Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

The role of microdosimetry and nanodosimetry for biologically relevant radiation quantities

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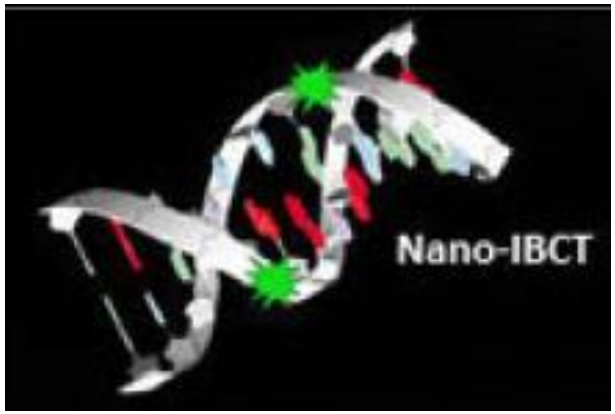
[6] *INFN-LNL, Legnaro, Italy*

[7] *Politecnico di Milano, Milan, Italy*

[8] *NCBJ, Otwock-Swierk, Poland*

[9] *IST-ITN, Sacavém, Portugal*

Sponsors of this workshop



COST Action MP1002
Nanoscale Insights into Ion Beam Cancer Therapy (NanoIBCT)

EURADOS

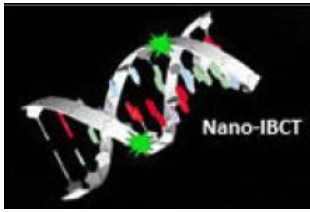
European Radiation Dosimetry Group e. V.
WG 6 Computational Dosimetry

BioQuaRT

EMRP Project Biologically Weighted Quantities in Radiotherapy

MedAustron

COST Action NanoIBCT "Nanoscale Insights into Ion Beam Cancer Therapy (2011-2014)



To study essential events of the IBCT scenario such as DNA damage and cell death on different temporal and spatial scales.

- WG1: Ion Propagation (Nuclear reactions and electromagnetic processes). Group leader - Bernd Huber (FR)
- WG2: Primary ionization in the medium (water and biological molecules), direct damage and production of secondary species. Group leader -Thomas Schlatholter (NL)
- WG3: Propagation of secondary species (secondary electrons, radicals, holes). Group leader - David Field (DK)
- WG4: Electron attack on DNA (dissociative electron attachment and direct ionization). Group leader - Franco Gianturco (IT)
- WG5: Radiobiological scale effects (DNA DSBs detection, prediction and cellular consequences). Group leader - Kevin Prise (UK)

COST Action NanoIBCT "Nanoscale Insights into Ion Beam Cancer Therapy" (2011-2014)

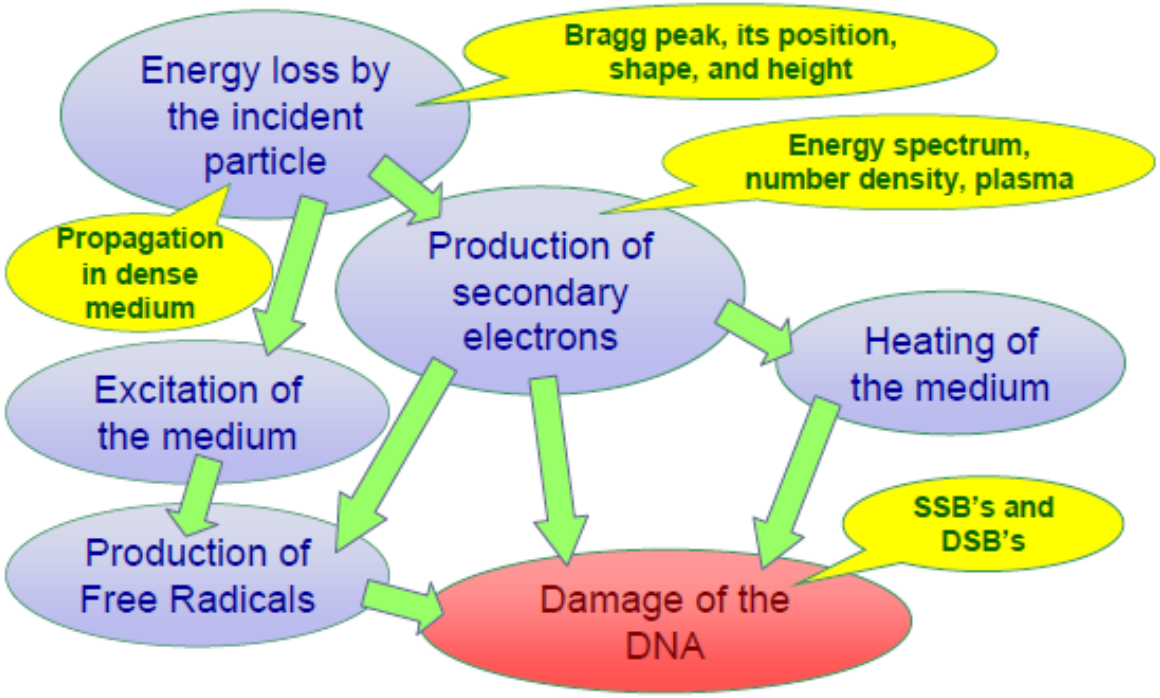


FIG. 1: Schematics of the multi-scale approach.

