

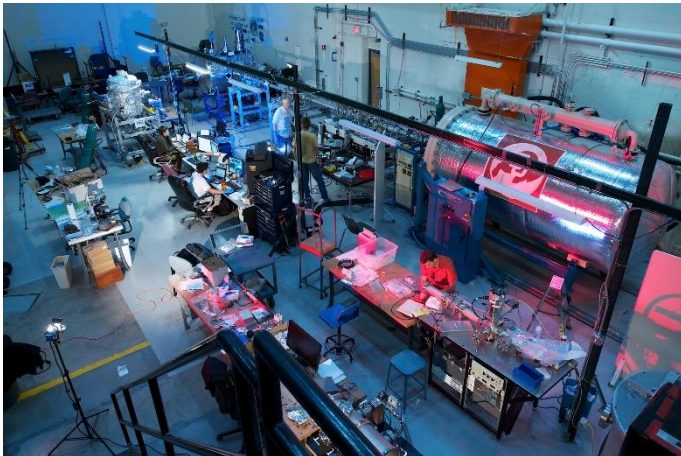
# Dust Impact Detection by Cassini's Langmuir Probe

By:

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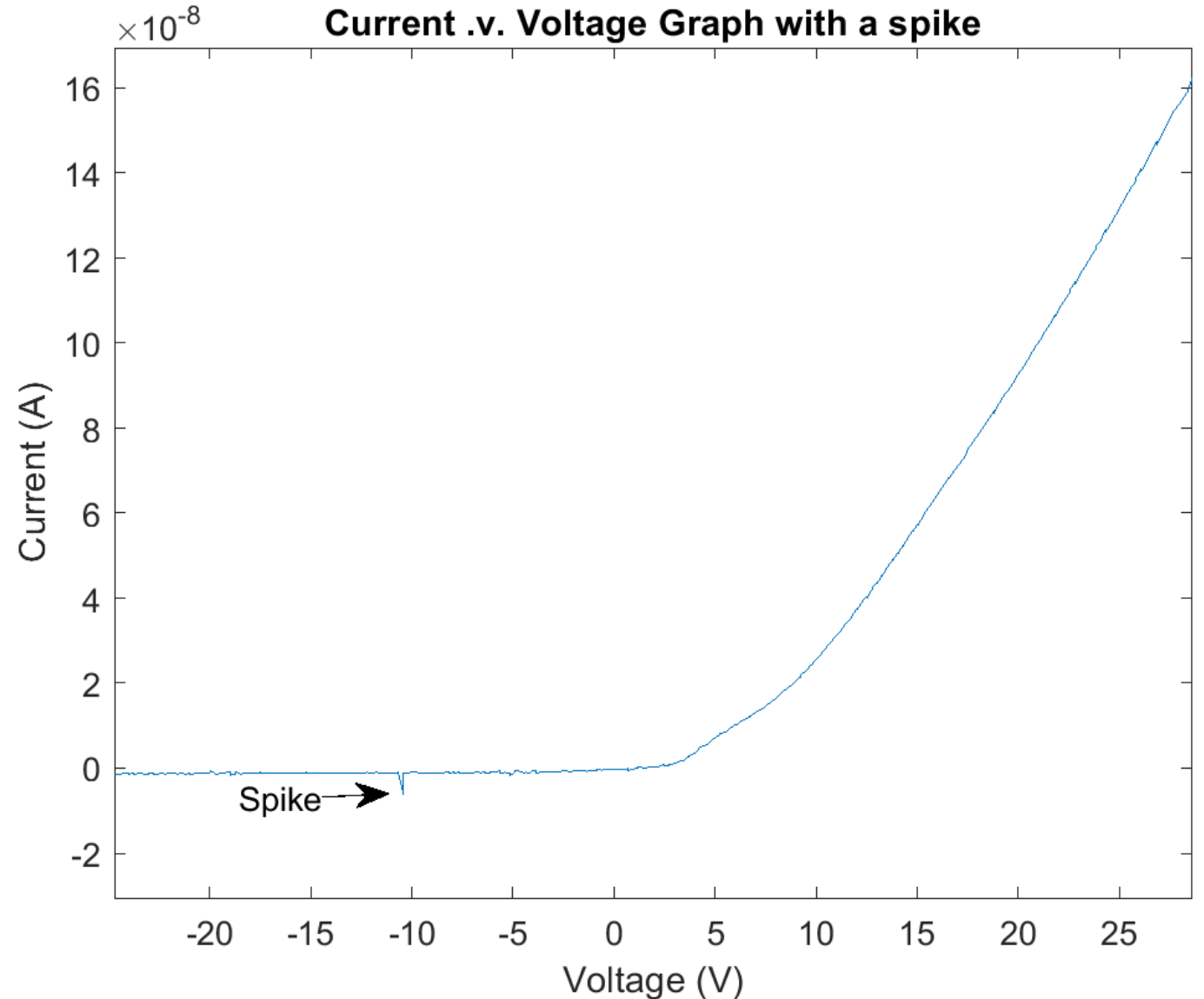
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# Motivation

- Explain unusual transient “spikes” events returned from Cassini’s Langmuir probe (LP)
- Our goal is to understand what was causing these spikes
- Hypothesis that these are dust impacts on the LP



# Overview

- Cassini-Huygens mission
- Saturn's E ring structure
- What happens when dust impacts at relativistic speeds of over a few kilometers a second- Impact Ionization
- Instruments onboard used to study dust
- Langmuir probe (LP)
  - Spike Characteristics
- Density of Spikes Compared to Density of the E ring

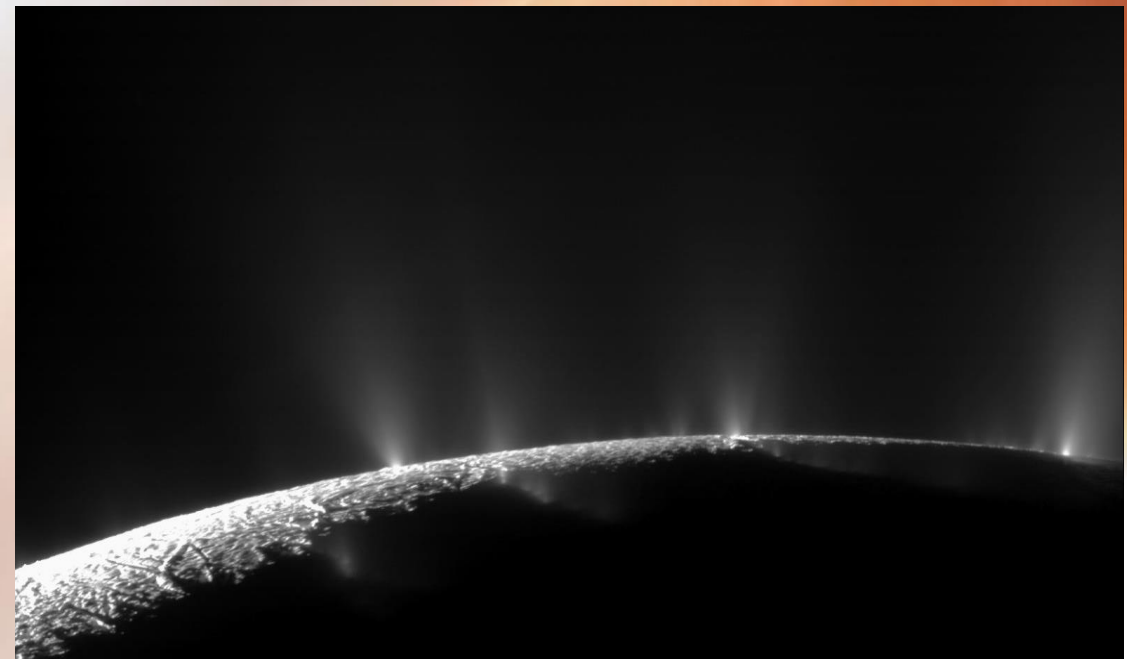
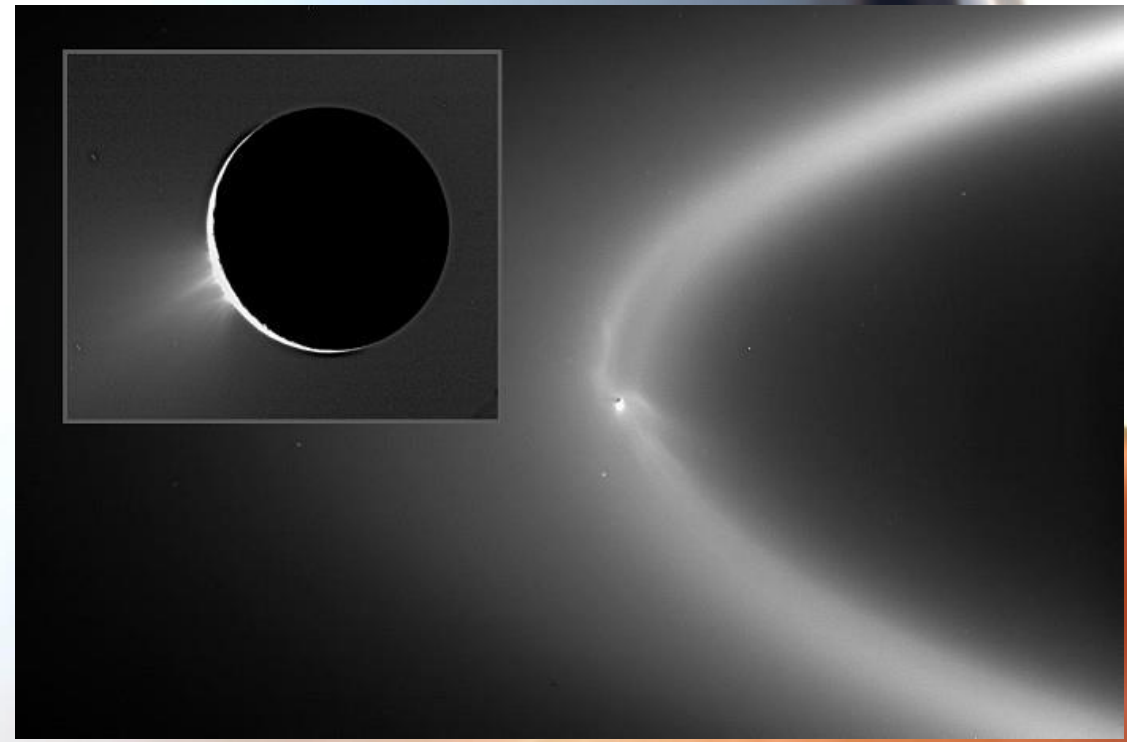
# Purpose of Cassini's Mission

