http://cern.ch/ENVISION

European Novel Imaging Systems for Ion Therapy

Imaging secondary particles to improve dose conformality of proton and ion therapy

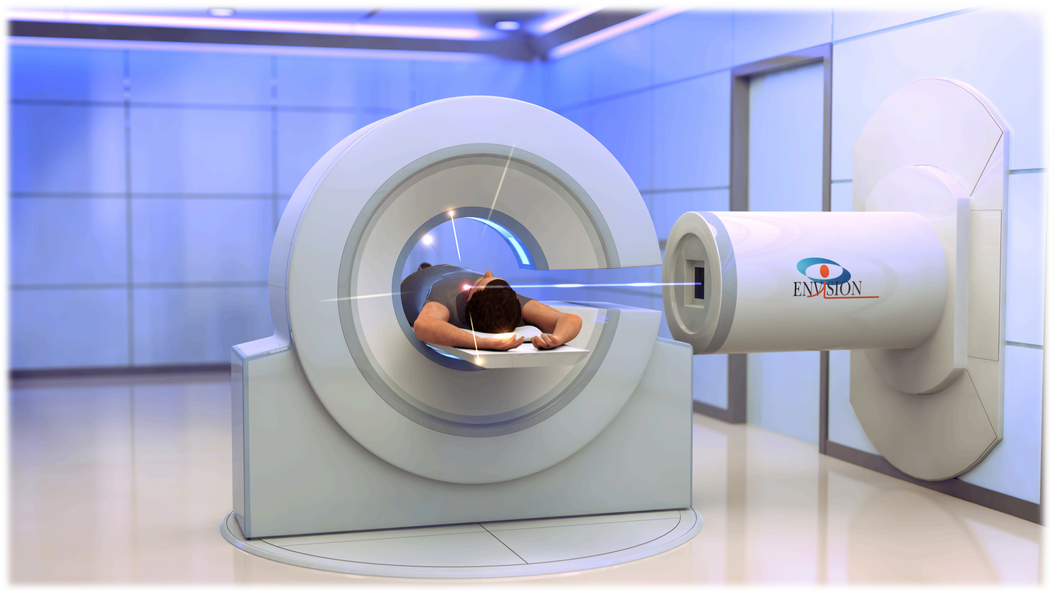
ENVISION tackles real-time monitoring, quantitative imaging, precise determination of delivered dose, fast feedback for optimal treatment planning, real-time response to moving organs, simulation studies

The Project

ENVISION is a four year funded project with a budget of 6 million Euros.
Launched in 02/2010 and prolonged to 07/2014
16 leading European research centers and industrial partners are coordinated by CERN

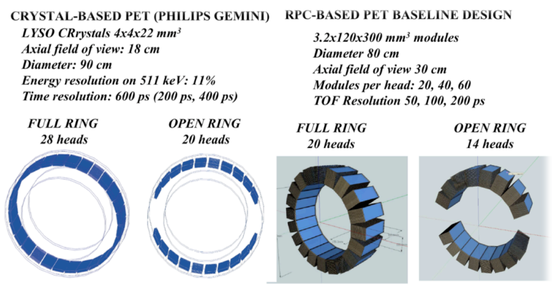
Project structure: 5 research work packages

- Time-of-flight in-beam PET (WP2)
- In-beam single particle tomography (WP3)
- Particle therapy in-vivo dosimetry and moving targets (WP4)
- In-vivo dosimetry, treatment planning and clinical relevance (WP5)
- Monte Carlo simulation of in-vivo dosimetry (WP6)



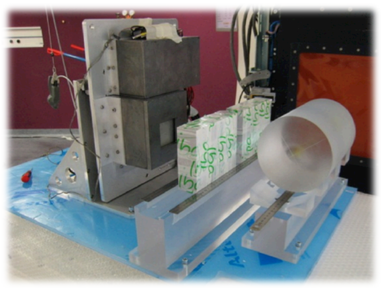
Time-of-flight in-beam PET

Compare technologies for achieving sub-nanosecond TOF resolution
Dual-head demonstrator
→ Crystal-based TOF-PET
→ RPC-based TOF-PET
Simulate a full ibPET system
Develop and optimize fast image reconstruction algorithms
→ Achieved TOF resolutions close to 200 ps
Improvements in image quality
→ Compton scatter rejection & artifacts reduction



In-beam single particle tomography

Develop and optimize detector systems & reconstruction algorithms for ibSPAT
Develop clinically real-time monitoring methods
Feasibility of prompt γ-ray imaging demonstrated
Passive system for prompt γ-ray imaging tested
→ Promising results for clinical application
Several dedicated Compton camera prototypes developed
→ Active collimation system in progress

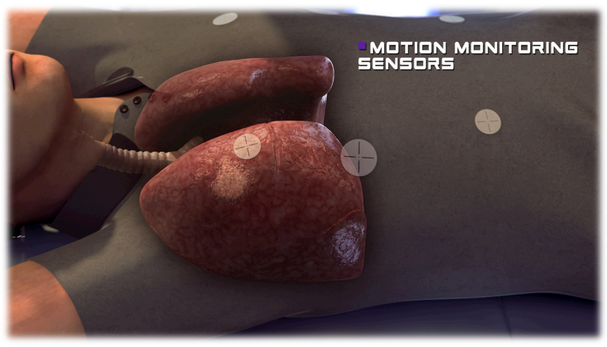


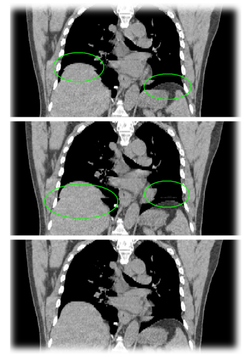
Scintillating fibre hodoscope for beam position measurement successfully tested

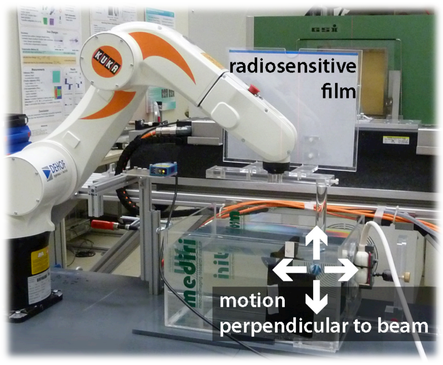
Monte Carlo simulations and experiments at HIT demonstrated that prompt γ imaging delivers a reliable particle range information

Particle therapy in-vivo dosimetry and moving targets

Assess feasibility and clinical potential of 4D in-vivo dosimetric
Imaging analysis systems of motion-compensated scanned ion beams
Experimental investigations at GSI (3D MLEM vs 4D MLEM)
→ Changes in high activity region due to beam delivery type
→ Automated range comparison
→ Detection of overranges & underranges
Integration of ultrasound tracking system
→ In PET/CT
→ In beam delivery

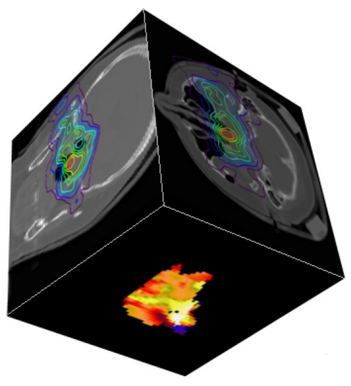






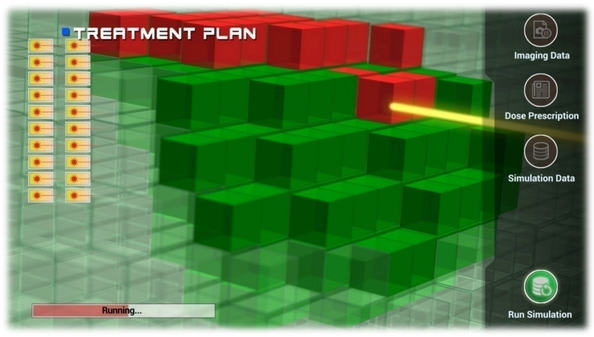
In-vivo dosimetry, treatment planning and clinical relevance

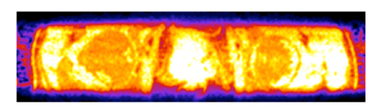
Development of an automated PT-PET evaluation tool
Development and test of purpose built phantoms ion beam dosimetry
Software development for PET verification (2 approaches)
→ Range comparison algorithm
→ Pearson correlation coefficient based evaluation
Moving phantom designed and constructed
Control software written to allow movement on predefined path



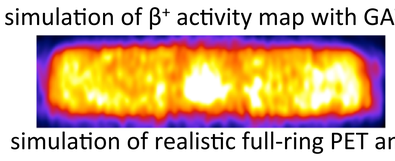
Monte Carlo simulation of in-vivo dosimetry

MC model development for production of β^+ and prompt γ emission
Simulation tools for actual patient cases
Toolkits: GEANT4, FLUKA, GATE, MCNPX
Steps for full simulation of clinical cases:
→ Importing DICOM
→ Generating complex detector geometriy
→ Production of sinograms for PET scanners
OpenPET and dual-head dedicated PET systems have been simulated
→ Spatial resolution and reconstruction ability correspond to real clinical proton irradiation





simulation of β^+ activity map with GATE



simulation of realistic full-ring PET and image reconstruction

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