VTT-03 – Machine learning accelerated pedestal MHD stability simulations
Primary WP: PrIO (also supported by WPTE)

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Repeated pedestal MHD stability simulations are a key component of many pedestal pressure prediction workflows

IMEP [Luda NF 2020, https://doi.org/10.1088/1741-4326/ab6c77]

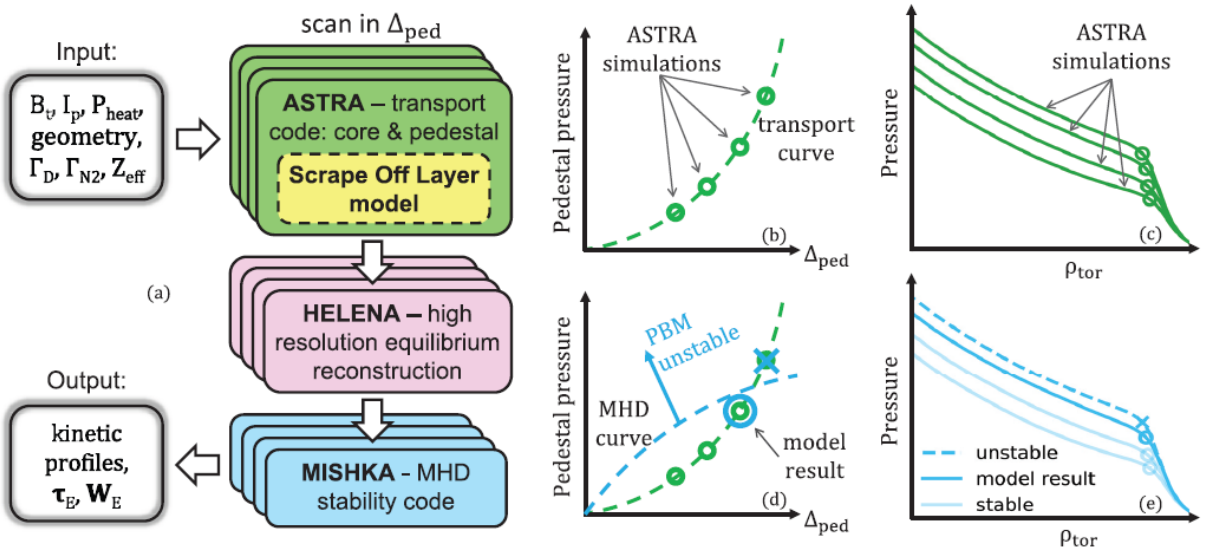


Figure 1. Chart representation of the modeling workflow (*a*). Multiple parallel ASTRA simulations calculate the kinetic profiles for different values of the pedestal width (*c*). The pedestal model integrated in ASTRA gives a transport constraint which determine the pedestal pressure for a given pedestal width (*b*). MISHKA tests the stability of the resulting profiles to find the highest stable pedestal pressure ((*d*) and (*e*)).

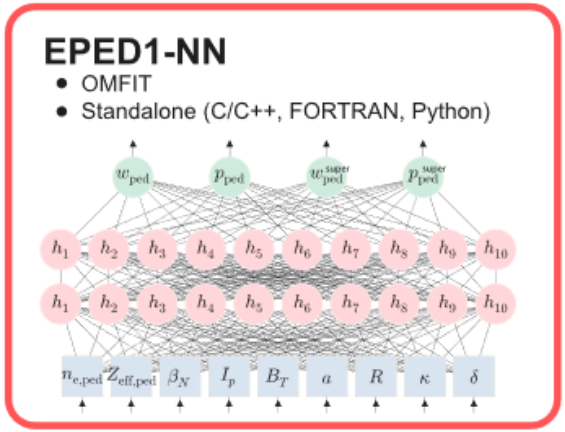
What if a generic surrogate would be available for the MHD stability simulations? Can such a surrogate be used to accelerate all of these workflows?

Common approach:

1. Generate a family of edge plasma profiles consistent with a transport model/assumption
2. Simulate the linear MHD stability with codes such as HELENA+MISHKA
3. Identify the pedestal width and height consistent with the two constraints

The repeated MHD simulations are typically a bottle neck component in codes such as EPED, Europed, IMEP or other integrated simulation workflows

Previous research activities have built surrogates for EPED and Europed for pedestal top predictions

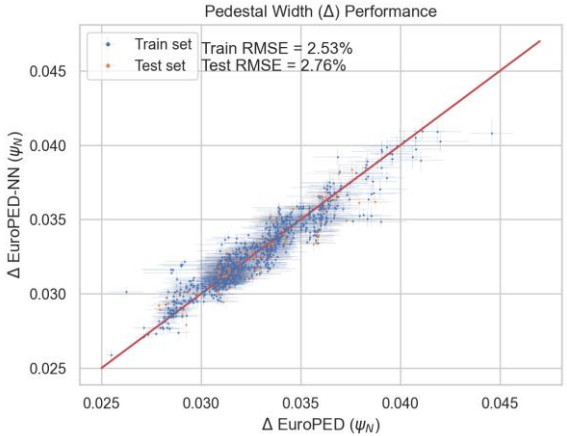


Meneghini NF 2017

https://doi.org/10.1088/1741-4326/aa7776

Multiple devices: ITER, JET, KSTAR, DIII-D

Europed surrogate (BNN-NCP)



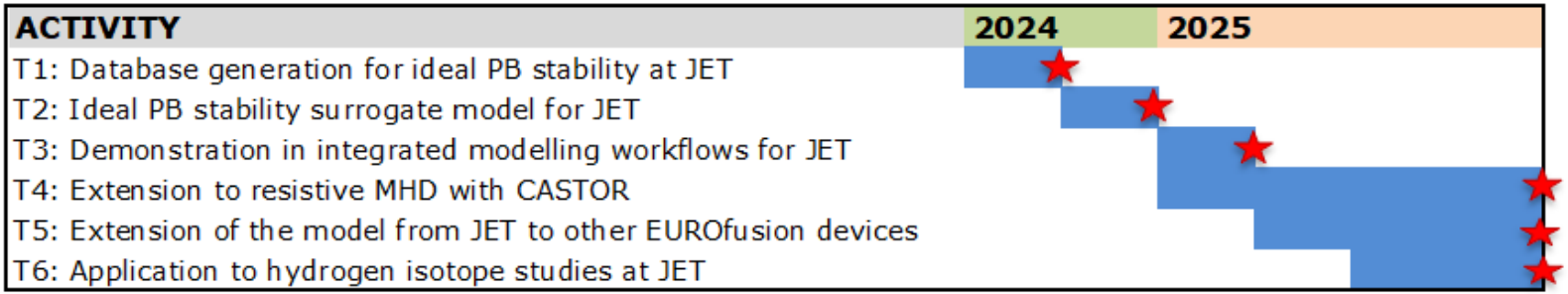
Panera-Alvarez, submitted to PPCF

https://arxiv.org/abs/2402.00760

JET

- These are including the transport assumption in the surrogate model (ballooning critical pedestal in EPED)
- In this project, the aim is for the model to be generally applicable to various transport models/assumptions

Plan & team of the proposal



Team:
VTT: PI Aaro Järvinen, PhD student Amanda Bruncrona
VR: Lorenzo Frassinetti, PhD student Hampus Nyström
UAKEA: Samuli Saarelma, Lorenzo Zanisi

Status of the work

- Kick-off meeting with the team organized last week
- A proof-of-principle database of about 10 000 HELENA equilibria with about 60 000 MISHKA stability simulations done – Parameterized plasma shape, plasma parameters relevant to JET
- A poster presentation in the ICDDPS-5 conference in August 2024 by A. Bruncrona