JUICE spacecraft charging in the auroral zone of Ganymede

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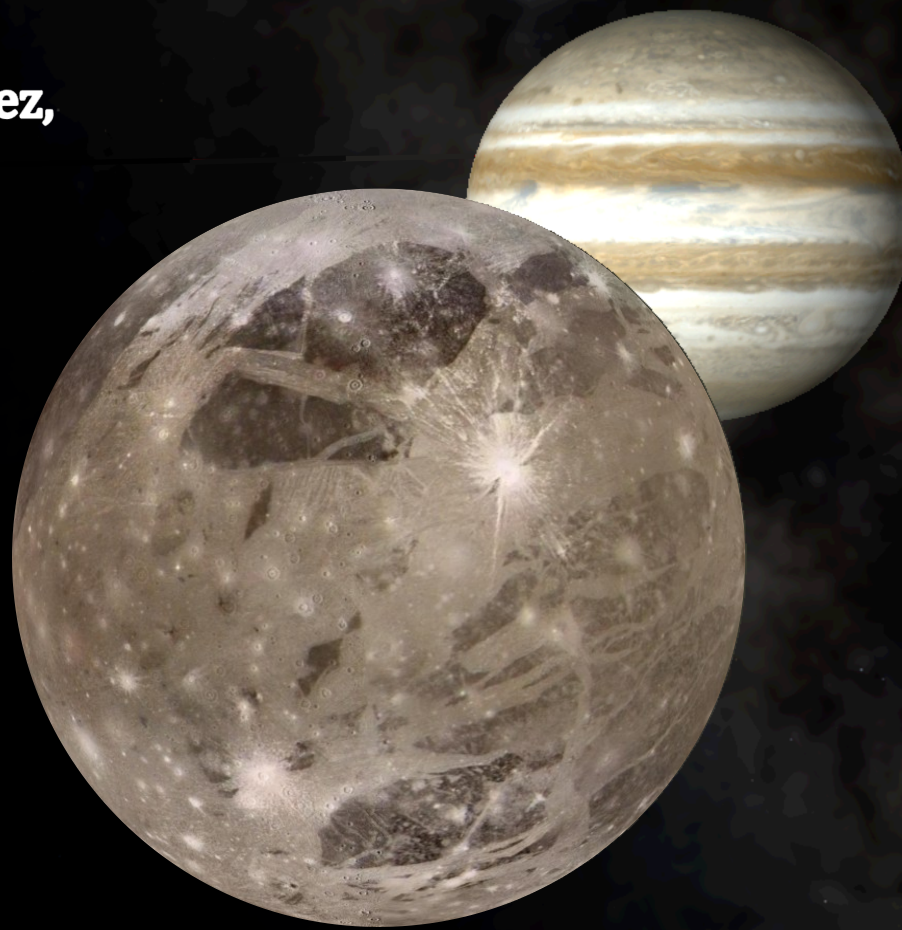

