Photon Reconstruction Studies

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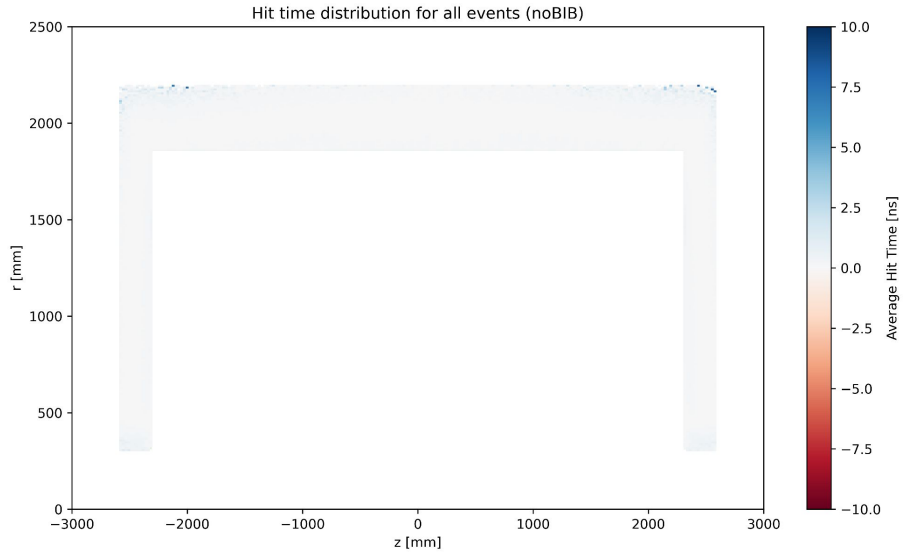
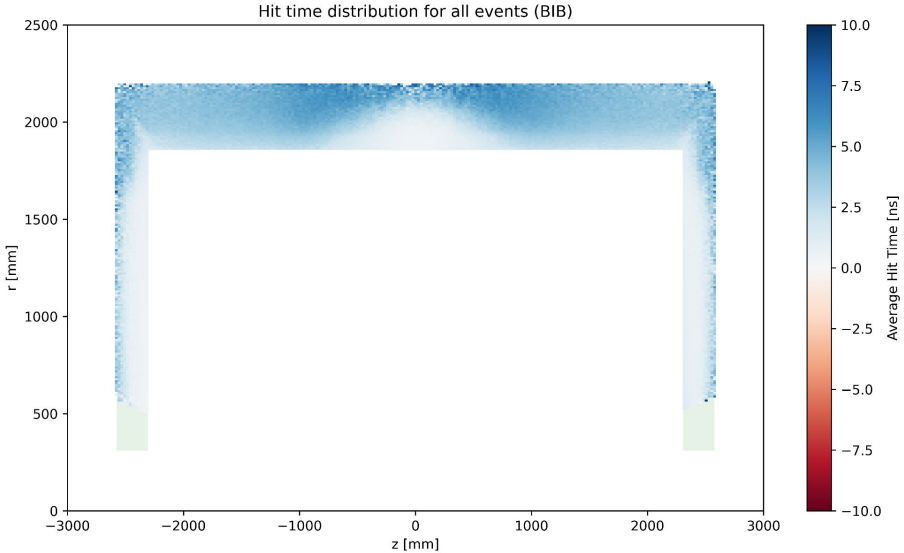
Introduction

- My project focuses on developing an effective photon reconstruction algorithm that mitigates the effects of BIB by using techniques such as time cuts and spatial cuts
- No PFO is used; we develop an algorithm that reconstructs photon energy using ECAL hits within a $\Delta R = 0.2$ cone around the incoming photon direction
- Most plots in this slide deck are created using v5 0-1000 GeV data (it will be marked out if it's not)

