



The Abdus Salam
**International Centre
for Theoretical Physics**



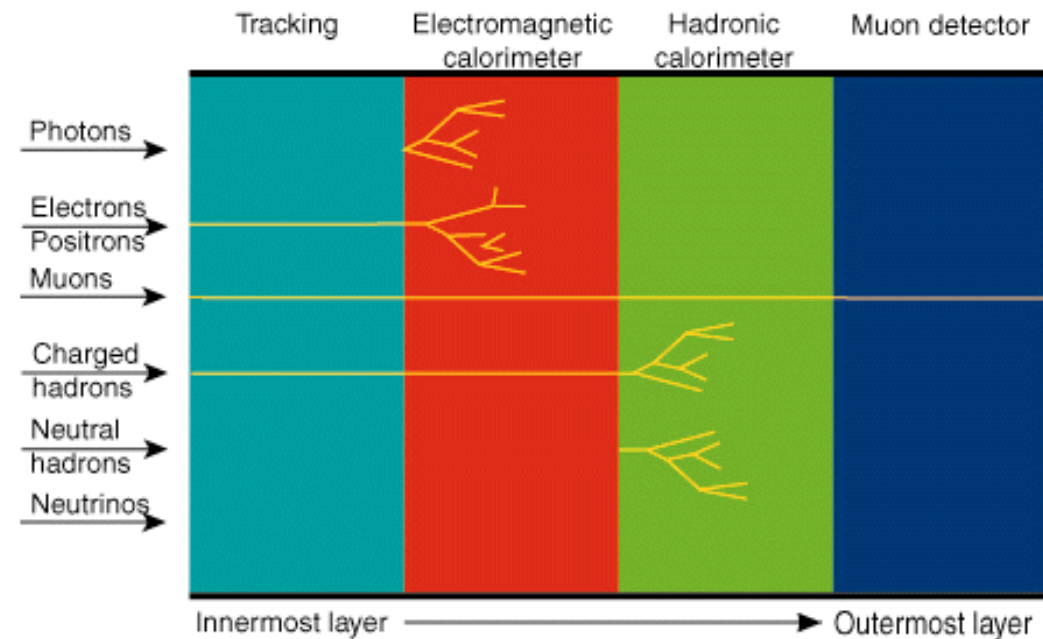
SoC-based trigger-less data acquisition for multichannel detectors

