

Langmuir Probes

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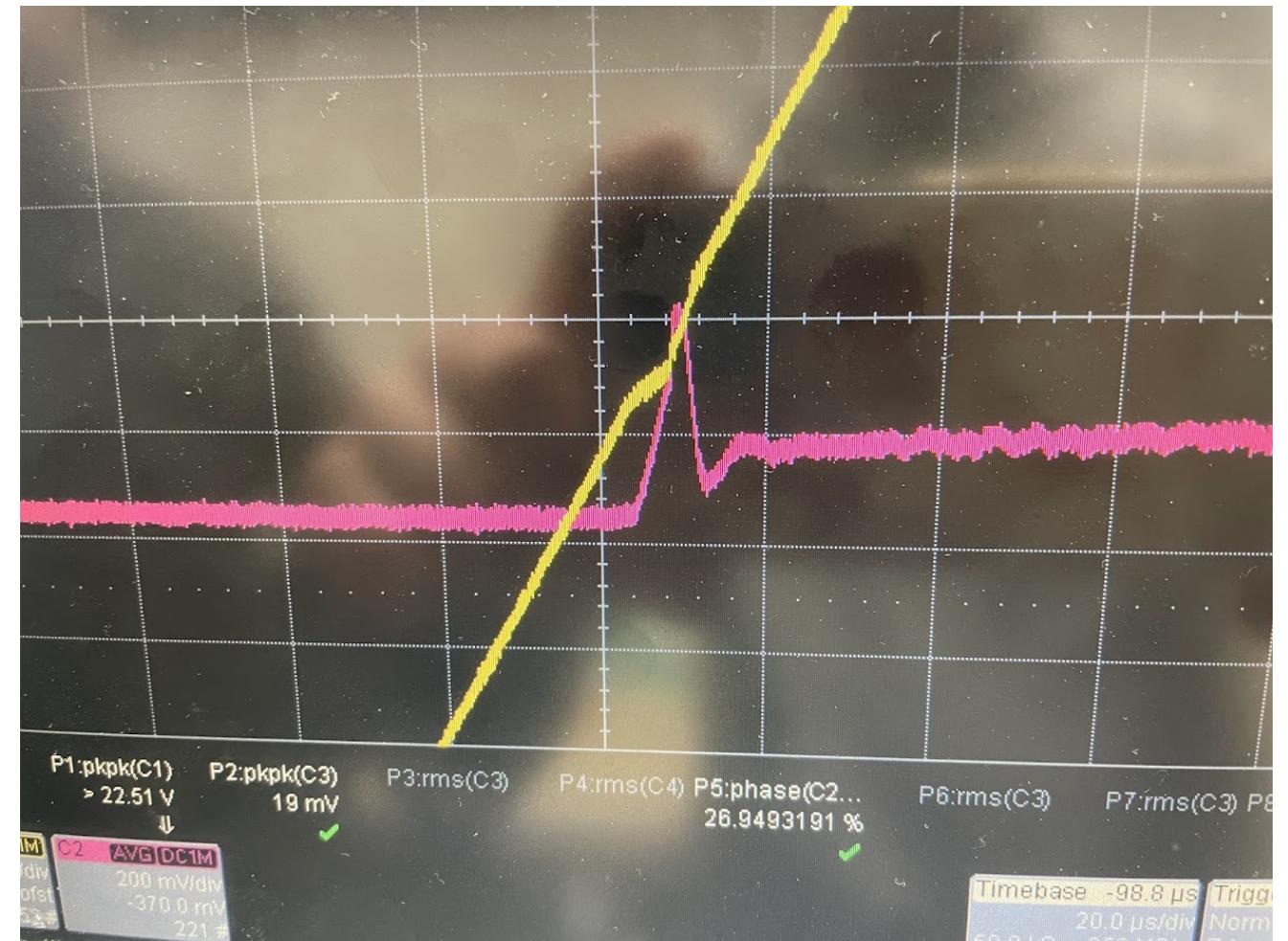
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Physics 180E Plasma Lab
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Debye sheaths form around conductors in a plasma

