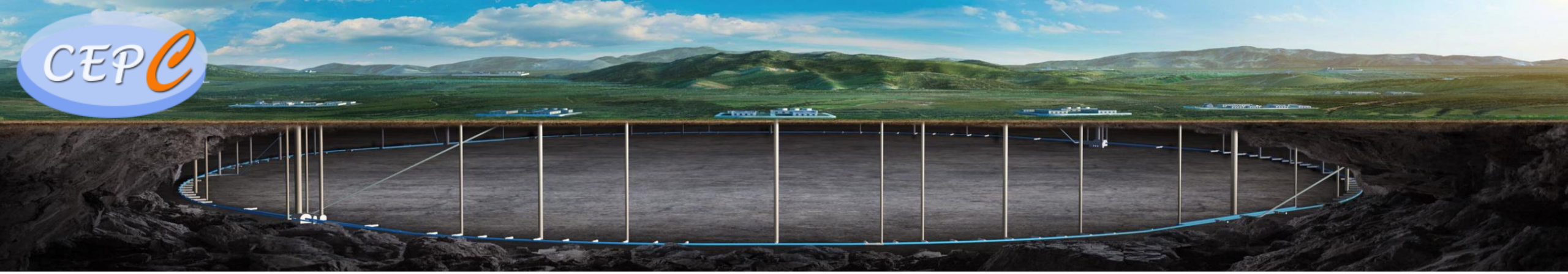

Plan of the BIB Study at Next Phase

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Outline

- Status of the BIB Study at (Ref-Det) TDR Phase
- Brief Requirements from the Review Committees
- Goal of the BIB Study at next Phase
- Plan of the BIB Study

- All thoughts in the slides are a draft used for discussion here

Status of the BIB Study

- We mainly focus on estimation of the BIB level at 50 MW Higgs and 12.1 MW Z (Low-Lumi-Z) mode.
  - Also have an estimation for 50-MW Z (High-Lumi-Z) mode. But the mitigation is still under optimization.

Table 3.3: Design parameters of the CEPC accelerator used in beam-induced background study. The parameters of 50 MW Higgs mode and high luminosity Z mode (High-Lumi-Z) are taken from Ref. [1] and Ref. [6], while the parameters of 12.1 MW low luminosity Z mode (Low-Lumi-Z) taken from Ref. [7].

Parameters	Higgs	Low-Lumi-Z	High-Lumi-Z
Number of IPs		2	
Half crossing angle at IP (mrad)		16.5	
Solenoid Magnet[T]		3	2
SR power per beam [MW]	50	12.1	50
Energy [GeV]	120	45.5	45.5
Bunch number	446	3978	13104
Bunch spacing [ns]	277.0	69.2	23.1
Train gap [%]	63	17	9
Bunch population [10^{11}]	1.3	1.7	2.1
Beta functions at IP β_x^*/β_y^* (m/mm)	0.3/1	0.2/1.0	0.13/0.9
Emittance x/y (nm/pm)	0.64/1.3	0.27/5.1	0.27/1.4
Beam size at IP x/y [um/nm]	14/36	6/72	6/35
Bunch length (total) [mm]	4.1	8.8	10.6
Energy spread (total) [%]	0.17	0.13	0.13
Energy acceptance (DA) [%]	1.6	1.0	1.0
Luminosity per IP [$\times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$]	8.3	26	192

- Single Beam
  - Touschek Scattering
  - Beam Gas Scattering(Elastic/inelastic)
  - Beam Thermal Photon Scattering
  - Synchrotron Radiation
- Luminosity Related
  - Beamstrahlung/Pair Production
  - Radiative Bhabha Scattering
- Injection
- SuperKEKB like sudden beam loss
- Failure Case(injection/extraction/Power Loss…)

Done for Ideal beam with beam-beam
The misalignment and beam orbit change is ongoing with acc. colleagues, since the final strategy and beam orbit has not been fixed yet.

From Last Dipole+FFS+Uniform Solenoid, VTX only

Pair Production with Gienea-Pig++

Just started. The final strategy has not been fixed yet.

