BTTB12, Edinburgh 2024

The EPFL SciFi telescope

Speaker: Federico Ronchetti

17 April 2024

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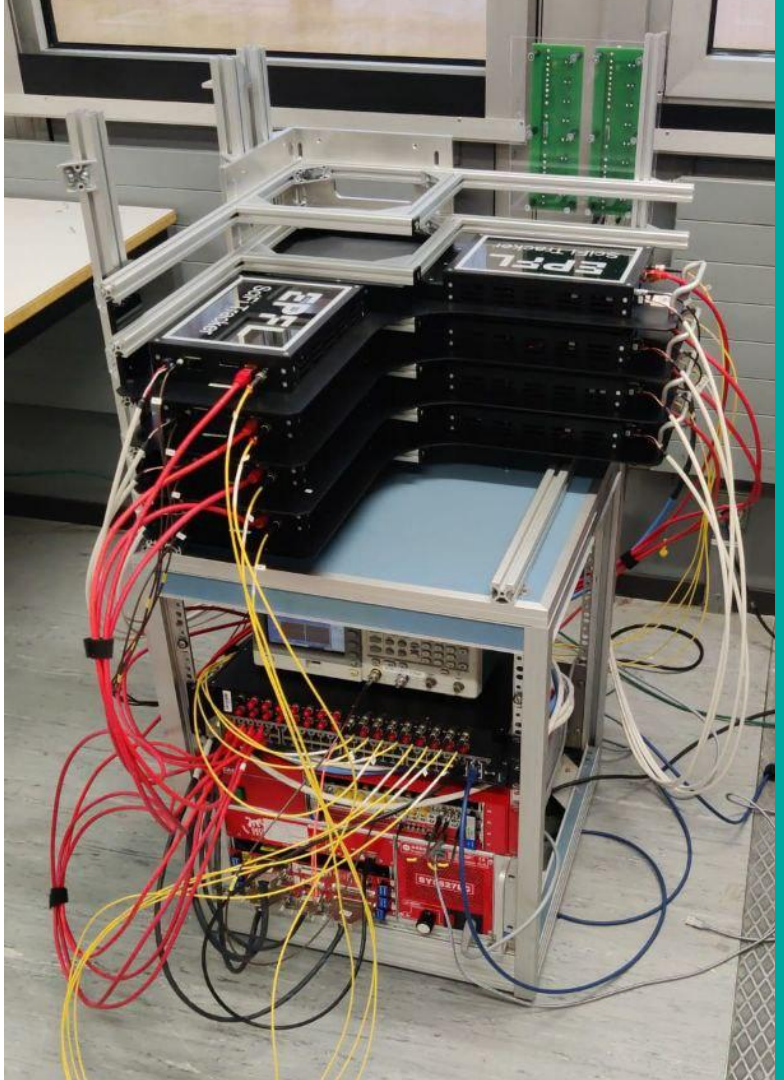

Contents

- Detectors overview
- Telescope characteristics
- Data AcQuisition
- Testbeam integration and examples

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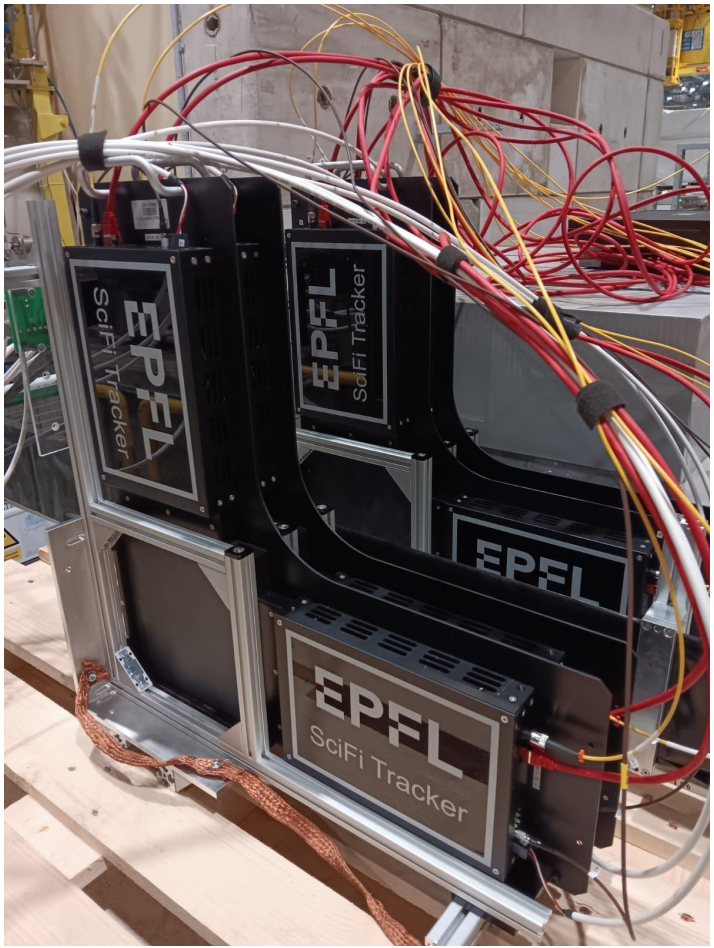
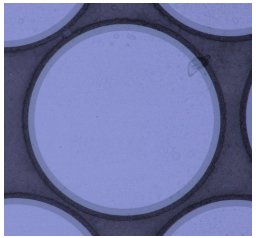
The SciFi telescope

