IFIGENEIA

Innovative Facility for Isotope GENeration with Efficient Ion Accelerator

National Centre for Scientific Research “Demokritos”

Anastasios Lagoyannis, NCSRD

Kick-off meeting
3-4 March 2025
Thessaloniki, Greece

This project has received funding from the European Union’s Horizon Europe Framework Programme for Research and Innovation under grant agreement no 101186921.

Partner profile

- 60.000 sq meters Campus
- 55.500 sq meters Building Area
- Approx. 200 researchers and 500 technicians and administration permanent staff

NCSR-D hosts research infrastructures unique in the country:

- 5.5 MV TANDEM Accelerator (I.N.P.P.)
- 250 kV High-current single-stage Accelerator (I.N.P.P.)
- 2.5 MV AMS accelerator (under installation
- 17 MeV Cyclotron (to be installed)

Partner profile

National Center for Scientific Research “Demokritos”

Consists of 6 Institutes

- Informatics and Telecommunications
- Biosciences and Applications
- Nuclear and Radiological Sciences and Technology, Energy and Safety
- Nanoscience and Nanotechnology
- Nuclear and Particle Physics
- Quantum Computing and Quantum Technology

Main activities & competencies

Basic Research Program (35%):
Nuclear Astrophysics – Nuclear Reactions

Applied Research Program (65%):
Materials – Cultural Heritage – Environment
Test bench for Detector R&D

5.5 MV Tandem Accelerator

- Major upgrades during 2018-2024 (funds by ESPA CALIBRA project, ≈3.5 M€)
- Open access to more then 40 external users from almost all Greek Universities and Europe
- Supports various projects funded by: FP, ESA & EFDA/Fusion

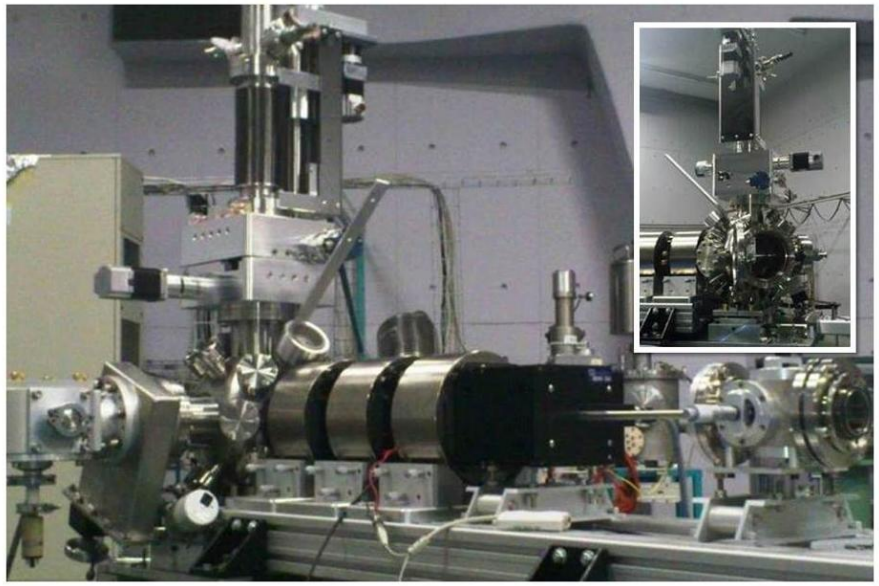
Funding attracted during the last 5 years ≈ 6 M€

- Education (2015-today):

