CRILIN update

Building a large-scale prototype

• **SiPMs Procurement:** 800 SiPMs (3x3 mm² with 10 μm pixel size) have been acquired, sufficient for 400 crystals (with 2 SiPMs in series per channel – 1 channel per crystal).

• **MC Design:** The Crilin full-scale prototype design in the Monte Carlo simulation has been completed.

• **Mechanical Design:** The first design of the new mechanical envelope is complete, and the prototype matrix for 3x3 crystals is done.

• **Electronics:** The design of the electronics has been finalized.

DRD 6 Task 3: Deliverables Status

- We are almost on schedule.

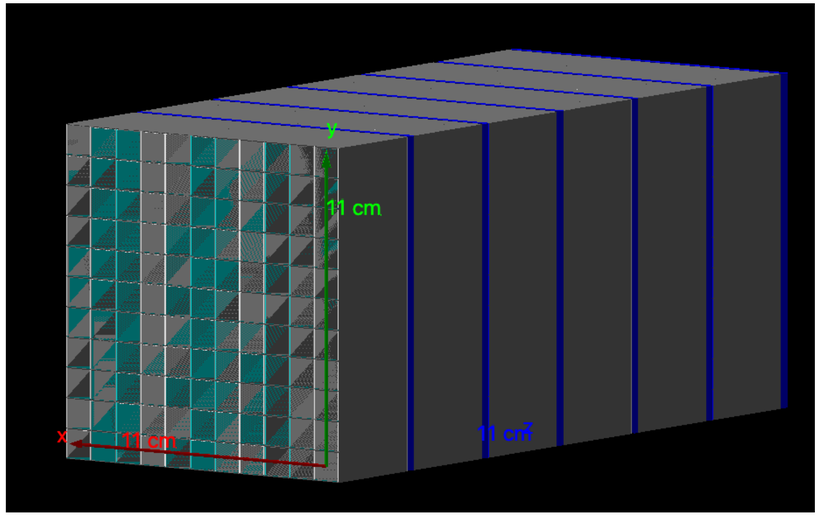
- We won an Italian grant for a small-scale prototype (5x5x5 layers).

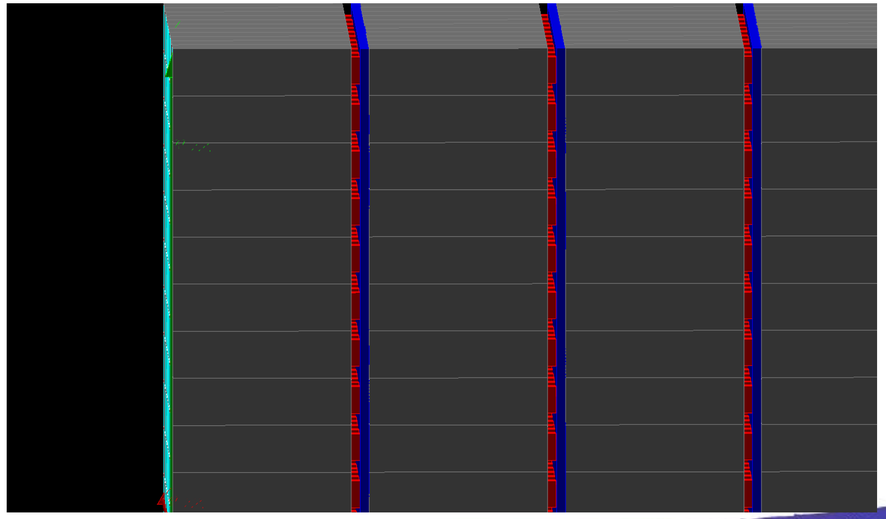
- **Funding from the agency is still delayed until 2025, which may cause potential issues with the readout of the full-scale prototype (details to follow).**

	Milestone	Deliverable	Description	Due date
		D3.4	Acquisition and tests of crystals and SiPMs; design and production of electronics boards; design and production of the mechanical components	2024
Crilin		D3.5	Calorimeter fully assembled	2025
	M3.8		Beam test characterisation of a full containment EM calorimeter prototype	2025
	M3.9		Report on testbeam results	2026

Geant4 simulation of the new prototype

- Initial proposal **11x11 x6 layer** (crystals 10x10x40 mm^2 each) → **2.5 R_M – 26 X_0**
- Crystals wrapped in 150 um Mylar foils and placed a 150 um aluminum honeycomb
- 2 SiPMs 3x3 mm^2 per cystal, 2 mm thick, per layer
- 2 mm thck PcB, per layer
- Photostatistics and noise measured during beam tests : Poisson 0.3 p.e./MeV, Gauss 5 MeV

