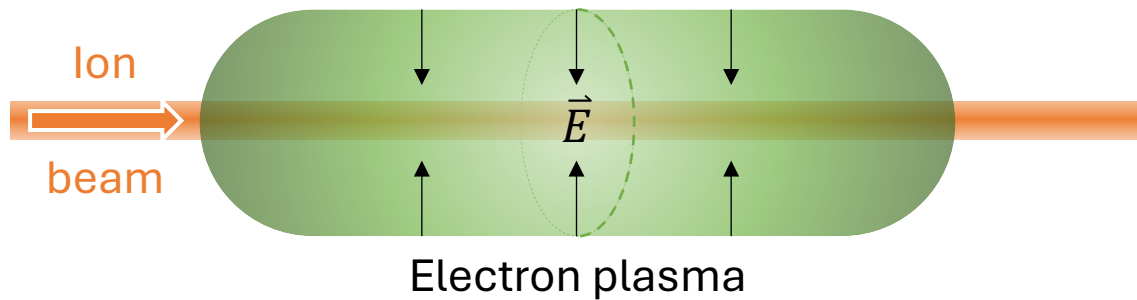


Proton and Ion Capture

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

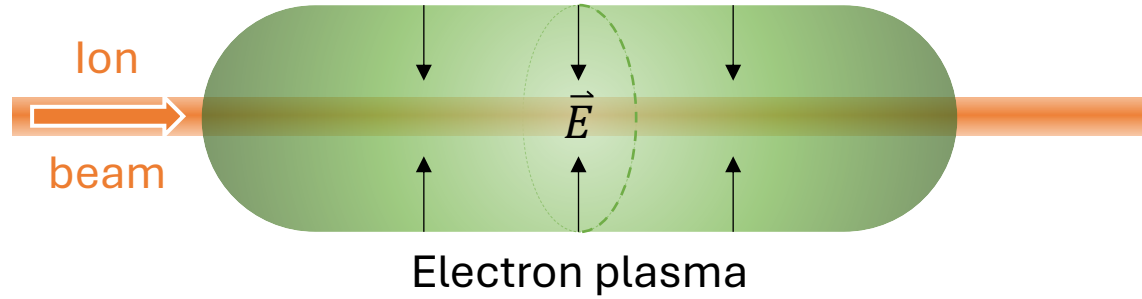
ϵ_0

is the permittivity of free space

U

is the kinetic energy of the positively charge particle.

Gabor Lens

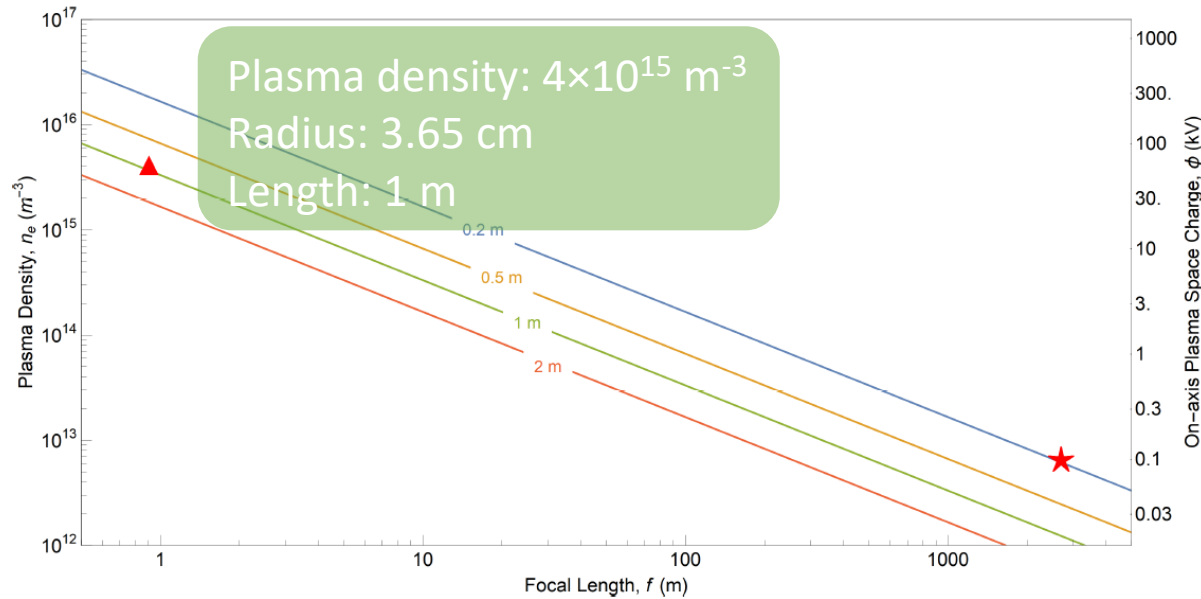


- The focal length (f) of the Gabor lens:

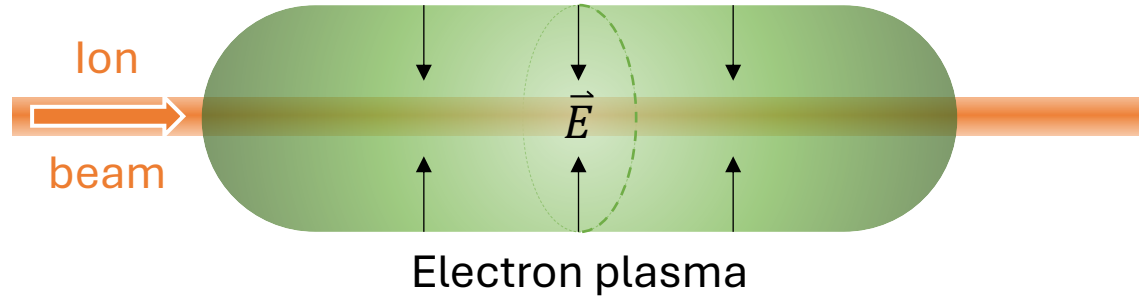
$$\frac{1}{f} = \frac{e^2 n_e l}{4\epsilon_0 U}$$

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.



