High-Speed Continuous DAQ System for Readout of the ALICE SAMPA ASIC

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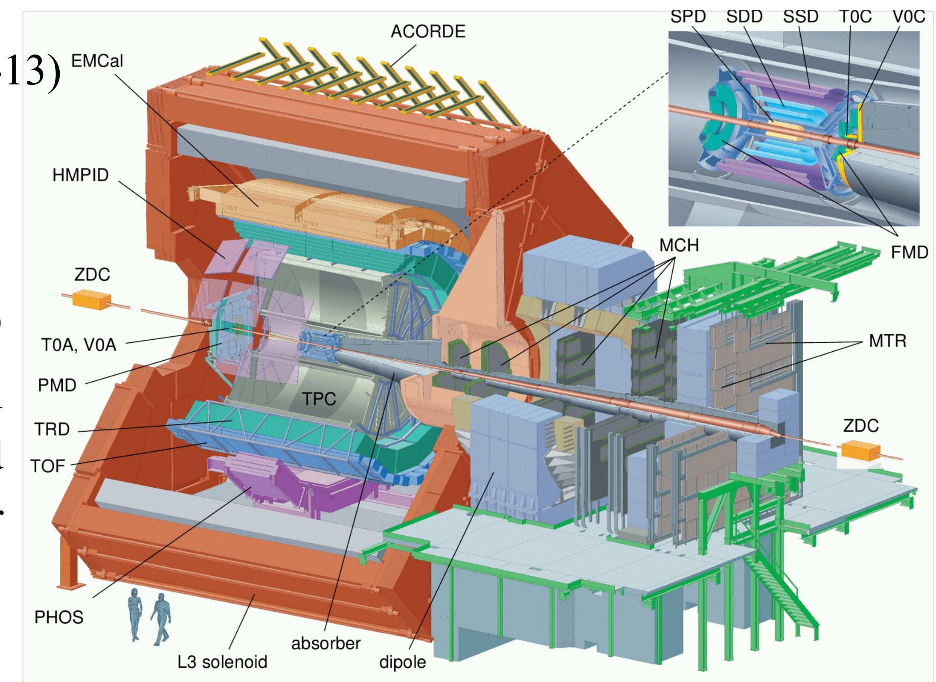
For the ALICE collaboration

ALICE Experiment and Upgrade

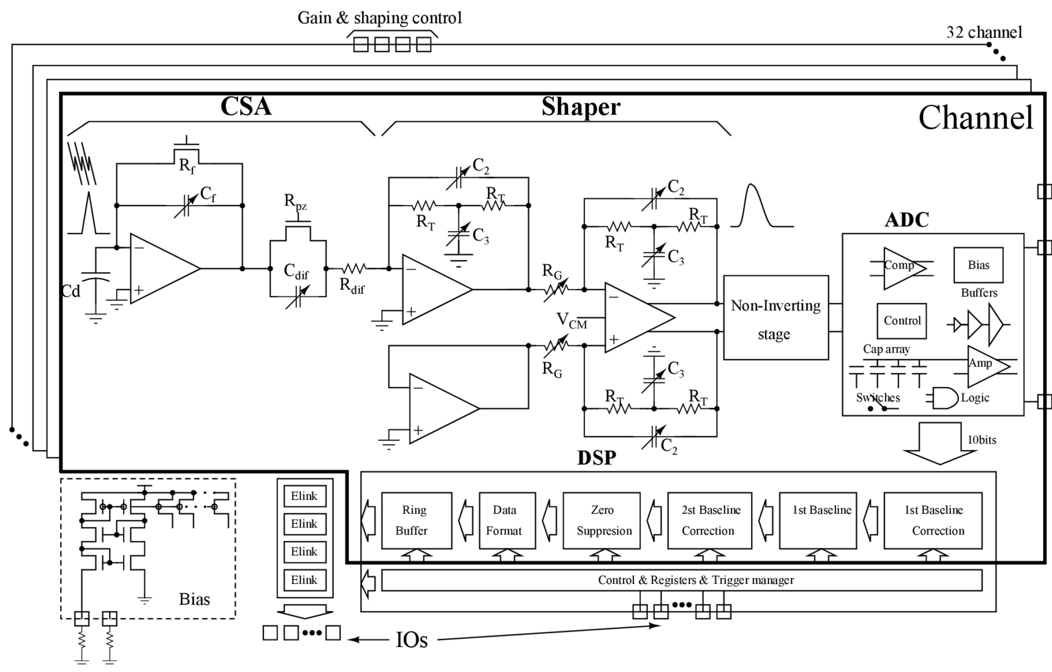
- ALICE experiment studies the outcome of heavy ions (Pb-Pb), p-Pb and pp collisions at LHC, to characterize the strongly interacting matter at extreme energy densities where Quark-Gluon Plasma (QGP) is produced
- ALICE has successfully completed Run1 (2010-13) and Run2 is now in progress (2015-2018)
- After Run2 some of the ALICE sub-detectors (TPC, ITS, MCH etc.) will be upgraded to improve performance before Run3 starts in 2020
- The ALICE Time Projection Chamber will upgrade to GEM readout chambers and continuous readout to accommodate the higher collision rates (50 kHz) during Run3
- In continuous readout:
  - GEM signals will be processed by five custom-made SAMPA ASICs (32 channels/each)
  - The SAMPA output will be multiplexed and transmitted using GigaBit Transceivers via optical links to a common readout unit
  - The common readout unit is an interface to the on-line farm, trigger and detector control system