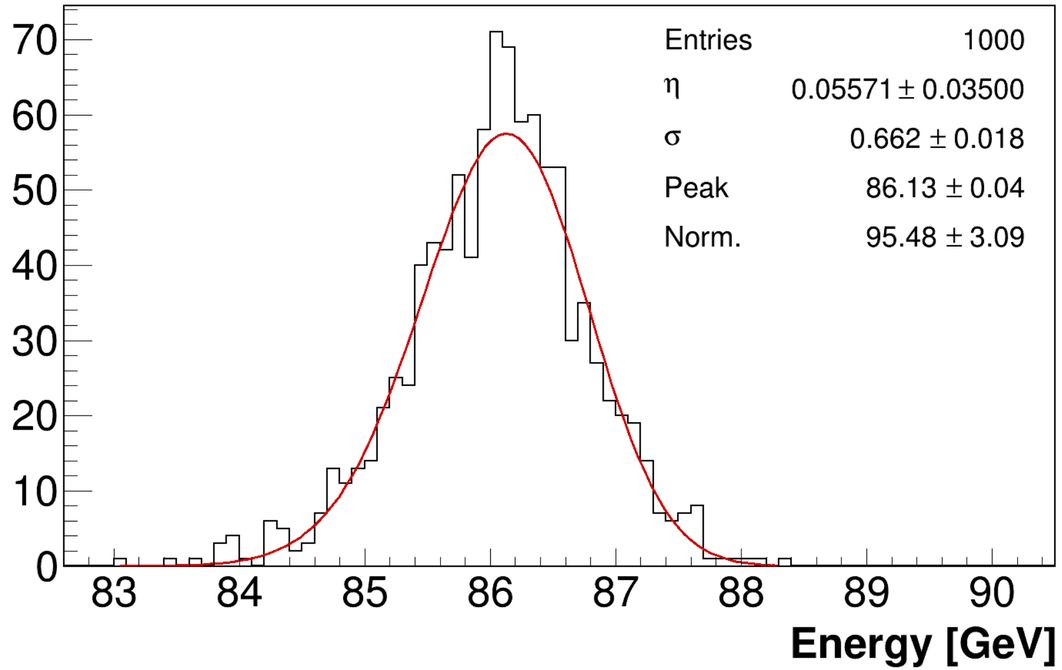


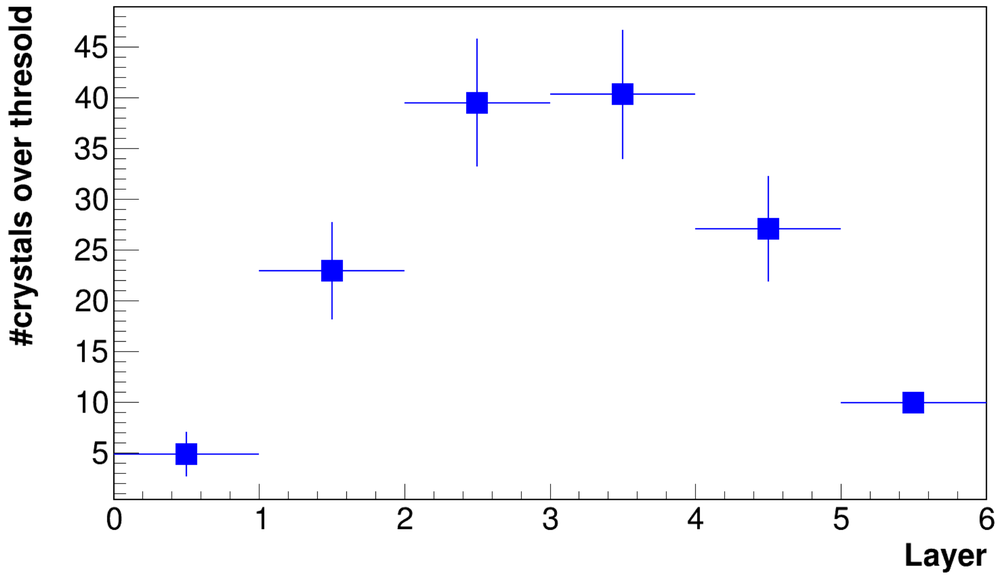


Number of crystals optimization

- By setting a threshold similar to that expected for the Muon Collider (i.e. 40 MeV) per crystal, we optimized the number of crystals, with the goal of minimizing the energy resolution loss

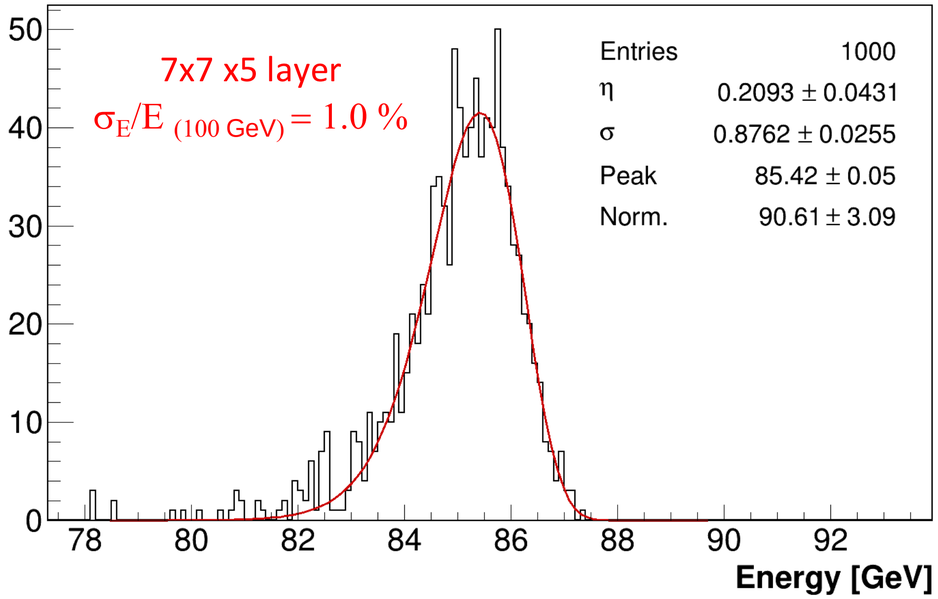
  → optimization performed for an electron beam with 100 GeV of energy.