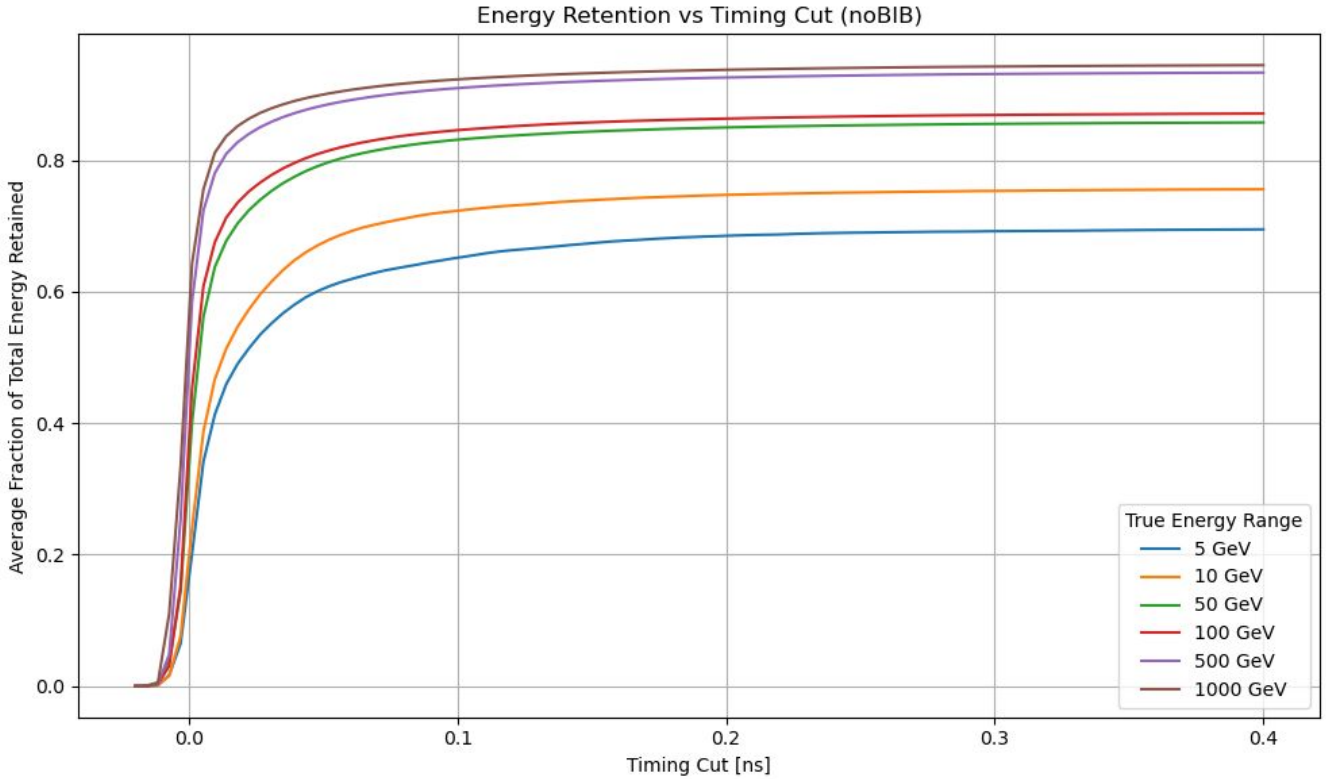
Average hit time distribution in the z-r plane

- noBIB plot: hit times are well-calibrated and centered near zero in the ECAL.
- BIB plot: hits arrive later on average and show a characteristic time distribution across the ECAL.



