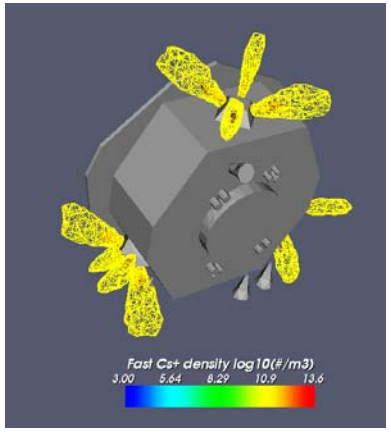
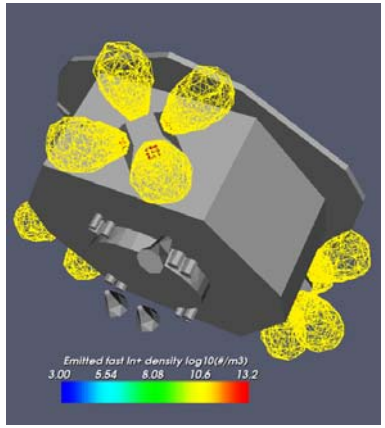
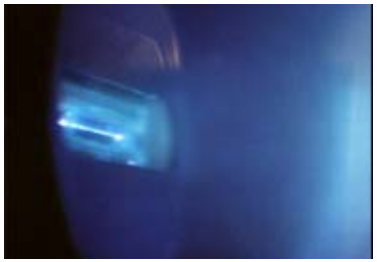
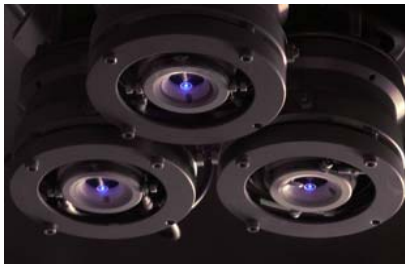
SPIS modelling of FEEP thrusters for LISA Pathfinder



Prepared by Bjarne Andersson
The LISA Pathfinder project
ESTEC, SCI-PNM







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7. Summary
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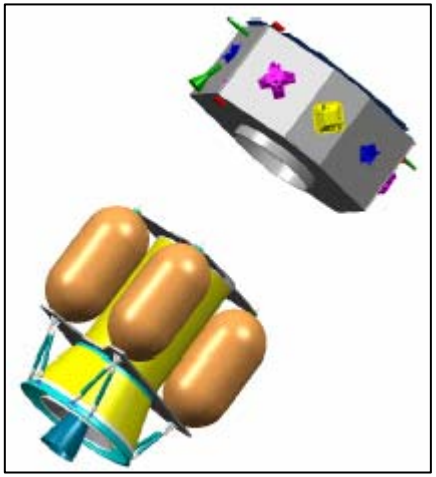
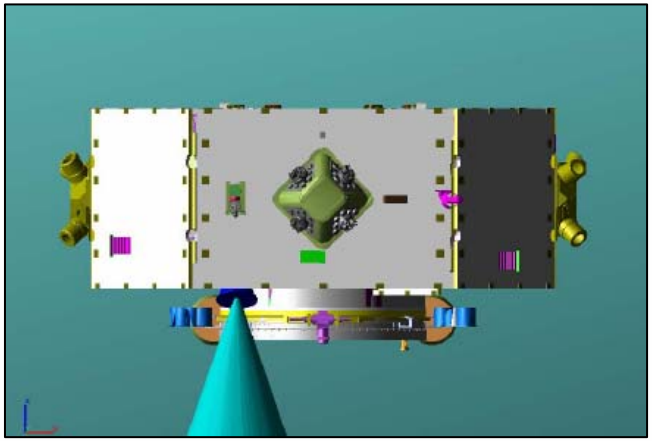
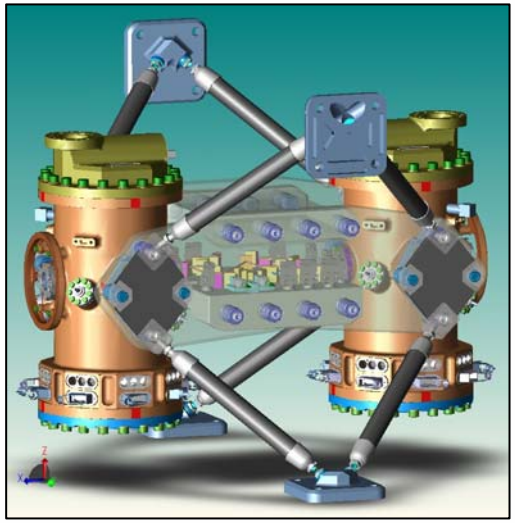
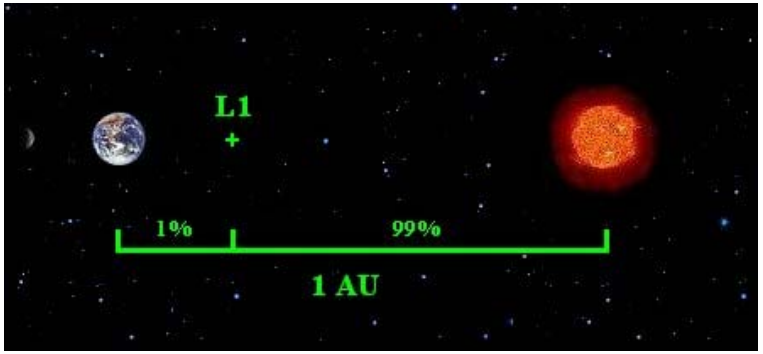
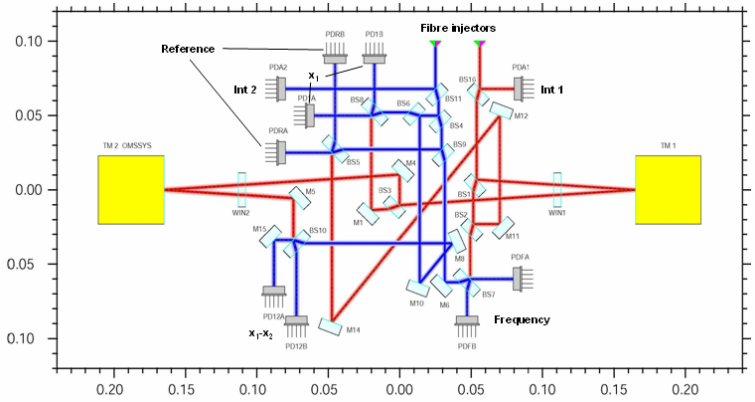
LISA Pathfinder