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- Electron vs ion speed
- Measure current (I) in response to probe bias voltage (V)
- Extract temperature & number density from IV curve
- **Hypothesis:** uniform axial magnetic field confines plasma



Experimental setup

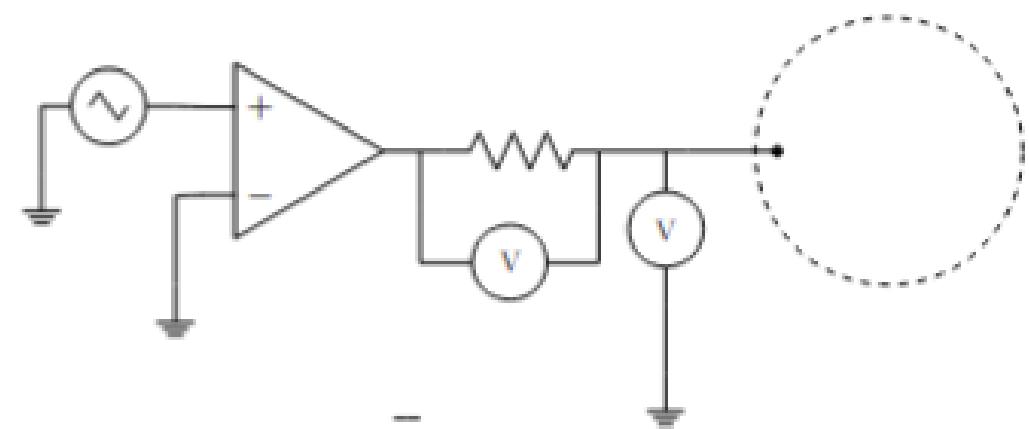
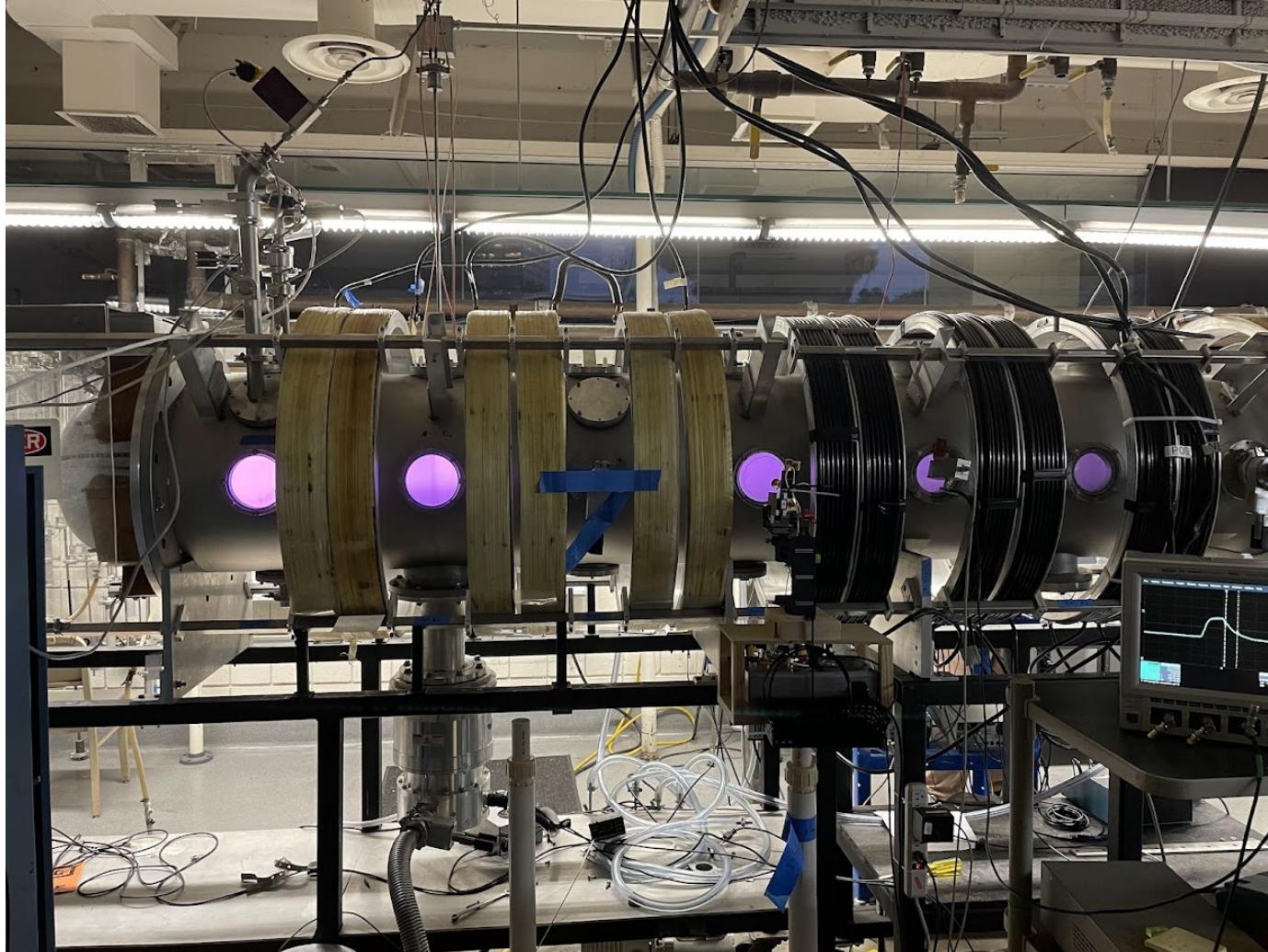
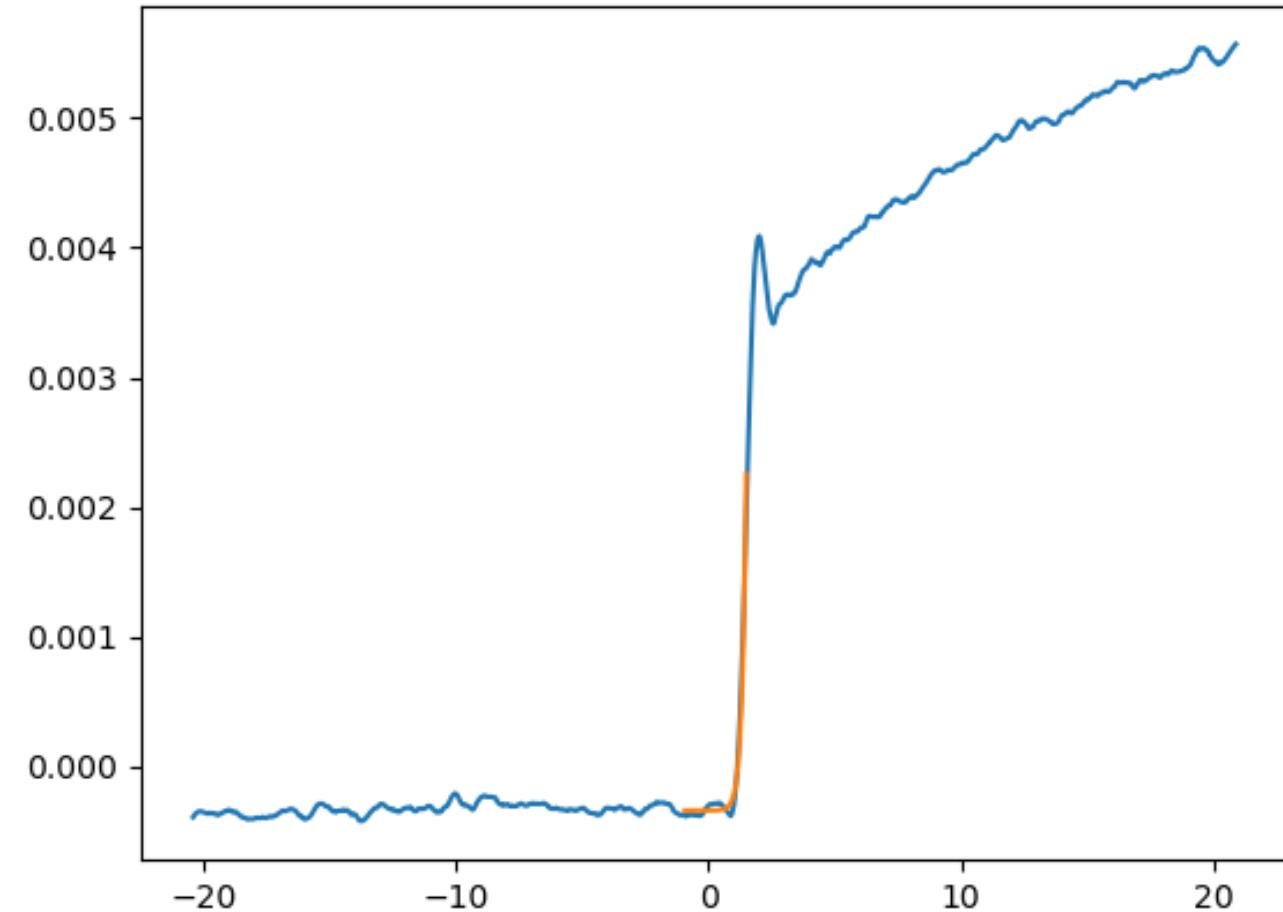


