

DEvelopment and testing of Medical physics instrumentation (DENIM)

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Outline

- DENIM team
- Facilities and research activities
 - CCB IFJ PAN proton therapy center (medical physics R&D perspective)
 - IJC Lab Health Pole
- DENIM project objectives
- Preliminary results
- Future prospects

DENIM team

IJC Lab

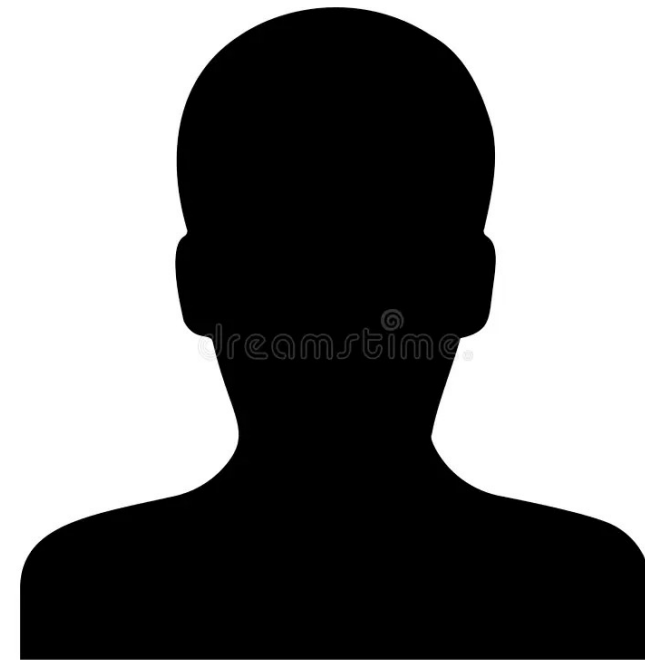
CCB IFJ PAN



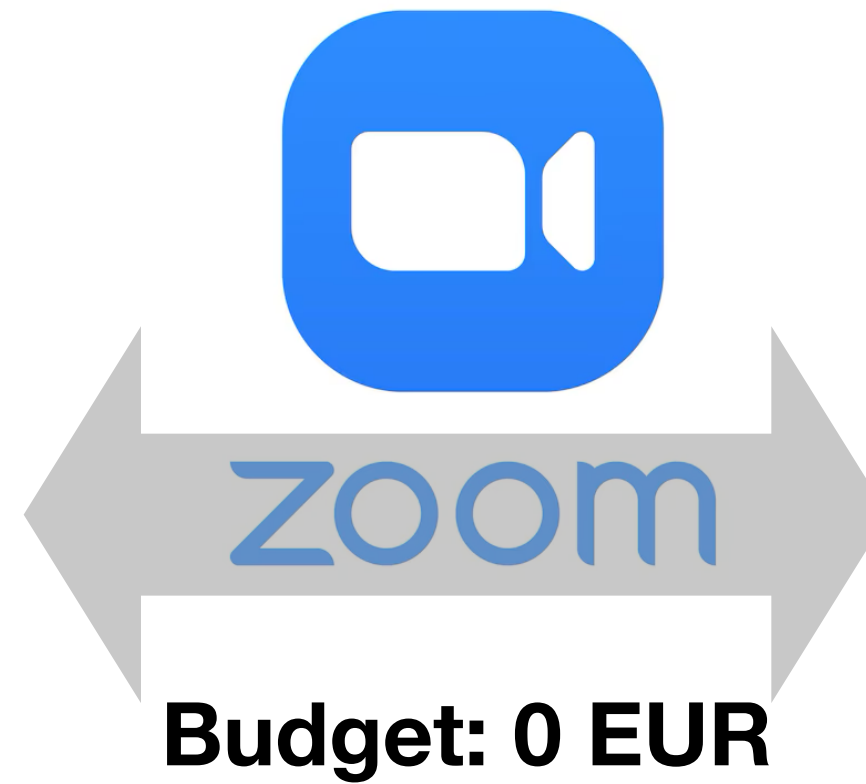
Marc Antoine
Verdier



Quentin
Mouchard



Philippe
Lanière



Victor
Merza



Jan
Gajewski



Renata
Kopeć



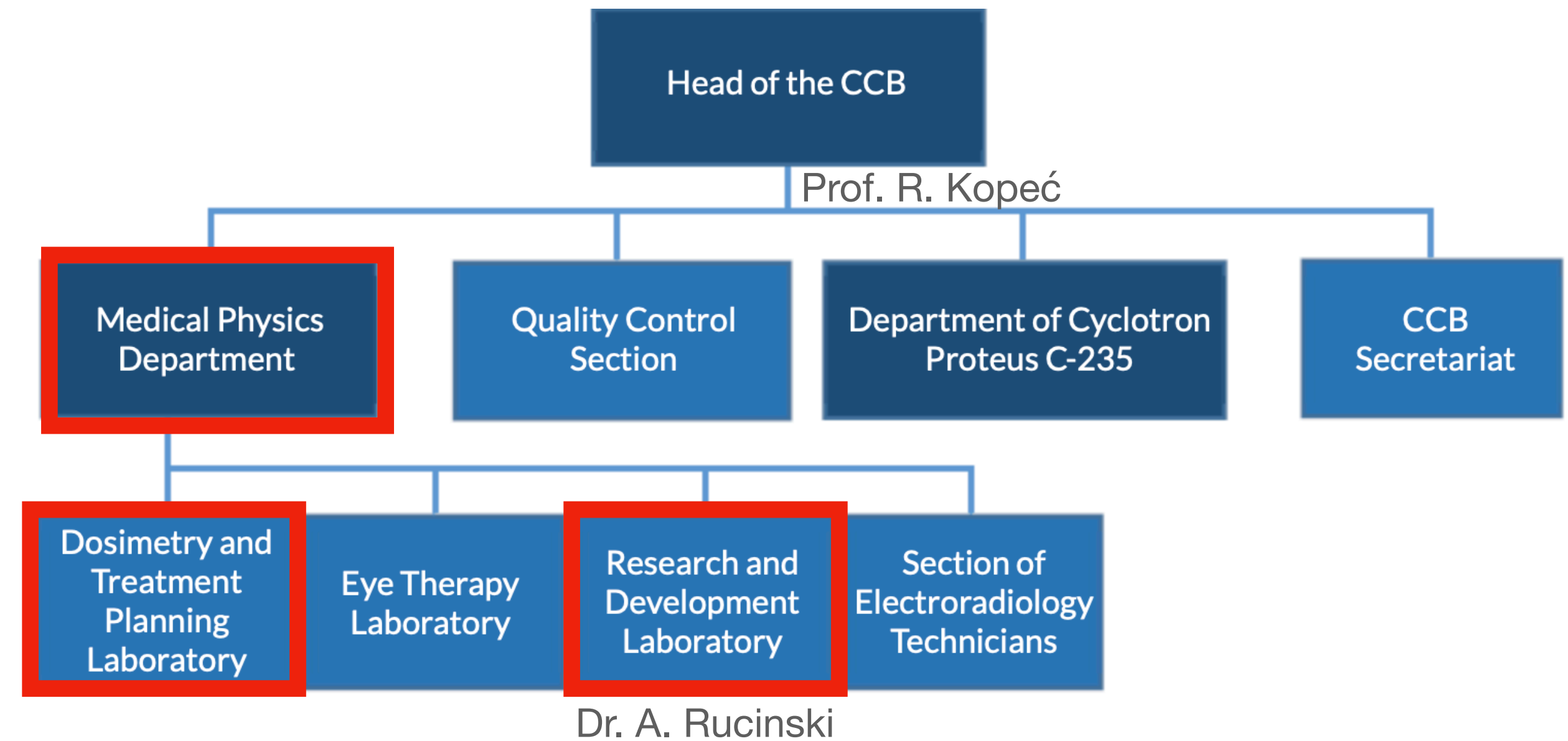
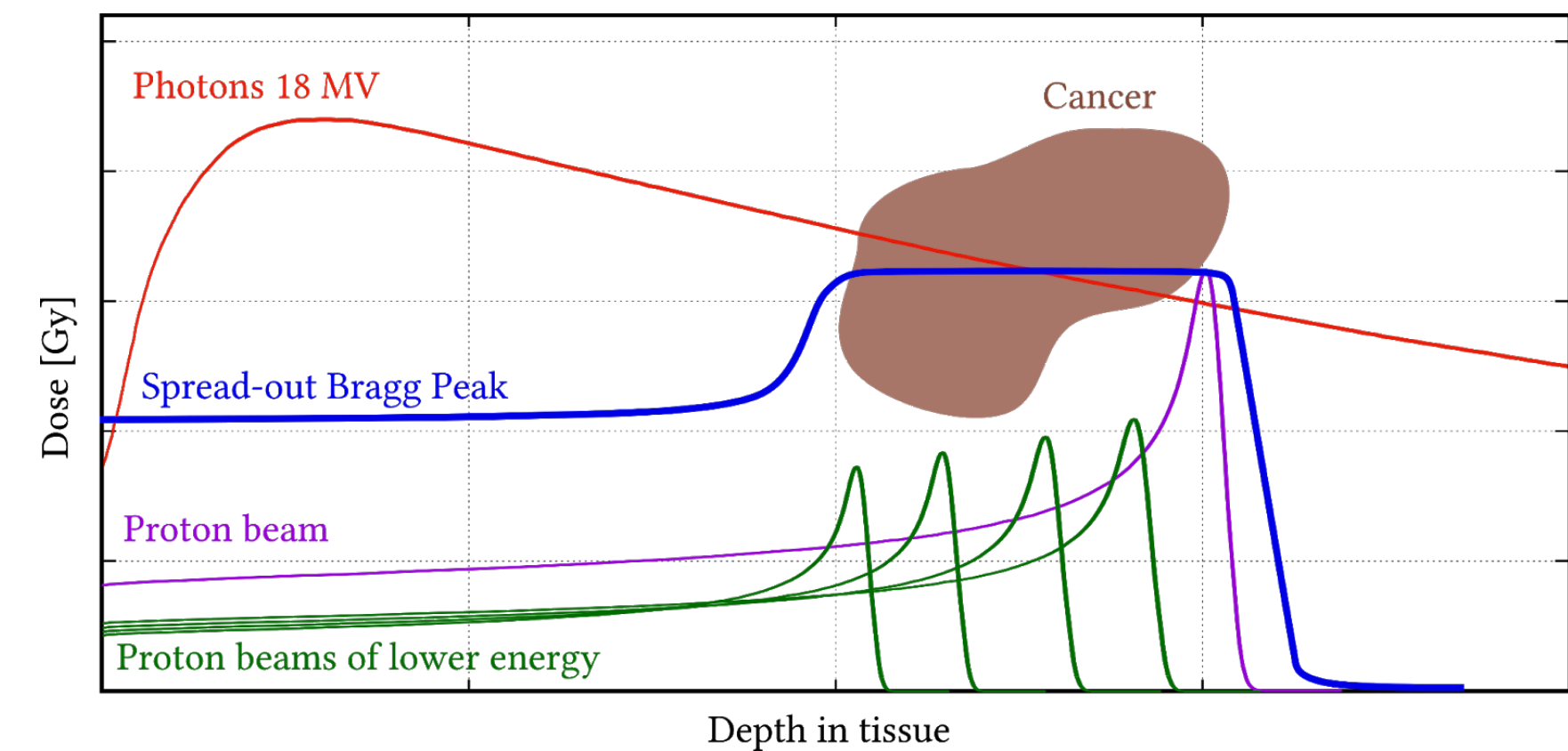
Antoni
Ruciński

- Common interests:

- Condensed history and track structure simulations: Scientific committee of GATE (Geant4/Geant4-DNA) collaboration
- Radiobiological response to ionizing radiation in micro- and nano-scale
- Detector development for beamline modeling and characterization of radiation quality

CCB Kraków proton center

Structure and relevant data/equipment



- Scanned clinical proton pencil beams at 70-230 MeV/u operated at therapeutic, low, and FLASH beam rates
- Access to proton beams in Gantry rooms for experiments
- Anonymized patient data for TP studies and protocol development
- Radiobiology labs equipped to perform in vitro experiments (from 2023)

