Temporal Evolution of the Plasma Sheath Surrounding Solar Cells in Low Earth Orbit

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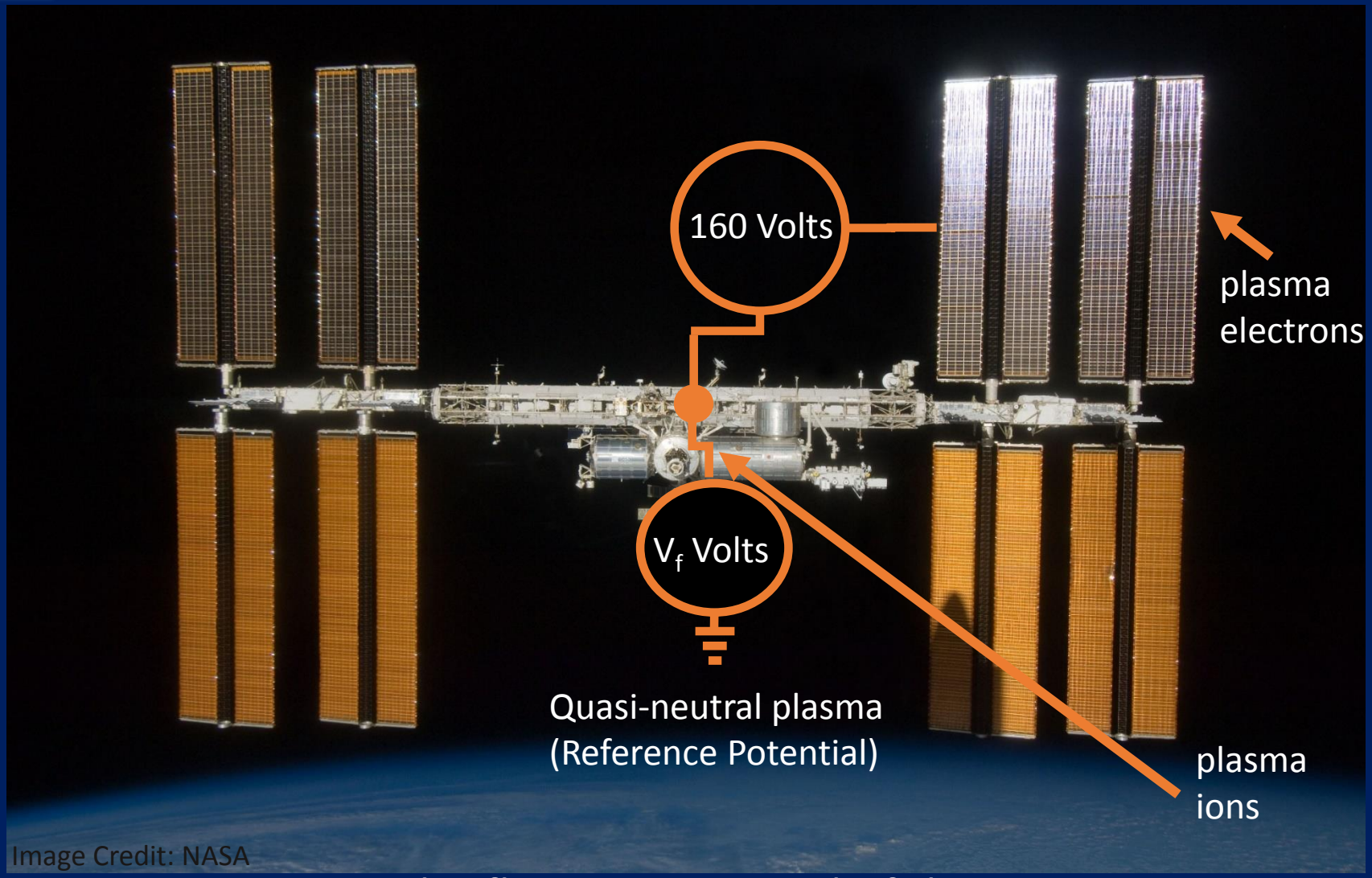
Outline

- Solar Array Operations Overview
- Standard ISS Floating Potential Observations
- Transient ISS Floating Potential Observations
- Particle in Cell Simulation
- Lumped Element Model
- Conclusion and Forward Work

Solar Array Operations Overview

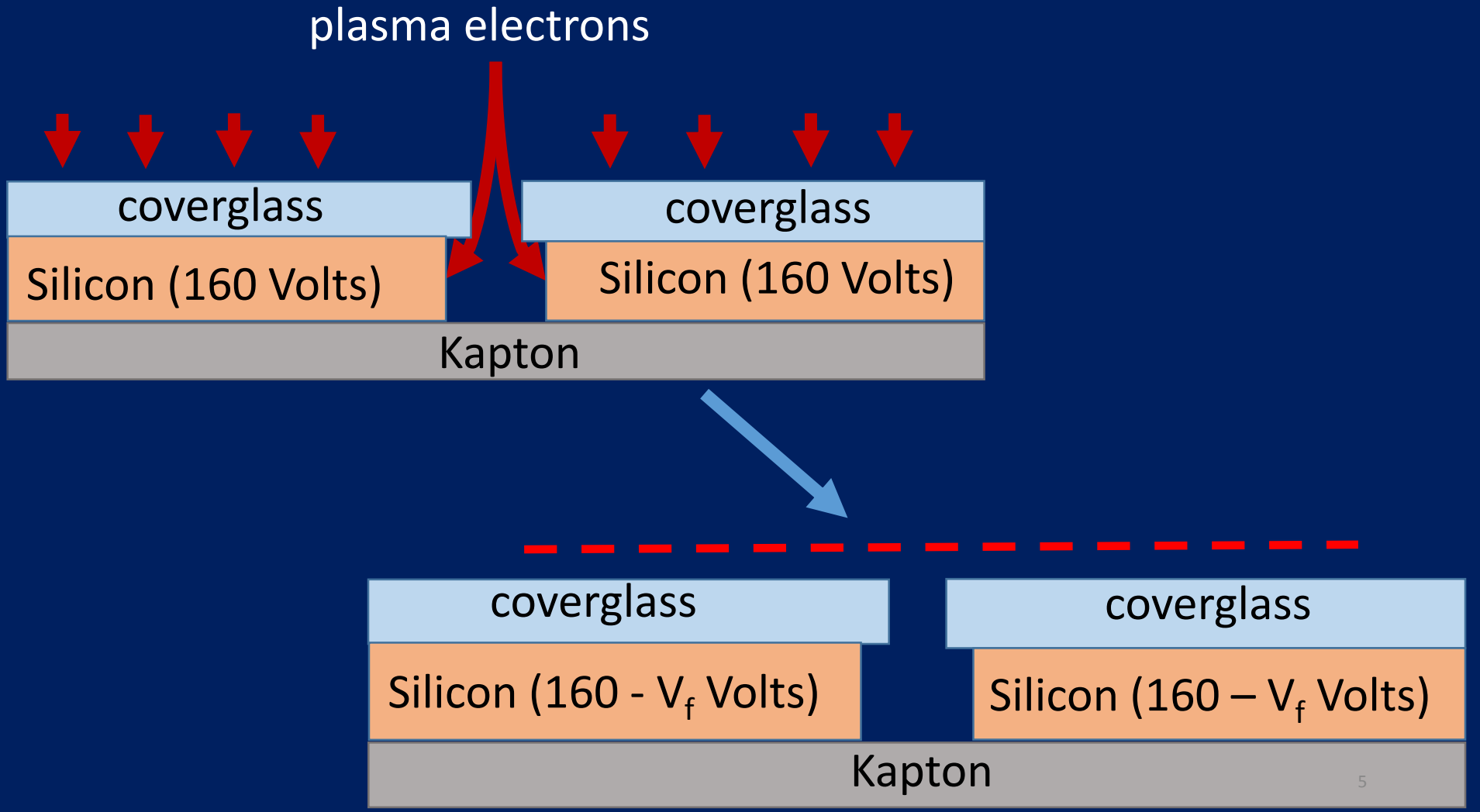


V_f is the floating potential of the ISS

Solar Cells

8 cm x 8 cm

Solar Cells


plasma electrons
coverglass
coverglass
Silicon (160 Volts)
Silicon (160 Volts)
Kapton
coverglass
coverglass
Silicon (160 - V_f Volts)
Silicon (160 – V_f Volts)
Kapton

Normal

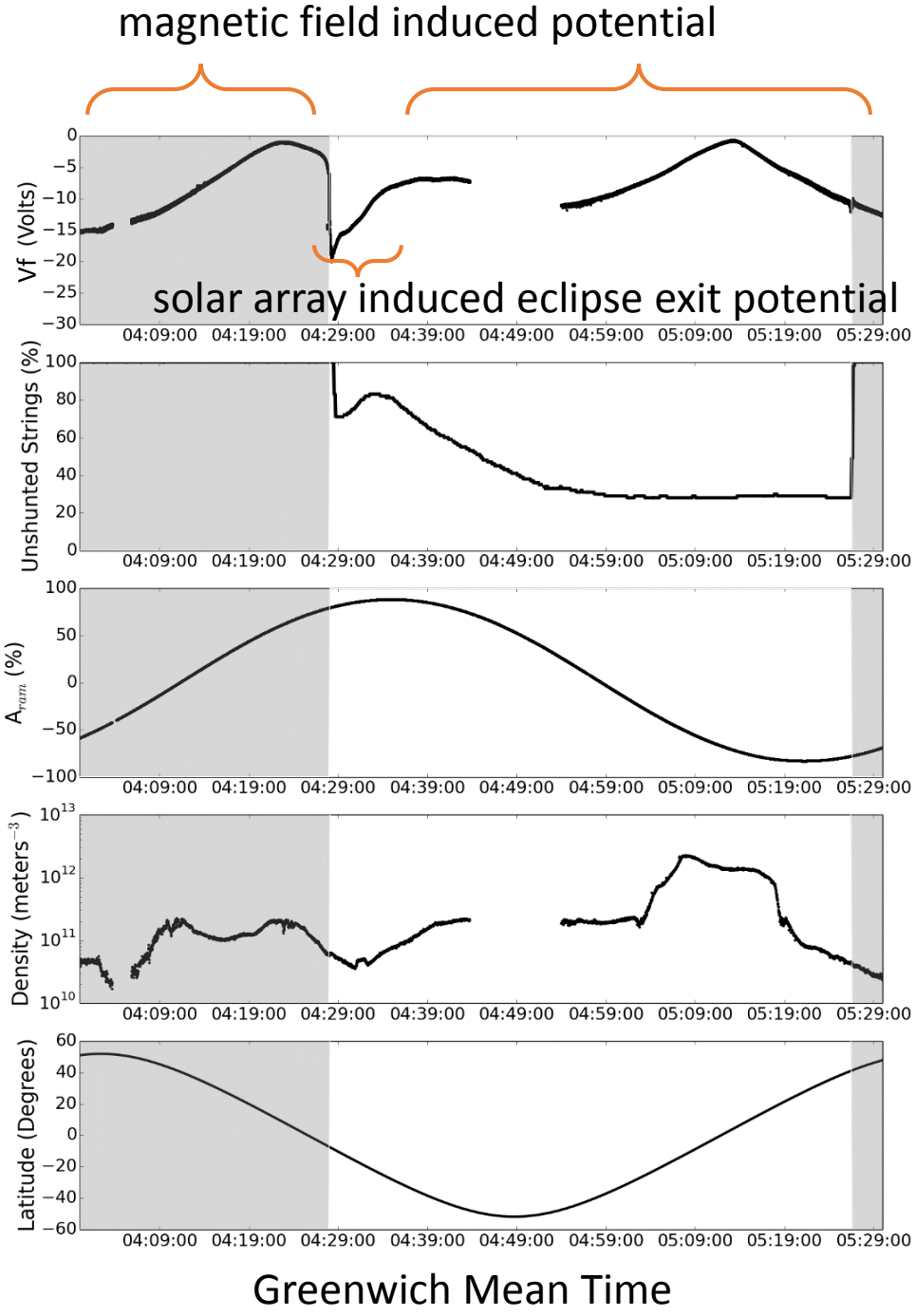
a) Floating Potential

b) Active Array Strings

c) Array Orientation

d) Plasma Density

e) ISS Latitude



Transients

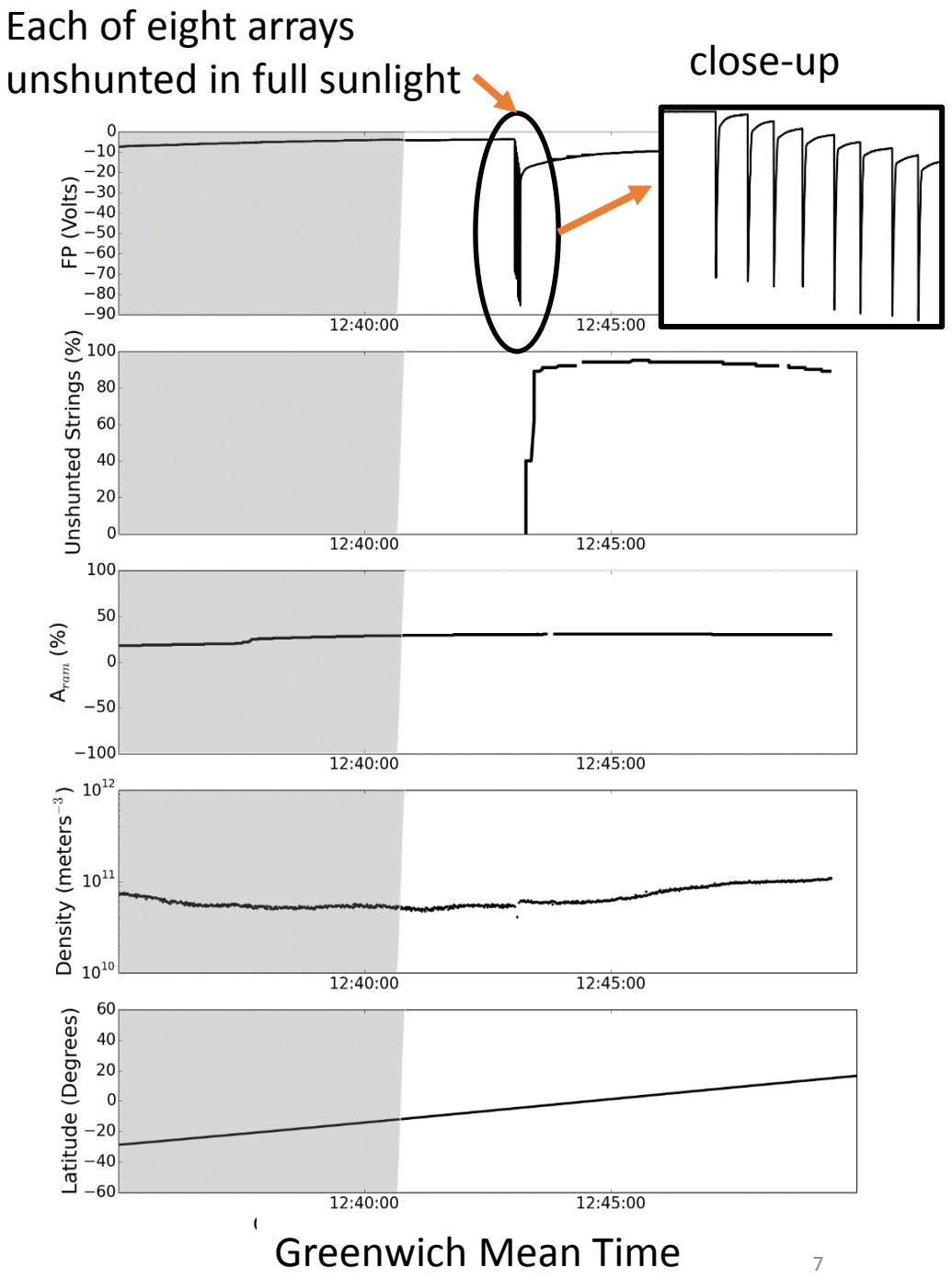
a) Floating Potential

b) Active Array Strings

c) Array Orientation

d) Plasma Density

e) ISS Latitude



Transients

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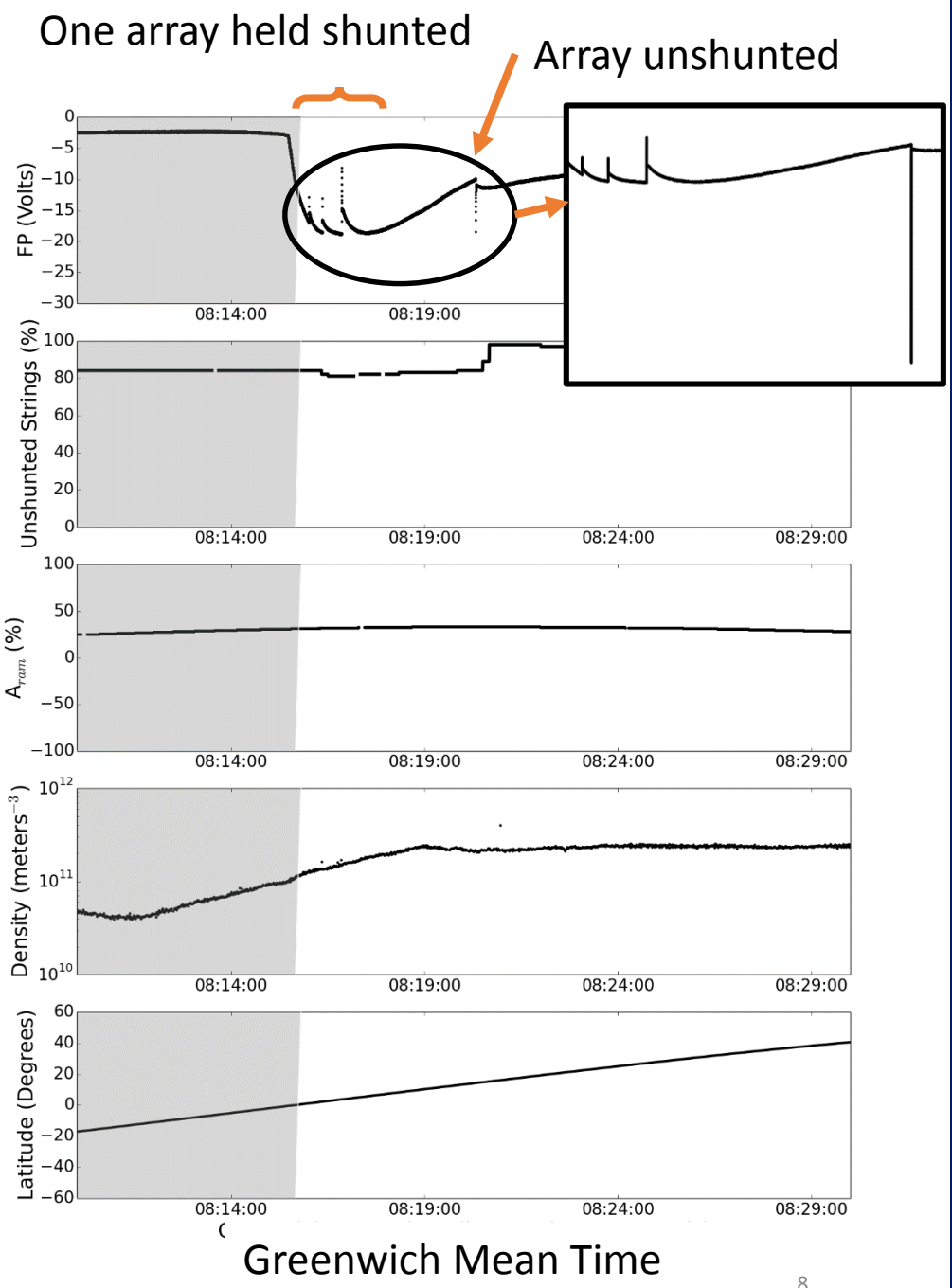

Transients

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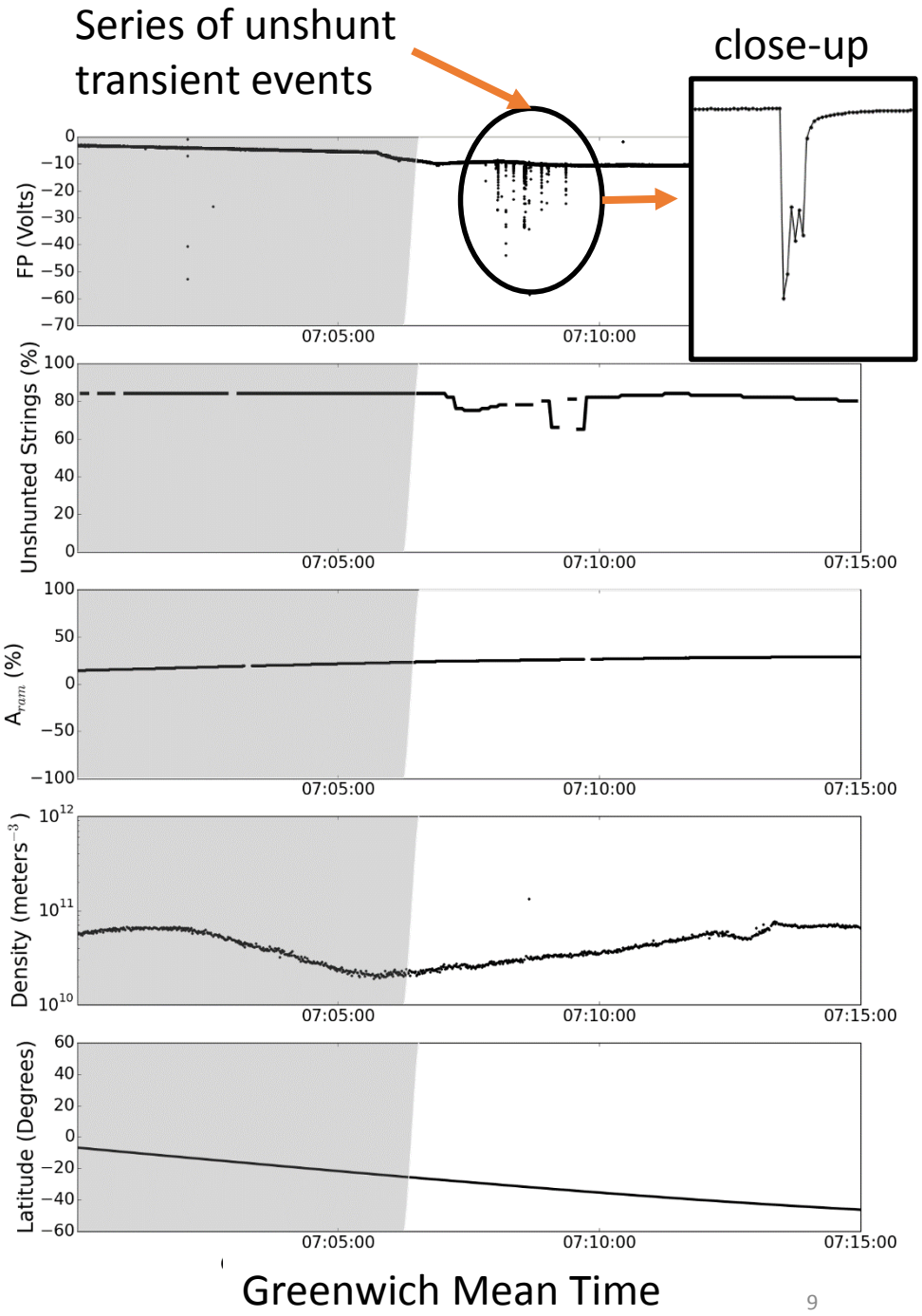
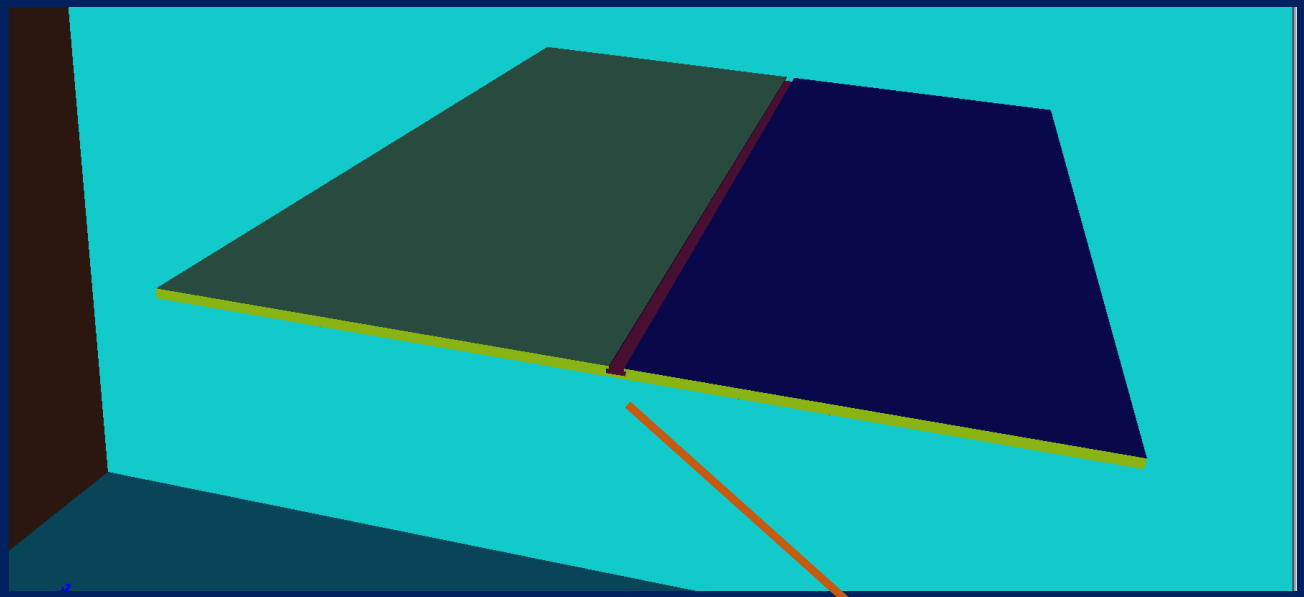
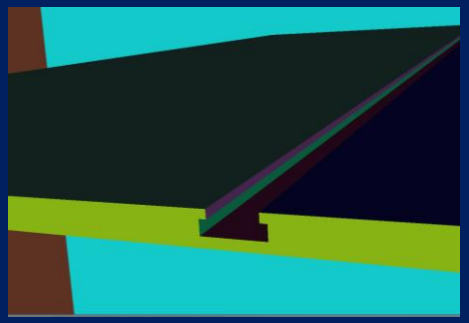


SPIS Setup – Steady State

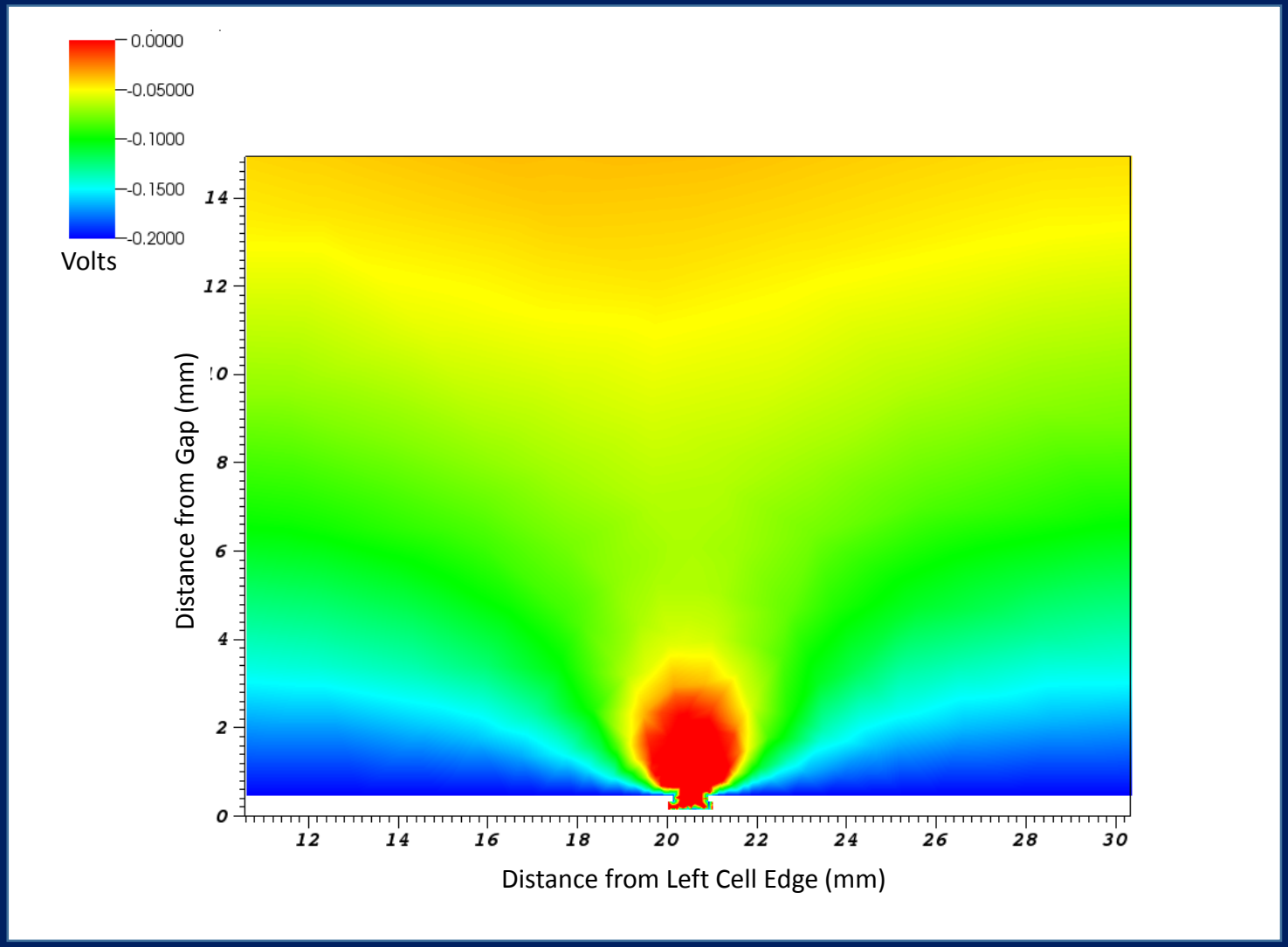




Coverglass surface set to −0.2 Volts.
Solar Cell set to 150 Volts
Plasma Density 1E11 m^{-3}
Plasma Temperature 0.1eV
Cell area 2 cm x 4 cm
Cell spacing 0.8mm
Coverglass overhang 0.2mm

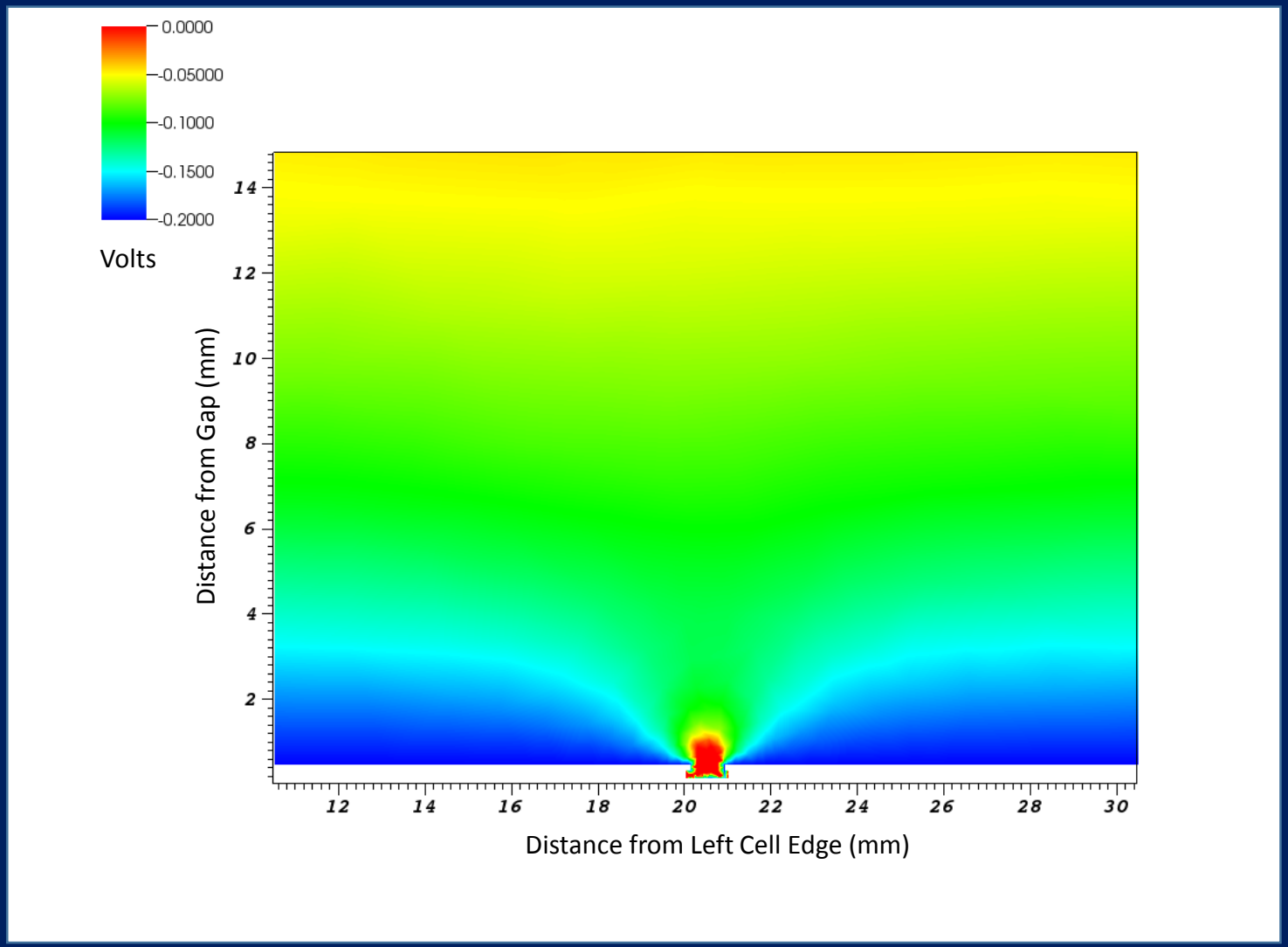
SPIS Results for 150 V Cell at Steady-state

barrier to electron collection of of -0.07V at 6mm from the gap.

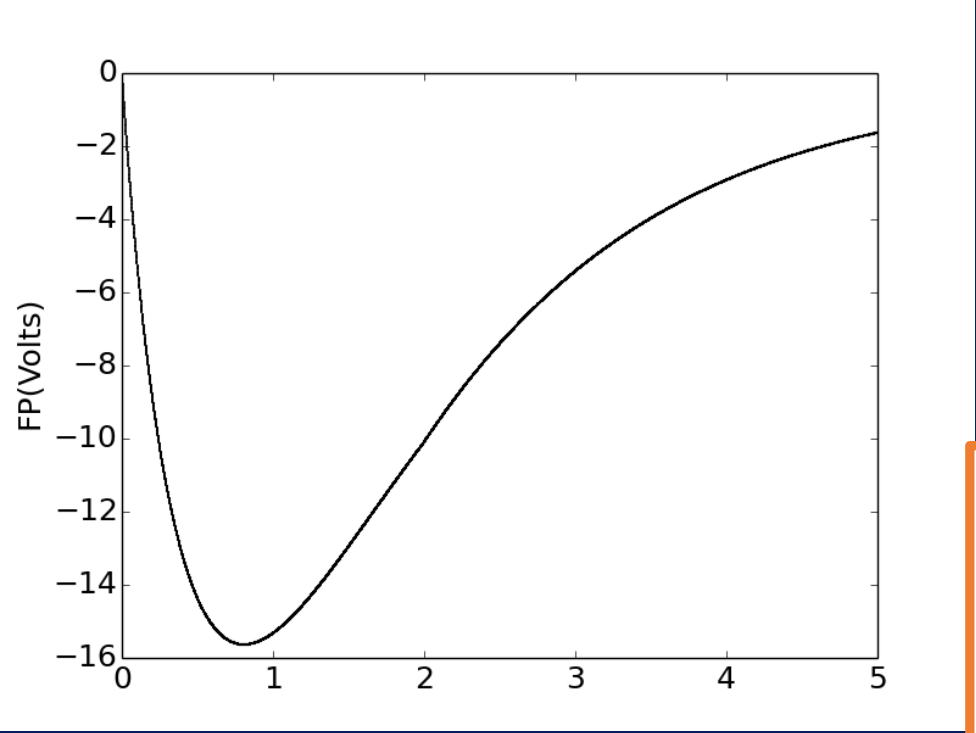


SPIS Results for 50 V Cell at Steady-state

barrier to electron collection of of -0.12V at 3mm from the gap.

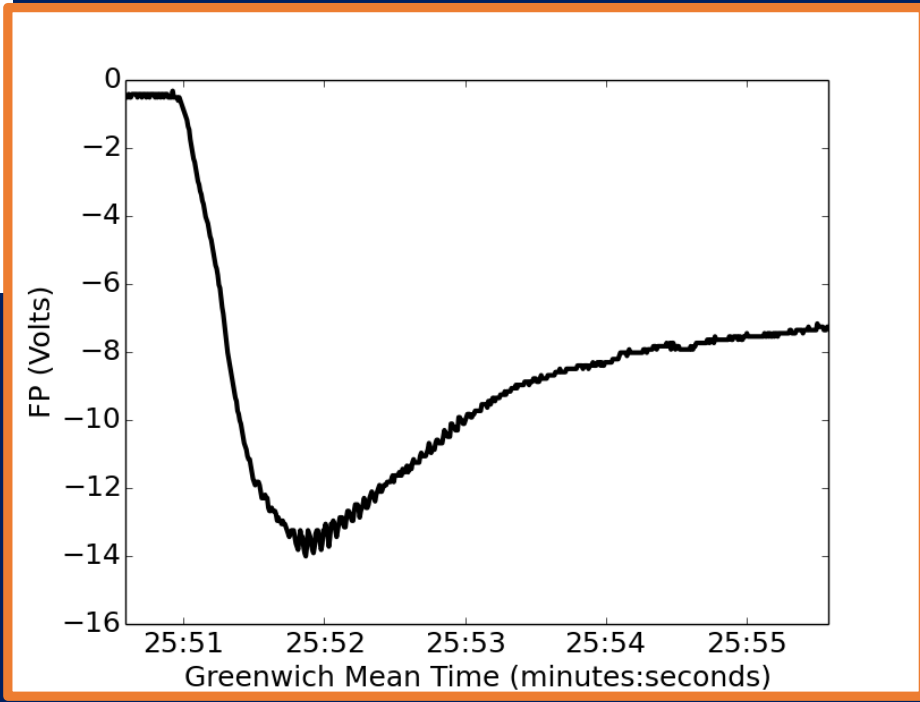


Existing Current Balance Model for Rapid Charging[1-2]



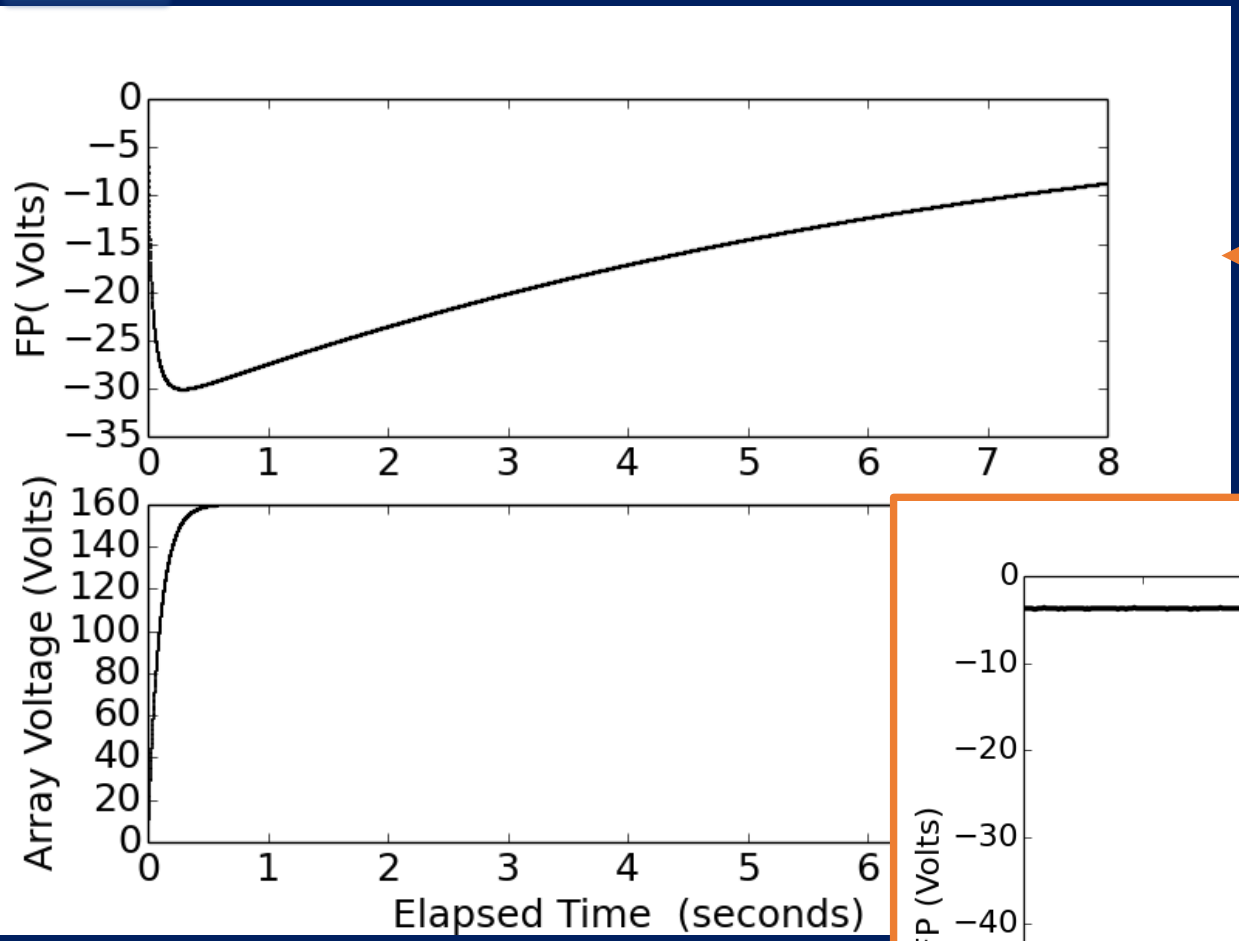
← Model Output

FPMU Data ↓



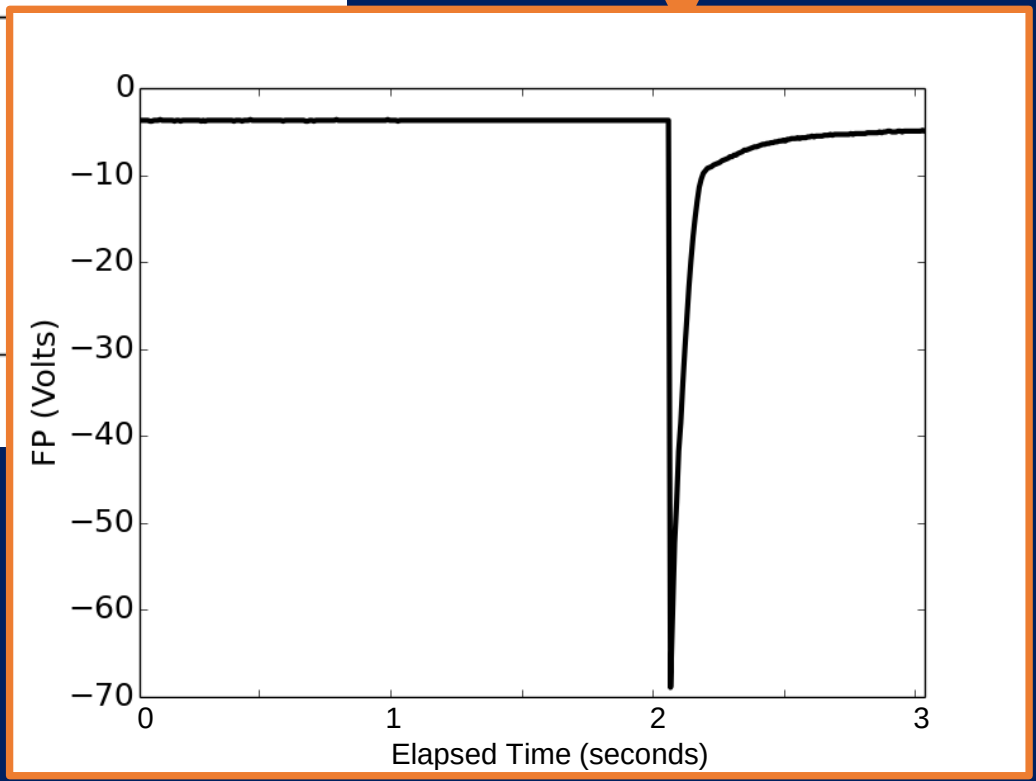
Model output agrees well with FPMU data

Current Balance Model Applied to Transients



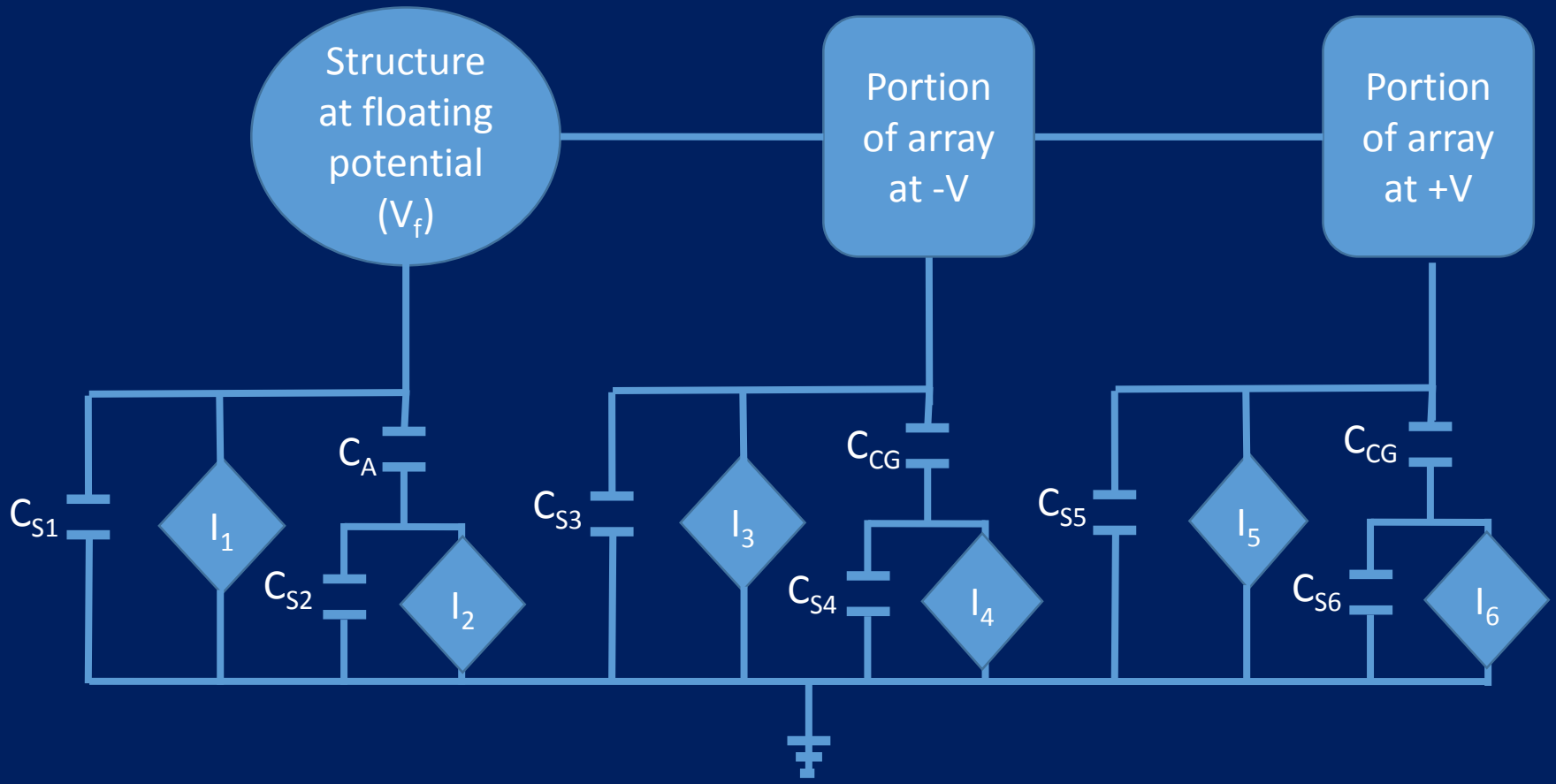
Model Output

FPMU Data

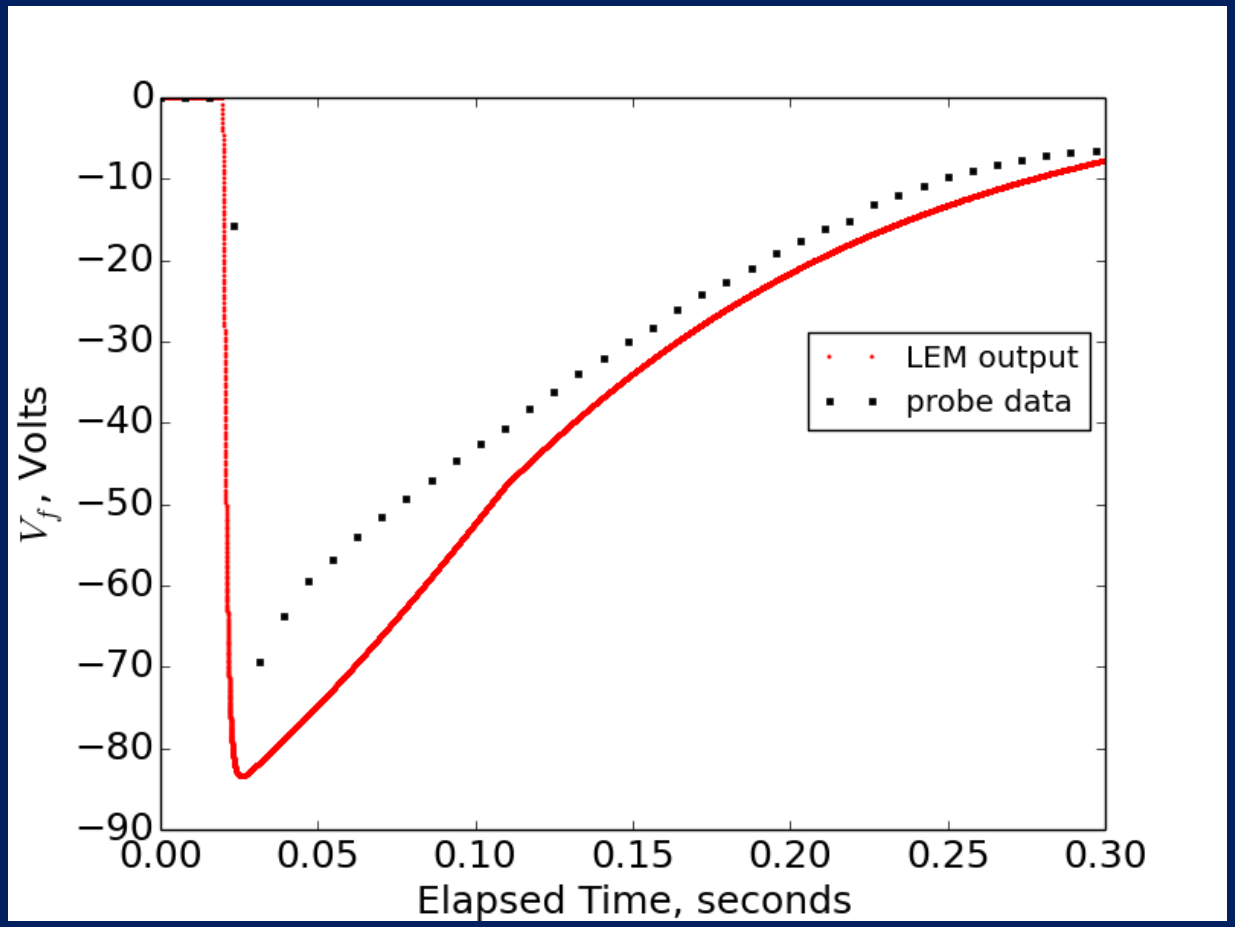


Model output does not reproduce FPMU data

New Lumped Element Model Design



Initial LEM Results



Model output agrees well with FPMU data

Conclusions and Future Work

- Floating potential transients attributed to solar array operations have been observed in ISS FPMU data.
- These transients are not reproduced by existing current balance models, therefore a more accurate model of the current collection is needed.
- This research is investigating the time dependent development of the barrier potential. The questions to answer include:
  - How long does it take for the barrier to develop?
  - How does the current collection develop in time along with the choking effect?
- These questions will be answered by:
  - Particle In Cell simulation of a unit ISS solar cell using parameters consistent with LEO and ISS operations.
  - Evaluation of the results of the PIC simulation to determine if it is possible that the electron collection to the solar cells can account for the transient observations.

References

- [1] J. Huang, Z. Yi, H. Zhao, L. Meng, and Y. Liu, “Model for rapid-charging events for the International Space Station, "Journal of Spacecraft and Rockets, vol. 51, no. 1, pp. 11-15, 2014.
- [2] J. Huang, Z. Yi, H. Zhao, L. Meng, and Y. Liu, “Mechanism for rapid charging events on International Space Station,“ Journal of Spacecraft and Rockets, vol. 51, no. 3, pp. 917-921, 2014.