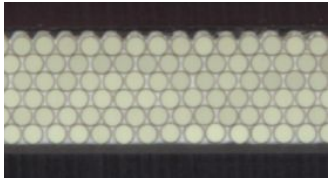
- **Scintillating Fibre** tracking technology
- **4 tracking stations** each measuring X and Y coordinates
- 130 x 130 mm^2 active area per plane
- Stand-alone support structure and alignment
- **SiPMs bias voltage ~ 55 V**
- No external cooling needed
  - FE air cooling with integrated fans

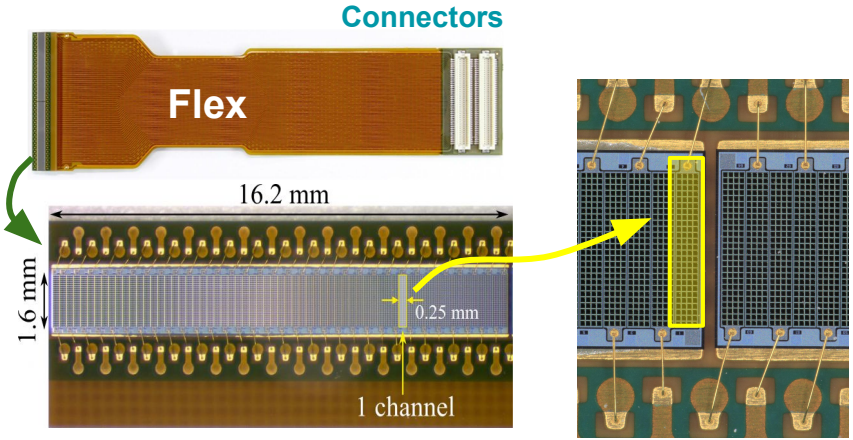


Fibre mats and SiPM readout

- Fibre mat = 6 layers of stacked glued 250 µm scintillating fibres
- Mirror on one side
- 1 module = 2 XY fibre mats
- Material budget ~ 0.7% X_0 per module







- Hamamatsu S135552-H2017 SiPM arrays
- 4 x 128 channels (1.62 mm x 250 µm ch size)
- Pixel size = 62.5 x 57.5 µm^2
- Operational voltage ~ 55 V (OV ~ 3.5 V)
- Used in LHCb SciFi and SND@LHC

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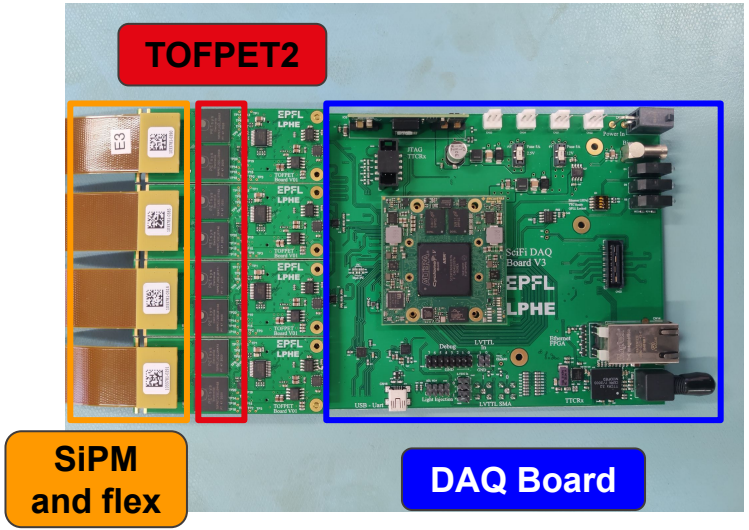
Data AcQuisition

