



THE HENRYK NIEWODNICZAŃSKI
INSTITUTE OF NUCLEAR PHYSICS
POLISH ACADEMY OF SCIENCES



CYCLOTRONE CENTRE BRONOWICE

Division Head: **Dr. hab. RENATA KOPEĆ**, Prof. IFJ

Presenter: **DAWID KRZEMPEK**



AGENDA

1. INFRASTRUCTURE & RESOURCES
2. PROTON RADIOTHERAPY AT CCB
3. RESEARCH ACTIVITIES
4. HIGHLIGHTS



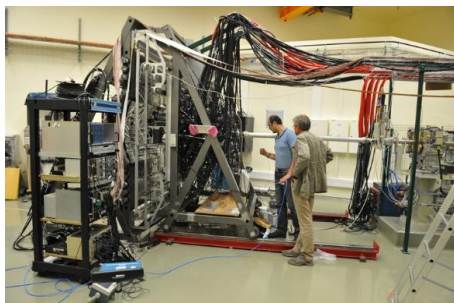
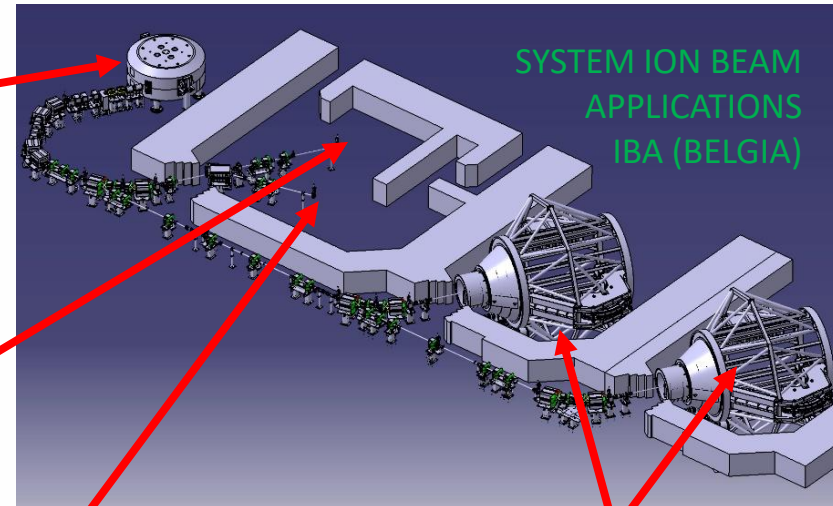


INFRASTRUCTURE & RESOURCES

CYCLOTRON BASED INSTALLATION



CYCLOTRONE PROTEUS C230



EXPERIMENTAL HALL



EYELINE TR

horizontal beam, passive scattering



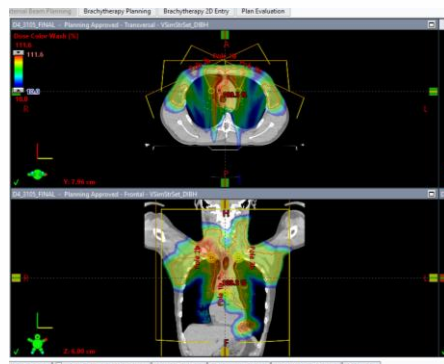
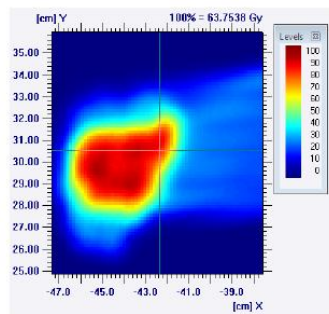
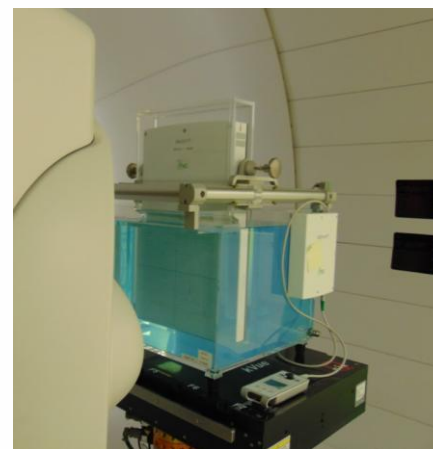
GANTRY TR