FIG. 1. Circuit diagram for measuring Langmuir probe output. The dashed circle represents the plasma chamber. The triangle wave generator sweeps over a range of voltages, which is amplified by a factor of 20. A voltmeter across a resistor measures current flowing out of the probe, and another voltmeter between the probe and ground measures the voltage of the probe.

Processing & analyzing IV curves

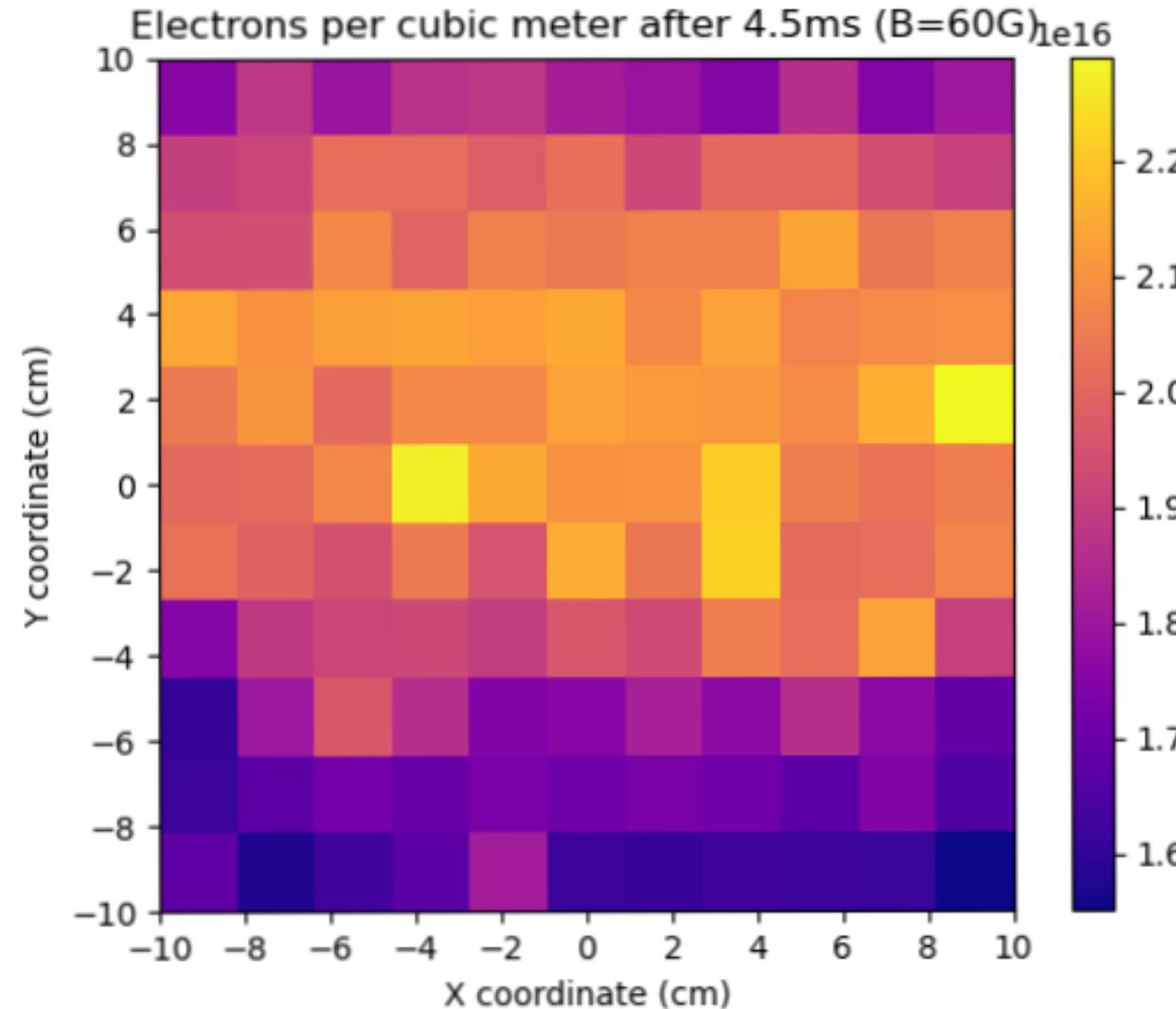
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- Savitzky-Golay filter
- Point with lowest second derivative corresponds to plasma potential & electron saturation current
- First derivative resembles Gaussian, exponential region is approx $(\mu-20\sigma, \mu)$
- Fit exponential region to vertically-offset exponential function



