Characterization of innovative scintillating materials and CRILIN data analysis introduction

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Lab Introduction

- Lab divided into two sections :

1. Characterization of innovative scintillators (CRY18, GAGG) with X-ray source
   - Working principles of SiPMs and Inorganic crystals
   - Description of the experimental setup
   - SiPM Gain evaluation
   - X-Ray spectrum evaluation
   - LY of crystal sample

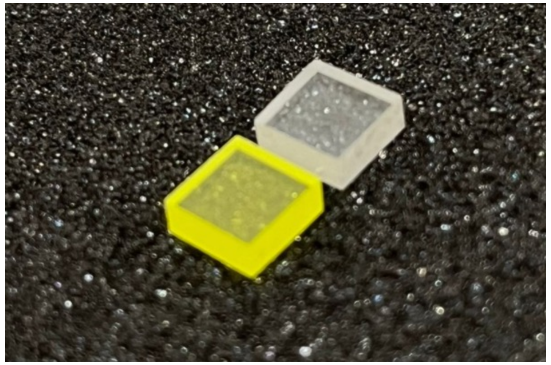
2. Data analysis of the TB data from the CRILIN calorimeter
   - Alternative solution for Muon Collider ECAL barrel
   - TB performed in August 2023 @ H2 Lines in Cern
   - Evaluation of the timing and energy resolution

Scintillating material used during this lab

- **CRY18**
  - rare-earth silicate recently released scintillator

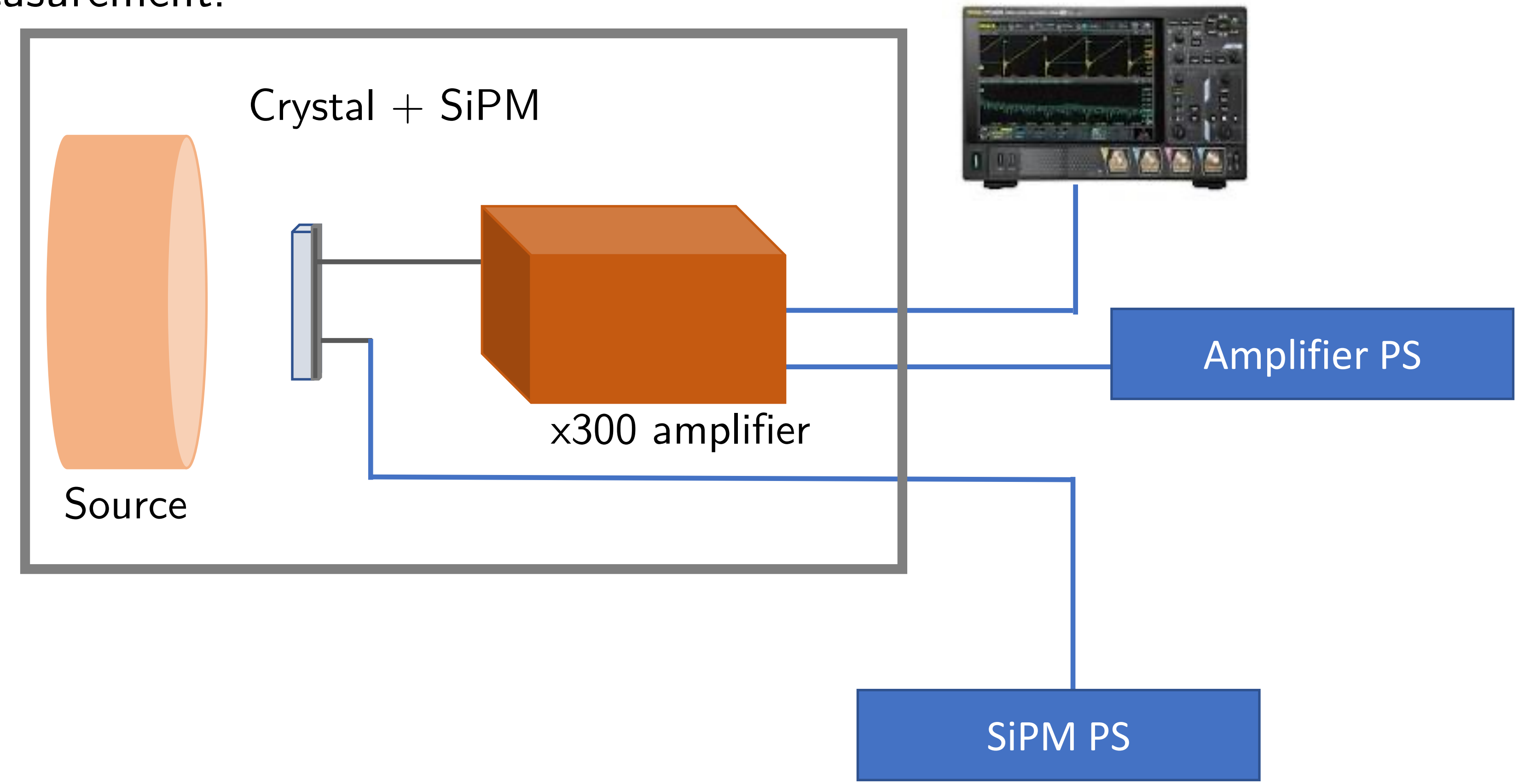
- **Gadolinium Aluminum Gallium Garnet: GAGG**

