

Observations of Transient ISS Floating Potential Variations during High Voltage Solar Array Operations



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Introduction

- Goal – Determine if observed ISS floating potential transients can be reproduced with current models. Describe the ISS charging process, present transient observations, and show that current models do not reproduce them.
- Method
 - Study the history of solar array charging studies
 - Identify the controlling factors in array induced charging
 - Produce examples of transient charging
 - Describe the current balance model
 - Apply the current balance model to transient conditions
 - Analyze results and suggest future work
- Results
 - Model results
- Conclusion and Forward Work

Outline

- History of solar array charging studies
- Controlling factors in array induced charging
- Examples of transient charging
- Current balance model
- Current balance model applied to transient conditions
- Conclusions and future work

History of Solar Array Interactions Studies



1960s

- Studies of solar array interactions with the space environment initiated.¹⁻³

1970s

- Studies show that interactions with the space environment are highly dependent on array voltage.⁴⁻⁶

1980s

- Space based experiments confirmed the dependence of environment interactions on solar array voltage.^{7,8}

1990s

- Research initiated specific to ISS solar cell interactions with the space environment.^{9,10}

2000s

- Initial ISS probe data received and studied.¹¹⁻¹⁶

2010s

- Solar array induced transients observed.

Spacecraft Charging Induced by High Voltage Solar Arrays

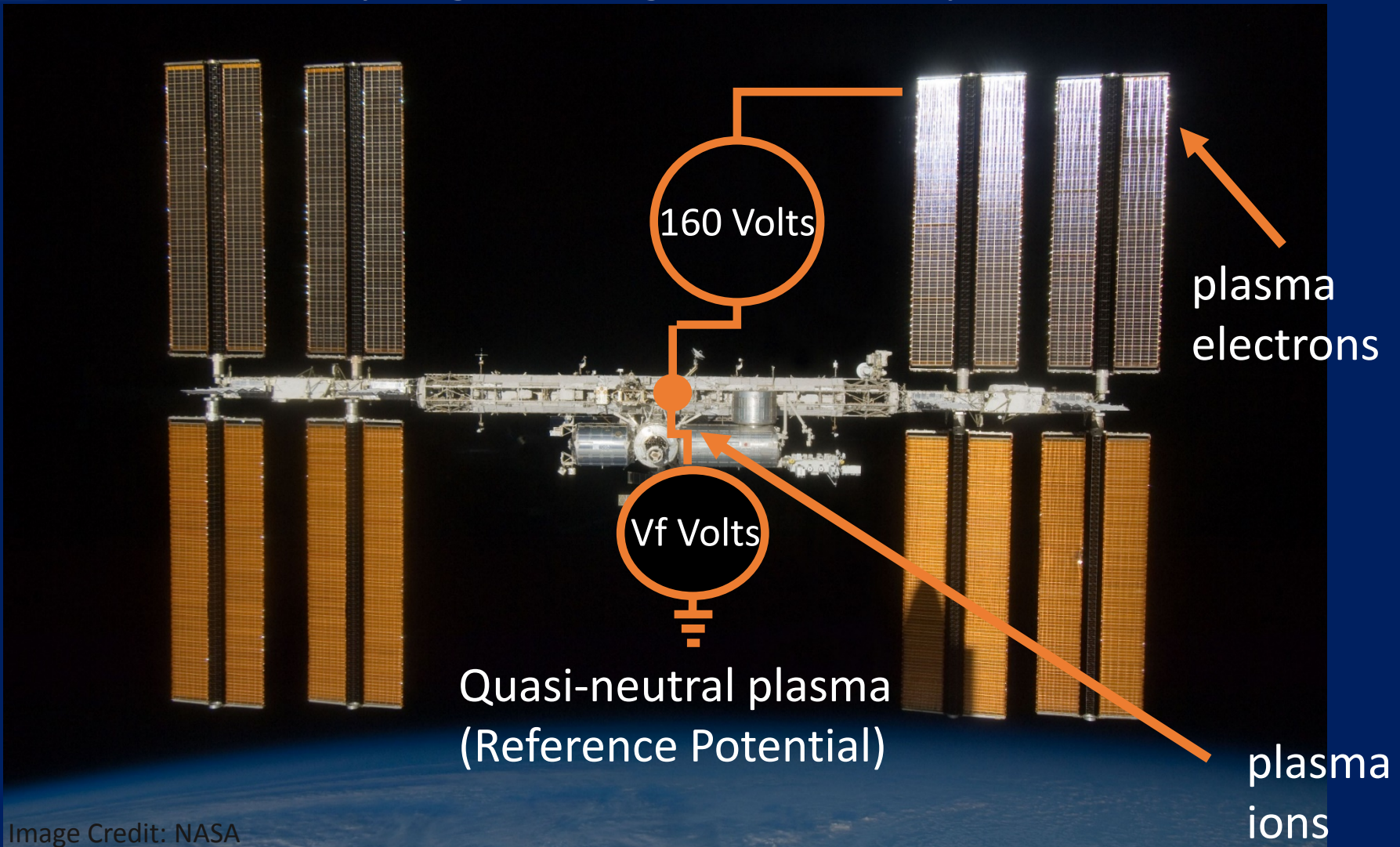
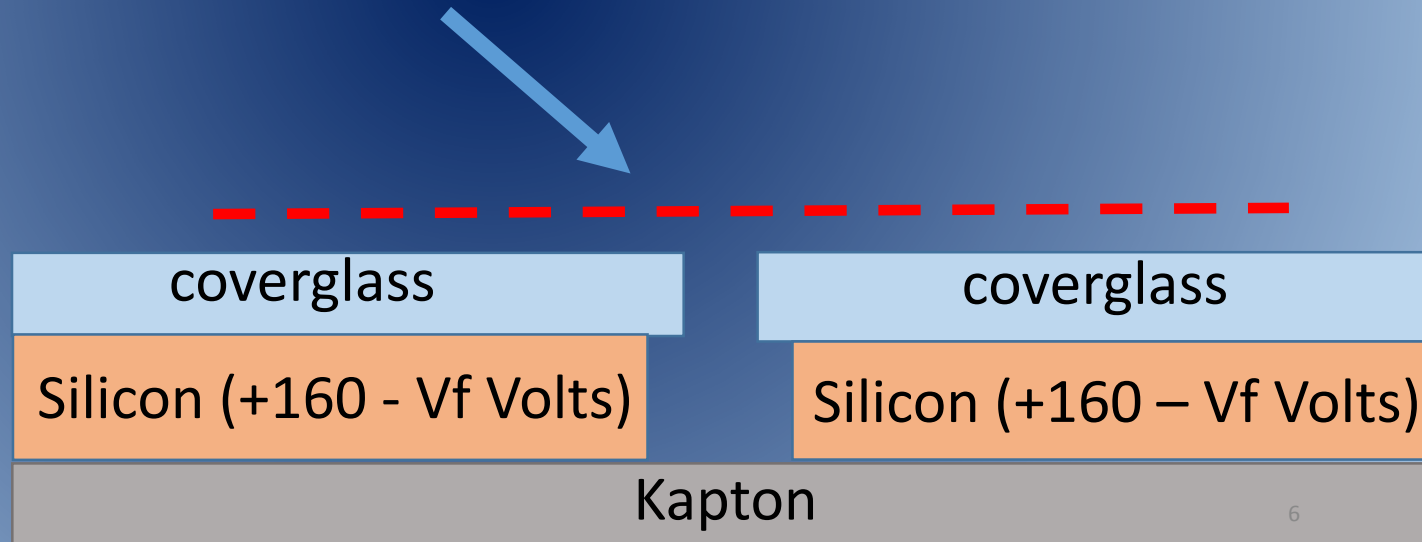
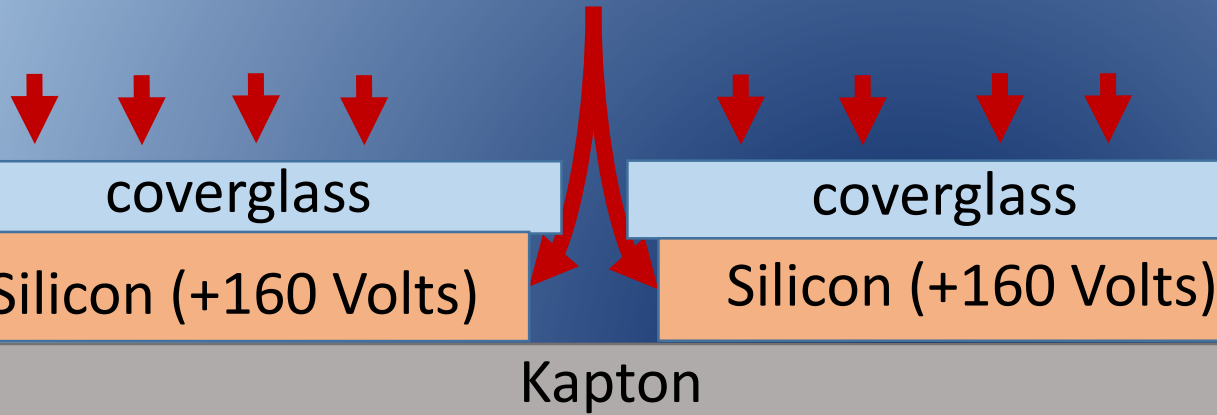


