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

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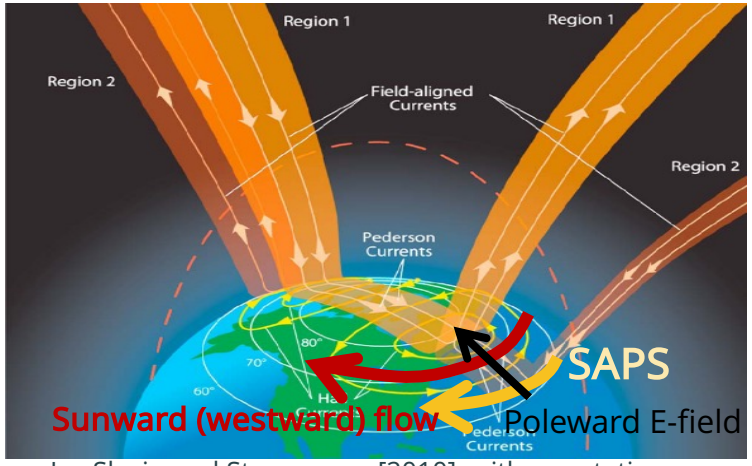
# Intro.:
# Subauroral Polarization Streams (SAPS)

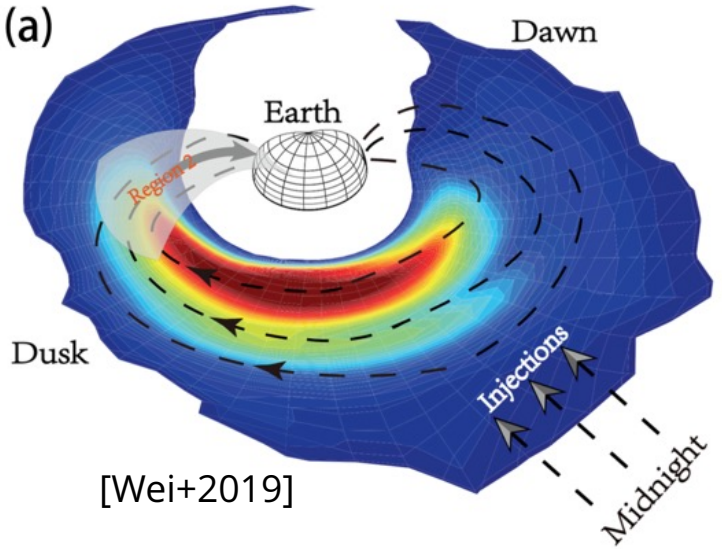
## SAPS:

- 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].

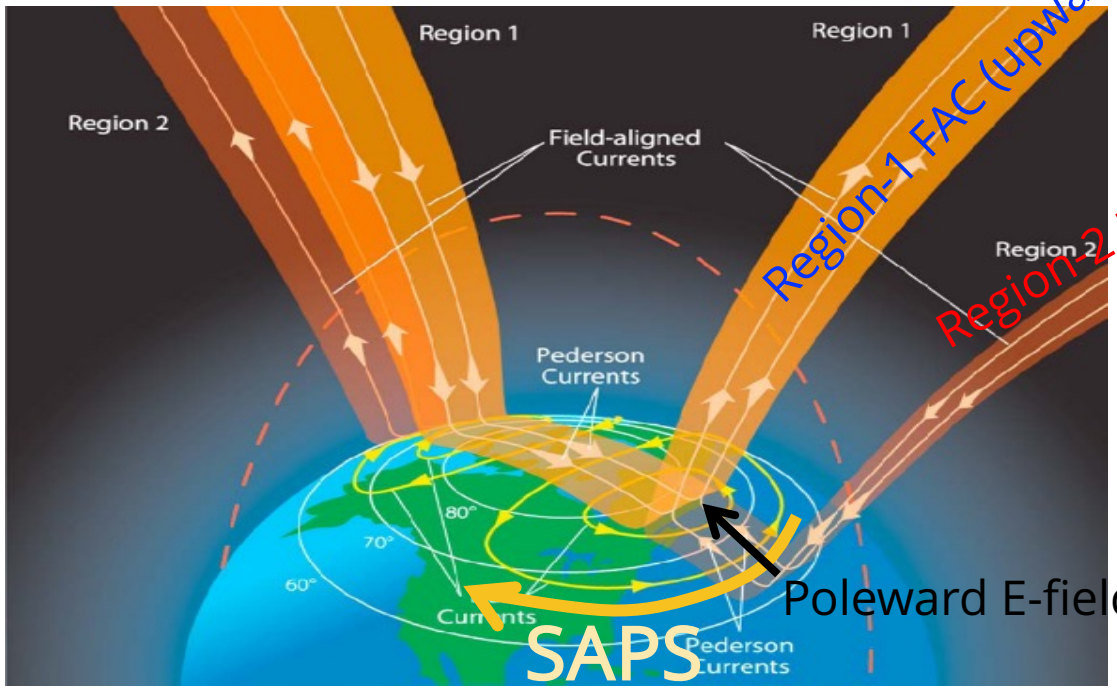


Le, Slavin and Strangeway [2010], with annotations



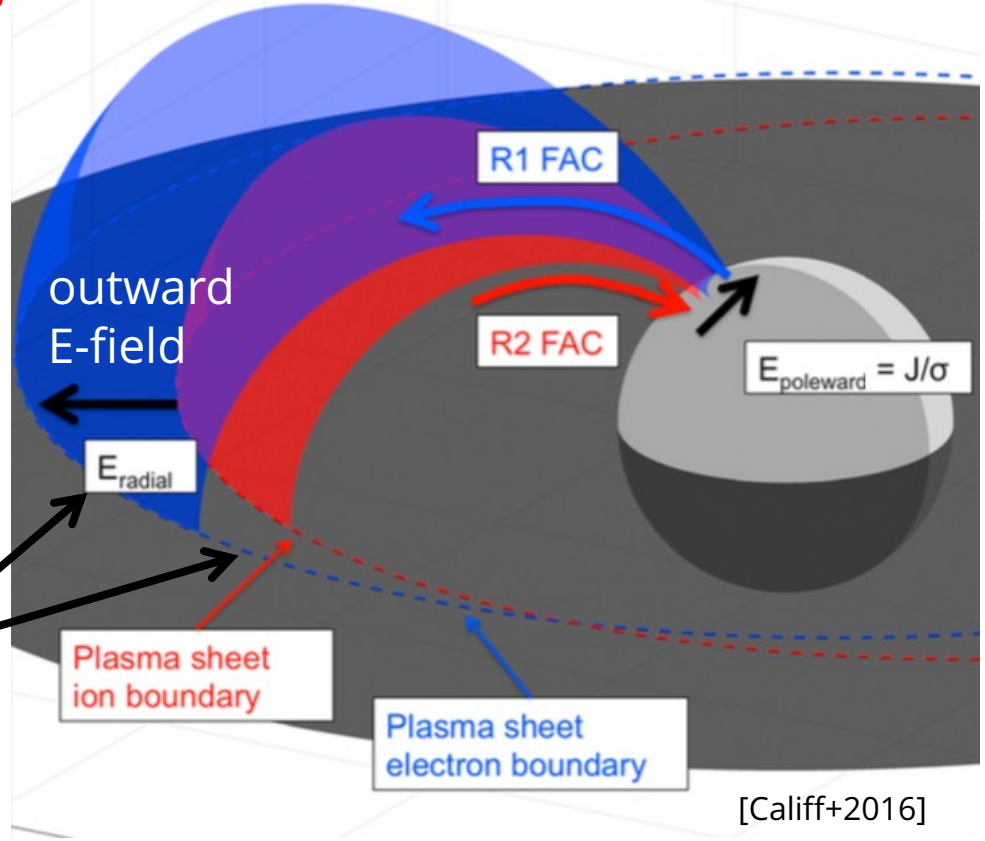
[Wei+2019]

# Intro.:
# Subauroral Polarization Streams (SAPS)




Le, Slavin and Strangeway [2010], with annotations

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




[Califf+2016]

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

# Intro.:
# SAPS E-field and particle boundaries as seen in the equatorial magnetosphere on dusk

[Califf+2016]