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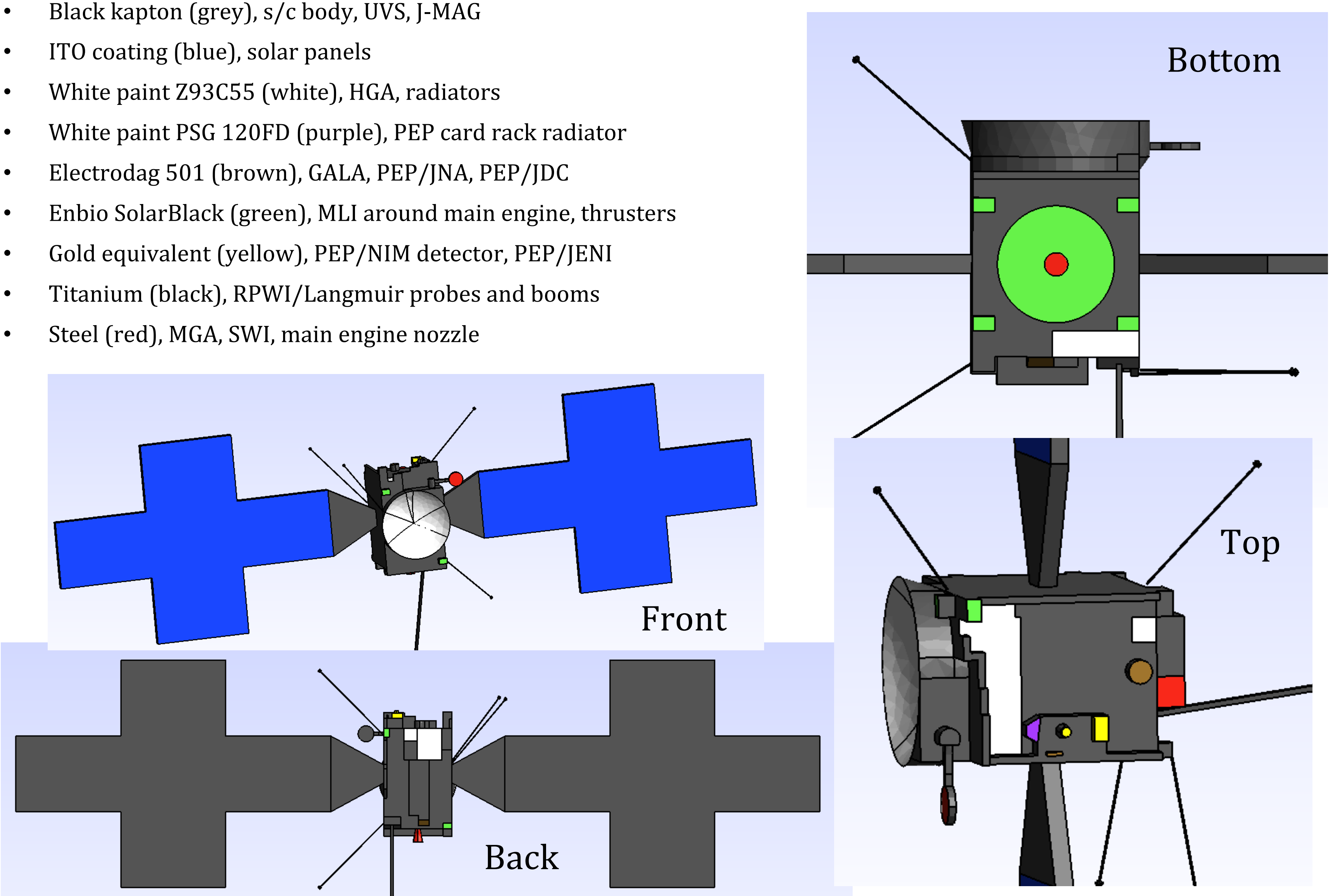
Simulation setup – Juice spacecraft model

- Black kapton (grey), s/c body, UVS, J-MAG
- ITO coating (blue), solar panels
- White paint Z93C55 (white), HGA, radiators
- White paint PSG 120FD (purple), PEP card rack radiator
- Electrodag 501 (brown), GALA, PEP/JNA, PEP/JDC
- Enbio SolarBlack (green), MLI around main engine, thrusters
- Gold equivalent (yellow), PEP/NIM detector, PEP/JENI
- Titanium (black), RPWI/Langmuir probes and booms
- Steel (red), MGA, SWI, main engine nozzle



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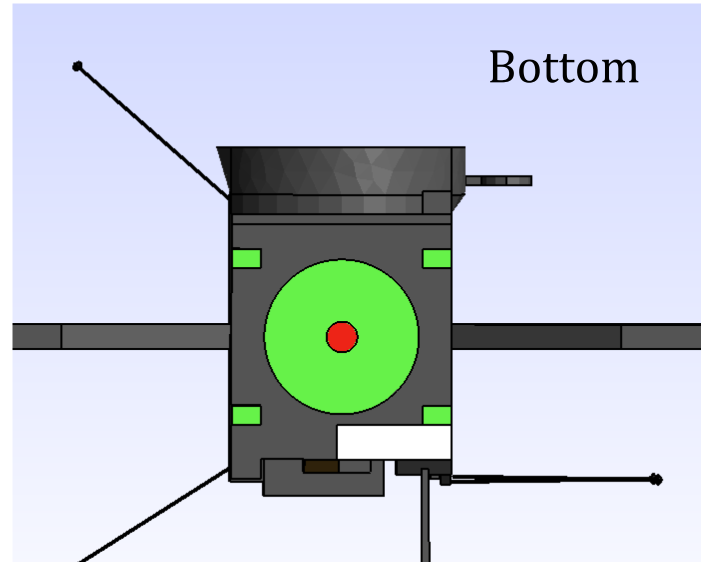

