MRT DOSIMETRY

Metrology for clinical implementation of dosimetry in molecular radiotherapy

MRTDosimetry: a new pan-European project for implementation of dosimetry in molecular radiotherapy

European workshop on the principles and clinical implementation of dose calculation in molecular radiotherapy

Andrew Robinson on behalf of the MRTDosimetry collaboration

EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

MetroMRT

Metrology for Molecular Radiotherapy

June 2012 - May 2015

http://projects.npl.co.uk/metromrt

"The MetroMRT project was a watershed in that it is the first time that the disciplines of clinical science and metrology have combined to solve the problem of individual patient dosimetry in molecular radiotherapy, and to bring it into line with all other modalities of radiotherapy."

- Activity Measurement
- Quantitative Imaging
- Absorbed Dose Calculation & Measurement
- Uncertainty Analysis

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MetroMRT

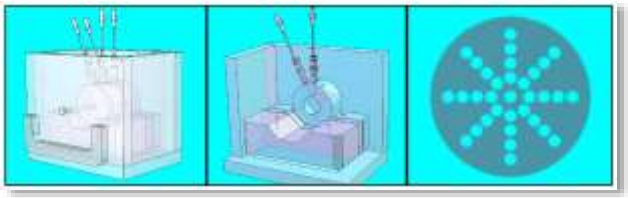
Metrology for Molecular Radiotherapy

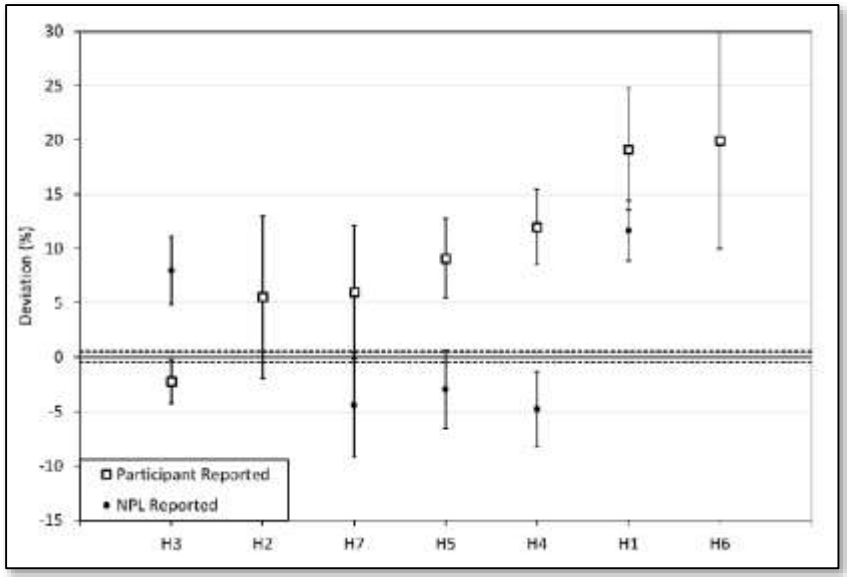
IOP Publishing | Bureau International des Poids et Mesures
Metrologia
Metrologia 53 (2016) 1259–1271
doi:10.1088/0026-1394/53/6/1259

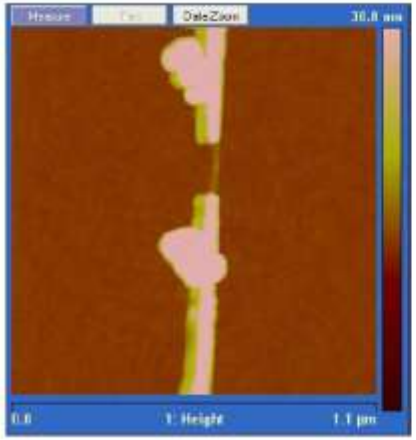
Development of a primary standard for absorbed dose from unsealed radionuclide solutions

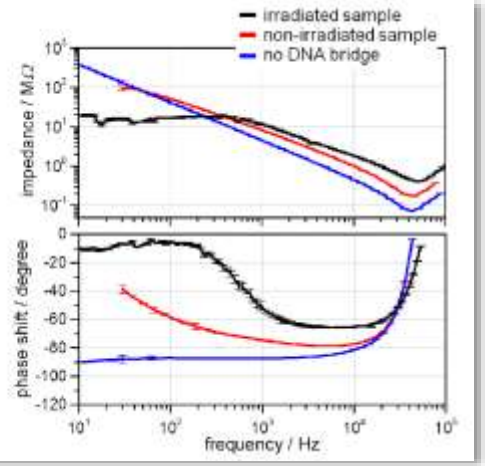
I Billas, D Shipley, S Galer, G Bass, T Sander, A Fenwick and V Smyth

