Dose distribution in the sample container of an X-ray irradiator used for biological applications*

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Objectives

- Obtain the dose distribution as a function of the radial distance under static and dynamic conditions for a 150 keV X-ray irradiator using cylindrical containers to irradiate biological samples.
- Compare simulation results with previously obtained experimental values of the dose uniformity ratio (DUR)

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Characteristics of the Irradiator

- Cylindrical X-ray source in the center of the irradiation chamber
- Five cylindrical sample canisters located around the X-ray source, rotating and revolving around it for uniform dose
- Maximum electron energy 150 keV
- Maximum cathode current 45 mA

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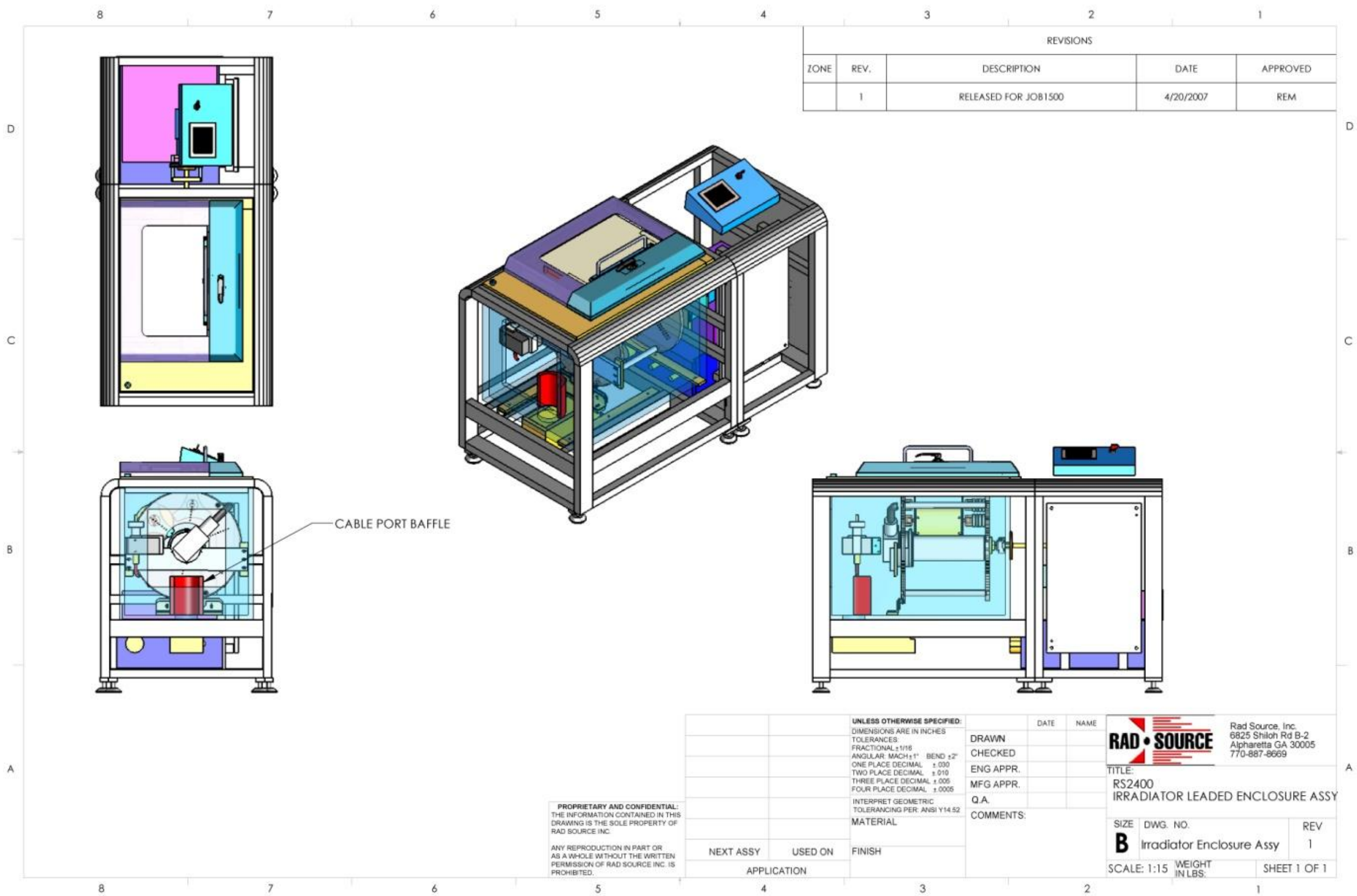
X-ray irradiator



