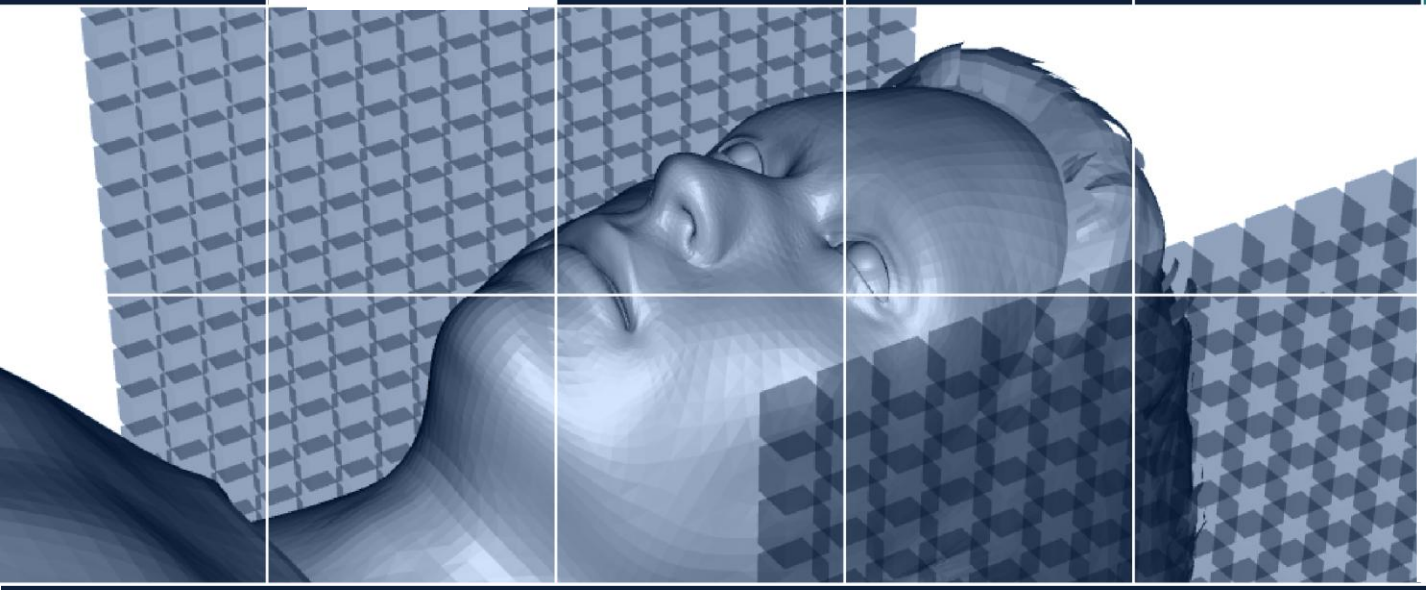
Follow PetVision project on LinkedIn



Flexible, Mobile and Modular PET Imaging

Gašper Razdevšek

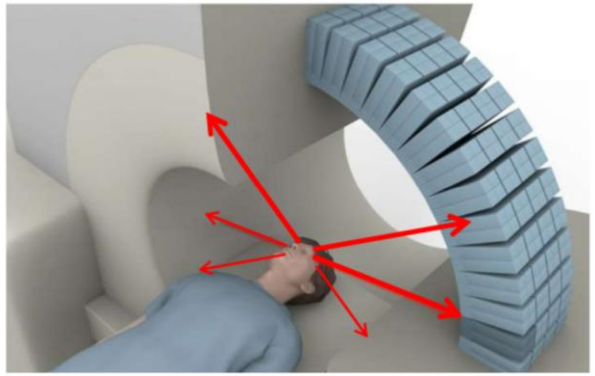
Institut "Jožef Stefan" Ljubljana, Slovenija

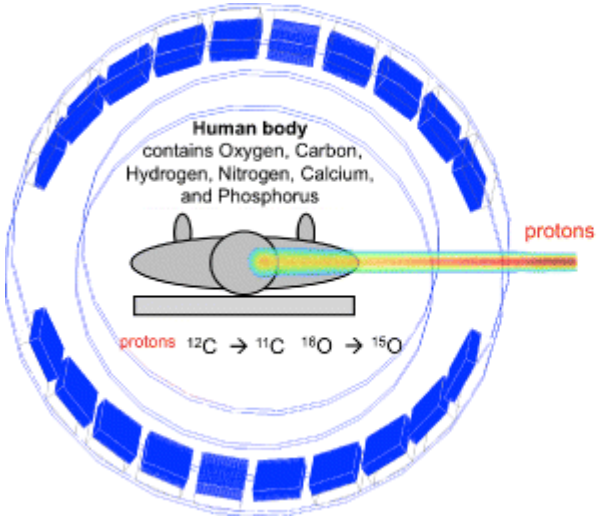
PET VISION

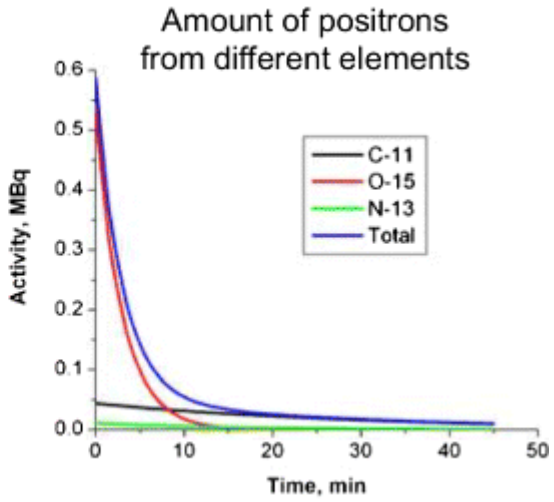
6th Jagiellonian Symposium on Advances in Particle Physics and Medicine, Kraków July 5-10 2026

PET scanners

- Full-ring PET is the clinical standard.
- Ring systems are not ideal for every clinical or research scenario.
- Can we make the geometry more flexible without sacrificing image quality?





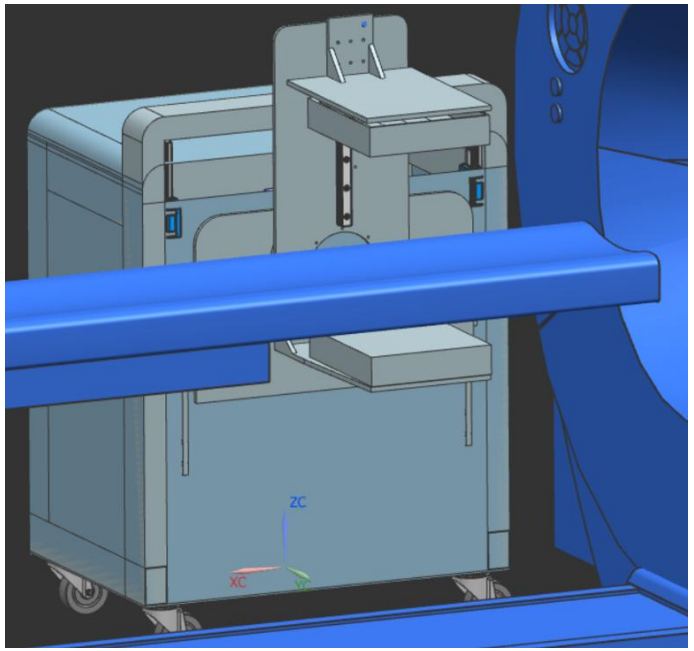


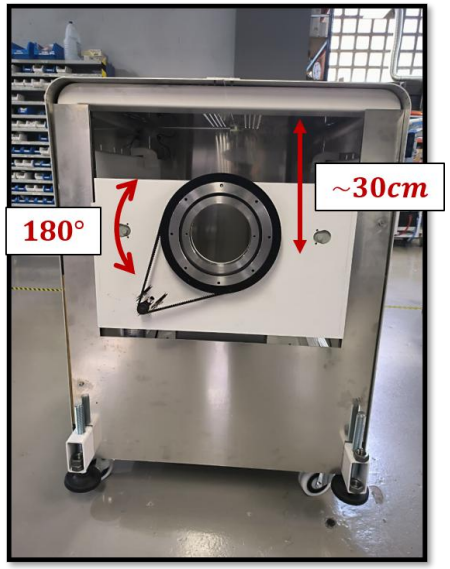
Vandenberghe et al., EJNMMI Physics 3, 3 (2016), doi:10.1186/s40658-016-0138-3

The Walk-Through PET (https://www.wt-pet.org/)

PetVision project

- Develop a flexible, modular and cost-effective PET scanner based on **two opposing planar detector panels** with **excellent TOF resolution**.





