Simulation Results for Different Setups to Define the Shadow of Eppendorf Tube

Zohrab Amirkhanyan

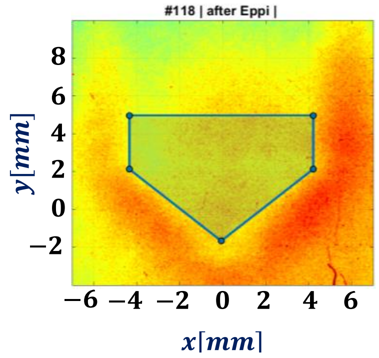
HELMHOLTZ

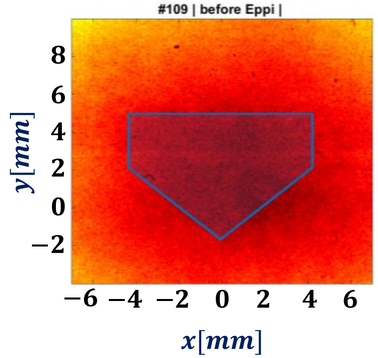
The goal and simulation setup

Film Analysis in Radiation Dose Calculations:

- In film analysis, the back film of the tube is used to determine the position of the tube relative to the beam.
- This information is then used to find the shape of the tube on the front film of the tube.
- The data obtained is then used to calculate the dose received by the irradiated sample.

However, this method has limitations, such as variations in the sizes of the films used and the need for manual cropping of images from the scanner.



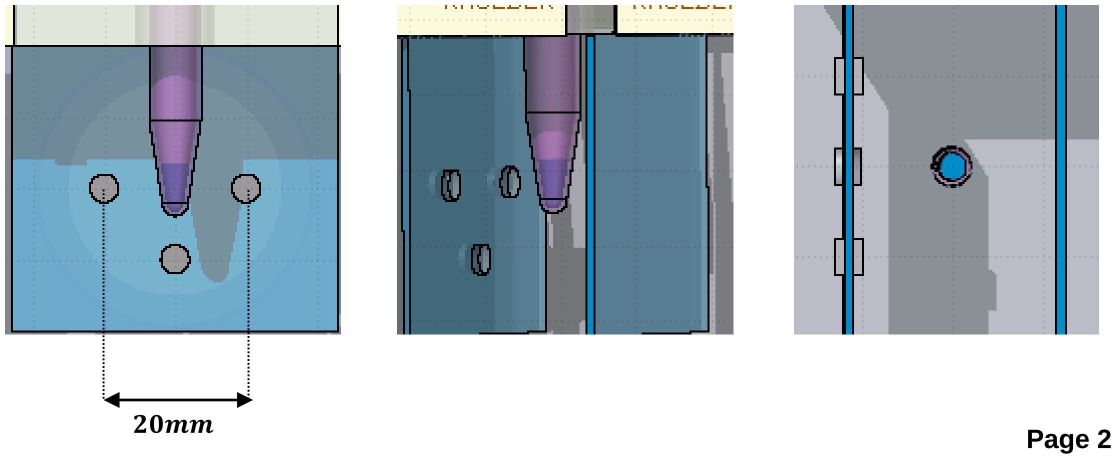


Improving Accuracy in Radiation Dose Calculations

- The primary objective of this study is to determine the optimal settings for obtaining a shadow of the same point on both the back and front films of the tube.
- This will improve the accuracy of film analysis in radiation dose calculations.

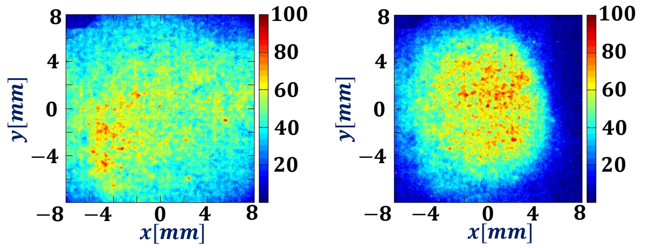
Simulation Setup

- For obtaining shadow on both films, three 4mm diameter holes were made in the front film of the tube.
- The simulations were carried out for two cases:
  - ➢ **The hole area: air (empty)**
  - ➢ **Aluminum discs 2 mm thick and a diameter of 4mm are attached to both sides, without the need to cut holes in the film.**



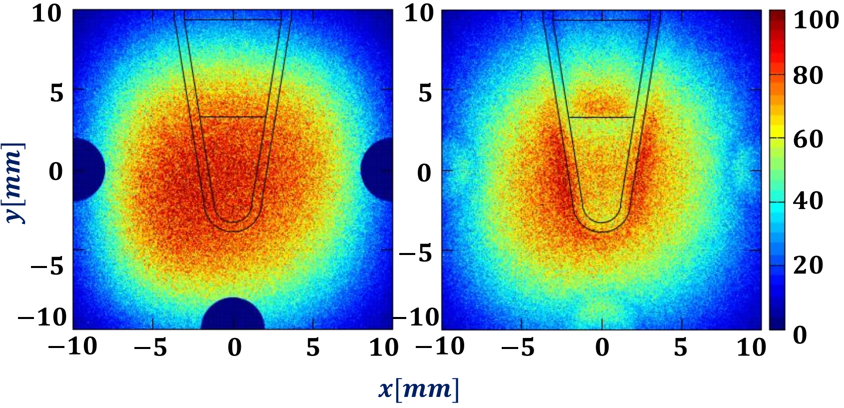
Dose profile on films

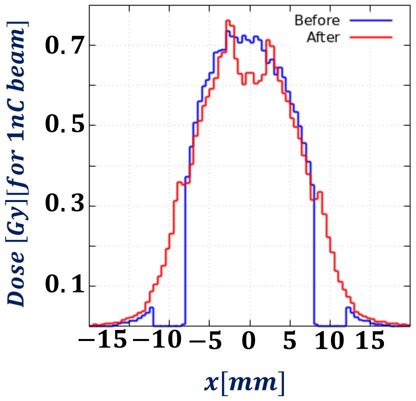
Epp. Tube $0.5mL$ with water volume $50\mu L$



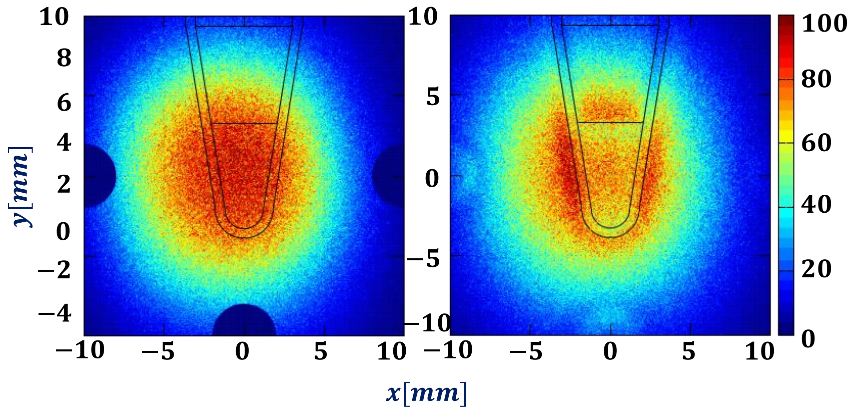
Air

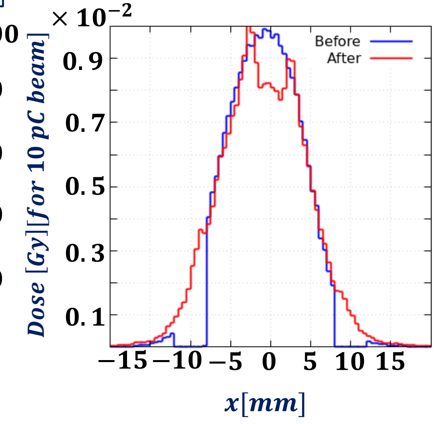
Dose Profile Before of Tube | *Dose Profile After of Tube*





