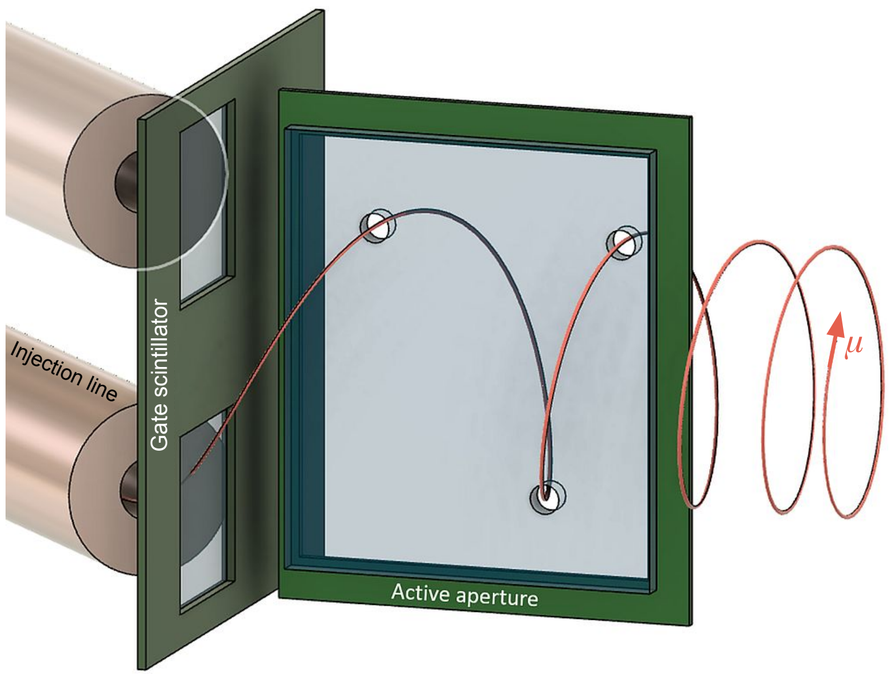
Trigger and DAQ system for the muEDM experiment

Mario Rossi[1], Luca Bianchi[2], Giulia Verdi[1,3]

[1] Università di Pisa, [2] Politecnico di Milano, [3] INFN Sezione di Pisa

The **muEDM experiment** aims to measure the **muon EDM** with a sensitivity of $\sigma_d \leq 6 \times 10^{-23}$ e $\cdot$ cm. It will employ one of the high-intensity **muon beam** at the Paul Scherrer Institute (PSI) in Switzerland, exploiting for the first time two key techniques to test the existence of the muon EDM: a fast magnetic pulse generated by the **kicker coils** to stop and store muons in a storage orbit of 30 mm radius, and the **frozen-spin method** using two cylindrical electrodes to maintain the muon spin direction fixed with respect to its momentum. By measuring the **asymmetry in the emission** of decay positrons along and opposite to the magnetic field of the main solenoid, the experiment can directly probe the presence of a muon EDM.



Requirements

For the trigger:

- High time-resolution signal to start the data acquisition (DAQ) and the kicker coils at the correct muon position:
- Only muons following a precise trajectory activate the trigger $\sim 4 \times 10^{-3}$ of total muons).

For the DAQ:

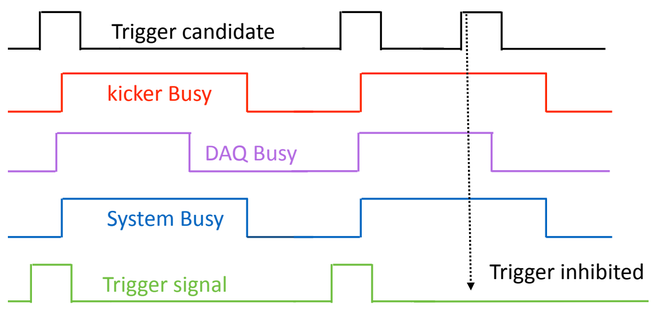
- Wide acquisition window (including pre-trigger hits and muon decay);
- Multi-hit capability on each channel;
- $\lesssim 1$ ns time resolution for the time-of-flight (ToF) detectors and the tracker;
- Global synchronization < 100 ps;
- ~ 2000 SiPM channels.

The trigger detector

- **Gate detector**: 35×35 mm^2 scintillator tile with a thickness of 50 μm read out by four SiPM.
- **Aperture detector**: 5 mm-thick scintillator tile read out by eight SiPMs connected in parallel. The tile includes six apertures, three for each muon injection line, positioned around the expected muon trajectories.

The **trigger logic** is defined by the **gate** in **anti-coincidence** with the **aperture**.

