The Relation between Energetic CIR Ions at 1 AU and The Sun's Magnetic Field from STEREO Observations

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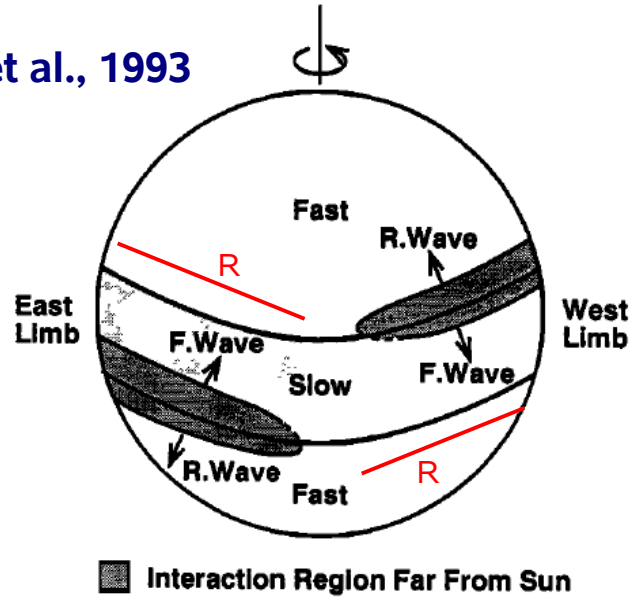
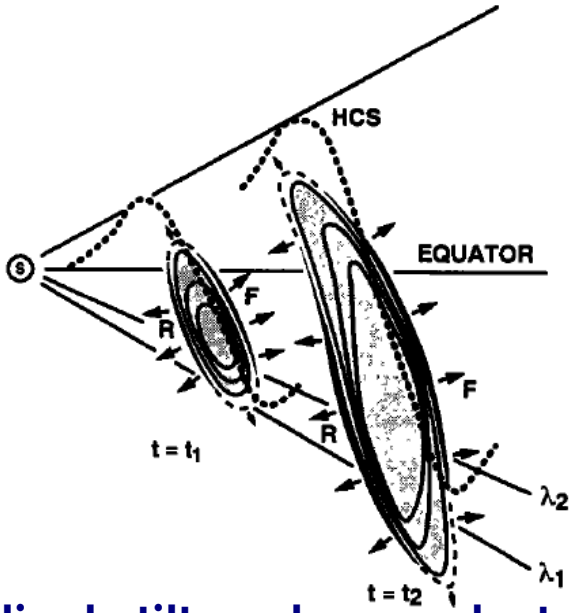
MAX-PLANCK-GESELLSCHAFT

