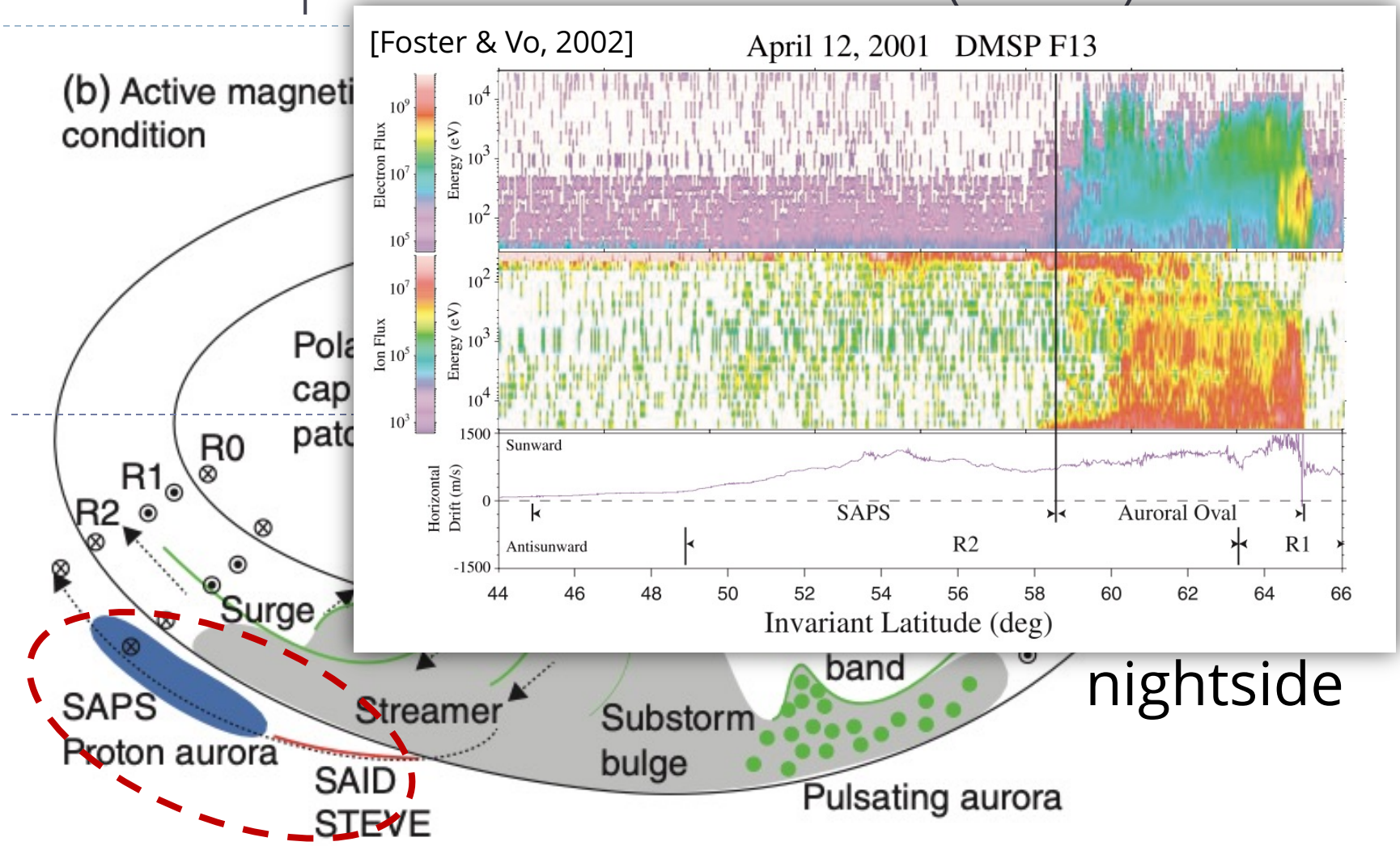
SAPS electric field and particle boundaries as observed by SuperDARN and Arase

T. Hori, Y. Miyoshi, S. Nakamura, Y. Kasaba, T. Nakagawa, M. Kitahara, S. Matsuda, N. Nishitani, A. Kumamoto, F. Tsuchiya, Y. Kasahara, K. Asamura, C.-W. Jun, Y. Kazama, S.-Y. Wang, K. Keika, S. Kasahara, S. Yokota, A. Matsuoka, I. Shinohara

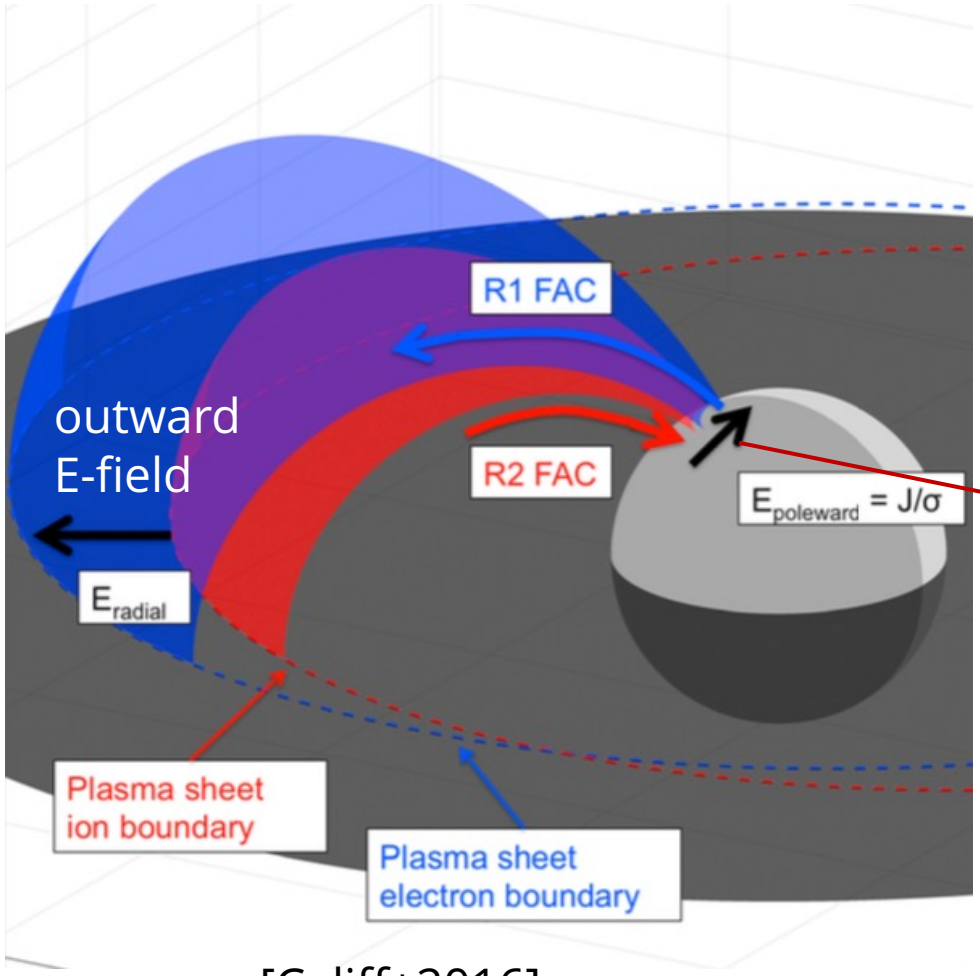
Subauroral polarization streams (SAPS)



