中国科学院高能物理研究所
Institute of High Energy Physics Chinese Academy of Sciences

CEPC MDI status and challenges

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On behalf of the CEPC MDI group

Institute of High Energy Physics

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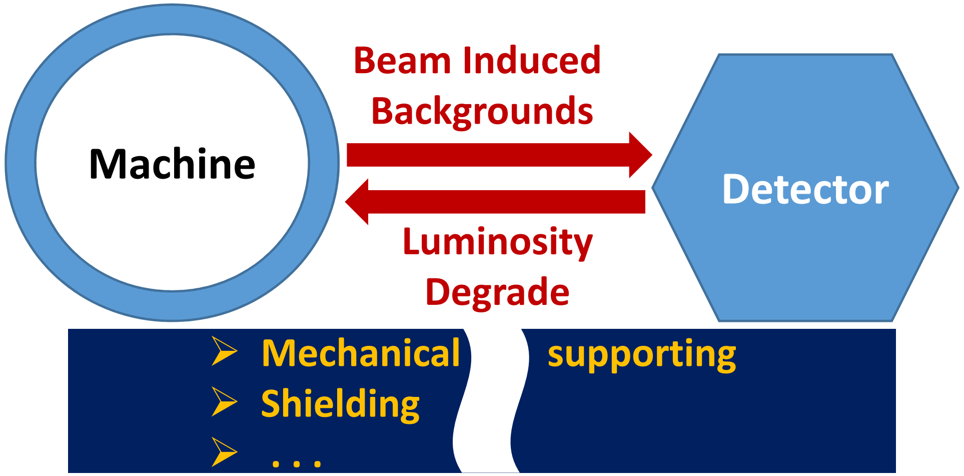
Tsinghua University

Outline

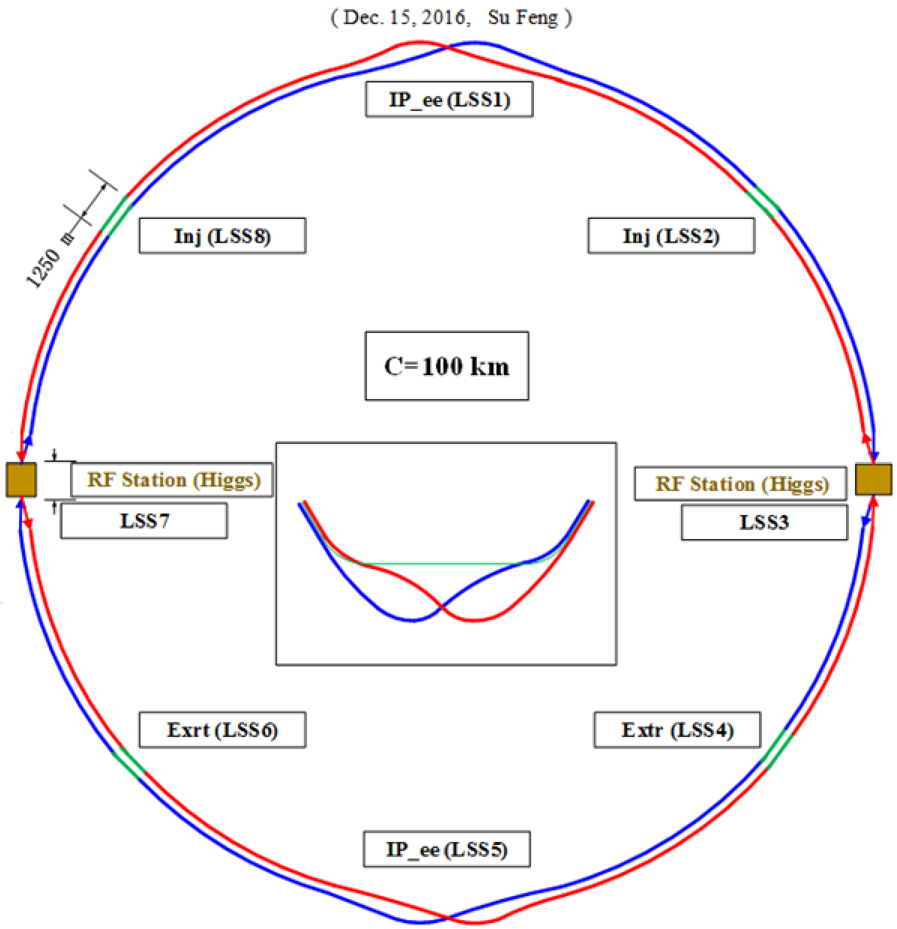
- Introduction
- Baseline and IR design
- Final focusing magnets
- Solenoid compensation
- Beam pipe
- Mechanical supporting
- Beam induced backgrounds
- Luminosity calorimeter
- Summary

Machine Detector Interface



- Mutual influence between the machine and the detector
  - Luminosity degraded by the detector solenoid field
  - Beam induced background
  - . . .
- Integration of machine and detector
  - Global design: confliction between the machine and the detector
  - Mechanical Supporting
  - Shielding

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 2/4)

