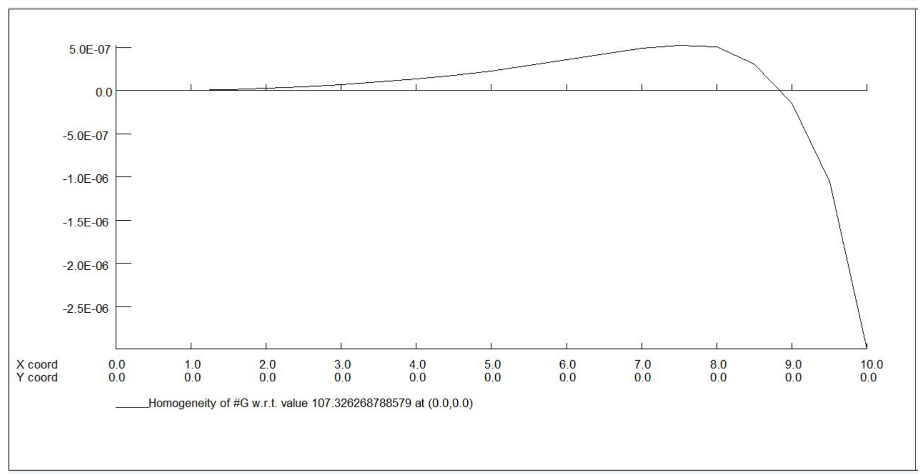
Updated Field Maps

- Updated calculation of the QD0/QF1 field maps



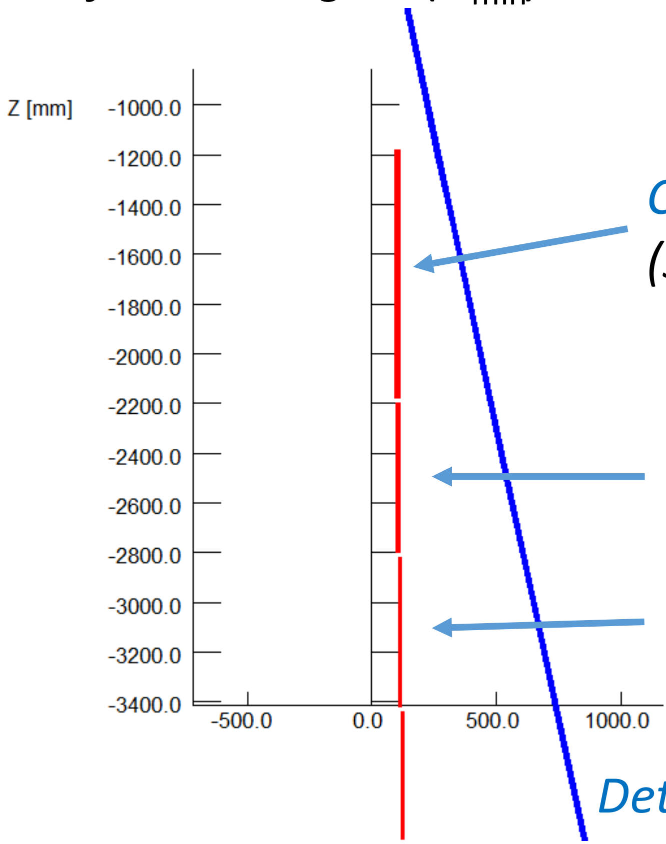






Magnet Layout

- Magnets along the z-axis, outer radius (including cryogenics and mechanical structure) yet to be estimated → *defining the detector coverage in the forward region (θ_{min})*



Compensating magnet
(space given to LumiCal?)