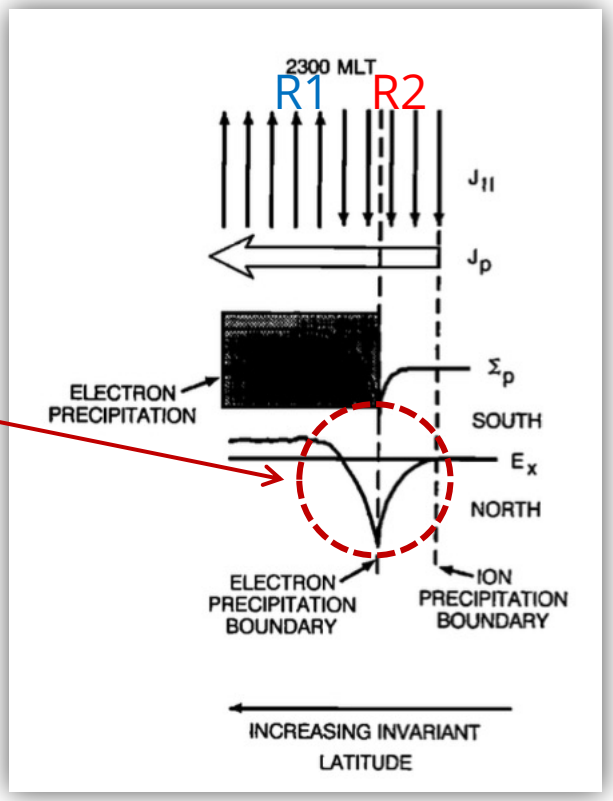
fast westward flow of typically 100s to over 1000 m/s driven by a poleward E-field

[Nishimura+2021]

SAPS and plasma sheet boundaries



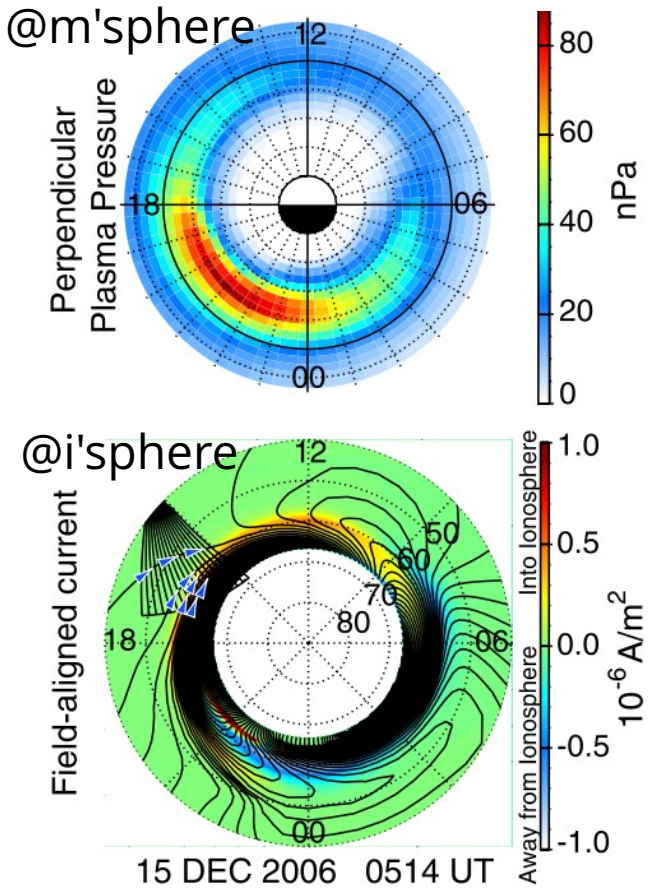
[Califf+2016]

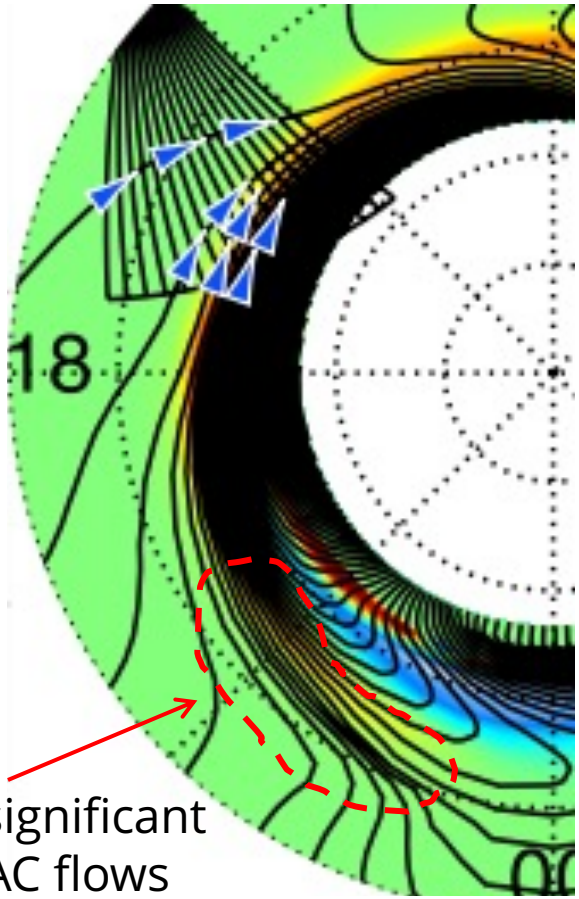


[Anderson+1993]

FAC generated at the inner boundary of RC

[Ebihara+2008]





A weak, but significant downward FAC flows in here, enhancing the poleward E-field.

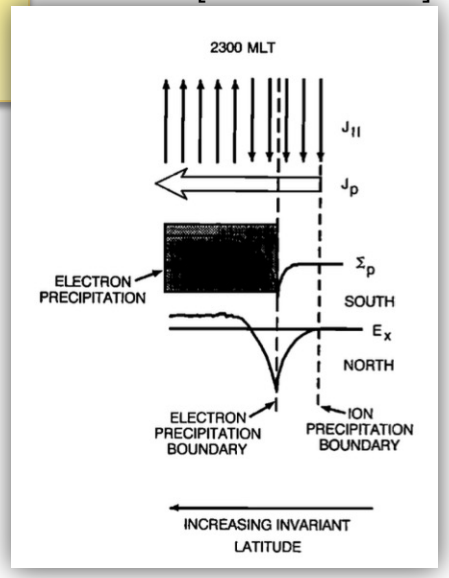
SAPS E-field and particle boundaries as seen in the equatorial magnetosphere on dusk

