The Abdus Salam
International Centre
for Theoretical Physics

SoC-based trigger-less data acquisition for multichannel detectors

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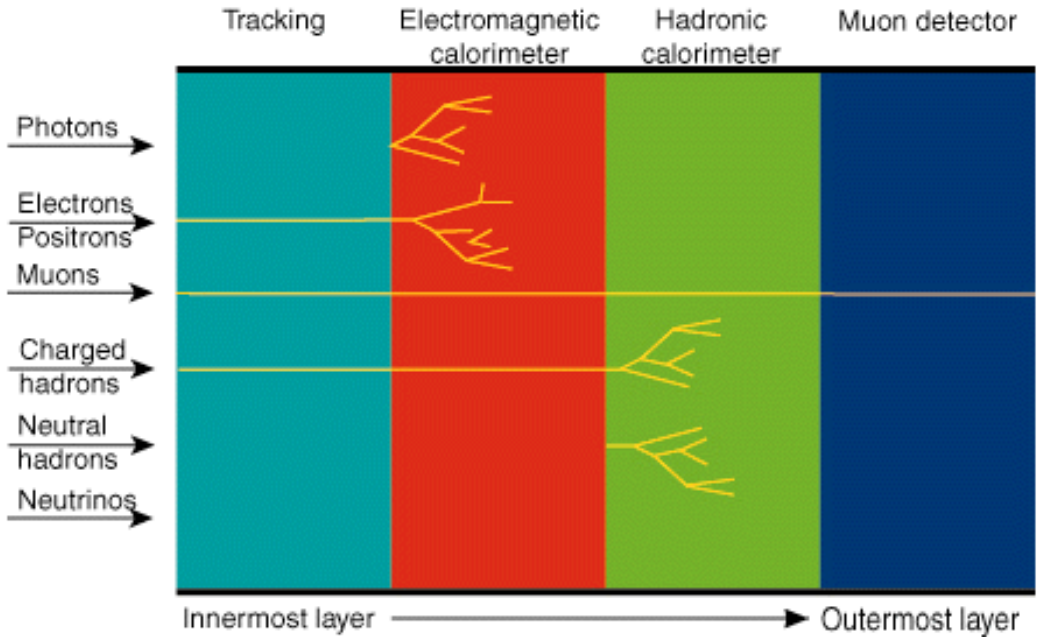
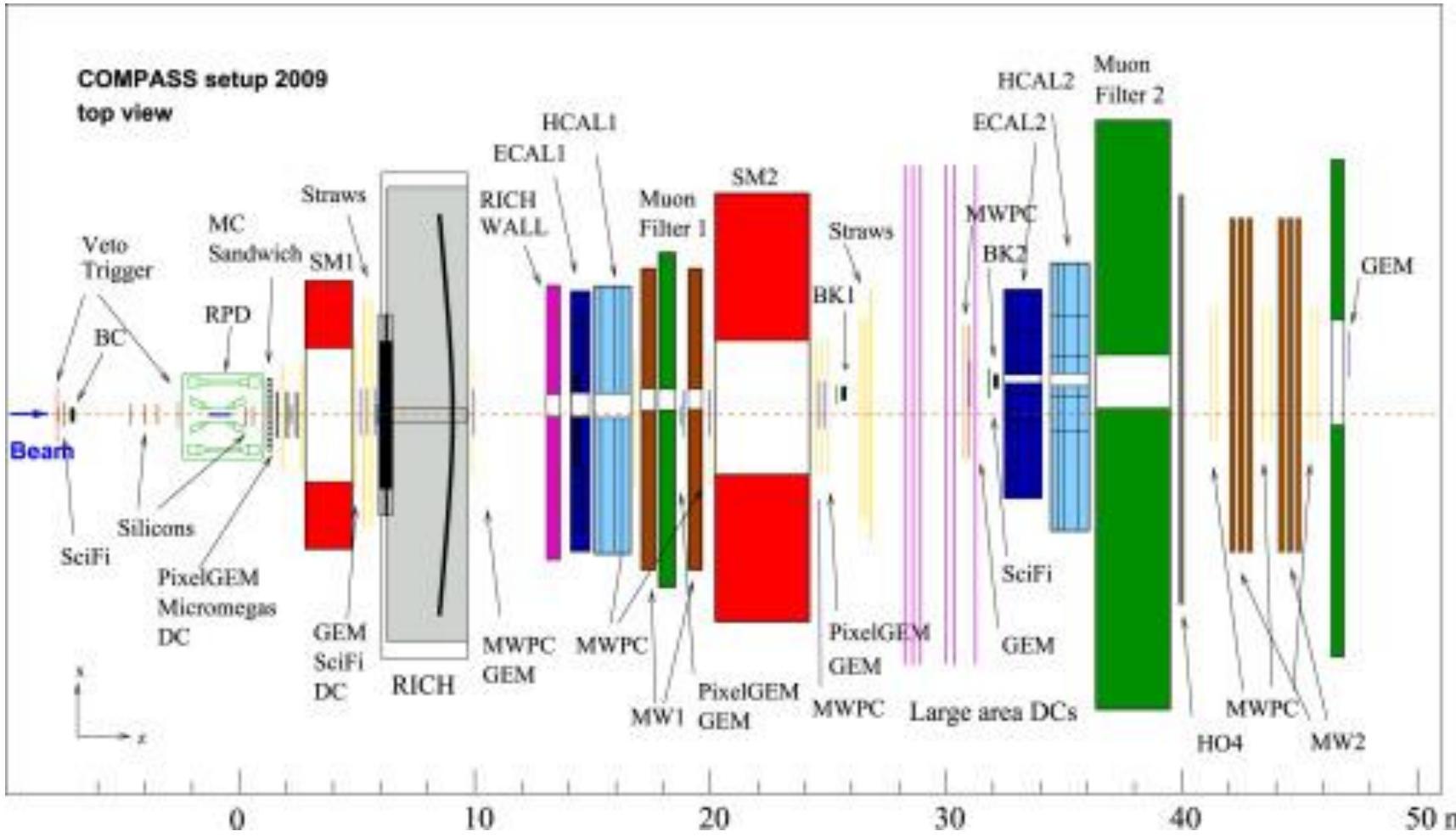
DAQ characteristics in Particle Physics experiments