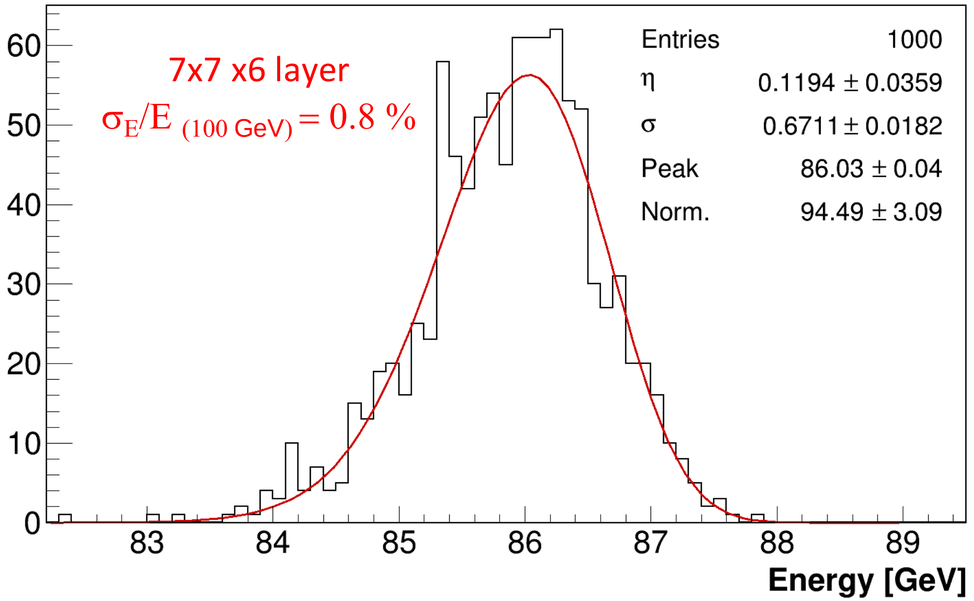




Number of layers optimization – 1

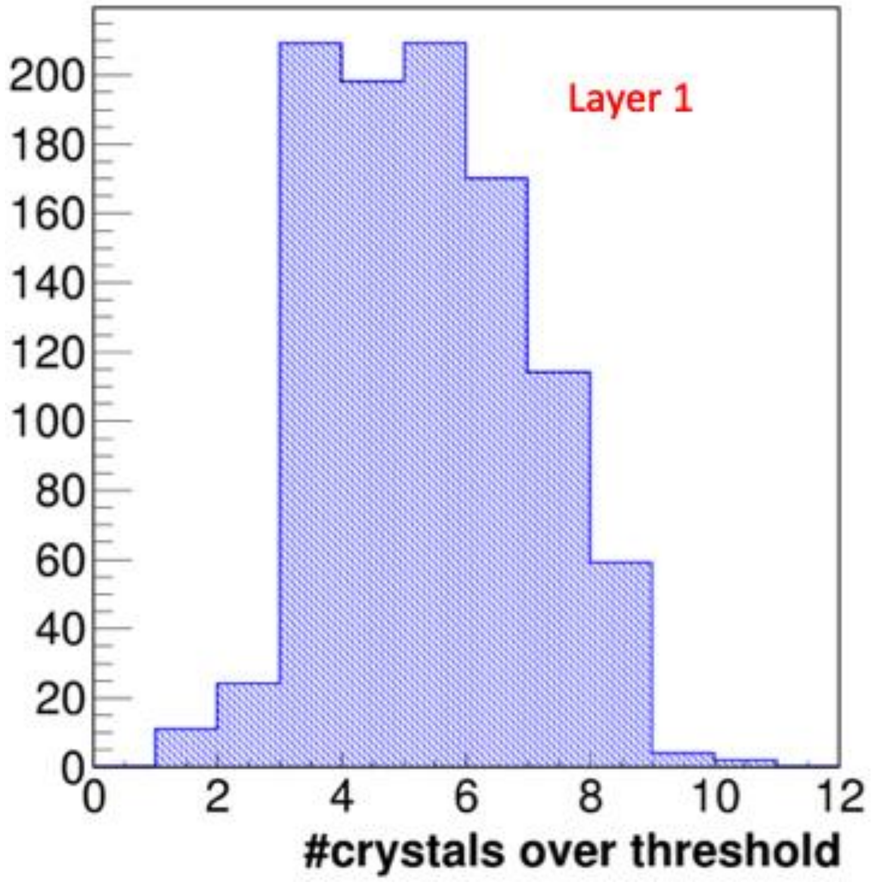
- The average number of crystals triggered above the threshold leads to a 7x7 configuration for layers 2, 3, 4, and 5.
- **The sixth layer is crucial for maximizing energy resolution**→ longitudinal leakage creates a much larger energy fluctuation compared to lateral leakage (for the same amount of leakage).

