INCANTO

InNovative CAlorimeters for New Topologies and Operation

Davide Zuliani, PD Local Coordinator

26 June 2025, Riunione preventivi Gruppo 5

Objectives -1-

INCANTO

- The INCANTO project is designed to push calorimeter technology well beyond the current state of the art, addressing the stringent requirements posed by future collider detectors and high-intensity fixed-target experiments.

- The project targets the following deliverables:

  1) Construct and test **two longitudinally segmented ECAL prototypes** based on **dense, fast, radiation-hard crystals** (PbF2 and PWO-UF), exploring both **oriented and non-oriented crystal** configurations. One module will feature **SiPM matrices** for compact, low-power readout in magnetic fields, while the other will use **fast PMTs** for high-intensity environments.

Objectives -2-

2) Develop and assemble a **~1.5 λ_I high-granularity semi-digital HCAL** module based on **MPGD technologies** (MicroMegas and/or µRWELL), capable of achieving fine spatial and temporal resolution, by leveraging sampling layers interleaved with absorber materials. Specifically, we will improve the MPGD design by **optimizing the width of the drift gap to improve the time resolution at the O(1ns)** level.

3) **Implement dedicated front-end electronics**, combining both **commercial solutions** (e.g., CAEN) and **custom-developed designs**, with a focus on scalability, fast timing performance (sub-100 ps), and radiation tolerance. For the MPGD-HCAL, the final readout electronics should ensure low noise (ENC ~1000 e^-) and a wide dynamic range (1–100 fC), enabling studies of various semi-digital readout architectures.

Objectives -3-

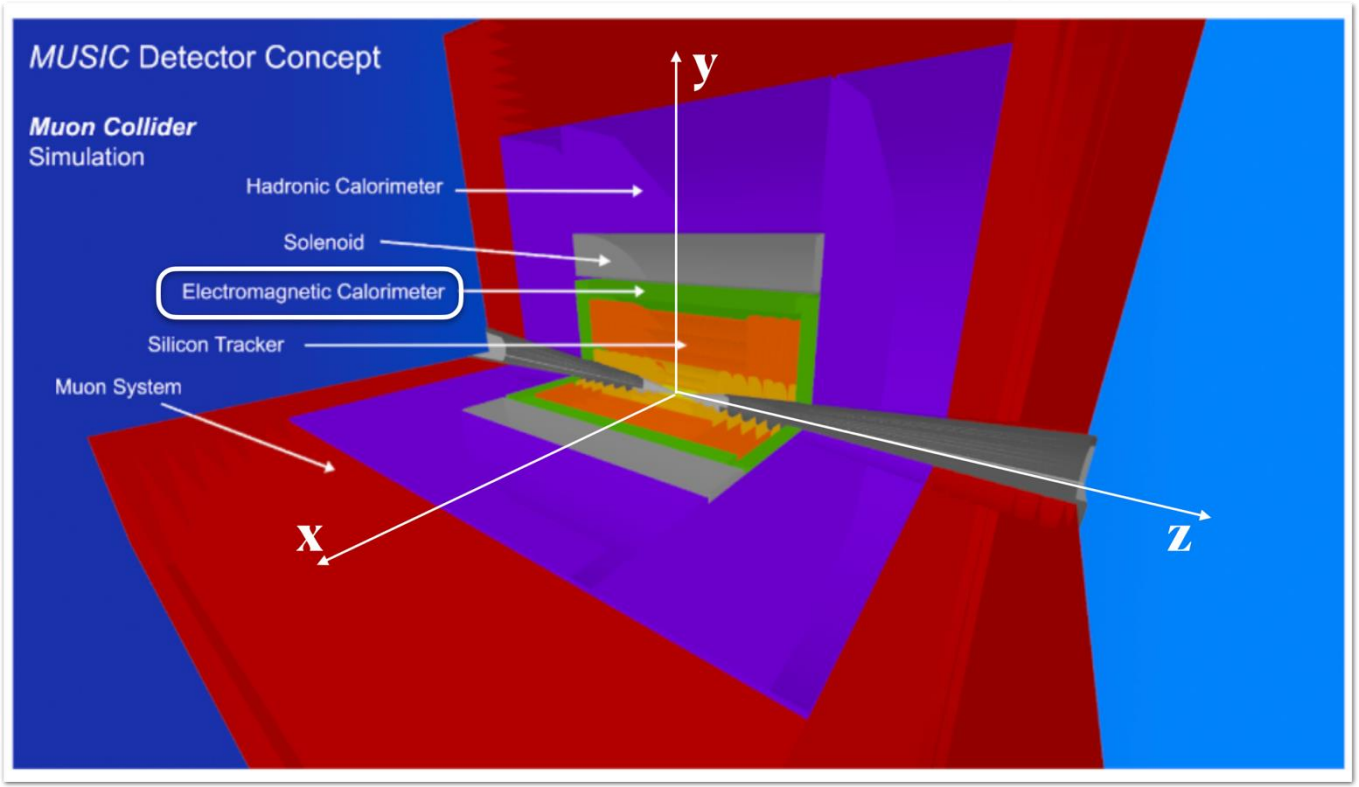
4) A rigorous validation program is planned, including **extensive test beam campaigns on both individual components and integrated calorimeter modules**. The combined ECAL+HCAL systems will be tested to assess their performance in terms of energy resolution, reconstruction techniques, and particle identification capabilities.

