

Geant4 Simulations for Beta Dosimetry and Activity Measurements in Brachytherapy

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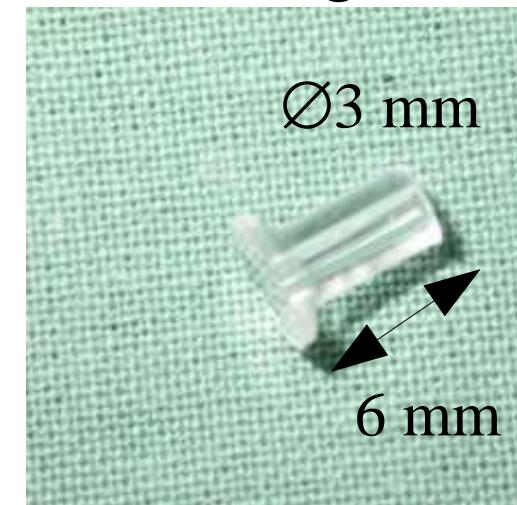
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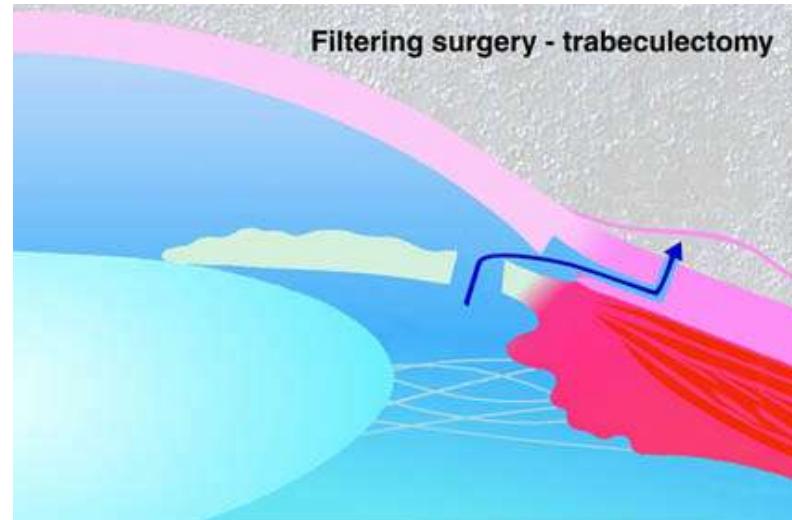
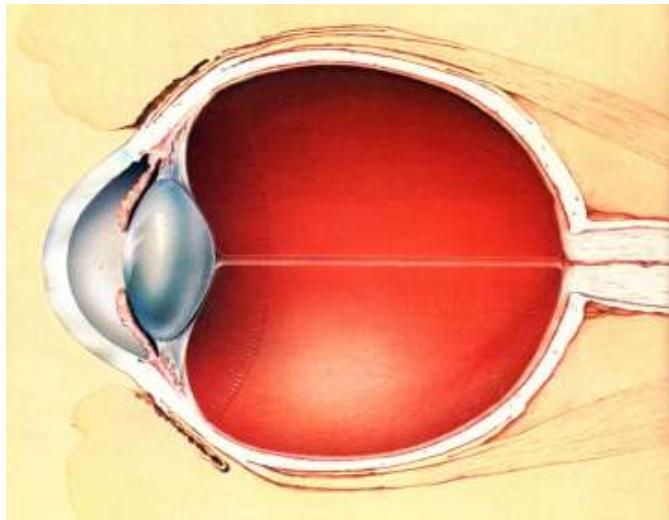
- **RadBioMat-project**
- Dosimetry
- Activity measurements and simulations

RadBioMat – Project Goals

- Modulation of wound healing by low dose irradiation
- New manufacturing technology for brachytherapy implants using ^{32}P radiation (1.7 MeV e^- , no gamma)
- Implantation of radioactive ions into organic and even biodegradable materials
- Studies on materials and cell biology
- Clinical problems: Inhibition of undesired scarring after surgery, not only tumor therapy
 - Coronary stent: great experience base
 - Ophthalmology: Using the short treatment range of beta radiation for glaucoma surgery
 - ENT: keeping artificial orifice open



Glaucoma Treatment I

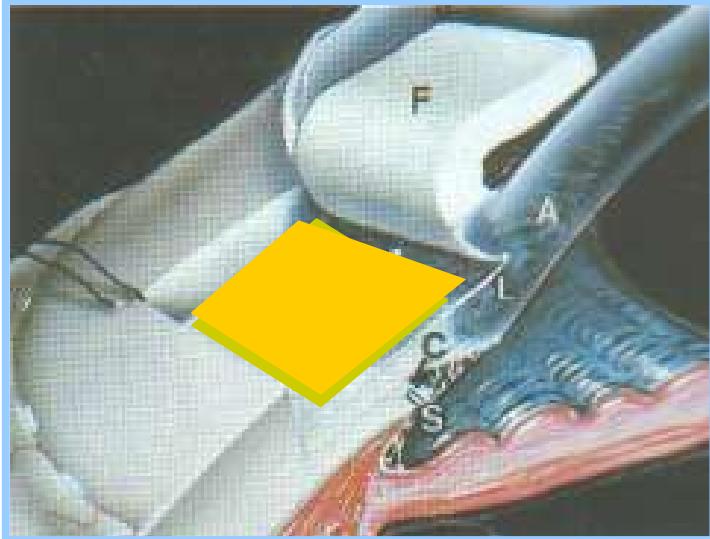


- Sensitive areas: Lense and nerve
- Implant: PLGA,
biodegradable
 $2 \times 2 \text{ mm}$, 0.3 mm thick

