Progress of MDI

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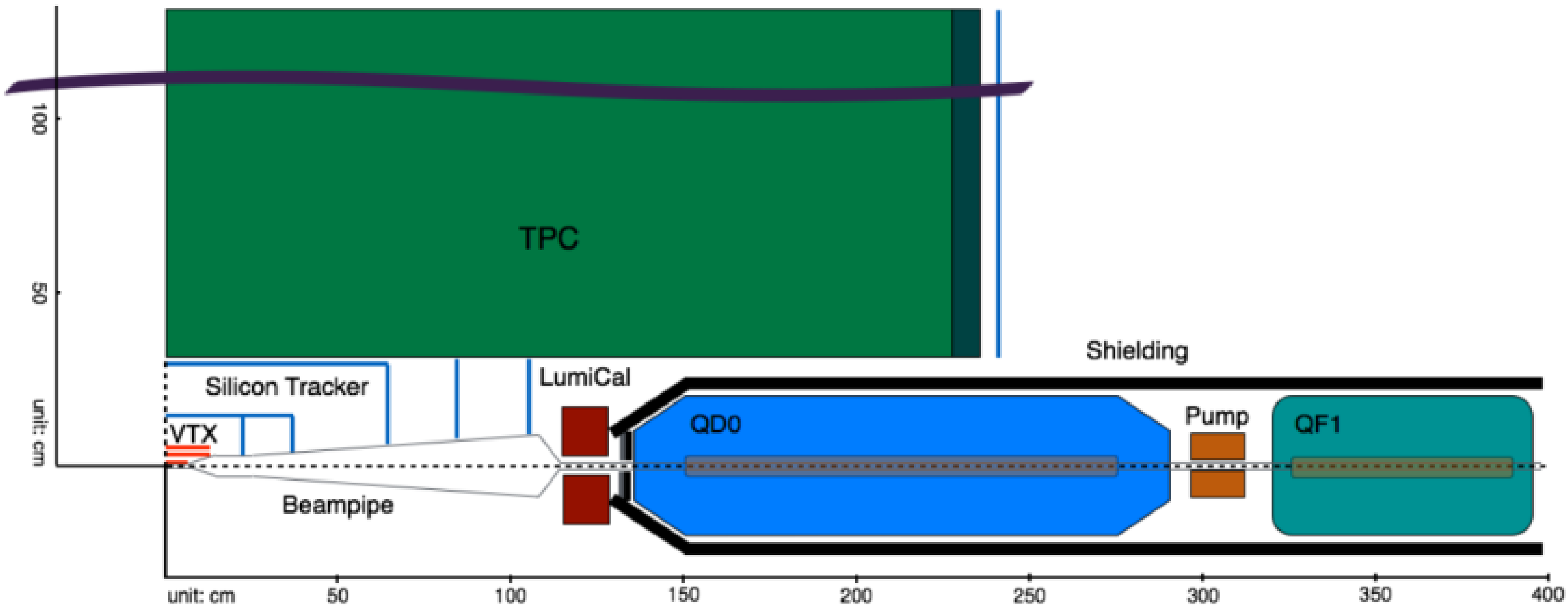
Outline