National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK









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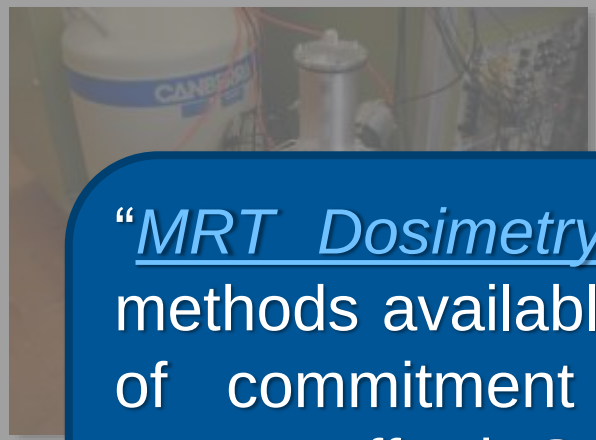
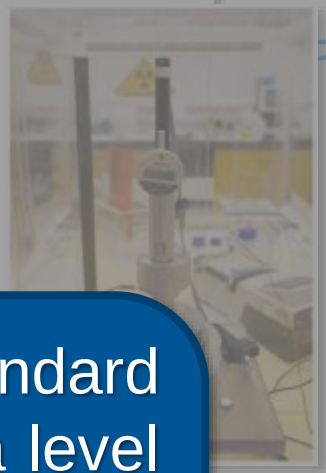
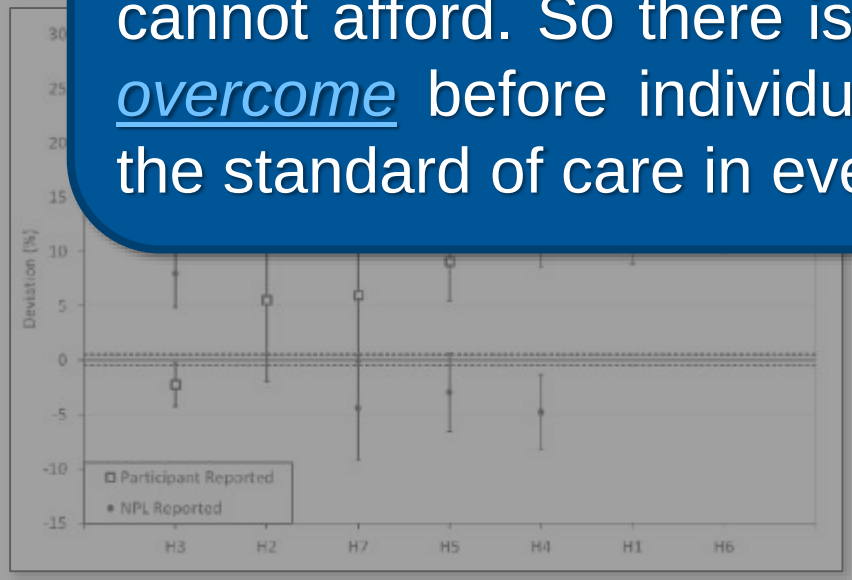
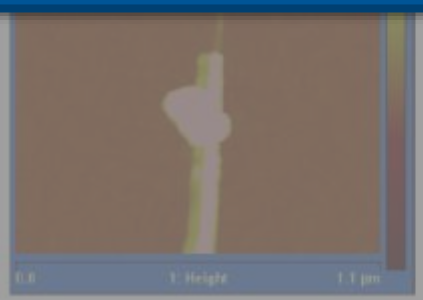
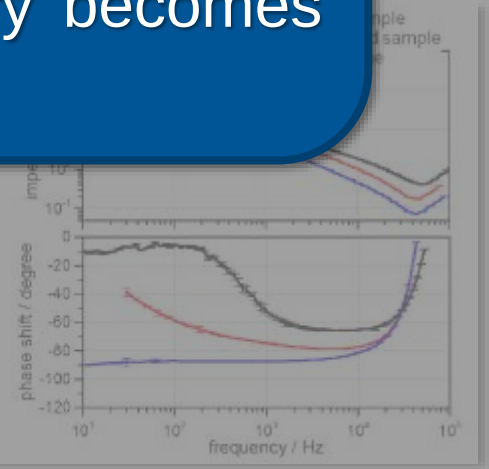




"*MRT Dosimetry is difficult*, and with no standard methods available the implementation requires a level of commitment that regular non-research clinics cannot afford. So there is a *considerable inertia to be overcome* before individual MRT dosimetry becomes the standard of care in every clinic."







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MRT DOSIMETRY

Metrology for clinical implementation of dosimetry in molecular radiotherapy

June 2016 to May 2019

http://mrtdosimetry-empir.eu/

"To provide the metrology for the clinical implementation of absorbed dose calculations in Molecular Radiotherapy (MRT). The project builds on the results and outputs from MetroMRT. The focus of this follow-on project is *clinical implementation* and it is strongly directed by the *involvement of leading MRT clinics across Europe* as well as building on metrology expertise."

NPL National Physical Laboratory

BEV Bundesamt für Eich- und Vermessungswesen

cea DE LA RECHERCHE À L'INDUSTRIE

CMI

ENEA

SCK•CEN STUDIECENTRUM VOOR KERNENERGIE CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

SERVIZIO SANITARIO REGIONALE EMILIA-ROMAGNA Azienda Ospedaliera di Reggio Emilia Arcispedale S. Maria Nuova

Inserm Institut national de la santé et de la recherche médicale

UK

LUNDS UNIVERSITET

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Oxford University Hospitals NHS NHS Trust

IIBEAA

Azienda Unità Sanitaria Locale LATINA

The Christie TOWARDS A FUTURE WITHOUT CANCER

ΘΕΑΓΕΝΕΙΟ ΑΝΤΙΚΑΡΚΙΝΙΚΟ ΝΟΣΟΚΟΜΕΙΟ ΘΕΣΣΑΛΟΝΙΚΗΣ

The Royal Surrey County Hospital NHS NHS Trust

SERVIZIO SANITARIO REGIONALE EMILIA-ROMAGNA Azienda Ospedaliero - Universitaria di Bologna Policlinico S. Orsola-Malpighi

Bambino Gesù OSPEDALE PEDIATRICO

MRTDosimetry Workshop – Prague (26th – 27th Sept 2018)