Image Credit: NASA

“Vf” is the floating potential of the ISS

plasma electrons



Normal Charging

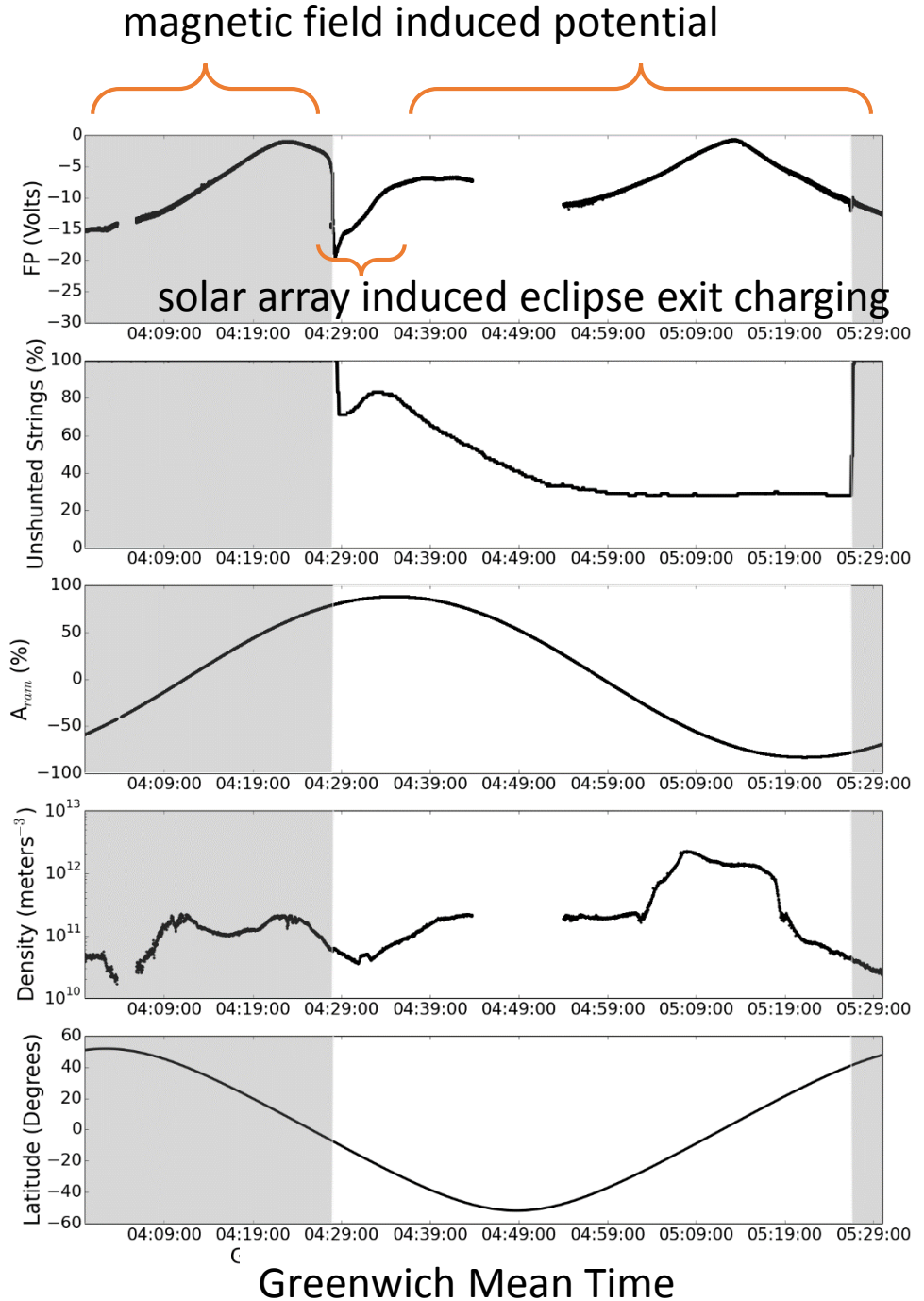
a) Floating Potential →

b) Active Array Strings →

c) Array Orientation →

d) Plasma Density →

e) ISS Latitude →



Transients