QD0 + Screening magnet

QF1

Detector/machine separation requires more careful considerations
(NB. FCC-ee θ = 100 mrad)

Revised Magnet Parameters

Table 1: Main design parameters of CEPC interaction region quadrupole magnet

Magnet name	QD0
Field gradient (T/m)	150
Magnetic length (m)	1.749
Coil turns per pole	25
Excitation current (A)	2300
Coil layers	2
Conductor size (mm)	Rutherford Type NbTi-Cu Cable
Stored energy (KJ)	19.5
Inductance (H)	0.0074
Peak field in coil (T)	3.3
Coil inner diameter (mm)	38
Coil out diameter (mm)	50
Cold mass weight (kg)	100

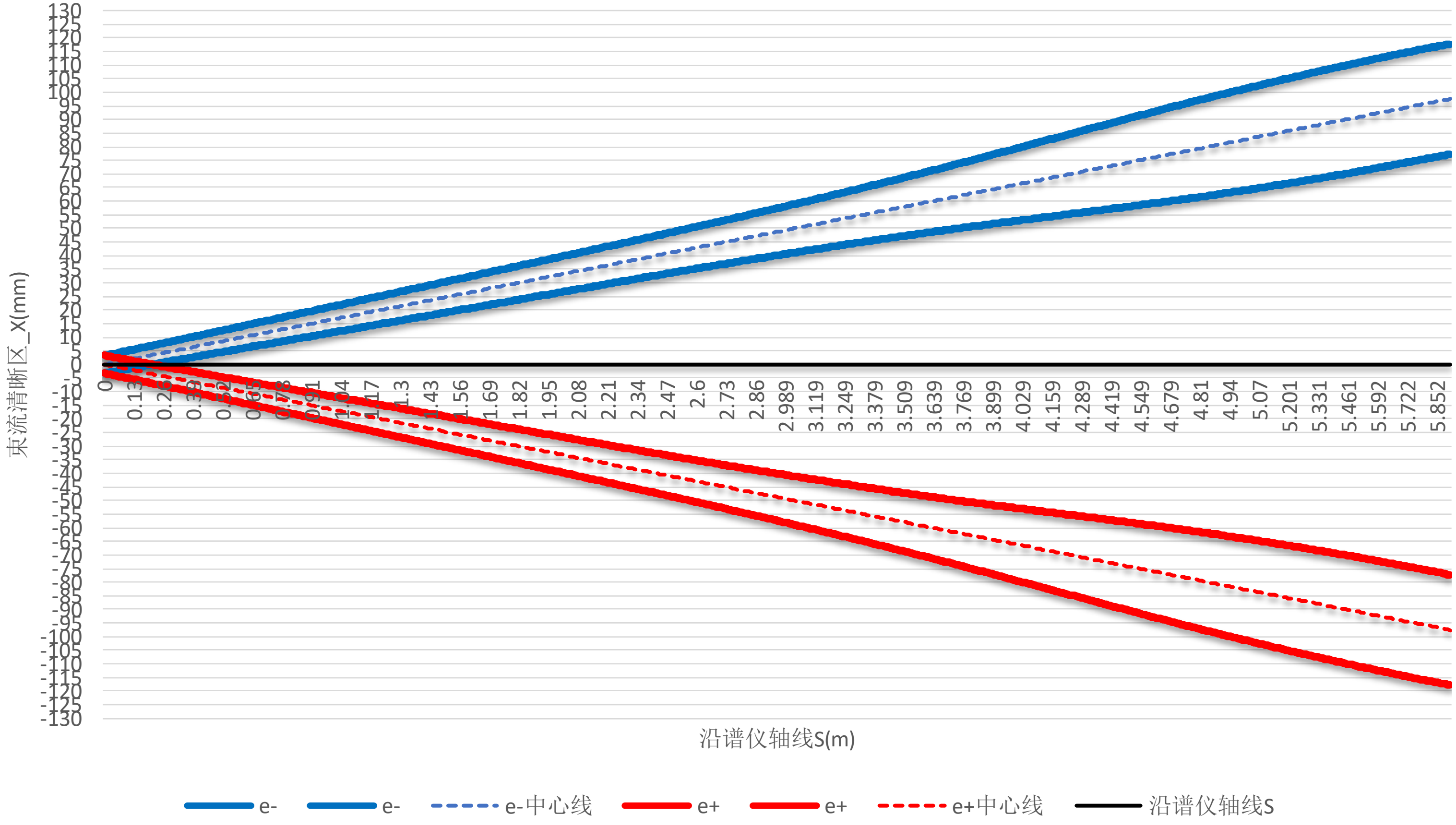
Table 2: Main design parameters of CEPC interaction region anti-solenoids