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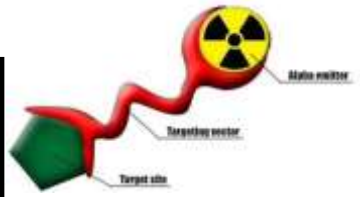
Molecular Radiotherapy (MRT)

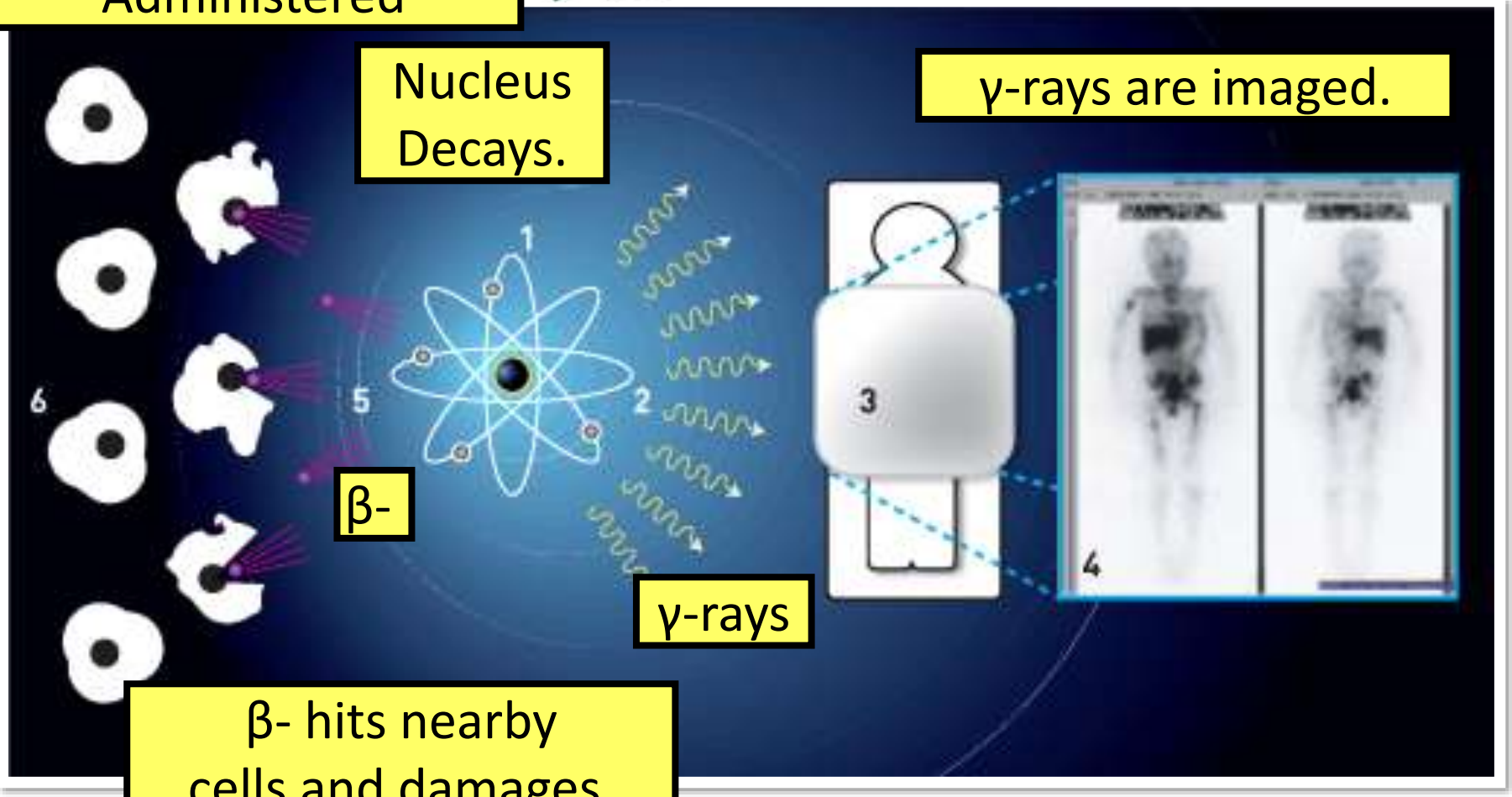
NPL National Physical Laboratory

Radiopharmaceutical Administered



Nucleus Decays.

γ-rays are imaged.



β- hits nearby cells and damages or kills them.

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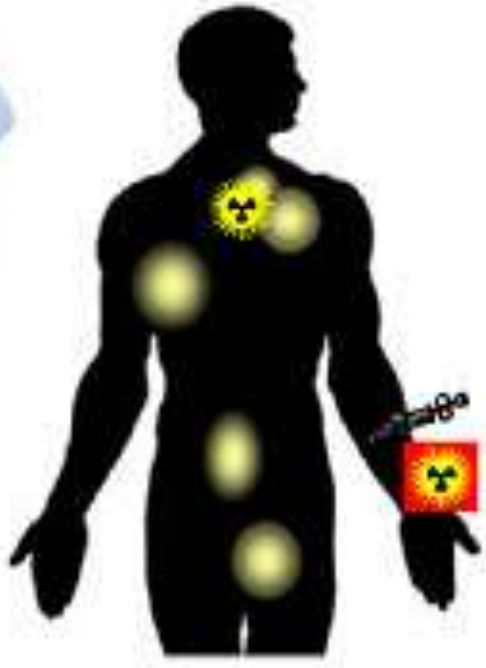
Molecular Radiotherapy (MRT)

