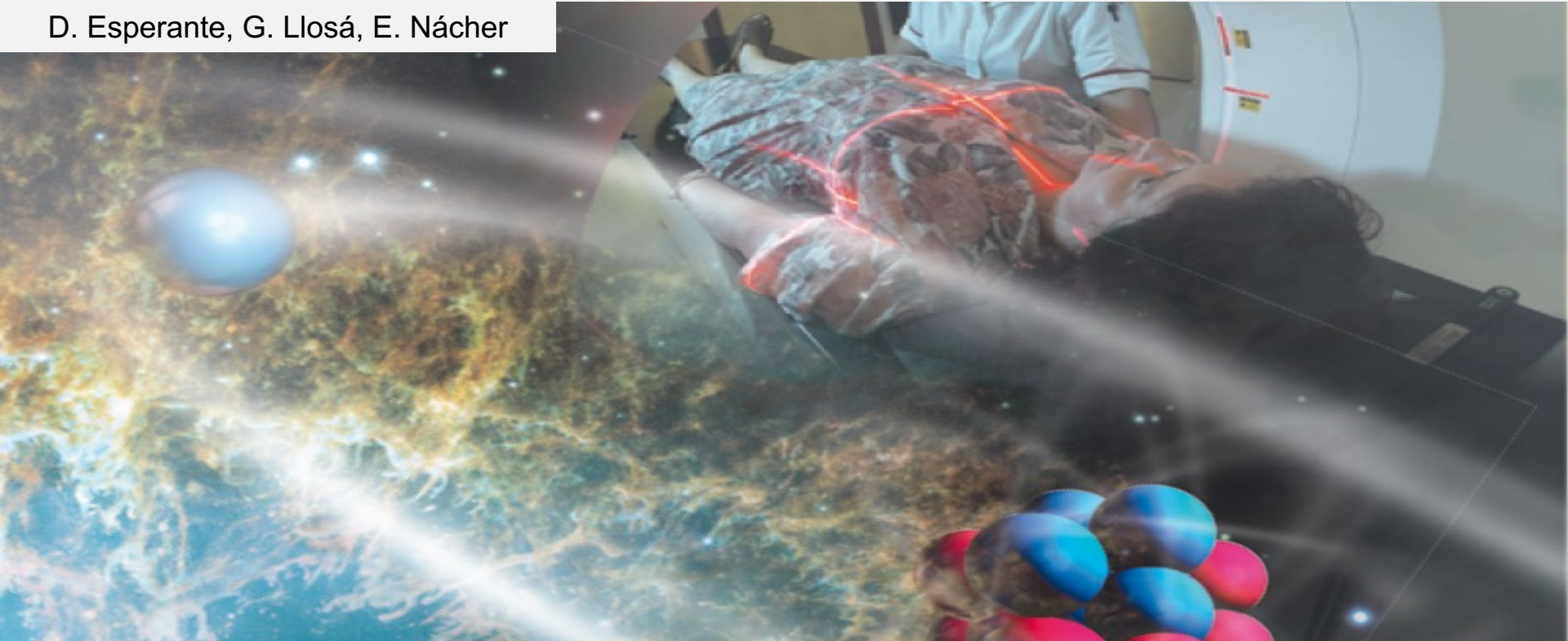


L8: ADVANCED INSTRUMENTATION & COMPUTING FOR THE SOCIETAL CHALLENGES

D. Esperante, G. Llosá, E. Nácher



ASAMBLEA GENERAL

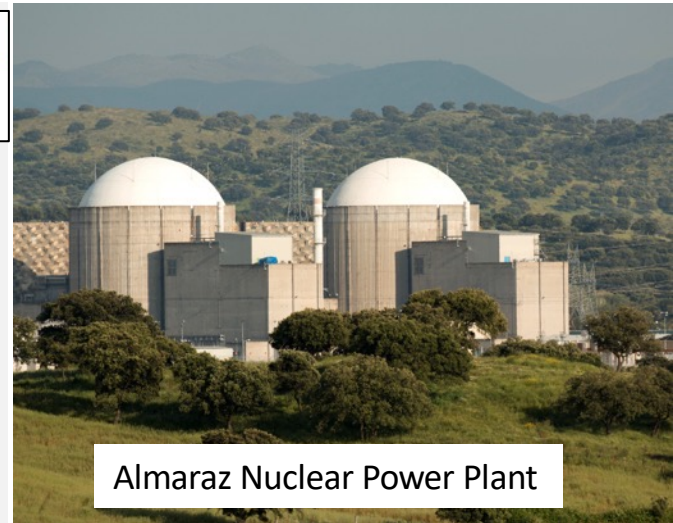
IFIC

2023

M. Martínez, M. Simeó, N. Yahlali, J. Díaz

Design, construction and commissioning of automatic stations for real-time monitoring of low radioactivity levels of tritium in water from NPP

Funded by EU INTERREG-SUDOE program, Consortium of 6 institutions from 3 southwestern European countries: **Spain-Portugal-France**



Almaraz Nuclear Power Plant

Publications: Achievements - Year 2023

1. C.D.R. Azevedo et al., Design, setup and routine operation of a water treatment system for the monitoring of low activities of tritium in water, **Nuclear Engineering and Technology**, **55** (2023), 2349-2355.
2. C.D.R. Azevedo et al., Development of a real-time tritium-in-water monitor, **accepted for publication in JINST. Dec 2023**

Conferences:

M. Martínez, M. Simeó, N.Yahlali, J. Díaz, “ TRITIUM: a quasi-real-time tritium in water monitor, oral presentation at NERIS conference, Dublin, October 9th. 2023.

