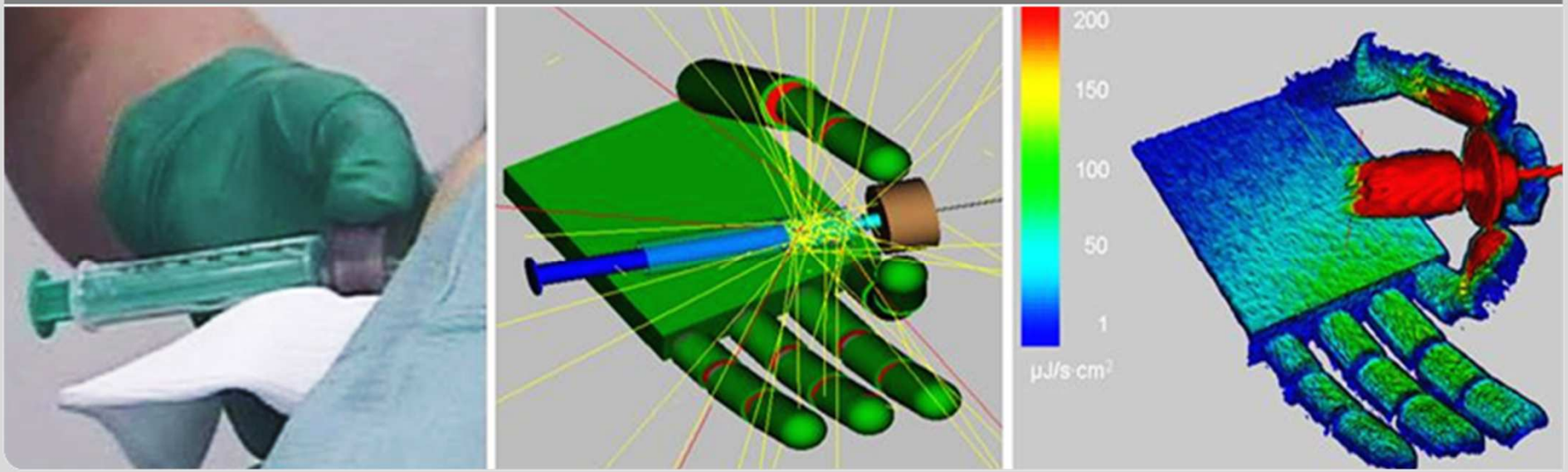
Karlsruhe Institute of Technology

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

Ch. Blunck and F. Becker

Institute for Nuclear Waste Disposal



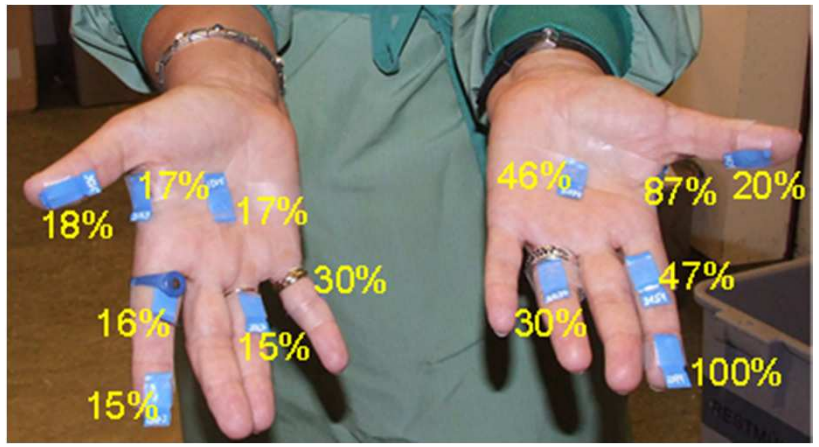
KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

Beta radiator handling scenarios

Possibility of large local skin doses

Preparation and injection of Y-90

Uncertainties in dosimetry

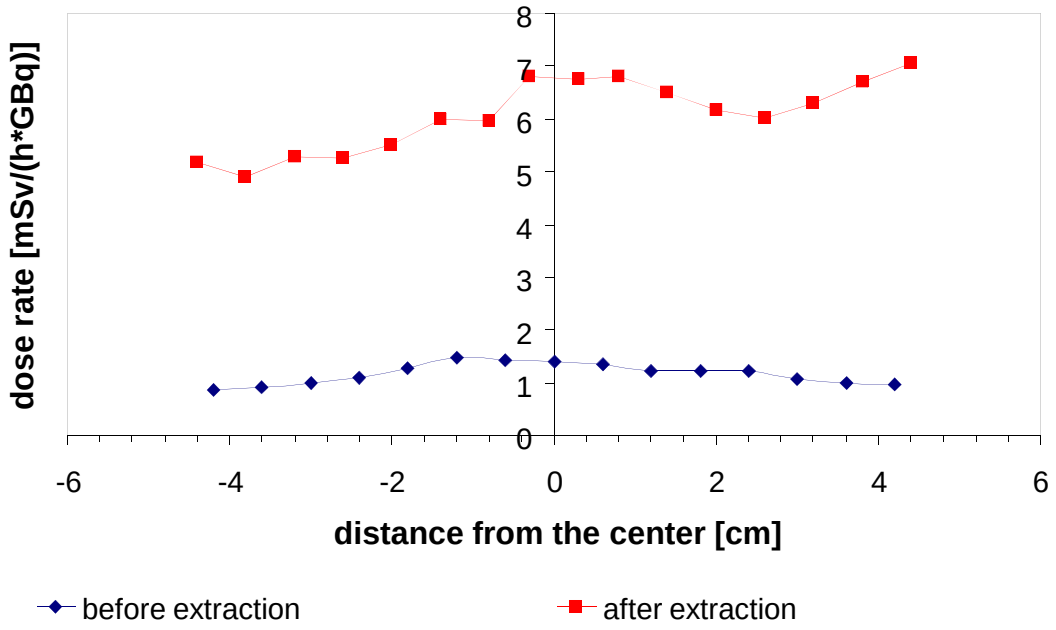


Dose distribution at the hands

- **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**

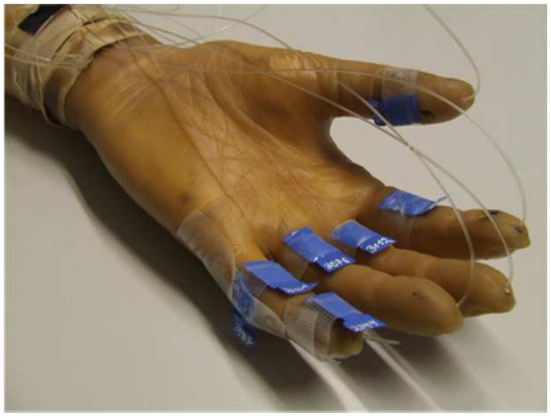
Examples of investigated radiation scenarios

