Gate activities @ LaTIM

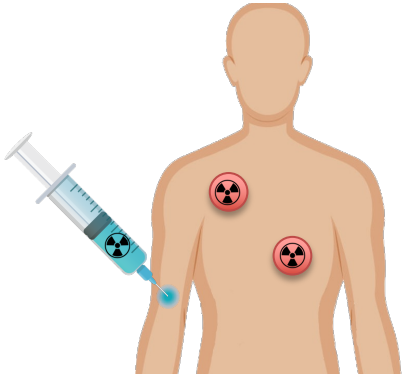
Julien BERT

LaTIM – INSERM UMR1101

Team: Dose Optimization in Image-Guided Therapy

Brest, France

Targeted Radionuclide Therapy



New innovative therapeutic class

⚠ **Generic Dose**
Toxicity ↗
Efficiency ↘
New protocol: alpha

💡 **Personalize the treatment dose and improve protocol**

Methods in AI
⚠ **Data availability**
→ **Synthetic data**

EURATOM projet **SECURE**
Jing Zhang (postdoc)

Kuopio University Hospital · NRG · BME · univerzitetni klinični center ljubljana

Virtual patient
- Morphology
- Biodistribution (PBPK)
- Protocol
- X-cat / patient

	MC	Det. (fast)
PET	**3D MC simu.** • Siemens Biograph (20 rings) • whole body scan • **6.6 day** (1 CPU core) • 2h (80 CPU core) • 14M coincidence • **GATE10** + **CASTOR**, • Recon. **35 min** (1 CPU core)	**3D fast simu.** • Siemens Biograph (20 rings) • whole body scan • Projection method • **4 minutes** (1 CPU core)
SPECT	**2D GPU-based MC** • GE NM 670 • 7.4GBq, 177Lu-PSMA • **GGEMS** • **10 minutes**	**2D fast simu.** • GE NM 670 • 7.4GBq, 177Lu-PSMA • **11 minutes**
Dose	**3D Dose MC** • Ac225, 7.4 MBq • **GATE10** • Stat. uncertainty < 5% • **30h** (1 CPU)	

Validation against clinical data (postdoc)

PIANOFORTE projet **LutADose**

CASTOR software https://castor-project.org/

GGEMS software https://ggems.fr

Targeted Radionuclide Therapy

EURATOM projet **SECURE**
Jing Zhang (postdoc)

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UNIVERSITÄTSSPITAL BERN
HÔPITAL UNIVERSITAIRE DE BERNE

Phys. Med. Biol. **71** (2026) 025005 https://doi.org/10.1088/1361-6560/ae36df

Physics in Medicine & Biology

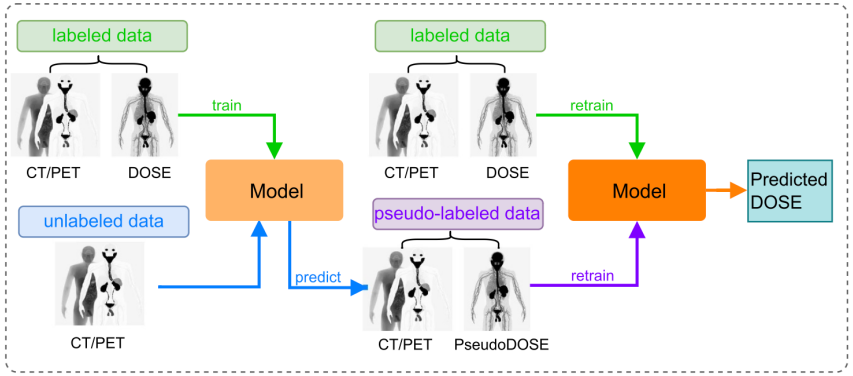
IPEM Institute of Physics and Engineering in Medicine

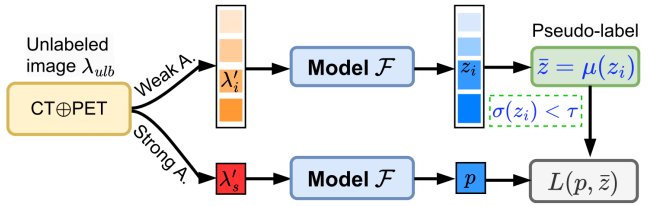
PAPER

Semi-supervised learning for dose prediction in targeted radionuclide therapy: a synthetic data study

Jing Zhang[1,*], **Alexandre Bousse**[1], **Chi-Hieu Pham**[1], **Kuangyu Shi**[2] and **Julien Bert**[1]

[1] LaTIM, INSERM-UMR1101, University of Brest, Brest, France
[2] Department of Nuclear Medicine, University of Bern, Bern, Switzerland
[*] Author to whom any correspondence should be addressed.

