

# Performance Studies of the CRILIN Semi-Homogeneous Calorimeter with PbF<sub>2</sub> Crystals and SiPM Readout

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The CRILIN calorimeter is a semi-homogeneous system based on PbF<sub>2</sub> crystals and UV-extended SiPMs, designed for operation at the Muon Collider. Its high granularity enables efficient particle discrimination and jet substructure identification, which are crucial in the presence of intense beam-induced backgrounds. Simulations predict a photon flux with an average energy of 1.7 MeV and a fluence of 4.5 MHz/cm<sup>2</sup>. Precise time-of-arrival measurements, combined with good energy resolution, are essential to correctly associate hits to interaction vertices and to reconstruct jet kinematics.

Radiation hardness studies validate the operation of CRILIN up to a total ionizing dose of 10 kGy/year and a neutron fluence of 10<sup>14</sup> cm<sup>-2</sup>/year. In 2023, using the Proto-1 detector (two layers of 3×3 crystals), we demonstrated a timing resolution better than 50 ps for energy deposits above 1 GeV. In a subsequent test beam campaign in September 2025 at the Beam Test Facility of the INFN Laboratori Nazionali di Frascati, different crystal wrapping and surface treatment techniques were evaluated to enhance light collection. In addition, beam monitor sensors were integrated to assess the spatial resolution and detection efficiency.

A new 7×7 prototype, composed of five layers of 1.3×1.3 cm<sup>2</sup> PbF<sub>2</sub> crystals, is currently under construction and is foreseen for testing in 2026. The detector is designed to contain electromagnetic showers with energies up to several hundreds of GeV. The 7×7 modules are housed in aluminum structures with internal septa 150 μm thick. Signal and bias routing is implemented through custom Kapton strips, while preserving a 2 mm thick external aluminum shell. Consistently with the semi-homogeneous CRILIN design, crystal matrices alternate with SiPM layers along the longitudinal direction.

Dedicated simulation studies of the 7×7 prototype have been performed to evaluate the energy resolution and linearity of the system under realistic operating conditions. Monte Carlo results predict an energy resolution characterized by a stochastic term of about 5%/√ $E$  [GeV].

Experimental results from the characterization of the crystals and SiPMs, along with the outcomes of previous test beam campaigns, and an update on the construction status of the 7×7 calorimeter, will be presented.

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