Hot He^+ events in the inner magnetosphere observed by Cluster

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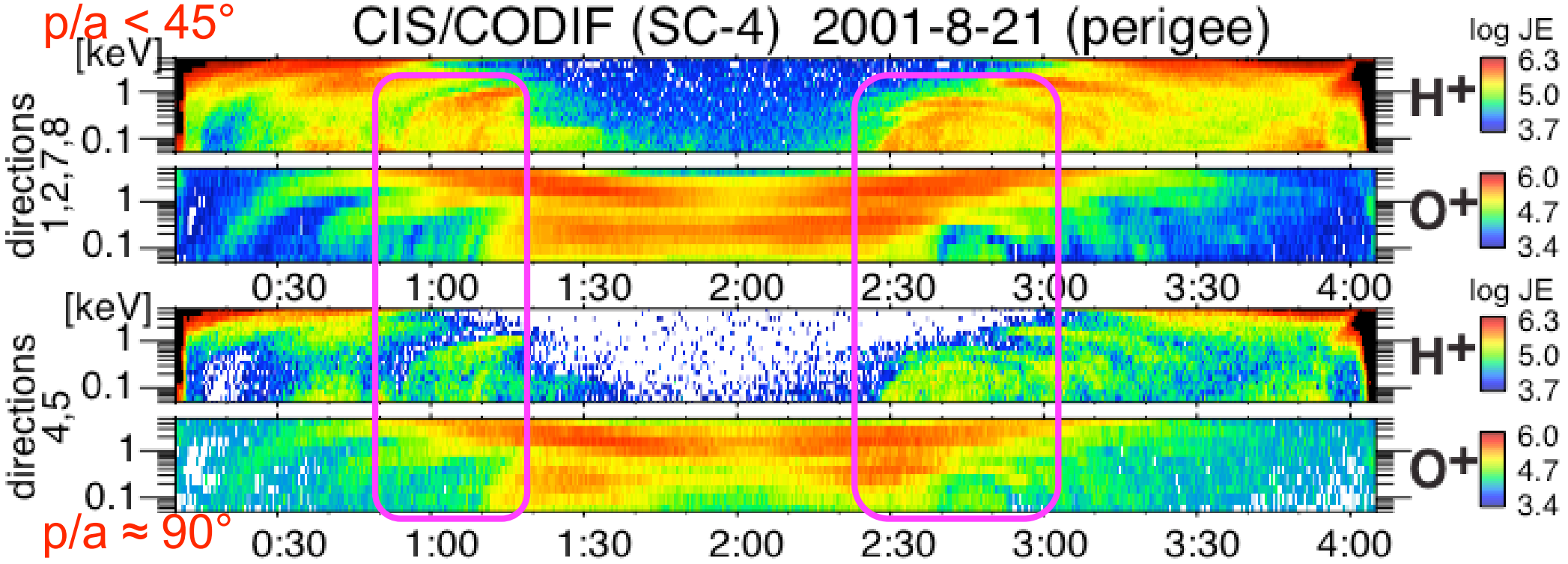
Motivations

* Sometimes drifted ion pattern (including pitch angles) are mass dependent (theory predicts the same energization and the same drift velocity for different species if the initial energy is the same).



* Sometime heated He^+ are observed in the inner magnetosphere at different energies from H+ or O+ (ion cyclotron wave is the strongest candidates (e.g., Young et al., 1982).

Analyses

Where? Inner Magnetosphere at L=4~7 (**Cluster perigee**)

Species? He^+ of 10 eV ~ 10 keV (CIS/CODIF energy range)

