EVALUATION OF DOSE DISTRIBUTION IN DIFFERENT EPPENDORF TUBES

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SIMULATION SETUP

- The simulation was performed with the following

  - Geometry
    - Eppendorf tube 0.5mL and 2.0 ml, whose dimensions are shown in fig 1 and fig2.
    - Exit titanium window with a diameter of $30\ mm$ and a thickness of $50\ \mu m$.
    - The distance from the exit window to the center of the tube is 20 mm.
    - Various amounts of water in the tubes.

  - Bam parameters

    - Different Initial beam rms:
      - 0.5mL : $\begin{cases} \sigma_x = 4.83mm; \sigma_y = 3.38mm \\ \sigma_x = 4.32mm;\ \sigma_y = 3.06mm \\ \sigma_x = 3.89mm;\ \sigma_y = 2.40mm \end{cases}$
      - 2.0 ml : $\begin{cases} \sigma_x = 4.83mm; \sigma_y = 3.38mm \\ \sigma_{x,y} = 5.0\ mm \\ \sigma_{x,y} = 6.0\ mm \end{cases}$
    - Beam energy: 22 MeV

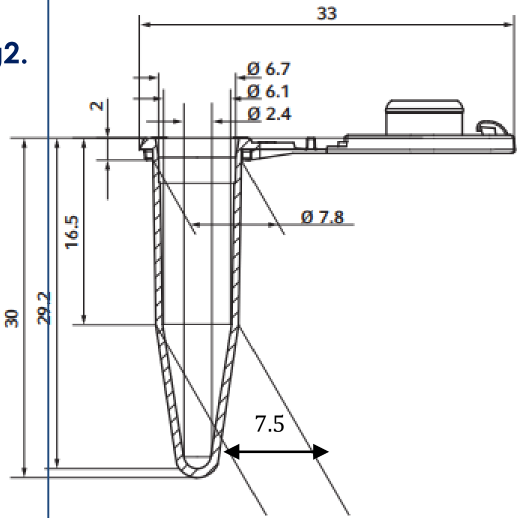
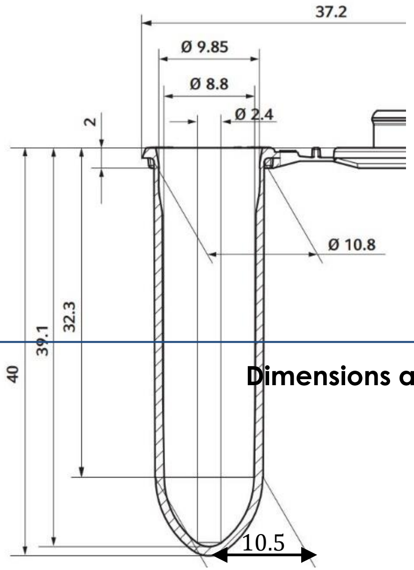


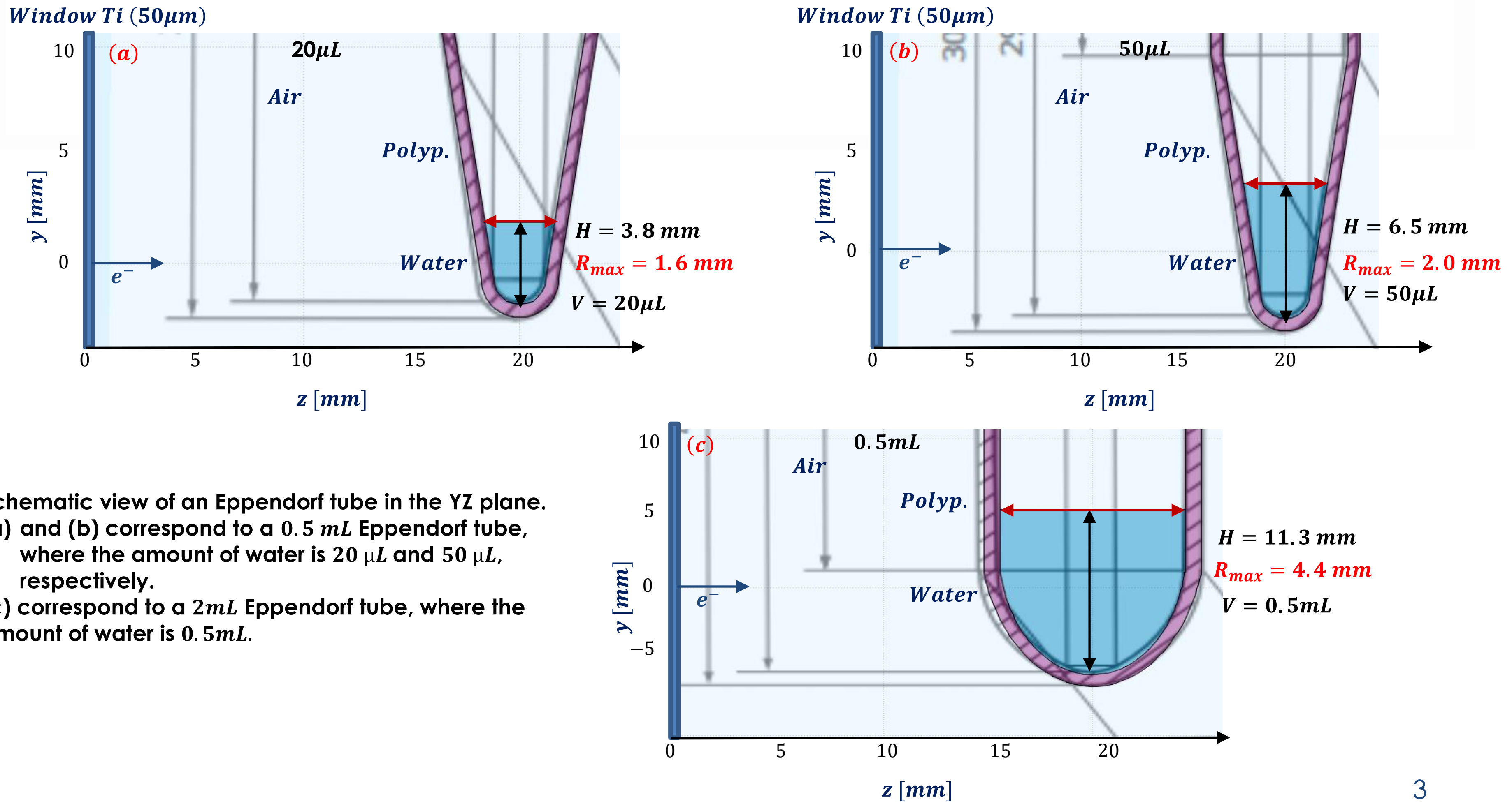
Figure 1: Eppendorf tube 0.5 ml



Dimensions are in millimeters

Figure 2: Eppendorf tube 2.0 ml

EPPENDORF TUBE



Schematic view of an Eppendorf tube in the YZ plane.

(a) and (b) correspond to a $0.5\ mL$ Eppendorf tube, where the amount of water is $20\ \mu L$ and $50\ \mu L$, respectively.

(c) correspond to a $2mL$ Eppendorf tube, where the amount of water is $0.5mL$.