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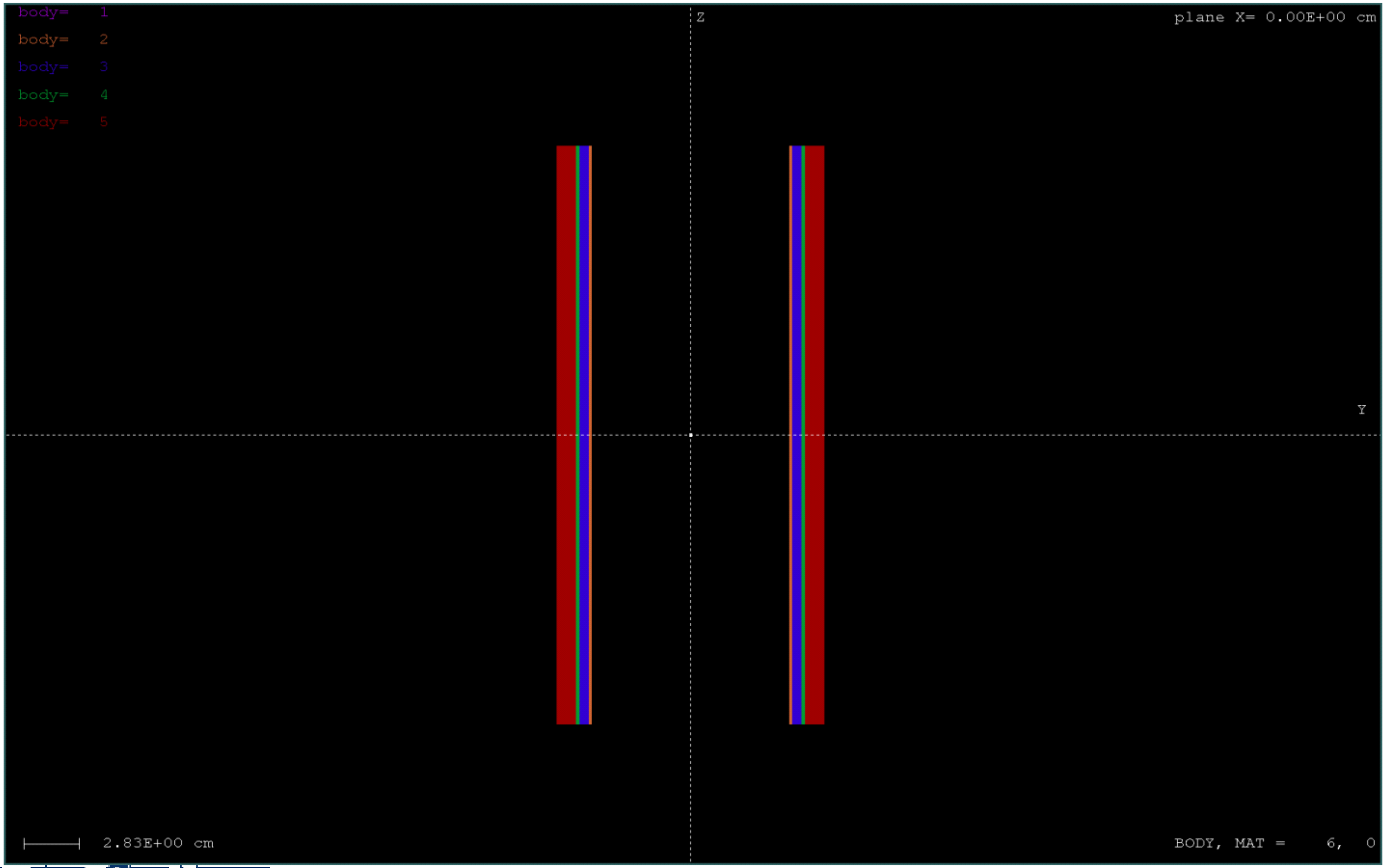
Simulation Code characteristics