- A **busy system** is integrated to take into account the recovery time of the kicker coils (~ 1 ms).



DAQ Hardware: CAEN FERS-5200 system

FERS-A5202

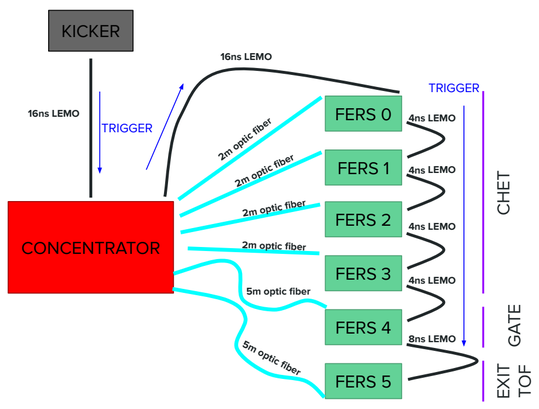
- 64 input channels;
- Internal SiPM biasing (A7585D PS module), signal preamplification and discriminator (Citiroc-1A chip);
- Charge (QDC) and time (TDC) measurements with multi-hit TDC.

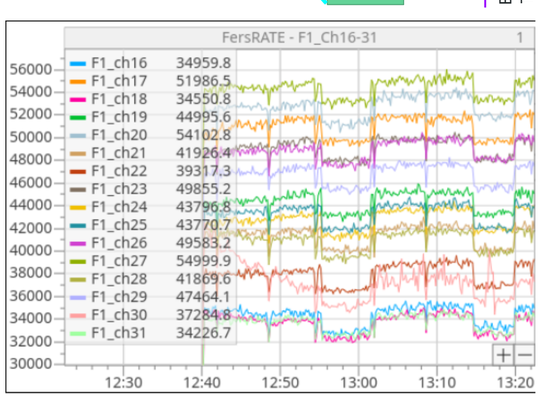
DT5215 Concentrator board

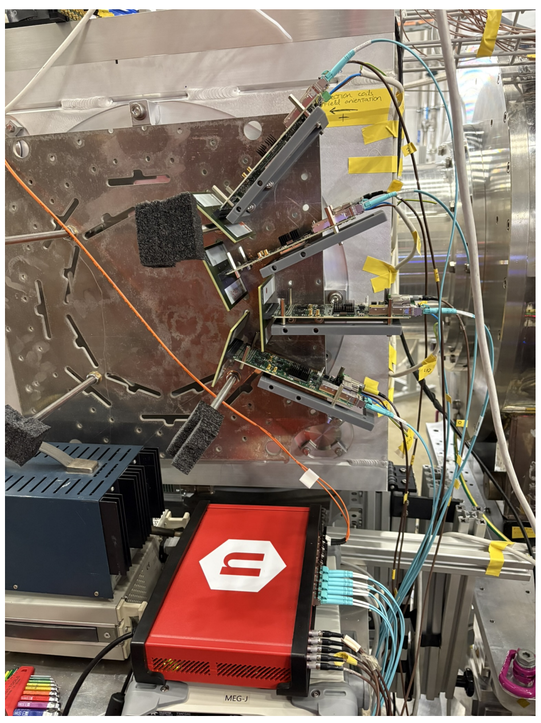
- Handling of up to 128 FERS boards with TDLink optic fibers;
- Time synchronization;
- Bridge for commands and data packets between computer and the FERS boards.

Test beam in 2025

- 6 FERS + Concentrator (25 FERS in final configuration);
- Trigger received via LEMO cables used to open a 20 μs;
- For each hit time-of-arrival (ToA) and time-over-threshold (ToT) are saved.



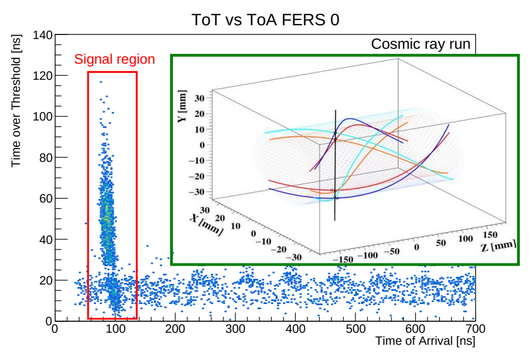




DAQ software

Development of an independent *C++* library to control and configure multiple FERS boards.

- It relies on CAEN functions which directly communicate to the hardware;
- Boards are configured using an XML file;
- Library implemented initially into a command-line program and subsequently into a MIDAS frontend.



Laboratory tests with MIDAS software, the positron tracker, and cosmic rays.