Hadronterapia:
monitorización de rango y dosis neutrónica

Proyecto Prueba de Concepto MICIN 2021
Joint project IFIC-Valencia & UPC-Barcelona

C. Domingo-Pardo, F. Calviño, V. Babiano-Suárez, J. Balibrea-Correa, A. de Blas, L. Caballero, D. Calvo, R. García Sánchez, I. Ladarescu, J. Lerendegui-Marco, J.L. Taín, A. Tarifeño-Saldivia, S. Tortajada, S. Touriño

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

IFIC INSTITUT DE FÍSICA CORPUSCULAR

UPC UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

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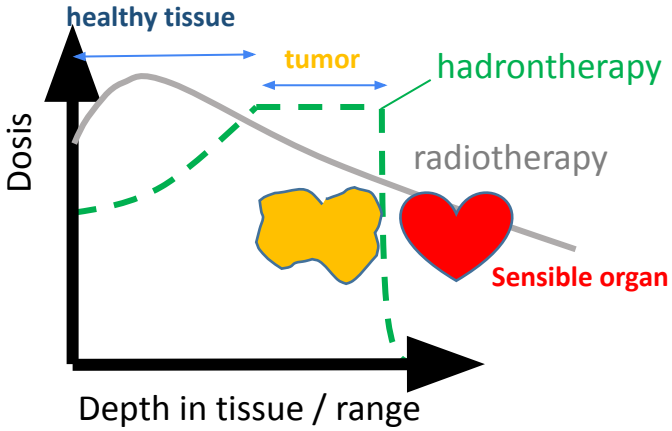
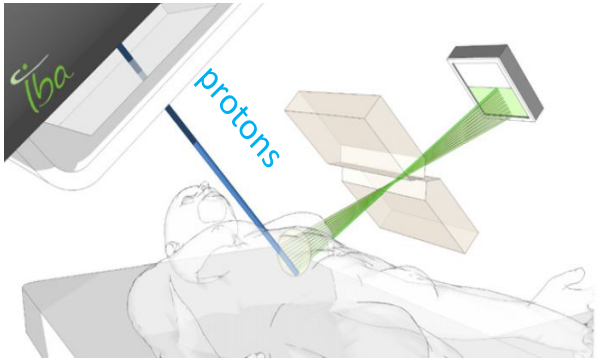
erc European Research Council

Hadron therapy: Benefits and Challenges



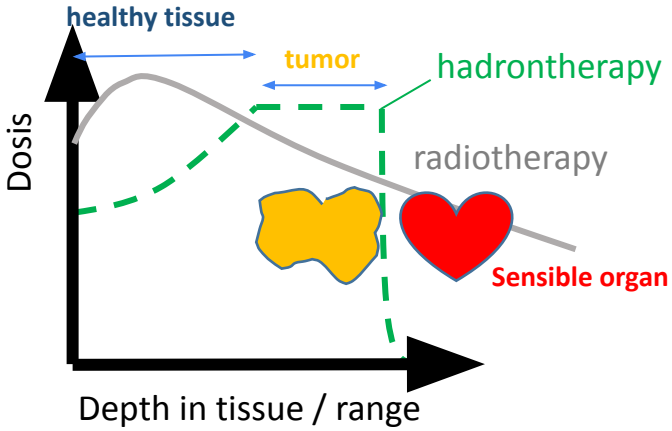
Important to monitor ion-range in real time with high accuracy



Two main challenges!

- ✘ Uncertainties in range limit the benefits of having a sharp Bragg peak.
- ✘ Assessment of secondary (unwanted) dose due to neutrons.

Hadron therapy: Benefits and Challenges



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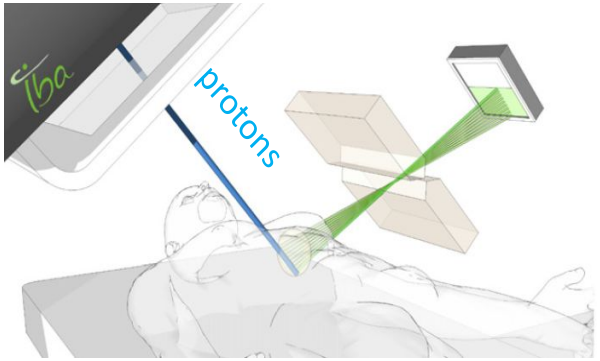


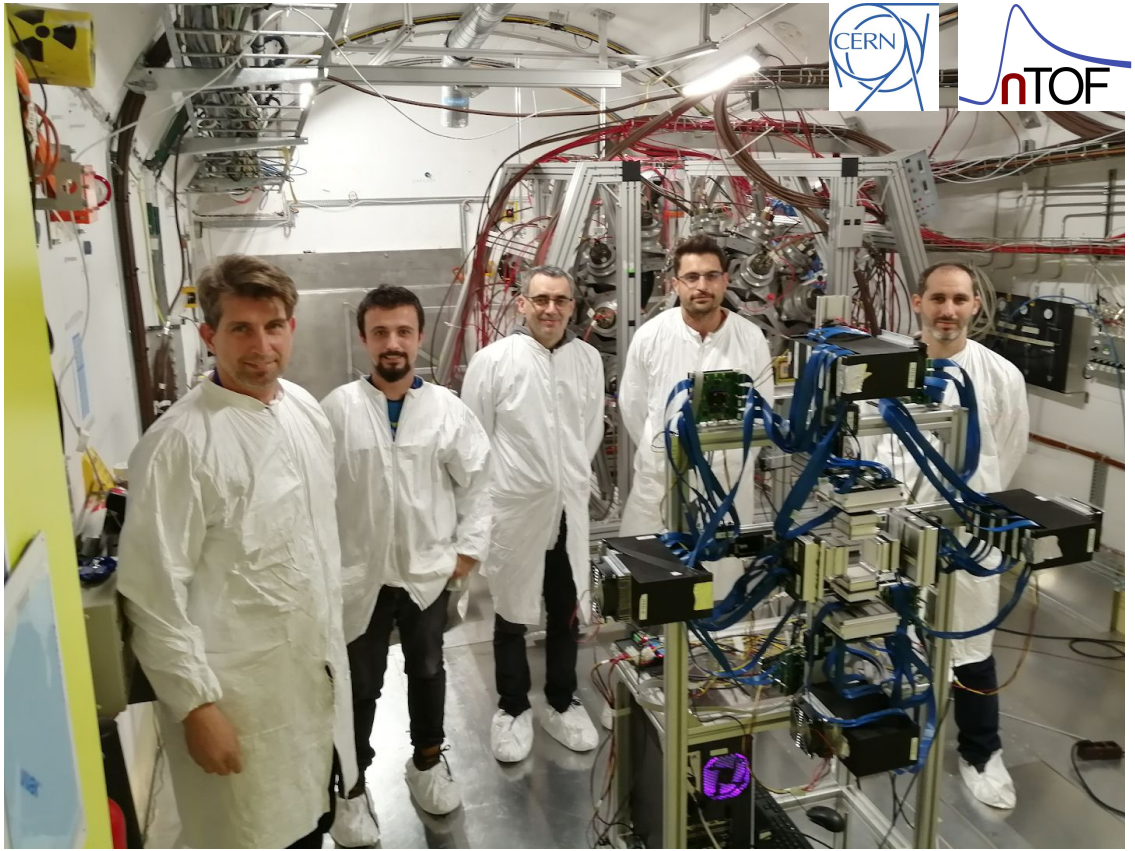
Two main challenges!