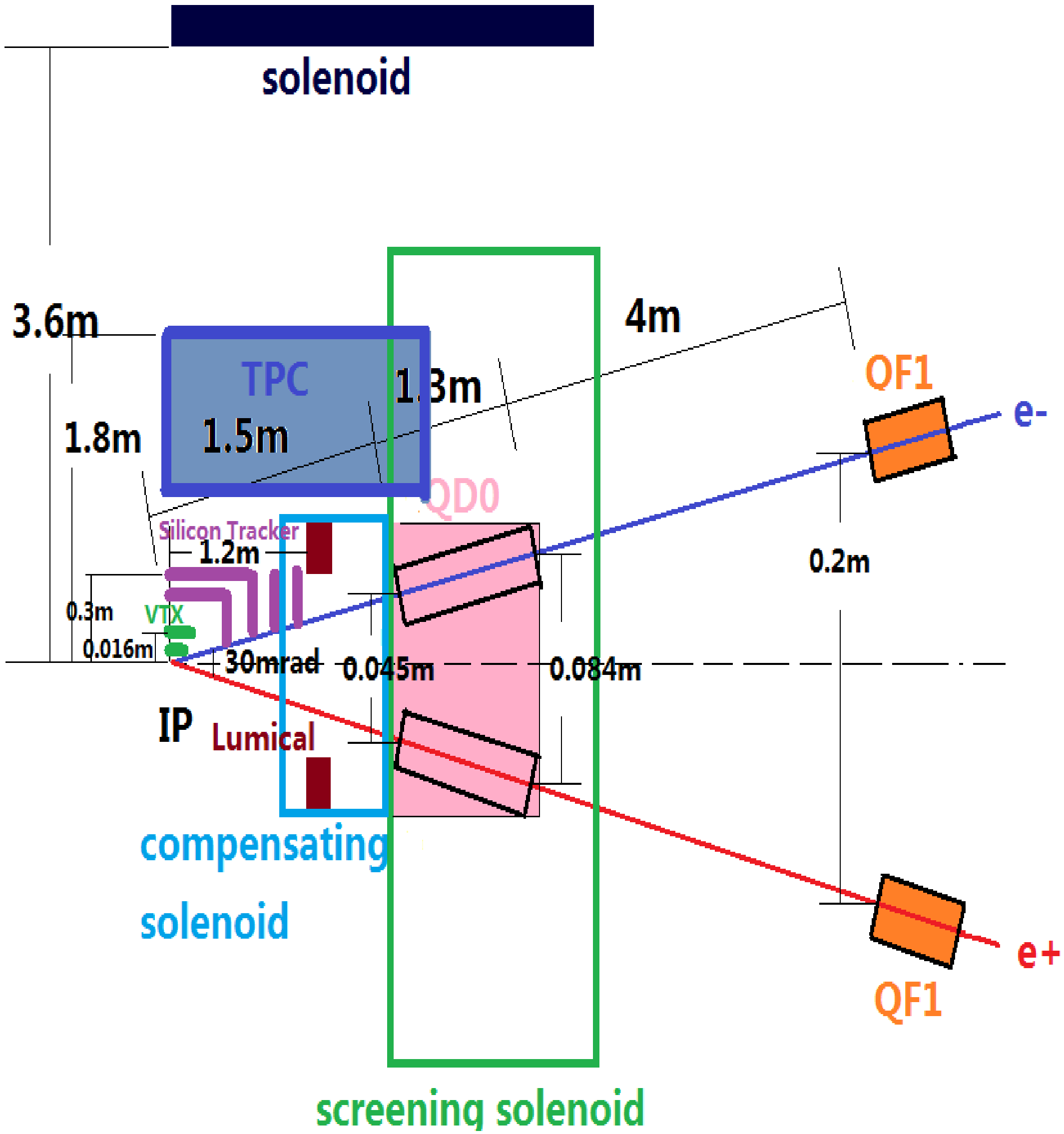
- Tasks of MDI
  - IR lattice and layout design
  - Final Focusing magnets
  - Luminosity Measurement
  - Beam Induced Background Estimation
  - Detector shielding and radiation protection
  - Mechanics and integration
- Regular group meetings
  - Indico: http://indico.ihep.ac.cn/category/323/
  - Twiki: cepc.ihep.ac.cn/~cepc/cepc_twiki/index.php/Machine_Detector_Interface
- Will compare the difference between single ring and partial double ring.

IR Layout -- Single Ring



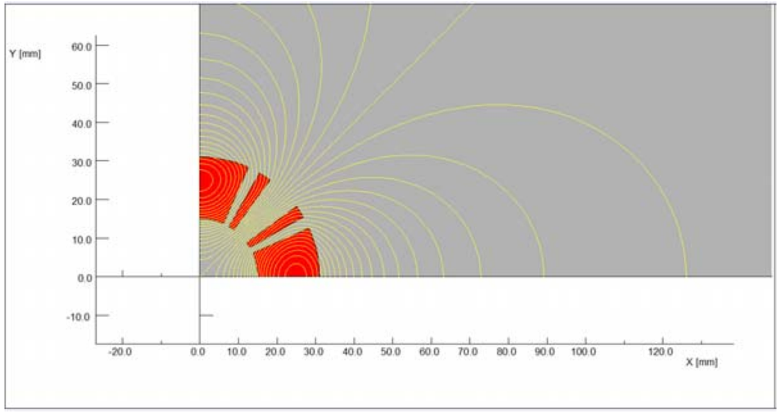
- L* = 1.5m
- To meet requirements from both accelerator and detector
- Suppress the beam backgrounds as more as possible

