UNIVERSITY OF Southampton

Case study of quasi-steady reconnection in Saturn's magnetotail, and update on our current understanding of mass transport and loss in Saturn's nightside magnetosphere

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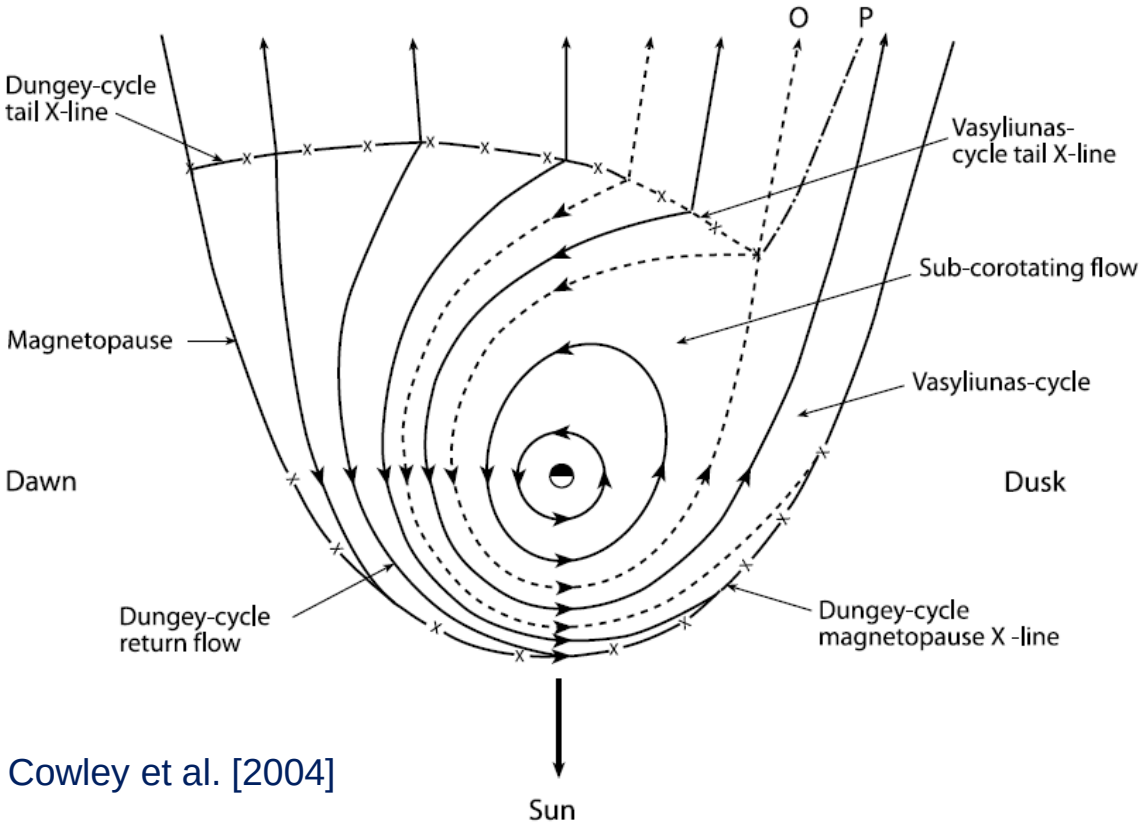
Open questions regarding reconnection at Saturn