Rok Pestotnik
Coordination, Design Integration, Reconstruction
Institut "Jožef Stefan" Ljubljana, Slovenija

David Gascon
Chip design
Universitat de Barcelona

Alberto Gola
Photo sensors 2D integration
Fondazione Bruno Kessler

Georges El Fakhri
Associated P. Hospital: Design & Validation
Yale

Rafael Ballabriga
Chip design
CERN

Wolfgang Weber
Hospital: Validation
MRI TUM

Jose Benlloch
Readout Electronics Data Acquisition
i3M

David Sanchez
SME: Mechanics & Software
ONCO VISION

Panel detectors

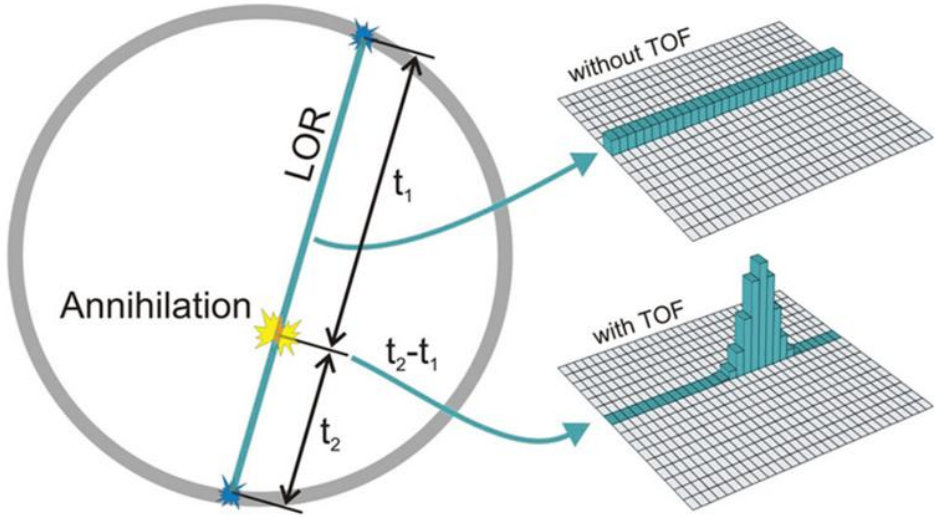
- Two-panel PET: back to the past? Not with excellent TOF resolution.

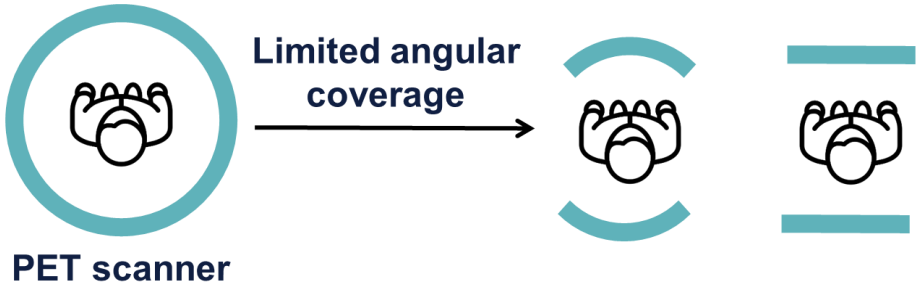
The PC-I, completed in 1969, used two planar arrays of crystals and was one of the first PET imaging devices.

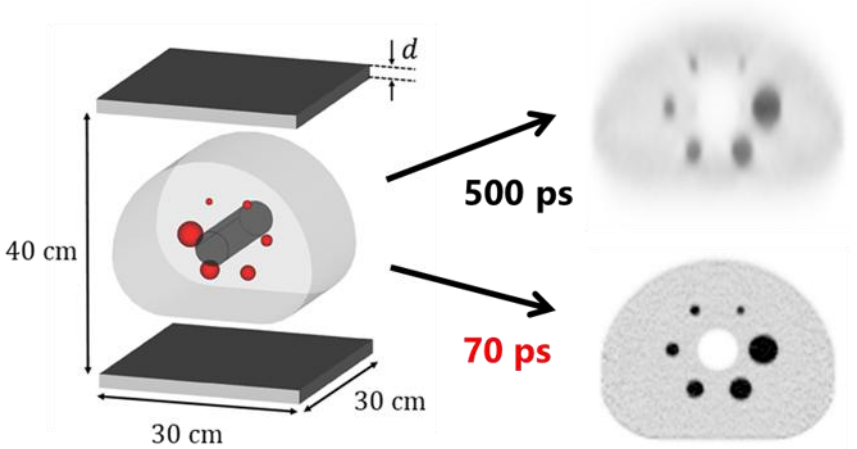
- PetVision aims for artifact-free open-geometry imaging without rotating the panels.

Time-of-flight (TOF) information

- Improves localization of the annihilation event, reduces noise correlations, and increases image signal-to-noise ratio (SNR) → **sensitivity amplifier**
- TOF also **enables reduced angular sampling** → open-PET geometry







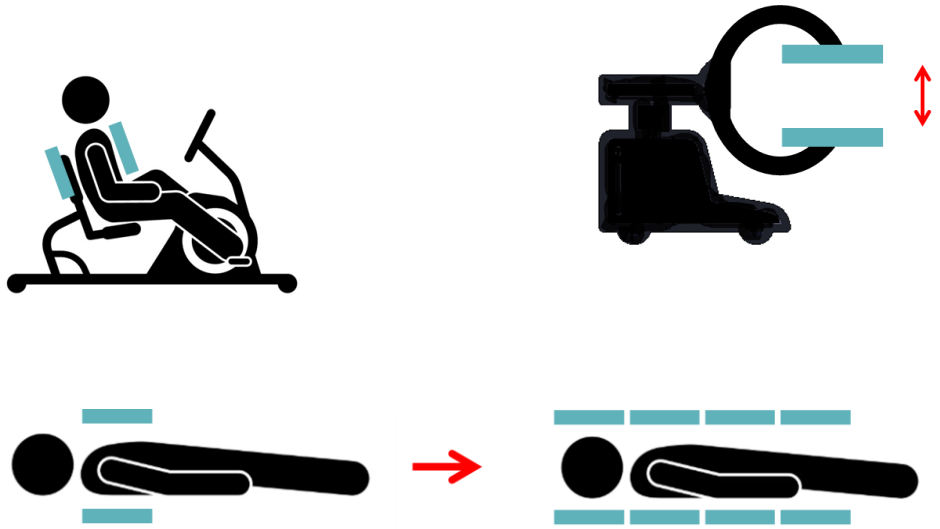
Advantages of panel detectors

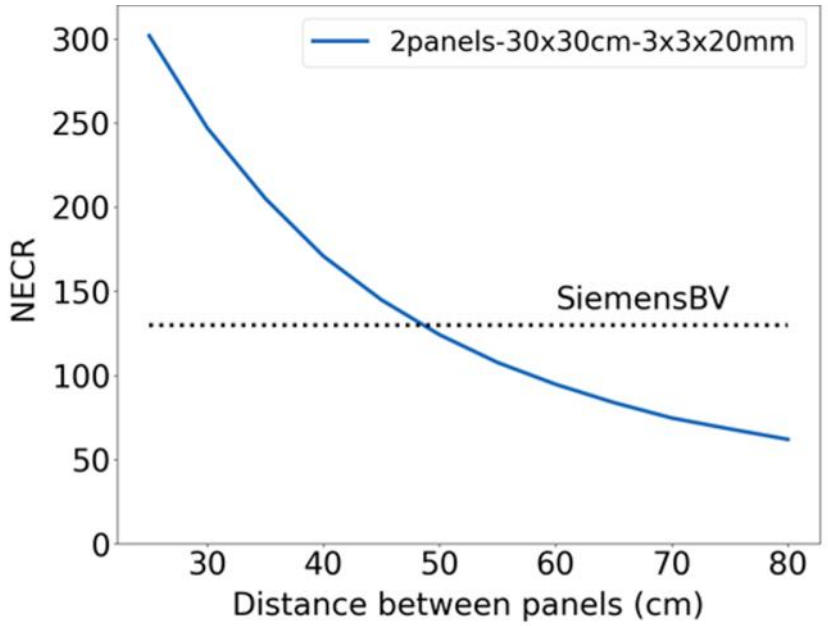
Flexibility → adjustable FOV and sensitivity