- Study Saturn and its magnificent rings and satellites
- Carried Instruments just to study dust



# The Best ring around

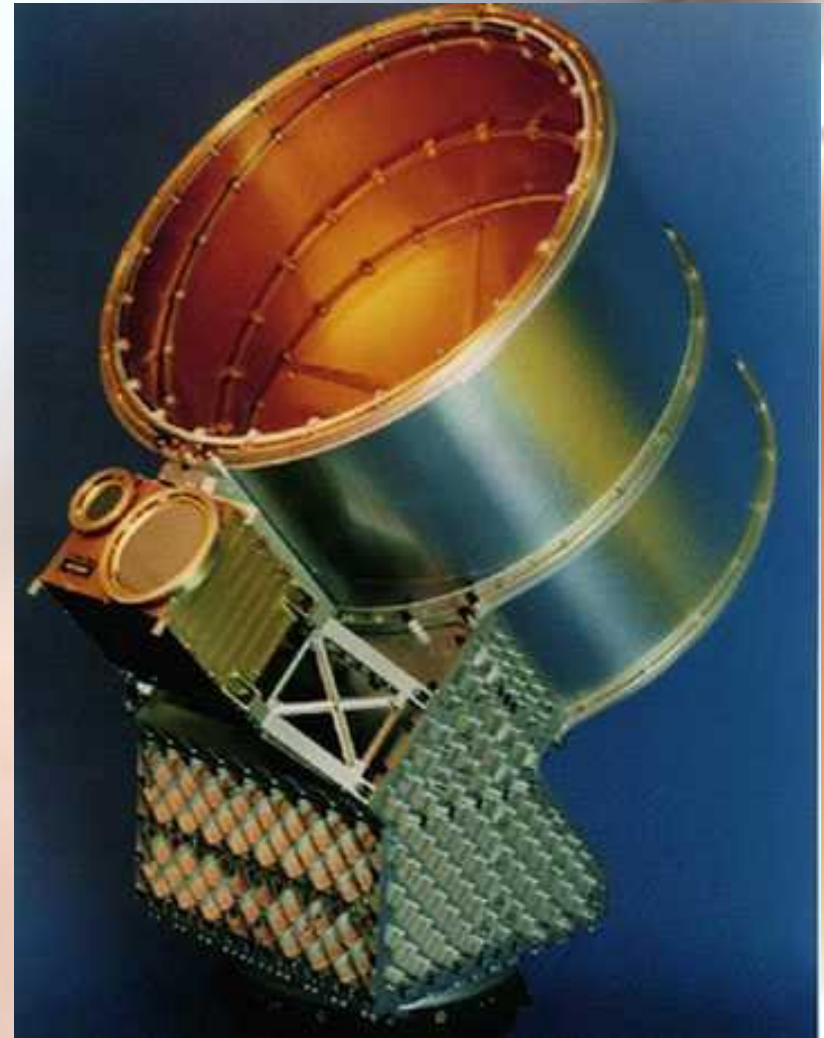
- Saturn's E Ring
- Large and diffuse ring
  - Spanning from 3 Saturn Radii to 20 Saturn Radii
- Source of E Ring is Saturn's Satellite Enceladus
  - Plumes of water from Enceladus's underground ocean
  - Since this is the Source thickness varies with radial distance





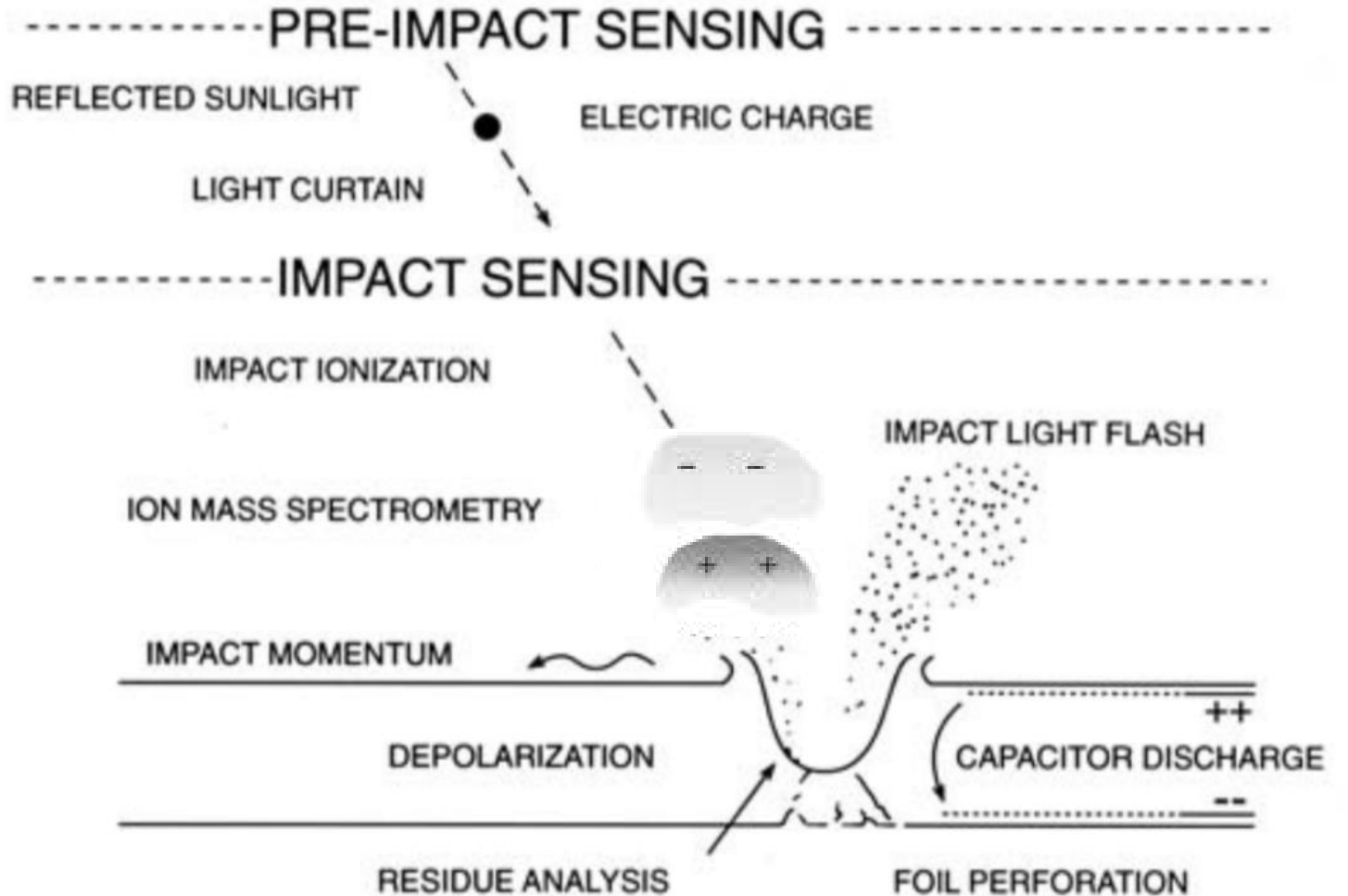
# Cosmic Dust Analyzer (CDA)