- **MC code used: PENMAIN from Penelope**
- **Geometry Files to determine:**
  - Dose distribution under static conditions
  - Dose distribution under dynamic conditions
- **Atomic composition files for all the materials used in the simulations**
  - X-ray source
  - Sample
  - Energy detectors
- **Input files to steer the MC program and to determine the required quantities**
  - Depth-dose distributions
  - Dose uniformity under dynamic conditions

Simulation of X-ray source



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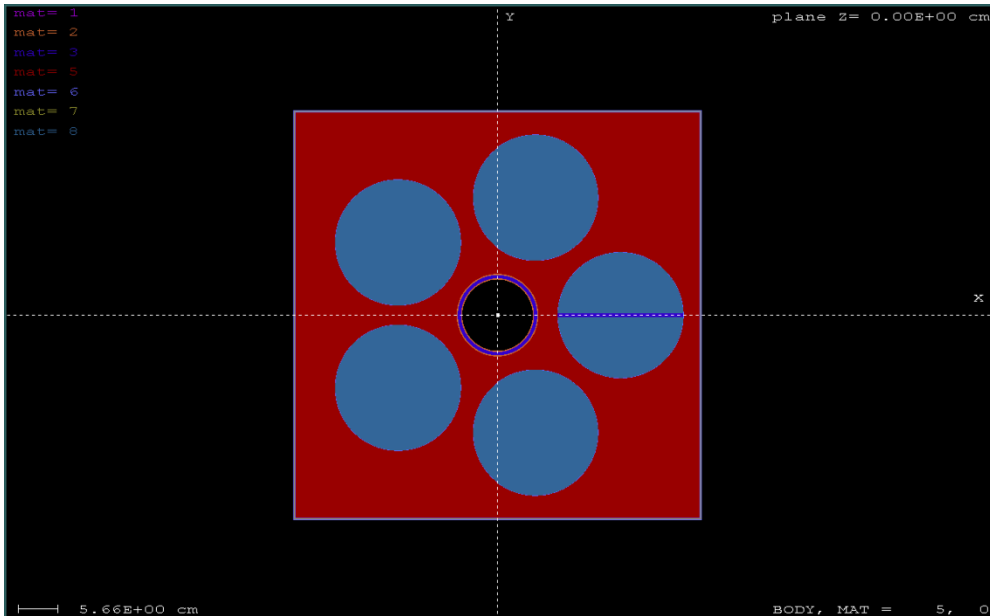
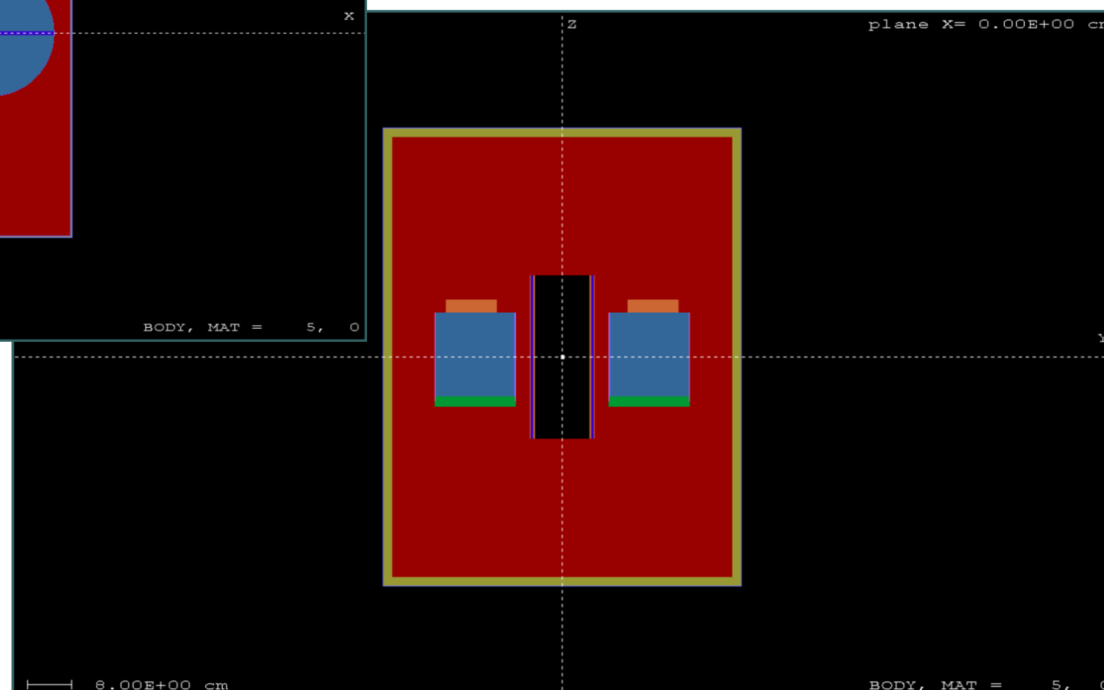
Geometry file to obtain dose distribution in canisters (static)





