Radiosensitivity of children - Health issues after radiation exposure at young age

Round table discussion:

Dosimetry challenges of radiation dose estimation – unwanted doses

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Challenges in medical dosimetry for early-age irradiation:

Develop robust, widely applicable techniques for organ dose estimation in diagnostic imaging and radiotherapy

Diagnostic imaging:

- Generally "low" dose (Effective Doses, 0.1 – 10 mSv)*
- No detailed absorbed dose distributions for individual patients
- Surrogate dose quantities (kerma-area product, CTDI, DLP……) + conversion factors
- Organ dosimetry based on phantom measurements and Monte Carlo simulation

Radiotherapy

- Target dosimetry well-established
- Out-of-field dosimetry less so
- Wide range of doses (10 mGy – 10s of Gy)

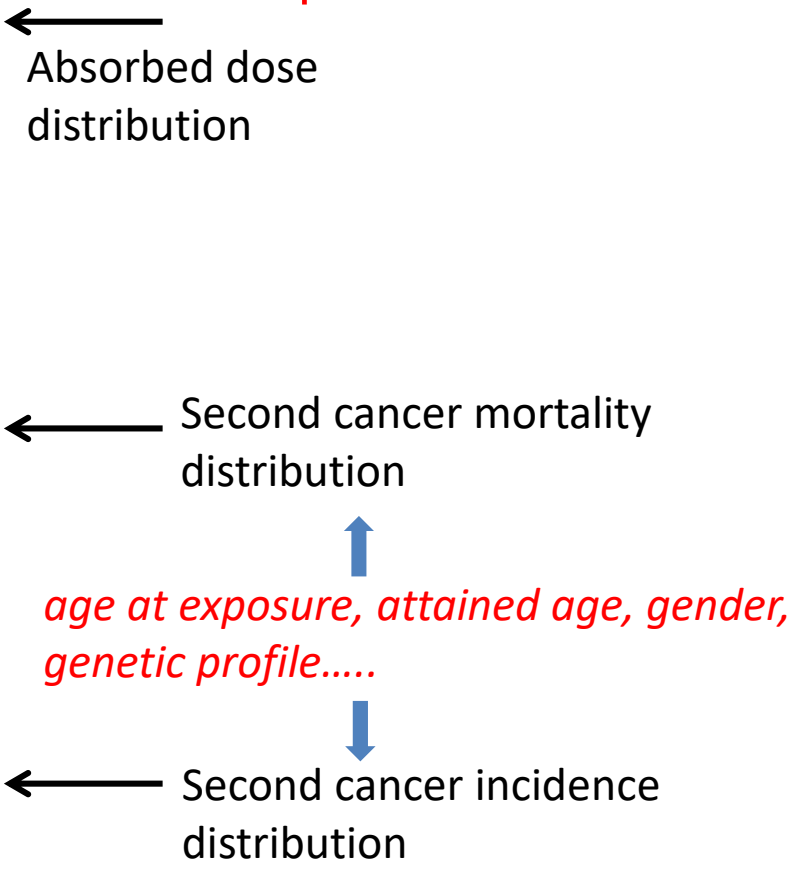
** but cumulative Effective Doses may > 100mSv, with some organs > 100 mGy*

Craniospinal irradiation for medulloblastoma using passively scattered proton beams

For images of the medulloblastoma treatment, please see the reference below*

The absorbed dose image shows the treatment volume where the dose may be calculated with confidence and the out-of-field volume where dose calculation and measurement techniques are generally less well developed than shown in this example.

These images show that it is possible to generate cancer incidence and mortality images if the appropriate risk factors are known.



*Nature Reviews Cancer *Wayne D. Newhauser and Marco Durante* Assessing the risk of second malignancies after modern radiotherapy June 2011 vol. 11 438-448.

