CMS iRPC cluster finding algorithm in Backend electronics

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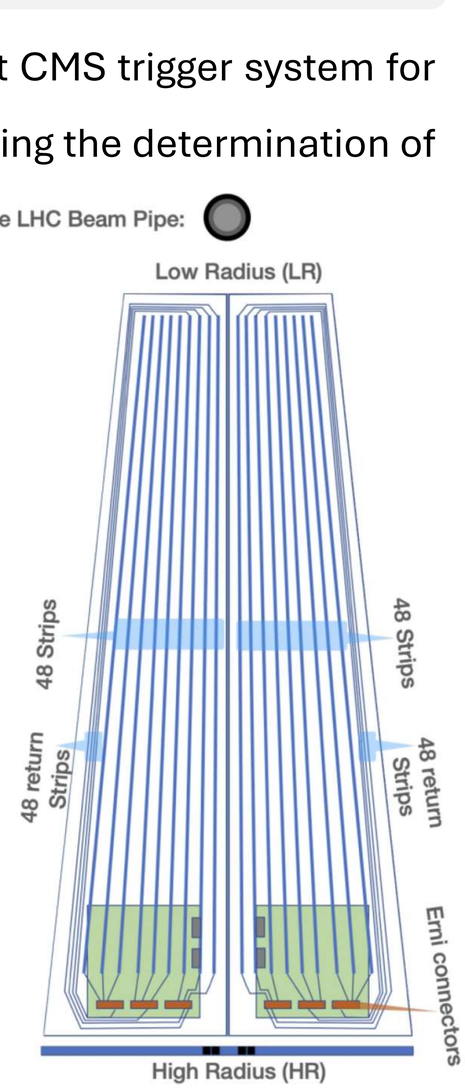
Abstract

One of the primary objectives of the iRPC detector is to address the efficiency drop experienced by the current CMS trigger system for single muon triggers in the high eta region. The iRPC detector features **a double-ended read-out** method, allowing the determination of the hit position along the strip using the time difference between signals from both ends.

To fully utilize this feature and integrate iRPC cluster information into the CMS trigger system, a **segment-based 2-Dimensional** (2D) cluster finding algorithm was proposed. This algorithm was implement in FPGA device in Backend Electronics, providing the 2D coordinates to CMS Level-1 trigger system.



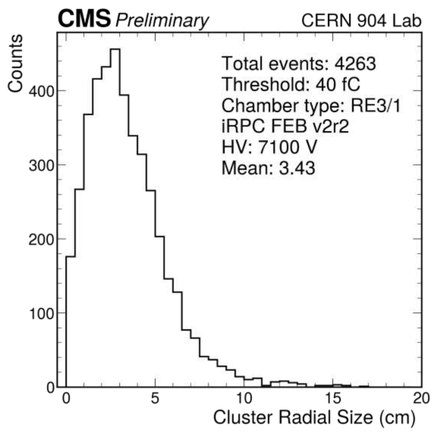
iRPC strips and readout

iRPC cluster geometric features

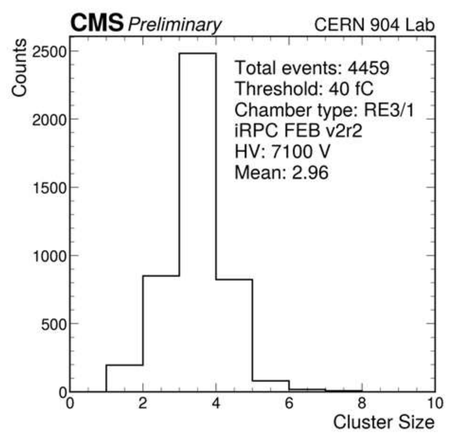
Cluster geometric features study in 2 dimensions :

- Cluster size: **the number of continuous fired strips** when a muon passes the chamber.
- Cluster radial size: **the maximum hit position difference** along the strip within a cluster.

The study was done with a **cosmic muon setup** and one RE31 Chamber. The chamber was set at a Working high voltage point of 7.1 kV and the FEB threshold is 40 fC.



