

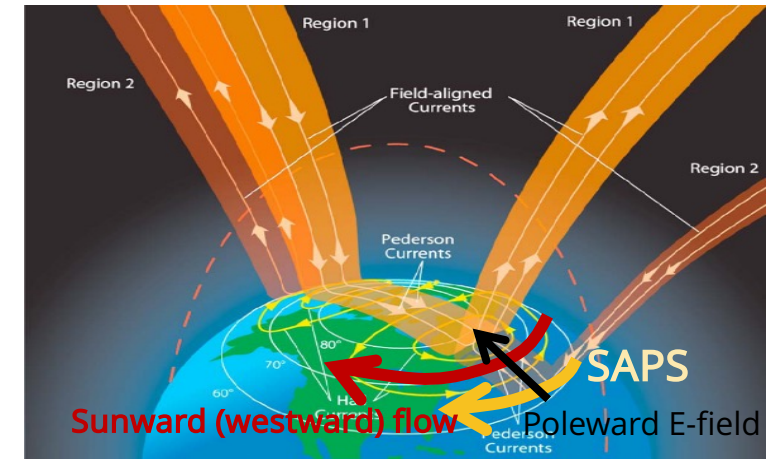
Initial results of the Fall 2023 SuperDARN-Arase conjunction campaign: SAPS and related magnetospheric features

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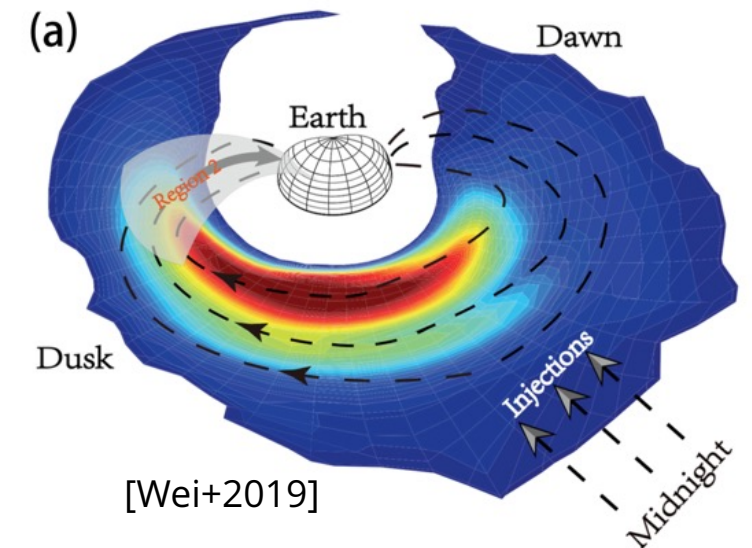
Intro: Subauroral Polarization Streams (SAPS)

SAPS:

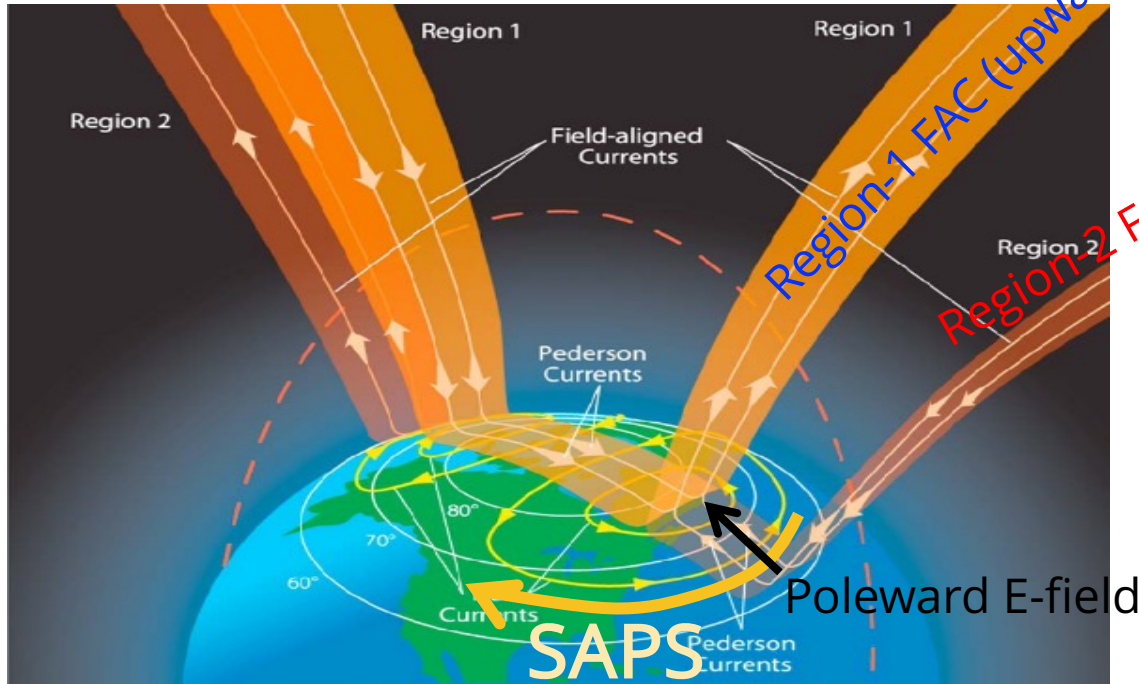
- ▶ A **fast westward flow** formed during geomagnetically disturbed times over **midnight to dusk** in the **subauroral ionosphere** [e.g., Foster and Burke, 2002]
- ▶ SAPS can appear **at mid-latitudes during very disturbed times** such as magnetic storms [e.g., Oksavik+2006, Kataoka+2008].



Le, Slavin and Strangeway [2010], with annotations



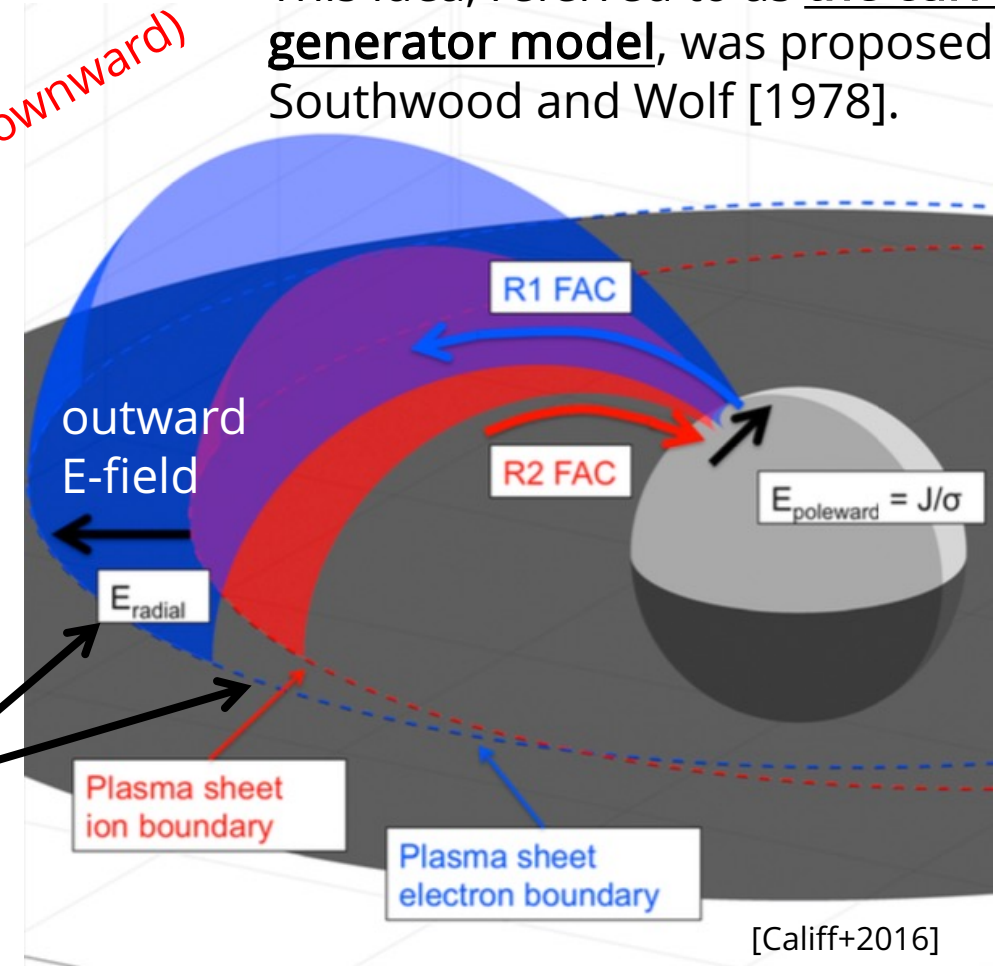
Intro.: Subauroral Polarization Streams (SAPS)



Le, Slavin and Strangeway [2010], with annotations

- ▶ The inward-displaced hot ions drive the **downward R2 FAC** and the **poleward** (radially-outward in m'sphere) **E-field**.

This idea, referred to as **the current generator model**, was proposed by Southwood and Wolf [1978].



Intro.:

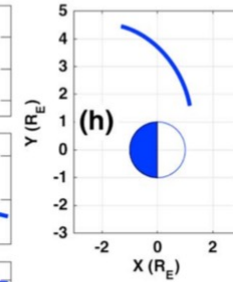
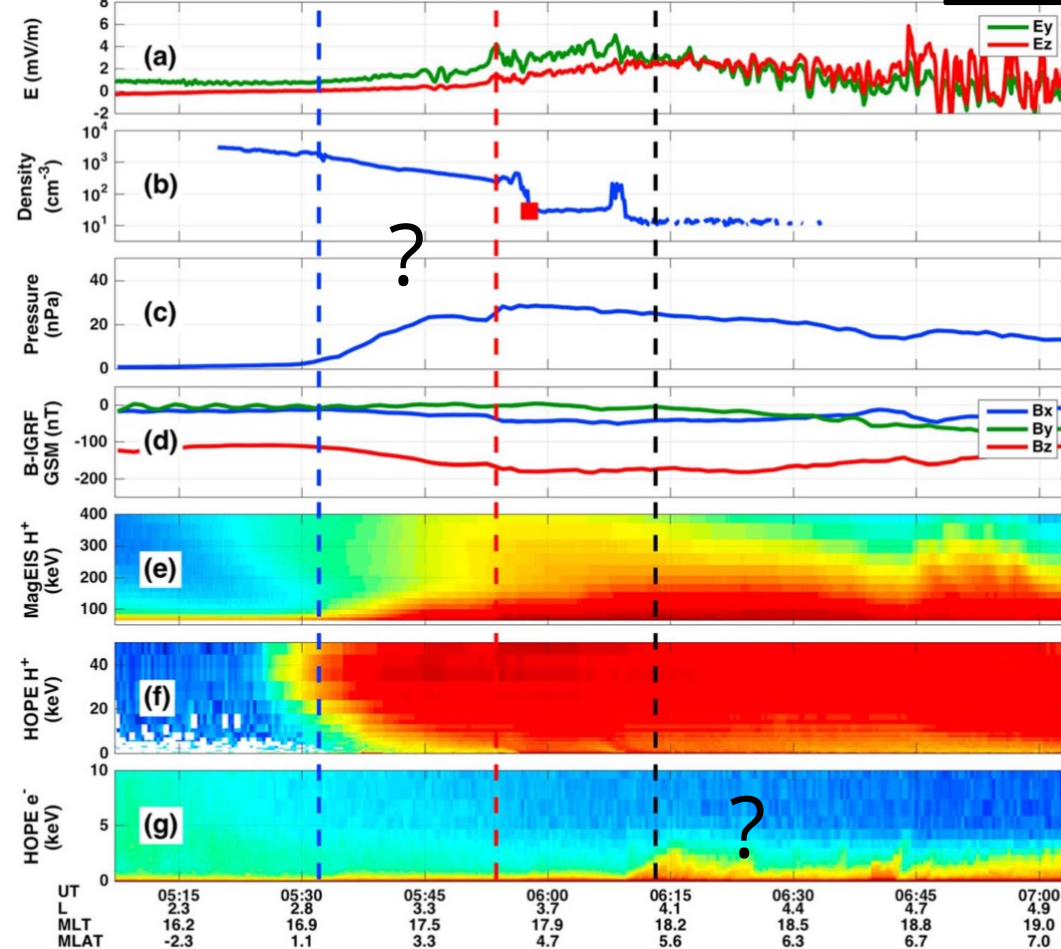
SAPS E-field and particle boundaries as seen in the equatorial magnetosphere on dusk



E-field

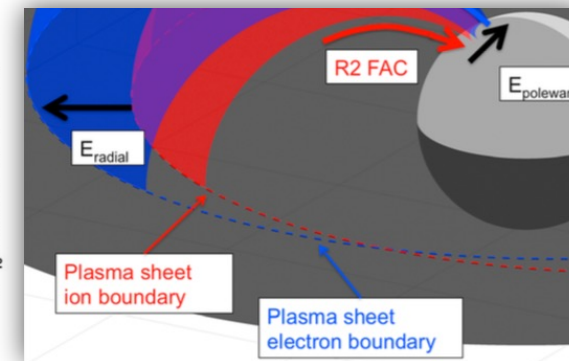
[Califf+2016] ← SAPS → Just before the recovery phase

