BOUT++ & Machine-Learning at UKAEA

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ExCALIBUR / SiMLInt workshop - 05 June 2023

UK Atomic Energy Authority

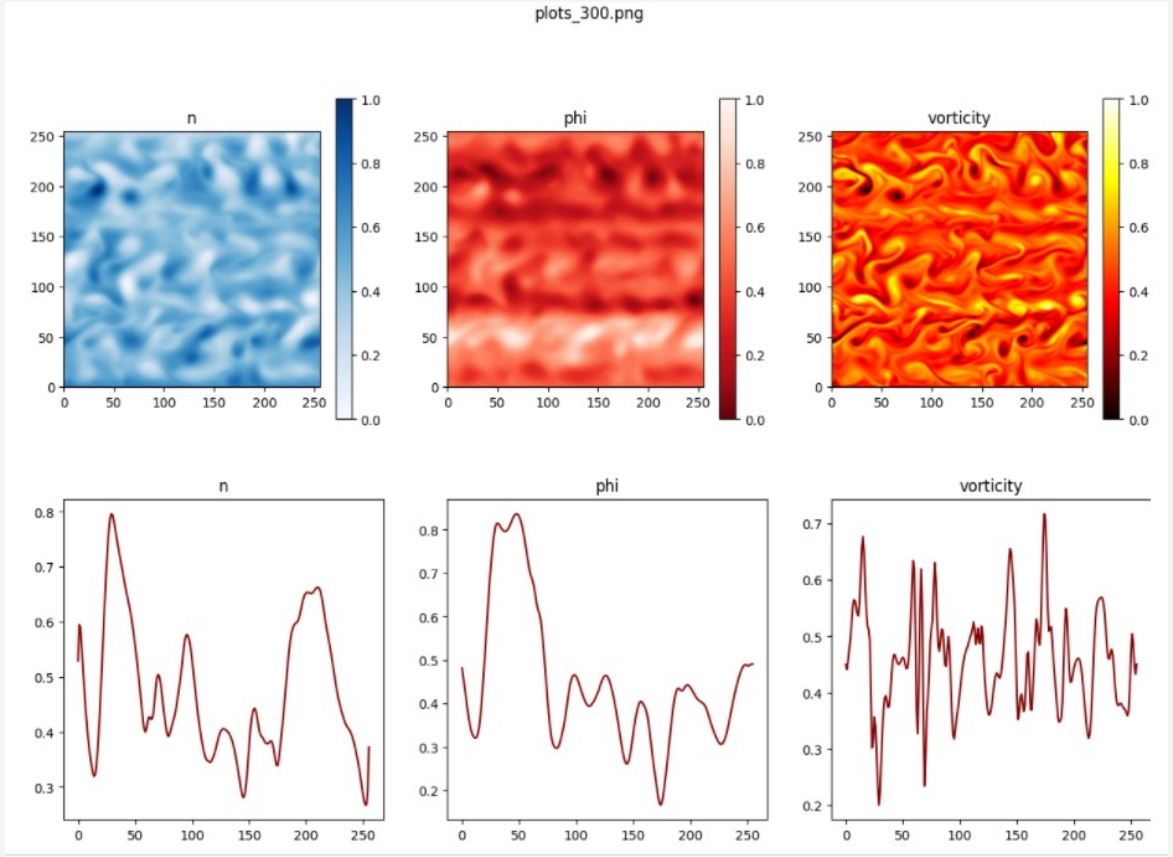
COMPUTING DIVISION

StyleGAN to accelerate BOUT++ simulations

See Jony Castagna's slides

→ Hasegawa-Wakatani model

→ Use GAN to generate detailed solution from filtered solution