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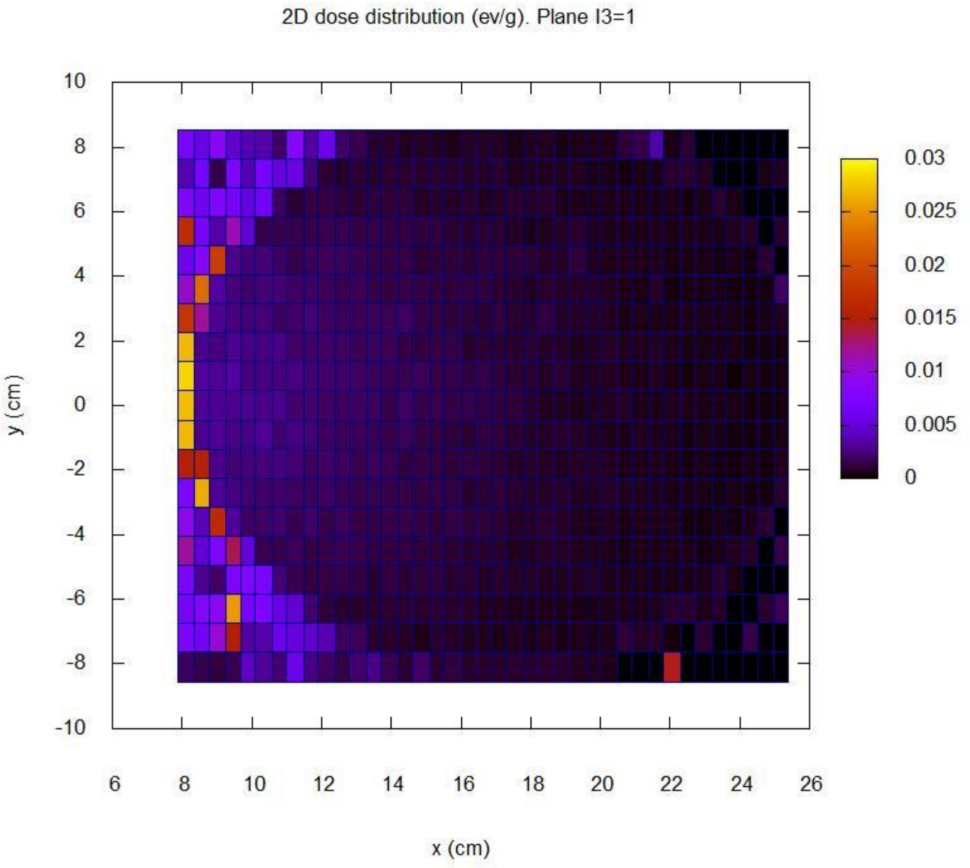
Energy absorbed in sample canister



