The CBM-TRD Cluster Finder

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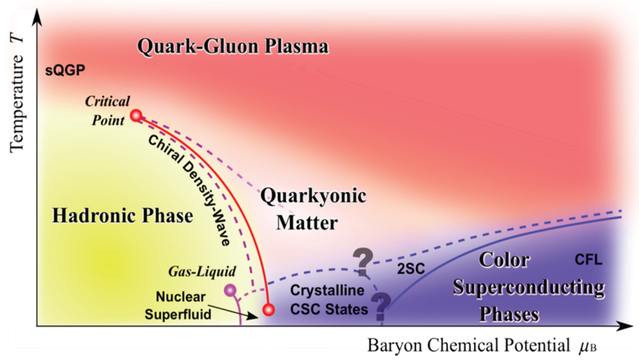
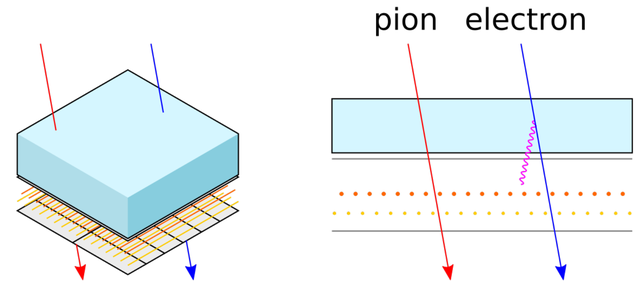
The Compressed Baryonic Matter Experiment



- Explore phase diagram at high net-baryon densities
- Focus on rare particles as probes
- Requires unprecedented statistics

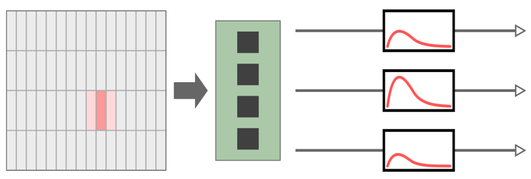


- CBM-TRD consists of 4 layers
- Channel density increasing towards center
- 84,432 channels per layer, 329,728 channels total
- One of the biggest data producers
- Great candidate for preprocessing in the FPGA
- 4D online event selection to limit data volume
- FPGA preprocessing to aid computational load

TRD Readout ASIC

SPADIC
Self triggered Pulse Amplification and Digitization asIC

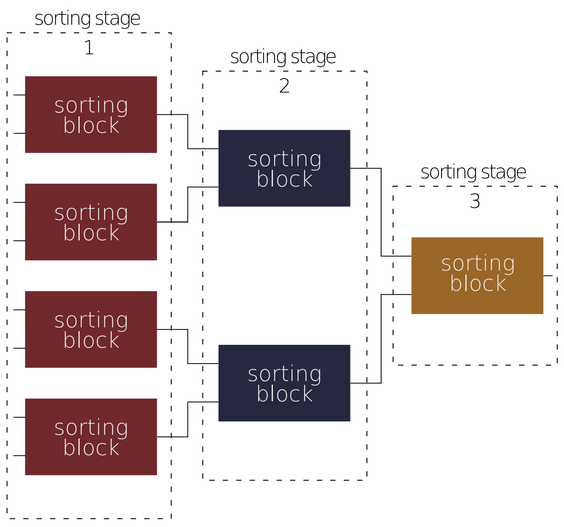
- Oscilloscope-like sampling
- Integrated trigger logic



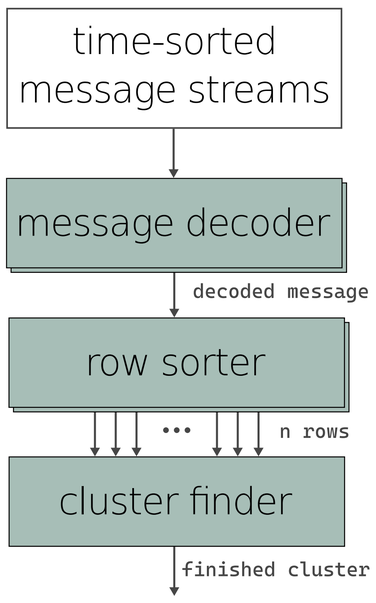
- Features configurable forced neighbor trigger logic
- Up to 32 ADC samples per trigger message
- Marked with timestamp, channel ID, and a trigger type
- 16 channels per output link, output sorted in time
- Allows read out of adjacent pads without lowering the threshold into the noise
- Trigger type 1: fulfilled trigger logic
  Trigger type 2 : forced neighbor trigger