BEAM PROFILE

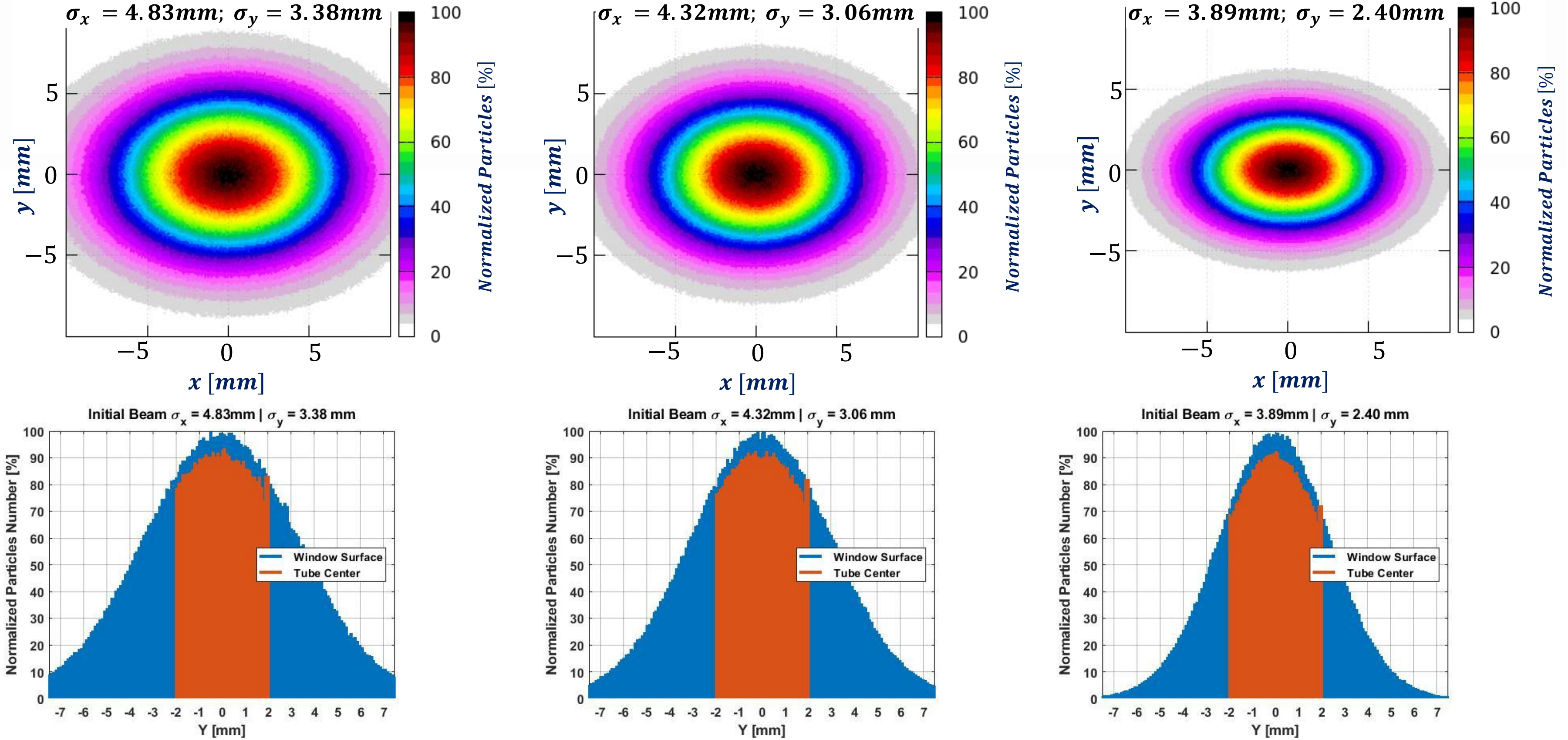


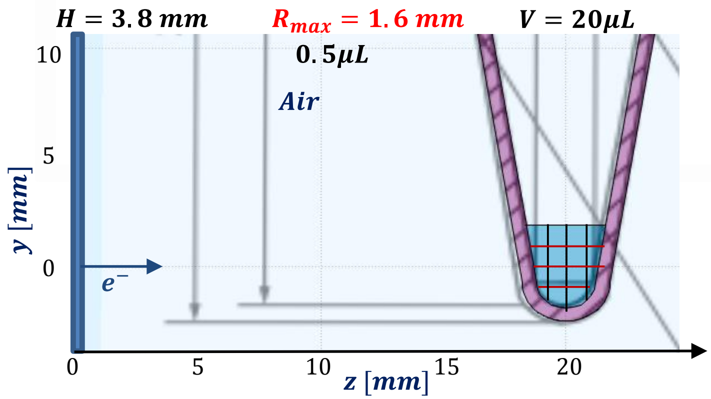
Figure 3: The curves on the graph represent the transverse spatial distribution of the electron beam along the Y axis for different planes: on the exit window surface and in the center of the tube.

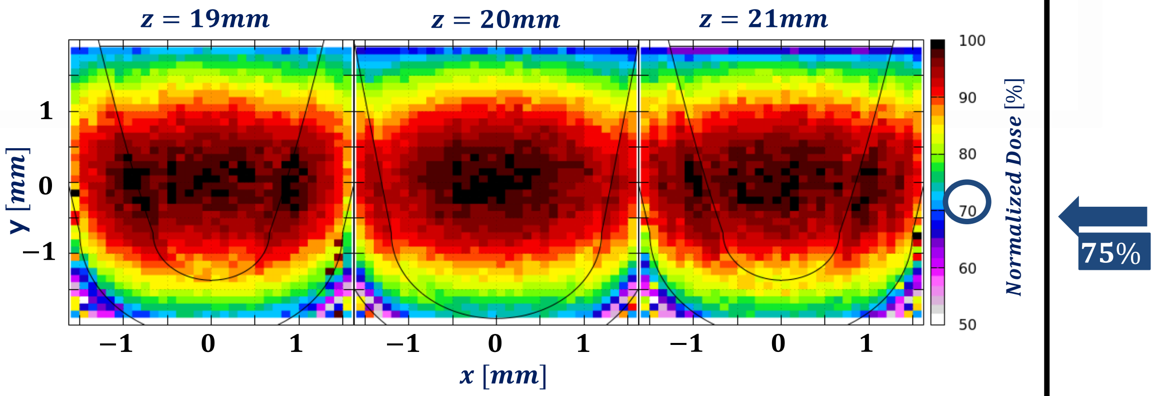
Compared to the amount of particles on the surface of the window and in the center of the tube, about 10% of primary particles are scattered in the window and in the air.

Dose is integral over longitudinal axis 0.1mm.

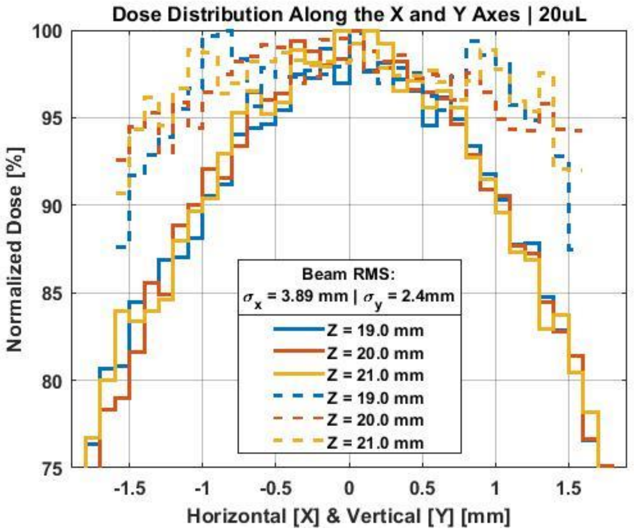
DOSE DISTRIBUTION

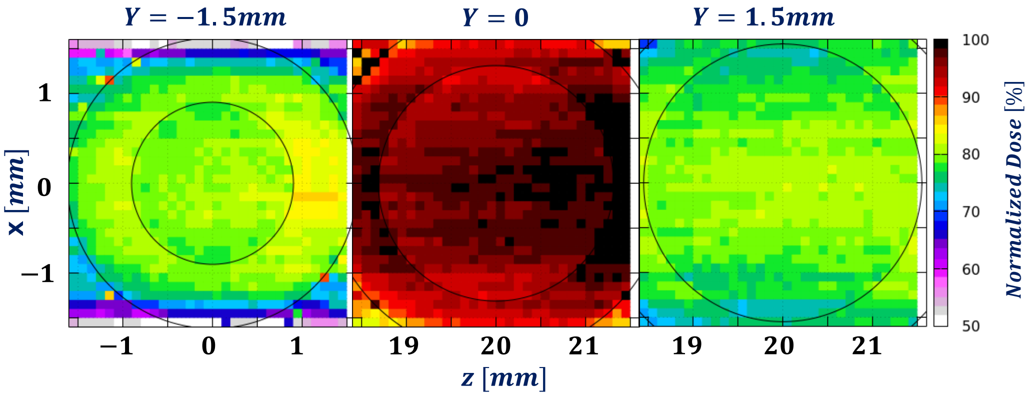
$\sigma_x = 3.89mm; \ \sigma_y = 2.40mm$





Dose distribution in XY plane perpendicular to the incident electrons path.



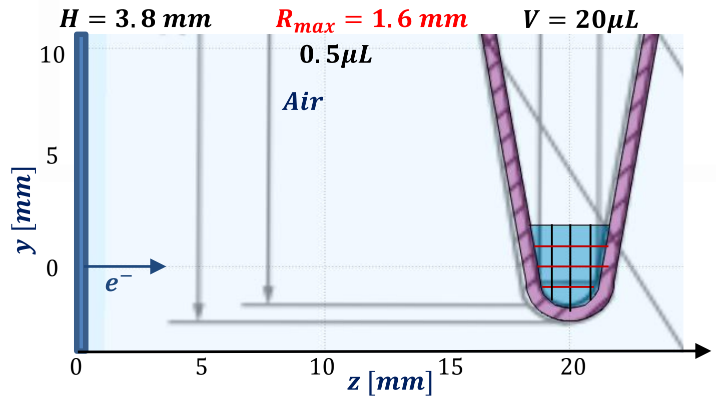


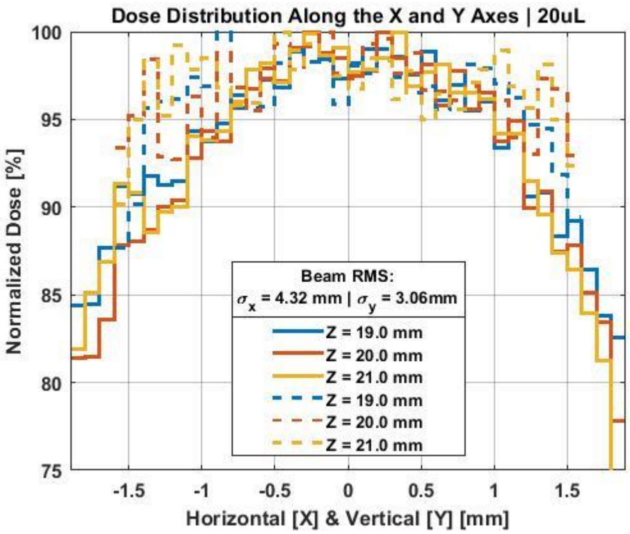
Dose distribution in the XZ plane parallel to the incident electron trajectory.

