GOETHE UNIVERSITÄT FRANKFURT AM MAIN

DPG

Online data pre-processing for the CBM MVD

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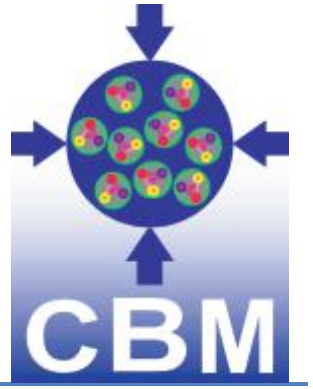
for the CBM-MVD Collaboration



Outline

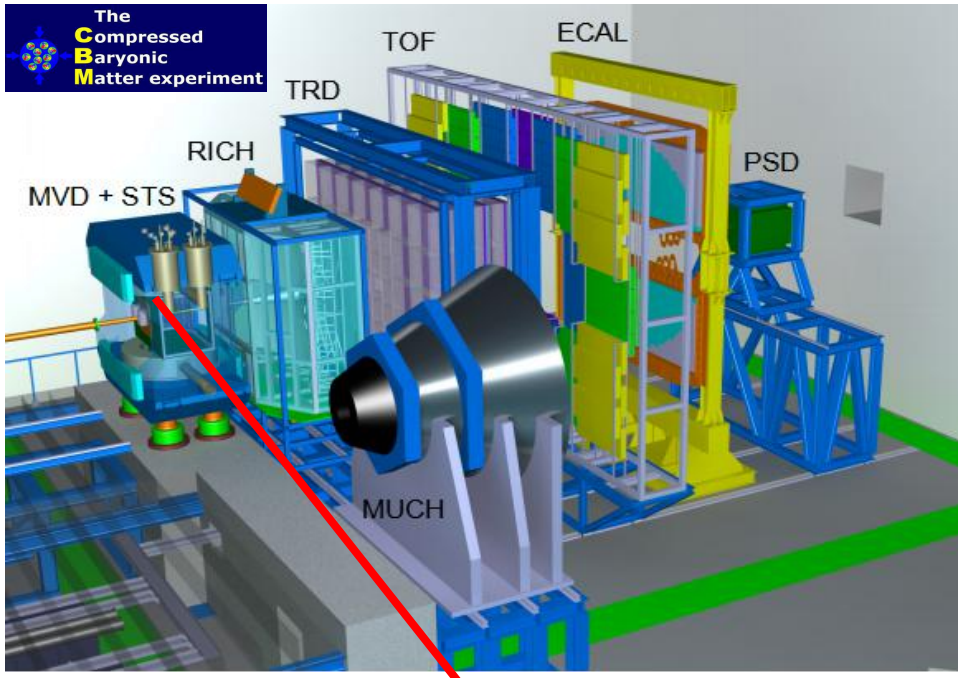
- Strategy and requirements
- Implementation on FPGA
- Results in real time test
- Summary

Introduction

- **CBM: high rate experiment,** collision rates of
  10^7 Au+Au coll/s, 10^9 p+A coll/s

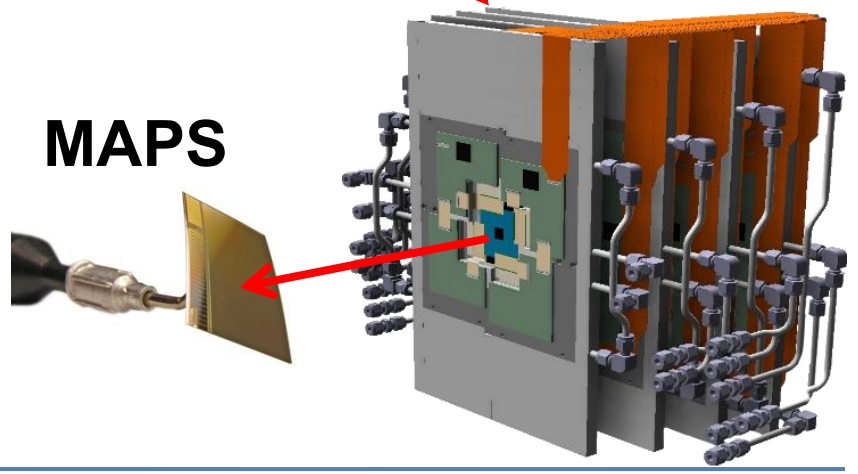
- **Micro-Vertex-Detector (MVD)**
  Requires high spation resolution: 5µm, 0.3% X_0
  Operates at high particle fluxes (70 MHz/cm²)
  --> High radiation dose
  --> High data rate

