Femtosecond electrostatic electron gun design and optimization

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Overview

- Motivation
- Electron gun design
- Simulation of beam focusing

Motivation

Accelerators are widely used

Larger accelerator → larger possible energies

Smaller and cheaper accelerators are desired in many applications

We are very good at lasers, let‘s use them

Electron gun design - properties of the beam

Photons of sufficient energy may be absorbed by electrons leading to their emission
= photoemission

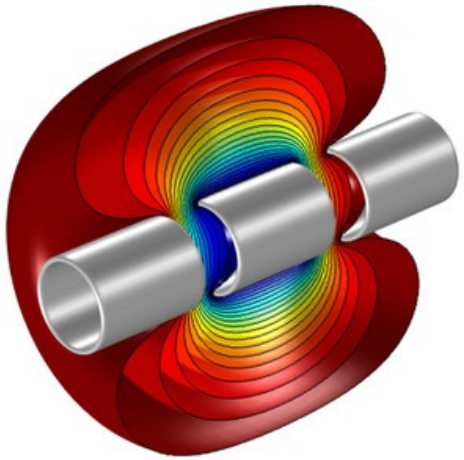
Work function of metals ~ few eV
Laser energy ~ few eV
Accelerating static field strength ~ hundreds of kV

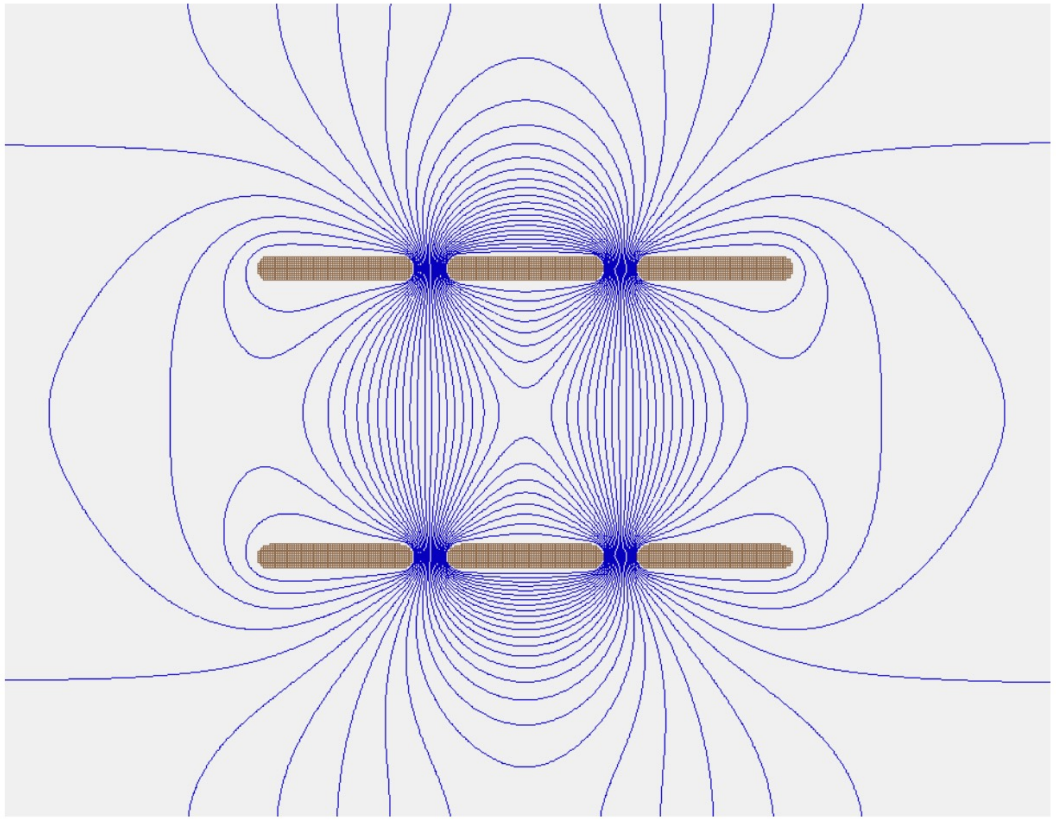
} Almost colimated and monoenergetic bunch

Femtosecond laser, quick energy losses in the material → very short beam

Electron gun design - focusation

Electrostatic **einzel lens**



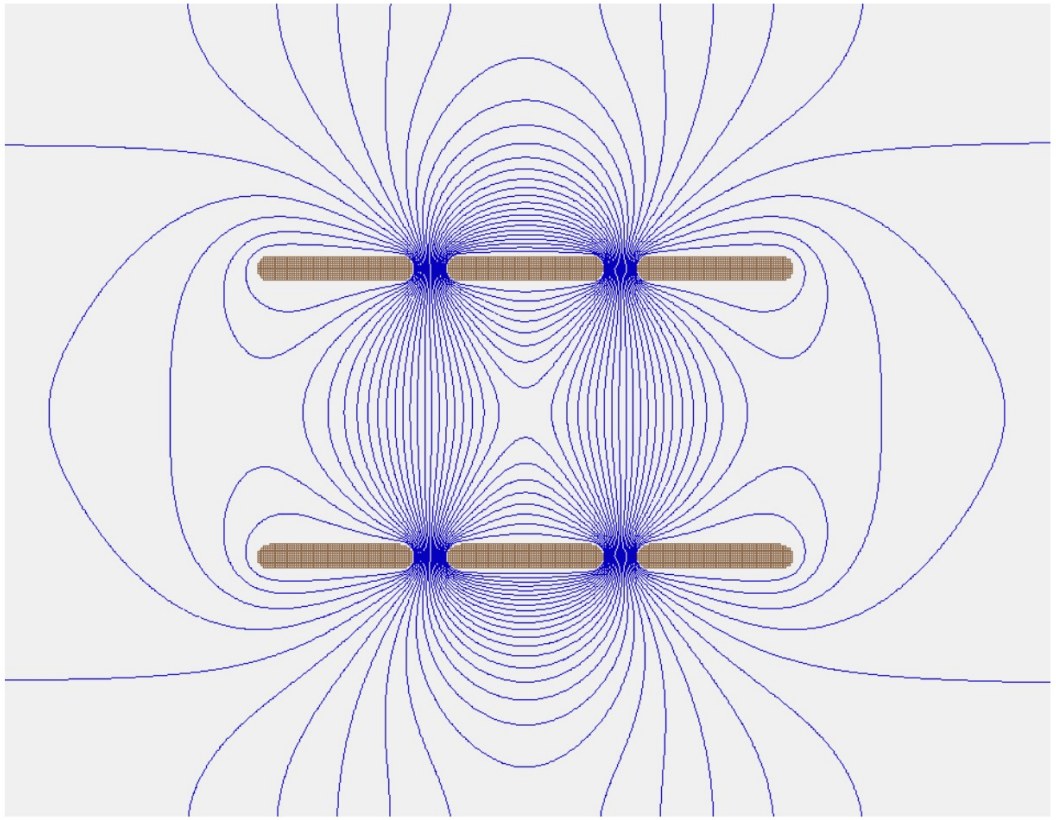


Electron gun design - focusation

Electrostatic **einzel lens**

Electron gun dimensions → voltage on the central cylinder

I aim for focus point few tens of cm from the einzel lens

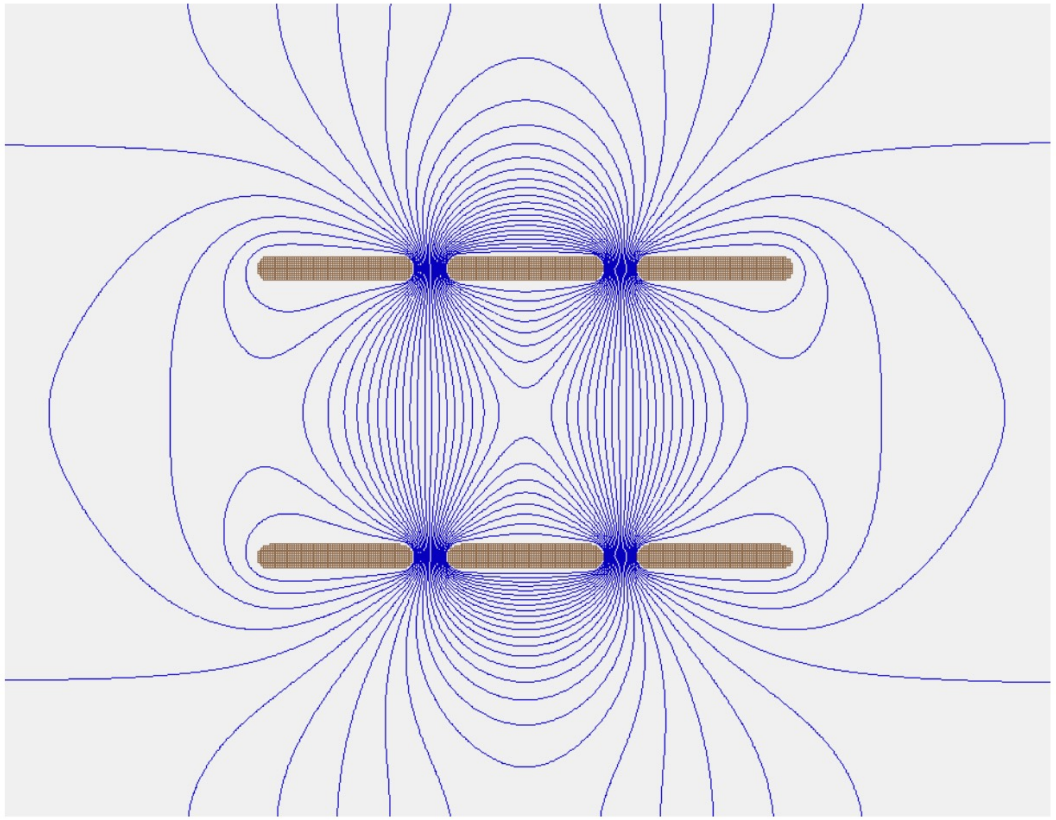


Electron gun design - simulation

What I do:

simulation of the einzel lens and its effect on the beam

Study of the energy profile, time profile, transverse profile of the beam in the focus point



