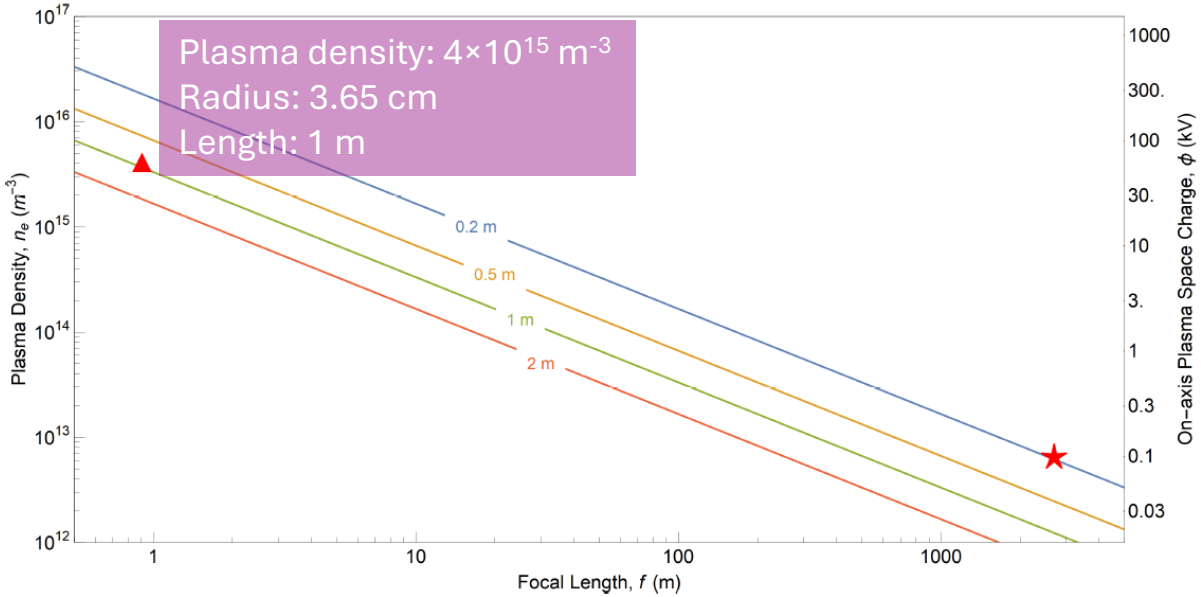
WP3: Proton and ion capture

Gabor lens

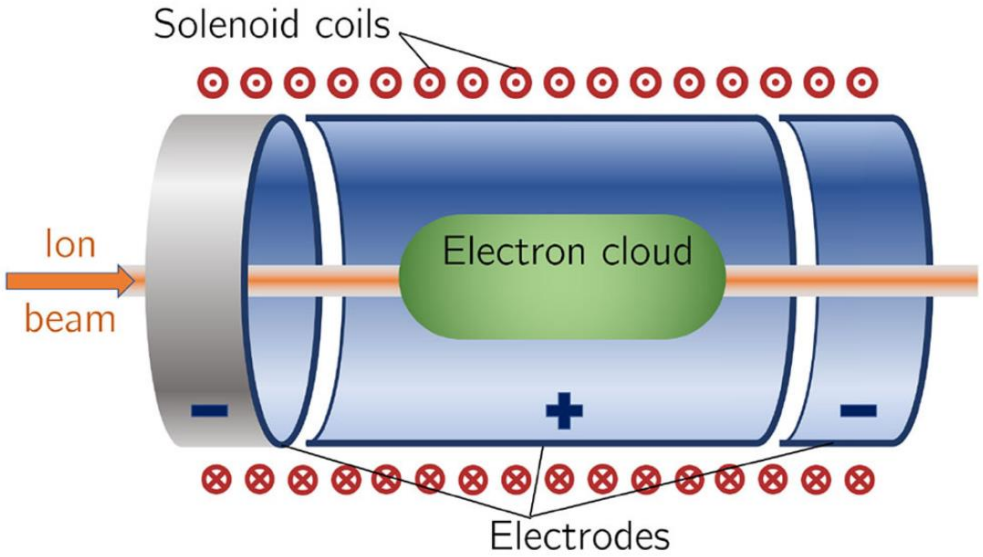
- **The focal length (f) of the Gabor lens:**

$$\frac{1}{f} = \frac{e^2 n_e l}{4\epsilon_0 U}$$

where e is electric charge of the electron
n_e is the plasma density
l is the length of the plasma
ϵ_0 is the permittivity of free space
U is the kinetic energy of the positively charge particle.

