Langmuir probe data interpretation with a neural network

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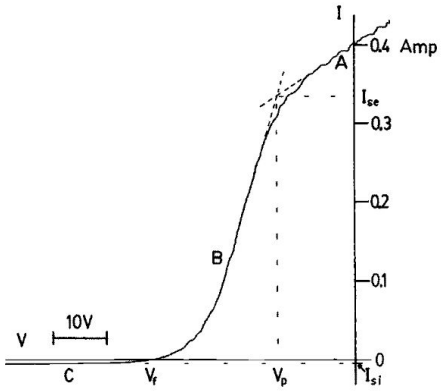
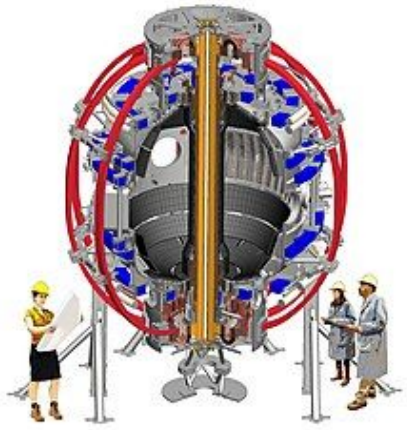
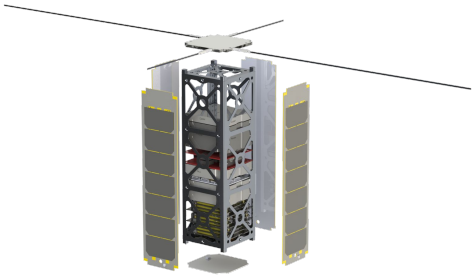
Langmuir Probes & Project Context

- Electrostatic probe, bias voltage swept in time to generate current-voltage characteristic
- Useful for diagnosing plasma temperature, density and other parameters
- **Lots of data**, but Langmuir theory well-understood[1,2]; allows training of neural network
- Theory applicable to wide range of plasmas

Example Langmuir probe trace[1]

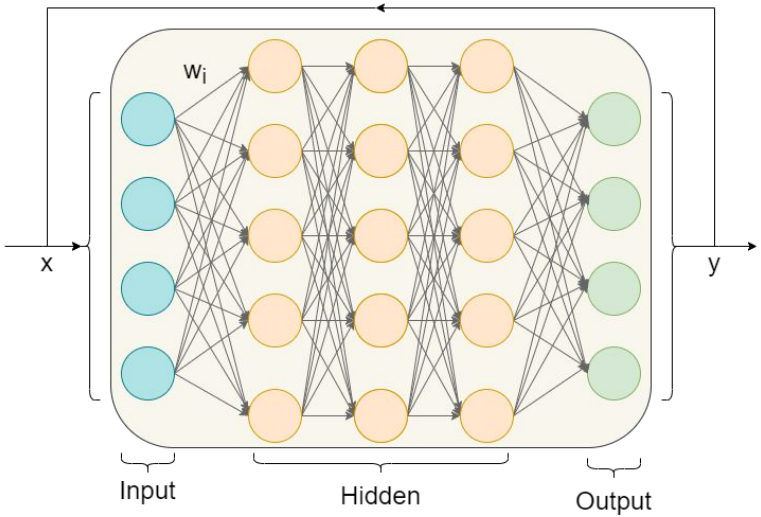




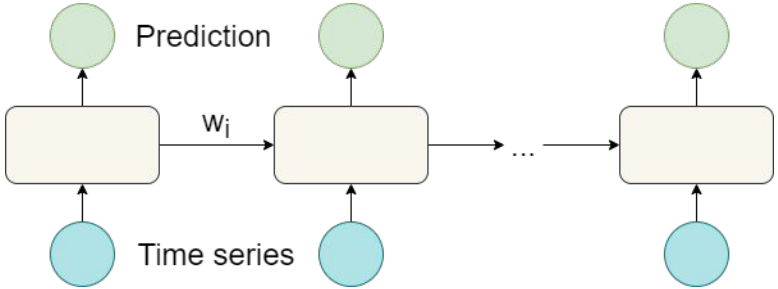


NSTX (left), STF-1 (right)