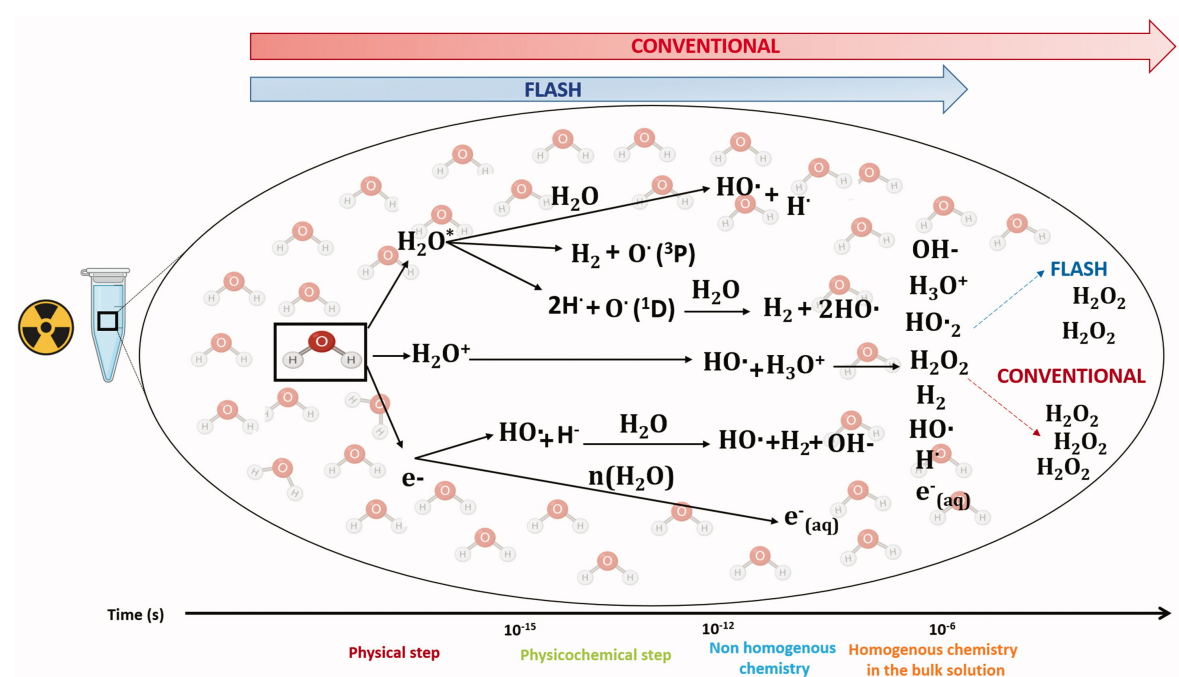
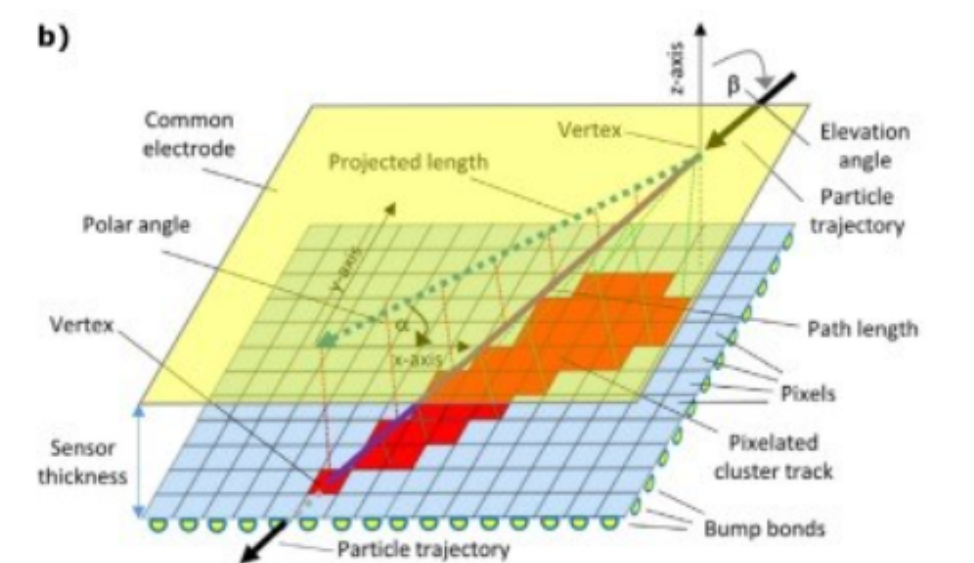
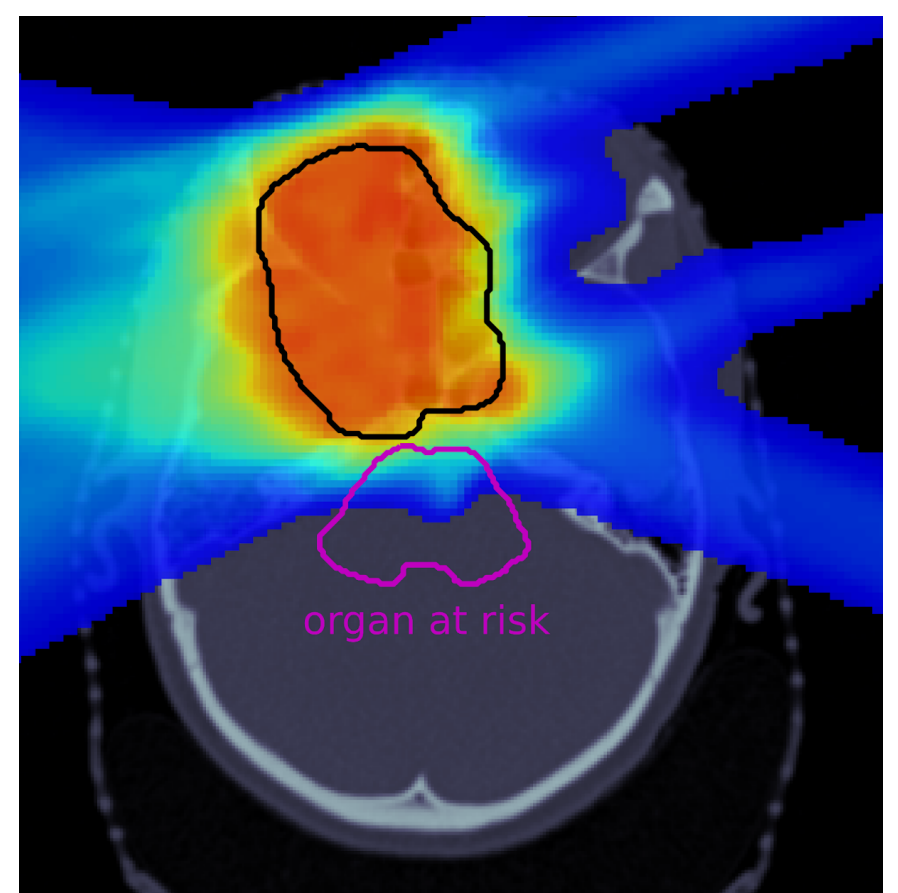
Activities of R&D lab of CCB proton center

Computations and modelling



Physics experiments & radiobiology

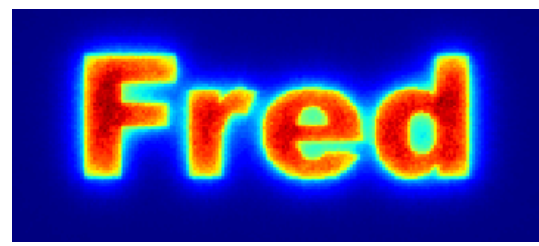
Proton Radiotherapy project
Justyna Miszczyk
Mathilde Badoual
Friday 9:40am



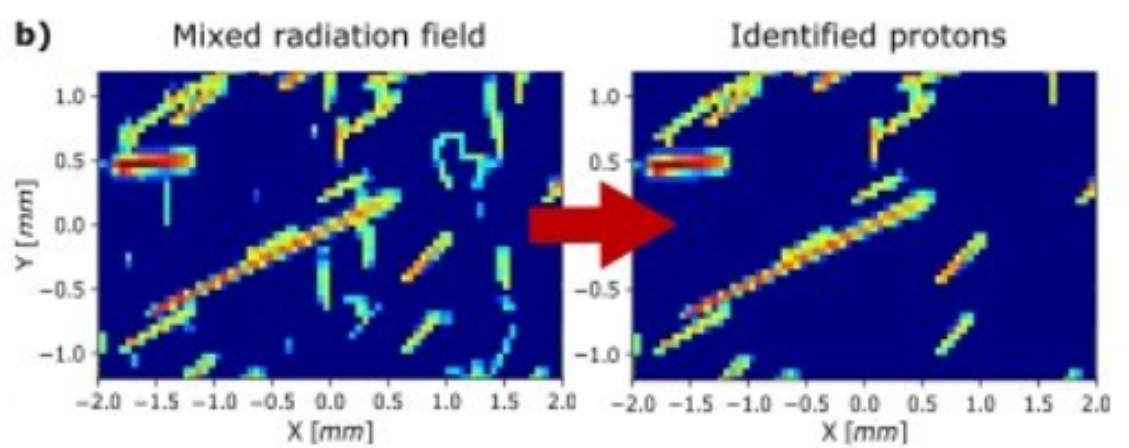
Physics, heterogeneous and homogenous chemistry stages of FLASH effect.
M. Rydygier, A. Ruciński



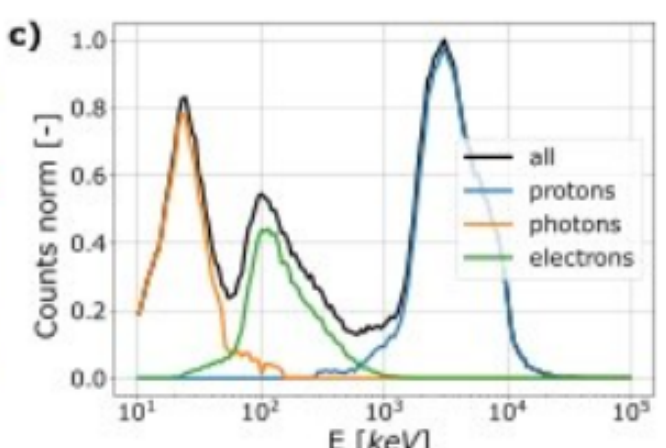
J-PET
JAGIELLONIAN UNIVERSITY IN KRAKOW



Treatment planning and quality assurance in proton radiotherapy using fast Monte Carlo calculations on GPU graphics cards.
J. Gajewski & A. Ruciński