Gabor Lens



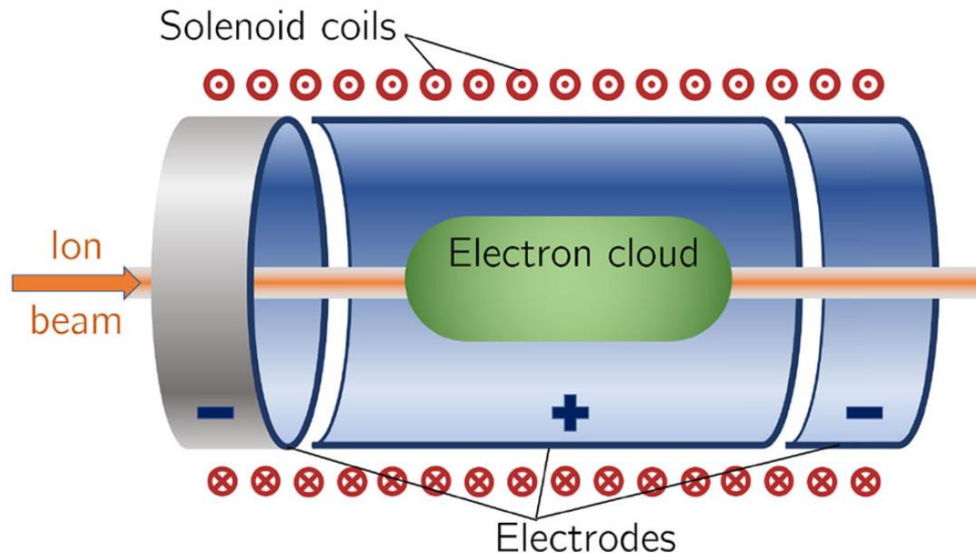
- The focal length (f) of the Gabor lens:

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

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.

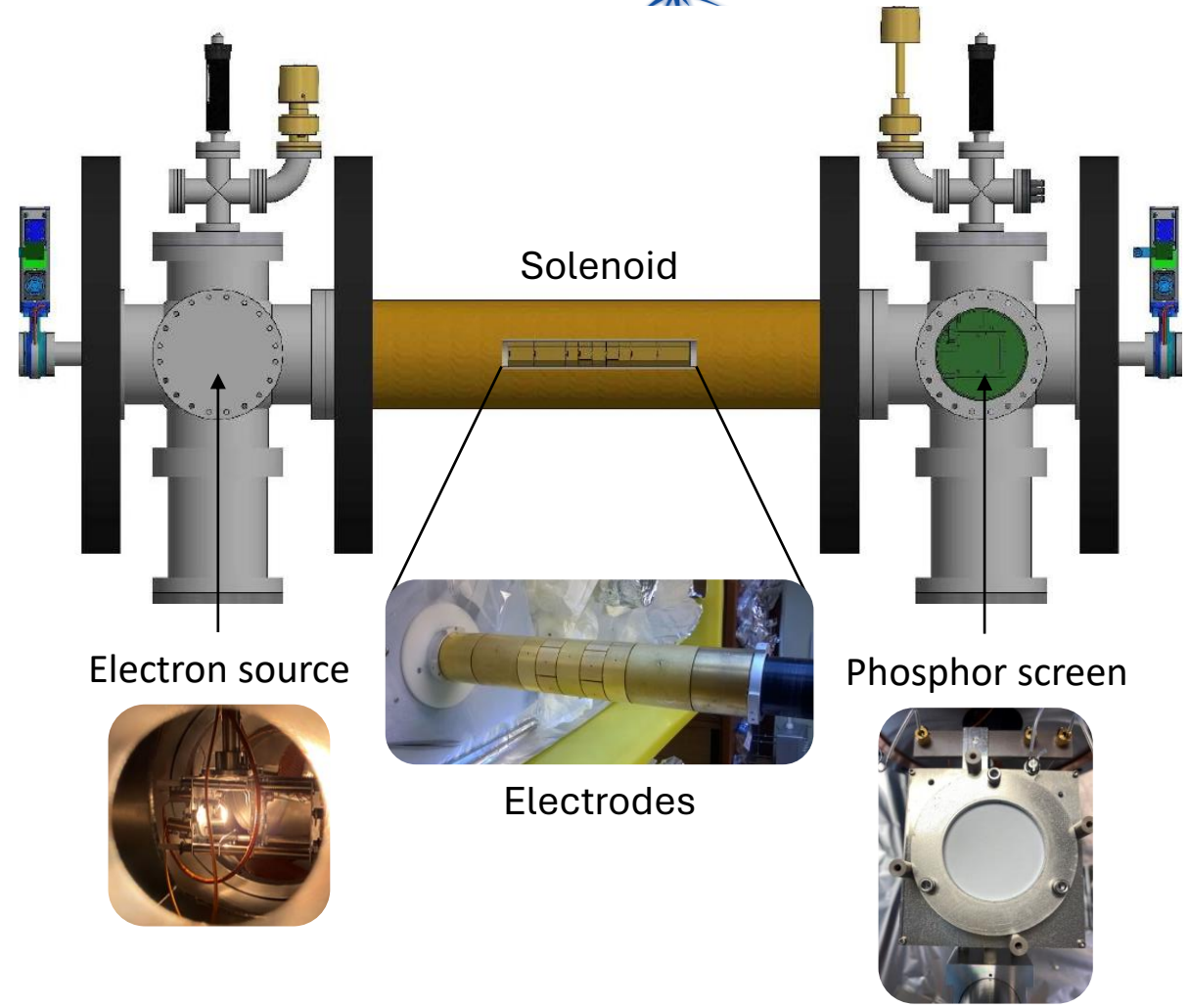
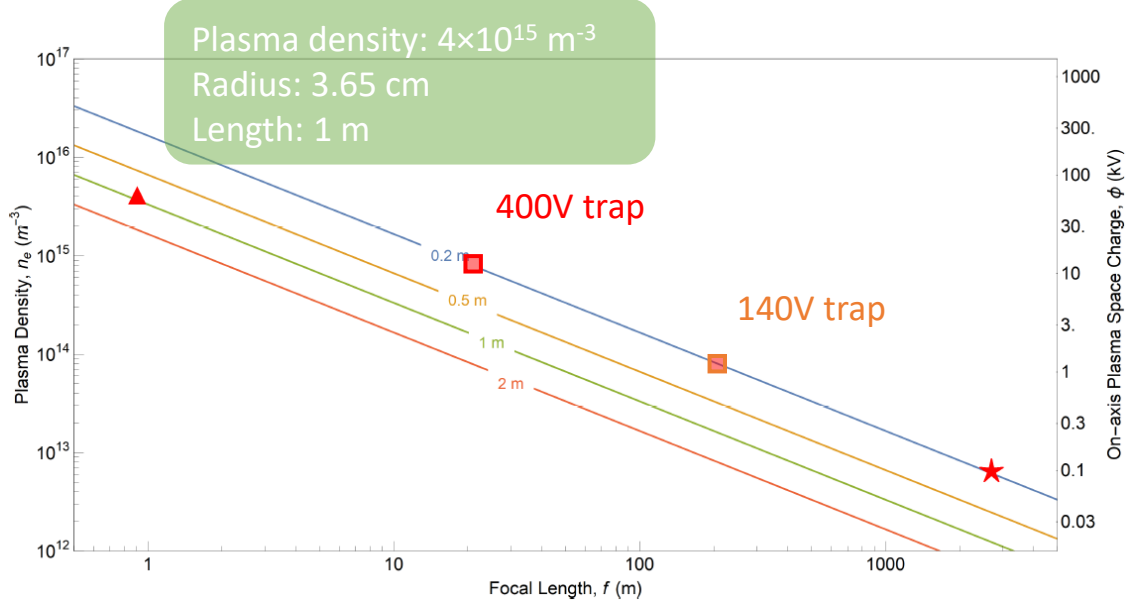
- Penning-Malmberg Trap



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.