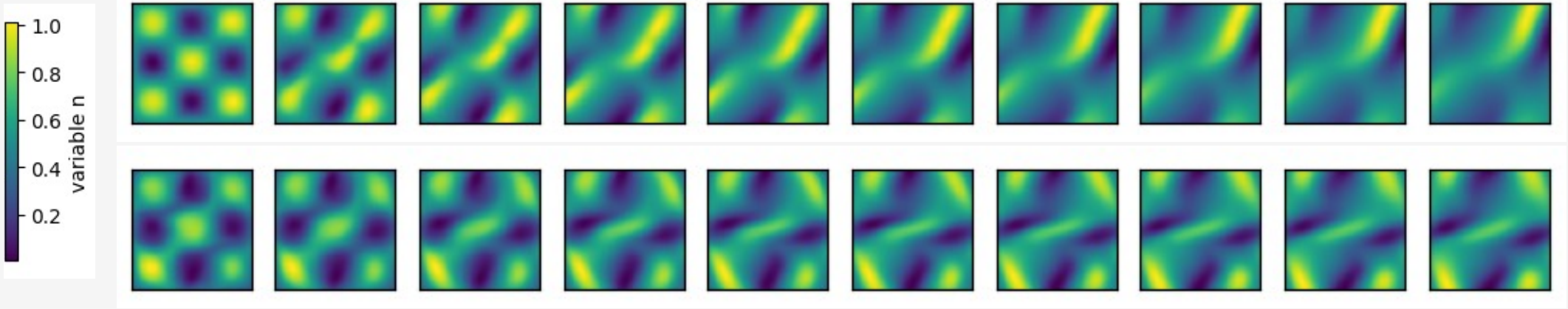
Physics Informed Neural Networks

UK Atomic Energy Authority

Can PINNs scale up to fusion relevant use-cases?
→ Large resolutions
→ Large physics models
Hasegawa-Wakatani model

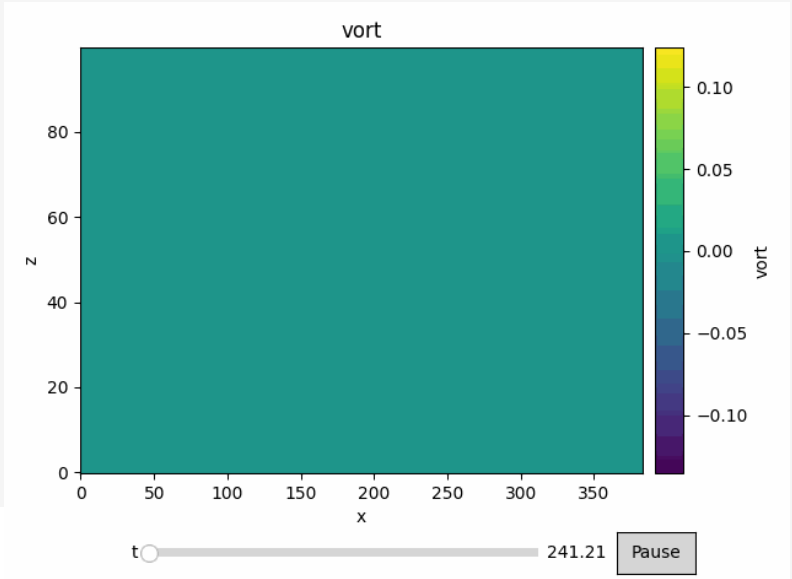
Lucy Harris (UKAEA), ICDDPS conference 2023, Okinawa, Japan