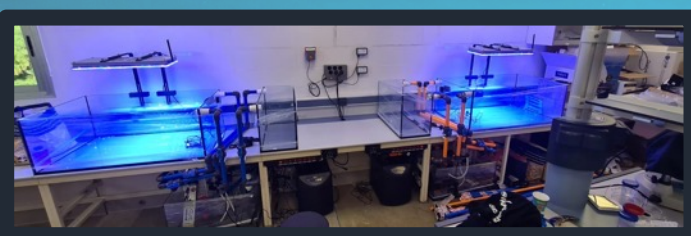
Funding: Capitalization funds Consellería **GVA, 2023. 13kEur**

Patents : **two patent applications** have been presented in July 2023 and are presently in process

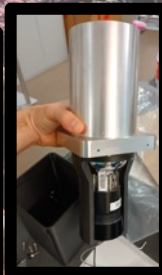
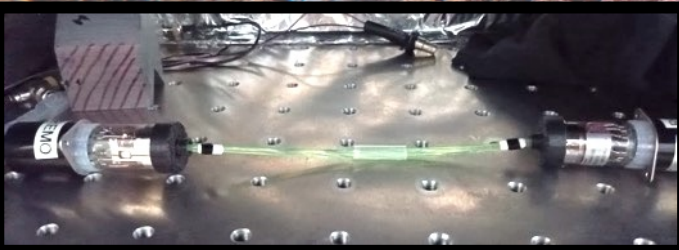


Radiotrazadores para el estudio de Ecosistemas Marinos y Oceanicos

E. Nácher, B. Rubio, J. Balibrea, M. Martínez, J. Lerendegui, L. Sánchez



- Dual-Aquarium + buffer + filtration plant + pH sensing and control... installed and working
- Corals growing... and dying :o(



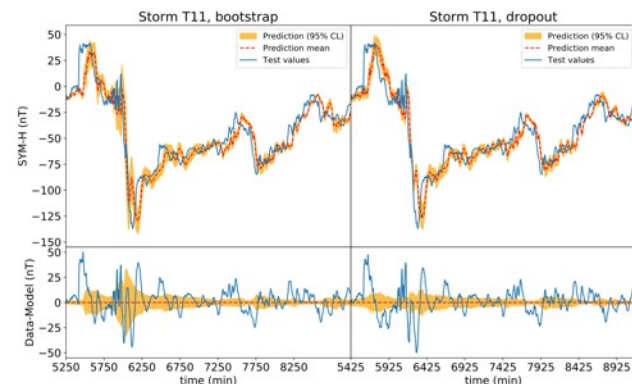
- Fiber detectors tested... not the best
- Liquid Scintillation Counter built and tested: promising!!
- ^{45}Ca radiotracer produced at ILL and coming soon!!

Radiotracers for the study of Marine and Oceanic Ecosystems
E. Nácher^{1,*}, B. Rubio^{1,2}, J. Balibrea¹, J. Ladrales¹, J. Lerendegui-Marco¹, M. Martínez¹, L. Sánchez¹, D. García-Párraga², J. L. Crespo-Picazo², M. Roche³, C. Tomás⁴, and G. de Angelis⁵
¹IC (CSIC) Uni. Valencia, Valencia, Spain
²IC (CSIC) Uni. Valencia, Valencia, Spain
³IC (CSIC) Uni. Valencia, Valencia, Spain
⁴IC (CSIC) Uni. Valencia, Valencia, Spain
⁵IC (CSIC) Uni. Valencia, Valencia, Spain

EPJ Web of Conferences 290, 08007 (2023)
EuNPC 2022



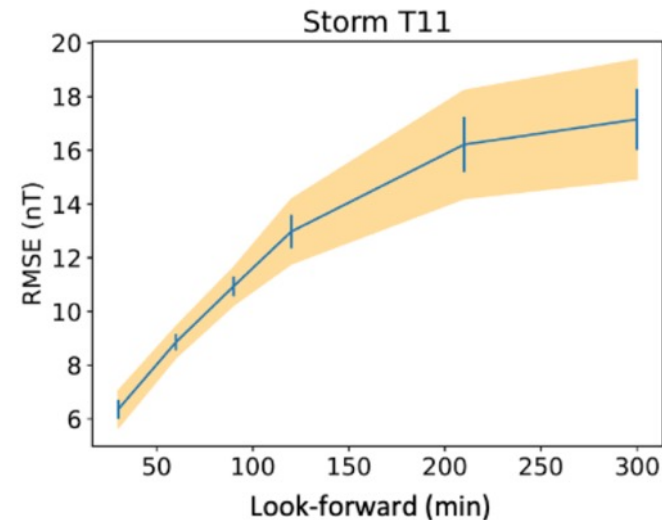
Proyecto Space Weather (F. Castillo, D. Conde, C. Escobar, C. García, J. E. García, V. Sanz y B. Zaldivar)



Highlights 2023

- Primer modelo predictivo, basado en una red LSTM, para predecir el índice geomagnético SYM-H con múltiples horas de antelación.
- Estimación de incertidumbres asociadas al modelo (block-bootstrapping y concrete dropout).
- Determinación de la robustez y fiabilidad de las predicciones basadas en la estimación cuantitativa de las incertidumbres.

- Desarrollo mediante técnicas avanzadas de *deep learning* del primer modelo predictivo en tiempo real de amenazas asociadas a corrientes inducidas geomagnéticamente (GICs), producidas por la actividad solar, en infraestructuras críticas españolas (redes de transmisión de energía, comunicación y/o transporte) Alto impacto social, económico y político
- Colaboración con Red Eléctrica Española, la Agencia Estatal de Meteorología, etc
- **Proyecto coordinado – Plan Nacional (PID2020)**
 - Observatorio del Ebro (modelado de GICs)
 - Universidad de Barcelona (modelado del campo geoelectrico)
 - IFIC (análisis de datos y técnicas avanzadas de *deep learning*)



• Presentación en la conferencia más importante del campo:

- 28th General Assembly of the International Union of Geodesy and Geophysics (IUGG 2023). Talk: “Forecasting geomagnetic storm disturbances and their uncertainties using deep learning”. C. Escobar. 16/07/2023. Berlín (Alemania) — 3715 participantes!

