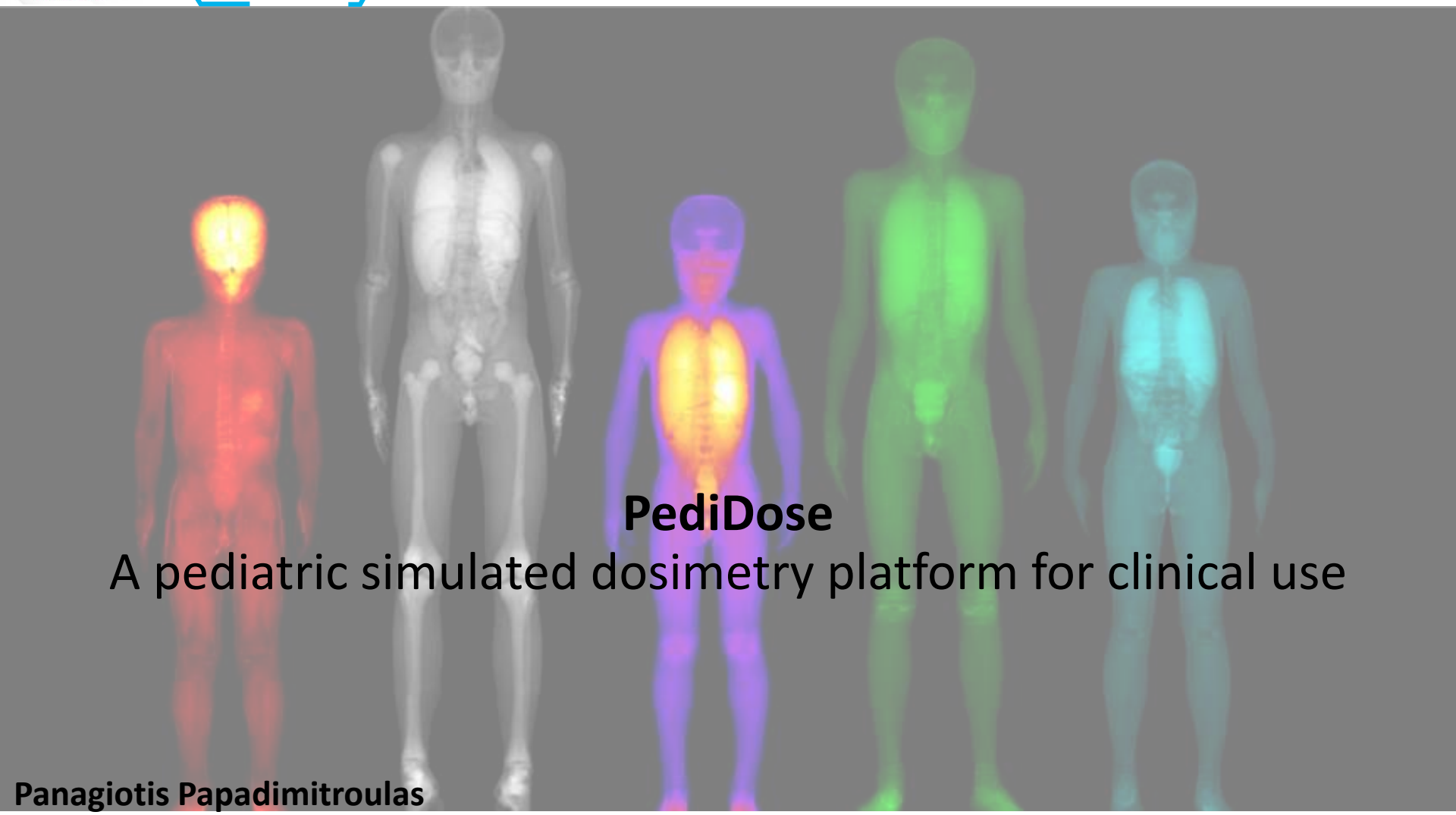


PediDose

A pediatric simulated dosimetry platform for clinical use

Panagiotis Papadimitroulas
panpap@bioemtech.com
PhD Medical Physics
Project Director @ BIOEMTECH

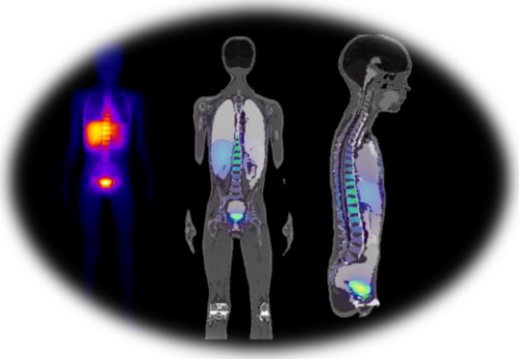
EuroCC@Greece/ FF4Europe Joint Event
Athens, 15.07.2021

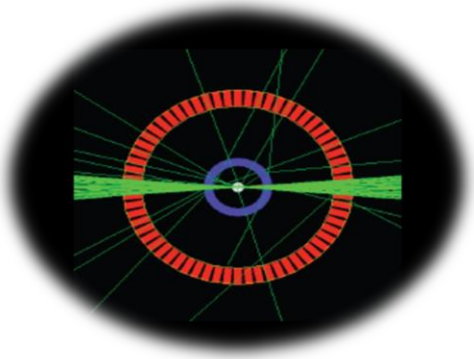
Background (a bit of history…)

BIOEMTECH

- 2003-2009: BSc in Applied Physics (NTUA)
- 2009-2011: MSc in Medical Physics (UPAT)
- 2011-2015: PhD in Medical Physics (UPAT)
- 2013-Today: Co-founder & Project Director (BIOEMTECH)