NPL National Physical Laboratory

External Beam	MRT
	
Requires knowledge of tumour location	**Requires knowledge of tumour biology**

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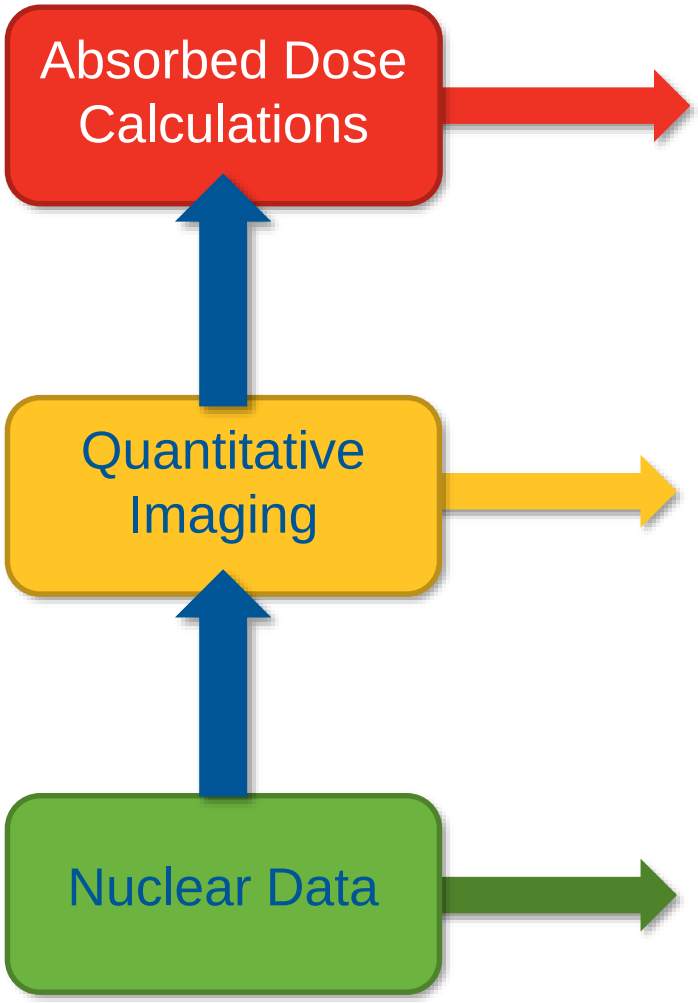
MRT DOSIMETRY

Metrology for clinical implementation of dosimetry in molecular radiotherapy

Project Structure



"What is the distribution of absorbed energy from the decays?"

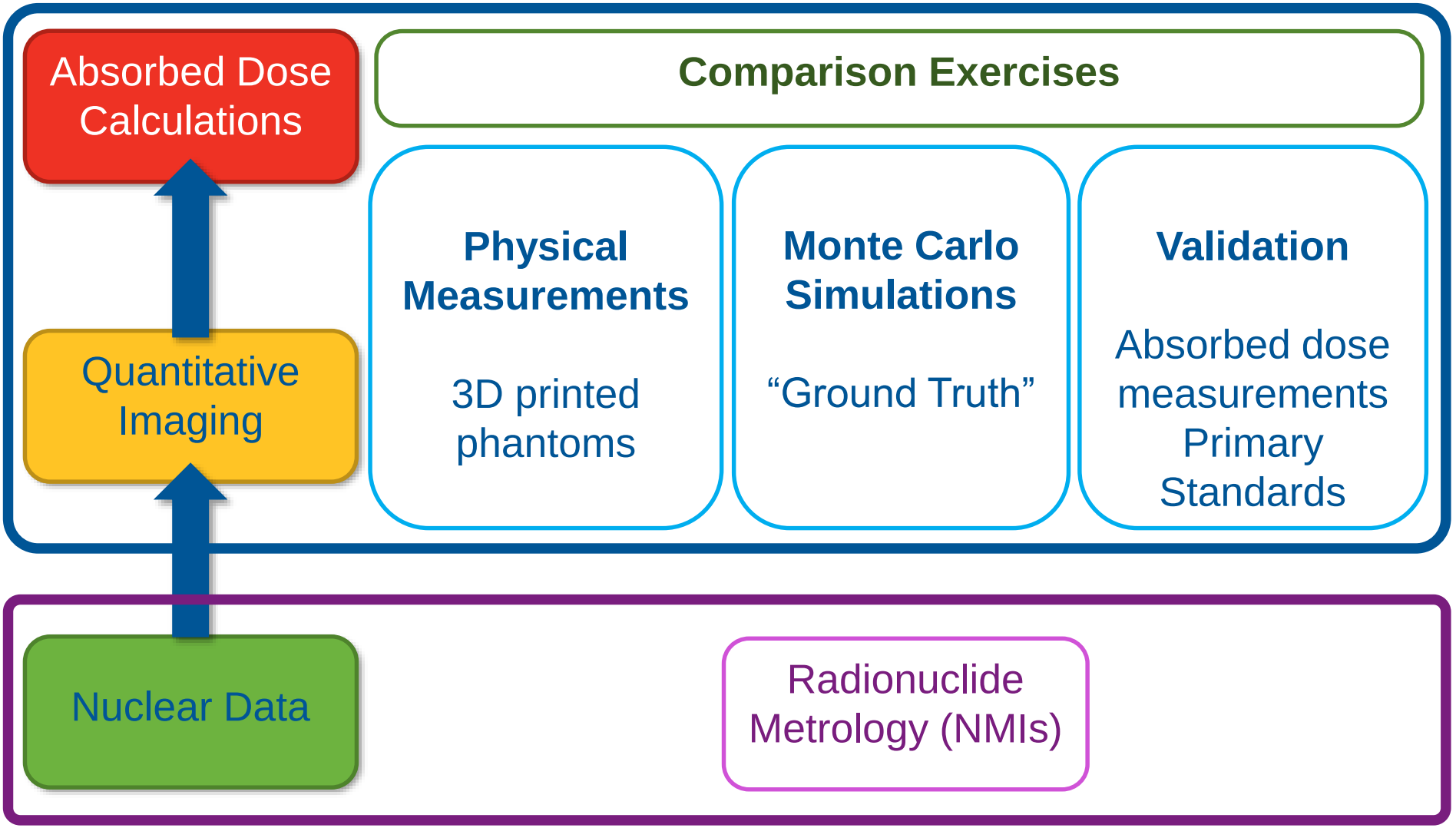
"How do we best convert the signal from events detected in a SPECT camera to an activity distribution?"

