JOHNS HOPKINS
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Contrasting behavior of dipolarization-related electron and ion injections inside GEO

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Dipolarizations and injections

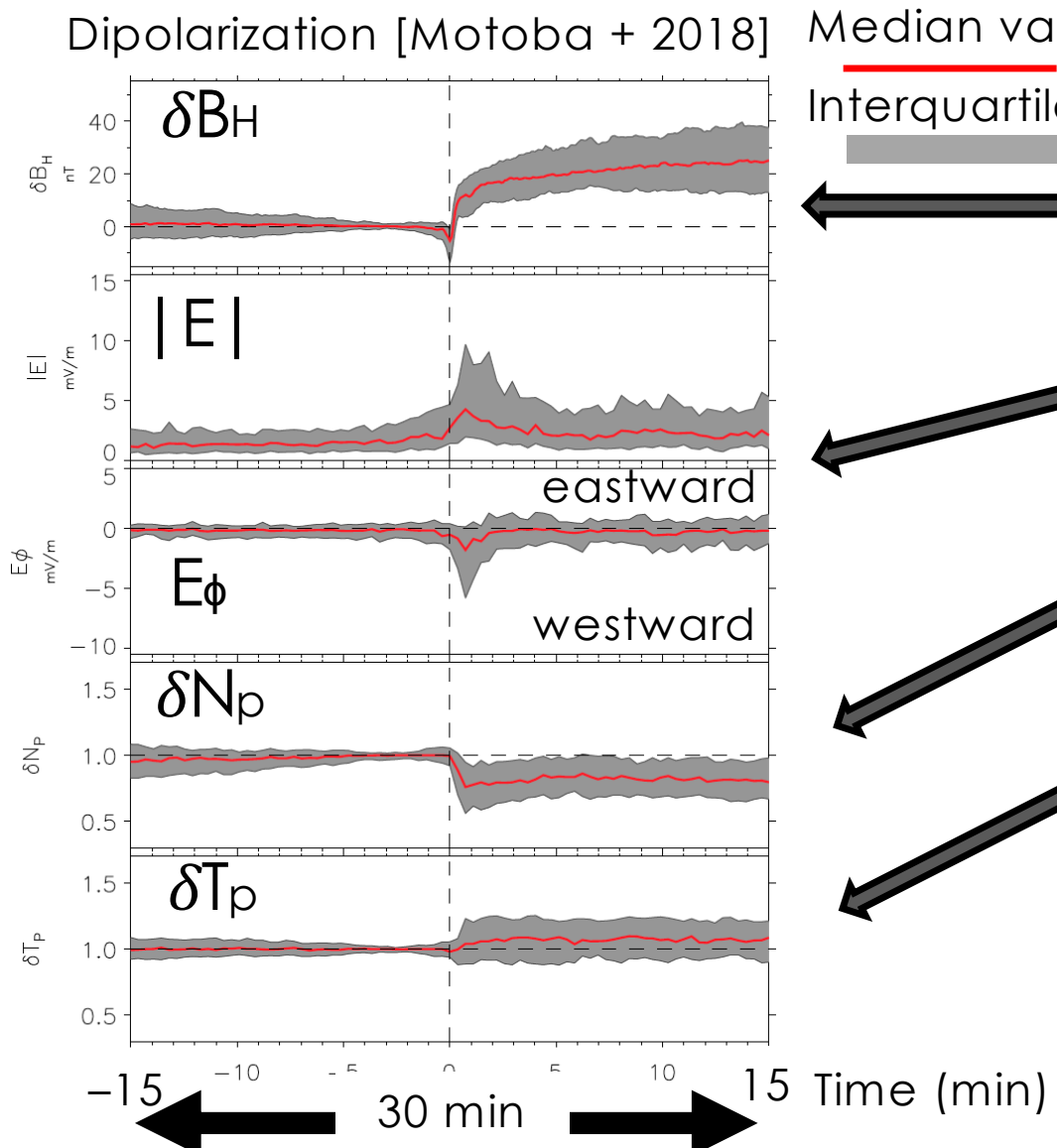
Magnetic dipolarizations and plasma injections are key processes at/near the onset of magnetospheric substorms. However,

- Don't completely understand how magnetic dipolarization inside GEO affects the transport and/or energization of energetic electrons and ions.
- Energy-/species-/charge-/pitch angle-dependent properties provide a clue to determine the transport and energization mechanisms.

Motoba et al. [2018]: Superposed epoch analysis of different ion species during dipolarization inside GEO, based on 144 dipolarization events:

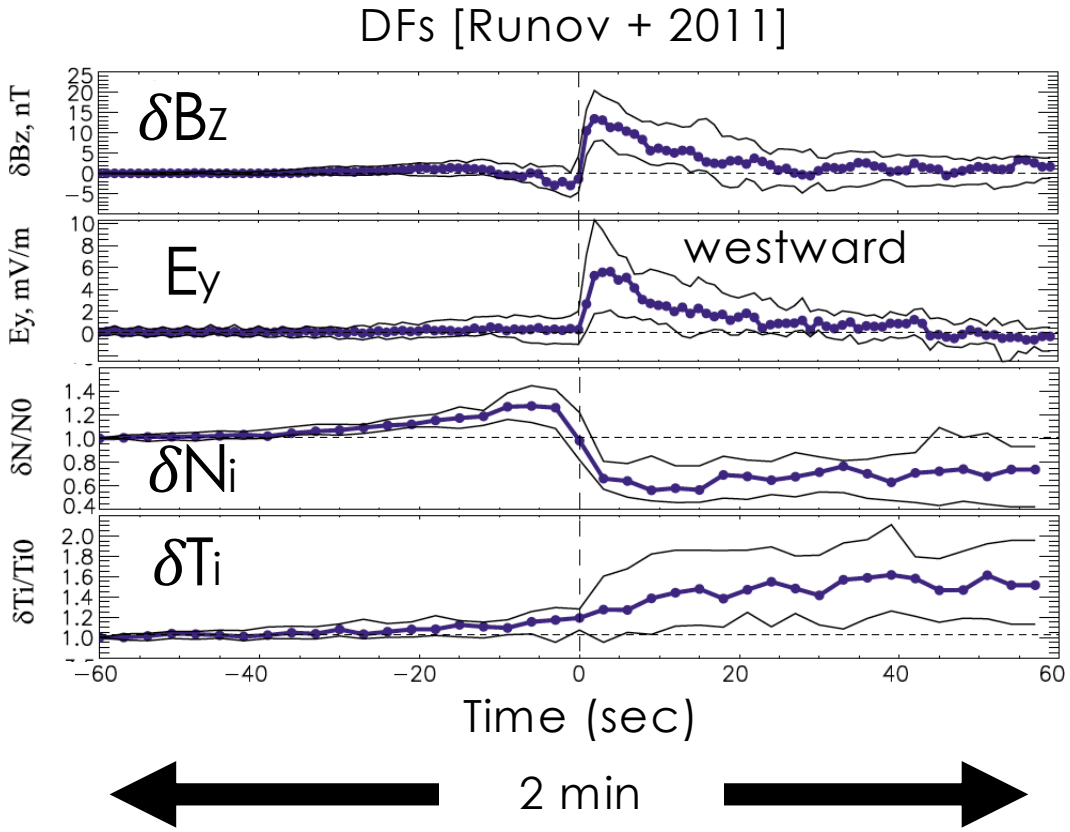
- Similar properties to DFs in the near-Earth tail
- Solar wind origin ions with high charged states (e.g., He^{++}, O^{6+})
- Ion flux enhancement little depends on mass.