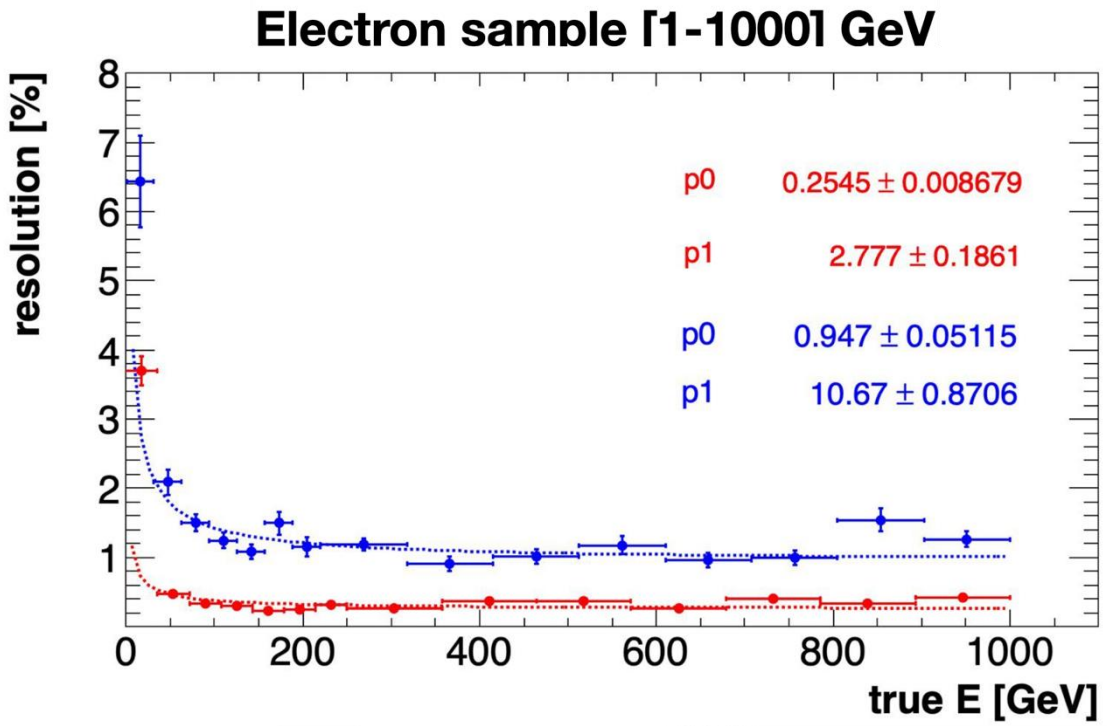
- The project also fosters the creation of a **unified Italian calorimetry community, combining expertise in detector development, electronics, simulations, and data analysis**, thus positioning itself at the forefront of global calorimeter R&D efforts.

@ Padova: simulation

- The Padova group has always been involved in simulation activities of calorimeters for future colliders
- In particular, evaluation of ECAL performance for a Muon Collider

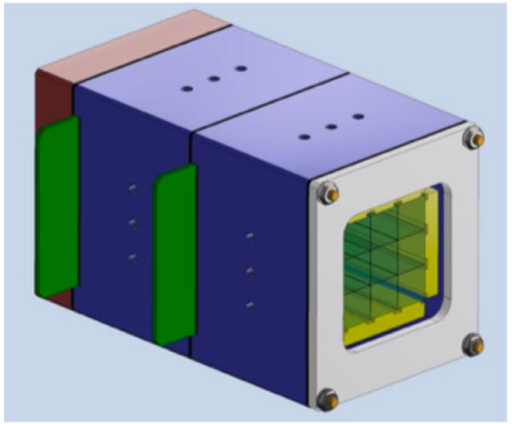
MUSIC: MUon System for Interesting Collisions

