

# **A simulation for the METAS electron beam primary standard dosimeter**

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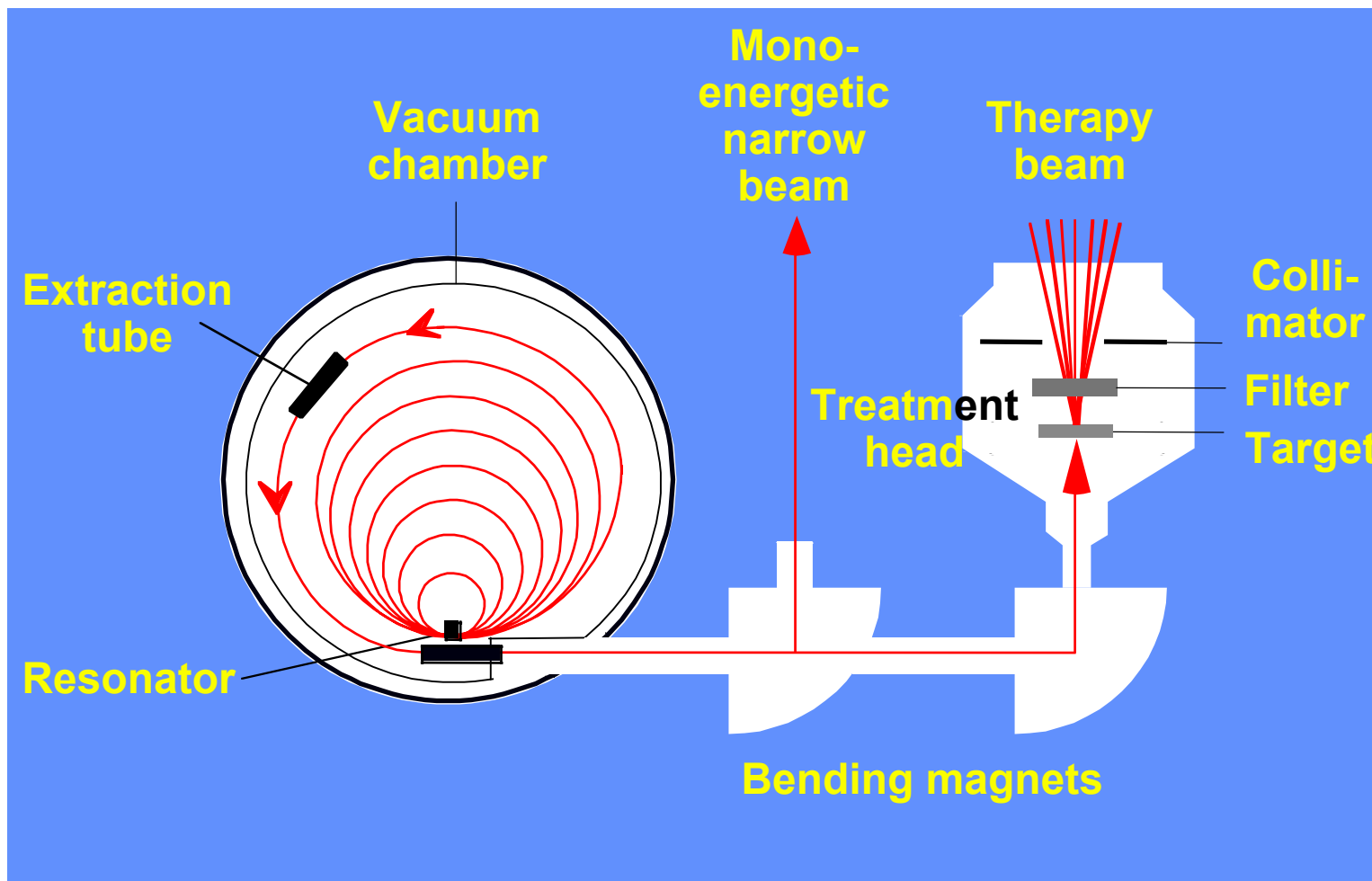
**3003 Bern-Wabern**

**Switzerland**

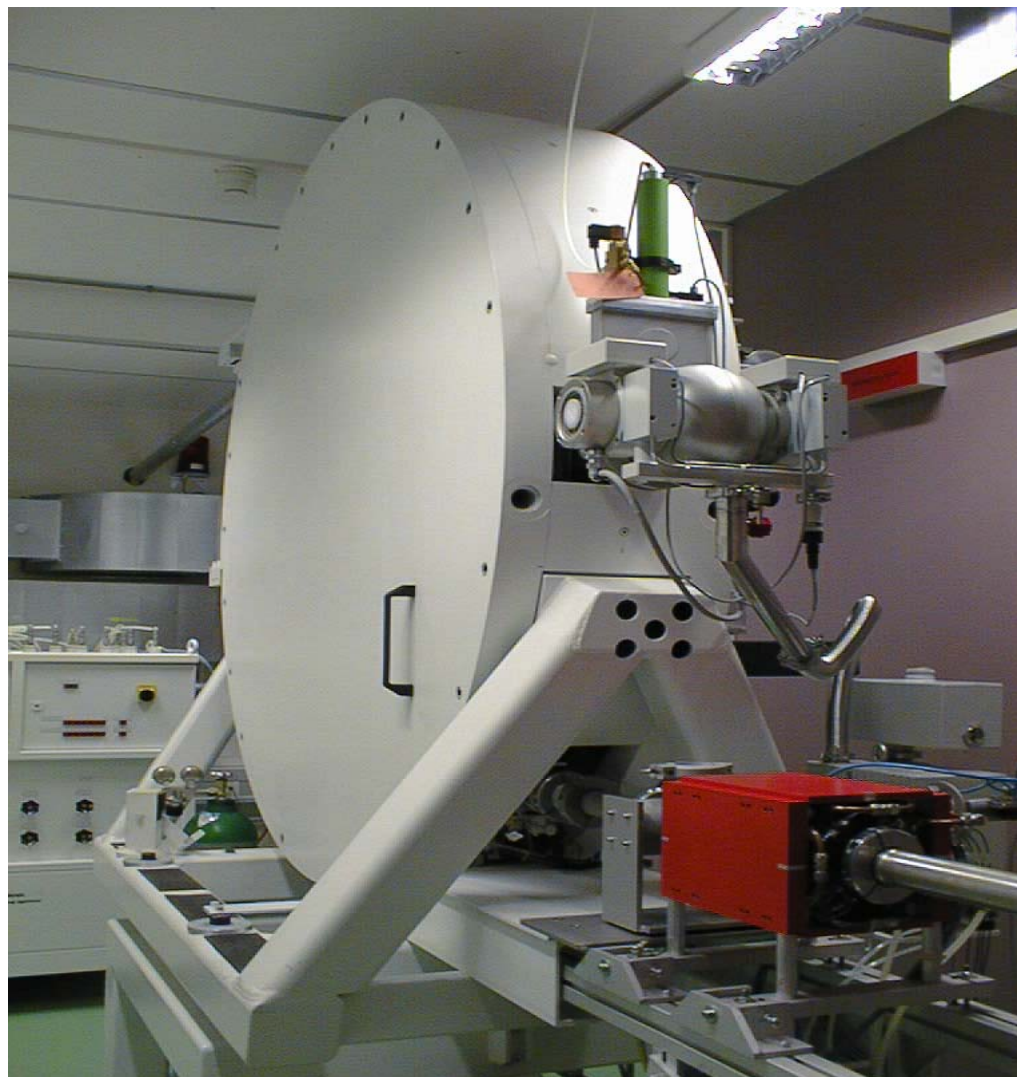
# The METAS electron beam for primary standard dosimetry