1: Similar properties to DFs



Median value

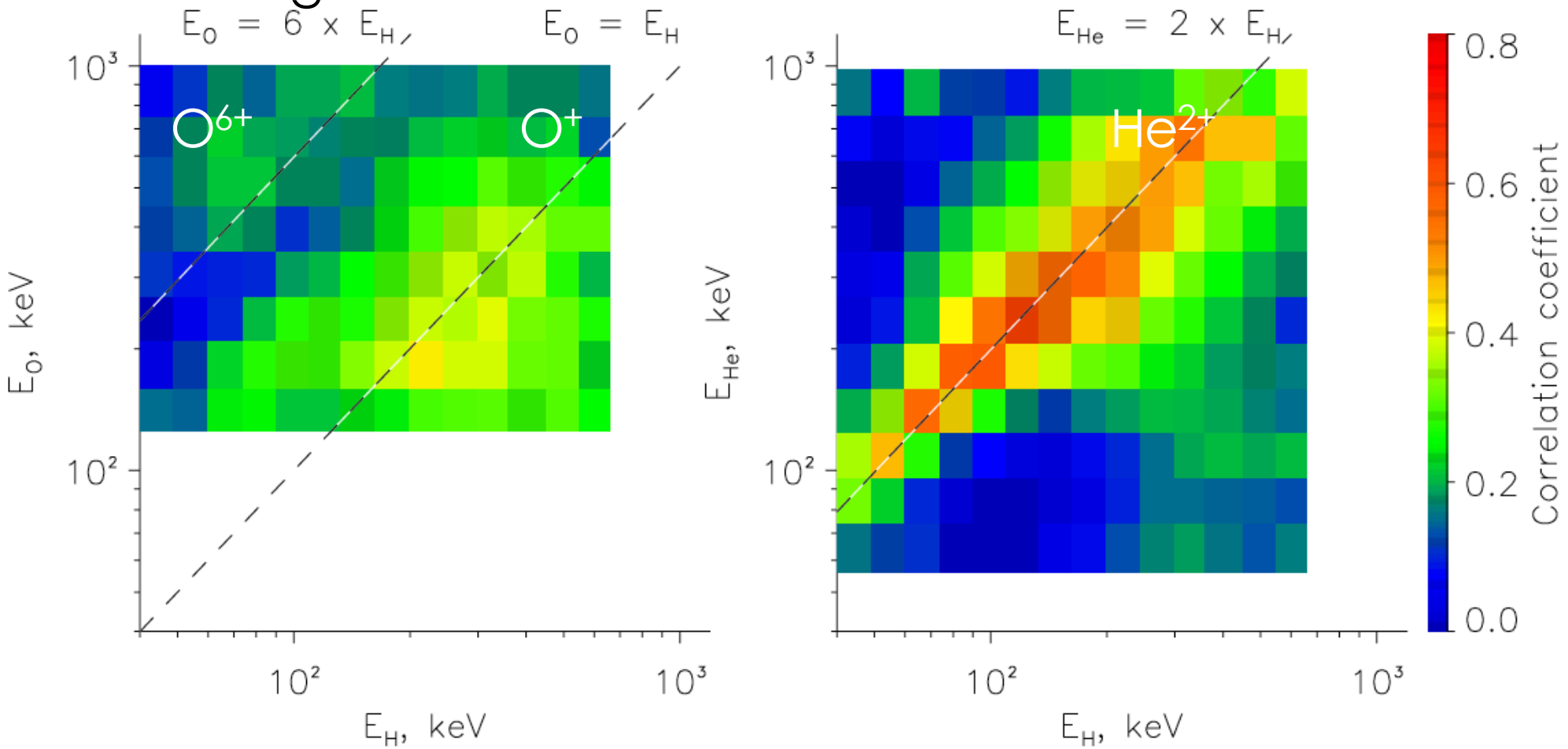
Interquartile range



Dipolarizations and DFs would have some commonality for their physical processes.

2: Heavy Ions with high charge states

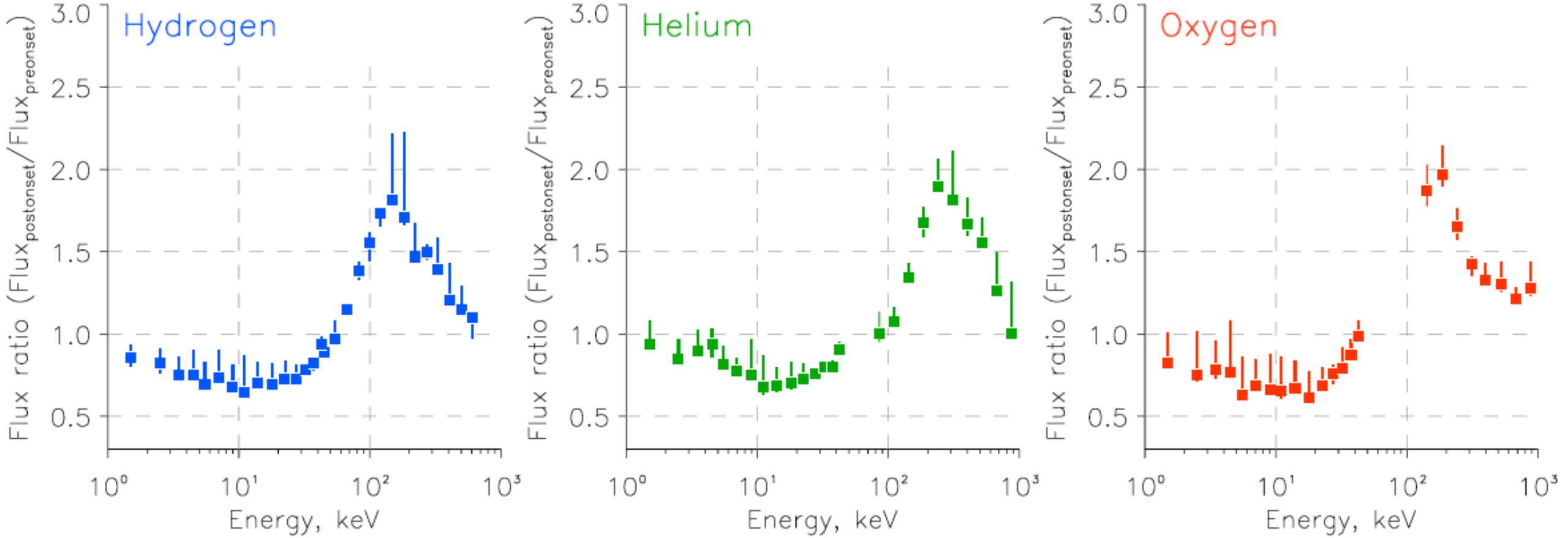
Average correlation btw H and O and btw H and He



High correlation at channels of which

- O energy is the same as H energy (O^{+}) and 6 times H energy (O^{6+}).
- He energy is twice H energy (He^{2+}).

