The Status of CEPC MDI at EDR Phase

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On behalf of the CEPC MDI Working Group

International Workshop at the CEPC, 2026/10/24, Shanghai, China



Outline

- Introduction
  - MDI Identity, design goal and inputs
  - MDI geometry and layout
- Study on the Beam induced backgrounds at the CEPC
  - Background sources
  - Mitigation methods
- Study on the design and integration
  - Beampipe and vacuum chamber
  - Luminosity Measurement
  - Magnets and cryostat
- Integration and alignment
- Overall estimation on safety, tolerance, and benchmark.
- Summary and outlook

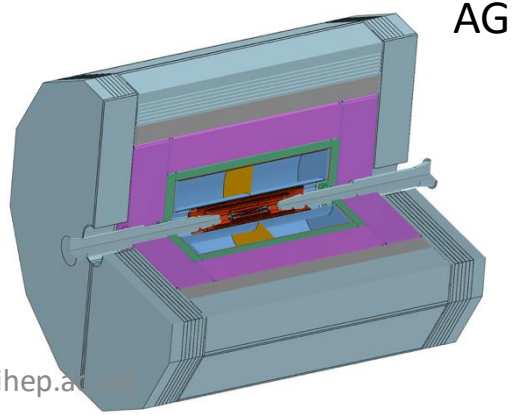
Introduction

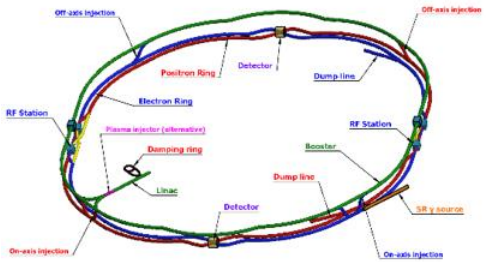
- MDI stands for ”Machine Detector Interface”
  - 2 IP, with 33 mrad crossing angle of two beams
- Flexible optics design
  - Common Layout in IR for all energies
  - High Luminosity, low background impact, low error
  - Stable and easy to install, replace/repair
- Acc. Lattice and AGORA design as inputs.
- Goal of EDR phase of CEPC MDI: Detailed engineering design of the whole sub-system and key components, including the integration/alignment and so on.
- As AGORA proposed for FCC-ee, the re-estimation of the beam induced background level of AGORA will be performed gradually, under the collaboration with FCC-ee MDI group.
- Many synergies with FCC-ee MDI related studies.

TDR Updates

	Higgs	W	$t\bar{t}$	Z	Low-Lumi-Z
Number of IPs	2				
Solenoid(T)	3				
Circumference (km)	99.955				
Half crossing angle at IP (mrad)	16.5				
Bending radius (km)	10.7				
SR power per beam (MW)	50				12.1
Energy (GeV)	120	80	180	45.5	45.5
Energy loss per turn (GeV)	1.8	0.357	9.1	0.037	0.037
Damping time $t_x/t_y/t_z$ (ms)	44.6/44.6/22.3	150/150/75	13.2/13.2/6.6	816/816/408	816/816/408
Piwinski angle	4.88	5.98	1.23	29.52	24
Bunch number	446	2162	58	13104	3978
Bunch spacing (ns)	277.0	138.5	2585.0	23.1	69.2
[× 23.08 ns]	12	6	112	1	3
Train gap [%]	63	10	55	9	9
Bunch population (10^{11})	1.3	1.35	2.0	2.1	1.7
Beam current (mA)	27.8	140.2	5.5	1345.2	325.0
Phase advance of arc FODO (°)	90	60	90	60	60
Momentum compaction (10^{-5})	0.71	1.43	0.71	1.43	1.43
Beta functions at IP b_x^*/b_y^* (m/mm)	0.3/1	0.21/1	1.04/2.7	0.2/1.0	0.13/1.0
Emittance e_x/e_y (nm/pm)	0.64/1.3	0.87/1.7	1.4/4.7	0.27/5.1	0.27/5.1
Betatron tune n_x/n_y	445/445	317/317	445/445	317/317	317/317
Beam size at IP s_x/s_y (um/nm)	14/36	13/42	39/113	6/72	6/72
Bunch length (natural/total) (mm)	2.3/4.1	2.5/4.9	2.2/2.9	2.6/9.8	2.5/8.8
Energy spread (natural/total) (%)	0.10/0.17	0.07/0.14	0.15/0.20	0.04/0.15	0.04/0.13
Energy acceptance (DA/RF) (%)	1.6/2.2	1.05/2.5	2.0/2.6	1.2/1.7	1.0/1.7
Beam-beam parameters x_x/x_y	0.015/0.11	0.012/0.113	0.071/0.1	0.0046/0.074	0.0053/0.082
RF voltage (GV)	2.2	0.7	10	0.12	0.12
RF frequency (MHz)	650				
Harmonic number	216720				
Longitudinal tune n_s	0.049	0.062	0.078	0.035	0.035
Beam lifetime (Bhabha/beamstrahlung) (min)	40/40	60/195	81/23	120/280	150/180
Beam lifetime requirement (min)	20	25	18	81	68
Luminosity per IP (10^{34} cm^{-2} s^{-1})	8.3	26.7	0.8	95.2	26

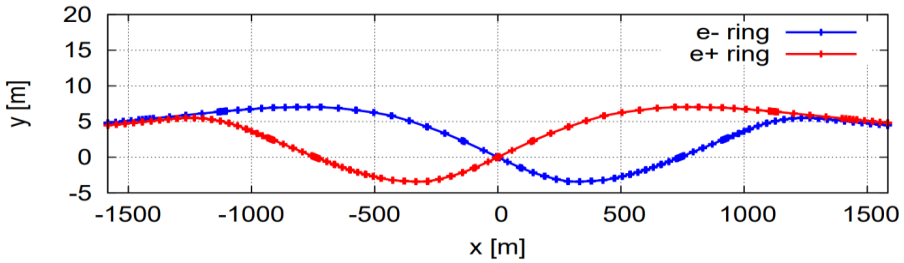
AGORA

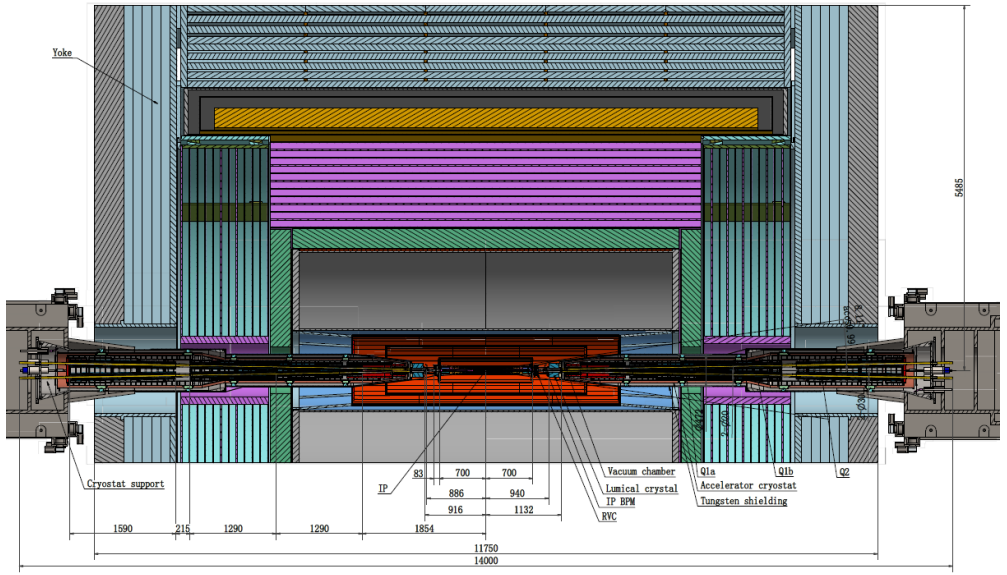


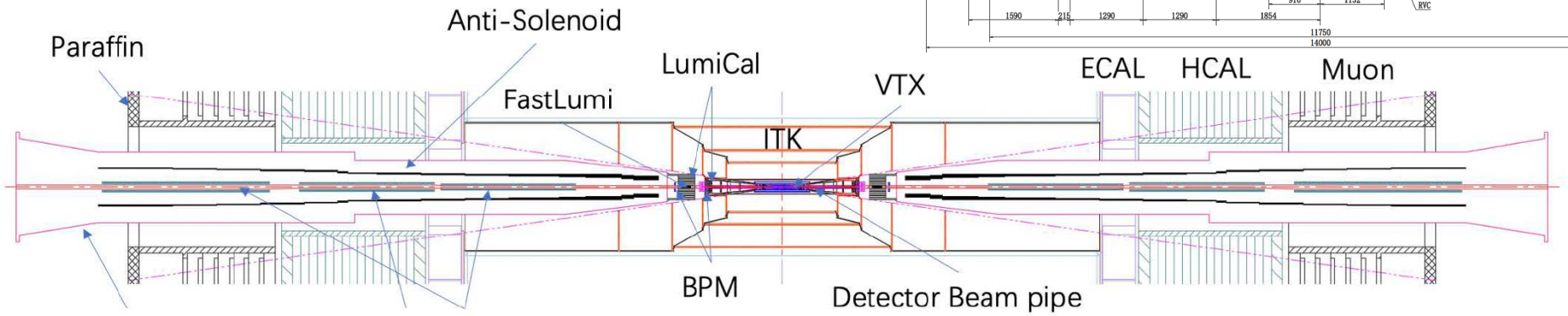


Interface region layout

- Asymmetric interaction region implemented.
- The length of MDI Region is 14m since TDR Phase
- This region locates:
  - All Sub Detectors
  - All MDI accelerator components
  - The interface parts
- Detecting Angle = 0.99
  - The MDI and accelerator components, including the cables, service and support components, must be designed within a cone angle of 140 mrad.







