

Novel Inorganic Scintillators for Future High Energy Physics Experiments

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Total absorption electromagnetic calorimeters (ECAL) made of inorganic crystals provide the best energy resolution and detection efficiency for photons and electrons, so are the choice for those HEP experiments requiring the ultimate energy resolution. Novel crystal detectors are being discovered in academic research and in industry, providing an important opportunity for future HEP detectors. Following the priority research directions documented in the DOE basic research needs for HEP instrumentation [1], the Caltech HEP crystal lab has been actively investigating novel inorganic scintillators along the following three directions: 1) fast and radiation hard inorganic scintillators to face the challenge of severe radiation environment expected by HEP experiments at future hadron colliders, such as the HL-LHC and FCC-hh, where radiation damage is induced by ionization dose, protons and neutrons; 2) ultrafast inorganic scintillators to face the challenge of unprecedented event rate expected by future HEP experiments searching for rare decays, such as Mu2e-II, and ultrafast time of flight (TOF) system at future hadron colliders, and 3) cost-effective inorganic scintillators for the homogeneous hadron calorimeter (HHCAL) concept to face the challenge of both electromagnetic and jet mass resolutions required by the proposed Higgs factory. This report presents recent progress in all directions: LuAG:Ce fibers for RADiCAL [2], Lu₂O₃:Yb ceramics for ultrafast scintillator, Ce-doped aluminoborosilicate (ABS:Ce or GFO:Ce) and Ce-doped BaO•2SiO₂ glass (DSB:Ce or BGS:Ce) glass scintillators for the HHCAL and CalVision concepts [3], and up to 60 cm-long BGO crystals for the proposed CEPC total absorption ECAL [4]. The result of this investigation may also benefit nuclear physics experiments, GHz hard X-ray imaging, medical imaging and homeland security applications.

1. B. Fleming. (2020). Basic Research Needs for High Energy Physics Detector R&D. Online: https://science.osti.gov/-/media/hep/pdf/Reports/2020/DOE_Basic_Research_Needs_Study_on_High_Energy_Physics.pdf
2. T. Anderson *et al.*, “RADiCAL: Precision-timing, ultracompact, radiation-hard electromagnetic calorimetry,” 2022, arXiv:2203.12806.
3. CalVision Collaboration, <https://detectors.fnal.gov/projects/calvision/>
4. CEPC Study Group, “CEPC Technical Design Report -- Reference Detector,” 2025, arXiv:2510.05260.

Acknowledgements A. Wu, J. Li, L. Su, L.S. Pandian, Y. Wang, J. Glodo, S. Qian, V. Dormenev, R. Novotney, S.H. Wang and J.F. Chen provided samples in this paper. F. Yang, J.F. Chen, C. Hu and L.Y. Zhang measured these samples. This work was supported in part by the U.S. Department of Energy under Grant DE-SC0011925 and DE-SC0024094.