Not studied yet. Power loss studied by PMP group.

Status of the BIB Study

Only Higgs and Low-Lumi-Z mode considered

Background	Generation	Tracking	Noise Simulation	Radiation Simu.
Synchrotron Radiation	BDSIM/CEPCSW, from Last Bending, FFS and Solenoid	BDSIM/CEPCSW with ideal lattice	CEPCSW with 3T uniform solenoid, SF of 10, real solenoid doing	Not studied yet
Beamstrahlung/Pair Production	Guinea-Pig++ with some questions to be solved	-	CEPCSW with 3T uniform solenoid, SF of 2	FLUKA with No SOL
Radiative Bhabha	BBBREM with some questions to be solved	Not included	Not included	Not studied yet
Beam-Thermal Photon	Random in range (acceptance as min)	SAD with bare lattice	CEPCSW with 3T uniform solenoid, SF of 2	CEPCSW with 3T uniform solenoid, SF of 2
Beam-Gas Bremsstrahlung				
Beam-Gas Coulomb				
Touschek				
Injection Background	Not studied yet	Not studied yet	Not studied yet	Not studied yet
Sudden Beam Loss				
Failure Case	PMP	PMP	PMP	PMP

Requirements from Reviewers

- (IDRC) The committee recommends continuing the study of discrepancies observed between data and simulation from BESIII. Understanding these differences is important for validating the assumptions underlying the CEPC machine–detector interface design.
- (IDRC) Closer collaboration with the accelerator team should be established to explore the full range of possible beam steering scenarios. This coordination is especially important for refining the design and placement of synchrotron radiation (SR) masks and collimators, ensuring that they remain effective across realistic operational conditions.
- (IARC) A further study of SR power distribution, including the effects of beam-pipe fabrication errors and misalignments, needs to be conducted
- (IARC) The radiation tolerance of each sensor component used in the TDR detector should be carefully assessed and compared with beam-loss simulation results to determine the safety margins of the estimated beam background rates
- (IAC) The impact of beam backgrounds also needs realistic modelling of the MDI.

Goal of the BIB study at next Phase

- Address all the issues last page before the end of 2028.
  - Focus on Higgs/Low-Lumi-Z/W mode firstly, and finish it before the end of 2027.

Main Issues should be addressed in next phase of the study

- Generation/Generator:
  - Checking/Validation on generator of each sources of BIB
  - Impacts of beam parameters variation
- Tracking:
  - Impacts of the beam orbit errors, including the misalignments of the magnets
  - Impacts of the misalignments of the beam pipe
  - Improve of the collimation system
- Noise Simulation/Radiation Simulation:
  - Impacts of the real simulation of the solenoid/anti-solenoid
- IR/Mitigation Methods Optimization:
  - The safety margin of the design(safety factor)
  - Improve of the shielding and other mitigation methods(including the photon dump).
- Operation Modes:
  - Higgs->Low-Lumi-Z/W->ttbar/High-Lumi-Z

Generator - I

- Pair Production(Boping Chen, Chenguang Zhang, Haoyu Shi, etc; aim to finished before 26.6, a dedicated paper)
  - ✓ The impacts of tracking limits and Bz(Wei, Yanbang, Chenguang, Xiaotian)
  - – The differences on cross-section with BDK in cross-section in LL process
  - – The impacts of beam parameters(scan among all the possibilities)
  - – The cross-check on beamstrahlung lifetime with accelerator
- Radiative Bhabha(Shiyuan Wang, etc; starts from 26.7)
  - – The impacts of beam parameters(scan among all the possibilities)
  - – The cross-check on rbb lifetime with accelerator