Electron gun design – focus point

Exact focus point difficult to find

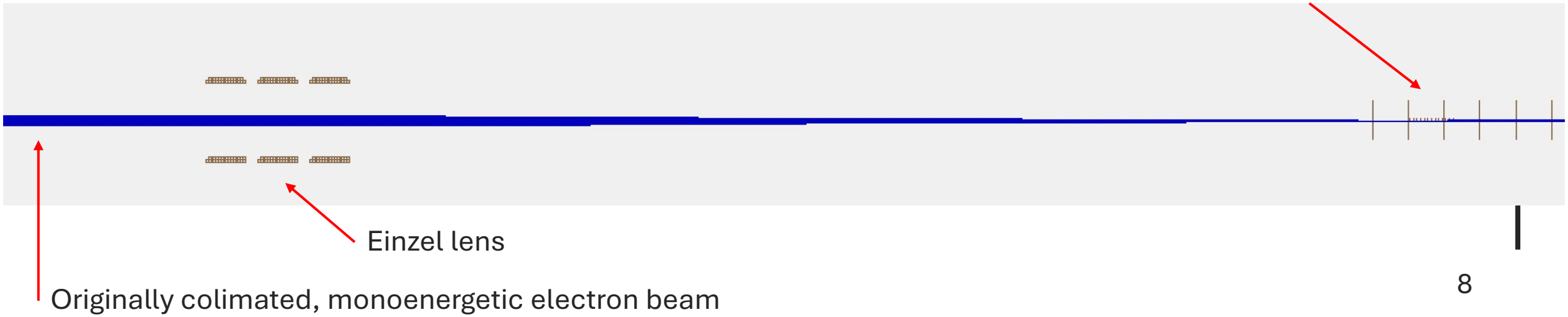
Study of the beam properties in the area of the focus point

Several transverse planes in which the beam properties are measured

Electron gun design – focus point

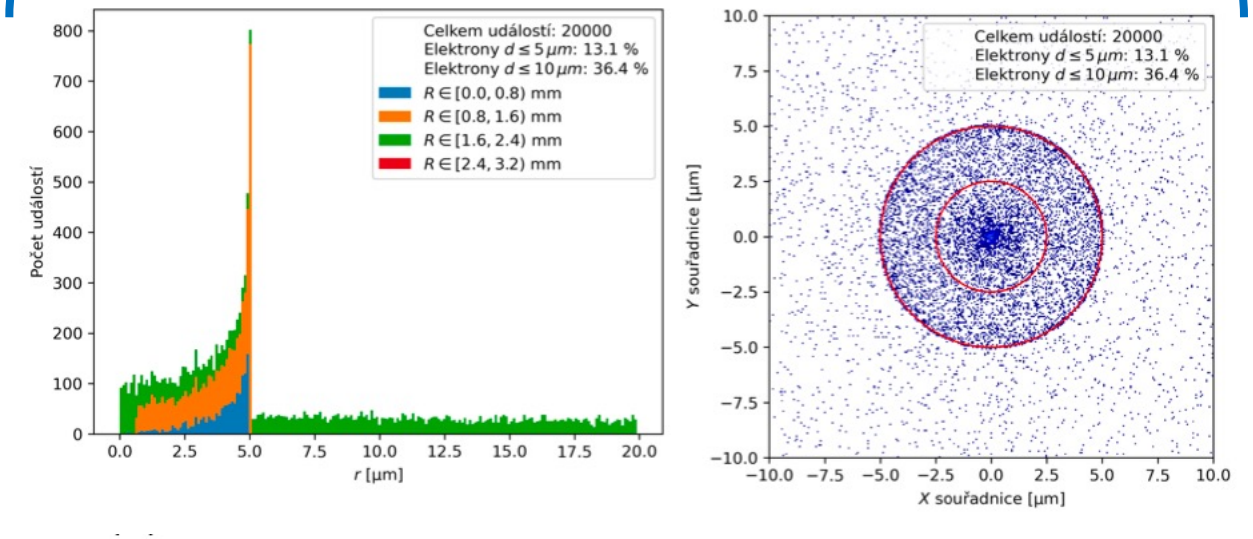
Electron source:

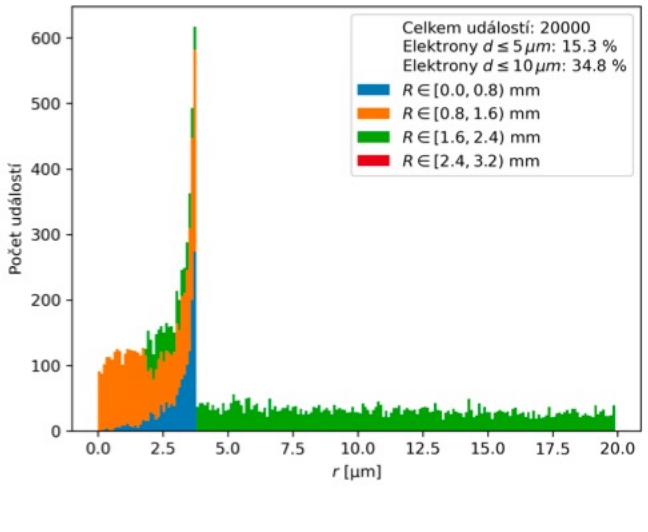
- Monoenergetic colimated electrons (200 keV)
- Uniform, circle distribution

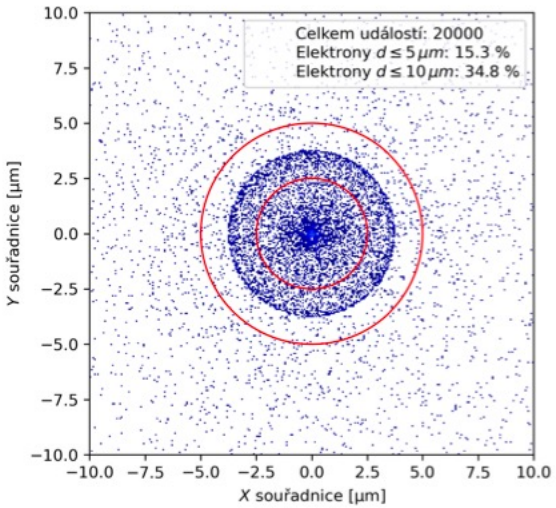


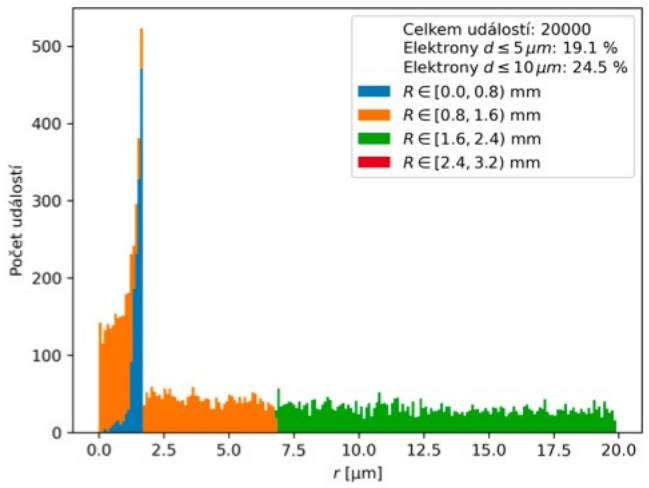
Electron gun design – transverse profile