- Instrument specifically designed to analyze dust
- Can identify dust one millionth of a millimeter in size
- Identifies up to 10,000 dust particles per second
- The main source for our understanding of Saturn's rings



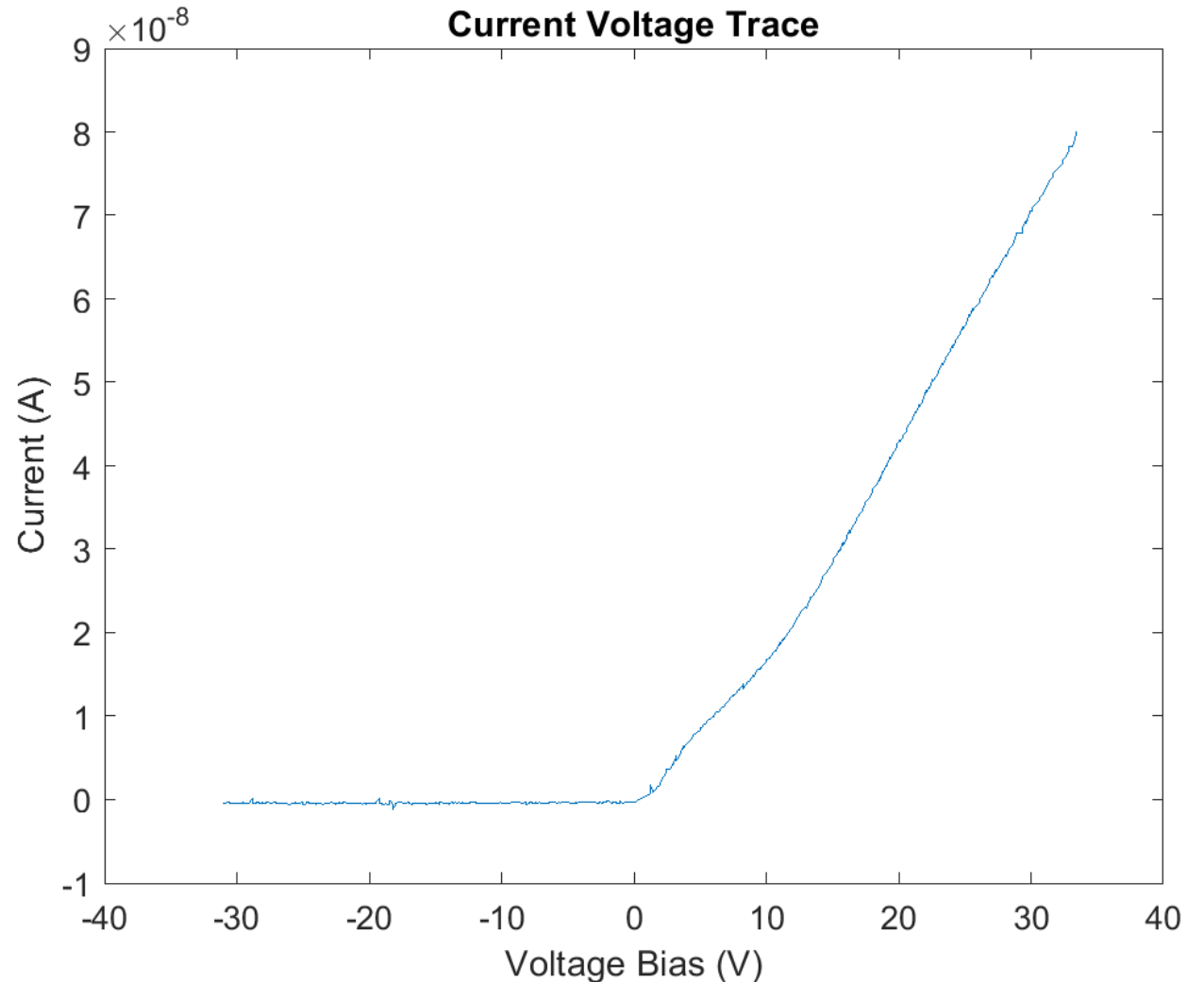
# What happens when dust hits a spacecraft?

- Impact Ionization
  - Dust hits instrument or SC at very fast speeds
  - Formation of ions and electrons
  - Expansion of ion clouds



# Langmuir Probes (LP)

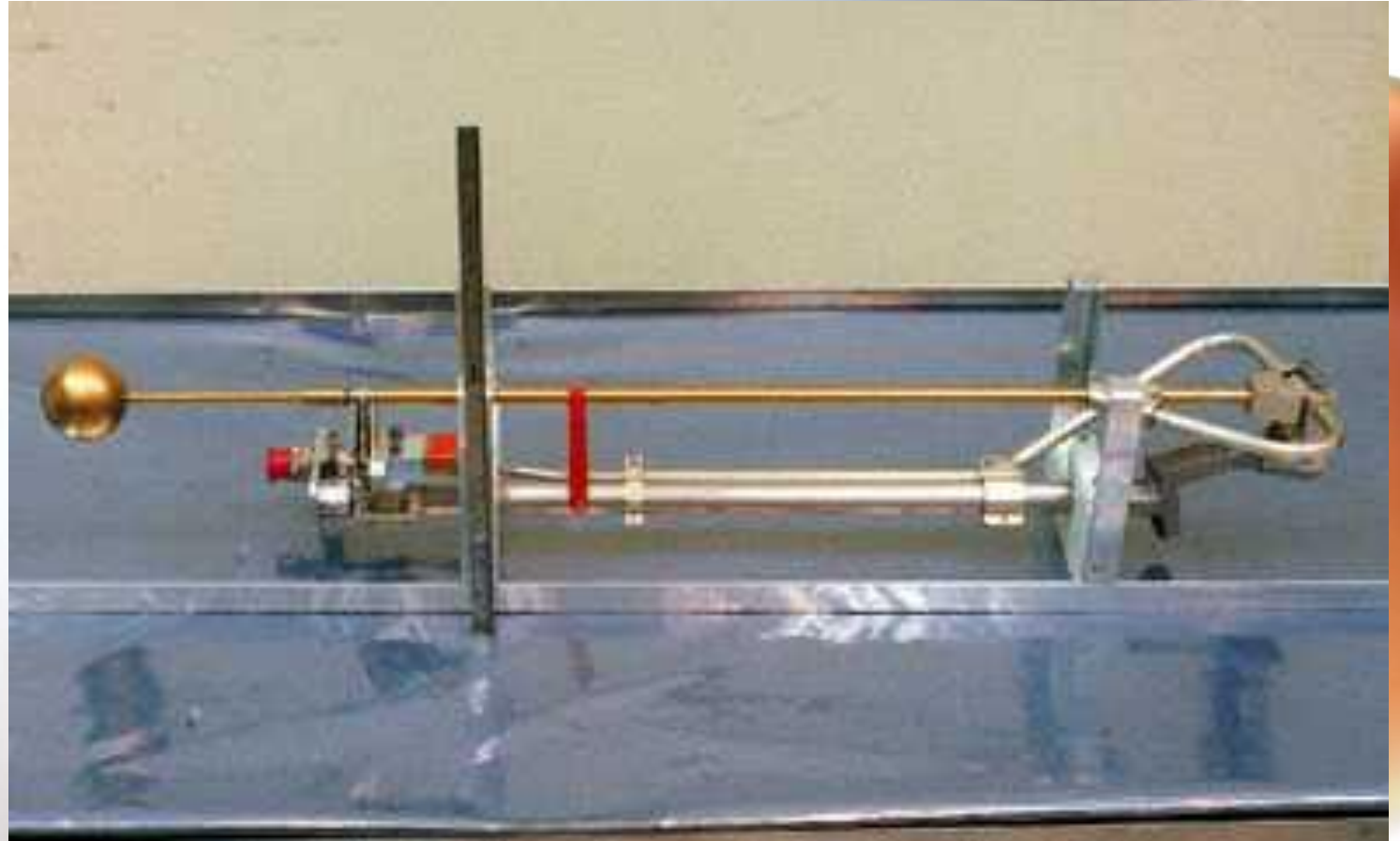
- an electrode immersed in charged particle plasma, whose current voltage (I-V) characteristics can be measured
- Electrons, anions, and cations cause current
  - From current we can study Electron temperature and electron density





