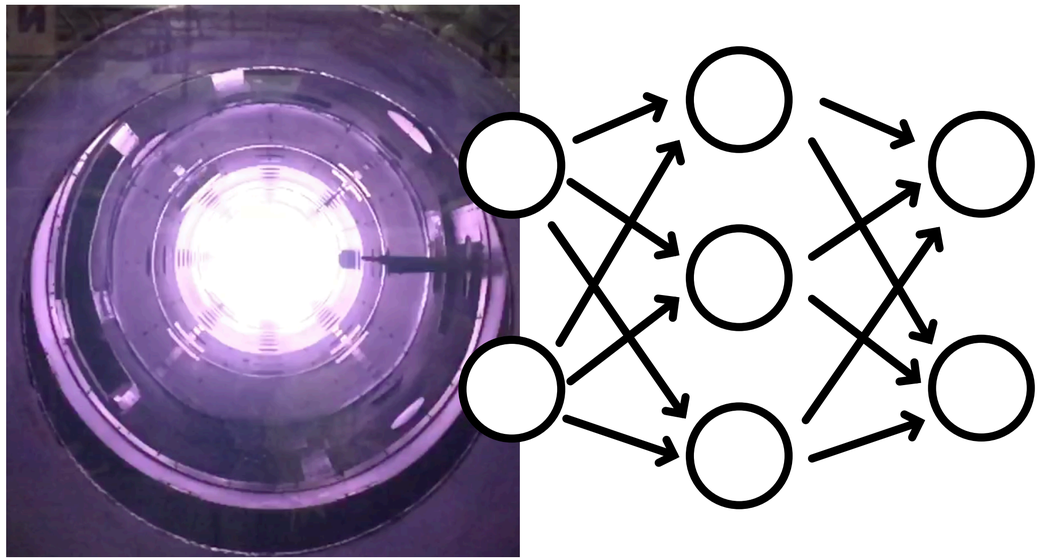
Autosweep: automated Langmuir sweep analysis



Phil Travis
phil@physics.ucla.edu
APS DPP, November 10th, 2020

Work supported by the US DOE and NSF, and performed at the Basic Plasma Science Facility (BaPSF), UCLA.

Autosweep: automated Langmuir sweep analysis

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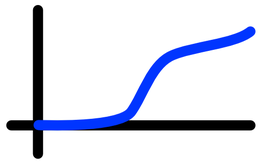
- Langmuir sweeps measure T_e and V_p in the LAPD



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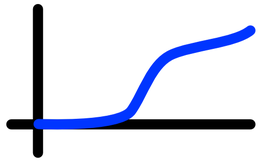

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Autosweep: automated Langmuir sweep analysis

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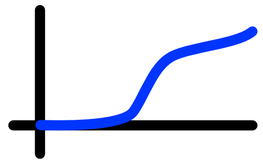

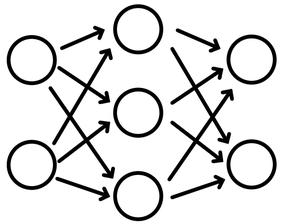

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Autosweep: automated Langmuir sweep analysis

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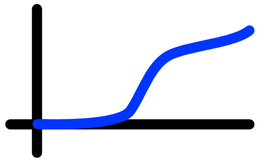

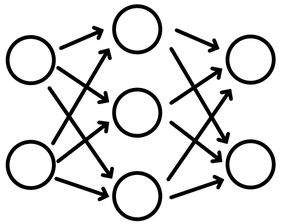

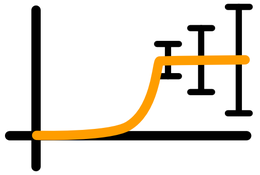

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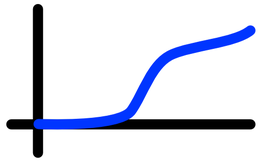
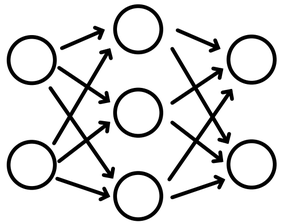
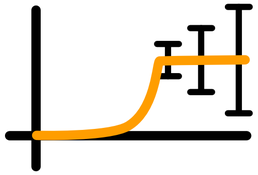
- Code is on github







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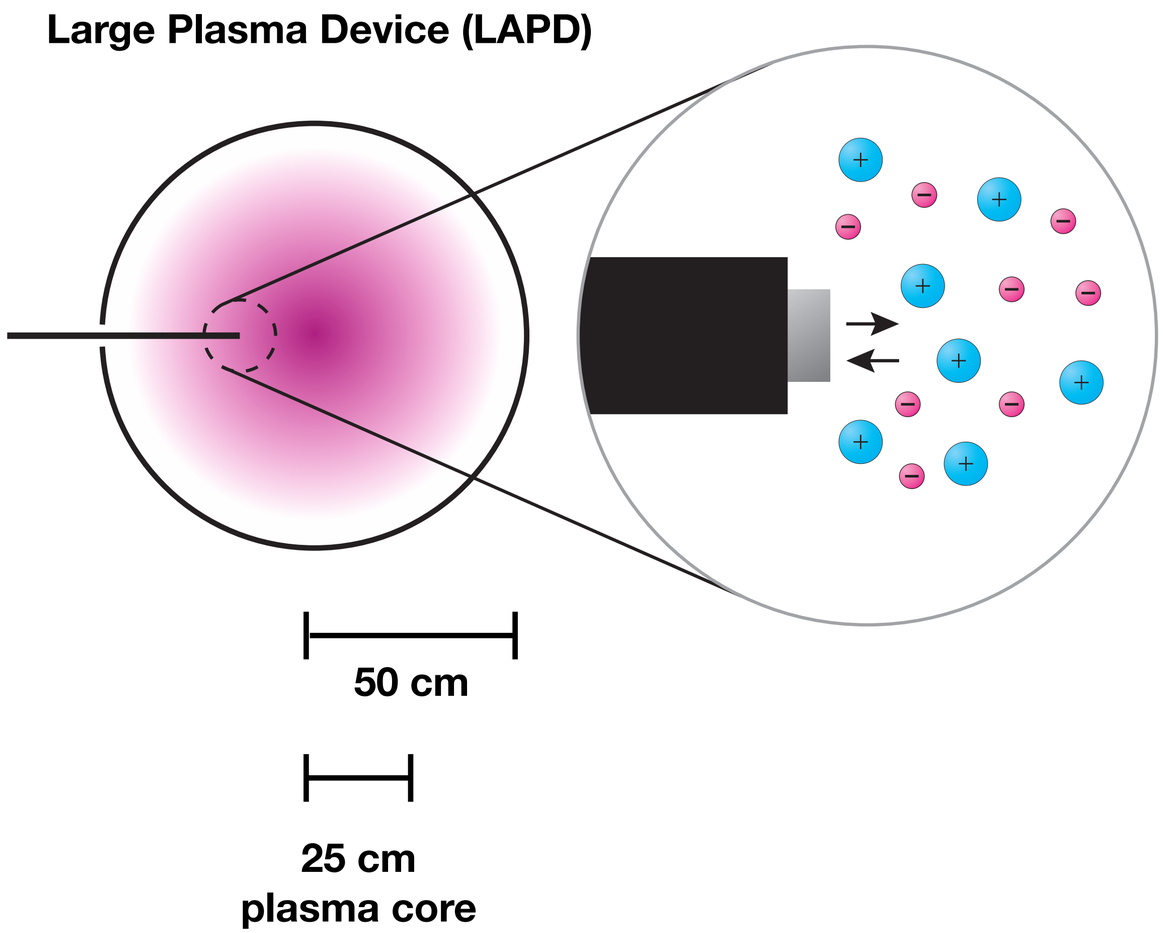
Plasma parameters can be measured with Langmuir probes



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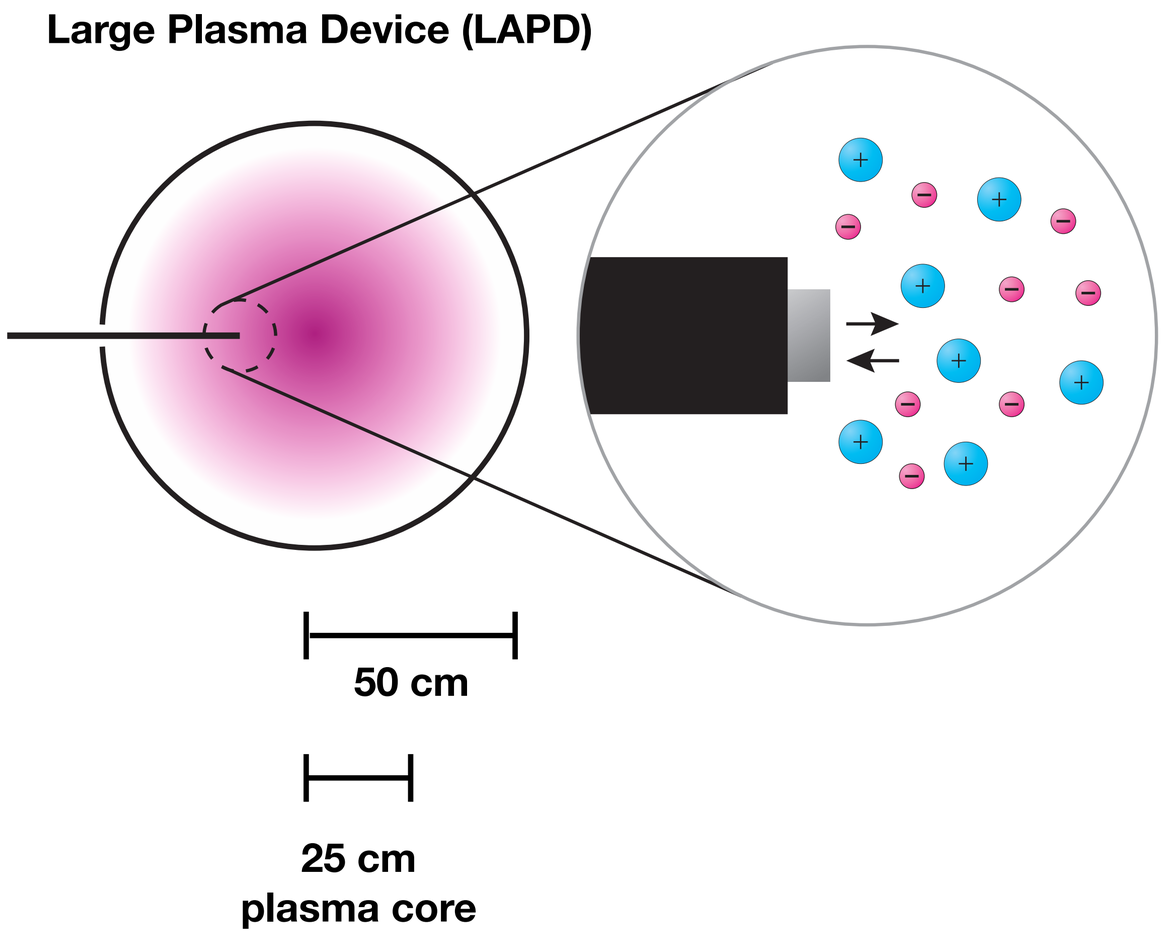

- Lots of turbulence / fluctuations out in the edge

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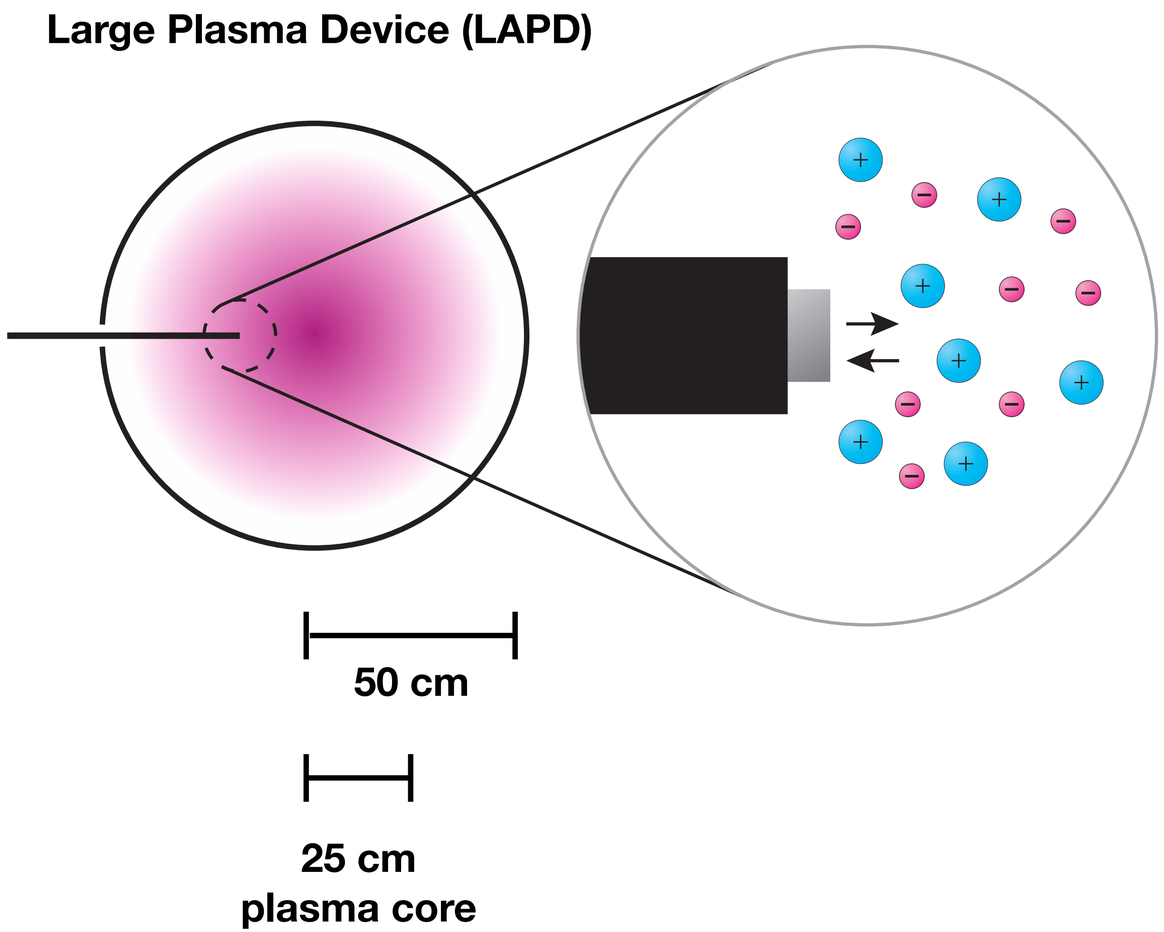

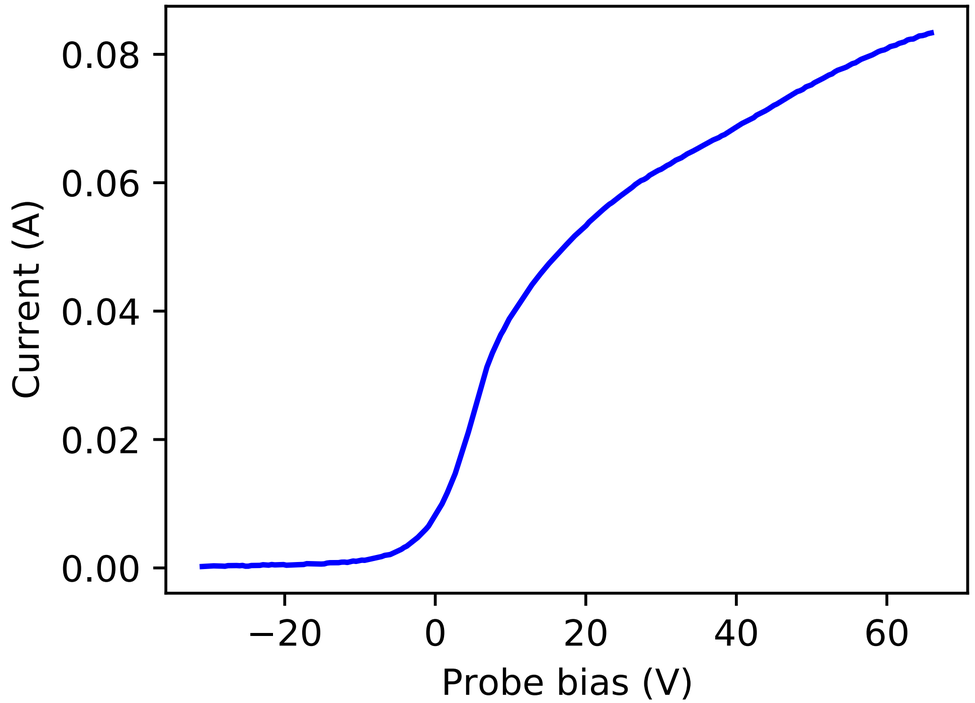

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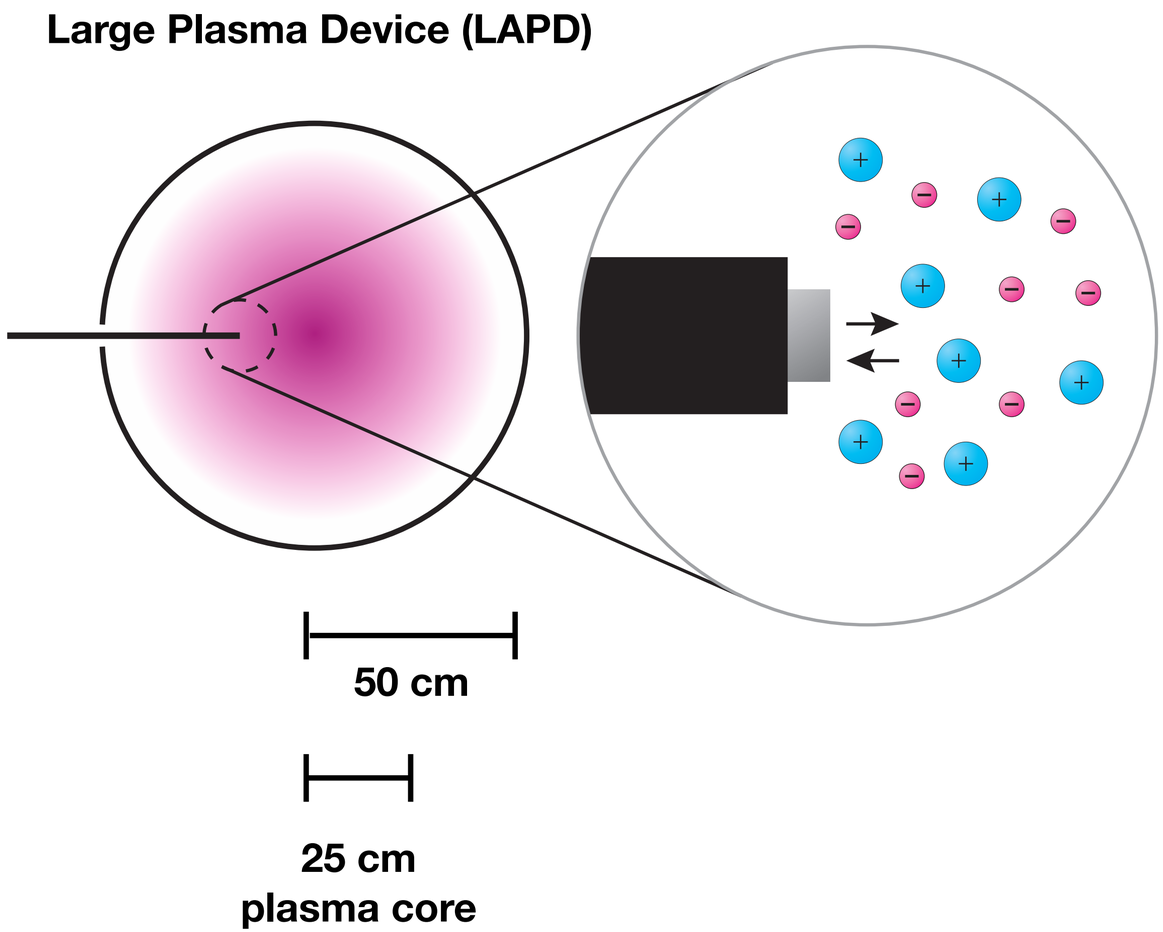