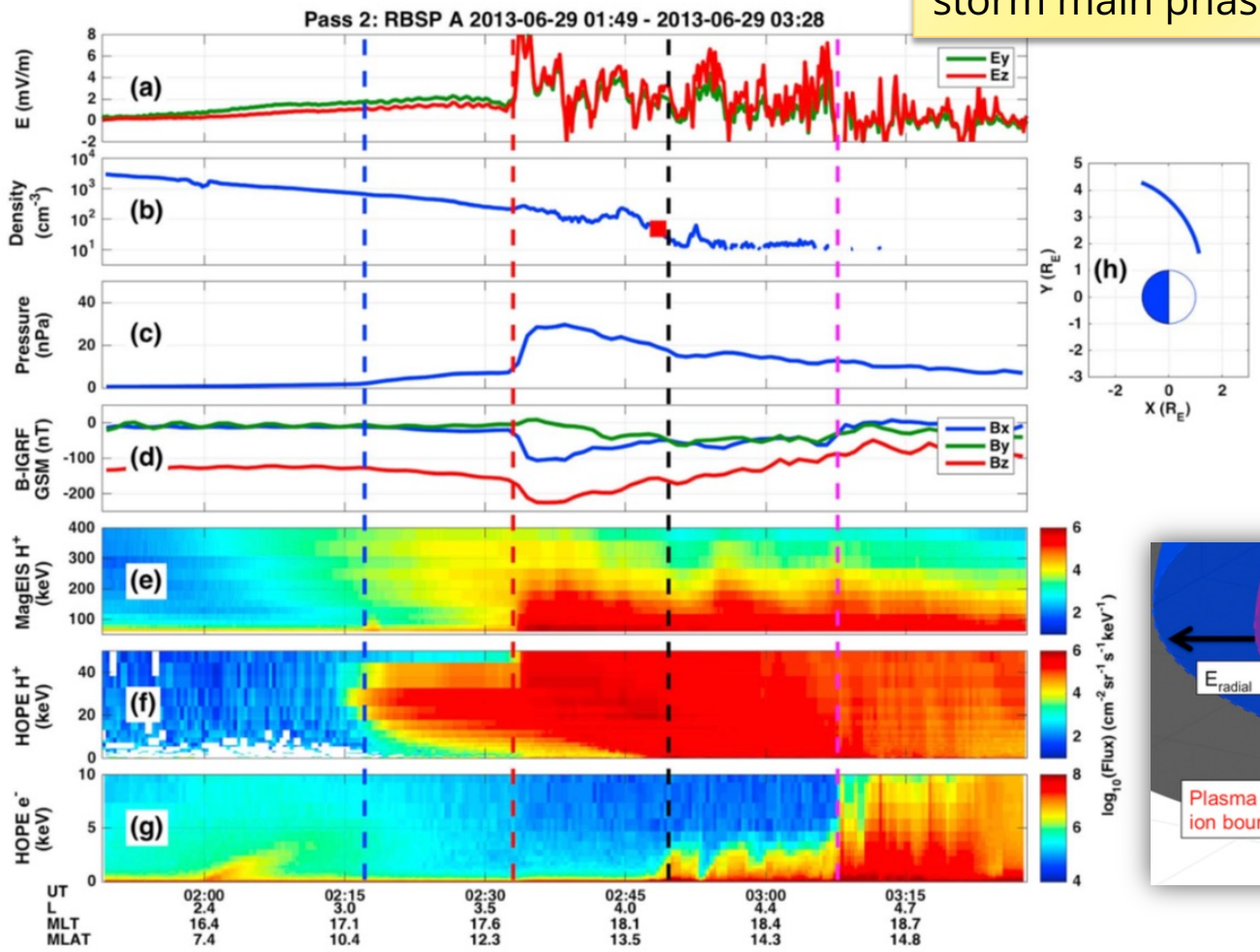
[Califf+2016]

SAPS

Near the peak of storm main phase

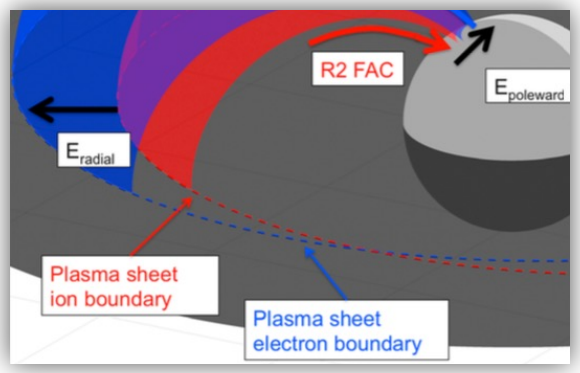
[Anderson+1993]





H+

e-

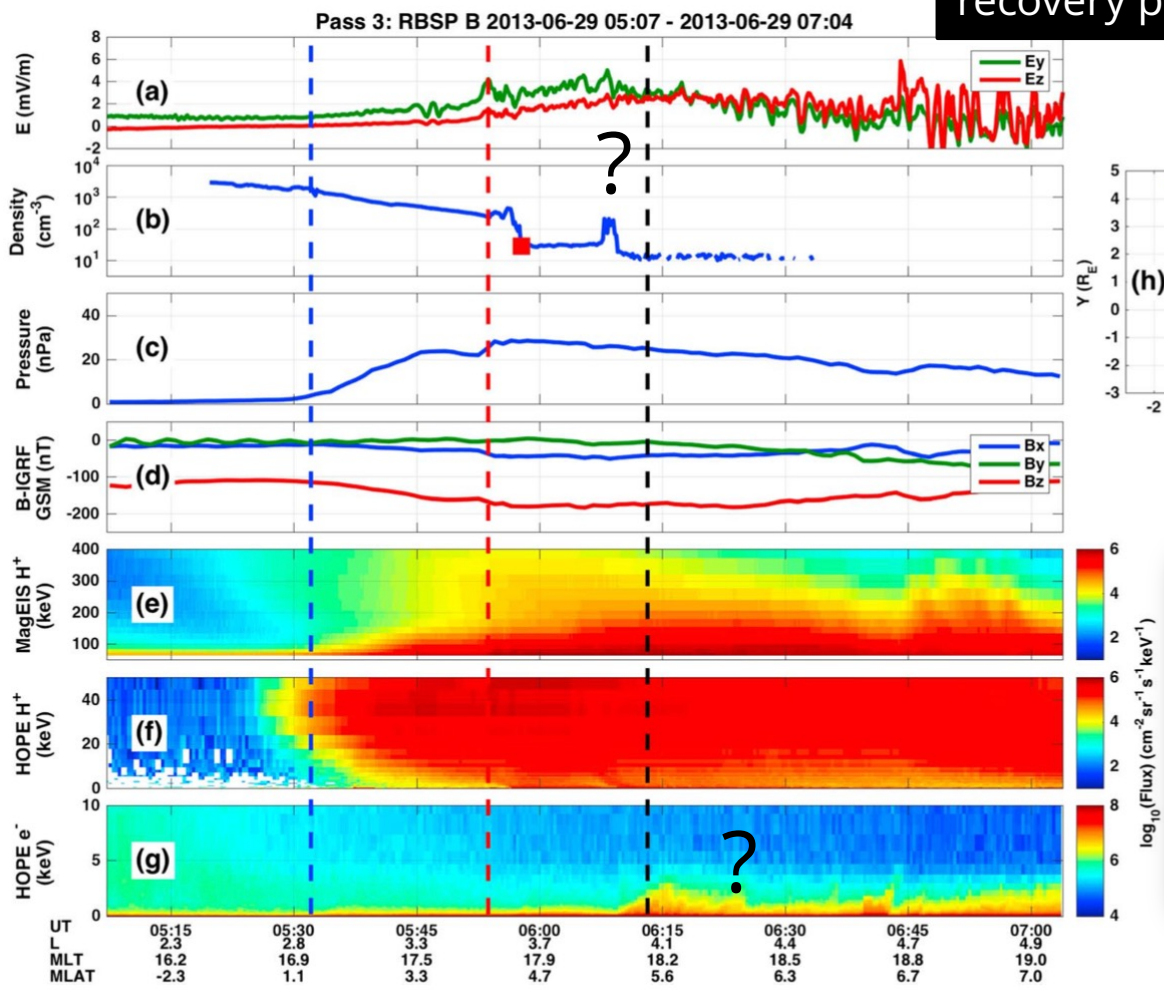


SAPS E-field and particle boundaries as seen in the equatorial magnetosphere on dusk