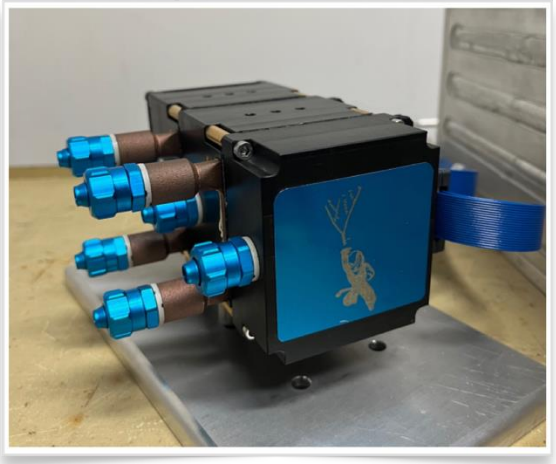


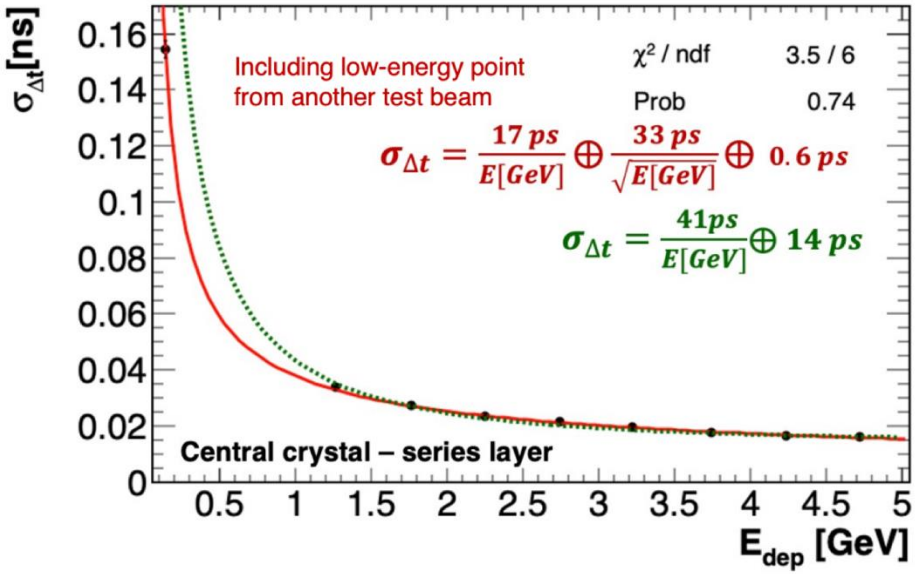


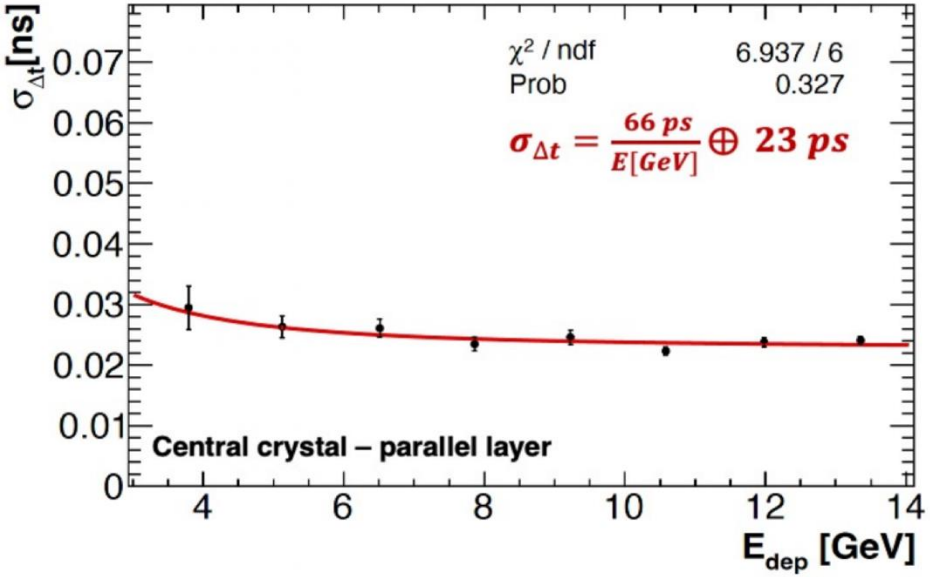
@ Padova: test beams

- The Padova group has also been involved in recent test beam activities for performance evaluation of calorimeter prototypes
- Characterization of energy and time resolution
- Several test beams @ different facilities (SPS, LNF-BTF)