IR Layout -- Partial Double Ring

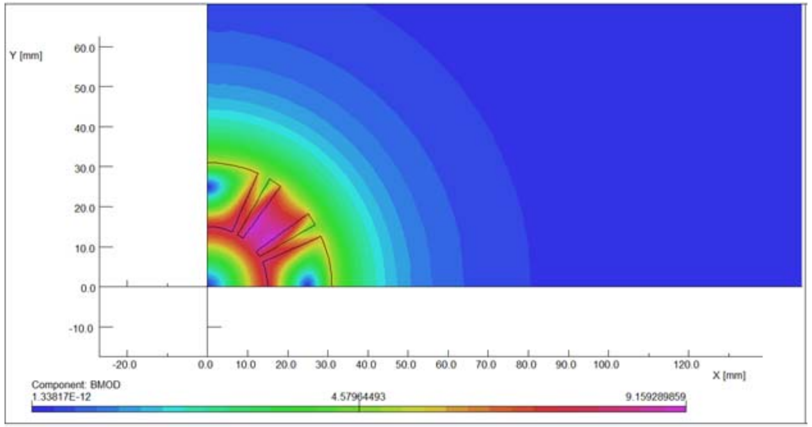


- Crossing Angle = $30mrad$
- L* = 1.5m
- Influence on the detector is under studying

Final Focusing Magnetic -- Single Ring



2D flux lines

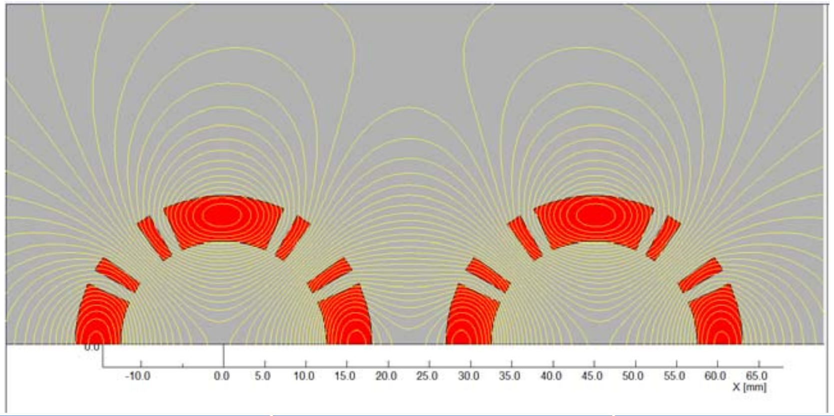


Magnetic flux density distribution

Magnet	Length	Field Gradient(T/m)	Coil Inner Radius (mm)	Coil Outer Radius (mm)
QD	1.25	304 → ~**200**	20	37
QF	0.72	309 → ~**110**	20	37

- Coils in Rutherford type Nb_3Sn cables clamped by stainless steel collar
- The field gradient will be decreased to match the feasibility in technology