• Primer *paper* publicado en la revista más importante del campo (Q1):

- Conde, D., Castillo, F. L., Escobar, C., García, C., García, J. E., Sanz, V., Zaldivar, B., et al. (2023). Forecasting geomagnetic storm disturbances and their uncertainties using deep learning. Space Weather, 21, e2023SW003474. <https://doi.org/10.1029/2023SW003474>

HENSA++ project: Advanced instrumentation on neutron detection for space weather and medical applications (A. Tarifeño, J.L. Taín, A. Quero, et al.)

.High efficiency spectrometer for space weather applications:

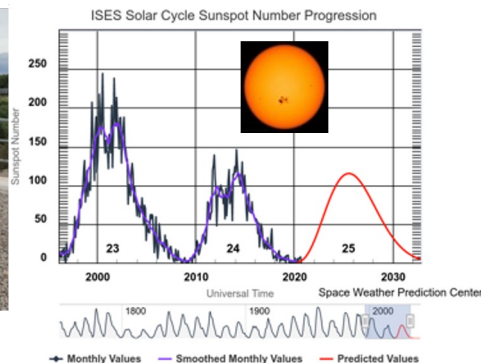
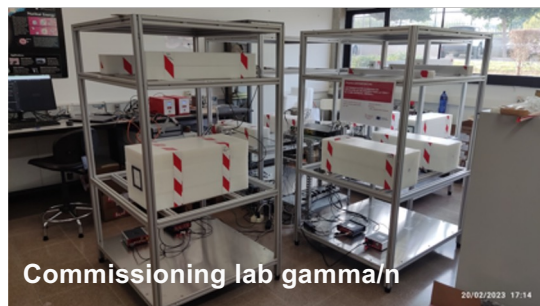
- Array of 16 detectors (3He, 4 atm, 60 cm AL) for measurements of cosmic-ray neutrons.
- **Sensitivity from thermal neutrons up to 10 GeV.**
- Focus on monitoring **solar activity** and **environmental radioactivity**.
- System assembled and **commissioning during 2023** (detector array, electronics and auxiliary systems).
- Final deployment for **first experimental run planned during 2024** at the Observatorio Astrofísico de Javalambre

Proyecto: IDIFEDER/2021/002

INSTRUMENTACIÓN AVANZADA EN
DETECCIÓN DE NEUTRONES PARA LA VIDA Y
EL CLIMA ESPACIAL: HENSA++



Financiado por
la Unión Europea



NESTA: NESTED NEUTRON SPECTROMETRY ARRAY



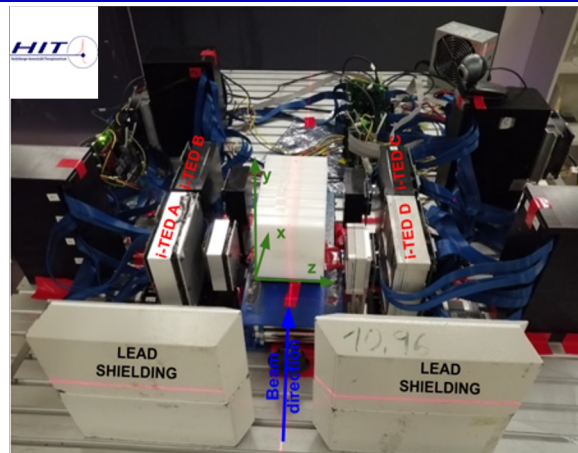
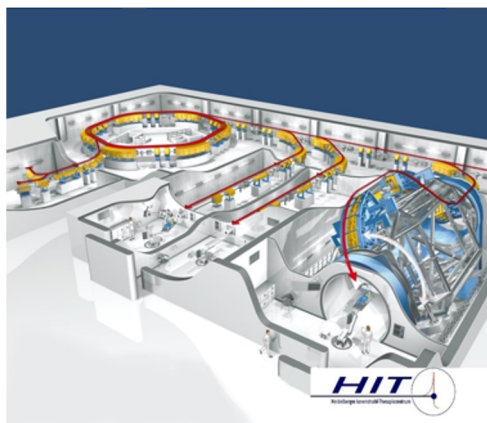
.Dedicated spectrometer for medical applications:

- 15 detectors (3He, 10 atm, 5 cm AL) able to operate in parallel.
- Fully based on digital electronics.
- Focus on out-of-field measurements in PT centers and medical LINACS.
- First prototype (NESTA) already tested at the n_TOF facility (CERN).

