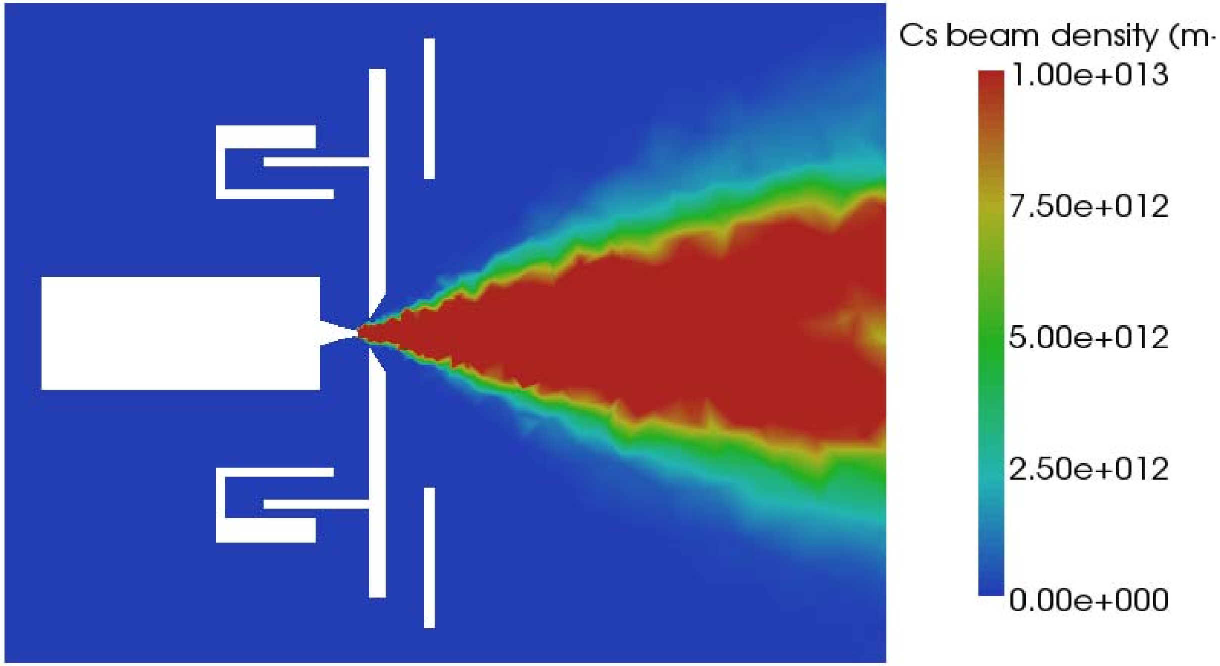
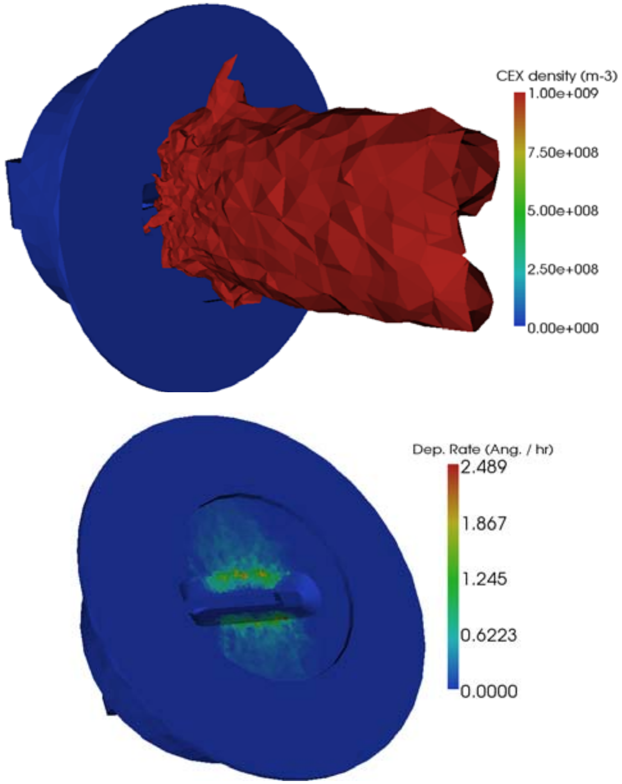




SPIS Application: Detailed FEEP thruster modelling

Simon Clucas - ESA/ESTEC

13th SPINE Meeting, 28-29 Sept 2009ONERA, Toulouse

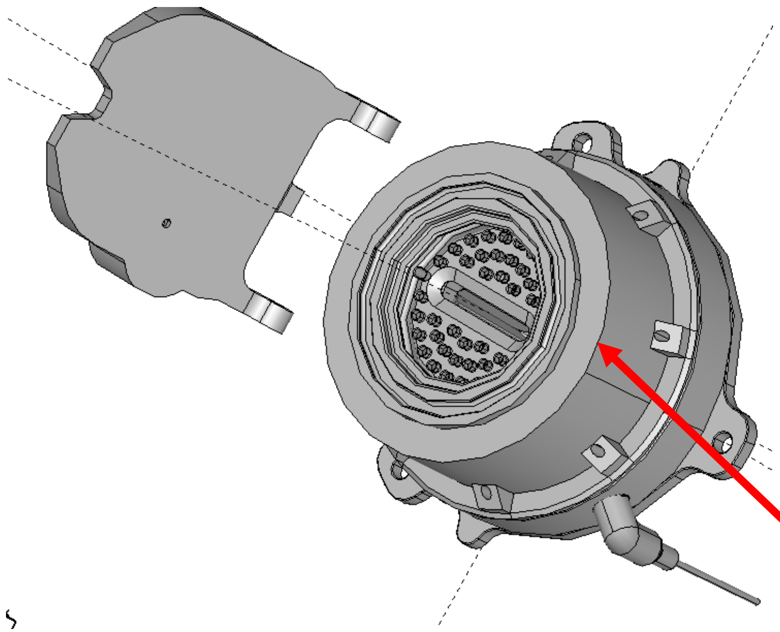
Contents

- Introduction
- Geometry
- Simulation outputs / comparison
- Electron back streaming
- Remarks