-1.63347, 12.9397

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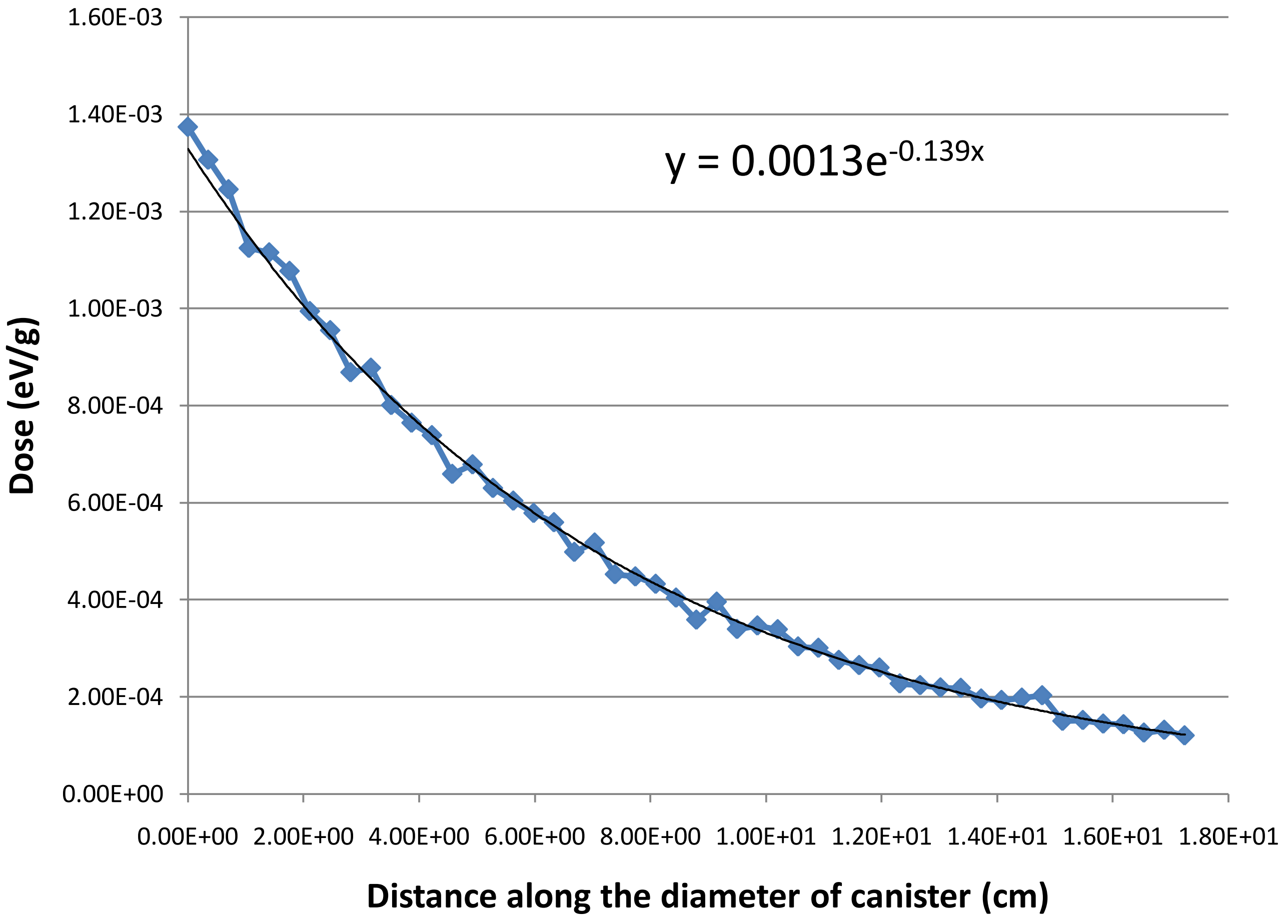
Depth-dose distribution static case



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Dose distribution (dynamic)