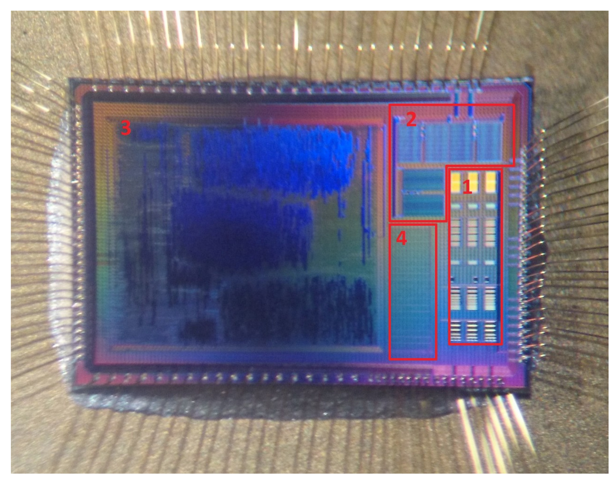
ALICE Detector

SAMPA Frond-End Chip

SAMPA Chip Schematic



First Prototype



1. Preamplifier and shaper
2. Analog-to-Digital Converter
3. Digital Signal Processor
4. Shift register for radiation tests

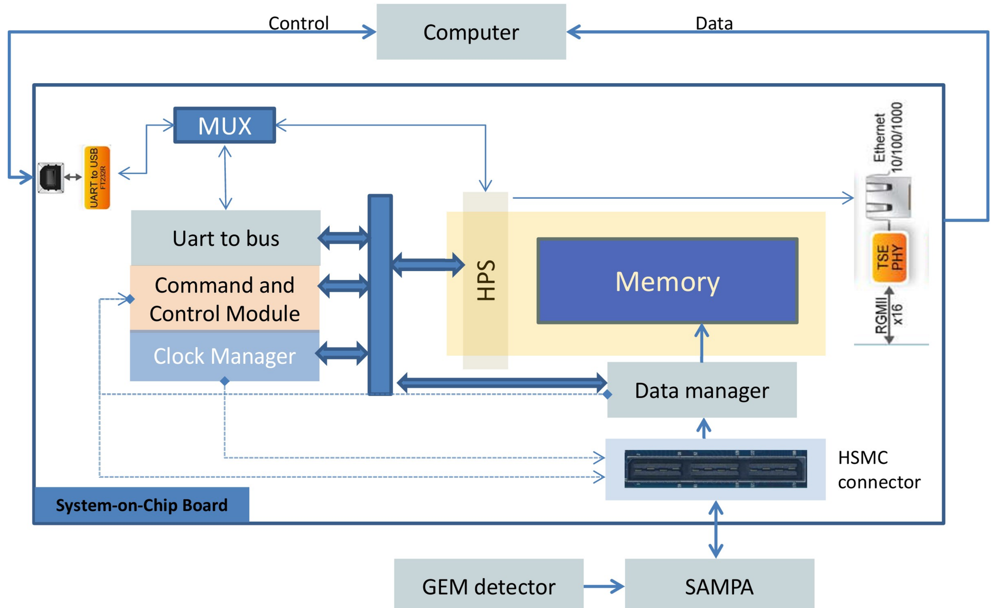
- The SAMPA contains: Charge-Sensitive preamplifier (CSA), Shaper, 10 bit/10 MHz digitizer (ADC) and Digital Signal Processing (DSP) block
- The acquired data from the SAMPA is transferred at 1.2 Gbps over four 320 Mbps serial links
- 32 channels continuous as well as external triggered readout is possible
- The first version of the SAMPA chip with 3 channels was produced in 2014
- The full scale 32 channel SAMPA chip will be delivered in June 2016