- **Electron accelerator (microtron) M22**
- **Electron energies range from 5.3 to 22.4 MeV**
- **Electrons travel in bunches of  $\sim 3.3 \mu\text{s}$  duration**
- **Narrow beam with  $\text{FWHM} < 3 \text{ mm}$**
- **Beam energy spectrum has  $\text{FWHM} \sim 25 \text{ keV}$**

# METAS microtron M22



# METAS microtron M22



# Chemical dosimeter: Fricke solution



0.001 Mol/L



0.001 Mol/L



0.4 Mol/L

## Properties:



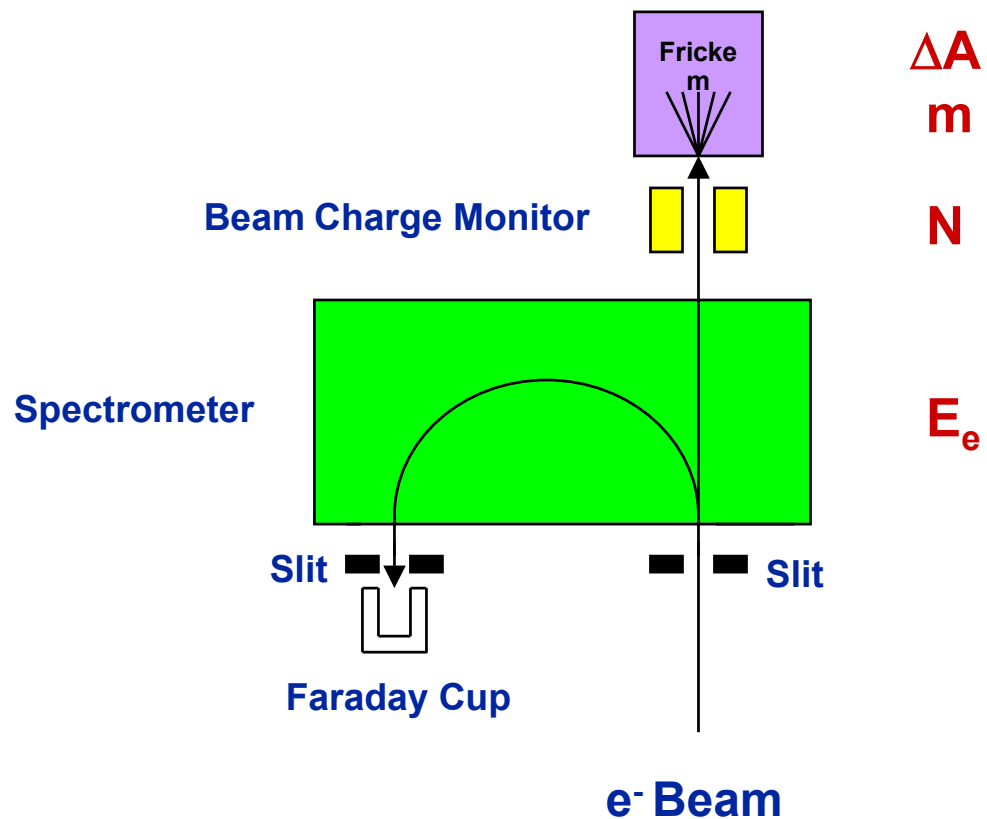
$[\text{Fe}^{3+}] \sim D$

$$D_F = \frac{\Delta A}{\epsilon \cdot G \cdot \rho \cdot l}$$

$\Delta A$  measured at 304 nm

# Total absorption experiment

Electron Energy  $E_e = 5.3 - 22.4$  MeV

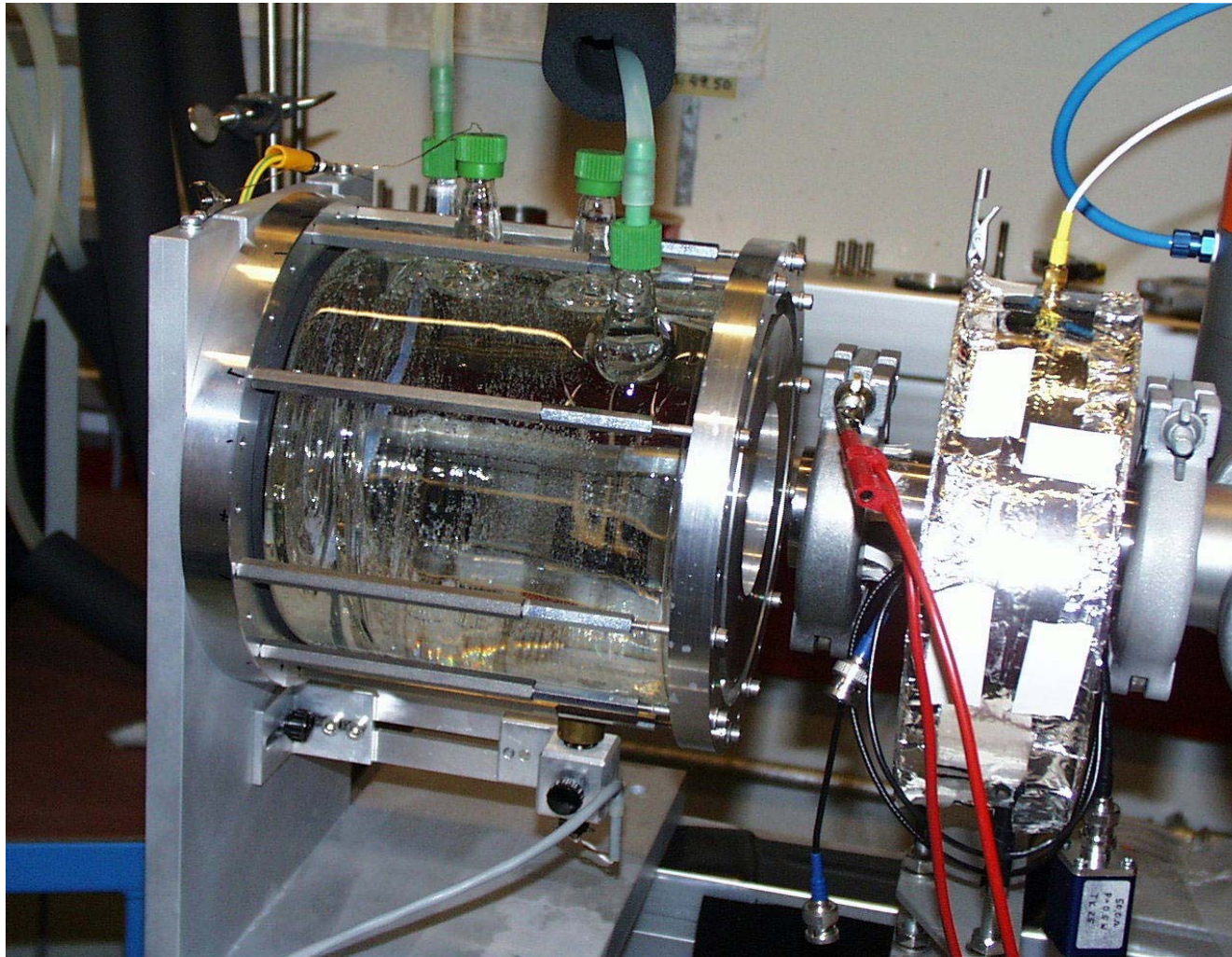


$$D_F = \frac{E_{\text{abs}}}{m} \quad E_{\text{abs}} = E_e \cdot N \cdot f_{\text{MC}}$$

$$D_F = \frac{\Delta A}{\varepsilon \cdot G \cdot \rho \cdot l}$$

$$\varepsilon \cdot G = \frac{\Delta A}{\rho \cdot l} \cdot \frac{m}{E_{\text{abs}}}$$