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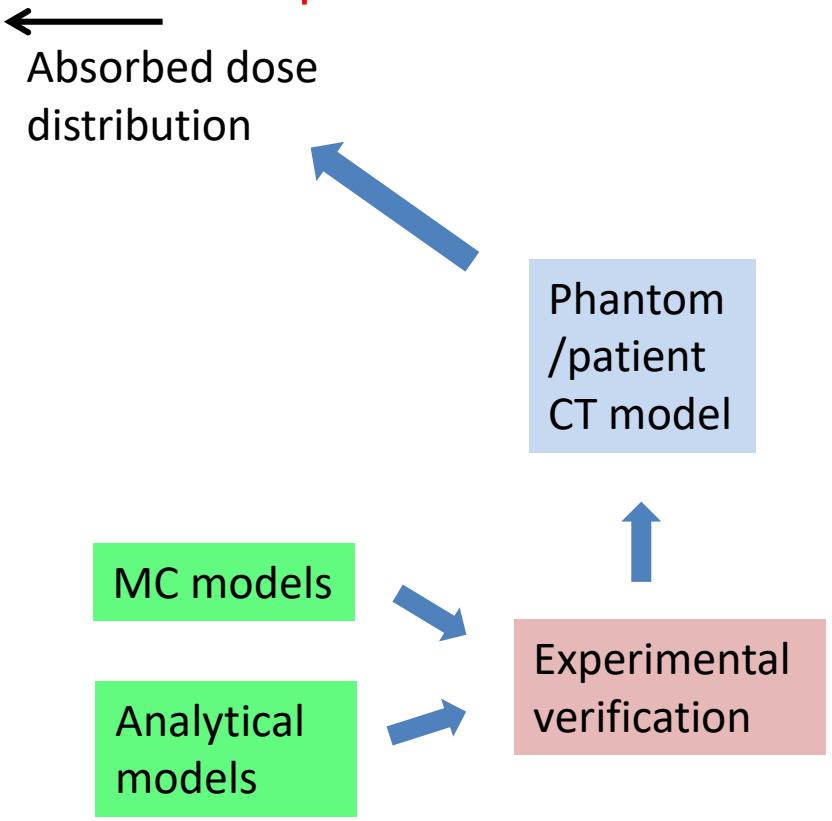

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Radiotherapy + imaging dose

- X-ray linacs
- Robotic arm systems
- Proton & ion beams
- Gammaknife
- Brachytherapy
- Targeted molecular radiotherapy

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etc.

- On-board kV & MV imaging
- CT
- PET
- SPECT
- Radiography

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etc.

Many combinations of imaging and treatment modalities are possible

European Radiation Dosimetry Group: EURADOS

- 80 Voting Members (institutions) represented by designated individuals
- 600 scientists

Dosimetry developments in:

- *Harmonisation of individual monitoring (WG2)*
- *Environmental dosimetry (WG3)*
- *Computational dosimetry (WG6)*
- *Internal dosimetry (WG7)*
- *Dosimetry in radiotherapy (WG9)*
- *Retrospective dosimetry (WG10)*
- *High energy radiation fields (WG11)*
- *Dosimetry in medical imaging (WG12)*