Beam induced background estimation

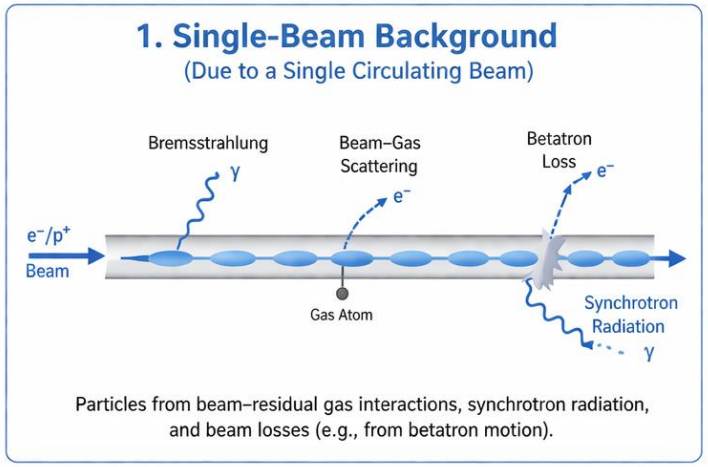
One of the major field we start to collaborate with FCC-ee

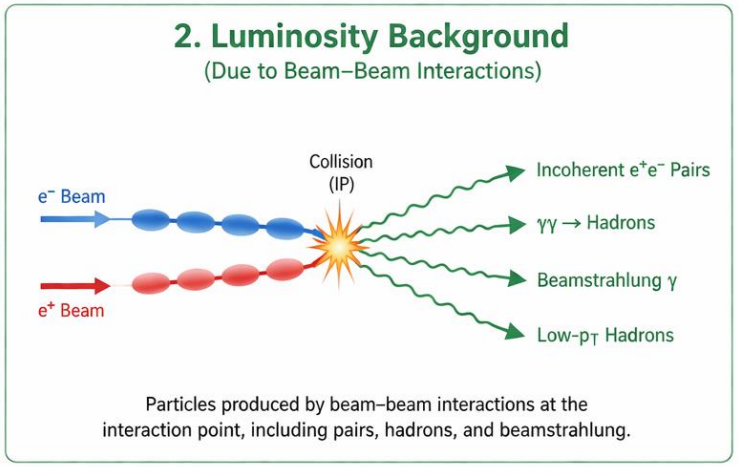
- Single Beam
  - Synchrotron Radiation
  - Touschek Scattering
  - Beam Thermal Photon Scattering
  - Beam Gas Scattering(Elastic/inelastic)
- Luminosity Related
  - Beamstrahlung/Pair Production
  - Radiative Bhabha Scattering
- Injection(Preliminary)
- Failure Case(including SBL, not started yet except for electricity loss)

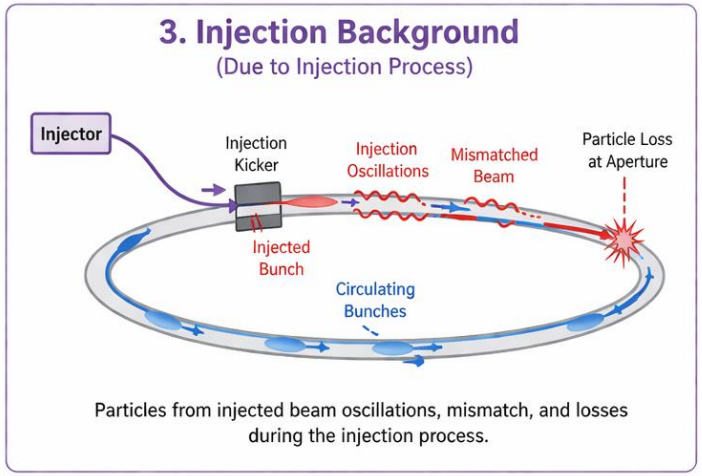
Working flow:

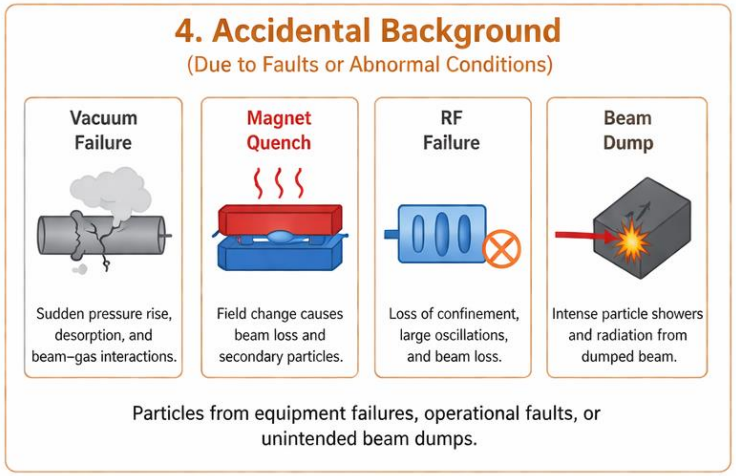


Detector Response simulation(hits/occupancy)
Radiation Environment simulation





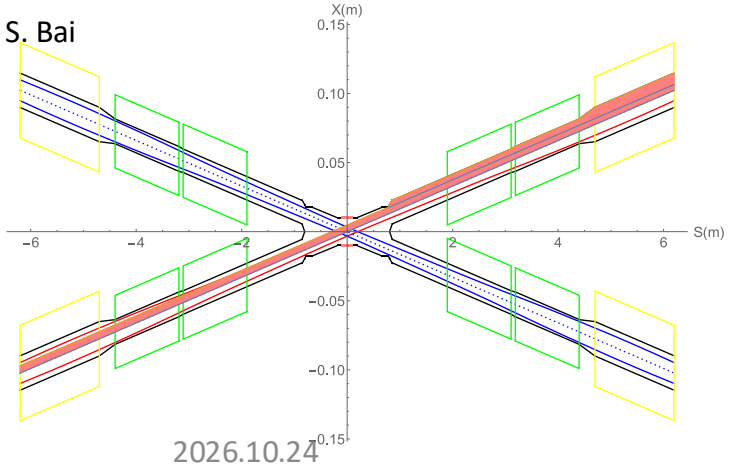




Synchrotron Radiation

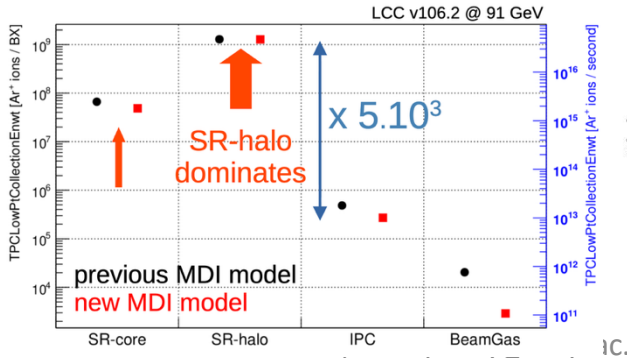
- Synchrotron Radiation must be dealt with the first priority when designing the central beam pipe and the interaction region.
  - The central beam pipe was carefully designed to avoid the direct hitting of the SR photons
  - The last bending magnet also been designed to decrease the critical energy of the IR SR photons
- CEPCSW with modified geometry was used as generator in RefDet-TDR phase, BDSIM was implemented in EDR phase. FLUKA model is also being built.
- During Daniel Jeans' talk at FCC Week 2026, the huge impact of SR generated by beam tail had been highlighted. To solve this issue:
  - We start to investigate the case at CEPC and got similar results. We are checking the lifetime estimations, while trying different mitigating methods.
  - For AGORA proposed for FCC-ee, we are collaborating with Daniel, DESY and FCC people(GAS Det. Group)

S. Bai

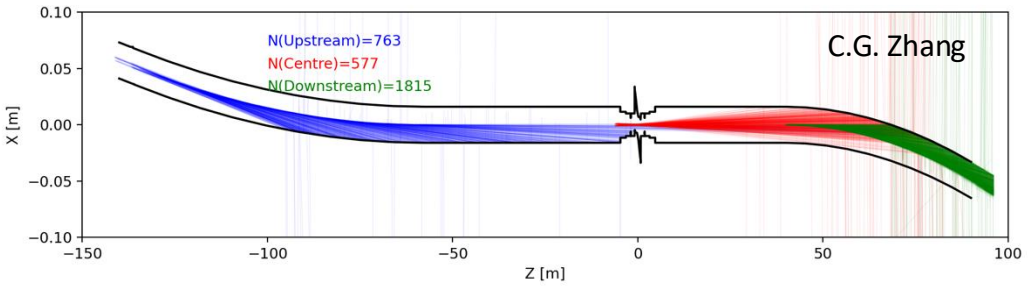


Time Projection Chamber (ILD):
ion production

D. Jeans



Please refer to Jianbo Zheng's talk in this workshop

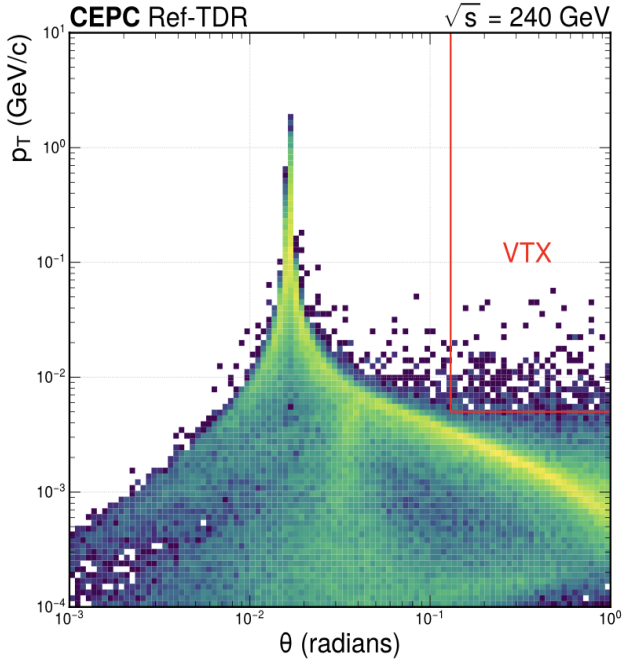


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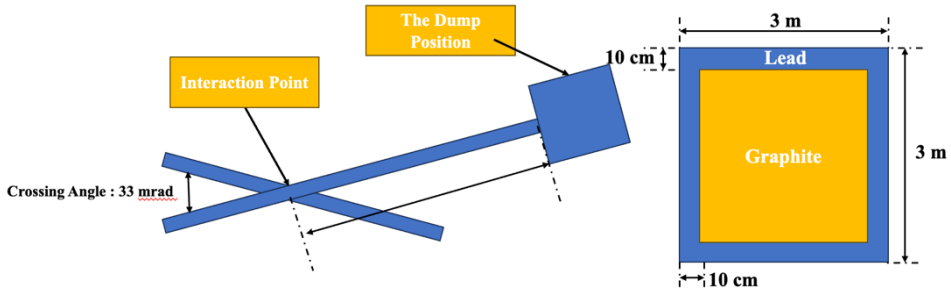
Pair Production(Beamstrahlung)

- Luminosity related backgrounds, one of the dominant backgrounds at the CEPC(and FCC-ee also), may lead to two different impacts:
  - The impacts on detector, caused by the electrons/positrons produced by photons
  - The impacts on accelerator components outside of the IR, caused by the photons directly.
- Generated using Guinea-pig++(modified v1.2.1 and v1.2.2).
  - Implemented the external solenoid field, uniform distribution in this range with the threshold of the outputted e- and e+ decreased to 0.511 MeV.
- Currently, we are working on following aspects with a dedicated working group:
  - Checking the cross-section of the generator to estimate the uncertainty and using LEP data to validate.
  - Studying the impact of setting parameters. A set of stable values has been found and used.
  - Studying the impact of accelerator parameters to see what happens if the parameters is not the nominal one.
- A machine-learning based tool for quick generation has been built, please refer to Yanbang Tang's poster for more information.