Magnet name	Compensating solenoid QD0	Screening solenoid QD0
Central field (T)	6.6	2.5
Magnetic length (m)	1.0	1.75
Conductor Type	NbTi-Cu, 4×2mm	NbTi-Cu, 4×2mm
Coil layers	6	4
Excitation current (kA)	2.0	1.5
Stored energy (KJ)	500	163
Inductance (H)	0.25	0.14
Peak field in coil (T)	6.7	2.6
Solenoid inner diameter (mm)	160	180
Solenoid outer diameter (mm)	250	280
Cold mass weight (kg)	350	250

Beam Pipes

S. Bai

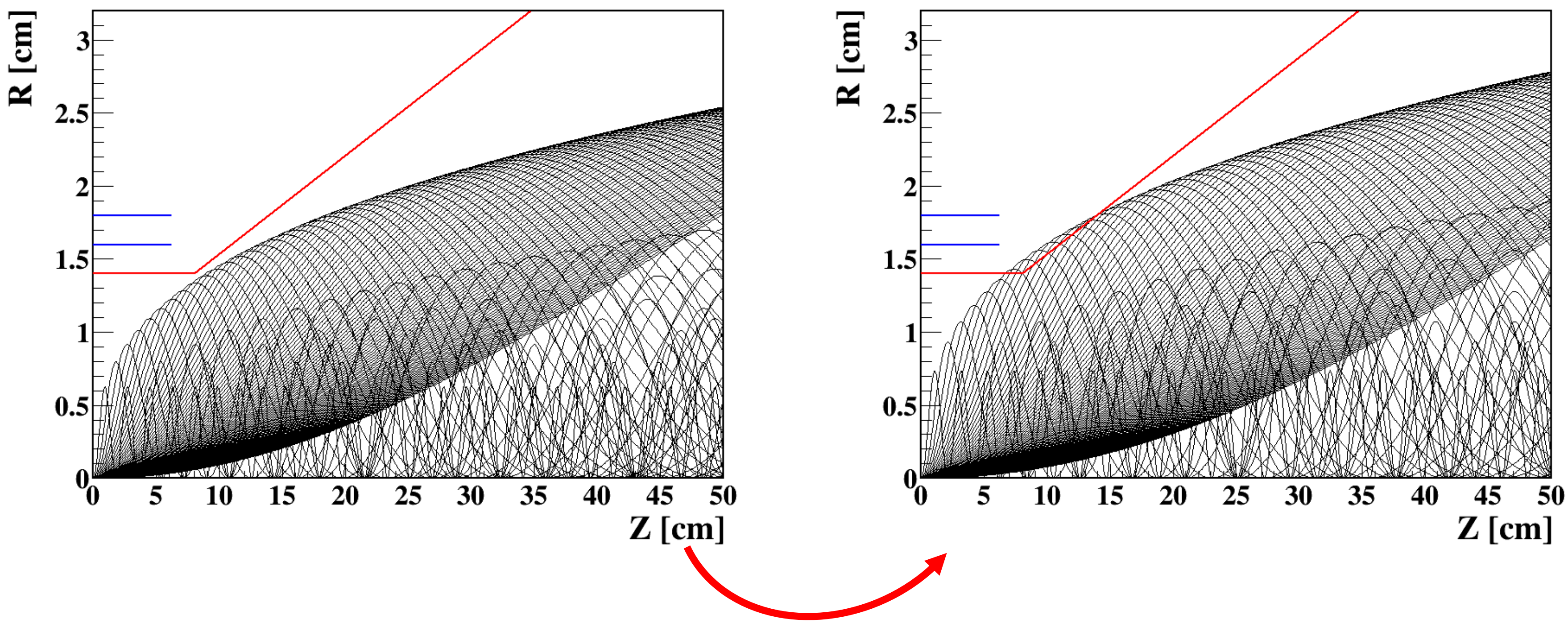
- Electron and positron beam pipe clearance areas → *important input into the beam pipe shape design (ongoing effort)*
- *Central beam pipe not constraned*



