Hadron Beam Dosimetry Perspectives

Christoph Bert
University Clinic Erlangen and GSI, Darmstadt

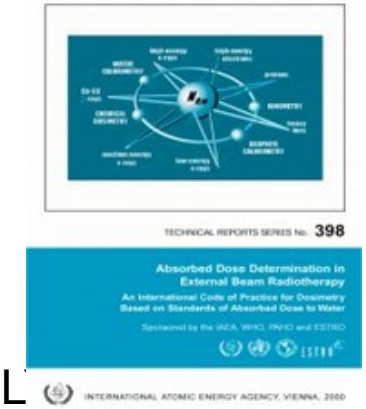
PSDLs and SSDLs

Primary standard for absorbed dose to water

- Calorimeter
  - Graphite or water

- Chemical using Fricke solution
  - (1mM FeSO4 or Fe(NH4)2(SO4)2 + 0.8N H2SO4 air saturated + 1mM NaCl) Fe2+ oxydizes to Fe3+, which absorbes at 304 nm
  - Used e.g. at the German PSDL (PTB Braunschweig)

$$D_{w,Q} = M_Q N_{D,w,Q_o} k_{Q,Q_o}$$



Radiation qualtiy at calibration: Q_0 - ALL PHOTONS ONL

AARHUS PARTICLE THERAPY GROUP

Calorimetry – Current Challenges

- All correction factors are not fully characterized in ion beams.
(chemical and physical heat defect, gap corrections, impurity corrections, heat transfer corrections,...)

Reasons:

- Time consuming experiments
- Where clinical beams are available, extended blocks of beam time are difficult to get.

(Hugo Palmans, NPL, private communication yesterday)

AARHUS PARTICLE THERAPY GROUP

European initiative for primary standards

- Beam time demands which could be provided by CERN facility
- Collaboration / satellite / outpost for Primary Standards Labs
  - contact to EC project BioQuaRT
- Development / maintenance of own calorimeter / Fricke dosimetry system
- Beam time for stopping power measurements
  $\Rightarrow$ I-value definition for compounds

LET / Z dependence of detector systems

- Wish/need for (3D) LET-dependent detector (LET-o-meter)
- Detector signal depends on radiation quality very similar to biological systems
- Solid state detectors needed for various applications (e.g., high spatial resolution for homogeneity measurements)
- Modelling required for prediction of detector

$$\eta_{Q_0,Q} = \left.\frac{D_{Q_0}}{D_Q}\right|_{\mathrm{iso-effect}} \qquad \mathrm{RBE} = \left.\frac{D_{Q_0}}{D_Q}\right|_{\mathrm{iso-effect}}$$

Models for R B/D E

- Relative Biological / Detector Effectiveness can be nearly modeled by a single code
  - improved understanding
  - differentiation of biology / physics
- Integration of modelling / treatment planning
  - not necessarily a CERN-based topic but
  - integration of existing groups essential
- One of the main uncertainties in RBE-weighted dose
- Biological dosimeters, i.e. cell/tissue/animal experiments required
  - trained staff +
  - dedicated facilities needed

Dosimetry for patient specific QA

- Very close links to
  - *in-beam monitoring and imaging* session
  - treatment planning
  - *dose delivery* session
- Needs to integrate phantom developments
- Potentially more workflow than detector development

Interaction of 8 topics

- 9th challenge will be interaction / communication / design of complete system
- Software development / data exchange is essential
  - time consuming + complex
  - played crucial role in previous installations
- Open platforms / communication standards (DICOM RT ION, ...)

Modularity

- Not rescanning *or* tracking but module for rescannning *and* module for tracking
- Potential to explore unknown combinations, e.g. new in-beam imaging option with dedicated treatment planning modules resulting in improved dosimetry

Collaboration

- Close integration of existing groups
- Beam time offer to (new) groups based on proposals that are evaluated by an expert committee
- Need for CERN-based bio-medical research group?