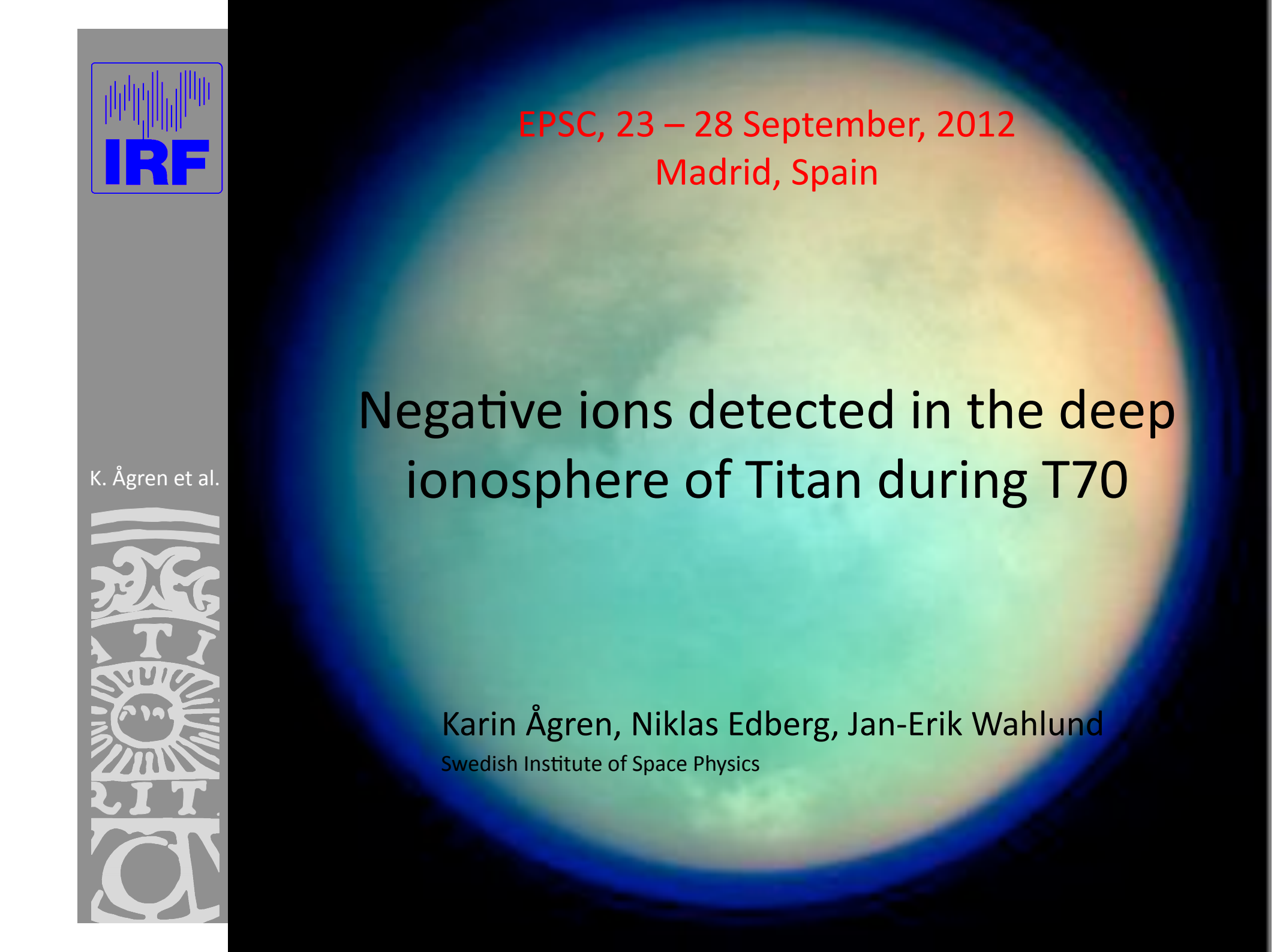

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Madrid, Spain

Negative ions detected in the deep ionosphere of Titan during T70

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