PetVision Newsletter; 6th edition
December 2025

Welcome to the 6th edition of the PetVision Newsletter!

We are pleased to bring you the December 2025 edition of the PetVision Newsletter, highlighting recent developments, partner insights, and research contributions within the project. In this issue, we introduce two of our project partners- I3M and the Yale Biomedical Imaging Institute- whose expertise plays an important role in advancing the PetVision vision of highly sensitive, accessible PET imaging.

We also shine a spotlight on the work of two master's students from the University of Ljubljana, whose thesis projects provided valuable insights into scintillator crystal characterization and detector geometry simulations. Their efforts support PetVision's continued progress toward enabling a new generation of flexible, modular, and affordable PET scanners.

We thank you for following our journey and invite you to explore the updates in this edition as we continue working together toward future breakthroughs in PET technology.

About the project

Over 2.7 million people in the EU were diagnosed with cancer in 2020, while 1.3 million people lost their lives to it. Cancer cases are predicted to increase by 24% by 2035, making it the leading cause of death in the EU. The current leading imaging diagnostic technique sensitive to cancer is Positron Emission Tomography (PET). Due to the high implementation cost of PET, this highly sensitive diagnostics is only available in less than 0,5 % of the medical centers in the world. One of the main components of the overall cost is the cost of PET scanners. The main objective of PetVision EIC Pathfinder project is to develop a flexible, modular PET scanner, based on planar detector panels with exquisite time-of-flight (TOF) resolution and sensitivity. It will enable affordable, fast and precise dynamic scanning, and hence improve access to early cancer detection and therapy follow-up, paving the way for personalized medicine.

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Presentation of selected project partners

Institute of Instrumentation for Molecular Imaging (I3M): Our main area of research is the development of instrumentation for Medical Imaging, in particular for Molecular Imaging (PET). That it is why PetVision fits perfectly with our interests and area of expertise.

We decided to take part in PetVision because we believe the developments that will take place is that project might represent the next generation of detectors for Molecular Imaging scanners. Our main role in the project is to develop the readout electronics and Data Acquisition System of the PET detectors and small scanner.

The Yale Biomedical Imaging Institute is dedicated to the development of novel imaging tools, and their translation to clinical practice. It focuses on the use of nuclear imaging (SPECT, PET), magnetic resonance imaging (MRI) and other imaging modalities to understand physiological processes linked with health and disease. The mission of the Institute includes developing high-resolution, high-sensitivity PET scanners to help answer new scientific questions in neurology, cardiology, cancer imaging, etc. The core mission of the Institute is also to help disseminate these imaging tools, and develop affordable systems that can be deployed in many imaging centers and institutions. To that end, developing affordable PET scanners, that do not compromise in sensitivity and resolution is a unique opportunity to democratize access to PET imaging and collaborate on an impactful project.

The Institute's expertise in the physics of image formation, instrumentation, image reconstruction and clinical evaluation synergistically align with the goals of the PetVision project. The main role in the project is to contribute to the design decisions from a clinical perspective, to assist in the simulation and optimization of the system, and to develop an image reconstruction platform to process the data collected from the PET scanner.

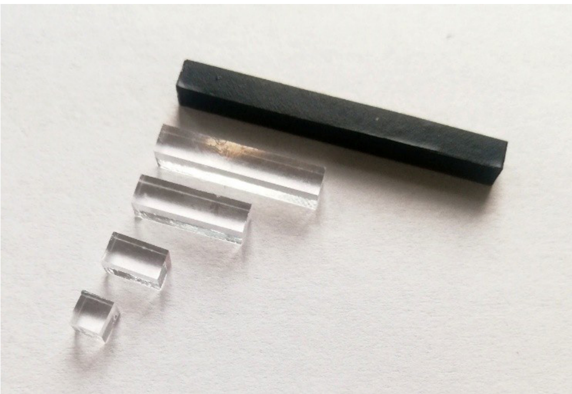
Besides imaging systems, we are developing novel imaging biomarkers (e.g., PET tracers targeting synaptic density) to understand a variety of neurodegenerative diseases and conditions such as Alzheimer's disease, Parkinson's disease and others. Outside of the brain, we are also developing methods to quantify cardiac function and response to cardiotoxicity. Additionally, we are developing theranostics strategies to combine cancer therapy and imaging in order to personalize and optimize treatment planning.

