Triggering on Muon Showers at the CMS Experiment

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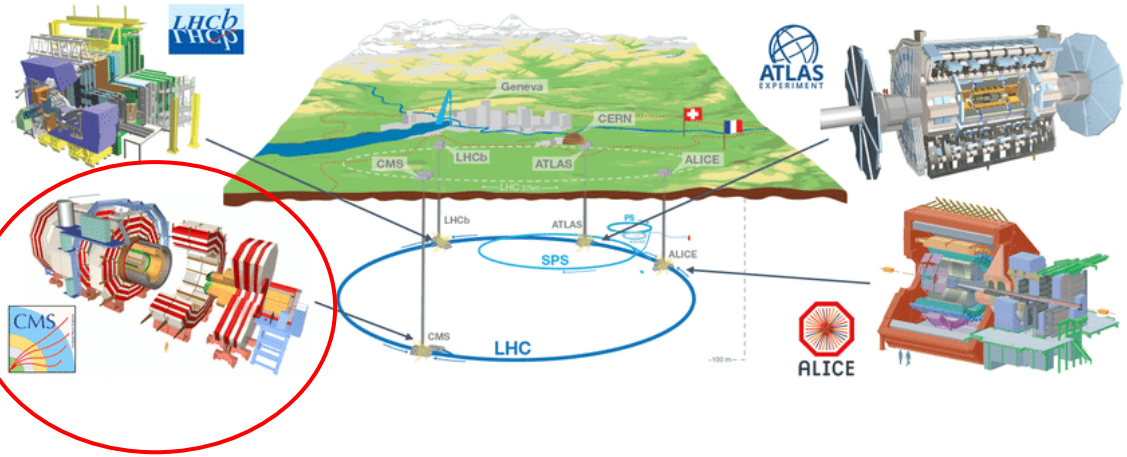
Universidad de Oviedo

Introduction

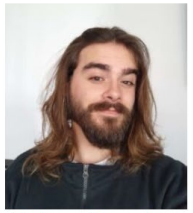
INnovative **TR**igg**E**r techniques for beyond the standard model **P**hys**I**cs **D**iscovery at the LHC



Members of the INTREPID team:


Prof. Santiago Folgueras


Dr. Andrea Cardini

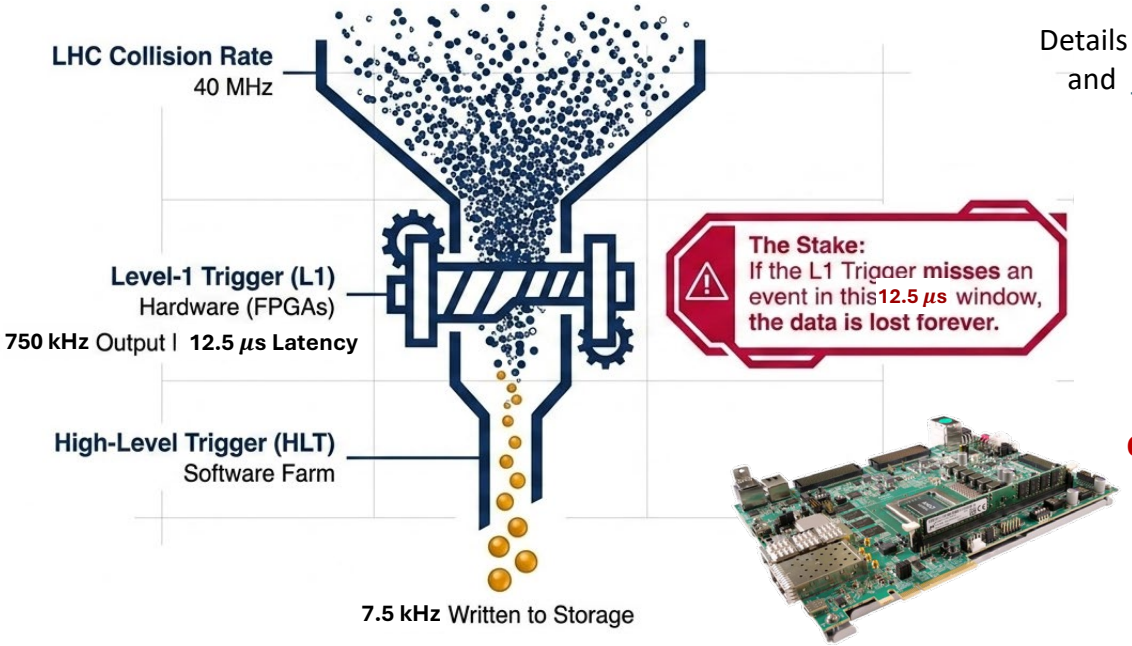

Pelayo Leguina


Daniel Estrada


Javier Prado


Elena Aller

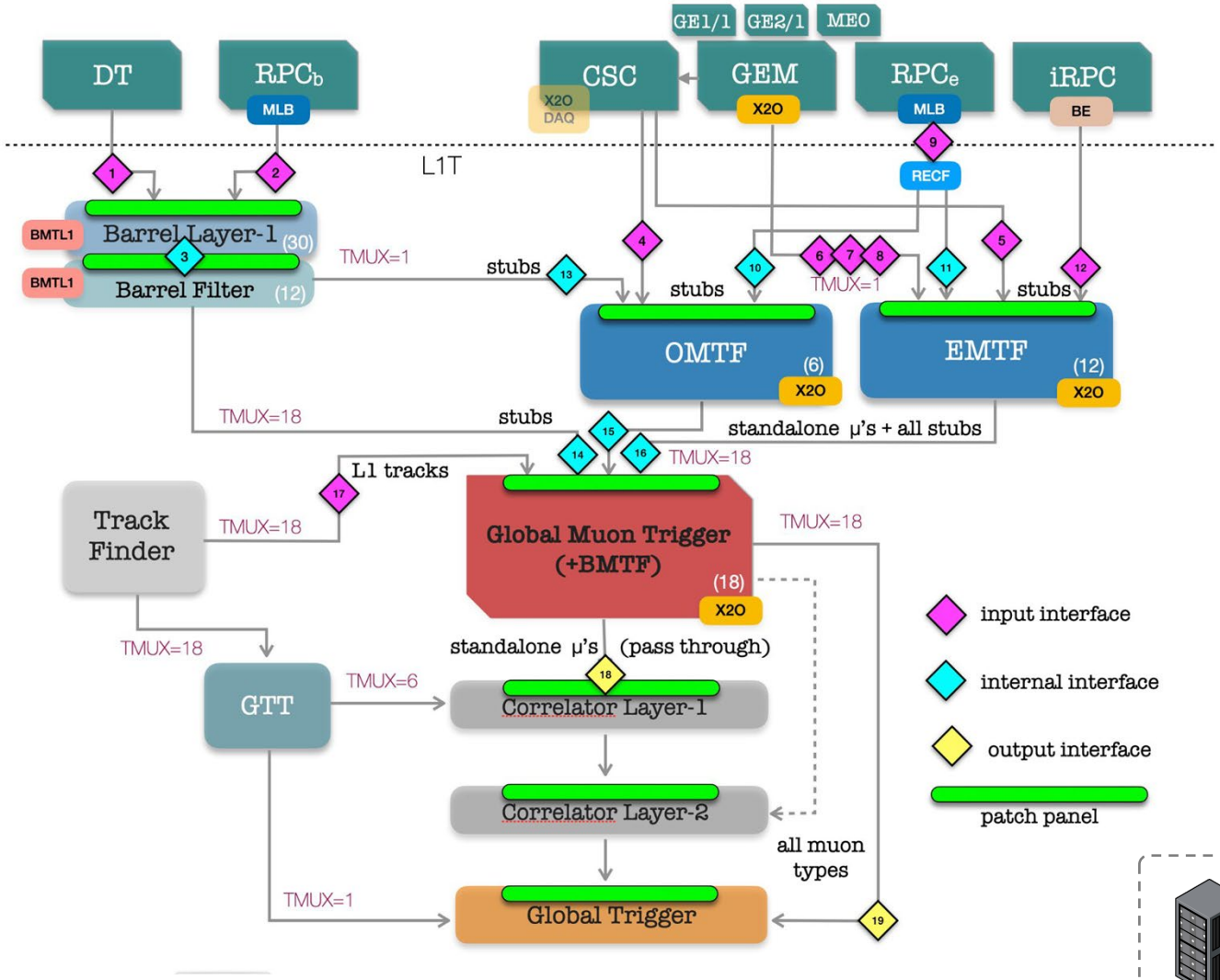
Deploy complex algorithms in the CMS Level-1 Trigger for Phase-2.



