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## Exploration of fast materials and light production mechanisms for high energy charged particles time detectors

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Precise timing evaluation is expected to play a crucial role in particle detectors at future collider experiments, as its knowledge can improve vertices reconstruction by mitigating the pile-up effects in the harsh radiation environment expected there. A single-detector time resolution of 20 - 30 ps  $\sigma$  was estimated to be needed for precise events reconstruction. In order to fulfil this requirement, previous studies have already demonstrated the possibility of exploiting fast scintillating materials as LSO:Ce,Ca, LYSO:Ce and aluminium garnet crystals (YAG:Ce, LuAG:Ce, GAGG:Ce) coupled to compact silicon photomultipliers (SiPMs) for the implementation of an ad-hoc precision timing device housed inside a larger particle detector.

The aim of this study was the investigation of the timing capabilities of many materials producing light through different processes as minimum ionizing particles (MIPs) detectors under 150 GeV charged pions produced along the H2 extraction line at the CERN SPS proton accelerator. The materials tested in this work included standard dense scintillators (e.g. LSO:Ce,Ca, LYSO:Ce, GAGG:Ce, BGO), materials which mainly exploit Cherenkov radiation (e.g. BGSO, PbWO<sub>4</sub>, PbF<sub>2</sub>), and cross-luminescent crystals (e.g. BaF<sub>2</sub>, BaF<sub>2</sub>:Y). Small pixel samples having 3 or 10 mm lengths and transverse sizes of 2 × 2 mm<sup>2</sup> or 3 × 3 mm<sup>2</sup> were glued to Hamamatsu SiPMs and their signals were read out using fast high-frequency electronics.

The best single-detector time resolution achieved was 12.1 ± 0.4 ps ( $\sigma$ ) for a 10 mm long LSO:Ce,Ca pixel when a time-walk correction is applied. Many other samples like LYSO:Ce, GFAG, highly doped GAGG:Ce,Mg and EJ232 achieved sub-20 ps time resolution. BaF<sub>2</sub> and BaF<sub>2</sub>:Y have also achieved an impressive time resolution of about 16 ps despite worse measurement conditions compared to other samples. Finally, timing capabilities with  $\sigma$  ranging from 24 and 36 ps were obtained for several materials whose timing properties are mainly related to Cherenkov emission.

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