from: arXiv:0811.0988v1 [physics.bio-ph] 6 Nov 2008

European Radiation Dosimetry Group e. V.
WG 6 Computational Dosimetry

EURADOS

Task Grp. 2 "Computational Micro- and Nanodosimetry"

Core Group:

- Hans Rabus (PTB, Germany) [Coordinator]
- Elisabetta Gargioni (UKE, Germany) [Deputy Coordinator]
- Carmen Villagrasa (IRSN, France)
- Maria-Claude Bordage (LAPLACE, France)
- Marion Bug (PTB , Germany)
- Bernd Heide (KIT, Germany)

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WG 6 Computational Dosimetry

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Task Grp. 2 "Computational Micro- and Nanodosimetry"

1. Uncertainty exercise in modeling track structure

   Stage 1: Comparison of existing codes (ca. Jul 2014 – Feb 2016)

   Stage 2: Investigation of uncertainty contributions (2016)

   - Uncertainty resulting from uncertainties of cross sections
   - Uncertainty resulting from influence of the aggregate state

2. Fundamental issues in track structure simulations
   - classical trajectories; electron cross-sections below 1 keV
   - Objective: a pragmatic solution in track simulations.

EMRP Project "Biologically Weighted Quantities in Radiotherapy" (2012-2015)

BioQuaRT

Consortium

PTB

ENEA

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

IST itn

ne oi

NPL
National Physical Laboratory

POLITECNICO MILANO

Researcher Grants

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

MRI
Klinikum rechts der Isar
Technische Universität München

IST-ID
Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento

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

Collaborators

Microdosimetry

- University of Surrey
- METAS Federal Office of Metrology
- SCK·CEN Studiecentrum voor Kernenergie / Centre d'Etude de l'Energie Nucléaire
- UOIT Challenge Innovate Connect
- Royal Surrey County Hospital NHS Foundation Trust
- Clatterbridge Centre for Oncology NHS Foundation Trust

Nanodosimetry

- Loma Linda University (To Make Man Whole)
- Università degli Studi di Padova (MCCXXII)
- Uniwersytet Warszawski (Universitas Varsoviensis) / Środowiskowe Laboratorium Ciężkich Jonów

Indirect Effects

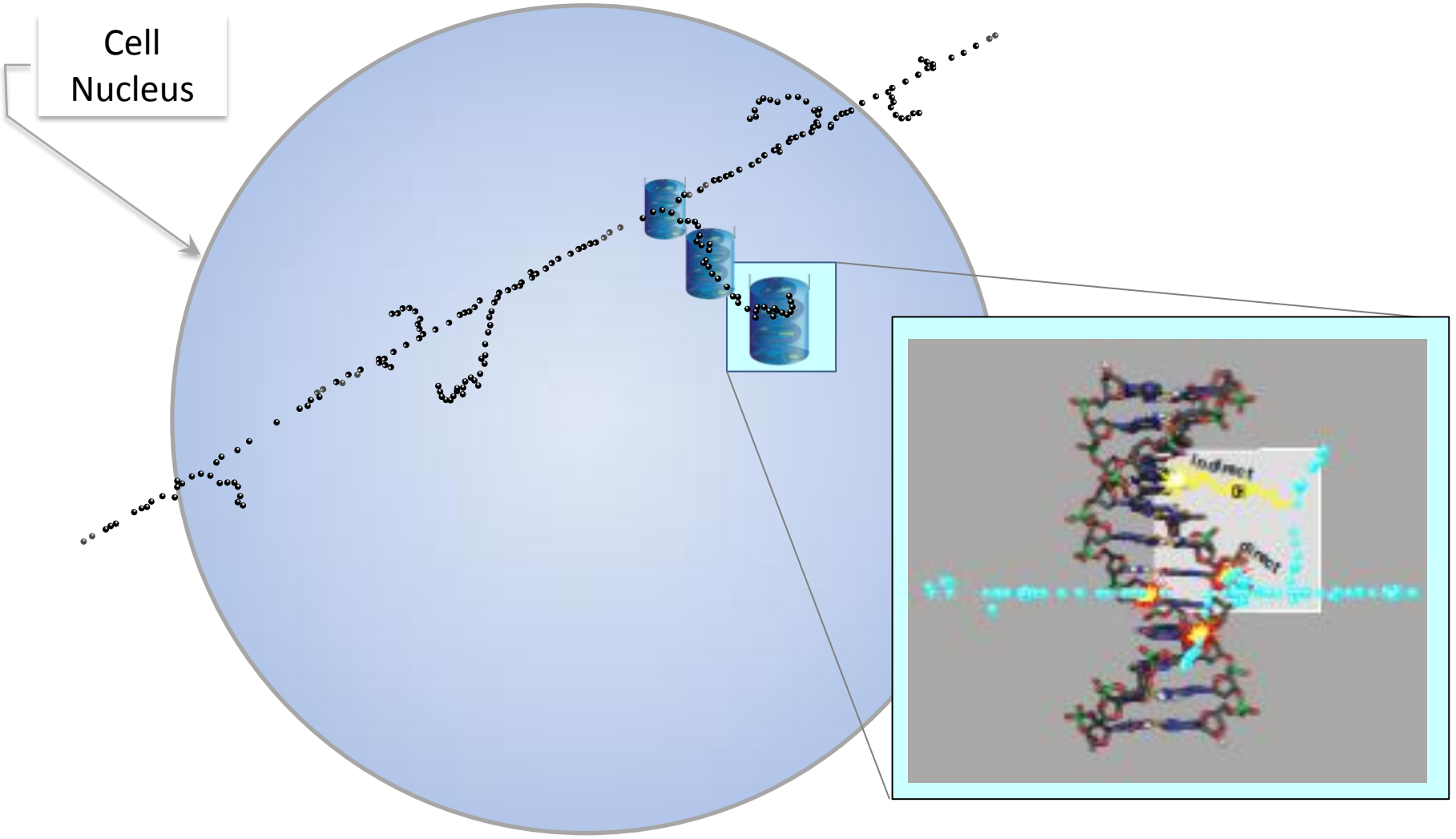
- Università degli Studi di Palermo (Panormitanæ Studiorum Universitatis Sigillum)