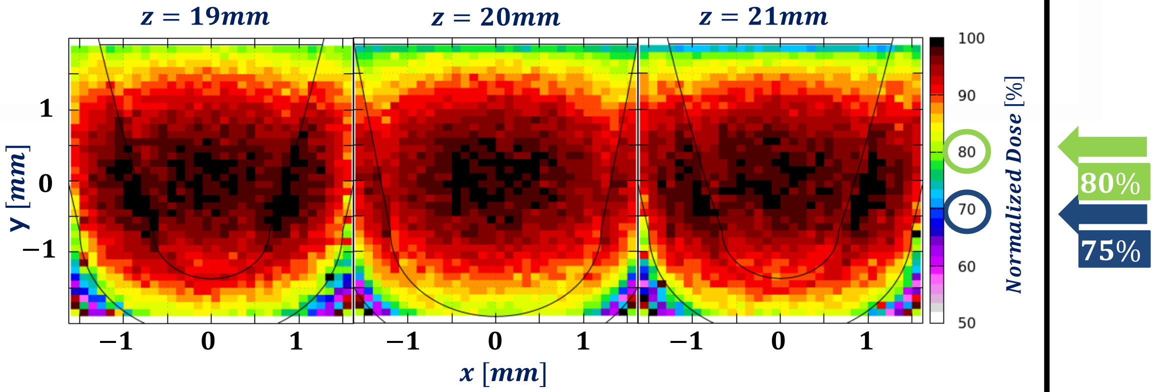
Dose is integral over longitudinal axis 0.1mm.

DOSE DISTRIBUTION

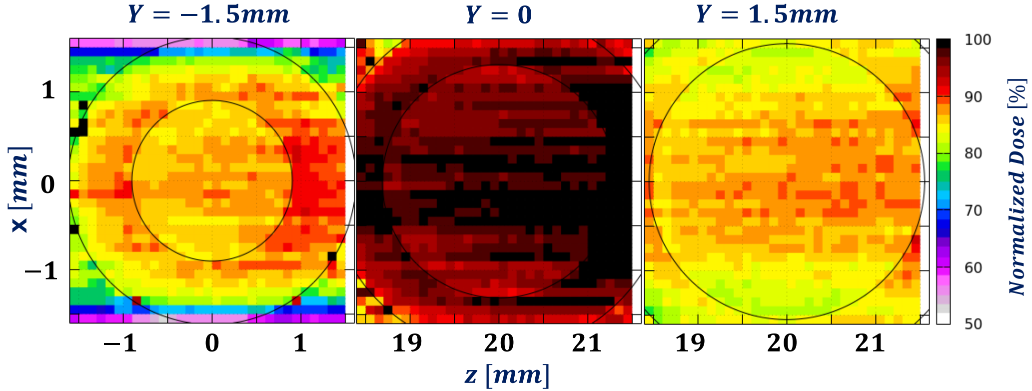
$\sigma_x = 4.32mm;\ \sigma_y = 3.06mm$







Dose distribution in XY plane perpendicular to the incident electrons path.

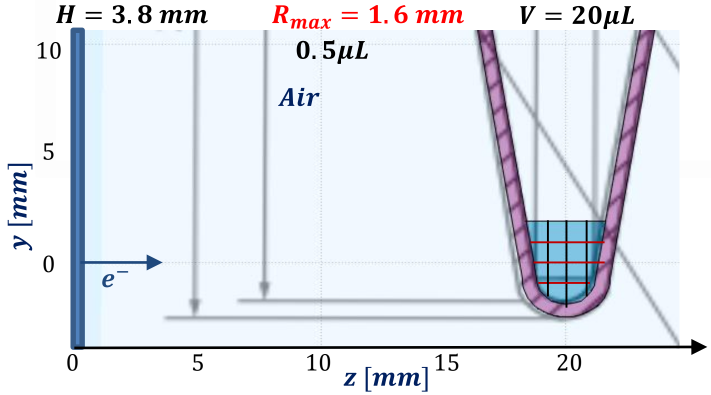


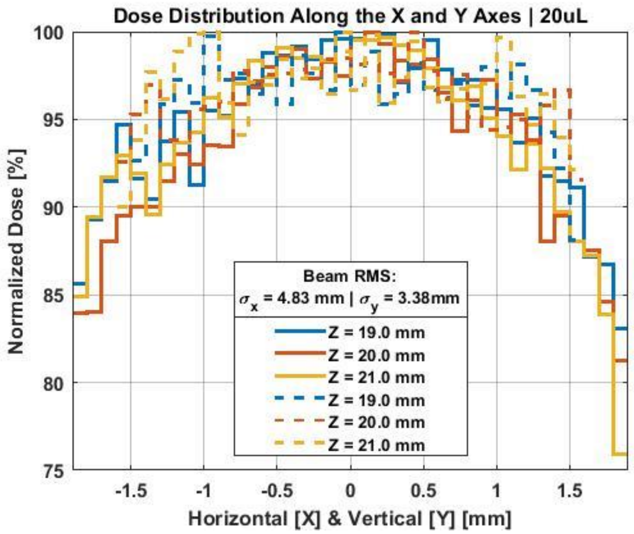
Dose distribution in the XZ plane parallel to the incident electron trajectory.

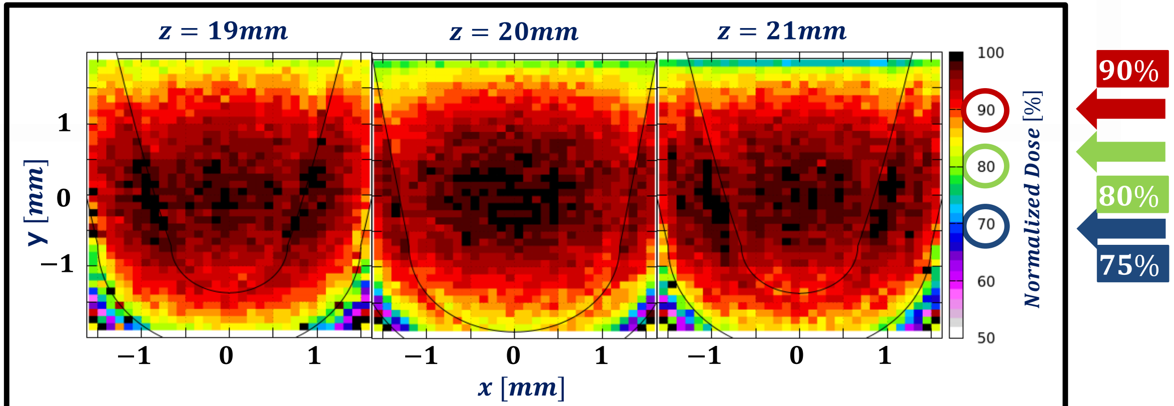
Dose is integral over longitudinal axis 0.1mm.