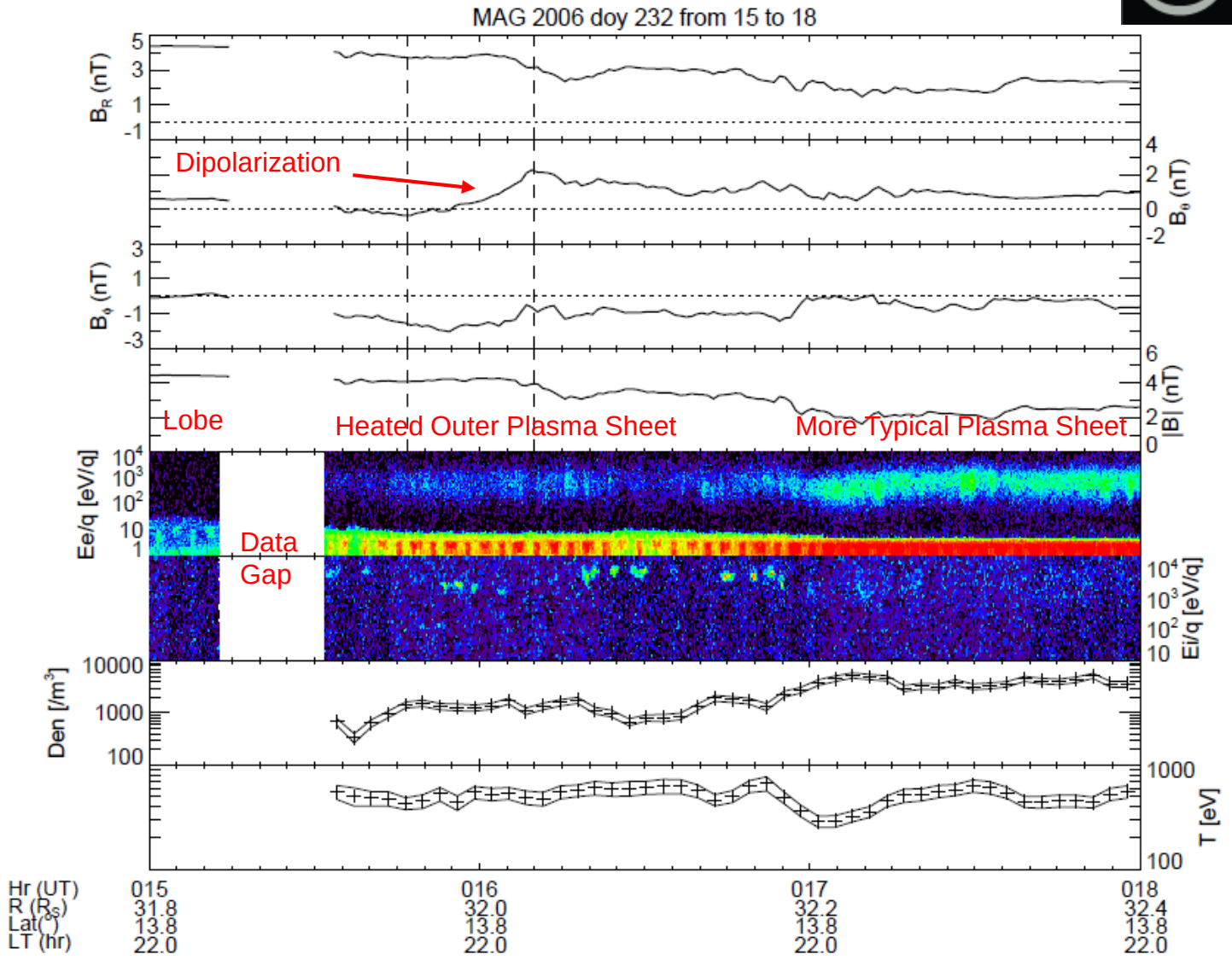
Cowley et al. [2004]

Dungey cycle involves opening and closing of **flux**.

Both Dungey (external) and Vasyliunas cycles (internal) can involve plasmoid release (**mass loss**)