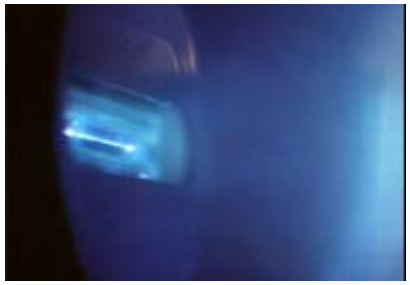




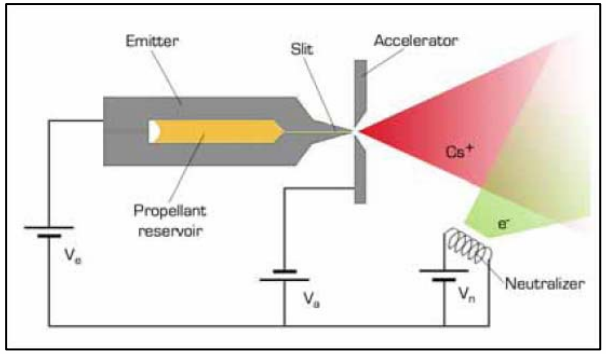


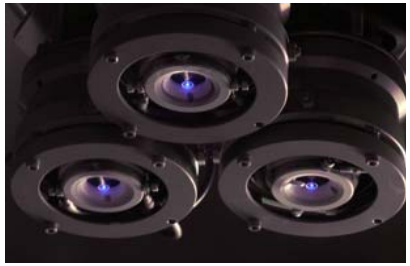


LISA PF's micro-propulsion systems

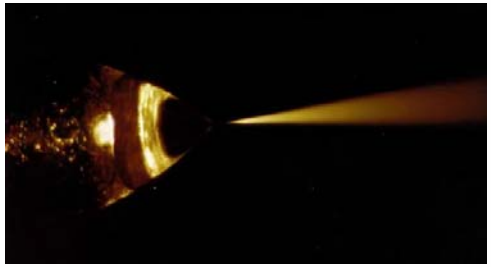


FEEP Cesium slit

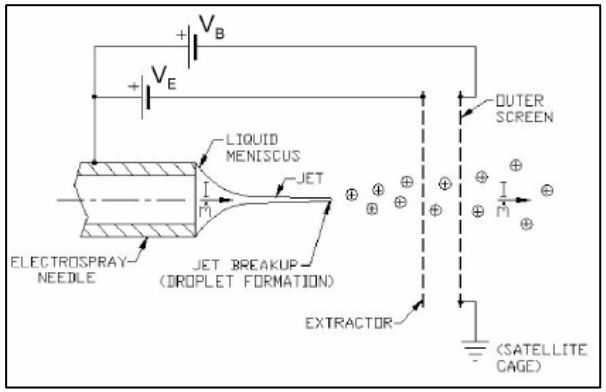




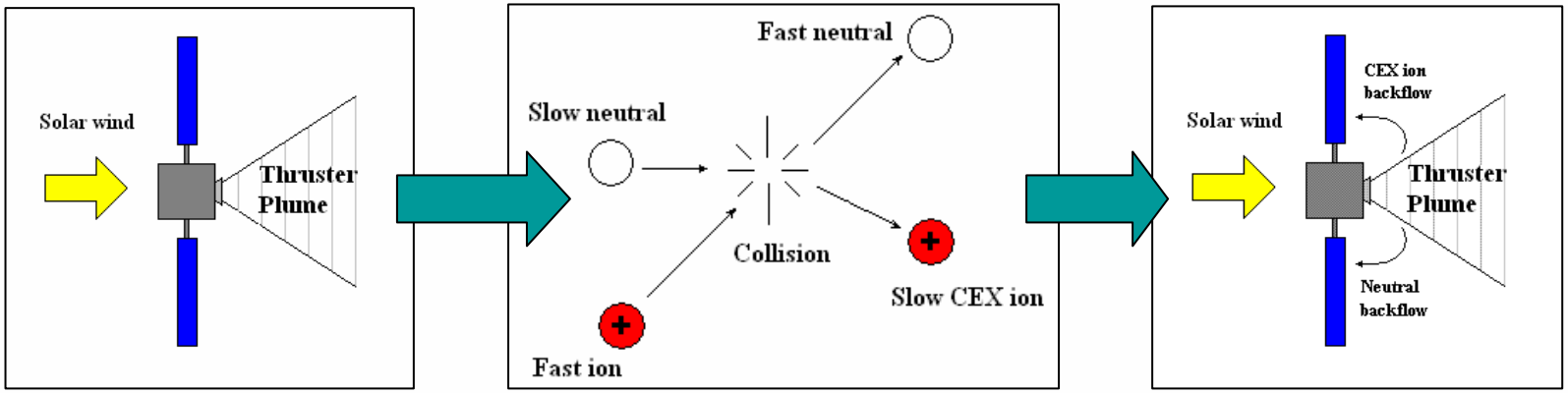
FEEP Indium needles



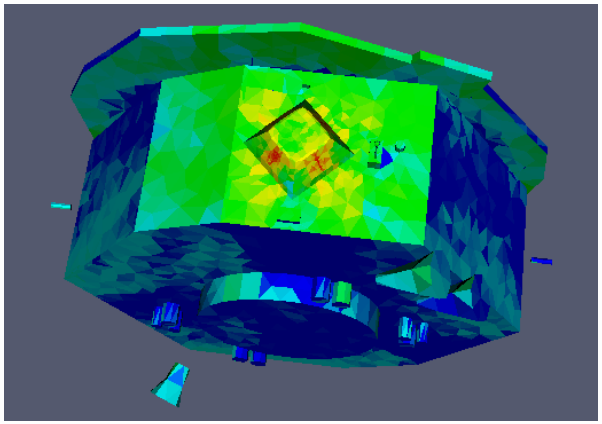
Colloidal thrusters



CEX ions generation and plume flow-back



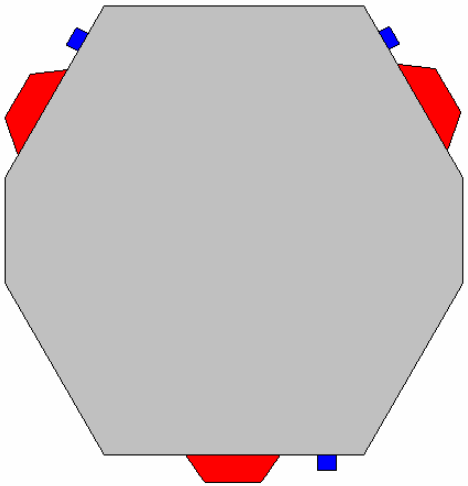
CEX collisions



Contamination !!