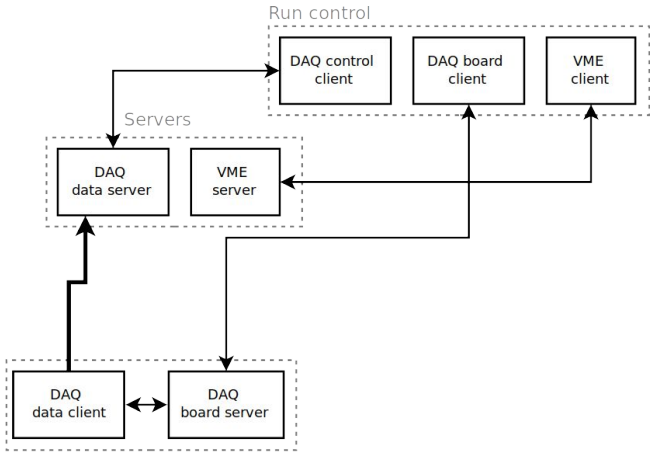
Hardware

- Front End: TOFPET2 ASICs
- DAQ Board: ALTERA Cyclone V FPGA + CPU
- **Asynchronous channel readout**
- Data sent via Ethernet to the PC, optical fibre for board synchronisation
- SiPM biasing via DAQ Board
- BONUS: External trigger accepted



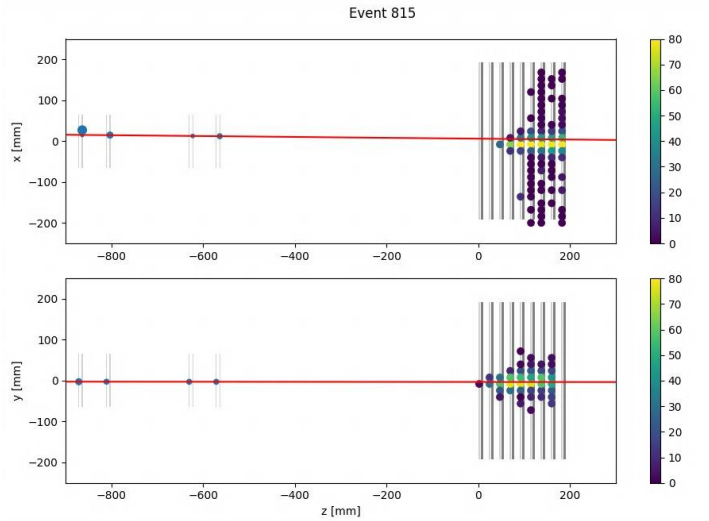
Software

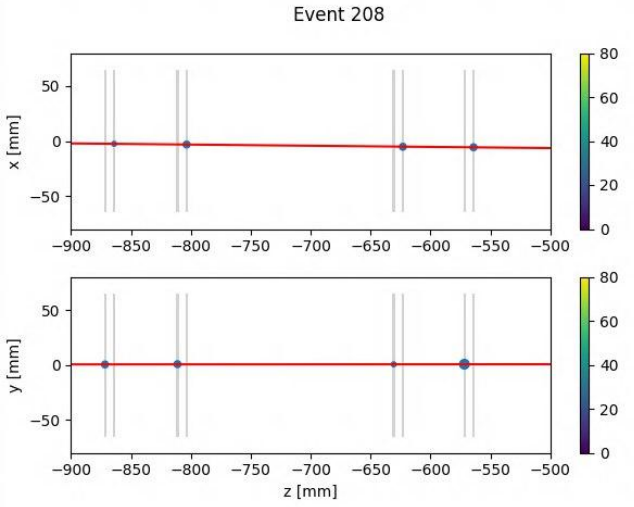
- Same as for SND@LHC
- DAQ data server → **online event builder** and noise suppression
- VME server-client → VME crate for clock generation and synchronous reset (TTC system)
- Run control written in python with user-friendly GUI in development