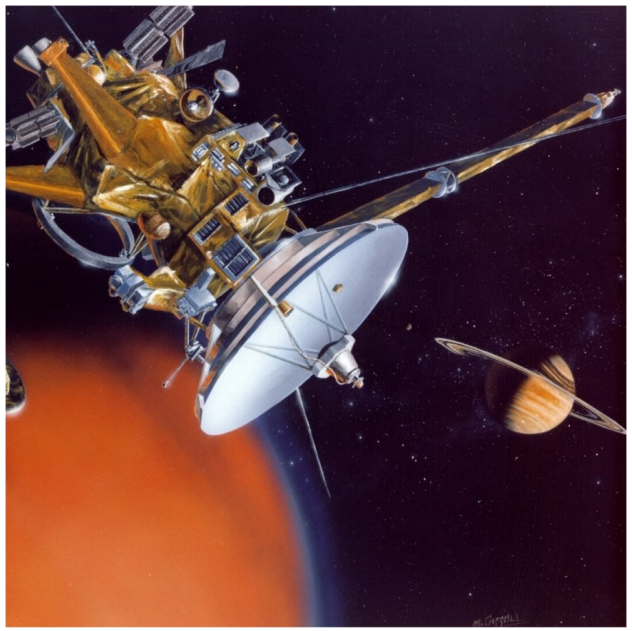
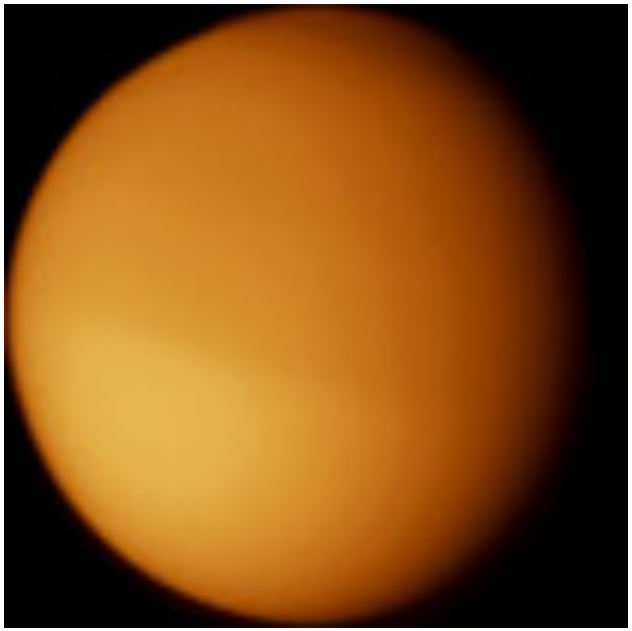
Outline

- Introduction
  - Titan's ionosphere
  - Langmuir probe (LP) theory
- T70 data analysis
  - Ion current
- Results