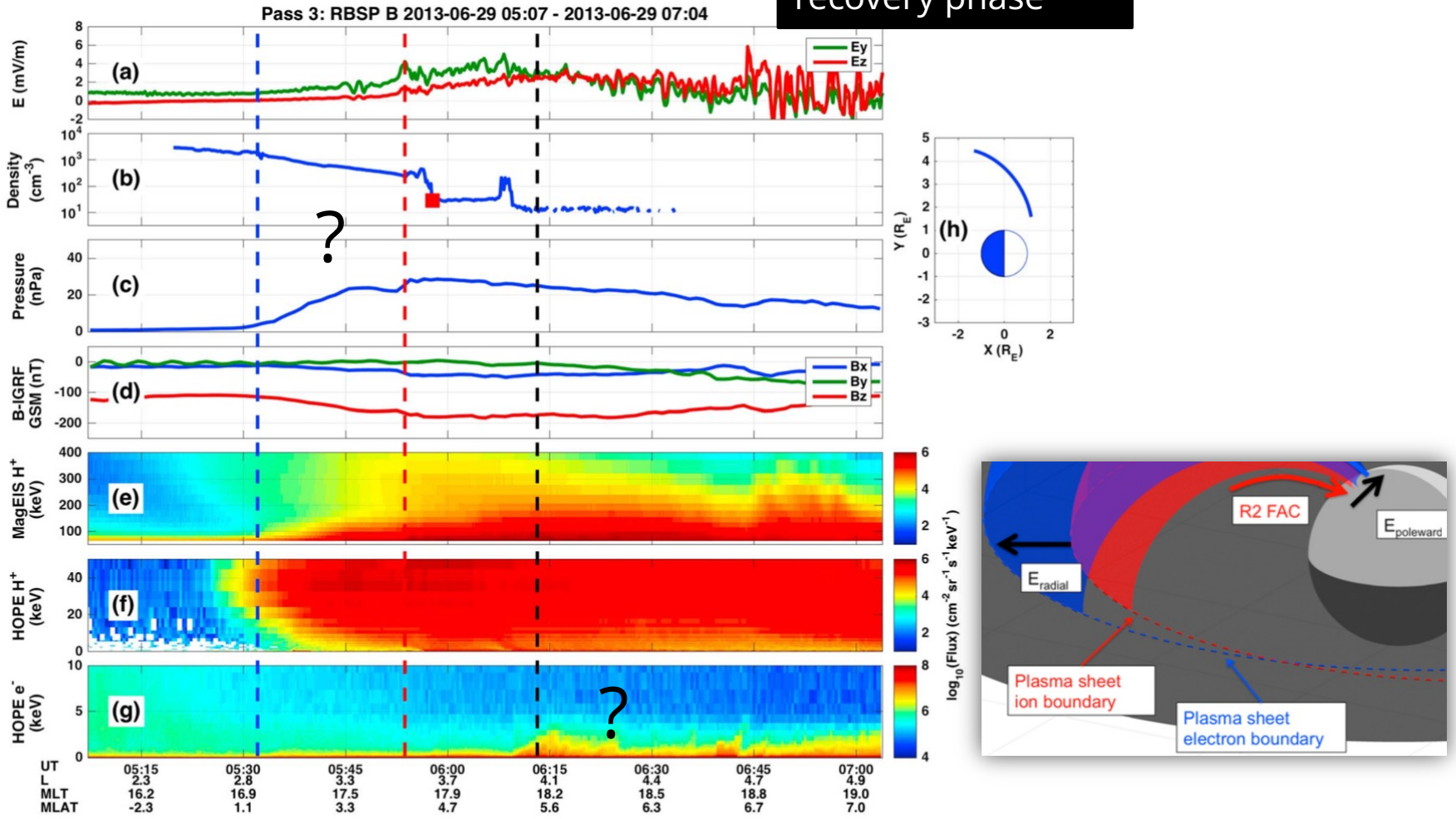
SAPS

Just before the recovery phase

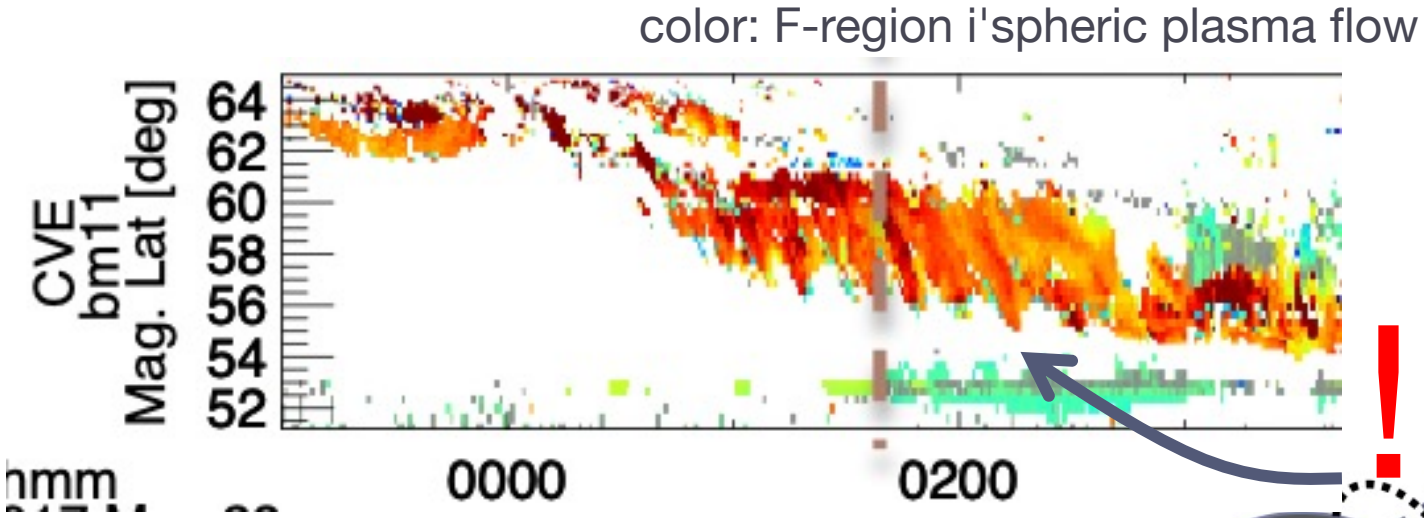
E-field

H+

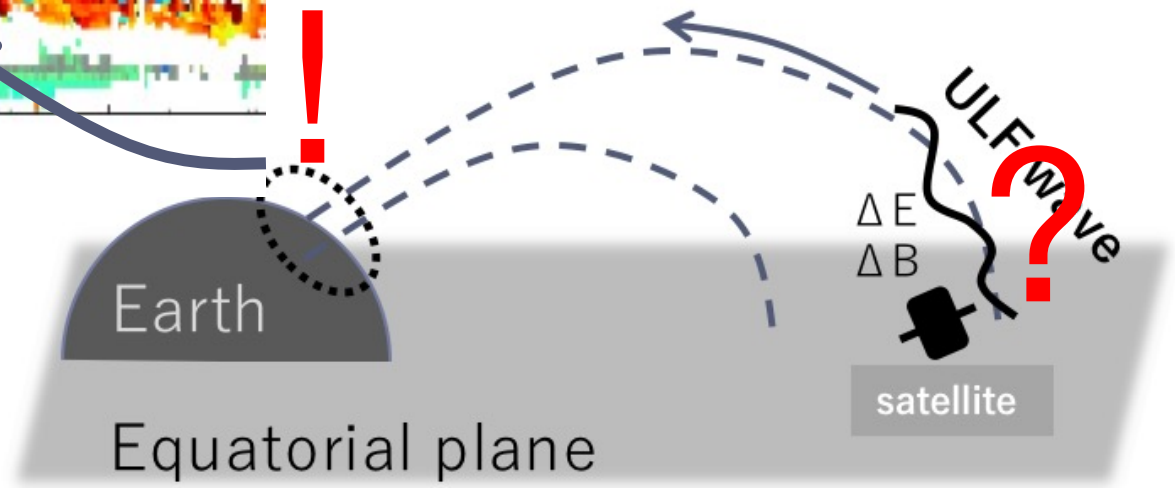
e-



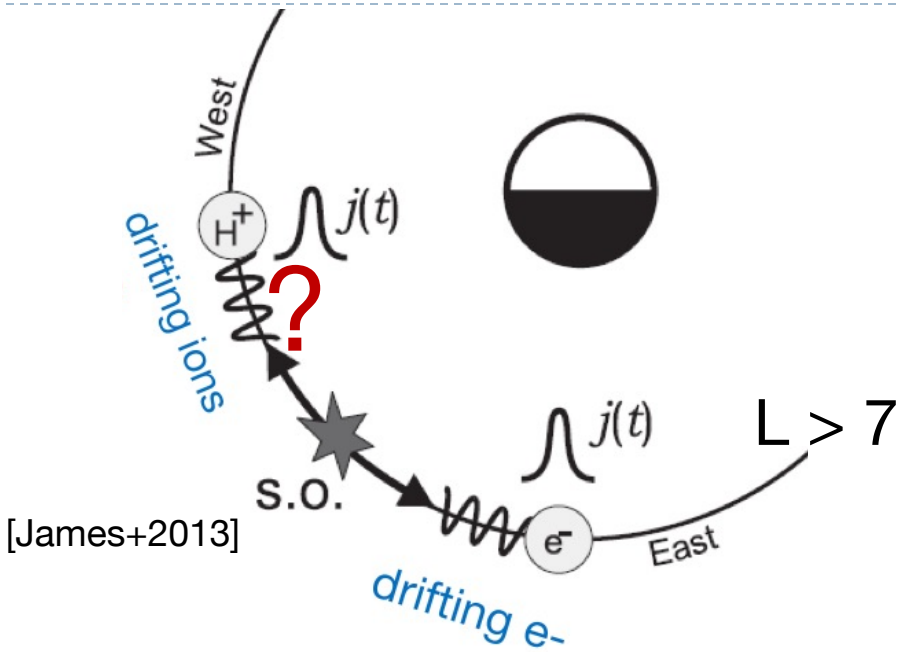
# Intro.:
# SAPS wave structure (SAPSWS): dynamically varying SAPS



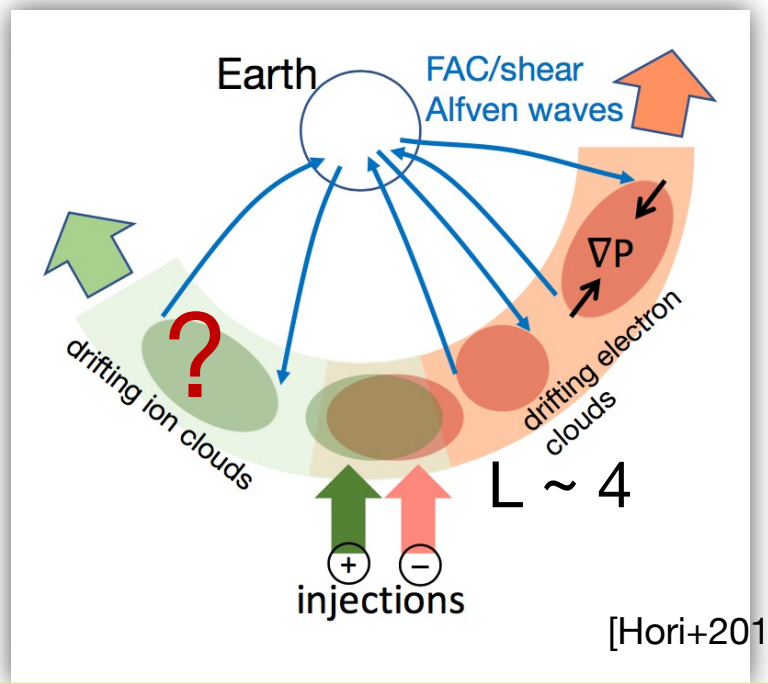

- Fluctuations (f ~ $10^0$–$10^1$ mHz) in plasma velocity embedded in SAPS.
- Often propagate westward.



# Intro.:
# What causes SAPSWS seen by SDs?




[James+2013]



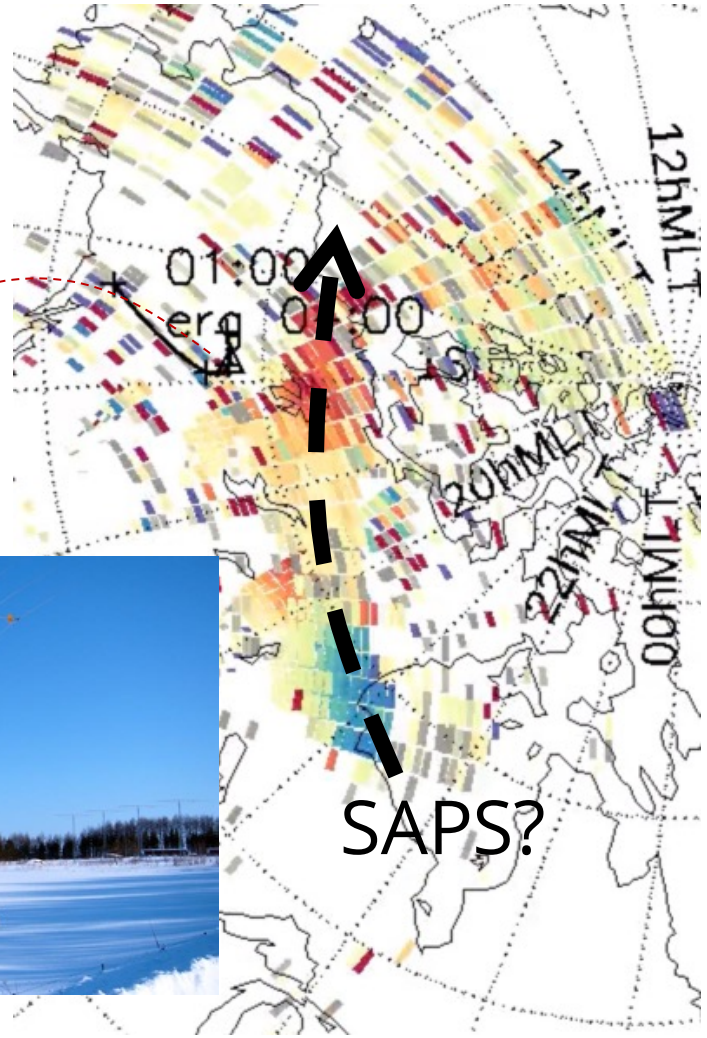

[Hori+2018]

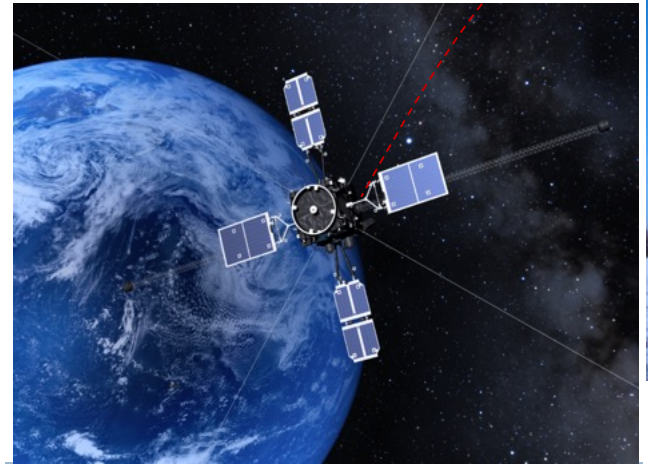
Possible drive mechanisms that have been proposed are:

- 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]

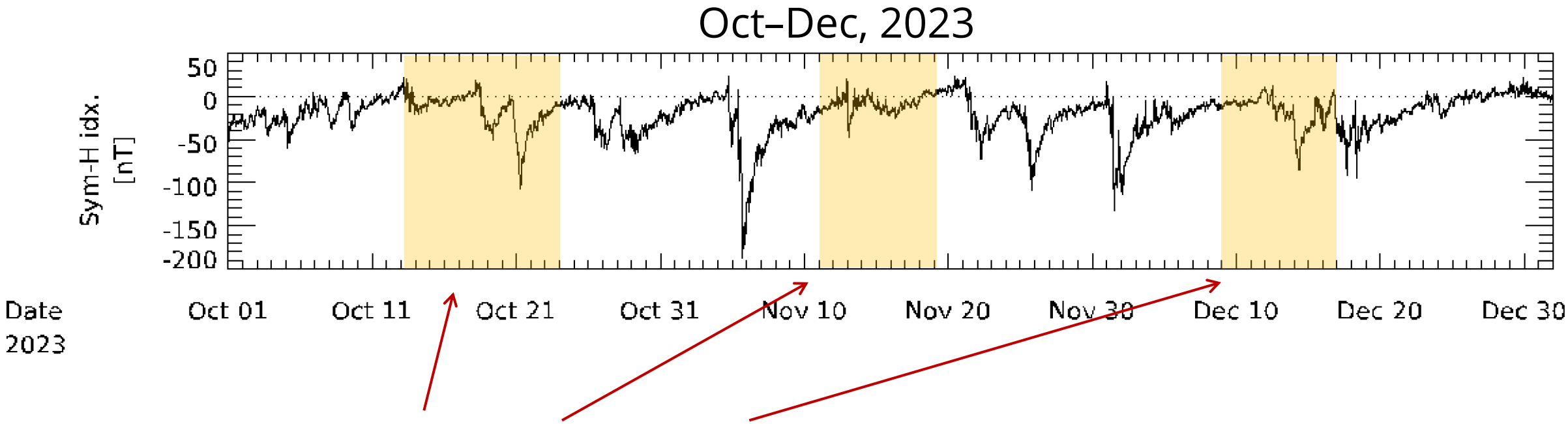
# Our approach:
# Arase–SuperDARN campaign observations

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.