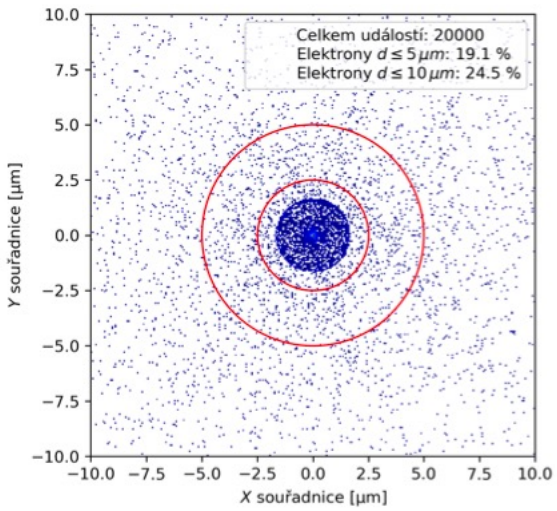
One plot

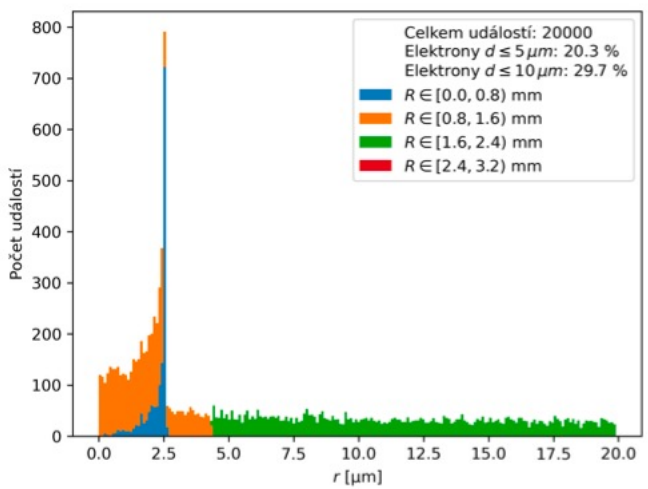


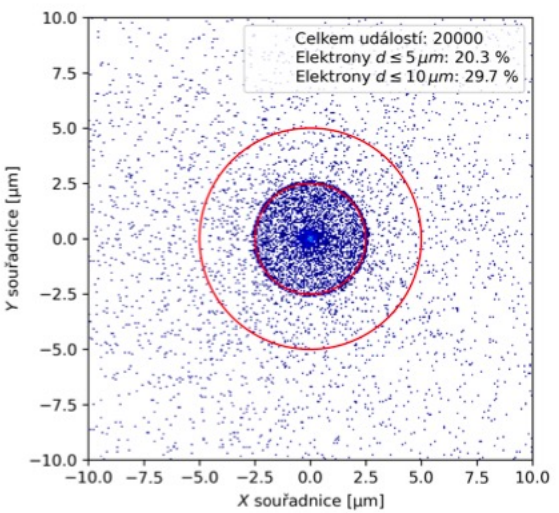




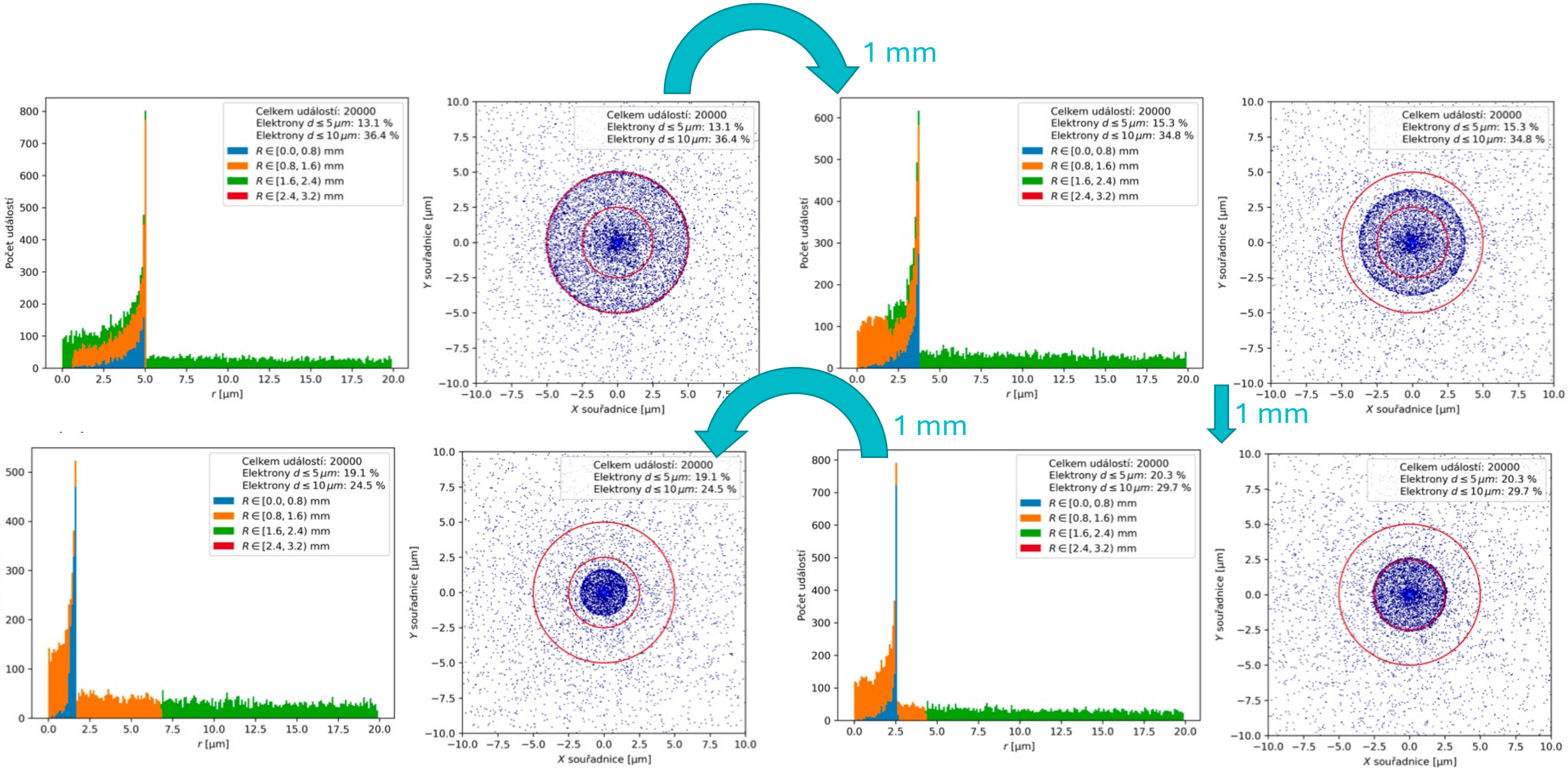




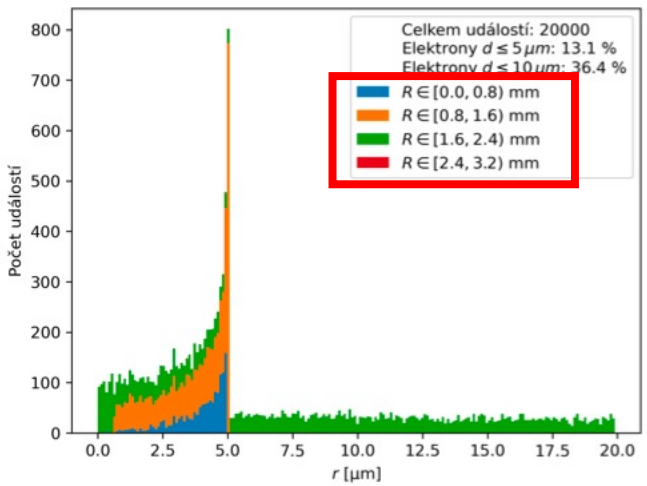


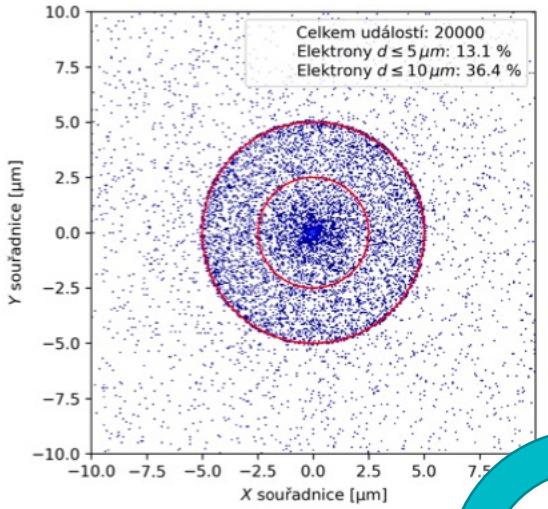


Electron gun design – transverse profile

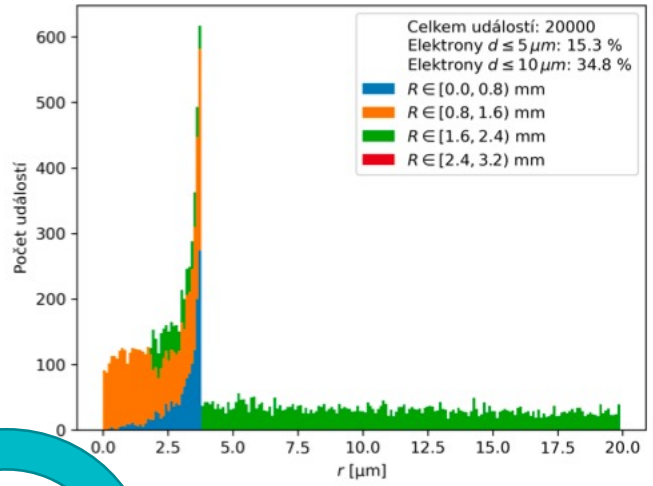


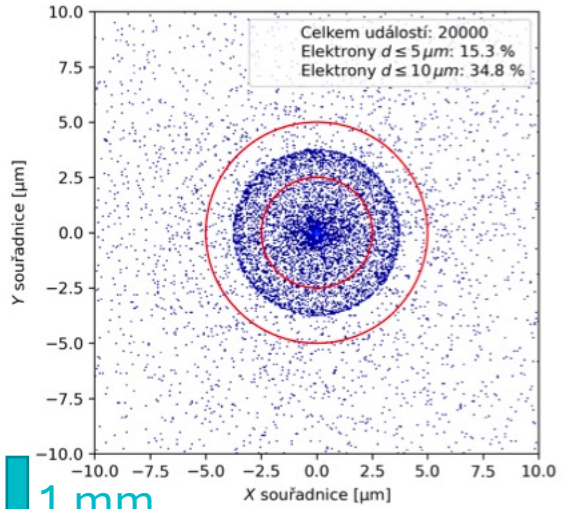
Electron gun design – transverse profile





