SPIS advancement proposal: Coupling to other open-source solvers, automation, cloud deployment

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Outline

PlasmaSolve
Simulation at the service of coating industry

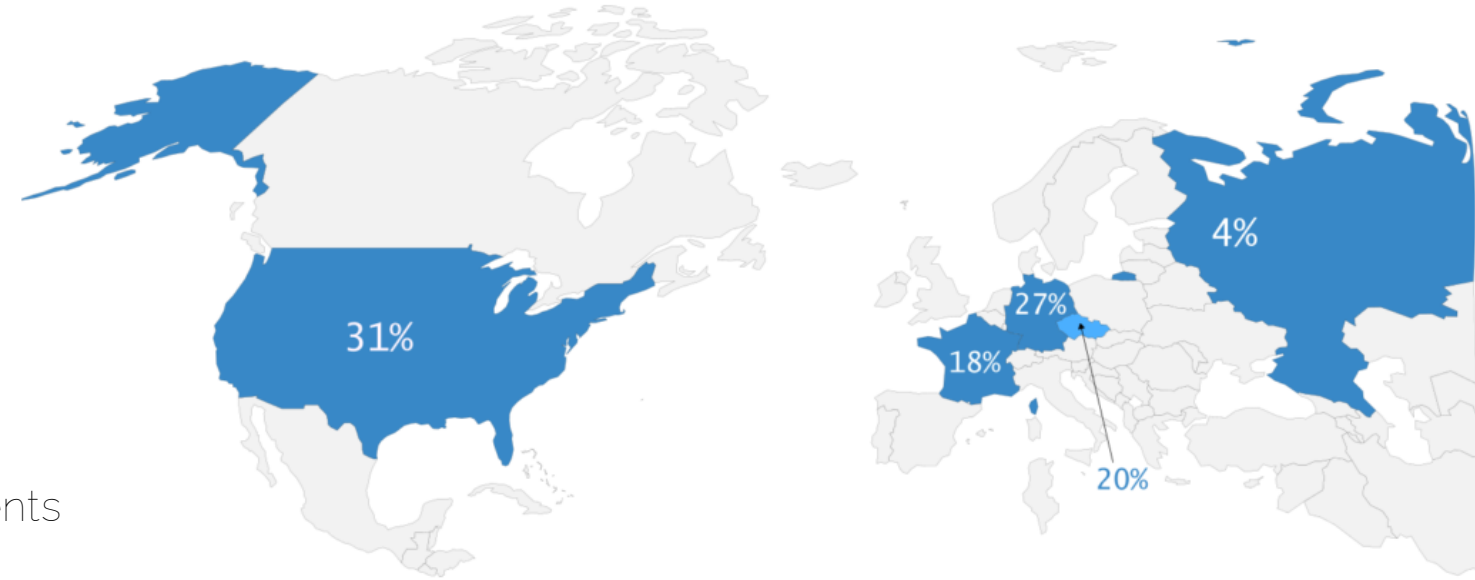
- About PlasmaSolve
- Why we want to use SPIS
- Complementary competence
  - Rarefied gas flow and sputtering physics
  - Automation and cloud deployment
- Project idea and conclusions

About PlasmaSolve

PlasmaSolve
Simulation at the service of coating industry

- Company objective: Develop „digital twin" simulation tools for technologies that leverage plasma. Our tools aim to be industry-grade in terms of speed and quantitative accuracy
- Clearly defined market segments: (1) plasma coating, (2) laboratory ion sources, (3) EP and space plasma?
- Agile and agnostic approach: Leveraging open-source tools and cloud computing

- Technology start-up based in Brno, CZ
- Started 4 yrs ago
- 5 people + 3 junior staff
- Bootstrapping startup = no outside investments



Our "space heritage" – The PlasmaJetPack

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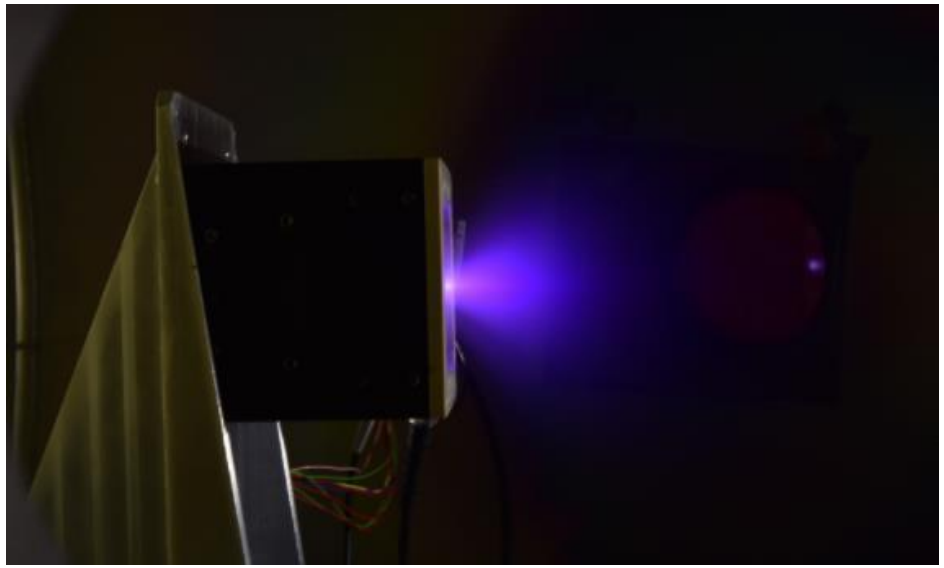
- International Horizon 2020 project
- Development of pulsed vacuum-arc thruster electric propulsion
- Aim to increase thrust by magnetic field
- Electric propulsion with solid propellant – sacrificial cathode
- IOD/IOV scheduled for 2021



comat GROUPE AGORA INDUSTRIES

OHB SWEDEN

cnrs

der Bundeswehr Universität München

ThalesAlenia Space

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Our "space heritage" – SpaceLabEU ABEP

