



Feedback of 2025 IDRC Review Report



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Machine Detector Interface

- F-A-3-1: A layout of the interaction region—including the anti-solenoid, final focus quadrupoles, IP beam pipe, and Luminosity Monitor—has been presented. Although not yet final, it is sufficiently advanced to proceed with detailed component design.
- The Be beam pipe has an inner diameter of 10 mm and a length of 220 mm. It consists of an inner Be layer 0.2 mm thick and an outer Be layer 0.15 mm thick, separated by a 0.2 mm gap, which seems quite aggressive. The default coolant is water, with paraffin as a backup. The cooling technology is well-established, and the cost estimates are considered reliable. The coolant flow remains in the stable laminar regime. Mechanical analyses for cantilever support during installation have been performed, and no issues have been found. With an inlet water temperature of 15° C, the Be pipe temperature remains below 20° C, which is within acceptable limits.
- F-A-3-2: Beam background sources—including synchrotron radiation (SR) photons, pairs, and off-energy particles—have been studied in detail, along with other minor contributions. For SR photons, important interactions such as the photoelectric effect and Rayleigh scattering have been simulated. It was found critically important to employ high-Z SR masks to protect the IP beam pipe region. Pair backgrounds are mitigated by designing the IP beam pipe to stay outside the high-density region. The hit rate on the first layer of the vertex detector (VTX) is estimated to be around 1 hit per cm² per bunch crossing. Backgrounds from off-energy particles are suppressed by placing collimators at strategic points around the ring and heavy metal masks near the IP to absorb secondary showers.
- F-A-3-3: Experience from BESIII was presented, showing that real background levels were about 1/5 of those predicted by simulation.
- F-A-3-4: An updated design of the LumiCal, using a silicon detector and LYSO crystals for pile-up event veto, is included in the Reference TDR. Mechanical design and optimization are complete, and construction of a large prototype is planned for the EDR phase. The selected technology appears feasible, although achieving the required luminosity precision will demand electron impact position measurements at the level of better than ten microns.

- C-A-3-1: From the presentations and draft Ref-TDR, it is unclear whether a gold (Au) coating is applied to the inside of the Be beam pipe, and if so, what thickness is used. Further study on this issue may be necessary.
- C-A-3-2: The current SR mask configurations require further study. In particular, changes in beam orbit— such as during commissioning—must be considered to ensure continued protection of the Be beam pipe region.
- C-A-3-3: While heavy metal masks can effectively reduce backgrounds from off-energy particles, they may also generate secondary backgrounds. This study suggests the effect is moderate, but further investigation is needed, especially concerning the tungsten (W) masks near the IP.
- C-A-3-4: The discrepancy between real background measurements and simulations observed at BESIII is a significant concern. Although the energy scales differ between BESIII and CEPC, understanding this discrepancy is critical for evaluating the reliability of CEPC background predictions.
- Answer: The comments above are also mentioned in the recommendations, therefore we will directly go to the recommendations part to answer. All the suggestions are taken.

- C-A-3-5: Although background rates (after shielding) are presented, detailed histograms and numerical data characterizing these backgrounds (e.g., energy spectra, multiplicity, polar and azimuthal angle distributions) are often missing. Such information is essential to assess the impact on the entire apparatus, particularly on the first layers of the vertex detector and LumiCal.
- Answer:
 - The information can be presented in various forms, including the initial energy and angular distributions at the sub-level generation, the energy and position distributions of impacts on the inner wall of the beam pipe within the collision region, the hit distributions in the detectors, and the correlated distributions across the entire detector region.
 - For the distribution in the generator level, we presented information on pair production in Figure 3.8(also shown on left below), and the energy spectra of single beam loss backgrounds on right figure below. Those information has been used in accelerator tracking and detector simulation.