- Modern particle detectors consist of layers of subdetectors, each designed to look for specific properties, or types of particles.
- Tracking Devices, Calorimeters, Particle Identification.
- Different response speed
- Quantity of channels (> 10^4)
- Huge data generation per unit of time (TB/sec)
- Precise timing calibration and synchronization
- Complex data handling architectures



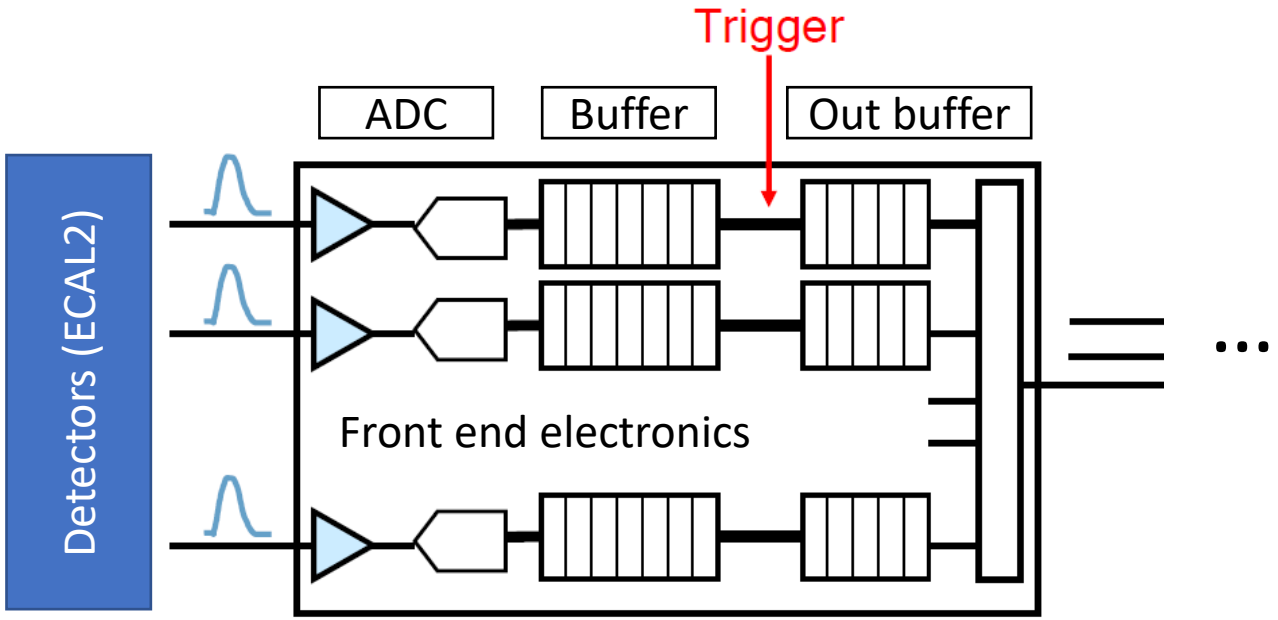
COMPASS DAQ System



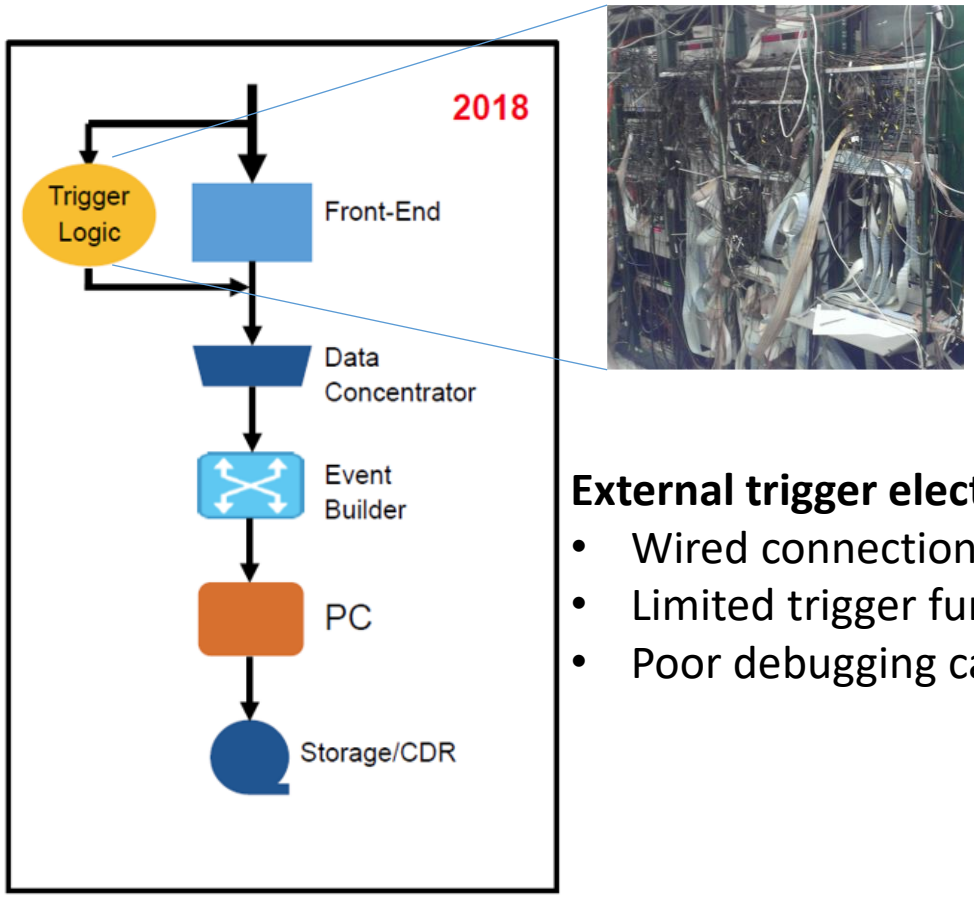
- fixed target experiment at the M2 beam line of the SPS
- Two stages spectrometer, large angle and momentum; small angles
- >100.000 channels
- Complex data handling scheme

Trigger event based DAQ

- Data sampled and buffered continuously
- Data take in all channels simultaneously
- Need for precise calibration due to different delays from trigger generation to detectors
- Hard trigger logic structures



