Technological Developments and Radiobiological Studies on Novel Hadron Therapy Techniques

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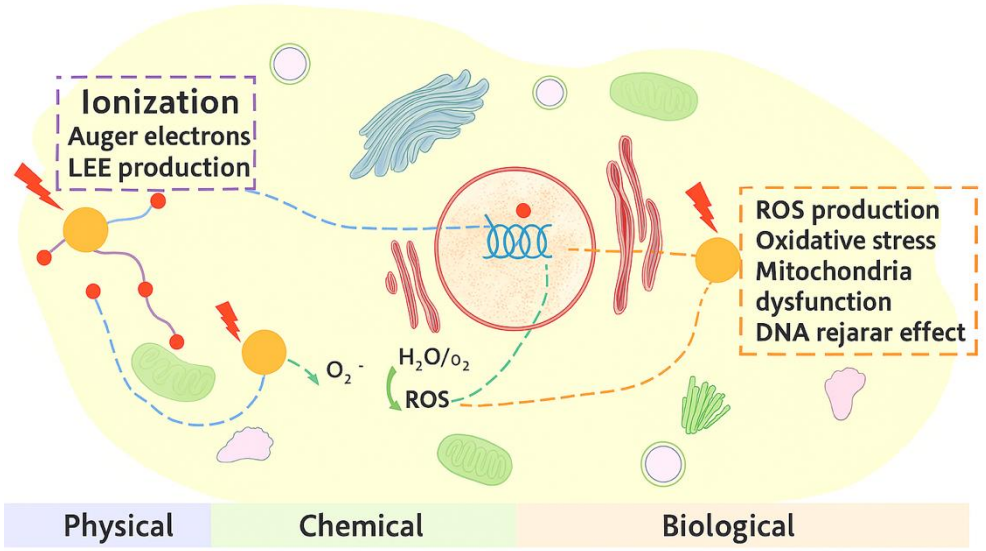
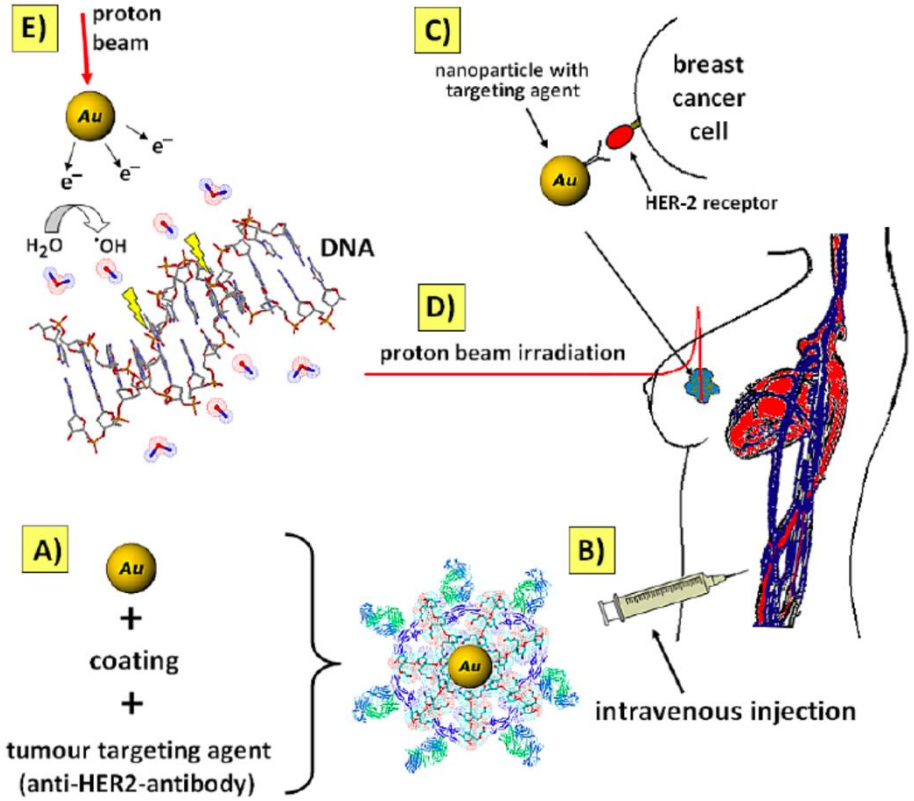
Física Médica S8A
17 February 2026

Metallic nanoparticles as radiosensitizers

❑ **Several experiments *in-vitro* and *in-vivo*** demonstrated the potential of high-Z NPs to enhance the efficacy of proton therapy





❑ **Main challenges :**

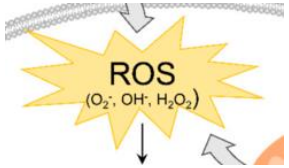
- **Insert** the NPs **only** into the tumour cells
- **Control** the concentration and biodistribution within the treatment duration and after
- **Modelling** of the phenomenon for **treatment planning**
  - ✓ Subjacent mechanisms behind the effect are still controversial

Goals

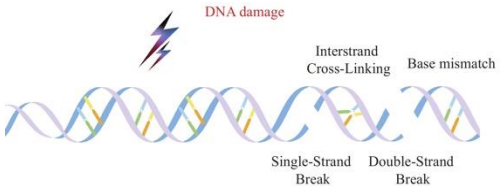
❑ **Multidisciplinary collaboration**
(Biochemist, Physicist, Biologist, Chemist)

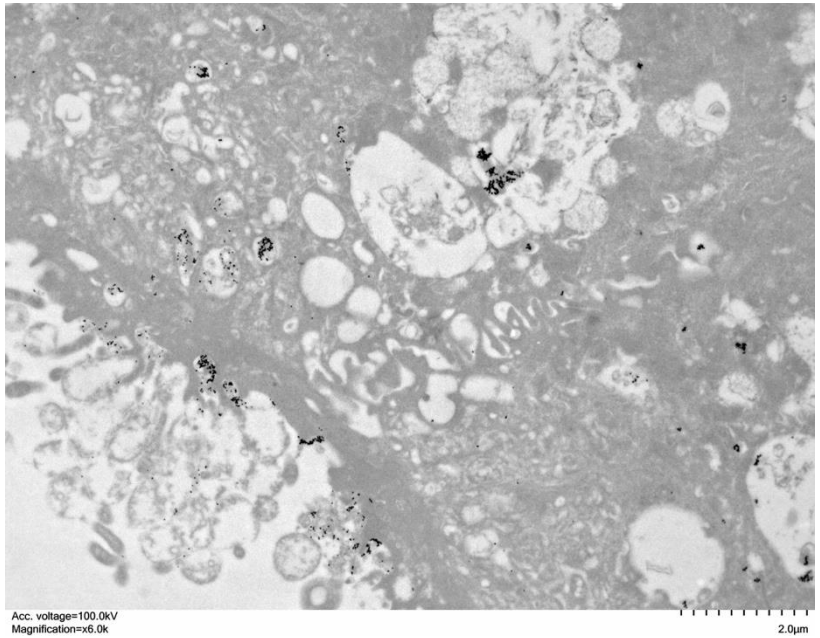
❑ **Radiobiology experiments** to study the radiosensitization effect of **gold NPs with protons**

- Evaluate, quantify the effect and modelling studies
  - ✓ Clonogenic assays

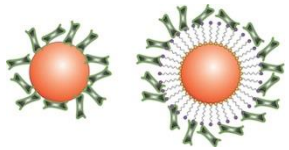


- Investigate the underlying mechanisms
  - ✓ ROS
  - ✓ DNA damage assays
  - ✓ Proteomic studies



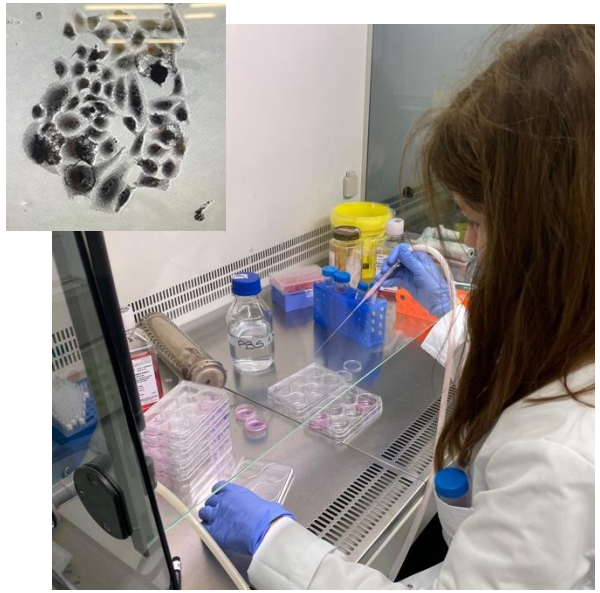


- Develop and test selective nanoparticles
  - ✓ First prototype for prostate cancer under test



Radiobiology experiments

- **Nanoparticles characterized at UV**
- **Biological samples for irradiation** prepared at **CABIMER** (*Centro Andalúz de Biología Molecular y Medicina Regenerativa*)
- **Irradiations** performed at the Cyclotron External Beam Line at **CNA** (*Centro Nacional de Aceleradores*)
  - ✓ Optimized for 3 cm ⌀ homogeneous irradiation fields
  - ✓ **In-line dose measurements**



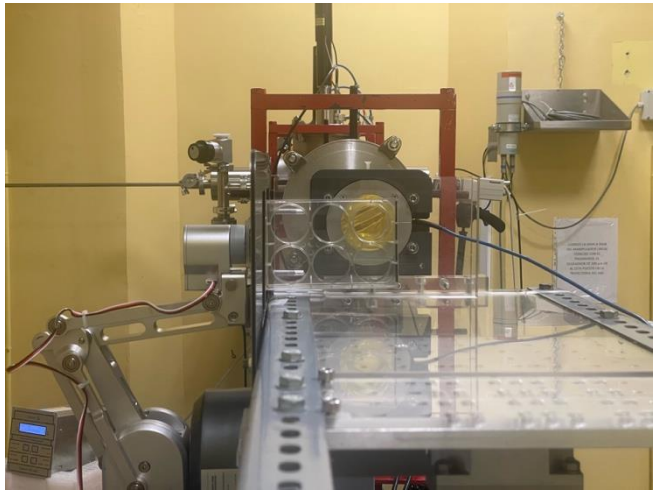
Operational since 2025

In collaboration with V. Girbés, J. L. Sanchez

Founded by : **Desarrollos para la terapia con protones (IP: Carmen Jiménez Ramos)**

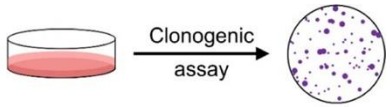
Financiado por la Unión Europea

Plan de Recuperación, Transformación y Resiliencia



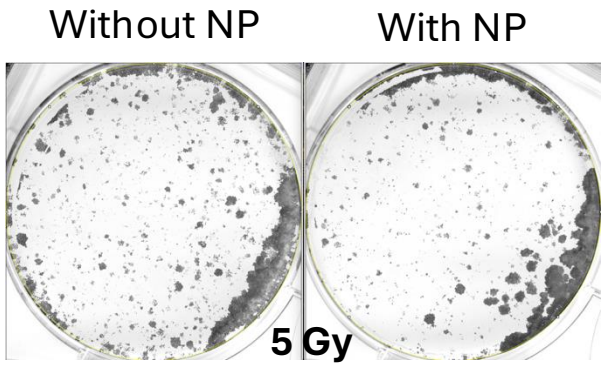
Radiobiology experiments

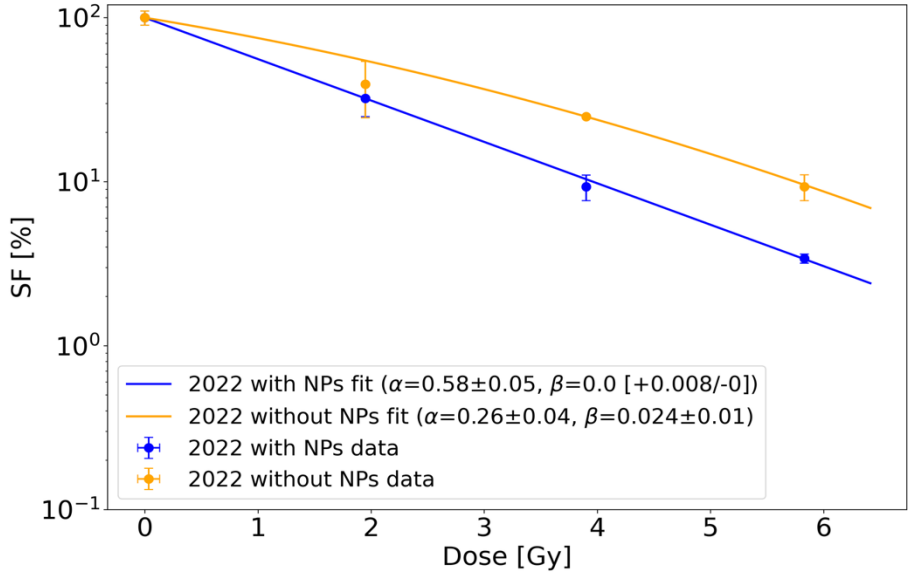
- Experimental campaigns in 2022, 2023, 2024, with conventional 20 and 50 nm AuNPs from cytodiagnostics



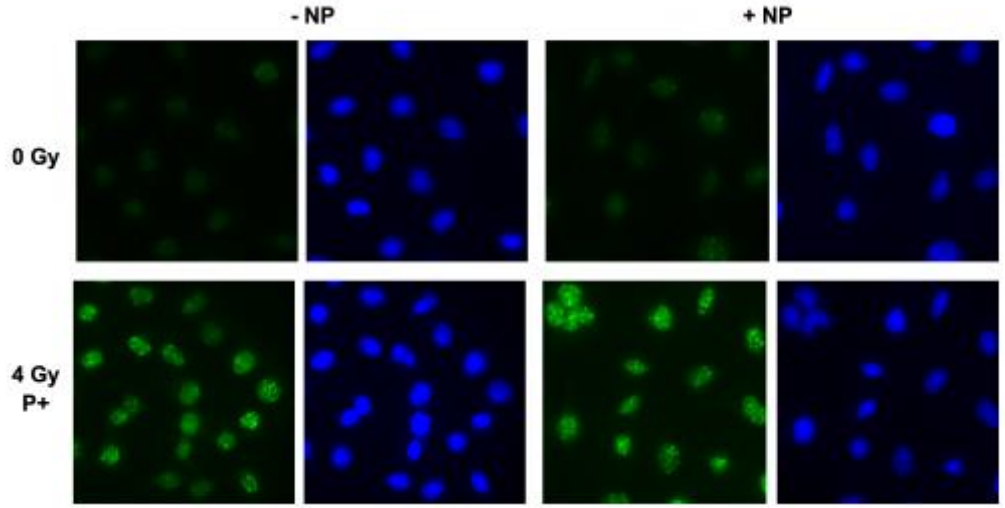
$$SF = \frac{colonies\ after\ irradiation\ at\ X\ Gy}{Seeded\ cells \times PE} \times 100$$

$$PE = \frac{colonies\ without\ irradiation}{Seeded\ cells} \times 100$$





- DNA-damage assays revel an increase of different markers when AuNPs are used



V Jornadas RSEF/IFIMED de Física Médica. N. Fuster-Martínez et al.,
Technological developments and evaluation of the radiosensitizing potential of gold nanoparticles (AuNPs) for hadron therapy

Article submitted under revision in Medical Physics Journal

FLASH proton therapy

Plan Complementario AstroHEP: Tecnlogías avanzadas para la exploración del universo y sus componentes.

L. A.1: Desarrollo de instrumentación de vanguardia para futuros experimentos de Física de Partículas y Nuclear

Título de la actuación 1.4: Desarrollos para la terapia con protones (IP: Carmen Jiménez Ramos)

CNA Ciclotrón 18/9 MeV

Financiado por la Unión Europea

Plan de Recuperación, Transformación y Resiliencia

CNA Centro Nacional de Aceleradores

Infraestructuras Científicas y Técnicas Singulares

Junta de Andalucía

Objetive

Design and fabrication of a new beam pulsing system for the external beamline of the CNA cyclotron (University of Seville, CSIC, Regional Government of Andalusia) for radiobiology studies in FLASH regime

IFIC Institut de Física Corpuscular

CSIC Consejo Superior de Investigaciones Científicas

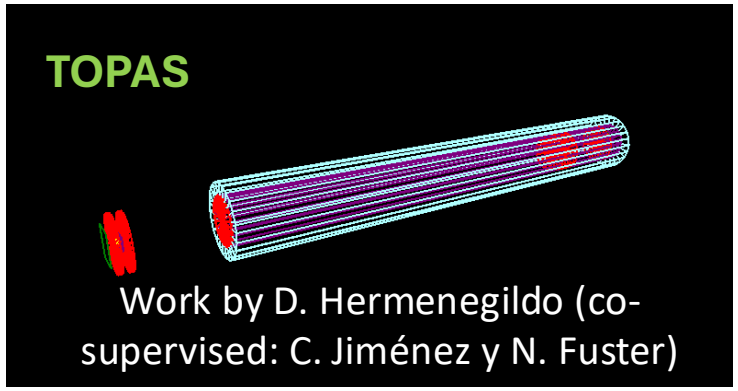
Universitat de València

AITANA

FLASH proton therapy

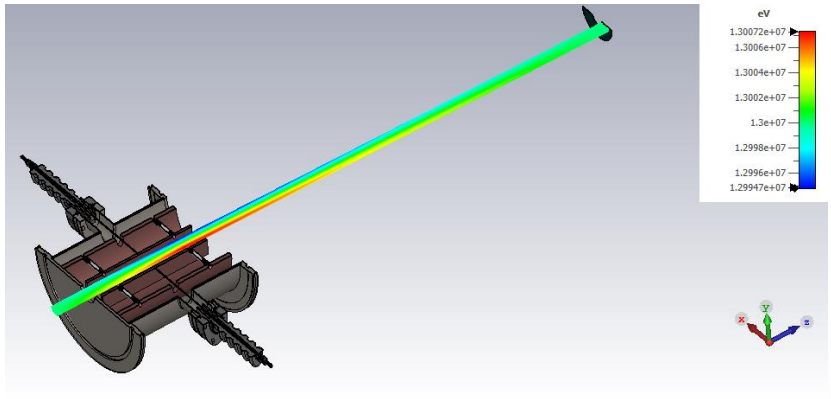
- Pulsing system designed and fabricated to be commissioned in early 2026

- Beam line and beam parameters optimization for radiobiology experiments on-going (TOPAS, Xsuite)

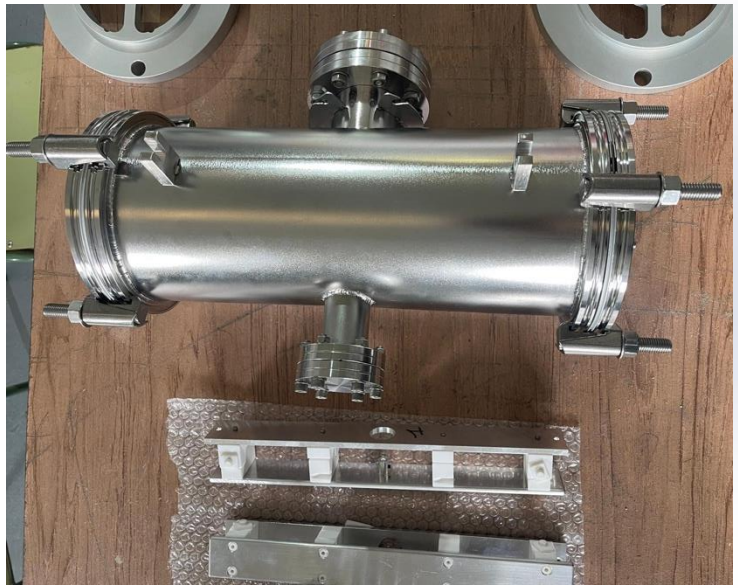


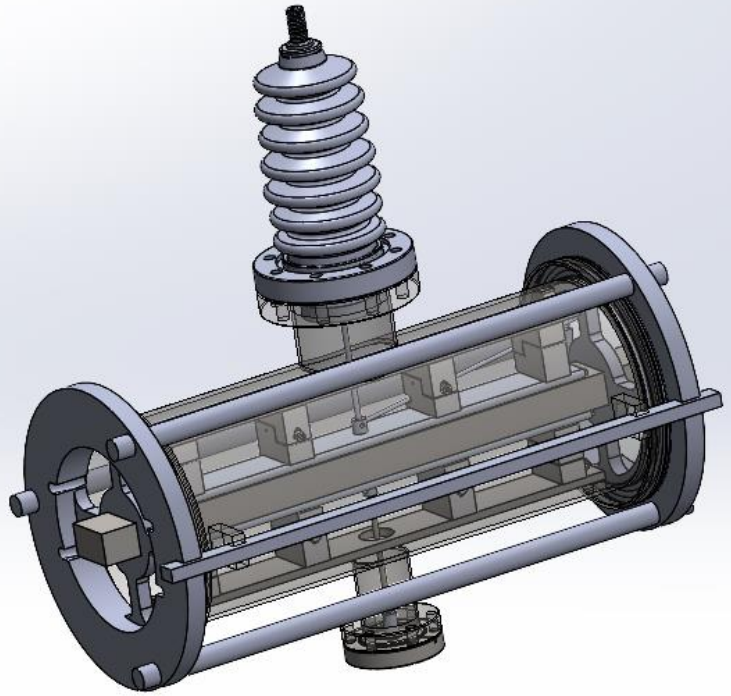
Work by D. Hermenegildo (co-supervised: C. Jiménez y N. Fuster)

- Radiobiology experiments under FLASH conditions



Pulse	30 kV
Rise/fall time	1 µs
Pulse Rep. Rate	1 kHz
Chopping pulse width	10 - 50 µs

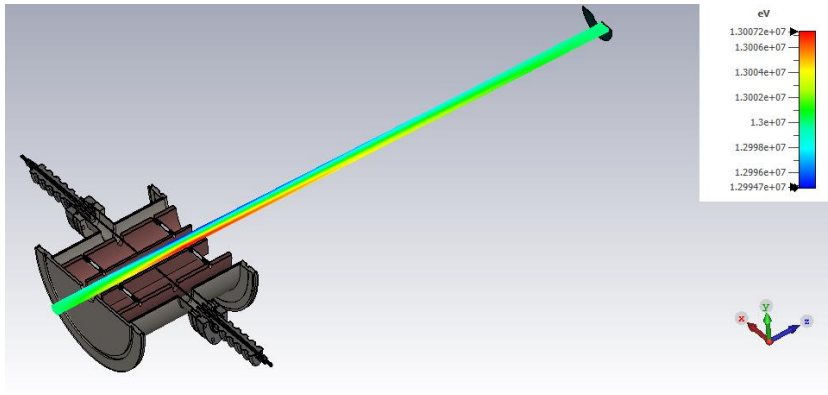




EM and mechanical design by C. Blanch, D. Esperante, N. Fuster and *Neptury Technologies*

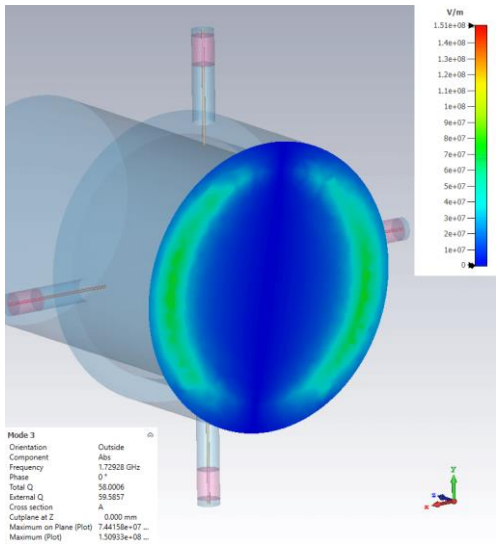
Ideas for financial support

❑ Software



- Two years of **CST-PS license update** (~1200 euros per year)
  - ✓ 3D EM simulations
  - ✓ Eigenmode solver, PIC solver, Wakefield solver…
  - ✓ EM design, beam dynamics studies…

❑ Equipment:



- **High-performance oscilloscope** (> 40 GSa/s, High Resolution, High Band width)
  - ✓ Performance characterization of instrumentation, diagnostics for ALMA
  - ✓ Radiation measurements in future RF laboratory tests in view of the cavities for the ALMA energy upgrade
- **High performance Vector Network Analyzer**
  - ✓ RF and microwave components characterization
  - ✓ Useful for ALMA RF components characterization and future energy upgrade studies

❑ ALMA accelerator users first **workshop** to be organized in 2026.