PROJECT NEPTUNE

WORK PACKAGE 4: SUPPORT AND COORDINATION

Steven Wright, Ben Dudson, Peter Hill, David Dickinson, Edward Higgins, Chris Ridgers

University of York

Gihan Mudalige, Tom Goffrey, Ben McMillan

University of Warwick

FM-WP4 Code Structure and Coordination

Software Support Procurement

Based around three deliverables:

- **Continual monitoring and update of state-of-the-art reviews**
- **Demonstrator implementations**
- **Edge Physics consultancy**

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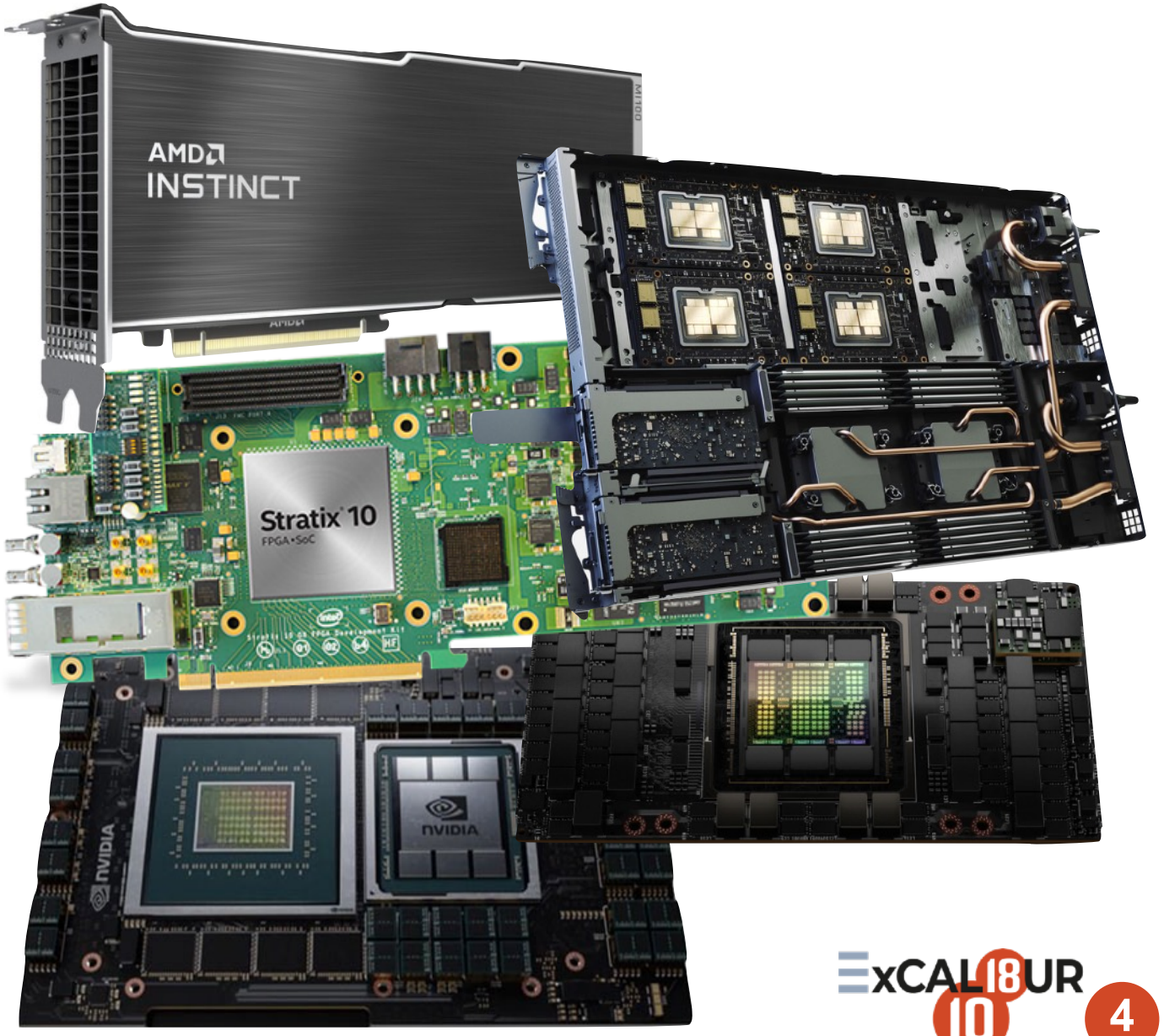
State-of-the-art Reviews

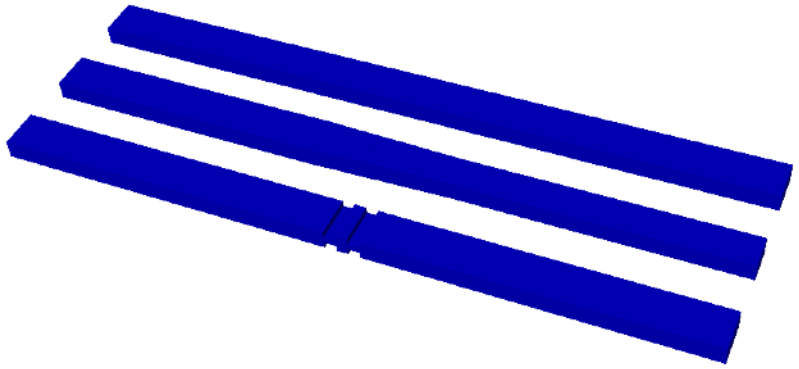
New Hardware

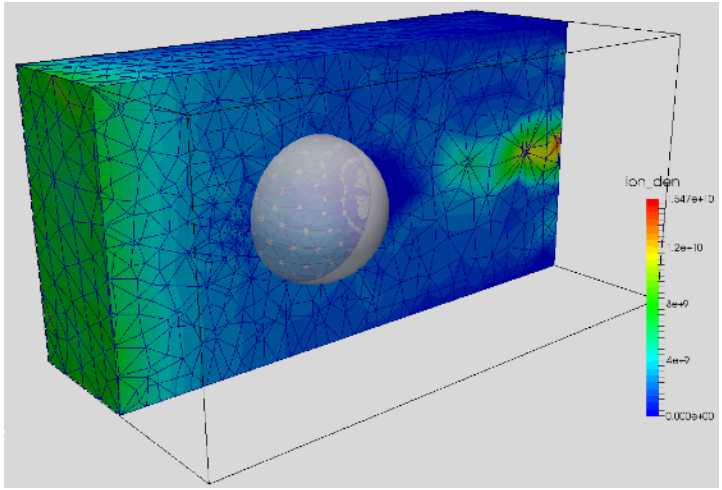
- Evaluate new hardware (assuming access)
  - AMD GPUs (and new CPUs)
  - Intel GPUs (… and new CPUs)
  - AMD/Intel FPGAs
  - NVIDIA GPUs and CPUs
  - …?



State-of-the-art Reviews

New Applications





- **Fluid Codes**
  - **FDTD3D – 3D Maxwell solver on fixed grid using Yee method**
  - **MAXWELL – Maxwell FEM code implemented in MFEM**
  - **HIPBONE – GPU port of Nekbone spectral element code**
- **Particle Codes**
  - **SHEATH-PIC – 1D PIC code with GPU implementations**
  - **FEM-PIC – Our developed PIC mini-app**
- **Assess representativeness (e.g. cosine similarity)**

State-of-the-art Reviews

New Programming Models

- Increase coverage of programming models
  - More SYCL evaluations
  - Evaluation with different SYCL compilers
  - Julia
  - More OP-DSL evaluations
  - … etc
- Maintain and expand our evaluation repository

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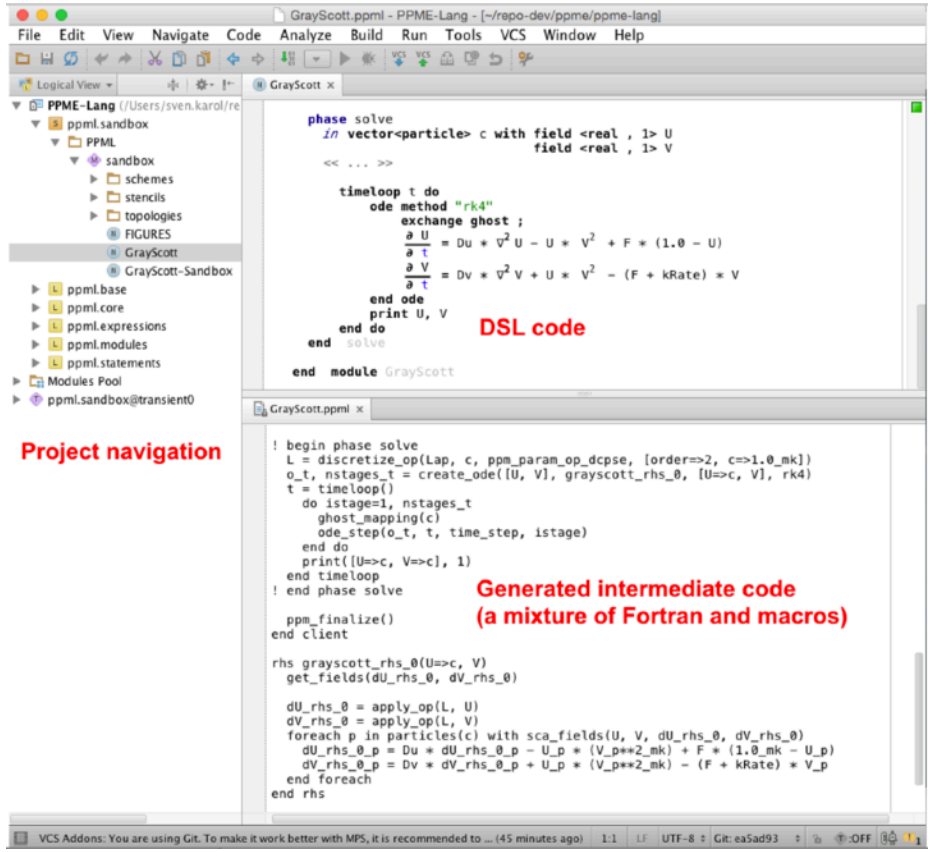
Demonstrator Applications

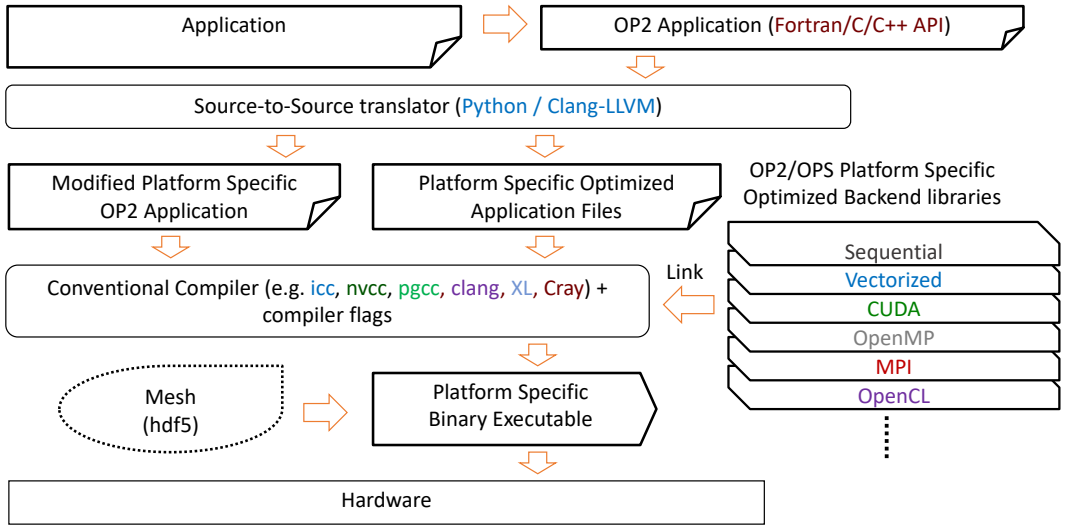
Mini-applications as DSL Demonstrators

- **T/AW087/21 will culminate in a proposal for a particle-based DSL**
- **This project will rely on collaboration with UKAEA, consulting on development of a new DSL for hybrid fluid/particle simulations**



Demonstrator Applications

Mini-applications as DSL Demonstrators

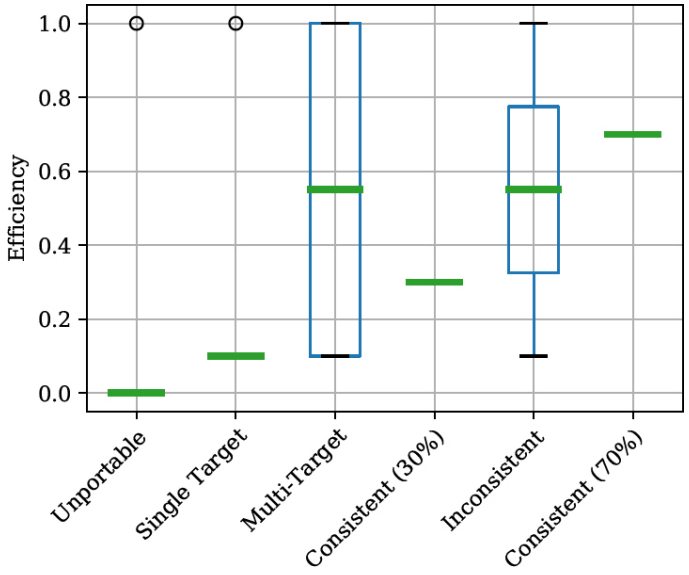


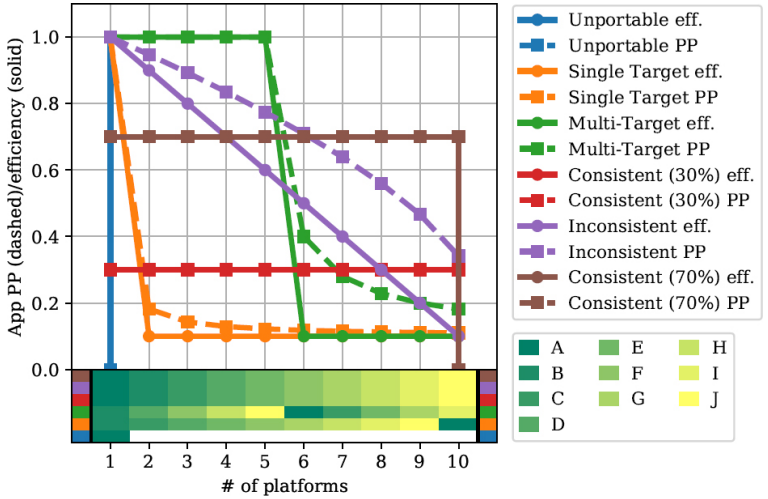
- We will develop miniaturised demonstrator applications in a DSL
- e.g. port mini-FEM-PIC
  - … to a UKAEA-developed DSL
  - … to OP2 w/ an implementation of our proposed particle DSL

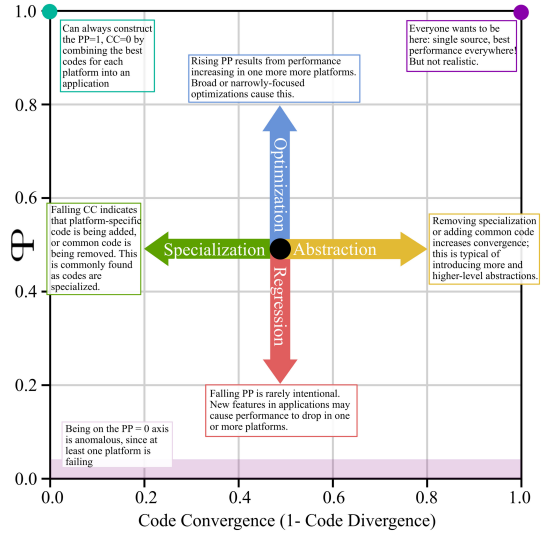
Demonstrator Applications

Mini-applications as DSL Demonstrators

- **Developed demonstrator application will be evaluated for performance and portability**
- **Evaluation will follow our current methodology**
- **Will additionally assess productivity of DSL [1]**







[1] S.J. Pennycook, et al. Navigating Performance, Portability, and Productivity. In Computing in Science & Engineering, pages 28-38, 2021.

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Edge Physics Consultancy

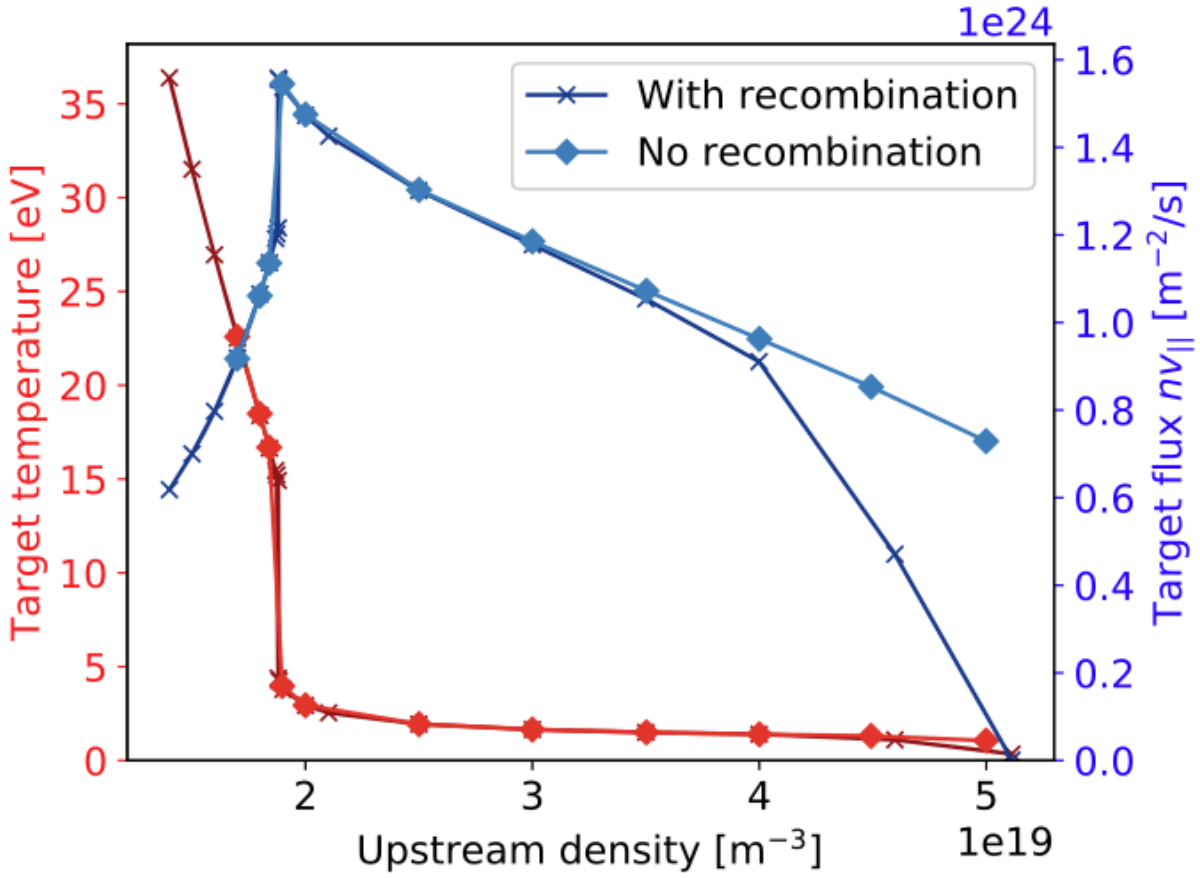
Verification and benchmark calculations with existing plasma software

- Software tools – SD1D (& Hermes), EPOCH
- SD1D – 1D Fluid code readily extendible to include further physics modules (Hermes is same but 2D)
- EPOCH – Particle-in-cell code. Ab-initio kinetic physics for electrons and ions but lacks additional physics modules

Edge Physics Consultancy

Verification and benchmark calculations with existing plasma software

- **Activity 3.1/3.2 – identify edge physics test cases for 1D/2D system**
- **SD1D/Hermes have suite of example cases of varying complexity (steady state and transients)**
- **Example – benchmark temperature/ flux on target for range of included physics packages**
- **Support with fully kinetic, particle-based EPOCH simulations**

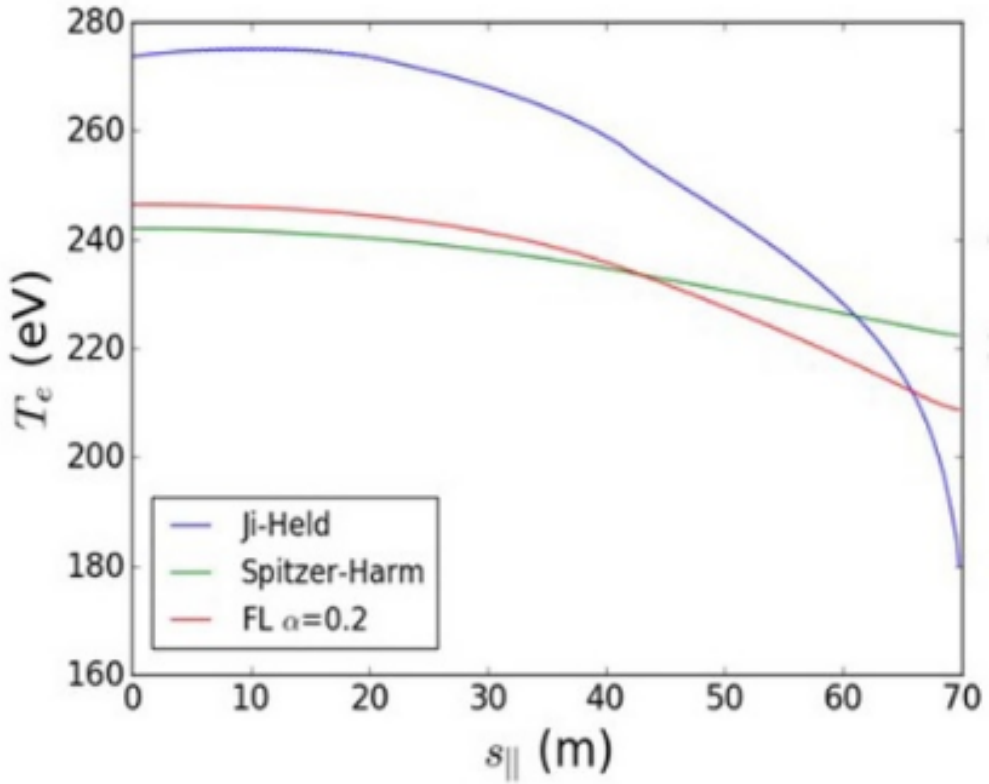


B. Dudson et al., PPCF, 61, 065008 (2019)

Edge Physics Consultancy

Verification and benchmark calculations with existing plasma software

- **Activity 3.3 - Explore mini-apps for incorporating kinetic effects in system 2-2**
- **Kinetic electron/neutral physics under development for SD1D/Hermes**
- **Validate against PIC and/or Vlasov Fokker Planck**
- **Models of different dimensionality. First step existing 1D kinetic electron transport models coupled to Hermes.**



M. Wigram et al., Nucl. Fus., 60, 076008 (2020)

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