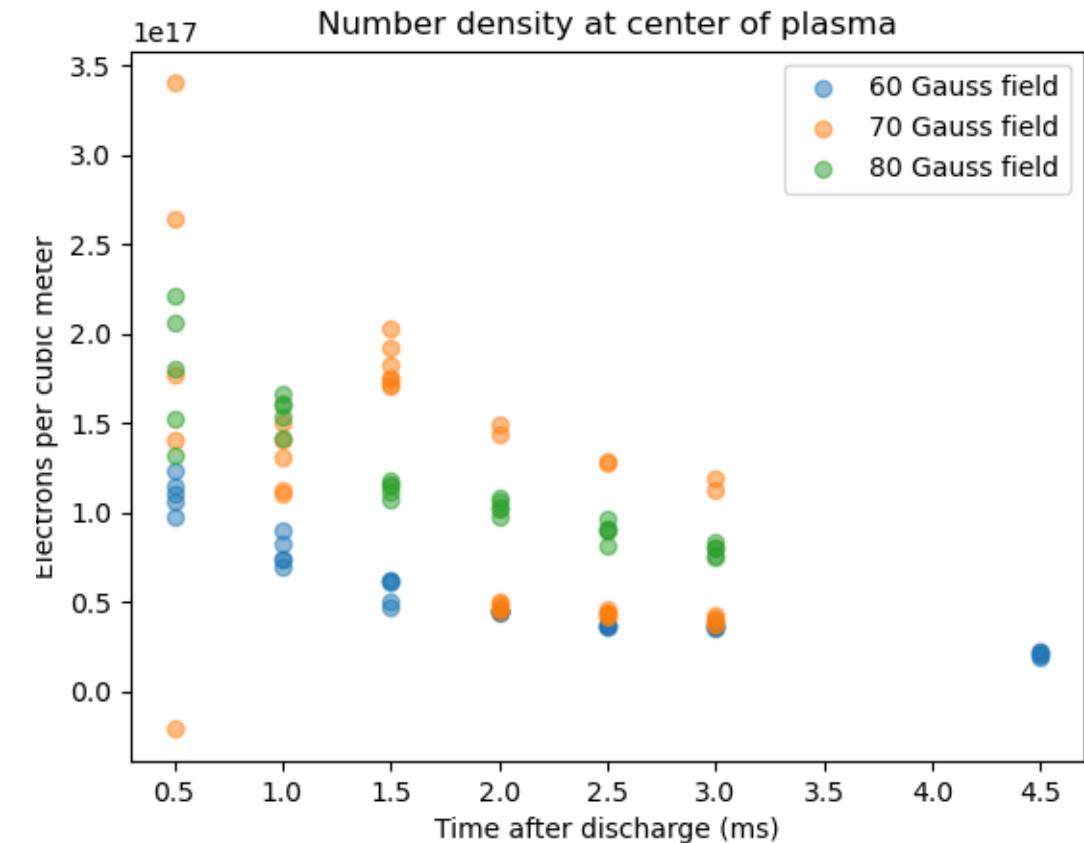