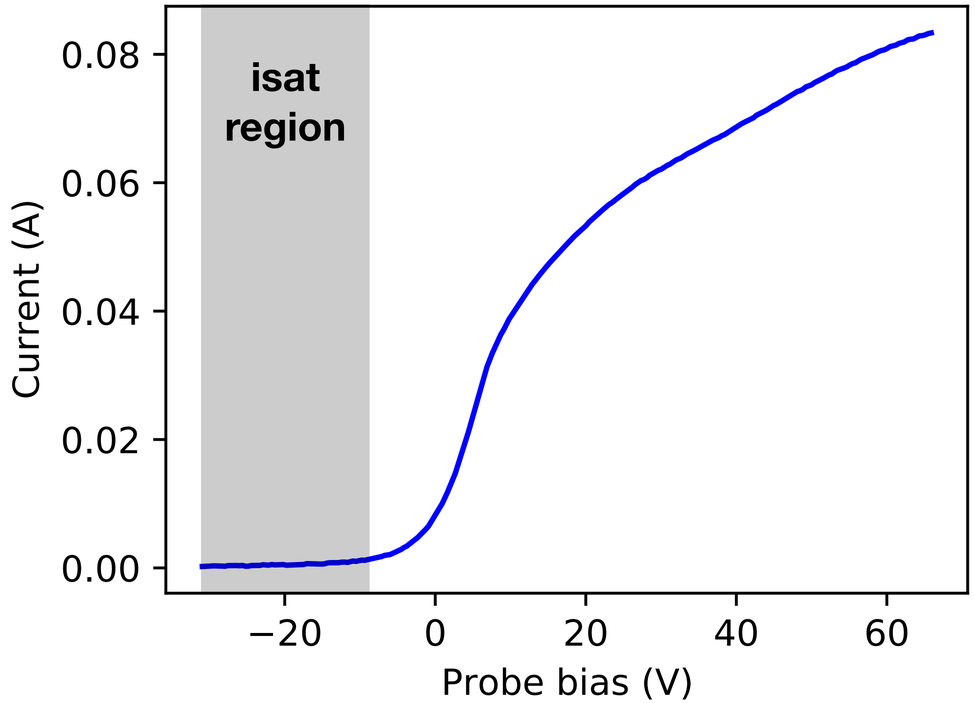

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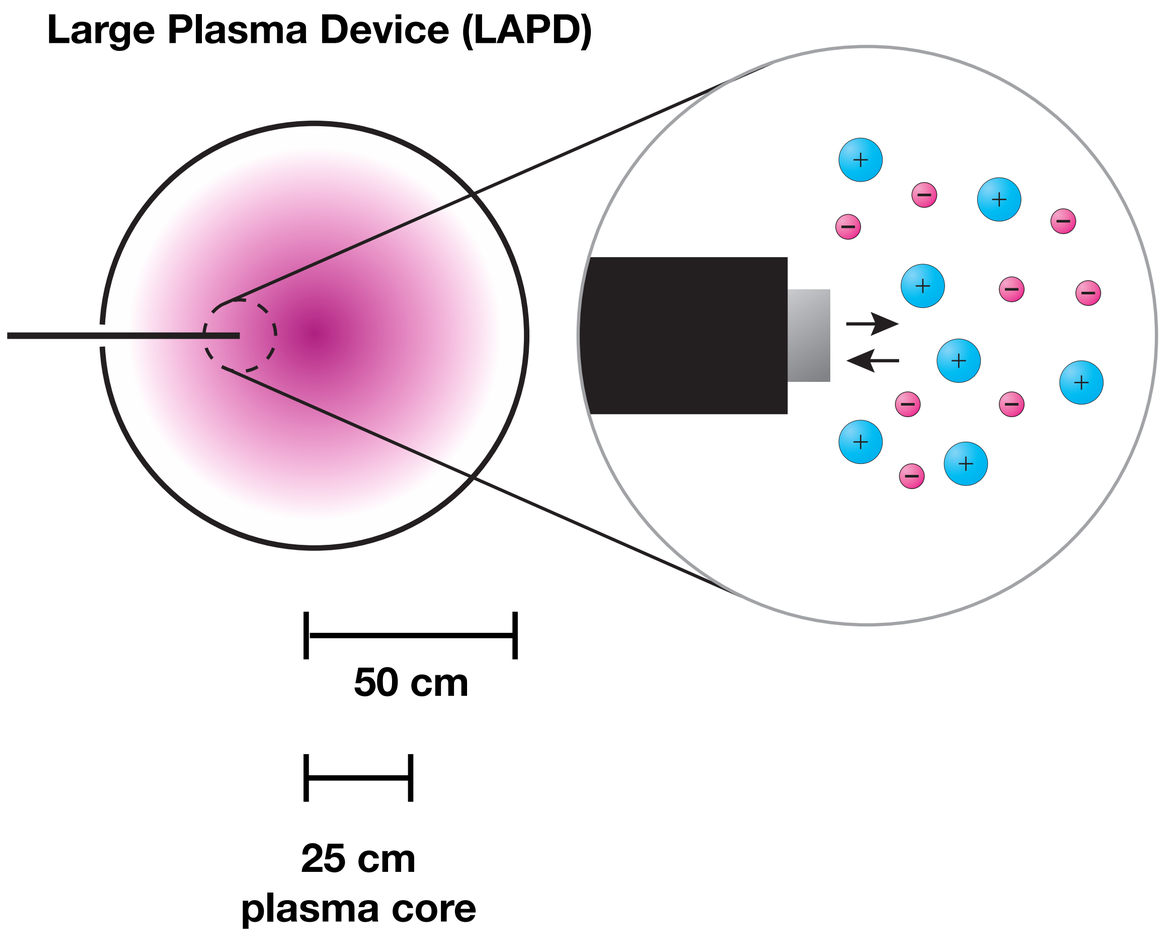

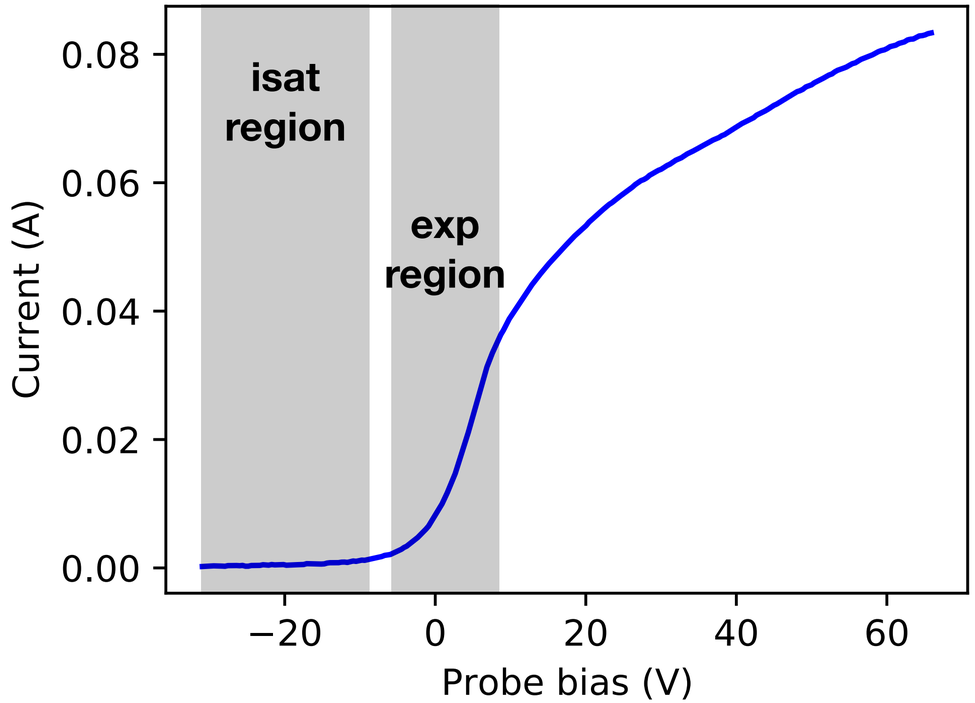

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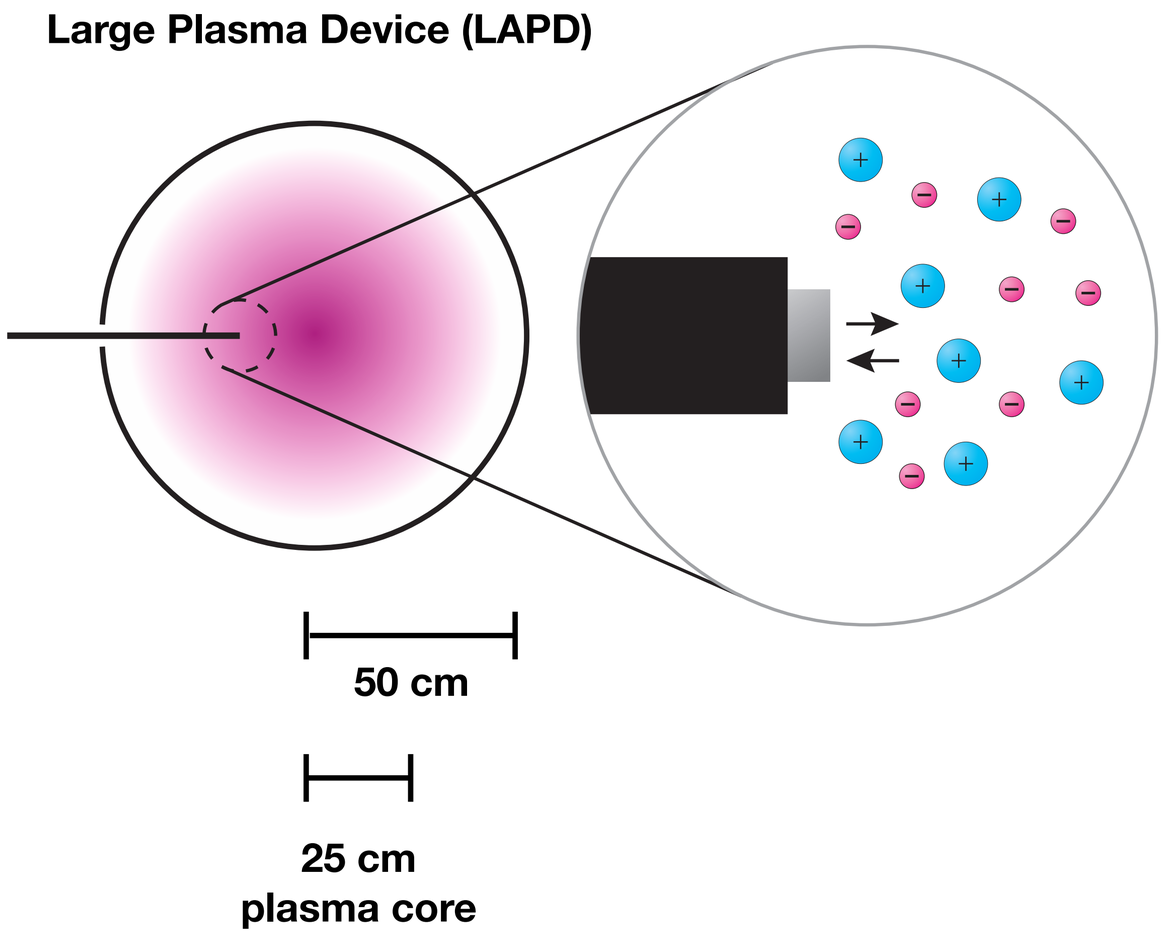

