Status and Plan of MDI WP towards CEPC Detector Ref-TDR

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On Behalf of the CEPC MDI&Lumi WP of Detector Ref-TDR

CEPC Day

2024.4.23

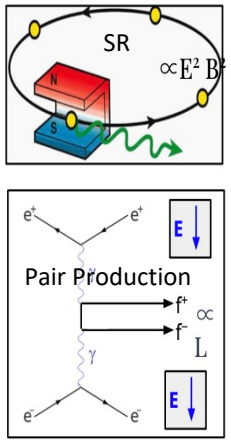
MDI+LumiCal

- Interface region with Acc.(Discussion when needed)
- Beam Induced Backgrounds
  - Estimation(Simulation) of Impacts and Radiation Environment
  - Software Upgrade/Migration
  - Validation and optimization of the Codes/Results
- LumiCal
  - Detector Design of the LumiCal
    - Detector Technology/Electronics/Readout…
    - Software/Simulation
- Optimization of Interaction Region/MDIInterference with other detectors/acc components
  - Detailed design on IR components as a system
  - Shielding for the detectors/detector hall
- Key Technology Issues:
  - Gold Coating
  - The manufacture of Beryllium pipe, including the welding with Al.

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

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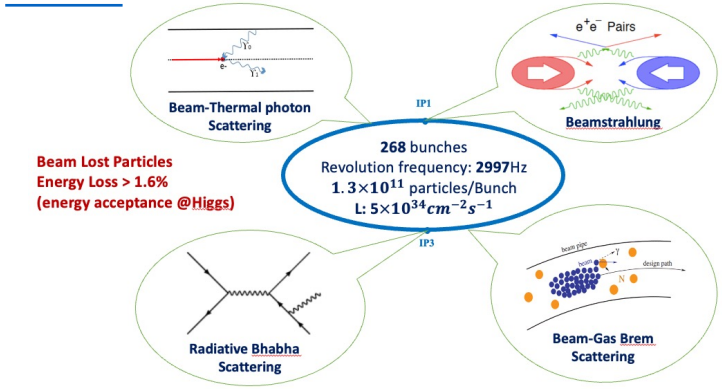
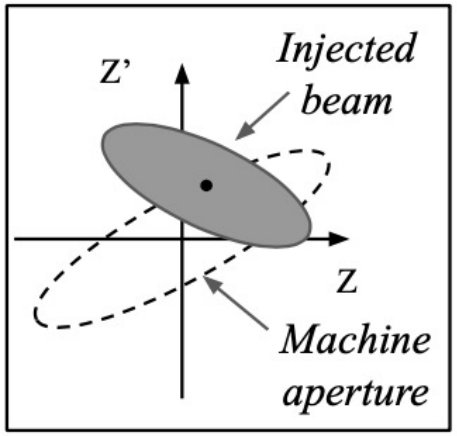


Beam Loss BG

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	PyTSC		

- One Beam Simulated
- Simulate each background separately
- Whole-Ring generation for single beam BGs
- Multi-turn tracking(1000 turns)
  - Using built-in LOSSMAP
  - SR emitting/RF on
  - Radtaper on
  - No detector solenoid yet(Z updating)

Plan - Beam Induced Backgrounds

- Estimation of Impacts and Radiation Environment(50MW)
  - First Preliminary version: Using existing geometry in CEPCSoft with beam pipe and inner vertex updated; Focusing on Higgs/Z of vertex; without any safety factor – Finished
  - Implementing BG Simulation in CEPCSW(Generator-like): Before the end of June
  - Second Preliminary version: Using new tool/geometry; all 4 modes; without any safety factor – Late July/Early August
  - Optimization of the IR layout/configuration…(need help from all sub-D)
  - Final Ref-TDR version: Based on CEPCSW; all 4 modes; with optimized safety factor if possible-- Late October/Early November
- Offering BG samples for mixing/detector optimization: when needed, data saved as database, mixing in hit level
- Validation of the tool/simulation: Using BII/BIIU this year.
- Shielding design will be performed when the simulation was done.