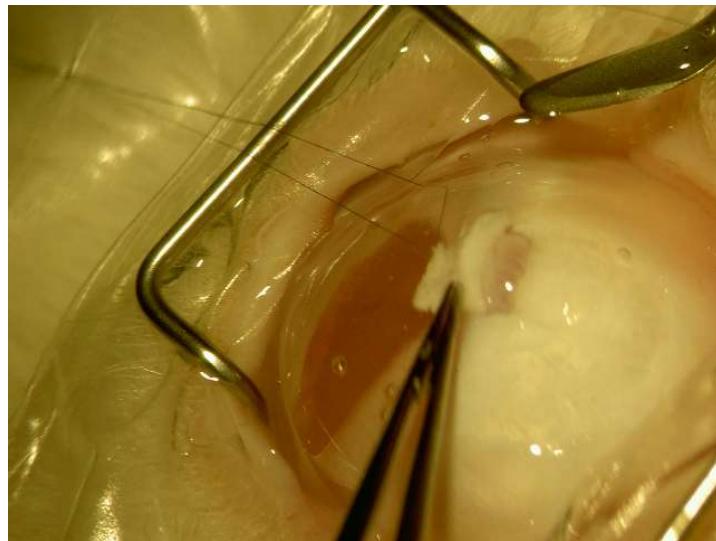


Glaucoma Treatment II

Dosimetry

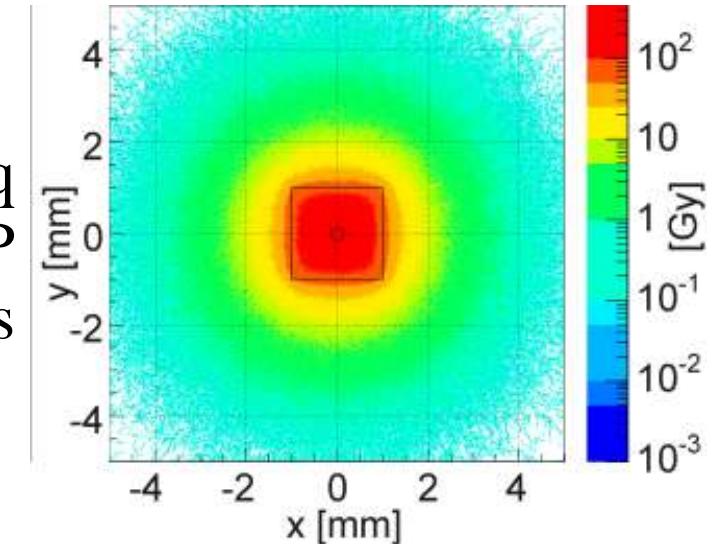


Scleral flap and implant position

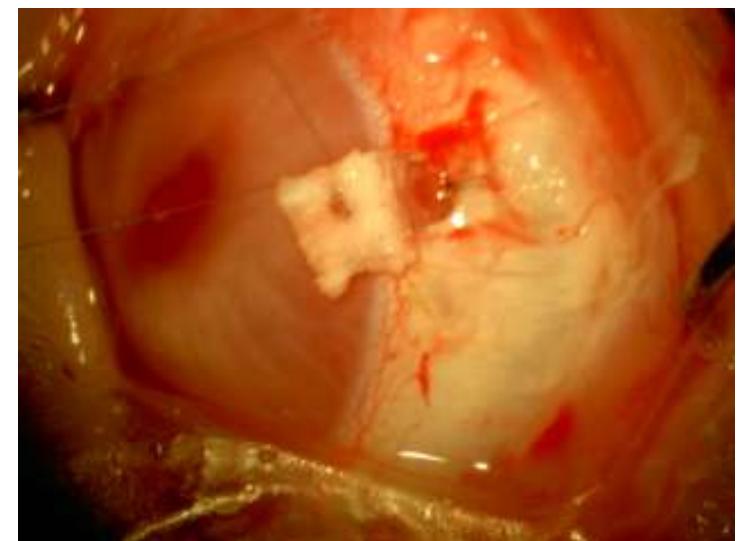


Animal model:
New Zealand
White Rabbit

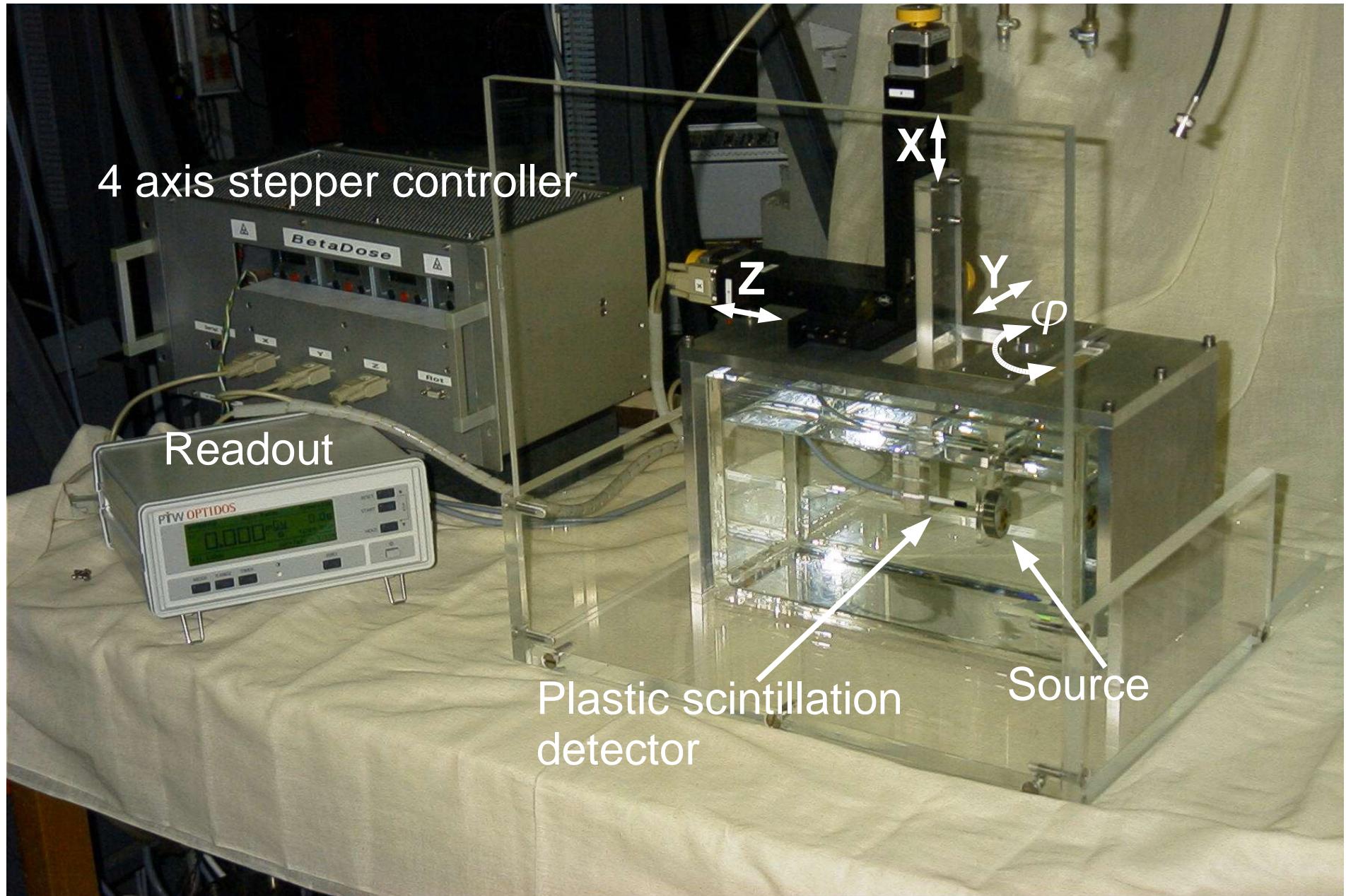
45 kBq
 ^{32}P
in 7 days



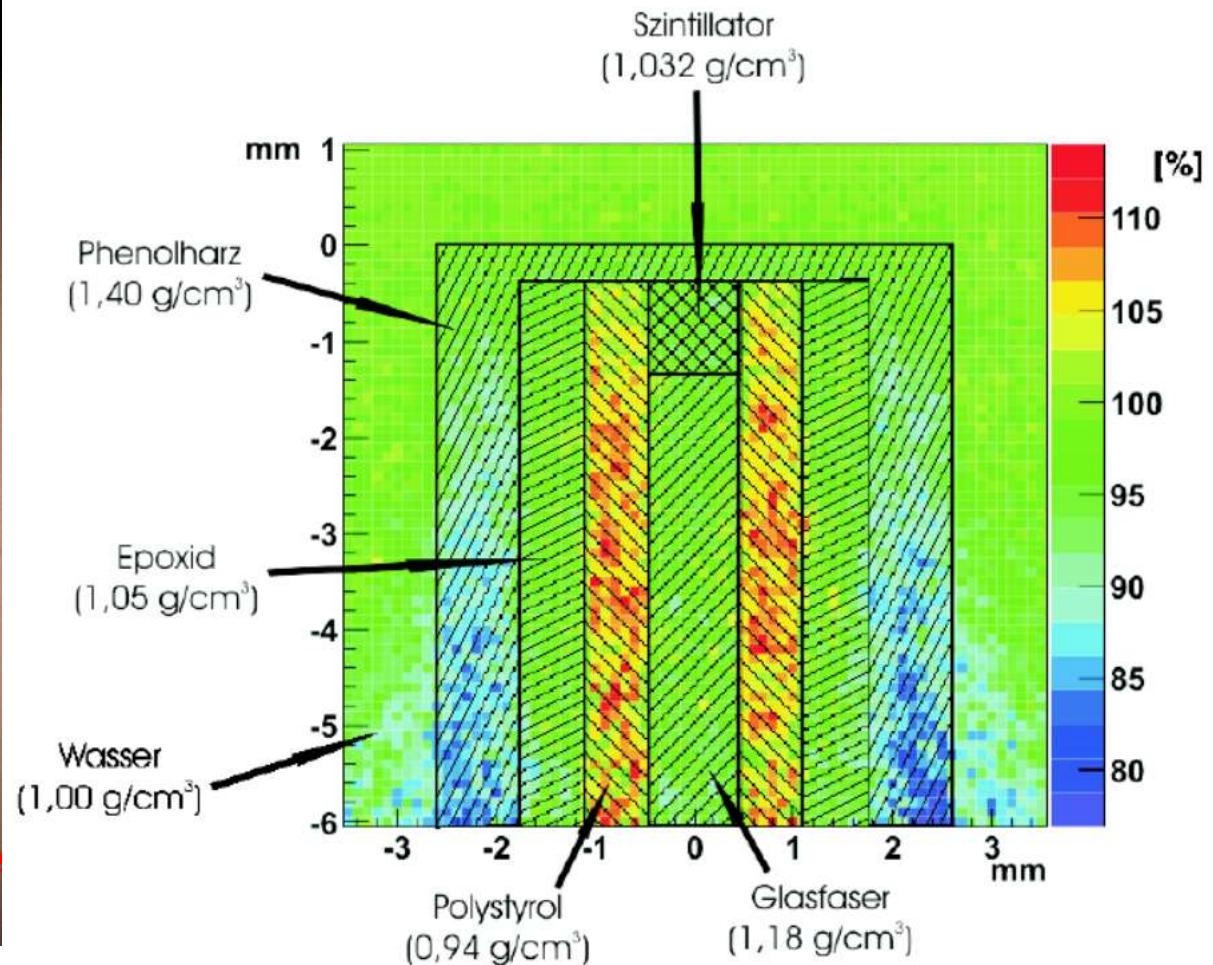
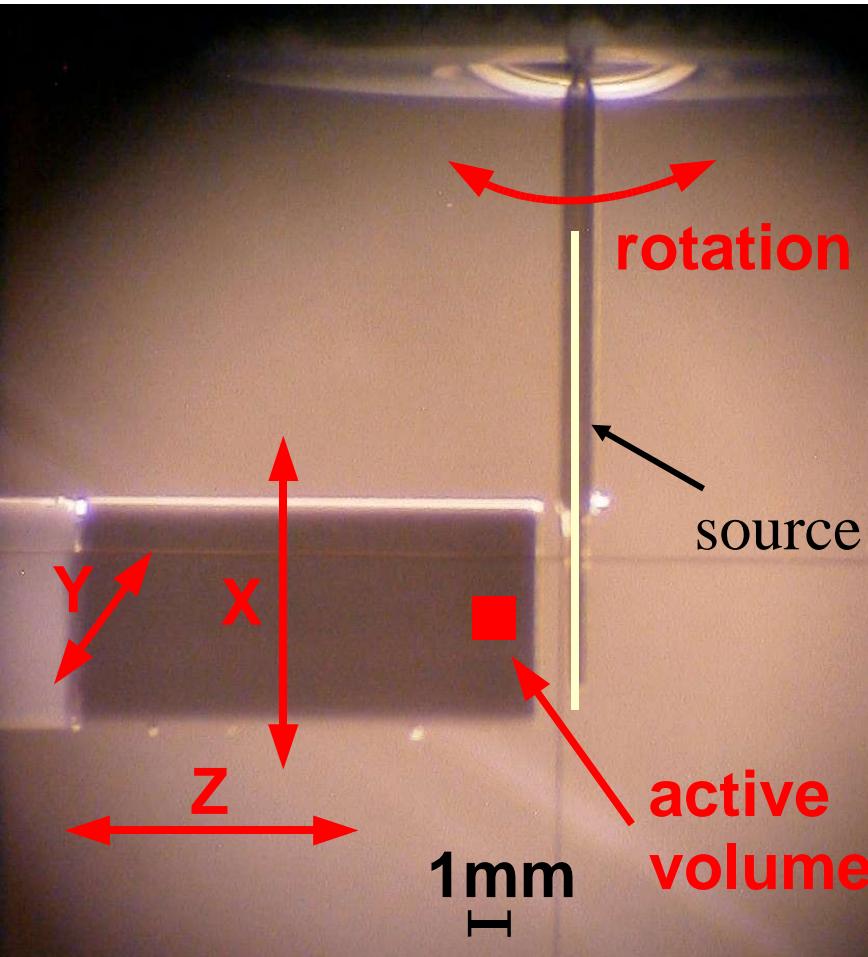
Geant4 calculated dose distribution