Preliminary IR Lattice Design

Y. Wang

- *To ease the magnet design*

L*= 2.2m

βx*= 0.171mm

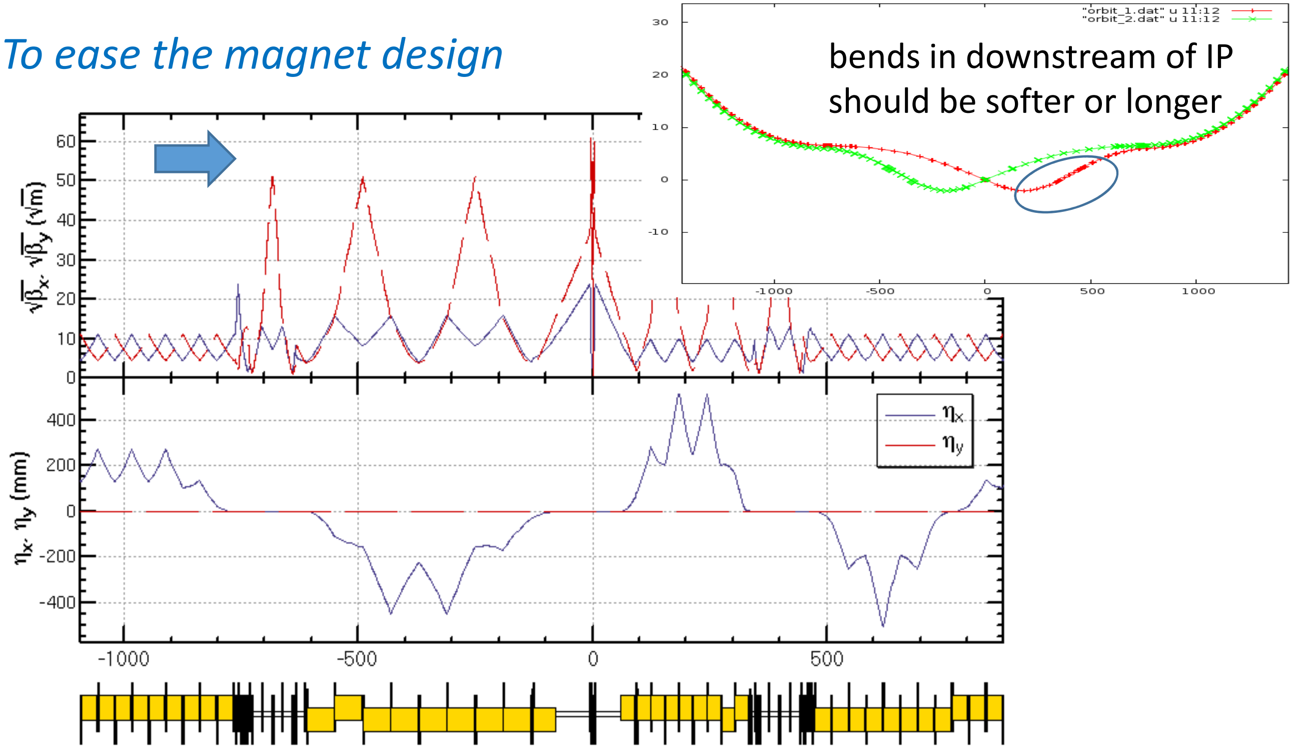
βy*= 2mm

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*

QD0/QF1 parameters

S. Bai

QD0	Horizontal BSC 2（$20\sigma_x$+3）	Vertical BSC 2（$40\sigma_y$+3）	e+ e- beam center distance
entrance	13.73 mm	20.24 mm	72.61 mm
Half	18.06 mm	23.65 mm	101.45 mm
exit	25.94 mm	22.11 mm	130.33 mm
Good field region	Horizontal 25.94 mm； Vertical 23.74 mm		
Effective length	1.7489m		
Distance from IP	2.2000m		
Gradient	150 T/m		

QF1	Horizontal BSC 2（$20\sigma_x$+3）	Vertical BSC 2（$40\sigma_y$+3）	e+ e- beam center distance
entrance	31.84 mm	19.83 mm	146.83 mm
Half	38.46 mm	17.41 mm	170.99 mm
exit	40.54 mm	16.62 mm	195.11 mm
Good field region	Horizontal 40.55 mm； Vertical 19.83 mm		
Effective length	1.4636m		
Distance from IP	4.449m		
Gradient	106 T/m		

SC Magnet Designs

Y. Zhu

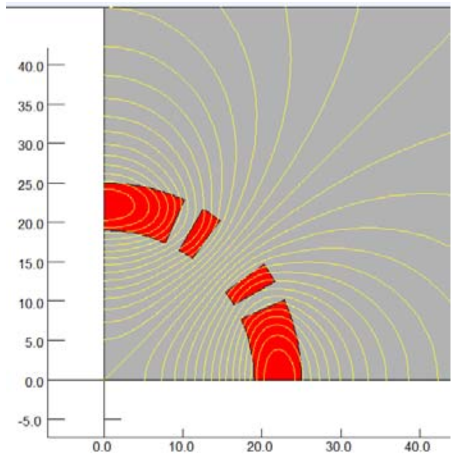
- Updated parameters of the magnets based on the new L* = 2.2 m and lower detector solenoid of B=3 T

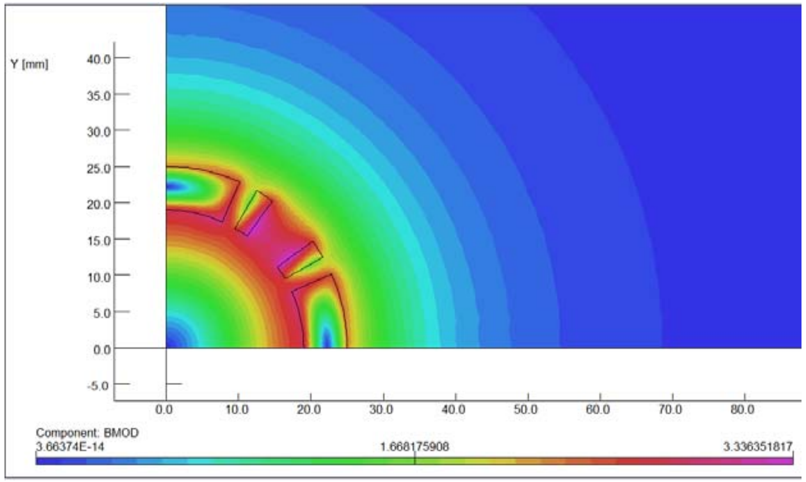
Magnet	Field Strength	Length (m)	Inner Radius (mm)
QD0	150 T/m	1.7489	19
QF1	106 T/m	1.4636	26
Compensating solenoid	6.6 T	1.0	90
Screening solenoid	2.5 T	1.7489	100

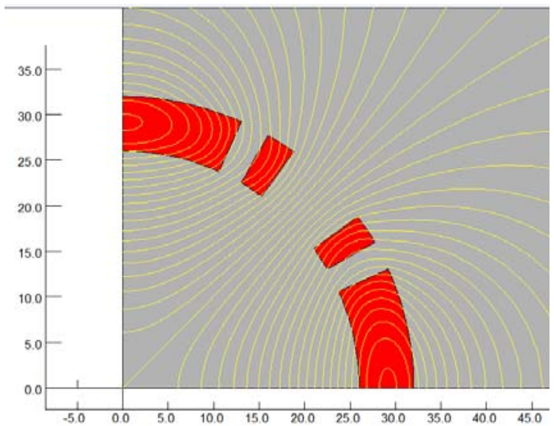
- Weaker QD0/QF1 field strengths would introduce less harder SR photons in the IR → easier collimation and less backgrounds
- Lower compensating solenoid makes it possible to construct the magnet with the cutting-edge superconducting magnet technology → motivation to increase L* (+ clearance between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

