

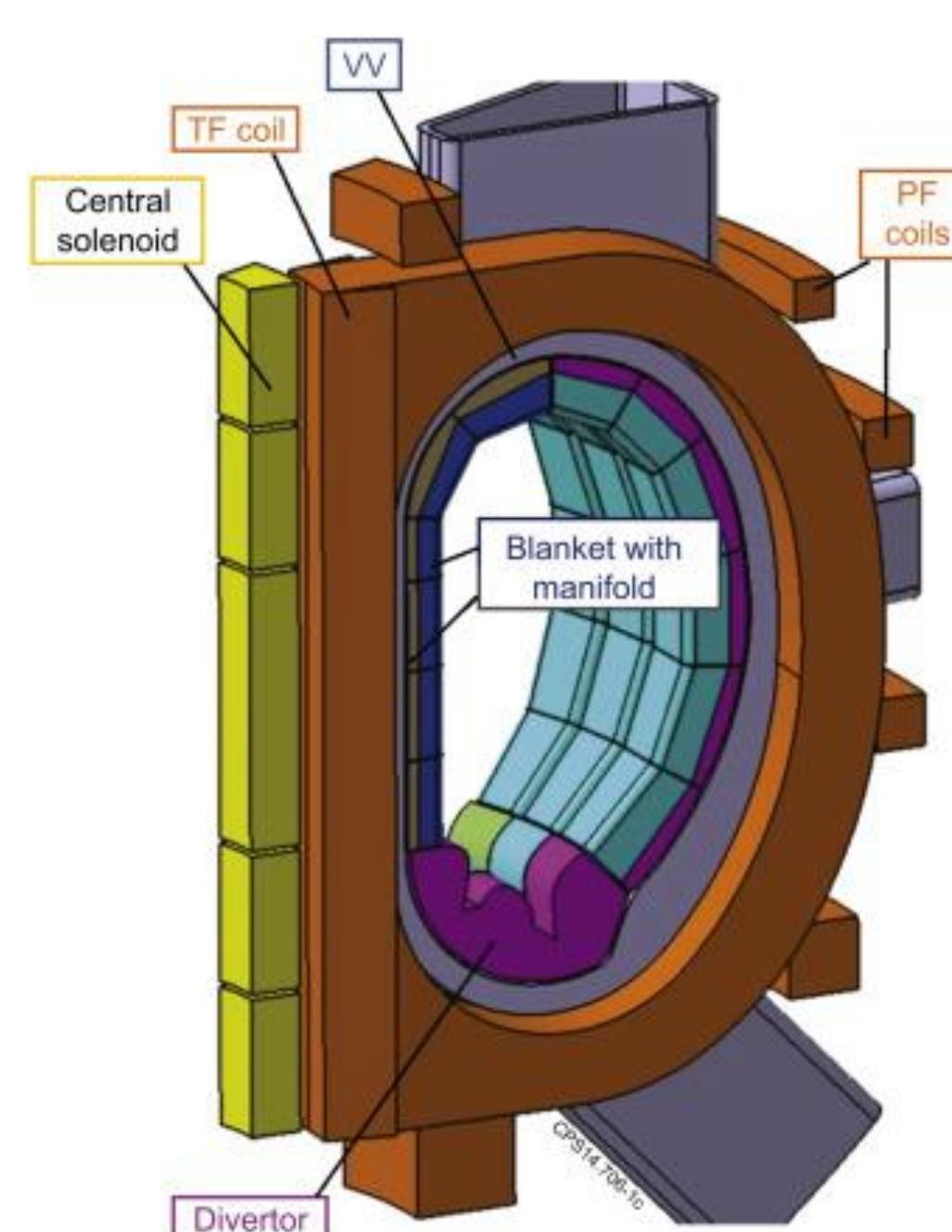
# DSMC Modeling of H2 in a Lithium Vapor Box Experiment