ICTP-INFN
Università degli studi di Trieste

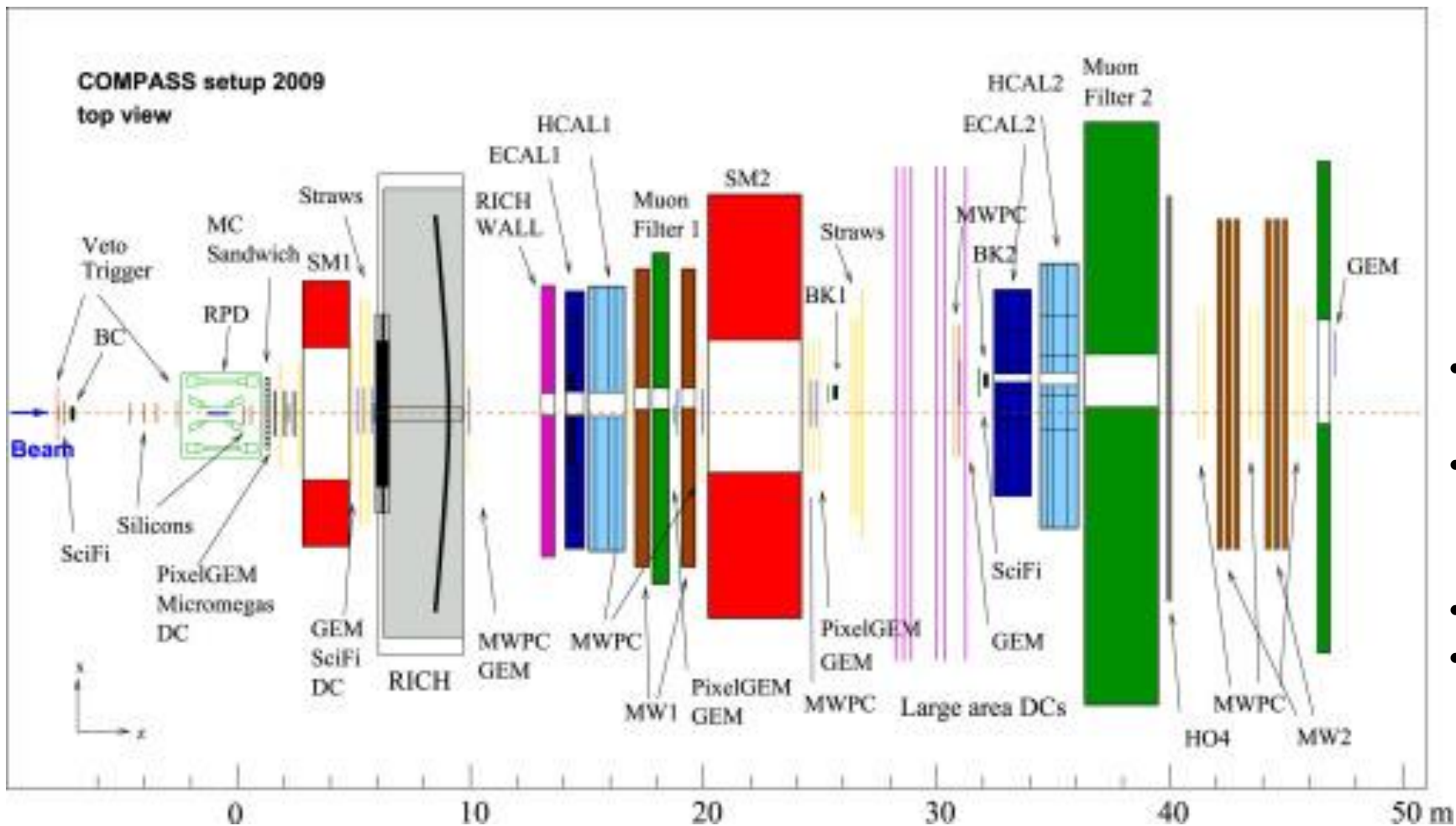
Bruno Valinoti

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



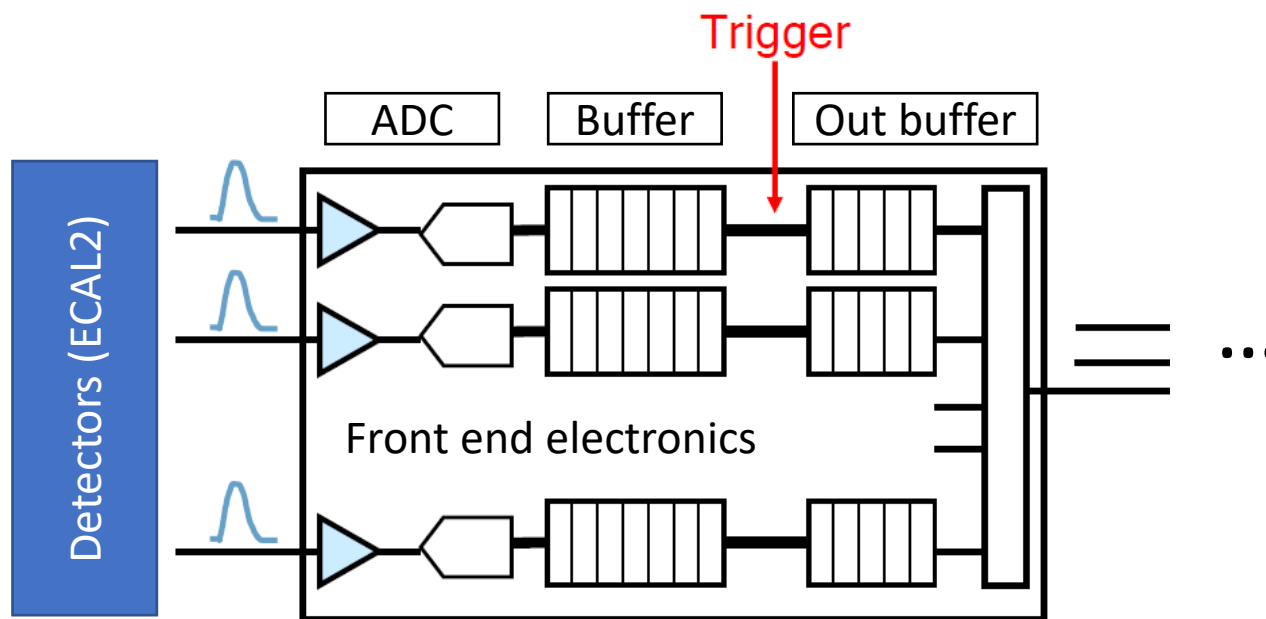
COMPASS DAQ System



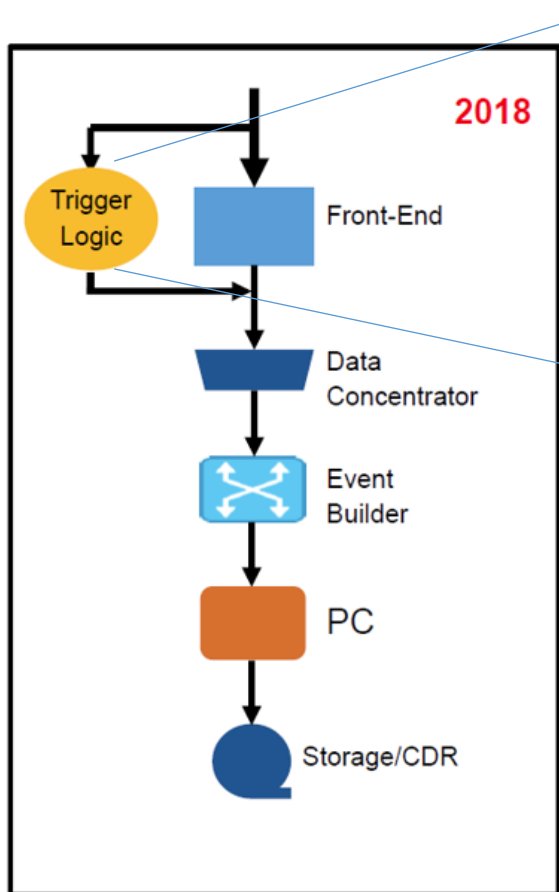
- fixed target experiment at the M2 beam line of the SPS