C.G. Zhang



Please refer to Boping Chen's talk in this workshop



Single Beam Loss Particles

- Single beam induced backgrounds, the original particle would be the beam particle which loss energy or change direction significantly.
  - Sensitive to aperture of the accelerator.
  - Lower beam lifetime means higher loss rate. IR would be the most vulnerable part of the ring.
- Using formula-based Monte-Carlo code to generate.
  - Whole-ring generation, generate at the scattering position than tracking in the ring for a dumping time.
  - Only energy or angle changing considered. No photon emitted in simulation.
  - The cross-section("weight") can be integrated to generator or can be used as parameter.
- SAD was initially used, APES is implemented. The consistency between two codes have been checked. Please refer to Shiyuan Wang's poster.

Background	Lifetime@ CEPC Higgs Mode	Lifetime formula	Notes
Touschek Scattering	119 h	$\frac{1}{\tau}=\frac{Nr_e^2c}{8\pi\sigma_x\sigma_y\sigma_z\gamma^2}\left(\frac{1}{\eta^3}\right)D(\xi)$	
Beam-Thermal Photon	50.66 h	$\frac{1}{\tau}=8\pi(\frac{kT}{hc})^3\int_0^\infty\frac{x^2}{e^x-1}dx\cdot c\cdot\frac{8\pi}{3}r_e^2\cdot f$	
Beam-Gas Coulomb	14.85 h	$\frac{1}{\tau}=\frac{4\pi Z^2r_e^2}{\gamma}\cdot\frac{192\beta_s\beta_{max}}{192\gamma R^2+\beta_s\beta_{max}Z^{2/3}}c\frac{P}{k_BT}$	Mainly H_2, 10^{-7} Pa
Beam-Gas Bremsstrahlung	221 h	$\frac{1}{\tau}=4\alpha r_e^2[\frac{4}{3}\left(ln\frac{1}{\eta}-\frac{5}{8}\right)F(Z)+\frac{1}{9}Z(Z+1)(ln\frac{1}{\eta}-1)]c\frac{P}{k_BT}$	

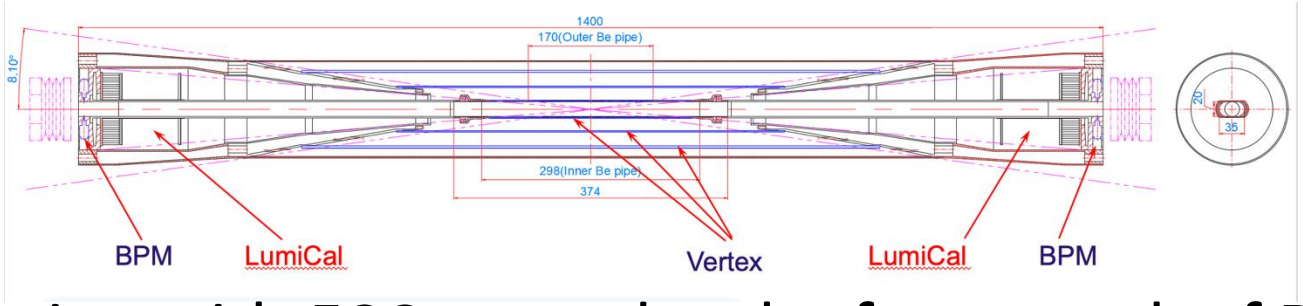
Mitigation Methods

- We thought we have three principles to mitigate the level of the beam induced backgrounds
  - Decrease the loss rate
    - Increase the dynamic aperture, but it faces the design challenges
    - Increase the vacuum level. NEG coating and pumps are implemented, but we have no more space in MDI region.
    - Increase the bunch size, but the luminosity would be decreased.
  - Decrease the IR loss rate
    - Increase the physical aperture of the central beampipe, but the performance of the VTX would be decreased.
    - Implemented the collimators to shield the BIB particles outside of the IR, which increase the impendence budget, also would be risk if closer to IP.
  - Decrease the number of BIB particles who could enter the detecting angle.
    - Using shielding in the interface area, which increase the weight of the cryo-module.

Beam pipe, vacuum chamber

Please refer to Jian Wang's talk in this workshop

Inner diameter: 20 mm
Outer Be Layer: 0.15 mm
Gap: 0.2/0.3 mm, Coolant(Water/Paraffin)
Inner Be Layer: 0.2 mm
Inner Layer: 10 μm Gold coating
Thickness: ~0.45% X_0

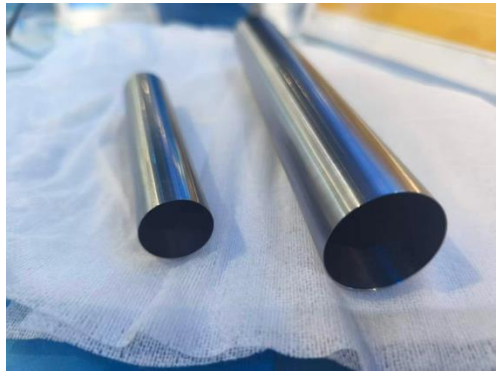


Q. Ji, L. He

Collaborating with FCC-ee under the framework of DRD8.



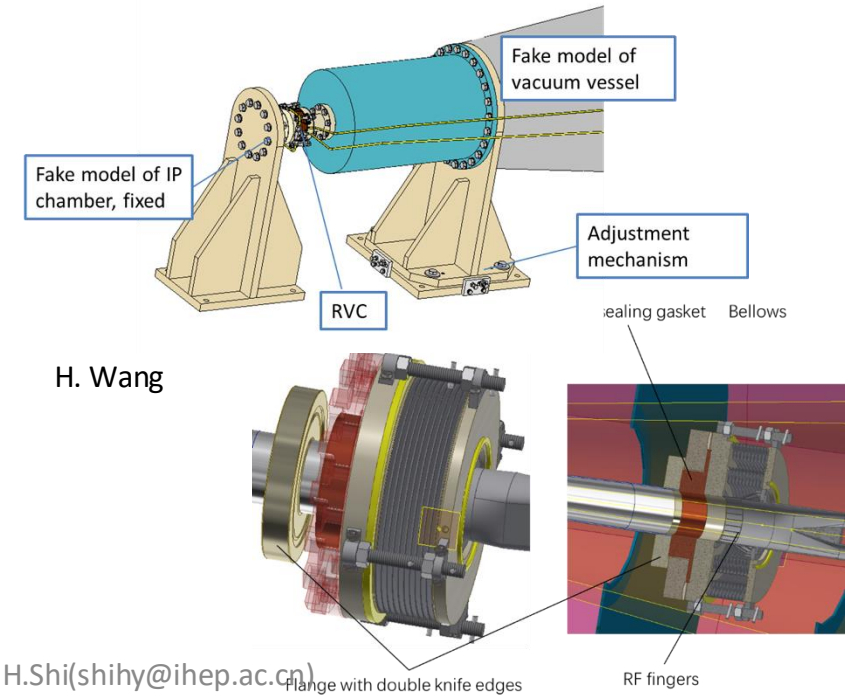
Be Samples





Al prototypes





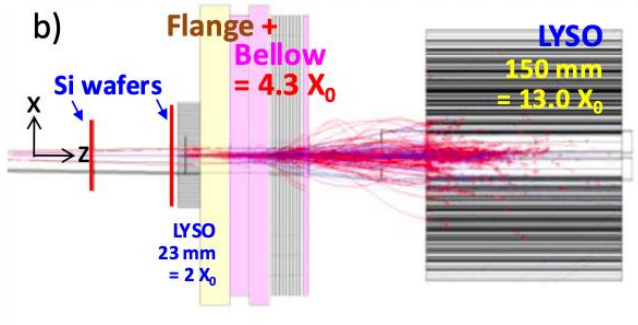
H. Wang

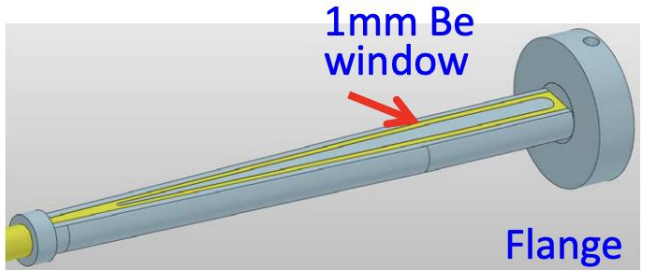
Remote Vacuum Connection (RVC) implemented as integrator between detector beam pipe and accelerator vacuum chamber. Design complemented, a prototype is considered and planed.

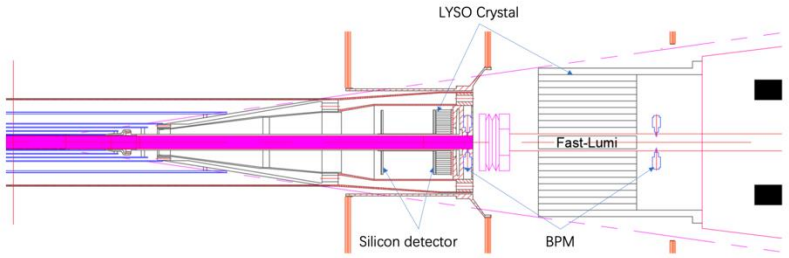
Luminosity Measurement

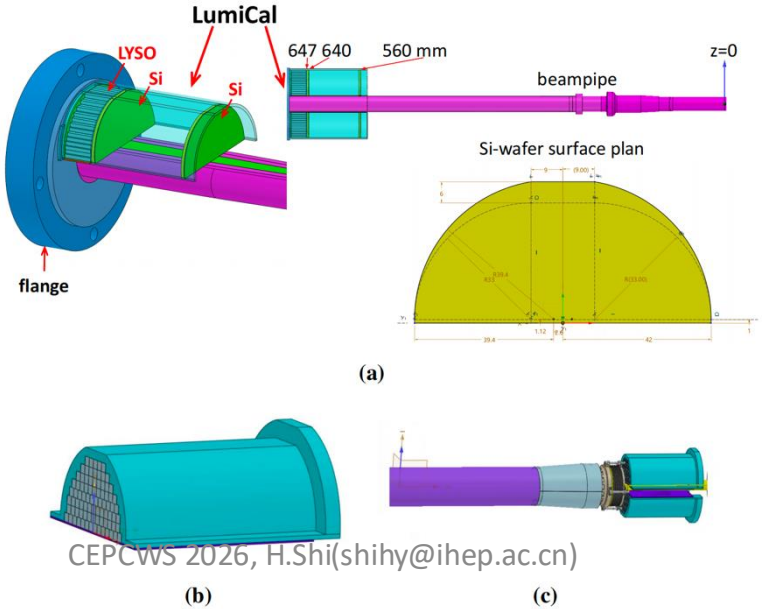
- BPM + FastLumi + LumiCAL
- Before flange: Electron impact position by Si-Det + 2X_0 LYSO
  - The Silicon locates at 560mm and 640mm, using AC LGAD technologies
  - 5 μm resolution for electron impact position cross-reference to measure upstream multiple scattering of rms ~50 μm
  - LYSO with Si-Det for e/γ of radiative photons, mooncake-like design
- Beyond flange: Electron ID with long 13.0 X_0 LYSO,
  - Cooling by the beam pipe from calculation
  - Covered, fixed and supported by an Al plate and a tungsten shell
- **A dedicated luminosity detector inspired by this design is under construction at BESIII, please refer to Lei Zhang's talk later for more information.**