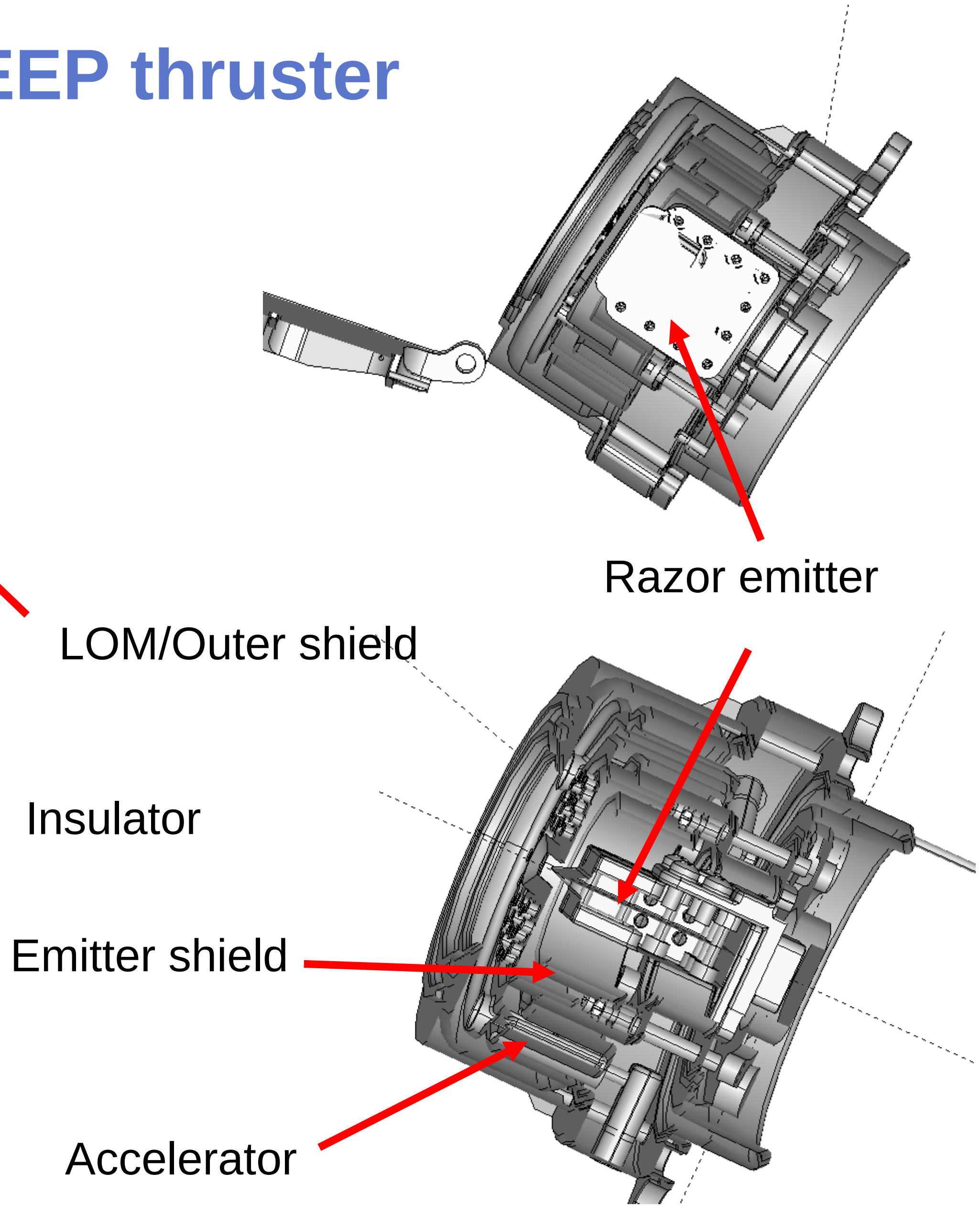
Introduction - Motivation

- Lisa Pathfinder (LPF) has a requirement for ultra-precise electric propulsion – FEEP/Colloidal thought to be solution
  - Flying both Cs FEEP thrusters and NASA supplied colloidal EP
- Requested to model Caesium FEEP thruster:
  - consider CEX deposition inside the thruster and on outer face of acceleration grid
  - compare different thruster designs
  - investigate possible electron back streaming issues
- Part of the LPF project investigating possible issues relating to leakage currents within the thruster

