Subtask 3.1.4
DRD6: Calorimetry collaboration hosted by CERN

Progress and Perspectives of the ORiEnted calOrimeter (OREO) R&D project

XXII Seminar on Software for Nuclear, Subnuclear and Applied Physics

Alghero, Italy, 12 June 2025

Pierluigi Fedeli Ph.D.
INFN & University of Ferrara
pierluigi.fedeli@fe.infn.it

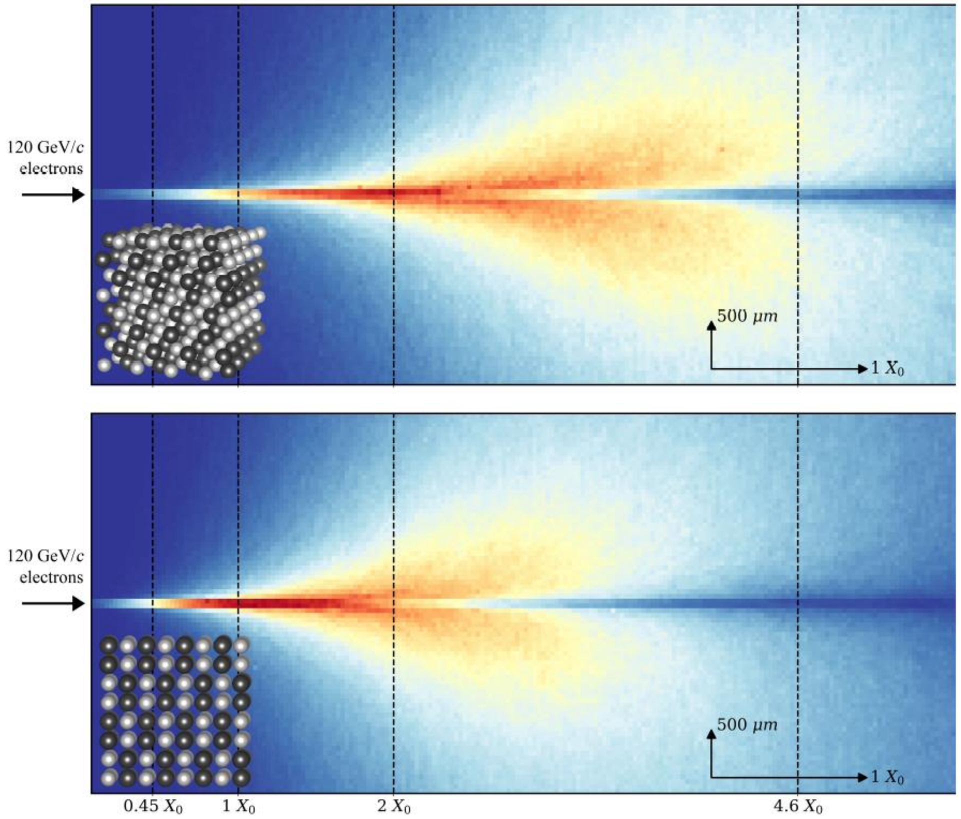
Electromagnetic interactions in oriented crystals

- Scintillator crystals widely used for ECAL, but **lattice effects** are usually neglected.
- A HE e/γ impinging along the crystal axis experiences a **Lorentz-contracted electric field** in its rest frame:

  E=γE (E ≈ 10^{11} V/cm is the Axial field for PWO)*

  At high-energy, E* can reach the **Strong Field (SF) Limit**

  $E* \geq E_0 \simeq 1.3 \times 10^{16}\, V/cm\ (\Theta_0 = U_0/mc^2)$.
- Above this limit, the **shower** development is accelerated, being much **more compact**.



L. Bandiera et al., Phys. Rev. Lett. 121 (2018) 021603

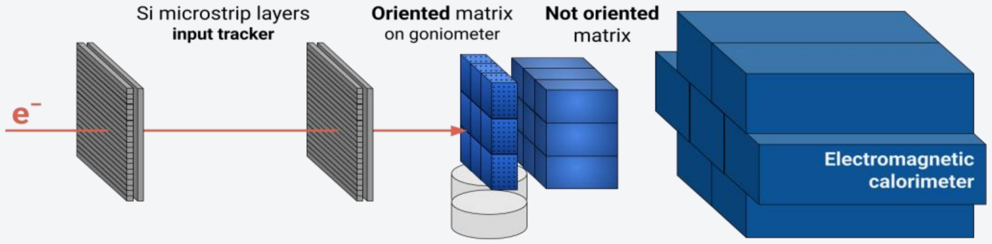
M. Soldani et al., arXiv:2404.12016v1

The ORiEnted calOrimeter project

- OREO is made by one oriented layer of ~5 X_0 and one non-oriented of ~11 X_0. Each layer consits in a 3X3 matrix of PWO crystals (CRYTUR Type-UF)
- **PWO SF threshold @20 GeV** (Θ_0~1 mrad).
- The crystals are coated with a reflective paint and glued together with a misalignment <0.2 mrad.
- Readout: SiPM matrix, each coupled to one of the crystals.