- **CMOS Monolithic Pixel Sensors(MAPS)**
  are used for the CBM-MVD
  MIMOSA-26 is the sensor for the MVD prototype



MVD

MAPS

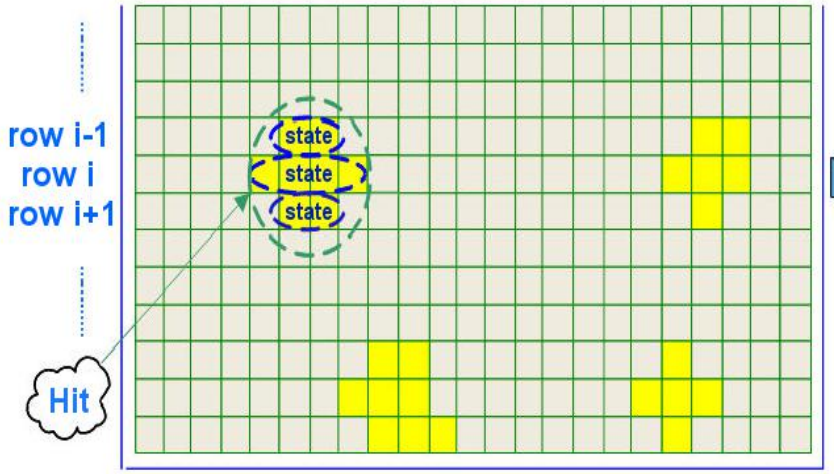


Question and approach

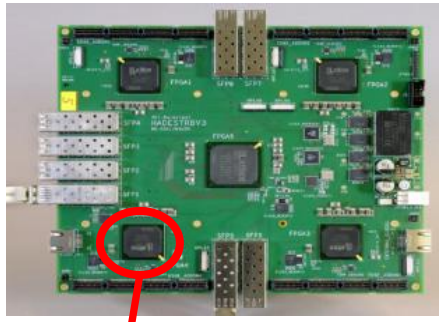
- Charge sharing on MAPS

=> One particle hit creates 2-dimensional cluster

=> Cluster finding is needed



Readout Control Board



Raw data

Cluster data

Computer farm: FLES

Clusters

CPU cluster finding

tracking, event reconstruction...

On-chip electronic: 0-compression and 1-dim cluster finding

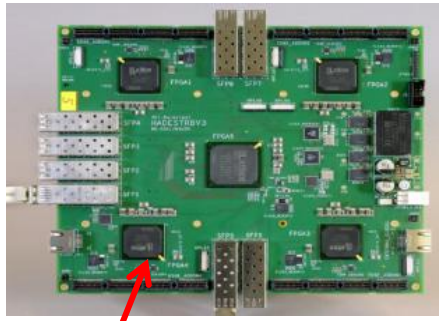
2-dim cluster finding on the FPGA of MVD-ROC with it's un-used resource to reduce CPU-time