Multi-scale model

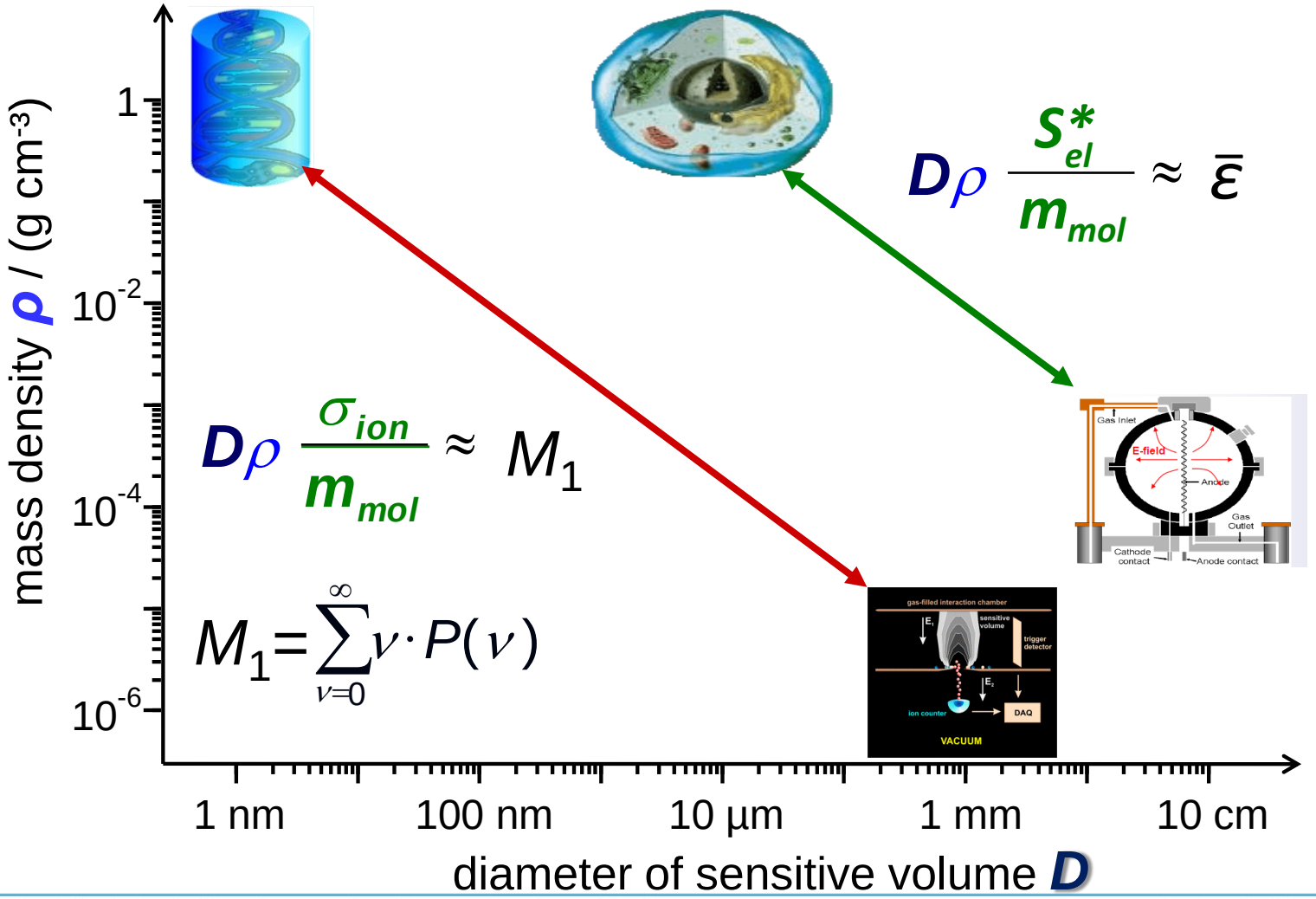
- Universität Hamburg (1919)

- HelmholtzZentrum münchen – Deutsches Forschungszentrum für Gesundheit und Umwelt
- Centre for Medical Radiation Physics
- Nuclear Physics Institute of the ASCR public research institution

