

Pollen Trap Instructions

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1 Introduction

Visitors see the pollen particles suspended in mid-air and trapped inside an oscillating quadrupole trap and end-cap electrodes. In this trapped state the pollen should still look like a little square as it oscillates with the quadrupole oscillations. The end cap voltages can be varied to move the pollen, letting it expand and contract as the voltages change.

2 Vague Scripts

2.1 General

2.1.1 Demonstrating the Activity

This trap uses electric forces to trap and manipulate charged particles. The rods create a quadrupole field and at either end are charged electrodes. The electrodes stop particles leaving out the end. The quadrupole fields squeeze the particles in one direction and pull them apart in the other. (Use hands for better explanation). By changing the direction rapidly we can trap the particles. It is very hard to see electrons so instead we use pollen, which is negatively charged. [Insert the pollen into the trap or point at some in the trap]. As you can see the pollen is suspended in mid-air, and if you look very closely you can see it is actually moving around in a little square as the quadrupole fields switch their directions. And, by changing the electrodes' voltages we can expand the pollen line, and some might even escape. But, we can trap them again by increasing the voltage.

2.1.2 Discussion and Link to LhARA

In the same way we manipulate the pollen here, LhARA manipulates charged particle beams for radiotherapy research. At LhARA we are developing new ways to generate and manipulate charged particles to allow more flexible and varied research, which could provide doctors with new tools in cancer treatment.

Alternate option: We trap electrons in the Gabor lens in the same way we trap the pollen here. The Gabor lens focusses the beam and allows control to deliver a nicely controlled and adaptable beam. It is cheaper and less energy consuming than their conventional counterparts. It is also has many applications outside of LhARA including nuclear fusion and semi-conductor production.

2.1.3 BPs and Key Takeaways

1. Explain the confinement due to the quadrupole fields and the end-cap electrodes
 2. Point out the particle motion
 3. Use the electrodes to expand and squeeze the pollen
 4. Link to controlling beams for radiotherapy
 5. Say how LhARA plans on manipulating the beam to deliver a wider range of beam characteristics and research different radiotherapy delivery styles
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2.2 Children

2.2.1 Demonstrating the Activity

Would you like to see charged particles levitating? By using electric forces we can float particles in mid-air. We use electric fields to squeeze the particles into a cylinder, but they only squeeze one direction at a time and so we have to keep switching which direction they squeeze in. If you look really closely you can see the particles wiggling as the fields switch direction and the particles tries to escape. We can also squeeze the particles from the ends and we can let them out. [Release the electrode voltage]. Can you see the particles leaving since they are no longer trapped?

2.2.2 Discussion and Link to LhARA

Now by controlling particles even smaller than these and making them into a beam we can make super-high precision tools for killing cancer without damaging the surrounding healthy tissue. In fact the protons that we manipulate and use to destroy the tumour are ten-thousand million times smaller than the pollen (If a proton were the size of a pea then the pollen would be the be slightly less than the width between the Earth and the Moon).

2.2.3 BPs and Key Takeaways

1. Show the levitating particles
 2. Point out the particle motion
 3. Use the electrodes to expand and squeeze the pollen
 4. Link to controlling beams for precise treatment that does not damage healthy tissue
 5. Link to trapping in a Gabor lens
 6. Discuss positives of Gabor lens and its applications outside of LhARA
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2.3 Scientists

2.3.1 Demonstrating the Activity

This is a trap for negatively charged particles. We use pollen since they are negatively charged and easier to see than electrons. The trap consists of two end-cap electrodes, which traps the pollen longitudinally, and oscillating quadrupole fields, which trap the pollen radially. In fact, if you look closely you can see the pollen oscillating with the switching quadrupole fields. And by changing the end cap electrodes we can vary the distribution of the pollen along the trap.

2.3.2 Discussion and Link to LhARA

In the same way as we manipulate the charged pollen particles, we wish to manipulate the charged particles in the beam to deliver a range of radiotherapy regimes from high dose rates to multiple ion species. This flexibility starts at the laser-driven acceleration, which allows higher dose rates and rapid adjustment of the beam. However, a lens is required to capture the beam and the trapping principle on display here is very similar to how we would trap electrons for a Gabor lens. A Gabor lens is a cloud of electrons that provides a symmetrical focussing force for a positively charged beam. It is confined by two end-cap electrodes and an axial magnetic field, and produces the same focal strength as conventional symmetric focussing devices such as a high-field pulsed solenoid for a much lower magnetic field. This allows LhARA to deliver its flexibility in radiotherapy research and would have many applications outside of LhARA including nuclear fusion, semi-conductor production and other particle accelerators.

2.3.3 BPs and Key Takeaways

1. Explain the confinement due to the quadrupole fields and the end-cap electrodes
2. Point out the particle motion
3. Use the electrodes to expand and squeeze the pollen
4. Link to LhARA manipulating the beam to deliver a wider range of beam characteristics and research different radiotherapy delivery styles
5. Link to trapping in a Gabor lens
6. Discuss positives of Gabor lens and its applications outside of LhARA

3 Link to other activities

1. VR: If you want to see how the beam travels through the facility, you can watch it using the VR headset
 2. Popomatic: If you want to see what other new technology is involved in LhARA?
 3. EVE Chair/Treatment Planning: If you want to learn more about current treatments and how LhARA is linked to improving current treatments
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4 Using the Trap

4.1 Powering Up

The trap has three separable components: the cable, the power unit/control box and the trap itself. To set up connect the end with pins into the power unit. Requires a hard push. If the grey cable is not plugged into the plasma trap plug it in at the bottom of the trap. Worth pushing hard, but be careful with rotating and moving the trap around too much. Plug the power unit into the mains.

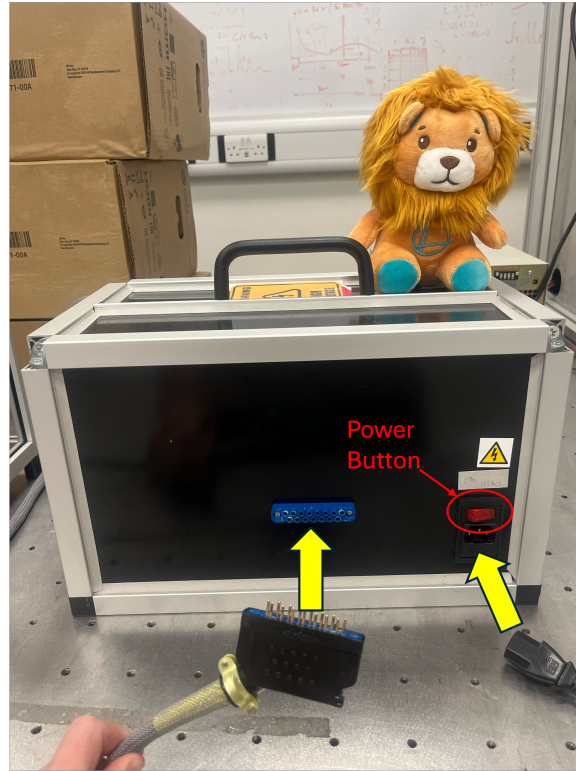


Figure 1: Figure showing how to connect the cables into the power unit

4.2 Deconstructing

Turn the mains power off first, and wait a few minutes before removing the grey cable, since there are some capacitors inside. The plug under the trap is worth leaving in place as the connection is probably the weakest link. The plug in the power unit is quite hard to remove and requires some wiggling.

4.3 Controlling

Figure 3 shows which switch controls which part of the trap. The laser and the quadrupole fields can be left on during a demonstration.

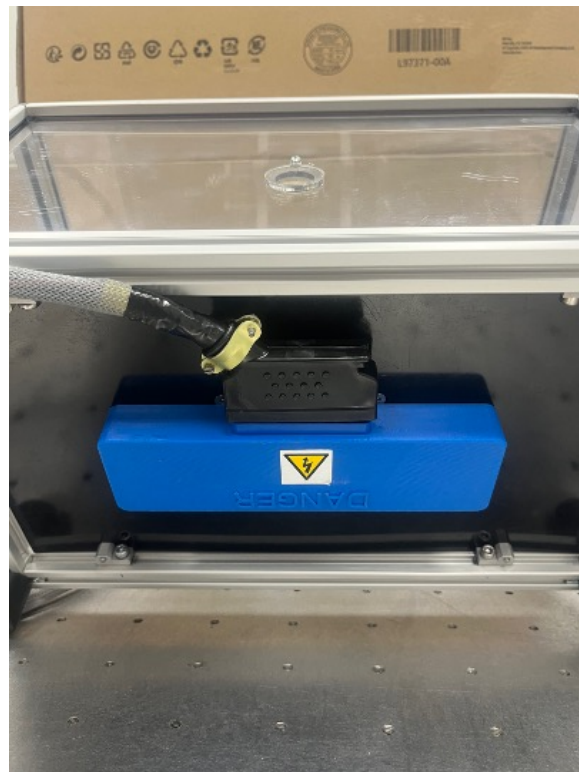


Figure 2: Figure showing where to connect the grey cable into the plasma trap

The trap is simple to use. The knobs on the power unit control the end-cap electrodes. Turning both inwards (the left one clockwise and the right one anti-clockwise) has both end cap voltages at their max. Turning the knobs in the opposite direction lowers their voltage. The left knob controls the left end cap and equivalently with the right side (when looking from the side of the pollen hole).

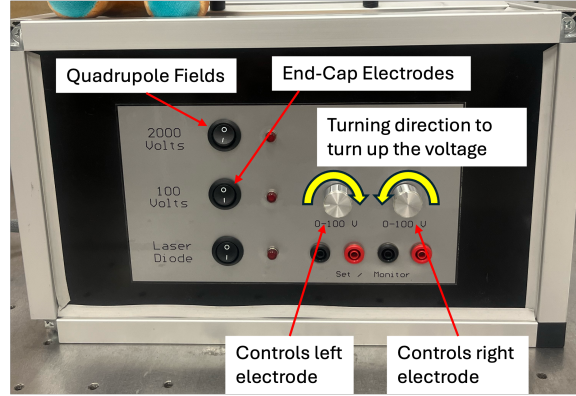


Figure 3: Figure showing all the power unit controls and what they control

4.4 Demonstrating

The pollen is inserted using a wand. Dip the wand into the pollen and then insert the wand through the trap window. To expel the pollen into the trap push the little button forwards and release (Figs 5 and). I suggest having the electrodes at their maximum when inserting the pollen. Then by reducing the each end cap one can show how we can manipulate charged particles using electric fields. This should let the pollen expand to fill more of the trap until they leave the trap. Increasing the voltages brings the pollen together again.

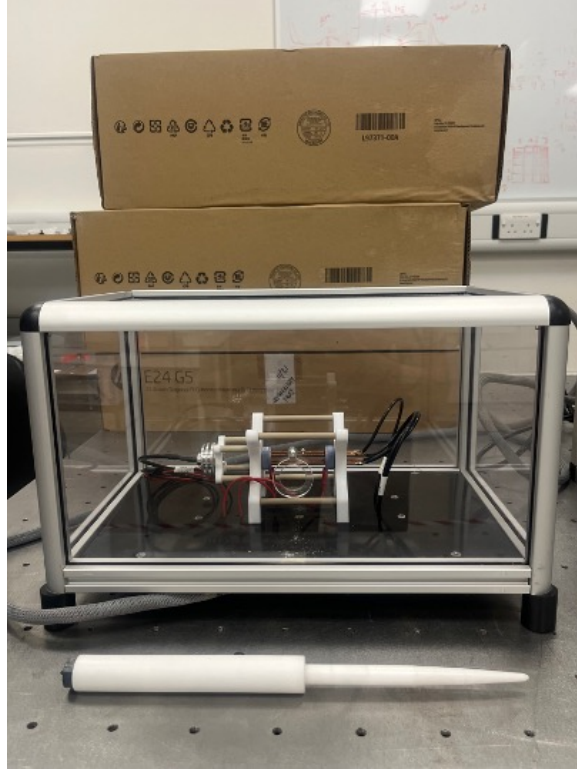


Figure 4: Picture of the plasma turned off

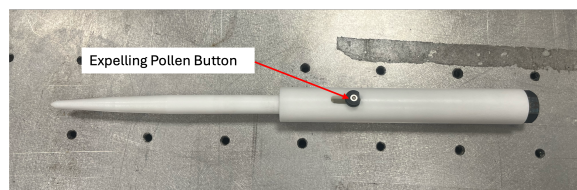


Figure 5: Picture of the pollen wand

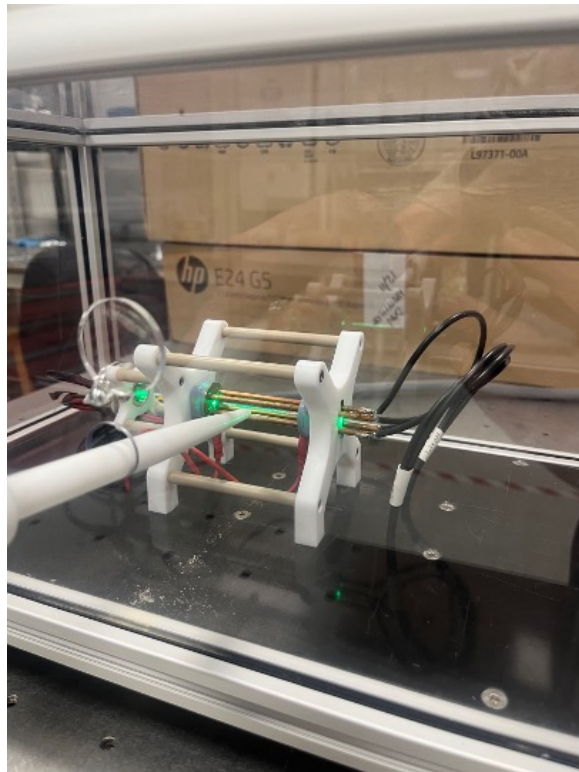


Figure 6: Picture showing how to load the pollen into the trap using the wand

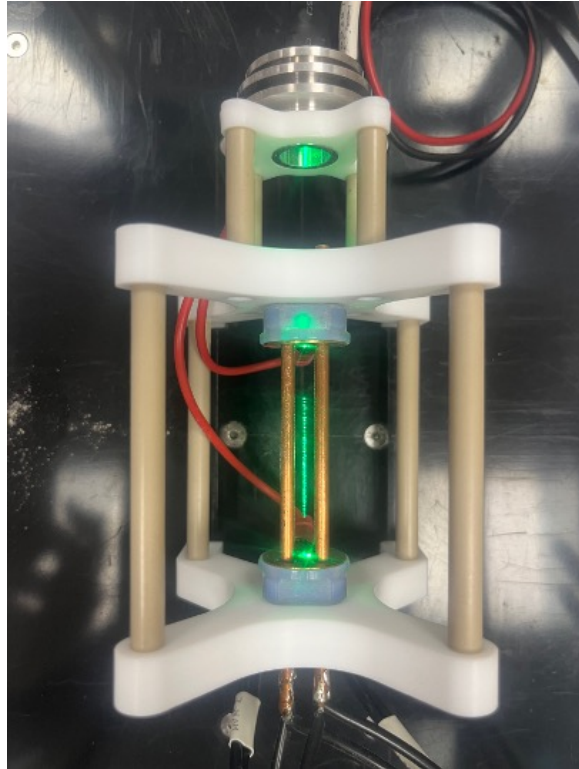


Figure 7: Picture showing the plasma trap with successfully loaded pollen