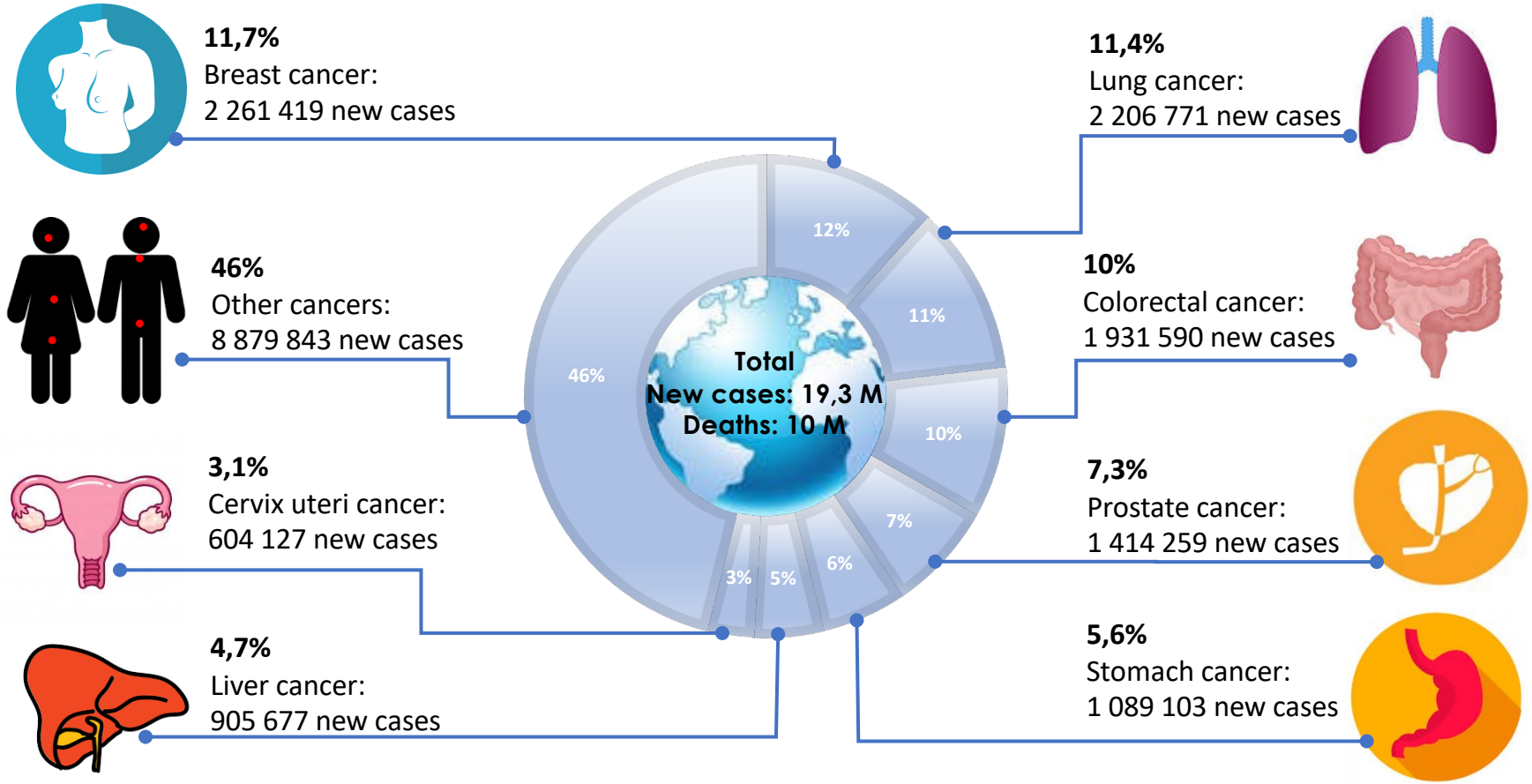
A NEW FACILITY DEDICATED TO LASER-PLASMA ACCELERATOR BASED VHEE RADIOTHERAPY

ARNAUD COURVOISIER, ANTON GOLOVANOV, EYAL KROUPP, LIDAN FRIDMAN, RAJAKRISHNA KALVALA, TOMER FRILING, VICTOR MALKA

ēbeam 4therapy

Funded by the European Union

INTRODUCTION – CANCER STATISTICS



Estimated number of new cases in 2020, all cancers, overall population, all ages

World Health Organization: press release No 238, (2020)