# Total absorption experiment, large vessel



# Total absorption experiment, medium vessel





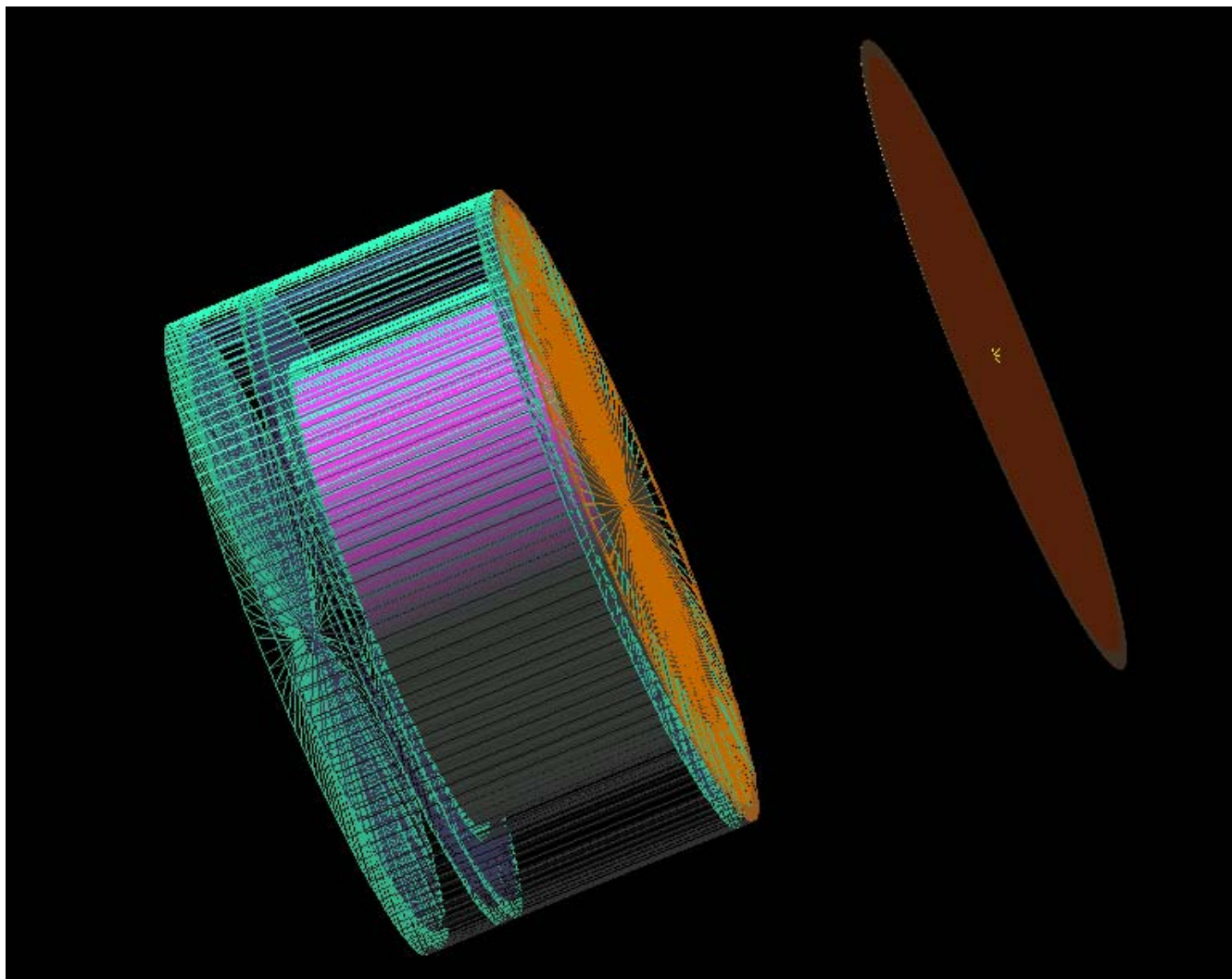
# Simulation: Monte Carlo parameters

- Using EGSnrc V3 code
- 100'000 incident electrons (measured energy spectrum)
- Parallel beam with box or Gaussian radial profiles
- Transport cut off energy : 700 / 10 keV for  $e^-$  / photon
- Single scattering mode boundary crossing
- Spin effects for  $e^-$  elastic scattering
- Bethe-Heitler bremsstrahlung cross section
- Rayleigh and bound Compton scattering not included

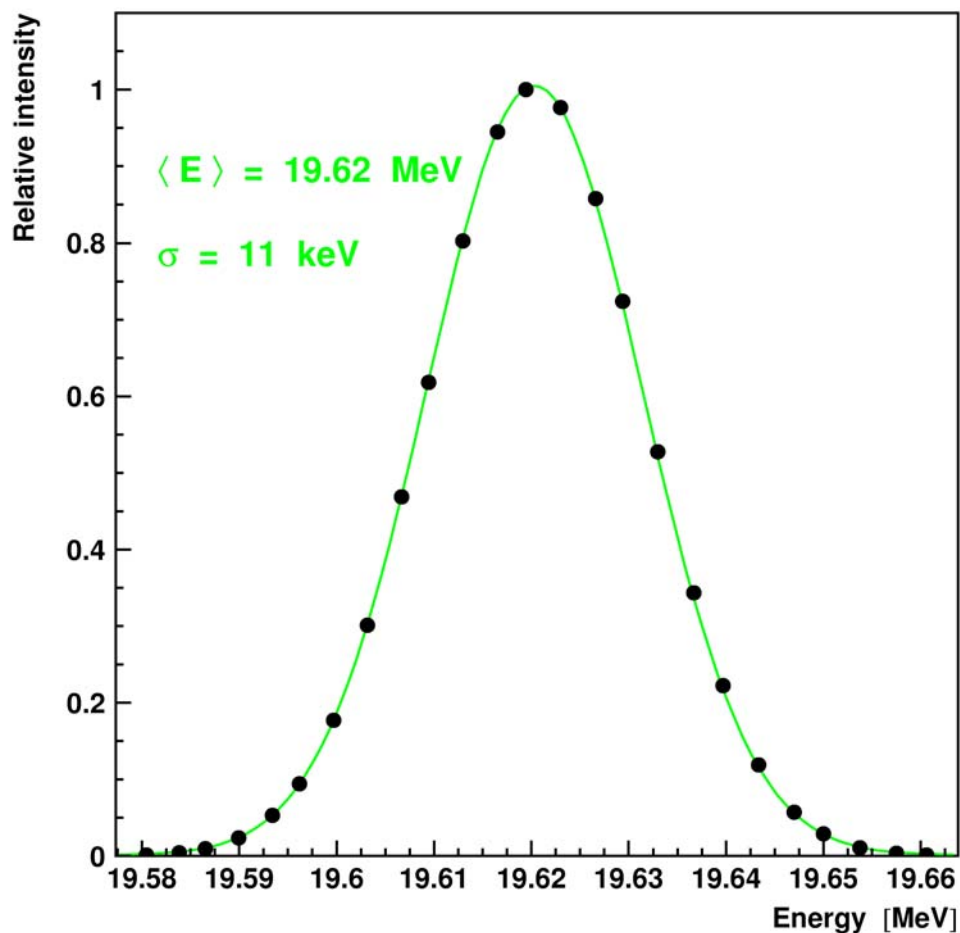
# Simulation: Geometry description and physical quantities scoring and output

- **DOSRZnrc package used for geometry description**
  - Ideal for a cylindrically symmetric experimental setup
- **New scoring and output structure independent of geometry**
  - 3D arrays and 2D planes with any binning that can be positioned anywhere
  - Can overlap several geometry regions
  - “Boundaries description” for use with boundary crossing algorithm
  - Cylindrical (with azimuthal information) or Cartesian scoring regions possible
  - Parameters input using the DOSRZnrc GET\_INPUT routine
  - Output in HBOOK format or ascii file (double precision) for analysis in a separate program