3: Mass-independent flux change



Flux ratio has almost the same peak value, but its energy is different among H, O, and He.
Mass-dependent acceleration process may be less important.

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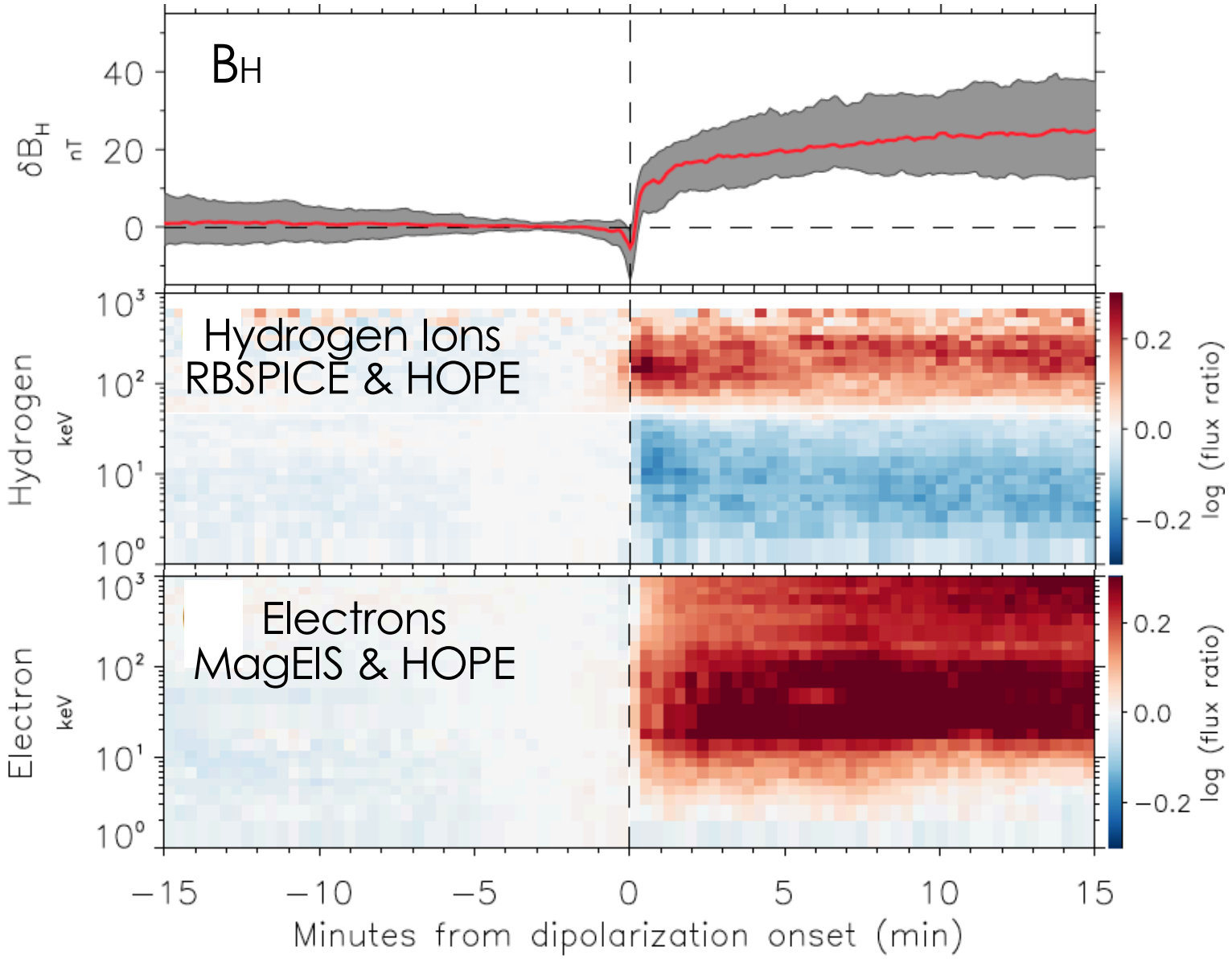
In this study we have done the same superposed epoch analysis of electrons to compare the electron properties with the ion ones.

Superposed epoch analysis

	H+ ions	Electrons
Energy at which flux ratio peaks	130–160 keV	30 keV
Demarcation energy	~50 keV	~5 keV
Flux increase	Transient < 1 min	Gradual ~2-4 min
Decay	Rapid < 2 min	Slow > 10 min

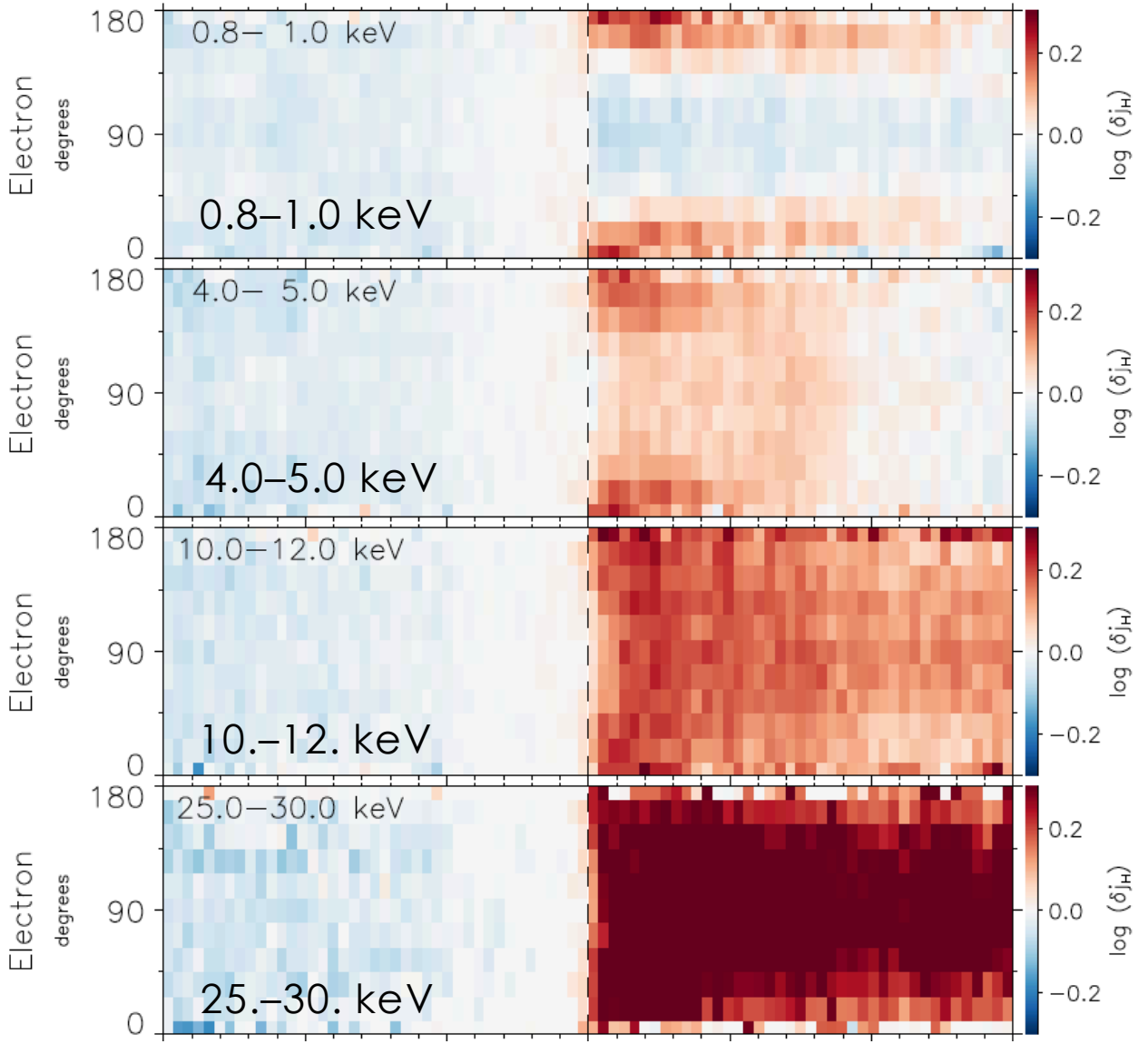


electron PAD (HOPE)

E < 2 keV
Increase at PA = 0 & 180

2 < E < 10 keV
Increase at PA = 45 & 135

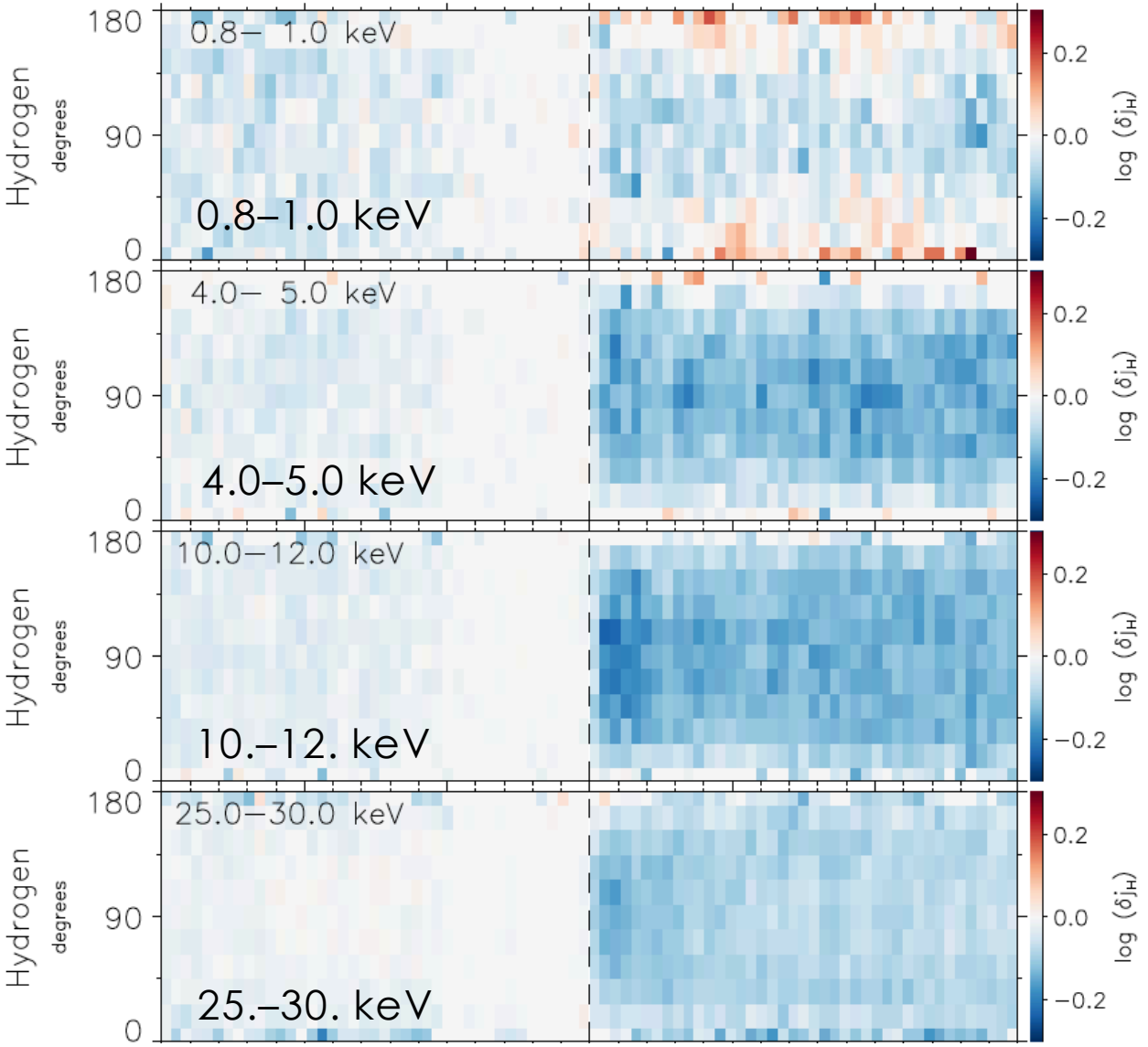
> 20 keV
Increase at PA = 90



Hydrogen PAD (HOPE)

< ~1 keV
Increase at PA = 0 & 180

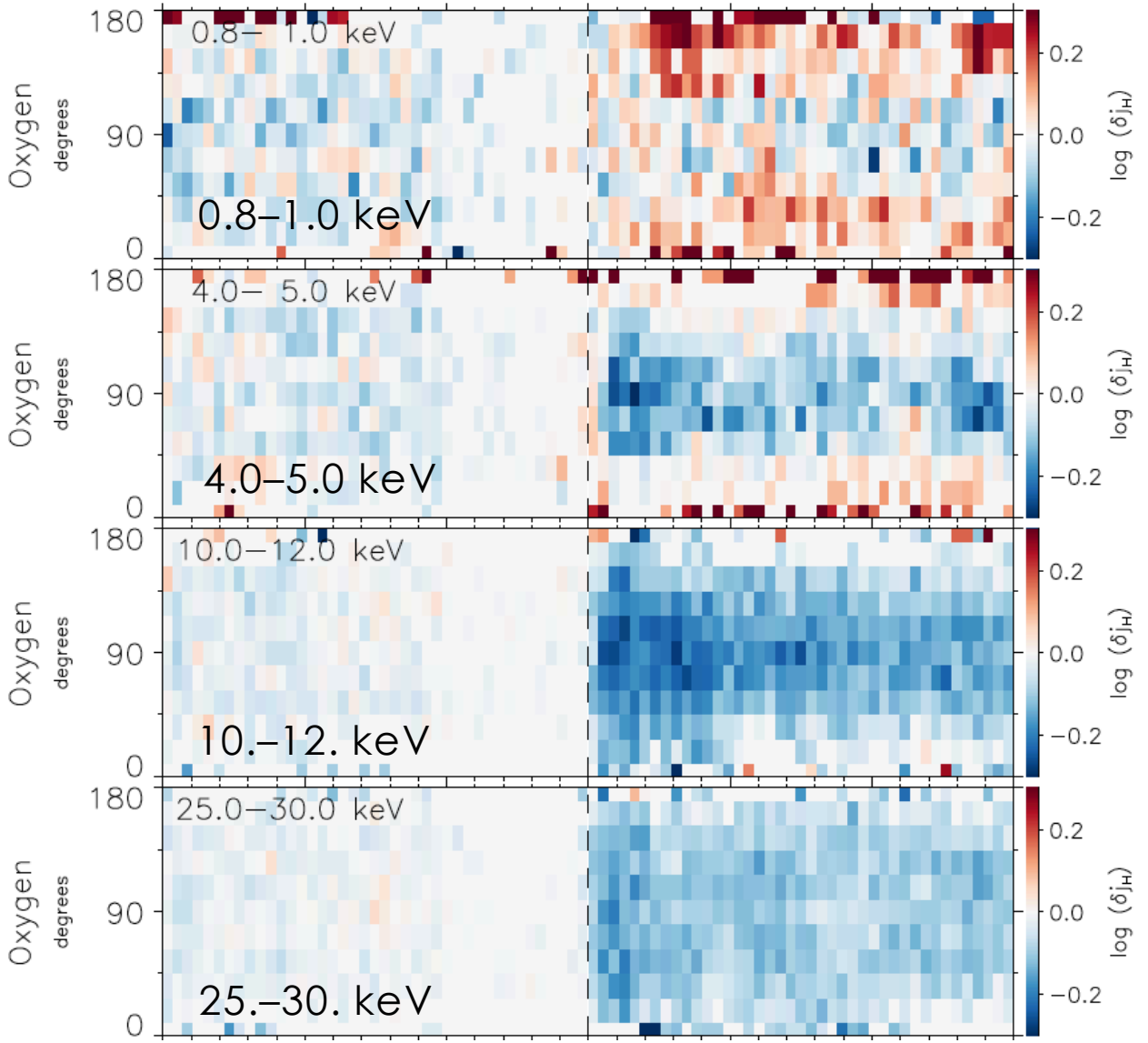
> ~1–45 keV
Decrease at all PAs (especially 90)



Oxygen PAD (HOPE)

< ~10 keV
Increase at PA = 0 & 180

~10–45 keV
Decrease at PA = 90



Energy-pitch angle distribution

Electron flux enhancement
- PA = 0° & 180° at <10 keV
- Butterfly at 10–30 keV
- PA = 90° at > 30 keV

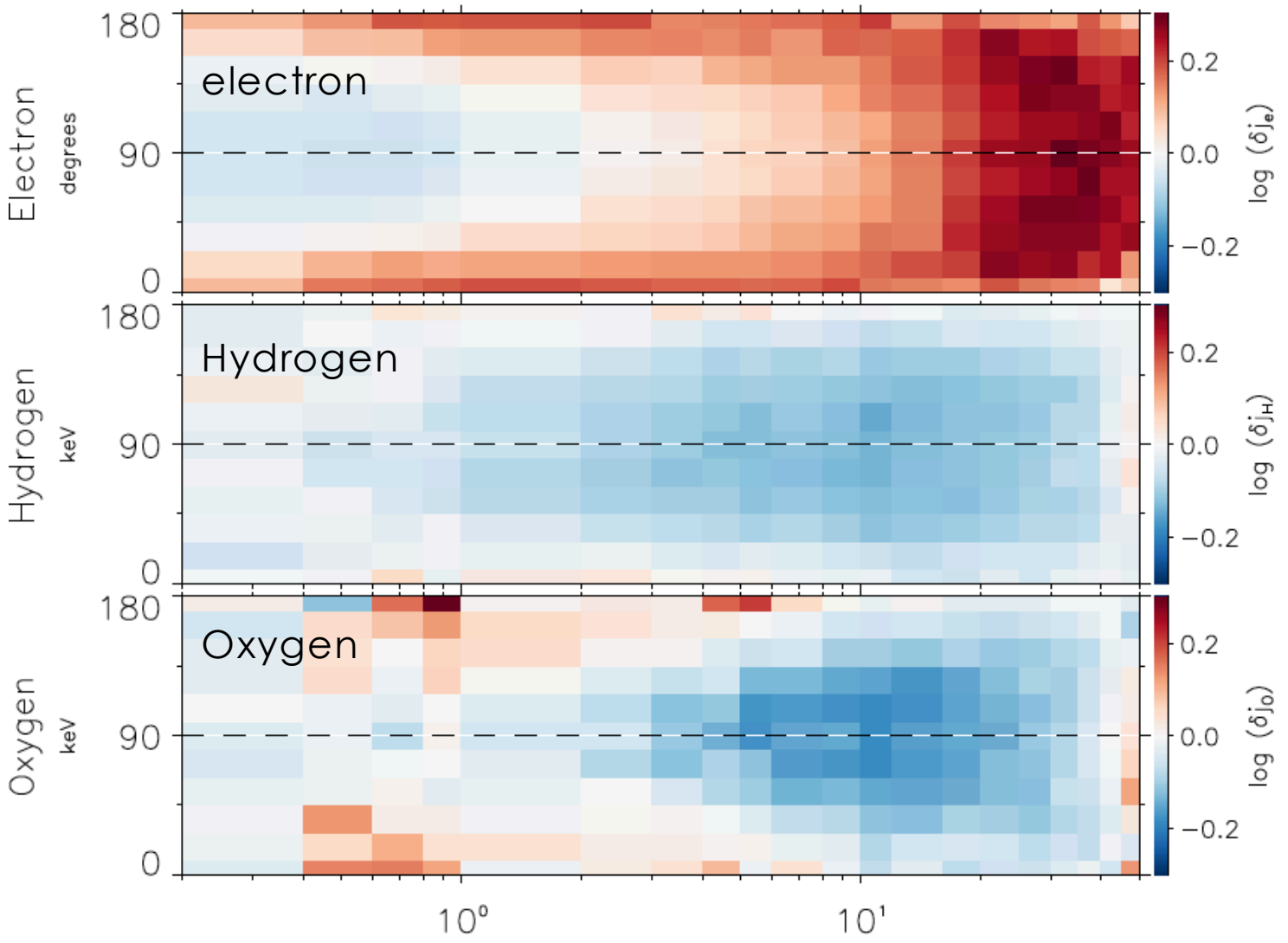
Fermi and/or Betatron

H & O ion flux decreases
- PA = 90° at < 40 keV

local energization and/or deep penetration of plasma bubble?