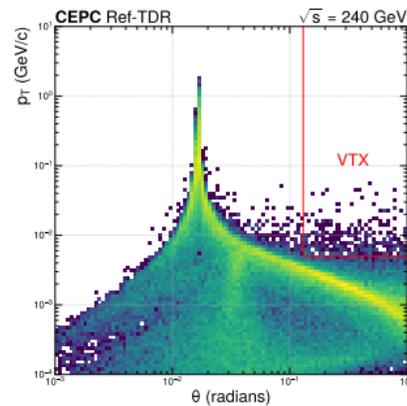
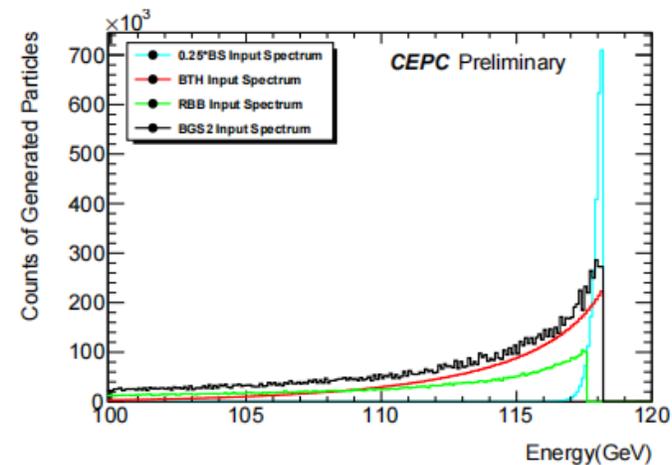


Figure 3.8: Energy and polar angle distribution of particles out of the pair production beam-induced background at Higgs mode. VTX means the vertex detector.

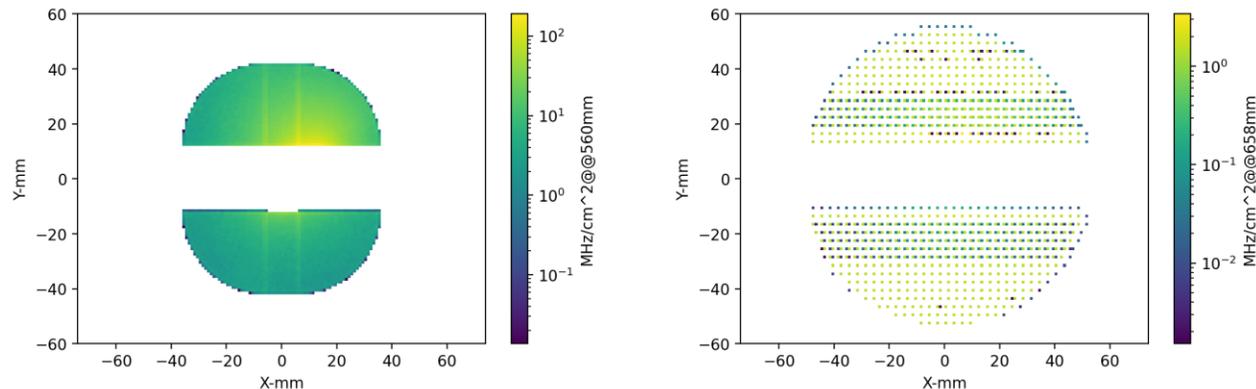


[ICHEP 2020 PoS](#)

Figure 1: Energy distributions of the off energy beam particles from different scattering processes.

Comments

- C-A-3-5: Although background rates (after shielding) are presented, detailed histograms and numerical data characterizing these backgrounds (e.g., energy spectra, multiplicity, polar and azimuthal angle distributions) are often missing. Such information is essential to assess the impact on the entire apparatus, particularly on the first layers of the vertex detector and LumiCal.
- Answer:
 - The information of the polar and azimuthal angle distributions of the hits in detector has been given to sub-detector designers and presented in their Chapter if necessary (like Figure 4.8 and 4.9 in Chapter 4 for the vertex detector). The performance study of the vertex detector and the LumiCal with backgrounds have been conducted.



Hit distribution on LumiCal

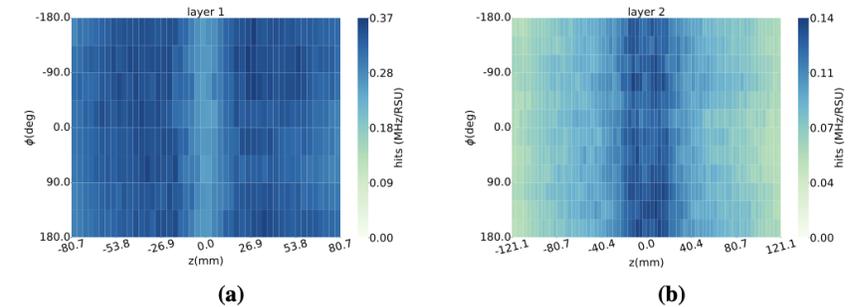


Figure 4.8: Spatial distribution of beam-induced background hit rates in the VTX during Higgs mode operation. Each cell indicates a single RSU. The VTX geometry is approximately cylindrical, with the horizontal axis representing the global z -coordinate (along the beam pipe) and the vertical axis showing the azimuthal angle ϕ . (a) Layer 1: The hit rate is relatively uniform across the layer, with a slight reduction near $z = 0$. (b) Layer 2: The distribution is also mostly uniform in ϕ , but shows a concentration within $|z| < 40$ mm. The remaining layers are not shown as their hit rates are significantly lower.