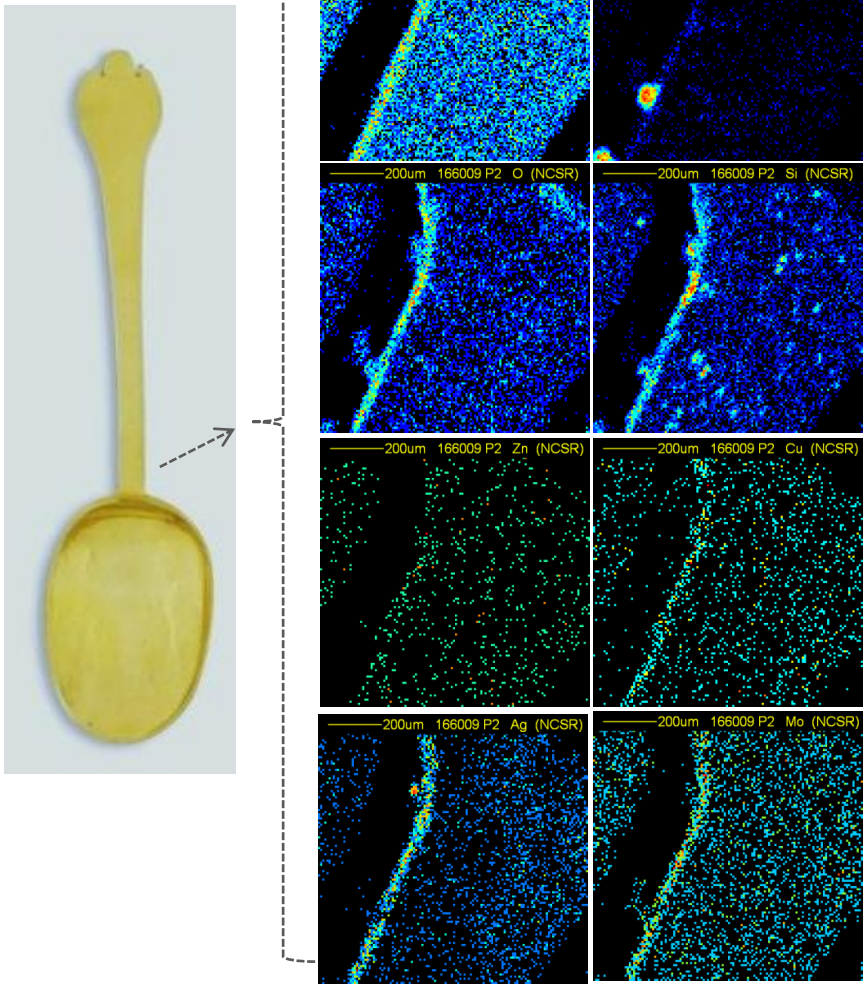
26 Diplomas, 10 Master's, 11 PhD

Unique installation in Greece,
one of the few now available in Europe
Total investment:
≈ **10 M€** (scientific infrastructure) **+**
≈ **12 M€** (building with shielding)