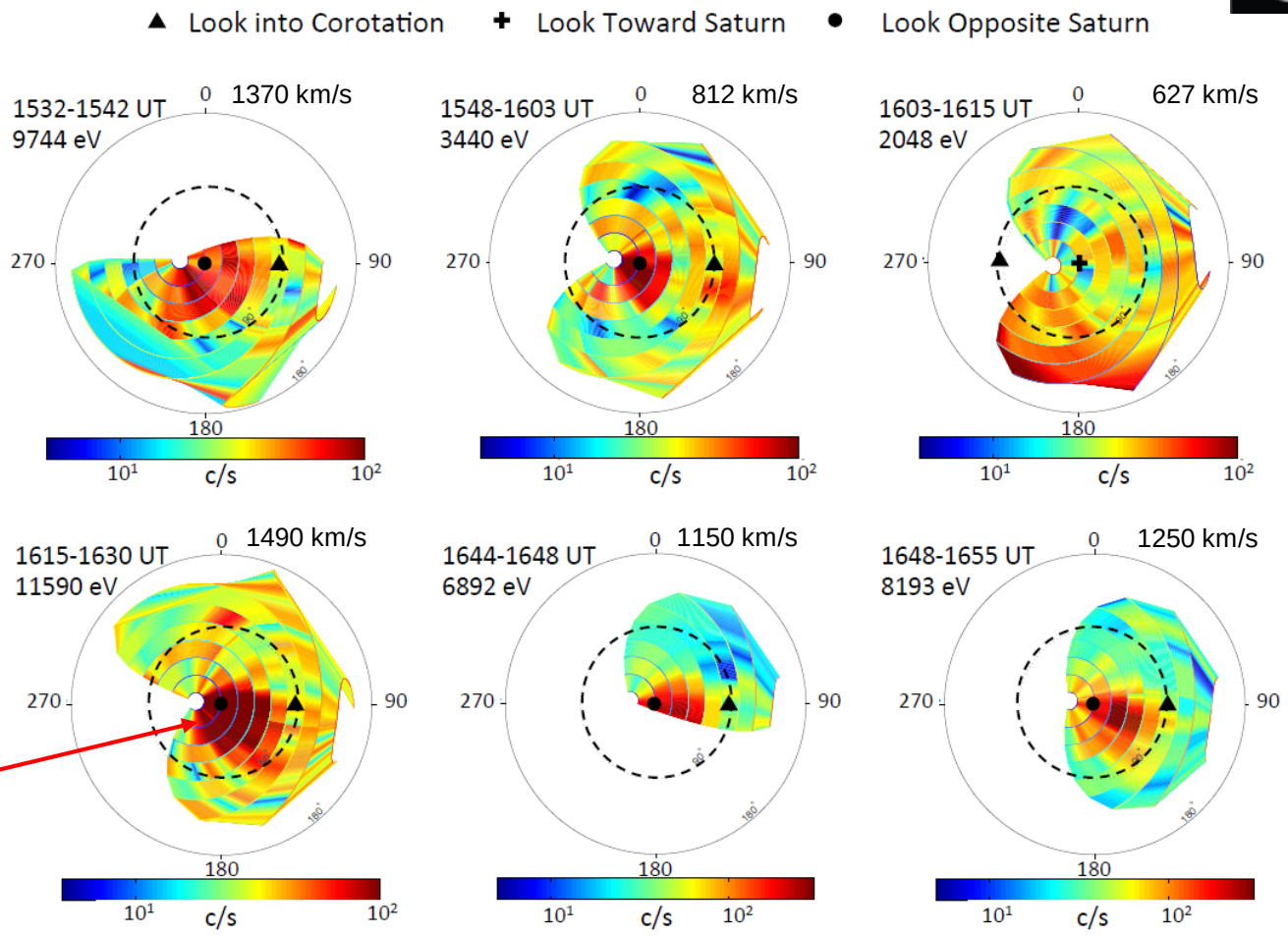
- Where do the Dungey and Vasyliunas cycles operate?
- How is the mass budget balanced?
- What is the recurrence rate of reconnection?

Dipolarization case study



23-minute southward turning of the field: dipolarization passing the spacecraft.

Plasma data: Flows (All-sky images)

