Multi-purpose muon telescope

Workshop Laboratori Progetto di Eccellenza

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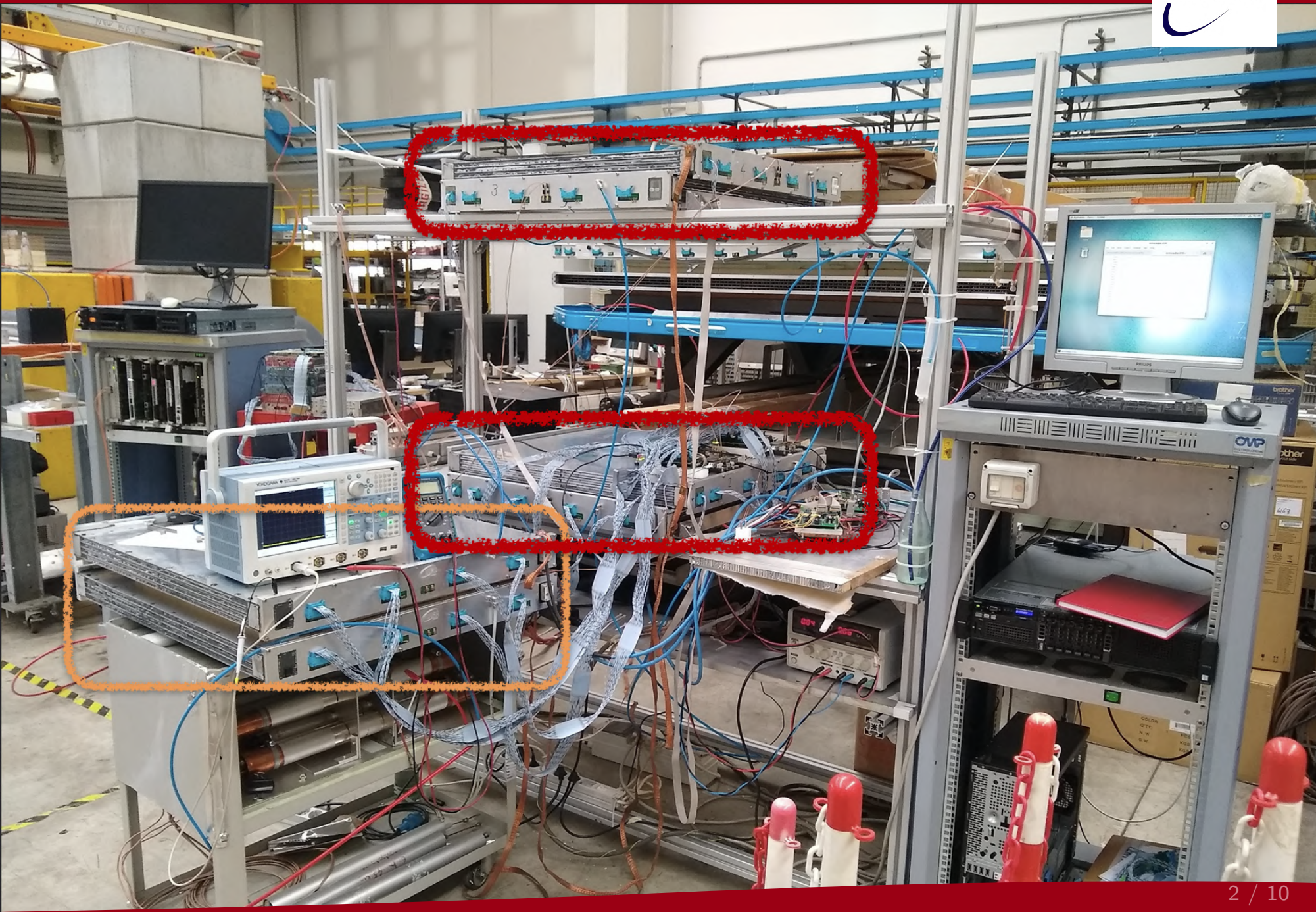
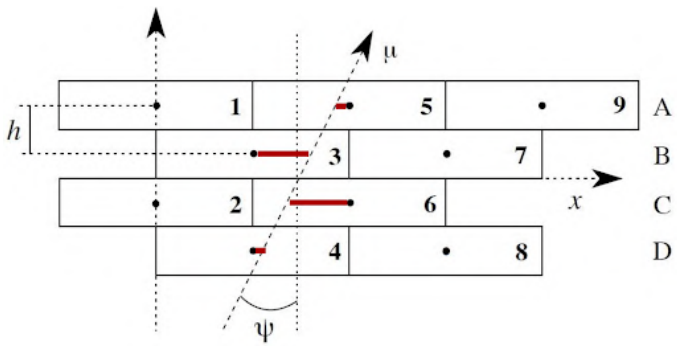
Mini-DT muon telescope

