The "OREO" ORiEnted calOrimeter project

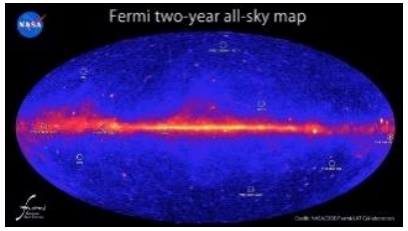
OREO goal: realization of an ultra-compact ultra-fast oriented crystal-based Electromagnetic Calorimeter

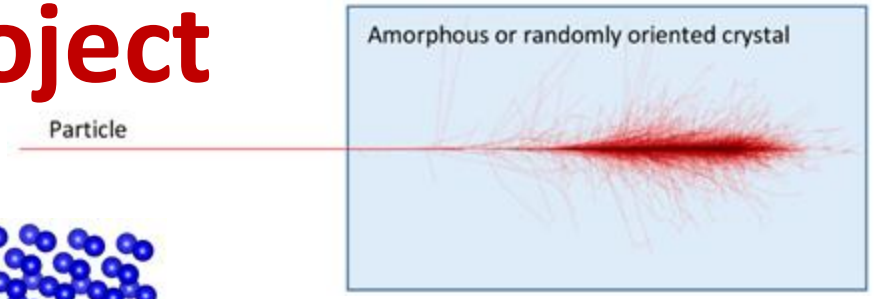
- **Application in:**
  - **Particle Physics**

Forward-geometry in accelerator-based experiments

  - **Astroparticle Physics**

Ultra-compact space-borne telescope for VHE gamma rays detection (interest from Fermi-LAT and ASI community)





INFN Units: FE, LNL, MiB
National Coordinator:
Laura Bandiera
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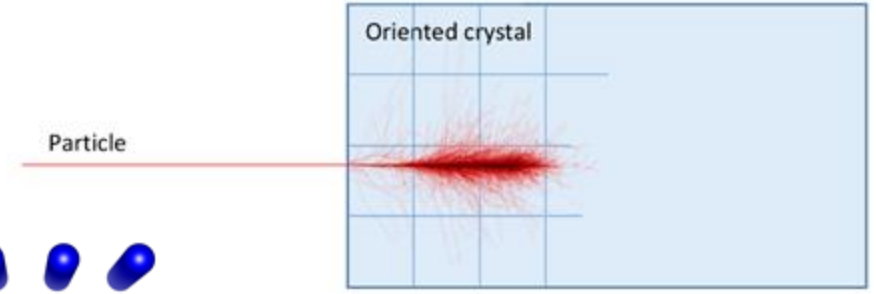
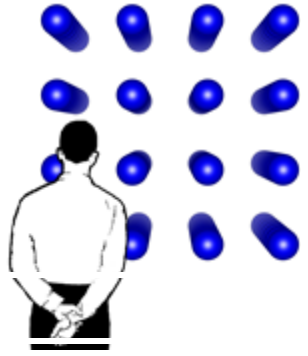
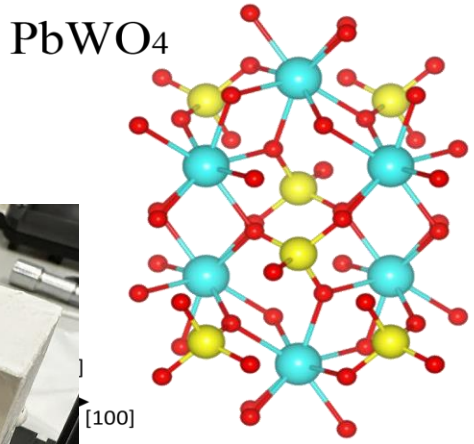