Generated electron plasma

- **Current status:** Generate a high-density plasma through ionization of **CO₂ gas** by heated seed electrons



- **Nex step:** Conduct the experiments using **Ar gas** instead of CO₂ gas.

Interruption of experimental operations



Issue

- Cooling water chiller malfunctioned and became non-operational

Impact on experiment

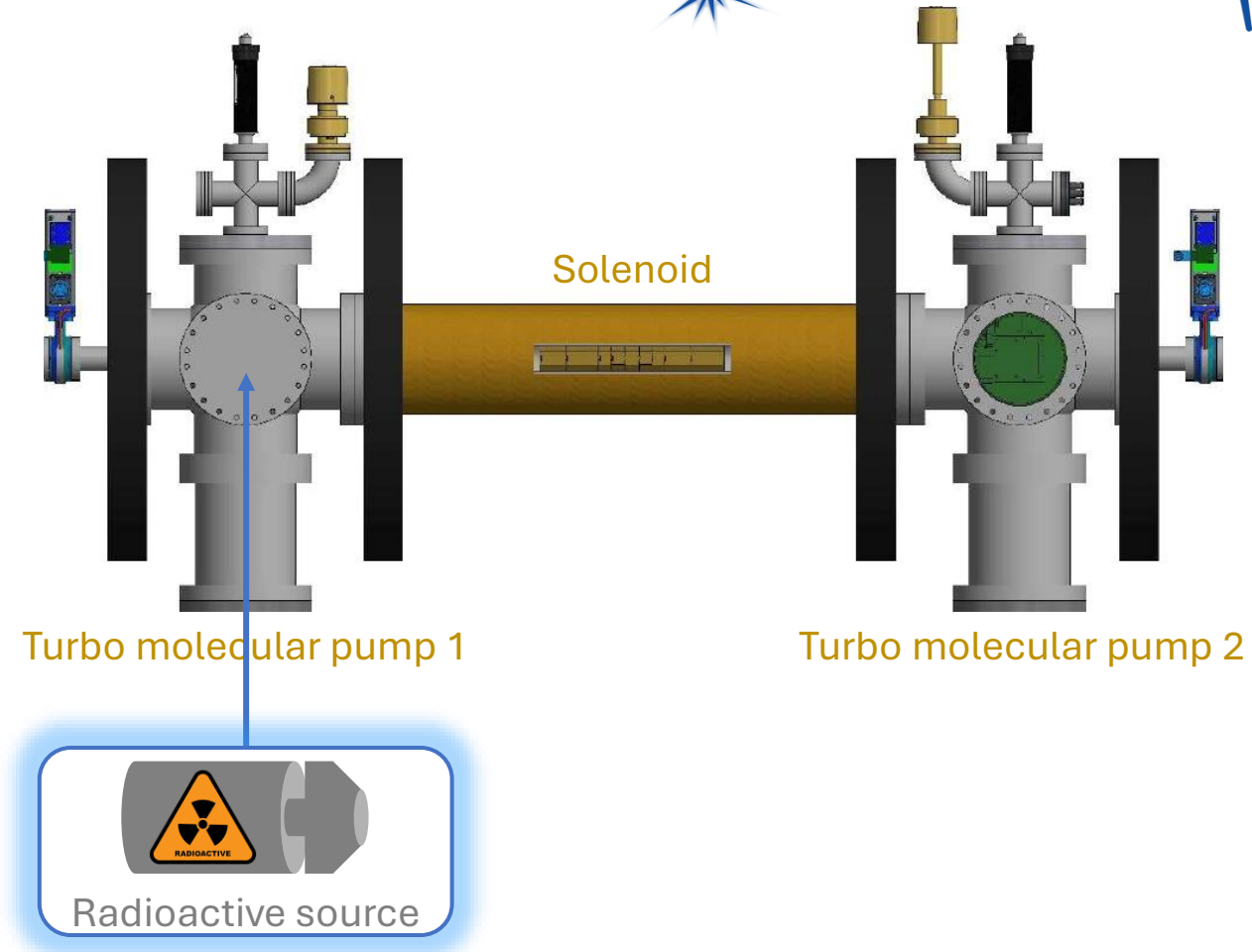
- Inability to operate solenoid coil due to overheating risk
- turbo molecular pumps could not be run safely without cooling

Duration

- Approximately 3 months of downtime (January to March)