Crucial for solar cells, sun sensors, star trackers…

LISA PF input summary

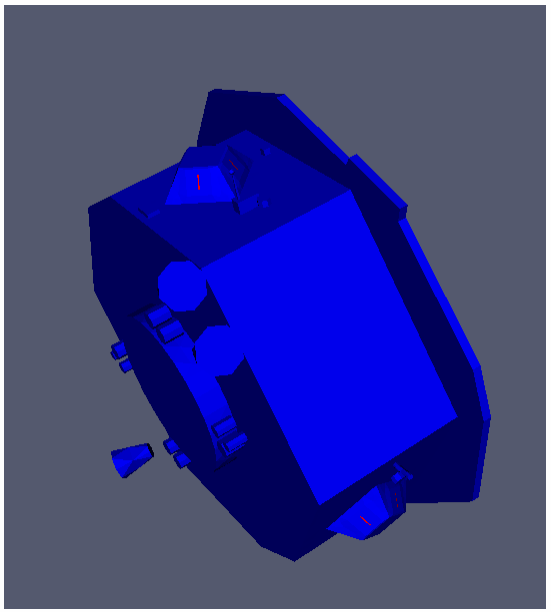


FEEP Cluster locations

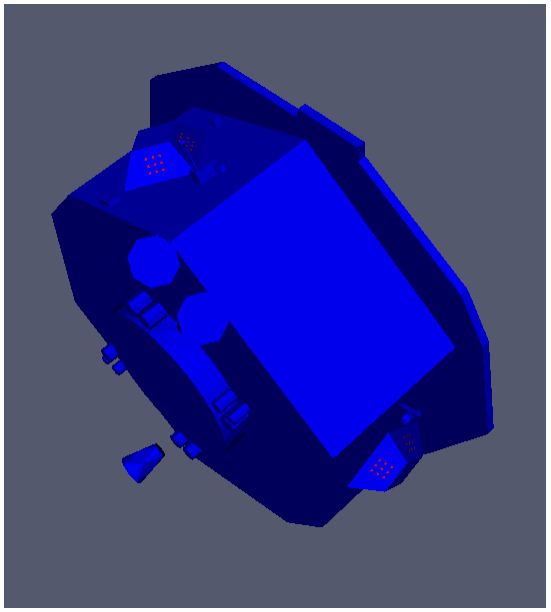
- **L1 orbit environment**
  - **Ambient H+ ions (5e6 #/m^3, 4.3eV, 375km/s)**
  - **Ambient electrons (5e6 #/m^3, 10.3eV)**
- **FEEP thruster plume models**
  - **Based on real plume models which will be confirmed by experiments**
  - **Neutral fraction: 20% Cs, 50% In**
- **Geometrical model**
  - **SPIS cannot handle real CAD models**