1 mm





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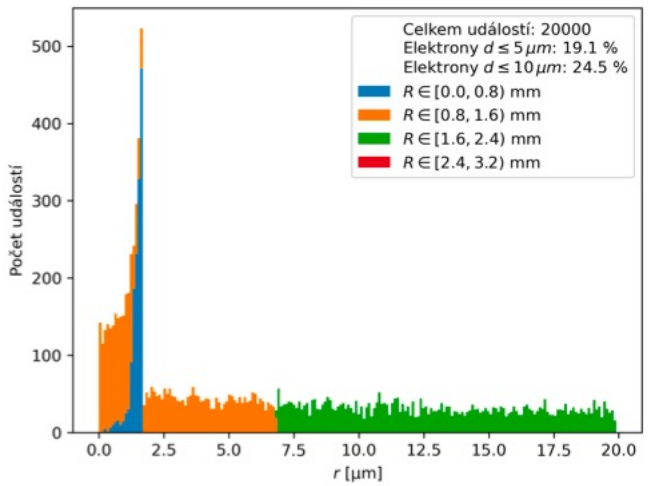
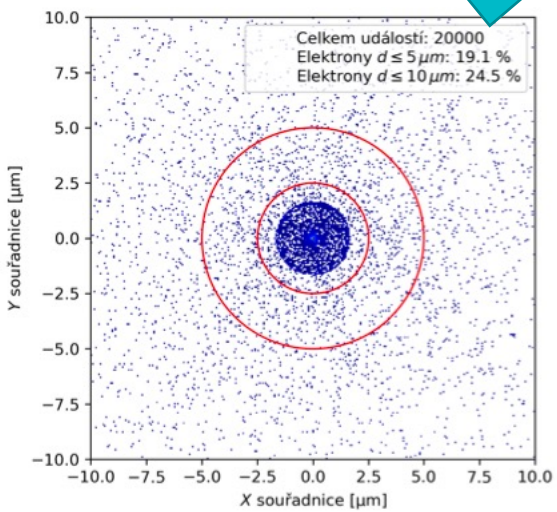
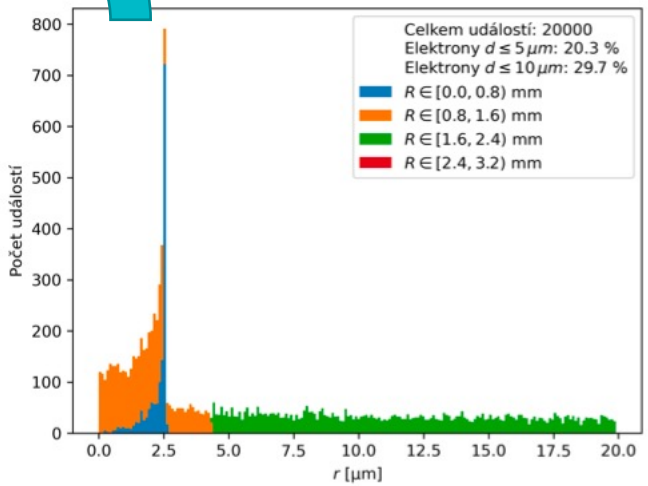
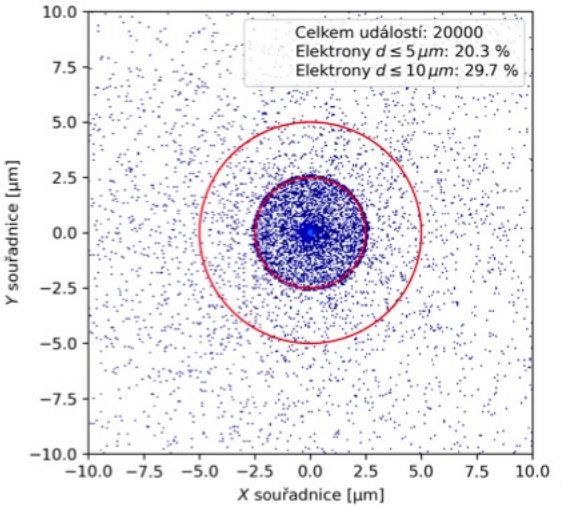