Properties	CRY18	GAGG
Density [g/cm^3]	4.5	6.67
Radiation Length X_0 [cm]	2.74	1.61
Light Yield [% NaI(Tl)]	80	>70
Decay Time[ns]	45	<88
Wavelength [nm]	425	520



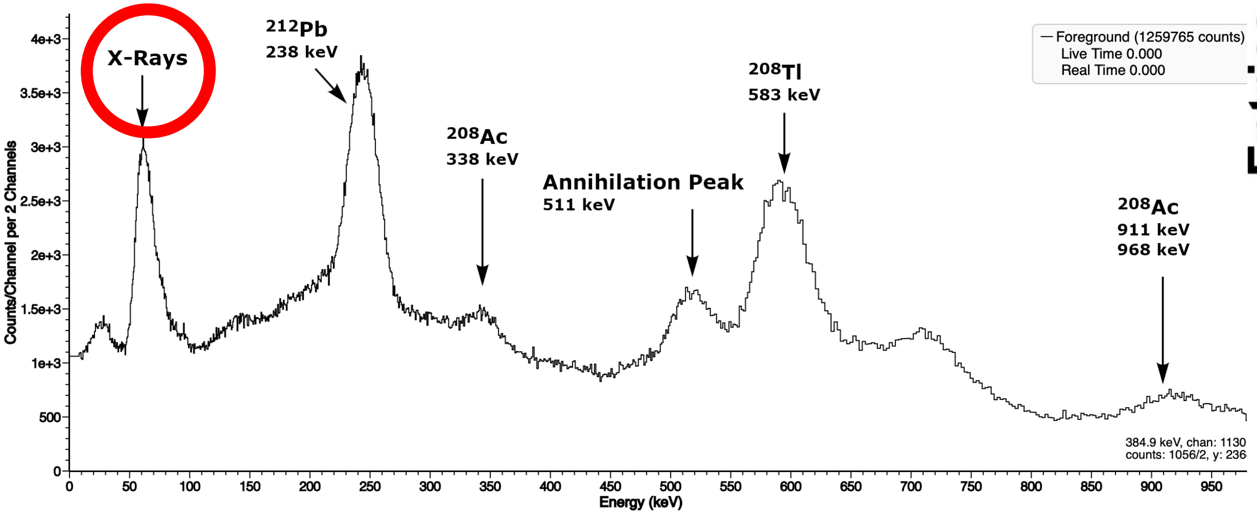
The experimental setup

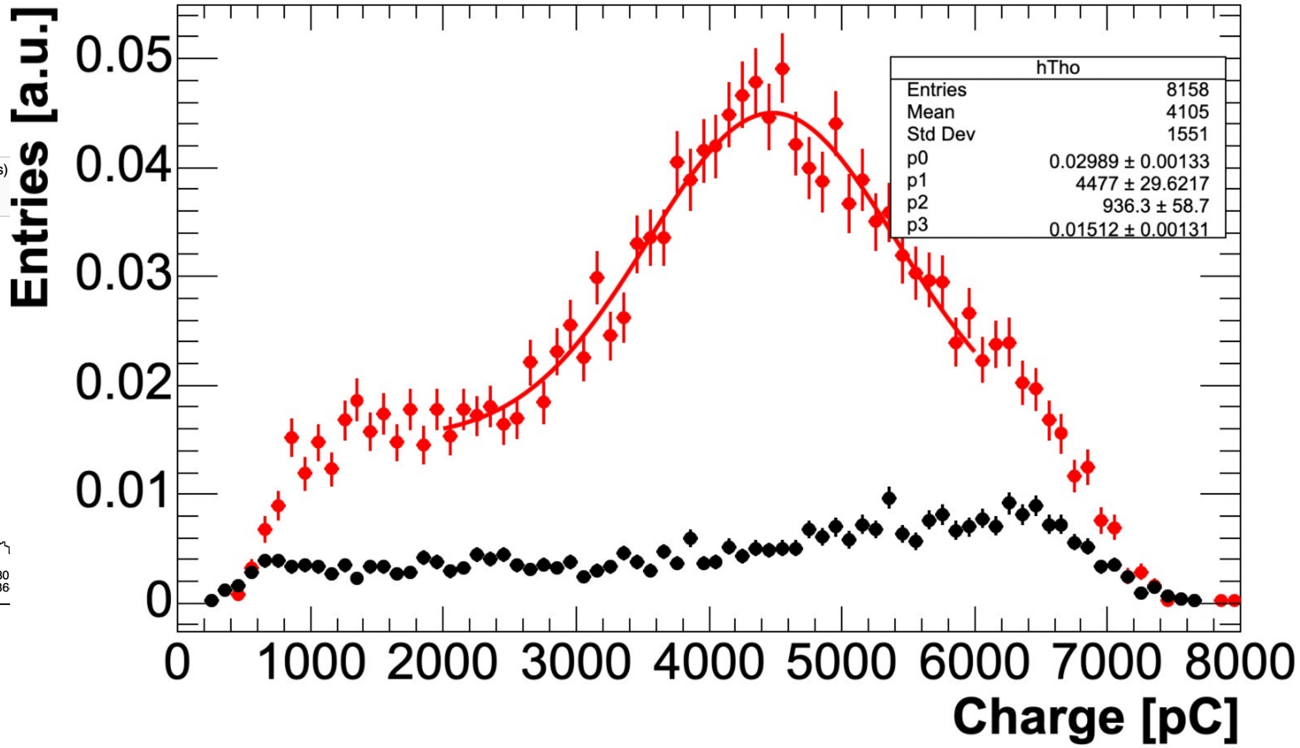
- 6x6x2.5 mm^3 CRY18 and GAGG crystals
- 6×6 mm^2 Hamamatsu S13360-6075CS SiPM with 75 µm pixel size and nominal gain (@ 25°C and V_{op}~54 V) of 1.7x10^6
- low-noise, high gain, custom amplifier providing excellent photon-counting capabilities and allowing a quasi-digital measurement.



