Calorimetry and particle reconstruction at the 10 TeV Muon Collider

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RD_MUCOL Italia, Turin 05/12/2024

International MUON Collider Collaboration
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INFN PADOVA
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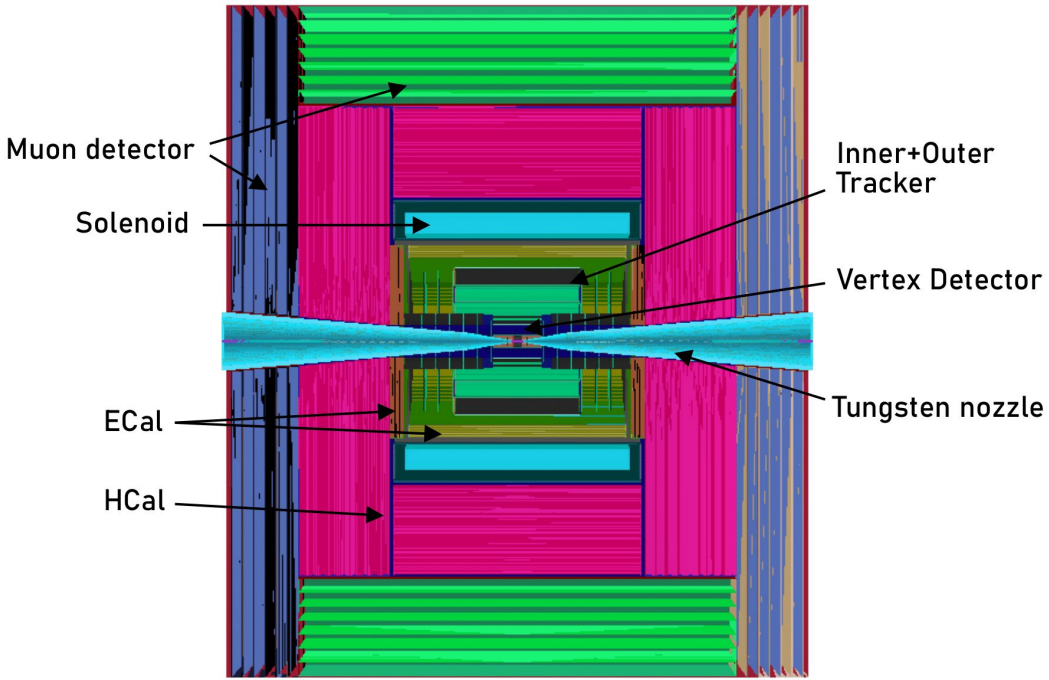
Co-funded by the European Union
G.A. No. 101094300 and 101004730

MUSIC: a detector concept for the 10 TeV stage

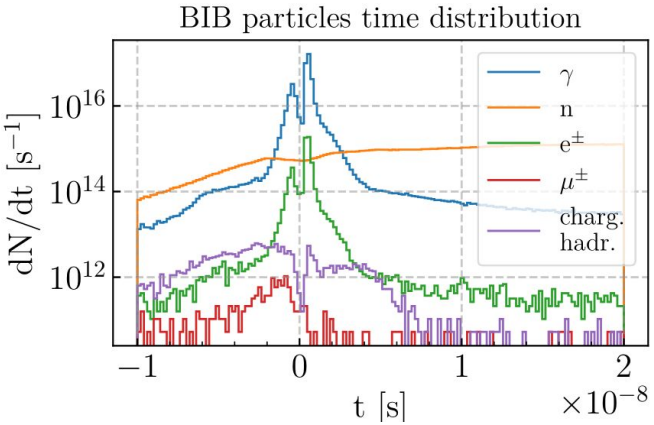
- For details, talk by Massimo and SIF contribution by Carlo (links)

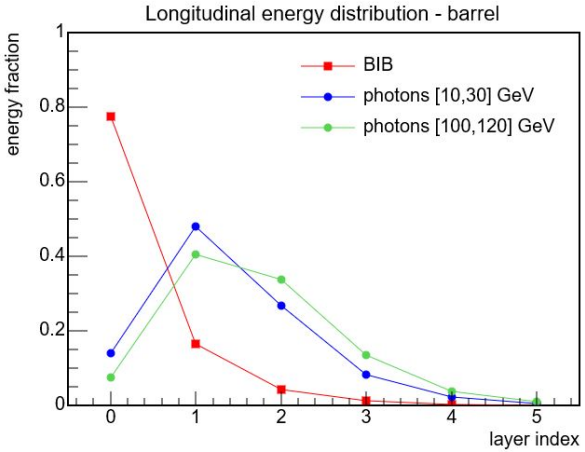


CRILIN electromagnetic calorimeter

- O(100) cm^{-2} BIB particles (mostly photons) at ECal surface per bunch crossing
  - → >200 TeV deposited throughout the detector!
- Detector requirements:
  - → time resolution < 100ps
  - → longitudinal segmentation
  - → high granularity
  - → good energy resolution
- CRILIN (next talk by Ivano) is the chosen technology
  - → time resolution <50ps above 1 GeV
  - → 1x1x4 cm^3 cells
  - → 6 layers implementation (26X0)