✘ **Uncertainties in range** limit the benefits of having a sharp Bragg peak.

✘ Assessment of secondary (unwanted) dose due to neutrons.

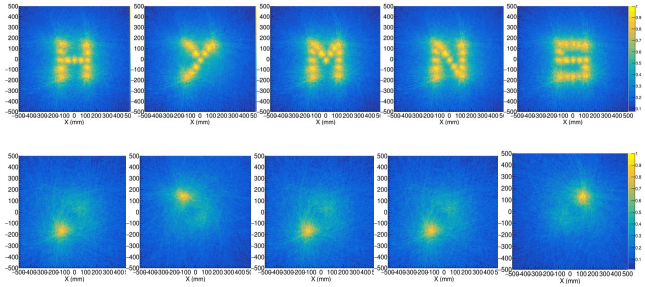
→ Presently ion-range monitoring:
Imaging of prompt high-energy gamma-rays or in-situ positron emission tomography (PET)

The HYMNS Project and i-TED



HYMNS

High sensitivitY Measurements of key stellar Nucleo-Synthesis reactions



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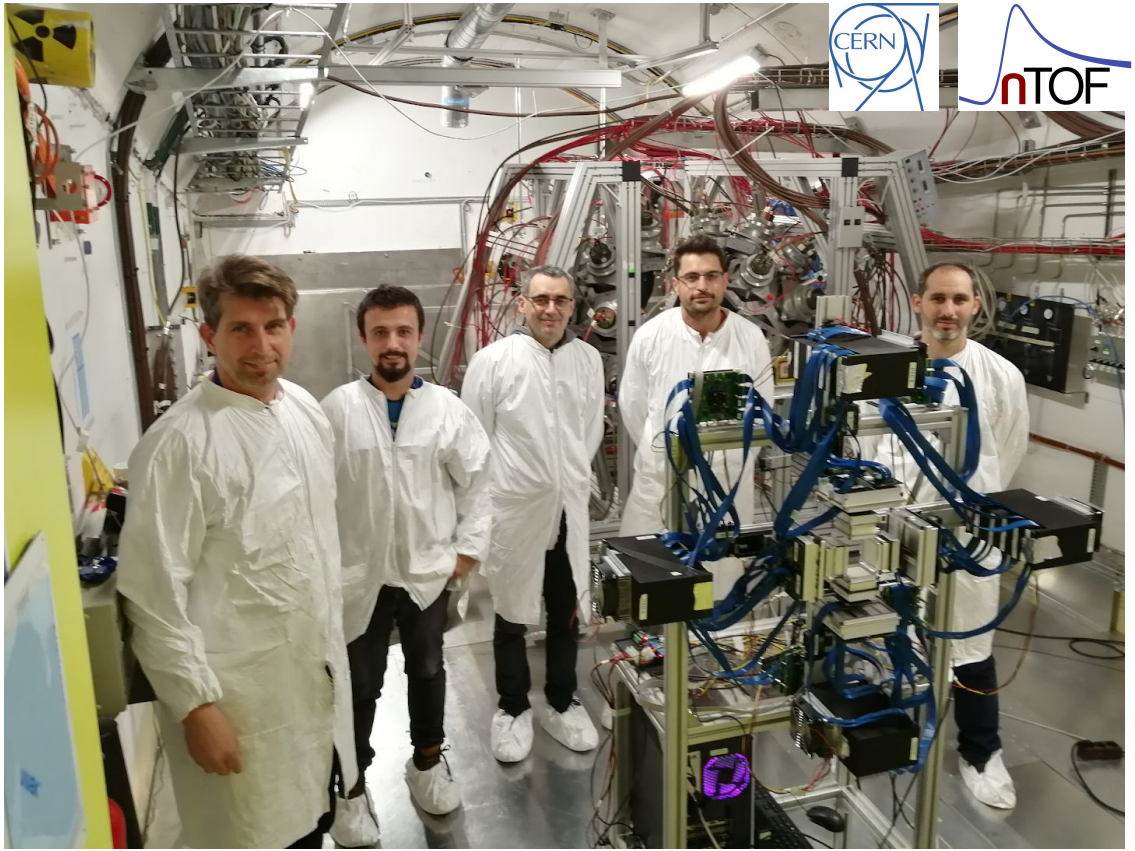
The HYMNS Project and i-TED



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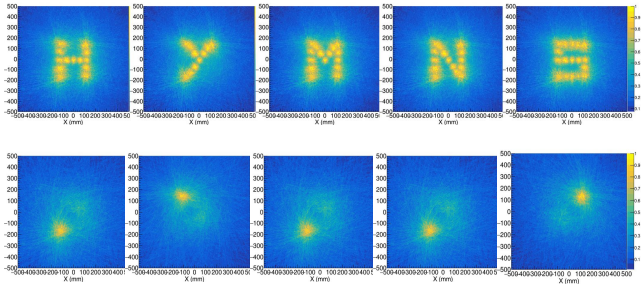

Imaging applied to (n,g) experiments at CERN → Application to Hadrontherapy?

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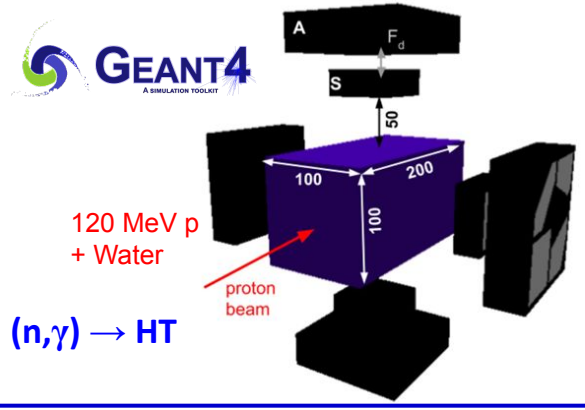
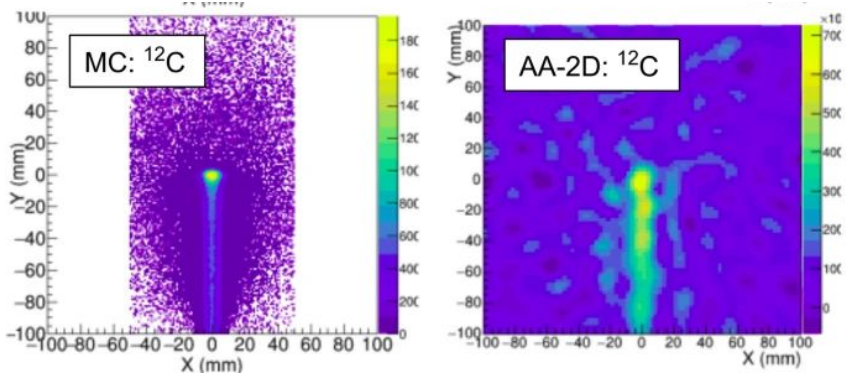
erc European Research Council

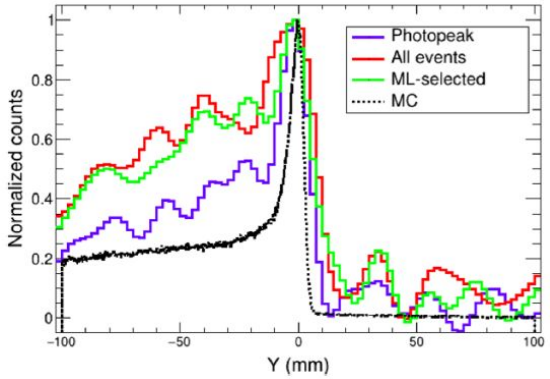
Suitability of i-TED for proton-range monitoring: First MC study

✘ **Uncertainties in range** limit the benefits of having a sharp Bragg peak.