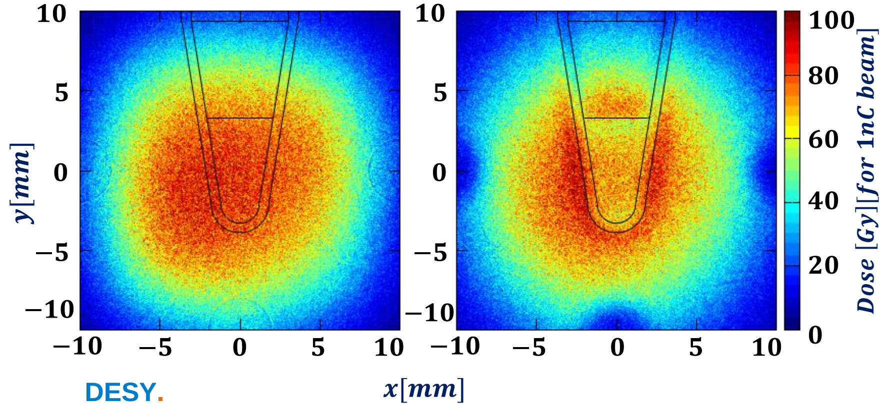
Dose Profile Before of Tube | *Dose Profile After of Tube*

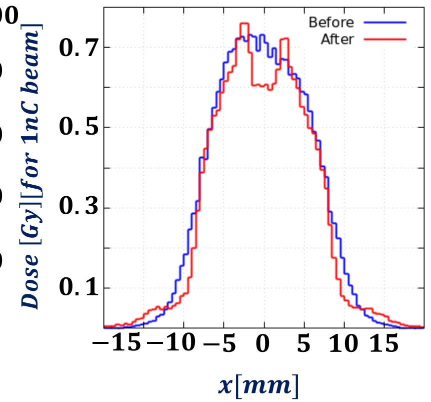




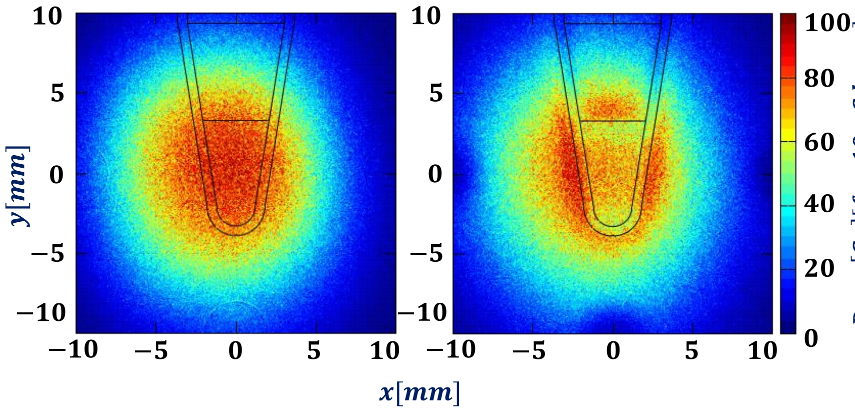
Aluminum disc

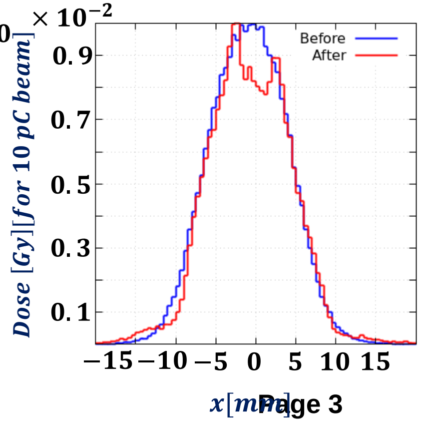
Dose Profile Before of Tube | *Dose Profile After of Tube*





Dose Profile Before of Tube | *Dose Profile After of Tube*

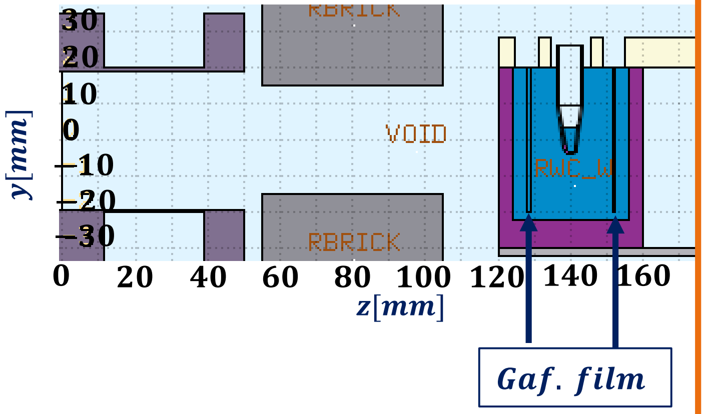




Simulation Setup

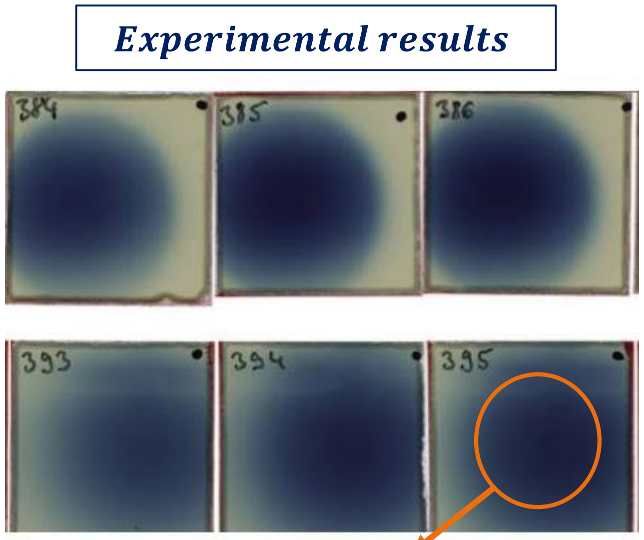
Current Geometry setting:

- The tube in water bath

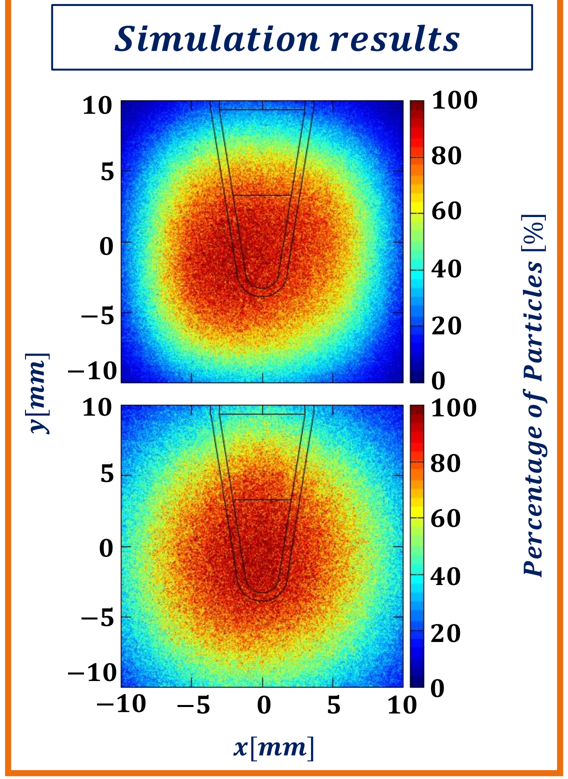


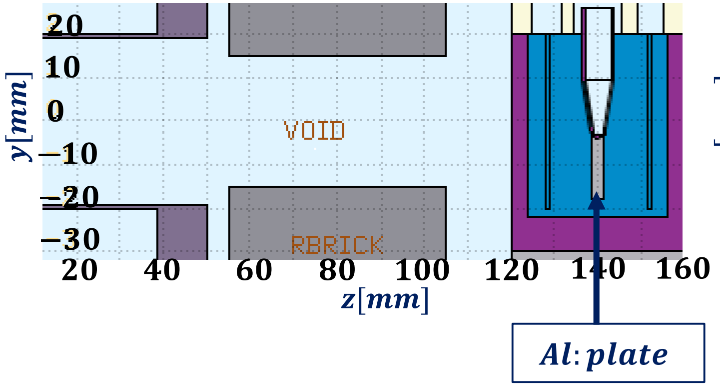
New Geometry setting:

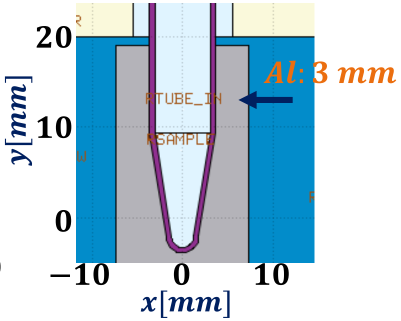
- Aluminum plate with the Epp. tube-shaped cutout.
- The thickness of the plate is 3 mm, which is installed in the position of the tube.

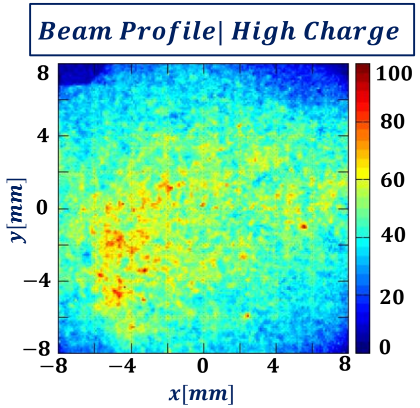


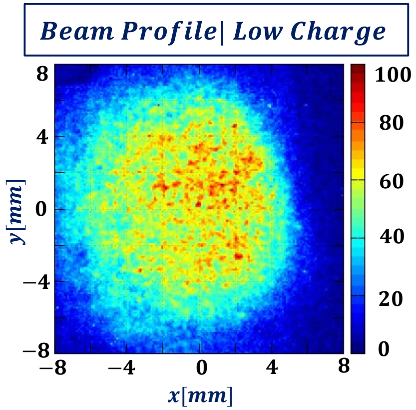
We can't distinguish the position of the tube.