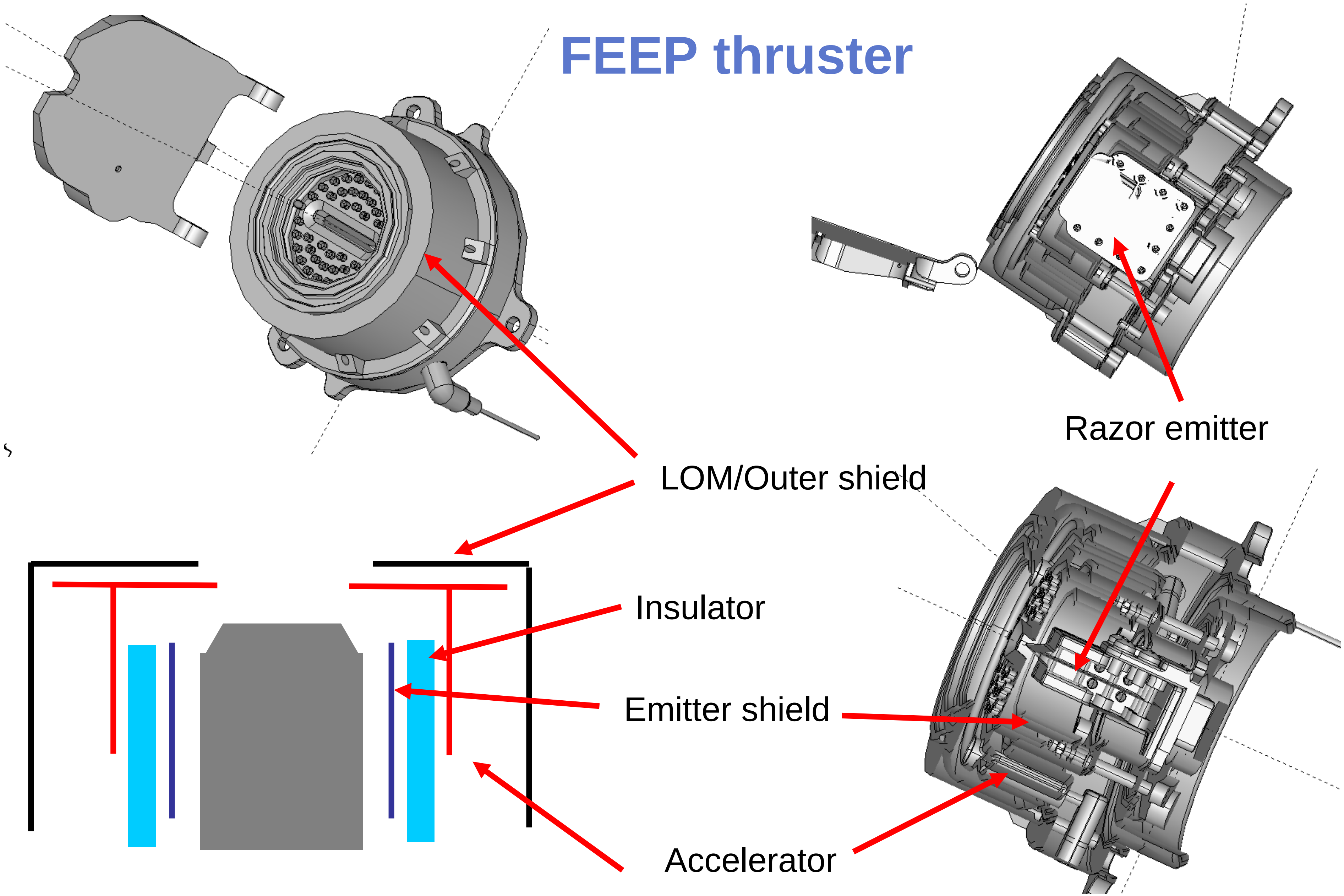
FEEP thruster



Full, complex STEP
Geometry file



FEEP thruster



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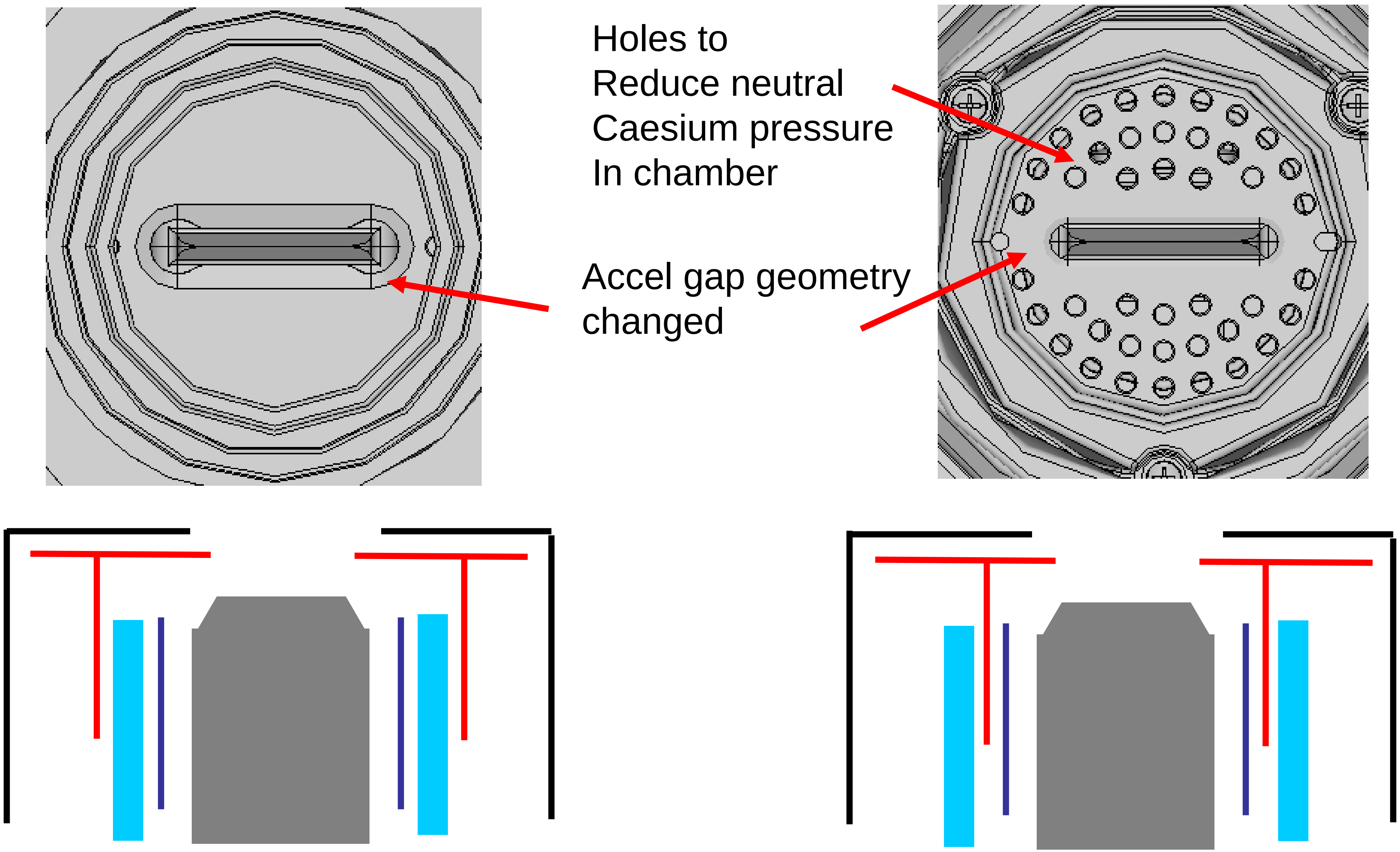
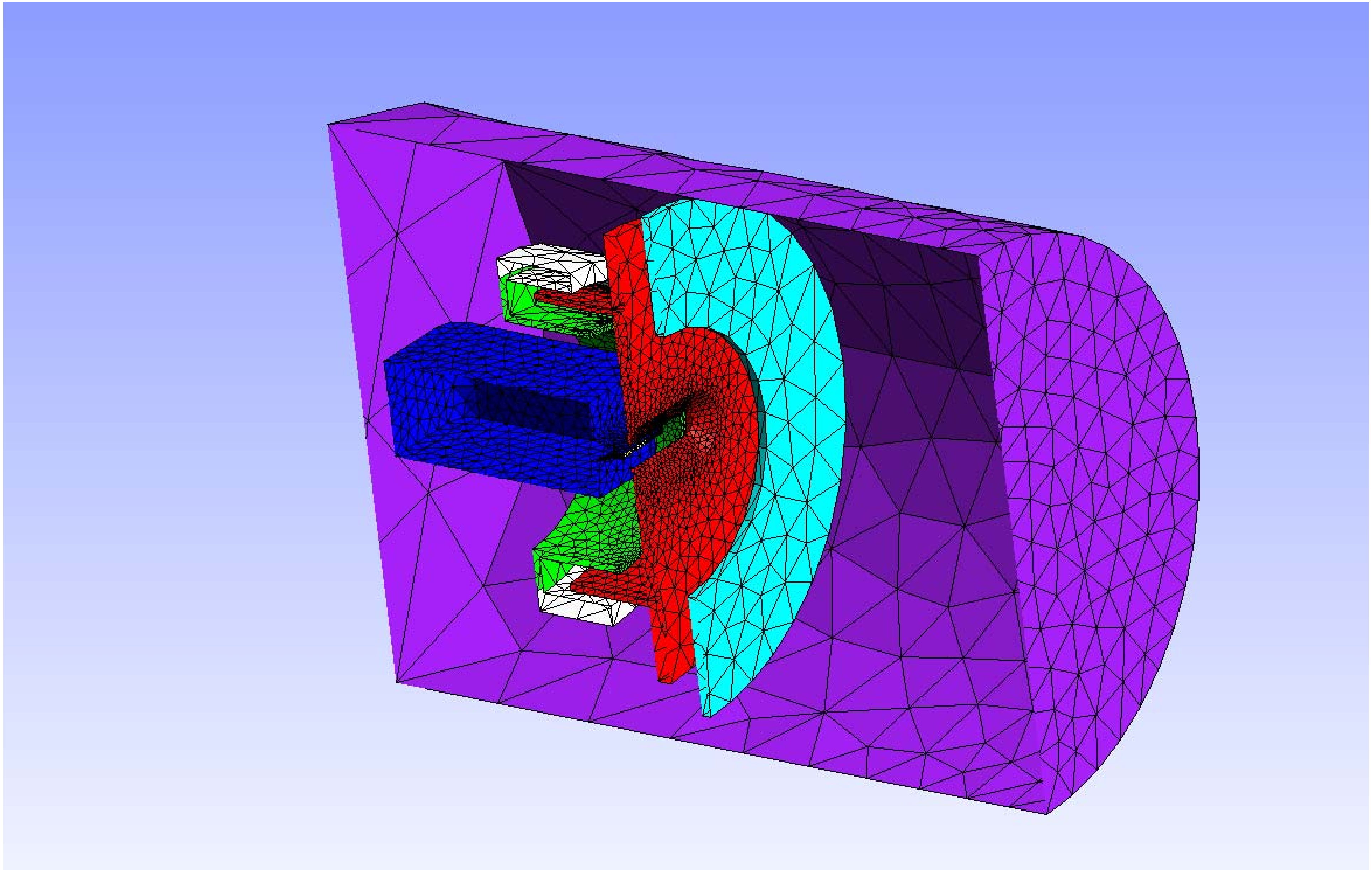