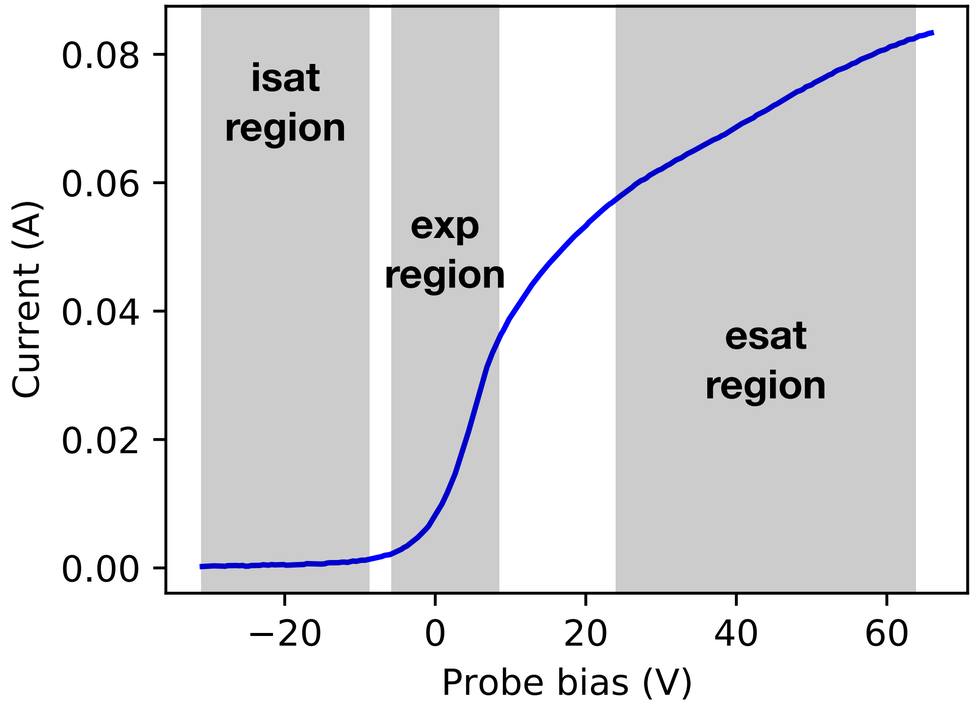

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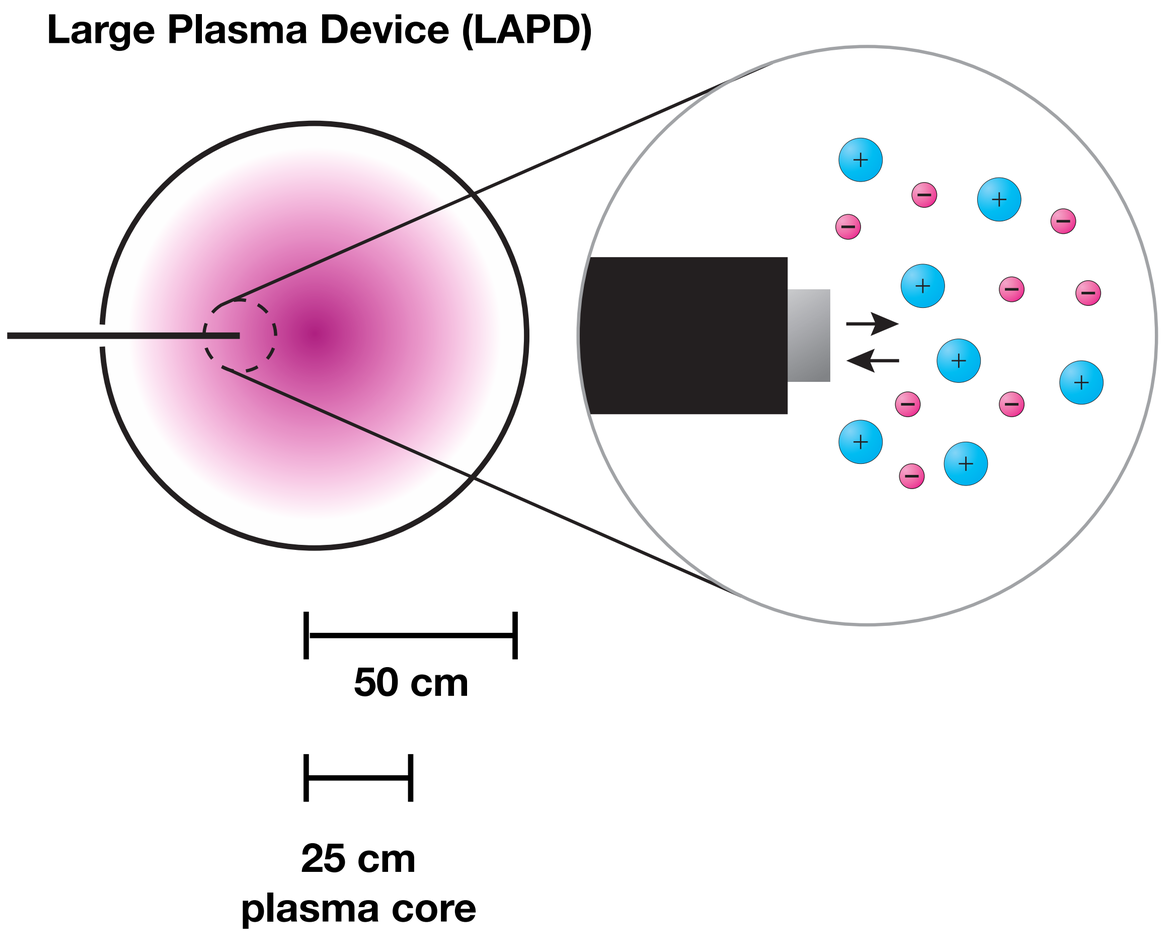
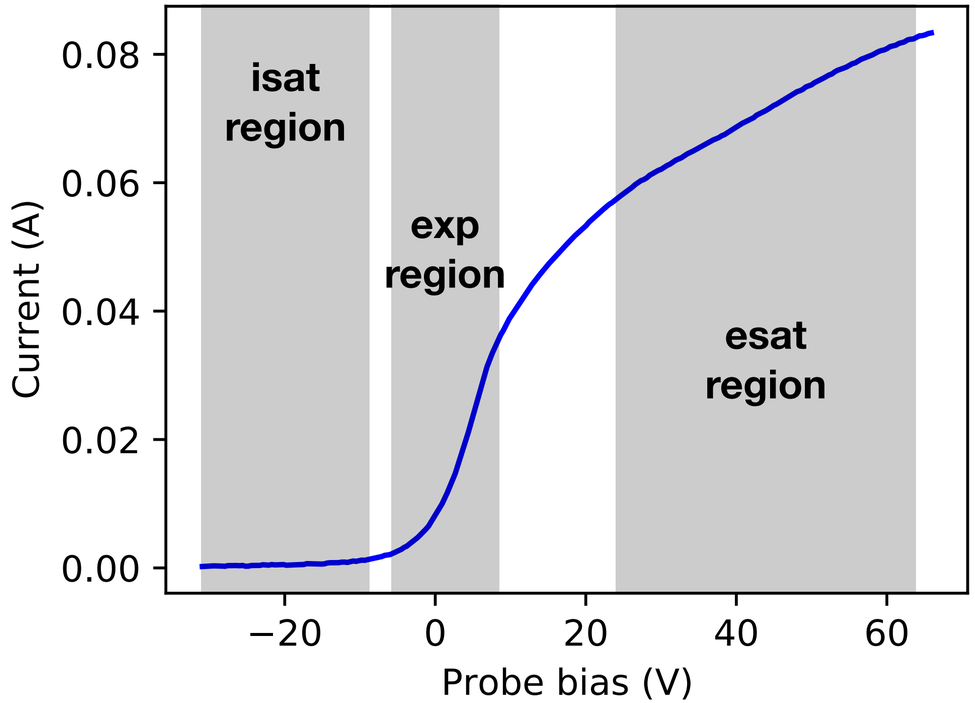
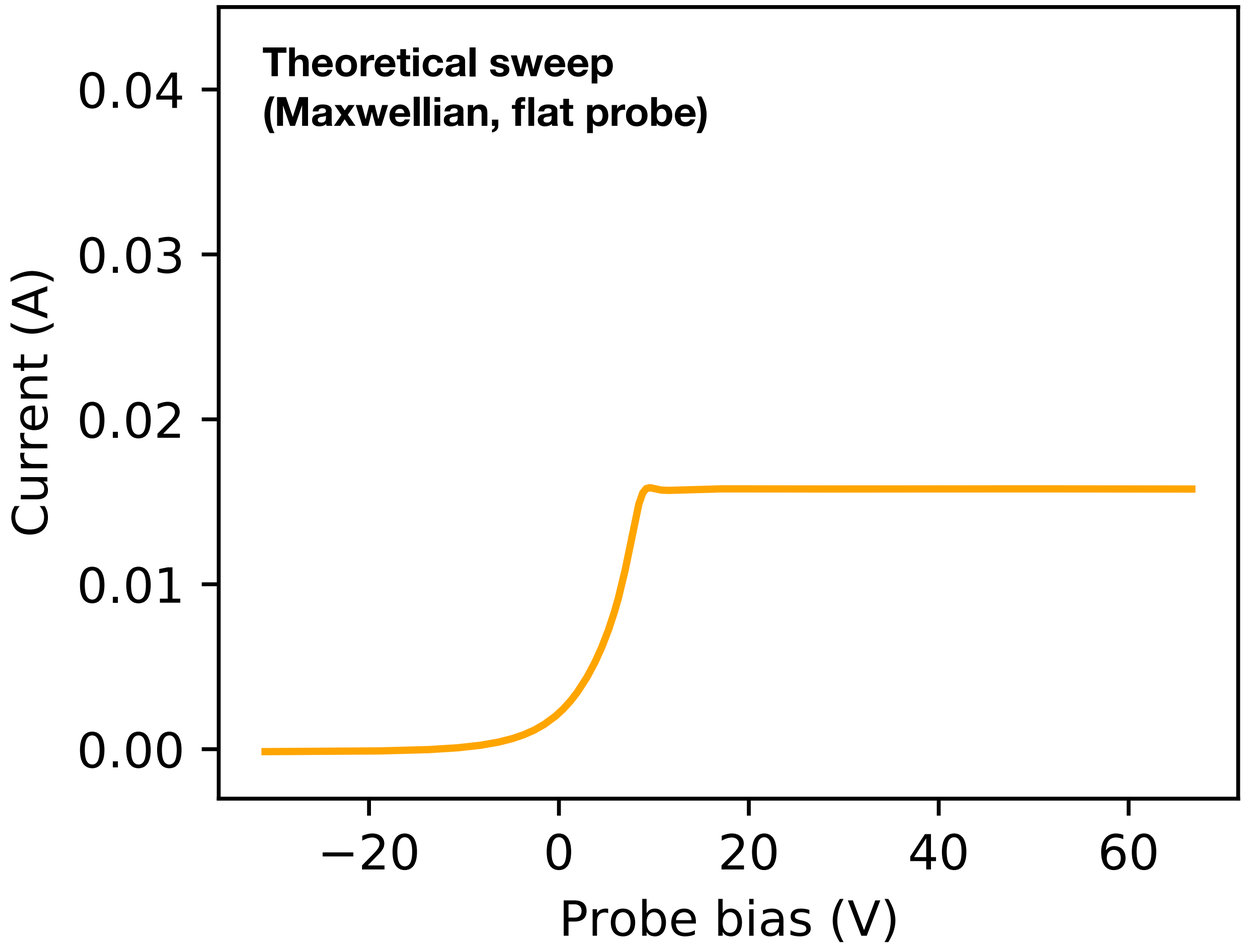




- Lots of turbulence / fluctuations out in the edge
- We can measure temperature, plasma potential (but density is hard to get from esat)

Theoretically, sweeps are simple



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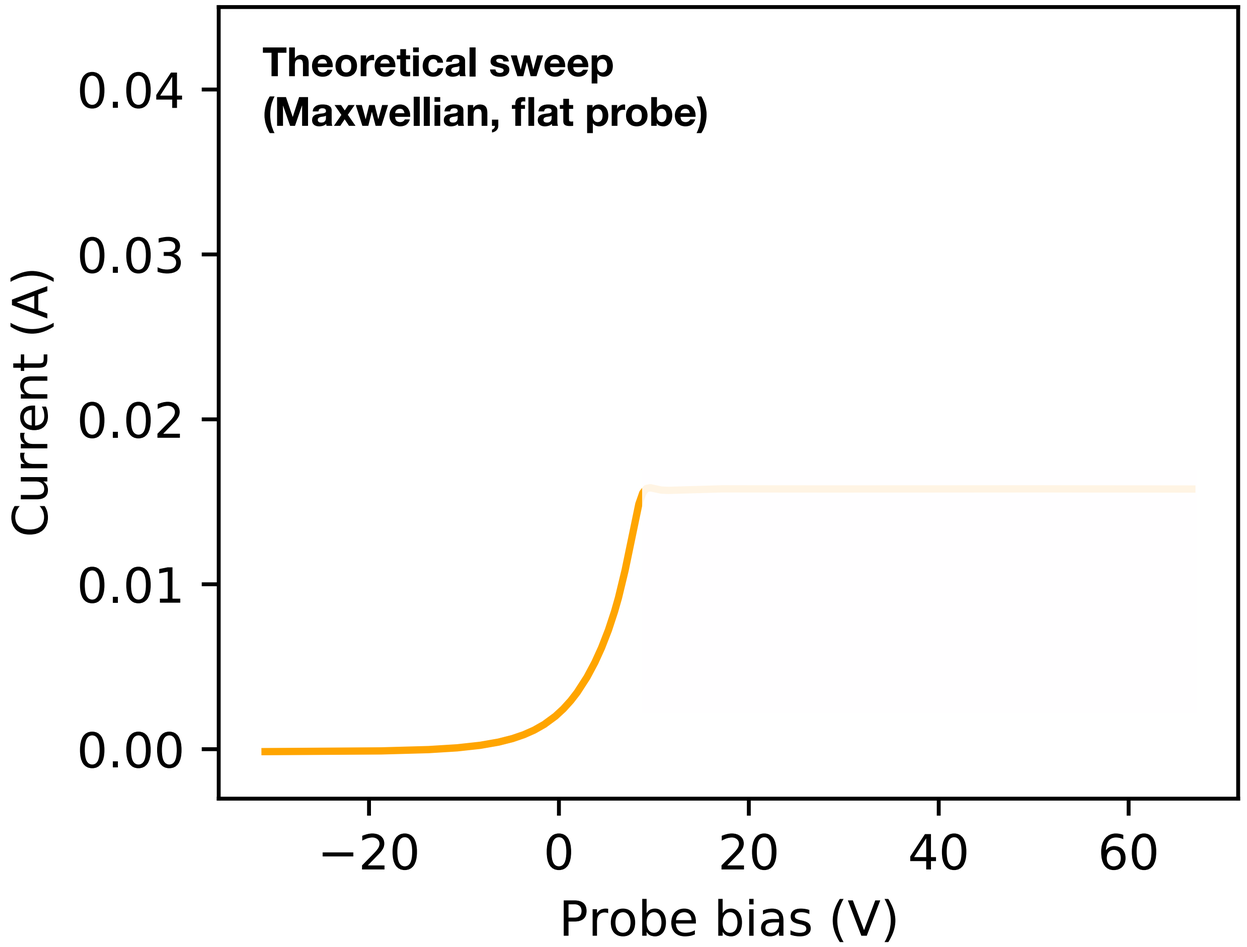

Plasma potential

$$I\left(V_B\right) = A_{eff} n_e e \sqrt{\frac{T_e}{2\pi m_e}} e^{-\frac{e\left(V_p - V_B\right)}{T_e}}, V_b < V_p$$

Probe bias

Electron density

Electron temperature

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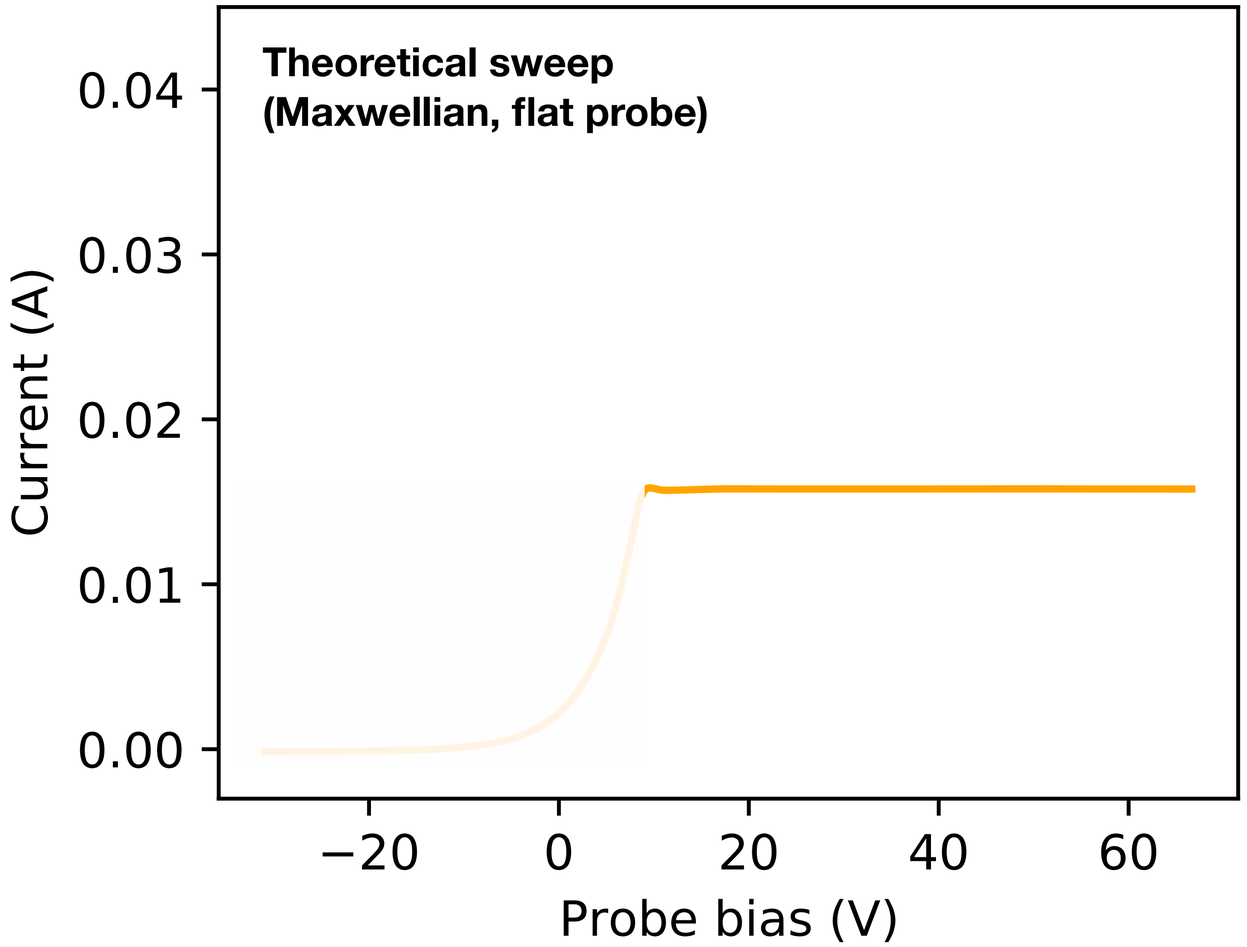

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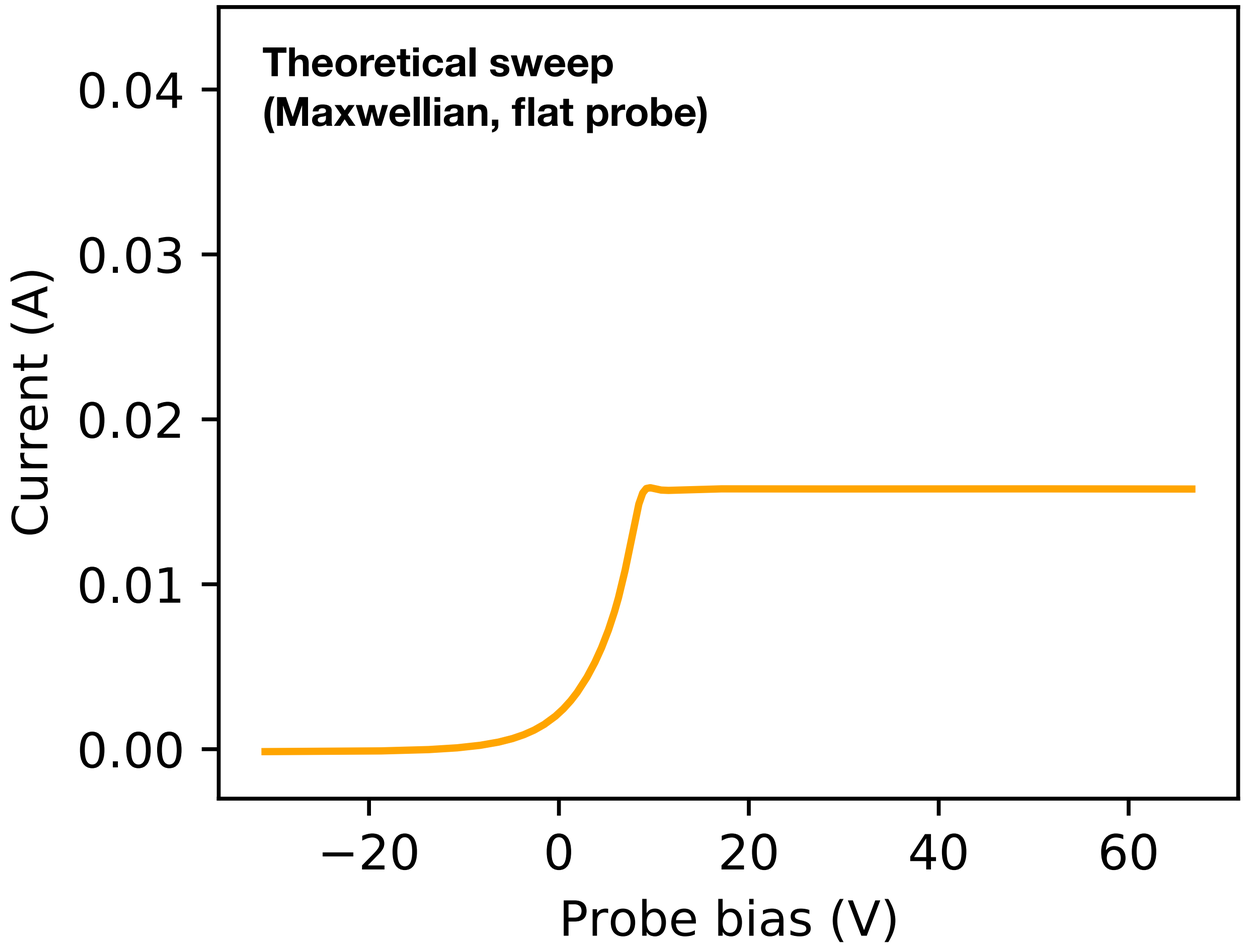

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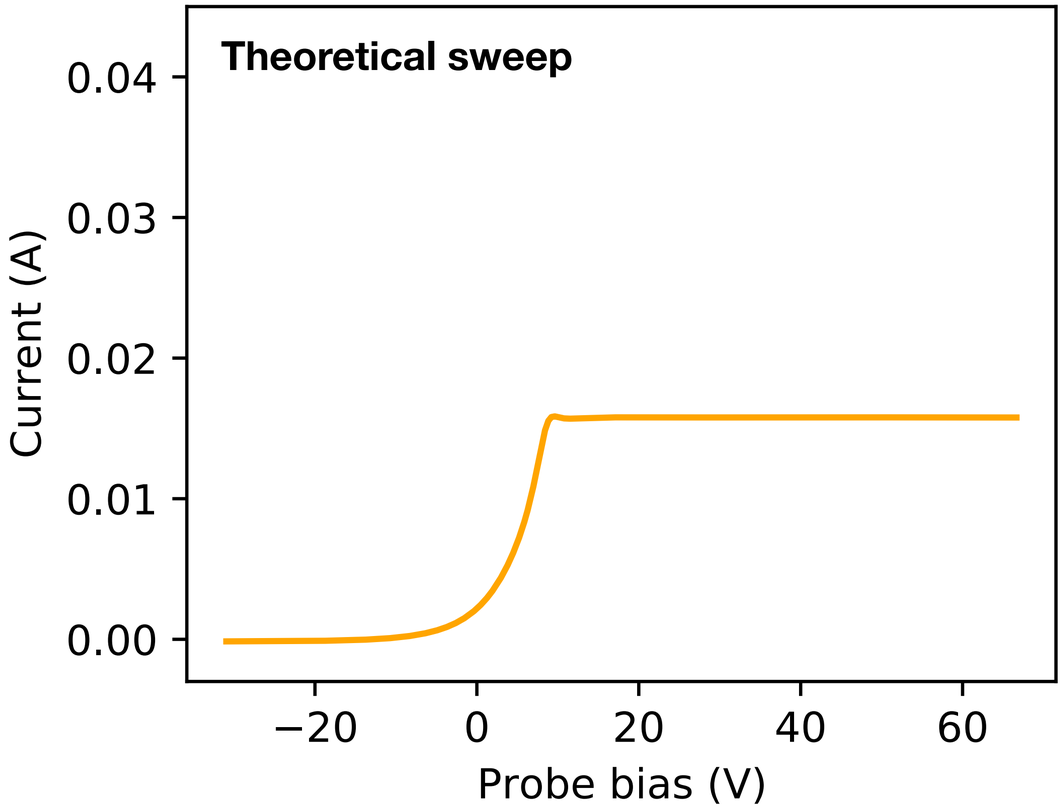