Pass 3: RBSP B 2013-06-29 05:07 - 2013-06-29 07:04



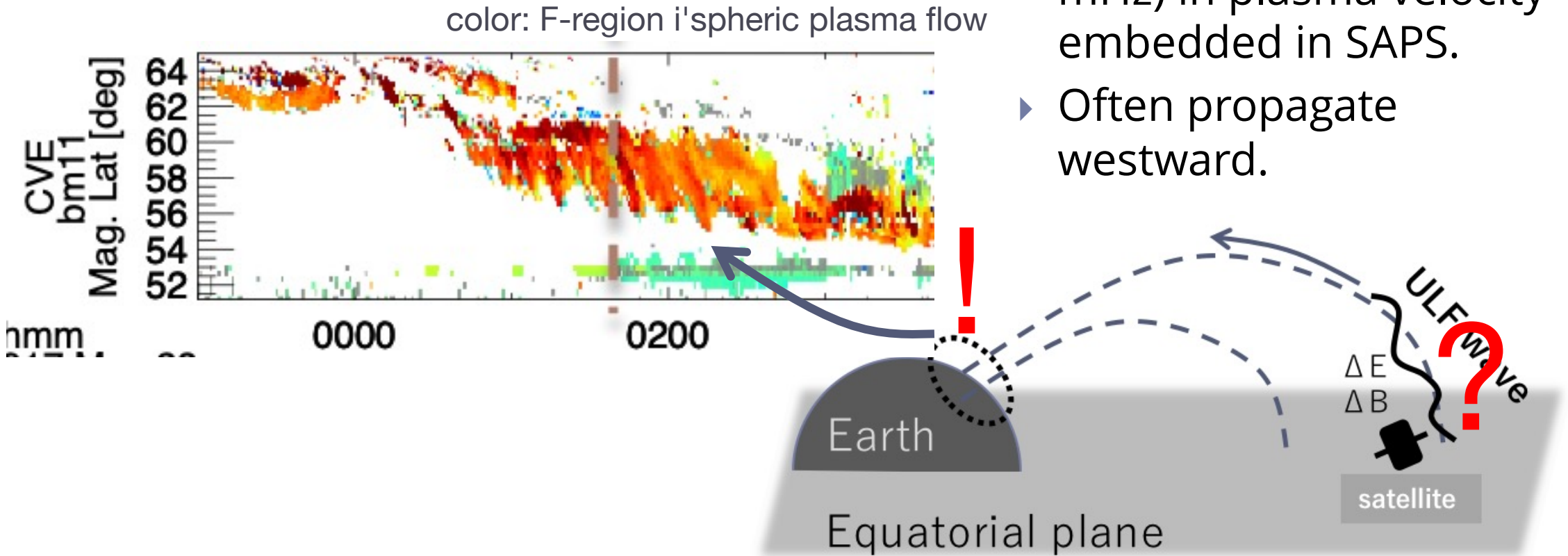
H^+

e^-



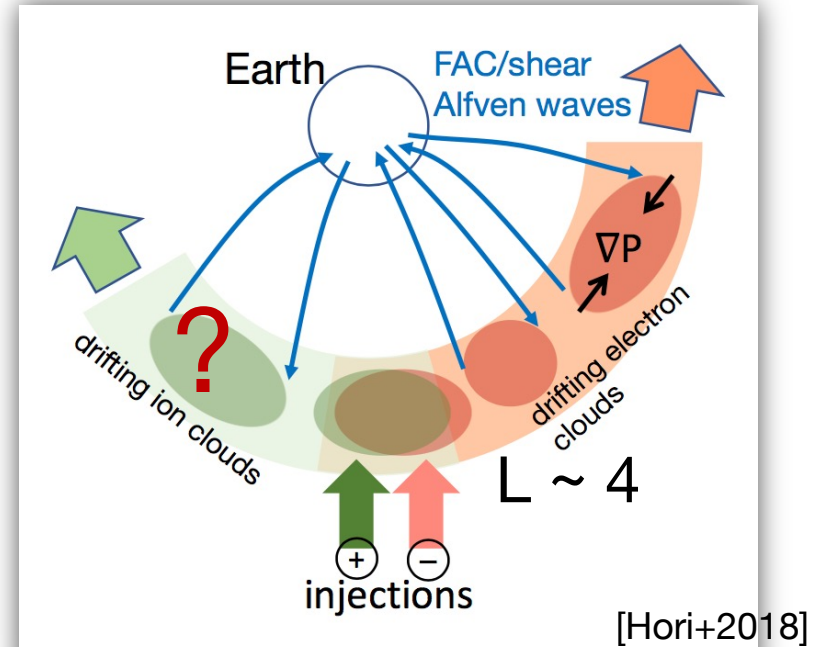
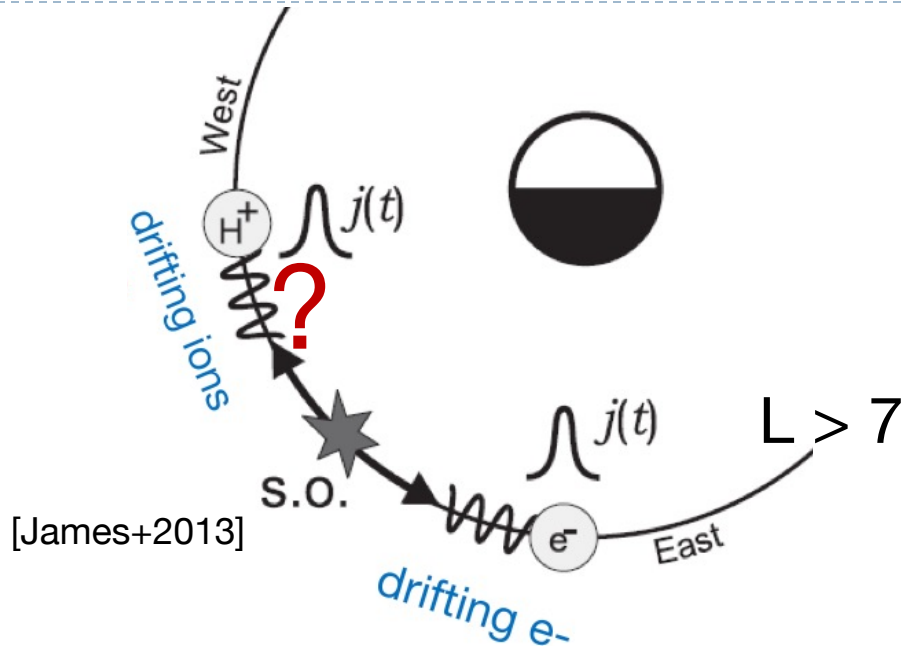
Intro.:

SAPS wave structure (SAPSWs): dynamically varying SAPS



- ▶ Fluctuations ($f \sim 10^0 - 10^1$ mHz) in plasma velocity embedded in SAPS.
- ▶ Often propagate westward.

Intro.: What causes SAPSWS seen by SDs?



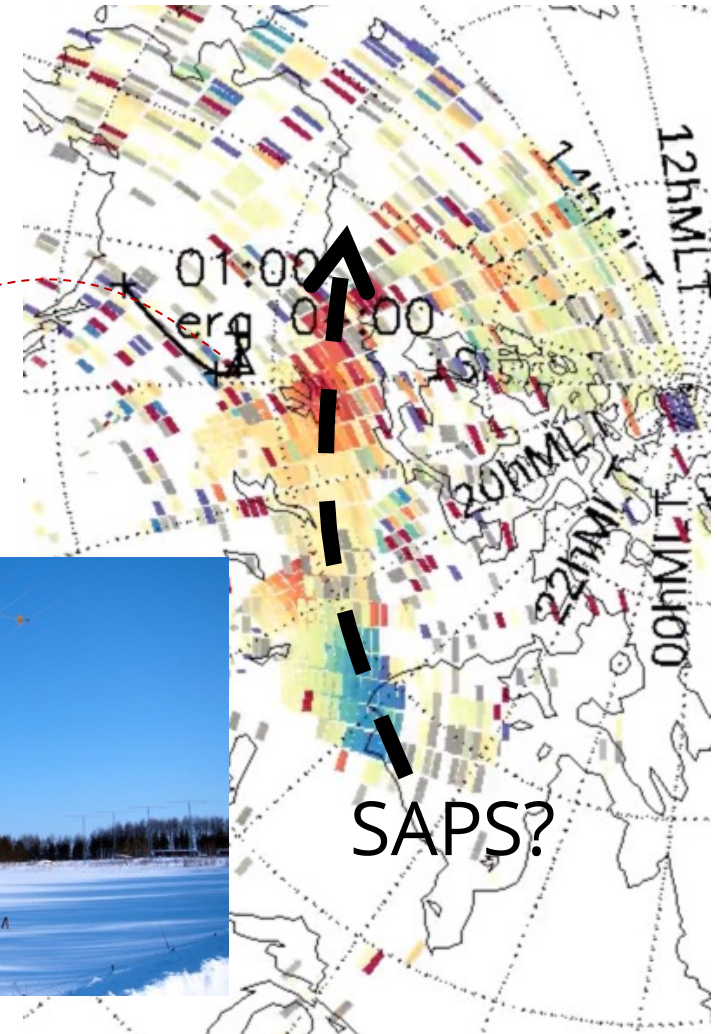
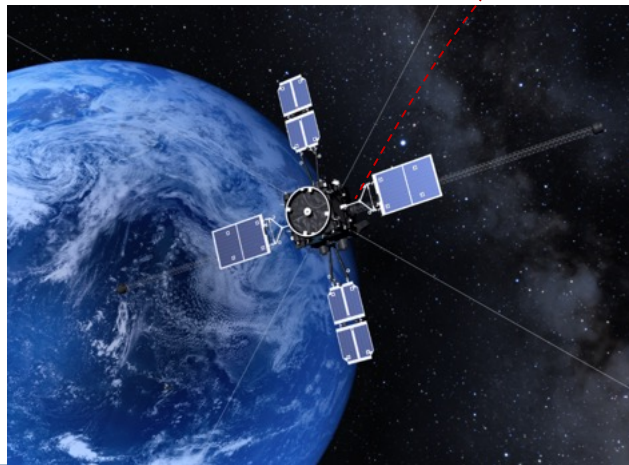
Possible drive mechanisms that have been proposed are:

- ▶ **Driven coherent wave: via drift resonance [e.g., James+2013]**
 - ▶ Bump-on-tail distribution? ($\partial f / \partial W > 0$)
 - ▶ radially inward gradient of phase space density ($\partial f / \partial L < 0$)
- ▶ **Not coherent wave:**
 - ▶ Pressure bumps by multi-injections [e.g., Hori+2018]
 - ▶ SAPS wave structure (SAPSWS) [e.g., Mishin+2003, Makarevich+2014]



Our approach: Arase-SuperDARN campaign observations

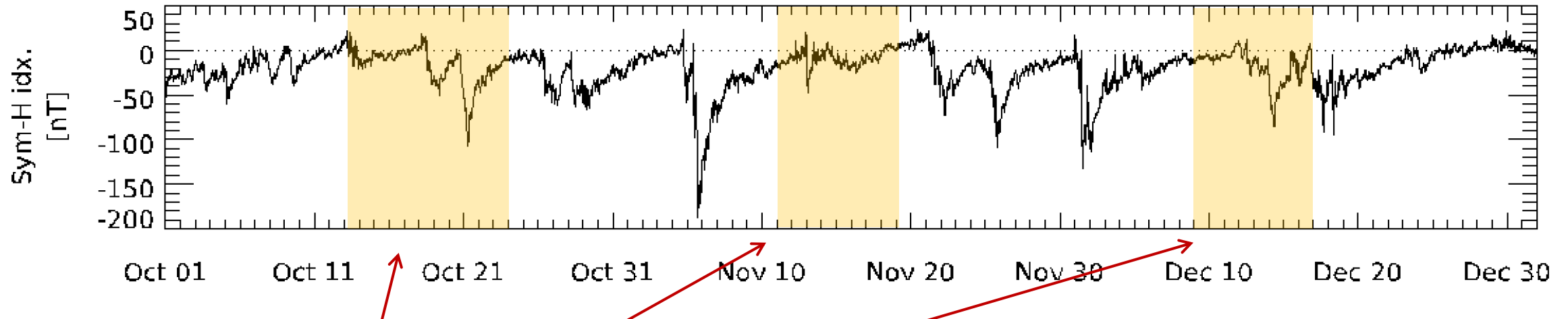
Some researchers and SD PIs in Japan conducted **campaign observations with SD and Arase in Fall 2022 and 2023**. Well coordinated campaigns have achieved a dozen (even more?) of good conjunction observations.





