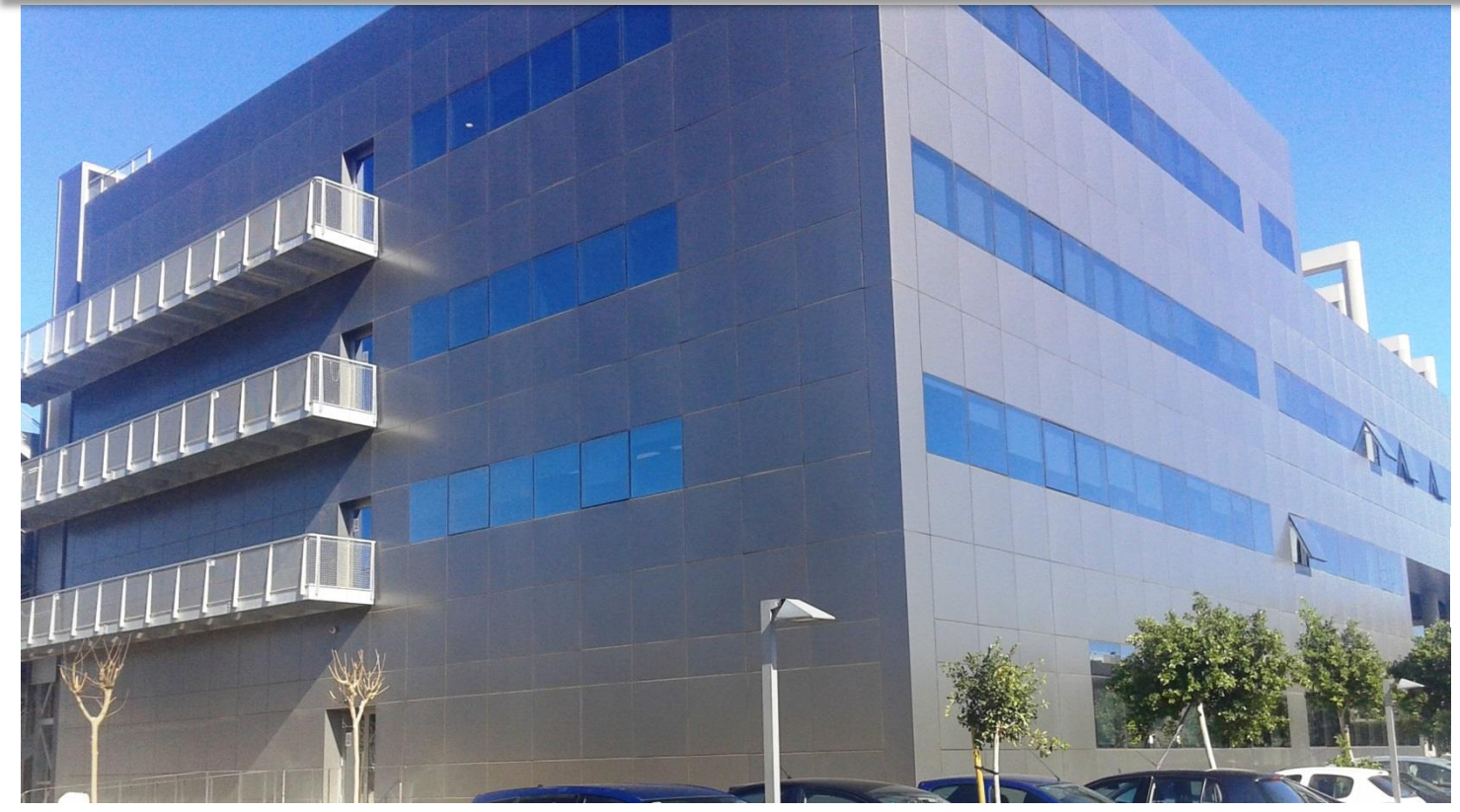
I JORNADAS RSEF / IFIMED de Física Médica

10-11 Marzo 2016 IFIC- VALENCIA

IFIMED: A FACILITY FOR MEDICAL APPLICATIONS OF PHYSICS



José Bernabéu

IFIC, Valencia

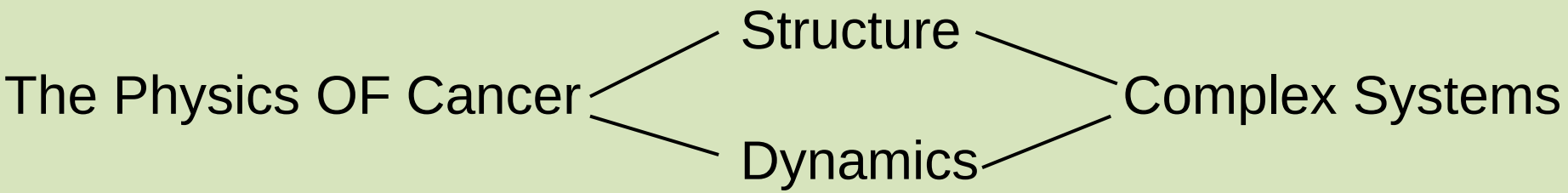
VNIVERSITAT DE VALÈNCIA

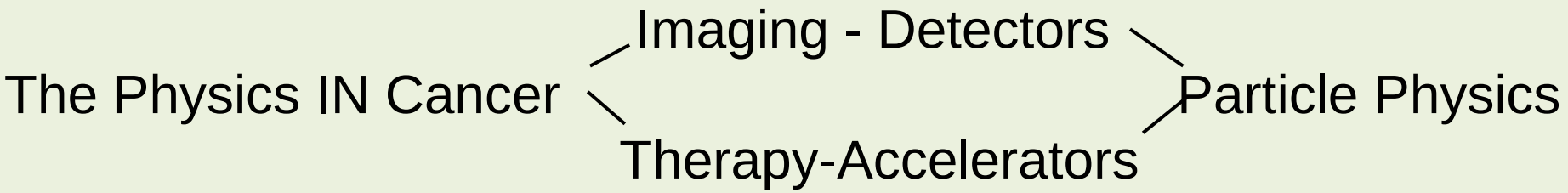
CSIC Consejo Superior de Investigaciones Científicas

IFIC Institut de Física Corpuscular

EXCELENCIA SEVERO OCHOA

OUTLINE





Physics OF Particle Therapy ---------- Atomic-Molecular Physics

IFIMED: Facility for Medical Physics

- Phase I for labs. Radiofrecuency and Detectors completed
- Small Animal PET Scanner as University of Valencia Service
- Plan for Phase II → Experimental Hall + PROTONTHERAPY

PARTICLE THERAPY and IMAGING are no longer Disjoint Activities

COMPLEX SYSTEMS

- CASCADING FAILURES
- They may be OPEN
- They may have a MEMORY
- They may be NESTED

- DYNAMIC NETWORK of MULTIPLICITY
- They exhibit EMERGENT BEHAVIOUR
- Relationships are NON-LINEAR
- Relationships contain FEEDBACK LOOPS