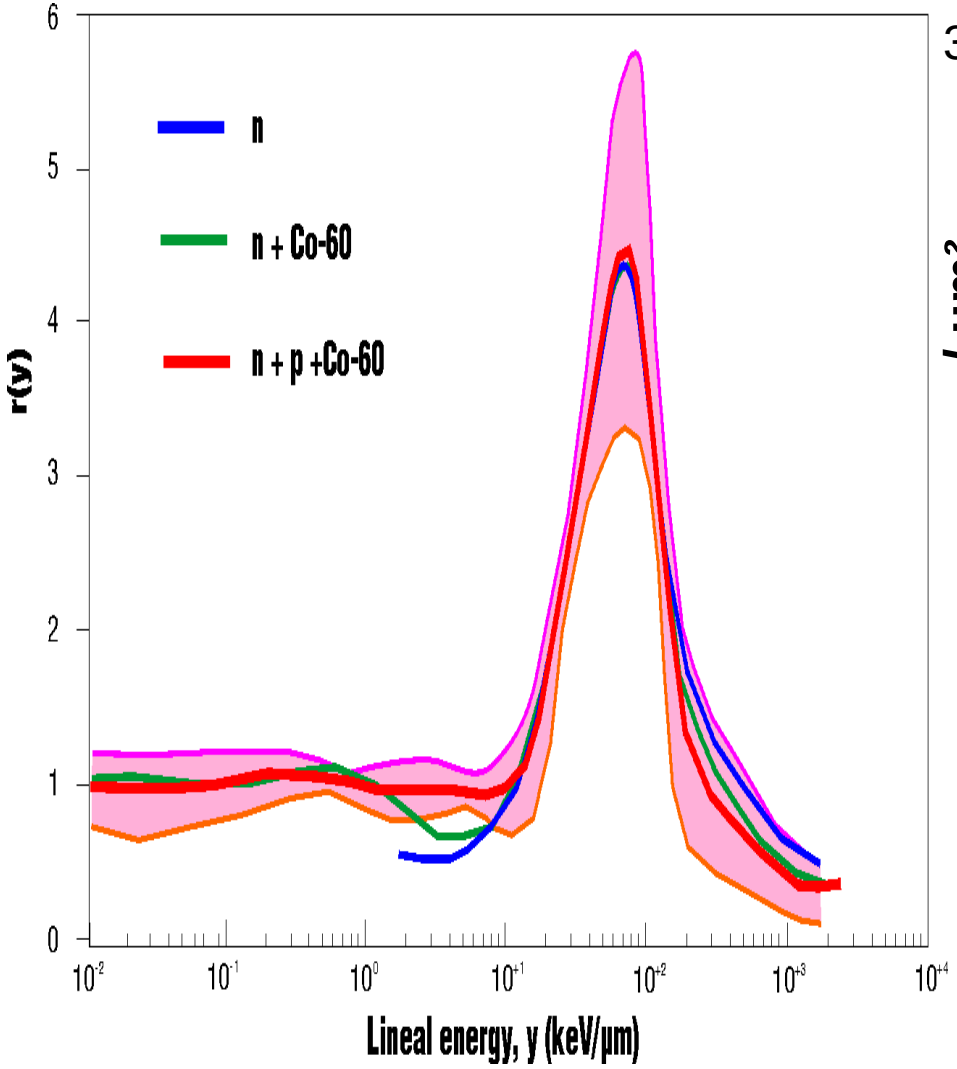
Microdosimetry, Nanodosimetry, Radiobiology

