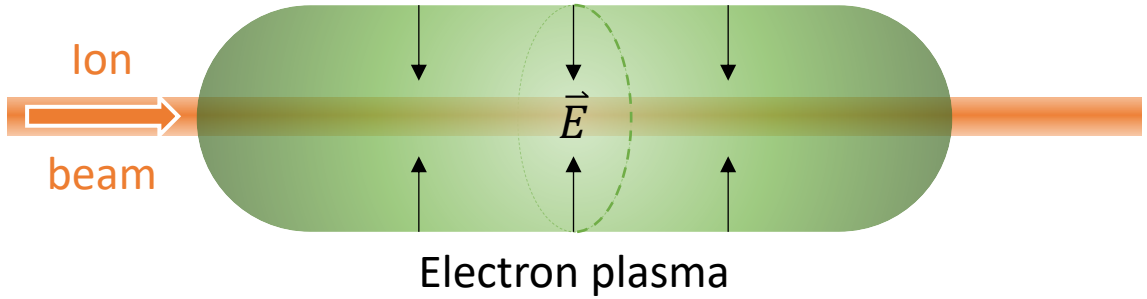
Proton and Ion Capture

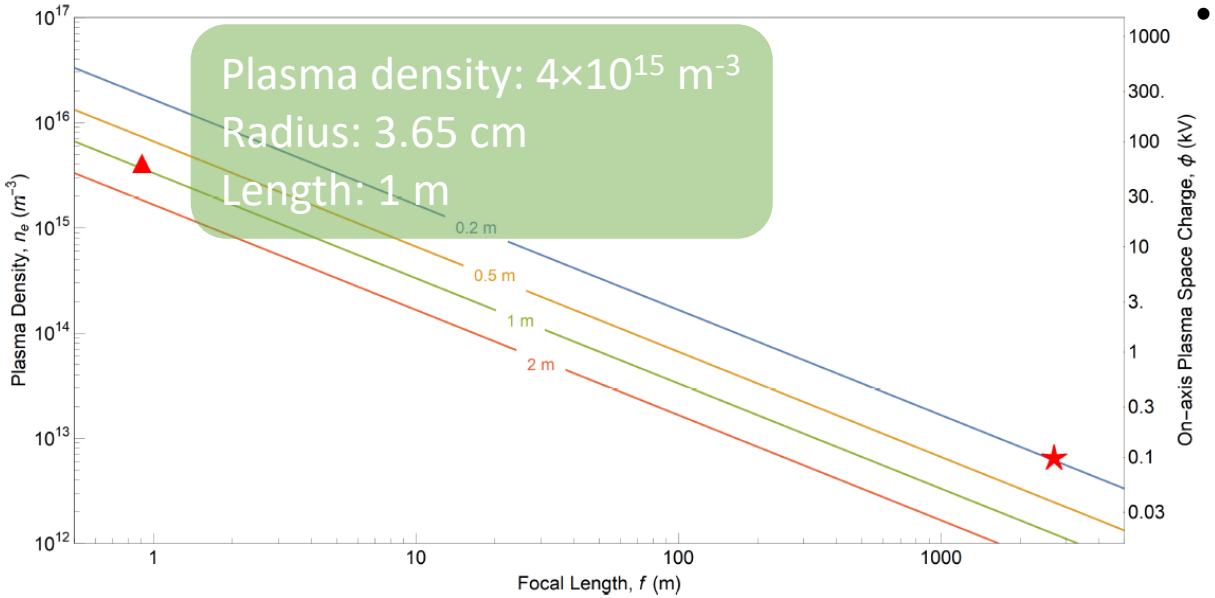
Gabor Lens



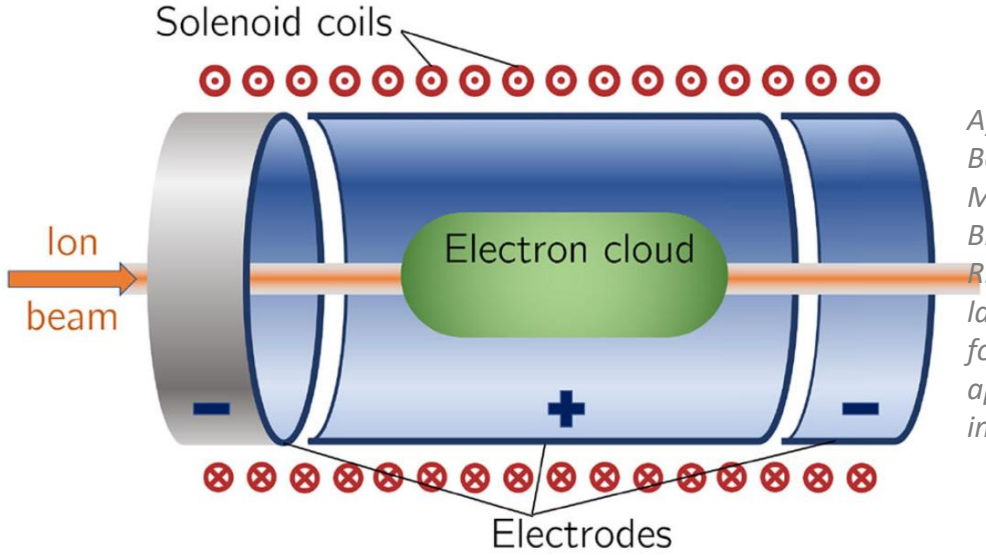
- **The focal length (f) of the Gabor lens:**

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

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.

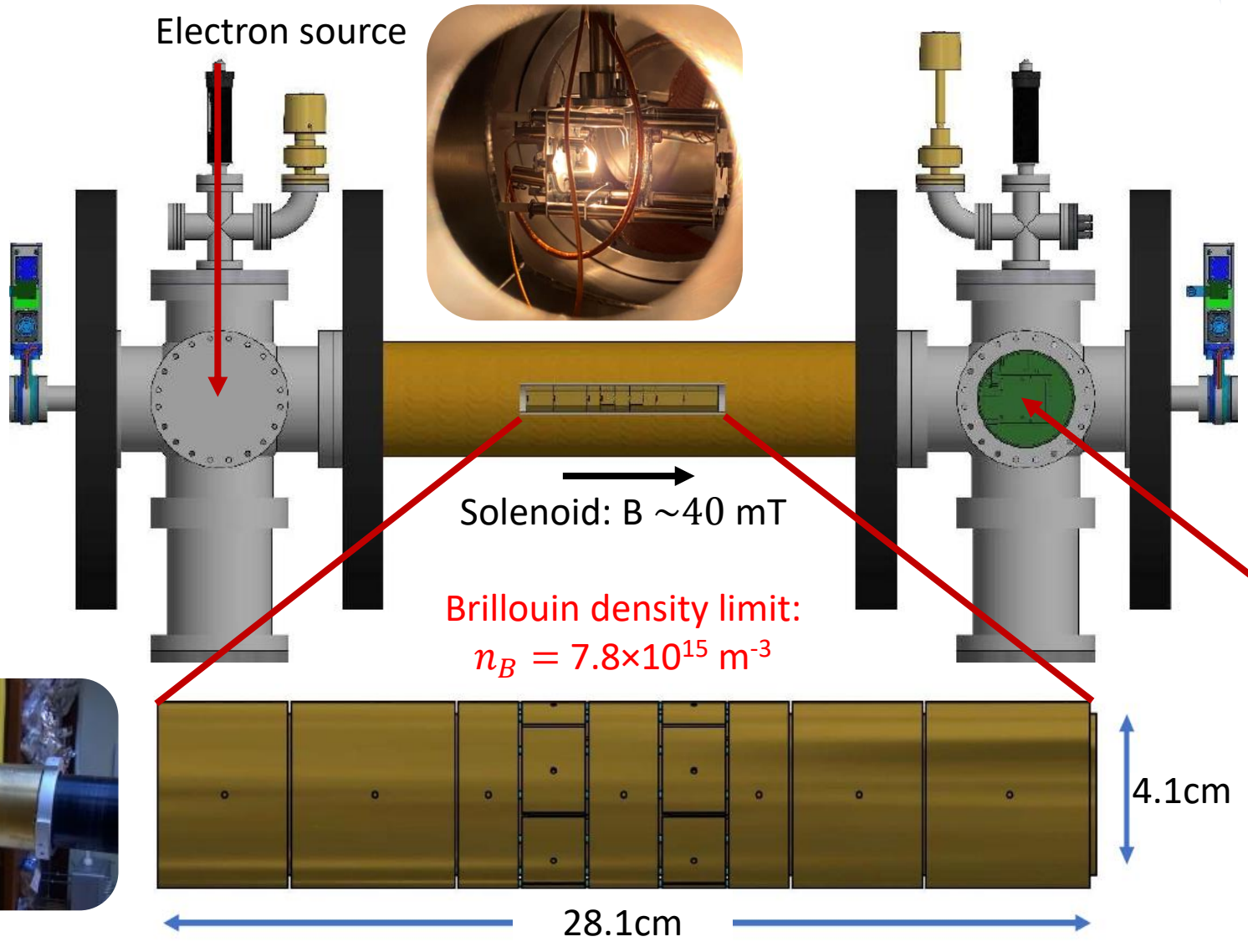


- **Penning-Malmberg Trap**



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.