Evaluation of Diagnostic, Therapeutic and Dosimetric Protocols in Nuclear Medicine, with the Development of Computational Models and the Use of Monte Carlo Simulations





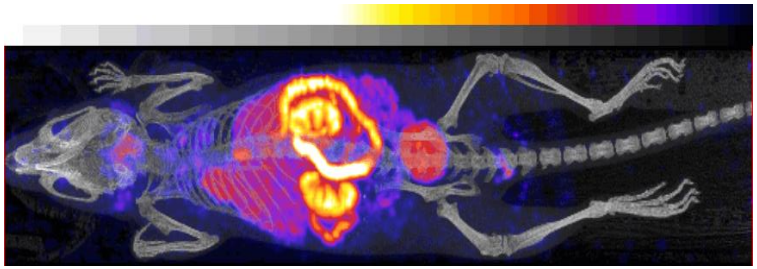
BIOEMTECH activities

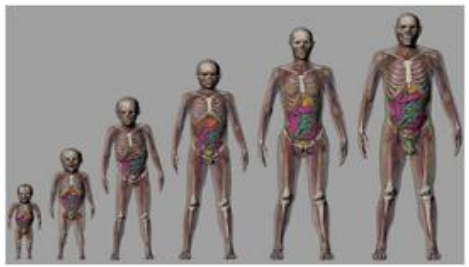
BIOEMTECH

BIOEMTECH develops and offers innovative solutions in pharmaceutical, medical physics and biotechnology research.

We focus on **molecular imaging, dosimetry & biomedical engineering**:

- ✓ Design and construction of low-cost benchtop imaging devices
- ✓ Performance of preclinical imaging services in our imaging platform
- ✓ Computational solutions using MC simulations & AI techniques





BioEmission Technology Solutions
Lefkippos Attica Technology Park – N.C.S.R Demokritos, Greece • Tel: +302130290586 • info@bioemtech.com • www.bioemtech.com

EURO Greece

HPC 1st experience

BIOEMTECH

Intensive Monte Carlo simulations for medical purposes

using anthropomorphic computational models with the GATE toolkit

HPC-Europa2

Pan-European Research Infrastructure on High Performance Computing

- ✓ 2011 – Access in MareNostrum HPC

  (1 month visit)

BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

- ✓ 2017 – Access in ARIS HPC

  (Application for projects involving industry - Pilot Call)

grnet
hpc.grnet.gr

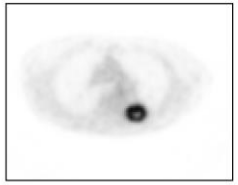


Figure 1: Clinical PET image

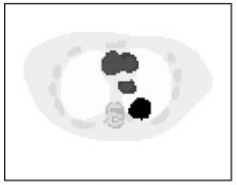


Figure 2: NCAT phantom, adapted to the clinical data with homogeneous tumor

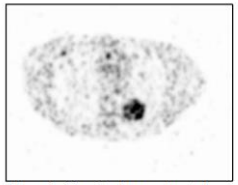


Figure 3: Simulated reconstructed image from the NCAT phantom in HPC (MareNostrum).

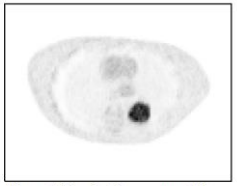


Figure 4: Simulated reconstructed image from the NCAT phantom in GateLab.

FF4EuroHPC 1st call

BIOEMTECH

"Helps facilitate access to all high-performance computing-related technologies for SMEs and thus increases the innovation potential of EU industry. Whether it is ***running high-resolution simulations****, doing* ***large-scale data analyses****, or incorporating* ***AI applications*** *into SMEs´ workflows"*

"The key concept behind FF4EuroHPC is to demonstrate to SMEs how they can strongly benefit from the use of advanced HPC services and thereby take advantage of these innovative ICT solutions for business benefit."

Application process

BIOEMTECH

- ✓ Simple procedure
- ✓ Clear definition of the problem addressed
- ✓ Identification of the best partners in order to cover:

Domain Expertise – End User – HPC expertise / provider

Attention:

Strong impact with industrial relevance

Exploitation of the results

Justification of the resources

Clear use and benefit of the HPC

Innovation of the idea

Quality of the consortium

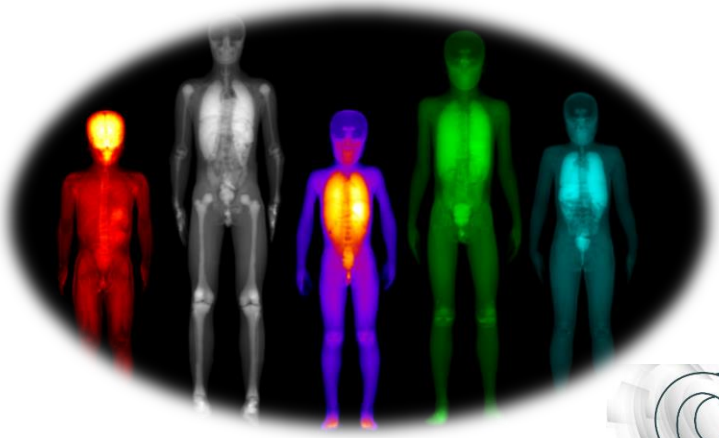
PediDose – Overview

BIOEMTECH

A pediatric simulated dosimetry platform for clinical use

Aim to develop a realistic simulated dosimetry database using a pediatric digital phantoms' population. The goal is to exploit the database for the creation of a novel software tool that will offer the clinician to assess internal radiation dosimetry considering personalized characteristics of the patients

- Call: FF4EuroHPC Call-1 (Deadline end of January)
- Consortium: 2 SMEs & 1 HPC expert (**BIOEMTECH** – **iKnowHow – GRNET**)
- Duration: 15 months
- Start Date: 1st of June 2021