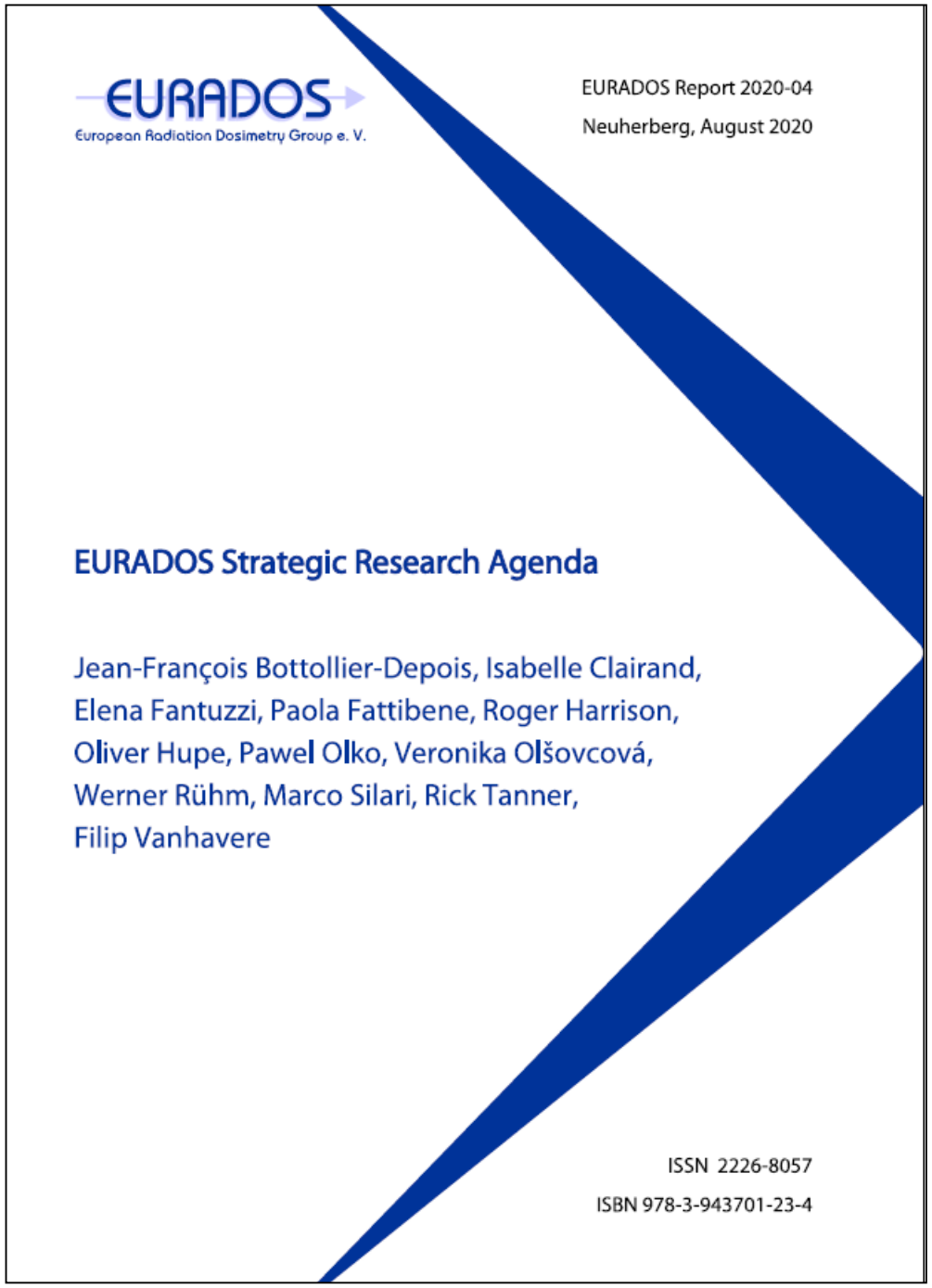
Future research needs in radiation dosimetry

Dosimetry in radiotherapy (WG9)

- *Dosimetry for proton and ion beam radiotherapy*
  - high dose rate scanning beams and ultra-high dose rates in FLASH therapy
  - Dosimetry in spot-scanning arc therapy (SPArc)
  - mixed field dosimetry (neutrons, protons, photons)

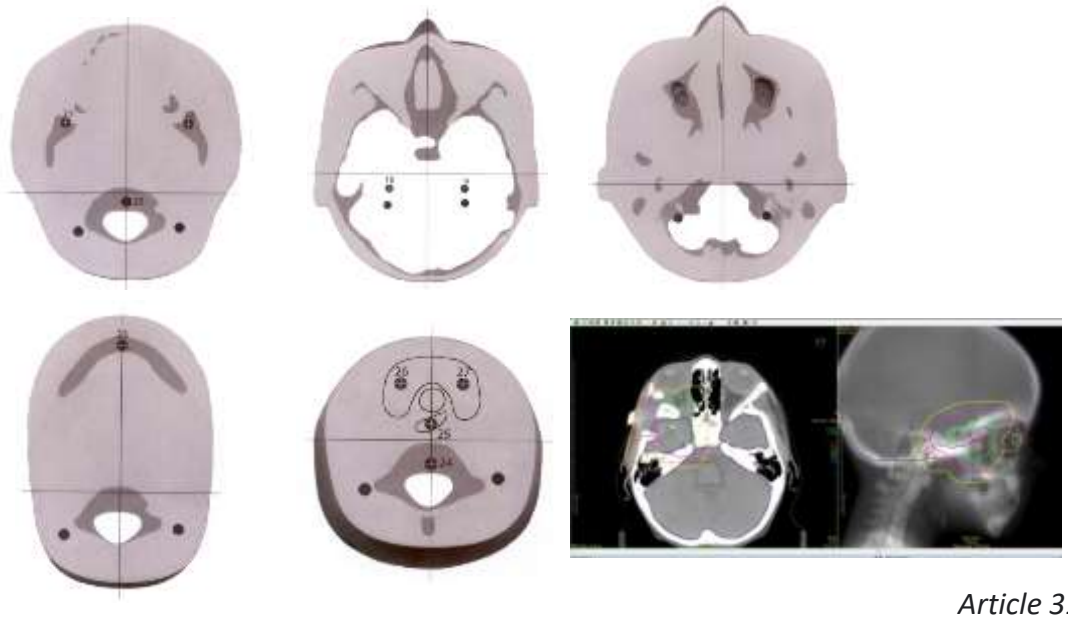
- *links between nano-, micro-, and macro-dosimetry and radiobiology*

