HiDRa: a calorimeter prototype for future particle accelerators

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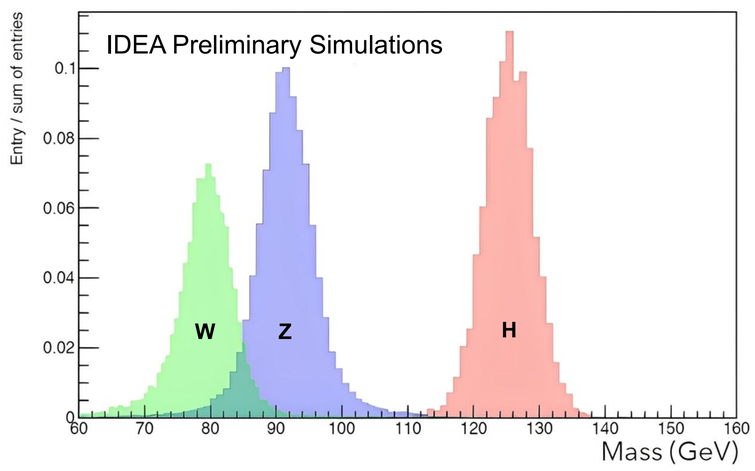
On behalf of the HiDRa and RD_FCC collaborations

Introduction

Calorimeters play a crucial role in high-energy physics by **measuring particle energy**.

Future lepton colliders, like **FCC-ee**, aim at probing fundamental physics with unprecedented precision. This requires excellent energy resolution, in particular for jets reconstruction.

The **IDEA** detector, proposed for FCC-ee, addresses this need with a **dual-readout calorimeter**, measuring scintillation and Cherenkov light to correct for electromagnetic fraction-fluctuations in hadronic showers. The goal of modern calorimetry is to achieve an energy resolution of $\mathbf{30\%/\sqrt{E}}$ to separate W, Z, and Higgs bosons in their decays to jet pairs. We are constructing a prototype, **HiDRa,** as a demonstrator of the achievable performance with fibre-sampling dual-readout calorimetry.



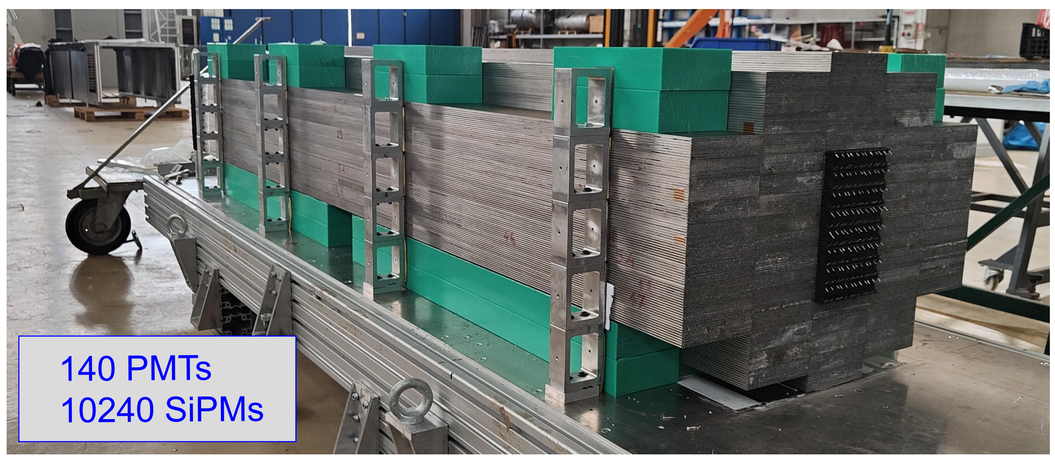
HiDRa construction process

The HiDRa prototype was assembled in Pavia INFN laboratories and is composed of:

- **80 modules**: 70 read out by Photomultipliers (PMTs), in the peripheral zone, and 10 by Silicon Photomultipliers (SiPMs), in the central region (**high granularity**).

Each module is made of:

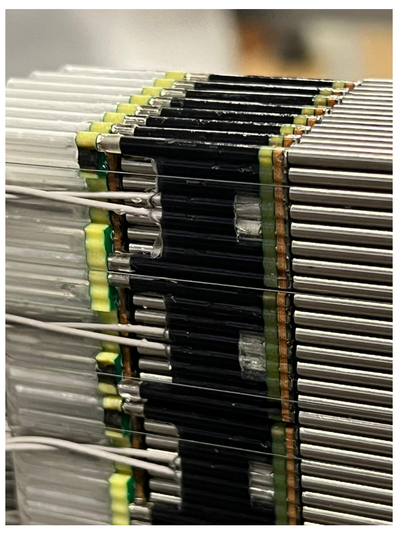
- 16×64 (**1024**) **stainless steel tubes** (1 mm internal diameter) alternating rows of scintillating and Cherenkov fibres. The overall dimension is **60×60×250** $\boldsymbol{cm^3}$.