Mobility → portable or bedside PET imaging

Modularity → multi-organ/total-body PET scanner

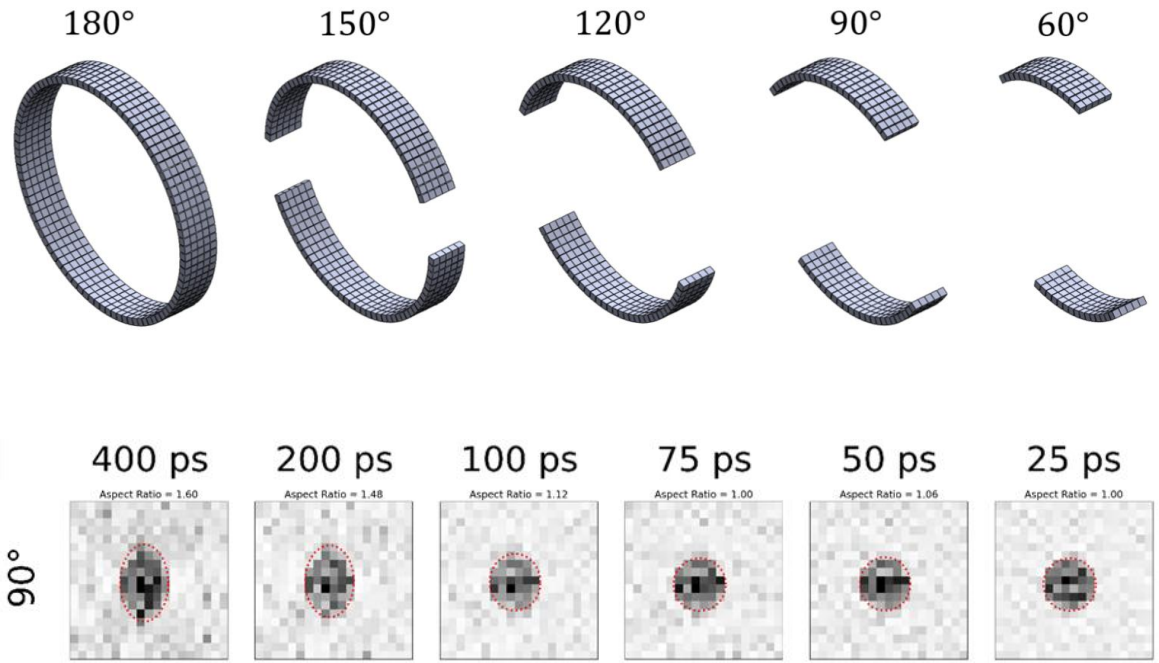
Accessibility → reduced manufacturing cost and complexity

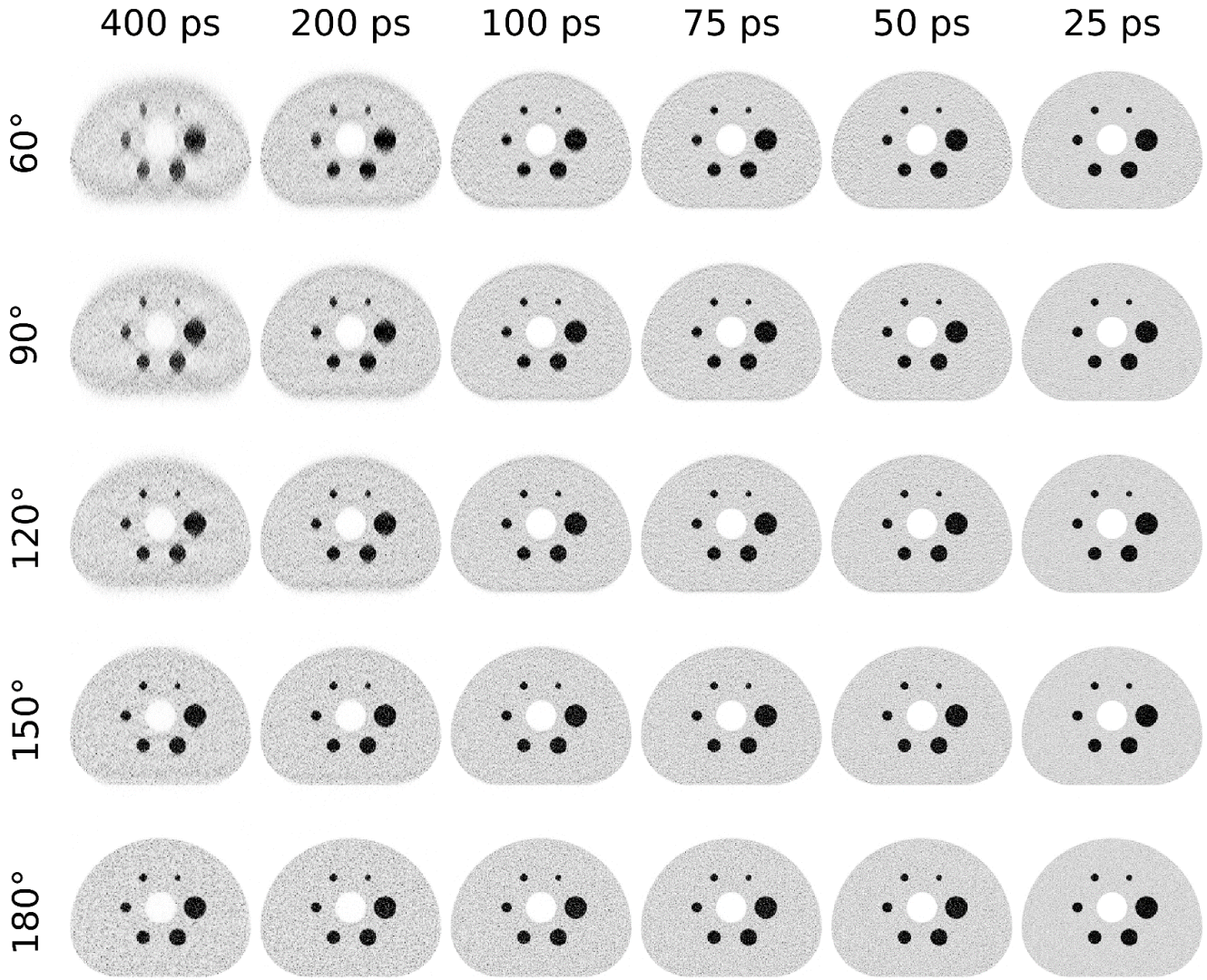




Razdevšek G, et al. Flexible and modular PET: Evaluating the potential of TOF-DOI panel detectors. Med Phys. 2025; 52: 2845–2860. https://doi.org/10.1002/mp.17741