$ 10,150,000,000

The estimated size of the global radiotherapy market by 2025

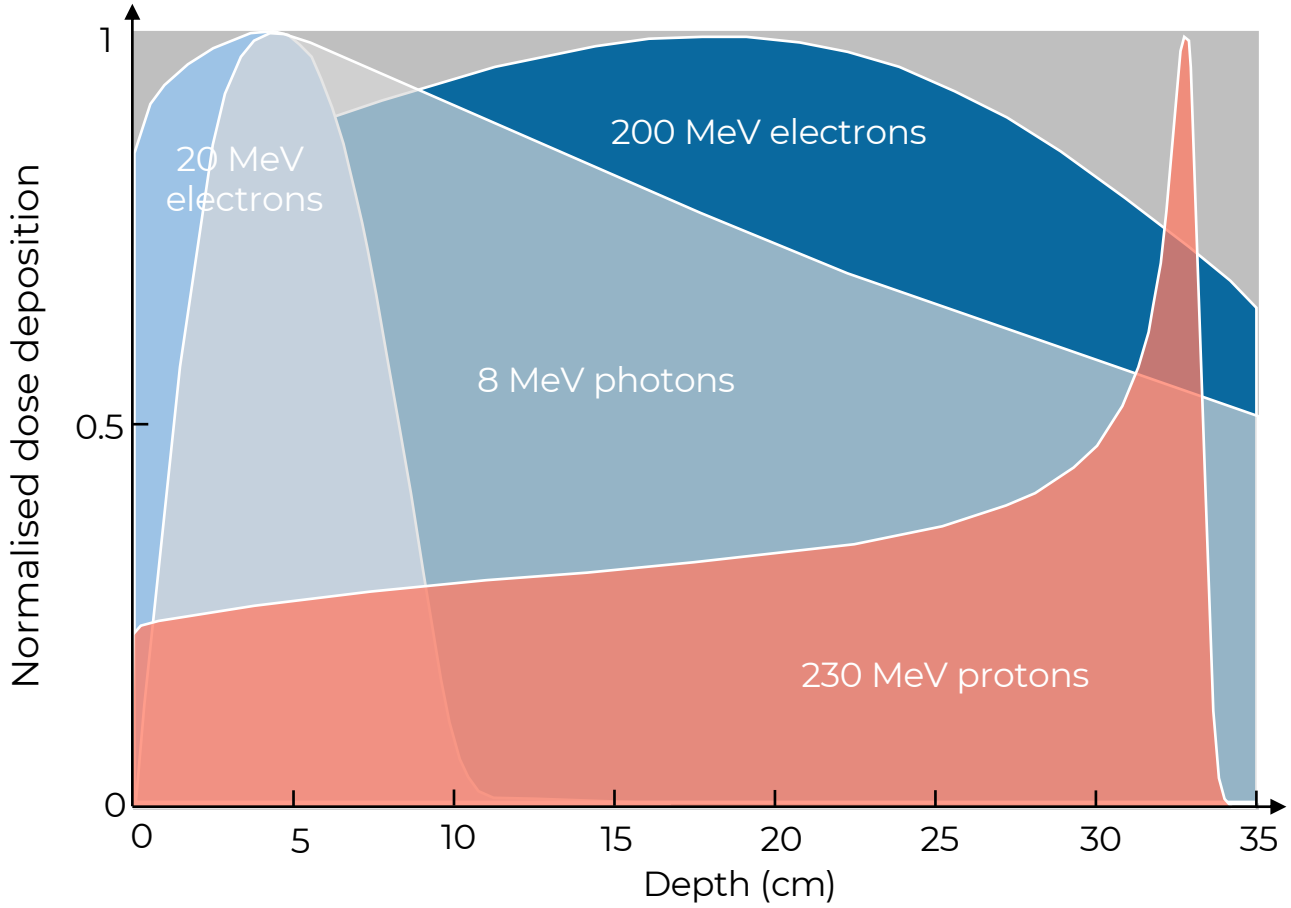
25,000,000

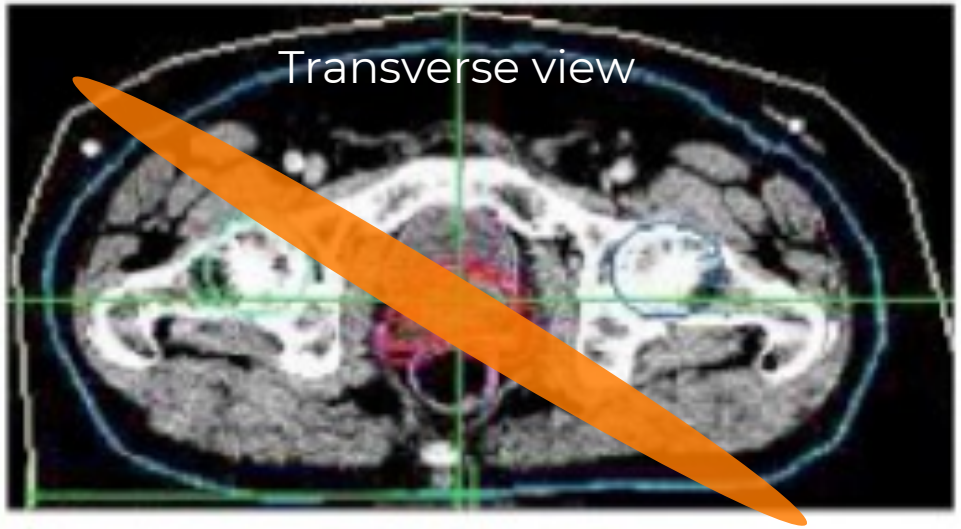
The expected number of new cancer cases annually by 2030

> 12,000

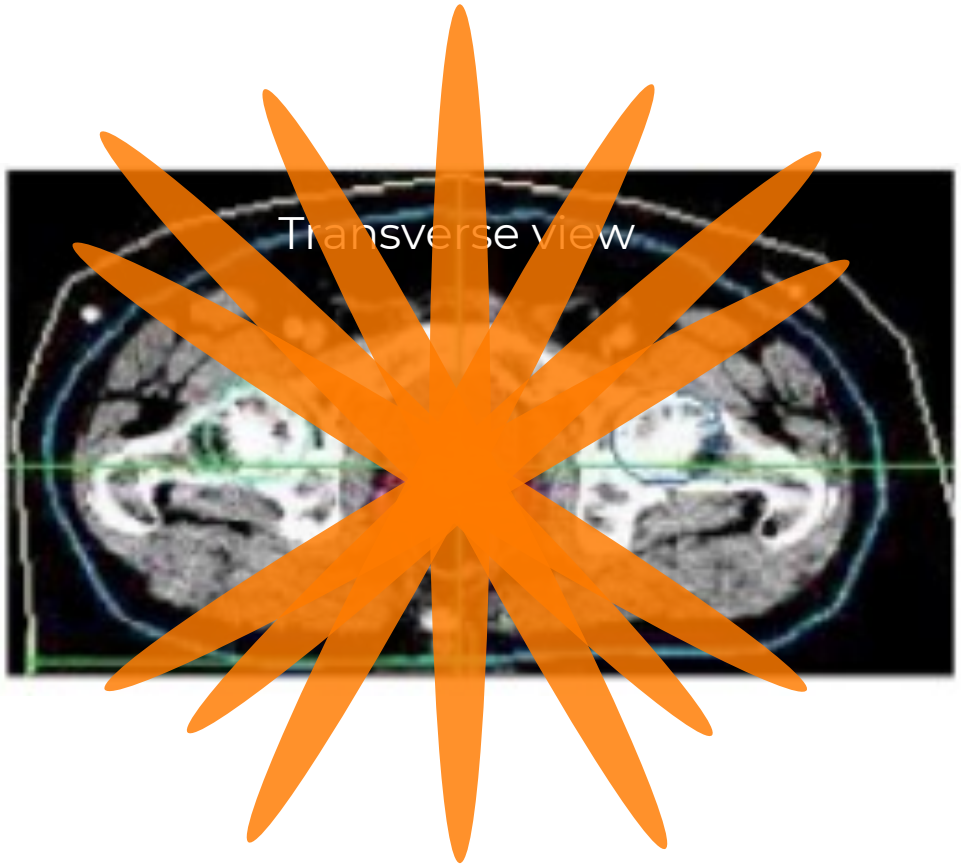
The number of additional RT machines required by 2035 in low- to middle-income countries alone