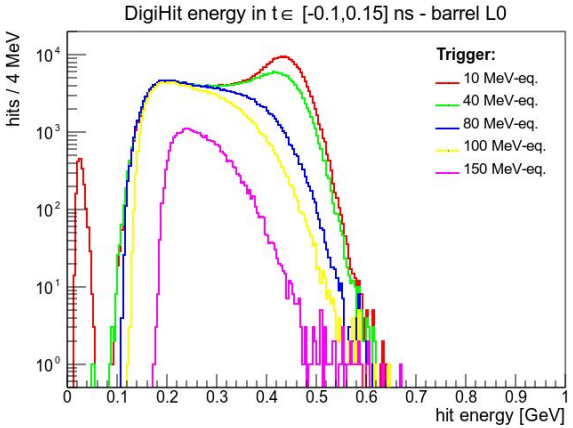
Credits: D. Calzolari, ICHEP24

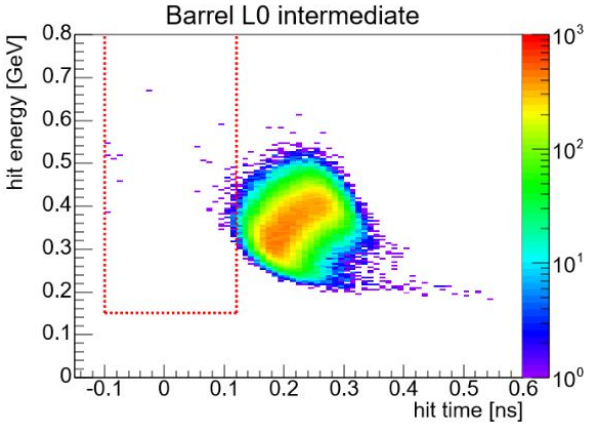




BIB mitigation at single-hit level in ECal

- Implemented a signal trigger emulation in Marlin's ECal digitizer
  - → More realistic hit time assignment
  - → independent trigger parameters for each layer
- Implemented time-energy selection of ECal hits
  - → independent cuts for each layer
  - → user can define detector regions to set local cuts
- In this study:
  - → 3 Z-regions for ECal Barrel, 3 R-regions for Endcap
  - → Trigger threshold set for each layer
  - → Total hit energy threshold for each layer and region
  - → Hit time window for each layer and region