- Two stages spectrometer, large angle and momentum; small angles
- >100.000 channels
- Complex data handling scheme

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



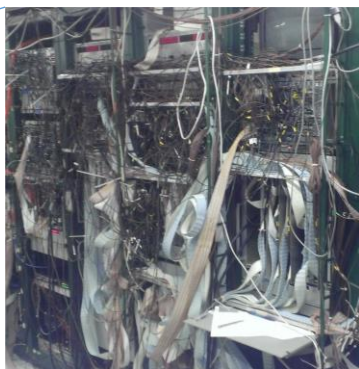
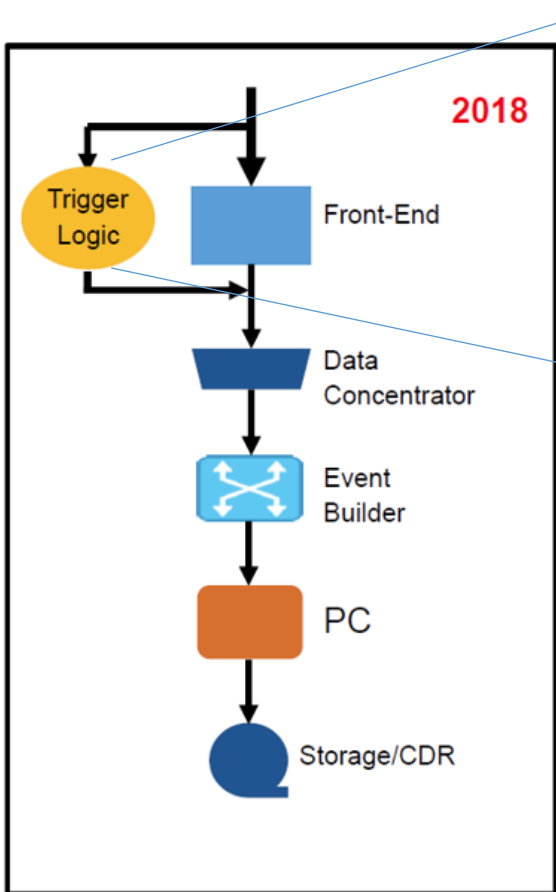
Towards Trigger-less DAQ