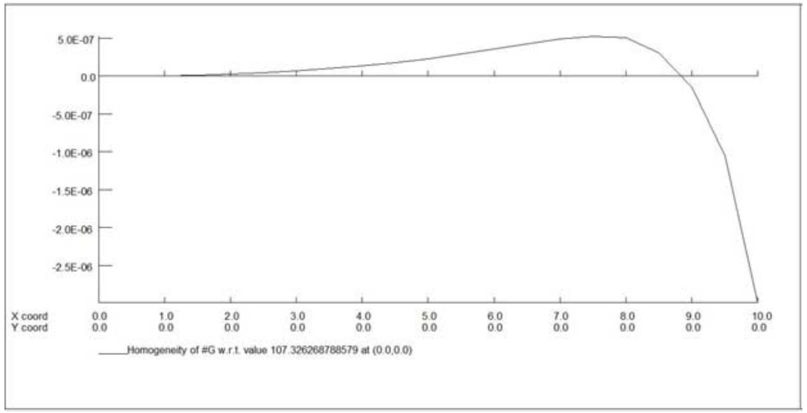
Updated Field Maps

- Updated calculation of the QD0/QF1 field maps



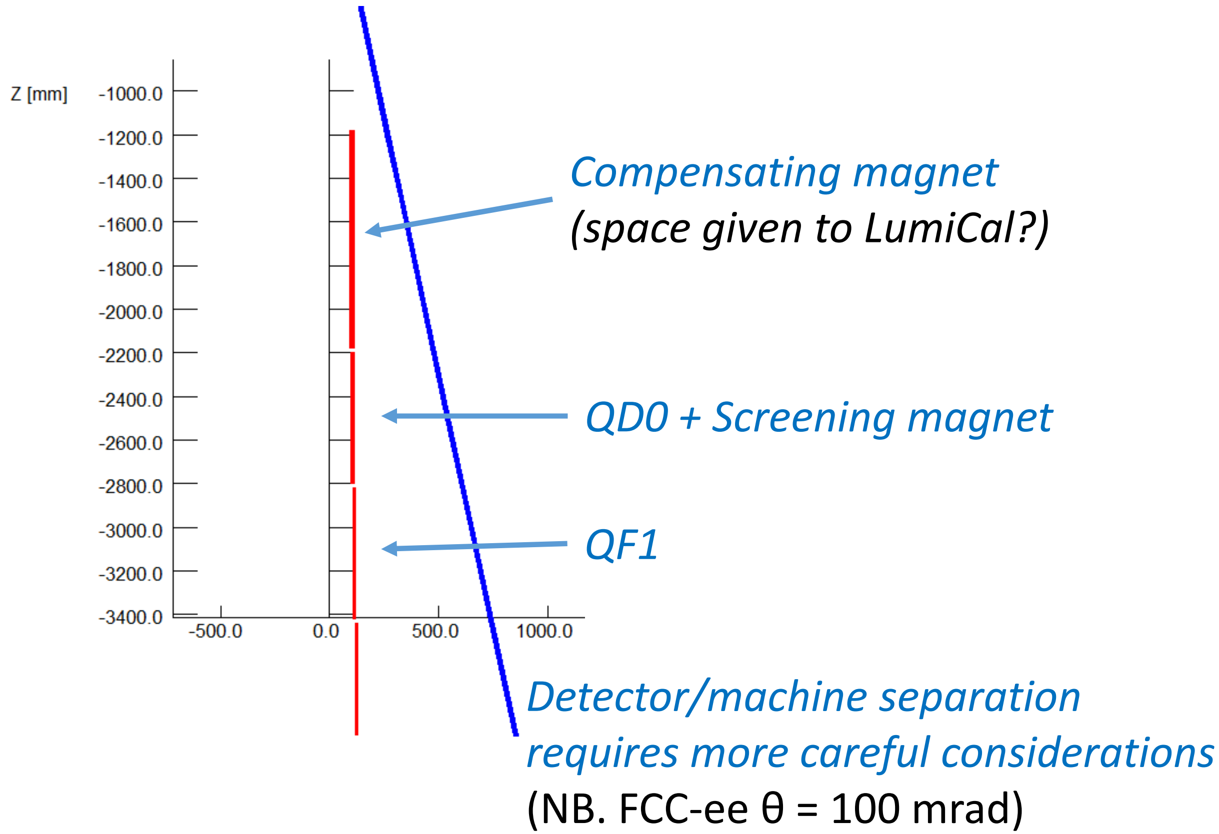






Magnet Layout

- 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})*



SC Magnet Parameters

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

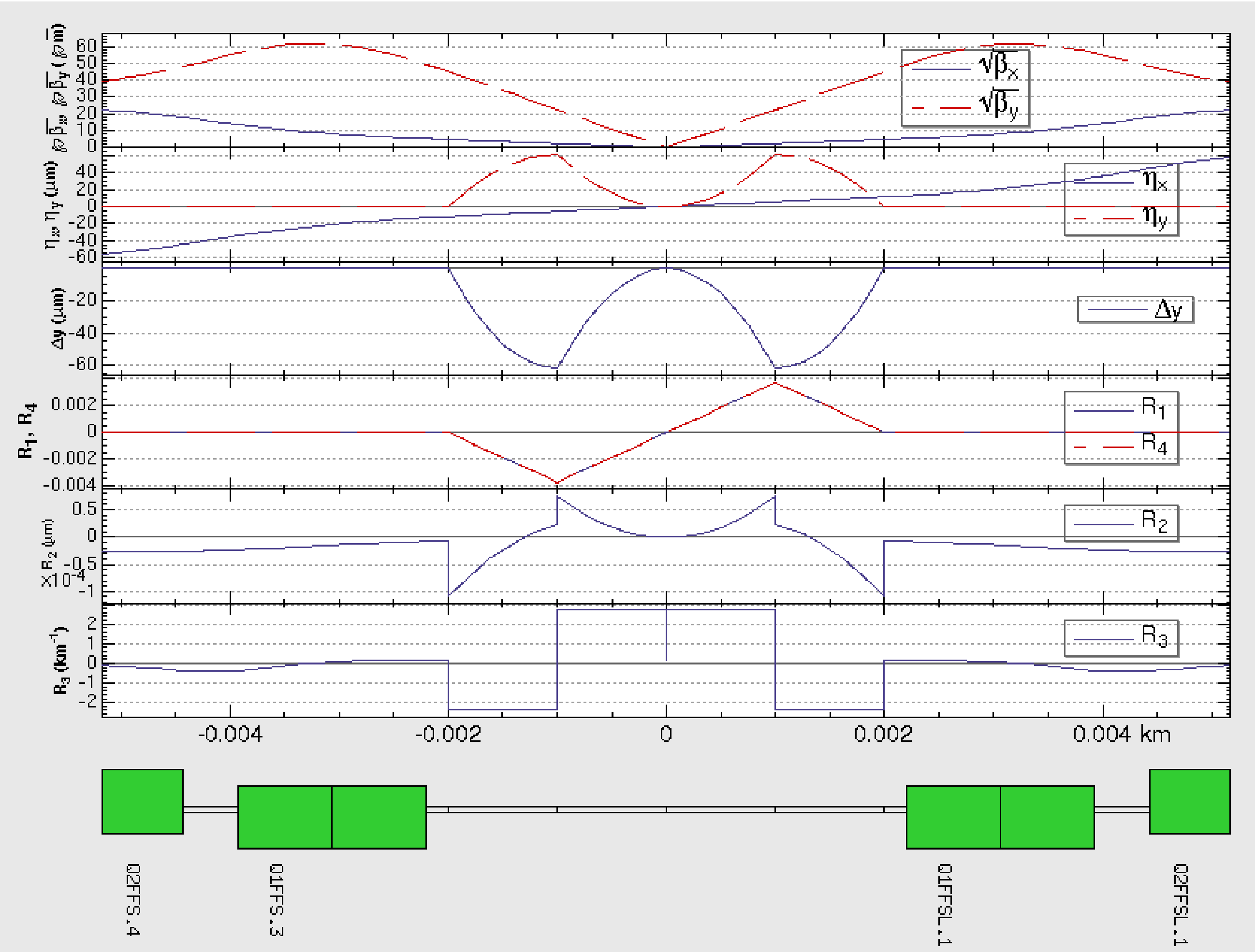
Magnet name	QD0
Field gradient (T/m)	150
Magnetic length (m)	1.749
Coil turns per pole	25
Excitation current (A)	2300
Coil layers	2
Conductor size (mm)	Rutherford Type NbTi-Cu Cable
Stored energy (KJ)	19.5
Inductance (H)	0.0074
Peak field in coil (T)	3.3
Coil inner diameter (mm)	38
Coil out diameter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