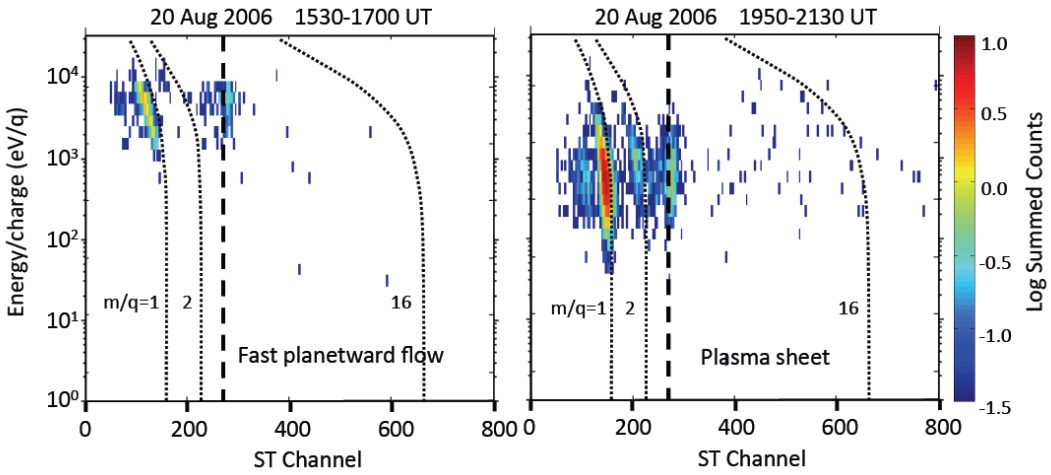


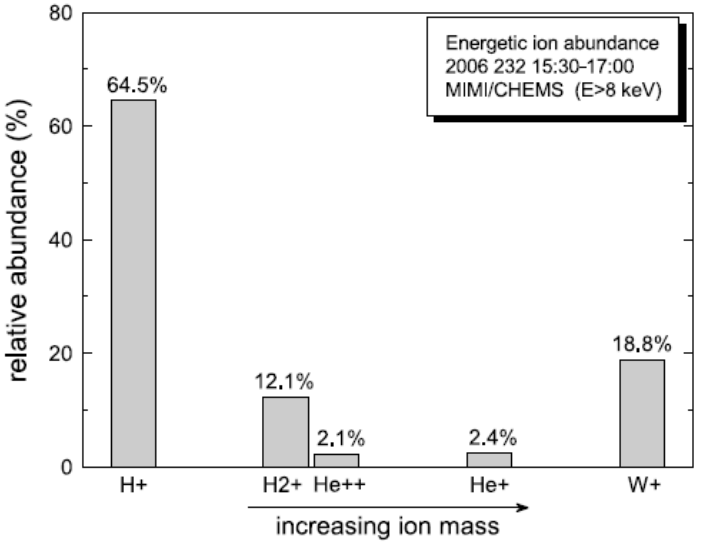
Strong Planetward flow at time of Dipolarization

Good viewing in CAPS (rolling spacecraft). Strong, narrow (in energy) planetward flow, speeds ~600-1500 km/s, significantly enhanced compared to typical corotation speeds of ~300-400 km/s near tail plasma sheet.

Interpretation: Reconnection ongoing tailward of Cassini - producing directional flows.

Plasma and energetic particle data: Composition





Water group ions: Internally generated. Light ions: Internal/external

Plasma within the fast planetward flow population is significantly depleted of water group ions compared to typical plasma sheet.

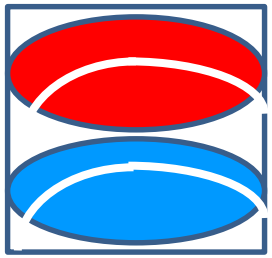
Could be due to centrifugal confinement or energization out of CAPS range.

Corresponding CHEMS data show the “missing” water group ions. H_2^+ (magnetospheric constituent) is ~6 times more abundant than He^{++} (solar wind constituent).

Energetic particle data: Flows

Angular distribution of energetic hydrogen and oxygen

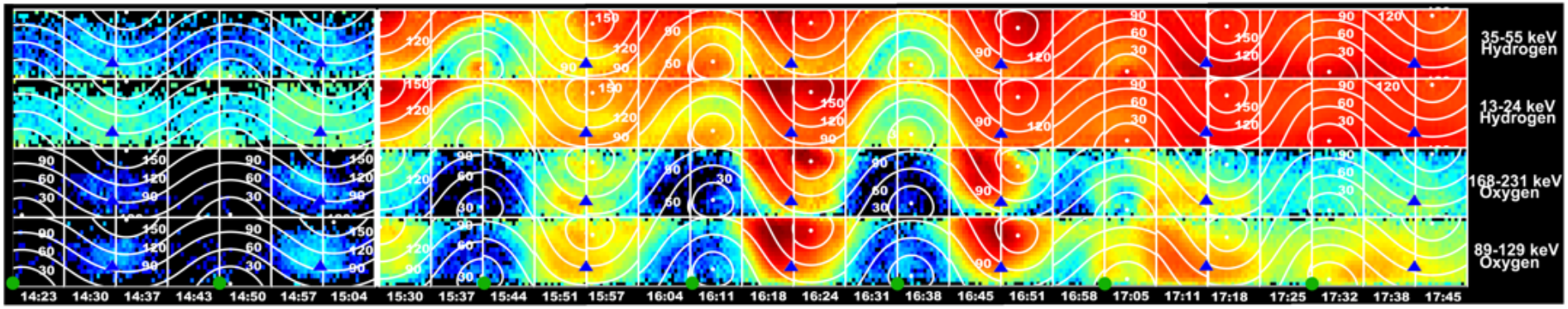
White pitch angle contours show rolling spacecraft



