LhARA
Source & Capture
Design & Integration Meeting

13th Jan 2023

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(on behalf of WP1.3)

Agenda

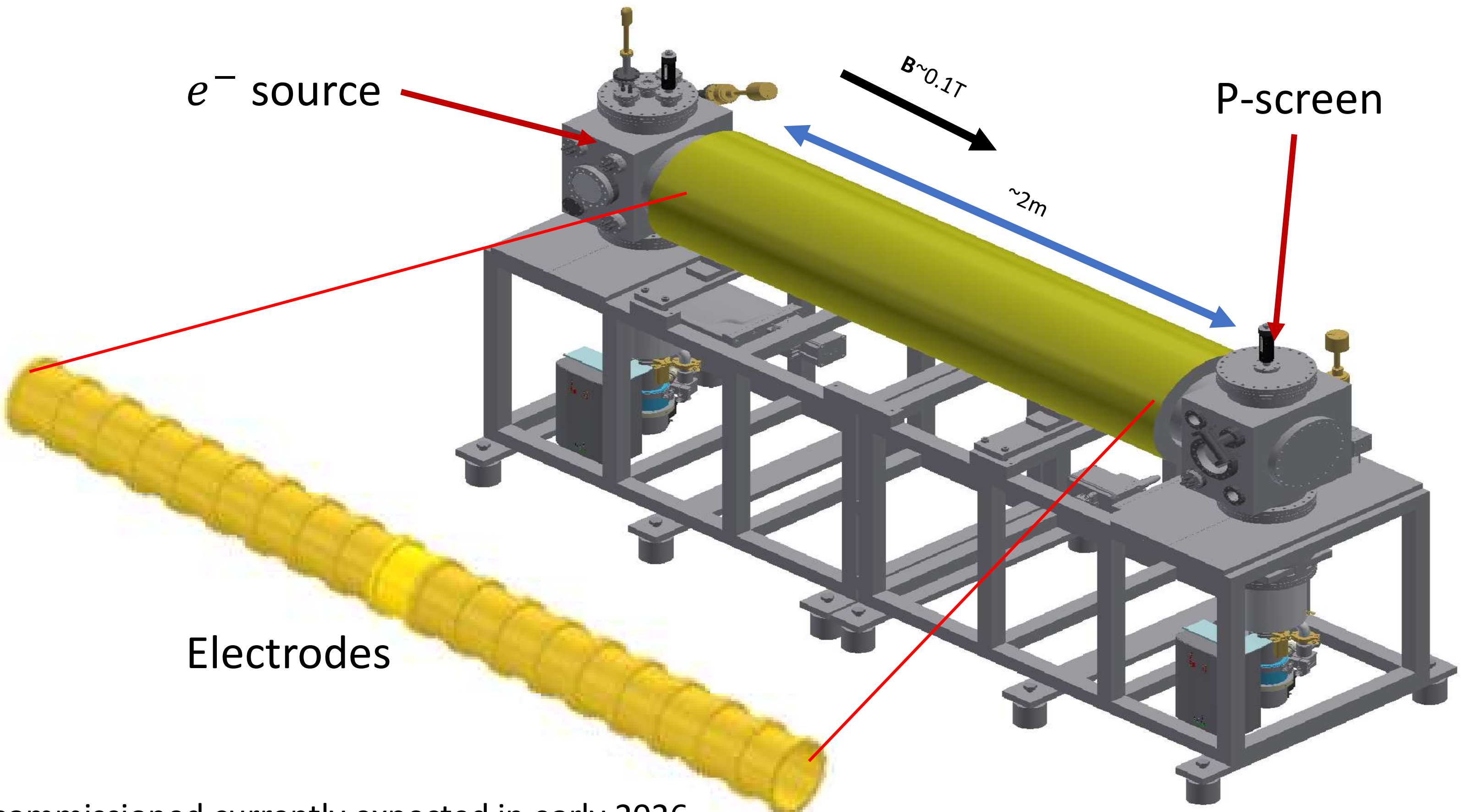
- Constraints
    1. Physical
    2. Vacuum
    3. Magnetic Field
    4. Desirable Changes

Agenda

- Constraints
  1. Physical
  2. Vacuum
  3. Magnetic Field
  4. Desirable Changes

- As the Gabor lens is yet to begin the initial design phase
  - We expect a great deal of flexibility
  - We expect changes as the experimental campaign produces results (2026!?)

Proposed Apparatus (preconstruction phase)



Assembled & commissioned currently expected in early 2026

1a. Physical constraints (size)

- Increasing the acceptance implies increasing plasma radius

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- Increasing plasma radius increases charge

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- Increasing plasma radius increases space-charge & corresponding confinement voltages:

  $n=5\text{x}10^{15}m^{-3}$, L=0.8 m, $r_p=3$ cm, $r_w=10$ cm, $\phi\sim70$kV, $N\sim1\text{x}10^{13}$

  $n=5\text{x}10^{15}m^{-3}$, L=0.8 m, $r_p=6$ cm, $r_w=18$ cm, $\phi\sim260$kV, $N\sim5\text{x}10^{13}$

  $n=5\text{x}10^{15}m^{-3}$, L=0.8 m, $r_p=10$ cm, $r_w=30$ cm, $\phi\sim720$kV, $N\sim1\text{x}10^{14}$

  $n=5\text{x}10^{15}m^{-3}$, L=0.8 m, $r_p=10$ cm, $r_w=15$ cm, $\phi\sim410$kV, $N\sim1\text{x}10^{14}$

1b. Physical constraints (positioning)

- Presence of uncontrolled / grounded surfaces is bad for plasma confinement

2. Vacuum constraints

- In general, increasing pressure decreases plasma confinement time so non-neutral plasmas typically operate in UHV regime (<10^{-8} mbar)
  - See e.g. Chao [Phys. Plasmas 7831 (2000)] or Malmberg & Driscoll [PRL 44 654 (1980)] …
- However, we expect to use Rotating Wall so collisional cooling *might* be beneficial
  - e.g. In low B-field using e^+, SF_6 at 10^{-6} mbar is required
  - Depends upon background gases…
    - Limited information as such e^- systems use radiative cooling from Tesla-level SC magnets
    - Most commonly deleterious
- Large (r=10cm) electrodes provides very high conductance
- Some non-neutral plasma apparatus use electrodes at cryogenic temperatures…

3. Magnetic field (0.1 T)

- Increasing the acceptance implies increasing plasma radius

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- Increasing plasma radius increases electrode radius*

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- Increasing electrode radius increases vacuum chamber & magnet radius

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- Increasing magnet radius increases manufacture and running costs
  - Wire length scales ~linearly with radius, power scales ~linear with wire length
    - Increasing magnet radius by 30% likely increases costs by ~30+%

- If required, B-field shielding of source likely more difficult (while maintaining transport efficiency)

* Currently an outstanding experimental question

4. Desirable changes

- Increasing B-field provides better confinement
  - Confinement & cooling times scale favourably as B^2
  - Due to costs, a smaller radius solenoid would be beneficial to achieve this