Included in AIDAINNOVA
WP8 task 3.1 Crystal Calorimeters

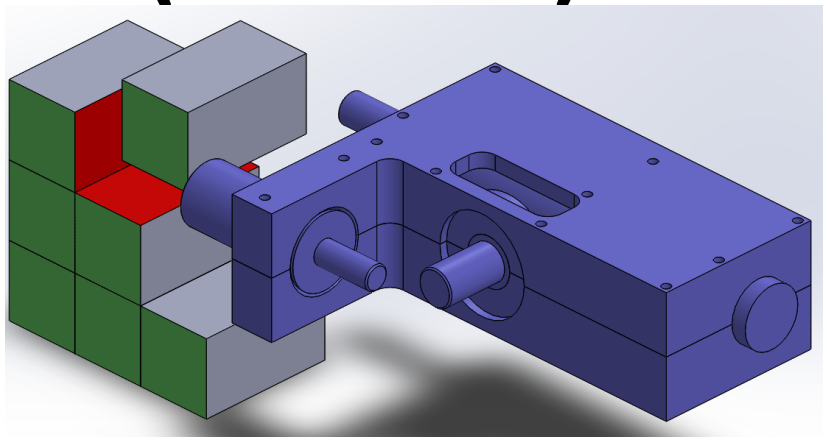
L. Bandiera et al., Front. Phys. 2023 11:1254020. doi: 10.3389/fphy.2023.1254020

2024: Construction of the OREO prototype
3x3 matrix of ultrafast PWO (PWO-UF)

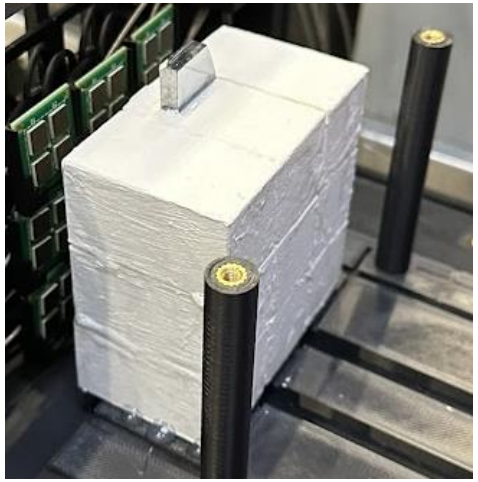


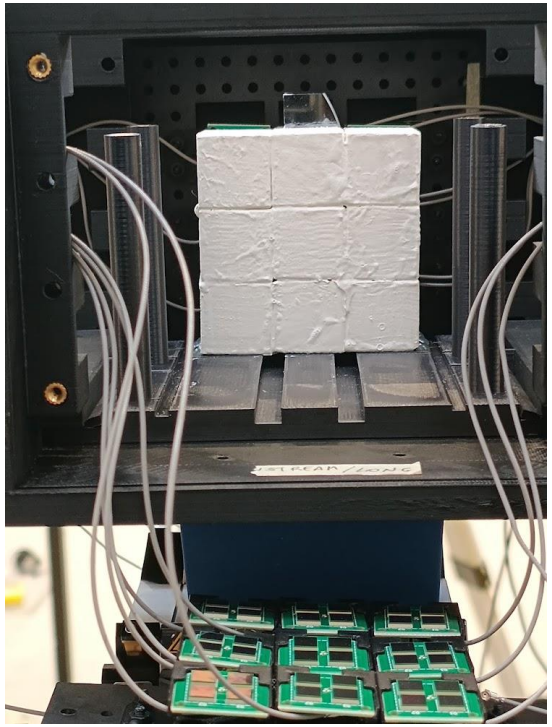
A newly developed PWO-Ultrafast is a candidate for the HIKE Small Angle Calorimeter

Scintillation decay decreased down to the subnanosecond (0.7 ns)
M. Korjik et al., NIM A, 1034 (2022) 166781



Orientation control: handling system based on motorized optomechanical components (Thorlabs) and autocollimator laser