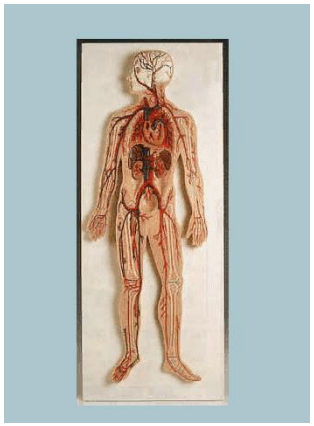


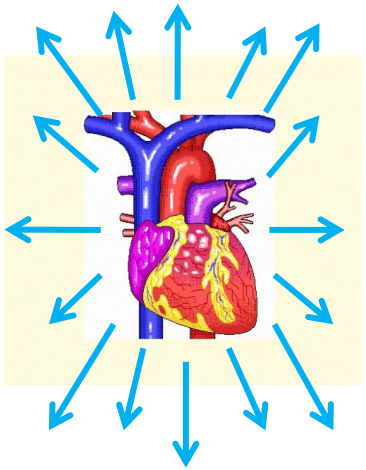
IKH grnet hpc.grnet.gr

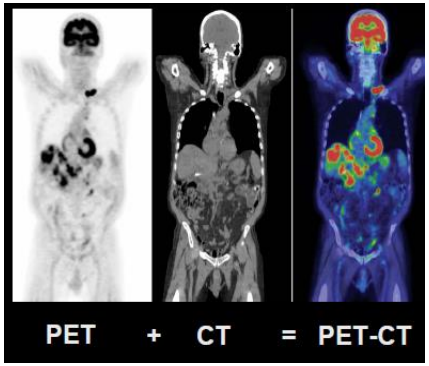
BIOEMTECH

The problem…

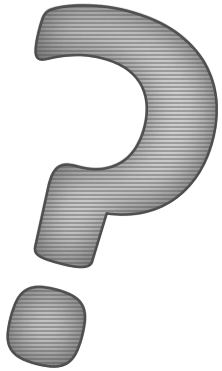
BIOEMTECH







- Nuclear Medicine procedures involve radioactivity
- No way to measure the absorbed dose in each organ (internal dosimetry)
- Ionizing radiation can lead to cancer
- Estimations based on the images
- Pre-calculations with MC simulations based on standard models
- Pediatric patients are higher radiosensitive than adults
- Optimization of pediatric dosimetry based on personalized patient's characteristics

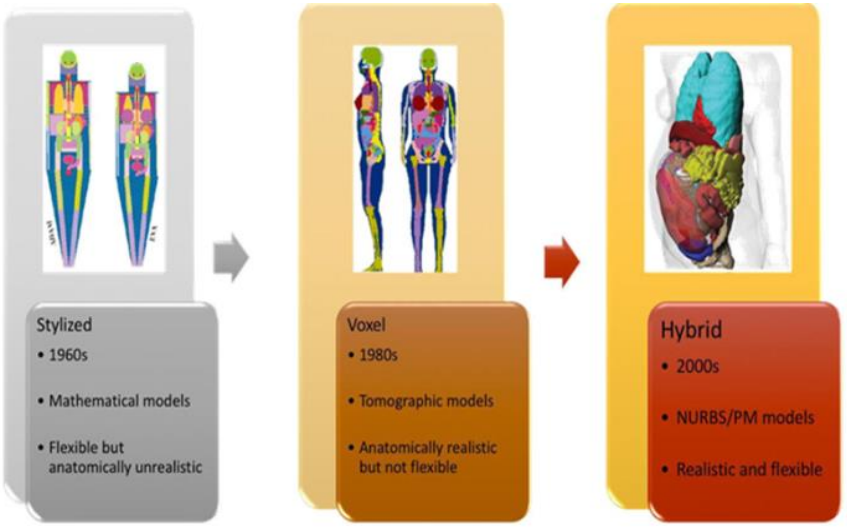


Current solution…

BIOEMTECH

"Monte Carlo method is a statistical approach to solve deterministic problems and define a specified system using random number generators"

- MC techniques took their name form the Monte Carlo Casino.
- >40 years MC techniques are applied in Medical Physics.
- MC simulations serve as ground truth for dosimetry.
- Calculations of doses per/organ from a specific adult phantom (rescaling for pediatrics)



BioEmission Technology Solutions
Lefkippos Attica Technology Park – N.C.S.R Demokritos, Greece • Tel: +302130290586 • info@bioemtech.com • www.bioemtech.com

EURO Greece

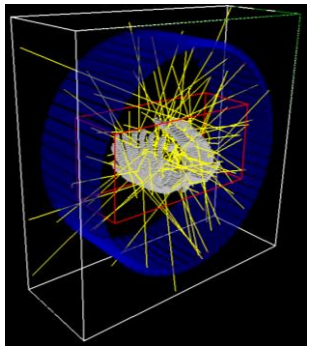
Our idea…

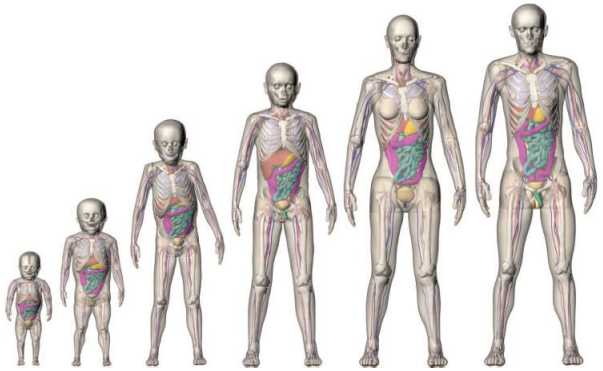
BIOEMTECH

- Non IT experts
- Develop a new product – clinical software tool – assist clinicians
- Personalized pediatric dosimetry prediction
- Based on a methodology previously developed
  (H2020-MSCA-RISE ERROR project (https://error.upatras.gr/)