360°, scanned beam (PBS)



INFRASTRUCTURE & RESOURCES MUCH MORE

- CT SCANNER (SOMATOM SIEMENS DEFINITION AS)
- VARIAN ECLIPSE 16.1 TPS
- VISION RT SGRT SYSTEM
- PATIENT PREPARATION ROOMS
- BIOLOGICAL LABORATORIES
- DOSIMETERS, DETECTORS, PHANTOMS
- WORKSHOP ROOM
- 3D PRINTER ORIGINAL PRUSA XL
- ...





INFRASTRUCTURE & RESOURCES

PEOPLE

Department of Cyclotron
K. Guguła

Eye Therapy Laboratory
T. Horwacik

Dosimetry and Treatment Planning Lab
D. Krzempek

Section of RTTs
M. Radolińska

Research and Development Lab
A. Ruciński

Quality Control Section
B. Michalec

CCB Secretariat
G. Glaz/K. Kałat

**THE INTERDISCIPLINARY TEAM INCLUDING ABOUT 60 PEOPLE:
ENGINEERS, CERTIFIED MEDICAL PHYSICISTS, PHYSICISTS, RADIATION THERAPISTS,
BIOLOGISTS**



PROTON RADIOTHERAPY AT CCB CLOSE COLLABORATIONS WITH HOSPITALS

EYE TREATMENT



University Hospital in Kraków

- Proton therapy of eyeball tumors
- scattered beam;

OTHER LOCATIONS



National Institute of Oncology in Kraków

- Proton radiotherapy in gantries
- pencil beam scanning;



im. Marii Skłodowskiej-Curie
Państwowy Instytut Badawczy
Oddział w Krakowie





PROTON RADIOTHERAPY AT CCB CLOSE COLLABORATIONS WITH HOSPITALS

RO – RADIATION ONCOLOGISTS
MP – MEDICAL PHYSICISTS
RTT – RADIATION THERAPISTS
ENG - ENGINEERS

HOSPITALS

PRETREATMENT PROCEDURES

TREATMENT PRESCRIPTION (RO)

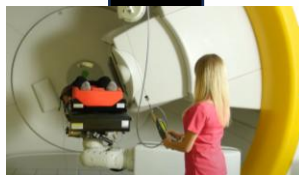
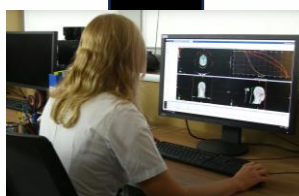
PATIENT ACCOMODATION

NURSING CARE

TREATMENT PLANNING (MP)

PHYSICIAN CARE DURING TREATMENT (RO)

POSTTREATMENT PROCEDURES + PATIENT CARE (RO)



CCB IFJ

PTS SYSTEM ADMINISTRATION & MAINTENANCE (ENG)

BEAM PRODUCTION AND SUPERVISION (ENG)

MACHINE-SPECIFIC QA (MP)

PATIENT IMMOBILIZATION (RTT)

CT SCAN (RTT)

TREATMENT PLANNING (MP)

PATIENT-SPECIFIC QA (MP)

PATIENT POSITIONING + FRACTION DELIVERY (RTT)