2 thruster designs – changing the location of the insulating ring + others



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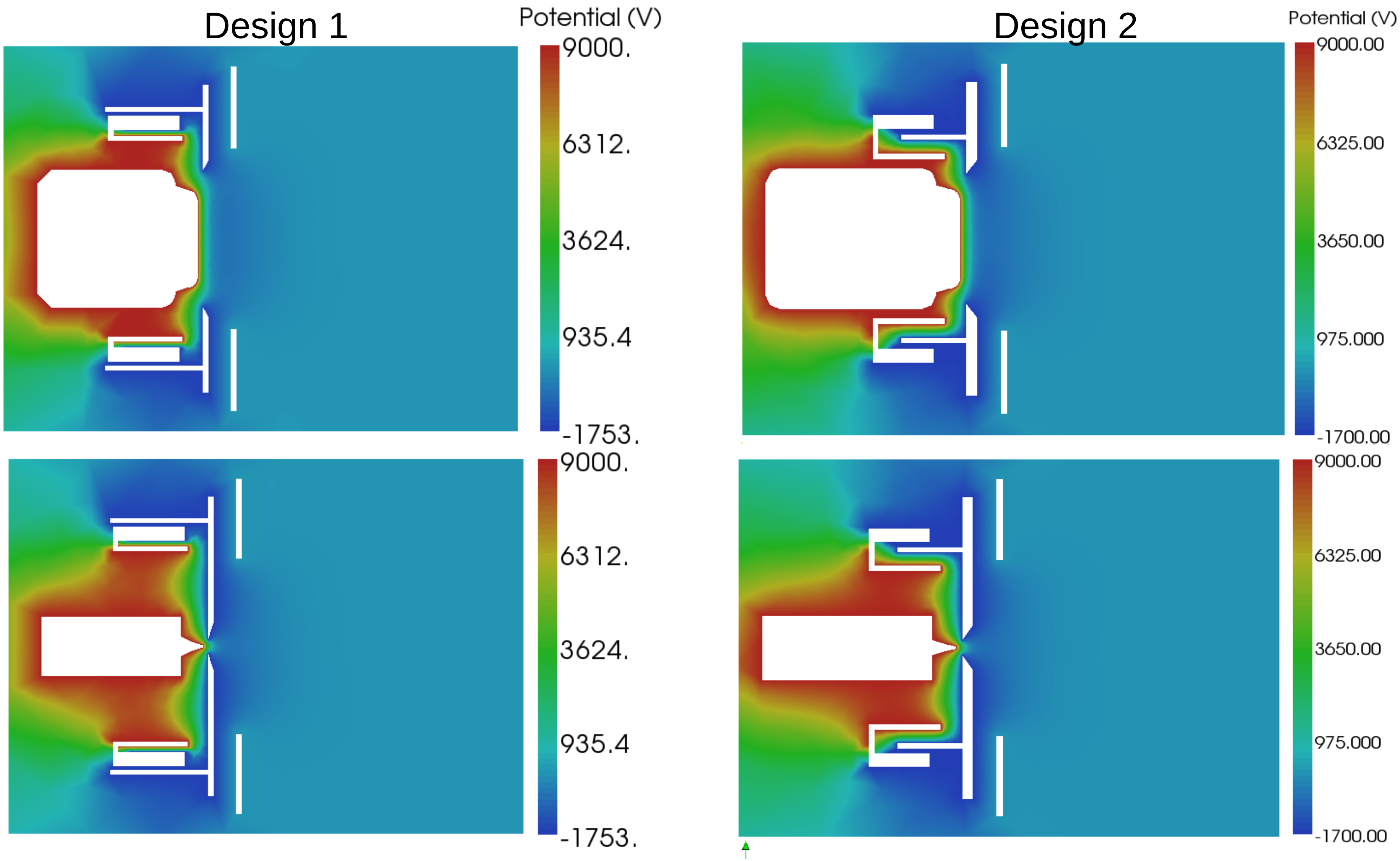
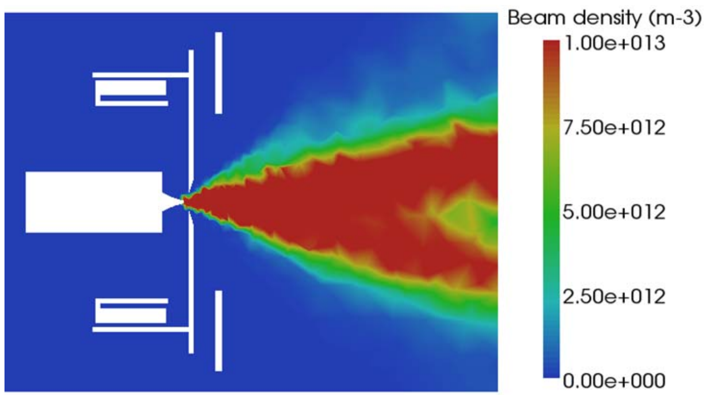
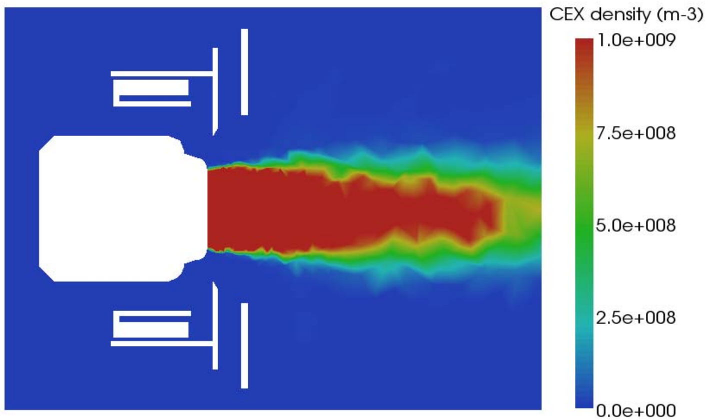
Simulation outputs



