LADEE/LDEX observations of pick-up ion variability in the lunar exosphere

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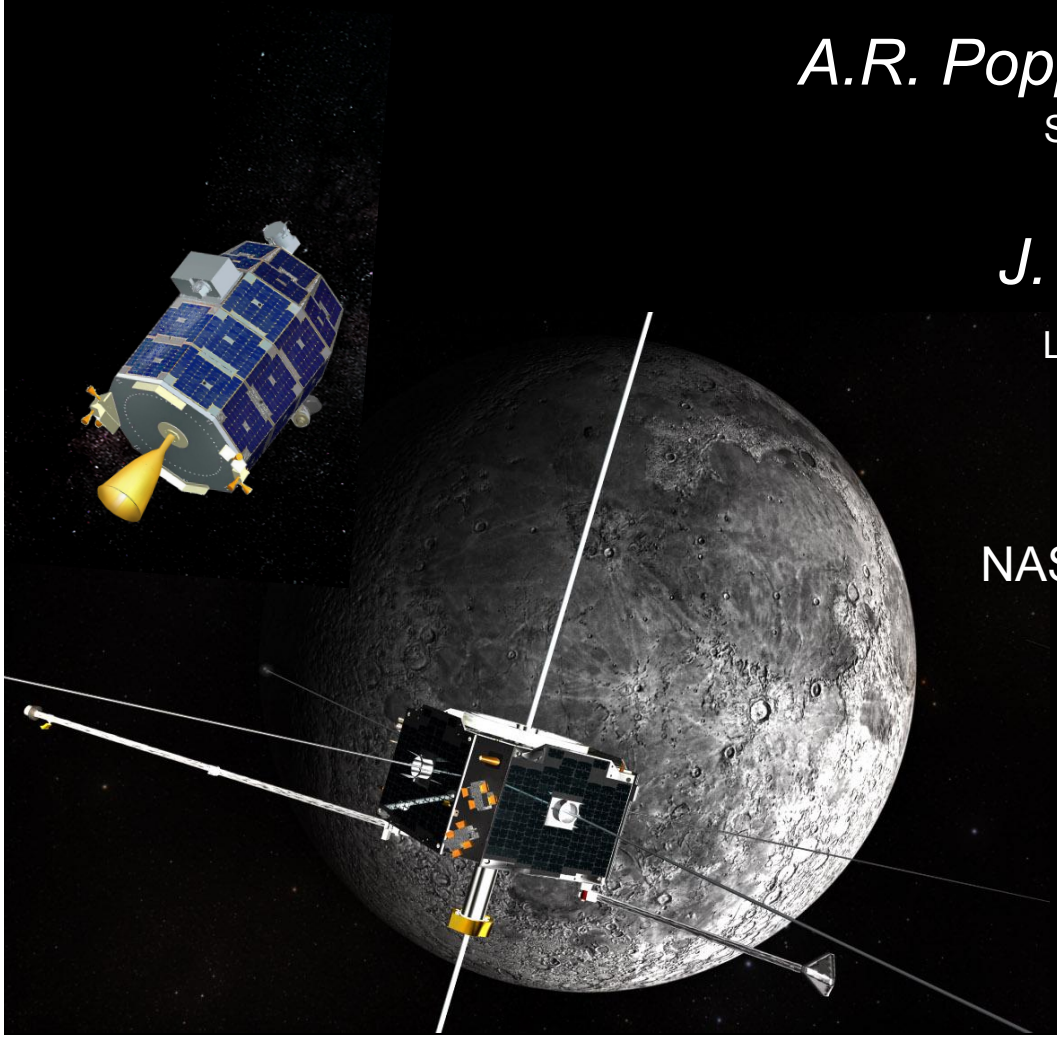
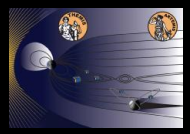
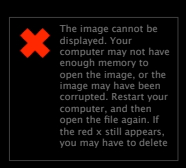
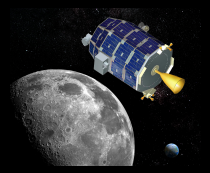


NASA Exploration Science Forum
July 22, 2014







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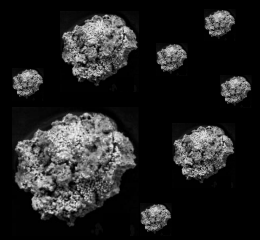
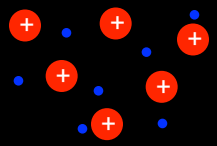
Lunar Exosphere Production and Loss Mechanisms

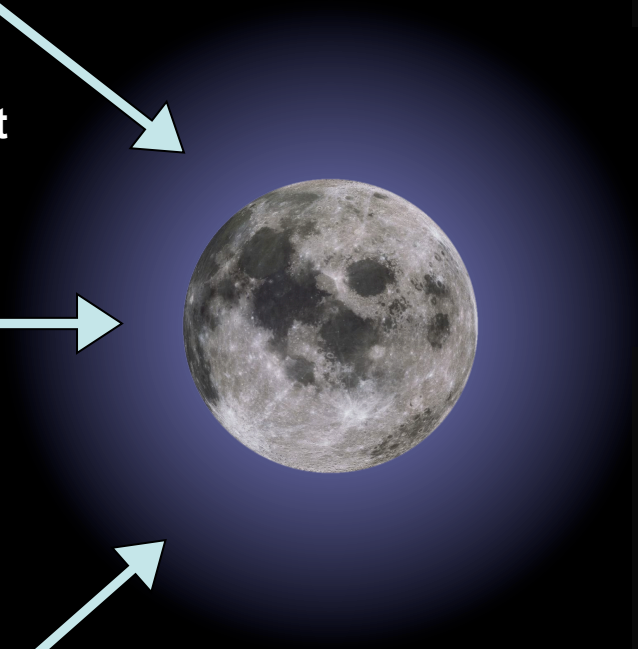
Photon-stimulated desorption
Thermal desorption

Micrometeoroid bombardment



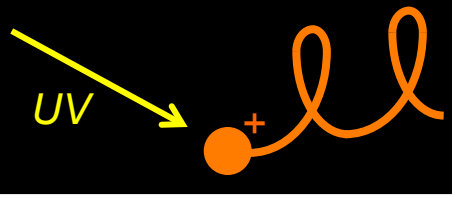
Solar wind sputtering
Electron-stimulated desorption





