Results on Beam induced backgrounds at the CEPC Vertex

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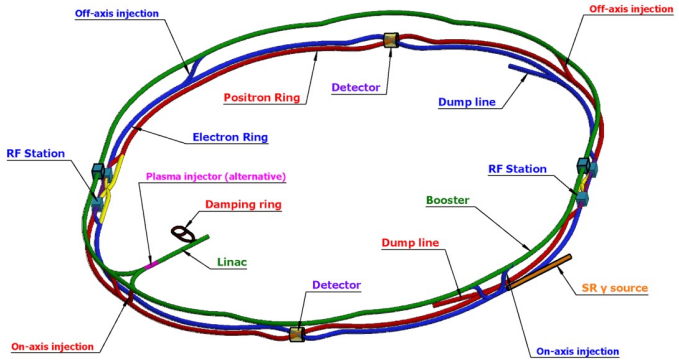
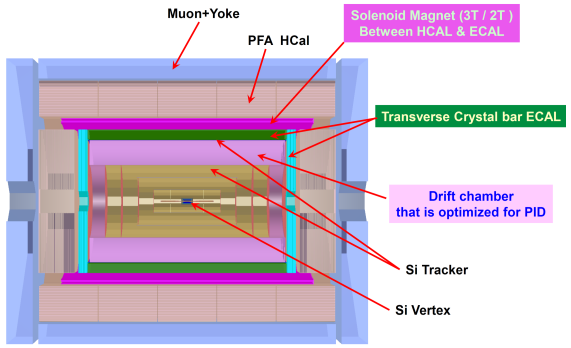
Introduction – CEPC MDI

- MDI stands for ”Machine Detector Interface”
  - 2 IPs
  - 33mrad Crossing angle
- Flexible optics design
  - Common Layout in IR for all energies – TDR 50MW



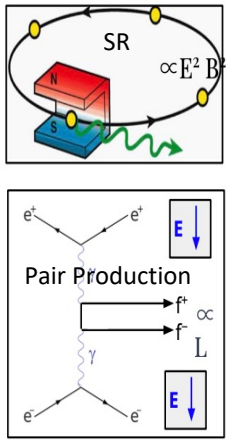


	Higgs	Z	W	$t\bar{t}$
Number of IPs	2			
Circumference (km)	100.0			
SR power per beam (MW)	50			
Half crossing angle at IP (mrad)	16.5			
Bending radius (km)	10.7			
Energy (GeV)	120	45.5	80	180
Energy loss per turn (GeV)	1.8	0.037	0.357	9.1
Damping time $\tau_x/\tau_y/\tau_z$ (ms)	44.6/44.6/22.3	816/816/408	150/150/75	13.2/13.2/6.6
Piwinski angle	4.88	29.52	5.98	1.23
Bunch number	446	13104	2162	58
Bunch spacing (ns)	355 (53% gap)	23 (10% gap)	154	2714 (53% gap)
Bunch population (10^{11})	1.3	2.14	1.35	2.0
Beam current (mA)	27.8	1340.9	140.2	5.5
Phase advance of arc FODO (°)	90	60	60	90
Momentum compaction (10^{-5})	0.71	1.43	1.43	0.71
Beta functions at IP β_x^*/β_y^* (m/mm)	0.3/1	0.13/0.9	0.21/1	1.04/2.7
Emittance $\varepsilon_x/\varepsilon_y$ (nm/pm)	0.64/1.3	0.27/1.4	0.87/1.7	1.4/4.7
Betatron tune ν_x/ν_y	445/445	317/317	317/317	445/445
Beam size at IP σ_x/σ_y (um/nm)	14/36	6/35	13/42	39/113
Bunch length (natural/total) (mm)	2.3/4.1	2.7/10.6	2.5/4.9	2.2/2.9
Energy spread (natural/total) (%)	0.10/0.17	0.04/0.15	0.07/0.14	0.15/0.20
Energy acceptance (DA/RF) (%)	1.6/2.2	1.0/1.5	1.05/2.5	2.0/2.6
Beam-beam parameters ξ_x/ξ_y	0.015/0.11	0.0045/0.13	0.012/0.113	0.071/0.1
RF voltage (GV)	2.2	0.1	0.7	10
RF frequency (MHz)	650			
Longitudinal tune ν_s	0.049	0.032	0.062	0.078
Beam lifetime (Bhabha/beamstrahlung) (min)	40/40	90/930	60/195	81/23
Beam lifetime requirement (min)	20	81	25	18
Hourglass Factor	0.9	0.97	0.9	0.89
Luminosity per IP (10^{34} cm^{-2} s^{-1})	8.3	192	26.7	0.8

Background Estimation

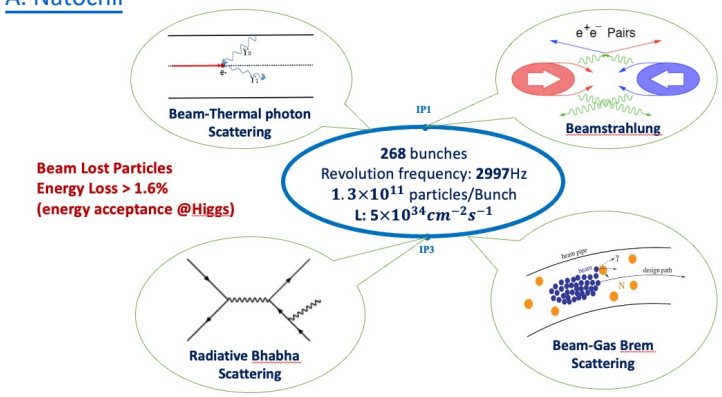
- Single Beam
  - Touschek Scattering
  - Beam Gas Scattering(Elastic/inelastic)
  - Beam Thermal Photon Scattering
  - Synchrotron Radiation
- Luminosity Related
  - Beamstrahlung
  - Radiative Bhabha Scattering
- Injection