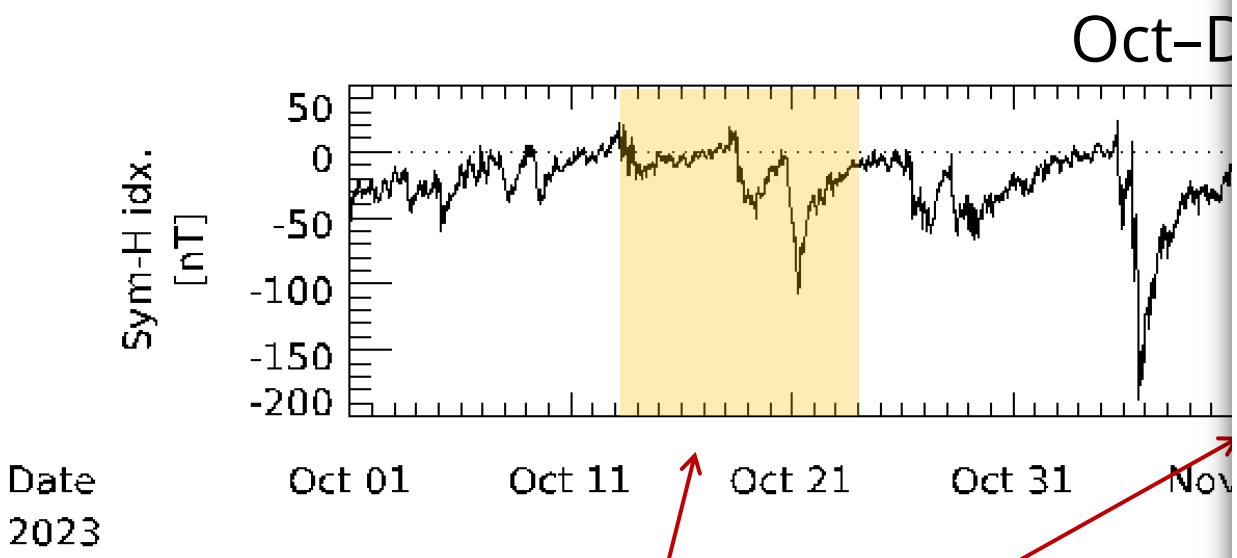
# 2023 Fall SuperDARN-Arase campaign observations

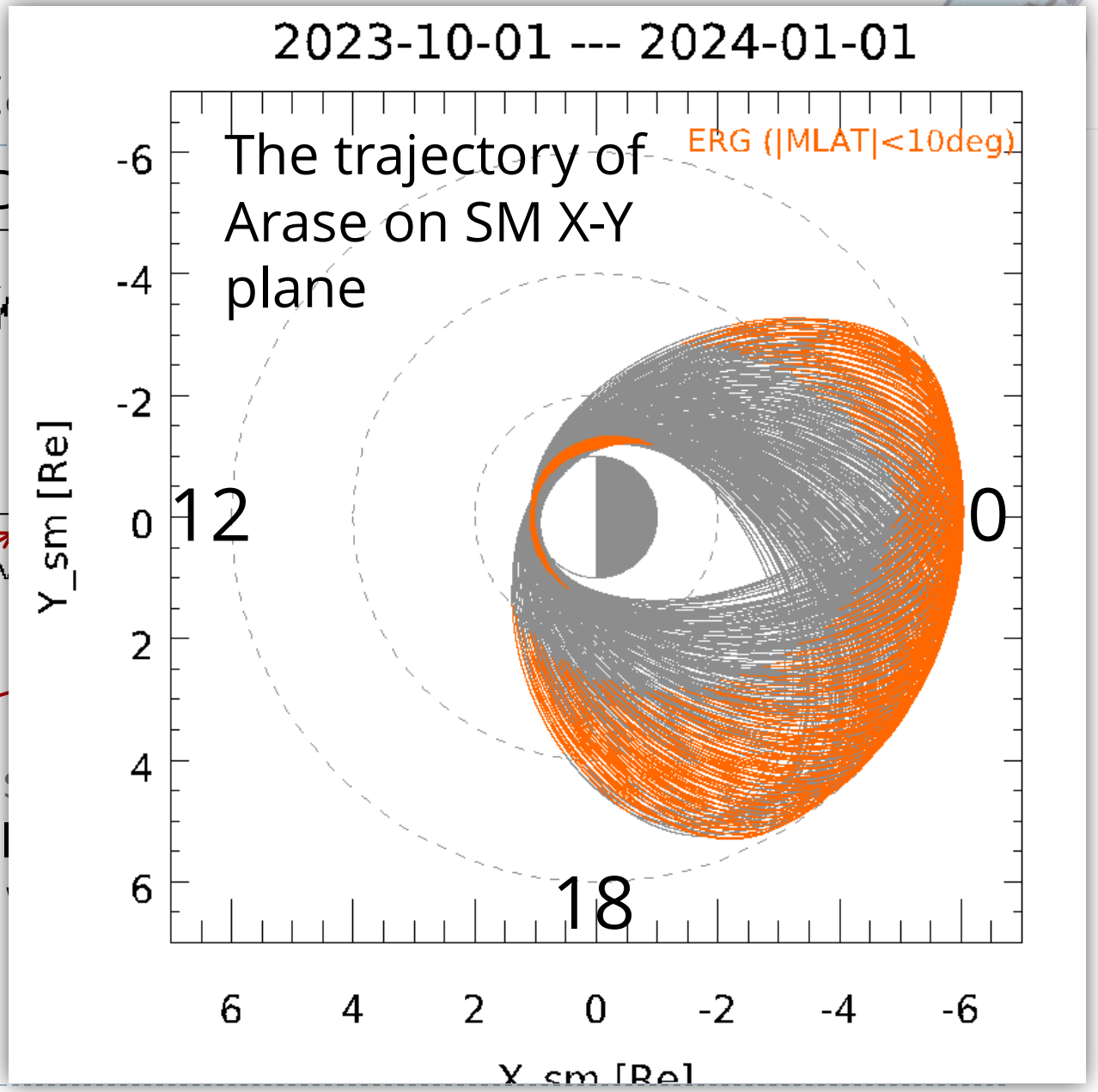



## Campaign observations: several days / month

- 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 c

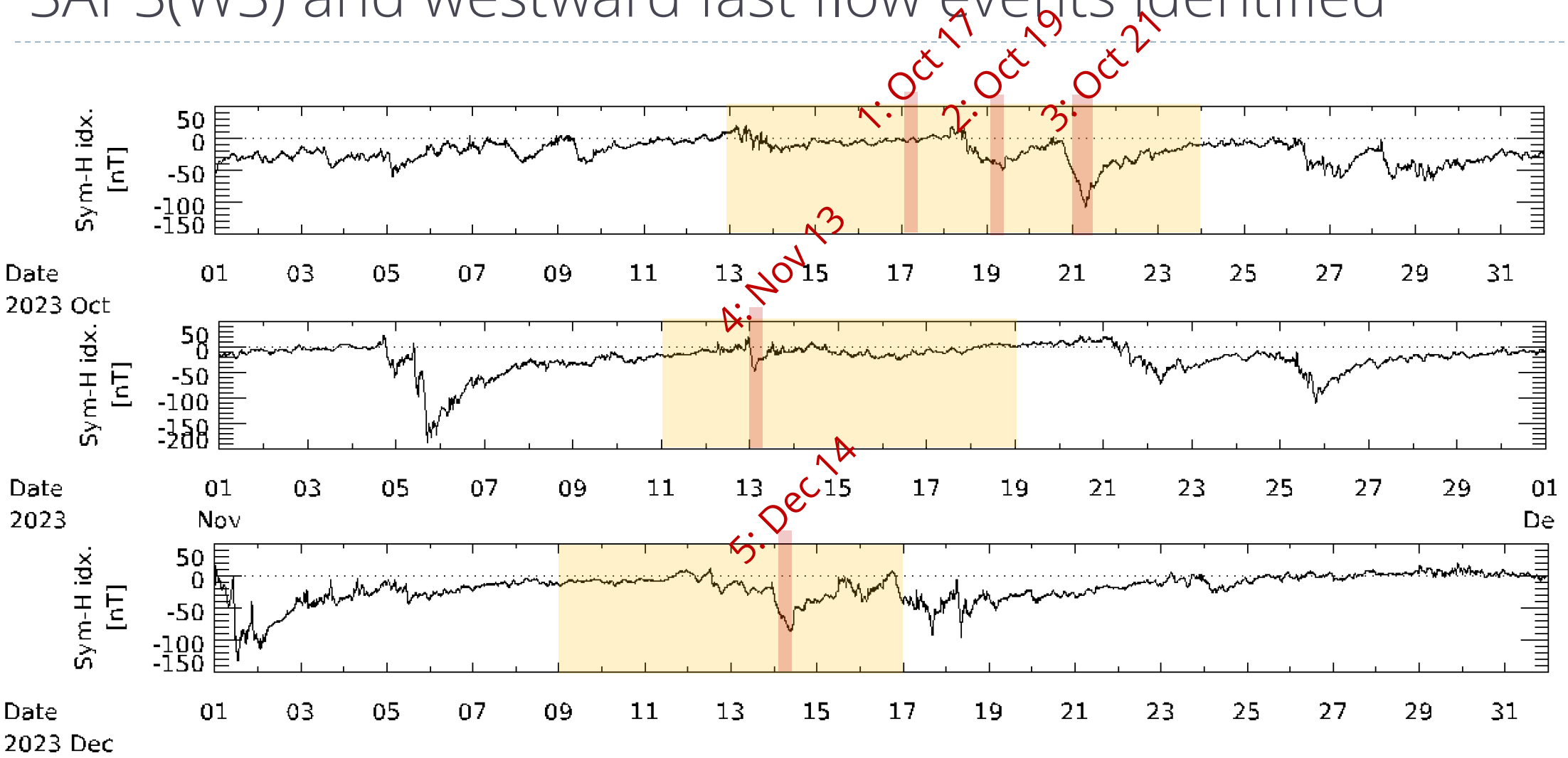



## Campaign observations:

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

# SAPS(WS) and westward fast flow events identified




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

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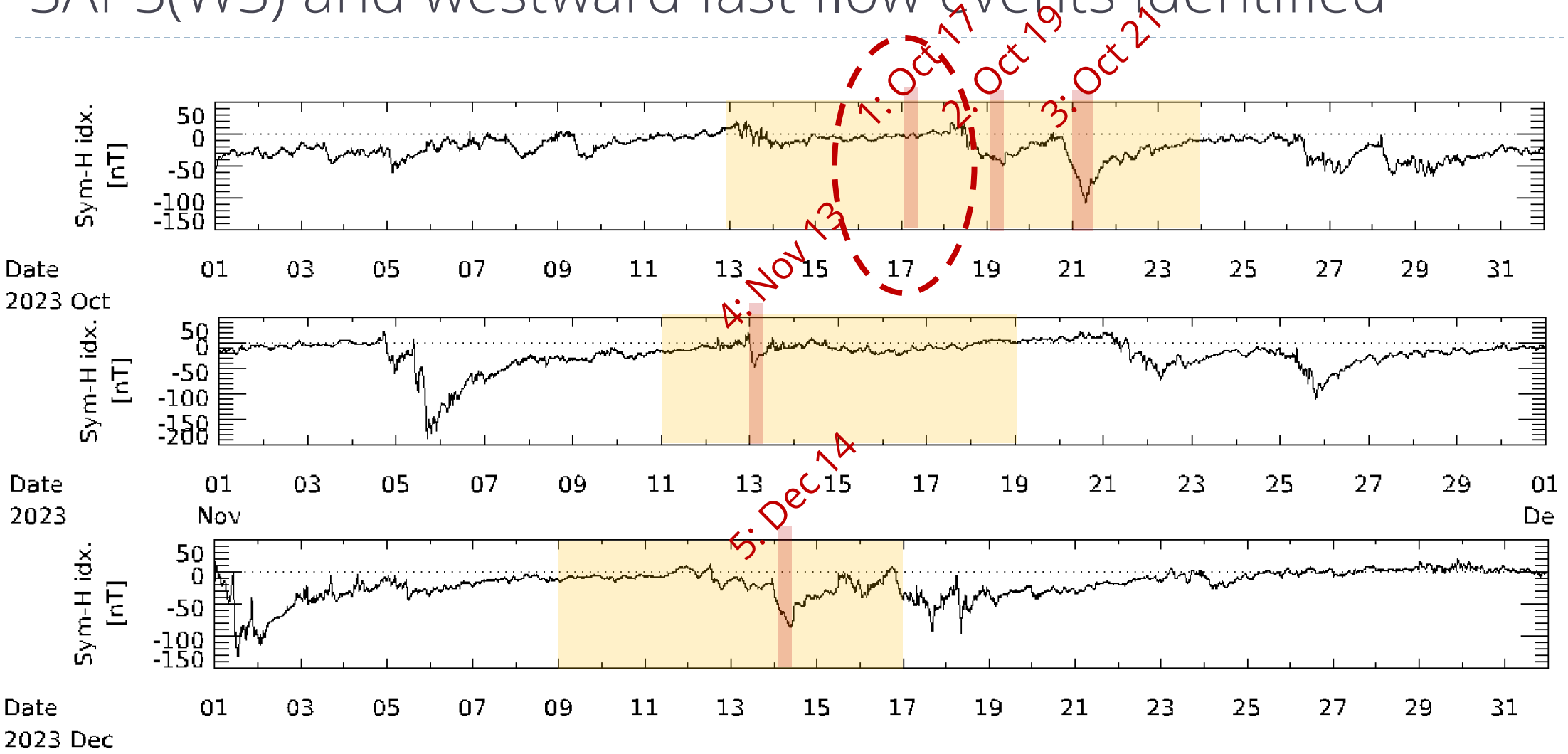