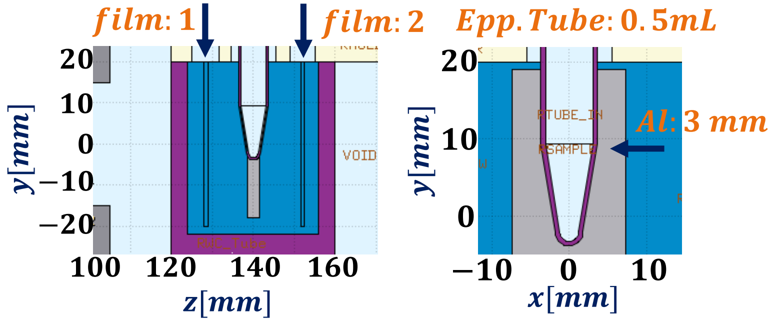


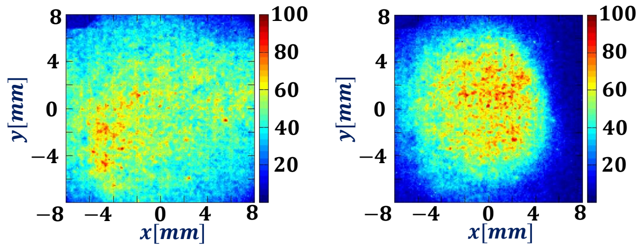




Epp. Tube 0.5mL

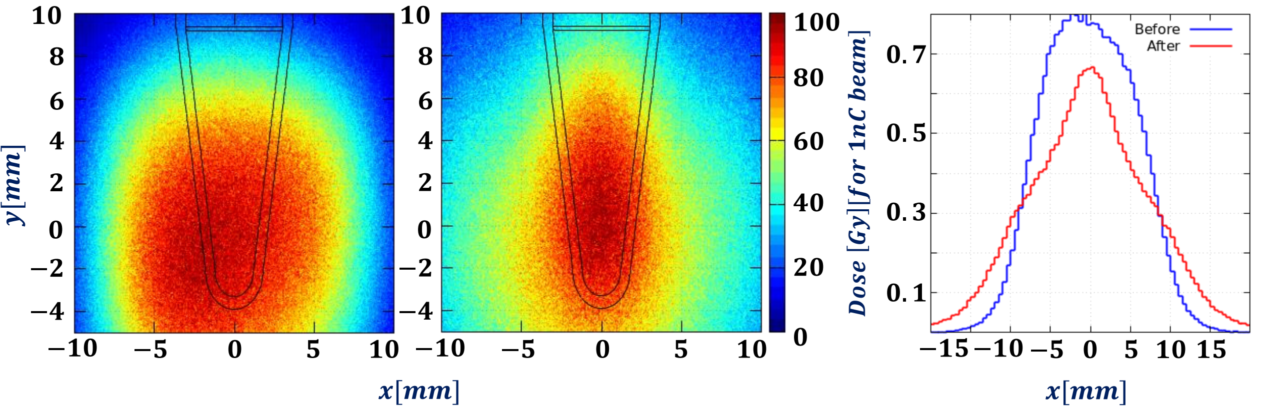
Dose distribution on films

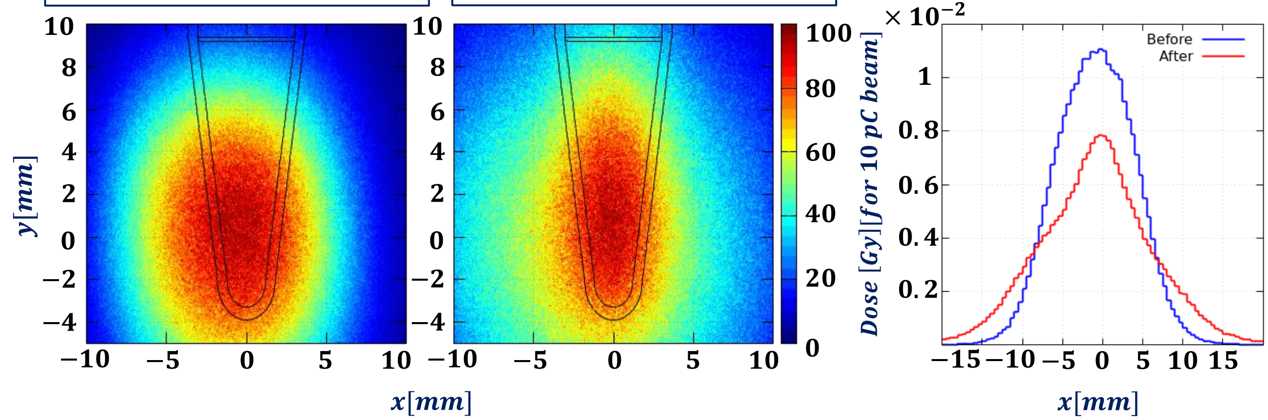




Beam propagates on axis

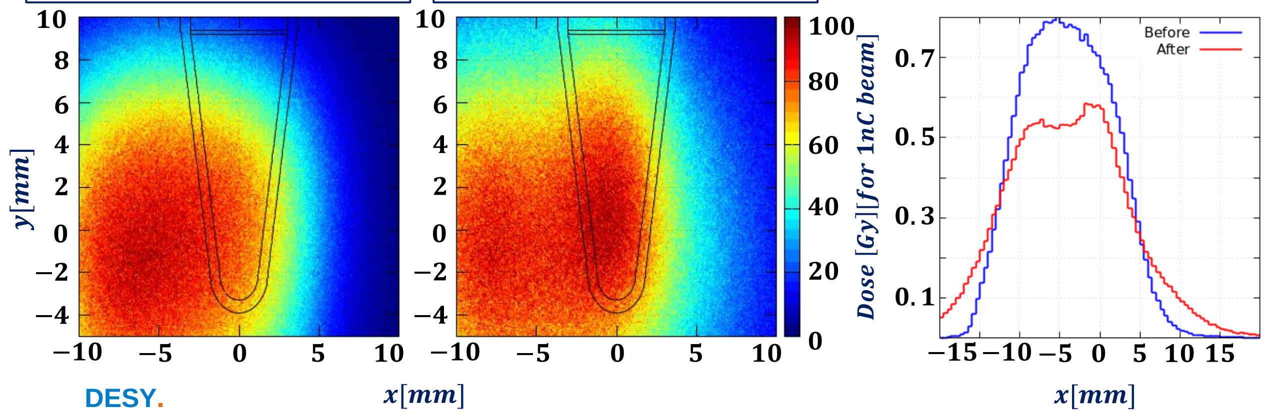
Dose Profile Before of Tube | *Dose Profile After of Tube* | *Dose Profile Before of Tube* | *Dose Profile After of Tube*

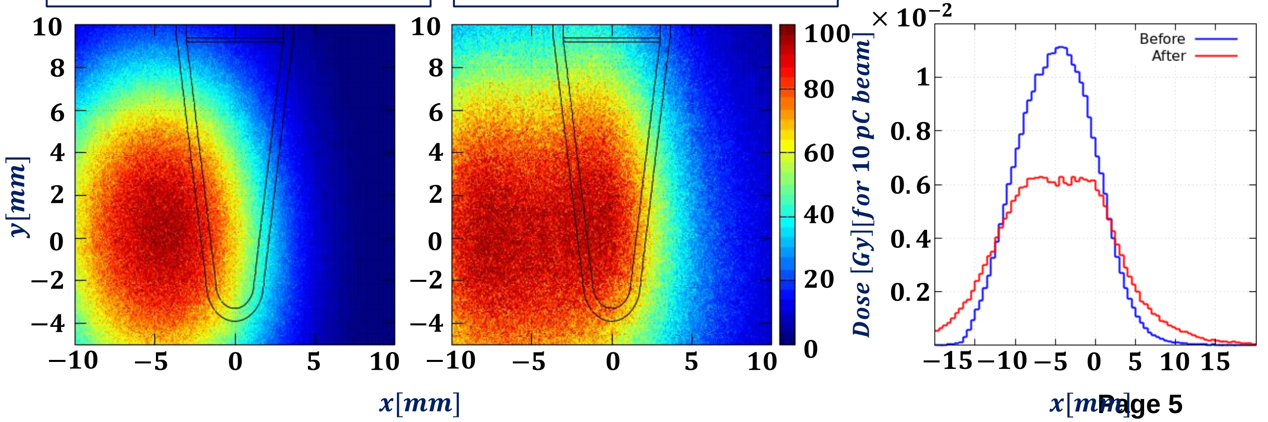




Beam propagates off axis

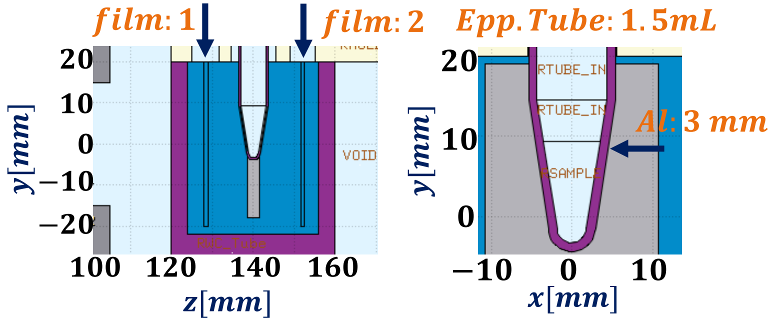
Dose Profile Before of Tube | *Dose Profile After of Tube* | *Dose Profile Before of Tube* | *Dose Profile After of Tube*