CONVERGENCE OF BIOLOGICAL AND PHYSICAL SCIENCES

THE PHYSICS OF CANCER

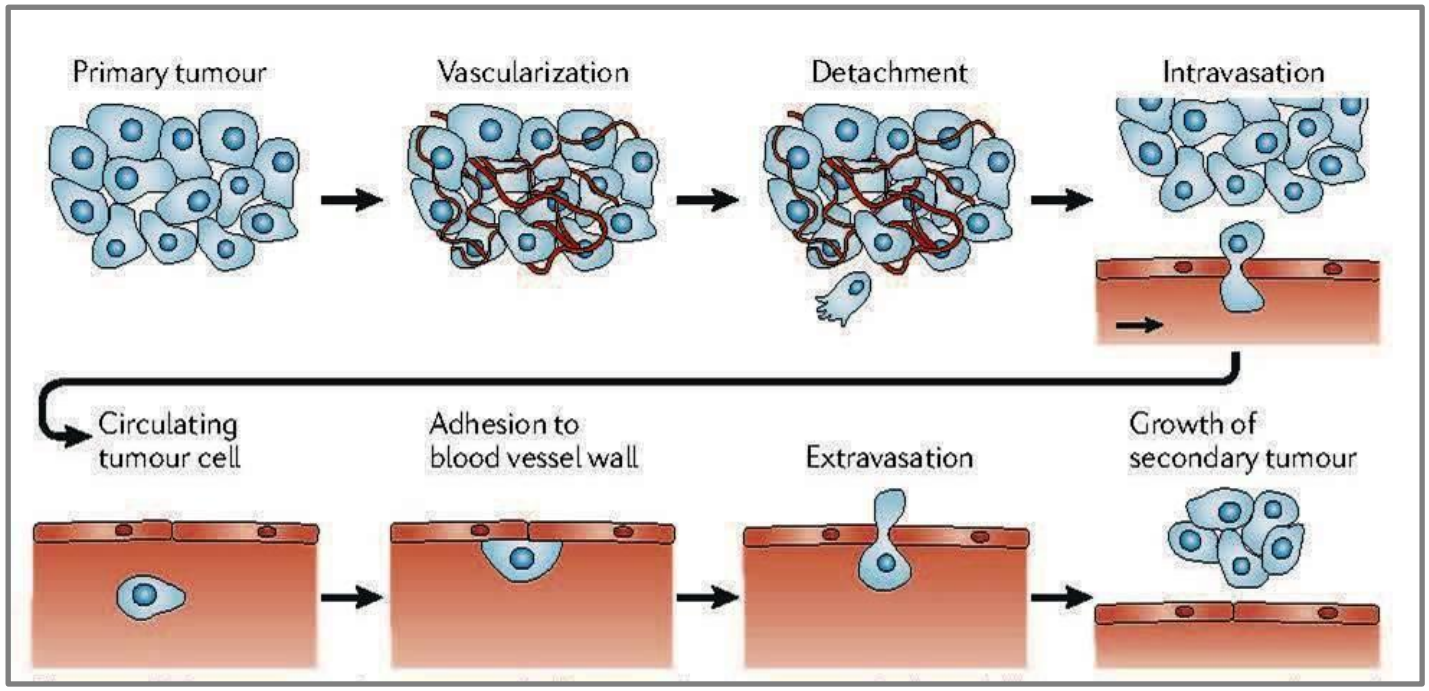
PERSPECTIVES

nature REVIEWS CANCER

OPINION

The physics of cancer: the role of physical interactions and mechanical forces in metastasis

Denis Wirtz, Konstantinos Konstantopoulos and Peter C. Searson

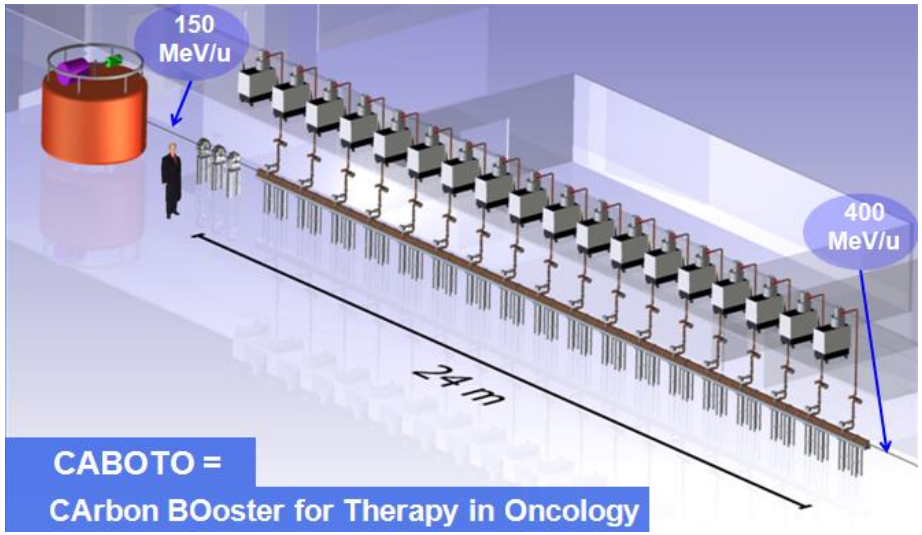


IFIMED

IFIMED is a Facility for Research and Development of applications of the techniques of Particle and Nuclear Physics to the therapy and diagnostics of oncological and neuro-degenerative diseases. Such a facility is now completed in PHASE I with Scientific Equipment for RESEARCH in components of particle accelerators, particle detectors and image science, as well as a research PET scanner for, among other topics, radiobiological studies.