Background Estimation

Q. Xiu

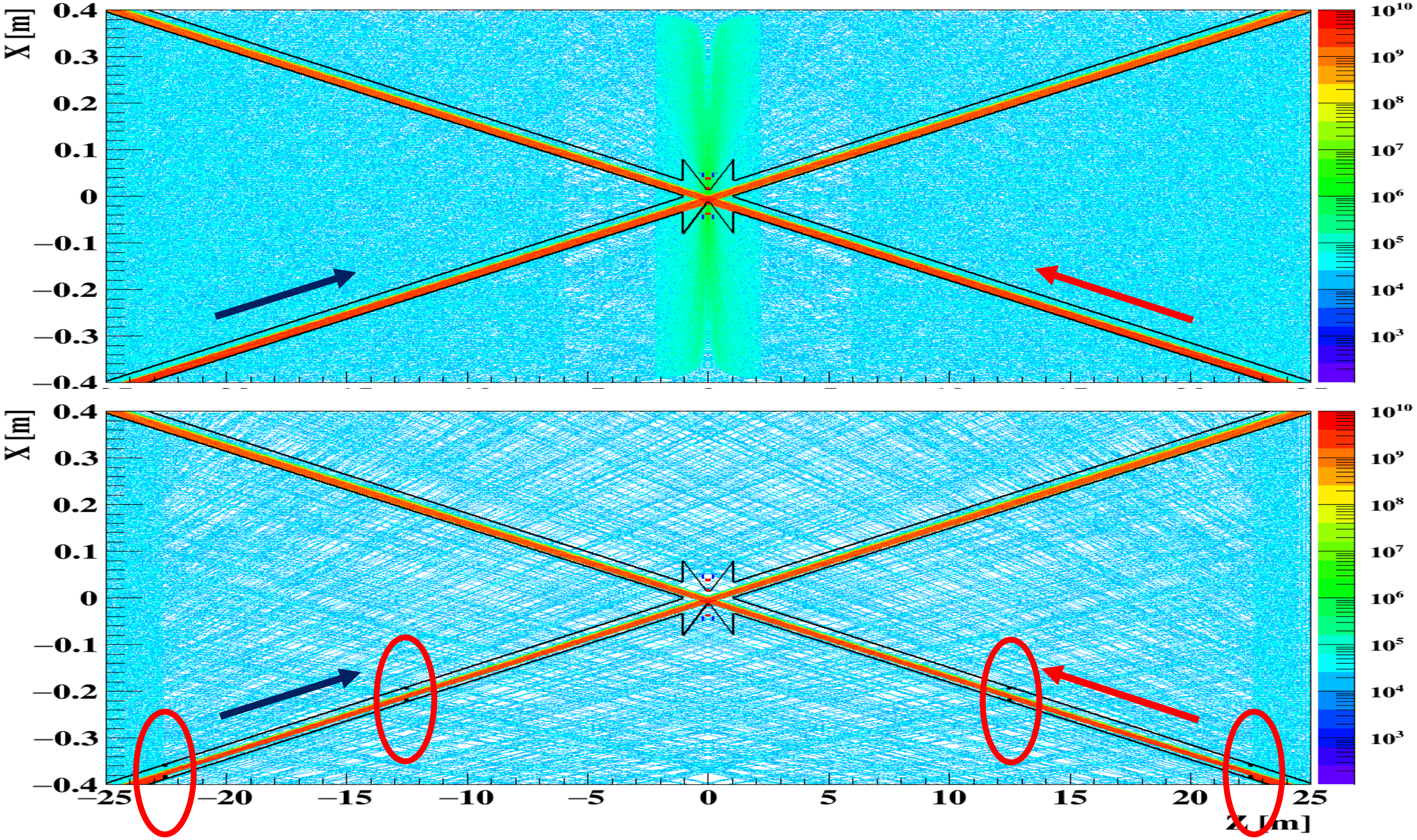
- Impact of the lower detector solenoid (3.5 T → 3.0 T)
- Helixes formed by the electrons/positrons from the kinematic edge of pair production out of the beamstrahlung
- To-Do: Beam pipe position to be adjusted followed by the updated detector background estimation