DOSE DISTRIBUTION

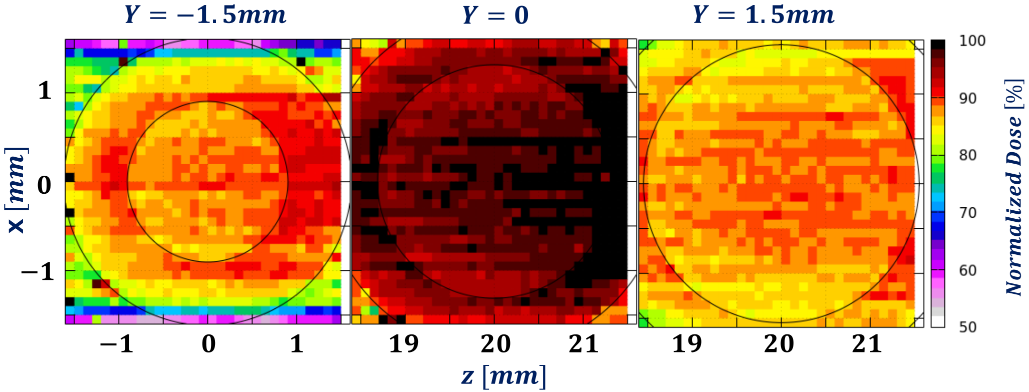
$\sigma_x = 4.83mm;\ \sigma_y = 3.38mm$





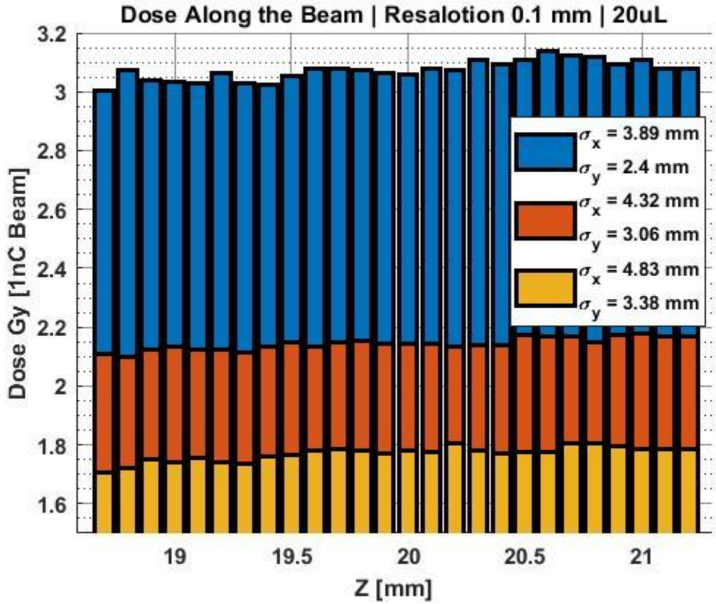


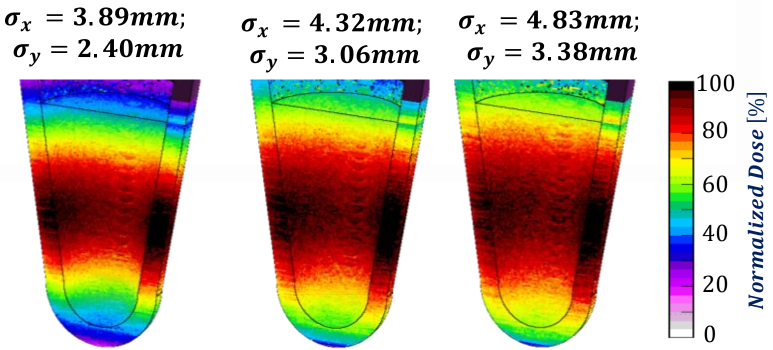
Dose distribution in XY plane perpendicular to the incident electrons path.

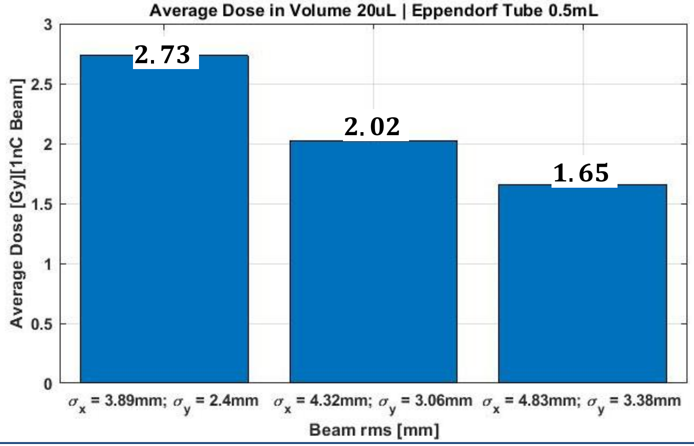


Dose distribution in the XZ plane parallel to the incident electron trajectory.

DOSE DISTRIBUTION







Dose distribution in water along the beam path where two transverse dimensions are integrated for central (a) $0.1 \times 0.1mm^2$.

Line colors correspond to different RMS beam sizes.
The unit of deposition energy is Gy per 1 nC beam.

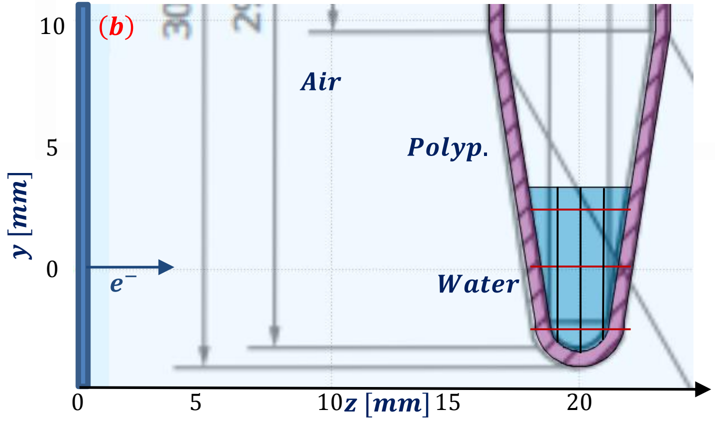
The average energy deposition in the entire volume of water depends on the size of the beam spot.
The volume of water is $20\mu L$.

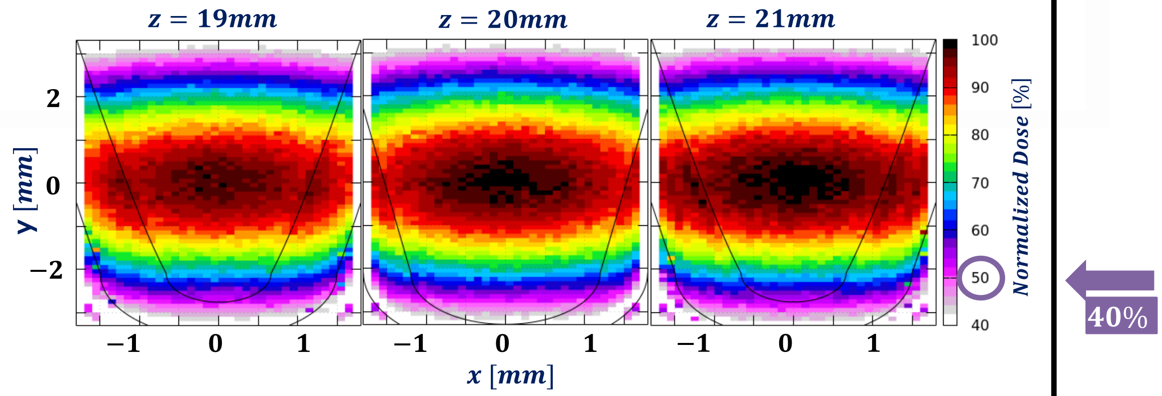
Dose is integral over longitudinal axis 0.1mm.

DOSE DISTRIBUTION

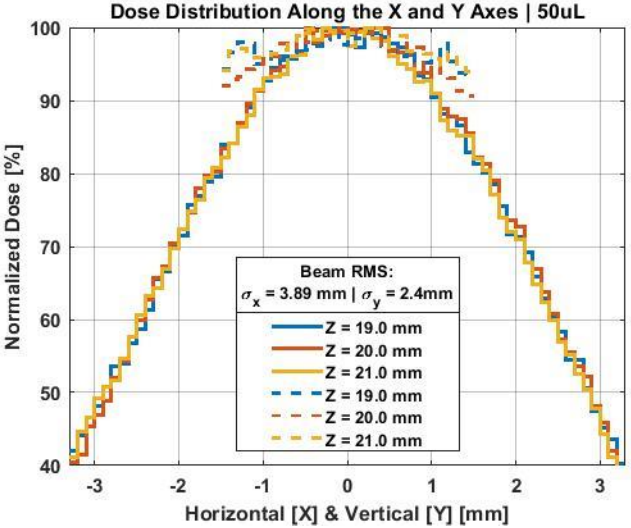
$\sigma_x = 3.89mm;\ \sigma_y = 2.40mm$

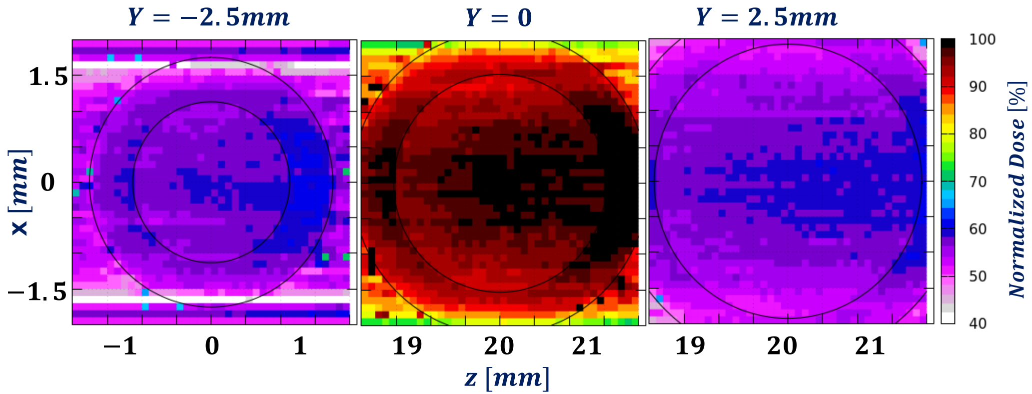
$H = 6.5\ mm$ $R_{max} = 2.0\ mm$ $V = 50\mu L$





Dose distribution in XY plane perpendicular to the incident electrons path.





