LhARA - $^1/_2$ day work session
Proton and ion capture

Proposed experiment at Swansea

10th June 2021

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Aims of the proposed experiments at Swansea

A – Validation: confined electron plasmas **vs.** PIC simulations (VSim)

- Build models to predict results of existing diagnostics.
- Inform us on the suitability of the PIC code to do **predictions** on the confinement of an electron plasma in the **next design** iteration of the Gabor lens.

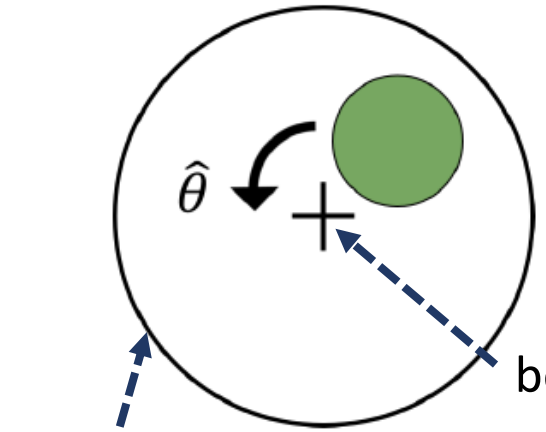
B – Development:

- Investigate the experimental limitations of the lens in relation to the focusing properties called for by the design of LhARA.

C – New measurements:

- Measure focusing of positron beam by electron cloud.

(A) Diocotron mode



Rotating plasma
(“**diocotron**” mode)

- Measure the **diocotron frequency**

$$f_d = f_d(N, L, D, \dots)$$

- Locate electron source off-axis
  - Beam capture with identical emission current for various lengths (L)
    - Same density $(\propto N)$
  - Beam capture for various emission currents for a fixed length
    - Vary density
  - Beam capture with identical emission current and electrodes at various displacements (D)

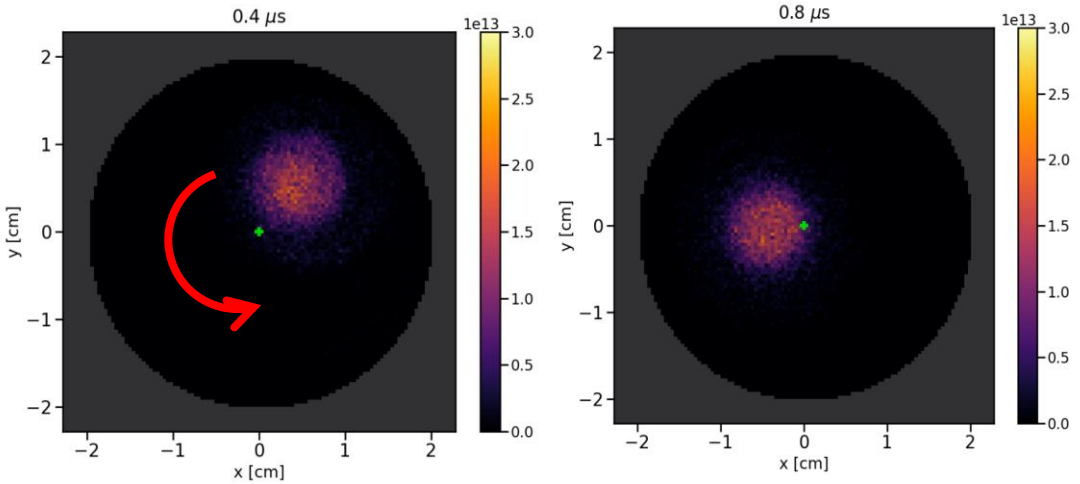
(A) Diocotron mode

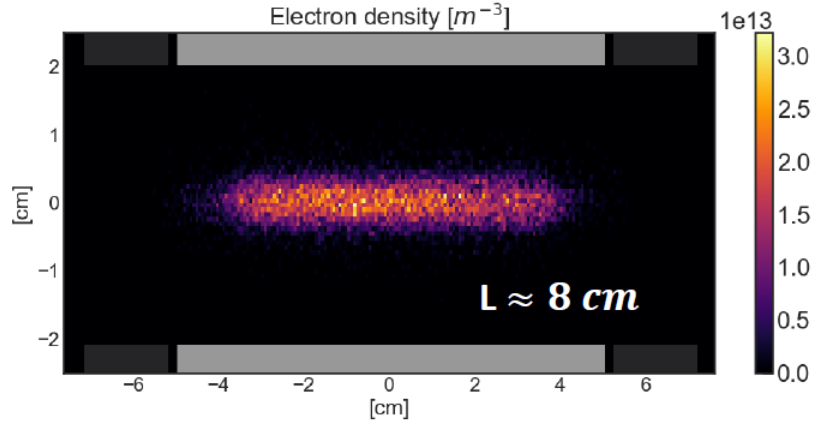
Simulation capabilities

- The instability was observed in PIC simulations
- Range of plasma lengths and densities limited by CPU time

Analytical model also available

- Several critical parameters
  - Number of electrons
  - Plasma length and radius
  - Plasma temperature



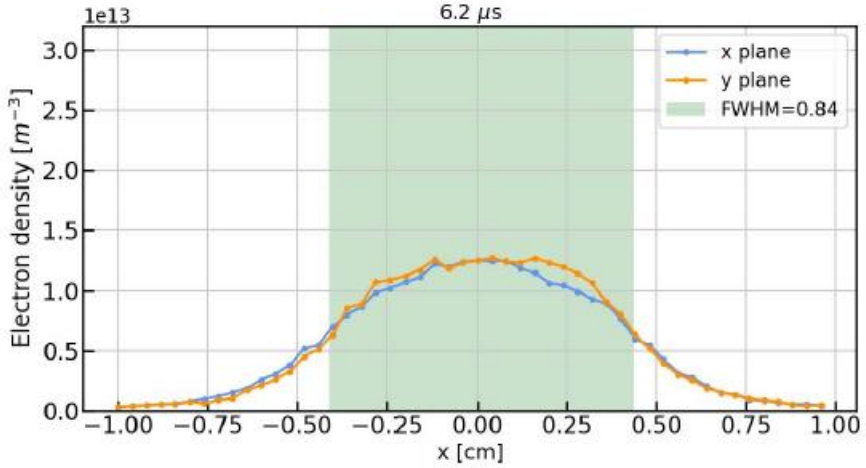


(A) Stable electron plasma

- Measure the transverse plasma profile for a range of plasma lengths and electron numbers

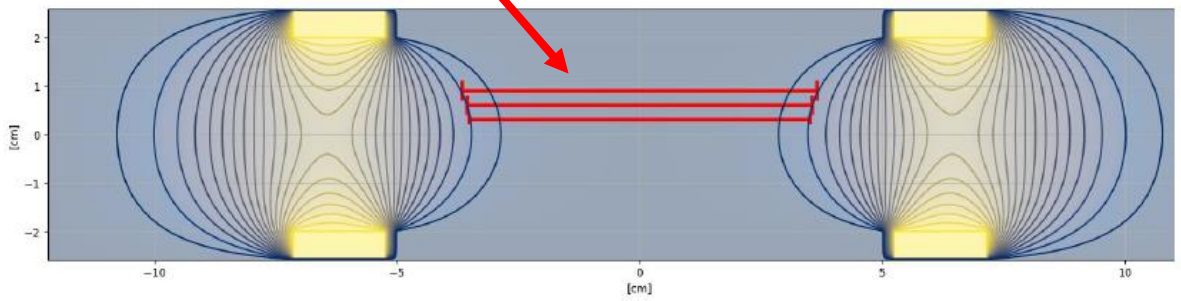
Simulation capabilities

- Transverse/Longitudinal plasma profile
- Can provide field maps for beam tracking
- Simulation times limited to 10s of μs
- Currently assessing methods to model the beam-capture phase

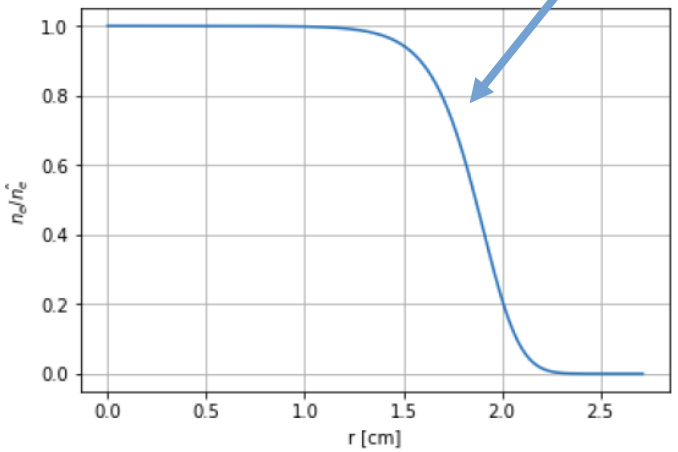


Analytical models also available:

Plasma length



Plasma radial profile



(B) Experimental limits on size and density of electron cloud

- Locate electron source on-axis
  - Study total number (likely space charge limited)
  - Use RW – attempt to change density/plasma radius for given conditions

- **Trapping efficiency**
  - Investigate upper limit on electron number trap with/without the RW
    - density as % out of the Brillouin limit
  - Size of the region with uniform plasma

Brillouin density limit

$$n_B = 4.8 \times 10^{18}\ \mathrm{m}^{-3} \left(\frac{B}{1\ \mathrm{T}} \right)^2$$

(C) Positron focusing by electron plasma

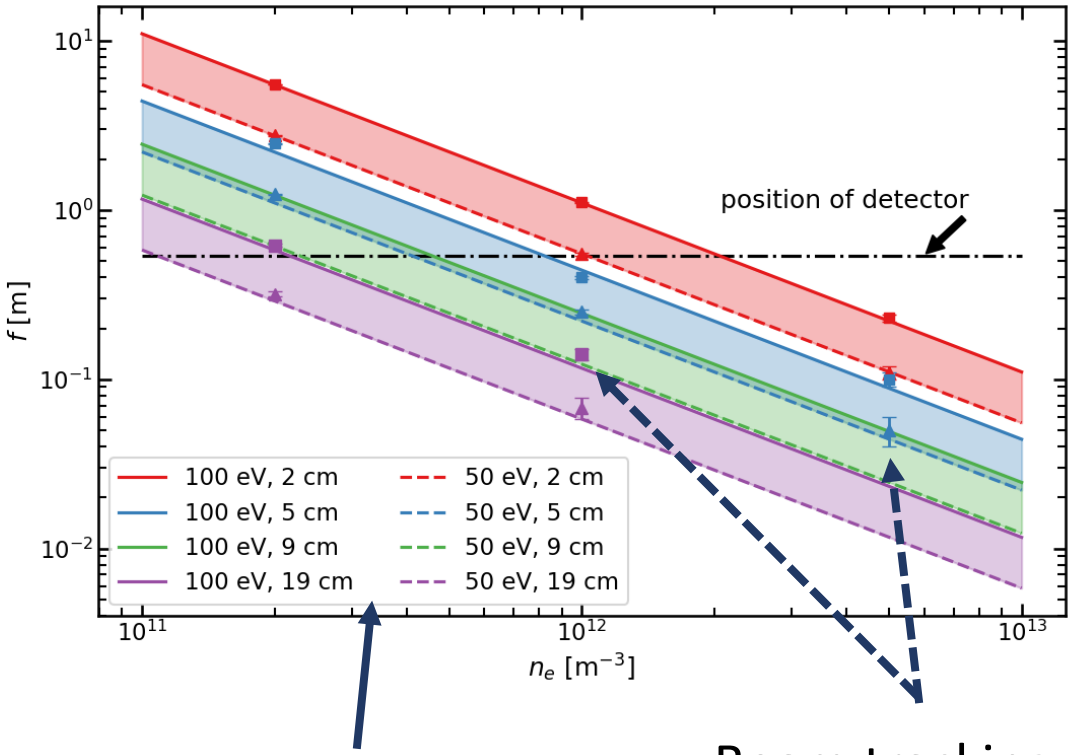
- Low energy positrons
  - DC beam, on-axis
    - Measure the change in radius
  - AC ‘cloud’, off-axis
    - Measure the change in position

Simulation capabilities

- Positron tracking through beamline + idealised plasma
- PIC simulation of positron beam passing through electron plasma

- On-going work to evaluate the effect of the surrounding B-field

Focal length of electron plasma



Beam tracking

Analytical model:
various positron energy
& plasma lengths

Towards practical Gabor lens

- Change amplifiers & electrodes for kV space charge plasma
- Replace filament for higher emission current
- Replace MCP/P-screen with P-screen (higher damage threshold)