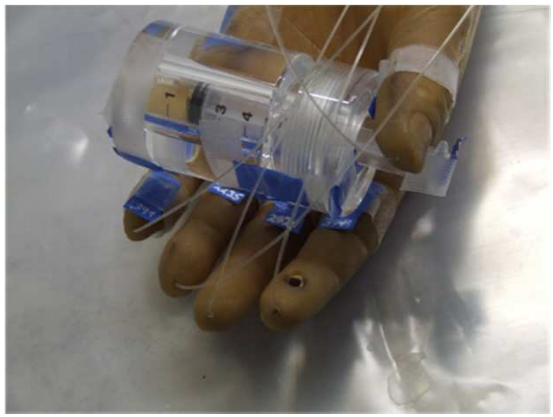
- Normalized doserate above ^{90}Y transport vial
- Less ^{90}Y activity in vial → higher dose rate
- Simulation shows: Local distribution of small amounts of activity often has more effects than activity in the bottle

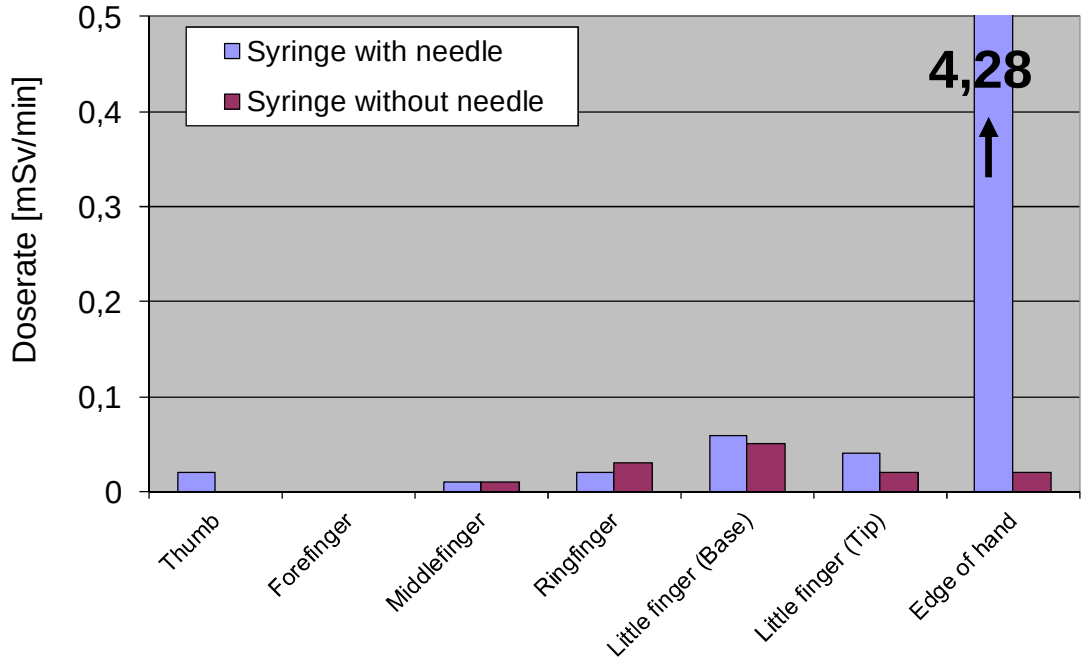


Examples of investigated radiation scenarios

- 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

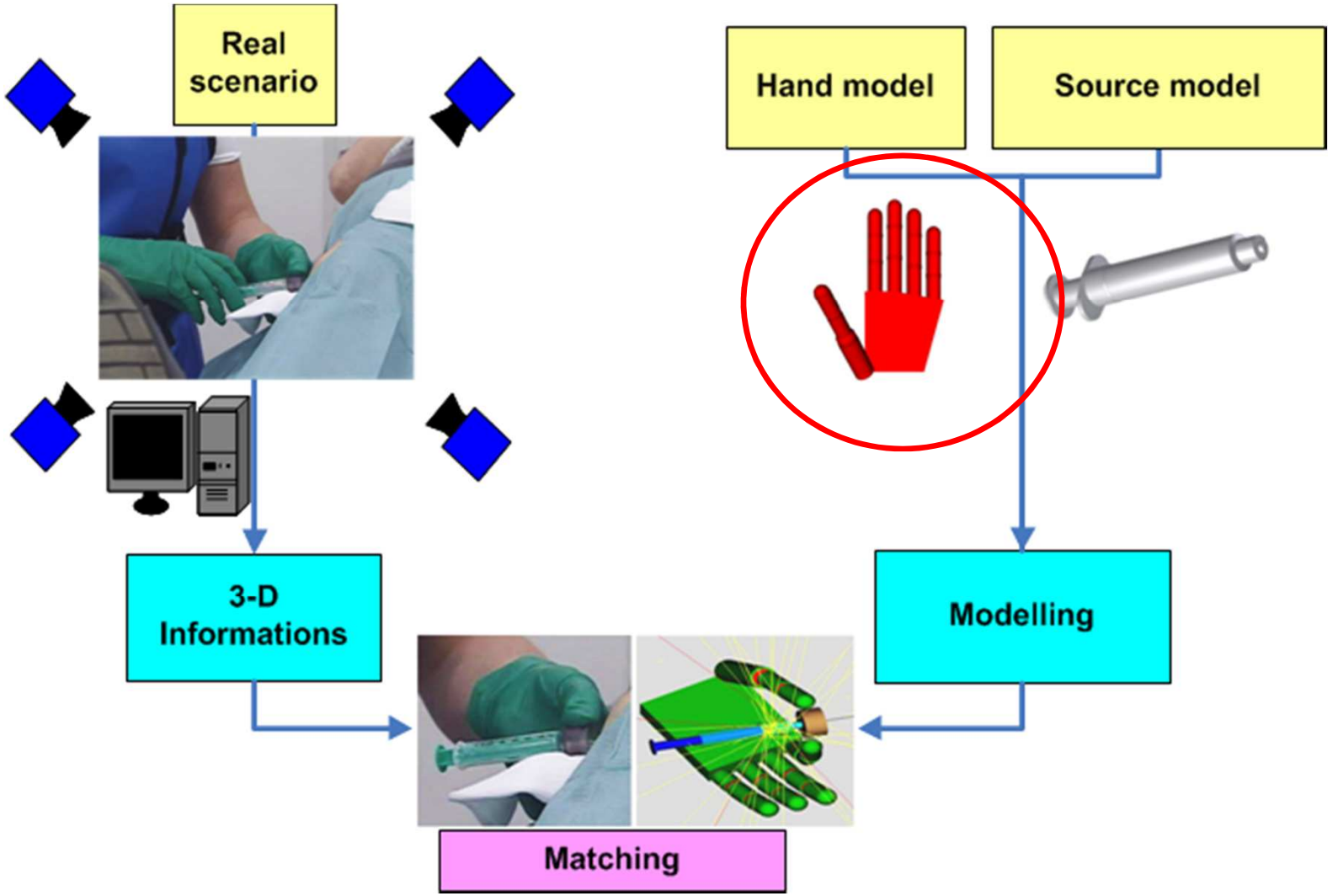






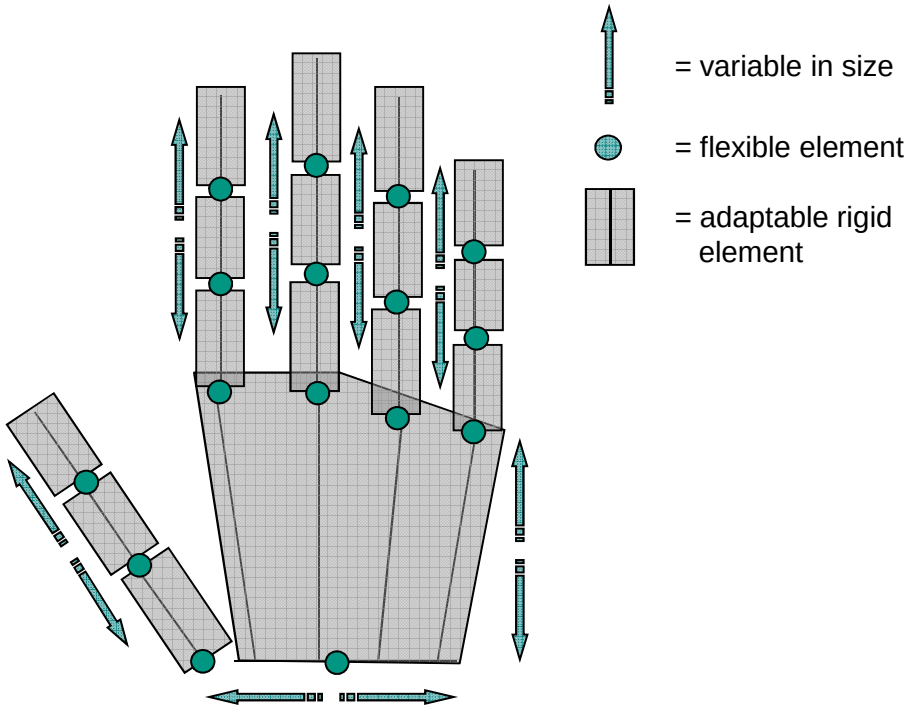
Diploma thesis: Stephanie Trappen