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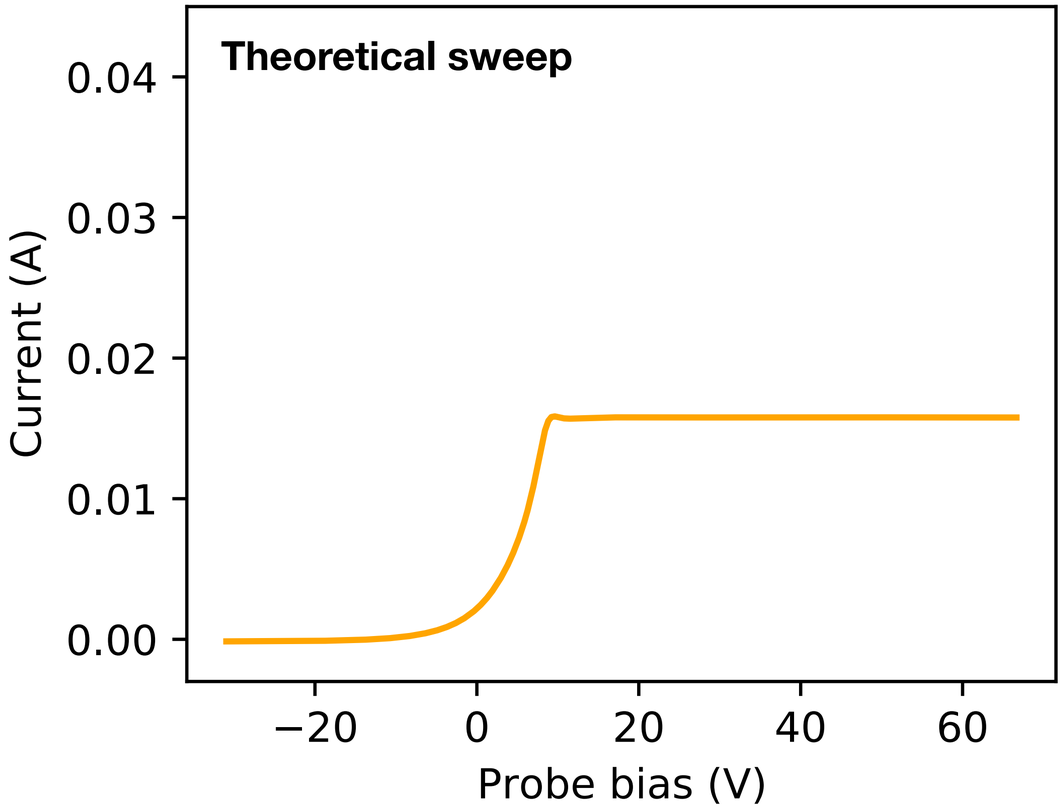
Real sweeps, not actors



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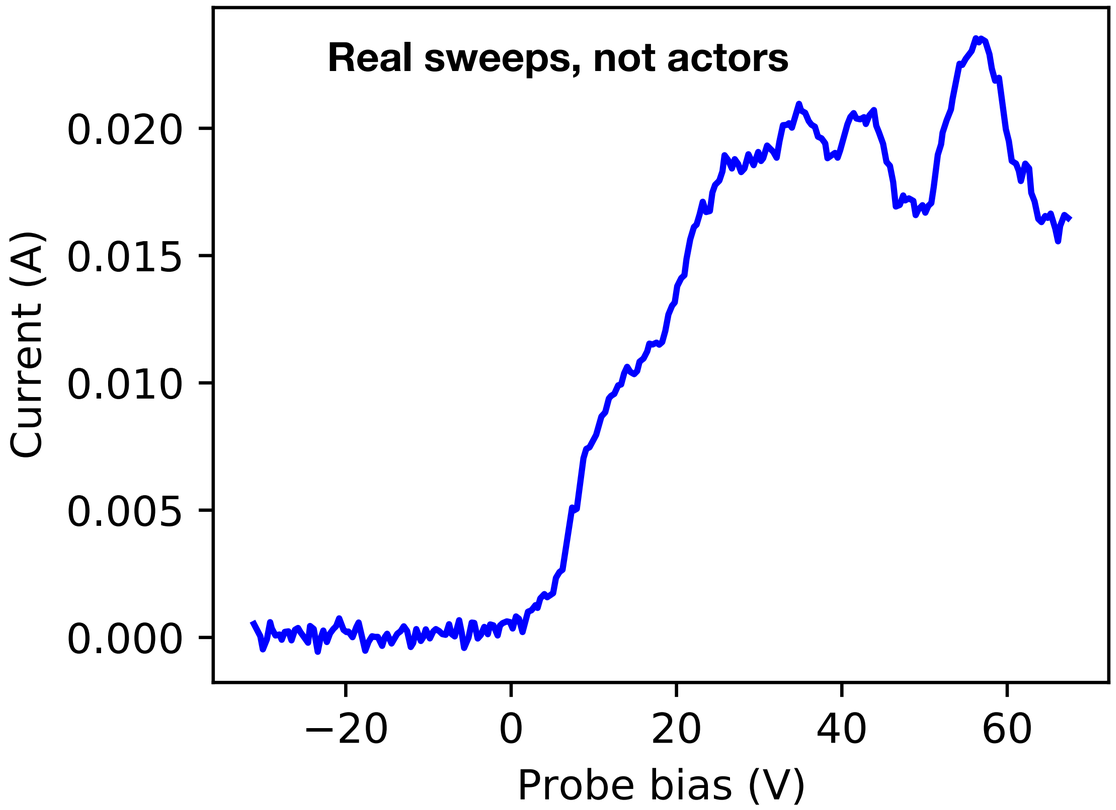

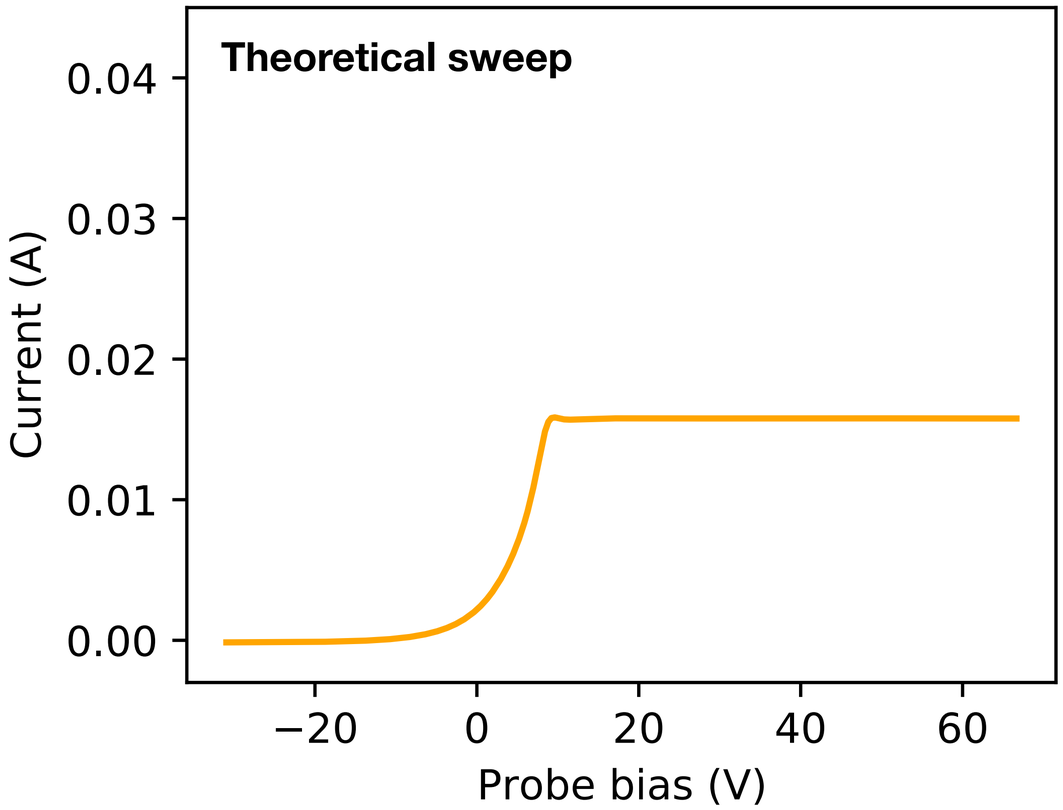

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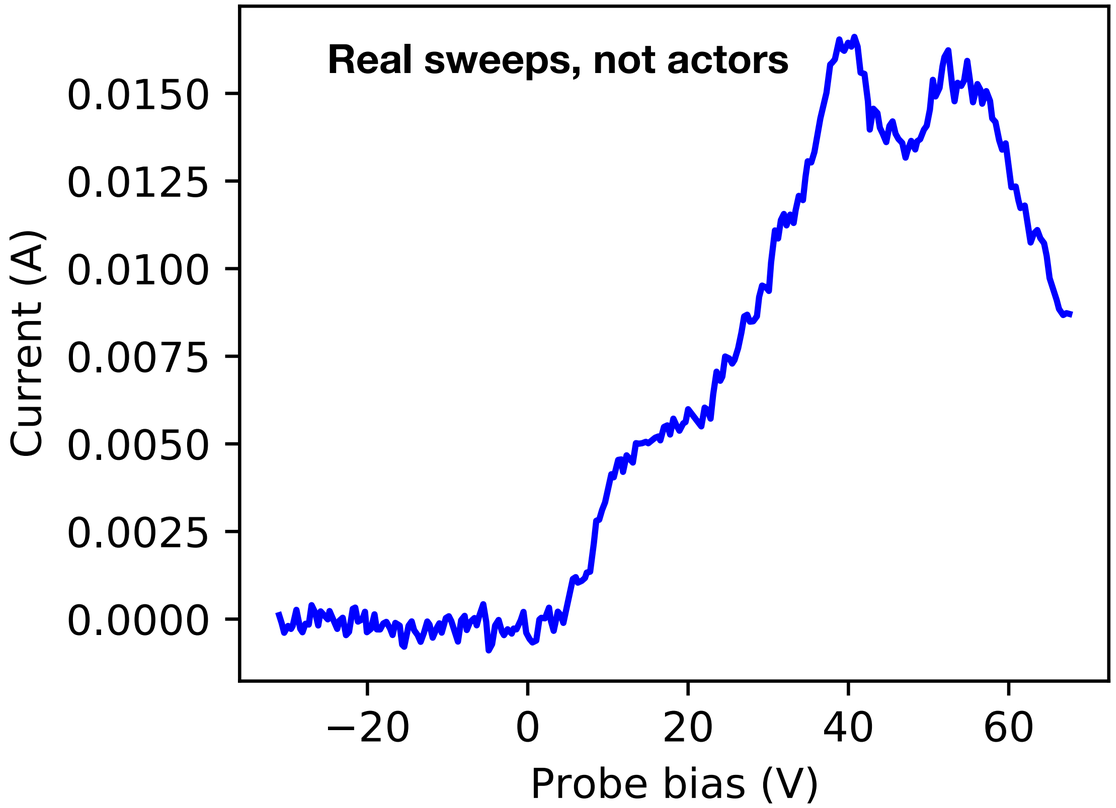

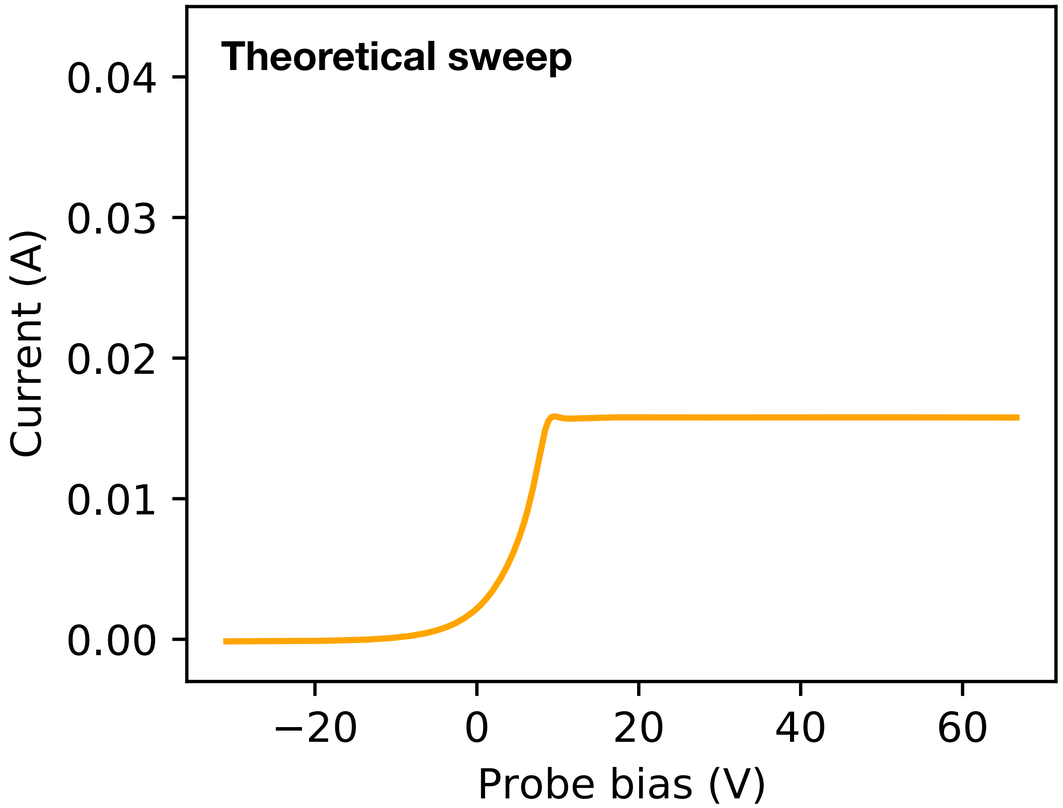

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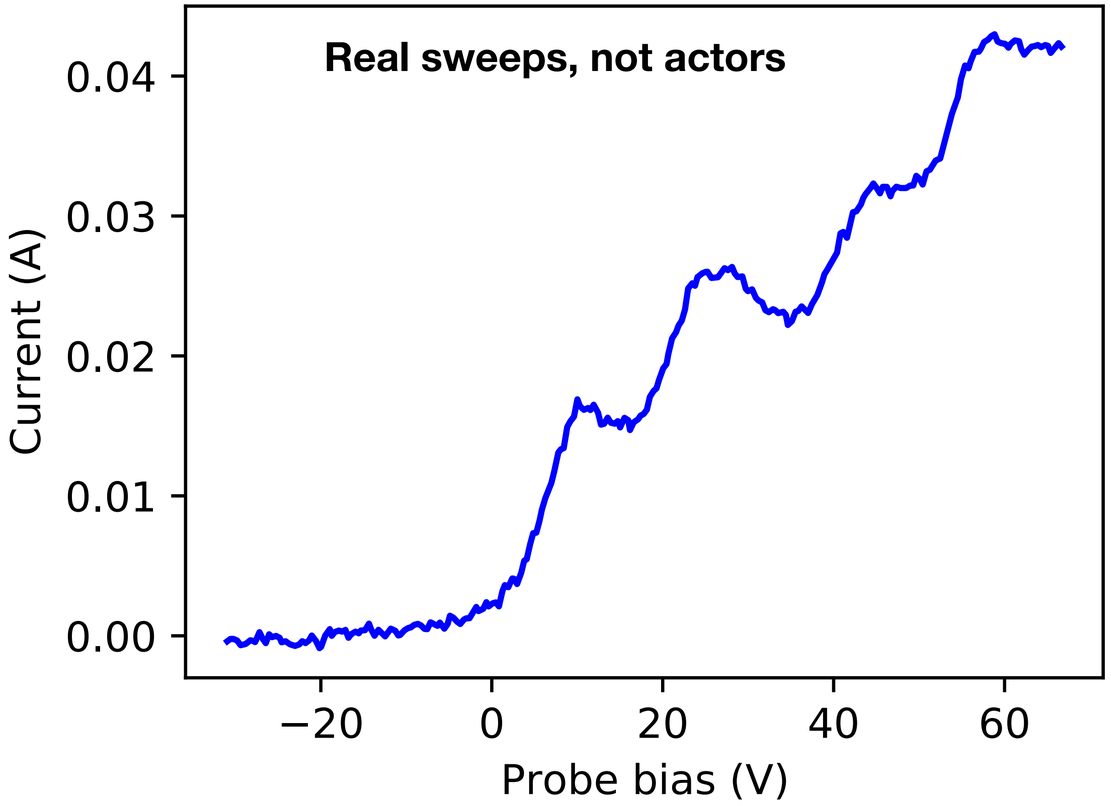

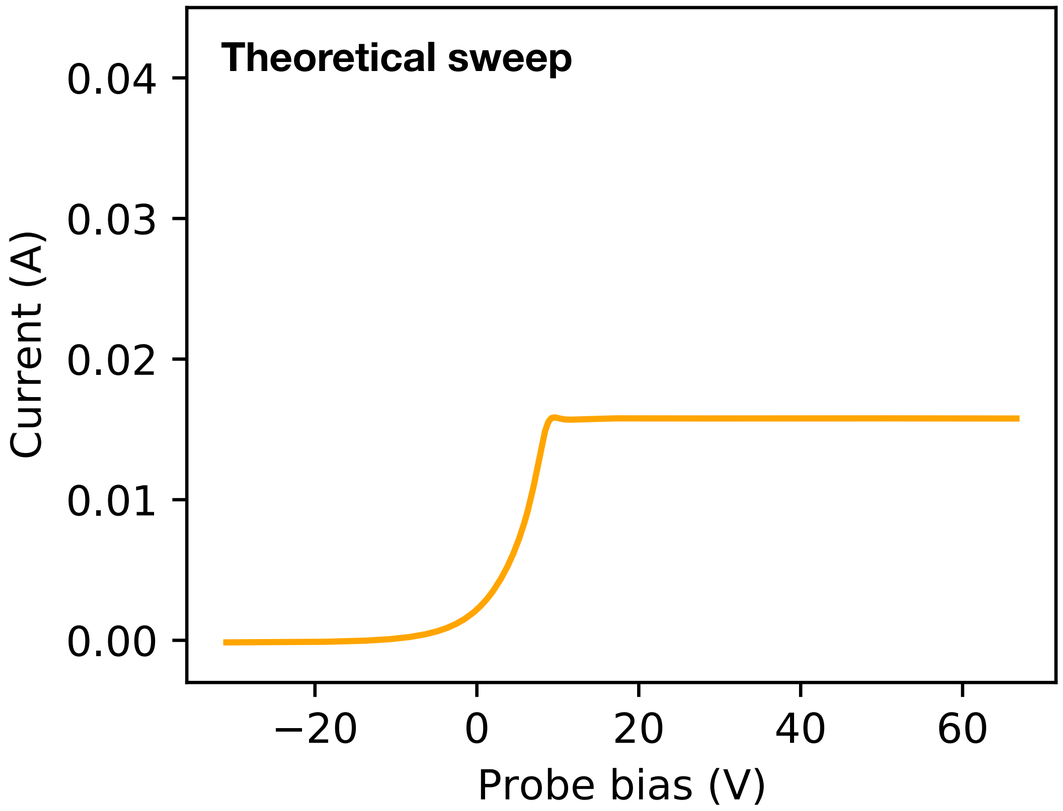

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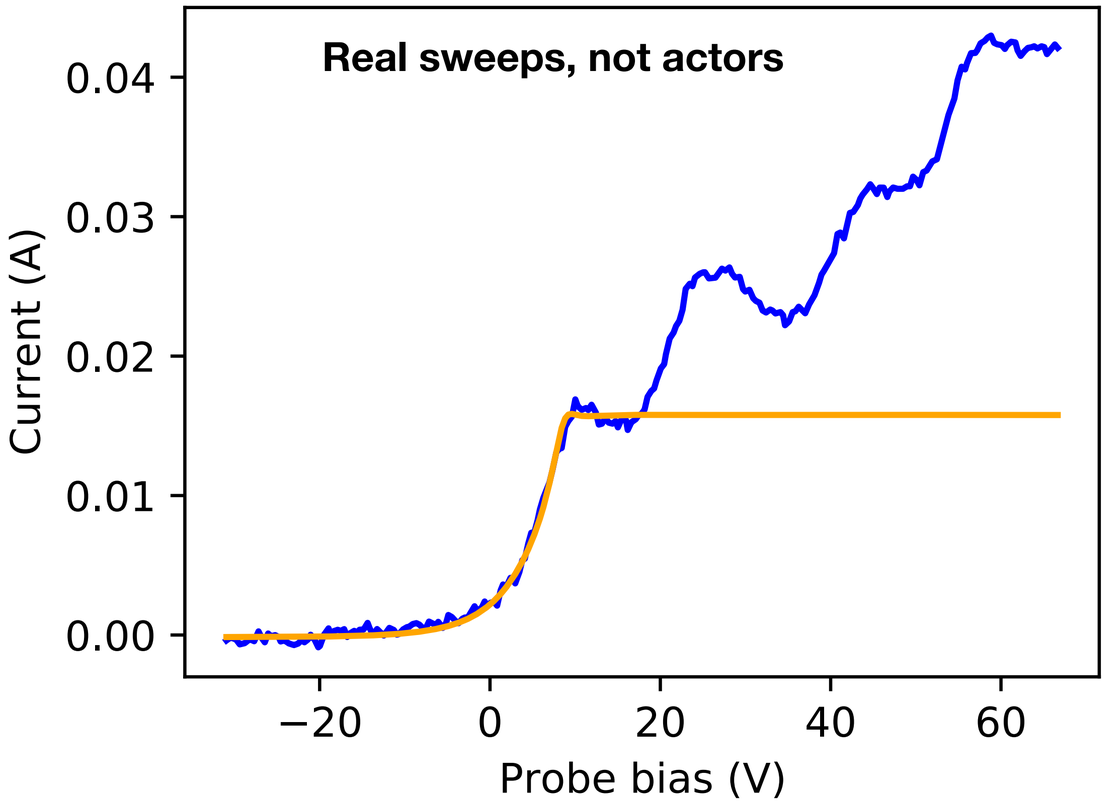

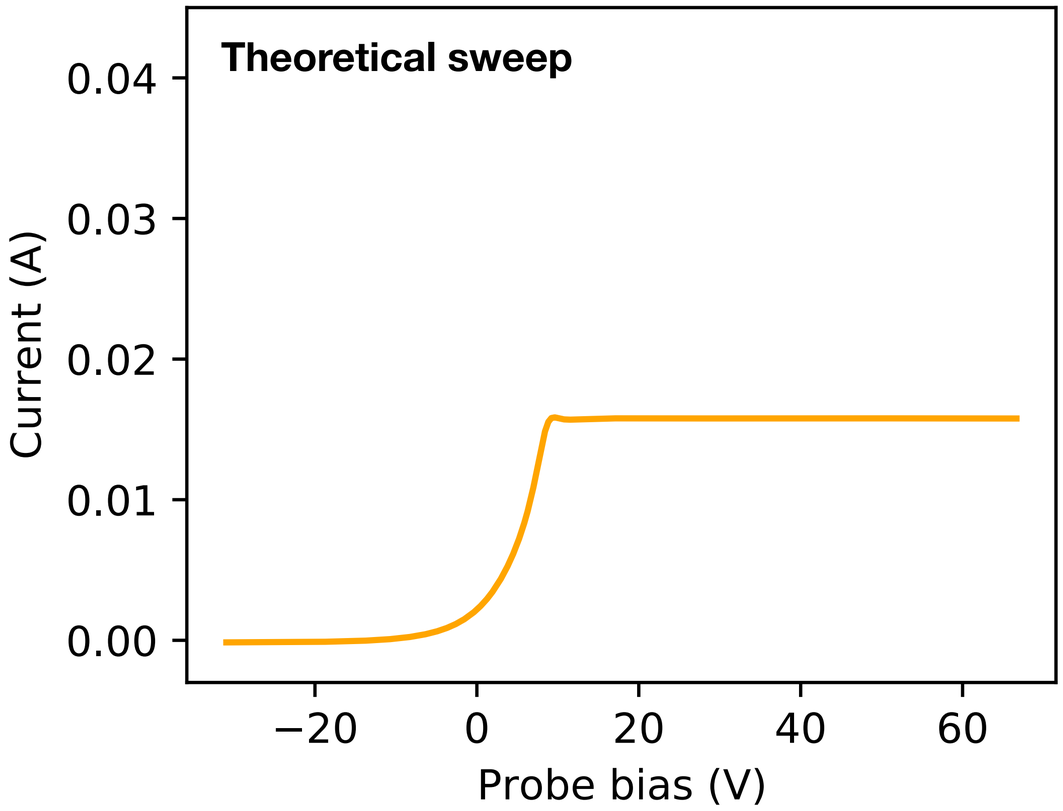

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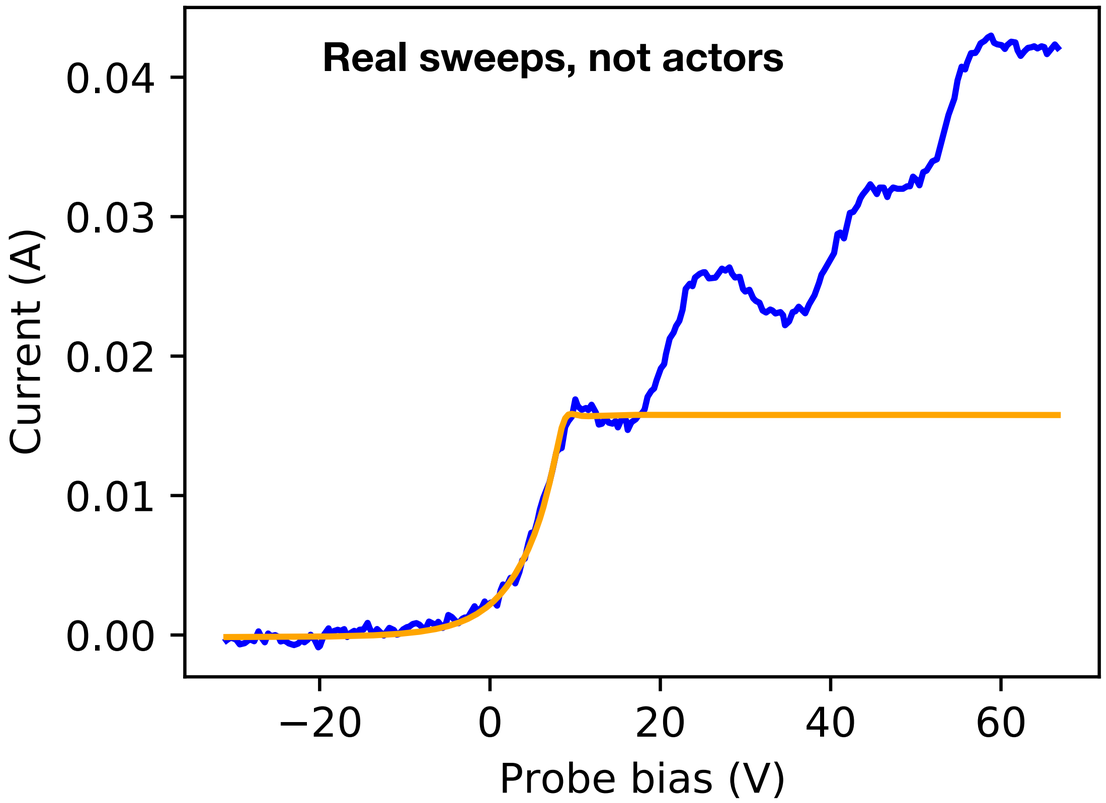
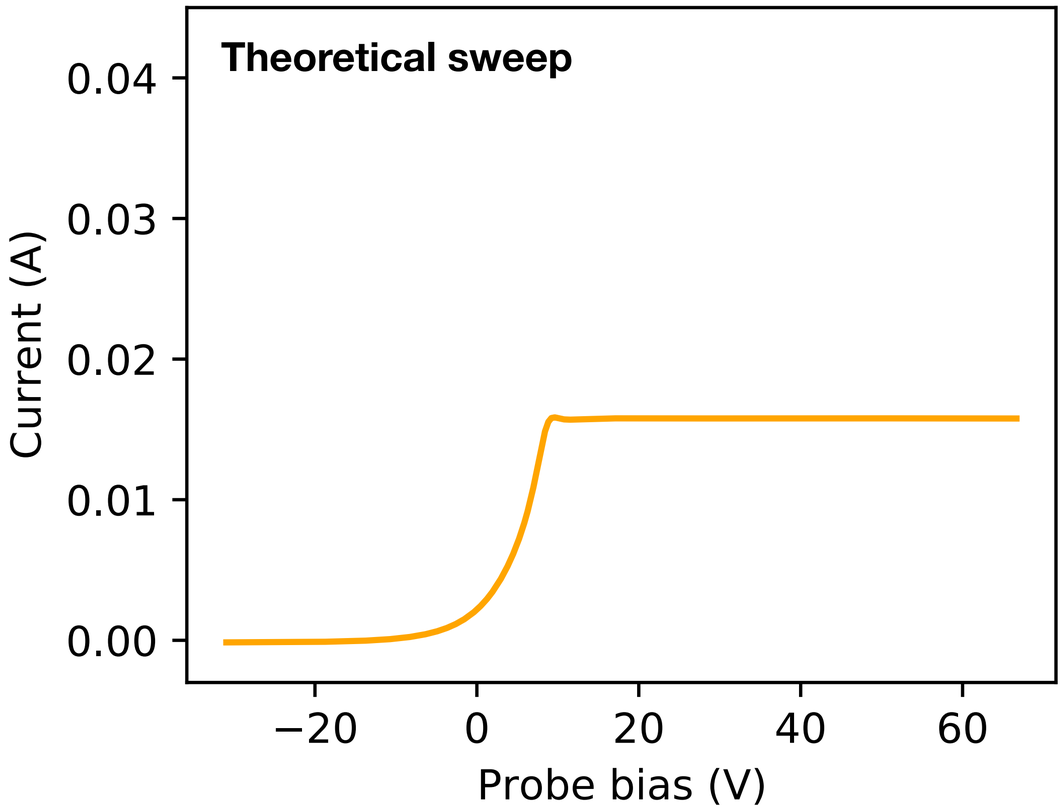
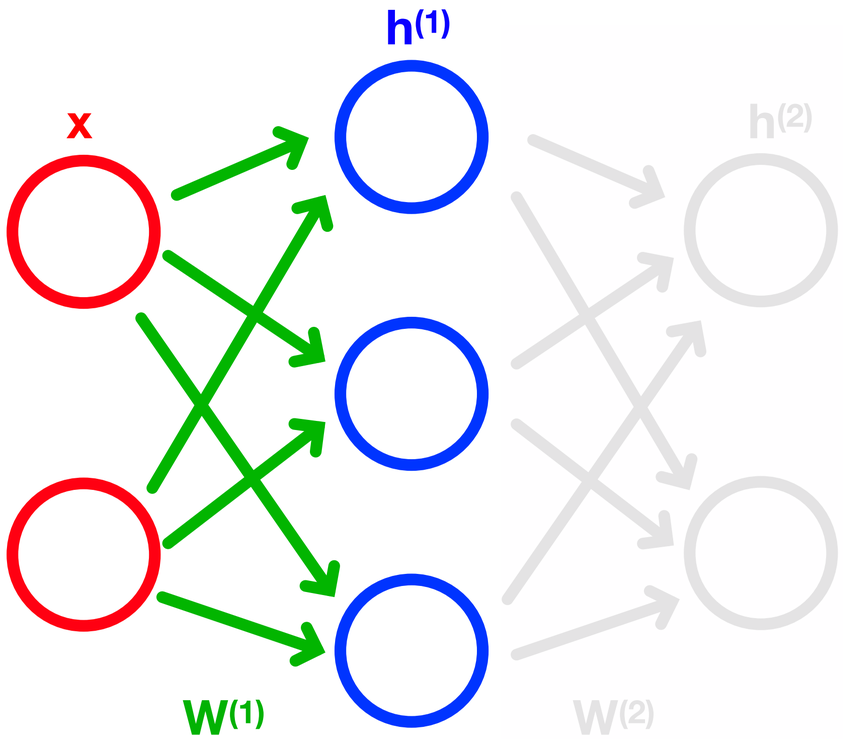




- Lots of turbulence / fluctuations past 25 cm
- Routines that work for one parameter range will break for others

Performing this fitting task with machine learning (neural nets)



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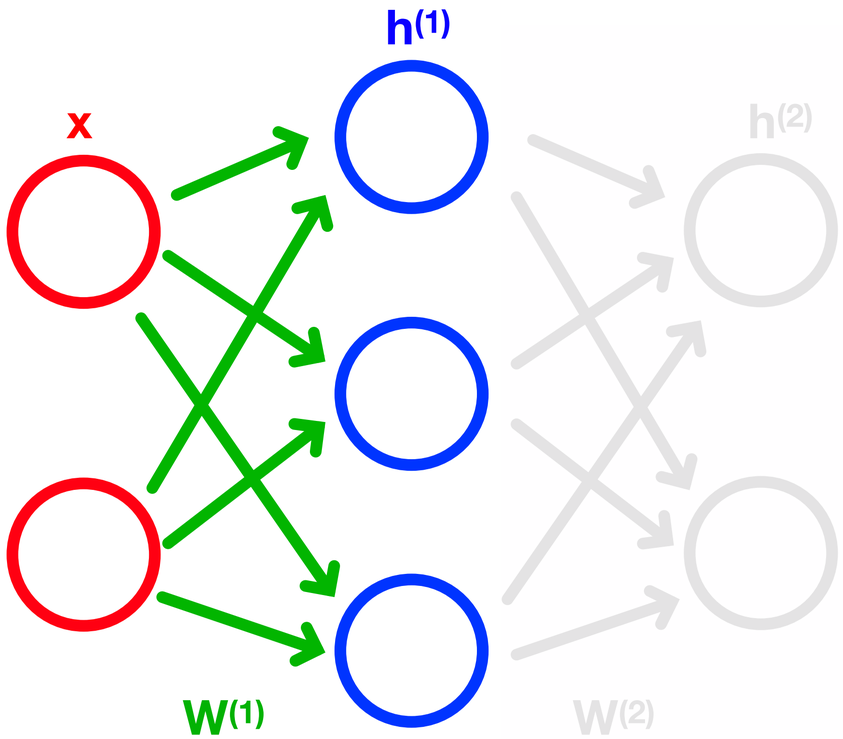

$$h^{(1)} = g^{(1)}\left(W^{(1)T}x + b^{(1)}\right)$$

activation

nonlinear function

weights

inputs

bias

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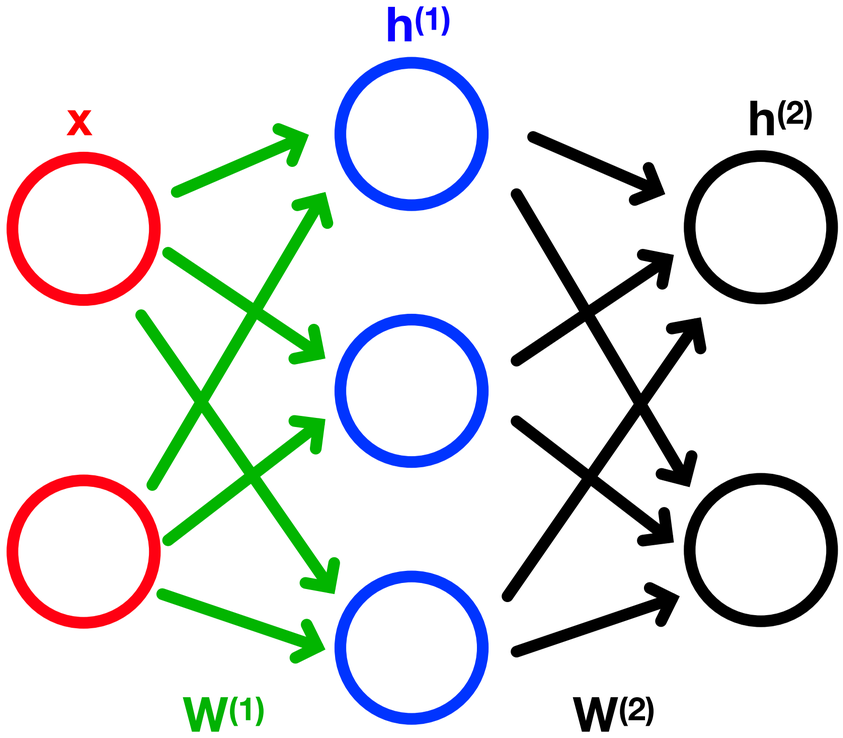

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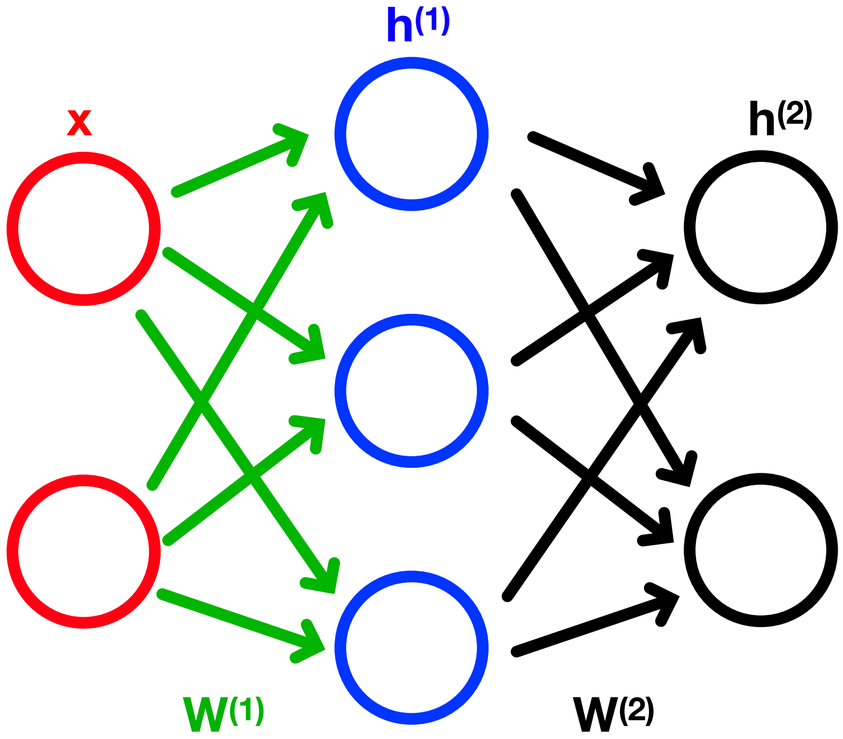

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activation — nonlinear function — weights — inputs — bias

^ can learn any function

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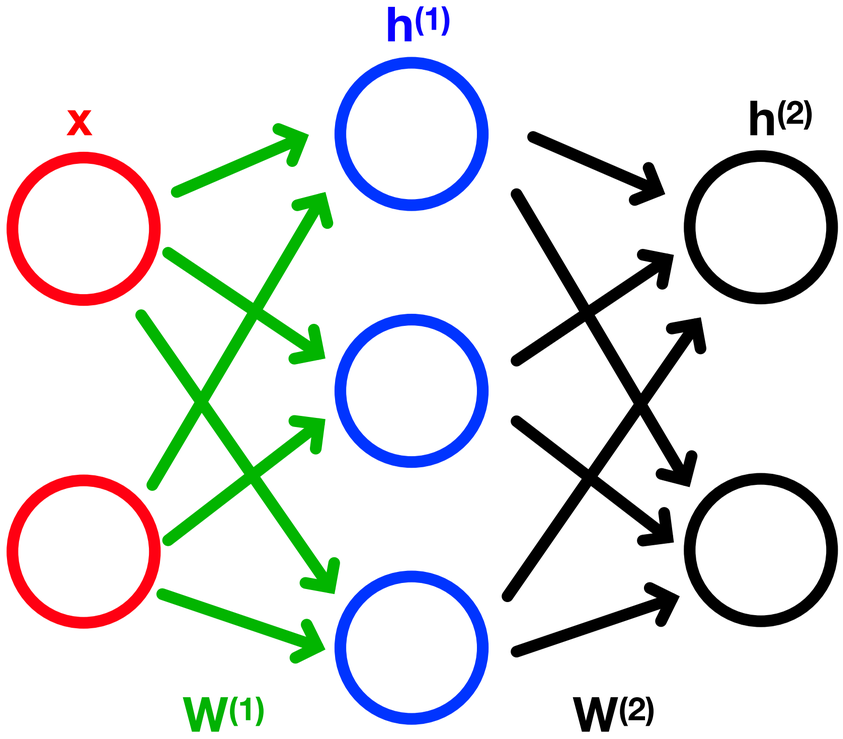

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(Deep Learning by Ian Goodfellow)

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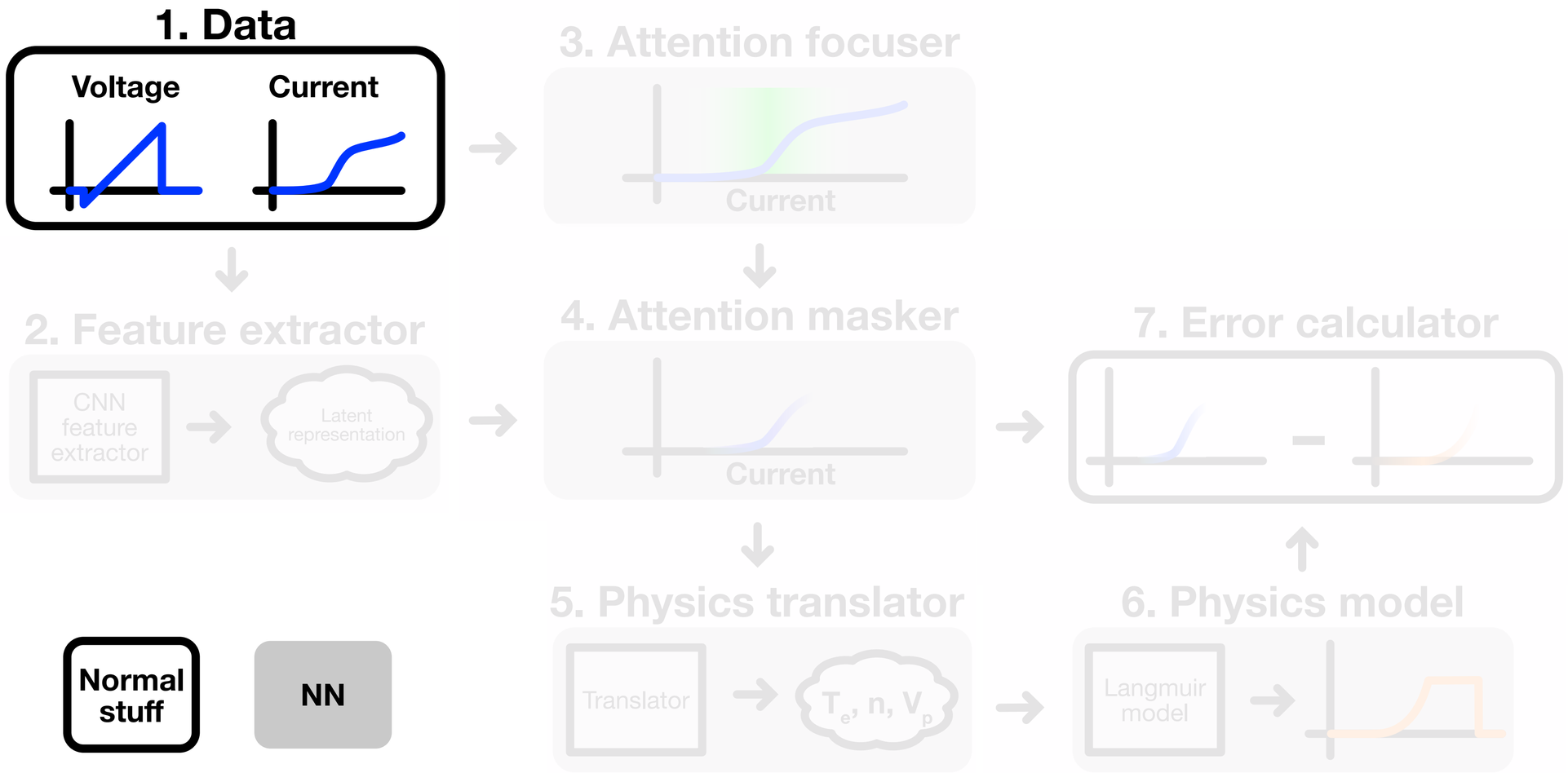

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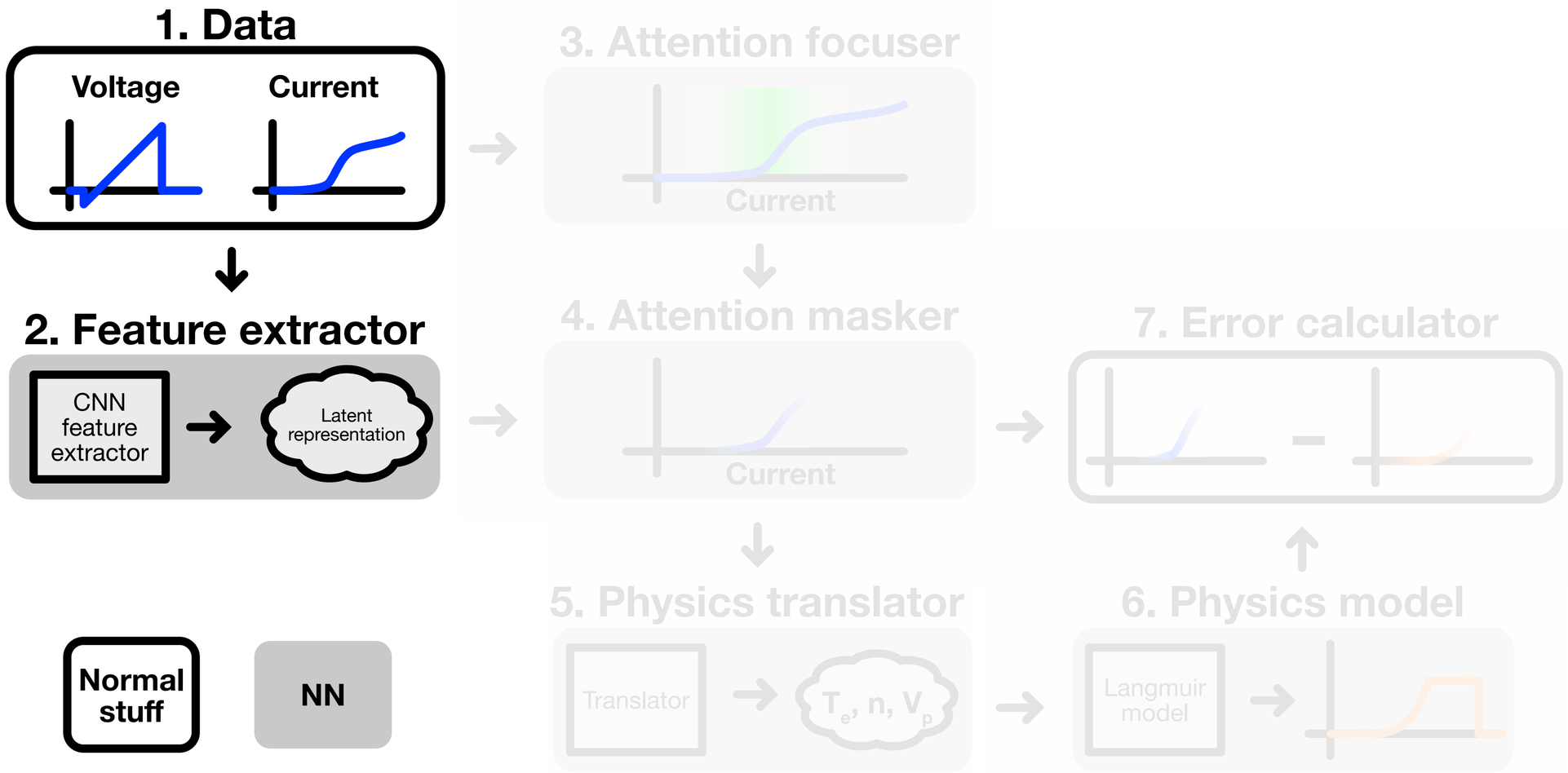

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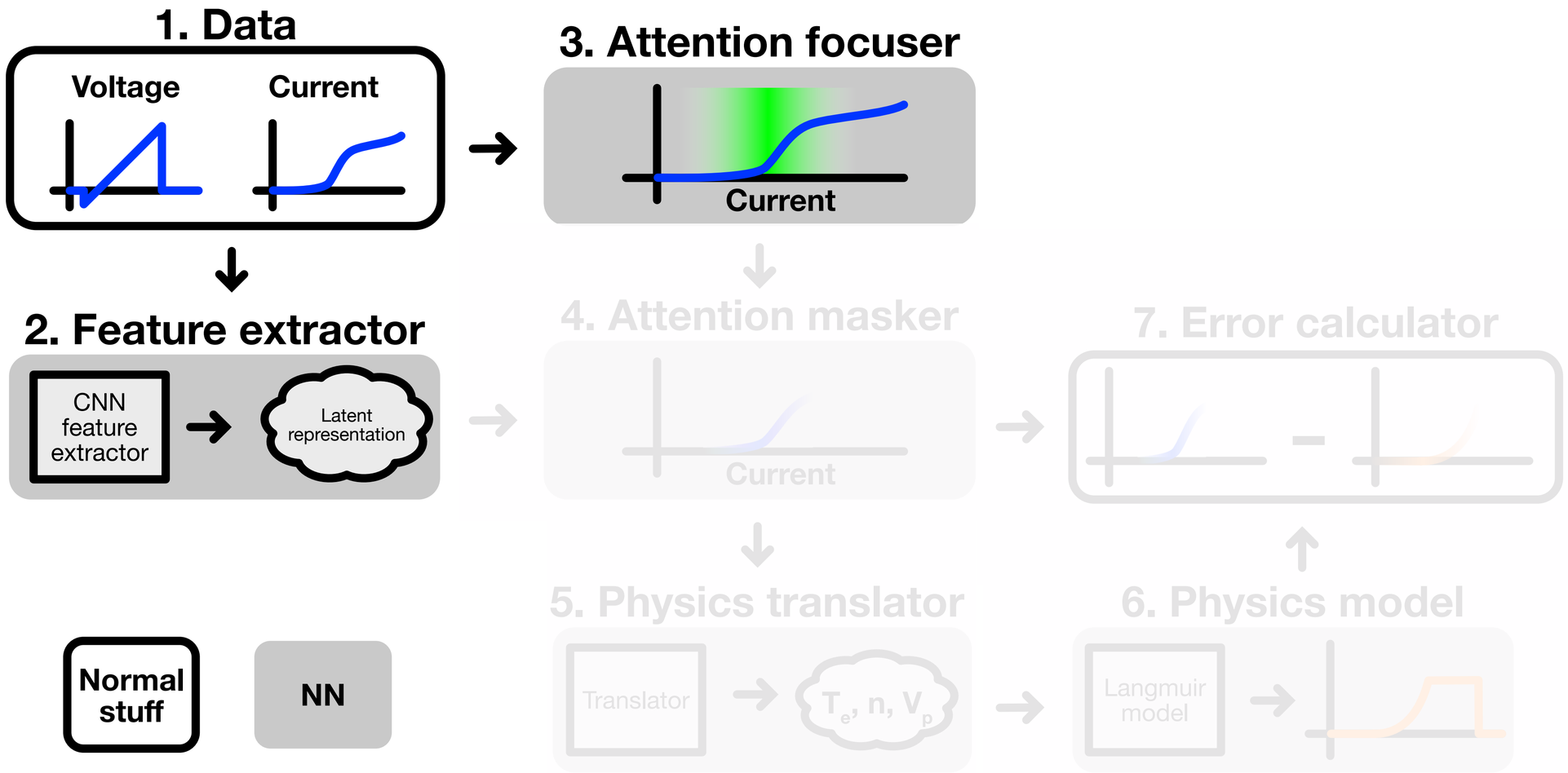

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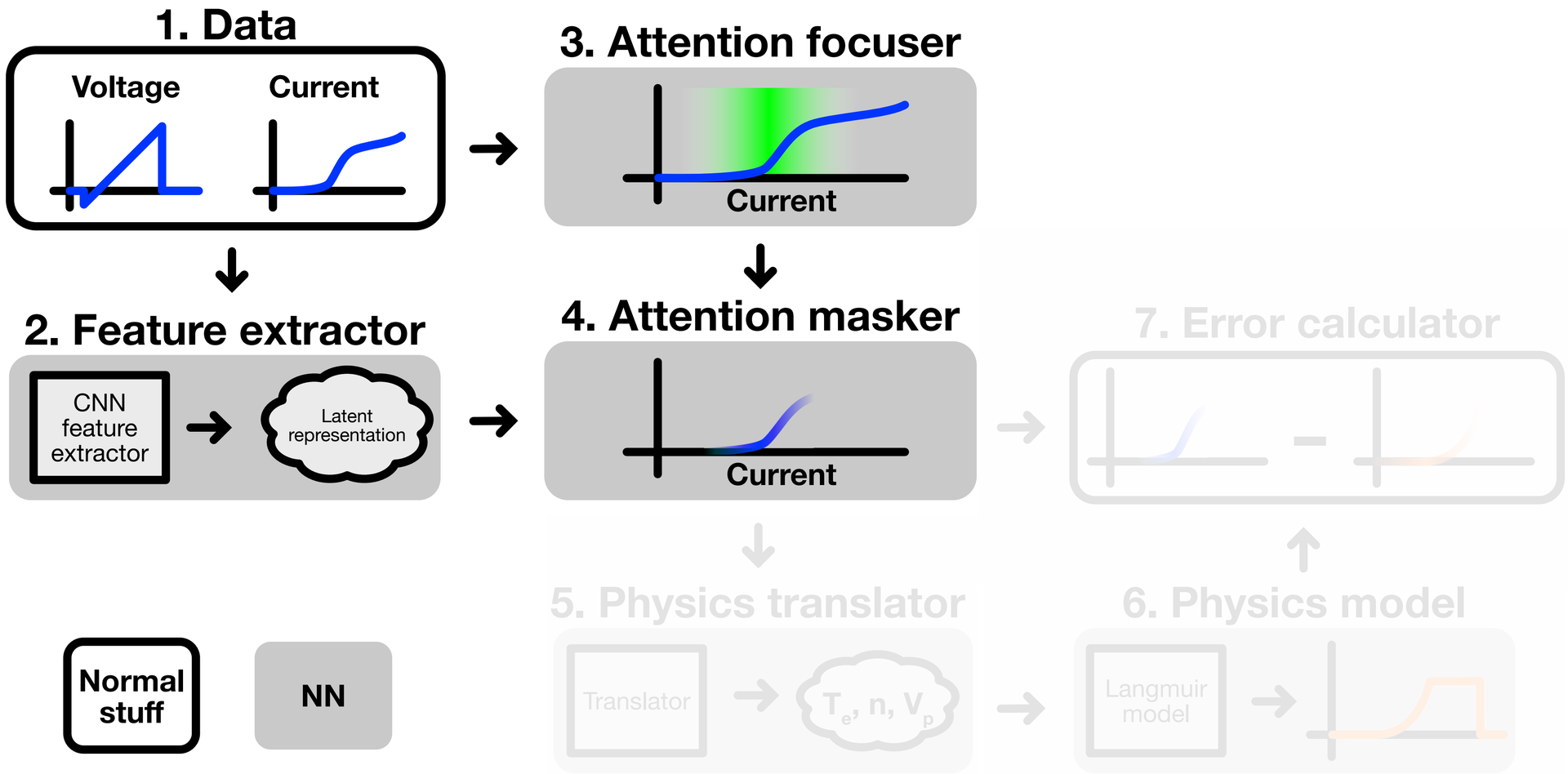

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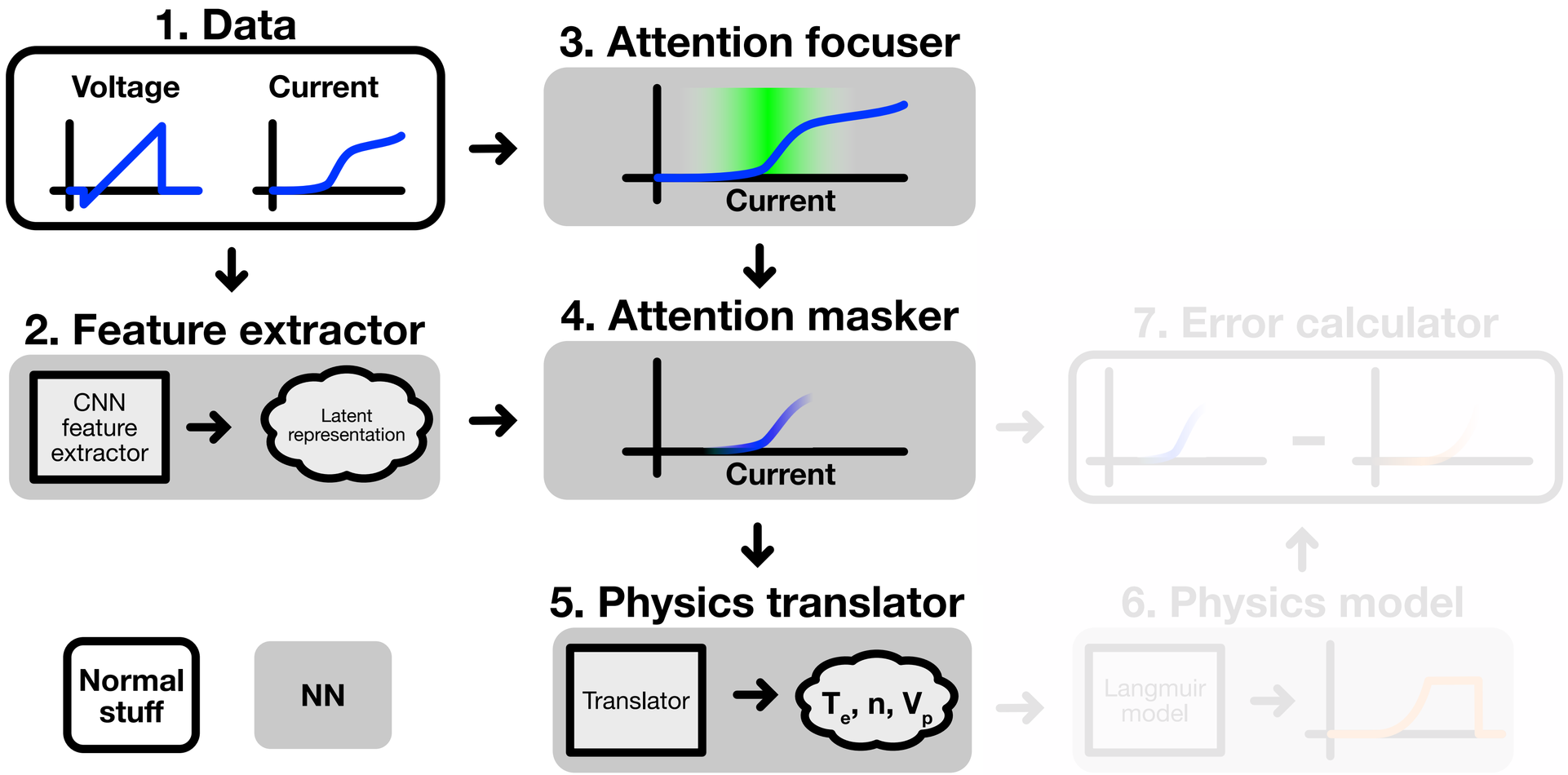

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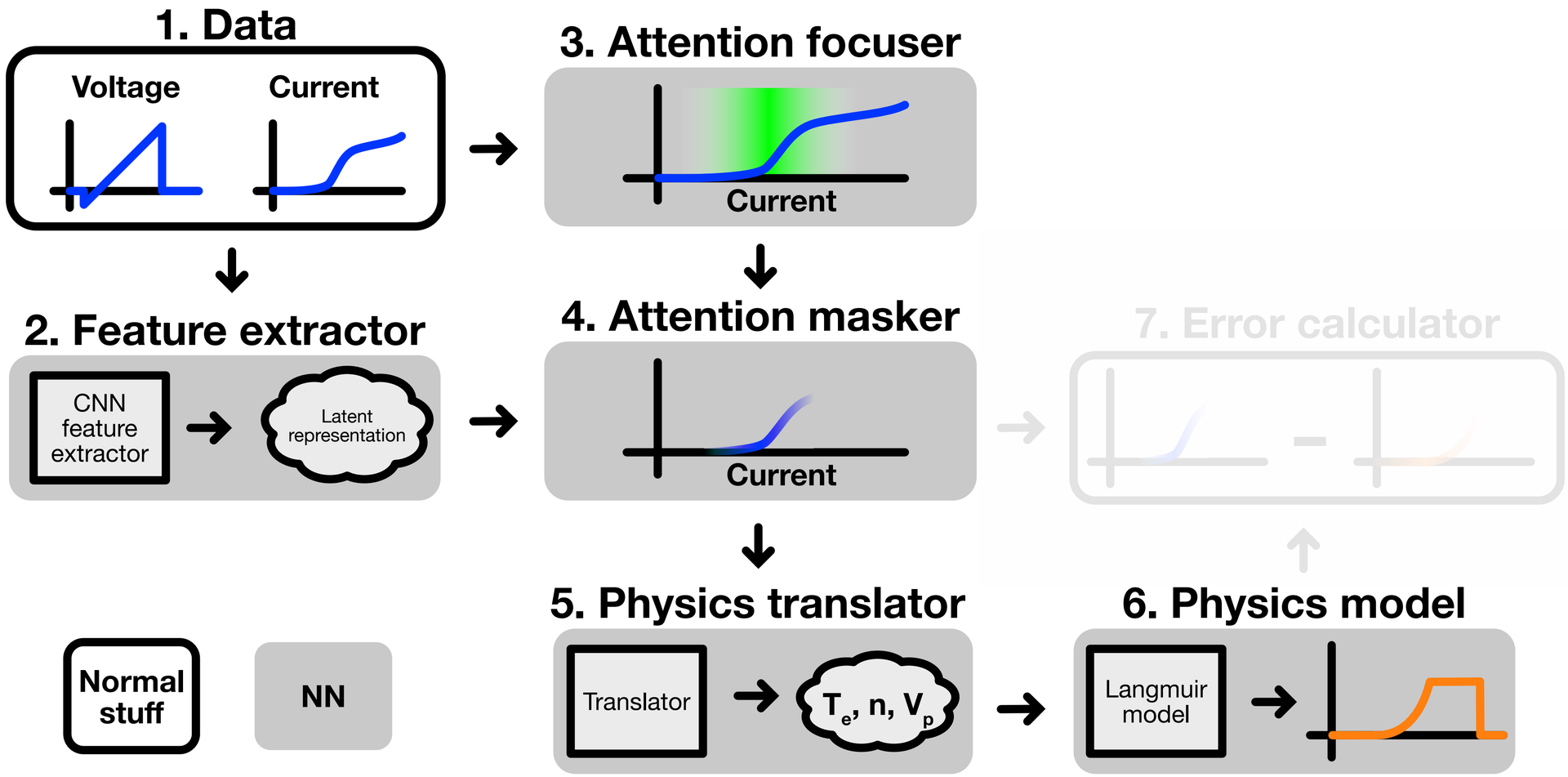

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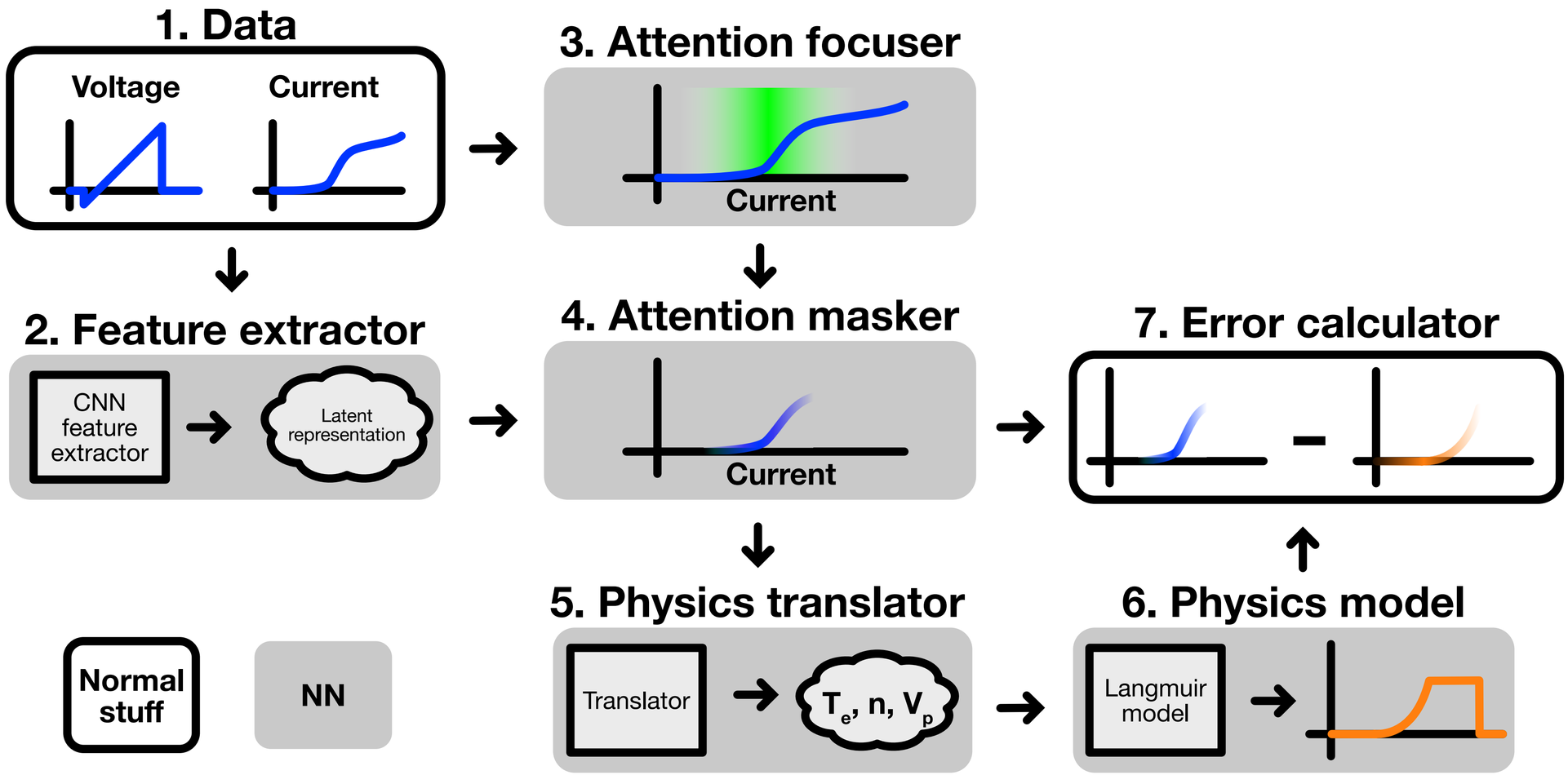

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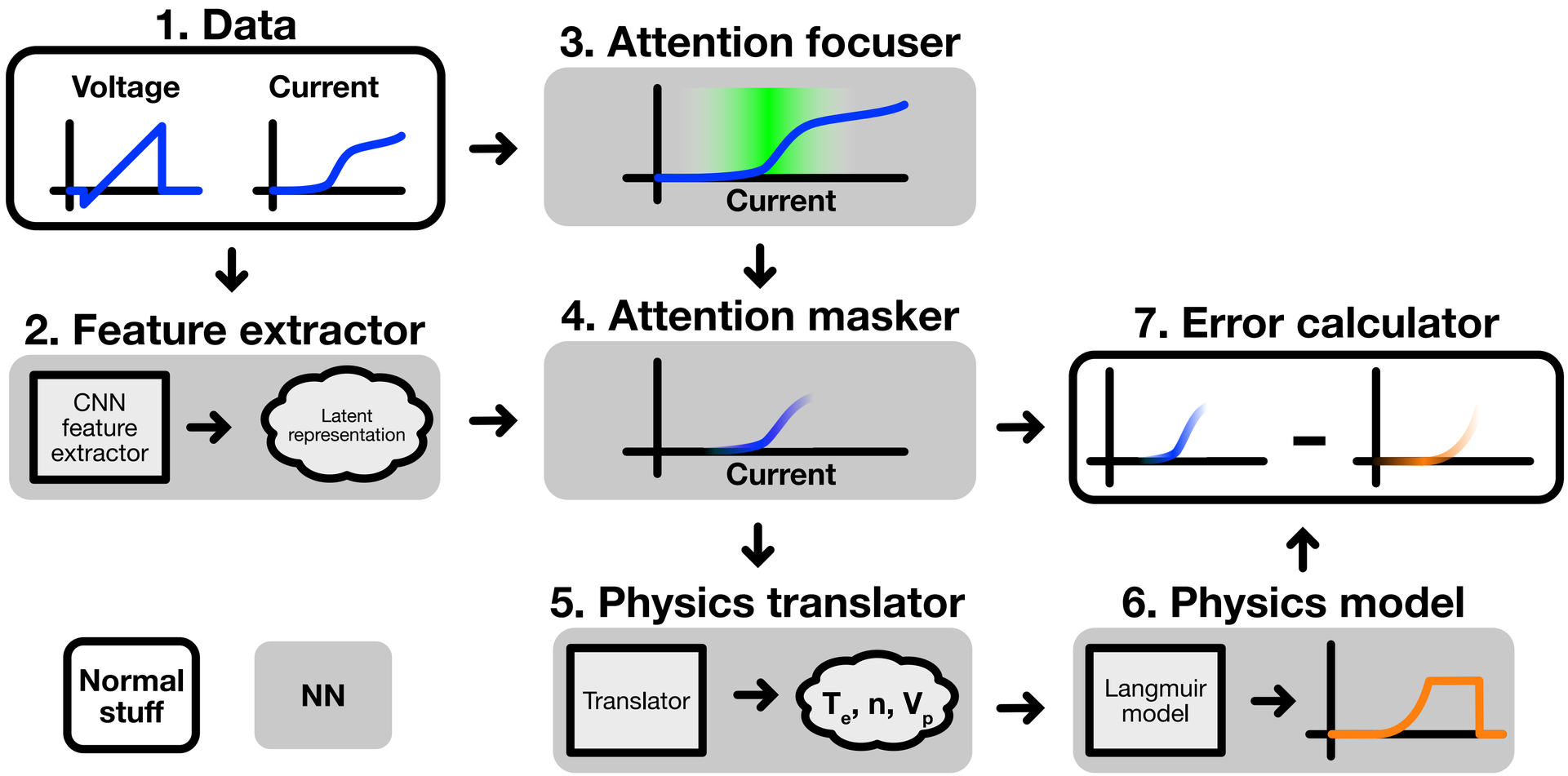

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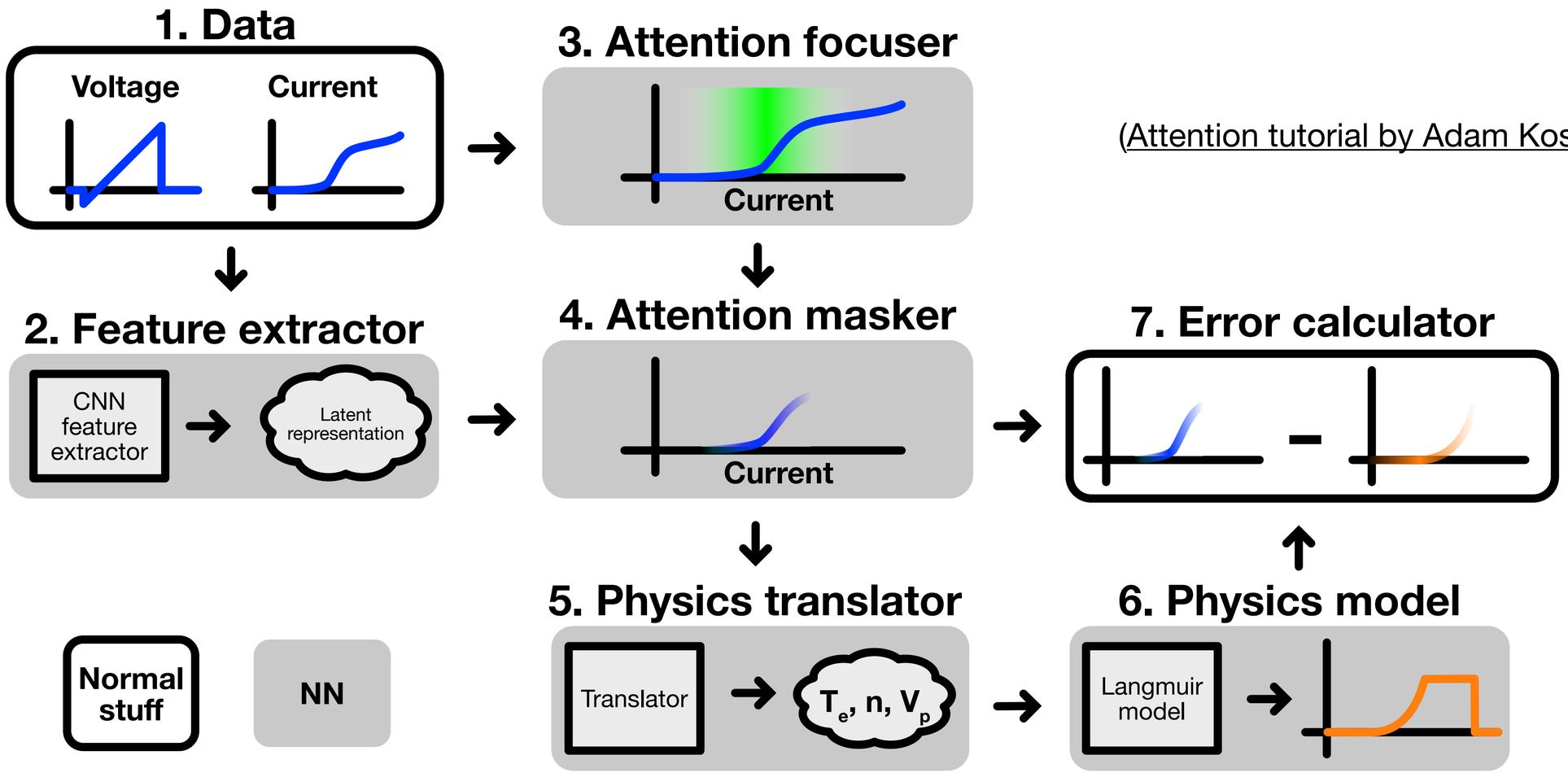

(Attention tutorial by Adam Kosiorek)

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Performance is decent (with Maxwellian distributions)

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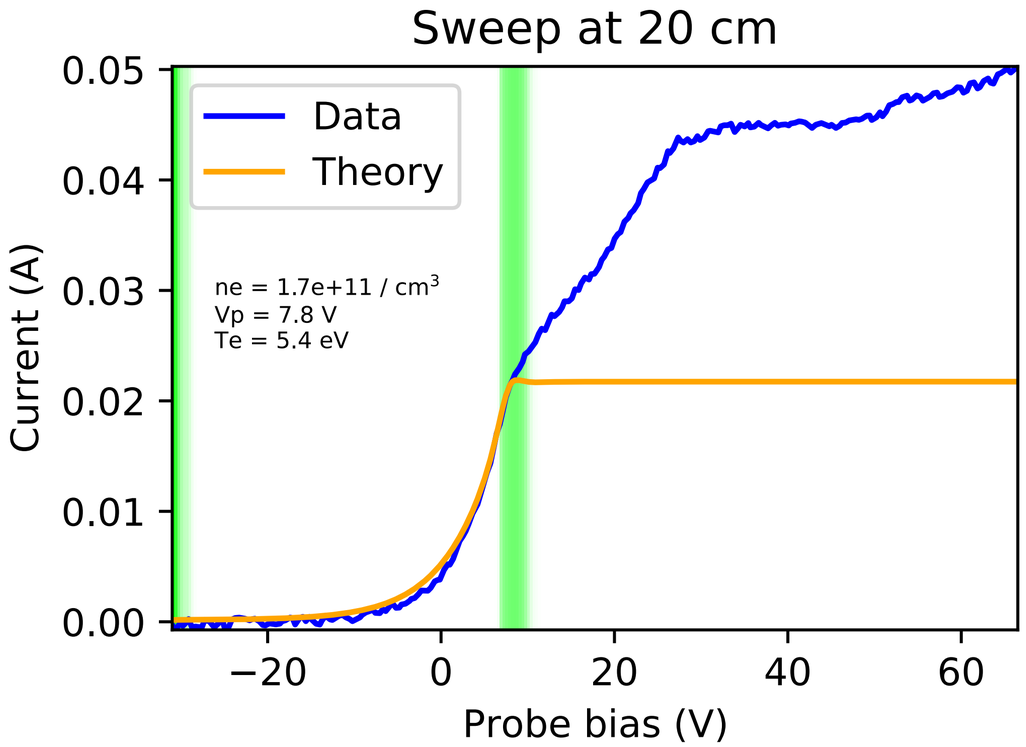