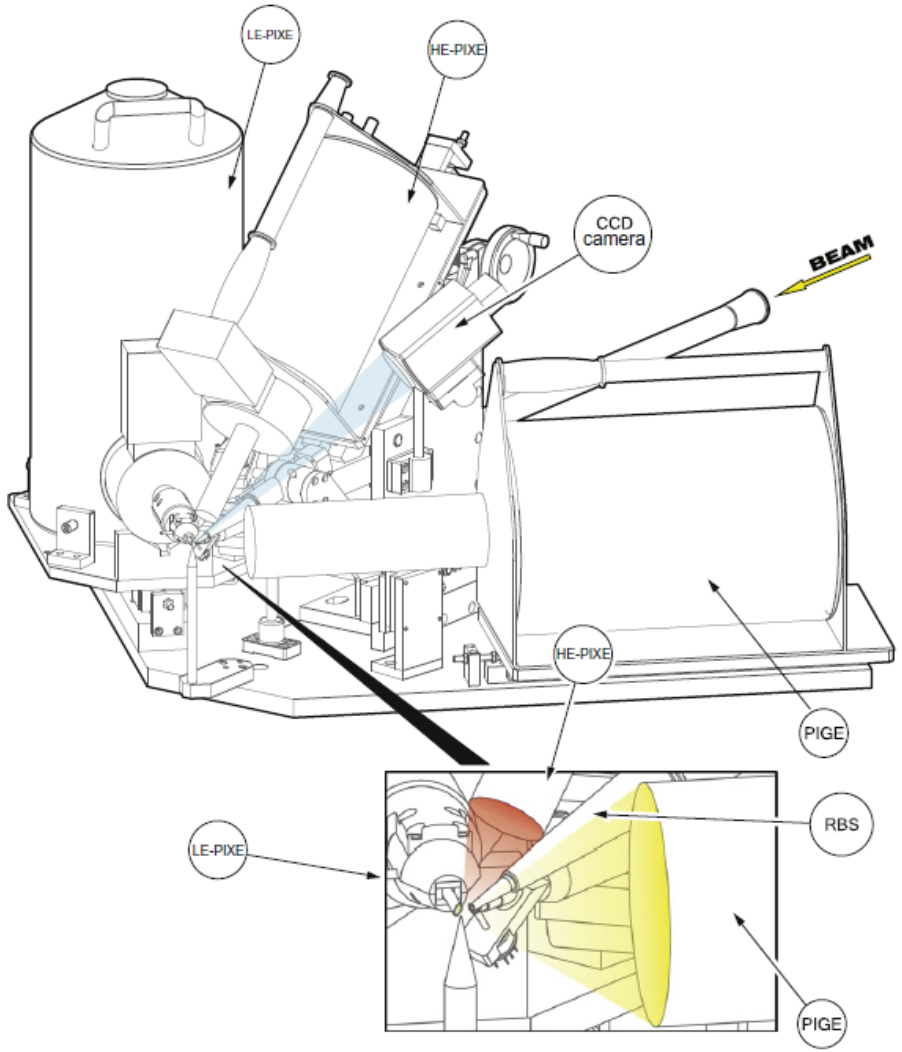
Main activities & competencies



Nuclear micro-probe
(beam spot on sample ∅≈1 μm)
dedicated to the analysis of cultural heritage objects, biological samples, aerosol filters etc.

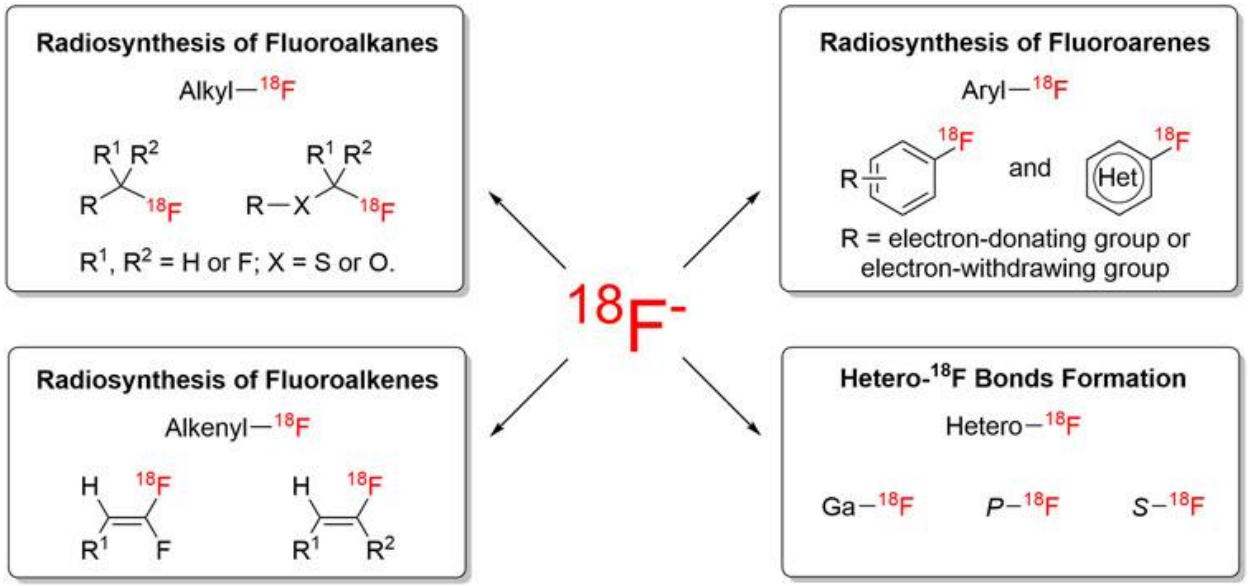


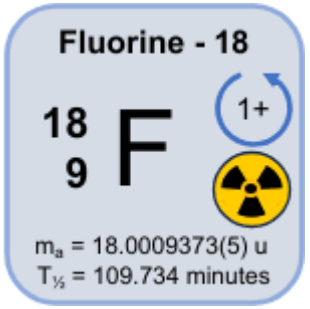
Main activities & competencies



External beam setup
(analysis of large samples on air – cultural heritage objects & biological samples)