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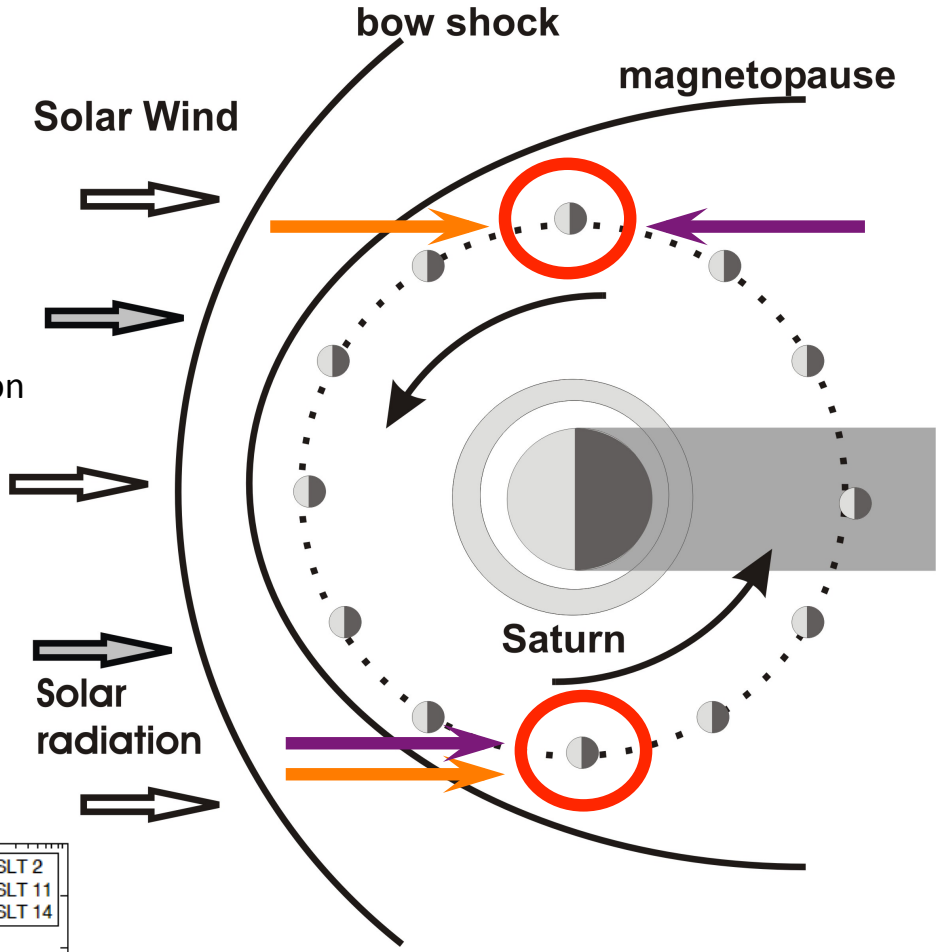
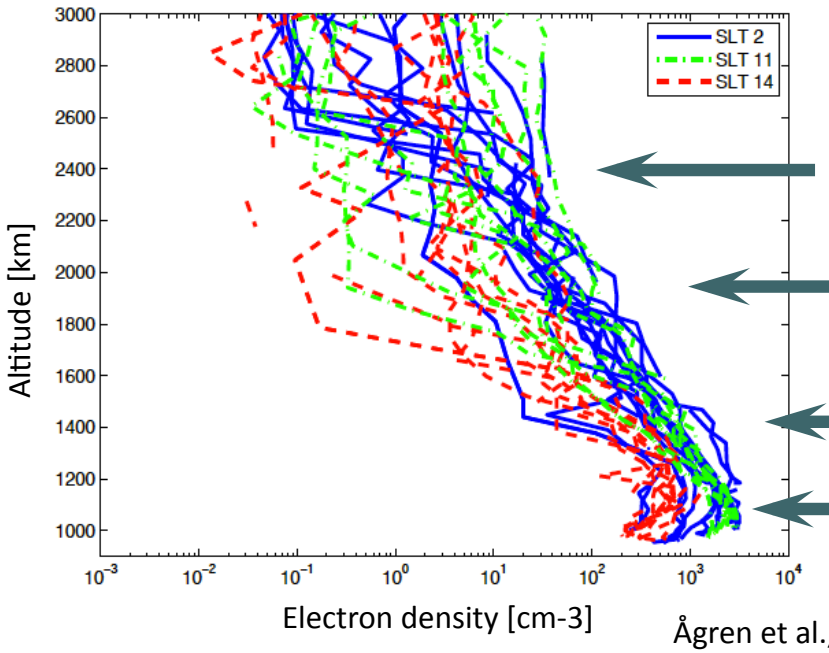
Two main ionisation sources

- Ionisation by solar radiation
- Magnetospheric impact ionisation

The ionisation is dependent on

- Solar zenith angle (SZA)
- Saturn local time (SLT)





Saturn's magnetosphere

Exo-ionosphere

Exobase

Ionospheric peak

Ågren et al., 2009

Flyby T70

- C/A at 880 km (deepest planned flyby)
- Latitude 82 degrees N
- SZA 81 degrees
- LP data available

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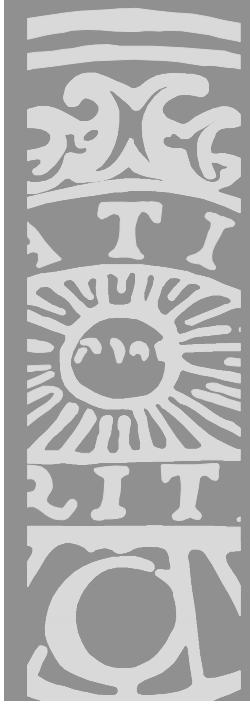

CAPS/ELS

Negative ions are detected during all deep flybys where the ELS field-of-view passes through the ram direction