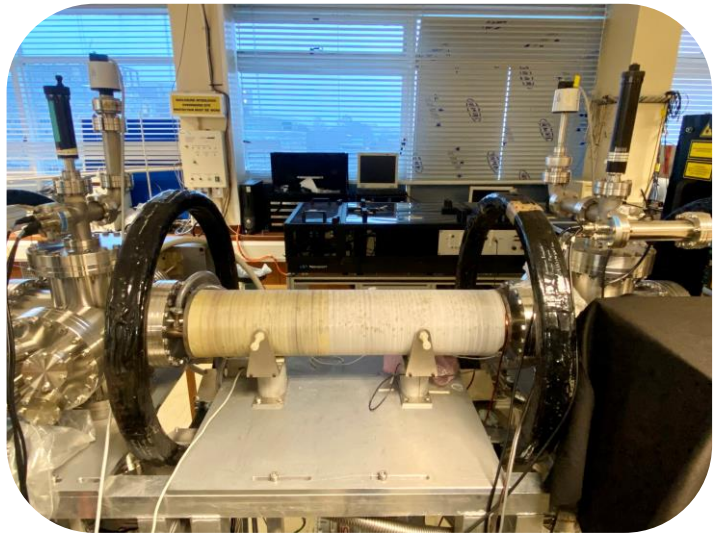


- **Penning-Malmberg trap**

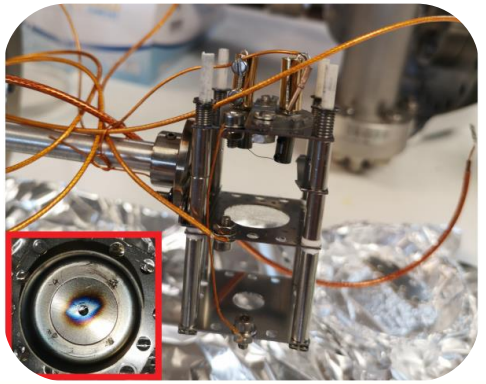


Aymar, G., Becker, T., Boogert, S., Borghesi, M., Bingham, R., Brenner, C., ... & Xiao, R. (2020). LhARA: the laser-hybrid accelerator for radiobiological applications. Frontiers in Physics, 8, 567738.

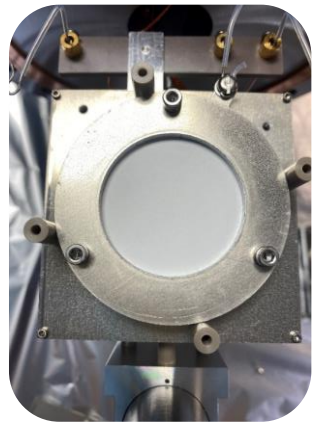
Existing apparatus

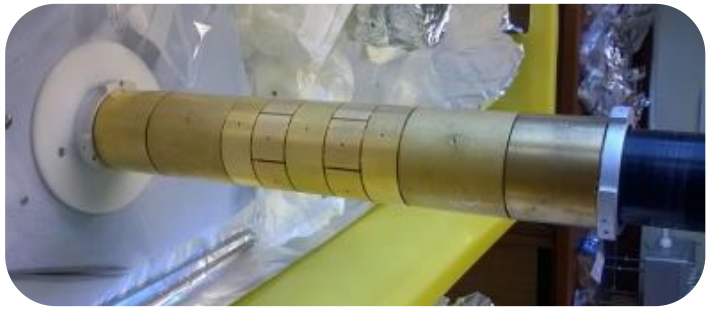


Electron source



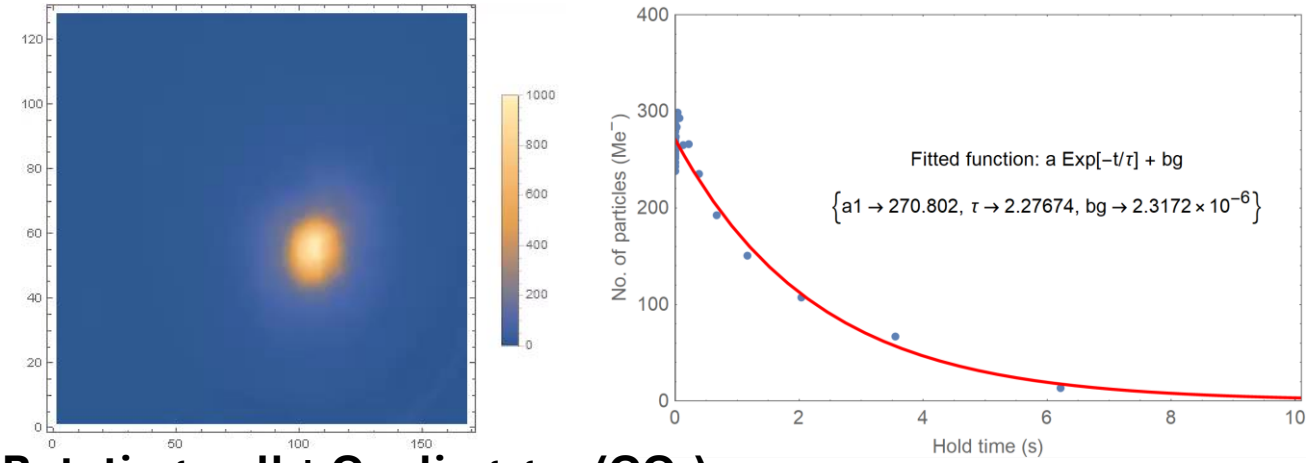
Phosphor screen





Trapping e⁻ plasmas

- **Plasma lifetime**



- **Rotating wall + Cooling gas (CO_2)**

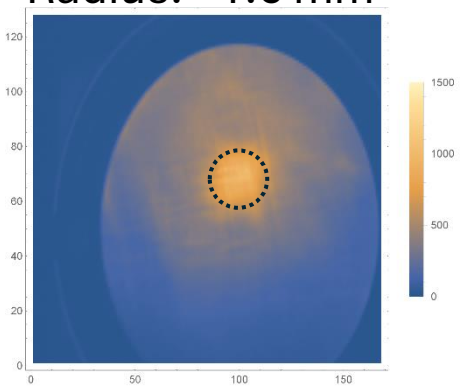
April 2024:

Trap potential: -140V

Number of e⁻: 1.7×10^9 electrons

Peak density: 2.3×10^{14} m^{-3}

Radius: ~1.6 mm

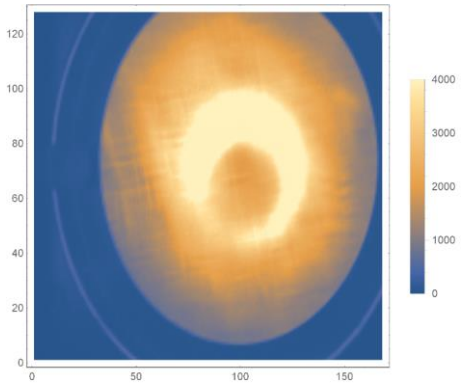


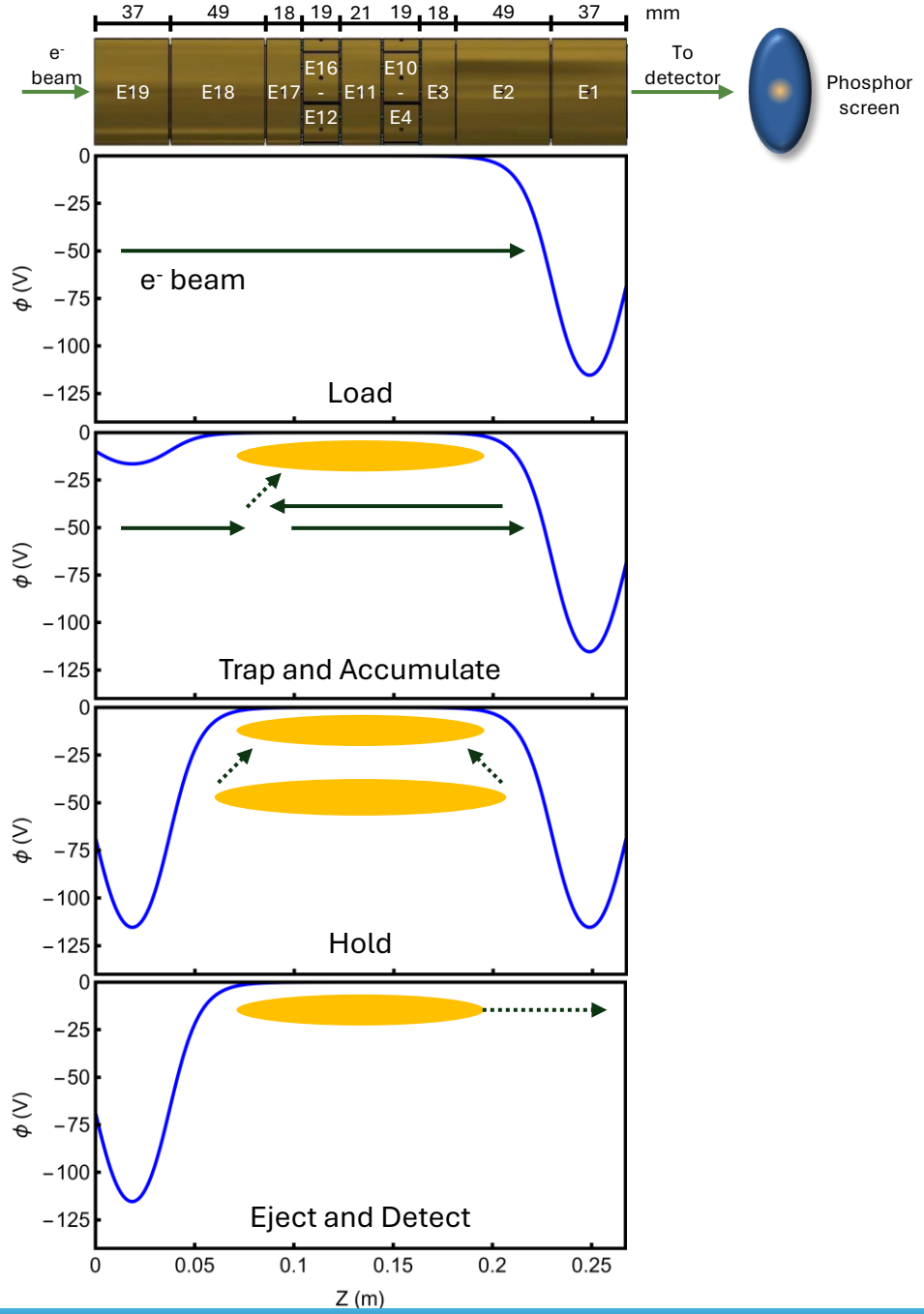
September 2024:

Trap potential: -400V

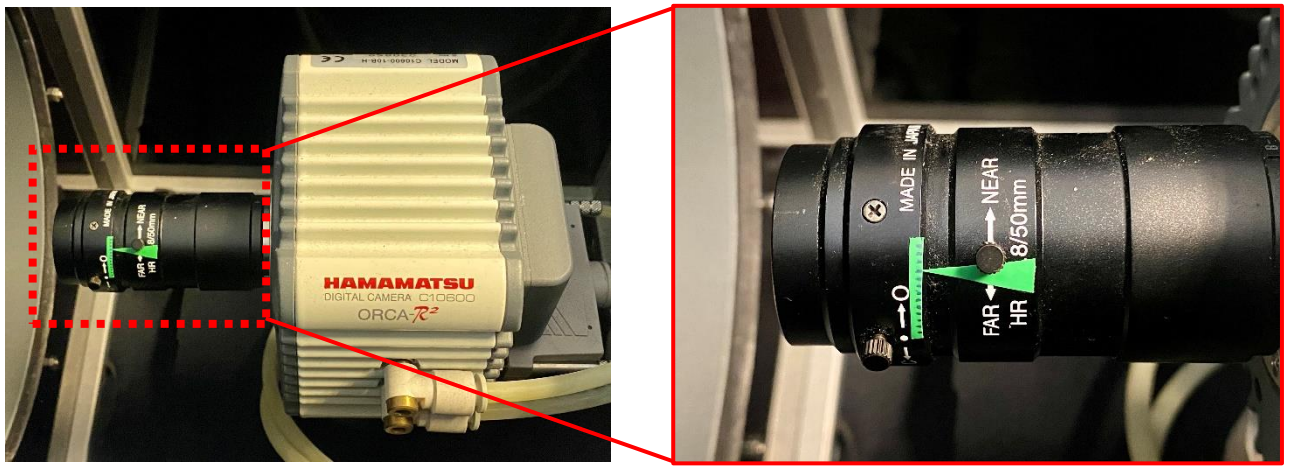
Peak density: ??

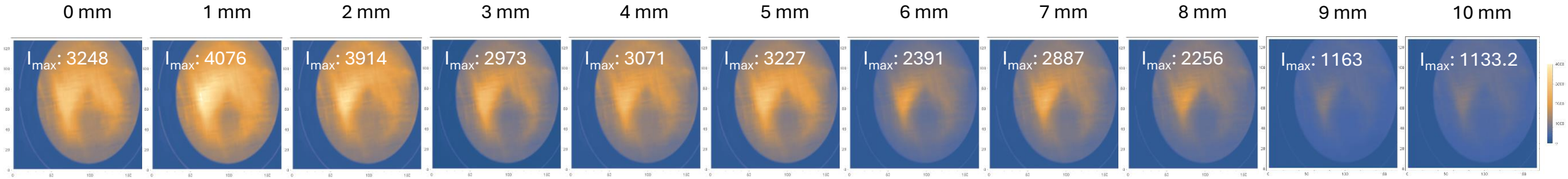
Radius: ??





Adjusting the camera iris





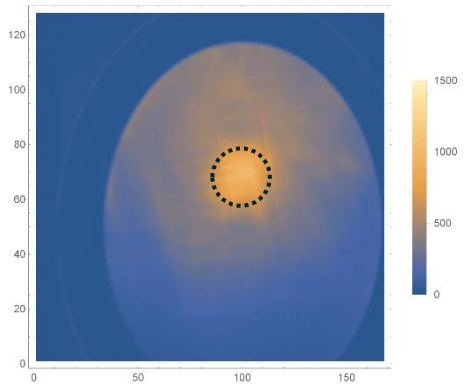
Calculating peak density

April 2024:

Trap potential: -140V

Peak density: 2.3×10^{14} m^{-3}

Radius: ~1.6 mm

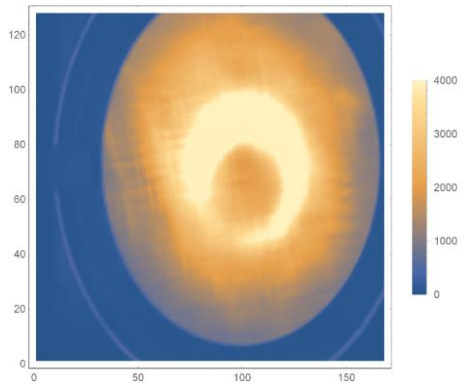


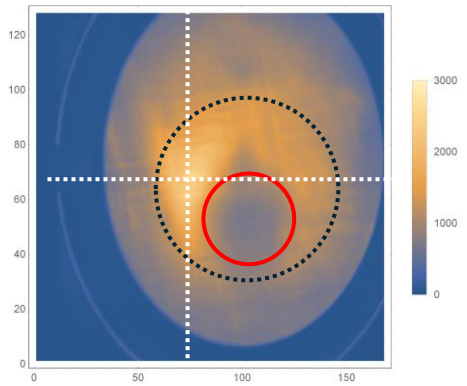
September 2024:

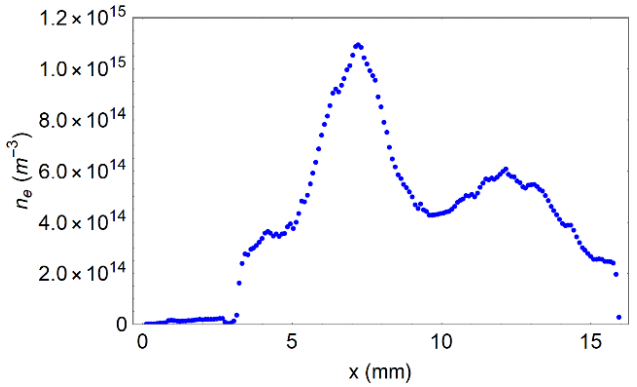
Trap potential: -400V

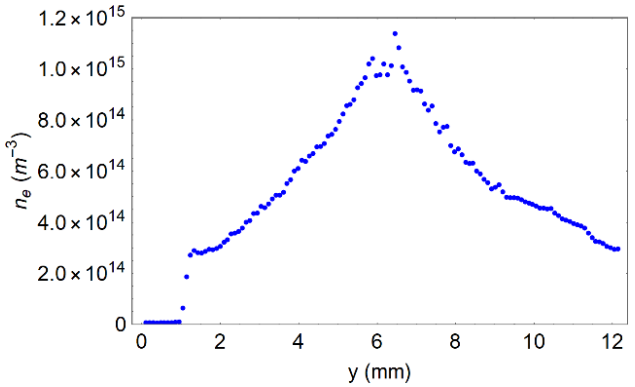
Peak density: 1.1×10^{15} m^{-3}

Radius: ~5 mm

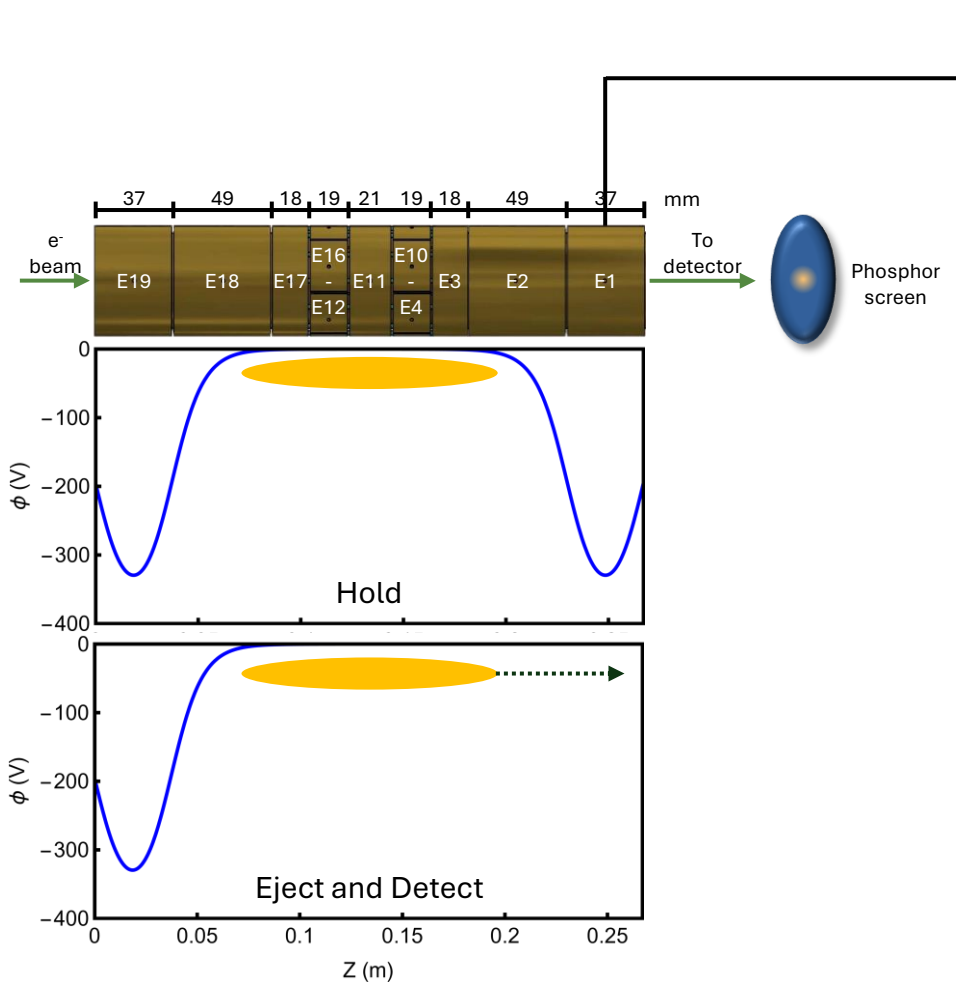




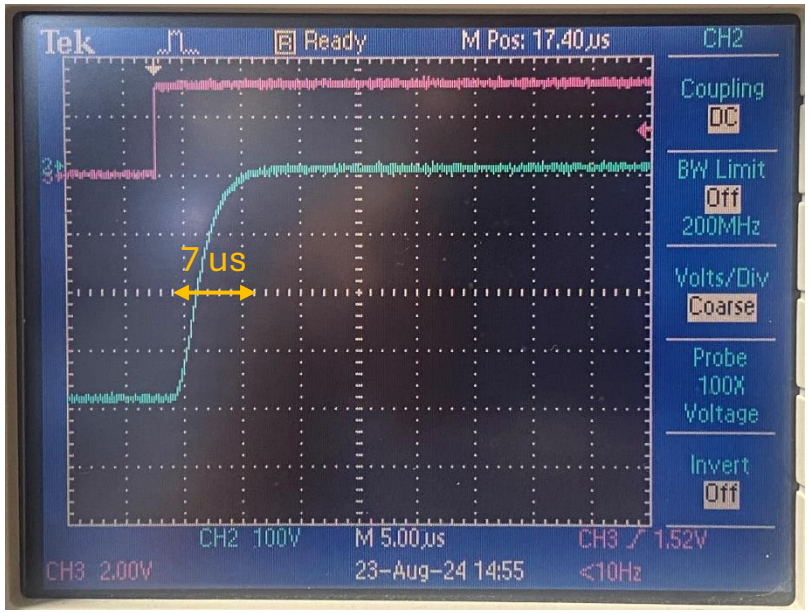




Checking E1 output signal