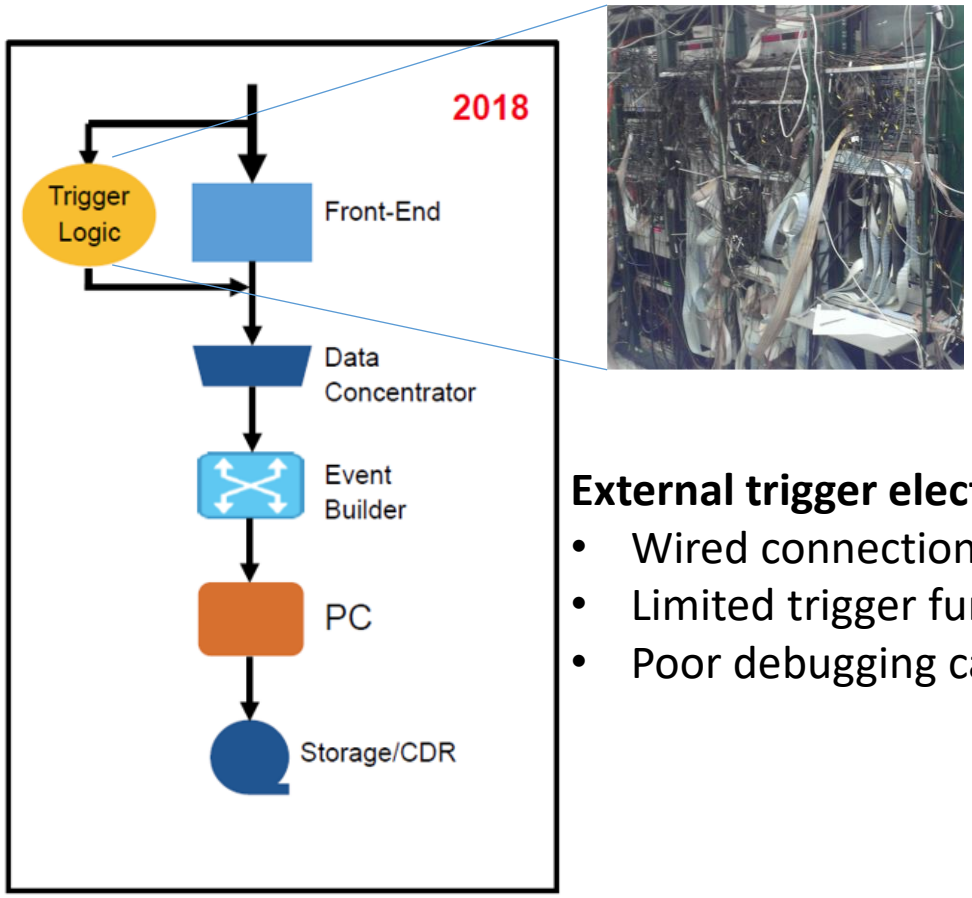
Towards Trigger-less DAQ



External trigger electronic modules

- Wired connections
- Limited trigger functions
- Poor debugging capabilities