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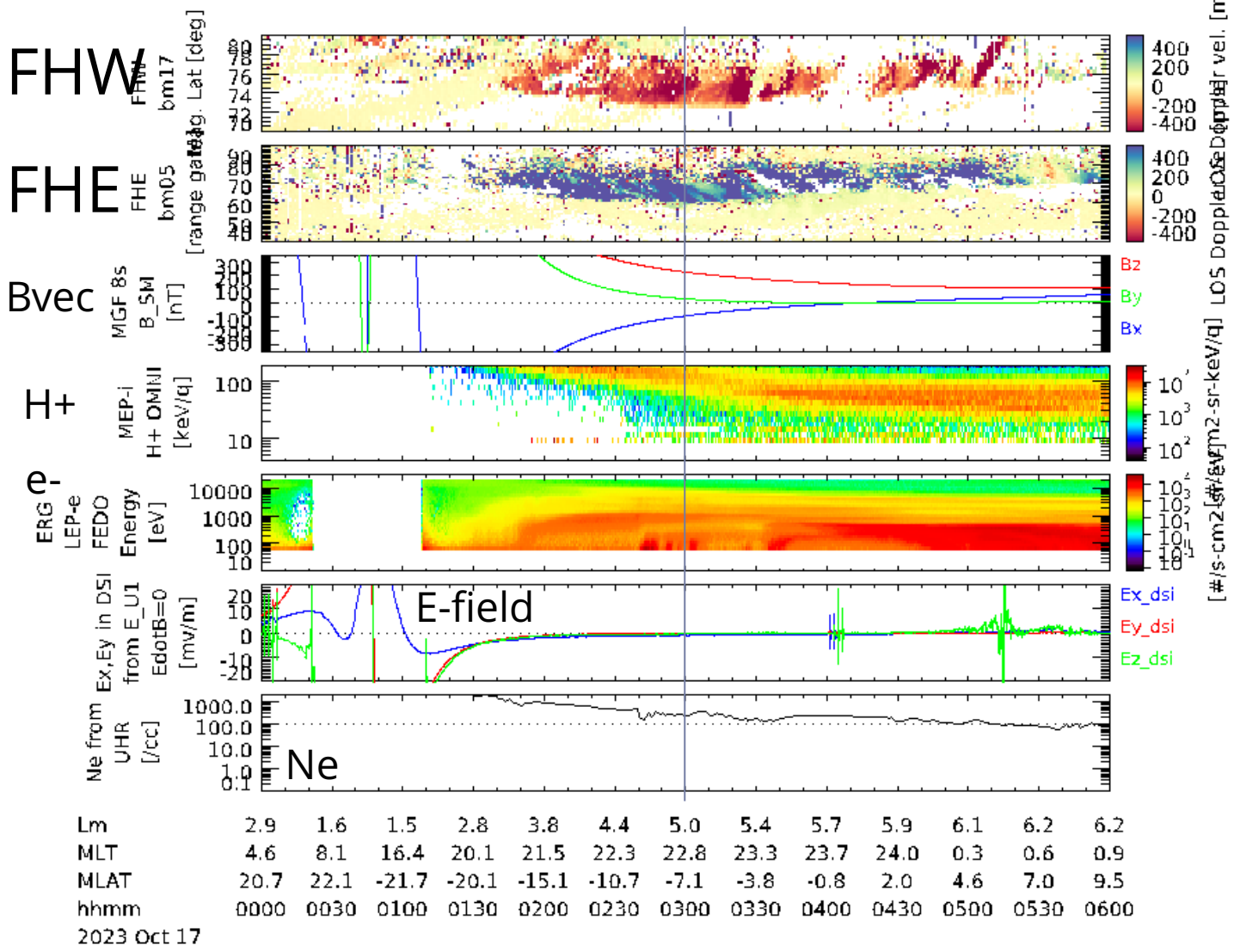
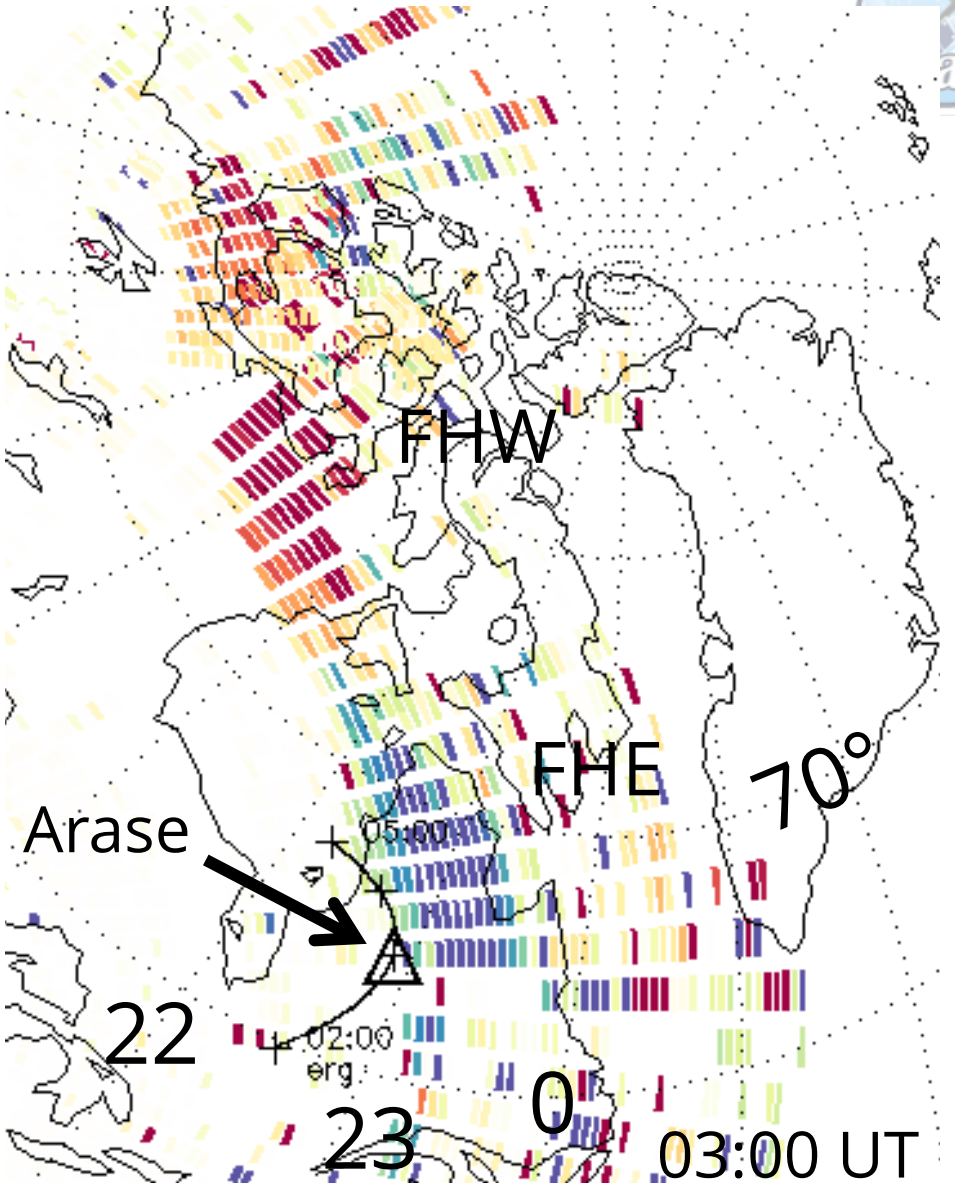
# Event 1: Oct. 17, 2023



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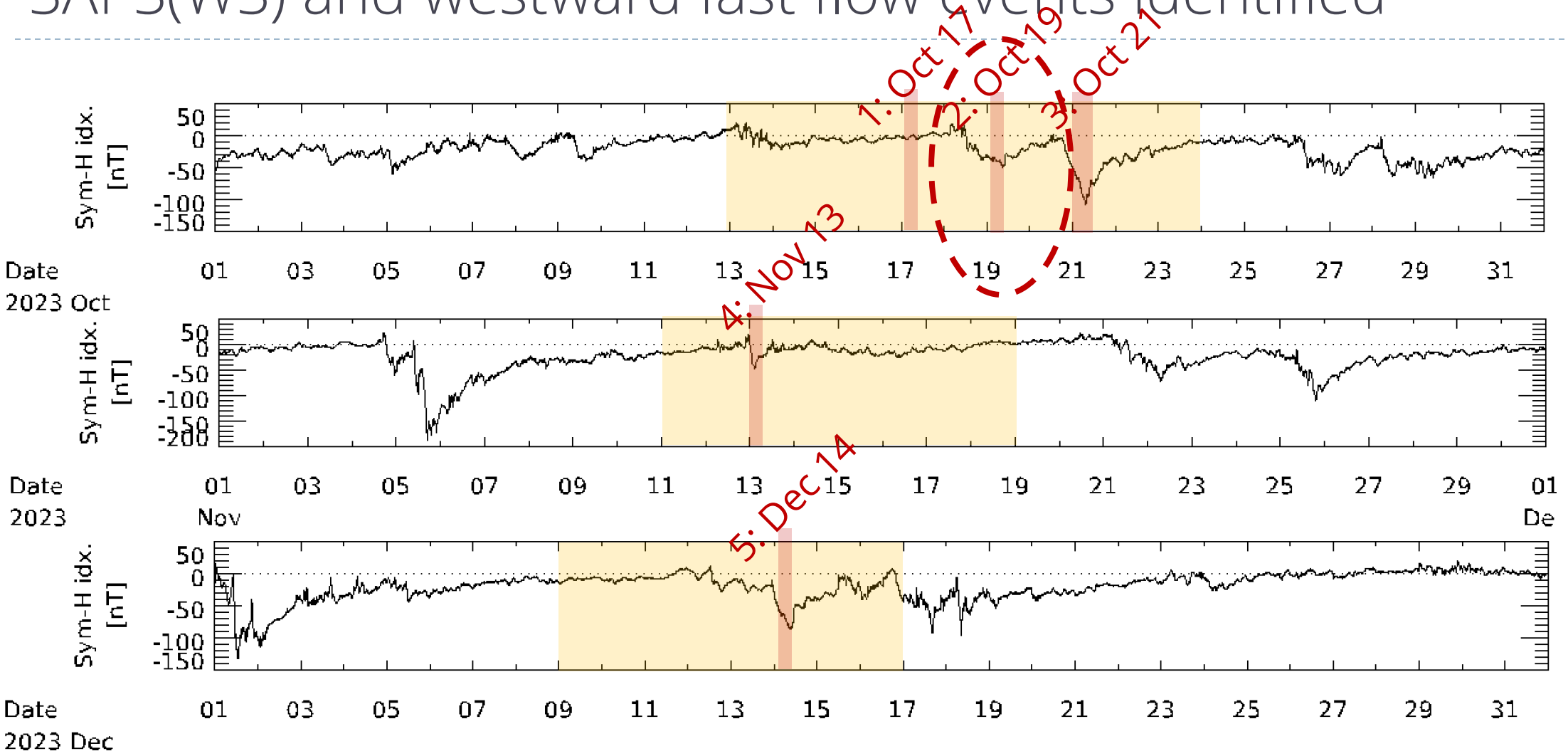


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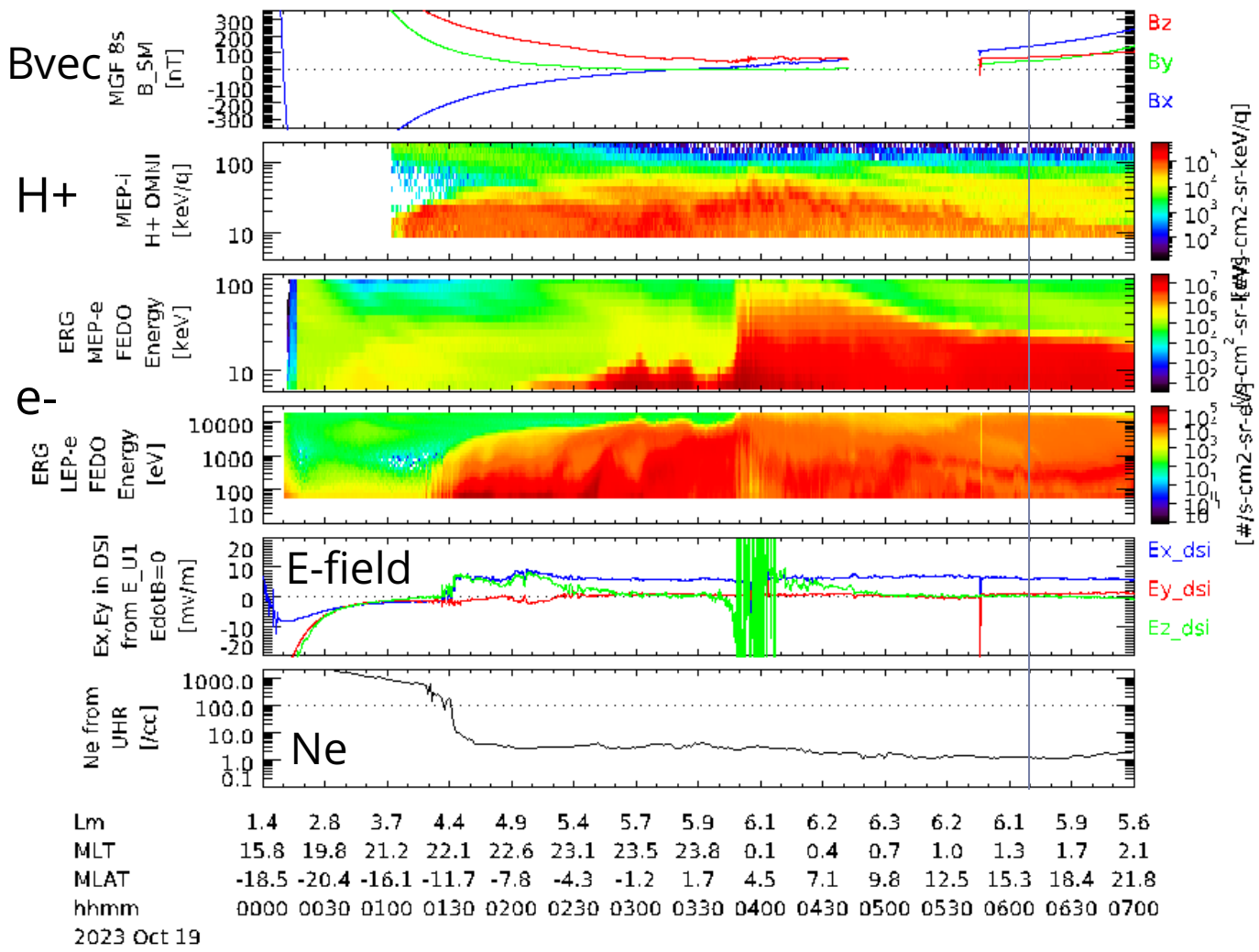
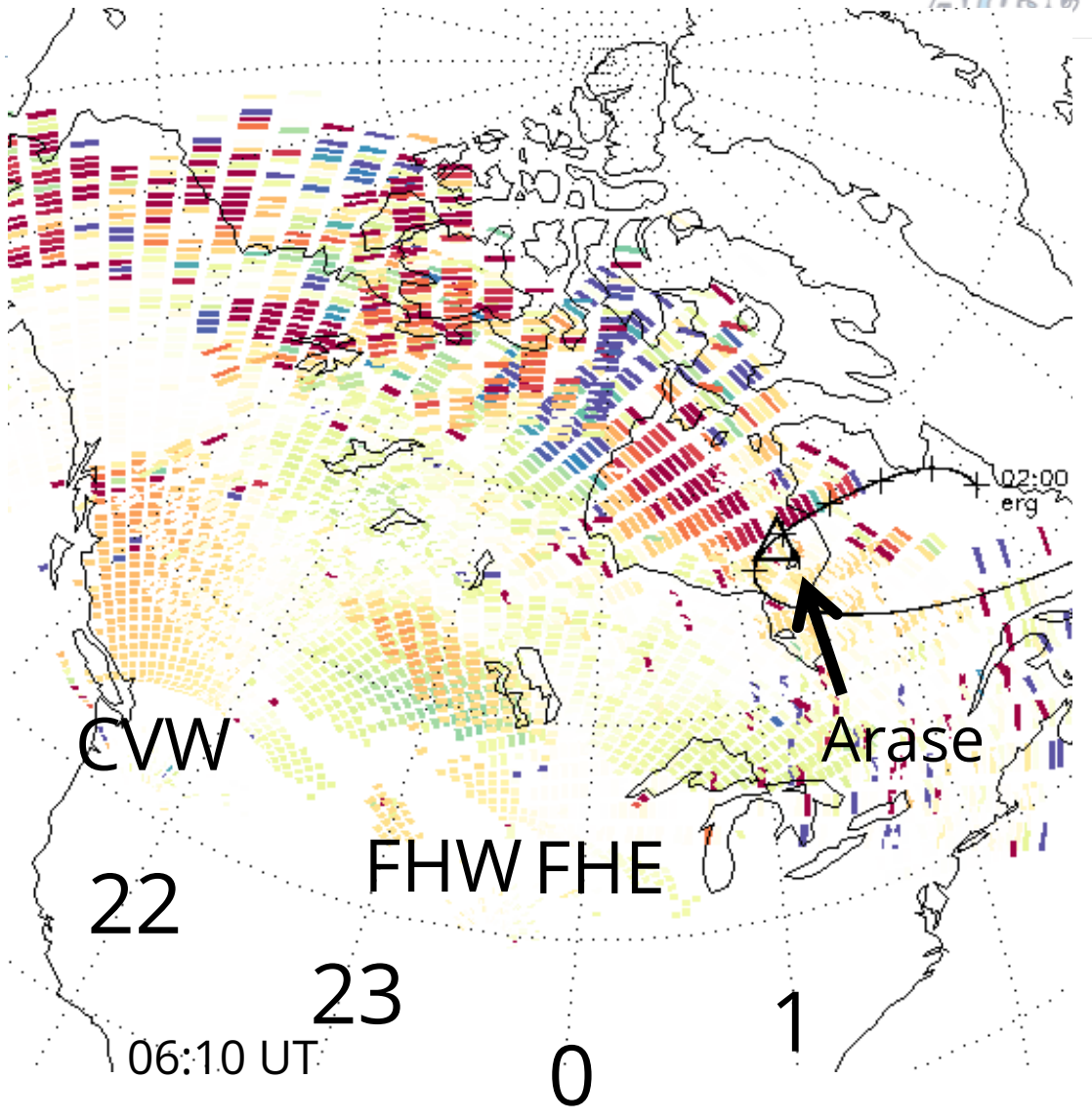
# Event 2: Oct. 19