# The specifics of Cassini's LP

- Cassini's LP can sweep from -32 volts to 32 volts
- 1.5 meters away from the space craft body
- Preamplifier to lessen the photoelectric effect



# The purpose of Using data from the E ring

- From Days Cassini Stayed Within the e ring
- From 6 different days in form 2009-2010
- Produced on the magnitude of hundreds of spikes after filtering

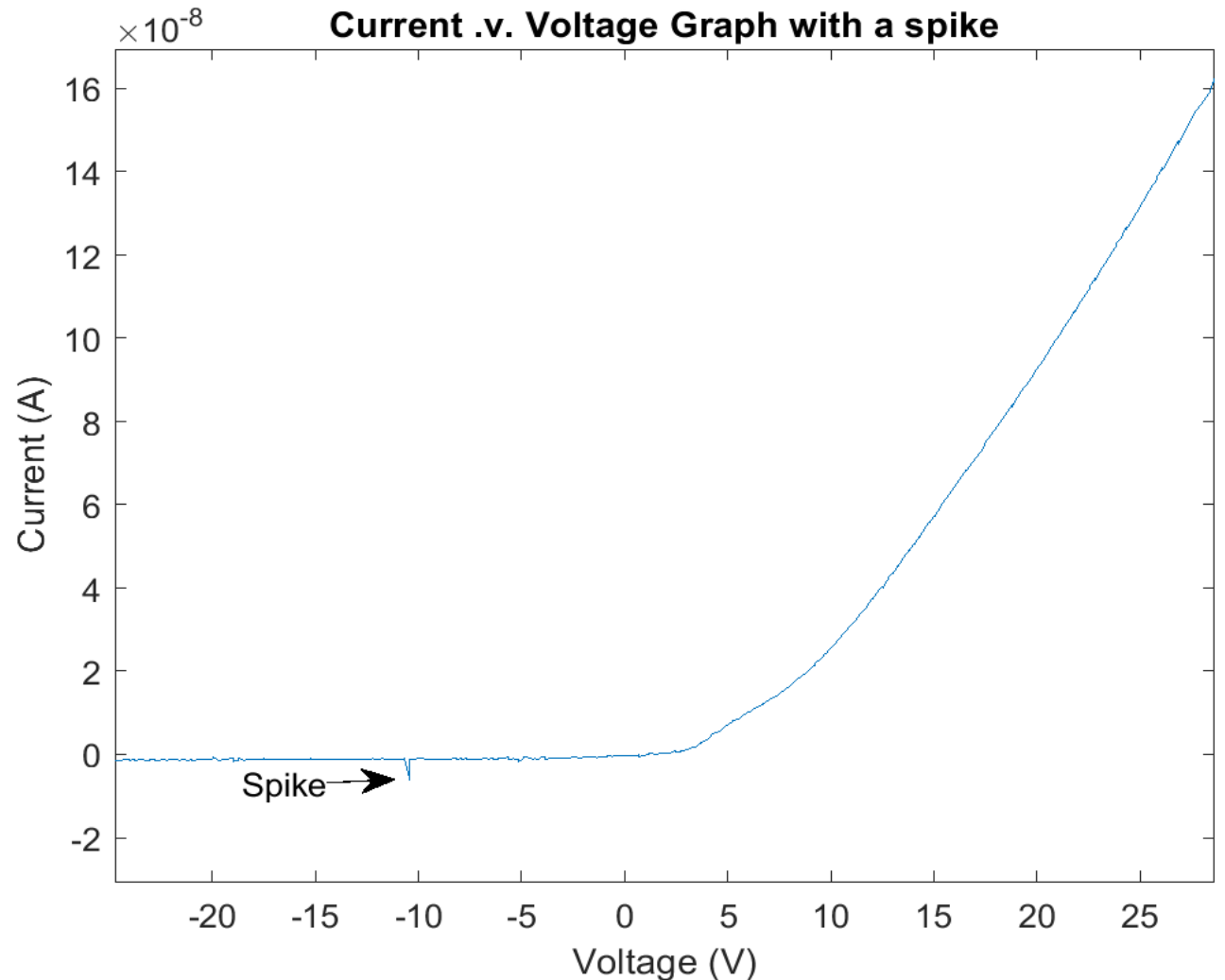


# Identifying Spikes

- Chauvenet Criterion
  - Calculates the probability a normal point would deviate as much as the point being investigated
    - If below .5 outlier
- Amplitude filter
  - Gets rid of spikes under 1 nA

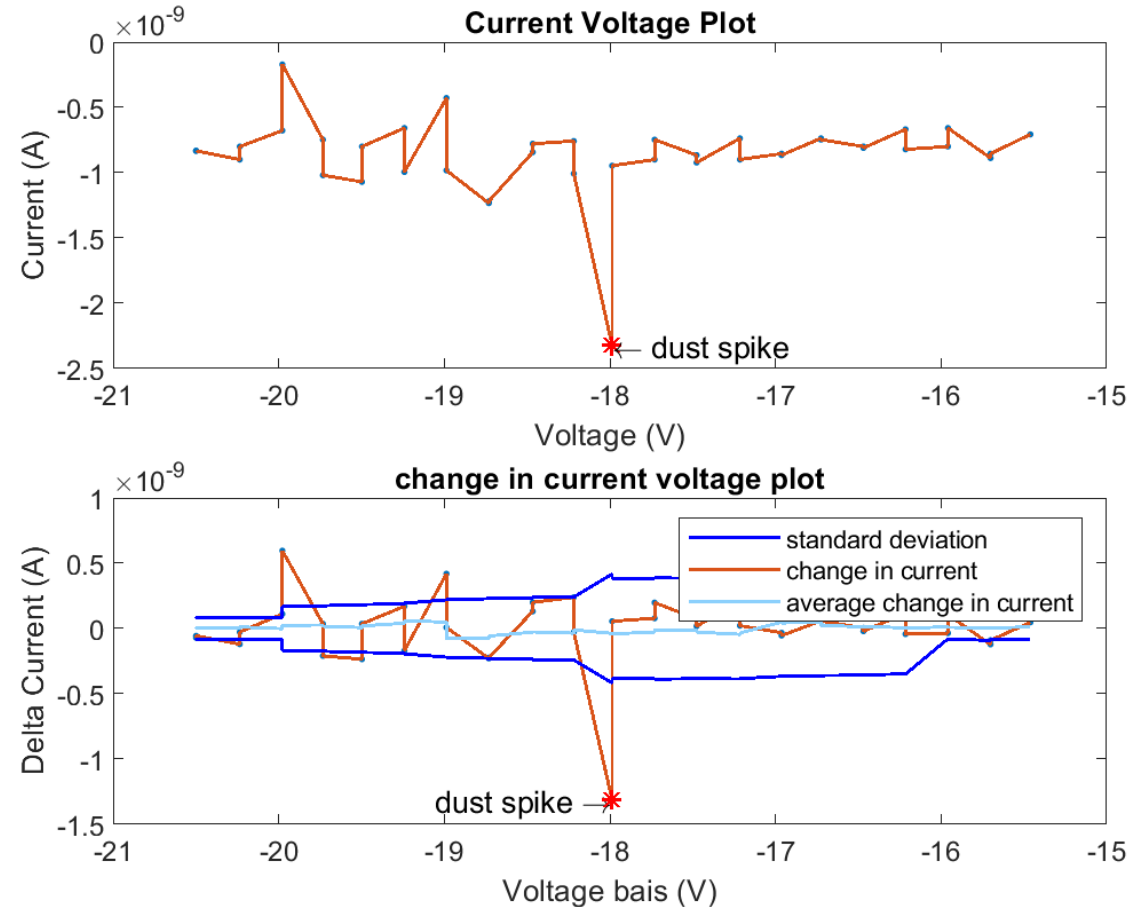
# Transient “Spike” Events From Cassini’s LP

- During the analysis of Data returned from Cassini’s Langmuir Probe’s Current Voltage “Spike” events found



