# Beam-induced backgrounds in the CEPC 240 GeV CM energy interaction region

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Aug 27, 2016

# Outline

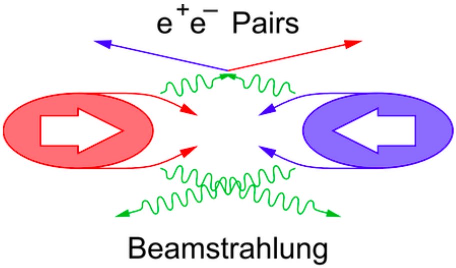
- Main sources of backgrounds
- The angular distribution of the whole detectors
- Analytical estimation of backgrounds
- Conclusion

# Main sources of backgrounds

- Beamstrahlung photons
- Coherent pair production
- Incoherent pair production
- $\gamma\gamma \rightarrow$ hadrons events
- Radiative bhabha
- Synchrotron radiation

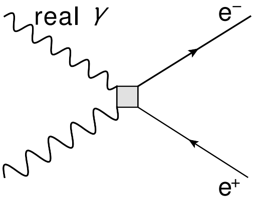
# Beamstrahlung photons

- Beamstrahlung photons
  • In $e^+e^-$ collisions, the trajectory of the beam particles will be bent by the electromagnetic field of the other bunch, resulting in the emission of high-energy photons.



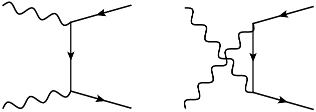
# Coherent pair production

- Due to the beamstrahlung photons during collision, QED and QCD backgrounds are produced.
  - Coherent pair production
  - Incoherent pair production
  - $\gamma\gamma \rightarrow$ hadrons events
- Due to the strong fields during the collisions, photons from beamstrahlung interact with the coherent field of the oncoming bunch and produce $e^+e^-$ pairs.

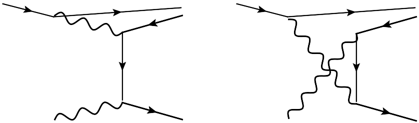


# Incoherent pair production

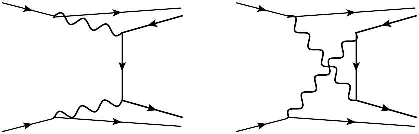
The direct interaction of two photons will also lead to the production of electron-positron pairs, including three main processes.



(a) Breit−Wheeler



(b) Bethe−Heitler



(c) Landau−Lifschitz

# Others

- $\gamma\gamma \to$ hadrons events
- Radiative Bhabha

  • The collision of the electron-positron lead to the emission of a photon in the final state. $(e^+e^- \to e^+e^-\gamma)$
- Synchrotron radiation

  • Synchrotron radiation (SR) is electromagnetic radiation emitted by charged particles when they move at the speed close to that of light in a magnetic field.

  ◇ the last bending magnet

  ◇ the focusing quadrupole magnets

# Summary

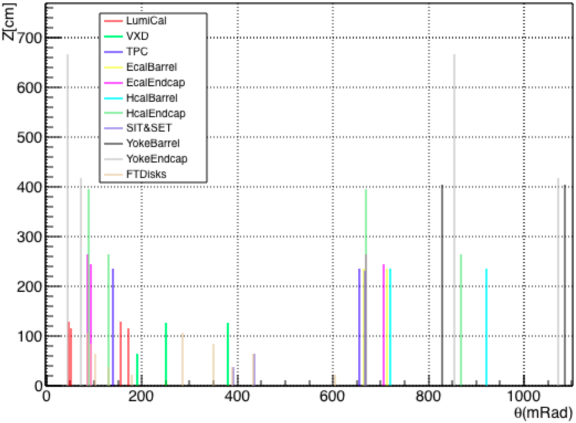
Expected beam-beam background rates per bunch crossing.