TOF Requirements for Artifact-Free Open-Geometry PET

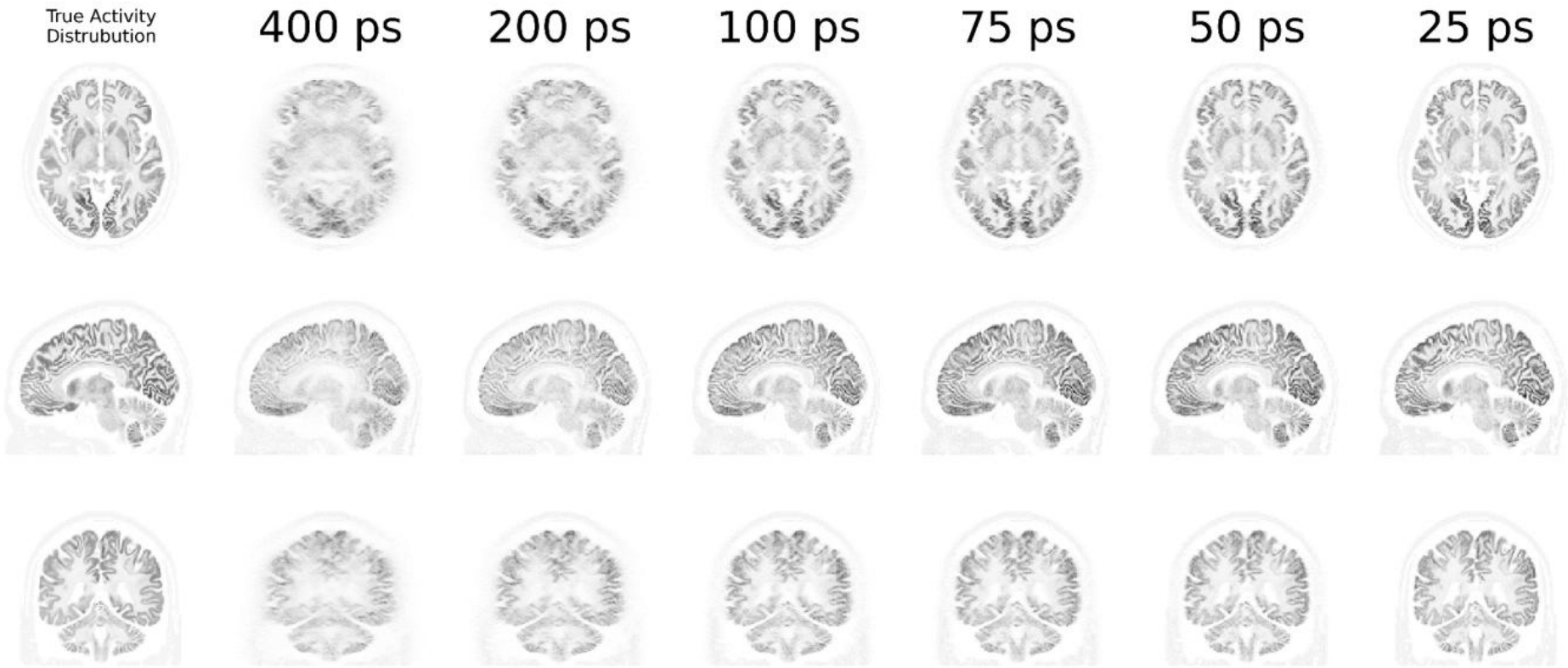


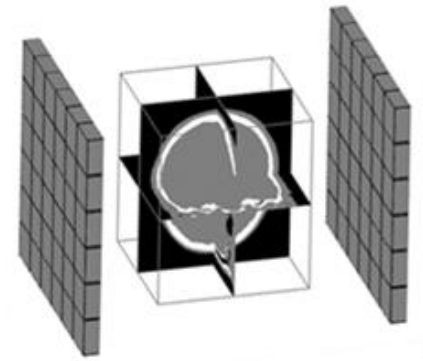


TOF ≤ 100 ps → the key to unlocking the full potential of open-geometry PET imaging

2-Panel System: Monte Carlo simulation

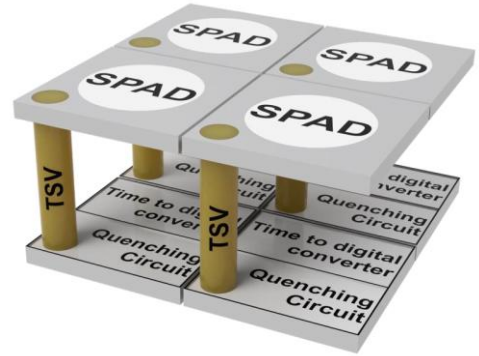
- 2 panels: 30 x 30 cm, panel separation: 30 cm (90° angular coverage)
- High-resolution brain phantom [18F]FDG, 100 M true events

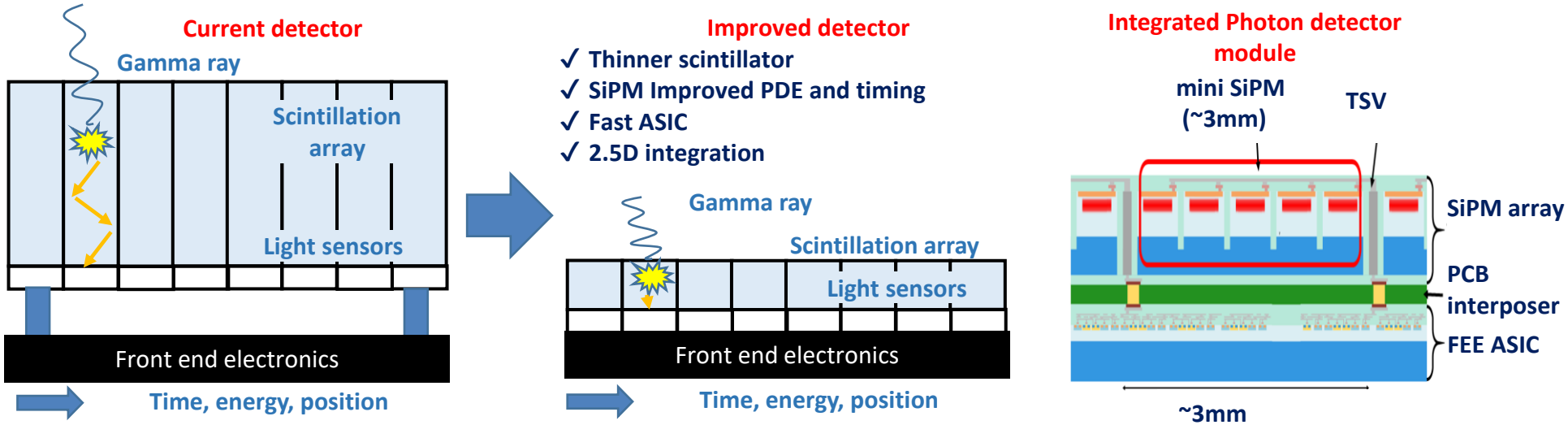




How do we plan to achieve sub-100 ps TOF resolution?

- Shorter crystals → 10 mm (3×3×10 mm + 100 ps ≈ 3×3×20 mm + 200 ps)
- High-PDE SiPMs → Sensor based on NUV-HD-MT + TSV technology
- Fast ASICs → PoETIC, a highly configurable pixelated ASIC for fast-timing applications based on FastIC
- Minimized-capacitance interconnects → 2.5D integration