# Spike Characteristics

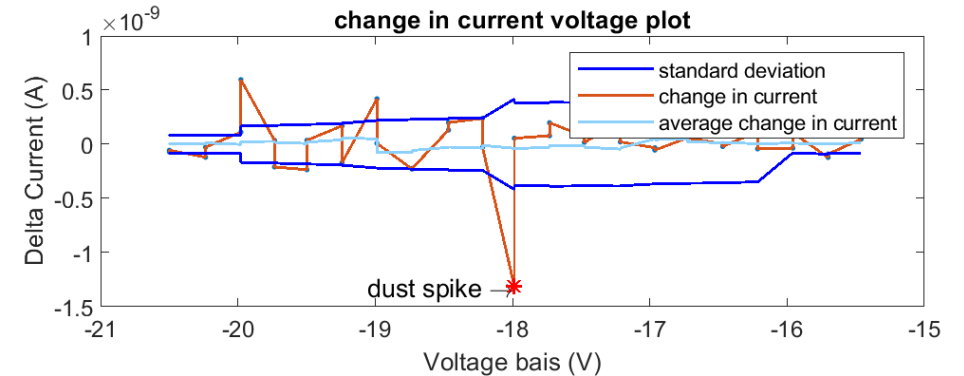
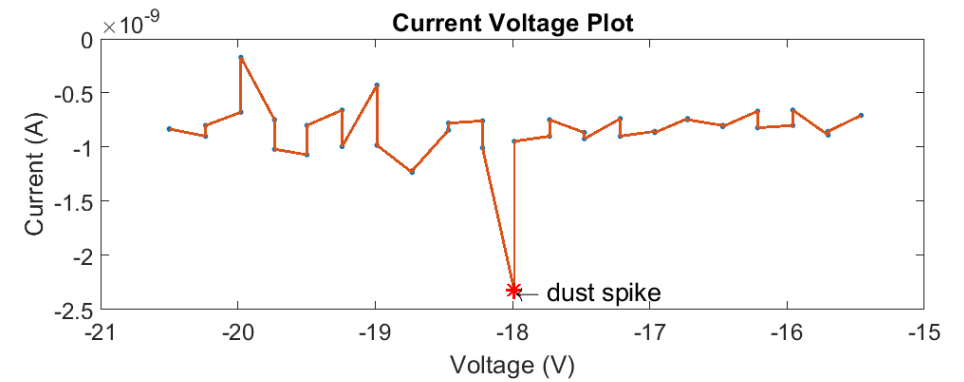
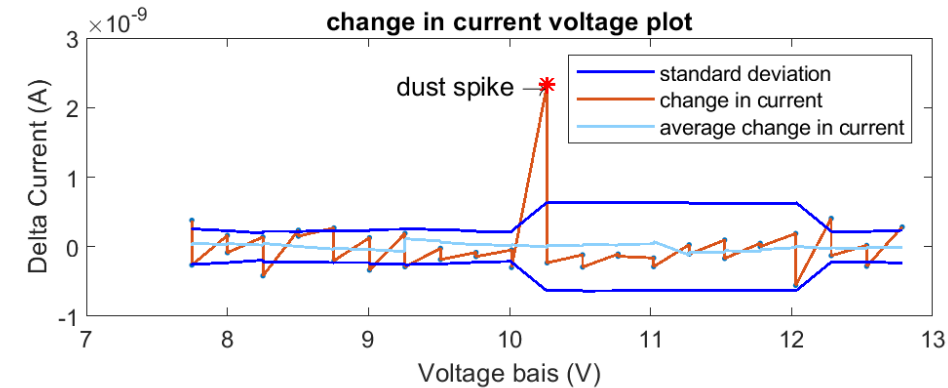
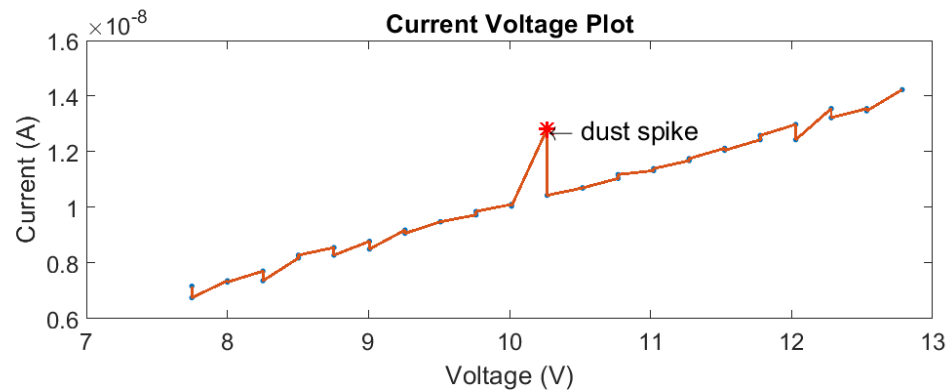
- Spikes are believed to be caused by Dust impacts
- Many spikes are one-point anomalies So they are under a millisecond





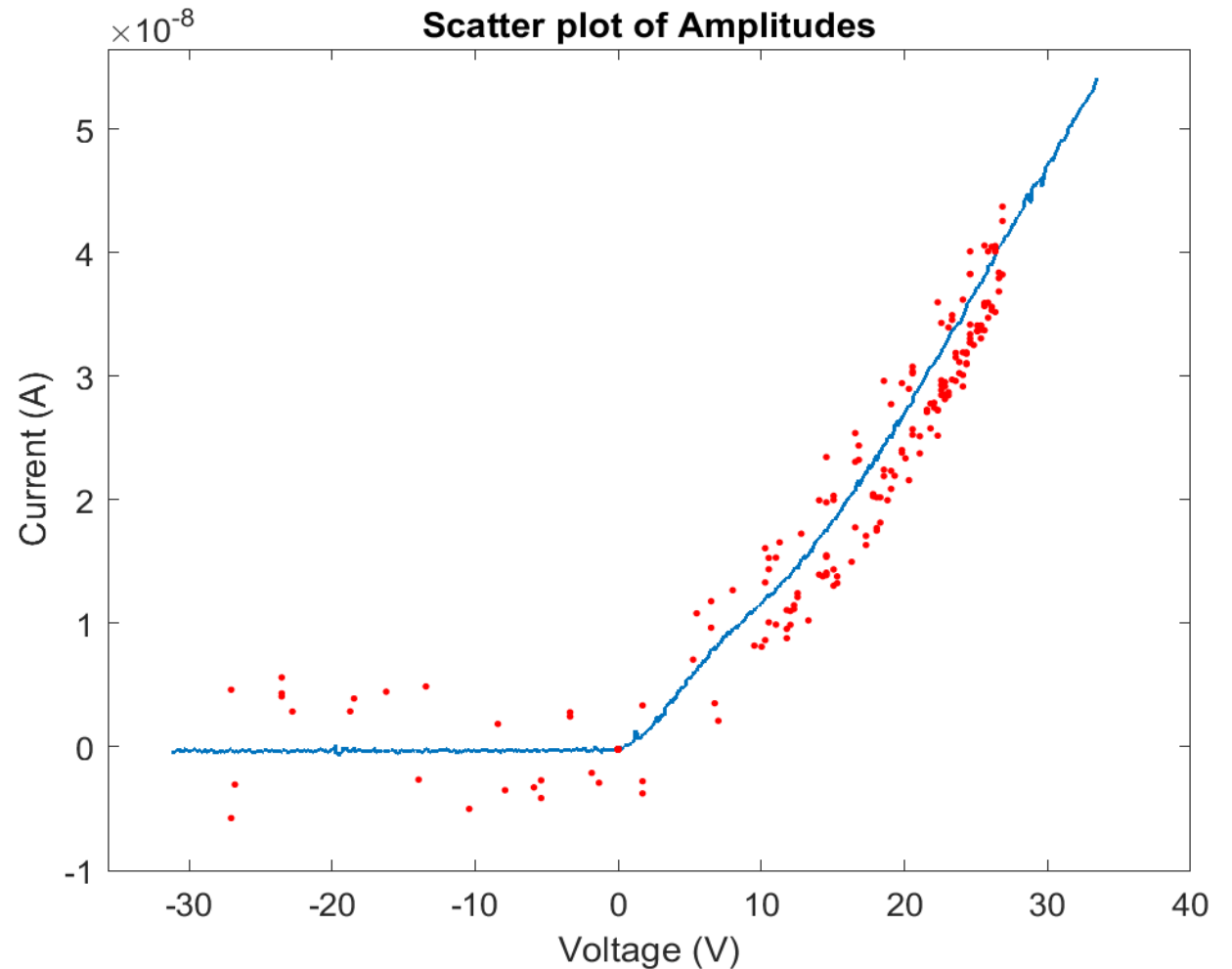
# Polarity of Spikes

- Found Different polarity Spike
- Ratio of 3 negative spikes to 2 positive spikes