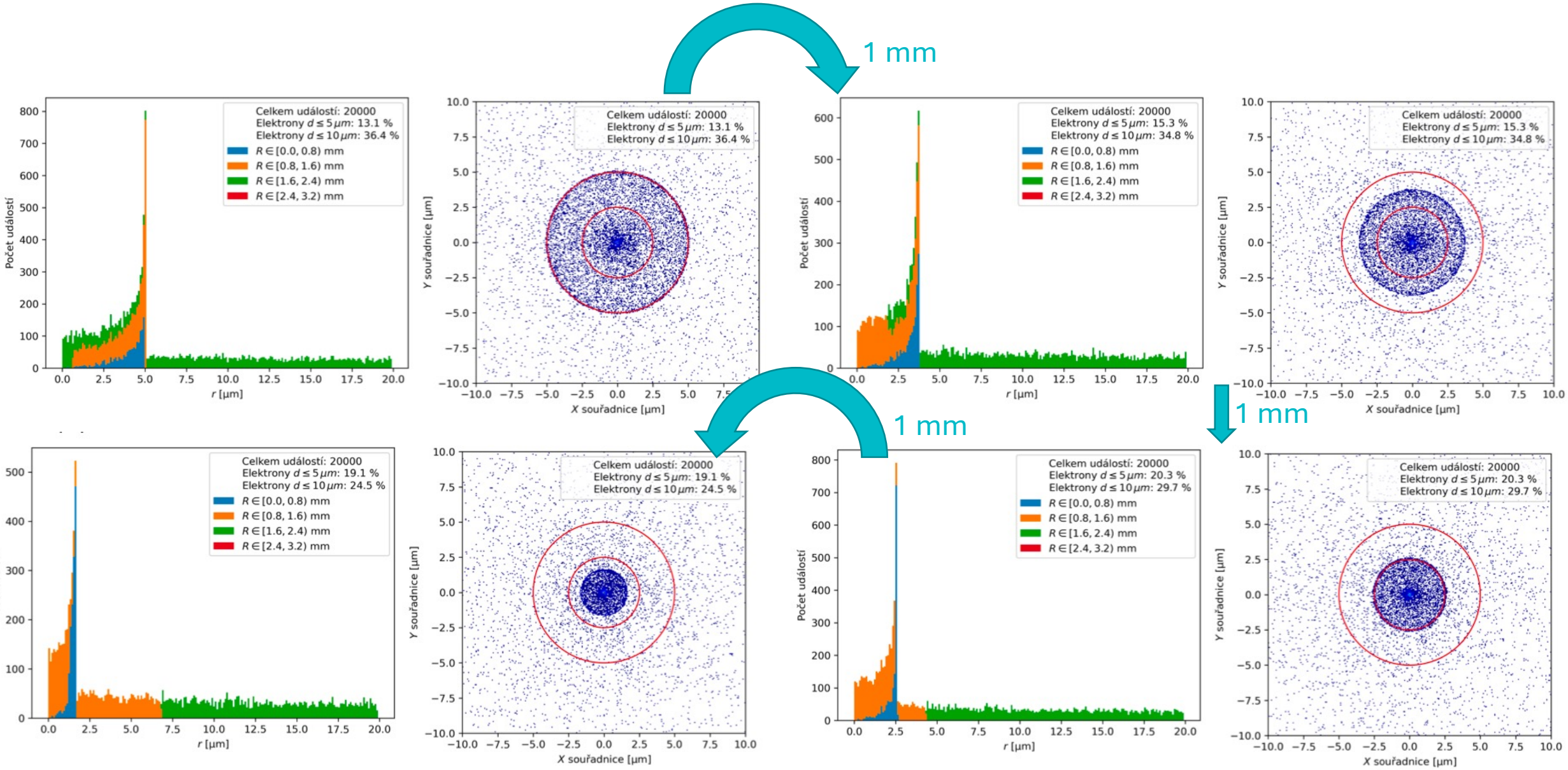


1 mm

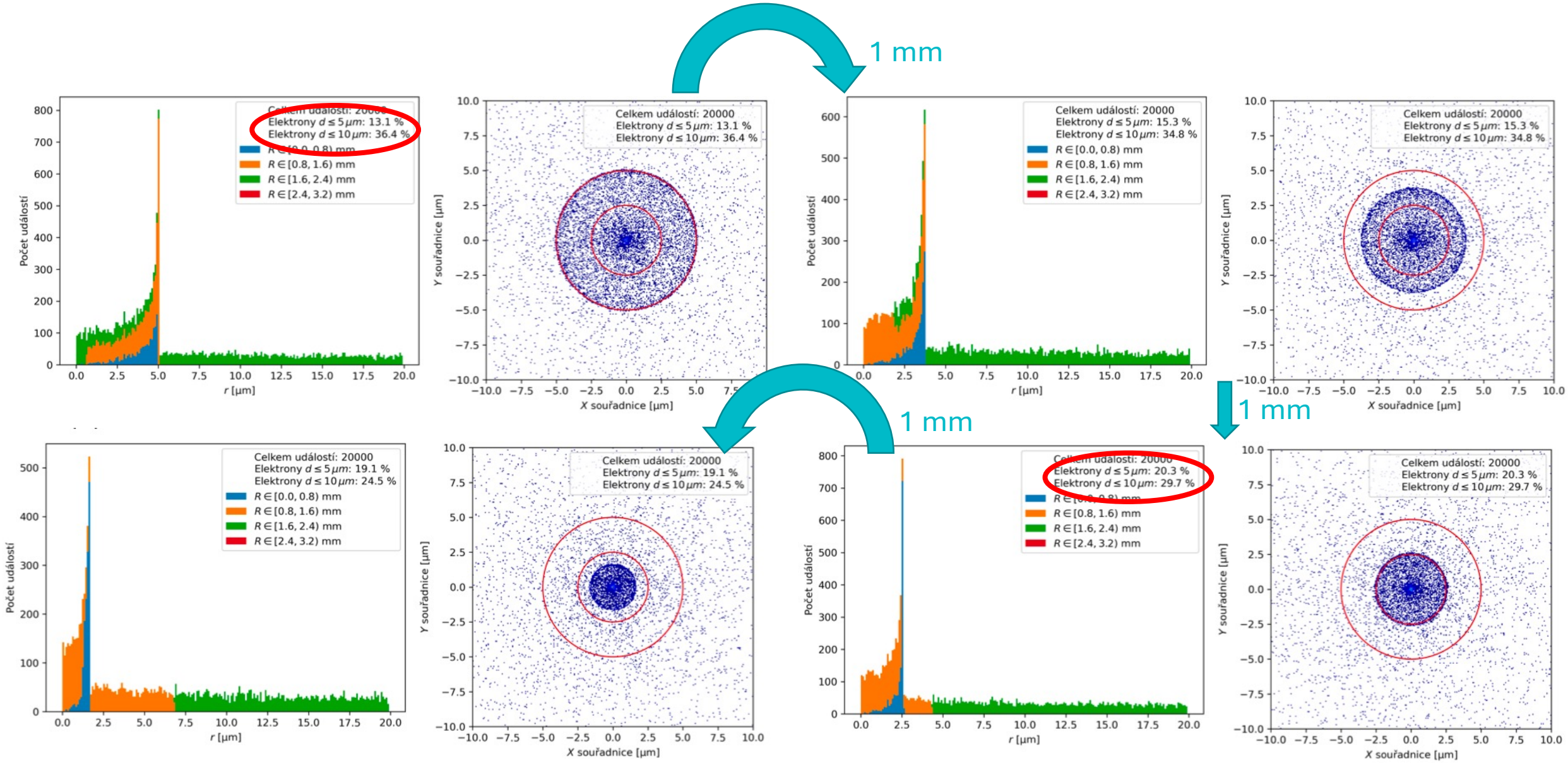




Electron gun design – transverse profile

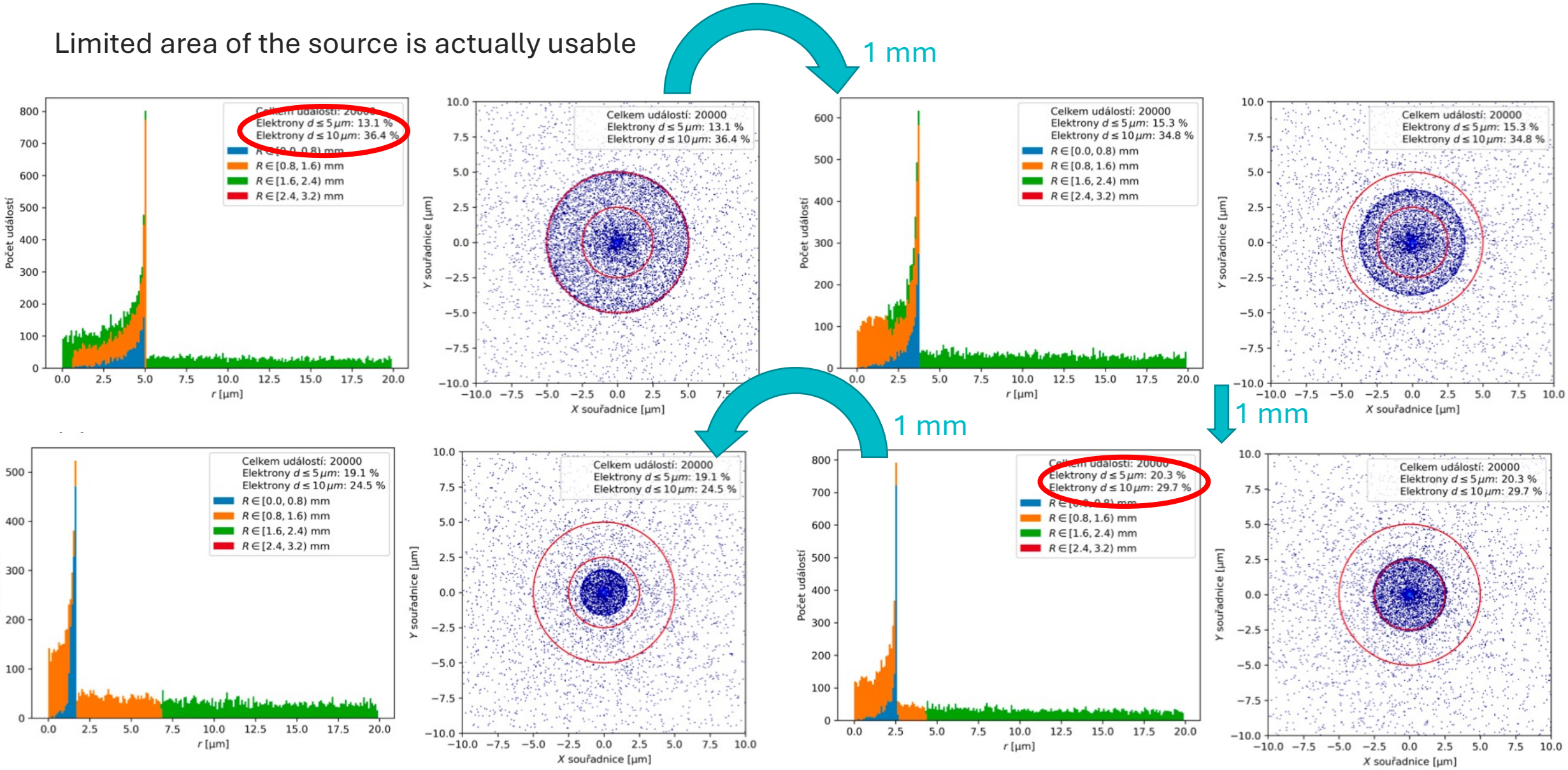


Electron gun design – transverse profile



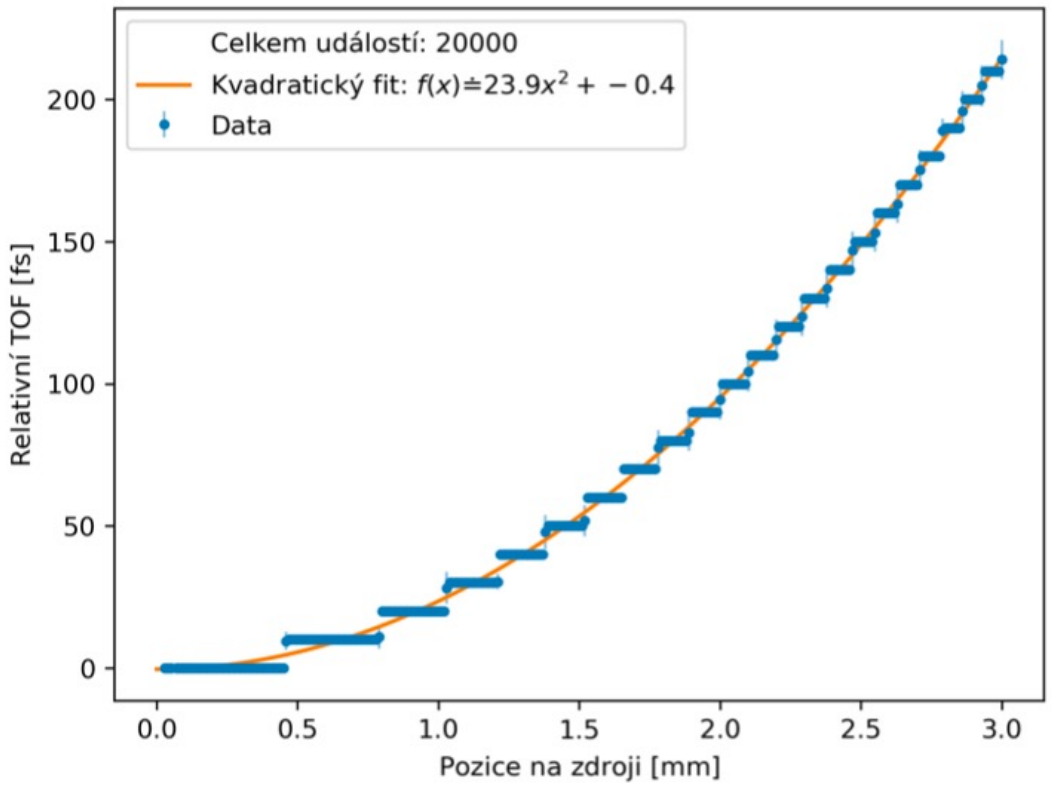
Electron gun design – transverse profile

Limited area of the source is actually usable



Electron gun design – time profile

- Difference in path lengths
- Effects in the lense



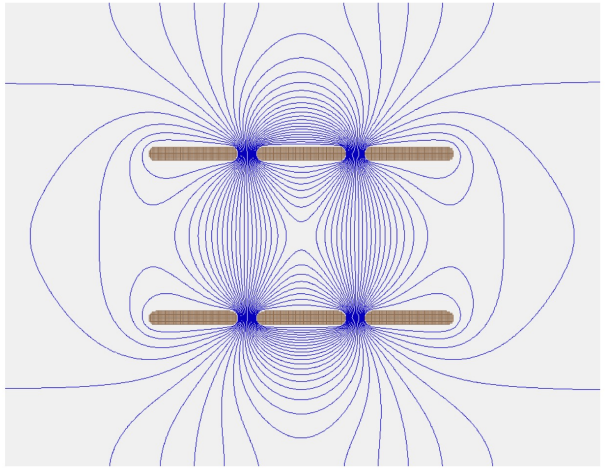
Electron gun design – optimization

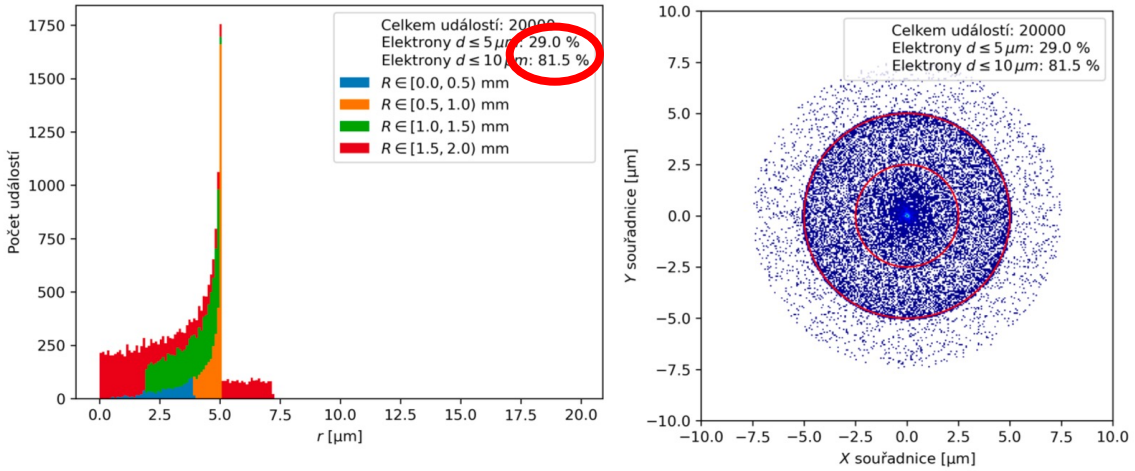
Effect of the einzellens depends on the initial transverse position of the electron