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## Introduction

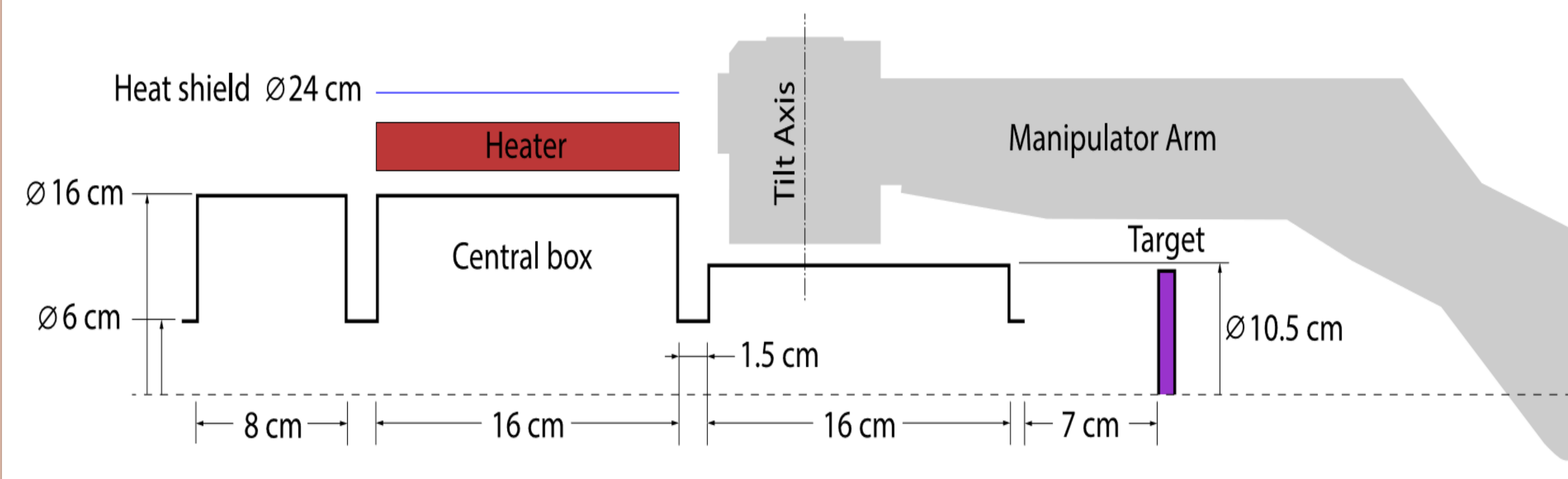
- A tokamak is a torus shaped device that uses magnetic fields to confine a hot plasma.
- The divertor is at the bottom of the of the vessel and receives a high heat flux, potentially causing damage to the solid surfaces.
- The lithium vapor box concept is focused on saving the materials of the divertor by using a cloud of lithium vapor to detach the plasma and decrease the heat flux on the materials.
- Plasma detachment occurs when the temperature decreases enough that the heat flux decreases as it hits the surface of the divertor.



Bachmann, Christian, et al. "Initial DEMO Tokamak Design Configuration Studies." *Fusion Engineering and Design*, vol. 98-99, Oct. 2015, pp. 1423-1426.

## Vapor Box Magnum-PSI Application

- Goal:** Prove the H2 cannot detach a plasma on its own, then add lithium to determine if it can cause detachment and decrease the heat flux at the target.
- Set up:** 3 boxes with a target 7 cm from the outer box. There are two sets of tests, with and without lithium. In the tests without lithium, none of the boxes are preheated. When lithium is added, the center box is heated and contains the lithium vapor that will be used to test the detachment possibility with a plasma.
- Detachment occurs when sufficient lithium vapor is present to cool the plasma, lowering the temperature and the heat flux at the target.
- Lithium was chosen because it is low-Z ( $Z = 3$ ) and, if some were to escape into the plasma, the lithium can be pumped out.



Vapor box set up for Magnum-PSI with a target 7 cm to the right of the boxes and a heater surrounding the central box. The central box houses the lithium vapor, the outer boxes are used to keep lithium from reaching the target chamber. The tilt axis is a reference point and not used in the experiment.