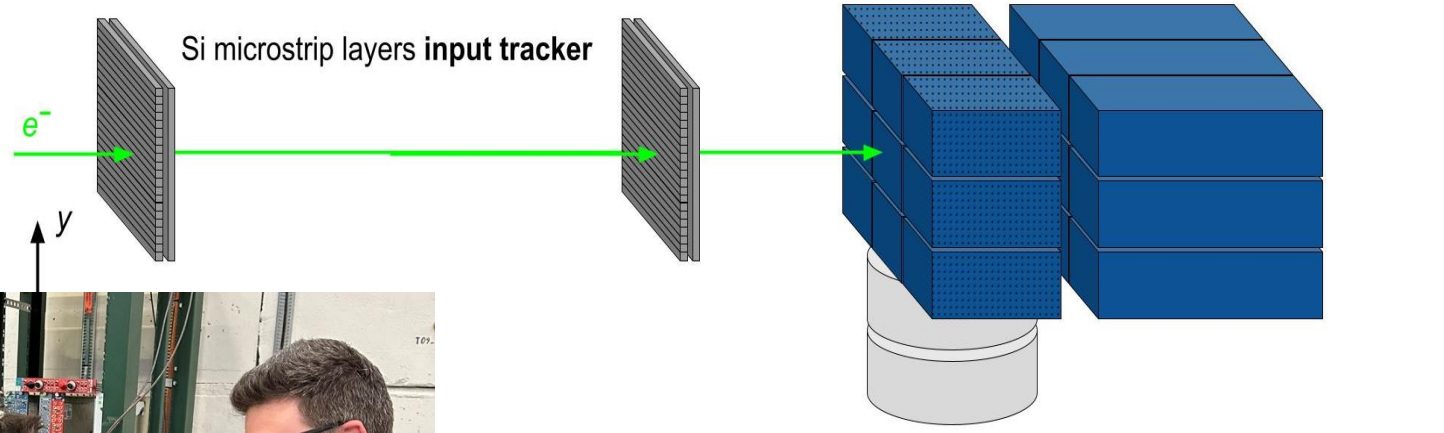
Crystals were coated with a reflective paint and the glued together.

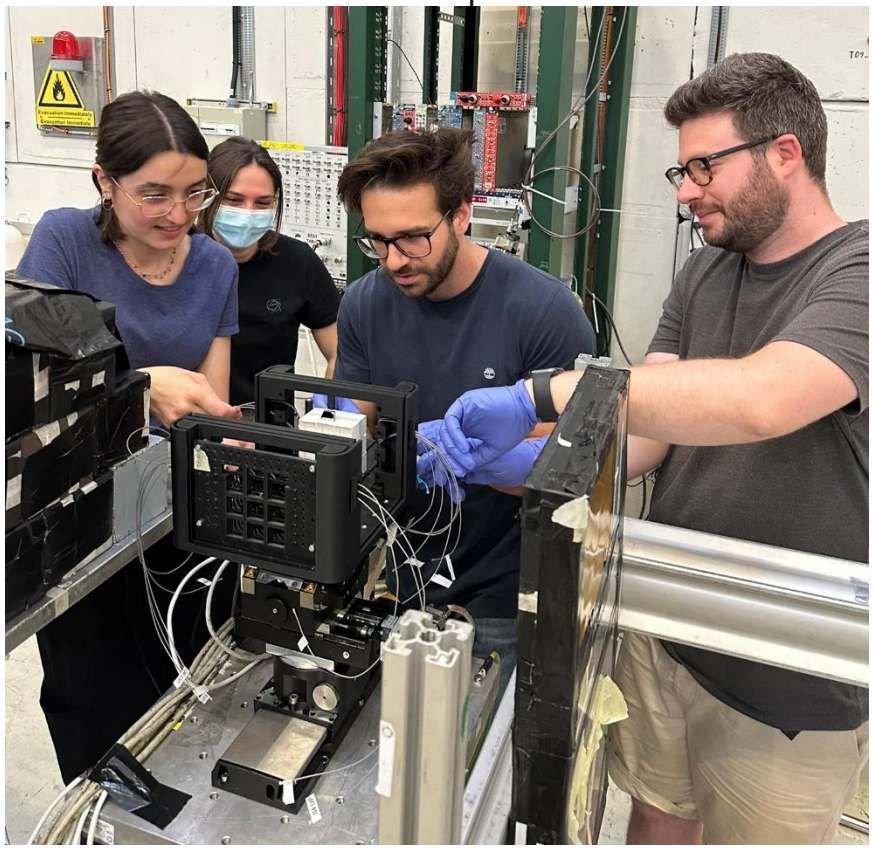
Misalignment < 0.3 mrad ($< \Theta_{max}$)