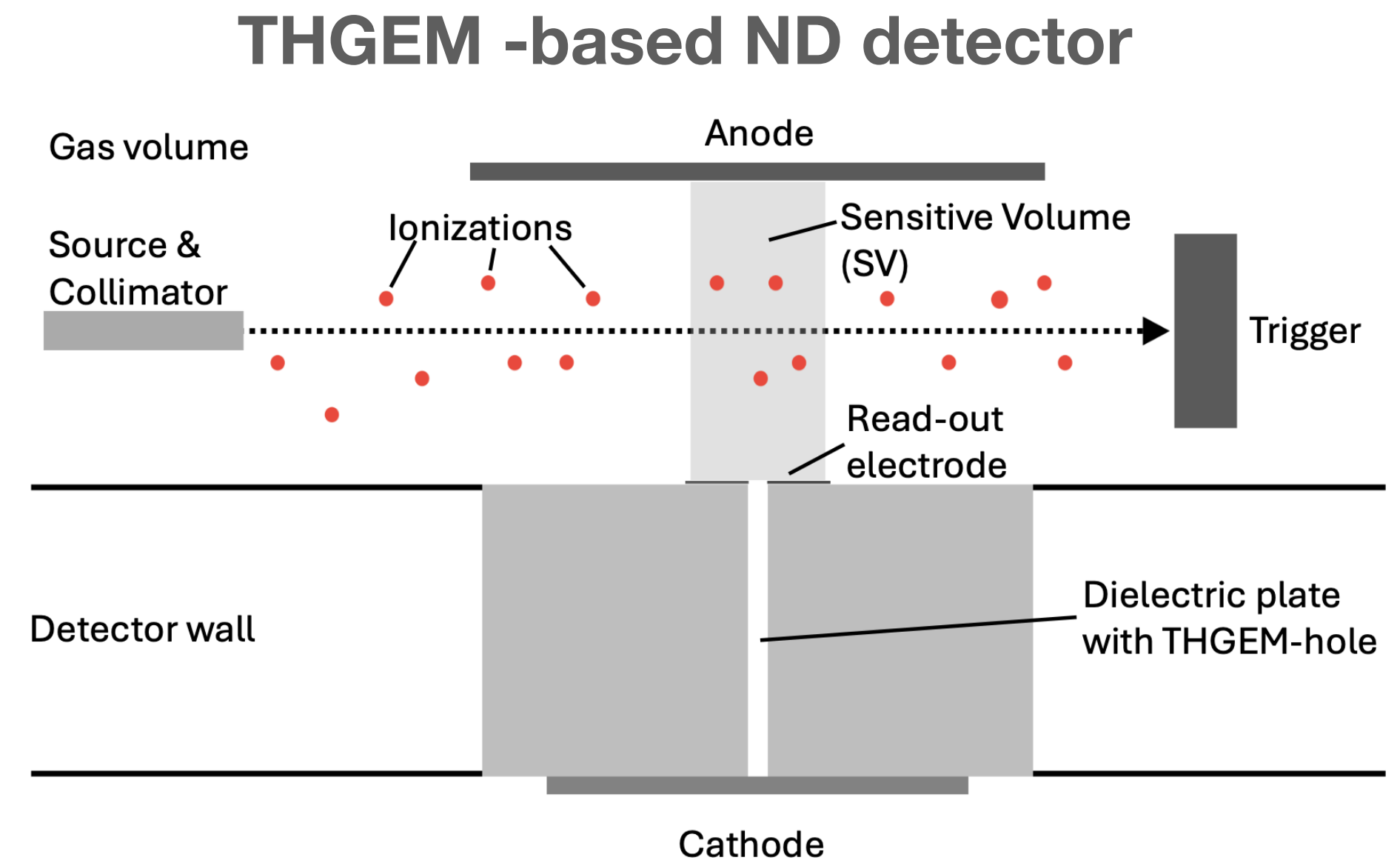
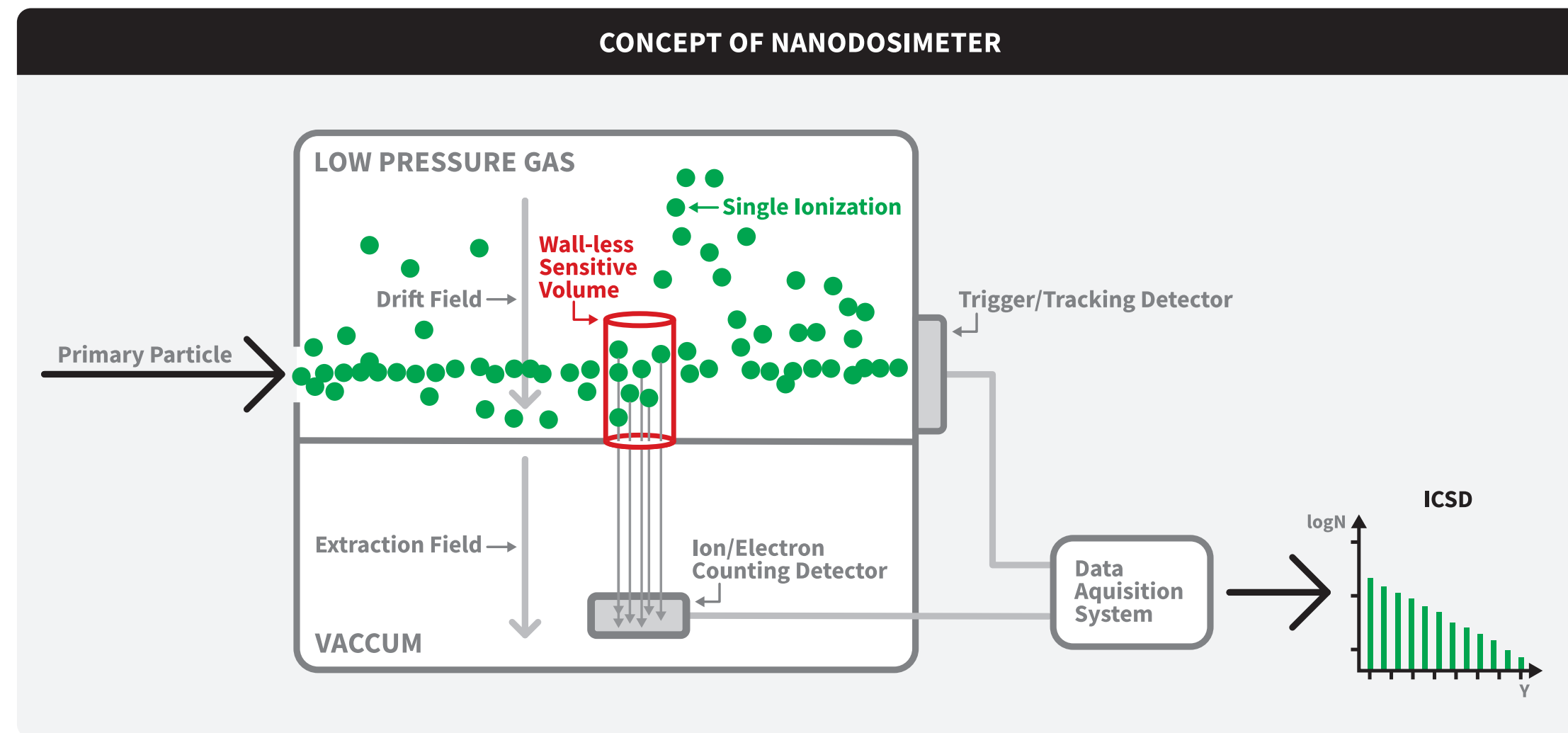


Proton beam dosimetry including radiation quality information using TimePix detectors (CERN).
J. Gajewski



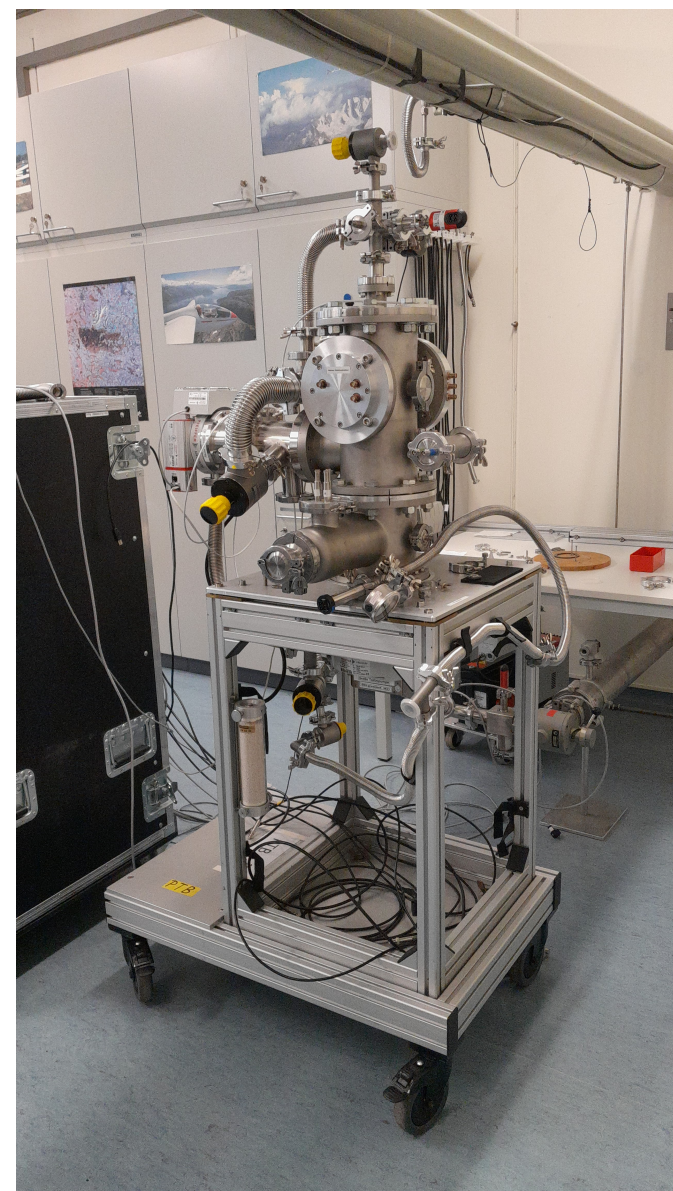
Monitoring of proton beam range in proton radiotherapy using the J-PET detector based on plastic scintillator technology.
A. Ruciński & P. Moskal

Foundation of nanodosimetry lab @CCB IFJ PAN



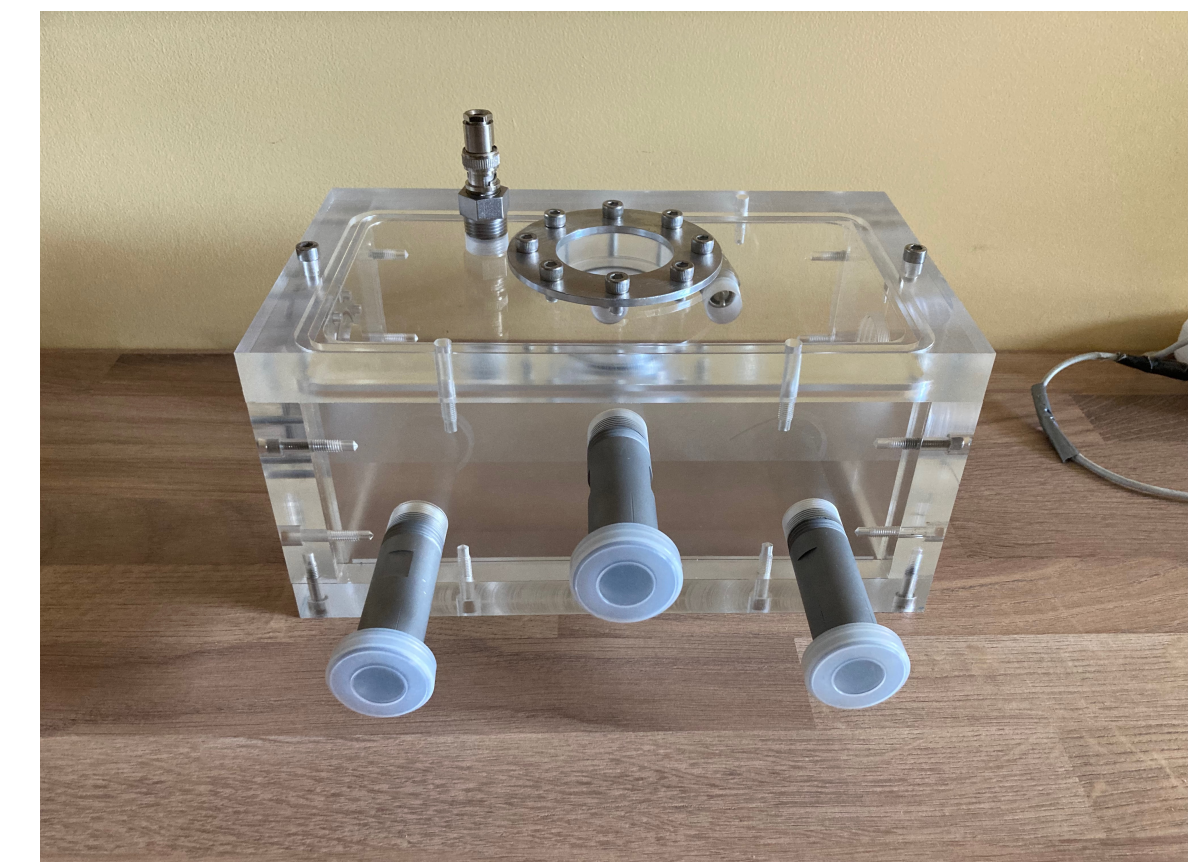
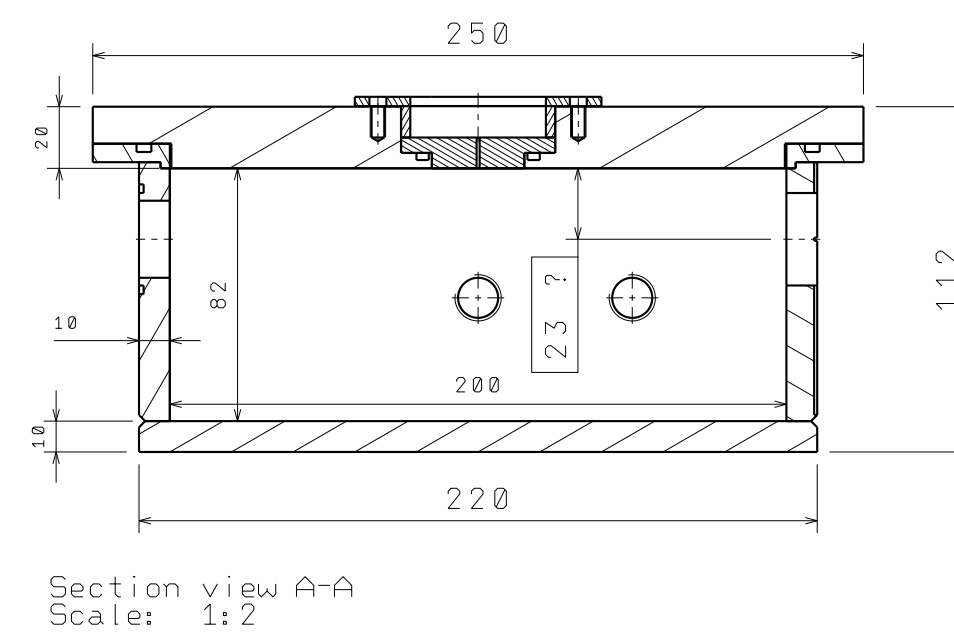
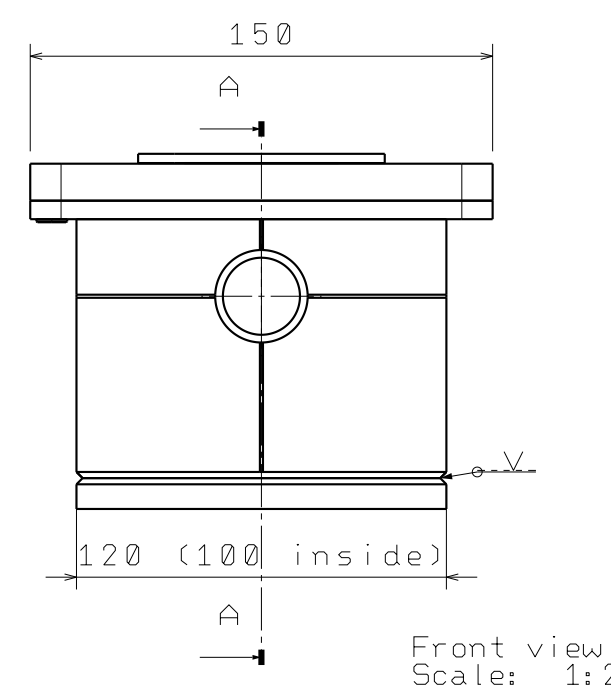
**PTB IC ND
Ion Counting
Nanodosimeter**