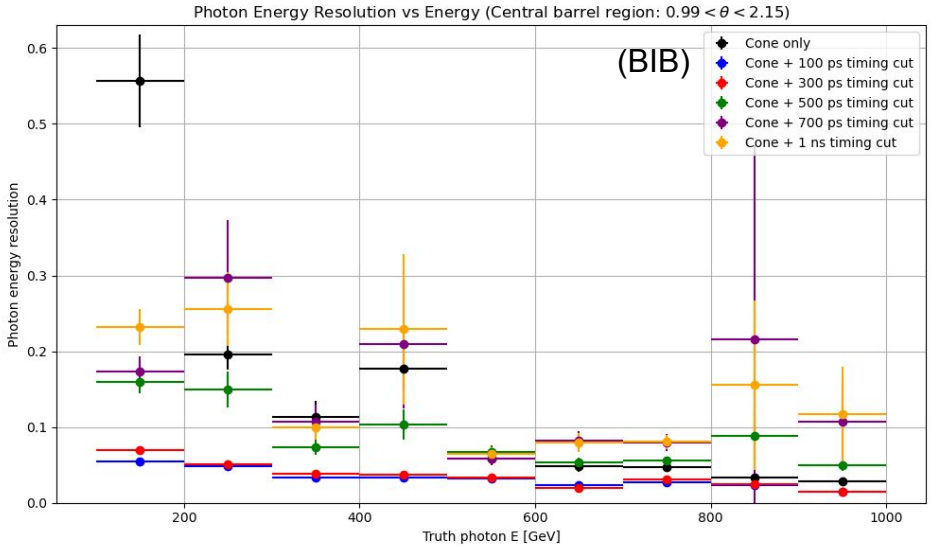


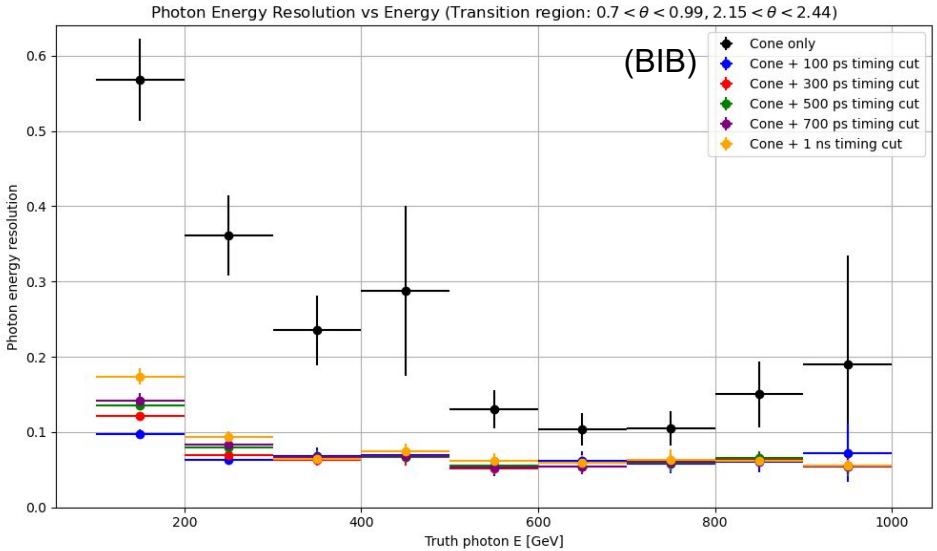
Average fraction of retained energy versus time cuts



- A timing cut of about 0.1 ns is needed to capture vast majority of the recoverable signal energy across the studied energy ranges

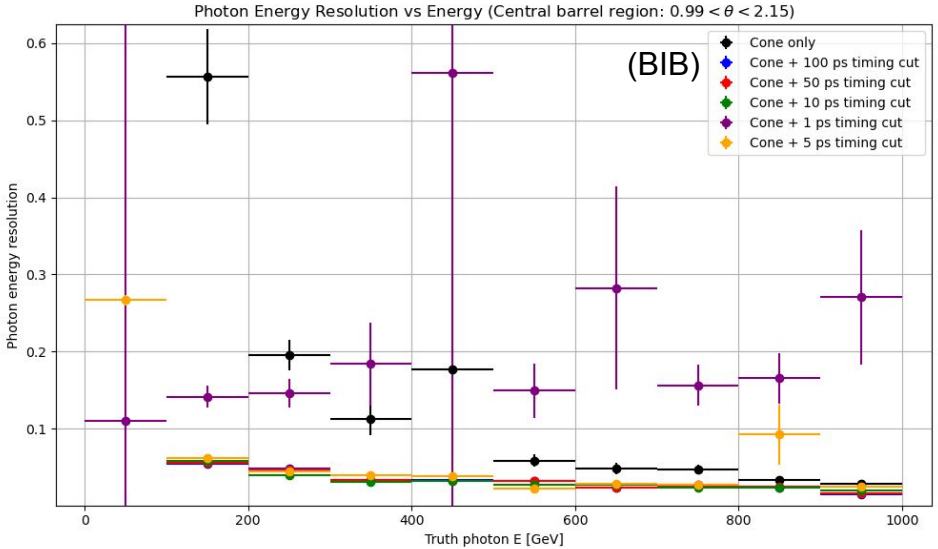
Optimizing time cuts (start with longer time cuts)