INTRODUCTION - VHEE AND RADIOTHERAPY





T. Fuchs et al. Phys. Med. Biol. ***54****, 3315-3328 (2009)*



T. Fuchs et al. Phys. Med. Biol. ***54****, 3315-3328 (2009)*

OUR OBJECTIVE

To develop an inexpensive, low-footprint laser plasma accelerator technology capable of reliably generating focused very high energy electron beams (200-250MeV) suitable for next-generation ***radiotherapy applications****.*

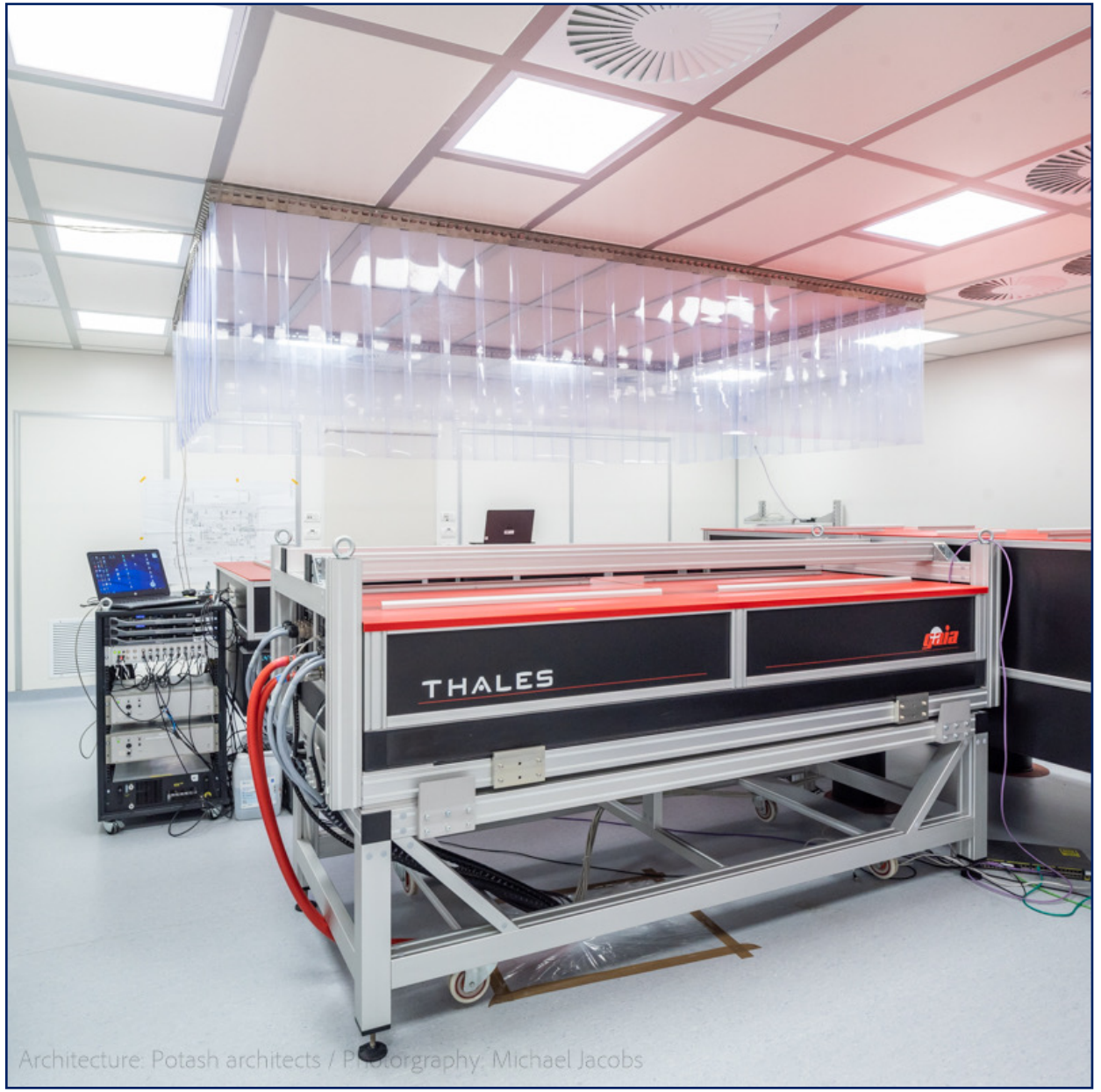
OUR VISION BEYOND THE EIC TRANSITION

Together with an industry partner (discussions ongoing), we will incorporate the LPA technology into a **compact** & **cost-effective** VHEE-RT machine prototype that will then be taken to preclinical and clinical validation in collaboration with university hospital partners. Next-level funding will be sought to make this possible.

The new RT device is expected to **fit within existing treatment rooms** and provide **improved treatment outcomes** deep-seated and inhomogeneous tumours by the better sparing of healthy tissues.