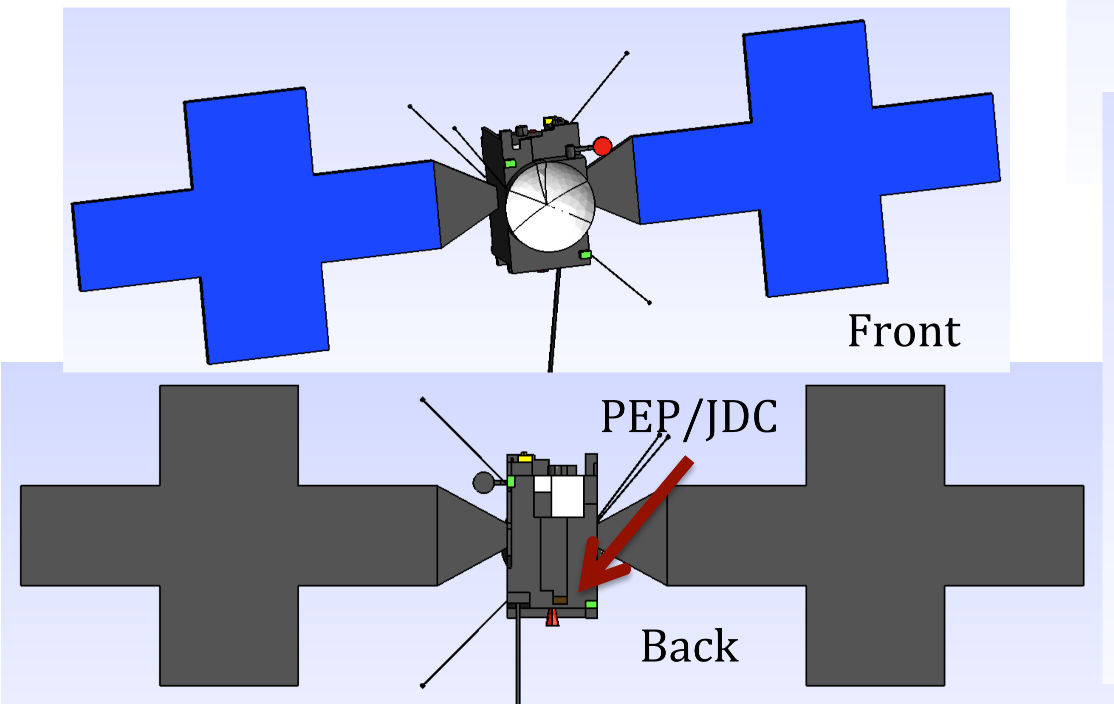

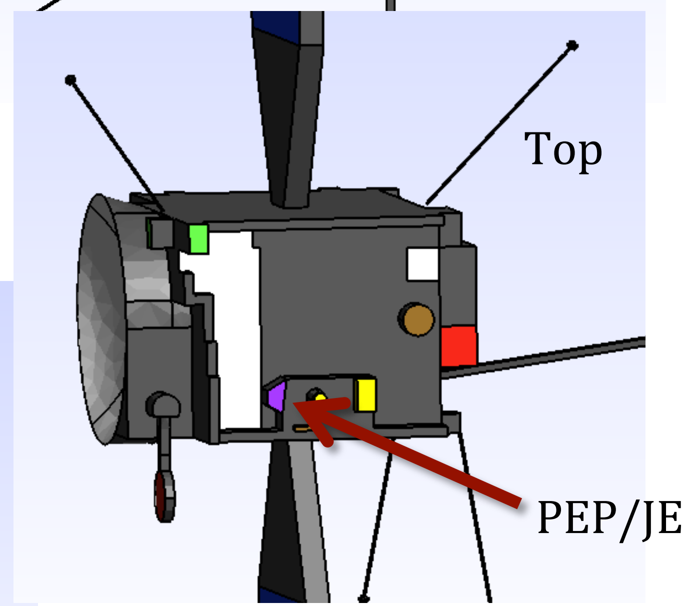

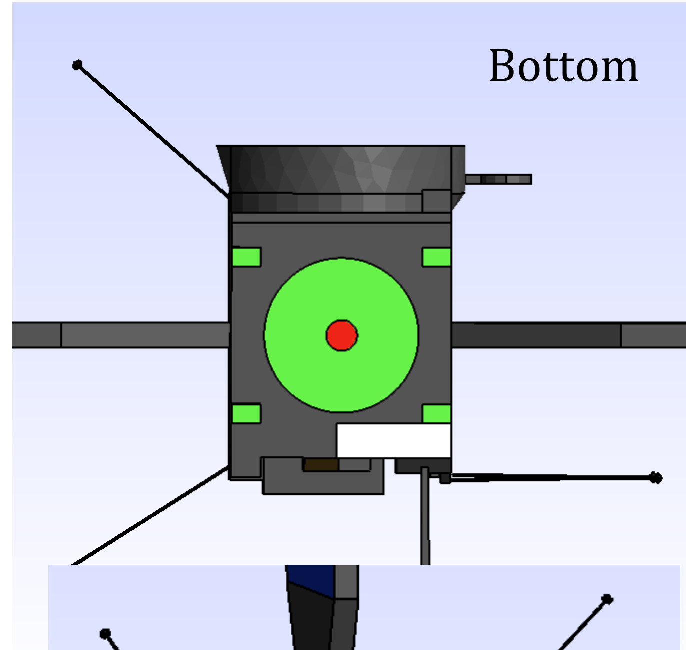
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