2023 Fall SuperDARN-Arase campaign observations

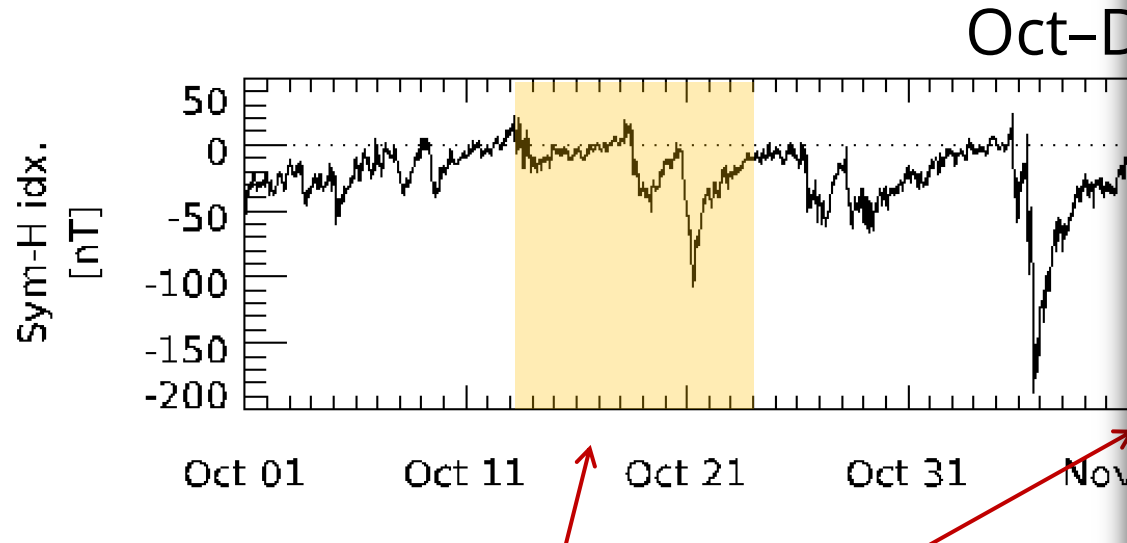
Oct-Dec, 2023



Campaign observations: several days / month

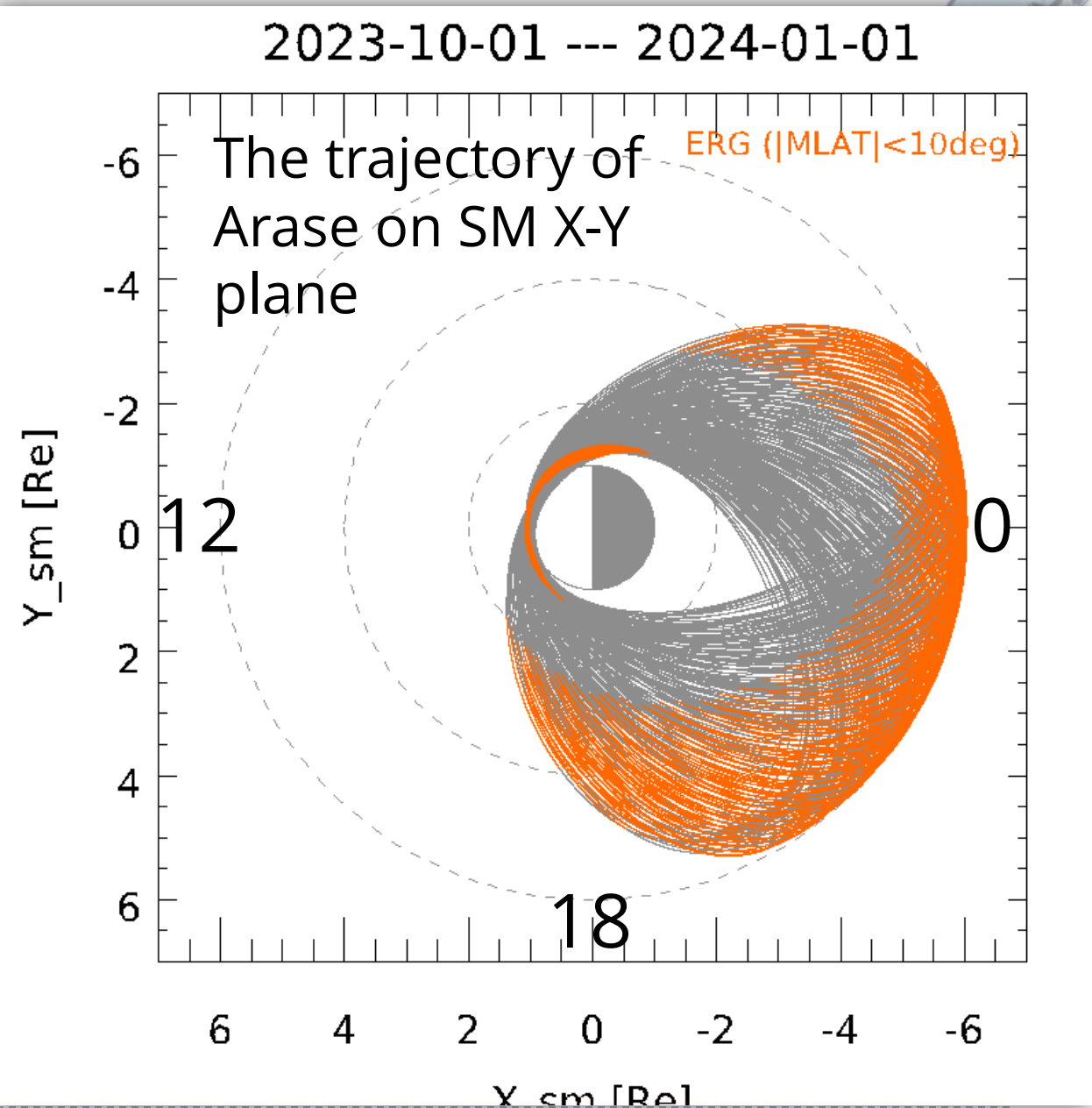
- SuperDARN: operated with interleaved normal scan
- Arase: MEP-i and LEP-i operated with the normal mode (3-D flux distri.)

2023 Fall SuperDARN-Arase campaign



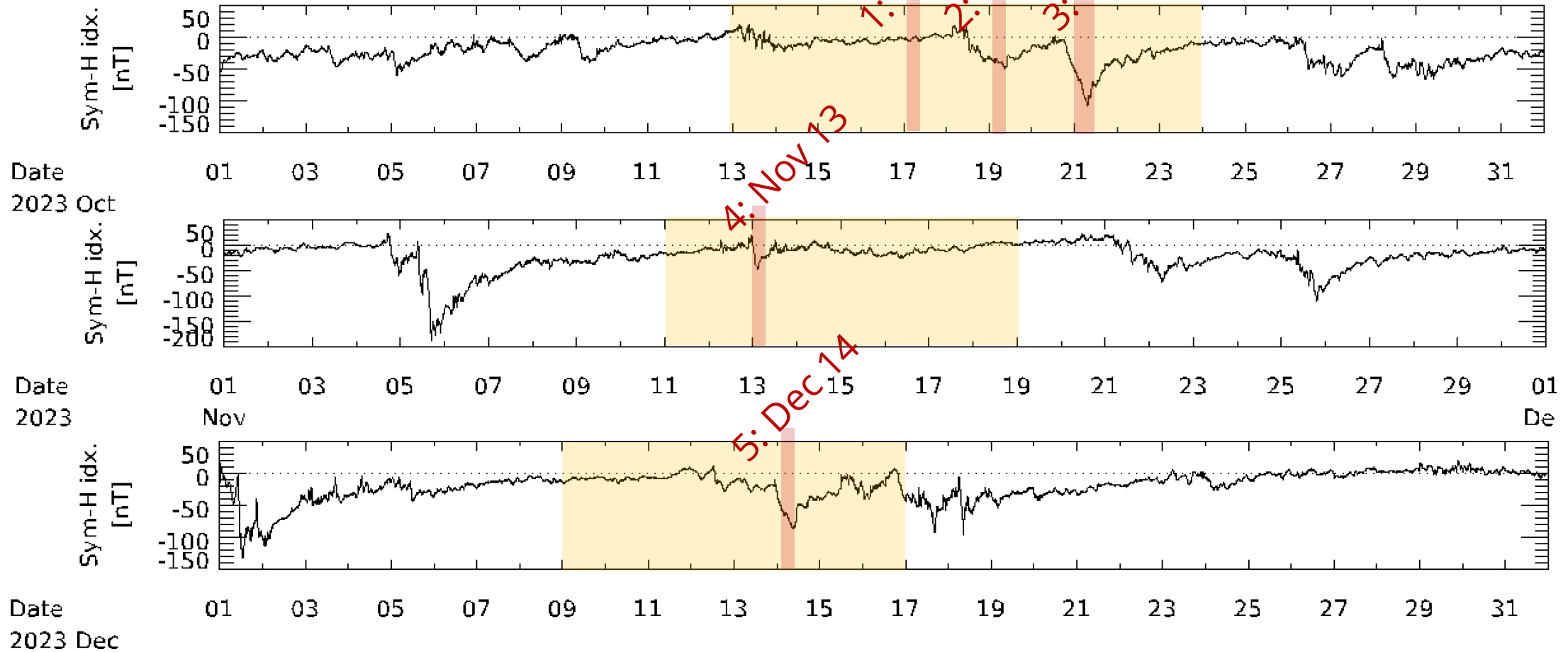
Campaign observations:

- SuperDARN: operated with interl
- Arase: MEP-i and LEP-i operated





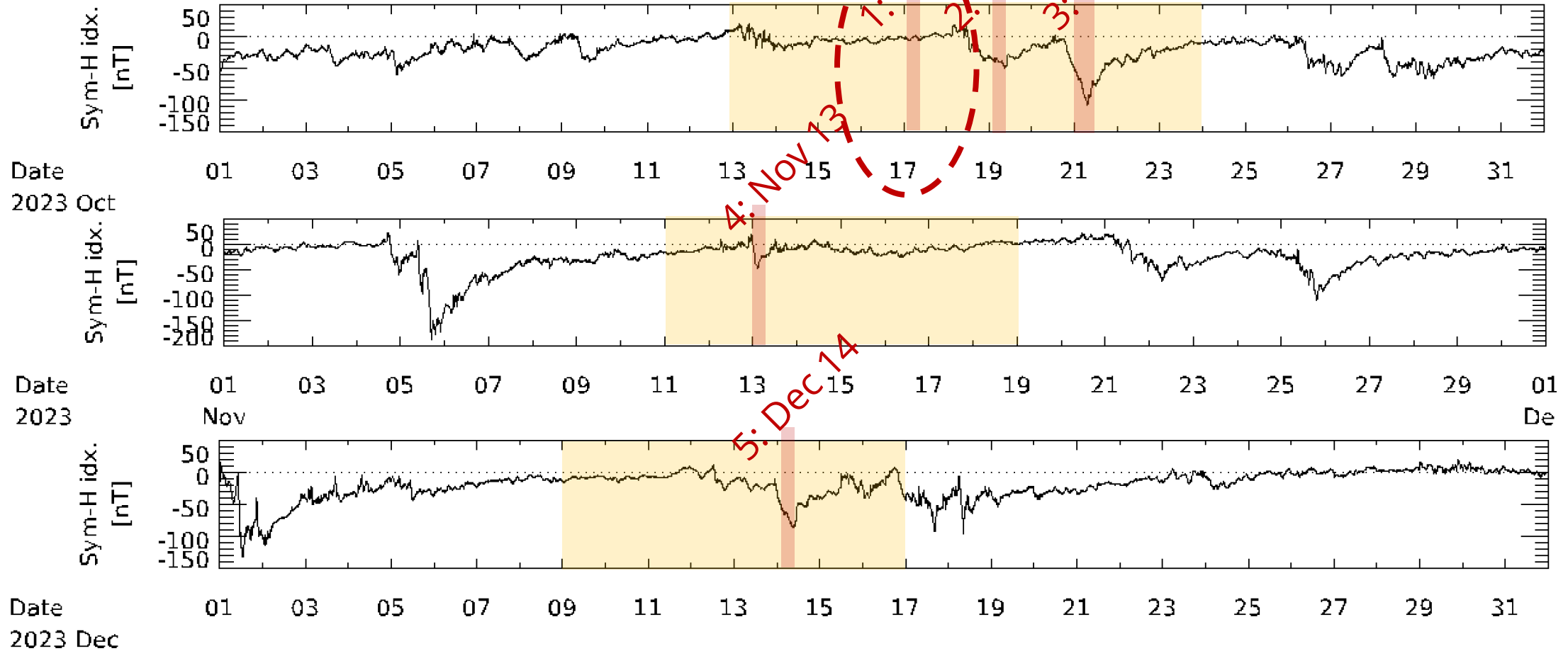
SAPS(W)S and westward fast flow events identified



The most critical factor: how much **SD echoes** obtained and **how close Arase** located

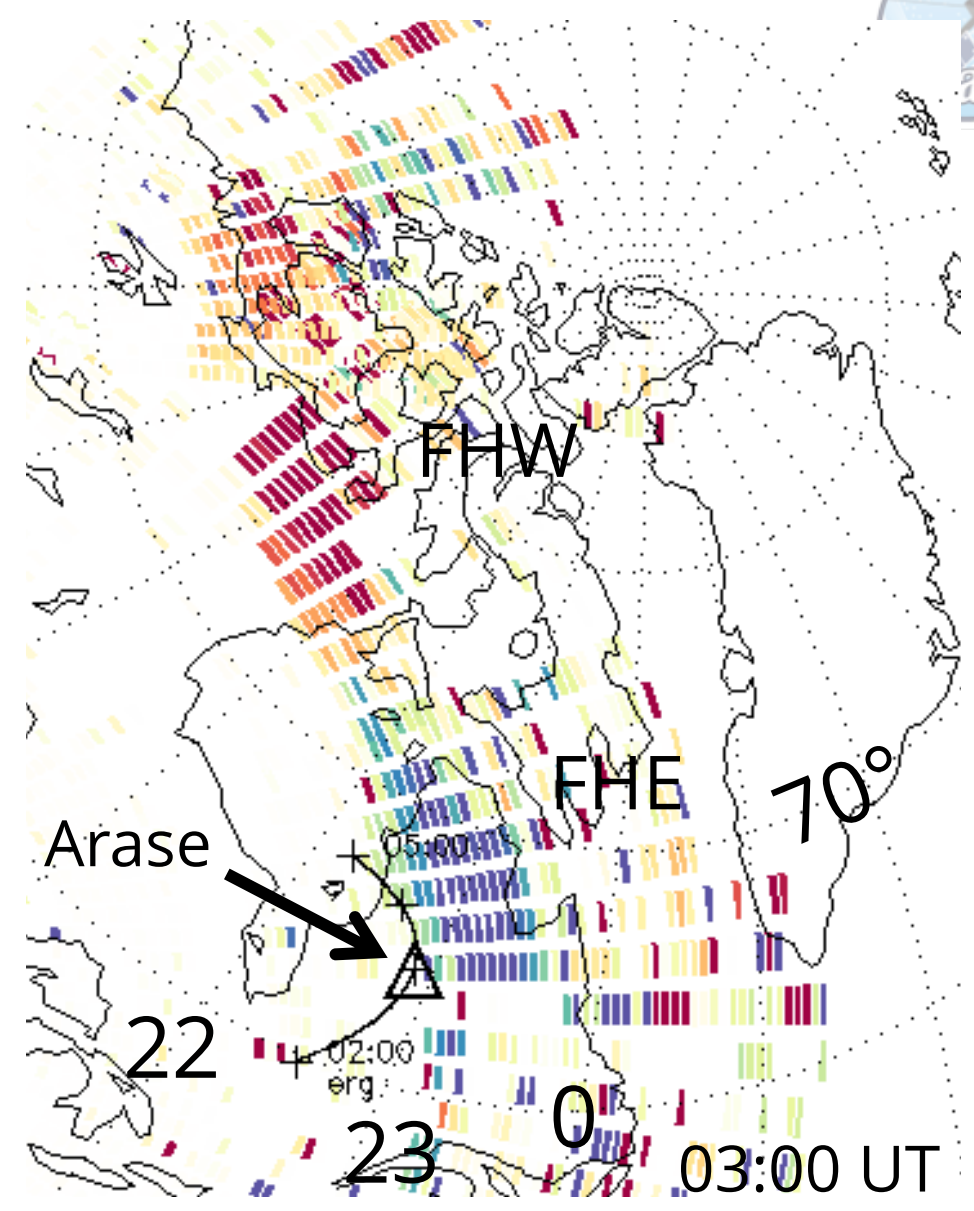
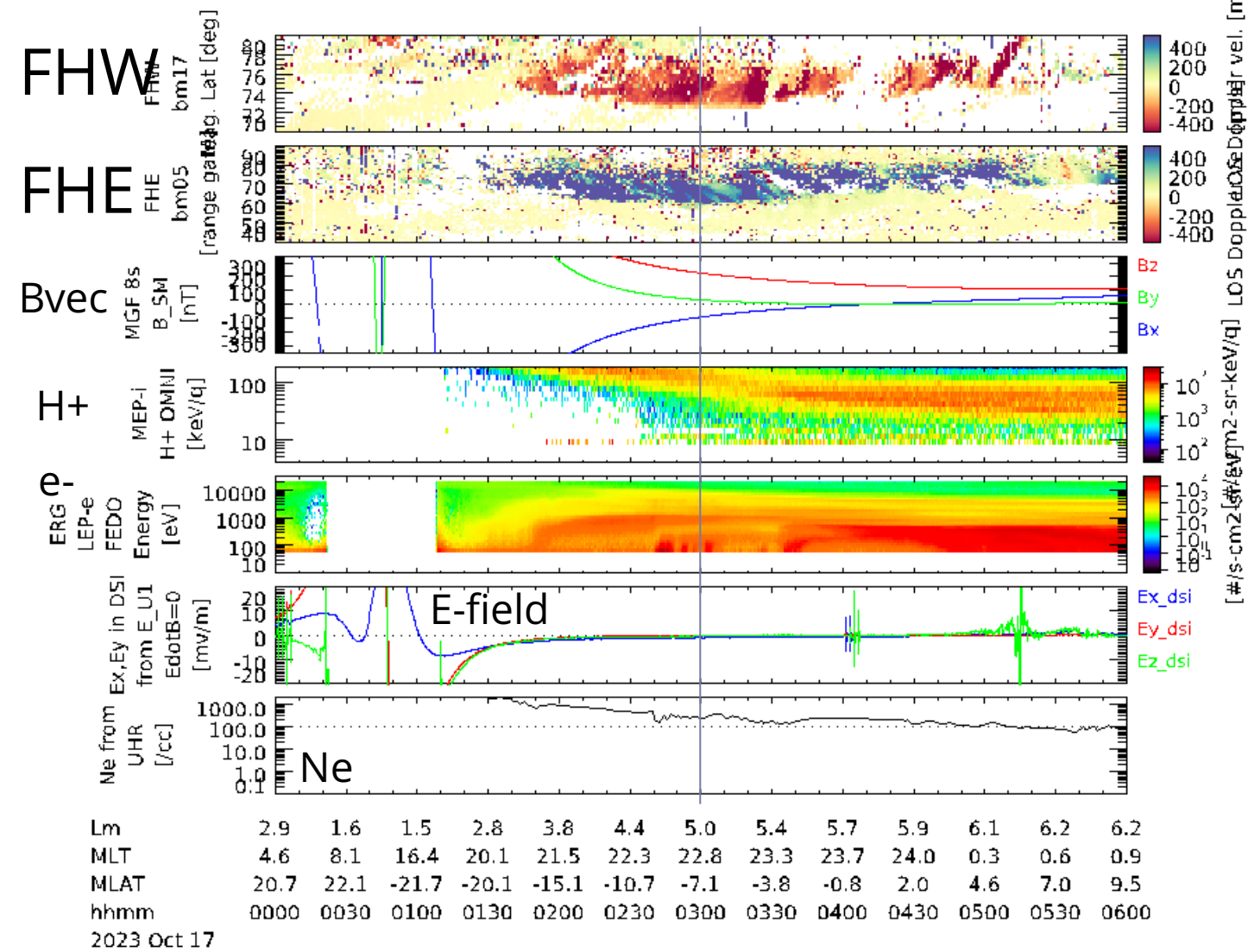


