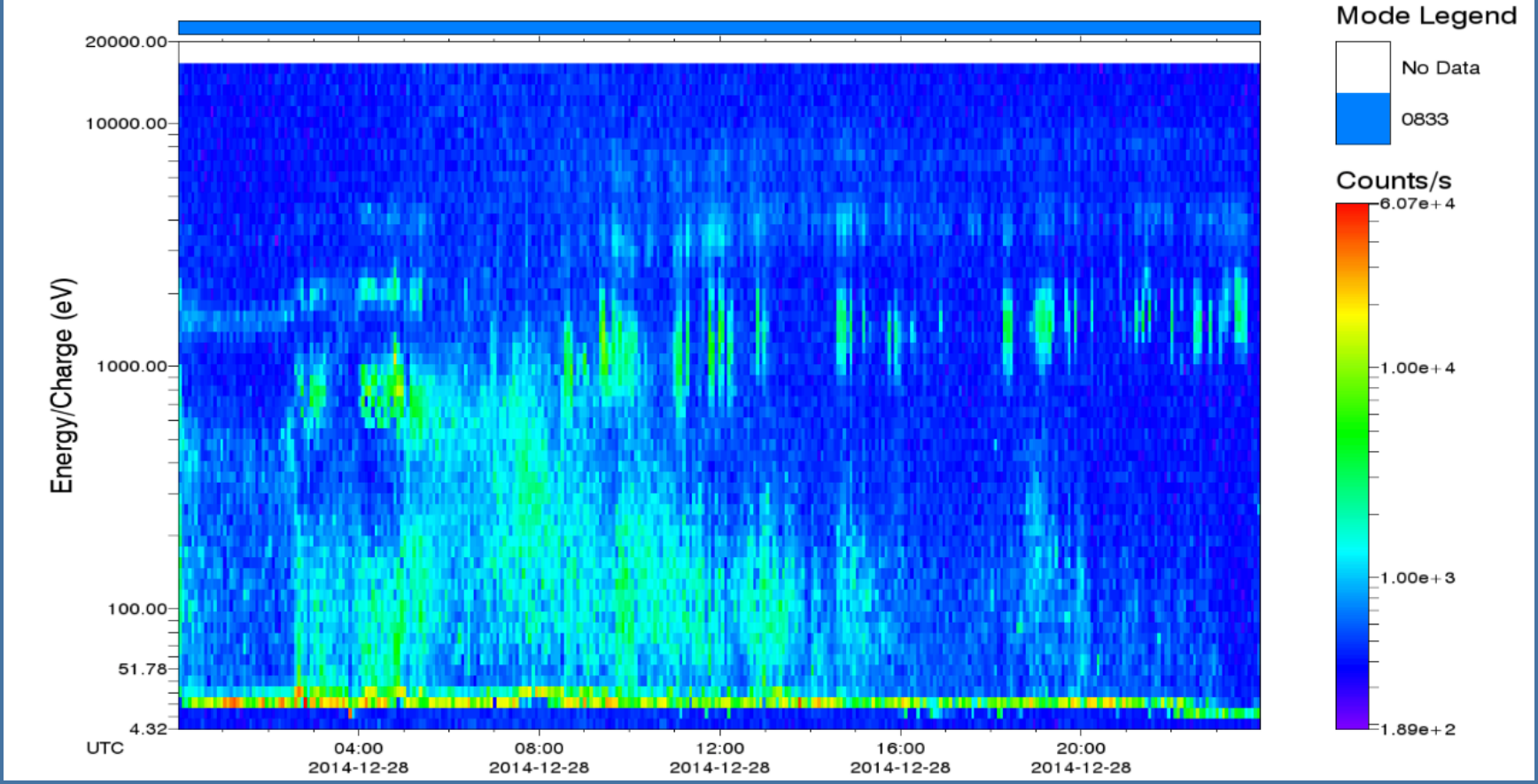
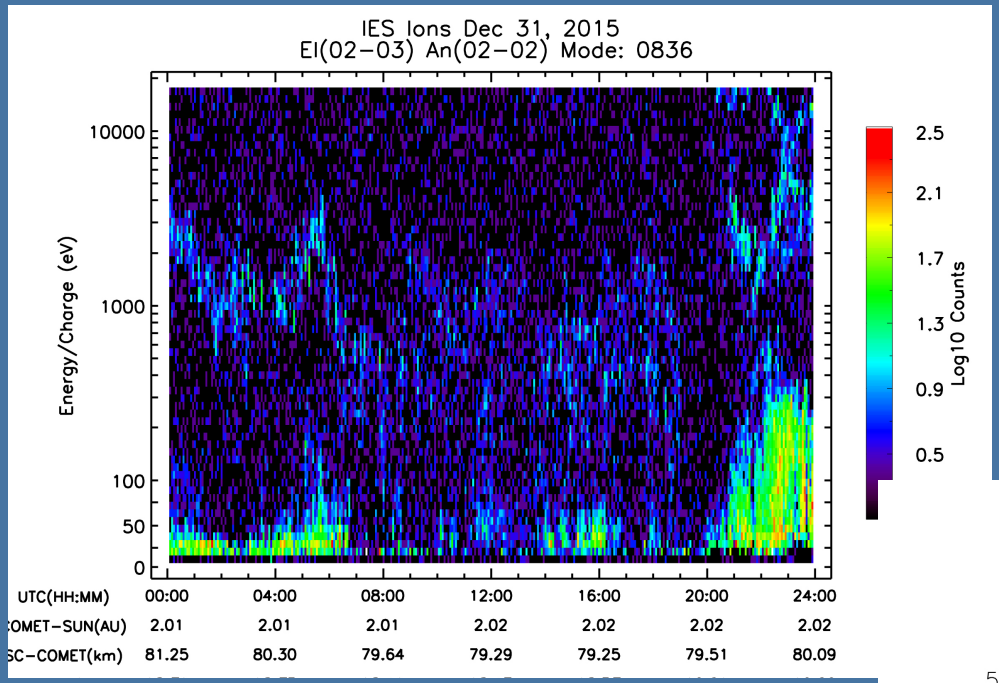
Outline

- Pickup of cometary ions by the solar wind
- Emission and pickup of nanograins
- Negative hydrogen in solar wind near the comet
- Acceleration of electrons to keV energies near the comet
- Variation of plasma phenomena through perihelion
- Development of diamagnetic cavity
- Increase of hot electron population

RPC-IES Ion Spectrogram (Dec. 2014, 2.7 AU to Sun, ~28 km to CG) Showing Solar Wind and Moderate Energy Pickup Ions

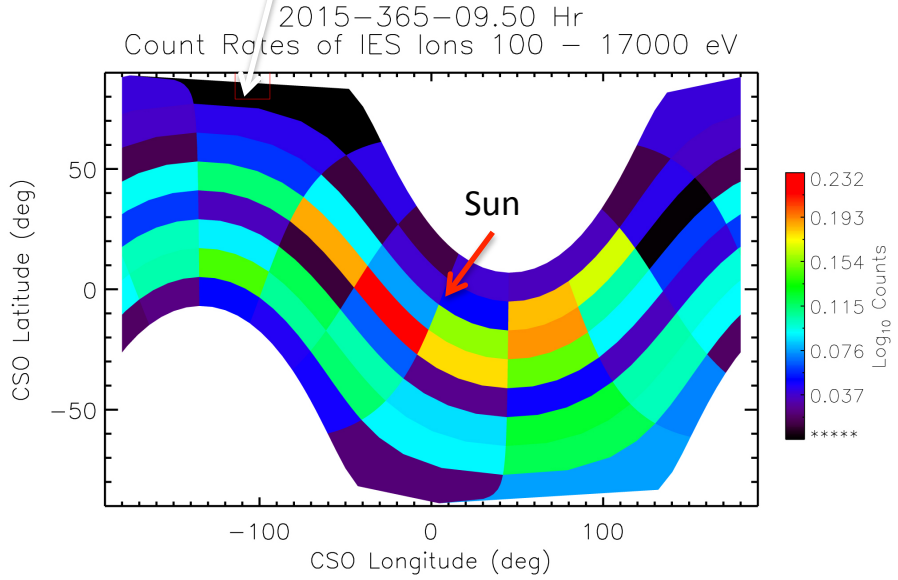


Mixture of Solar Wind and Pickup Ions Observed by RPC-IES on 31 Dec. 2015 (80 km to CG, 2.0 AU to Sun)

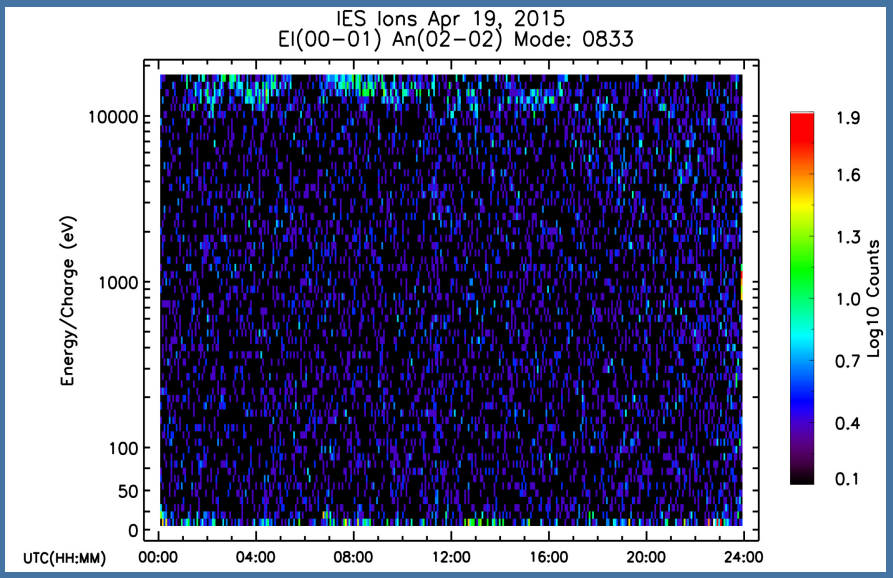


Comet Solar Orbital coordinates

Comet

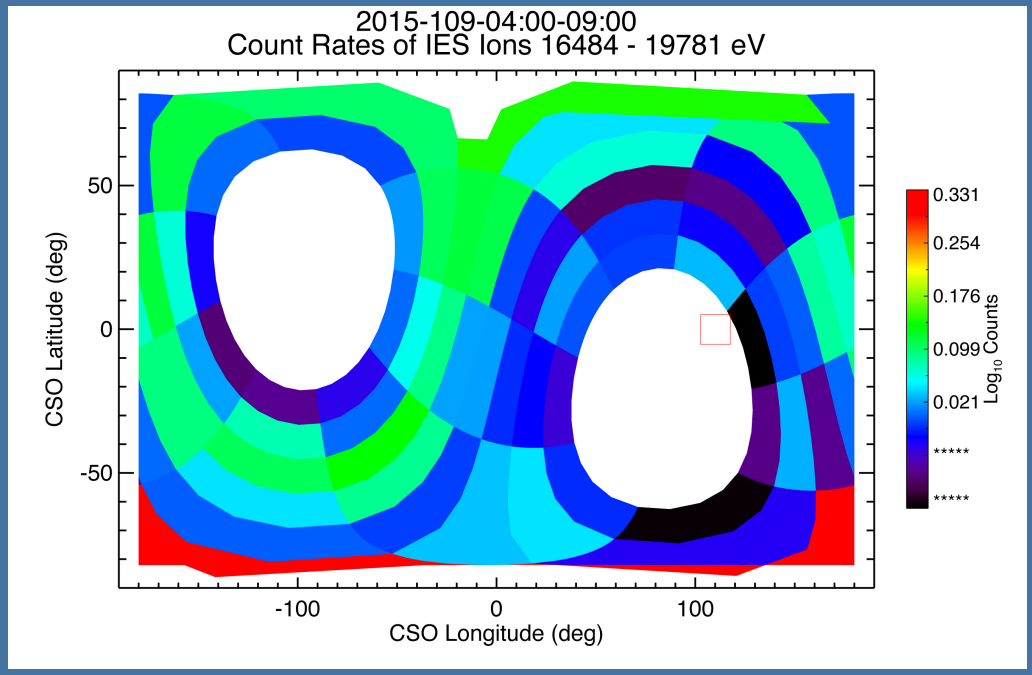


Very High Energy Pickup Ions Observed by RPC-IES on 19 April 2015 (105 km to CG, 1.8 AU to Sun)

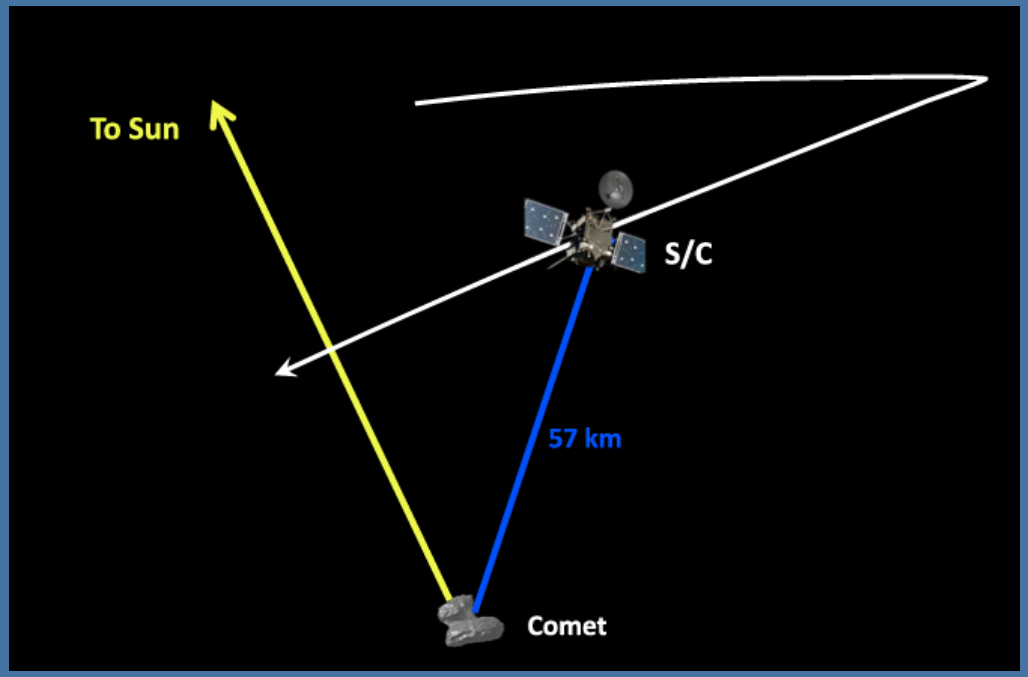


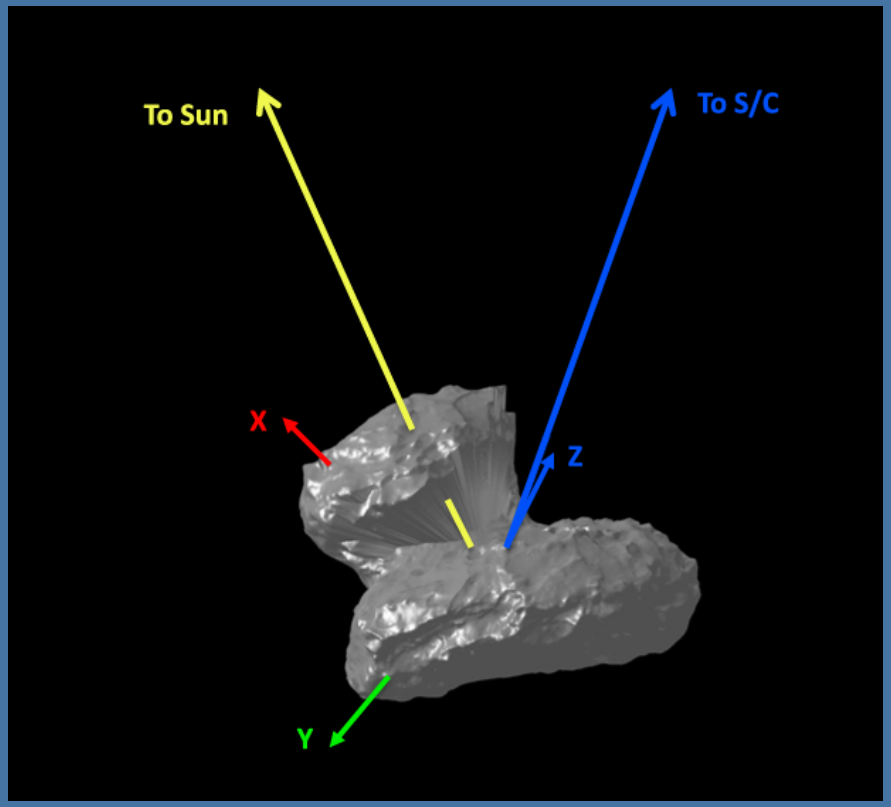
- Full day of data on April 19, 2015
- Look angle corresponding to red area in contour plot

- Pickup of cometary ions into shell distribution
- Magnetic field estimated into page



Charged Nanograins

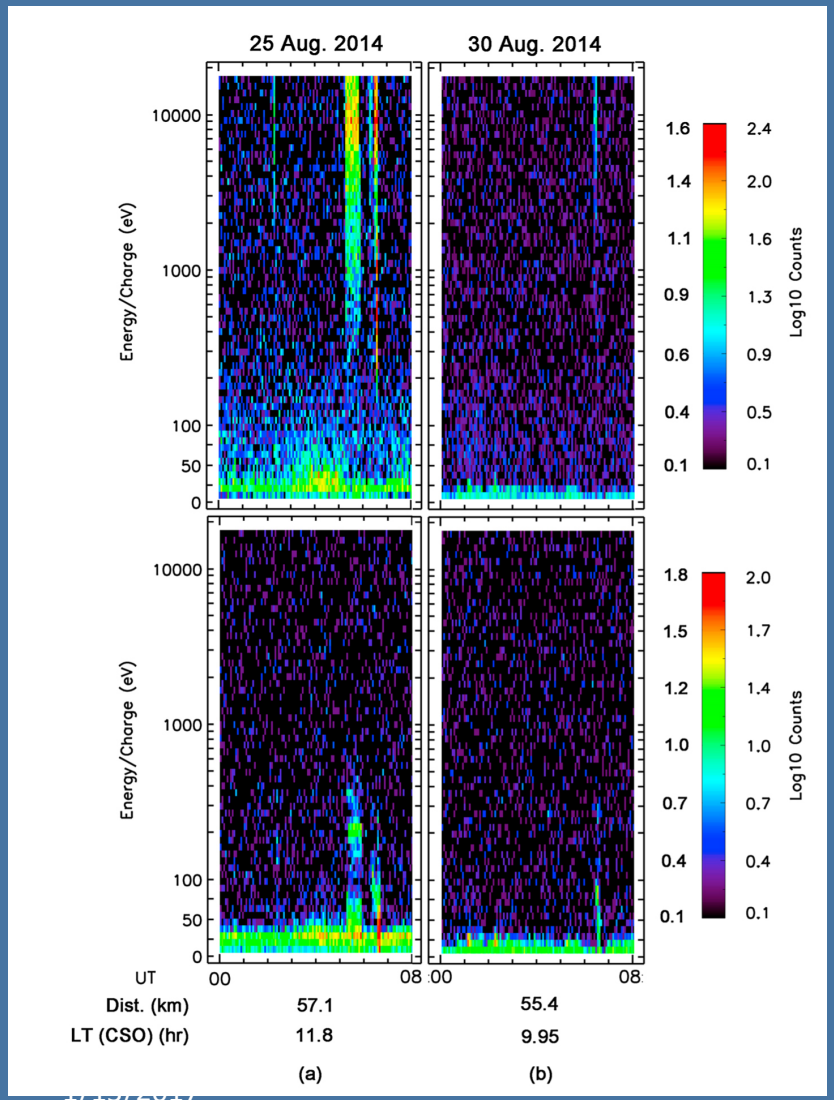


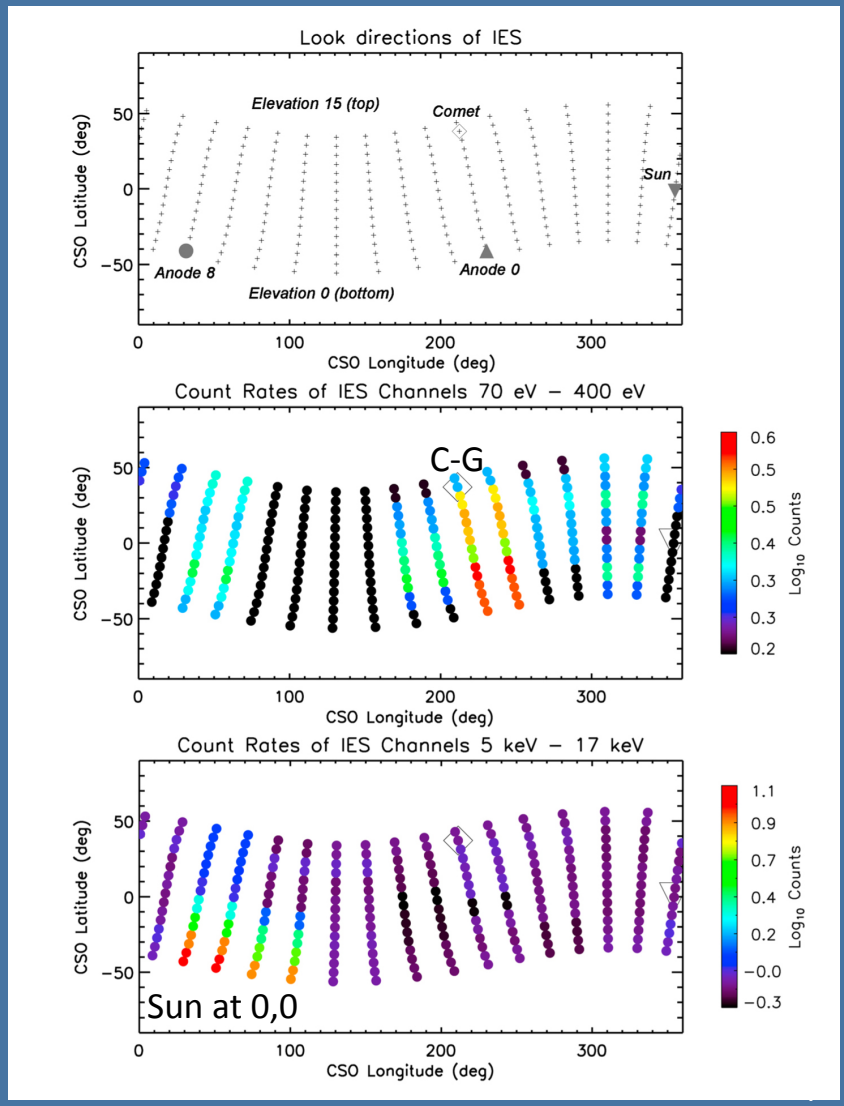


Burch et al. [2015]

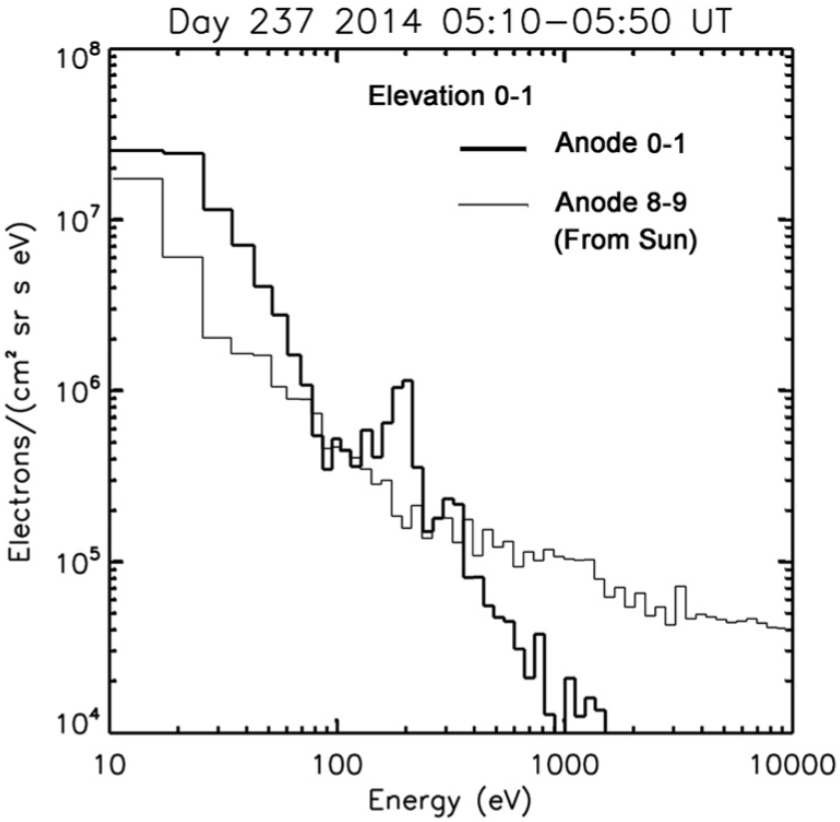
Nanograins

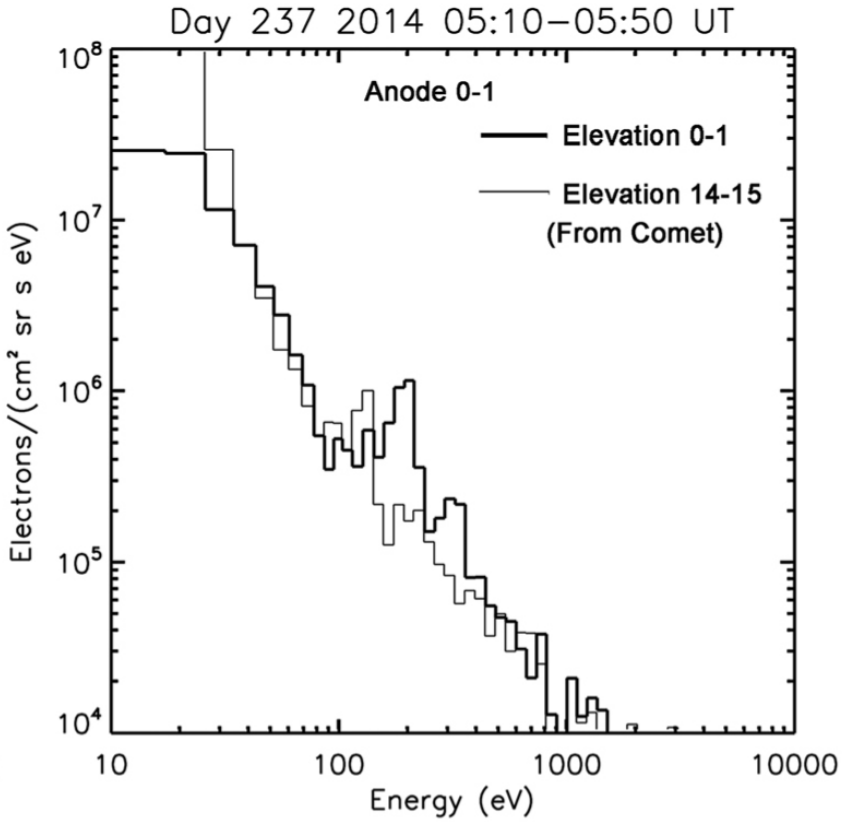
Low energy nanograins come from the comet, high energies from the Sun





Nanograin Energy Spectra

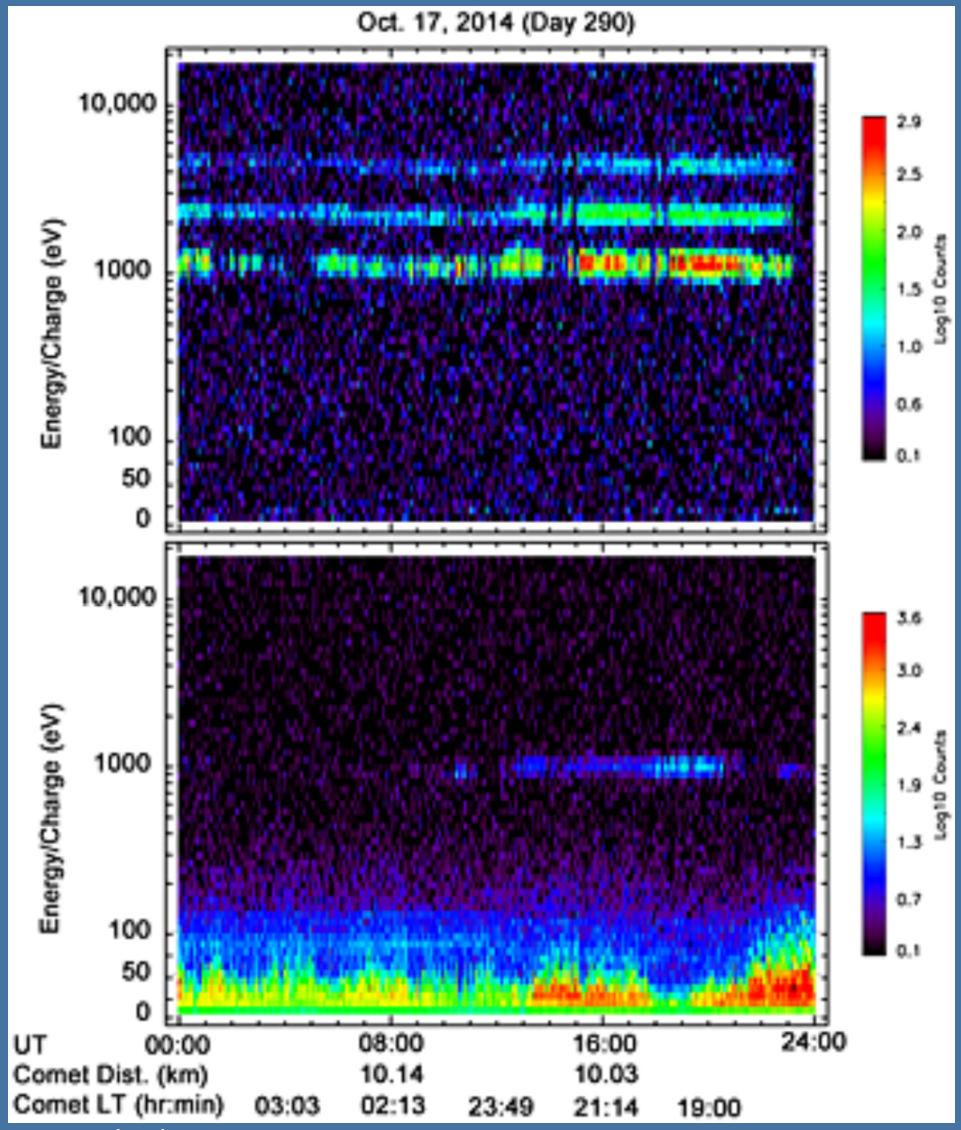


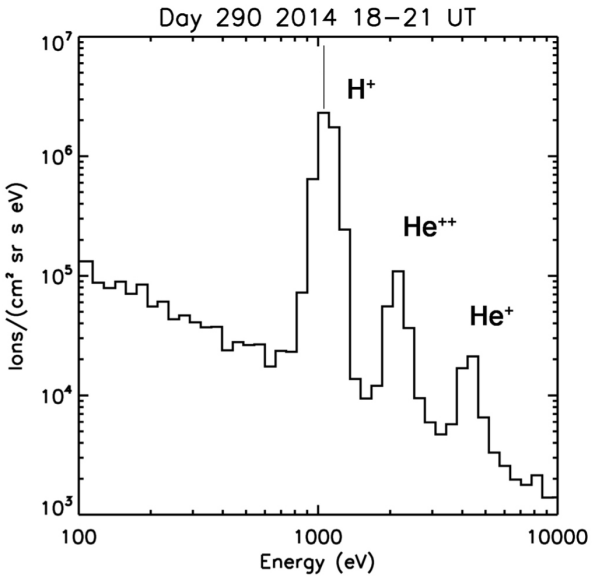


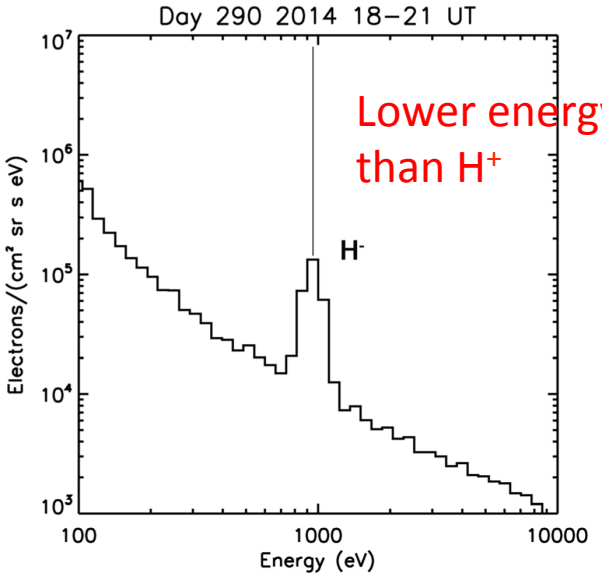
Light: Peak flux from Sun's long.
Dark: Peak flux from comet long.

Light: Peak flux from comet long. and lat.
Dark: Peak flux from comet long. Double peaks possibly from different masses or charge states with constant velocity. Energy shift from solar wind E field.

Negative Hydrogen in Solar Wind







Lower energy than H^+

Mass Spectra and Neutral Density

Double charge exchange needed for H^{-}:

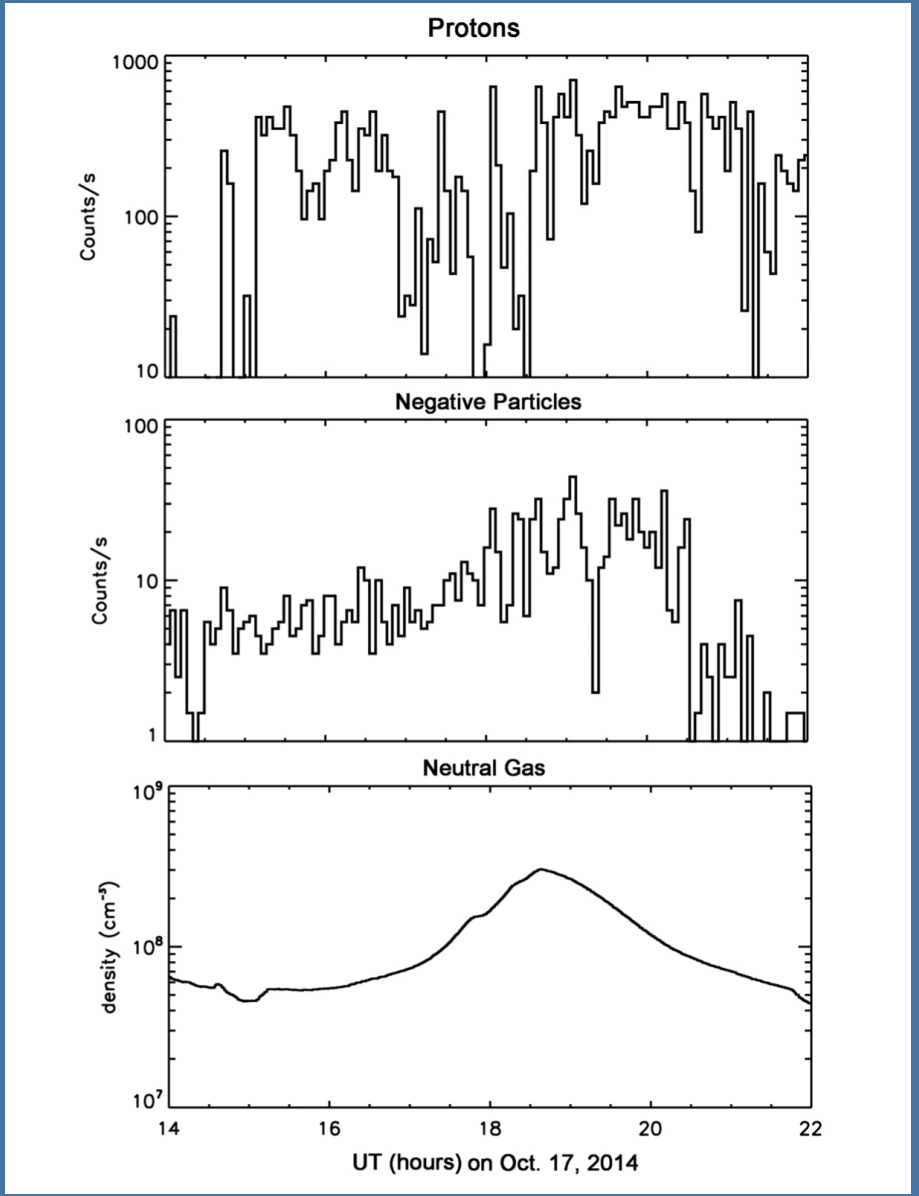
$H^{+} + M \longrightarrow H + M^{+}$

$H + M \longrightarrow H^{-} + M^{+}$

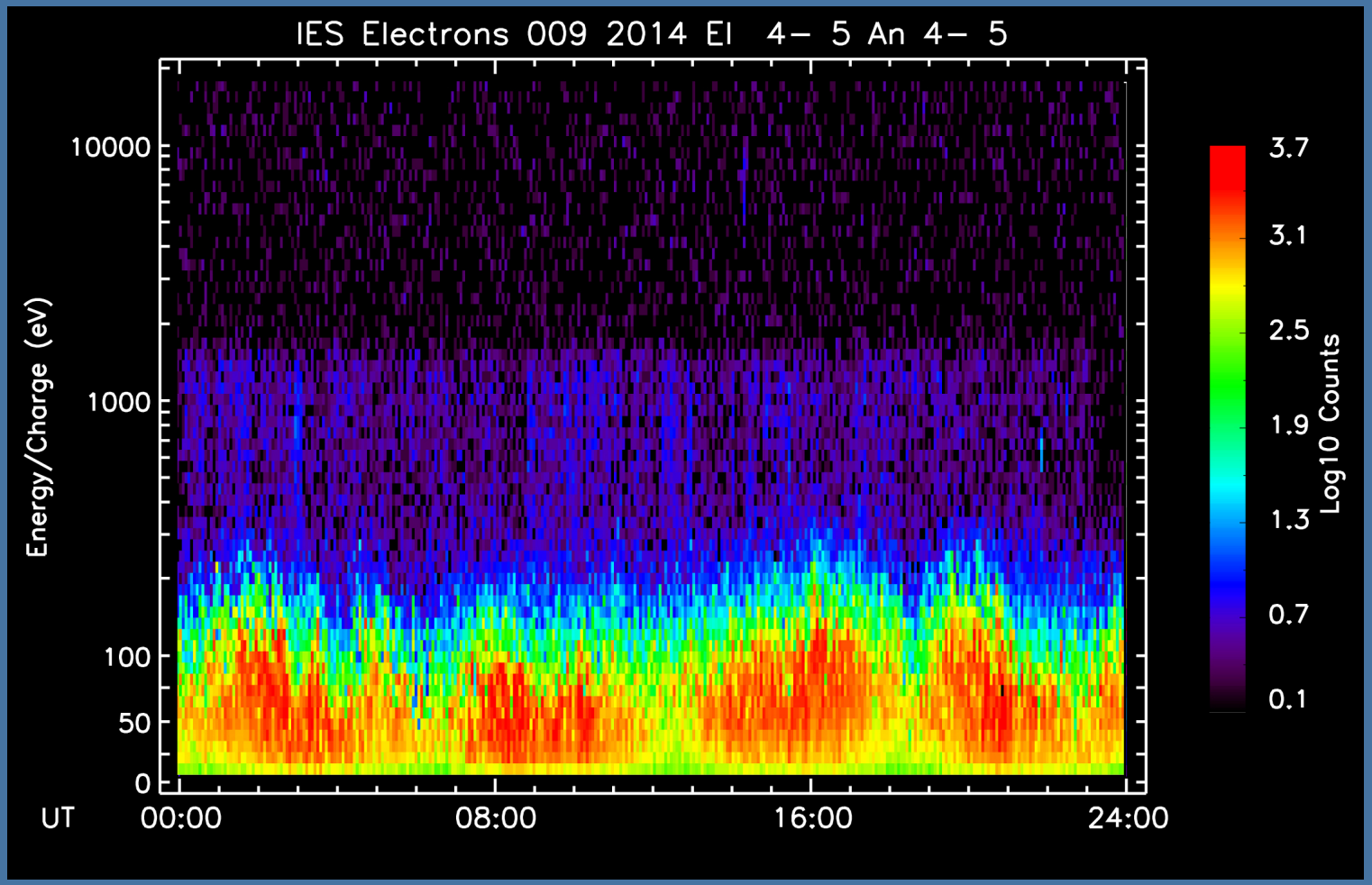
$(M \longrightarrow H_2O, CO_2, OH, \text{etc.})$

Total energy deficit of about 70 eV as observed.

Burch et al. [2015]

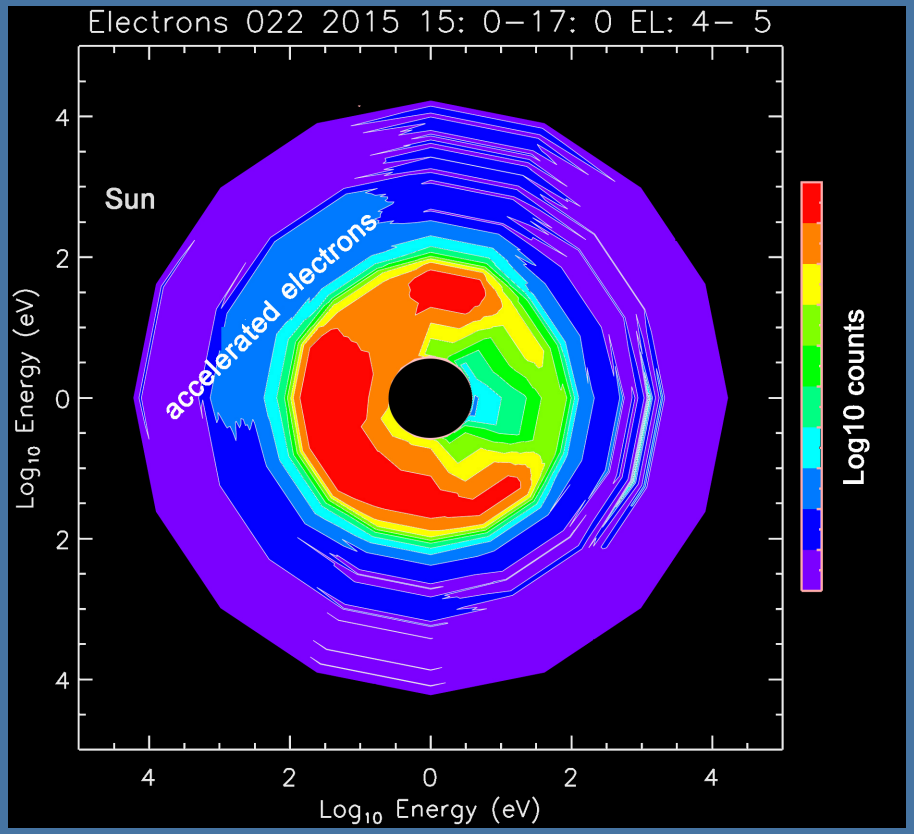


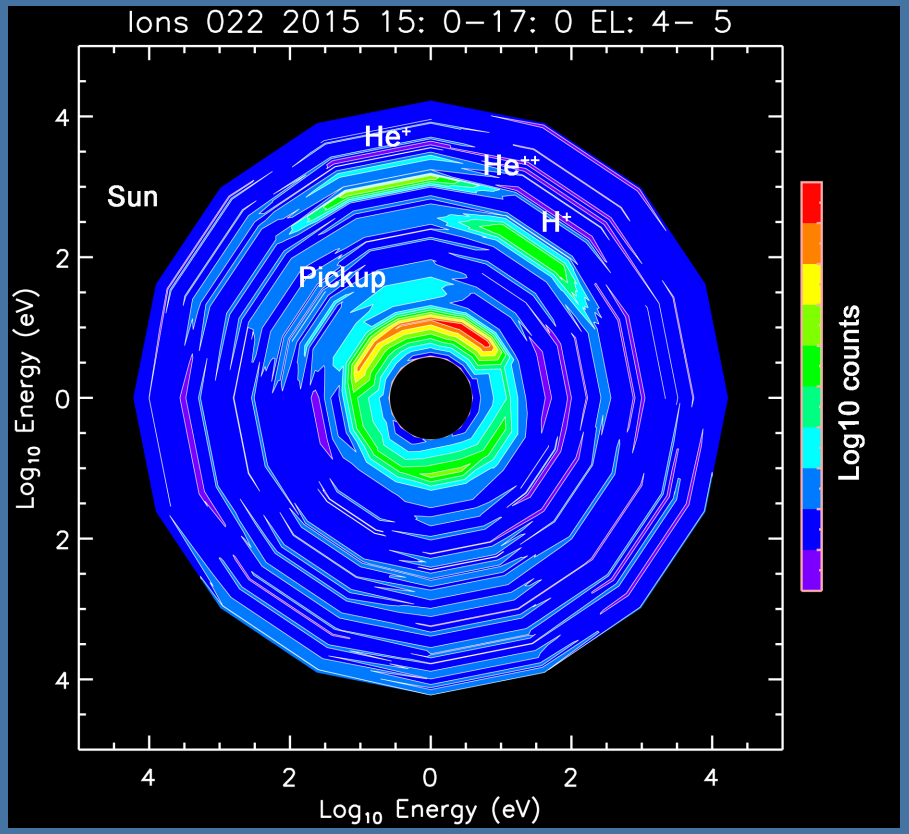
Electron Acceleration



- Electrons accelerated to a cutoff energy up to a few keV. Periodic pattern of low-energy electrons is caused by comet rotation.
- 2.5 AU from Sun, ~30 km from Comet.

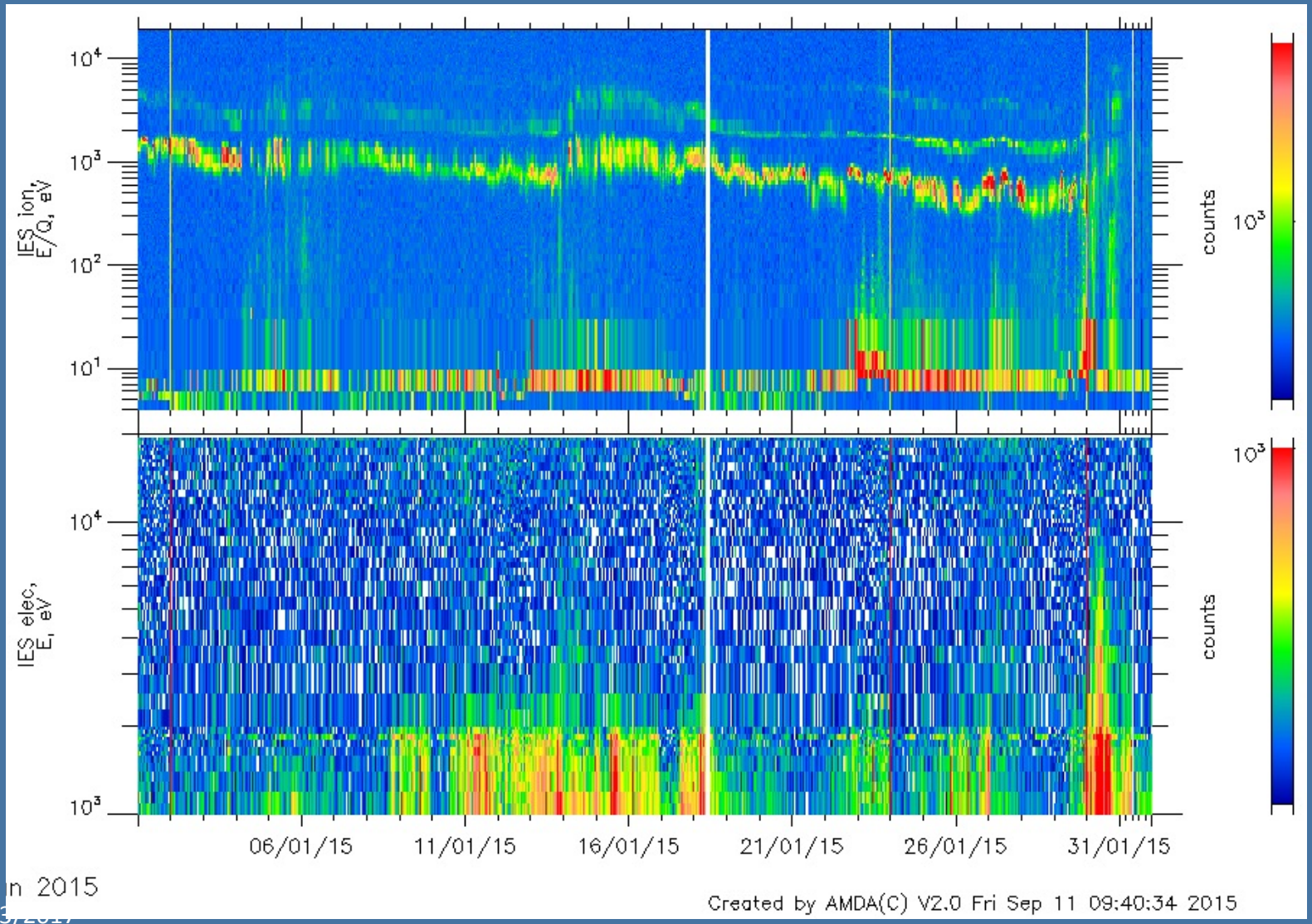
Electron Acceleration



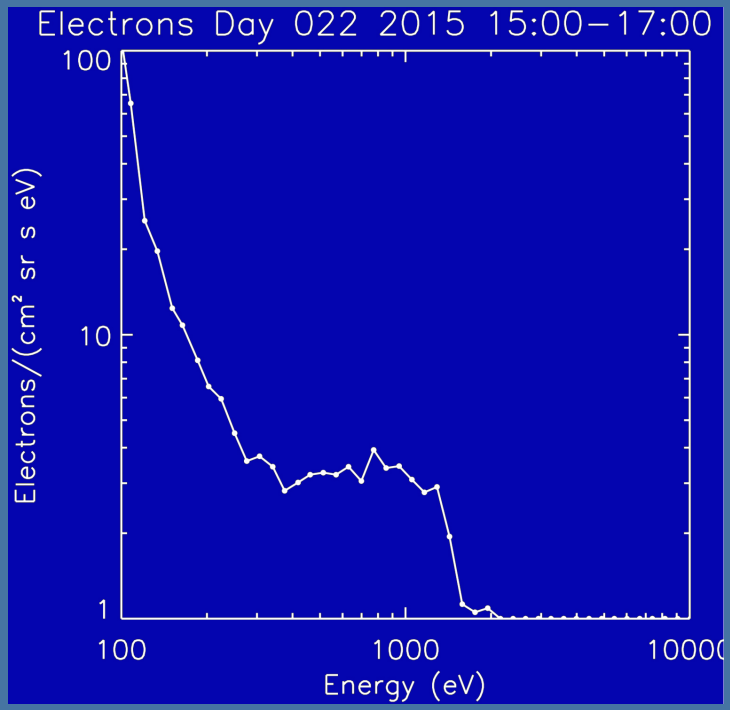


Electrons accelerated to keV energies. Coming from the solar direction. Observed continuously during most of January 2015 and returned in December 2015.

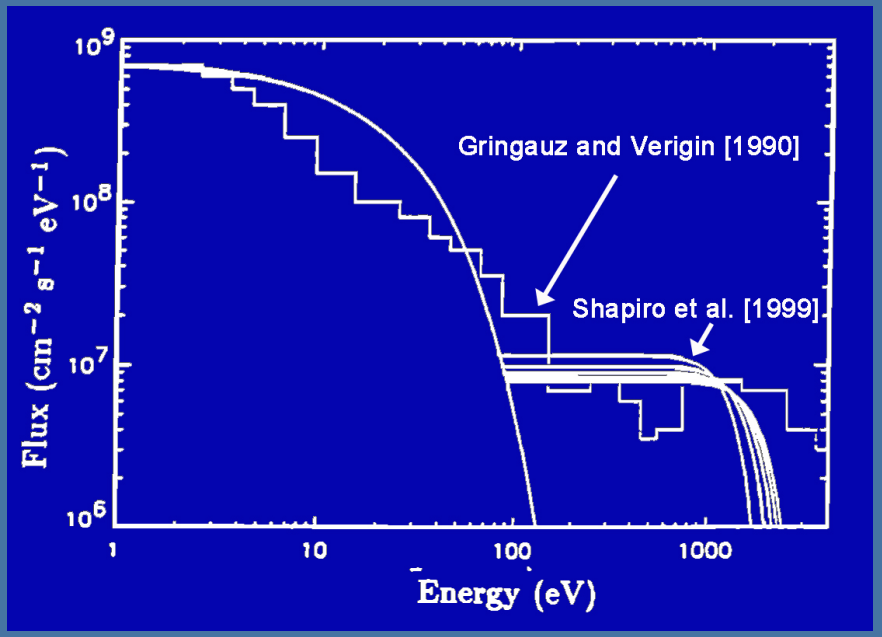
January 1015 IES Ions and KeV Electrons



Observed by Giotto



IES near comet,
no bow shock

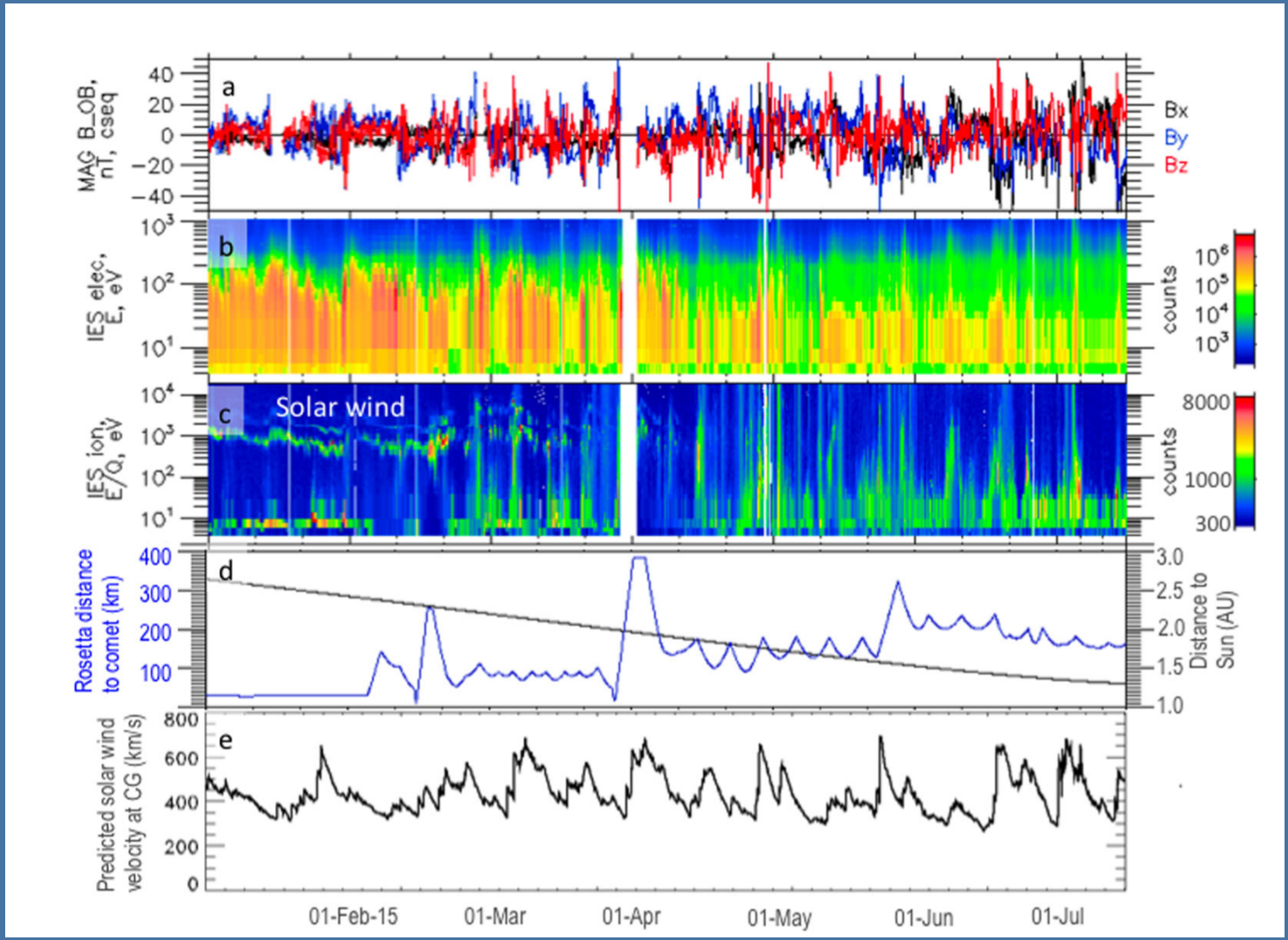


Giotto near
bow shock

Search for lower hybrid
waves inconclusive

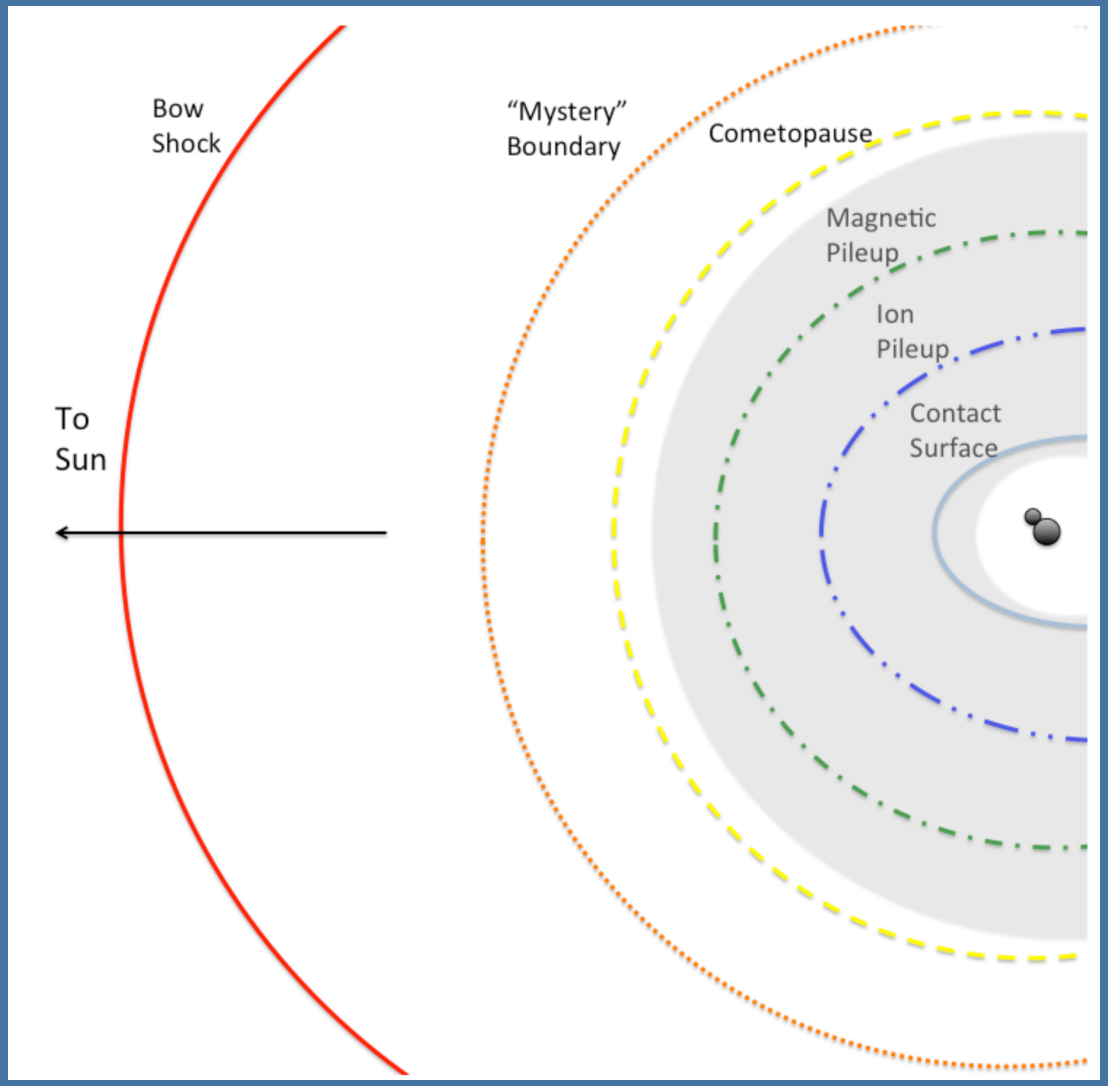
Shapiro et al. showed similar plateau caused by lower hybrid wave acceleration.

Evolution of Plasma and Magnetic Field toward Perihelion [Mandt et al., 2016]



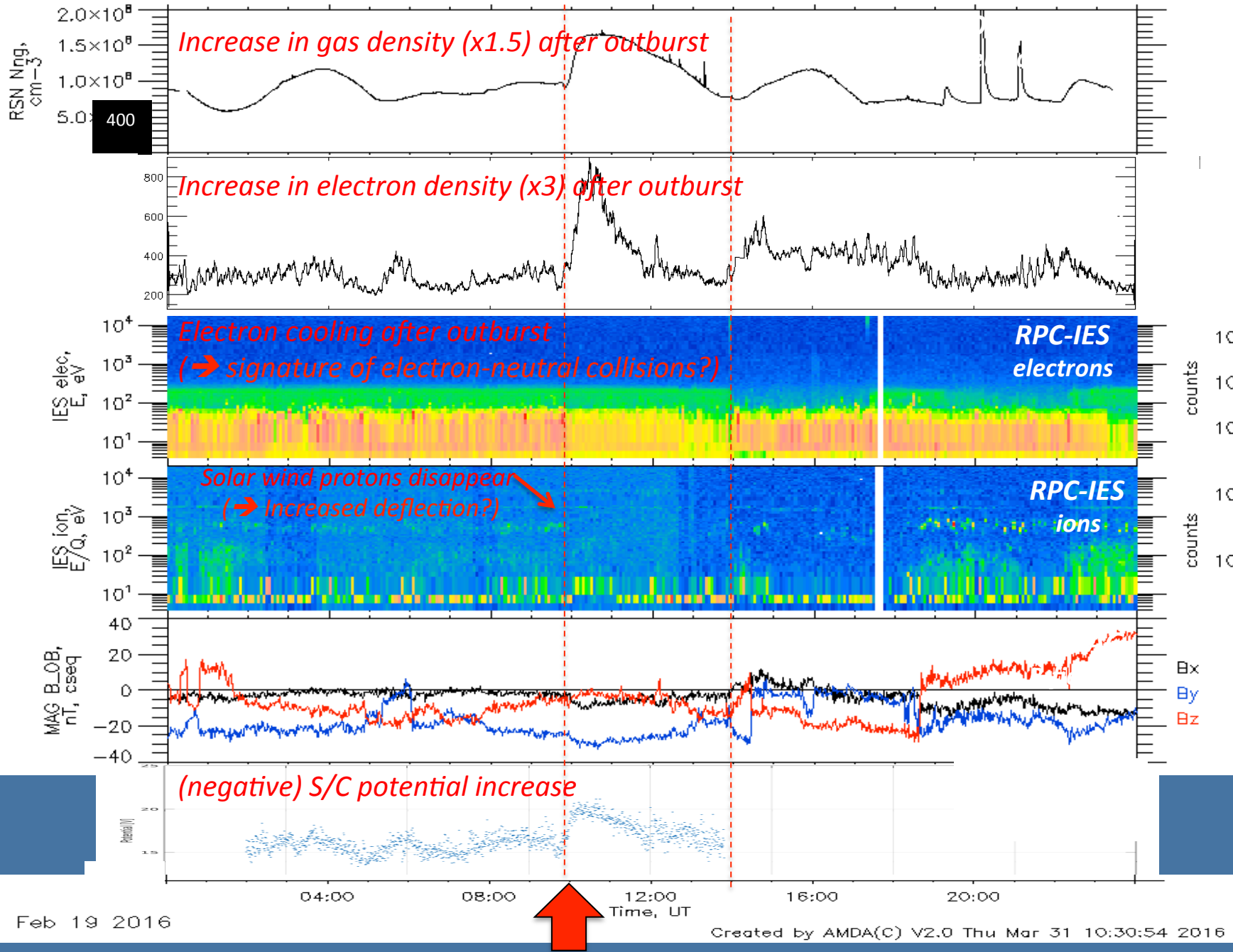
Solar Wind/Comet Boundaries

- Grey area shows region sampled by Rosetta when close to perihelion on May – Dec. 2015.
- Bow shock, mystery boundary (Giotto), and cometopause not observed by Rosetta.

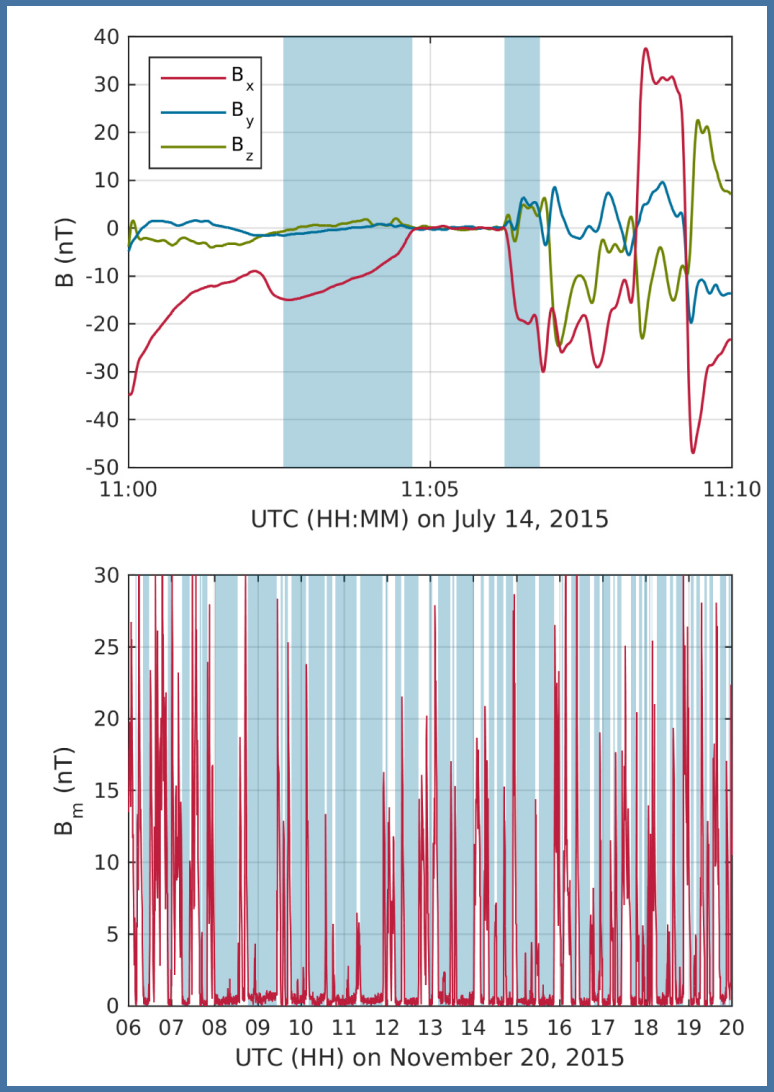


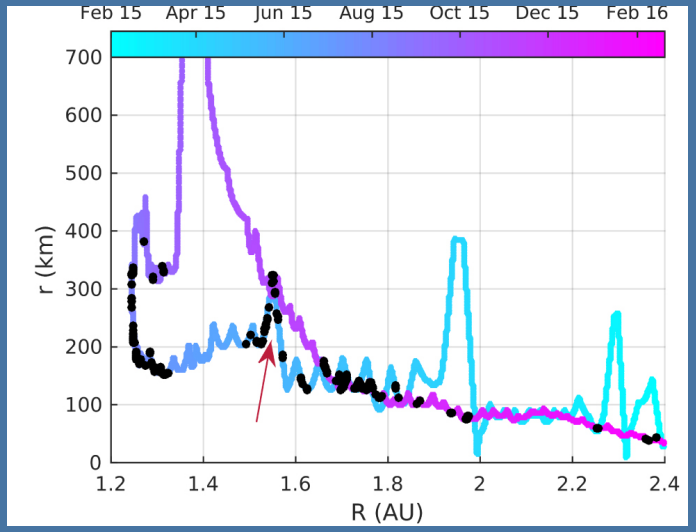
Mandt et al. [2016]

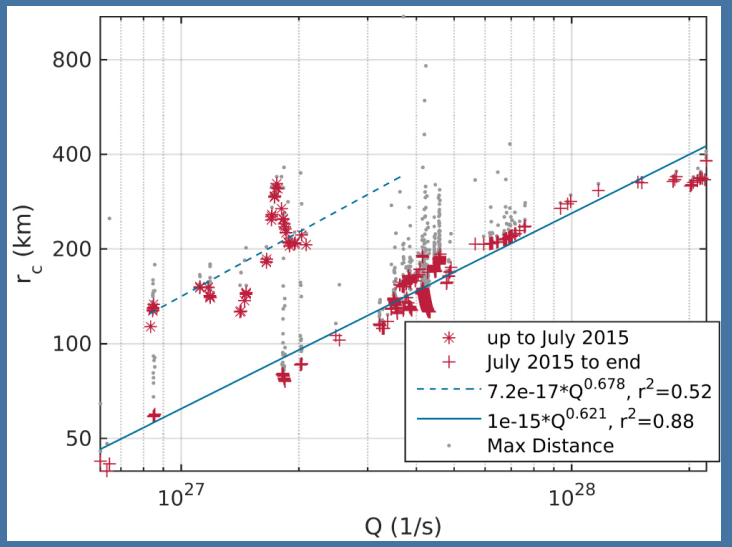
In the context of other RPC and COPS measurements



Diamagnetic Cavities

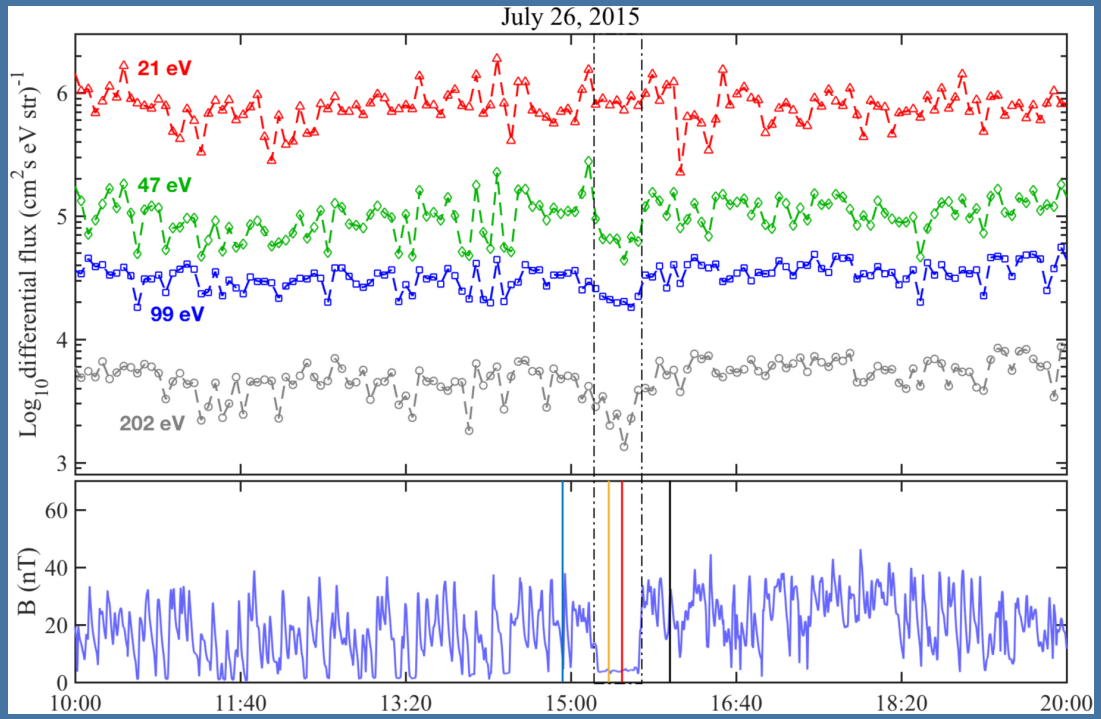




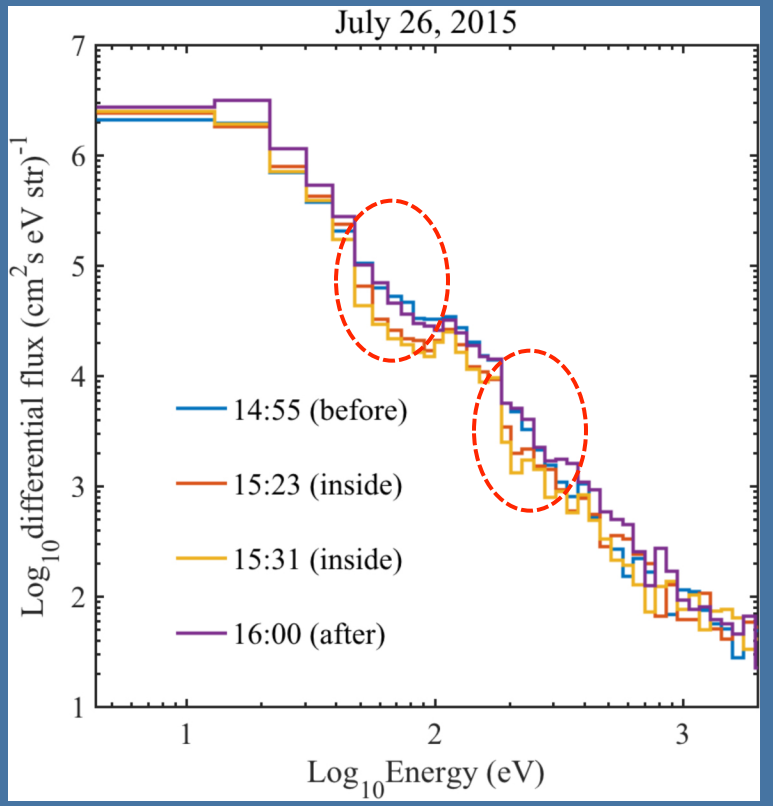


Gotz et al. [2016]

Electrons in Diamagnetic Cavity [Madanian et al., 2016]

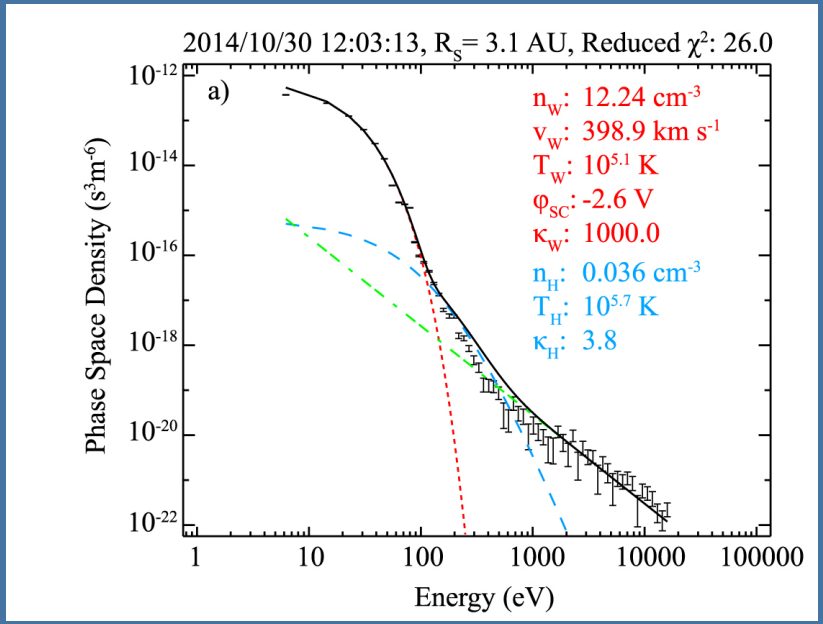


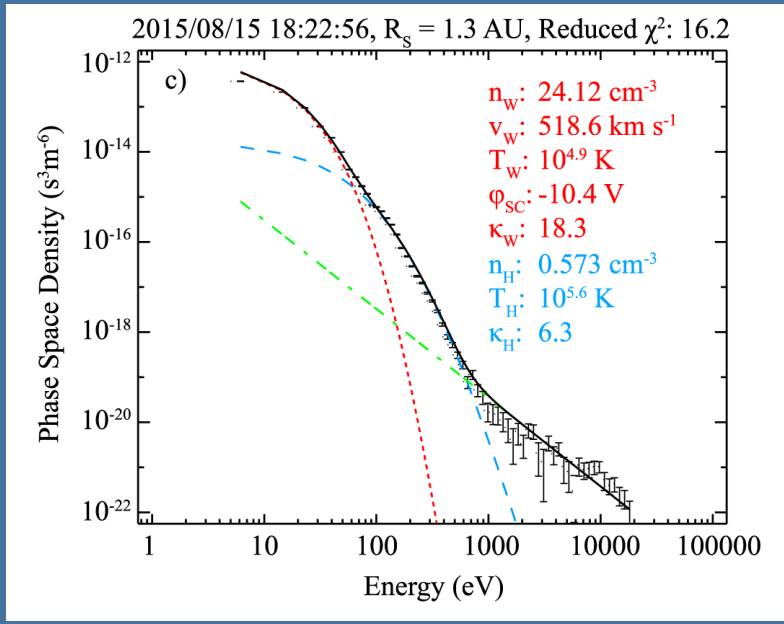
More noticeable drop at 60-90 eV and 150-250 eV ranges.



The flux of electrons from 40 eV to a few hundred eV decreases when Rosetta is in the magnetic field-free regions.

Electron Populations Fit with Two Kappa Distributions [Broiles et al., 2016]





At 3.1 AU there is a warm dense population (red) and a hot tenuous population (blue). The combination is fit well with Kappa distributions.

At 1.3 AU the warm dense population (red) is unchanged but the density of the hot tenuous population (blue) increases by more than 10x.

Suggestion is that the source of the warm dense population is cometary (photo/coma electrons) while the hot tenuous population is solar-wind halo.

Summary

- Rosetta stayed close to the comet from > 3 AU to perihelion (1.29 AU).
- At distances >2 AU IES observed solar wind and cometary nanograins, charge exchange producing He^+ and double charge exchange producing H^- within the solar-wind beam, and low-energy pickup ions.
- Inside ~2 AU IES observed higher energy pickup ions that deflected the solar wind away from the comet.
- Inside 2.4 AU Rosetta observed numerous diamagnetic cavities.