Final Focusing Magnetic – Partial Double Ring

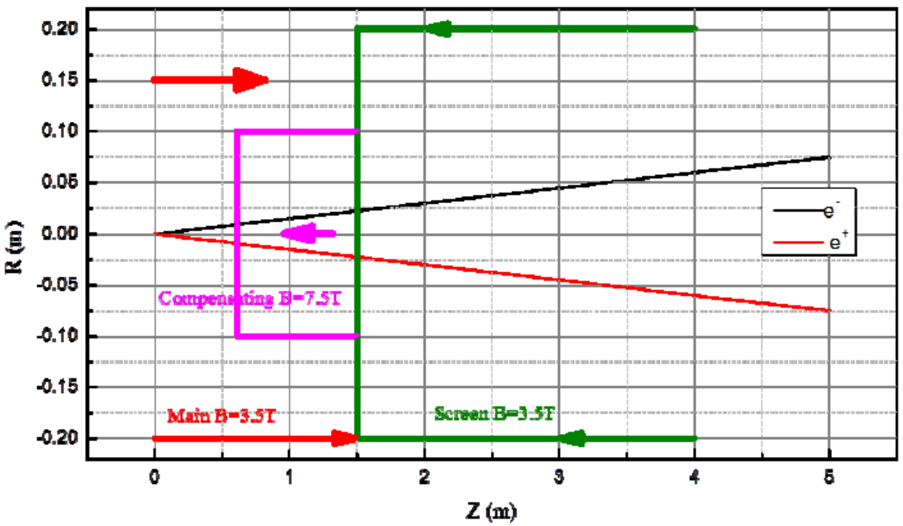


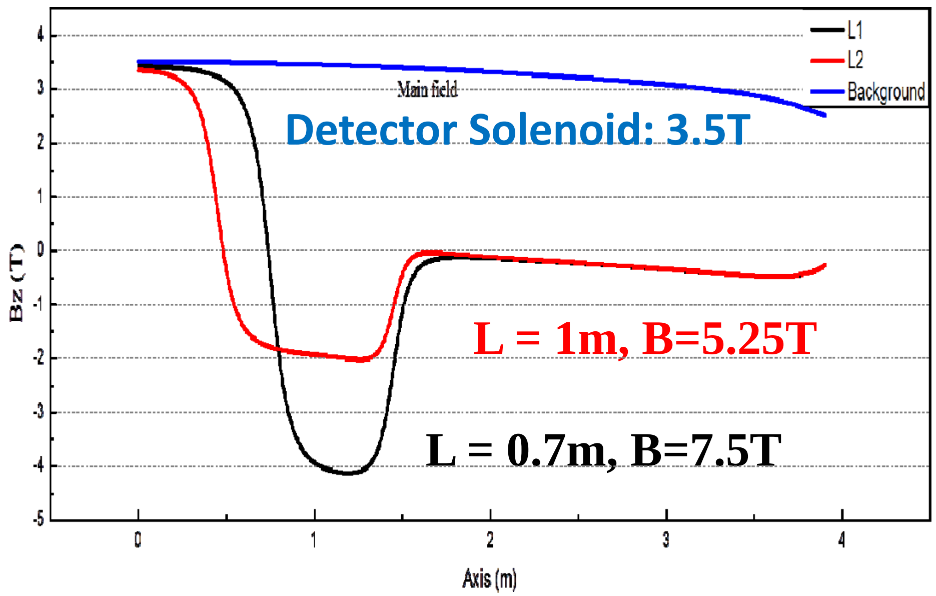
Magnet	Length	Field Gradient(T/m)	Coil Inner Radius (mm)	Coil Outer Radius (mm)
QD	1.25	**~200**	**12.5**	**18.5**
QF	0.72	**~110**	20	37

- 2 isolated QD are required to make sure e+ e- pass through the center of the quadrupoles separately.
- The thickness of the coil is tightly limited by the radius of beam pipe and the distance between two beam pipes.
- Cross talk of field between two quadrupoles need be further studied.

Anti-solenoid Design

- Cancel the influence of the detector solenoid on the beam
- $\int B_z ds = 0$
  - The coupling should be cancelled before beam enter the quadrupoles (Compensating solenoid)
  - The longitudinal field inside the quadrupole should be 0 (Screening solenoid)
- How to reduce the length of the solenoid
  - Stronger magnets
    - **8T @ 4.2K**
    - **Known Record: 11.7T, need lower temperature**
  - Reduce the detector field



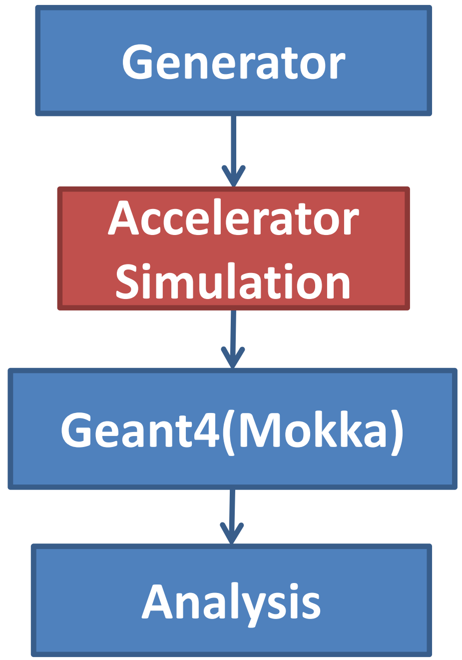


Luminosity Calorimeter

- Because the tight space in the IR region, the Lumical might be built inside the compensating solenoid (very strong magnetic field)
- In the partial double ring scheme, the effective region of the detector might be suppressed by the other beam pipe.
- The detector parameters should be optimized according to the simulation.
  - Have checked the whole process of luminosity measurement
  - Accomplished a very preliminary selection program and a naive input/output check.