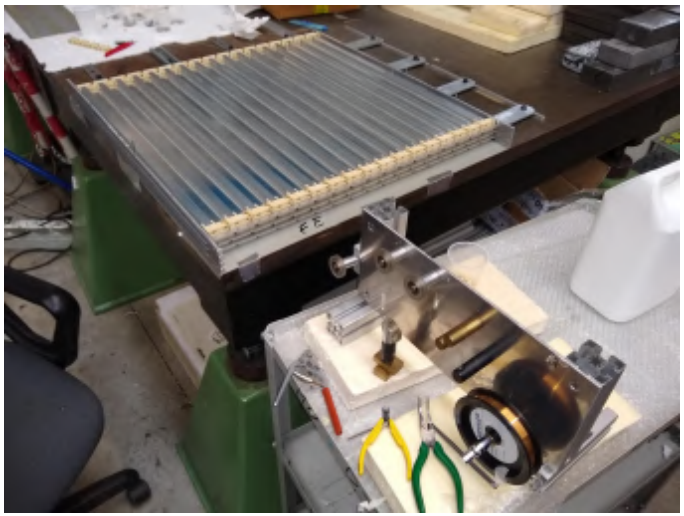


Mini-DT muon telescope

Reduced-size **Drift Tubes** chambers (mini-DT) assembled, operating in LNL

- Almost identical design to the Drift Tubes chambers built for the CMS experiment at CERN
  - same cell geometry, electrodes, and "superlayer" (quadruplet) configuration
- Reduced dimensions: 70×70 cm^2 (real ones are 2×2.5 m), 64 channels per chamber (real ones $\leq$ 240 channels)
- Single-hit resolution unchanged at 200 μm

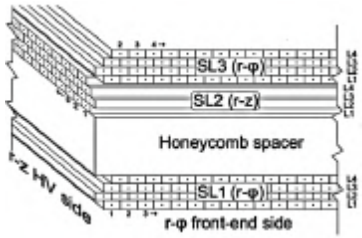




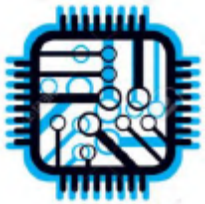
- Entirely built in LNL (detector and chambers electronic boards)
- 6 have been built and commissioned, 2 more on the way
  - Bologna and Torino groups "sponsored" 2 chambers each
- Cosmic muon rate is $\mathcal{O}(100)$ Hz
- Excellent benchmark for **triggerless** data readout (continuous, high rate data flow without trigger selection)

Trigger-less DAQ, online processing

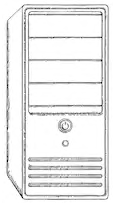
Detector



Detector's electronics



Accelerated server



Broker

Distributed processing

CMS Drift Tubes muon chambers

HL-LHC prototype electronics

Xilinix KCU PCIe FPGA

INFN CloudVeneto data-center

INFN Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO

Dipartimento di Fisica e Astronomia Galileo Galilei

Based on "big-data" industry-standard softwares:

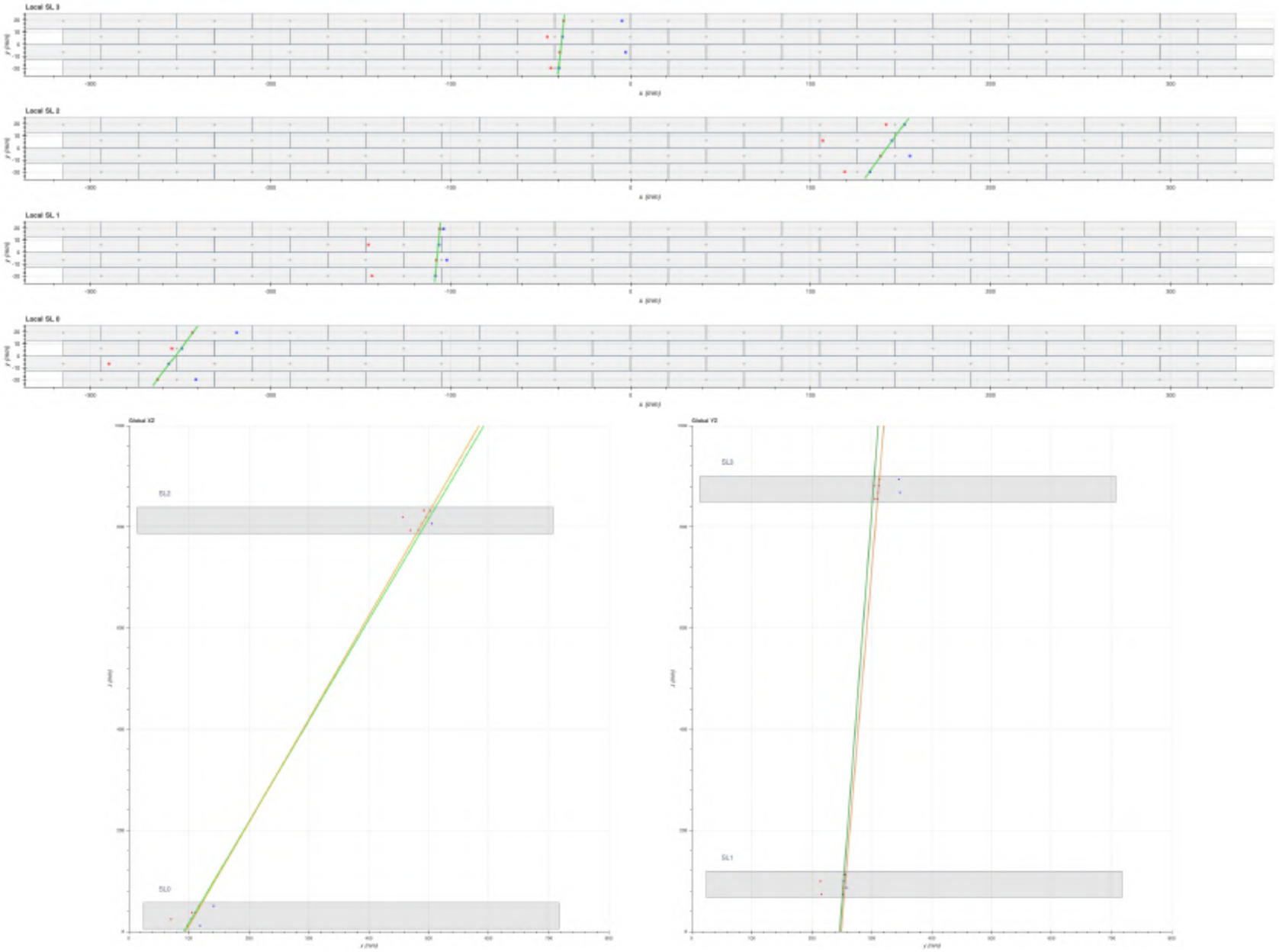
- kafka for stream processing
- Apache Spark for distributed cluster-computing

Real-time monitoring and analysis

Based on "big-data" industry-standard softwares:

- elastic for stream monitoring
- KIBANA for data visualization

Real-time monitoring and analysis



Mini-DT for CMS Phase-II DT upgrades

Trigger/HLT/DAQ

- Track information in L1-Trigger
- L1-Trigger: 12.5 ms latency – output 750 kHz
- HLT output 7.5 kHz

New Endcap Calorimeters

- Rad. tolerant – high granularity
- 3D capable

New Tracker

- Rad. tolerant – high granularity – significant less material
- 40 MHz selective readout (pT>2 GeV) in Outer Tracker for L1 -Trigger
- Extended coverage to h=4