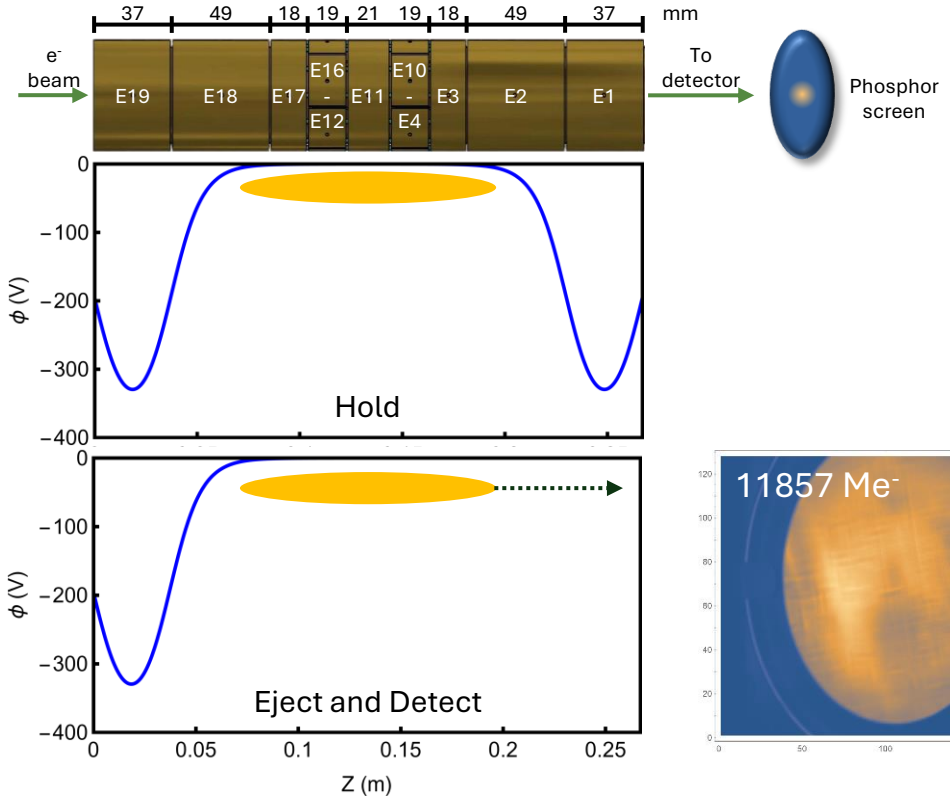
Electrode 1 : -400V → 0V



HV trap completely filled with e⁻

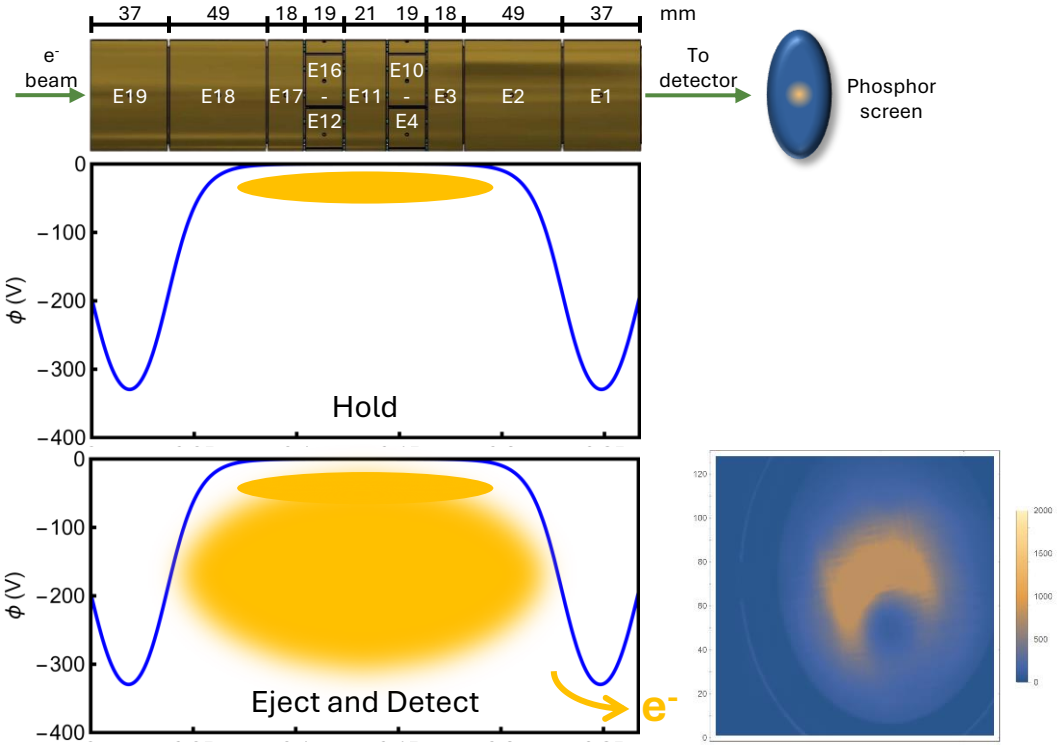
Experimental sequence

1) Load: 1s
2) Hold: 17us
3) RW: 14 MHz, 2.95 V_{pp}, 1s
4) Dump + Trigger CAM: 5 ms