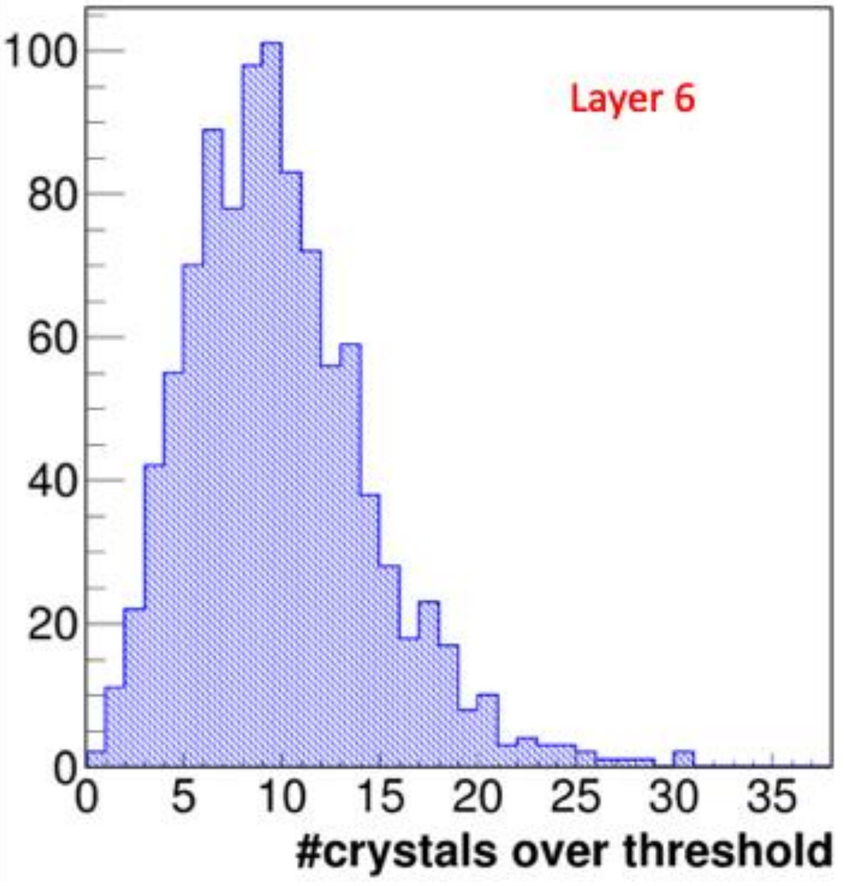




Number of layers optimization – 2

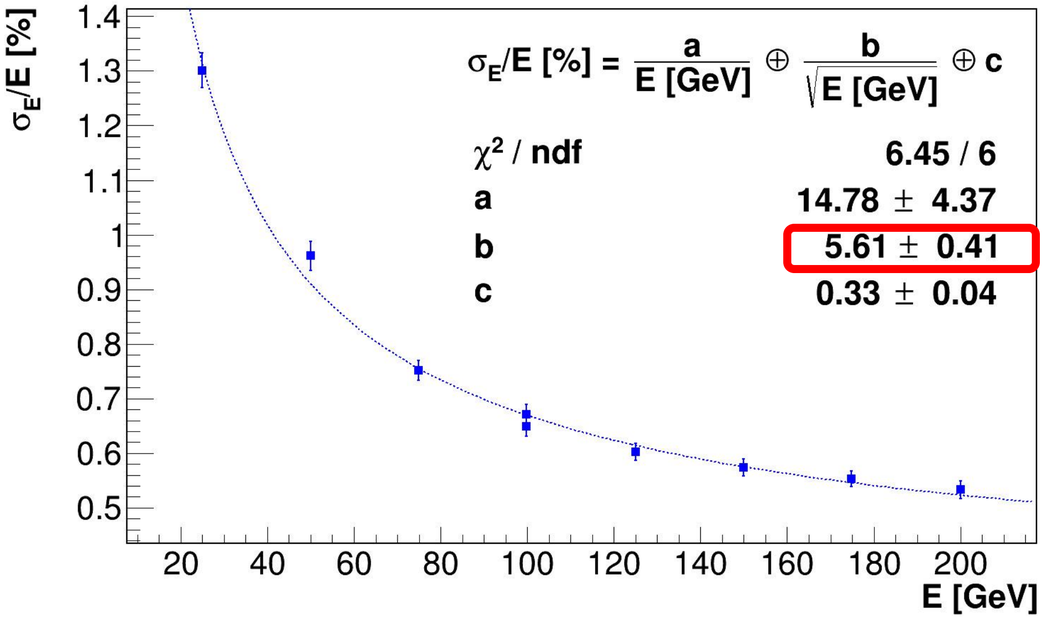
- The average number of crystals triggered above the threshold leads us to a 5x5 configuration for layers 1 and 6.

