Fate of cold ions in the inner magnetosphere: energization and drift inferred from morphology and mass dependence

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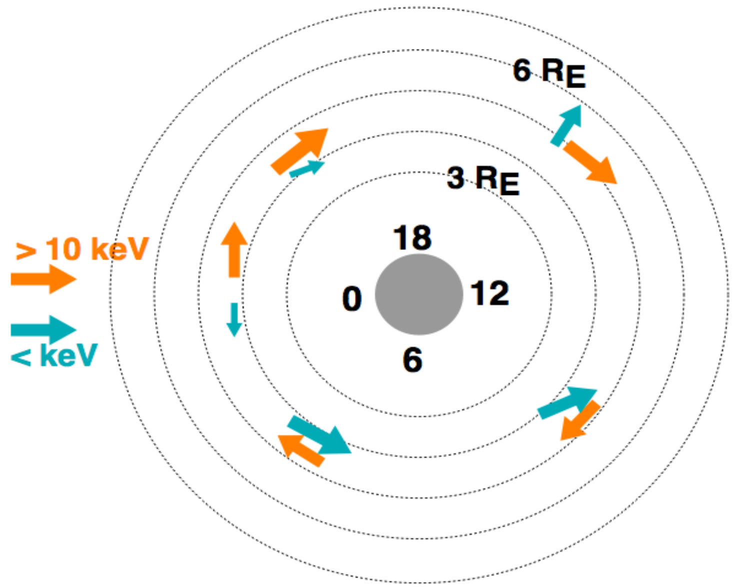
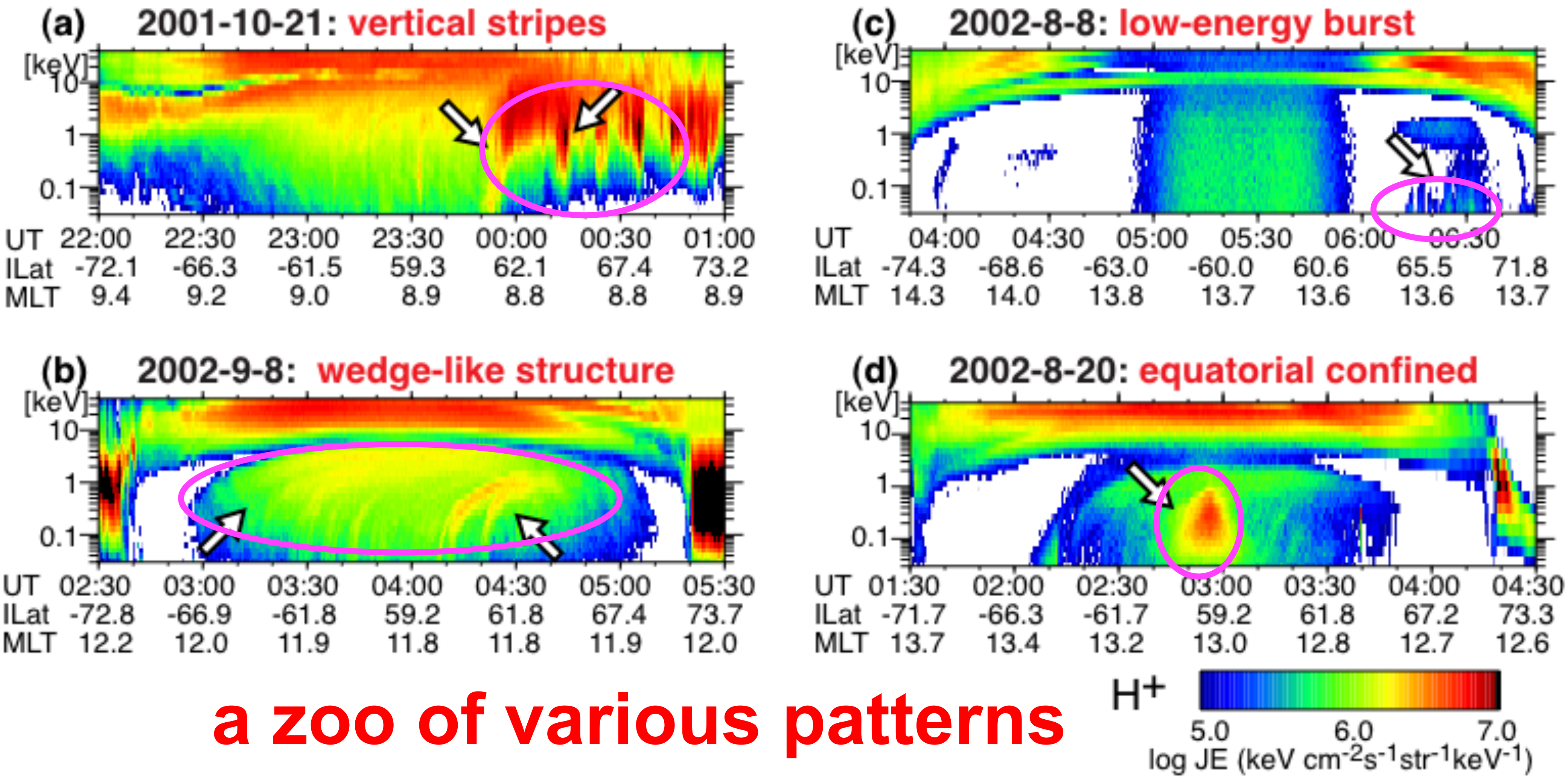


