Study of Synchrotron radiation at CEPC

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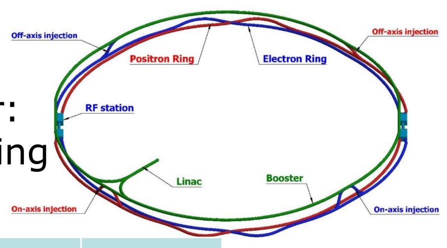
Introduction

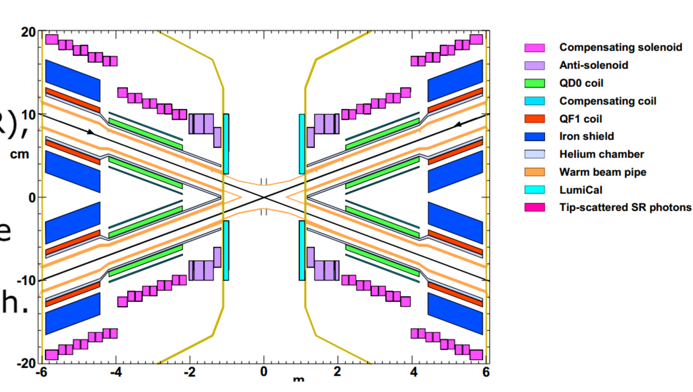
Circular **E**lectron **P**ositron **C**ollider:
100km circumference, double ring



	Higgs	W^+W^-	Z(3T)	Z(2T)
Number of IPs	2			
Beam energy(GeV)	120	80	45.5	
Luminosity ($10^{34} cm^{-2}s^{-1}$)	3	10	17	
Years	7	1	2	
Number of bunches	242	1524	12000	
Beam current (mA)	17.4	87.9	461.0	
Synchrotron radiation power (MW)	30	30	16.5	
β_x^*/β_y^* (m)	0.36/0.0015	0.36/0.0015	0.2/0.0015	0.2/0.001
Emittance x/y (m)	1.21/0.0024	0.54/0.0016	0.18/0.004	0.18/0.0016

Challenge from **M**achine-**D**etector **I**nterface (MDI)

Huge background from Synchrotron radiation (SR), Beamstralung...
For example, at CEPC, 4×10^4 photons will hit the central Be beampipe ($\pm$7 cm from IP) per bunch.

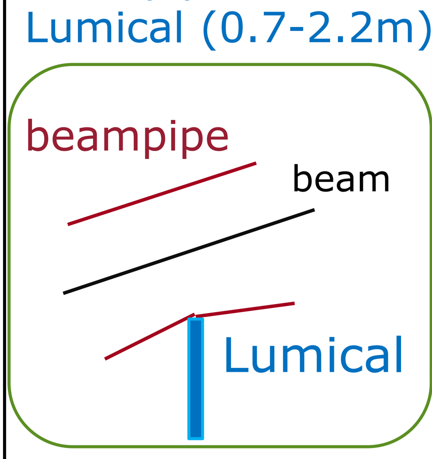


MDI parameters in simulation

To suppress SR,

- Last bend magnet: relatively soft, 93m long ($\rho = 8\times10^4$m), ~67m away from IP,
- Critical SR energy: ~45 keV

Beampipe around Lumical (0.7-2.2m)



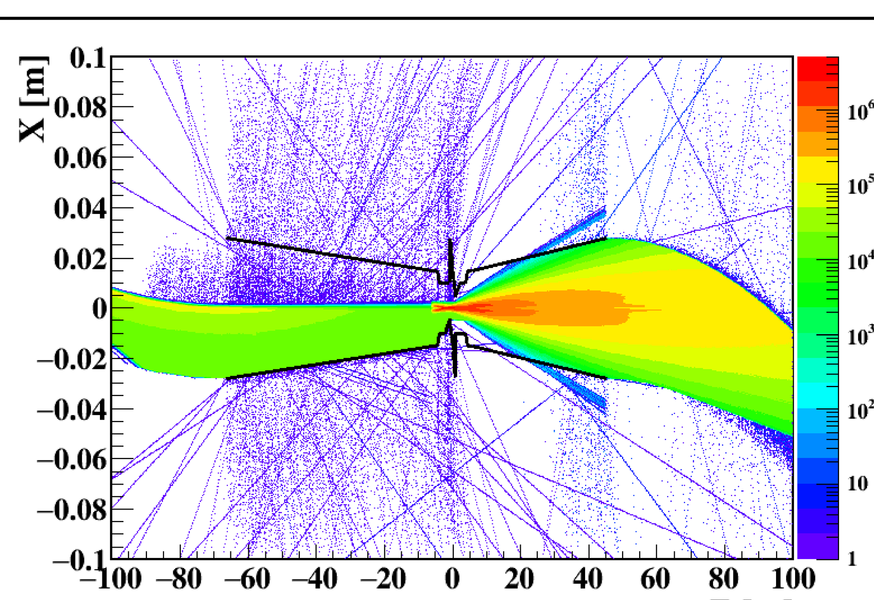
MDI parameters	Values
L^* (m)	2.2
Crossing angle (mrad)	33
Strength of QD0 (T/m)	150
Strength of detector solenoid (T)	3.0
Strength of anti-solenoid (T)	7.0