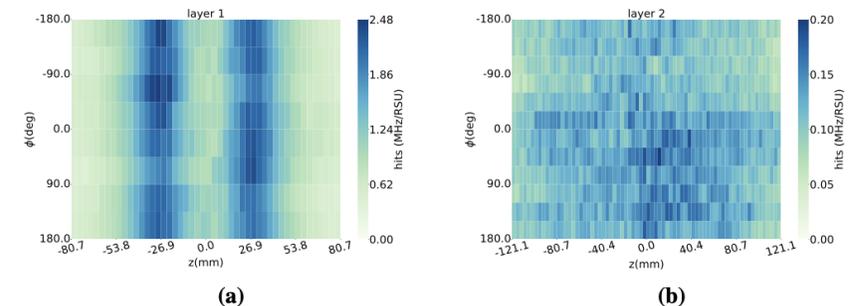
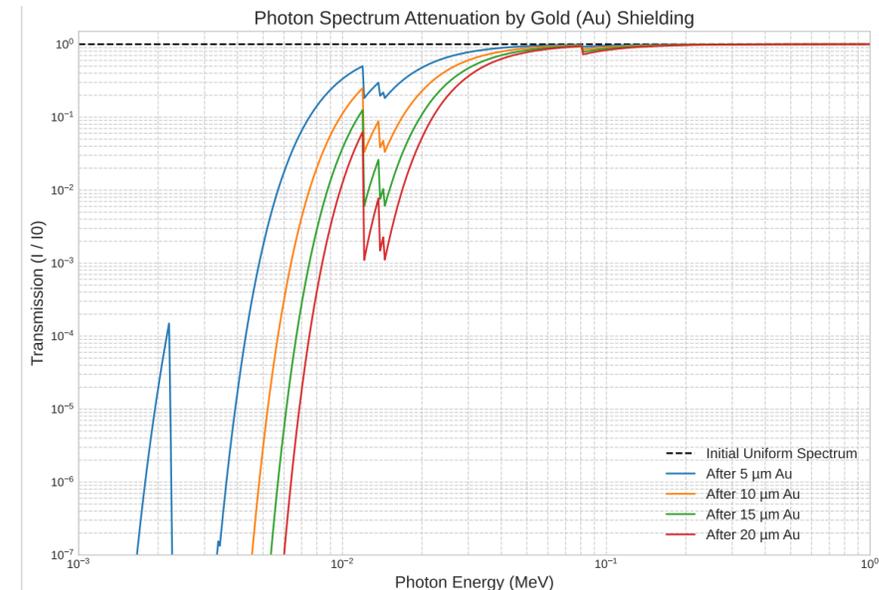
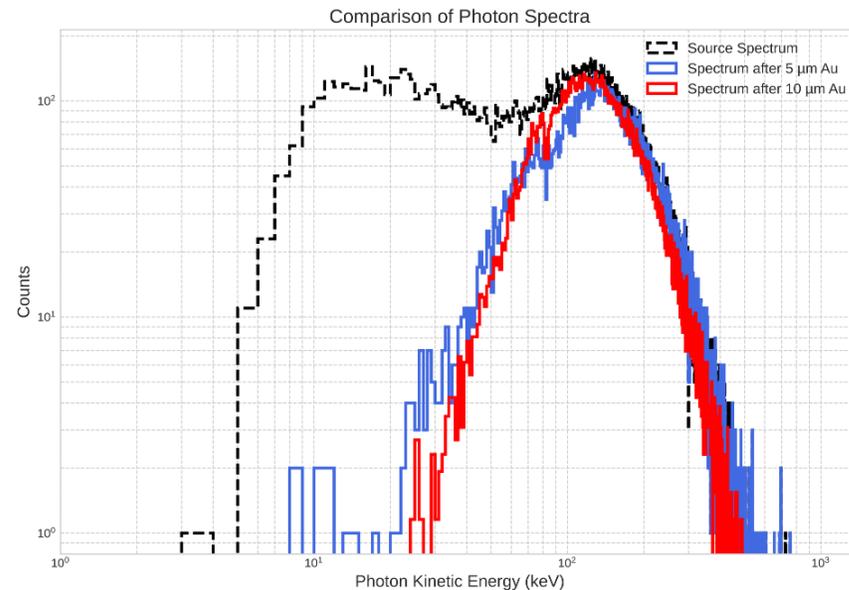