Dosimetry measurements I



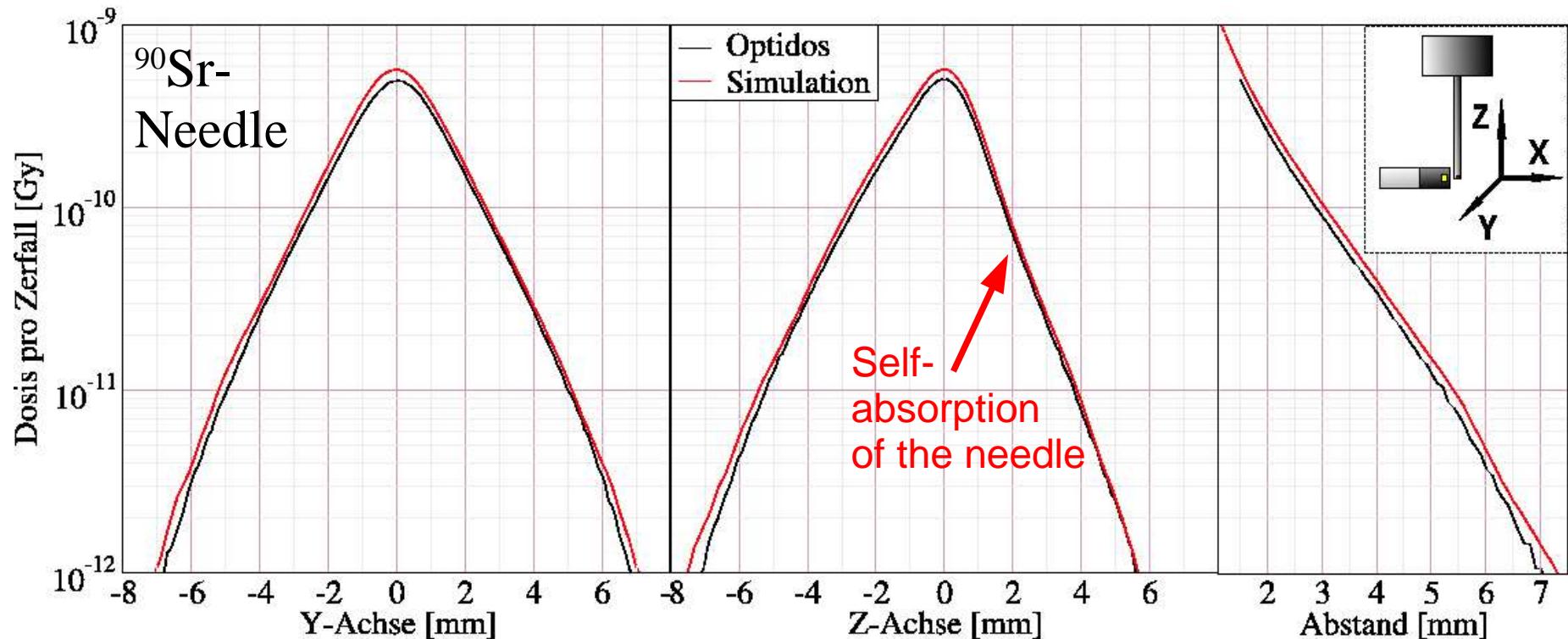
Dosimetry measurements II



- Water equivalent
- Min activity for required $\sim 1 \text{ MBq}$
- Positioning accuracy $\pm 30 \mu\text{m}$
- Scintillator BC-400, lin.
- Current measurement
- $0,4 \text{ mGy/s} - 500 \text{ mGy/s}$