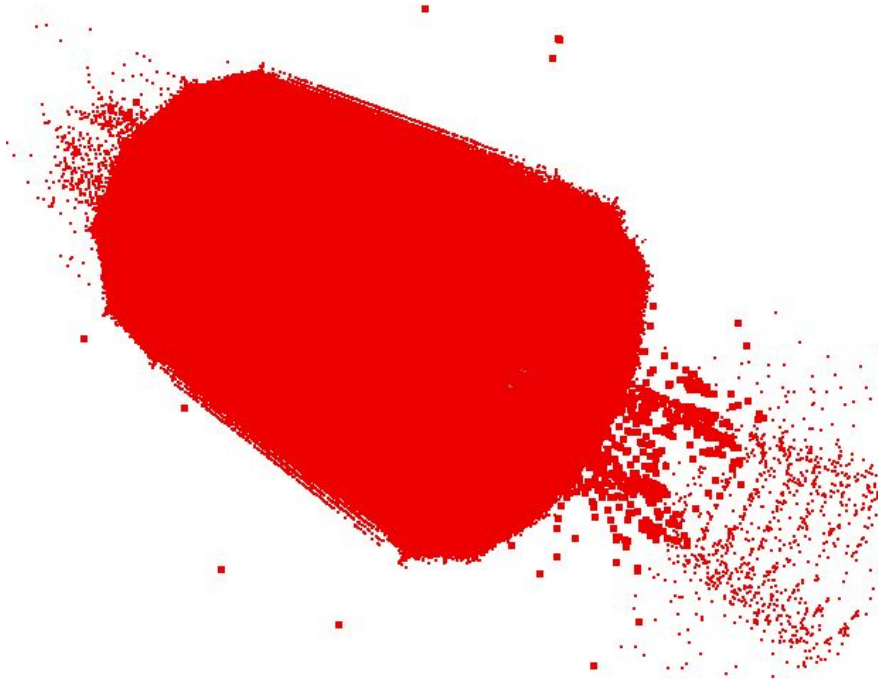


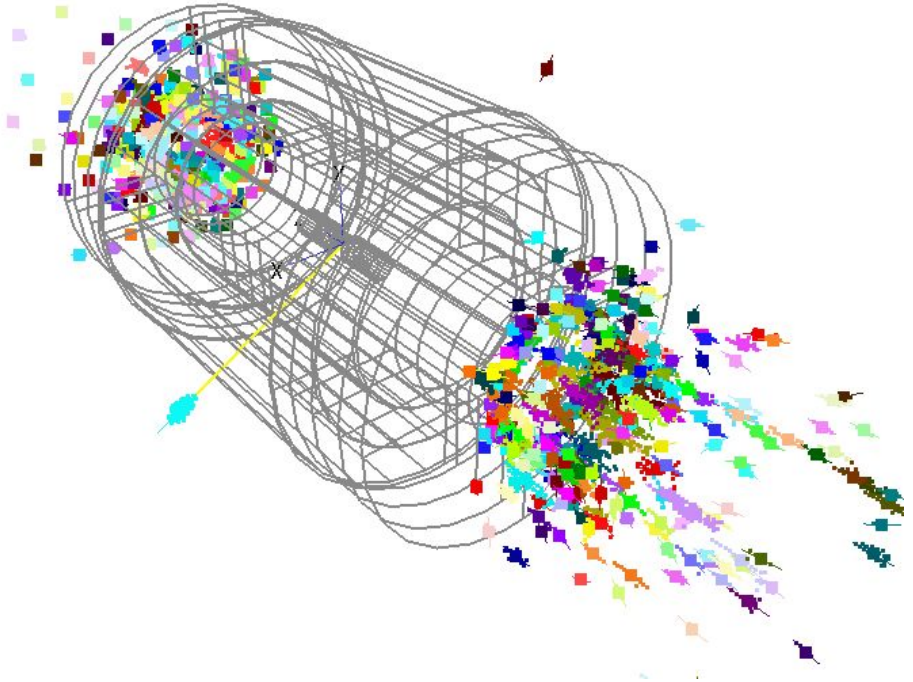


BIB mitigation at hit clustering level in ECal

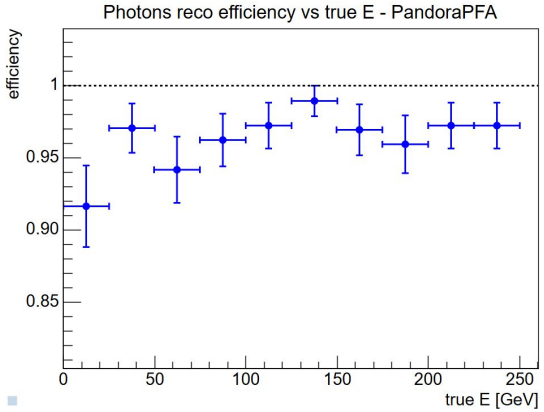
- Hit clustering in ECal is performed by PandoraPFA during particle reconstruction
  - → designed for almost background-free environments (sub-optimal!)
  - → but highly customizable
- The default Pandora workflow includes tens of clustering attempts with varying parameters
  - → very optimized for CLIC detector, but hard to tune
- Simplified Pandora workflow: only one clustering attempt
  - → allows detailed setting of the clustering parameters
  - → optimize for best energy resolution and reconstruction efficiency
- Tested using single photons with 1-250 GeV energy

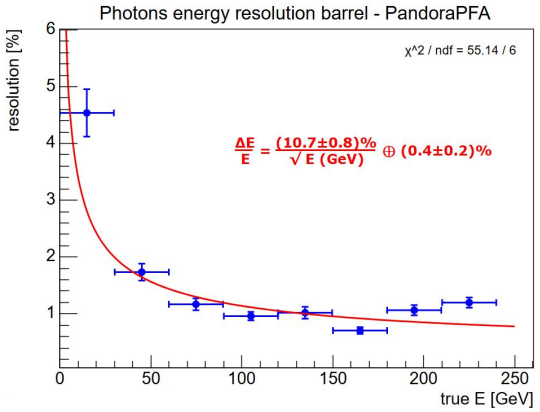
Event example before/after background mitigation