Towards Trigger-less DAQ



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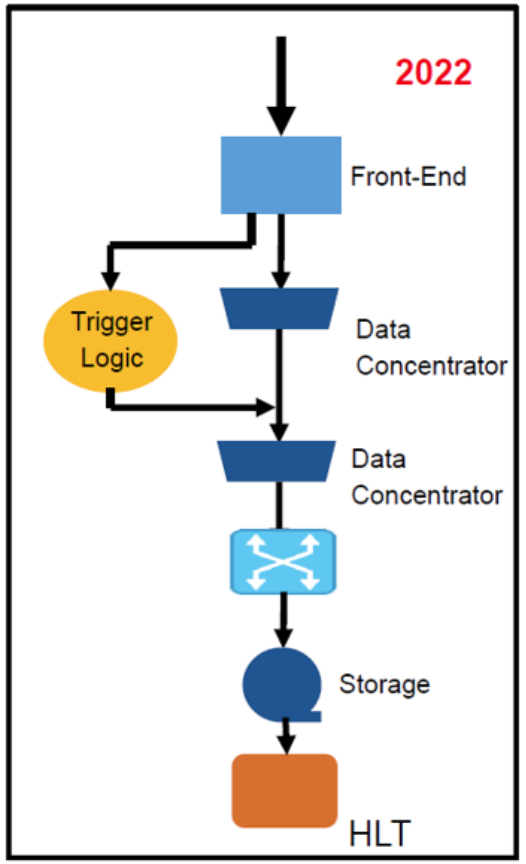
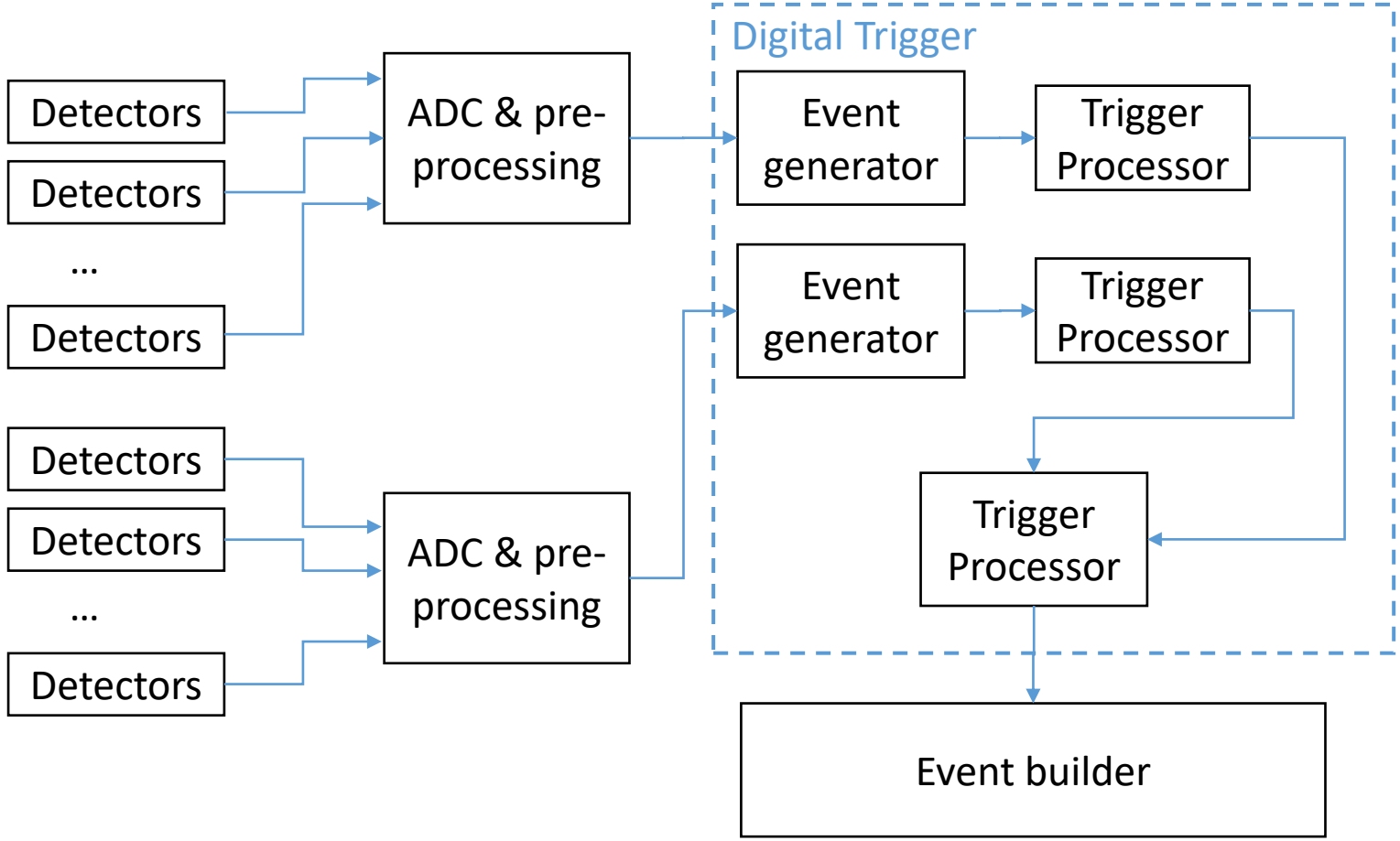