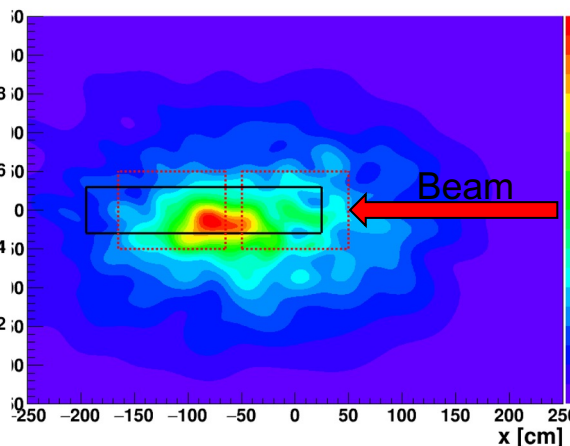
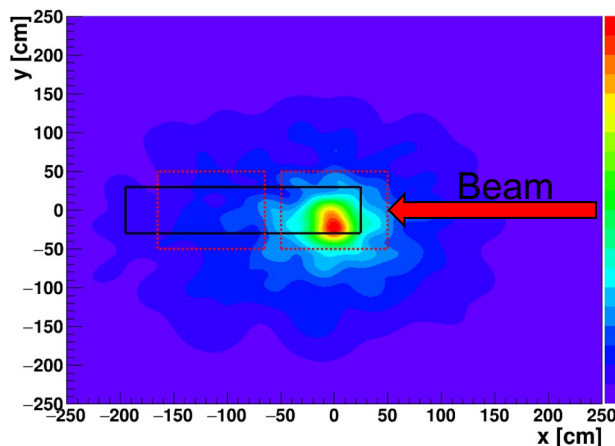
Hybrid Compton-PET ion-range verification for hadron-therapy: first PoC tests @ HIT with p, He & C

Experiment @HIT combining prompt γ and PET:

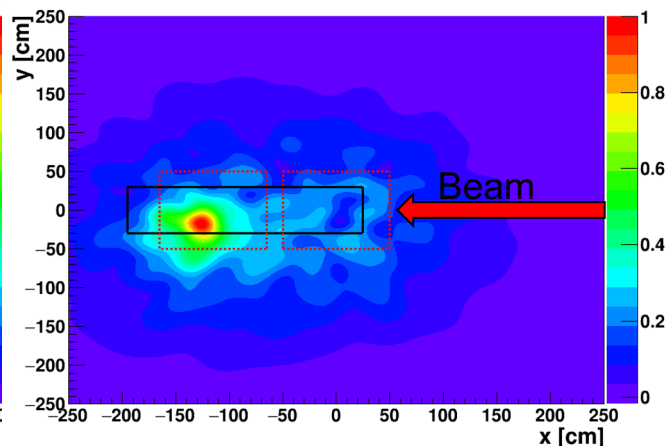
- 1st time these techniques are combined
- Results on protons, ^4He and ^{12}C (clinical cond.)



All i-TED



All i-TED



GN-Vision: dual gamma-neutron imaging device (J. Lereendegui, C. Domingo et al.)



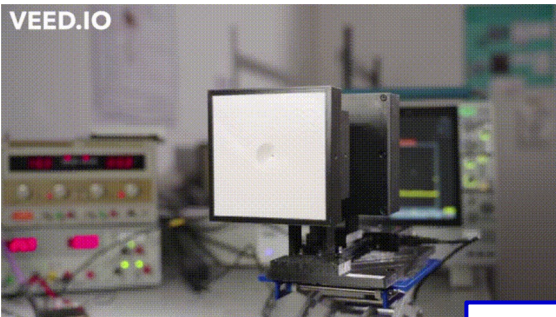
Hadrontherapy

Medical and industrial applications:



Nuclear safety & security

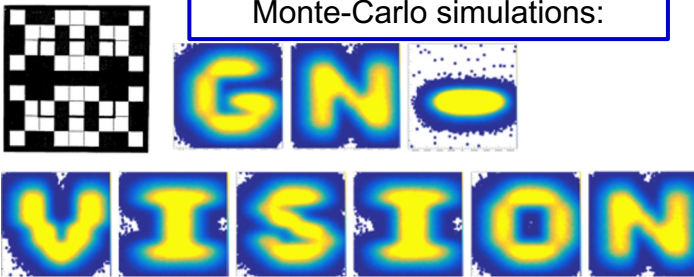
Dual & simultaneous imaging in a single device: **Gamma + Neutron**



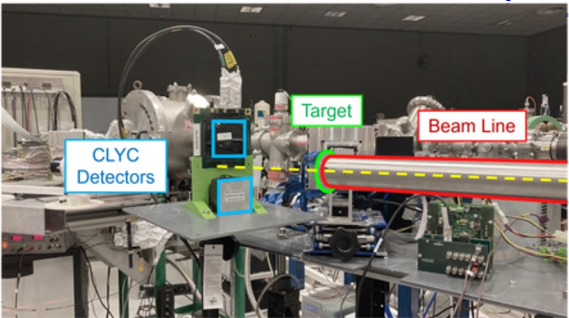
Experimental development

Valoritza i Transfereix UV-INV_PROVAL21-1924580
J. Lereendegui-Marco et al. [EPJ-TI \(2023\)](#)
Patent: [ES2877772A1](#)

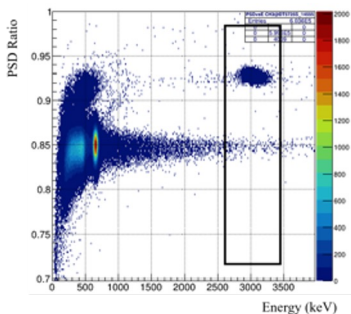
Monte-Carlo simulations:



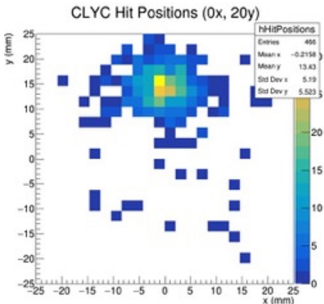
Thermal neutron imaging with coded mask



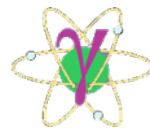
Characterization w/ neutrons & gammas at CMAM



Neutron-gamma discrimination CLYC

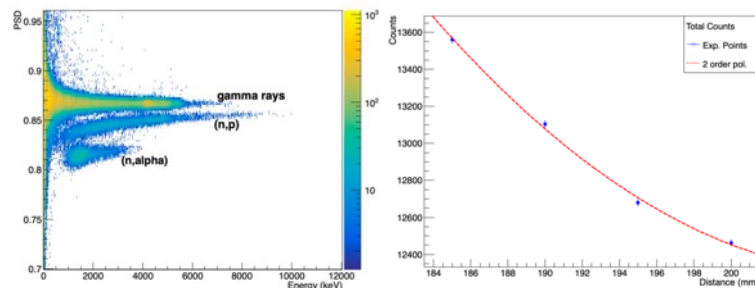
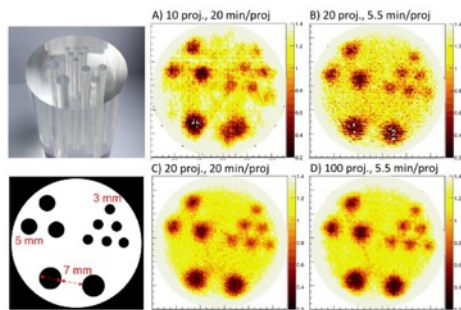


Position sensitivity CLYC



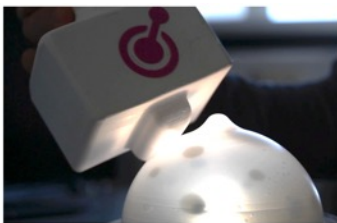
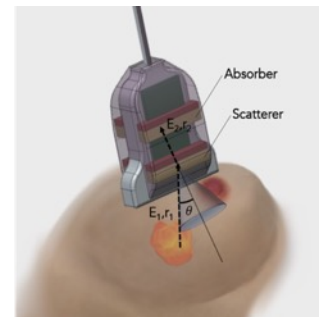
PRIDE: Proton Range and Imaging DEvice (E. Nácher, M. Martínez, C. Fonseca, et al.)

- Imaging finished, experiments at CCB (Krakow): radiographs published and tomography published soon
- Range using a coaxial detector (pure LaCl_3 !!) for neutrons and gammas tested at CMAM: OK



MAGAS: breast cancer biopsy guided by gamma imaging + ultrasound (L. Caballero et al.)

The patented technology of the MAGAS project that allows the guidance of cancer biopsy by combining molecular imaging with ultrasound, improving the diagnosis and treatment of cancer has been transferred to HYBRIMS, a spin-off or EBT (Empresa Basada en el Conocimiento) of the CSIC and UVEG.



Premio Secot a la Excelencia Fundación REPSOL 2023 para "HYBRIMS" en la categoría de Proyecto de Mayor Impacto

UV Medical physics

Participación en organizaciones internacionales durante el año 2023:

Miembro de:

- Brachytherapy Source Registry Work Group (AAPM)
- Brachytherapy Subcommittee (AAPM)
- TG56.B - Update of the AAPM TG56 report (AAPM)
- Unit 78 - Brachytherapy Dosimetry Consensus Datasets (AAPM)
- WG on Brachytherapy Dosimetry (AAPM)
- BRAPHYQS (ESTRO)
- Guidelines Sub-group on Physics (ESTRO)

Responsable de

- WG on Model-Based Dose Calculation Algorithms in brachytherapy (AAPM+ESTRO+ABG+ABS)

J. Vijande

Se ha publicado el report conjunto de la European Society for RadioTherapy and Oncology (ESTRO), Australasian Brachytherapy Group (ABG), American Brachytherapy Society (ABS), y American Association of Physicists in Medicine (AAPM) que regula el comisionado y puesta en marcha de la nueva generación de sistemas de planificación en tratamientos de braquiterapia.

MEDICAL PHYSICS

The International Journal of Medical Physics Research and Practice

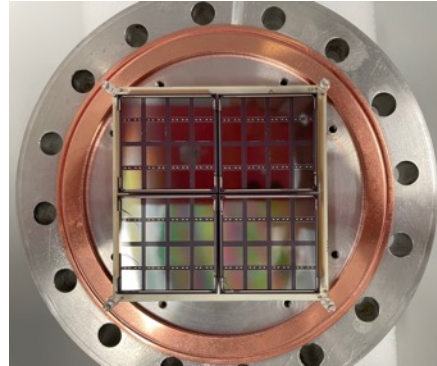
AAPM SCIENTIFIC REPORT | [Full Access](#)

AAPM WGD CAB Report 372: A joint AAPM, ESTRO, ABG, and ABS report on commissioning of model-based dose calculation algorithms in brachytherapy

Luc Beaulieu ✉ Facundo Ballester, Domingo Granero, Åsa Carlsson Tedgren, Annette Haworth, Jessica R. Lowenstein, Yunzhi Ma, Firas Mourtada, Panagiotis Papagiannis, Mark J. Rivard, Frank-André Siebert, Ron S. Sloboda, Ryan L. Smith, Rowan M. Thomson, Frank Verhaegen, Gabriel Fonseca, Javier Vijande ... [See fewer authors](#) ^

First published: 10 July 2023 | <https://doi.org/10.1002/mp.16571> | Citations: 2

- Positron Emission ToF Apparatus based on Liquid xenOn: prove the feasibility of a **LXe** PET scanner, with **silicon photomultipliers** as read-out.
- Funded with an ERC StG.
- Group@IFIC: P. Ferrario, N. Salor, S. Teruel, M. Querol, V. Álvarez, S. Cárcel, JM Benlloch-Rodríguez.
- Collaboration with Donostia International Physics Center, Universidad Politécnica de Valencia.