Track reconstruction

- The EPFL SciFi telescope software already comes with track reconstruction!
- Linear track interpolation
- It works with **multiple tracks** as well
- Flexible software for **user-specified tracking parameters**
- Possibility to extrapolate tracks on an arbitrary plane





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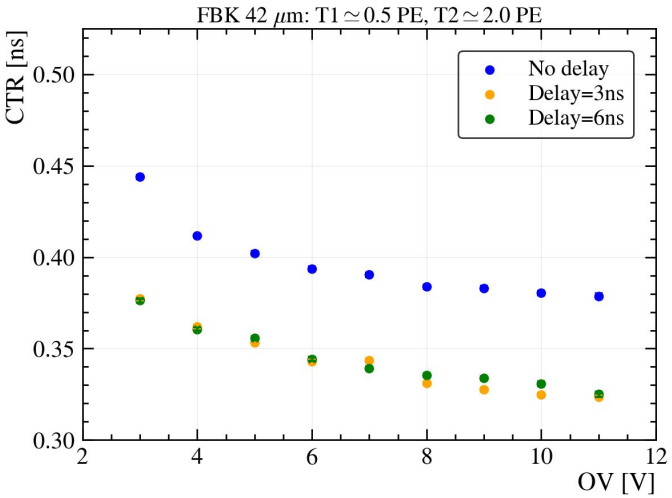
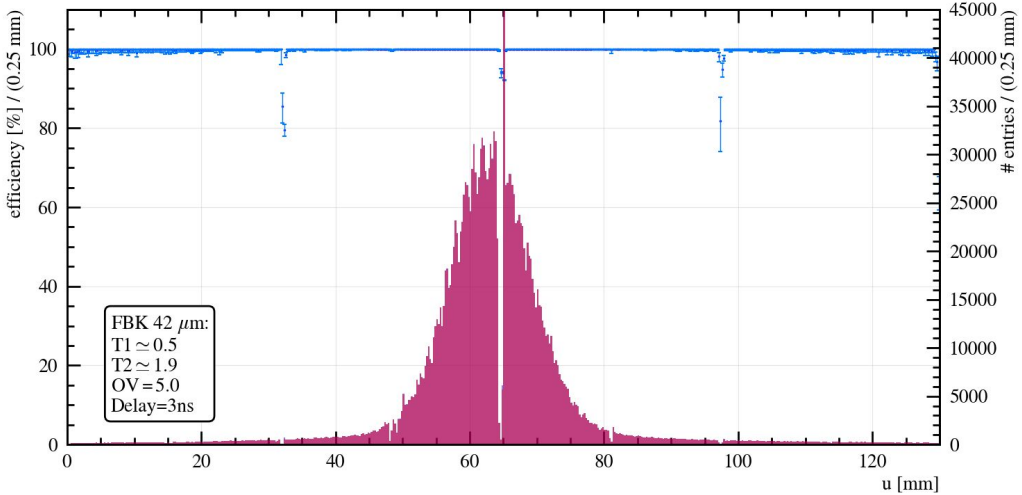
Performance

- Efficiency > 98%
- Spatial resolution < 100 µm
- Time resolution
  - ~ 250 ps (single plane) Hamamatsu
  - ~ 230 ps (single plane) **FBK**
- Accepted particle rate ~ 500 kHz





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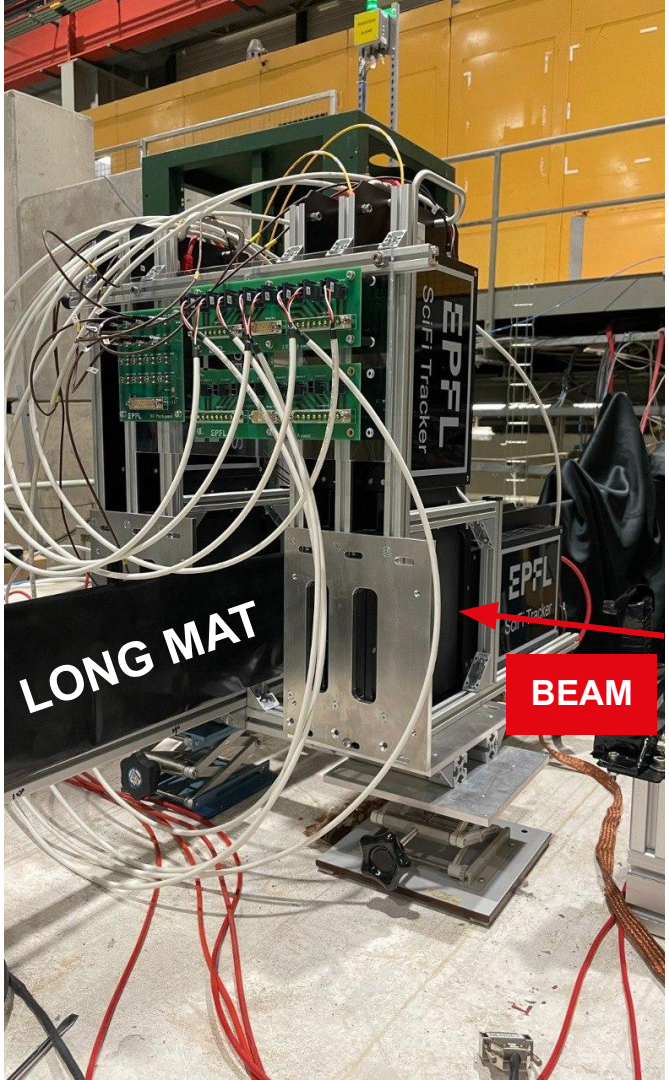
LHCb SciFi testbeam