Experimental Setup

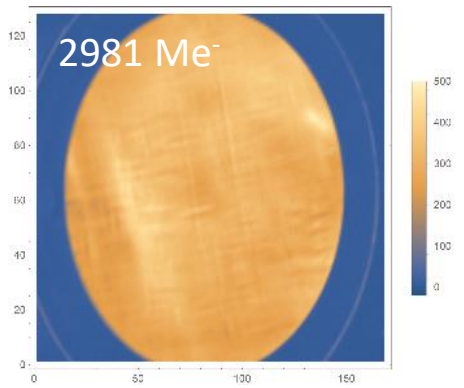


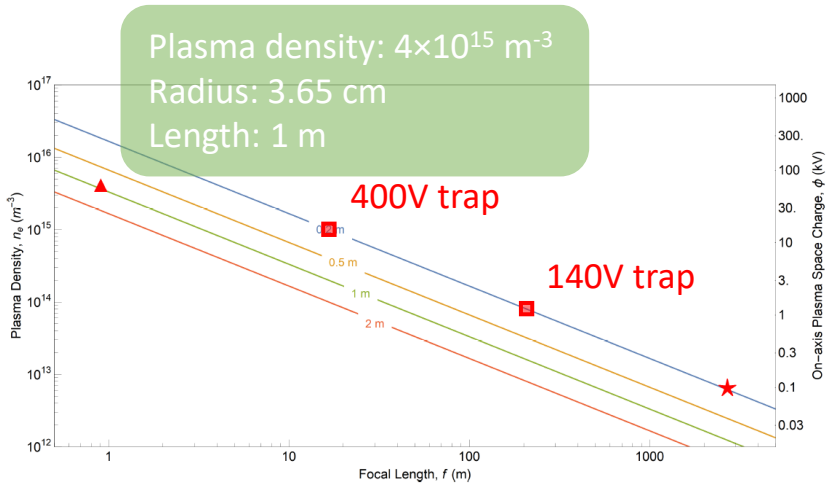
Previous Results

To generate a stable and high-density plasma, two key components are required:

1. Oscillating electric field
2. Dimple that traps ions

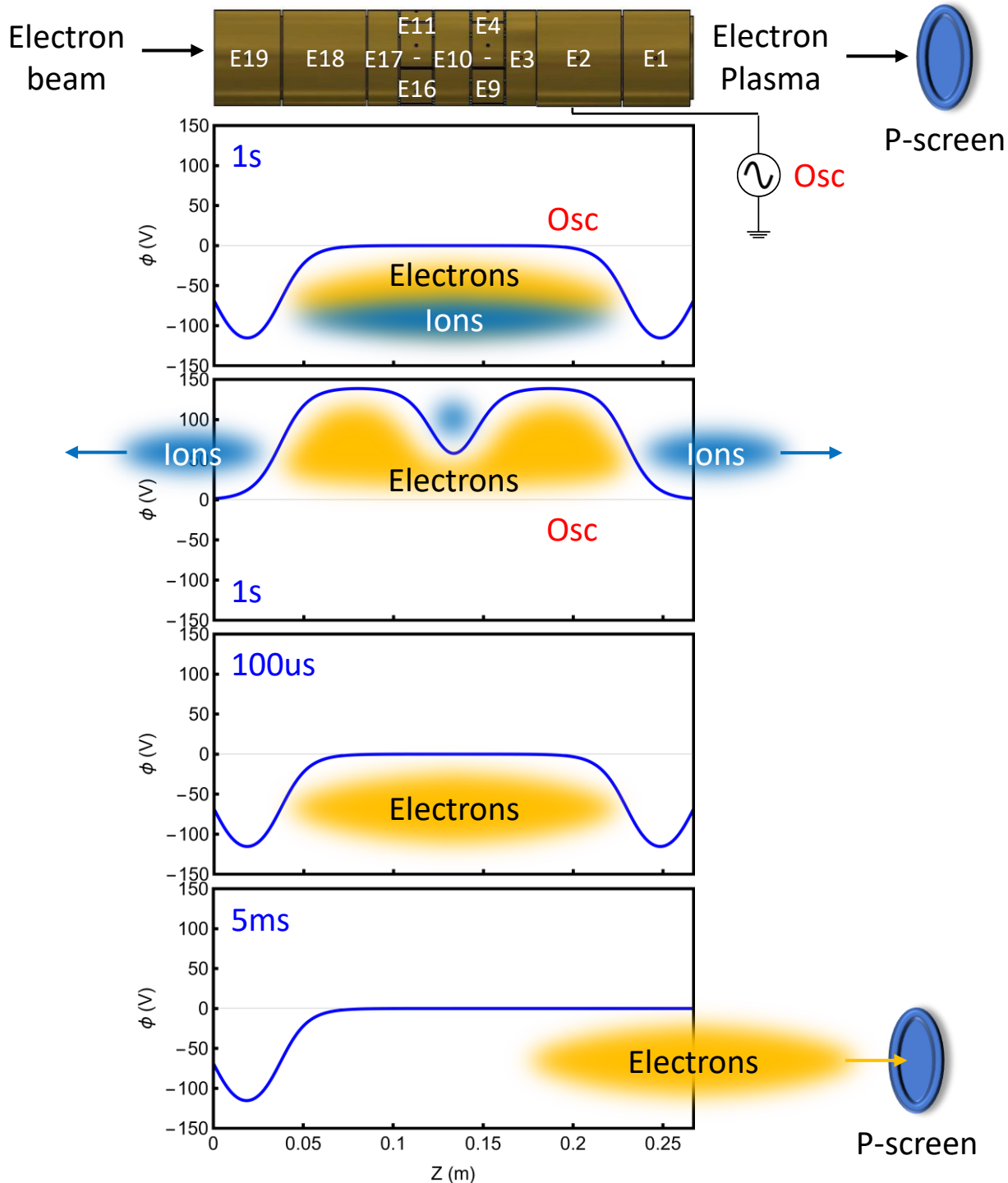
This plasma can be initiated using a very small number of seed electrons.



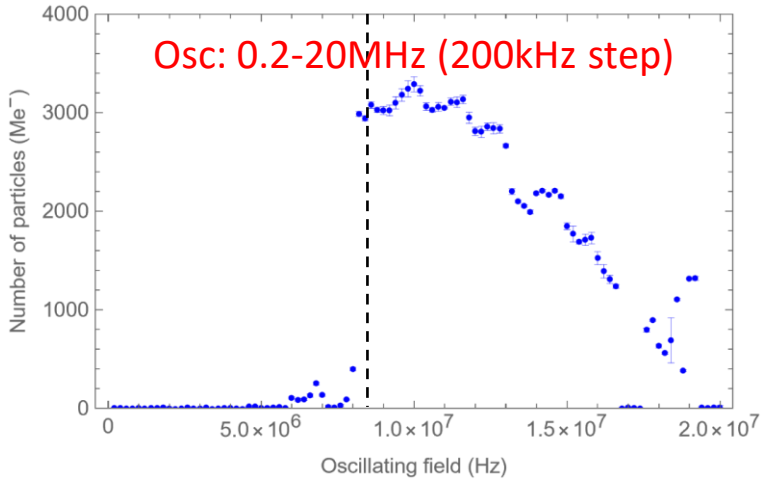


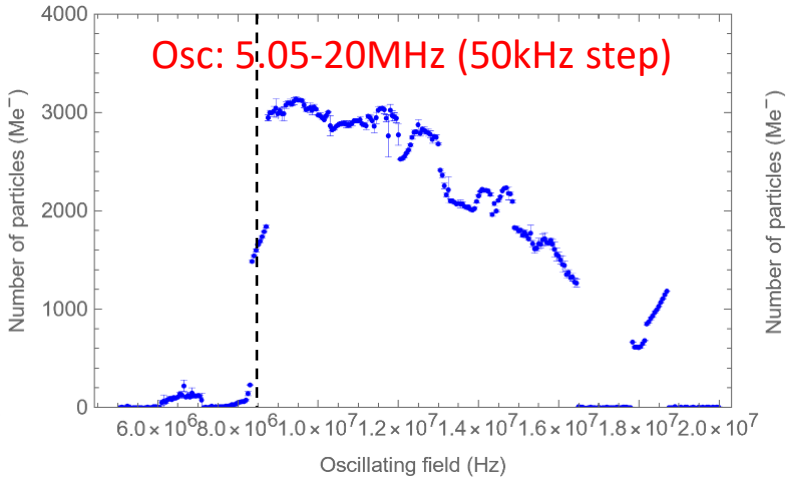
140V trap: Peak density ≈ 8×10^{13} m^{-3}

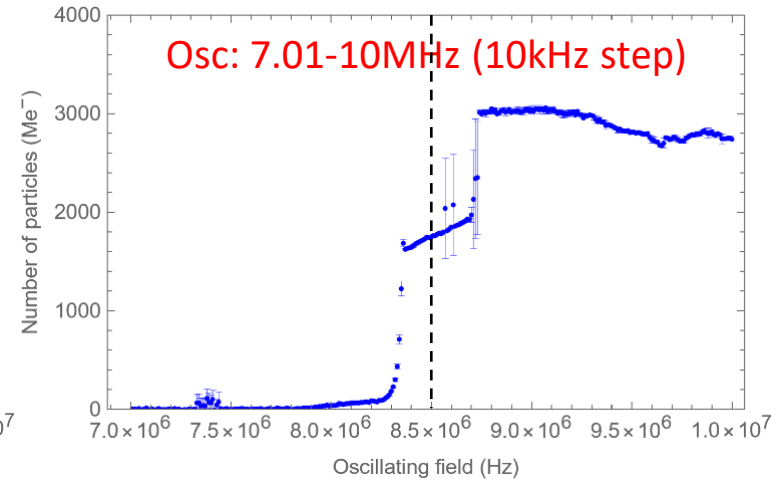
400V trap: Peak density ≈ 1×10^{15} m^{-3}