- High **gamma-ray energy** (6-7 MeV) → optimized i-TED setup
- Very **large n-induced backgrounds** → optimized choice of crystals & software
- **Real time** attained via large-efficiency scalable system + GPU-Boosting

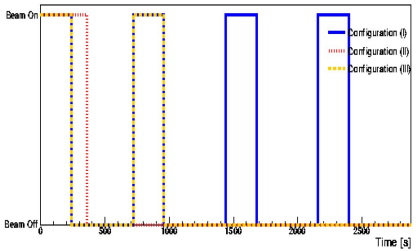


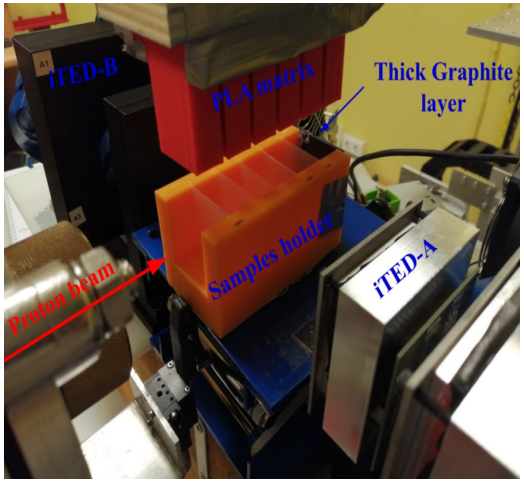


Suitability of i-TED for proton-range monitoring: First tests @ 18 MeV (CNA)

✘ **Uncertainties in range** limit the benefits of having a sharp Bragg peak.

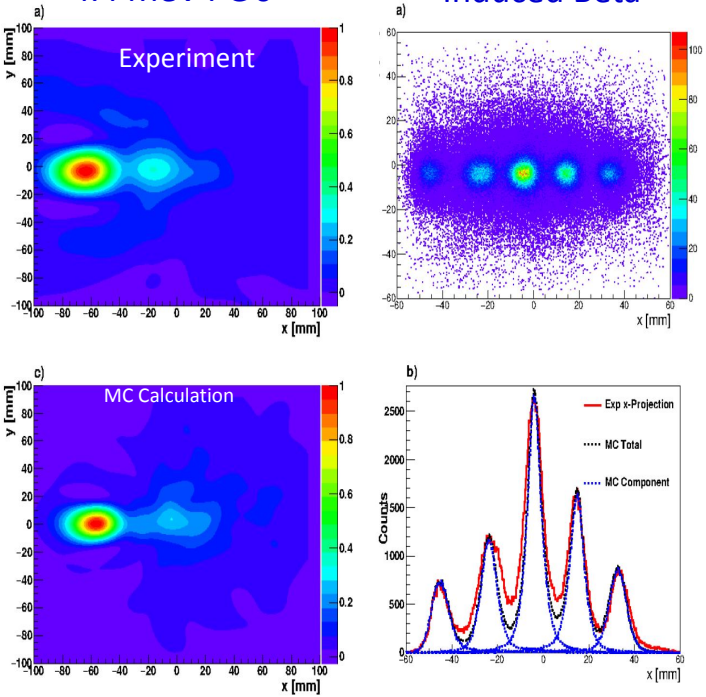
+18 MeV Cyclotron
+Nylon, PMMA, C
+Beam-On / Off cycle





Compton:
Beam On
4.4 MeV PG's

PET:
Beam-off
Induced Beta+



In-beam PET and Compton imaging for enhanced accuracy proton-range verification

Javier Balibrea-Correa[1,*], Jorge Lerendegui-Marco[1], Ion Ladarescu[1], Carlos Guerrero[2], Teresa Rodríguez-González[2,3], Maria del Carmen Jiménez-Ramos[3,4], Begoña Fernández-Martínez[2,3], and César Domingo-Pardo[1]

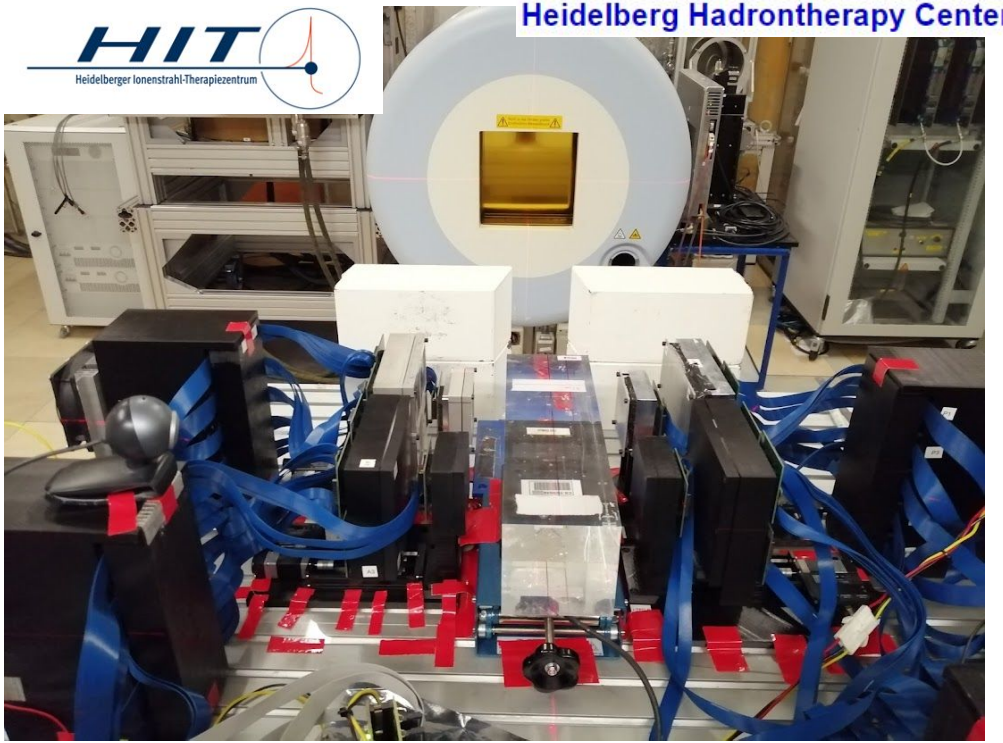
Preliminary results in ANPC Proceedings:

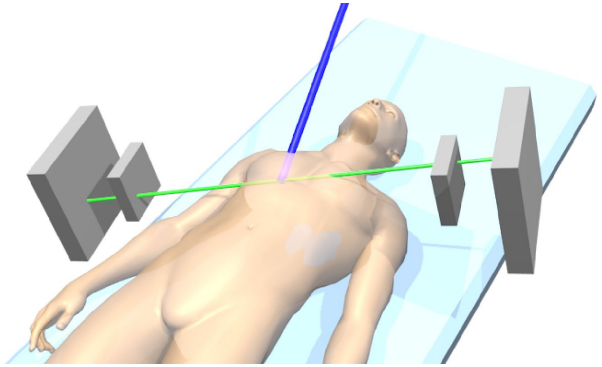
https://doi.org/10.1051/epjconf/202226105002