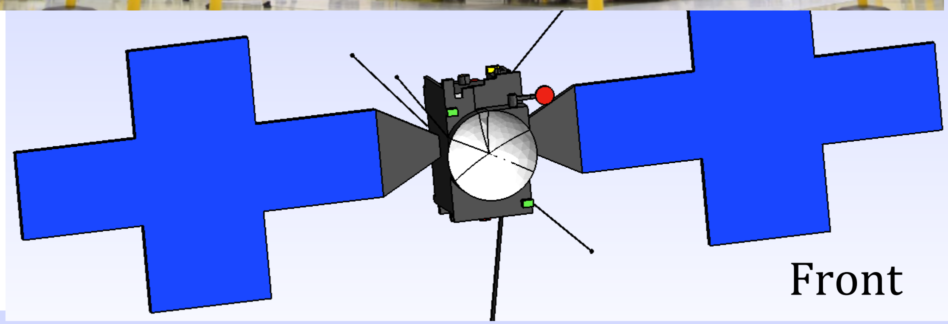
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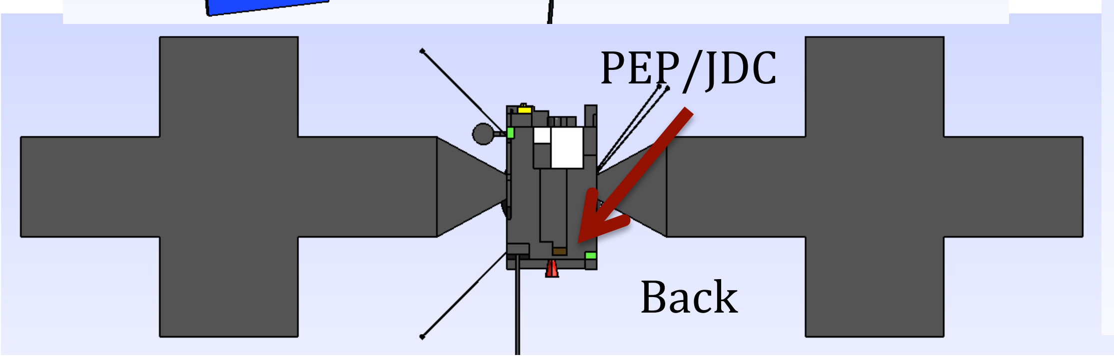
PEP/JDC
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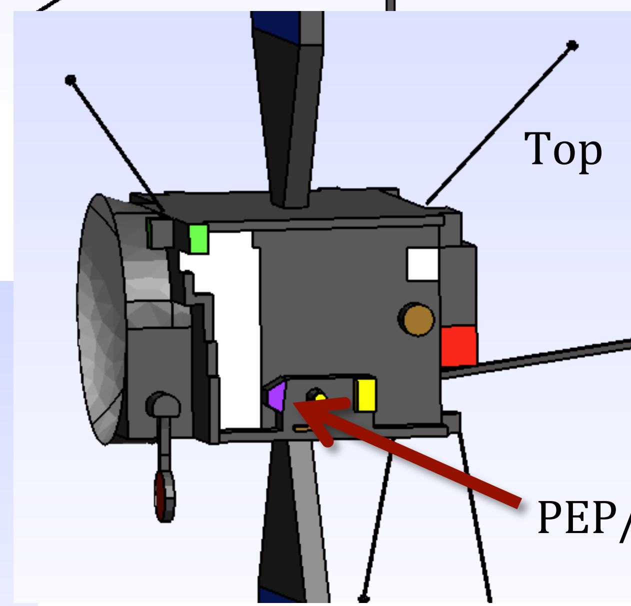
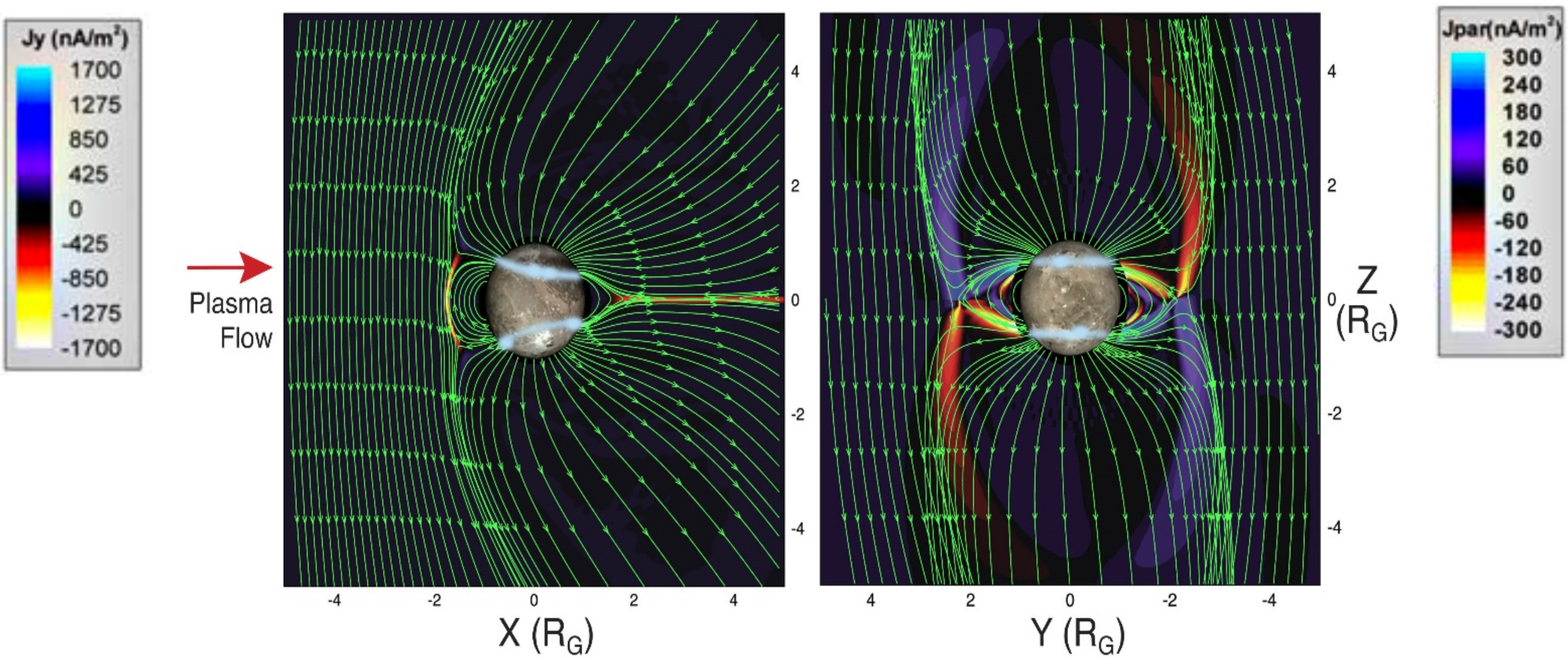

Top
PEP/JEI

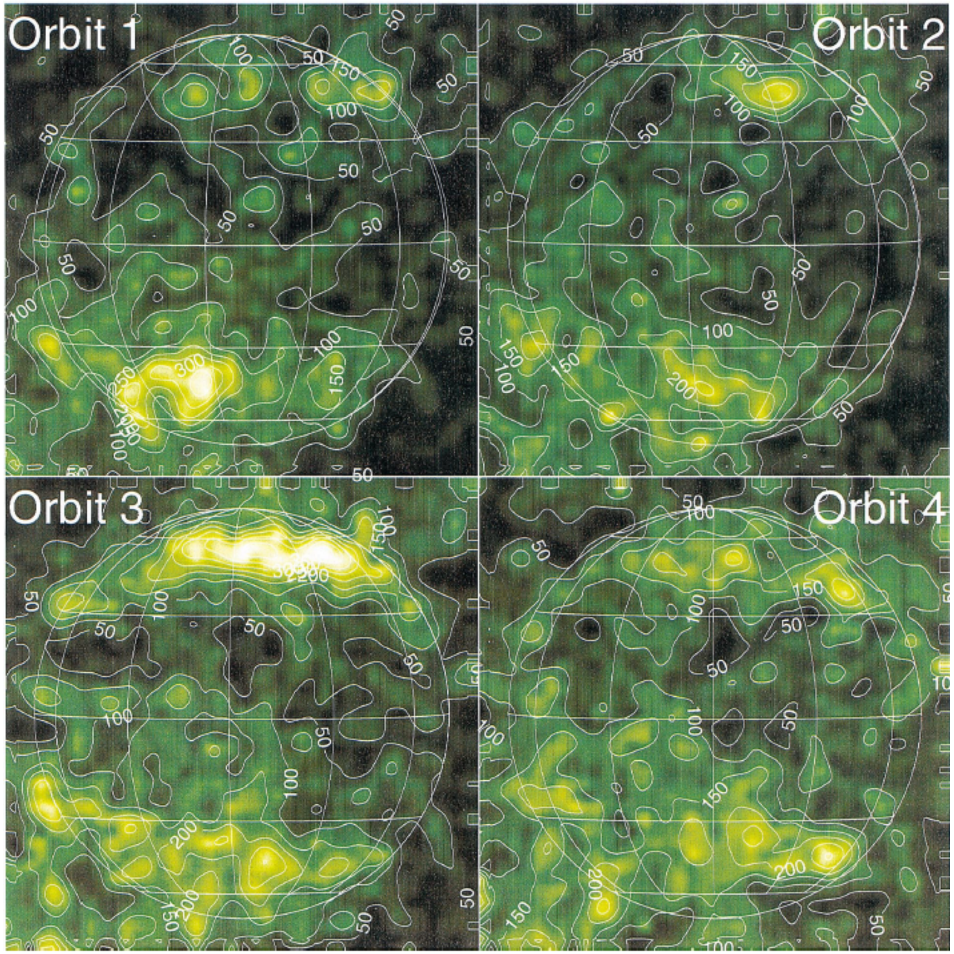
Aurora on Ganymede

- Ganymede orbits at ~15 R_J and has a radius of R_G = 2634.1 km
- Ganymede is the only moon in our Solar System known to have its own global magnetic field
- Figure adapted from Jia et al. 2008



Aurora on Ganymede

- Will auroral particles at Ganymede cause substantial charging of JUICE?



From Eviatar et al., 2001

- Hubble Space Telescope observations
- Continuous background emission requires no acceleration of the ambient plasma population
- Common intensity 50-100 Rayleigh
- Intense auroral bright spots around and above 300 Rayleigh requires acceleration of the ambient plasma population and/or higher densities
- Rarely exceeds 300 Rayleigh

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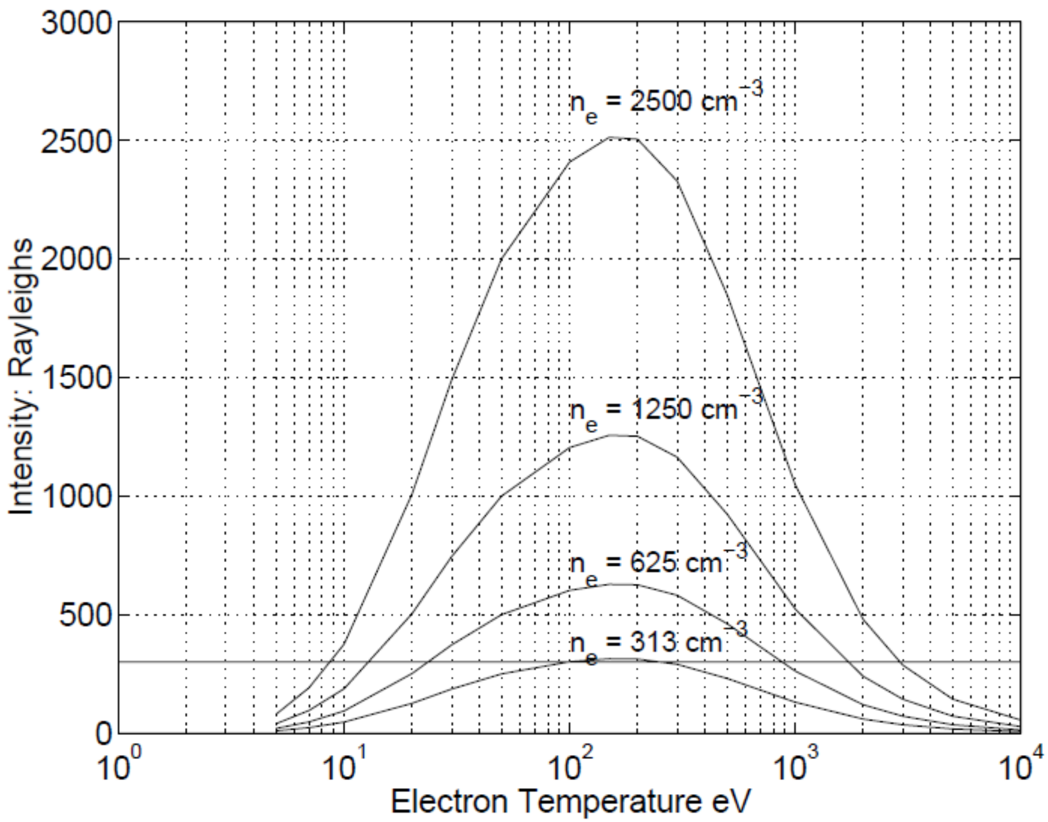

FIG. 3.—Calculated intensity of O I λ1356 emission. The 300 R value is marked to show the conditions required.

From Eviatar et al., 2001

- What electron temperatures are needed to produce intensities above 300 Rayleigh?
- T_e = 100 eV – 230 eV and n_e = 313 cm^{-3} will generate the same intensity as T_e = 9 eV and n_e = 2500 cm^{-3}
- Spacecraft charging depends both on the density and the temperature

Aurora on Ganymede – SPIS simulations

Global parameters	Ionosphere + auroral pop 1	Ionosphere + auroral pop 2
e^- density, ionosphere	100 cm^{-3}	100 cm^{-3}
e^- temperature, ionosphere	5 eV	5 eV
e^- density, aurora	300 cm^{-3}	1250 cm^{-3}
e^- temperature, aurora	200 eV	11 eV
Ion density, ionosphere+aurora	400 cm^{-3}	1350 cm^{-3}
Ion temperature, ionosphere+aurora	50 eV	50 eV
Flow velocity, ionosphere	65 km/s	65 km/s
Flow velocity, aurora	0 km/s	0 km/s
Dominant ion species	O_2^+	O_2^+
Spacecraft velocity, $\|v_{s/c}\|$	13 km/s	13 km/s
Magnetic field strength, $\|B\|$	500 nT	500 nT

- Hot electron component irrelevant?
- Drift velocity of auroral population?
- How to treat the auroral ion population?

Aurora on Ganymede – SPIS simulations

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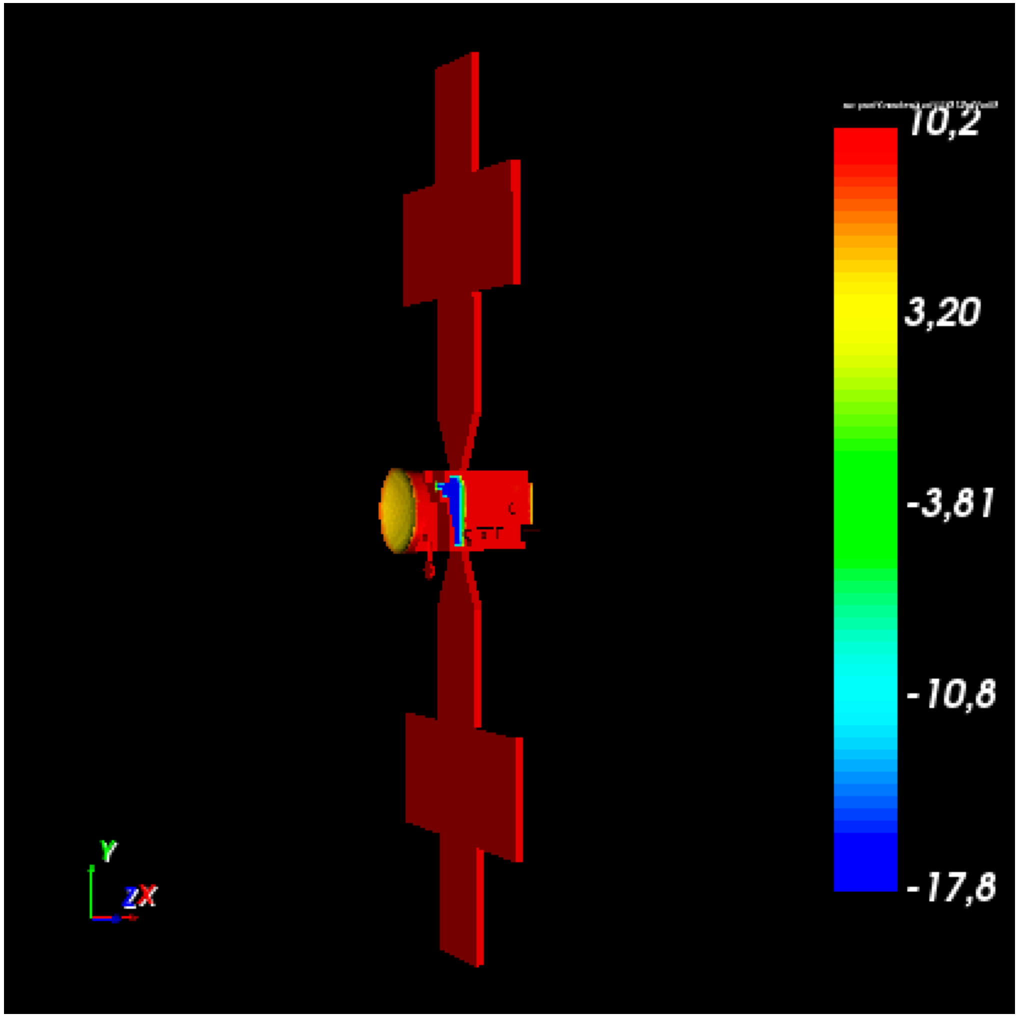

- Surface potential from -17.8 to 10.2 V.
- s/c charges positively due to the extreme amounts of secondary electrons produced by the auroral population.
- Does not correspond to the situation of spacecraft charging in the auroral zone at Earth. Auroral electrons at Earth are in the energy range keV (not efficient at producing secondary electrons)

Orientation of the solar panels

- Surface potentials in Ganymede's ionosphere without the auroral population.

Case	Surface potential (V)
1. y || v & S	-15.5 (-19.3 to -10.8) *
2. y || S, y ⊥ v	-10.9 (-19.2 to -5.8)
3. y || v, y ⊥ S	-10.0 (-18.8 to -6.8)
4. y ⊥ v & S	-7.9 (-18.9 to -3.8)

- y is aligned with solar panels
- v is the plasma flow direction
- S is the direction of the solar radiation

Conclusions

- JUICE will spend ~10 months in orbit around Ganymede with a high inclination orbit, and repeatedly cross the auroral zone.
    - Accelerated auroral particles will impact the spacecraft charging of JUICE
    - Preliminary results shows potentials from -17.8 to 10.2 V
- The orientation of the solar panels can be used to alter the surface potentials
    - Simulation the potential in the ionosphere of Ganymede shows frame potentials varying from -7.9 V to -15.5 V
- Future work
    - How would a different surface density and column density of oxygen in the atmosphere of Ganymede impact the results?
    - How does the orientation of the solar panels impact the potential obtained in the auroral zone?