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ISMA –CERN collaboration in the field of oxide scintillators

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The collaboration between ISMA and CERN began in the early 1990s when ISMA (then part of the Institute for Single Crystals), played a pioneering role in the development of lead tungstate (PbWO4), a scintillator implemented in both in CMS and ALICE experiments at the Large Hadron Collider. Works by L. Nagornaya et al. demonstrated the feasibility of achieving an extremely fast scintillation response and growing highly uniform large PbWO4 crystals with high radiation tolerance [1].
Since over 30 years, the collaboration continued within the Crystal Clear collaboration and the SCINT community initialized in 1992 for the needs of new inorganic scintillators for future HEP experiments. More recently collaboration between CERN and ISMA on R&D on scintillators was reinforced by many European projects: With the INTELUM H2020 project (2015-2019, Grant Agreement n°644260), which focused on the fabrication technology of garnet scintillation fibers for high-granularity calorimeters. Ce-doped Y3Al5O12 (YAG:Ce) and Lu3Al5O12 (LuAG:Ce) fibers with 1-2 mm cross-section and lengths of up to 55 cm were produced using the micro-pulling-down method in collaboration with ILM. The luminescence attenuation length in LuAG:Ce fibers reached 1 m, meeting transparency requirements [2]. Meanwhile, although the micro-pulling-down technology could provide ready-to-use fiber-shaped crystals without post-growth mechanical treatment, the growth of bulk crystals and cutting them into fibers proved to be a more reliable approach for producing many thousands of fibers required for large-scale experiments at colliders.
Materials development for fast-timing applications has started with the COST Action (Fast, COST TD1401) and continues in the ongoing Horizon Europe TWISMA project (Grant Agreement n°101078960), involving ISMA, CERN, and ILM, and focusing on bulk crystals produced by the Czochralski method. It addresses rare earth garnets such as YAG:Ce and GAGG:Ce with accelerated luminescence rise/decay times and enhanced time resolution. These materials are considered as potential candidates for the upgrade phase of the inner part of the electromagnetic calorimeter of LHCb experiment [3]. For this purpose, very fast radiation hard scintillators are required to eliminate any pileup of signals at the frequency of particle collision of 25 ns. Various codoping schemes of garnet crystals are being verified to achieve a balance between cerium luminescence quenching, providing a decay faster than the Ce3+ intrinsic lifetime, and reasonable light yield. Another focus of TWISMA is crystals for dual-readout detectors for simultaneous and independent registration of scintillation and Cherenkov light at future colliders [4]. Bi4Si3O12 and Bi4(Ge1-xSix)3O12 have been proposed [5] as monolithic crystals capable of registering both scintillation light emitted in the visible band and providing a wide transparency window in the UV at >290 nm for Cherenkov light registration.

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[3] CERN-LHCC-2021-012 LHCb TDR 23, 24 February 2022, ISBN 978-92-9083-623-0.
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