EXPERIMENTAL FACILITY

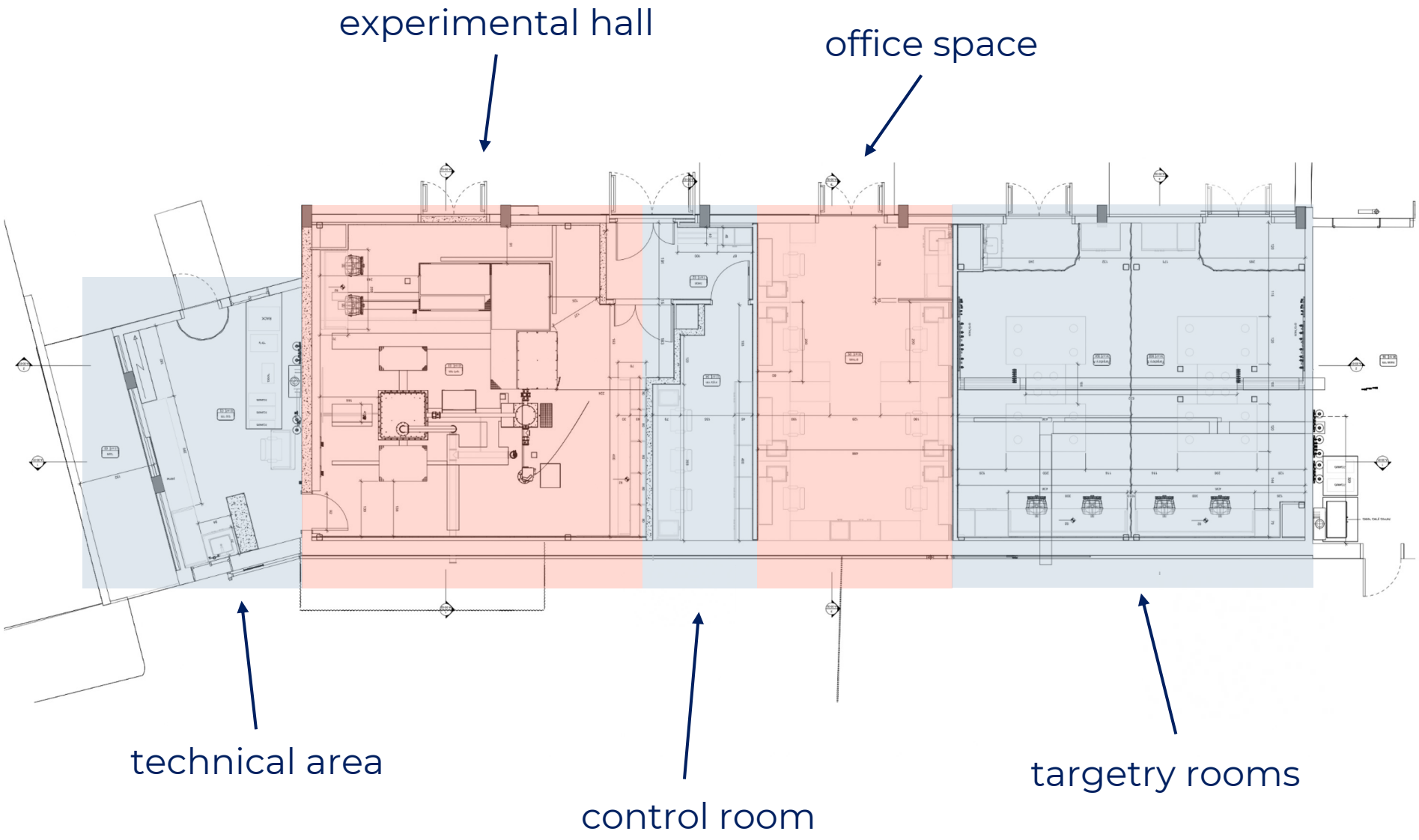
- 2x100TW Ti:Sa
- 30fs pulse length
- 2.7J per beam
- 1Hz repetition rate



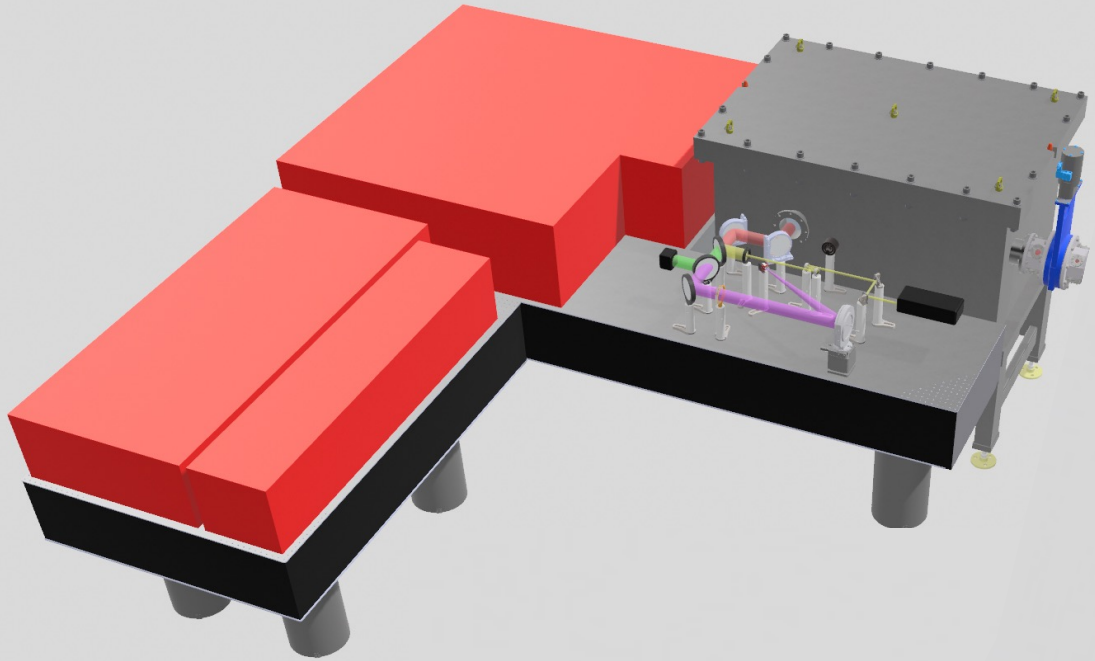
EXPERIMENTAL FACILITY

- large laboratory space
- two chambers
- fundamental science
- electron and proton acceleration