Modelling of simulation scenario

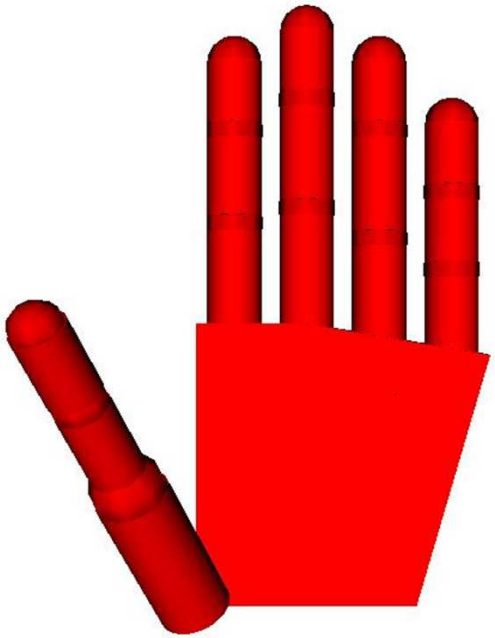


Mathematical hand model

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

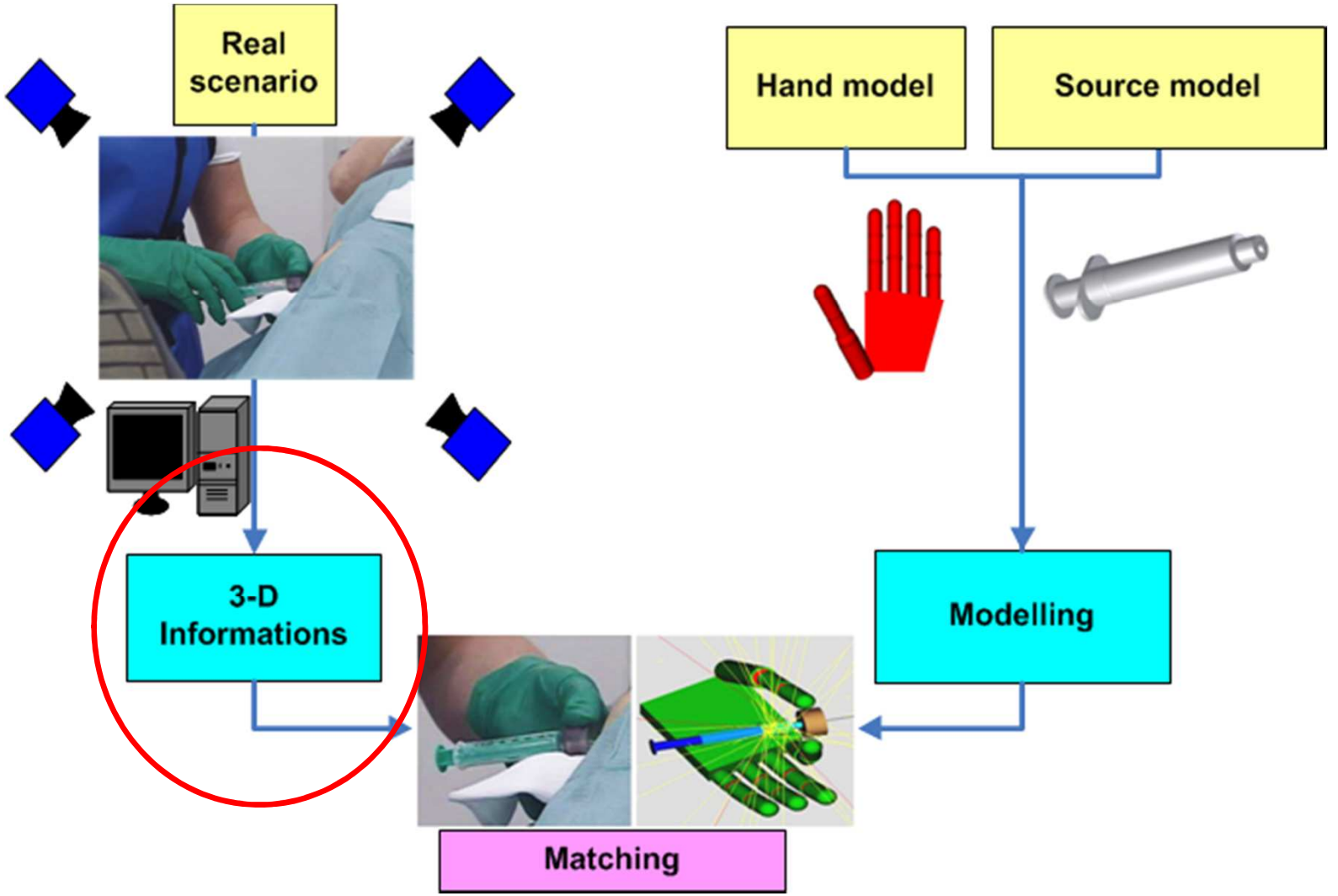


Functionality of the hand model



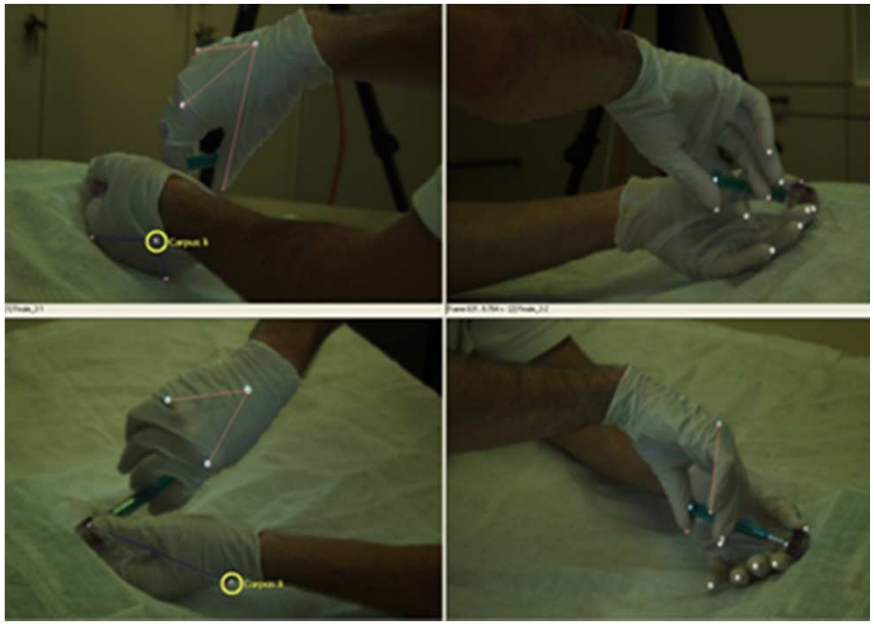
