Throttling Studies for the CBM Self-triggered Readout

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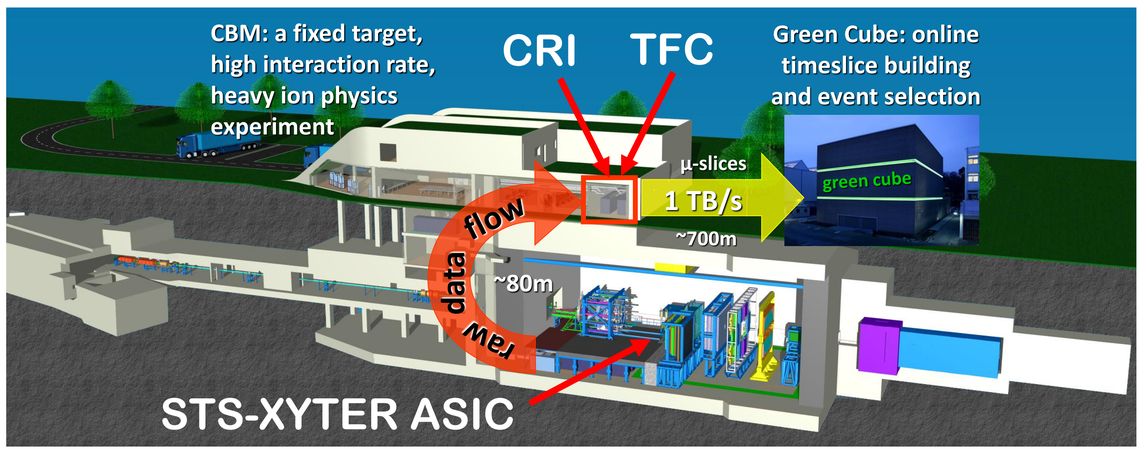
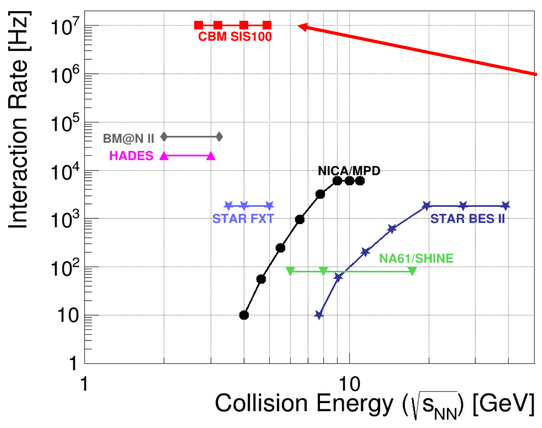
CBM at FAIR

Compressed Baryonic Matter experiment at FAIR

The CBM data challenge

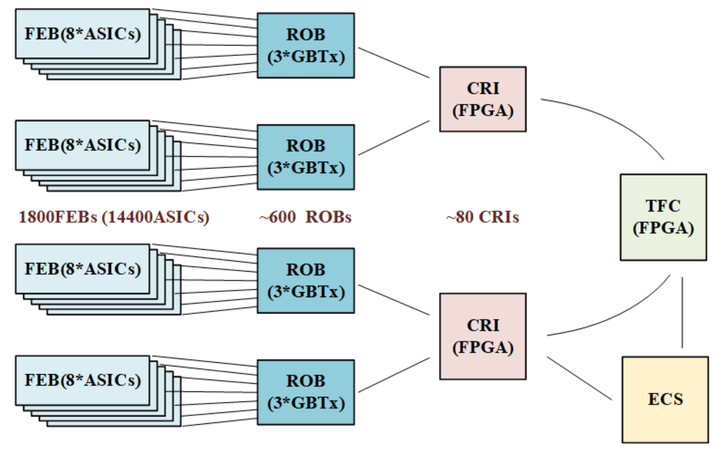




Interaction Rate for CBM at SIS100

- fixed target setup to investigate the QGP phase diagram in region of high baryon-densities
- high interaction rate environment: 10^5 – 10^7/s (A+A), up to 10^9/s (p+A)
- fast and radiation hard detectors with free-streaming readout electronics
- high-speed Data AQuisition (DAQ) system
- more than 5.000 GBT links operating at 4.8 Gbps as data source
- about 1 TByte/s bandwidth to the Green Cube