Data Preparation

- Xilinx Kintex Ultrascale readout FPGA (XCKU115)

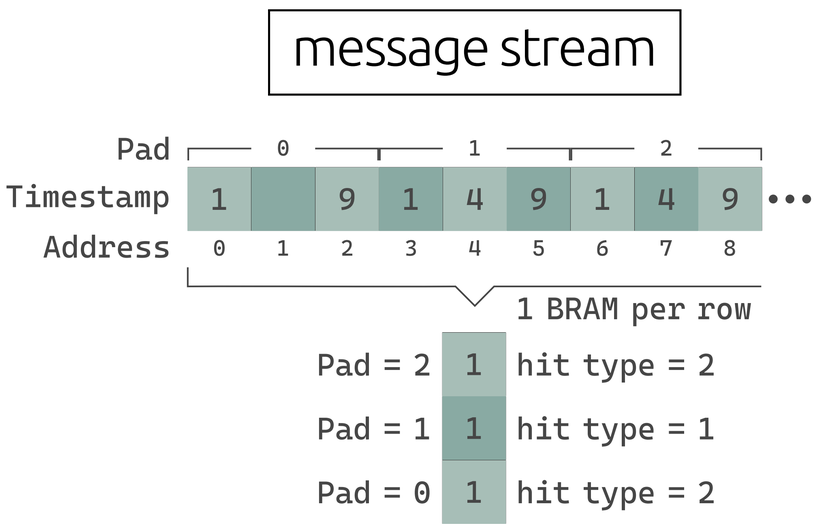


- Front-end ASICs aggregated with GBTx
- Data preprocessing developed with Vitis HLS
- Raw data from 3 GBTx (42 elinks) is merged and sorted in time

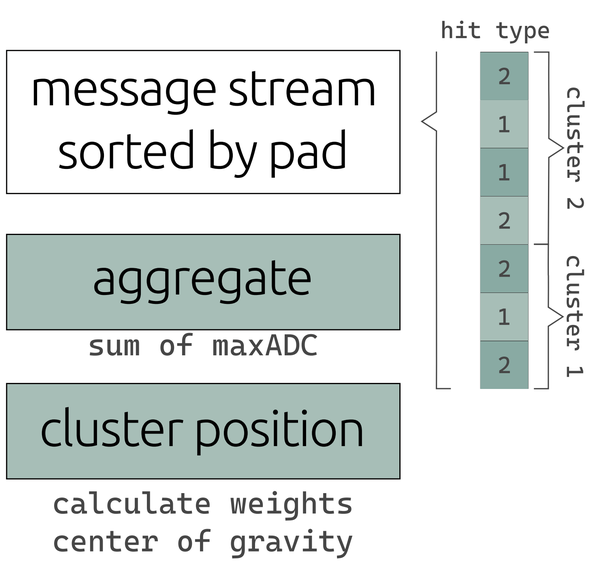


- Features of raw message frames are extracted in message decoder
- Baseline correction
- Maximum ADC value is extracted
- More precise signal time is reconstructed
- Pile-up is detected and removed for a potential pile up reconstruction

Cluster Finder



- Stream is sorted according to pad configuration
- Sorting is done per detector row
- Each pad has 3 cells in a BRAM
- Messages which share a timestamp are written into the same relative cell
- If a new timestamp is detected the data is marked as ready to be read and cell writing index is increased
- Reading index increased after all cells were read
- Each cluster finder instance processes 6-8 rows depending on the readout chamber



- Clusters are aggregated using the hit type information
- Cluster position calculation is shared between rows
- Simple center of gravity calculation
- The cluster finder is fully pipelined with an initiation interval of 1 and operates at a frequency of 200 MHz
- The development with HLS significantly simplifies the implementation of fully pipelined algorithms