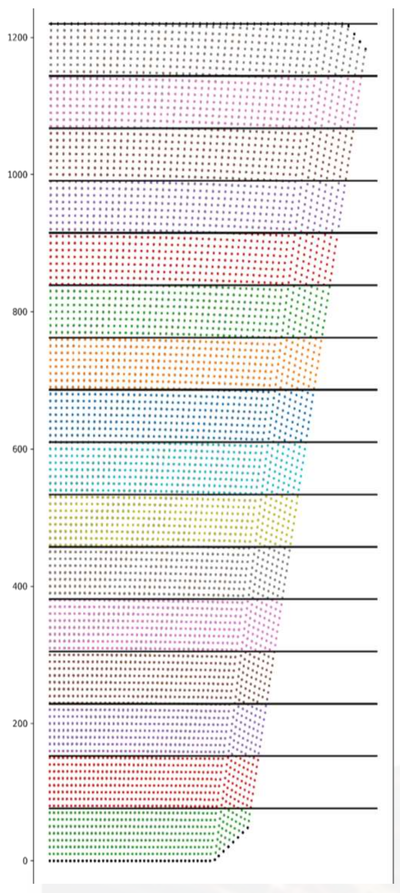
Cluster radial size distribution



Cluster size distribution

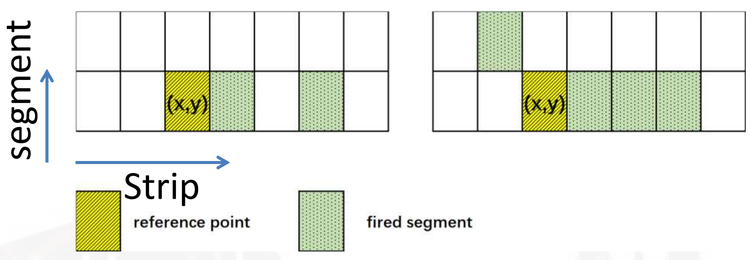
Algo & implementation in FPGA

- The main idea on the algorithm is the **strip segmentation**, use parallel boundaries to eliminate the geometric effect (non-standard trapezoid strip profile).



Strip segmentation

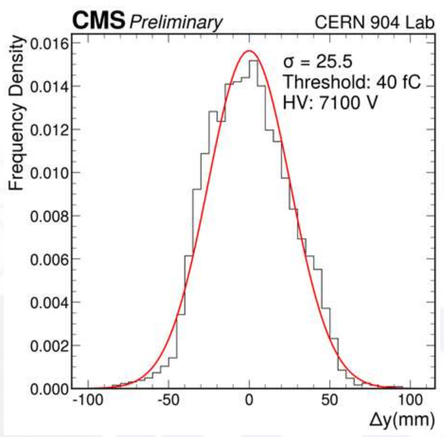
- **Sliding area of interest** is used to search clusters within the chamber. Sliding area size = **2 segments* 7 strips**.
- The segment length is decided to be **9.1 cm**, related to **16** segments per strip on RE3/1 Chamber. Sliding area of interest coverage efficiency is around **99.3%**.
- Examples:



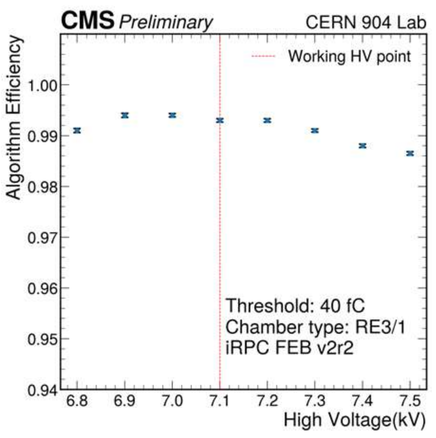
- Coordinates determination based on the weight in the sliding area of interest.
- Cluster center: **Left: (x+1.5,y); Right: (x+1,y+0.5)**

Algo performance results

- **Position output precision**: the difference between offline reconstructed position and cluster finding algorithm output position. The study demonstrated a precision of 25.5 mm with a segment length of 9.1 cm, yielding an effective spatial resolution of 2.97 cm when combined with the spatial resolution of the iRPC, which is 1.5 cm.
- **Algorithm efficiency**: the ratio of the events with acceptable cluster finding output to the events with acceptable offline reconstructed output. >99% efficiency shown at the working high voltage.



Position output precision (along the strip)



Algorithm efficiency (Working point highlighted)