Benchmark of software (CbmRoot): uses sizable fraction of the computing time

Requirements

Real time

Readout Control Board



Resource limited

Cluster data

Bandwidth limited

Unpacking cluster data needs time

Computer farm: FLES

unpack cluster data

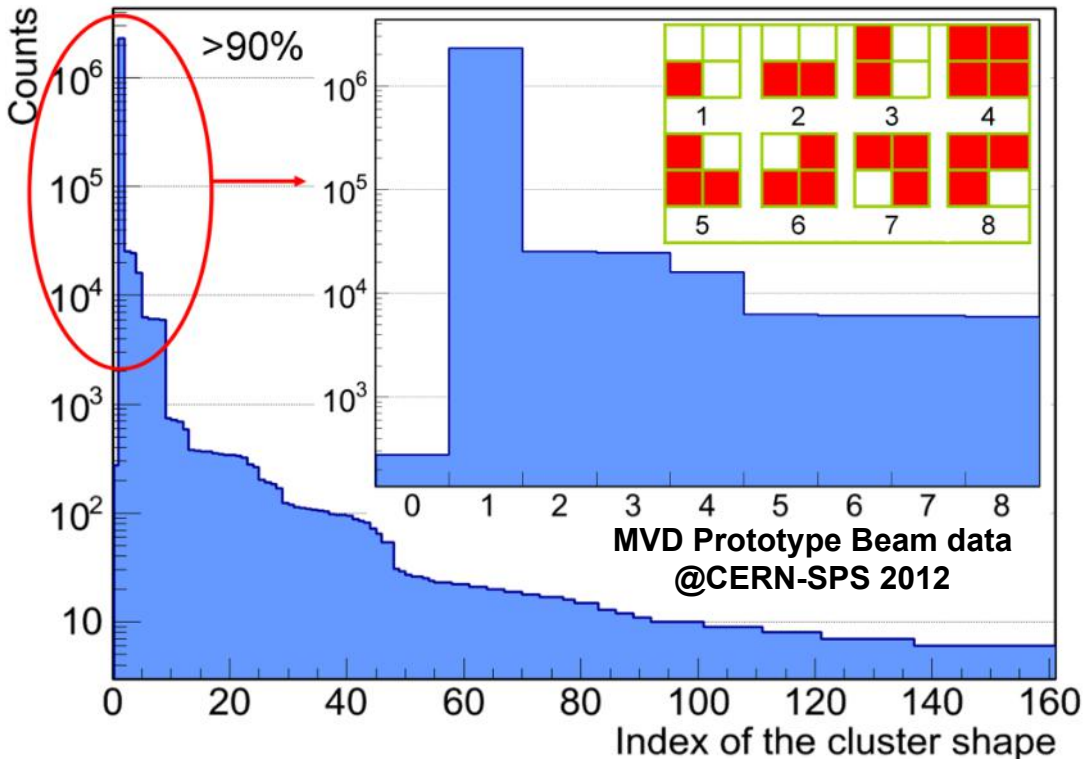
tracking, event reconstruction...

Refined processing should be possible

Requirements:

- Real time operation
- Cluster data encoding must not lose information and be feasible on FPGA
- Data volume must not be expanded
- Cluster data decoding must be efficient on CPU

