The challenge of track reconstruction at a multi-TeV Muon Collider

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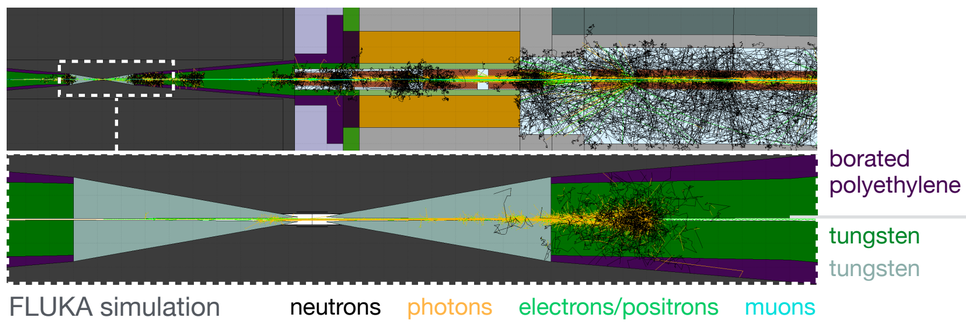
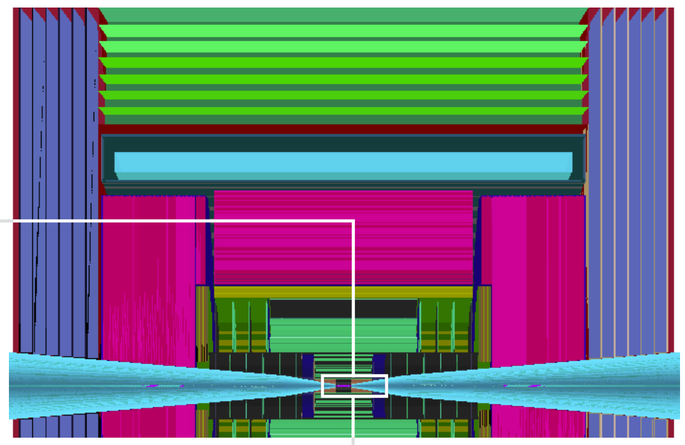
Muon Collider environment

Very clean final state

+ Beam Induced Background (BIB) ▶
muon decay products interacting with the accelerator lattice

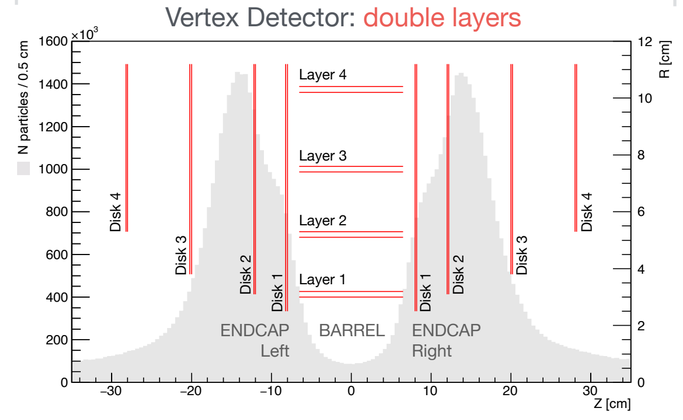




Tungsten nozzles around the beam pipe required for BIB suppression ▶

↳ **3.6 × 10⁸ particles** reaching detector at every bunch crossing (BX) $\sqrt{s}$ = 1.5 TeV
leading to extreme hit density: **up to 1K hits/cm²** in the Vertex Detector

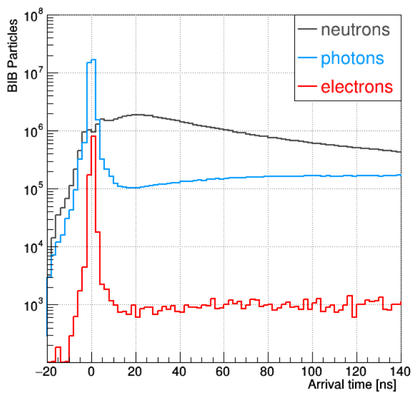
Unmanageable combinatorial background for track reconstruction



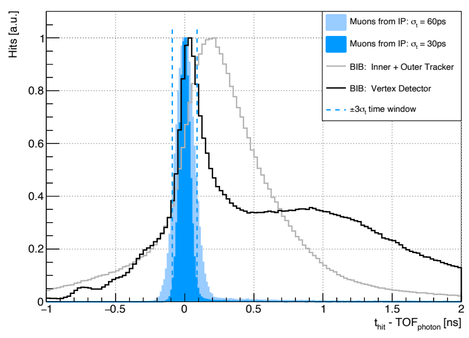
BIB rejection methods

Distinct features of BIB particles allow to strongly reduce the effective hit density

