Study of Light Transport inside Crystal Fibres

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Long optical attenuation length in scintillating fibre calorimeters is essential for uniform light collection, ensuring a homogeneous detector response and accurate energy measurement. The attenuation length depends on several parameters, including intrinsic material absorption, internal defects and surface states of the fibre.

To investigate the impact of these effects, a dedicated optical bench was developed. The setup consists of an LED exciting the fibre at multiple positions along its length, while the light emerging from both fibre ends is detected by spectrometers. This configuration enables wavelength-resolved measurements of the luminescence light. A dedicated Monte Carlo simulation framework was developed to complement the experimental setup. Additionally, an analytical model was developed for crystal fibres with ideal surface states, successfully reproducing the experimental measurements.

This contribution will present studies performed on cerium-doped aluminum garnet crystal fibres from different producers, with varying chemical composition, lengths and surface states. A subset of the samples were irradiated at CERN IRRAD proton facility, up to several hundreds of kGy, to investigate the impact of radiation damage. The analytical model derived in this study is in excellent agreement with the simulations and the measurements, and hence provides a powerful tool to study and optimize the scintillating fibre calorimeters.

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