3.5 T → 3.0 T

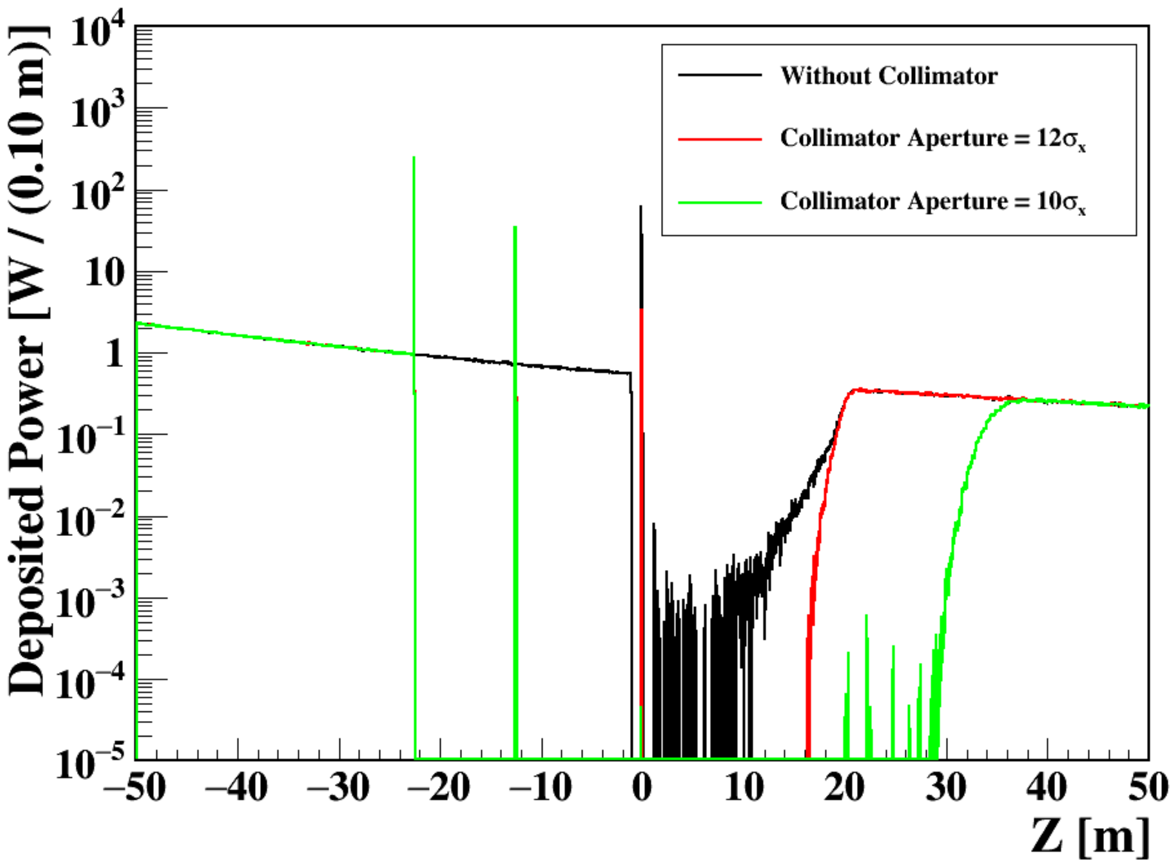
Synchrotron Radiation

- SR Photon flux re-estimated with the preliminary lattice



SR Power Deposition

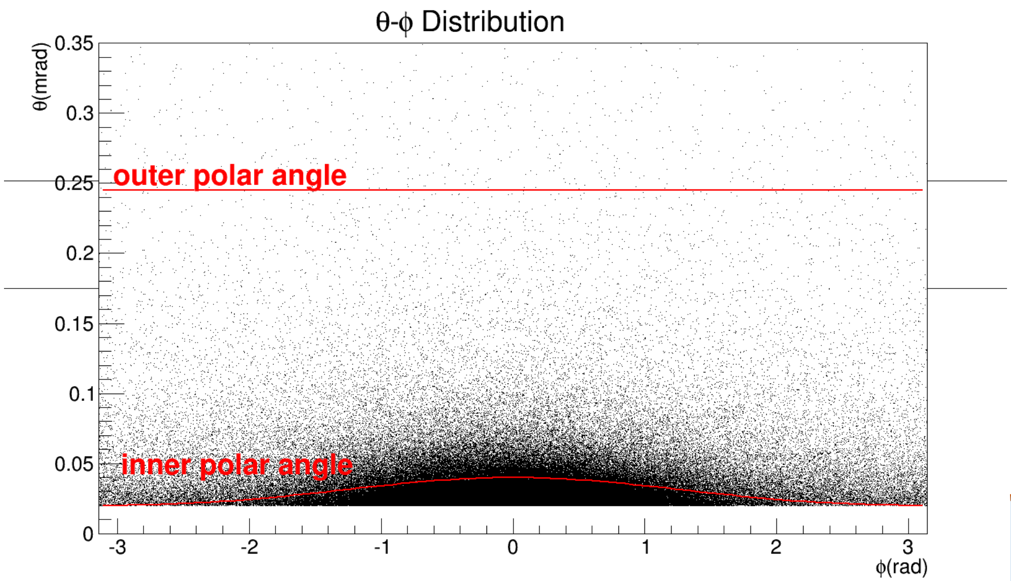
- Power deposition of SR photons along the z-axis
- Significant effect of the collimators even with low statistics → proof of principle, may have to consider more realistic designs