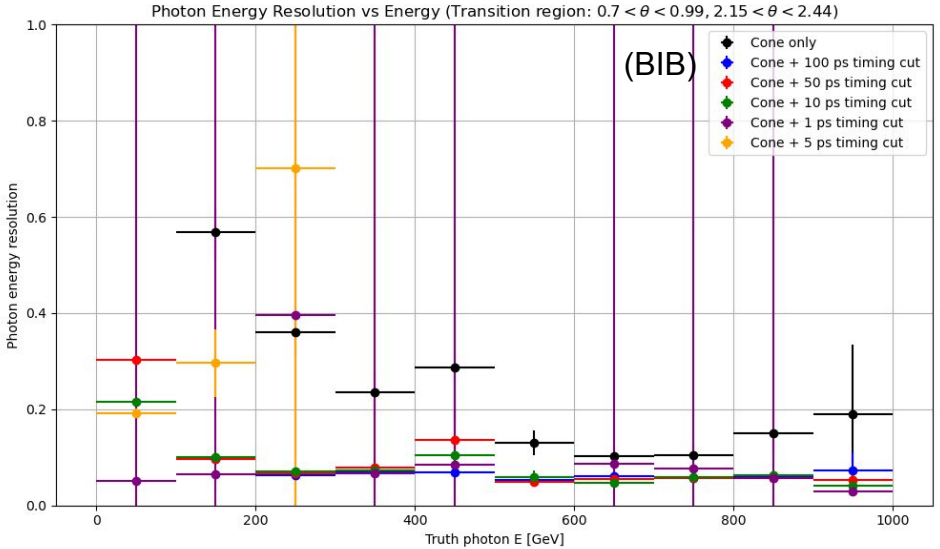




- Applying a time cut improves photon energy resolution
- Performance seems to plateau around 300ps

Optimizing time cuts (look at shorter time cuts next)