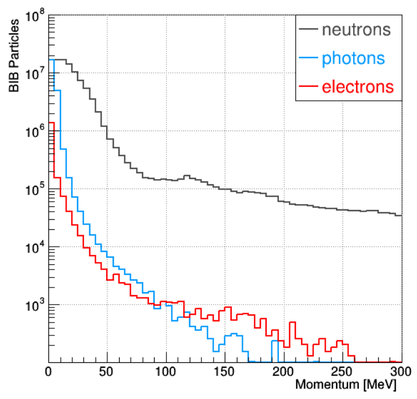
Late arrival time



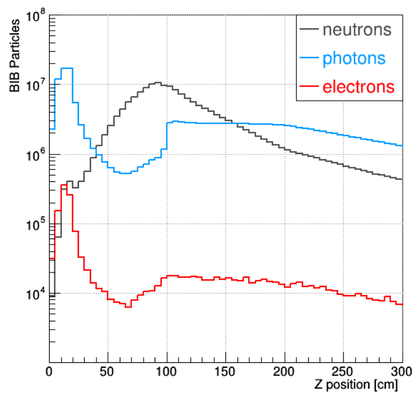
Imposing a narrow readout time window



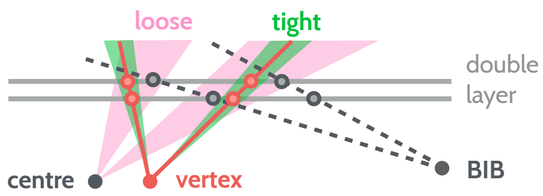
Easily absorbed



Displaced origin



Selecting only doublets pointing at the vertex

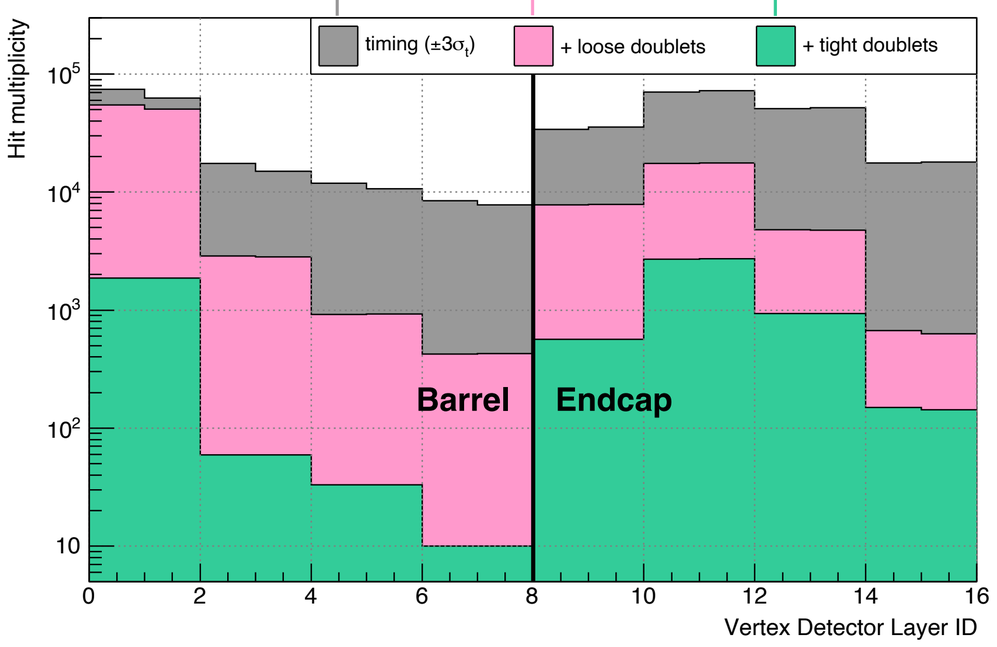


Great reduction of the number of hits in a single event ▶

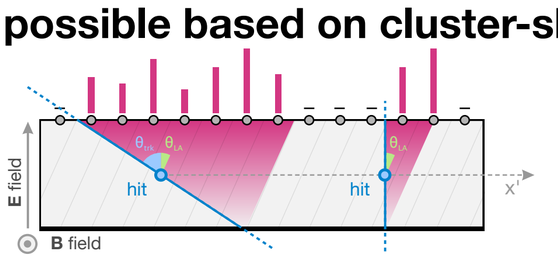
↳ tremendous reduction of combinatorics during **track reconstruction**