PTB -> CCB



CCB prototype

Vacuum chamber (working version)



Victor Merza PhD project



The IJClab health pole

3 research teams and 1 Bio Exp platform

21 Permanents

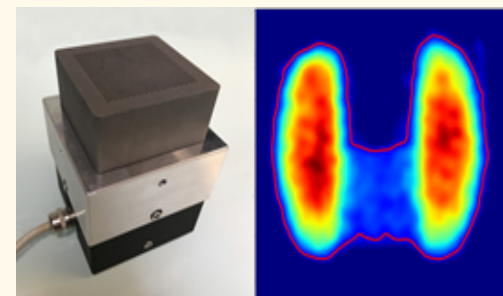
18 researches

3 Ing and Tech CNRS

8 PH students et post-docs

Main research axes

→ *Radiotherapy*

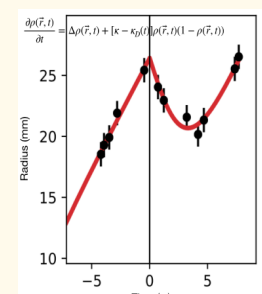


γ-caméra for dose control (thyroid)

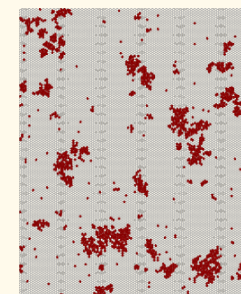


Irradiation Platform for experimental radiotherapy

→ *Modelling of living*



Model of the effect of radiotherapy treatment on low grade gliomas



Collective migration of cells in interaction

$$D_{eff} = \frac{\gamma a^2}{2d} \left(\frac{\Gamma}{\Gamma + \Lambda} \right) \left[1 + \frac{2\gamma}{\Lambda} (1 - \rho)(1 - 2\rho) \right]$$

→ *biomedical imaging*

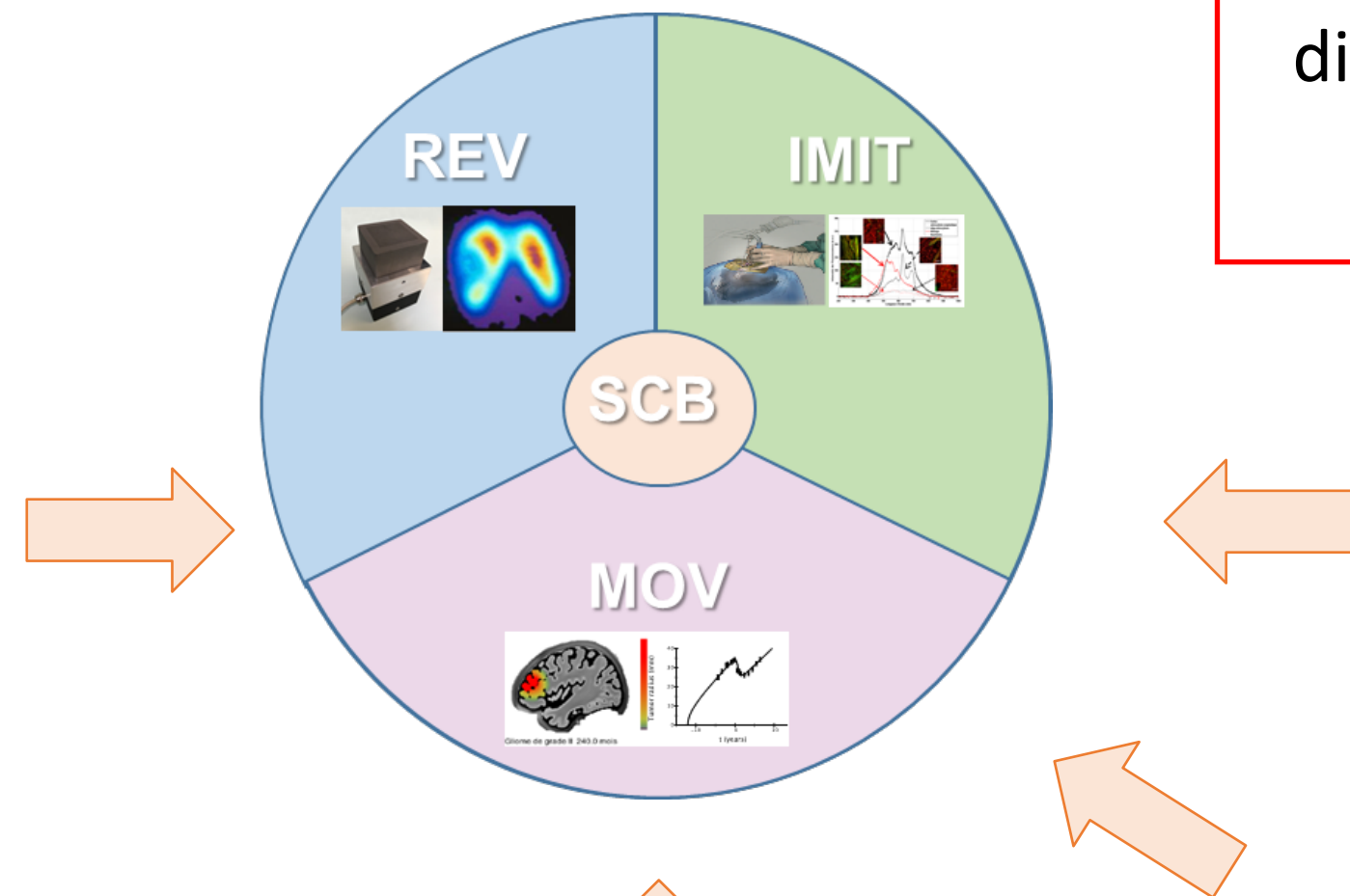


fibred multimodal endomicroscope and clinical analysis of brain tumors



intracerebral isotopic probe for behavioral neuro-imaging on awake animal

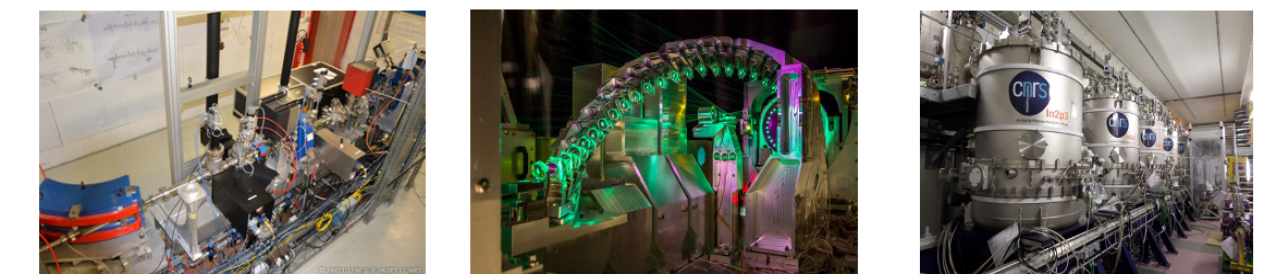
IJClab Health Pole



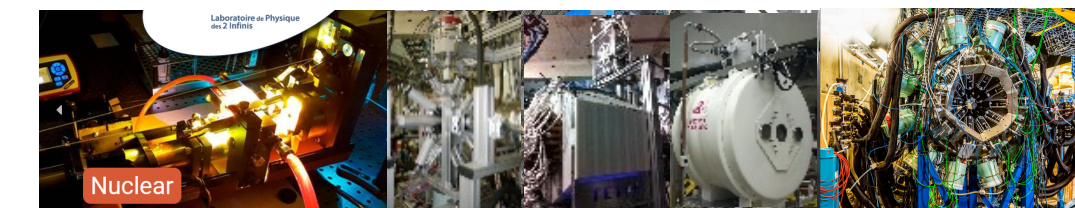
Scientific Challenges :

Propose new instrumental, methodological and theoretical approaches to promote the exploration and understanding of living organisms and enhance the diagnosis and treatment of pathologies.

Accélérateur Pole



Associated Plateforms associées

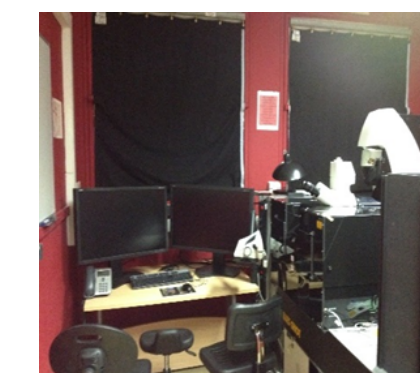


ALTO
Accélérateur Linéaire et Tandem à Orsay



SCALP/Sidonie
Système & Caractérisation using on-line data for Radiotherapy research

PIMPA
Plateforme d'imagerie Multiphotonique du Petit Animal



virtualdata



1 Pôle Ingénierie 4 Départements

~ 250 IT/BIATSS
Instrumentation, informatique, électronique, mécanique

DENIM project

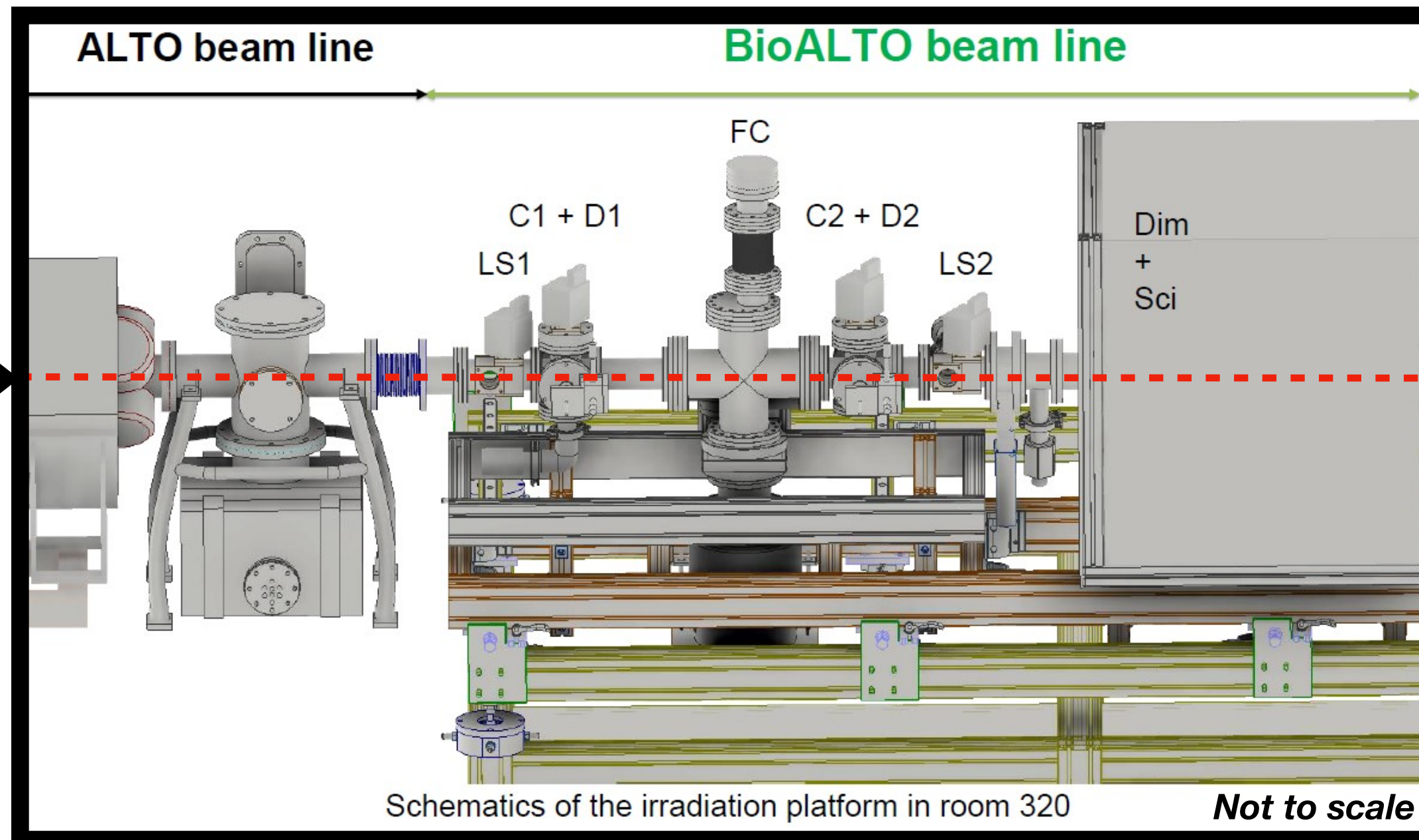
- Specific Objectives
 - Modeling and characterization of Bio-ALTO facility beamline
 - Exploring BioAlto ion beams for radiobiology and detector characterization
- Methods
 - BioAlto Beams: protons: <25 MeV, Alphas: <43 MeV, Carbon: <87 MeV
 - Nanodosimetric detector
 - TimePix detectors for BioAlto beam characterization