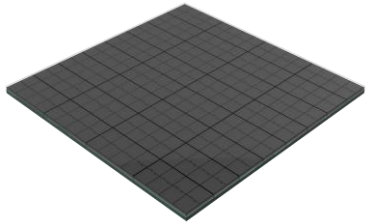


Timeline

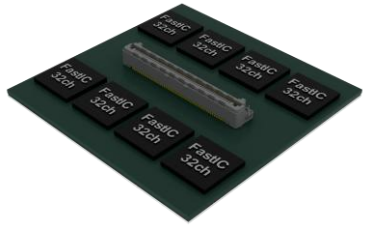
2026

PetVision

3x3 mm² Photo Sensor with improved performance

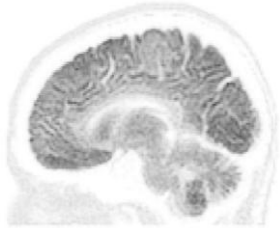


PoETIC ASIC and integration into a digital module



Integration of the prototype: 2 panels 30x30 cm²

Validation in two hospitals



Further developments & exploitation

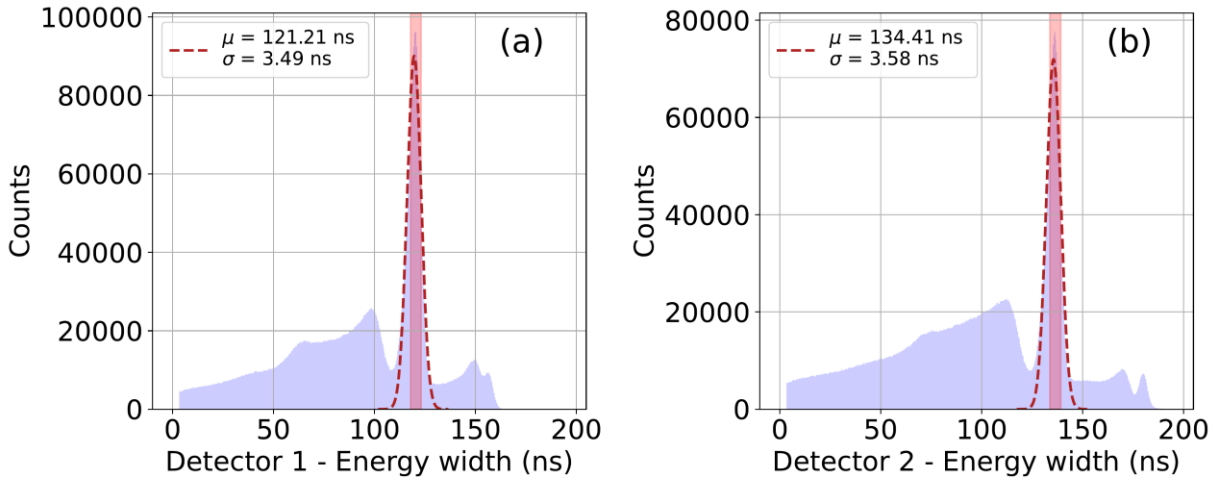
Year 2 | Year 3 | Year 4 | Year 5 | Year 6-7

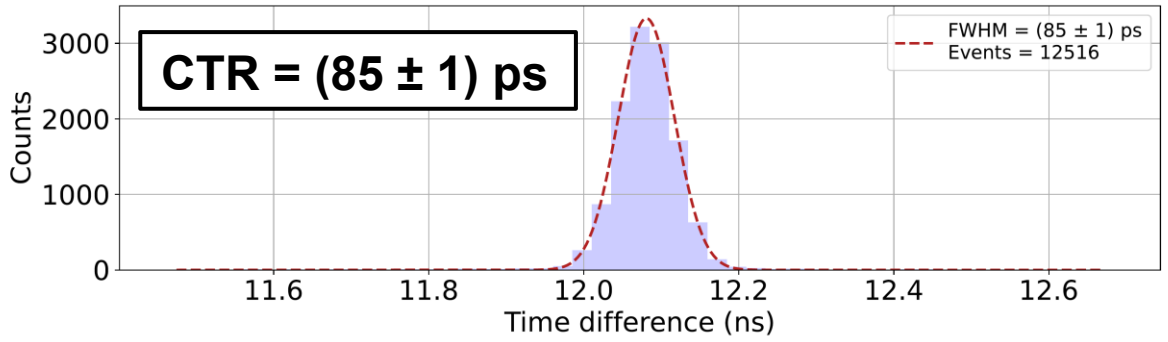
Further funding

Proof of principle: FastIC+ CTR performance

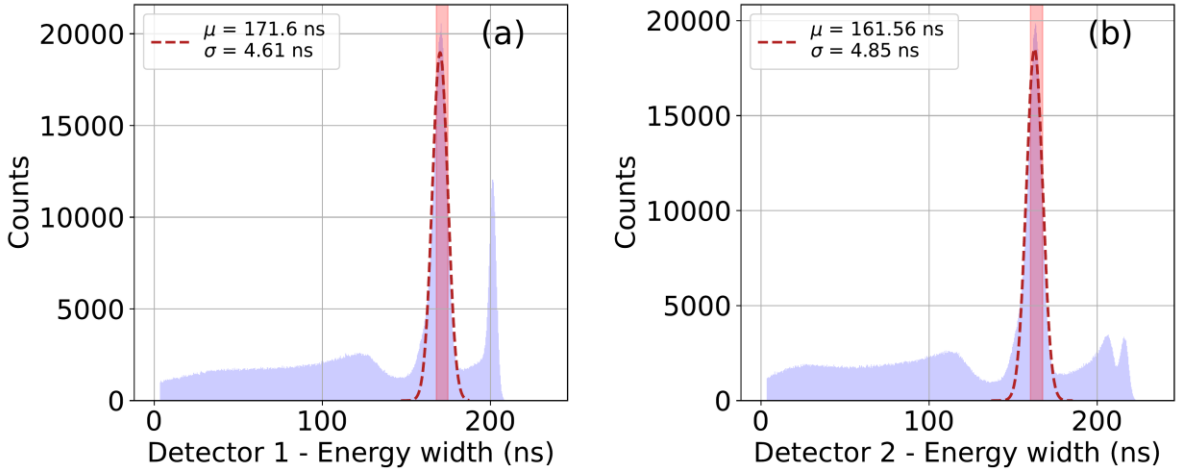
Results with FastIC+ (the predecessor of the final chip) and without 2.5D integration

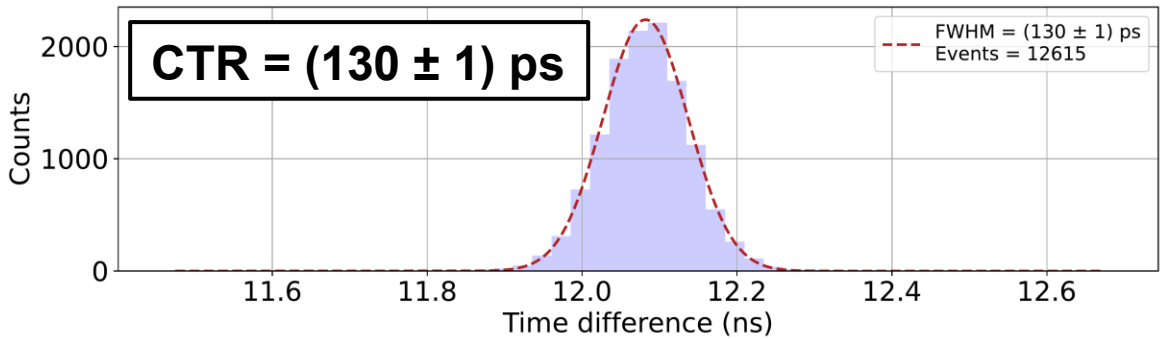
- **SiPM:** FBK NUV-HD-MT LFv2 M0 3x3 mm^2 50 µm SPAD
- **Over-Voltage:** ~10 V
- **Crystal**: Fast-LGSO (Oxide Corporation) – 2x2x3 mm^3





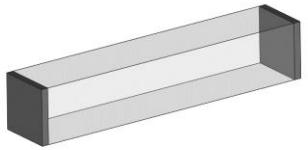
- **SiPM:** FBK NUV-HD-MT LF 4x4 M0 mm^2 40 µm SPAD
- **Over-Voltage:** ~10 V
- **Crystal:** LYSO:CeCa (Taiwan Applied Crystals) – 2.8x2.8x20 mm^3





Beyond PetVision

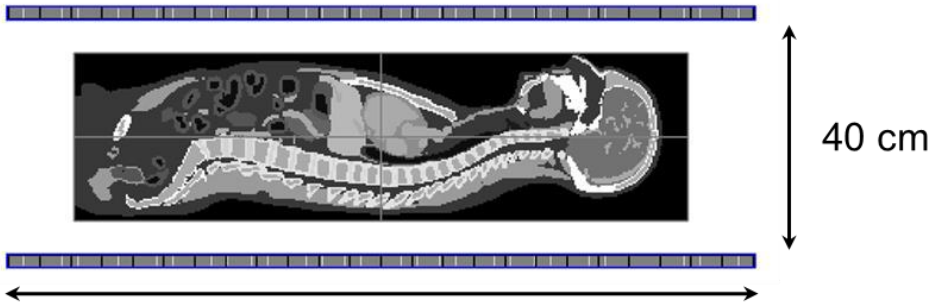
- FastSight project: panel detectors with depth-of-interaction (DOI) capability from dual-sided readout of longer crystals (20 mm)
- Long axial FOV PET imaging