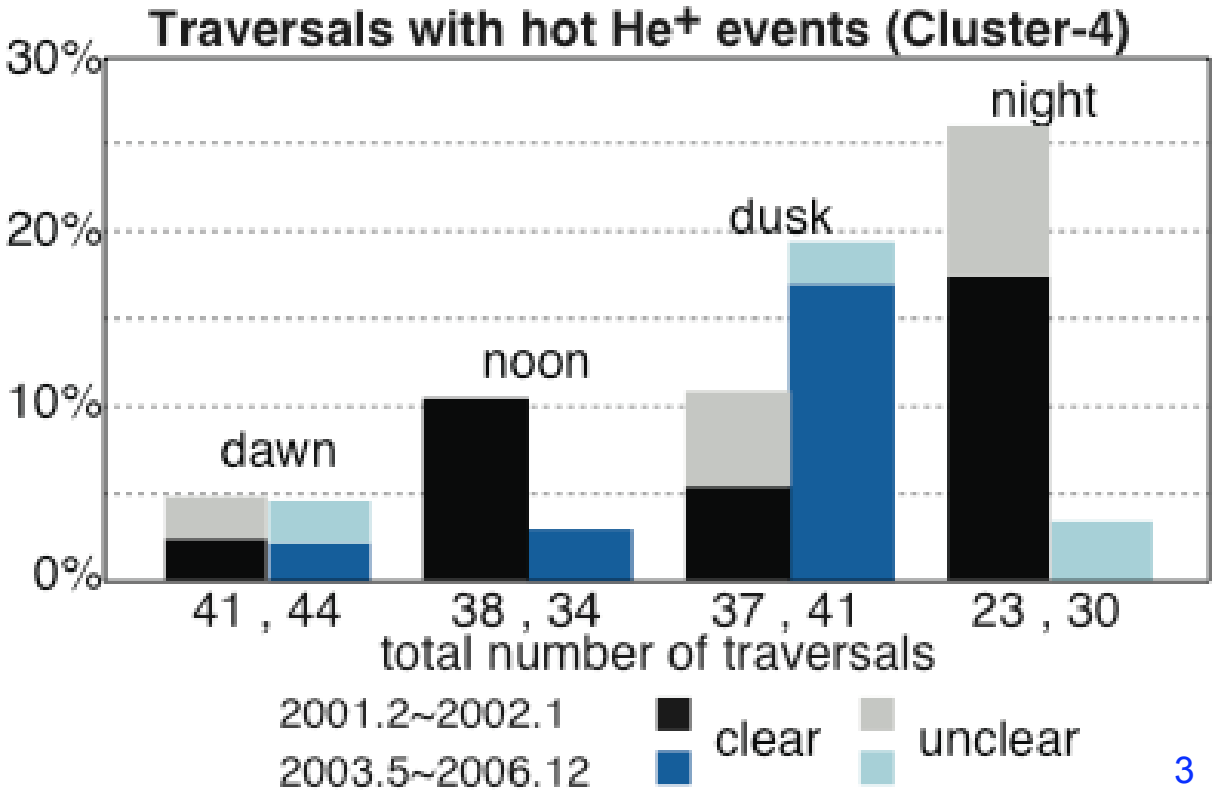
Distribution? He^+ enhancement independent of H^+ and O^+

In this work:

* Survey entire 2001-2006 data (~300 relatively clean data out of ~760 traversals)