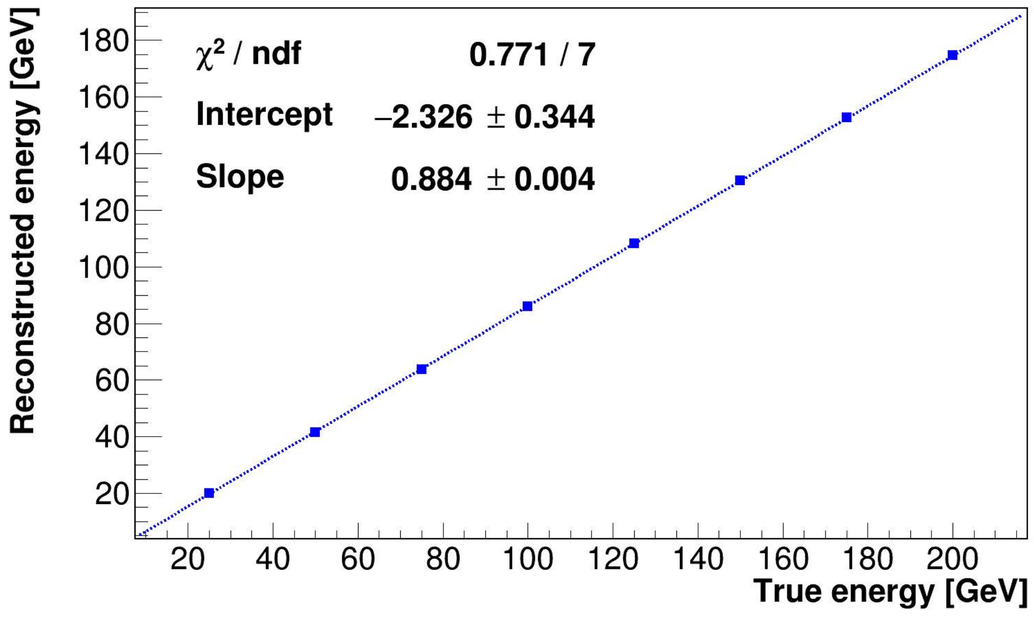




Energy resolution

- Energy Resolution and Linearity as a function of E for the reduced matrix:
- 7x7 in layers 2, 3, 4, and 5, and 5x5 in layers 1 and 6 → ~ 250 crystals in total.





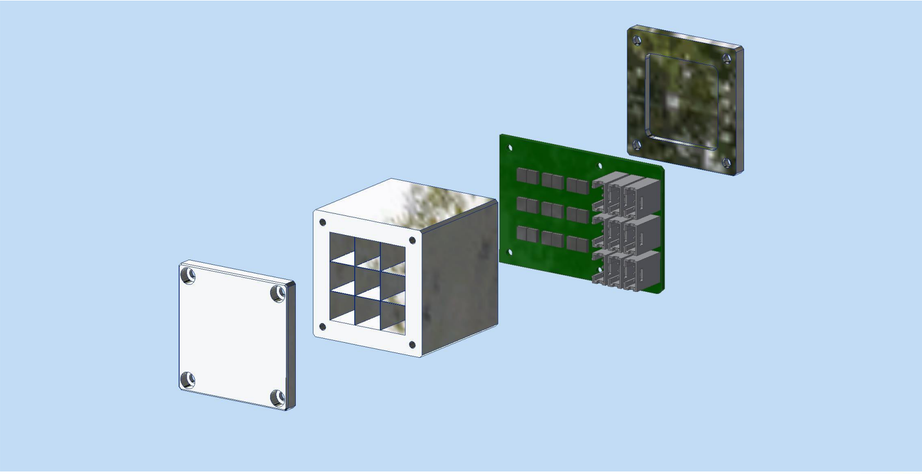
2024: Prototype Development for Mechanics, Electronics, and Data Acquisition

For the acquisition of the required 250 channels, we have two options:

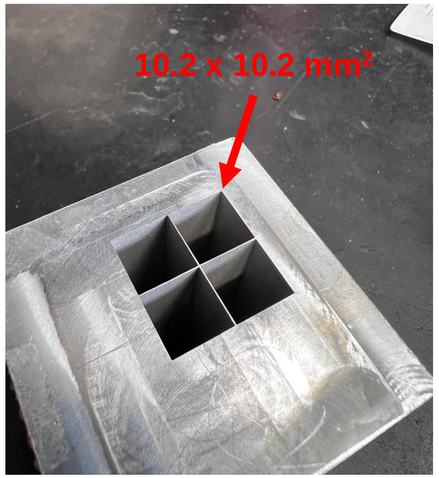
- **Custom front-end electronics paired with CAEN V1742 flash ADC digitizers** (cost ~ 40+80k EUR needed)
- **CAEN A5204 board** with integrated amplification electronics, based on the 64-channel Radioroc unit for FERS-5200 and Pico TDC (total cost for 250 channels ~ 60k EUR needed)