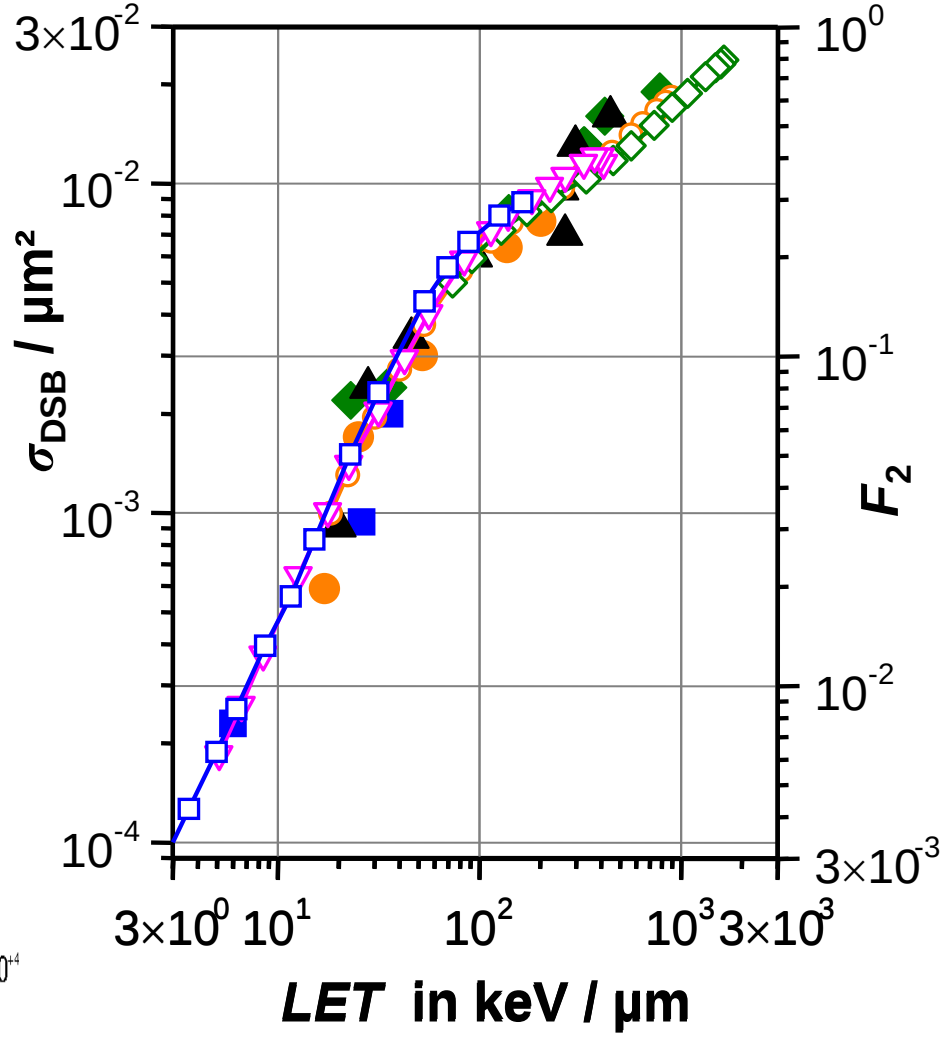


Scaling of lineal energy spectra or ionisation cluster size distributions



Micro- and nanodosimetry and radiobiology

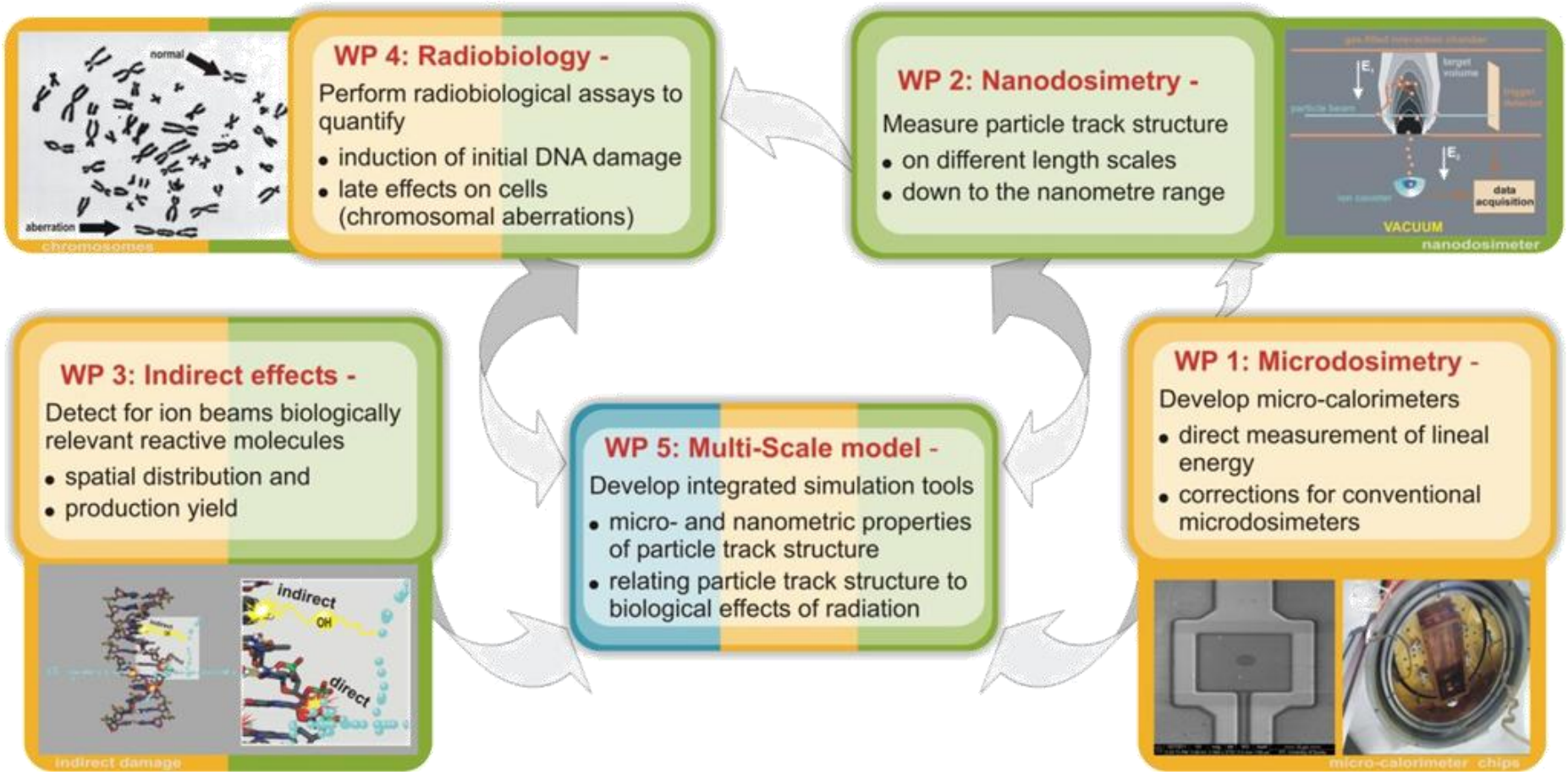




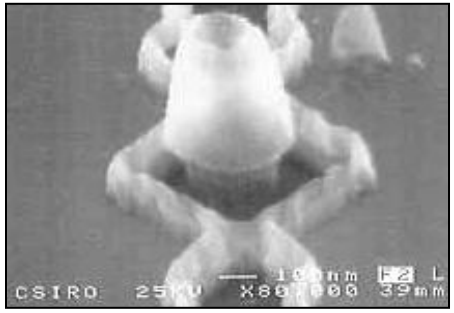
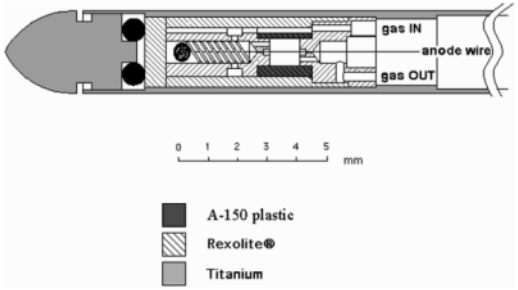
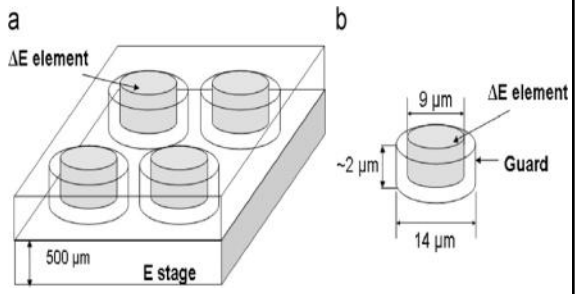
The Overarching Objectives of BioQuaRT

- Experimental techniques for characterisation of ion track structure in terms of
  - microdosimetry
  - nanodosimetry at different length scales
  - production of reactive species
- Multi-scale simulation of track structure and relating it to early and late biological effects