FPGA based trigger processor

- Programmable latency
- Programmable conditions
- Built-in monitoring

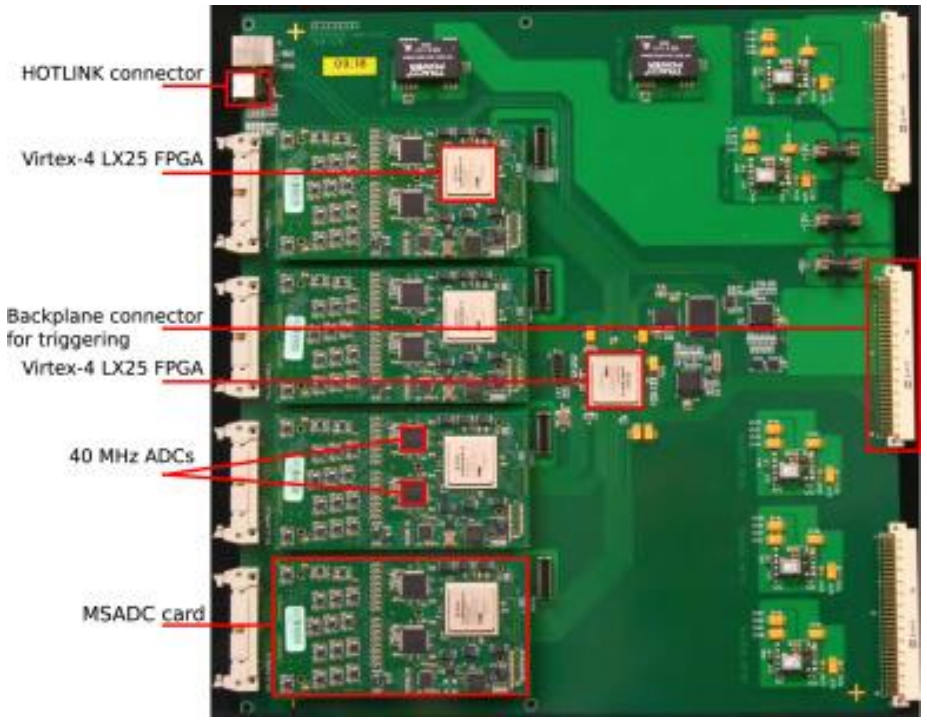
Trigger-less DAQ Approach

- Free Running Mode: continuous data streams from the detectors are saved to disk for later analysis.
- Event build approach: Online information from trigger processors is used to reduce data size before it is written to disk. Hierarchical event analysis