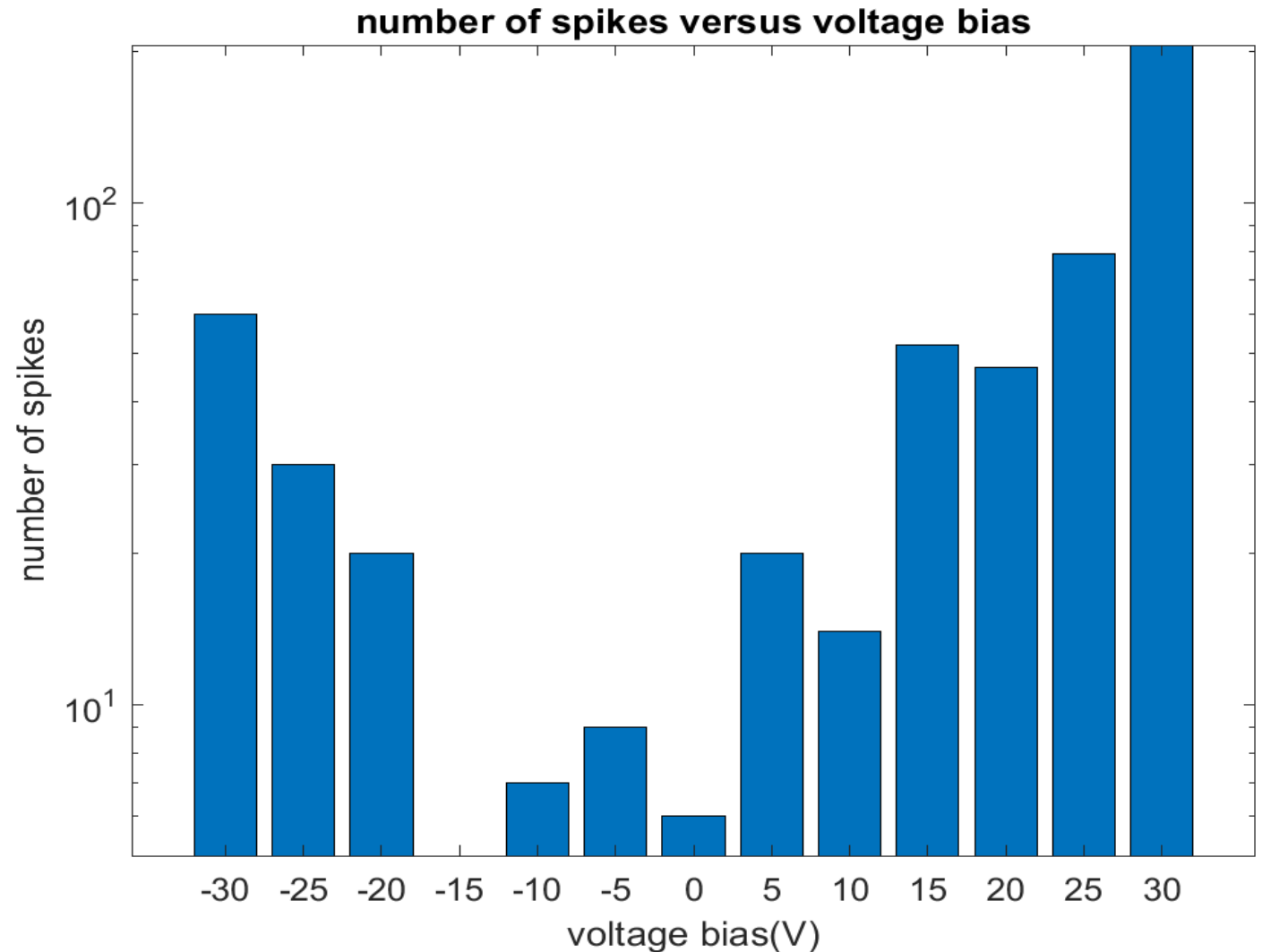
# Polarity Distribution

- We expected to find mainly positive spikes at positive Bias voltage and Visa Versa
  - Ion collection could be the culprit but we are still unsure
- Waiting on Cassini's LP detailed electronics to conduct an experiment



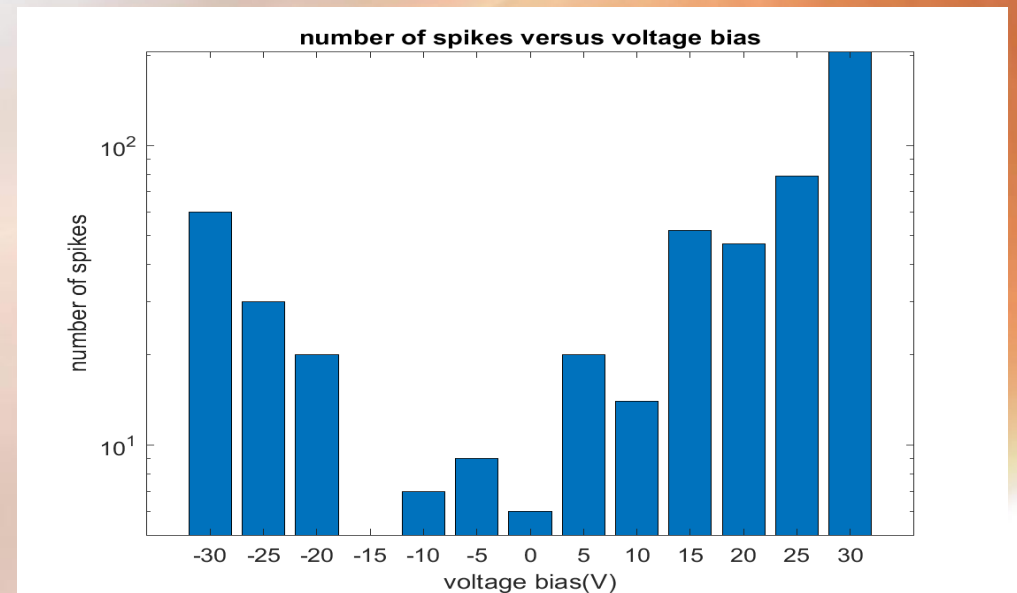
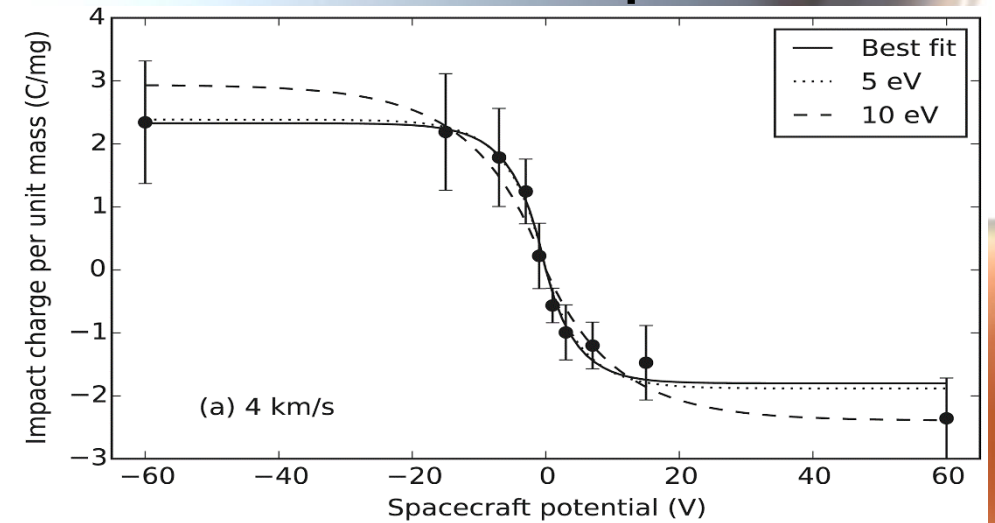
# Distribution of Spikes

- Dust Doesn't care if your biased positively or negatively will hit regardless
- Remember Electrons are easier to collect than ions



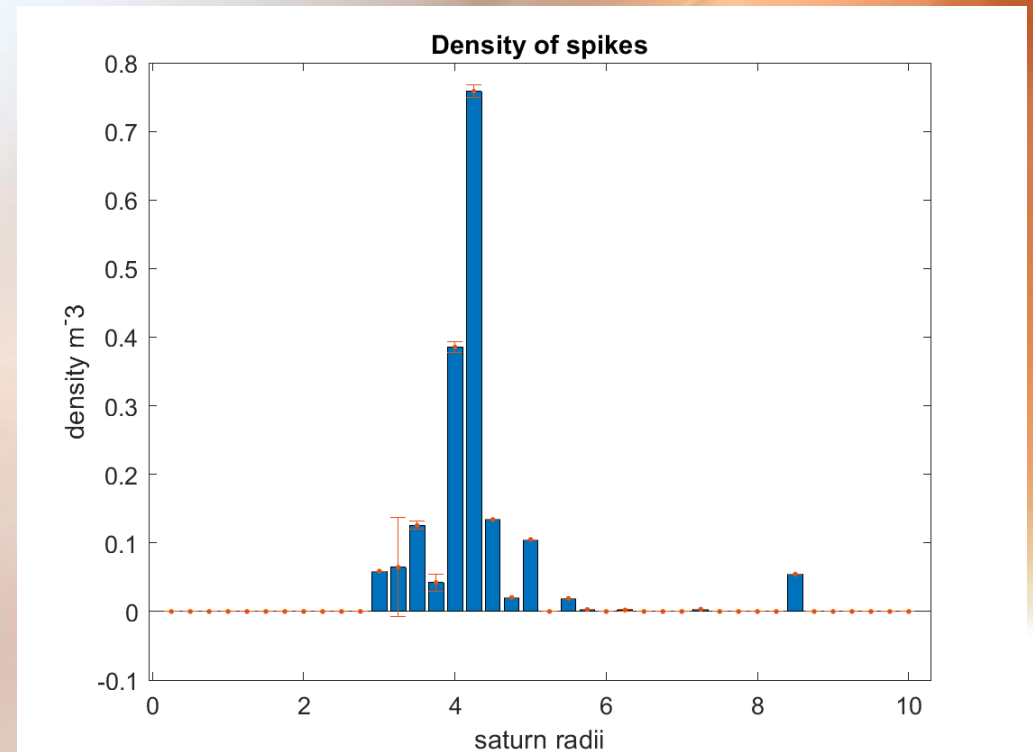
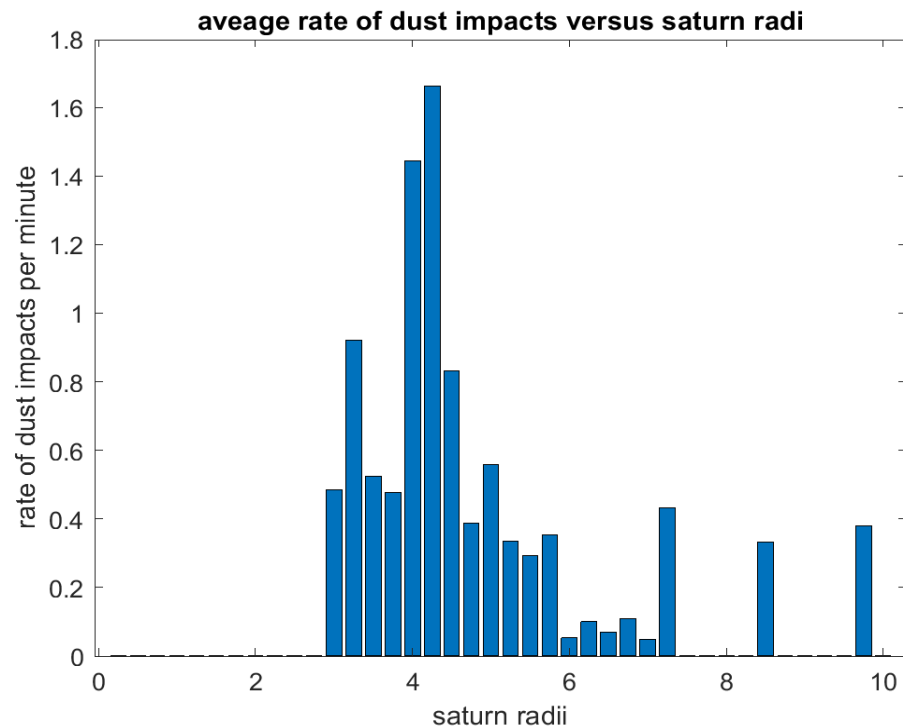
# Expected Spike distribution to Real Spike Distribution

- The graph on top shows the typical charge collected at different voltage biases
  - From this graph we expect our spike distribution to increase in spikes collected until positive and negative 15 volts then even out
- We very loosely see this trend



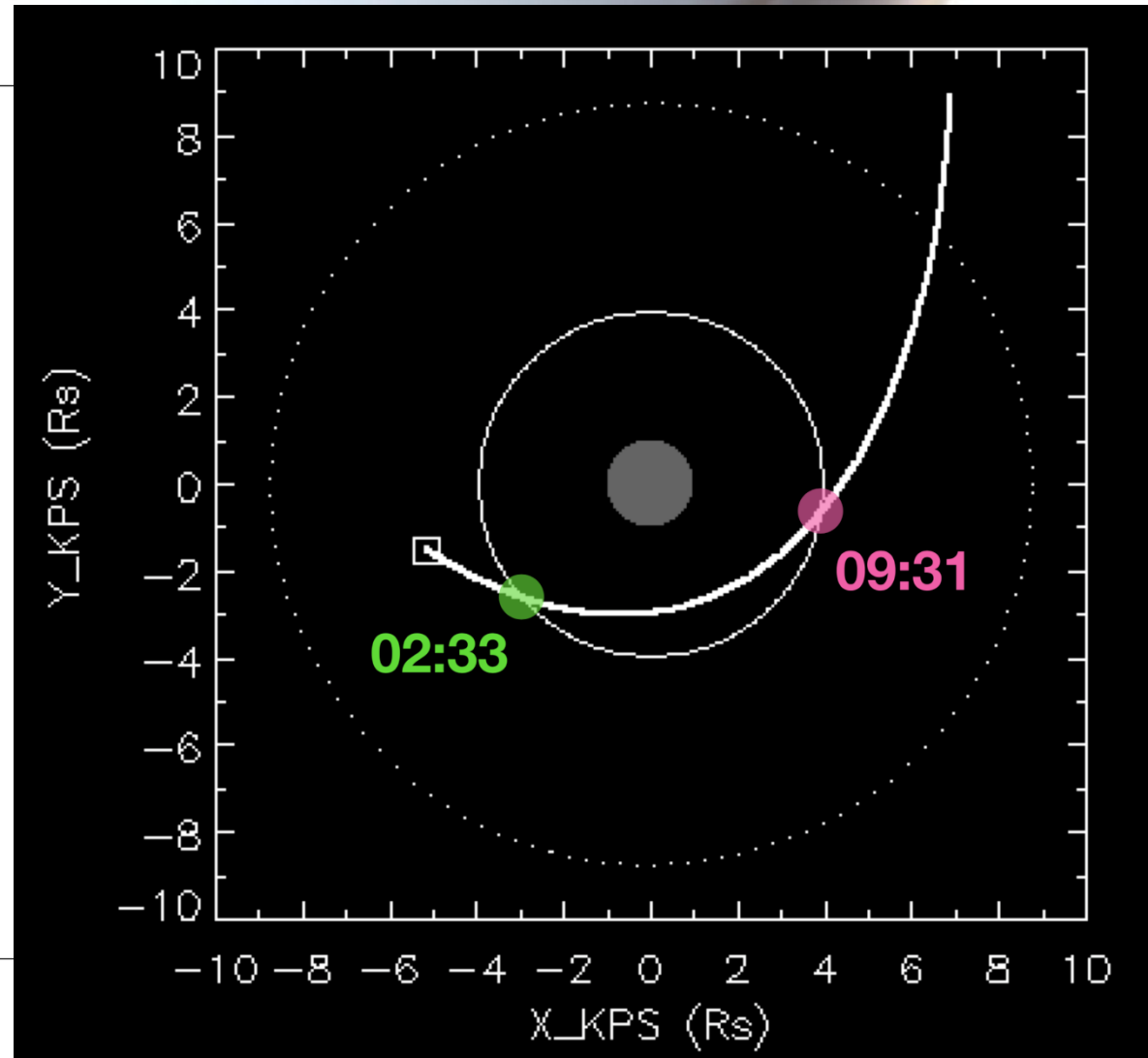
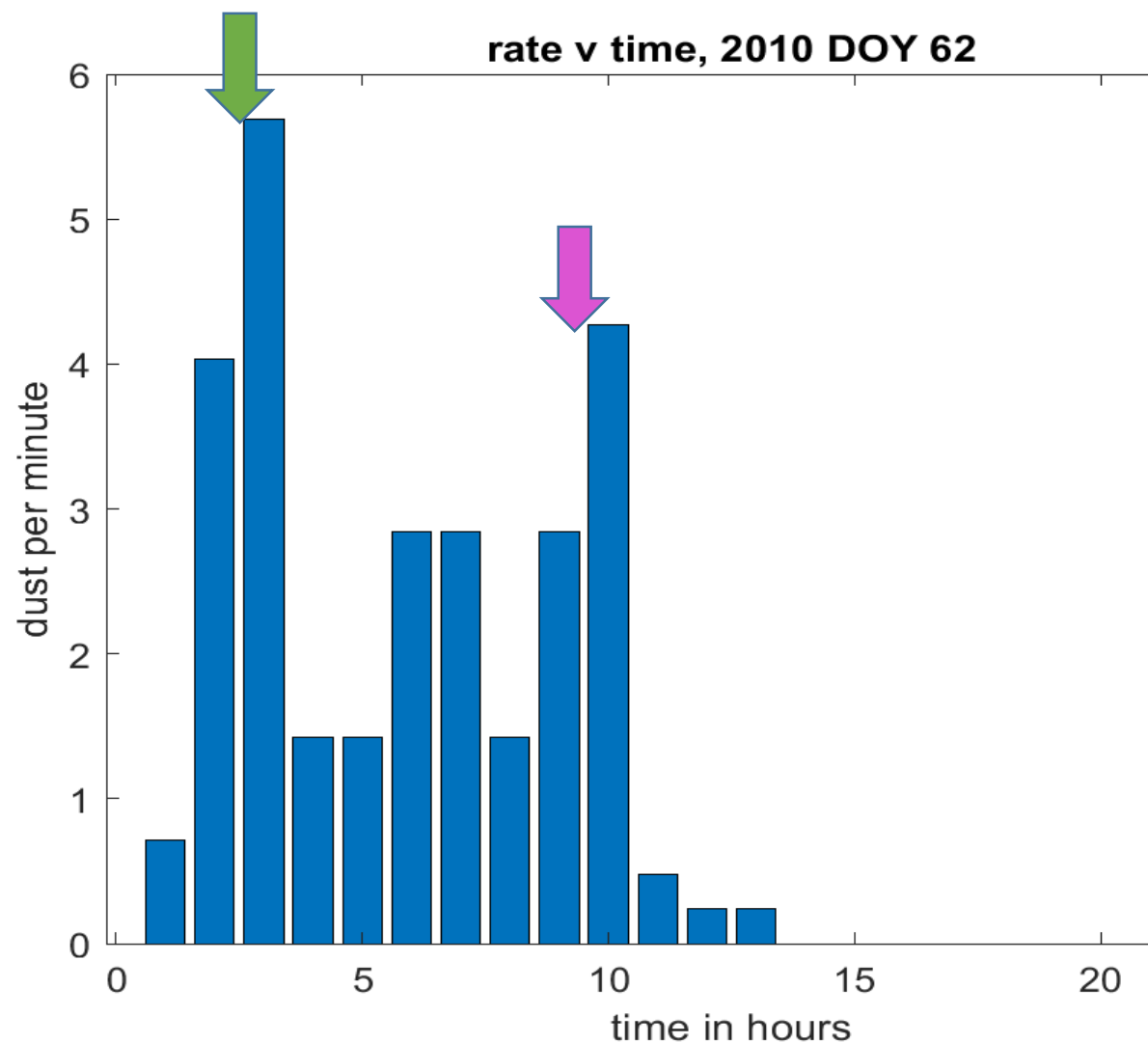
# Spatial distribution of dust compared to spike distribution

- Maximum density distributions occurs at 4.12 Saturn radii (Hedman et al., 2012)
  - Source of the E ring is Enceladus which orbits at 3.95 Saturn radii



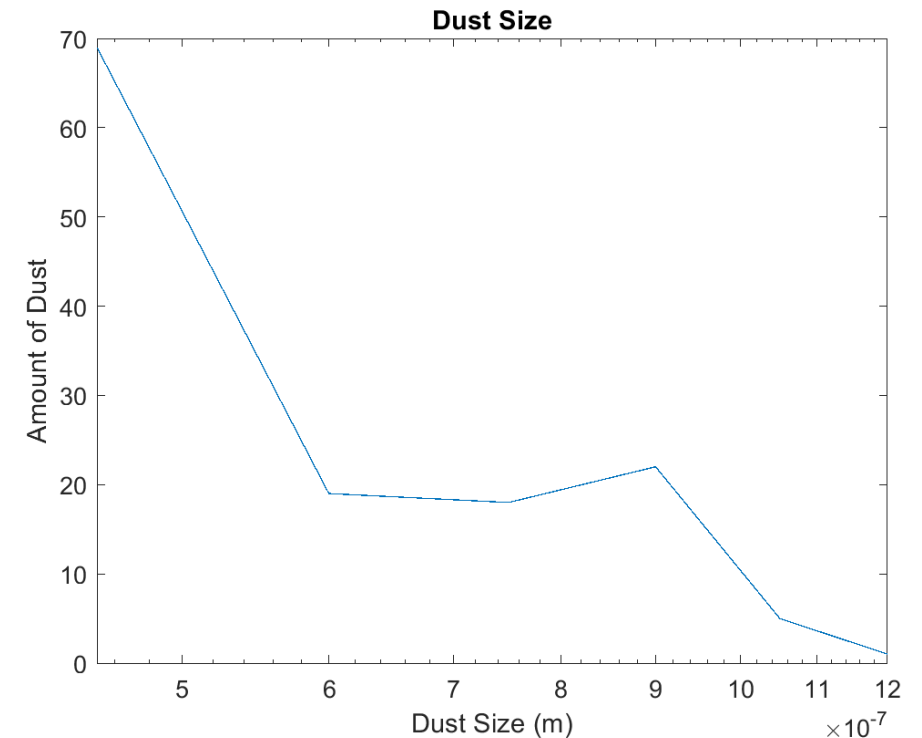
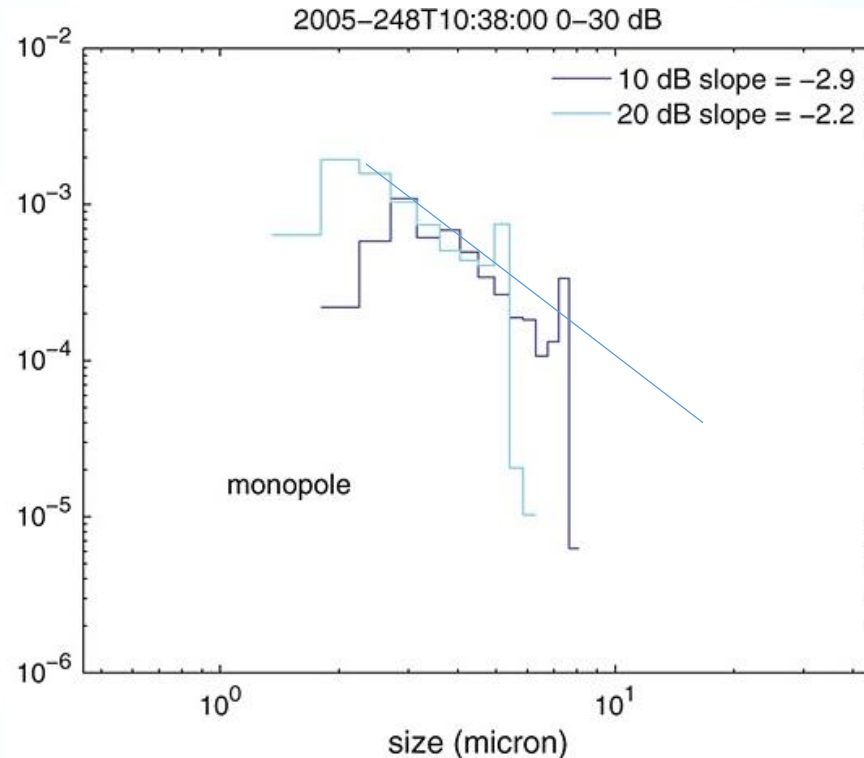


# Cassini's Radial distance from Saturn compared to Transient events



# Dust Size

- Found an average size of 0.78 microns and the majority of dust particles in the E ring sub micron
  - We obtain the size from comparing our density distribution to the CDA
- Figure on the right shows size distribution obtained from Collette, et al.



The figure on the left is obtained from Ye, et al., and is of the distribution observed from RPWS antenna showing the size distribution of dust in the E ring

# Summary and Recommendations

- Due to the Distributions of dust in Saturn's E ring and the distribution of transient events we are fairly certain we are identifying dust
- Due to constraints on information about the Schematics of Cassini's Langmuir probe couldn't obtain size independently from other instruments
  - Also, couldn't run experiments to see what's causing different polarities

# Acknowledgments

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