* Classify these He^+ events into local types and remote types

* Examine location in terms of plasmasphere and relation to substorms



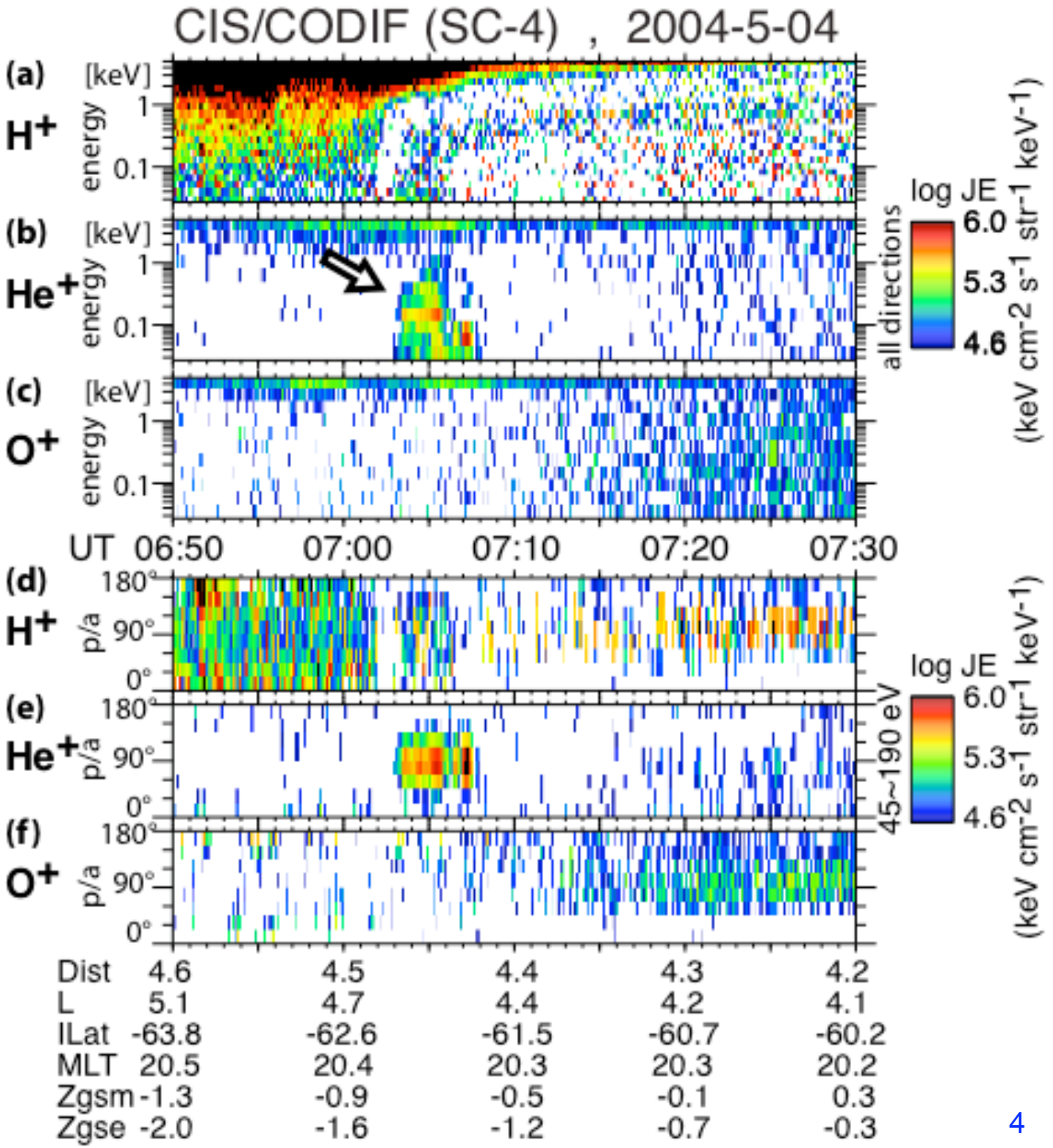
Local burst: type-A

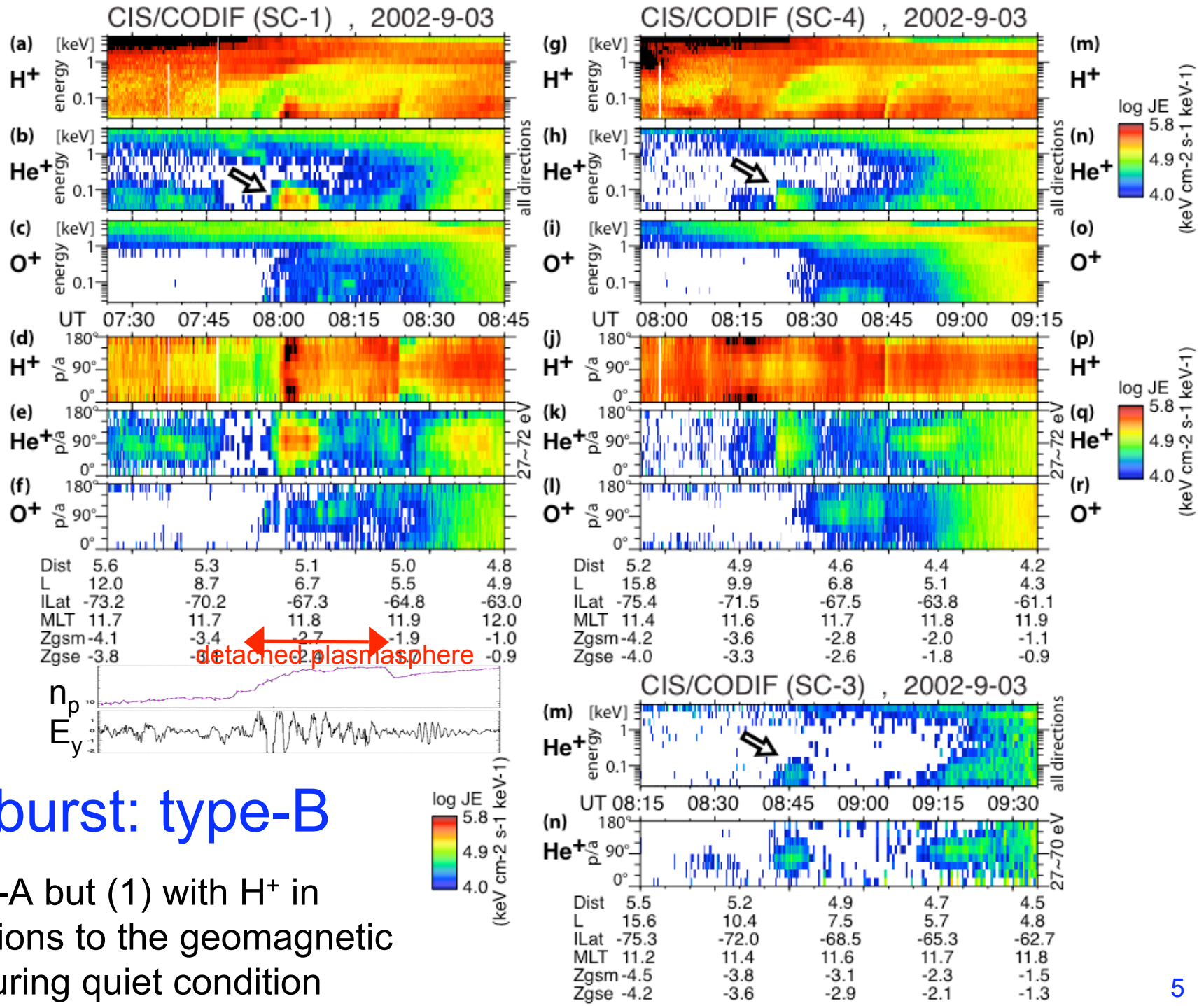
(1) Only He^+ (faint H^+, no O^+ or He^{++}) in ⊥(trapped) direction to the geomagnetic field.

(2) No energy-time dispersion (= no drift), while very faint H^+ with energy-latitude dispersion.

(3) During or right after substorms mainly in the late evening sector.

(4) Timescale~1 h? (too little statistics of multiple spacecraft observations)





Local burst: type-B

Similar to type-A but (1) with H^+ in different directions to the geomagnetic field and (2) during quiet condition