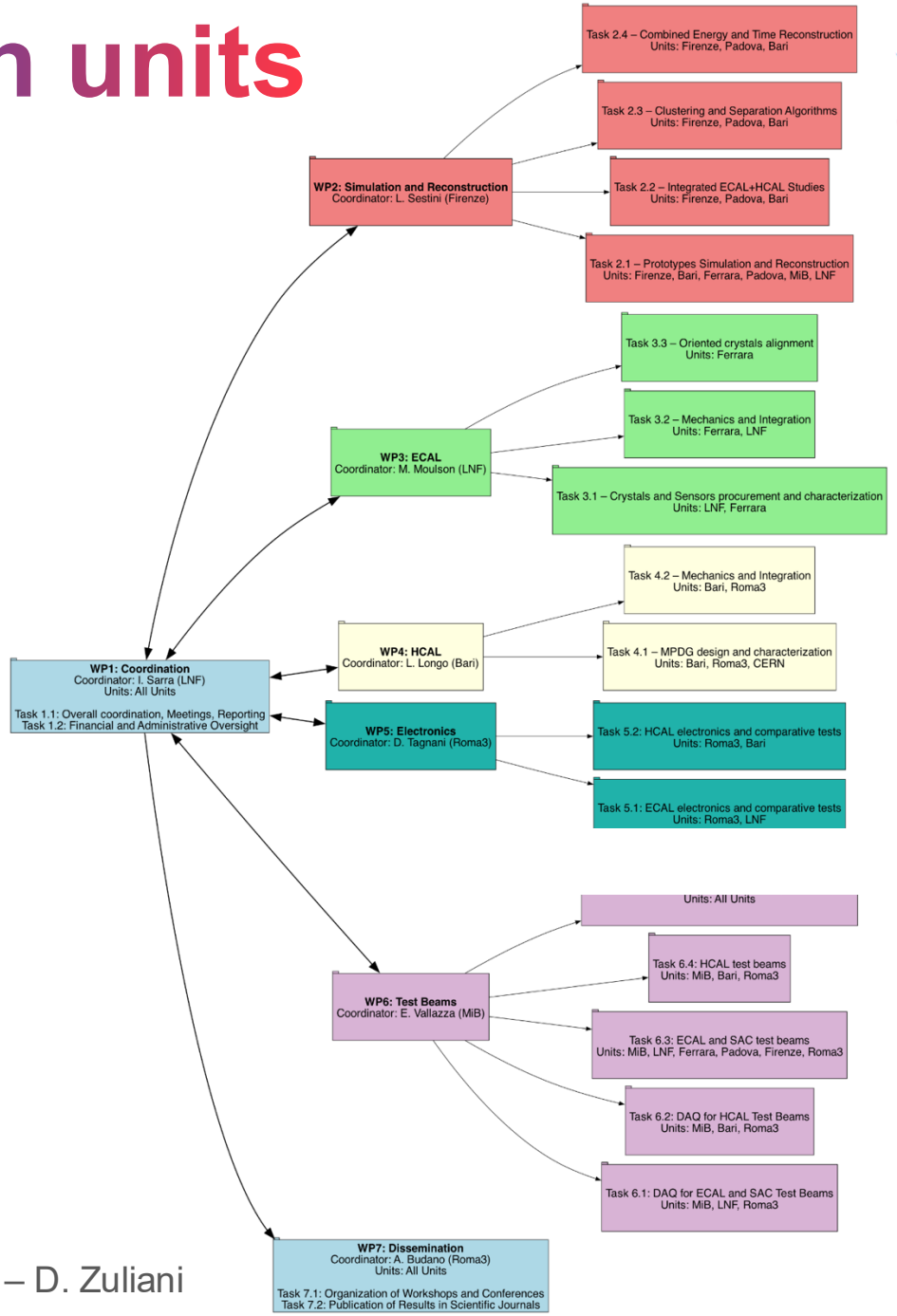




Research units

- The INCANTO project is built on the consolidated expertise of INFN units (Bari, Ferrara, Firenze, LNF, MiB, Padova, Roma3), which have long-standing experience in detector development, supported by technical infrastructures and international collaborations:
  - **47 people – 11 FTE** (2026)
  - **49 people – 14 FTE** (2027-2028)

- The work is organized in **seven Work Packages,** each coordinated by a unit with specific responsibilities.