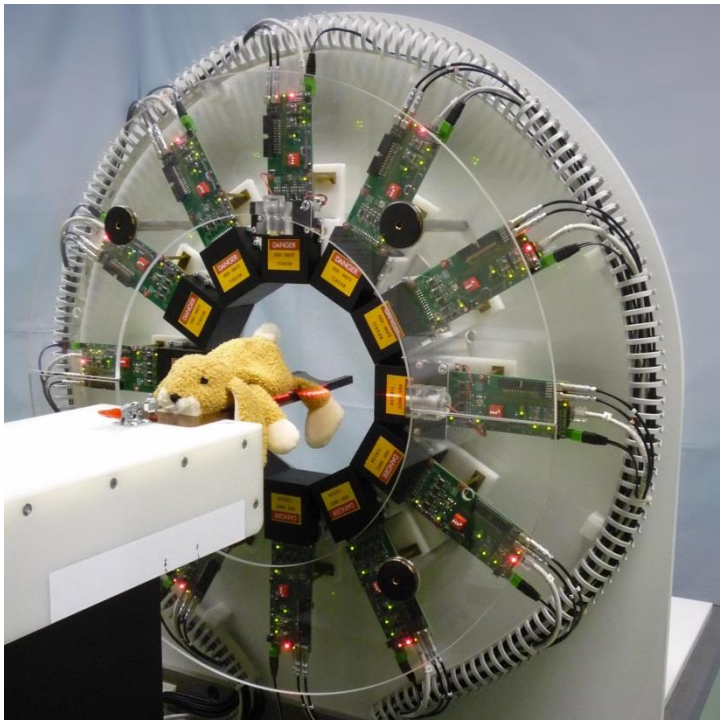
GAP *Cyclinac* = cyclinac

+ fast-cycling high-frequency RF linac



Variable Beam Energy

+ High Gradient



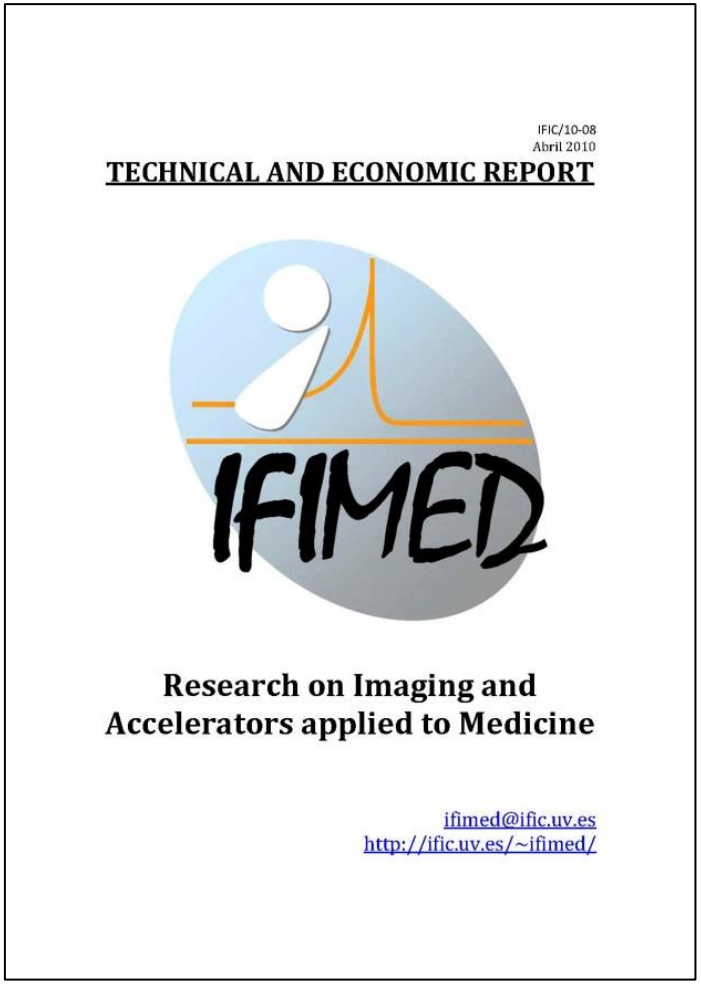
SMALL PET SCANNER

BASED O MRI-COMPATIBLE LIGHT SENSOR

IFIMED

The Scientific-Technical and Economic Report was approved by CAIS, the Ministerial Committee for Singular Infrastructures, in 2010.

At present, Phase I for Scientific Equipment of accelerator and imaging labs has been completed and mainly supported by FEDER under the Agreement between the State Secretary of Research and the University of Valencia.



INTERNATIONALIZATION

Since 2007, IFIMED is a member of **ENLIGHT**, the European Platform of Particle Therapy Centers for activity in Medical Physics, coordinated by CERN, the European Laboratory for Particle Physics. ENLIGHT has been essential in the promotion of European Collaborations and Projects funded by the EU.

These research projects include **PARTNER**, The Particle Training Network of European RadioTherapy, **ENVISION**, the on-line non-invasive monitoring of the application of hadrontherapy to patients -Imaging in Real Time-, **ENTERVISION**, **OMA**, the Optimization of Medical Accelerators, and **OpenMED** (Bio-LEIR), the design of a prototype of an ideal accelerator for Particle Therapy taking advantage of the Bragg Peak.

http://partner.web.cern.ch/partner/

ENLIGHT

http://enlight.web.cern.ch/

OMA

ENVISION

COOPERATION

http://envision.web.cern.ch/ENVISION/

KNOWLEDGE AND TECHNOLOGY TRANSFER

Its technological applications will imply the transfer of knowledge and innovation to the Spanish medical and industrial sectors.

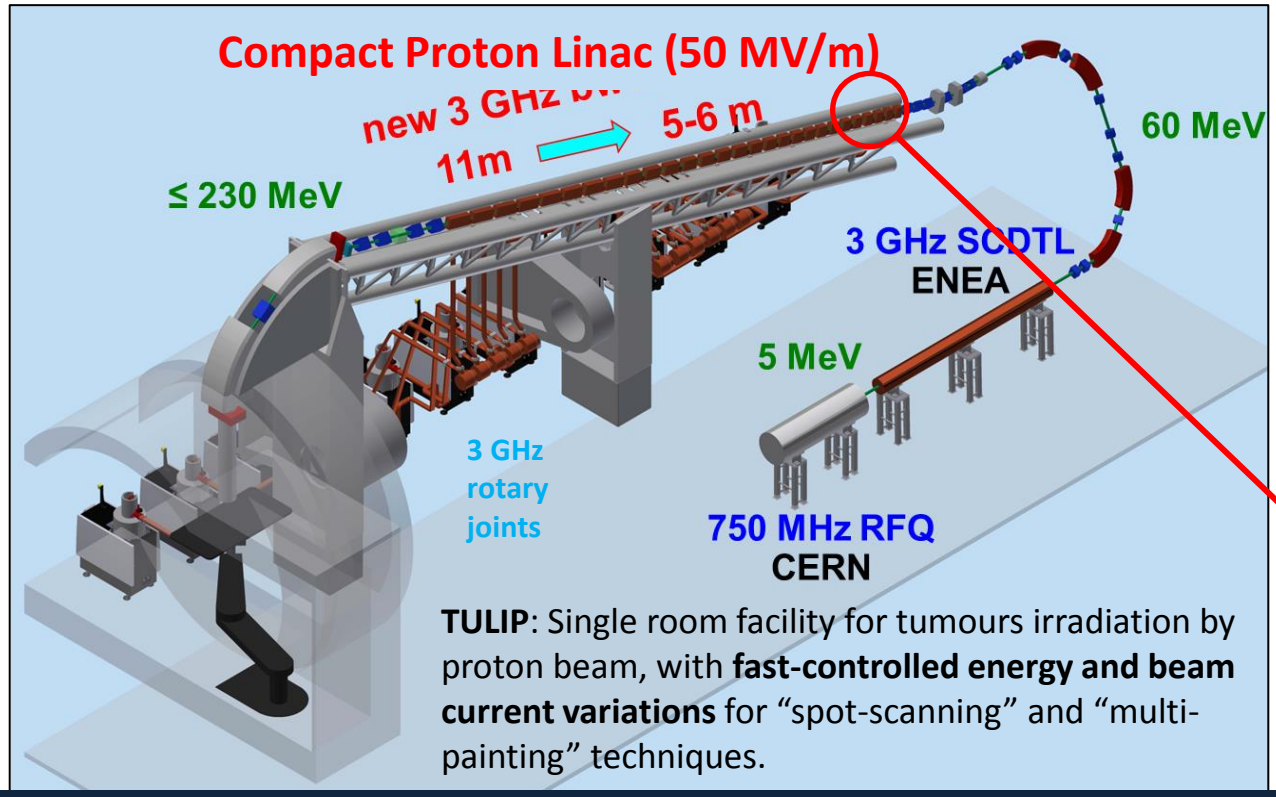
IFIMED conceived as a Facility for USERS. The High Gradient-Radiofrequency Lab. will be part of an European Network coordinated by CERN, and the Small Animal PET Scanner is integrated in the Centre of Services of University of Valencia.

HIGH-GRADIENT IN HADRON THERAPY ACCELERATORS

This work is developed within the framework of a Knowledge and Transfer (KT) project thanks to a collaboration agreement between IFIC and CERN:

- KT “High-Gradient accelerating structures for proton therapy”
- KE2638/BE/CLIC “Development of accelerator science and technologies associated with the CLIC accelerating structure design”

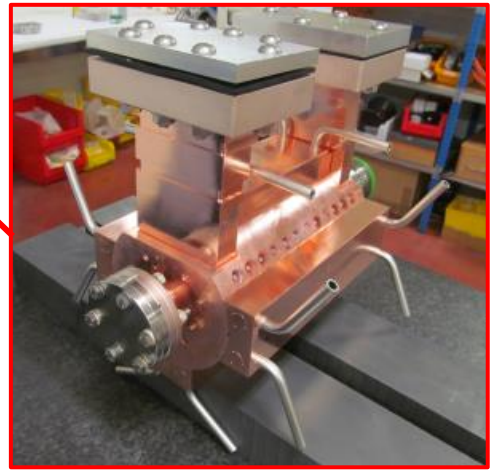
The scope of this project is the design, construction and high-power test of two high-gradient prototype 3 GHz accelerating structures at 76 MeV and 213 MeV of a proton linac destined for the TULIP (Turning Linac for Proton therapy) project.



TULIP: Single room facility for tumours irradiation by proton beam, with **fast-controlled energy and beam current variations** for “spot-scanning” and “multi-painting” techniques.

First prototype produced following the CLIC standard procedure.

To be tested in CTF3 (CLIC Test Facility) in 2016 and later at IFIMED

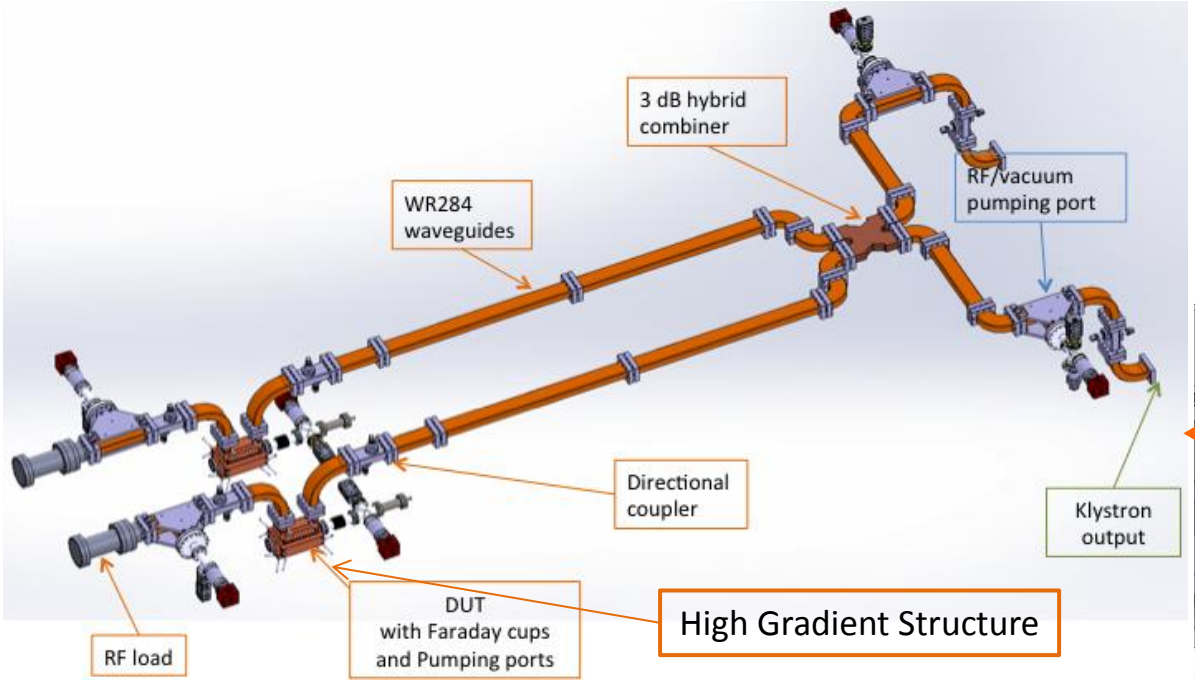


HG-RF laboratory

Aim: High-gradient research topics at 3 GHz (RF testing, breakdown studies, structure conditioning…)

Technical specifications:

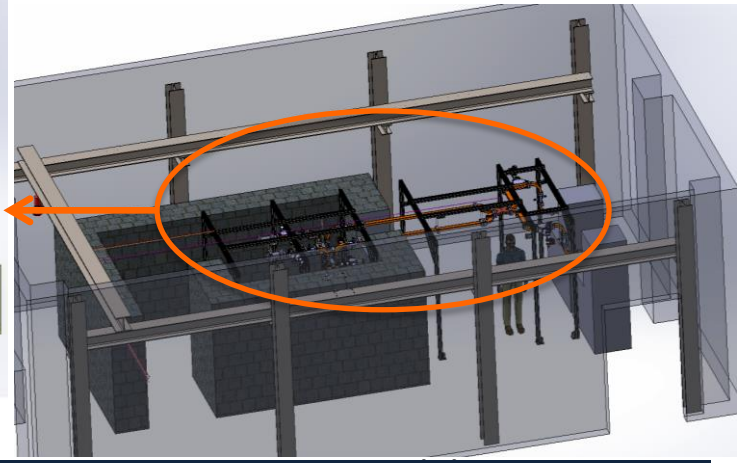
- Pulsed High Power RF (HPRF) in S-Band (2.9985 GHz) :
  - 2 x pulsed power klystron+modulator (up to 7.5 MW, 5 us pulse, 400 Hz)
  - High power waveguide RF network that allows power combining: enables to test 2 structures at a time at up to 15 MW, 5 us pulse, 200 Hz repetition rate
- Low level RF (LLRF): real-time control system with fast system interlock based on Ni-PXI acquisition system
- Running on Ultra-High vacuum (10^{-9} mbar)



Purchase of equipment finalized

Commissioning on-going

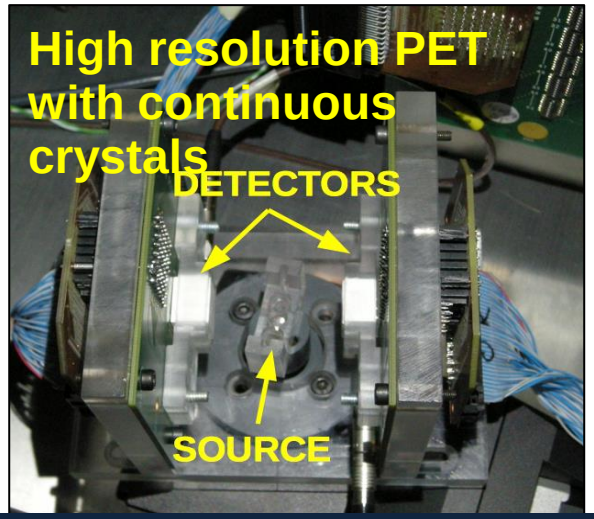
First accelerating structures to be tested along this year

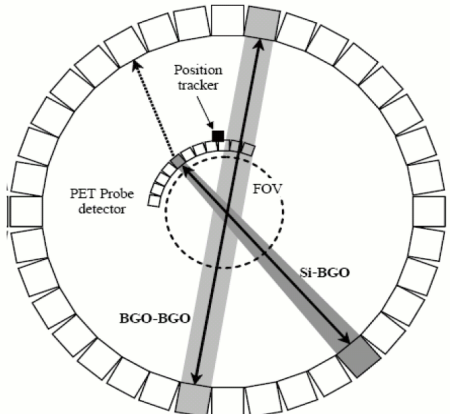


IFIMED Imaging laboratory

- Fully equipped medical imaging laboratory.
- Activities focused mainly on **PET** and **Compton imaging**, in different types of systems and for different applications. National and European projects.
- It includes simulations, detector development and image reconstruction.