A NEW EXPERIMENTAL FACILITY



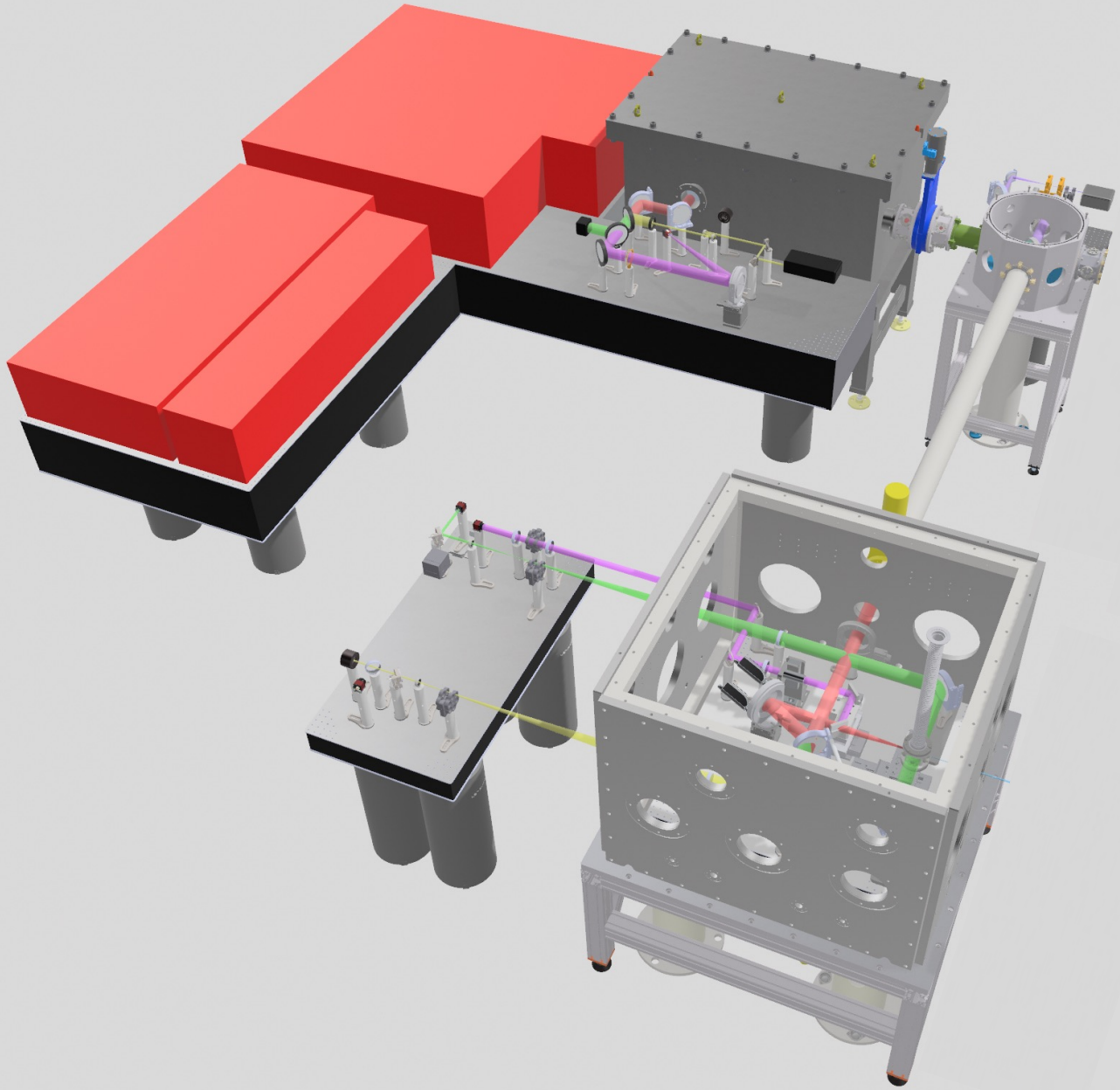
A NEW EXPERIMENTAL FACILITY



Laser :

- THALES
- 1.3 Joules per pulse
- 25fs pulse duration
- 5Hz repetition rate
- deformable mirror
- extensive diagnostics
  (wizzler, wavefront sensor, psf, spectrum)