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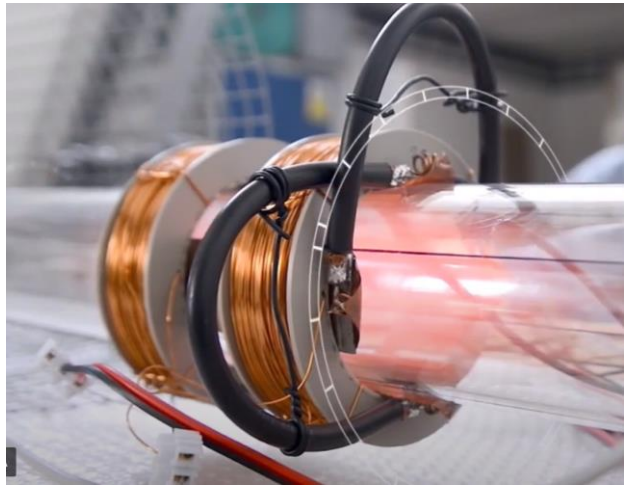
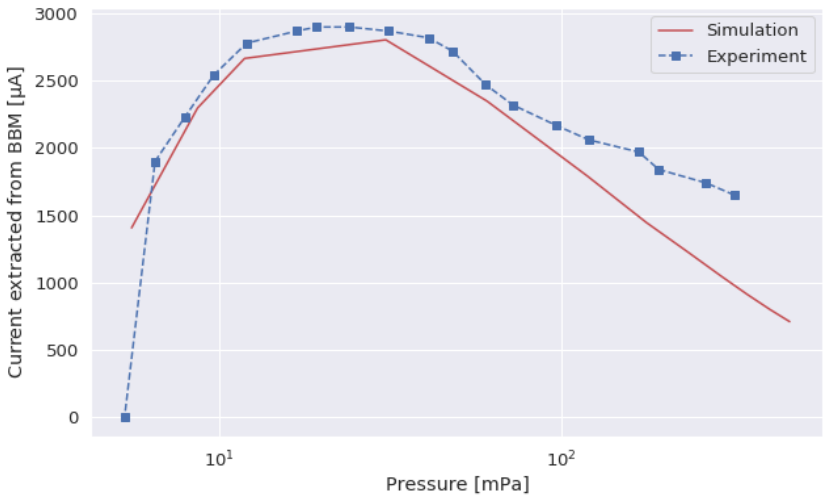
- Czech initiative for an air-breathing electric propulsion system
- Coordinated by SpaceLabEU SE and VZLU (Czech Aerospace Research Institute)
- Small but consistent private funding
- Achievements:
  - Breadboard model of high-efficiency ECR ion source
  - Plasma operation at 10 mPa and 4 watts
  - Implementation and validation of global plasma model for ECR in air
  - DSMC simulation of intake and rarefied flow at VLEO

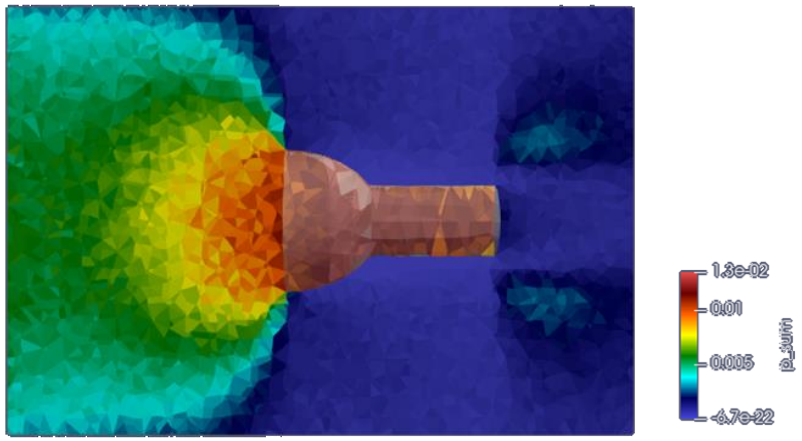
SPACELAB EU
Aerospace R&D and Commercialization

PlasmaSolve

VZLU







Why we want to use SPIS?

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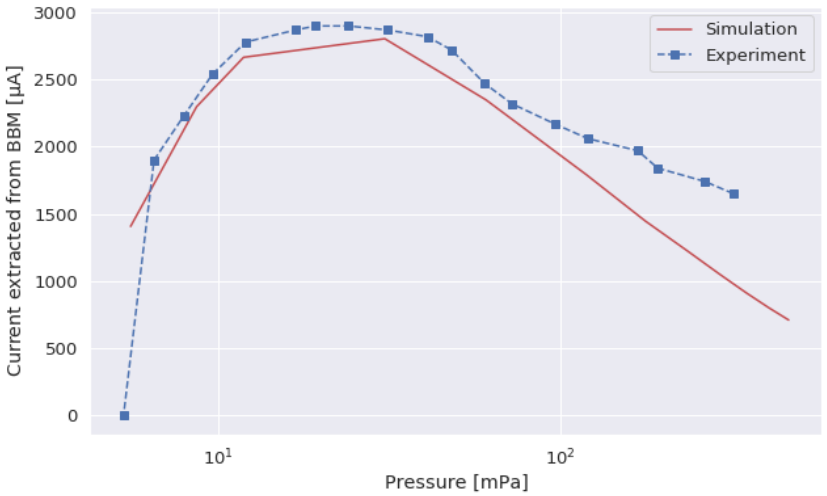