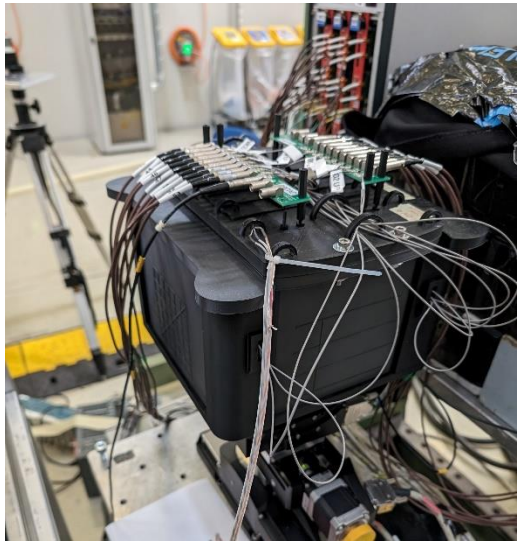
Readout: SiPM matrix, each coupled to one of the three crystals

First test of the OREO **3x3 matrix** @CERN PS

Setup on T9 line of the Proton Synchrotron







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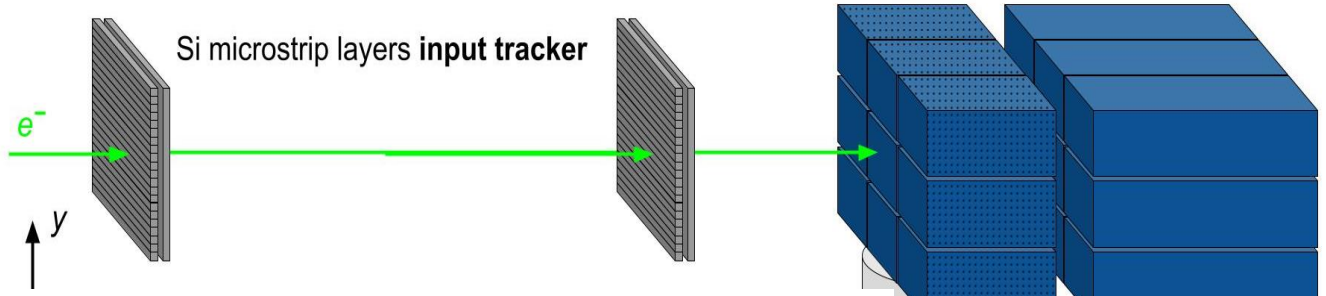
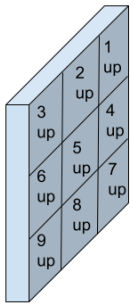
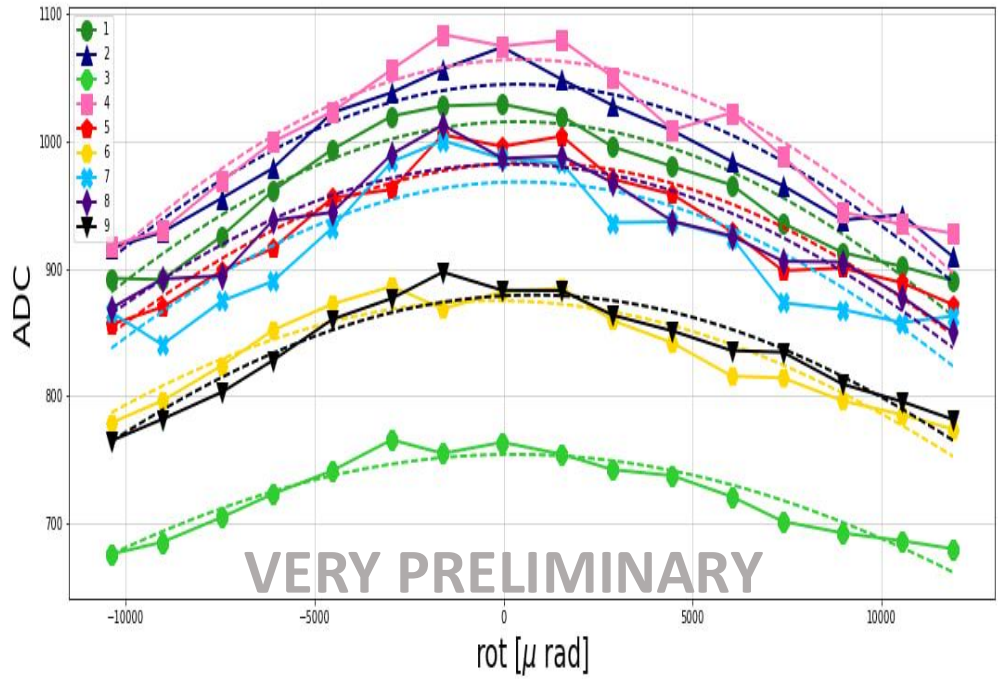