Master's Students Aleks Skok and Dominik Vitas add Valuable Insights to Scintillator Studies and Detector Development

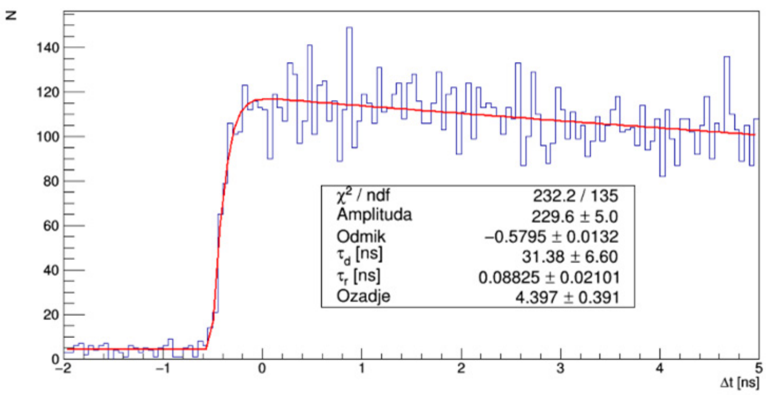
The PetVision project is developing an advanced modular time-of-flight PET imager, enhancing current PET/CT technology based on excellent time resolution of the PET detectors. This can only be achieved by innovations in photodetectors, readout electronics, and their optimized integration in a photodetector module. While the photodetector and readout electronics development and integration are a central part of the PetVision project, another detector component playing a crucial role in the final performance are the scintillation crystals that convert the radiation emitted from the patient into visible light. To identify the crystals which will enable the best possible performance of the PetVision detectors, experimental characterization of commercially available scintillation crystals was performed. Another open question was the exact dimensions of the crystals that will achieve optimal utilization of the produced scintillation photons with the specific geometry of the photodetectors developed by the PetVision project.

These questions are just two examples of specific challenges faced within a technically and scientifically complex project like PetVision. The scope and timelines of these two challenges were perfect to be studied as topics for master theses. Two students from the Physics programme at the Faculty of Mathematics and Physics, University of Ljubljana chose to tackle these challenges. **Aleks Skok** performed the experimental work necessary to characterize the scintillation properties of five different scintillator crystals available at the time, and presented the results in a master's thesis titled "Characterization of scintillation crystals for advanced detectors in positron tomography". **Dominik Vitas** studied the effects of detector geometries by means of precise physical simulations of propagation of optical photons within the scintillator crystals and their detection by the photodetector, and culminated his work with a master's thesis titled "Use of depth of interaction measurement in flat panel positron emission tomography".

As part of his master's thesis work, Aleks Skok developed an experimental system capable of measuring the properties of scintillation crystals which affect the performance of PET scanners, particularly the properties of temporal evolution of the pulse of scintillation light, emitted after absorption of annihilation gamma ray. The light starts being emitted almost, but not exactly, instantaneously and the short time before the start of light emission is characterized by a rise time constant. After that, in the solid-state scintillators used in PET, the emission of light subsides in a couple of tens of billionths of a second, characterized by a decay time constant. To measure these properties of the scintillator, a time correlated single photon counting (TCSPC) was used. This method is based on two very fast photodetectors sensing the light emitted from the scintillator in two different ways. The first photodetector, called the start detector, is directly coupled to the crystal and therefore exposed to the full pulse of the scintillation light, capable of marking the start of the scintillation process. The second photodetector, called the stop detector, is positioned further away, so that on average only one of the scintillation photons produced reaches it. By analyzing the differences in detection times from these two detectors exact shape of the temporal evolution of the photon production is obtained. To be able to measure the extremely short rise time constant, typically only a fraction of a billionth of a second, the response of the experimental system itself had to be precisely understood, which was achieved by using precise pulses of laser light as a source instead of a scintillation crystal. While the crystals selected for the study represented the state-of-the art in currently available scintillation materials and their performance parameters were closely matched, this study demonstrated that samples of one manufacturer were statistically significantly better from the rest. Consecutive measurements of coincidence timing resolution (CTR) with the same crystals confirmed the theoretical expectations of PET performance based on the rise and decay time constants measured in this study.