| Background | CLIC | CEPC |
|---|---|---|
| Beamstrahlung photons | 2.1 per beam particle | 0.22 per beam particle |
| Coherent pairs | $6.6 \times 10^8$ | $\approx 0$ |
| Trident pairs | $6.7 \times 10^6$ | × |
| Incoherent $e^+e^-$ pairs | $3.3 \times 10^5$ | 1693 |
| Incoherent muons | 12.5 | × |
| $\gamma\gamma \to$ hadrons | 102 (3.2) | $\approx 0.0022$ |
| Radiative Bhabha | $1.1 \times 10^5$ | $1.0 \times 10^4$ |
| Synchrotron radiation | ? | ? |

- Number of particles in one bunch is $3.71 \times 10^{11}$.
- The incoherent $e^+e^-$ pairs is the dominant background induced by the beamstrahlung.
- Collimators or masks are needed to prevent IR from being hit directly by lost particles and SR photons.

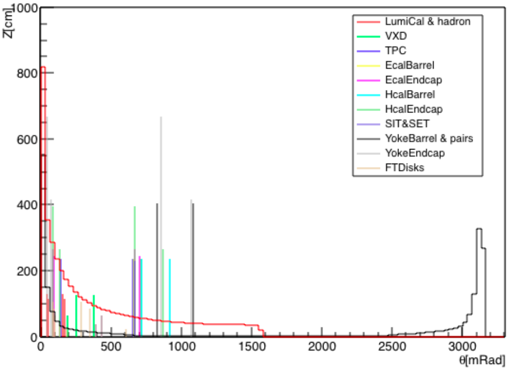
# Result

The angular distribution of the whole detectors.



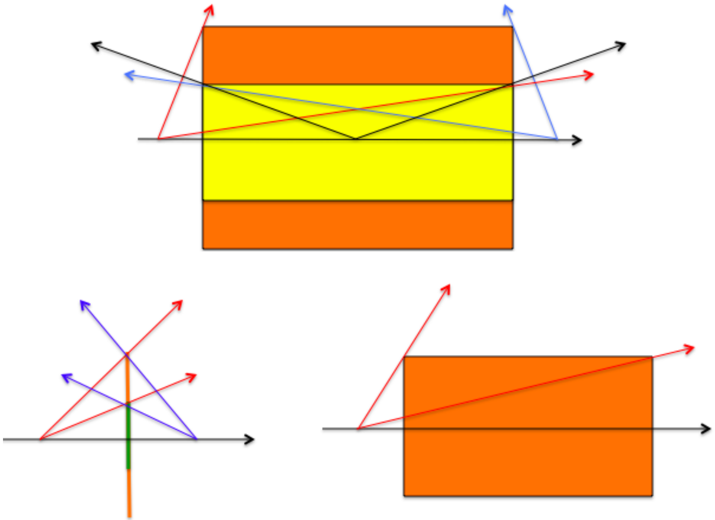
# Result

The angular distribution of the different background particles in the angular range of the half of the whole detector.