BEAM



Energy deposited in the 9 OREO oriented crystals (ADC) vs. crystal orientation (zero is for PWO axis)

Tested @CERN PS/SPS in June 2024 with 6 GeV electrons

SUCCESS: All the crystals aligned with each other!!

Will be tested @CERN SPS with 100 GeV electrons at the end of Summer

Application of the OREO technology

forward-geometry accelerator-based experiments

fixed-target **collider forward region**

- improved shower containment ⇒ energy resolution
- higher γ efficiency ⇒ ideal for γ vetoes
- better γ/hadron discrimination ⇒ ideal for γ/n in small-angle calorimeters on neutral hadron beamlines

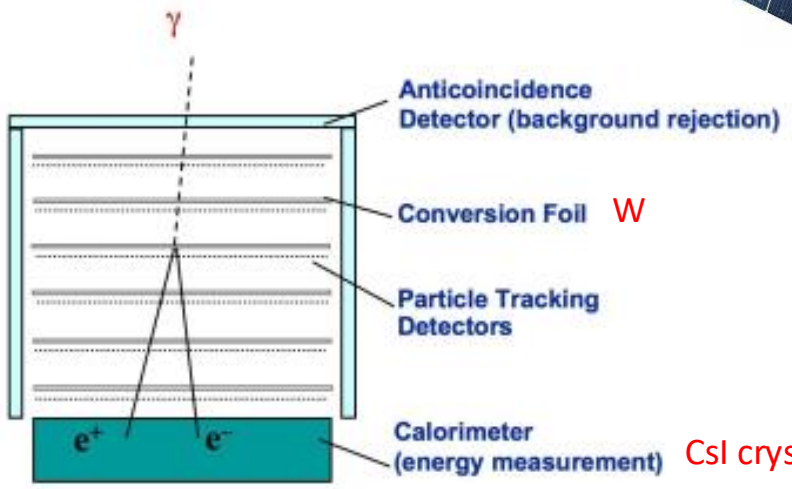
- in **dark matter search**, to realize **compact active beam dump or target** with an **increased sensitivity to light dark matter.** **Interest by the POKER collaboration with NA64++ @SPS**
- **Longitudinally segmented e.m. calorimeters** ***(as for HIKE – NOT APPROVED)***

HE Astroparticle Physics

- **pointing a telescope towards a source**, thus measuring the spectrum of γ-rays with energy larger than 100 GeV can be completely contained in a quite compact volume, **reducing the necessary weight and cost.**

Collaboration with Fermi-LAT and ASI researchers

FERMI-LAT tower



OREO in DRD6 Calorimetry

OREO
as a new subtask in WP3 Task 3.1 homogeneus EM CAL
(a final decision by the WP3 Board is expected in a week)
Interest by different groups working in future colliders: Cerenkov ECAL, RADiCAL...