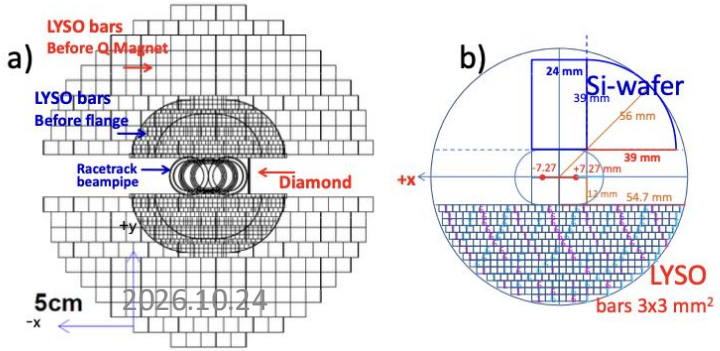
Please refer to Suen Hou's talk in this workshop

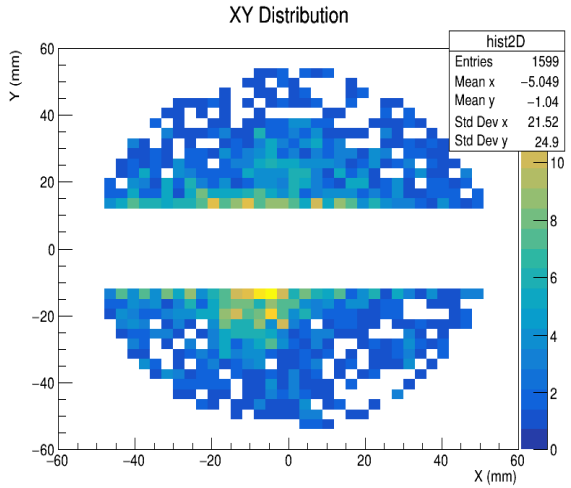








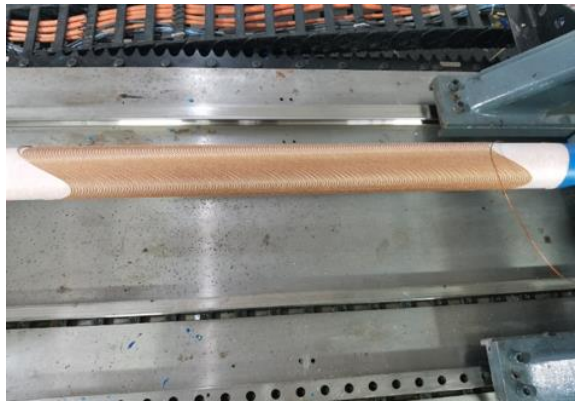




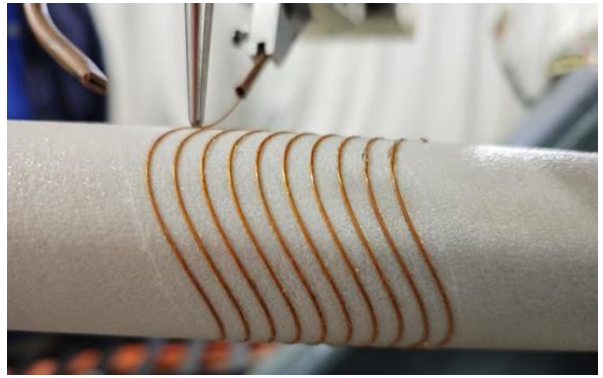
SC Magnets and Cryo-Module

- In CEPC, there are two combined-function Superconducting magnets in MDI for the baseline design.
- Each combined-function magnet includes double aperture high gradient quadrupole (Q1a, Q1b, Q2) and anti-solenoid, around each side of the IP point, placed on a cantilever support.
- Iron-free structure is selected for CEPC IR SC magnets using Direct Winding CCT Coils
- The cryostat is used to provide the cryogenic environment for SC magnets, which is below 5.0 K.
- The prototype has been started, the shape of the test CCT winding looks good.

- Superconducting magnets are immersed in the helium tank for the low temperature.
- One thermal shield is set for the heat interruption from the ambient temperature.

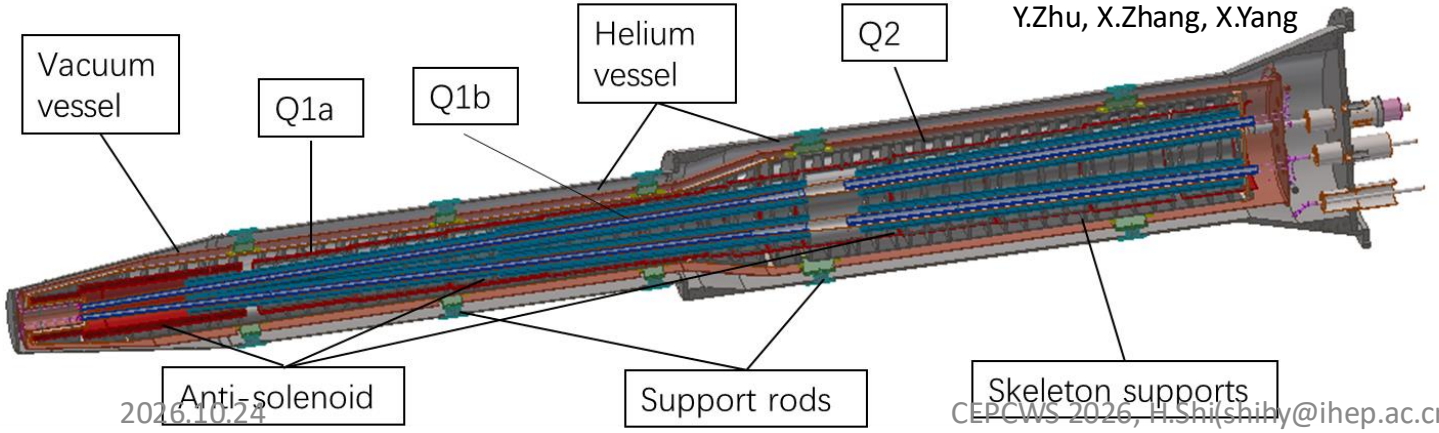


Y.Zhu



Please refer to Yingshun Zhu and Xiaochen Yang's talk in this workshop

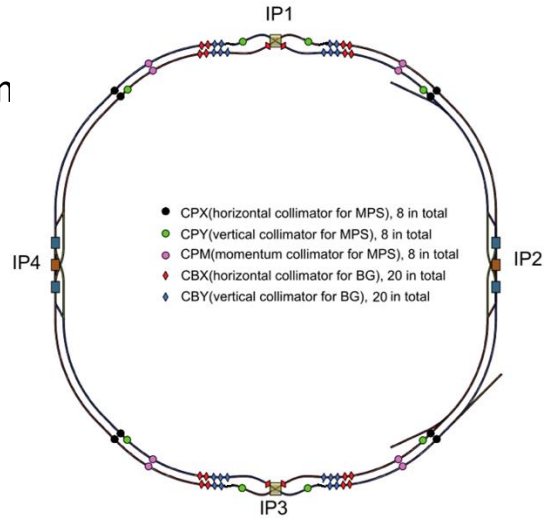
Y.Zhu, X.Zhang, X.Yang

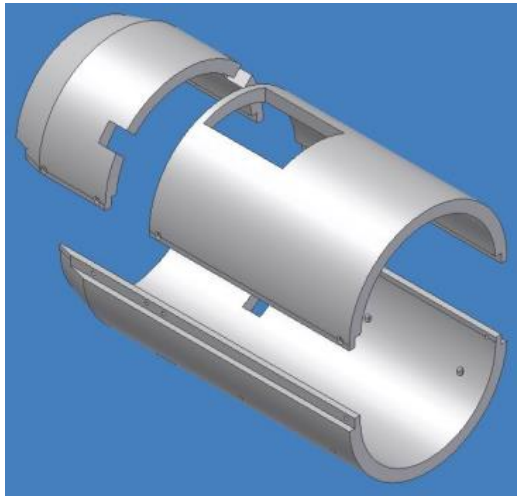


- The shield is extended between the helium tank and the beam chamber.
- The 4K cold mass is cooled by supercritical or subcooled helium, and the shield is by liquid nitrogen.

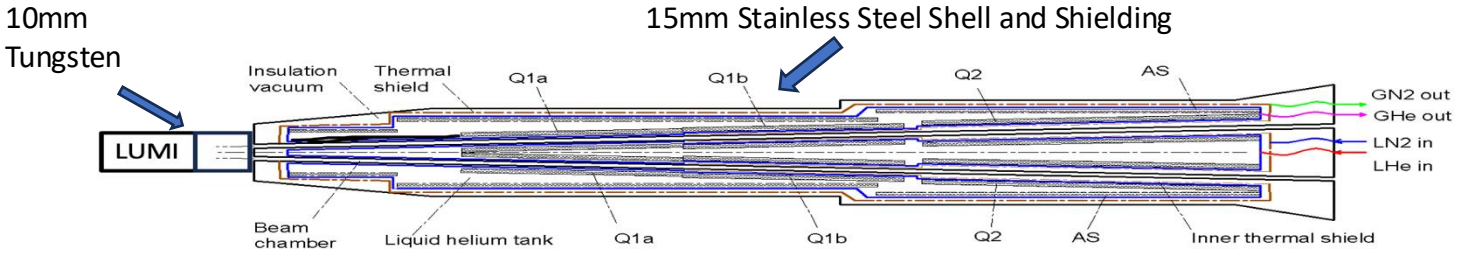
Collimators, masks, and shielding

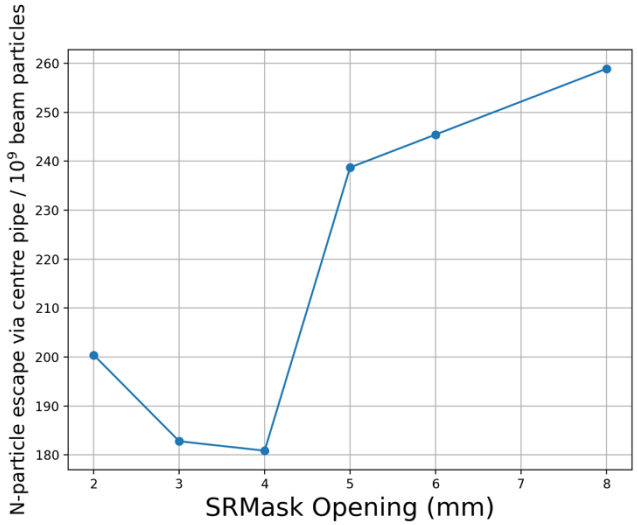
- Collimators were implemented to reduce IR loss caused by single beam.
  - In TDR phase, 12 sets of collimators were installed for passive machine protection and will also contribute to mitigating beam background.
  - In TDR phase, 5 sets of collimators per IP per ring were implemented for MDI purpose with updated position. We assume same aperture . The parameters of the collimators is keeping optimizing.
  - All collimators are designed to be movable.
- Masks are implemented to shield the SR photons hit the central beam pipe.
  - Currently we have 2 masks, locates at -7.2 m and -1.9 m.
  - The masks are designed to be non-movable.
- Shielding has also been implemented.