Source of Beam Backgrounds at CEPC

- Synchrotron Radiation
  - Bending Magnetic
  - Quadrupoles
- Lost Particles
  - Radiative Bhabha
  - Beamstrahlung
  - Beam-Gas Scattering
- Beamstrahlung
  - Pair production
  - Hadronic background

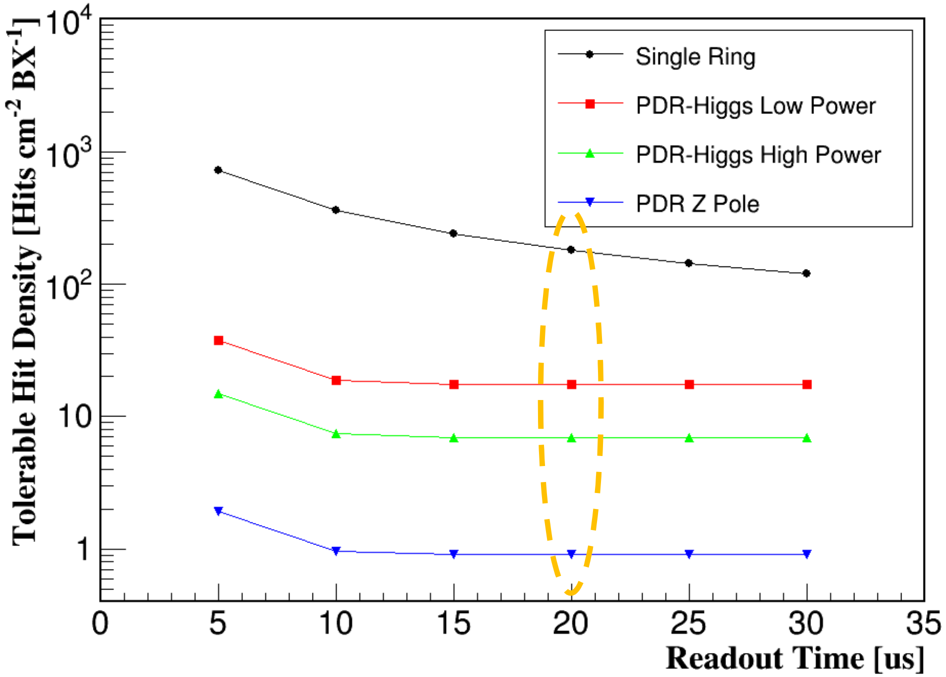


Framework for Background Simulation

- Have established a framework for background simulation on the IHEP computing platform.
  - Generator:
    - Guinea-Pig++: Beamstrahlung
    - BBBrem: Radiative Bhabha
    - Self developed codes: Beam-gas scattering and other backgrounds
  - Accelerator Simulation:
    - SAD (Strategic Accelerator Design): Beam particle tracking
    - BDSIM: Also used as generator for synchrotron radiation
  - Detector Simulation:
    - Geant4 (Mokka)
    - Fluka
- Interfaces between all the software have been implemented.
- Developed a toolkit to use these software conveniently