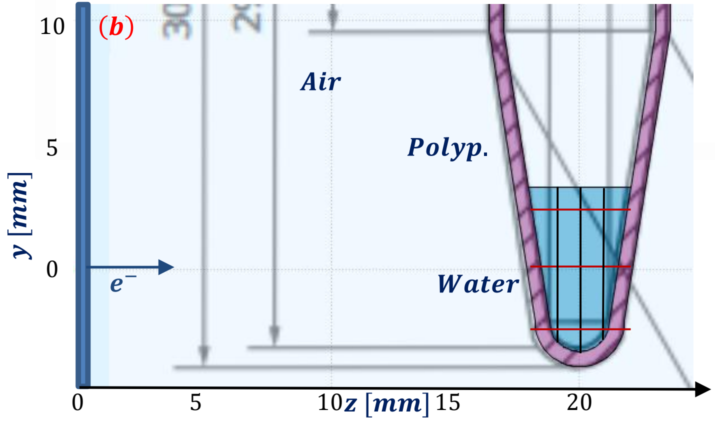
Dose distribution in the XZ plane parallel to the incident electron trajectory.

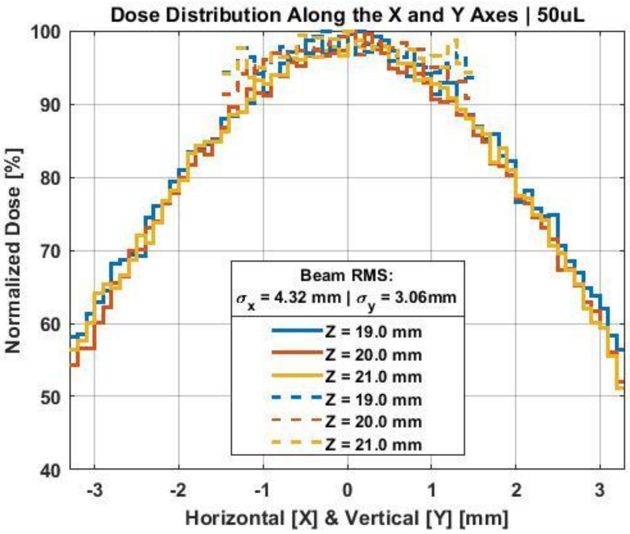
Dose is integral over longitudinal axis 0.1mm.

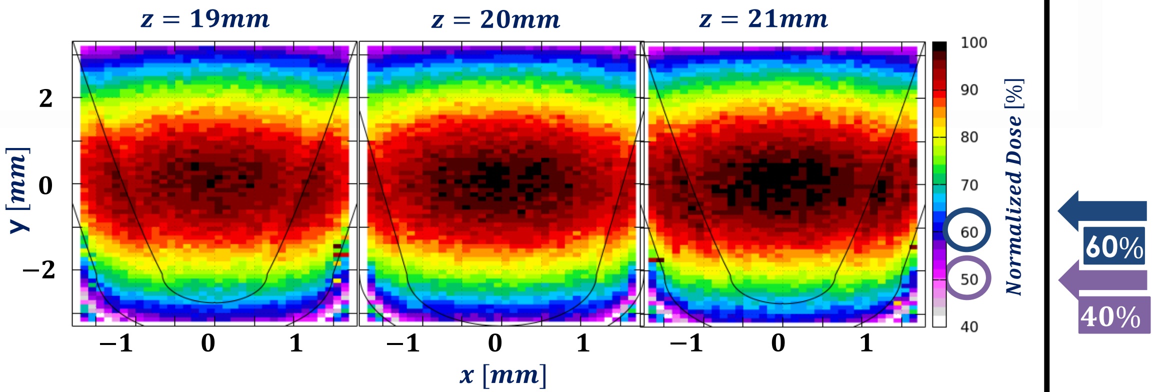
DOSE DISTRIBUTION

$\sigma_x = 4.32mm;\ \sigma_y = 3.06mm$

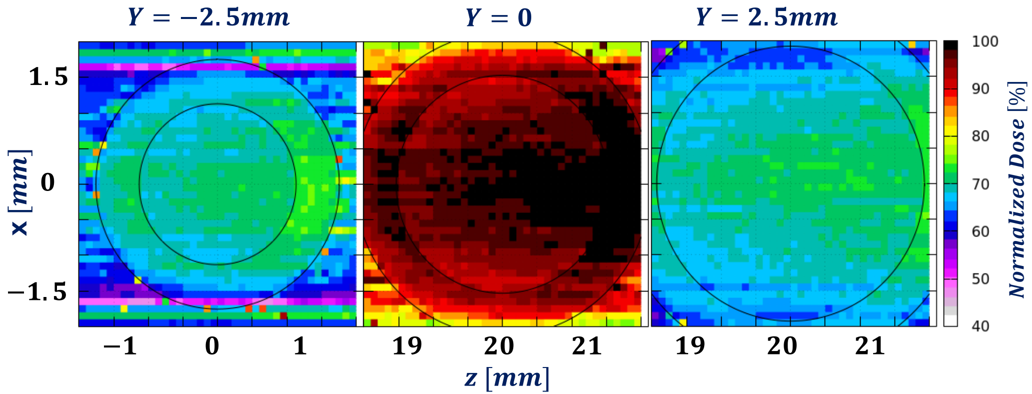
$H = 6.5\ mm$ $R_{max} = 2.0\ mm$ $V = 50\mu L$







Dose distribution in XY plane perpendicular to the incident electrons path.

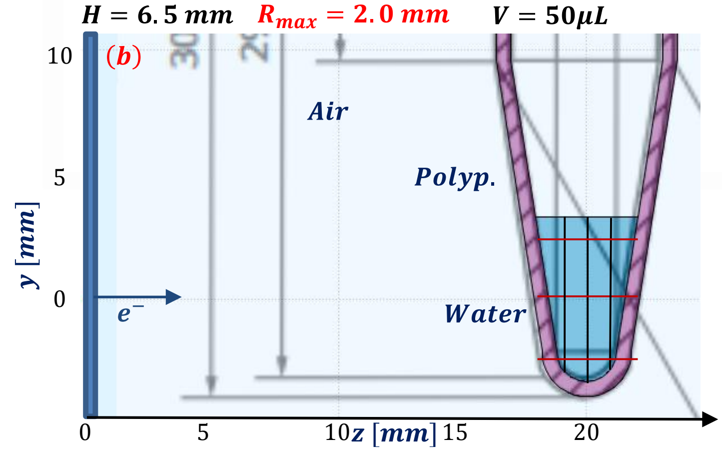


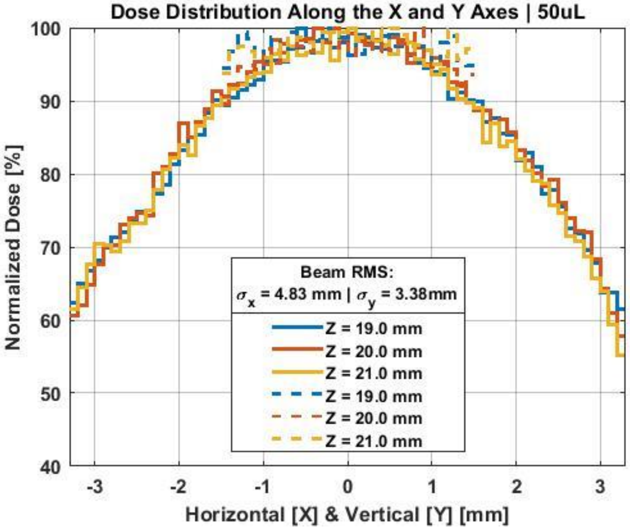
Dose distribution in the XZ plane parallel to the incident electron trajectory.

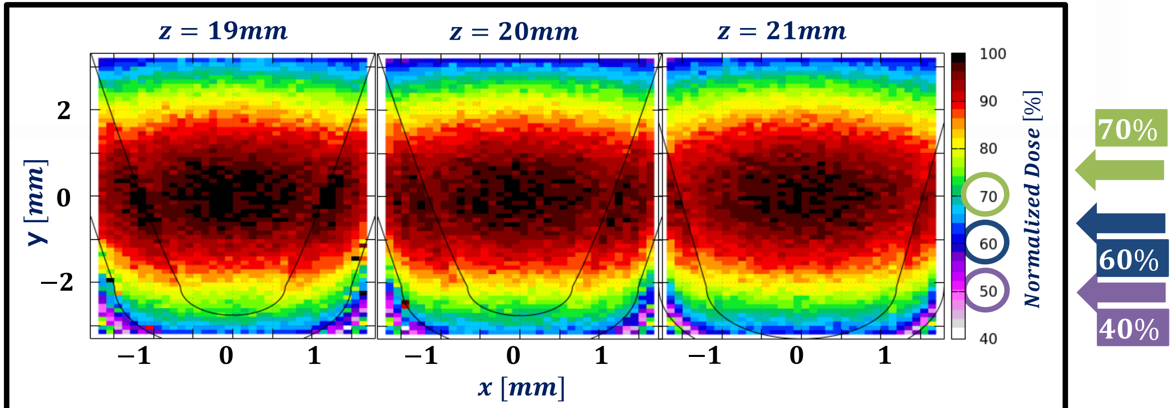
Dose is integral over longitudinal axis 0.1mm.