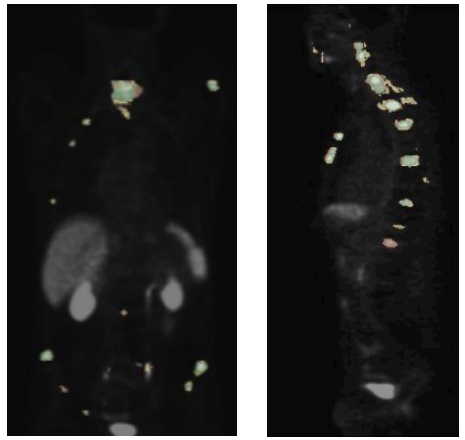




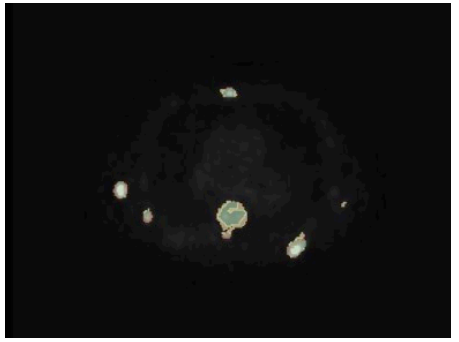
RegFixMach

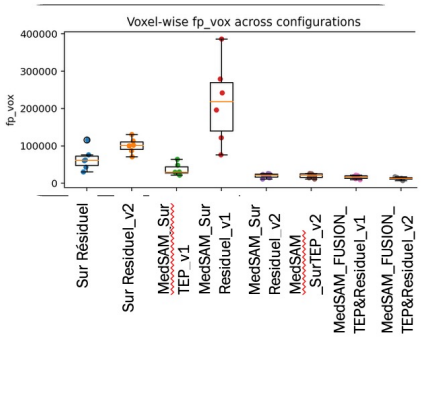
250 synthetics SSL ≈ 1 000 synthetics Fully S.
MRE 10-12 %

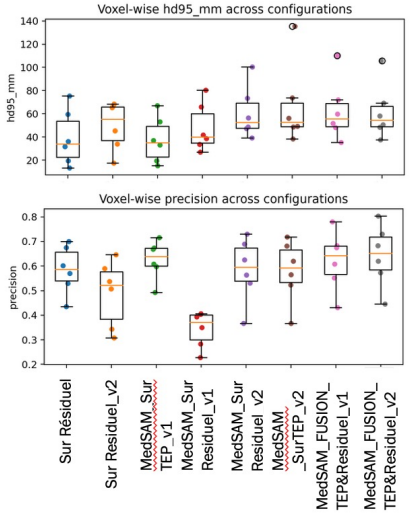
Digital Twin and Synthetic Data for PET/SPECT
Meta. Segmentation using Foundation Model
Nassib Abdallah (Researcher CHU Brest)



68Ga-PSMA







KU LEUVEN
CHRU NANCY
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

FP = false positives | HD95 = Hausdorff 95% | Vox = voxel

Targeted Radionuclide Therapy

Deep Learning-based **PET Scatter Correction**

Baptiste Laurent (Researcher CHU Brest)

- Siemens Biograph Vision Quadra model
- Training on **synthetic data**
- U-Net
- Sinogram space