Work Package 1: Sampling calorimeters with fully embedded electronics

Task/Subtask	Sensitive Material/ Absorber	DRDTs	Target Application	Current Status
Task 1 1: Highly pixelised electromagnetic section				
Subtask 1.1.1: SiW-ECAL	Silicon/ Tungsten	6.2	e e collider central detector	Prototype for finalising R&D for LC, Specification for CC and of timing for PFA needed
Subtask 1.1.2: Highly compact calo	Solid state (Si or GaAs)/ Tungsten	6.2	e e collider forward part	Prototypes with non-optimised sensors, Sensor optimisation and data transfer studies ongoing
Subtask 1.1.3: DECAL	CMOS MAPS/ Tungsten	6.2, 6.3	e e collider central detector. Future hadron collider	Prototypes with non-optimised sensors, Sensor optimisation ongoing
Subtask 1.1.4: Sc-Ecal	Scintillating plastic strips/ Tungsten	6.2	e e collider central detector	Prototype for finalising R&D for LC, Specification for CC and of timing for PFA needed
Task 1 2: Hadronic section with optical tiles				
Subtask 1.2.1: AHCAL	Scintillating plastic tiles/ Steel	6.2	e e collider central detector	Prototype for finalising R&D for LC, Specification for CC and of timing for PFA needed
Subtask 1.2.2: ScintGlassHCAL	Heavy glass tiles/ Steel	6.2	e e collider central detector	Material studies and specifications for prototypes
Task 1 3: Hadronic section with gaseous readout				
Subtask 1.3.1: T-SDHCAL	Resistive Plate Chambers/ Steel	6.2	e e collider central detector	Prototype for finalising R&D for LC, Specification for CC and of timing for PFA needed
Subtask 1.3.2: MPGD-HCAL	Multipattern Gas Detectors/ Steel	6.2, 6.3	collider central detector	Small prototype for proof-of-principle, Lateral and longitudinal extension envisaged
Subtask 1.3.3: ADRIANO3	Resistive Plate Chambers +Scintillating plastic tiles/ Heavy Glass	6.1, 6.2, 6.3	e e collider central detector BSM searches in MeV-GeV range	RPC, Scintillating Tiles advanced status, R&D on heavy glass needed

Table 1: Table summarising the projects in Work Package 1, their grouping into tasks and their status and plans.

Work Package 2:Liquid Nobel Gas Calorimeters

Project	DRDTs	Milestone	Deliverable	Description	Due date
Noble-Liquid Calorimeter	6.1, 6.2, 6.3	M2.1	D2.1	Design review of test module sign-o	2025
				Test module assembled	> 2026
		M2.2		Test module ready for cool down	> 2026

Table 3: Deliverables and milestones in Work Package 2.

Work Package 3: Optical calorimeters

Project	Scintillator WLS	Photodetector	DRDTs	Target
Task 3.1: Homogeneous and quasi-homogeneous EM calorimeters				
HGCCAL	BGO, LYSO	SiPMs	6.1, 6.2	e e
MAXICC	PWO, BGO, BSO	SiPMs	6.1, 6.2	e e
Crilin	PbF_2, PWO-UF	SiPMs	6.2, 6.3	
Task 3.2: Innovative Sampling EM calorimeters				
GRAiNITA	$ZnWO_4$, PCO	SiPMs	6.1, 6.2	e e
SpaCal	GAGG, organic	MCP-PMTs,SiPMs	6.1, 6.3	e e /hh
RADiCAL	LYSO, LuAG	SiPMs	6.1, 6.2, 6.3	e e /hh
Task 3.3: EM+)Hadronic sampling calorimeters				
DRCal	PMMA, plastic	SiPMs, MCP	6.2	e e
TileCal	PEN, PET	SiPMs	6.2, 6.3	e e /hh
Task 3.4: Materials				
ScintCal	-	-	6.1, 6.2, 6.3	e e / /hh
CryoDBD Cal	TeO, ZnSe, LiMoO NaMoO, ZnMoO	n.a.	-	DBD experiments

Table 4: Overview of R&D activities on optical calorimeter concepts.

2025 OREO activities, requests and FTE

- **2025 – additional year**
  - Full characterization of OREO with the PS&SPS beam @CERN (not possible in the 2024 week assigned)
    - Test with secondary mixed beams
    - possibly test of transverse development of the shower – also with different crystal size (FROM HIKE SAC R&D) and configuration
  - Final MC package in Geant4
- FTE INFN-MIB 2025
  - **Michela Prest (RL) 50% (come 2024)**
  - Alessia Selmi 100% (come 2024)
  - Giosuè Saibene 20% (nuovo)
  - Erik Vallazza 35% (come 2024)
- Solo richieste di missioni: 2 mesi-uomo al CERN