Generator – II

- SR(Chenguang Zhang, Haoyu Shi, Sha Bai, Yanbang Tang, etc; finish BEPC simulation before 26.6(major BEPC part to test the feasibility within one month))
  - ✓ Re-test the feasibility of using BDSIM as generator(Chenguang, Haoyu)
  - – Study BEPCII SR using BDSIM(cross check by different people) and check with the experiments
  - – When finished, build/upgrade the CEPC lattice with orbit correction and full IR magnetic field map to study the CEPC case.
- Single Beam Loss(Haoyu Shi, Bin Wang, Shiyuan Wang, etc; some schedule as SR)
  - – Simulation BEPCII case with the scan of the possibilities (cross check by different people) and cross-check on lifetime in experiment(Haoyu, Shiyuan, Bin)
  - – Simulation HEPS beam lifetime and check with the experiments
  - – When finished, simulate CEPC case with orbit correction, full IR magnetic field map and real distribution of pressure

Generator - III

- Injection BG(Qiming Ye, Qiyu Zhang, Haoyu Shi, Dou Wang, etc):
  - Scan with parameter variation, finished before 26.5. Discussion with accelerator experts end of this month to determine what to do next.
- Sudden beam loss: Waiting for SKEKB
- Failure Case: PMP

Tracking

- Study the impacts of the IR beam pipe misalignments(scan all the possibilities within 30 meters from IP) at Ref-TDR Higgs mode, before 26.6 by Yanbang Tang to get the trending of such error and determine how to implement this misalignments in future study (For Single beam loss and SR).
- Finish the loss map at Higgs/Low-Z/W mode using based on generation results, before 26.12
- Design/update the mitigation methods based on loss map, including the masks and collimation system at Higgs/Low-Z/W mode before 27.3

BESIII Experiments on Single Beam Loss / SR

- Two parts, generation/tracking, and detector simulation.
  - Generation/Tracking already mentioned
  - Detector simulation focus on MDC first.
- Re-do the work using 2021's data, and improve the simulation with BESIII experts(Cong Li, Shiyuan Wang, Linghui Wu, Aiqiang Guo, Bin Wang, Haoyu Shi, etc.)
  - Finish first round before 26.6
  - Re-do all simulation based on new version of the tools and codes, re-do all the analysis using more data, then compare.
- Using some passive methods(dose monitor maybe) to do the SR experiment, details needs to be discussed.

Detector Simulation

- Noise Simulation:
  - Extend the geometry of CEPCSW to implement the experimental hall by available people before 26.6.
  - Simulate the case based on new loss map with real distribution of the IR magnetic field map and geometry before 27.3 on Higgs/Low-Z/W mode.
- Radiation Simulation:
  - Implement of the real IR magnetic field map/IR geometry including the experimental hall by Tairan Liang before 26.6.
  - Simulate the case based on new loss map with real distribution of the IR magnetic field map and geometry before 27.3 on Higgs/Low-Z/W mode.
- Requirements from sub-detectors and other groups.

Optimization on Mitigation

- Design/update the IR shielding according to the hotspots before 27.12 at Higgs/Low-Z/W mode with the misalignments considered together with accelerator colleagues.

Priority of the tasks

1. Validate the tools and codes we used(2026)
   a. Generator for Pair Production with cross-check and calculation
   b. Generator/Tracking tools for SR/Single Beam Loss BG with other tools and experiments
2. Understand the missing issues in detector simulation using BESIII/BEPCII(2026)
3. Finish the study flow to test the feasibility using CEPC Higgs mode(Hopefully 2026)
4. Other modes and optimization of the IR design

Goal/Plan of the BIB study at next Phase

- Addressed all the issues in page 5 before the end of 2028.

	2026.12	2027.12	2028.12
Generation	Finish the validation of all the generators	-	-
Tracking	Study the impacts of beam pipe alignments on Higgs mode Finish the new version of IR loss map	Update the mitigation methods at Higgs/Low-Z/W mode	Update the mitigation methods at all modes
Noise Simulation	Merge all the analysis of sub-detectors to a dedicated BG branch of CEPCSW	Finish the Higgs/Low-Z/W mode	Finish all modes
Radiation Simulation	Implement of the real IR magnetic field distribution	Finish the Higgs/Low-Z/W mode	Finish all modes
Optimization on Mitigation		Update the shielding based on hotspots at Higgs/Low-Z/W mode	

Backup