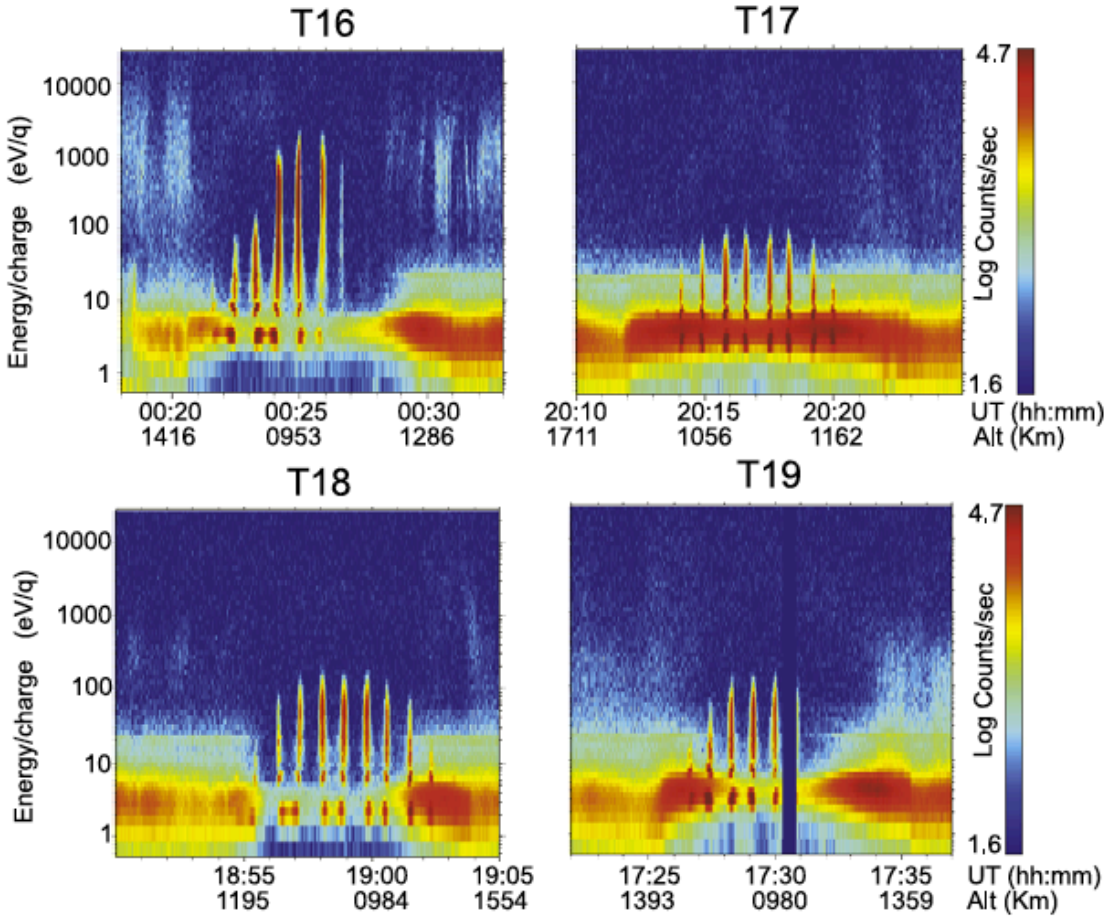

Figure 2. Energy-time spectrograms for 15 minute intervals centred on the T16-19 encounters. Negative ions can be seen in each case.