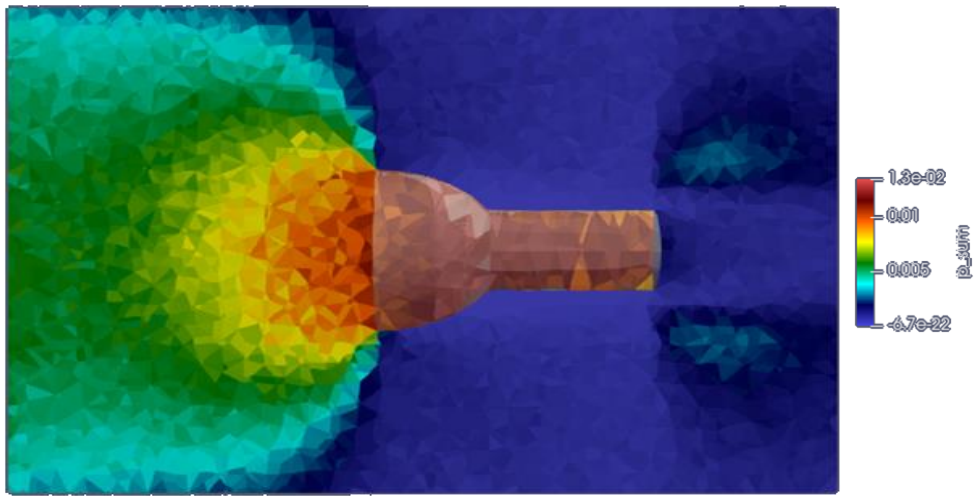

- Mostly because of the ABEP project
  - Interaction of plume with ABEP-powered spacecraft
  - Charging of ABEP-powered spacecraft
  - Extraction grids simulation
- Plus we like the open-source feeling of the community ☺.

Rarefield flow and sputtering physics

Rarefied flow and sputtering transport

PlasmaSolve
Simulation at the service of coating industry

- DSMC simulations for plasma coating industry
- Internal fork on dsmcFoam and dsmcFoamPlus solvers (to be published online once the documentation is better)

Rarefied flow and sputtering transport

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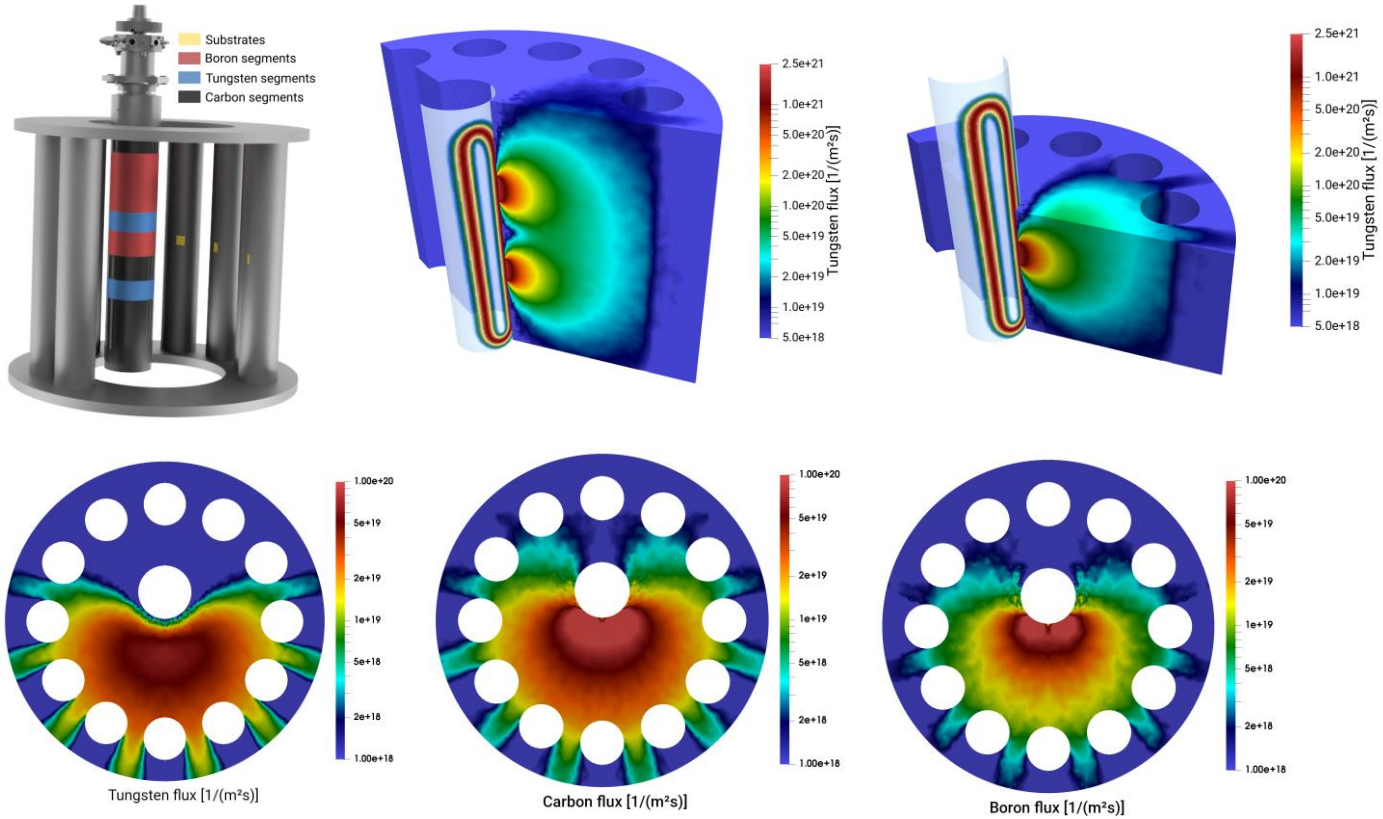
- Our additions:
    1. Advanced collision models and validation
    2. Advanced boundary conditions (particle injection, reactive BC)
    3. Dynamic load balancing
    4. Coupling layer to external solvers
    5. Surface physics with TRI(3)DYN