Visualization of the hand model

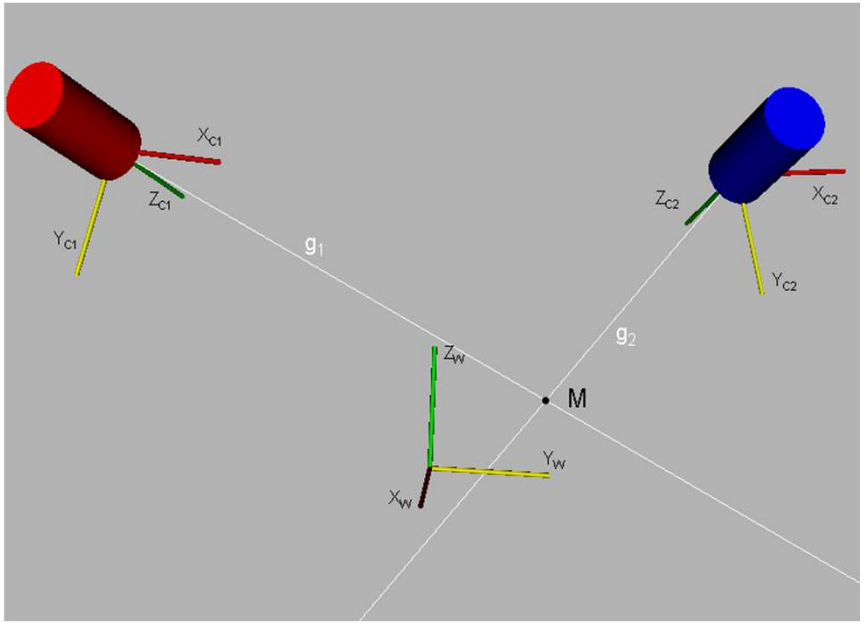
Modelling of simulation scenario



3D-Informations

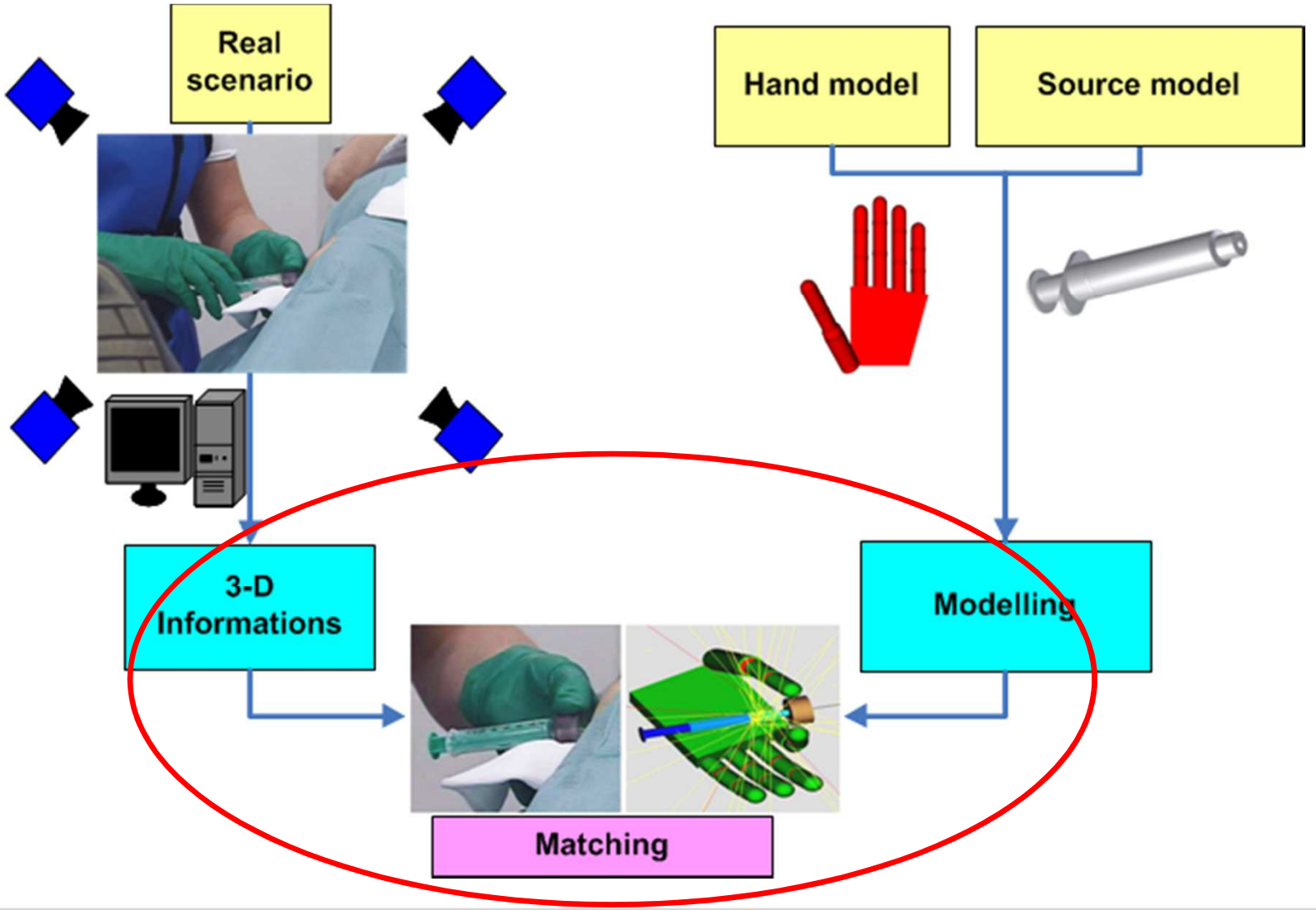
- Calibrated Camerasystem
- Tracking of marked points at the hand
- Triangulation for 3D-Coordinates