Figure 4.9: Spatial distribution of beam-induced background hit rates in the VTX during low-luminosity Z mode operation. Each cell indicates a single RSU. (a) Layer 1: The highest hit rates are observed in this innermost layer. (b) Layer 2: The hit rate pattern is more diffuse, with less pronounced structure.

Recommendations

- R-A-3-1: Conduct studies to finalize the decision on the Au coating inside the Be beam pipe, including its thickness and the possibility of omitting it.
- Answer:
 - Our final decision is to use 10 μm gold coating. “The gold coating on the inner surface of the central beryllium pipe has a thickness of 10 μm .”
 - We did the literature research, found that a 4 μm -20 μm layer of gold coating is usually used, including the Belle, Belle II, PEP-II, and BES-III. We noticed that PEP-II had a more complex coating layer, also including the Ni and Ta besides of the Au, and we are performing the simulation to compare.
 - Our studies confirm that the gold coating on the inner Be beam pipe is essential for mitigating the, and we have determined that 10 μm is a reasonable thickness balancing the need of shielding and the requirement of low material budget. The necessity of the coating is evident from left figure, which shows the unattenuated SR spectrum’s high flux of low-energy photons would hit the detector. Right figure confirms that Au is effective at shielding the sub-100 keV photons characteristic of the SR background.



Recommendations

- R-A-3-2: Continue detailed studies of SR mask configurations and materials, considering the effects of beam orbit steering in collaboration with the accelerator group.
- Answer:
 - We continued such study, and a mask made by tungsten at -1.9m has been introduced as final design at TDR phase.
 - Different scenarios are simulated. The wall, 10um of gold coating, and the shielding inside the detector are always applied. We've changed the height, material, position and numbers of the masks.
 - Considering the beam orbit change, we are performing the study in collaboration with the accelerator group. The misalignment of the magnets and pipes are limited to 100 um, and the orbit change due to the misalignment is less than 100 um (after the correction). We plan to and the misalignment component by component, which is ongoing, and still needs time to be finished.
 - Currently, we simulated the particle distribution in Gaussian up to $10 \sigma_x$, which already covered the range of the orbit change.
 - For the commissioning phase, the detector(including the Be pipe) will be absent at the beginning. When them are installed, the beam orbit already become much stable. The beam current also will be much lower in that phase. Therefore, the detector and Be pipe will be safe during commissioning.
 - After the beam orbit for both normal operation and commissioning with orbit correction are fixed, we will perform dedicated simulation, and the optimization of the mitigation methods on SR to ensure the safety of the Be pipe and the detector.

Mask Position	Mask Height [mm]	Aperture Size [σ_x]	Material	Hit Density at VXD [MHz/cm ²]
-1.9m + -4.3m	4	143 + 49	Cu	10
-1.9m + -7.2m	4	143 + 57	Cu	<4.2(0)
-1.9m + -7.2m	3	167 + 62	Cu	1786.8
-1.9m	4	143	W	<4.2(0)
-1.9m	3	167	W	1836.7