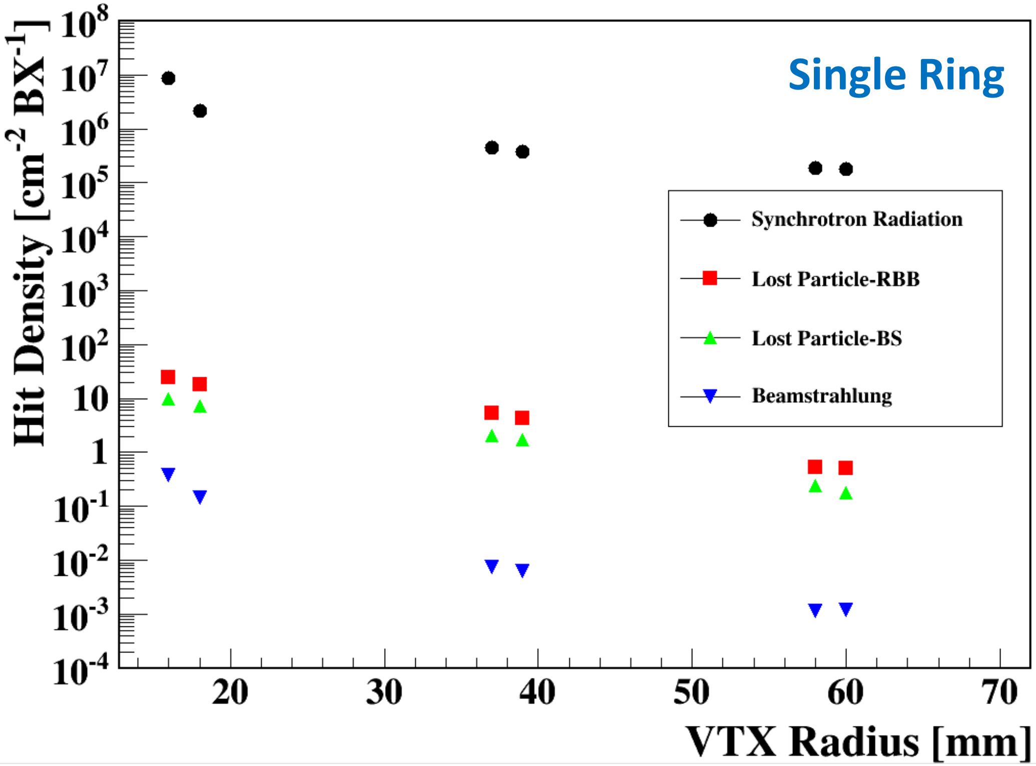
Physical Requirement to Background Level

- Vertex Detector Requirement: Occupancy not exceeding 1%
  - VTX Pixel Density: $5 \times 10^5\ cm^{-2}$ (Pixel pitch: $\sim 14\ \mu m$)
  - Safe factor: 5
- The tolerable hit density in partial double ring will be much lower than that of single ring.



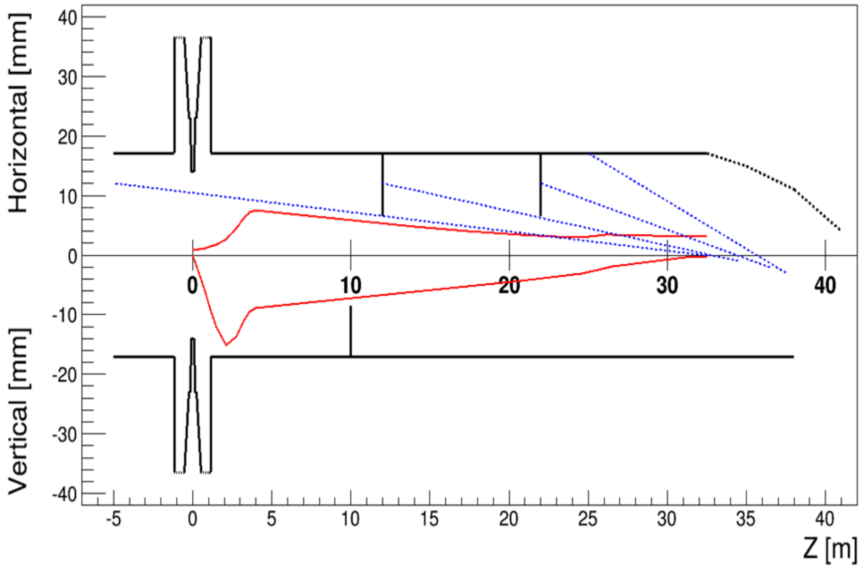
Parameters	Single Ring	PDR-H Low Power	PDR-H High Power	PDR Z Pole
Number of Bunches	50	57	144	1100
Bunch Spacing (μs)	3.6	0.187	0.074	0.0097
Hit Density in VTX ($\text{Hits} \cdot cm^{-2} \cdot BX^{-1}$)	< 200	< 20	< 10	< 1