High-Speed Data Acquisition System

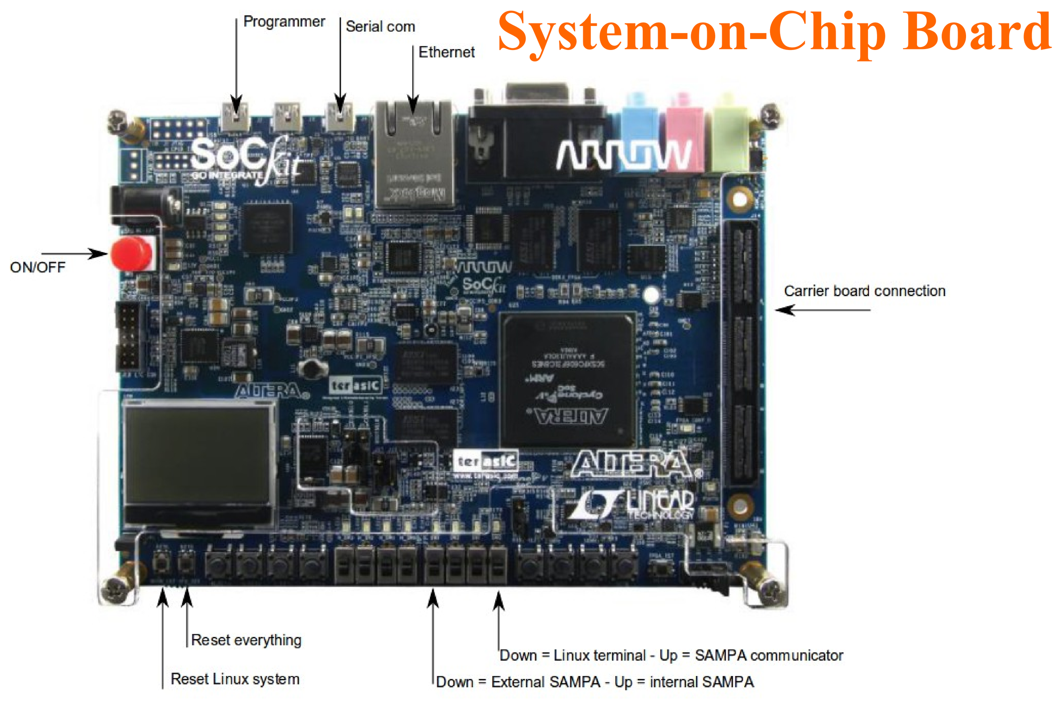
SAMPA Test Framework – DAQ System

- Firmware design for system-on-chip board
- SAMPA Communicator
  - Control program for the SAMPA and the DAQ
- SAMPA Analyzer
  - Data acquisition and online monitoring using ROOT framework

Block Diagram of Firmware Design



System-on-Chip Board

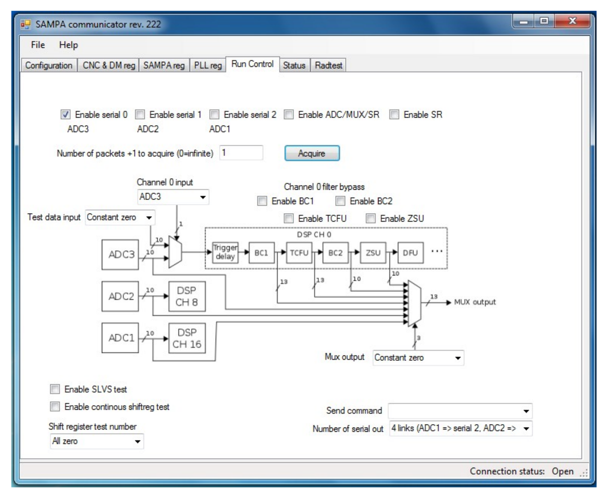


Firmware Design – Data Flow

- Data manager de-serializes data into packets and writes the packets to shared memory
- Microprocessor (HPS) takes data from the shared memory and transmits it over Ethernet to the SAMPA Analyzer on the computer
- SAMPA Communicator interfaces with the SAMPA via Command and Control module

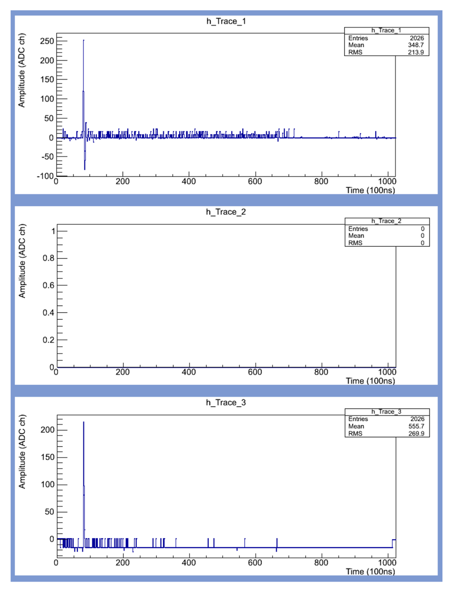
SAMPA Communicator

- Software environment to control and configuration of the DAQ and the SAMPA
- User friendly interface for run control
- Simplifies register access
  - Clock configuration on the fly
  - Data flow handling
  - Online status information



SAMPA Analyzer

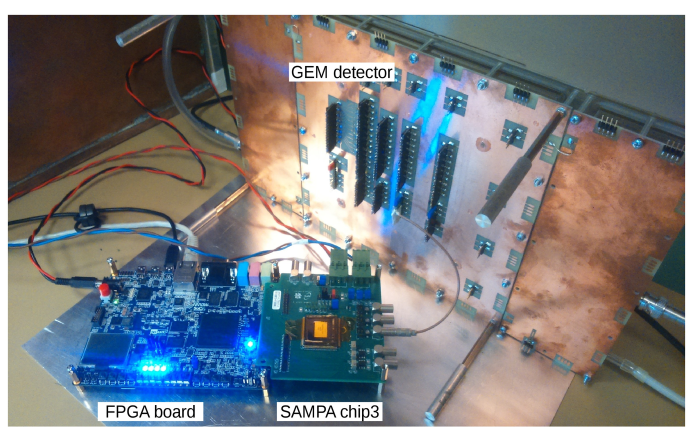
- Setup Ethernet connection with the DAQ board
- Monitor data:
  Decode header, read data part of packet and plot using ROOT
- Write data to file:
  Store data samples in ROOT file for off-line analysis using ROOT macro
- Monitor and analyze multiple channels in parallel

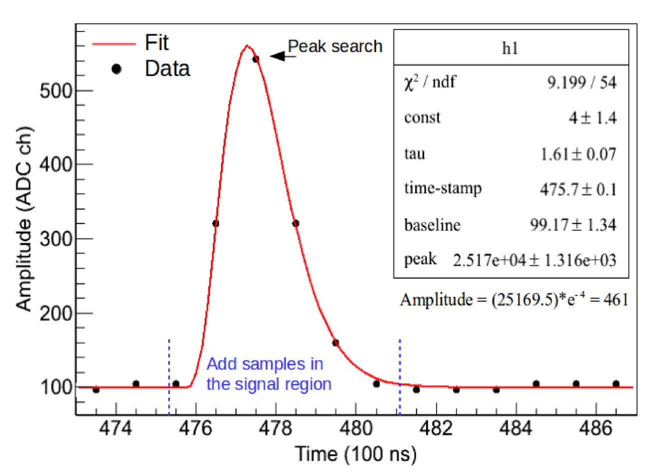


Test Setup and Analysis

- Performance tests of the complete SAMPA system were carried out with charge generated from:
  - Signal generator
  - 3-GEM detector chamber
- Feature-extraction (amplitude, time) of the SAMPA output signals was done by applying following methods:
  - Peak search
  - Integrating samples in the signal region
  - Fitting using following function:

$$f(x) = A\left(\frac{x-t}{\tau}\right)^{N} e^{-N\left(\frac{x-t}{\tau}\right)} + Bl$$

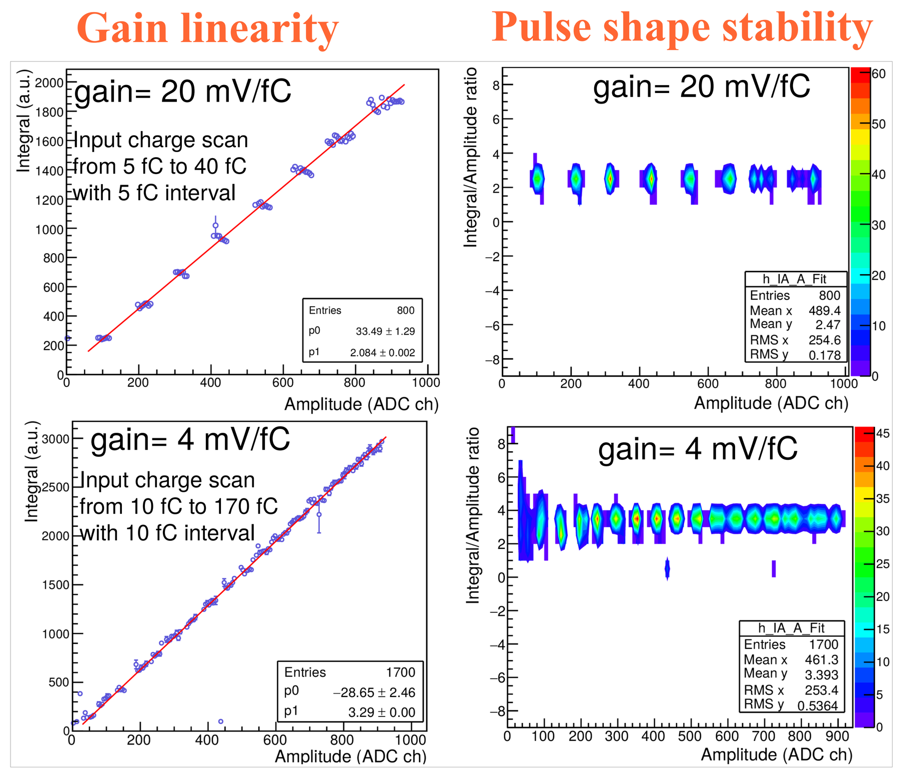




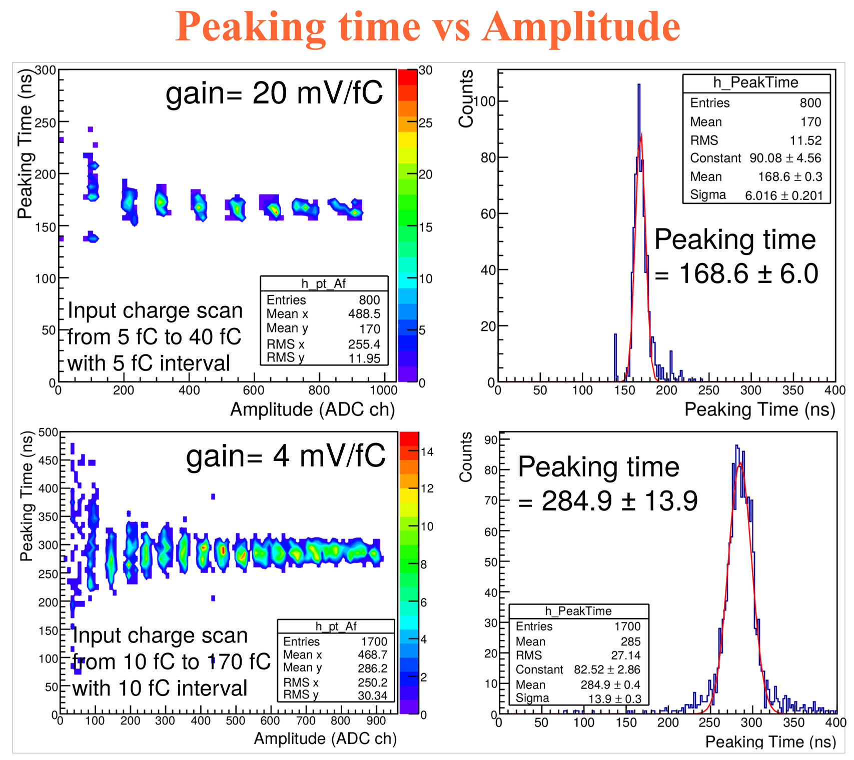
Where, A is peak, $N=4$ is the shaping order of the amplifier, the waveform amplitude is obtained from ($A{*}e^{-N}$), Bl is the baseline, τ is the peaking time, and t is time stamp of the waveform.

Results

Gain linearity / Pulse shape stability

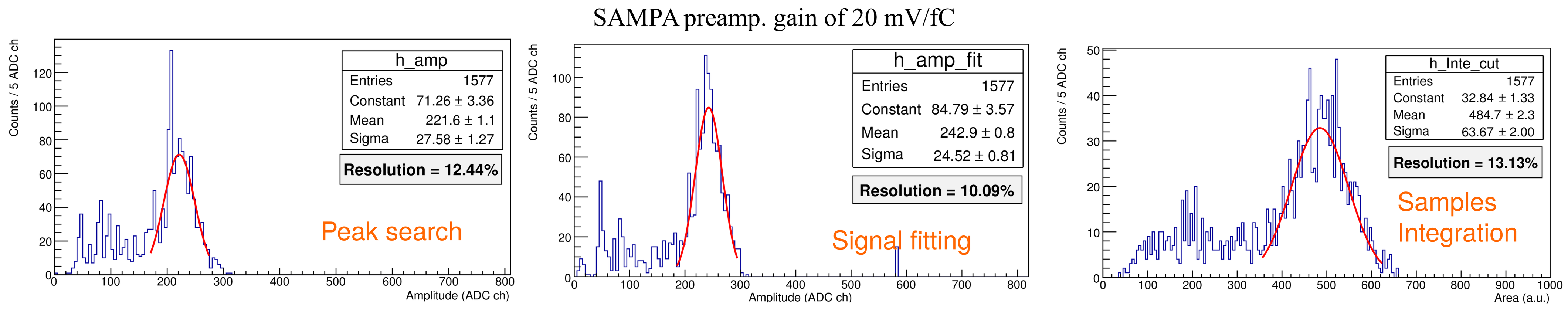


Peaking time vs Amplitude



Fe55 photon (5.9 keV) energy spectrum – Signal fit gives better result

SAMPA preamp. gain of 20 mV/fC



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