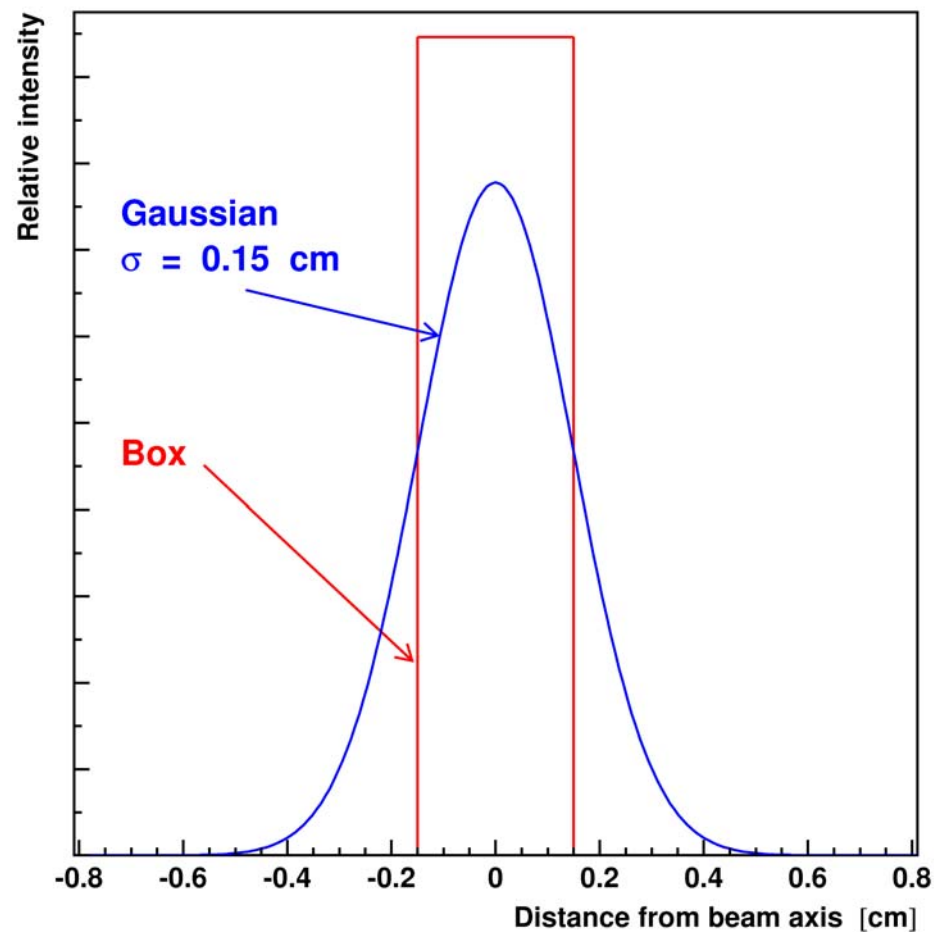
# Simulation: Small vessel geometry



# Simulation: Input spectra for EGSnrc