Basic strategy



- **Study the cluster feature based on MVD prototype**
- **Observation:**

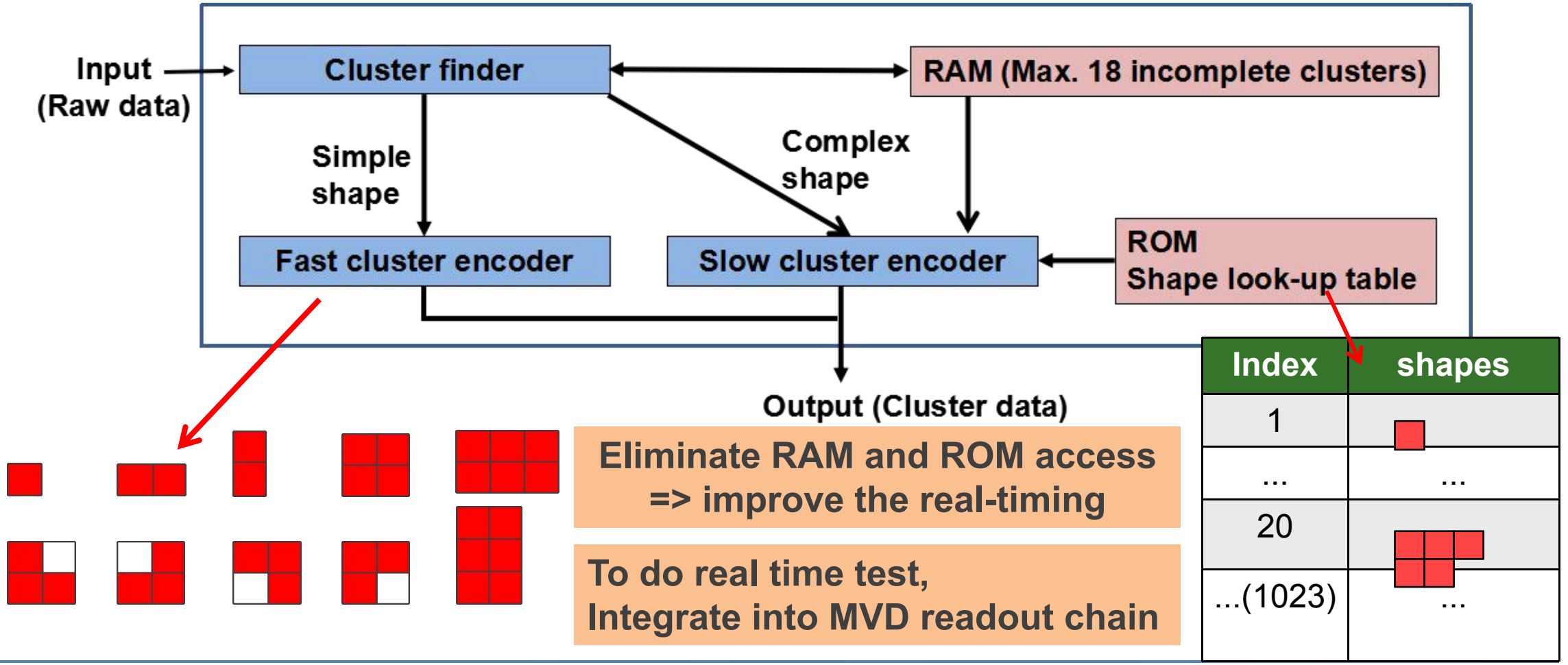
  Only a limited number of different cluster shapes
- **Idea:**
  - Associate an **index** to each cluster shape.
  - Send cluster index instead of shape information
  - Decode cluster index with look-up table.
- **Encoding way:**
  - 21 bits for cluster position
  - 10 bits for shape information