A. Natochii



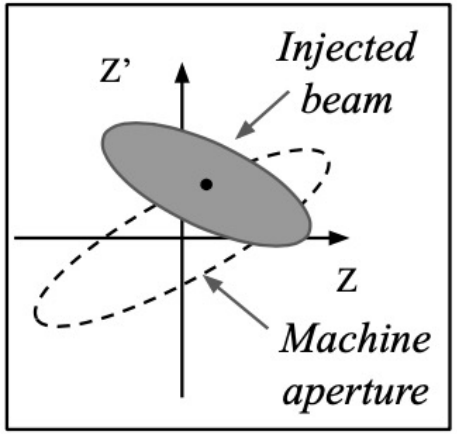
Photon BG

A. Natochii



Beam Loss BG

A. Natochii



Injection BG

Background	Generation	Tracking	Detector Simu.
Synchrotron Radiation	BDSim	BDSim/Geant4	Mokka/CEPCSW/FLUKA
Beamstrahlung/Pair Production	Guinea-Pig++	SAD	
Beam-Thermal Photon	PyBTH[Ref]		
Beam-Gas Bremsstrahlung	PyBGB[Ref]		
Beam-Gas Coulomb	BGC in SAD		
Radiative Bhabha	BBBREM		
Touschek	TSC in SAD		

- One Beam Simulated
- Simulate each background separately
- Whole-Ring generation for single beam BGs
- Multi-turn tracking(50 turns)
  - Using built-in LOSSMAP
  - SR emitting/RF on
  - Radtaper on
  - No detector solenoid yet(except for Z)

Estimation of Impacts in the IR

- Noise on Detector(Backgrounds)
  - Hit Density/Occupancy
  - CEPCSoft(moving to CEPCSW , Same tool with physics)
  - Methods: $HD = \frac{Number\ of\ hits}{area}\left[\frac{\frac{hits}{cm^{-2}}}{BX}\right]$
- Radiation Environment(Backgrounds, currently no signal)
  - Radiation Damage of the Material(Detector, Accelerator, Electronics, etc…)
    - CEPCSoft(moving to CEPCSW, Same tool with physics), or FLUKA
    - TID(Total Ionizing Dose): $TID = \frac{E_{deposited}}{M_{detector}} = \left[\frac{MRad}{yr}\right]$
    - 1 MeV equivalent neutron fluence: $\frac{NIEL(E_k,type)}{NIEL(1MeV,Neutron)}Fluence$
    - Hadron Fluence(>20MeV)
- Take the highest bin result, the calculate results(max_average)

Detector Impact – Preliminary Results

- Preliminary results for 1st Layer of vertex, mixing of scaling from CDR/simulation based on TDR, without safety factor
  - No SR

Background	Hit Density($cm^{-2} \cdot BX^{-1}$)		TID($Mrad \cdot yr^{-1}$)		1 MeV equivalent neutron fluence ($n_{eq} \times 10^{12} \cdot cm^{-2} \cdot yr^{-1}$)	
	Higgs	Z	Higgs	Z	Higgs	Z
Pair production	0.54	0.2	0.08	2.8	0.03	5.3
Beam Loss	0	0.1	0	2.05	0	5.5
Total	0.54	0.3	0.08	4.85	0.03	10.8

Take SR into account(Scale from previous results with some assumptions) on 1st Layer of Vertex, Higgs only

BG Source	Hit Density($cm^{-2} \cdot BX^{-1}$)	Hit Density($cm^{-2} \cdot s^{-1}$)
Pair Production	0.54(electron/positron)	0.81M
Synchrotron Radiation	1.7(photon, av.e.~53keV)	2.6M

Questions & Next Step

- Questions based on current simulation:
  - Where is the vertex?(First one or two layers)
    - Length
    - Radius
  - Which number you prefer?
    - Hit Density per cms per BX or per second?
    - TID/NIEL/Hadron Fluence per year or per what?
- Next Step:
  - Moving to CEPCSW/Add more algorithms like hit distribution to occupancy(with huge help from Tianyuan)
  - Layout Completion(Electronics? Other Materials?)

Backup

Detector Impact – Preliminary Results

- Preliminary results on Higgs mode on layers of Vertex. Without safety factor

Layer	Hit Density($cm^{-2} \cdot s^{-1}$)		TID($krad \cdot yr^{-1}$)		1 MeV equivalent neutron fluence ($n_{eq} \times 10^{12} \cdot cm^{-2} \cdot yr^{-1}$)	
	Pair	Be.Lo.	Pair	Be.Lo.	Pair	Be.Lo.
1	3.9e5	0	81.7	0	0.003	0
2	2.5e5	0	57.8	0	0.010	0
3	2.5e4	1.4e3	6.1	24.5	0.014	0.002
4	2.2e4	1.2e3	5.4	24.6	0.012	0.002
5	4.5e3	7e2	1.2	19.3	0.004	0.0008
6	4.5e3	6.5e2	1.0	13.3	0.003	0.001