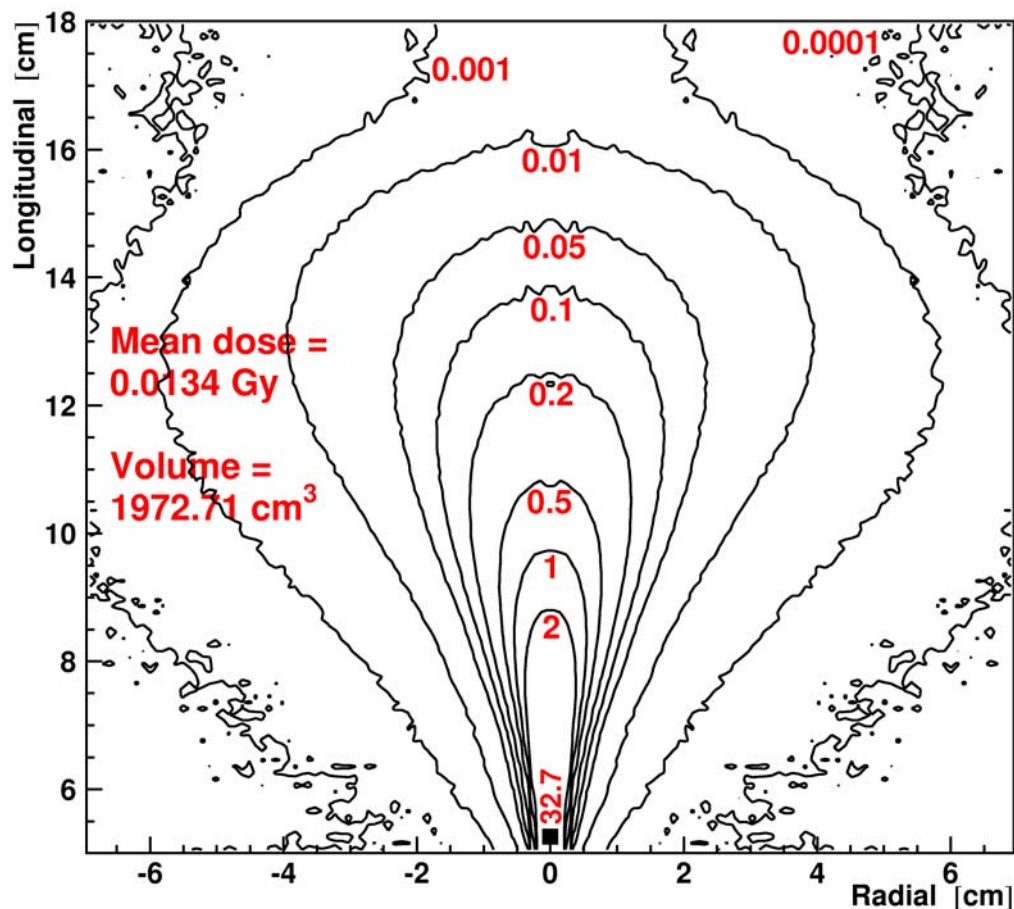


Energy spectrum of 20 MeV beam

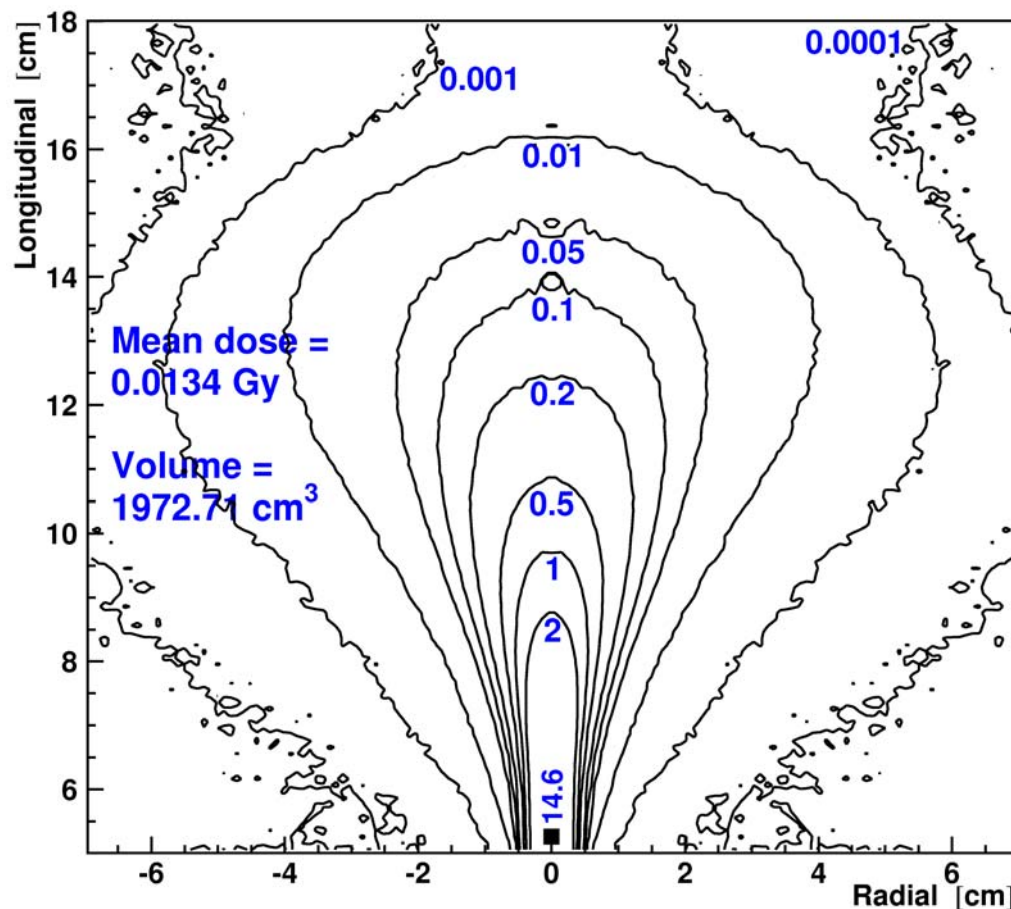


Transverse beam profiles