  => Models made ‘by hand’ based on blueprints

GMSH geometrical models of LPF



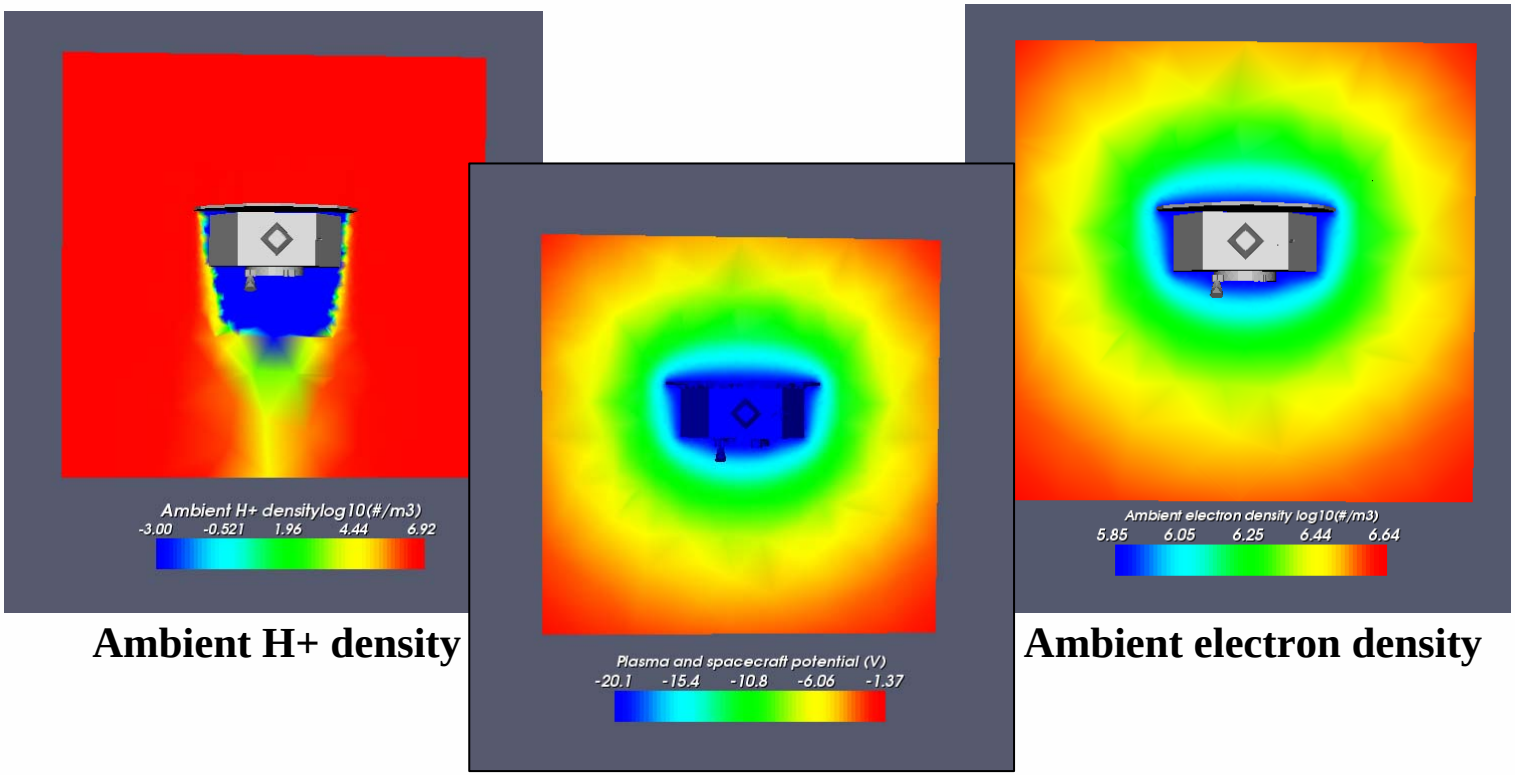
FEEP Cs cluster



FEEP In cluster

- Gives a mesh of approximately 30000 nodes and 180000 elements
- SPIS simulation lasting a few hours up to few days [2.4GHz, 2.5GB]

Floating potential during non-emission



Ambient H+ density **Ambient electron density**

Floating s/c potential during non-emission (without photoemission): **~ -20V**

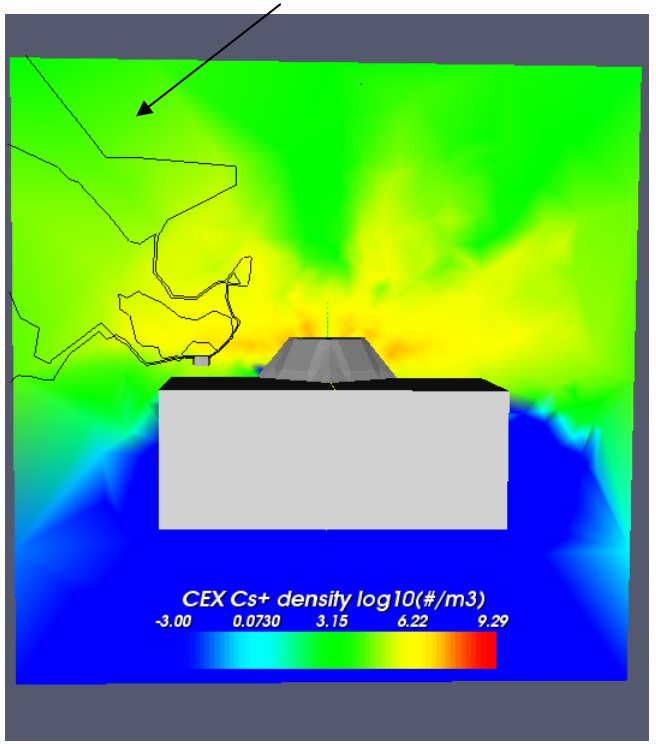
Does the FEEP neutraliser influence the flow-back?

SPIS models with one FEEP Cs cluster and one FEEP neutraliser indicates…

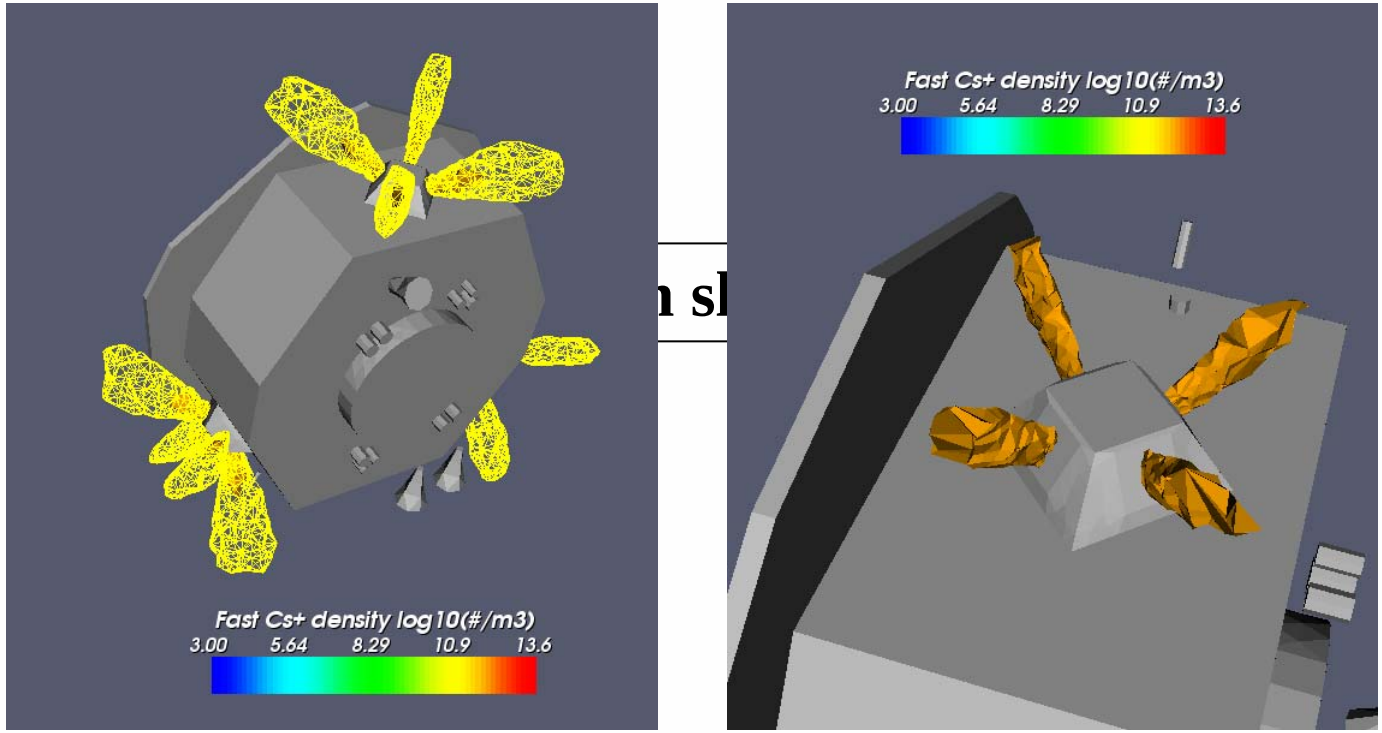
- **No shift in the fast Cs+ plume**
- **No major shift in the CEX Cs+ plume**
- **The strong solar wind causes a shift in the FEEP neutraliser electron beam**

To be confirmed!

FEEP NA electron density isolines at 10^8,10^9,10^{10},10^{11} #/m3

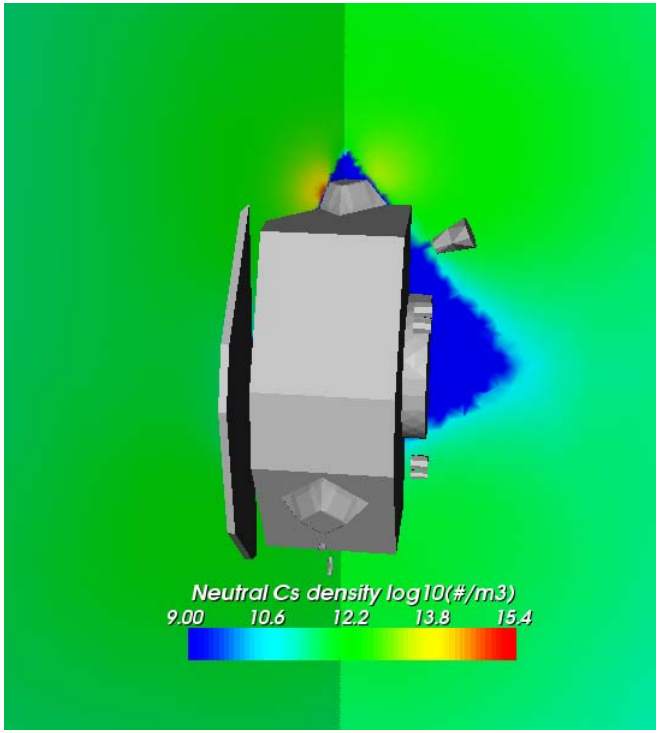


CEX Cs+ density log10(#/m3)

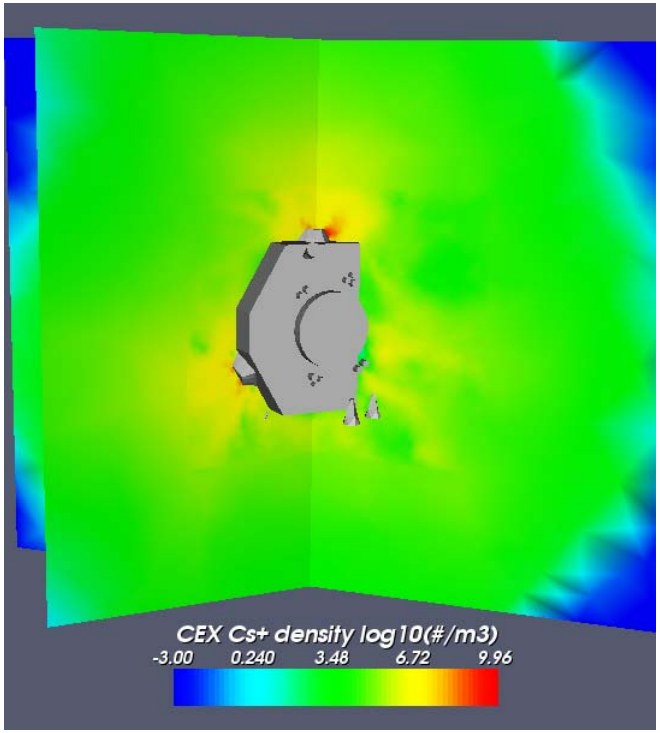


Fast Cs+ density log10(#/m3) - isosurfaces at 11 and 12

FEEP Cesium slit thrusters

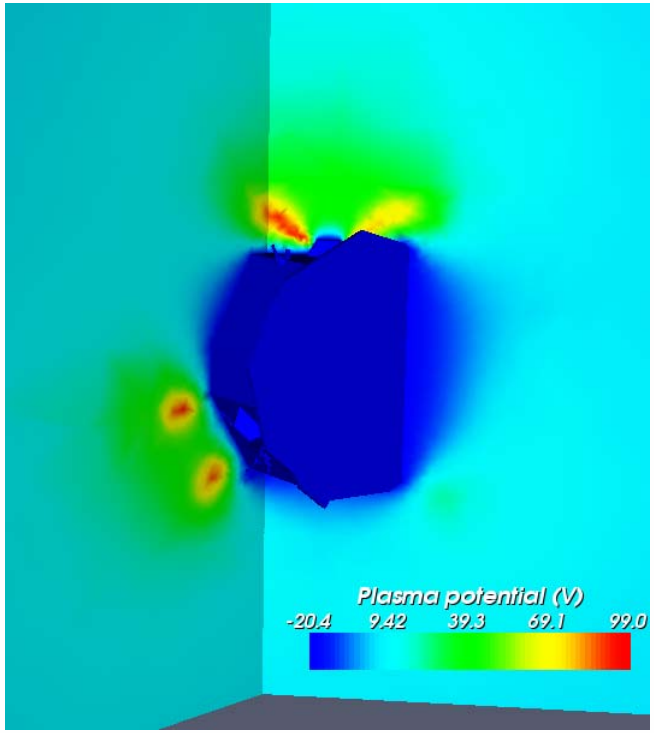


Neutral Cs density log10(#/m3)

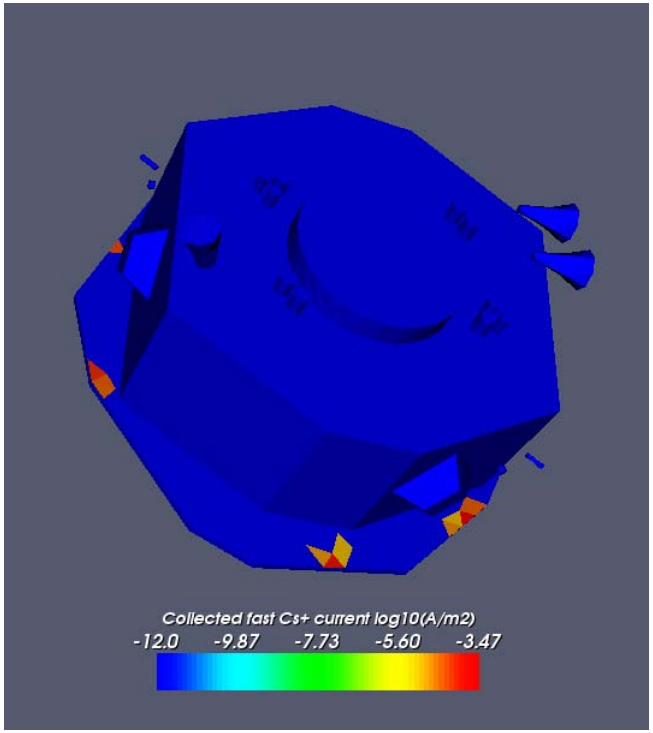


CEX Cs+ density log10(#/m3)

FEEP Cesium slit thrusters

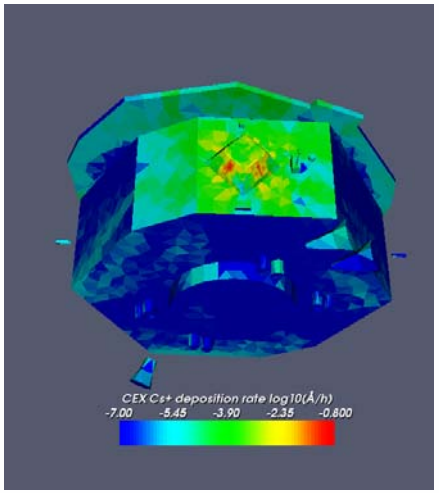


Plasma potential (V)

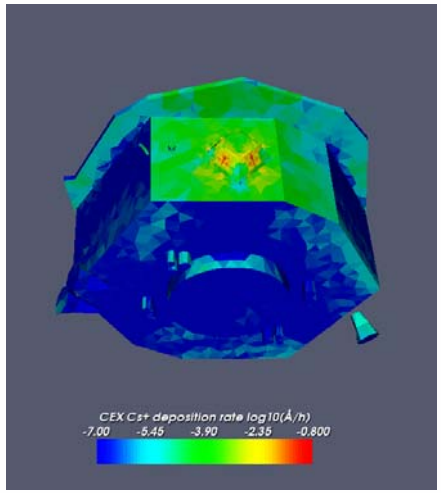


Collected fast Cs+ current log10(A/m2)

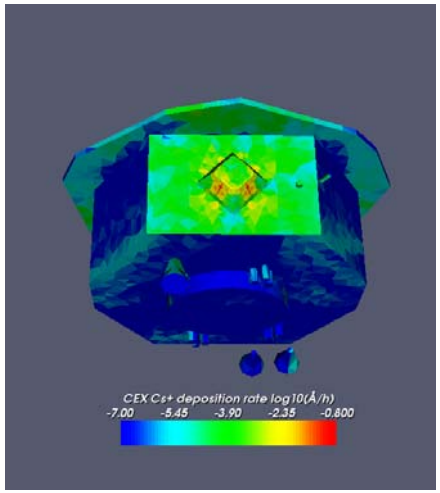
FEEP Cesium slit thrusters



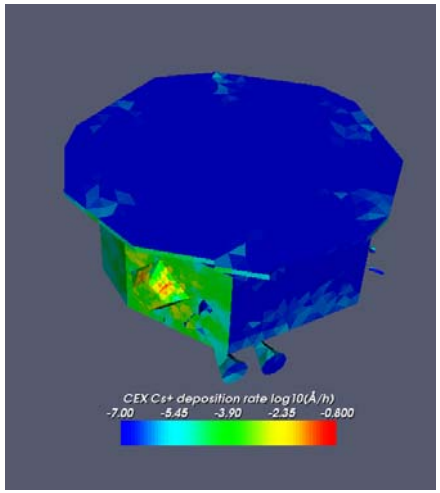
FEEP cluster 1



FEEP cluster 2



FEEP cluster 3



Top view

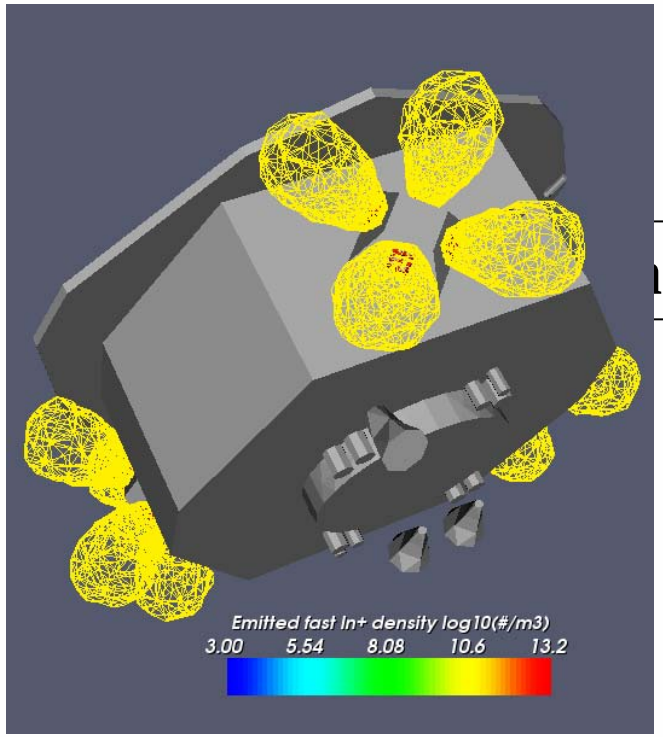
CEX Cs+ deposition rate log10(Å/h)

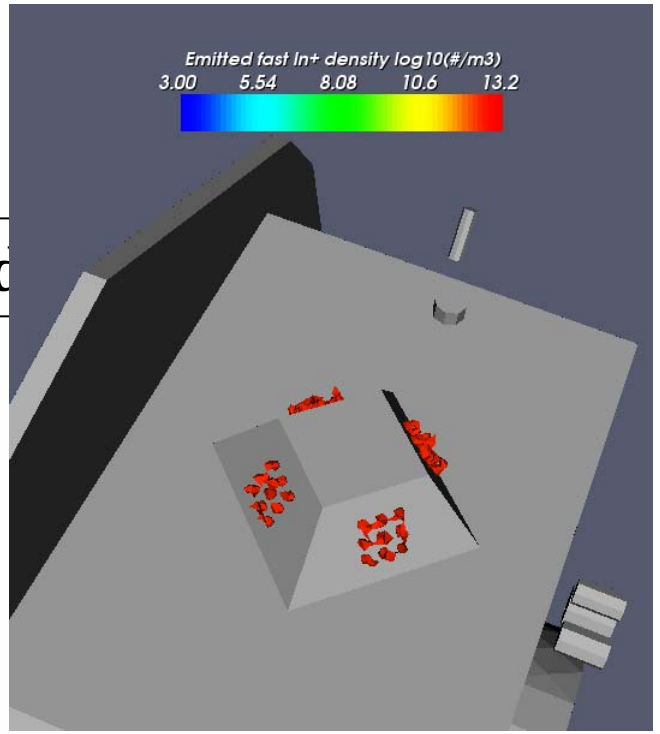
<u>Still to be included:</u>

-Neutral Cs deposition rate

-Impact of evaporation

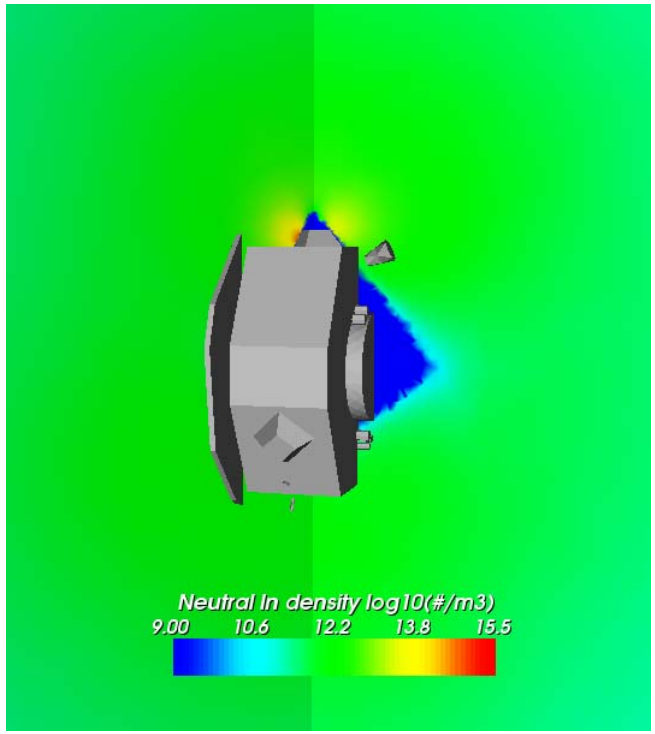
-Test materials for exposure



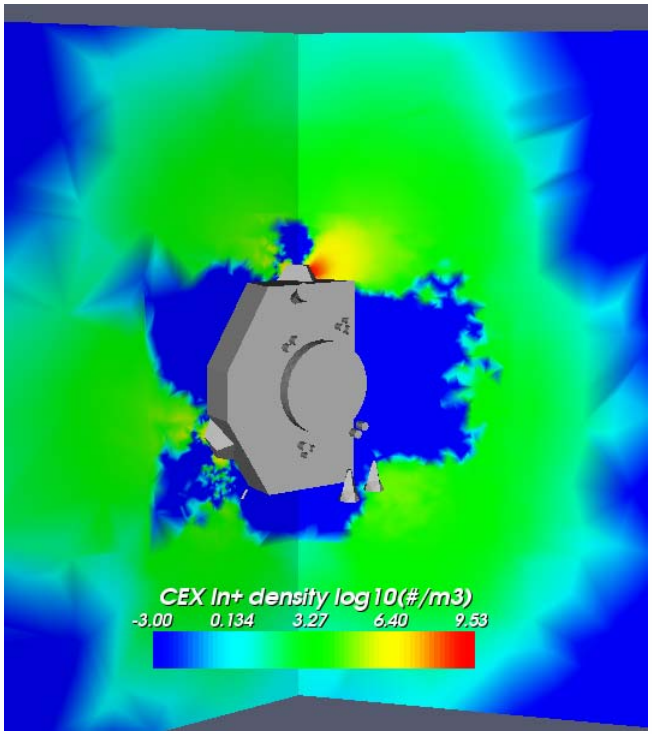


Fast In+ density log10(#/m3) – ***isosurfaces at 11 and 12.5***

FEEP Indium needles thrusters

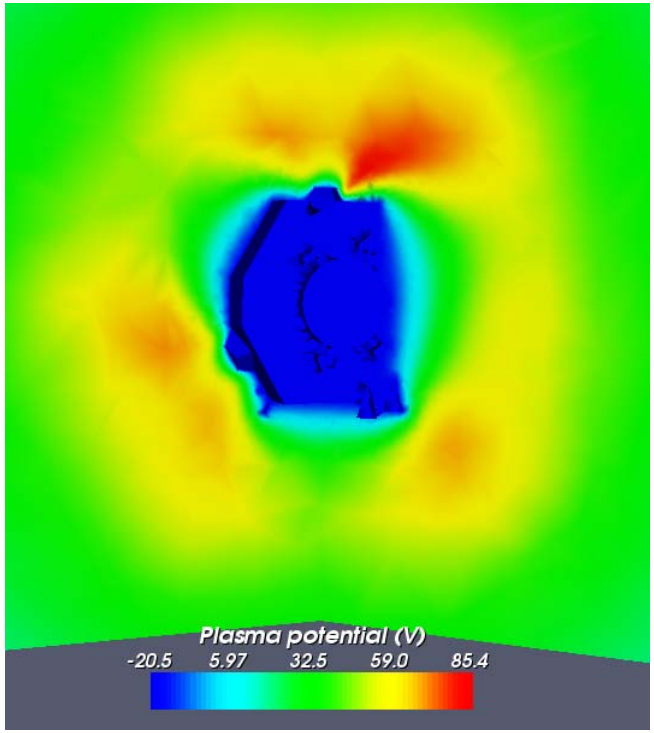


Neutral In density log10(#/m3)

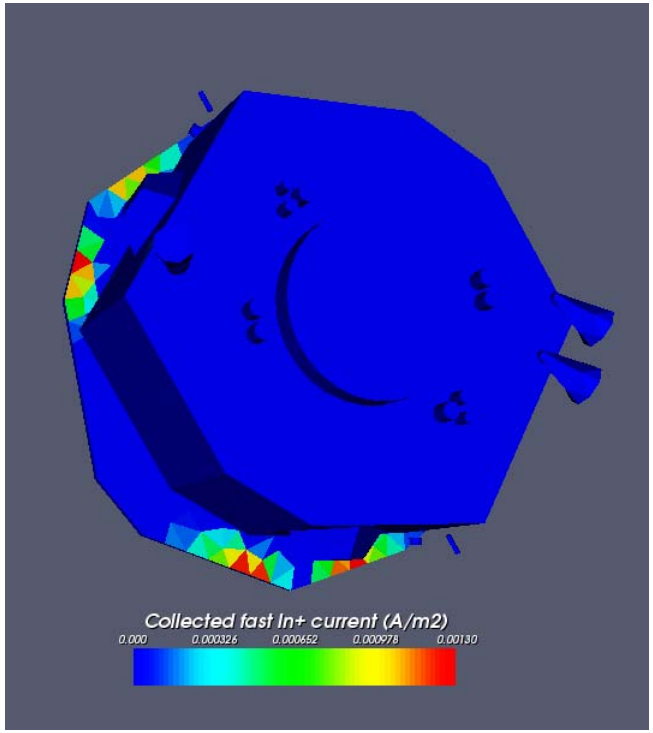


CEX In+ density log10(#/m3)

FEEP Indium needles thrusters

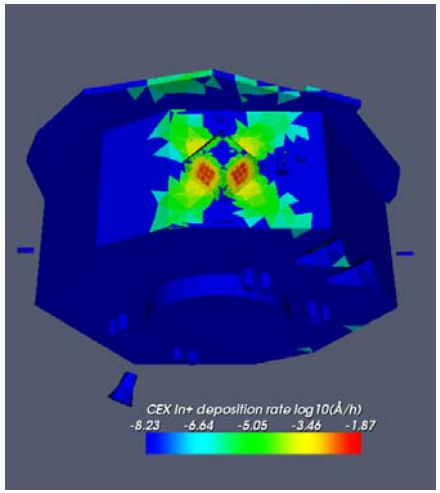


Plasma potential (V)

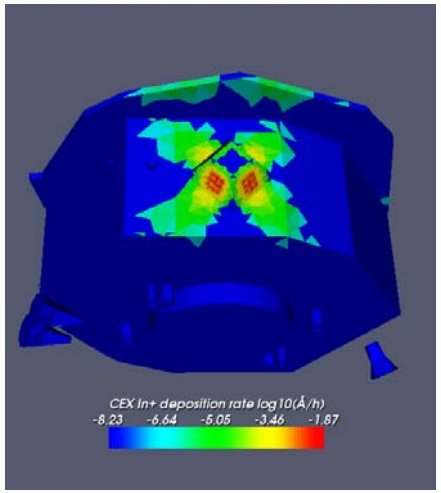


Collected fast In+ current (A/m2)

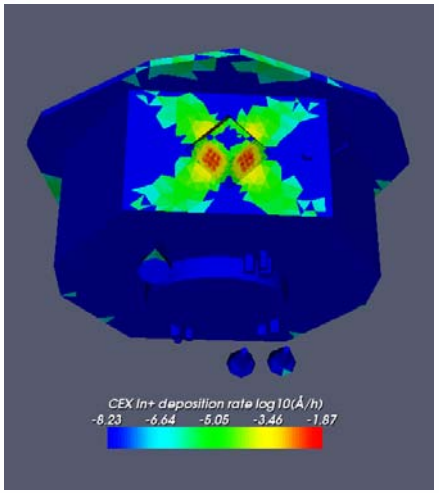
FEEP Indium needles thrusters



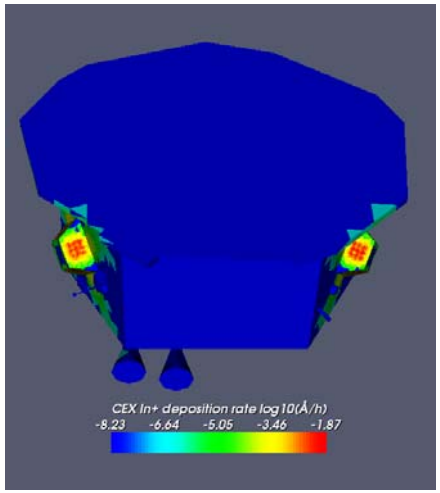
FEEP cluster 1



FEEP cluster 2



FEEP cluster 3



Top view

CEX In+ deposition rate log10(Å/h)

Still to be included:

- **Long simulation run**
- **-Neutral In deposition rate**
- **-Impact of evaporation (if any)**
- **-Test materials for exposure**

Summary

FEEP Cs slit thrusters

Thruster performance and CEX Cs+ generation are ok

CEX Cs+ flow-back is ok

Neutral Cs flow-back still to be modelled

FEEP In needles thrusters

CEX In+ deposition rate had to be added to the SPIS code

Thruster performance and CEX In+ generation are ok .

A longer simulation is needed for the CEX In+ flow-back

Neutral In flow-back still to be modelled

General SPIS feedback

Positive

- Generates good 3D views
- Possible to set many input properties and parameters
- Open source → Code development possible according to ones need
- Great support!!

Negative

- Hard to learn without any help. Real tutorials would be useful!
- 'Bugs' and inconveniences still exists!
- Model results confirmed with experiments?
- Construction of GMSH geometrical models are 'tricky'

Thank you!

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