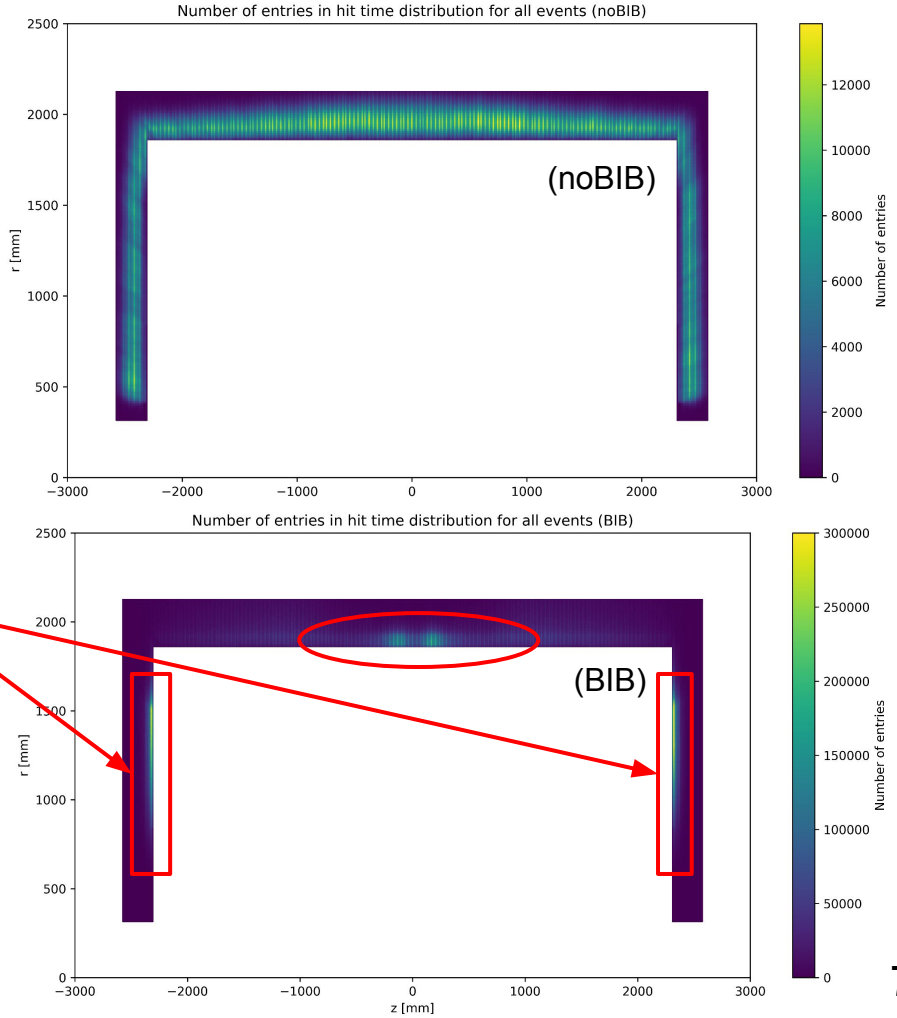




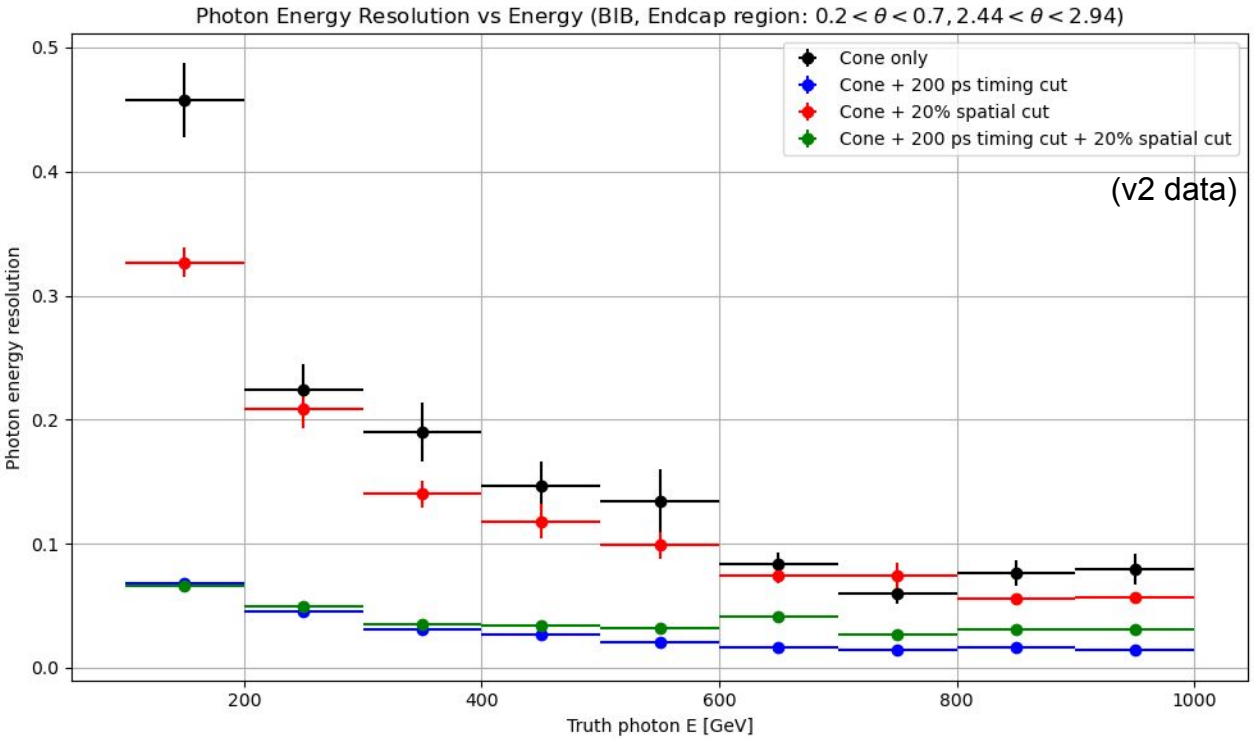
- Cuts below ~5 ps start to worsen the resolution
- From 10-300 ps, improvements are marginal → we will use a time cut of 200 ps for now considering technology & practicality

Number of entries in ECAL

- noBIB plot: signal mostly deposit in the middle depth region of the ECAL
- BIB plot: observe a significantly higher number of entries near the inner boundary of the endcaps and the central barrel
- We can reject hits from shallow ECAL layers in the endcaps and central barrel to suppress BIB



Evaluating the resolution



- Removed the first 20% of hits near the inner endcap boundary, where BIB dominates
- Spatial cut improves resolution compared to cone only
- Adding the spatial cut on top of the timing cut does not yield further improvement

Conclusion and next steps

- Performance plateaus starting at ~300 ps and worsens when it drops below ~10 ps → applying a ~200 ps time cut improves photon energy resolution
  - Next steps: Explore more sophisticated timing selection, e.g., asymmetric cuts, energy-dependent cuts, and cluster-dependent cuts
- Most signal deposit in mid-depth ECAL layers, while most BIB hits deposit in the shallower layers of endcaps → rejecting shallower layer hits improves photon energy resolution as well
  - Next steps: Rather than cutting out cell information from spatial cuts, find more optimal approach to include cell information, e.g., via weighting cell contribution to energy or applying higher energy thresholds

Backup: Zoomed in z-axis to observe more subtle time