# Simulation: Isodoses for 1 accelerator bunch

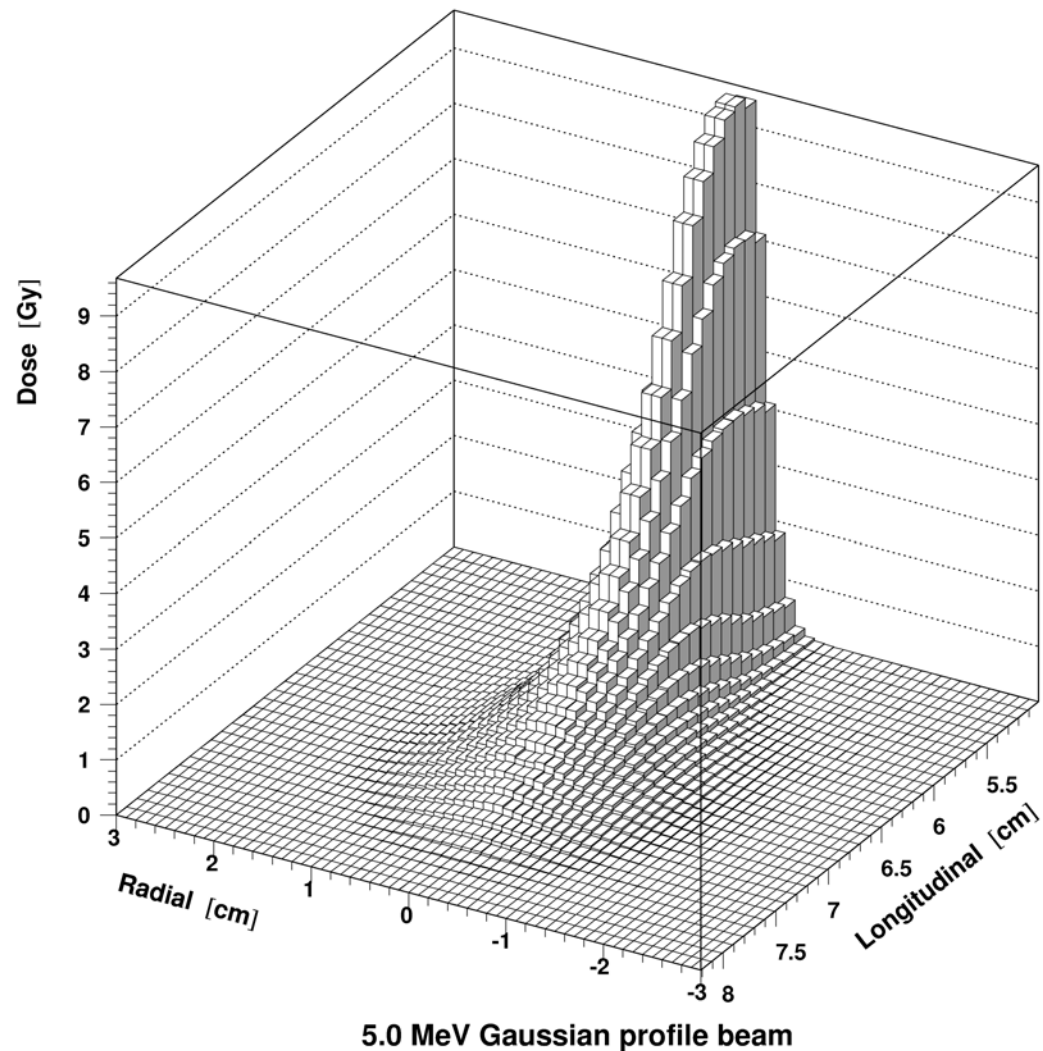
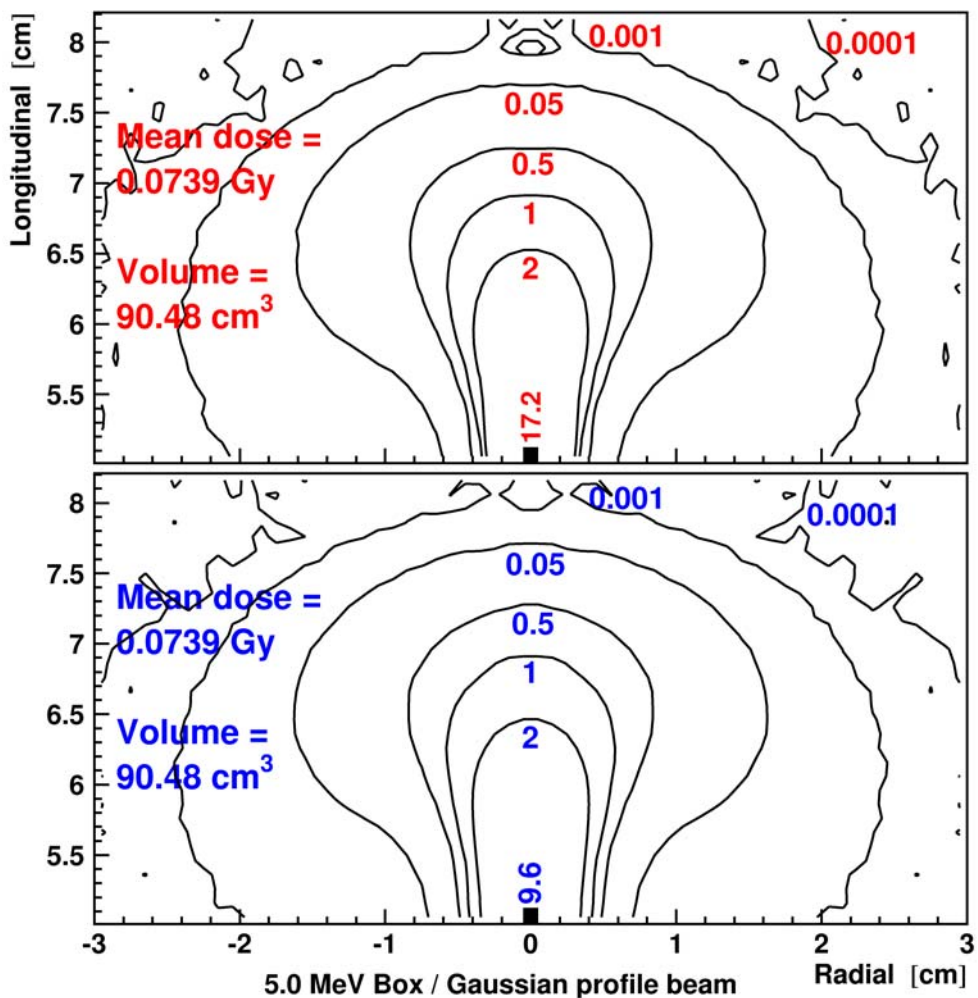