MIP Precision Timing Detector

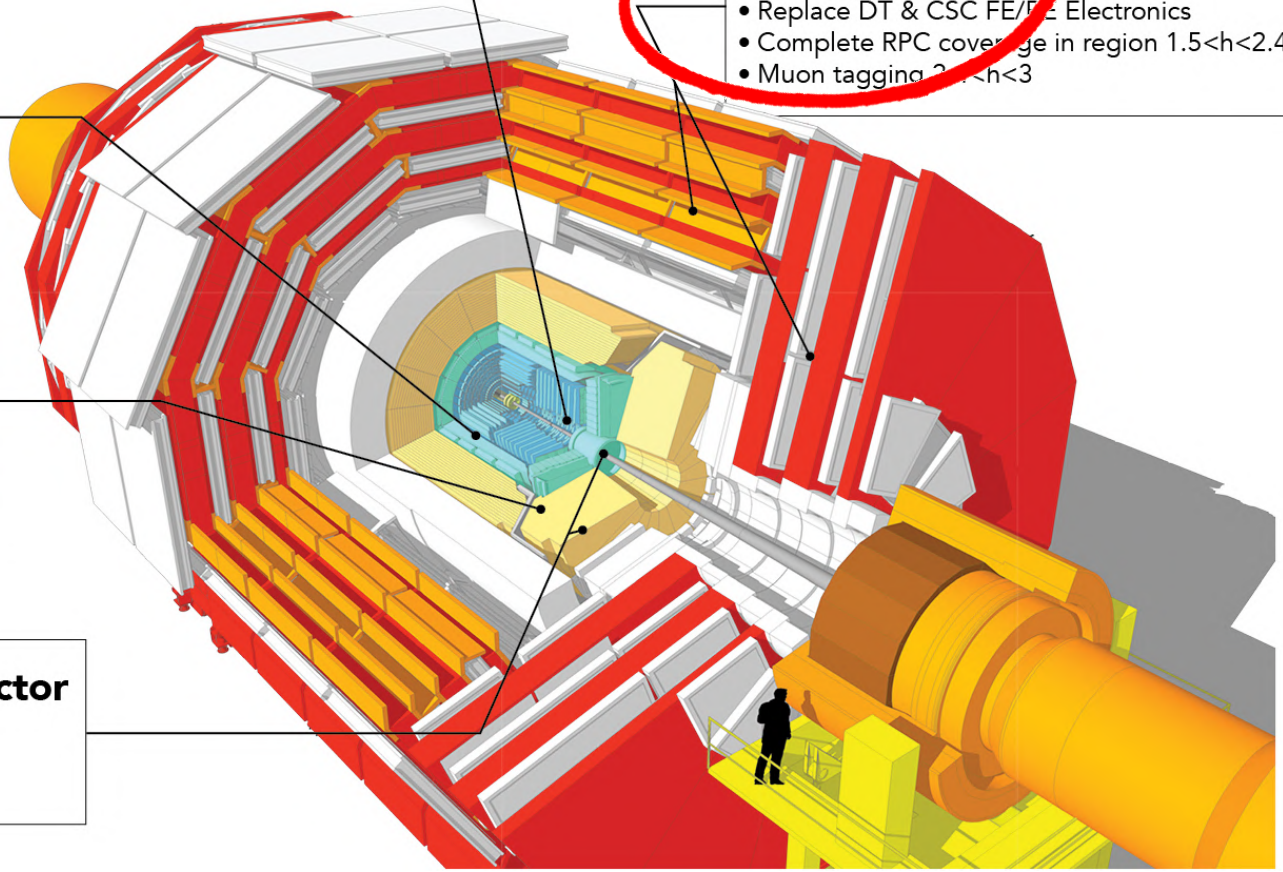
- Barrel: Crystal +SiPM
- Endcap: Low Gain Avalanche Diodes

Barrel ECAL/HCAL

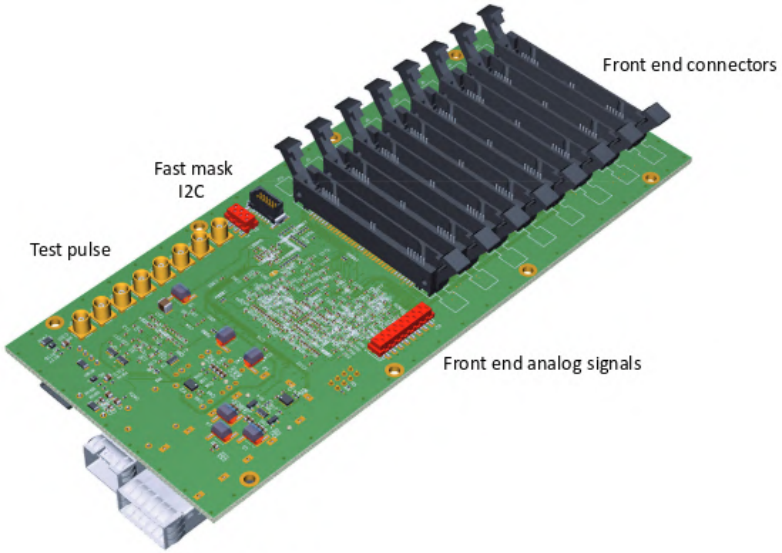
- Replace FE/BE electronics
- Lower ECAL operating temp. (8 °C)