SAPS(W)S and westward fast flow events identified



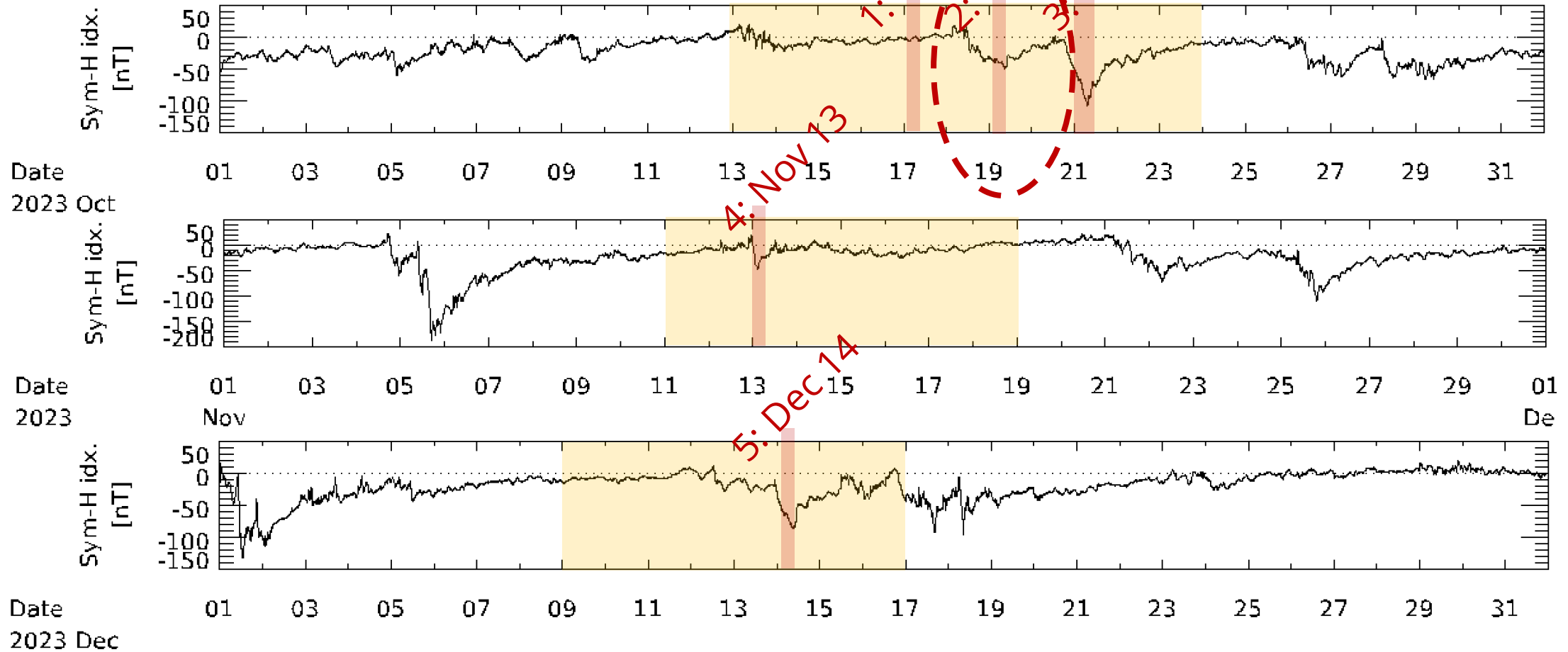
The most critical factor: how much **SD echoes** obtained and **how close Arase** located

Event 1: Oct. 17, 2023



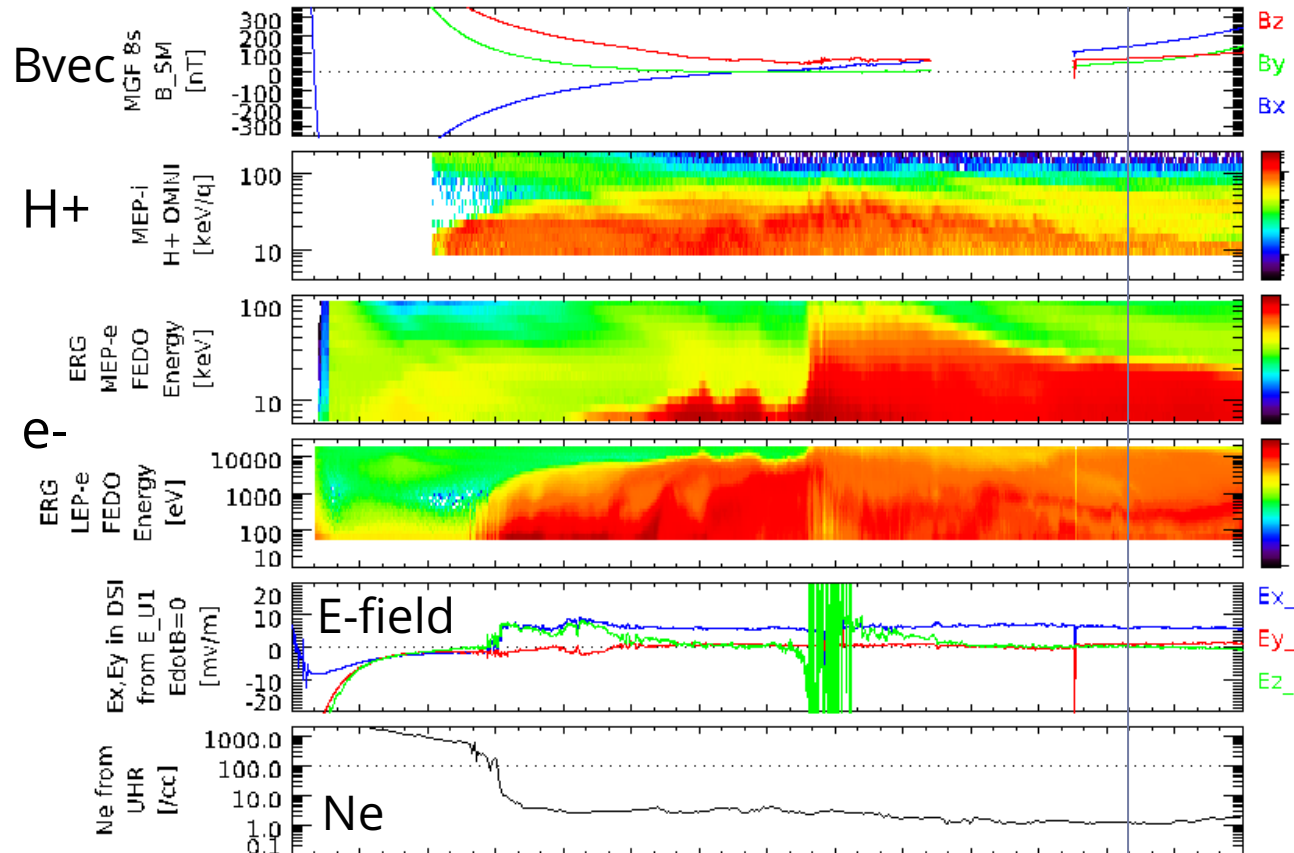


SAPS(W)S and westward fast flow events identified

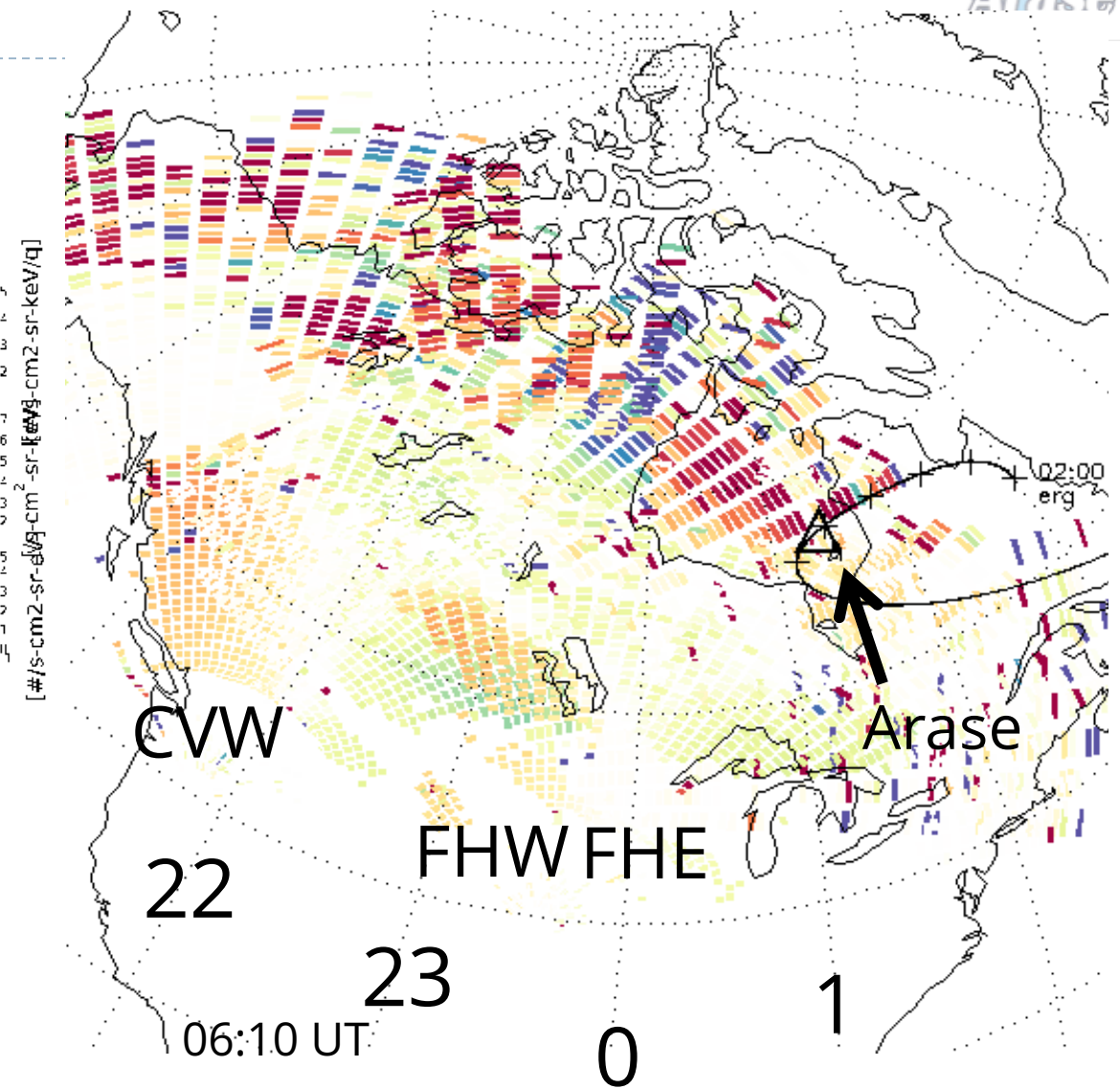


The most critical factor: how much **SD echoes** obtained and **how close Arase** located