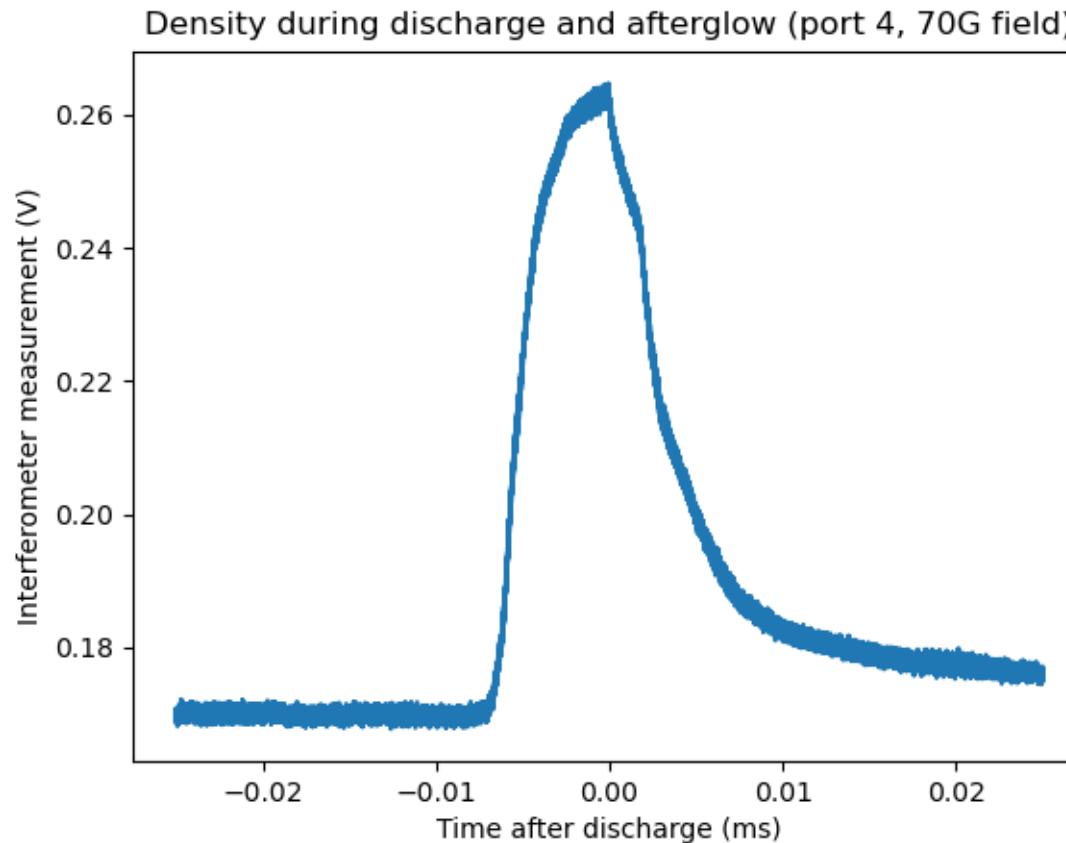
Plasma is not centered in XY plane

