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Test beam results with a sampling calorimeter of cerium fluoride scintillating crystals and tungsten absorber plates for calorimetry at the HL-LHC

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A sampling calorimeter using cerium fluoride scintillating crystals as active material, interleaved with absorber plates made of tungsten,and read out by wavelength-shifting fibers has been studied as a calorimeter option for detectors at the upgraded LHC collider at CERN. A prototype has been exposed to high-energy electron beams at the CERN SPS H4 beam line, as well as to lower-energy beams at the INFN Frascati Beam Test Facility in Italy. Results from the studies performed on the prototype will be presented, with energy resolution as the main focus.

Collaboration

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Summary

Experiments are considering upgrades to their detectors for running at the future High-Luminosity LHC collider at CERN (HL-LHC) after 2022, because of the stringent requirements imposed by the high rates of ionising radiation. One of the options considered for an electromagnetic calorimeter is a design using cerium fluoride scintillating crystals as active material, interleaved with heavy absorber plates, and read out by wavelength-shifting (WLS) fibers. Experiments are considering upgrades to their detectors for running at the future High-Luminosity LHC collider at CERN (HL-LHC) after 2022, because of the stringent requirements imposed by the high rates of ionising radiation.

One of the options considered for an electromagnetic calorimeter is a design using cerium fluoride scintillating crystals as active material, interleaved with heavy absorber plates, and read out by WLS fibers.

The presentation will summarize the results of two different beam tests: data from electrons of energies up to 500 MeV were collected at the INFN Frascati laboratories' Beam Test Facility (BTF), whereas higher-energy electrons were produced in the SPS accelerator complex at CERN. The results will focus on energy resolution studies.

The scintillator and absorber dimensions have been optimised for this test, to give an adequate granularity and sampling fraction, while minimising the amount of scintillator needed. In this study a single channel is used, comprising 10 (15) samplings for a total of 17 (25) X_0, respectively for the BTF (SPS) data-taking.

Its transverse cross section is 24x24 mm^2. The active samples are 10 mm thick, while each absorber layer thickness is 3.1 mm.
While R&D is being performed by several material science and high-energy physics groups worldwide to develop radiation resistant WLS fibers suitable for use at the HL-LHC, conventional 3HF, single-clad plastic fibers from Kuraray have been implemented as WLS for this test, since it has been demonstrated that they are photo-luminescent in the range of wavelengths of the cerium fluoride scintillation emission. The light from each WLS fiber is read out individually by a Hamamatsu R1450 photomultiplier.
The electron energy resolution of the single calorimeter tower was studied as a function of the beam energy and proven to be in very good agreement with Montecarlo expectations. The stochastic term of the energy resolution that can be obtained from this geometry is about 10%/sqrt(E).
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