[Califf+2016]

SAPS

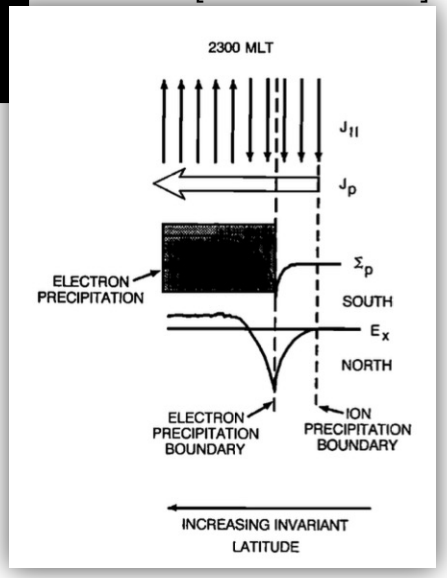
Just before the recovery phase

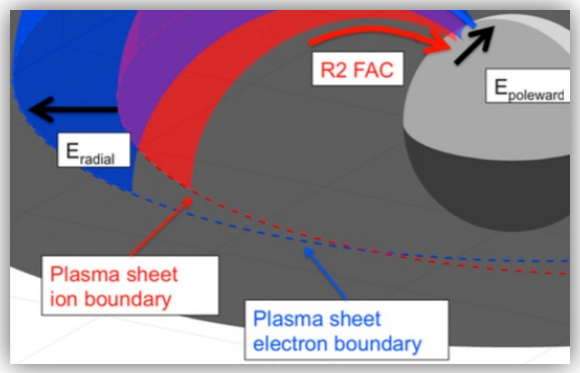


H+

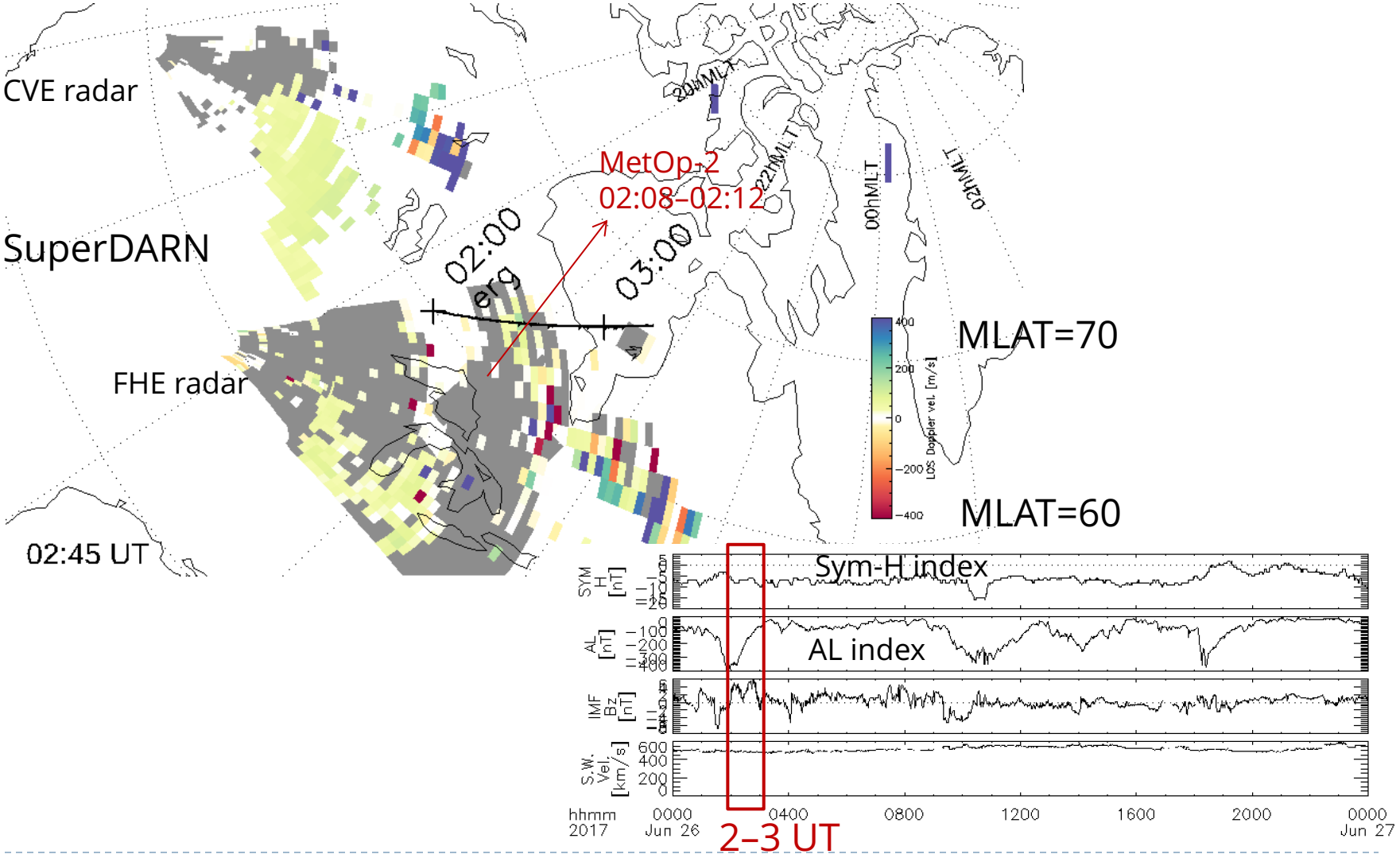
e-

[Anderson+1993]

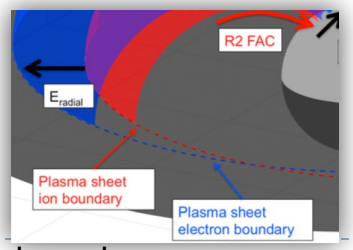




Event #1: Jun. 26, 2017



Event #1: 01:00–03:30 Jun. 26, 2017 Arase observations



Outward E → poleward E on i'sphere → SAPS!

SAPS inner edge matches the inner edge of ion RC

Lv.2 E_spin (Eu) in FA coord.