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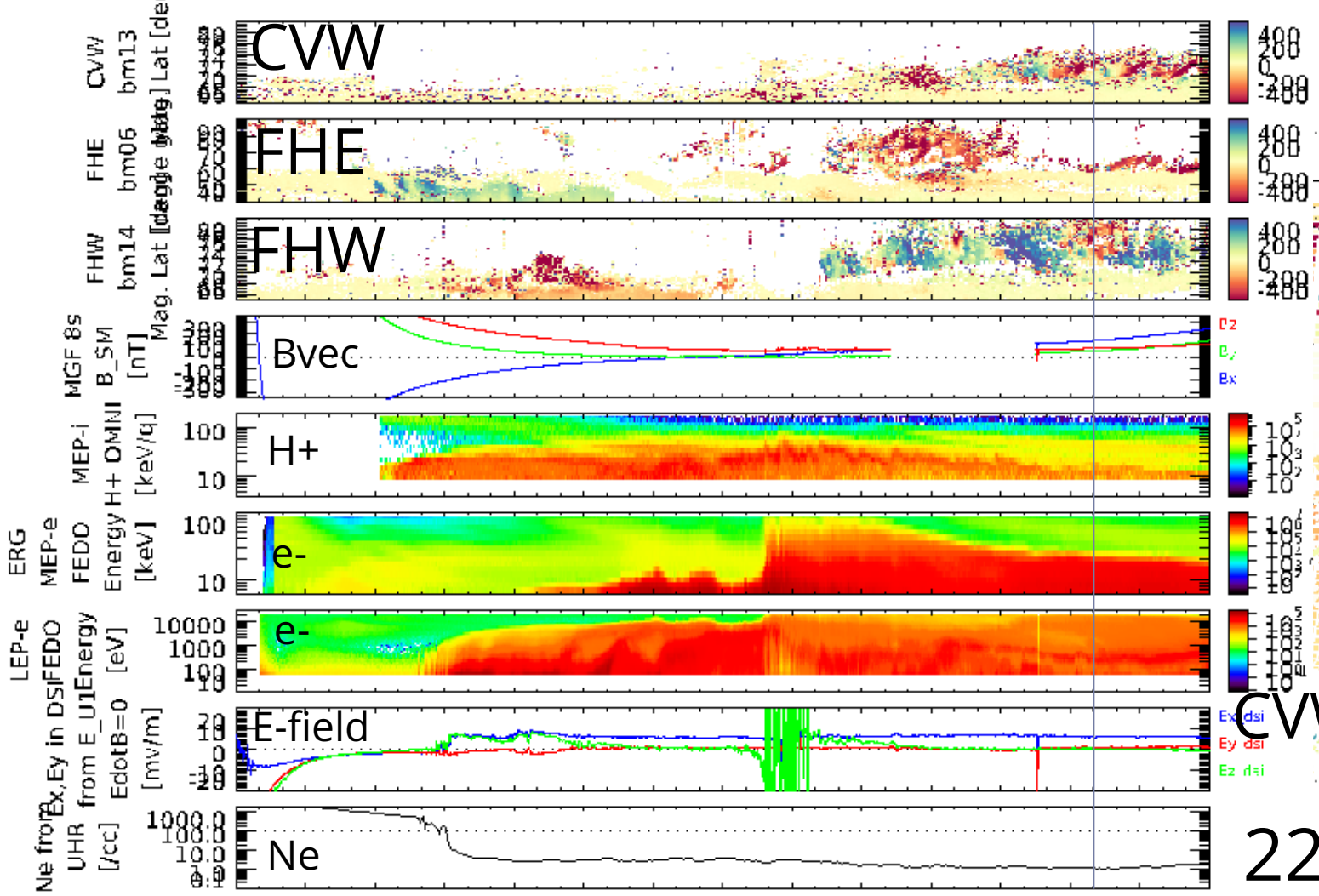