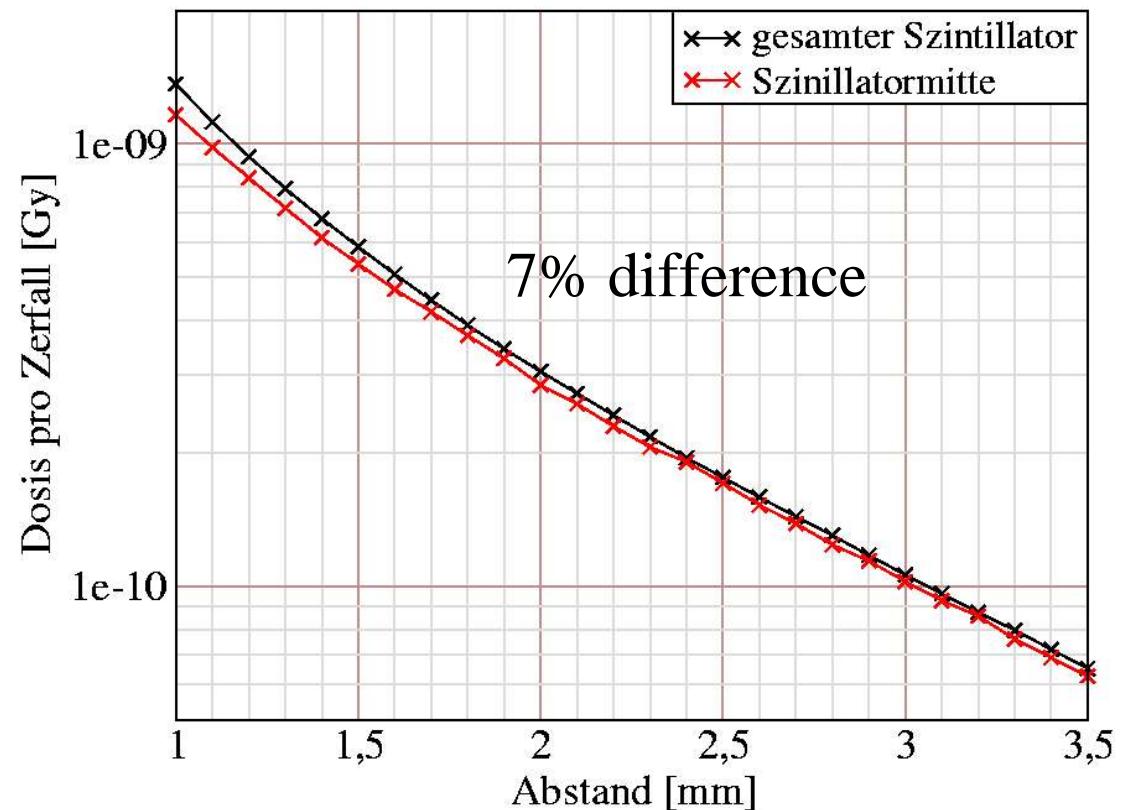
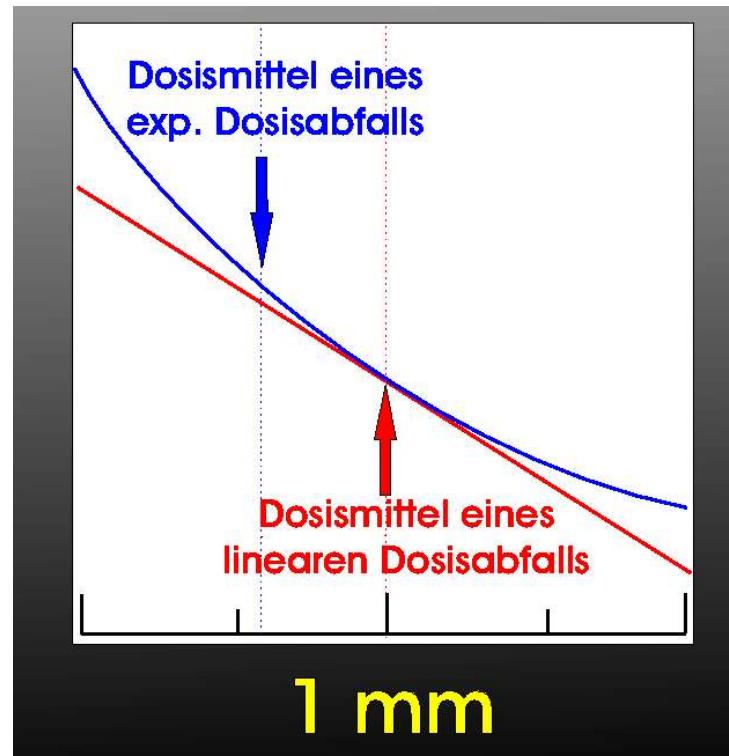
Measurement <-> Simulation I

- 10-15% more dose in simulation than in measurement (dose maximum 13,2% difference)
- The difference is a constant percentage over all doses
- The energy conservation in the calculation prevents a scaling error.



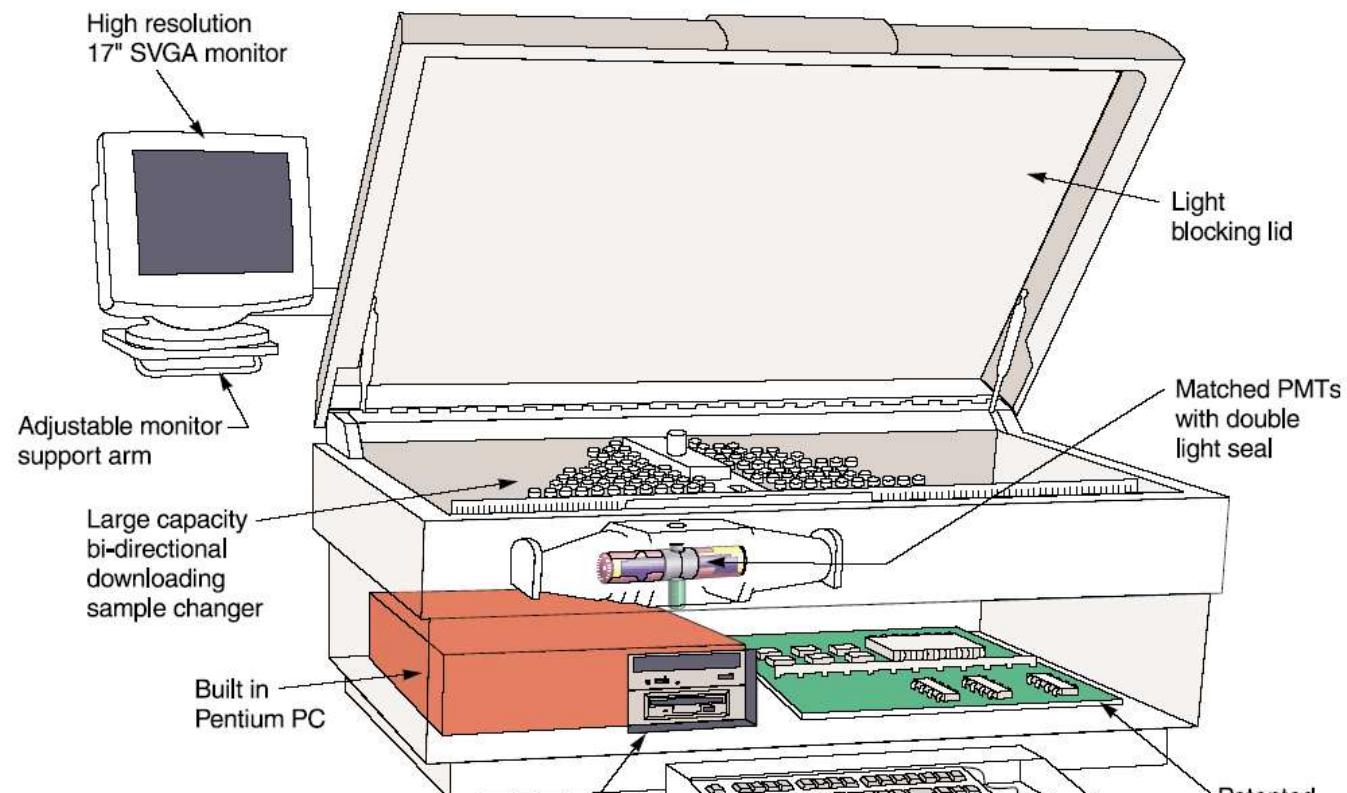
Measurement <-> Simulation II

- Optidos® was built for activity [distribution] checks on afterloading sources
- 16% accuracy given by manufacturer
- Calibration factor of Optidos® is ignoring the dose decay inside the detector