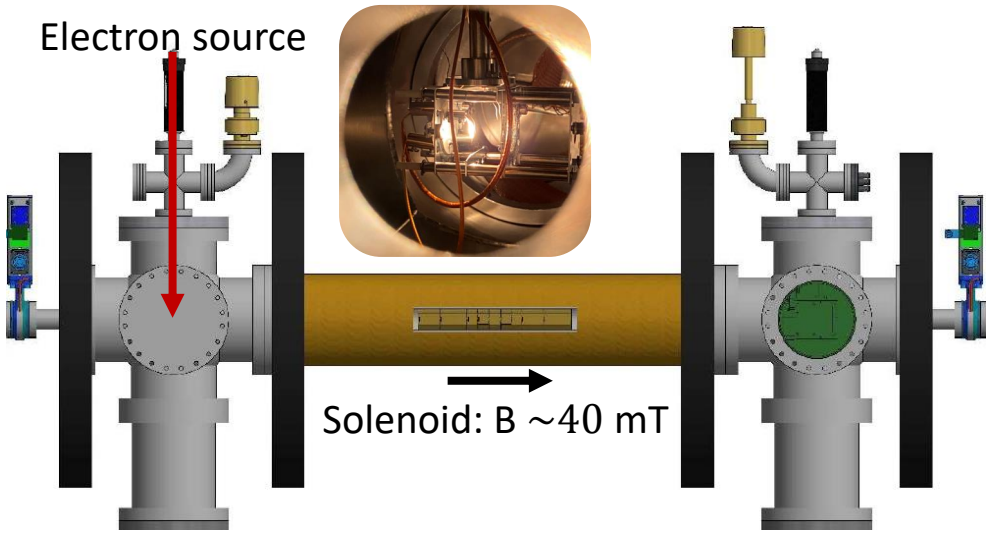
Previous Results







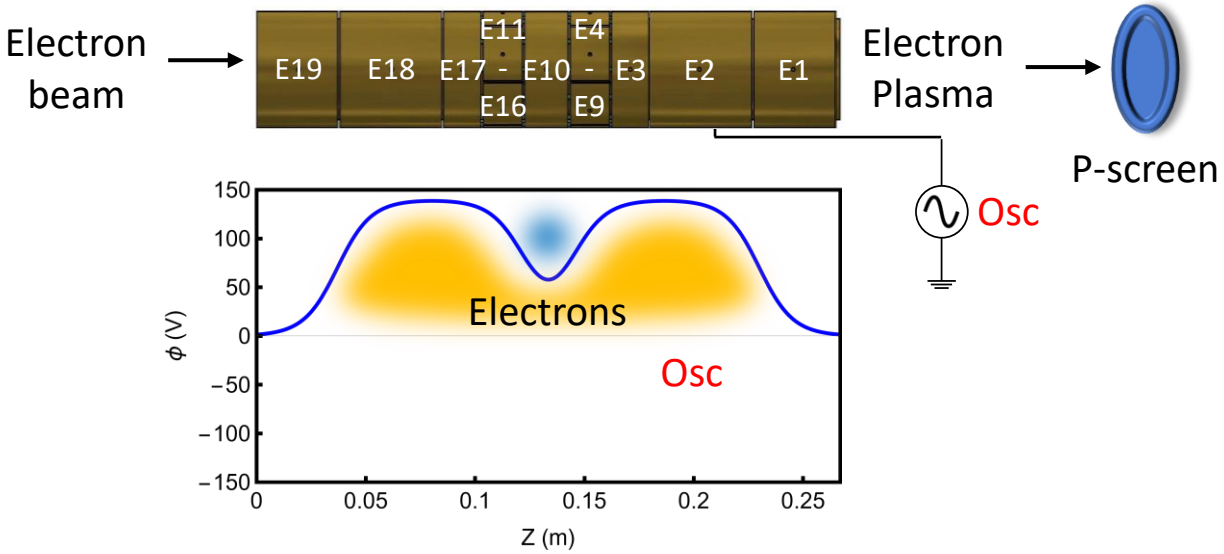
Onset at around 8.5 MHz



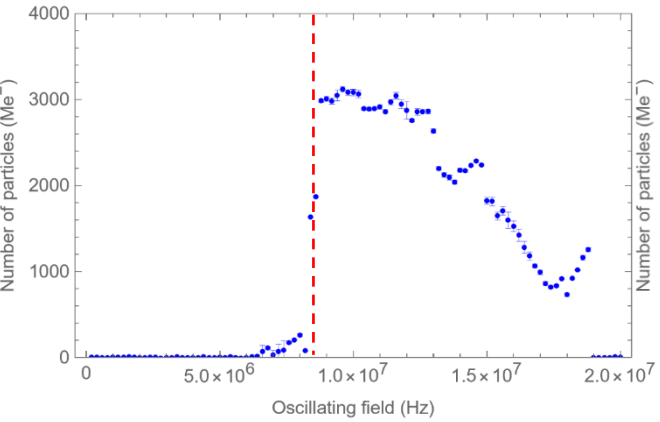
Experimental parameters:

1. Electron energy (E-gun bias voltage)
2. Magnetic field
3. Trap potential
4. Oscillating field amplitude
5. Dimple depth

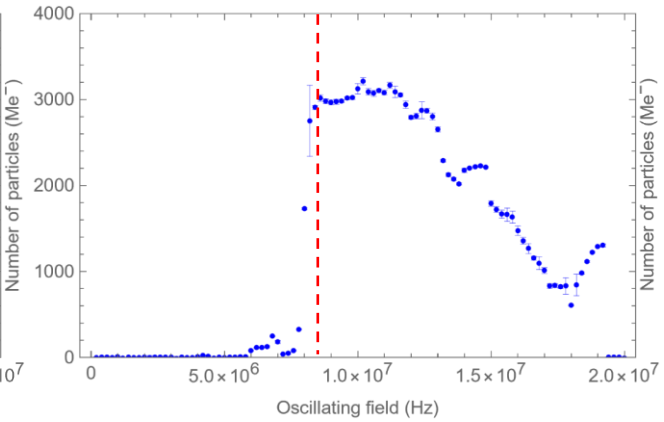
1. Vary E-gun bias voltage



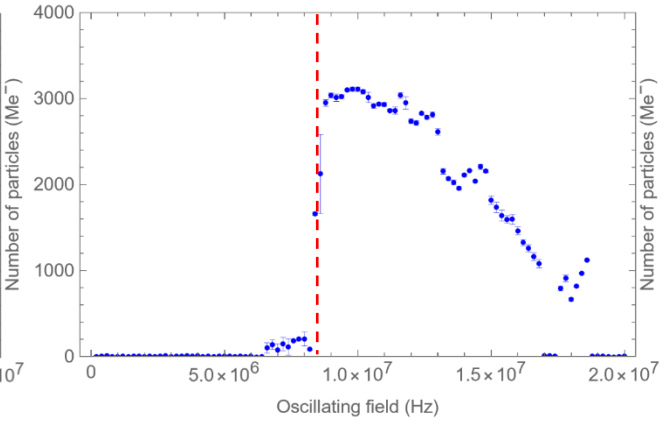
V_{bias}= -30V



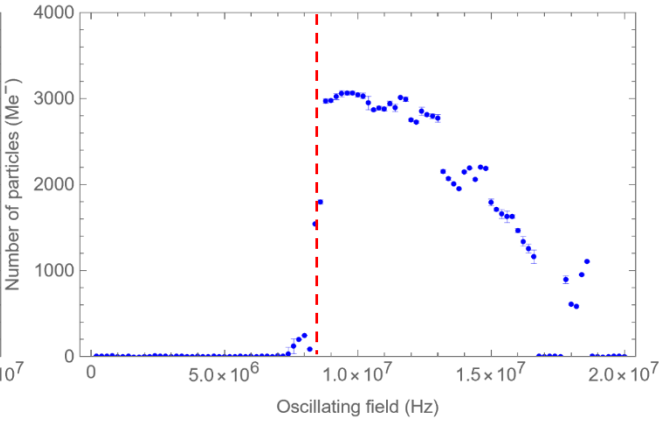
-28V (typical bias voltage)



-26V

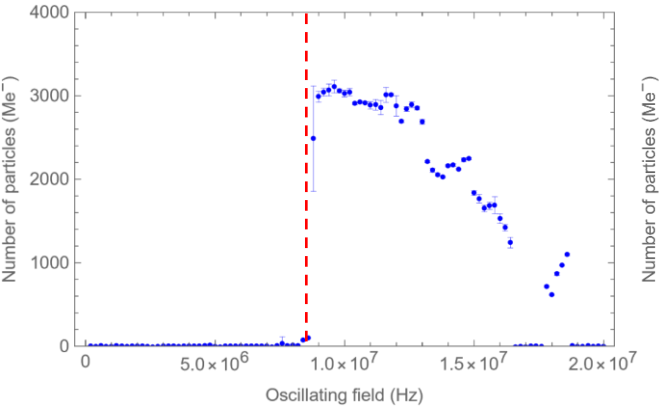


-24V

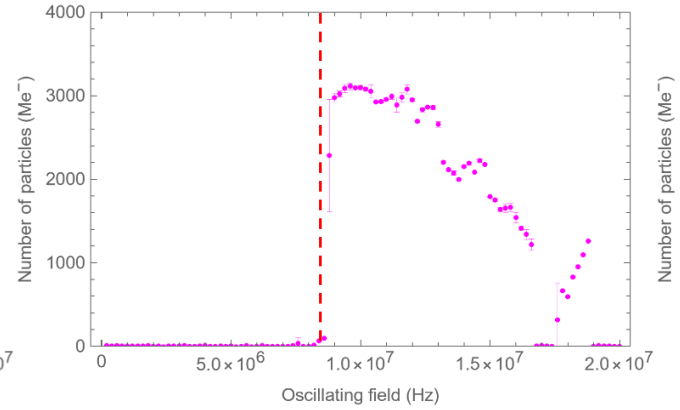


2. Vary magnetic field

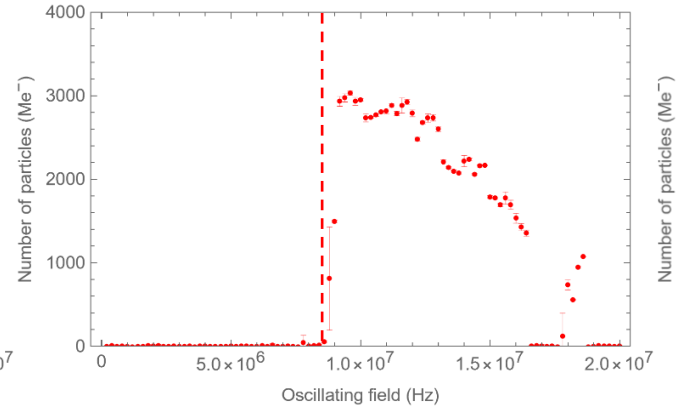
$I_{solenoid}$ = 31 A



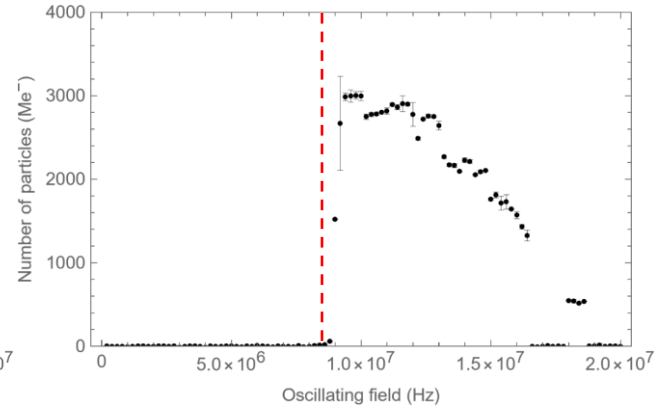
30 A (typical current)