Neural Networks



Neural Network (NN)

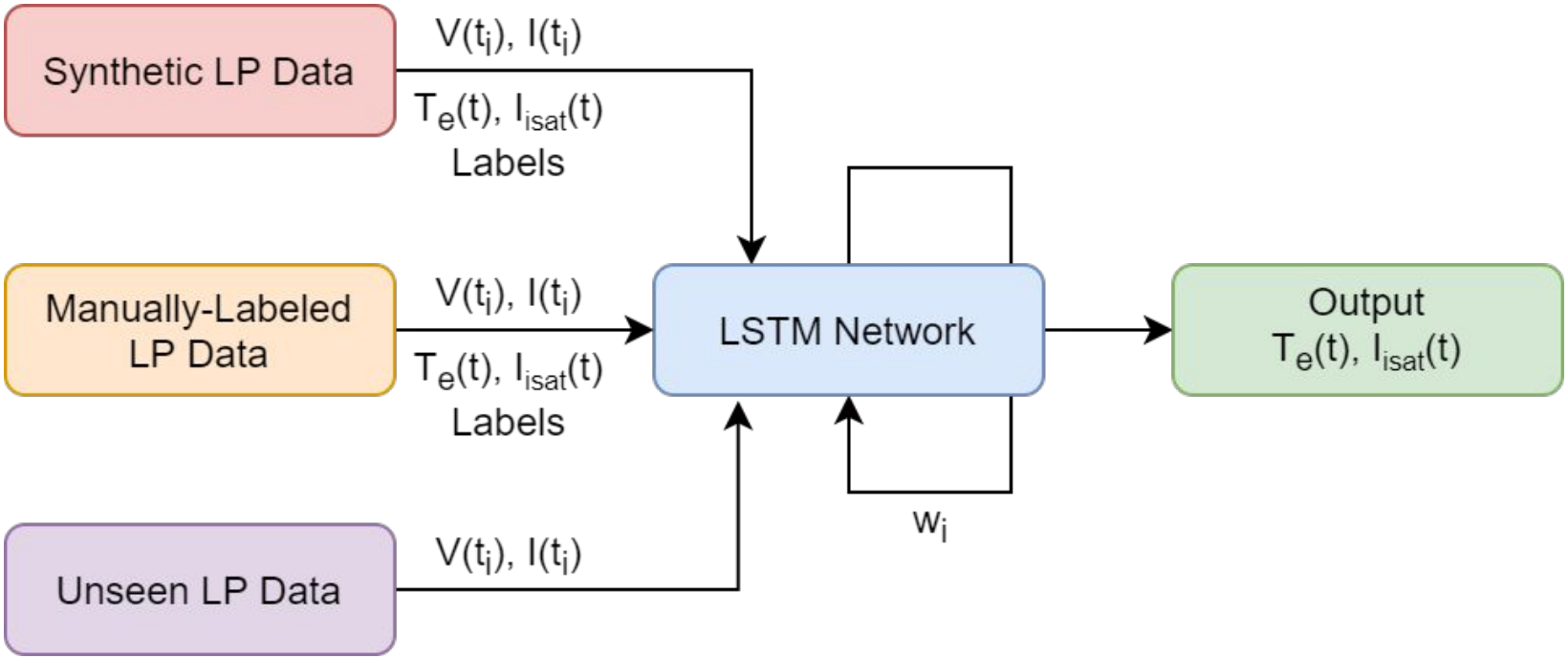


Recurrent NN (RNN)