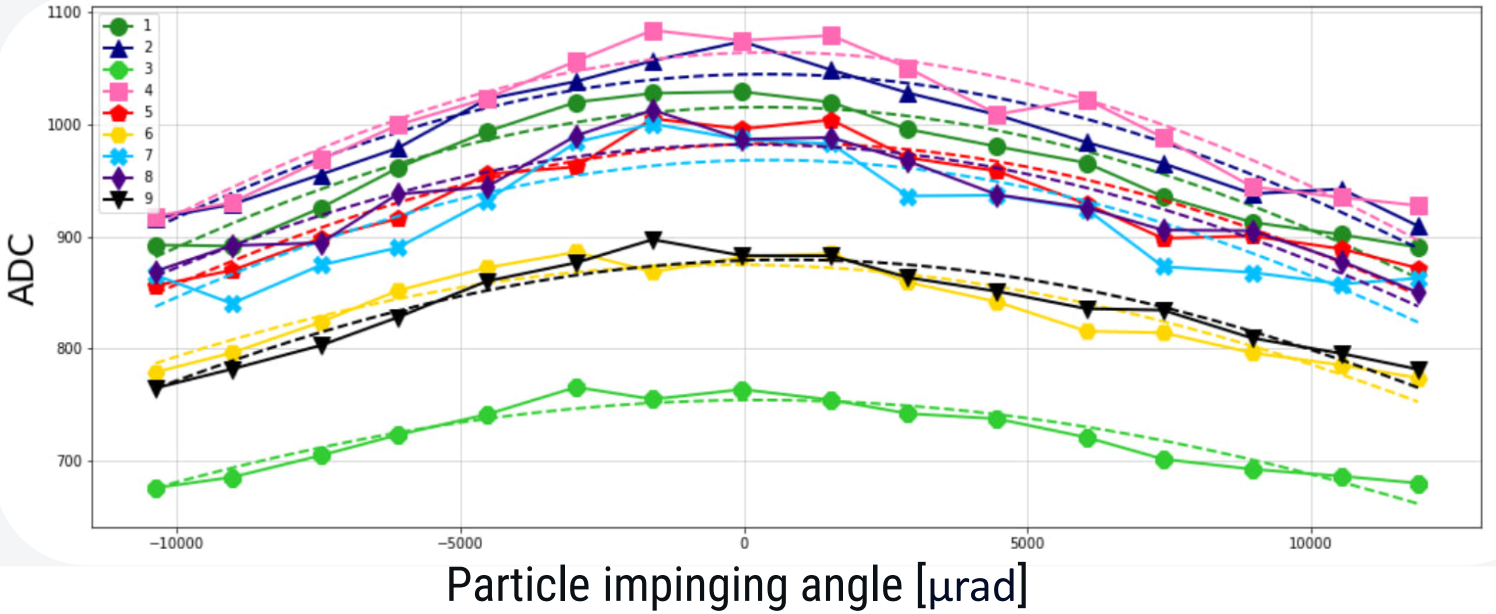
OREO test beam @CERN

Tests @CERN PS&SPS with 1-150 GeV e-



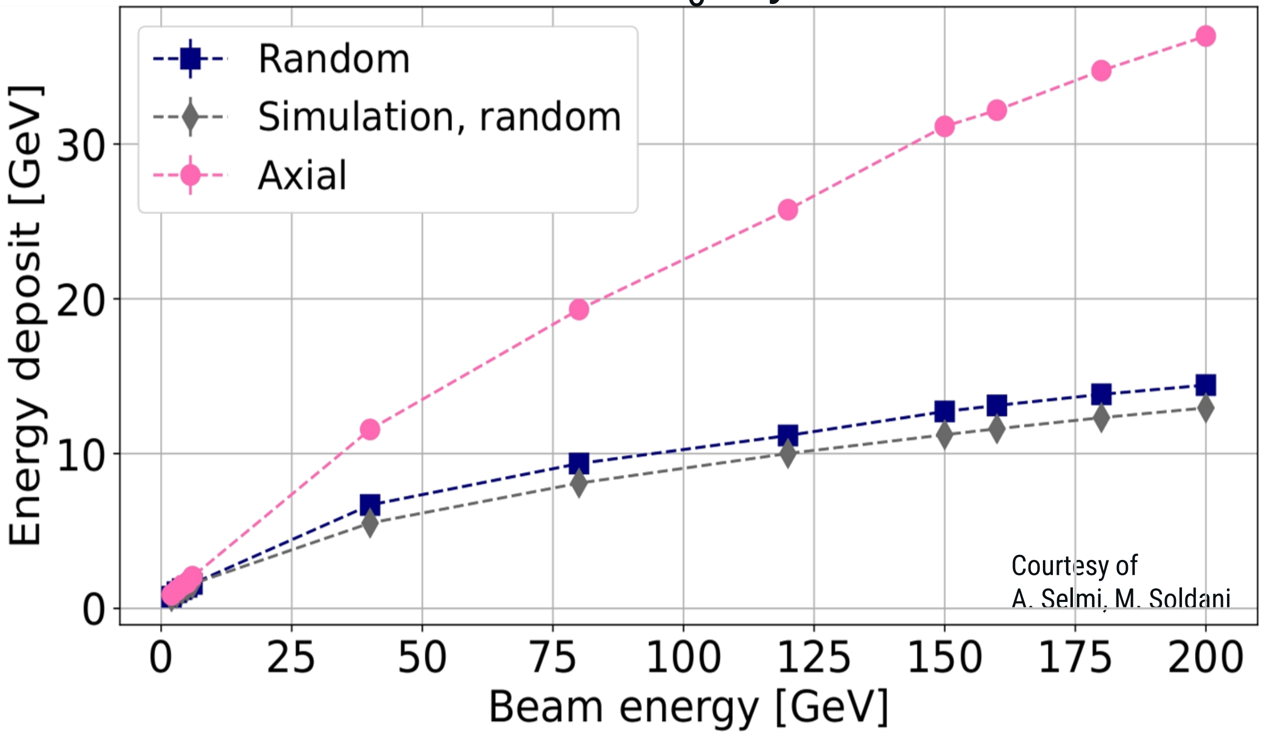
Success: all the crystals aligned!

