Triggering on Muon Showers

42nd International Conference on High Energy Physics

July 2024

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On behalf of the CMS collaboration

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Introduction:

- **HL-LHC** will open up an unprecedented opportunity for HEP: **high-precision SM measurements** and **extending BSM searches.**
- The **detector readout electronics** and **DAQ** will be **upgraded** to allow an increased L1 trigger rate (750 kHz) and latency of 12.5 μs.
- Goal: select events that are likely to contain **interesting muon-related information** to extend physics program.

CMS-TDR-021

Background:

- The Analytical Method (AM) produces compatible straight line muon trigger primitivesfrom the adjacent drift tube cells.
- Implemented in dedicated FPGA boards for simultaneous readout of the Drift tubes(DT) + Resistive plate chamber (RPC) system. **Matching segments within a 25ns window is 99% efficient**.
- In case of a muon shower, multiple cells will be active in a small area, producing a combinatorial explosion of many possible trigger primitives, producing **spurious data** and **taking too long to process.**

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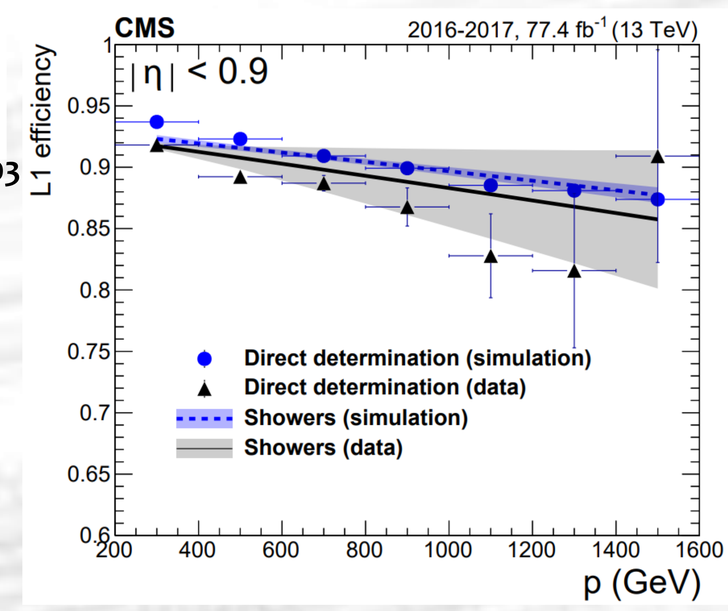
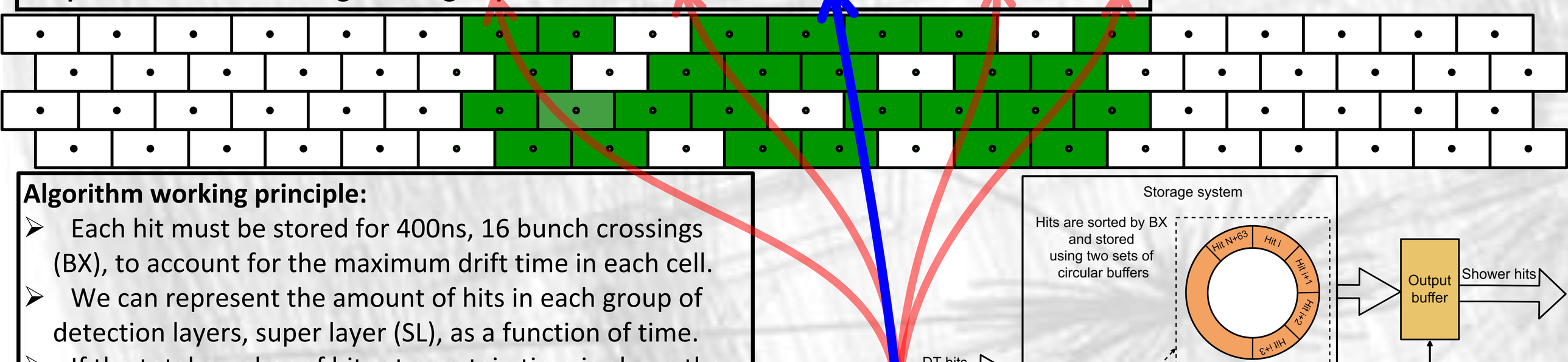


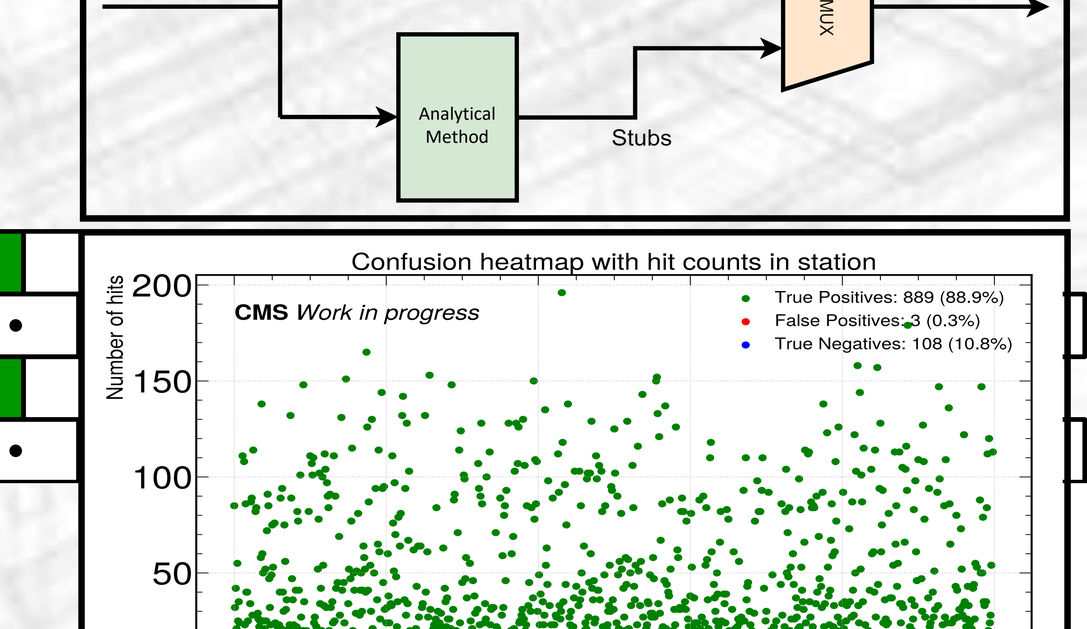
Physics motivations:

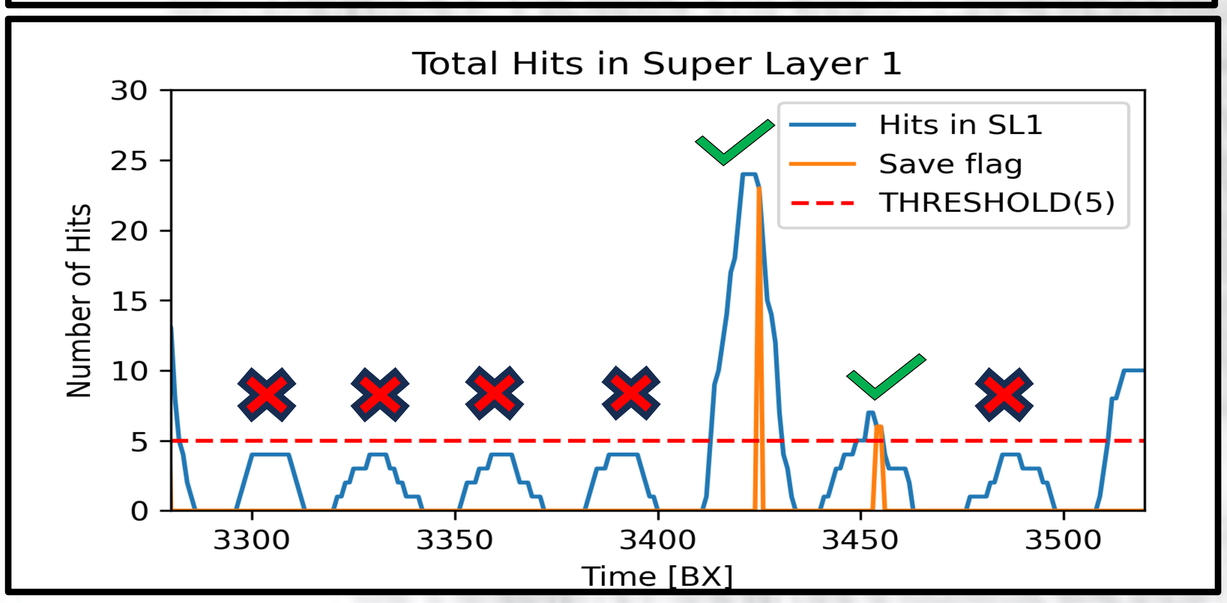
- Particle shower identification for high momentum muon tagging and **hadronic shower reconstruction**.
- Extended sensitivity for long-lived particles.
- Improved efficiency of the Analytical Method.

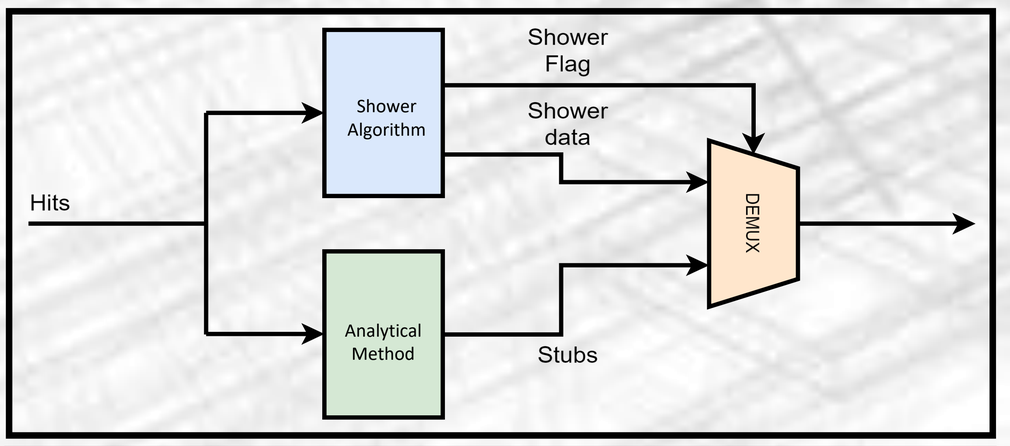


Algorithm working principle:

- Each hit must be stored for 400ns, 16 bunch crossings (BX), to account for the maximum drift time in each cell.
- We can represent the amount of hits in each group of detection layers, super layer (SL), as a function of time.
- If the total number of hits at a certain time is above the threshold, the event is flagged as a shower.
- A peak detector is used to trigger the data recolection only after the maximum amount of hits is reached.







Results:

To test the algorithm, a private simulator in Geant4 was used, generating 1000 events of $p_T = 2\ TeV$.

- Efficiencies **>99%** for tagging events that produced electrons due to radiation.
- **88%** of the hits corresponding to the shower are recovered due to the logic of the algortihm.
- Preliminary FPGA resource consumption using XCVU13PXCVU13X:
  |8K/1.7M LUTS |101K/3.45M CLB|

From 1000 events produced, 997 were correctly identified. A clear division between shower and non radiating events is shown.