Simulations of BioAlto beamline and ND detector response

BioAlto Beamline

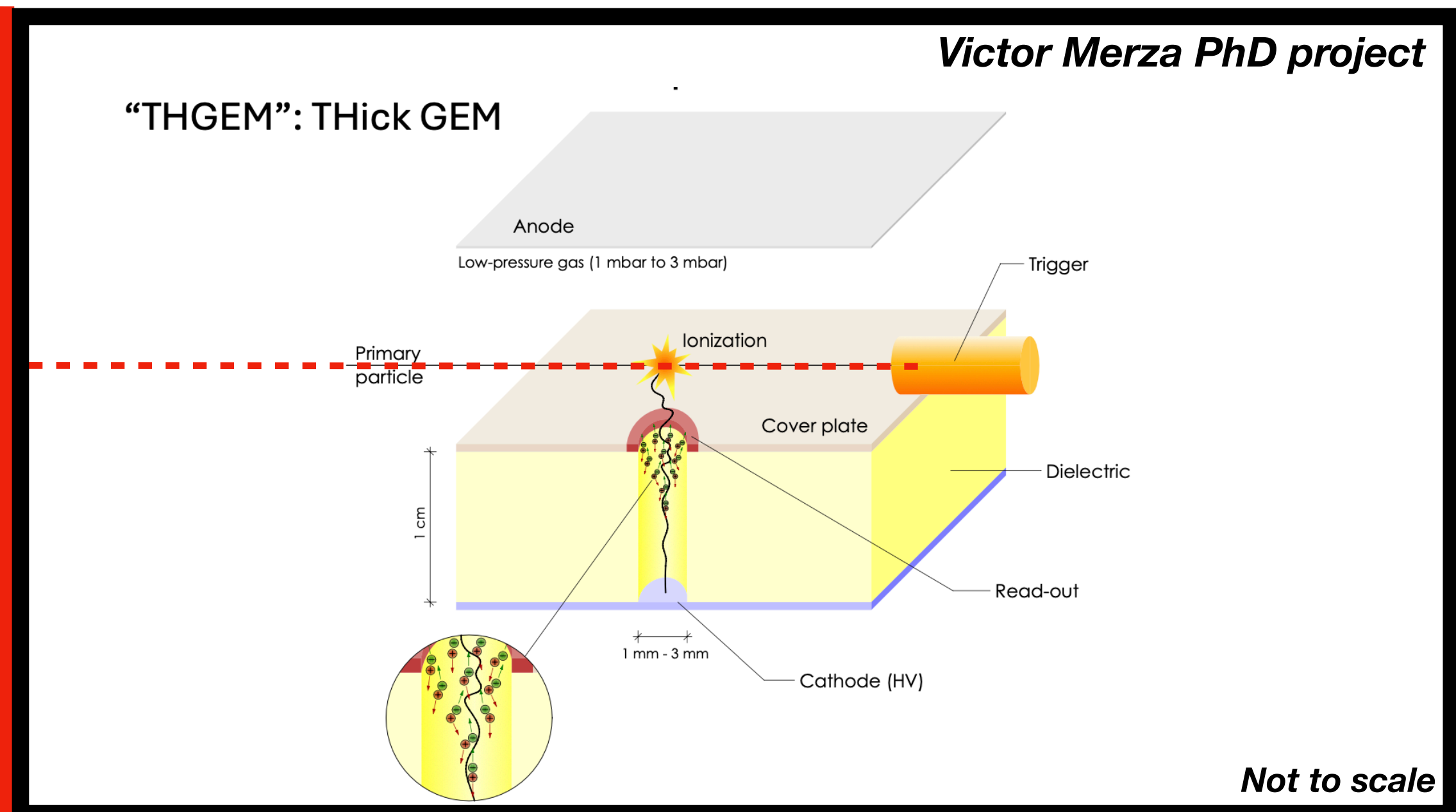
Nanodosimetry detector

ALTO Beams:
5 MeV proton
6 MeV Helium



LS: luminescent target
C: collimators
D: scattering foil (Au)
FC: Faraday cup
Dim: diamond counter
Sci: scintillating fibre counter

IJC lab simulations



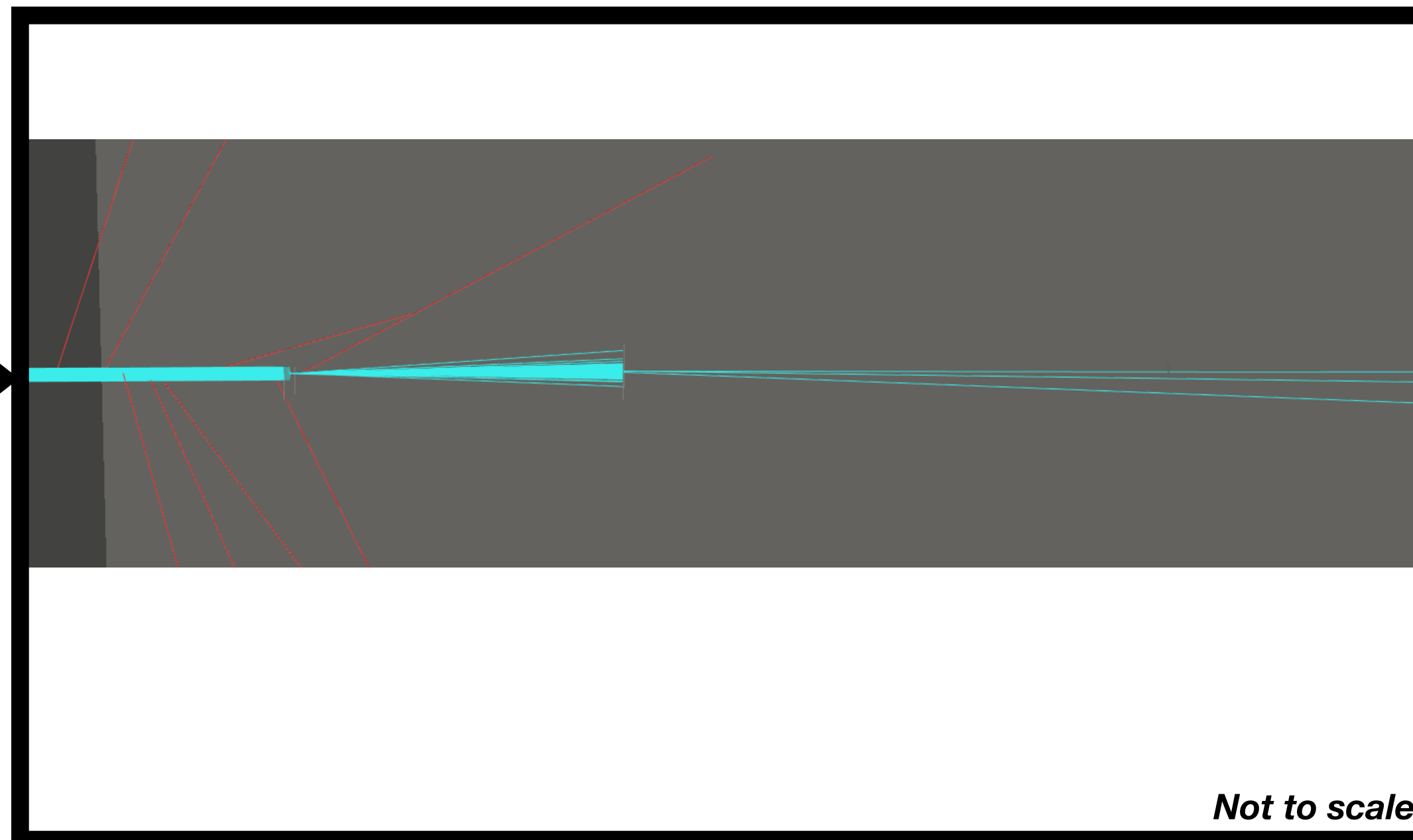
CCB IFJ PAN simulations

Simulations of BioAlto beamline and ND detector response

BioAlto Beamline

Nanodosimetry detector

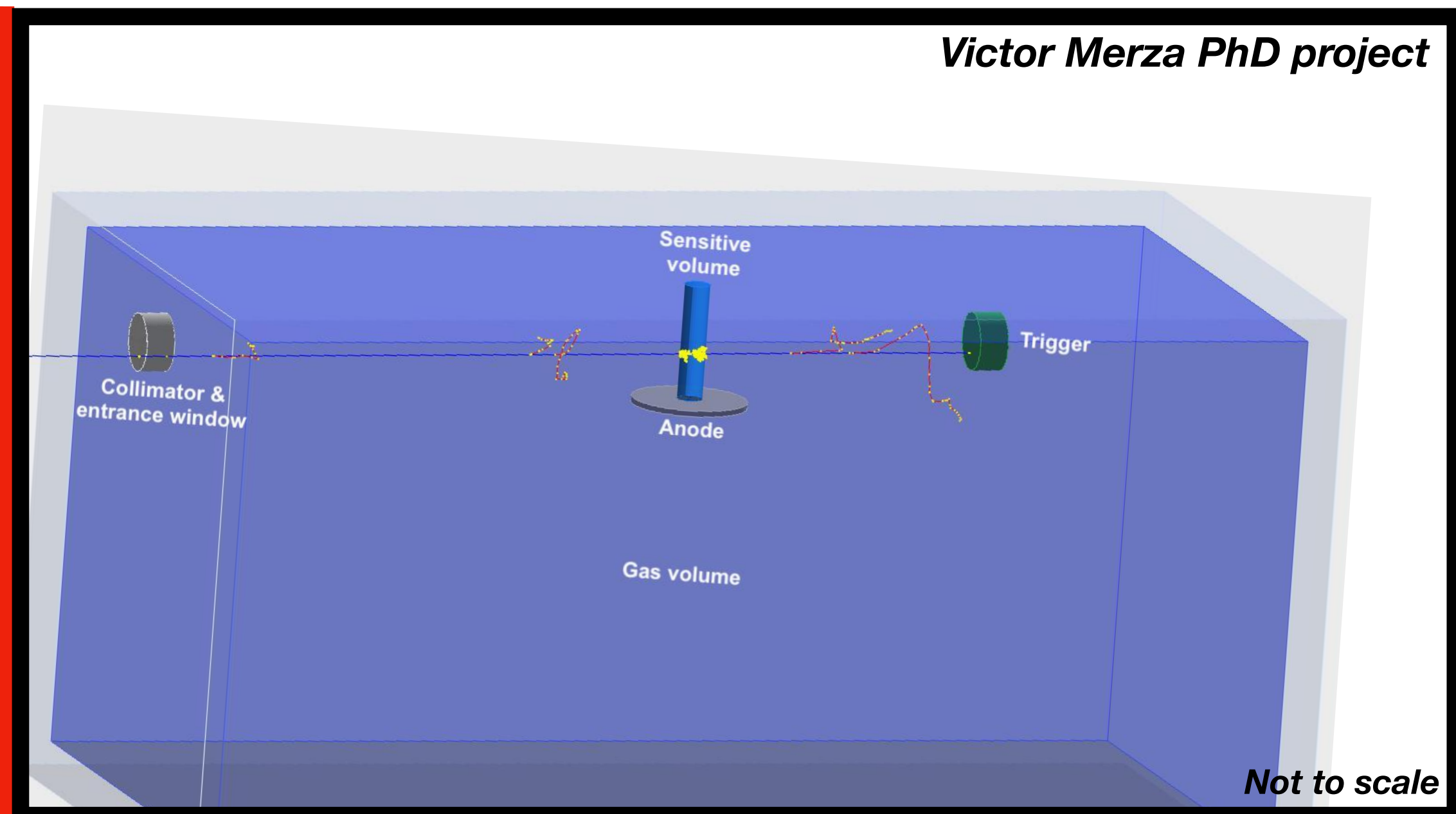
ALTO Beams:
5 MeV proton
6 MeV Helium



Not to scale

LS: luminescent target
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IJC lab simulations