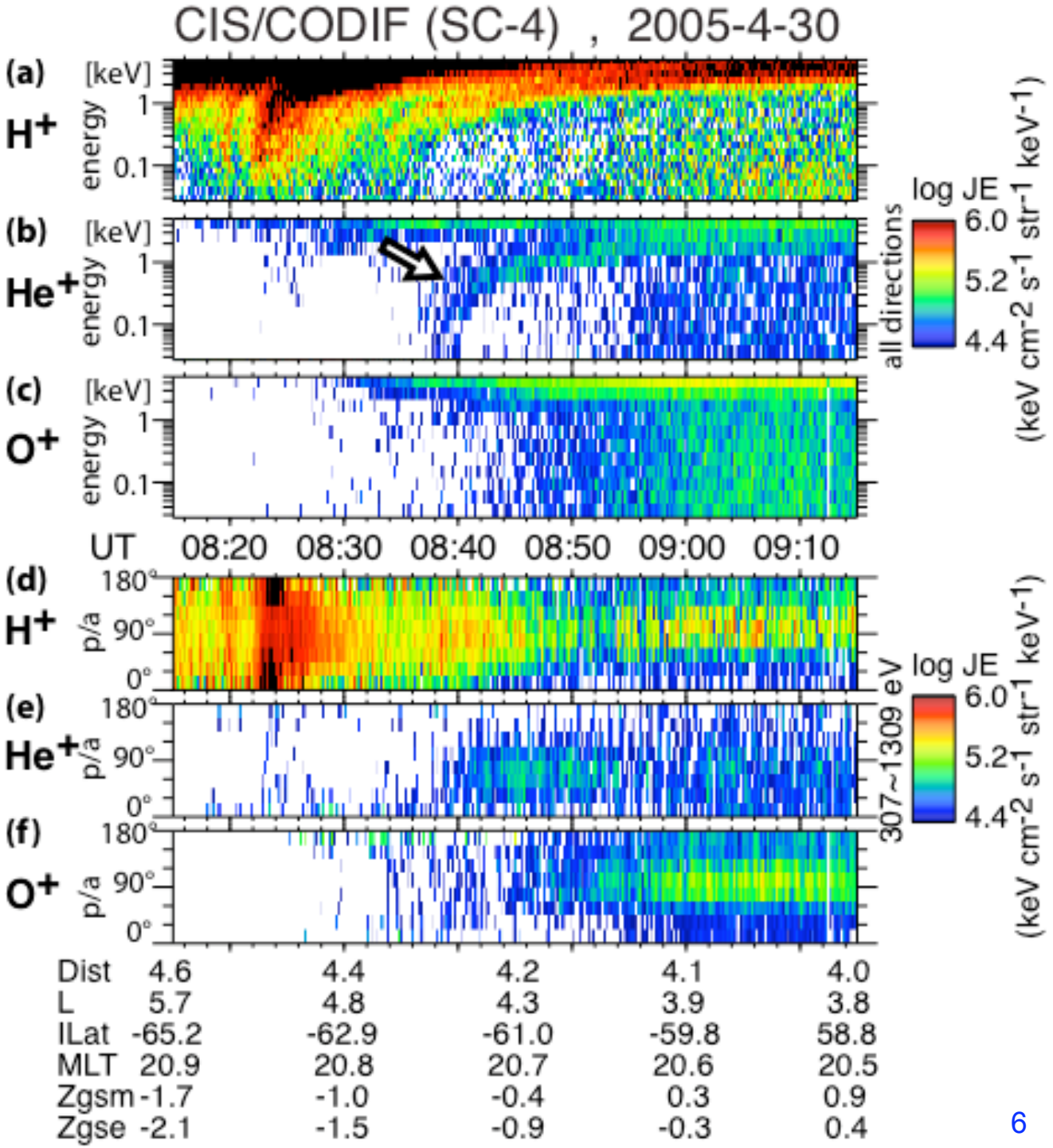
Drifted from Remote: type-A

(1) Strong energy-latitude dispersion mainly in ⊥(trapped) direction to the geomagnetic field (= long drift time).

(2) Timing (or energy) of He^+ is quite different from that of H^+ (or O^+).