No BC's

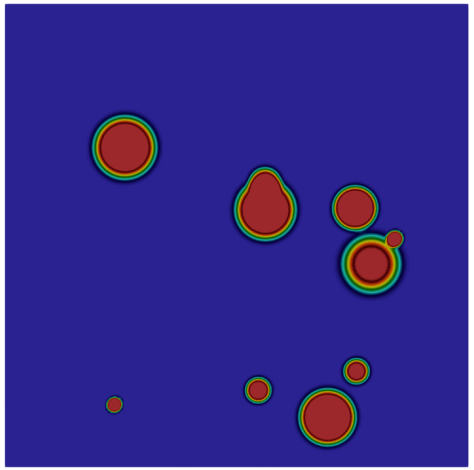


Periodic BC's

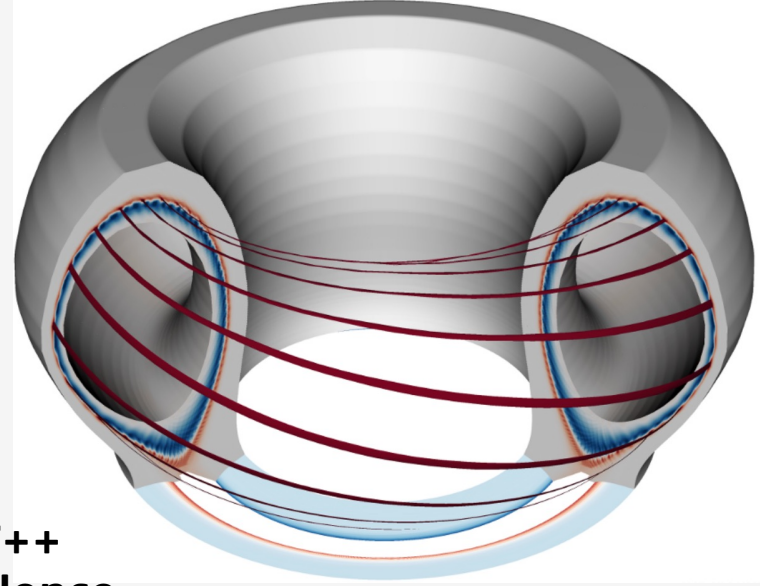
Surrogates of 2D slab simulations



STORM 2D turbulence

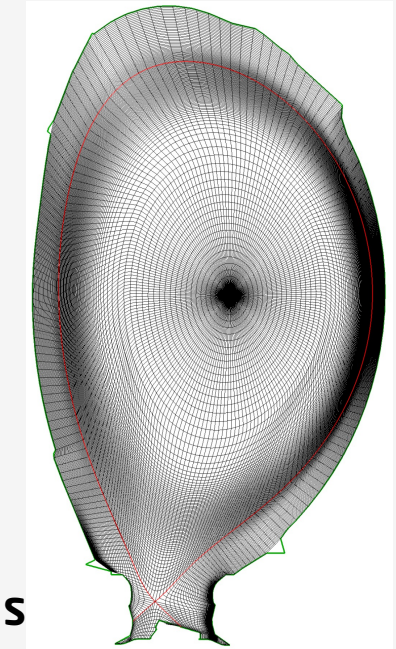


JOREK 2D blobs



BOUT++ turbulence

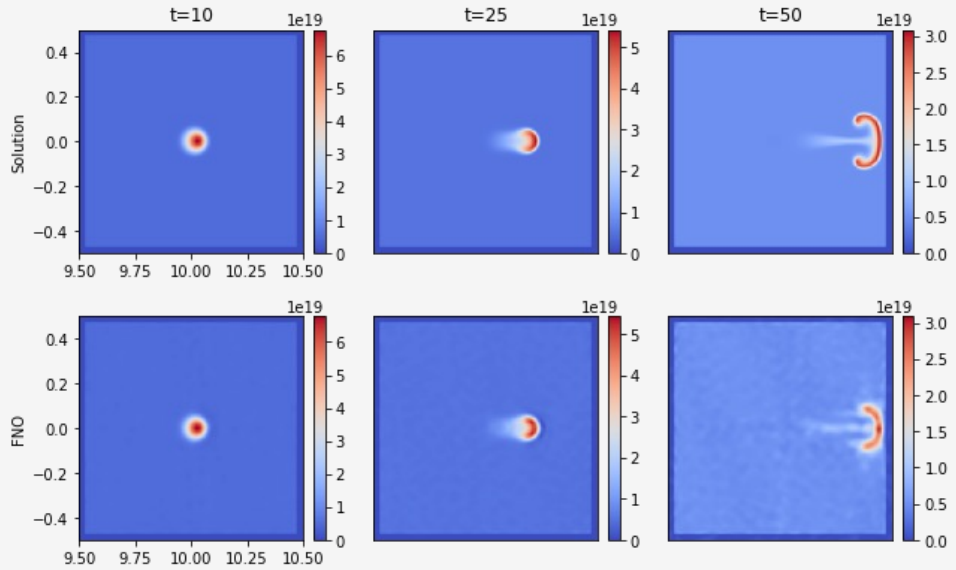
Long-term goal:
→ extend to full geometry

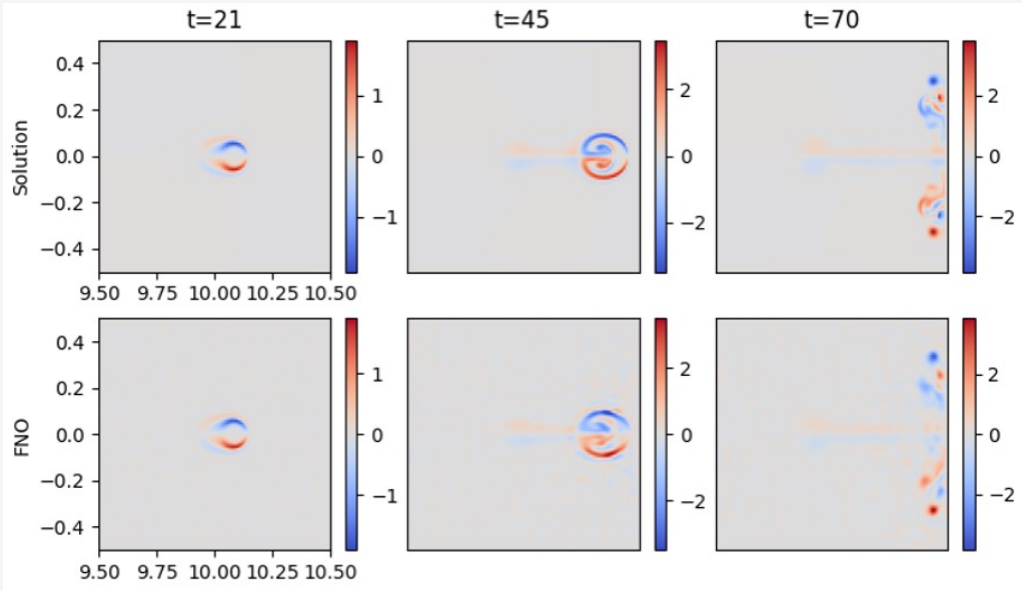


JOREK ELMs

Where AI/ML is used in fusion: Prediction

So far only applied to JOREK blobs, but currently working on BOUT++ dataset too



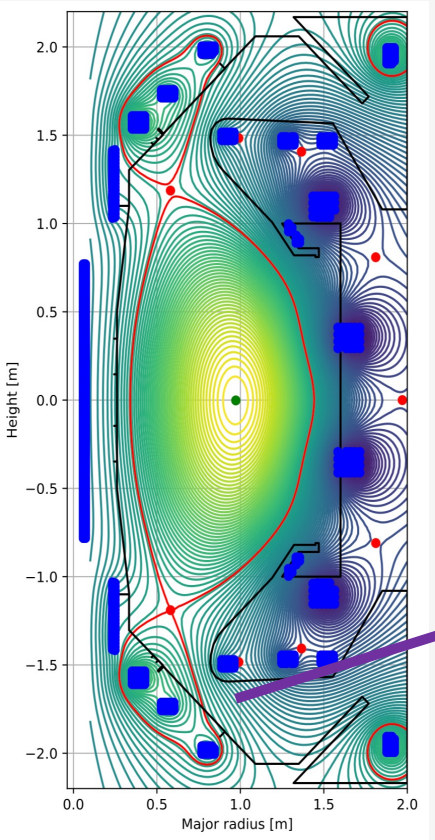


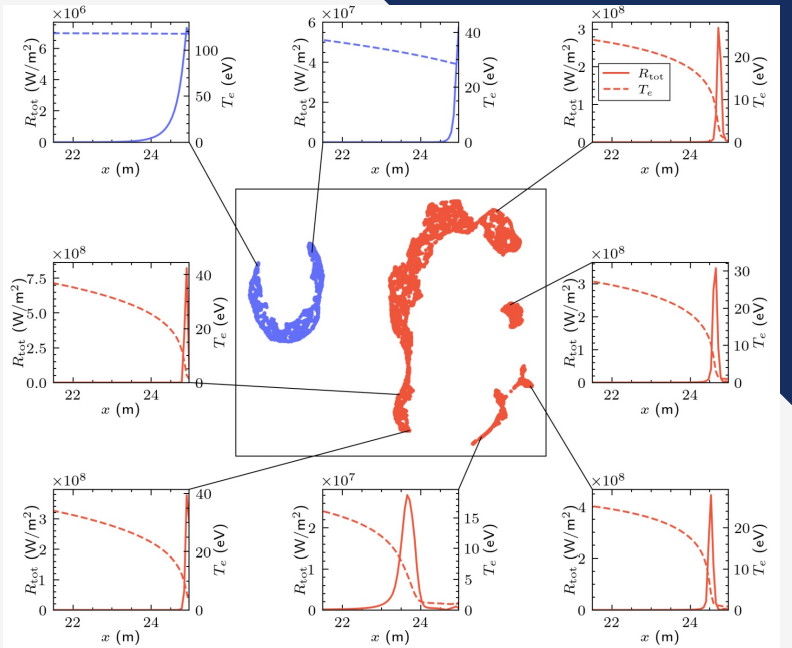
V.Gopakumar, NeurIPS Conference 2022, New Orleans, USA

SD1D detachment control

Reinforcement Learning requires a surrogate:
→ Large database of SD1D runs

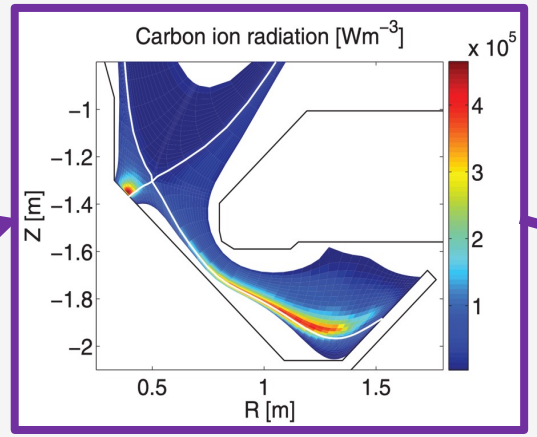
G.Holt, ICDDPS conference 2023, Okinawa, Japan



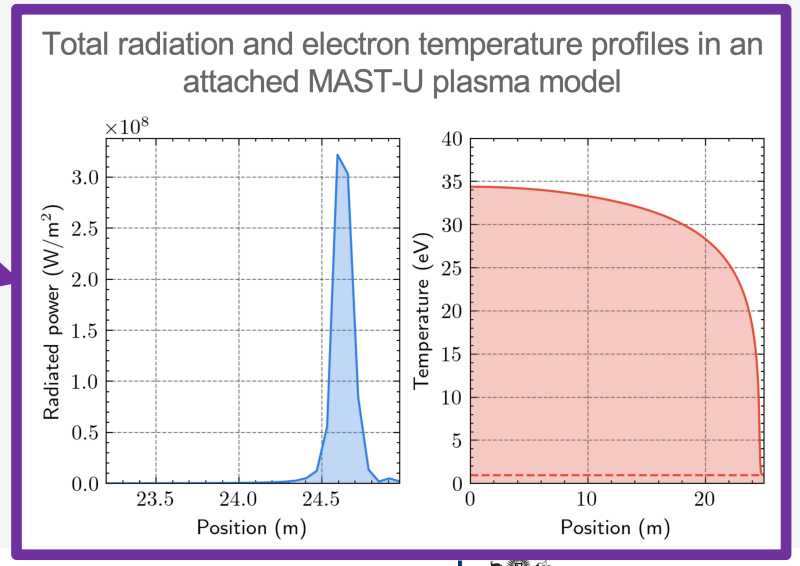


Dimensionality reduced dataset with colours indicating cluster (attached/detached). Orbiting plots show selected samples of radiation and temperature profiles.

Scrape-off layer



SD1D Simulations of detachment



Conclusion

- Starting to generate large databases of small simulations:
  - → Hasegawa-Wakatani
  - → 2D turbulence in STORM
  - → SD1D detachment

- Need to scale up to larger geometries:
  - → 3D for turbulence
  - → 2D for detachment