What can we change in the einzel lens? Voltage / dimensions

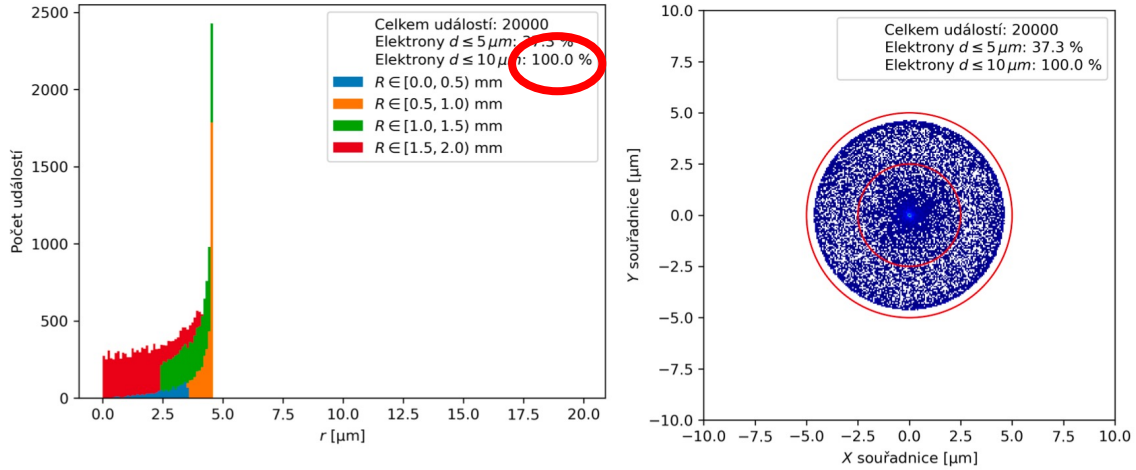
Electron gun design – size of the cavity

- Same voltage on the einzel lens
- Different cavity radius
- → different positions of focus points





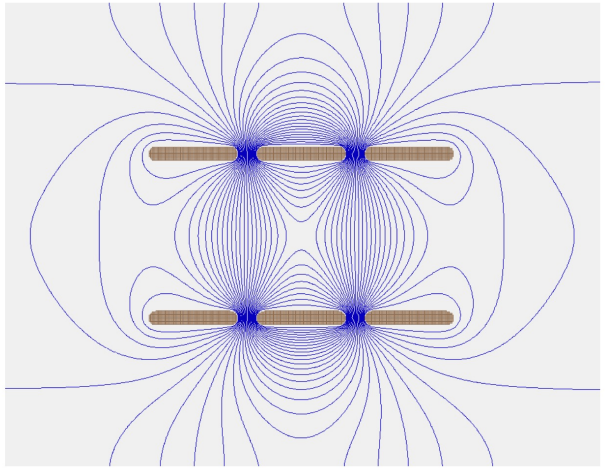
Cavity radius : 2 cm
Focus point distance: ~60 cm

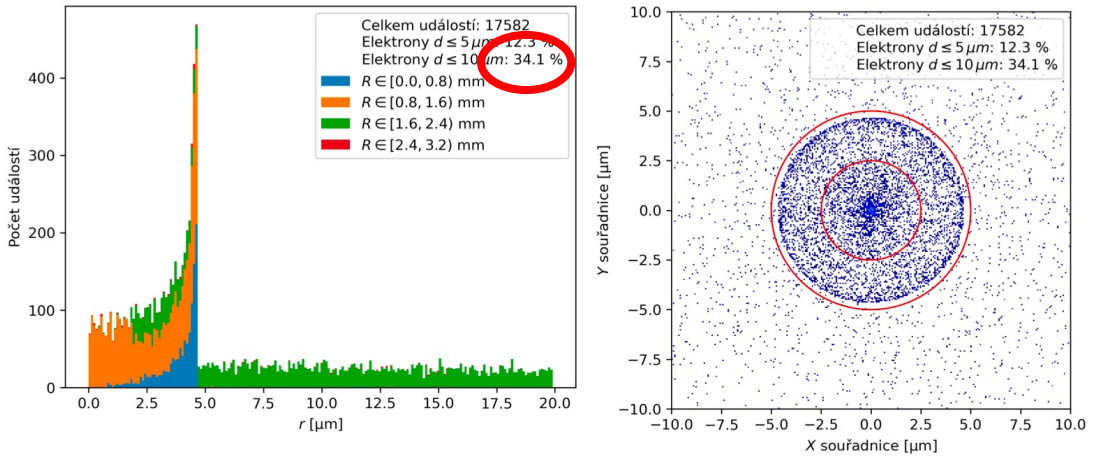


Cavity radius : 3 cm
Focus point distance: ~150 cm

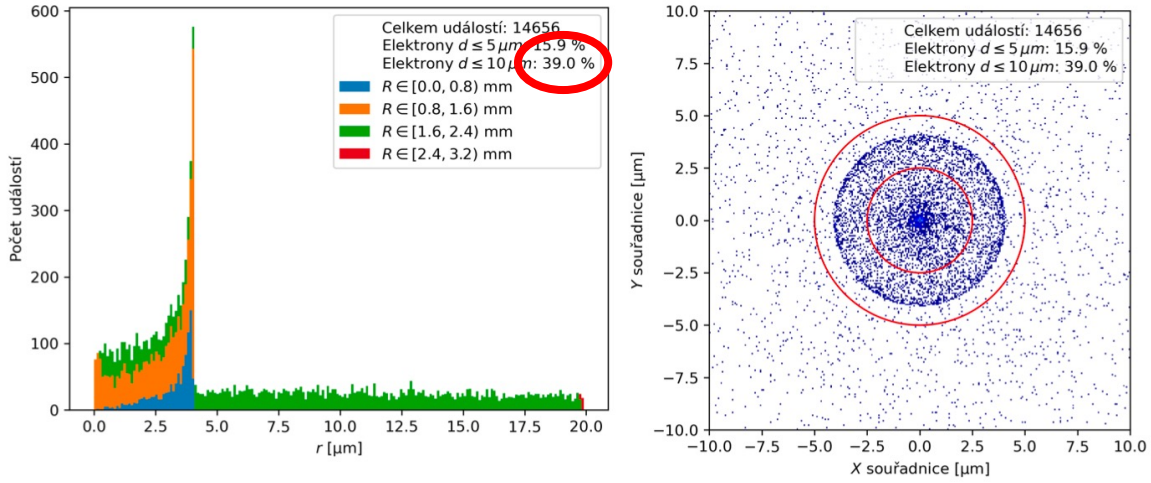
Electron gun design – voltage

Voltage does not significantly influence the transverse properties of the beam in the focus point





Voltage: 75 kV



Voltage: 190 kV

Conclusion

I study the influence of einzel lens on the properties of electron beam in the focus point

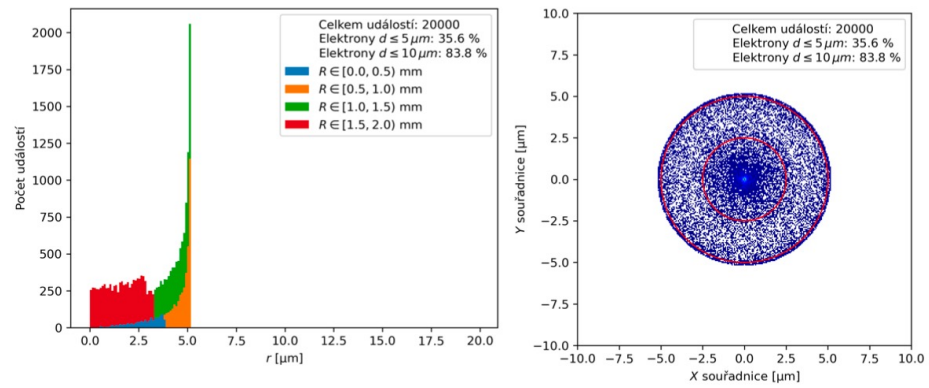
There is a dependance on the initial position in the source (spherical aberation)

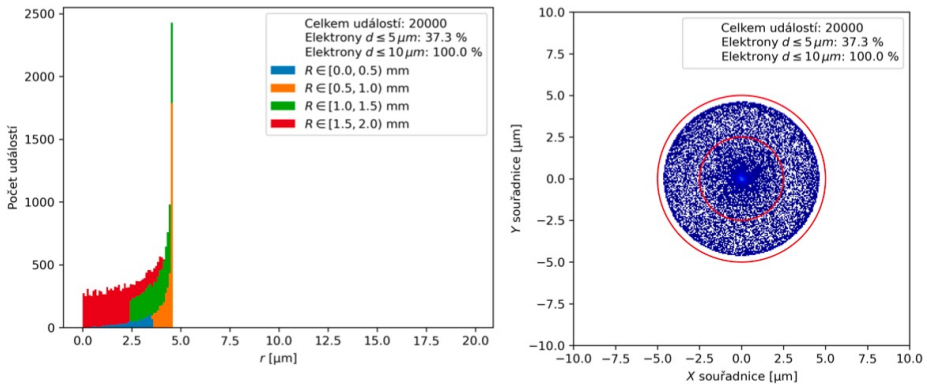
This effect can be limited by geometry of the einzel lens