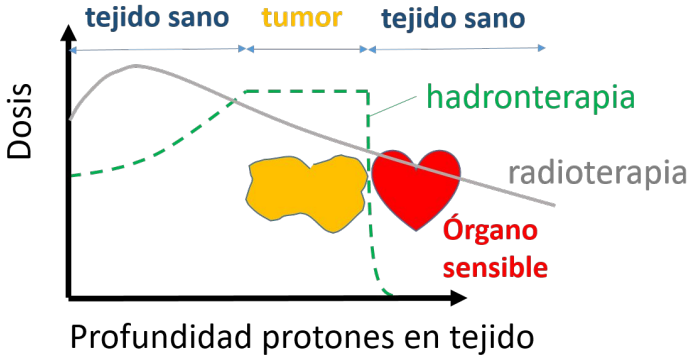
Full paper:
https://arxiv.org/abs/2202.06556

In-situ Compton and PET imaging with i-TED: Clinical conditions at HIT Heidelberg

✘ **Uncertainties in range** limit the benefits of having a sharp Bragg peak.







→ **i-TED** in front-to-front configuration enable for **simultaneous prompt-gamma Compton imaging and Positron-Emission Tomography (PET) in clinical conditions**

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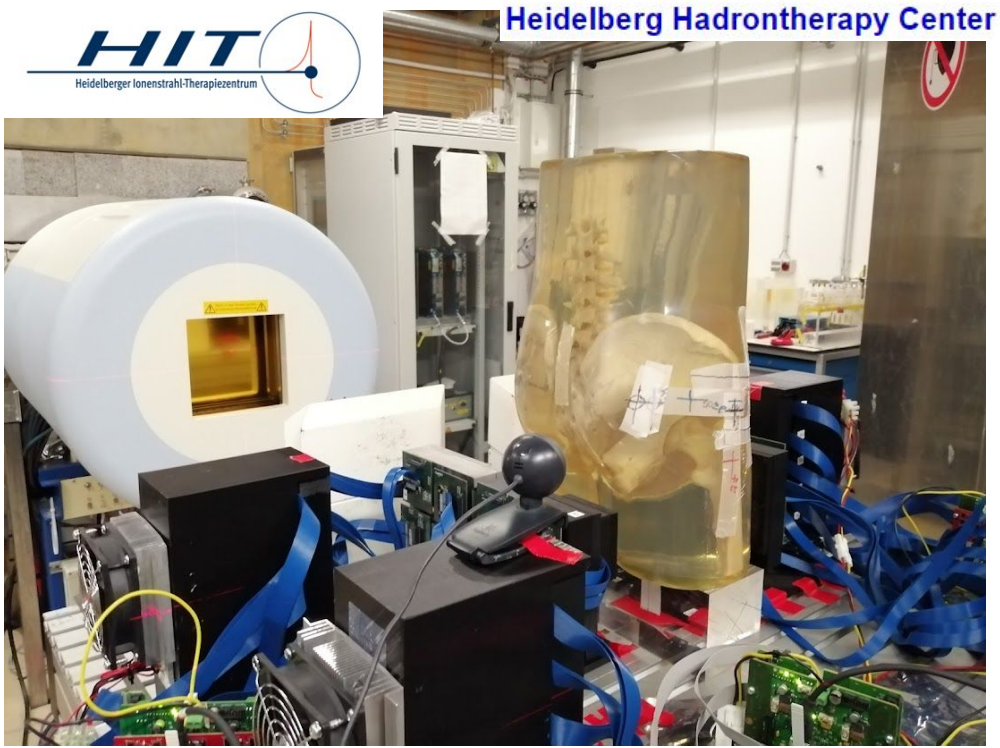

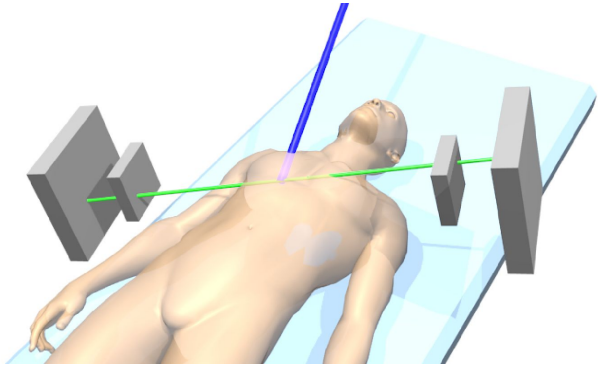

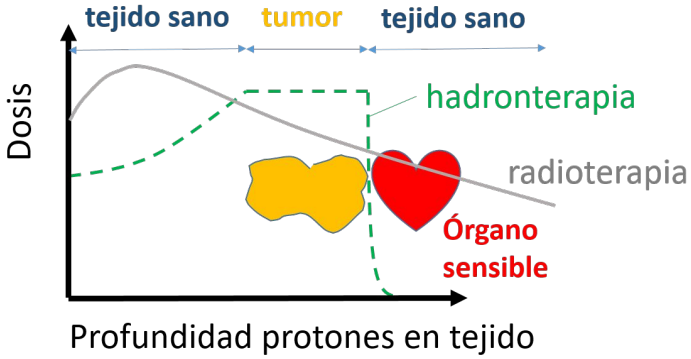

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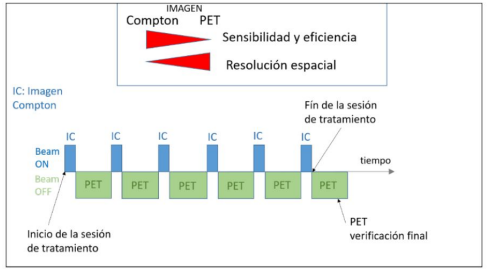
In-situ Compton and PET imaging with i-TED: Clinical conditions at HIT Heidelberg

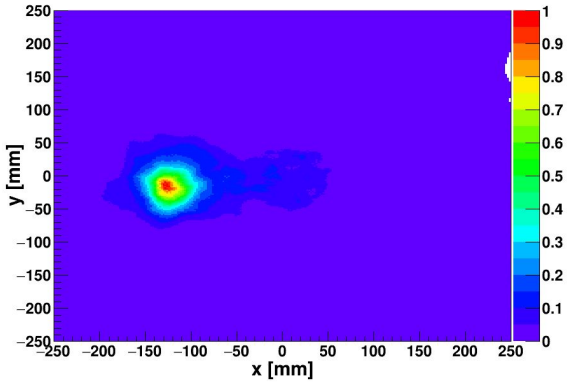
Uncertainties in range limit the benefits of having a sharp Bragg peak.