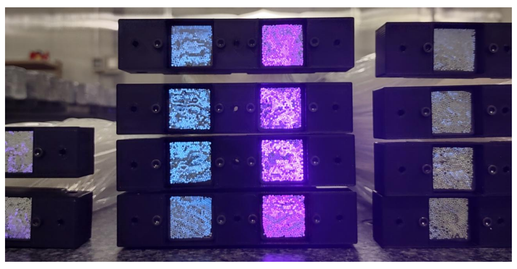


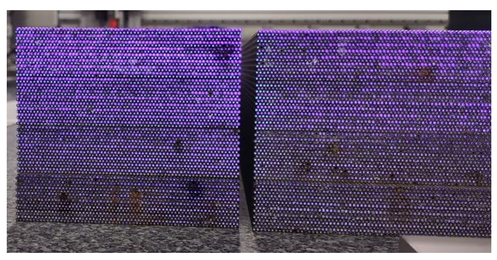
Assembly procedure main steps:

- High quality tube selection and gluing
- Critical fibre insertion process
- PMTs and SiPMs integration.

The developed integration and readout system sets an **international** benchmark in the field

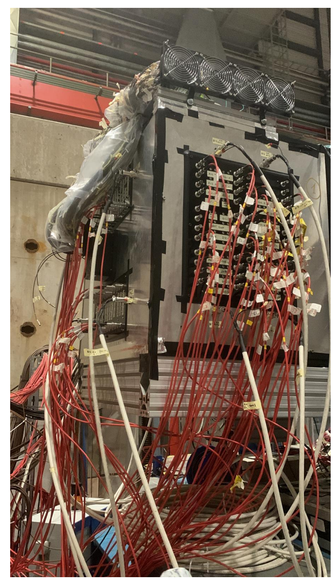






HiDRa test beam campaign

September 2025 campaign at CERN SPS: **70 modules** tested with electrons, pions and muons of different energies. The analysis has just started.

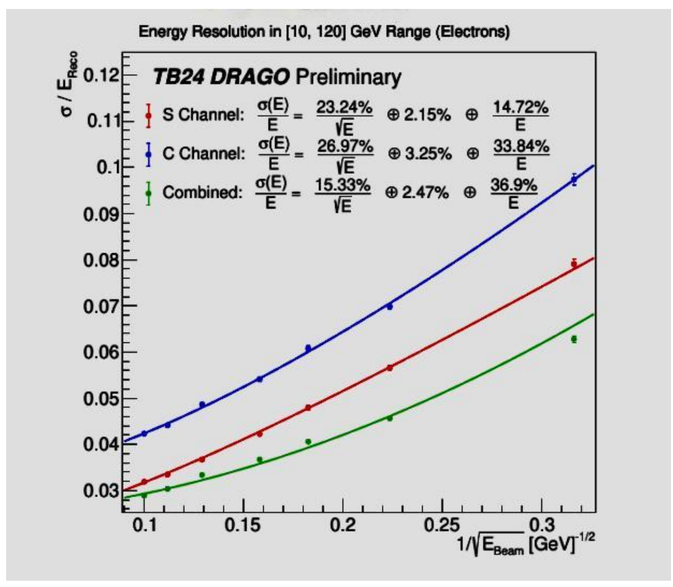


June 2026 campaign: complete integration with **80 modules.**

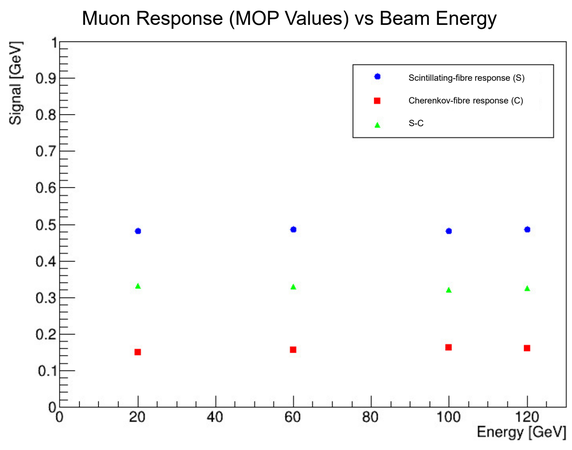
Data analysis

Data collected in test beam campaigns need to be properly analysed with a high focus on the:

- **Performance** of the calorimeter, to see if this matches the requirements of future colliders.
- **Detector response analysis**, to better understand the underlying physical processes.



*Electron-energy **resolution** estimation for the 2024 prototype.*

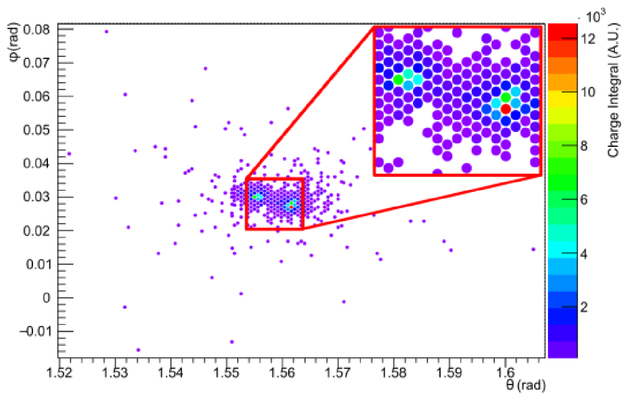


*Analysis of detector **response** to muons with the 2023 prototype.*

Strong focus on detector physics

Simulations

Detailed **simulations** of the entire IDEA detector and physics processes within it were performed.



40 GeV π^0 shower as sampled and reconstructed with the IDEA calorimeter Cherenkov fibres.

Many thesis possibilities

- Test beam and data analysis
- Simulations
- Physics studies at FCC-ee with simulated events

DISCOVER THE COLLABORATION