  => 32 bits per cluster is needed

31	Bit(21-30)	Bit(10-20)	Bit(0-9)
OVF	Index of Shape	Addr_Col	Addr_Row

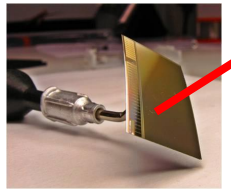
Implementation on FPGA

- **FPGA cluster finding logic structure**

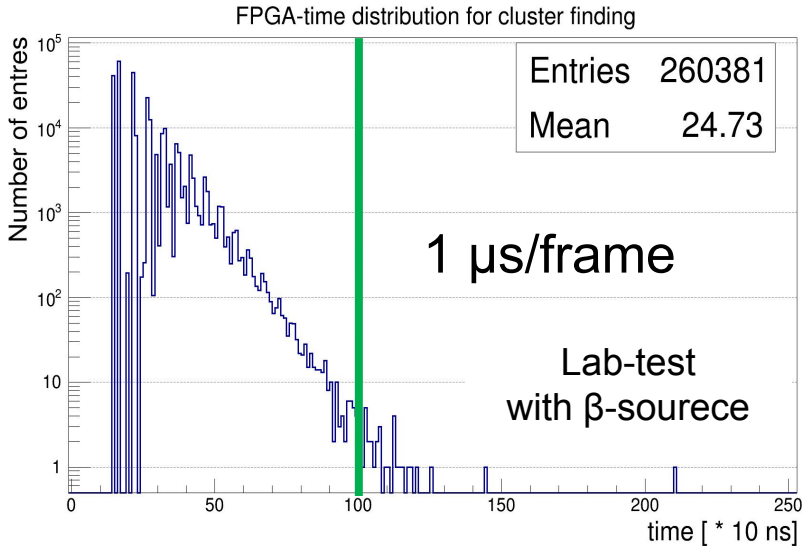


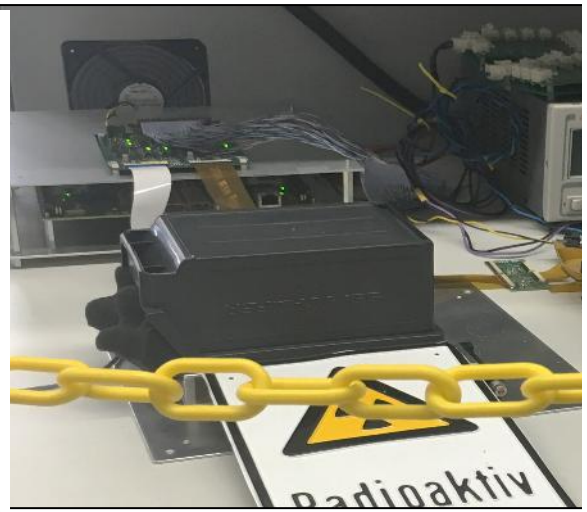
Result in Lab test