18F radiopharmaceuticals

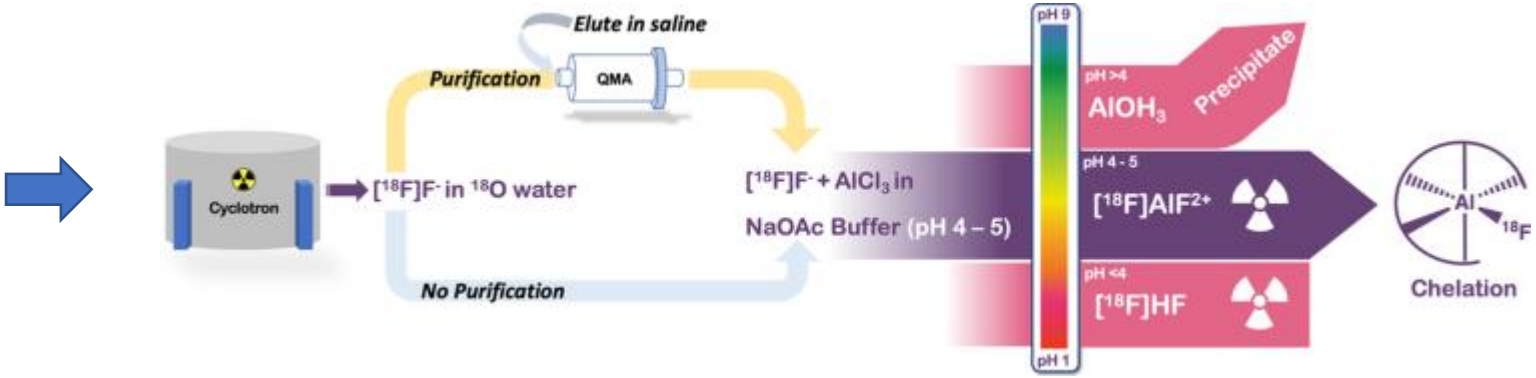




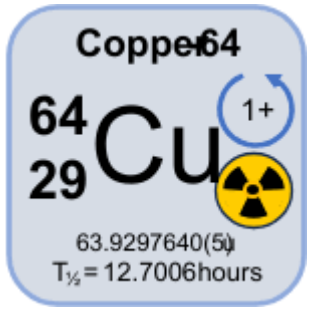
^{18}F is the most frequently employed radionuclide for PET imaging with wide clinical applications

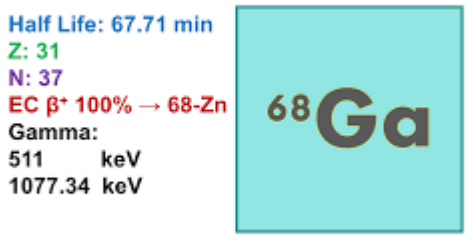
Direct introduction in molecules through in C-^{18}F bonds

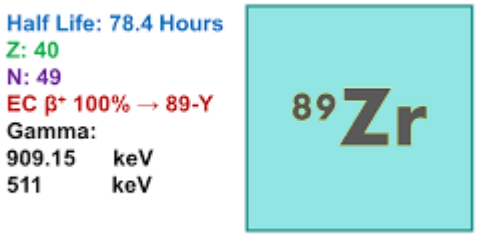
Can also be introduced via ligand-metal chemistry through $[^{18}F]AlF^{2+}$