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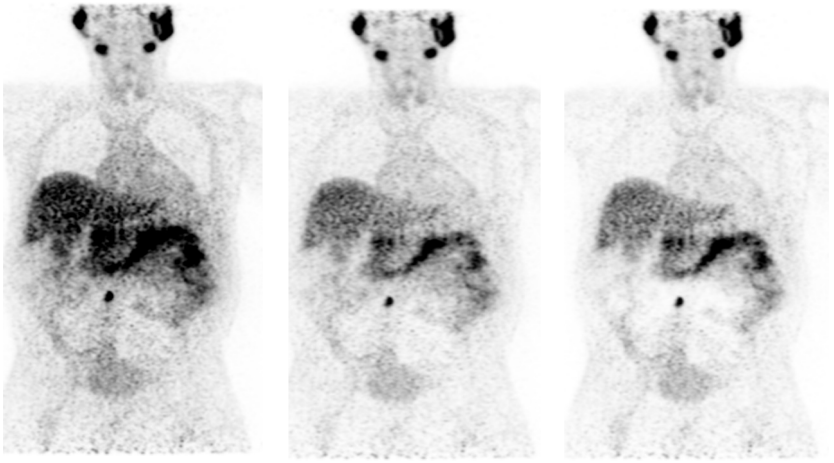
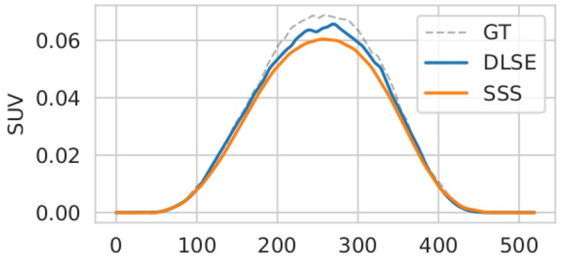


No correction DLSE SSS

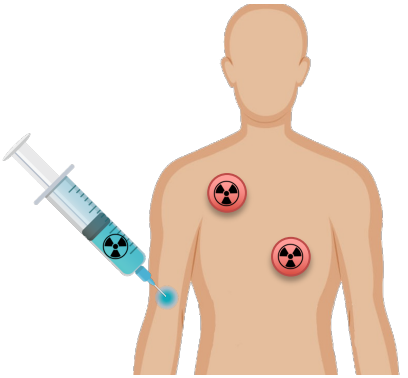


DLSE > SSS
- Quality
- Speed

- Evaluation of deep learning-based scatter correction on a long-axial field-of-view PET scanner. Laurent B., Bousse A., Merlin T., Rominger A., Shi K, Visvikis D. Eur J Nucl Med Mol Imaging 52, 2563–2576 (2025).
- PET scatter estimation using deep learning U-Net architecture. Laurent B, Bousse A, Merlin T, Nekolla S, Visvikis D. Physics in Medicine & Biology. 2023;68(6)

SPECT

SPECT Scatter Correction



Targeted Radionuclide Therapy

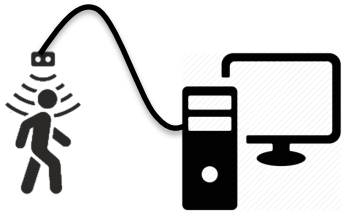
Fast Dose Calculation based on MC simulations

Radiation exposure in operating room (X-ray guided procedures)

- Image quality improvement (**exposure**)
- **More and more** interventions
  - *France, 2020, 600 000 pr. / year*
- **Complexity** constantly increasing,
- Pushing the **limits** of interventional surgery
- Few years ago, **procedure time** 30 min, today up to 5h
- **exposure**

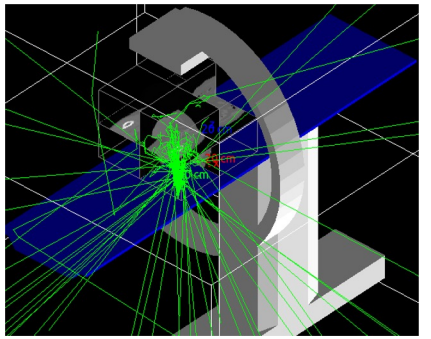
© CHRU de Brest

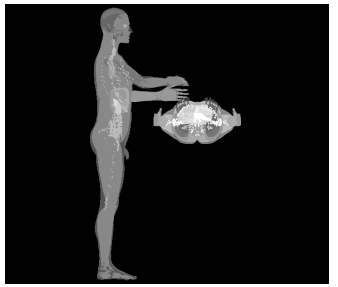
Real-time exposure monitoring in the operating room