All the appropriate tools and technology exist

- MC tools well validated (high accuracy)
- Advanced computational anthropomorphic models
- HPC resources (highly demanding in computational time)





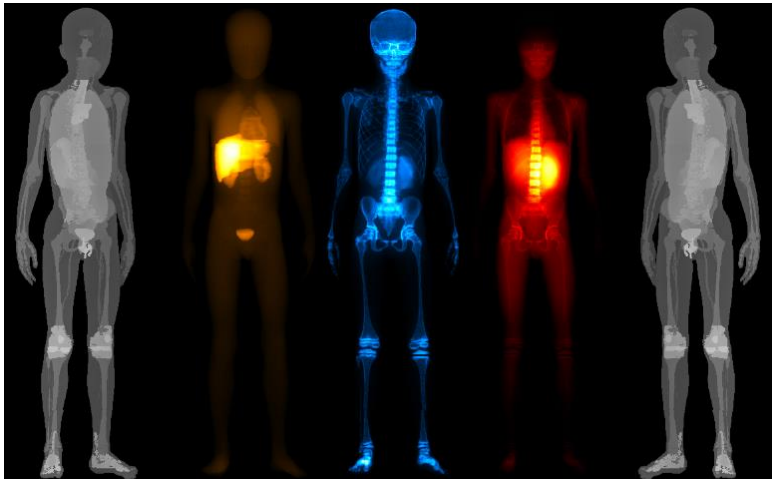
The goal…

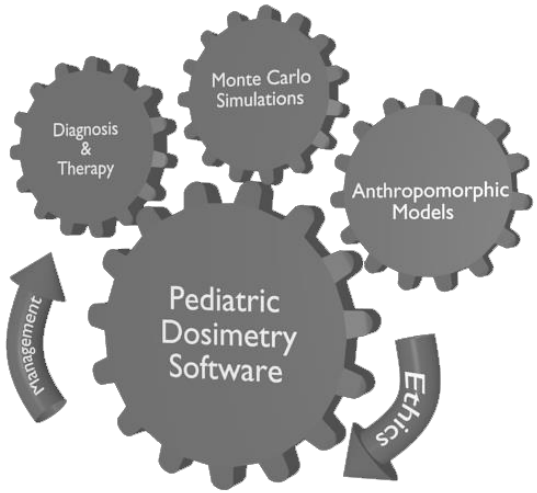
BIOEMTECH

Development of a platform for personalized pediatric dosimetry

Creation of a product: support tool for clinicians

- Develop a platform with a Graphical User Interface (GUI), using computational tools and MC simulations, for the calculation of the absorbed dose / organ before the acquisition of NM examinations.
- Exploit Artificial Intelligence: ML/DL techniques
- The clinician will have a good estimation and could reconsidered the applied protocol.



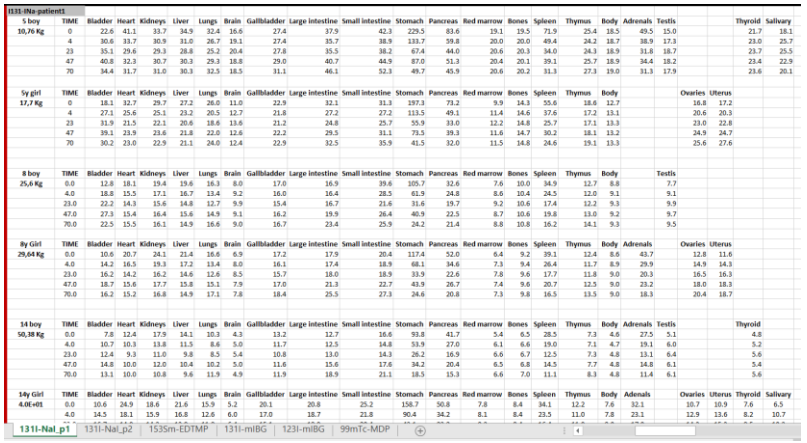


Methodology

BIOEMTECH

MC simulations

Use clinical data to create dosimetry databases for all organs of interest on a population of pediatric phantoms with different anatomies.