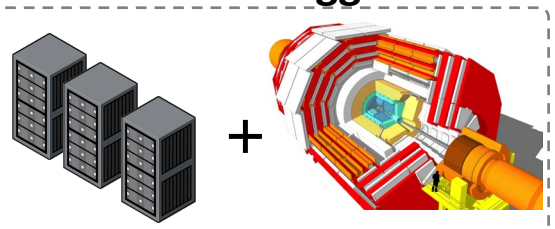
Details in Santiago's talk and Florencia's talk

offline-style algorithms can now be deployed

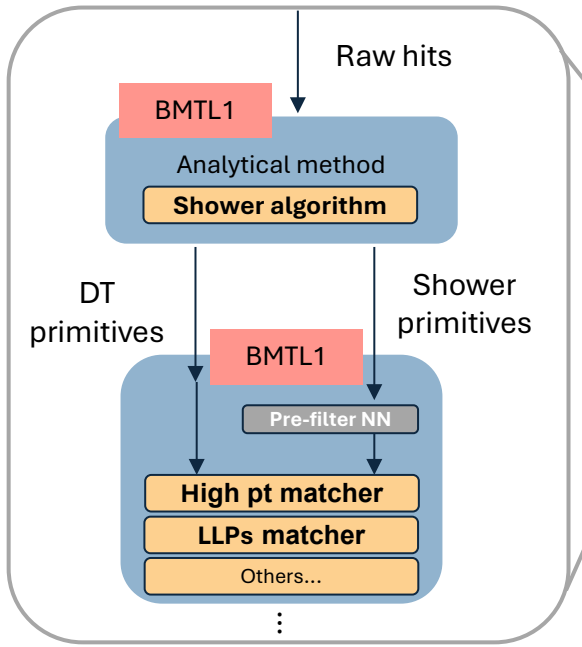
Introduction



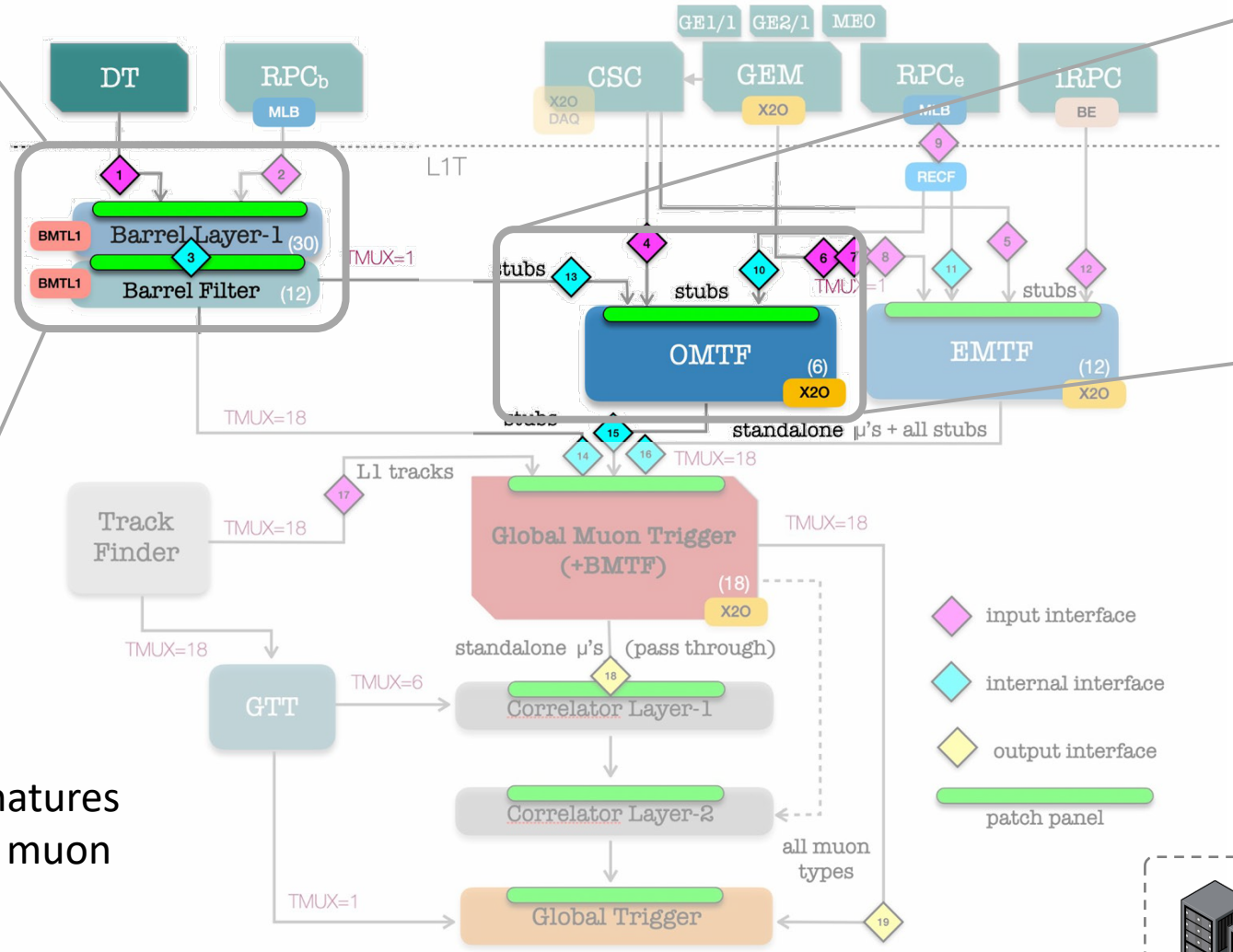
CMS L1 Trigger



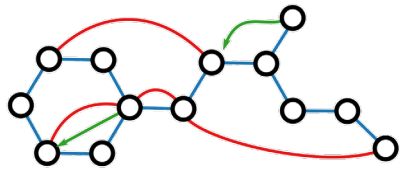
Introduction



Pattern-recognition approach



GNN

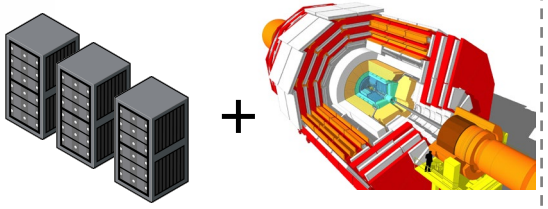


See Elena's talk

Machine-Learnig approach

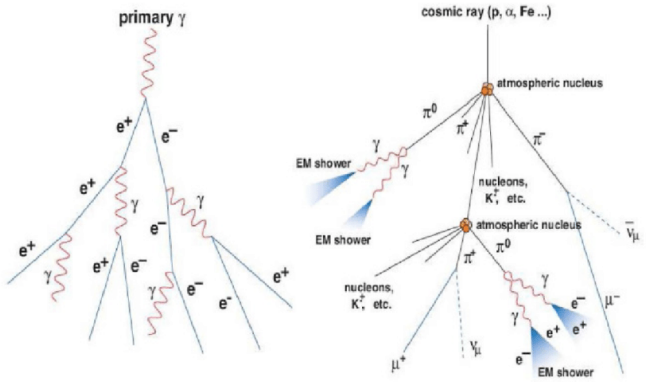
Detect **muon-showers** signatures in the Barrel region of the muon Level-1 Trigger