- Utilising track structure parameters on the macroscopic scale (e.g. treatment planning)

EMRP Project "Biologically Weighted Quantities in Radiotherapy" (2012-2015)

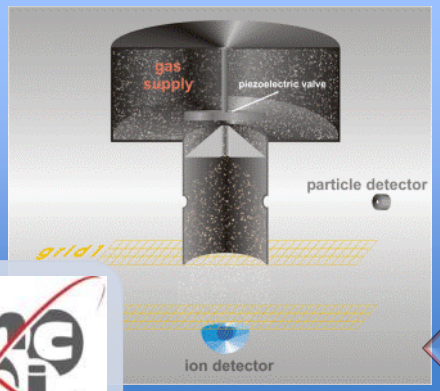


WP1: Microdosimetry

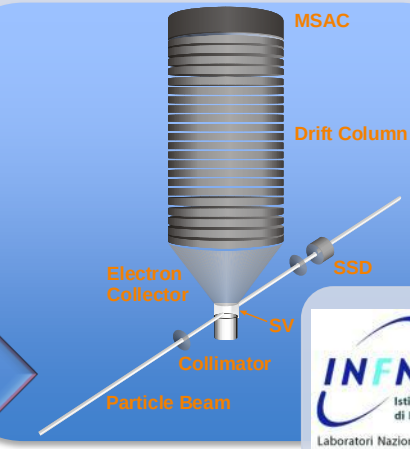
	**Microcalorimeter:** Measures energy deposition, medium is water equivalent	Cryogenic technology NPL National Physical Laboratory
	**Mini-TEPC** Sensitivity, flexible	Gas phase, measures ionisation INFN Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Legnaro
	**Si microtelescope** Condensed phase, simultaneous differential and total energy measurement	Measures ionisation, medium is non-water equivalent POLITECNICO MILANO