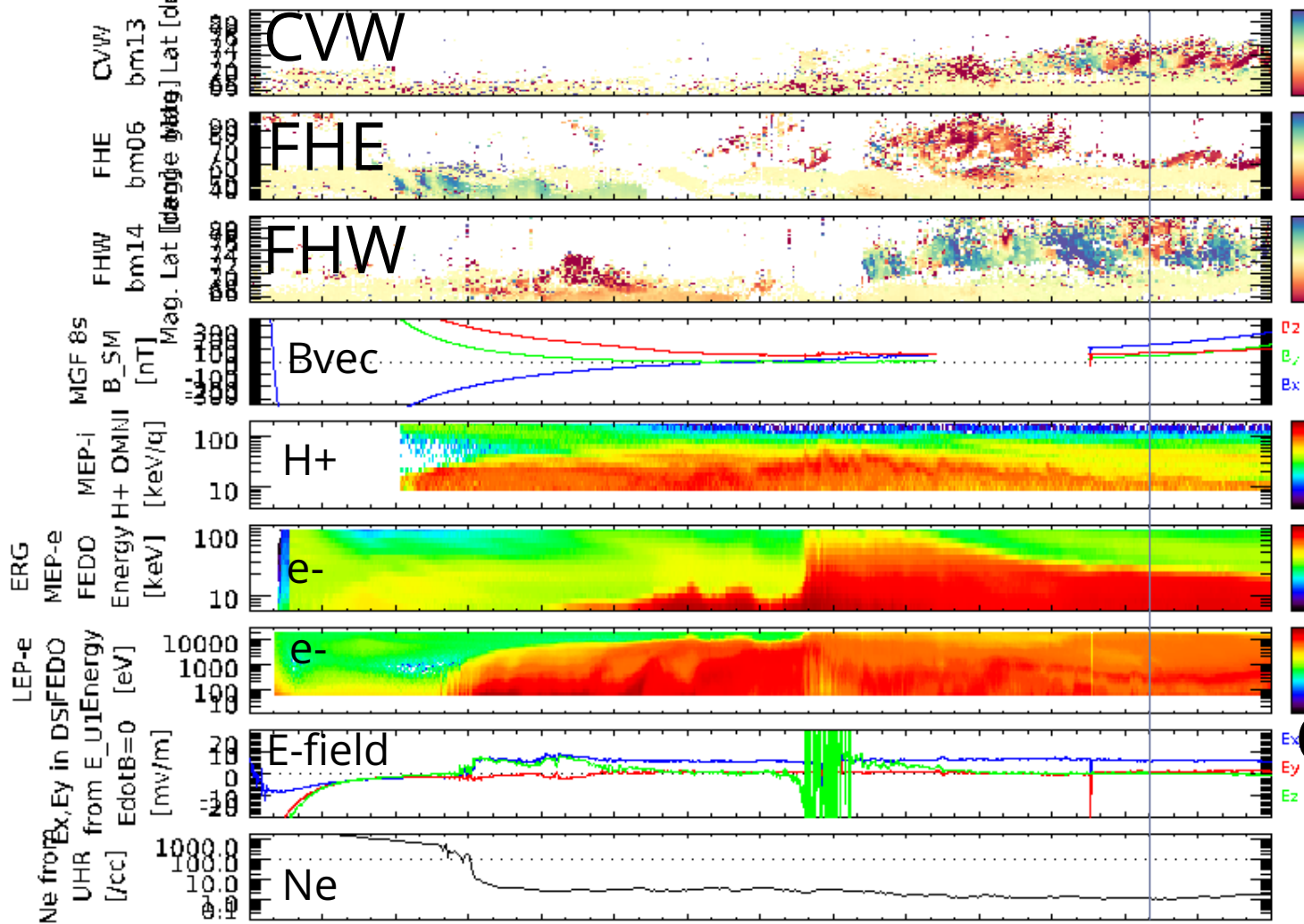
Event 2: Oct. 19



Lm	1.4	2.8	3.7	4.4	4.9	5.4	5.7	5.9	6.1	6.2	6.3	6.2	6.1	5.9	5.6
MLT	15.8	19.8	21.2	22.1	22.6	23.1	23.5	23.8	0.1	0.4	0.7	1.0	1.3	1.7	2.1
MLAT	-18.5	-20.4	-16.1	-11.7	-7.8	-4.3	-1.2	1.7	4.5	7.1	9.8	12.5	15.3	18.4	21.8
hhmm	0000	0030	0100	0130	0200	0230	0300	0330	0400	0430	0500	0530	0600	0630	0700

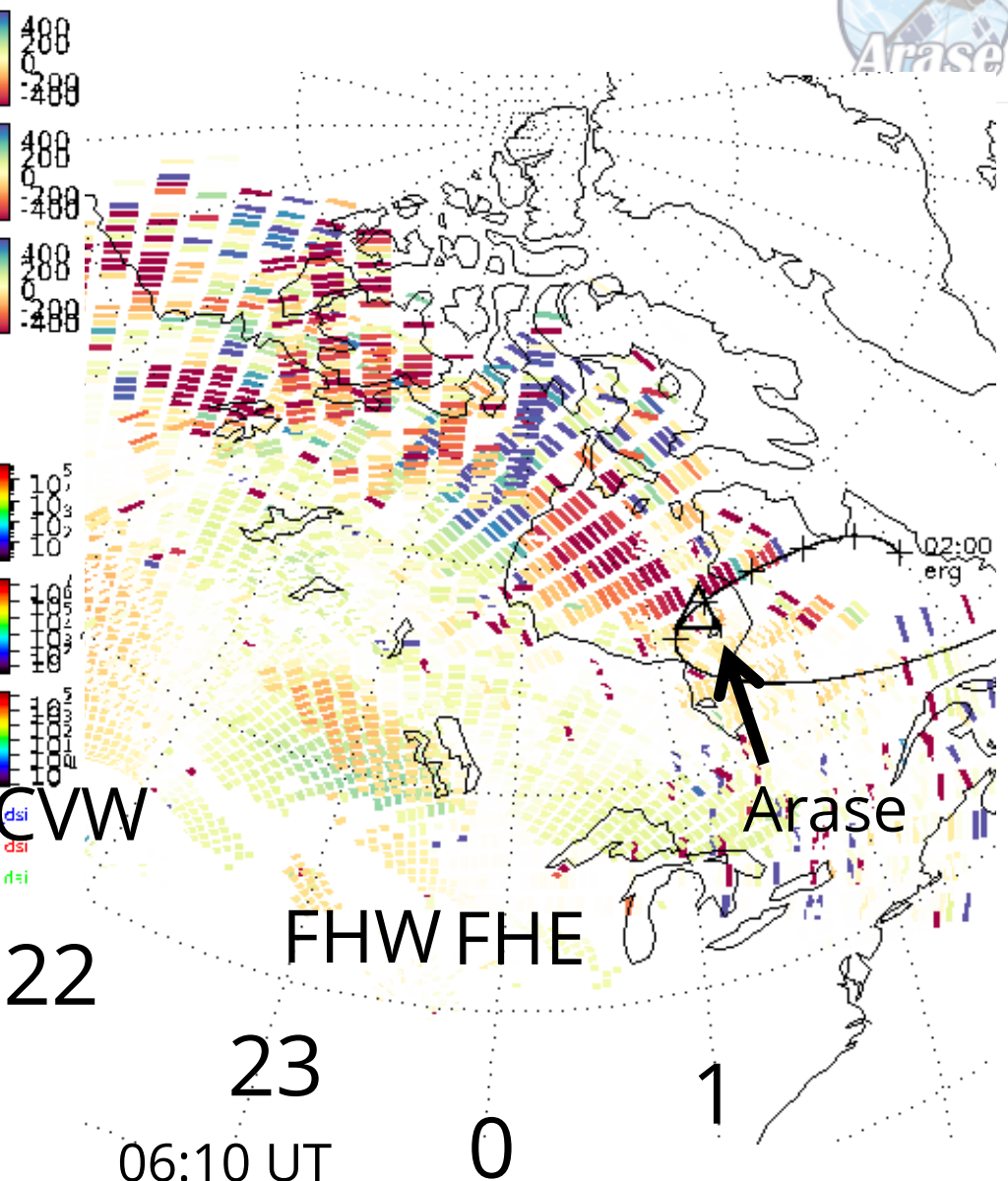


Event 2: Oct. 19



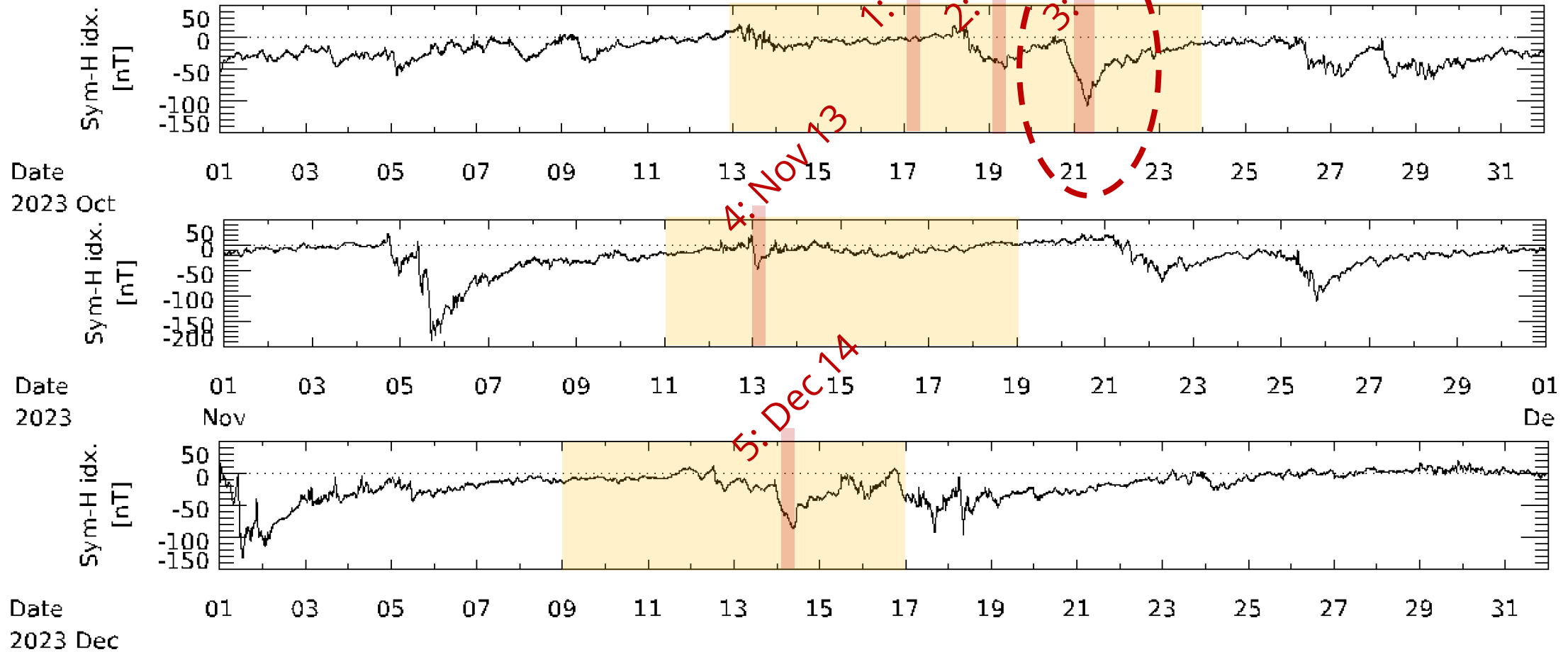
Lm	1.4	2.8	3.7	4.4	4.9	5.4	5.7	5.9	6.1	6.2	6.3	6.2	6.1	5.9	5.6
MLT	15.8	19.8	21.2	22.1	22.6	23.1	23.5	23.8	0.1	0.4	0.7	1.0	1.3	1.7	2.1
MLAT	-18.5	-20.4	-16.1	-11.7	-7.8	-4.3	-1.2	1.7	4.5	7.1	9.8	12.5	15.3	18.4	21.8
hhmm	0000	0030	0100	0130	0200	0230	0300	0330	0400	0430	0500	0530	0600	0630	0700