Triangulation with 2 Cameras

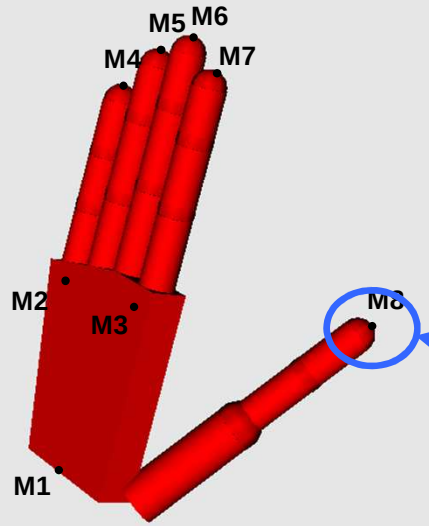
Modelling of simulation scenario

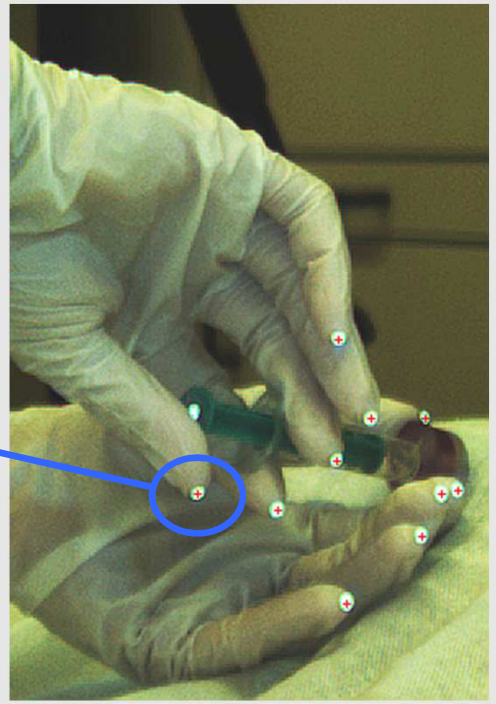


Hand pose reconstruction

- **Initial pose**

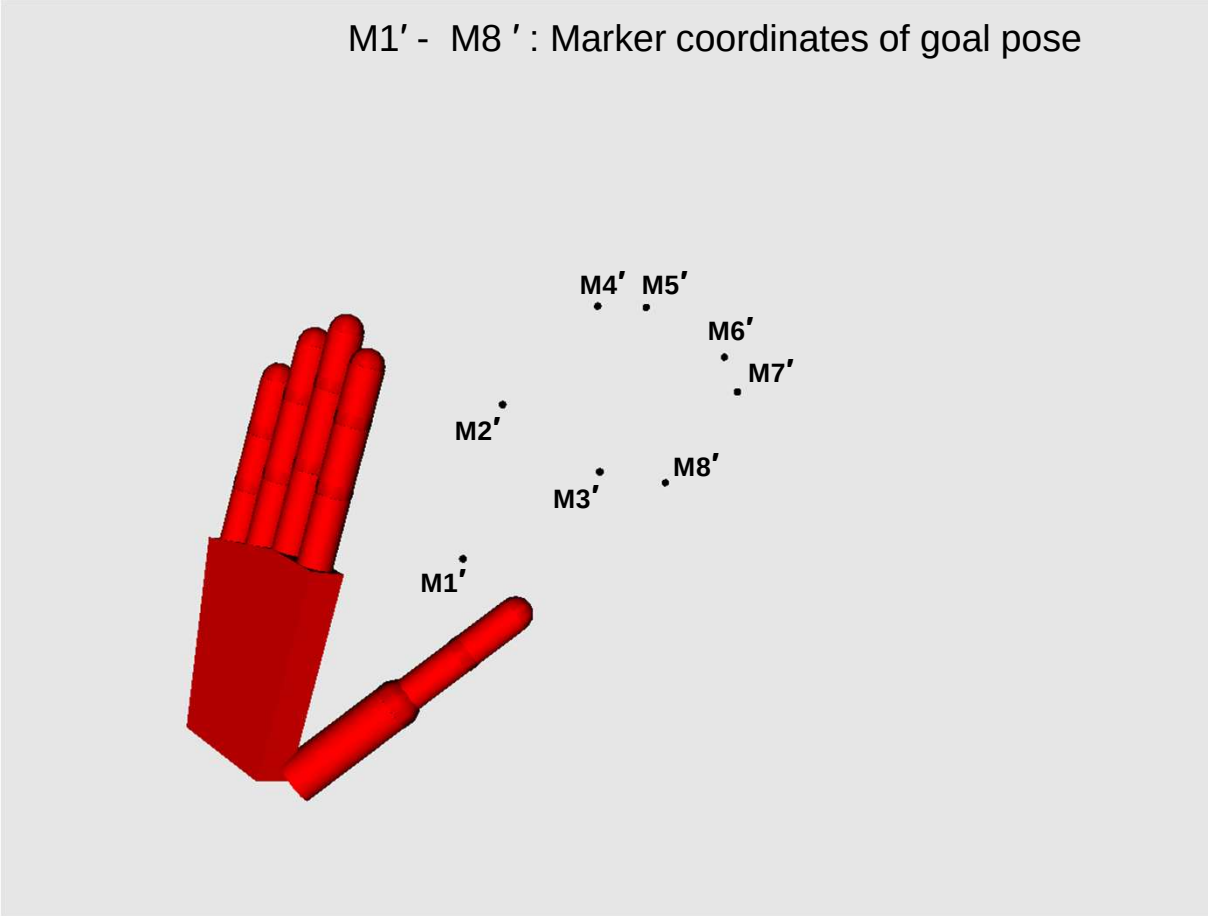
M1 - M8 : Marker coordinates of initial pose





Hand pose reconstruction

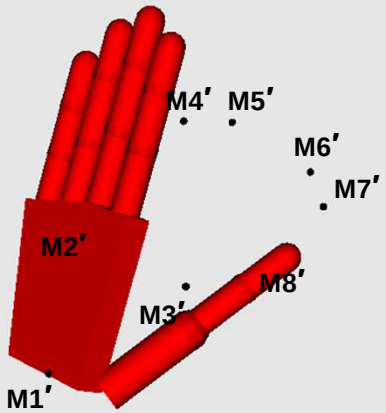
- **New hand pose**



Hand pose reconstruction

- **Translation of hand**

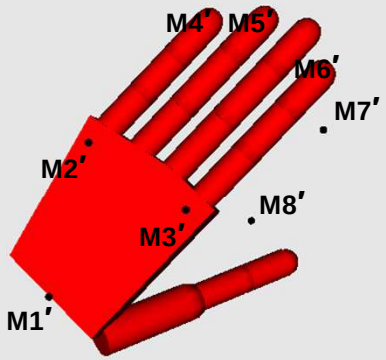
M1′ - M8 ′ : Marker coordinates of goal pose



Hand pose reconstruction

- **Rotation of hand**

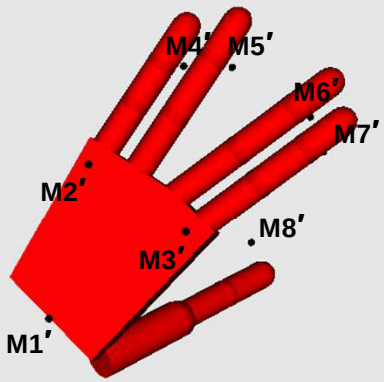
M1′ - M8 ′ : Marker coordinates of goal pose



Hand pose reconstruction

- **Spreading of fingers and the thumb**

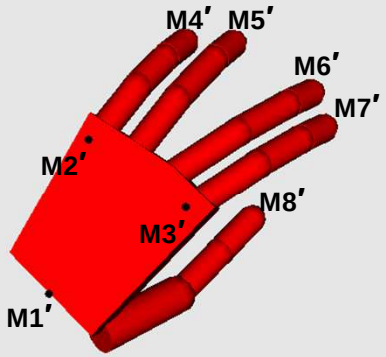
M1′ - M8 ′ : Marker coordinates of goal pose