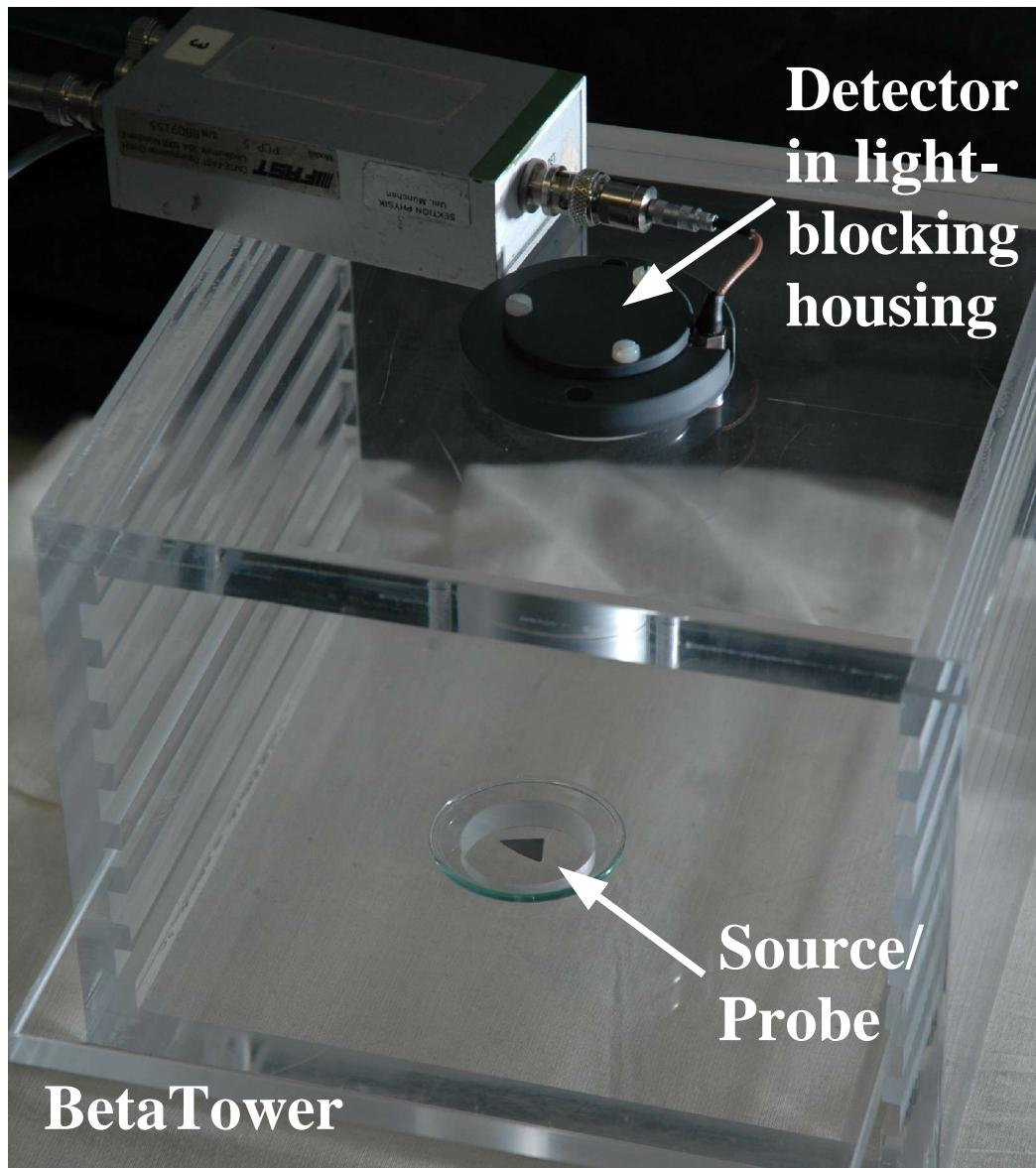
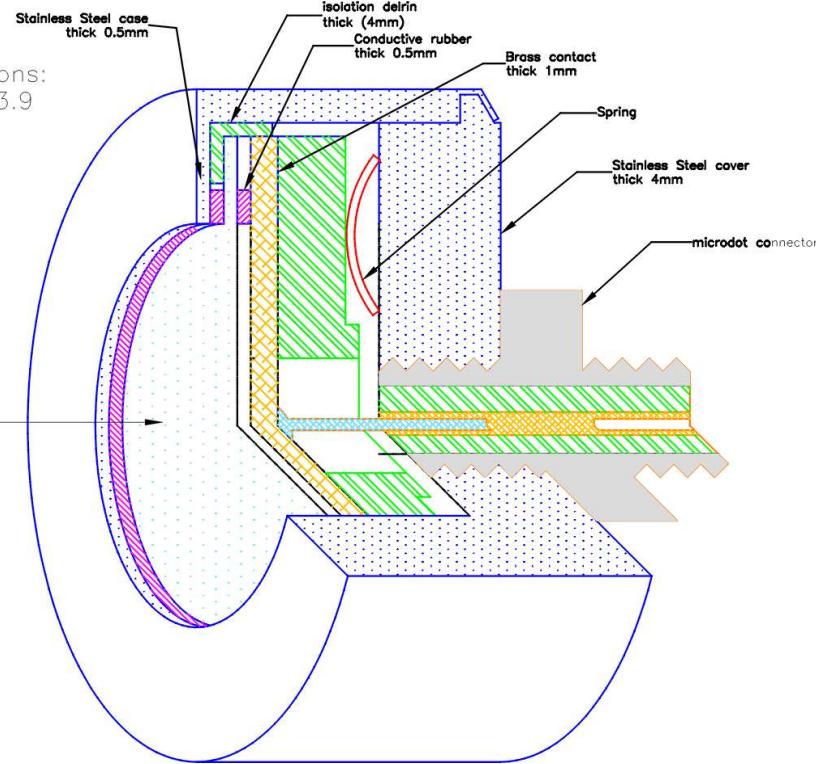
Liquid Scintillation Counting