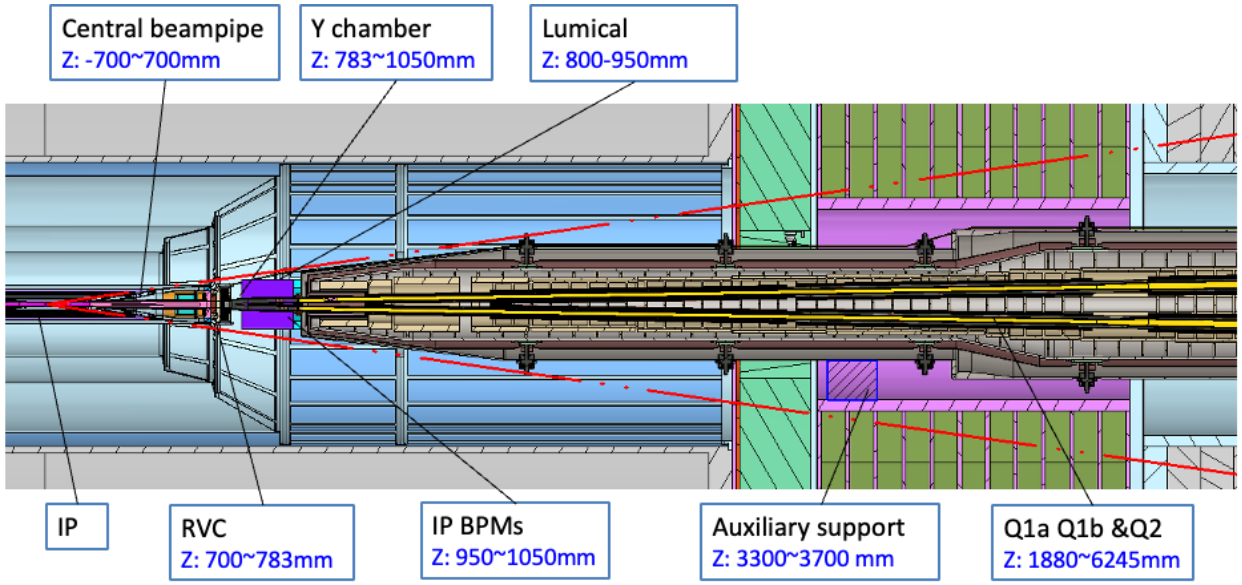


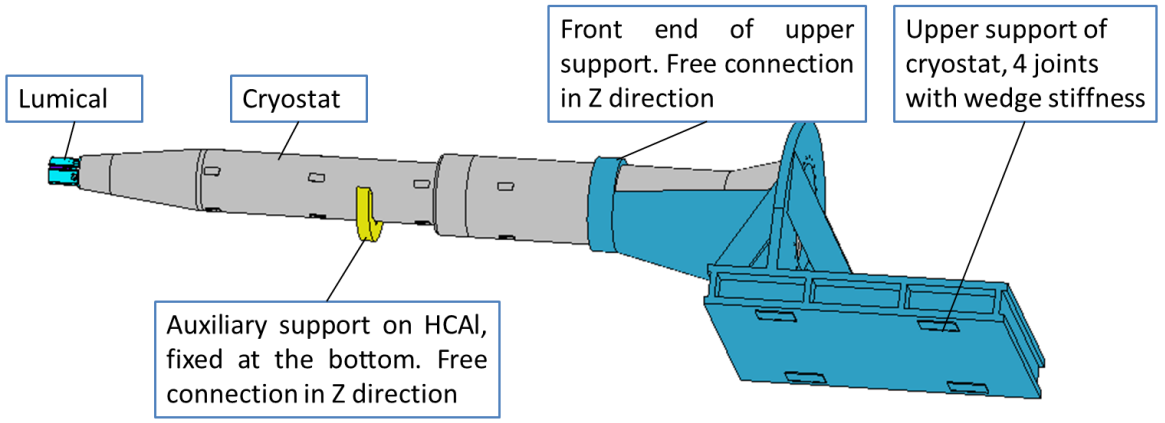
Shielding at BESIII





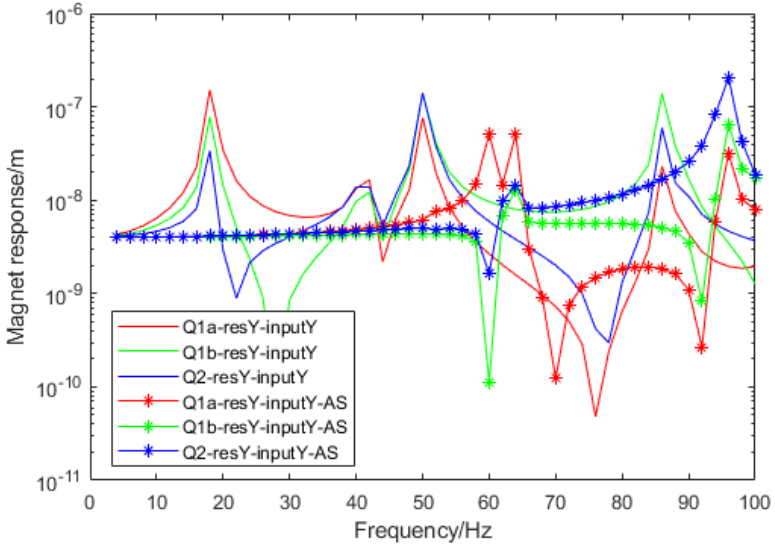
Integration and alignment





H.J. Wang

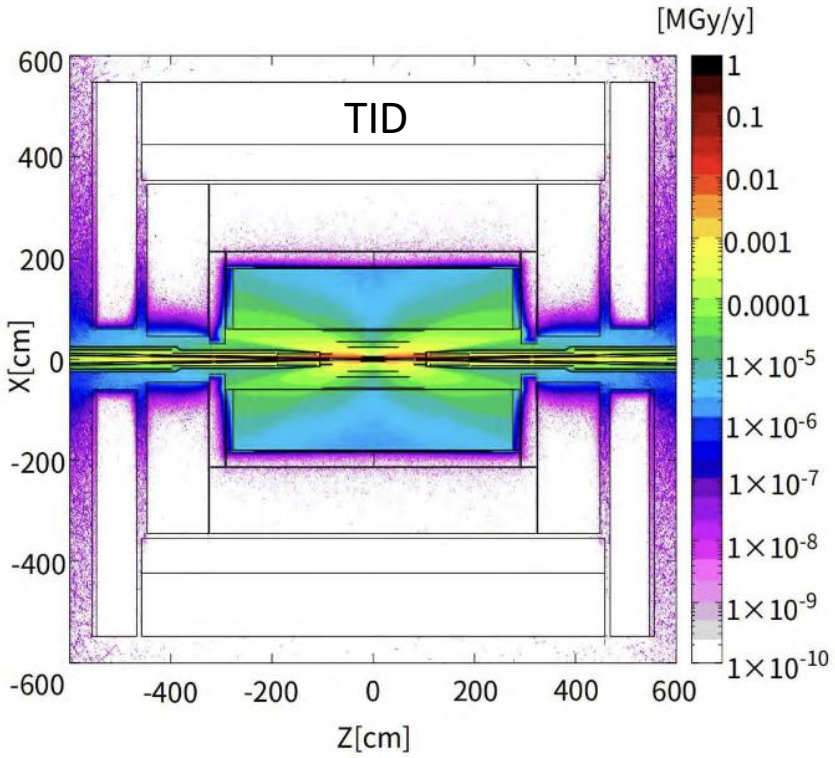
- The auxiliary support decrease the max change from 2000 um to 84 um.
- The cryo-module has a shell with a thickness of 15 mm, stainless steel.
  - It starts at 1050 mm, ends at 7000 mm.
  - It also plays the role of shielding.
  - Relative thicker shell is also good for the mechanical design, the max. change decreased from 84 um to 33 um.
  - On-site vibration test is on-going.
- The on-going alignment strategy design brings the co-work both from acc and det.



Estimation on the impacts in the IR

- We have obtained a preliminary estimate of the beam-induced background levels in Higgs mode
  - Assume an operational time of 7000hr/yr
  - Safety factor of 10 for SR, two for others.(Pair dominant, on average, it is ~2)

Sub-Detectors	Ave. Hit Rate		Max. Hit Rate		Max. Occupancy [%]	
	Higgs	Low-Lumi-Z	Higgs	Low-Lumi-Z	Higgs	Low-Lumi-Z
VTX [MHz/ cm^2]	0.22	0.52	12	39	2.1×10^{-2}	1.3×10^{-2}
ITK-Barrel [kHz/ cm^2]	0.92	1.7	2.6	6.6	6.4×10^{-3}	1.3×10^{-2}
TPC [kHz/ cm^2]	2.4	5.2	26	24	0.15	0.14
OTK-Barrel [kHz/ cm^2]	0.74	1.3	1.2	2.2	4.2×10^{-3}	9.2×10^{-4}
ECAL-Barrel [MHz/bar]	1.4×10^{-2}	2.2×10^{-2}	1.7	0.66	1.6	0.4
HCAL-Barrel [kHz/gs cell]	4.6×10^{-3}	8.4×10^{-3}	14	24	8.0×10^{-4}	8.0×10^{-4}
ITK-Endcap [kHz/ cm^2]	3.0	5.4	24	50	2.4×10^{-3}	5.0×10^{-3}
OTK-Endcap [kHz/ cm^2]	1.9	3.1	8.2	13	7.4×10^{-2}	12×10^{-2}
ECAL-Endcap [MHz/bar]	0.062	0.10	7.2	13	7.0	1.8
HCAL-Endcap [kHz/gs cell]	0.24	0.24	640	340	8.0×10^{-2}	6.0×10^{-3}
MD-Endcap [Hz/ cm^2]	1.4	0.92	2.5	14	0.18	0.05