O ion flux enhancement
- PA = 0° & 180° at < 1 keV

O^+ outflow [Nose + 2016; Gkioulidou + 2018 submitted]



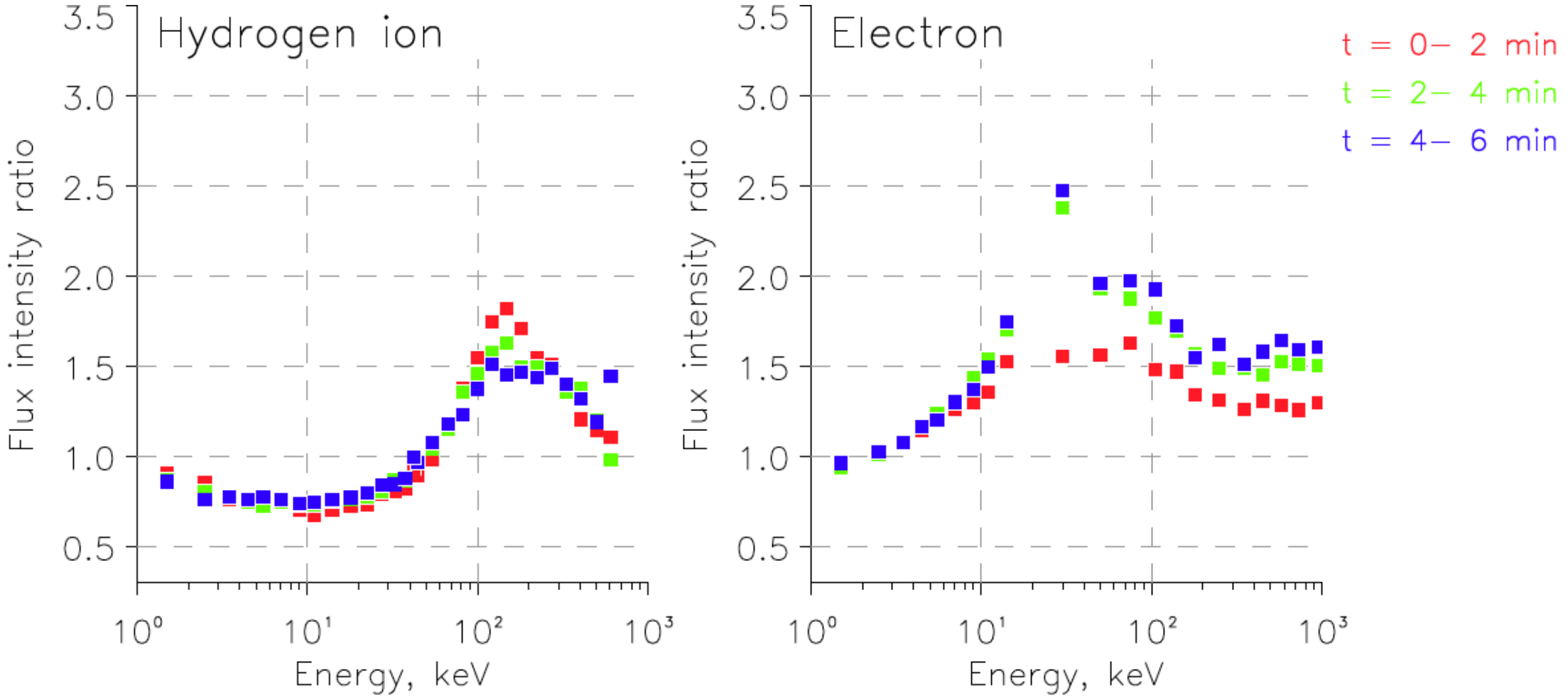
Summary: Average picture

Main differences between ions and electrons:

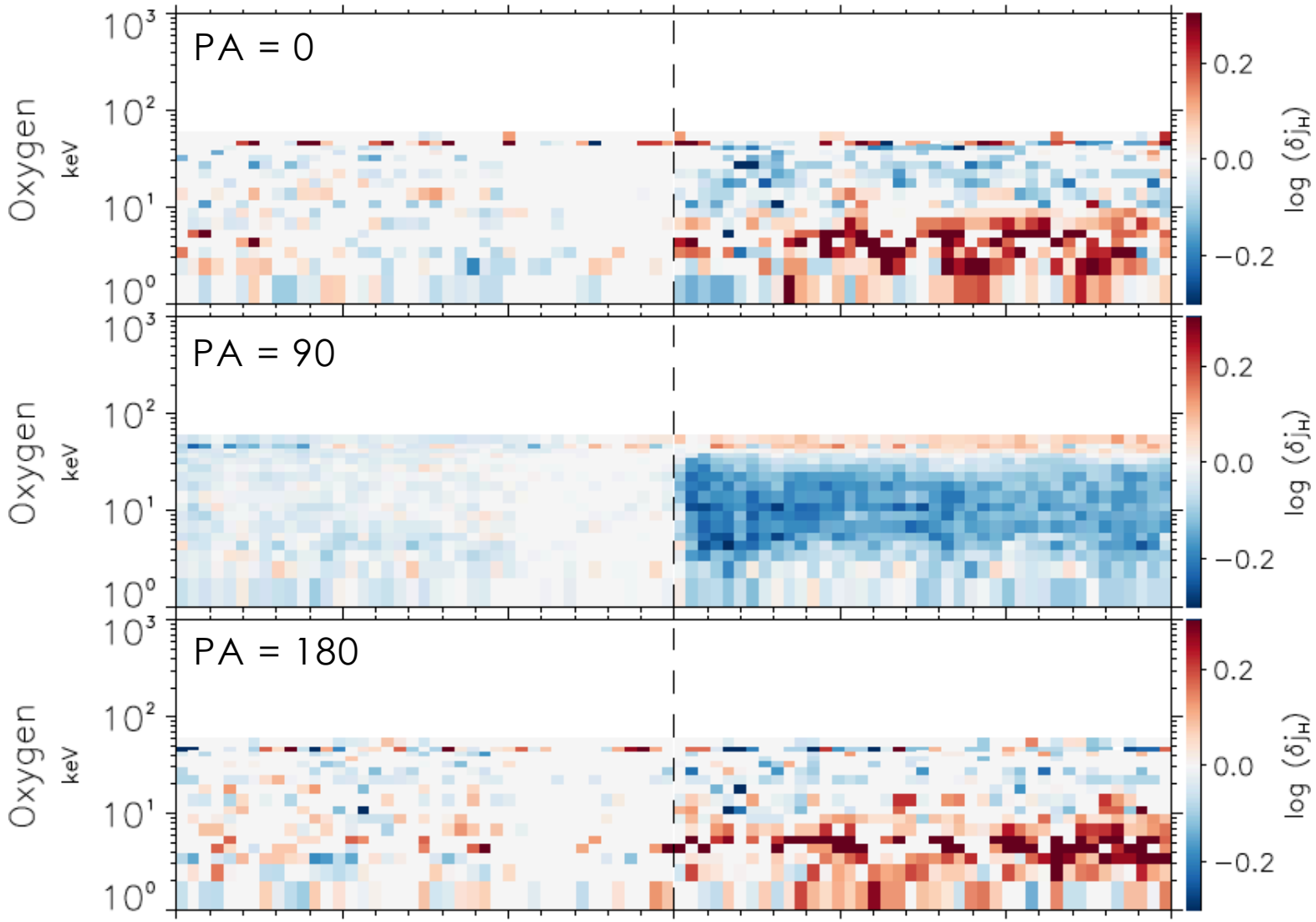
- Energies of which flux ratio reaches a peak
- Demarcation energy
- Flux increase (transient/gradual) Decay times
- Energy-dependent PADs (< 50 keV)

Backup

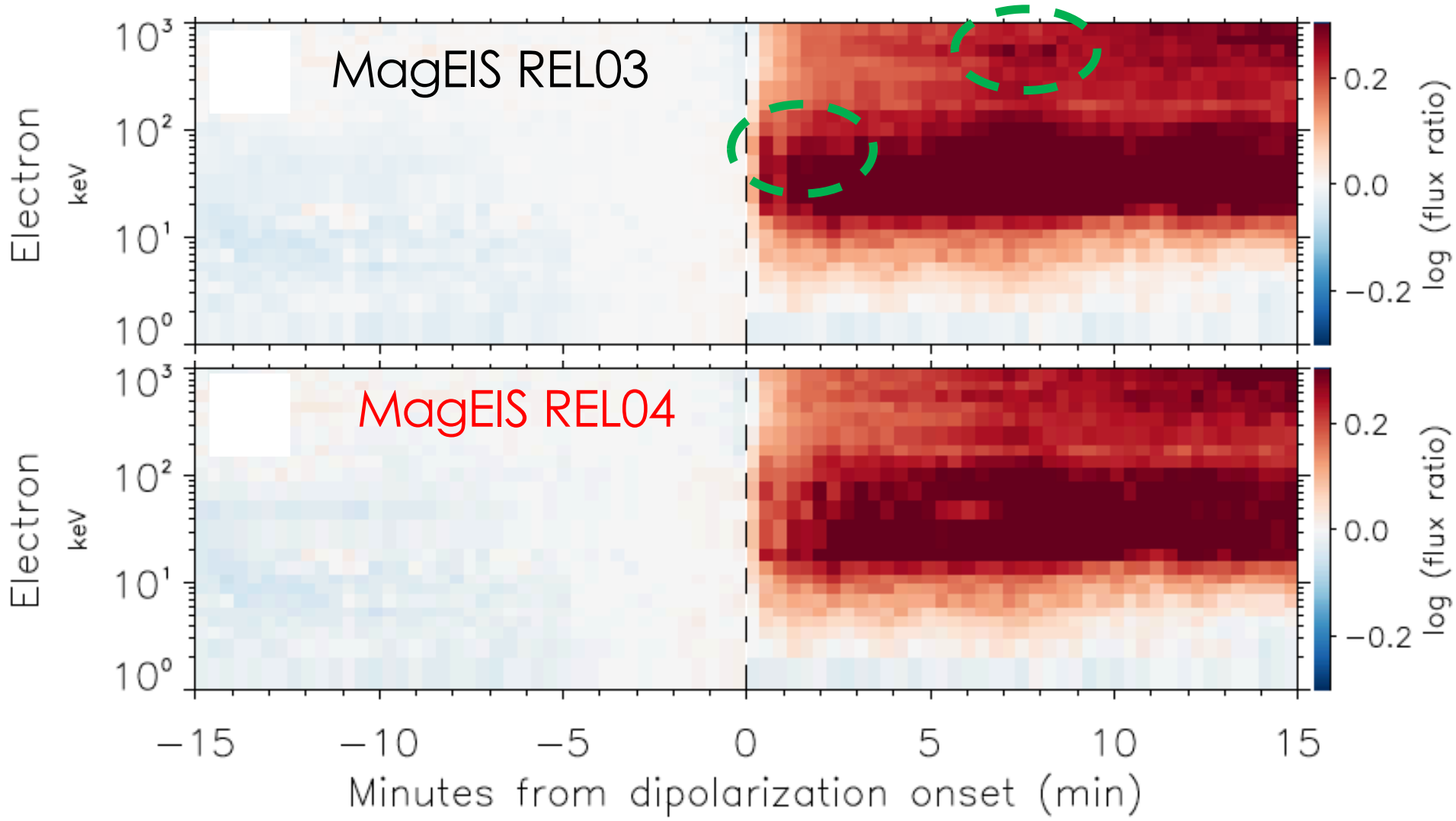
Energy dependence of H and e⁻ flux ratios