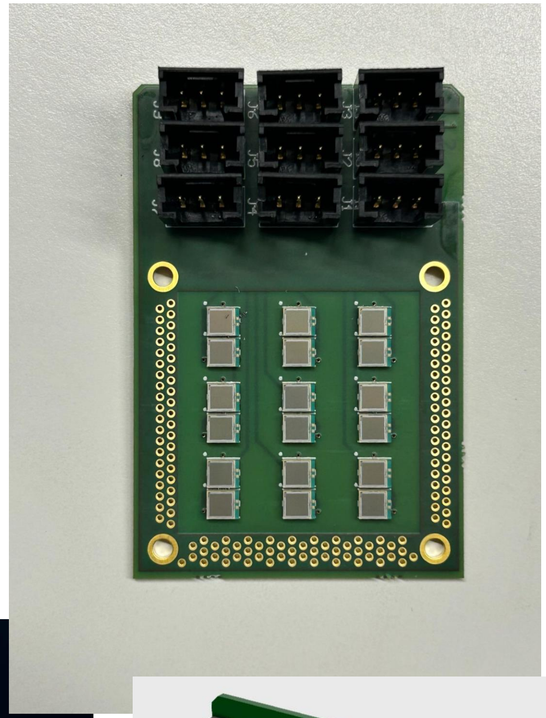
➢ We have developed a 3x3 prototype compatible with both solutions and will assess the effectiveness of the CAEN board in a dedicated test beam at the beginning of 2025.

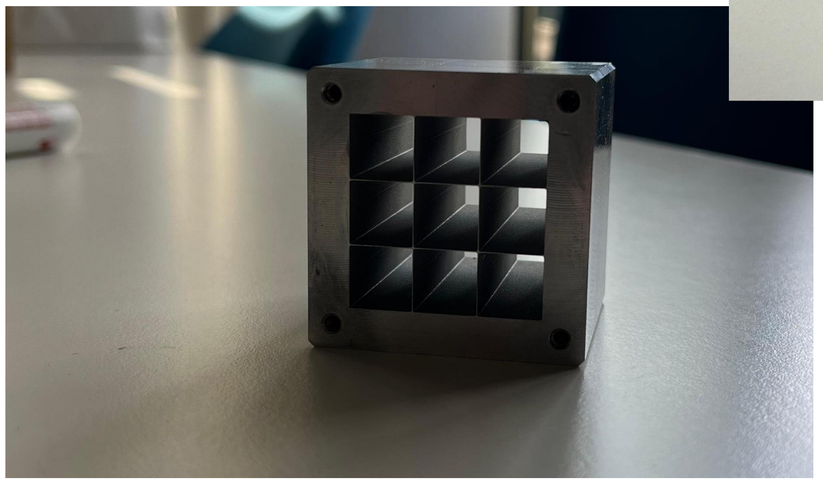
➢ The first solution (custom electronics and flash ADC) has already been proven effective in previous Proto-1 tests, achieving timing O(20 ps) for deposited energies >1 GeV.

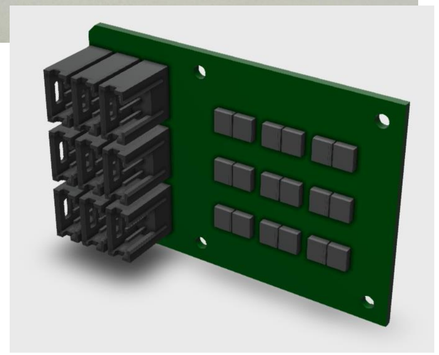


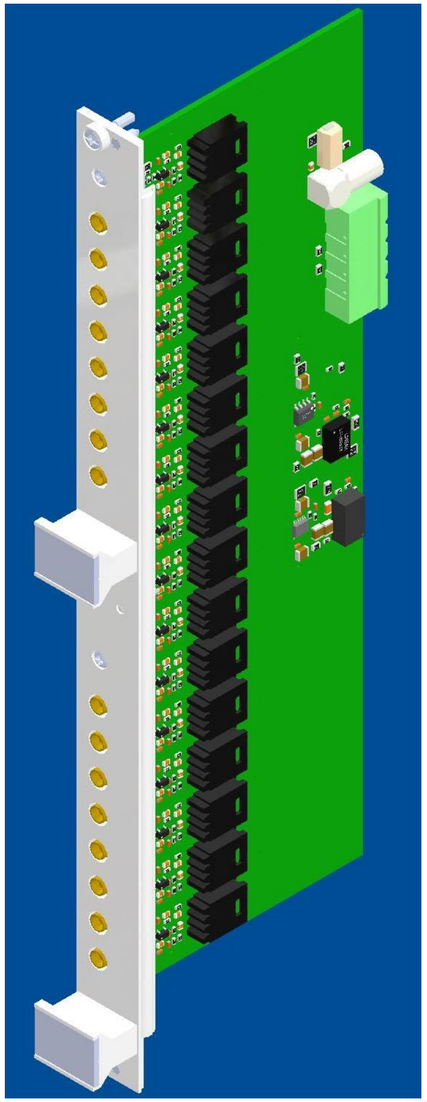
2024: Prototype Development for Mechanics , Electronics, and Data Acquisition