Jeans (thermal) escape

Photo-ionization



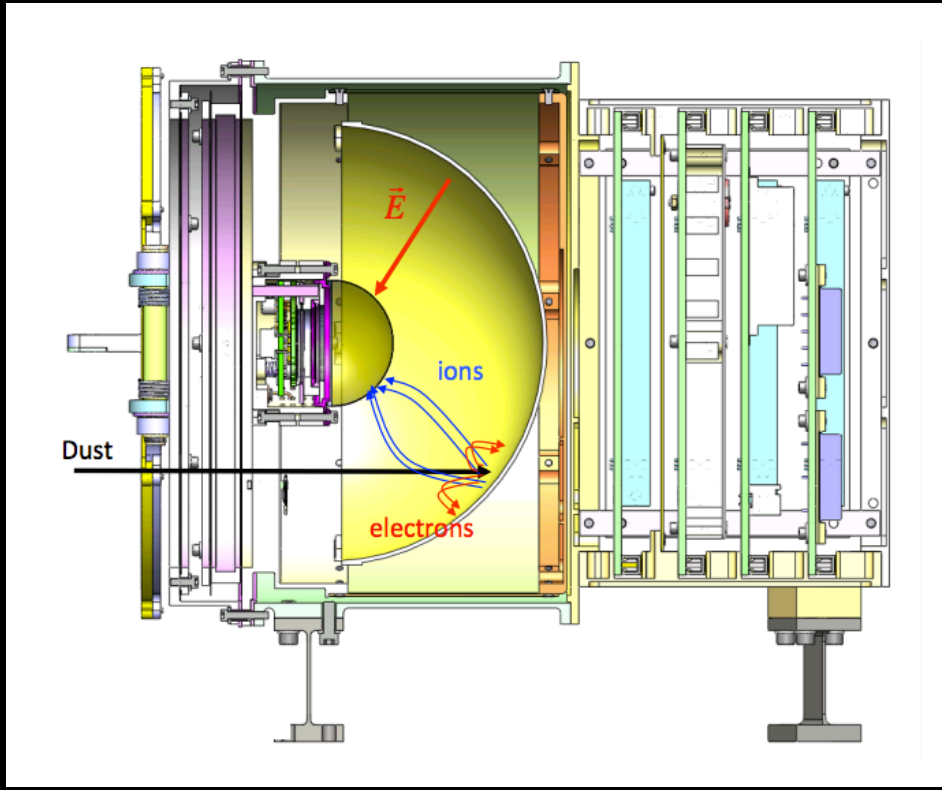
Surface capture

Nightside sequestration

The Lunar Dust EXperiment (LDEX)

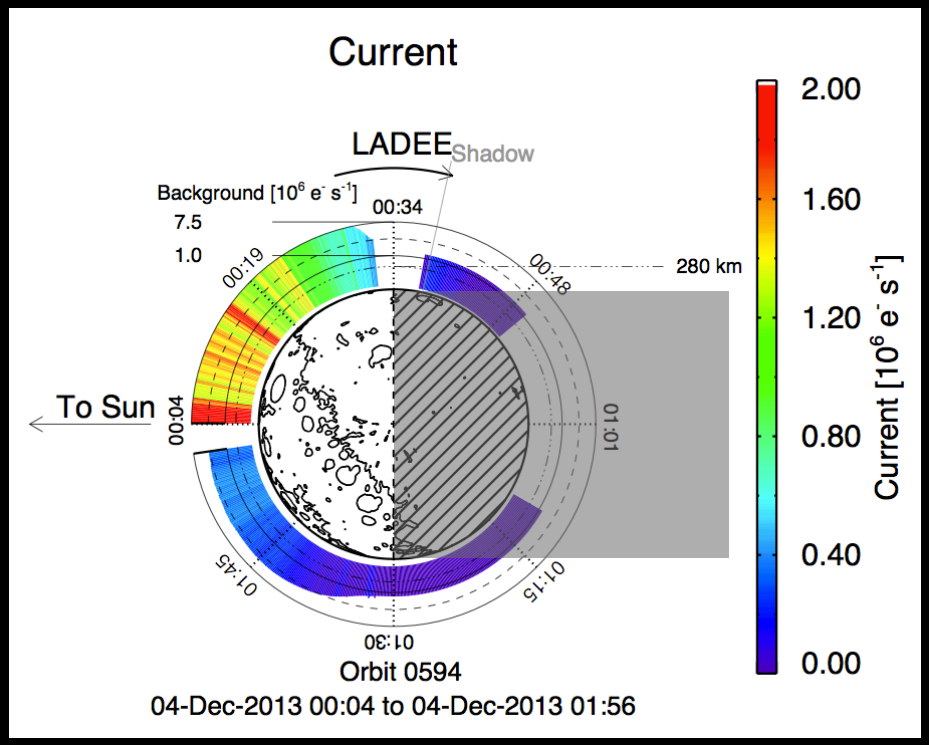
Designed to measure the micron and sub-micron sized dust environment surrounding the Moon:

- Large (> 0.7 μm) grains via direct impact
- Small grains (< 0.7 μm) via collective integrated current



LDEX current measurements also respond to low-energy (< 200 eV) ions from the ambient plasma environment

Heavy Lunar Ions: A Possible Current



Pick-up ions from photo-ionized neutrals above the lunar dayside are accelerated by the convection electric field and, <u>if the geometry allows</u>, can be detected by LDEX

Heavy Lunar Ions: A Possible Current

Goal:

Use LDEX data to determine how lunar pick-up ions respond to changes in exospheric inputs, specifically, solar wind sputtering and micrometeoroid bombardment

Method:

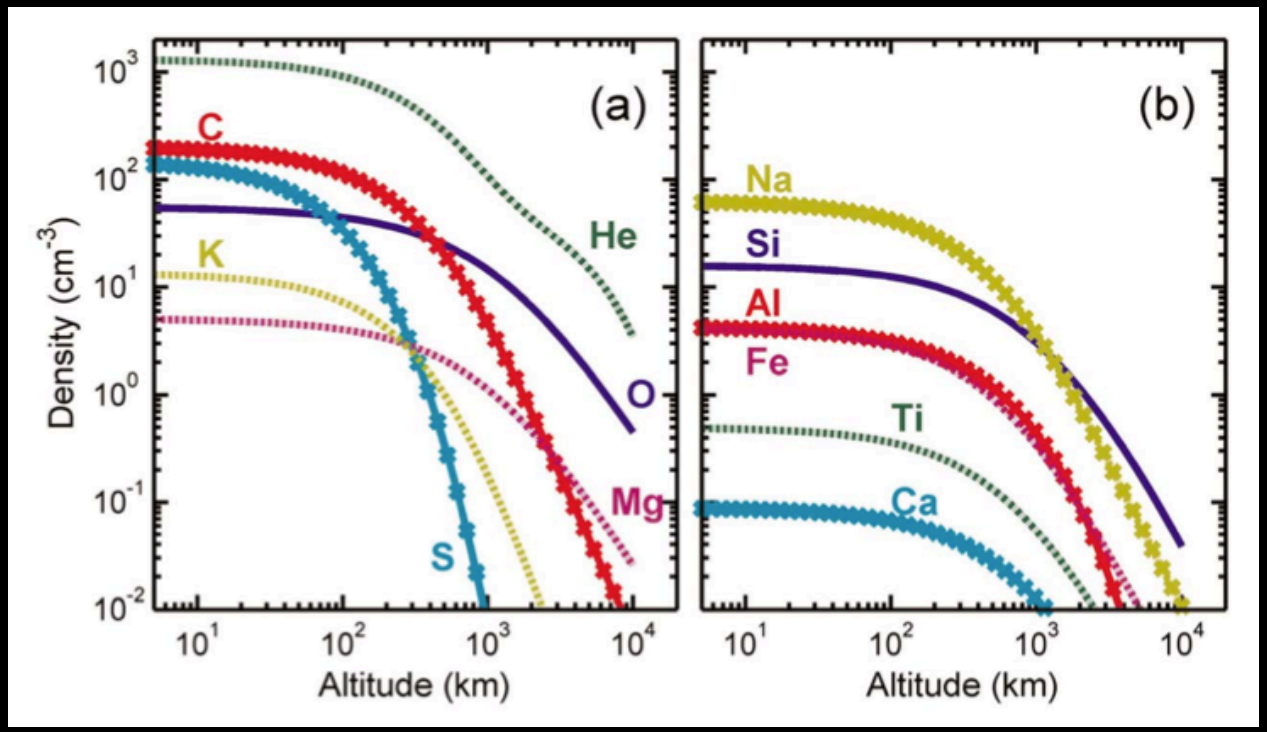
1. **Build a model of predicted pick-up ion current to LDEX with static exosphere (i.e., no time variation in inputs)**

2. **Identify and aggregate LDEX periods of pick-up ion measurement and subtract any background signals**

3. **Compare LDEX current to model-predicted current as a function of solar wind sputtering and MM flux**

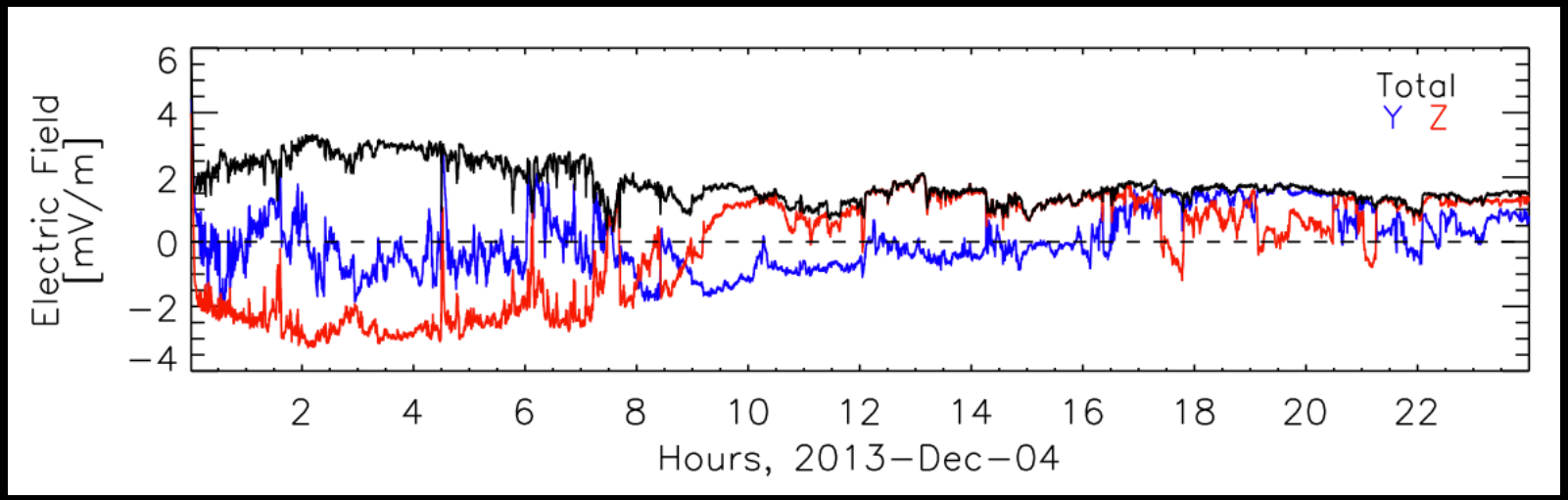
Model Exosphere

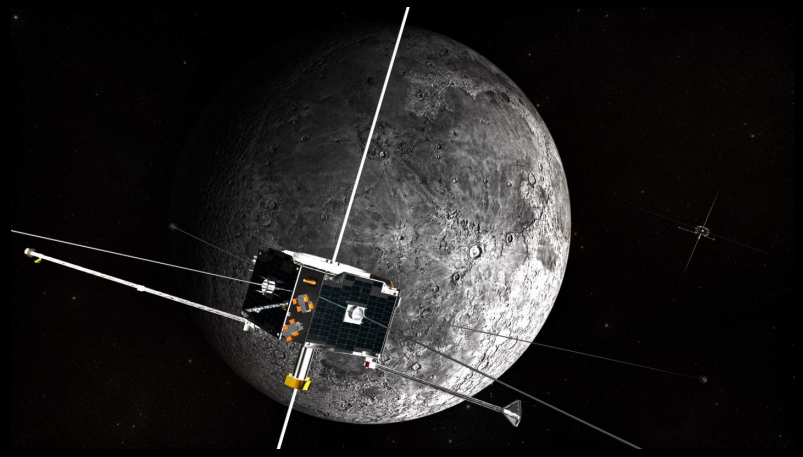
- Based off of *Sarantos et al., 2012* with nominal additions of various volatile species (CH_4, CO, CO_2) and noble gases (He, Ne, Ar)
    - Spatial variation in neutral density as warranted by source process (thermal, SW sputtering, micrometeoroid, etc.)



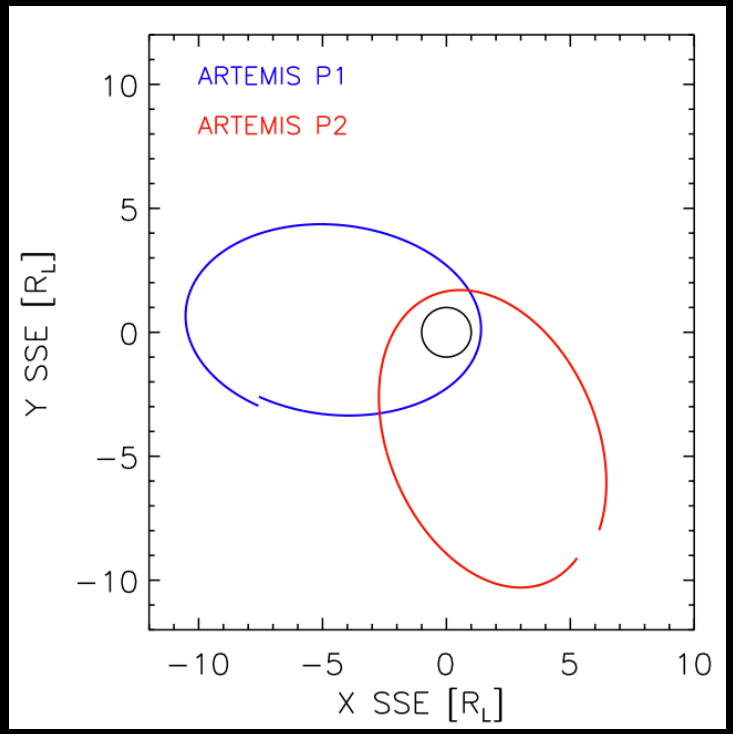
Sarantos et al., 2012

ARTEMIS monitors the plasma environment

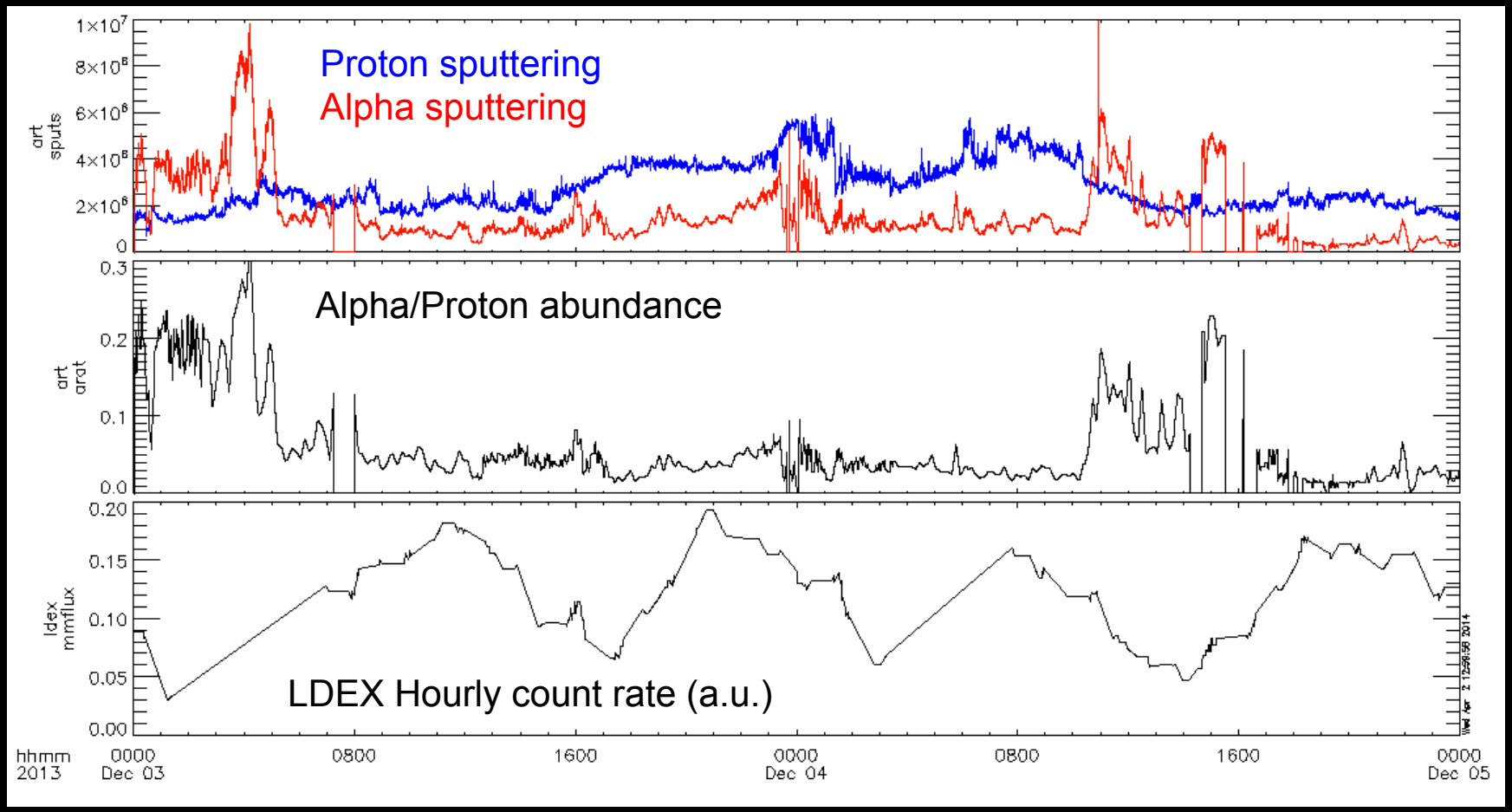




The solar wind magnetic and electric fields control the trajectories of pick-up ions – feed ARTEMIS measurements into our model

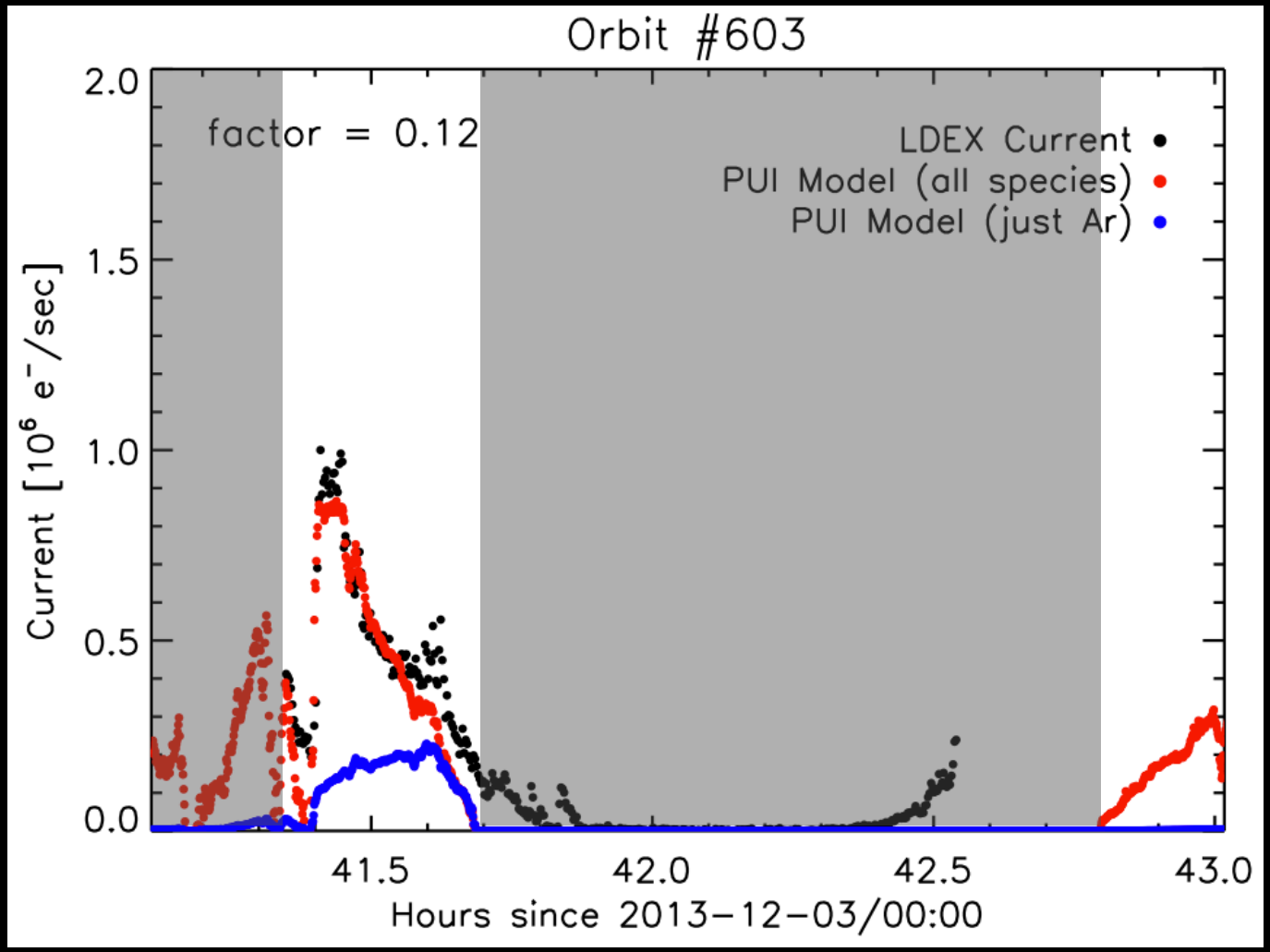


Step 3a: Calculate sputtering fluxes and micrometeoroid bombardment rate



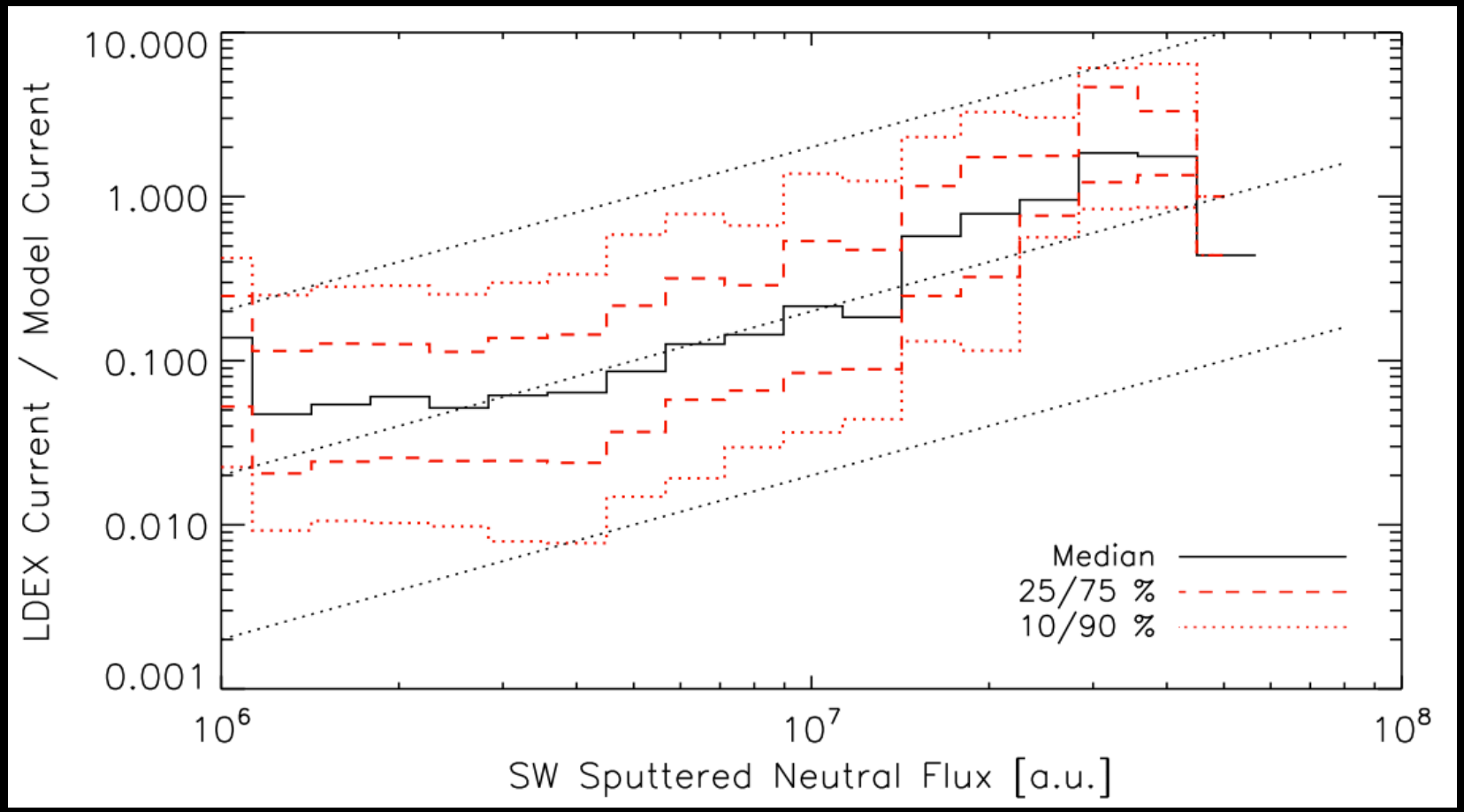
ARTEMIS provides SW input – convert to sputtered flux
LDEX hourly hit rate used as *rough* proxy for MM influx

LDEX/Model Comparison: Individual Orbit



ARTEMIS provides SW input – convert to sputtered flux
LDEX hourly hit rate used as *rough* proxy for MM influx

LDEX Pick-up Ion Current vs. SW Sputtering



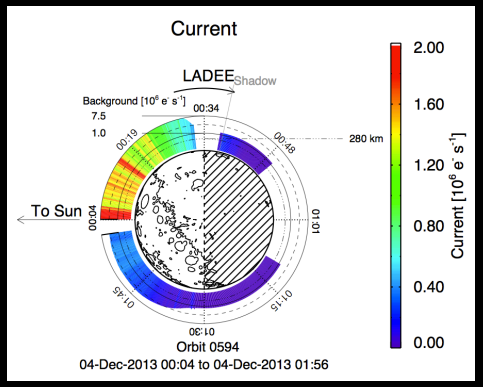
LDEX sees a linear trend in pick-up ion current as function of the solar wind sputtered flux

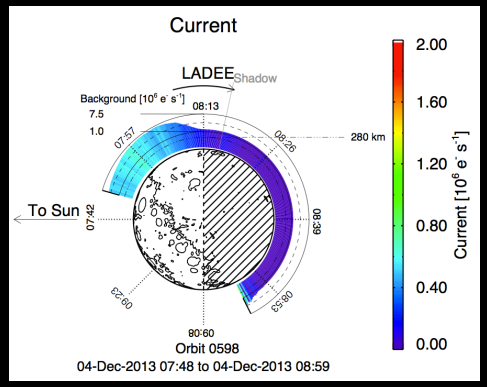
Conclusions and Future Work

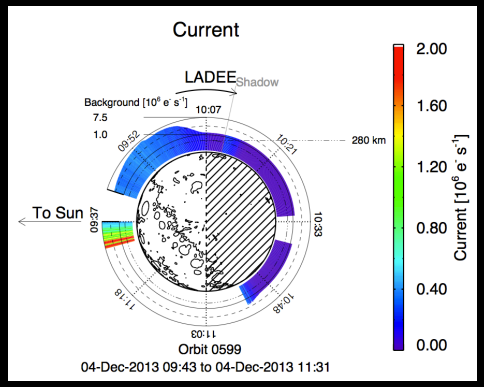
- The LDEX instrument measures ions generated from the lunar exosphere through its “current” channel
  - These ions respond to interplanetary electric and magnetic fields (measured by ARTEMIS)
- High degree of correlation between pick-up ion current and solar wind sputtering of the lunar surface
  - More sputtering -> more neutrals -> more pick-up ions

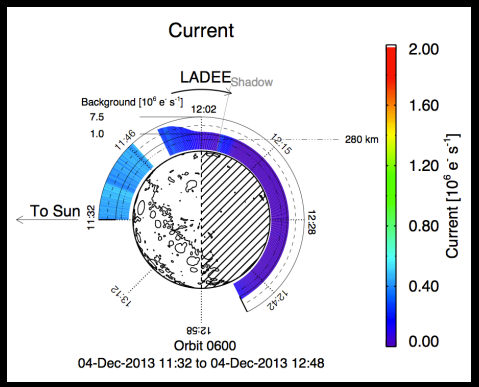
Backup Slides

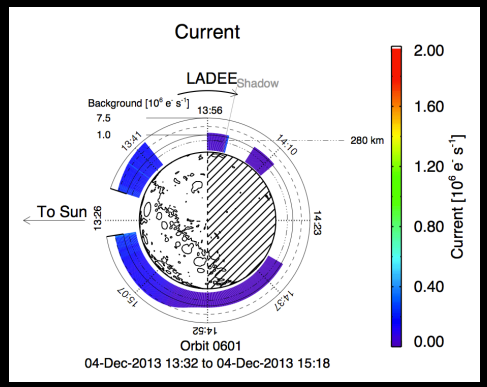
A Day in the Life of LDEX Current

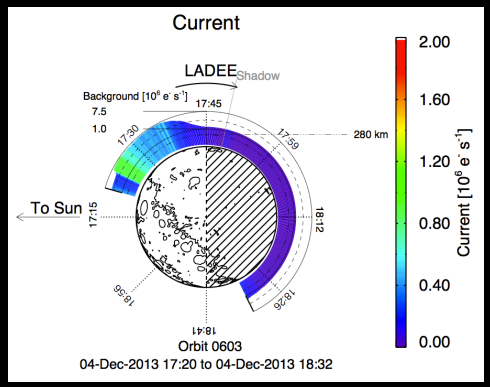


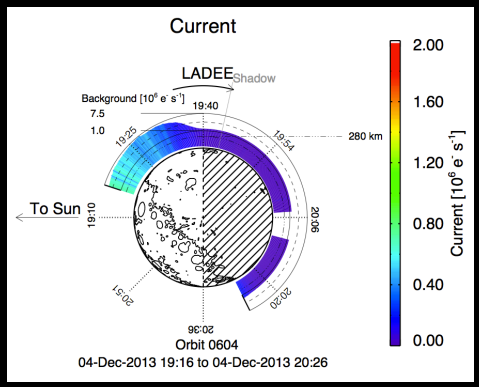


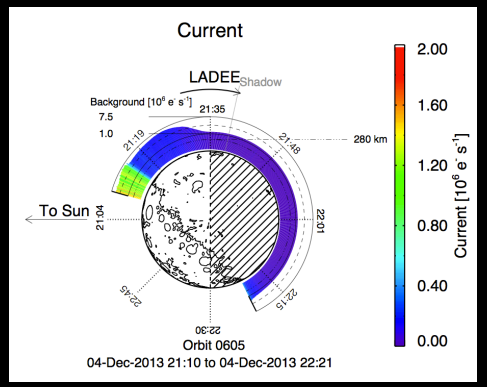


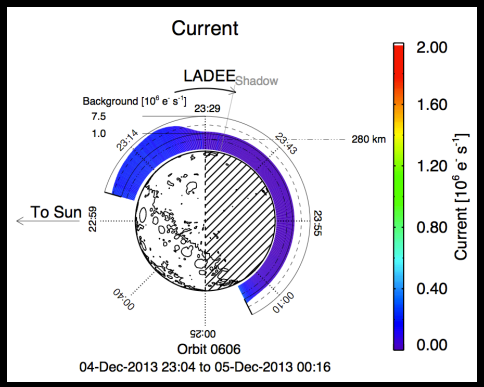




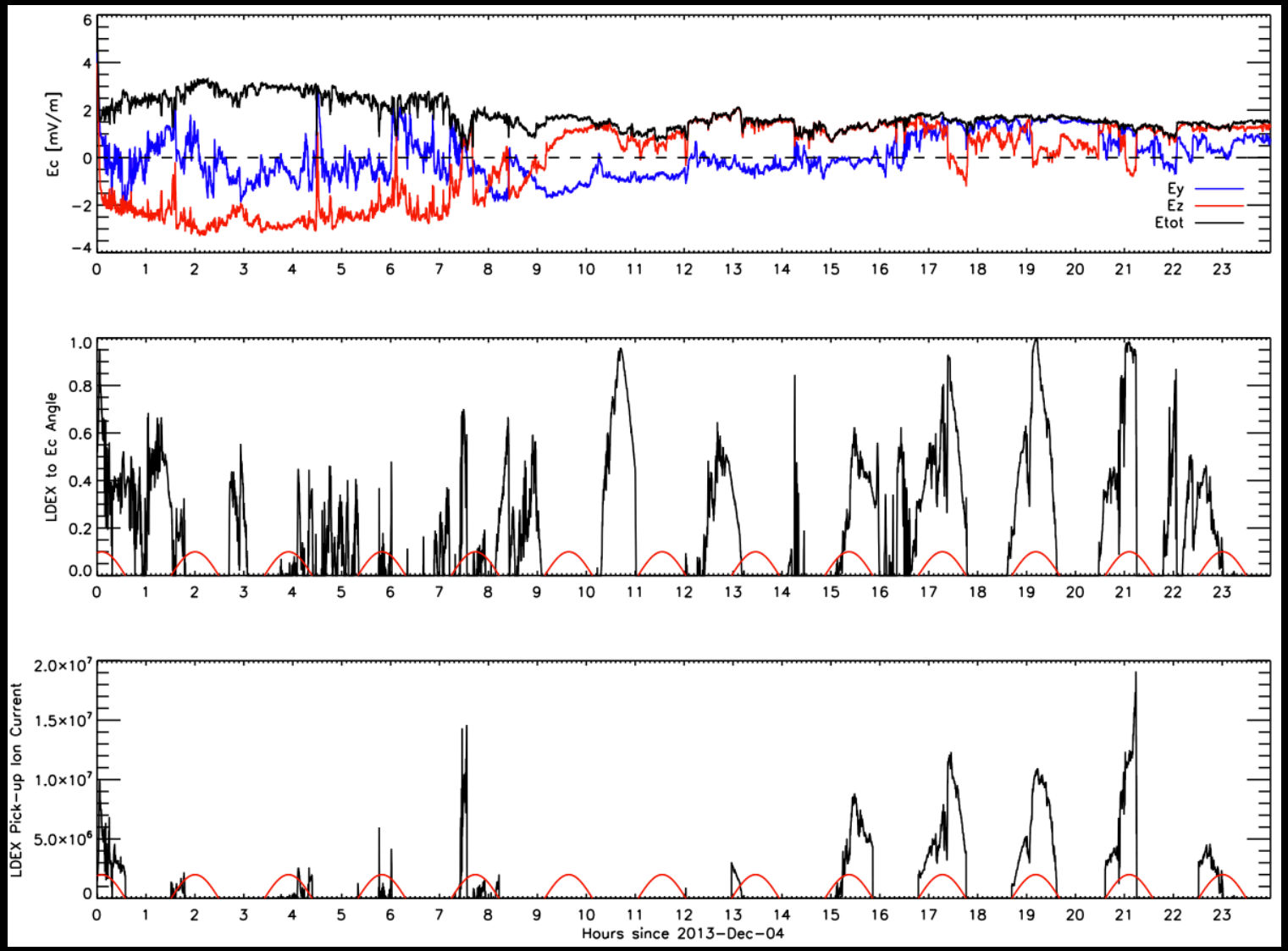




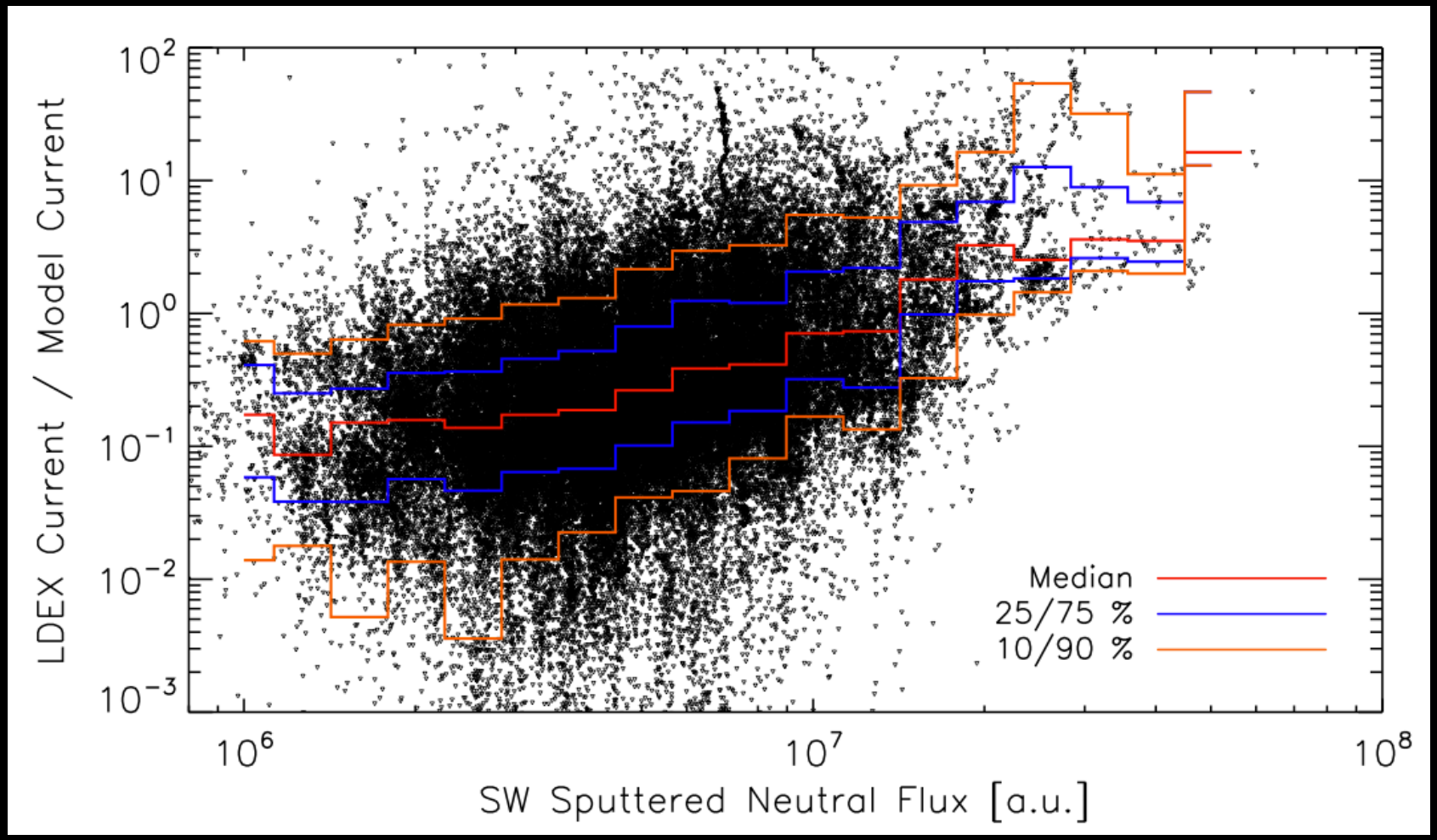




Model Output for Example Day

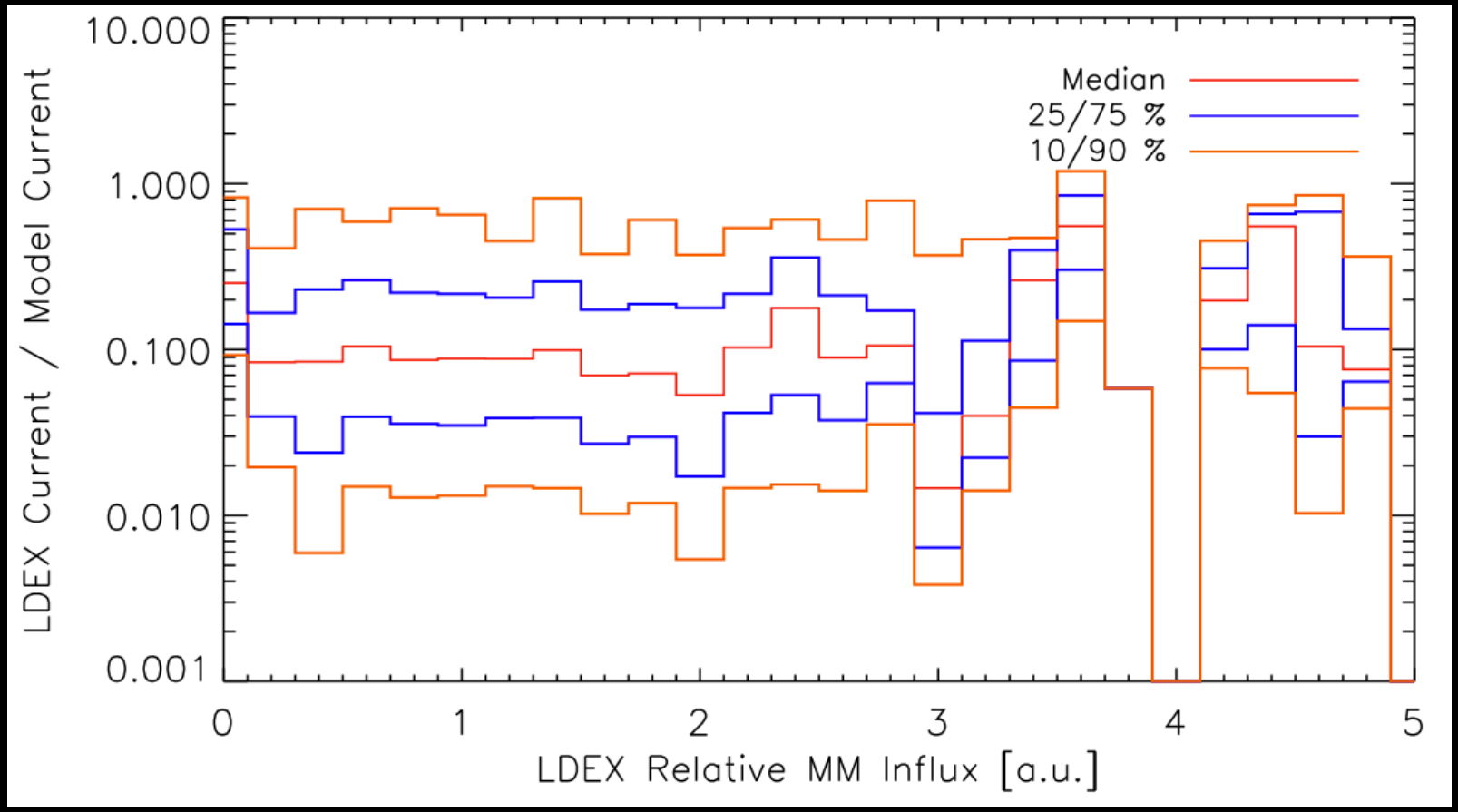


Pick-up Ion Current vs. SW Sputtering



Linear increase in pick-up ion current as a function of solar wind sputtering is seen clearly in the raw data

Pick-up Ion Current vs. MM Bombardment



No obvious trends seen in LDEX current as a function of micrometeoroid bombardment