2023 Oct 19



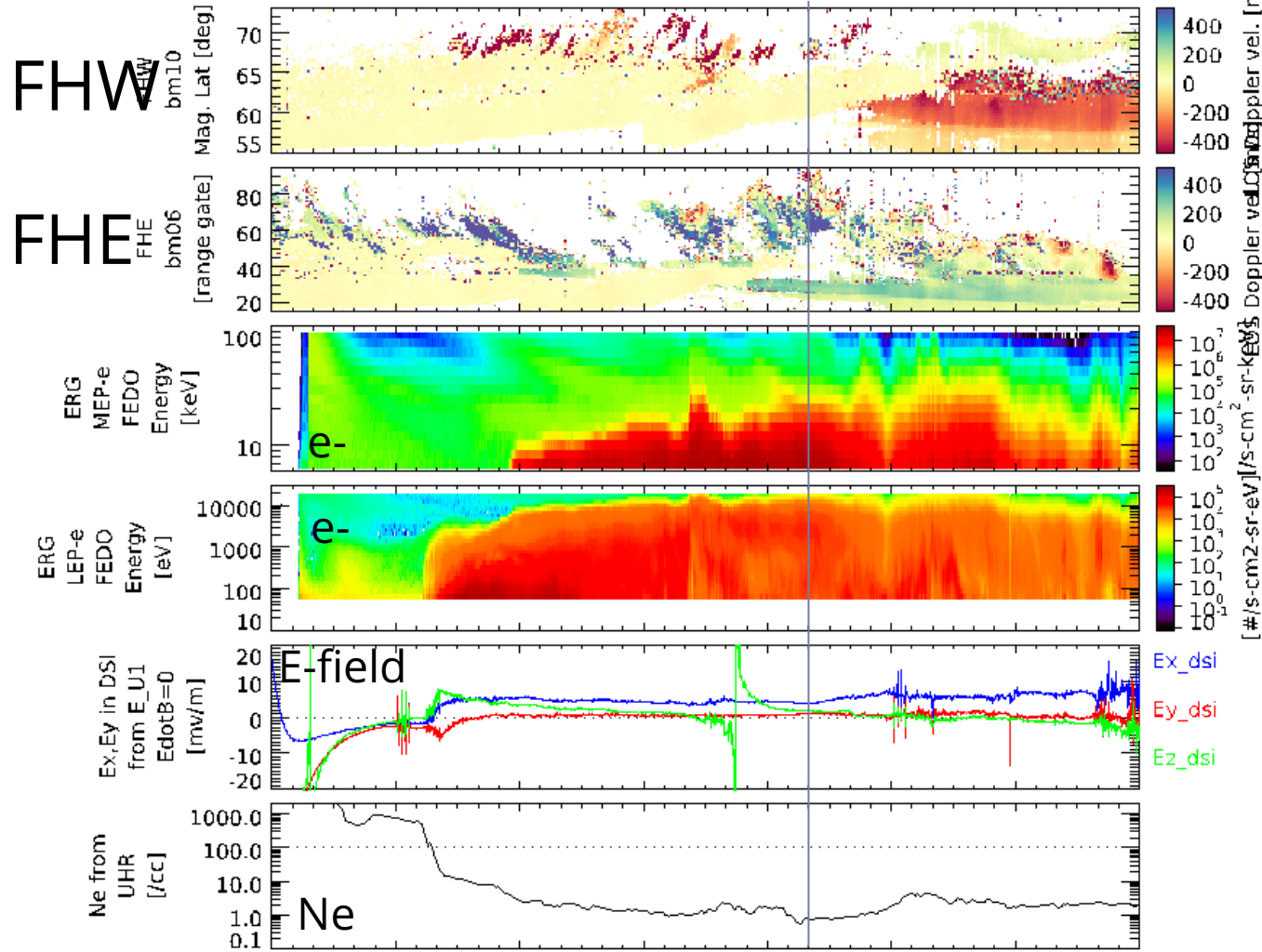


SAPS(W)S and westward fast flow events identified



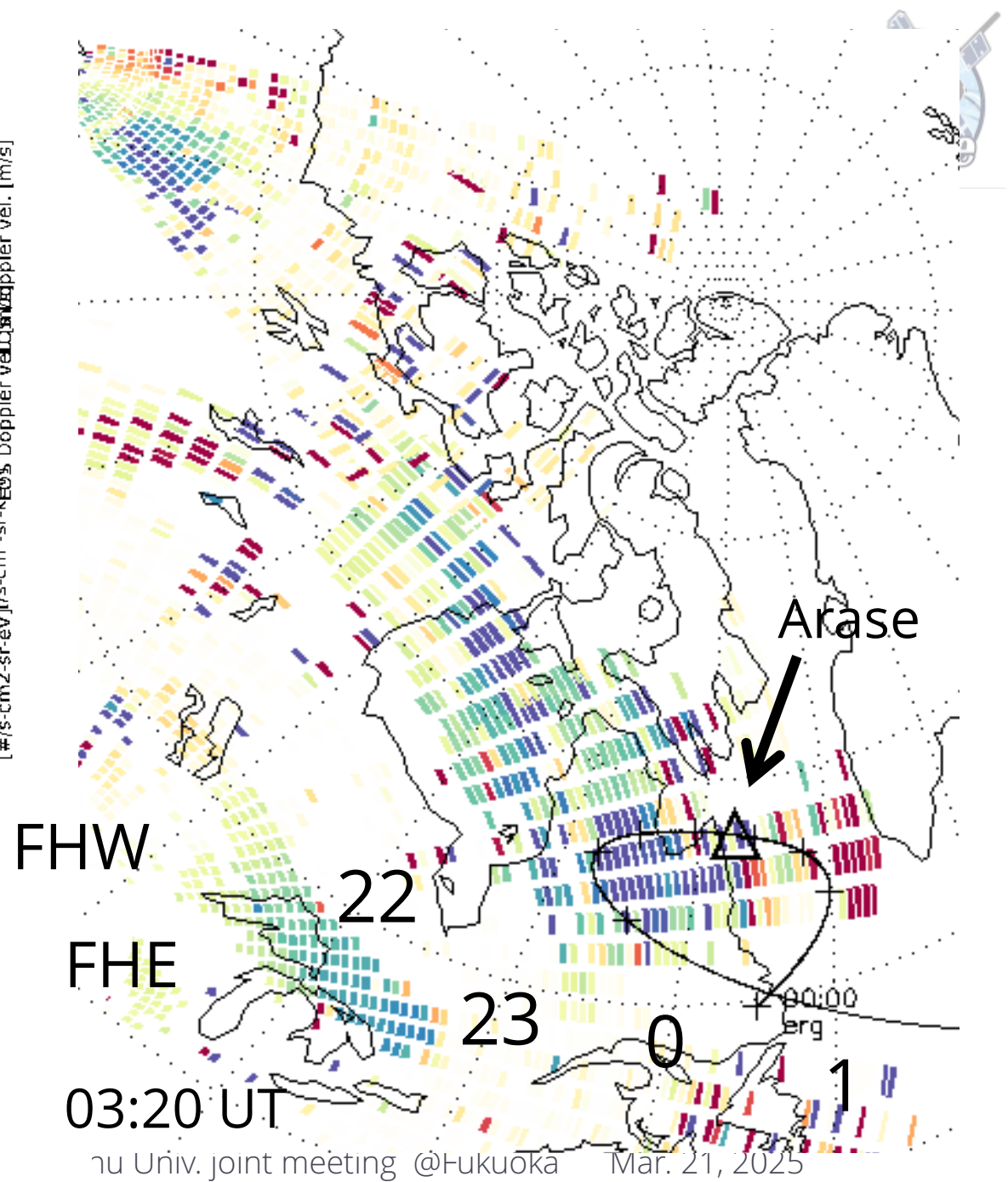
The most critical factor: how much **SD echoes** obtained and **how close Arase** located

Event 3: Oct. 21

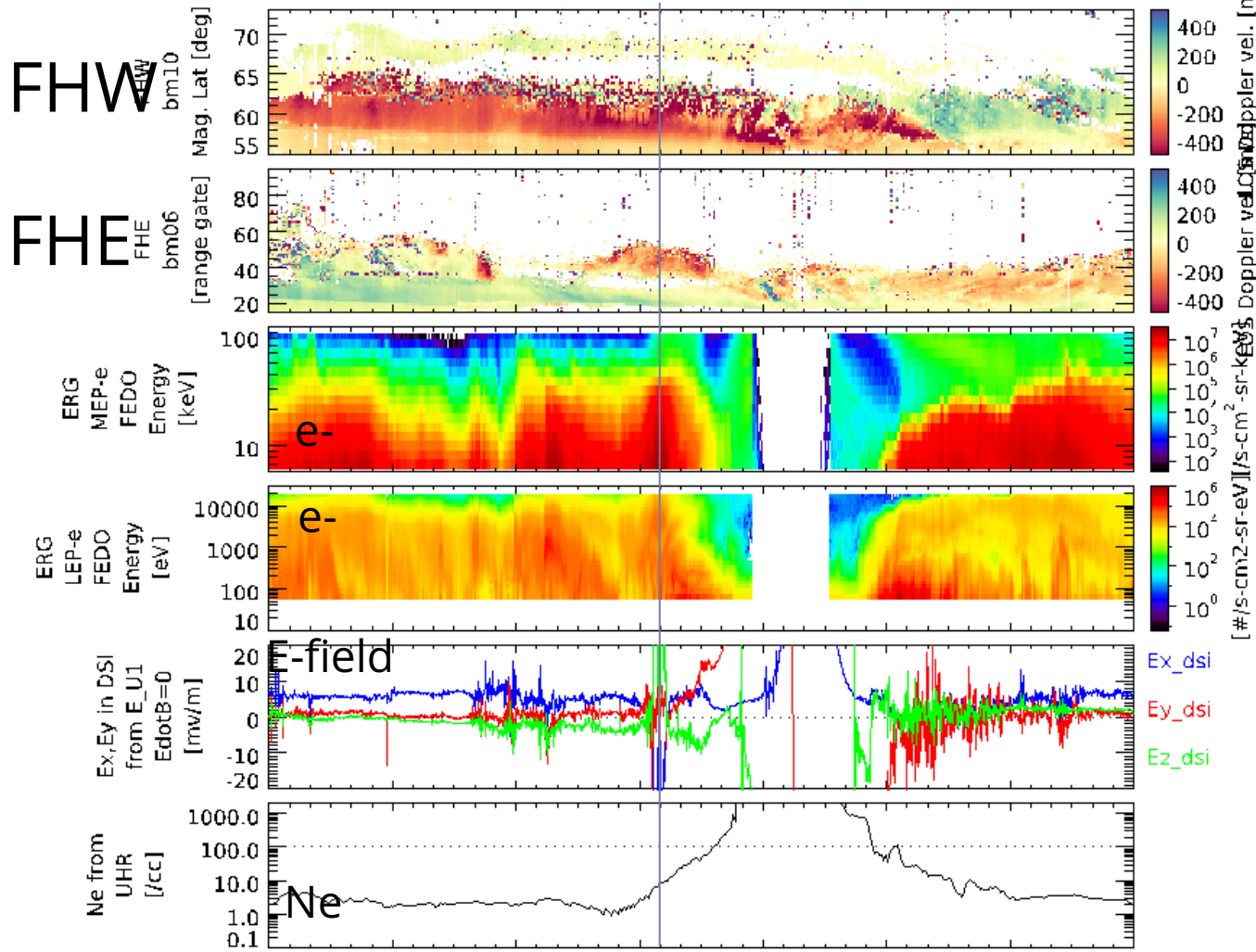


Lm	1.3	3.7	4.9	5.7	6.1	6.3	6.1	5.6
MLT	15.1	21.0	22.5	23.3	23.9	0.6	1.2	2.0
MLAT	-15.2	-17.5	-9.0	-2.1	3.8	9.5	15.2	21.7
hhmm	2300	0000	0100	0200	0300	0400	0500	0600
2023	Oct 20	Oct 21						

[#/s-cm2-sr-eV]/[s-cm2-sr-keV] Doppler vel. [m/s]