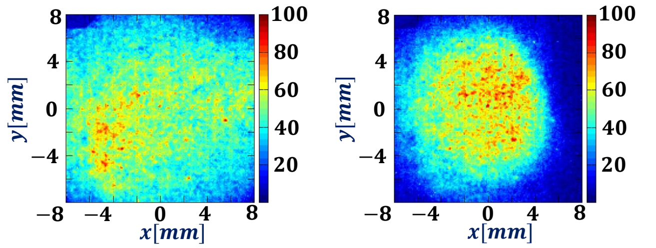




Epp. Tube 1.5mL

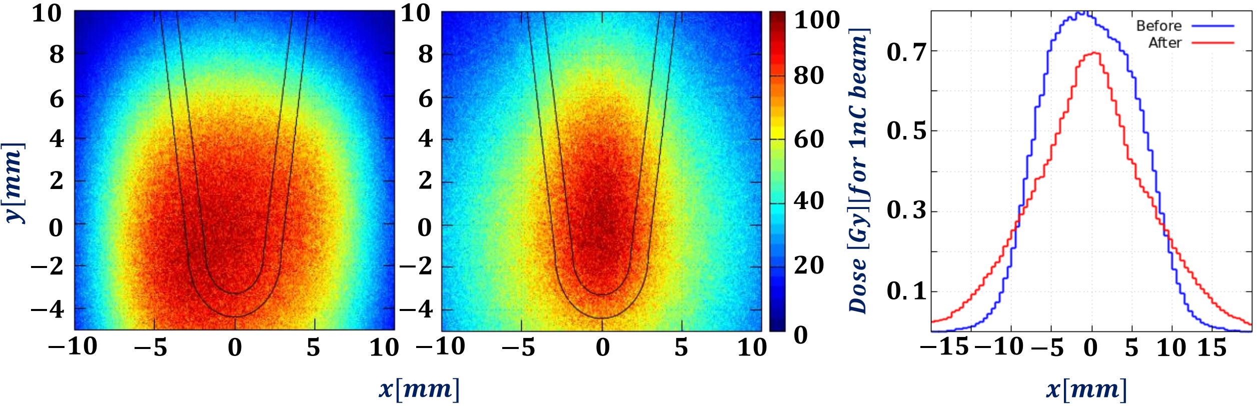
Dose distribution on films



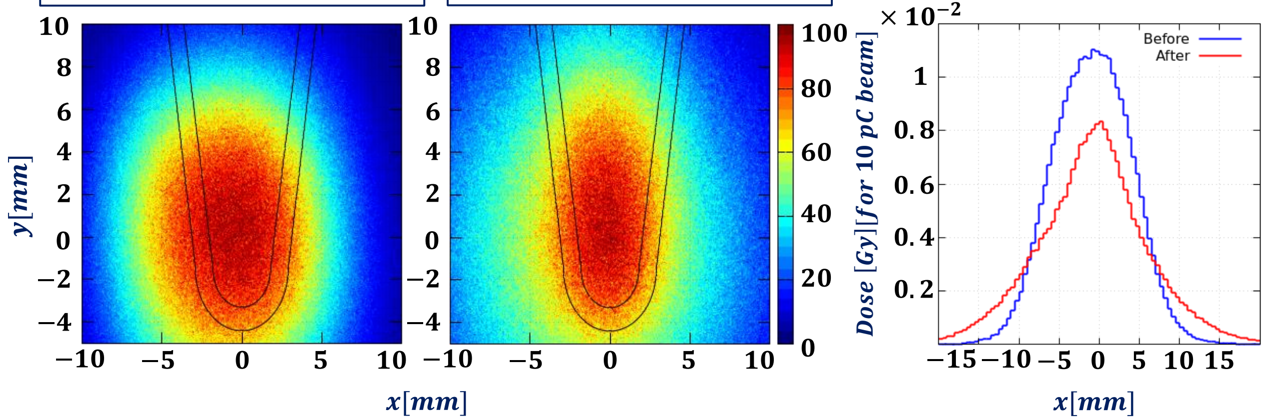


Beam propagates *on axis*

Dose Profile Before of Tube | *Dose Profile After of Tube*

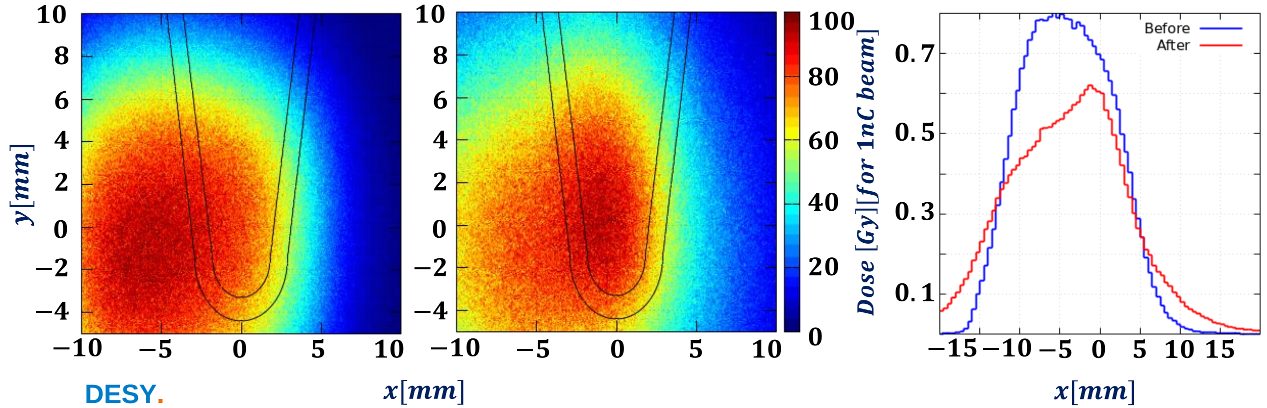


Dose Profile Before of Tube | *Dose Profile After of Tube*

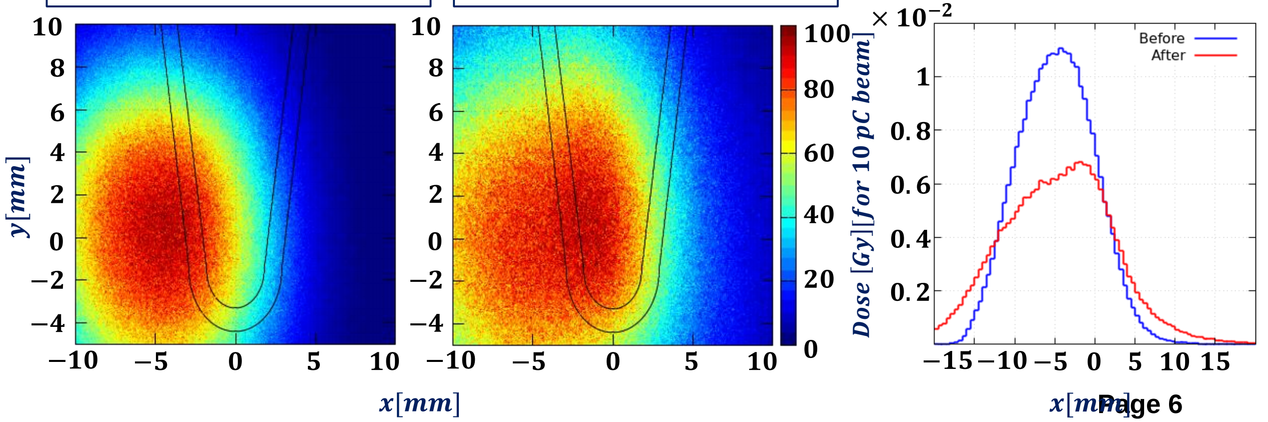


Beam propagates *off axis*

Dose Profile Before of Tube | *Dose Profile After of Tube*

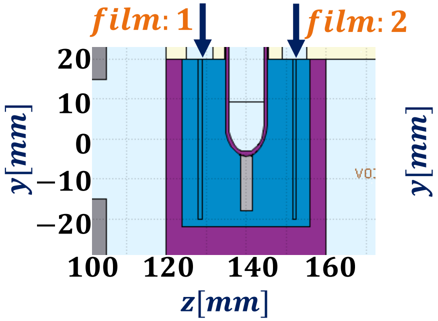


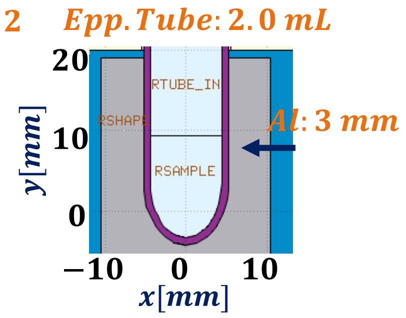
Dose Profile Before of Tube | *Dose Profile After of Tube*