A very home-made example (1)

- Thoriated Tungsten electrodes contain 2% of Thorium
- α particles from Th decay create W-K_α lines at ~60 keV



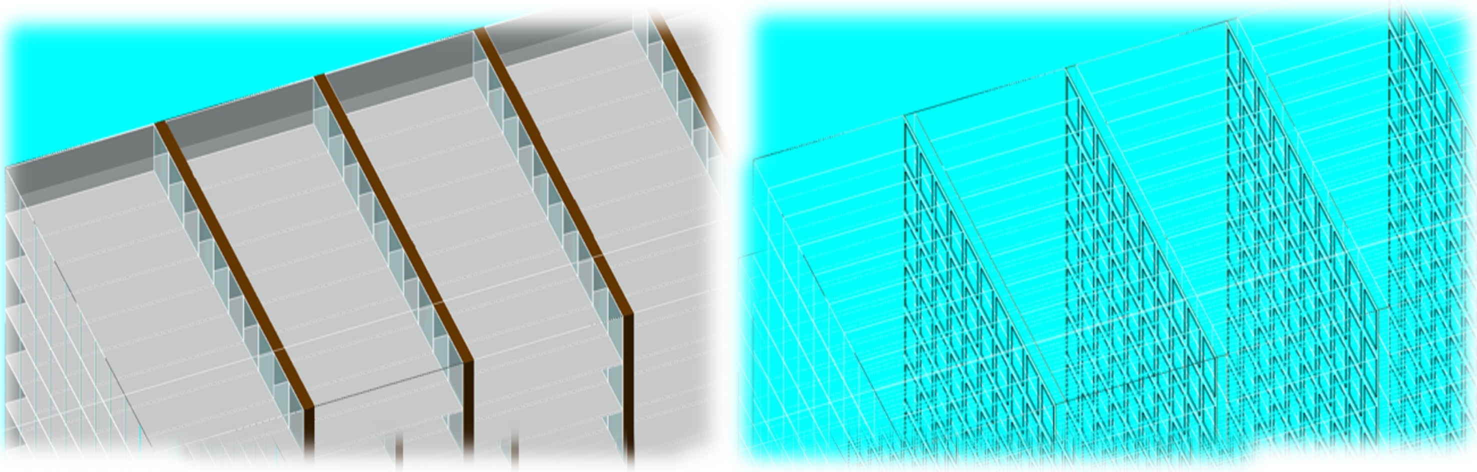


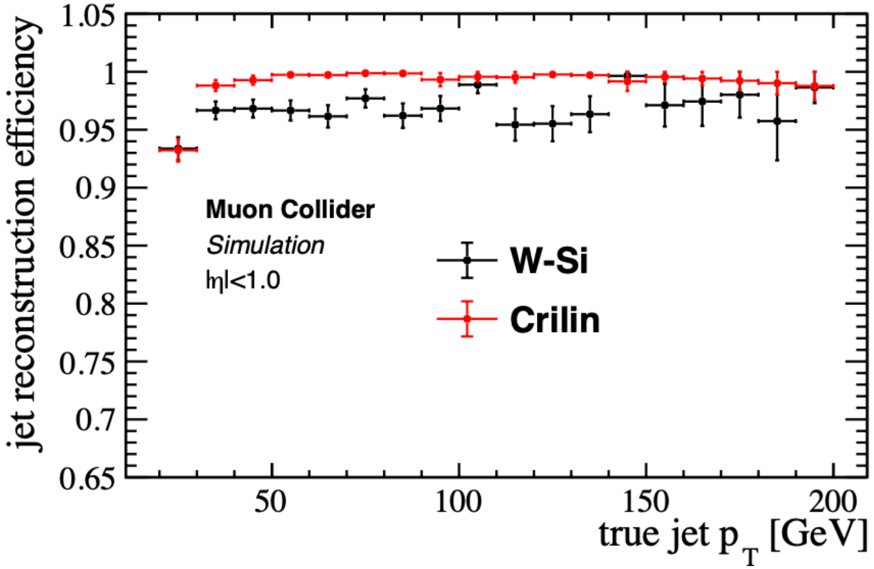
Motivation to MC

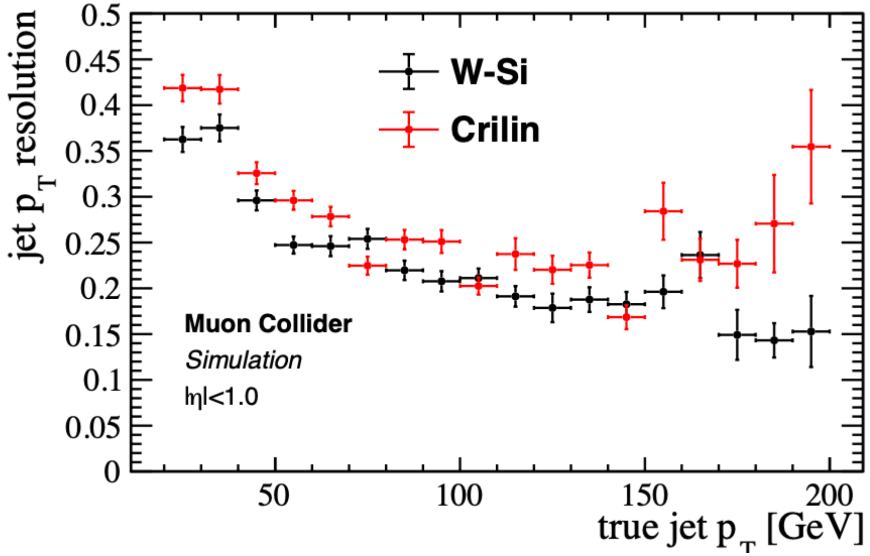
- Muon Colliders (MC) could represent the keystone for accessing the energy frontier of high energy physics
- Great potential, especially in the TeV range:
  - negligible synchrotron radiation (m_{μ}/m_{e}~200)→ high collision energy as in hadron colliders;
  - no significant beamstrahlung → improved energy resolution for physics measurements.
- Challenging development due to the instable nature of muons ($\tau_{\mu} = 2.2\ \mu s$)
  - Decay products of the circulating μ interacting with the machine elements → not so clean environment;
  - 4×10^{5} decays/m at 1.5 TeV with 2×10^{12} μ/beam→O(10^{10}) background reach the interaction region and enter the detector: **Beam-Induced Background (BIB).**
    - Very soft momenta;
    - Displaced origin w.r.t. the interaction region;
    - Asynchronous time of arrival w.r.t. the bunch crossing;

CRILIN calorimeter

- **Semi-homogeneous** electromagnetic calorimeter made of **Lead Fluoride Crystals** (PbF_2) matrices where each crystal is readout by 2 series of 2 UV-extended surface mount **SiPMs**
- **valid and cheaper alternative to the W-Si Muon Collider ECAL**.