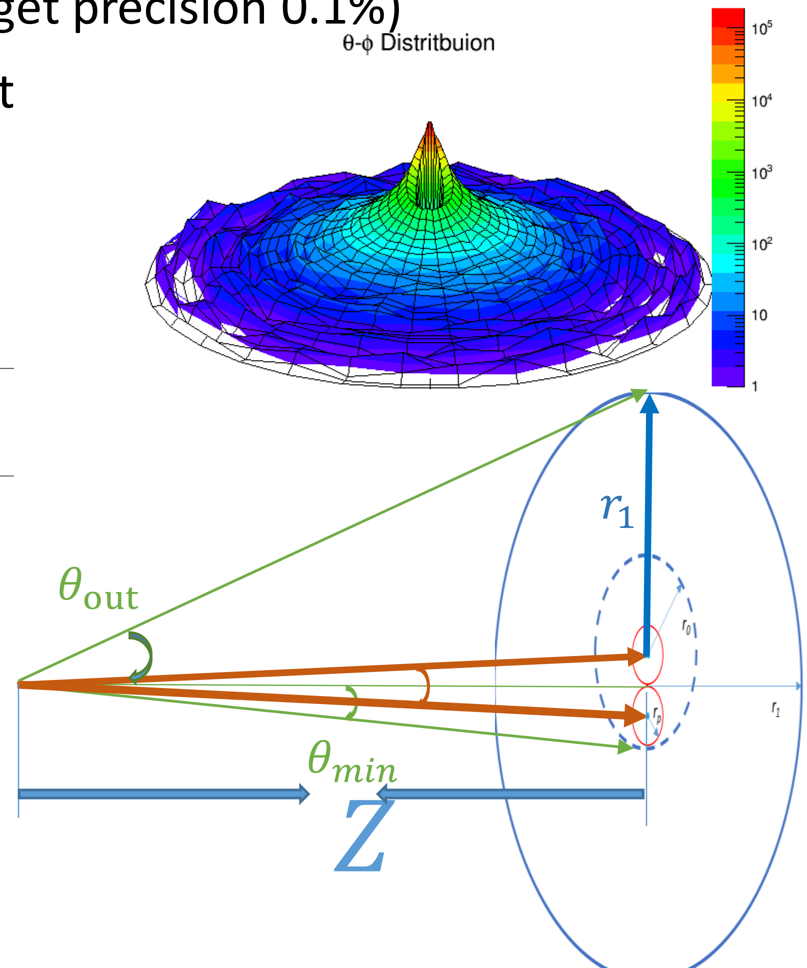
LumiCal

K. Zhu & L. Yang

- E_{CM}=250 GeV, crossing angle = 33 mrad; detector positions: Z=950 mm , r1=200 mm (space constrained by the compensating magnet)
- Measurement with Bhabha events (target precision 0.1%)
- Detector technology not considered yet