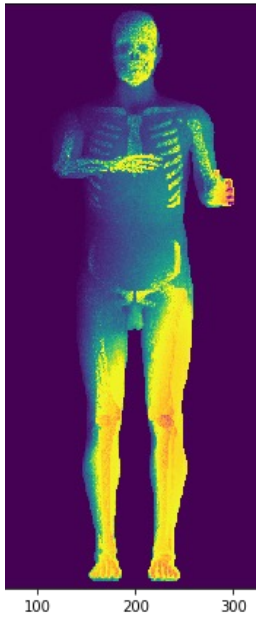


Monte Carlo simulation
- Very accurate dosimetry
- Personalized dosimetry

AI (Machine and Deep learning)
- Fast
- Learns complex models

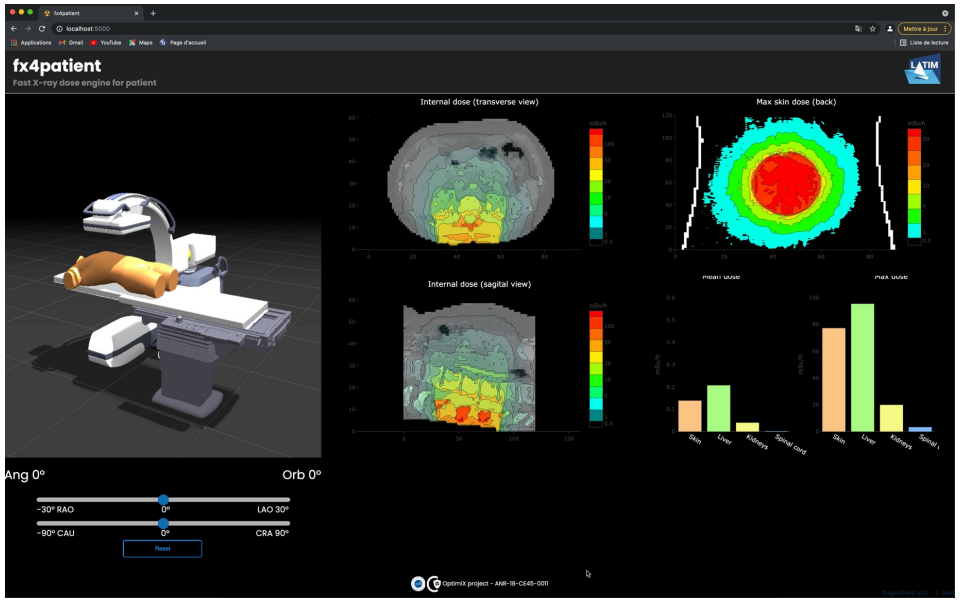






Fast Dose Calculation based on MC simulations

Patient dose calculation



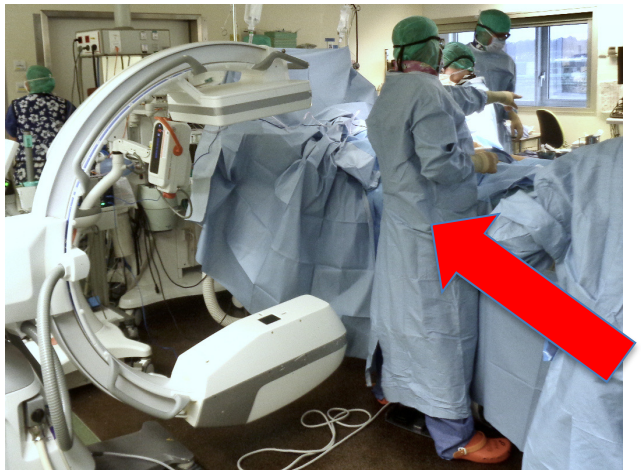
- **MC vs Deep learning:**
  - Avg. total body dose Rel. err. **2.3% ± 0.6%**
  - Avg. skin dose Rel. err. **2.1% ± 0.6%**

- **Calculation time** **< 100 ms**

- **Clinical study (Deep vs exp.)** Mean relative error **6 ± 5%**

First operator dose calculation

?