External trigger electronic modules

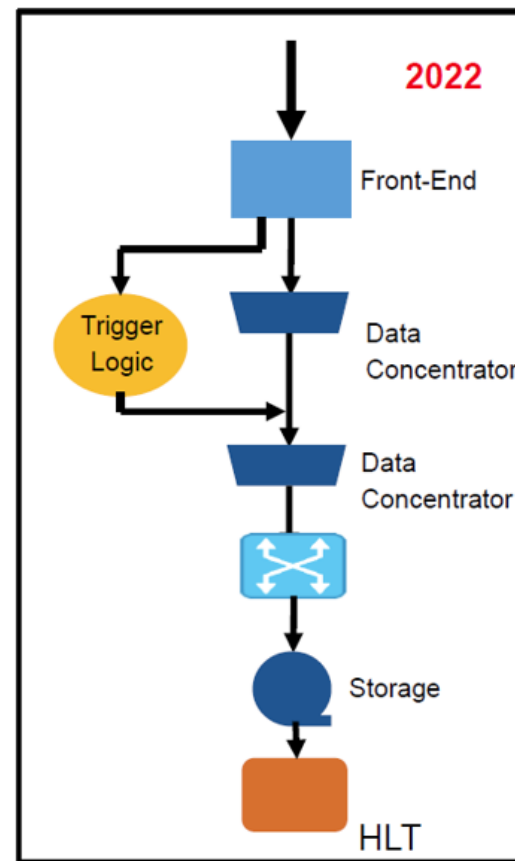
- Wired connections
- Limited trigger functions
- Poor debugging capabilities