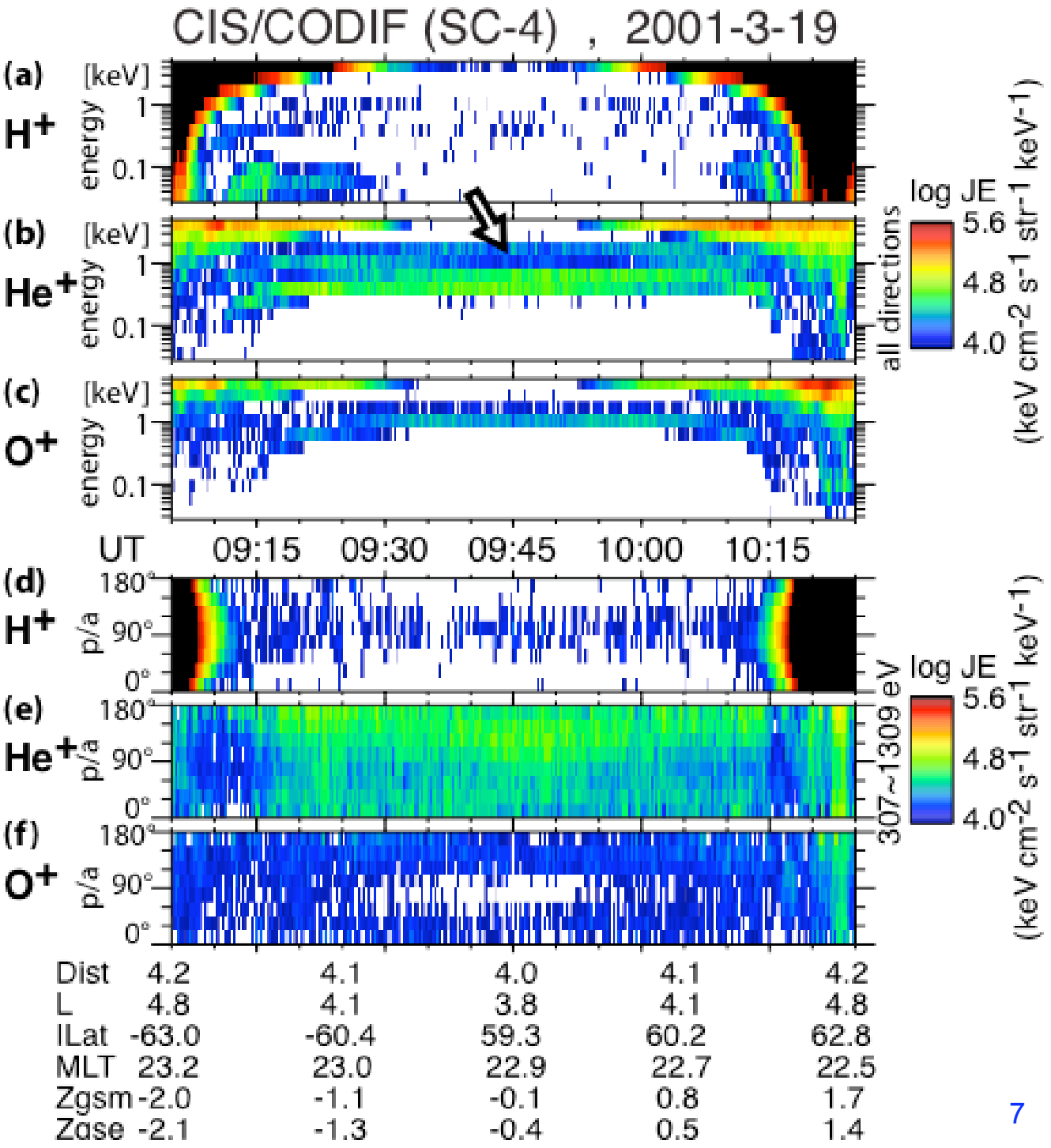
(3) After enough drift time from substorms energization.

(4) Timescale~1 h? (too little statistics of multiple spacecraft observations)



Drifted from Remote: type-B

Similar to type-A but (1) H^+ intensity is much less than He^+ intensity or O^+ intensity, and (2) after long quiet periods.



Summary

Low-energy (< keV) He+ enhancement events without the same type H^+ enhancement in the inner magnetosphere (L=4-7) are surveyed using all Cluster perigee traversals during 2001-2006.