a) Floating Potential →

b) Active Array Strings →

c) Array Orientation →

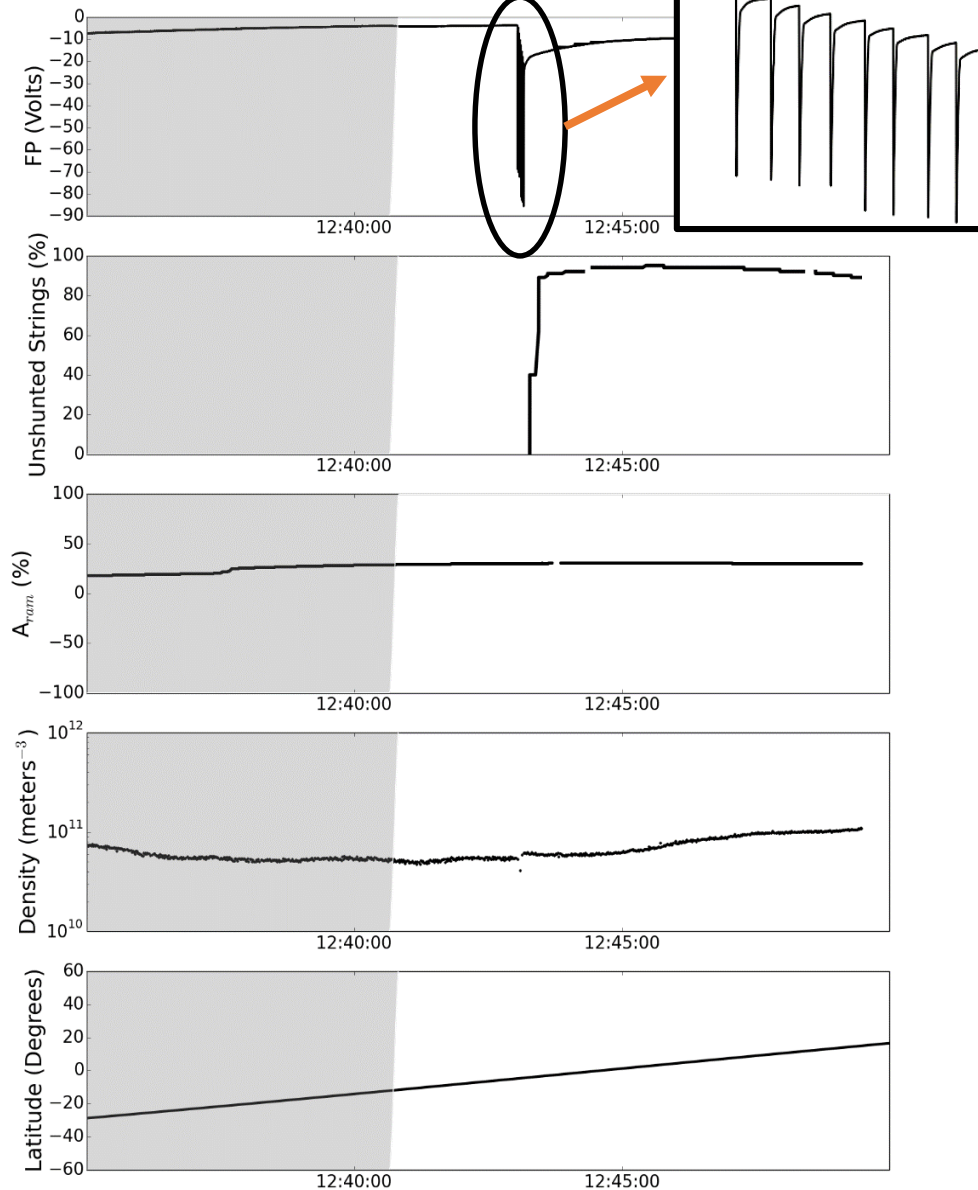
d) Plasma Density →

e) ISS Latitude →

Each of eight arrays

unshunted in full sunlight

close-up



Transients

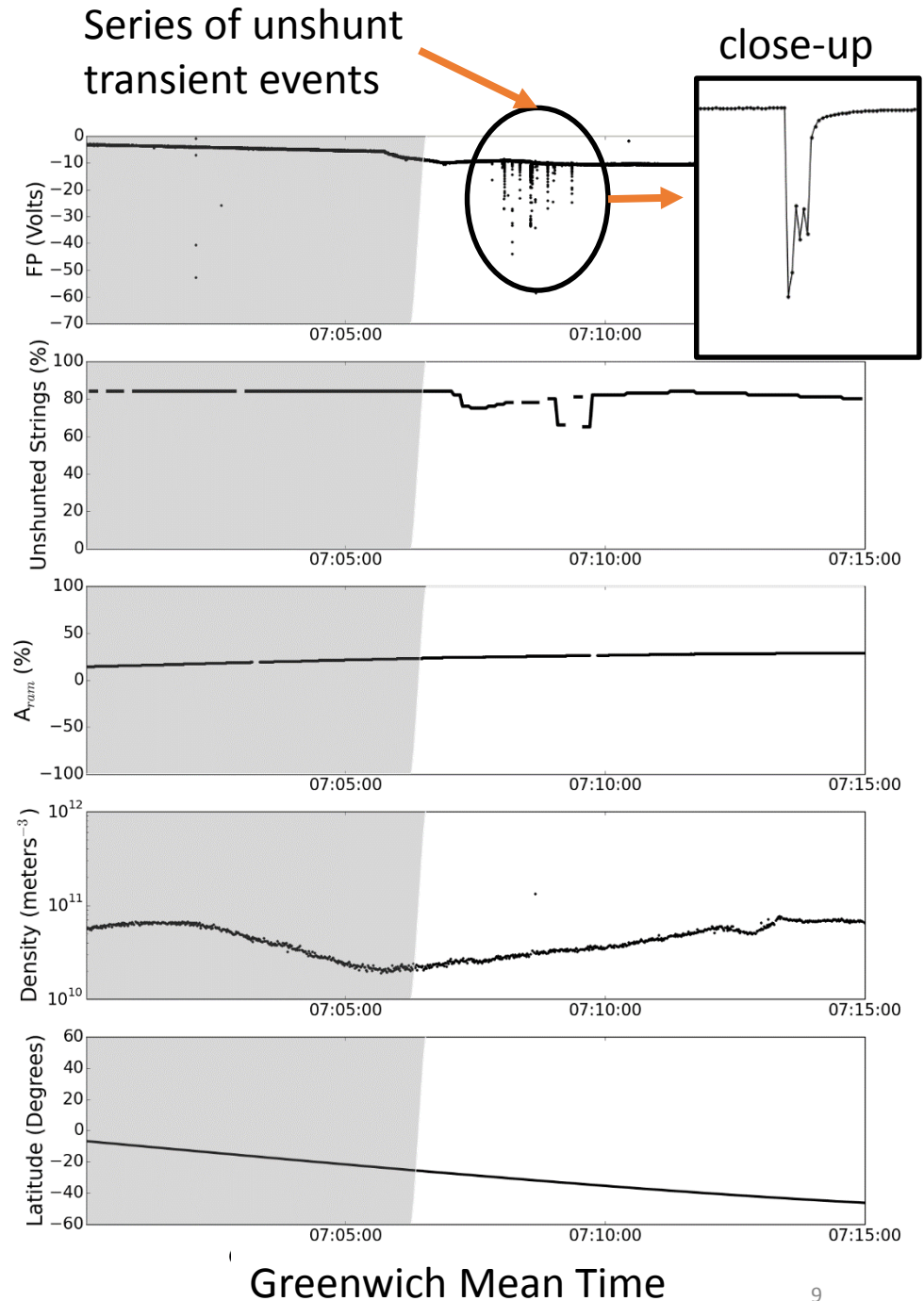
a) Floating Potential →

b) Active Array Strings →

c) Array Orientation →

d) Plasma Density →

e) ISS Latitude →



Transients

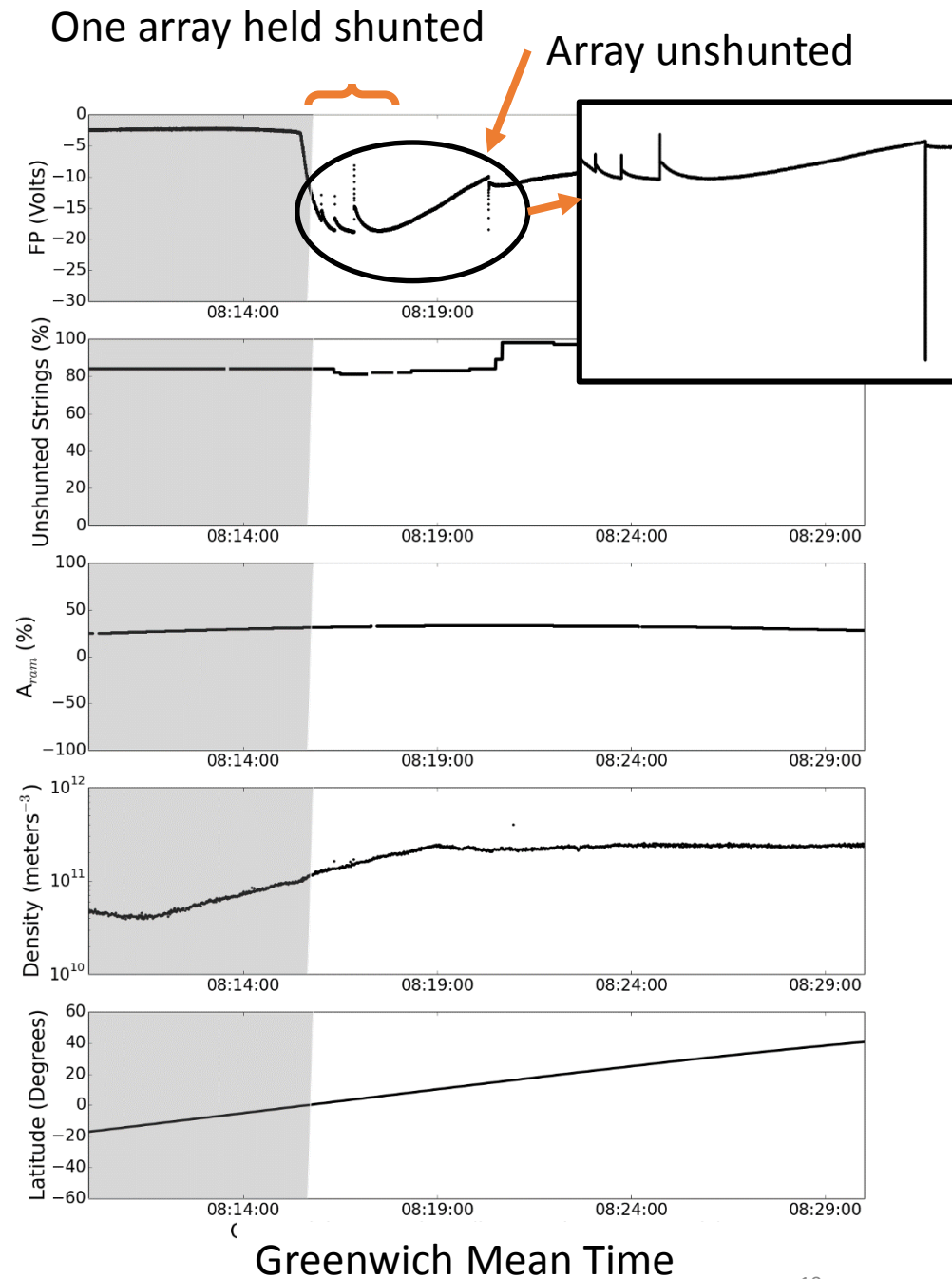
a) Floating Potential →

b) Active Array Strings →

c) Array Orientation →

d) Plasma Density →

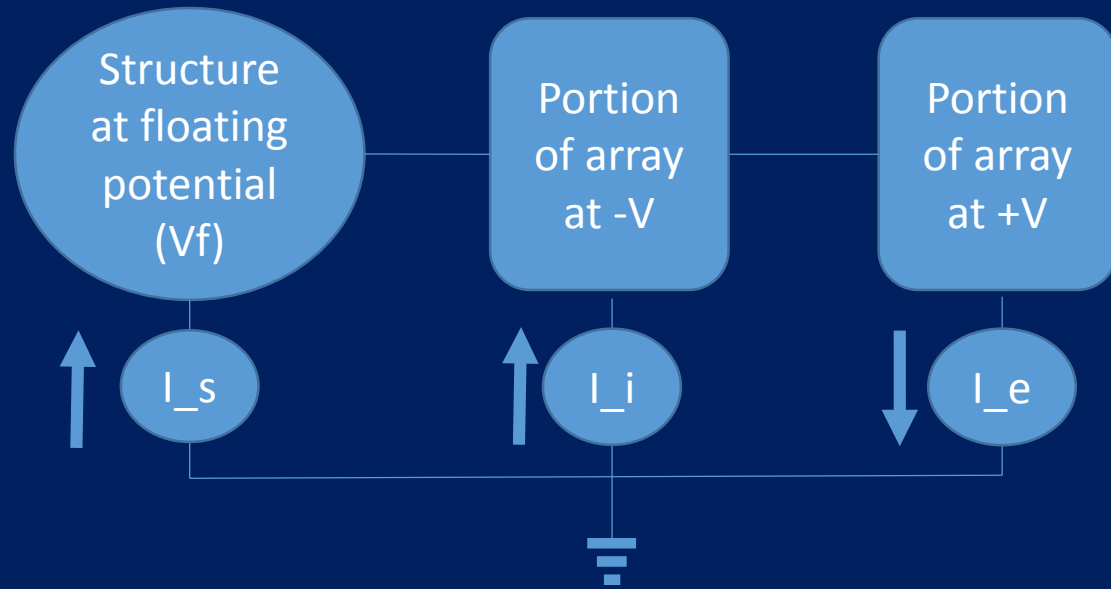
e) ISS Latitude →



$I_s(V_f, t)$: structure current

$I_e(V, V_f, t)$: positive array current

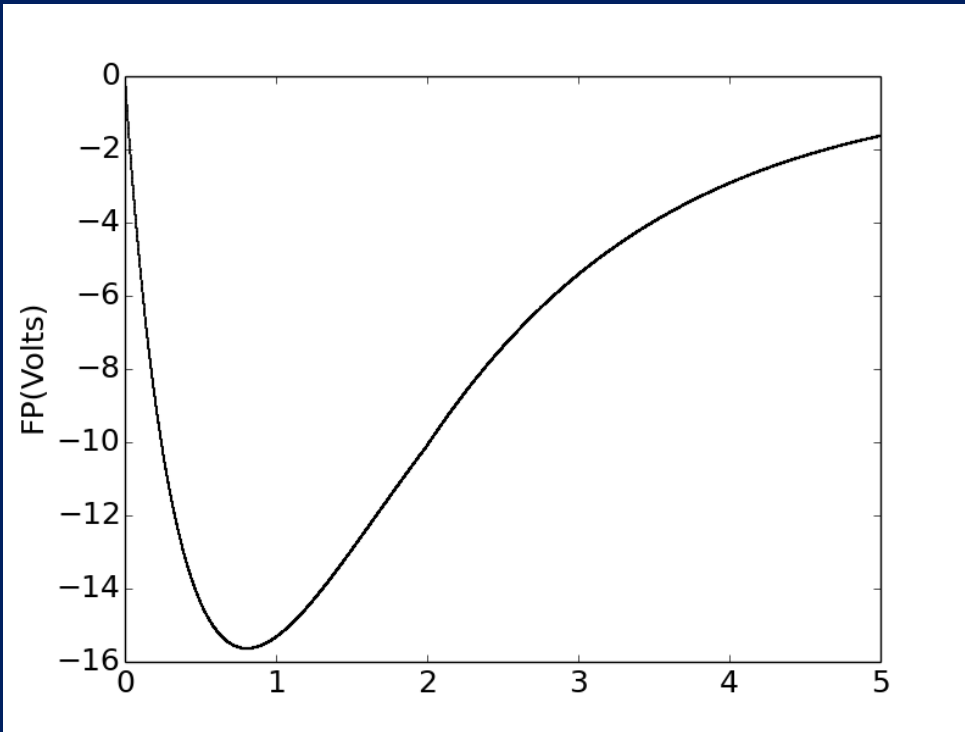
$I_i(V, V_f, t)$: negative array current



Spacecraft will float to a potential (V_f) such that the net current collected is zero¹⁷

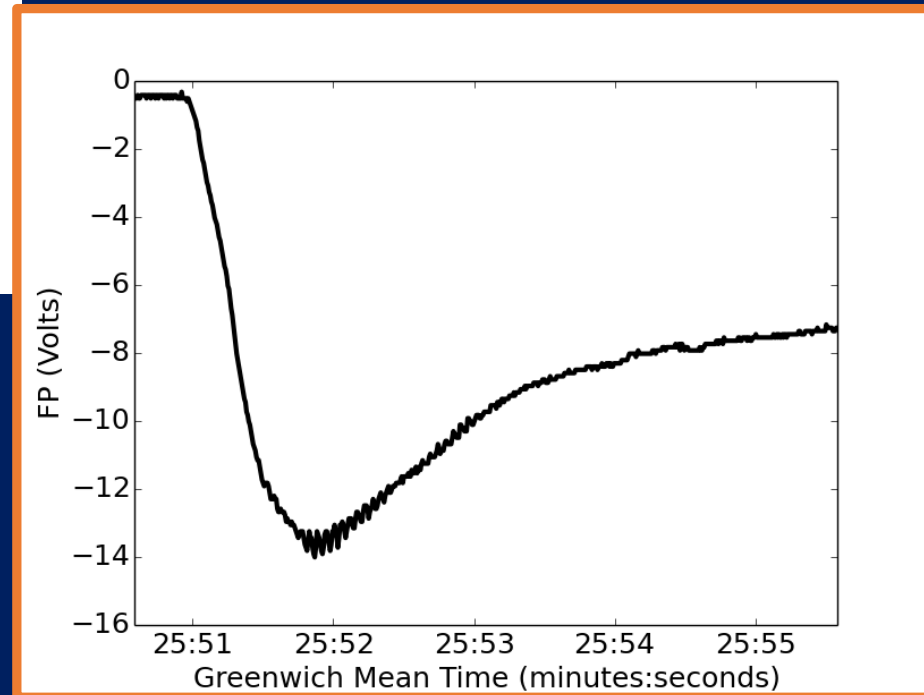
$$0 = \sum_j I_j$$

Current Balance Model for Rapid Charging¹⁴⁻¹⁶



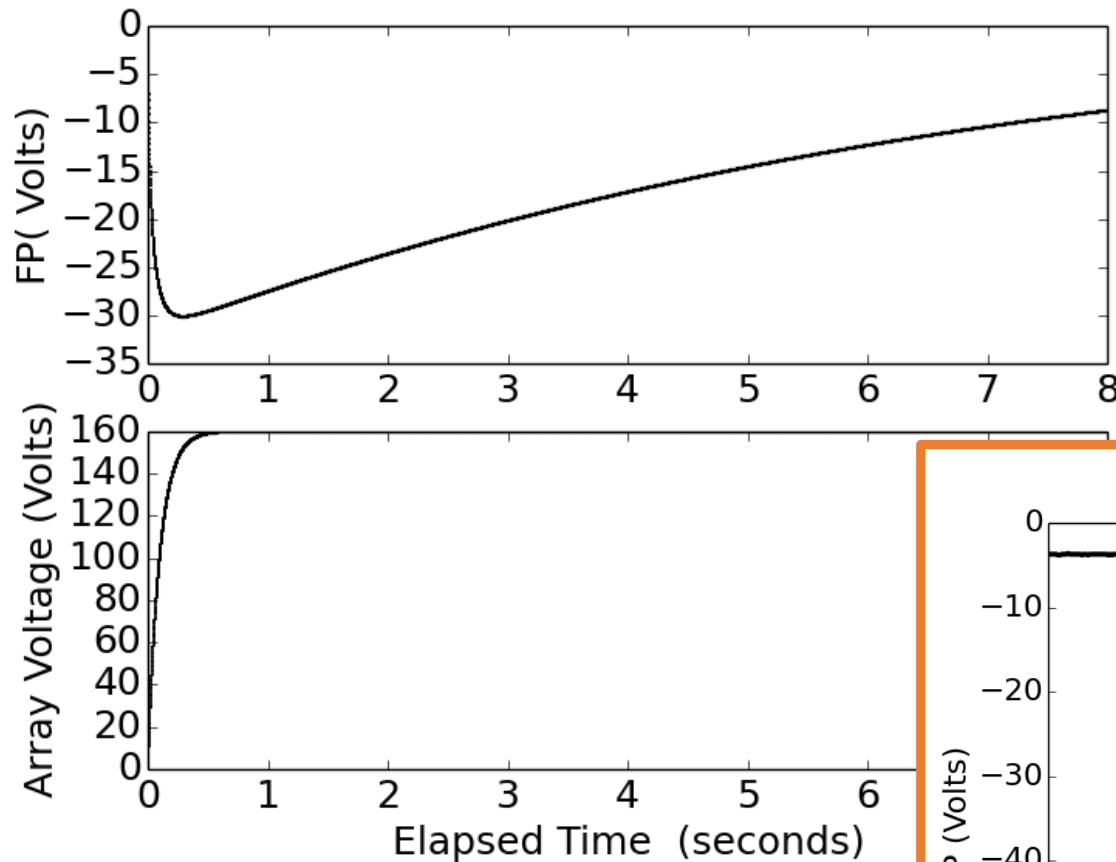
← Model Output

FPMU Data

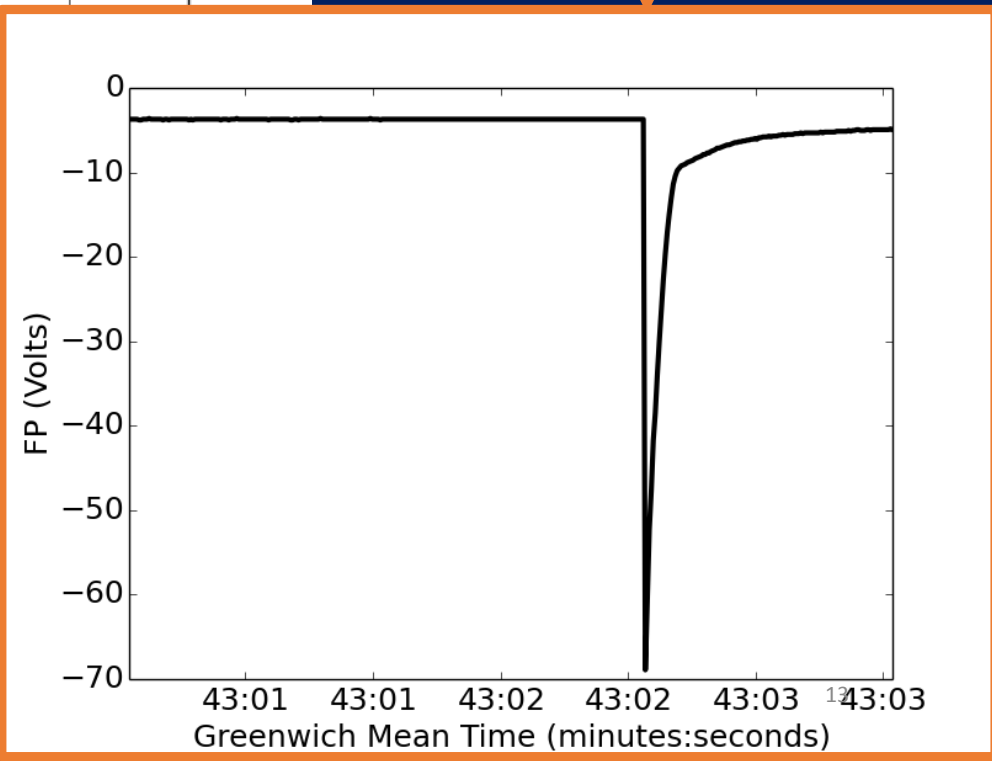


Model output agrees well
with FPMU data

Current Balance Model Applied to Transients



← Model Output
FPMU Data



Model output does not
reproduce FPMU data

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 current balance models.
- Future work: research focused on the time dependent nature of the screening effect and its effect on electron collection to solar arrays.

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