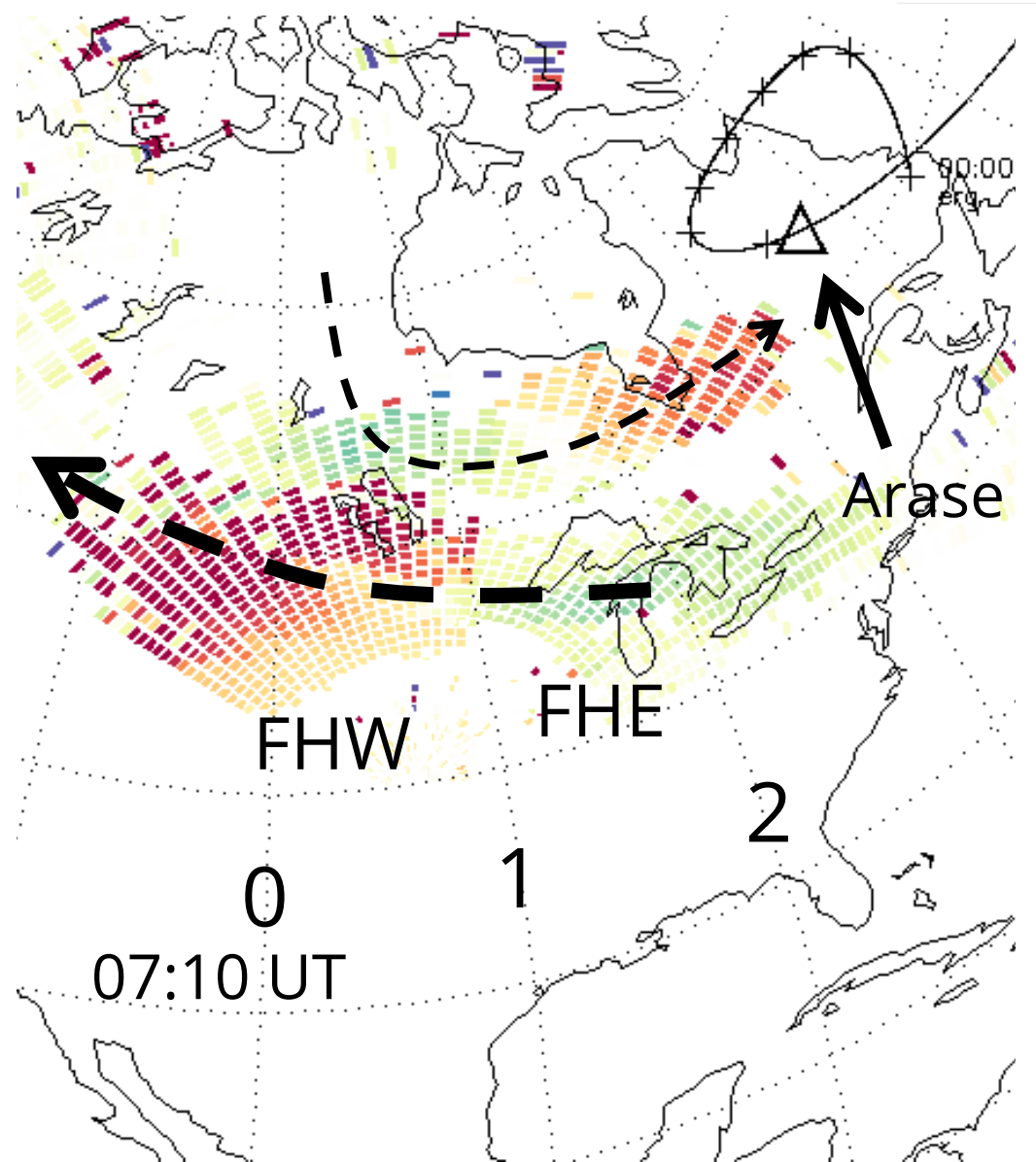


Event 3: Oct. 21



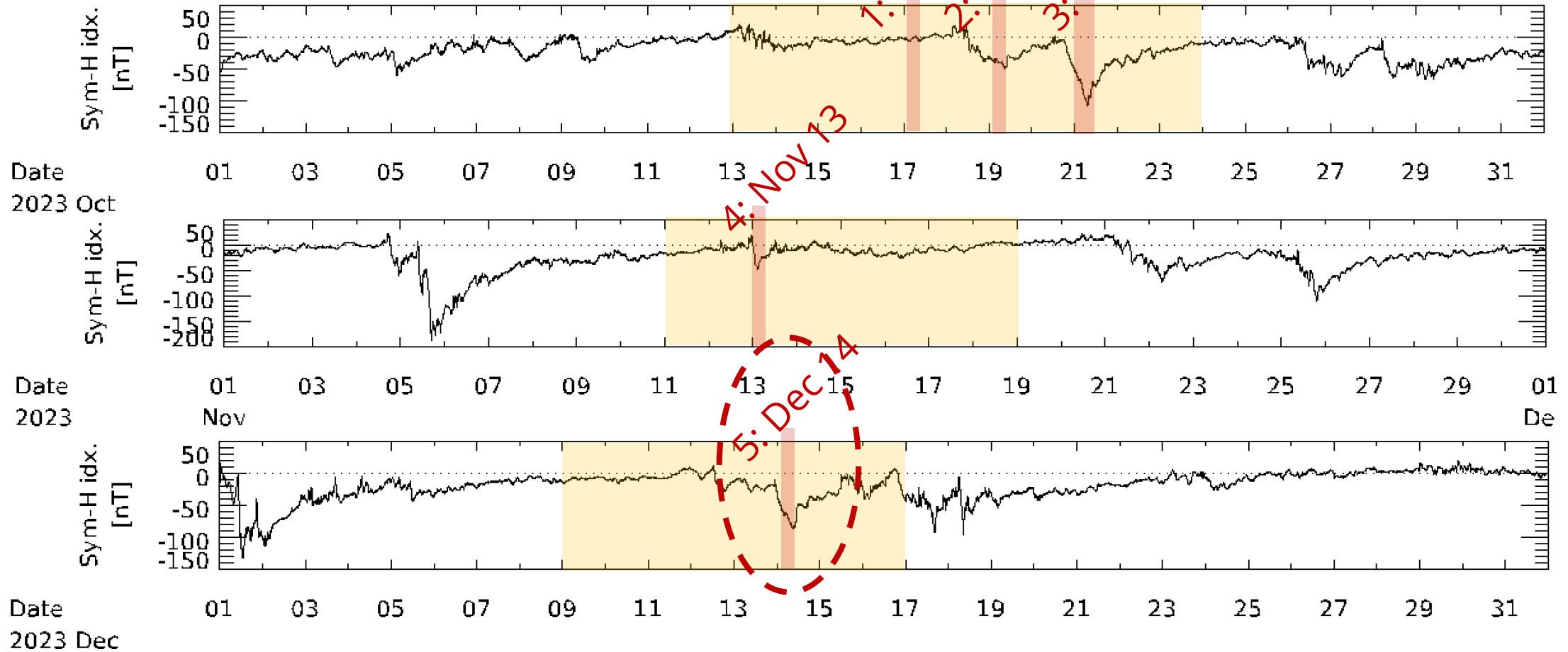
Lm	6.3	6.1	5.6	4.7	1.6	3.8	4.9	5.6
MLT	0.6	1.2	2.0	3.3	8.6	20.6	22.6	23.4
MLAT	9.5	15.2	21.7	30.7	22.8	-35.6	-22.4	-15.6
hhmm	0400	0500	0600	0700	0800	0900	1000	1100
2023 Oct 21								

Arase missed
this beautiful flow complex...



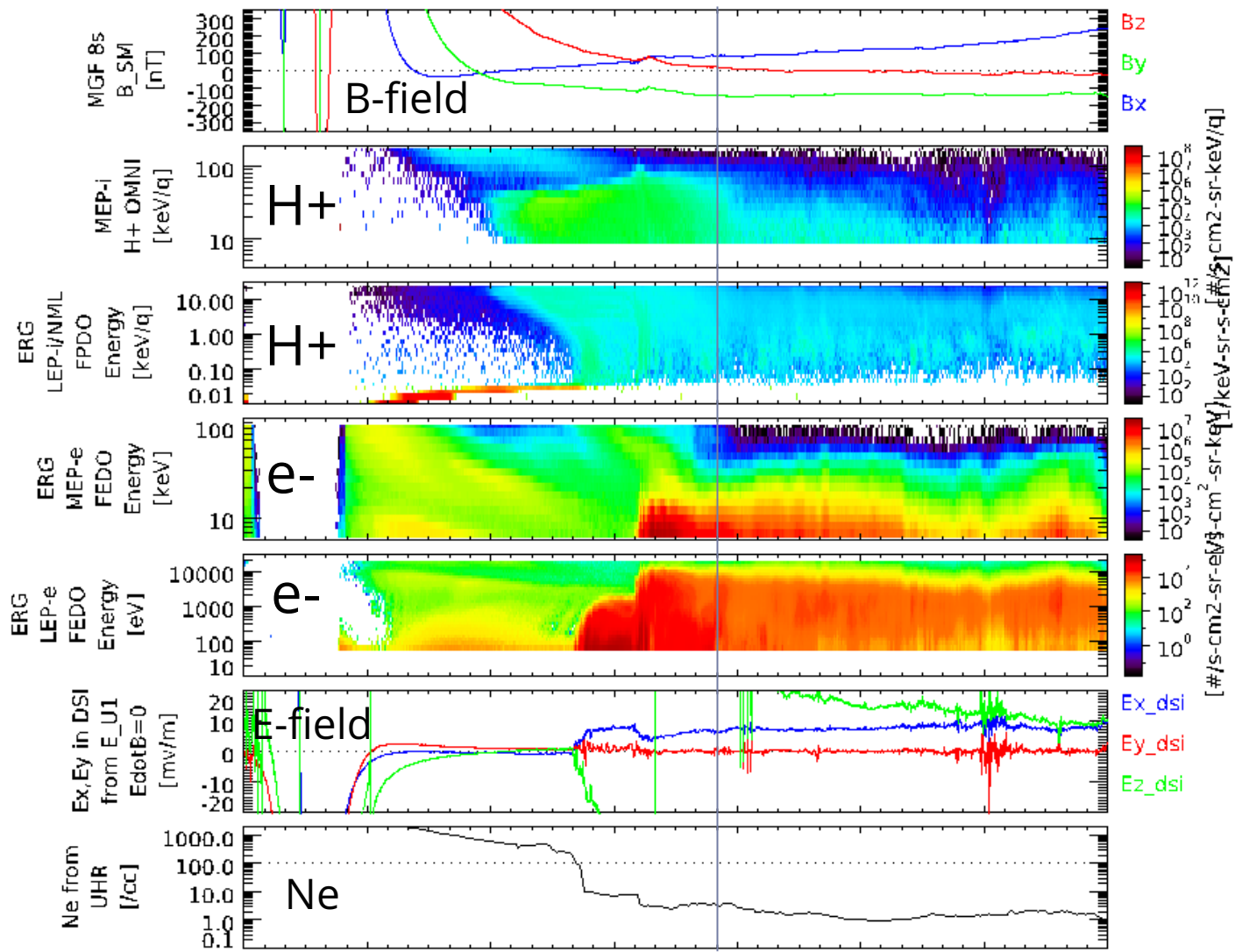


SAPS(W)S and westward fast flow events identified

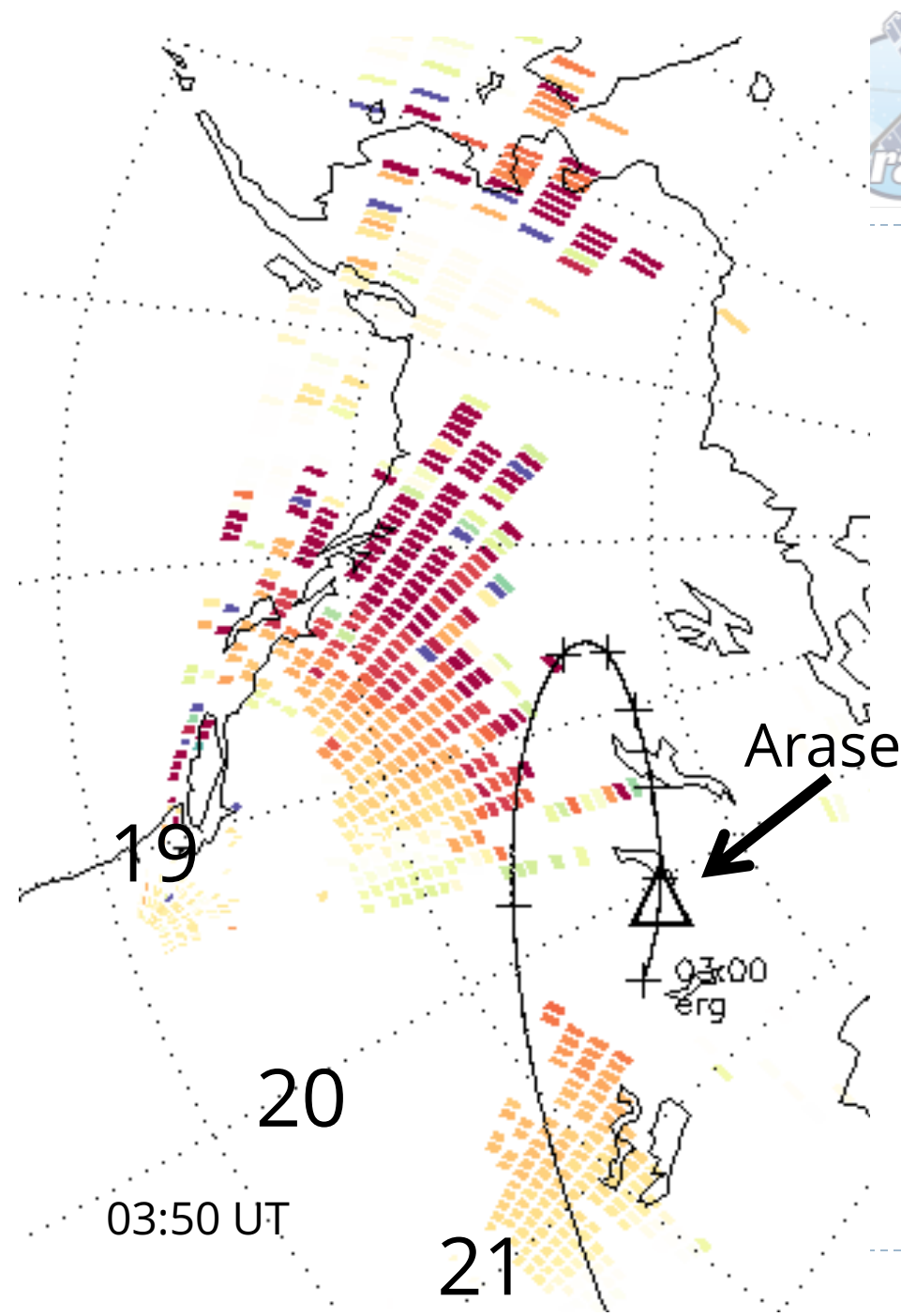


The most critical factor: how much **SD echoes** obtained and **how close Arase** located

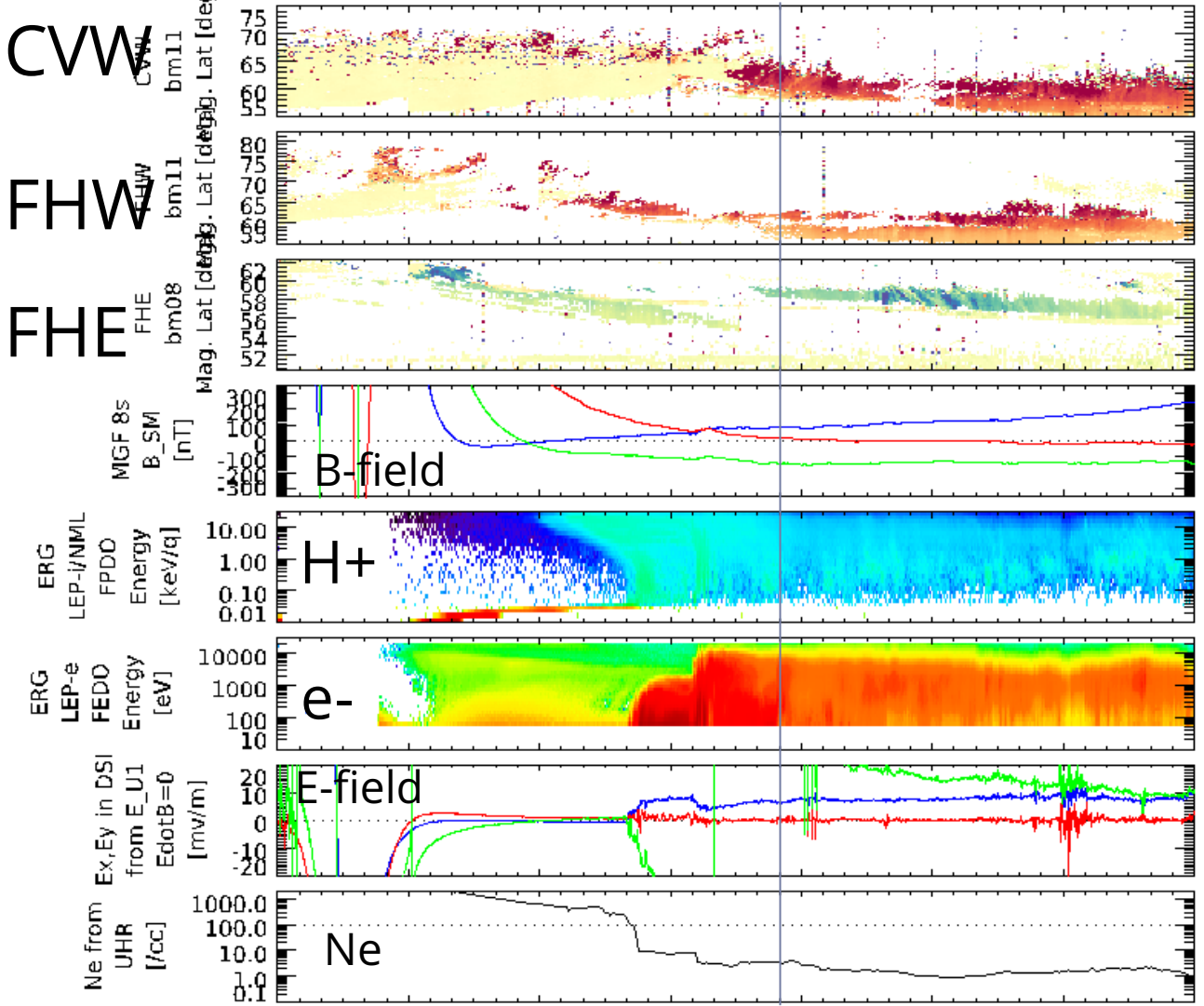
Event 5: Dec. 14



Lm	2.2	2.3	3.9	5.3	6.3	6.9	7.1	6.8
MLT	3.2	16.2	18.6	19.5	20.2	20.8	21.4	22.2
MLAT	22.8	-20.4	2.6	11.4	16.6	20.5	23.8	27.5
hhmm	0000	0100	0200	0300	0400	0500	0600	0700
2023 Dec 14								



