Advanced ML Techniques and Hybrid Dual-Readout Systems for Electroweak Jet Identification and Particle Flow Enhancement in Future Collider Detectors

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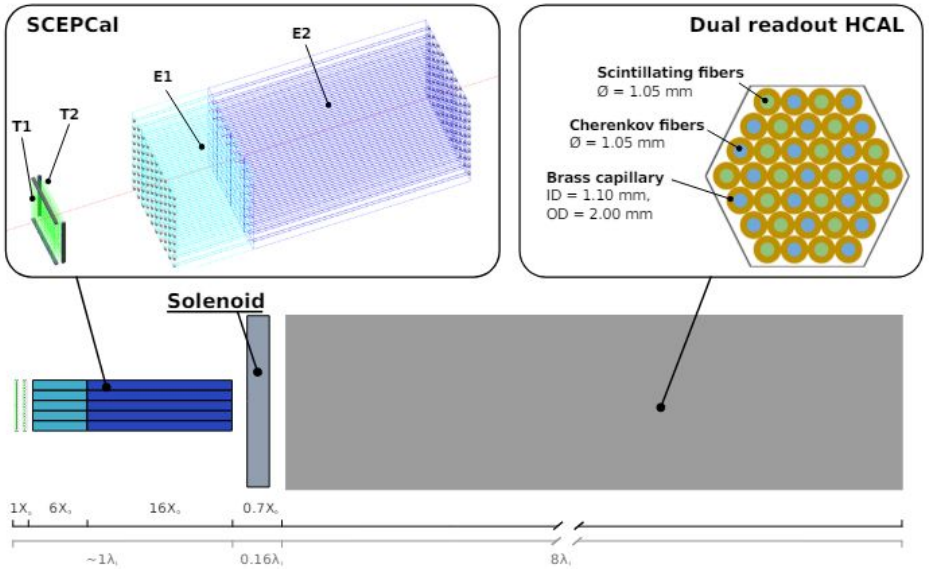
Hybrid Dual-Readout Systems

Hybrid Dual-Readout Systems (HDRS) in represent a significant advancement in particle physics. These systems improve upon traditional calorimeters by simultaneously detecting both scintillation and Cherenkov light produced by particles interacting with detector materials. This dual-readout capability enhances the accuracy of energy measurements and enables precise identification of particle types based on their light emission characteristics.



Overview of a hybrid segmented calorimeter layout featuring 4 front segments which exploit scintillating crystals for detection of EM showers followed by an ultrathin-bore solenoid and a hadron calorimeter based on scintillating and quartz fibers. [1:p.15]

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Photon pointing mechanism

Photon pointing in calorimetry refers to determining the direction of incoming photons as they interact with a calorimeter. When high-energy photons enter a calorimeter, they initiate cascades of secondary particles through processes like pair production and Compton scattering. These interactions create electromagnetic showers, where energy is deposited in the detector's material.

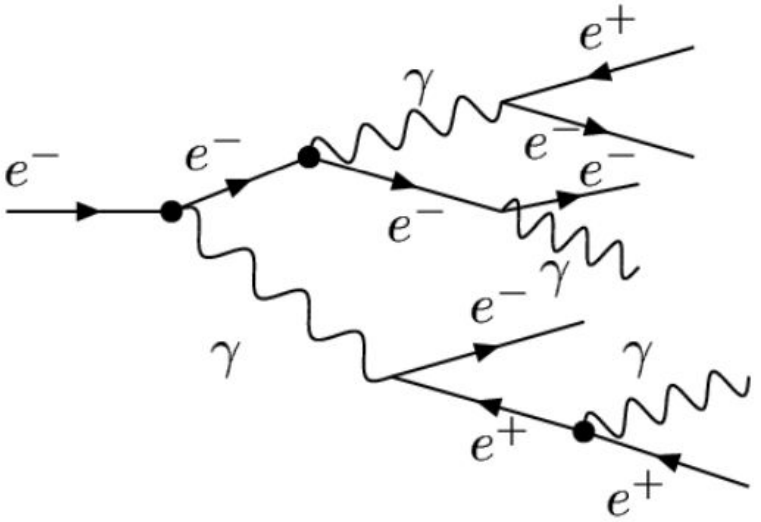
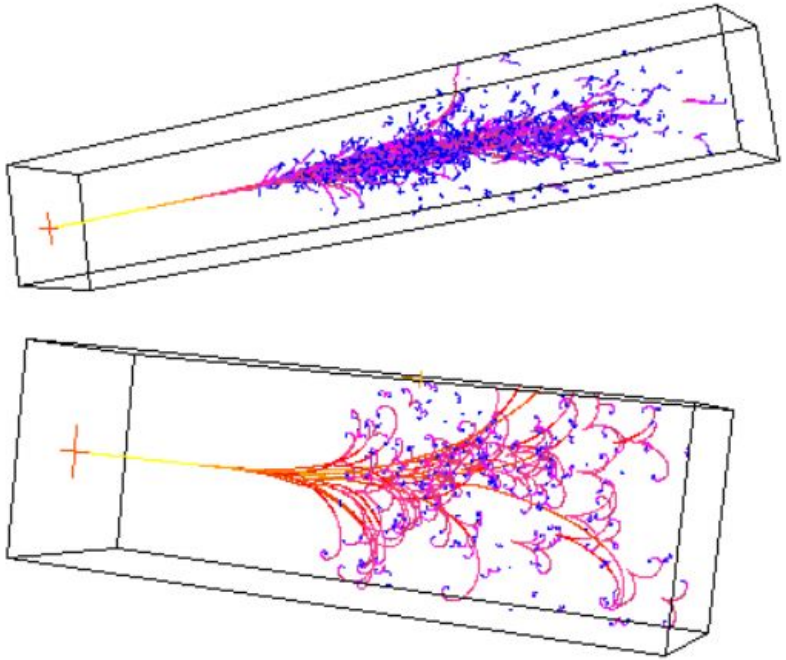


Figure 2. Electromagnetic shower diagram. [4;p.22]

First goal: Monte Carlo and data simulation.

First goal: Simulate the data of scattering processes that photons undergo when interacting with matter using Monte Carlo techniques and GEANT4 environment. Create the training data for future machine learning model.



Simulations of electromagnetic showers. [5]

Machine Learning in photon pointing. Next goals.

Using supervised learning techniques, such as regression or neural networks, ML models can be trained to predict the centroids based on the extracted features. Training involves optimizing the model parameters to minimize errors between predicted and actual centroid positions.

Main goal: Achieve the corresponding two centroid measurement in two depths of a proposed crystal calorimeter.

References

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