Geospace2014@Rhodos, 2014-9-17

Quick south-to-north scan of inner magnetospheric ions by Cluster 4

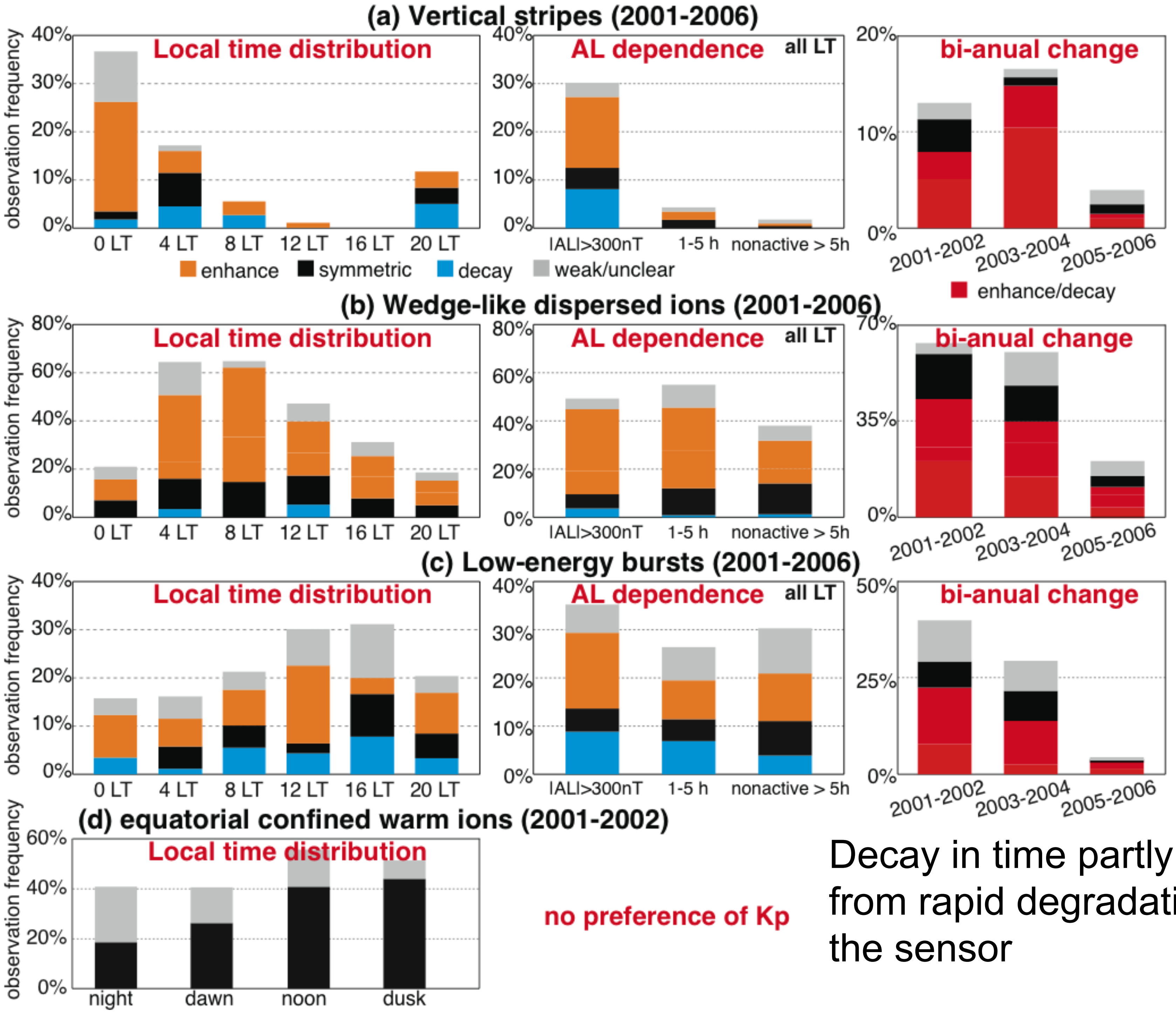
all patterns at 0.05-1 keV



a zoo of various patterns