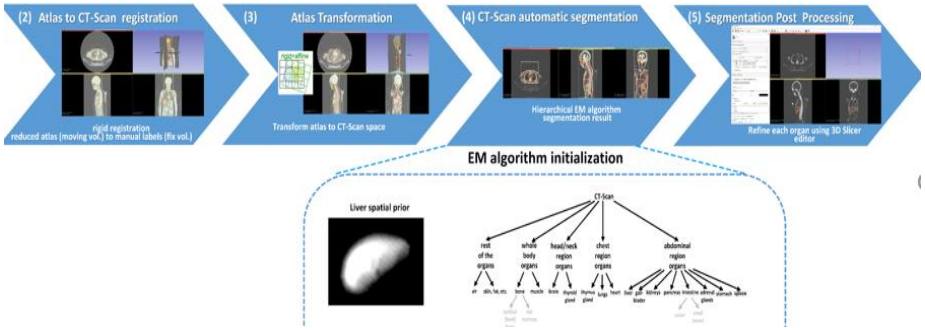
131I-INa-patient1																							
5 boy	TIME	Bladder	Heart	Kidneys	Liver	Lungs	Brain	Gallbladder	Large intestine	Small intestine	Stomach	Pancreas	Red marrow	Bones	Spleen	Thymus	Body	Adrenals	Testis			Thyroid	Salivary
10,76 Kg	0	22.6	41.1	33.7	34.9	32.4	16.6	27.4	37.9	42.3	229.5	83.6	19.1	19.5	71.9	25.4	18.5	49.5	15.0			21.7	18.1
	4	30.6	33.7	30.9	31.0	26.7	19.1	27.4	35.7	38.9	133.7	59.8	20.0	20.0	49.4	24.2	18.7	38.9	17.3			23.0	25.7
	23	35.1	29.6	29.3	28.8	25.2	20.4	27.8	35.5	38.2	67.4	44.0	20.6	20.3	34.0	24.3	18.9	31.8	18.7			23.7	25.5
	47	40.8	32.3	30.7	30.3	29.3	18.8	29.0	40.7	44.9	87.0	51.3	20.4	20.1	39.1	25.7	18.9	34.4	18.2			23.4	22.9
	70	34.4	31.7	31.0	30.3	32.5	18.5	31.1	46.1	52.3	49.7	45.9	20.6	20.2	31.3	27.3	19.0	31.3	17.9			23.6	20.1
5y girl	TIME	Bladder	Heart	Kidneys	Liver	Lungs	Brain	Gallbladder	Large intestine	Small intestine	Stomach	Pancreas	Red marrow	Bones	Spleen	Thymus	Body			Ovaries	Uterus		
17,7 Kg	0	18.1	32.7	29.7	27.2	26.0	11.0	22.9	32.1	31.3	197.3	73.2	9.9	14.3	55.6	18.6	12.7			16.8	17.2		
	4	27.1	25.6	25.1	23.2	20.5	12.7	21.8	27.2	27.2	113.5	49.1	11.4	14.6	37.6	17.2	13.1			20.6	20.3		
	23	31.9	21.5	22.1	20.6	18.6	13.6	21.2	24.8	25.7	55.9	33.0	12.2	14.8	25.7	17.1	13.3			23.0	22.8		
	47	39.1	23.9	23.6	21.8	22.0	12.6	22.2	29.5	31.1	73.5	39.3	11.6	14.7	30.2	18.1	13.2			24.9	24.7		
	70	30.2	23.0	22.9	21.1	24.0	12.4	22.9	32.5	35.9	41.5	32.0	11.5	14.8	24.6	19.1	13.3			25.6	27.6		
8 boy	TIME	Bladder	Heart	Kidneys	Liver	Lungs	Brain	Gallbladder	Large intestine	Small intestine	Stomach	Pancreas	Red marrow	Bones	Spleen	Thymus	Body		Testis				
25,6 Kg	0.0	12.8	18.1	19.4	19.6	16.3	8.0	17.0	16.9	39.6	105.7	32.6	7.6	10.0	34.9	12.7	8.8		7.7				
	4.0	18.8	15.5	17.1	16.7	13.4	9.2	16.0	16.4	28.5	61.9	24.8	8.6	10.4	24.5	12.0	9.1		9.1				
	23.0	22.2	14.3	15.6	14.8	12.7	9.9	15.4	16.7	21.6	31.6	19.7	9.2	10.6	17.4	12.2	9.3		9.9				
	47.0	27.3	15.4	16.4	15.6	14.9	9.1	16.2	15.9	26.4	40.9	22.5	8.7	10.6	19.8	13.0	9.2		9.7				
	70.0	22.5	15.5	16.1	14.9	16.6	9.0	16.7	23.4	25.9	24.2	21.4	8.8	10.8	16.2	14.1	9.3		9.5				
8y Girl	TIME	Bladder	Heart	Kidneys	Liver	Lungs	Brain	Gallbladder	Large intestine	Small intestine	Stomach	Pancreas	Red marrow	Bones	Spleen	Thymus	Body	Adrenals		Ovaries	Uterus		
29,64 Kg	0.0	10.6	20.7	24.1	21.4	16.6	6.9	17.2	17.9	20.4	117.4	52.0	6.4	9.2	39.1	12.4	8.6	43.7		12.8	11.6		
	4.0	14.2	16.5	19.3	17.2	13.4	8.0	16.1	17.4	18.9	68.1	34.6	7.3	9.4	26.4	11.7	8.9	29.9		14.9	14.3		
	23.0	16.2	14.2	16.2	14.6	12.6	8.5	15.7	18.0	18.9	33.9	22.6	7.8	9.6	17.7	11.8	9.0	20.3		16.5	16.3		
	47.0	18.7	15.6	17.7	15.8	15.1	7.9	17.0	21.3	22.7	43.9	26.7	7.4	9.6	20.7	12.5	9.0	23.2		18.0	18.3		
	70.0	16.2	15.2	16.8	14.9	17.1	7.8	18.4	25.5	27.3	24.6	20.8	7.3	9.8	16.5	13.5	9.0	18.3		20.4	18.7		
14 boy	TIME	Bladder	Heart	Kidneys	Liver	Lungs	Brain	Gallbladder	Large intestine	Small intestine	Stomach	Pancreas	Red marrow	Bones	Spleen	Thymus	Body	Adrenals	Testis			Thyroid	
50,38 Kg	0.0	7.8	12.4	17.9	14.1	10.3	4.3	13.2	12.7	16.6	93.8	41.7	5.4	6.5	28.5	7.3	4.6	27.5	5.1			4.8	
	4.0	10.7	10.3	13.8	11.5	8.6	5.0	11.7	12.5	14.8	53.9	27.0	6.1	6.6	19.0	7.1	4.7	19.1	6.0			5.2	
	23.0	12.4	9.3	11.0	9.8	8.5	5.4	10.8	13.0	14.3	28.2	16.9	6.6	6.7	12.5	7.3	4.8	13.1	6.4			5.6	
	47.0	14.8	10.0	12.0	10.4	10.2	5.0	11.6	15.6	17.6	34.2	20.4	6.5	6.8	14.5	7.7	4.8	14.8	6.1			5.4	
	70.0	13.1	10.0	10.8	9.6	11.9	4.9	11.9	18.9	21.1	18.5	15.3	6.6	7.0	11.1	8.3	4.8	11.4	6.1			5.6	
14y Girl	TIME	Bladder	Heart	Kidneys	Liver	Lungs	Brain	Gallbladder	Large intestine	Small intestine	Stomach	Pancreas	Red marrow	Bones	Spleen	Thymus	Body	Adenals		Ovaries	Uterus	Thyroid	Salivary
4.0E+01	0.0	10.6	24.9	18.6	21.6	15.9	5.2	20.1	20.8	25.2	158.7	50.8	7.8	8.4	34.1	12.2	7.6	32.1		10.7	10.9	7.6	6.5
	4.0	14.5	18.1	15.9	16.8	12.6	6.0	17.0	18.7	21.8	90.4	34.2	8.1	8.4	23.5	11.0	7.8	23.1		12.9	13.6	8.2	10.7