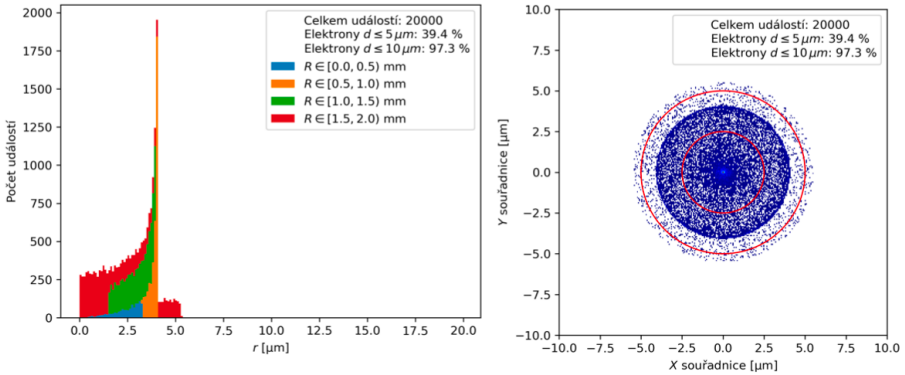
Parametres can be optimized (to some point) for the needs of the actual experiment / device

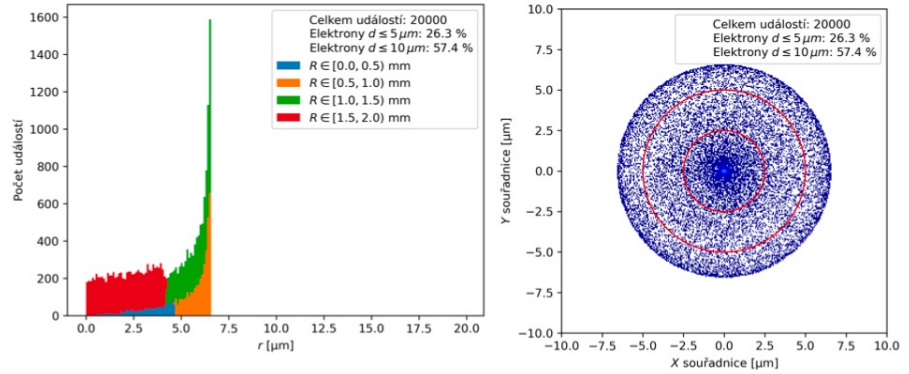
Backup Slides

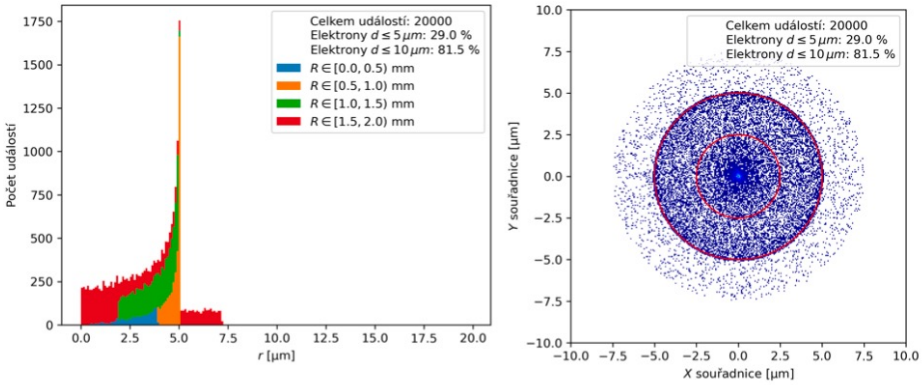
Electron gun design – size of the cavity