DOSE DISTRIBUTION

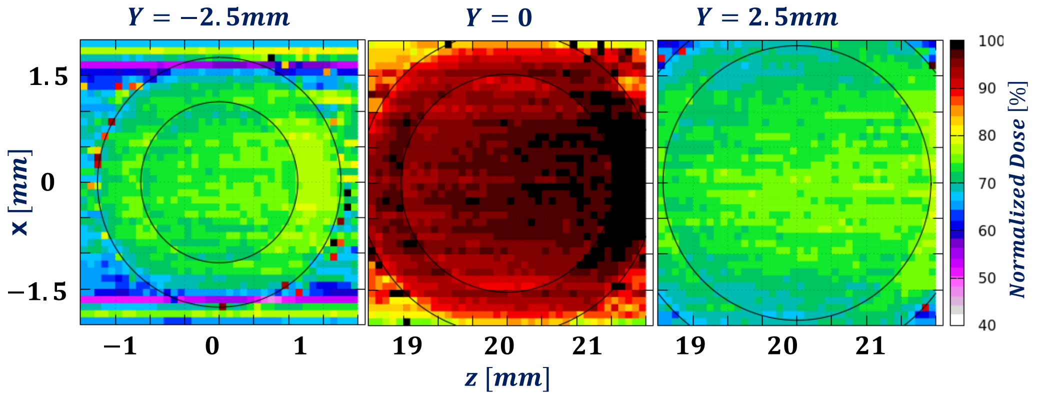
$\sigma_x = 4.83mm;\ \sigma_y = 3.38mm$





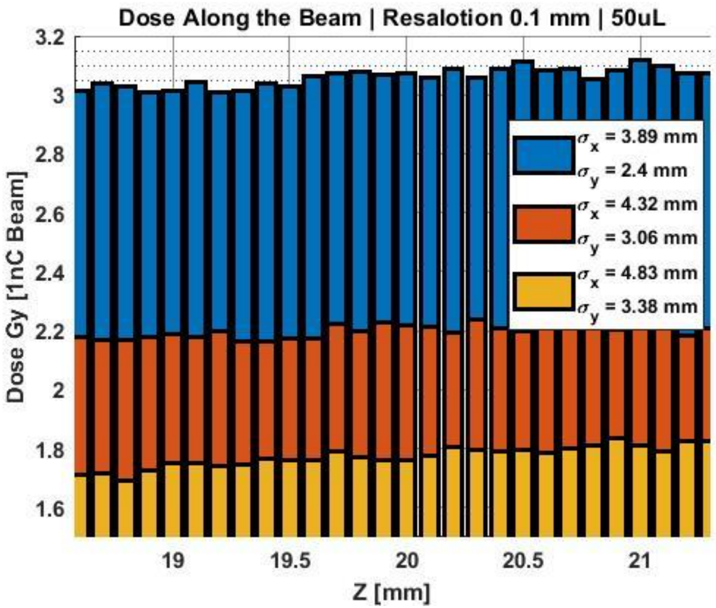


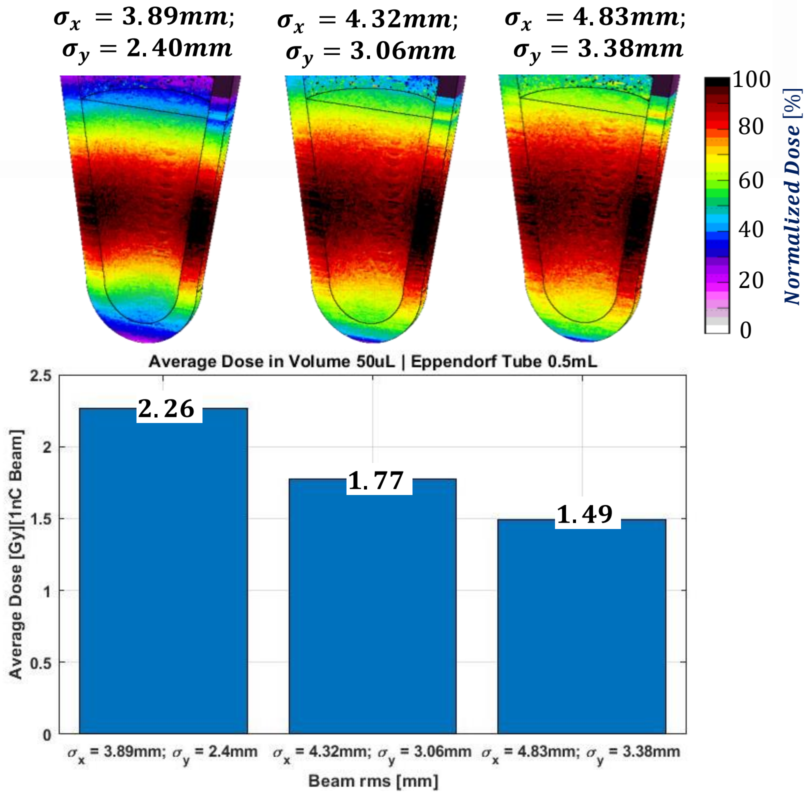
Dose distribution in XY plane perpendicular to the incident electrons path.



Dose distribution in the XZ plane parallel to the incident electron trajectory.

DOSE DISTRIBUTION





Dose distribution in water along the beam path where two transverse dimensions are integrated for central (a) $0.1 \times 0.1mm^2$.

Line colors correspond to different RMS beam sizes.
The unit of deposition energy is Gy per 1 nC beam.

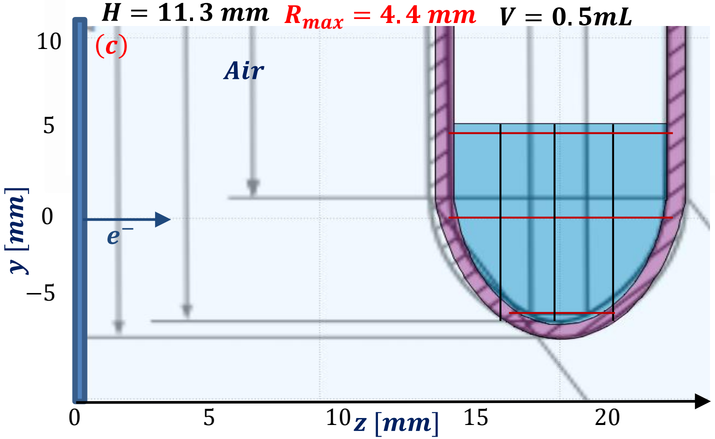
The average energy deposition in the entire volume of water depends on the size of the beam spot.
The volume of water is $20\mu L$.

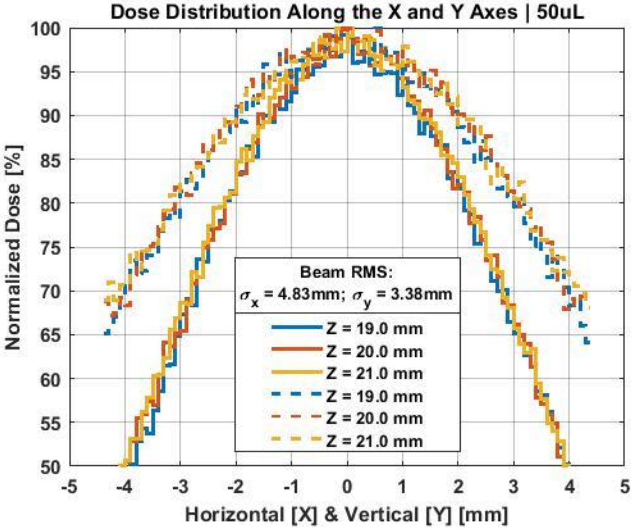
Dose is integral over longitudinal axis 0.1mm.

