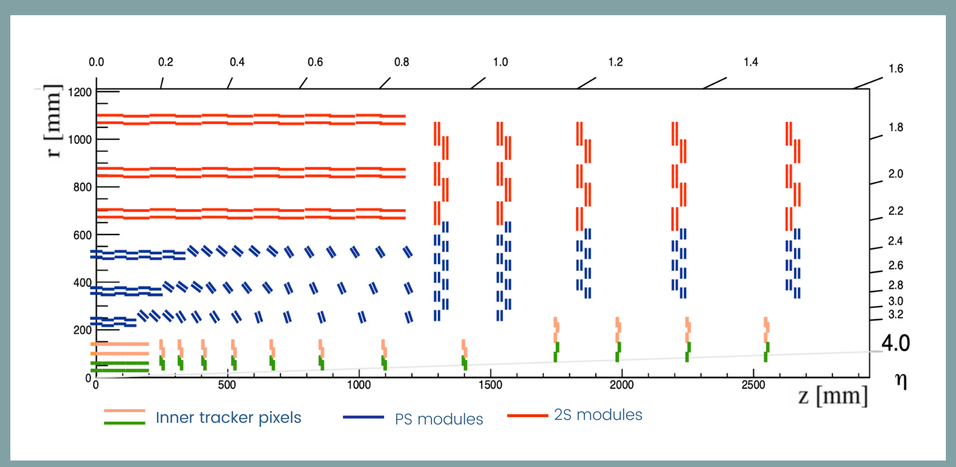
DAQ chain tests for 2S modules for CMS Phase2 outer tracker upgrade.

Matteo Magherini on behalf of CMS collaboration | matteo.magherini@cern.ch

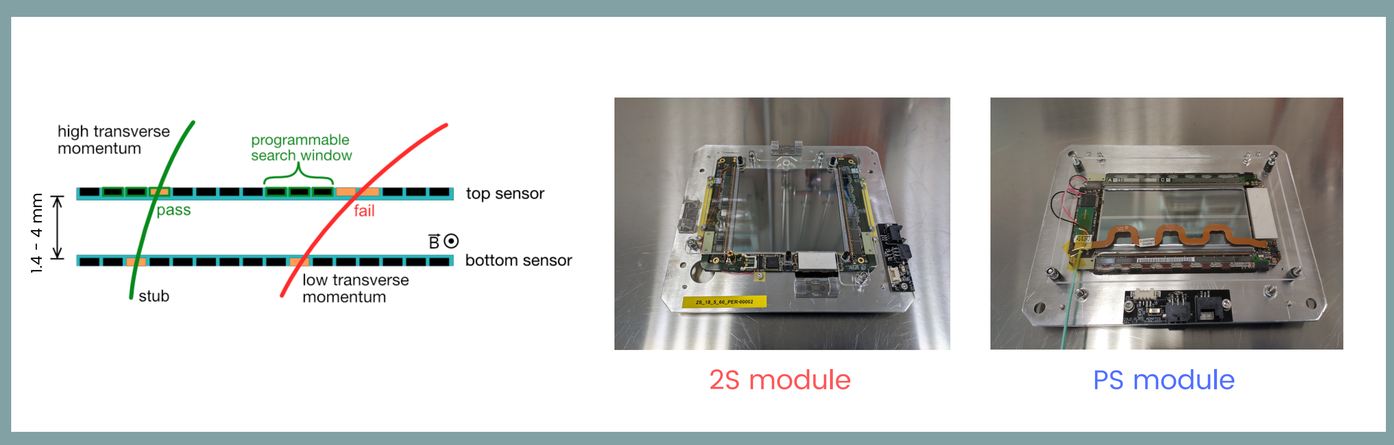
Phase-2 upgrade

- Hi-Lumi upgrade of LHC after LS3
  - Peak Luminosity ~7.5e34 $cm^{-2}s^{-1}$ (~3.5 times more than Run3)
  - **Higher rates wrt Run3**: expected Pile-up ~200 (~3.5 times more than expected for Run3)
  - Higher radiation doses wrt Run3: farthest outer tracker layers will see >1e14 MeV equivalent neutron fluence, more than today's innermost strip tracker layer after 10 years of LHC running
- Necessary upgrade of current tracker:
  - Big part of **current tracker will be inoperational** due to leakage current or full depletion voltage limitations
  - Higher radiation tolerance
  - Increase of granularity needed in order to achieve efficient tracking in higher pileup environment
  - **Contribution to level-1 trigger**