COMPASS ECAL2 DAQ System

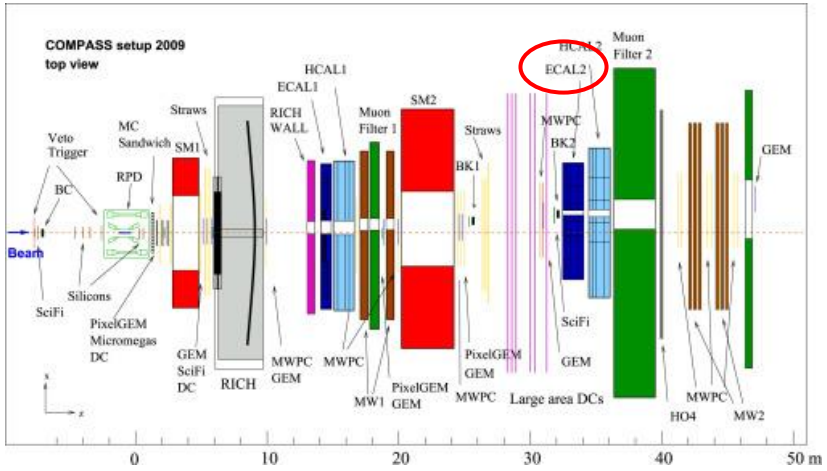
ECAL2 DAQ Hardware



MSADC, Digitizer board

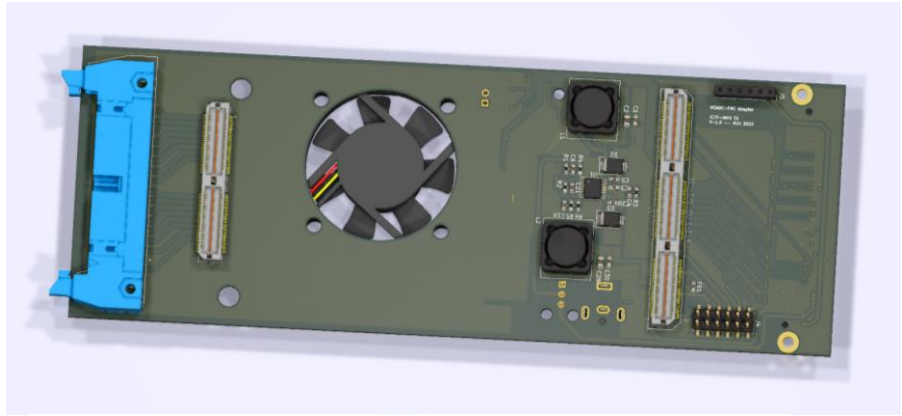
- 16 analog channels
- 12bits @ 80MHz

- FPGA frontend based
- Triggered event based
- 3068 analog channels



ECAL2 DAQ Hardware, updates

- New Carrier card FPGA-SoC based (Xilinx XCZU15EG)
- MSADC to FMC Adapter board for development
- PC software, remote control, data visualization and storage