Density distribution for species of different weight – tungsten, carbon and boron.

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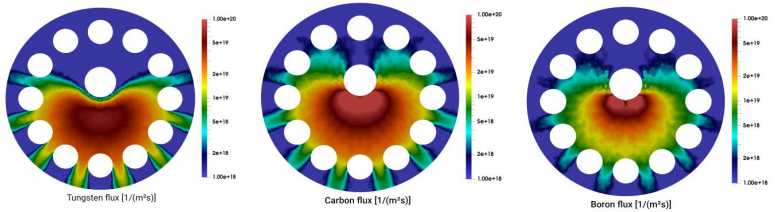

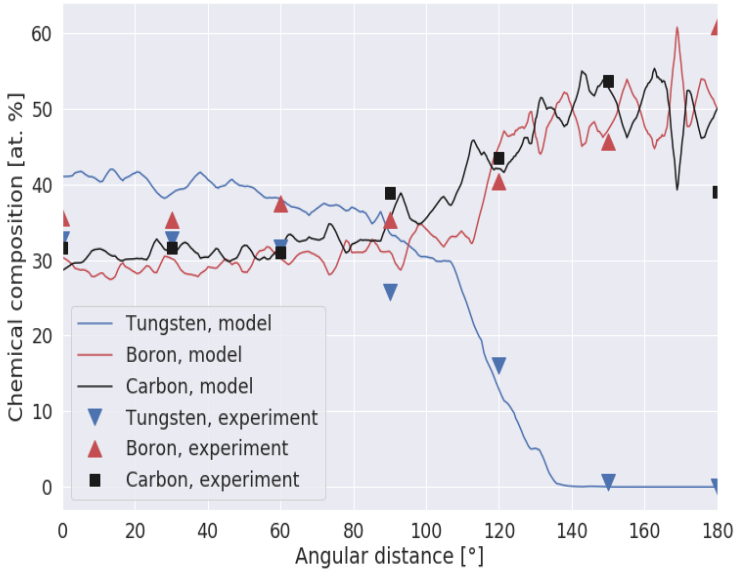