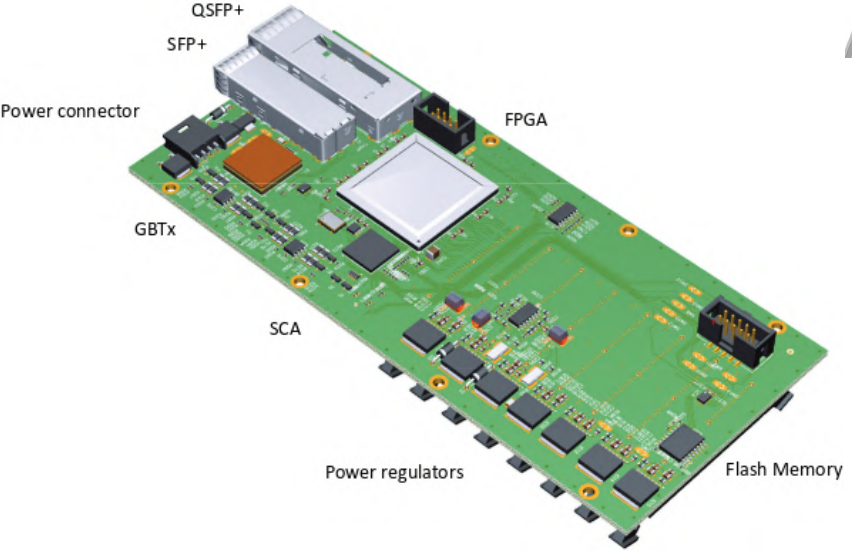
Muon Systems

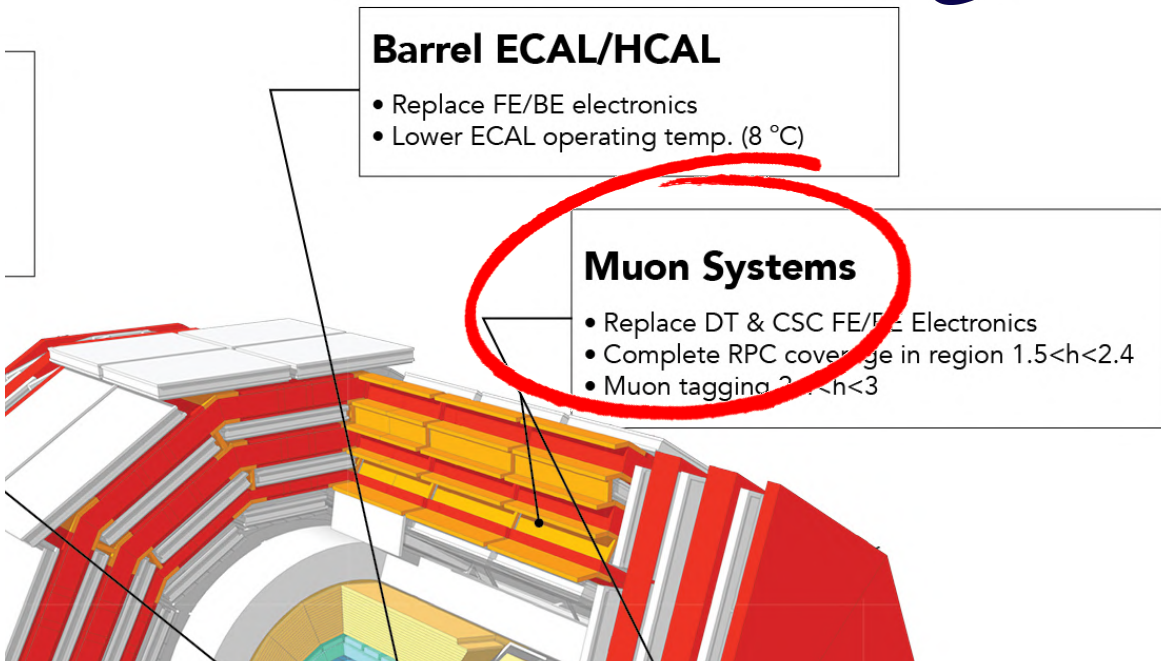
- Replace DT & CSC FE/BE Electronics
- Complete RPC coverage in region 1.5<h<2.4
- Muon tagging 2.4<h<3