- 4 SFP+ optical links
- Ethernet connection
- 4 GBytes DDR4



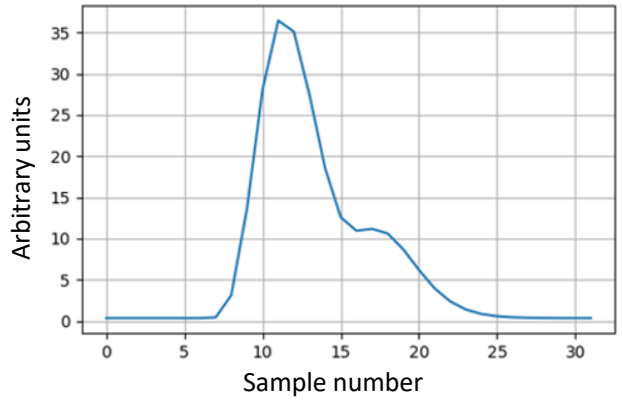
Top layer

Bottom layer

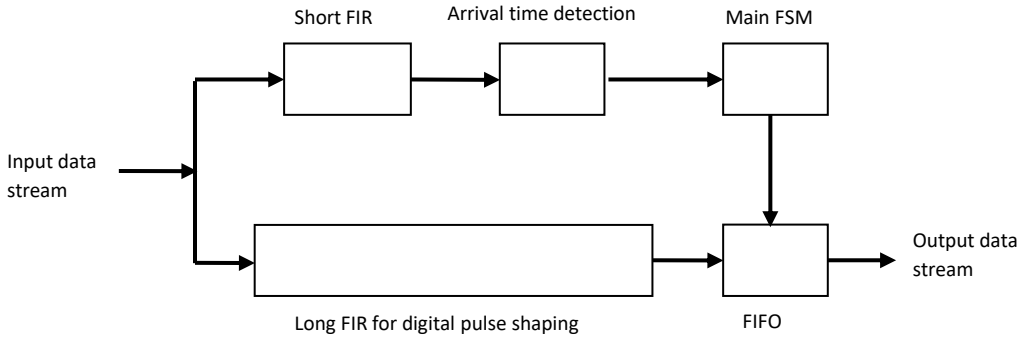
Extended features

- Data features extraction
- Trigger-less operation
- Data compression
- Free running mode

Features Extraction



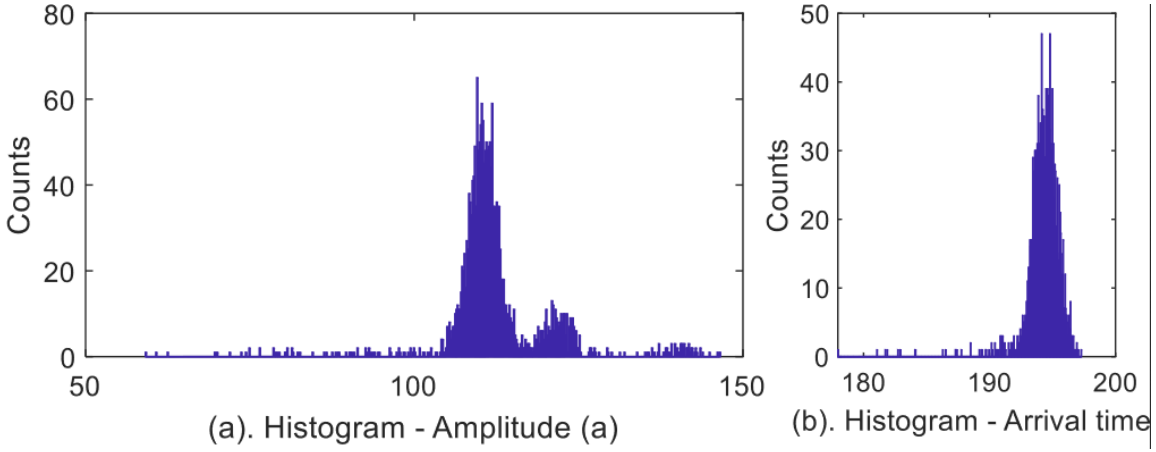
Digital Pulse Processor schema based on FIR filtering