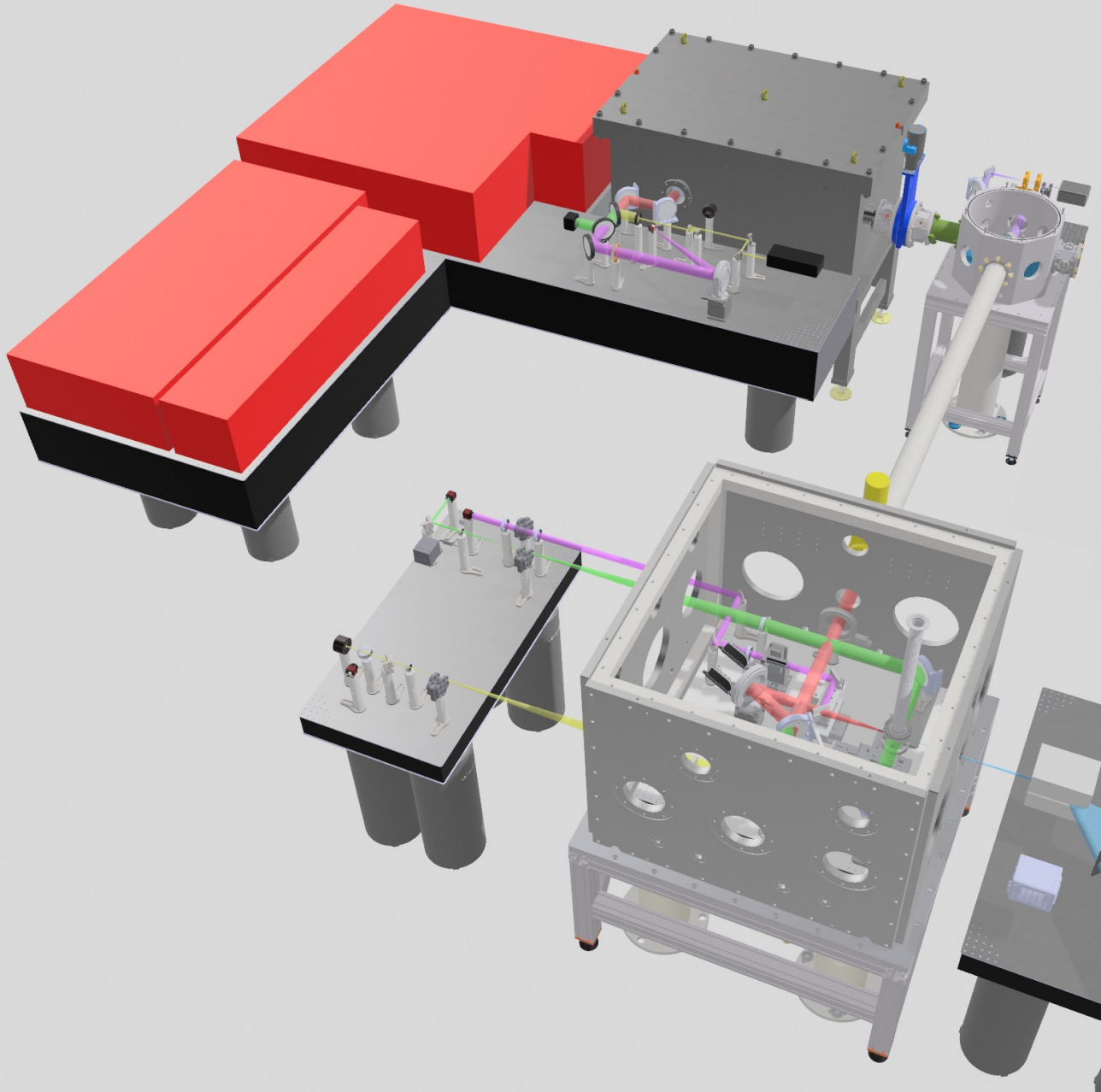
A NEW EXPERIMENTAL FACILITY



Laser beam line :

- in-vacuum
- stability
- guide beam
- plasma density
- shadowgraphy
- beam pointing
- gas target

A NEW EXPERIMENTAL FACILITY



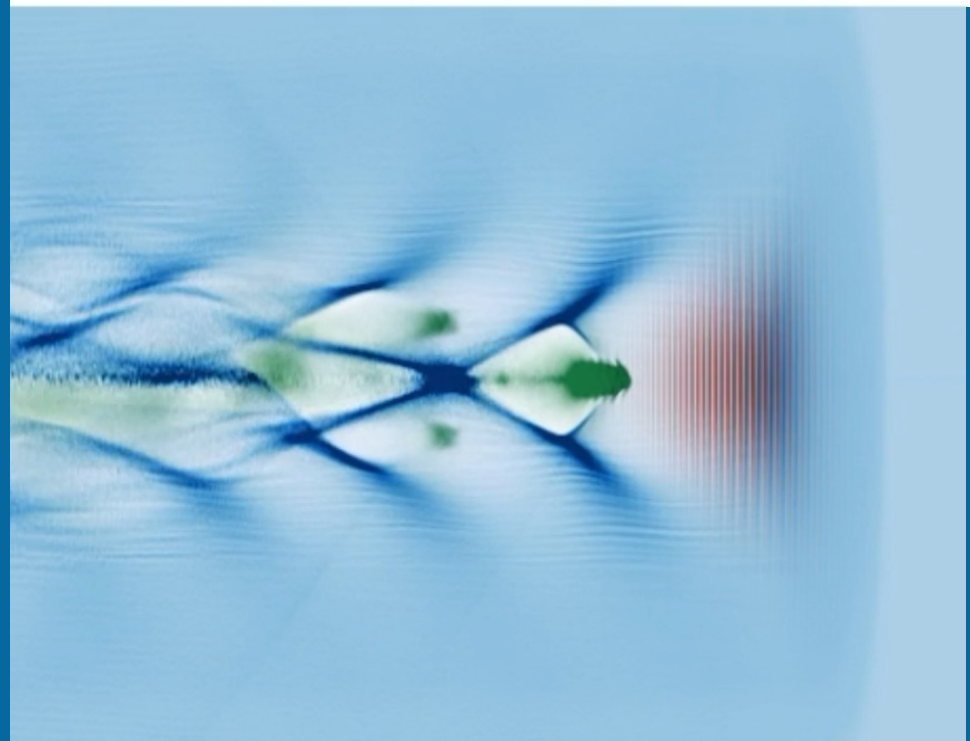
Electron line :

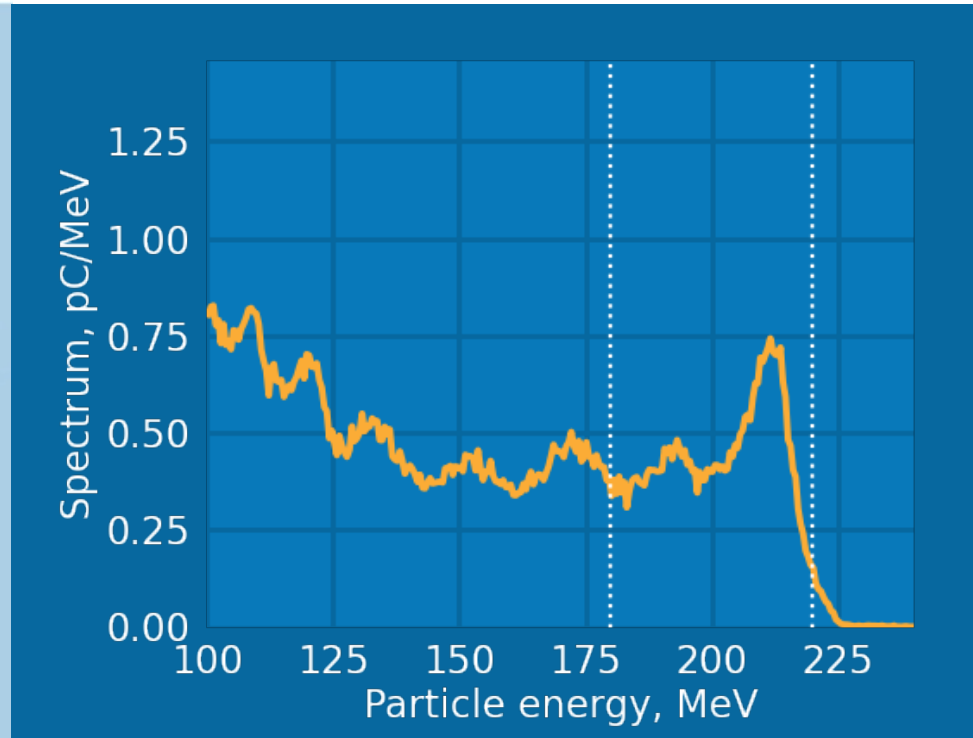
- spectrum
- charge
- phantom
- dosimetry
- quadrupoles