PROTON RADIOTHERAPY AT CCB PATIENT STATISTICS

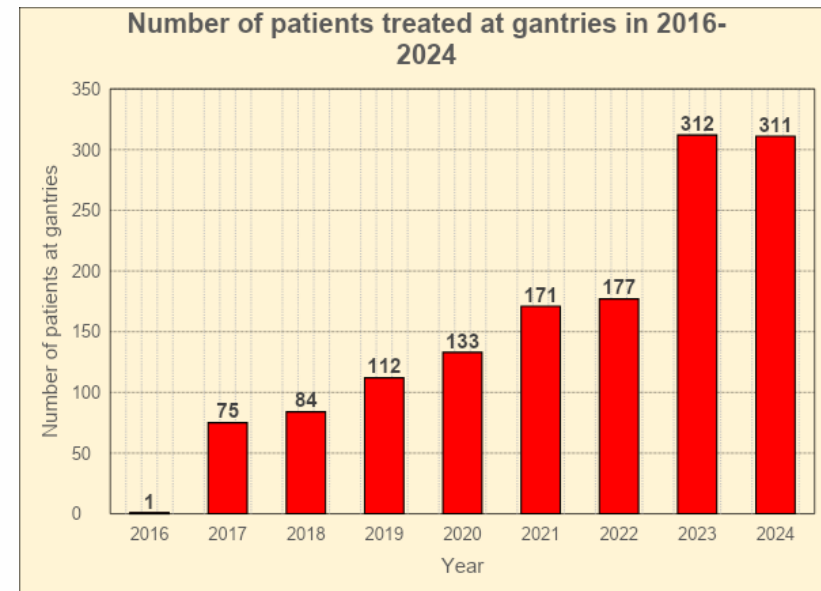
Since 2011 more than 2 000 patients were irradiated at IFJ PAN.

Eye treatment:

- Clinic Ophthalmology of University Hospital (since 2011): **387 patients** (128 on cyclotron AIC-144); prof. B. Romanowska-Dixon

Gantries: **1616 patients:**

- National Oncology Center PIB (since 2016):
 - 1455 adults patients (dr. T. Skóra)
 - 161 children – since 08.2022 (dr. K. Drosik-Rutowicz);



Currently about 50 fractions delivered per day.



RESEARCH ACTIVITIES

Clinical routine-
protontherapy



Research work in
radiotherapy,
radiobiology and
Medical Physics

Clinical CCB team

Research and Development Lab
A. Ruciński
(9 employees)





RESEARCH ACTIVITIES

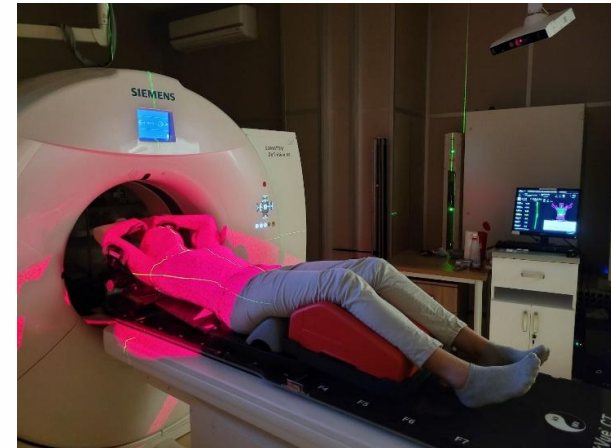
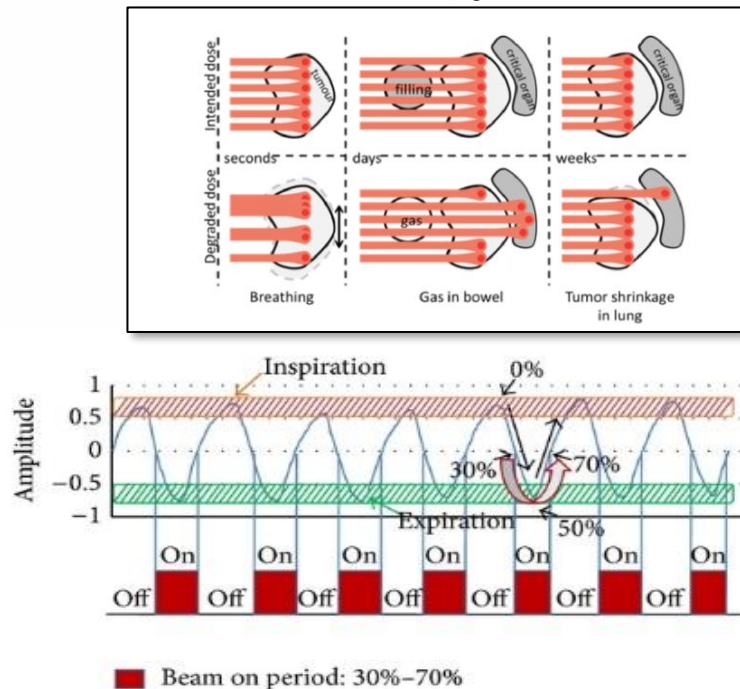
ONGOING PROJECTS AT CCB IFJ (2024-2025)