Coates et al., 2007

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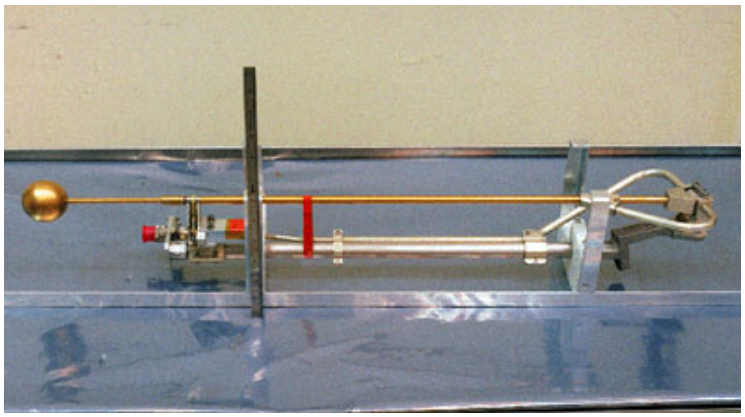
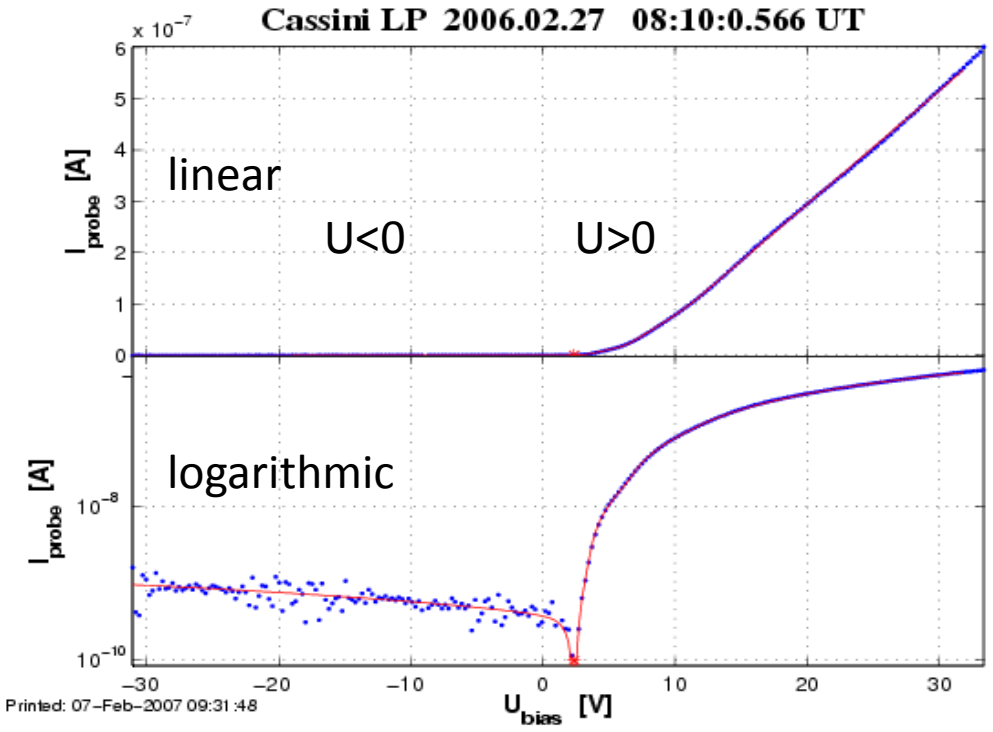
Instrumentation



Langmuir probe

swept in bias ->
measures the total current

$$I = I_e + I_i$$



Current-voltage characteristic

U<0

Ion current dominant

U>0

Electron current dominant

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LP measurements

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$U < 0$

Ion current dominant

$$I_e = I_{e0}\exp(+\chi_e) <<$$

$$I_i = I_{i0}(1-\chi_i)$$

$U > 0$

e^- current dominant

$$I_e = I_{e0}(1-\chi_e)$$

$$I_i = I_{i0}\exp(-\chi_i) <<$$

Flow kinetic energy term

$$I_{x0} = -A_{LP} n_x q_x \sqrt{\frac{v_x^2}{16} + \frac{k_B T_x}{2\pi m_x}}$$

$$I_{e0} = -A_{LP} n_e q_e \sqrt{\frac{k_B T_e}{2\pi m_e}}$$

Thermal energy term

$$\chi_x = \frac{eU}{\frac{m_x v_x^2}{2} + k_B T_x}$$

$$\chi_e = \frac{eU}{k_B T_e}$$

Negative ion current

A negative ion current behaves as a current of heavy electrons

$U < 0$

Ion current dominant

$$I_e = I_{e0}\exp(+\chi_e) <<$$

$$I_i = I_{i0}(1-\chi_i)$$

$$I_{x0} = -A_{LP} n_x q_x \sqrt{\frac{v_x^2}{16} + \frac{k_B T_x}{2\pi m_x}}$$

$$\chi_i = \frac{eU}{\frac{m_i v_i^2}{2} + k_B T_i}$$

$U > 0$

Electron current dominant

$$I_e = I_{e0}(1-\chi_e)$$

$$I_i = I_{i0}\exp(-\chi_i) <<$$

$$I_{i-} = -A_{LP} n_{i-} q_{i-} \sqrt{\frac{v_{i-}^2}{16}} \exp\left(\frac{eU}{\frac{m_{i-} v_{i-}^2}{2}}\right) \rightarrow 1$$

$$A_{LP} = 4\pi r_{LP}^2$$

$$I_{i-} = +Z\pi r_{LP}^2 v_{i-} n_{i-}$$

The negative ion current will give a near constant contribution

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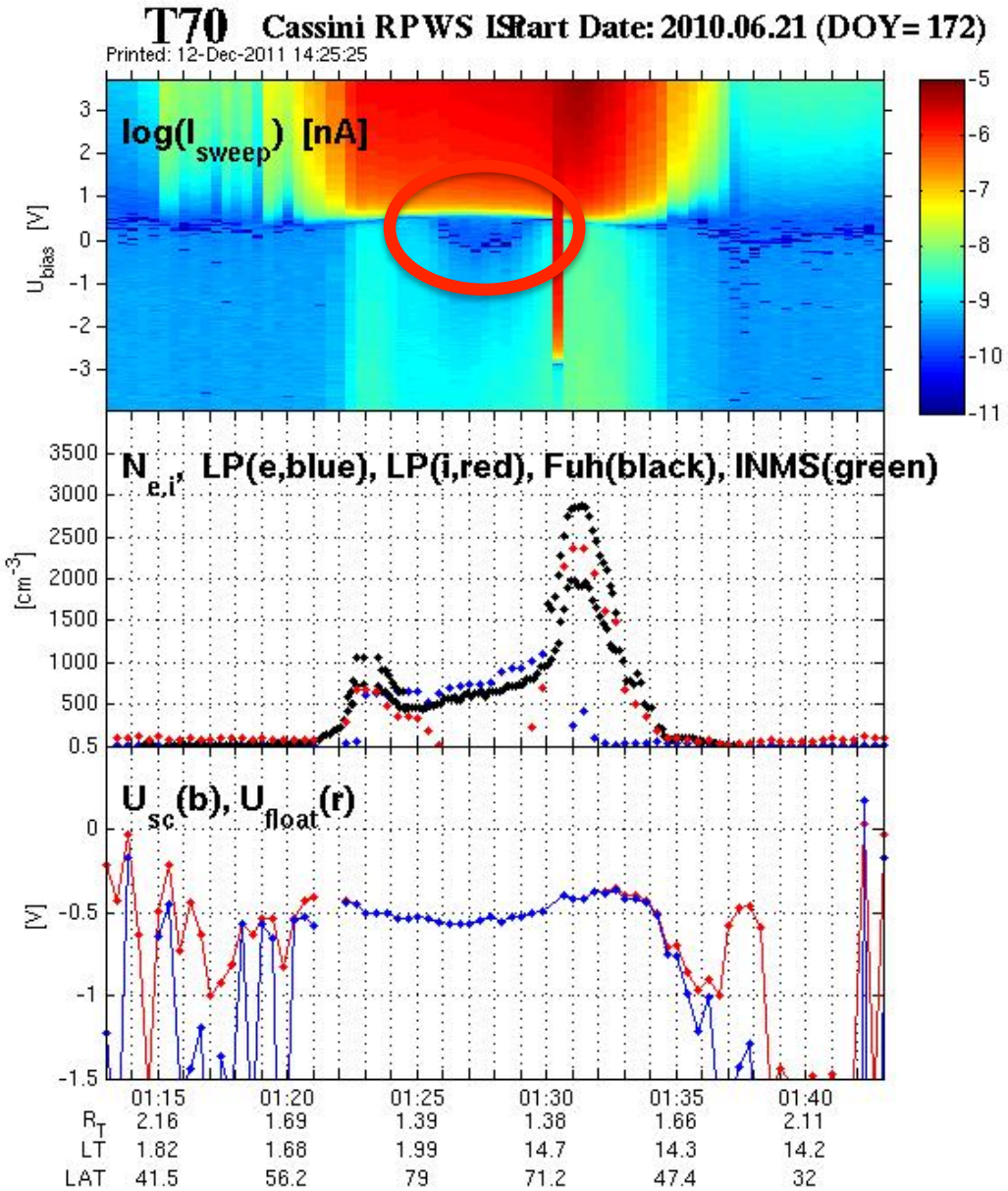
Heavy negative ions



Negative ions!