Mini-DT for CMS Phase-II OBDT board commissioning





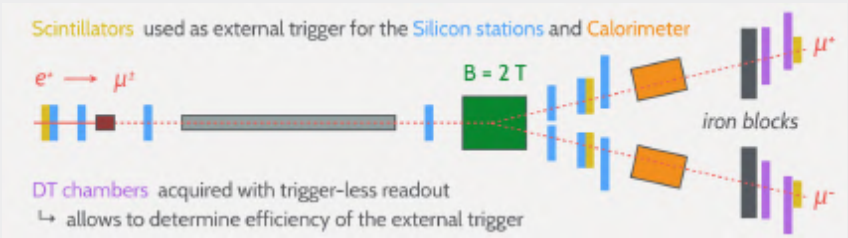


- The setup is currently used to commission with a **real detector** the OBDT boards for CMS Phase-II upgrade
- The OBDT features are an excellent fit in the trigger-less DAQ project
- See Antonio's presentation for more details

Mini-DT applications

Beam experiments

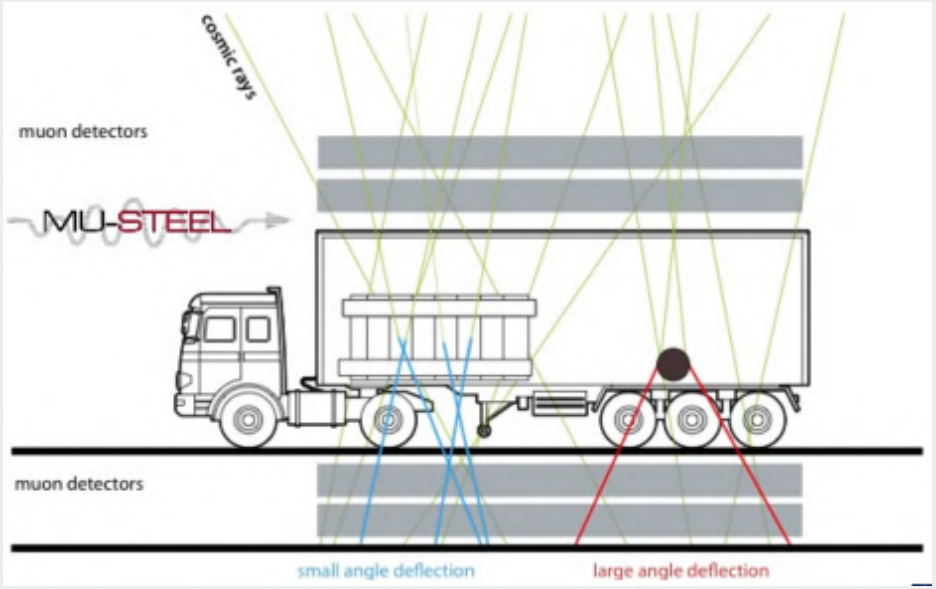
- Mini-DT chambers are highly-efficient detectors that can be used in **fixed-target beam experiments**
  - deployed in 2018 in testbeams for the muon collider prototype Low EMittance Muon Accelerator (LEMMA) [1]
  - proposed for MuOnE too



- Planning to **integrate** the DT with other tracking detectors (pixel, GEM) in a **triggerless DAQ system**

Muon tomography

- Mini-DT can be used to reconstruct 3D images using muons scattered by an heavy object (muon tomography)



- Practical deployment thanks to **reduced size**
  - applicable where full-size chambers (MuSteel, MuBlast) can not fit

Future outlook

- The construction and commissioning of the mini-DT has been performed in Legnaro, but operations are not necessarily limited to LNL
- The muon telescope can be easily replicated or moved to the Department
  - needs $8 - 10\ m^2$, power, and a gas line
- Main users based at DFA (physicists, electronic engineers, and **students**)

Possible synergies at DFA

with cosmics μ μ tomography, possibily to add a magnet for p measurement, test for other detectors,...

with beams test integration with other components (pixels, GEM) for beam experiments

CdL in Fisica excellent hands-on setup for *Laboratorio Avanzato di Fisica*

CdL Ph.of Data unique chance to apply *big-data* techniques to a real use case