WP 2 Nanodosimetry

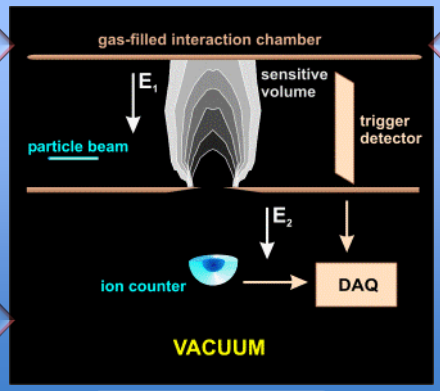
2 nm - 20 nm, d = 0



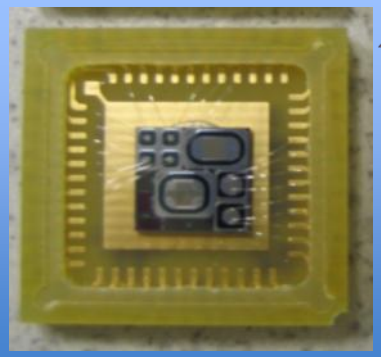
20 nm, d ≥ 0



2 nm, d ≥ 0



10 µm

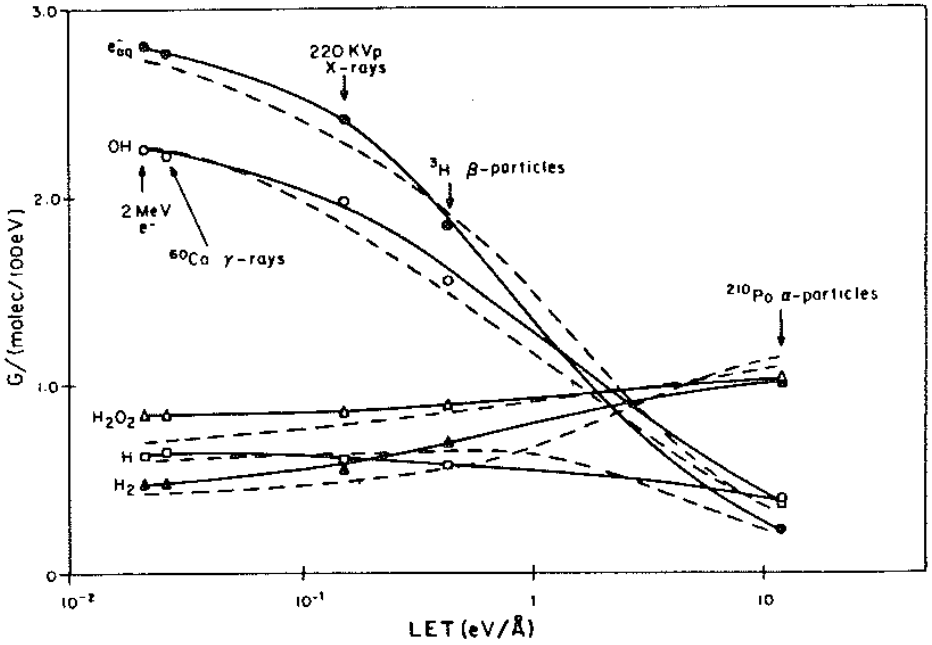


- Prototype multi-scale nanodosimeter
- DNA-equivalent target material
- Measurement of ion beams for WP4

