Real-time machine learning modeling of fusion plasma pressure and density

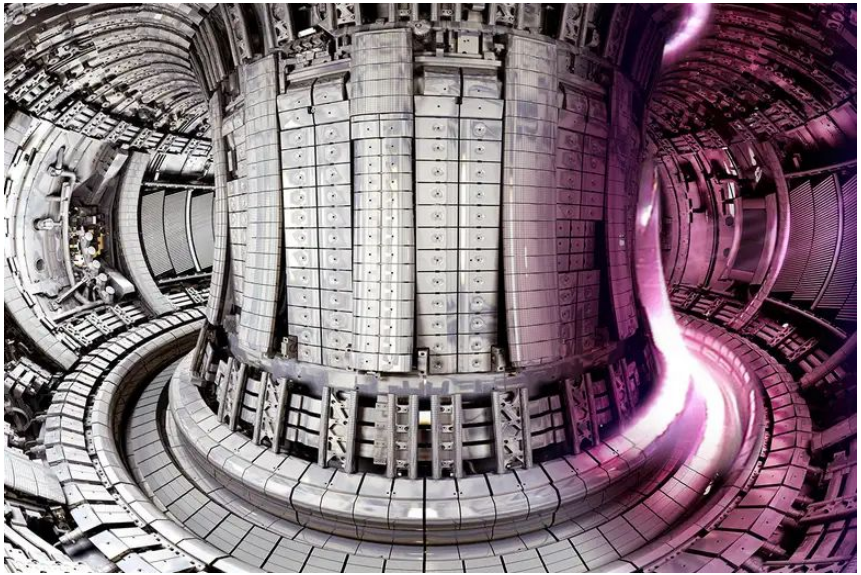
J. Chadwick[1], M. D. Boyer[2]

1 Carnegie Mellon University

2 PPPL

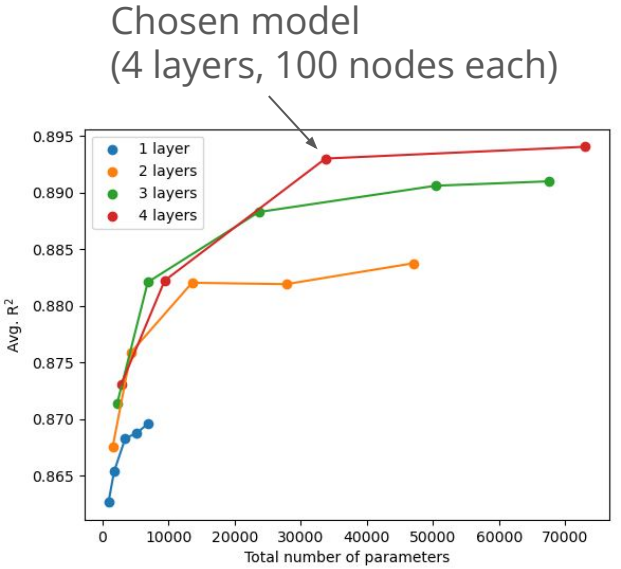
Overview

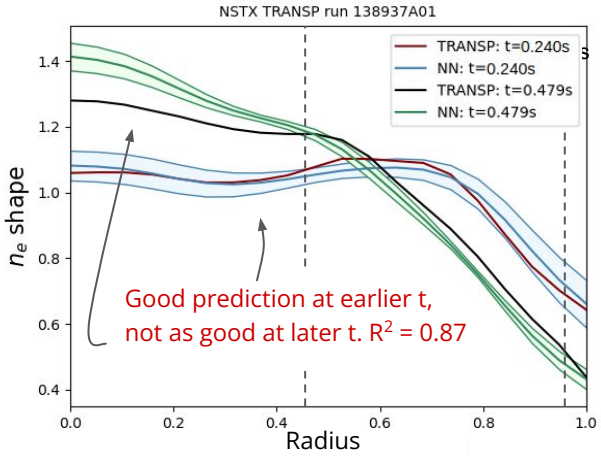
- **Fusion power** is a proposed safe, green energy source where hydrogen is superheated to produce energy the same way the Sun does
  - Many benefits over other energy sources
- Plasma is held in strong magnetic fields to prevent it from escaping
- We used neural networks to predict the future state of the plasma
  - Fast enough to run in real time



Results: initial model design

- Right: Models consisting of different numbers of layers and nodes per layer
  - Total number of parameters (nodes + connections) measures complexity

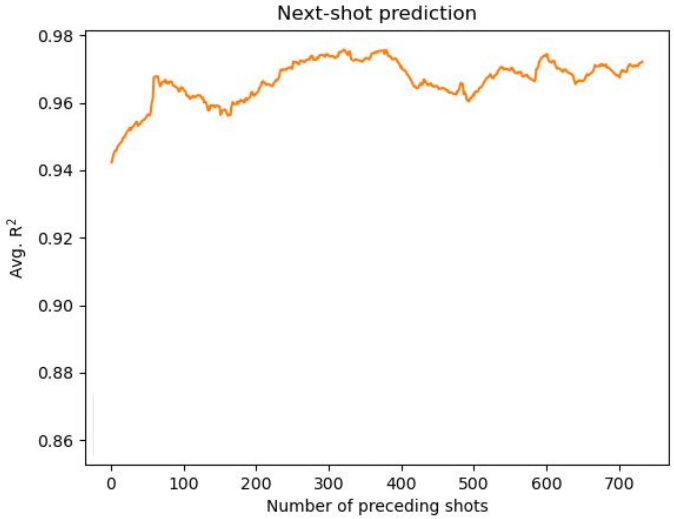


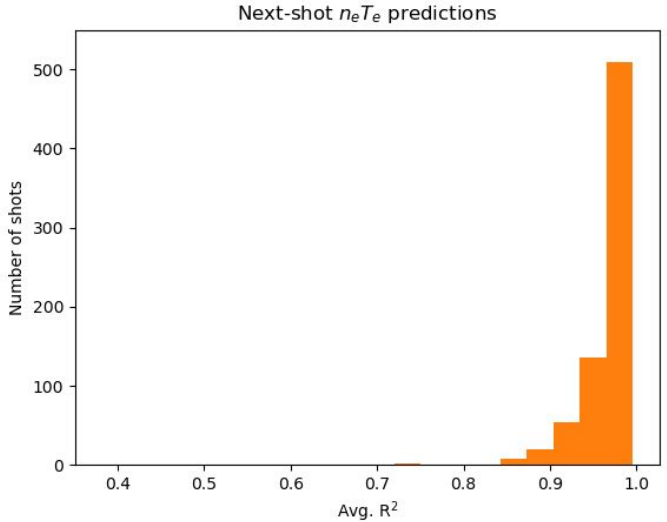


- Left: an example of the type of prediction that the net is making

Next-run prediction

- More realistic test: predict each run based only on **previous data**
  - More accurate representation of an actual use case
- Results: Good average predictions throughout dataset!





Conclusions

- A neural network can **reliably reproduce plasma profiles** with high accuracy
  - Promising for control system applications
- Model is capable of **predicting future runs** that are not in the training space - a realistic application
- Future work:
  - Test technique on other fusion reactors
  - Integrate into a real control system

Acknowledgements

This work was made possible by funding from the Department of Energy for the Summer Undergraduate Laboratory Internship (SULI) program. This work is supported by the US DOE Contract No. DE-AC02-09CH11466.