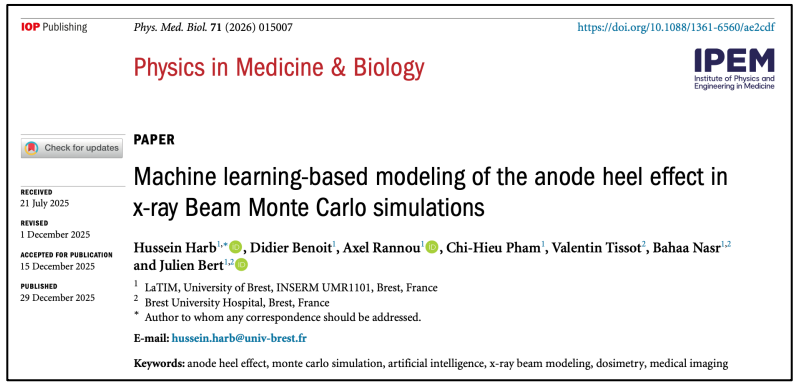
Complex scattering distribution
- Imaging system
- Patient
- Pose

- **Harb**, H., Villa, M., Benoit, D., Pham, C.-H., Nasr, B., Bert, J., 2025. Fast operating room scattered radiation calculation in X-ray guided interventions by using deep learning. J. Radiol. Prot.
- **Nasr**, B., Villa, M., Benoit, D., Visvikis, D., Bert, J., 2024. Monte Carlo Dosimetry Validation for X-Ray Guided Endovascular Procedures. Annals of Vascular Surgery S0890509623005927
- **Villa**, M., Nasr, B., Benoit, D., Padoy, N., Visvikis, D., Bert, J., 2023. Fast dose calculation in x-ray guided interventions by using deep learning. Phys Med Biol 68.

Fast Dose Calculation based on MC simulations

First operator dose calculation
Hussein Harb (PhD student)

GATE10 model
- Siemens Cios Alpha system (Siemens Healthcare, Germany)



IOP Publishing Phys. Med. Biol. 71 (2026) 015007 https://doi.org/10.1088/1361-6560/ae2cdf

Physics in Medicine & Biology

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Check for updates

PAPER

Machine learning-based modeling of the anode heel effect in x-ray Beam Monte Carlo simulations

RECEIVED 21 July 2025
REVISED 1 December 2025
ACCEPTED FOR PUBLICATION 15 December 2025
PUBLISHED 29 December 2025

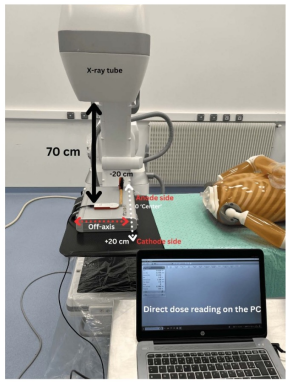
Hussein Harb[1,*], Didier Benoit[1], Axel Rannou[1], Chi-Hieu Pham[1], Valentin Tissot[2], Bahaa Nasr[1,2] and Julien Bert[1,2]

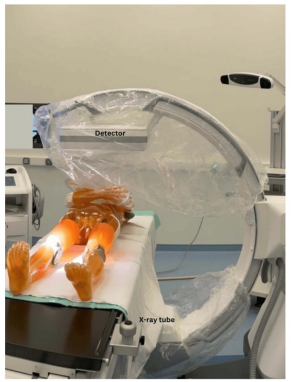
[1] LaTIM, University of Brest, INSERM UMR1101, Brest, France
[2] Brest University Hospital, Brest, France
[*] Author to whom any correspondence should be addressed.

E-mail: hussein.harb@univ-brest.fr

Keywords: anode heel effect, monte carlo simulation, artificial intelligence, x-ray beam modeling, dosimetry, medical imaging

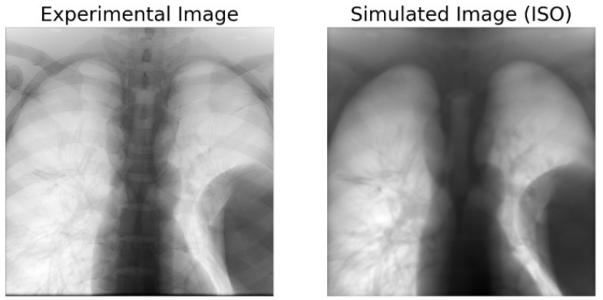
Anode heel effect
- Tube voltage
- Machine learning modeling
  - Reduce parameter storage
  - Transfer learning / fine-tuning