- Integrated mechanical system for **2.3 m long fibre mat** testing
- **Independent** from long mat movement → scan over the length of the long mat
- 2 DAQ configurations:
  - **External triggered** mode to couple with VATA64 SciFi readout
  - **Triggerless** mode for timing measurement
- CERN SPS H8 beam line
- Hadrons and Muons @ 180 GeV
- May / August / September 2023

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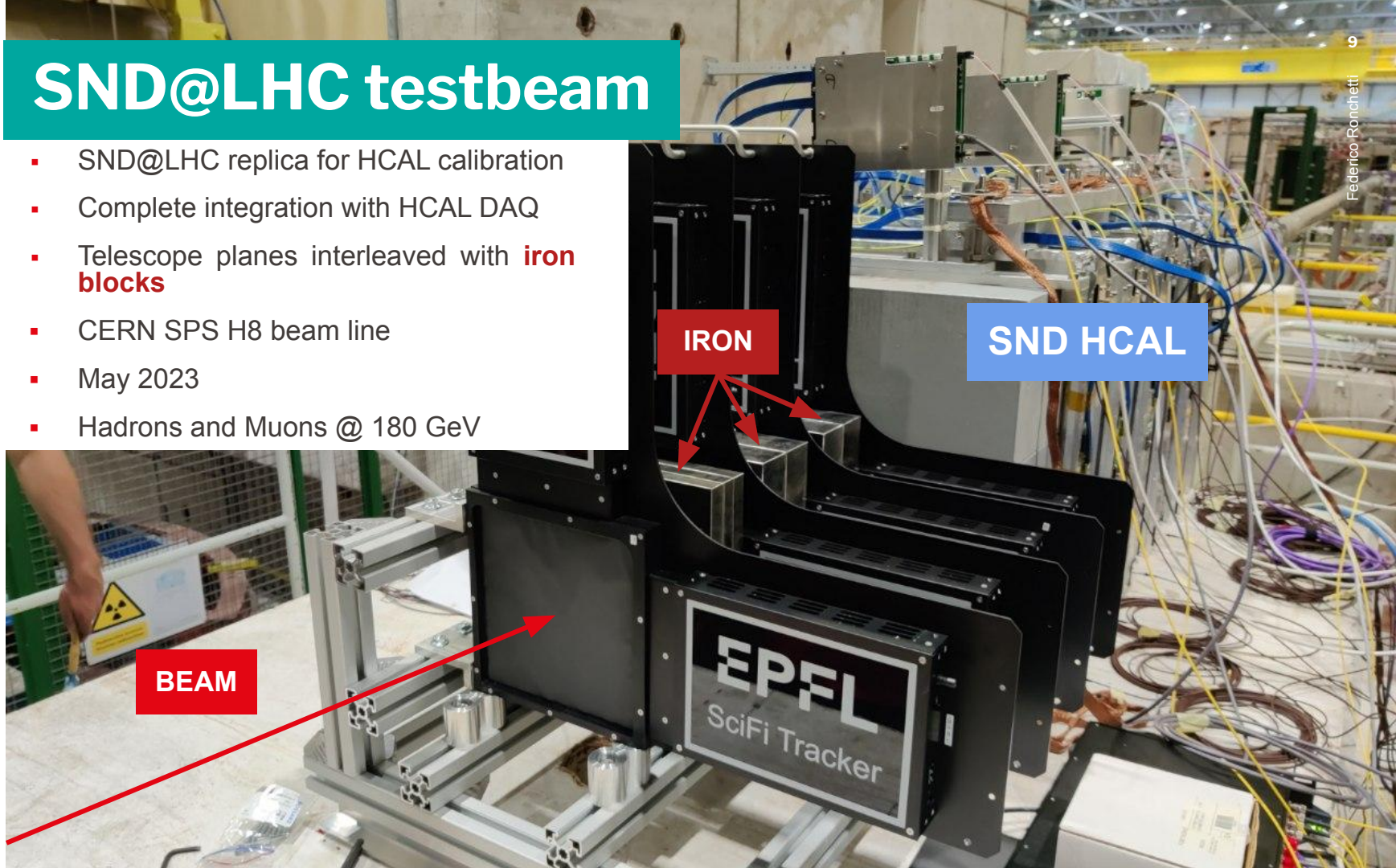
SND@LHC testbeam