131I-NaI_p1 | 131I-NaI_p2 | 153Sm-EDTMP | 131I-mIBG | 123I-mIBG | 99mTc-MDP

ML techniques

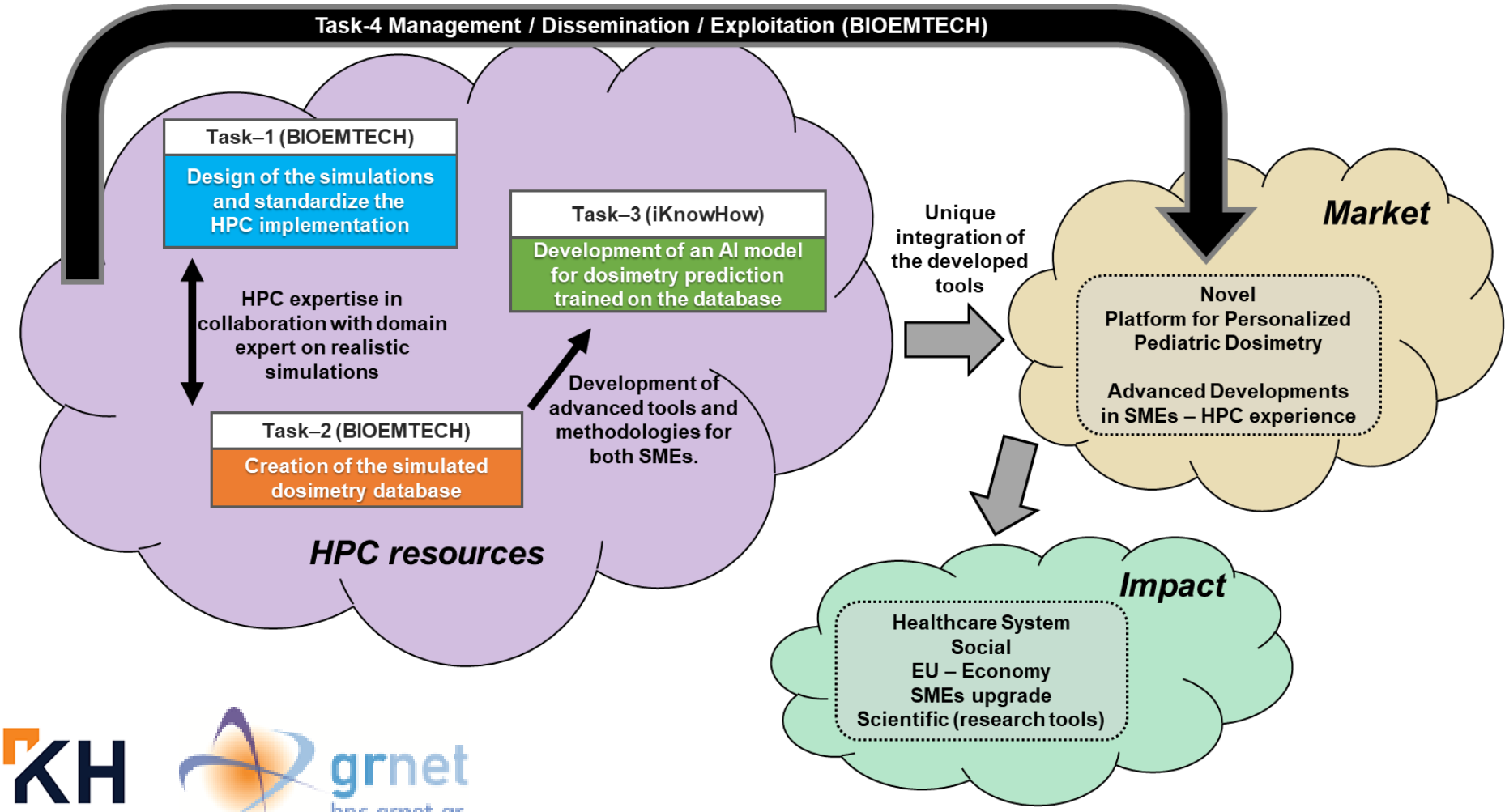
Develop techniques to predict dose from organs with different anatomies. Algorithms will be trained on the dosimetry database.