Implementation of beampipe:
3mm thick Copper.
Divided into 7500 parts in Mokka format.
Each part is a cone with length of 0.2mm

Simulation:

- Bdsim + Geant4
- Only use e^+ beam (e^- beam is the same)
- No secondary particles from the interaction between photon and beampipe

SR from last bend magnet



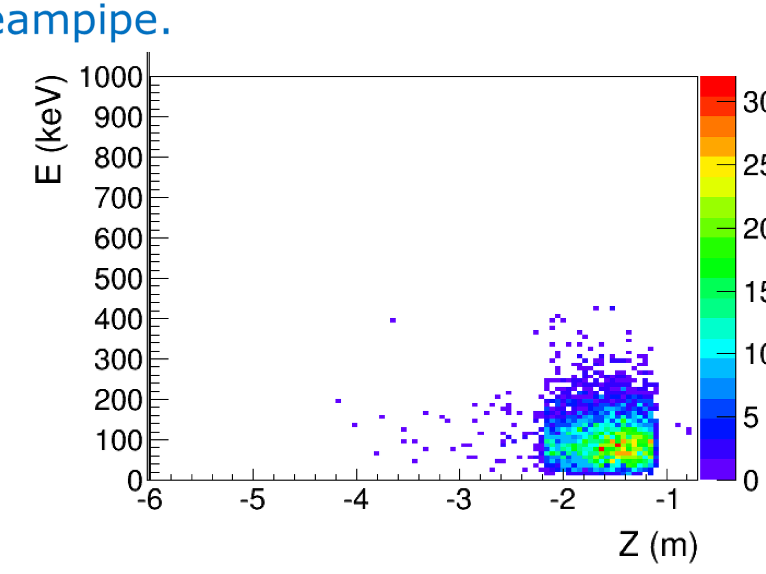
Z direction: e^+ beam.
Each photon is represented by a line and scaled by energy.
Current statistics 0.001 bunch.

Numbers of incident photons and deposit powers at different beampipe surfaces.

Beampipe position (m)	Deposit power (W)	Number of incident Photons per bunch
0.7-2.2	18.84	4.28e+09
2.2-4.2	4.38	9.50e+08
4.2-4.43	52.56	1.20e+10
4.43-5.91	4.19	9.55e+08

Incident photon can not hit the central beampipe ($\pm$7cm) directly.
But could hit the Cu beampipe and scatter to central beampipe.

The position distribution of the source of scattered photons which will hit central beampipe.



All of the scattered photons come from the beampipe at 0.7-4.2 m
(dominant by beampipe at 0.7-2.2m).

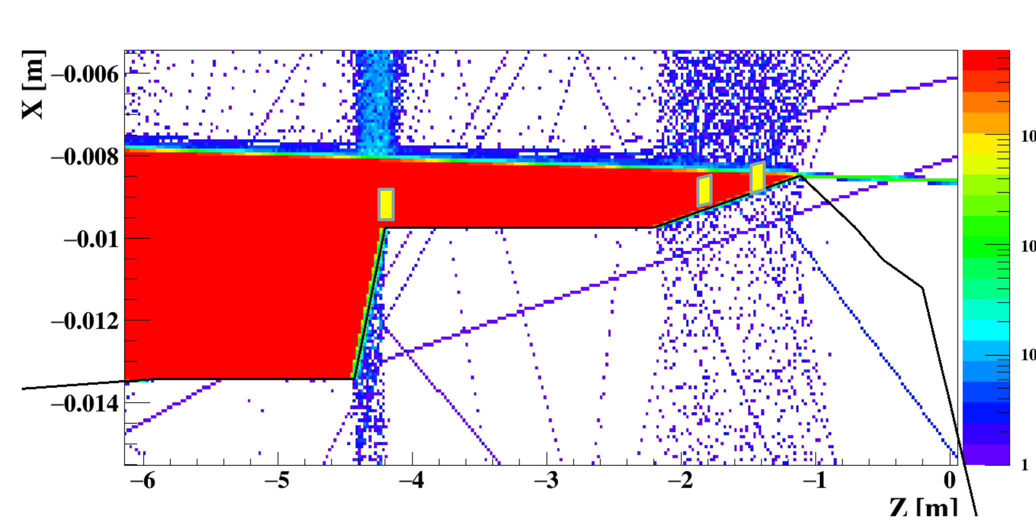
Protection from SR

In total, 4×10^4 scatterd photons at central beampipe per bunch.
The source is the beampipe at 0.7-4.2 m.

To study the protection, first we need more statistics.