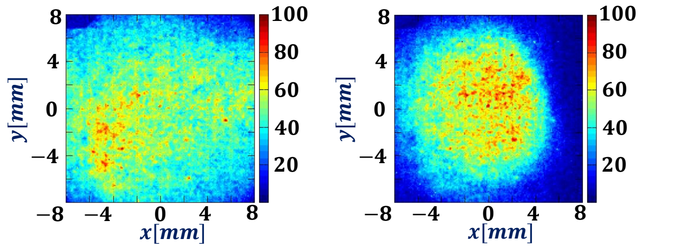


Epp. Tube 2.0mL

Dose distribution on films

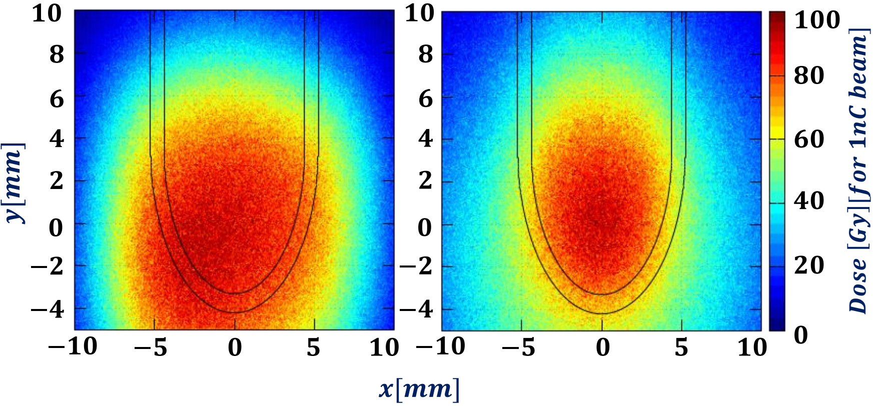


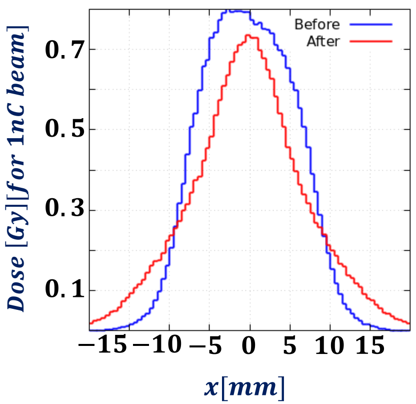




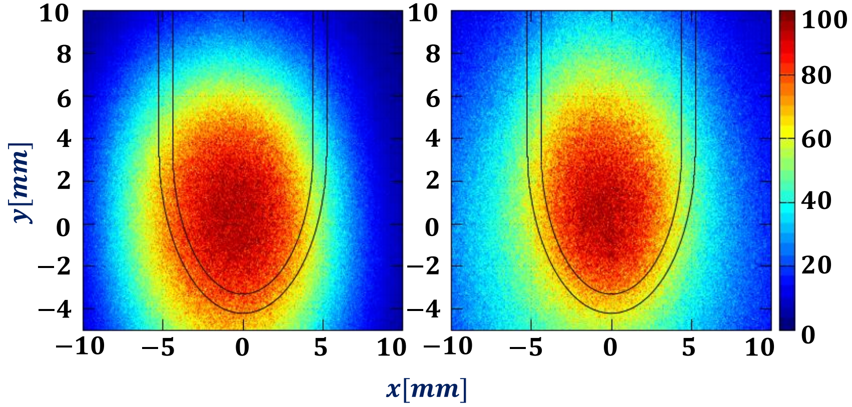
Beam propagates *on axis*

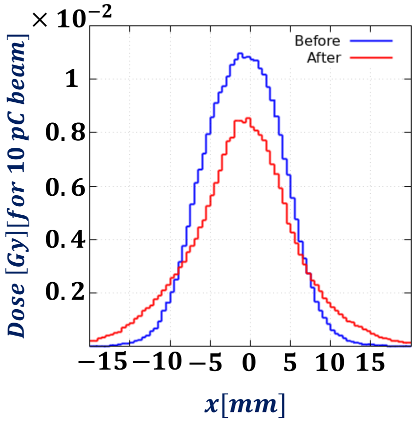
Dose Profile Before of Tube | *Dose Profile After of Tube*





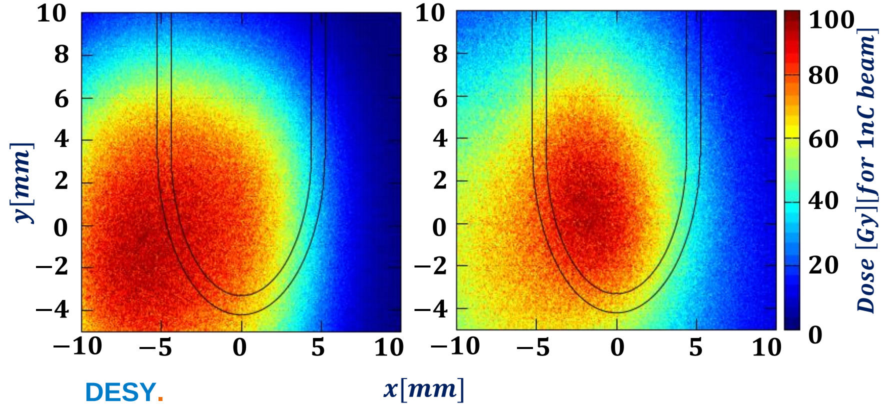
Dose Profile Before of Tube | *Dose Profile After of Tube*

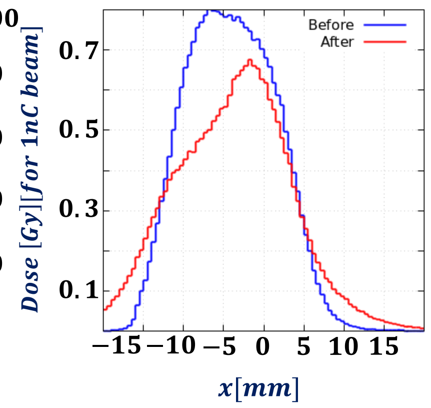




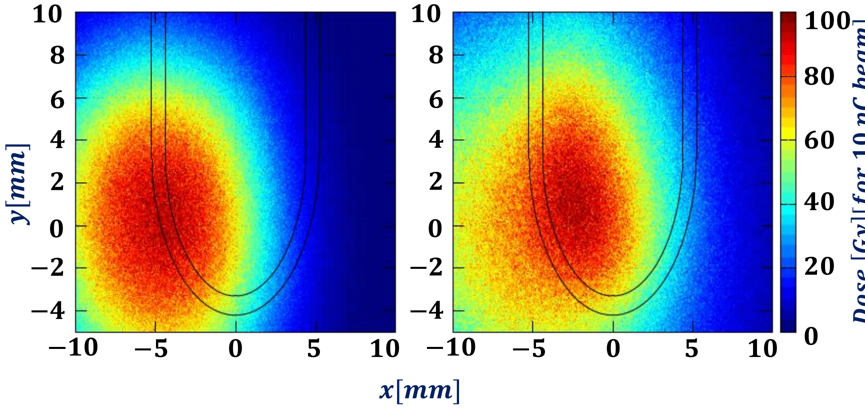
Beam propagates *off axis*

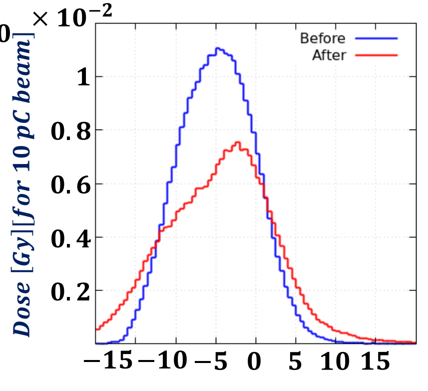
Dose Profile Before of Tube | *Dose Profile After of Tube*