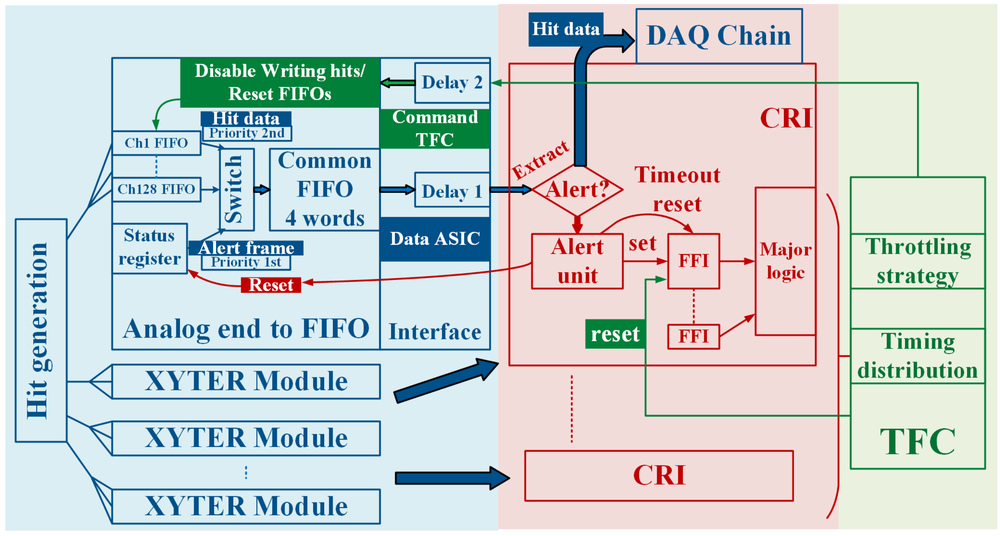
CBM readout topology based on STS



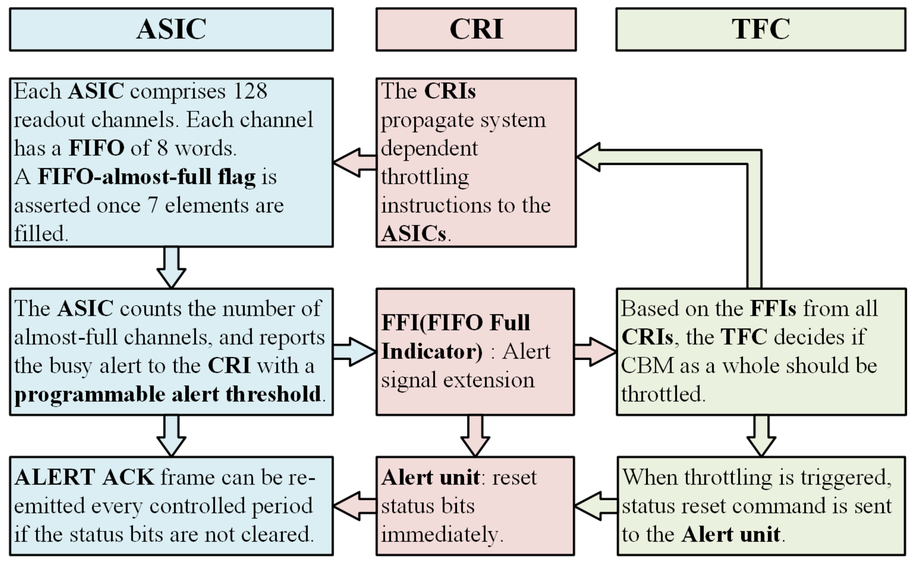
Hierarchy of the readout tree of the STS subsystem

- This study is based on Silicon Tracking System (STS) subsystem which is closest to the target.
- The setup comprises (from left to right) 14400 STSXYTER ASICs, populating 1800 Front-End Boards (FEB-8), interfacing to about 600 GBTx Readout Board (ROB-3), connecting to about 80 Common Readout Interface cards (CRI) which in turn are orchestrated by the Timing and Fast Control system (TFC)
- All of the components are under the supervision of the Experiment Control System (ECS)

Hardware functional diagram



Communication structure



Throttling strategies

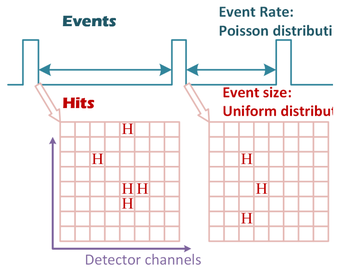
- "Clear" strategy : clear the ASIC channel FIFOs, then re-enable data taking immediately.
- "Stop" strategy: stop accepting new hits, drain the ASIC channel FIFOs, then restart accepting hits.