Victor Merza PhD project

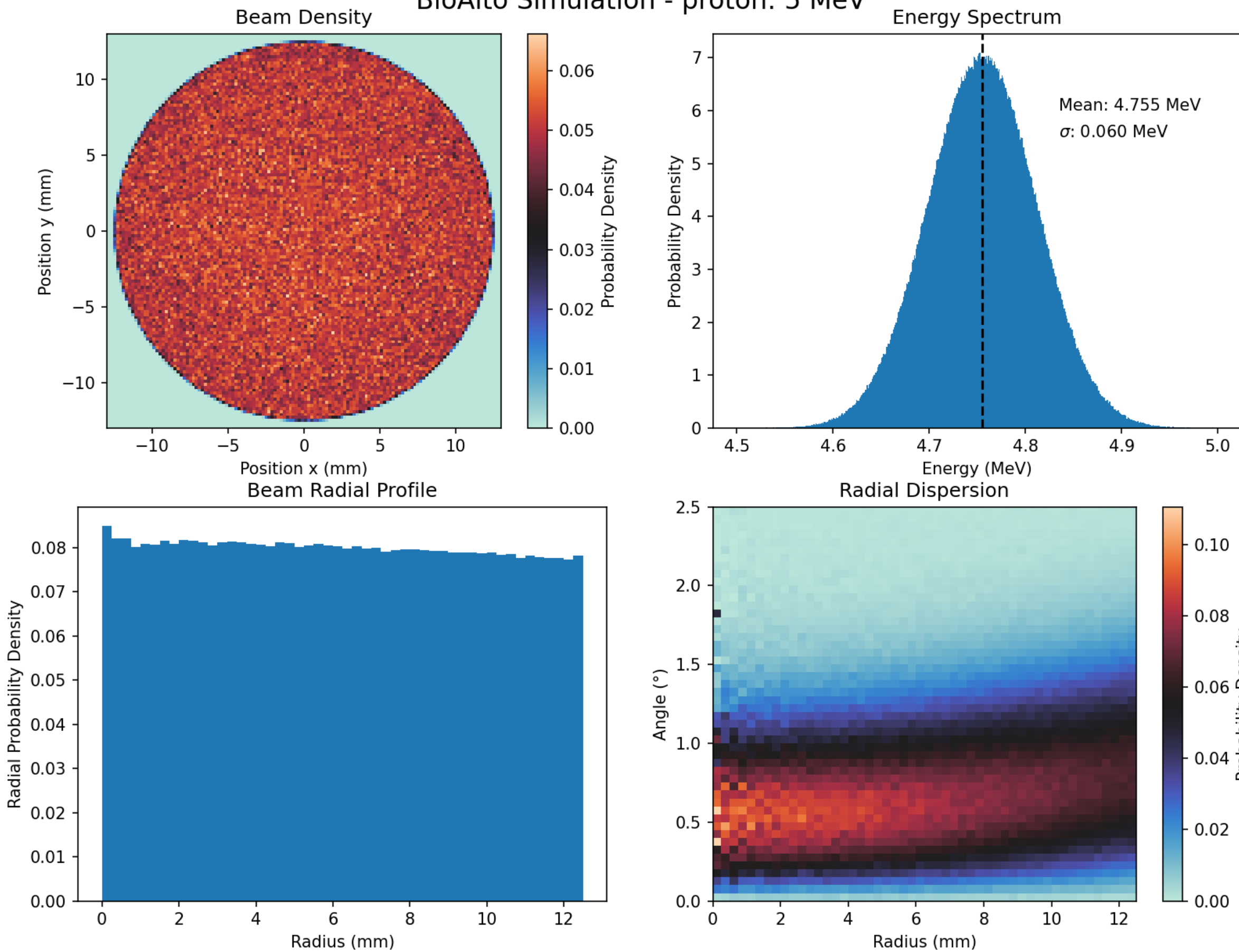
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CCB IFJ PAN simulations