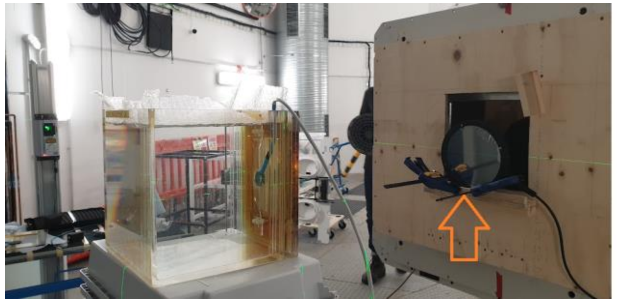


Dose Profile Before of Tube | *Dose Profile After of Tube*





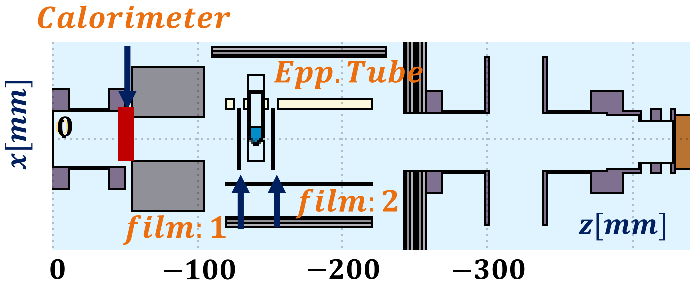
Transmission calorimeter

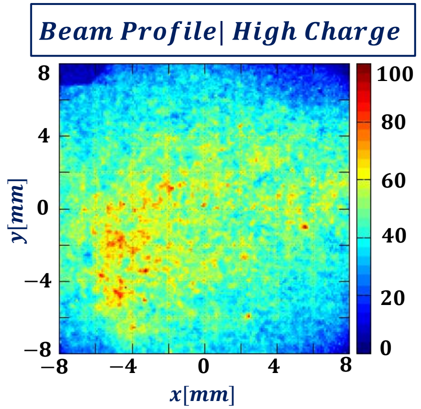


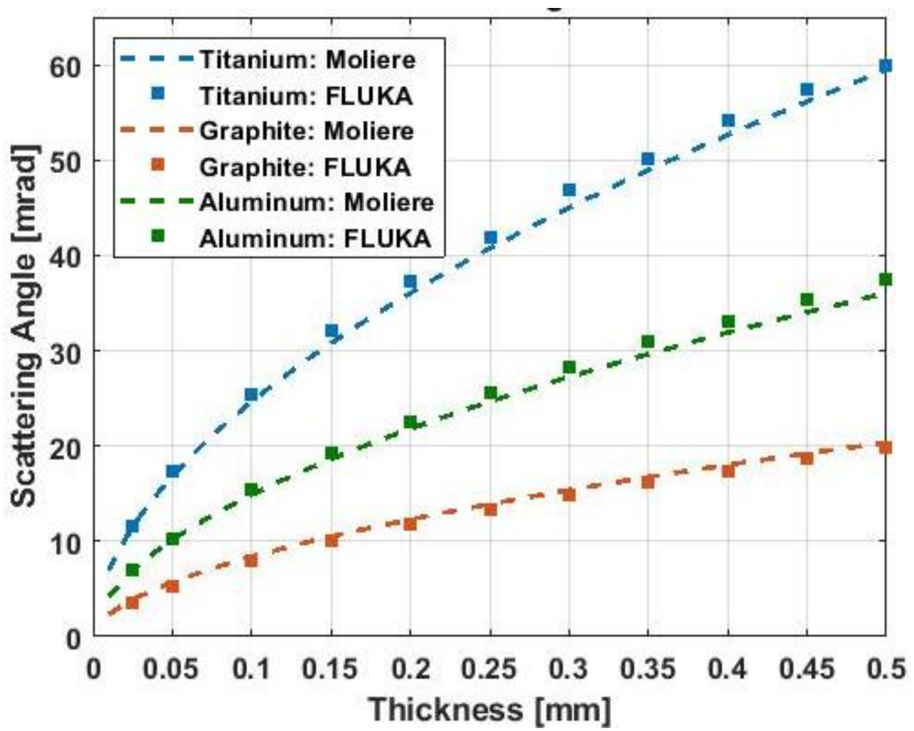
- The transmission calorimeter is an effective device for monitoring radiation dose in high-dose-rate environments.
- However, it is important to simulate and understand the impact that the transmission calorimeter can have on the radiation beam.

In the simulation, I used the transmission calorimeter exposure with the following settings:

- Calorimeter diameter: **5 cm**
- Calorimeter material: aluminum or graphite
- Calorimeter thickness: varied from **0.2 to 0.6 mm**
- Calorimeter was placed in front of a lead brick to model a realistic radiation environment.



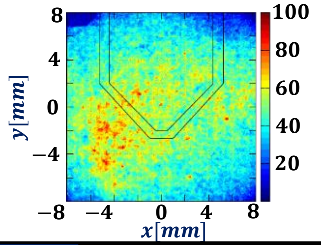




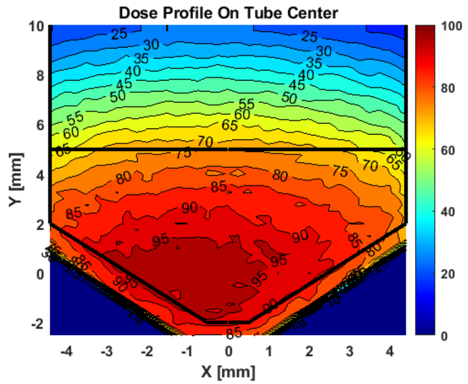
RMS of the electron scattering angle depending on the thickness of the material blue: titanium; red: graphite; green: aluminum