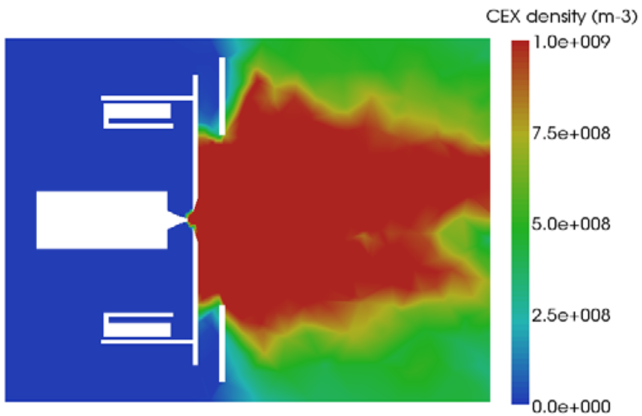
Simulation outputs





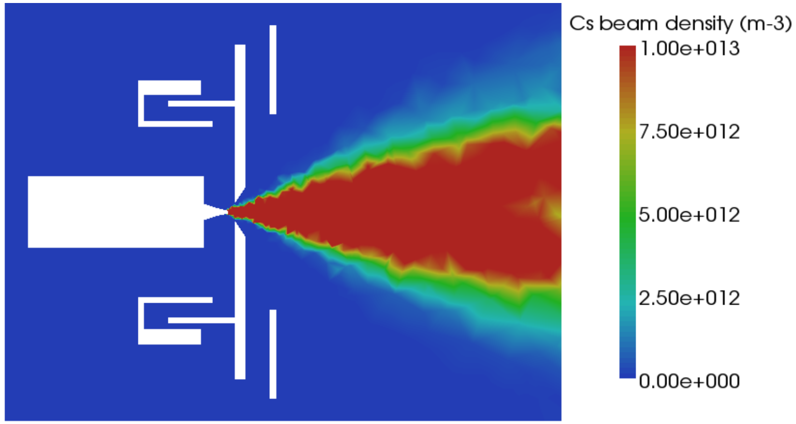
Primary beam charge density

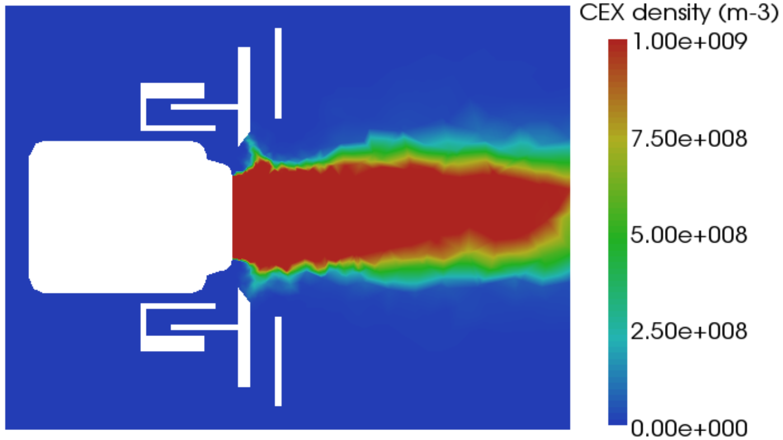
Design 1



CEX charge density

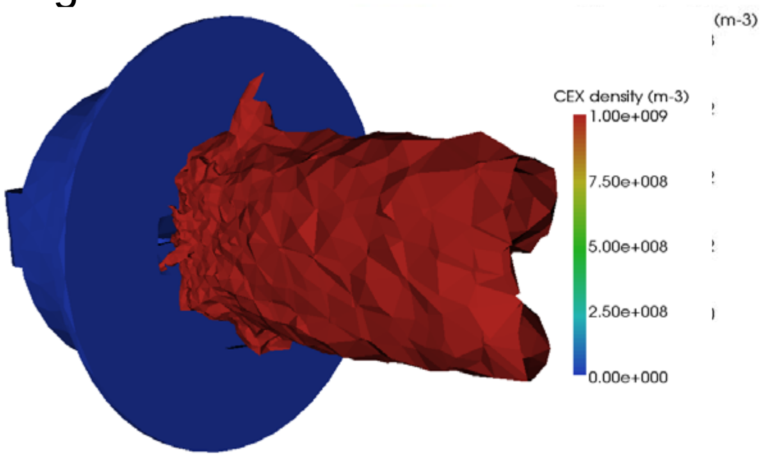
Simulation outputs

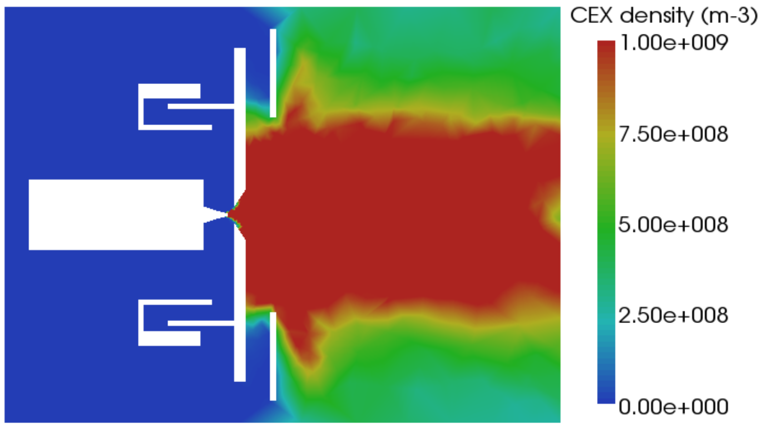




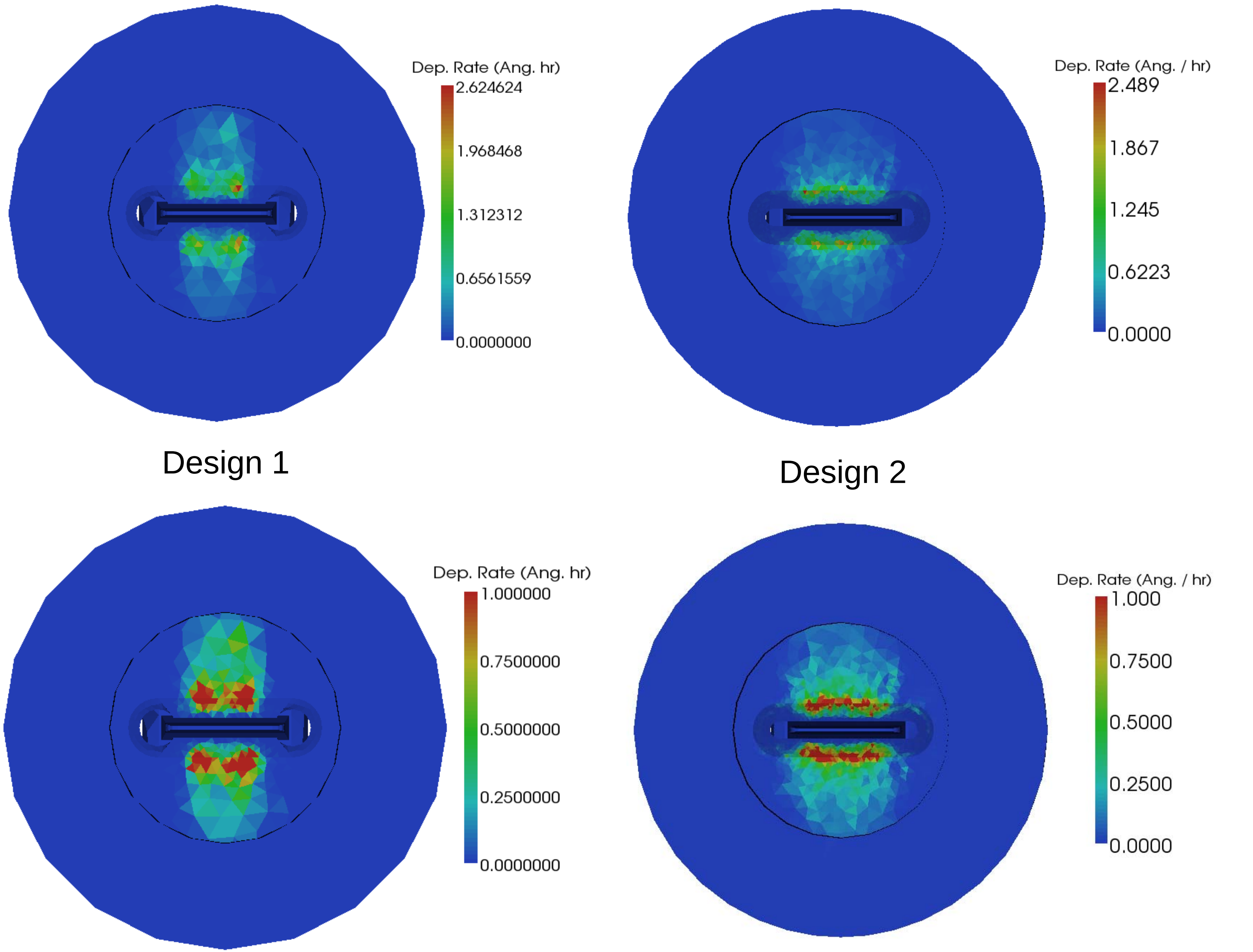
Primary beam charge density

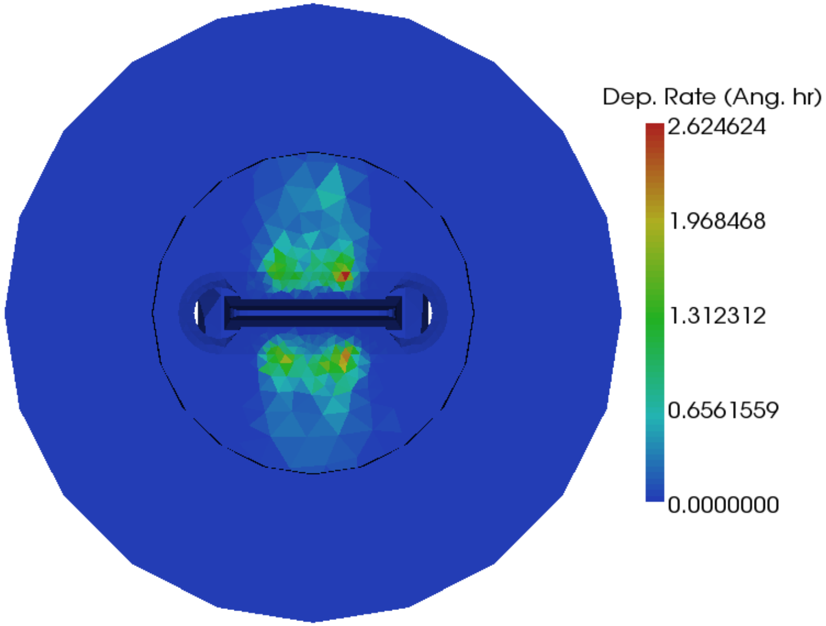
Design 2



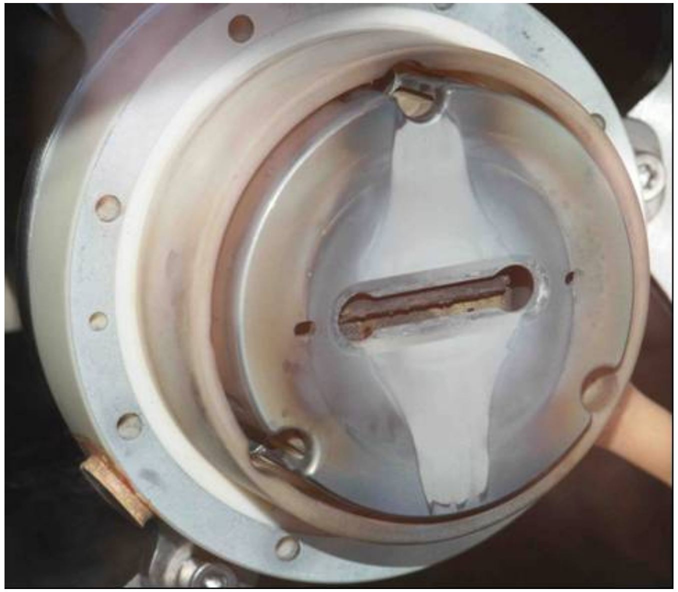


CEX charge density

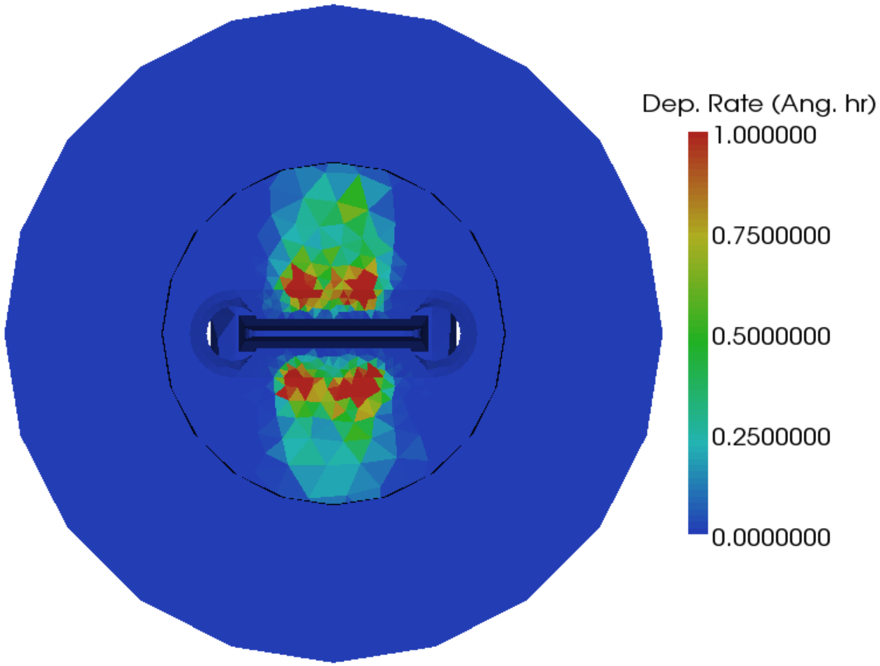

Dep. Rate (Ang. hr)
2.624624
1.968468
1.312312
0.6561559
0.0000000
Dep. Rate (Ang. / hr)
2.489
1.867
1.245
0.6223
0.0000
Design 1
Design 2
Dep. Rate (Ang. hr)
1.000000
0.7500000
0.5000000
0.2500000
0.0000000
Dep. Rate (Ang. / hr)
1.000
0.7500
0.5000
0.2500
0.0000



Design 1



Outer case removed



Cross-validation

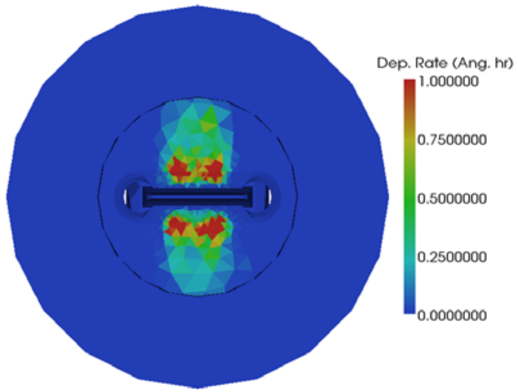
- Cross-validation with other codes / experiment was done

  - Primary beam
    - Agreed on magnitude and divergence with measurements
    - However comparing simulation outputs with measurements is relative difficult

  - CEX production compares well other simulation codes used by the manufacturer

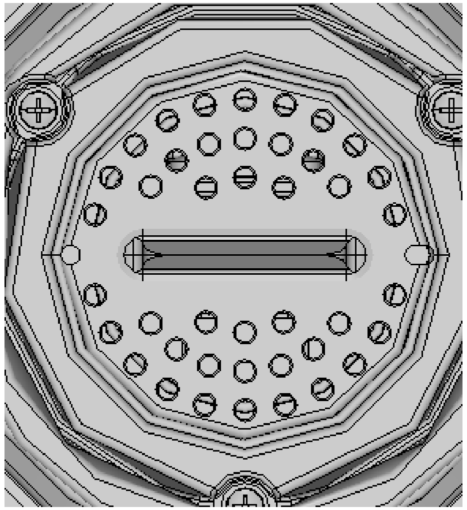
  - Resembles the CEX backflow onto the acceleration grid

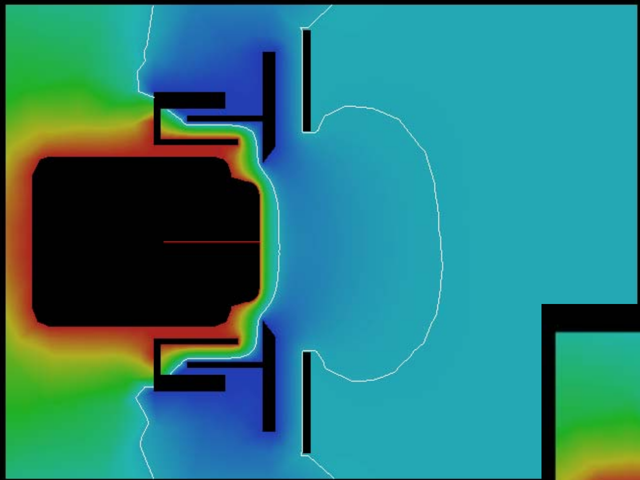
  - The addition of virtual detectors will help the comparison.



Electron back-streaming

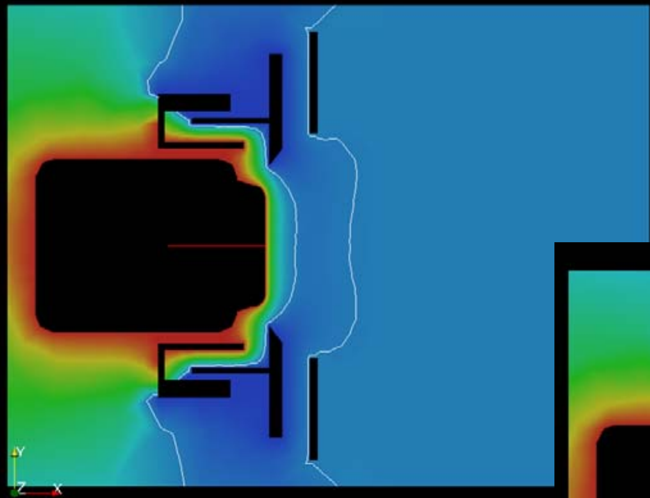
- It is extremely important not to have a significant current onto the emitter from back streaming electrons.
- Therefore to prevent back streaming, the emitter (9kV +ive) needs to be shielded from ambient and neutraliser electrons
- However, there is a strong design requirement to reduce the area of the accelerator plate to improve the venting of neutral Caesium from within the thruster.
- Design 2 introduced holes into the accelerator plate, whilst reducing the size of the main opening. (These holes were not modelled)
- A further design removed even more material from the accelerator plate (shown later)



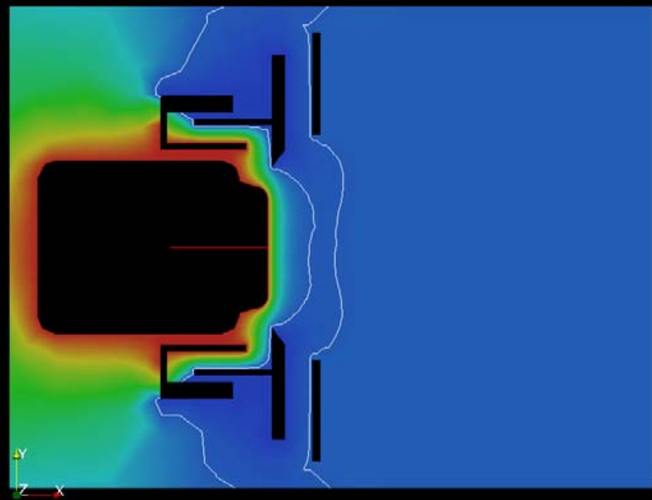


Va = -1700V

Fixed emitter potential of +9000V

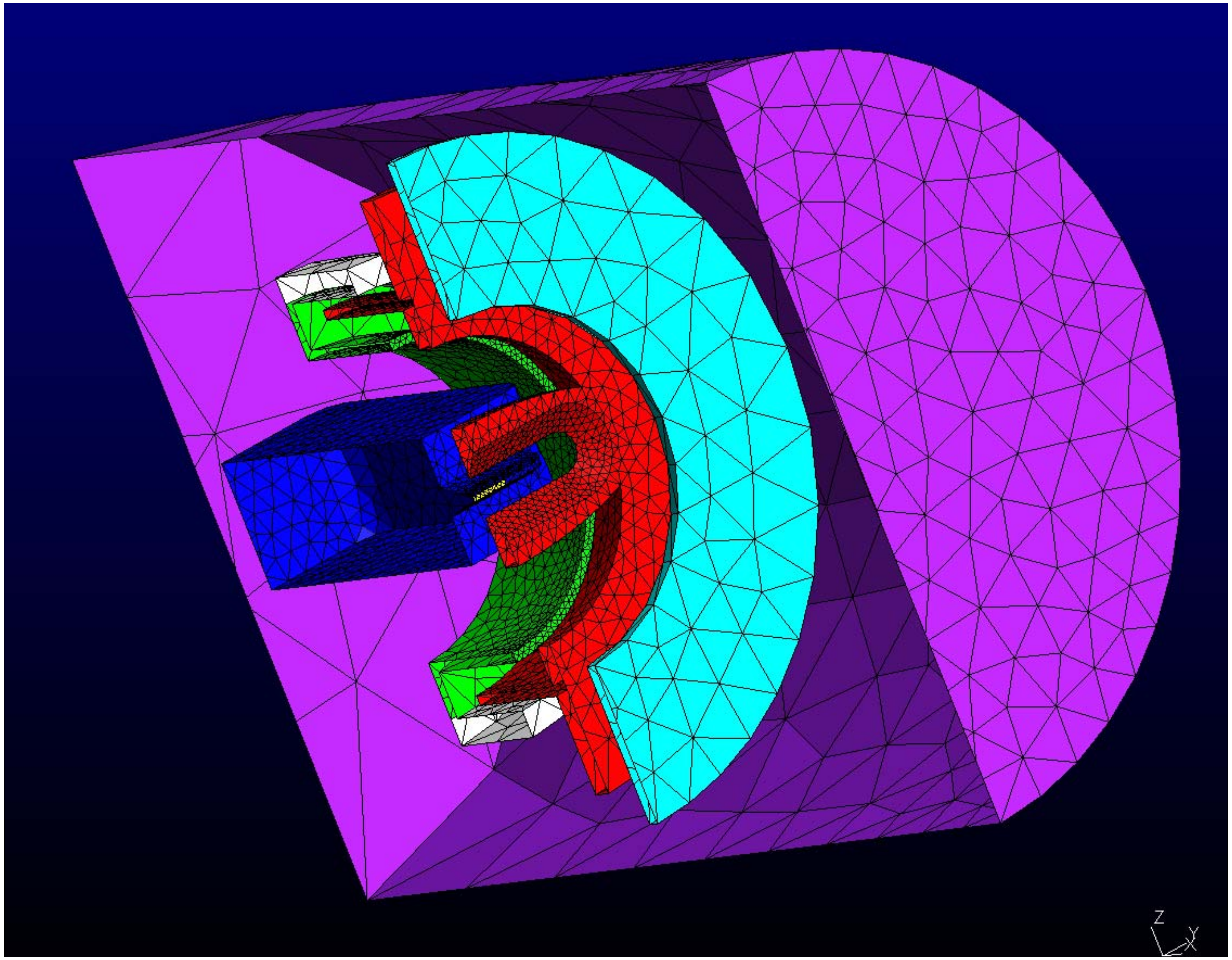


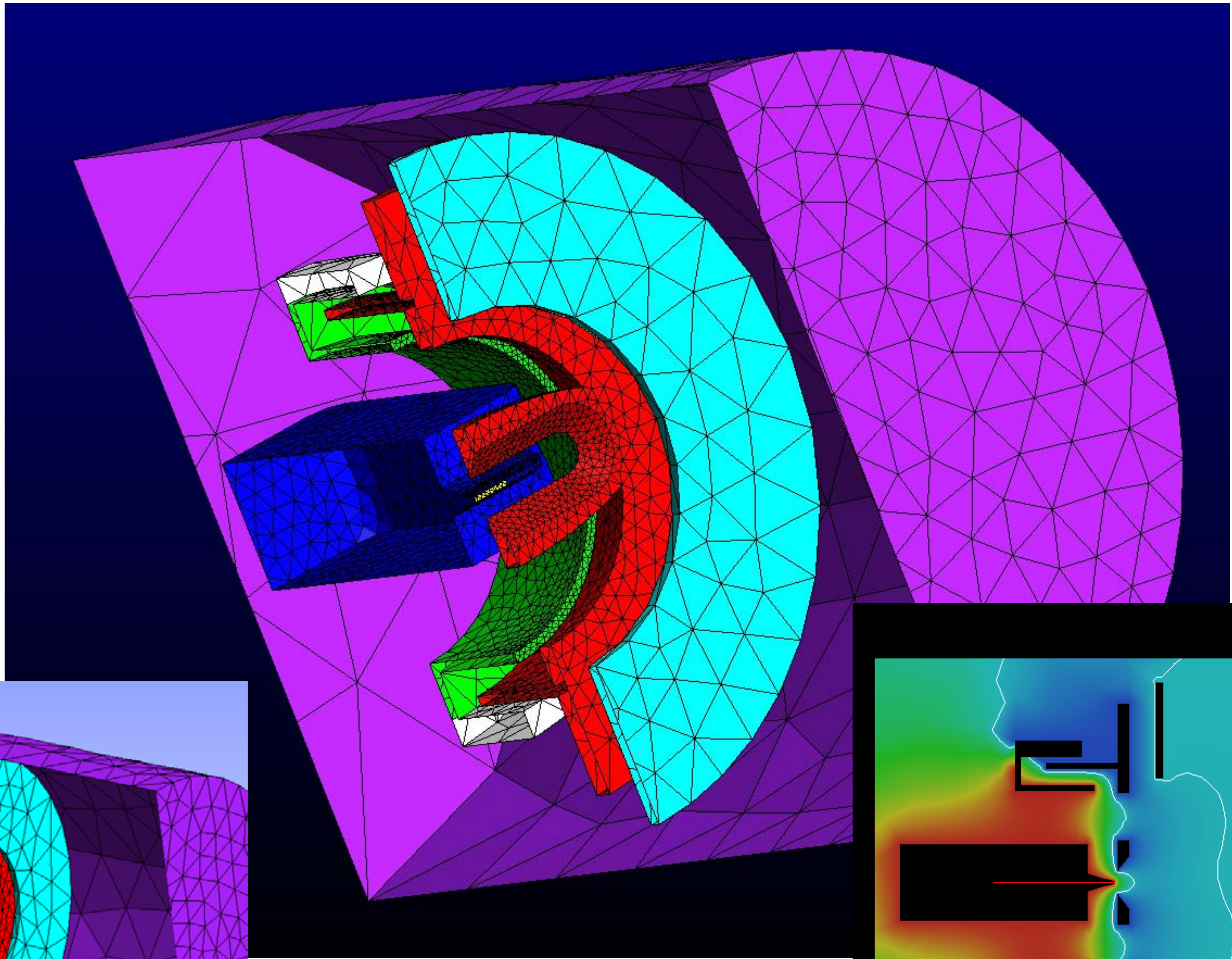
Va = -1000V

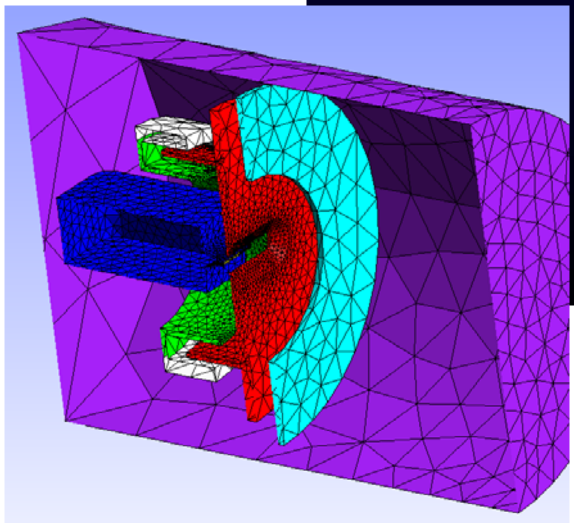


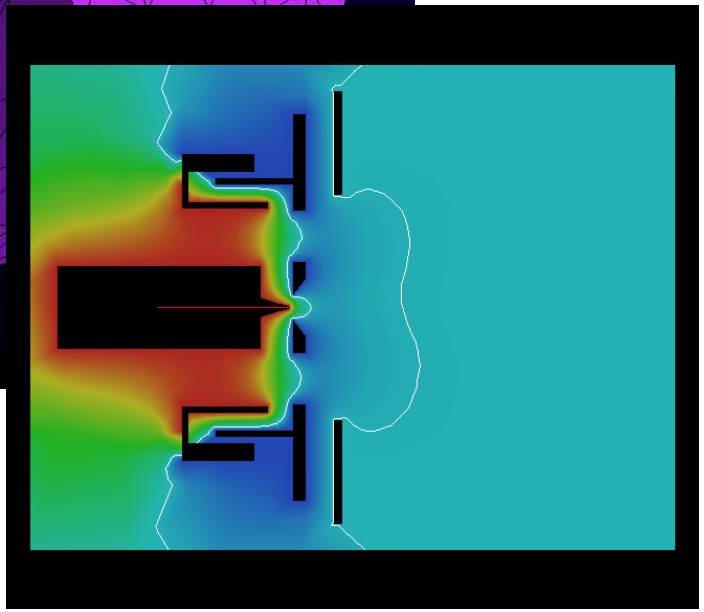
Va = -500V

Design 2 showing -50V contours (probable bias to be used for the neutraliser)


Z
Y
X







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Remarks

- Detailed FEEP thruster simulations were performed to aid the project to determine possible operational issues
- Matched well to measurements and other simulation codes
- Important inputs regarding CEX backflow and electron back streaming
- --- Additional SPIS capabilities -----
    - Limited mesh size (solved with SPIS4.0 + 64bit JVM/machine)
    - Fowler-Nordhiem emission (already in SPIS but could not be used – this has been extended in SPIS 4 to include field enhancement)
    - Virtual detectors to mimic measurements taken (ongoing)
    - Treatment of neutrals (ongoing)
    - Advanced CEX capability with neutral particle interaction (desirable)