- *The total dose to the radiotherapy patient*



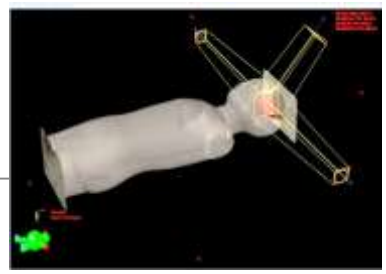
Measuring out-of-field doses from a paediatric brain tumour treatment (photons)

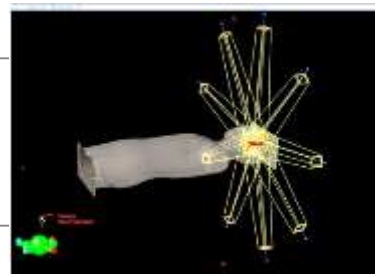
Institute of Nuclear Physics (IFJ) and Centre of Oncology, Krakow
Ruđer Bošković Institute, Clinical Hospital for Tumours & Clinical Hospital Centre, Zagreb



anthropomorphic phantoms

Paediatric brain tumour treatment (photons) [For full results, see reference below]



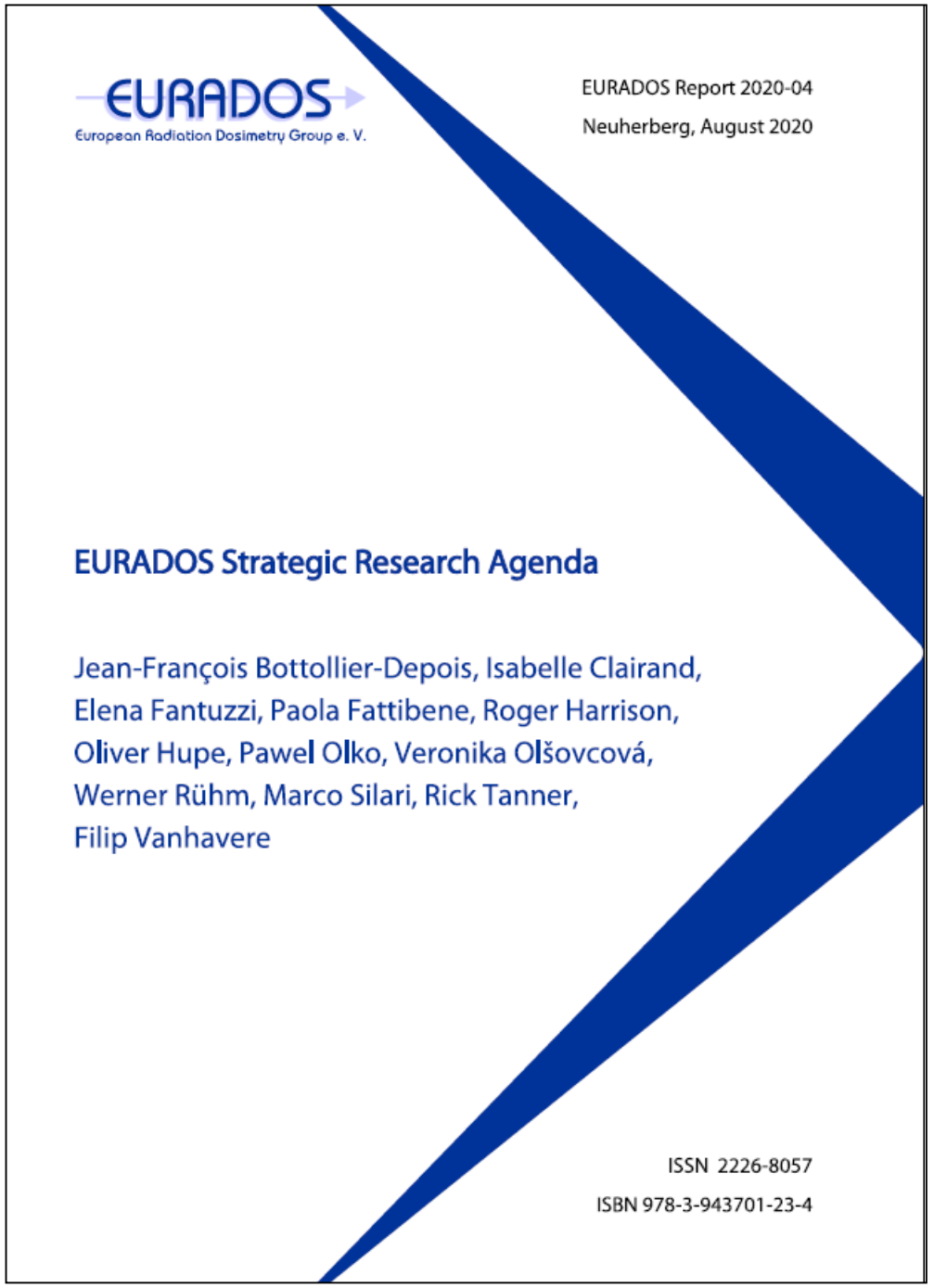


Further information: Majer et al. 2017 Out-of-field dose measurements for 3D conformal and intensity modulated radiotherapy of a paediatric brain tumour Rad. Prot. Dos. 176:3 331-340

Future research needs in radiation dosimetry

Dosimetry in medical imaging (WG12)

- Skin and organ doses in interventional radiology and cardiology
- Patient-specific dose estimates in CT imaging



Goal

Better understand the long-term health effects of medical exposure to ionising radiation in children:

- Cancer patients treated with modern radiotherapy modalities
- Cardiac patients treated with X-ray guided imaging procedures