Solenoid compensation

Y. Zhang



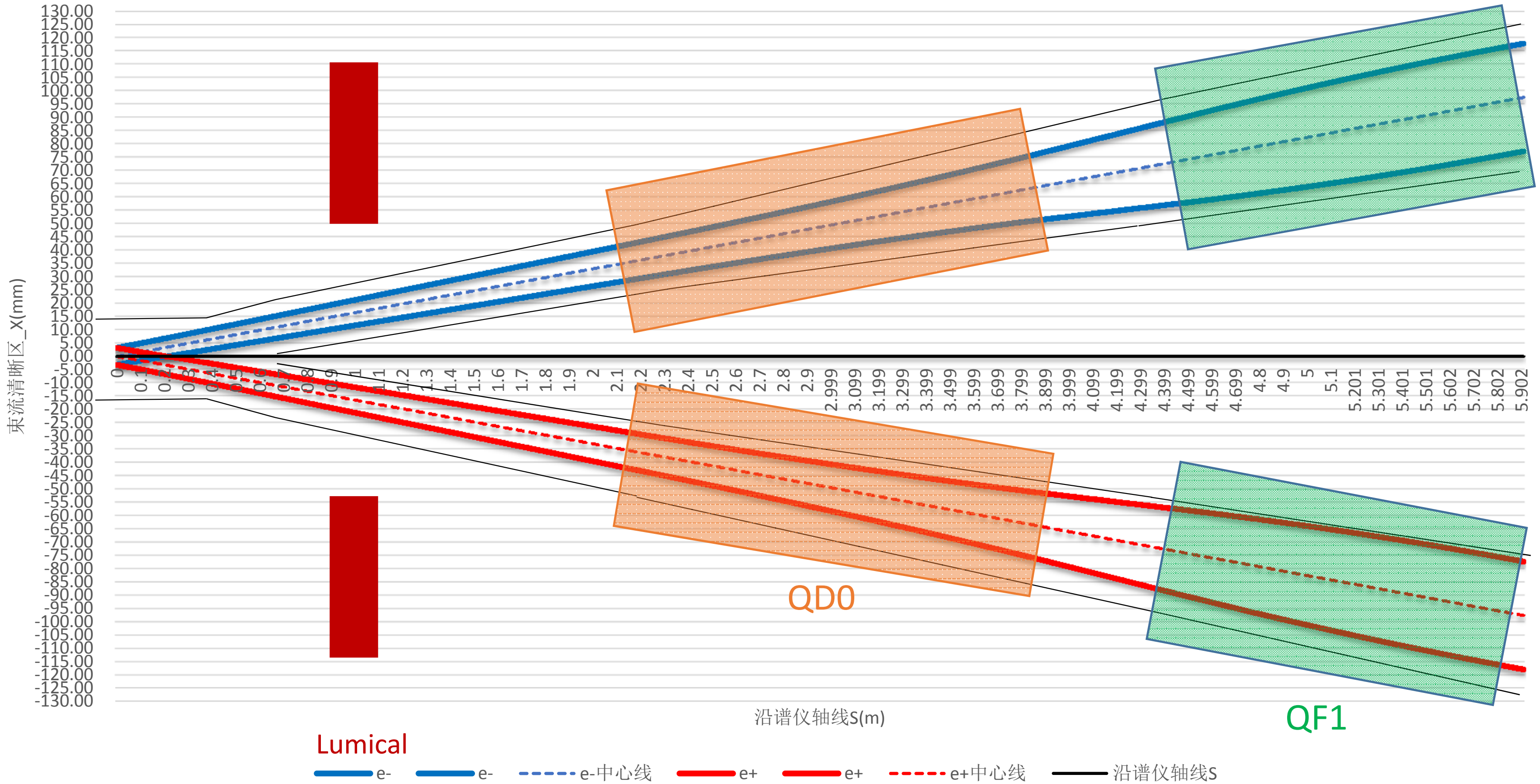
	Design	With solenoid compensation
Horizontal emittance	1.31nm	1.59nm
Vertical emittance	4pm	4.066pm

The vertical emittance could be accepted for the current solenoid configuration~ 3T

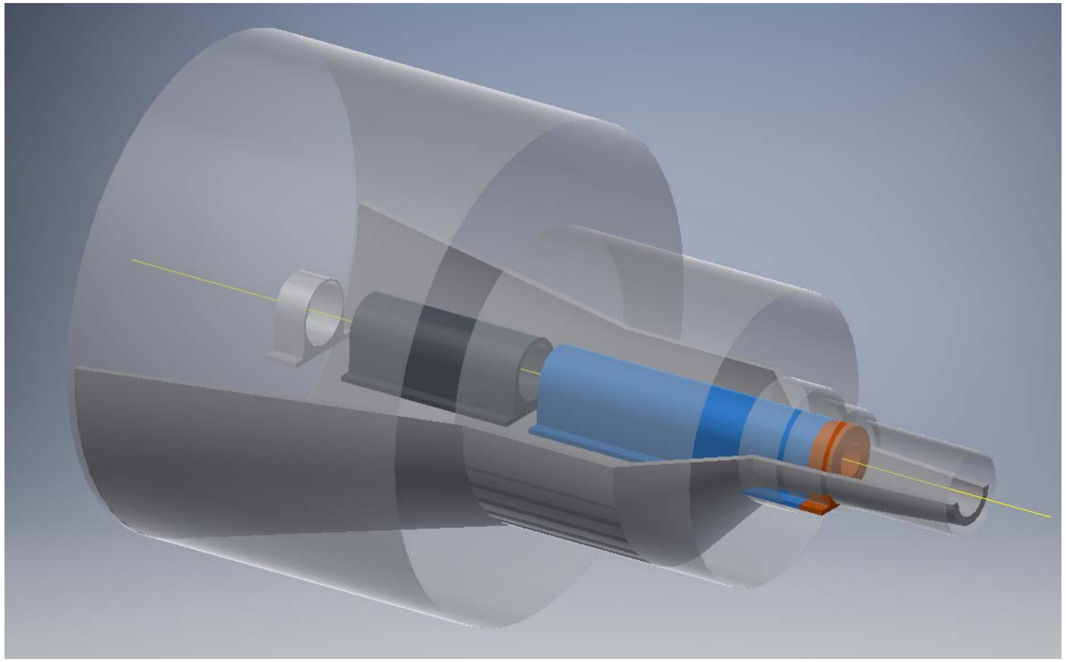
Beam pipes

S. Bai

- Electron and positron beam stay clear region→ *important input into the beam pipe shape design , connection from single pipe to double pipe is realized by flange CF35.*
- *Central beam pipe decided by the Be pipe radius from detector design*