Auto segmentation procedures…



Project Implementation

BIOEMTECH



IKH

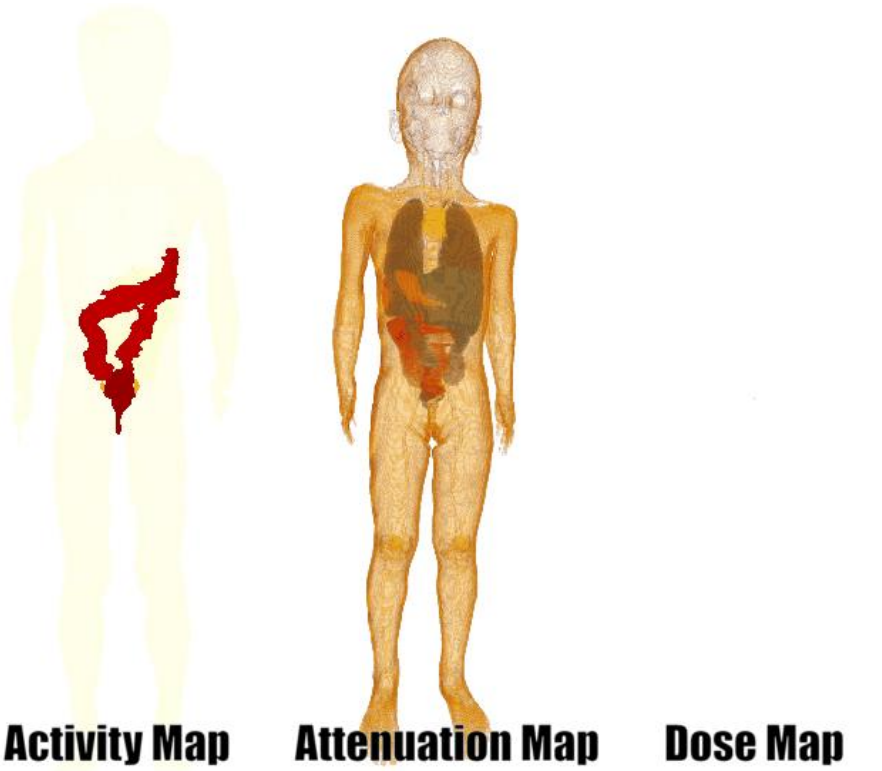
grnet
hpc.grnet.gr

HPC: The need

BIOEMTECH

- Large number & Intensive simulations:
  - There is ~25 pediatric models (2-15 years old)
  - Test at least 5 most common radiopharmaceuticals
  - To have an accurate dosimetry assessment, 4 time points will be used.

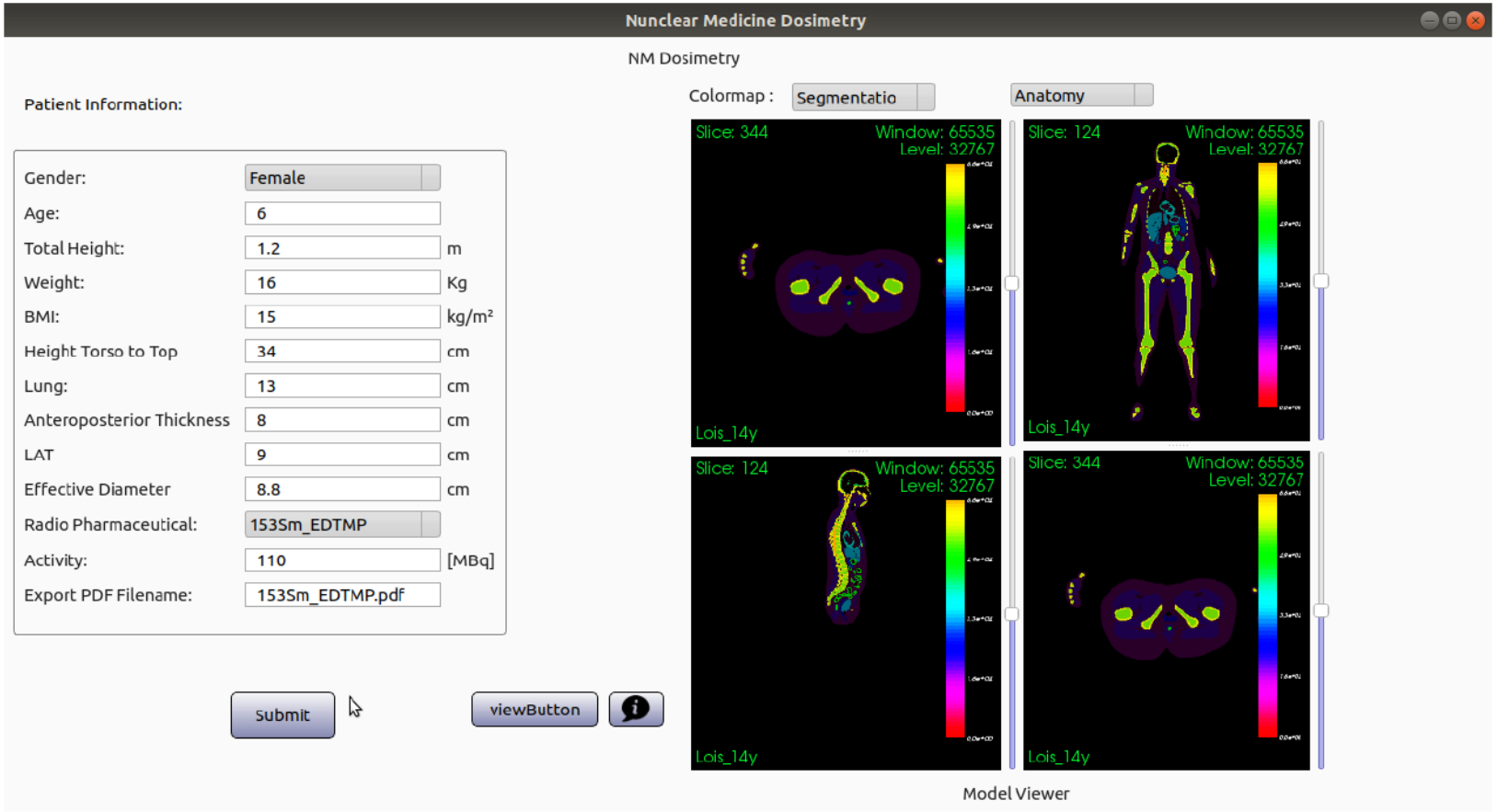
  ~500 different simulations.
- Machine Learning training models:
  - Training of the models will be tested in HPC to investigate their speed up



Final Software Product

BIOEMTECH

The clinician will have a good estimation and could reconsidered the applied protocol



General thoughts - Discussion

BIOEMTECH

- Years of thoughts for an in-house cluster

- HPC could be considered a daily tool for business
  - ✓ Developers daily use (like cloud services – Share files etc.)
  - ✓ Many tasks could benefit from HPC (image processing, simulations, AI) !