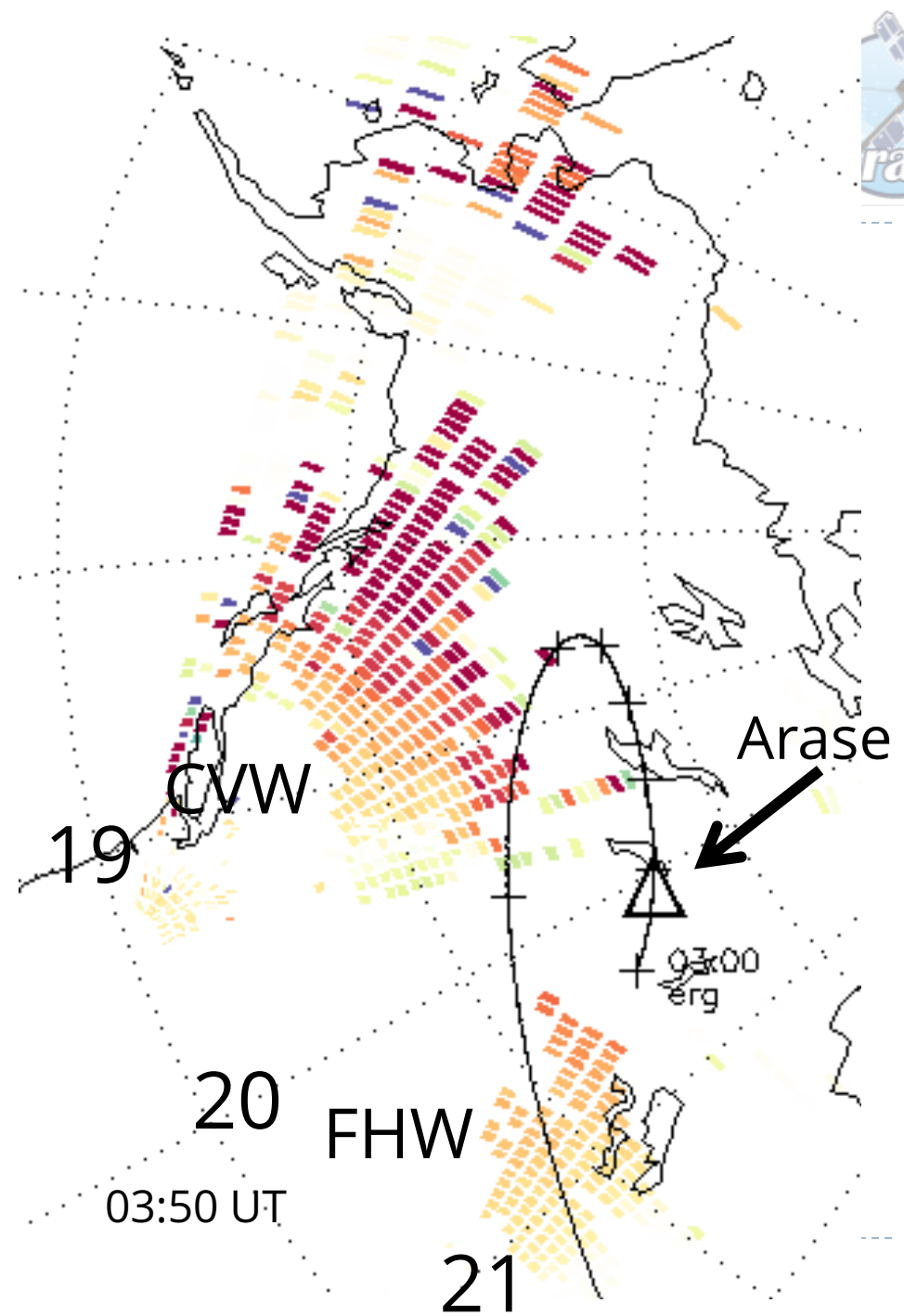
Event 5: Dec. 14



LOS Doppler vel. [m/s]
 LOS Doppler vel. [m/s]
 LOS Doppler vel. [m/s]
 Bz
 By
 Bx
 10¹⁰
 10⁸
 10⁶
 10⁴
 10²
 10⁰
 Ex_dsi
 Ey_dsi
 Ez_dsi
 1000.0
 100.0
 10.0
 0.1

Lm	2.2	2.3	3.9	5.3	6.3	6.9	7.1	6.8
MLT	3.2	16.2	18.6	19.5	20.2	20.8	21.4	22.2
MLAT	22.8	-20.4	2.6	11.4	16.6	20.5	23.8	27.5
hhmm	0000	0100	0200	0300	0400	0500	0600	0700

2023 Dec 14



03:50 UT

CVW

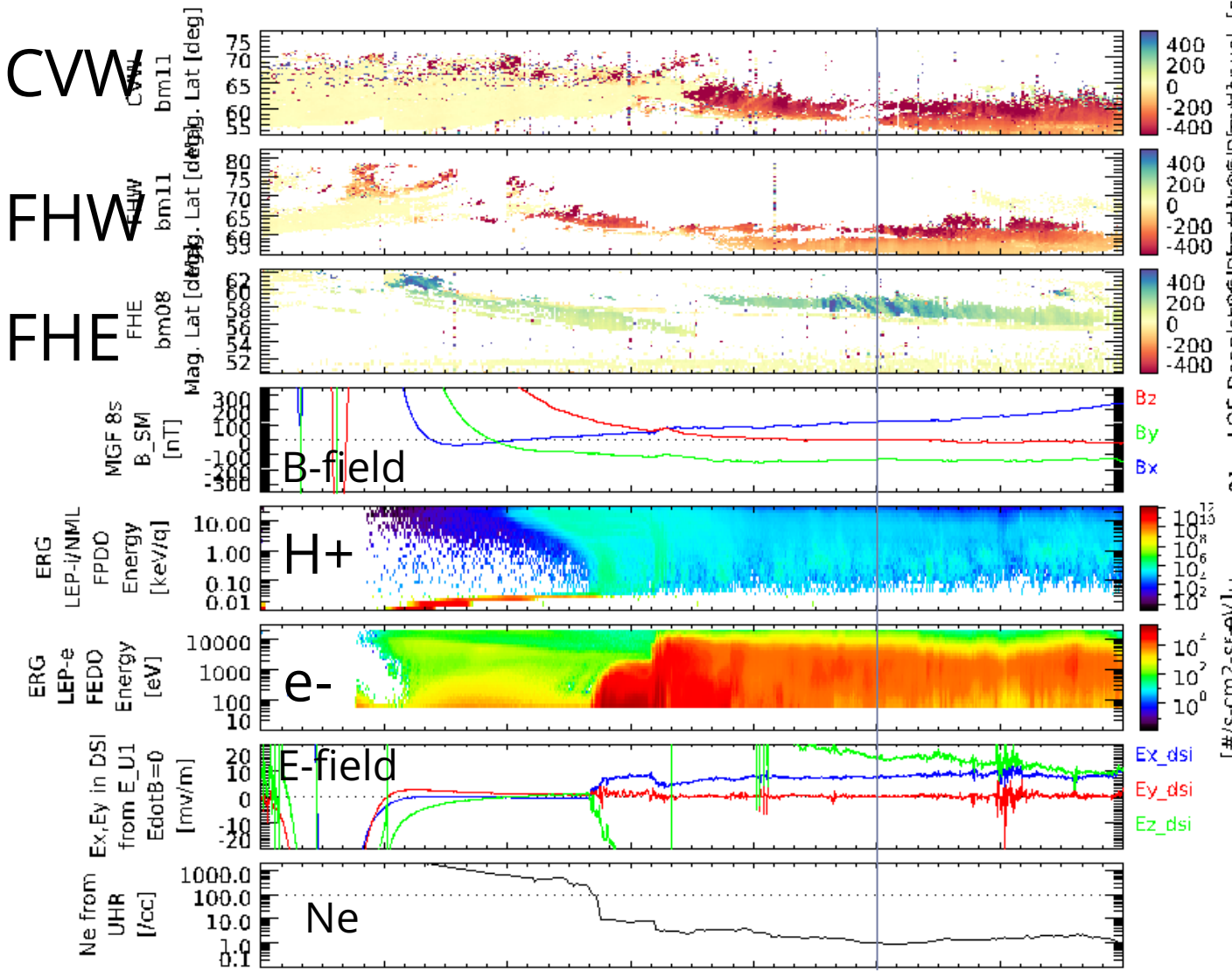
FHW

Arase

03:00
erg

21

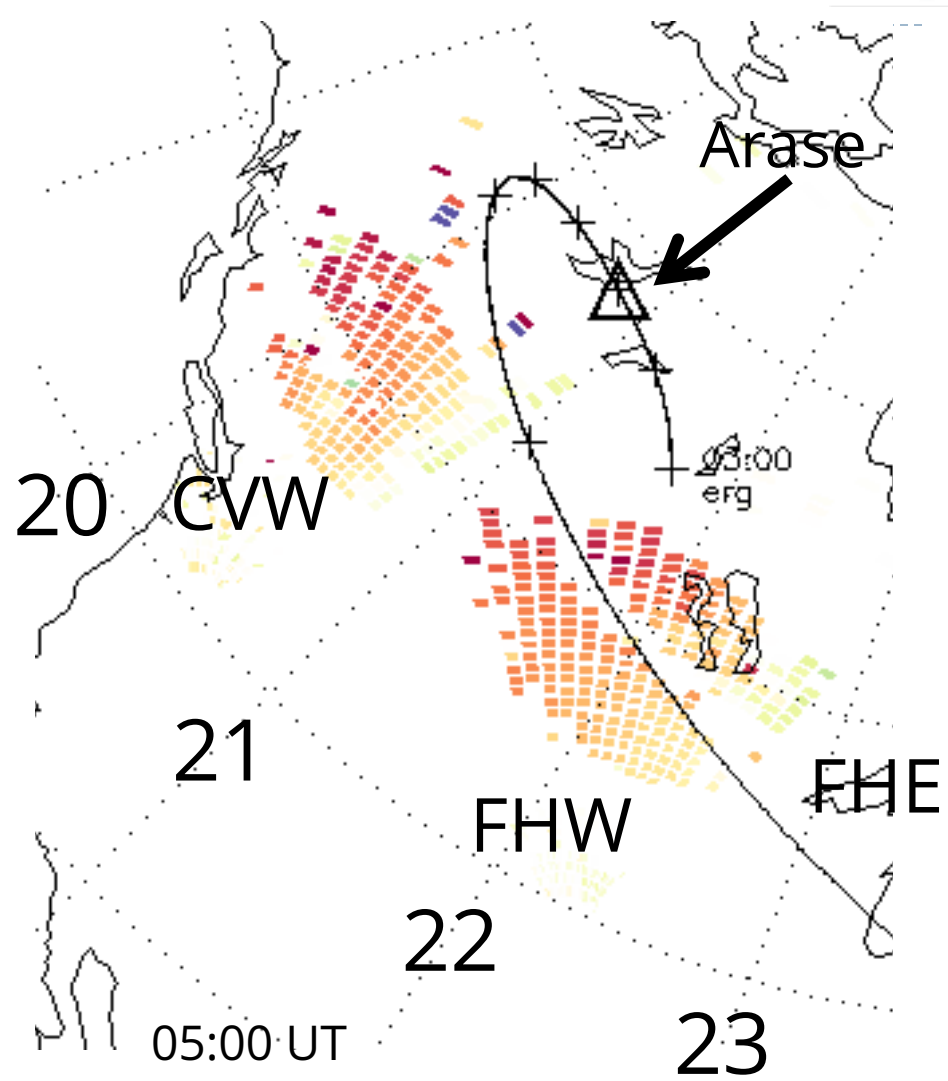
Event 5: Dec. 14



Lm	2.2	2.3	3.9	5.3	6.3	6.9	7.1	6.8
MLT	3.2	16.2	18.6	19.5	20.2	20.8	21.4	22.2
MLAT	22.8	-20.4	2.6	11.4	16.6	20.5	23.8	27.5
hhmm	0000	0100	0200	0300	0400	0500	0600	0700

LOS Doppler vel. [m/s]

#/s-cm2-sr-keV-s-cm2





Summary and conclusions

- ▶ The SuperDARN–Arase campaign has successfully been carried out during Oct–Dec, 2023, achieving many interesting events in terms of SAPS-related studies, as well as those for ULF waves.
- ▶ Currently we push ourselves hard to examine the observations obtained to see how dynamically SAPS varies and evolves.

Tentative conclusions:

- ▶ SAPS **with WS** and SAPS **without WS**.
- ▶ SAPSWS appears in association **with energetic particle injections, dipolarization, ...**
- ▶ Velocity fluctuations of SAPS **propagate westward**, while its counter part, **eastward flow** on dawn, may also be **accompanied by eastward-propagating velocity fluctuation**.
- ▶ None of fluctuations penetrate further inward of the SAPS region.