Mechanical Supporting

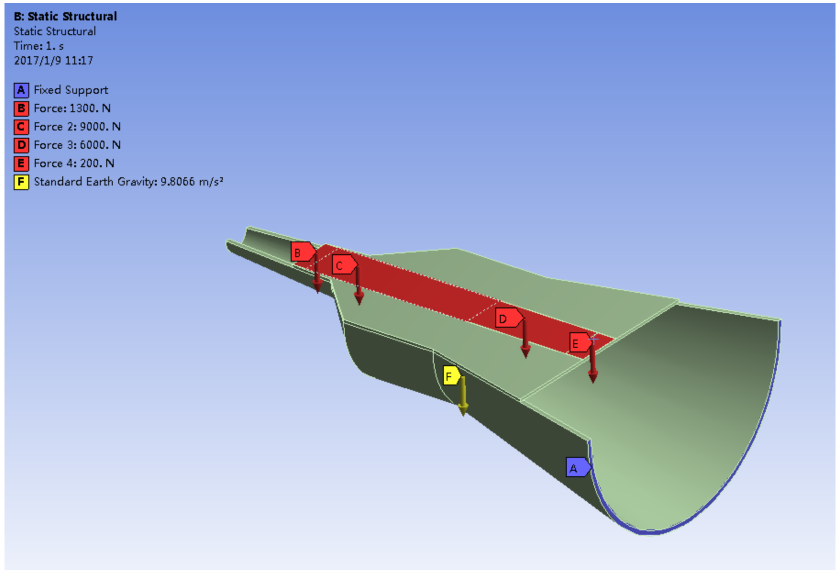


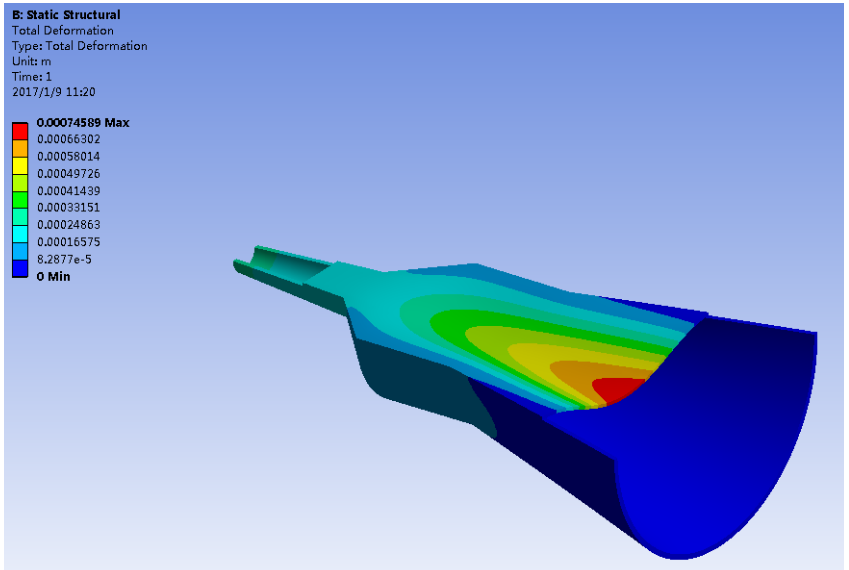
➢ *By Shujin Li, Jianli Wang, Huamin Qu*

Elements	Mass (kg)
LumiCal	130
QD0(Including solenoids)	900
QF1	600
Pump	20

- Space for mechanical supporting: 150 mrad ~ 300 mrad
- The supporting point will be at about 6 m away from the IP
- The feasibility of the mechanical supporting has been preliminary studied

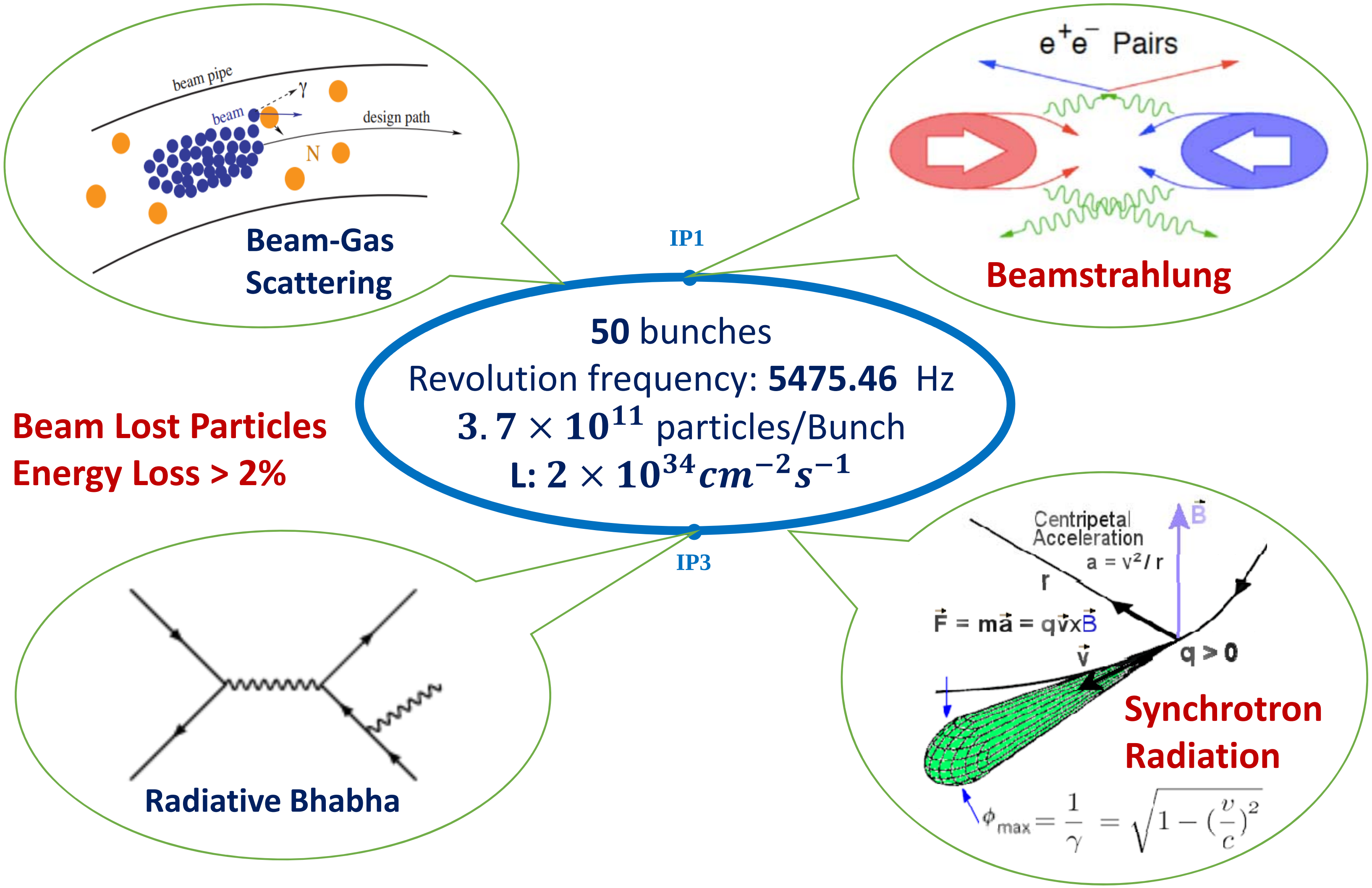
Preliminary Results





- The gravity force of accelerator elements are applied to a virtual plane on the supporting structure
- The deformation at the IP is about 300~400 micron meters
- Need consider more factors to improve the design and simulation