Other radionuclides of interest

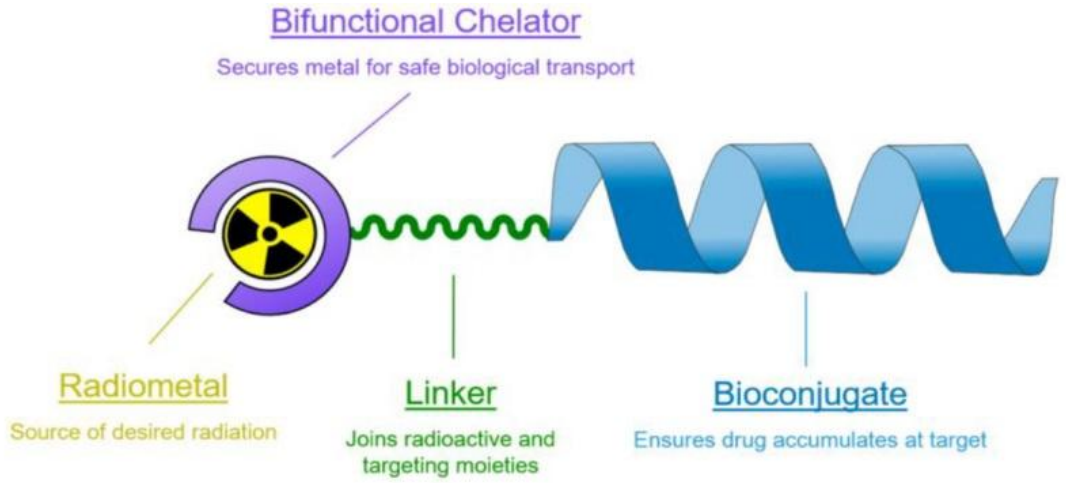






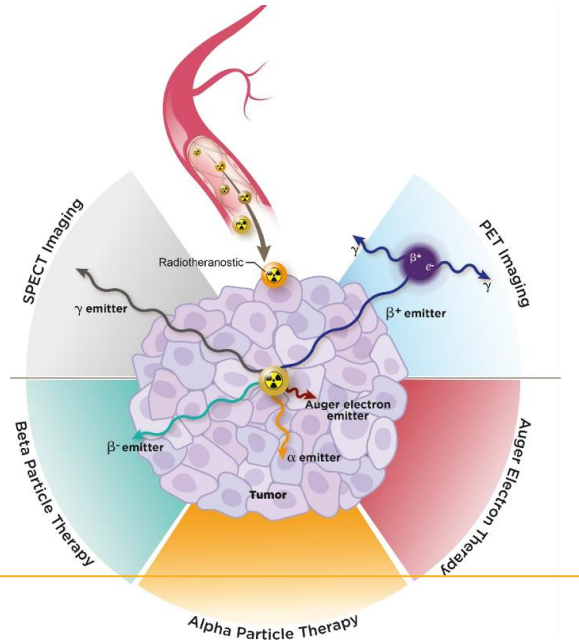
SPECT imaging

PET imaging



Nanobrachytherapy

A great number of studies reveal that injectable radiopharmaceuticals exhibit outstanding therapeutic effects along with minimizing the discomfort associated with existing brachytherapy procedures. In this perspective, ***radioactive nanoparticles*** could represent ***a promising alternative to current brachytherapy methods with outstanding results compared to conventional brachytherapy***.

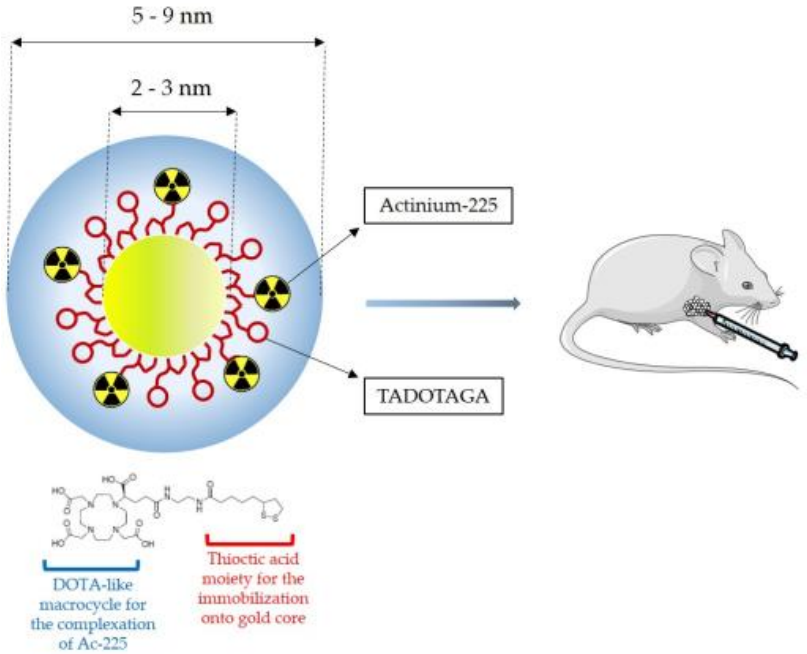


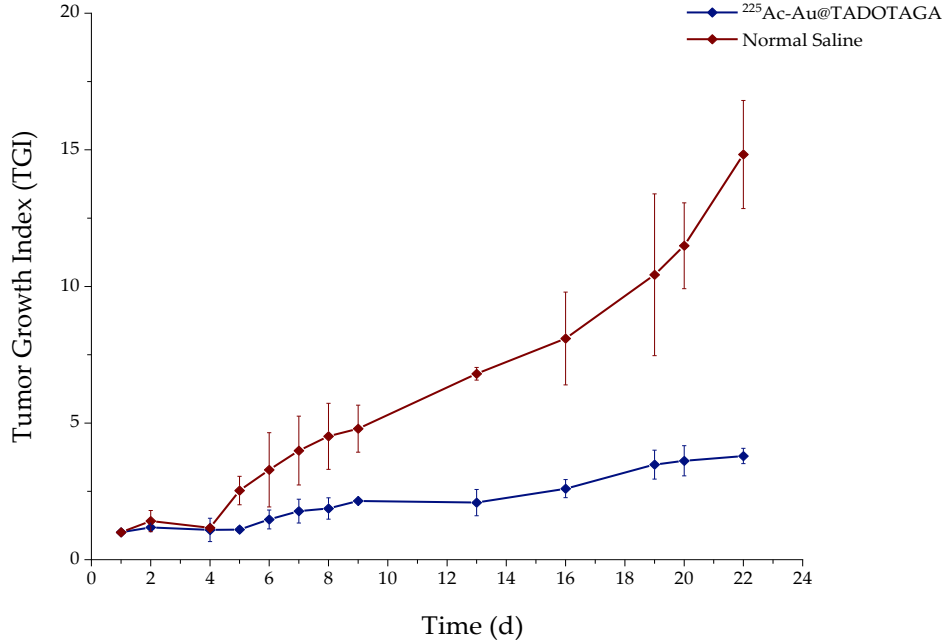
Advantages

- Administration easier/less invasive: injection instead of implantation
- No seed removal required
- NPs provide imaging and therapy capabilities (contrast agents/hyperthermia/photothermal therapy of cancer)

Nanobrachytherapy with particle-emitting radioisotopes such as Actinium-225 (alpha-particle emission), Lutetium-177 (beta-particle emission) and Terbium-161 (Auger electron and beta-particle emission)

Nanobrachytherapy with ^{225}Ac, ^{177}Lu and ^{161}Tb

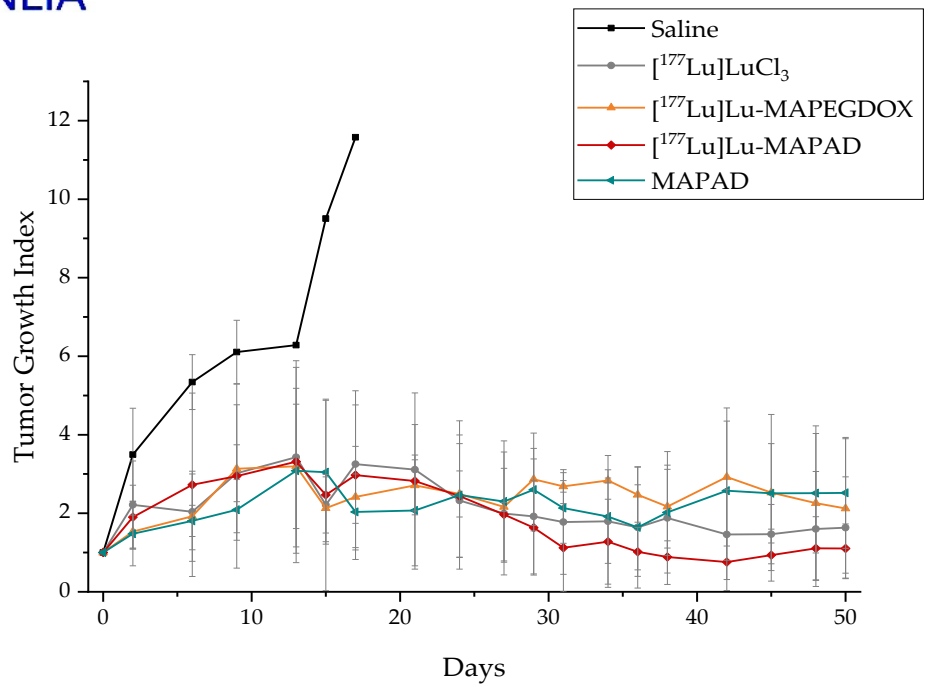


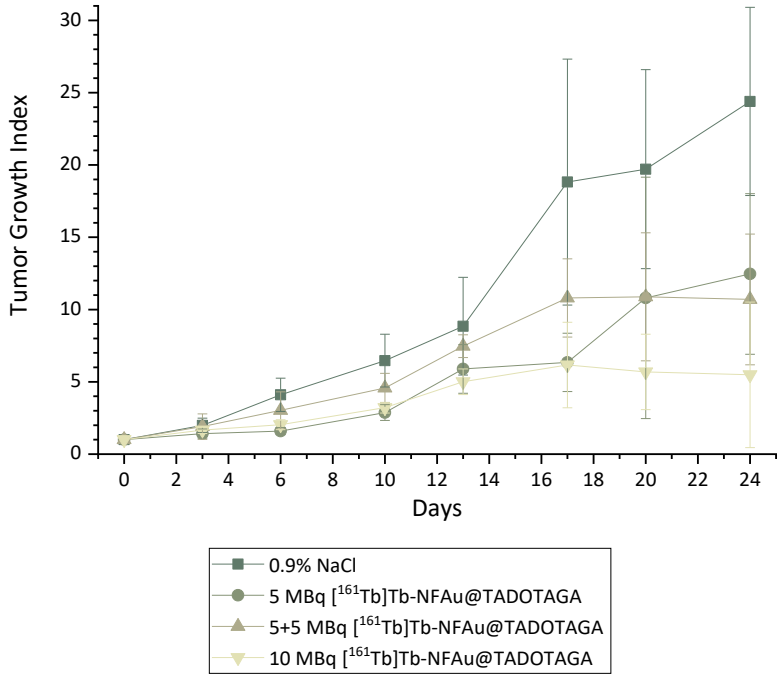


Effect of intratumoral injection of [^{225}Ac]^{225}Ac -Au@TADOTAGA (Group A, blue line) or saline (Group B, red line) on the Tumor Growth Index (TGI) of U87MG tumor-bearing SCID mice. Mice in Group A received three injections of [^{225}Ac]^{225}Ac-Au@TADOTAGA (total activity: 15 kBq).

Gold nanoparticles radiolabeled with ^{225}Ac via the macrocyclic chelator TADOTAGA resulted in the retardation of tumor growth after their intratumoral injection in U87MG tumor-bearing mice, even though very low activities were injected per mouse.

Nanobrachytherapy with ^{225}Ac, ^{177}Lu and ^{161}Tb





Therapeutic efficacy study of ^{177}Lu-radiolabeled iron oxide nanoparticles after intratumoral administration in 4T1 tumor-bearing SCID mice. The most prominent therapeutic effect was observed for the iron oxide nanoparticle [^{177}Lu]Lu-MAPAD (red line), which was functionalized with the monoclonal antibody bevacizumab, for prolonged detention at the injection (tumor) site.

Therapeutic effect of [^{161}Tb]Tb-NFAu@TADOTAGA after intratumoral administration in 4T1 tumor-bearing SCID mice. Three different therapeutic protocols were applied: bolus dose of 5 MBq, two doses of 5 MBq and a bolus dose of 10 MBq

Dose-dependent therapeutic effect when compared to the control group (0.9% NaCl).

Main involvement in IFIGENEIA

Work package WP3 – LINAC design dedicated to radioisotope production and other societal Applications

T3.1 LINAC/RFQ design and beam dynamics studies

- The **front-end application for cultural heritage endeavours** will encompass designing various components such as the switching magnet, beamline, ion optics, and proton beam exit nozzle into the air.
- A **compact arrangement for gamma, X-ray, and particle spectroscopic systems** will be devised to facilitate the detection of Particle Induced X-ray (PIXE), Gamma Emission (PIGE), and Rutherford Backscattered (RBS) protons.
- **Feasibility study on fast elemental imaging utilizing pulsed proton beams**.

T3.5 Study of the Safety and Radiation protection requirements

Work package WP4 – Radioisotope production and radiopharmaceuticals

T4.2 Identify best Isotopes for production with LINAC

T4.3 Investigate best Ligands for development within excellence hub (M5-M42)

IFIGENEIA staff

- Andreas – Germanos Karydas, Director of Research (Coordinator)
- Penelope Bouziotis, Director of Research
- Aristeidis Chiotellis, Senior Researcher
- Anastasios Lagoyannis, Director of Research