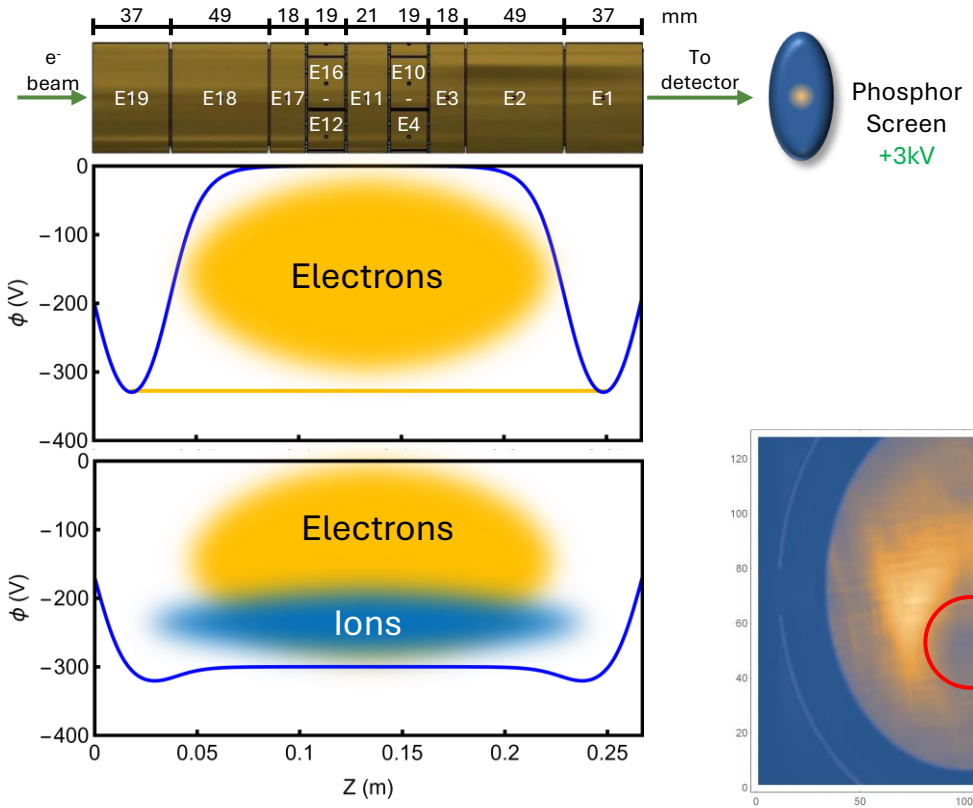


Experimental sequence

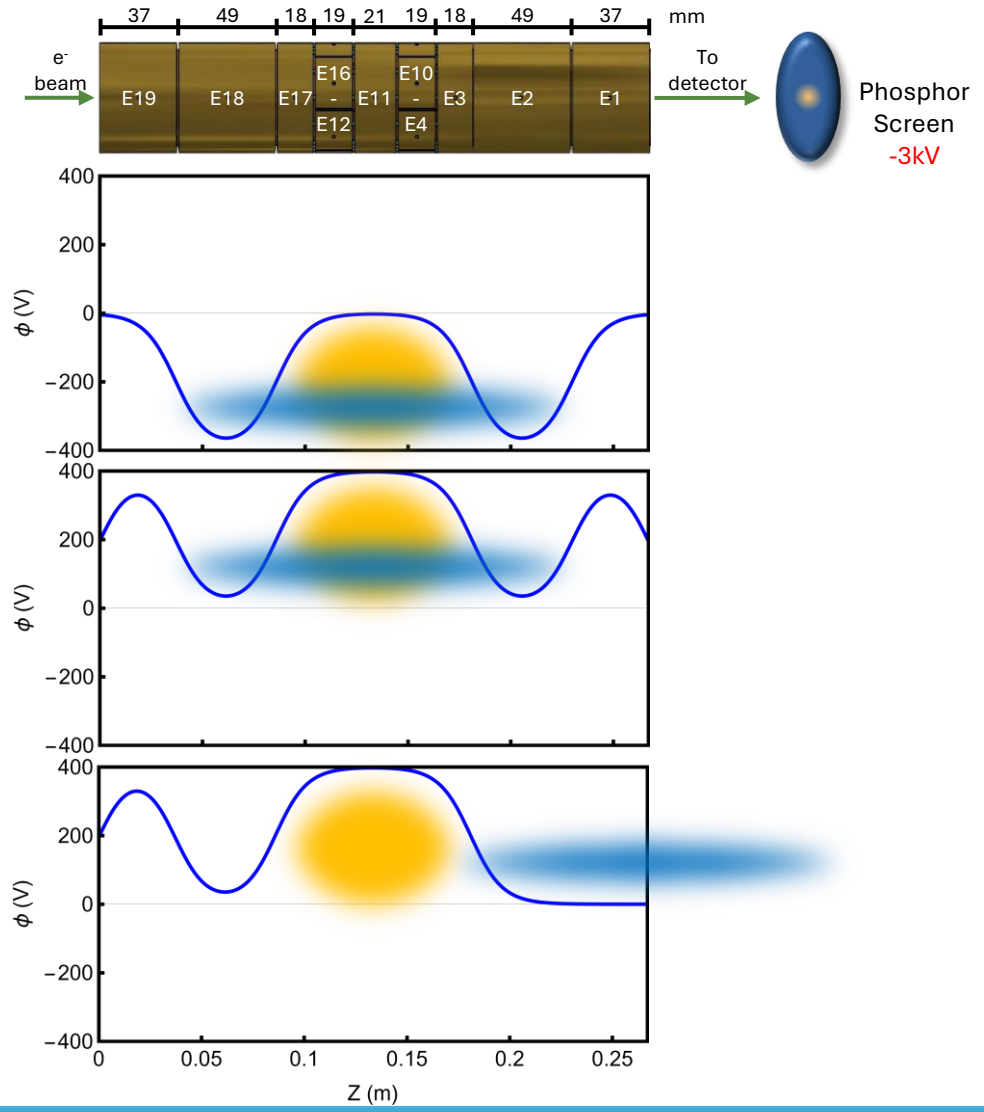
1) Load: 1s
2) Hold: 17us
3) RW: 14 MHz, 2.95 V_{pp}, 1s
4) No Dump + Trigger CAM: 5 ms