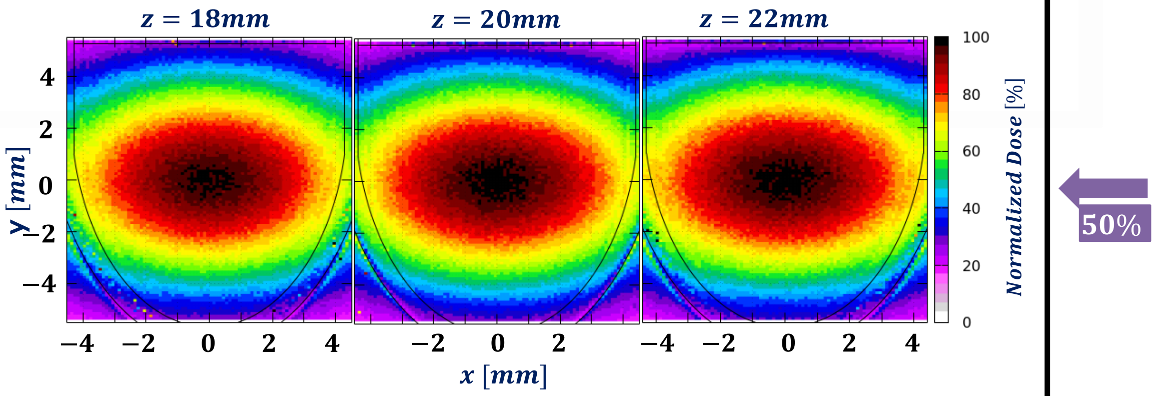
DOSE DISTRIBUTION

$\sigma_x = 4.83mm;\ \sigma_y = 3.38mm$

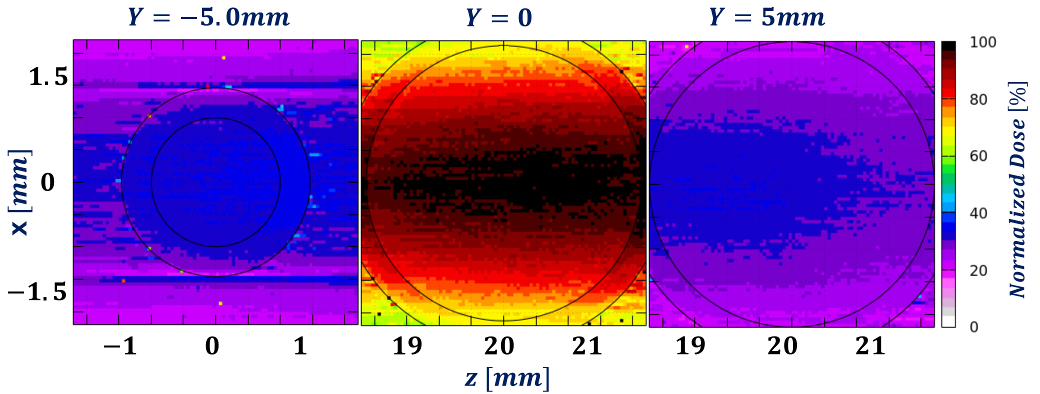
$H = 11.3\ mm$ $R_{max} = 4.4\ mm$ $V = 0.5mL$







Dose distribution in XY plane perpendicular to the incident electrons path.



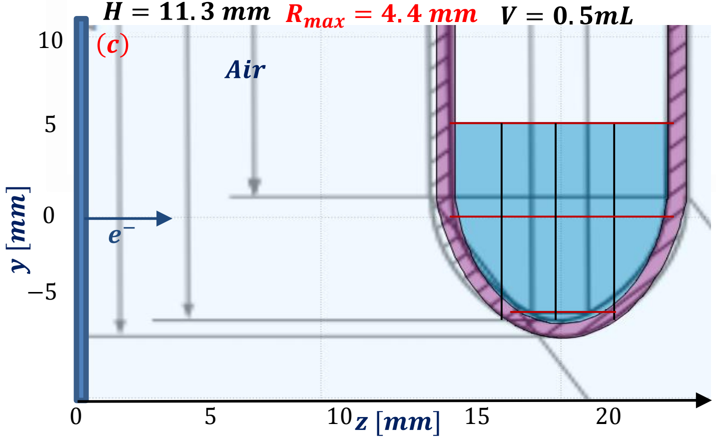
Dose distribution in the XZ plane parallel to the incident electron trajectory.

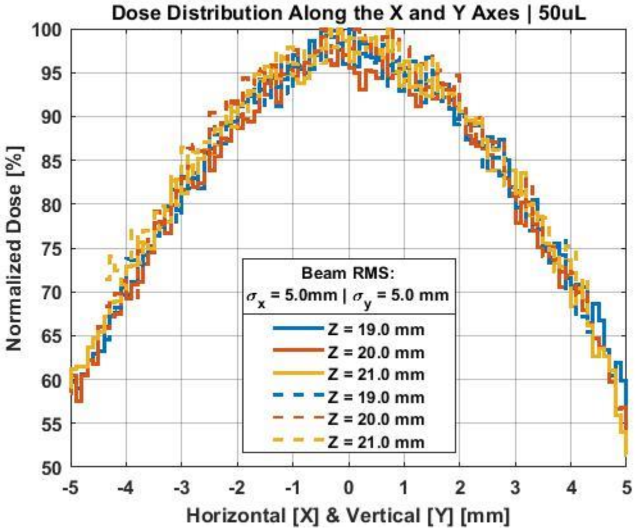
DOSE DISTRIBUTION

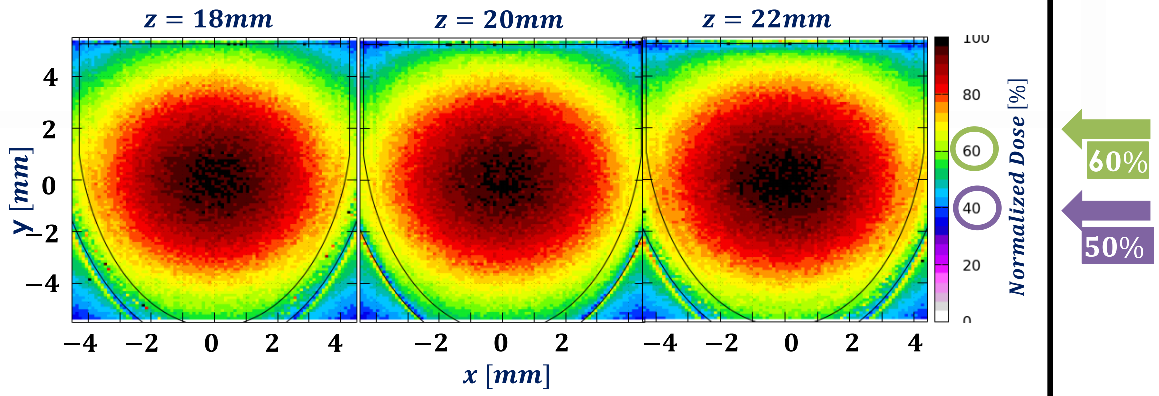
Dose is integral over longitudinal axis 0.1mm.

$\sigma_{x,y} = 5.0mm$

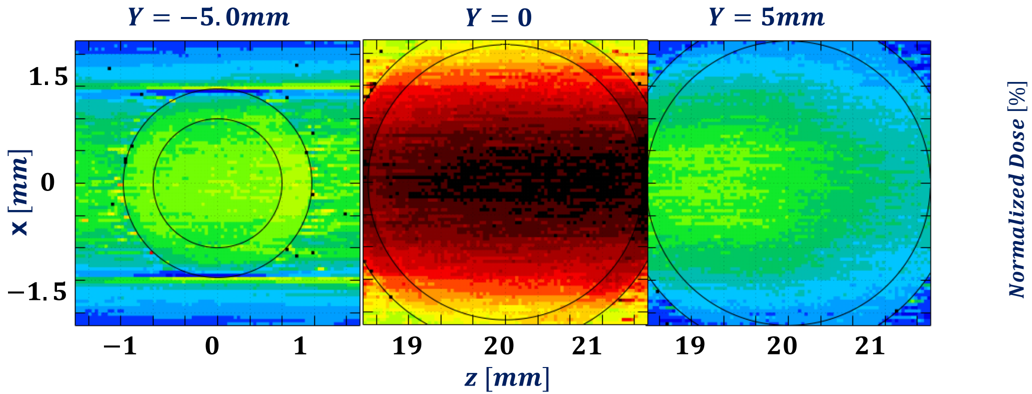
$H = 11.3\ mm$ $R_{max} = 4.4\ mm$ $V = 0.5mL$







Dose distribution in XY plane perpendicular to the incident electrons path.

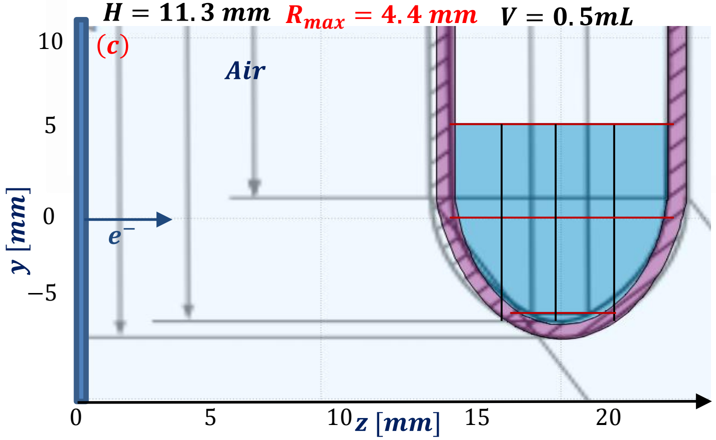


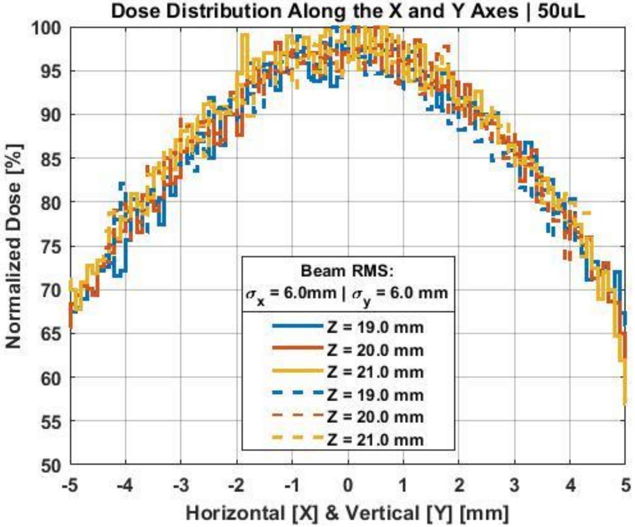
Dose distribution in the XZ plane parallel to the incident electron trajectory.