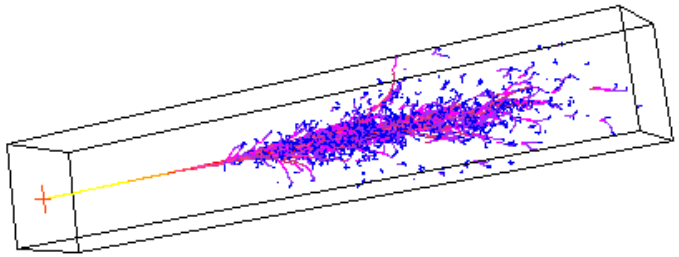
CMS L1 Trigger



What is an Electromagnetic showers ?

It forms when a sufficiently energetic particle interacts with materials, producing secondary photons and e^+/e^- pairs.



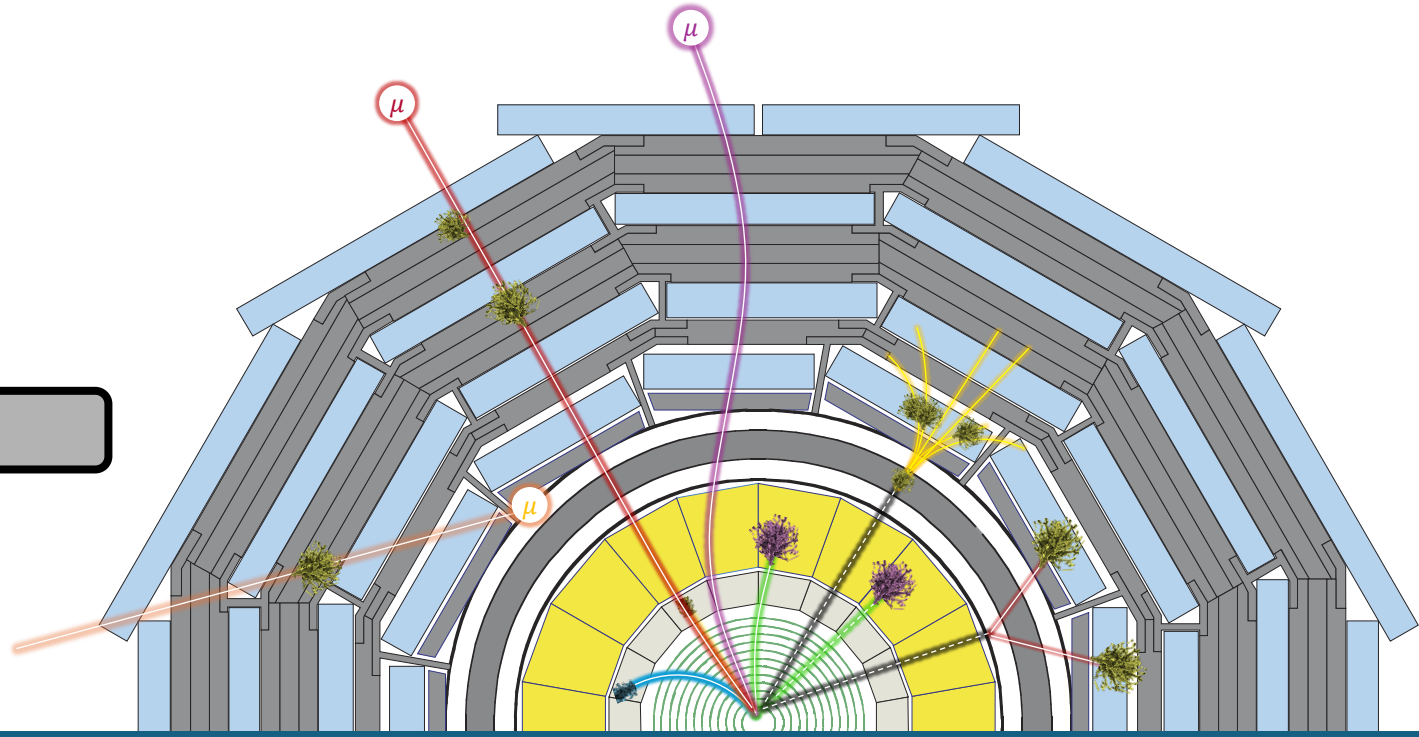


In CMS context, energy deposits are expected in the **ECAL** and **HCAL**; but shower-like signatures can also appear in the **muon system**.

High-energy muons radiate via **bremsstrahlung**

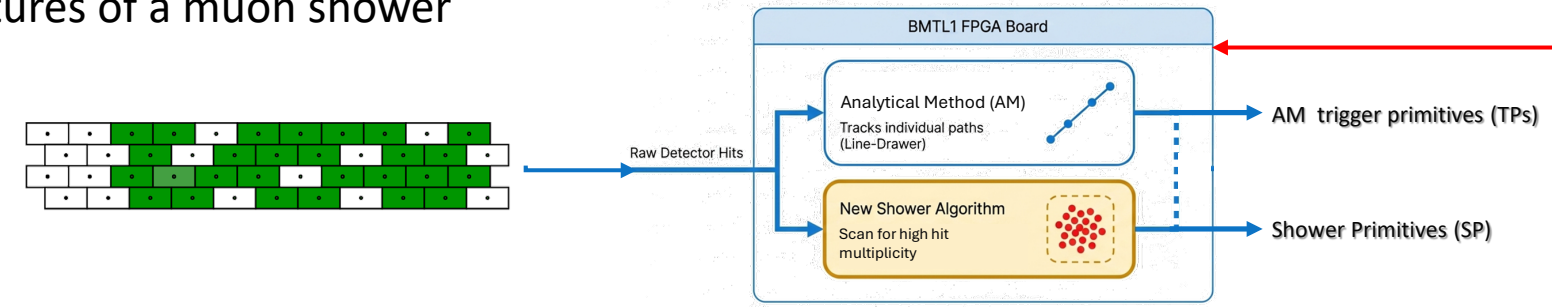
Long-lived particles (LLPs) can decay beyond the HCAL