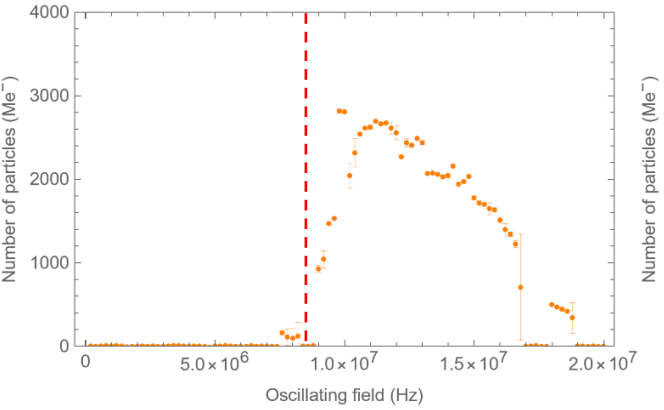
28 A



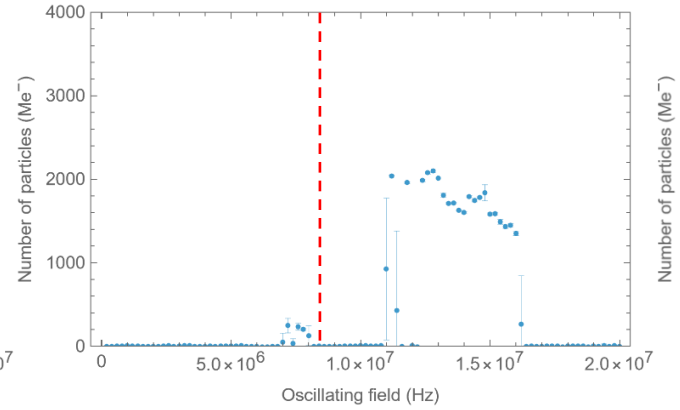
26 A



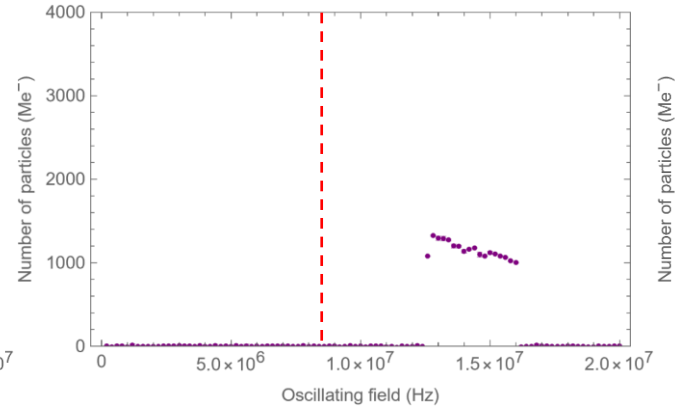
20 A



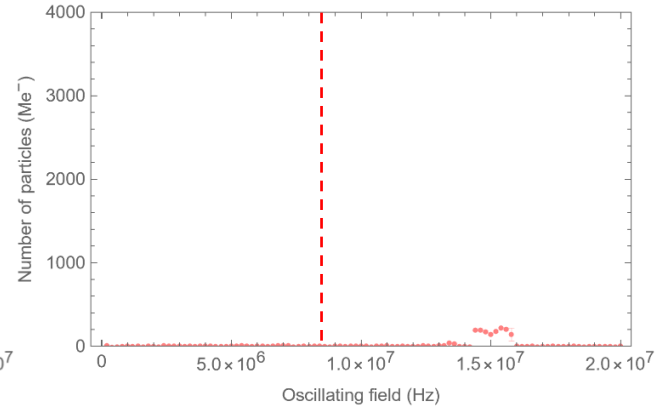
15 A



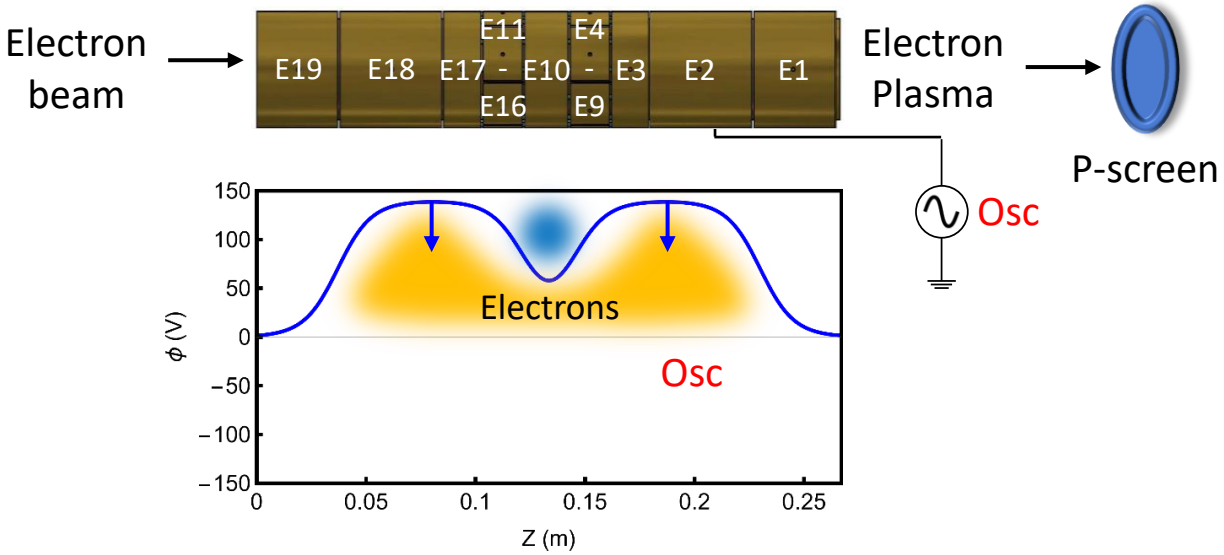
10 A



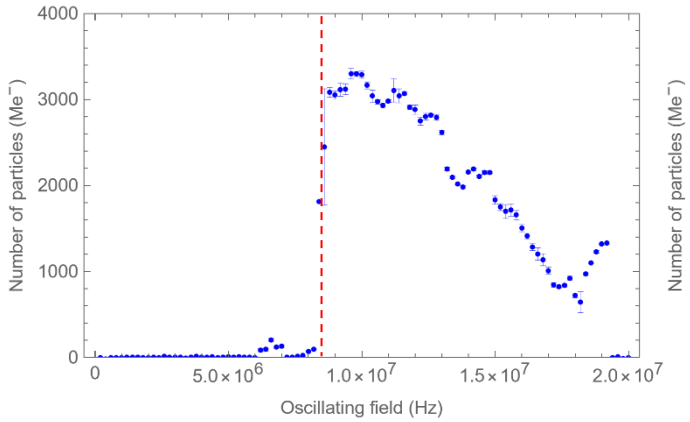
5 A



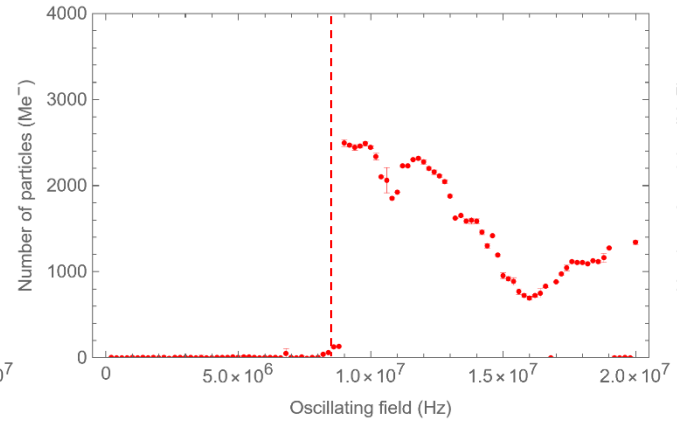
3. Vary trap potential



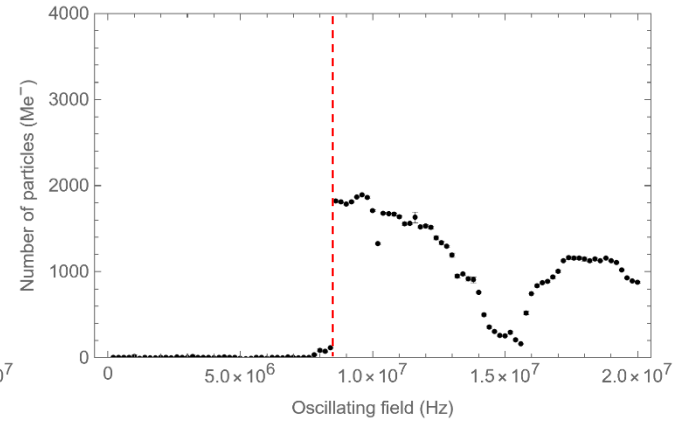
Trap depth= 140 V (typical trap depth)