E-field measurement is unreliable

Inward $E_\perp$

Westward $E_\perp$

Cold e- density

2 UT @ L ~ 3.9

PP

3 UT @ L ~ 5.8

Ion kinetic pressure

ion ring current

Mid. ene. H+

Ion plasma sheet

Low ene. H+

Ele. plasma sheet

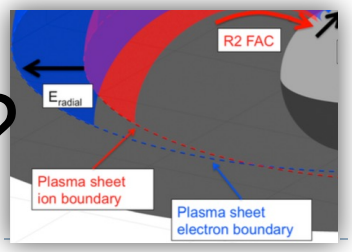
Low ene. e-

SAPS E-field coincides with the region of an outward pressure gradient.

very narrow or almost no gap between ion and e- PS @L ~ 4.9, MLT ~ 21

Event #2: 04:50–05:20 Apr. 8, 2017 Arase observations

△?



SAPS E-field

SAPS inner edge

Lv.2 E_spin (Eu) in FA coord.

E-field measurement is unreliable

Inward $E_\perp$

Westward $E_\perp$

Cold e- density

PP

Ion kinetic pressure

Mid. ene. H+

ion ring current

Low ene. H+

Ion plasma sheet

Low ene. e-

Ele. plasma sheet

L ~ 4.0

L ~ 4.7

The gap between ion PS (L ~ 4.2) and e- PS (L ~ 4.4) @ MLT ~ 1

Motivation & objectives

- Their spatial correspondence in the equatorial magnetosphere is not as simple and unique as expected from the simple model [e.g., Nishimura+2008, Califf+2016].

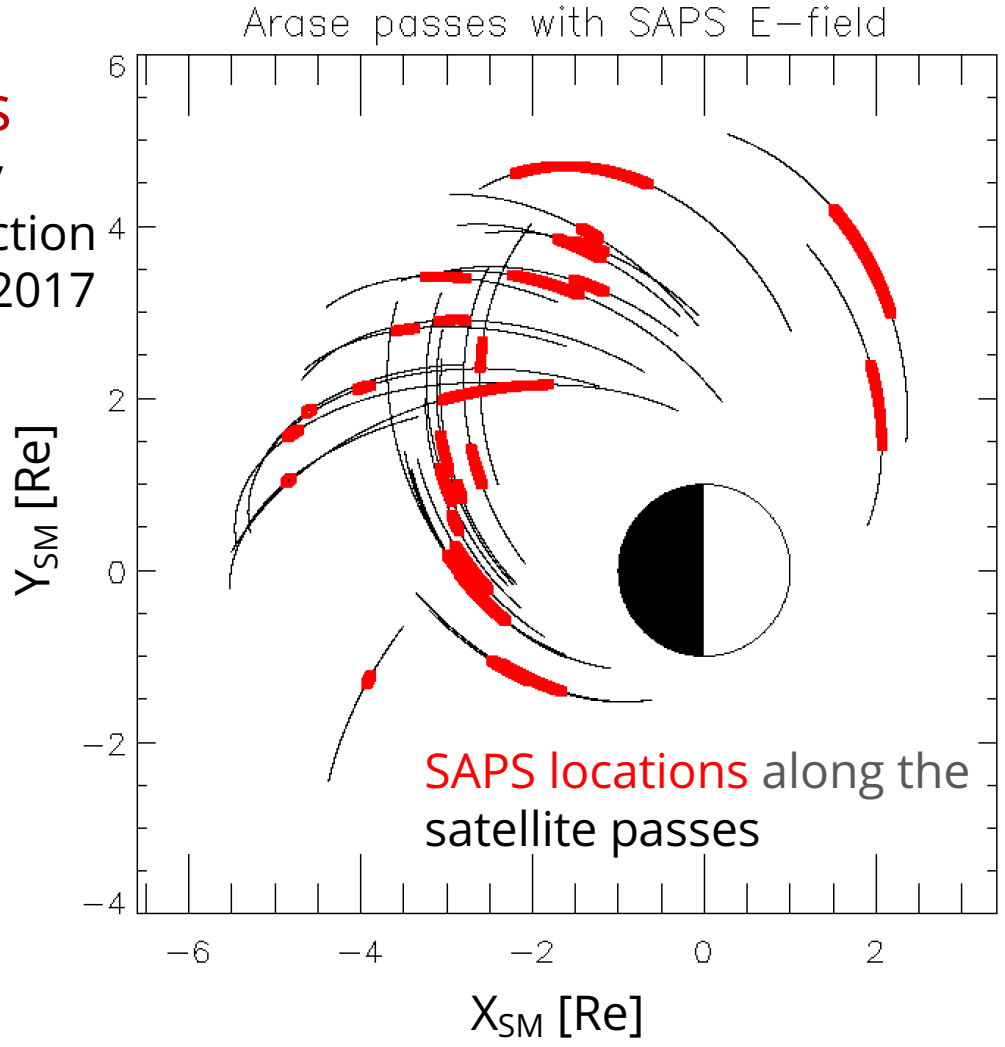
This study addresses…

- the correspondence and gap in position of SAPS and particle boundaries examined **statistically** based on simultaneous observations of Arase and SuperDARN.

SAPS conjunction events

SAPS identification:
- fast westward flow with SD
- >6 mV/m inward of e- PS with Arase

30 events identified by visual inspection during Apr. 2017 to Sep. 2018

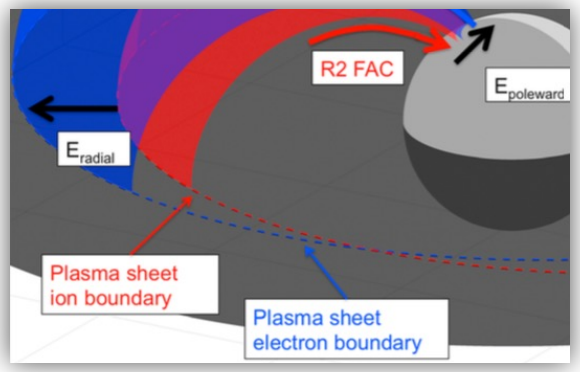


All events occurred during either the expansion phase, recovery phase, or prolonged activity of substorm.

The inner edge of SAPS E-field matches the ion inner edge?

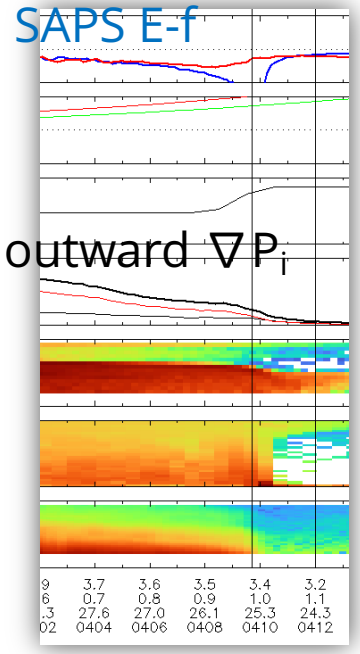
Question	YES	NO	(unclear)
SAPS inner edge matches the inner edge of the ion RC or PS structure?	8	22	0

- Most of the events do NOT seem to be consistent with the simple current generator model.

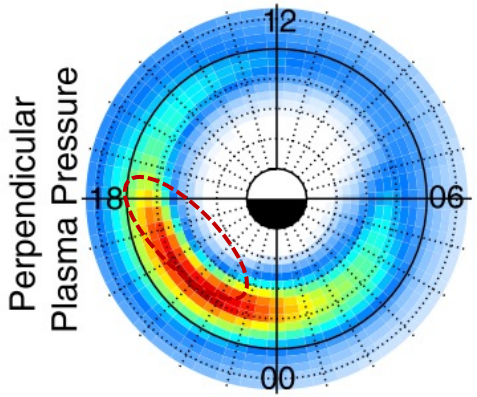


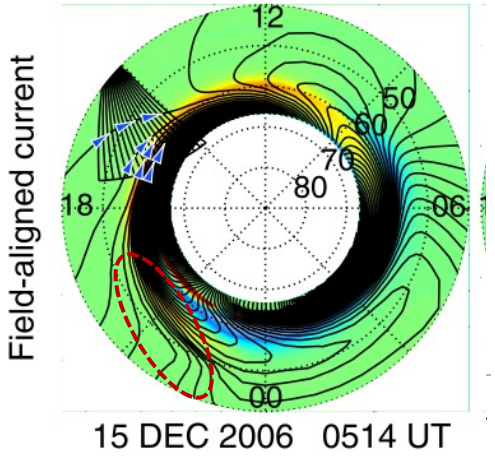
The inner edge of SAPS E-field matches the ion inner edges?

Question	YES	SAPS ended at middle of ∇P_i	(unclear)
SAPS inner edge matches the inner edge of the ∇P_i structure?	11	10	9



- Most of the SAPS E-field lie in the region of outward ∇P_i.

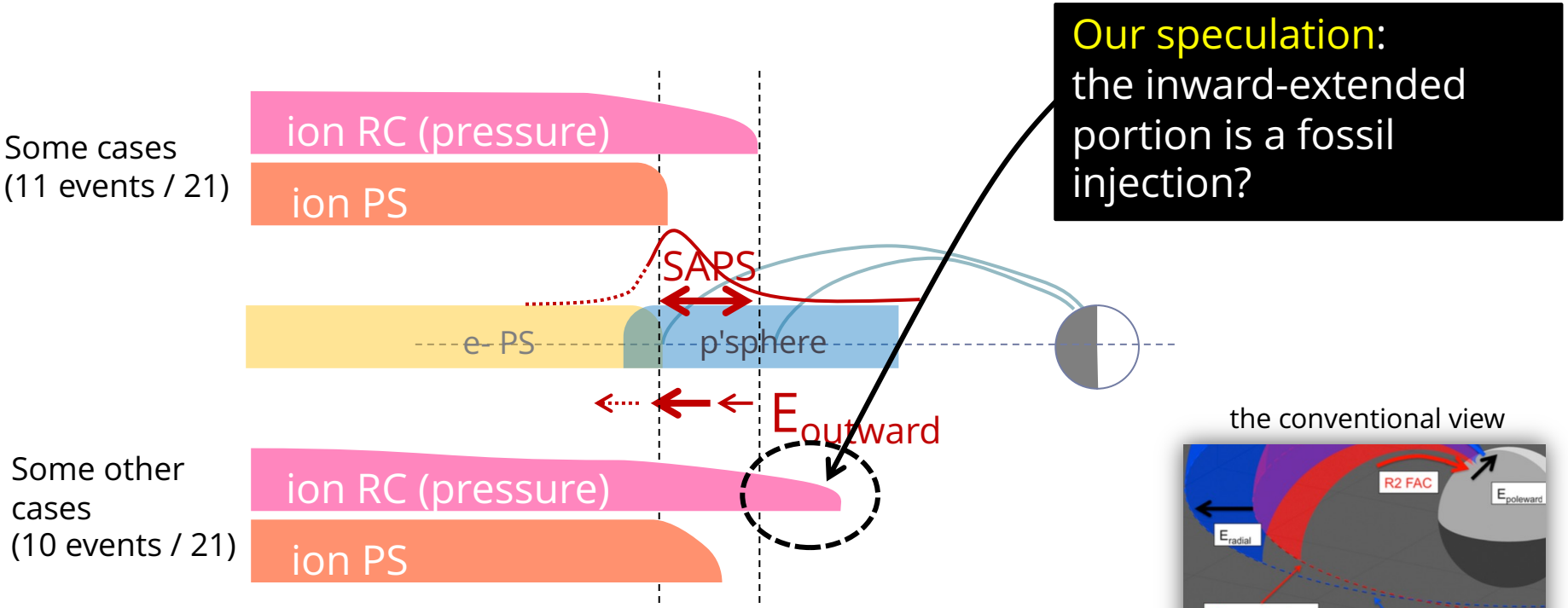




Discussion:
Summary of the present observations

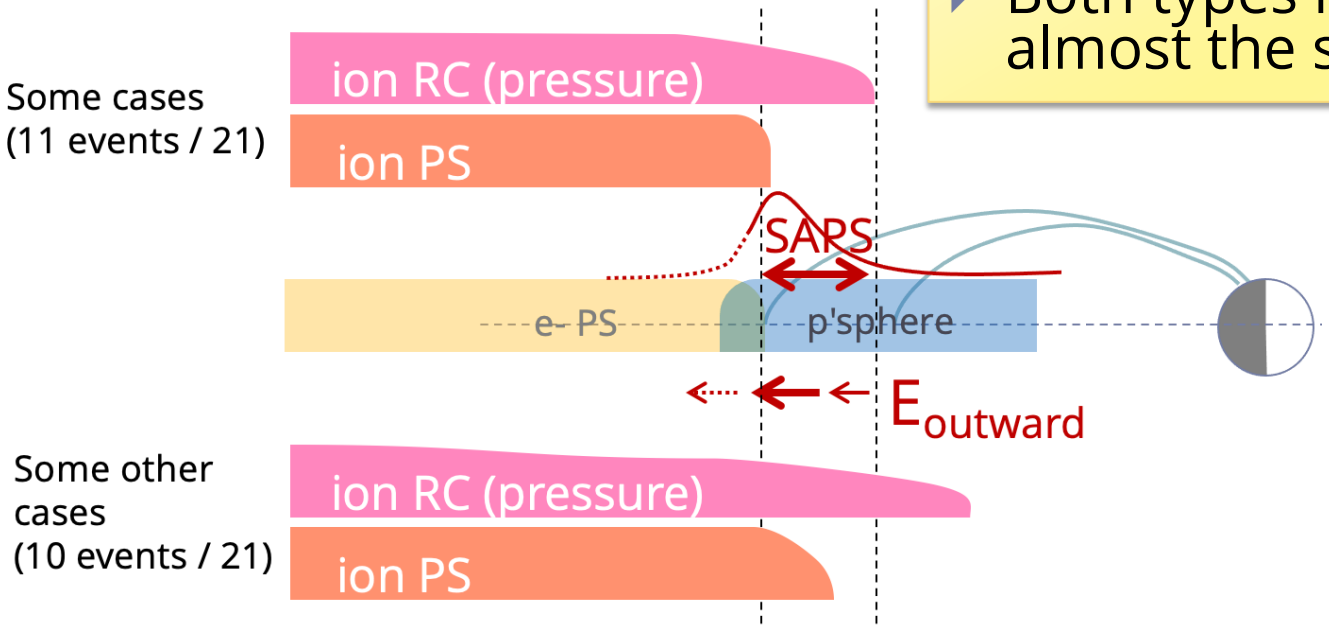
As seen in the equatorial m'sphere, SAPS is:

- associated with the region of outward ∇P_{ion}.
- but somehow insensitive to the inner edge of ion RC.



Statistics:
The inner edge of SAPS E-field matches the ion inner edges?

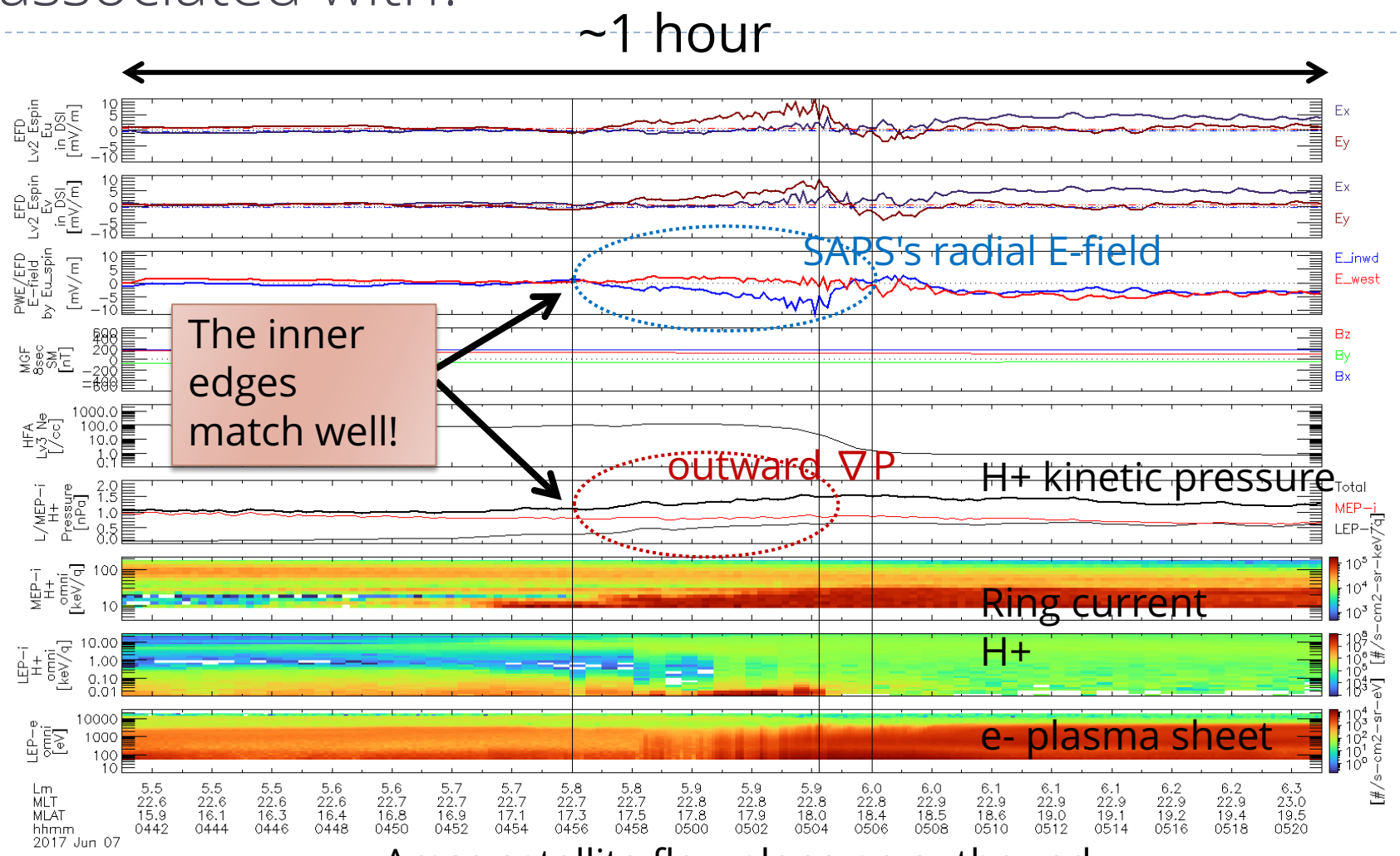
- Both types happen with almost the same frequency.



Next question:

What substorm / injection history causes each type of SAPS?

What substorm activity are the SAPS events associated with?

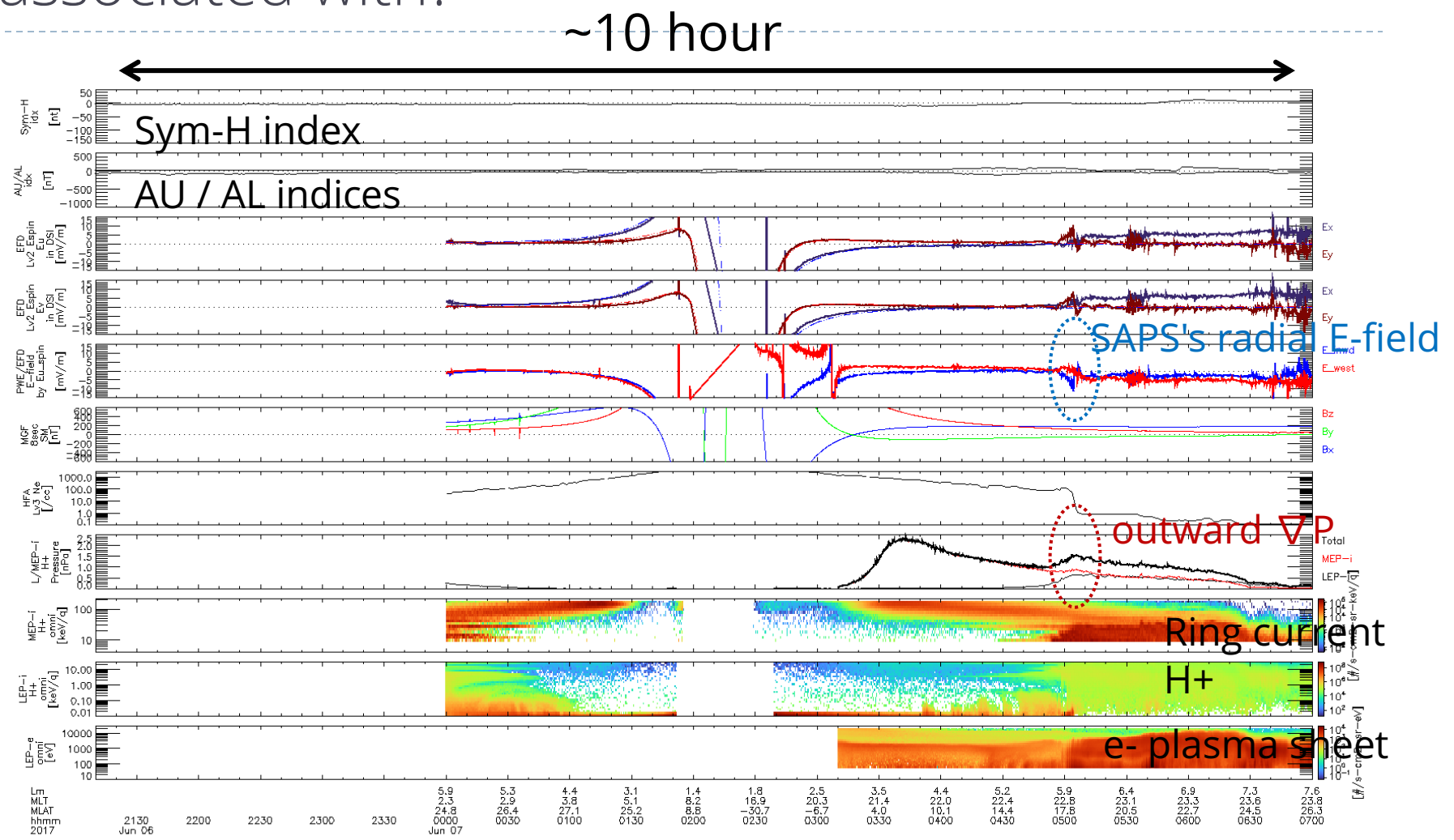


L ~ 5.5

Arase satellite flew along an outbound pass at MLT ~ 22-23

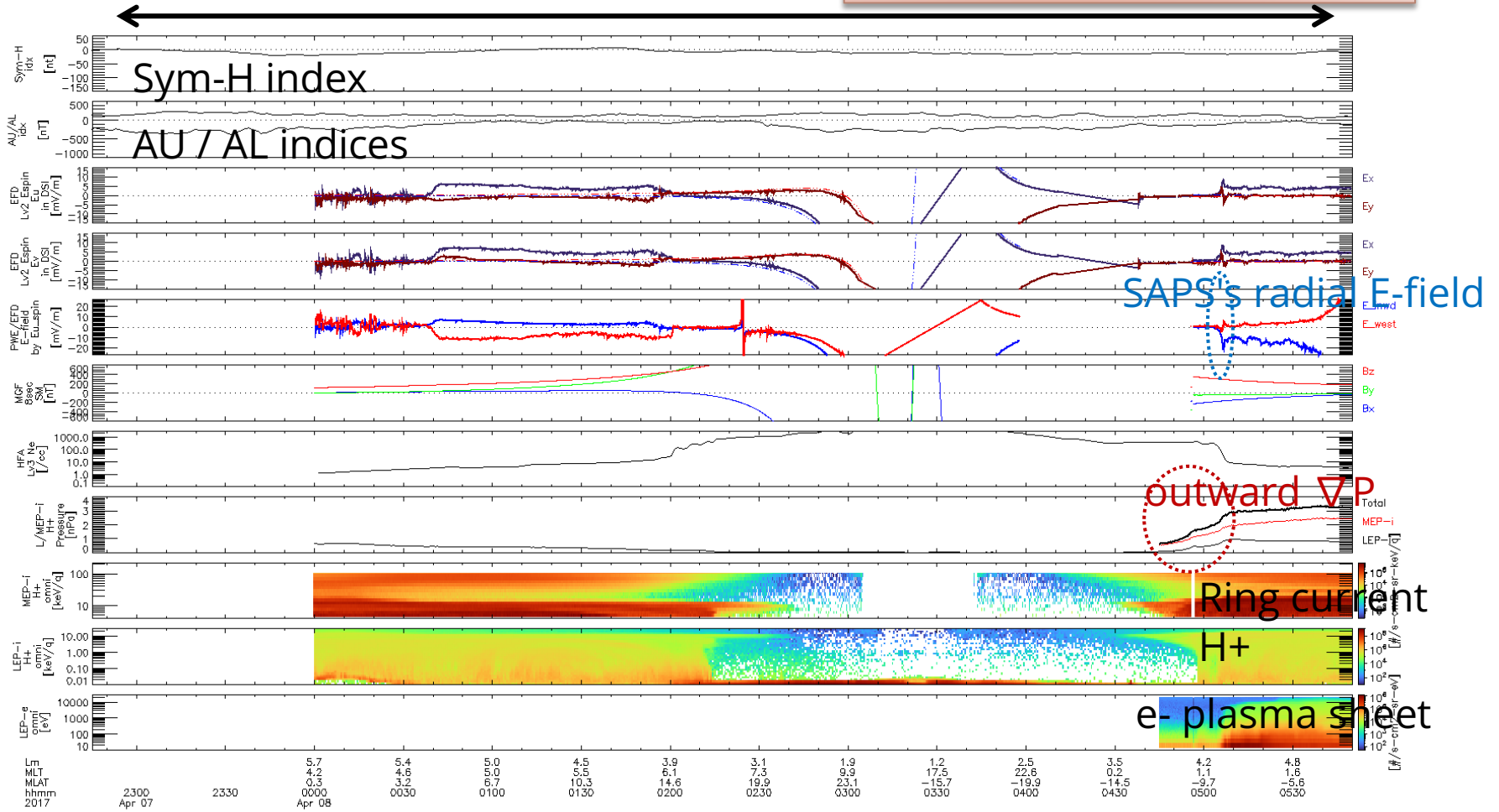
L ~ 6.3

What substorm activity are the SAPS events associated with?



What substorm activity are the SAPS events associated with?

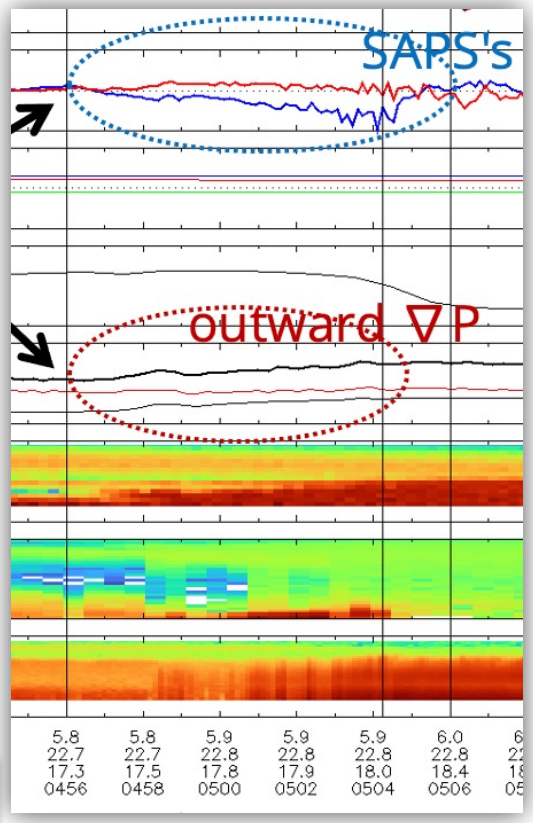
Another SAPS event in which ∇P extended further inward



Preliminary statistics have revealed…

- Events in which SAPS inner edge matches with the RC inner edge are associated with:
  - an **isolated** substorm
  - the **largest** substorm during last ~10 hours
  - Unclear/undetermined for 2 events

  → consistent with our expectation!



However…,
SAPS events with inward-extended RC follow a variety of substorm history:
- pre-existing substorm activity
- isolated substorm

Summary and conclusions

- The inner edge of the ion ring current population matches well with that of SAPS in some cases, while they do not in other cases.
- The former SAPS-RC structure would be formed by relatively simple, fresh substorm activity. The latter cases follow some complicated history of substorm / injection.