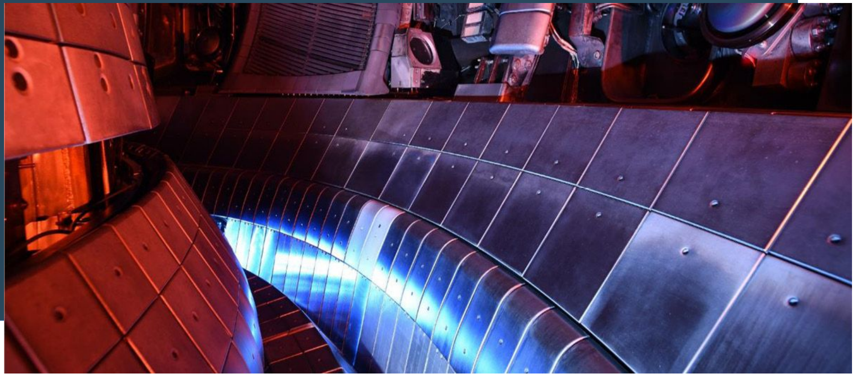
MAX-PLANCK-INSTITUT
FÜR PLASMAPHYSIK

First wall heat flux estimations with THEODOR – recent updates

D. Stieglitz, M. Faitsch, T. Lunt

6th IAEA technical meeting on Data Analysis



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- Solve Heat Diffusion equation
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- **In**: surface temperature (T)
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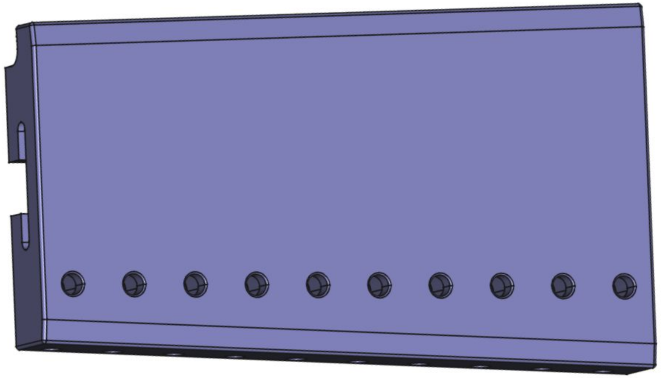

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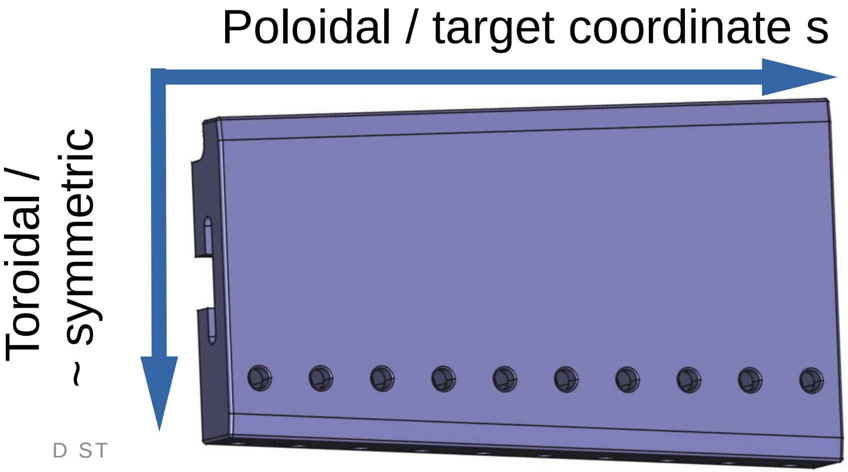

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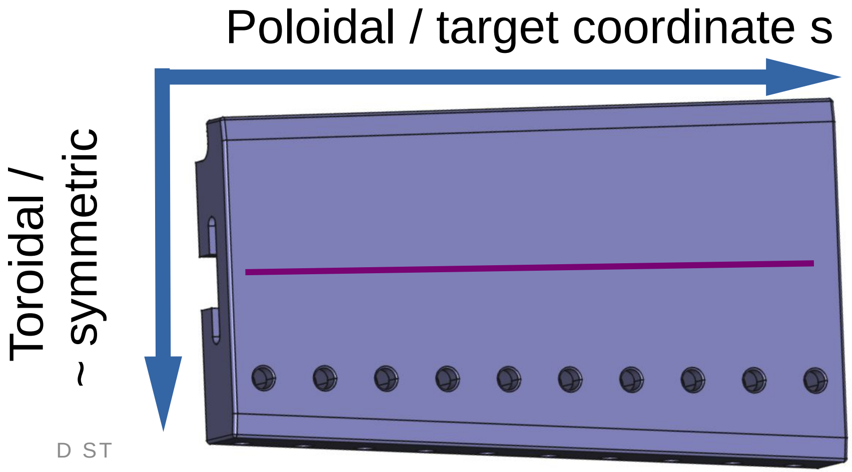

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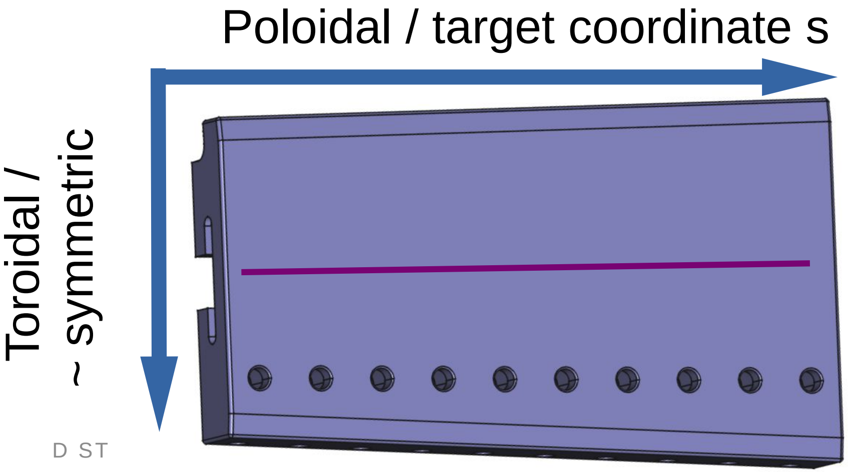

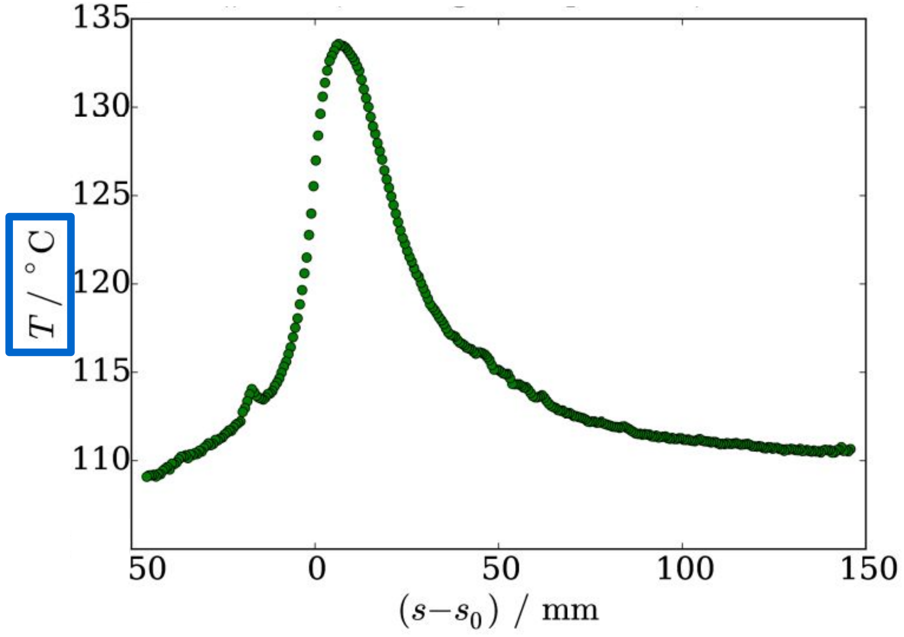

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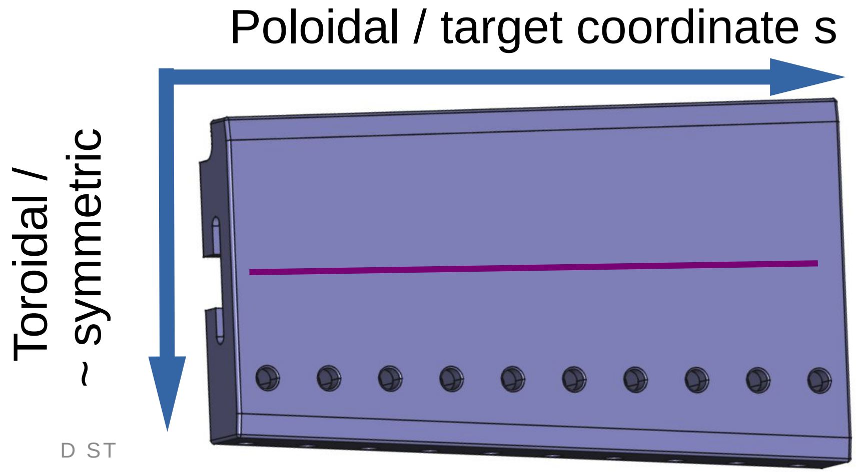

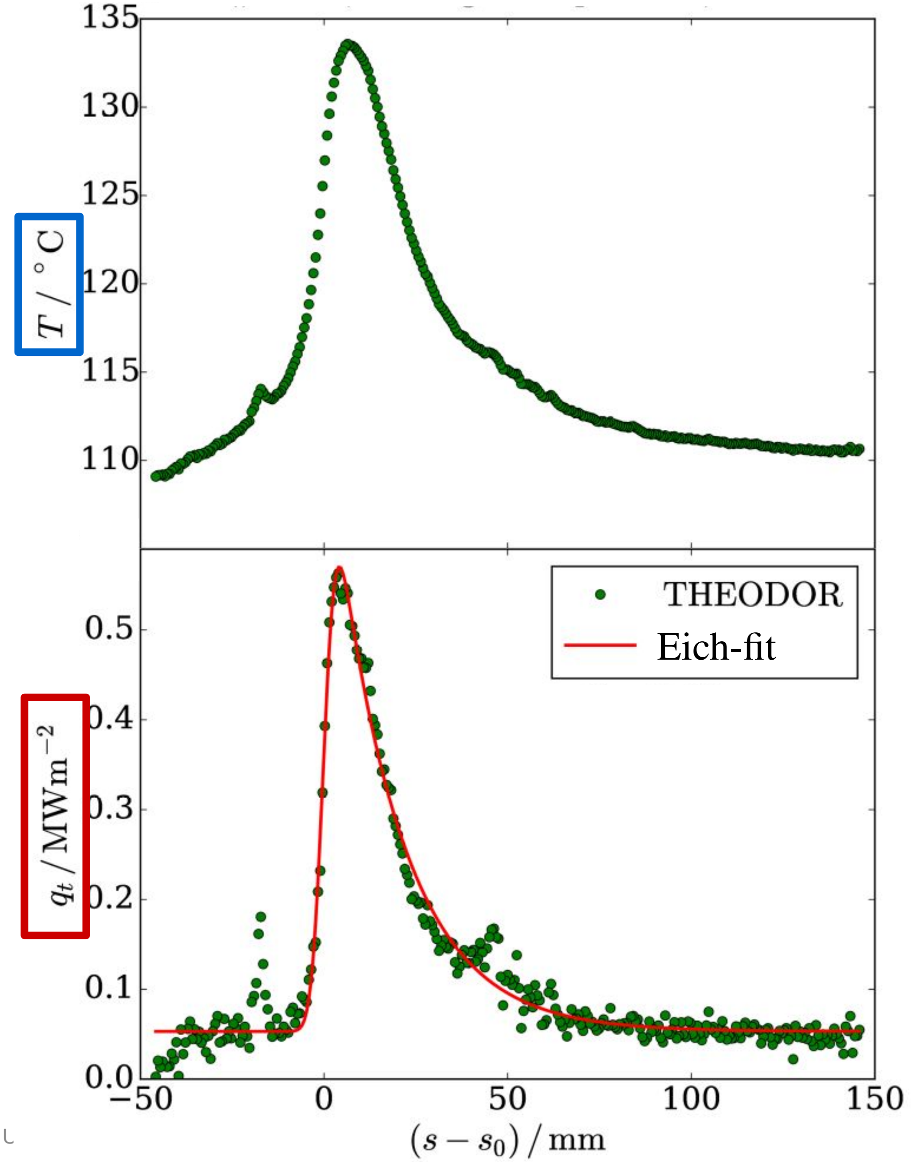

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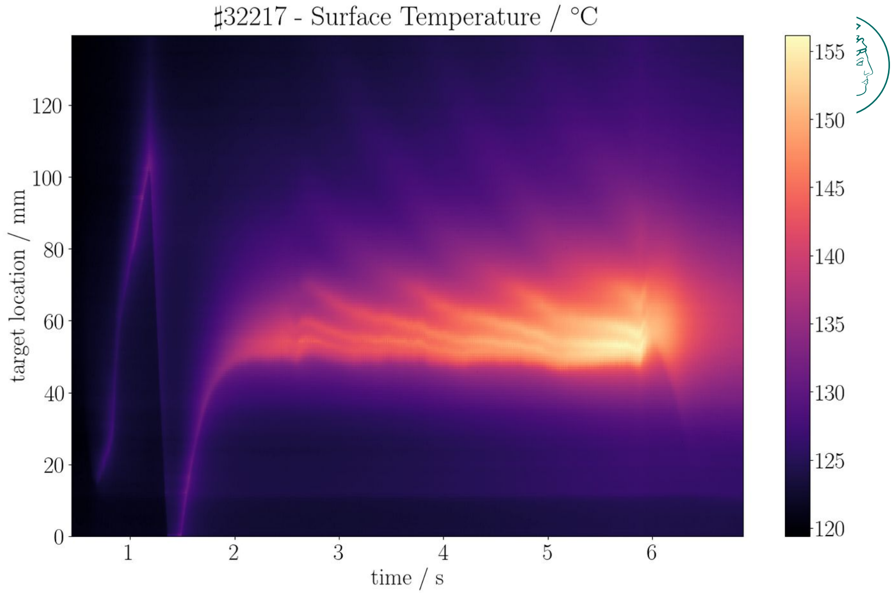
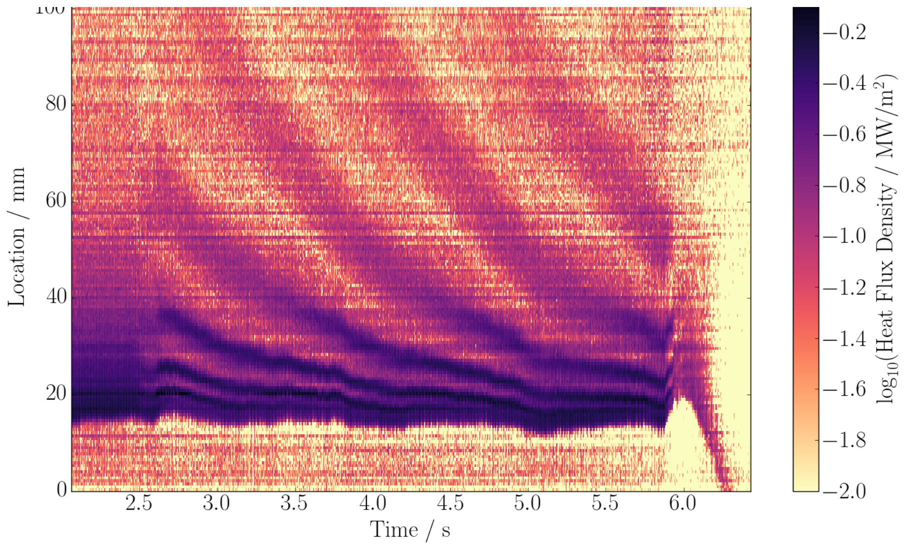
(instead of ANSYS, COMSOL etc)

- Tailored to this task
- Simple to set up and apply
- C++ and **Python** versions …





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- Fast evaluation (Python values:)
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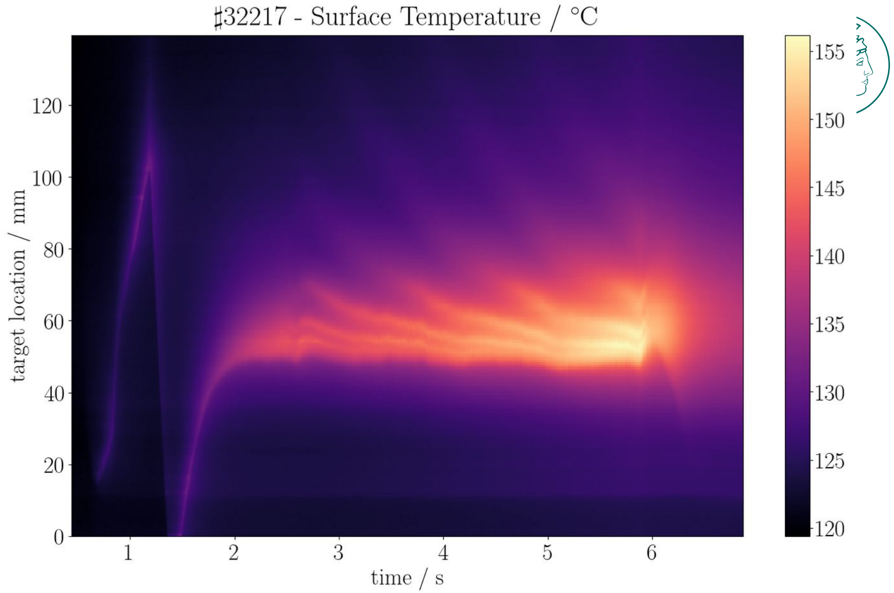
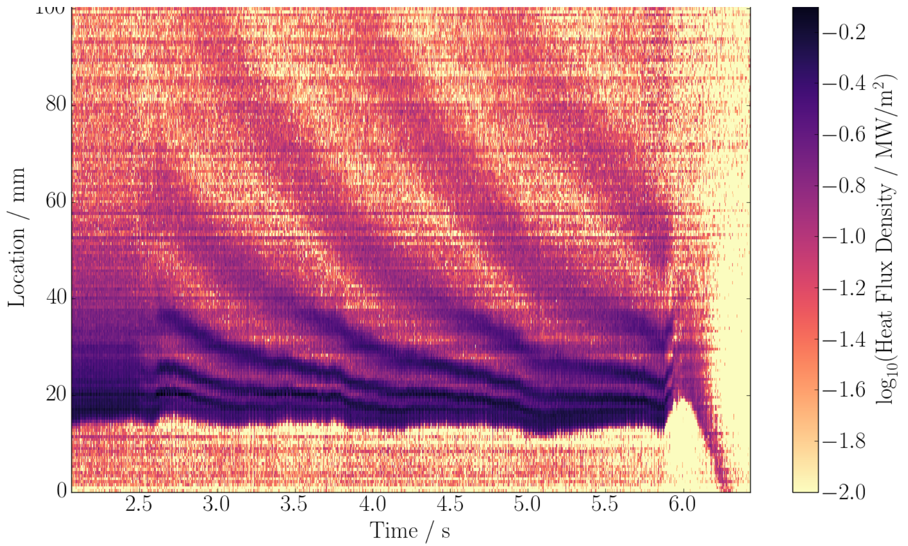
  2D/3D ~ 100Hz (10^6 cells, 4 cores)
- Simplified material properties suitable for Tungsten and Graphite





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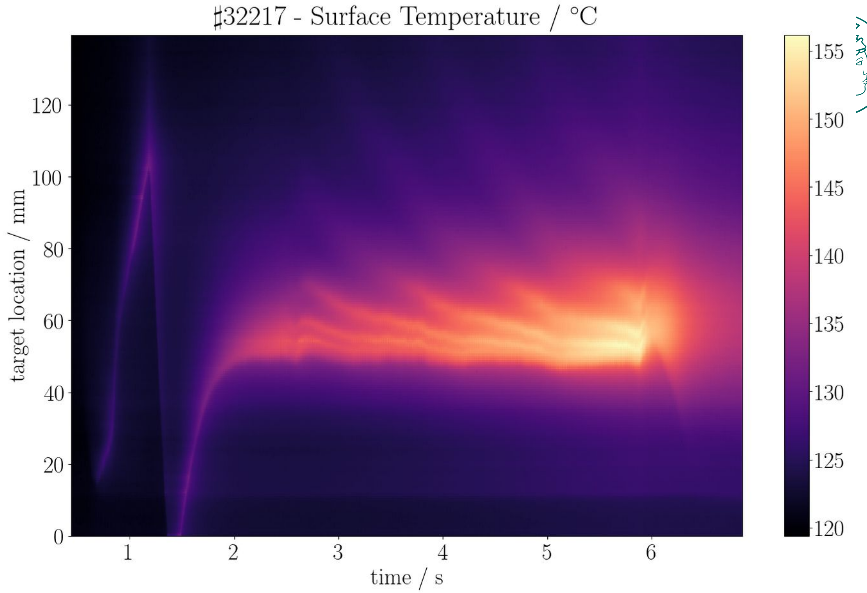
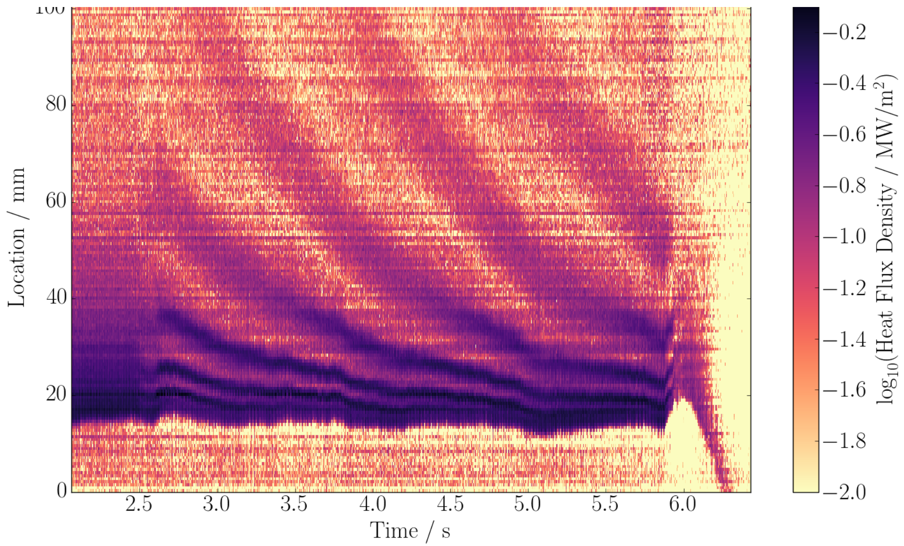
- Used at AUG, W7X, TCV, JET, MAST, DIII-D, Proto-MPEX, ...





Most relevant updates (since 2015)

Explicit → implicit solver with operator splitting (still FD)

- Ideal for exp. data analysis
- Computational cost ~ #cells
- 1D, 2D & **3D** Geometry
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- Tune discretisation
- Material transitions
- Tune surface layers
- Model voids (0 conductivity)
- Non-trivial geometry

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Soon: **Python THEODOR** will be made **Open Source**

Basic Setup (after git clone & install)

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theo_inst = Theo2d(
    material = 'AUG_Graphite',  # defined in theodor/materials/materials.yaml
    ref_dt = ref_dt,            # reference time step (CFL etc)
    T0 = 20,                    # initialisation temperature
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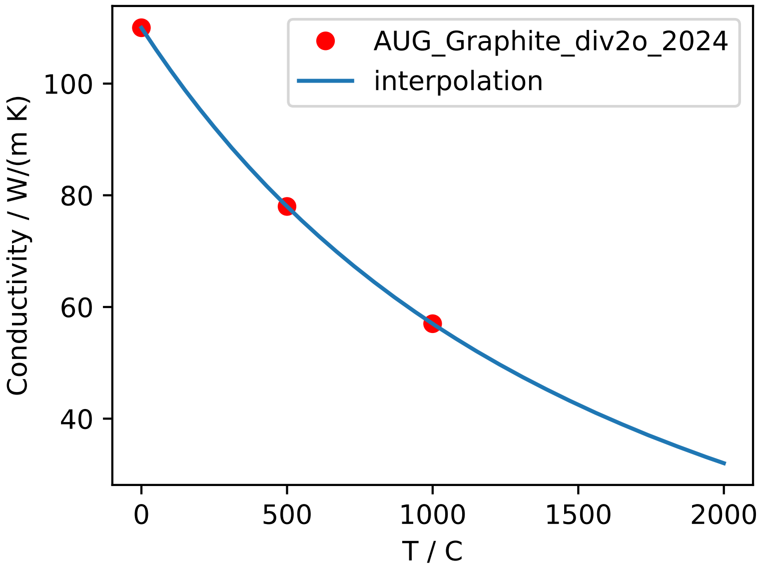
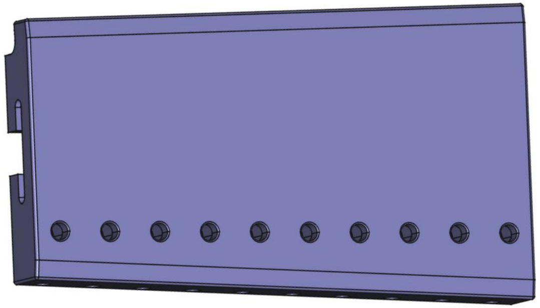



```
# Reference points are [0, 500, 1000] C
'AUG_Graphite':  # material name
    # K: the conductivity in W/(K*m)
    'K': [110, 78, 57]
    # D: the diffusivity in m**2/s
    'D': [70.54e-06, 21.57e-06, 13.07e-06]
```

Why 3D geometry at AUG

- Minor: Tiles are not cuboids, but trapezoids: toroidal width has R-dependence



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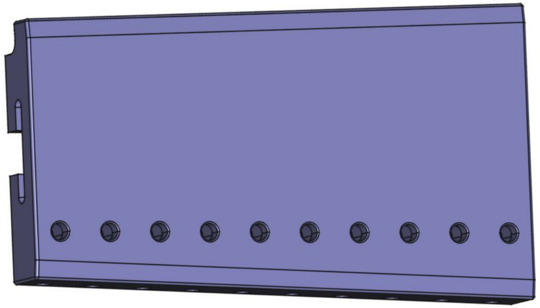

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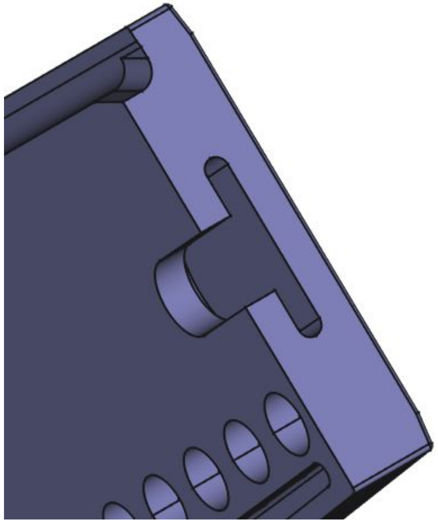

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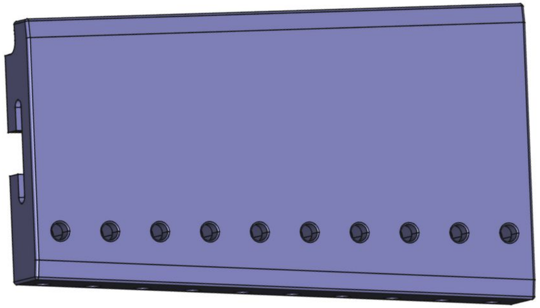

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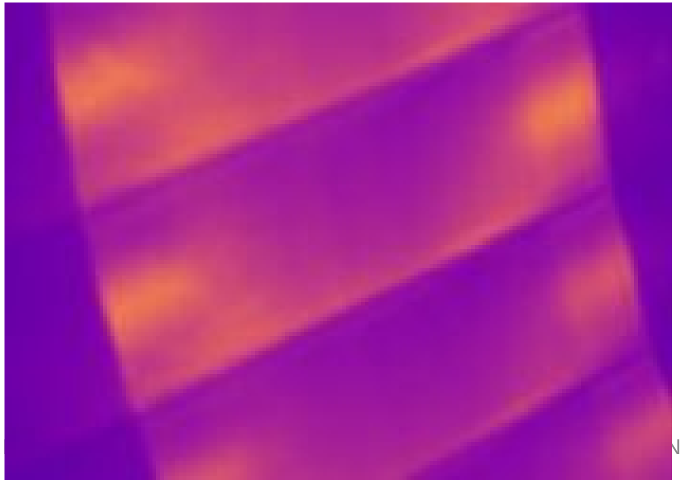

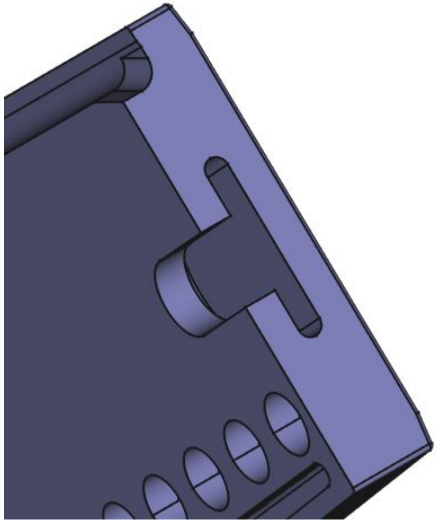

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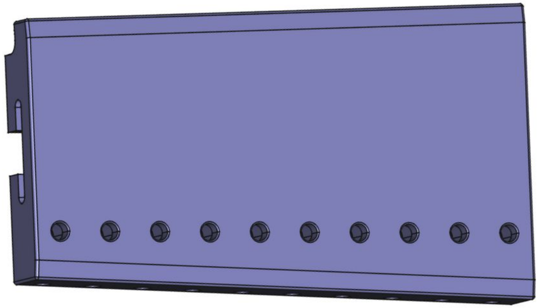

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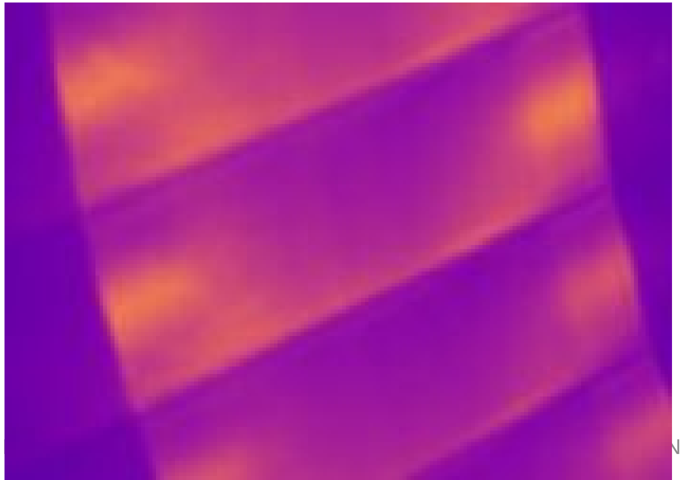
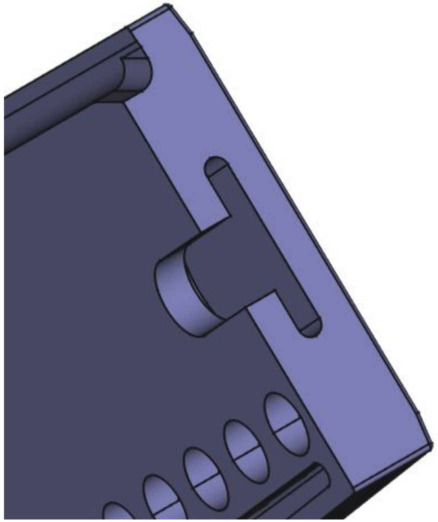
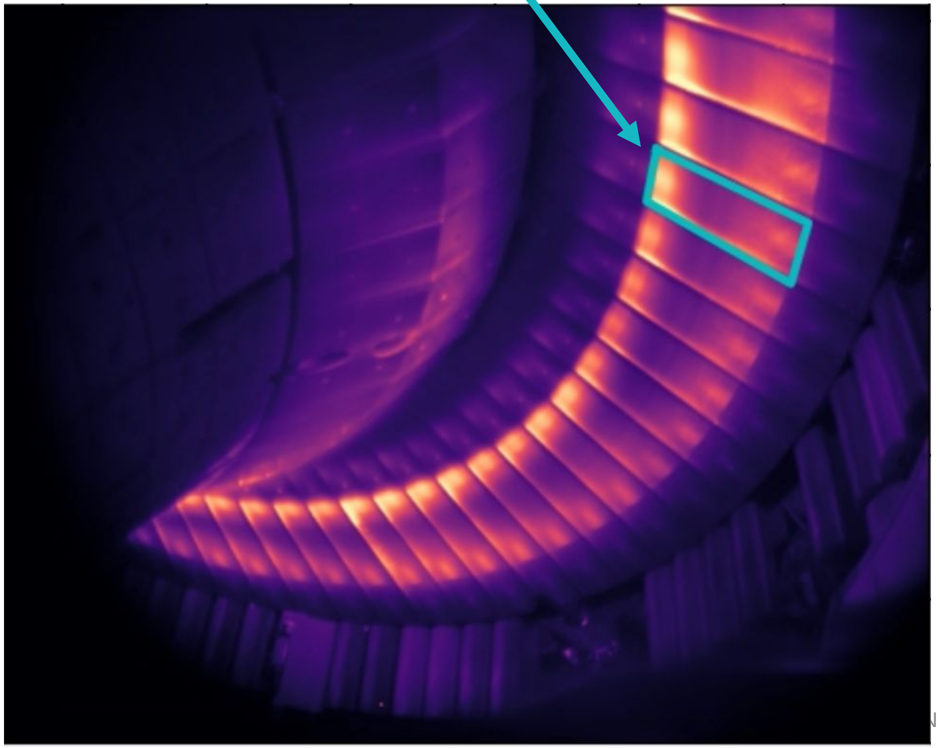
DISCLAIMER: PRELIMINARY RESULTS





Why 3D geometry at AUG

Outer, middle tile surface for 3D evaluation



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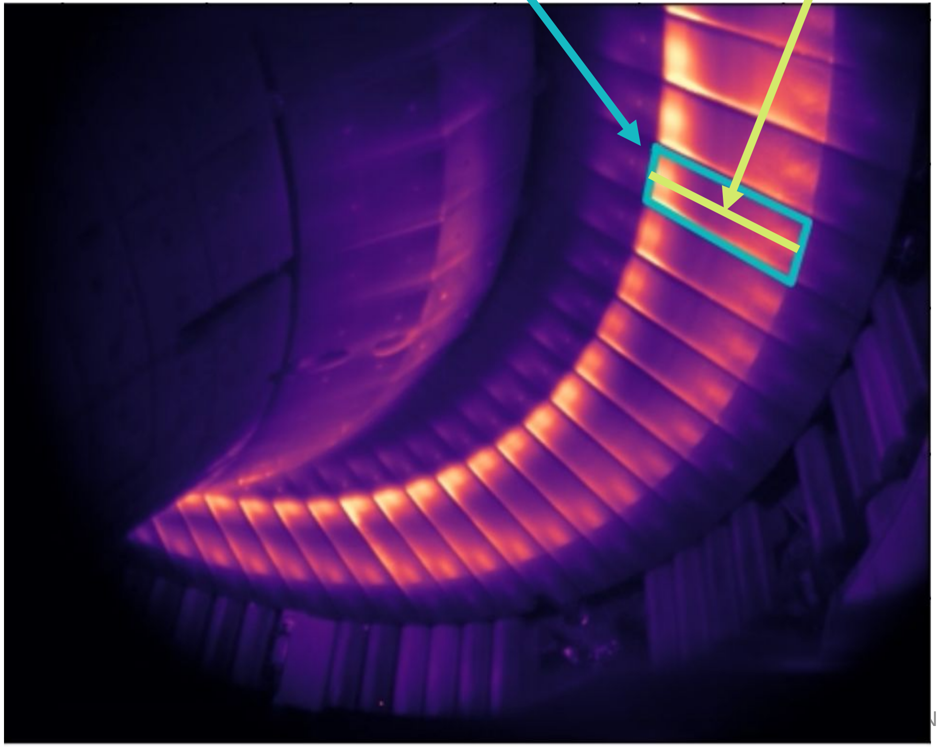

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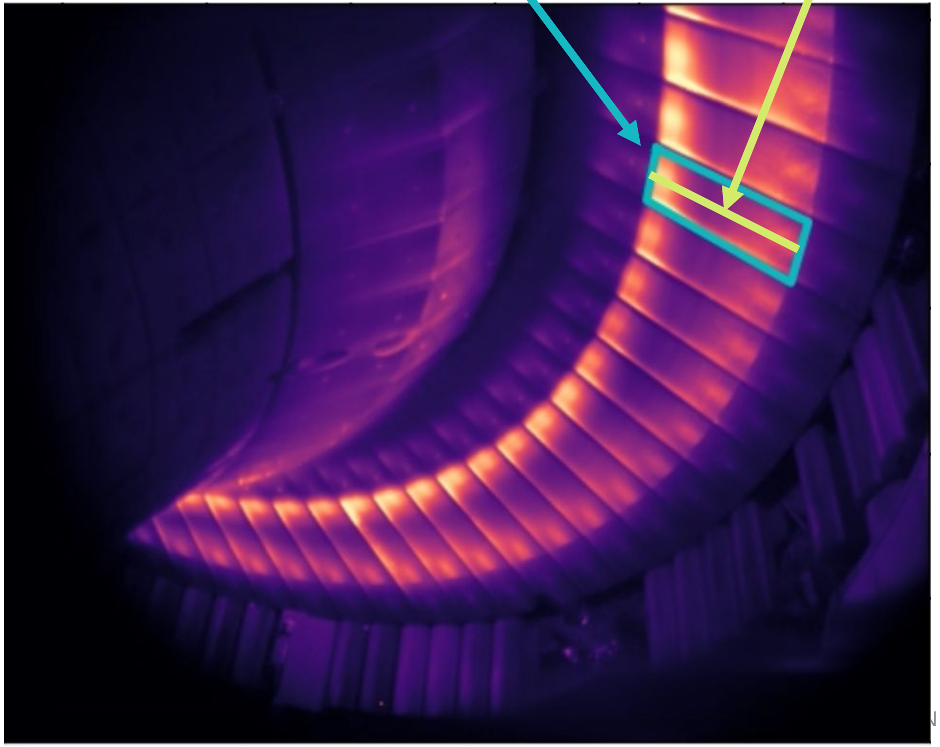

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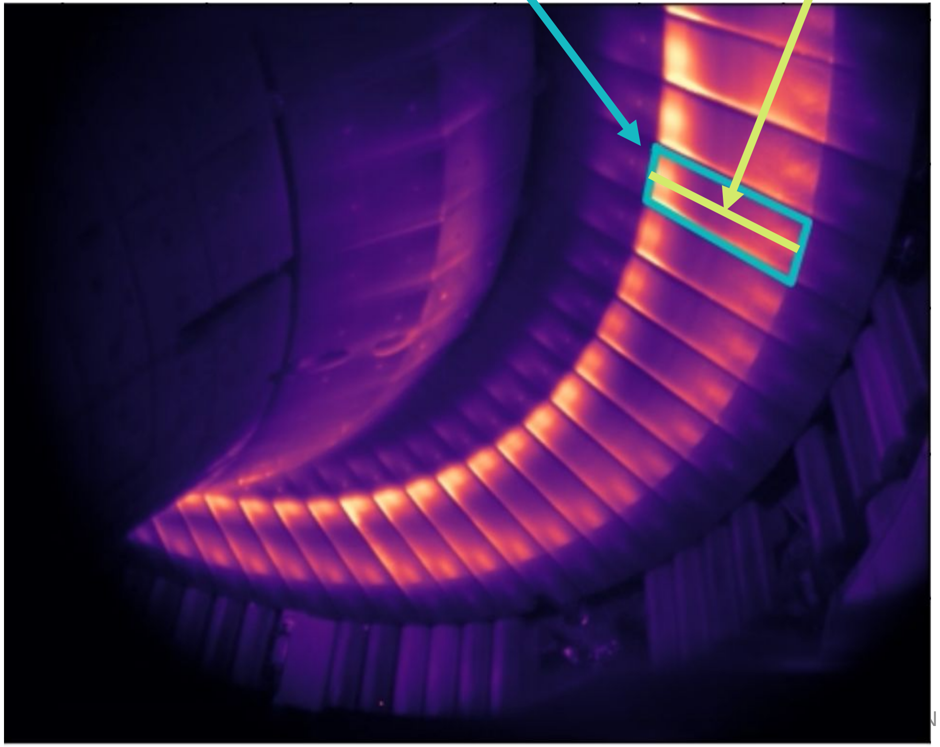

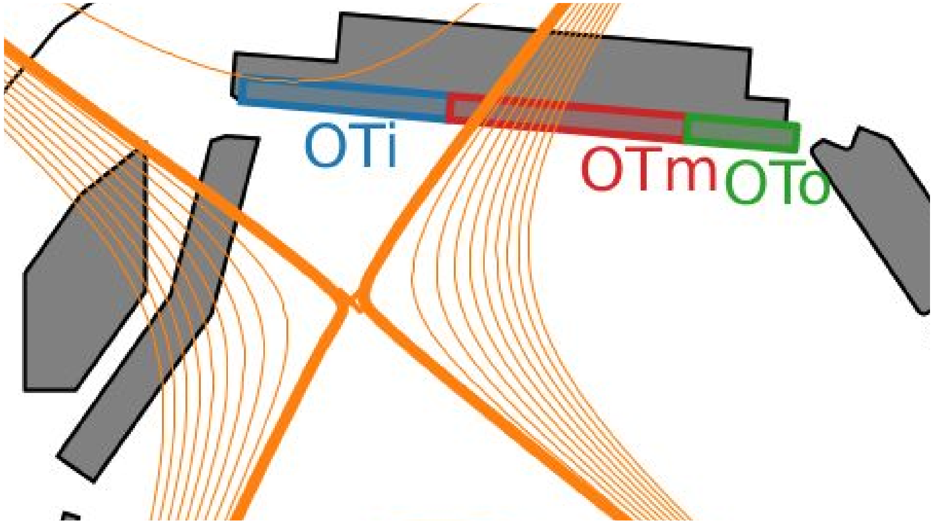

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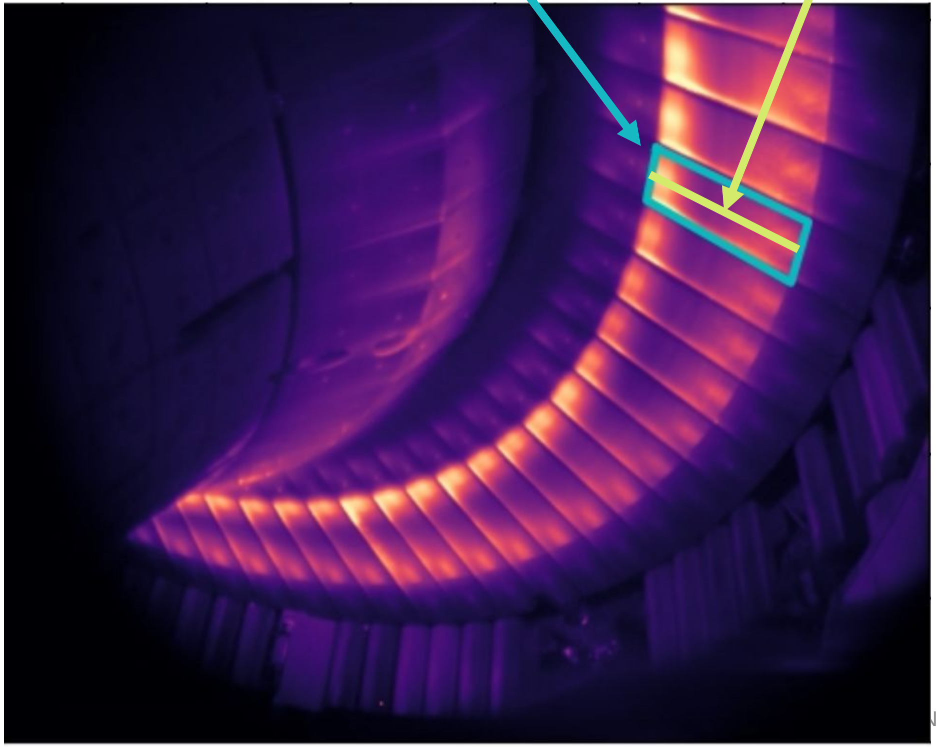
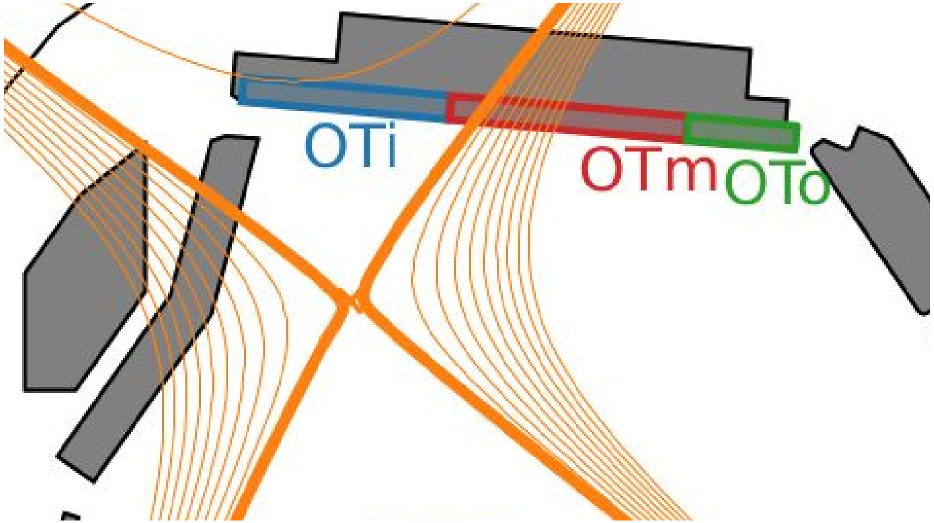
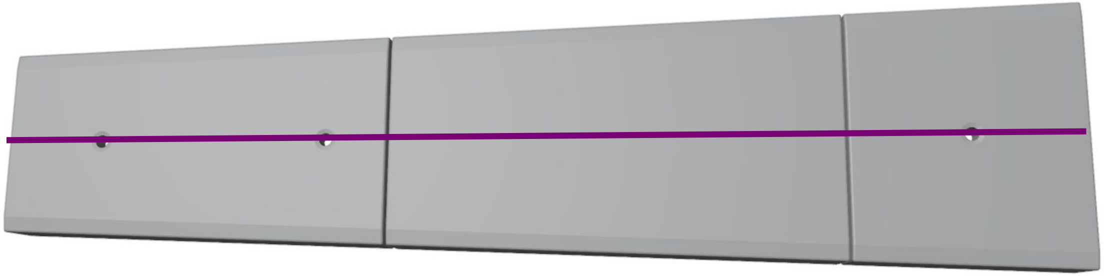
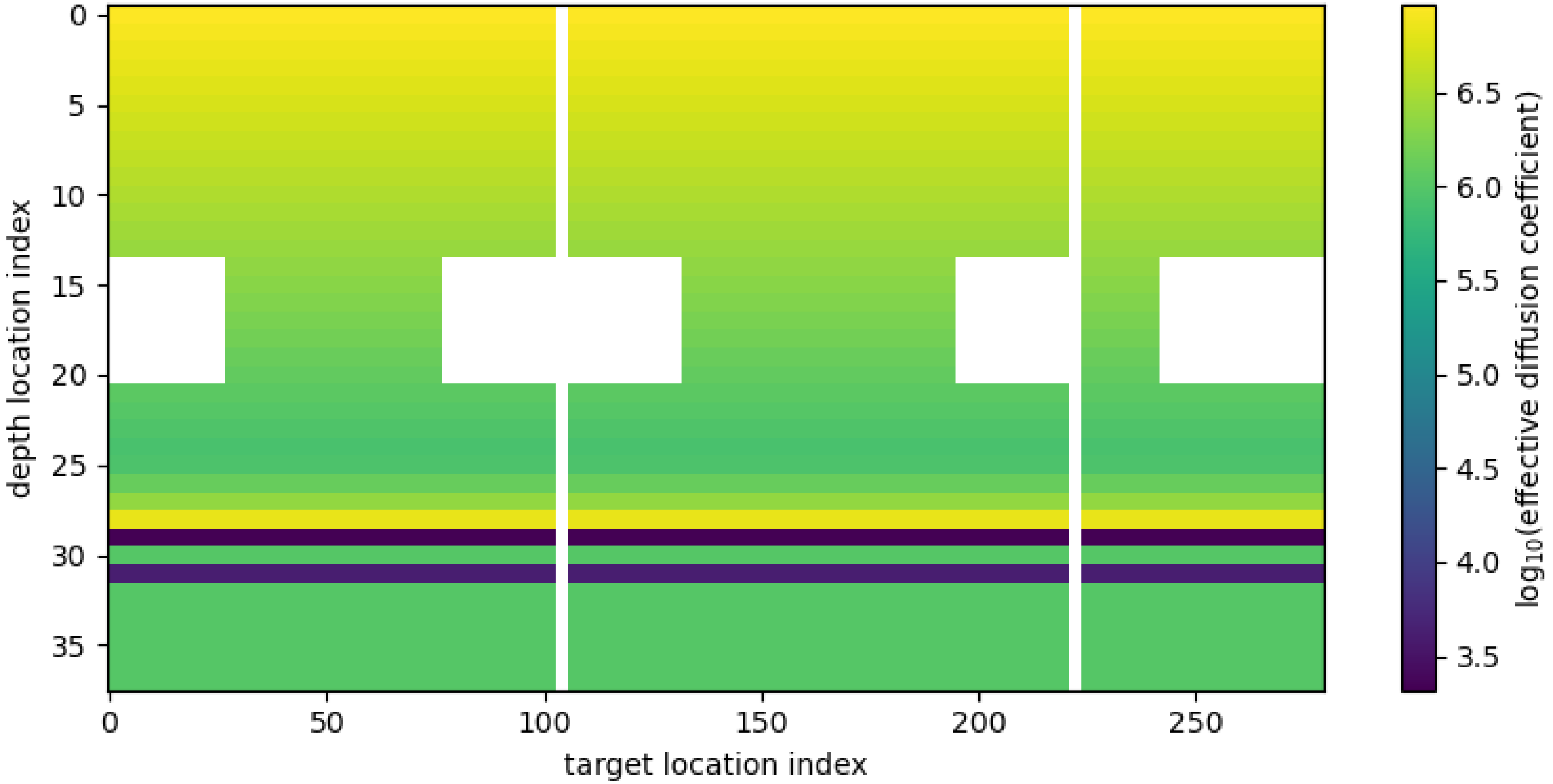






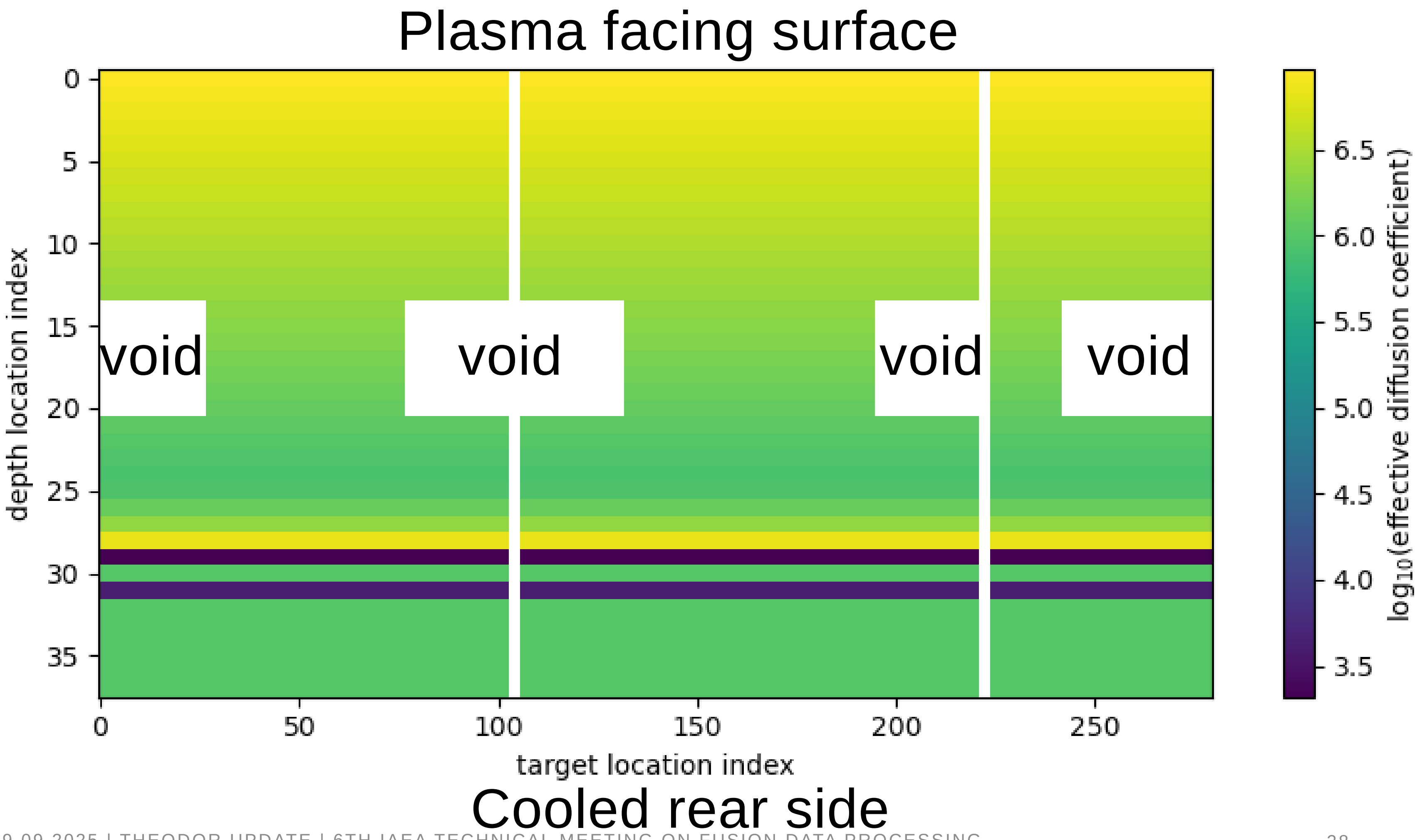
Coefficient cross-section

Plasma facing surface



Cooled rear side

Coefficient cross-section



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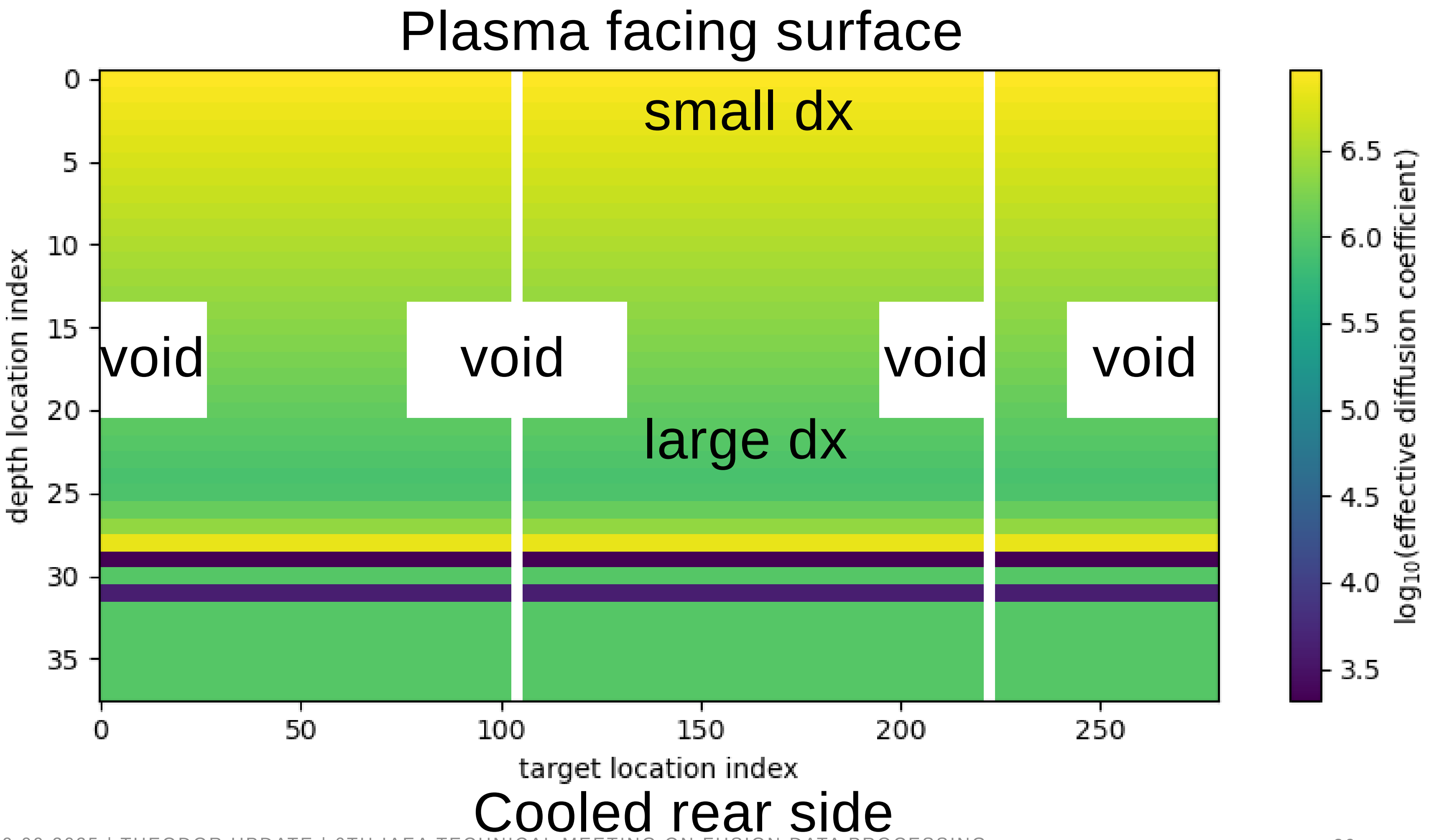

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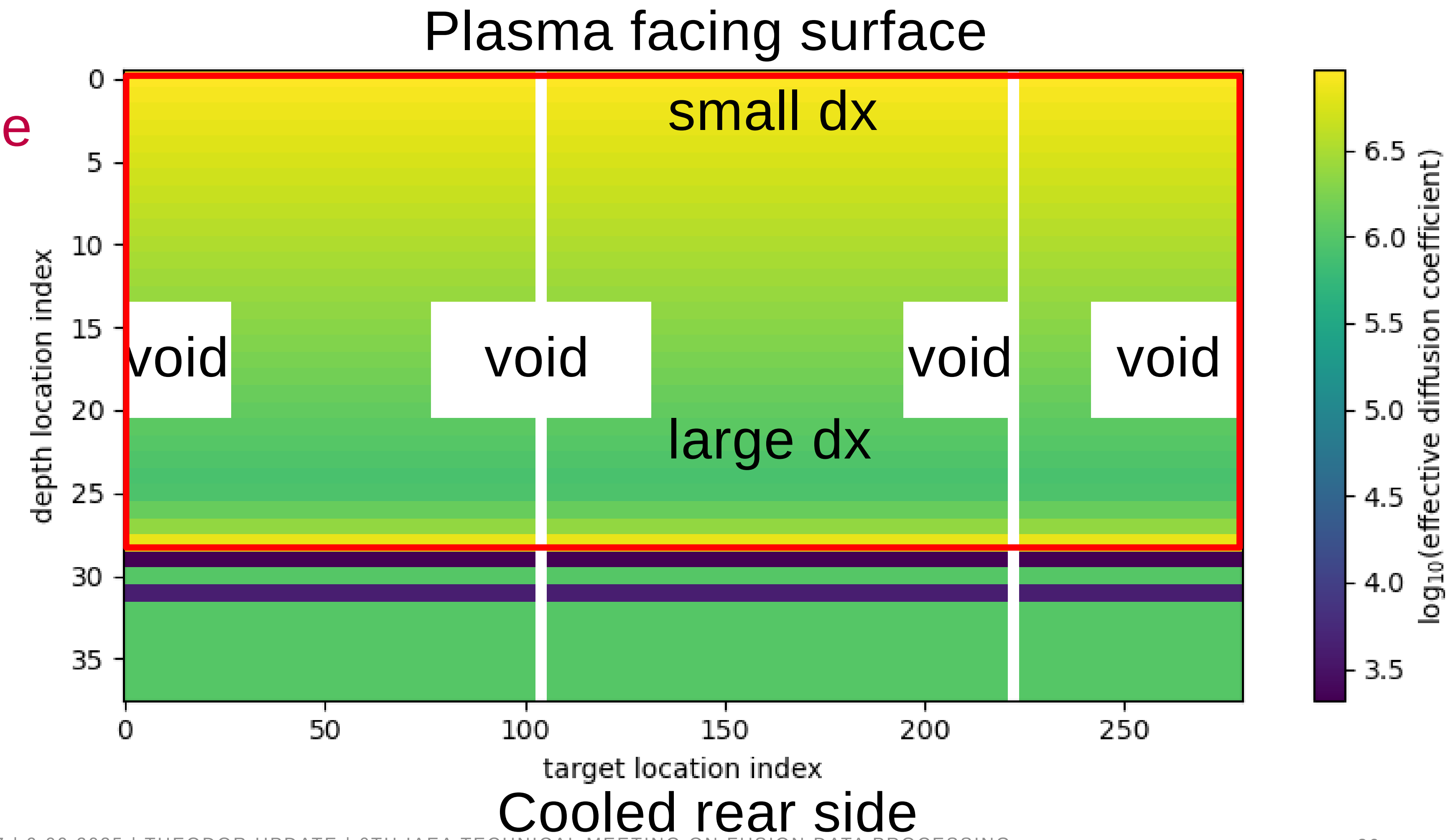

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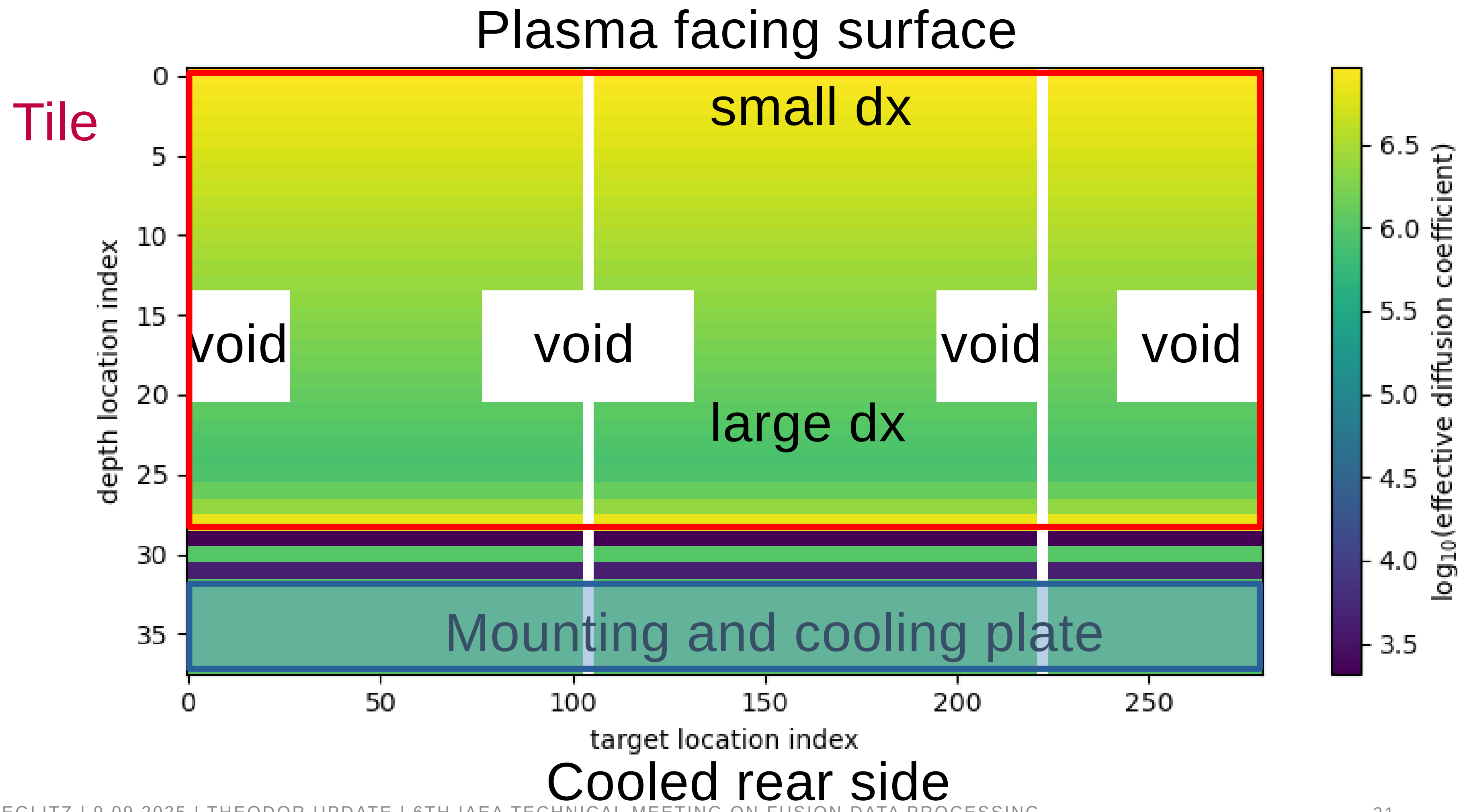

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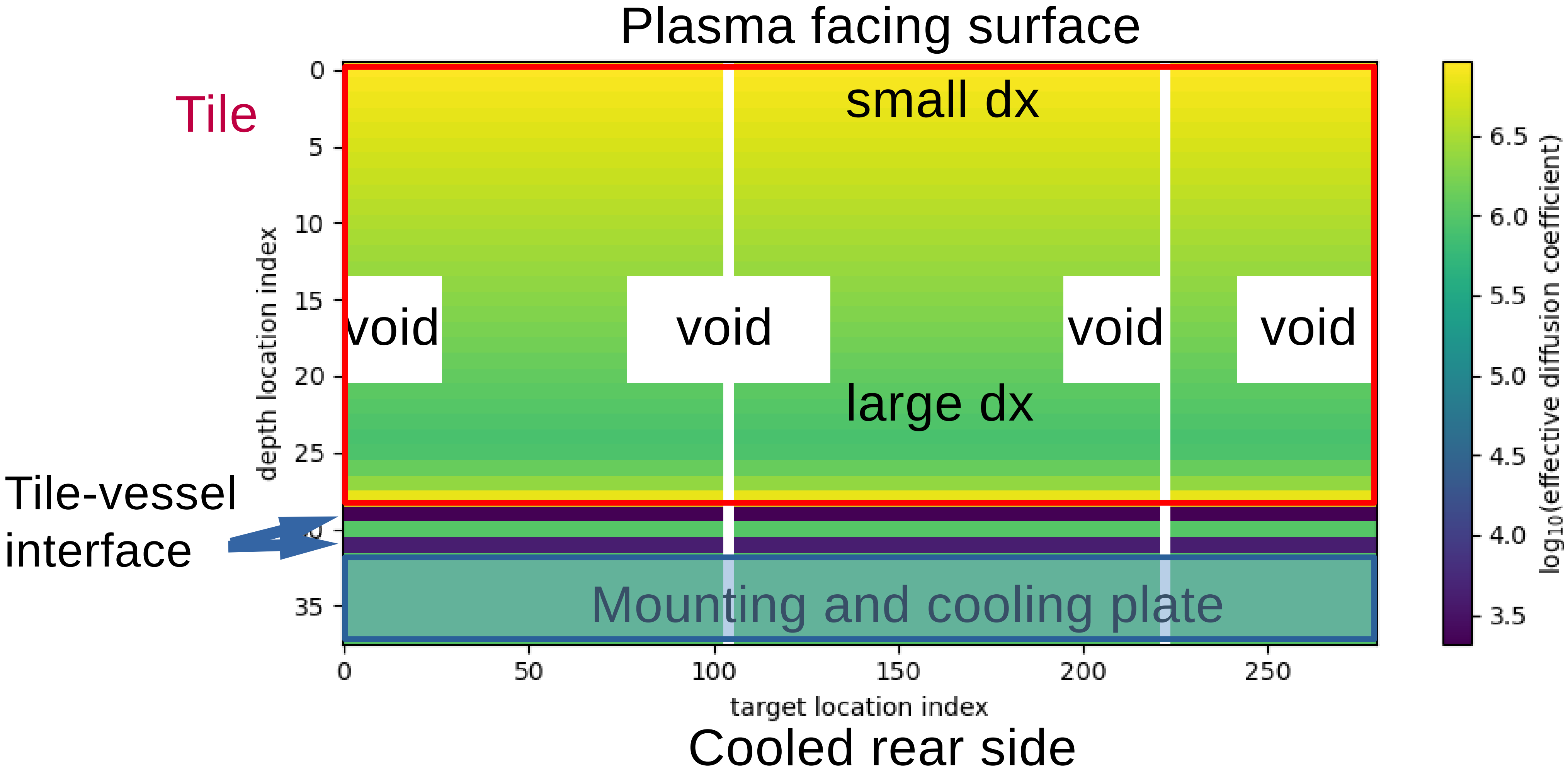

Workflow

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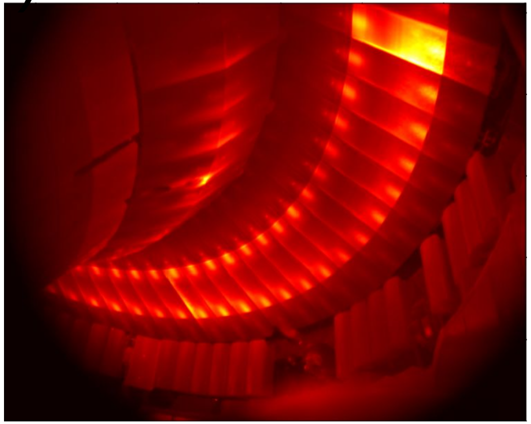

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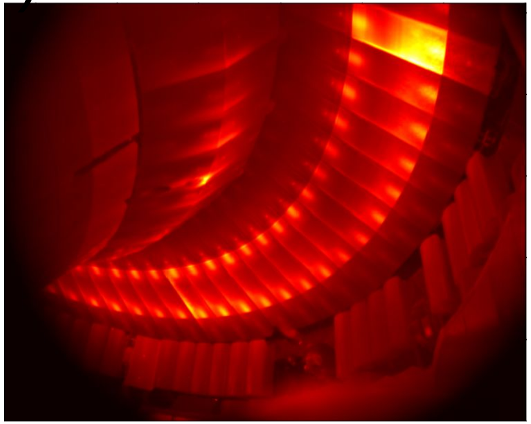

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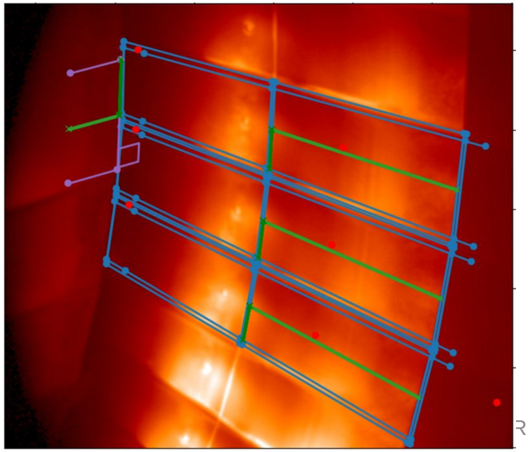

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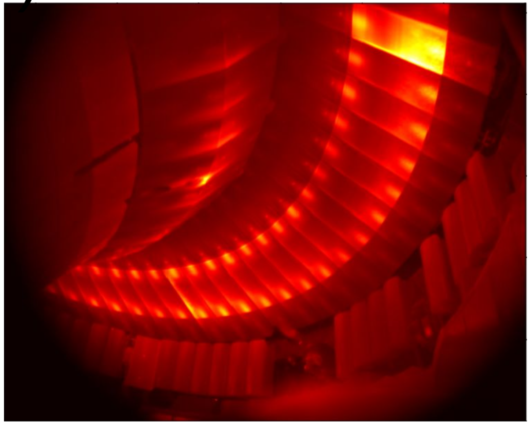

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Movment correction during resampling

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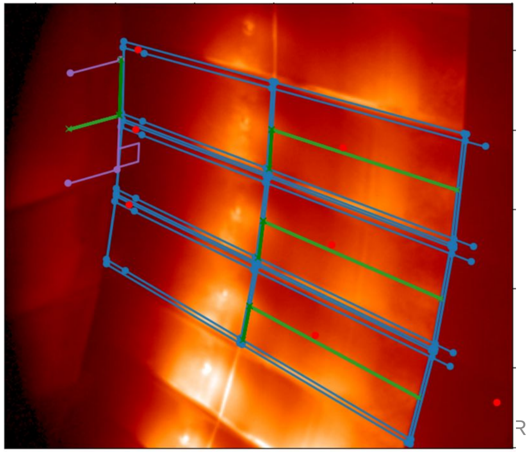

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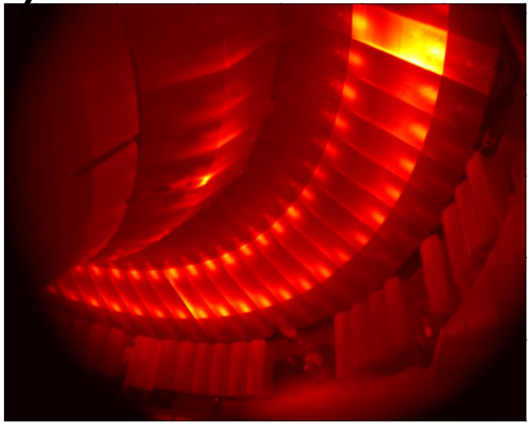

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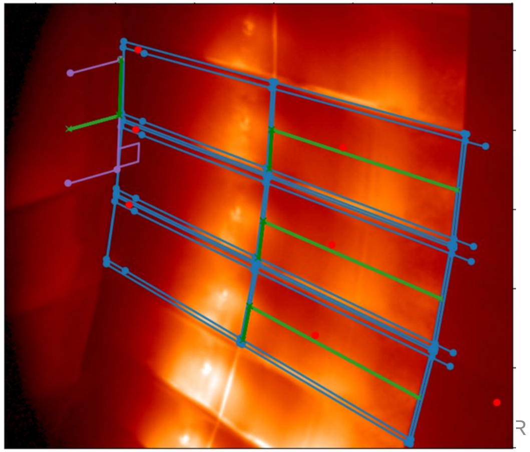
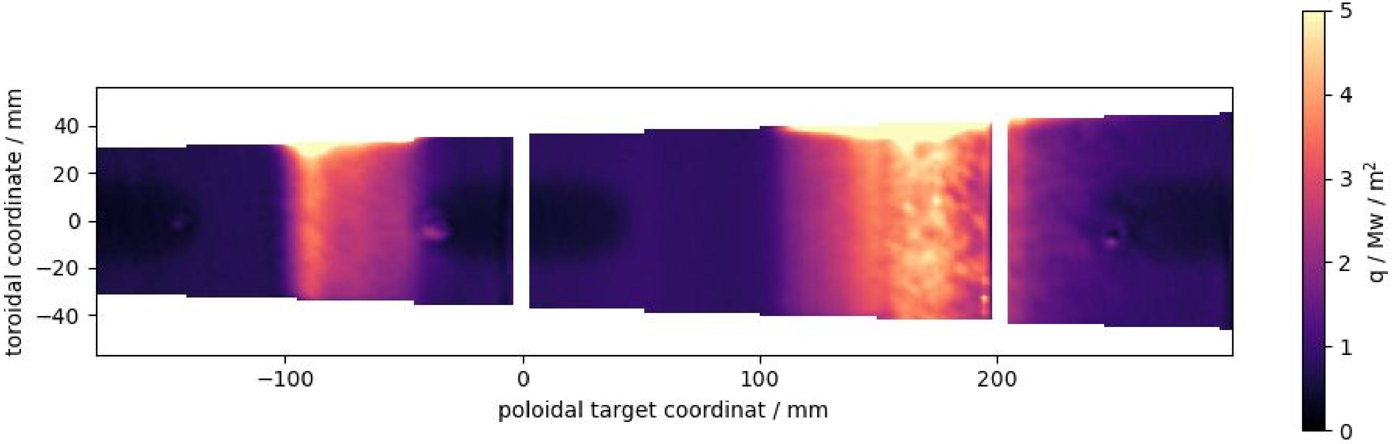
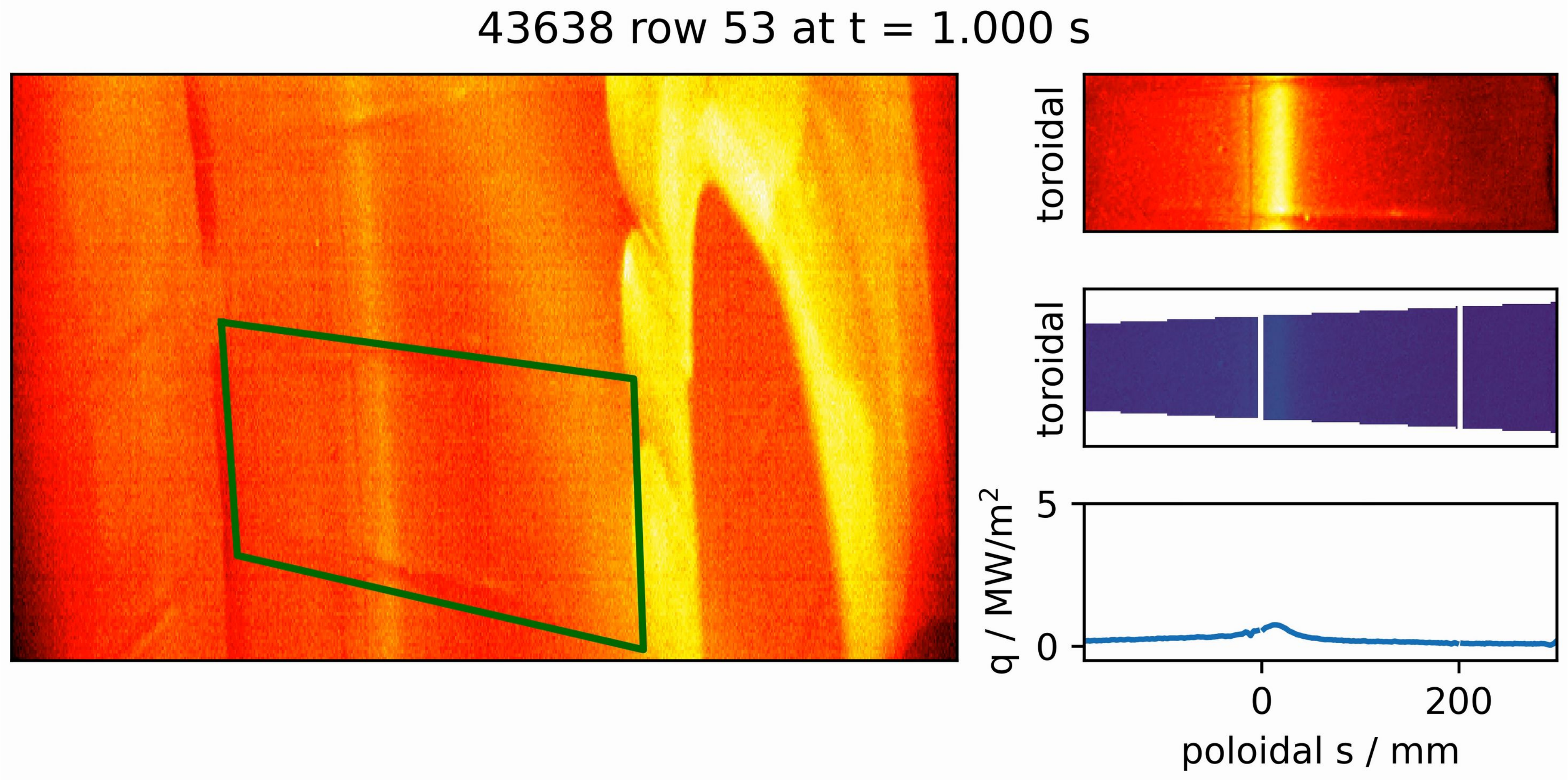


4) Run THEODOR



First results for new upper divertor

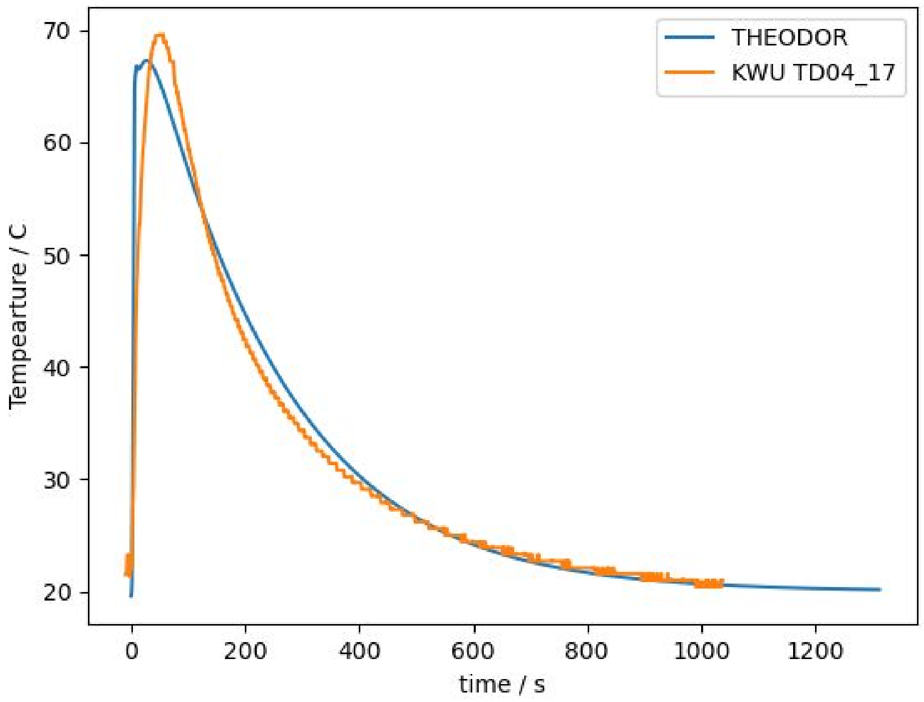


Thermocouple comparison – first steps

THEODOR models T-distribution
→ just read at TC location

To check/validate

- Thermal contact of TC to tile (graphite/ceramic based glue)
- Thermal contact tile to vessel
- IR emissivity
- Rear boundary condition



Outlook

- Open Sourcing Python THEODOR
  → people using THEODOR should update!
- Validation of thermal model (GLADIS heat flux tests with IR)
- Testing and validating of surface layers, thermal bridges/brakes, jumps in material properties → collaboration
- Proof: surface layers → improved resolution, no low pass

Summary / Conclusions

- THEODOR gained many abilities, established and improving
- Adapted to non-trivial geometry of new divertor in AUG
- Same tool for all geometries: validated and consistent