Top of frame: Planetward flow

Red: strongest fluxes
Blue: weakest fluxes

Bottom of frame: Tailward flow



Lobe

Data Gap

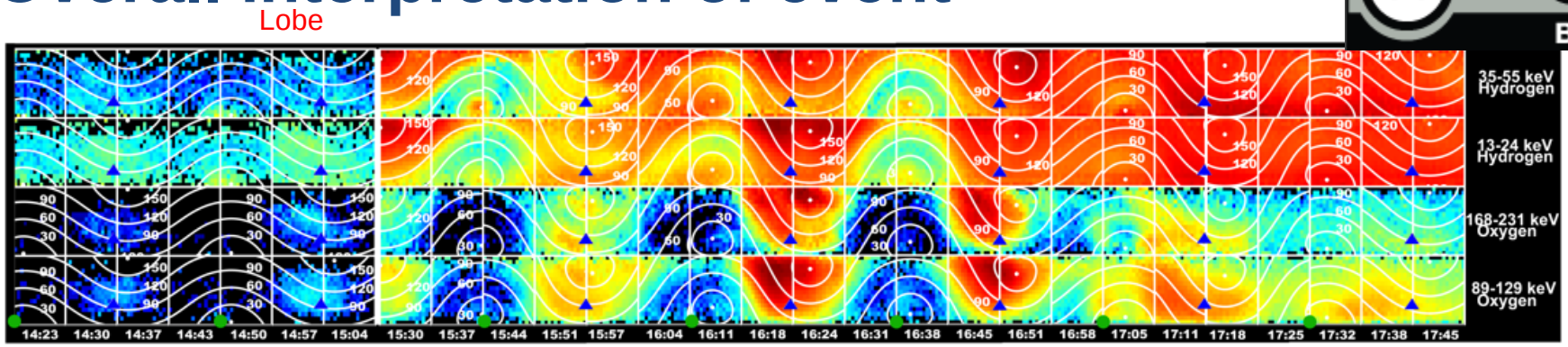
Heated Outer Plasma Sheet
Planetward H+ and O+.
Tailward H+ beam

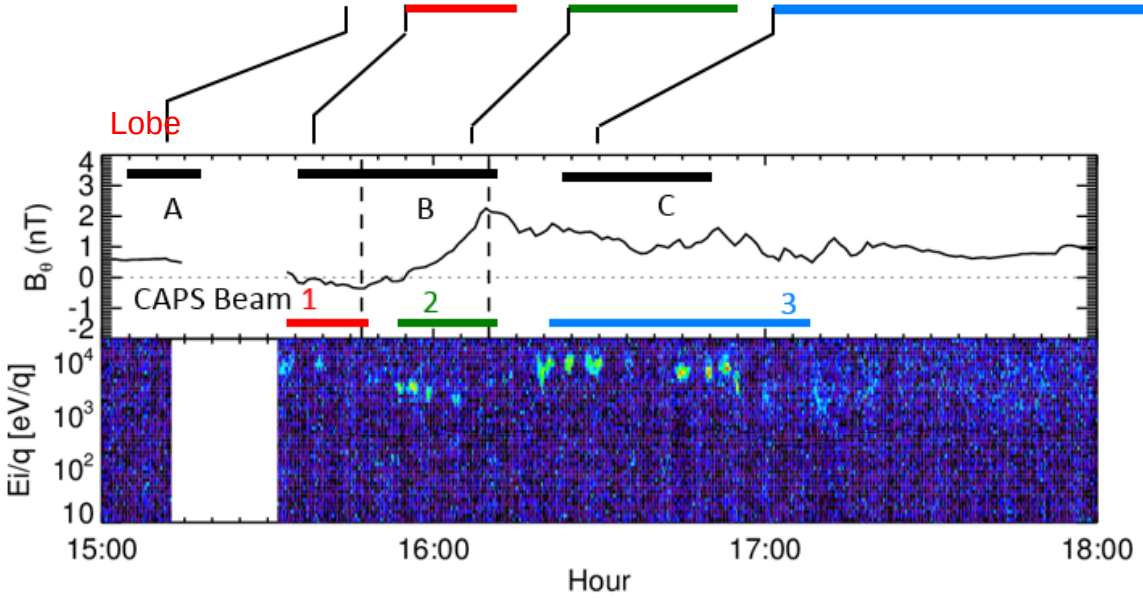
More Typical Plasma Sheet, Isotropic Population