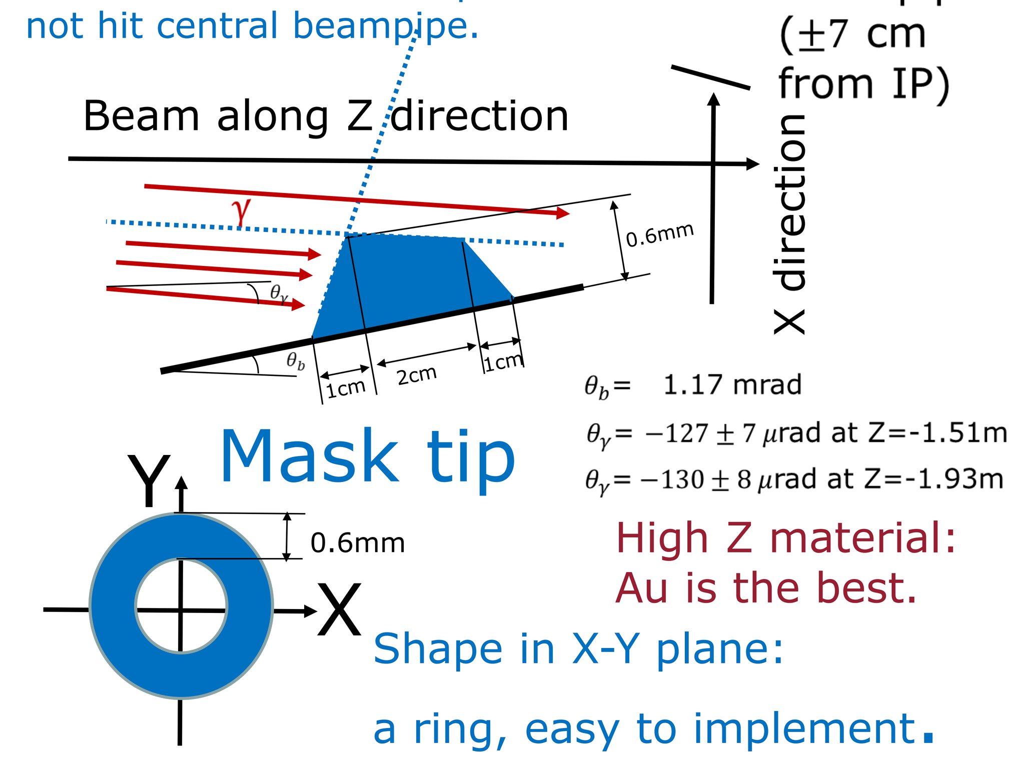
- Modify the code of Bdsim and Geant4 to generate the SR photon at specific region: beampipe 0.7-4.2m.
- Generate a small sample of SR photons first.
- Take the energy, momenta and positions distributions (6 variables).
- Then generate a larger toy MC, enlarged by 1000 times.
- Use Geant4 to simulate the interaction between these photons and beampipe.
- In total statistics: 3 bunches.
- Time: ~one week (300CPU, generation+interaction +analysis)
- Disk space: 50 TB.

SR photons distribution with more statistics



To protect central beampipe from the scattered photons, we introduce three mask tips at Z= $\pm$(4.2,1.93 and 1.51) m
(yellow box in above figure)
Define the beam stay clear region:
$15\sigma + 3$mm in X, $20\sigma + 3$mm at Y
Height of mast tips can not be too much, 0.6 mm

Extension line should be far way from central beampipe, so the most favored scattered photon can not hit central beampipe.

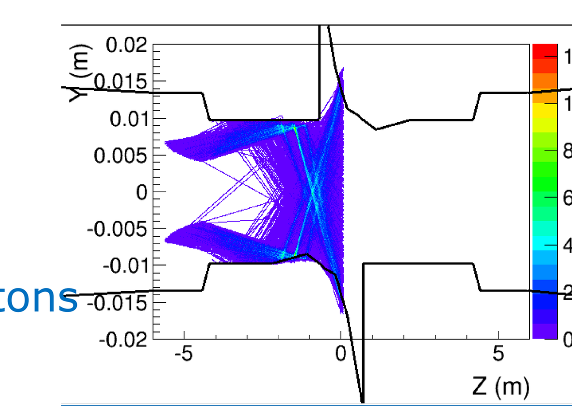


With three tips, number of photons at central beampipe: **~60 per bunch.**
Decreased significantly.
Now all the photons come from mask tips.

SR from quadrupole (QF1, QD0)

Use a uniform beam, Trace back the scattered photons to see the source.

Trajectory of the photons which will hit central beampipe.



The source positions are out of beam stay clear region. So the impact of quadrupole is negligible.

Coating the central beampipe

To further absorb the scattered photon, we can coat the inner surface of central beampipe with Au. Use the energy spectrum, the thickness to absorb $1/e$ photons is 7.2 μm

Beam halo

The beam halo is simulated with same parameter of beam core but the size is enlarged by 3 times and the fraction in total beam is assumed to be 1.35%. The halo is included in the final result.

Summary and future plan

- SR is simulated at CEPC and can contribute 4×10^4 photons at central beampipe per bunch. All of them come from the scattering at beampipe (0.7-4.2m).
- With three mask tips at $\pm$(4.2, 1.93 and 1.51)m, , the number of photons reduced to ~60 per bunch.
- The secondary photons, i.e. K-shell photon, is missing in current study and will be included in future.
- Further optimization of mask tips maybe needed.
- Simulation of the scattered photon and detector will be performed with enough statistics.