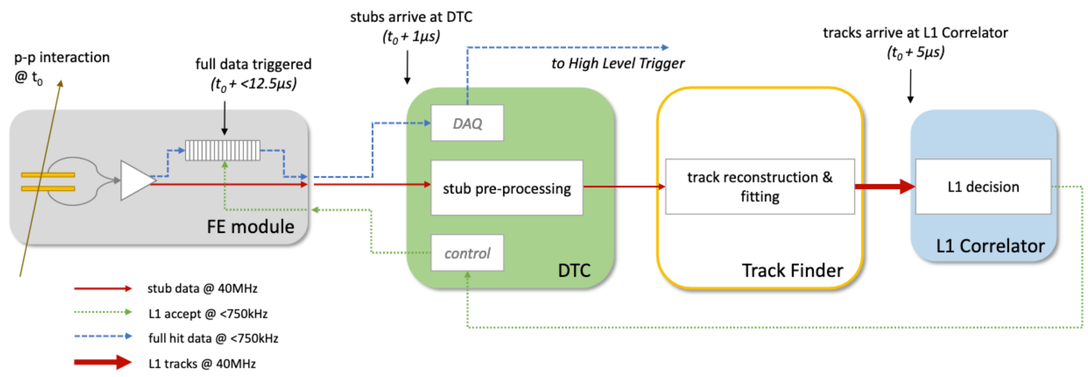
p_T modules

- **p_T selection at readout level** in order to reduce the L1 tracking input data size -> selection from pT ~ 2 GeV/c² with efficiency ~98% [1]
- Two silicon sensors with small spacing in a module, different spacings for different detector regions (1.4 to 4 mm)
- Flex hybrid in order to get **data from both sensors to one ASIC** → select track **«stubs»**
- 2 different kind of modules [1]:
  - 2S: 2 micro strip sensors with 5cm x 90μm strips
  - PS: one strip sensor (2.5cm x 100μm strips) + one macro pixel sensor (1.5mm x 100μm pixels)
- Tunable search window

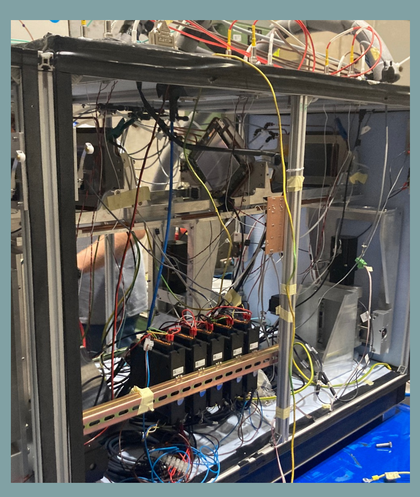


Data stream

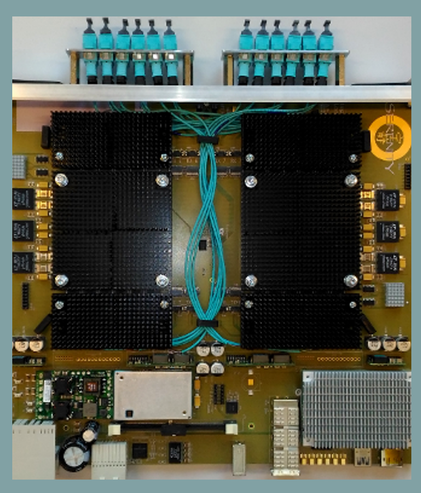
- Stubs: average position of the cluster in the bottom sensor + average position of the cluster in the top sensor
  - L1 trigger
  - 40 MHz readout
- Hits: information on all the strips/pixel in a module (one bit per strip/pixel)
  - Final DAQ
  - 750 kHz readout



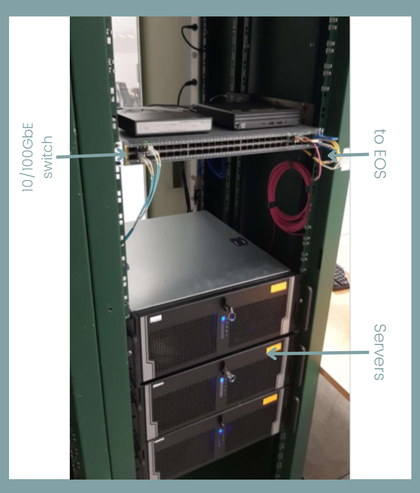
Test beam setup and data acquisition

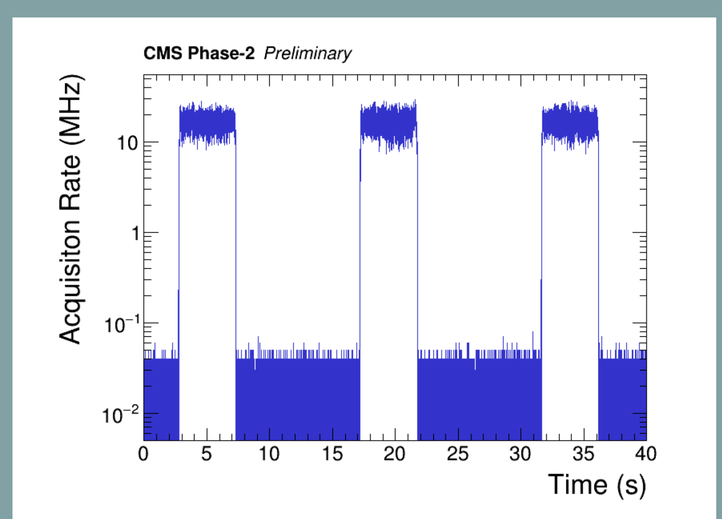


- 19th to 26th October – **joint effort with MUonE** [3]
- TB took place on the high intensity muon beam line located in CERN North Area (M2) upstream COMPASS
- Beam from SPS: **1e7 to 1.8e8 muons in 5 seconds** (spill) every ~15 s
- **6 2S modules for Phase-2 Outer Tracker upgrade** installed on structural support
- Temperature and humidity monitored
- Remote drivers for modules alignment
- FC7s [4] for auxiliary functions