Recommendations

- R-A-3-3: Further investigate the role of heavy metal masks in absorbing particle backgrounds, including the possibility of operating without them.
- Answer:
 - The secondaries has been studied already, considering the heavy metal SR masks, collimators near the IP, and the shielding.
 - As presented in previous answers, the SR mask at -1.9 m is necessary to mitigate the SR background. However, it may increase the impact of single beam loss background. Since BGC is the highest single beam loss background source, we performed a dedicated study. The loss rate due to SR mask is ~4 kHz at Higgs mode, mainly from beam gas Coulomb(BGC). Considering the high energy of the lost particles(119.976 GeV on average), the impact on detector caused by these particles are rare(0.06MHz/cm² on VTX detector, contributes ~5%). We thought this level of increase is acceptable.
 - The collimators are much more far away to the IP except for APTX.9, which is ~19m upstream of the IP. The APTX.9 only helps to mitigate the BGB backgrounds, and the impacts considered in simulation(~2kHz/cm² on VTX detector). Our experiences on the study of passive machine protection system, shown that the other collimators can be safely assumed to be ideal since they won't increase the loss rate of the IR. The farthest drift distance of the secondary particles after interacting with collimator in our simulation is less then 100 m. Considering that other collimators are >2 km away from the IP, we can assume that they are safe at current stage. Once the beam orbit and all the collimator settings are fixed, we will perform the full simulation of all the collimators to see the effect.
 - The shielding material has also been studied. We studied the case of no dedicated shielding, using 15 mm Stainless steel(3+12, ~0.85% X₀) as shielding, and using 10 mm tungsten as shielding(3 + 2 Ti alloy as supporting structure of the cryo-module of accelerator, ~4% X₀), as listed below using CEPCSW 25.1
 - The results shown that the shielding effects of the TiW is ~30% better in ECal/TPC, almost same at other sub-detectors. Considering the heavier W shielding cause trouble for accelerator operation and manufacturing, the stainless steel is chosen to be the baseline.

Sub-Detectors	Ave. Hit Rate(MHz/cm ²)		Max. Hit Rate(MHz/cm ²)	
	Stainless Steel	Ti + W	Stainless Steel	Ti + W
ITK	0.00552	0.00545	0.01608	0.01810
TPC	0.0037	0.0028	0.012	0.008
ECal -B/E(in cell)	0.011/0.045	0.007/0.023	0.424/2.8	0.172/1.7

Recommendations

- R-A-3-4: Pursue deeper studies of BESIII backgrounds to understand the discrepancy between simulation and data.
- Answer:
 - We understood that understanding of this discrepancy is critical.
 - The study published on [NIMA](#) shows that the discrepancy has been decreased by the improving on simulation such as the refinement of the geometry and the consideration of collimators as shown in the left figure, and another publication on [RDTM](#) shows that the consideration of the beam-beam also decreased the discrepancy.
 - We are checking the threshold setting of MDC in experiment and simulation. The difference of those information won't have much impact on signal, but will have impacts on BIB. There are also some assumptions on the beam parameters due to lack of the measurement like the beam size at the IP and the little data on beam gas background, therefore we are aiming at using BEPCII-U to perform more dedicated beam induced background study in future. We are sure that with more data and measurement of the beam condition, we can decrease the discrepancy further.

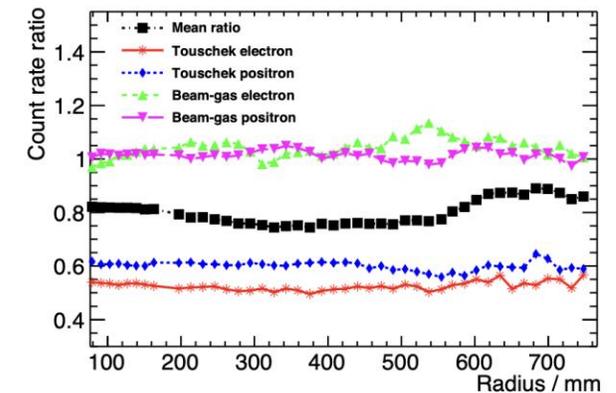
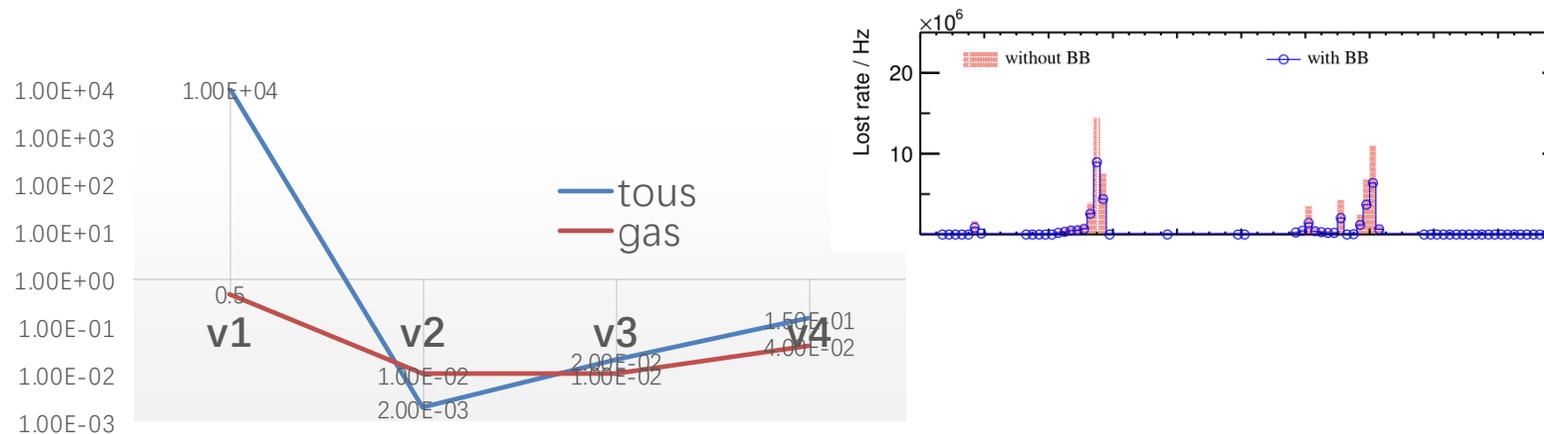
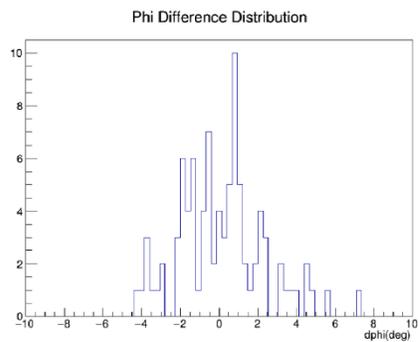