- Measurement with Optidos®
- Dissolving of the sample
- Mixing with liquid scintillator
- Activity measurement by TriCarb® LSC
- Comparison

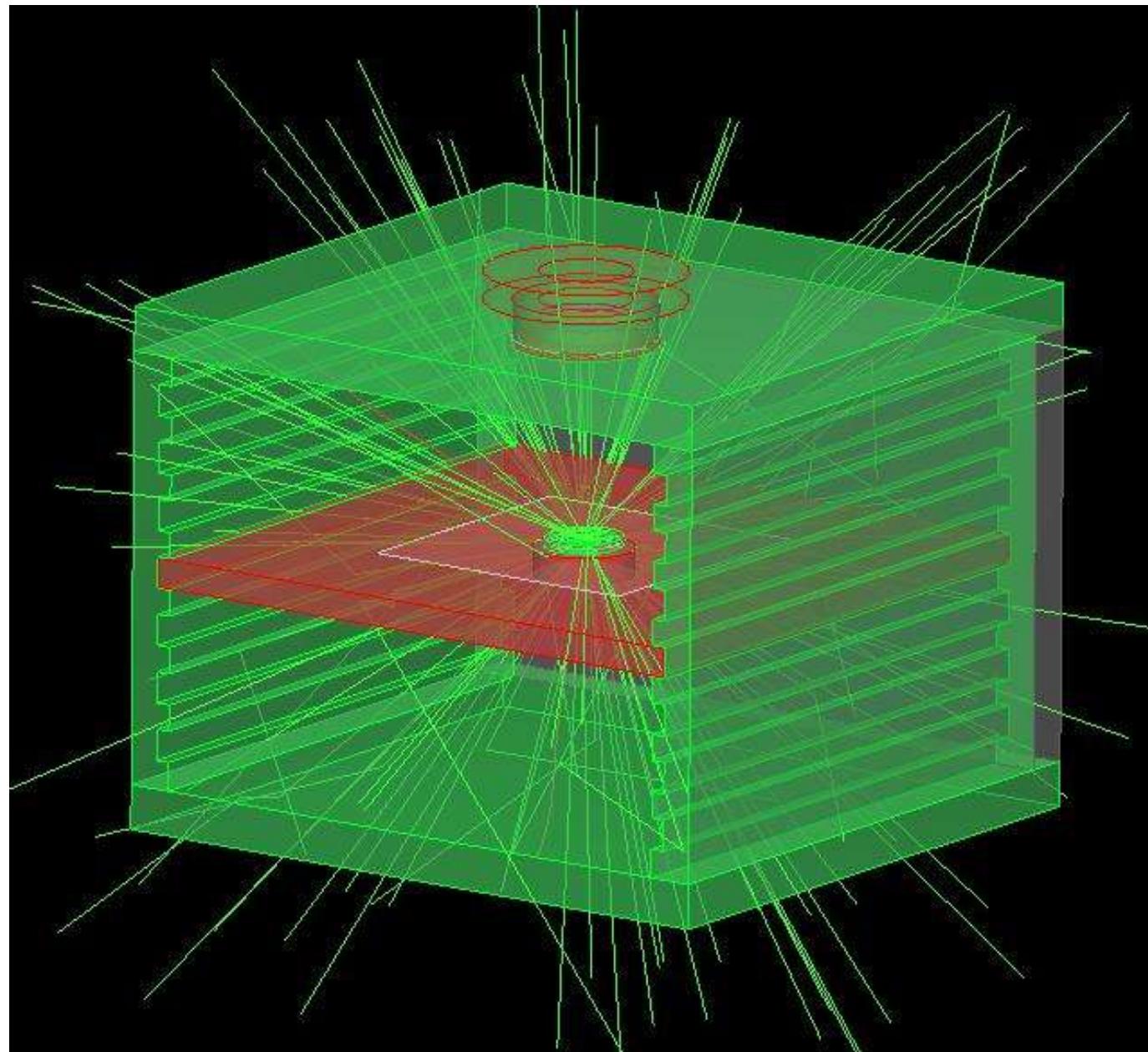


Activity Measurement

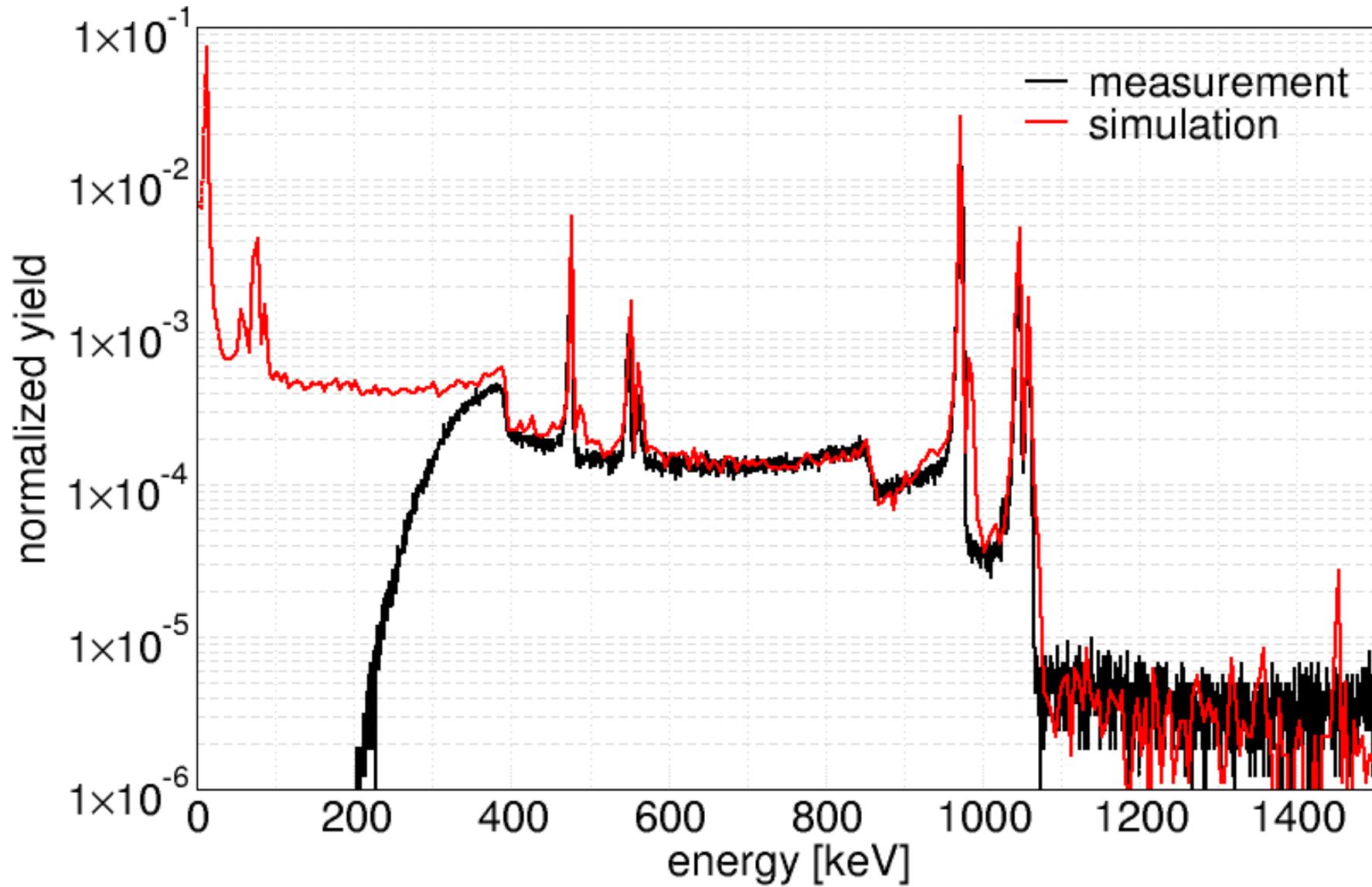
- Needed for production and quality control
- Silicon PIPS detector
 - Thickness: 700 μm
 - Area: 150 or 450 mm^2



Geant4 Simulation

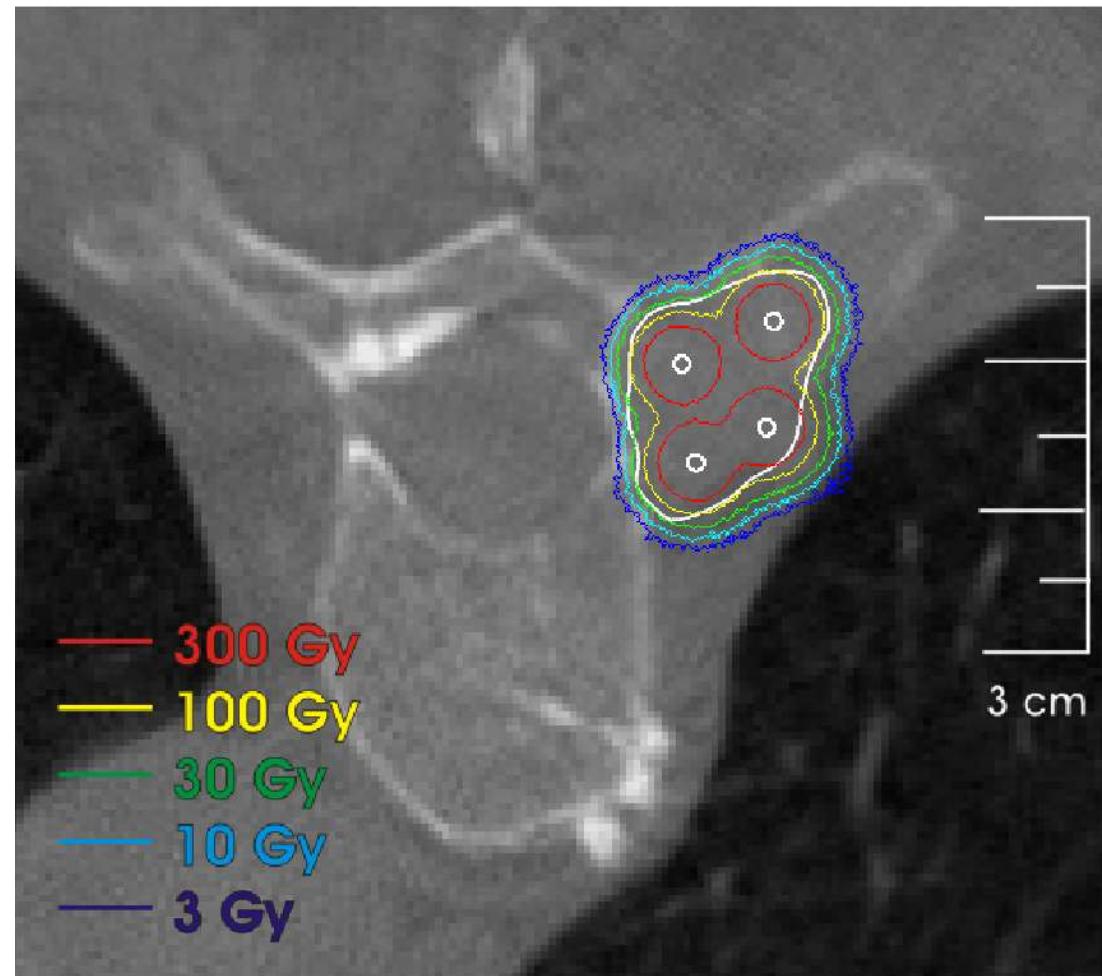


^{207}Bi Spectrum Measurement and Simulation



Conclusion

- Simulation on a 50 CPU Linux-Cluster using MPI
- Parallelisation by event/seed distribution
- Histogramming: ROOT-Toolkit
- Geant4 is used for:
 - Dose calculations
 - Helping to develop or calibrate detector systems
 - Future use
- Dose planning using CT-data
 - Dicom-library DCMTK
 - Clinical study
 - ^{32}P implants
 - Tumor therapy



Betadosimetry – Dose Reduction