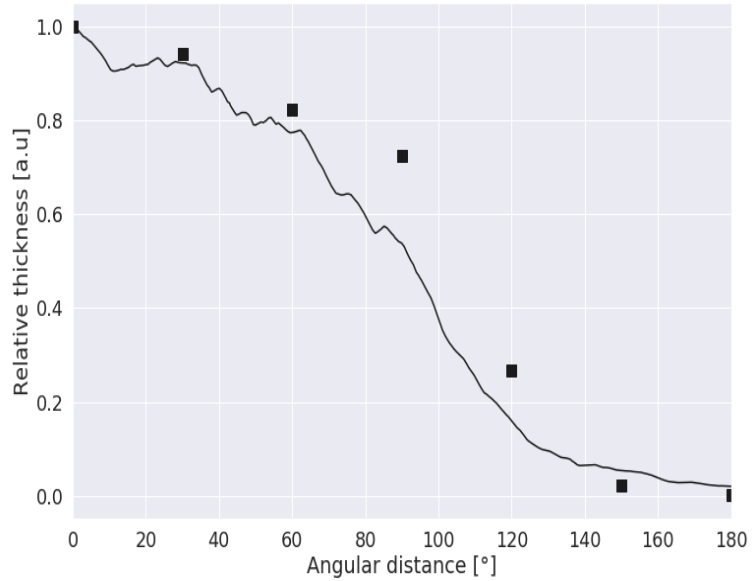

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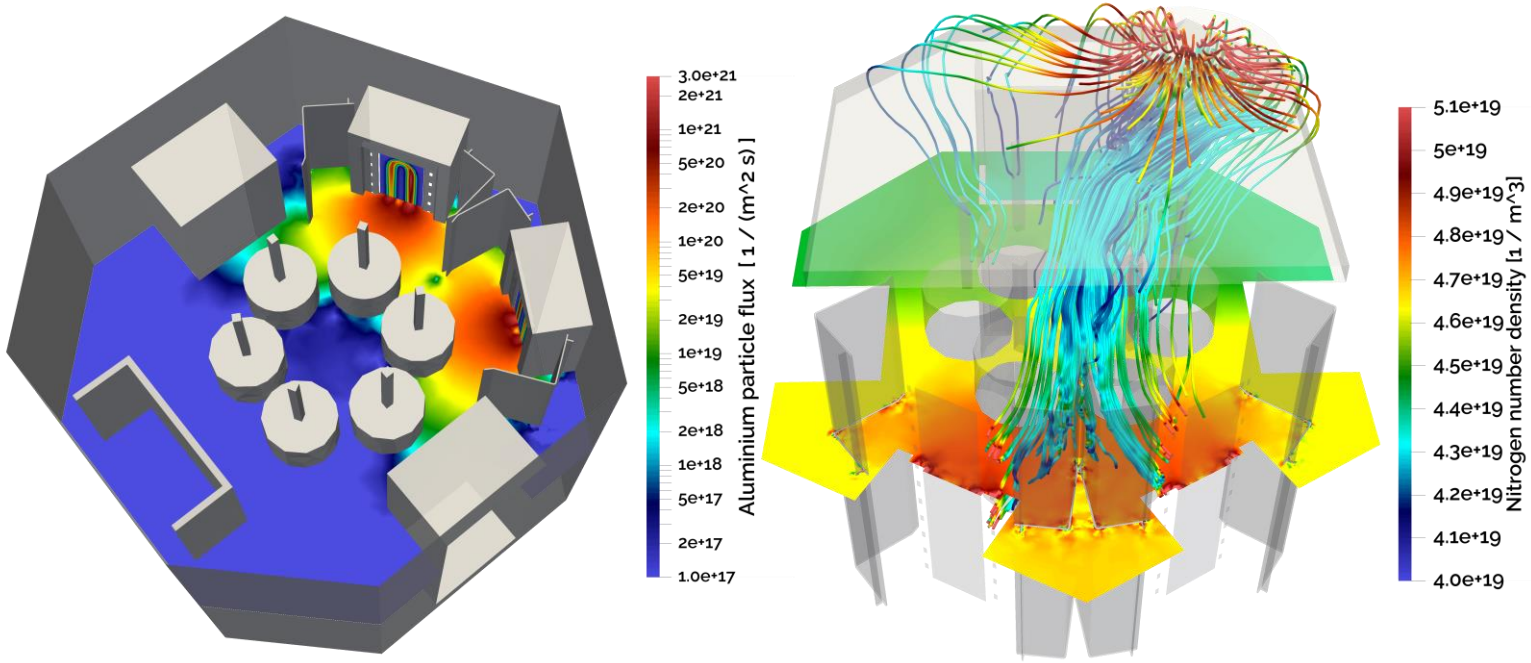

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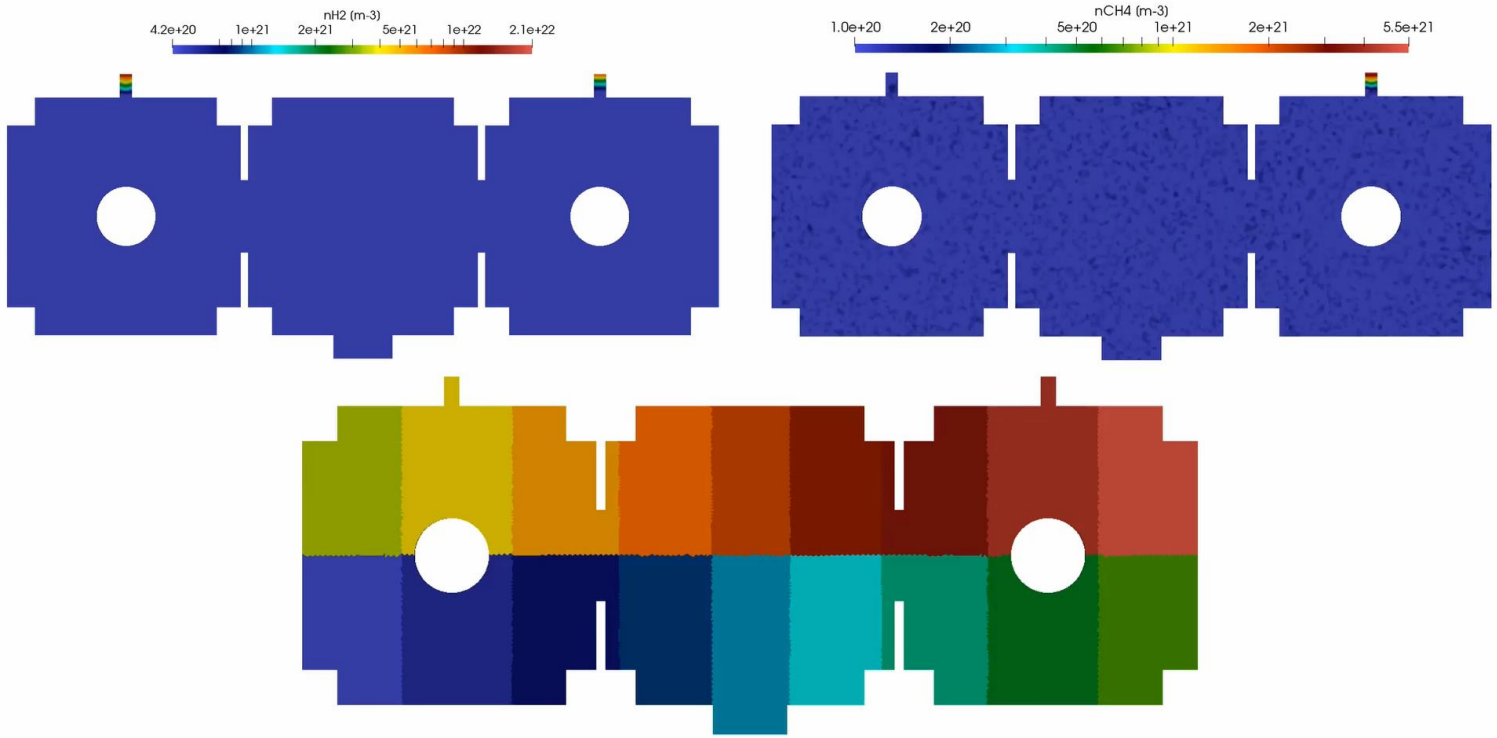