- The sample cylinders are rotating around the X-ray source
- The sample cylinders are fixed around their axis of symmetry for an observer outside the irradiation chamber
- Nine energy detectors in the form of concentric cylindrical shells were simulated inside each sample container
- The energy absorbed in each one of the detectors was determined from the simulation

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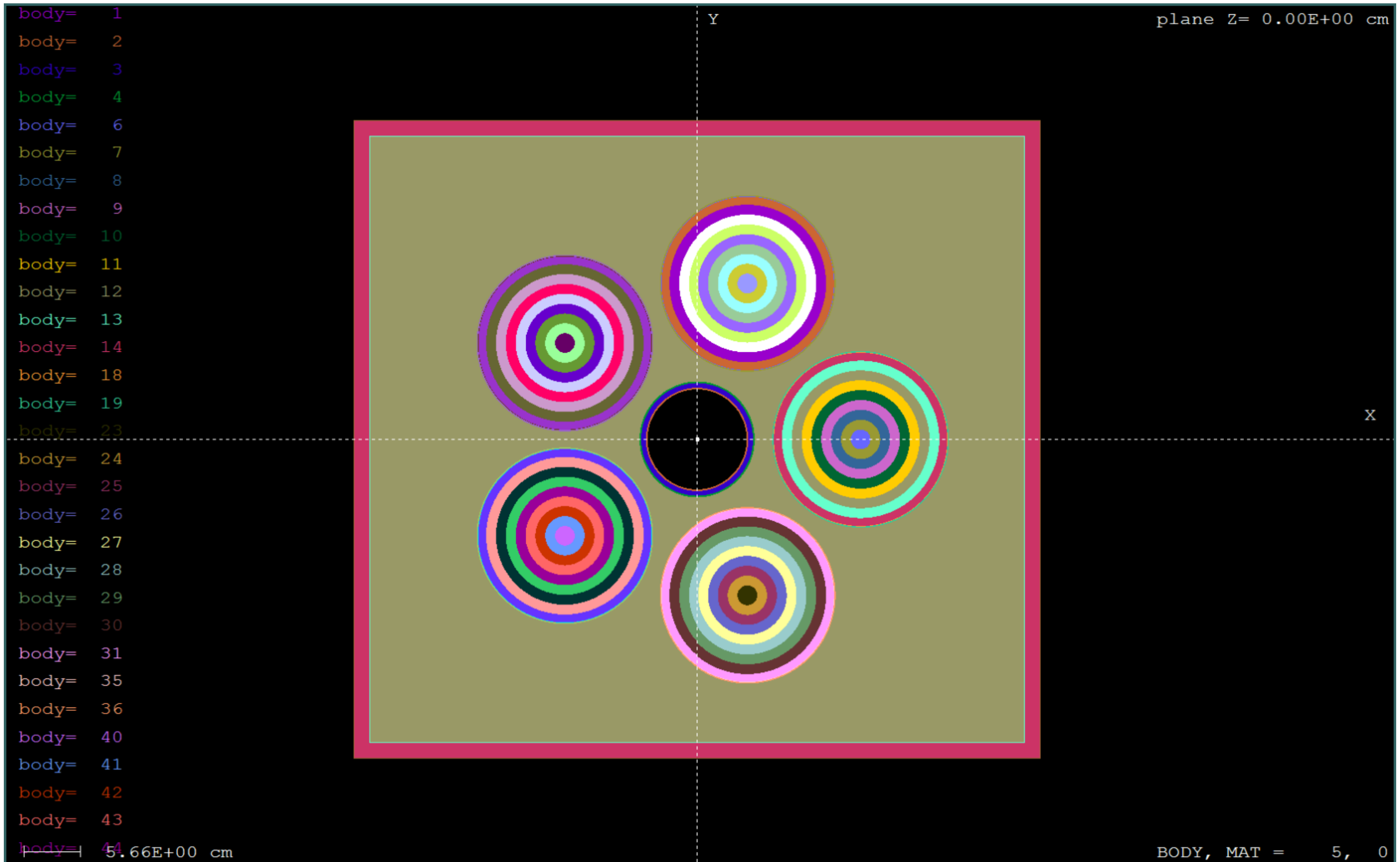
Geometry file to obtain dose distribution in canisters (dynamic)