- PIANOFORTE/ HORIZON-EURATOM-2021-NRT-01 , "Towards safe, optimized and personalized radiology and radiotherapy procedures for pregnant patients" (SONORA) Dawid Krzempek 2024/08/X/NZ7/00625
- MINIATURA 8 : Combination of modern, complex multidrug chemotherapy with radiotherapy (proton or photon) as a new treatment strategy for glioblastoma multiforme, Anna Zając-Grabiec, 11.10.2024 - 10.10.2025, 49 500 zł
- MNSiW, NdS/544985/2021/2021 Image-guided proton radiotherapy for the treatment of musculoskeletal tumors, Renata Kopec, : 31.05.2022 - 31.05.2025, 1 715 800 zł
- MNSiW, NdS-II/SP/0295/2023/01, The importance of proton radiotherapy in the treatment of patients with central nervous system tumors, Justyna Mischczyk, 21.12.2023 - 20.12.2026, 1 000 000 PLN
- MNSiW, NdS-II/SP/0292/2024/01, Optimization of irradiation methods and dosimetric characteristics of the FLASH proton beam, Marzena Rydygier, 29.03.2024 - 28.03.2027, 1 000 000 PLN
- MNSiW, 01.01.2025, NdS/544748/2021/2021, Application of computational dosimetry in proton radiotherapy of oncological patients, Antoni Ruciński, 02.09.2022 - 01.01.2025, 1 570 200 zł
- Weave-UNISONO, Computational and Experimental Nanodosimetry in Proton Radiotherapy, Antoni Ruciński, 3 343 200 zł , 48 months
- SONATA BIS-14, From Plasmid DNA to FLASH Radiotherapy: Experiments and Computations, Antoni Ruciński, 5 536 200,00 zł
- Pianoforte: KAYAC+: Knowledge on outcome of adolescent and young adults with cancer – Renata Kopec (...)

RESEARCH ACTIVITIES

DOSE DELIVERY TO A MOVING TARGET

4D Radiation therapy (X, Y, Z, Time)



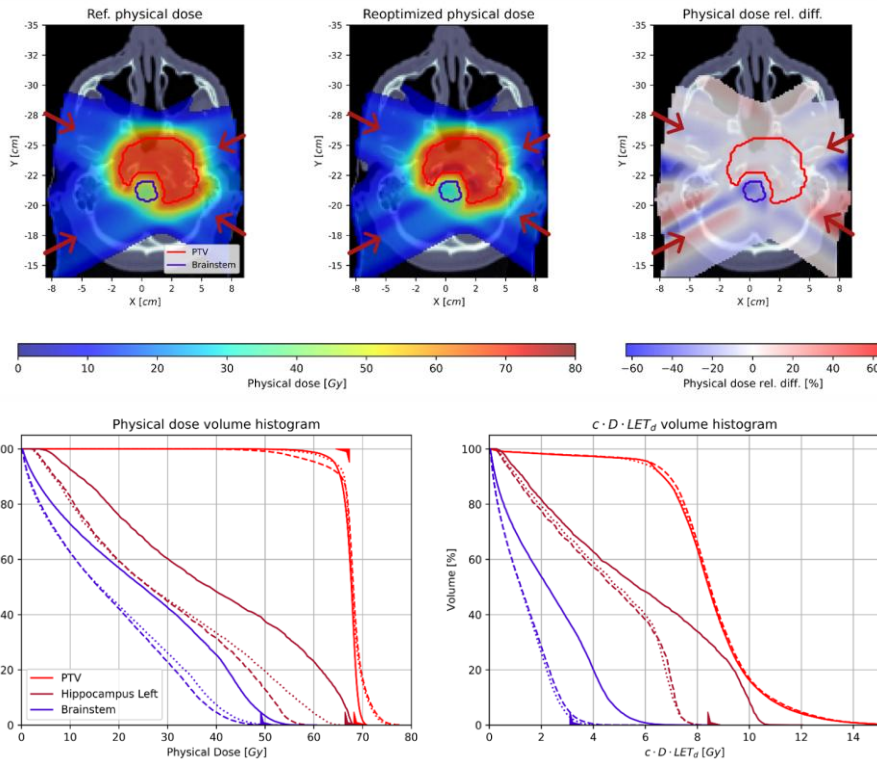
Optimized for breathing phase
(shrinking margins):

