INVESTIGATION OF RADIATION EXPOSURE OF MEDICAL STAFF: MEASUREMENTS SUPPORTED BY SIMULATIONS WITH AN ARTICULATED HANDPHANTOM

Ch. Blunck and F. Becker
Beta radiator handling scenarios

Possibility of large local skin doses

Uncertainties in dosimetry

Preparation and injection of Y-90

Dose distribution at the hands

- Analyzing operation procedures in respect of radiation protection
  - Safest way of operation and adequate shielding measures
- Numerical simulation of radiation scenarios with MCNPX
  - Determination of dose(rate) distribution and visualization

ORAMED-Workshop Barcelona 20.-22. January 2011
Examples of investigated radiation scenarios

- Normalized doserate above $^{90}$Y transport vial
- Less $^{90}$Y activity in vial $\rightarrow$ higher dose rate
- Simulation shows: Local distribution of small amounts of activity often has more effects than activity in the bottle

![Graph showing dose rate vs. distance from the center](image)
Examples of investigated radiation scenarios

- Measurement with a hand phantom from the regional office for personal dosimetry and radiation protection education in Mecklenburg-Vorpommern
- Small amounts of activity in the needle provides the main dose component

Diploma thesis: Stephanie Trappen
Modelling of simulation scenario
Mathematical hand model

Demands:
- Adaptable anatomy and flexible hand pose
- Rigid and flexible elements

Functionality of the hand model

Visualization of the hand model
Modelling of simulation scenario

Real scenario

Hand model

Source model

3-D Informations

Modelling

Matching
3D-Informations

- Calibrated Camerasystem
- Tracking of marked points at the hand
- Triangulation for 3D-Coordinates

Triangulation with 2 Cameras
Modelling of simulation scenario

Real scenario

Hand model

Source model

3-D Informations

Matching

Modelling
Hand pose reconstruction

Initial pose

M1 - M8 : Marker coordinates of initial pose
Hand pose reconstruction

- New hand pose

M1′ - M8 ′: Marker coordinates of goal pose
Hand pose reconstruction

Translation of hand

M1' - M8' : Marker coordinates of goal pose
Hand pose reconstruction

- Rotation of hand

M1′ - M8′: Marker coordinates of goal pose
Hand pose reconstruction

- Spreading of fingers and the thumb

\[ M1' - M8' : \text{Marker coordinates of goal pose} \]
Hand pose reconstruction

Bending of fingers and the thumb

M1' - M8': Marker coordinates of goal pose
Example of modelled operation procedure

- Re-enacted typical operation procedure
- In this case 60 moments were simulated
  - Simulation of few particles for visualization
- Method still in optimisation process
  - not yet tested with measurements
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*Energy deposition visualized with ParaView (left) and modeled scenario visualized with Sabrina (right)*
Measurement vs. Simulation

Dose [mSv]

- Wrist: 2
- Thumb: 28
- Base of little finger: 7
- Ringfingertip: 19
- Base of middlefinger: 69
- Base of forefinger: 79
- Forefingertip: 15

Measurement vs. Simulation
Simulation of Sr-90 Irradiation

- Measurement from the ORAMED Project
- Import of ORAMED voxelphantom
  - Voxel2MCNP (Lars Hegenbart (KIT))
- Modelling of hand model based on images from the measurement scenario and the imported voxelphantom

Picture from the ORAMED validation report
Summery and further investigations

- Small amounts of poor or unshielded activities lead to radiation fields of high local dose rates
- Simulations can help in analysing work sequences
  - Minimizing of doses
  - Optimized SOP
- Promising simulation of modelled radiation scenarios
- Different dose values between measurement and simulation mainly due to geometrical disparities
- Investigations with the hand phantom will follow
  - Further optimization
  - Reduction of calculation time
  - Validations
Thank You!