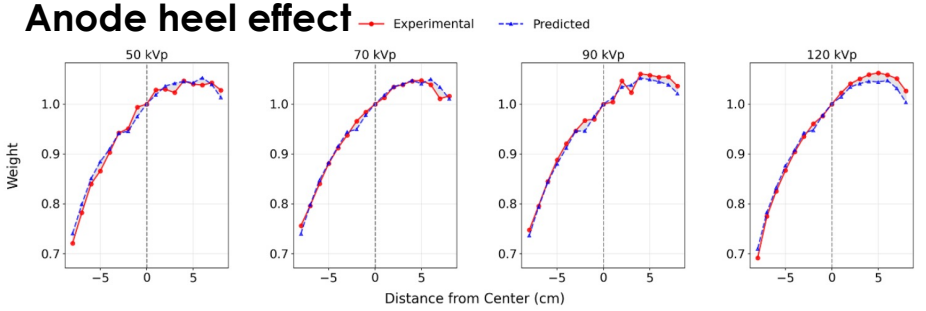


PLATIMED
Platform of the LaTIM for the Design & Evaluation of Innovative Medical Devices

Exp. vs GATE10



Anode heel effect



Fine-tuning strategies for cross-machine adaptation
- From **Cios** model to Philips **Zenition** 70 system
- Using only 6 spatial positions

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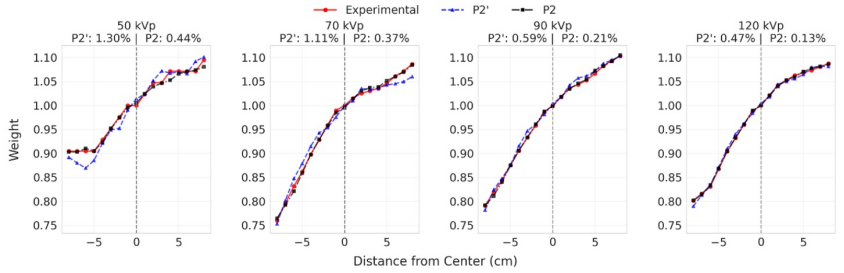


Plan to release the Cios Alpha in GATE10

Fast Dose Calculation based on MC simulations

First operator dose calculation
Hussein Harb (Phd student)

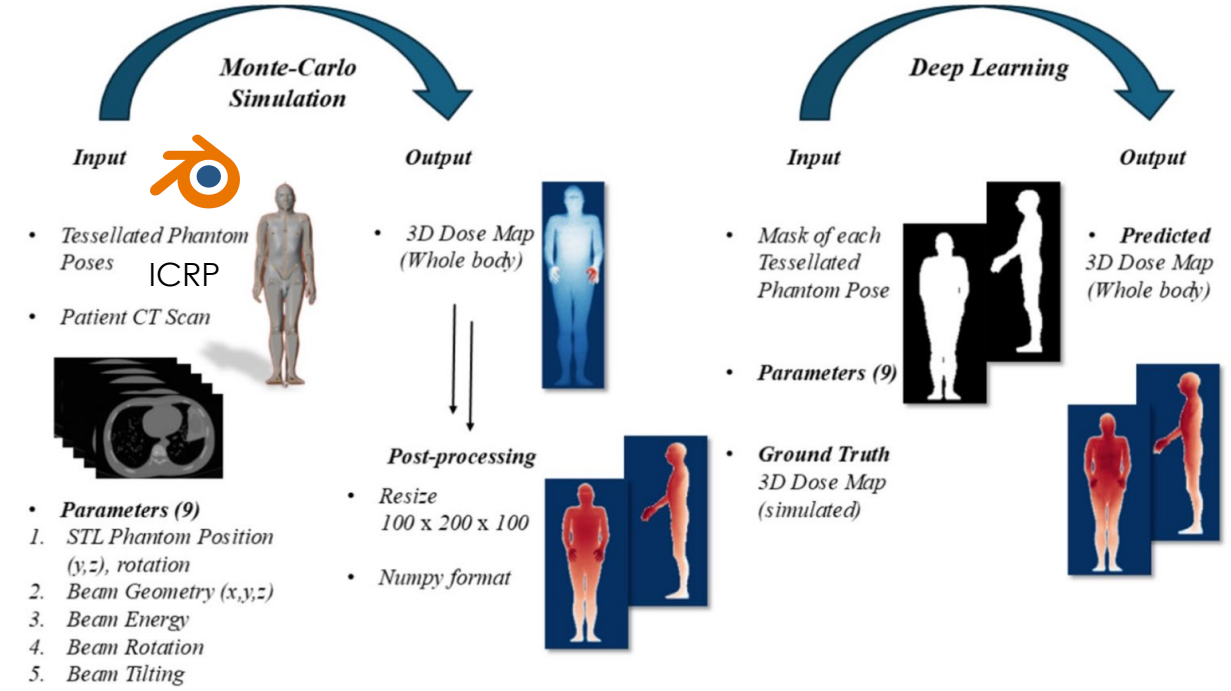
Radiological Physics and Technology
https://doi.org/10.1007/s12194-026-01043-z