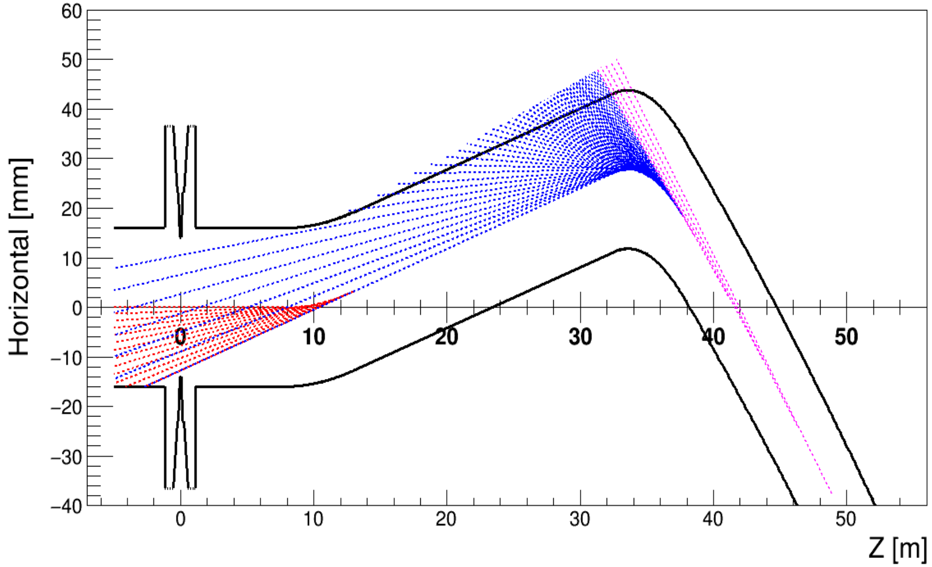
Hit Density Without Shielding



- Synchrotron radiation is the most important issue because of the huge photon flux
- The beamstrahlung in the partial double ring might be more serious than that in single ring due to the modification of beam pipe.
- Shielding and protection are essential to reach the physical requirements

Methods to Suppress Background Level

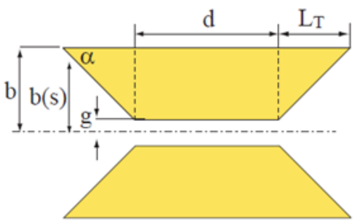




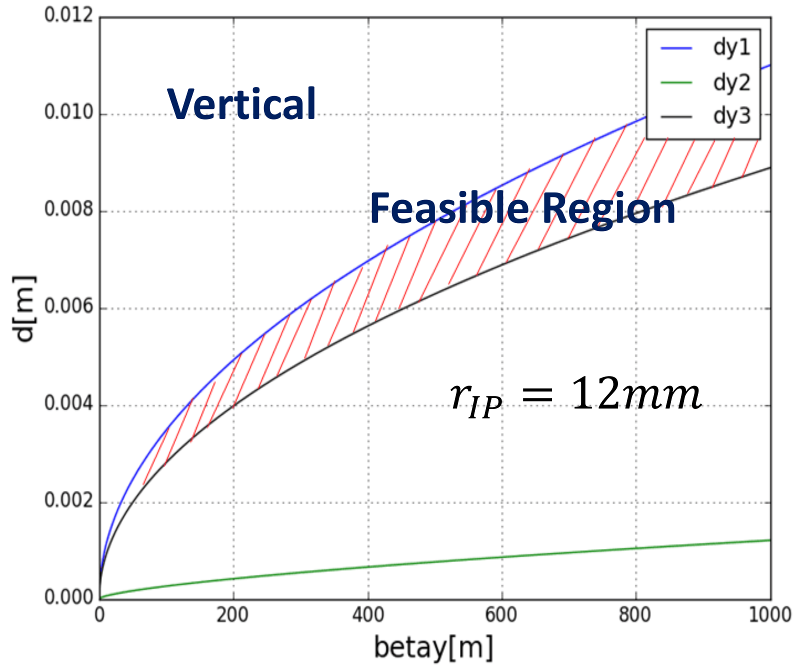
- Synchrotron Radiation
  - Shielding the synchrotron photons with collimators
  - Let the synchrotron photons pass through the IR by well designed beam orbit.
- Lost Beam Particles
  - Add collimators along the storage ring.

Preliminary Design of Collimators

- Shape and Material
  - Trapezium
  - Tungsten



- Position and Aperture d_c
  - Stop efficiency → Upper limit
  - TMCI (Transverse mode coupling instability) → Lower limit
  - Vertical injection → Lower limit