Digital Pulse Processor

- Precise amplitude measurement
- Pulse detection and Arrival time
- Pulse model likelihood
- Adjustable FIR coefficients per channel
- Rejection strategies

All hits are tagged with a time stamp instead of an event number. Timing information is provided by an FPGA based time distribution system

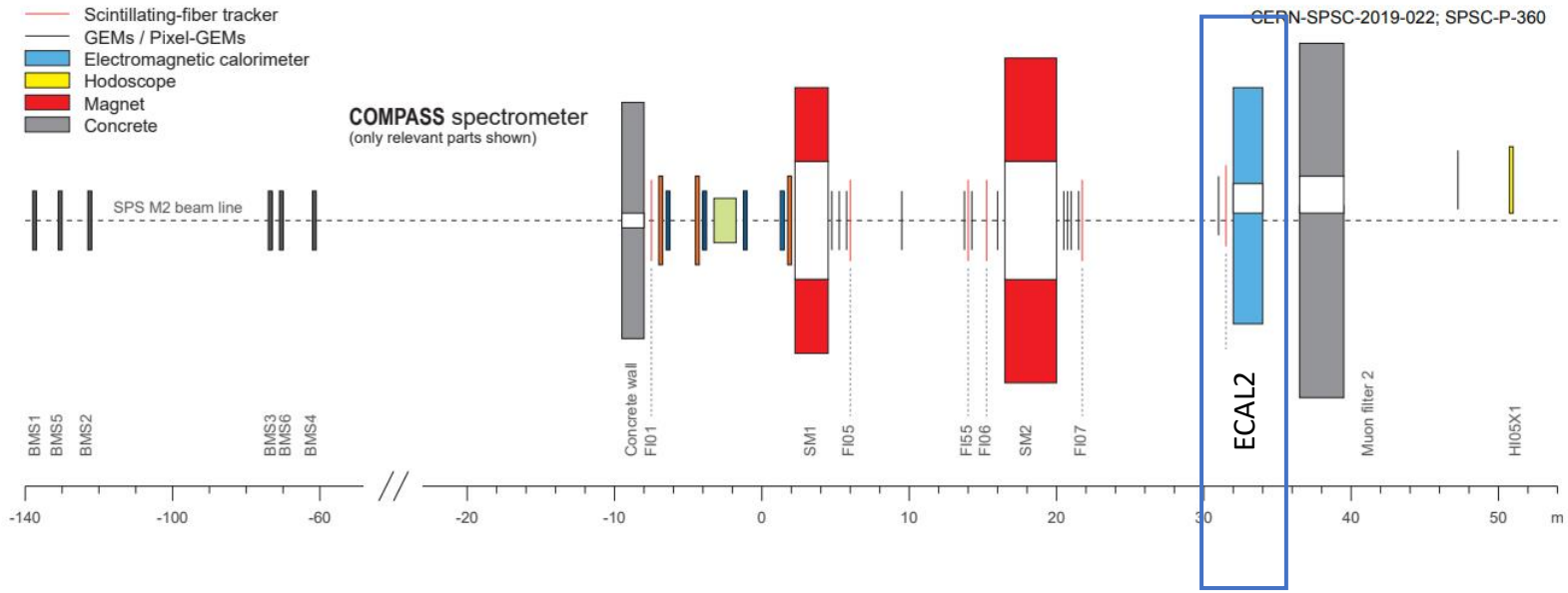


Data features extraction & Trigger-less approach

Conclusion

- Increase efficiency and selectivity in the data acquisition
- Reduce the amount of data per event
- Reduce the data storage requirements
- Pulse detection per channel in real time
- Adjustable parameters per channel
- Reuse the front-end electronics

PROTON RADIUS MEASUREMENT (2021?)



Thanks!

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