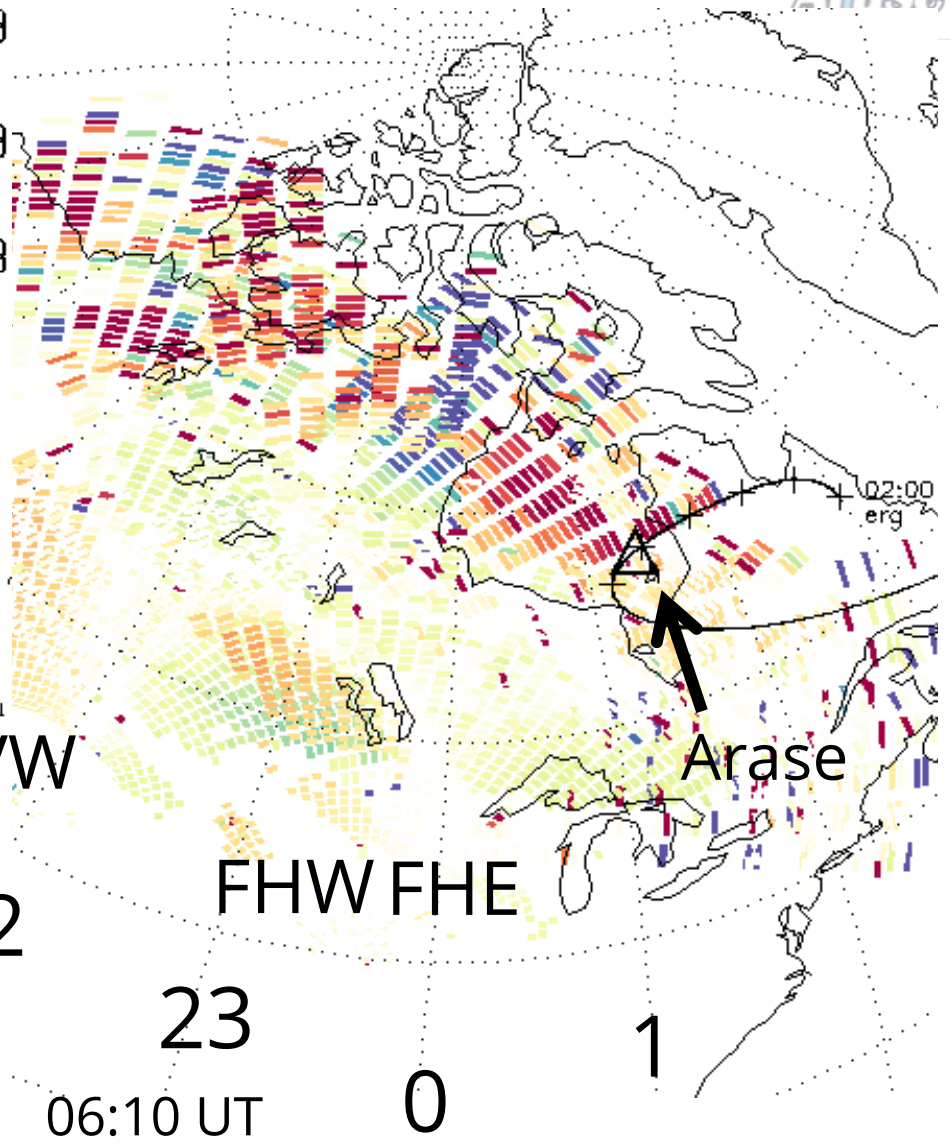

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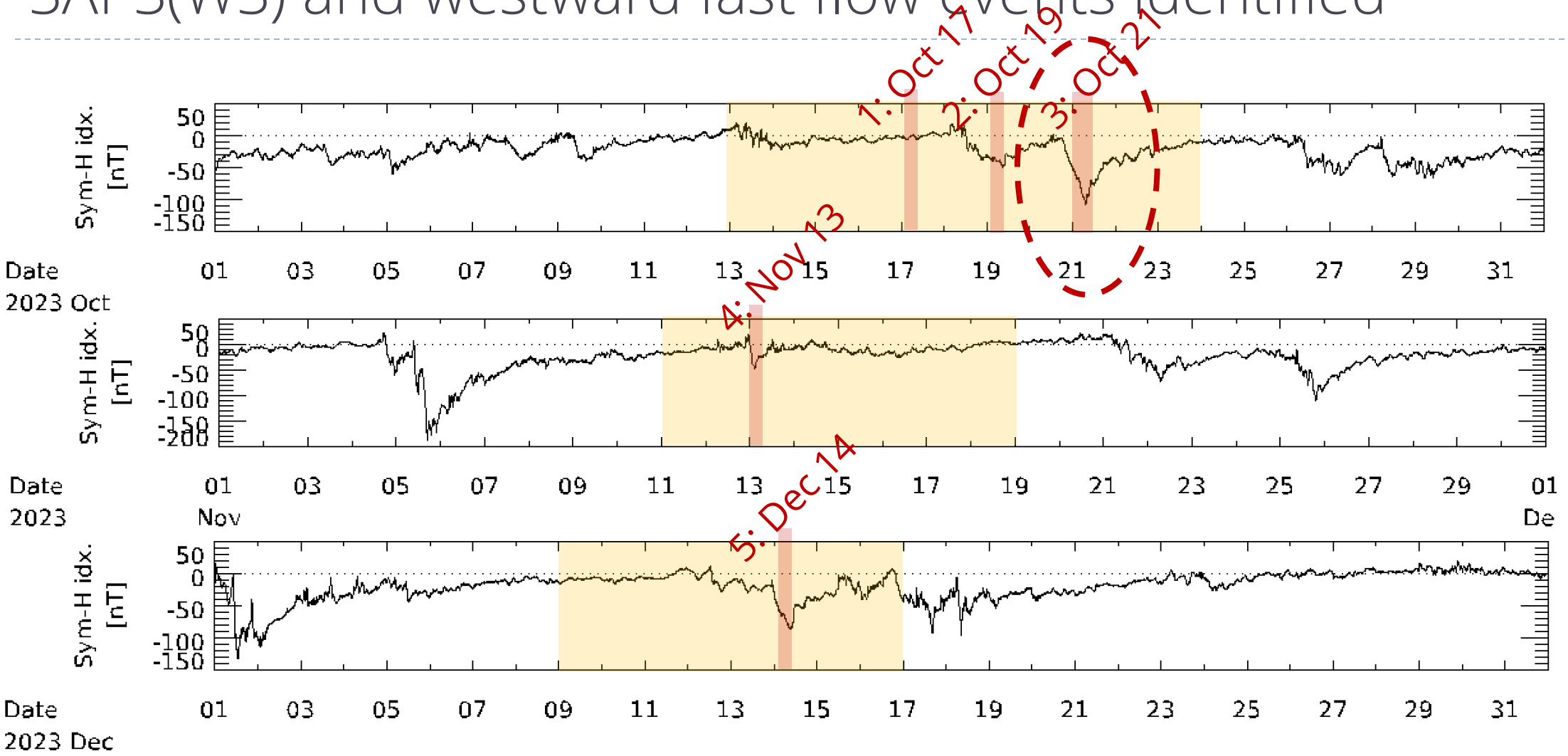
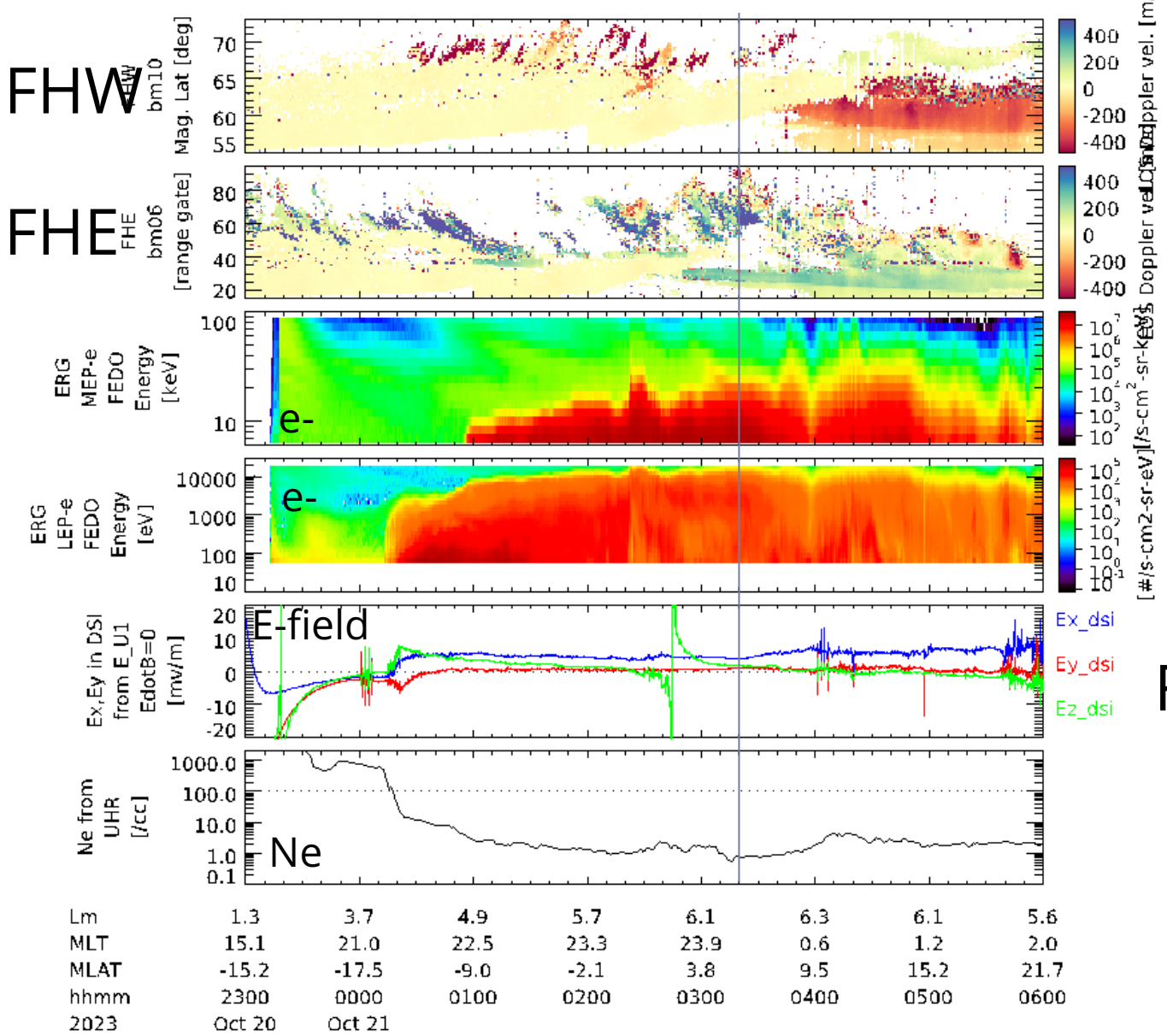
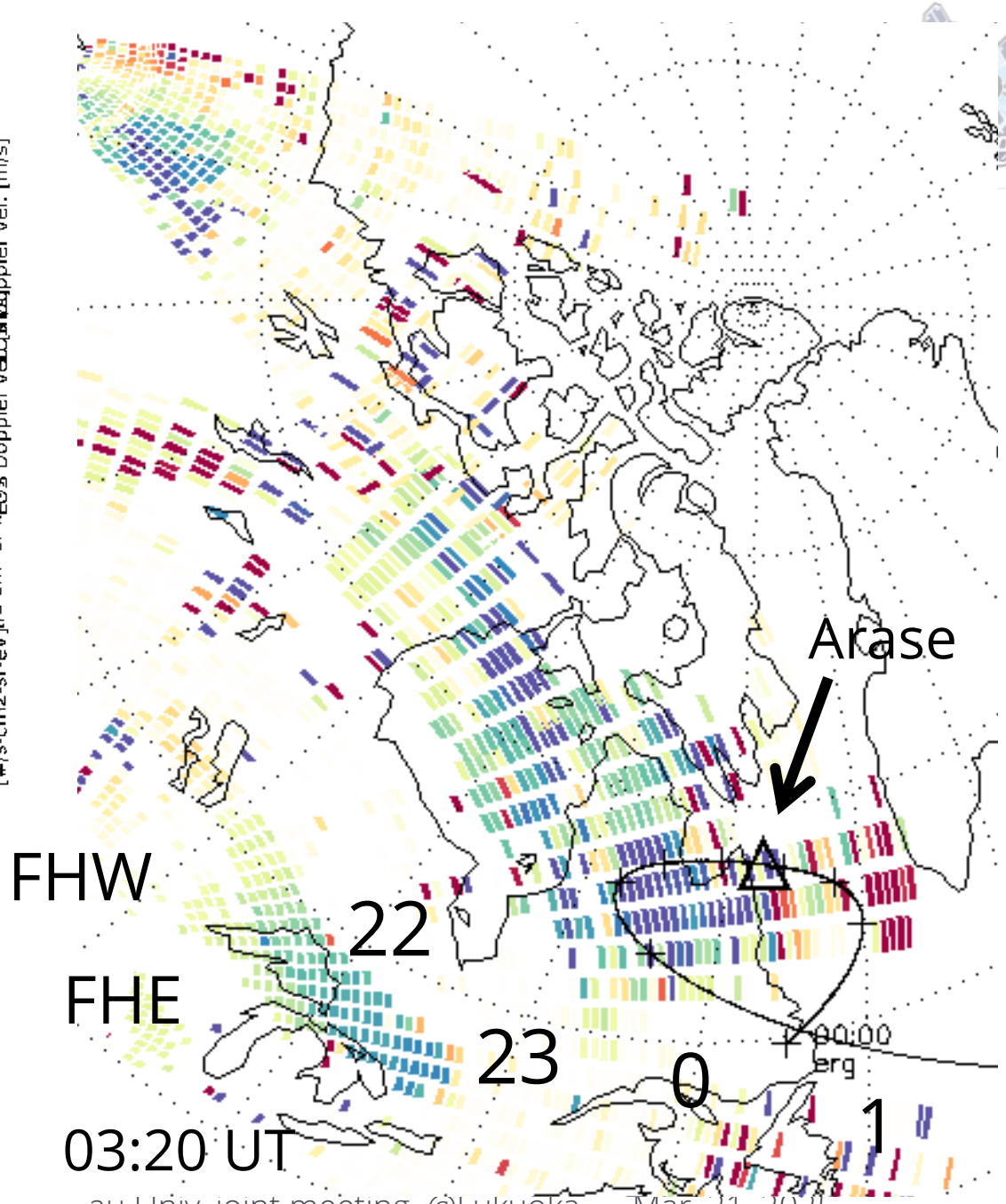



The most critical factor: how much SD echoes obtained and how close Arase located

# Event 3: Oct. 21



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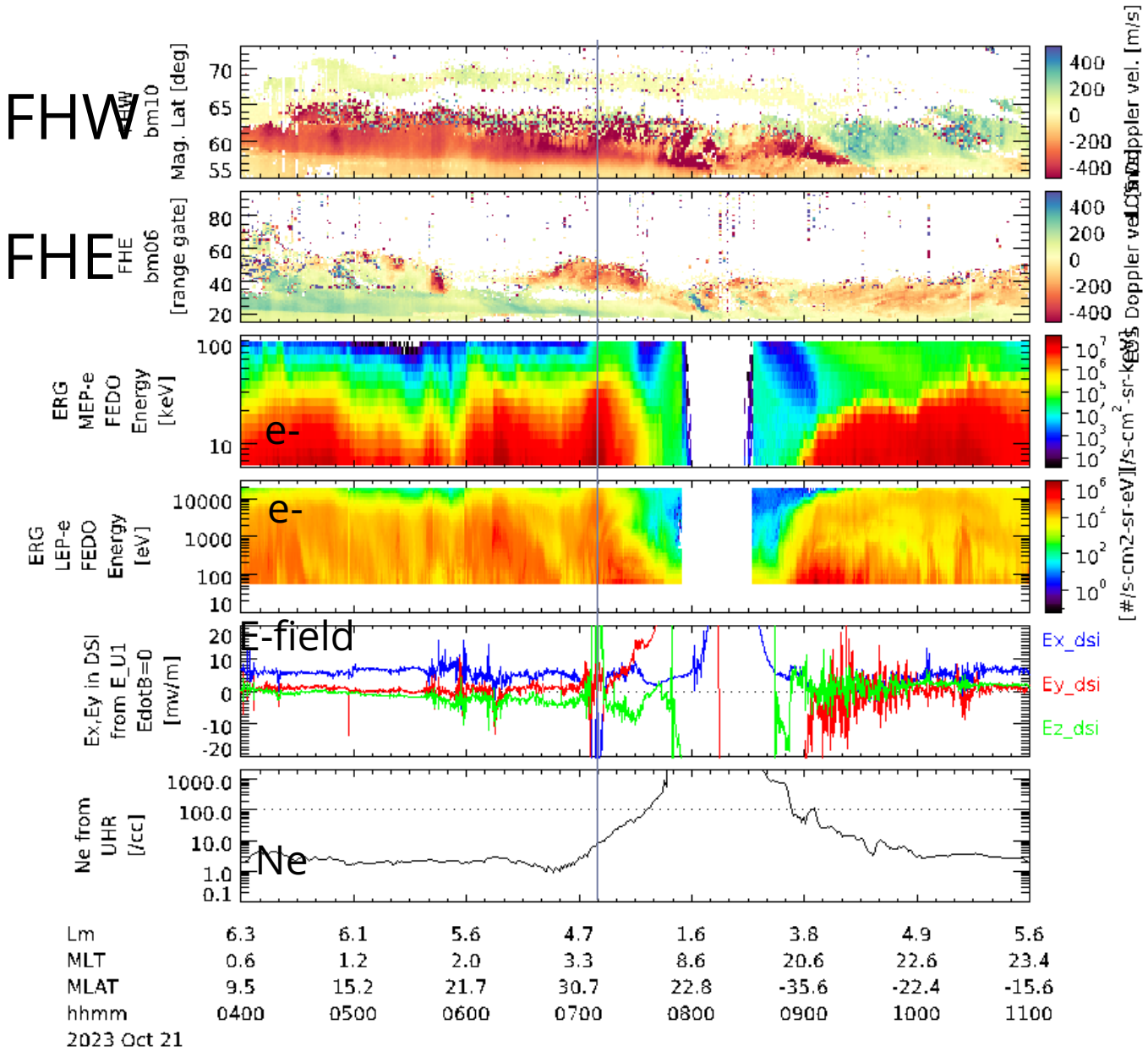
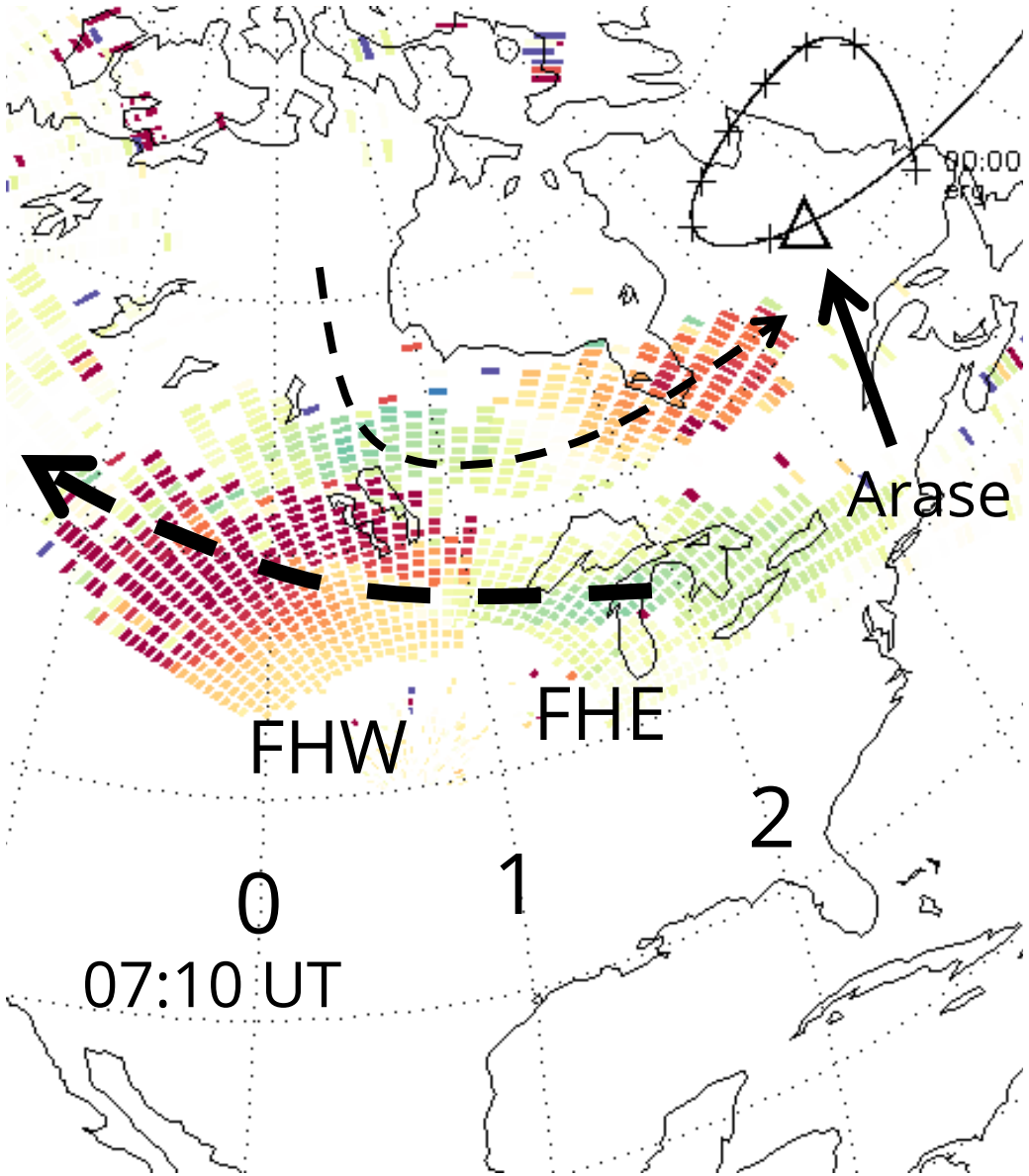



Arase missed
this beautiful flow complex...