RESEARCH ARTICLE

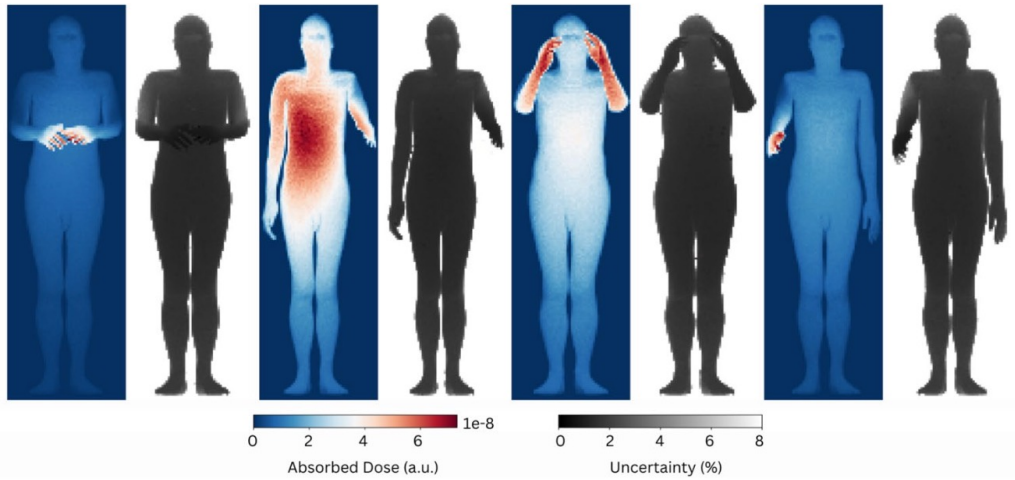
Fast 3D whole-body occupational dose estimation in interventional radiology using physics-informed deep learning

Hussein Harb[1] · Didier Benoit[1] · Chi-Hieu Pham[1] · Bahaa Nasr[1,2] · Julien Bert[1,2]

Received: 28 January 2026 / Revised: 18 March 2026 / Accepted: 19 March 2026



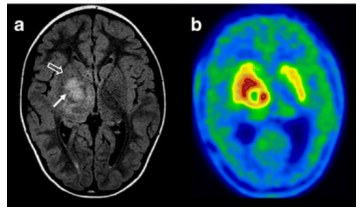
MC simulations (GATE 10, PMB 2025)