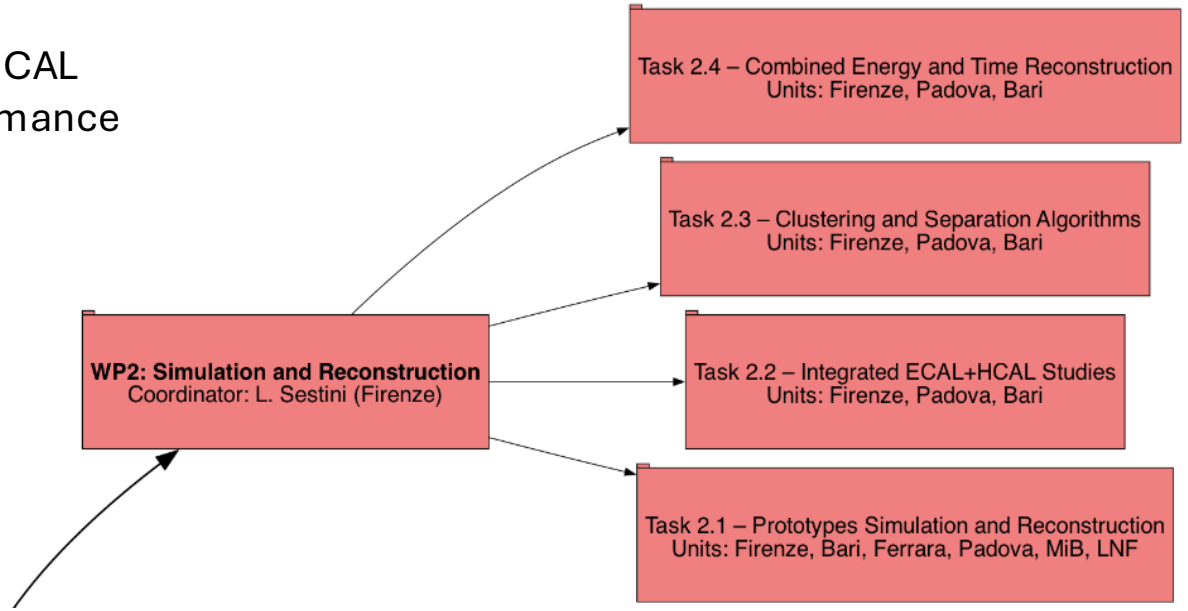


WP2: ECAL (zoom only on 2026 activities)

Coordinator: L. Sestini (Firenze)

Units: Firenze, Bari, Ferrara, Padova, MiB

This WP focuses on simulation and reconstruction of ECAL and HCAL prototypes, including digitization, oriented crystal studies, performance optimization, and energy/time reconstruction algorithms.



Task 2.1: Prototypes Simulation and Reconstruction [Months 1-12]
Task 2.2: Integrated ECAL+HCAL Studies [Months 12-24]
Task 2.3: Clustering and Separation Algorithms [Months 12-18]
Task 2.4: Combined Energy and Time Reconstruction [Months 24-28]

Milestones:
- M2.1: Preparation of simulation framework [Month 3]
- M2.2: ECAL and HCAL Prototypes Simulation Completion [Month 12]
- M2.3: Clustering Algorithm Implementation [Month 18]
- M2.4: Combined ECAL+HCAL Reconstruction Algorithms Implementation [Month 28]

Deliverables:
- D2.1: Prototypes Simulation Results [Month 12]
- D2.2: Oriented Crystal Simulation Report [Month 12]
- D2.3: Clustering and Separation Algorithms Report [Month 18]
- D2.4: Combined ECAL+HCAL Energy and Time Reconstruction Report [Month 28]

PD Research unit and financial request

Padova	Davide Zuliani	PostDoc	0.2	0.2	0.2	Local coordinator, expert in detector design and simulation
	Paolo Andreetto	Tecnologo	0.1	0.1	0.1	Computing expert, software development
	Alessio Gianelle	Primo Tecnologo	0.1	0.1	0.1	Computing expert, software development
	Leonardo Palombini	PhD	-	0.3	0.3	Simulation development and data analysis expert
	SUM		0.4	0.7	0.7	

- **3 people – 0.4 FTE** (2026)
- **4 people – 0.7 FTE** (2027-2028)

Padova	1,2,7	Coordination, meetings, and conferences	2	2	2	Travel
	6	Test beams	-	3	3	Travel
		Totale Padova	**2**	**5**	**5**	**12**