BEAM SIMULATIONS

- extensive pic simulations to prepare experimental optimisation
- ionization injection with air
- we aim at reducing the required laser energy
- source for further beam line simulations

electronic spectrum after acceleration in an air-jet
3mm long flat-top density, 500mJ, 25fs, 12µm waist, f-10

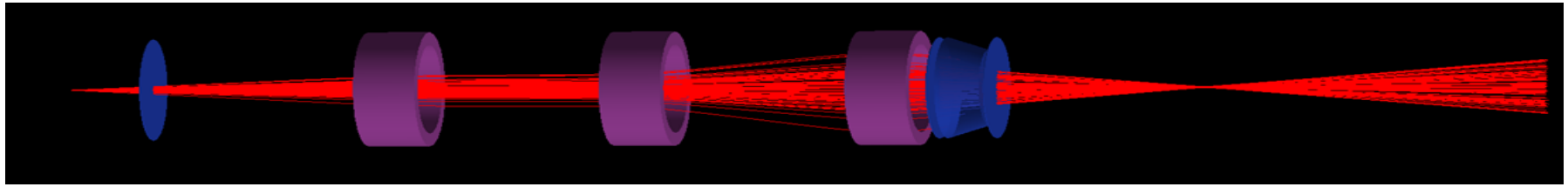




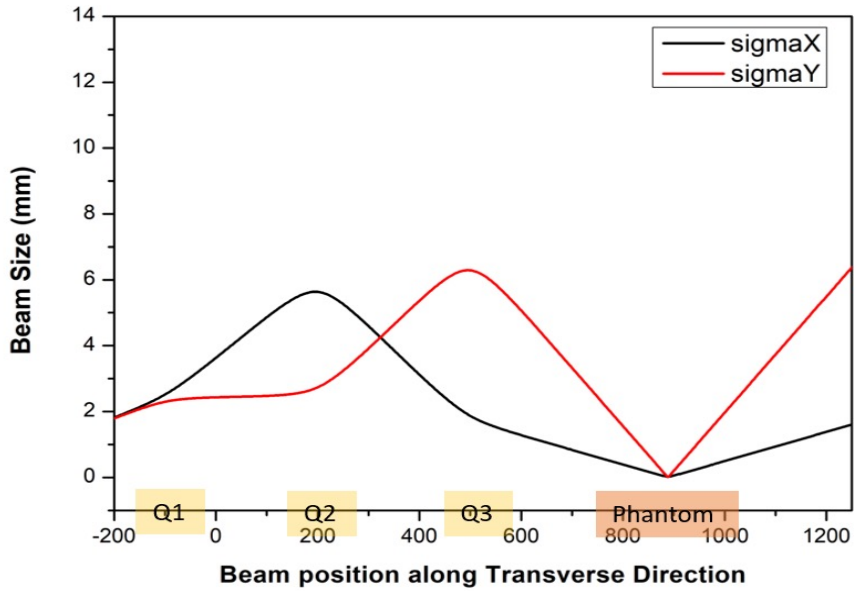
BEAM TRANSPORT - DESIGN

First version of our transport line :

- quadrupole triplet optimized for 250MeV VHEE
- a gaussian beam with 6mrad divergence is simulated in GEANT4
- better dose rates in lesser time and in less shots



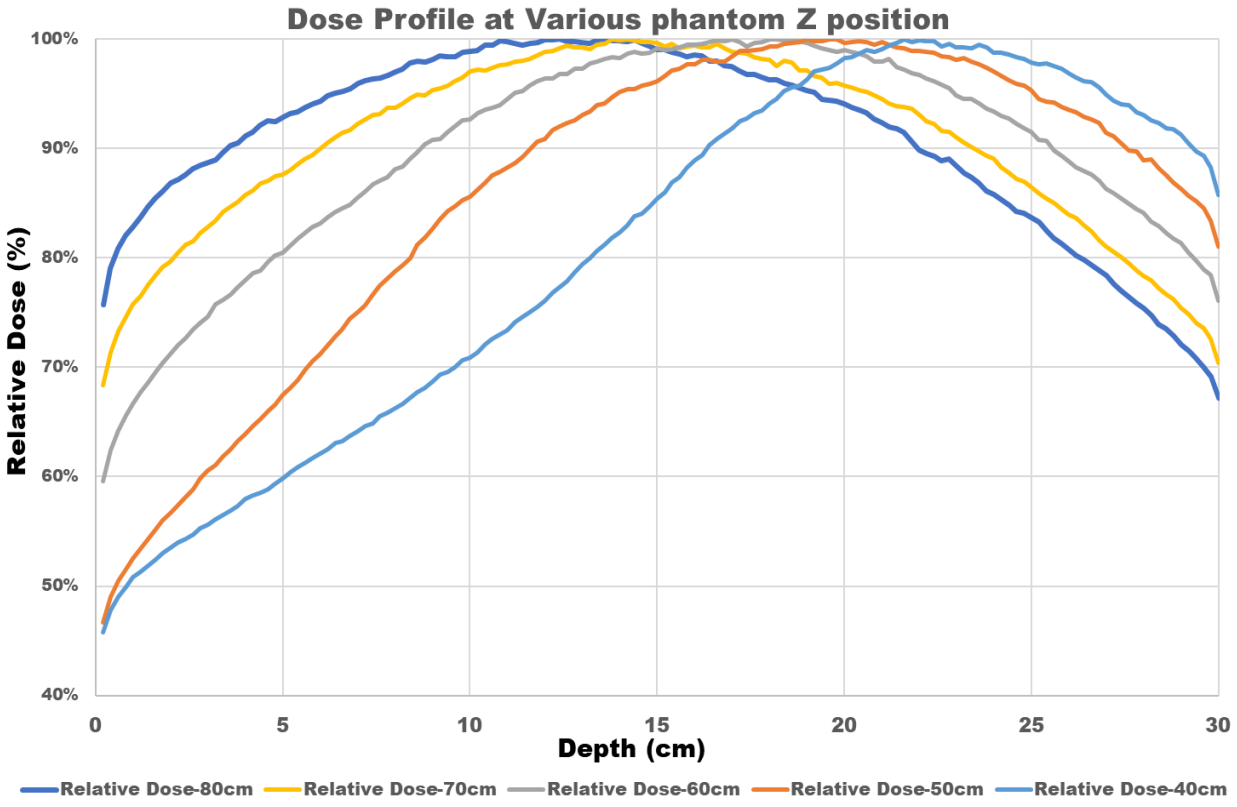
Triplet quadrupole beam focusing showing beam size along the transverse direction with sigma_x and sigma_y. At the focal point, the beam size is around 0.1 mm (in vacuum).