"Does the nucleus decay?"
"How does the nucleus decay?"
"How many nuclei have decayed?"

MRT DOSIMETRY

Metrology for clinical implementation of dosimetry in molecular radiotherapy

Project Structure



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MRT DOSIMETRY

Metrology for clinical implementation of dosimetry in molecular radiotherapy

Objectives

1. To determine branching ratios and emission probabilities for ^{90}Y and ^{166}Ho; develop a suitable transfer instrument optimised for accuracy of measurements of the activity of MRT agents in clinics.

2. To develop a range of quasi-realistic anthropomorphic phantoms (using 3D printing) containing compartments fillable with known activities of radioactive liquid or standardised sealed radioactive test sources; expand the protocol for traceable calibration of SPECT, validated by measurements using the quasi-realistic anthropomorphic 3D printed phantoms.

3. To generate multimodal (SPECT/CT/PET) images from phantom measurements or Monte Carlo (MC) simulations to provide material for an open-access database of reference images for commissioning QC

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MRT DOSIMETRY
Metrology for clinical implementation of dosimetry in molecular radiotherapy

Objectives

4. To improve the accuracy and metrological traceability in the calculation of dose from time-sequences of QI measurements; by optimisation of the time points, refinement of absorbed dose standards, and validation of absorbed dose calculation methods in phantoms using physical measurements.

5. To determine uncertainties in relation to the full MRT dose measurement chain from a primary standard to a range of commercial and non-commercial dosimetry calculation platforms. This includes image quantification, integration of TACs, propagation of uncertainties in NTCP models, and determination of the overall evaluated uncertainty in the absorbed dose quantification process.

6. To facilitate the take up by healthcare professionals (clinical centres) and industry (scanner manufacturers and software developers) of the technology and measurement infrastructure developed by the project.

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MRT DOSIMETRY

Metrology for clinical implementation of dosimetry in molecular radiotherapy

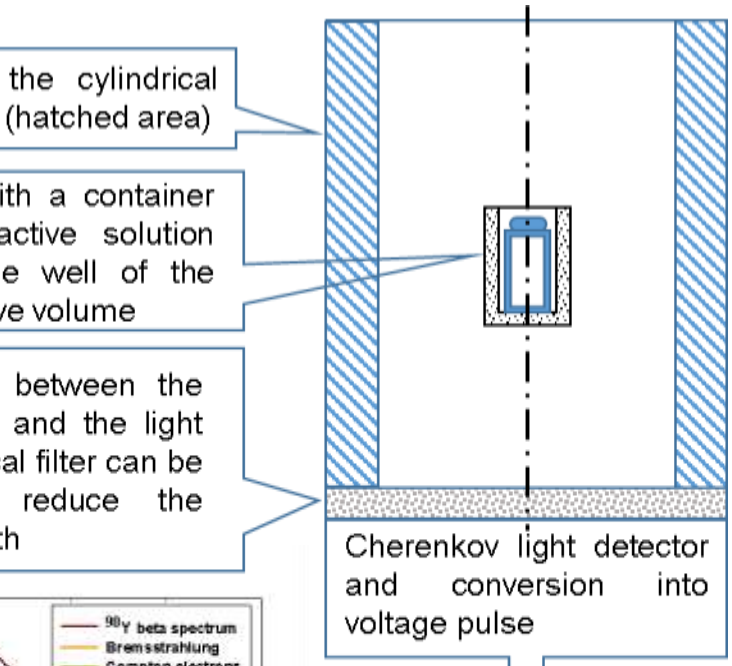
New Transfer Instrument

Geometry close to classical ionisation chambers (quasi 4π geometry)

Cutting plan of the cylindrical sensitive volume (hatched area)

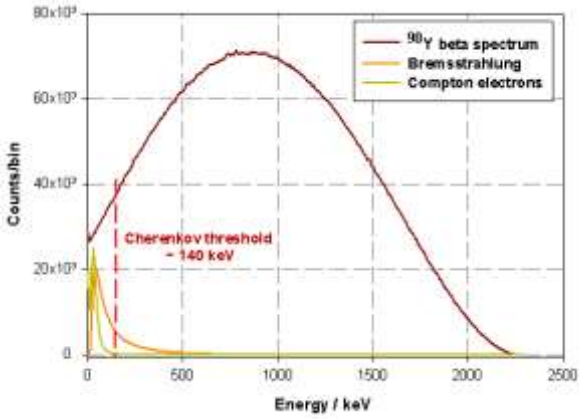
Source holder with a container filled with radioactive solution placed inside the well of the cylindrical sensitive volume

Optical coupling between the sensitive volume and the light detector. An optical filter can be also used to reduce the spectral bandwidth



Cherenkov light detector and conversion into voltage pulse

Electronic system for pulse counting based on extendable dead-time processing



Emission of electrons by a β⁻-emitter in the radioactive source: production of bremsstrahlung radiation along the track of electrons (solution radioactive solution, vial, source-holder, etc.)