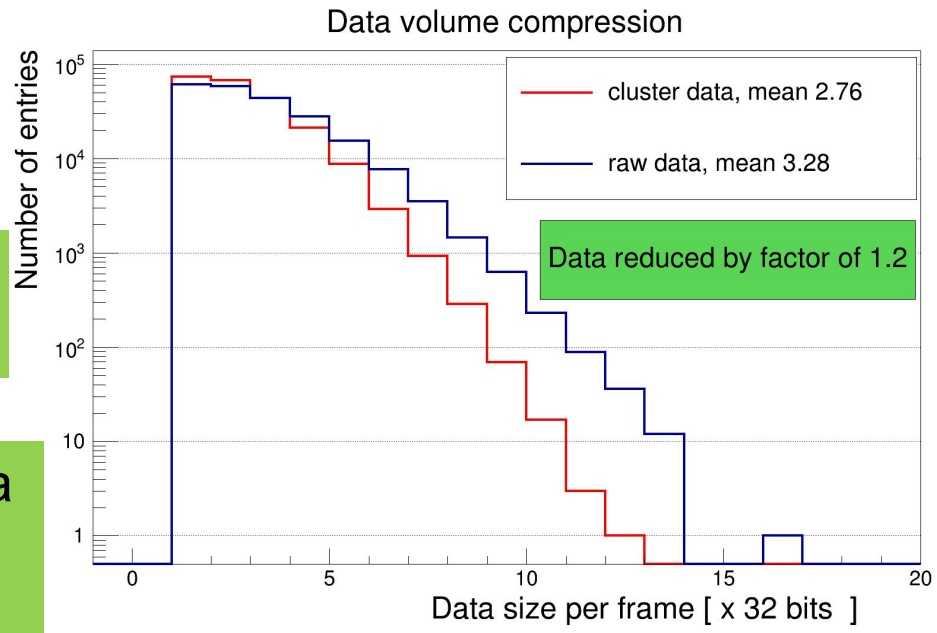
MIMOSA26,
illuminated with ^{55}Fe

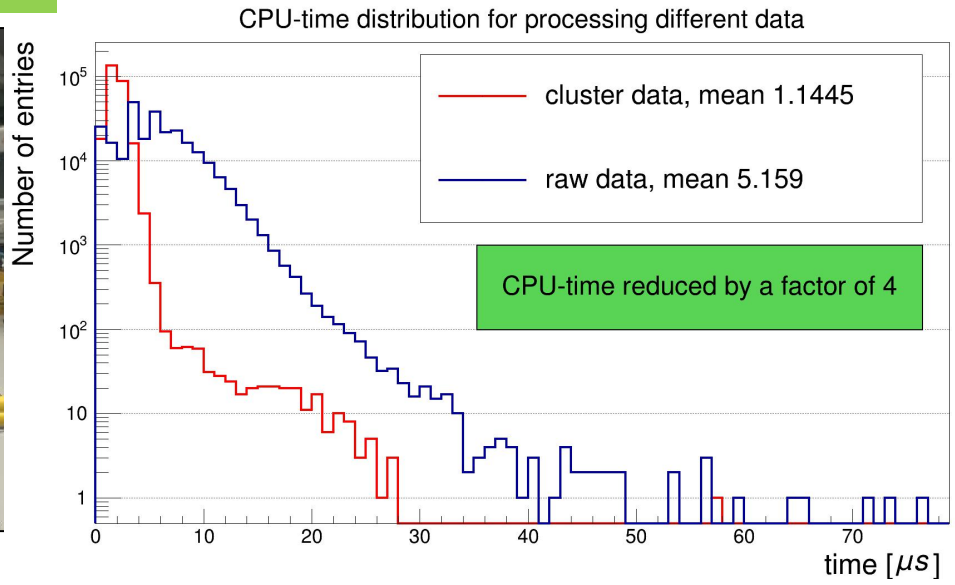


Cluster data vs Raw data
260K frames
No data loss





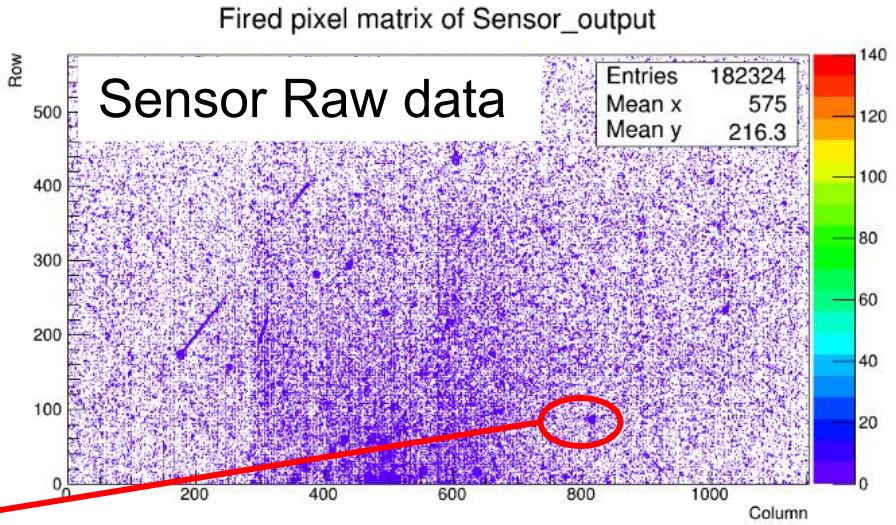


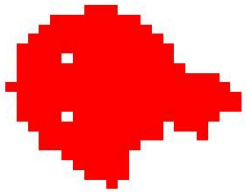


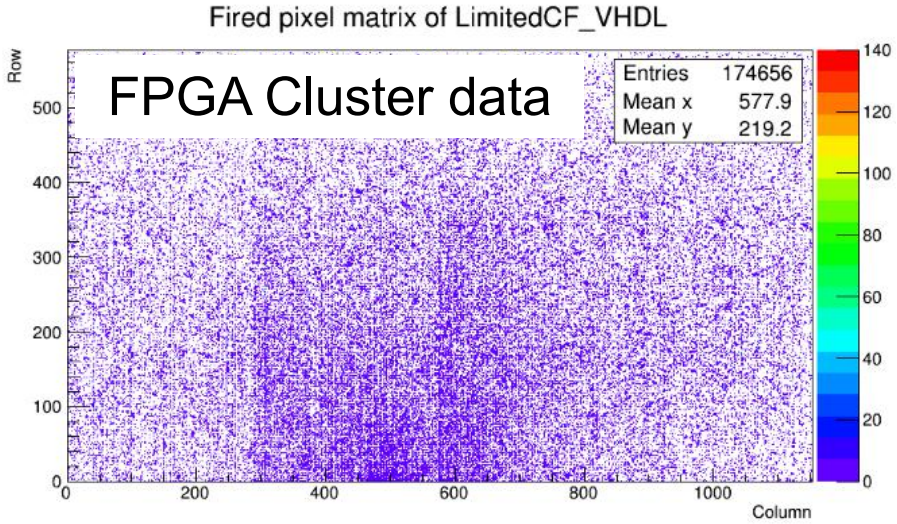
Robustness test with heavy ion experiment data