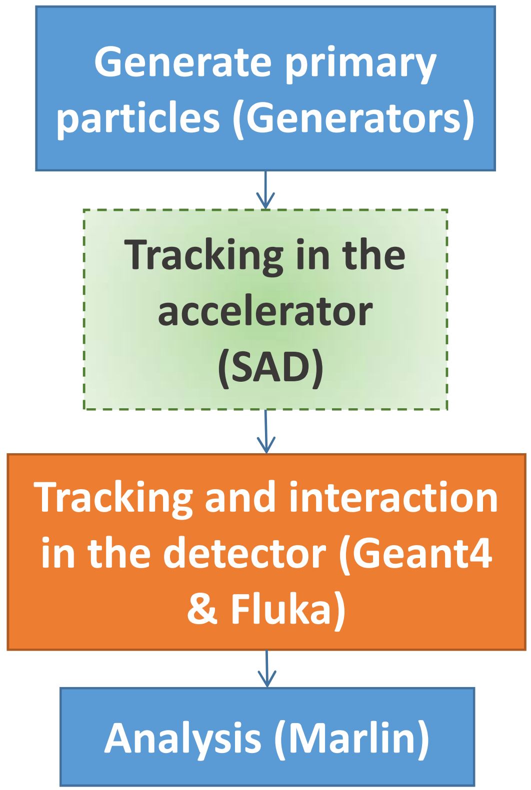
Beam Induced Backgrounds at CEPC



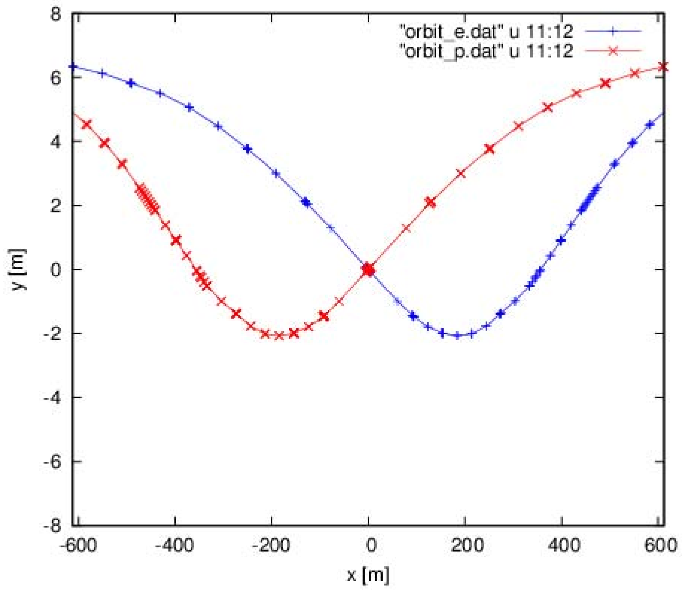
Procedures for Background Simulation

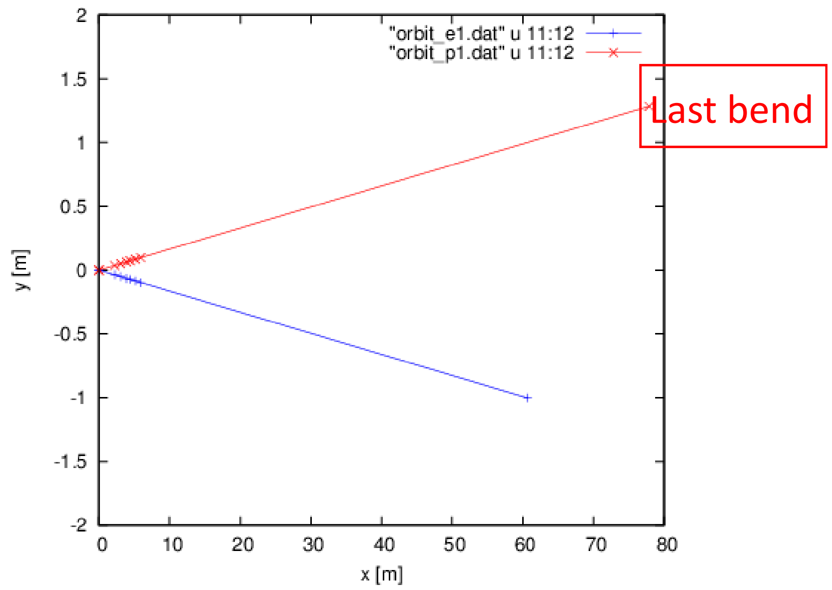
- All kinds of beam induced backgrounds will firstly be simulated by proper generators
- Background particles will be tracked in the accelerator (SAD) and the detector (Geant4 & Fluka)
  - SAD: Strategic Accelerator Design
- Extract hit information and analysis the results

➢ *By Qinglei Xiu, Sha Bai, Yiwei Wang, Dou Wang, Hongbo Zhu, Zhongjian Ma*



SR power



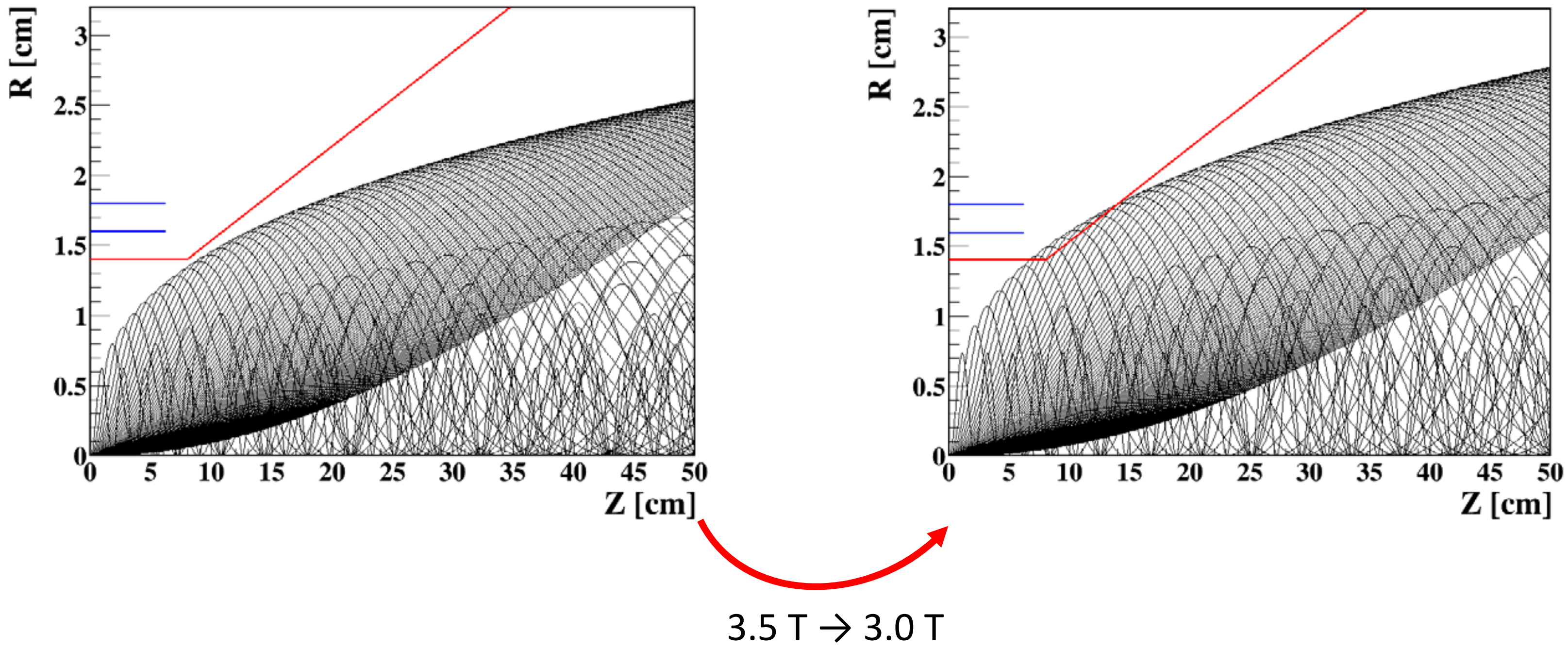


- The critical energy of the last bend at upstream of IP is ~100kev.
- The synchrotron radiation power to enter the IP is 93.2 W.