- Industrial access on HPC???
  - Funds? National support – resources?
  - Training – internal/external expert?

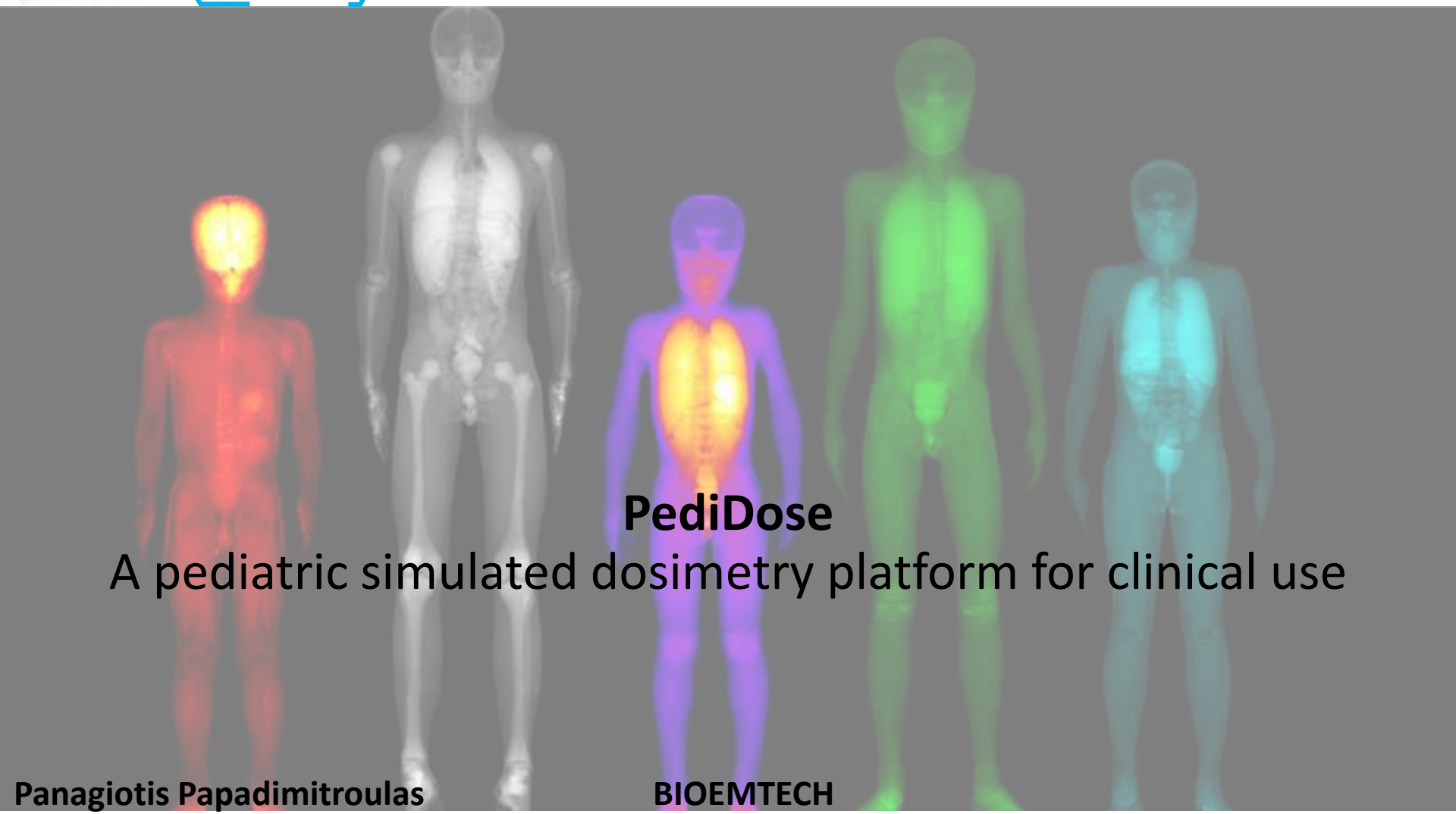
- Next steps – enhance quality of results and daily workflow
  - Attract interest of SMEs / Start-ups
  - Training & Dissemination activities (create awareness)
  - Industry should identify their needs!

Thank you !!!

BIOEMTECH

This project has received funding from the European High-Performance Computing Joint Undertaking Joint Undertaking (JU) under grant agreement No 951745. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Germany, Italy, Slovenia, France, Spain.

BioEmission Technology Solutions
Lefkippos Attica Technology Park – N.C.S.R Demokritos, Greece • Tel: +302130290586 • info@bioemtech.com • www.bioemtech.com



PediDose

A pediatric simulated dosimetry platform for clinical use

Panagiotis Papadimitroulas
panpap@bioemtech.com
PhD Medical Physics
Project Director @ BIOEMTECH

BIOEMTECH
Tel.: +30 2106548192
e-mail: info@bioemtech.com
www.bioemtech.com

EuroCC@Greece / FF4Europe
Athens, 15.07.2021