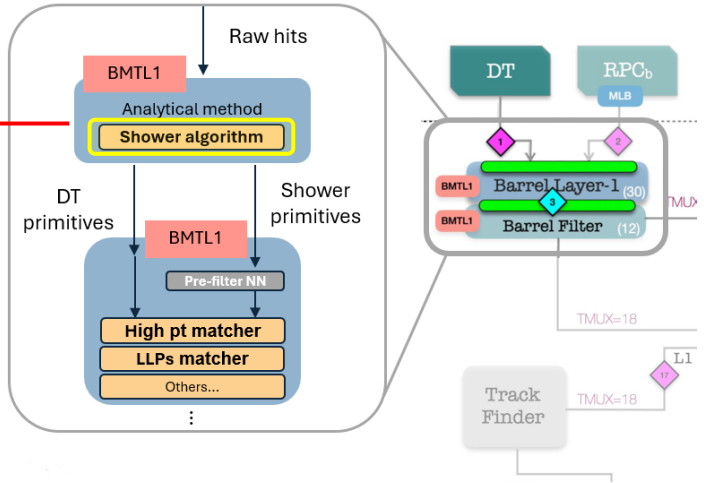
High-energetic **cosmic** muons

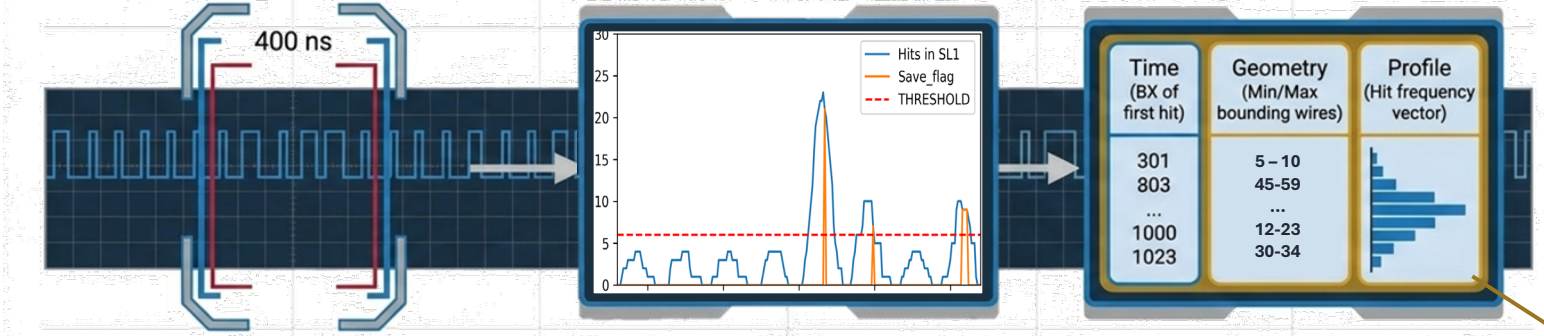


Step 1: construct shower primitives

Collect **high-hit multiplicity** information and reconstruct the presence and features of a muon shower



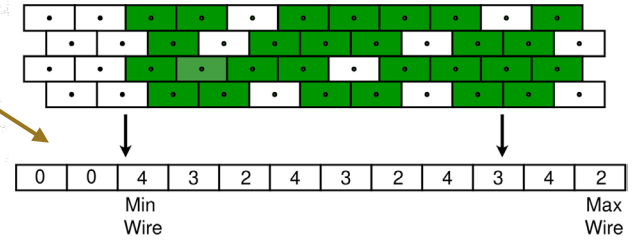




Accumulate Drift Tube hits in a strict 400 ns window (16 Bunch Crossings).

Does the hit count exceed the expected maximum for a normal muon?

If yes, package the data into a Shower Primitive (SP) payload.



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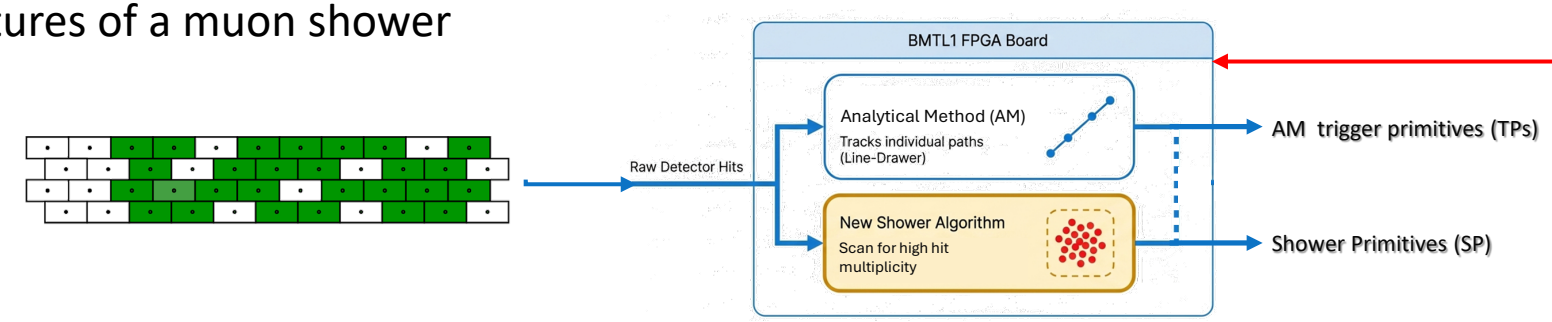
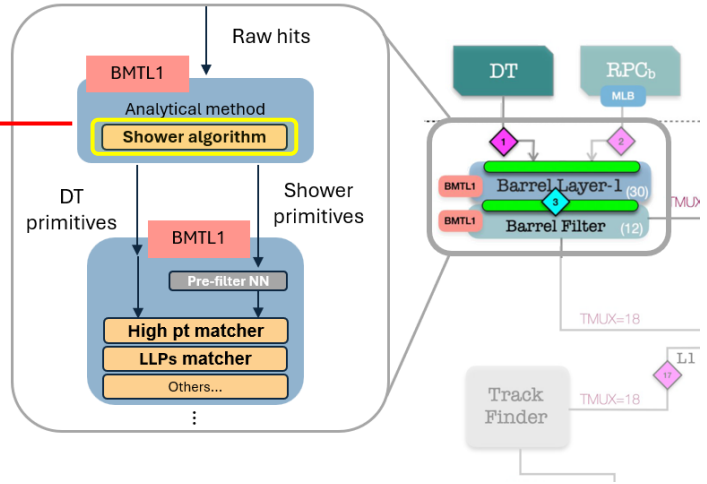
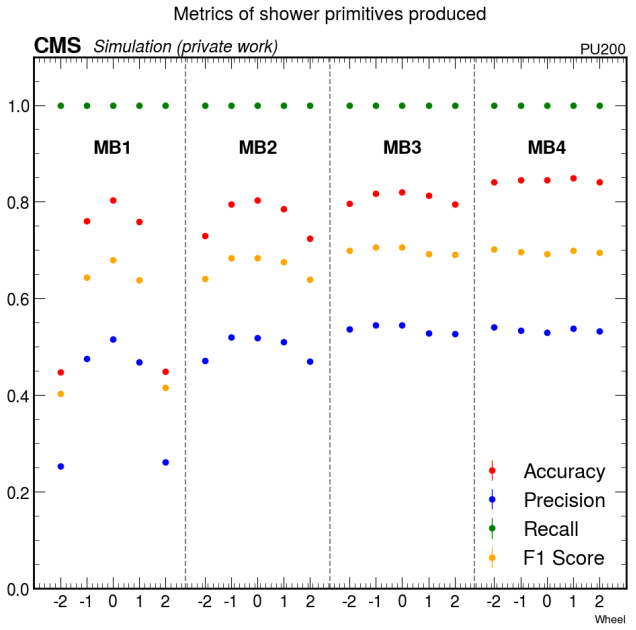
Collect **high-hit multiplicity** information and reconstruct the presence and features of a muon shower

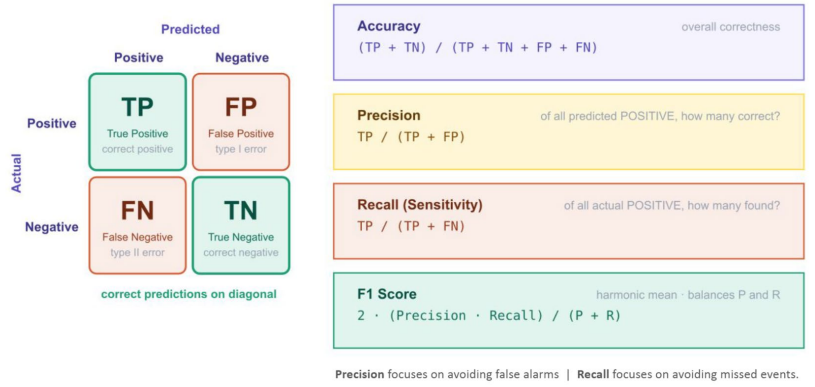




Simulation studies evaluated whether this simple approach can identify the shower.

- Fake cases remain frequent; threshold tuning and further refinements are required.
- **Current optimization prioritizes avoiding missed events.**





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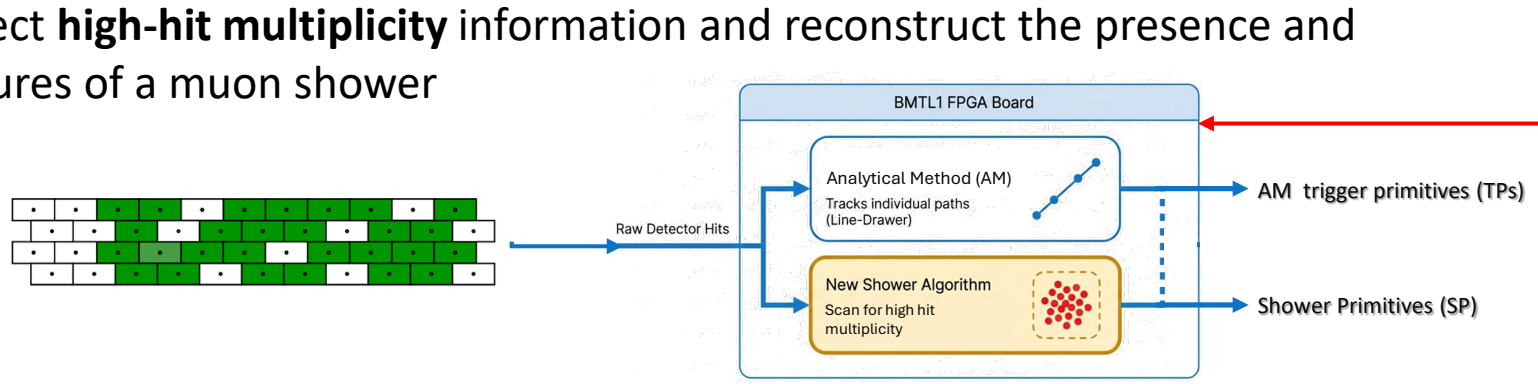
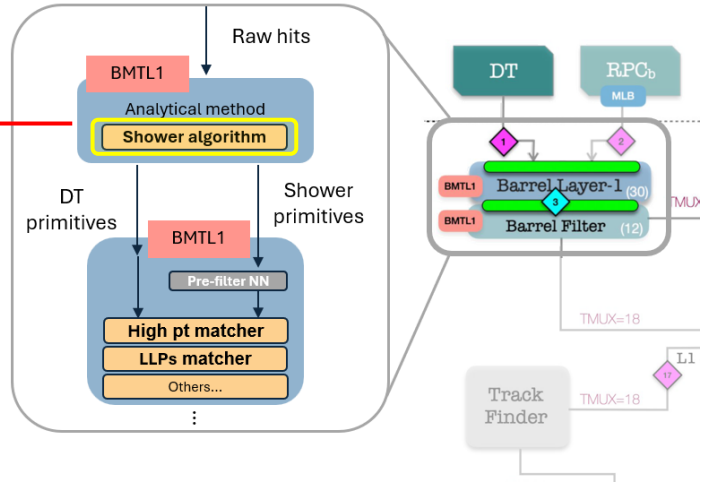
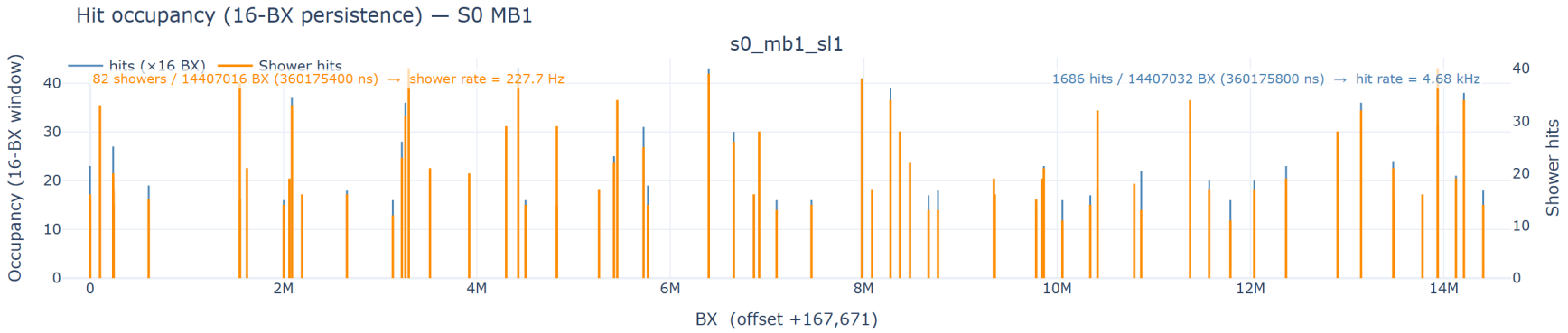
Collect **high-hit multiplicity** information and reconstruct the presence and features of a muon shower





A first version of this algorithm (firmware) has been deployed to record CMS data during slide test... (**couple of weeks ago**)

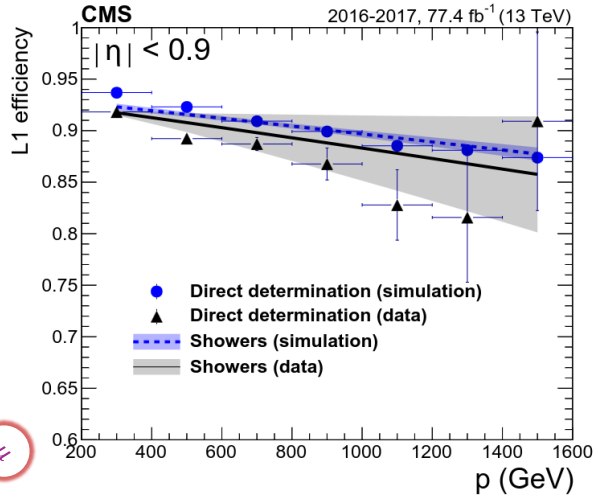


Next step: **Analyze these data** and verify whether observed behavior matches expectations

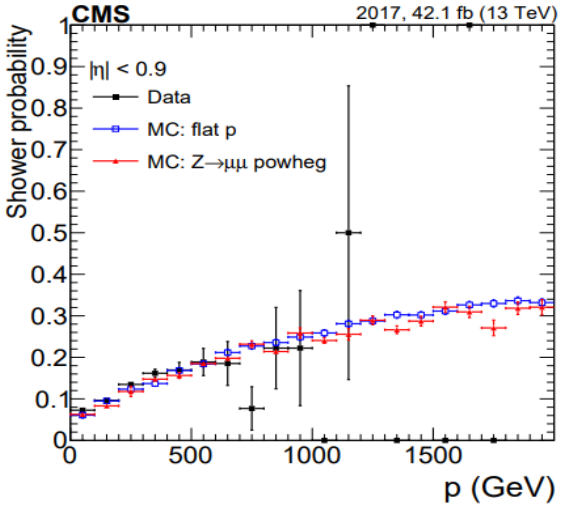
Step 2: use shower primitives

Use shower information to resolve interesting signatures...

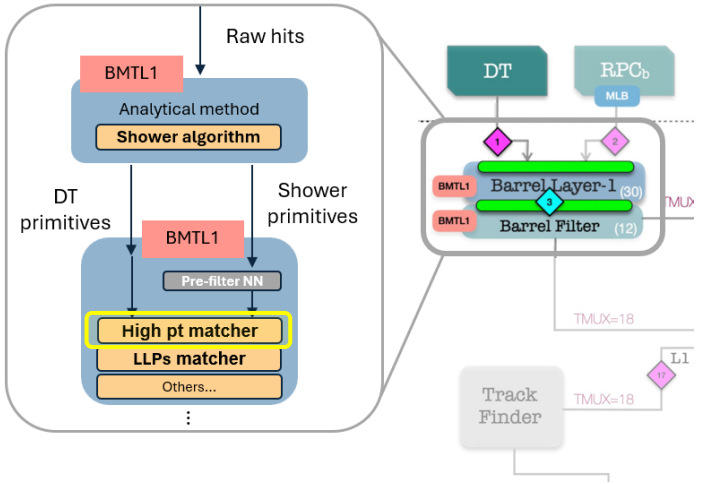
Trigger efficiency is reduce by wrong reconstructed muons

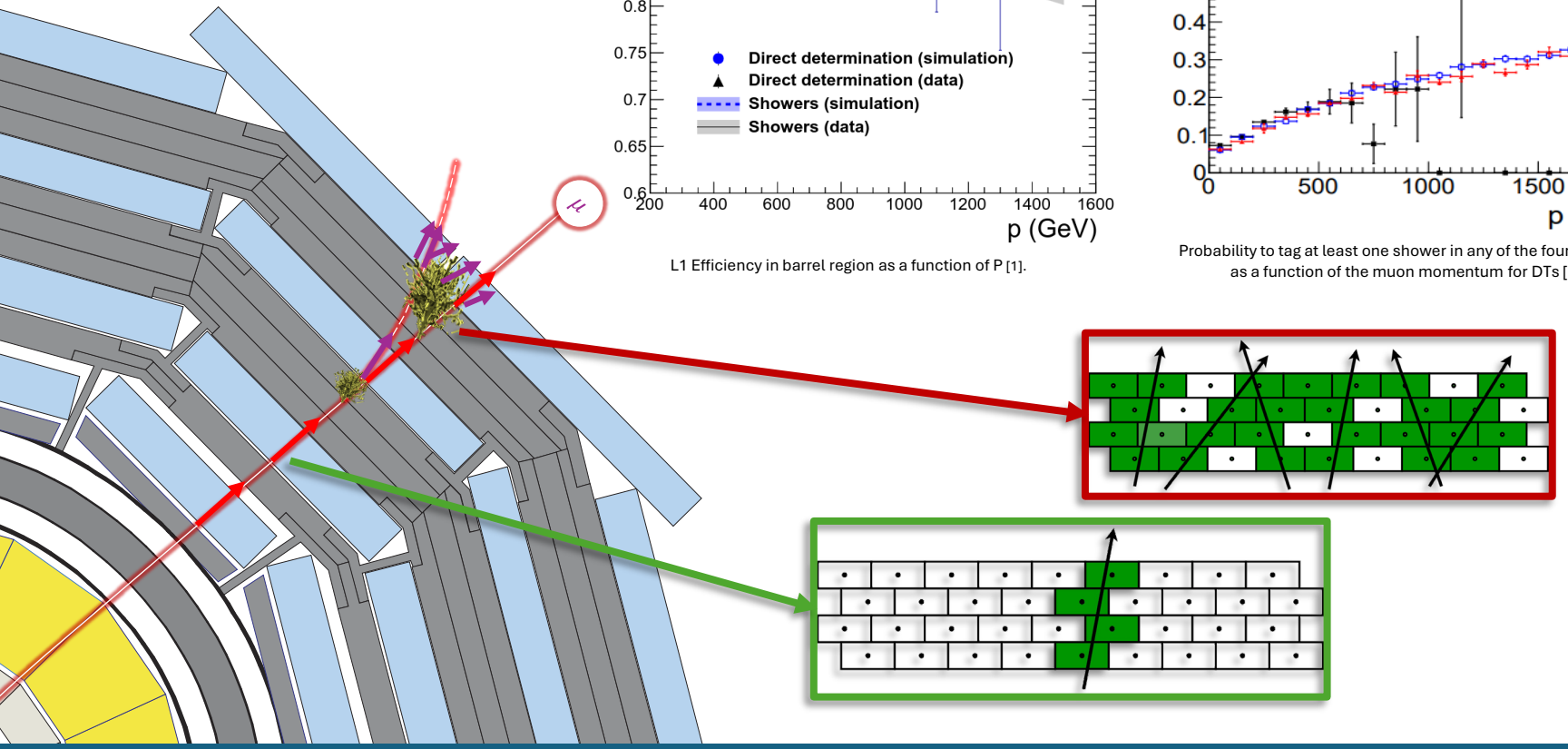


L1 Efficiency in barrel region as a function of P [1].



Probability to tag at least one shower in any of the four stations, as a function of the muon momentum for DTs [1].

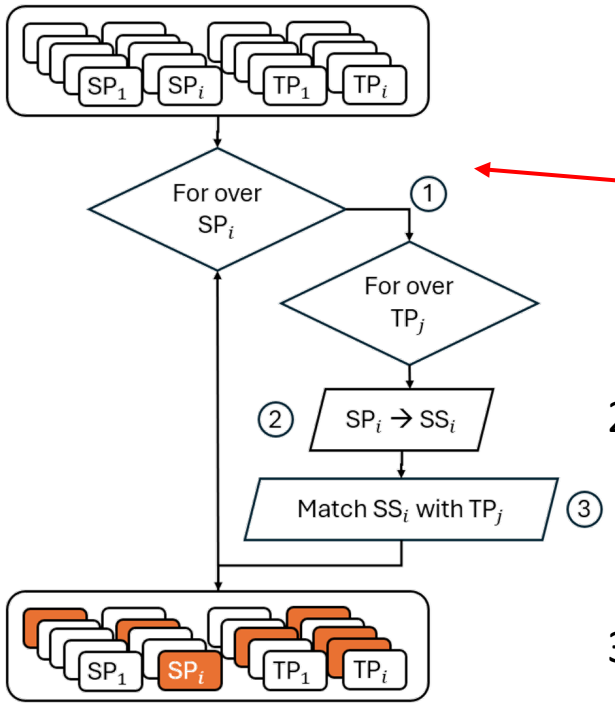


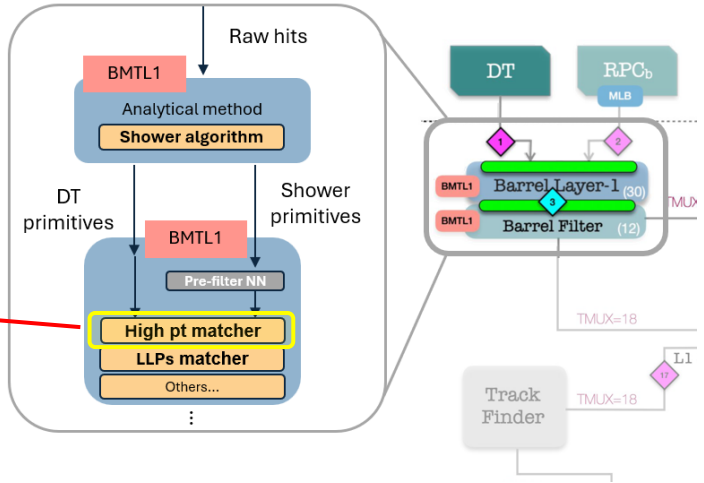


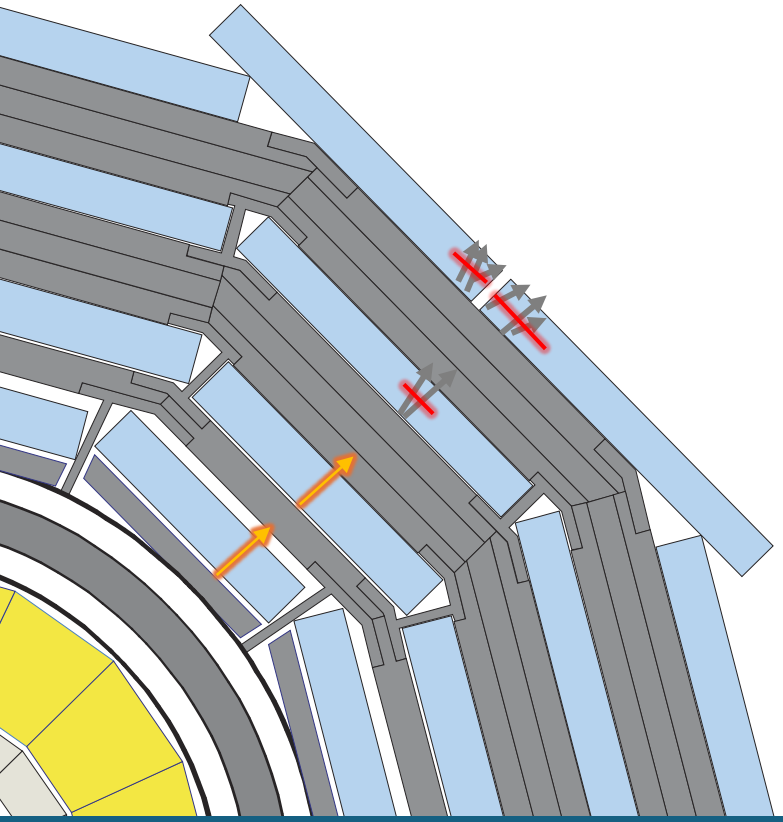
Step 2: use shower primitives

Use shower information to resolve interesting signatures...

1. For each shower, scan all TPs in adjacent sectors within a single wheel.







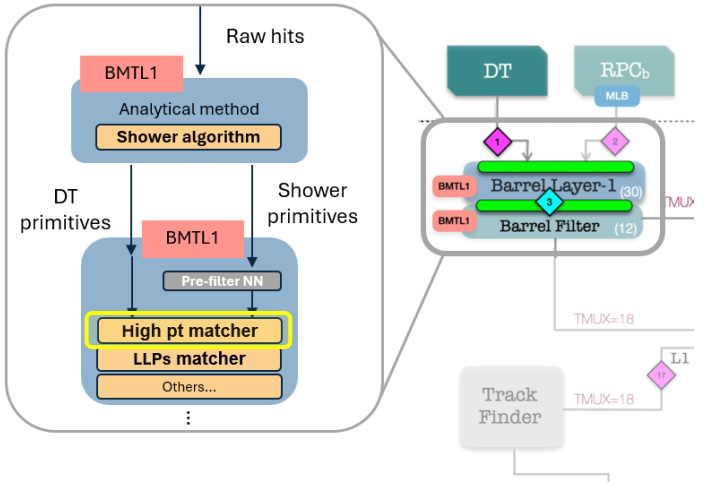
2. Represent the shower as a segment (SS) based on the Min and Max wire

3. Tag TPs that point to a SS

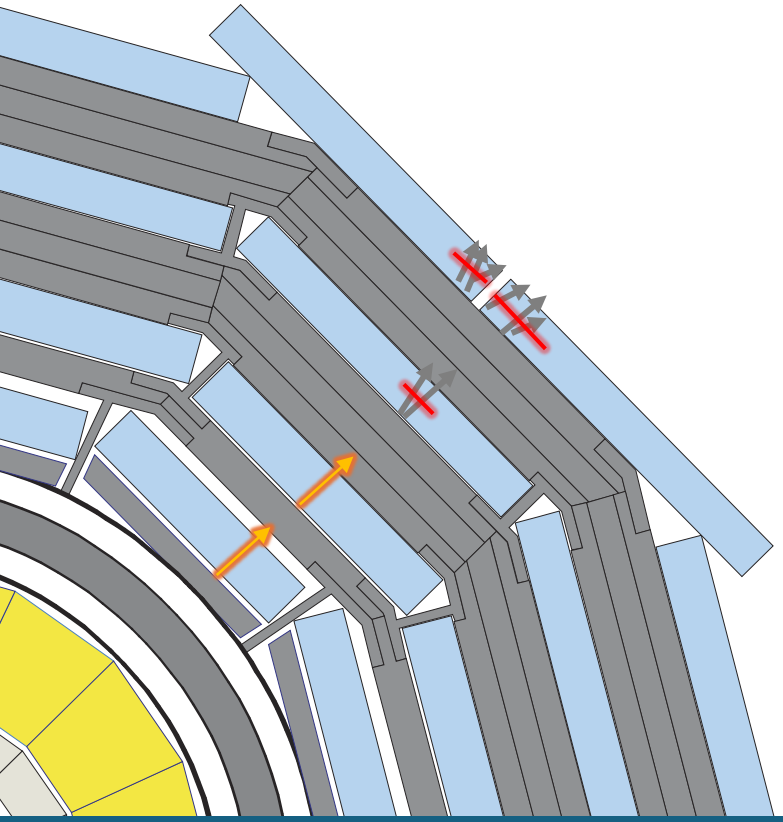
Goal: make **tracking-trigger algorithms** aware of showers in a muon path, so **affected measurements** can be excluded or treated cautiously.