- DIBH (Deep Inspiration Breath Hold)
- Beam Gating;
- Motion Tracking (e.g. with optical systems – VISION RT system)

An example of the respiratory gating radiation therapy during the specific period of respiration (Jung Ae Lee et al., *BioMed Research International*, vol. 2014, Article ID 306021)

RESEARCH ACTIVITIES INCORPORATING LET_d IN PROTON THERAPY PROCEDURES

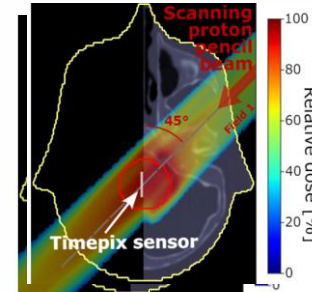
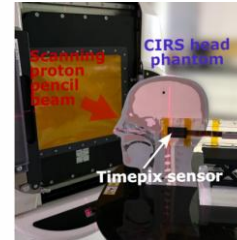
Treatment planning: dose and LET_d superiorization



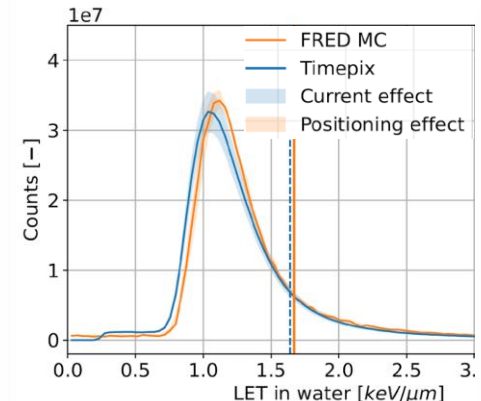
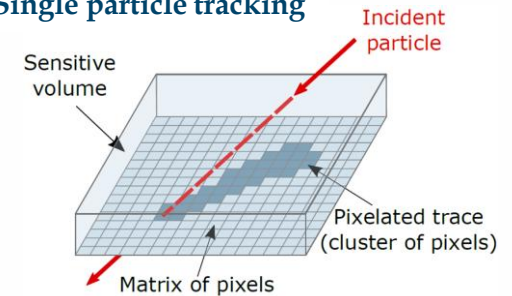
Borys et al. 2025, doi.org/10.1088/1361-6560/ade841
MNiSW: NdS/544748/2021/2021

Quality assurance: single particle LET_d measurement

Timepix MiniPIX



Single particle tracking



Stasica-Dudek, et al., 2023, <https://doi.org/10.1088/1361-6560/acc9f8>
Gajewski et al. 2025, <https://doi.org/10.1016/j.compbiomed.2025.110802>
Stasica-Dudek, et al., 2025, <https://doi.org/10.1088/1361-6560/adca99>
NCBI: LIDER/43/0222/L-12/20/NCBR/2021