- SND@LHC replica for HCAL calibration
- Complete integration with HCAL DAQ
- Telescope planes interleaved with **iron blocks**
- CERN SPS H8 beam line
- May 2023
- Hadrons and Muons @ 180 GeV



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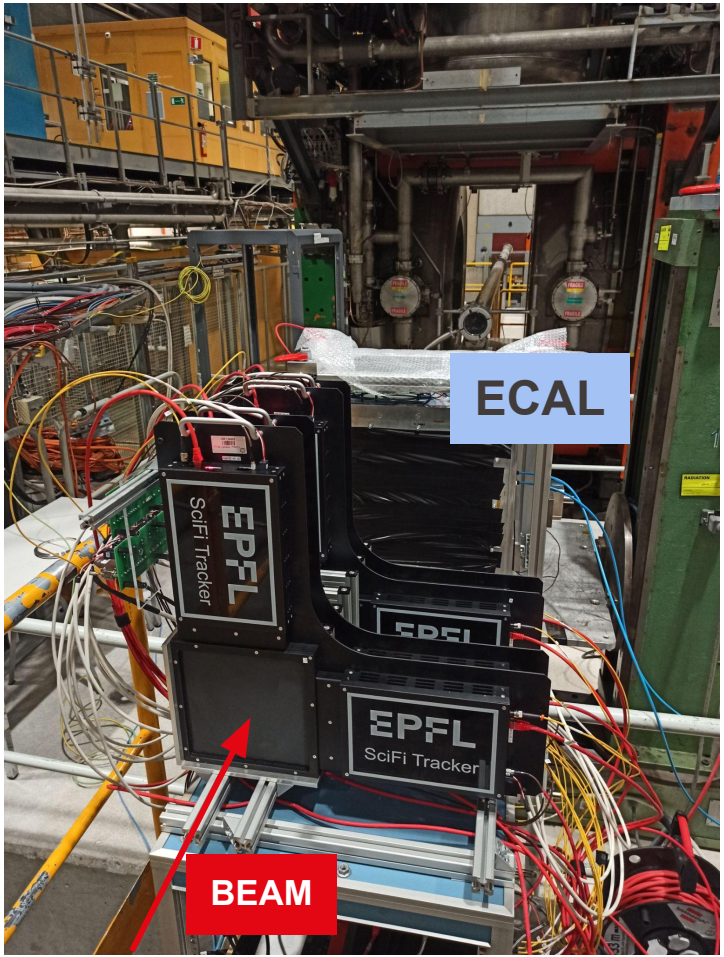
EPFL ECAL testbeam

- Electromagnetic calorimeter **energy calibration** and **characterisation**
- Need to cover a **large area** (40 x 40 cm^2)
- **Complete integration** with ECAL DAQ (both Telescope and ECAL in **triggerless mode**)
- CERN SPS H2 beam line
- Electrons @ (5 - 150) GeV
- April 2024