IJC Lab: Simulations of BioAlto beamline

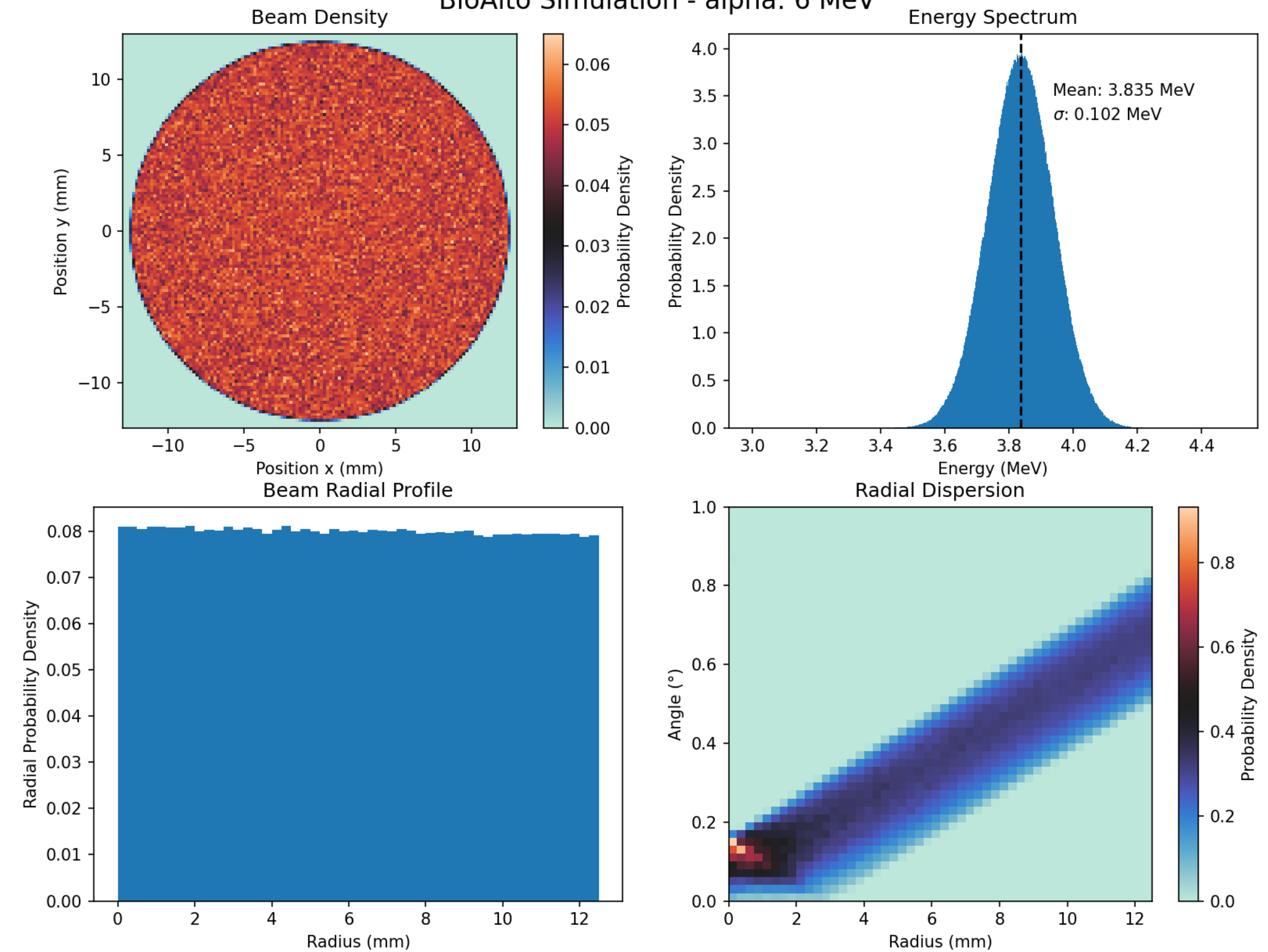
5 MeV proton

BioAlto Simulation - proton: 5 MeV



6 MeV alpha

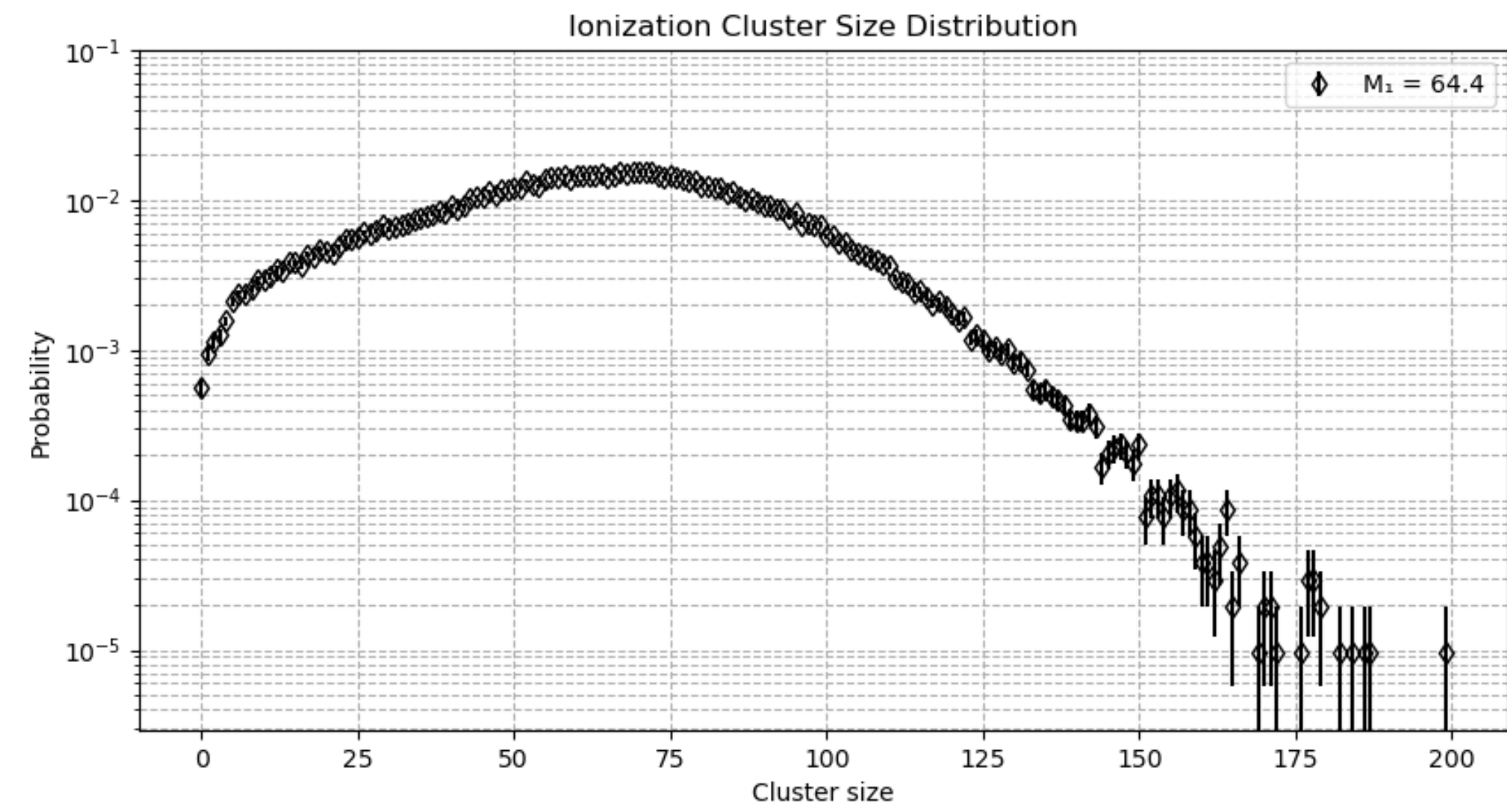
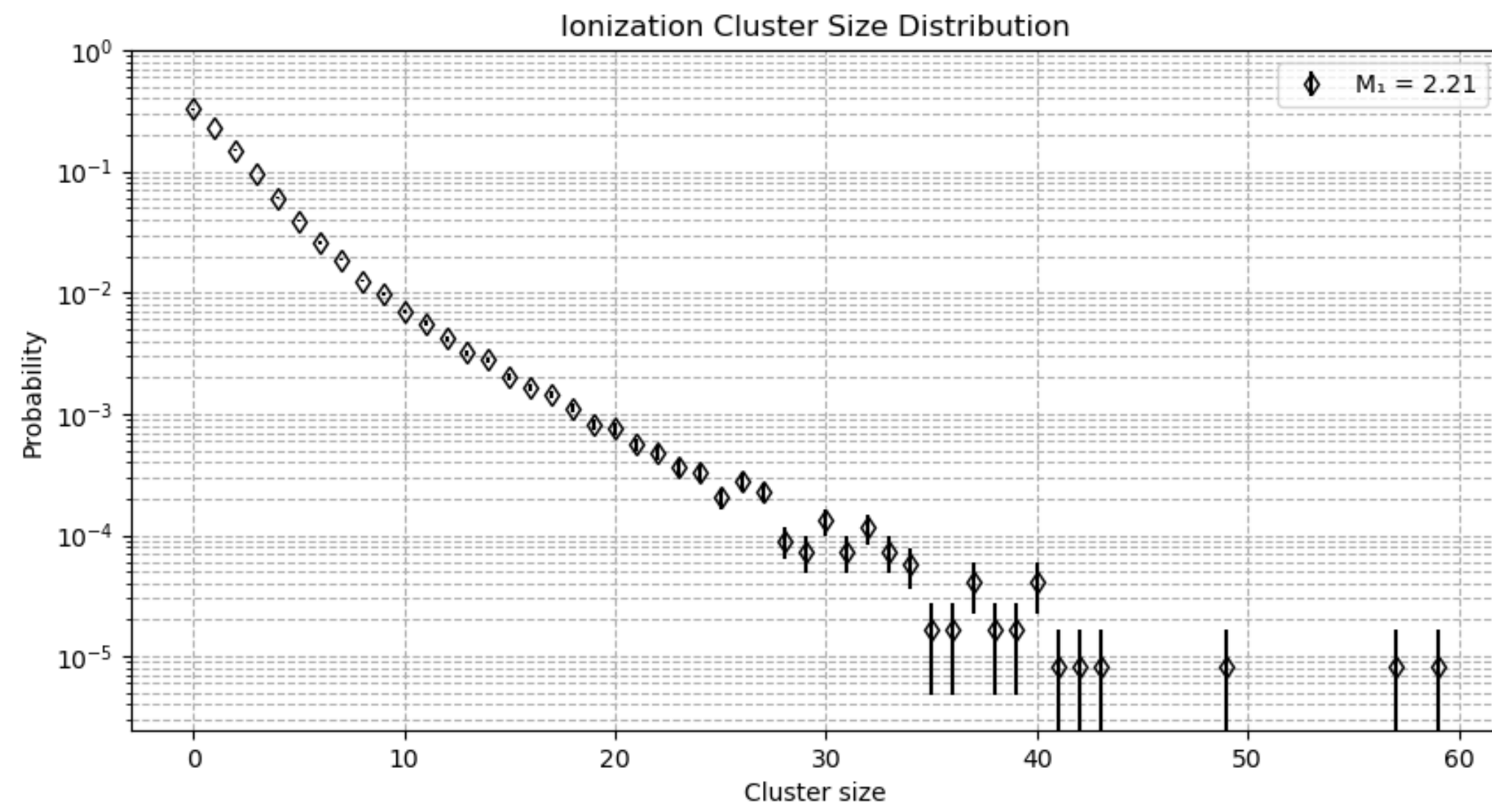
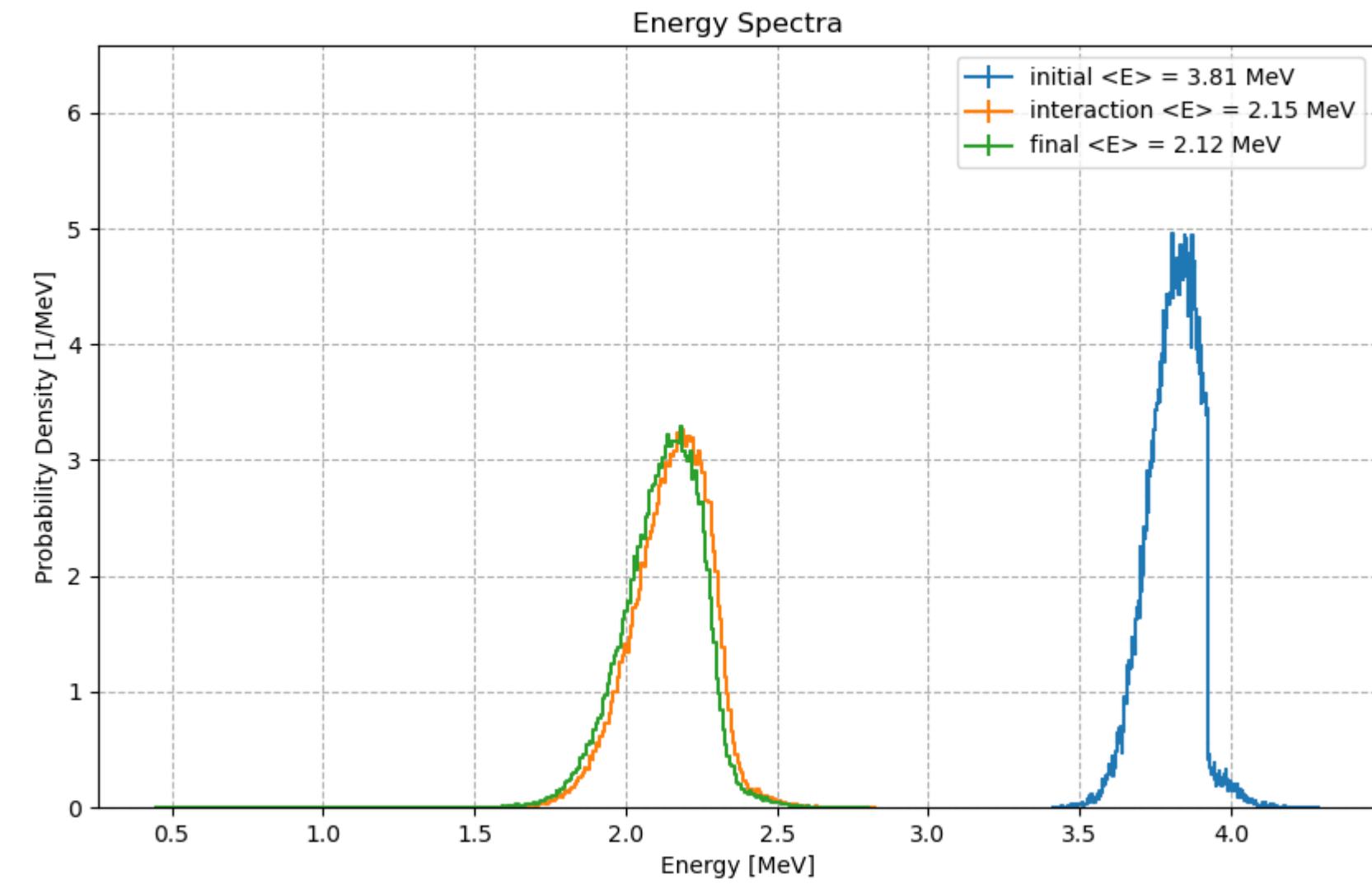
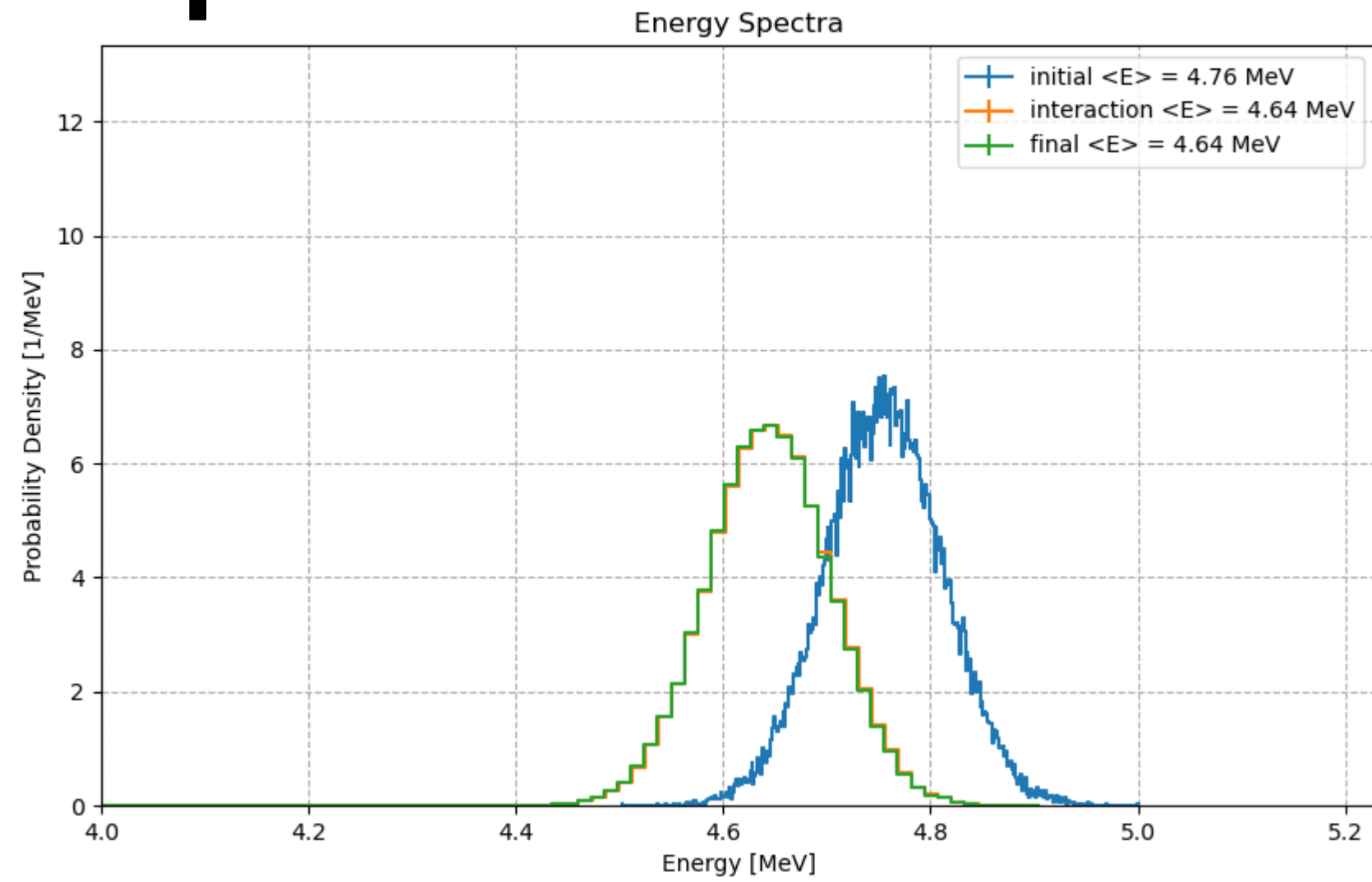
BioAlto Simulation - alpha: 6 MeV