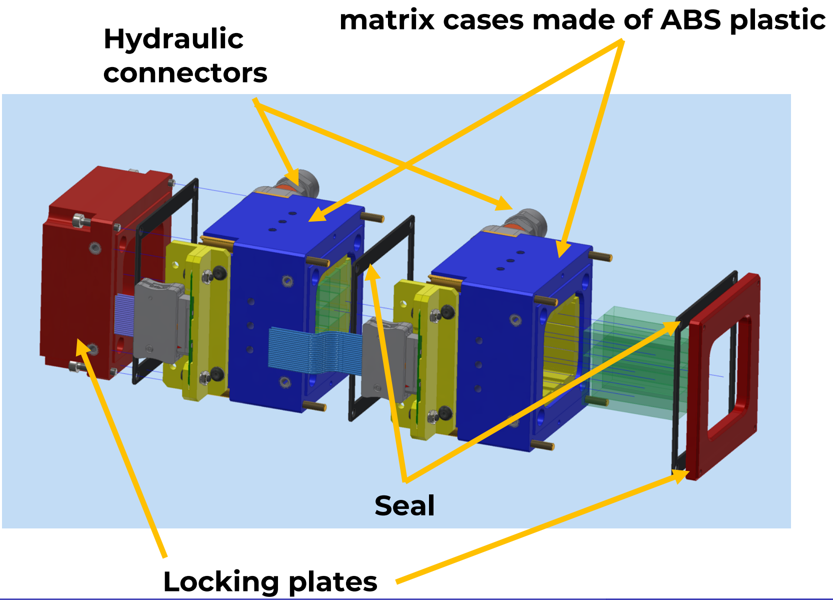


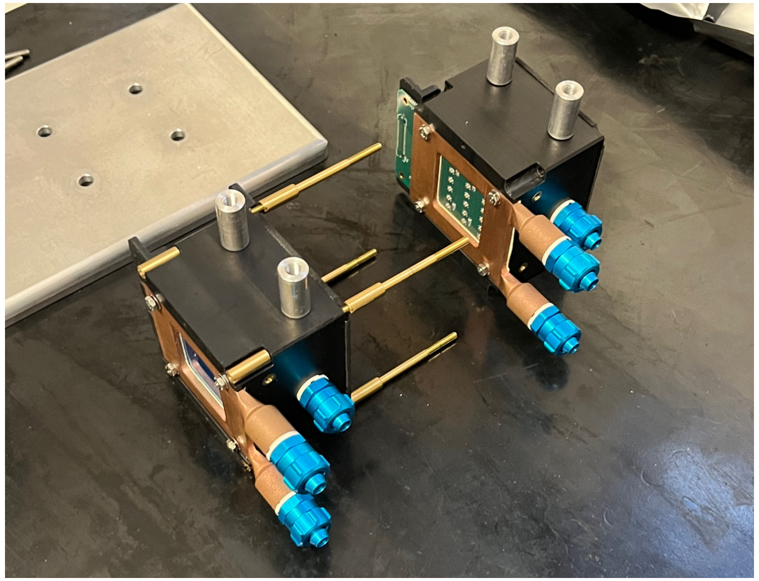


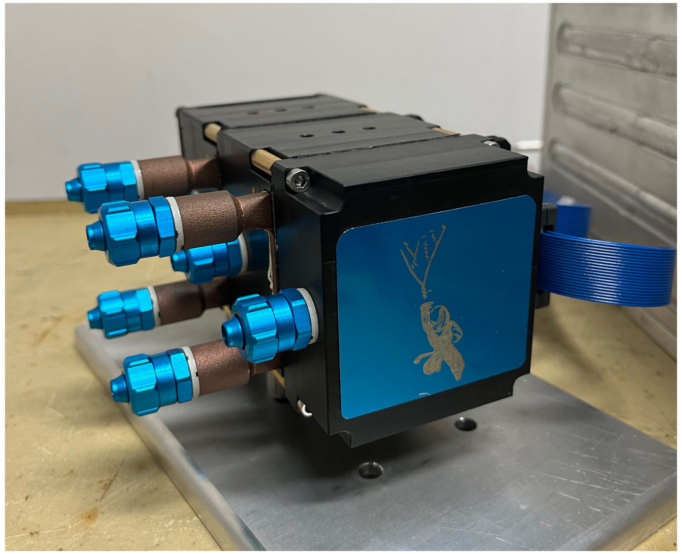


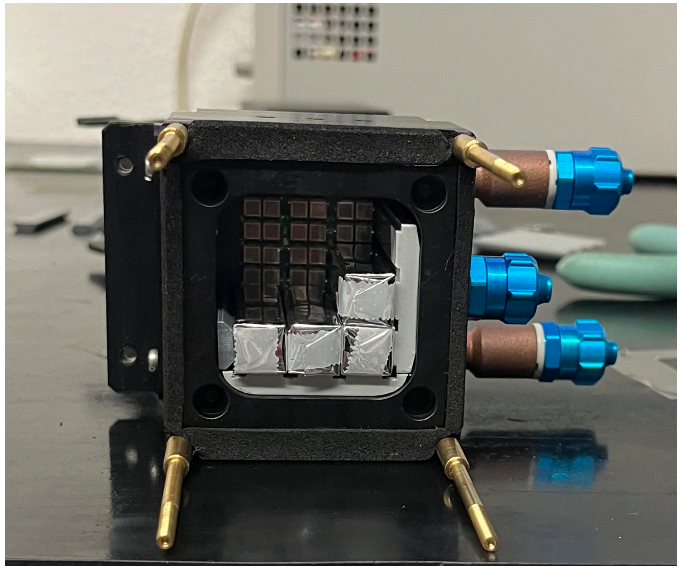
CRILIN Proto-1

- Two stackable and interchangeable submodules assembled by bolting, each composed of 3x3 crystals+36 SiPMs (2 channel per crystal)
- light-tight case which also embeds the front-end electronic boards and the heat exchanger needed to cool down the SiPMs.





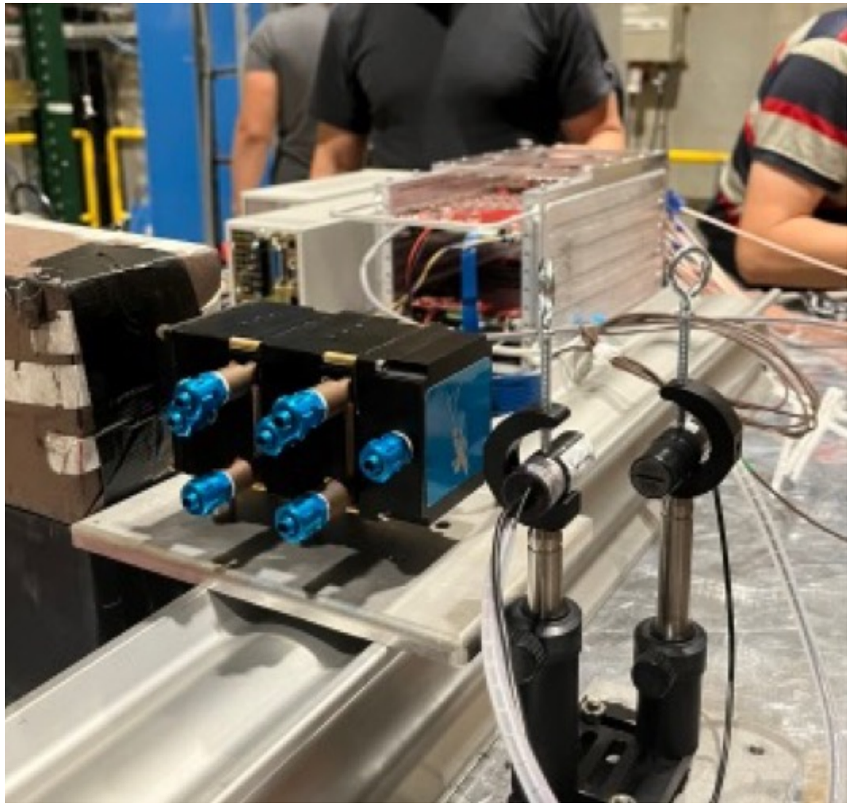




H2 Cern Test Beam

Aim:

- Validate the new readout electronics and readout scheme.
- Give a first raw estimation of energy resolution and clusterization capability.
- Measure time resolution achievable with different crystal choices.



Beam: Electrons at different energies in the GeV range produced at Cern SPS-H2 beamline.

Proto-1:

- 2 crystal options: **PbF2** (8.6 X0) **PWO-UF** (9 X0) wrapped in teflon.
- 36 10 µm pixel size SiPMs per layer: two independent readout channels (SiPM pairs connected in series).

Thank you