Hand pose reconstruction

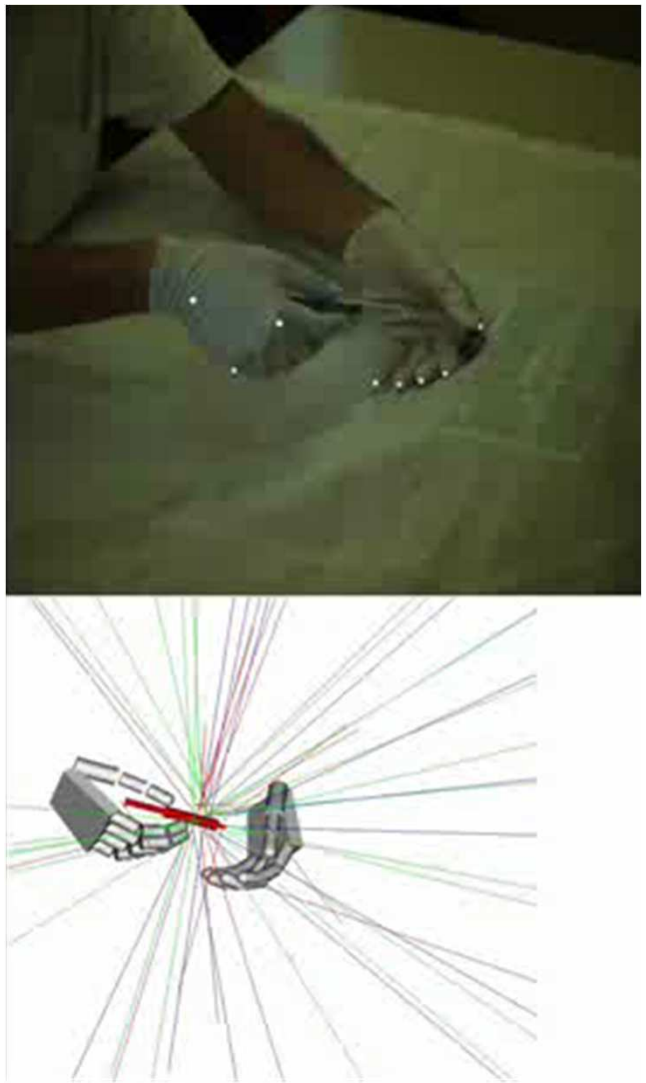
- **Bending of fingers and the thumb**

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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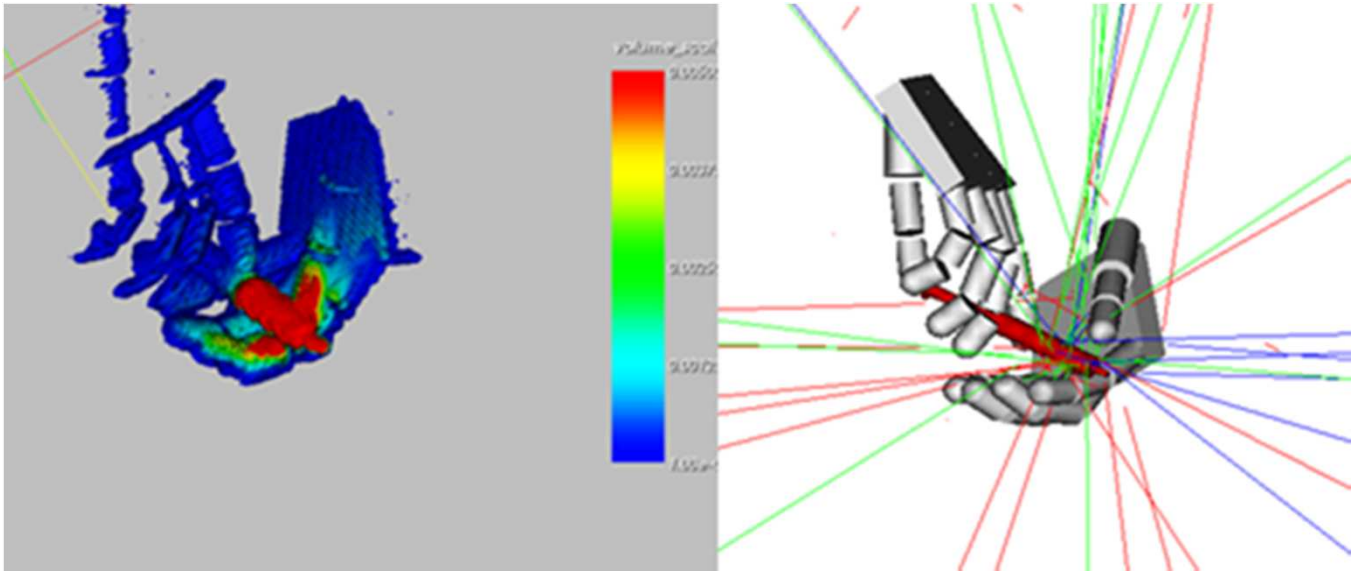
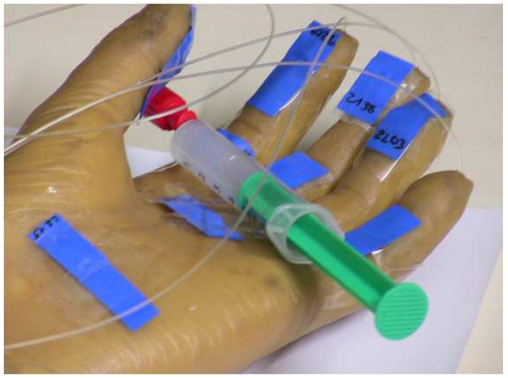
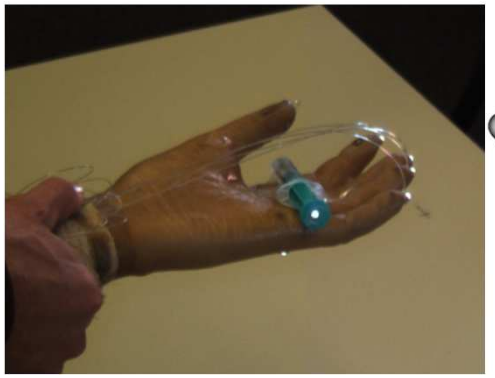
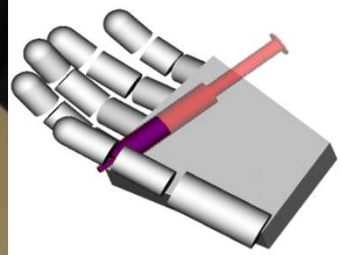