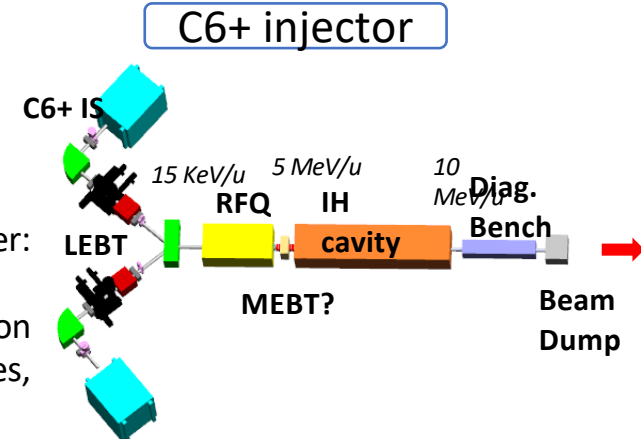
- **PETit**: first prototype built and operating.
- Hamamatsu 6x6 mm² SiPMs, VUV-sensitive.
- Debugging and understanding of TOFPET2 asic by PETsys.
- Preliminary measurement of energy resolution in liquid xenon using only scintillation of ~5% FWHM (to be refined).
- Measurement of Time-of-Flight of ~240 ps FWHM.



Accelerator physics and technology team (AITANA Group)

Highlight of the year: The C6+ Ion Injector

- ✓ Project: C6+ ion injector for Radiobiology Experiments.
- ✓ Funding agency: CDTI. 18 M€ budget to build the machine.
- ✓ Beneficiary: CSIC.
- ✓ Bidding process has been resolved on November 29th. Successful tenderer: AVS (Added Value Solutions).
- ✓ IFIC will have an important role on the construction: control and acquisition electronics, beam instrumentation and diagnostics, beam dynamics studies, design of beam energy upgrades, integration and commissioning.
- ✓ Preliminary specs:
 - ✓ Energy: 10 MeV/u.
 - ✓ Selection of different species: C6+, He2+, p
 - ✓ Repetition rate 200-500 Hz
 - ✓ Pulse length <5 μ s
 - ✓ Beam current >10 μ A
- ✓ IFIC group already building electronics equipment based on microTCA platform for first testing phase at CERN of the RFQ cavity.



❑ R&D on RF technologies



- ✓ The IFIC high power high-gradient RF laboratory activities resumed. CERN open to re-test their accelerating cavity at our premises.
- ✓ Design in collaboration with CERN a novel cavity based on ultra low-loss dielectrics. DAA (Dielectric Assist Accelerating) cavity:
 - ✓ They allow for higher power efficiency and accelerating gradient.
 - ✓ Discovery of a new “Non-resonant ultra-fast multipactor regime in dielectric-assist accelerating structures”. Analytical model develop and published.
 - ✓ A proof of concept prototype to be built during 2024.
- ✓ R&D on novel accelerating technologies (*collaboration with NOVAS group, ICMUV*):
 - ✓ Beam-driven Wakefield in a carbon nanotube (CNT). Theoretical model developed and in agreement with results obtained from simulations (PIC codes).



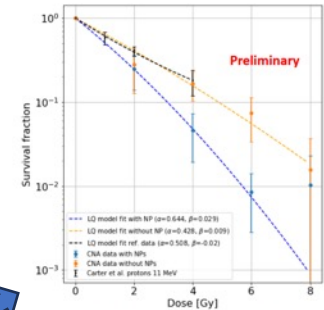
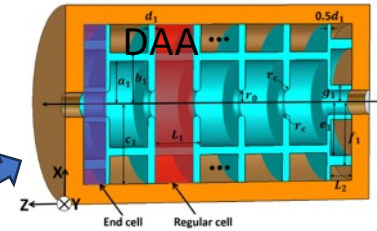
❑ Accelerator applications

- ✓ Combined use of hadron beams and nanoparticles for hadron therapy optimization. *Collaboration with biochemist from UV, Physicist from CNA and biologists from CABIMER (Sevilla)*
 - ✓ Study of radiosensitization effect of gold NPs for hadrontherapy.
 - ✓ Two test campaigns carried out at CNA (Sevilla) with promising results.

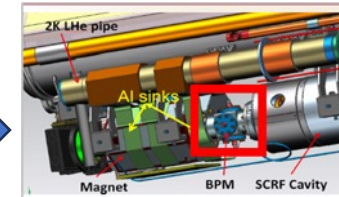
❑ Beam instrumentation

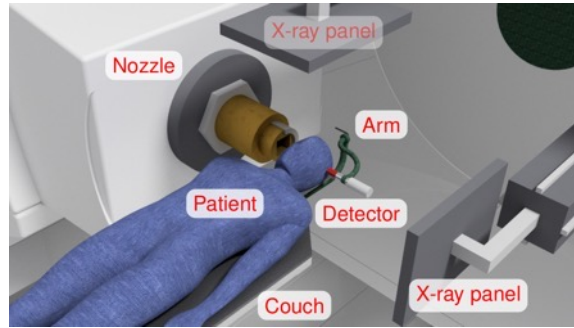


- ✓ Cavity BPMs R&D for the International Linear Collider project. Resolution to be met in the range of tens of nm. Simulations and design started and prototype construction to be started during 2024.

