Development of cesium lead halide nanocomposite scintillators for high energy physics

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Inorganic lead halide perovskite (LHP) nanocrystals with composition $CsPbX_3$ (X=Cl, Br, I) are widely studied as bright luminescent material with exciting properties for various light-emitting applications. In past years, their narrow spectrally tunable emission and also high atomic number have become of interest for radiation detection. Their ultrafast multiexcitonic emission is seen as perspective for enhancing the time-of-flight performance of medical imaging detectors.[1] Recently, LHP nanocrystals have also been proposed for application in emerging chromatic calorimetry concept.[2] This novel solution for high energy physics aims to exploit narrow and spectrally tunable emission of quatum dots to construct a segmented detector capable of identifying the longitudinal profile of electromagnetic shower.

In this contribution, we report advances in synthesis of nanocomposites based on cesium lead halide nanocrystals as prospective scintillating materials for these applications. We develop novel surface functionalization strategies to simultaneously enhance nanocrystal luminescence properties and improve nanocomposite transparency. Additionally, our surface treatment improves thermal stability of the ligand shell enabling us to perform nanocomposite synthesis with temperatures up to 110°C without compromising nanocrystal properties. Moreover, our approach can be used to tailor the nanocrystal compatibility to various polymers facilitating the search for matrix with the best radiation hardness.

Photoluminescence and radioluminescence properties of prepared nanocomposites are reported showing their fast timing potential and spectrally tunable emission. Lastly, initial experimental tests of prepared nanocomposites in view of the chromatic calorimetry concepts were carried out during experimental test beam campaign at CERN SPS facility in 2025 using electron beams with energies ranging from 20 to 100 GeV. The nanocomposite performance will be evaluated.

1. F. Pagano et al., “Nanocrystalline Lead Halide Perovskites to Boost Time-of-Flight Performance of Medical Imaging Detectors”. *Adv. Mater. Interfaces* 2024
2. Doser et al., “Quantum systems for enhanced high energy particle physics detectors”, *Front. Phys.*, **10**, 887738 (2022).

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