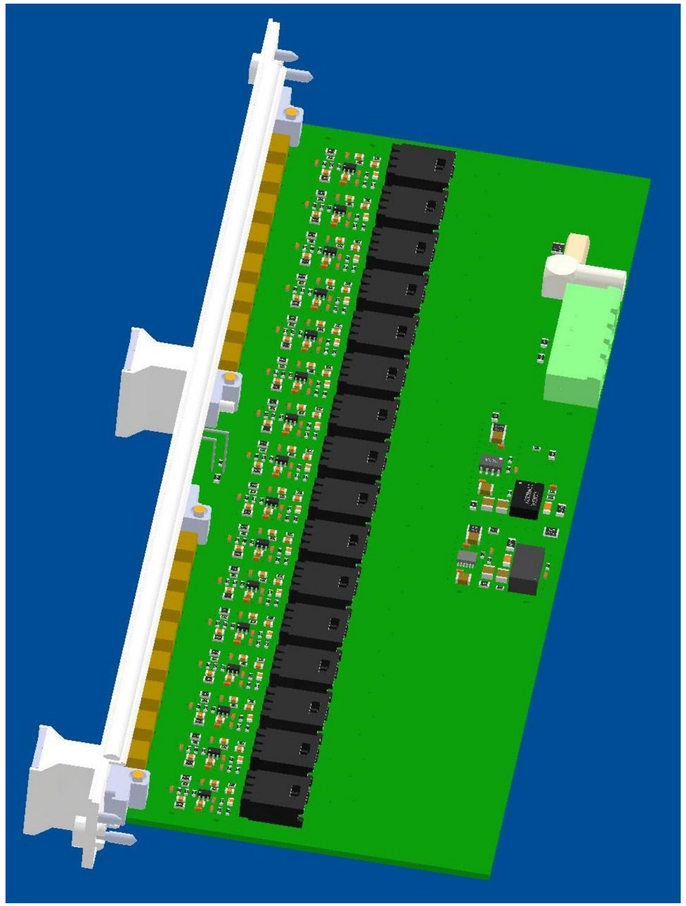






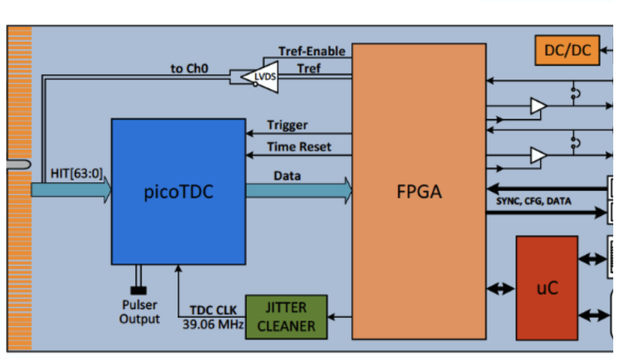




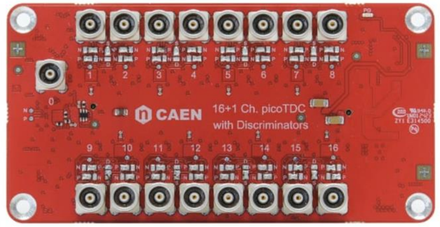


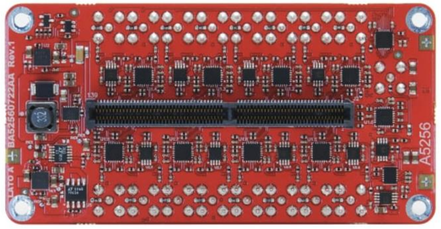
Electronics status

- **Custom front-end electronics paired with CAEN V1742 flash ADC digitizers** → ready before end of January 2025
- In collaboration with LNF Cupid group we brought also a CAEN A5203 board, composed of picoTDC only and 16ch of discriminator → for testing the time over threshold technique.

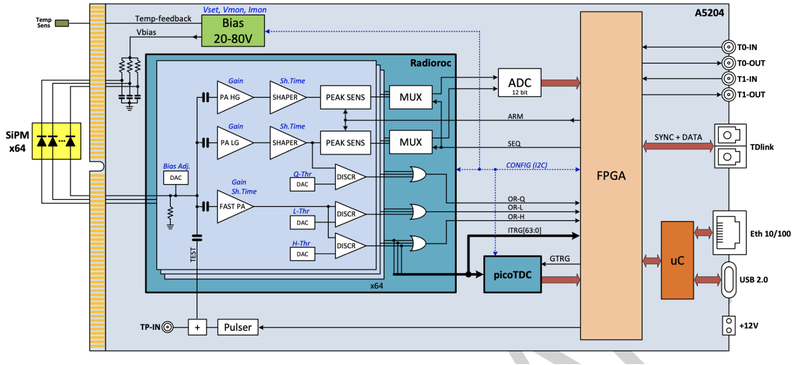


Simplified block diagram





- **CAEN A5204 board** acquired. Will be shipped to LNF on February 2025.