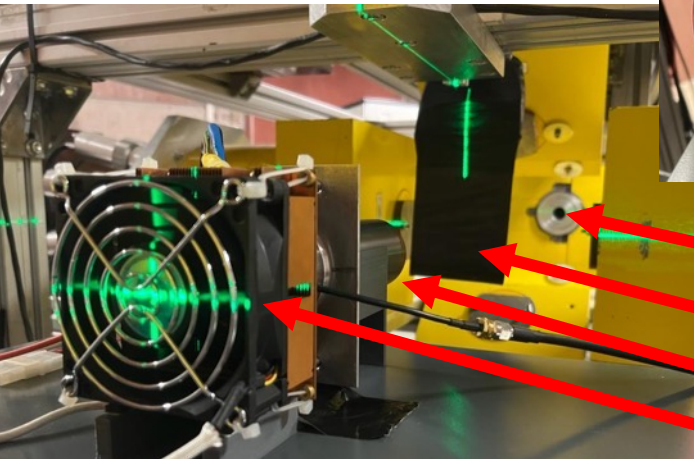
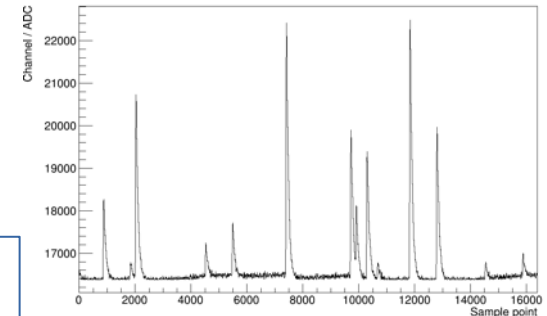
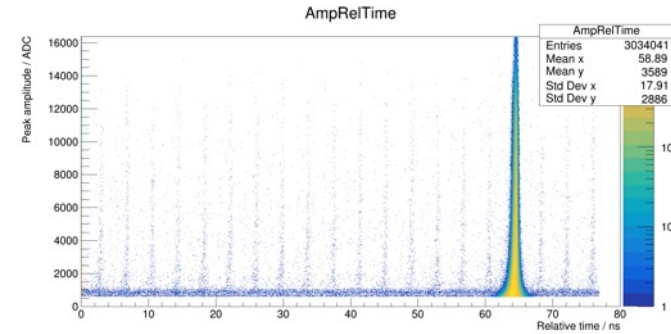
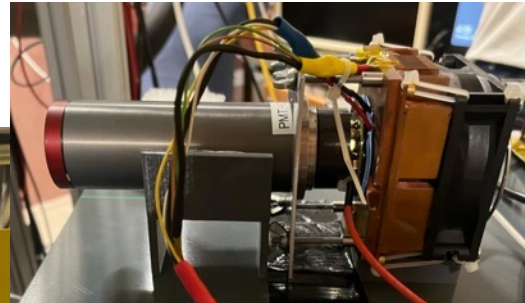


**Compared with data from Carter et al. Complex DNA Damage Induced by High Linear Energy Alpha-Particles and Protons Trigger a Specific Cellular DNA damage. HeLa cells, 12 MeV protons at 50Gy/min.





First testbeam at e- accelerator (Bremsstrahlung)
Colaboration with IGFAE-USC and HZDR

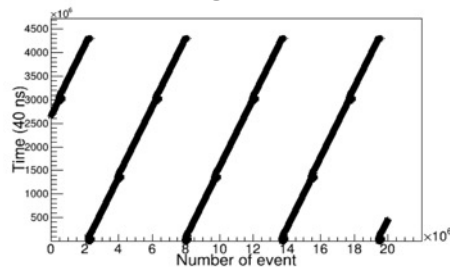


Beam line
Reference
CeBr
Cooling

CDEIGENT/2019/011

Probe for the improvement of the Spatial Resolution in total-body PET

Time resolution enhancement



- Raw data in singles
- Precision of 40 ns

PET scanner insert
500 ps temporal resolution

*Imaging Physics division (INM-4)
Institute of Neuroscience and Medicine
Forschungszentrum Jülich GmbH*

SEJI/2019/014

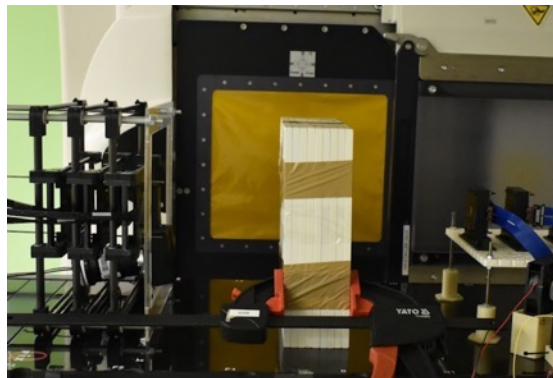
Positioning enhancement

Indoor Positioning Systems

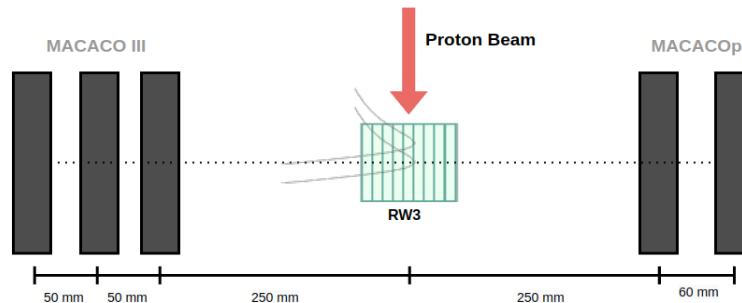
Lighthouses +
Light to digital converters



