ABLAMOD

Advanced Ablation Characterization and Modelling

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as coordinators and representative of the ABLAMOD team

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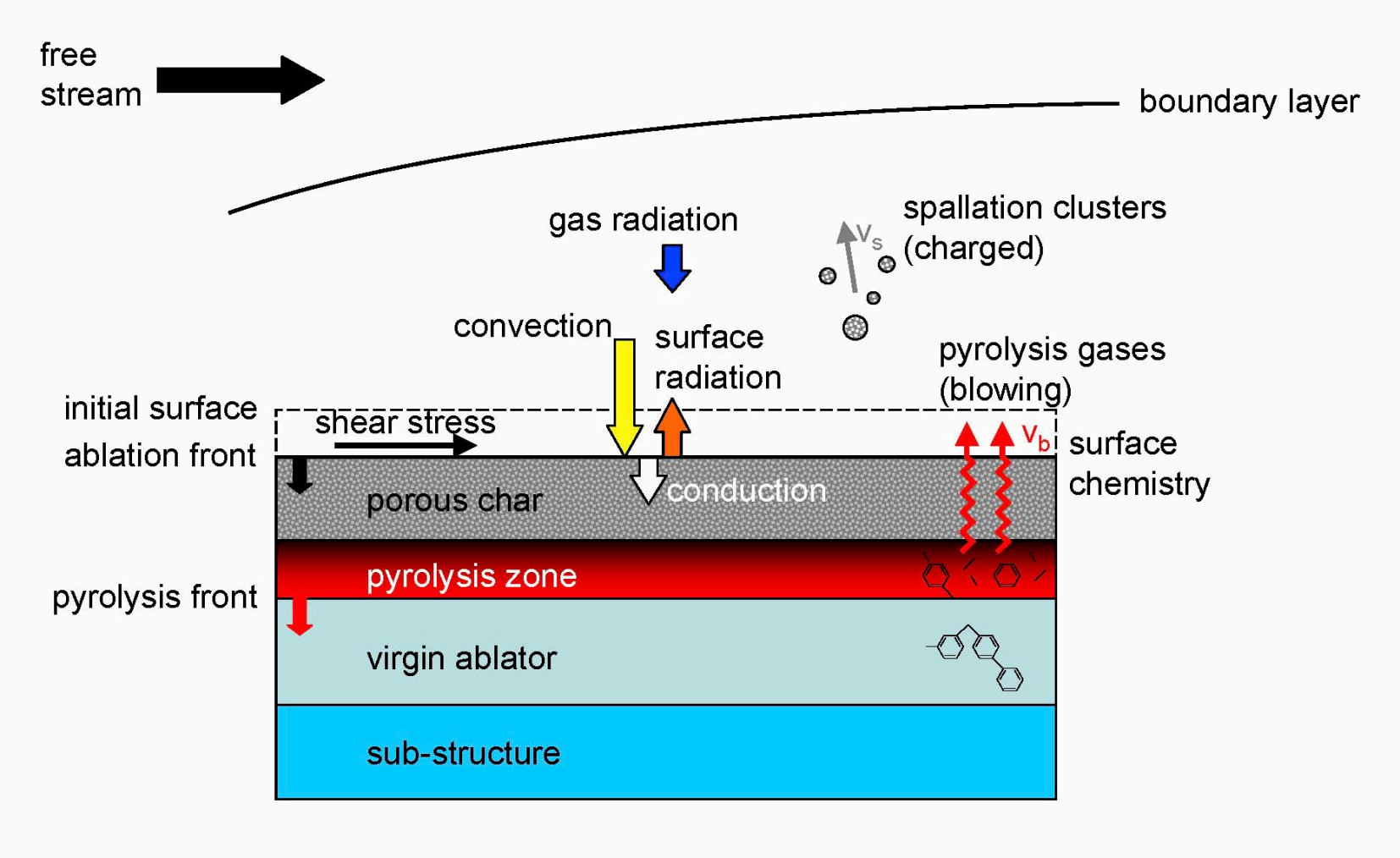
Overview

- Motivation
- Objectives
- Material thermal characterization
- Ablation tests
- Diagnostics for flow characterization
- Modelling and numerical simulation
- Coupling of different modules
- Concluding remarks and next steps

Motivation

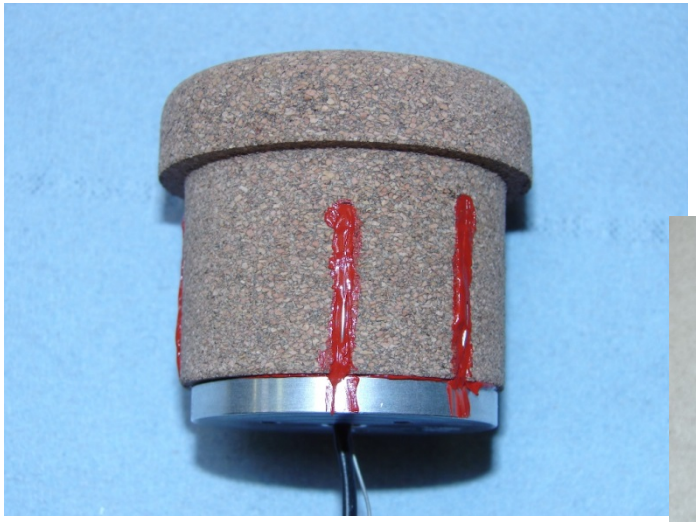

free
stream
boundary layer
gas radiation
spallation clusters
(charged)
v_s
convection
surface
radiation
pyrolysis gases
(blowing)
initial surface
ablation front
shear stress
v_b
surface
chemistry
porous char
conduction
pyrolysis zone
pyrolysis front
virgin ablator
sub-structure

Motivation

ABLAMOD Objectives

- Design and manufacturing of instrumented material samples of carbon, silicon and cork based ablators
- Thermal characterization of samples before and after ablation tests
- Ablation tests on ablators samples at well characterized test conditions using novel diagnostics in arc heated facilities
- Improvement of modelling with respect to ablator internal flow, transport properties and gas surface interaction
- Coupling of new modules with the baseline ablator code FABLE and flow solvers

Samples of ablation tests

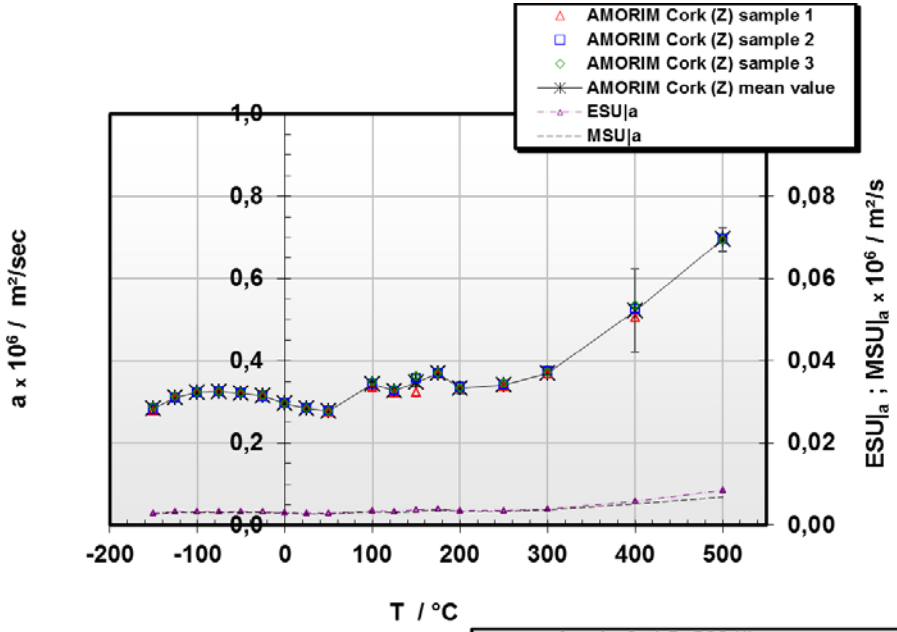


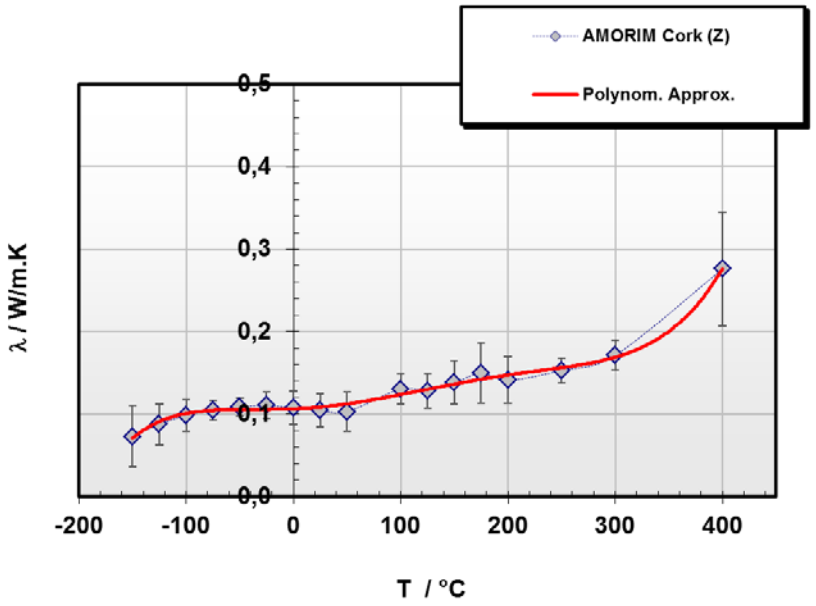
TPS3L Sample
(cork based)

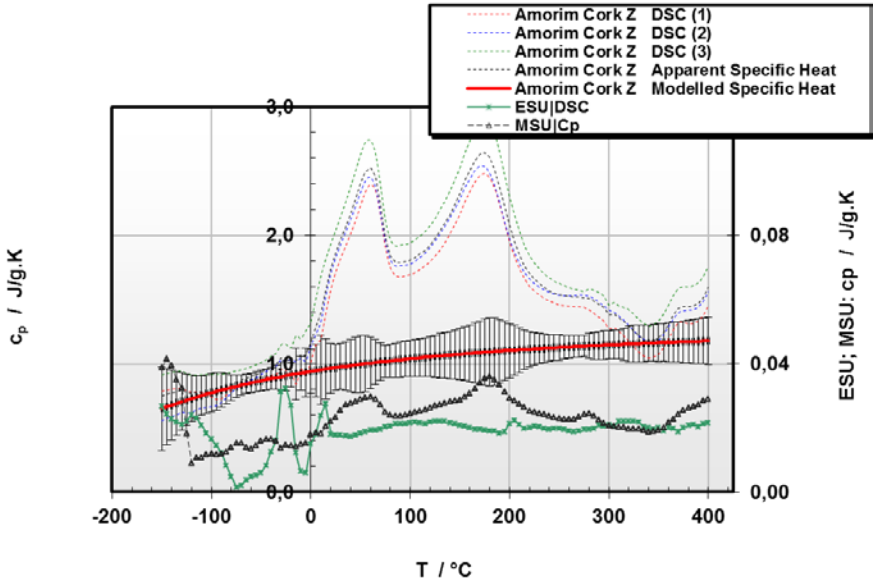
ASTERM
(carbon based)

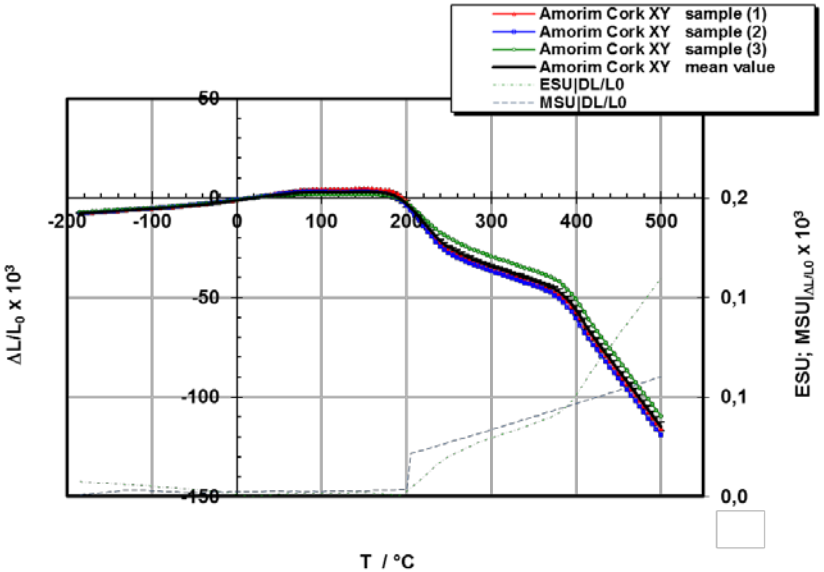
SV2
(silicon based)

Determination of thermal properties by AIT

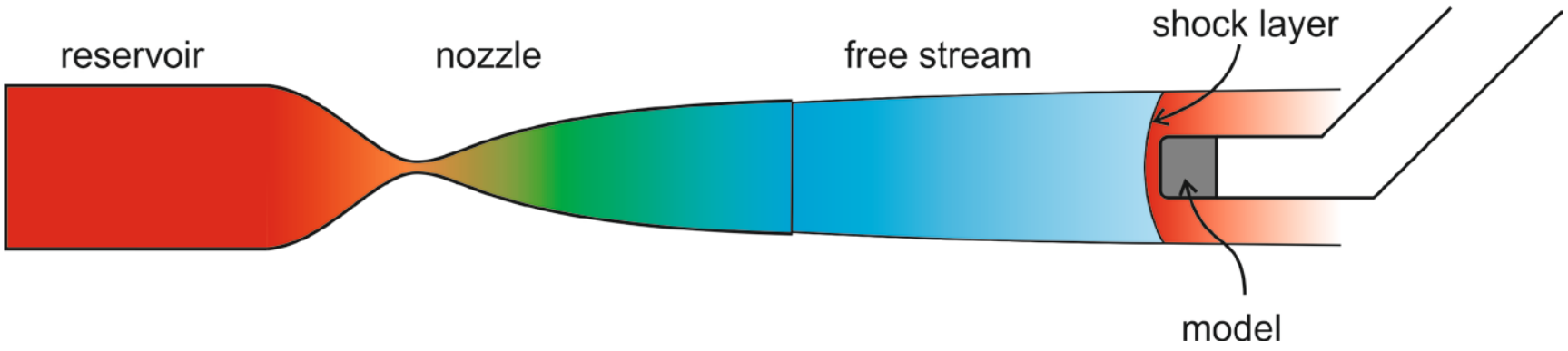




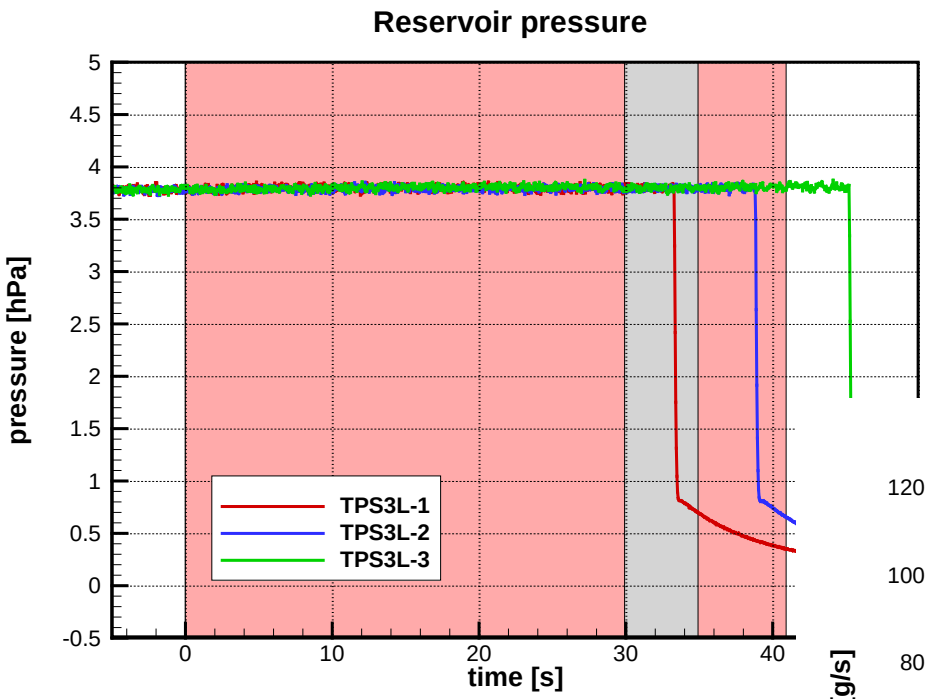


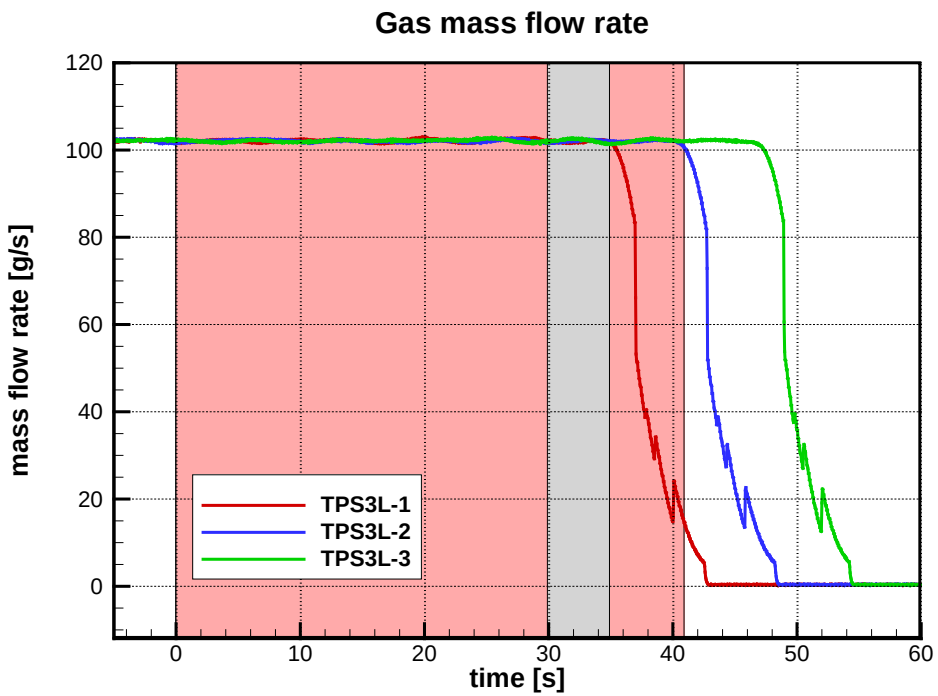


Ablation test environment

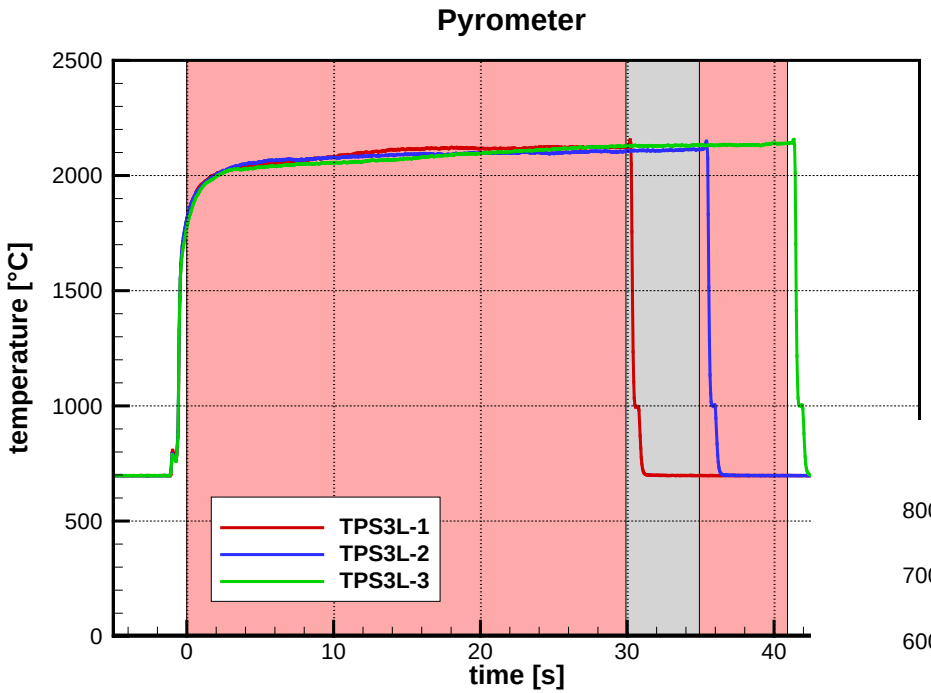


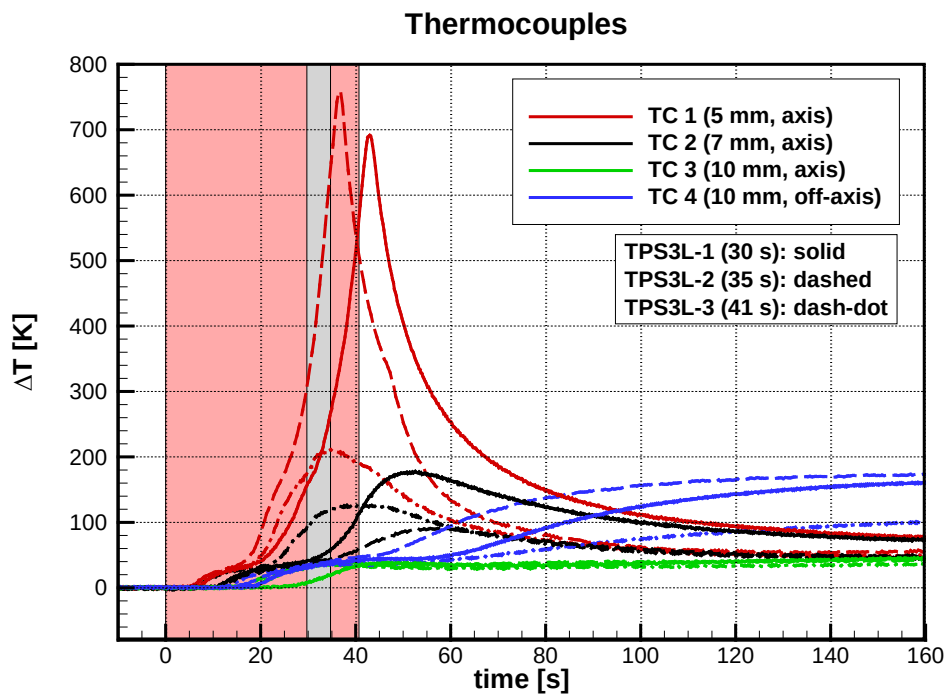
Setting flow parameters of ablation tests in L3K



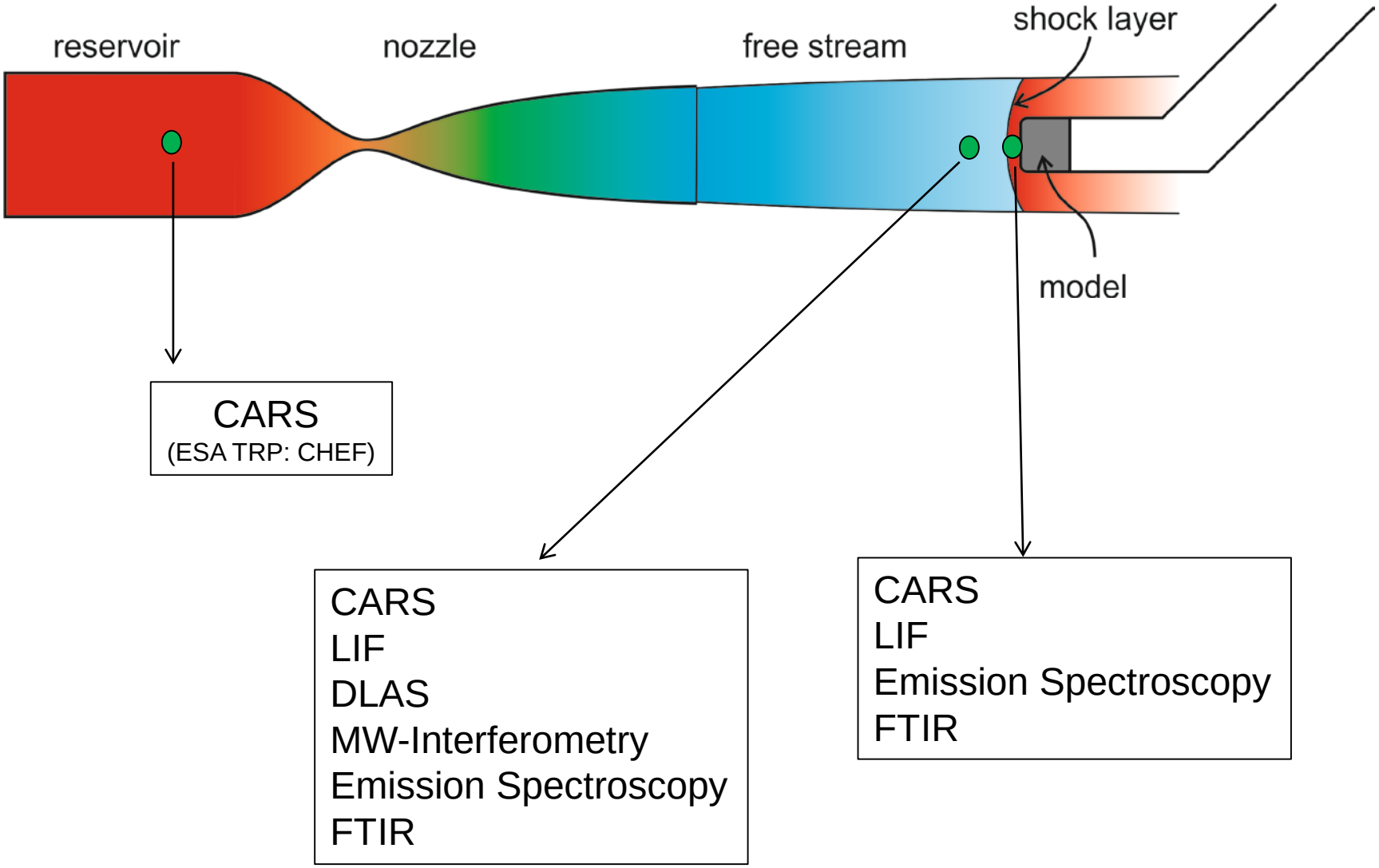


Ablation tests in L3K

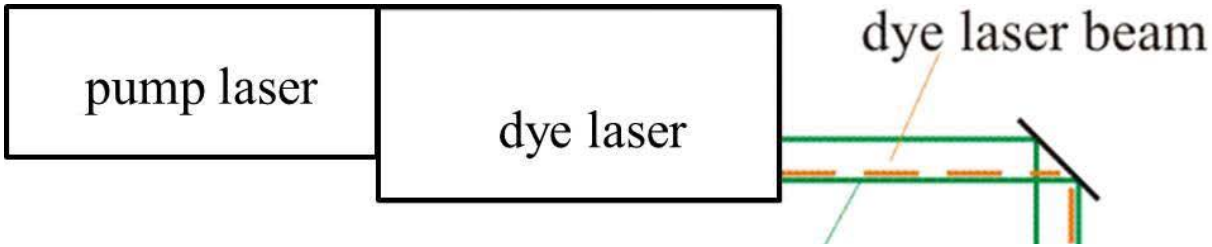


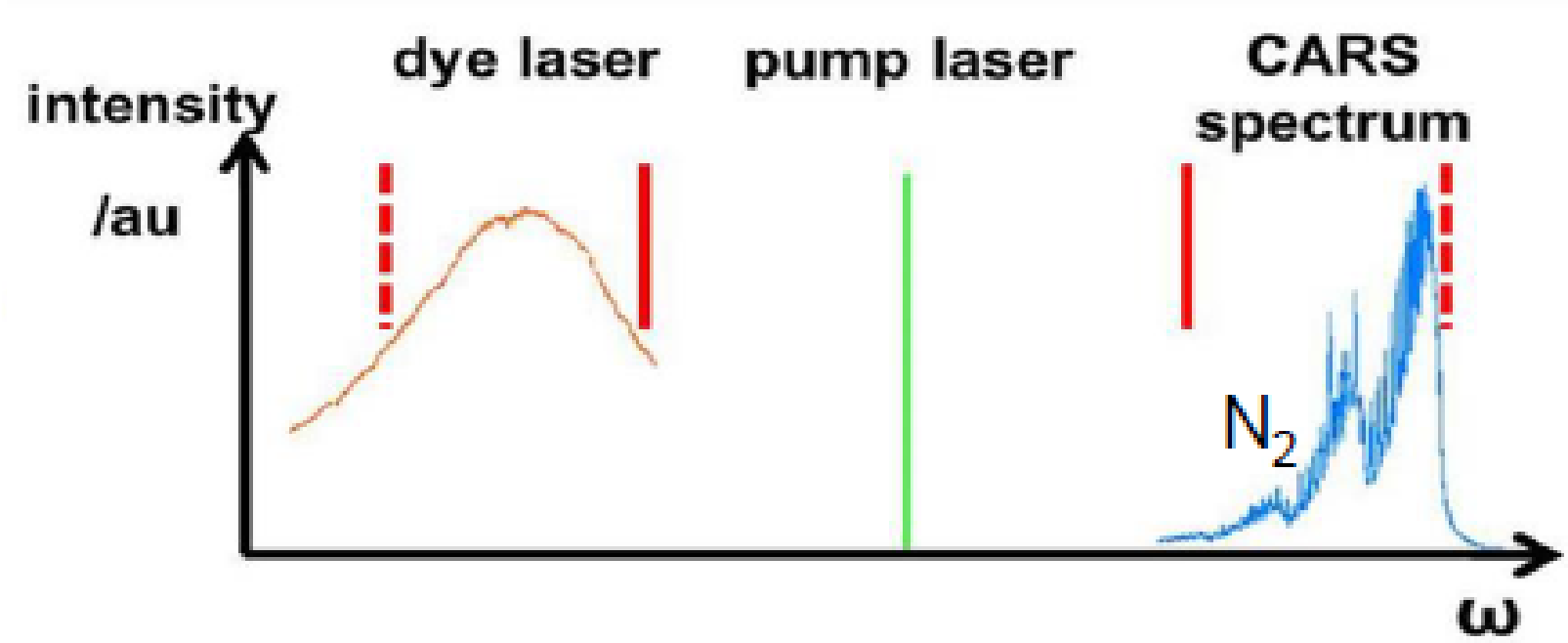


Diagnostics for flow characterization



CARS flow characterization in L3K



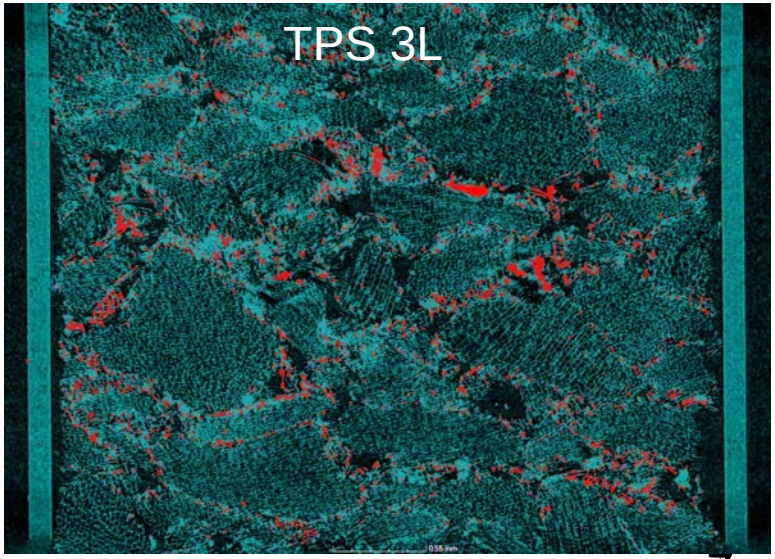


$$\omega_{CARS} = 2\,\omega_{pump\ laser} - \omega_{dye\ laser}$$

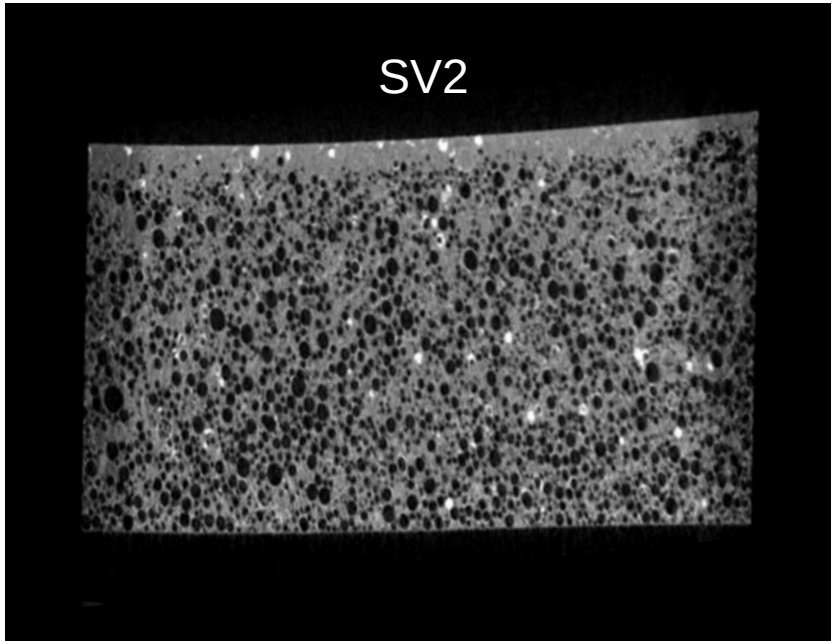
CARS flow characterization in L3K

Computer Tomography (CT) of the samples before testing by ÖGI

First CT have been performed on TPS3L and SV2 showing expected different microstructure



Plastic container (straw)



Resolution: 4 µm

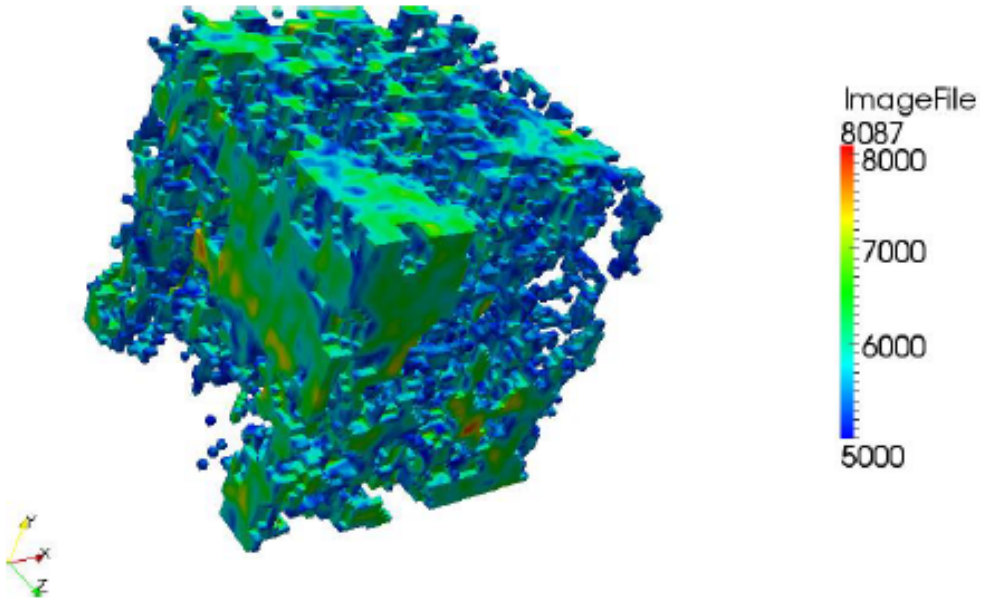
cyan = lower density material
red = higher density material
black = air

dark grey = lower density material
light grey = higher density material
black = air

Mesh Creation from measured CT data

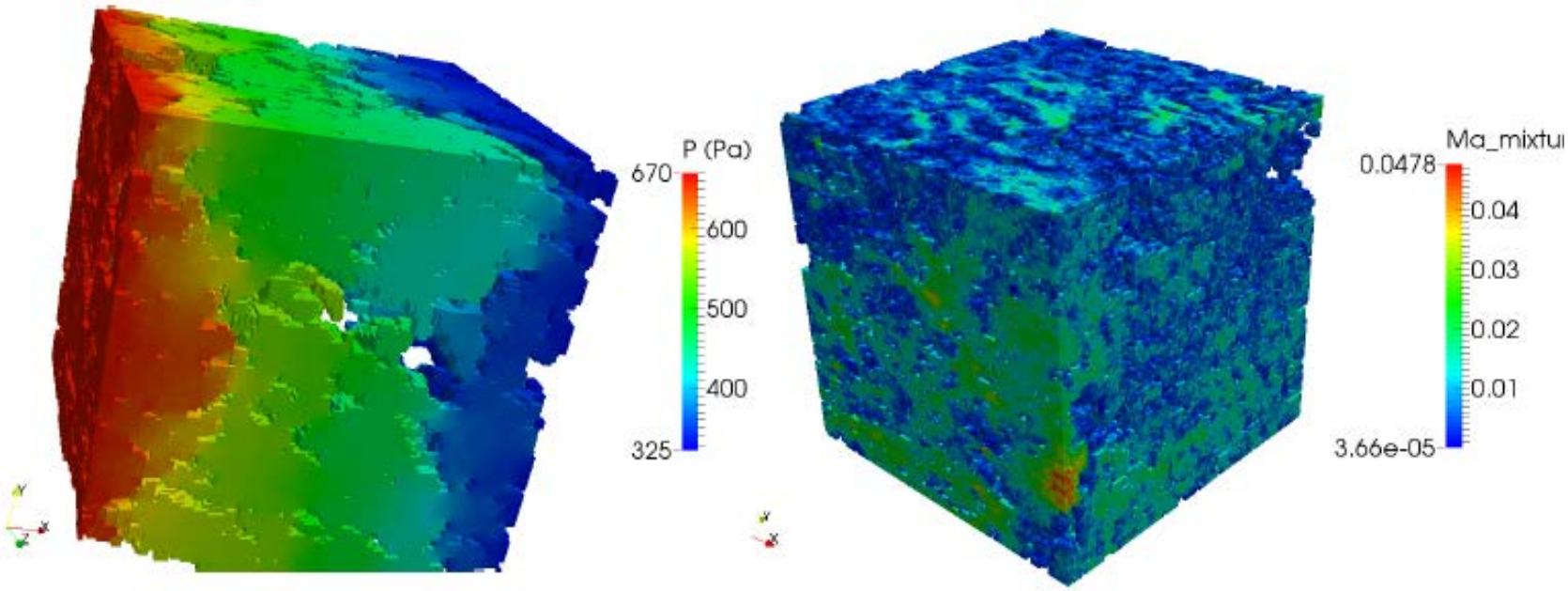
Creating a DSMC Mesh From CT Scans

- Specific 3D regions of the full voxel data can then be extracted in Paraview
- Voxels below the threshold value are removed
- The remaining voxels are exported in .x3d format
- This is opened in MeshLab (also open source) and exported as a .stl file
- .stl files can be used by the *snappyHexMesh* tool in OpenFOAM



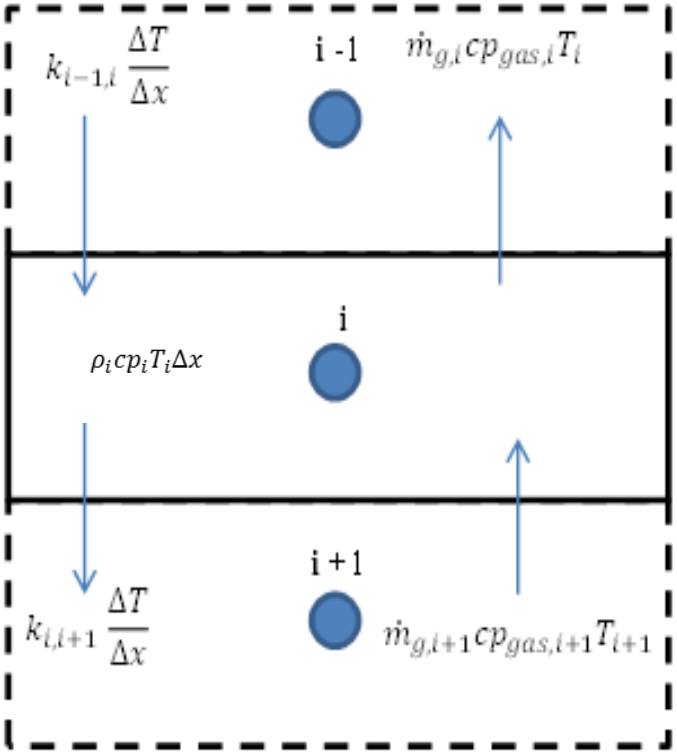
Permeability Determination

Measuring Permeability



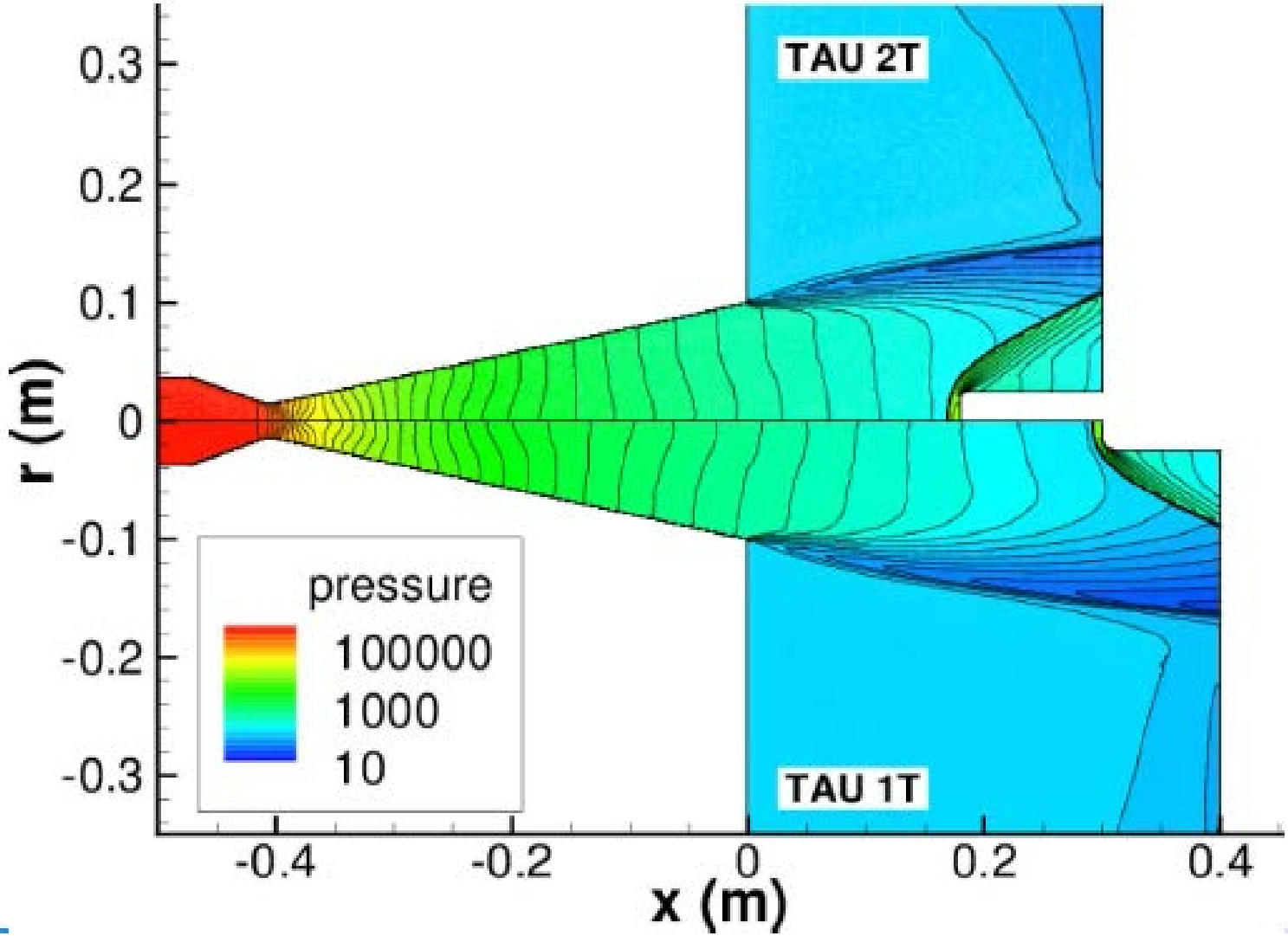
- Left, pressure contours across the 100^3 virgin carbon sample
- Right, Mach contours across the 100^3 virgin cork sample

Baseline Ablation Code FABL of FGE

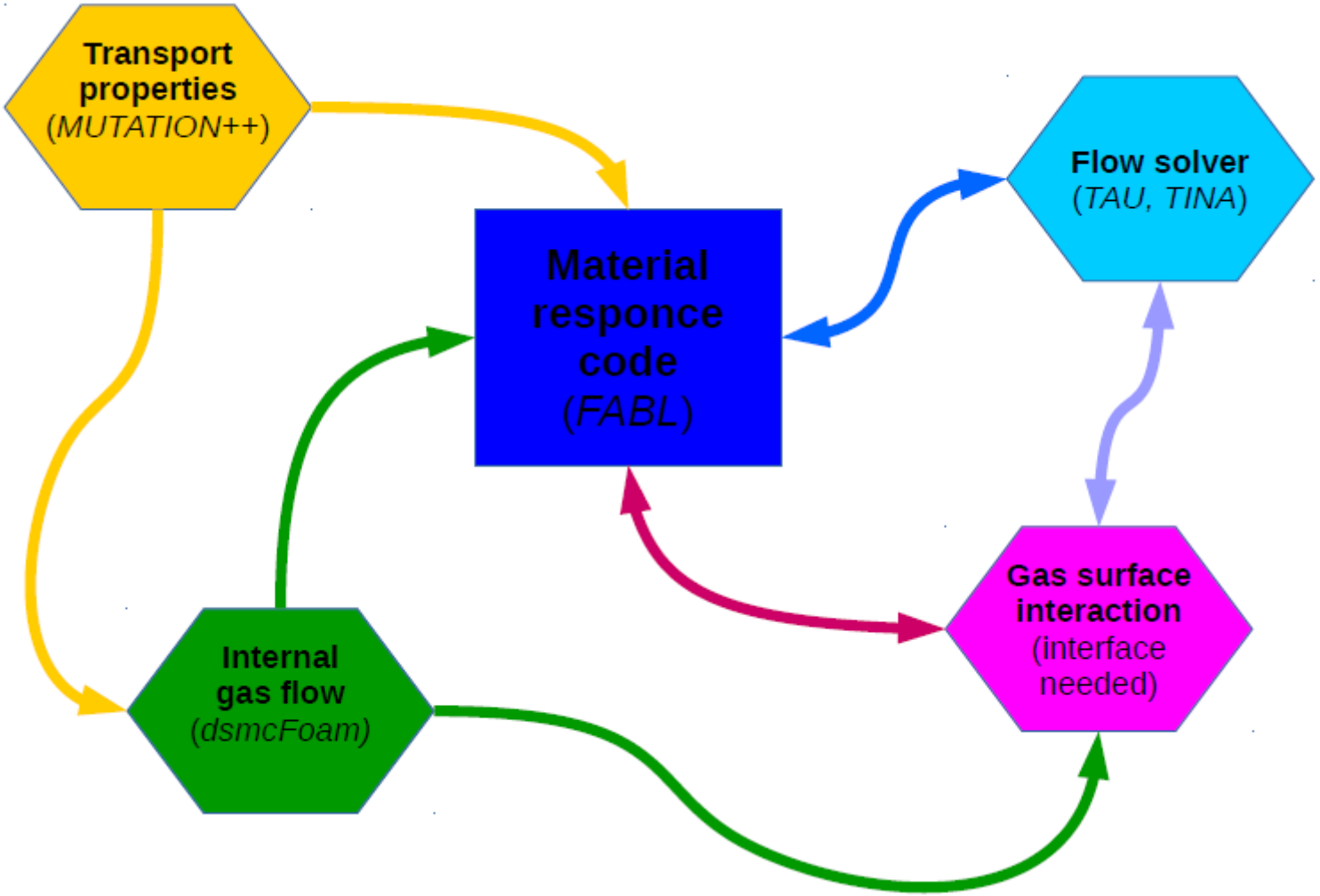


- Arrhenius rates used to describe the decomposition
  - Small number of equations assumed
  - Heating rate dependent – need an extra factor
- Conductivity and Cp calculated from the virgin and char properties (using density)
- No time dependent internal flow
  - Equilibrium
  - No distinguishing between reaction species

Pre-test CFD Simulation of Experiments



Coupling of different codes



Concluding remarks and next steps

- Thermal characterization before ablation testing has been carried out and microstructure of virgin material has been measured with CT
- Preliminary flow simulation has been performed and physical models are in preparation
- First ablation tests have been carried out
- Next steps
  - Flow characterization using spectroscopic methods
  - Further ablation tests
  - Completion of modelling tools and coupling
  - Simulation of experiments and extrapolation to flight

References

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