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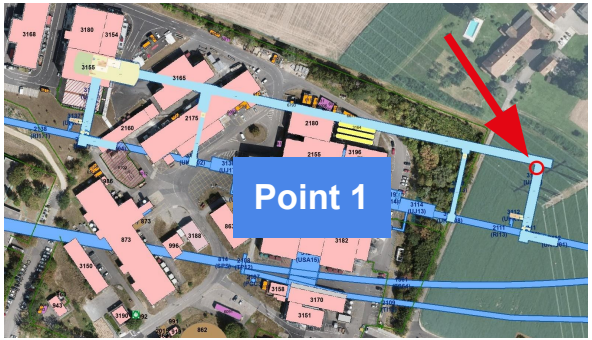
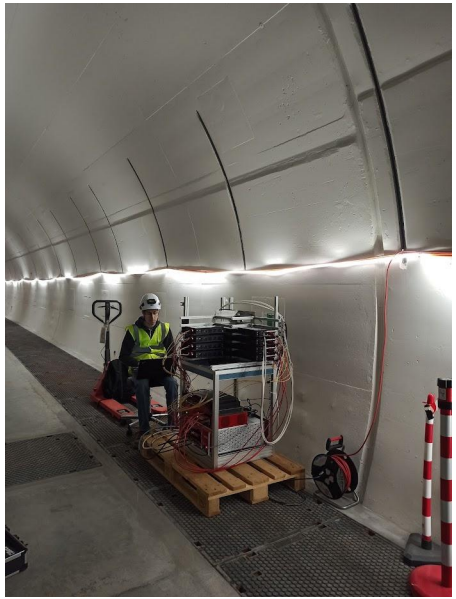
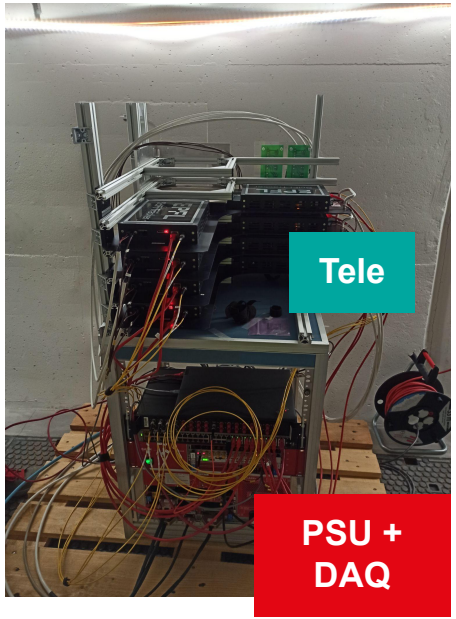
Muon flux measurement



- **GOAL**: measure the **muon flux** by **cosmic rays** and from the **interaction point**
- **LOCATION**: CERN LHC Point 1 / **HL-LHC facility (UA13)**
- **2** telescope **orientation** on an easily movable support
- April 2024
- Is this location suitable for SND@LHC **emulsion storage**?