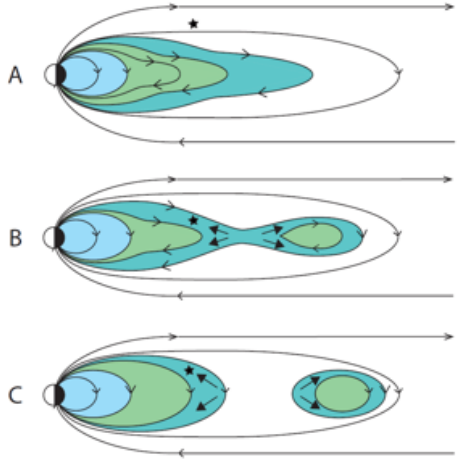
Before data gap: Weak O+ and H+ confirm lobe.

After data gap: Anisotropic, broad pitch angle “flow burst” in H+ and O+. Planetward flow consistent with tail reconnection products. Additional tailward-streaming beam of H+ seen ~15:37 at highest energies, interpreted as a population of ionospheric ions which have been accelerated at low altitude in a high field region.

Overall interpretation of event





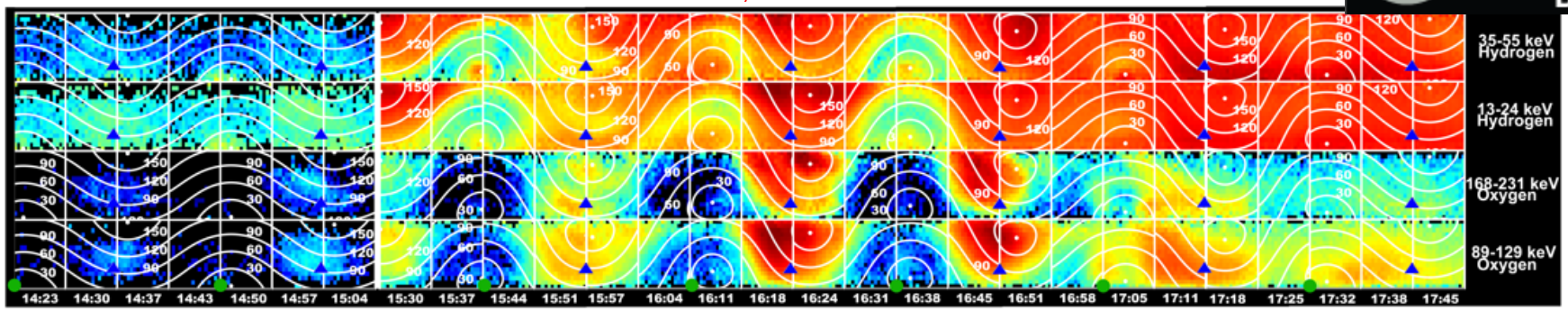


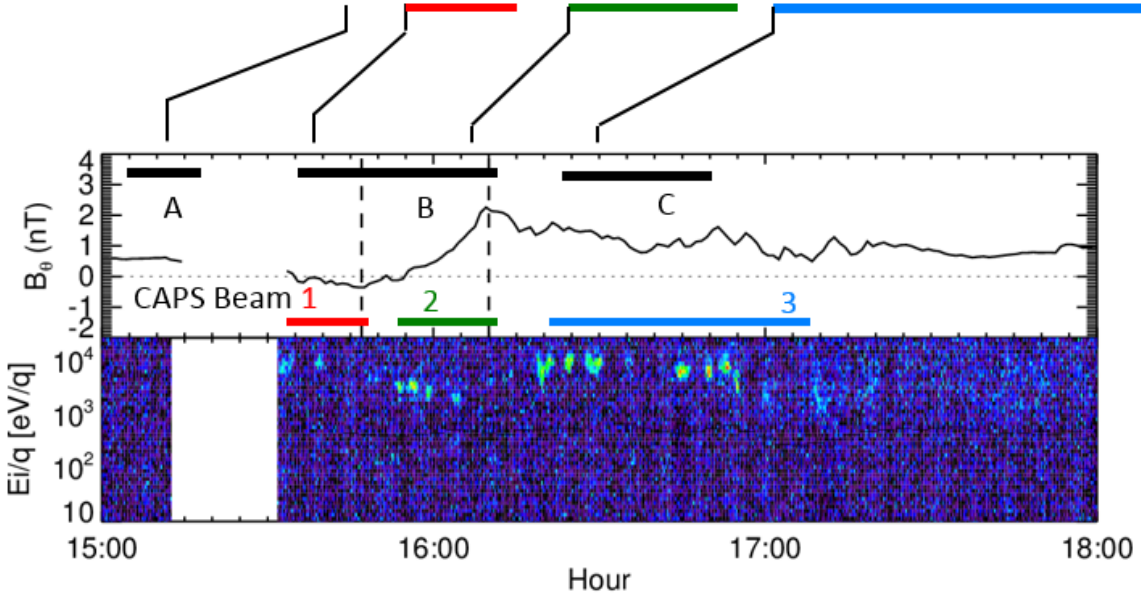
Interval A:

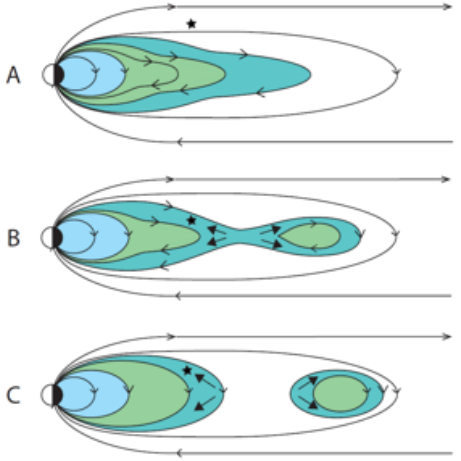
Lobe. Spacecraft sampling quiet magnetic field, weak O+ and H+ MIMI fluxes, “empty” CAPS spectrogram

Overall interpretation of event

Heated Outer Plasma Sheet, Planetward H+ and O+. Tailward H+ beam







Interval B:

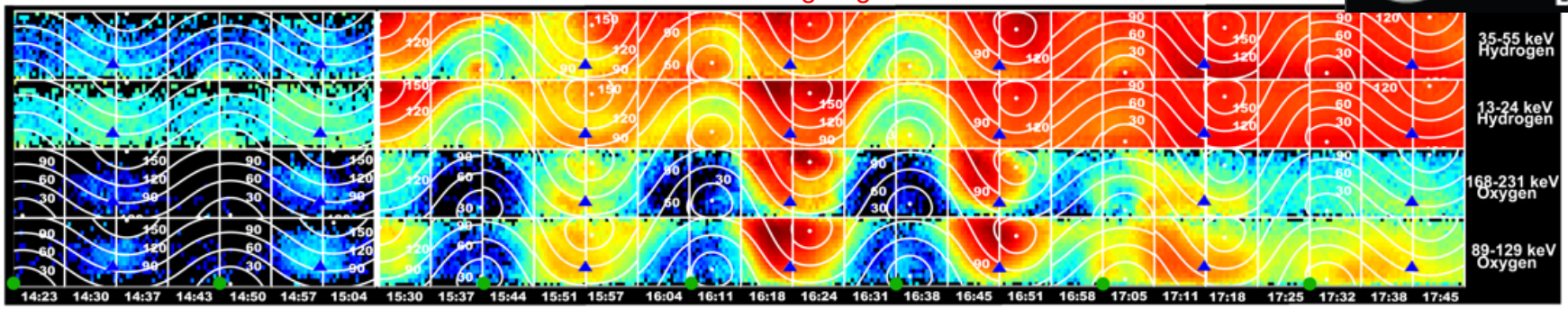
Dipolarization and planetward flow consistent with reconnection tailward of Cassini.