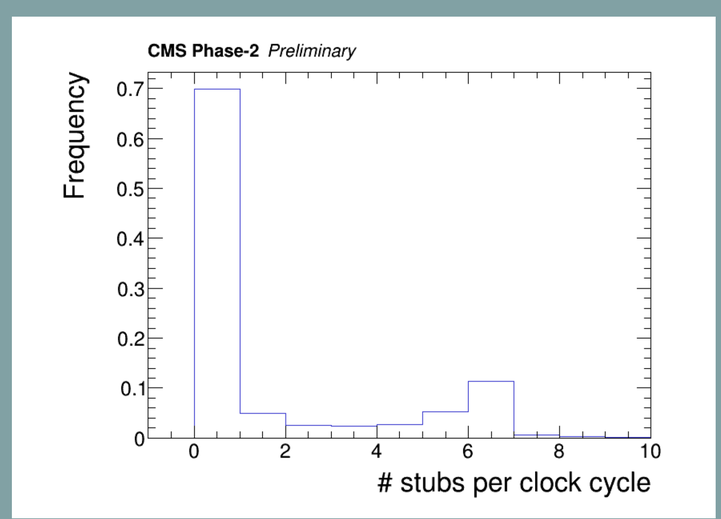


- **Optical readout** (lpGBT) of the stub stream **via Serenity platform** [5]
  - Triggerless acquisition at 40 MHz, asynchronous wrt beam
- Data strutcure:
  - Link packet: header (64b: run and packet number)
    - Payload packet: header (256b: errors + user data) + up to 256 stubs (32b each)
- Servers receive 10GbE data: buffering, packaging, DQM, ship to EOS.

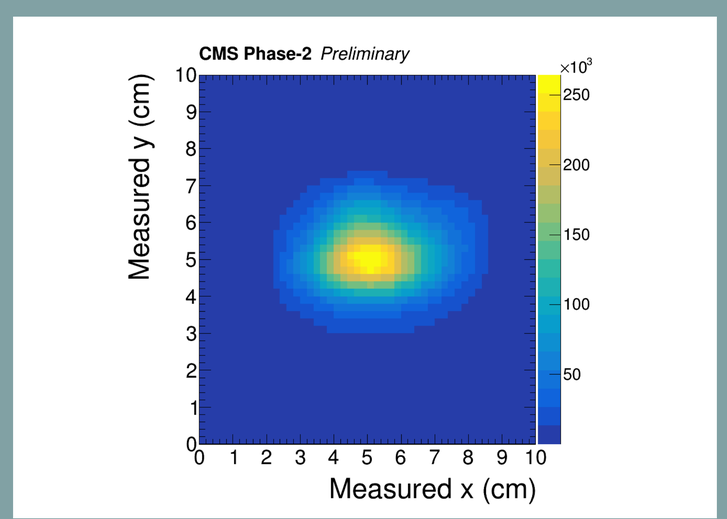




Rate for the number of stubs saved on disk from the six installed modules as function of time during a run with approximately 5e7 muons per spill. The SPS spill structure is clearly visible, with an average rate during the spill of 20 MHz.



Number of stubs acquired during a spill per clock cycle in the Serenity board. Given the asynchronous beam with respect to the clock of the Serenity board and the higher acquisition rate, a spike in 0 is observed, corresponding to clock cycles in which no muon is passing through the modules. The observed spike at 6, instead, correspond to the passage of a real particle firing all the modules.. Values between 1 and 5 are due to a number of different effects (noise, particles outside the detector acceptance, modules efficiency...). Events with more than 6 stubs are also observed, due to interaction of the muons with budget material.



Beam spot, obtained using all possible points given from stub position in the most upstream module, which measures x coordinate, and the second most upstream one, measuring y coordinate, acquired in the same clock cycle. First data reconstruction, further analysis (allignmet, tracking etc..) ongoing.

[1] Test beam performance of a CBC3-based mini-module for the Phase-2 CMS Outer Tracker before and after neutron irradiation. 5 2022.
[2] CMS Collaboration. The Phase-2 Upgrade of the CMS Data Acquisition and High Level Trigger. Technical report, CERN, Geneva, 2021
[3] G Abbiendi. Status of the MUonE experiment. Physica Scripta, 97(5):054007, apr 2022.
[4] M. Pesaresi, M. Barros Marin, G. Hall, M. Hansen, G. Iles, A. Rose, F. Vasey, and P. Vichoudis. The FC7 AMC for generic DAQ & control applications in CMS. JINST, 10(03):C03036, 2015
[5] Andrew Rose et al. Serenity: An ATCA prototyping platform for CMS Phase-2. PoS, TWEPP2018:115, 2019

indico agenda