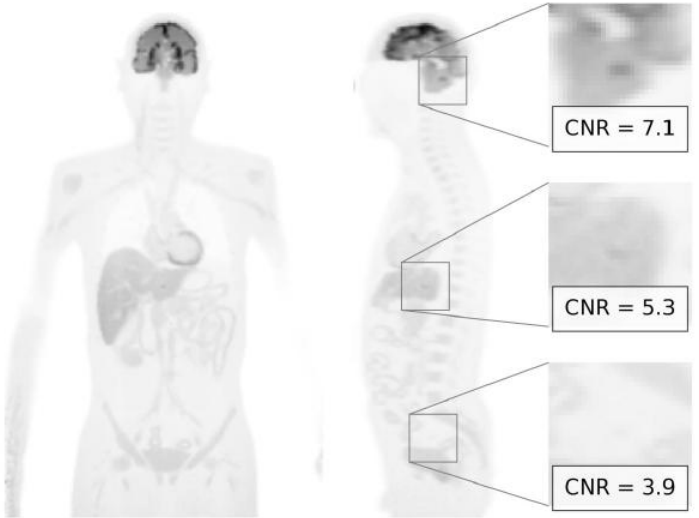


NIH National Institutes of Health
Turning Discovery Into Health
R01 EB036642

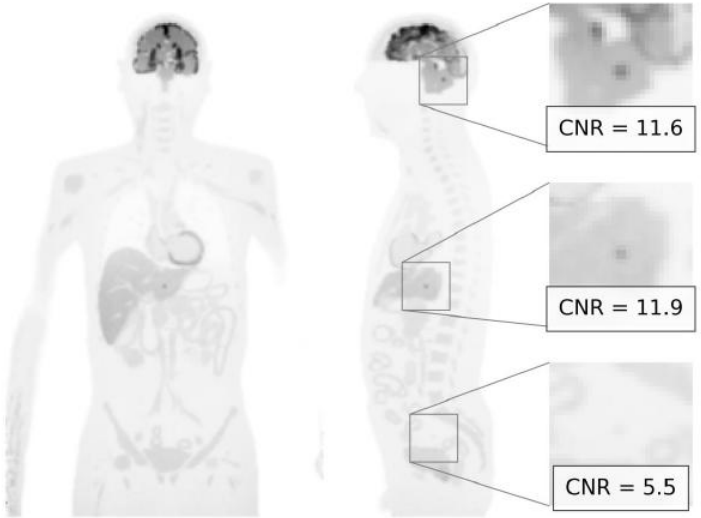
Yale

FBK, I3M, JSI, ICCUB





2panels-120x60cm-200ps-no-DOI-4min

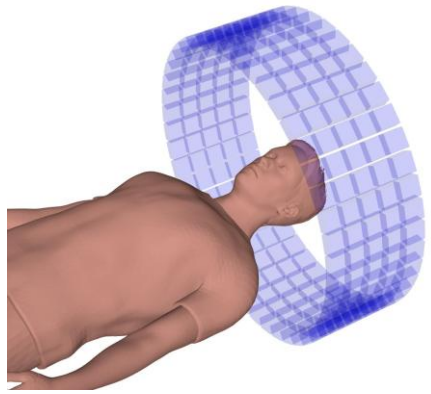


2panels-120x60cm-70ps-DOI-4min

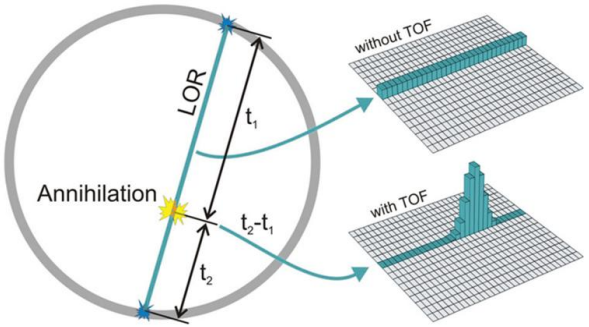
Summary

- TOF ≤ 100 ps is the key that unlocks open-geometry PET.
- TOF-enabled open geometry allows us to design the next generation of flexible, mobile, and modular PET scanners.

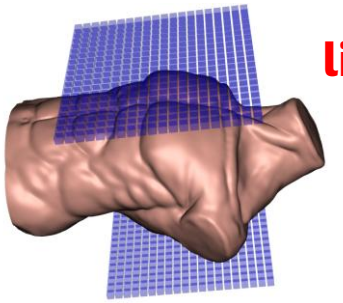
Traditional Full ring PET scanner

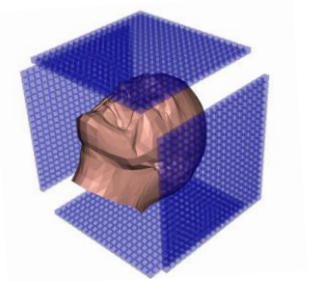


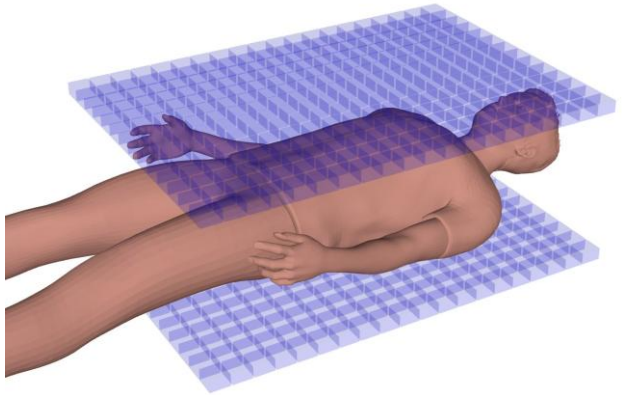
Very fast TOF PET < 100 ps



Modular panel-based limited angle PET scanner







Thank you to all PetVision collaborators

G. Razdevšek[1], R. Pestotnik[1], D. Gascon[2], A. Gola[3], J. Benlloch[5], J. Alamo[6], R. Ballabriga[7], J. Barbera[6], Y. Chemli[4], R. Dolenec[8, 1], J. Fernández-Tenllado[2], S. Gómez[9, 2], S. Korpar[10,1], P. Križan[8,1], S. Majewski[11], R. Manera[2], T. Marin[4], A. Mariscal[2], J. Mauricio[2], D. Mazzanti[2], G. Pavon[6], N. Pavon[5], M. Penna[3], A. Sanuy[2], A. Seljak[1], A. Studen[8,1], D. Žontar[1] , G. ElFakhri[4]

[1] Jožef Stefan Institute, Experimental Physics Department, Ljubljana, Slovenia, [2] University of Barcelona, Dept. Física Quàntica i Astrofísica, Institut de Ciències Del Cosmos, Barcelona, Spain, [3] Fondazione Bruno Kessler, Trento, Italy, [4] Yale School of Medicine, New Haven, United States of America, [5] The Institute of Instrumentation for Molecular Imaging, Valencia, Spain, [6] Oncovision, Valencia, Spain, [7] European Organisation for Nuclear Research - CERN, Geneva, Switzerland, [8] University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana, Slovenia, [9] Polytechnic University of Catalonia, Barcelona, Spain, [10] University of Maribor, Faculty of Chemistry and Chemical Engineering, Maribor, Slovenia, [11] University of California Davis, Dept. of Biomedical Engineering, Davis, California, USA

Funded by the European Union

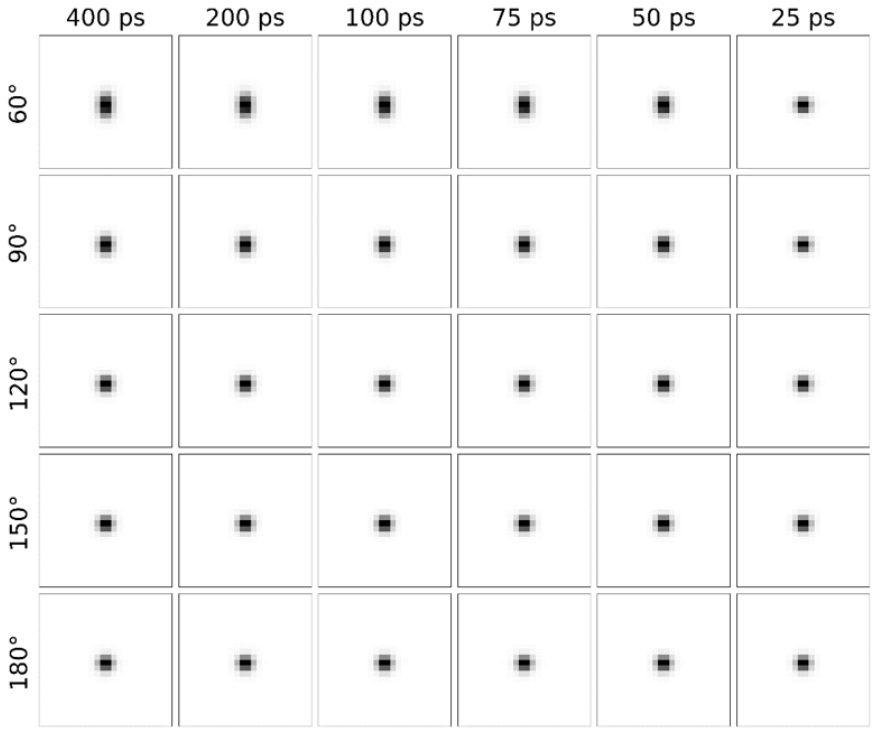
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101099896

Follow PetVision project on LinkedIn

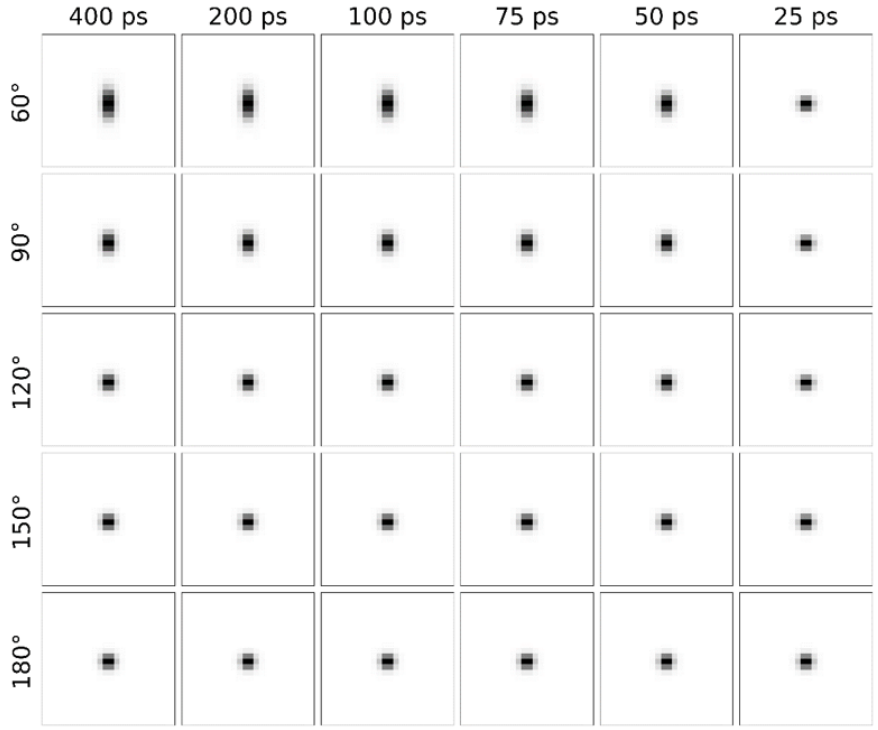
Spatial Resolution

- Point sources (NEMA standard)
- Voxel size: 0.75 mm

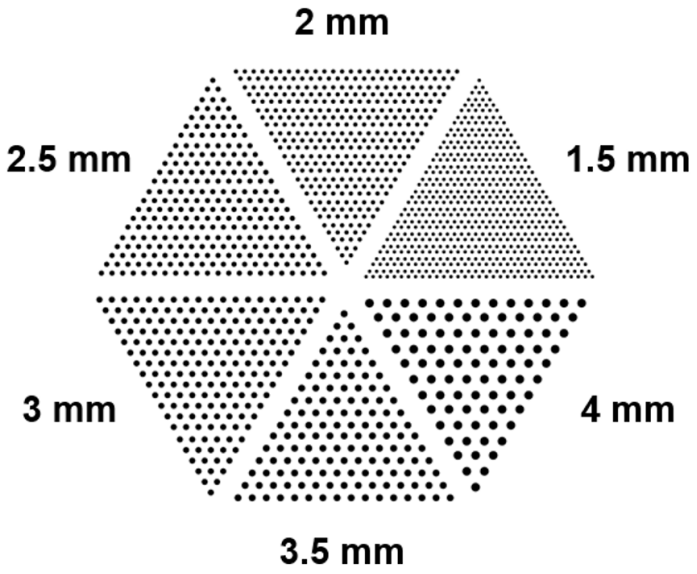
(0, 1, 0) cm

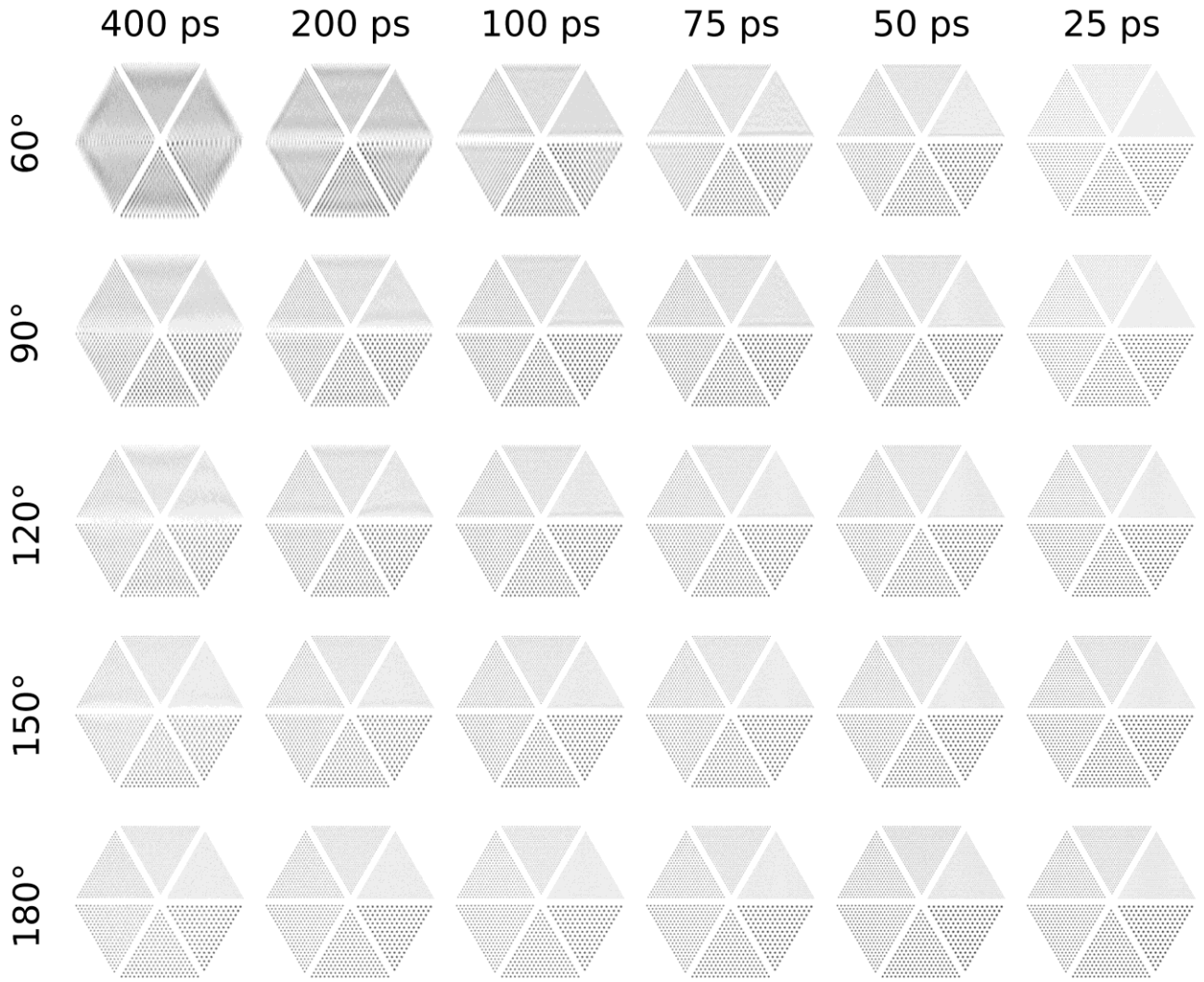


(10, 0, -10) cm

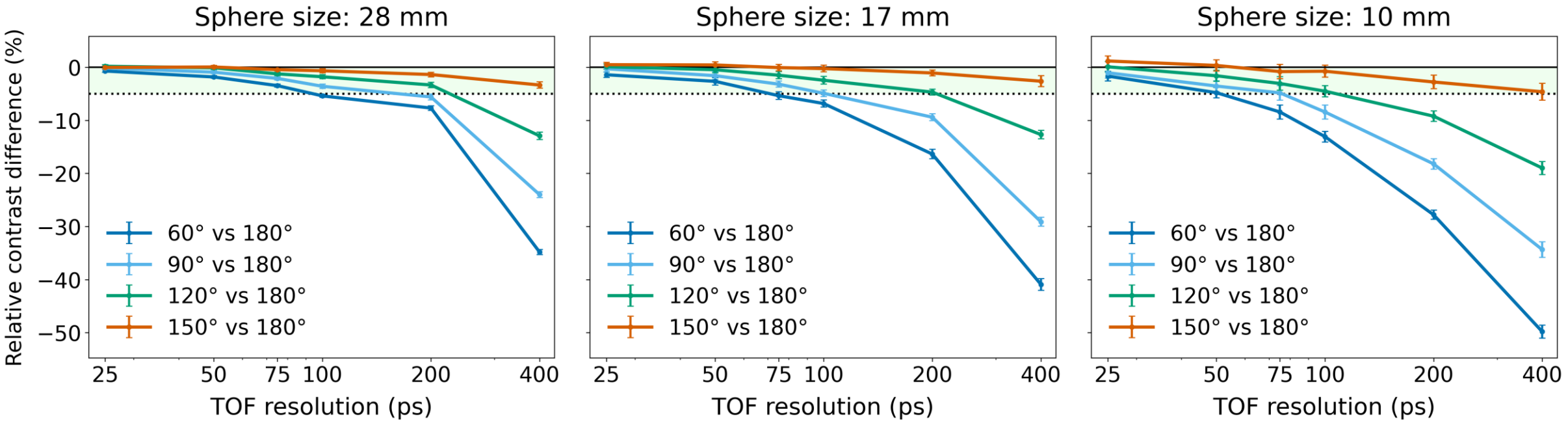


Spatial Resolution

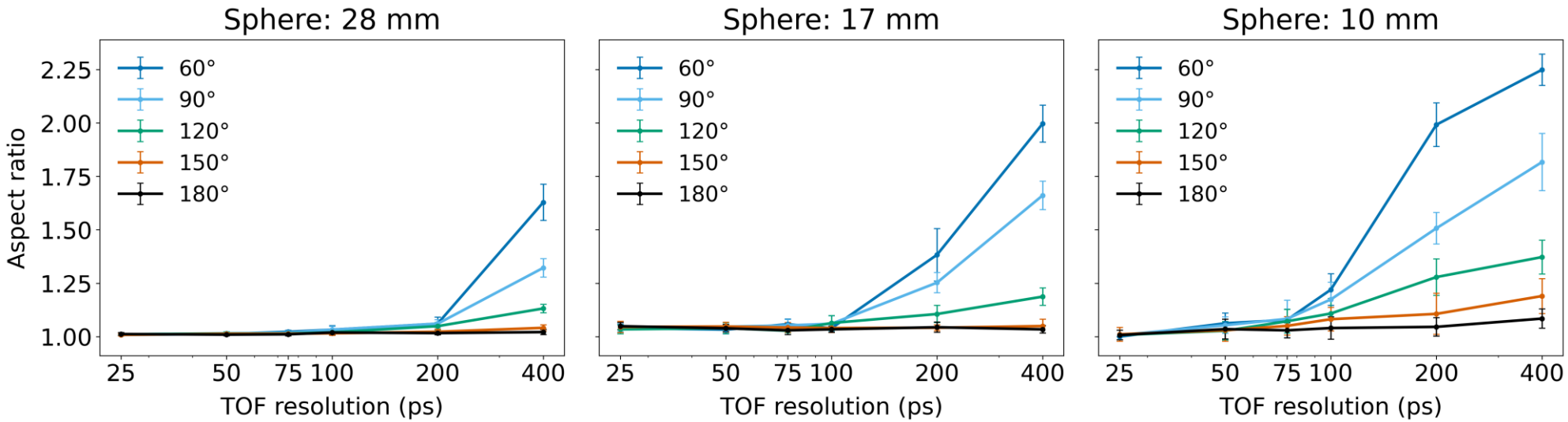


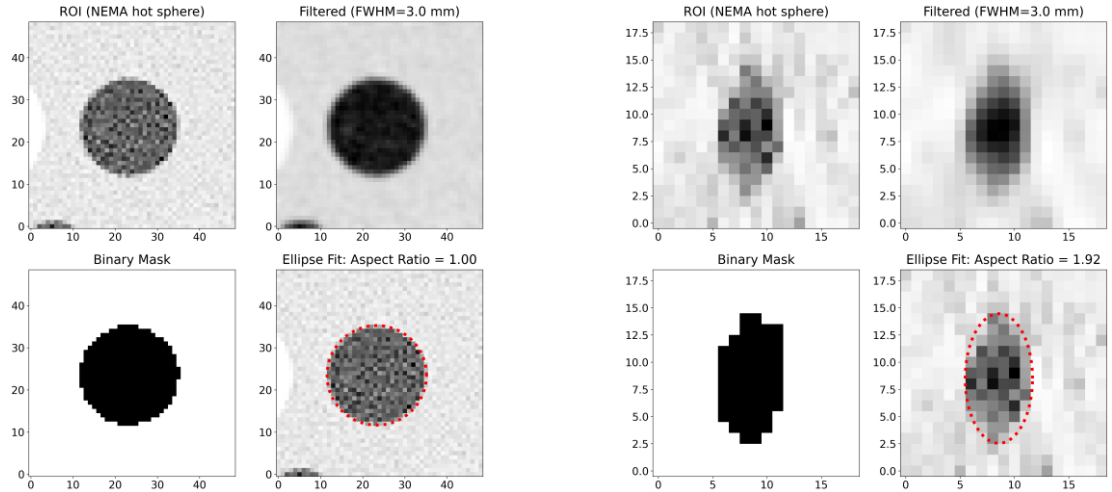


NEMA image quality phantom



Ellipse fitting to reconstructed hot spheres





Next generation ASICs based on FastIC family

- PoETIC - Highly configurable pixelated ASIC for Fast Timing applications based on FastIC

- Collaboration between the University of Barcelona and CERN
- Time Over Threshold
- Low power (~10 mW/ch),
- 25 ps bin TDC integration
- Packaged or direct 2.5D integration