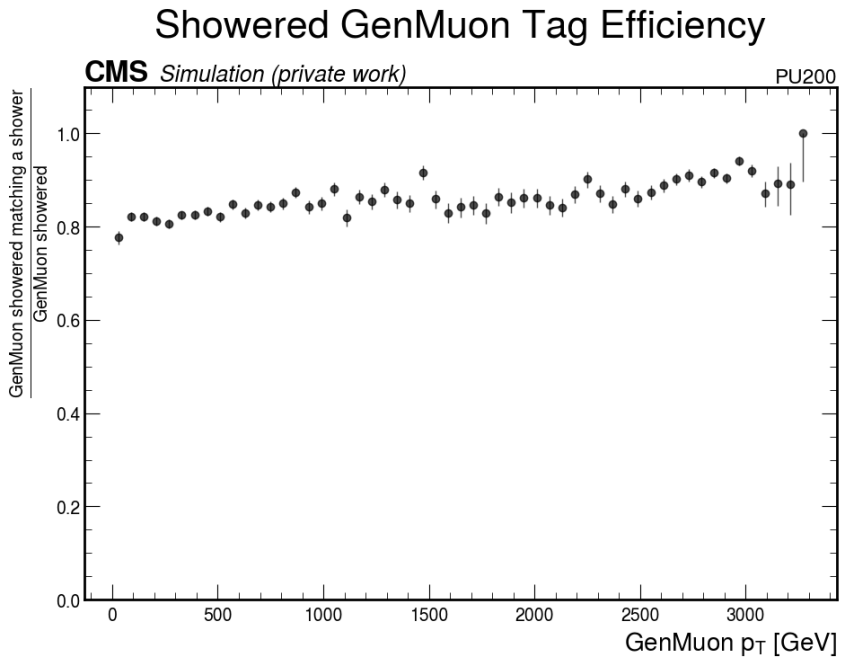
Step 2: use shower primitives

Use shower information to resolve interesting signatures...

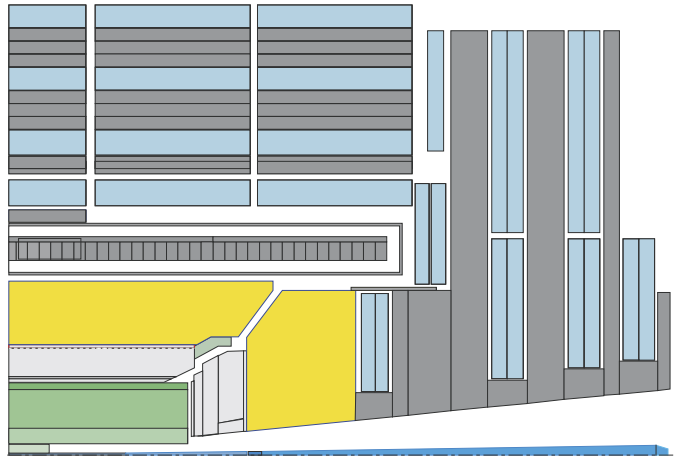


Simulation identifies muons that radiate with more than **80% efficiency**.





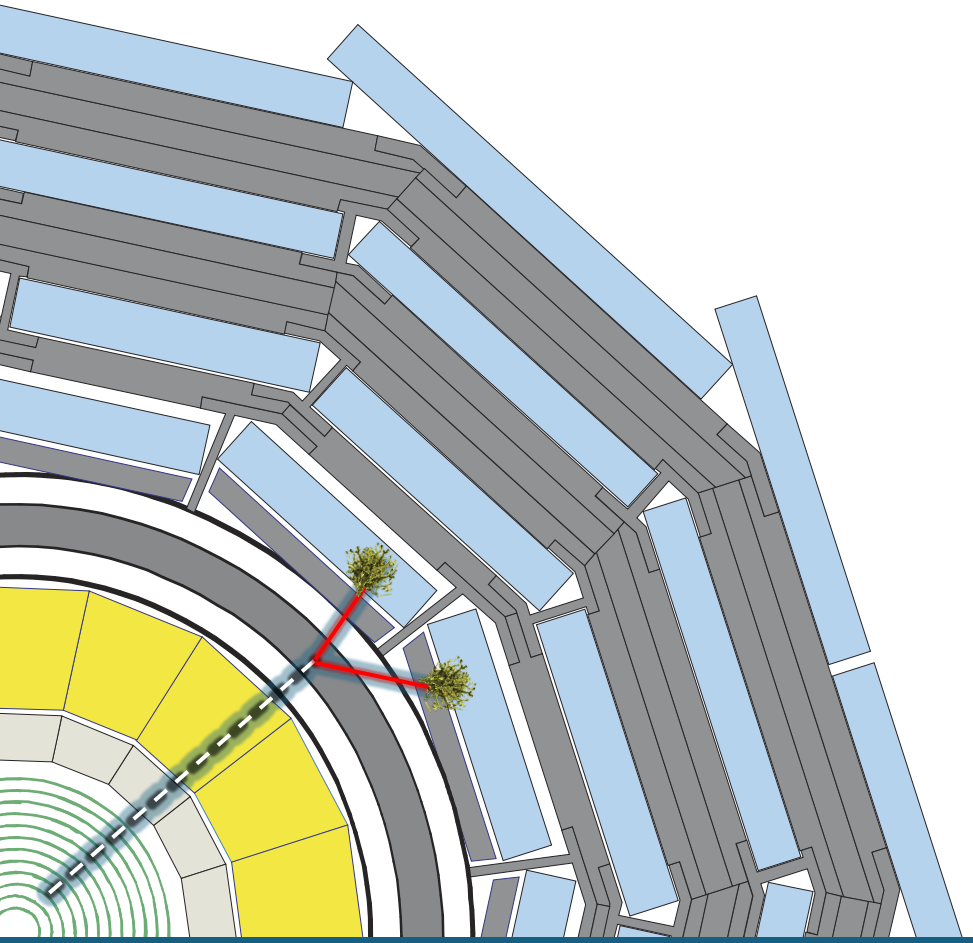
Hardware implementation is now **under development**.

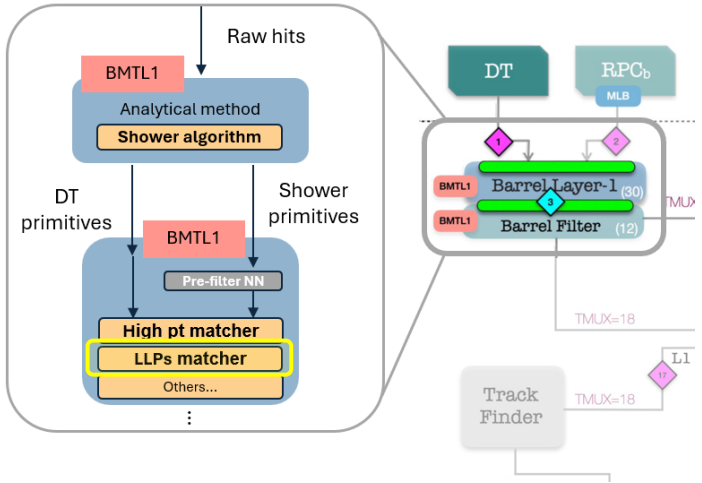


The logic will also be **extended to the longitudinal view** of the experiment.

Step 2: use shower primitives

Use shower information to resolve interesting signatures...





Next studies will evaluate **how SPs** can identify **displaced vertices**, a potential signature of **LLPs**.

Thank you

Questions?