Creation of Compton electrons in the transparent sensitive volume following the interaction bremsstrahlung radiation

Emission of Cherenkov photons along the track of Compton electrons in the transparent sensitive volume

Conversion of Cherenkov photons into a voltage signal by a light detector (e.g. PMT)

High activity beta emission u(A) < 2%

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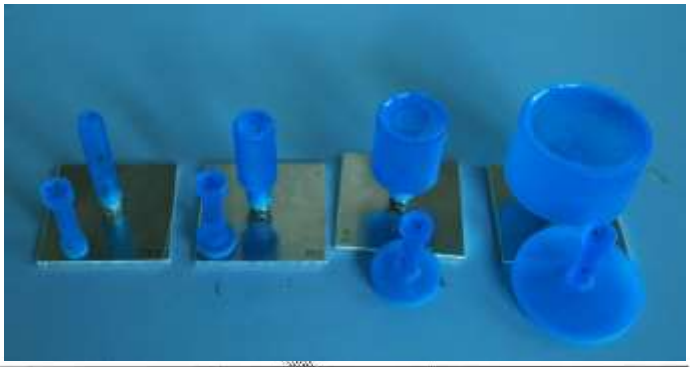
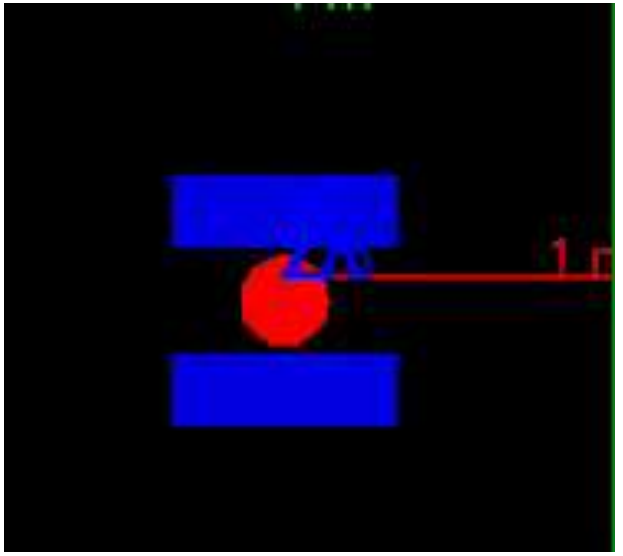
MRT DOSIMETRY

Metrology for clinical implementation of dosimetry in molecular radiotherapy

Sources, phantoms and simulations





2.1 Activity

Source reference number	Radionuclide	Activity (kBq)	Expanded relative uncertainty (k = 2) (%)
a3	Ba-133	341.8	2.6
b3	Ba-133	1377	2.6
c3	Ba-133	5280	2.6
d3	Ba-133	20860	2.6