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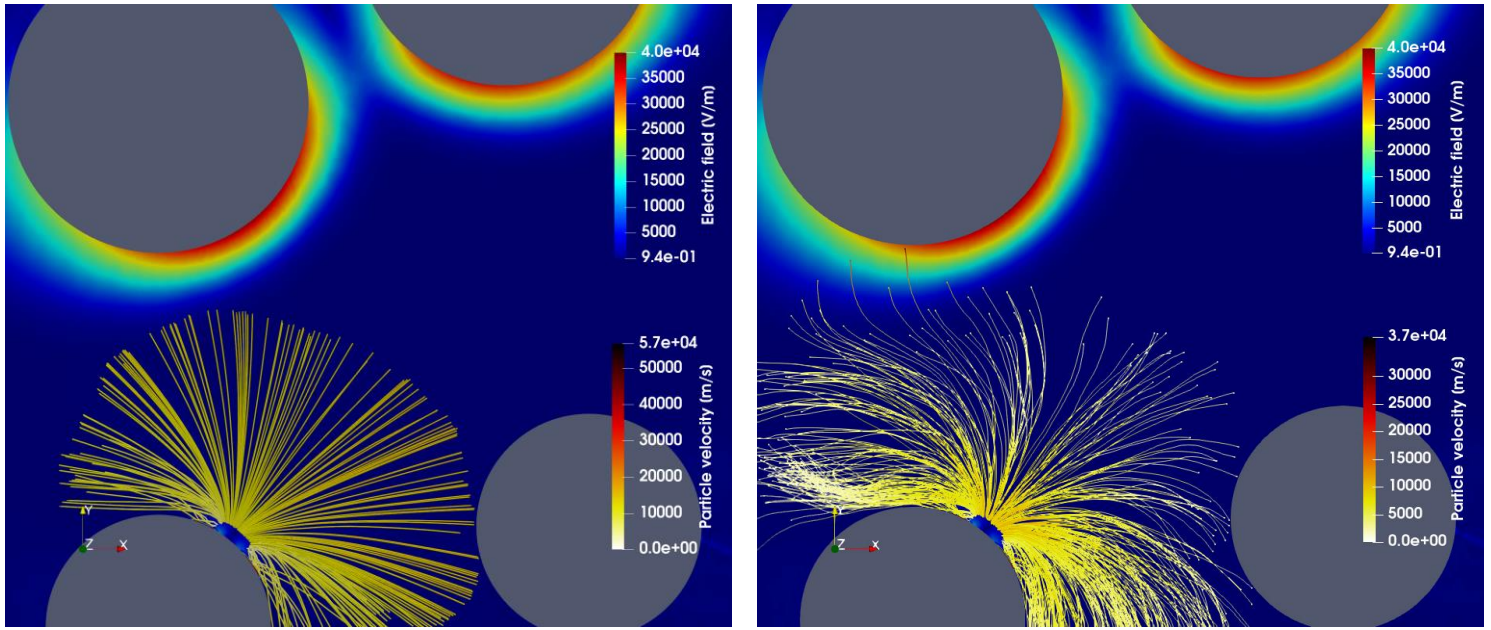

E and B fields calculated by Elmer, lagrangian particle tracing in dsmcFoamPlus (non-conformal meshes, iterative coupling)

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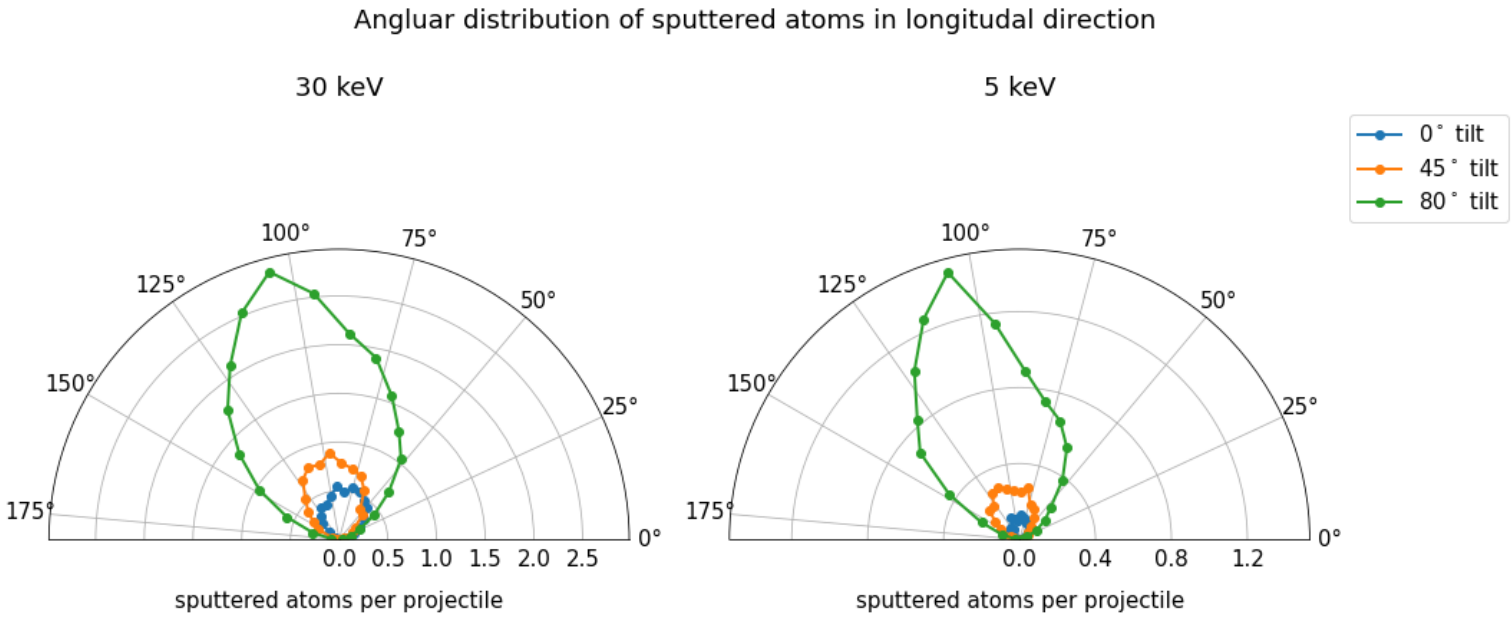