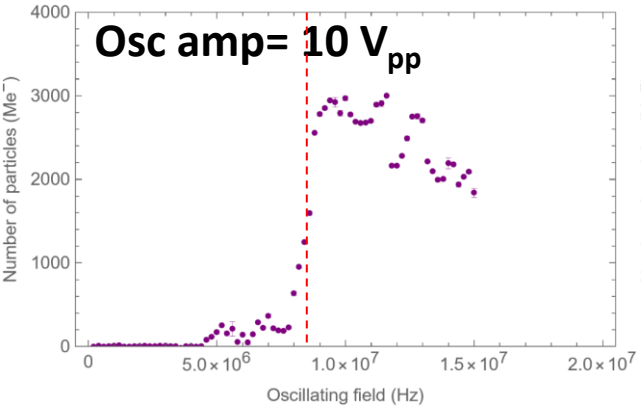
120 V

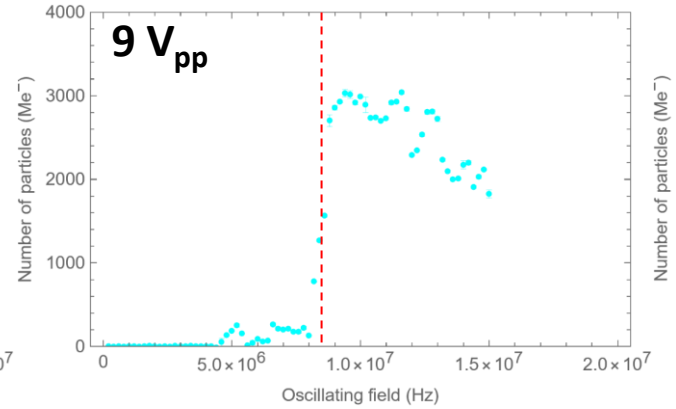


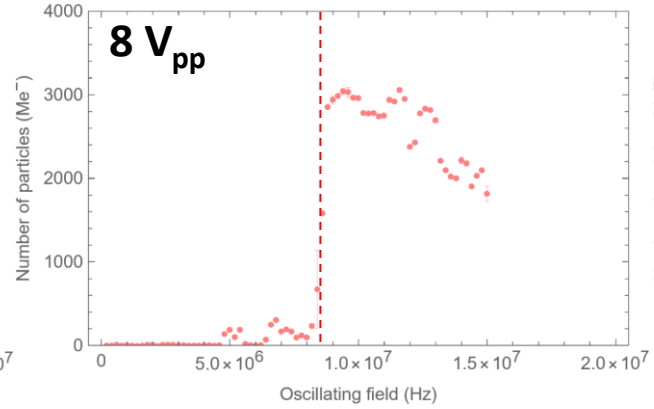
100 V

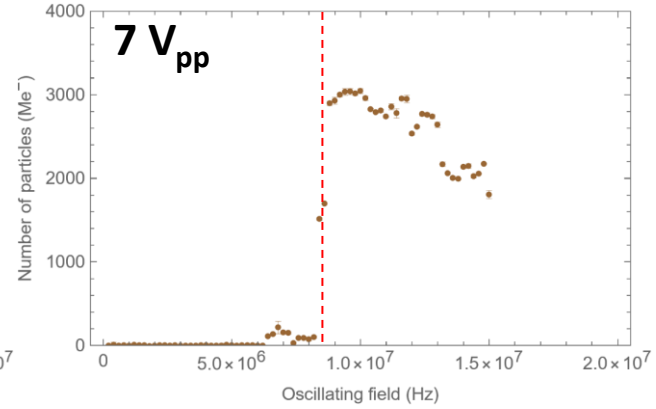


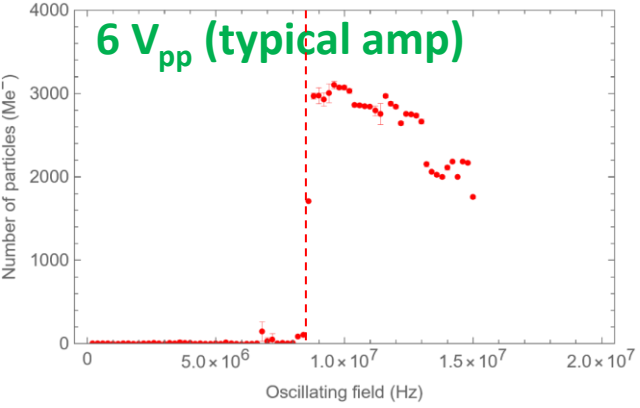
4. Vary Osc amplitude

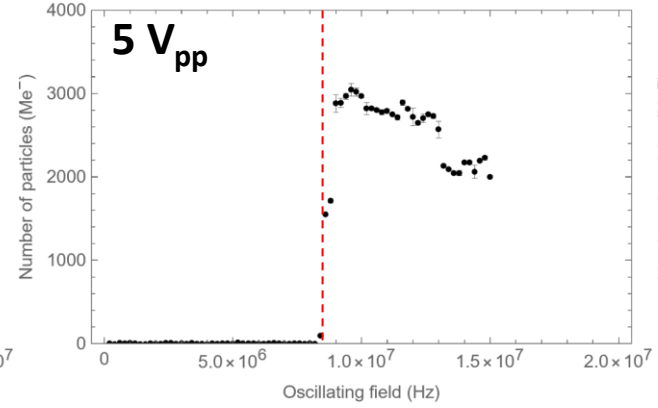


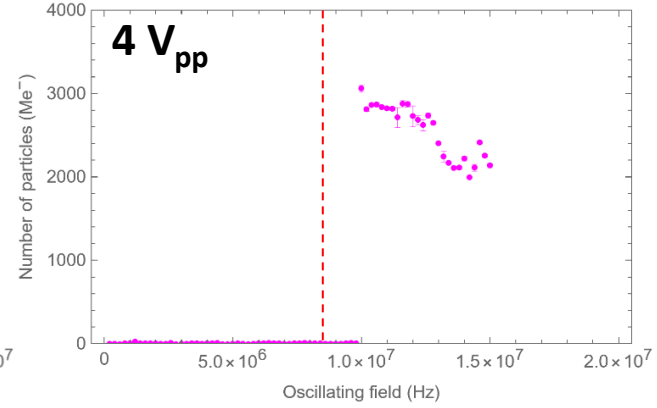


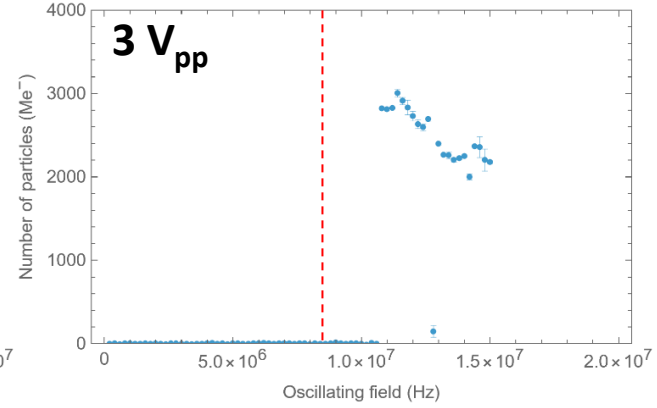


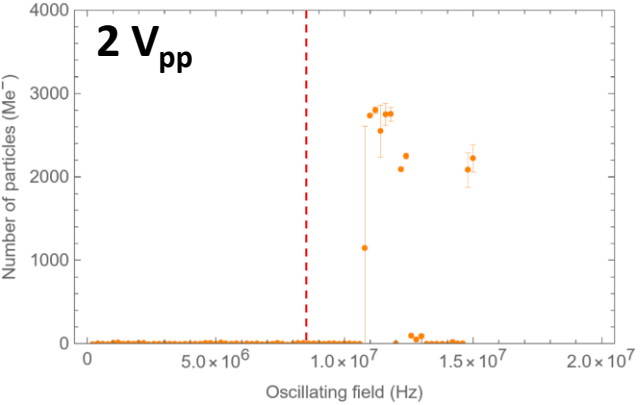




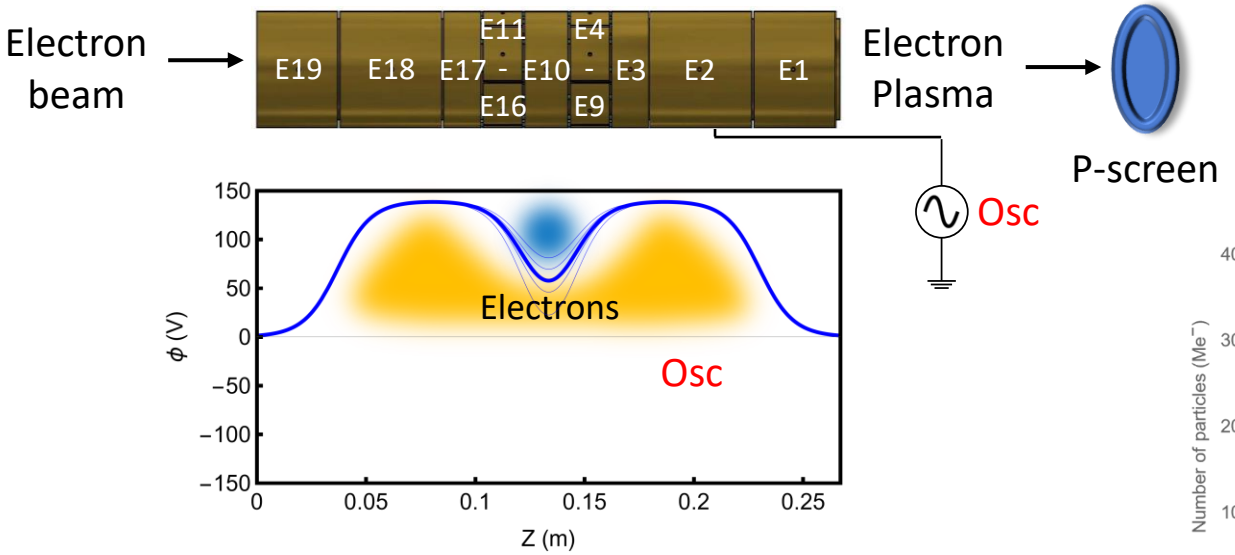




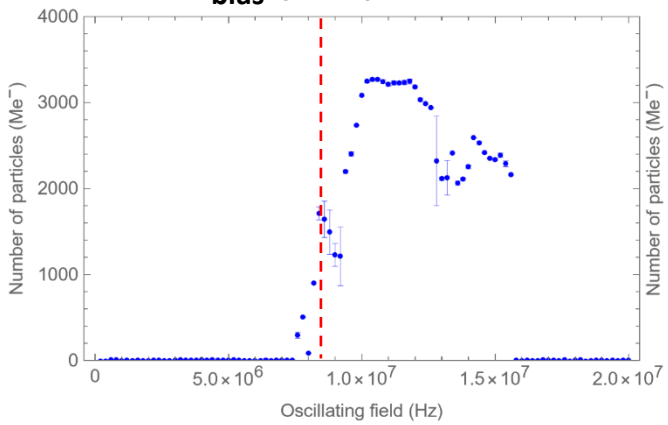




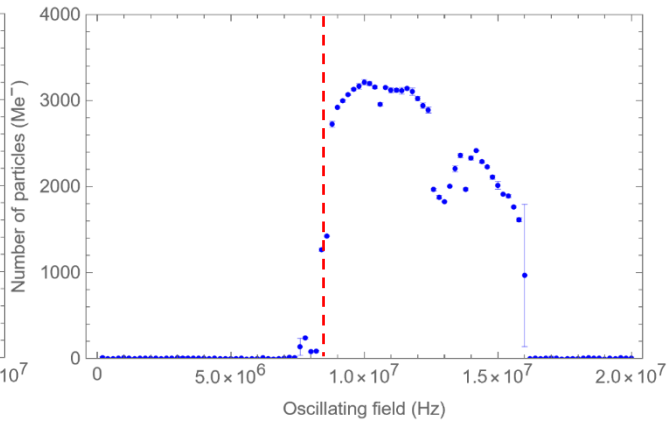
5. Vary dimple depth



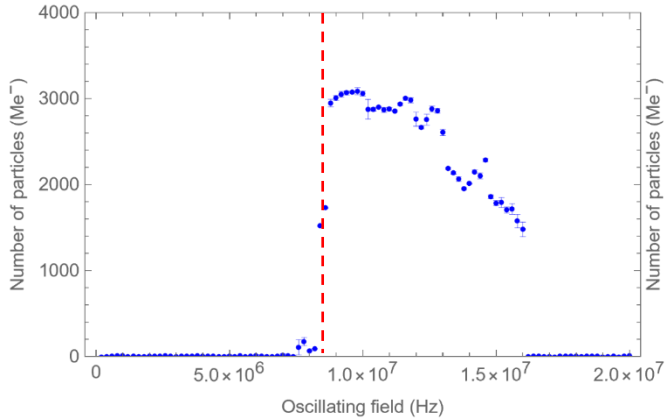
V_{bias} (E10)= 40V



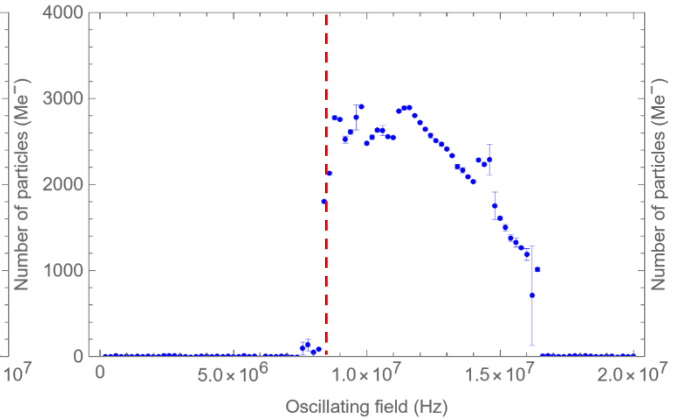
20V



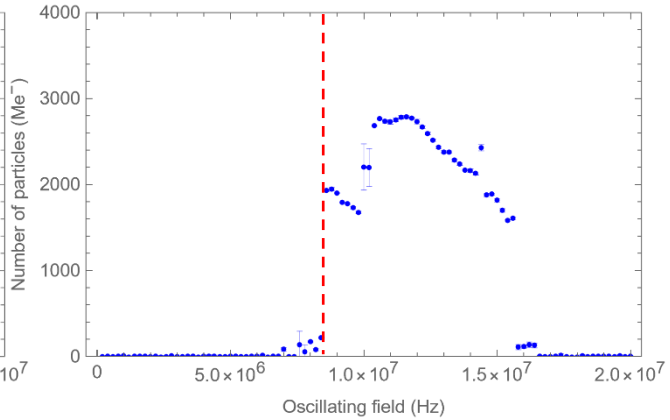
0V (typical bias voltage)