Towards Trigger-less DAQ



External trigger electronic modules

- Wired connections
- Limited trigger functions
- Poor debugging capabilities

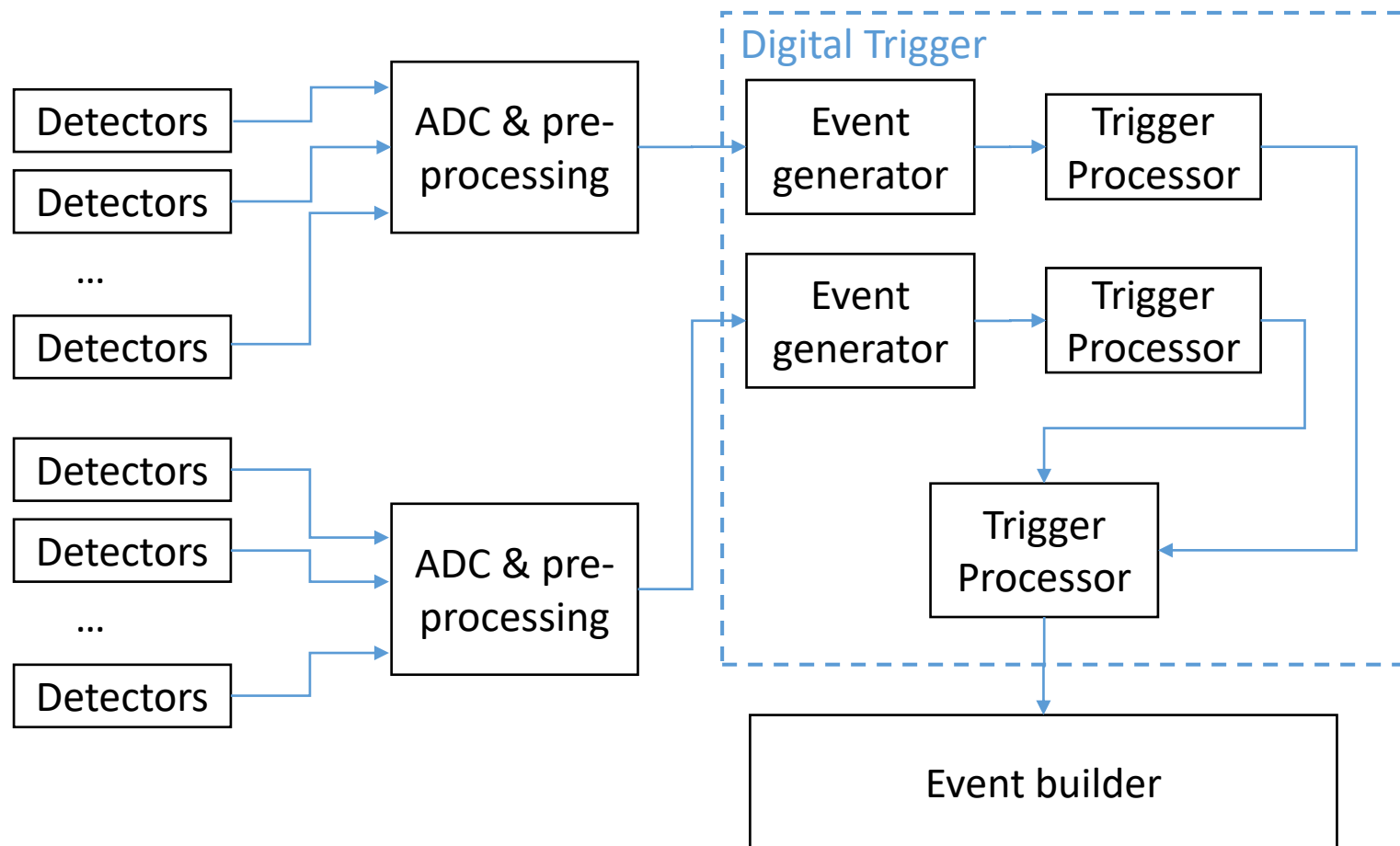


FPGA based trigger processor

- Programmable latency
- Programmable conditions
- Built-in monitoring

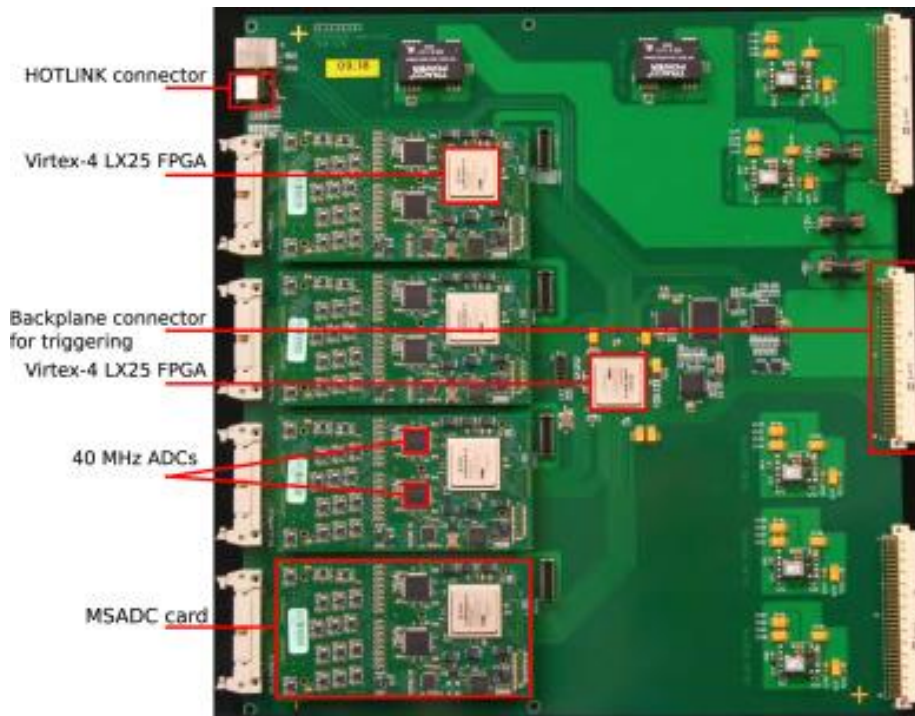
Trigger-less DAQ Approach

- 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