Background Estimation

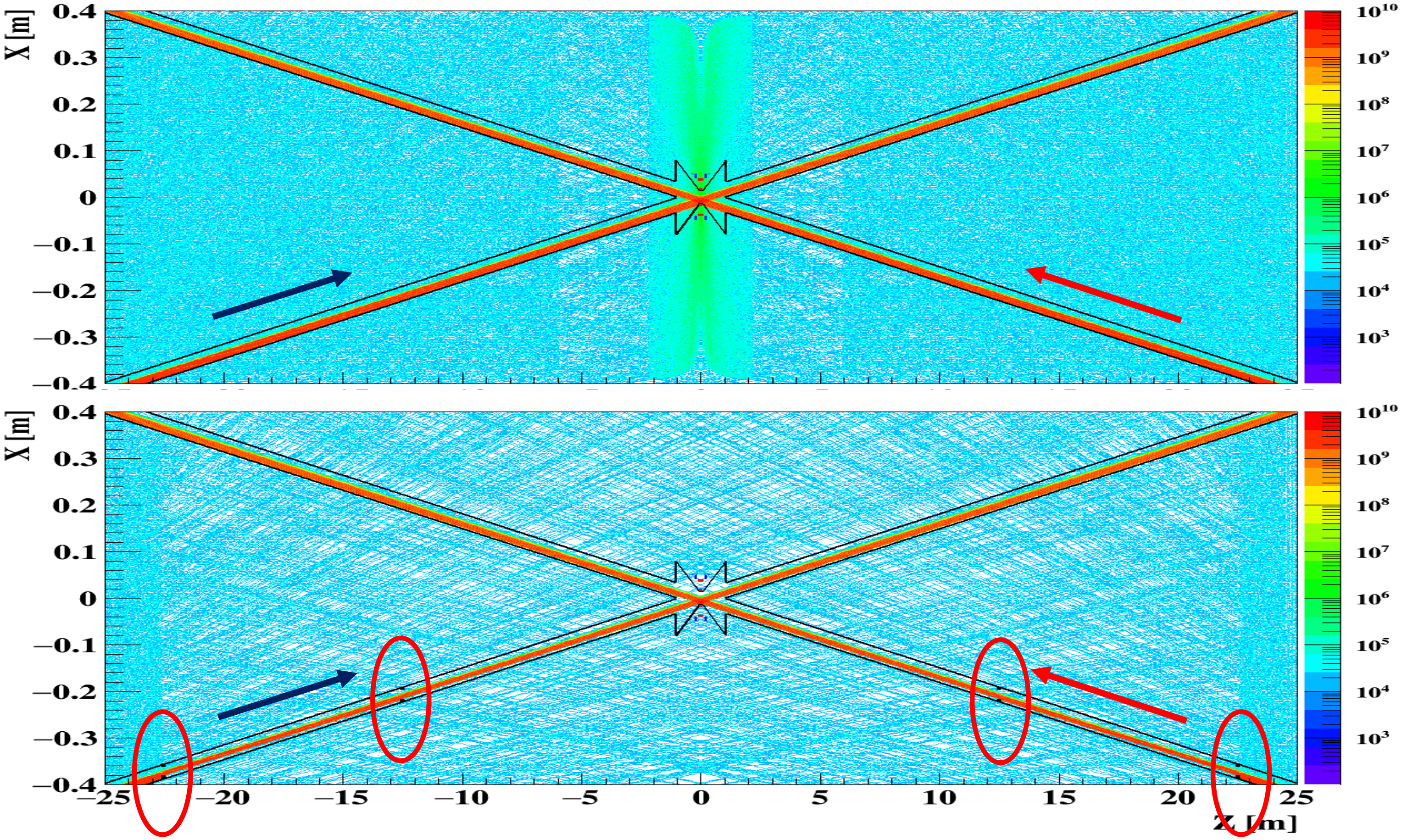
Q. Xiu

- 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
- Be pipe position has to be adjusted followed by the updated detector background estimation