Whole-body dose estimation

ResUNET < 10 % against **MC**
Inference **~200 ms**

Inter. Brain Surgery

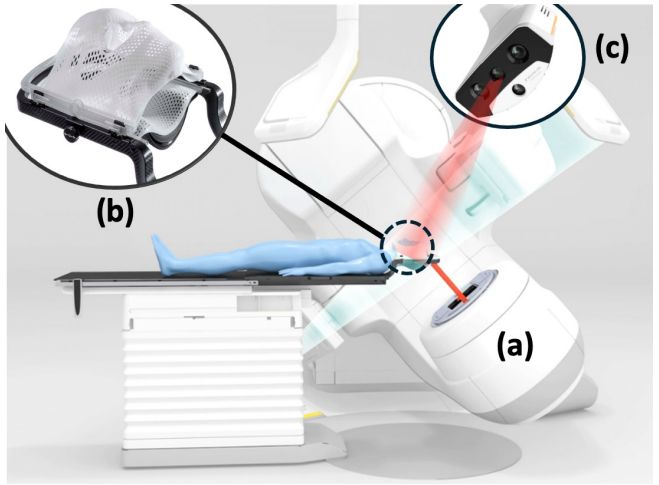


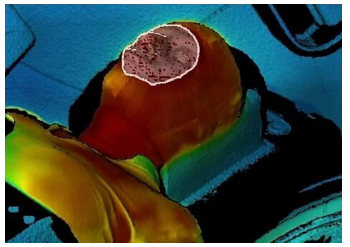
BEAMS · DASSAULT SYSTEMES · ASSISTANCE PUBLIQUE HÔPITAUX DE PARIS

Fast Dose Calculation based on MC simulations

Adaptative External Beam Radiotherapy

MaskFree: Brain stereotactic radiotherapy

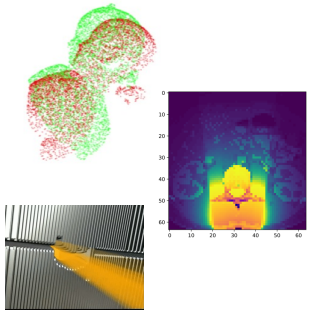




ExacTrac Dynamic Surface

⚠ **Immobilize the patient**

Remove the Restraint Mask



Real-time adaptative radiotherapy

- Real-time **Motion** estimation (surface)
- Real-time **Dose** calculation
- Real-time **Beam** control

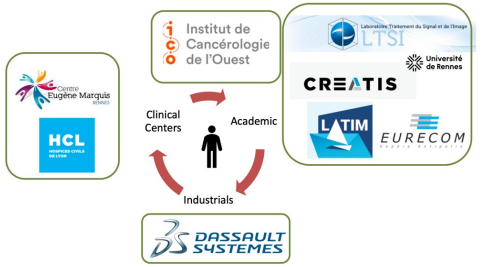
PhD student: Nihitha Malayarukil

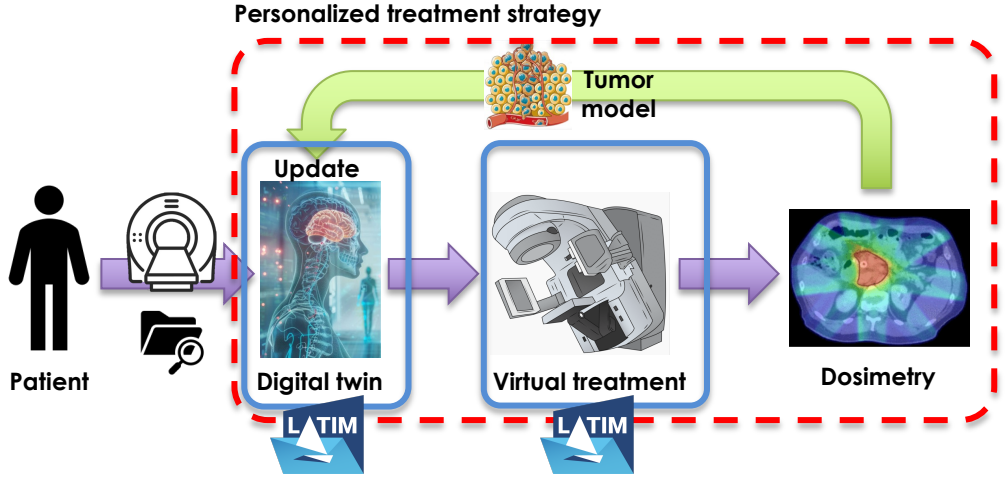
varian A Siemens Healthineers Company

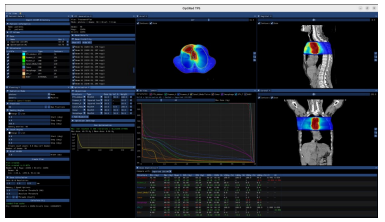
BRAINLAB

TwinCaRT: Digital Twin for Personalized Care and Planning in Prostate Cancer RadioTherapy

FRANCE 2030 PROGRAMME DE RECHERCHE SANTÉ NUMÉRIQUE







MR-LINAC Elekta Unity

- **GATE10** model
- Fast **dose** calculation (AI physics-informed)
- **TPS** using OptiRad (release coming soon)
- Looking for a **postdoc** (beginning of 2027)

Gate activities @ LaTIM

Julien BERT

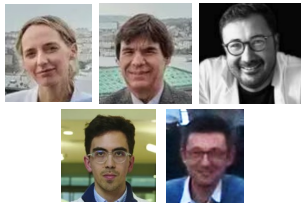
LaTIM – INSERM UMR1101

Team: Dose Optimization in Image-Guided Therapy

Brest, France

Sci. staff:

Med. staff:



Students: