The Canadian Electric Field Instruments on Swarm

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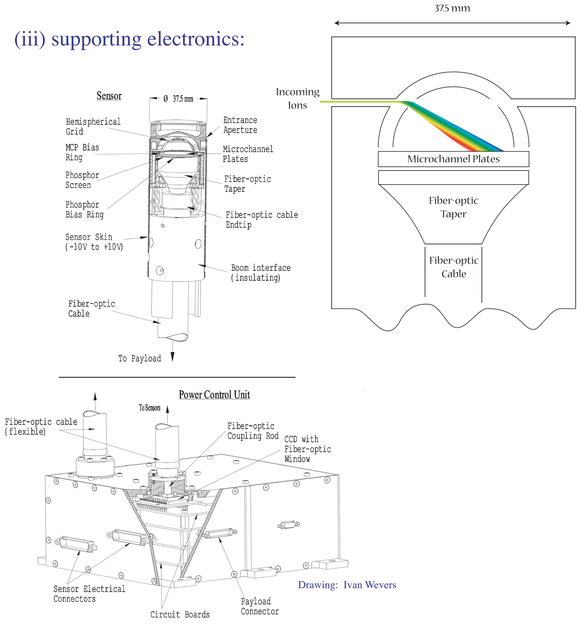
Heritage

The Suprathermal Ion Imager (SII) is comprised of:

(i) a hemispherical electrostatic analyzer that forms 2-D maps of low-energy ion distribution functions [*Whalen et al.*, 1994],

(ii) a high-resolution CCD-based detector with a resolution of up to 256x256 pixels [*Knudsen et al.*, 2003],

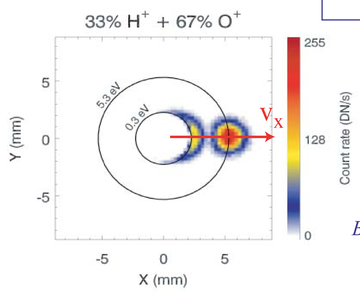
(iii) supporting electronics:



At orbital velocity, H^+ and O^+ ion distributions are separated by their ram kinetic energies:

$$E(r)/q = -\Phi_{sensor} + (m_i/2)v_x^2$$

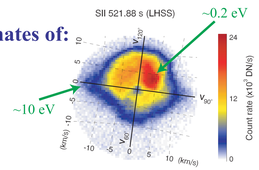
$$E(r)/q \sim Cr^{1.8}$$



Burchill [2003]

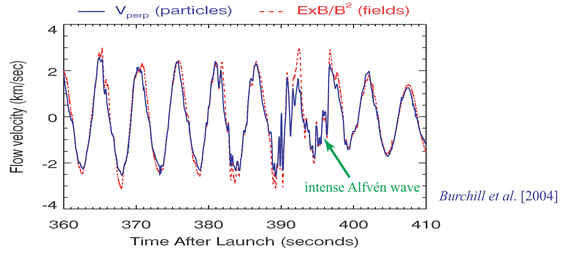
SII images allow estimates of:

- ion drift velocity $\mathbf{v}_i$
- ion temperature T_i
- ion density n_i
- anisotropies
- sensor-to-plasma potential $\Phi_{s/c}$ } using two ion species
- composition ratio



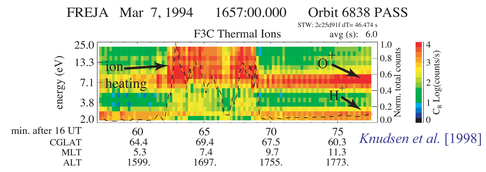
Sub-orbital example (GEODESIC) *Burchill et al.* [2004]

Velocity/electric field comparison (sub-orbital):



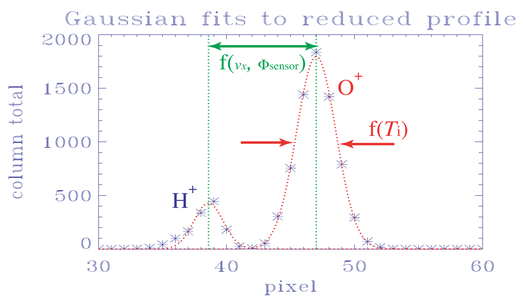
Burchill et al. [2004]

Orbital example: Freja Cold Plasma Analyzer



Knudsen et al. [1998]

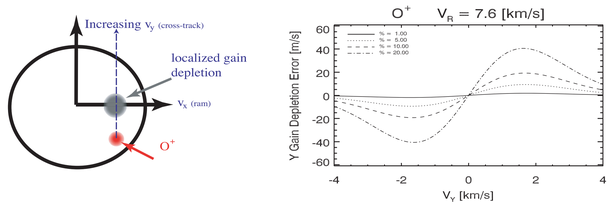
Data reduction, radial/ram direction, orbital velocity:



The relations between ion signal position, bulk velocity, and sensor potential, and between ion signal width and ion temperature are determined through forward modeling using a Monte Carlo simulation and trajectory tracing through an electrostatic model of the sensor.

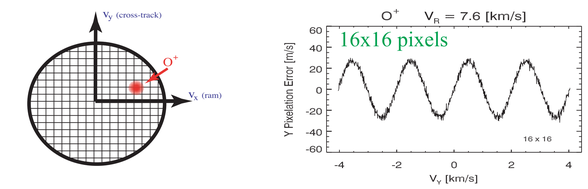
Error Analysis

Velocity errors arising from non-uniform detector gain:



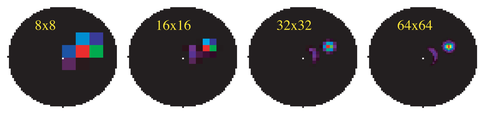
Above: Fitted cross-track velocity error as the SII O^+ signal passes over a Gaussian-shaped gain depletion. v_x = 7.6 km/s, T_i = 0.1 eV.

Velocity errors arising from detector pixellation:

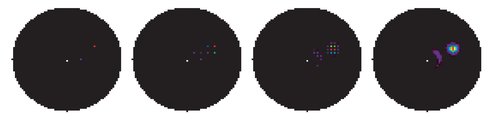


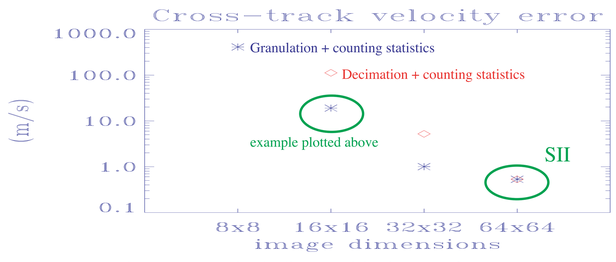
Above: Fitted cross-track velocity error as the SII O^+ signal passes over a 16x16 pixel detector array. v_x = 7.6 km/s, T_i = 0.1 eV.

Effect of pixel size:



Effect of decimation:



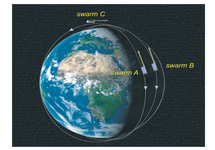


Above: Total r.m.s. error including statitical errors from particle counting for O^+ ions with density 10^4 cm^{-3}, v_x = 7.6 km/s, and T_i = 0.1 eV. Integration time = 10 ms.

esa

Primary Science:

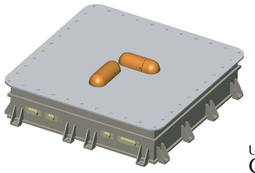
- Lithospheric magnetization
- 3-D electrical conductivity of the mantle
- **Magnetospheric and ionospheric current systems**



Mission:

- Flight: 2010-2014
- circular polar orbits
- 2 satellites at ~400 km, 10's km cross-track separation can measure full vertical component of $\nabla \times \mathbf{B}$
- 1 satellite at 530 km, 3-9 hours away in LT

Performance of the **Electric Field Instrument** (SII-based):



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Parameter	Resolution (2σ)	Accuracy (2σ)	Sample rate (Hz) Nominal (Max)
3-D ion drift	6 m/s	100 m/s	2 (16)
E = -v x B	0.3 mV/m	5 mV/m	2 (16)
T_i, T_e	1%	1%	0.08 (16)
ExH	1 μW/m2		2 (16)

REFERENCES

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