Courtesy NA61/SHINE

156 AGeV Pb+Pb in 2016

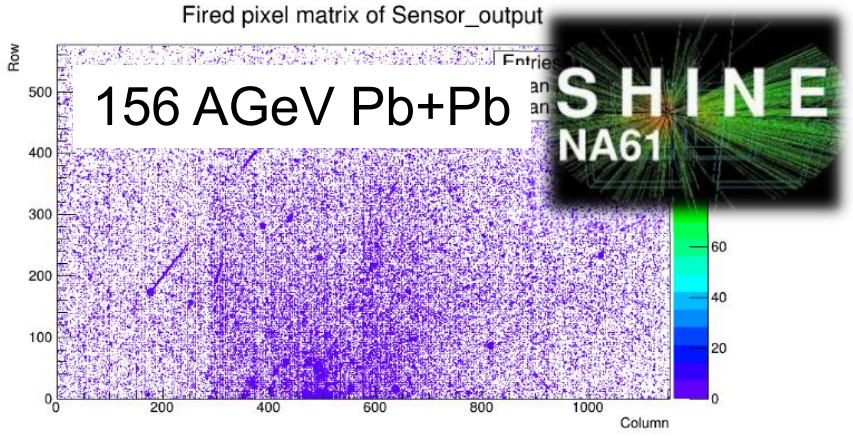


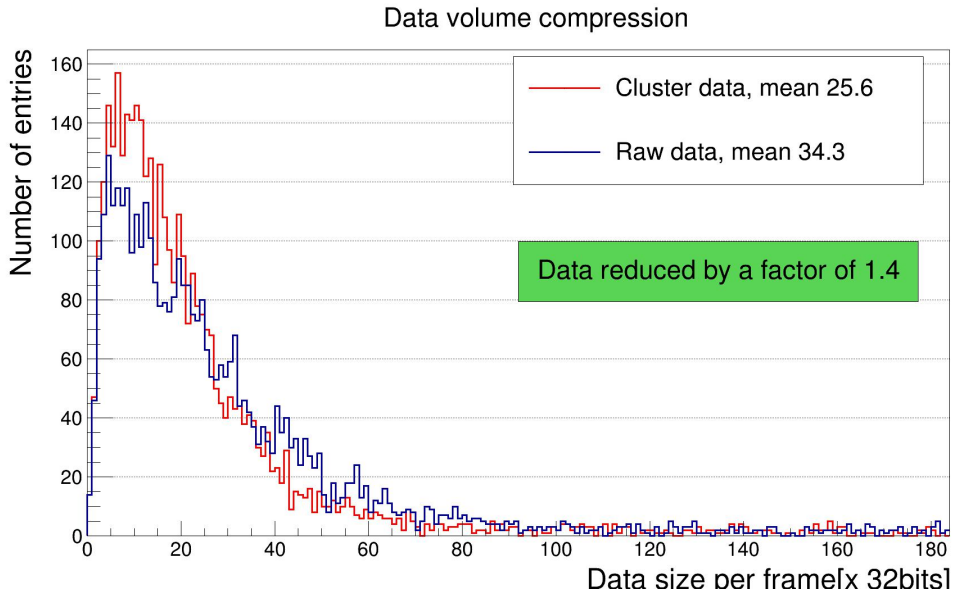


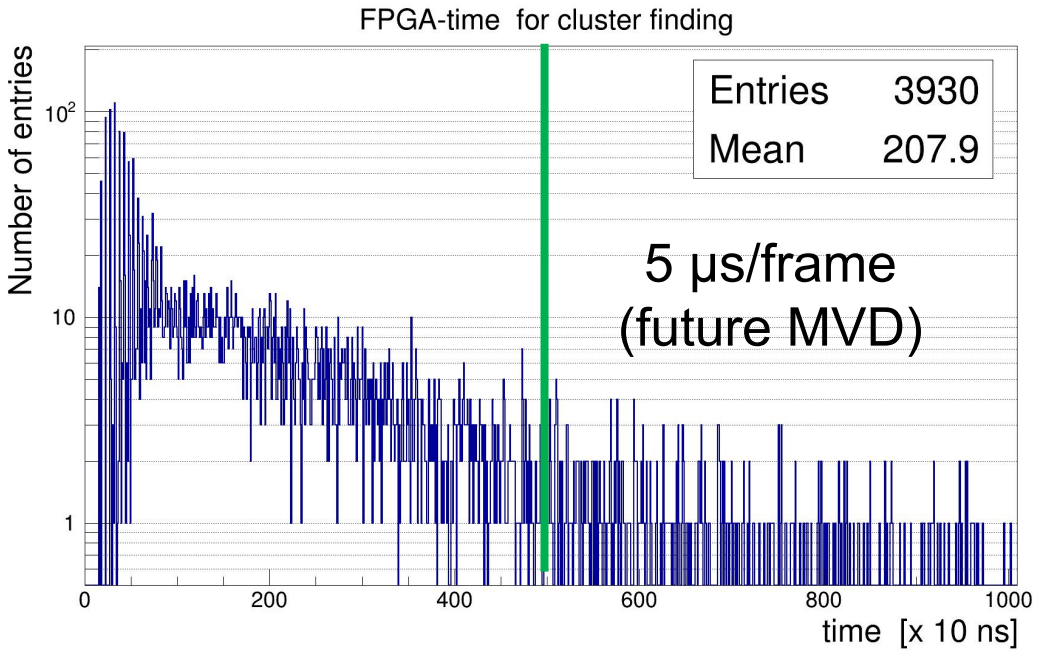


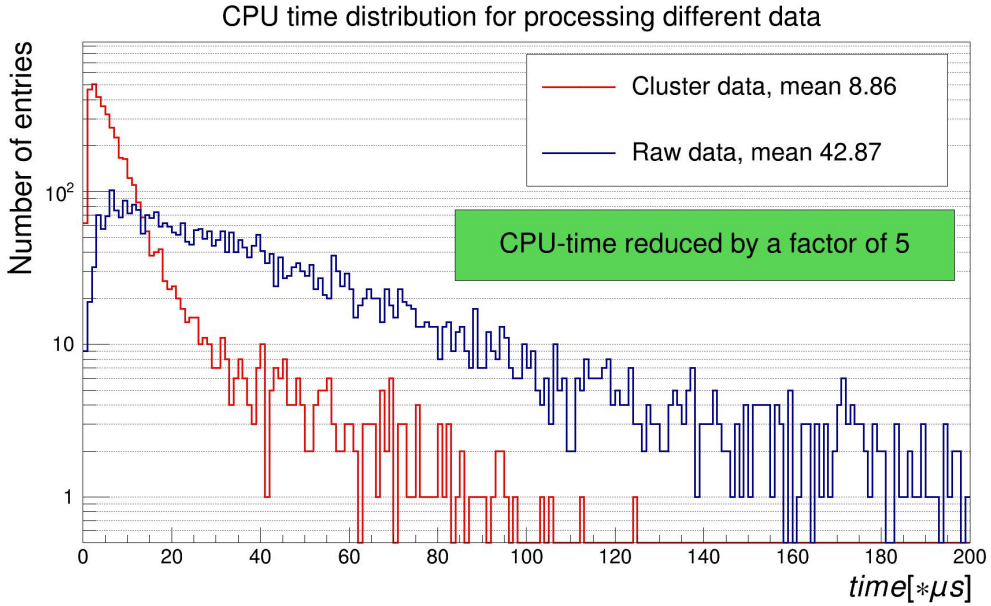
- 3% data loss in 4K frames
  - big clusters can not be encoded
  - broken line, overflow
  - Background of physics case, acceptable
- Works reliably

Result in Robustness test









Summary

- FPGA Cluster finding is designed and implemented in the MVD-ROC
- Real time is demonstrated by operating with MIMOSA26 in Lab-test
- The robustness is checked with heavy ion experiment data (NA61/SHINE Pb+Pb)
  => Works reliably, CPU-time reduced ~ 5, Data volume slightly reduced

Successfully demonstrates the potential and need of pre-processing the MVD raw data!

Thank you for your attention!