Backup



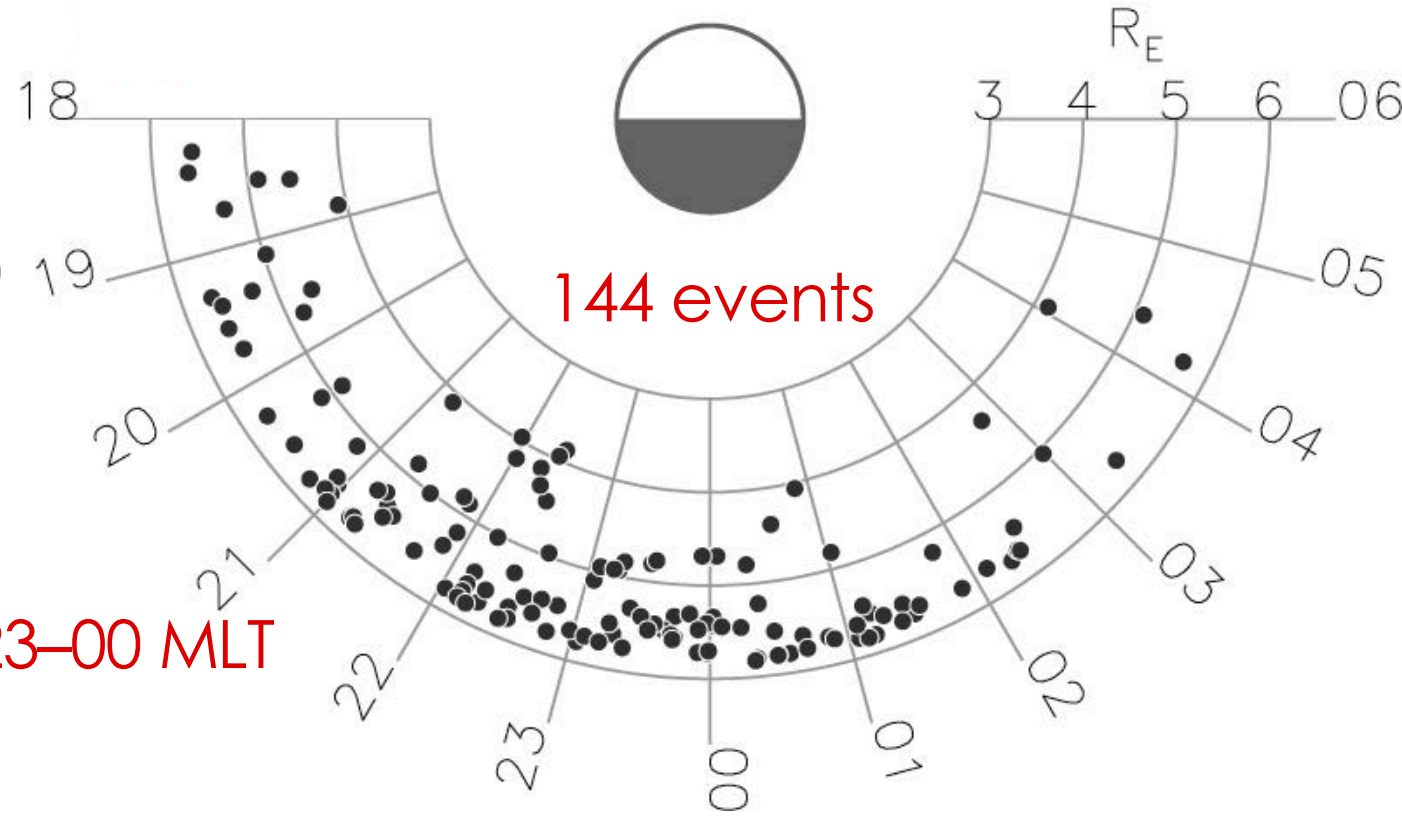
MagEIS REL03 vs. REL04



Backup

Data:
Van Allen Probes in the 2012–2016 tail seasons
EMFISIS, EFW, RBSPICE, and HOPE

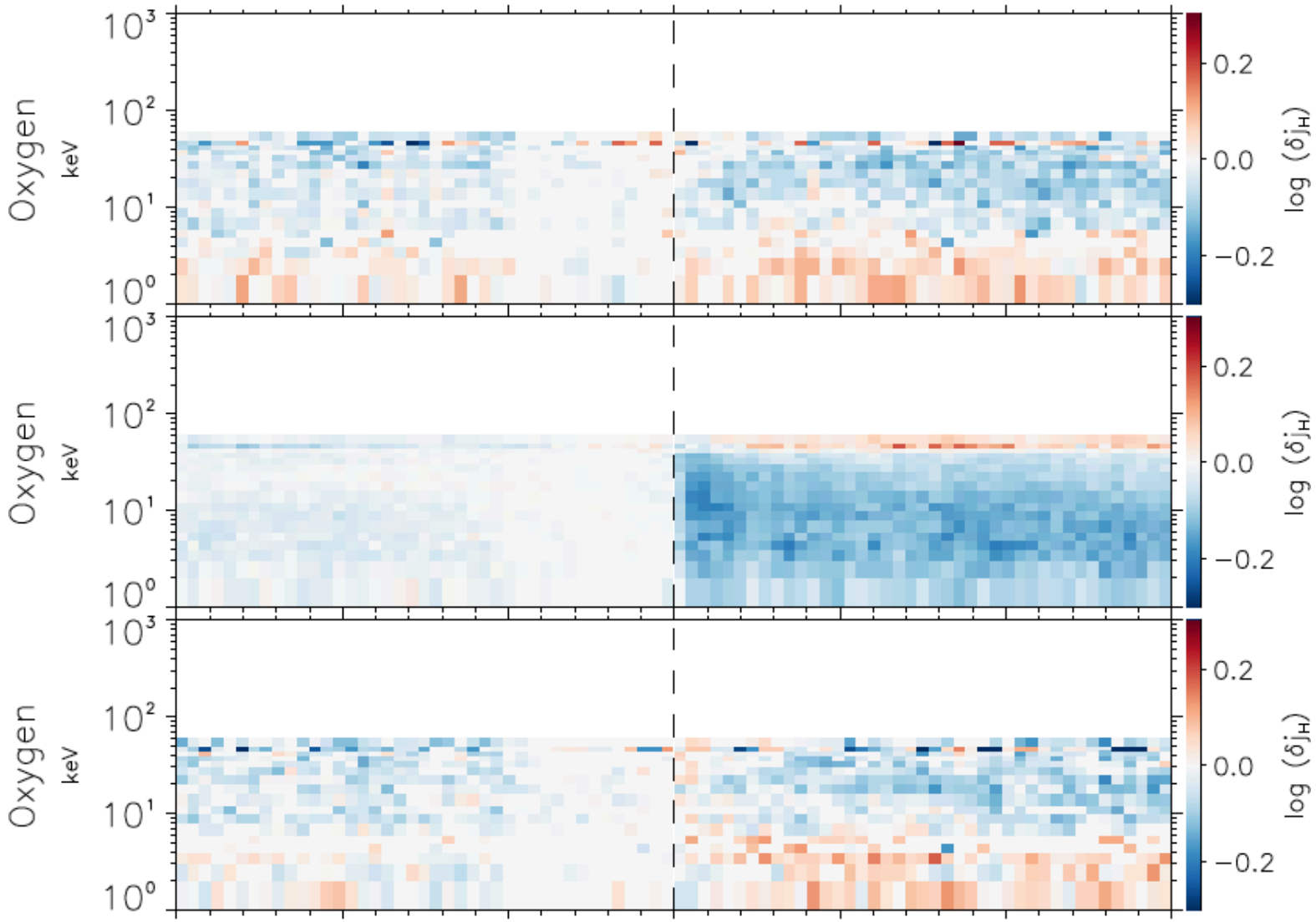
Event selection:
- A sharp increase in B_H (> 0.5 nT s^{-1})
- Magnetic inclination (θ_I) > 30° :
  $\theta_I = \tan^{-1}(|B_H|/(B_V^2+B_D^2)^{1/2})$



Occurrence:
- Premidnight MLTs with a peak of 23–00 MLT

Analysis:
Superposed epoch analysis of H, O, and He (1–1000 keV) flux changes around PA = 90°

Backup



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