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Dose in each detector

$$D = \frac{E}{m}$$

E is the energy deposited in each detector obtained from the simulation in eV/e

m is the mass of the cylindrical shell detector

$$m = \pi\rho(r_o^2 - r_i^2)l$$

r_o and r_i are the outer and inner radii of the shell; l the length of the cylinder and ρ the density of water

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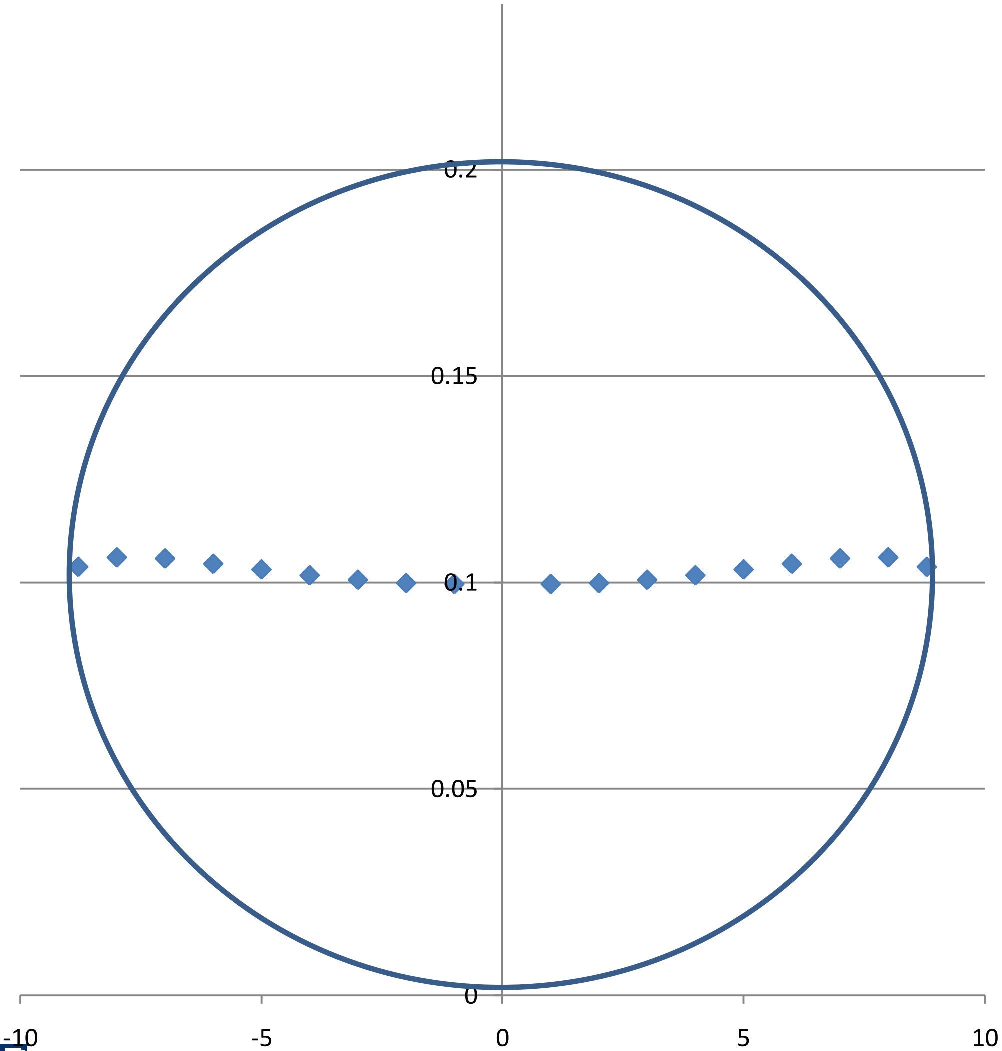
Dose distribution (dynamic)