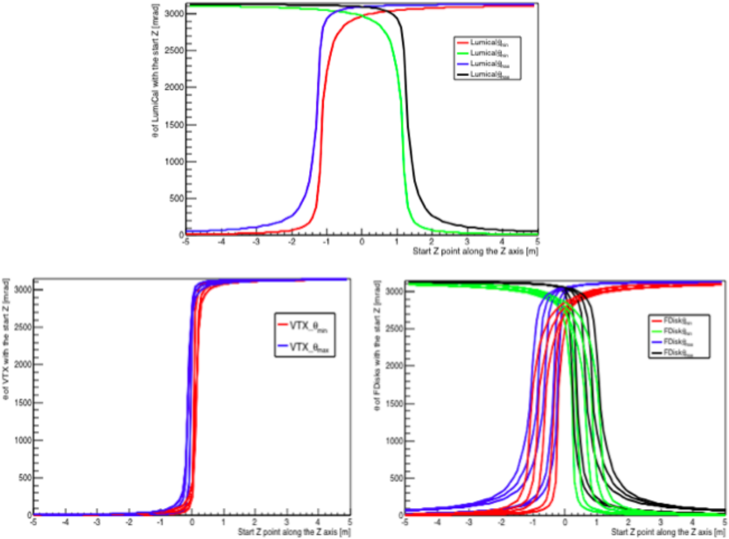



- The incoherent $e^+e^-$ pairs and the particles from hadron events extend to a polar angle large enough to cause a large rate of hits in the tracking detectors.
- So far only backgrounds that are directly produced at the IP were discussed.

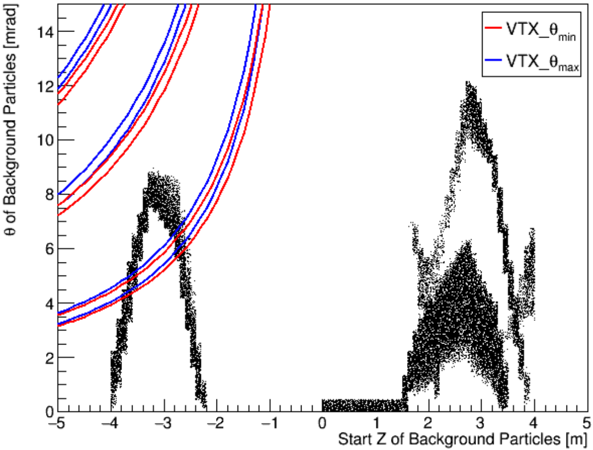
The angular distribution in Lumical, VTX, FDisks.



# The angular distribution in Lumical, VTX, FDisks.



The angular distribution of background particles in the angular of the VTX



# Analytical estimation of backgrounds

- Hit density
- Total Ionising Dose (TID)

  • The estimated total ionising dose is the sum of all energy deposits in a given volume divided by its mass.

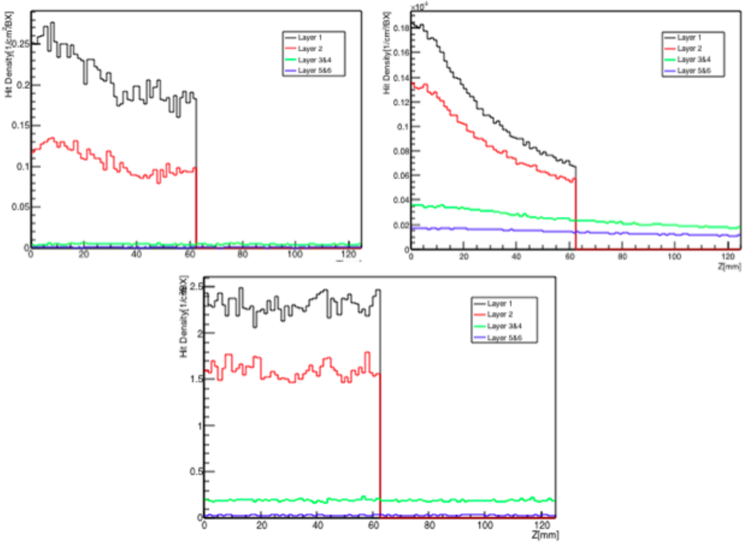
  • The TID can be roughly estimated according to the hit density in the detector.
- Non-Ionising Energy Loss (NIEL)

  • Factor from electron to 1 Mev neutron is about 0.1.

  • NIEL $\approx 3 \times 10^9$ TID

  • Radiation damage can be caused by the Total Ionising Dose (TID) and Non-Ionising Energy Loss (NIEL) in silicon detectors.

# Hit Density in the VTX



# Conclusion

- Beam-induced backgrounds are very sensitive to the lattice design of accelerator, interaction region design and detector design.
- Synchrotron radiation might be the most important backgrounds because the huge number of photons.
- Above all are need further study.