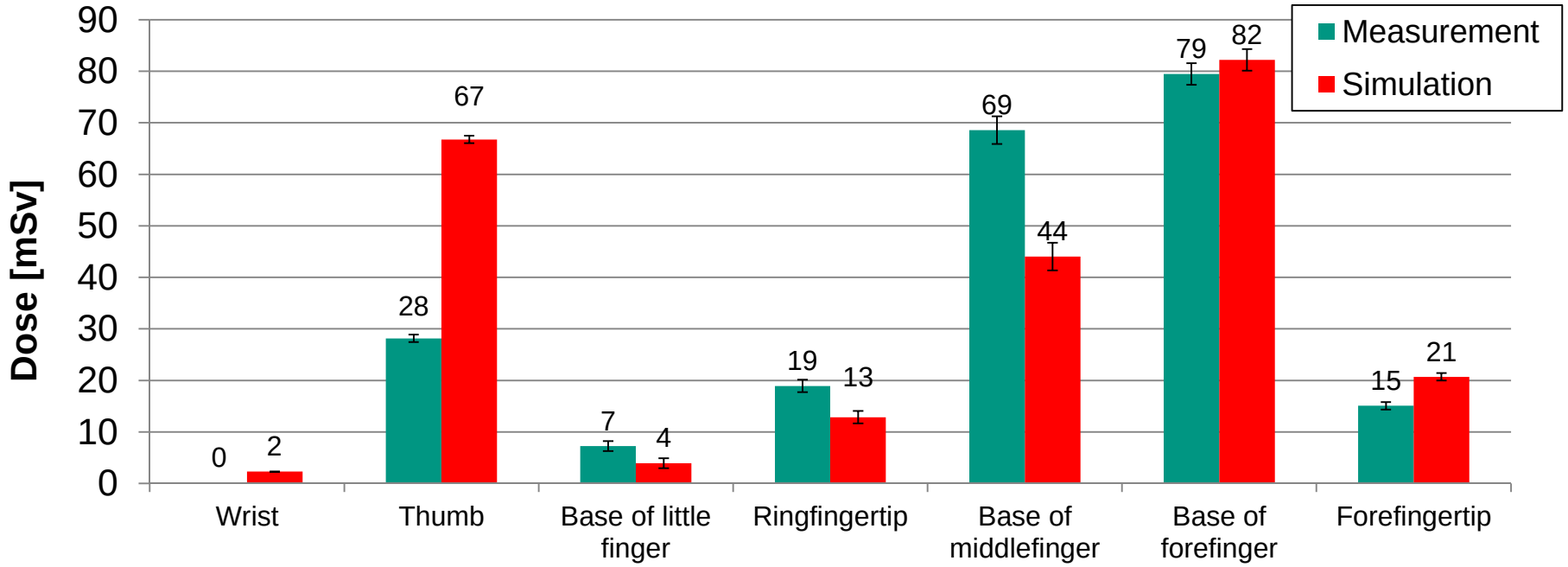
Energy deposition visualized with ParaView (left) and modeled scenario visualized with Sabrina (right)

Measurement vs. Simulation



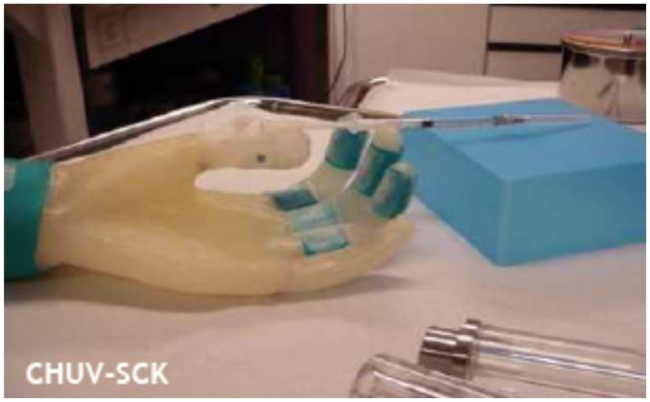




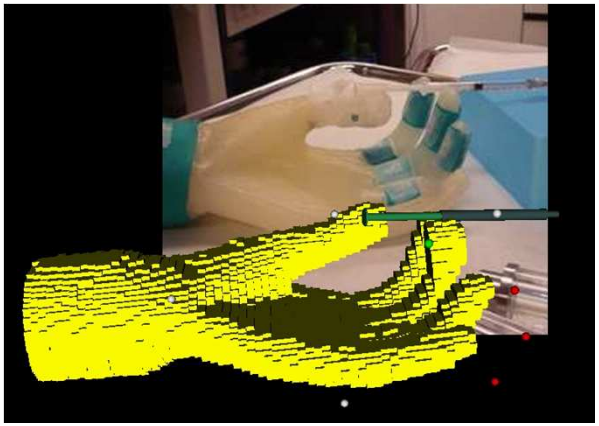


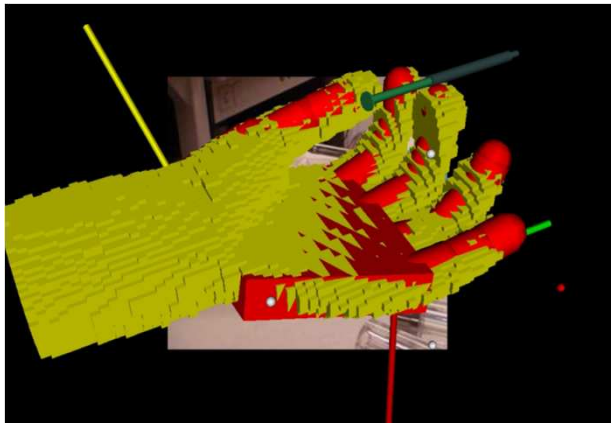
Simulation of Sr-90 Irradiation

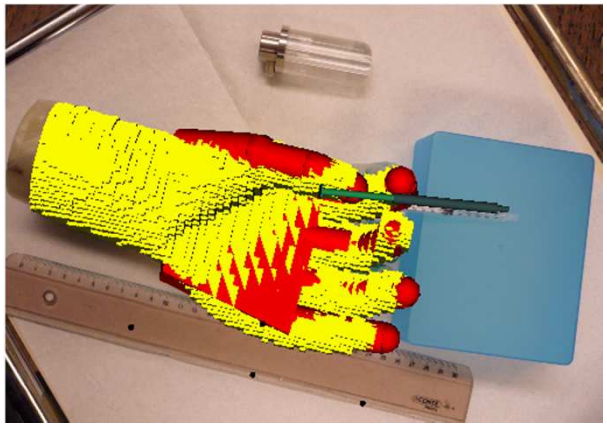
- Measurement from the ORAMED Project
- Import of ORAMED voxelphantom
  - Voxel2MCNP (Lars Hegenbart (KIT))
- Modelling of hand model based on images from the measurement scenario and the imported voxelphantom



Picture from the ORAMED validation report







Summery and further investigations

- Small amounts of poor or unshielded activities leads 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!