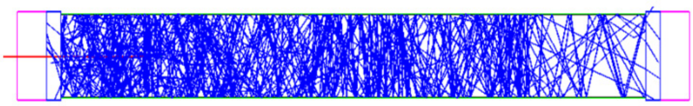


Scintillator crystal samples, characterized in the master's thesis "Characterization of scintillation crystals for advanced detectors in positron tomography".

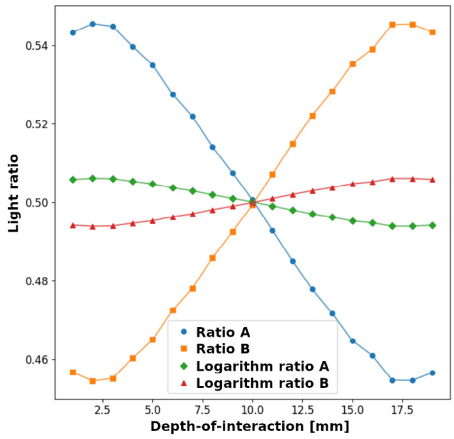


Temporal evolution of the scintillation light after annihilation gamma ray absorption, as measured in the master's thesis "Characterization of scintillation crystals for advanced detectors in positron tomography".

In another master's thesis, Dominik Vitas studied the potential improvements of PET detectors by maximizing the information extracted from the properties of optical photons reaching the photodetector after production and propagation in the scintillator crystal. Based on the open-source physical simulation tools established in the fields of high energy physics and nuclear medicine, a simulation model of a PET detector was developed, including the properties of scintillator crystals, their wrapping, photodetectors as well as the optical coupling between the crystals and the photodetector. The software was then used to precisely simulate the interactions between the annihilation gamma photons and the crystal material, production of the scintillation light photons, their optical propagation trough the crystal and potential detection by the photodetector. Specific geometric and physical properties of the scintillation materials and photodetectors planned to be used in the PetVision project were taken into account. The results of this study quantified the importance of coupling between the crystal and the photodetector, which has an important impact on the decisions related to the technical design of the photodetectors under developed by the PetVision collaboration. The study also demonstrated that, by measuring the number of photons reaching two opposite sides of the crystal, the depth-of-interaction (DOI) information of the gamma ray can be precisely reconstructed, enabling improvement in image quality due to reduced parallax error, which is of particular importance for planar detector geometry as envisioned for the PetVision scanner. In addition, the DOI information can be used to reduce the main remaining limitation to the CTR, the timing dispersion due to the crystal length. The results of this study indicate that by using optimized photodetectors and DOI information, CTR of 75 ps FWHM is achievable even with 20 mm long scintillation crystals.



Visualization of the simulated optical photon propagation in the scintillator crystal, including the optical coupling and the photodetectors in dual sided readout configuration, as studied in the master's thesis "Use of depth of interaction measurement in flat panel positron emission tomography".



The ratio of scintillation photons detected on the two photodetectors in dual sided readout configuration depending on the depth of gamma ray interaction, as studied in the master's thesis "Use of depth of interaction measurement in flat panel positron emission tomography".

Wishing you joy, happiness, good health, Happy Holidays, and all the best in 2026 as we continue moving toward PetVision's vision of improving well-being for people everywhere.

PET VISION

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