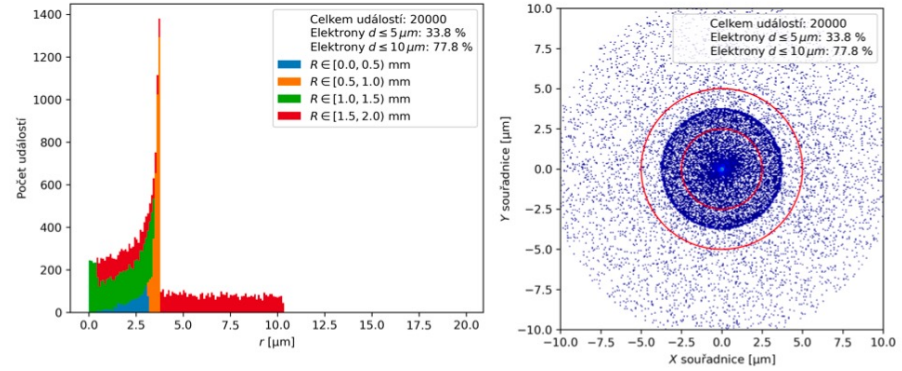




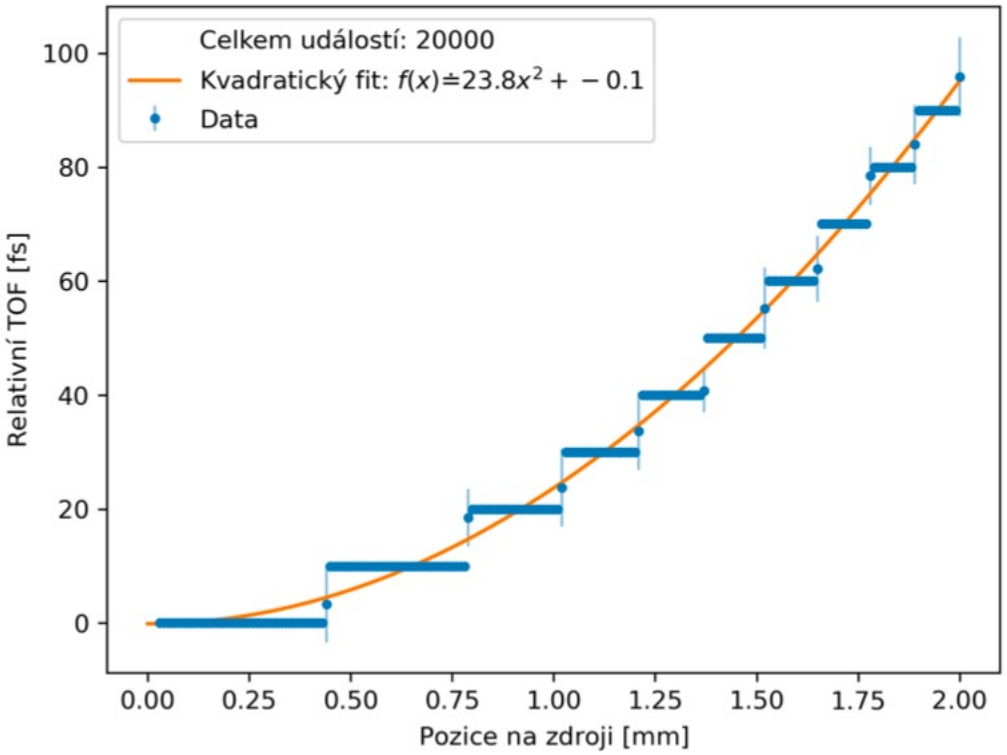




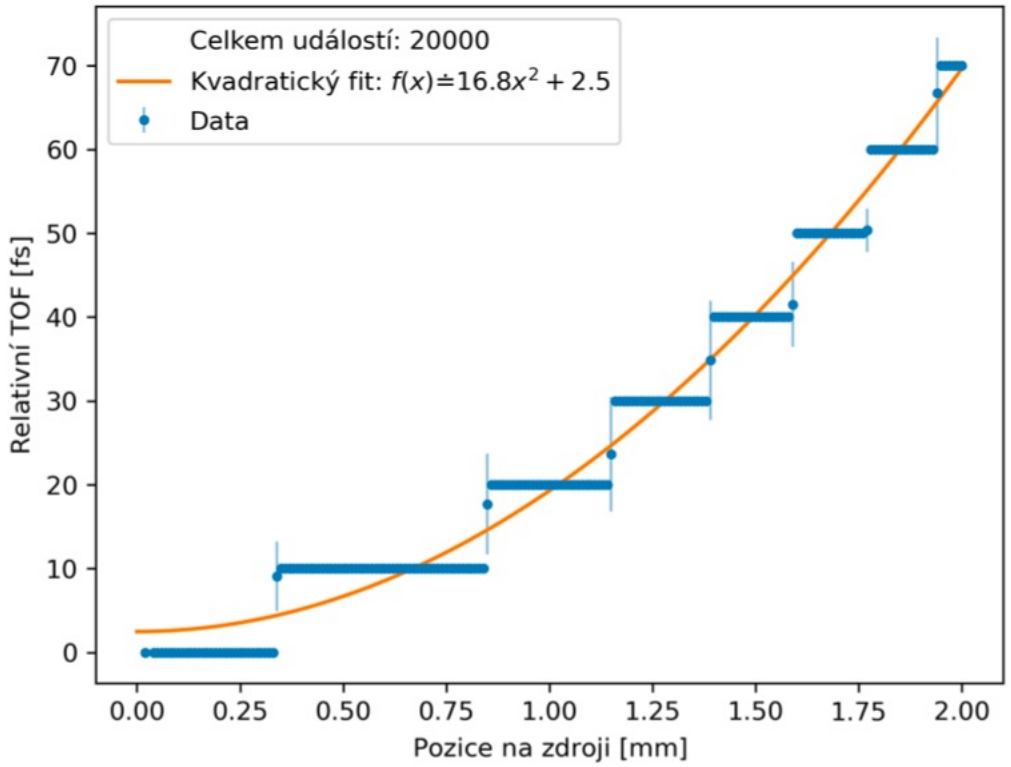




Electron gun desing – size of the cavity

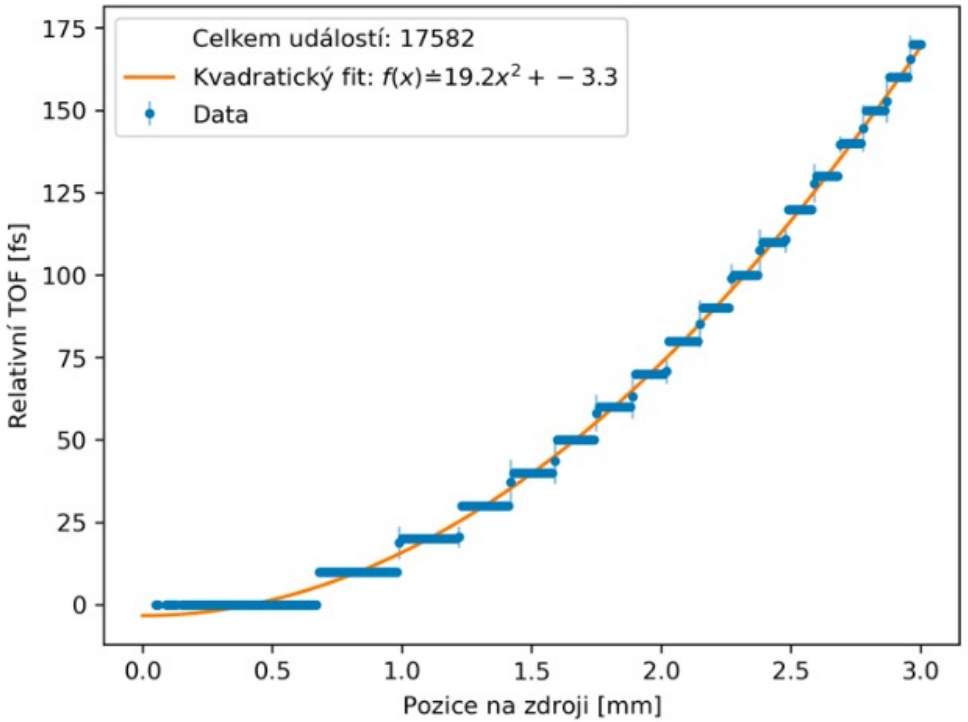


Cavity radius : 2 cm
Focus point distance: ~60 cm

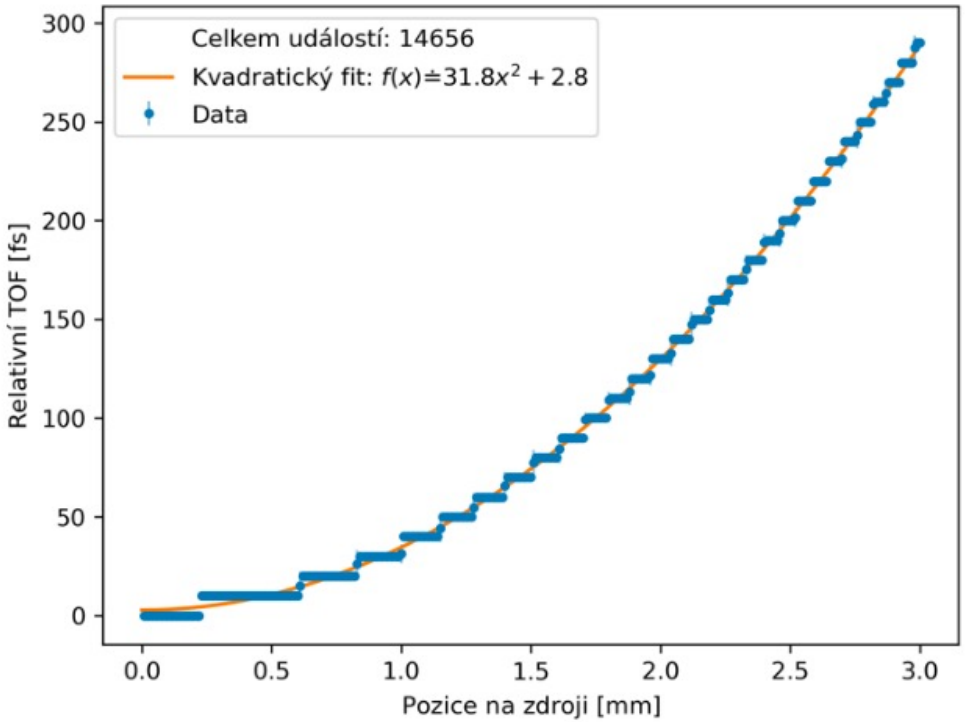


Cavity radius : 3 cm
Focus point distance: ~150 cm

Electron gun design – size of the cavity

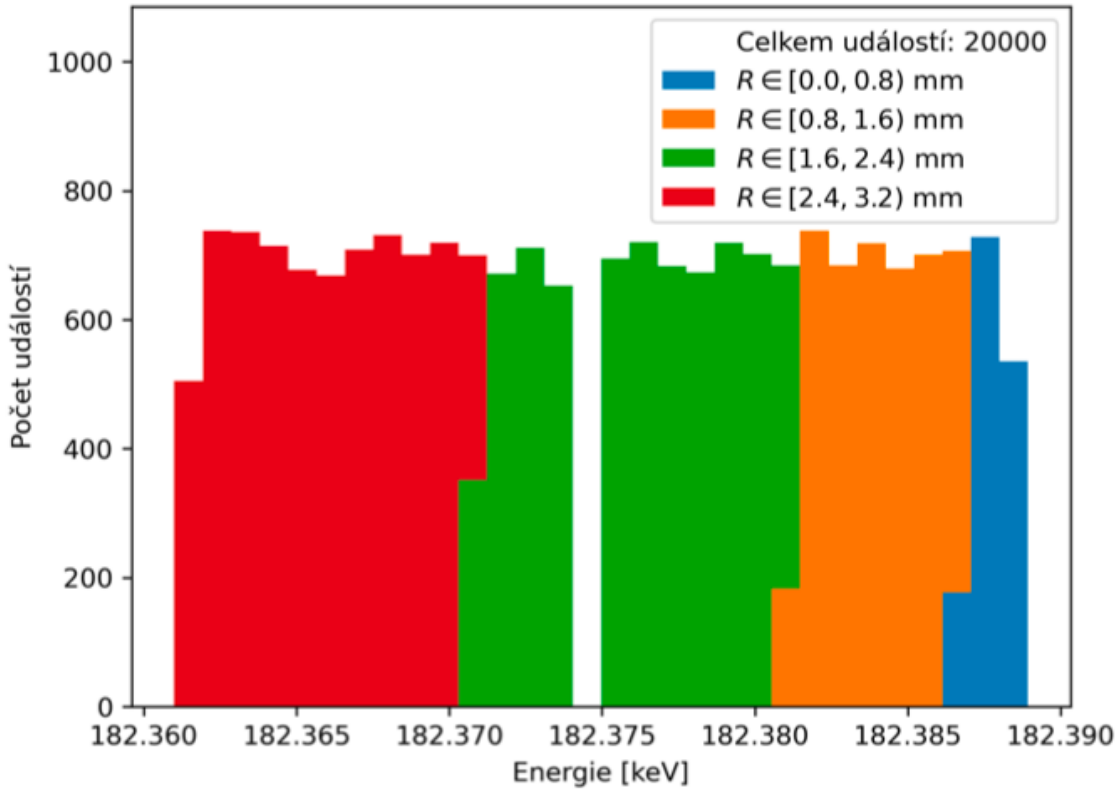


Voltage: 75 kV



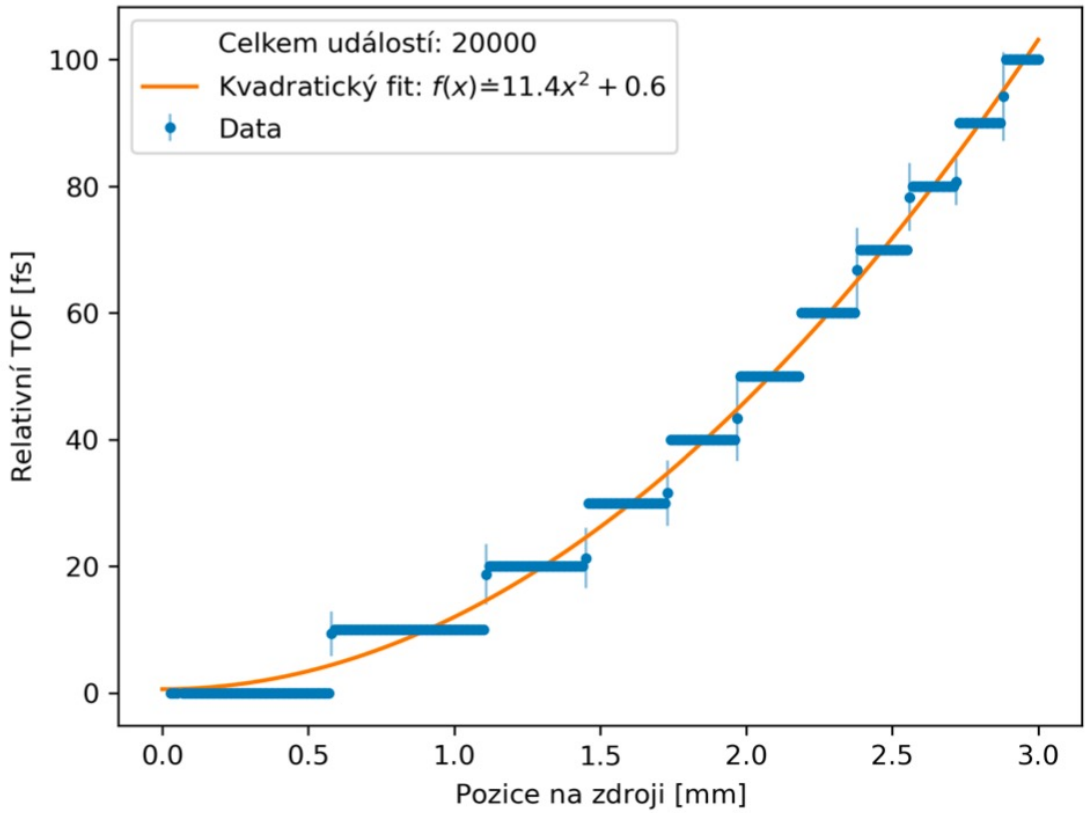
Voltage: 190 kV

Electron gun design – energy spectrum



Total energy spread: 25 eV

Electron gun design – time delay caused by the lense



Einzel lens dimensions