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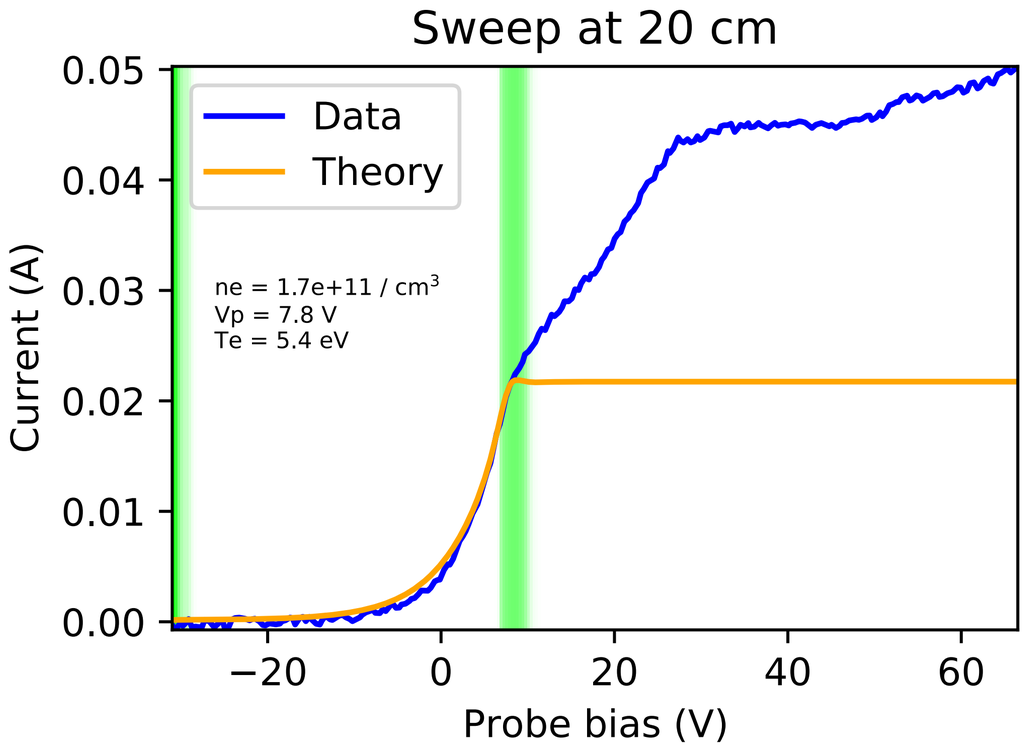

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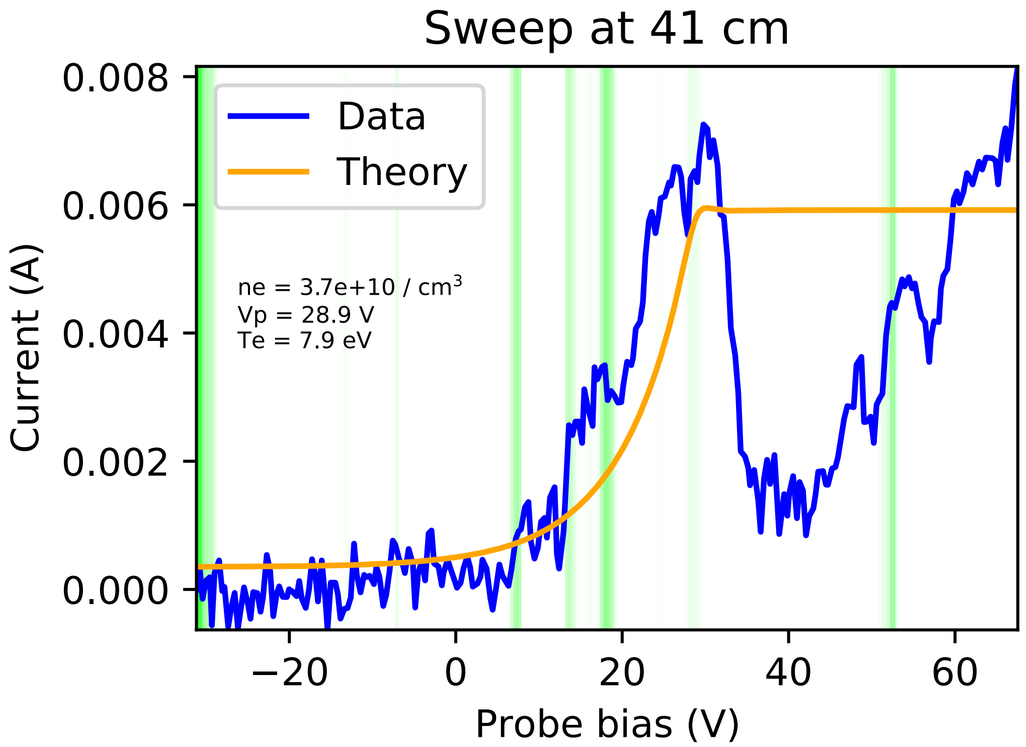

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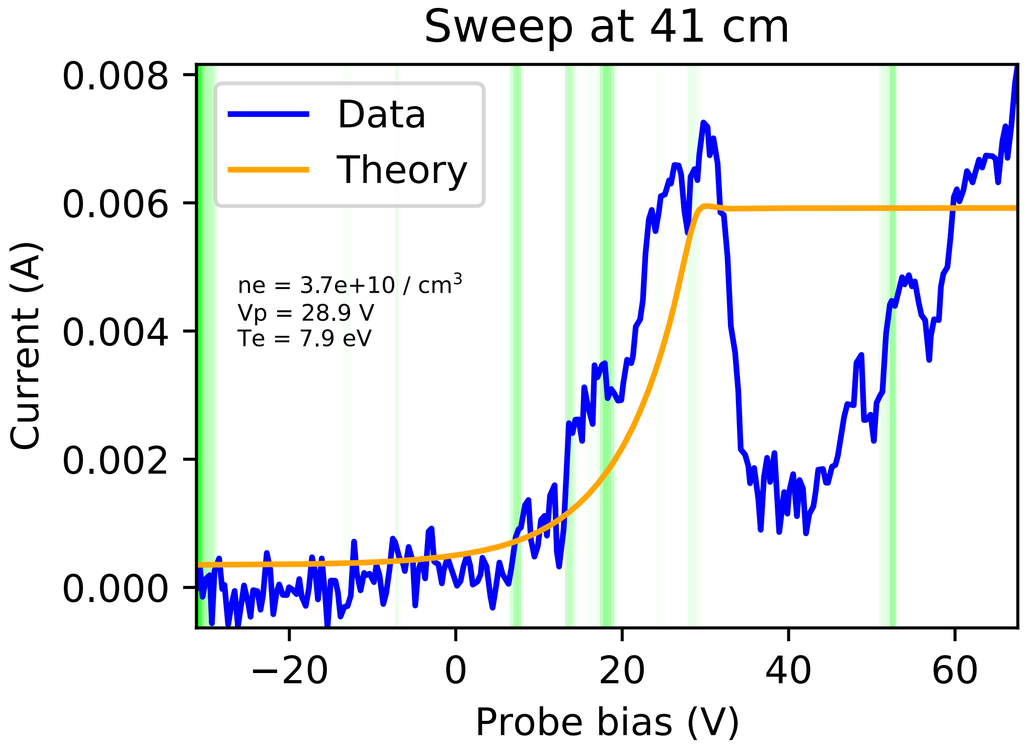

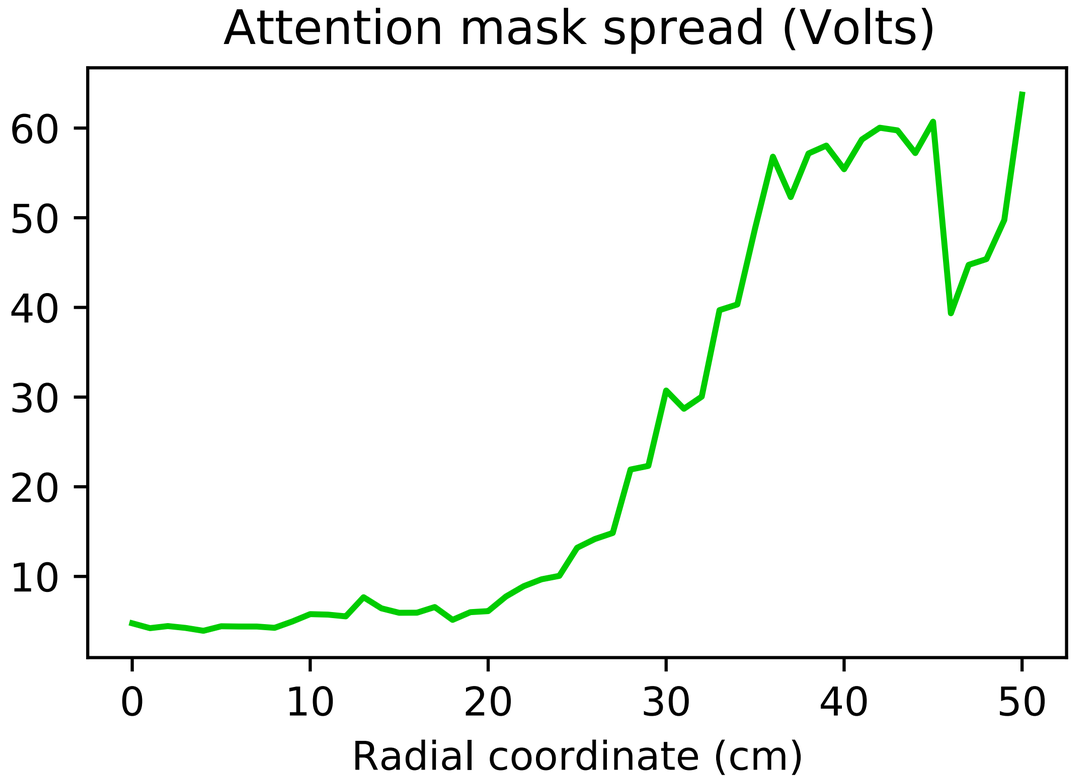

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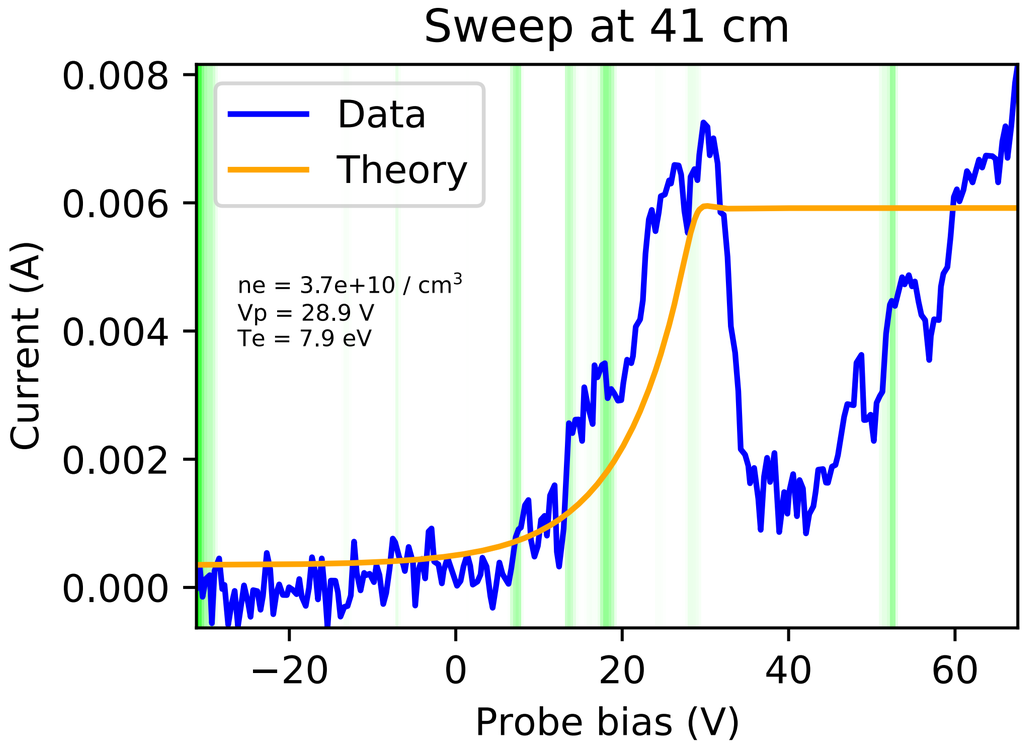

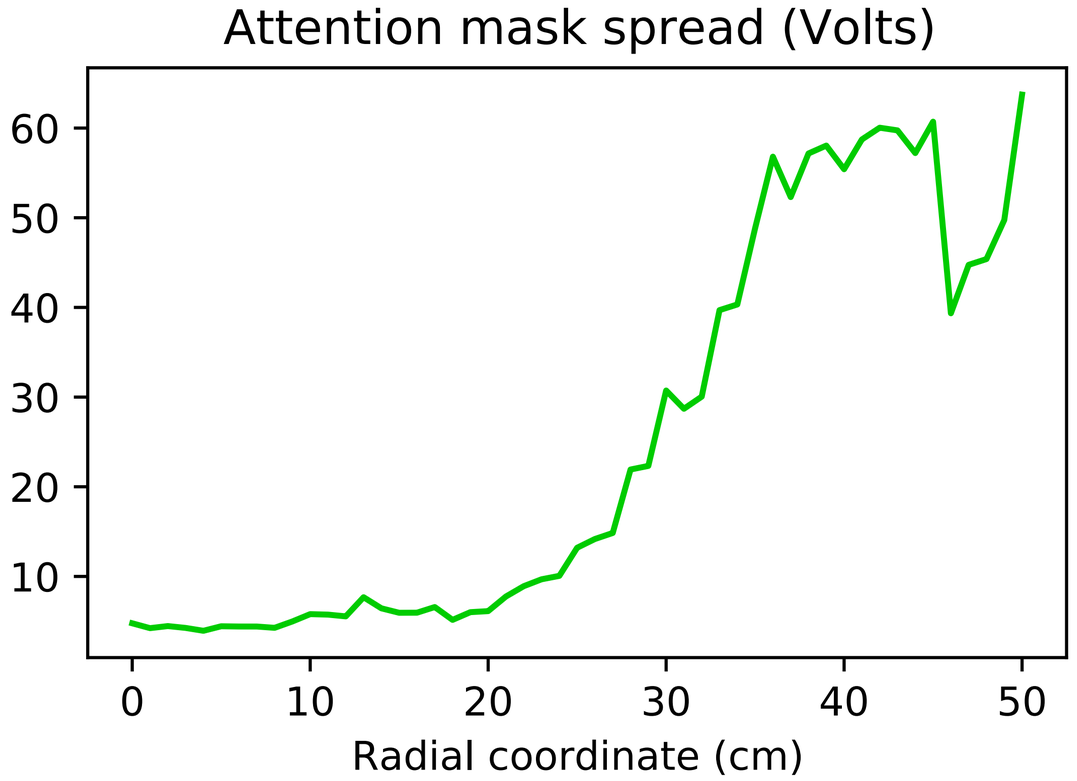

- Attention is like a learned window

- Get an uncertainty measure for free
- Can’t do magic

All the code, trained models, a bit of data can be found on Github

- https://github.com/physicistphil/sweep-langmuir-ml
- Requires TensorFlow ~2.2
- Train + build your own models (please contribute!)
- Will probably be rolled into bapsflib

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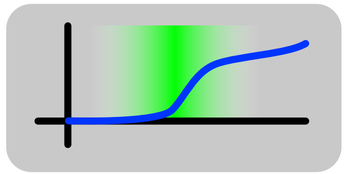
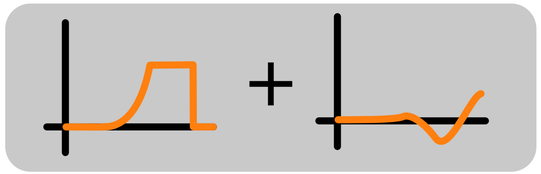


2. Discrepancy-based



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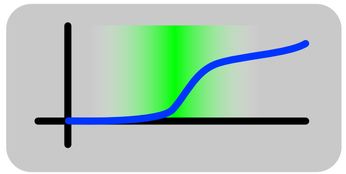

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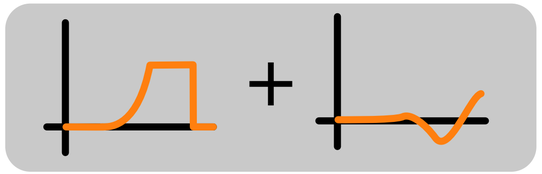

Future plans

- Build non-Maxwellian model
- Fine tuning the models, evaluate cross-device performance
- Find contributors!

Please enjoy the data-driven diagnostics revolution responsibly

- We use Langmuir sweeps to estimate T_e and other quantities
- Neural networks help us estimate quantities in noisier and (soon) non-Maxwellian regimes
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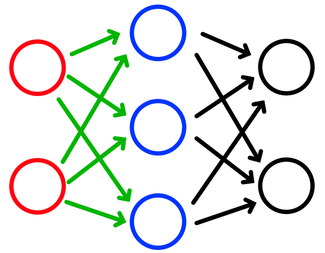

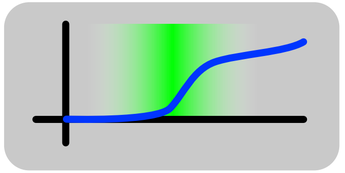

Github link

phil@physics.ucla.edu

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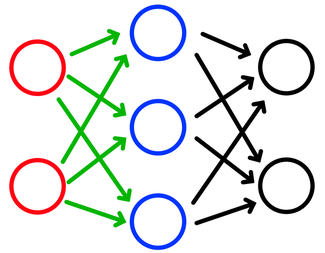

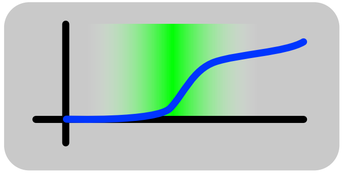

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