HIT Heidelberger Ionenstrahl-Therapiezentrum

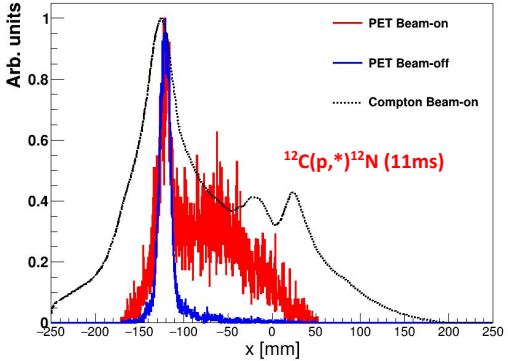
Heidelberg Hadrontherapy Center



Compton 4x i-TED: Beam-on

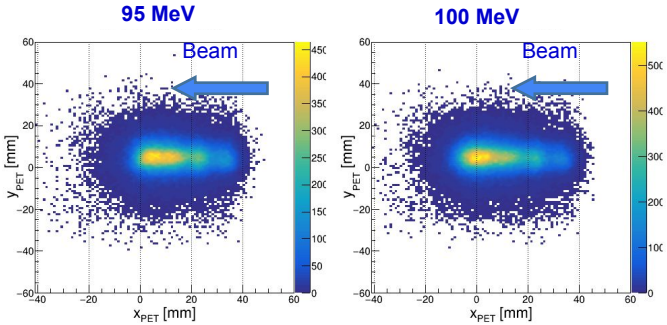


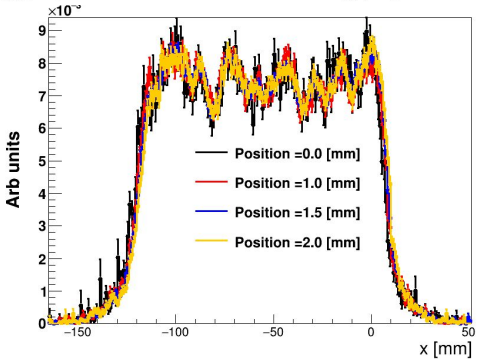
Compton vs PET 4x i-TED



PET Beam-off

95 MeV **100 MeV**





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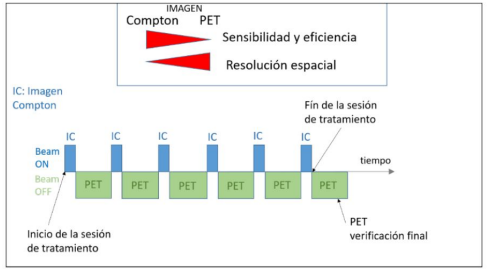
Heidelberg Hadrontherapy Center



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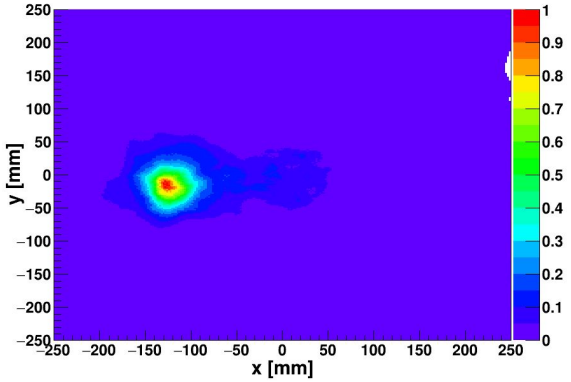

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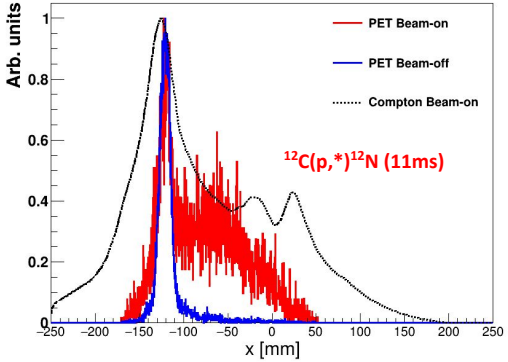

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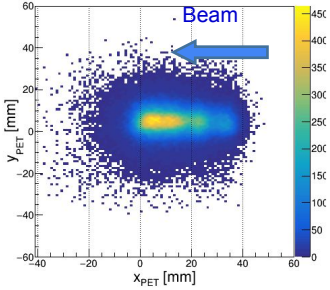
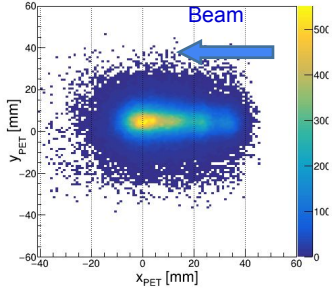
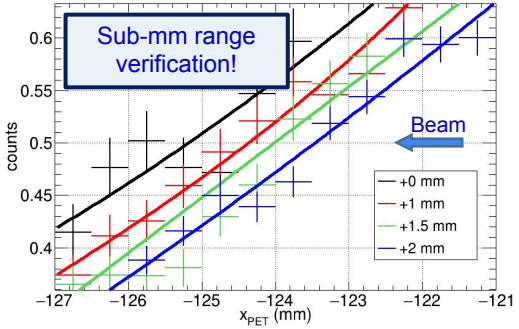


100 MeV





In-situ Compton and PET imaging with i-TED: Clinical conditions at HIT Heidelberg

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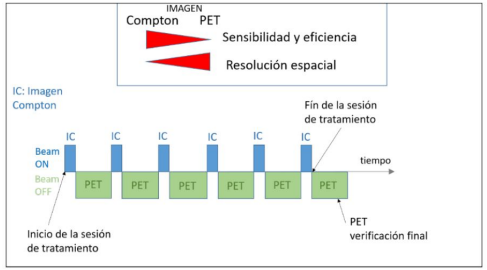

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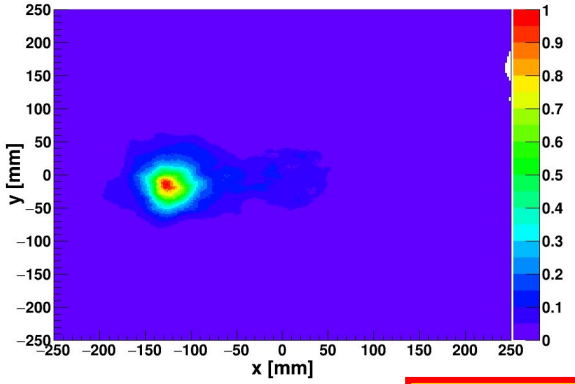
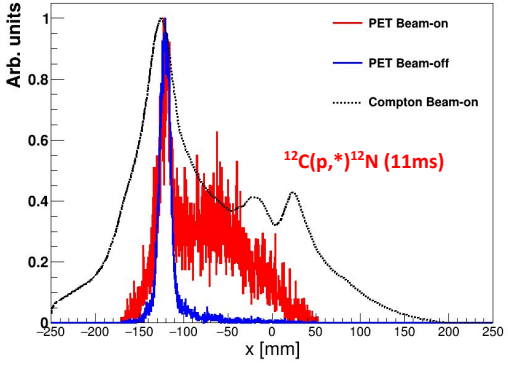


Compton vs PET 4x i-TED



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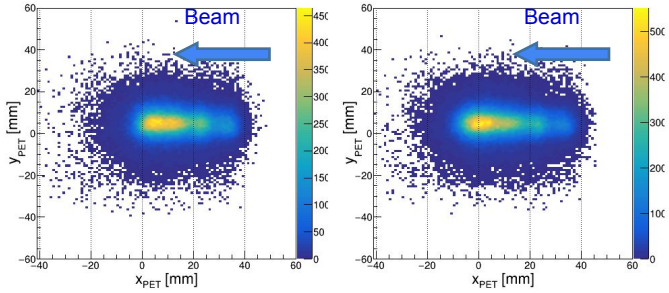


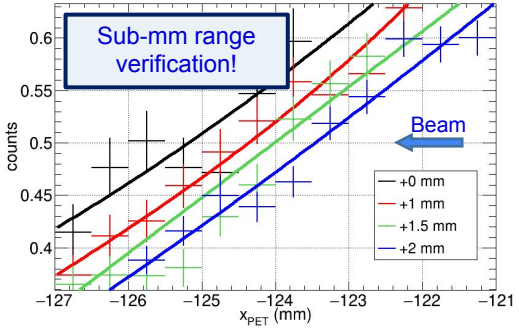
Simultaneous

In-situ

Compton & PET imaging

Proton-range

Clinical Conditions!