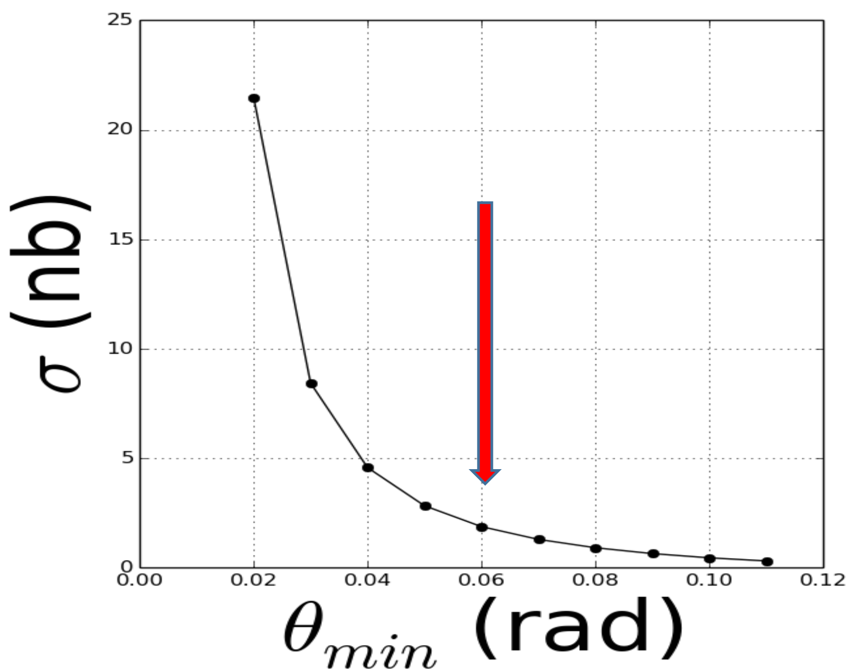
Events generated with WHIZARD

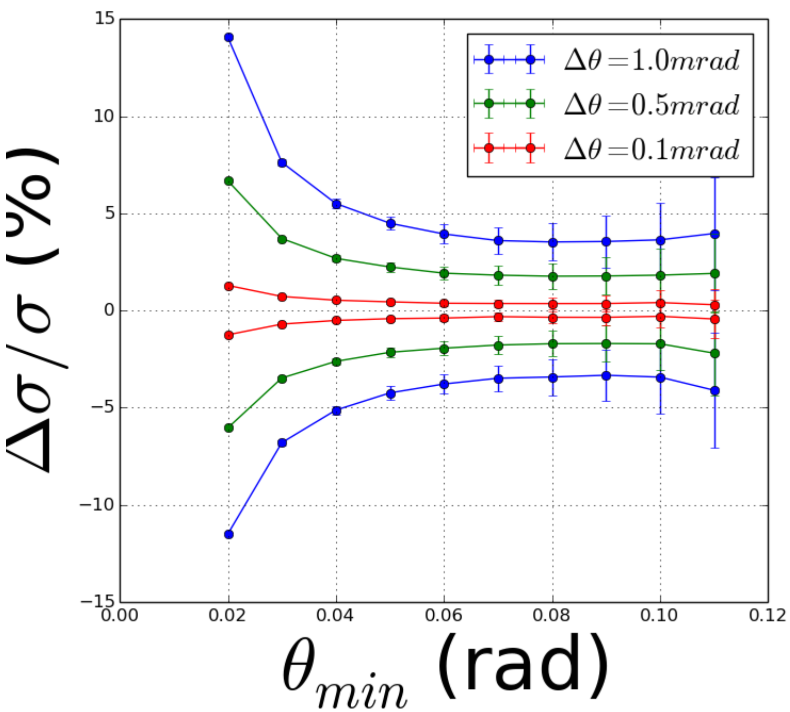


Systematic Uncertainties (selected)

- $\boldsymbol{\theta_{min}}$=$\mathbf{60}\ \boldsymbol{mrad}$ might be adopted given adequate statistics ($\boldsymbol{\sigma \sim 1.8nb}$)
- Small Δθ required to reduce the $\boldsymbol{\Delta\sigma/\sigma}$ to a preferred level

100 M Bhabha events ($\mathbf{20}$<$\boldsymbol{\theta}$<$\mathbf{350}$ mrad) generated with whizard-2.3.1)





Re-designing Interaction Region

- Comprehensive understanding of the requirements and constrains from both machine and detector
- To be updated: