Front-end, Trigger, DAQ, Data Management
POSTER REVIEW (II)

Emilio Radicioni - INFN

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1. Computing and Systems

Outcome of the KLOE-2 experiment after the conclusion of the data-taking period

Florin Sirghi (INFN-LNF) on behalf of the KLOE-2 collaboration

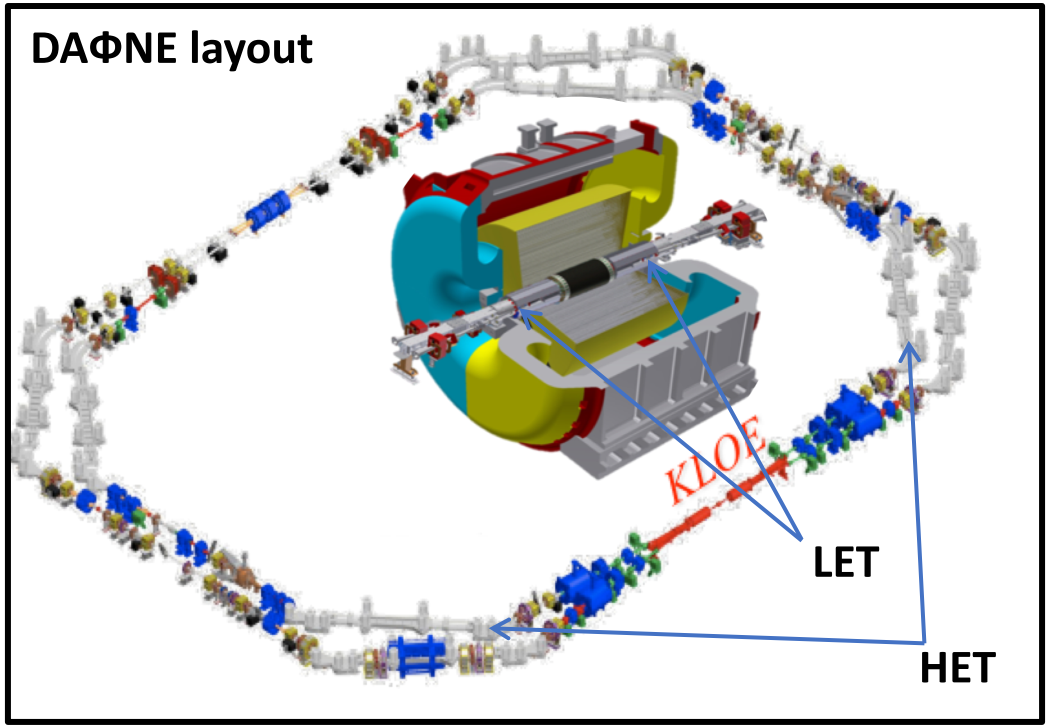
The KLOE-2 experiment at Laboratori Nazionali di Frascati has concluded the data taking at the $e^+ e^-$ DAΦNE phi-factory with more than 5 fb^{-1} of integrated luminosity collected. The new KLOE-2 detector shows good performance and their study is progressing to fully exploit their potentiality. KLOE-2 is the first high-energy experiment using a novel technology, that was developed at Frascati, to build light and compact tracking systems.

The KLOE detector, composed by one of the biggest Drift Chamber (DC) ever built,

surrounded by a lead-scintillating fiber Electromagnetic Calorimeter (EMC) among the best ones for energy and timing capability at low energies,

received several upgrades **to improve the performance and enlarge the physics reach (KLOE-2).**

The KLOE-2: a multi-purpose detector optimized for K_L physics at DAΦNE collider



The low angle calorimeters, CCALT – LYSO crystals QCALT – Tungsten and scintillating tiles to increase geometrical acceptance for neutral particles

The Tagging System, HET outside and LET inside the detector to tag events with photons irradiated in the detector, used for the study of γγ physics.

Finally, to improve the vertex reconstruction capabilities near the interaction point, a state-of-the-art cylindrical GEM detector has been developed and installed as Inner Tracker (IT).

14th Pisa Meeting on Advanced Detectors

Neutrino PLATFORM

CERN

Computing Infrastructure and its monitoring at the CERN Neutrino Platform (NP) prototype experiments

Nektarios Chr. BENEKOS - CERN and National Technical University of Athens, Hellas

The EHN1-NP computing cluster consists of nearly 2500 cores with various characteristics and the status and health of every host must be constantly monitored to ensure the correct and reliable operation of the whole online/offline data processing system.

It represents an effort to foster fundamental research in the field of Neutrino physics as it provides data processing facility.

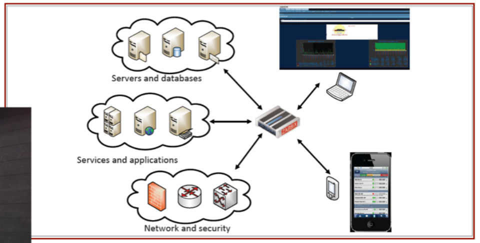
There is an evident need for an automated configuration management system for this cluster as monitoring of such infrastructure can be cumbersome. To manage the machines hosted in EHN1, some virtual machine (VM) servers are hosted on CERN OpenStack Cloud infrastructure. A Puppet-managed virtual machine was used and configured with Puppet to provide a longer-lived service to users.

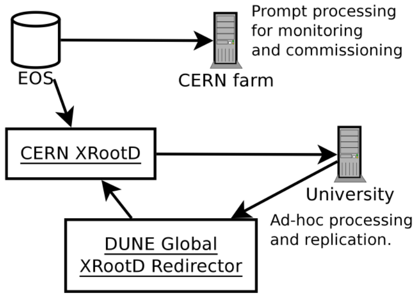
In the Neutrino cluster, open source Puppet helps to describe machine configurations in a declarative language, bring machines to a desired state and keep them there through automation. The deployment type of Puppet in this cluster was agent/master architecture. Puppet was used with Foreman, an open source tool that helps with the management of servers by an easy interaction with Puppet to automate tasks and application deployment. Foreman provides a robust web interface that allows us to provision, configure cluster nodes and leverage its External Node Classifier (ENC) and reporting capabilities to ease the management of Puppet.

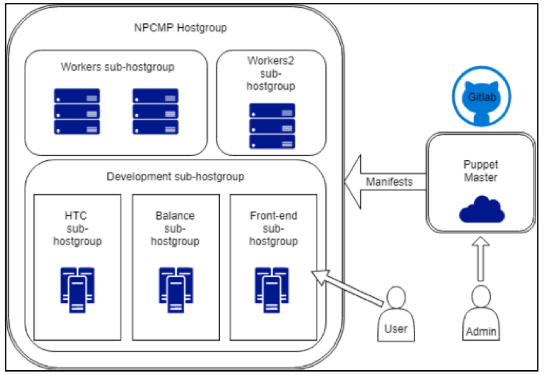
For a fully operational cluster these tasks must be carried out; implementation and monitoring of all the necessary web-paged tools for the NP cluster operational monitoring, including: frontend configuration, server nodes and users monitoring, job monitoring, batch process monitoring, sites availability, data management and transfers between CERN-EOS and EHN1 and the outside world.

Zabbix and Grafana monitoring systems have been combined to get a complete picture of the system. For active checks and alerting performing with different time intervals ranging between 5 minutes and 24 hours according to the need.

EHN1 computing cluster and Zabbix monitoring concept

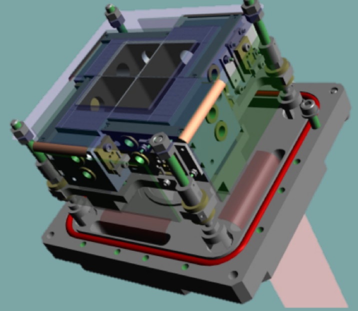






2. General DAQ

80Gb/s DAQ with ANN-based trigger system.



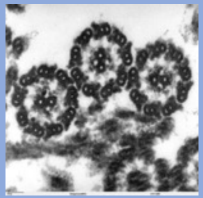
Mikhail Polovykh[2], Sascha Epp[1], Mohammed Ibrahim[2], Christian Koffmane[2], Jelena Ninkovic[2], Ivan Peric[3], Johannes Treis[2], Andreas Wassatsch[2]

EDET80k

- 12.5 μs/frame resolution
- Stroboscopic illumination
- Dynamic effects analysis
- Biological and chemical reactions in motion observation

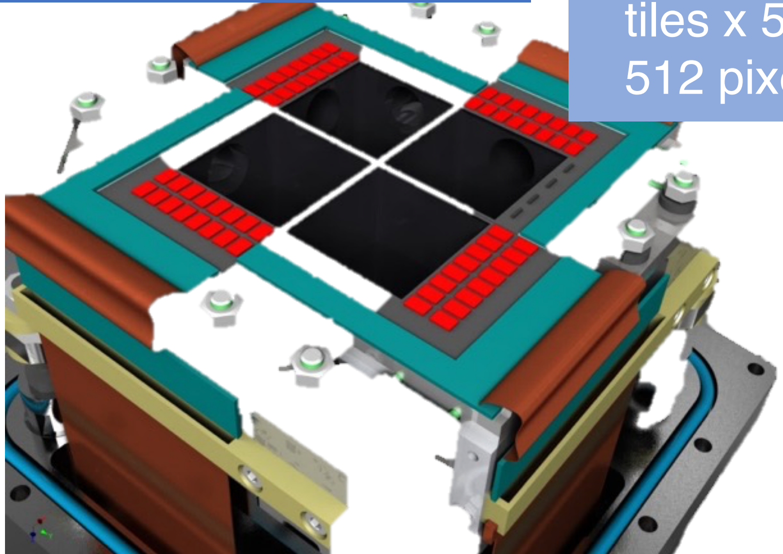
DePFET matrix

- 30μm sensor thickness;
- 4 independent tiles x 512 x 512 pixels = 1Mpixel FPA
- 80 kHz framerate (100 images burst)
- 100 Hz burst rate



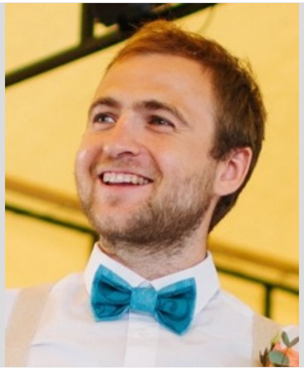
ANN in FPGA

- Less than 500μs latency respond estimated;
- Objects' shape type classification.

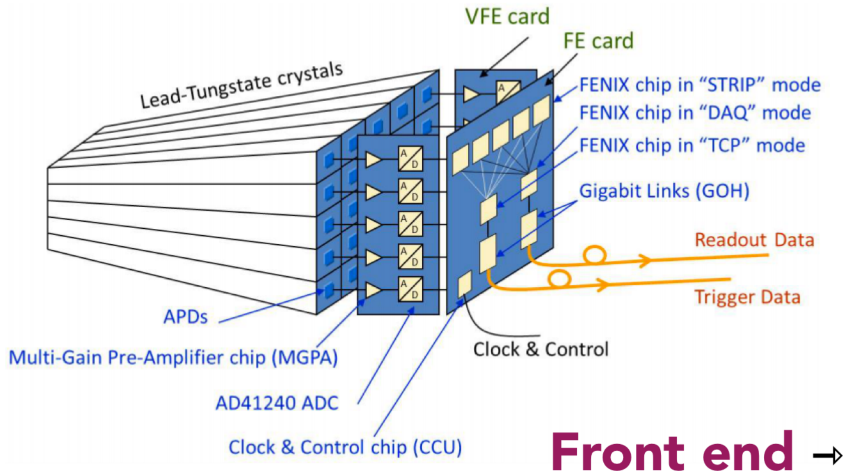


[1] Max Plank Institute for the Structure and Dynamics of Matter
[2] Semiconductor laboratory
[3] Karlsruhe Institute of Technology

Mikhail Polovykh
mpo@hll.mpg.de



Title: The performance of the CMS ECAL data acquisition system at LHC Run 2
Author: Tanvi Wamorkar
Main innovation: During 2017, the Large Hadron Collider has provided p-p collisions up to an integrated luminosity of 50/fb. The CMS detector was able to record 90.3% of this data. The CMS electromagnetic calorimeter (ECAL), made of 75848 scintillating PbWO_4 crystals and a silicon-lead preshower, has achieved an excellent data collection efficiency thanks to the reliable ECAL data acquisition (DAQ) system. The ECAL DAQ system follows a modular and scalar schema: the crystals are divided in sectors, each controlled by 3 interconnected boards. These boards are responsible for the configuration and control of the front-end electronics, the generation of trigger primitives for the central CMS L1 trigger, and the collection of data. A multi-machine distributed software configures the electronic boards and follows the life cycle of the acquisition process. With the increase of instantaneous luminosity in Run 2, the number of occasional errors due to radiation effects on the front-end electronics has increased. The ECAL DAQ has been improved to automatically detect and recover from these errors. We describe the ECAL DAQ system, its automatic recovery procedures, monitoring tools, and system performance.



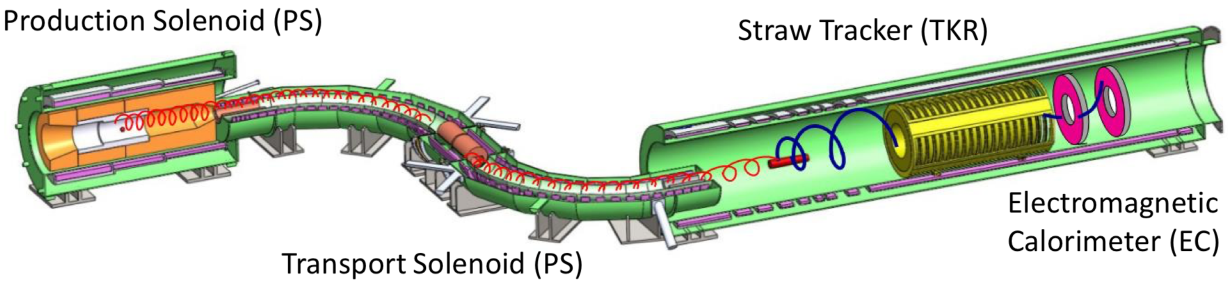
- ECAL Trigger and DAQ hardware system is divided in two parts:
  - On-detector: responsible for signal digitization and trigger primitives production
  - Off-detector: finalization of trigger primitive calculation & readout of full granularity data
- Trigger tower (TT): group of 25 adjacent crystals, basic detector unit
- Off-detector electronics is made of **54 identical modules: FED's** (Front End Driver)
- Every FED is made of Trigger concentrator card (TCC) + Clock & Control System (CCS) + Data concentrator card (DCC)

Front end → Off-detector trigger boards → Control path → DAQ path

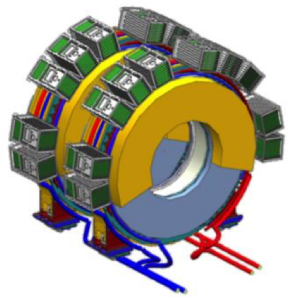
Mu2e calorimeter readout system

L. Baldini [1], D. Caiulo [1,2], F. Cei [1], F. D'Errico [1], S. Di Falco [2], S. Donati [1,2], S. Faetti [1], S. Giudici [1], L. Lazzeri [1], L. Morescalchi [2], D. Nicolò [1], E. Pedreschi [1,2], G. Pezzullo [3], G. Polacco [1], M. Sozzi [1], F. Spinella [1]

[1]University of Pisa, [2]INFN - Pisa, [3]Yale University



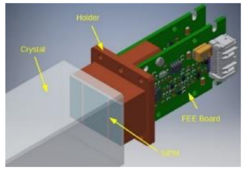
Look for the 105 MeV conversion electron

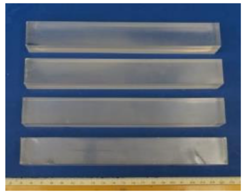


Calorimeter Requirements:

- Particle identification μ/e
- Seed for track pattern recognition
- Independent trigger

→ **$\Delta E/E$ < 10% and Δt < 500 ps**
→ **Position resolution of O(1 cm)**



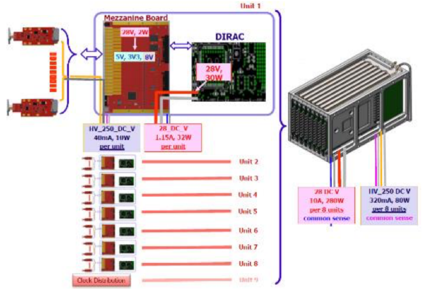


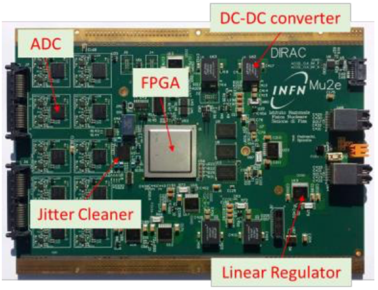
Digitizer Requirements:

- Very intense particle flux → high sampling rate digitizers to resolve pile-up → sampling frequency of **200 Msamples** with **12 bits** ADC
- System located inside the cryostat → harsh environment
- Limited space
- Limited acces

Front-end boards connected to SiPM provide:

- Amplification
- Local linear regulation of the bias voltage
- Monitoring of current and temperature
- Test pulse





- Working environment & sample rate imply limitations on the component choice
- Qualification for radiation tolerance
- DCDC converter must also be tested in magnetic field.
- Compatibility between FPGA and ADC must be tested

- ADC and the DCDC converter tested with neutrons and gamma rays for radiation tolerance.
- ADC test results: no evidence of bit flips or waveforms shape variation emerged
- DCDC converter tested under a strong magnetic field at the INFN Lasa laboratory

Scintillation Light DAQ and trigger system for the ICARUS T600 experiment at Fermilab

M.Babicz[1,2], F. Pietropaolo[2,3], A. Fava[4], W. Ketchum[4], D. Torretta[4], A. Falcone[5], S. Centro[3,6], A. Guglielmi[3], G. Meng[3,6], S. Ventura[6], T. Cervi[7,8], A. Menegolli[7,8], G.L. Raselli[8], A. Rappoldi[8], M. Rossella[8]

[1]Institute of Nuclear Physics PAN, Cracow (Poland), [2]CERN (Switzerland), [3]INFN Padova (Italy), [4]FNAL (USA), [5]University of Texas (USA), [6]University of Padova (Italy), [7]University of Pavia (Italy), [8]INFN Pavia (Italy)

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14th Pisa Meeting on Advanced Detectors

ICARUS T600 will soon become the far detector of the Short Baseline Neutrino program at FNAL (USA). The apparatus underwent a major refurbishing at CERN in which a new light detection system with 360 PMTs. The trigger system will exploit the coincidence of the prompt signals from the scintillation light in correspondence to the arrival time of neutrinos provided by the BNB and NuMI beams.

The main features of the scintillation light DAQ and trigger are presented.

Web-based Experiment Monitoring with HTML5

•Modern web technologies are the future of control and monitoring:

- JavsScript inside a browser renders graphics as fast as native applications a few years ago
- Operating system independent
- Runs on PCs, tablets, smartphones
- Remote access, no installation required
- Automatic software updates

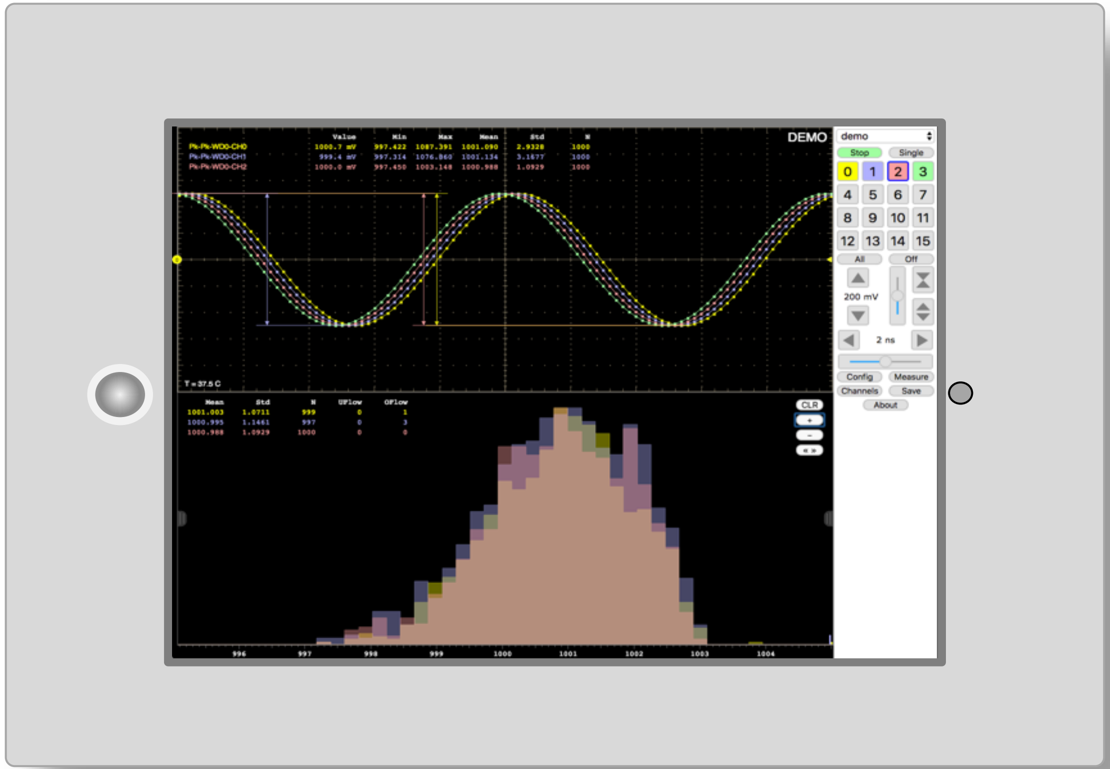
•Try yourself:

•http://elog.psi.ch/scope

Covered technologies:

- Mongoose web server
- JSON, JSON-RPC, Typed Arrays
- HTML5 canvas rendering
- Custom controls
- **Live demo** of DRS4-based WaveDREAM oscilloscope running in browser

Stefan Ritt, PSI



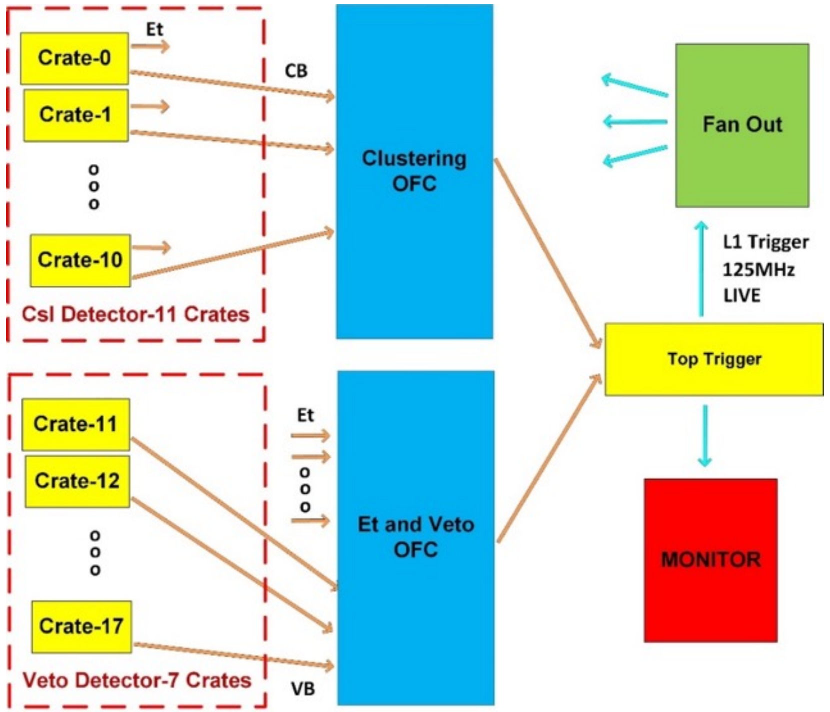
3. L1 Trigger and Algorithms in FPGA

The University of Chicago

Optical Fiber Center Module for the KOTO Experiment

Mircea Bogdan, Lin Chieh, Yuting Luo, Yu-Chen Tung, Yau Wah

The Optical Fiber Center (OFC) is a new module designed to reduce dead-time and latency and to expand logic and monitoring of the KOTO DAQ System, in JPARC, Japan.



Block Diagram of the KOTO Trigger with two OFCs :

- Et and Veto OFC collects calorimeter energy and veto decisions.
- Clustering OFC collects Cluster information and creates a Cluster Map for each Event.

Trigger decision is made based on physics of interest.

- Reduce trigger dead-time from 100 to 18 clocks, and trigger latency from 250 to 100 clocks;
- Lower CsI Total Energy threshold, therefore increase physics sensitivity;
- Eliminate the largest systematic error (5.5%) from L1 Veto, by using OFC veto as first level veto, and allow for Veto decisions on every clock;
- Expand the capability of doing complex trigger logic and improve monitoring and debugging of the trigger system.

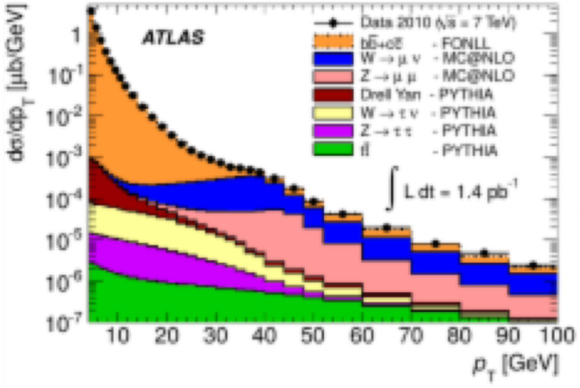
Fitted with a powerful Intel Arria V FPGA and 18 SFPs, this module can be a useful tool for many other HEP applications.

14th Pisa Meeting on Advanced Detectors
27 May to 02 June 2018 – La Biodola, Isola d'Elba, Italy

First-Level Muon Track Trigger for Future Hadron Collider Experiments

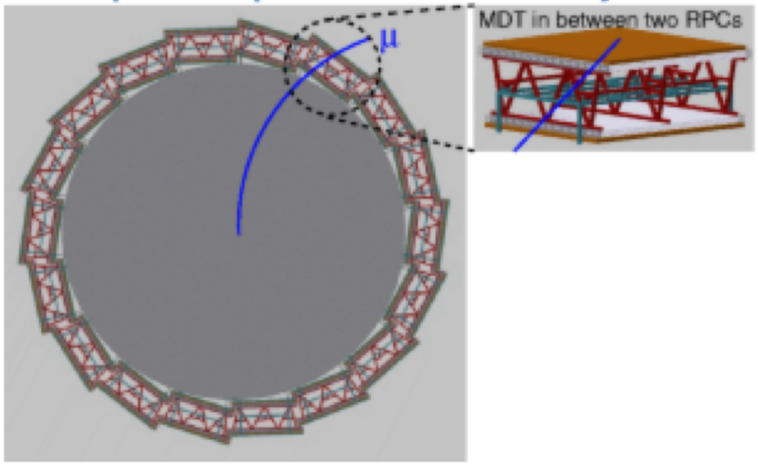
S. Abovyan, D. Cieri, M. Fras, Ph. Gadow, O. Kortner, S. Kortner, H. Kroha, F. Müller, S. Nowak, R. Richter, K. Schmidt-Sommerfeld
Max-Planck Institute for Physics, Munich, Germany

Importance of low p_T single-muon triggers at pp colliders

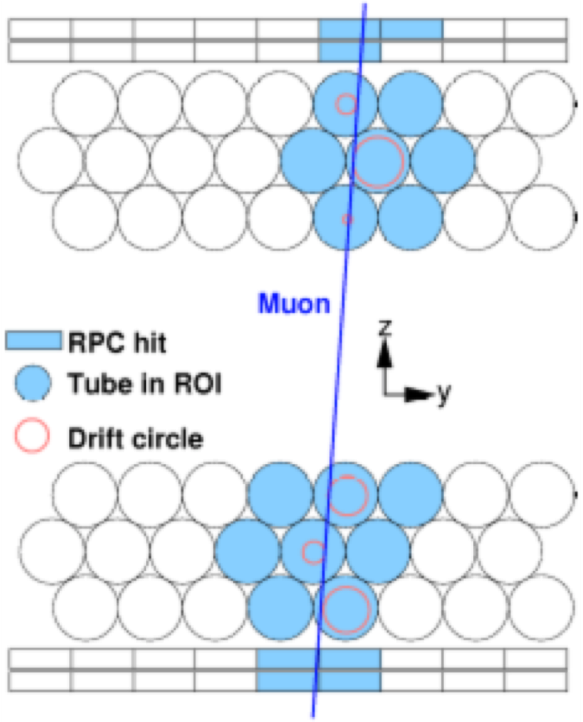


- The interesting electroweak physics is mainly at p_T>20 GeV.
- The inclusive muon cross section is very steeply rising with decreasing p_T.
- In order to limit the single muon rate at low transverse momenta, good momentum resolution at the trigger threshold is mandatory.

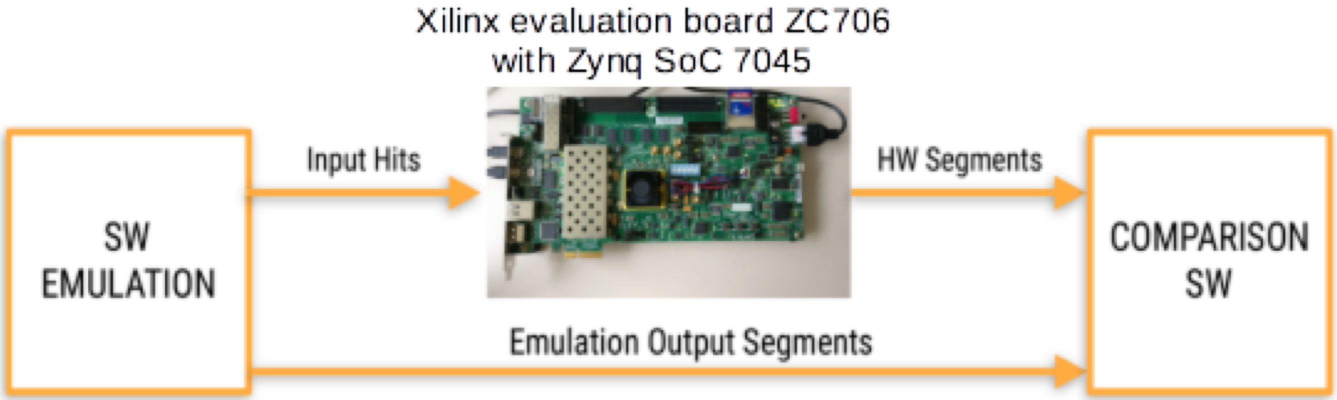
Example: Proposed FCC muon system



Compact muon finder algorithm for fast track reconstruction



- Work only in the ROI from the RPC system.
- Pattern recognition with a 1-D Hough transform (estimate for track angle from RPCs).
- Segment fit by linear regression to the hits found in the pattern recognition step.
- Algorithm successfully tested on a Zynq 7045 FPGA.
- Latency: 250 ns at 240 MHz clock frequency.



The Phase-I Trigger Readout Electronics Upgrade of the ATLAS Liquid Argon Calorimeters

Yi-Lin Yang (The University of Tokyo)
On the behalf of ATLAS LAr group

The Super Cell has been proposed in the Phase-I LAr upgrade to replace the existing trigger system "Trigger Tower" due to higher luminosity environments in Run 3 at LHC. The higher granularity of the Super Cell trigger systems requires higher data transmission (at least 25 Tbps)and processing rate. The new system is also needed to be compatible with the existing trigger system. To fulfill these requirements, the new electronics including frond end and back end are developed. So far, the demonstrator installed in 2014 shows good consistency with the main readout from the 2017 collision data. New demonstrator is installed and tested from 2018 collision data.

Back End – LDPS ❹

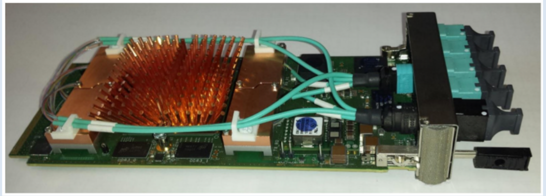
*LDPS(LAr Digital Processing System) receives digitized data(ADC), send E_T to FEX(Feature Extractors) and monitoring. Build on **ATCA** architecture*

◆LAr Carrier

Provides data transmitting, monitoring and control signal

◆LATOME - LAr Trigger Processing Mezzanine

- INTEL™ Arria™ 10 FPGA
- 2 GB DDR3
- 48 input fibers 5.12 Gb/s per fiber
- 48 output fibers 11.2Gb/s per fiber



- Capable up to 320 channels

◆ Energy Reconstruction in LATOME

- FIR Filter

$$E = \sum_{i=1}^{N} a_i (S_i - P)$$

a_i : coefficient P : pedestal
S_i : ADC data N : N. of samples

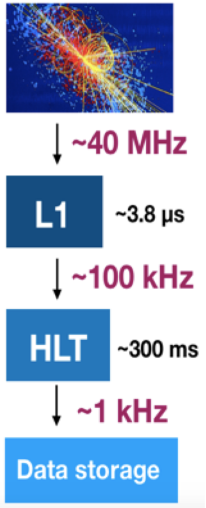
- Framework
  - Serialized 6 channels with 240MHz
  - 62 parallel processing
- Features
  - Coefficients & pedestals stored in circular buffer
  - Cascaded DSP blocks
    - ✓ Minimized wiring delay
    - ✓ All calculation done in DSP blocks

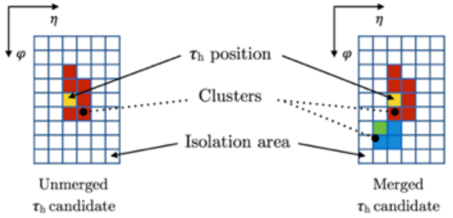
The CMS Level-1 tau lepton and Vector Boson Fusion triggers for the LHC Run II

C. Martín Pérez on behalf of the CMS Collaboration*

**Laboratoire Leprince-Ringuet, École Polytechnique, France*

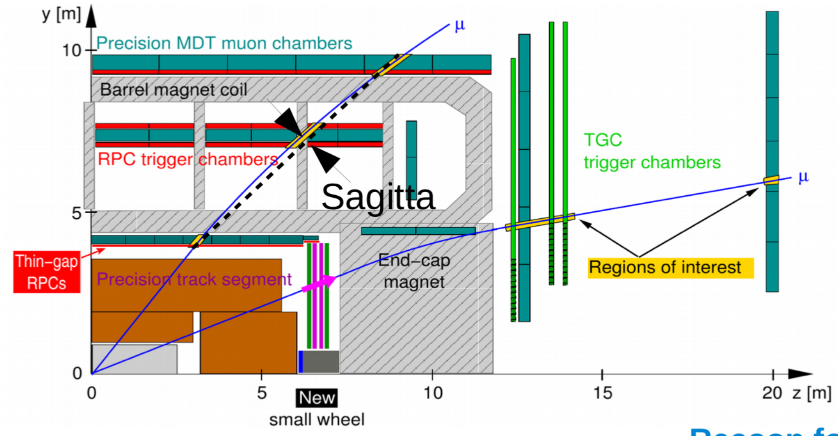
- The **CMS** experiment at the LHC implements a sophisticated **two-level triggering system** composed of Level-1, instrumented by custom-design hardware boards, and a software High Level Trigger.
- A **new Level-1 trigger architecture** with improved performance is now being used to maintain **high physics efficiency** for the more challenging luminosity conditions experienced during Run II.
- The **upgrades to the calorimeter** trigger will be described along with **performance** measured on Run II collision data.
- The algorithms for the **selection of final states with hadronically decaying tau leptons**, both for precision measurements and for searches of **new physics** beyond the Standard Model, will be described in detail.
- The implementation of the **first dedicated Vector Boson Fusion trigger** algorithm will be presented as well, along with its performance on **Higgs physics** signals.





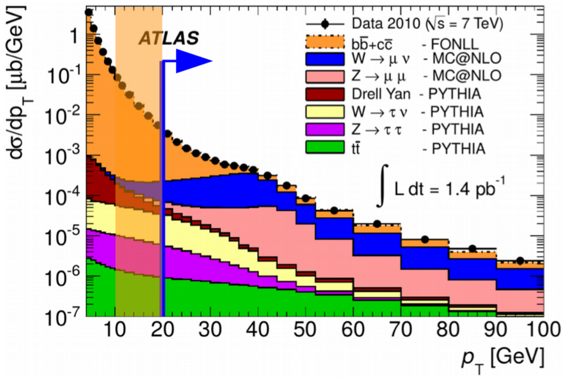
Development of a Highly Selective Muon Trigger Exploiting the High Spatial Resolution of Monitored Drift-Tube Chambers for the ATLAS Experiment at the HL-LHC

Oliver Kortner (MPI for Physics Munich, Germany) on behalf of the ATLAS Collaboration



Muon trigger at the HL-LHC

- 2-level trigger system: Hardware based level 0 (L0), software based high-level trigger (HLT).
- L0 muon trigger:
  - Pretrigger: Coincidence of RPC or TGC hits.
  - → pp collision time (BCID) + η and φ position of the muon (spatial region of interest (RoI)). p_T measurement with low resolution.
  - Final trigger: Use of precision hits of monitored drift-tube (MDT) chambers for precise p_T measurement.

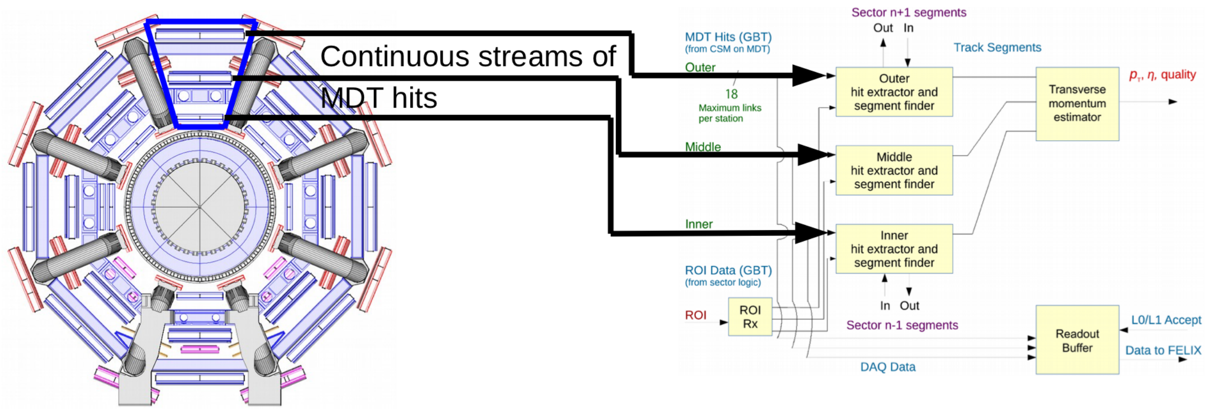


Reason for MDT trigger

- The interesting electroweak physics is mainly at p_T>20 GeV.
- The inclusive muon cross section is very steeply rising with decreasing p_T.
- Muon pretrigger without MDT data accepts a lot of muons with 10 GeV<p_T<20 GeV.

→ Reduction of the trigger rate due to sharpening of the turn-on curve and the rejection of accidental pretriggers:

	Rate without MDTs	Rate with MDTs
Barrel (|η|<1.05)	45-85 kHz	~15 kHz
End caps (1.05<|η|<2.4)	15-20 kHz	~10 kHz



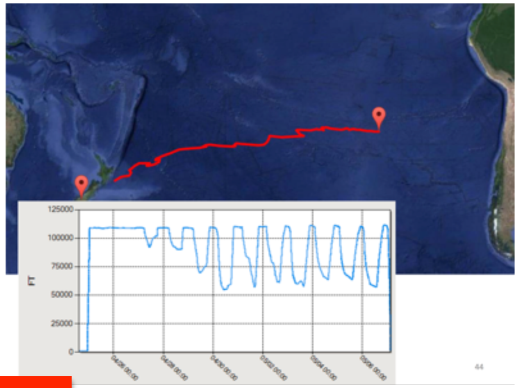
MDT trigger hardware and data flow

- Implementation on ATCA blades.
- Data flow:
  - Segment reconstruction in each chamber only in the ROI performed on a FPGA with the option of an associative memory chip for pattern recognition.
  - Momentum determination from segment positions and segment angles.
- Total muon trigger latency < 4.2 μs

Performance results of the trigger logic implemented in EUSO-SPB

J. Bayer[a], **M. Bertaina**[b], A. Cummings[c], J. Eser[c], F. Fenu[b], A. Jung[d], M. Mignone[b], H. Miyamoto[b], K. Shinozaki[b] for the JEM-EUSO Collaboration
a) IAAT Tuebingen - Germany, b) University & INFN Torino – Italy, c) Colorado School of Mines - US, d) APC Univ. Paris Diderot - France

FLIGHT CAMPAIGN from Wanaka, New Zealand



TEST CAMPAIGN in Utah

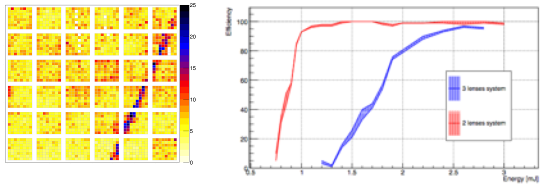


Figure 2: GLS laser event (2 mJ) going through the FoV of the PDM adopting the 2 lens system (left) and trigger efficiency as a function of laser energy (right) with 2 and 3 lens system for vertical shots. The 3 lens system was only tested up to 2.7 mJ.

TRIGGER LOGIC and PDM board

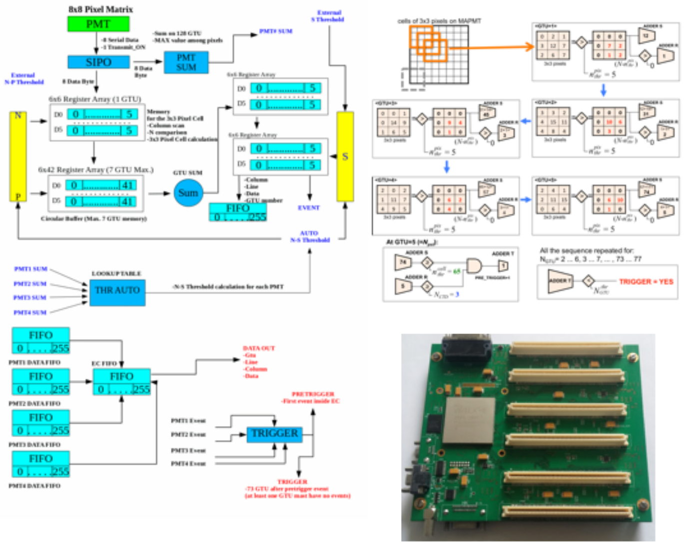


Figure 1: Top: Schema of the VHDL implementation of the FLT logic. Top right: The FLT trigger logic. Bottom right: PDM board.

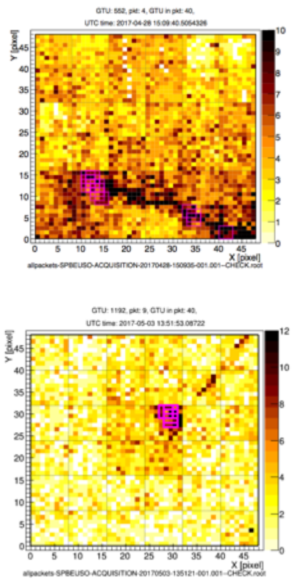


Figure 4: Examples of CRs interacting in the detector.

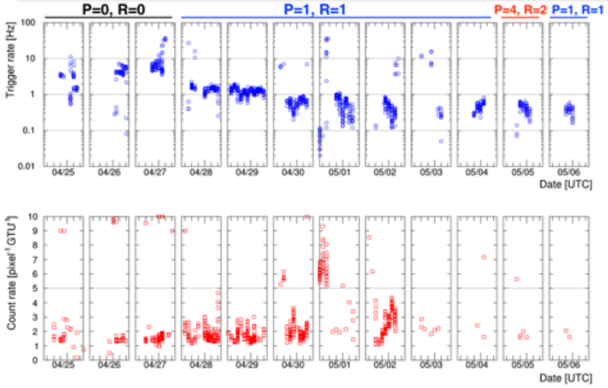


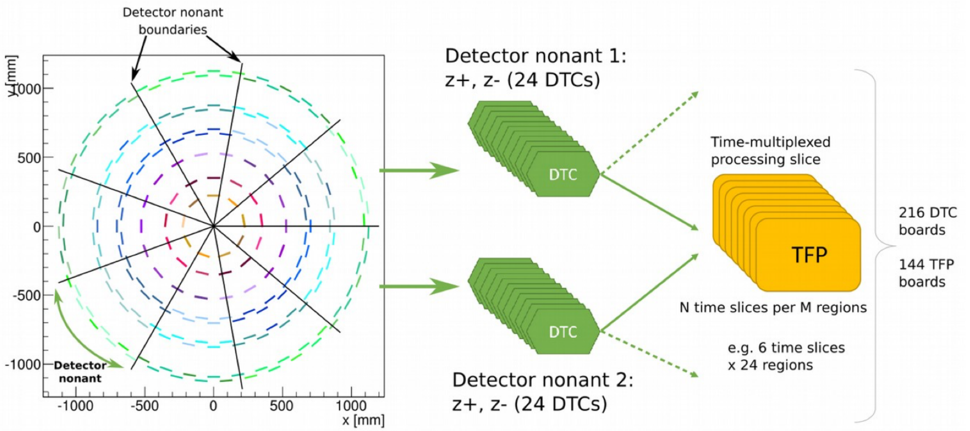
Figure 3: Top: EUSO-SPB trigger rate in flight. Bottom: average count rate measured at pixel level.

Level-1 track finding with an all-FPGA system at CMS for the HL-LHC

Luis E. Ardila-Perez
on behalf of the CMS collaboration

Challenges

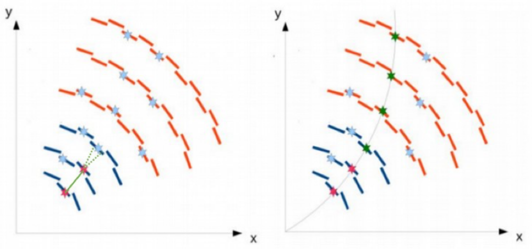
- Large data volume: about 10,000 stubs per bunch crossing (25 ns) with <PU>=140; data bandwidth 20-40 Tbits/s
- Perform pattern recognition to associate stubs to tracks
- Fit stubs for track parameters
- Fast data processing: 12.5 μs to make L1 trigger decision, ~4 μs of which is available for L1 track finding



Summary

- L1 track trigger at HL-LHC necessary but also challenging
- Two all-FPGA approaches: Tracklet and TMTT
  - Highly parallelized tracking algorithms
  - Data organization → pattern recognition → track fitting → duplicate removal
  - Both have demonstrated feasibility and good performance
- Efforts have started to merge the two approaches
  - Common infrastructure R&D

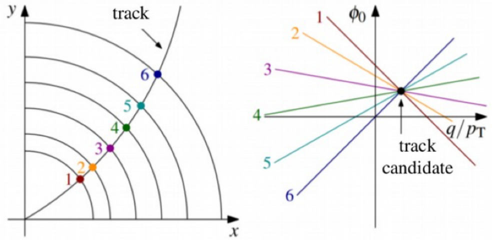
Tracklet Approach



- Combinatorial approach using **pairs of stubs as seeds**
- **Extrapolation** to other layers -> hit matching
- **Linearised χ^2 fit** on candidates
- Uses **full resolution stubs** at earliest stage of processing

- N time-slices x M regions -> 6 x 24 , 9 x 18

Hough Transform + Kalman Filter Approach



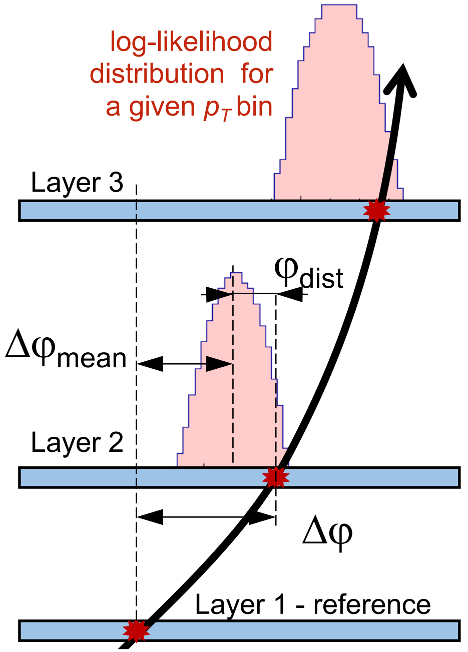
- Uses a **Hough Transform** to detect coarse candidates
- Candidates are filtered and fitted in a single subsequent step using a **Kalman Filter**
- Combinatorial problem pushed to latter stages of processing

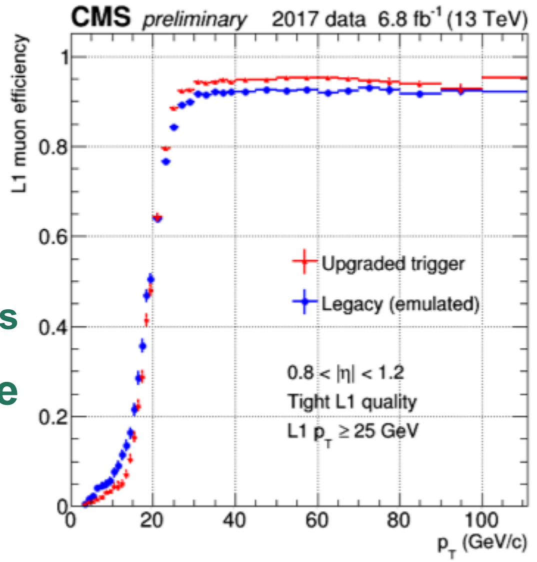
- N time-slices x M regions -> 18 x 9

The algorithm of the CMS Level-1 Overlap Muon Track Finder trigger

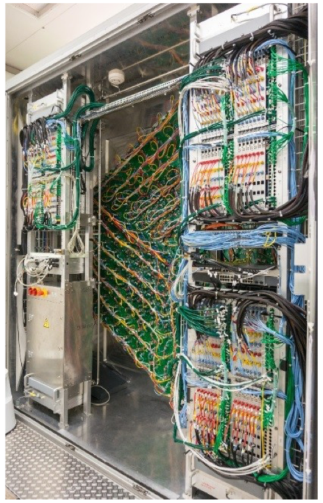
Karol Bunkowski, University of Warsaw

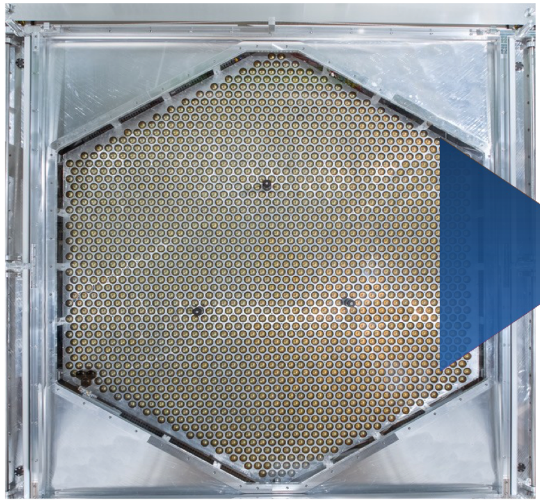
- **CMS Level-1 Trigger** – the system based on custom electronics built around the FPGA devices - **was upgraded in 2016**. The **new Muon Trigger** was divided into three parts, processing data from the barrel, **overlap** and endcap regions of the detector, respectively.
- **Overlap region**: **18 detector layers** (DT, CSC, RPC) samples the muon track in many points, but the challenge is to develop an algorithm for the p_T measurement that can use all these layers and fit into FPGAs.
- **Algorithm principles:**
  - The algorithm is based on the **classic machine learning algorithm: naïve Bayes classifier**.
    It is assumed that the log-likelihood that a muon has a given transverse momentum $p(p_T|hits)$ is just a sum of the log-likelihoods of the muon hit phi positions in each detector layer $p_{layer}(p_T|\varphi_{\text{dist in layer}})$.
    Maximum log-likelihood p_T is chosen as the muon p_T.
  - **The complexity of the algorithm is linear versus the number of layers**
- **Performance: 25% smaller rate and 2% better efficiency than the legacy muon trigger in the overlap region.**





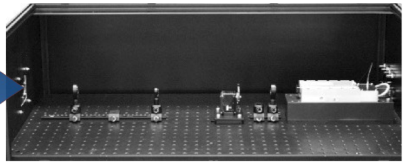
Trigger Performance Verification of the FlashCam Prototype



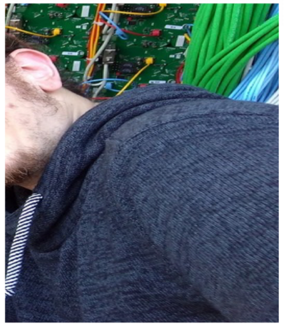


Lab. calibration unit

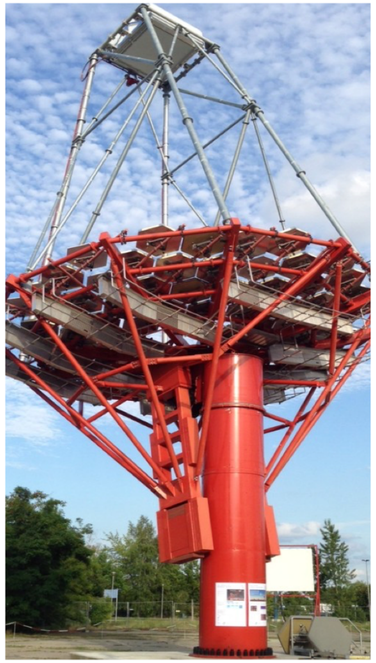
Pulsed Laser



Blue LED (Simulation of NSB)



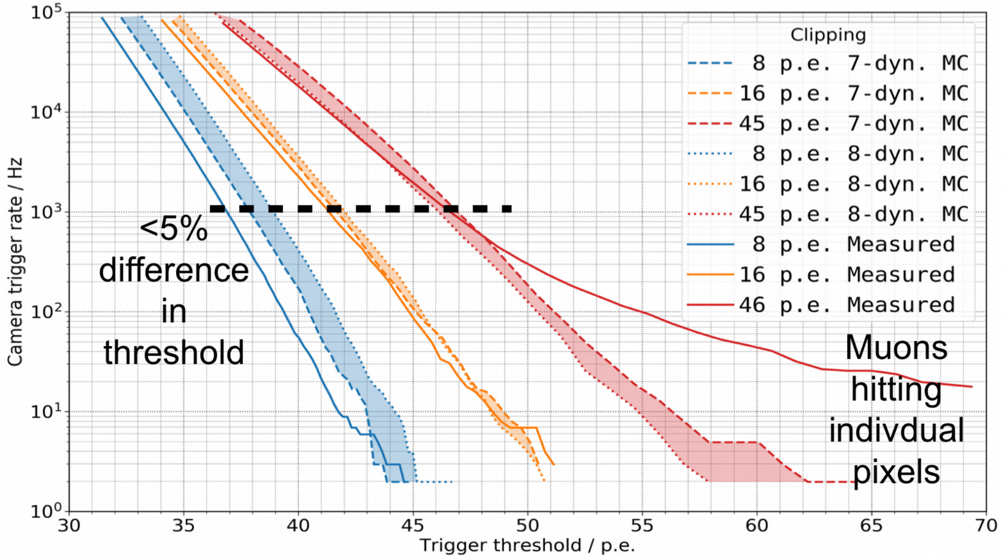
Simon Sailer
CTA FlashCam Project



Fully-digital topological trigger forming

Emulation of camera trigger in software on readout traces

Monte-Carlo versus measured camera trigger rates due to NSB with 300 MHz photo electrons / pixel



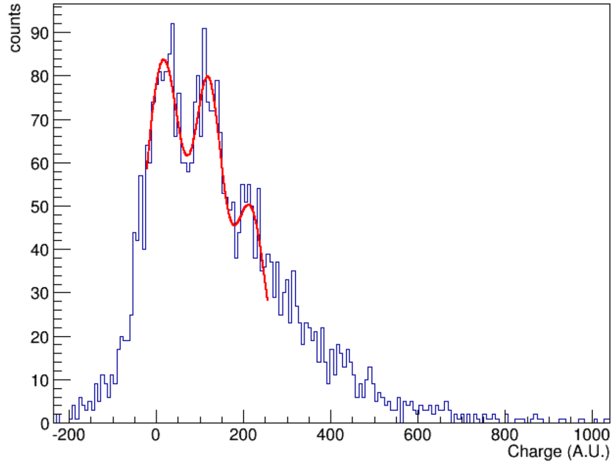
4. Validation of readout chains

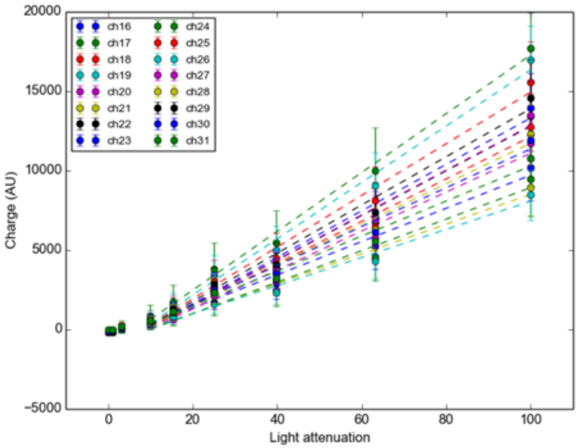
Readout chain validation of INFN modules for the CTA-pSCT camera

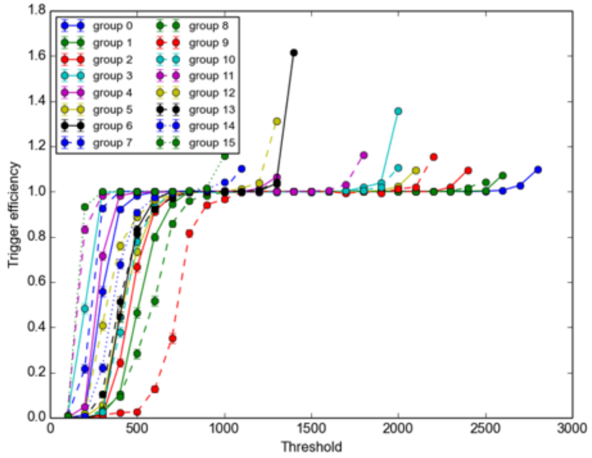
14th Pisa Meeting on Advanced Detectors

G.Ambrosi, M.Ambrosio, C.Aramo, B.Bertucci, E.Bissaldi, A.Boiano, C.Bonavolontà, M.Caprai, L.Consiglio, L.Di Venere, E.Fiandrini, N.Giglietto, F.Giordano, F.Licciulli, **S.Loporchio**, V.Masone, M.Movileanu, R.Paoletti, A.Rugliancich, L.Tosti, V.Vagelli, M.Valentino for the CTA Consortium

- FBK NUV HD3 SiPM + TARGET 7 coupling for the double mirror SCT telescope for CTA
- Waveform acquisition
- Charge spectrum
- ADC linearity
- Trigger efficienecy







Testing and integration of front end electronics for INO-ICAL RPCs

Ankit Gaur, Aman Phogat, Moh. Rafik, Ashok Kumar, Md. Naimuddin
Department of Physics and Astrophysics, University of Delhi, India

- The India based Neutrino Observatory (INO) is an particle physics approved project that involves the construction of a underground laboratory for the basic research in neutrino physics.

- The Iron CALorimeter is the flagship experiment in this facility and is going to shed light on many important issues related to the atmospheric neutrinos.

- The ICAL geometry is going to utilize about 29000 single gap Resistive Plate Chambers (RPCs) as triggering and tracking elements.

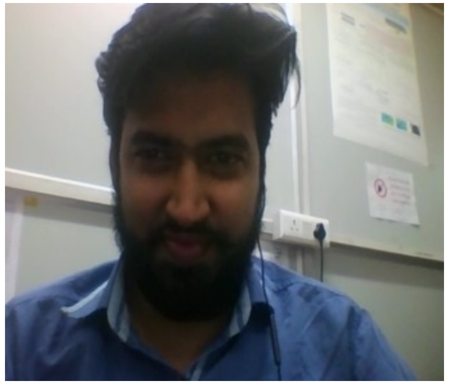
- In order to read signals , millions of electronic channels needed to be instrumented.

- Many technical challenges like power consumption, handling of the enormous channels and the long term stability have to be kept in mind before pursuing the final production and installation.

- To cope up with enormous number of electronic channels and considering important factors, a semi-digital front end readout namely HARDROC has been tested and commissioned.

- The performance of the HARDROC ASIC has been estimated with tests performed for the better understanding of the operational parameters and their impact on the readout chain. The goal was also to evaluate the effect of different parameters of all the readout modes with controls on the operational behaviour of the chip.

- Efficiency more than 90% is obtained using HARDROC and study relating cluster size and global efficiency is going on.

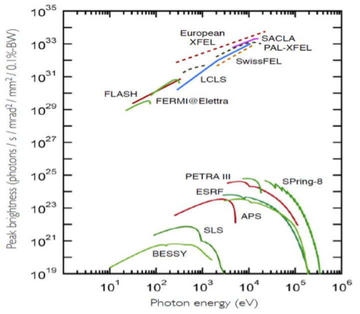


PERCIVAL characterization software framework

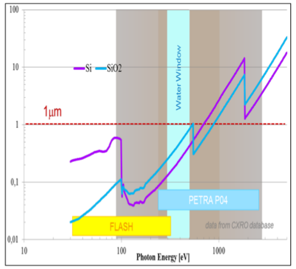
B.Boitrelle[a], J.Correa[b,g], A.Marras[b,g], P.Göttlicher[b], H.Graafsma[b,g], F.Krivan[b], M.Kuhn[b], S.Lange[b,g], F.Okrent[b,g], I.Shevyakov[b], M.Tennert[b,g], C.B.Wunderer[b,g], M.Zimmer[b], N.Guerrini[c], B.Marsh[c], I.Sedgwick[c], G.Cautero[c], D.Giuressi[d], A.Khromova[d], R.Menk[d], G.Pinaroli[d], L.Stebel[d], A.Greer[e], T.Nicholls[e], U.Pedersen[e], N.Tartoni[e], H.J.Hyun[f], K.S.Kim[f], S.Y.Rah[f]

Scientific motivations

Fast readout pixelated detector for Soft X-rays experiments



Brilliance of photon sources increases requiring new detectors:
- high dynamic range
- single-photon discrimination



- Water window detection: sub-μm absorption lengths for Si and SiO_2
- Entrance window needs to be minimized

PERCIVAL characterization software framework

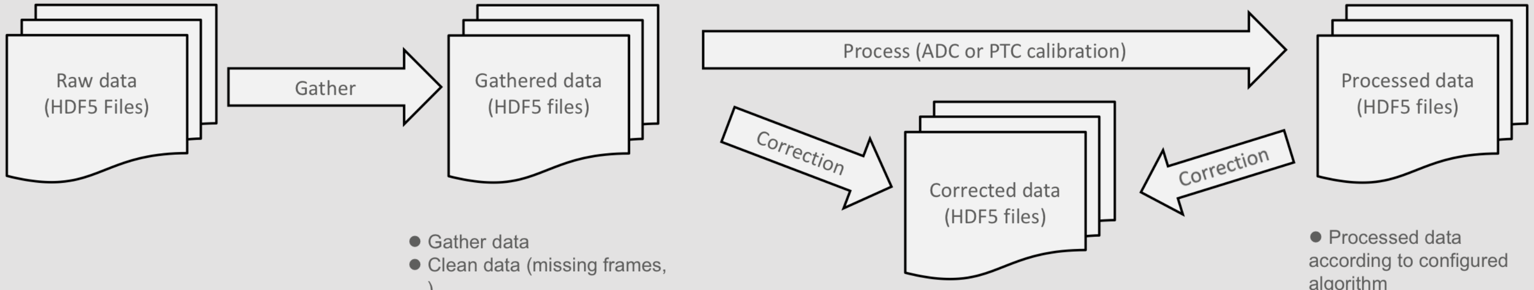
PURPOSES

- Calibration: generation of calibration constants (ADC calibration, PTC calibration)
- Correction: applying calibration constants
- Characterization: noise, MTF, clustering, CCE, INL/DNL, …
- Written in Python3 for treating HDF5 files format

Algorithm development:

- Users define algorithms using a provided scaffold architecture
  - Derive from a base class to include a set of methods for the analysis (fit, error bars,…)
  - Selection of algorithm to use via command line arguments or a configuration file
- Users create a set of files to contain the algorithms
  - Files are put into predefined folder (to contain all existing algorithms)
  - Commits only to this predefined folder
  - One 'file' per algorithm
- Different generations of algorithms at the same time
  - Need to be in different files
  - Default algorithm is defined in global configuration

Principle of calibration:



- Gather data
- Clean data (missing frames, …)
- Split into Coarse, fine, gain
- Optimise data layout

- Apply ADC calibration constants

- Processed data according to configured algorithm

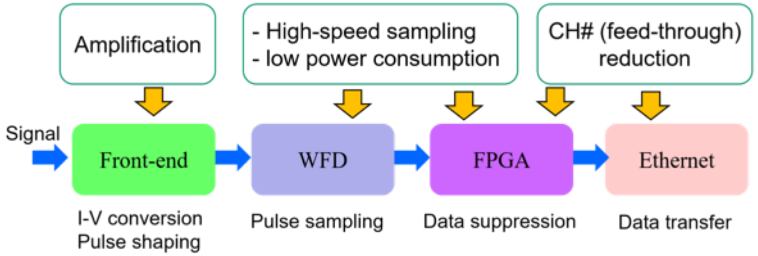
Design and performance evaluation of front-end electronics for COMET straw tracker

Kazuki Ueno[1], Eitaro Hamada[1], Shohei Hashimoto[2], Masahiro Ikeno[1], Satoshi Mihara[1], Hajime Nishiguchi[1], Tomohisa Uchida[1], Hiroshi Yamaguchi[1],

[1]KEK, [2]Kyushu University

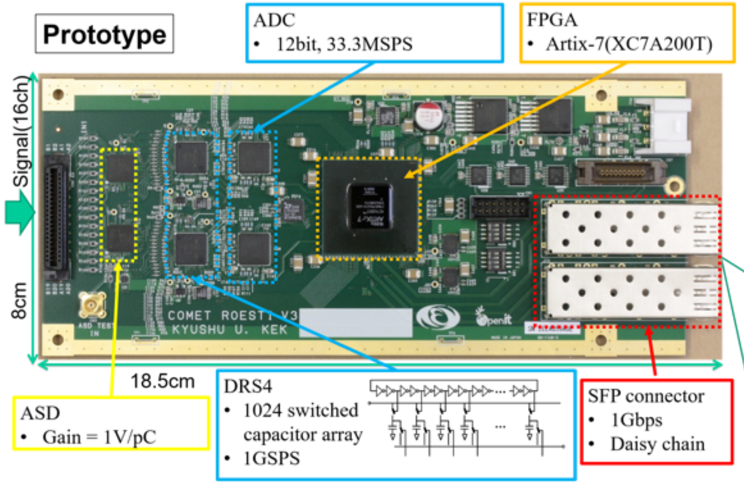
We have designed and developed front-end electronics for COMET straw tracker which is called ROESTI. Performance evaluation for the ROESTI was performed and we confirmed that the performance satisfied our requirements.

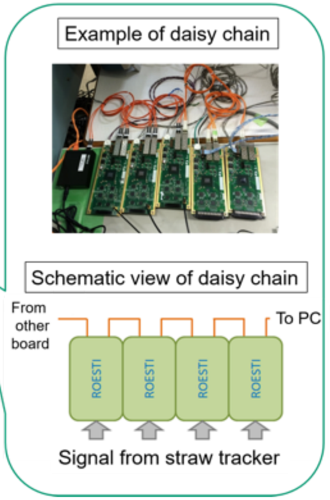
Block diagram



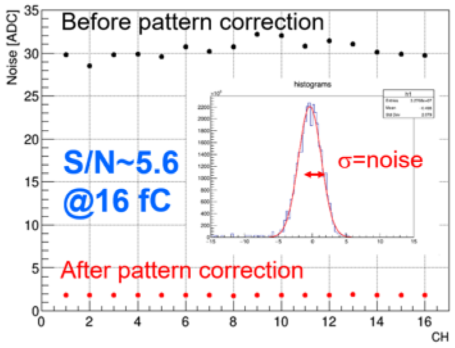
ROESTI

Read-**O**ut **E**lectronics for **S**traw **T**ube **I**nstrument

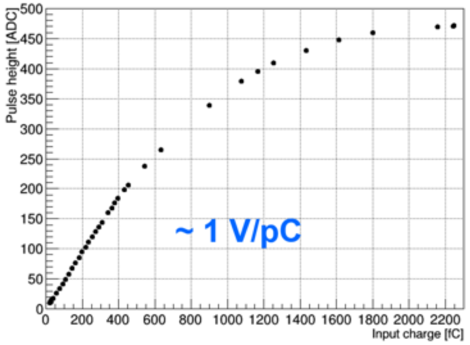




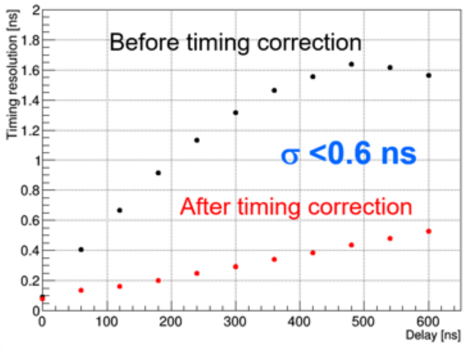
Noise



Gain/Linearity



Timing resolution



Param.	Req.	Meas.
Gain	1 V/pC	~1V/pC
S/N @ 16fC	5	5.6
Timing res.	1 ns	<0.6ns

5. Calibration systems

Design and test of the calibration system of the MEG II Pixelated Timing Counter

P. W. Cattaneo[a], G.Boca[a,b], F.Gatti[c,d], M.DeGerone[c], M.Nakao[e], M Nishimura[e], W.Ootani[e], M.Rossella[a], Y.Uchiyama[e], M.Usami[e]

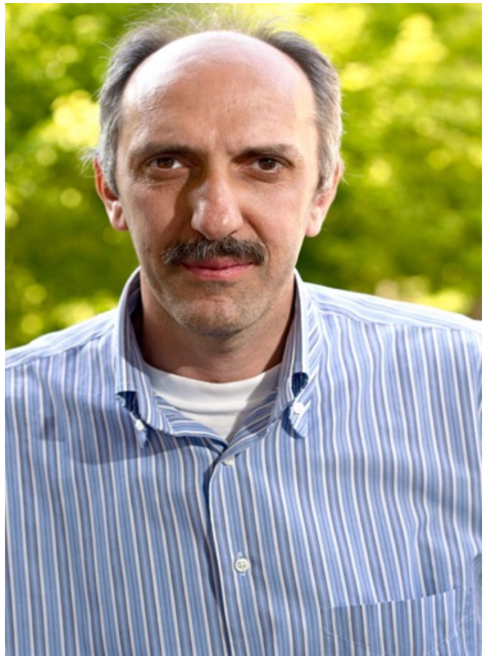
(a) INFN Pavia, (b) University of Pavia, (c) INFN Genova, (b) University of Genova, (e) The University of Tokyo

The Pixelated Timing Counter of the MEGII experiment is designed to measure the positron timing with a 30 ps resolution with 512 plastic scintillator counters read out by SiPMs by combining measurements with multiple pixels.

Based on the experience of the previous MEG Timing Counter, this resolution can be achieved only if the time offsets between pixels is carefully calibrated and monitored.

We present the design of a laser based system to continuously measure the pixels offsets with adequate precision.

In order to achieve the required resolution, the time delay and stabiliy of each component must be tested and taken into account. Those measurements are presented, showing that they are compatible with the requirement of the calibration system.

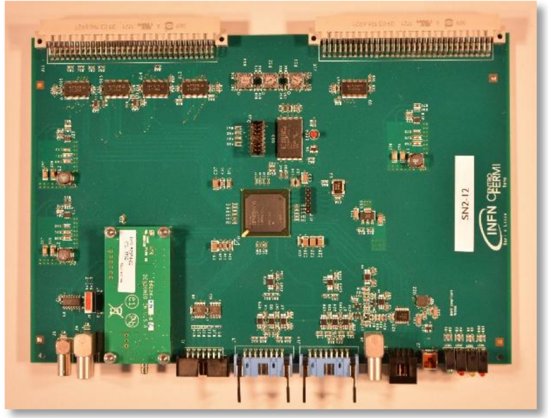


The New Trigger/GPS Module for the EEE Project

Maria Paola Panetta on behalf of the EEE Collaboration

The EEE Project is an experiment devoted to the **study of the Extensive Atmospheric Showers**. It consist of a network of 57 (at present) Multigap Resistive Plate Chambers muon telescopes, spread across **a very large area (3×10^5 km^2)**

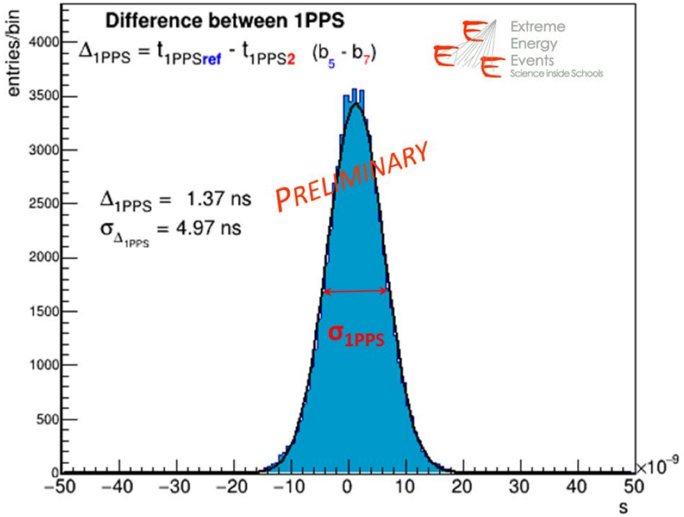
Precision timing of muon arrival is fundamental for studies as EAS and the search for long distant correlations between EAS.



The **absolute time** of an event is built as the **TDCs event time plus the GPS timestamp** for each one pulse per second **1PPS**.

A novel VME trigger unit for the EEE telescopes was developed, including an embedded GPS engine for timing application.
That allows extracting the event time stamping at level of the trigger unit, avoiding time drifts.

Time resolution measurements for **1PPS** between 2 different boards is evaluated as σ_{1PPS} from a distribution gaussian fit, showing adequate stability in time: $\boldsymbol{\sigma_{1PPS} \sim 5}$ **ns**



Muon g-2 Calibration system data flow

S. Mastroianni[1], O. Escalante[1,2], M. Iacovacci[1,2], A. Nath[1]
on behalf of Muon g-2 Collaboration

[1]Sez. Napoli, INFN, Italy, Napoli; [2]Università degli Studi di Napoli Federico II, Italy, Napoli

Laser Calibration System

- It provides a reference signal to calorimeter elements;
- The stability of the light distribution systems (Source and Local) are monitored at 10^{-4}
- Specialized electronics has been developed to manage signal processing and data readout.
  - ✓ MB module: preamplifier circuit, shaper and ADC conversion
  - ✓ Controller board collects the slave data by using a custom bus and sends them to the online farm.

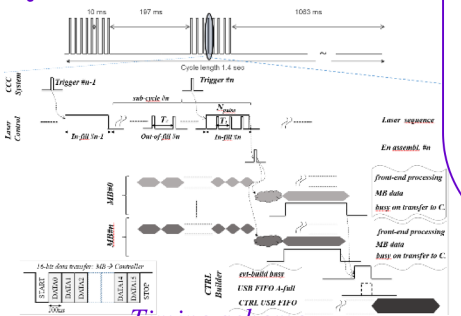
The data readout system

The data readout is able to accommodate several calibration modes in terms of pulse and data rate

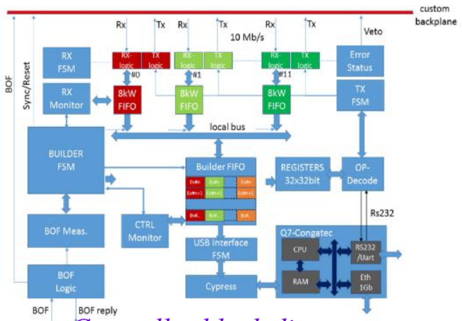
- In-Fill/Out-of-fill and simulation mode with a pulse rate in a large range (Hz ÷ MHz)

Readout chain with a trigger-driven algorithm.

- With new trigger → MB board performs frame assembling and data tranfer
- Controller performs the sub-frames collection, checks the data integrity and stores reconstructed frame in a local FIFO
- Data size for each pulse =10 byte/ch; data from MB over a serial link (Start/16-bit word/Stop) using 10 MHz reference
- An embedded CPU reads the data from USB device and sends them to the on-line farm over 1Gb Ethernet;
- A real-time monitoring is accomplished in a hardware without additional overhead on the CPU activities

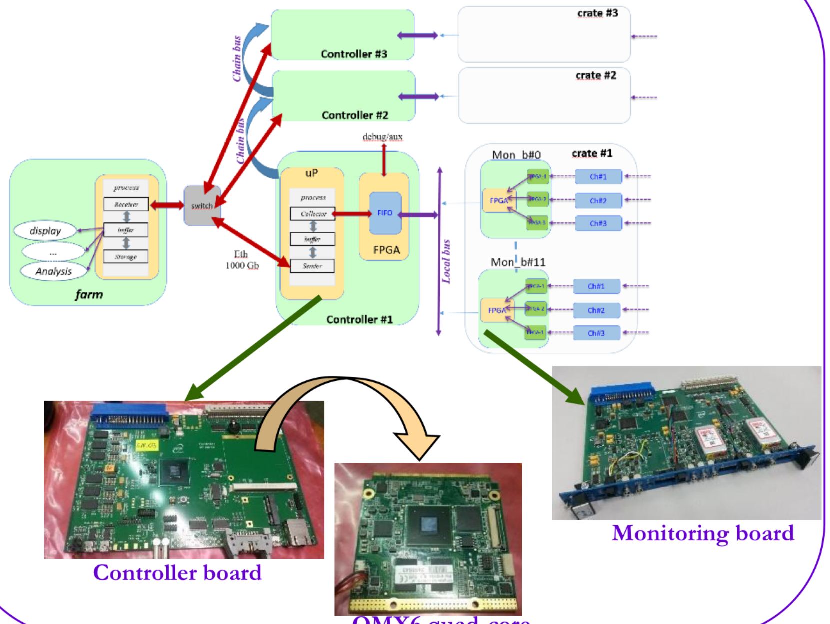


Timing scheme



Controller block diagram

DAQ based on a multiple crate system



Controller board

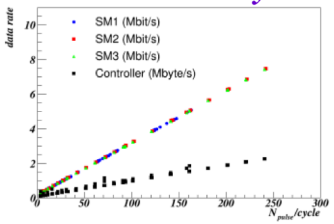
QMX6 quad-core

Monitoring board

Test results

A slice of the DAQ system was assembled at the Naples laboratory in order to integrate and test all the DAQ components under real conditions.

Data rate study



Linear behavior of the data transfer: SM and Controller measurements are carried out inside the Controller. The maximum value of slave data transfer is ~ 8 Mb/s. By design the peak value is about 9 Mb/s.

The Monitoring Electronics of the Laser Calibration system in the Muon g-2 experiment

M. Iacovacci[a,b], P. Di Meo[b], O. Escalante[a,b], S. Mastroianni[b], A. Nath[b]
on behalf of the Muon g-2 Collaboration

a. *Università "Federico II" di Napoli, Complesso Universitario di Monte Sant'Angelo, ViaCinthia, 80126 Napoli, Italy*
b. *INFN sez. di Napoli, Complesso Universitario di Monte Sant'Angelo, Via Cinthia, 80126 Napoli, Italy*

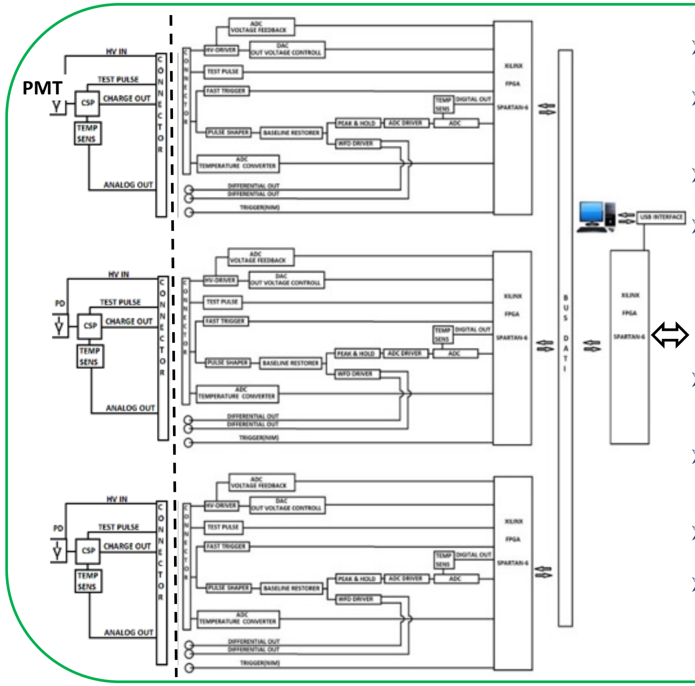
E-mail: iacovacci@na.infn.it

Abstract

The new Muon g-2 experiment at Fermilab (E989) will measure the muon anomaly $a_\mu = (g_\mu - 2)/2$ to an uncertainty of 16 x 10^{-11} (0.14 ppm), derived from a 0.1 ppm statistical error and roughly equal 0.07 ppm systematic uncertainties on the precession rate and magnetic field strength measurements. The experiment will run with a positive muon beam. The decay positrons will be detected by 24 electromagnetic calorimeters placed on the inner radius of a magnetic storage ring. They accurately measure arrival time and energy of the positron which curl to the inside of the ring following muon decay. Each calorimeter consist of 54 lead fluoride (PbF_2) crystals in a 6 high by 9 wide array. To achieve a systematic uncertainty of 0.07 ppm, the gain fluctuation of each calorimeter channel must be contained to less than 10^{-4}. To this aim a laser calibration system has been realized which is able to provide short laser pulses directly to each calorimeter crystal. The monitoring of these light signals is done by specific photo-detectors which translate the light pulse into electronic signal, which in turn is read by specialized Monitoring Electronics. The Monitoring electronics, organized in specific crates, performs full data acquisition of the calibration signals, starting from pre-amplification, then digitization of the signals and finally the transfer of the information. Here we describe the whole system in its structure along with the main features of the component boards.

Monitoring Board

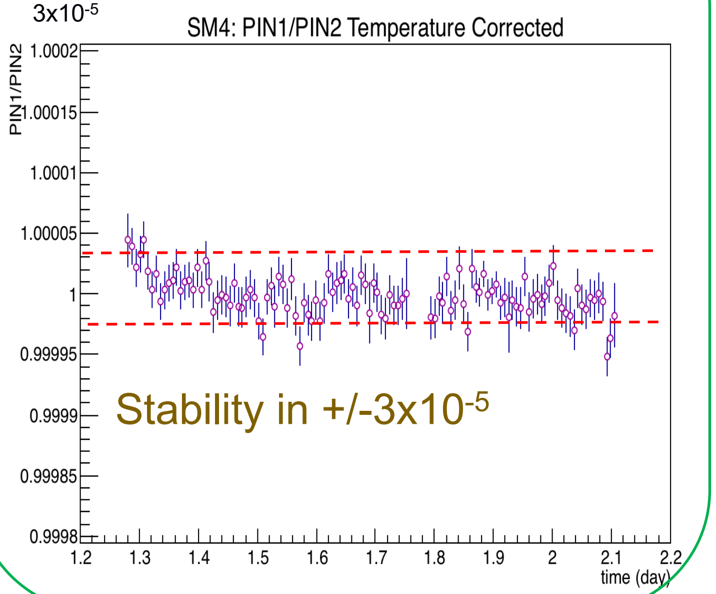
The calibration light signals are monitored both at the Source (laser output) and at the calorimeter level (delivery point) by the Monitoring Board (MB), which s the core of the system. It is meant to have high precision, stability and capability of self calibration.



- MB sends signal to a Wave Form Digitizer (WFD)
- Trigger: provides the LASER / Monitoring trigger to the WFD / DAQ
- Triggers the asynchronous mode of WFD/μTCA
- Digitizes the monitoring signals with a14-bit ADC and sends the values to a CONTROLLER board which in turns provides the data to the DAQ system via TCP / IP protocol.
- Digitization is started by the signal of the Laser Control (Start) suitably timed
- Provides BiasV/HV to the detectors (PiD/PMT) and monitor it
- Reads 3 Temp/channel (Tpream, Tboard, Tenv)
- Perform self-calibration of the electronic channel (known pulse at the preamplifier input)

Performance

Ratio of two calibration signals, as measured by the MB, after correction for Temperature dependence over 1 days of continuous data taking . It shows a stability at level of +/- 3x10^{-5}



6. Reconstruction algorithms

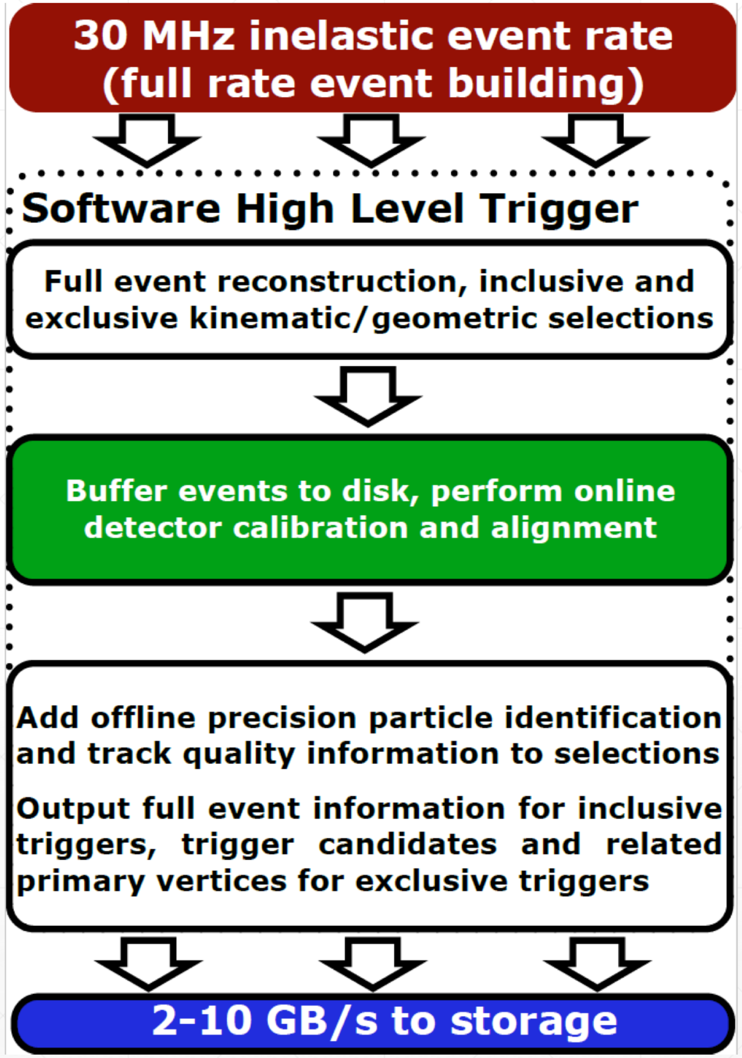
Monte Carlo response function simulations for the HEXITEC CdTe detector

Kjell A.L Koch-Mehrin[1], John E. Lees[1], Sarah L. Bugby[1], Matt D. Wilson[2]

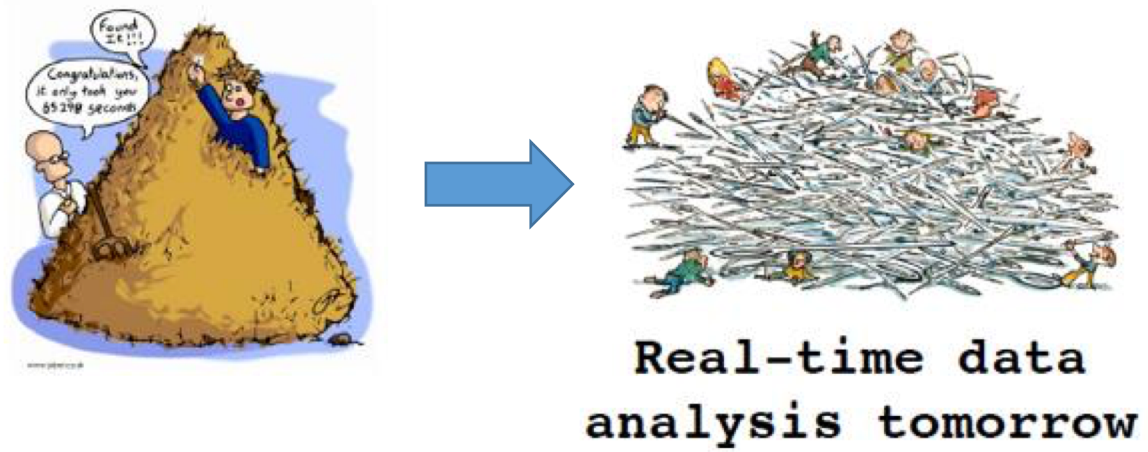
1 Space Research Centre, Michael Atiyah Building, University of Leicester, LE1 7RH, UK
2 Science and Technology Facilities Council, Rutherford Appleton Laboratory, Harwell Campus, Oxfordshire, OX11 0QX, UK

A pixelated (80x80 array on 250 μm pitch) high energy X-ray detector instrument (HEXITEC) has been developed by the Rutherford Appleton Laboratory (RAL) that can be used in a variety of imaging applications. The HEXITEC ASIC measures the energy and position of all detected X-ray photons. Coupled with a 1mm thick CdTe detector, the system can achieve an energy resolution of ~1 keV FWHM at the 59.5 keV. However, phenomena such as polarization, event pile-up and charge sharing are not fully understood and affect CdTe detector performance. Monte Carlo model simulations are used to show the effect of charge trapping at different energies, and experimental results show evidence of charge loss due to charge spreading.

LHCb Upgrade I Trigger System



- **Triggerless readout and full software trigger**
  - Process data at machine clock (40 MHz crossings and 30 MHz of visible interactions)
  - No L0 (hardware) bottleneck
- **No further offline processing**
  - All data taken in Turbo mode
  - Run II is a critical testbed for this technology
  - Offline resources can be used for simulation and central data analysis



Kalman meets Molière: optimal measurement of charged particle momentum from multiple scattering by Bayesian analysis of filtering innovations

D. Bernard & M. Frosini, LLR, Ecole Polytechnique, CNRS/IN2P3

Non-magnetic trackers / active targets :

- If track momentum, p, known, optimal tracking with Kalman filter.
- Momentum measurement with Molière theory $\Theta_{\text{multiple scattering}} \sim 1/p$. Some combination of many deflection measurements.
- How measure p optimally ?
  - Perform Bayesian analysis of Kalman filter(p) innovations applied to track.
  - Maximize probability

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“C++ implementation of Bethe-Heitler, 5D, Polarized, $\gamma \to e^{+} e^{-}$ Pair Conversion Event Generator”

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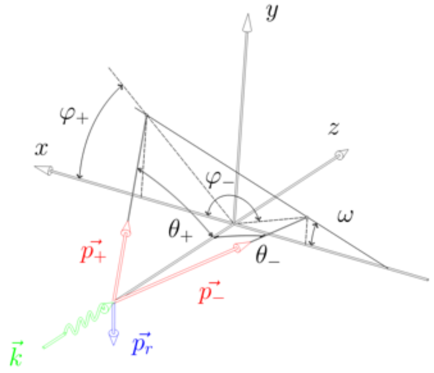

- *Implemented as Geant4 G4BetheHeitler5DModel*
- *Yielding a sampling of the five-dimensional Bethe-Heitler differential cross section*
- *Exact down to threshold, without any low-energy nor small-angle approximations*
- *Nuclear or electron (``triplet'') conversion target*
- *Detailed kinematic of gamma conversion*
- *Polarization asymmetry consistent with asymptotic values*
- *Linear polarized or non polarized beam*

The code was submitted to Geant4 EM group as a possible physics model of polarized gamma conversion in Geant4 framework and will be available in future release of Geant4.

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