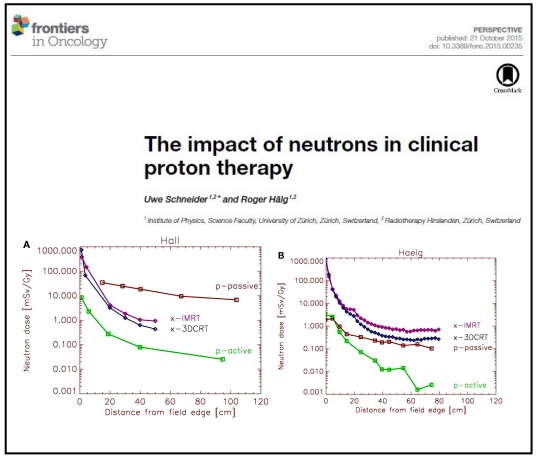
(article in preparation)

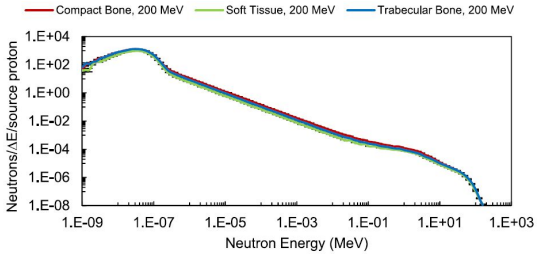
Supplying Accurate Nuclear Data for energy and non-energy Applications

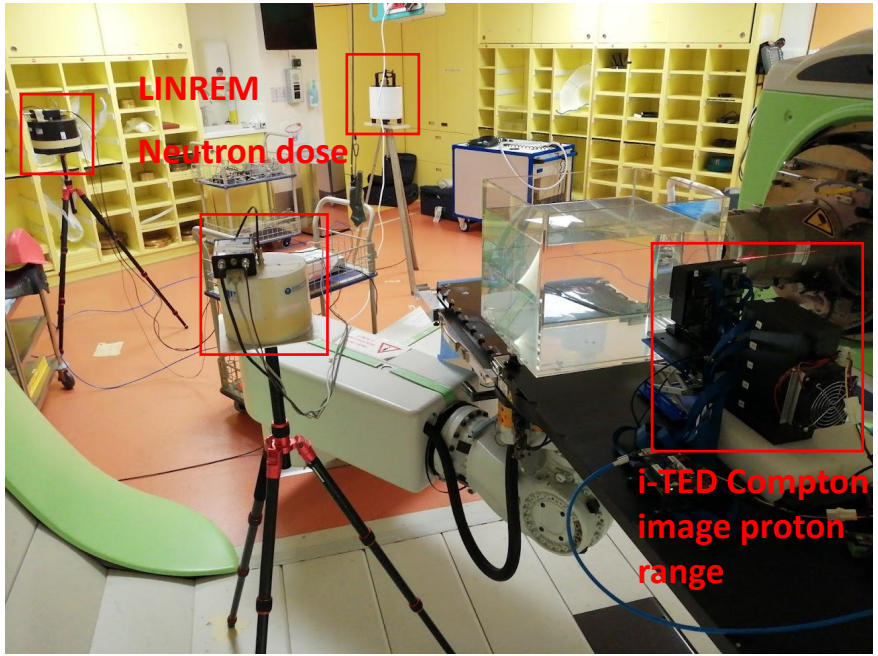
One step further: correlating therapeutic and secondary (neutron) dose (POC-MICIN)

✗ Assessment of **secondary (unwanted)** dose due to neutrons

- Explore the neutron dose in time-correlation with the therapeutic ion-dose
- **UPC neutron dosimeters** (A.Tarifeño's talk) + **IFIC i-TED Compton imager** @ ICPO Orsay HT-facility



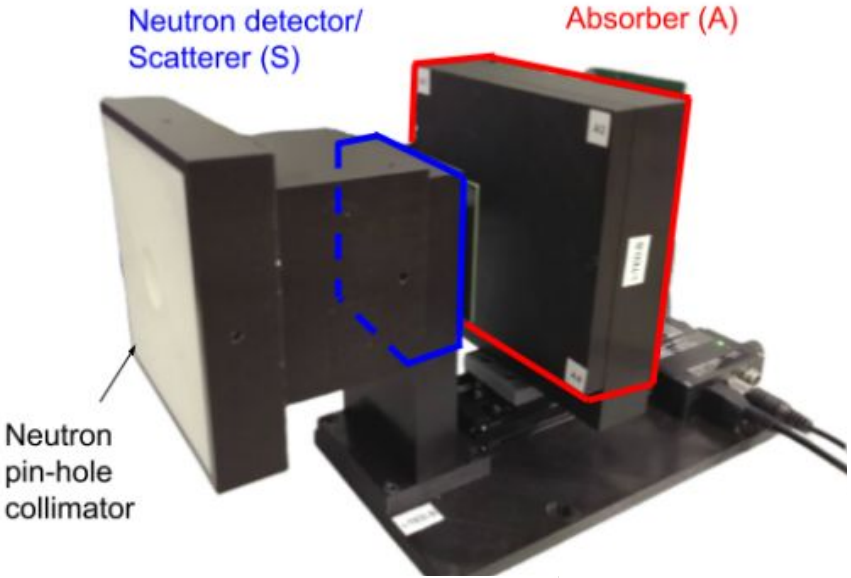


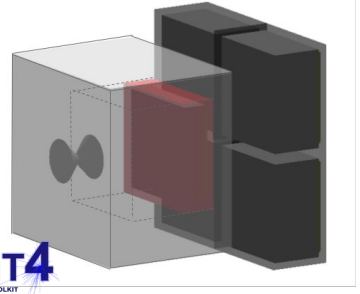


✓ **Proof-of-concept MICIN-2021, CDP (CSIC), F.Calviño (UPC) 2022/23**

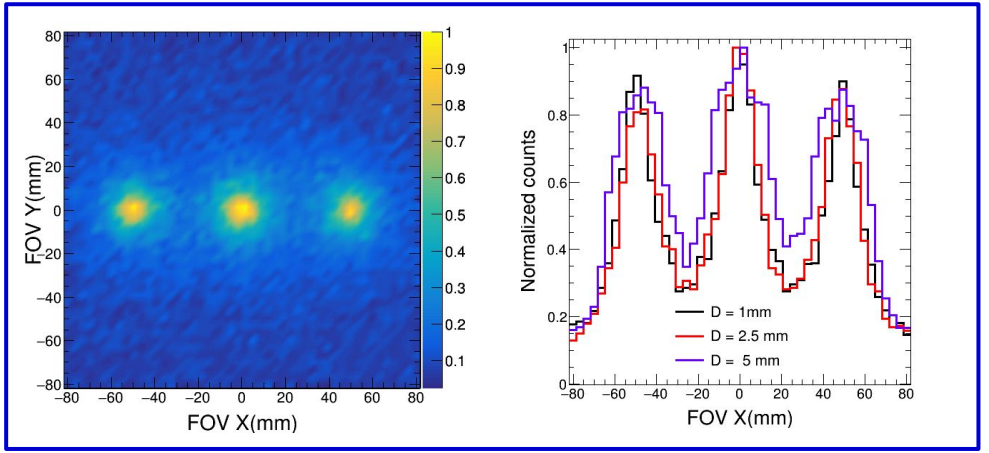
Future steps and further developments: GN-Vision