RESEARCH ACTIVITIES

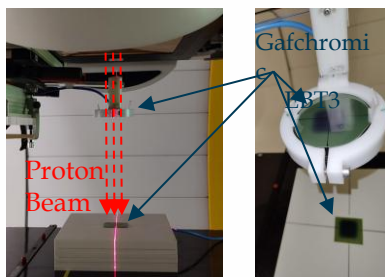
FLASH DOSIMETRY AND FUNDAMENTAL RESEARCH

FLASH radiation therapy

	CONV	FLASH
Total dose	40 - 60 Gy	> 10 Gy
Fractions	5 - 40	1
Delivery time	> 1 min	< 500 ms
Mean dose rate	~ 1 Gy/min	> 40 Gy/s

High dose rate FLASH irradiations enable better normal tissue sparing in comparison with conventional (CONV) radiation therapy

Technical aspects of FLASH radiotherapy

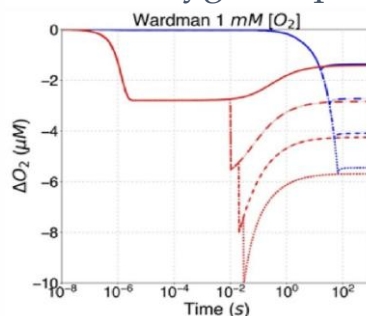


Measurement setup at the gantry facility

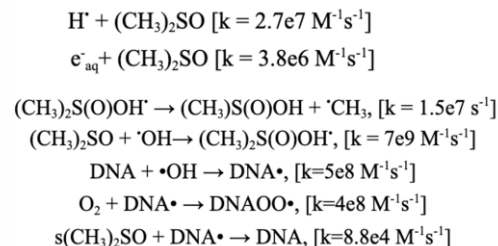
- Adaptation of C230 Cyclotron for FLASH beam irradiation
- Beam monitoring system evaluation
- Dosimetry methods evaluation

FLASH radiation chemistry modeling

Oxygen depletion in FLASH and CONV beams



Advanced chemistry modelling



Plasmid DNA

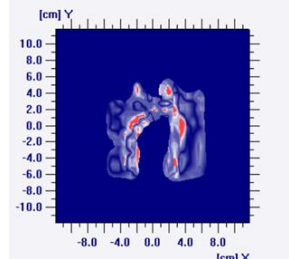
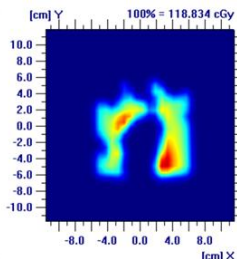
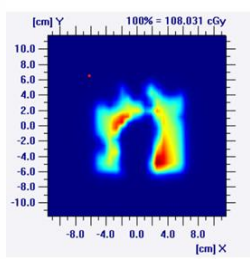
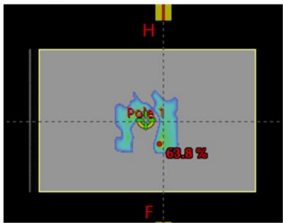
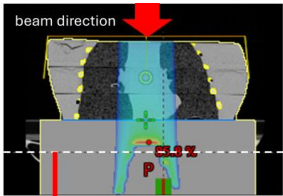


Kondo, ..., Rucinski et al. 2024. DOI: <https://doi.org/10.1088/1361-6560/ada517>, MNiSW: NdS-II/SP/0292/2024/01, NCN Sonata Bis: 2024/54/E/ST4/00457

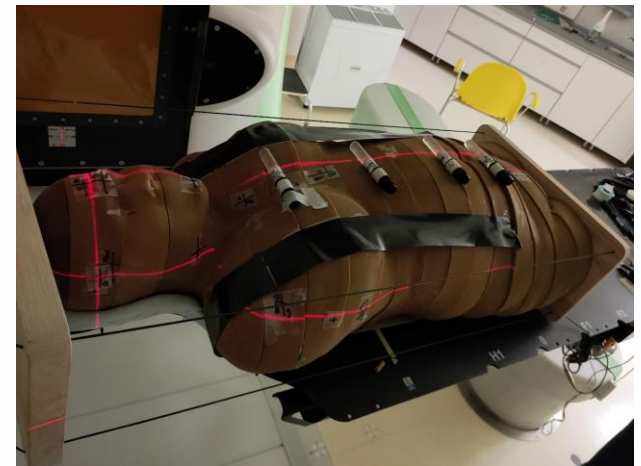
RESEARCH ACTIVITIES

RADIOTHERAPY OF PREGNANT PATIENTS

Pianoforte SONORA - Towards safe, optimized and personalized radiology and radiotherapy procedures for pregnant patients