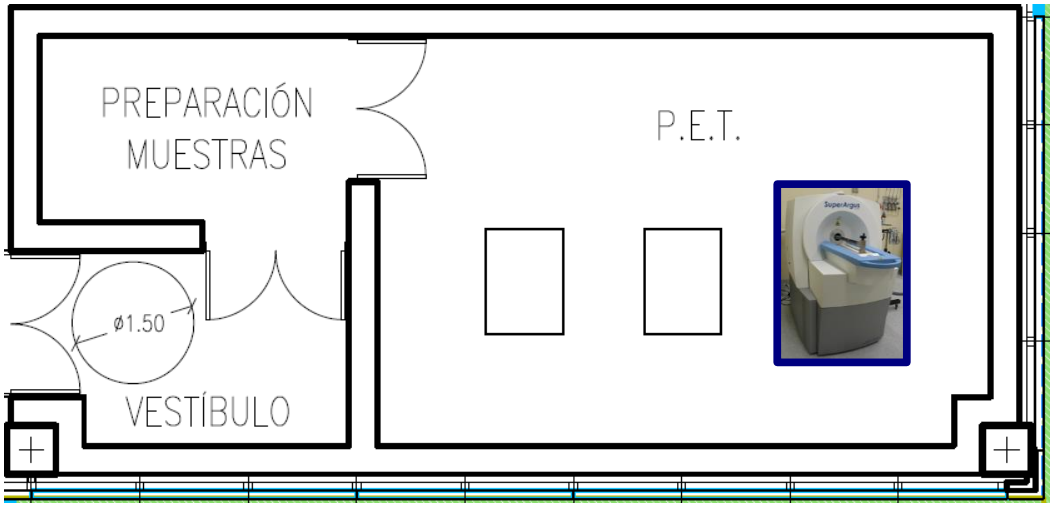
TECNIQUES	SYSTEMS
• Positron Emission Tomography (PET) • Compton Imaging	• PET • Probes • Dose monitoring in hadron therapy





PET magnifying probe

SMALL ANIMAL PET SCANNER

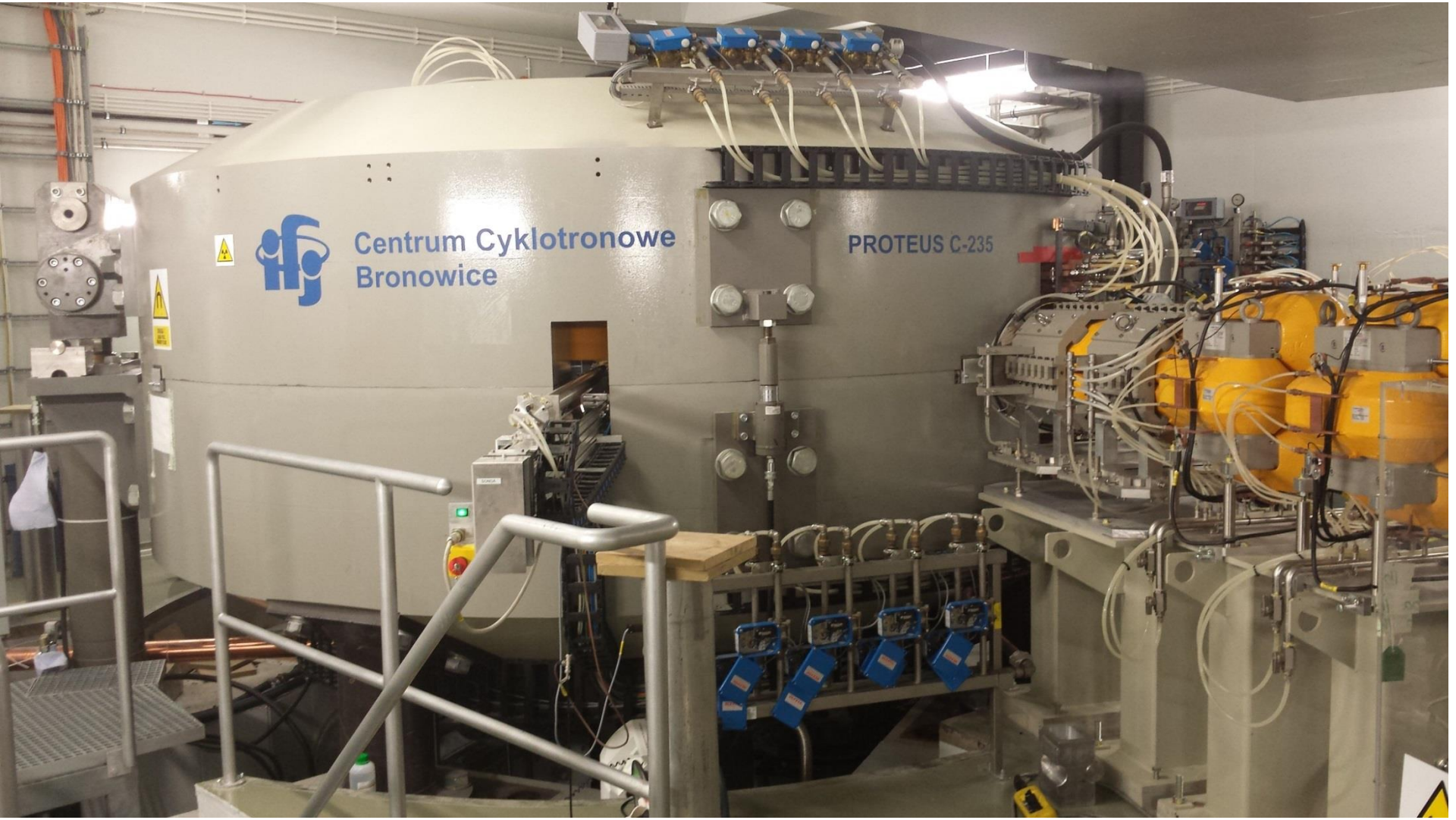


- Equipped with an **small animal PET/CT**
- It will be possible to use **FDG**
- The facilities are ***offered as a service***
  - For **end-users** (require only images)
    - Biomedical research (images of rats/mice …)
    - X-ray based tomographic images (CT)
  - For **research users** (require deeper knowledge)
    - Detector development (Si inserts, …)
    - Image science (novel reconstruction methods, model validation, etc...)

Being included into the "**Central Services of experimental research support**" of the University of Valencia scsie.uv.es

