Photon Reconstruction Performance for the 10TeV MAIA Detector Concept



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MAIA Detector Concept

- **Nozzles** (tungsten/borated polyethylene) to shield from BIB
- Inner, outer, vertex trackers (silicon sensors)
- 5T solenoid _
- **ECAL** (silicon and tungsten) photons, electrons
- **HCAL** (iron and scintillator) hadrons (neutrons, pions, etc)
- Muon detector system





Energy Response in the Electromagnetic Calorimeter (ECAL)



EU24 Lattice Update

- Latest lattice replaces unrealistic dipoles with chicane
- Non-negligible increase in BIB photons, ECAL occupancy



Etrue / Ereconstructed for photons



- Symmetric, non-linear **theta-dependence** - Introduced by **solenoid geometry** Photons lose energy to showering in the
 - magnet
 - **Stochastic** process, cannot be modeled
- analytically
- 2D response used to **calibrate** reconstructed energy

Plots courtesy of Daniele Calzolari, Federico Meloni.

Solenoid Geometry



Cartoon visualization of varying photon path length through the solenoid, depending on theta. Not to scale.

Photon Reconstruction Efficiency

- O(10⁵) generator photons propagated through detector simulation
- Reconstructed into particle flow objects (**PFOS**) with Pandora algorithm
- Truth photon matched to **highest-pT photon-identified PFO** within a **AR range of** 0.1
- Efficiency **above 95%** both with and without BIB for E > 100 GeV
- Efficiency dips slightly in transition regions (maximal solenoid contact)
- Degrades below 100 GeV; crossing of efficiency curves indicates **spurious photon** matching for BIB sample

Photon Energy Resolution

Resolution curves split into three regions due to **Procedure:** theta-dependence:

- *Endcaps* (no solenoid contact)
- **Central barrel** (some solenoid contact)
- **Transition** (maximum solenoid contact)



Distribution of $\Delta E/E_{true}$ fit to a Gaussian in each energy bin; σ of the fit reported here as resolution.

- Resolution degrades for BIB sample below 200 GeV
- More solenoid contact \rightarrow poorer resolution
 - Stochastic energy loss \rightarrow broadened resolution



Truth-Assisted Clustering

- Sum the energy of all ECAL hits within a cone of $\Delta R < 0.1$ around the generator photon
- Using this strategy with BIB sample produces green resolution curve at right
- Demonstrates ability to achieve **desired** resolution with BIB overlay with a more appropriately optimized reconstruction algorithm



Ongoing Work

- Adapting our photon reconstruction strategy to high-background environment
- Modifying existing Pandora algorithms to include **timing** considerations
 - Preliminary studies indicate cutting on hit time may aid considerably in BIB reduction

References:

[1] Lee, Larry. Images generated with Unreal Engine. (2024) [2] Calzolari, Daniele. "Muon Collider: MDI Update" (Internal meeting slides, 2025)