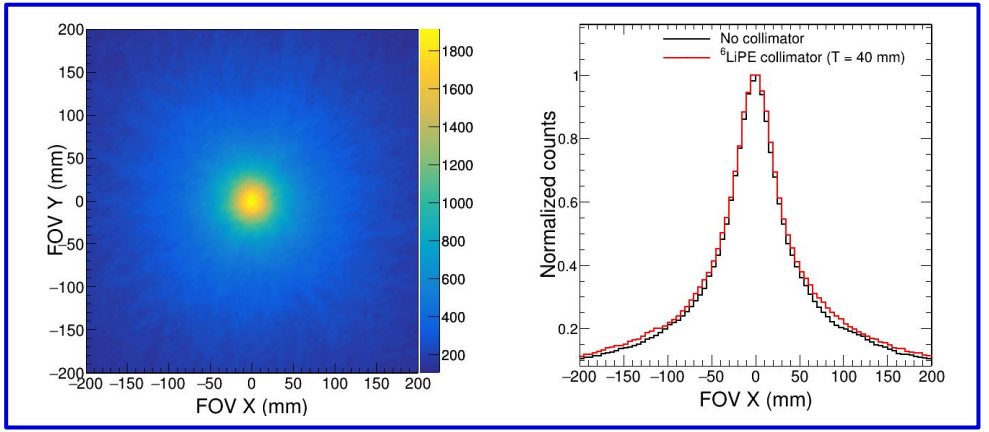
- Assessment of **secondary (unwanted)** dose due to **neutrons**.
  - **Simultaneous imaging of therapeutic beam range and secondary n-dose**





Neutron imaging: Mechanical collimation, thermal-100 eV



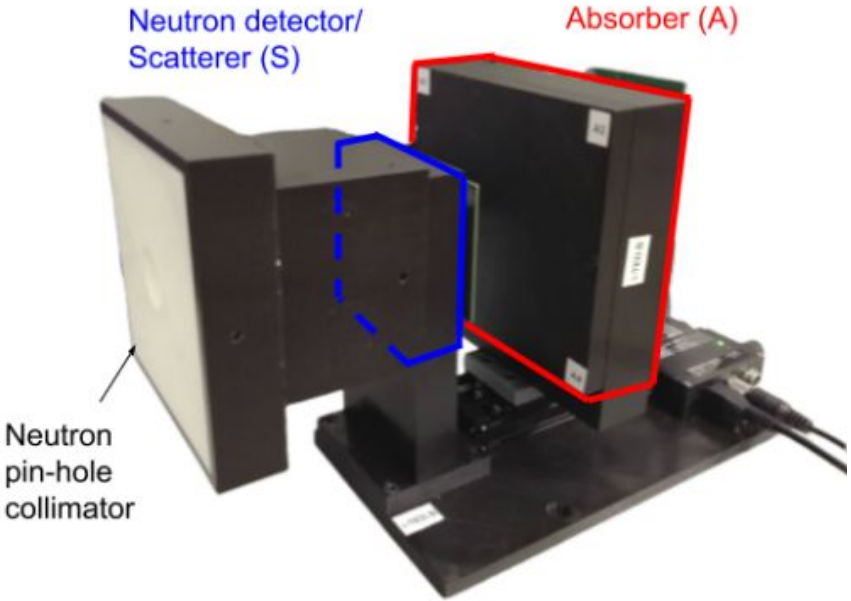


γ-imaging: Compton 200 keV - 10 MeV

Future steps and further developments: GN-Vision

Assessment of **secondary (unwanted)** dose due to **neutrons**.

- **Simultaneous imaging of therapeutic beam range and secondary n-dose**



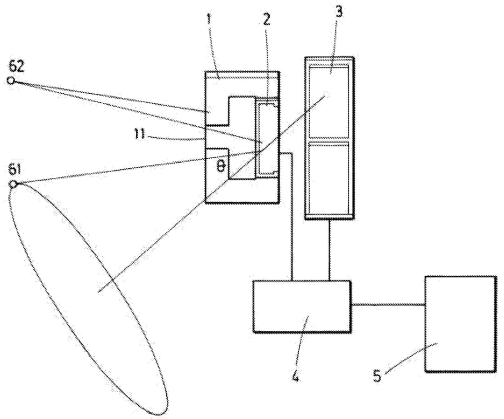


FIG.1

Patent:
DEVICE FOR THE SIMULTANEOUS DETECTION, IDENTIFICATION, QUANTIFICATION AND/OR LOCALIZATION OF GAMMA RADIATION AND NEUTRON SOURCES, ES2877772A1

First results MC modelling in ANPC Proceedings:
https://doi.org/10.1051/epjconf/202226105001

Full paper in preparation:

Simultaneous Gamma-Neutron Vision device: a portable and versatile tool for nuclear inspections and medical research

J. Lerendegui-Marco[1], V. Babiano, J. Balibrea-Correa, L. Caballero, D. Calvo, I. Ladarescu, C. Domingo-Pardo

Instituto de Física Corpuscular, CSIC-University of Valencia, Spain

Prueba de Concepto MICIN: Proton range verification & neutron dose in Hadron-therapy

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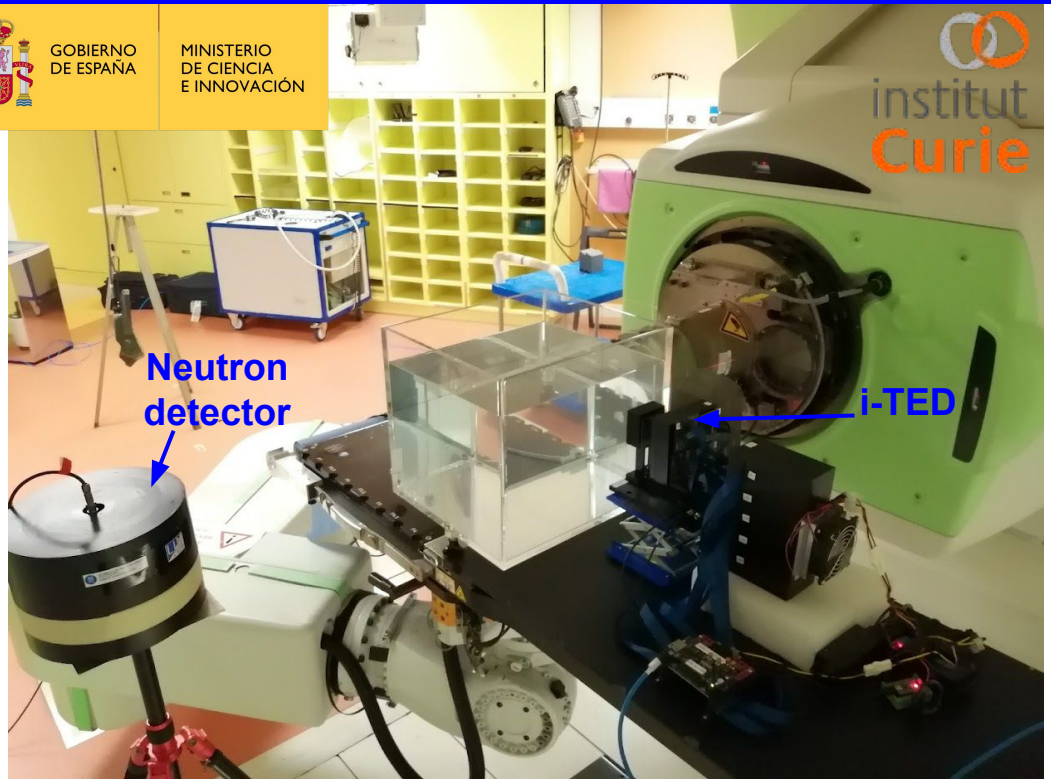