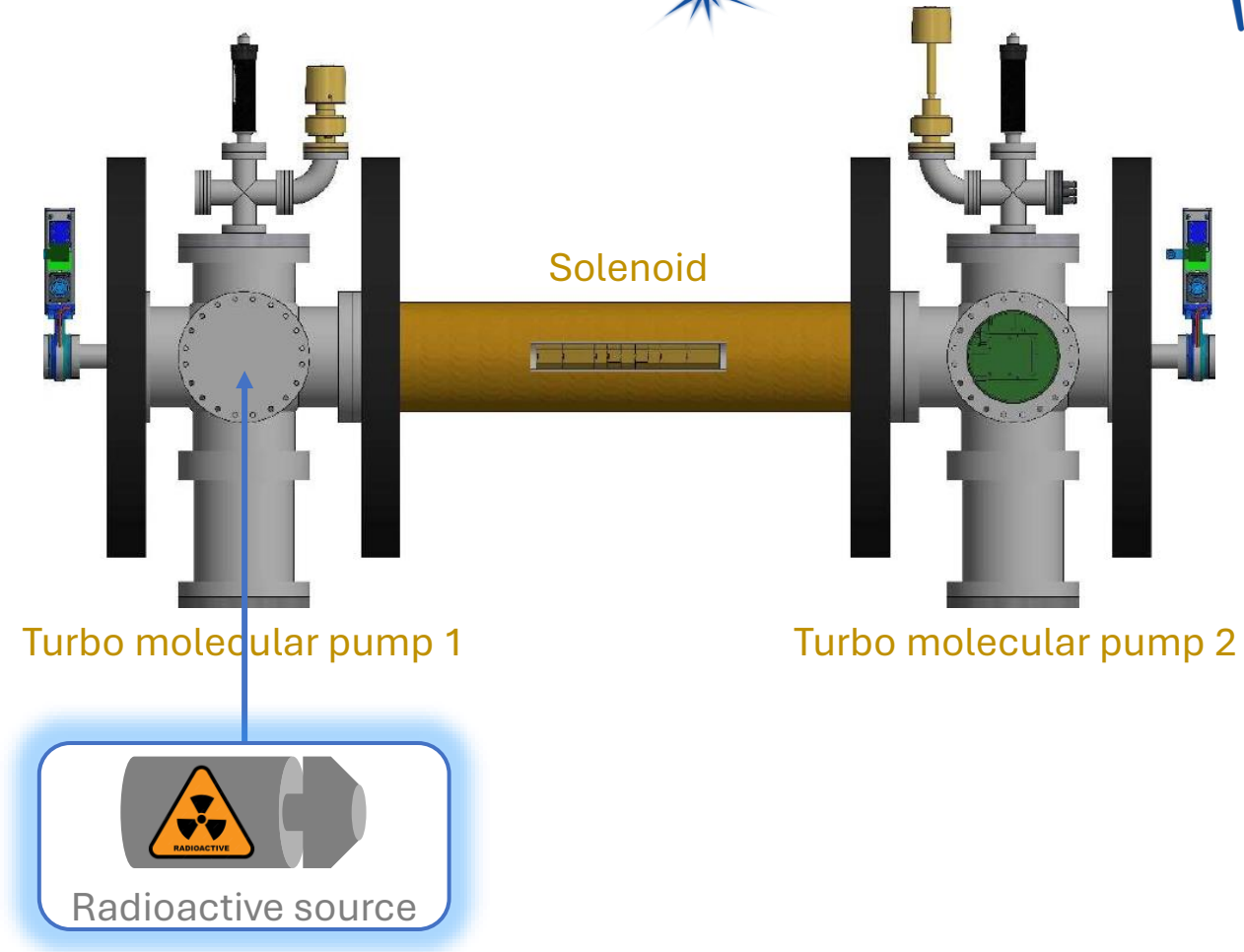
Current status

- System restored



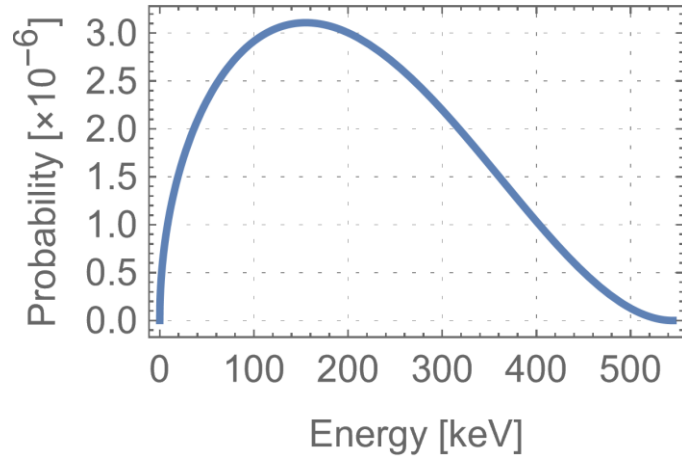
Source installation plan

1. Perform calculations to determine whether positrons can be focused and detected at the phosphor screen
2. Investigate positron emission distribution from the source

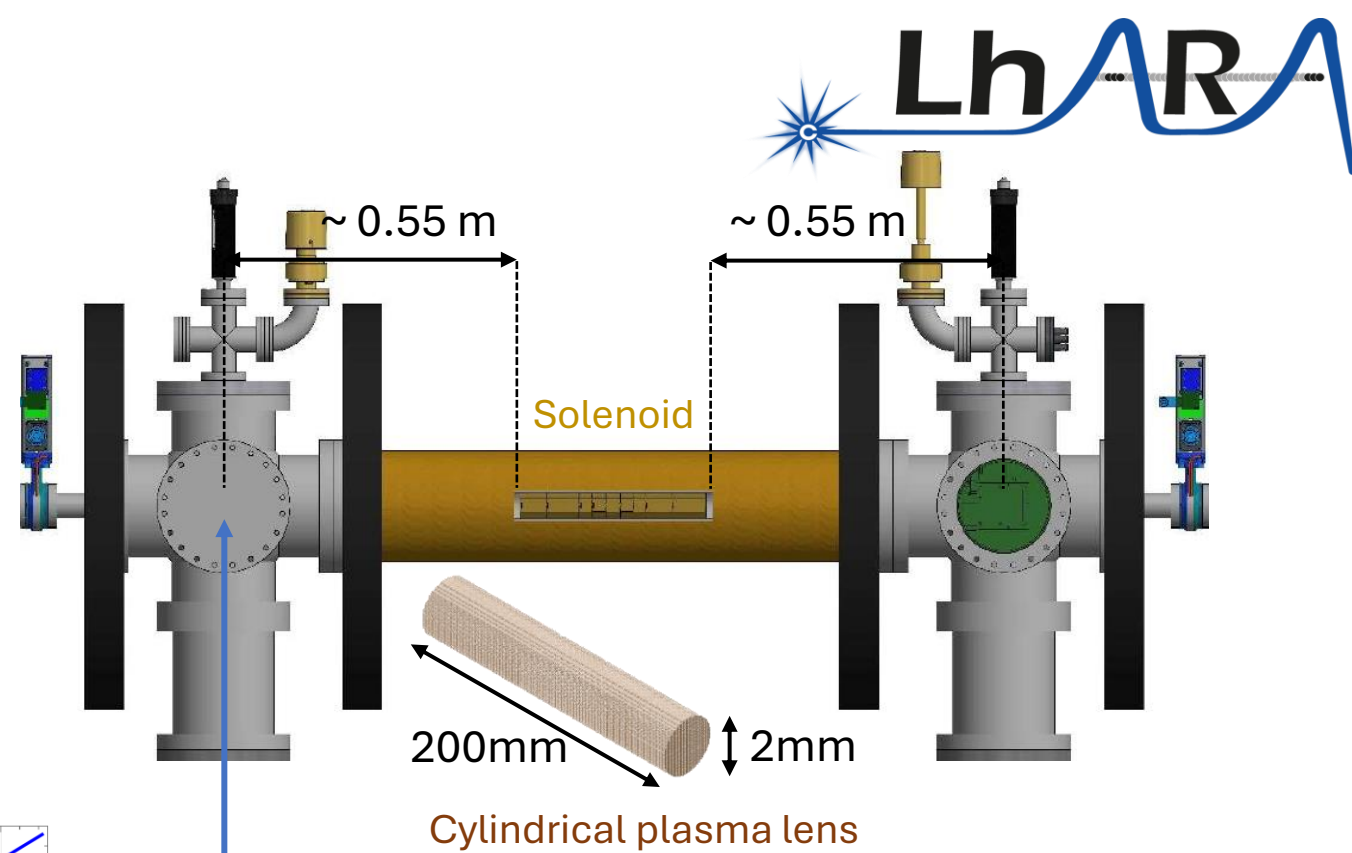
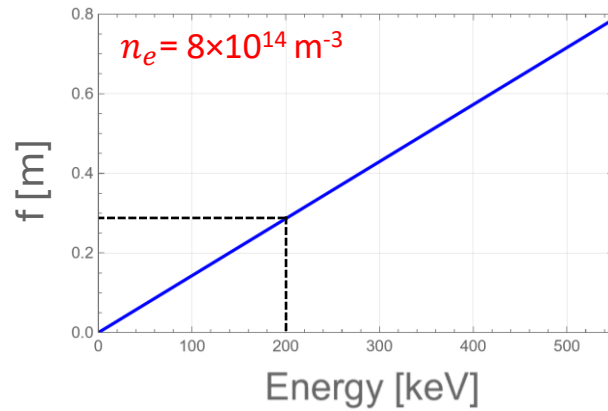
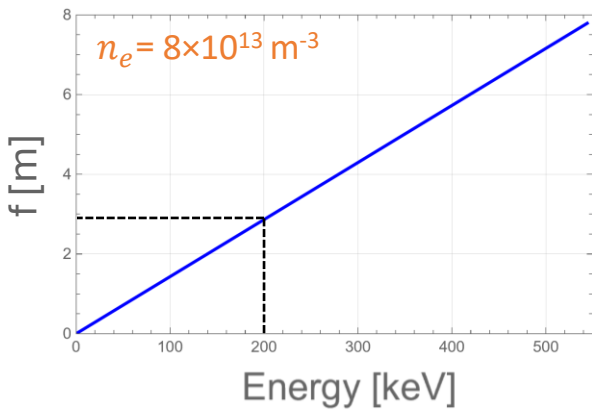


Calculations

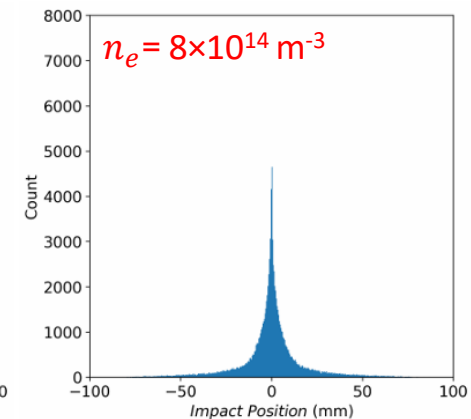
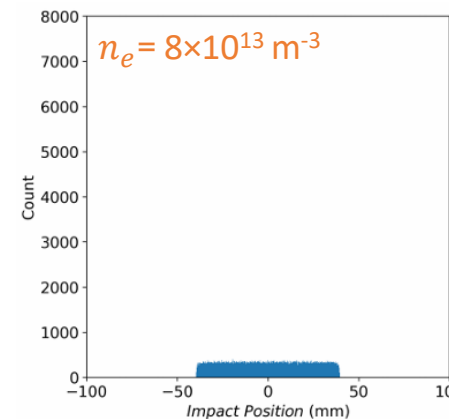
- Energy distribution of positrons emitted from ^{22}Na



- The focal length (f) of the Gabor lens: $\frac{1}{f} = \frac{e^2 n_e l}{4\epsilon_0 U}$



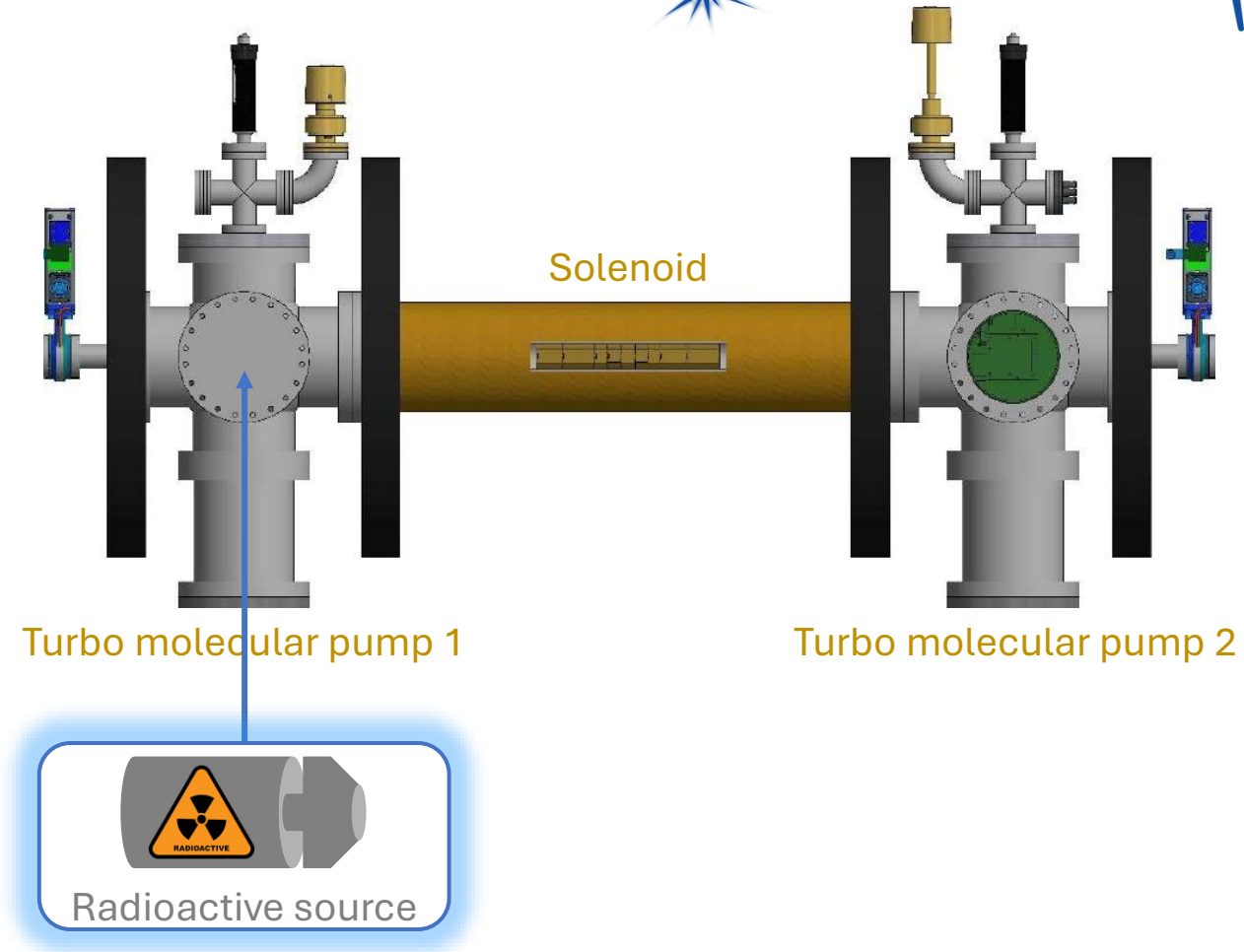
Preliminary simulation results



Source installation plan

1. Perform calculations to determine whether positrons can be focused and detected at the phosphor screen

2. Investigate positron emission distribution from the source



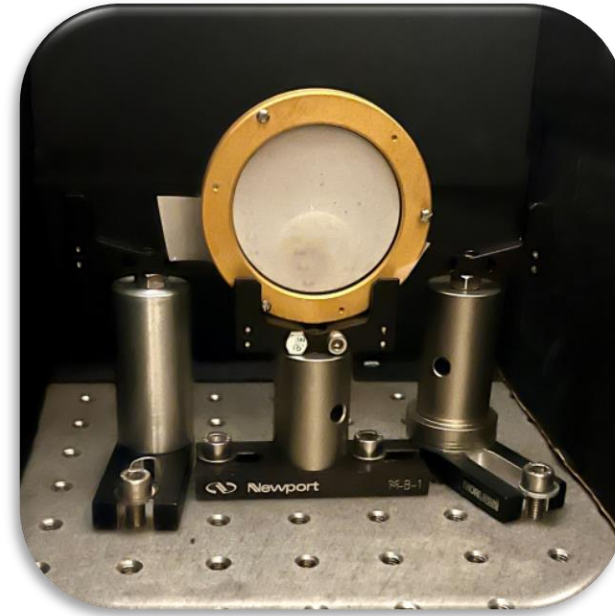
Imaging e^+ emission from radioactive sources

Experimental Conditions

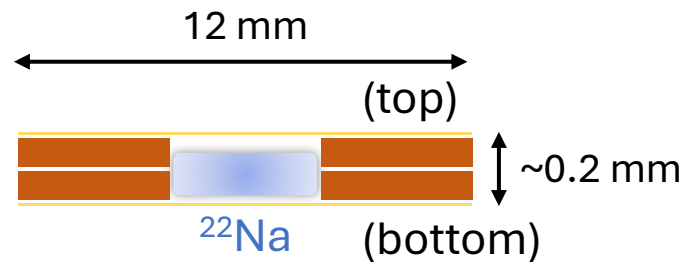
- Conducted at atmospheric pressure (No vacuum system)
- Entire setup enclosed in a light-tight blackout box: external light eliminated to improve signal-to-noise ratio

Setup Components

- ^{22}Na source (75.5 kBq activity)
- Phosphor screen (operated without bias voltage)
- CCD camera for optical detection



Cross section of the source capsule



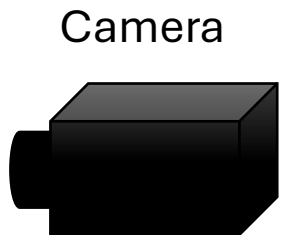
Thin Kapton film : 7 μm
Thicker Kapton film : 75 μm

^{22}Na source
(75.5 kBq)

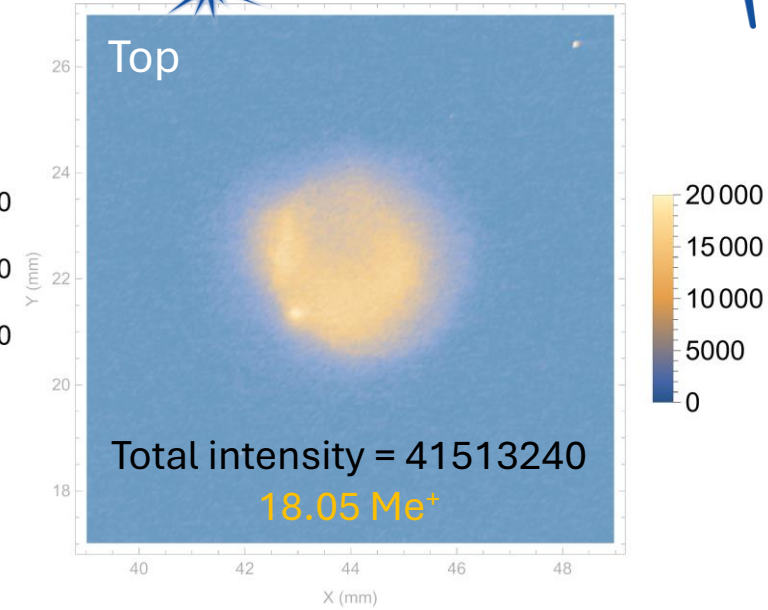
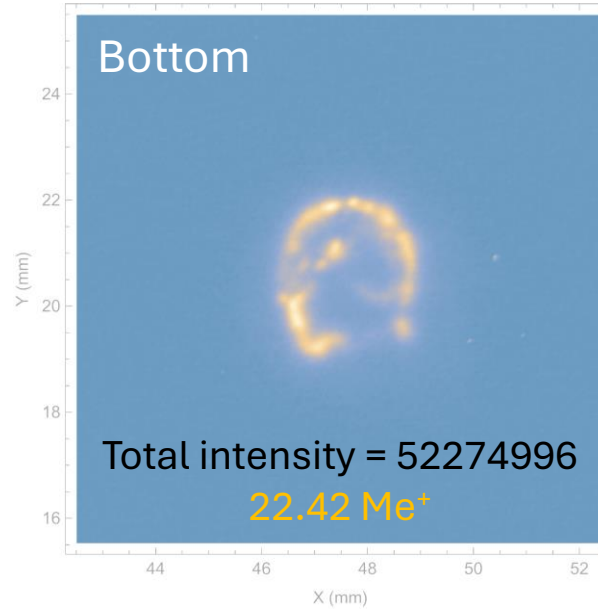
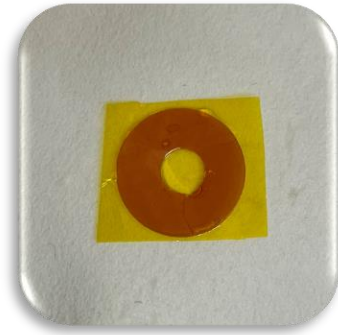
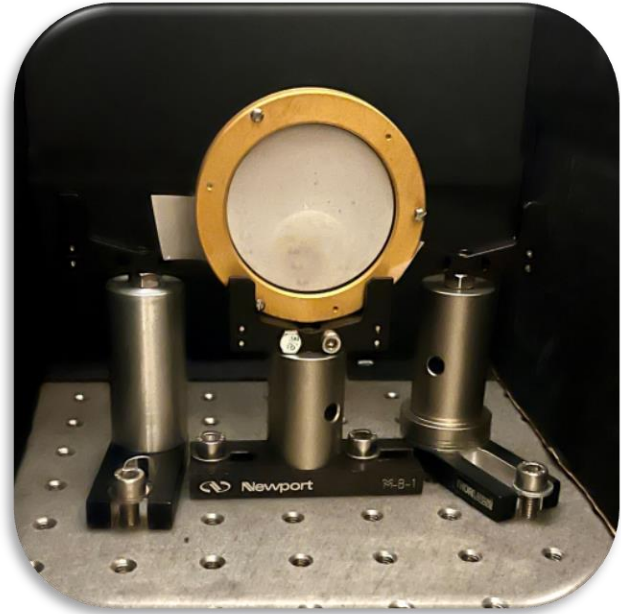
P-screen: 50 mm diameter
(No bias)



~ 500 mm

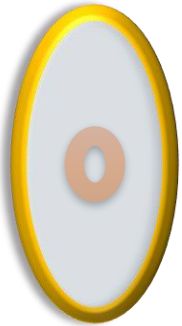


Imaging positrons : ^{22}Na (75.5 kBq)



~ 500 mm

P-screen: 50 mm diameter
(No bias)



^{22}Na source
(75.5 kBq)

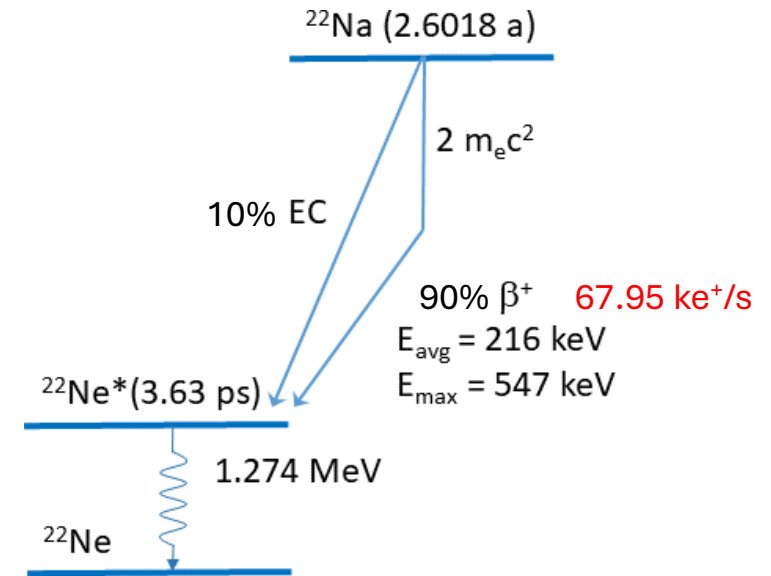
Camera



Camera setting:

Exposure time = 600s → 40.77 Me⁺

Gain = 255

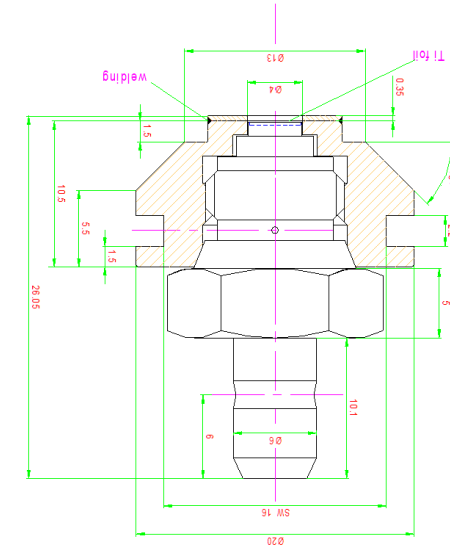
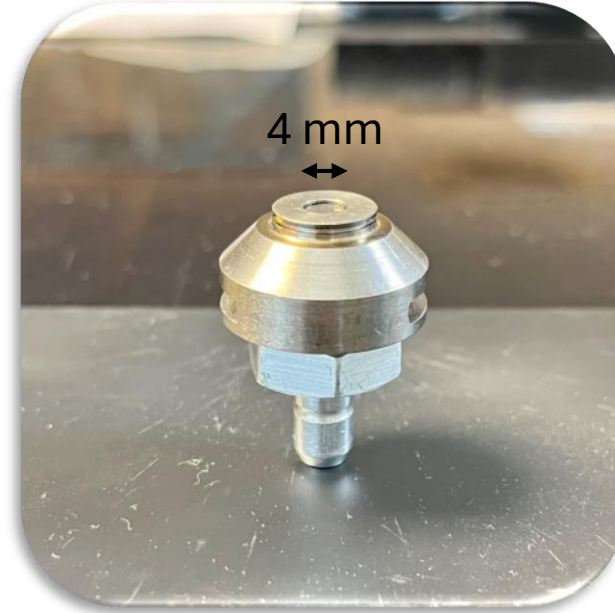
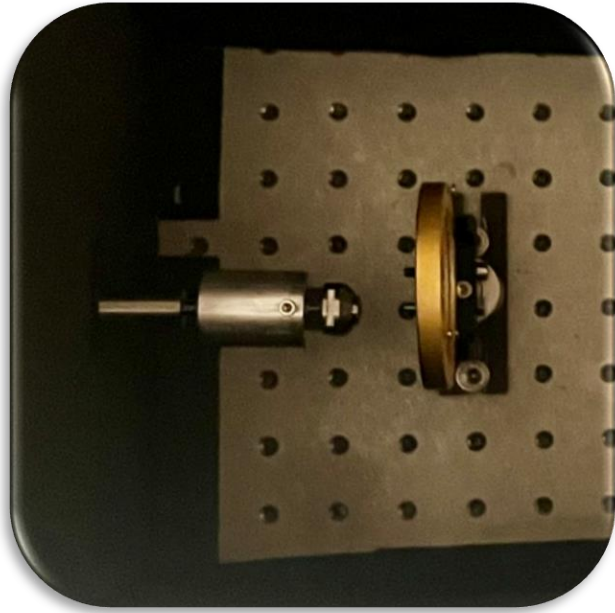


Imaging positrons : ^{22}Na (2 MBq)



^{22}Na source

(from iThemba Labs in Cape Town, South Africa)



~ 500 mm

P-screen: 50 mm diameter
(No bias)



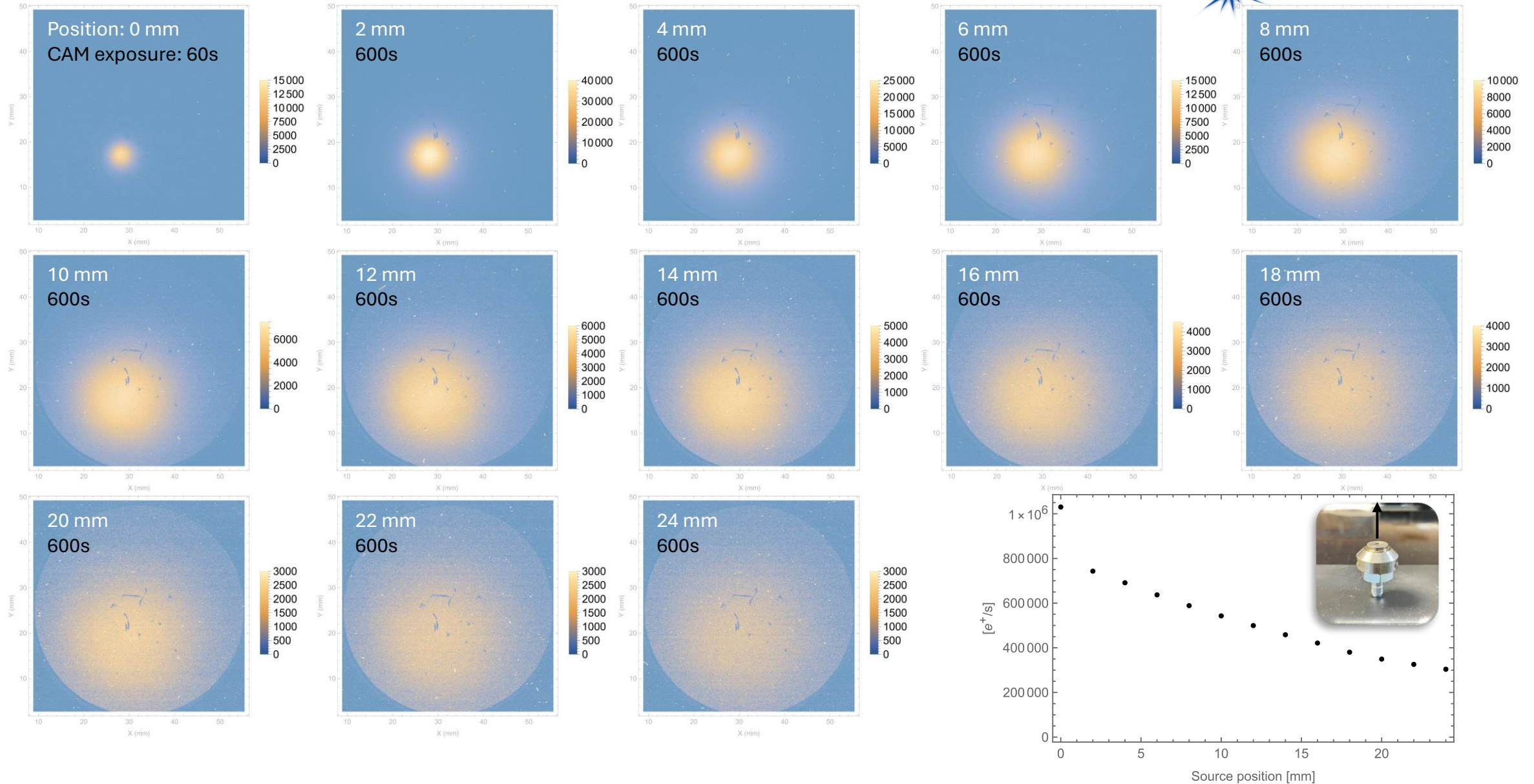
Camera



- A sealed capsule or contained material holding a radionuclide
- Designed to emit radiation in a controlled way
- Engineered with strict safety standards to prevent leaks

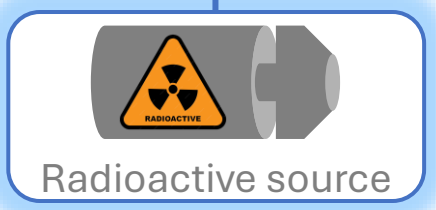
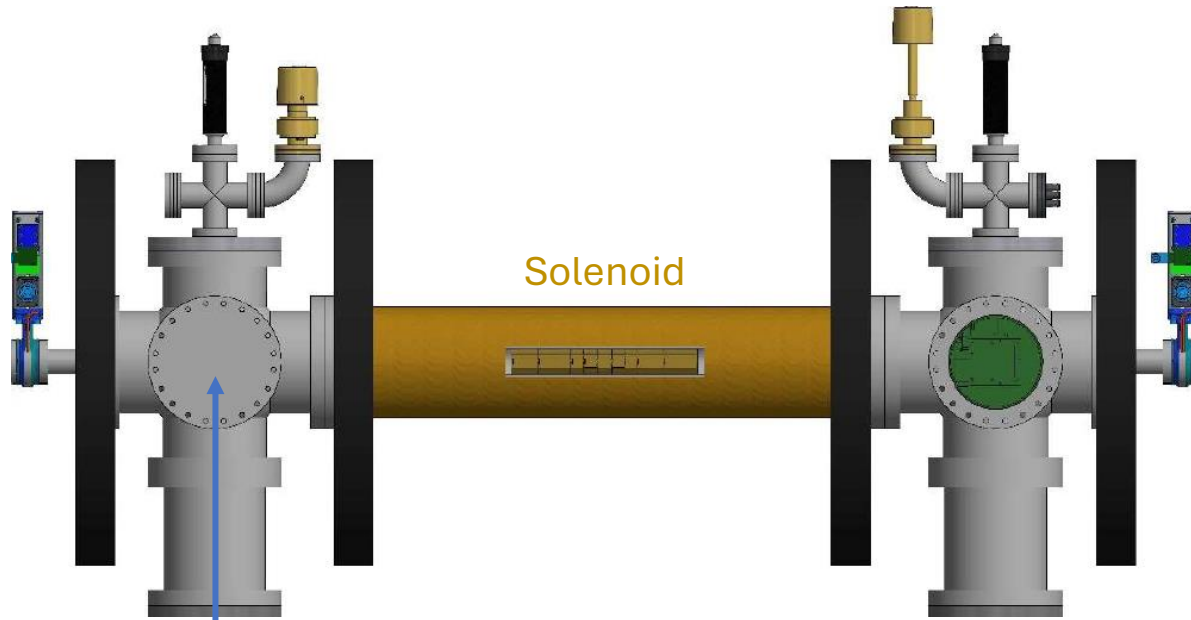
^{22}Na source
(2 MBq)

Imaging positrons : ^{22}Na (2 MBq)



Proton and ion capture progress (29th April 2026)

Next steps...



Radioactive source

Simulation Study

- Verify positron focusing effect using SIMION
- Model includes key experimental parameters:
 - Magnetic field
 - Electrostatic field
 - Electron plasma effects

Experimental Plan

- Upon successful simulation results:
 - Install a Na-22 source (~50 MBq)
 - Proceed with experimental validation
- Conduct the experiments using **Ar gas** instead of CO₂ gas.

Plasma lens group



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D. P. van der Werf