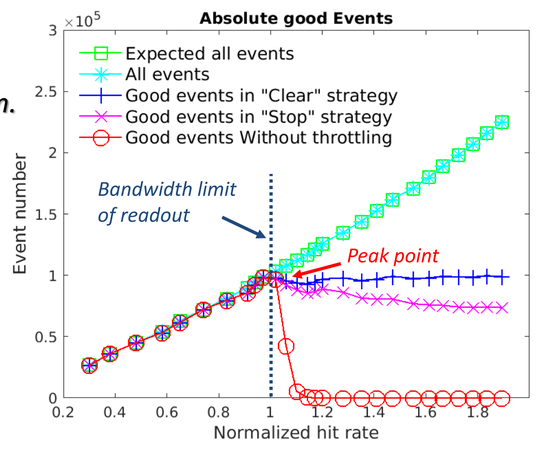
Simulation environment

- Closed-loop simulation model: The data flow model in Questa calls Linux shells to invoke the hit generator and result analysis in C++/ROOT.
- Simulation time: 10ms
- Simulation scale: 32 ASICs*128 Channels
- Readout bandwidth: 50M Hits/sec (5 readout links/ASIC)
- Drain time of the STSXYTER: 20.48 us
- Average event size = 5 hits/ASIC
- Hit rate = Event rate * Event size
- Normalized hit rate = Hit rate/Readout bandwidth
- Pileup correction: Valid hit rate decreases after removing pileup on the same channels.
- Good events: restorable events, in which 95% of hits are saved.

Simulation with stable beam intensity

Event rate obeys Poisson process with a constant average during simulation.





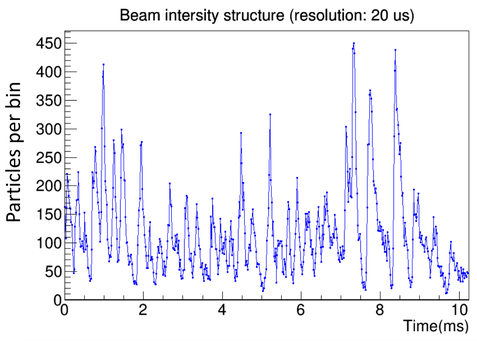
When the hit rate exceeds the bandwidth limit :

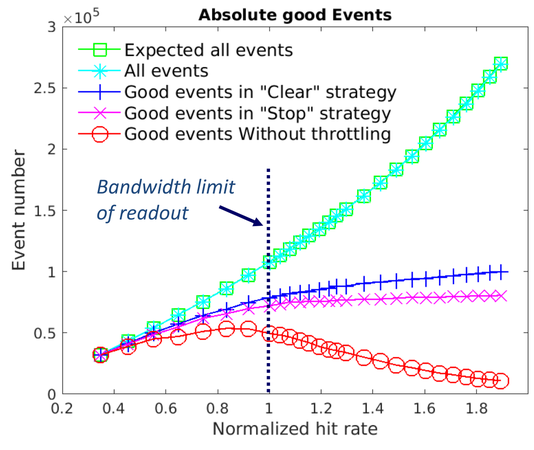
- **with clear strategy, the good events plateau.**
- **with stop strategy, the good events have a small decrease slope.**
- **without throttling, the good events are quickly down to 0.**

Simulation with realistic beam intensity fluctuation

The average event rate ∝ beam intensity;

Beam intensity resolution is 20us. The event rates obey Poisson process during each 20us.





When the hit rate exceeds the bandwidth limit :

- **with clear strategy, the good events have a small increase slope.**
- **with stop strategy, the good events plateau.**
- **without throttling, the good events decrease rapidly.**

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