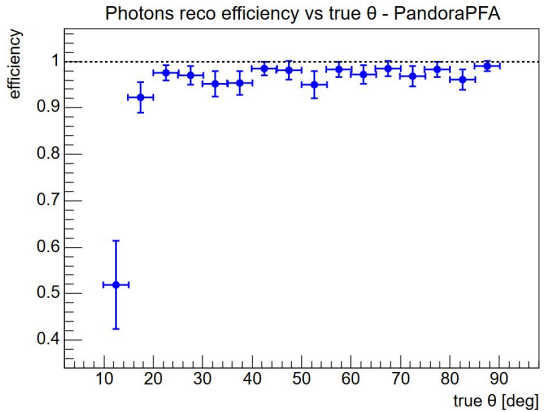


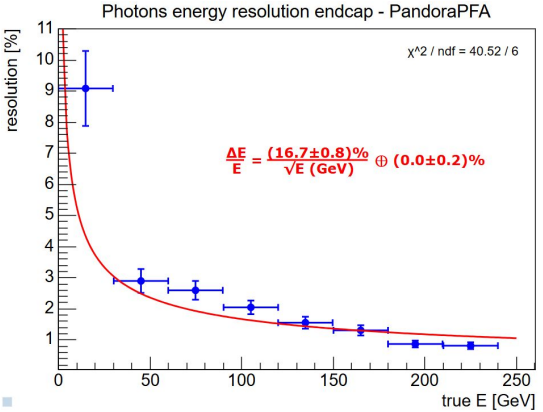


Performance with photons



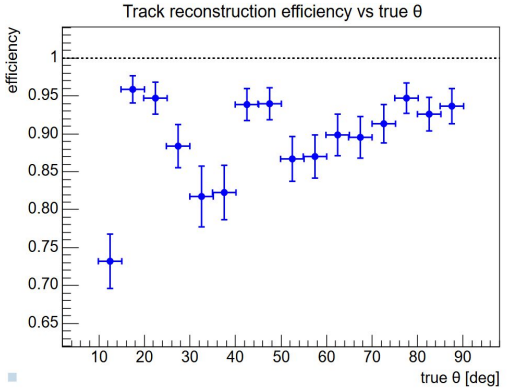




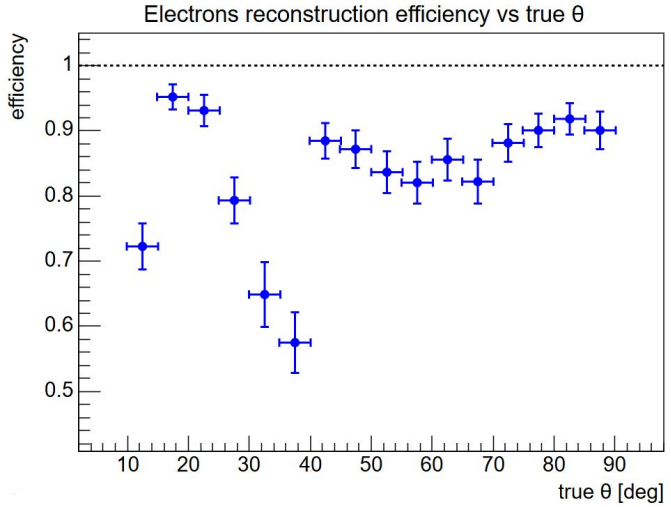


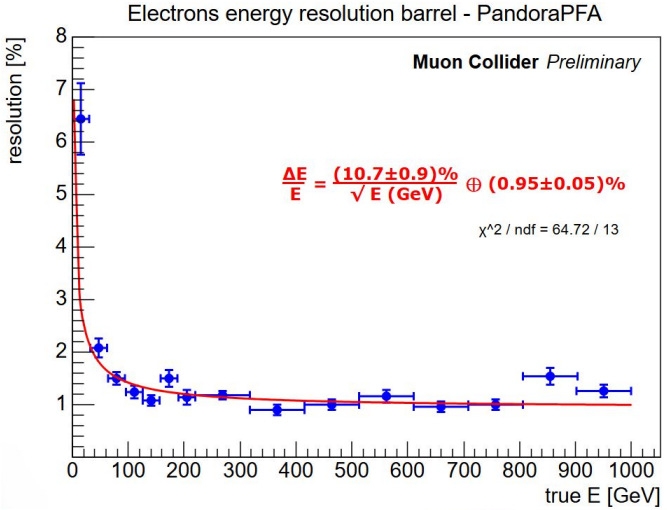
Electrons reconstruction

- Tested the complete reconstruction chain with electrons of 1-1000 GeV
- Tracking via ACTS, reconstruction via PandoraPFA
  - → Same ECal settings as photons
  - → Tighter track selection with respect to baseline (1.1 10^4 tracks post filter)



The issue here is the track-cluster association, found to underperform with high track densities.





Future improvements

- The ECal hit-level mitigation strategy is stable and reached good performance
- The ECal clustering has still large room for improvement, especially in the Endcap
  - → desirable to develop an alternative clustering algorithm
  - → reached **11%/√E** in the barrel, hitting the target energy resolution for the MUSIC concept
- The track-cluster association is the main limiting factor for isolated electrons reconstruction
  - → desirable to develop an alternative association algorithm
  - → very large improvement margin with a quite limited effort

Thank you!