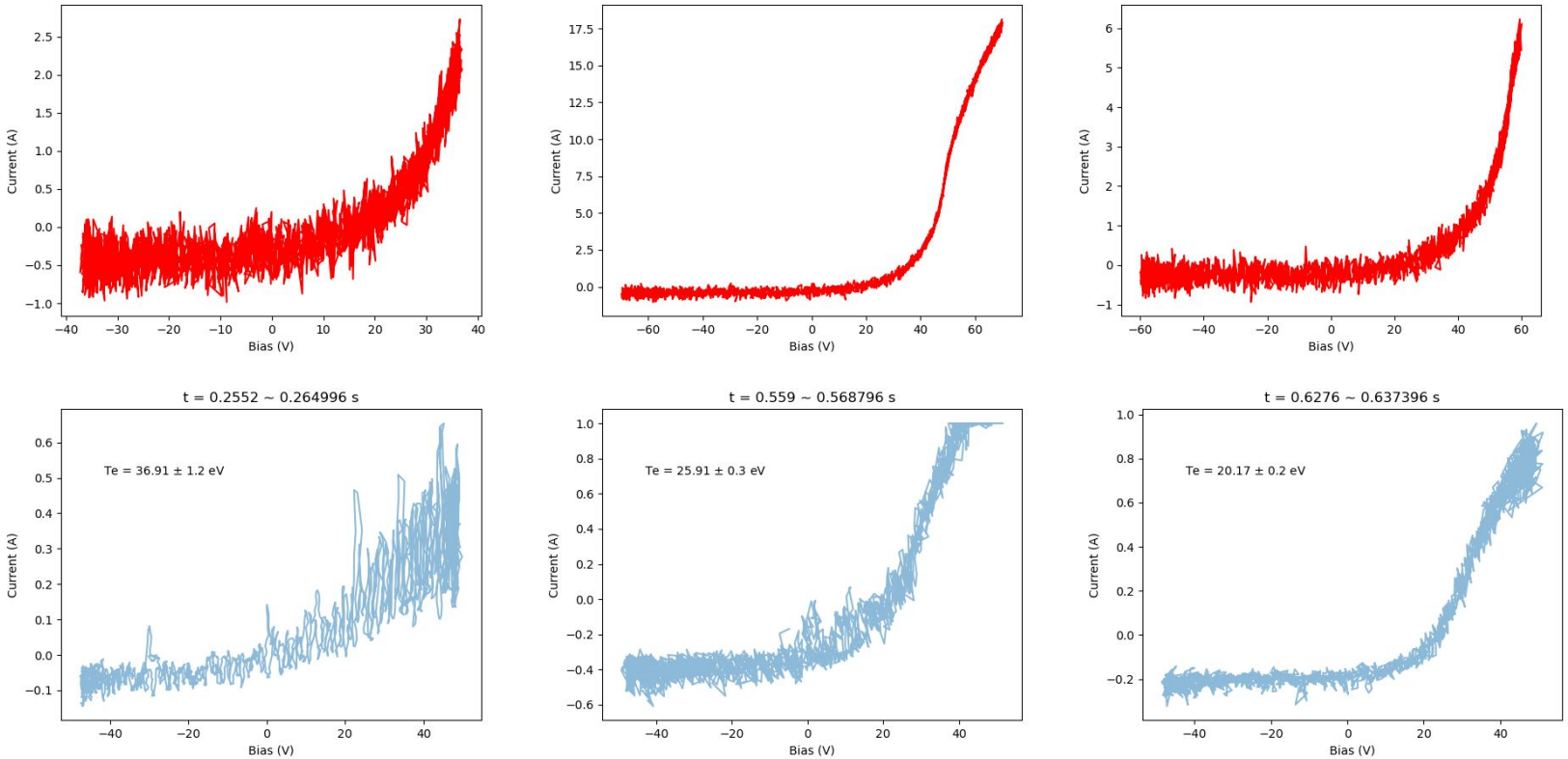
- We use an LSTM[3], one flavor of RNN, in the network
- Tensorflow by Google does a ***lot*** of the heavy lifting

TensorFlow

Program Workflow



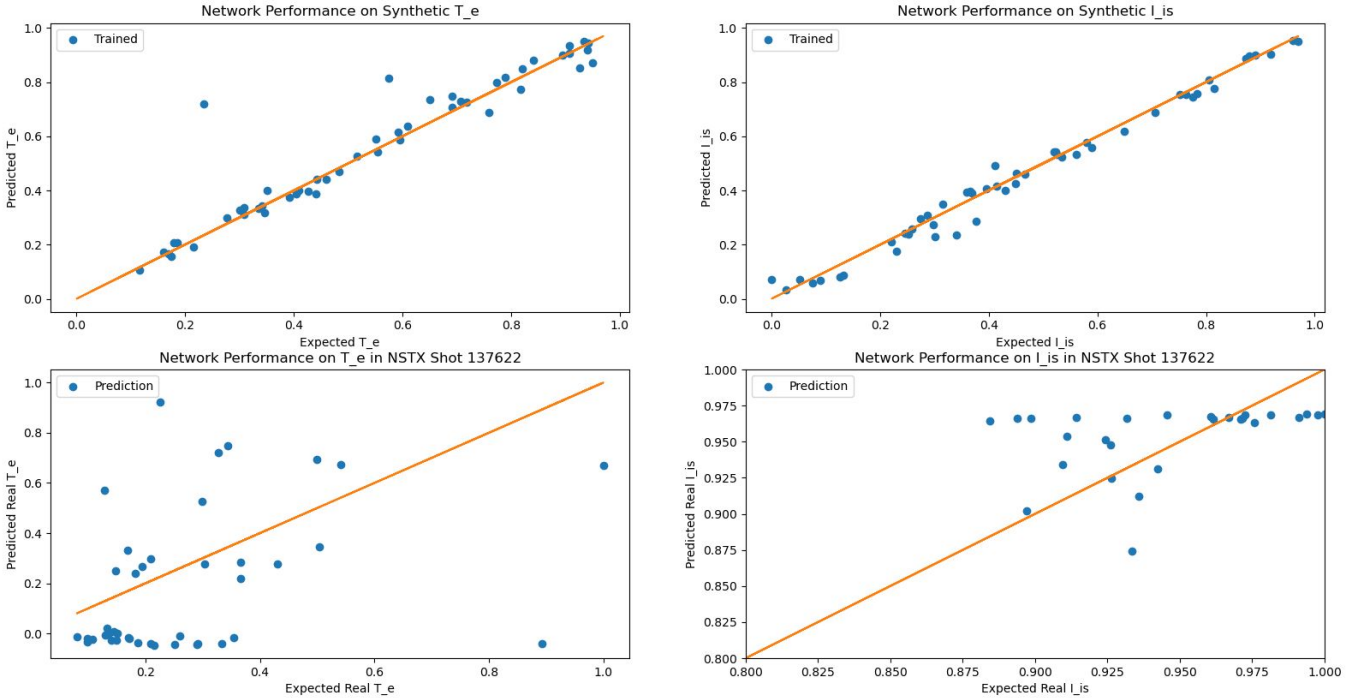
Training on Synthetic Data



Synthetic data (top row) and NSTX data (bottom row)

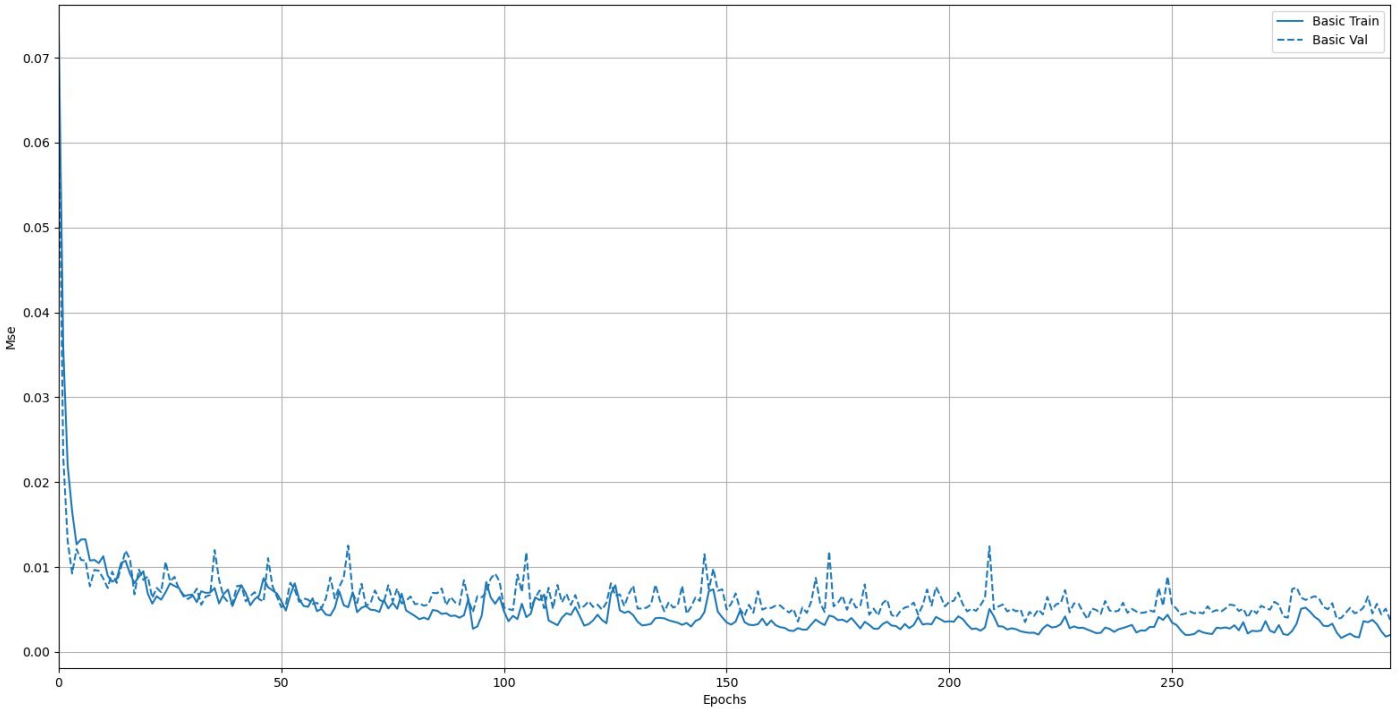
- Synthetic Langmuir probe data with noise generated, network trained to label plasma parameters

Network Validation & Testing on NSTX Data



- Network trained on 100,000 synthetic LP traces, validated on set of synthetic traces (top)
- Predictions made on NSTX shot 137622 (bottom)

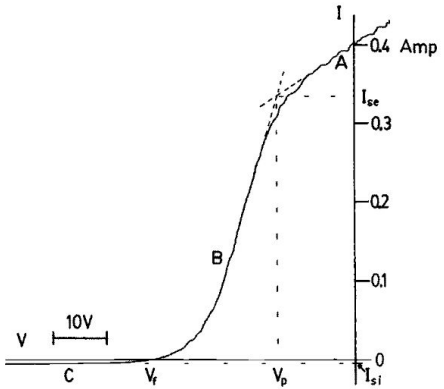
Network Validation & Testing on NSTX Data

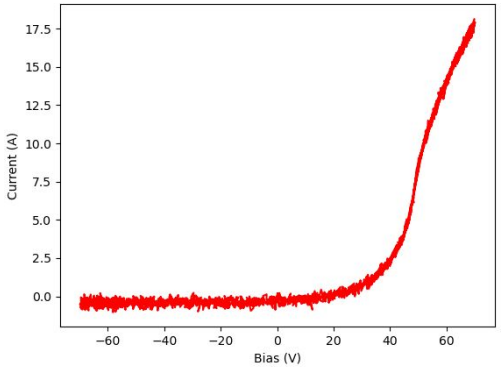


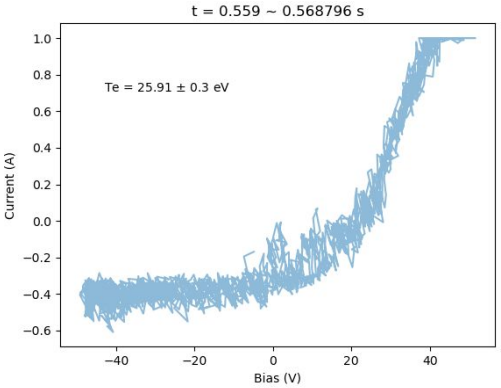
- Predictions made on NSTX shot 137622
- Mean Squared Error loss quantifies network performance as it trains

Further Plans

- Improve synthetic data model
- Check and improve human analysis
- Generalize network to use with various other plasmas







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Additional thanks to Xin Zhang and Francesca Poli for helping with the completion of the project, and to Arturo Dominguez and Deedee Ortiz for being awesome program coordinators!

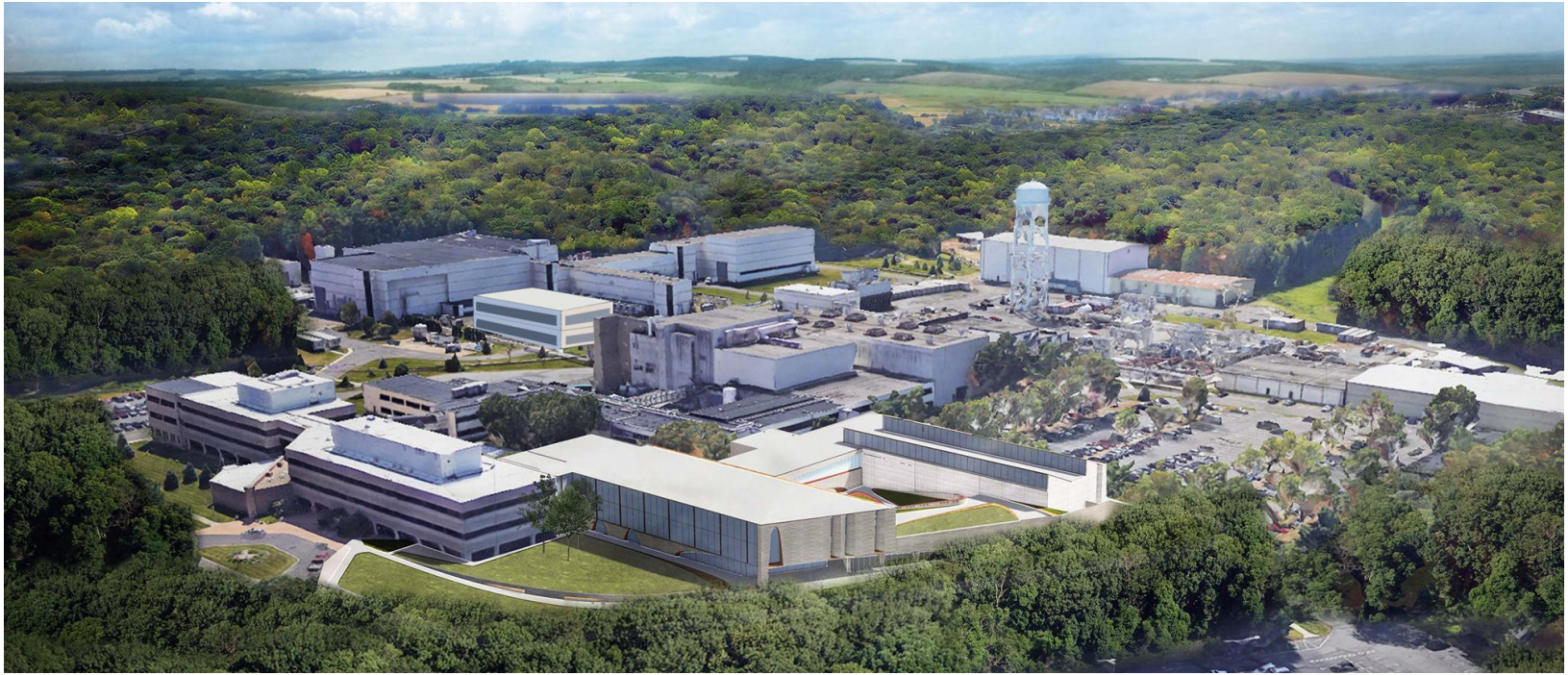
References

[1]I. H. Hutchinson, Principles of Plasma Diagnostics, 2nd ed. (Cambridge University Press, Cambridge, UK, 2005), pp. 55-72.

[2]M. A. Jaworski et. al, “Biasing, Acquisition and Interpretation of a Dense Langmuir Probe Array in NSTX”, Rev. Scientific Instruments **81**, 10E130 (2010); https://doi.org/10.1063/1.3490025

[3]S. Hochreiter, J. Schmidhuber, “Long Short-Term Memory”, Neural Computation 9(8), 1735-1780 (1997).

Questions?



Thank you for listening!

Feel free to ask questions directly during the SULI poster session, 8/12/20 11:30 AM - 3:30 PM or email me at matthewjlazo@gmail.com