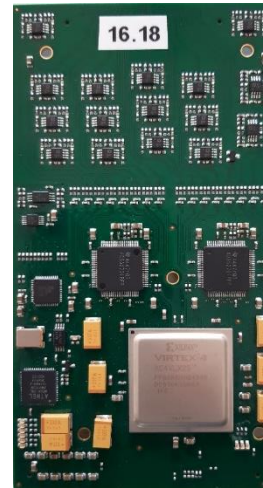
COMPASS ECAL2 DAQ System

ECAL2 DAQ Hardware

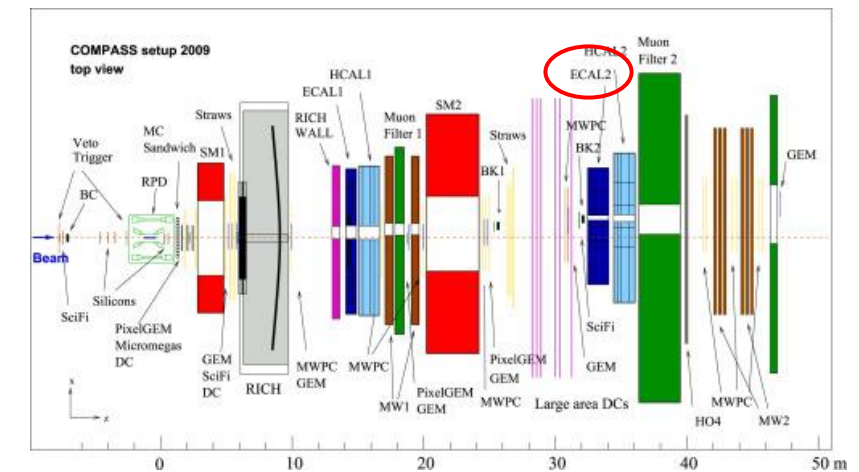


MSADC, Digitizer board

- 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

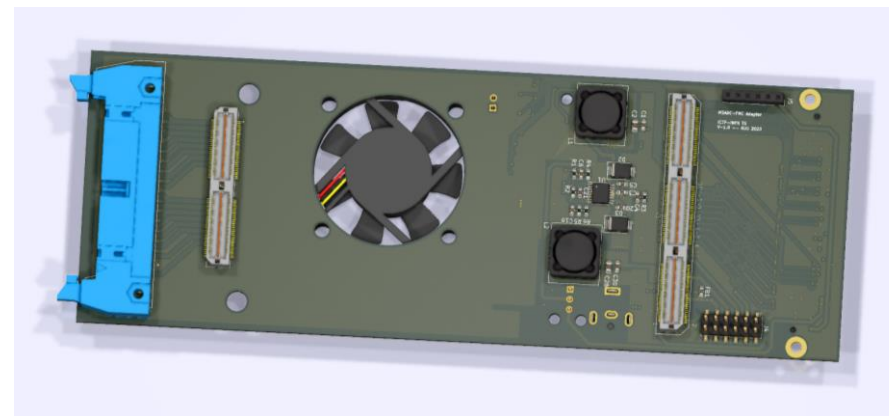
Extended features

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

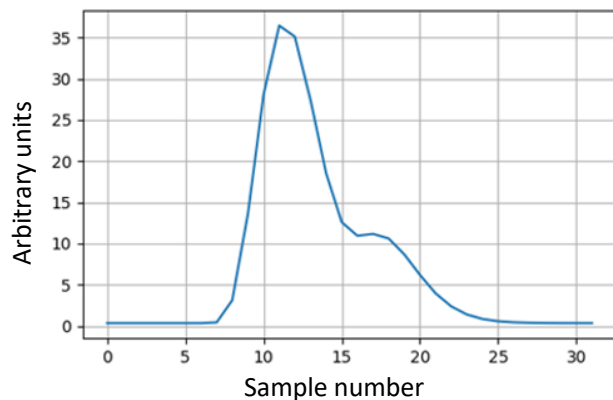
Top layer



Bottom layer



Features Extraction

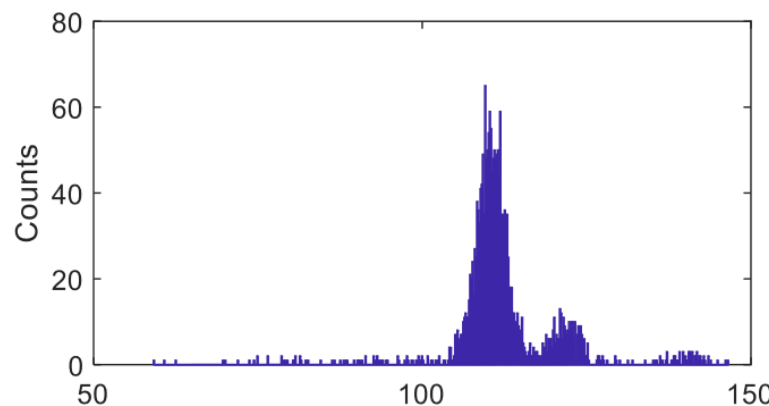
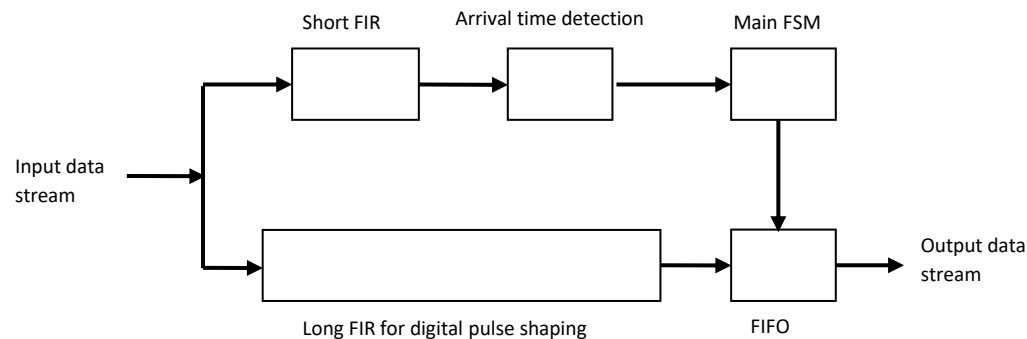


Digital Pulse Processor

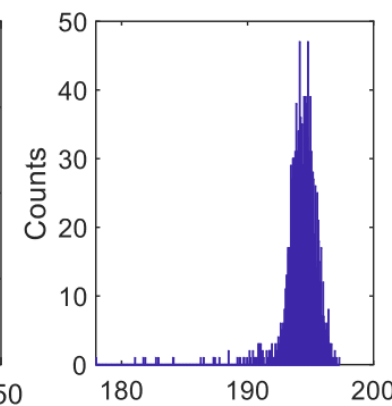
- Precise amplitude measurement
- Pulse detection and Arrival time
- Pulse model likelihood
- Adjustable FIR coefficients per channel
- Rejection strategies

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

Digital Pulse Processor schema based on FIR filtering



(a). Histogram - Amplitude (a)

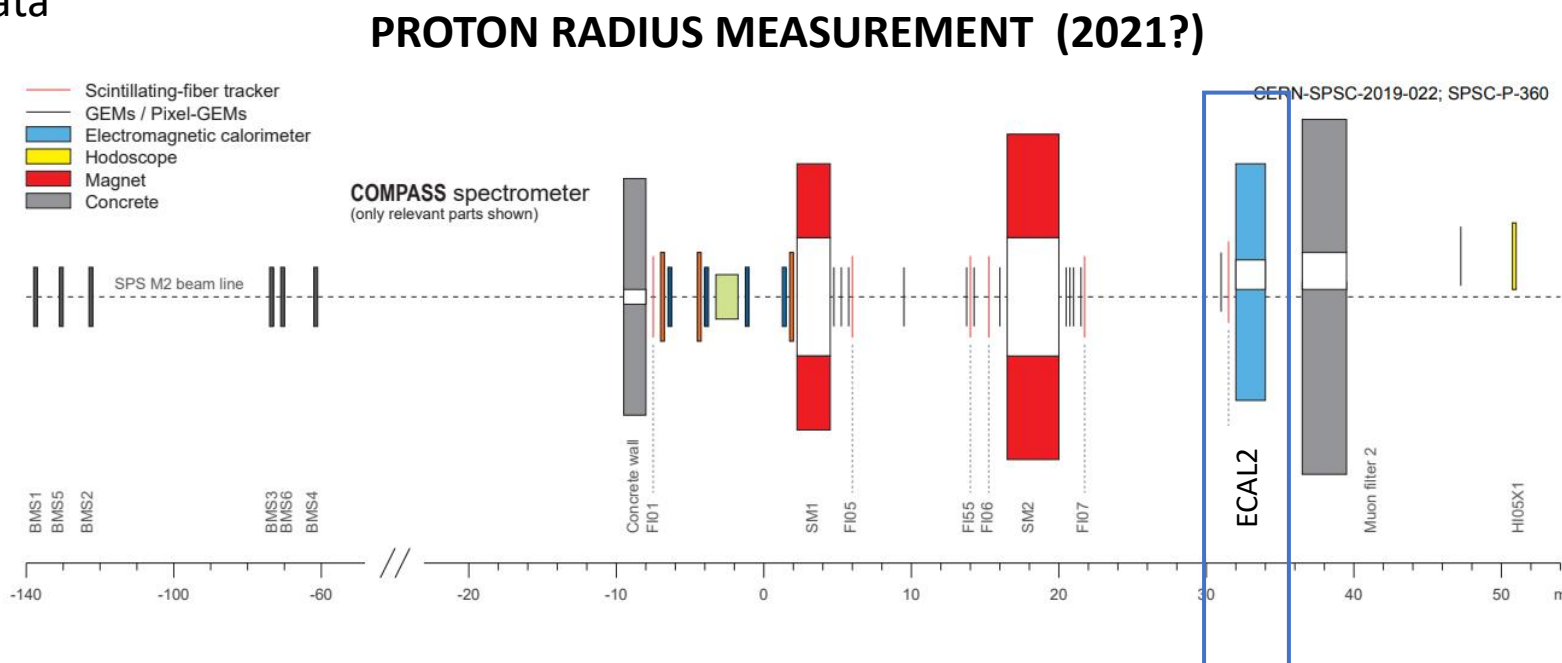


(b). Histogram - Arrival time

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



Thanks!

Bruno Valinoti

ICTP – INFN TS

bvalinot@ictp.it

bvalinot@ts.infn.it

ICTP – Multidisciplinary Laboratory

Permanent Staff

 Maria Liz Crespo mcrespo@ictp.it +39 040 2240 9930 MLAB-204 Research Officer	 Andres Cicuttin cicuttin@ictp.it +39 040 2240 9914 MLAB-204 Technical Assistant	 Federica Delconte delconte@ictp.it +39 040 2240 9932 MLAB-115A Group Secretary
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Long-Term Visiting Scientists

 Federico Bernardini fbernard@ictp.it +39 040 2240 9901 MLAB-101 Visiting Scientist	 Giacomo Vinci giacomo8vinci@gmail.com +39 040 2240 9901 MLAB-101 Visiting Scientist	 Werner F. Samayoa wflorian@ictp.it +39 040 2240 9913 MLAB-202 TRIL fellow
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

PhD Students

 Luis Garcia Ordoñez lgarcia1@ictp.it +39 040 2240 9912 MLAB-202 PhD student	 Bruno Valinoti bvalinot@ictp.it +39 040 2240 9912 MLAB-202 PhD student	 Romina S. Molina mromy00@gmail.com +39 040 2240 9912 MLAB-202 PhD student	 Kasun Mannatunga ksm@sjp.ac.lk +39 040 2240 9934 MLAB-111 PhD student
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

STEP Fellows

 Charn Loong Ng charnloong@gmail.com +39 040 2240 9912 MLAB-201 STEP PhD student	 Jerome Folla jfollure@yahoo.fr +39 040 2240 9926 MLAB-106 STEP PhD student
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------



Scientific Consultant

 Claudio Tuniz tuniz@ictp.it +39 040 2240 232 MLAB-115B Scientific Consultant