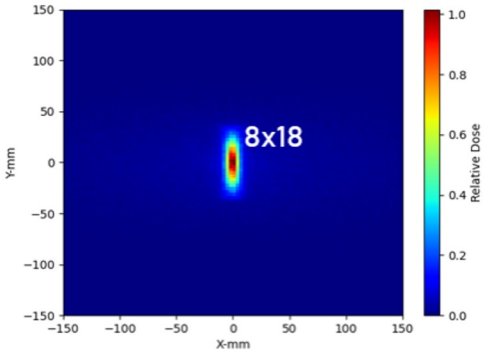
BEAM TRANSPORT – DOSE DEPOSTITION

First version of our transport line :

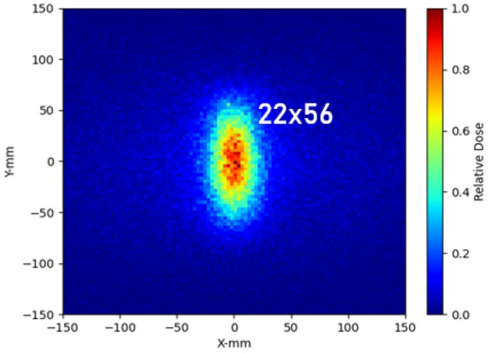
- broad on-axis dose profile resembles mono-energetic focused VHEE.
- peak-dose depth varies with relative phantom positioning down the line.
- linear relation between relative phantom position and peak dose depth



entrance dose profile

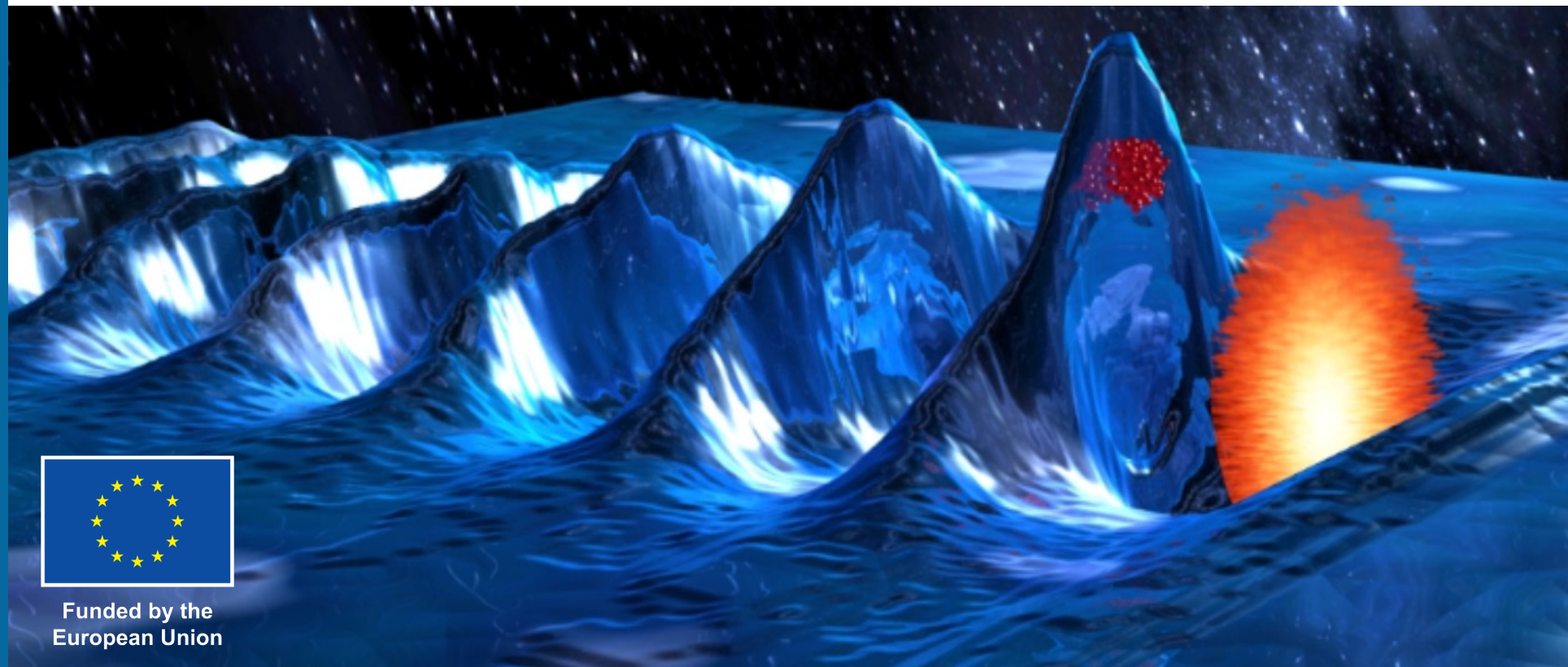


exit dose profile



CONCLUSION

- we are developing low-cost, low-footprint technology for VHEE radiotherapy that will fit in existing treatment rooms
- a new dedicated experimental facility is in construction
- beam transport line with focusing quadrupole triplets improve dose deposition and offer peak dose depth tuning
- 3D single-shot dosimetry via tomographic reconstruction



Funded by the European Union

THE TEAM

THANK YOU !

Industrial & Oncology Advisory Board: Prof. Dr. Michael Baumann (German Cancer Research Center), Prof. Katia Parodi (LMU Munich), Prof. Eric Deutsch (Institut Gustave Roussy), Mr. Kal Fishman (Empyrean Medical Syatems), Mr. Christophe Simon Boisson (Thales LAS France)

Funded by the European Union