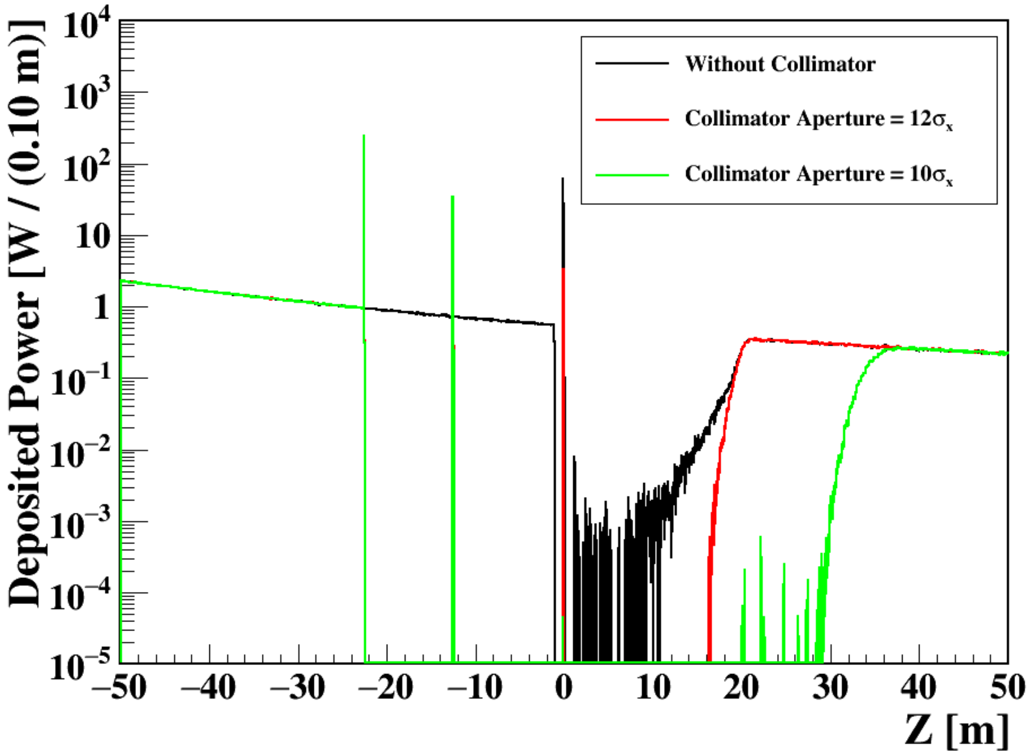
Synchrotron Radiation

- SR Photon flux re-estimated with the preliminary lattice



SR Power Deposition

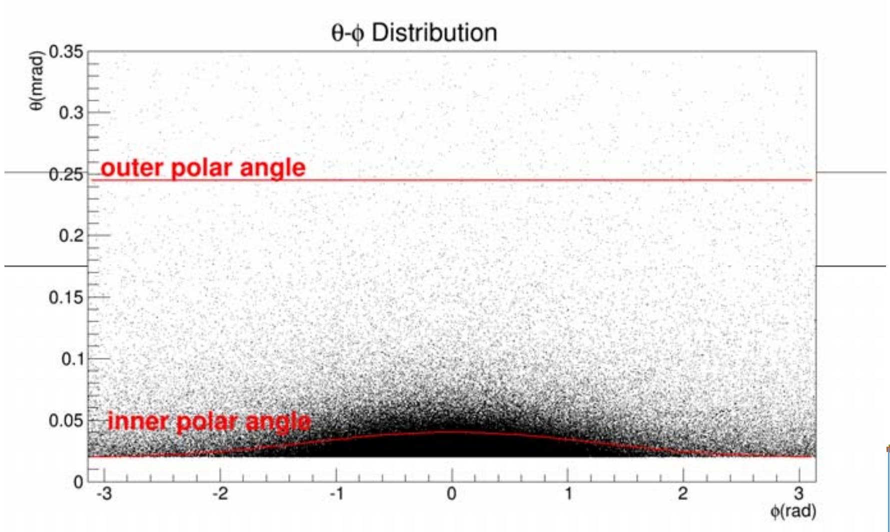
- Power deposition of SR photons along the z-axis
- Significant effect of the collimators even with low statistics → proof of principle, may have to consider more realistic designs



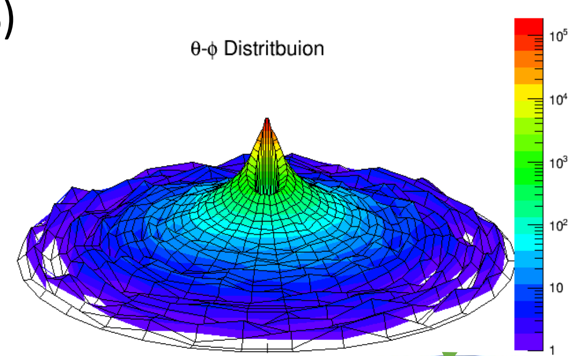
LumiCal

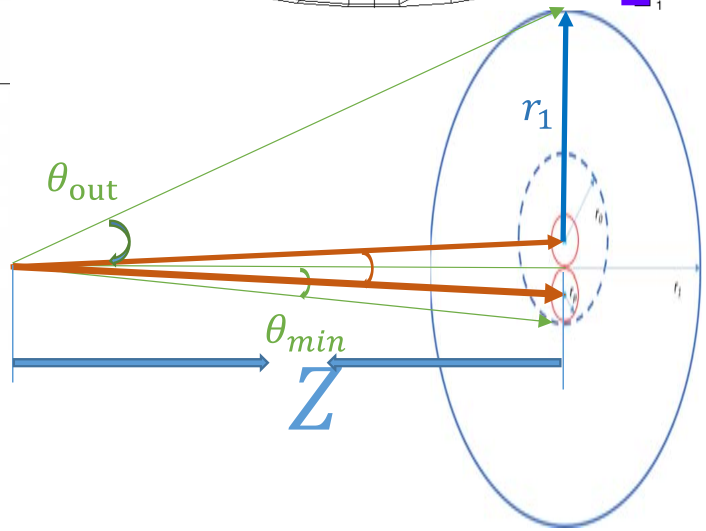
K. Zhu & L. Yang

- 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

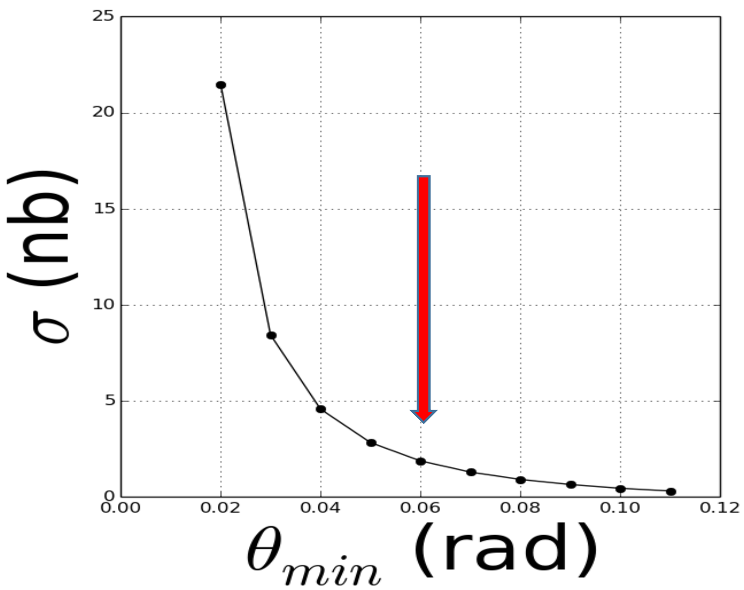


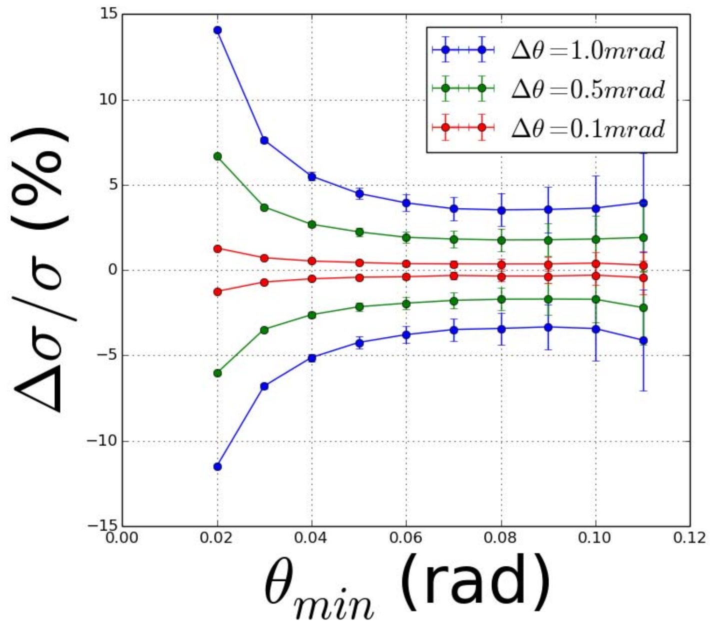


Systematic Uncertainties (selected)

- $\boldsymbol{\theta_{min}}$=$\mathbf{60\ mrad}$ 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)





Summary

- Full partial double ring has to be chosen as the baseline and a preliminary IR lattice has been designed.
- The mutual influences between machine and detector are under evaluate.
  - The L* of CEPC is set as 2.2 m to ease the magnet design and solenoid compensation and also to achieve the required luminosity.
  - The compensating solenoid and the screening solenoid are under designed to shielding the detector solenoid field
  - Beam induced backgrounds of CEPC are under evaluated. Useful software and tools were developed.
- The mechanical supporting have been preliminary studied
- The shielding and collimators need be further studied.

Thanks