Angularly-resolved sputtering yields calculated by TRIDYN

Rarefied flow and sputtering transport

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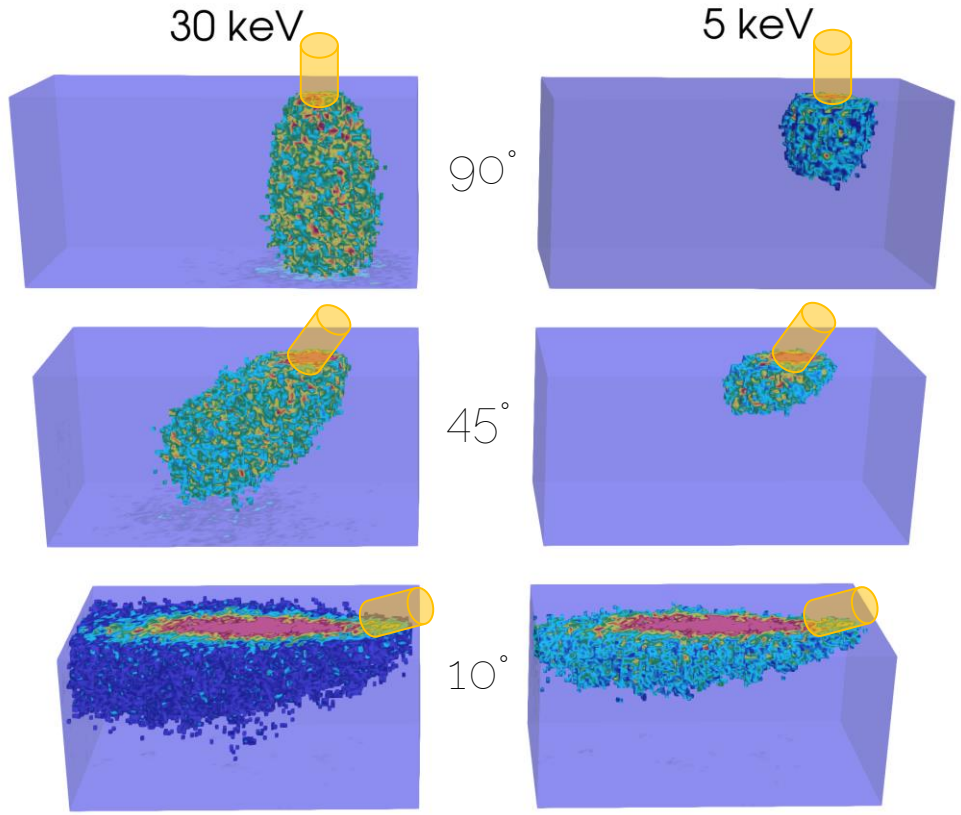

Material damage simulated by TRI(3)DYN for various ion incidence angles

Cloud deployment and automation of simulations

Cloud deployment of simulations

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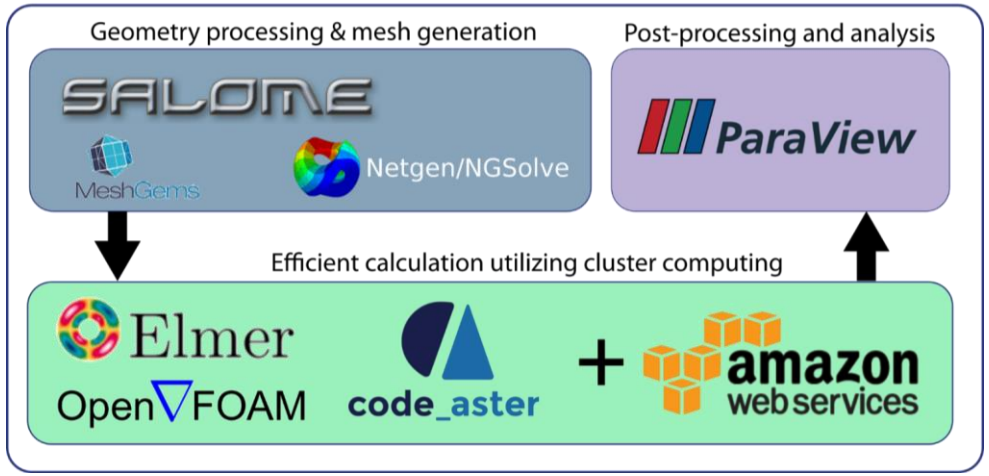
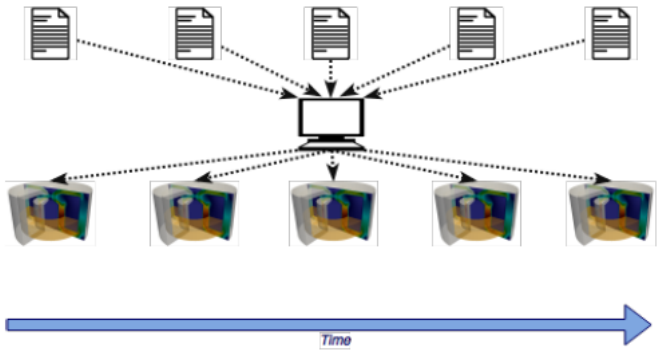
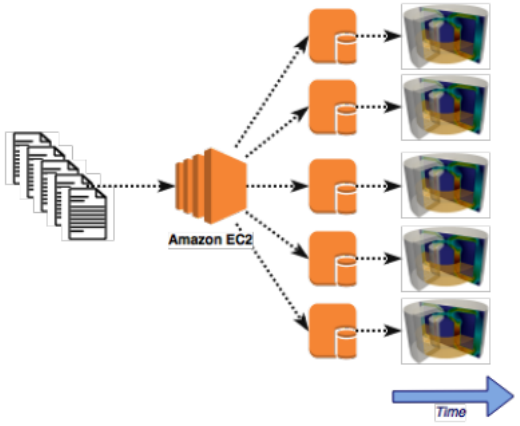
- PlasmaSolve does not have any computational HW in house, all simulations are run in the cloud.
- We have developed a software layer „p3s" that takes care of deploying *any simulation in the cloud*.
- Now we are working on an upgraded and more general version „p4s"



… any simulation?





Microsoft Azure

Google Cloud

IBM Cloud

ORACLE CLOUD

Alibaba Cloud

kubernetes

Cloud deployment of simulations

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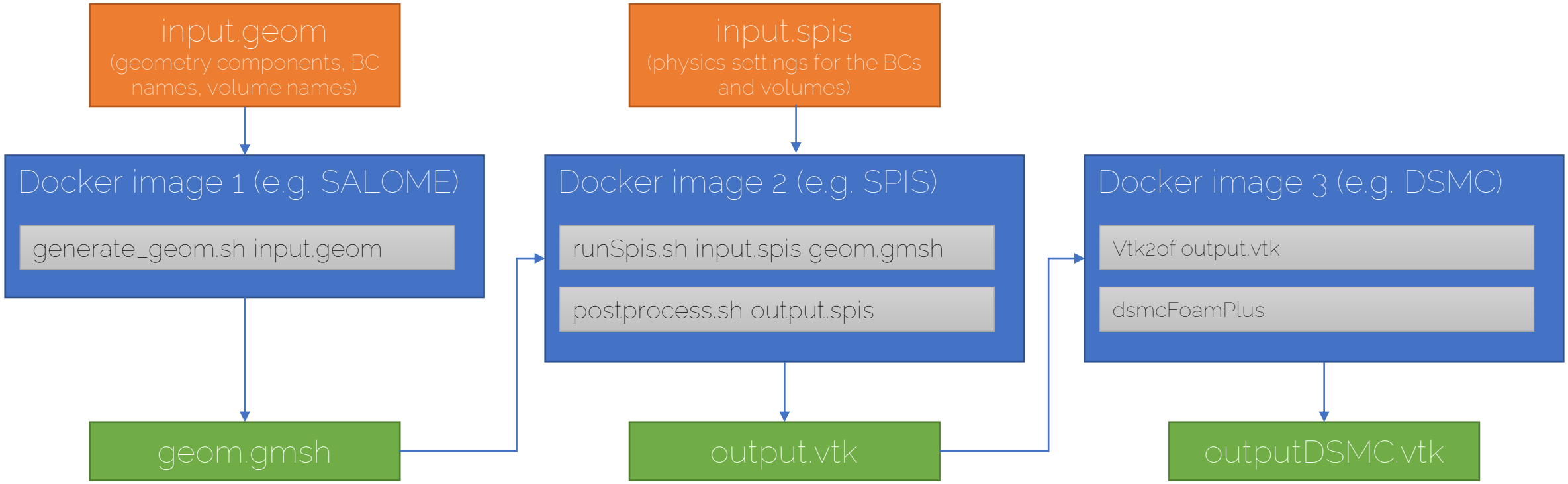
… as long as you can wrap it in a docker!



Representative example, not an existing pipeline

Conclusions

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- We would like to create a coupling layer beween SPIS and OpenFOAM, specifically the DSMC solver
- Two-way coupling:
  - SPIS boundary data/volume data loaded to OF
  - OF BC or volume data loaded to SPIS
- Added value:
  - Exact treatment of non-uniform gas background at VLEO
  - Exposure of S/C to reactive species flow
  - Growth of oxides/nitrides at VLEO due to sputtering?
  - Sputtering and redeposition simulation based on SPIS-calculated ion flux
  - …
- Co-funding of €30-50k needed to get to MVP. Considering ESA open calls, any other options?

- Alternatively, we can help with automated cloud deployment of SPIS simulations, should that interest anyone.

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