SMALL ANIMAL PET SCANNER

Phase II PROTONTHERAPY WITH CYCLOTRON + Experimental Hall

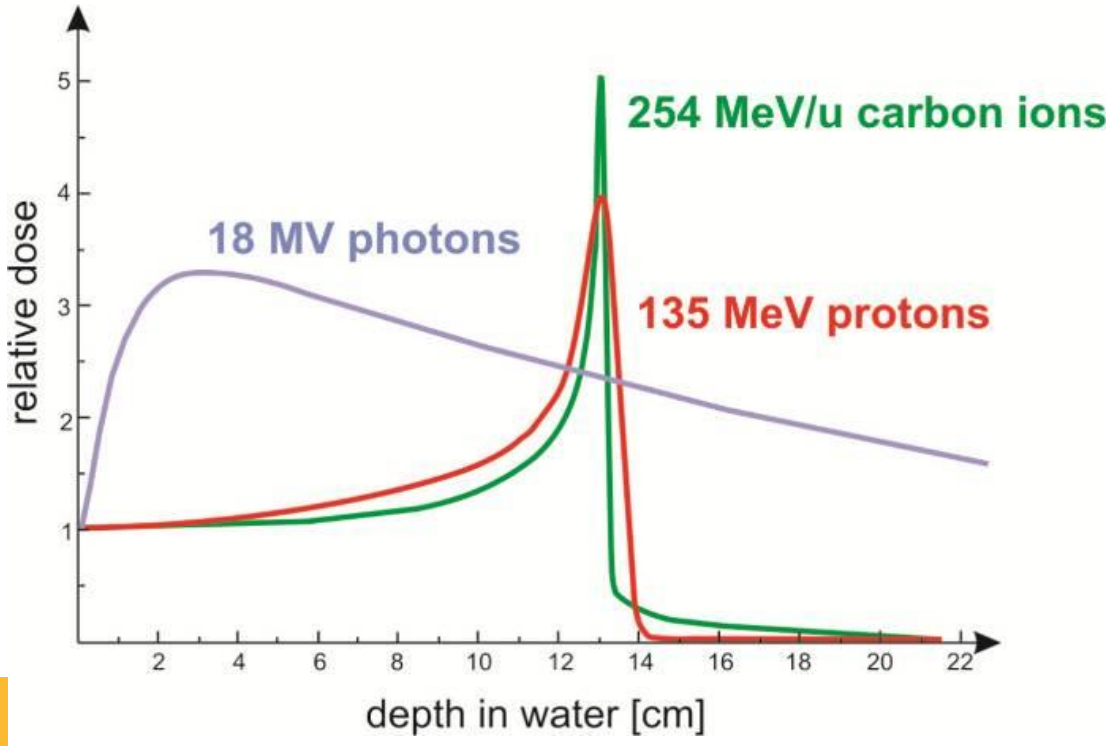


THE RATIONALE OF HADRON THERAPY

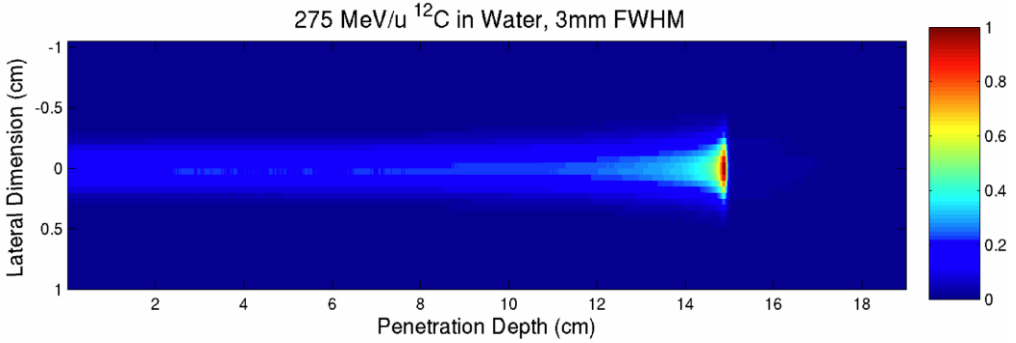
Conformal dose distribution results in saving healthy tissue

- **Dose distribution**

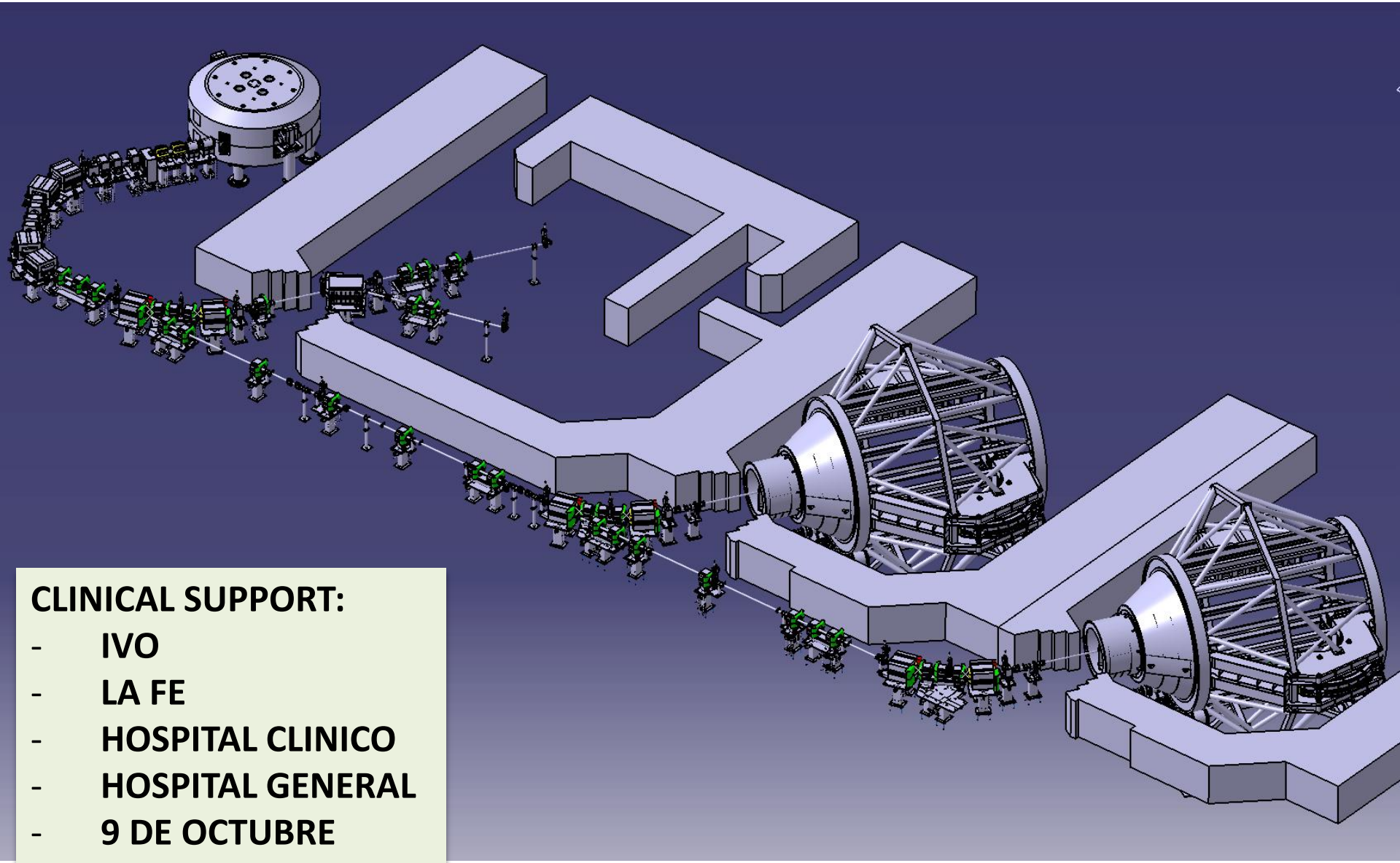
- **Verification**



PROTONTHERAPY IS BOOMING IN EUROPE:
~ 20 centres



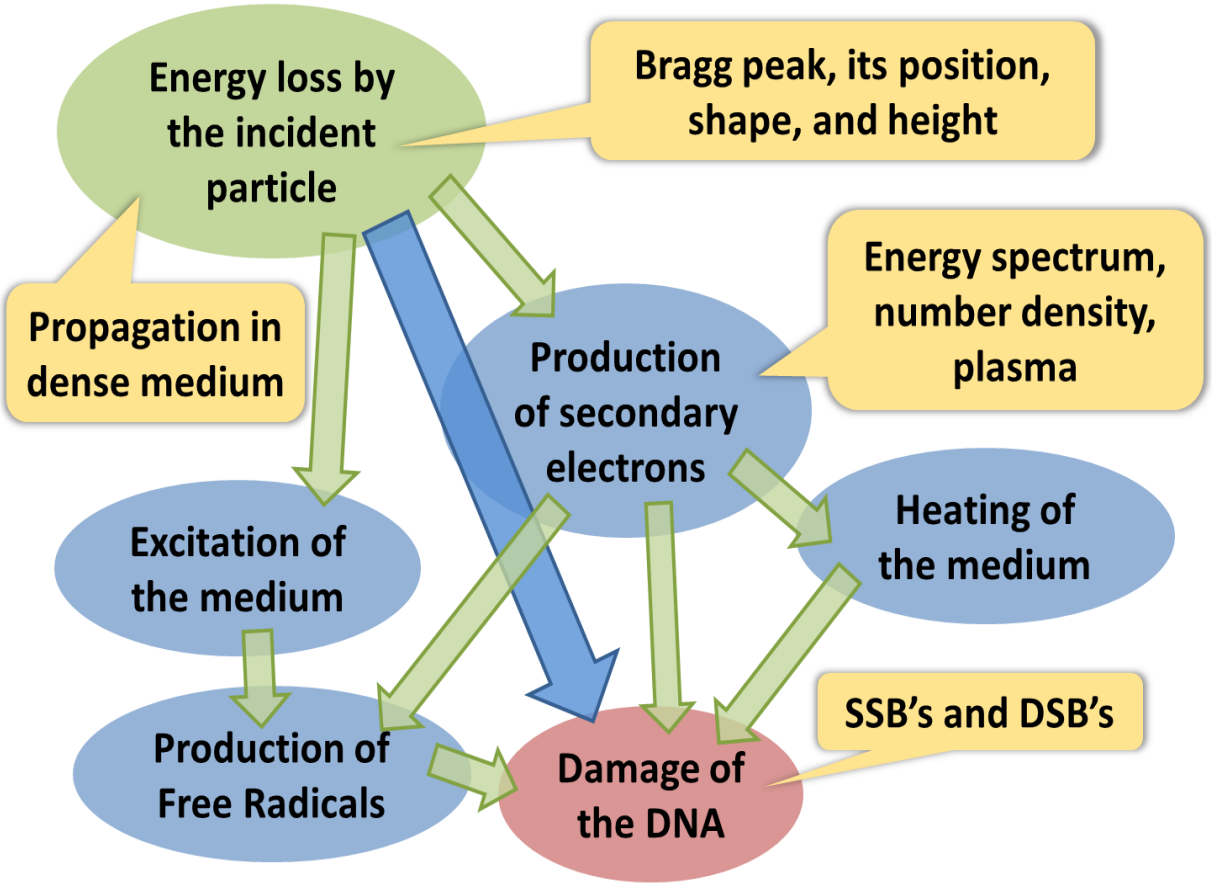
MINIMAL FACILITY

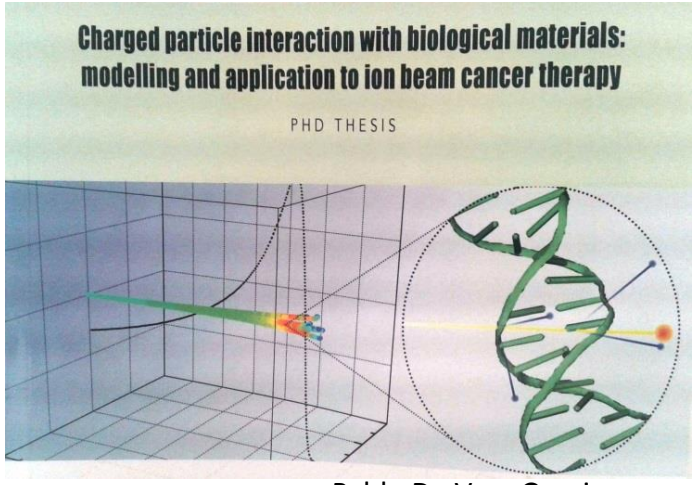


CLINICAL SUPPORT:

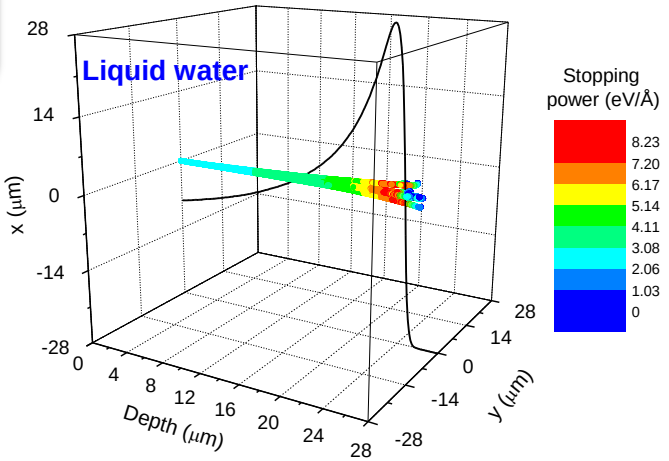
- **IVO**
- **LA FE**
- **HOSPITAL CLINICO**
- **HOSPITAL GENERAL**
- **9 DE OCTUBRE**
- **…**

PHYSICS OF PARTICLE THERAPY



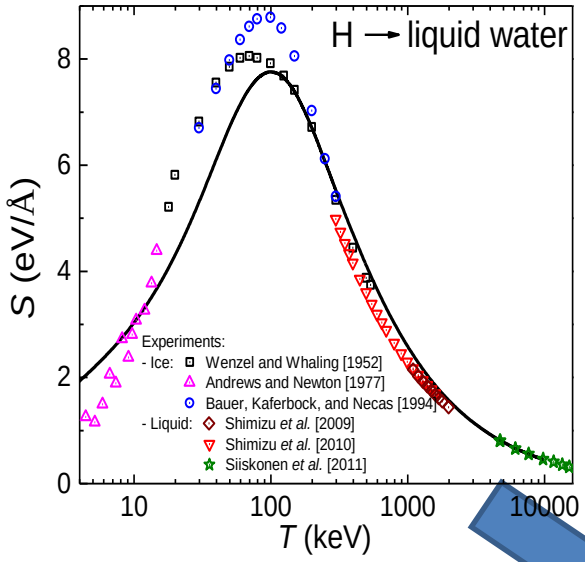


Pablo De Vera Gomis

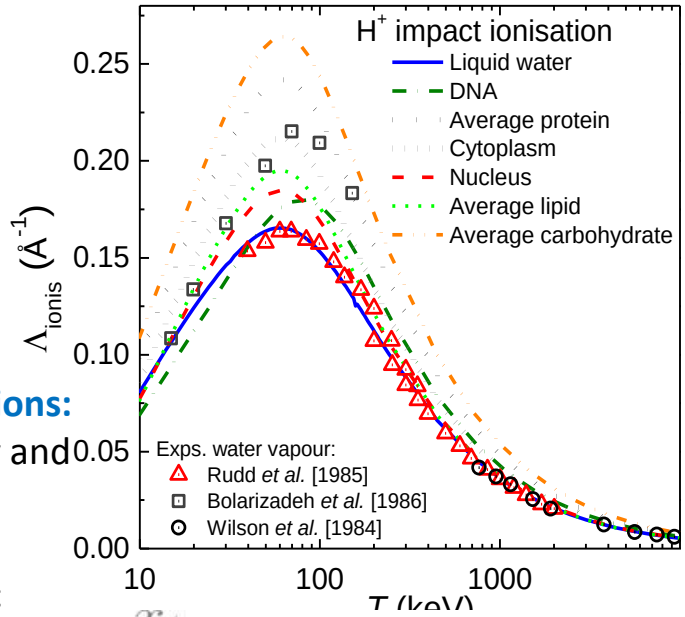


Monte Carlo and Molecular Dynamics simulation:
Propagation of swift ions in condensed biomaterials

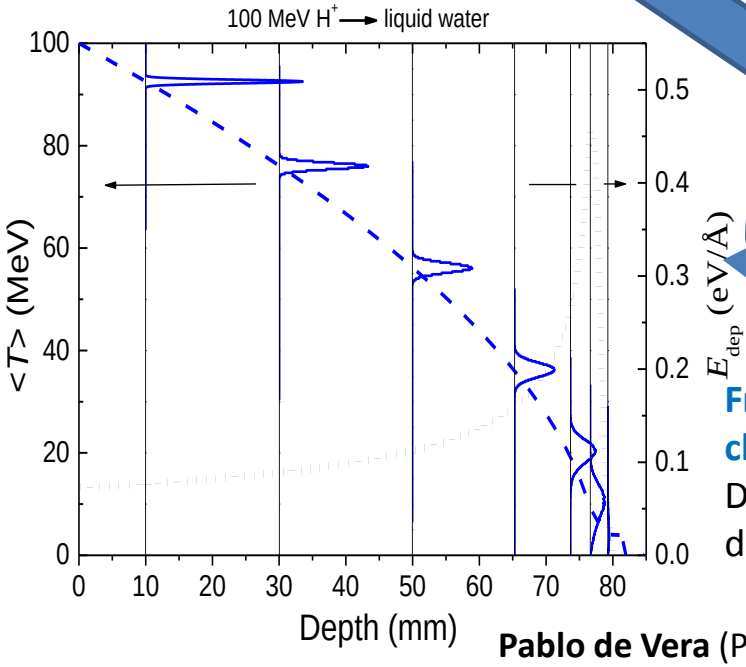
Physical modelling of ion beam cancer therapy



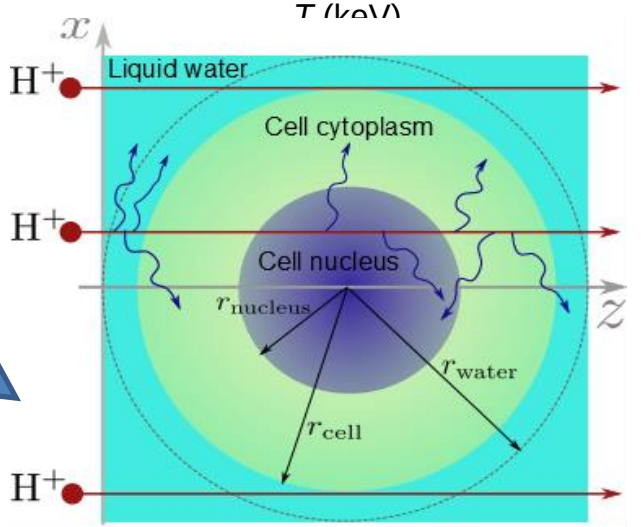
Electronic slowing down of charged particles:
Calculation of accurate stopping quantities of condensed biotargets for swift ions and electrons



Ionisation cross sections:
Calculation of energy and angular spectra of secondary electrons ejected from realistic biomaterials



From macroscopic beam characteristics:
Dose delivered, energy distribution of the beam…



Down to cells:
Model for ion irradiation of realistic subcellular compartments

Pablo de Vera (PhD Thesis, Universitat d'Alacant)
Isabel Abril (U. Alacant) and **Rafael Garcia-Molina** (U. Murcia)

OpenMED (Bio - LEIR) at CERN

A Biomedical facility at CERN,

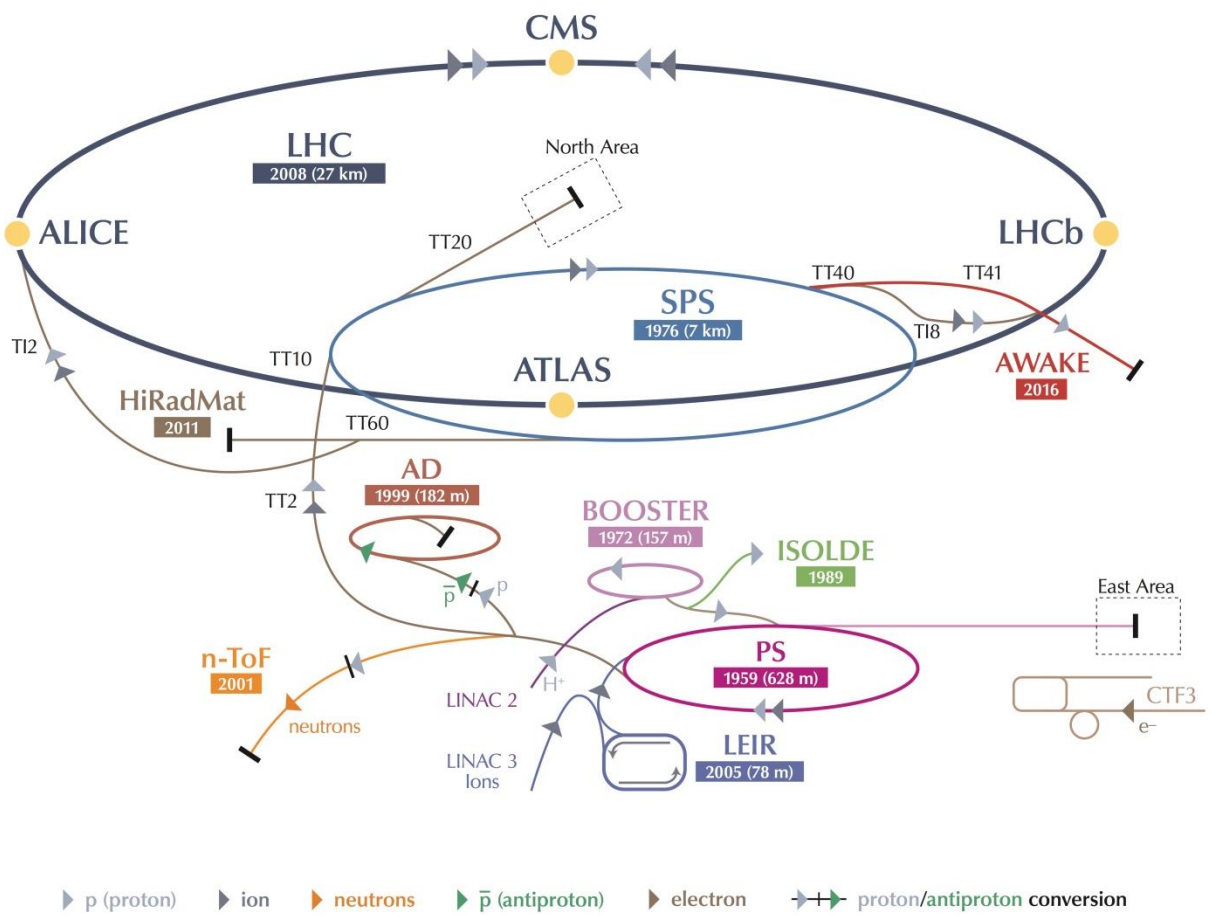
to provide particle beams of different types - p, He, Li, C- and energies to external users for radiobiology and detector development,

and to allow iterative experimental verification of simulation results.

FINAL OBJECTIVE → Ideal Design and Construction of an Accelerator Prototype for PARTICLE THERAPY

Bi-Annual Meetings for the Follow-Up of the Project: Divonne, France, February 2014, 2016, ...

Why at CERN?



CONCLUSION

- PHYSICS will continue giving applications to MEDICINE: Research, Imaging, Accelerator Therapy,…
- MEDICAL PHYSICS inserted within the Spanish Science System in the National Programme of Particle Physics and Accelerators FPA.
- Once Phase I of IFIMED is completed as a Research Facility, the conditions are met to enter Phase II with a Cyclotron for Experimental Hall + A Protontherapy Centre of GVA
- European Coordination, with CERN leadership, gives an Added Value to the objective of

PHYSICS FOR HEALTH.