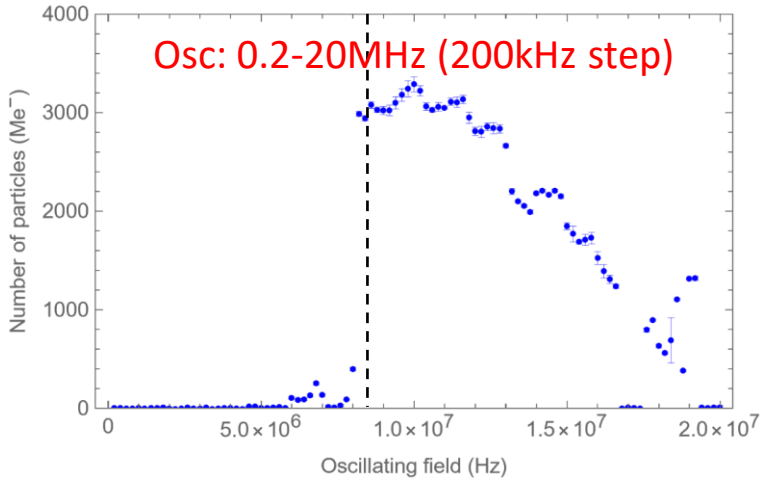
-20V

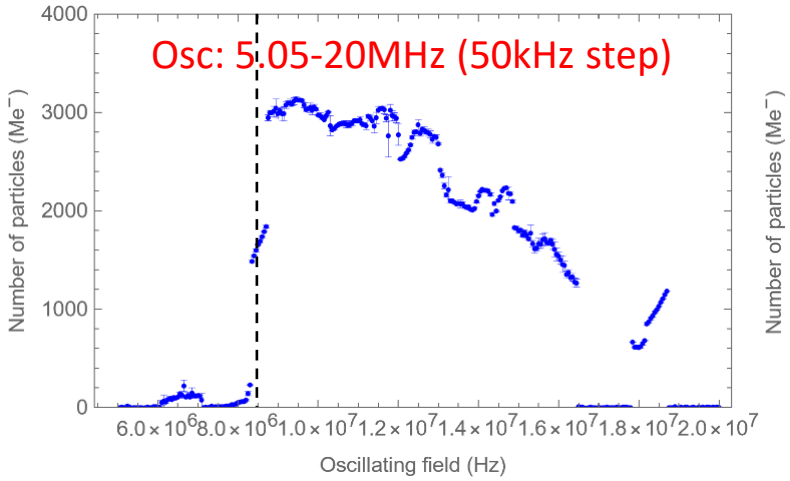


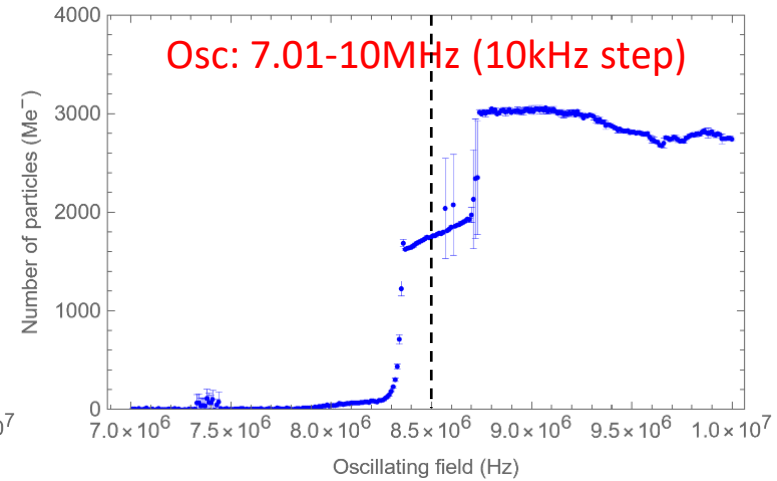
-60V



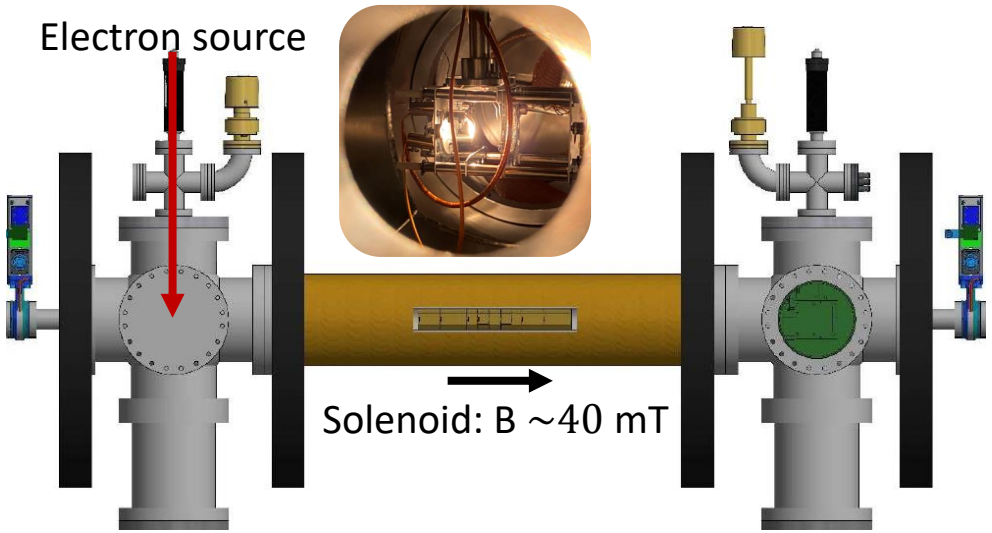
Discussion







Onset at around 8.5 MHz



Experimental parameters:

1. Electron energy (E-gun bias voltage)
2. Magnetic field
3. Trap potential
4. Oscillating field amplitude
5. Dimple depth

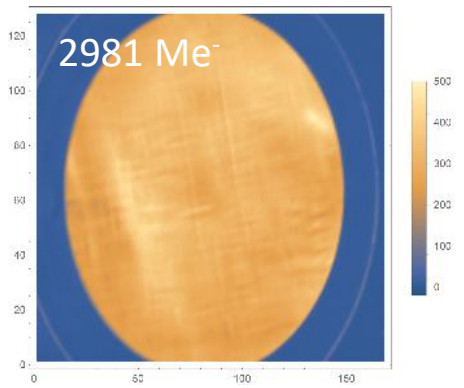
- Investigate the feed-through cables that connect the voltage supply to each electrode.

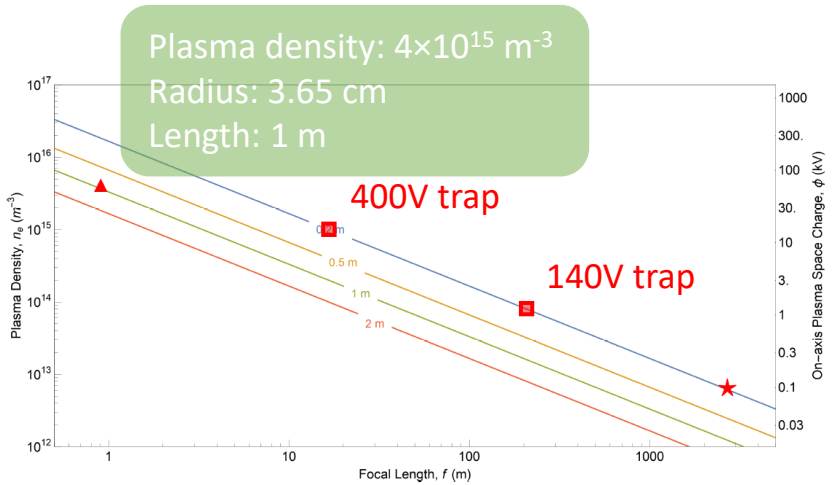
Discussion

To generate a stable and high-density plasma, two key components are required:

1. Oscillating electric field
2. Dimple that traps ions

Notably, this plasma can be initiated using a very small number of seed electrons.





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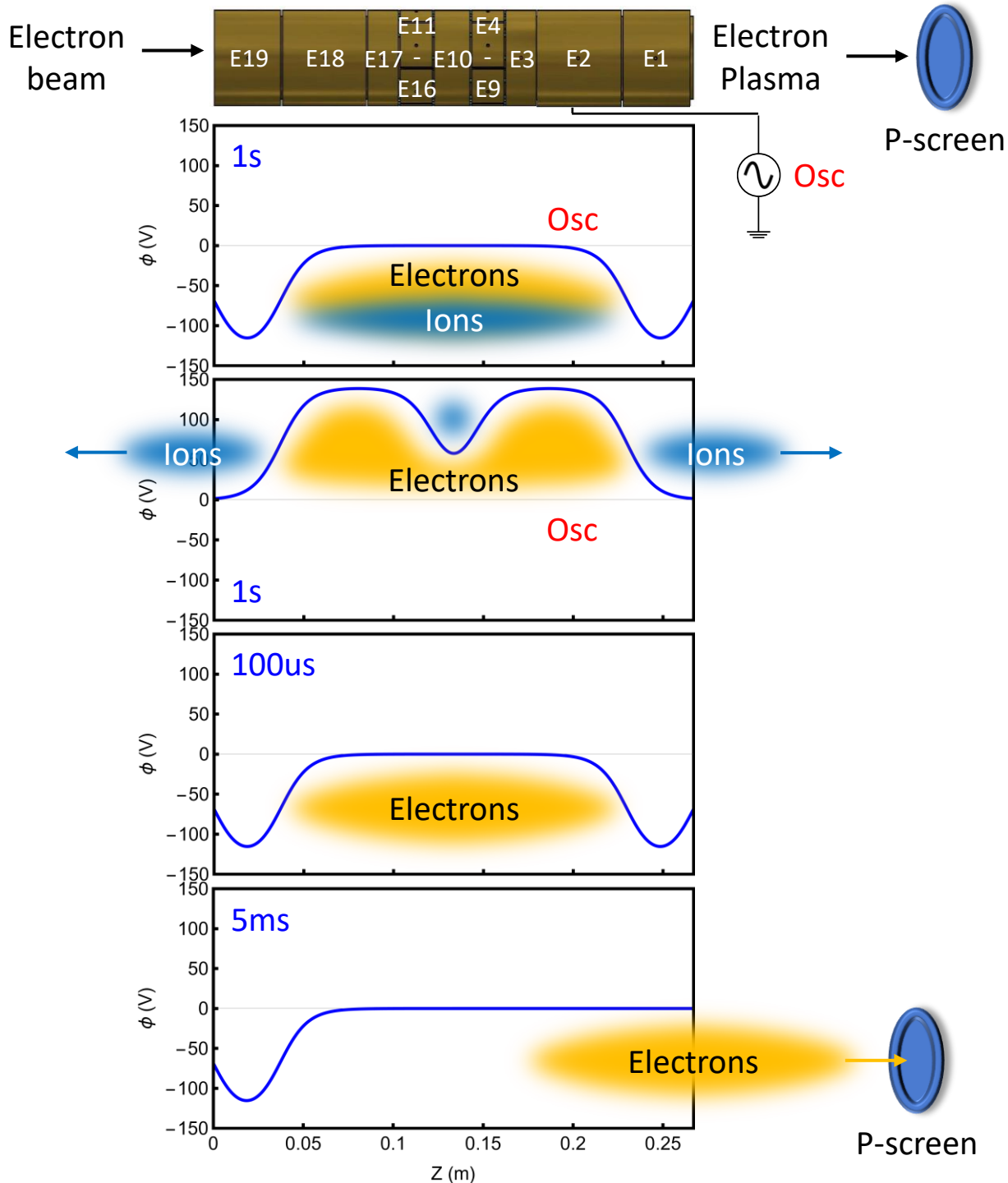
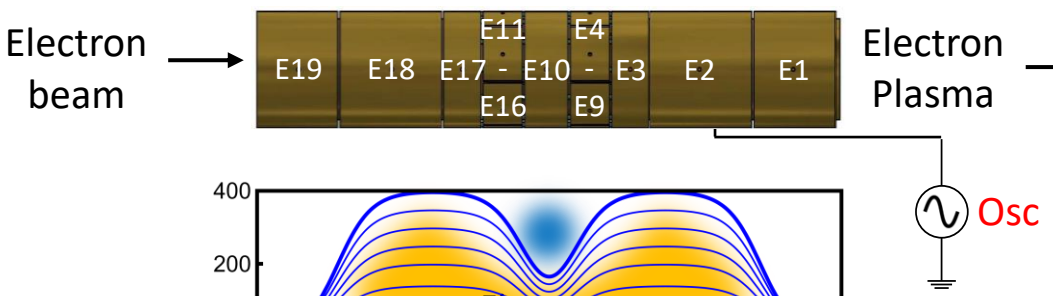
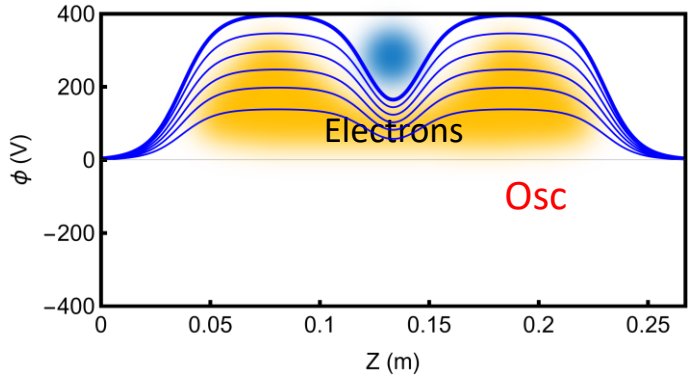
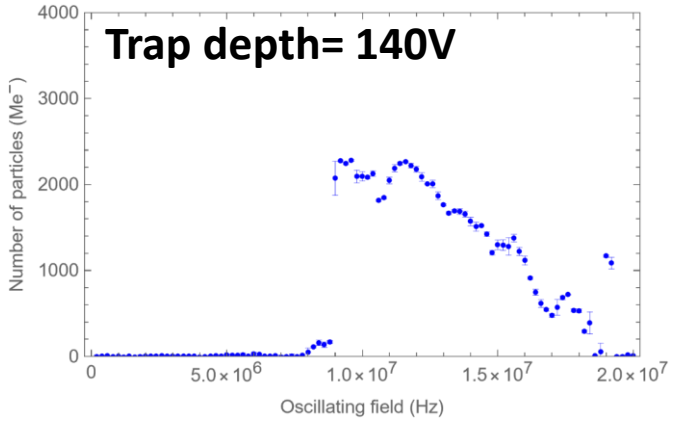
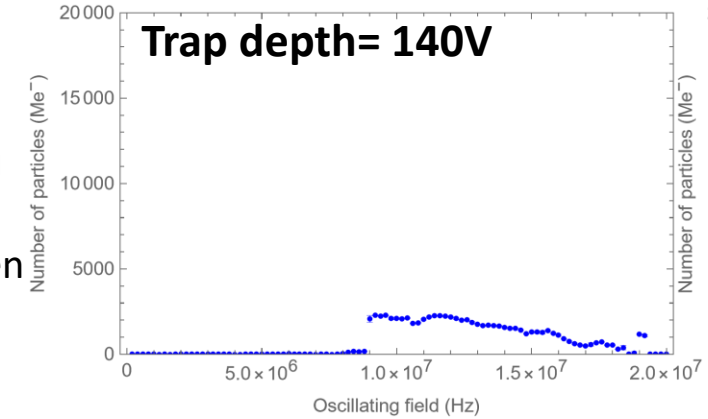


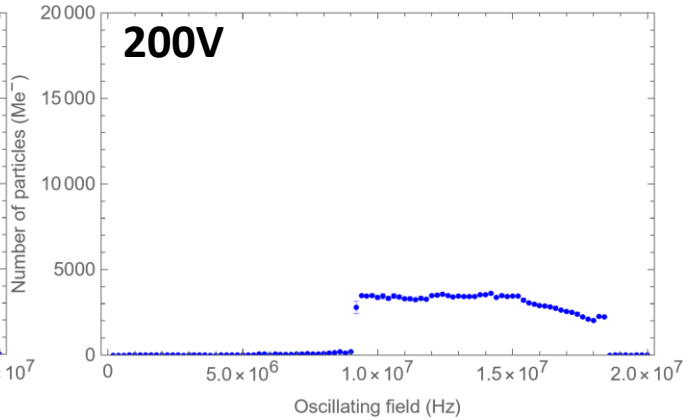
Plasma in HV traps

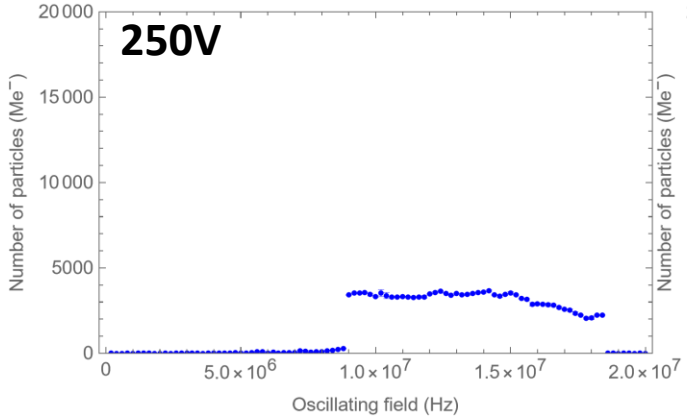


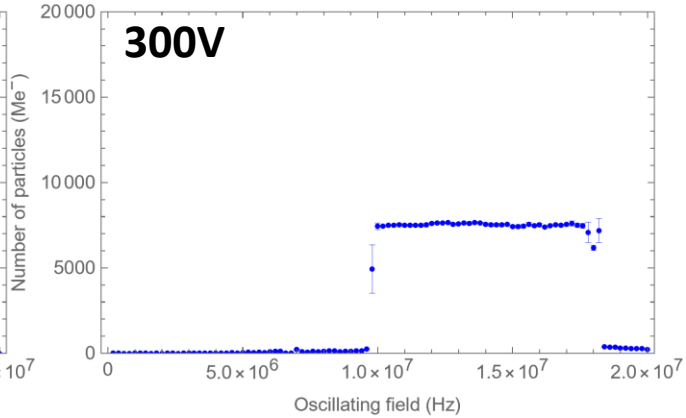


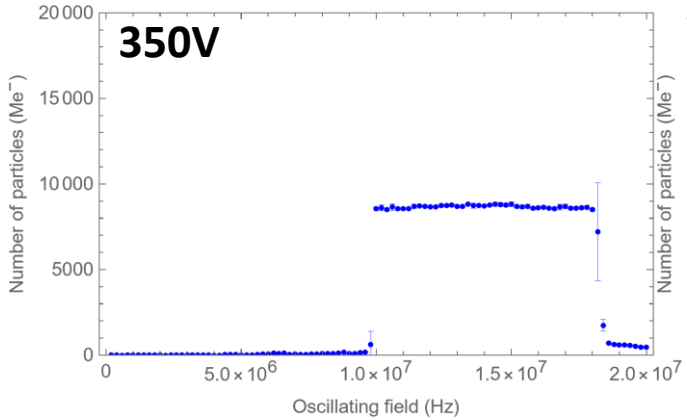


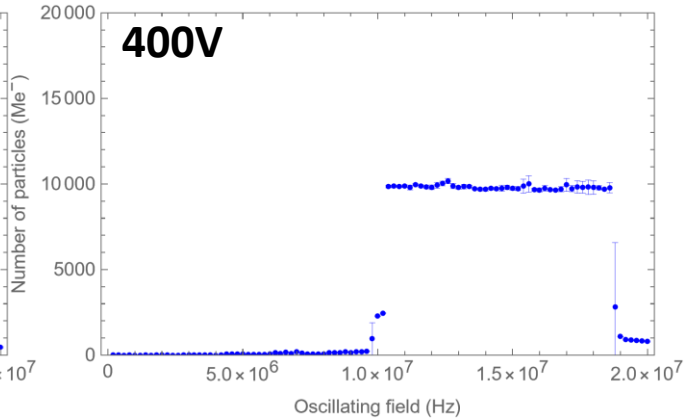




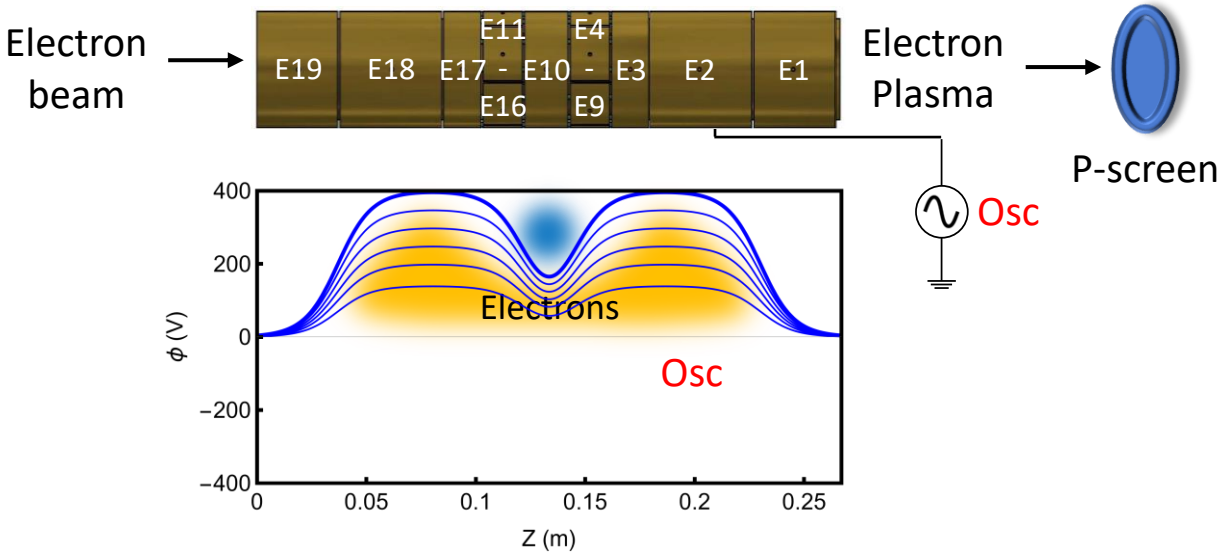


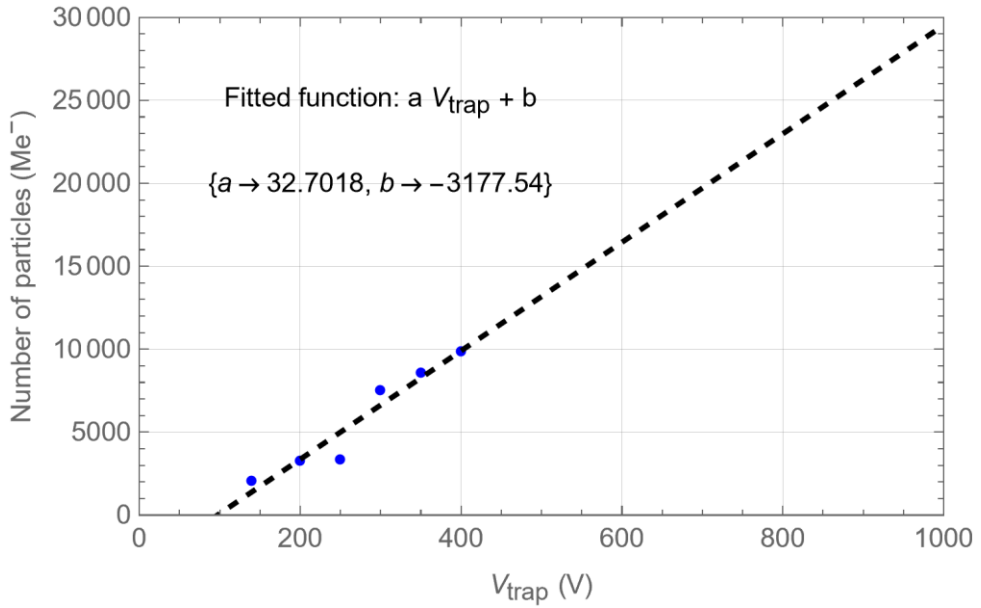




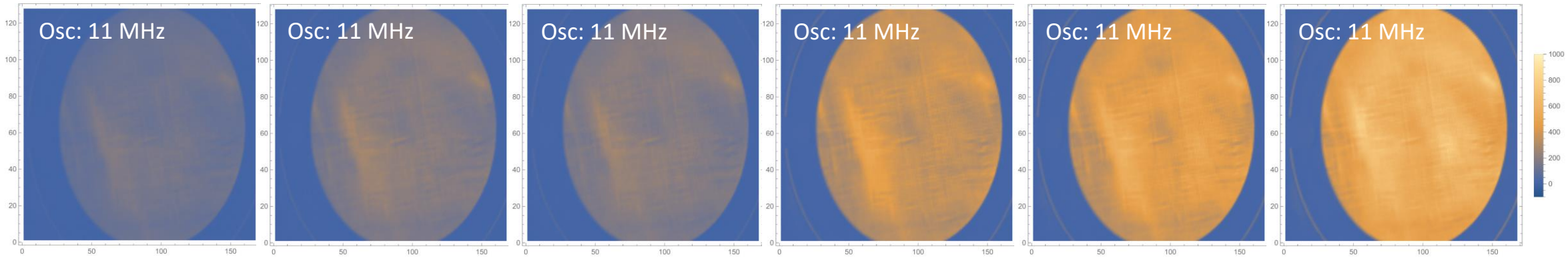


Plasma in HV traps





Trap depth= 140V **200V** **250V** **300V** **350V** **400V**

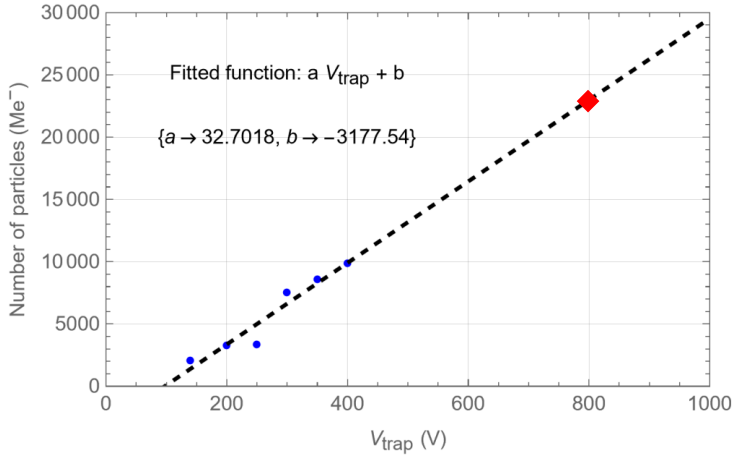


Conclusions and Outlook

To generate a stable and high-density plasma, two key components are required:

1. Oscillating electric field
2. Dimple that traps ions

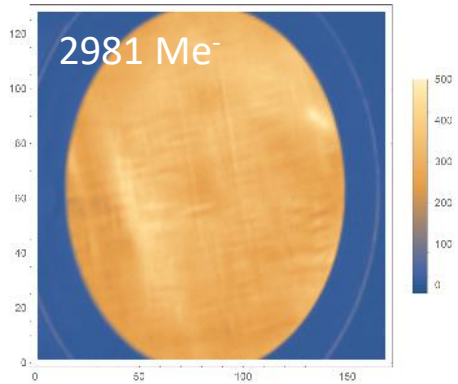
This plasma can be initiated using a very small number of seed electrons.

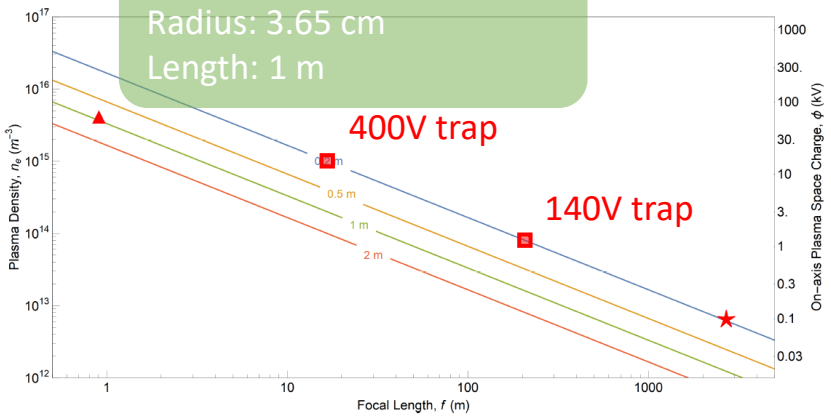


Next steps …

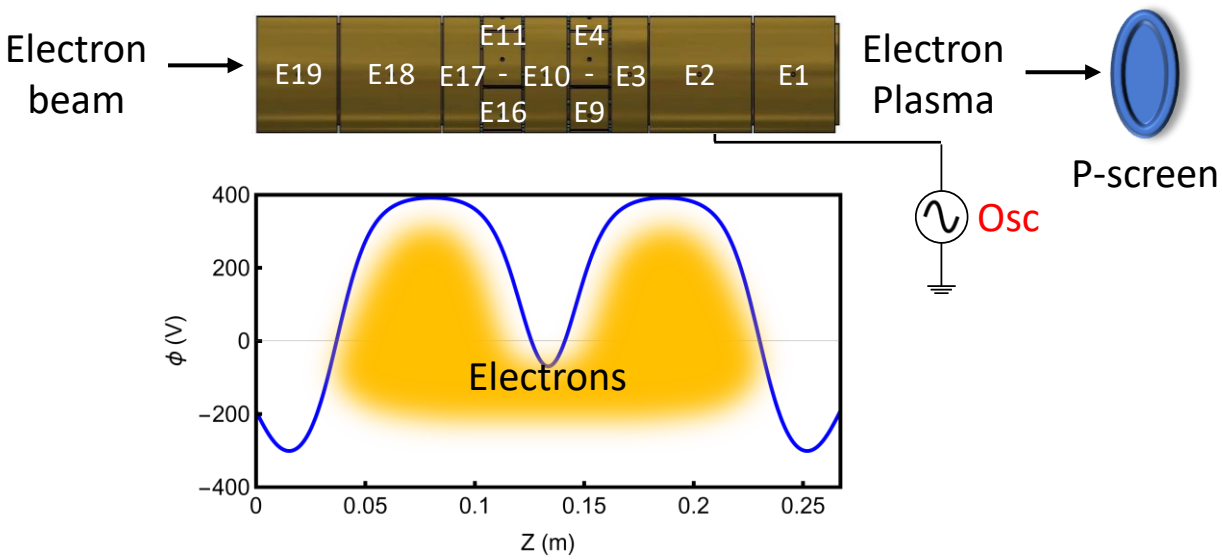
- Conduct the experiments using Ar instead of CO_2.
- Use numerical simulation to verify our diagnostics.

Plasma density: 4×10^{15} m^{-3}
Radius: 3.65 cm
Length: 1 m





140V trap: Peak density ≈ 8×10^{13} m^{-3}
400V trap: Peak density ≈ 1×10^{15} m^{-3}



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