(Assuming a positively charged ion component in the analysis)

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Adding a negative ion component to the analysis opens up for many possible fits to the data depending on the choice of

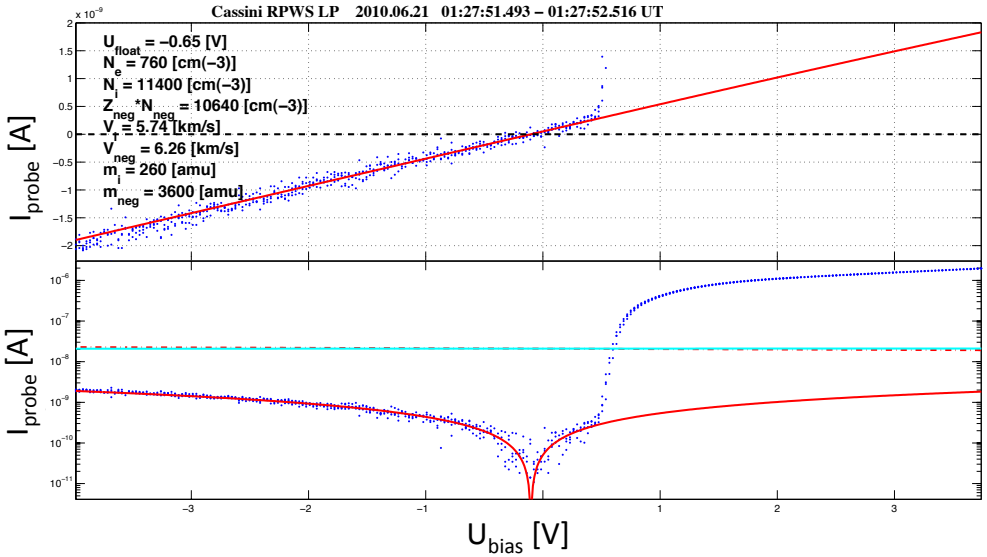
- Densities
- Relative speeds

Two good fits to the data either resulting in a high negative ion density (a), or high drift velocities of the ions (b)

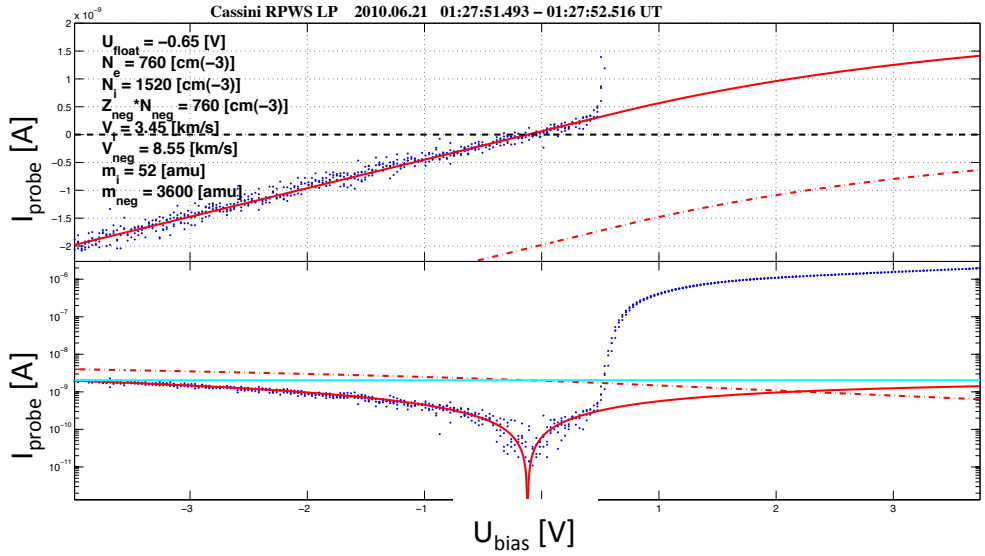
No agreement can be achieved without the addition of a negative ion population

Results

a)



b)



Conclusions

- Our measurements confirm the detection of heavy negative ions by CAPS/ELS

- The negative ion density in this region is at least comparable to the electron density
- The relative velocity of the ions is around – or higher than - a few hundred m/s
- More investigations are needed to put tighter constrains on the density and velocity of the ions

- Nevertheless; our measurements cannot be explained without the addition of a negative ion population

A substantial amount of negative ions is found in Titan's deep ionosphere during T70

Ågren et al., GRL, 2012

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