Status – Beam Induced Backgrounds

- BG Simulation using CEPCSoft: Almost Finished except for SR.
  - Results in root file of Histogram2D, higgs/z-pole mode would be available:
    - /cefs/higgs/shihy/work/cepc_bkg/Results/Ref-TDR/20240312/Higgs(Z)/*.root(available when exists)
      - Hit density in number/cm^2/BX
      - TID in kRad/yr
      - 1 MeV Silicon neutron eq. flux in number/cm^2/yr
    - Z-pole's beamloss was in 3T solenoid, which would be fixed soon.
    - The results from pair could be used as reference, from beam loss should not(too high, more mitigation needed)

<table>
<tr><td rowspan="5">Total.root</td><td rowspan="4">BeamLoss.root</td><td>BGB.root</td></tr>
<tr><td>BTH.root</td></tr>
<tr><td>BGC.root</td></tr>
<tr><td>TSC.root</td></tr>
<tr><td>Pairs.root</td><td>Paris.root</td></tr>
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Status – Beam Induced Backgrounds

- BG Code migrating to CEPCSW:
  - Generation/Tracking: Based on the latest TDR lattice, without Solenoid in Tracking Tool(SAD).
    - All the results would be converted to ROOT file
  - Plan to implement Solenoid when the Geometry fixed, and tool check finished.
  - Noise Estimation – Using the hit information directly from CEPCSW:
    - Baseline: Hit Level, Perform the simulation when the geometry fixed and generation finished
    - Alternative: Generator Level, sample available soon. Algorithm under development
    - Thanks for the help from Tao, Zhan and Fangyi.
  - Radiation Environment Estimation – Using the information from CEPCSW/FLUKA:
    - CEPCSW Code developing and prepare to be validated: Thanks for the help from Guangyi.
    - FLUKA Geometry updating: Could be finished soon when the final geometry fixed.

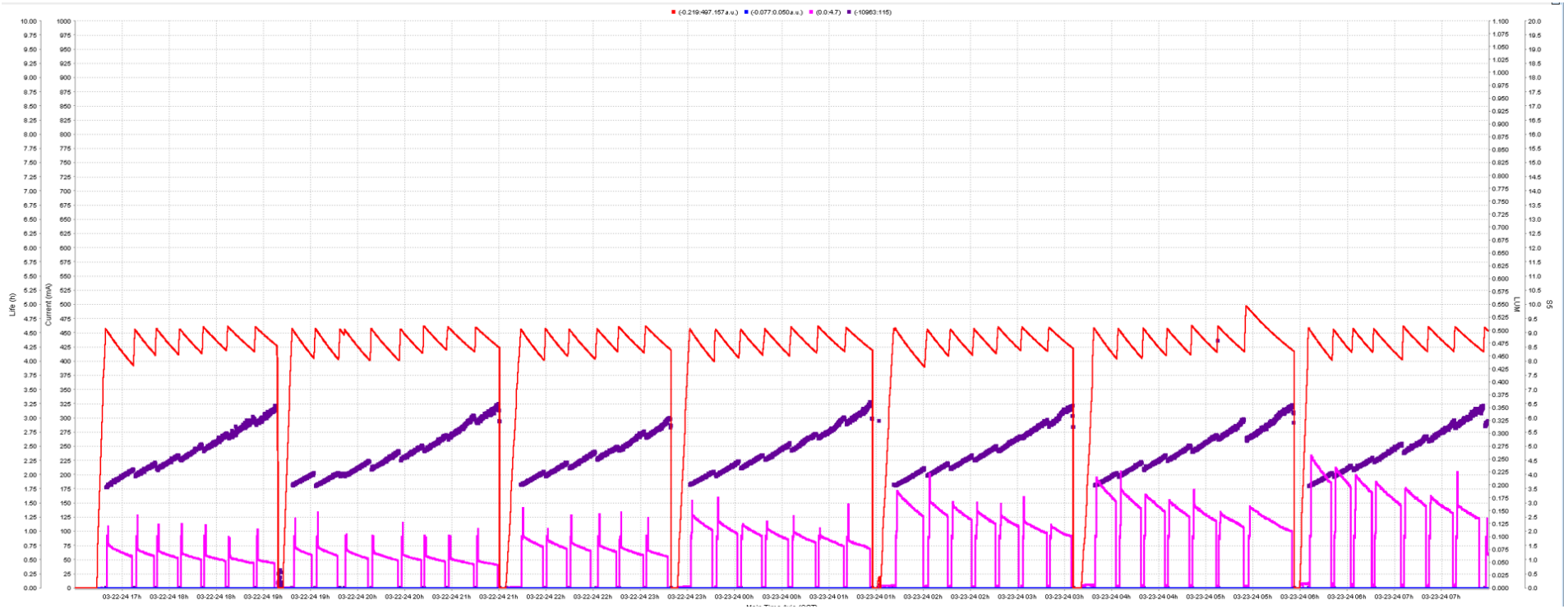
Status – Beam Induced Backgrounds

- Current Status towards Second Version(Based on CEPCSW):

