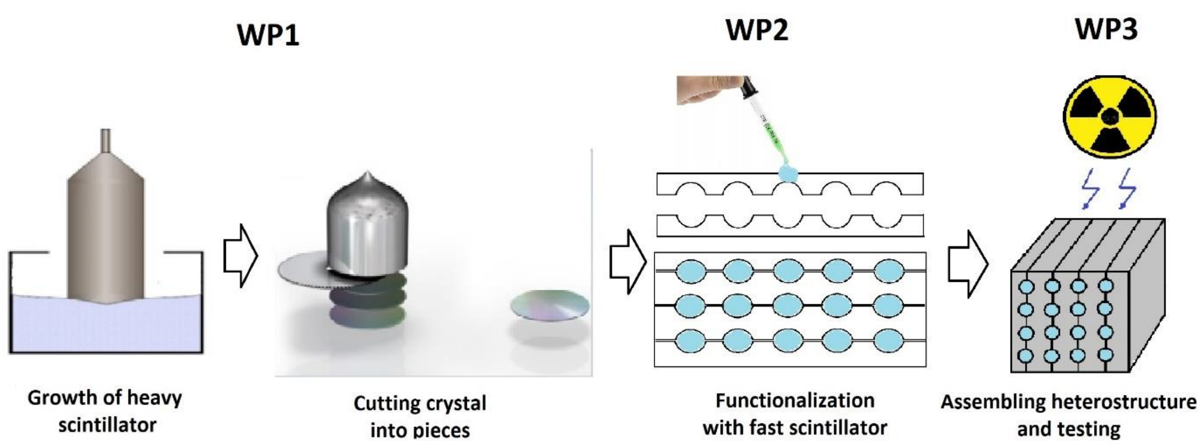
This project is dedicated to the development of ultrafast radiation detectors for medicine and high energy physics.

Positron emission tomography (PET) scanners are among the most efficient tools for the identification of tumors in the human body. However, the temporal resolution with PET is poor compared to other methods and is limited by both the technique and the metabolism of the tracer molecule. PET is based on the injection of radiopharmaceutical into patient's body, which accumulates in tumors and generates γ-quanta. The tumor location is determined by the time of flight of the γ-quanta to detectors located in opposite directions. If the timing resolution is too low, uncorrelated particles are also collected within each interval, creating false readings. In conventional PET scanners with a time resolution of ~500 ps, the imprecision in the localization of the event is ~7.5 mm. To increase PET sensitivity, more precise timing information of the detected γ-quanta is needed, enabling a more detailed picture of the disease site by enhancing the signal to noise ratio of the image. According to the estimations, a time resolution of ~10 ps is necessary to provide a spatial resolution of 1-2 mm. Moreover, there is an increasing demand for reducing the radioactive doses injected into the patients without impairing image quality. Fast timing is therefore vitally important for medical imaging.

A similar problem is faced in high energy physics experiments at colliders. The further research program at the Large Hadron Collider in CERN requires a significant increase both in the accelerator luminosity, and the frequency of particle collision that requires dedicated detectors. High-speed scintillation detectors are necessary to avoid pile-up and incorrect association of tracks with vertices.

There is no scintillator that meets the requirements to such detectors, as any known materials possess too low light yield, and/or too slow timing of a scintillation response. The idea is to combine in a heterostructure a heavy scintillator, which efficiently absorbs γ-quanta, with a light and fast scintillator, which converts recoil electrons from the heavy scintillator to fast light photons.

The project should clarify the relationships between the compositions of heavy (BGO/BGSO) and fast ($CsPbX_3$ (X=Br, Cl, I) and ZnO:Ga) scintillators and their design in a heterostructure, and scintillation performance of heterostructures. The work involves the growth of crystals of heavy scintillators, their cutting, and microsized patterning of their surface for functionalization with a fast scintillator and testing in CERN.



This project will constitute a step towards the development and engineering of heterostructure detector performance, establishing TOF-PET imaging as a less invasive, more precise diagnostic technology, and contribute to the development of detectors for high energy physics experiments at colliders.