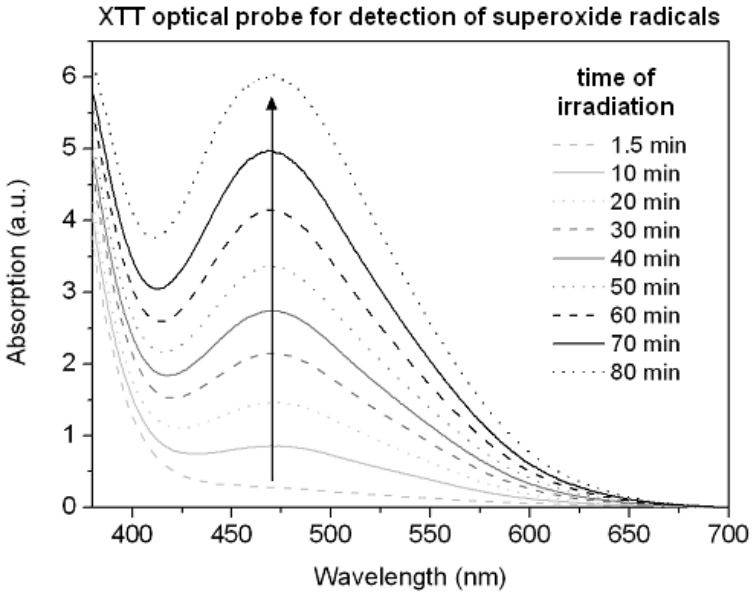
WP 3: Indirect Effects

Biologically significant reactive species in bulk solution

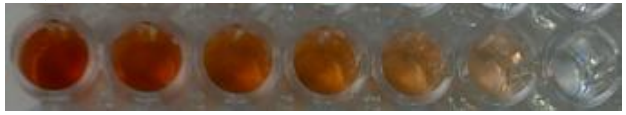
Quantification



Spatial distribution

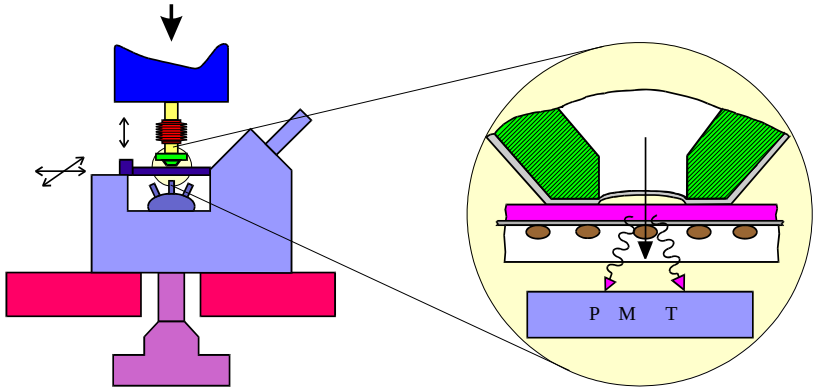


Increasing O_2^- radical concentration

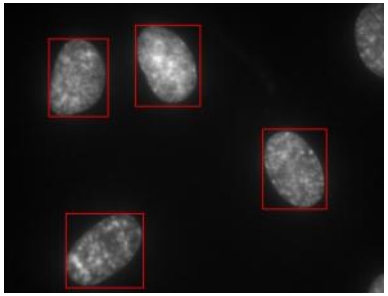


WP 4: Biology

➢ Ion microbeam cell irradiations

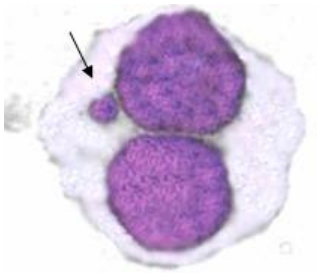


➢ γ-H2AX *foci*

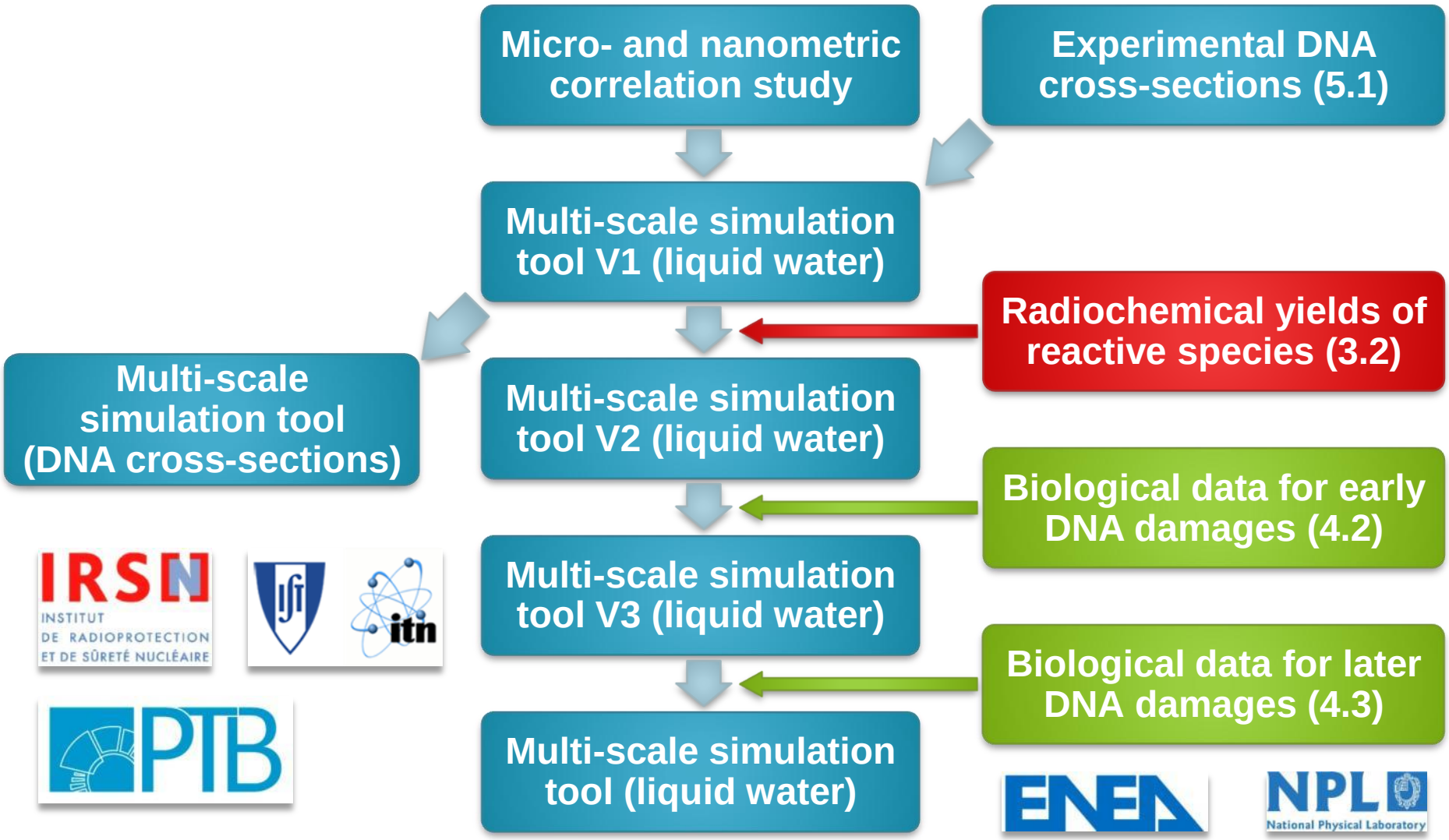


➢ dicentric chromosomes

➢ micronuclei



WP5: Multi-scale modelling



Issues addressed by BioQuaRT

- Relevance of condensed-phase effects?
- Relevant target size? (DNA segment, histone, cell nucleus)
- DNA cross sections & multi-scale approach
- Models for relation between track structure and biological effects
- How to utilise track structure parameters on the macroscopic scale (e.g. TP)?

Thank you for your attention!

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