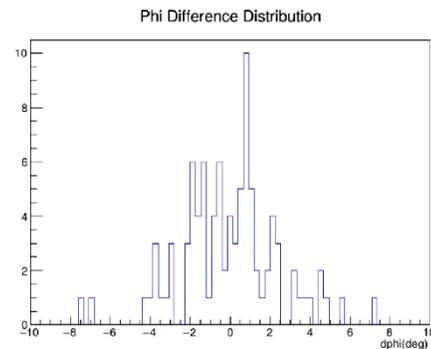
Fig. 4 The ratios of count rate in simulations with and without beam-beam effect in the radius of all MDC layers. The green and magenta curves represent the beam-gas background in the electron and positron beam, the red and blue curves correspond to the Touschek background, and the black curve shows the overall background

Recommendations

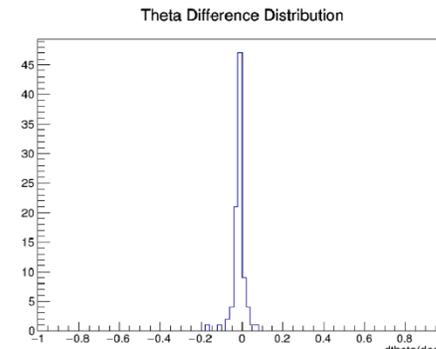
- R-A-3-5: Continue dedicated studies on LumiCal readout electronics at high rates, followed by beam tests with detector prototypes at later stages.
- Answer: The dedicated studies on LumiCal readout electronics at high rates is still ongoing. Our aim is to find the existing components in the market to build the system. We already found some components, and building the test modules used for beam tests, which will happen at later stages. We are also working on mitigate the BG level further at the same time.
- R-A-3-6: Study the effects of beam backgrounds on LumiCal reconstruction for realistic configurations.
- Answer: Sure. We have some preliminary study on this. The results shown that it won't affect the reconstruction much. And since less than 10% of the background is higher than the threshold set in the simulation, it can be further mitigated by more refined background suppression strategies.



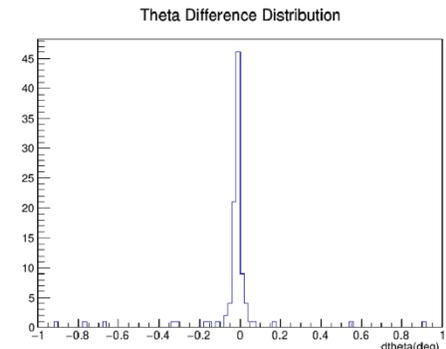
Without BIB



With BIB



Without BIB



With BIB