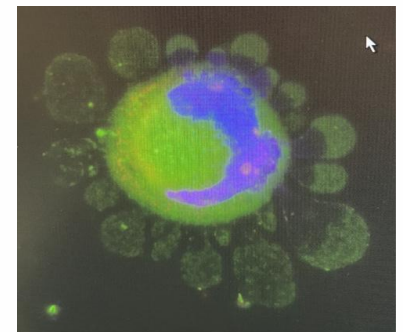
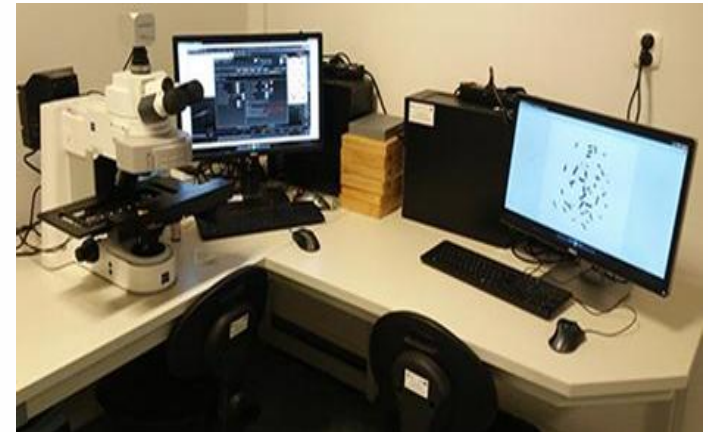
- ✓ Developing of physical and computational phantoms of different pregnancy stages
- ✓ Investigating fetal doses and dosimetry methods for different RT procedures

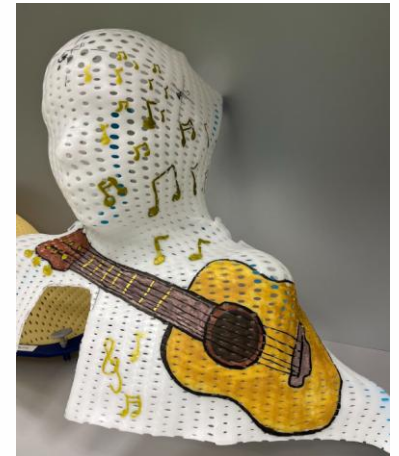




RESEARCH ACTIVITIES PROTON RADIOBIOLOGY STUDIES

- Studies of cancer and normal tissue effects induced by proton vs. photon therapy – mechanism, gaps, opportunities (mainly glioma IV) e.g. project: „The Role of Proton Radiotherapy in the Treatment of Patients with Central Nervous System Tumors”, NdS-II/SP/0295/2023/01, MNiSW (dr. hab. Justyna Miszczyk).
- Modeling, designing, and testing new compounds that may impact the effectiveness of proton therapy e.g. project „Combining Modern, Complex Multidrug Chemotherapy with Radiotherapy (Proton or Photon) as a New Treatment Strategy for Glioblastoma, 2024/08/X/NZ7/00625, MINIATURA 8, NCN, (dr. Anna Zająć-Grabiec).
- Collaboration with IJCLab in the topic of proton radiotherapy for the treatment of patients with central nervous system tumors: an experimental and modeling approach (Justyna Miszczyk & Mathilde Badoual coordinators)
- Serving outstanding expertise (Justyna Miszczyk) for the ESA (European Space Agency), particularly the IBPER Programme: “Investigations into Biological and Physical Effects of Radiation





THANK YOU FOR YOUR ATTENTION!