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Magnetic field affects density decay rate during afterglow

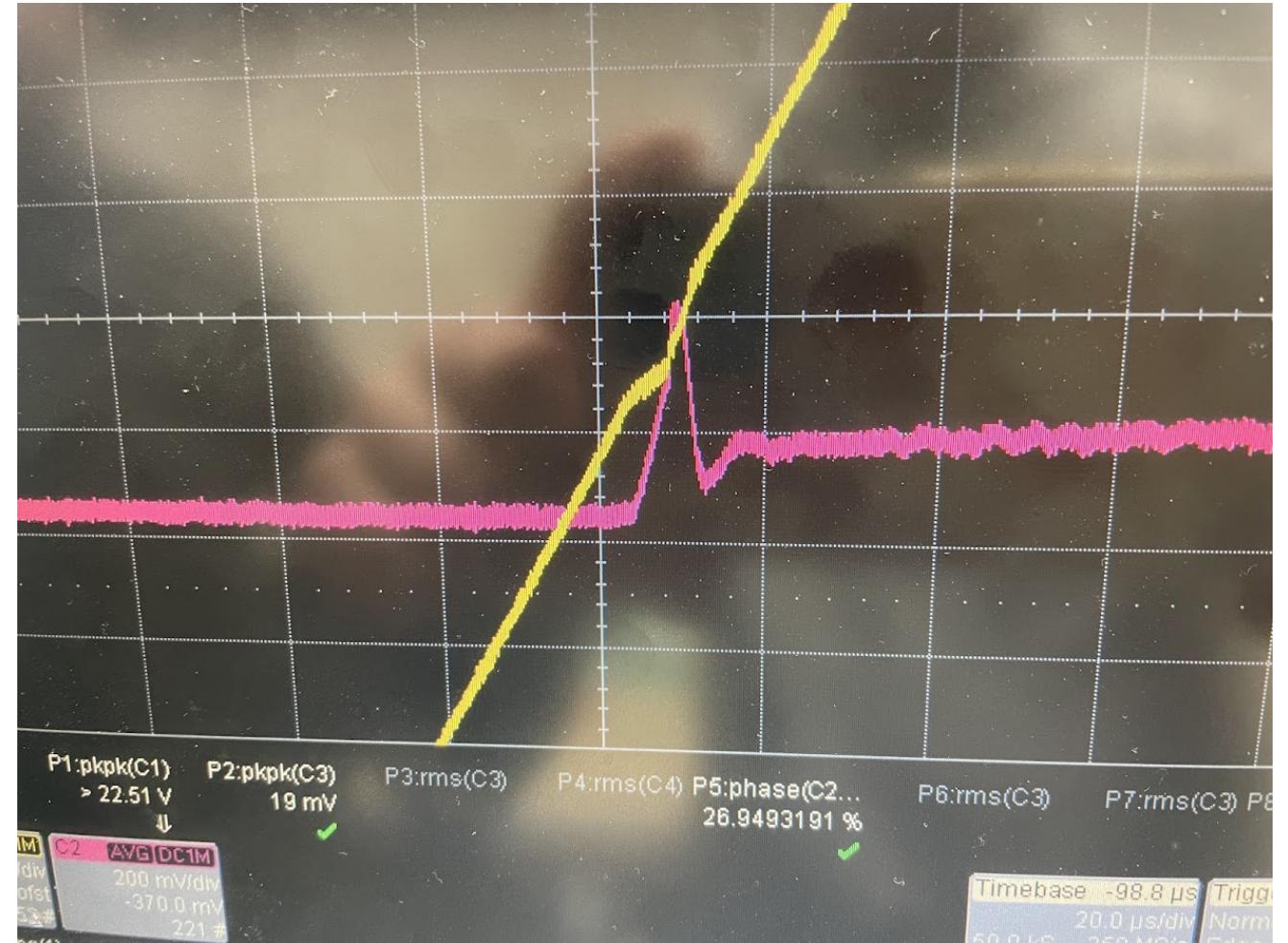
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Future Improvements

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- Experiment with different resistances for resistor
- Find decay rate as a function of B
- Use different theoretical models for ion saturation region



References

- [1] D. Schaeffer, Winter 2025 lecture slides for physics 180e: plasma laboratory (2025).
- [2] F. F. Chen, Lecture notes on langmuir probe diagnostics, <https://www.seas.ucla.edu/~ffchen/Publs/Chen210R.pdf> (2003).
- [3] W. Gekelman, P. Pribyl, Z. Lucky, S. W. Tang, J. Han, and Y. Qian, Design, construction and utilization of a university plasma laboratory, *Journal of Plasma Physics* **86**, 925860301 (2020).
- [4] J. Perez, `Icpd.magnetfieldsolver_w25.py`, python script to calculate magnetic field in the 180E machine as a function of current through each magnet.