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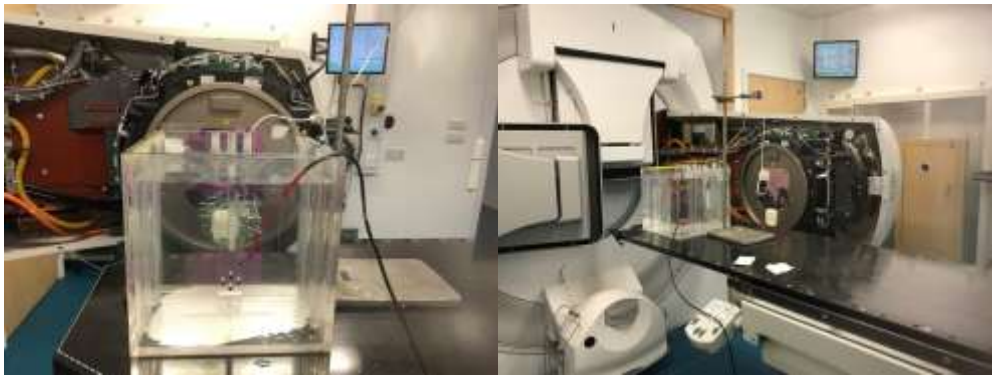
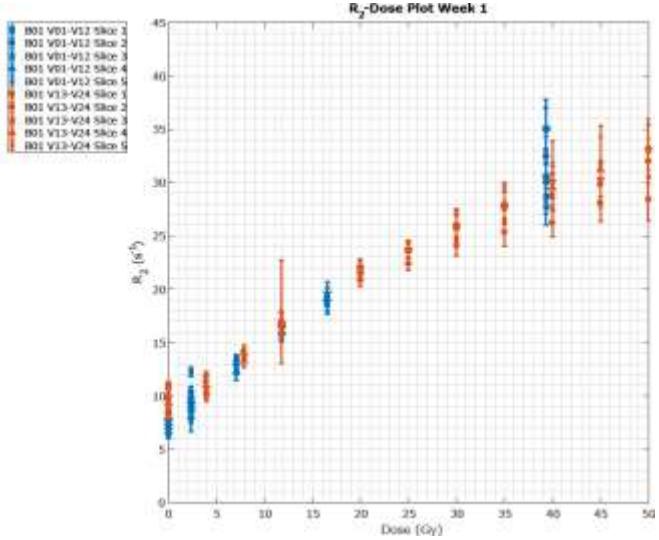
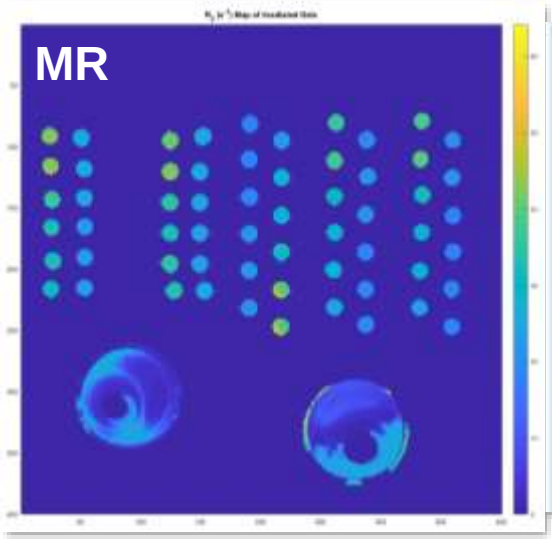
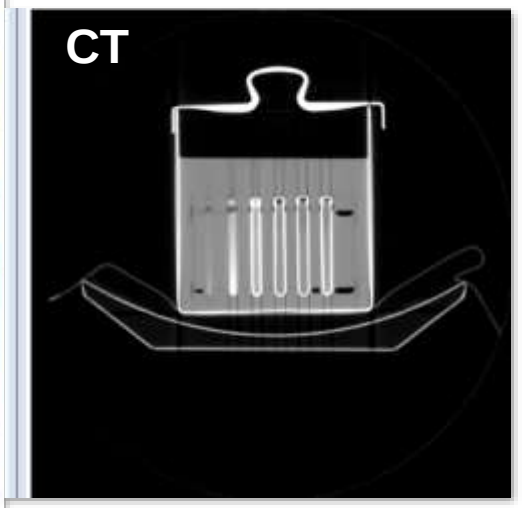
MR Sensitive Gels

Chemical	Target ppm
Ascorbic Acid	352
Copper Sulphate	20
Gelatin	80000
Hydroquinone	2000
MAA	90000
Water	827628









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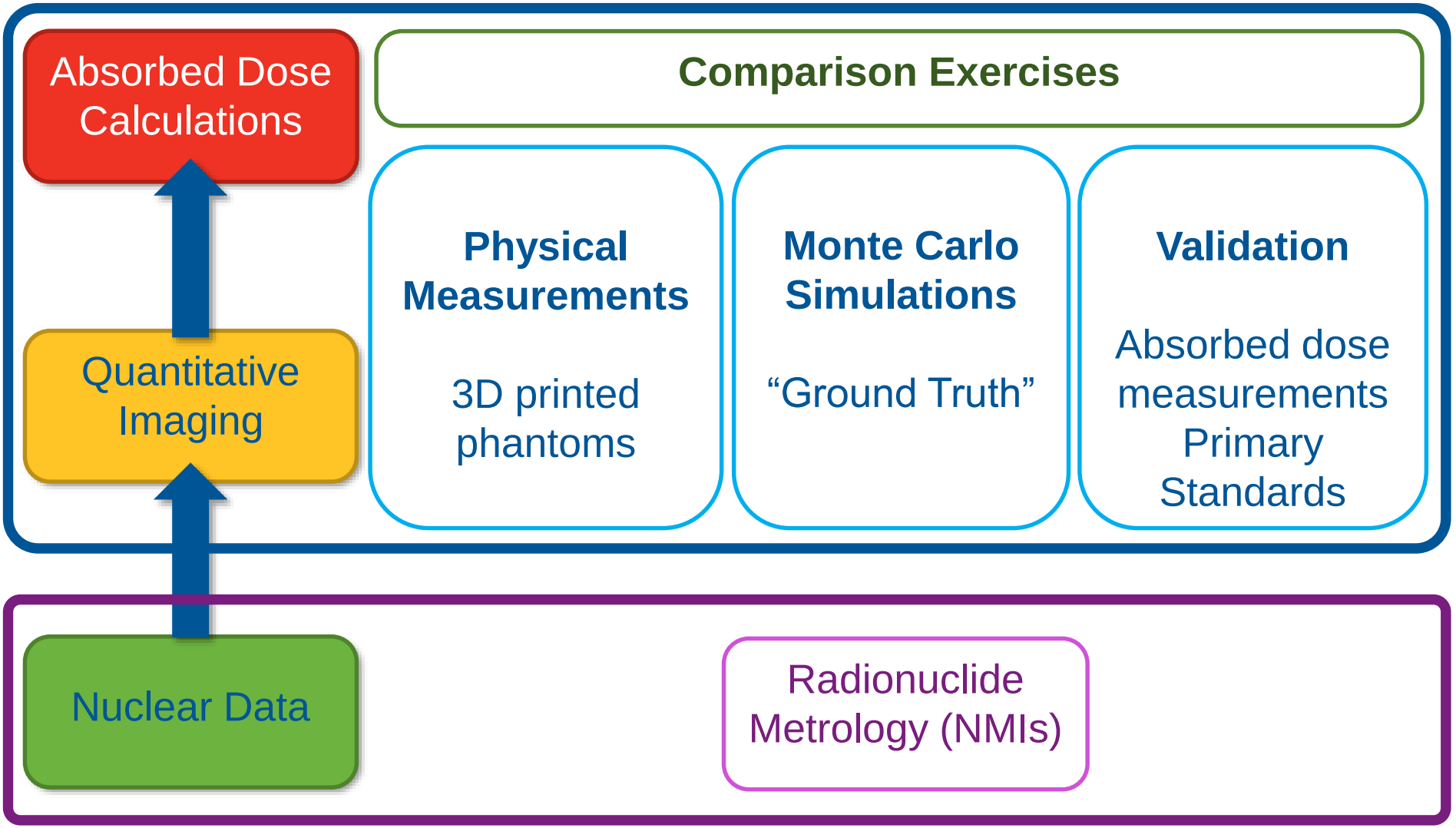