Background	Mode	Generation	Tracking	Noise Estimation	Rad. Da. Esti.	Rad. Env. Esti.
Synchrotron Radiation	Higgs	To do	To do	Code Implementing/ Geometry Updating	Code Implementing/Validating	Code Implementing/Validating
	Z	To do	To do			
Beamstrahlung/Pair Production	Higgs	Done	-			
	Z	Done	-			
Beam-Thermal Photon	Higgs	Done	Done w.o. Sol			
	Z	Done	Done w.o. Sol			
Beam-Gas Bremsstrahlung	Higgs	Done	Done w.o. Sol			
	Z	Done	Done w.o. Sol			
Beam-Gas Coulomb	Higgs	Done	Done w.o. Sol			
	Z	Done	Done w.o. Sol			
Radiative Bhabha	Higgs	Done	-			
	Z	Doing	-			
Touschek	Higgs	Doing	To do			
	Z	Done	Done w.o. Sol			

Status - Experiment at BEPCII/BESIII

- Performed new run of BG Experiment at BEPCII/BESIII last month to understand the performance of the movable collimators.
- We plan to simulate backgrounds at BIIU using the same code/methods at CEPC and validate the simulation.

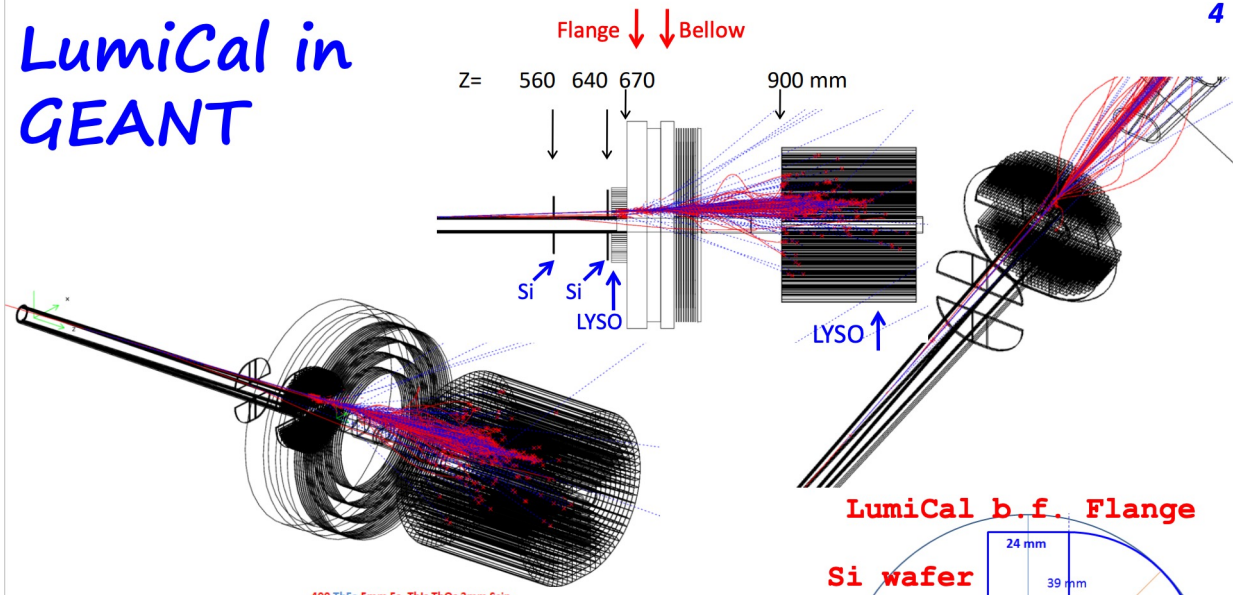


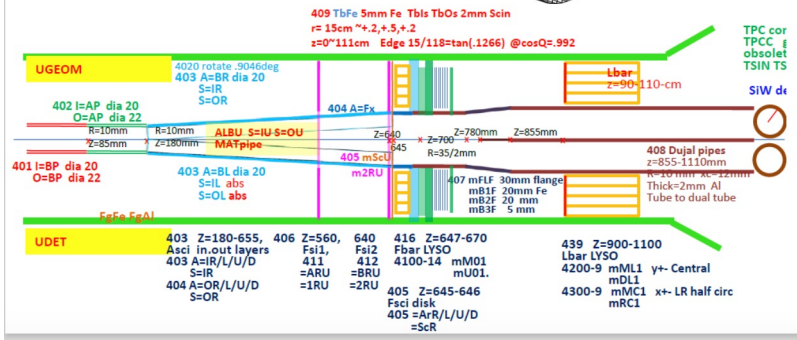
LumiCal

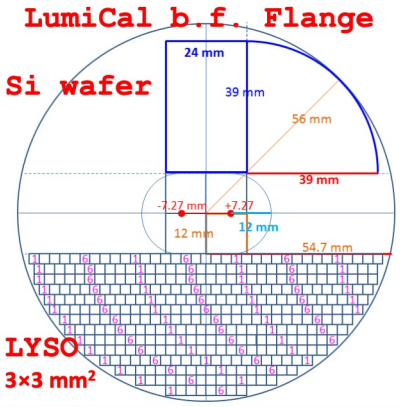
- After lots of iteration(>10 times) in last three years, currently we have baseline detector ready.

Suen Hou

LumiCal in GEANT





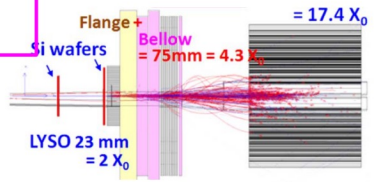


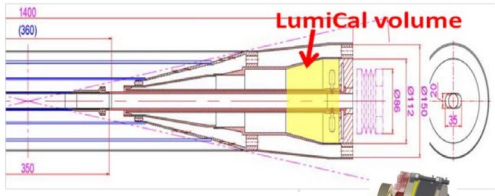
LumiCal geometry

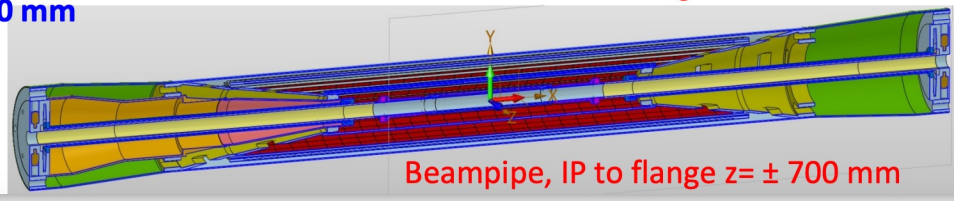
- ***L=2x10^{36}***/cm²s¹ **@Z-pole**, goal is ***10^{-4}*** systematics
  - ***ø 20 mm*** racetrack, beam-crossing: ***33 mRad***
  - IP bunch : ***σ_x σ_y σ_z = 6 µm, 35 nm, 9 mm***
  - Bunch crossing: ***23 ns***

- ***LumiCal before Flange***
  z = 560~700 mm
  - **Low-mass window**: **Be 1mm thick**
    traversing @22 mRad traversing L= 45 mm,
    = 0.13 X_0 (Be), 0.50 X_0 (Al)
  - **Two Si-wafers** for $e^{\pm}$ impact θ
  - **2X_0 LYSO** = 23 mm

- ***LumiCal behind Bellow:***
  z= 900~1100 mm
  - **Flange+Bellow : ~60 mm, 6 X_0**
  - **17 X_0 LYSO 200 mm**







Status – LumiCal

- Regular Meeting: Tuesday afternoon.
- Requirements and status of LumiCal.
  - The precision requirement form physics kept same as 1e-4.
  - Therefore, the requirement of the position measurement should not higher than 1 micro. Perhaps the optical survey and monitoring could meet this requirement, more study needed.
  - The understanding of different generator is on going.
  - The Geometry Updating and Full Simulation is on going:
    - The crystal part of the design is ongoing, together with the implementation of the geometry into CEPCSW.
    - The design of the silicon part is also ongoing, the help from other silicon detector group may be needed when we figure out the requirements.
  - We may also need novel ideas on the luminosity measurement together with other detectors.
  - The measurement of the luminosity change, and position of colliding is also need(Fast Lumi), this topic will be addressed together with accelerator colleagues.
  - The optimization and interference study will be performed together with det. Simulation.

Status – Overall design/optimization of IR

- A regular meeting with acc. People will be held at Thursday morning, minutes Link: CEPC MDI Meeting - HedgeDoc (ihep.ac.cn)
- The change of detector size may affect the design of accelerator components. A complete design of IR including detector/accelerator components are needed.
  - The detector size is almost determined, re-design of IR components needed.
  - Start from magnets and cryo-module. Already begun.
  - The change of the solenoid could affect the design of the anti-solenoid
  - After the individual design of solenoid/anti-solenoid, the joint optimization of the magnet and estimation of magnetic field near cyro-module will be provided.
  - The joint design of croy-module/inside components/lumical/beampipe also needed.
- The level of beam induced background is still high at least at Z mode.
  - More mitigation methods like collimators would be needed.

TOC of Ref-TDR

- One whole Chapter(same with CDR): Machine Detector Interface and Luminosity Detectors (Haoyu/Suen/Sha)
  - Introduction & Requirements
  - IR Layout(Haoyu/Sha/Quan/Haijing)
  - Key design/parameters(beampipe, final focusing, etc..)(Haoyu/Sha/….)
  - Detector/IR Backgrounds(Haoyu)
    - Introduction
    - Shielding Design/mitigation methods
    - Estimation
  - Luminosity Measurement System(Suen/Lei/Weiming)
  - Summary & Outlook
  - Ref. List

Thank You

Backup