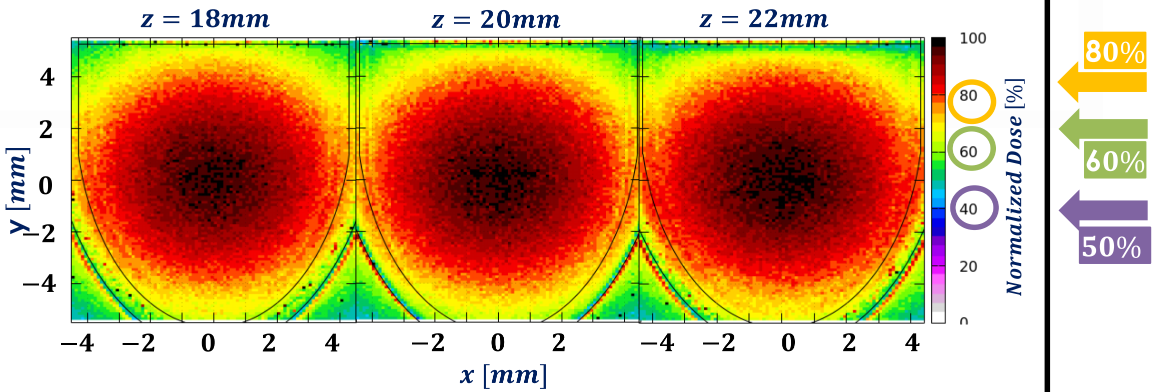
Dose is integral over longitudinal axis 0.1mm.

DOSE DISTRIBUTION

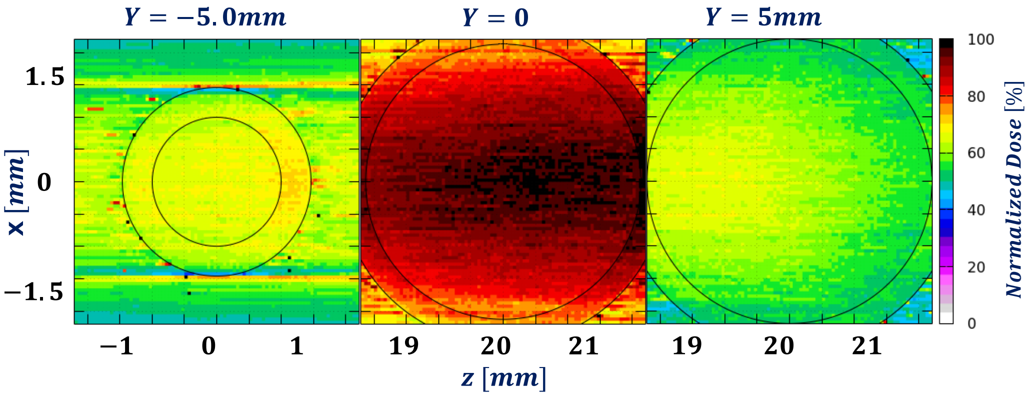
$\sigma_{x,y} = 6.0mm$





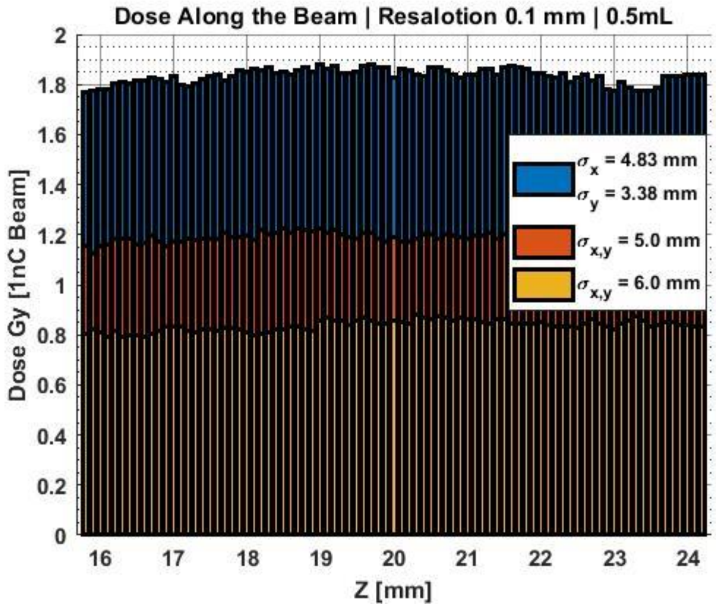


Dose distribution in XY plane perpendicular to the incident electrons path.



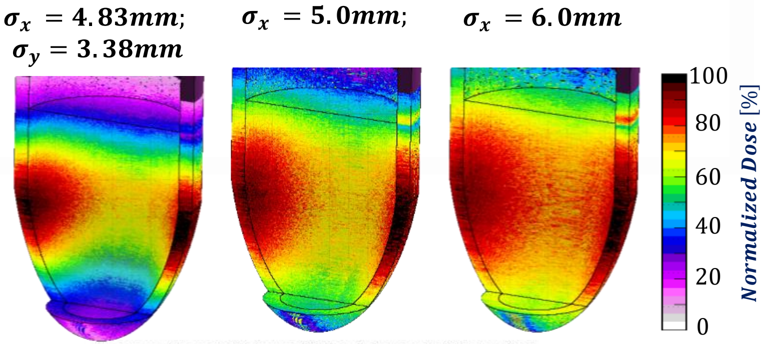
Dose distribution in the XZ plane parallel to the incident electron trajectory.

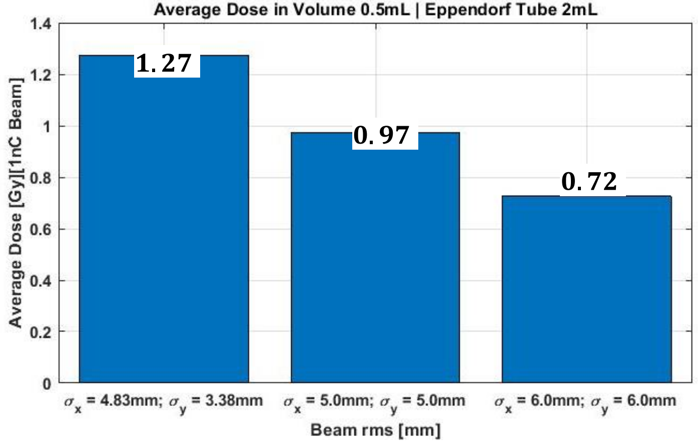
DOSE DISTRIBUTION



Dose distribution in water along the beam path where two transverse dimensions are integrated for central (a) $0.1 \times 0.1mm^2$.

Line colors correspond to different RMS beam sizes.
The unit of deposition energy is Gy per 1 nC beam.





The average energy deposition in the entire volume of water depends on the size of the beam spot.
The volume of water is $20\mu L$.

CONCLUSION

- Simulations were done for Eppendorf tubes of $\mathbf{0.5}\ \boldsymbol{mL}$ and $\mathbf{2}\ \boldsymbol{mL}$
  - For $\mathbf{0.5}\ \boldsymbol{mL}$ Eppendorf tube with a water volume of $\mathbf{20}\ \boldsymbol{\mu l}$:
    - For the beam rms size of $\{\mathbf{3.9, 2.4}\}\ \boldsymbol{mm}$ simulation shows dose homogeneity region of **70%** with and an average dose of **2.73 Gy** for 1nC beam**.**
    - For the beam rms size of $\{\mathbf{4.8, 3.4}\}\ \boldsymbol{mm}$ simulation shows dose homogeneity region of **90%** with and an average dose of **1.65 Gy** for 1nC beam
  - For $\mathbf{0.5}\ \boldsymbol{mL}$ Eppendorf tube with a water volume of **50 μl**:
    - For the beam rms size of $\{\mathbf{3.9, 2.4}\}\ \boldsymbol{mm}$ simulation shows dose homogeneity region of **50%** with and an average dose of **2.26 Gy** for 1nC beam
    - For the beam rms size of $\{\mathbf{4.8, 3.4}\}\ \boldsymbol{mm}$ simulation shows dose homogeneity region of **70%** with and an average dose of **1.49 Gy** for 1nC beam
  - For $\mathbf{2}\ \boldsymbol{mL}$ Eppendorf tube with a water volume of **0.5 ml**:
    - For the beam rms size of $\{\mathbf{4.8, 3.4}\}\ \boldsymbol{mm}$ simulation shows dose homogeneity region of **50%** an average dose of **1.27 Gy** for 1nC beam **.**
    - For the beam rms size of **6.0 mm** simulation shows dose homogeneity region of **80%** and an average dose of **0.72 Gy** for 1nC beam **.**

Thank you for your attention