Benchmark – Experiments

- Important to validate the modellings and Monte Carlo Simulation codes for the CEPC beam background simulation with real data where they are applicable.
  - BEPC II/BES III, SuperKEKB/Belle II, LEP I/II…
- Basic Principles – Key Parameters & Distinguish
  - Single beam mode: three dominant contributions from Touschek, beam-gas and electronics noise & cosmic rays.
  - $O_{single} = O_{tous} + O_{gas} + O_{noise+\mu} =$

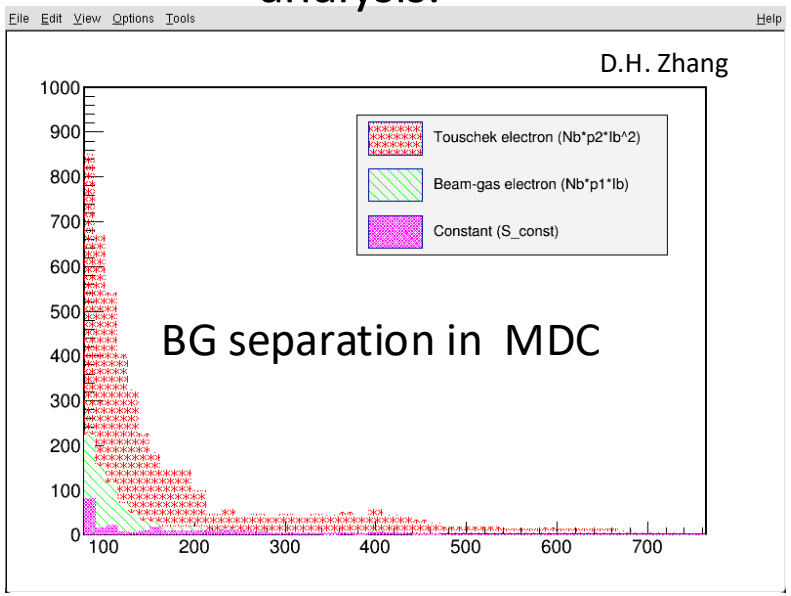
$$S_t \cdot D(\sigma_{x'}) \cdot \frac{I_t \cdot I_b}{\sigma_x \sigma_y \sigma_z} + S_g \cdot I_t \cdot P(I_t) + S_e$$

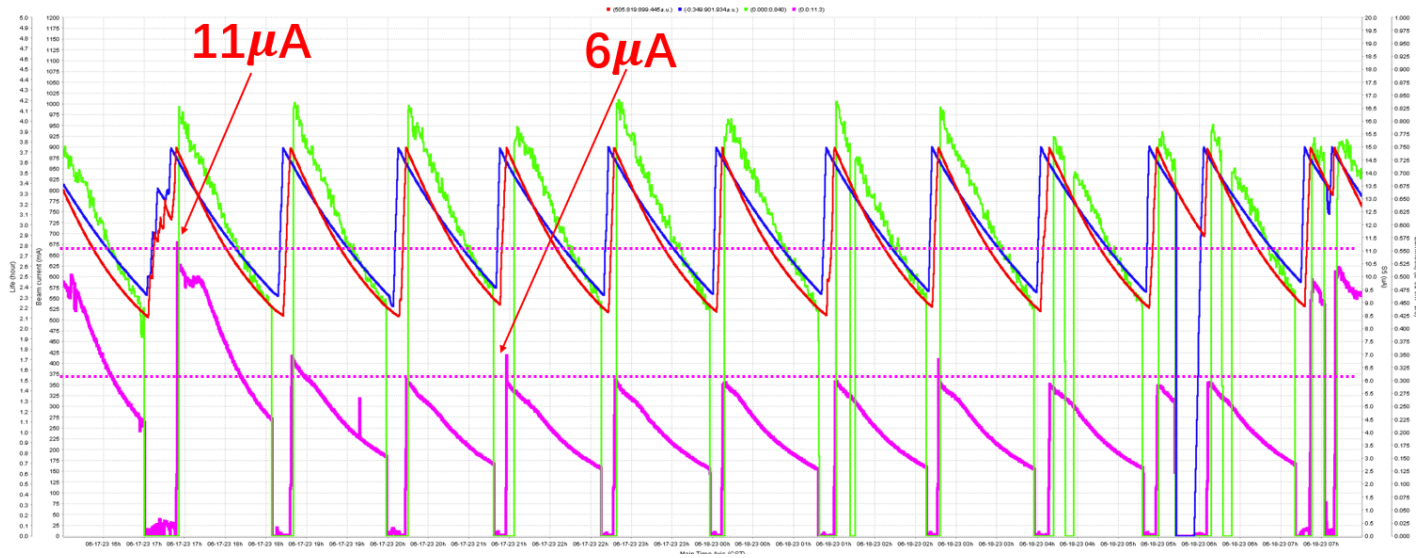
  - Double beam mode: additional contributions from luminosity related backgrounds, mainly radiative Bhabha scattering
  - $O_{total} = O_{e^+} + O_{e^-} + O_{\mathcal{L}}$(Ideal)

BESIII Benchmark

- BG experiments on BEPCII/BESIII has been done several times.
  - The experiment in 2021 separate the single beam BG sources, and we get a version of the data/MC ratio with beam-beam study and more realistic geometry model in simulation.
  - The experiment in 2022~2024 was focused on collimators. Backgrounds has been reduced ~40% with proper settings.
  - A dedicated BG experiments at BEPCII-U had been performed this summer. The data is under analysis.

H. Shi, B. Wang. H. Shi et.al





Summary and Outlook

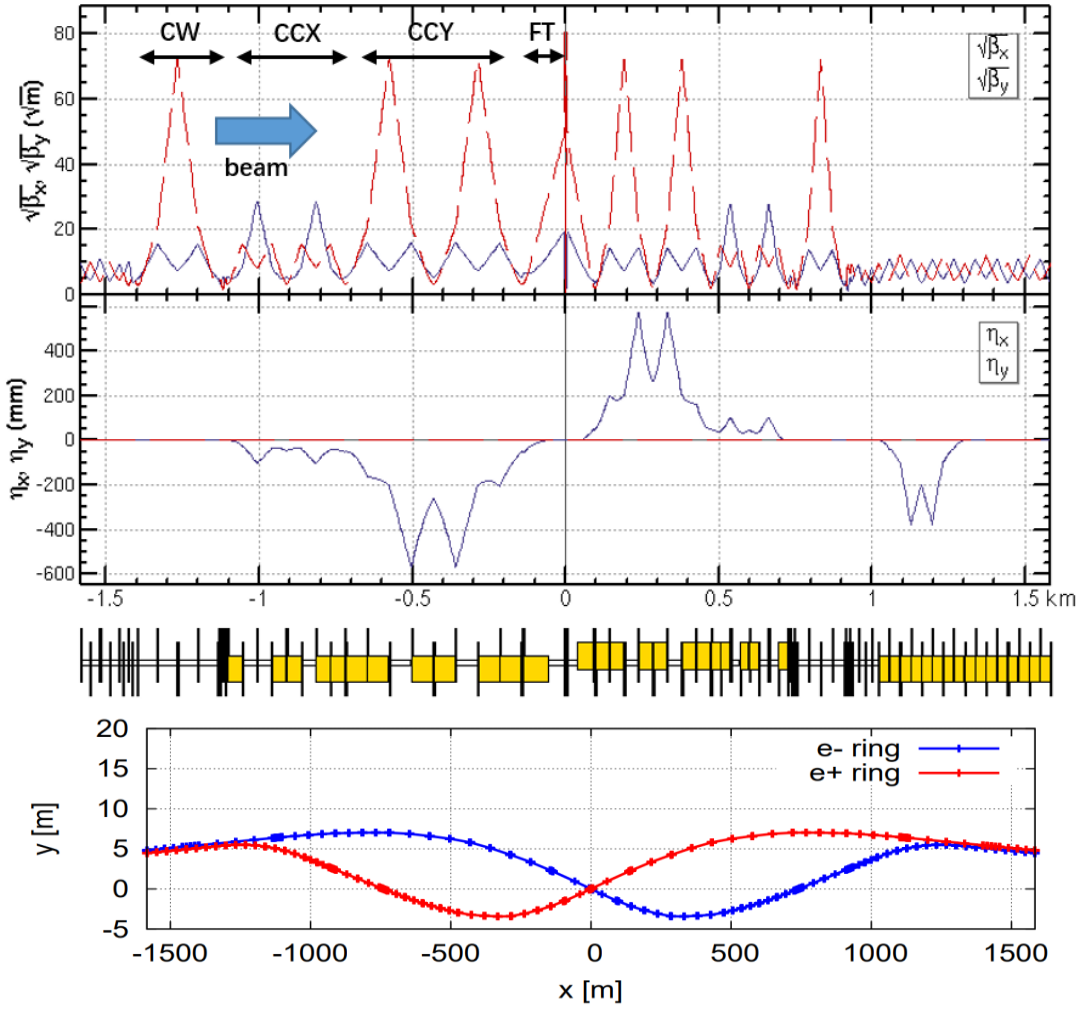
- MDI related study is one of the most critical and challenging ones when designing a future colliders, as well as the study on beam induced background. It should be start for a machine at the early design phase.
- Beam induced background is one of the driven factor of the MDI and IR design.
- For the MDI region at CEPC, we've updating the design in EDR phase , and we are carefully design the layout and key components to make it works better.
- We plan to focus on the understanding of the beam induced backgrounds, while do more experiments, mockups and prototypes on the hardware.
- As AGORA was proposed to FCC-ee, we are also studying the beam induced backgrounds in AGORA based on FCC-ee.
- Many synergies with FCC-ee:
  - IR Layout Design and Optimization with crab-waist implemented
  - Ultra-thin beam pipe study and mockup
  - Beam induced background estimations, simulations and benchmark experiments
  - Magnets and Cryo-stats
  - Luminosity and beam measurement…

Thank You

Backup

Lattice design of the interaction region

- Crab waist collision, local chromaticity correction, asymmetric interaction region



- Up to 3rd order chromaticity is corrected with pairs of main sextupoles, phase tuning and additional sextupoles respectively.
- Main resonance driving terms (RDT) due to sextupoles in 3rd and 4th order Lie operators are cancelled.
- The tune shift due to the finite length of the main sextupoles is corrected with additional weak sextupoles.