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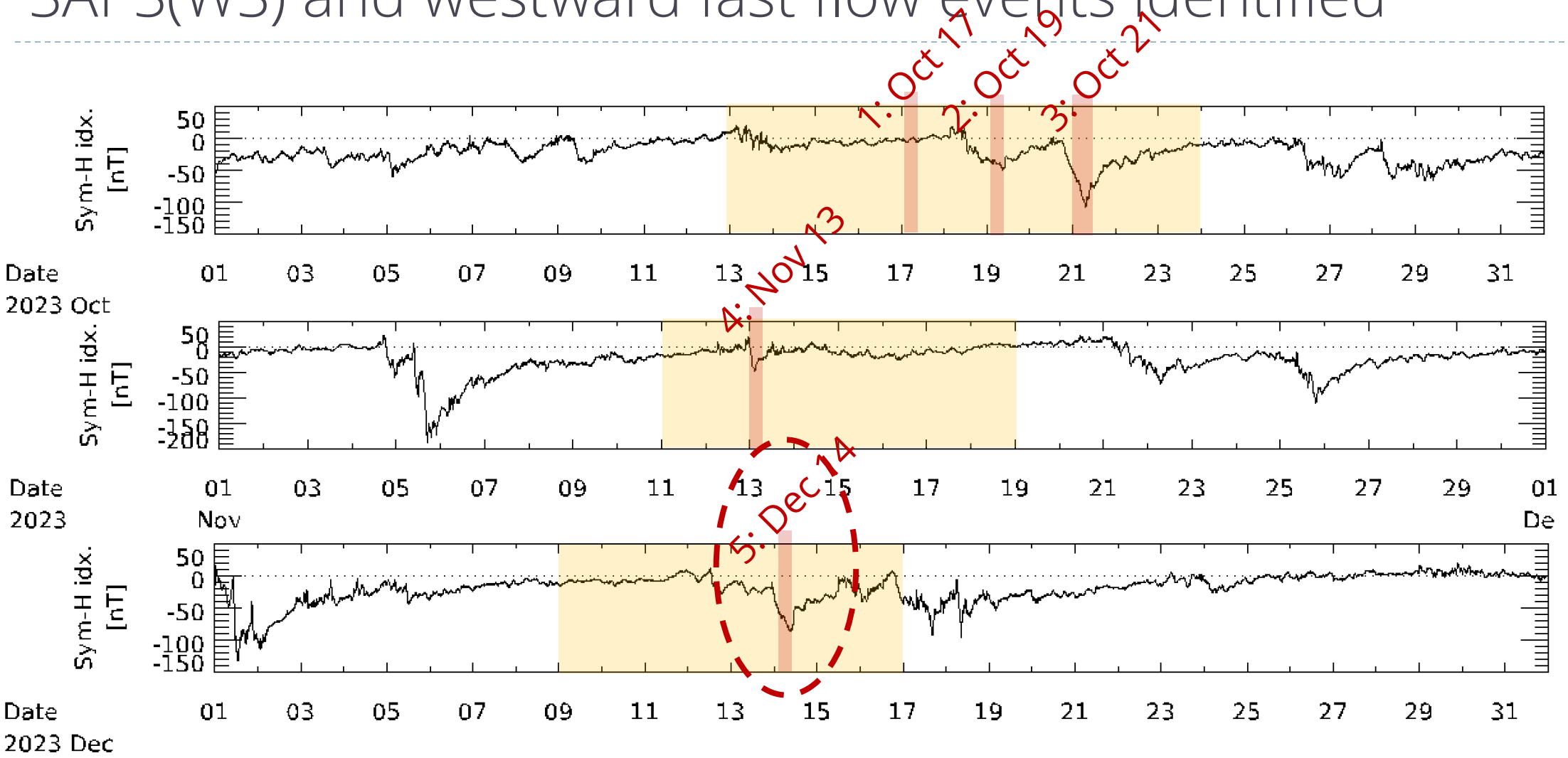


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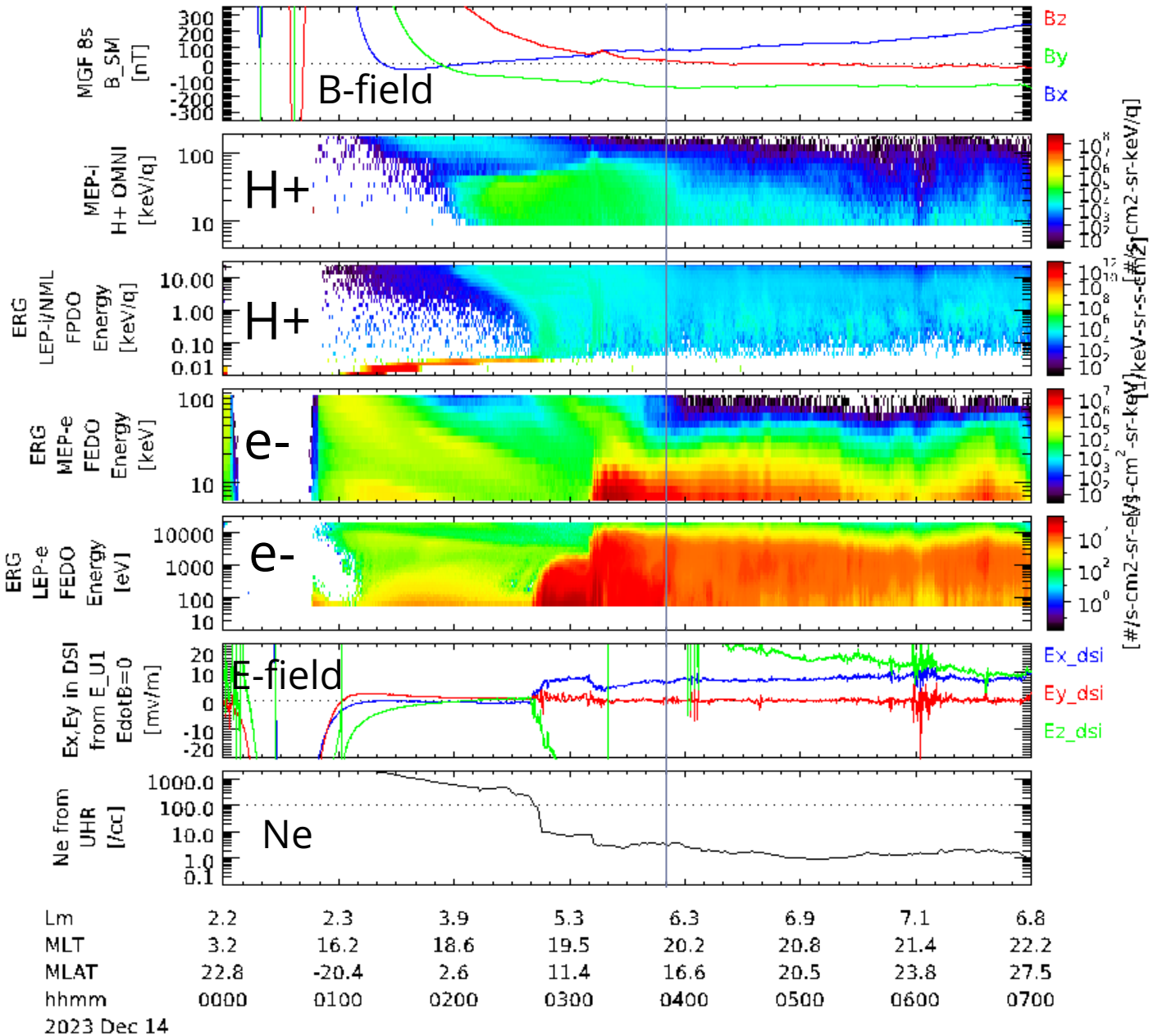
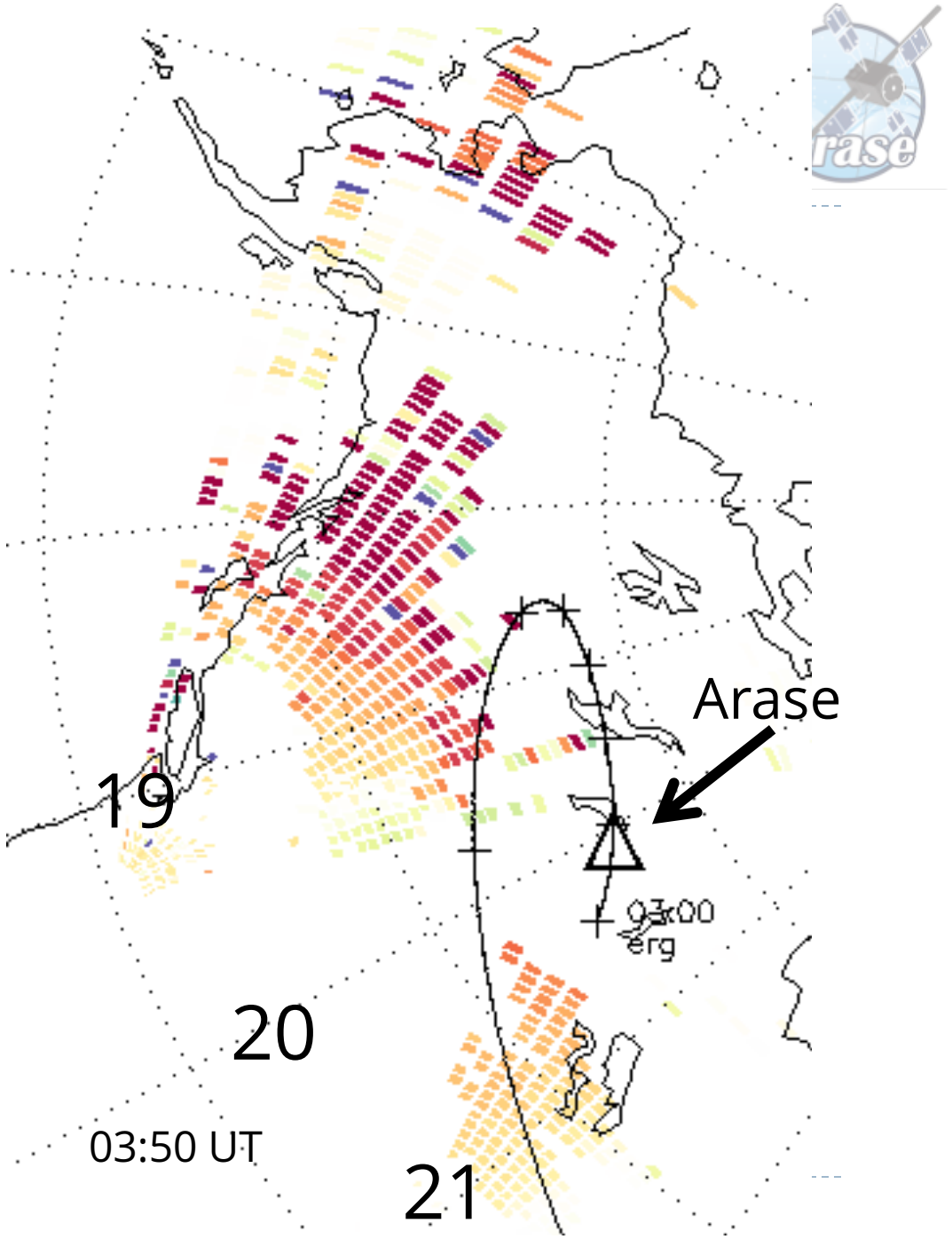
# Event 5: Dec. 14