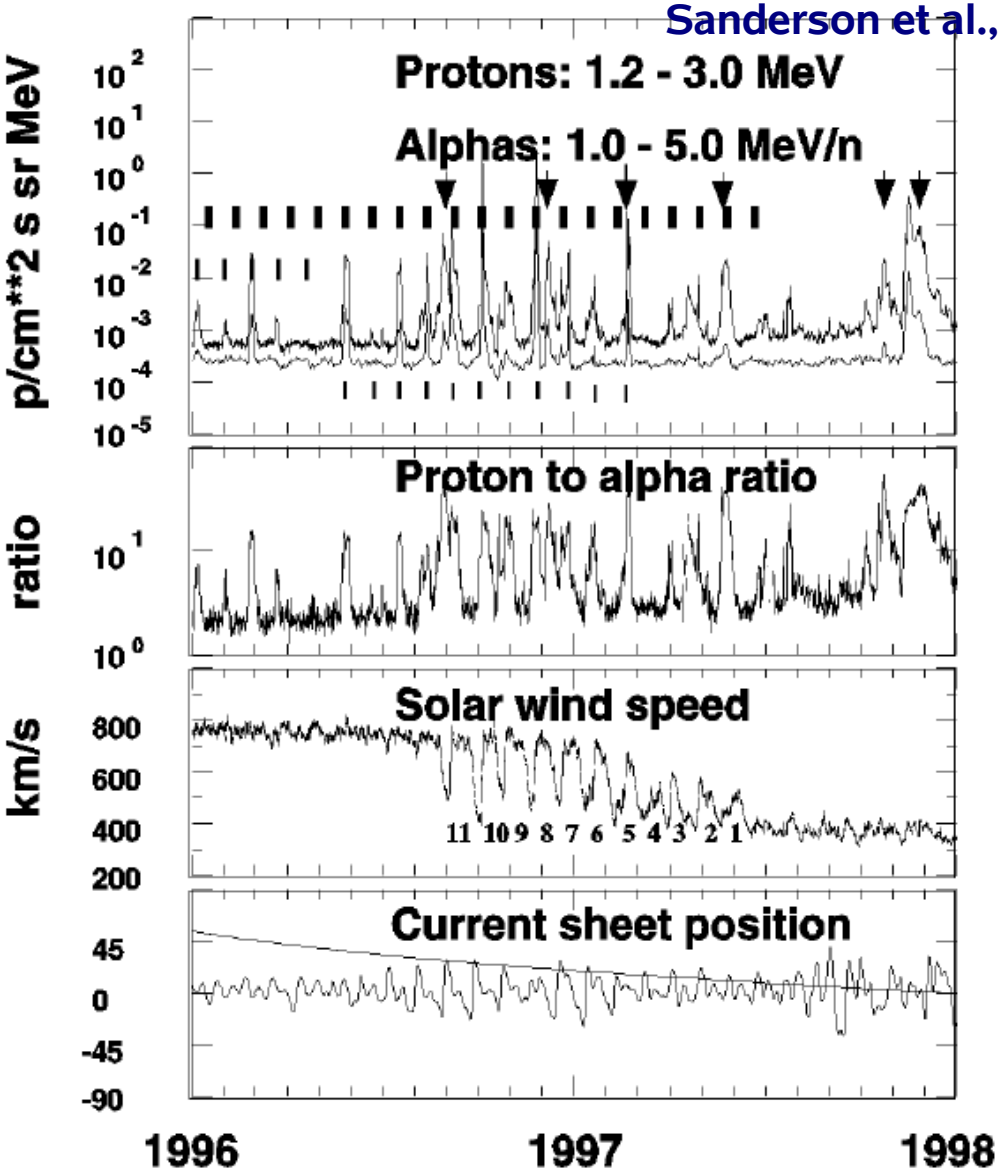
Gosling et al., 1993



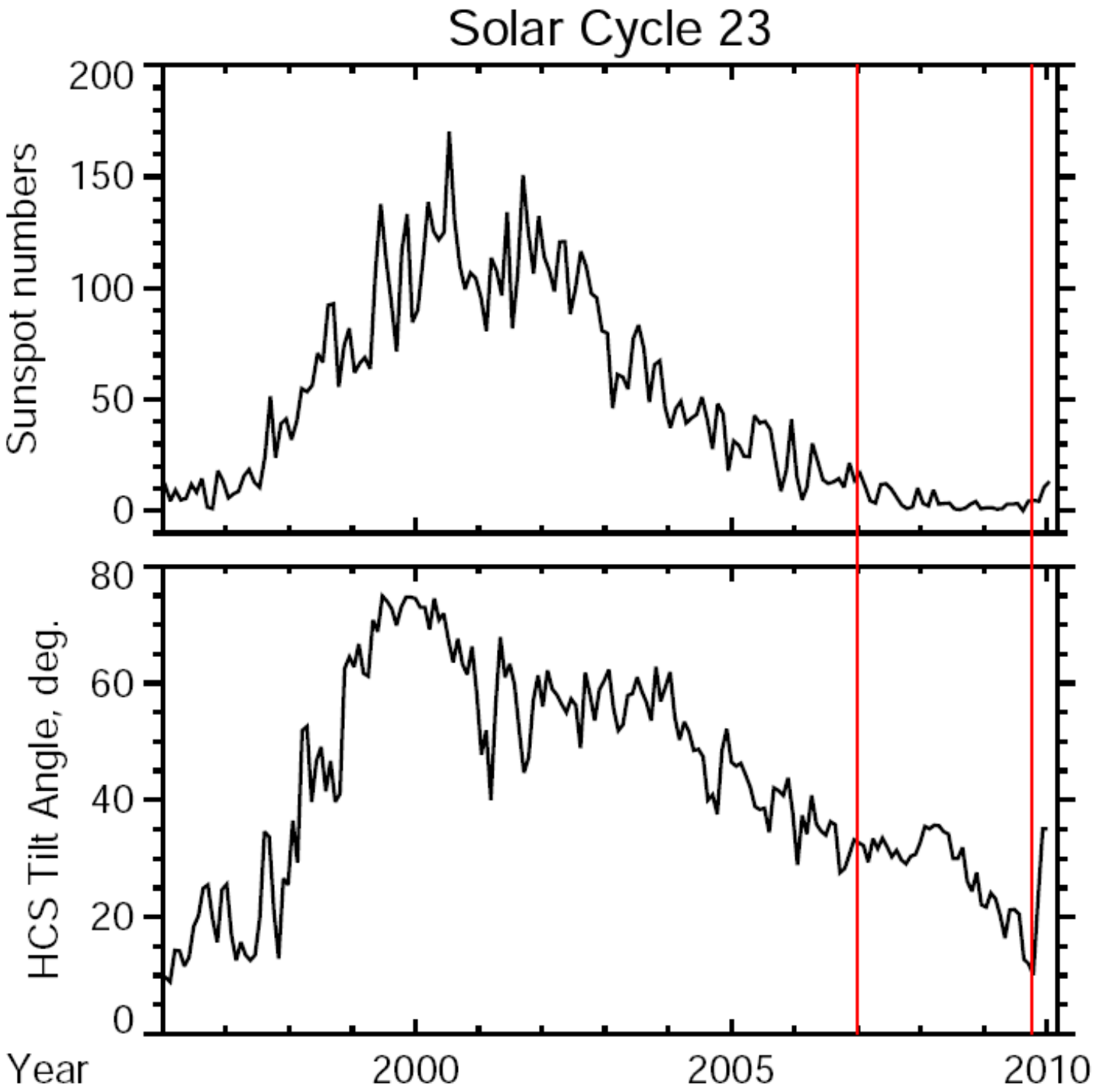


Small dipole tilt angle – weak stream-stream interaction; CIR activity is confined to narrow band about the heliocentric equator (Gosling and Pizzo,1999).

Sanderson et al., 1999

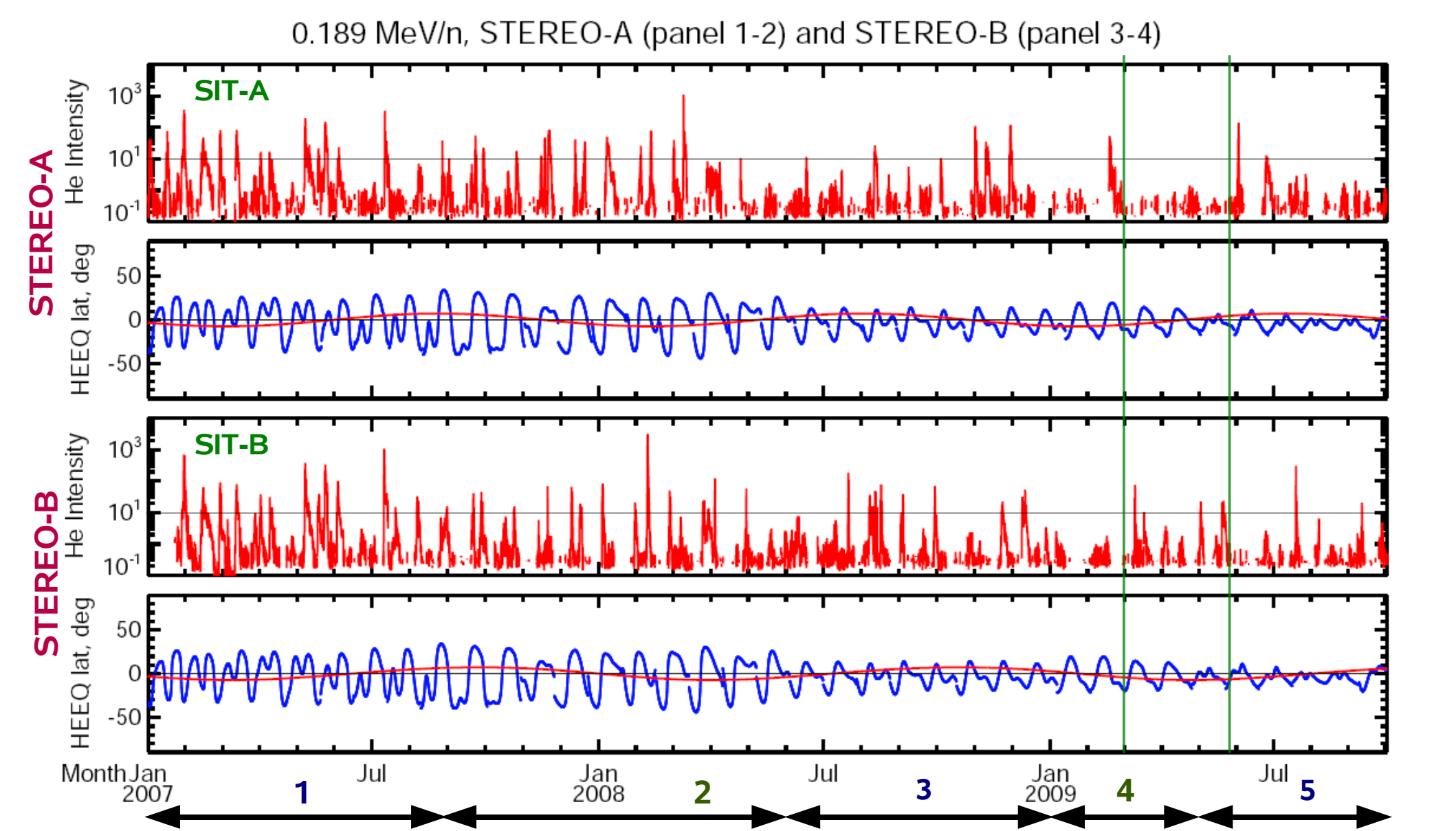


Tilt of the current sheet, the warps in the sheet, and the position of the spacecraft relative to the sheet influence the intensity and occurrence of the CIR-related particles (Sanderson et al., 1998;1999).



Investigated Period

- tilt angle changes by factor of ~3 in the investigated period
- ½ of the period - tilt varies in narrow range (~ 30-35 deg)
- long period of the solar minimum, almost without SEP activity, with some CIRs accompanied by ICMEs
- favorable for study of the CIR events



warps: event rate & ion int. high

HCS flat & higher tilt: rate & int. subsided

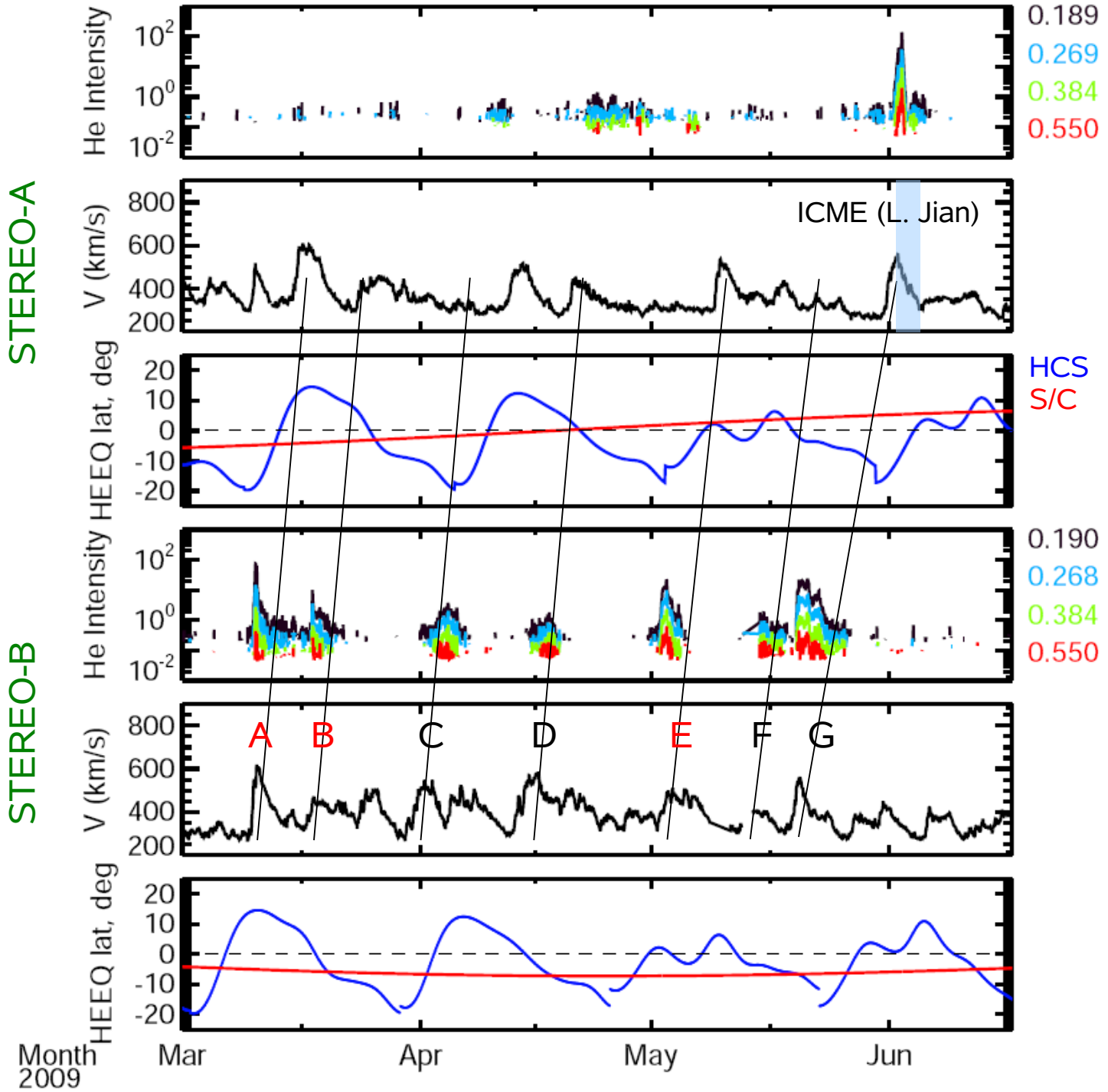
warps & lower tilt: rate decreased & int. remained same

HCS flat & higher tilt: CIR activity quiet

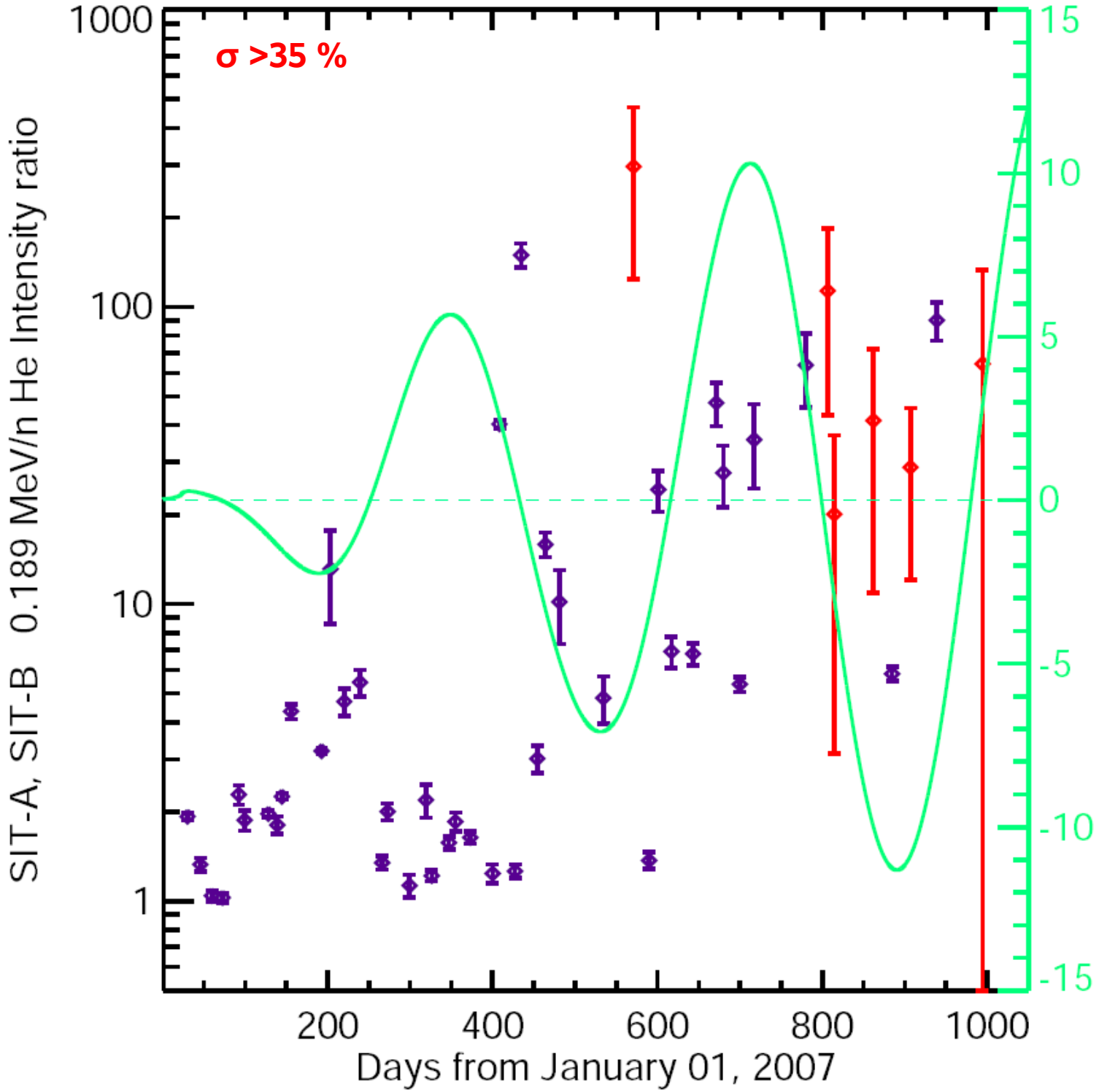
warps & lower tilt & s/c in stream belt in 3 CRs: CIR activity quiet

SIT-A, SIT-B int. - similar. s/c trace similar latitudes relative to the HCS

SIT-A, SIT-B latitude phase shift increases; diff. in particle intensities between s/c increase

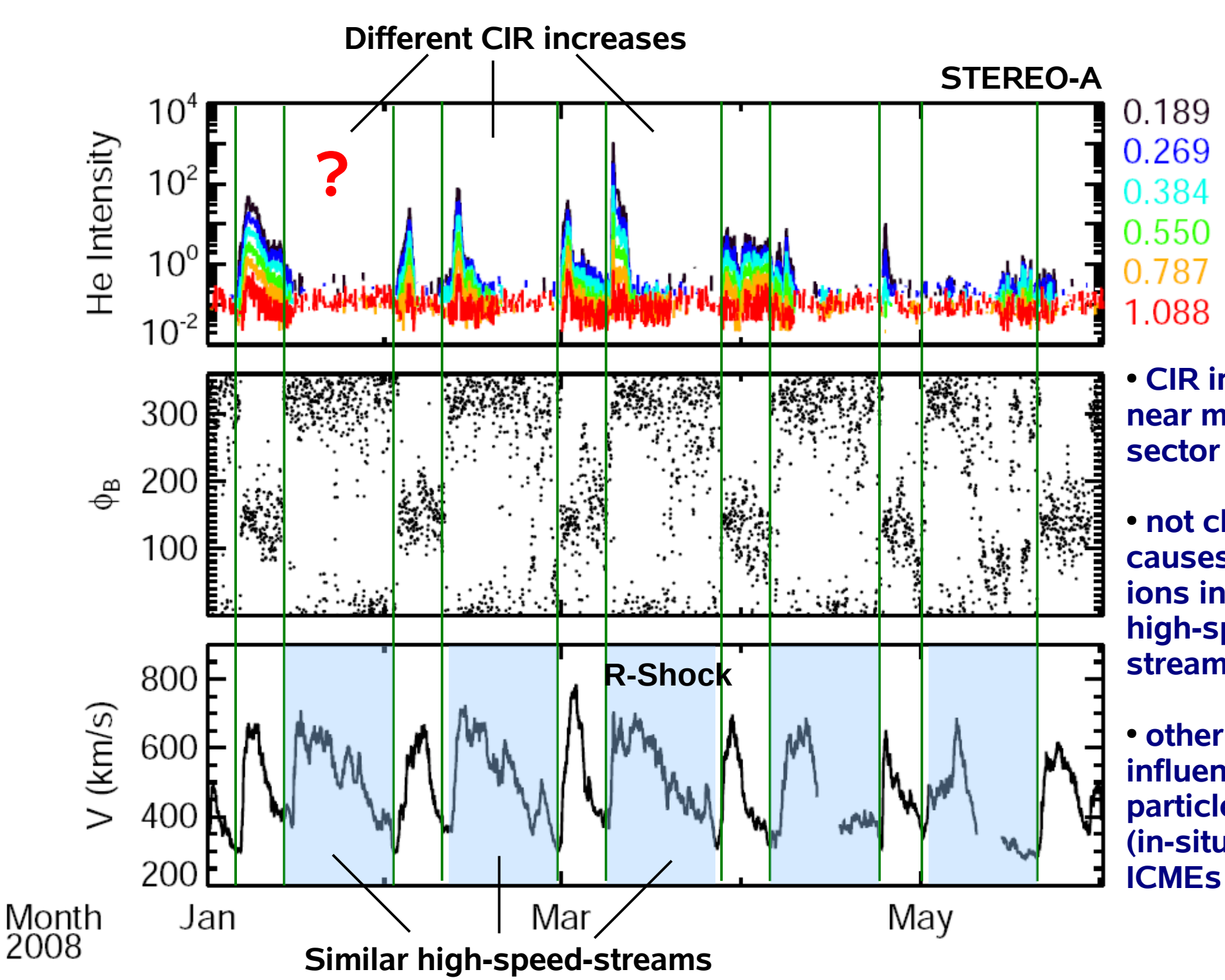


- marked differences in CIR energetic ions observed by SIT-A and SIT-B
- shape of the current sheet and tilt angle - nearly same
- STA found to be close to the streamer belt
- differences in energetic ions could be related to the different s/c positions relative to the current sheet.
- s/c Wind in the streamer belt no particles increases observed (Sanderson et al., 1998)
- ICME-CIR interaction (Herrero et al., 2009) may lead to strong event in June 2009



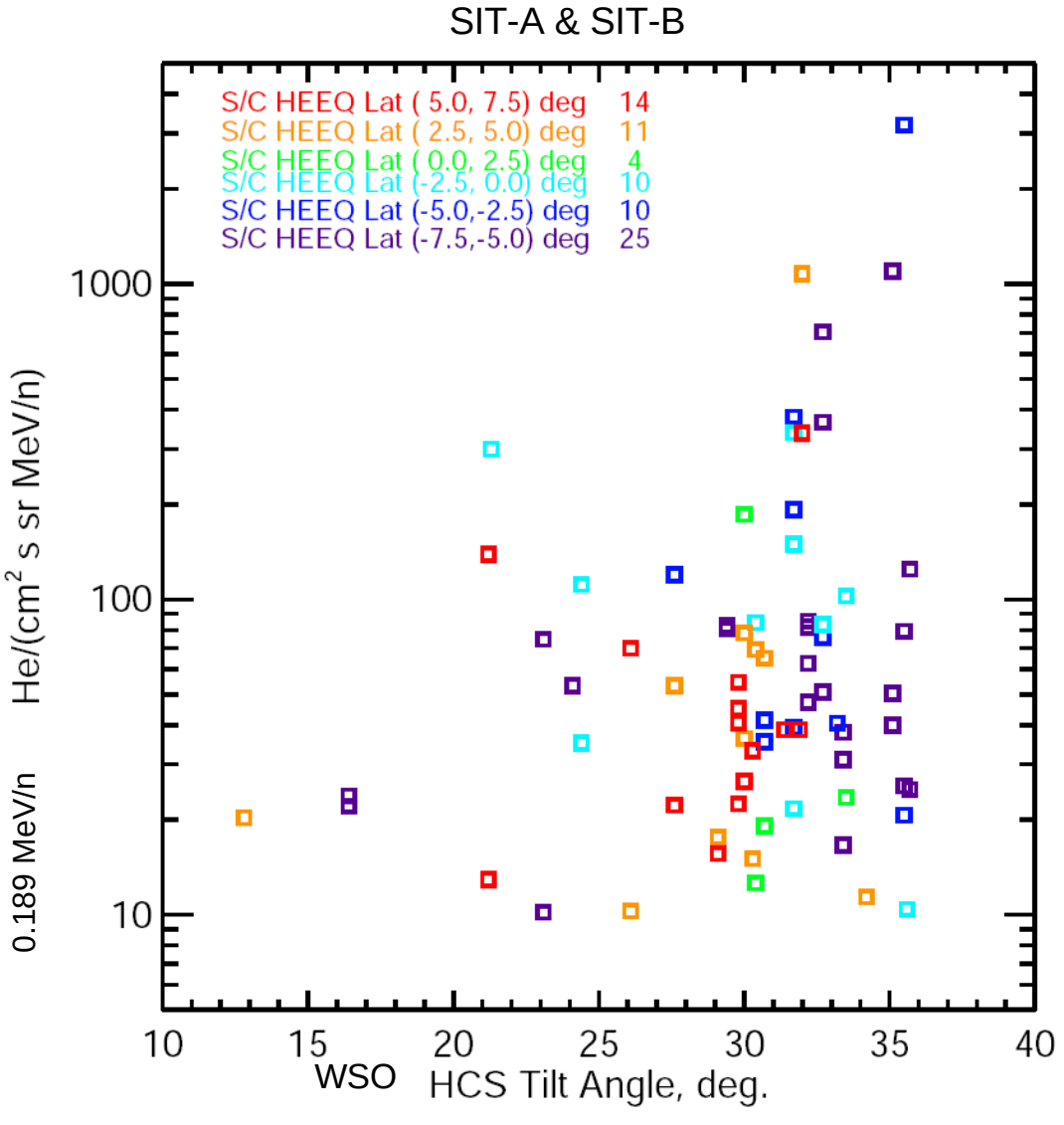
CIR ion Intensity differences: STEREO-A, -B

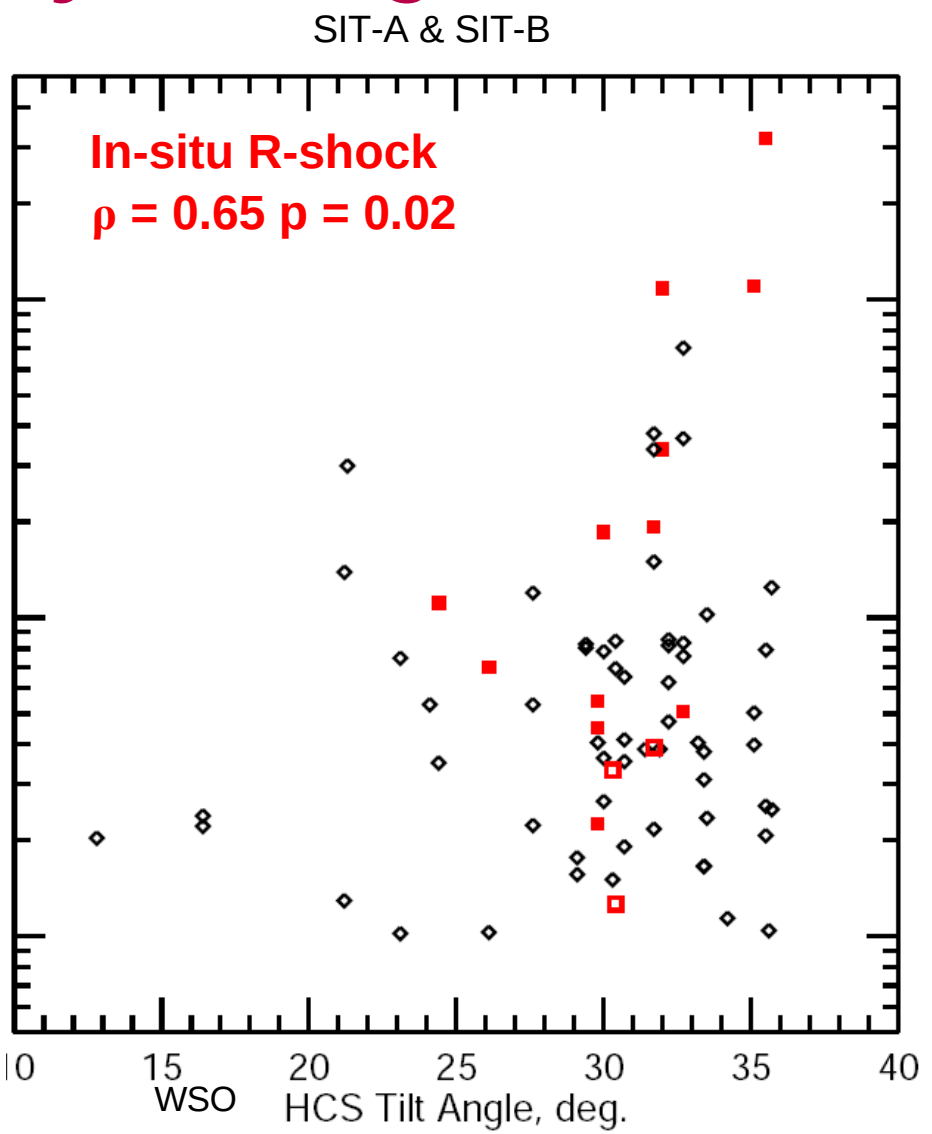
- differences are becoming greater as the spacecraft move farther apart (when amplitude of latitude differences increases)
- events where 0.189 MeV/n He I>10 at least on one s/c.
- 47 pairs of CIR events



- CIR increases near magnetic sector crossing
- not clear what causes lack of ions in some high-speed-streams
- other factors influence CIR particle events (in-situ shocks, ICMEs ...)

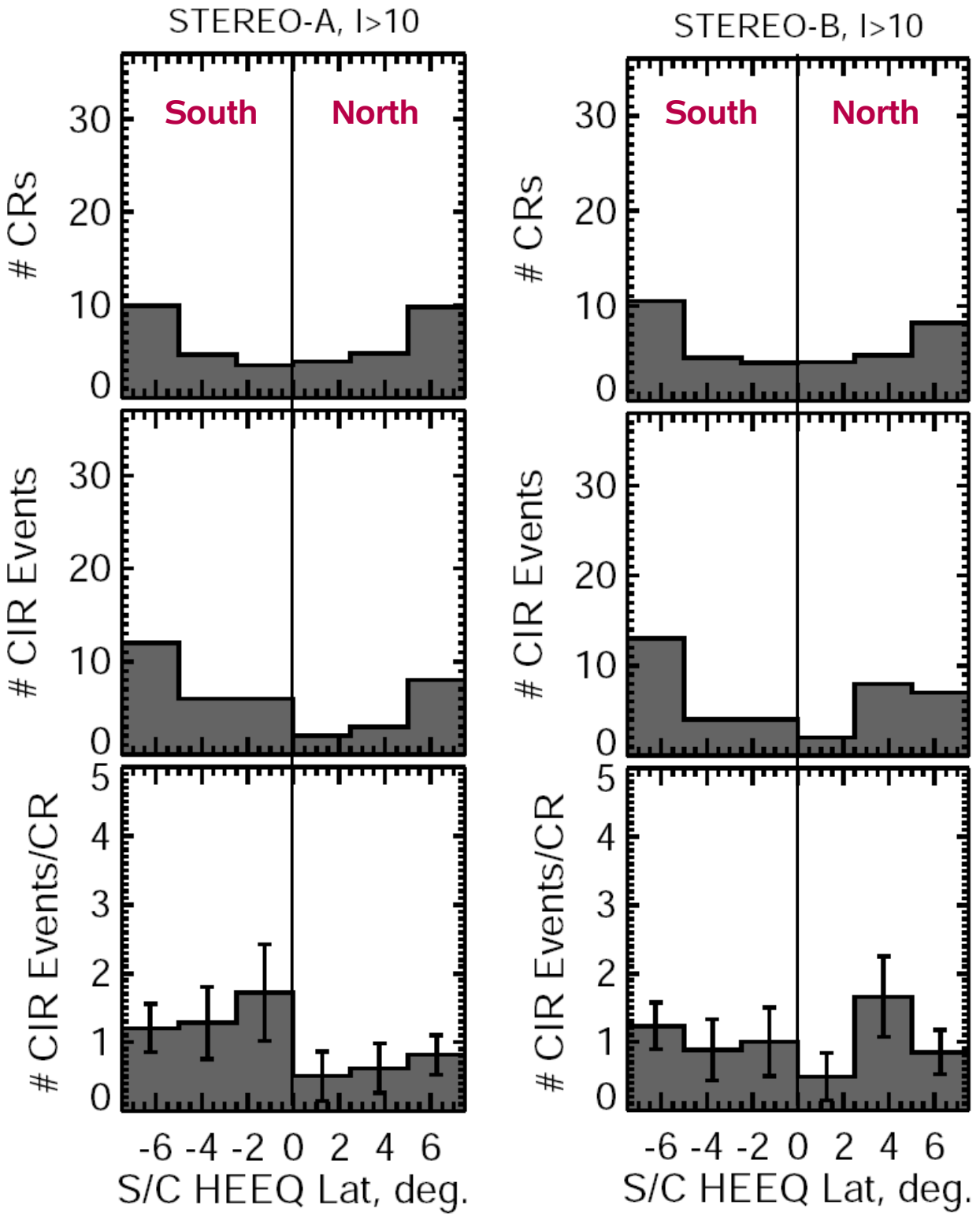
Peak He Intensity - Tilt Angle





- as tilt angle increases the higher intensities are seen but with lot of scatter
- north-south asymmetry in number of CIR events

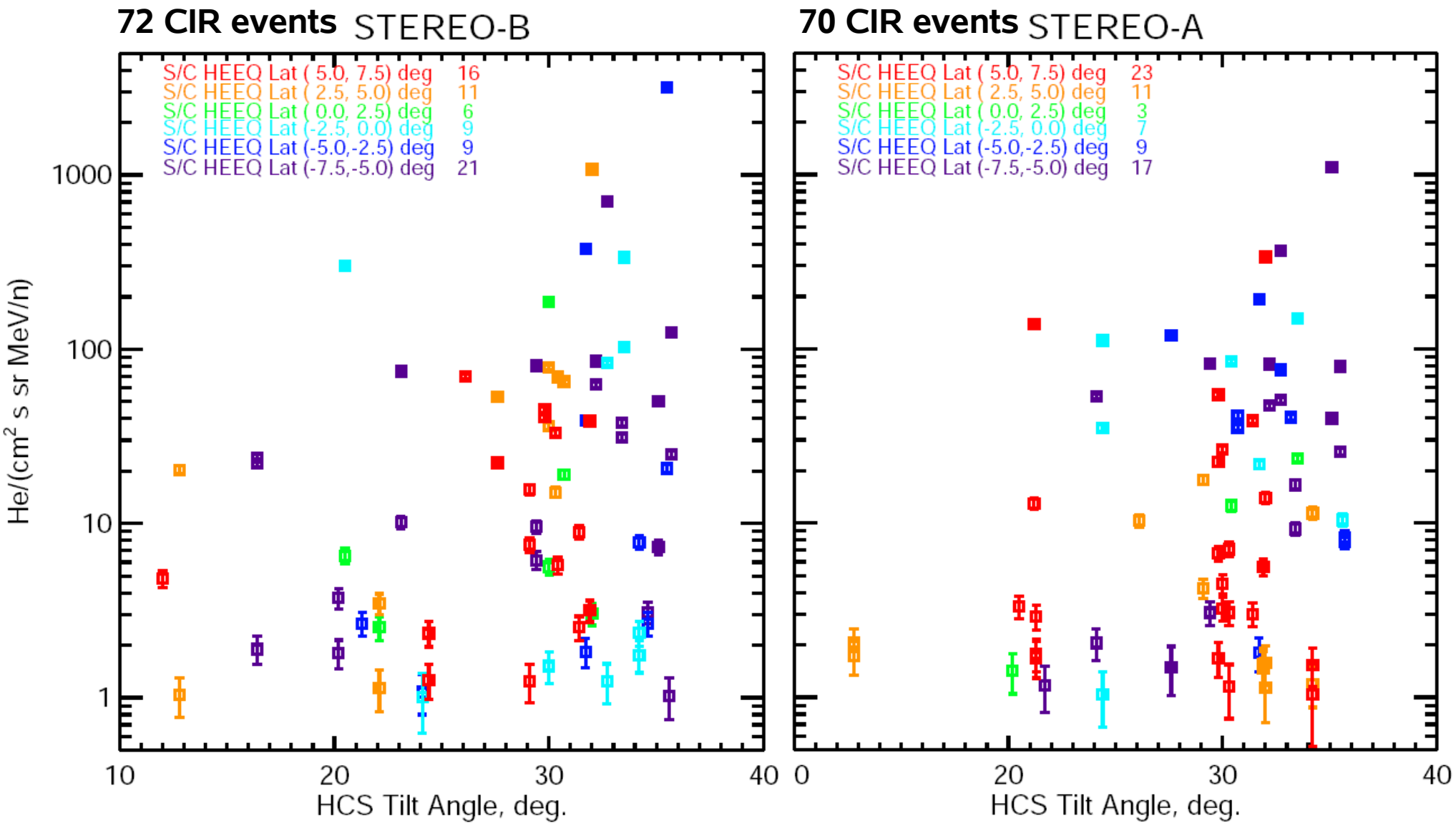
- positive correlation between intensity and tilt for events with in-situ R-shocks - acceleration is going on nearby
- for cases where acceleration is taking place well beyond 1 AU the correlation with the tilt would be expected to be weaker



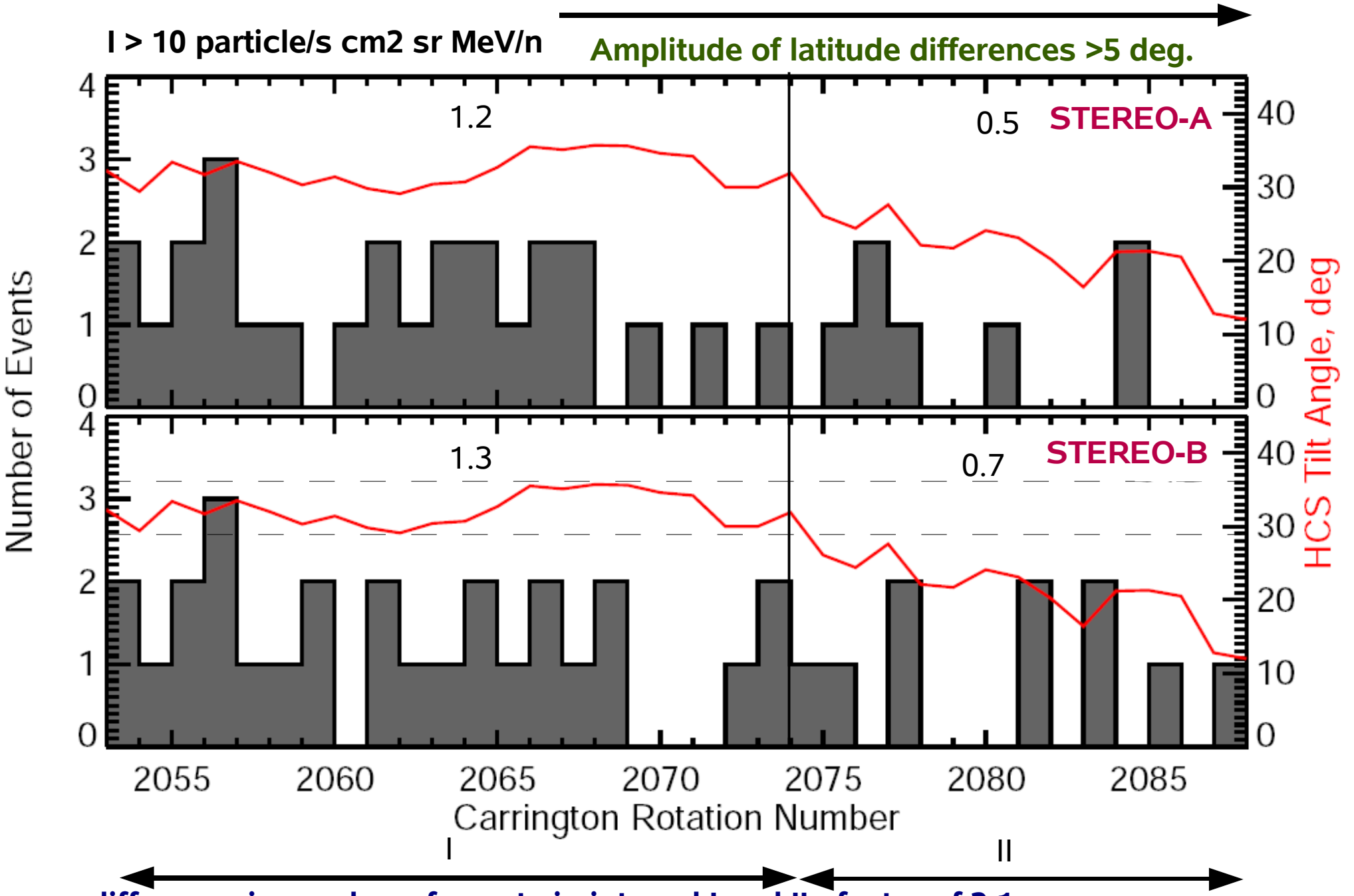
STEREO - at higher latitudes in majority of the solar rotations.

No large difference between northern and southern rate of the occurrence of the CIR increases within 1-σ errors.

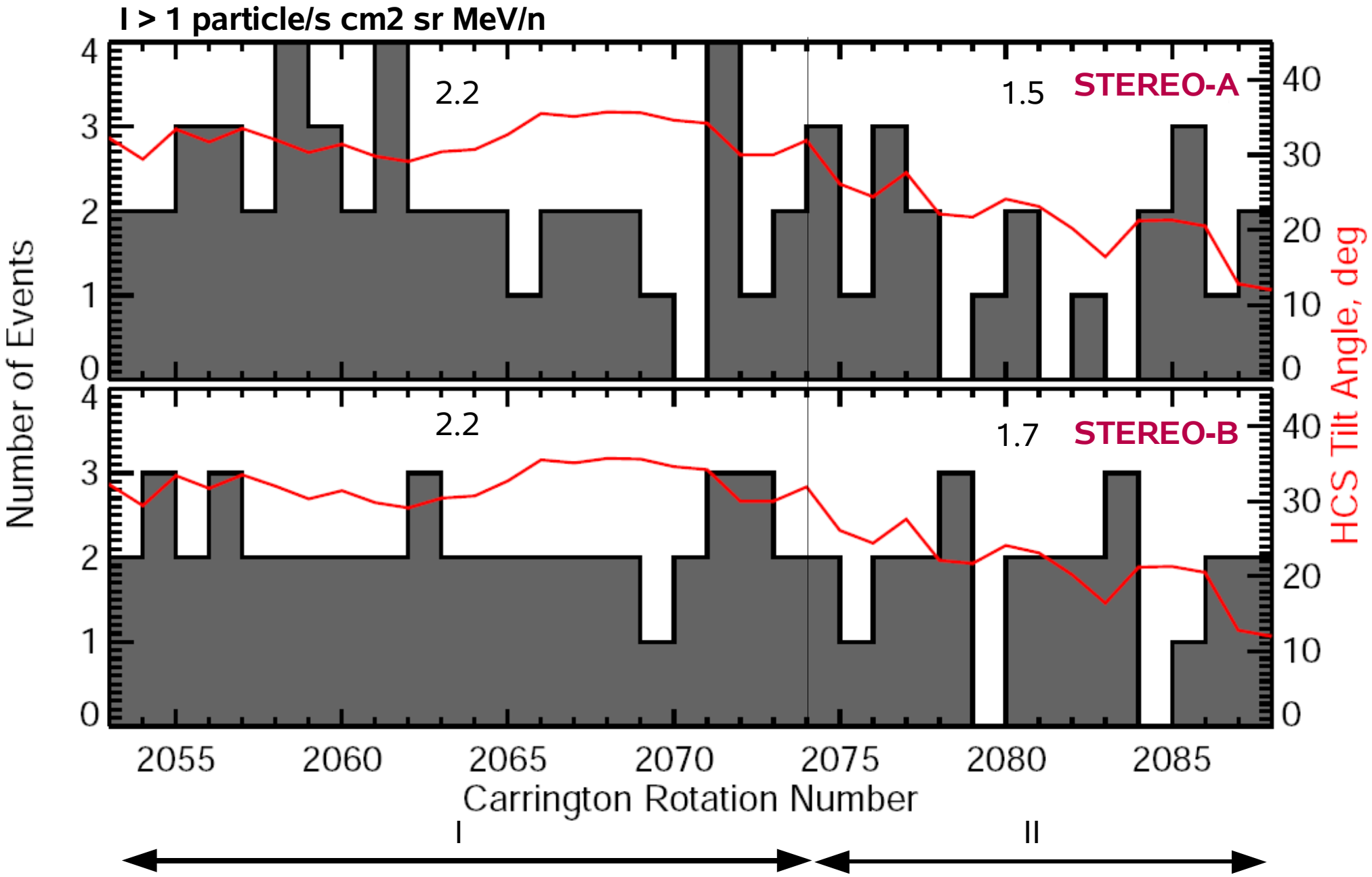
CIR events with peak I>1 1/cm2 s sr MeV/n



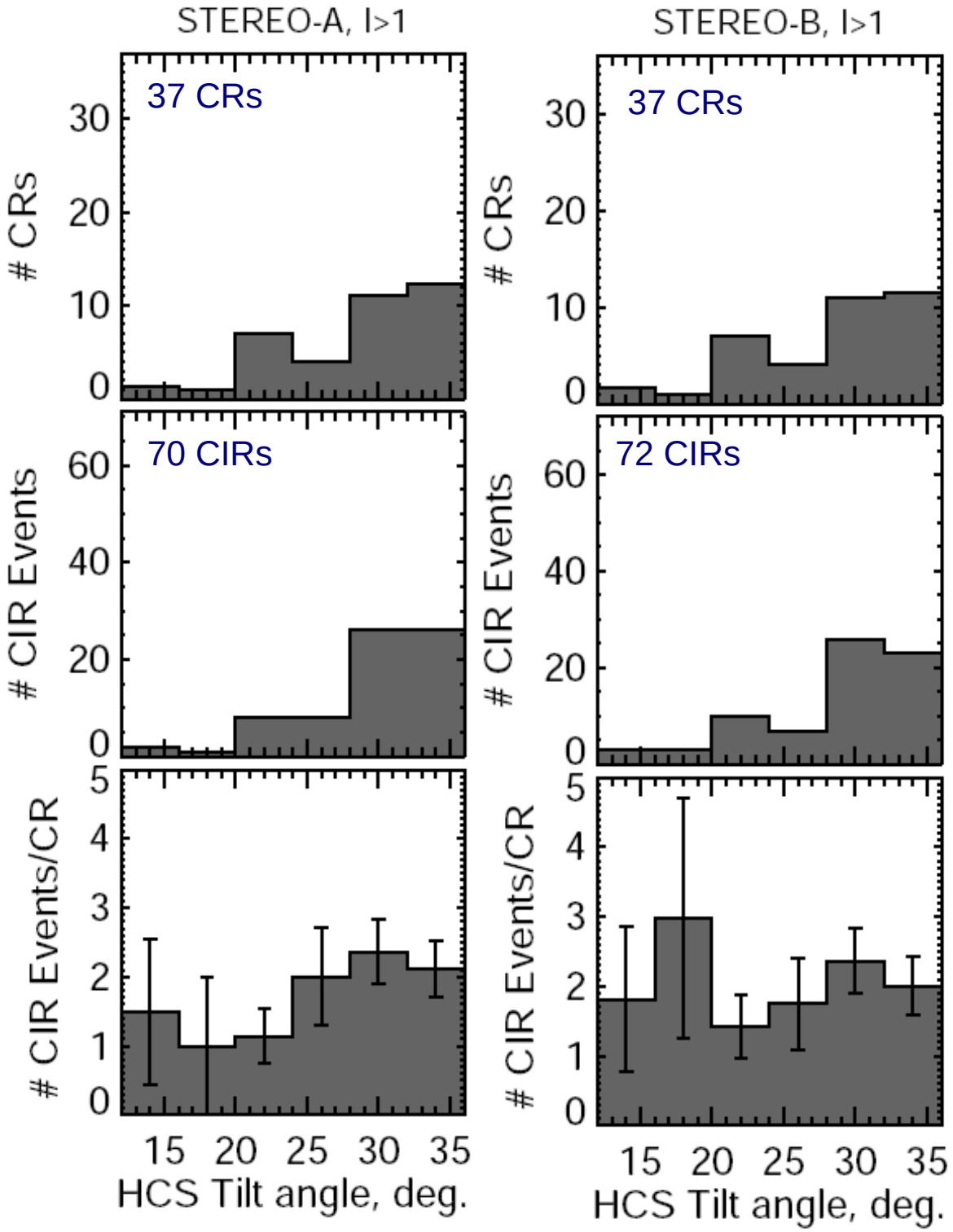
Not marked difference between STA and STB plots. The north-south asymmetry is not so striking.



- **difference in number of events in interval I and II - factor of 2.1**
- **differences in number of events between STA and STB are becoming greater as differences between s/c latitudes increase**



Difference in number of events in intervals I and II - factor of 1.4.

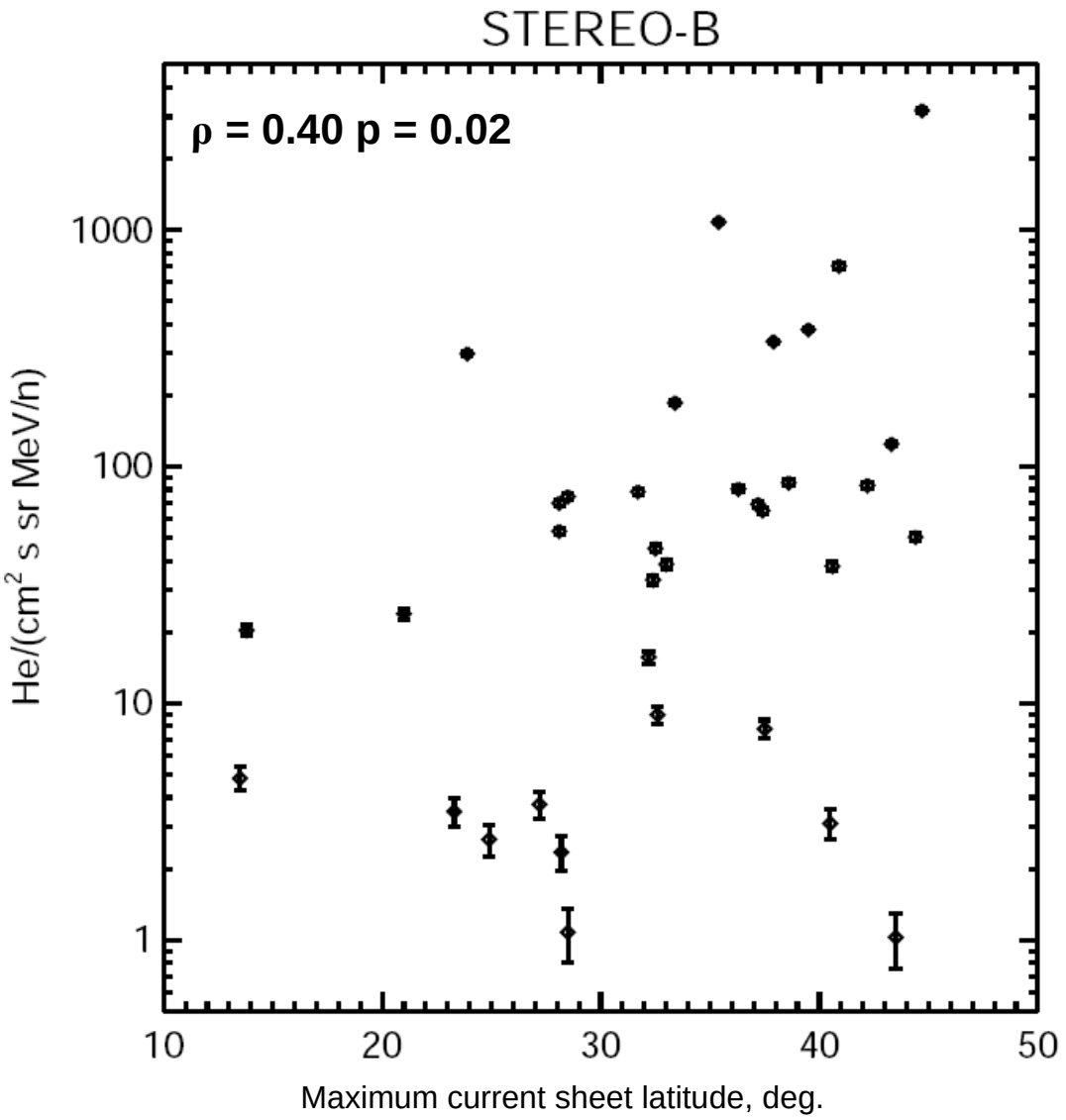


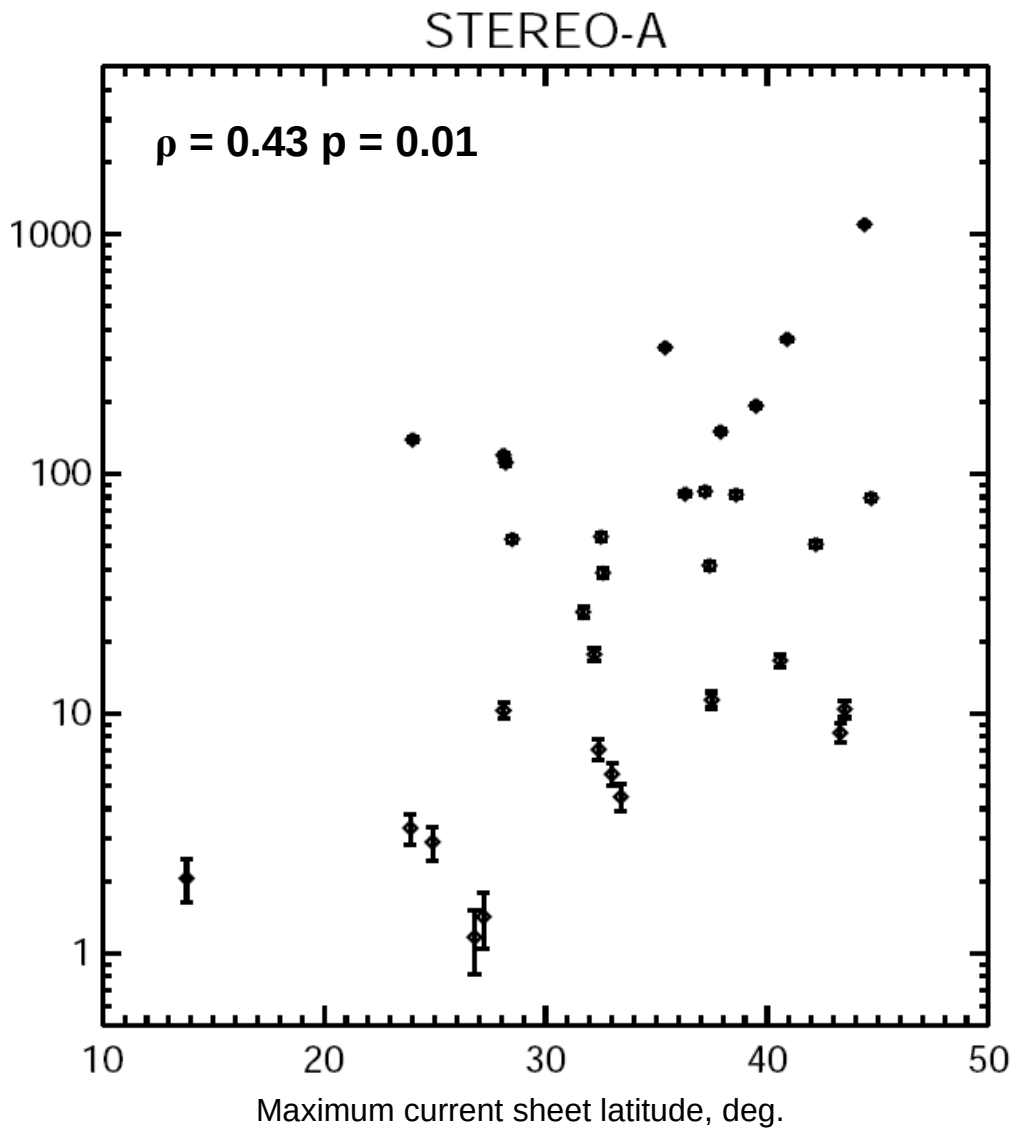
Distribution of number of Carrington rotations - only few rotations with low tilt angles.

Majority of CIR events at high tilt angles.

Distribution of number of CIR events per Carrington rotation - within 1-σ errors the number of CIR increases with the tilt angle.

Peak He Intensity – Maximum HCS Latitude





- **the strongest event per solar rotation – plotted**
- **some indication of a positive correlation**

Summary (1)

Tilt of the current sheet:

- **Observations show higher ion intensities at higher tilt angles. The dispersion in intensity is high - the factors different from tilt, and therefore different from strength of the compression region are important in determining CIR ion intensity (p. 8).**

- **Observations indicate that correlation between tilt and the intensity is found to be better for events with in-situ shocks, i.e. for events where ions are accelerated locally, than for events without in-situ shocks where ions are presumably accelerated further away (p. 8).**

- **Observations also indicate that maybe not the tilt angle of 'the whole solar rotation' but the tilt of the particular CIR (or 'local tilt of the current sheet') could be better organizing the measurements (p. 14).**

- **Rate of occurrence of the CIR events was higher in the period of high tilt angles (p. 11, 12).**

Summary (2)

Warps in the current sheet:

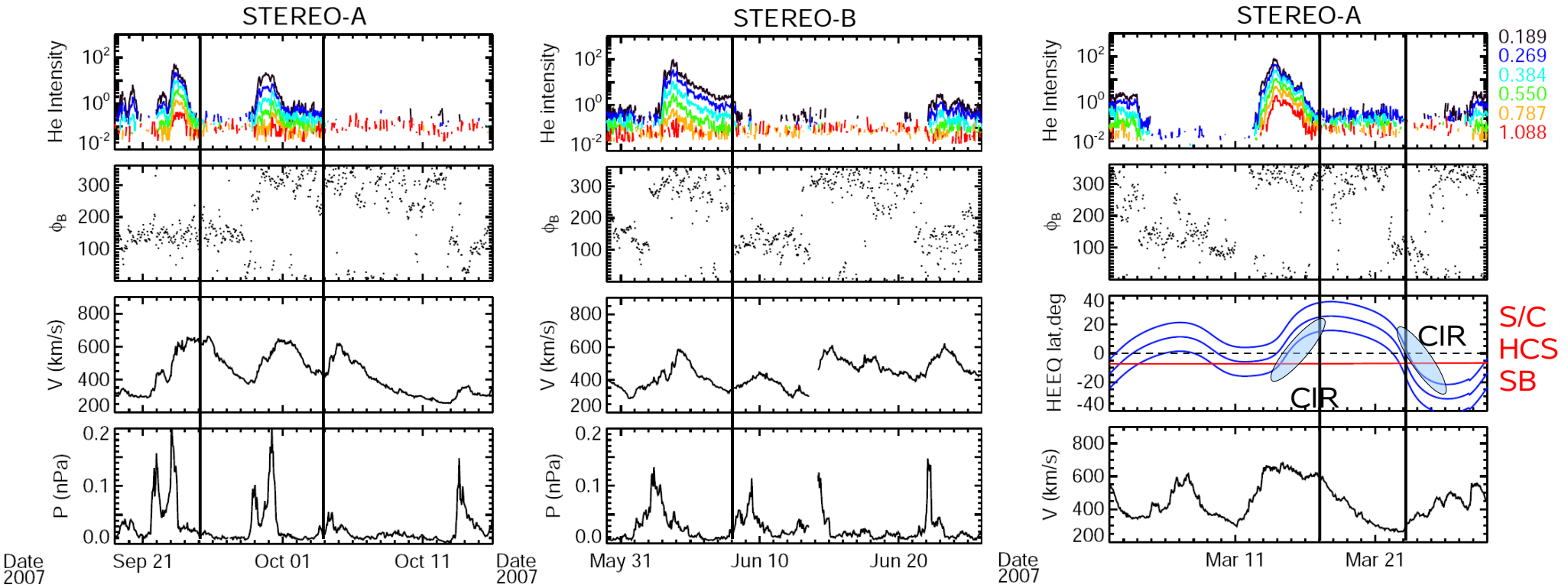
- **In the period of warped HCS (period 1), not only rate of the CIR events was high but also the ion intensity was higher compared to the interval without warps and with increased tilt (period 2) (p. 4).**

- **High ion intensities in the period of the warps are likely associated with three CIR-SEP mixed events (one in January, two in May) which could enhance seed population for acceleration by CIR.**

Position relative to the current sheet:

- **Differences in the ion intensities and in the rate of the occurrence of CIR events between satellites are becoming greater as latitudinal differences increase (p. 6,11); the differences are more pronounced when tilt angle is small (p. 4,5).**

Backup


STEREO-A
He Intensity
10^2
10^0
10^{-2}
ϕ_B
300
200
100
V (km/s)
800
600
400
200
P (nPa)
0.2
0.1
0.0
Date 2007
Sep 21
Oct 01
Oct 11
STEREO-B
He intensity
May 31
Jun 10
Jun 20
STEREO-A
0.189
0.269
0.384
0.550
0.787
1.088
HEEQ lat,deg
40
20
0
-20
-40
CIR
CIR
S/C
HCS
SB
Mar 11
Mar 21