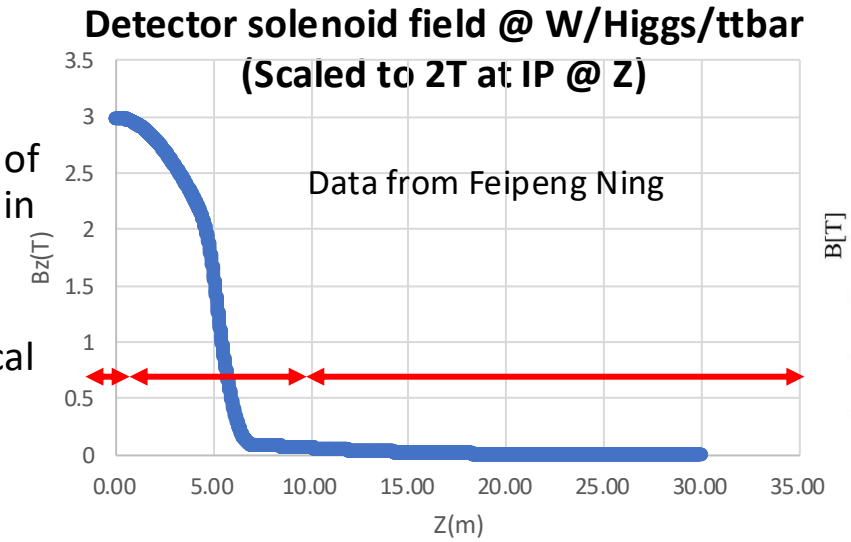
- Currently, we are working on a lattice design with orbit correction, and taking the solenoid and anti-solenoid into account

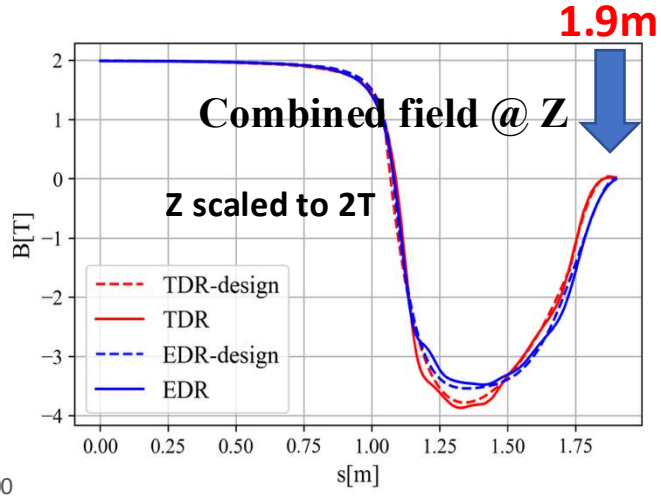
Please refer to Yiwei Wang's talk in this workshop

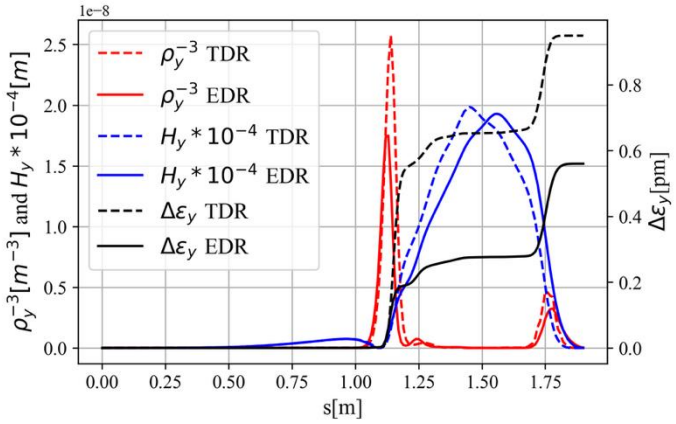
Solenoid field compensation in CEPC TDR and update

Ande MA, Yiwei Wang, Yingshun Zhu et al

- The detector solenoid are compensated **locally** with anti-solenoids
- From IP to the entrance of Q1A (0 to 1.9m):
  - ∫Bzdz cancled between the IP and the entrance of final quadrupole with strong anti-solenoid field in 1.1m to 1.9m.
  - Field configuration optimized to get emittance minimum and iterate with anti-solenoid technical constraints
- From the entrance of Q1A to Q3(1.9m to 10.55m)
  - Bz keep fully cancellation along this region
- From the Q3 to the last bend (farer than 10.55m)
  - ∫Bzdz from detector only < 0.5 T*m.
  - Along beam line (not z), fully cancelation in Q3 and pre-cancelation in some extension region (with length of 1m) for the long tail of the detector solenoid field







Emittance contribution from the from IP to the entrance of Q1A

	$t\bar{t}$ 3T	Higgs 3T	W 3T	Z 2T
Nominal ϵ_y[pm]	4.7	1.3	1.7	**1.4**
Solenoid contributed ϵ_y[pm](TDR)	0.04	0.36	1.20	**0.95**
Solenoid contributed ϵ_y[pm] (Update)	0.02	0.21	0.71	**0.56**

3T solenoid detector field for CEPC Z pole operation (local compensation scheme)

Ande MA, Yiwei Wang,
Yuan Zhang, D. Wang et al

- **Motivation: The TPC detector can run with much lower background when detector field is 3T comp. with 2T case.**
- With local compensation scheme
  - Bz0 2 T=>3 T, vertical emittance 0.56 pm => 3.9 pm
  - fulfill the nominal vertical emittance requirement of the 1st stage running (assuming 5.1pm including error effects from other region)

	Z 2T local	Z 3T local
Nominal ϵ_y[pm]	1.4	5.1
Solenoid contributed ϵ_y[pm] (Update)	0.56	3.9

Solenoid field induced a reduction factor 1.9 for the luminosity

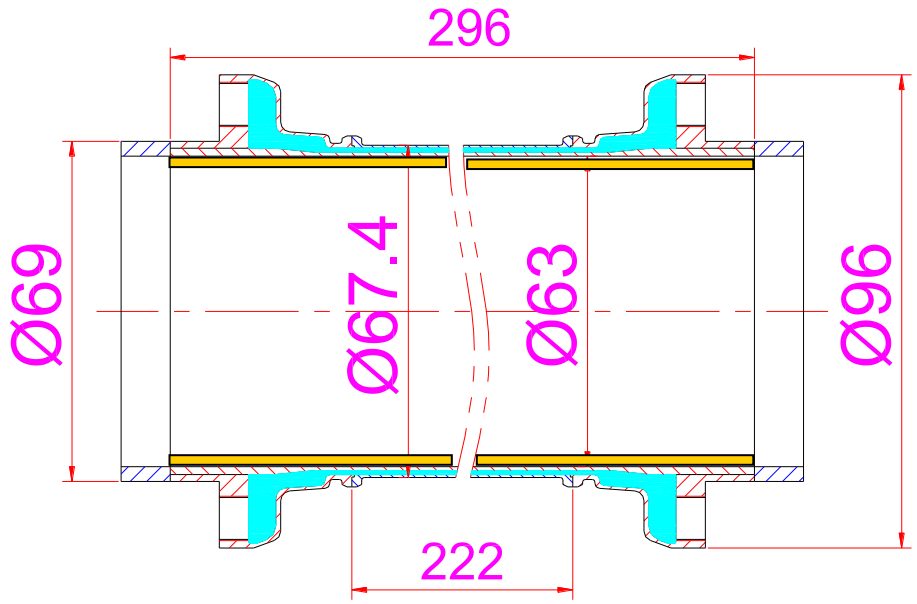
	Z (3T local, 1st stage running)
Number of Ips	2
Circumference (km)	99.955
SR power per beam (MW)	12.1
Half crossing angle at IP (mrad)	16.5
Bending radius (km)	10.7
Energy (GeV)	45.5
Energy loss per turn (GeV)	0.037
Damping time $\tau_x/\tau_y/\tau_z$ (ms)	816/816/408
Piwinski angle	24
Bunch number	3978
Bunch spacing (ns)	69.2
Bunch population (10^{11})	1.7
Beam current (mA)	325.0
Phase advance of arc FODO (°)	60
Momentum compaction (10^{-5})	1.43
Beta functions at IP β_x^*/β_y^* (m/mm)	0.13/1.0
Emittance $\varepsilon_x/\varepsilon_y$ (nm/pm)	0.27/5.1
Betatron tune ν_x/ν_y	317/317
Beam size at IP σ_x/σ_y (um/nm)	6/72
Bunch length (natural/total) (mm)	2.1/8.8
Energy spread (natural/total) (%)	0.04/0.15
Energy acceptance (DA/RF) (%)	1.0/2.2
Beam-beam parameters ξ_x/ξ_y	0.0053/0.082
RF voltage (GV)	0.16
RF frequency (MHz)	650 (2 cell cavity)
Longitudinal tune ν_s	0.041
Beam lifetime (Bhabha/beamstrahlung) (min)	150/180
Beam lifetime requirement (min)	68
Luminosity per IP (10^{34} cm^{-2} s^{-1})	26

CEPC parameters with 3T detector for Z in the 1st stage running

- The luminosity is mainly limited by both the current (**RF high order modes, factor 2.5**) and vertical emittance (**solenoid field induced, factor 1.9**)
- Luminosity goal 26E34/cm^2/s was accepted by the 1st stage running of CEPC detector

Experiences on BESIII Beam Pipe

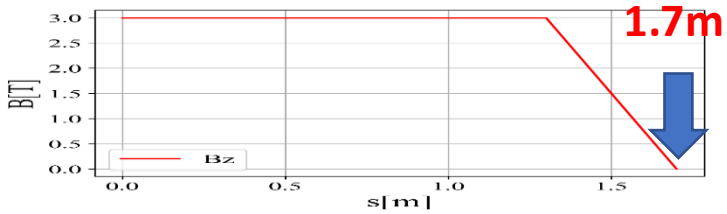
- The inner layer has a thickness of 0.8 mm
- The outer layer has a thickness of 0.6 mm
- The gap for the coolant has a thickness of 0.8 mm
  - Paraffin was used as coolant
  - An anti-corrosion coating is applied in the gap.
- For shielding the SR, a gold coating with a thickness of 15 μm is used.
- The critical manufacturing processes have been developed and tested during the construction of BESIII.
- Stable operation nearly two decades. We have the experiences and ability to deliver the Be beam pipe for future colliders.