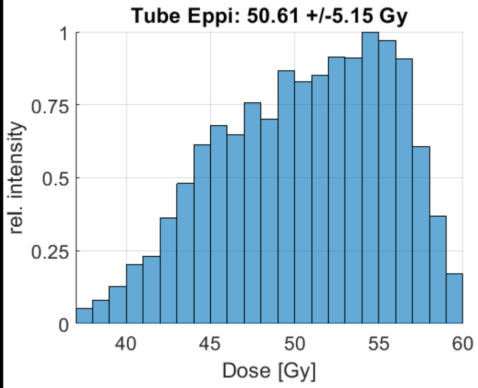
Transmission calorimeter

Dose profile on Epp. Tube center; tube type $2.0\ mL$

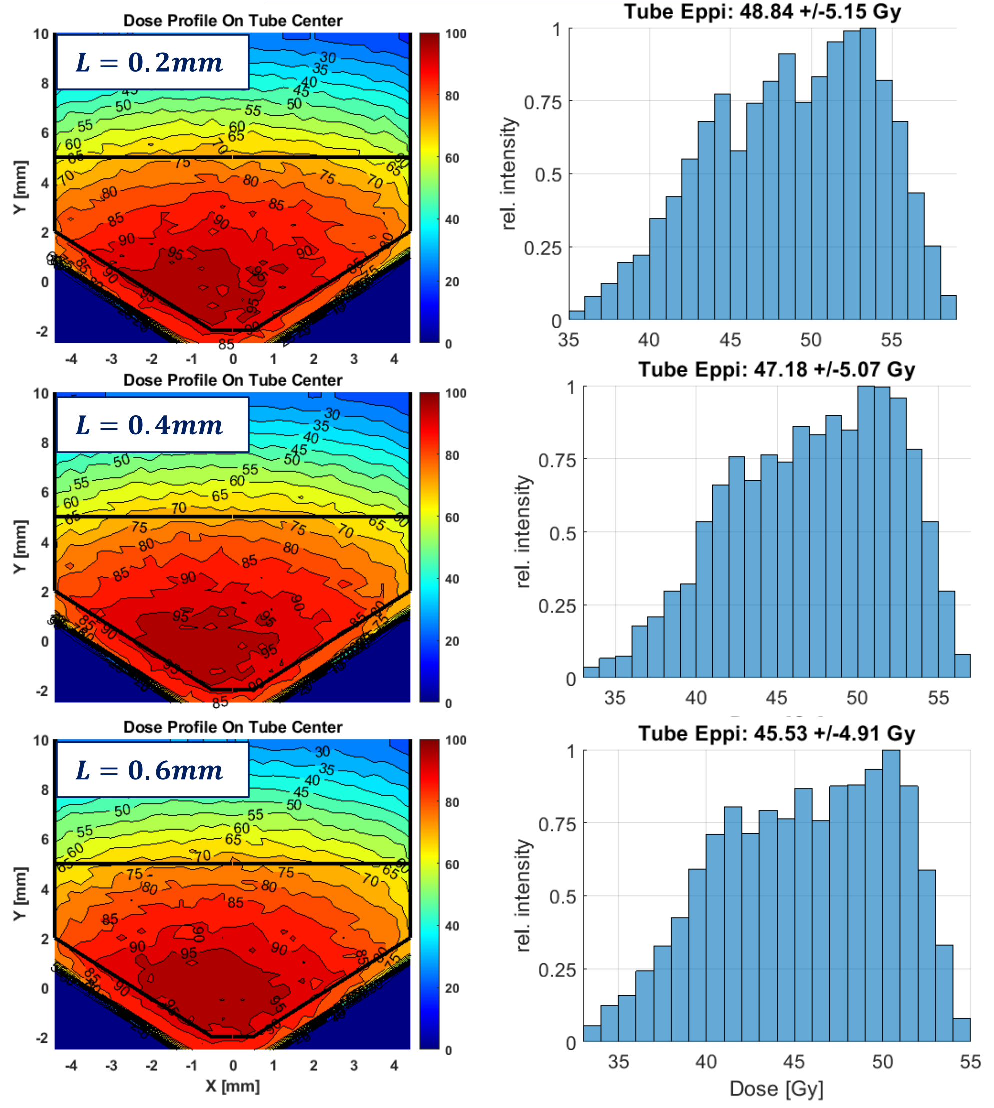


no colorimeter

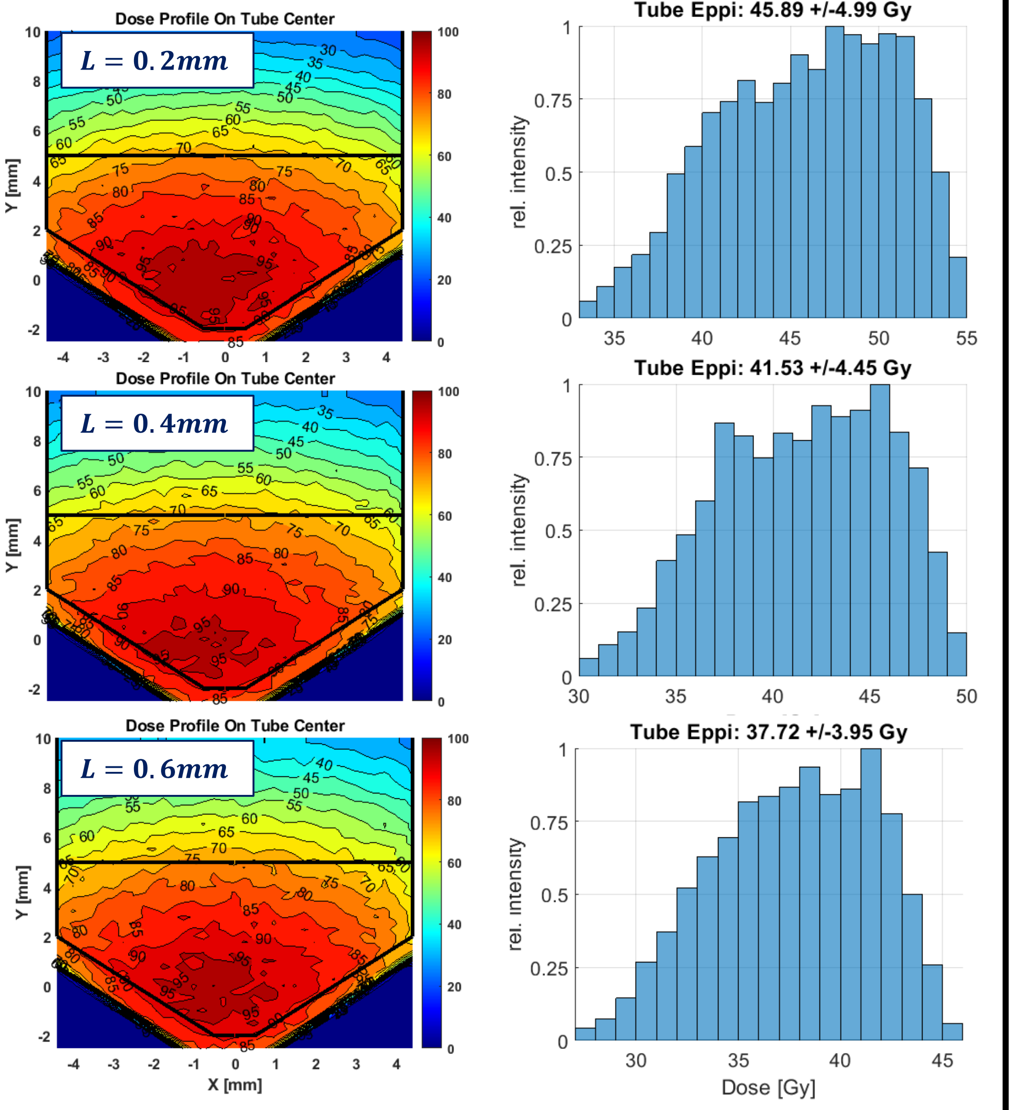




Material: graphite



Material: aluminum



Summary

Simulation results

- By using a hole or attaching aluminum discs onto the front film, it is possible to produce identical point shadows on both the back and front tube films.
- If the Eppendorf tube is submerged in a water bath, a 3 mm thick aluminum plate shaped like a tube can be used to cast a shadow on the back film of the tube.
- The transmission calorimeter is based on
- graphite
  - The scattering angle range of up to **20 mrad** and varying thicknesses **from 0 to 0.6mm**.
  - At thicknesses ranging **from 0 to 0.6 mm**, the dose in the tube is reduced by **10 percent**.
- Aluminum
  - The scattering angle range of up to **38 mrad** and varying thicknesses **from 0 to 0.6mm**.
  - At thicknesses ranging **from 0 to 0.6 mm**, the dose in the tube is reduced by **20 percent**.