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RADiCAL - Radiation-hard Innovative EM Calorimetry

To address the challenges of providing high performance EM Calorimetry in future experiments under high luminosity and difficult radiation and pileup conditions, R&D is being conducted on promising optical-based technologies that can inform the design of future detectors, with emphasis on ultra-compactness, excellent energy resolution and spatial resolution, and especially fast timing capability.

The strategy builds upon the following concepts: use of dense materials to minimize the cross sections and lengths (depths) of detector elements; maintaining Molière Radii of the structures as small as possible; use of optical techniques that can provide high efficiency and fast response while keeping optical paths as short as possible; and use of radiation resistant, high efficiency photosensors.

High material density is achieved by using thin layers of tungsten absorber interleaved with active layers of dense, highly efficient crystal or ceramic scintillator. Scintillator approaches under investigation include rare-earth 3+ activated materials Ce3+ and Pr3+ for brightness and Ca co-doping for improved (faster) fluorescence decay time.

Light collection and transfer from the scintillation layers to photosensors is enabled by the development and refinement of new waveshifters (WLS) and their incorporation into radiation hard quartz waveguide elements. WLS developments include the fast organic dyes of the DSB1 type, ESIPT (excited state intermolecular proton transfer) dyes having very low optical self-absorption, and inorganic materials such as LuAG:Ce, having high radiation resistance.

Optical waveguide approaches include thick-wall quartz capillaries containing WLS cores for: (1) energy measurement; (2) with WLS materials strategically placed at the location of the EM shower maximum to provide timing of EM showers, and (3) with WLS shifter elements placed at various depth locations to provide depth segmentation and angular measurement of EM shower development.

Light from the wave shifters is detected by pixelated, Geiger-mode photosensors.
These include small pixel (5-7 micron) silicon photomultiplier devices (SiPM) operated at low gain and cooled (typically -35℃ or below), and potentially via large band-gap devices such as GaInP.

Underway or in planning are bench, beam and radiation tests of individual components and modular elements. Recent results and program plans will be presented.

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