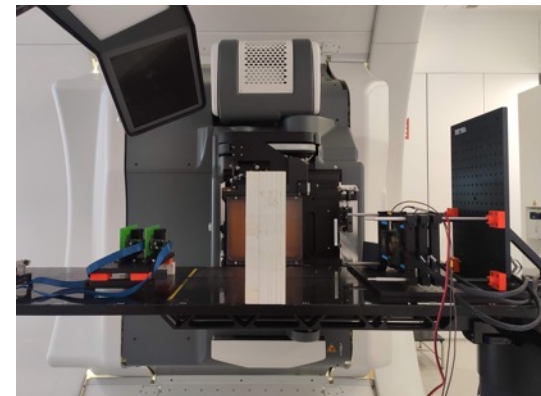
CCB Krakow



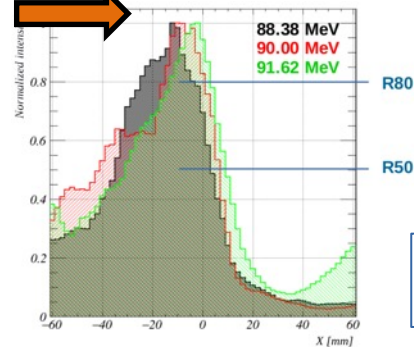
Tests in clinical beams



Quirónsalud, Madrid



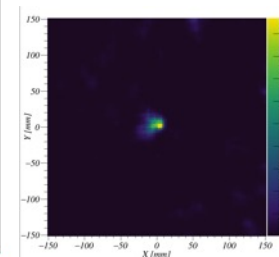
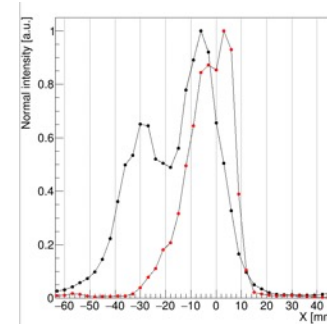
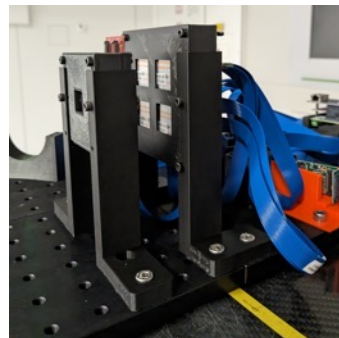
Proton beam



2 mm shifts
detected

PID2019-110657RB-I00
INNVA1/2021/37

FALCON



Spots reconstructed at different energies

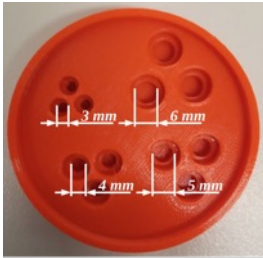
<http://ific.uv.es/iris>

La Fe, Valencia

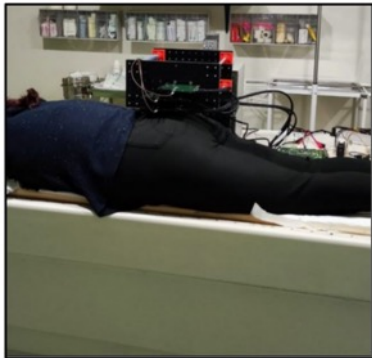
131

I-NaI

Phantom

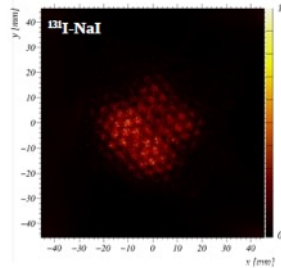


Patient

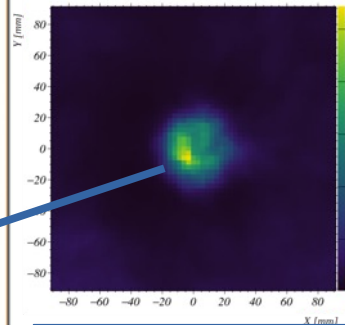
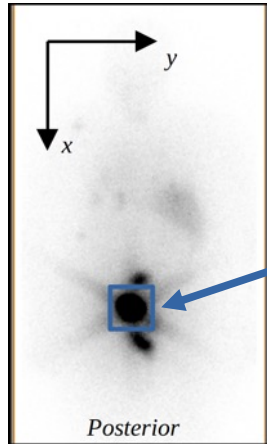
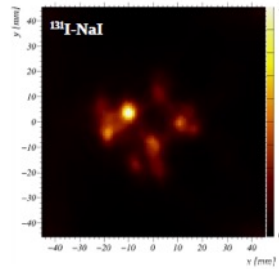


Tests in hospitals

Gamma camera



MACACO III

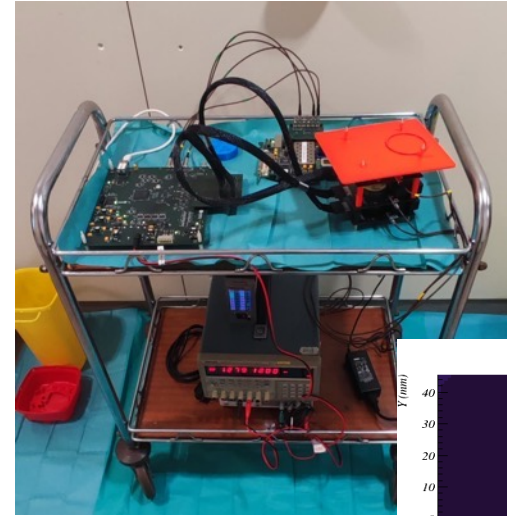


Léon Berard hospital, Lyon

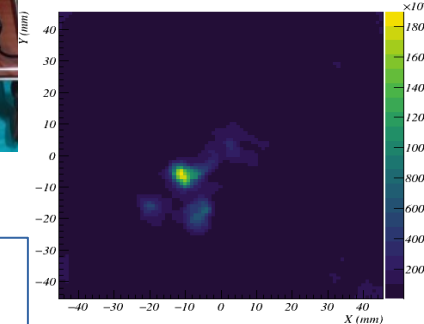
225

A

6 mm diameter
sector of the
phantom imaged



PDC2021-121839-I00
ASFAE/2022/019



Organization of IV Jornadas RSEF/IFIMED

L8: ADVANCED INSTRUMENTATION & COMPUTING FOR THE SOCIETAL CHALLENGES

D. Esperante, G. Llosá, E. Nácher



ASSEMBLEA GENERAL

IFIC

2023