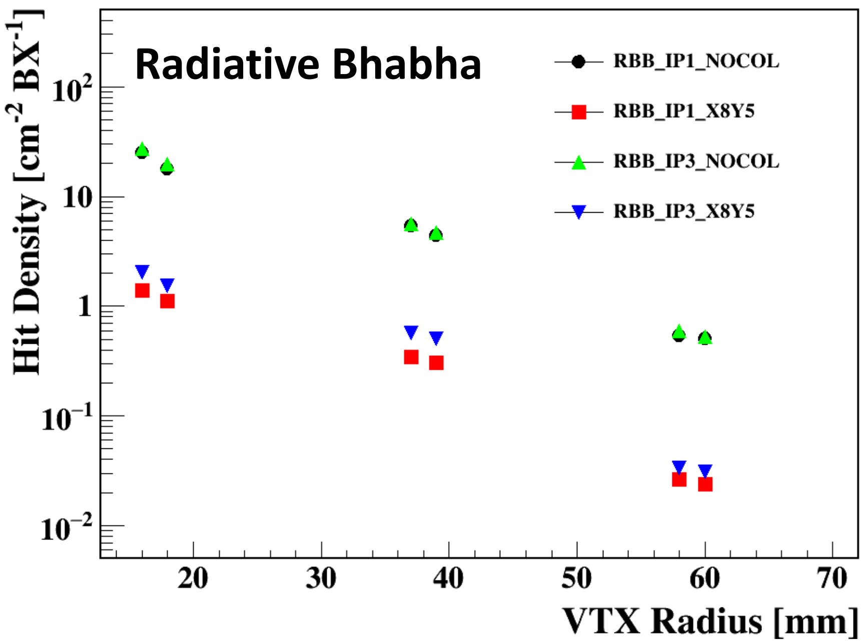


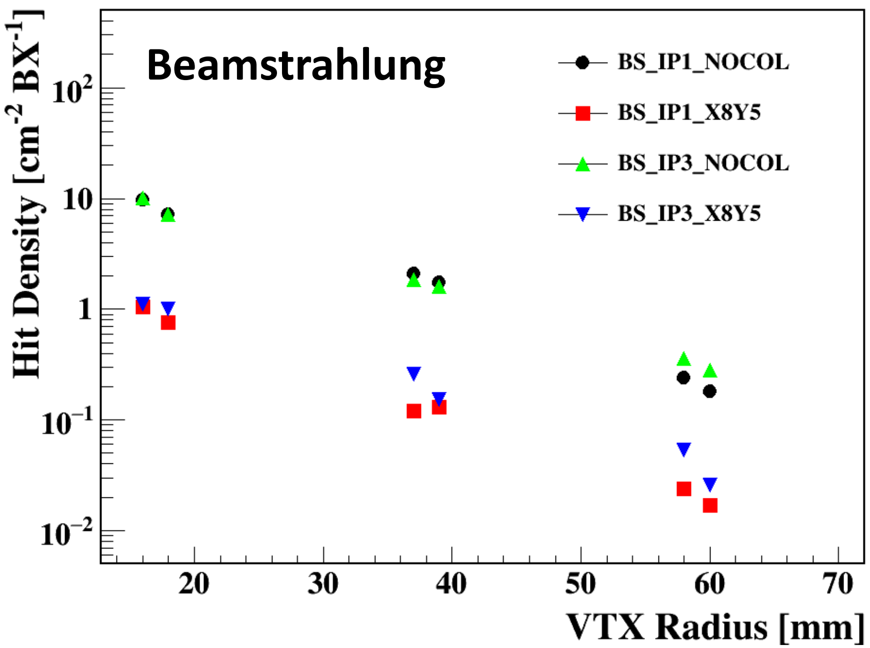
- **Upper Limit:** $d_c \le \dfrac{r_{IR}}{\sqrt{\beta_{IR,\max}}}\sqrt{\beta_c}$

- **TMCI:** $d_c \ge \left(\dfrac{0.215\,AIZ_0 c}{C_1 f_s\, E/e}\right)^{\frac{2}{3}}\left(\dfrac{\alpha}{\sigma_z}\right)^{\frac{1}{3}}\beta_c^{\frac{2}{3}}$

- **Injection:** $d_c \ge \sqrt{a\beta_c}$

Effects of Collimators to Lost Particles





- The hit density due to lost particles at VTX are significantly suppressed by collimators
- Shielding of other backgrounds are under studying

Summary

- Single Ring
  - Lots of progresses have been made in: IR design, final focusing magnets, luminosity calorimeter, background estimation and detector shielding
  - The beam pipe design, mechanics and integration have not been covered yet.
- Partial Double Ring
  - Most topics are in the starting stage.
  - The space for beam pipe and QD0 at L* is tighter than single ring.
  - The pressure of suppressing background level in detector is higher than single ring.

Thank You