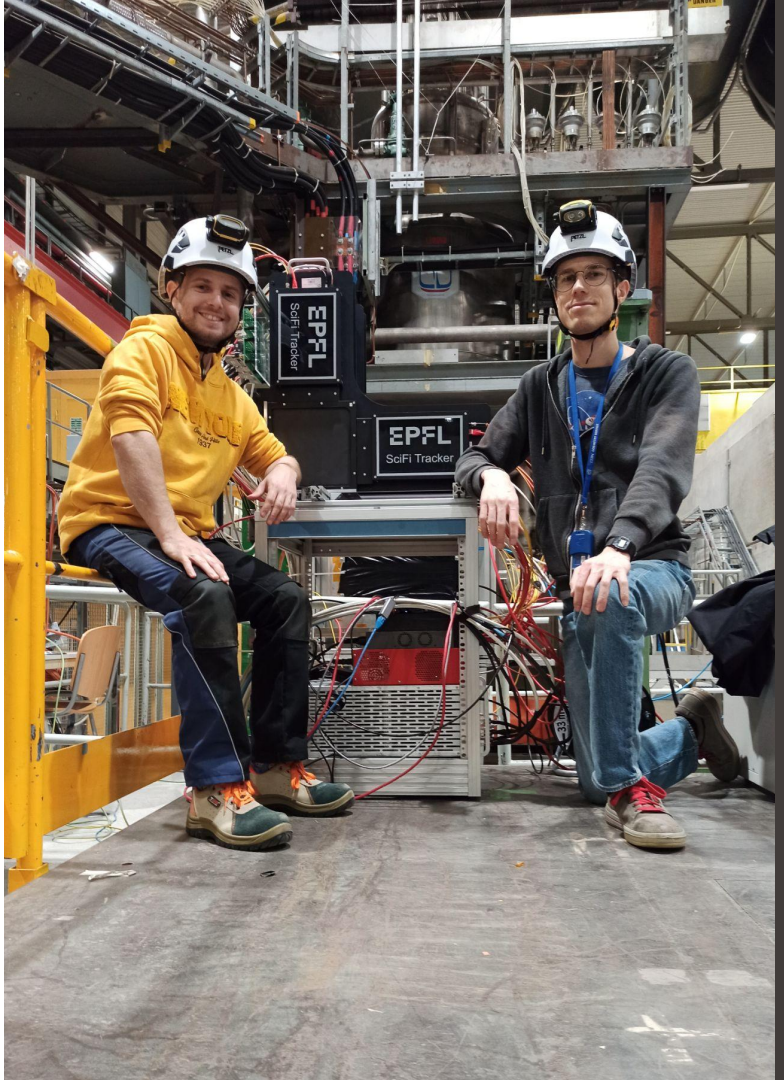




Conclusions and prospects

- The **EPFL SciFi telescope** is up and running and is used for different applications: from **detector testing** (testbeam) to **particle flux measurement**
- The **modular and compact setup** is easy to be transported, moved and installed in experimental areas
- The **large active area** with **high efficiency** suits perfectly **large detectors characterisation**
- The **DAQ** allows **particle rates up to 500 kHz** (SPS beam structure)
- The DAQ can be set either **triggerless** or **triggered** depending on the user's need

- SiPM replacement with **FBK SiPMs** → **higher efficiency** and **time resolution**
- This week, the telescope is being used in the **LHCb ECAL** testbeam, replacing wire chambers previously used for tracking



Thanks for the attention

Federico and Ettore

Contacts if interested in the Telescope

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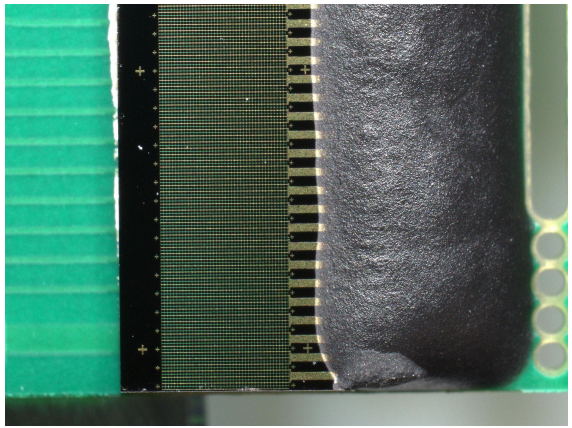
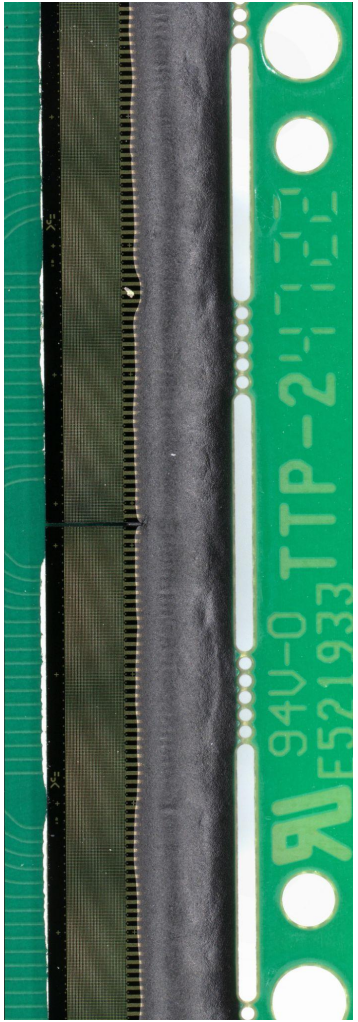
FBK SiPMs

- FBK NUV HV SiPMs
- Pixel size:
  - 42.73 x 42.73 μm^2
  - 31.3 x 31.3 μm^2
- Operational voltage ~ 38 V (OV ~ 8 V)





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External trigger mode

1. NIM or ECL trigger signal (25 ns long) from an external source (trigger detector)
2. The DAQ works still triggerless, so every hit above threshold is recorded
3. When a trigger signal is generated, a trigger packet is added to the data
4. The event builder reconstructs events based on trigger informations and not on hit's timestamps as in pure triggerless mode

The trigger selection is software applied