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Experimental results

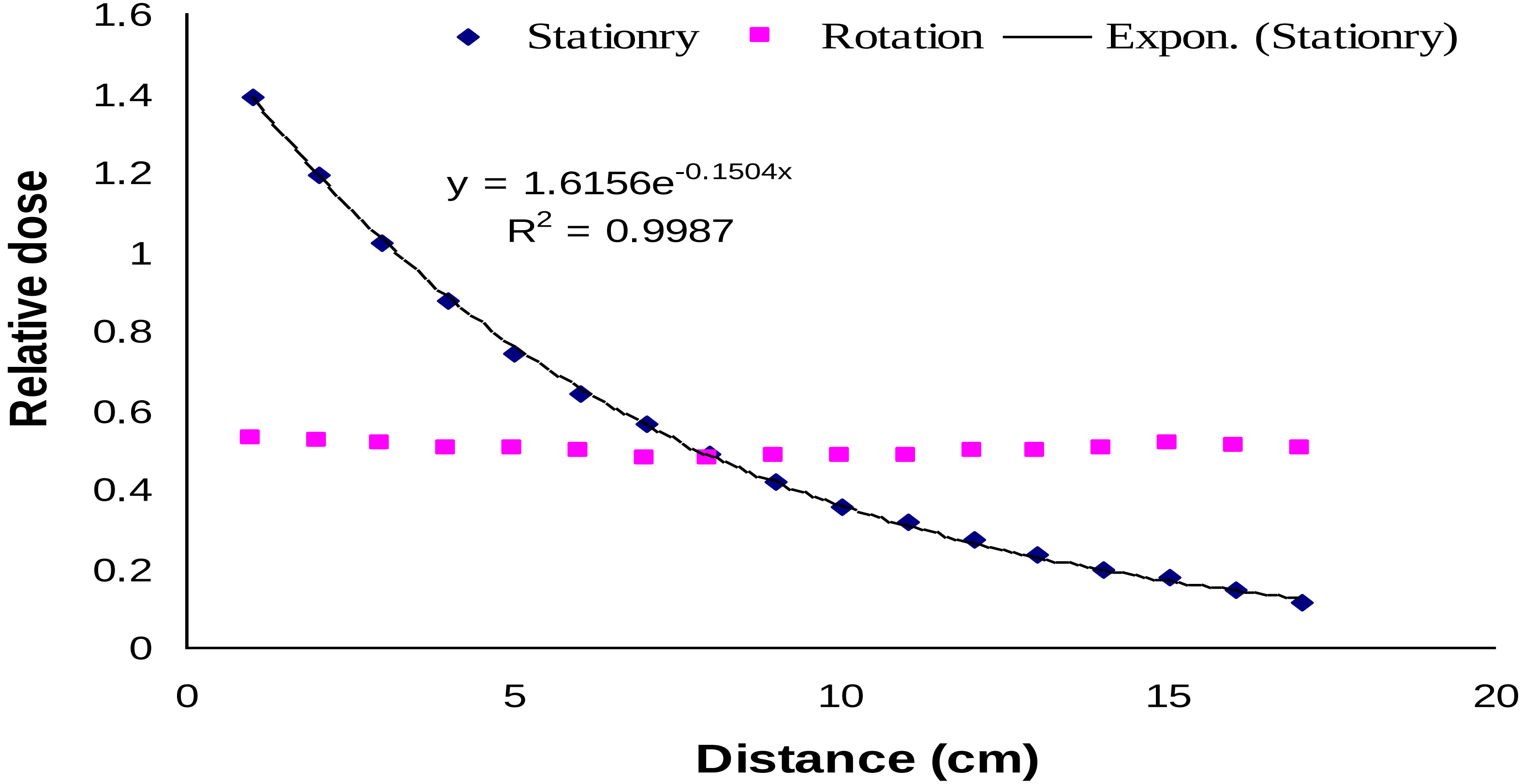

Fig. 9. Radial dose/depth distribution with and without rotation

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Conclusions

Dose Uniformity Ratio (DUR)

	Simulation	Experiment	% Difference
Static	1.15	1.16	0.9
Dynamic	1.06	1.08	1.9

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