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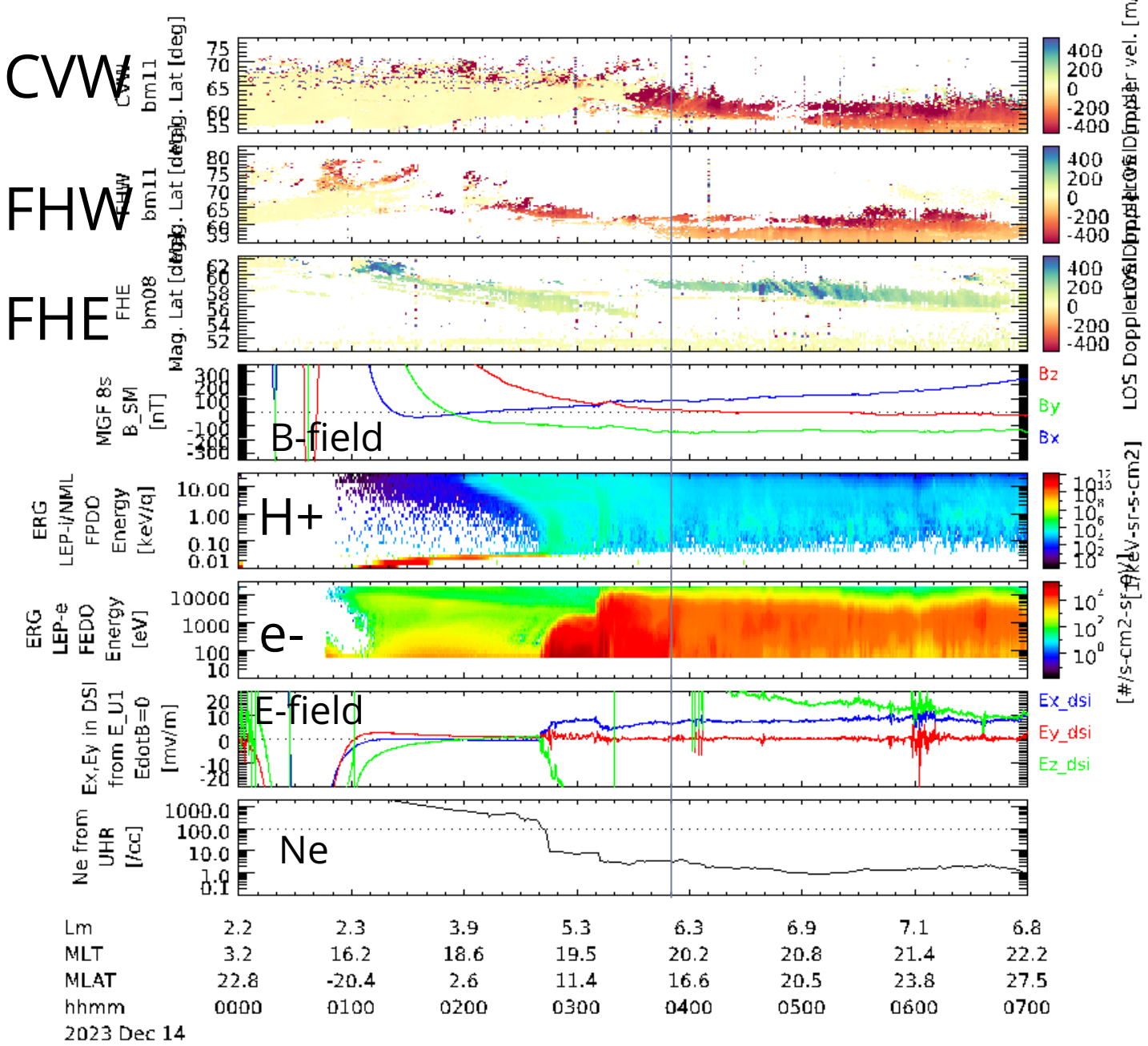


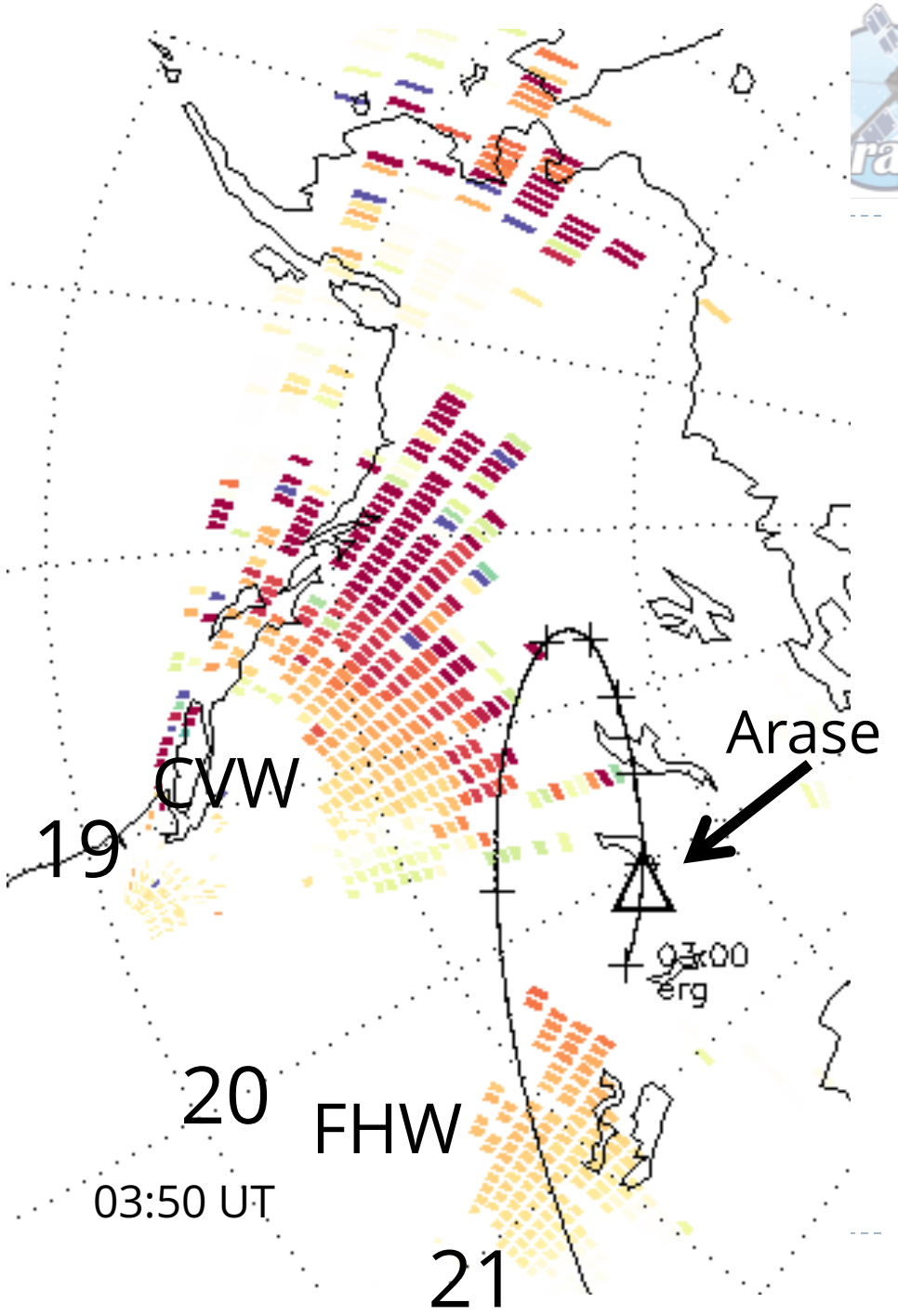

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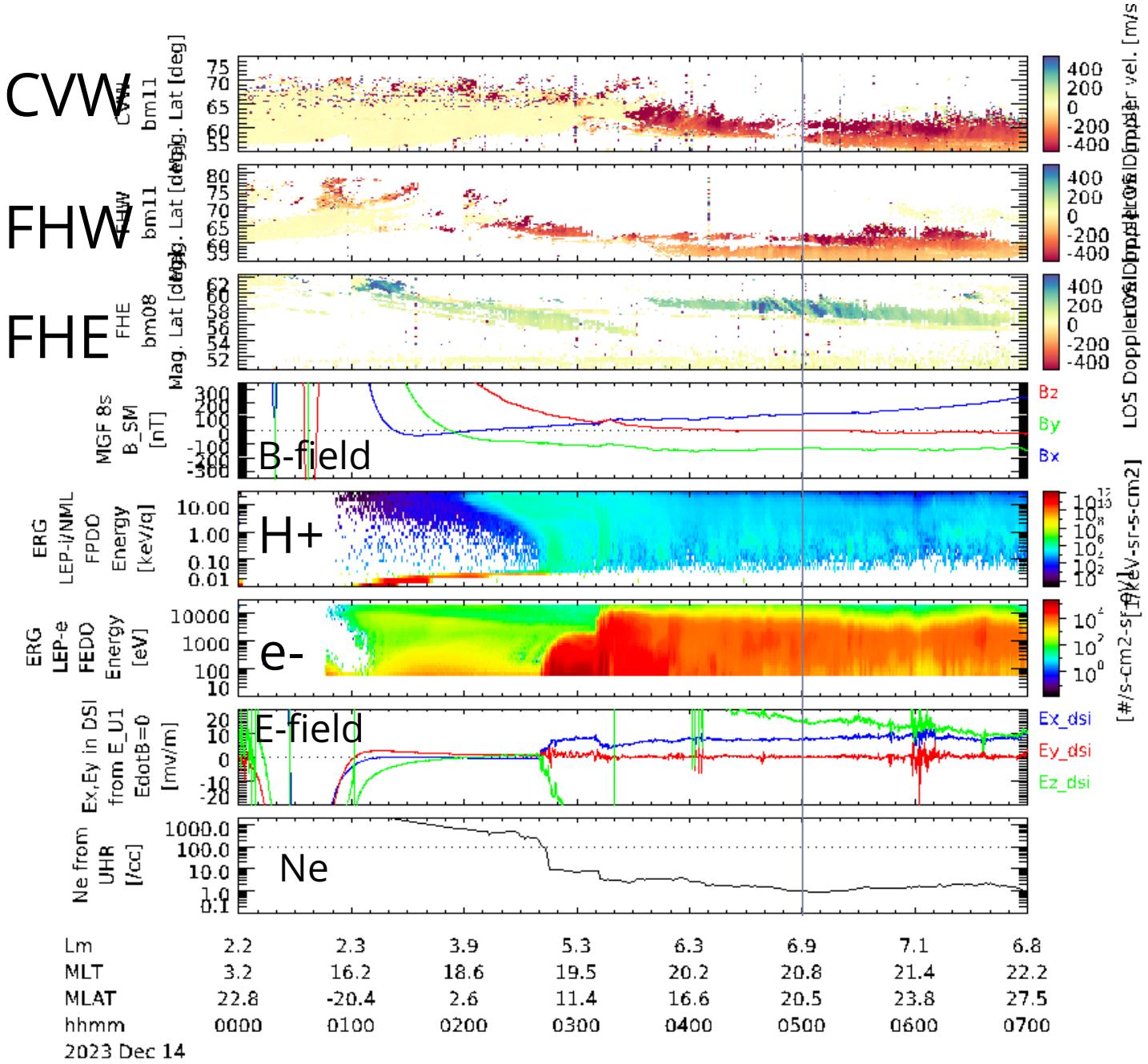


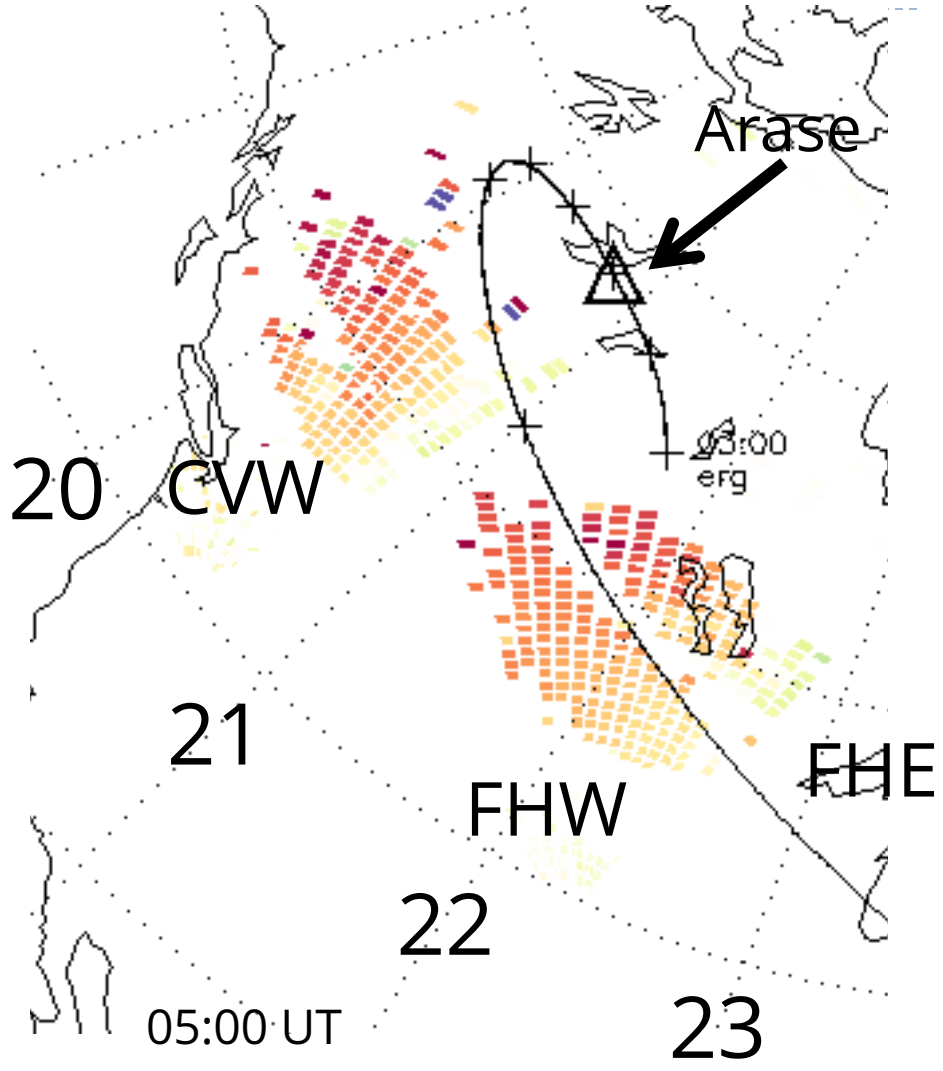

# Summary and conclusions

- 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.