22.0 MeV Box profile beam

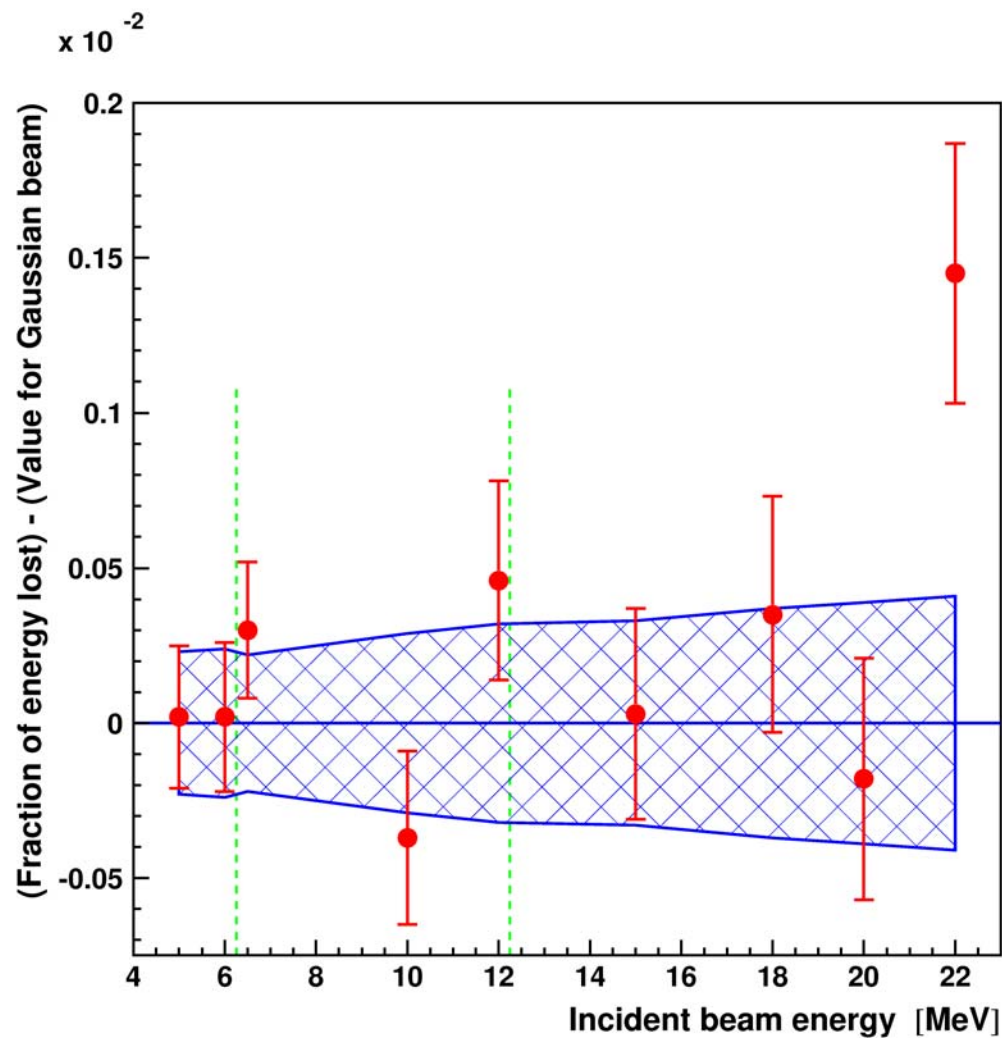
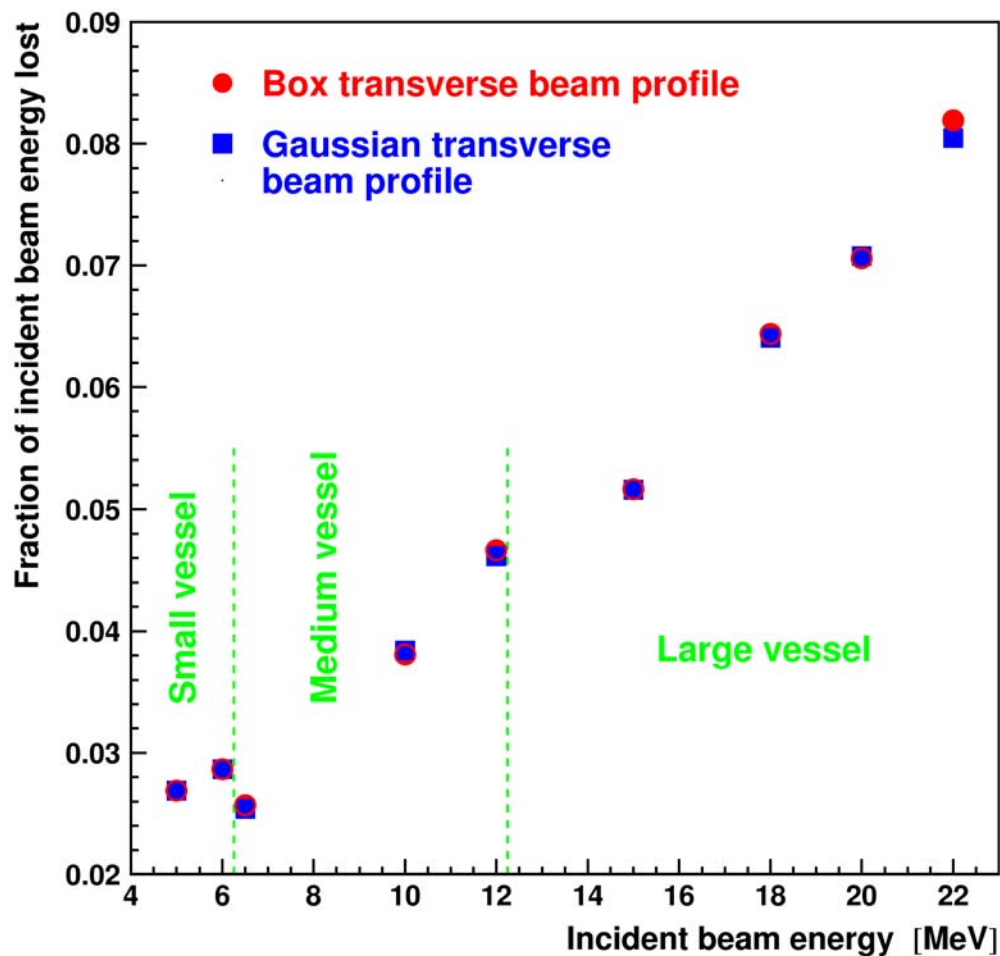


22.0 MeV Gaussian profile beam

# Simulation: Isodoses for 1 accelerator bunch



# Simulation: Correction factors ( $1 - f_{MC}$ )



# Simulation: Correction factors ( $1 - f_{MC}$ )

Beam energy (MeV)	Unregistered energy portion (Box profile) (1 std deviation stat. uncert.)	Unregistered energy portion (Gaussian profile) (1 std deviation stat. uncert.)
5.0	2.691% ± 0.023%	2.689% ± 0.023%
6.0	2.866% ± 0.024%	2.864% ± 0.024%
6.5	2.571% ± 0.022%	2.541% ± 0.022%
10.0	3.806% ± 0.028%	3.843% ± 0.029%
12.0	4.663% ± 0.032%	4.617% ± 0.032%
15.0	5.165% ± 0.034%	5.162% ± 0.033%
18.0	6.438% ± 0.038%	6.403% ± 0.037%
20.0	7.060% ± 0.039%	7.078% ± 0.039%
22.0	8.193% ± 0.042%	8.048% ± 0.041%



# Summary and Outlook

- **A simulation for the METAS electron beam primary standard dosimeter has been undertaken**
- **First results have been obtained using EGSnrc**
- **Corrections for losses between 2.69% (5 MeV beam) and 8.05% (22 MeV beam) have been obtained**
- **Simulation of the full ionisation chamber calibration procedure (2 steps) will be done**
- **GEANT4 will also be used for this simulation**