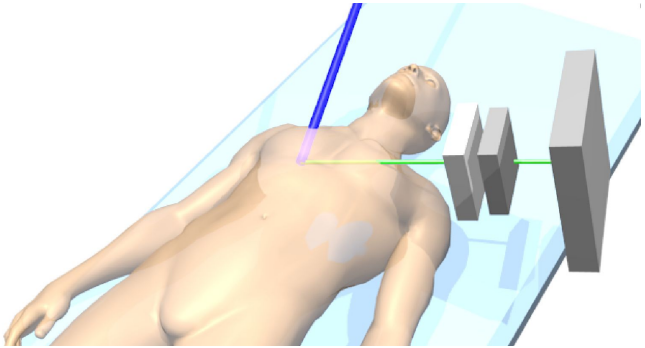

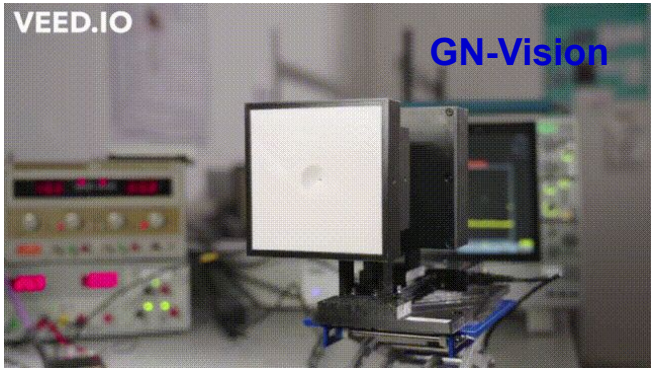

Proof Of Concept:

- Assessment of **ion/proton** range.

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Prueba de Concepto MICIN: Proton range verification & neutron dose in Hadron-therapy

GOBIERNO DE ESPAÑA
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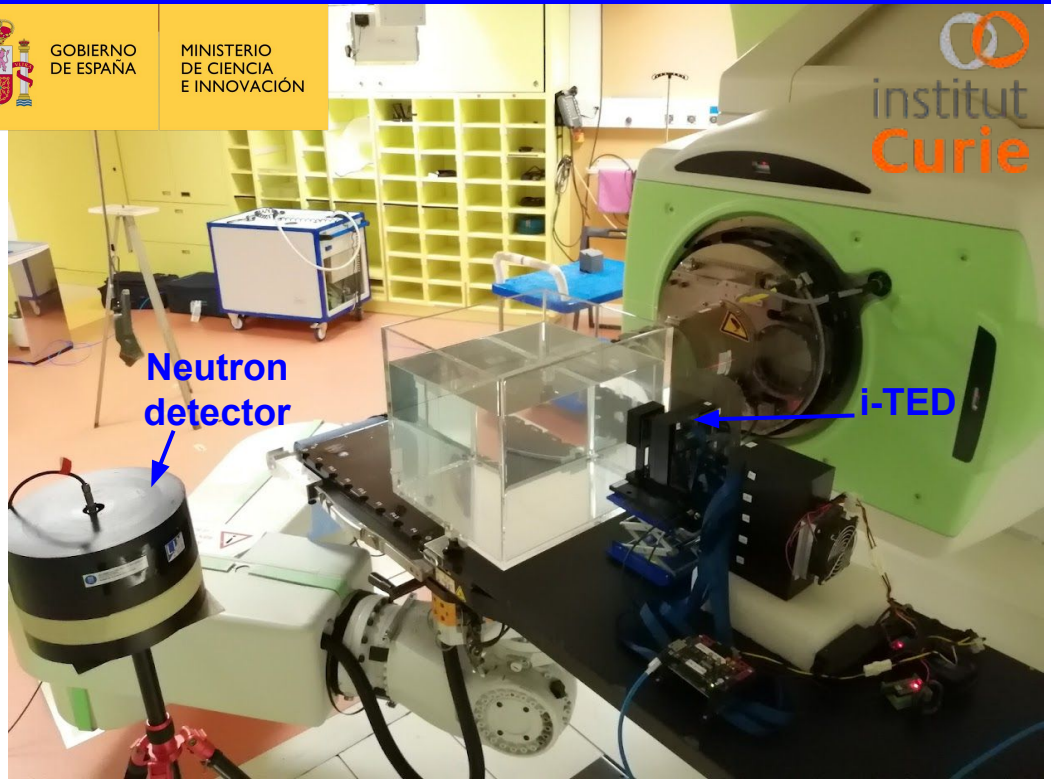

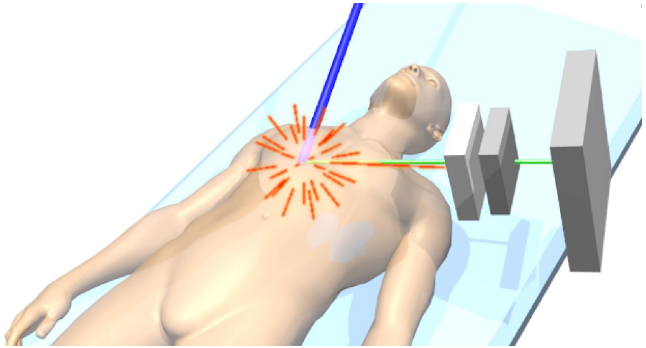

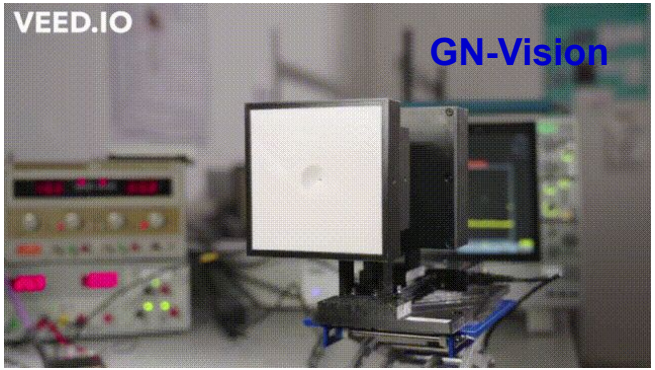

Proof Of Concept:

- Assessment of **ion/proton** range.
- Assessment of **secondary dose** from neutrons.

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