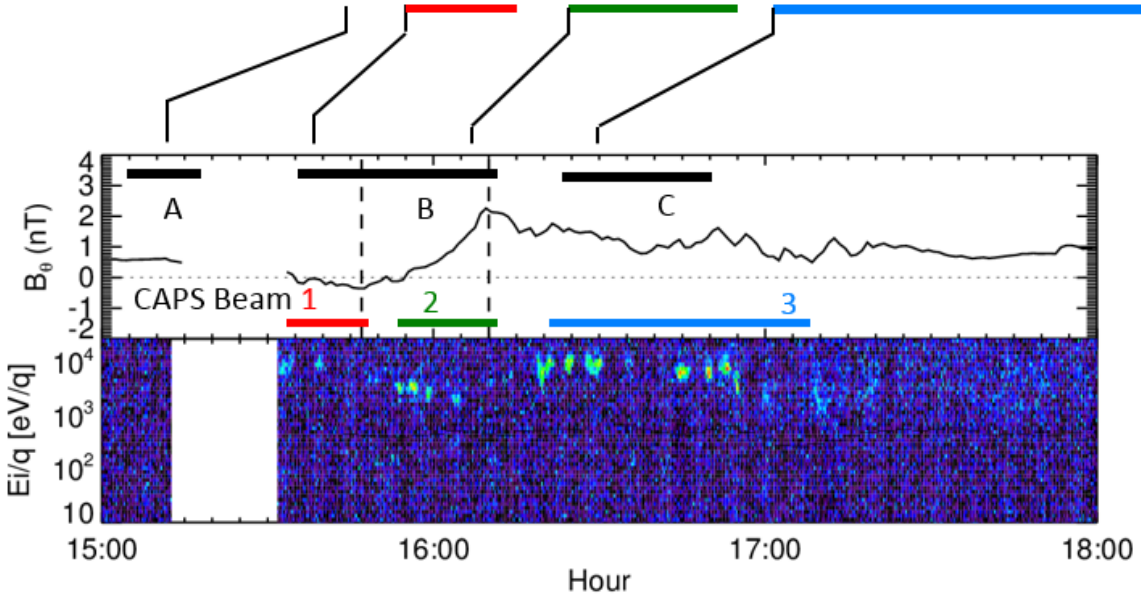
Plasma data indicate closed field line region, hotter than typical plasma sheet.

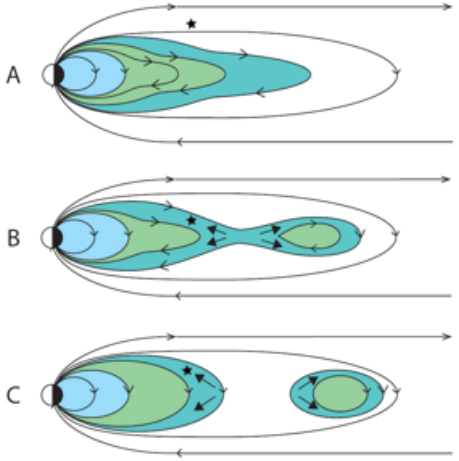
Overall interpretation of event

Ongoing Reconnection

More Typical P
Isotropic Popul







Interval C:

Ongoing planetward flow: Cassini still immersed in flows from ongoing reconnection.

From 16:58, more isotropic population, lower intensity plasma sheet.

Summary and context

- Persistent planetward flows, including energized ions for ~1.5 hours (longer than the 23-minute magnetic field dipolarization signature) indicate relatively long-lived reconnection.

- This reconnection over a significant fraction of a planetary rotation could have a large impact of the topology of the tail field and the nature of flows in this region.

- Plasma composition indicates that the reconnection involves internally loaded magnetospheric field lines, i.e., Vasyliunas-type reconnection. The dominance of H_2^+ over He^{++} as seen from the CHEMS data supports this picture.

Long duration/quasi-steady reconnection:
[e.g. Thomsen et al., 2013, 2.5-hour interval;
Arridge et al., in press, 2015, ~18-hour interval
Thomsen et al., submitted, 2015, 5-hour interval]
important to help understand the dynamics of outer planet magnetospheres

Content of this presentation in this published work:
Jackman, C.M., M.F. Thomsen, D.G. Mitchell, N. Sergis, C.S. Arridge, M. Felici, S.V. Badman, C. Paranicas, X. Jia, G.B. Hospodarksy, M. Andriopoulou, K.K. Khurana, A.W. Smith, M.K. Dougherty (2015), Observation of a field dipolarization, planetward ion beams and flow bursts: A case study of long-duration reconnection in Saturn's tail, J. Geophys. Res., 120*, doi:*10.1002/2015JA020995*.*