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Experimental measurement of strong enhancement of bremsstrahlung radiation by 120 GeV/c electrons in an oriented PWO crystal

Since their invention, scintillator materials found many applications in physics. Several e.m. calorimeters in HEP, e.g. in CMS, Fermi and Gamma-400, use crystal scintillators with high-Z elements as CsI and PWO.

The impact of crystal orientation of scintillators is usually poorly considered, whereas in fact the influence of the crystalline structure on radiation and pair production in more usual crystals, such as Si and Ge, has been known since decades. Indeed, due to the interaction with the strong crystalline field for small particle incidence angles with respect to crystal planes/axes, the radiation emitted by high-energy $e^{\pm}$ and pair production by photons may strongly increase as compared to an amorphous medium. Together these two processes substantially reduce the effective radiation length of the crystal, thus modifying the shower development.

We report the experimental measurement of 120 GeV/c electron radiation enhancement in a 4 mm thick (0.45 X_0) PWO crystal, carried on at the SPS-H4 line. The experimental results are in good agreement with simulations based on the Baier-Katkov method, which were recently validated in an experiment using a Si target [1]. We measured the transition from a nearly single-photon emission, where the crystal axis was not oriented with the beam direction, to a continuous e.m. shower development for alignment with <001> PWO axis. We also analyzed the e^- energy loss distribution under axial orientation, which peaks at more than 100 GeV, demonstrating a several-fold reduction of the effective radiation length.

The observed effect can be exploited to reduce the shower dimension and leakage in HEP calorimeters based on crystals, for instance to measure the TeV-energy cosmic rays or to decrease the calorimeter dimension and provide high angular resolution in gamma-telescopes [2].

[1] L. Bandiera et al, PRL. 111 (2013) 255502

[2] V.G. Baryshevsky et al, NIMB in press http://doi.org/10.1016/j.nimb.2017.02.066

Experimental Collaboration

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