Harmonic
Health effects of cardiac fluoroscopy and modern radiotherapy in paediatrics

EURATOM Research and Training Programme 2014-2018 under Grant Agreement No 847707

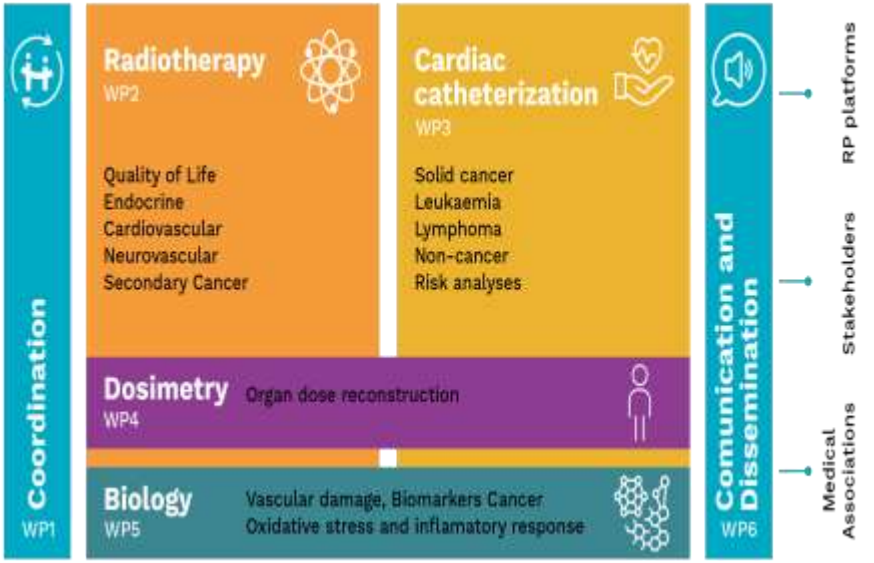
https://harmonicproject.eu

ISGlobal
Barcelona Institute for Global Health

How

Build European cohorts and registries of paediatric patients to investigate / establish:

- Late health effects of ionising radiation in children
- Cancer and non-cancer outcomes
- Tools for long-term follow-up of children exposed
- Radiation doses to specific organs
- Possible biological mechanisms
- Recommendations to optimise techniques and reduce radiation doses



Summary:

Dosimetry challenges, especially in early-age radiotherapy and radiodiagnosis

- Individualized dosimetry in medicine (therapy and diagnosis)
- Proton and ion beams – challenging dosimetry in mixed fields
- Combined doses: for the complete dosimetric picture and input to epidemiology studies
- Big growth in computational dosimetry, simulation and modelling - but experimental verification needed
- Inter-institutional & international collaboration needed for R&I and harmonisation