Discussions



Imaging ions in the trap



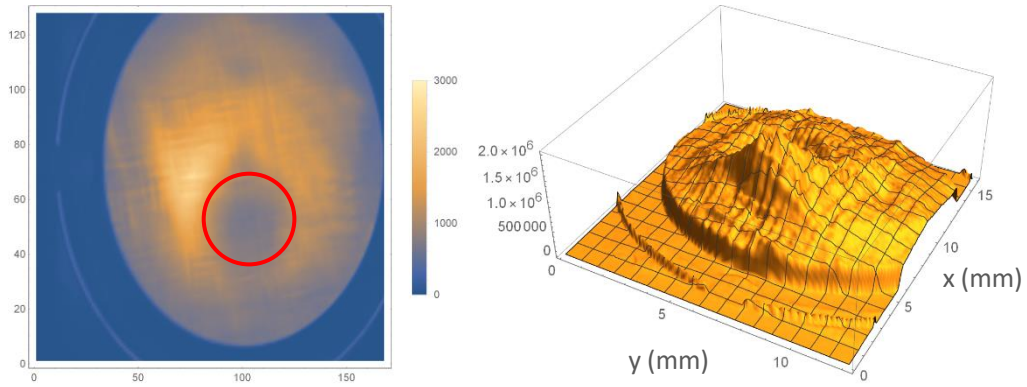
Conclusion and outlook

Density

- The peak density of the plasma is 1.1×10^{15} m^{-3}.

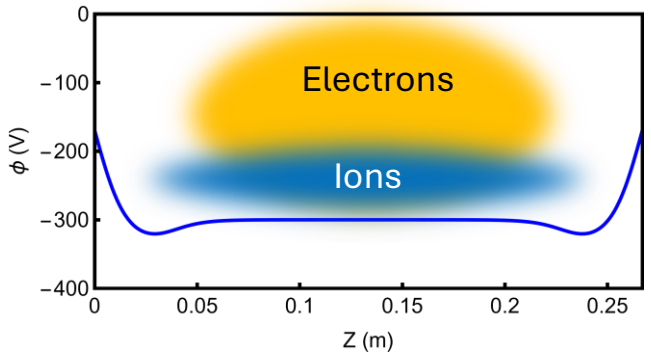
Radius = 5 mm.

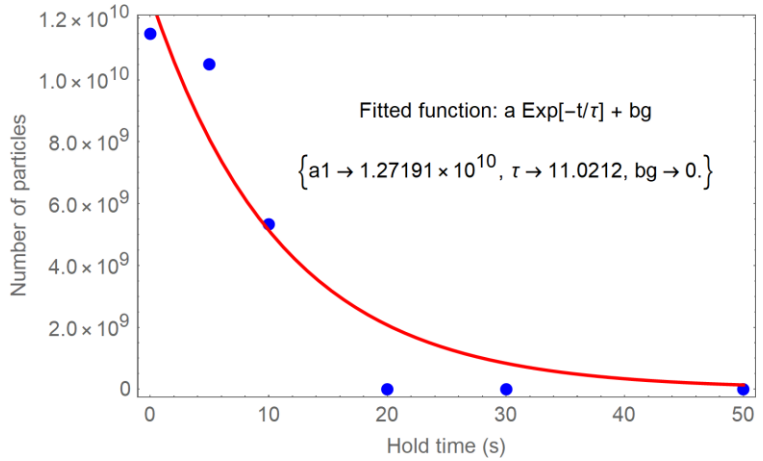
Lifetime = 11 seconds.



Next steps ...

- Image ions in the trap.
- Eliminate the ions
  e.g. applying a rotating wall at a frequency resonant with the ions.





WP3 Personnel

W. Bertsche
M. Charlton
S. Eriksson
D. P. van der Werf
C. A. Isaac
C. Baker
P. Ruksasakchai

T. Dascalu
J. Fajans
J. Wurtele
B. Bingham
R. Hugtenburg
J. Purden
A. Knoll
E. Bennet