Crystals

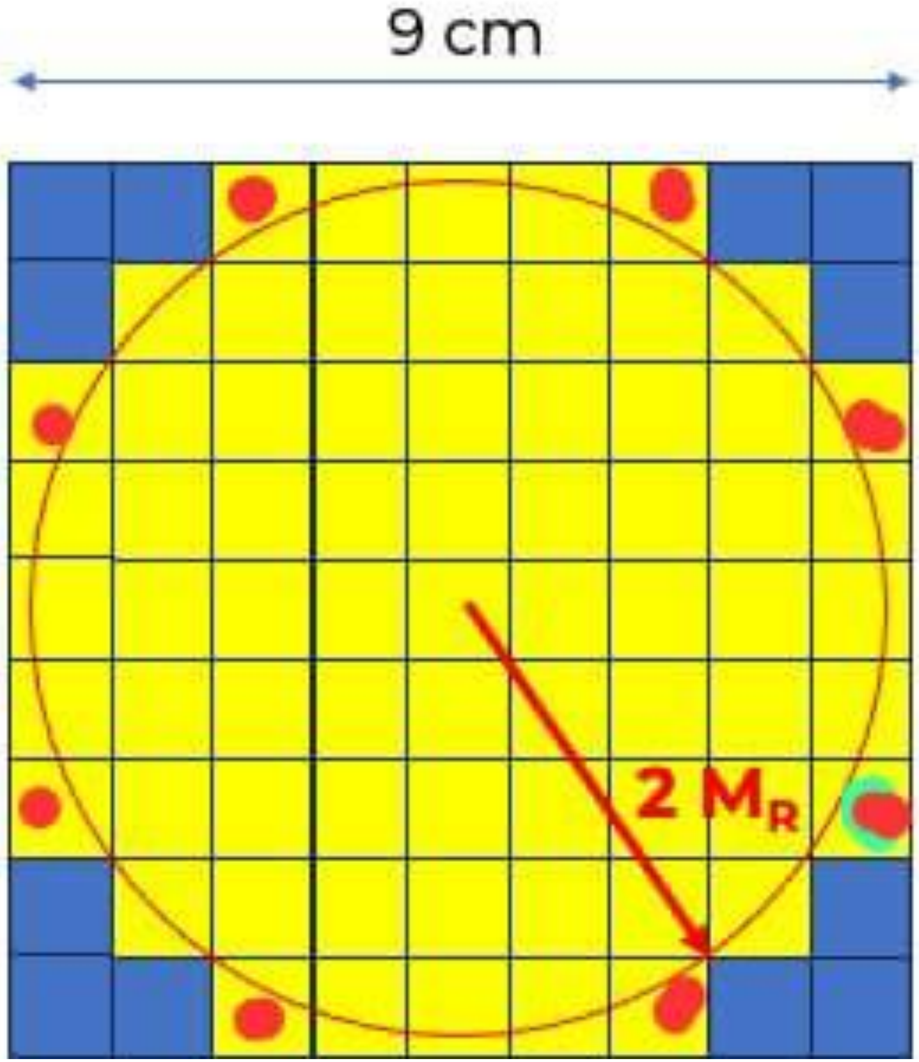
Opportunity with g-2 Crystals. **Samples Obtained**:
- Size: 24x24x130 mm^3.
- Cut to our required dimensions: 10x10x40 mm^3.
- Cutting operation handled by Silo.

• **Cost of Operation**:
- €80 + VAT per crystal (higher than expected).
- Still more economical compared to new Chinese crystals (~€110 + VAT).
- **30% savings** with the g-2 crystals.

• **g-2 Station Requirements**:
- Each station uses 54 crystals.
- We have enough to fill the entire matrix.

• **Updated Proposal**:
  • Fill the matrix with approximately **330 crystals**.
  • Total cost **~€30,000** (we already have ~35 good crystals).
  • **Optimization**: Focus on improving the electronics to enhance performance and cost efficiency.

Crystals New Proposal



61 Crystals x Layer
2-3-4-6
25 Crystals x Layer
1

Flash ADC and Funds

Confident in the completion of PADME by the summer of 2025, we can borrow the digitizers from them!

We have requested two test beams at CERN:

- **One week at the PS (or SPS, either works)** to test the electronics and make the final decision. The test is scheduled for **end of March 2025**.
- **Final test beam request**: For late November at the SPS, with energies between 40 and 150 GeV. It's likely that they will postpone it to March 2026. We will monitor and assess the scheduling. I will work to ensure everything is ready on time.

Costs and Available Funding:

•We still have approximately **€100k** from PRIN and RD_Mucol LNF.

•**Estimated Costs (assuming our electronics design)**:

- **Crystals purchase and cutting**: €30k
- **Crystals matrices:** €10k, if made at Ferrara, €30k if made out INF
- **SiPM matrices** (~€5k per layer) **+ Kapton**: €30k
- **FEE electronics for 25 boards** (16 channels each): €50k
- **Cables**: €5k
- **CAEN A5818 links**: €5k
- **2 Rubometers**: €10k

We are almost there
(about **€40k short + miscellaneous items**),
but we need the DRD6 funding: we have requested **€40k for FEE electronics** and **€80k for the digitizers**.
If PADME confirms, I would cancel the **€80k** request, but the new **€50k for FEE electronics** must be allocated 100%.

SPARES