CCB IFJ PAN research for DENIM

ND response simulations

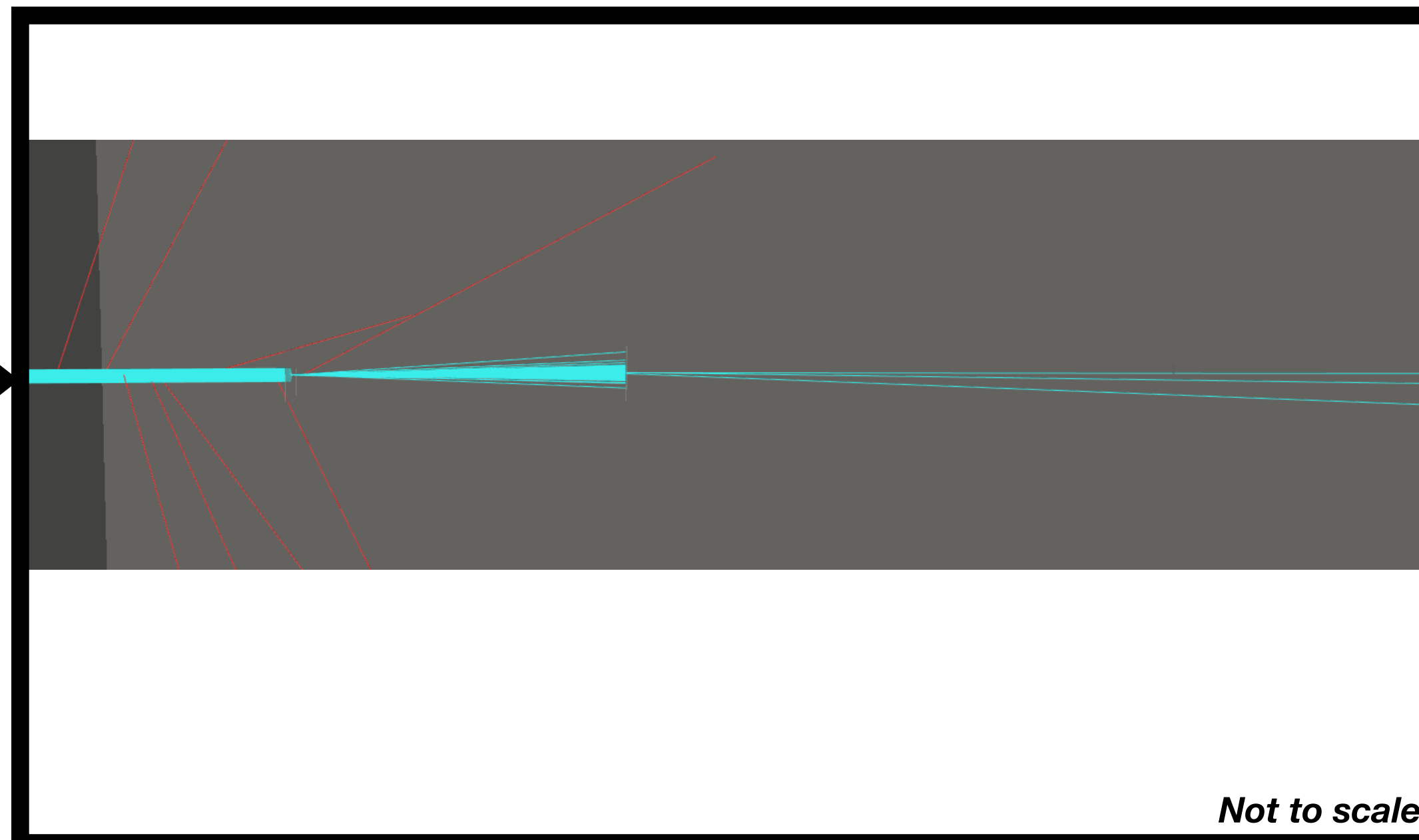
Victor Merza PhD project



Simulations of BioAlto beamline and ND detector response

BioAlto Beamline

ALTO Beams:
5 MeV proton
6 MeV Helium



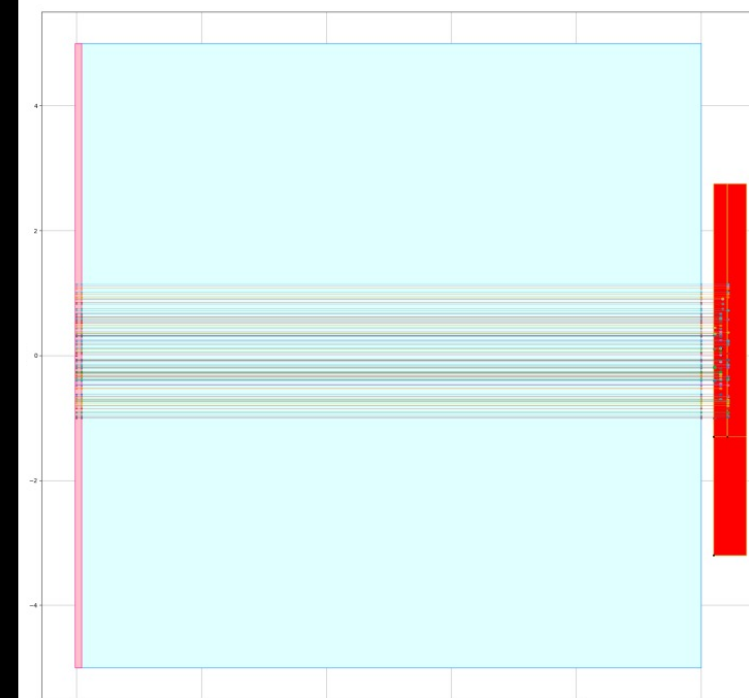
Not to scale

LS: luminescent target
C: collimators
D: scattering foil (Au)
FC: Faraday cup
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IJC lab simulations

TimePix detector signal

Courtesy of Jan Gajewski



TimePix sensor
14x14 mm
256x256 pixels
pixel size: 55 um



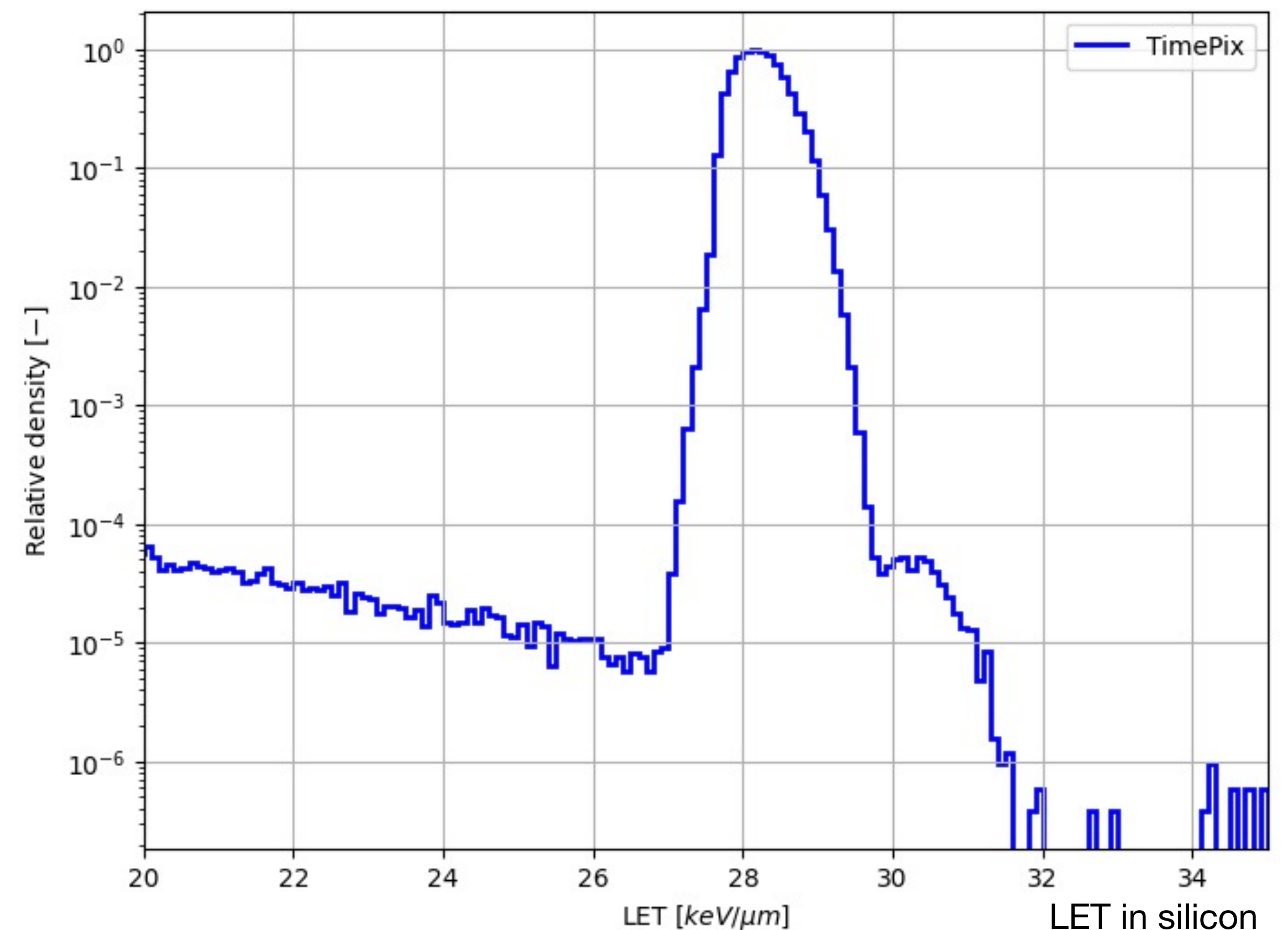
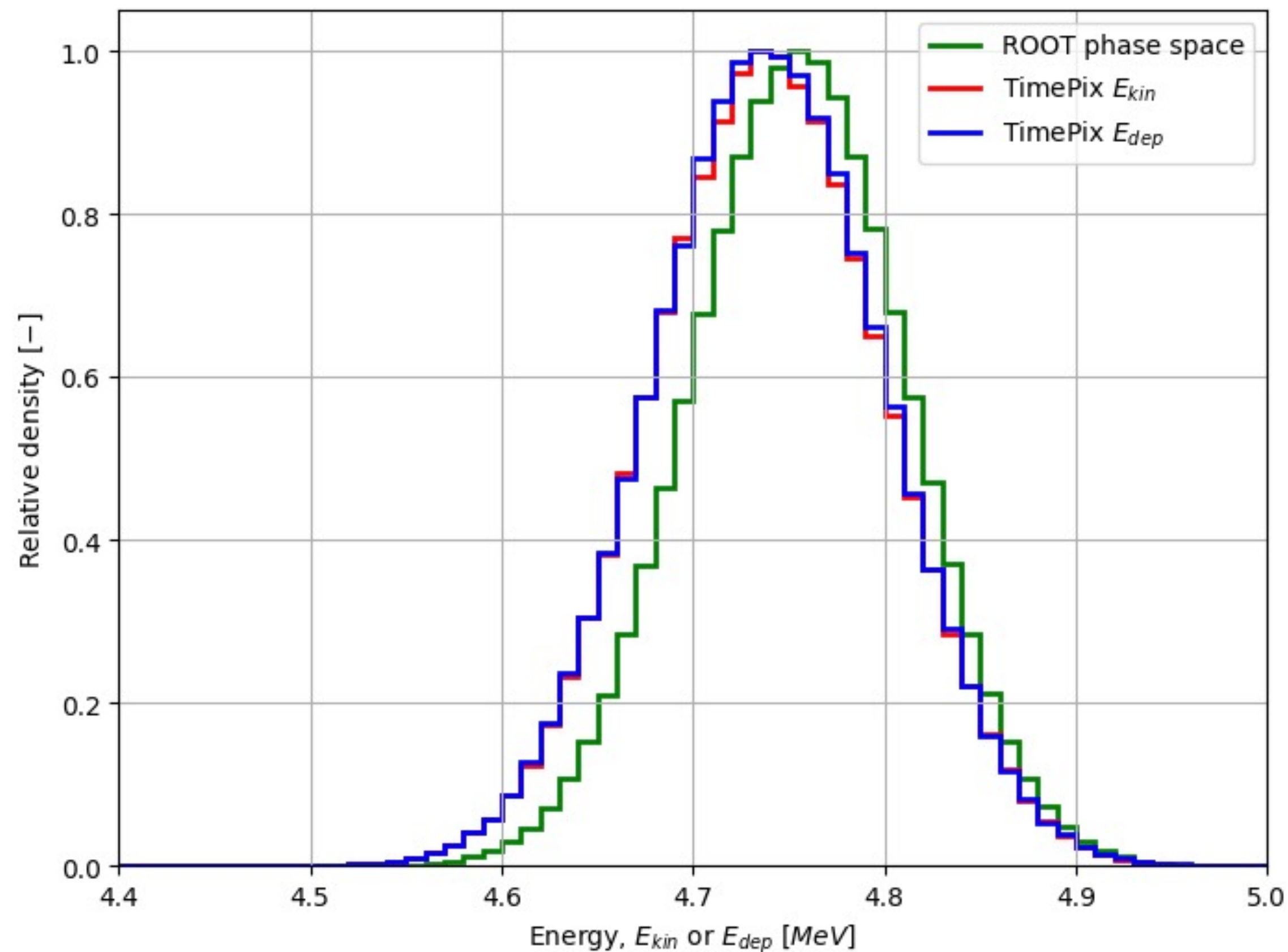
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CCB IFJ PAN simulations

IJC Lab research for DENIM

Modeling and characterization of Bio-Alto beamline (TimePix detector signal)

Courtesy of Jan Gajewski



Summary

- In 2023:
 - The BioAlto Health Pole and CCB teams have shown synergetic and complementary interests, expertise, and infrastructure (irradiation facilities, Monte Carlo simulation methods, and detector development). We defined complementary project objectives.
 - We request 2k€ per facility per year (8k€ in total for 2 years) for traveling required to detail specific research goals => we used 0k€ sparing resources for consulting for proof-of-concept experiments.
- In 2024, we performed preliminary simulations of:
 - Condensed history Monte Carlo simulations of BioAlto beamline for proton and helium beams and its characterization with TimePix detector
 - Condensed history and truck structure simulations of the response of a GEM-based nanodosimetric detector in proton and helium BioAlto beams

...demonstrating the feasibility of the proposed projects.

Future prospects

- **2025**

- More detailed simulations of beamline and detector setups (TimePix and CSIC microdosimeter)
- Participation in staff exchange grant application (NAWA proposal)
- Collaboration meeting in Orsay
- Definition of a common PhD student project (TBD if at IFJ or IJC lab)

- **2026**

- Test beams at the BioAlto beamline

We believe that dedicated, common research funds would accelerate achieving the long-term research goals.

Even collaboration is a hard job...



...somewhere in-between Paris and Orsay...

...we hope you will enjoy Krakow as we did Orsay in 2023



Thank you for your attention!