- **About 20 clear (+ 10 unclear) events in about 300 traversals. All events are found in the outer plasmasphere.**

- **Both locally heated ones and drifted ones from remote source are found, with various distributions (pitch angles, energy, and mass ratio) that are classified into 2 x 2 categories.**

- **Locally heated ones in the evening sector are related to substorm activities and remote types in the noon are found after long quiet period.**

Conclusions

- **There must be filtering mechanism(s) that select only cold He^+ and separates them from H^+ and O^+.**
- **The plasmasphere might be energized in a mass dependent way in the evening sector during substorms.**
- **The selective He^+ energization might take place during quiet periods near noon.**

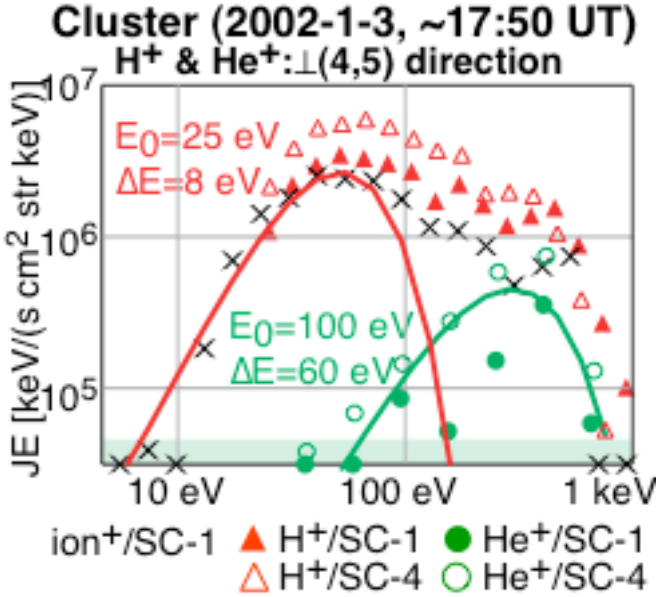
All clear events

All are located at outer plasmasphere

date (SC4)	UT	MLT	Ilat	R	Type	previous AL	AL value
2002-0330	08:17	22	+61	4.4	local-A	350 nT@3h	50 nT
2003-0530	06:25	19	+59	3.9	local-A?	600 nT@5h	100 nT
2003-0812	01:24	14	-65	4.8	local-A	-	500 nT
2003-1122	08:44	8	+64	4.3	local-A?	250 nT@0.5h	50 nT
2004-0504	07:03	21	-62	4.4	local-A	300 nT@3h	150 nT
2005-0528	20:10	19	-60	4.2	local-A	-	700 nT
2005-0702	02:26	17	±63	5.0	local-A?	600 nT@0.5h	200 nT
2001-0918	15:40	11	+64	4.1	local-B	<50 nT@1h	baseline=8h
2002-0903	08:22	12	-69	4.9	local-B	baseline	baseline=11h
2006-0505	00:06	21	-62	4.8	local-B?	onset @0.5h	150 nT
2001-0620	04:26	17	-61	4.1	remote-A	400 nT@3h	baseline=2h
2001-0821	00:53	13	-65	4.3	remote-A	baseline	baseline=6h
2005-0430	08:40	21	-61	4.2	remote-A	200 nT@0.5h	150 nT
2005-0605	00:06	19	-63	5.1	remote-A	-	400 nT
2001-0317	23:54	23	±62	4.0	remote-B	200 nT@4h	baseline=3h
2001-0319	09:17	23	±59~61	4.0~4.1	remote-B	100 nT@2h	baseline=1h
2001-0702	02:14	16	±60	4.0	remote-B	100 nT (>3h)	200 nT
2001-0921	00:21	11	-61	4.2	remote-B/A?	100 nT@1h	baseline=1h
2001-1215	16:29	5	-60	4.2	remote-B	400 nT@2.5h	baseline=2h
2002-0222	15:46	0	±60~61	4.4	remote-B	100 nT@1h	baseline=1h