We measured energy deposited enhancements for impinging angles **>1deg**

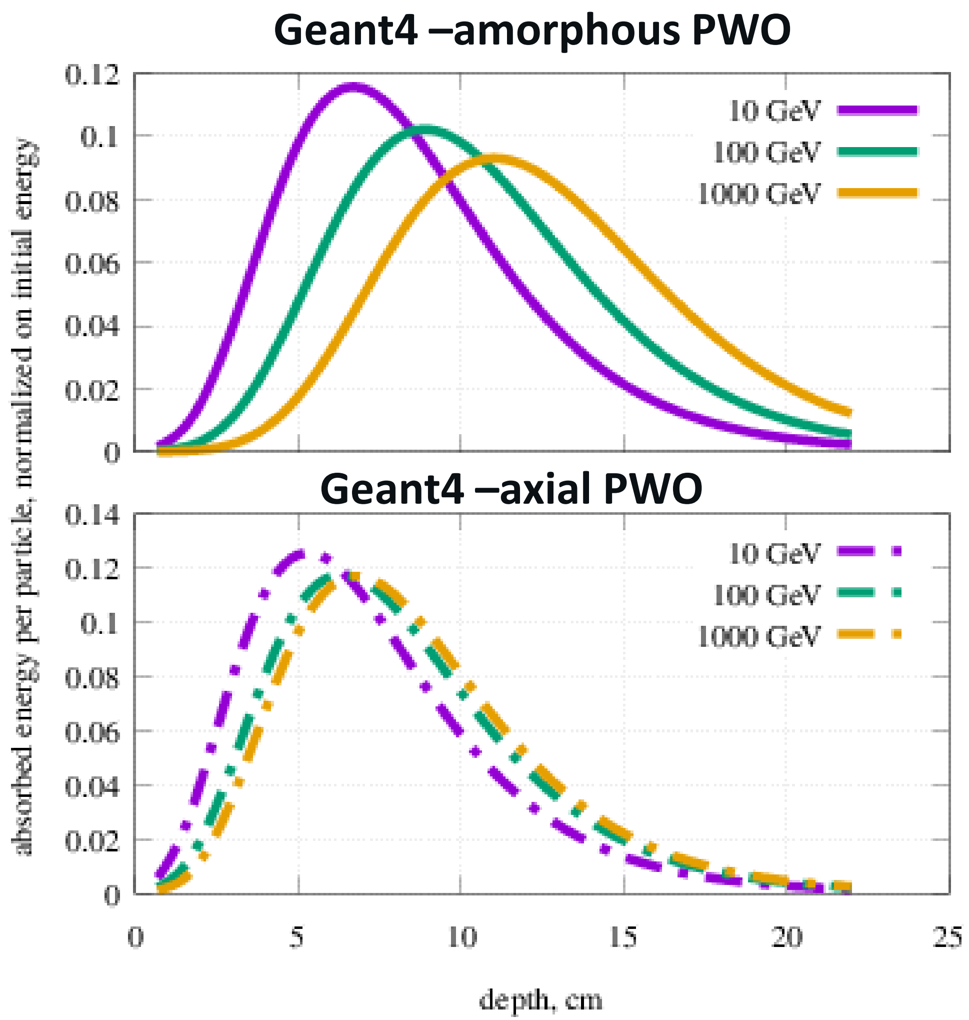


Test beam results with e- and G4 simulations

OREO $5X_0$ layer



Future test:
this summer 2 week at SPS H4
to align both the 2 layers



L. Bandiera et al.,Front. Phys. 2023 11:1254020

OREO's Applications

Oreo's Strength:

- Improved shower containment ⇒ energy resolution
- High γ-detection efficiency ⇒ ideal for γ vetoes
- High γ/hadrons discrimination

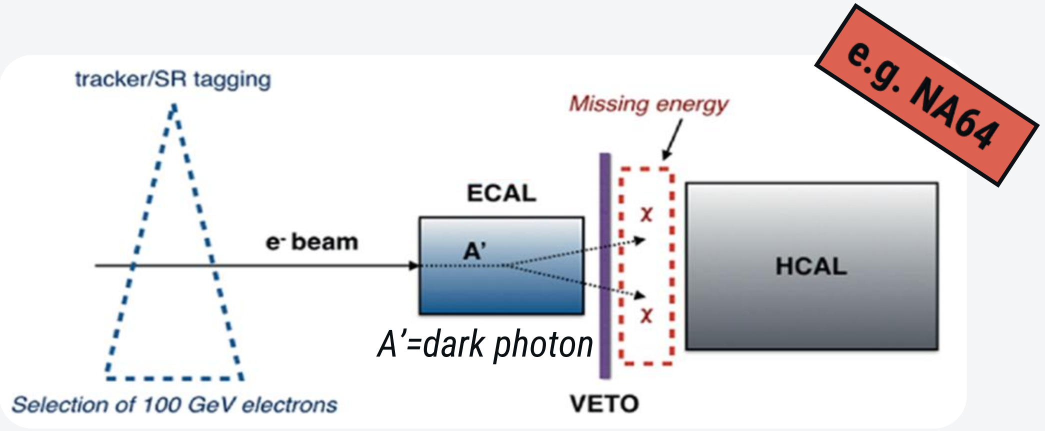
Fixed Target & Beam dump / Collider Forward region

- Compact em calorimeter in forward geometry

Space-borne γ-ray (VHE/UHE) detectors with pointing systems

- reduced thickness ⇒ more payload available for transverse size increase ⇒ acceptance

Example: Light Dark Matter search
A FIP produced in the calorimeter can only be detected if it survives for the overall length before decaying visibly: **the shorter the length, the higher the sensitivity.**



Credits to:
L. Marsicano and A. Celentano INFN Genova
Acknowledgment of initial discussions with M. Raggi.

Aknowledgment

Subtask 3.1.4
DRD6
Calorimetry

L. Bandiera (PI), N.Canale, P.Fedeli, A.Gianoli ,V.Guidi, L. Malagutti, A. Mazzolari, R.Negrello, G.Paternò, M.Romagnoni and A. Sytov (INFN Ferrara and University of Ferrara)
D. De Salvador, F. Sgarbossa and D. Valzani (INFN Legnaro National Laboratories and Univeristy of Padova)
S.Carsi, G.Lezzani, M.Prest, A.Selmi, E.Vallazza (INFN Milano Bicocca and University of Insubria)
M. Moulson, M. Soldani, L. Montalto (INFN LNF)
S. Cutini (INFN Perugia)
P.Monti-Guarnieri, F. Longo (INFN Trieste)

Special thanks to external collaborators:
V. G. Baryshevsky, M. Korjik, A. S. Lobko,
V. V. Tikhomirov, V. Haurylavets