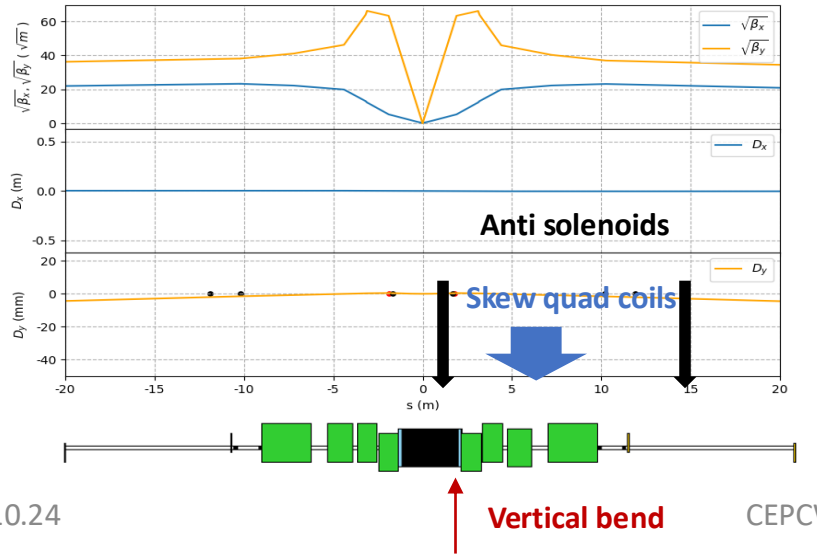
	Size	BESIII	CEPC
Outer layer	ID (mm)	66.2	20.8
	Thickness(mm)	0.6	0.15
	Length (mm)	218	170
Inner layer	ID(mm)	63	20
	Thickness(mm)	0.8	0.2
	Length (mm)	288	220
Cooling channel (mm)		0.8	0.2

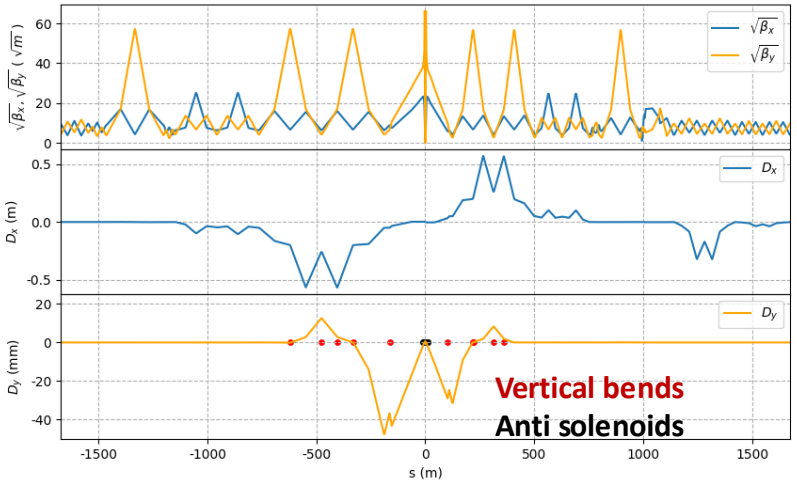
3T solenoid detector field for CEPC Z pole operation (non-local compensation scheme)

Yixian Dai, Yiwei Wang, Yuan Zhang



- If non-local compensation scheme with Bz0=3 T
  - Anti solenoid
    - assuming anti-solenoid in front of the final quadrupoles from 1.3m to 1.7m to cancel the Bz to be zero and kept zero until the end of the final quadrupoles
  - One bend in front of the final quadrupoles to partly correct the vertical angle
  - Add Skew quadrupole coils on the final quadrupoles thus the beam will match the quadrupole
  - Anti solenoid to cancel the ∫Bzdz to be zero right at down stream of the final quadrupole cryo-module
  - 5 more bends at the down stream to correct the orbit and dispersion y, y', Dy, Dy'

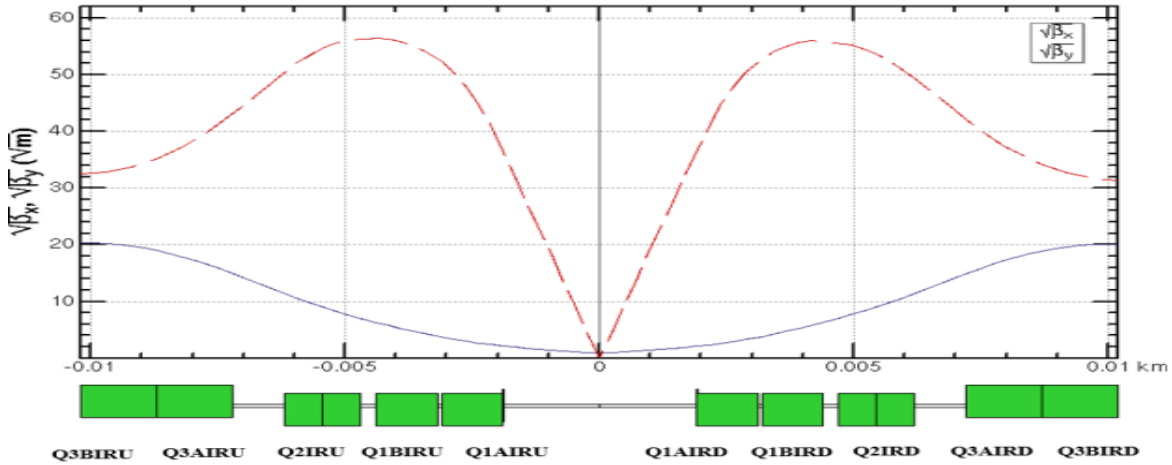




Super conducting final quadrupoles for all modes

- Dipole field aberration due to cross talk of the two aperture
  - Three types of SCQ design were designed
  - Beam dynamics: integrated dipole field should be corrected
  - Radiation and particle loss: **maximum 450/300/200/100 Gauss** in the good field region along the SCQs for ttbar/Higgs/W/Z modes (the requirement will be updated with simulation of **an integrated model of the quadrupoles, dipole error and solenoid**)
    - This is also the max field allowed for the correctors in SCQ
  - The normal conducting quadrupole of **Q3 for ttar running was moved outward** (outer end from 7.2m to 7.55m) due to conflict between the cryomodule and the Q3

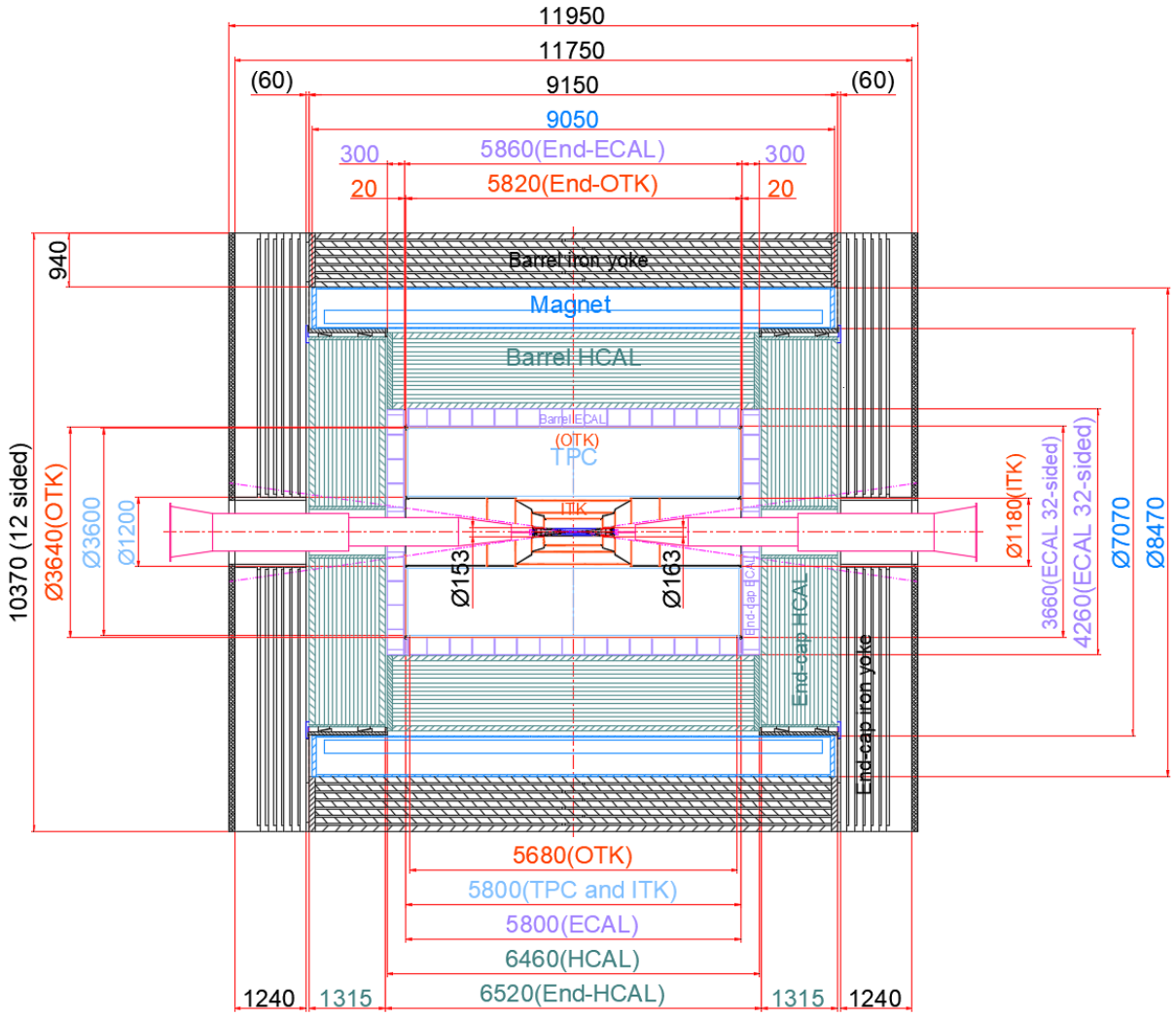
Layout of the dual aperture SCQ final quadrupoles



Parameters of the twin-aperture SCQs between the IP

Quadrupole	L [m]	Distance from IP [m]	Strength [T/m]			
			$t\bar{t}$	Higgs	W	Z
Q1AIRU	1.21	1.9	-142	-142	-95	-110
Q1BIRU	1.21	3.19	-59	-85	-57	+65
Q2IRU	1.5	4.7	-51	+97	+65	0
Q3IRU	3	7.2 (7.55)	+40	0	0	+2
Q1AIRD	1.21	-1.9	-142	-142	-95	-110
Q1BIRD	1.21	-3.19	-59	-85	-57	+65
Q2IRD	1.5	-4.7	-51	+97	+65	0
Q3IRD	3	-7.2 (7.55)	+40	0	0	+2

Detector Geometry and Mechanical Support



Sub-System	Supported by
Barrel Yoke	Base
Magnet	Barrel Yoke
Barrel HCal	Barrel Yoke
Barrel ECal	Barrel HCal
TPC + Barrel OTK	Barrel ECal
ITK	TPC
Beampipe + VTX + LumiCal	ITK
Endcap Yoke	Base
Endcap HCal	Barrel HCal
Endcap ECal + OTK	Barrel ECal

Sub-detector Installation Sequence

1) **Install the barrel sub-detector in the following order :**
   Yoke, Magnet, HCAL, ECAL, TPC(OTK), ITK, Beampipe(Vertex)
2) **Install the endcaps in the following order :**
   End ECAL(OTK), End HCAL, End Yoke

Easy to install, Easy to repair, Easy to replace