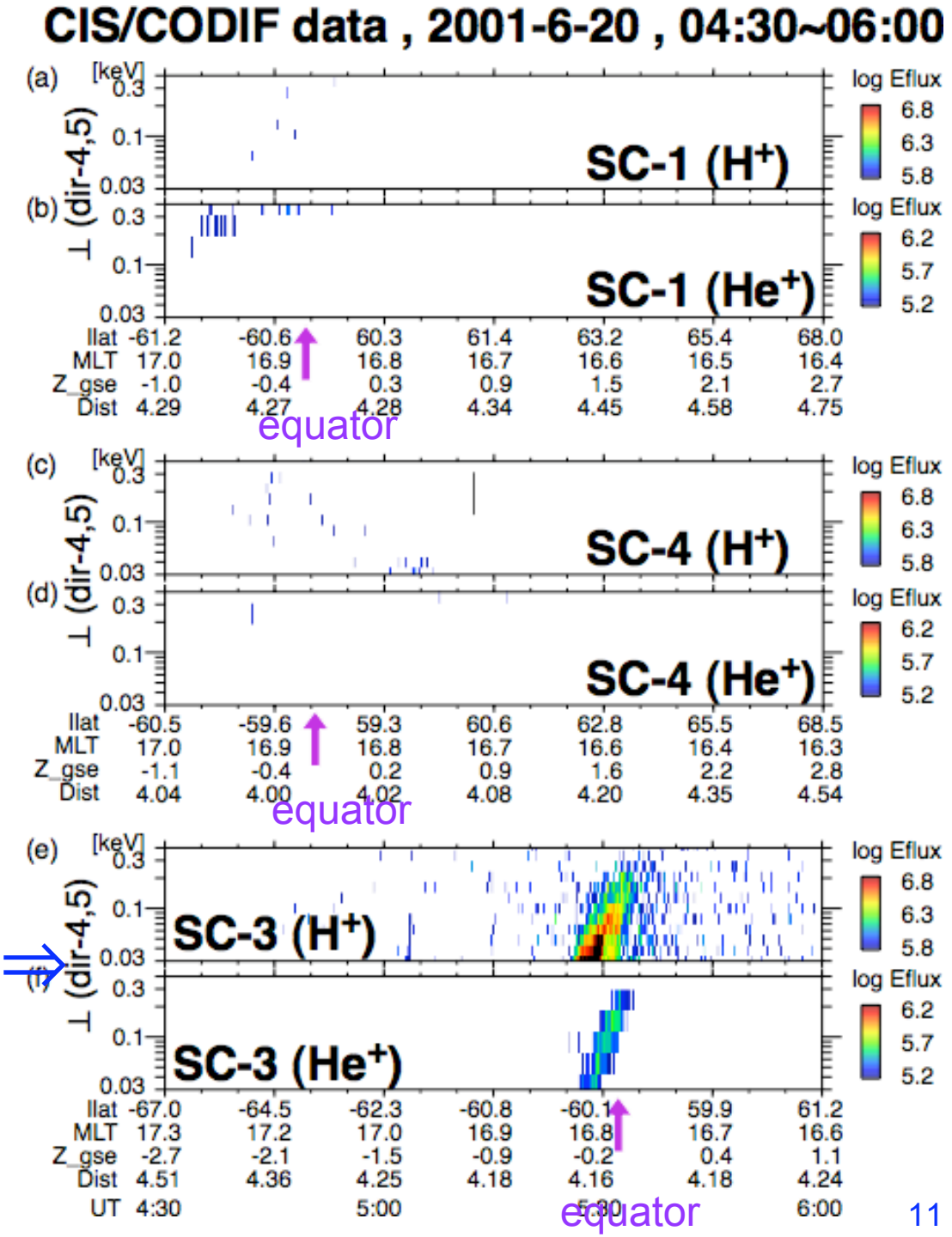
Example of local heating

Equatorially-confined hot ions sometime show **E(H⁺) < E(He⁺)** while majority is **E(H⁺) = E(He⁺)**



Example of shortest drift

"No dispersion" = local (only 40 min difference causes energy-time dispersion)



Example of local heating

Equatorially-confined hot ions sometime show **E(H⁺) < E(He⁺)** while majority is **E(H⁺) = E(He⁺).** He+ is certainly heated e.g. by He cyclotron waves (1980's)