## Hydrogen SPARTA Modeling

### SPARTA Direct Simulation Monte Carlo (DSMC) Code:

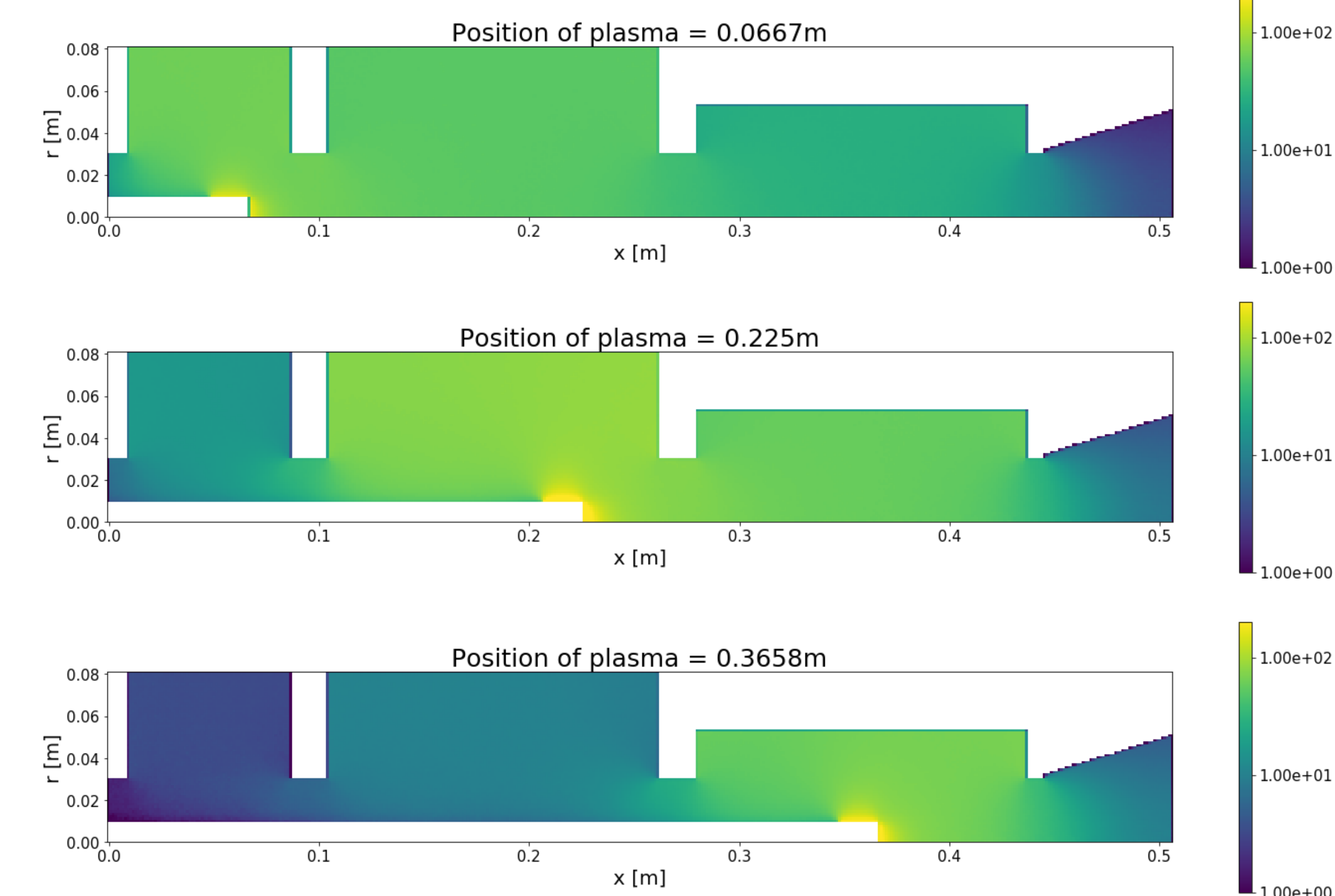
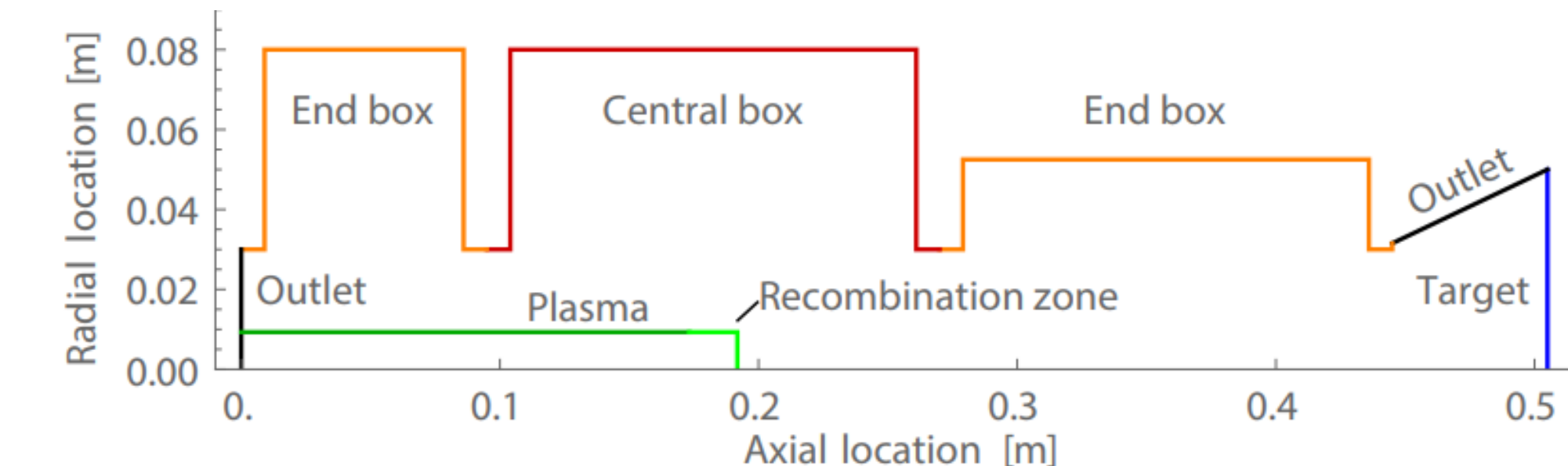
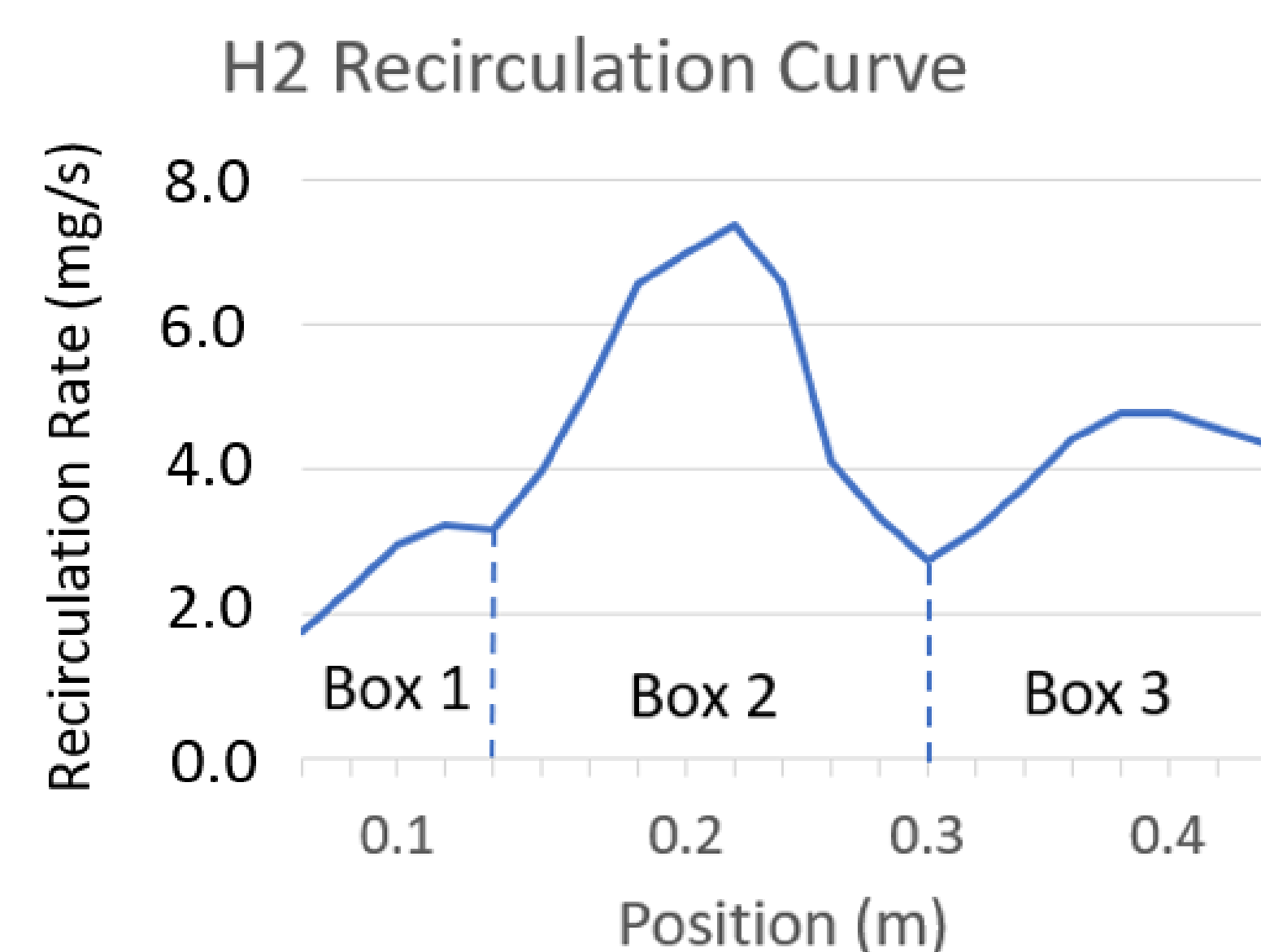
- Created at Sandia National Laboratory
- Parallel computing DSMC code is for gases with  $Kn > .001$  simulations in 2D and 3D.
- DSMC numerical method is used for modeling gases

### Requirements:

- Mean free path of particles must be greater than the grid size
- Mean free time must be greater than the time step
- Sufficient particles are present per cell

### SPARTA Specs:

- Grid size - 433 x 70
- Time step -  $3.7266e-7$
- Particles per cell – roughly 50
- Mfp : cell size  $> 1.5$
- Mft : timestep  $> 20$
- Boundaries – surfaces at the outputs of the geometry are absorbing, all others are specularly reflective



## H2 Modeling:

- Target positioned after the third box
- First need to prove that H2 cannot detach the plasma on its own in this set up based on the recirculation rate, which should be roughly 30 mg/s in order for detachment to occur.
- The recirculation rate is the amount of hydrogen that flows back into the plasma.
- Use recirculation values to determine if detachment will occur with H2 in this set up.

## Future Work

- Increase the accuracy of the simulations by:
- increasing the bounds of the simulation geometry.
  - adding in the affects of the neutrals interacting with the surfaces.

## Conclusions

- H2 shouldn't lead to detachment of a plasma in this set up. It is expected that 30 mg/s is needed for detachment to occur.
- When lithium is added, the amount absorbed by the plasma will be calculated and will determine if detachment can be achieved.

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