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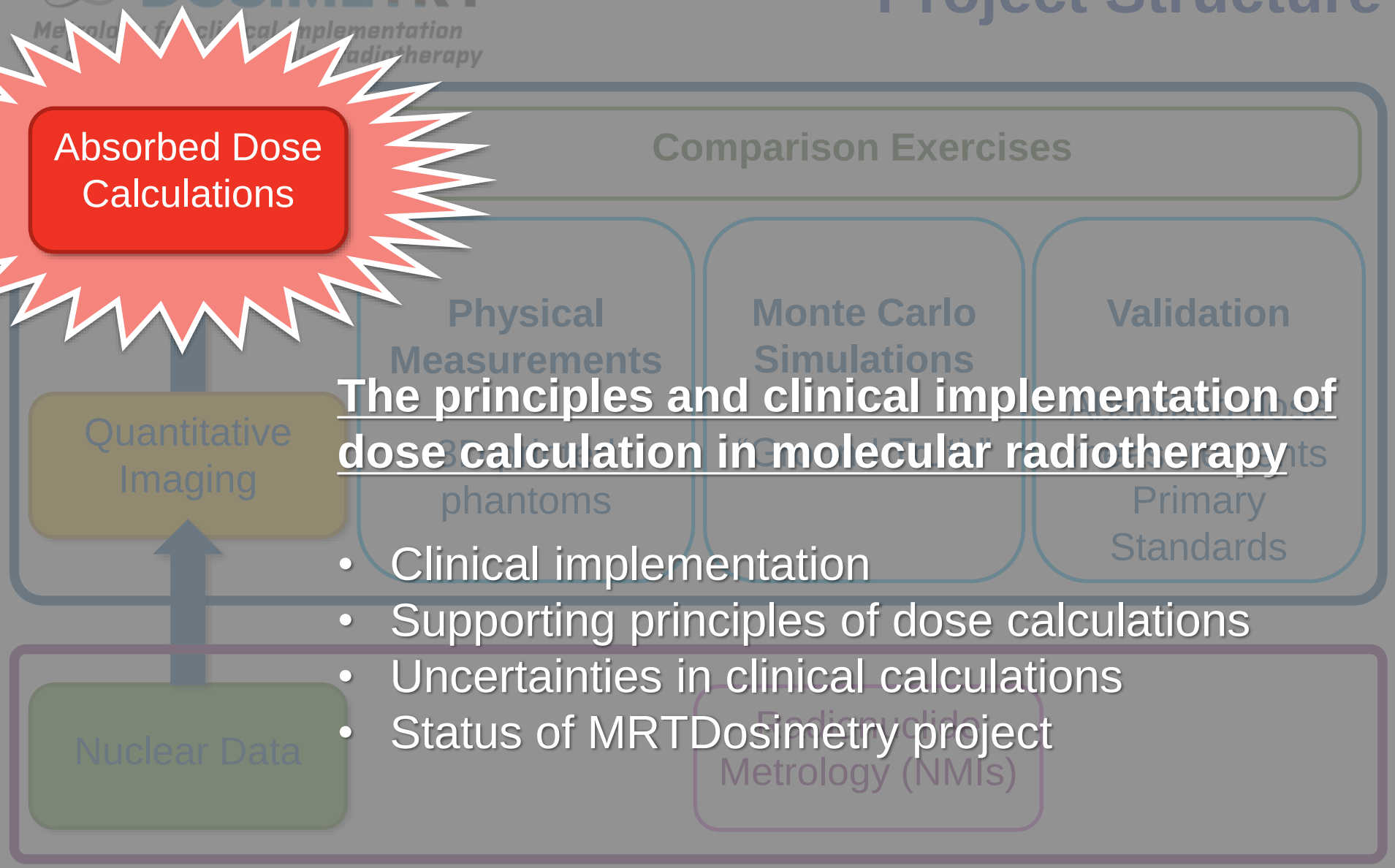

The principles and clinical implementation of dose calculation in molecular radiotherapy

- Clinical implementation
- Supporting principles of dose calculations
- Uncertainties in clinical calculations
- Status of MRTDosimetry project

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MRT DOSIMETRY
Metrology for clinical implementation of dosimetry in molecular radiotherapy

Summary

The ultimate aim of the project is to encourage and assist European MRT clinics, and those worldwide, to adopt dosimetry as a routine part of patient treatment and to bring MRT into line with other radiotherapy modalities.

The project will also support compliance with the EC Directive 2013/59/EURATOM, which states that individual dose planning for radiotherapy patients (including MRT) must be enforced in legislation by EU member states by 6th February 2018.

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