

SurfSat - Spacecraft surface charging and ESD measurements

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Electrostatic discharge events

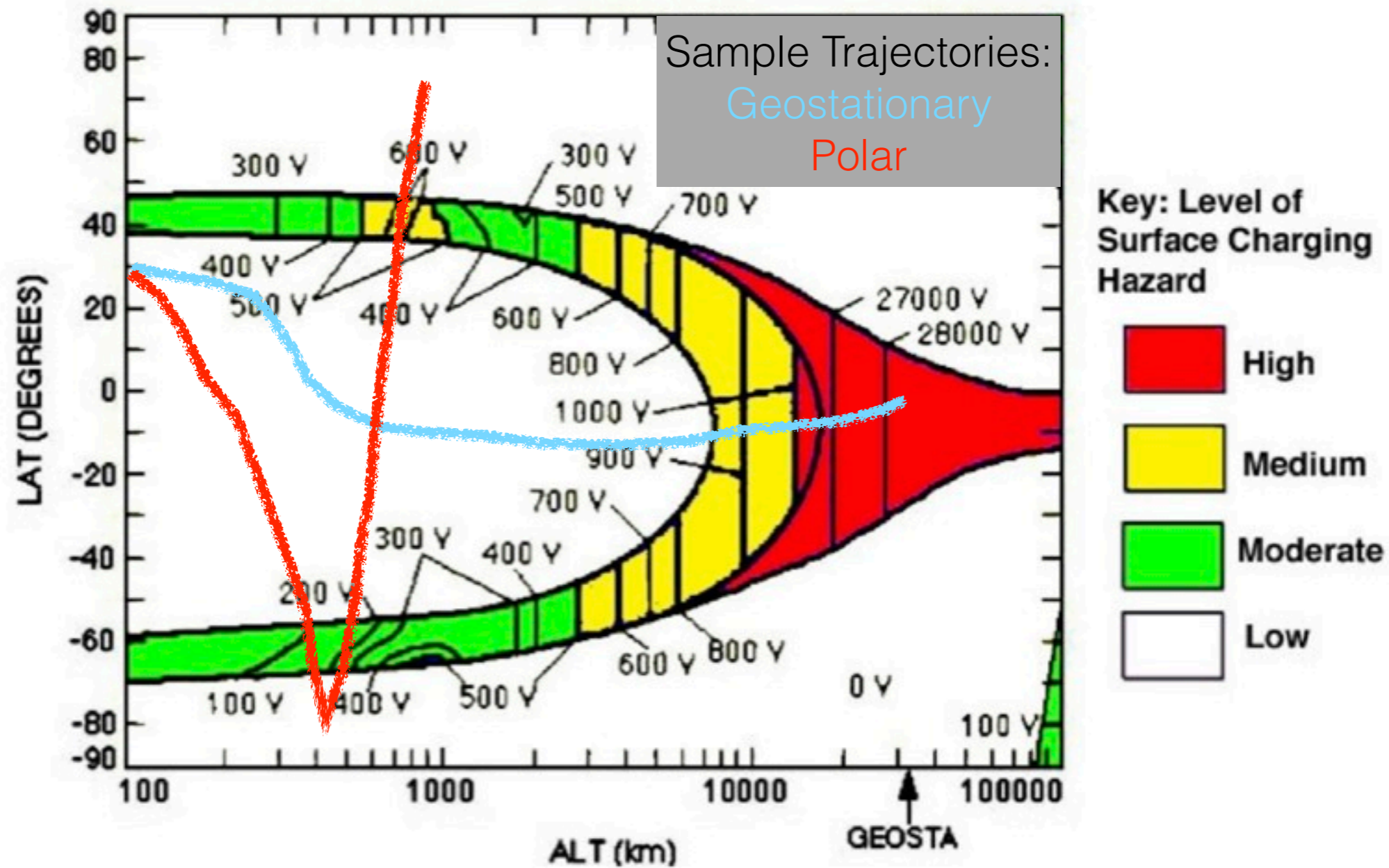
Apollo 12



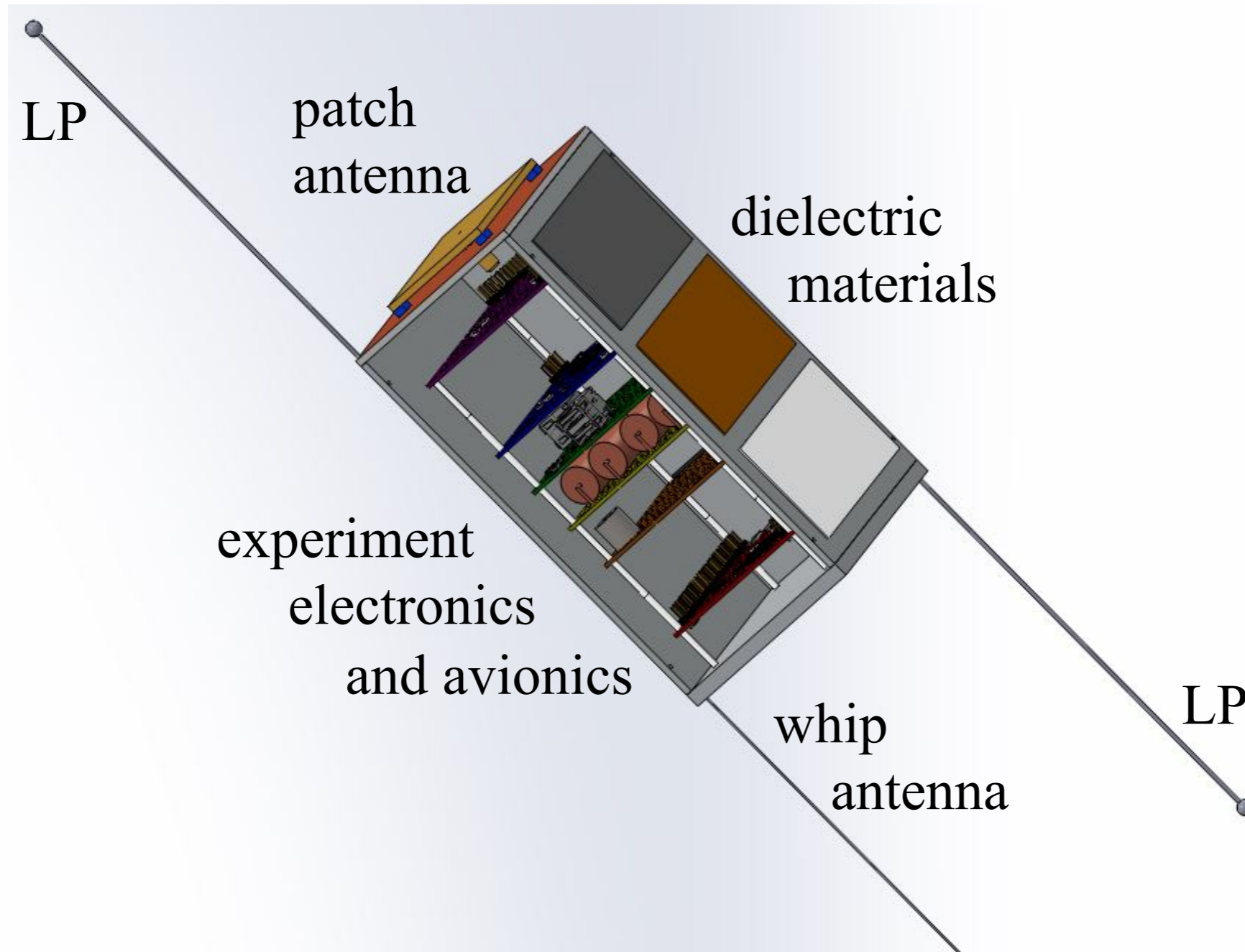
Spacecraft Surface Charging

- Spacecraft experience charging issues due to the ambient, dynamic plasma environment
- Differential buildup of charge can lead to ESD events
 - Higher energy electrons (>20 keV) dominate internal charging issues that can damage avionics
 - Lower energy electrons (<20 keV) dominate surface charging, which can lead to external or internal damage
- Charging characteristics are highly dependent on orbit, but also depend on spacecraft materials
- Look for correlation between surface charging and solar cycle activity (Kp index)

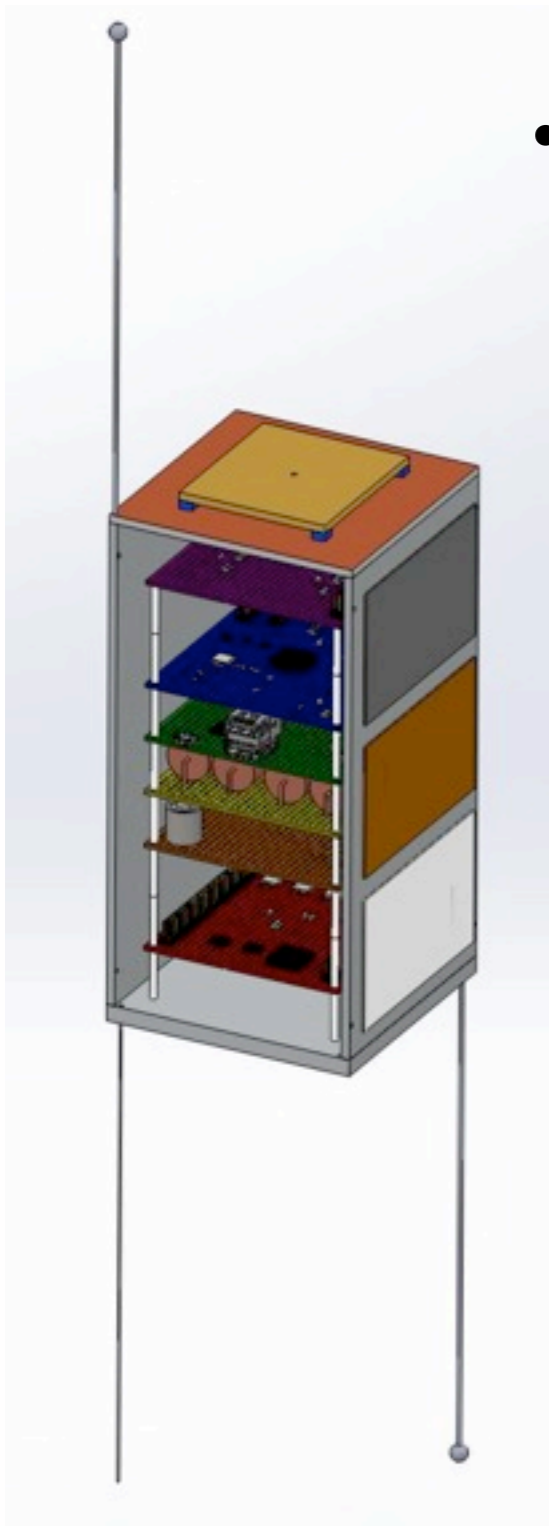
Launch Services Requirements



SurfSat design



SurfSat Science Requirements



- SurfSat will characterize ESD events on a CubeSat in a polar orbit
 - measure the ambient plasma environment
 - measure surface charge on relevant s/c materials
 - characterize current waveforms of discharge events

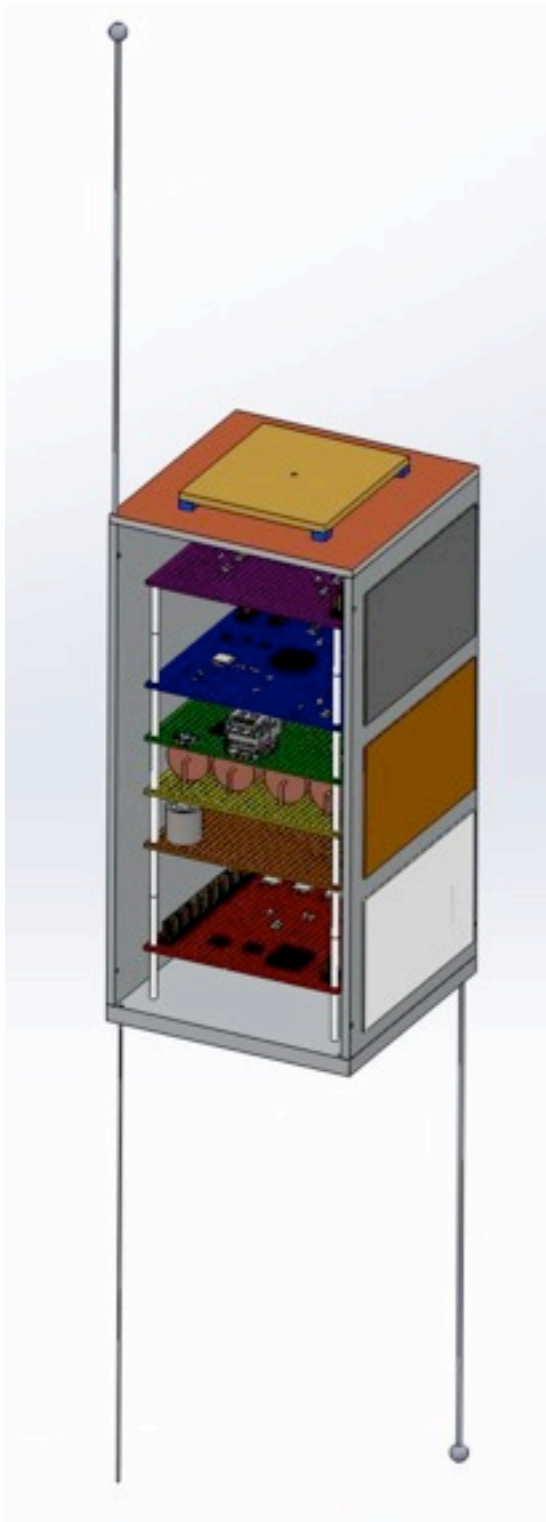
| Science Requirements | Instrument Requirements |
|--|--|
| In-situ plasma density measurements | 1. Range: $1 \times 10^{10} - 5 \times 10^{11} \text{ m}^{-3}$ 2. Resolution: $5 \times 10^8 \text{ m}^{-3}$ 3. Sampling rate: 30 Hz |
| Surface potential measurements | 1. Range: 1 - 10^3 V 2. Resolution: 1 V 3. Sampling rate: 1-10 Hz |
| Surface discharge current measurements | 1. Range: 350 MHz - GHz 2. Resolution: 1 ns 3. Sampling rate: 2 Gs/s |

Charging on Dielectric Materials

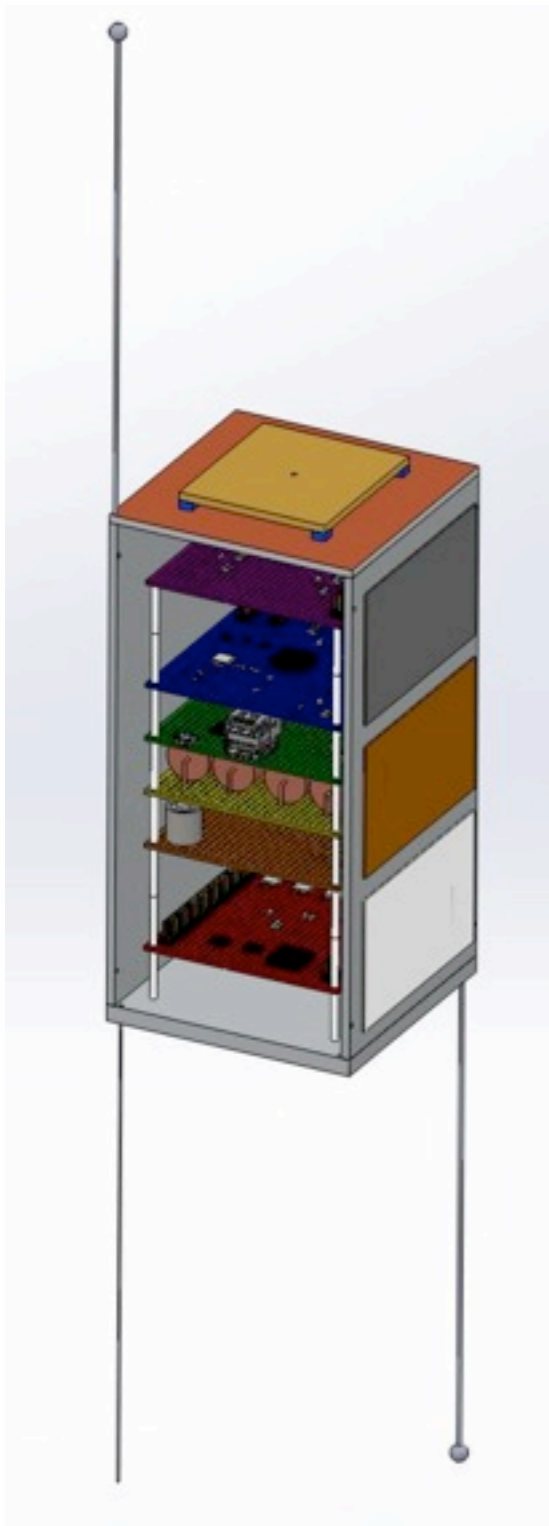
- Samples will be selected based on preliminary laboratory testing

| Material | Common Name | Bulk Resistivity ($\Omega\text{-cm}$) | Dielectric Strength (V/mil) |
|------------------|-----------------------------|---|-----------------------------|
| Kapton HN | Kapton | $\sim 10^{17}$ | 7000 |
| PTFE | Teflon | $10^{22} - 10^{24}$ | >500 |
| SiO ₂ | Glass | $10^{10} - 10^{14}$ | 230-350 |
| Al | Alodine Al | $10^{11}-10^{13}$ | 800 |
| AZ-93 / A-276 | Thermal Paint | TBD | TBD |
| Ag or AL/FEP | Silver or Aluminum paint | TBD | TBD |
| L-T-80 Tape | Al tape w/ acrylic adhesive | TBD | TBD |

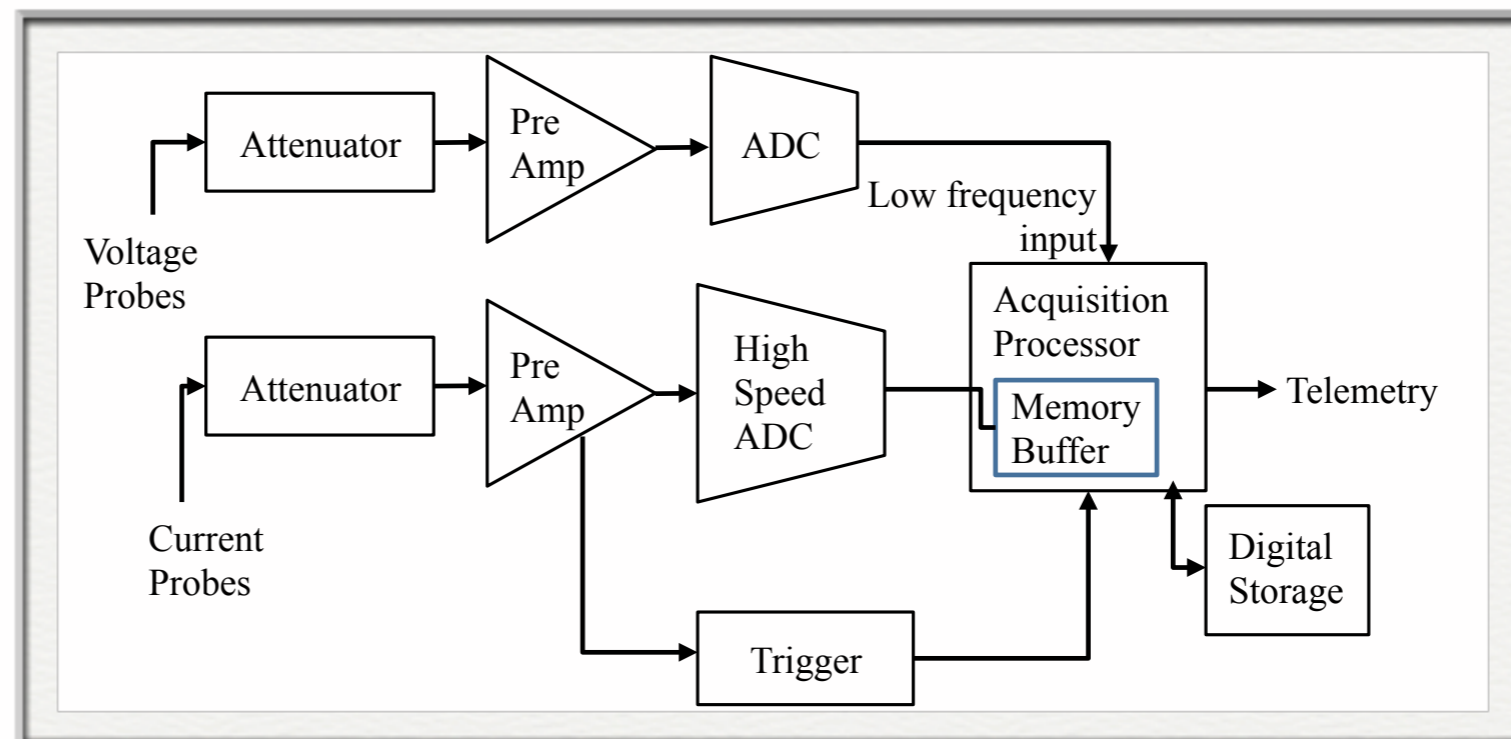
- Materials will be selected
 - from a range of resistivity classes,
 - based on discharge characteristics, and
 - based on size and power requirements



Measuring Current Waveforms

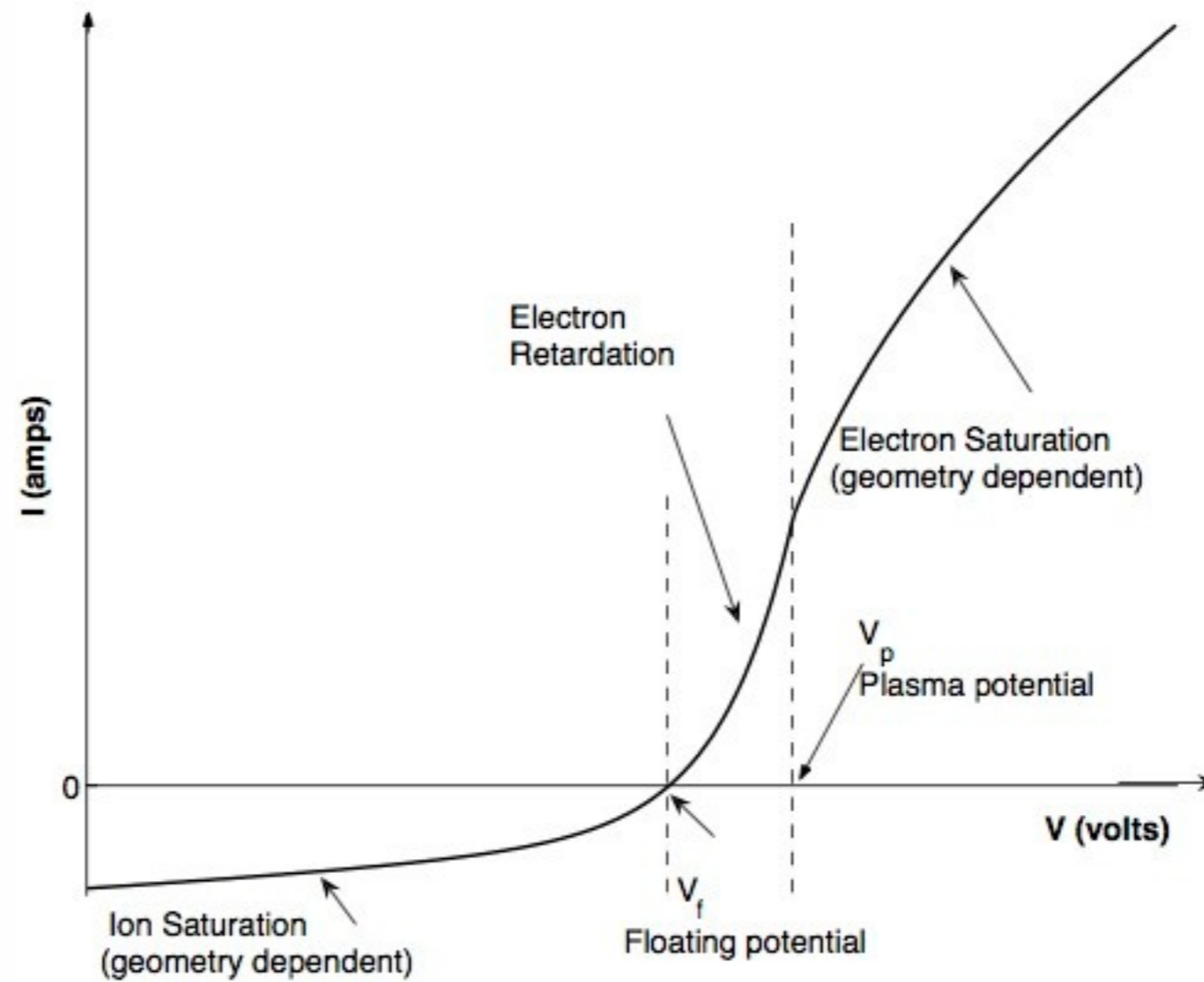
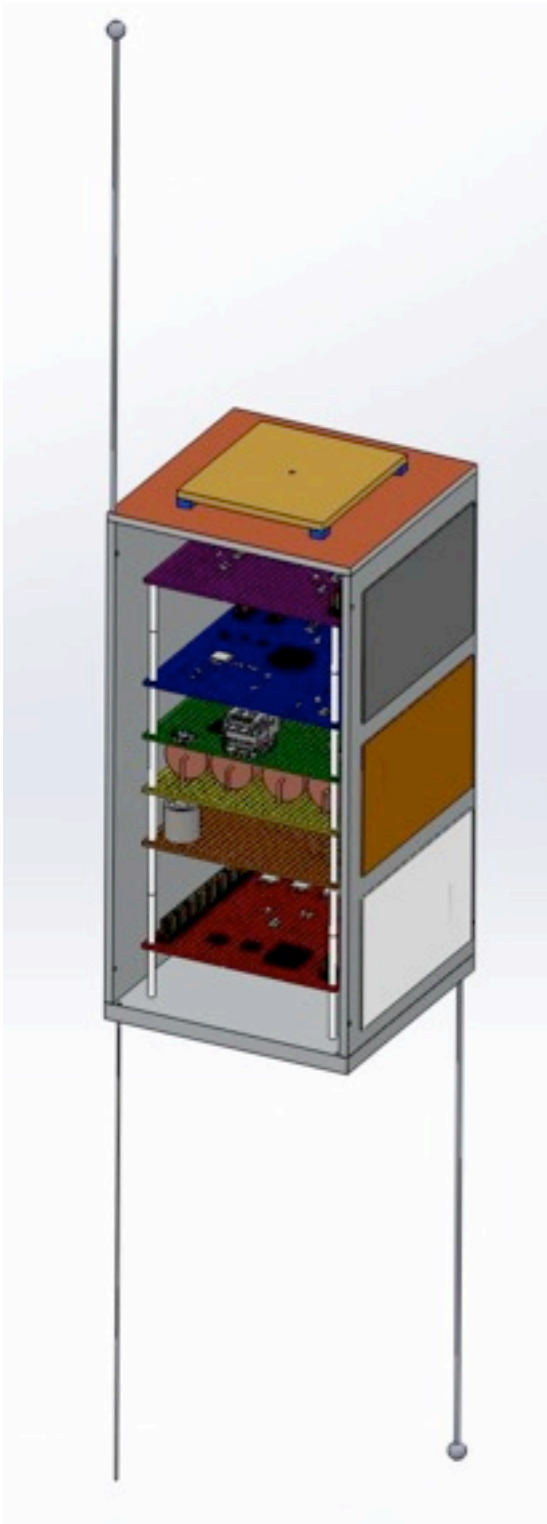


- Currents will be measured with a charged plate analyzer
- Continually measure surface potentials
- Measure transient ESD events



Characterizing the Environment

- Measure the plasma environment with Langmuir Probes



Summary

- SurfSat will enable us to compare on-orbit ESD measurements with ground-based experiments
 - can be used to validate current plasma charging test methods and simulations
- Results will be used to develop
 - design criteria for spacecraft materials and
 - modified launch vehicle and timing constraints