North-south symmetry of trapped particle motion for fixed MLT
⇒ inbound-outbound asymmetry = temporal change of 1-2 hour

Cluster Statistics



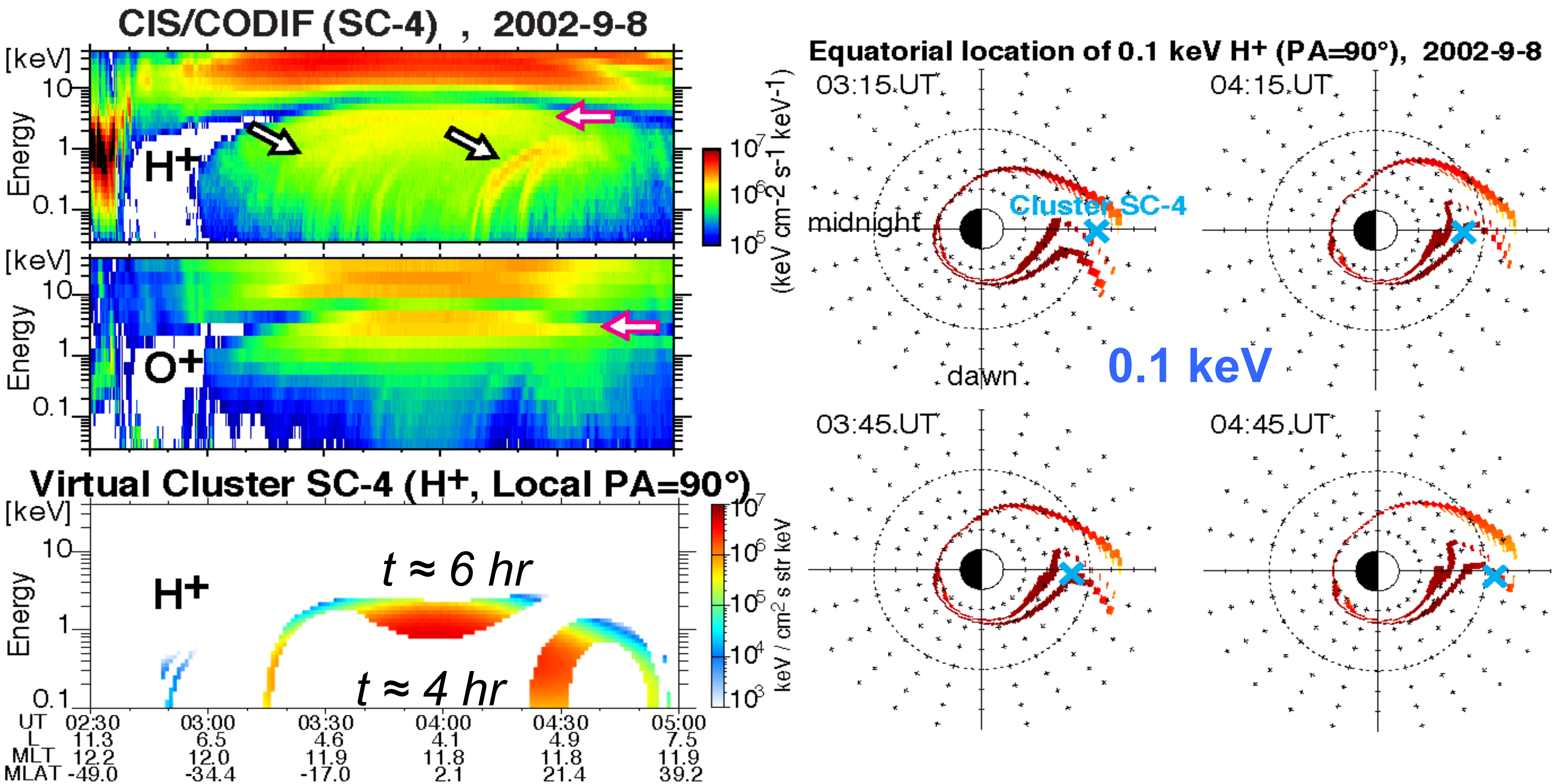
Decay in time partly came from rapid degradation of the sensor

(a) Vertical stripes: Nearly vertical in the spectrogram, extending from the about 10 keV to sub-keV (dispersion is very weak). Only found near midnight during substorms. Mostly inbound-outbound **asymmetric (life time~1h)**, indicating **substorm injection.**

(b) Wedge-like energy-latitude dispersed sub-keV ions: Stronger dispersion than (a), at slightly lower energy (up to few keV). Often found in the morning to noon sectors some hours after a substorm. Often inbound-outbound **asymmetric**, but can yet be **explained by ion drift (next figure) of <0.1 keV ion source.**

(c) Short bursts of low-energy ions: a peak energy flux less than 100 eV but not thermal. Found all local time without clear relation to geomagnetic activities. Often inbound-outbound **asymmetric (life time~1h)**, indicating **a local phenomena.**

(d) Warm trapped ions confined near equator: tens eV to a few hundred eV without dispersion. Found all local time without clear relation to geomagnetic activities. Comparison to different SC indicates **life time~1h**, indicating **a local phenomena.**



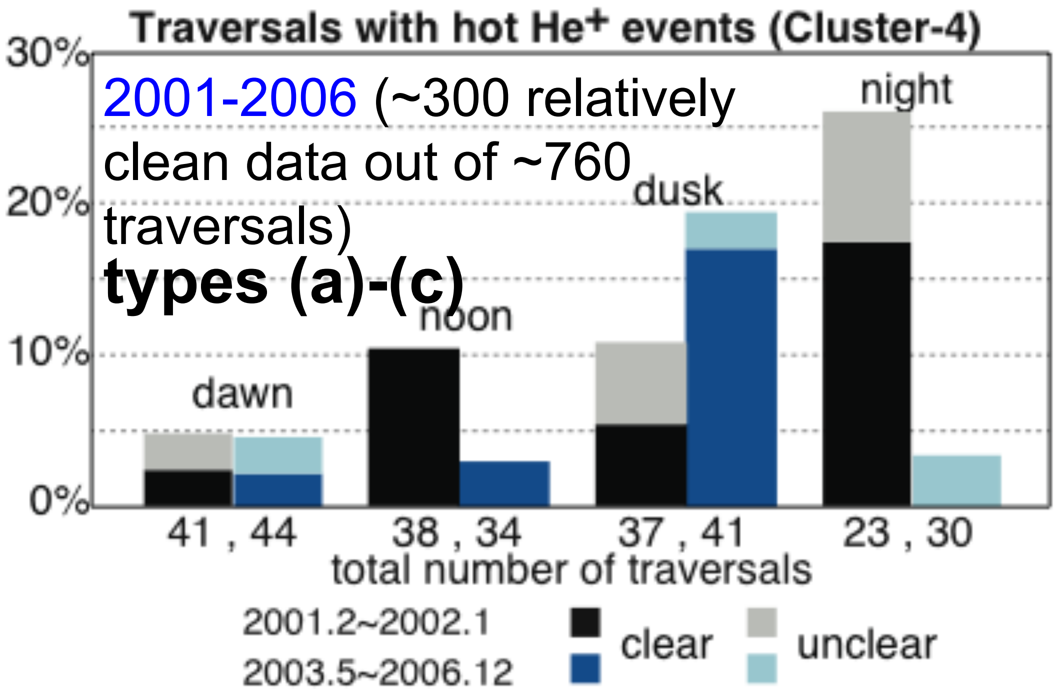
Comparison of observation and ion drift simulation.

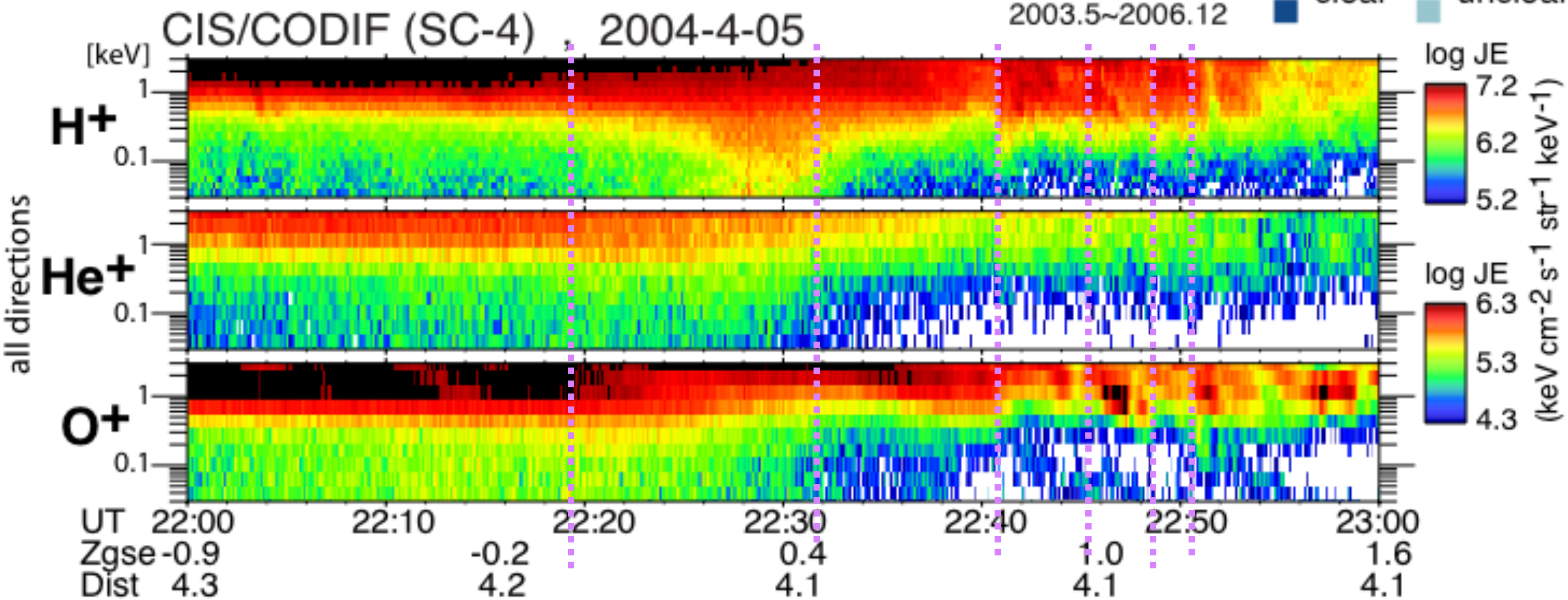
Cool source (<0.1 keV, but not cold) can cause wedge-like dispersed sub-keV ions with its inbound-outbound asymmetry even at noon, and hot source can cause ion band (keV). Due to different drift velocity, two population has different O/H ratio.

Next: O^+/H^+ and He^+/H^+ differences

(a) Vertical stripes

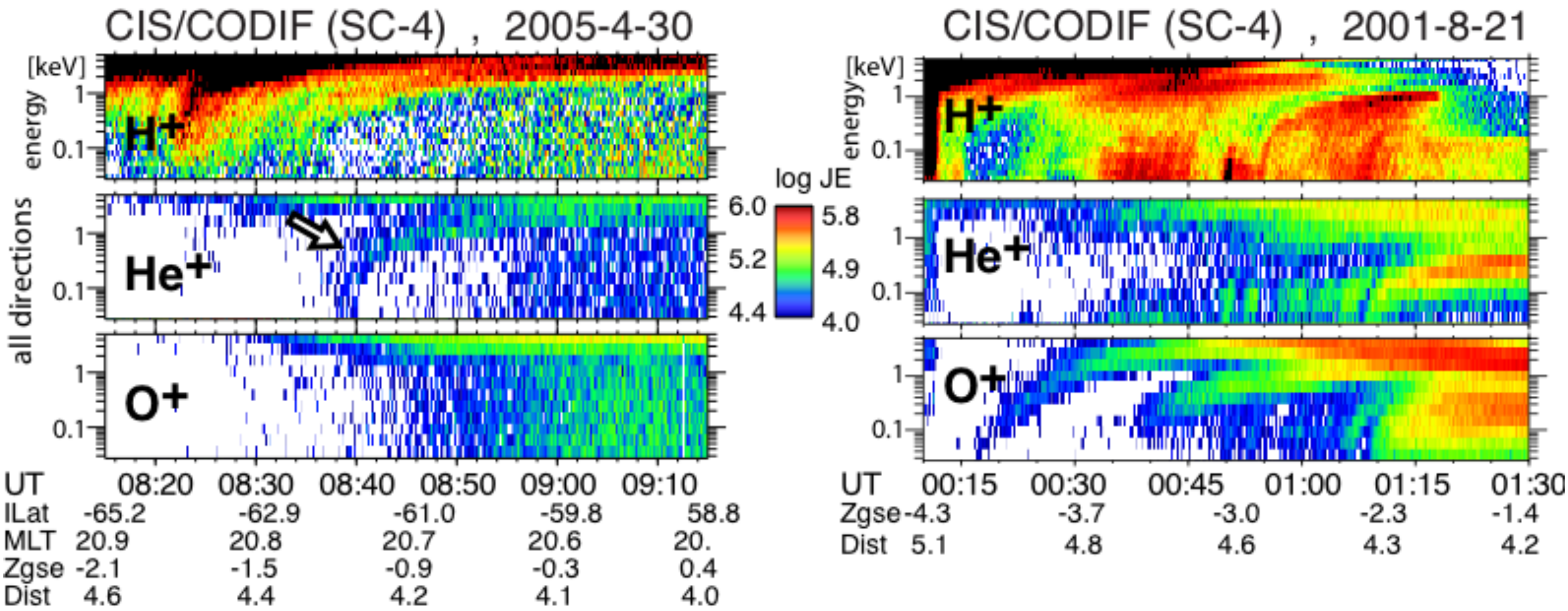
Appearances of H^+, He^+, and O^+ are not correlated



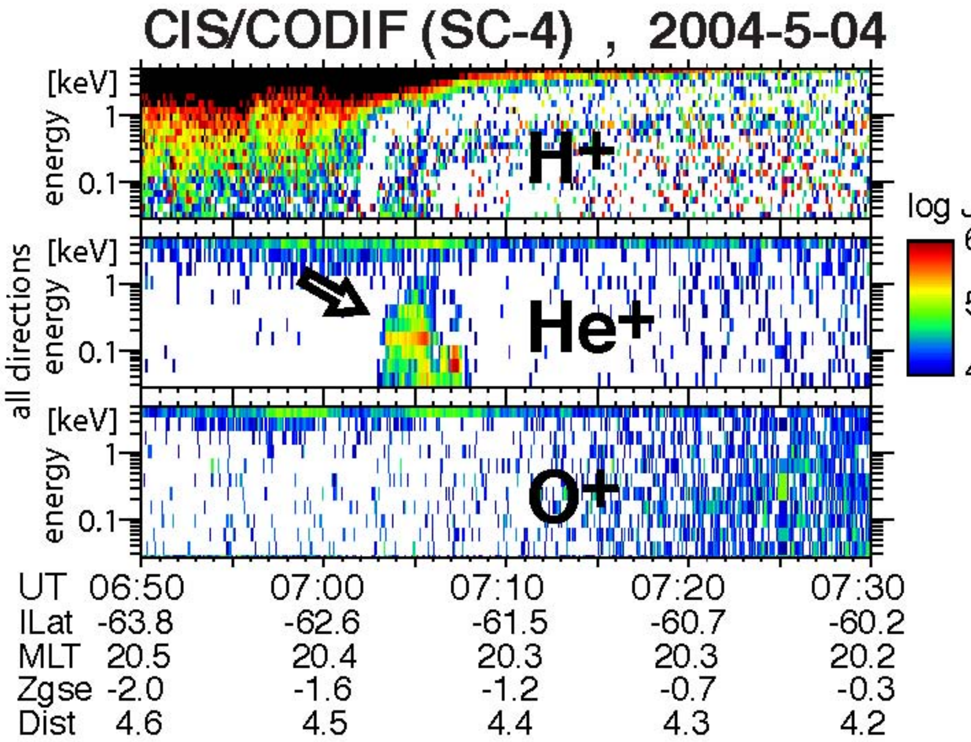


(b) Wedge-like energy-latitude dispersed ions

Timing & energy are quite different among H^+, He^+, and O^+ (drift theory predicts same energy-time diagram for all species).

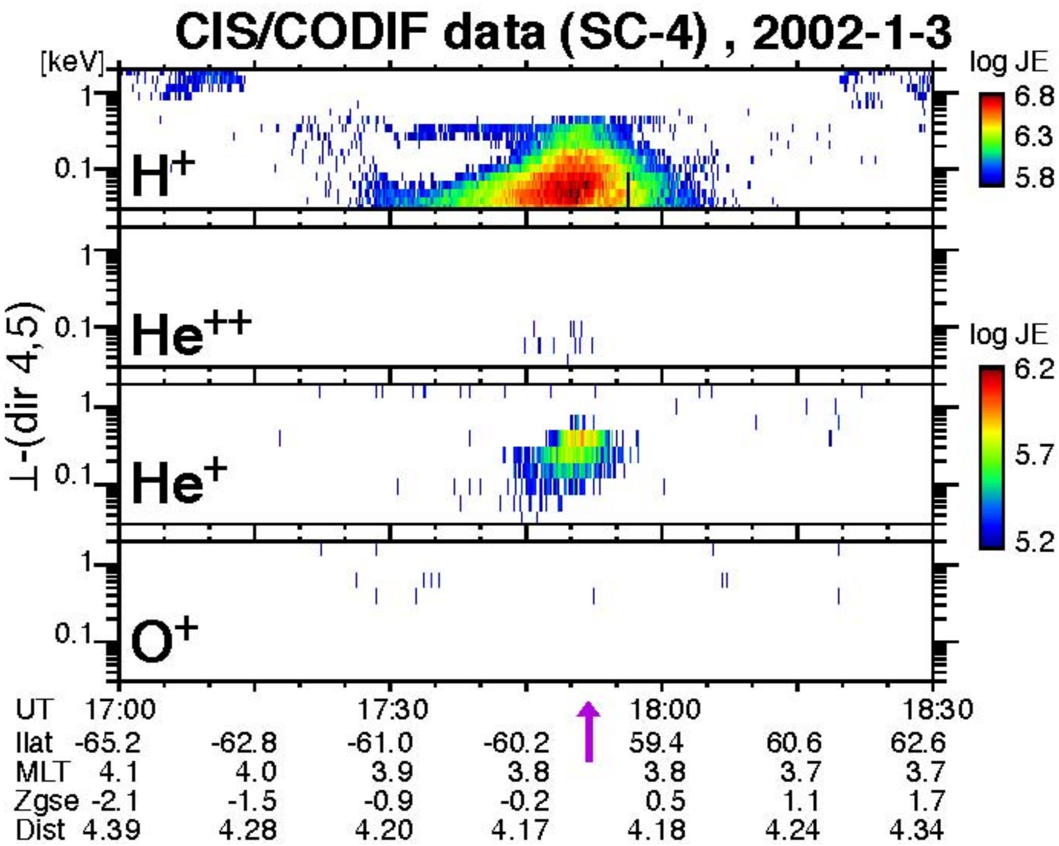


(c) Short bursts of low-energy ions:



Unlike most H^+ bursts, He^+ bursts (time scale~1h) are in perpendicular direction. It is also independent from O^+, indicating **local heating of He^+ only**.

(d) Warm trapped ions confined near equator



Equatorially-confined hot ions sometime show **$E(H^+) < E(He^+)$** while majority is **$E(H^+) = E(He^+)$.**

Conclusions & Future Observations

- There must be filtering mechanisms that select only cold He^+ and separates them from H^+ and O^+ for both energization and transportation.
- We need more investigation on Mass dependency

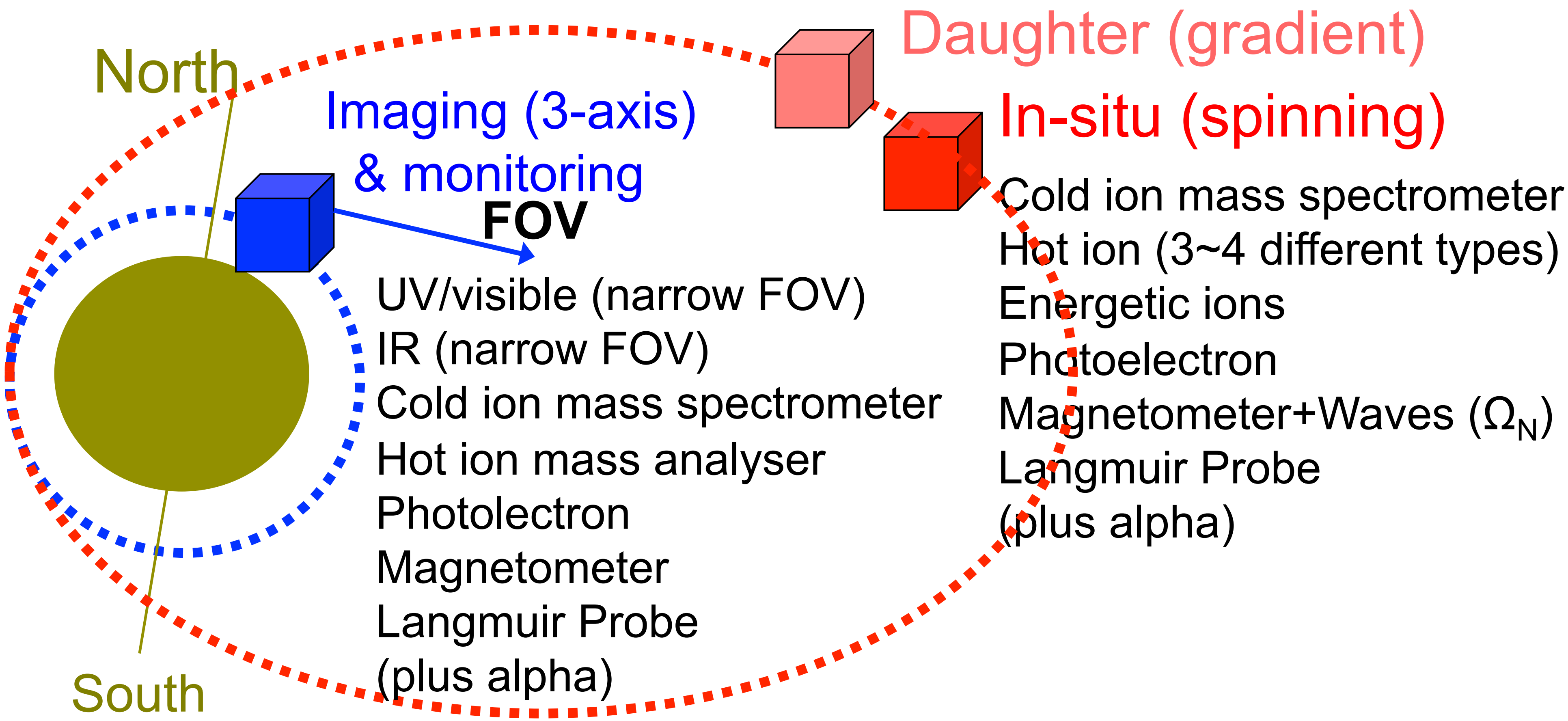
$\Downarrow$

Nitrogen Ion TRacing Observatory (NITRO)
for next ESA's M-class call

Sprinter meeting:

Saturday 11:30-16:00 (after coffee break)

3-spacecraft mission (high inclination)



In-situ spacecraft start with 6-7 Re apogee outside the radiation belts during the first 2 years, and then gradually decrease the apogee altitude to explorer the "dangerous" region. Monitoring satellite flies just above the polar ionosphere at altitude ~2000 km.

Payloads

In-situ #1 mother (spinning)

* Mass spectrometer (cold) *(Bern)*
* Ion analyzers (0.03 – 30 keV):
  (1) Narrow mass range (Kiruna)
  (2) Wide mass range (Toulouse)
  (3) No mass (LPP)
  (4) low G-factor mass (Japan)
* Ion mass analyzer (> 30 keV) *(UNH)*
* Electron (photoelectron) *(London)*
* Magnetometer *(Graz)*
* Waves ($\Omega_N \neq \Omega_O$) *(Prague)*
* Langmuir Probe (*Brussels*)
* ENA monitoring substorm *(Berkeley)*

* *(Potential Control=SC subsystem)*

Possible methods for ion analyzers:
Magnet, Magnet-TOF, reflection-TOF, MCP-MCP TOF, shutter-TOF

Remote sensing & monitoring (3-axis)

* Optical (emission) *(LATMOS & Japan)*
  (1) N^+: 91 nm, 108 nm
  (2) N_2^+: 391 nm, 428 nm
  (3) NO^+: 123-190 nm, 4.3 μm
  (4) O^+: 83 nm, 732/733 nm
* Mass spectrometer (cold) *(Goddard)*
* Ion analyzer (< 0.1 keV) *(Kirina)*
* Electron (photoelectron) *(London)*
* Langmuir Probe *(Brussels)*
* Ionospheric sounder *(Iowa)*
* Magnetometer *(Graz/UCLA)*
* Waves ($\Omega_N \neq \Omega_O$) *(Prague)*
* Ionospheric optical emission (???)

**** underline: core,***
**** colored: important,***
**** black: optional***

Optical imager needs a scanner keep in-situ spacecraft within FOV.