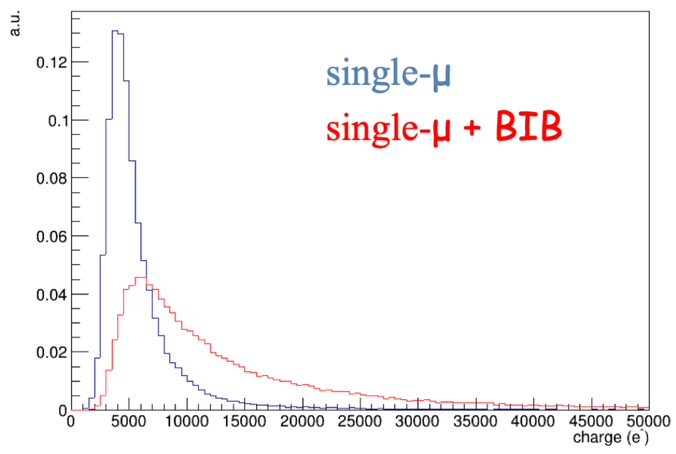
- **1 week**/event → **2 days**/event → **2 minutes**/event

using Conformal Tracking algorithm (developed by CLIC experiment)



Further suppression of BIB hits possible based on cluster-shapes

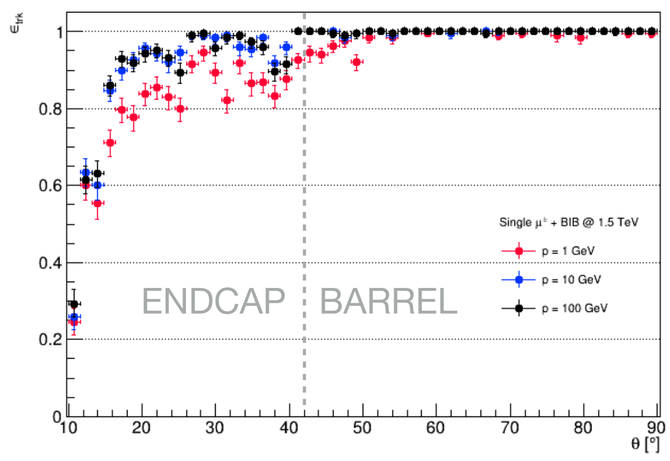




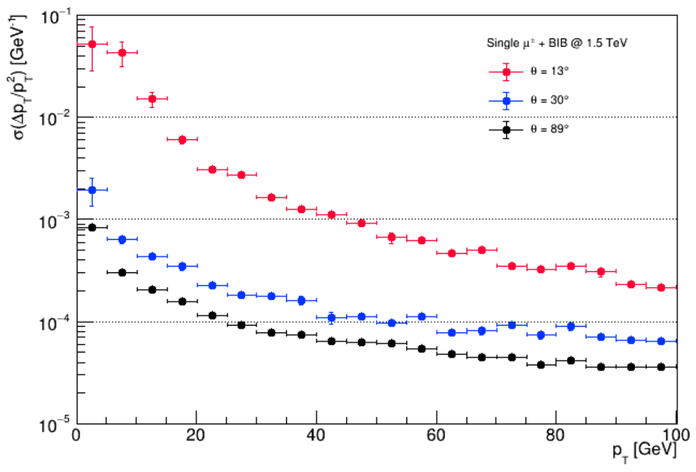
Tracking performance

High tracking efficiency ▶
degrading in the forward region

Simulated single muons + BIB
using Regions of Interest (ROI) around true muons
↳ reduced combinatorics

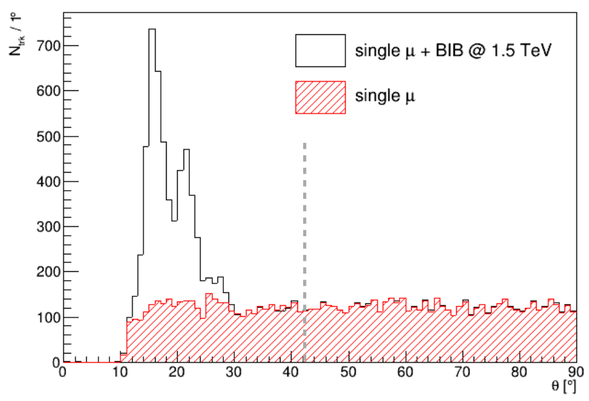


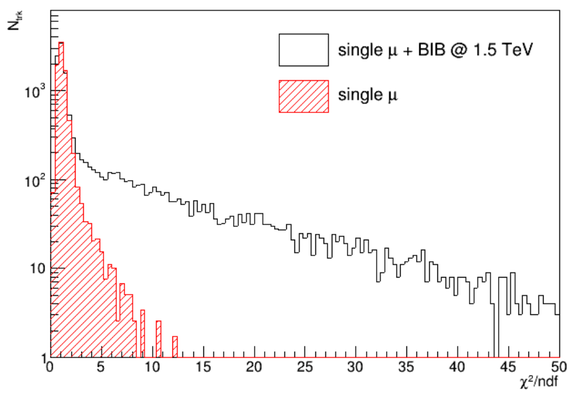
pT resolution ▶
affected by BIB hits



Many fake tracks in the forward region ▶

Better rejection of BIB hits is needed in the endcaps





Fake tracks clearly identifiable via Chi2

+ ongoing developments

- **High-performance tracking using ACTS**
- **Realistic cluster-shape simulations**
- **Topology specific reconstruction sequences**