# Observations of the Termination Shock: Magnetic Fields-Voyager

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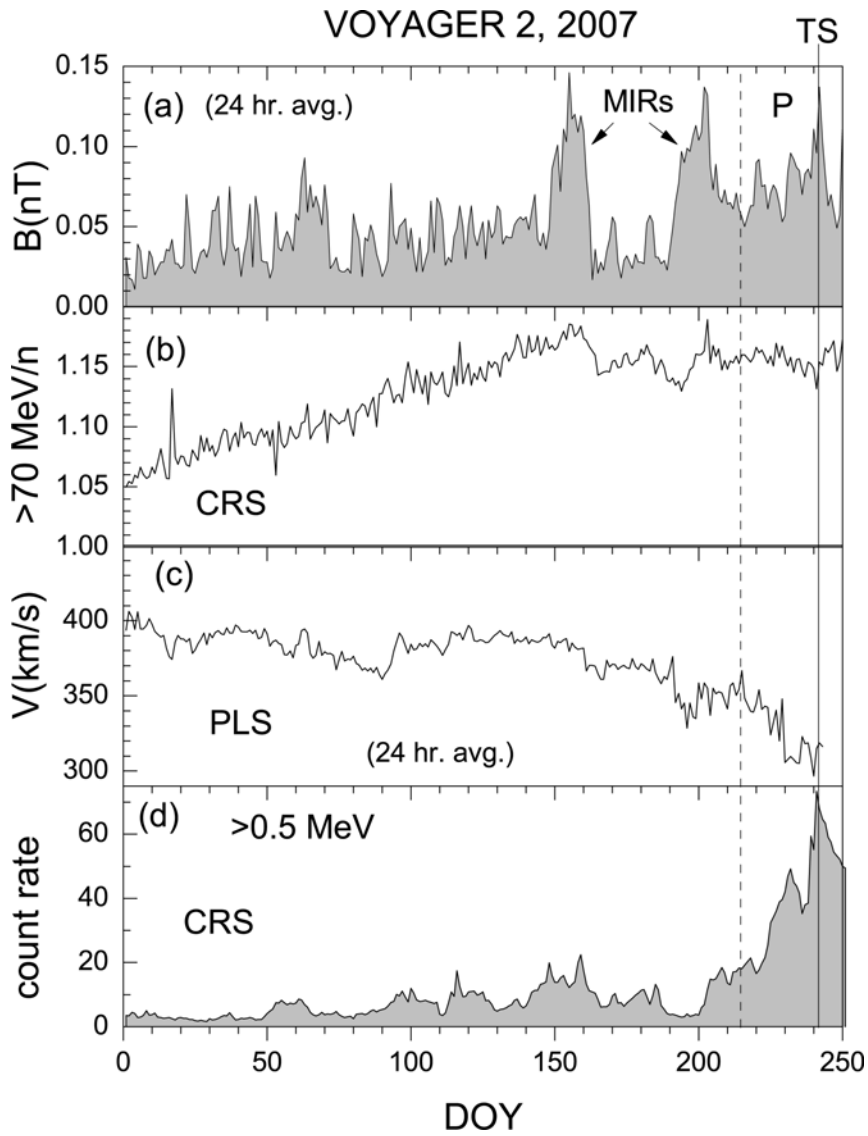
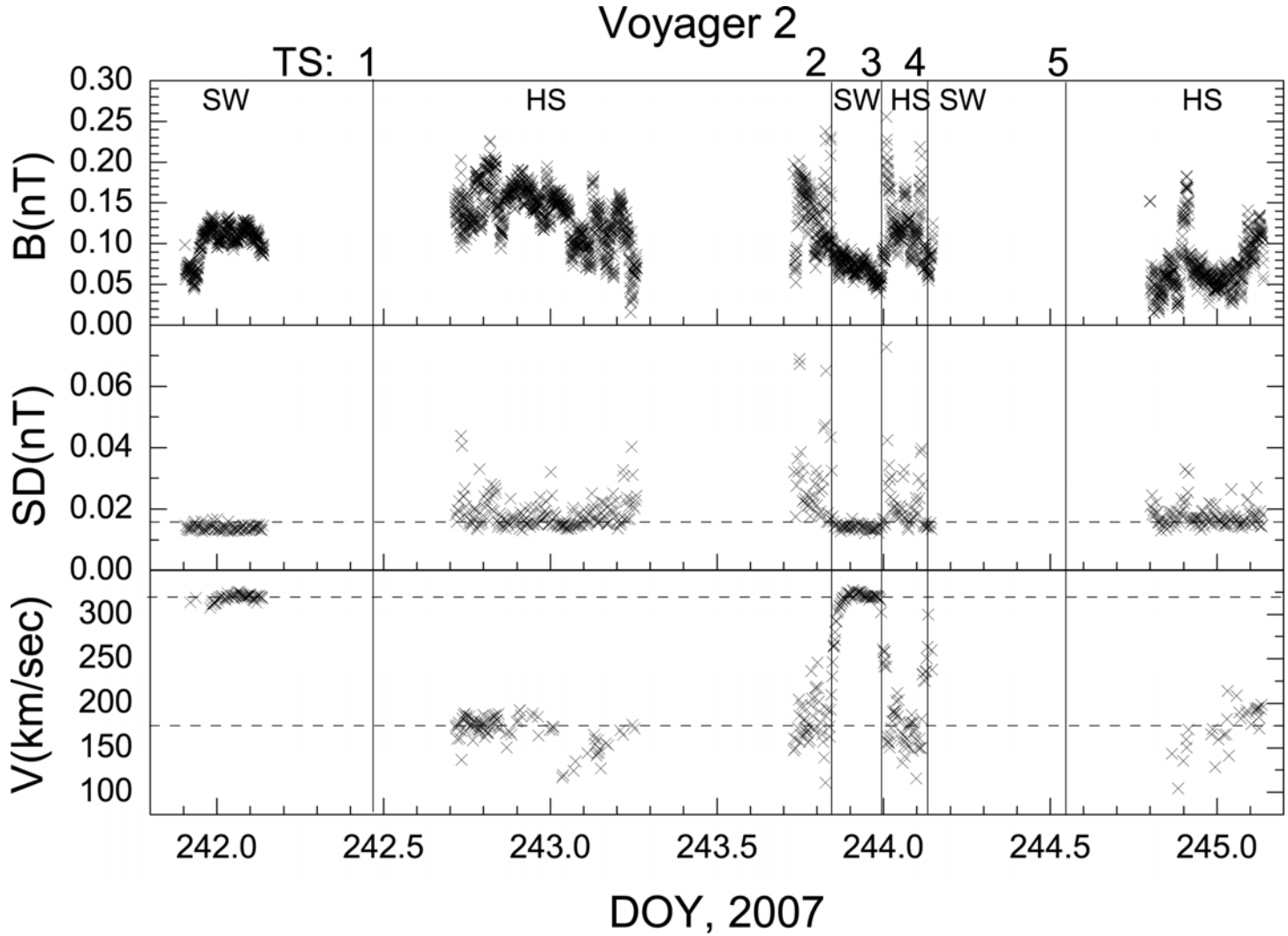
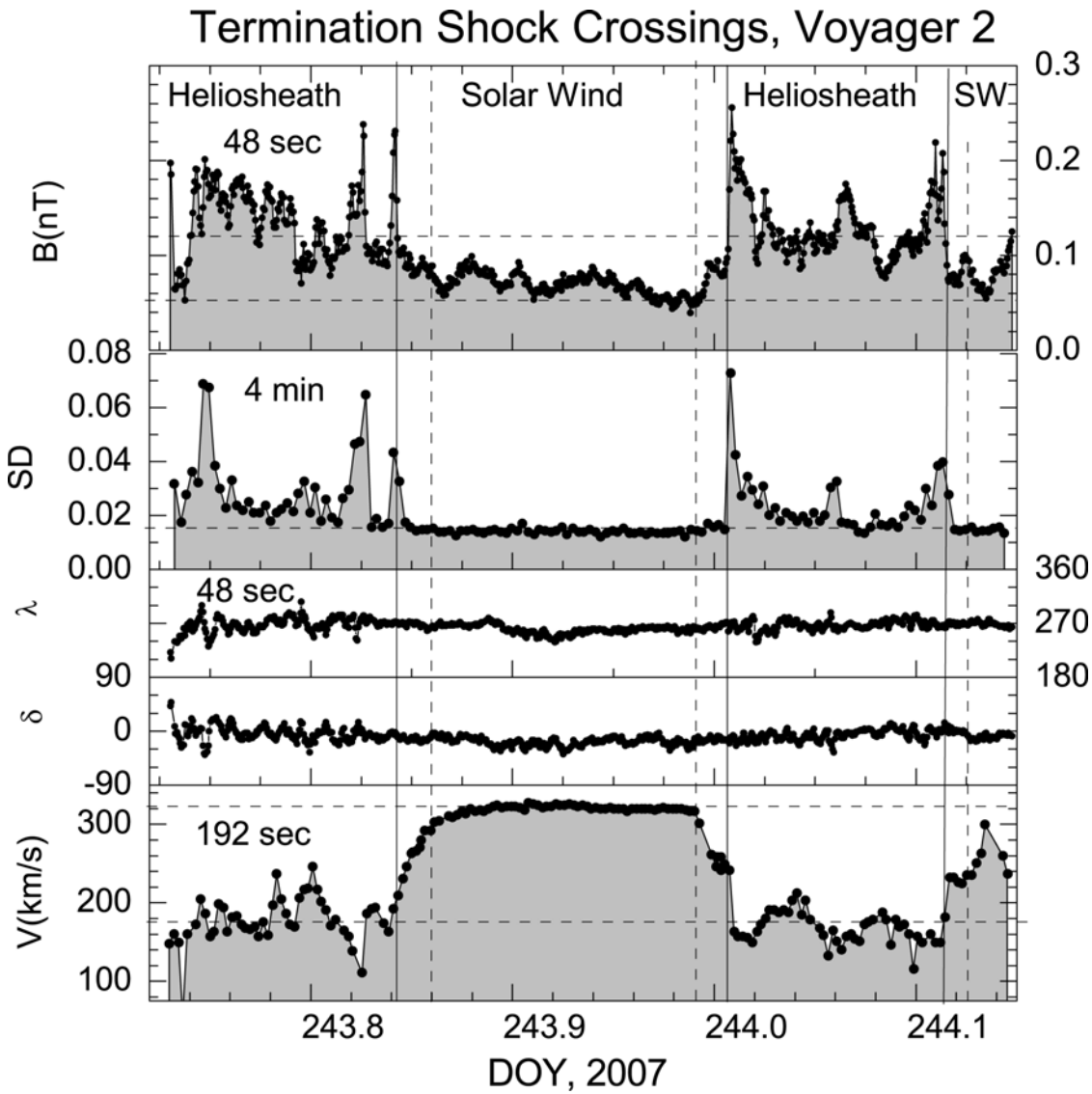
# Upstream Conditions




- Typical solar wind from DOY 1 - 147
- MIRs arriving on ~ DOY 148 & 191
  - stopped the cosmic ray recovery phase.
  - produced local cosmic ray decreases.
- Increasingly strong B from ~ DOY 216 to TS crossing on DOY 242 (region P) related to
  - increase in >0.5 MeV rate
  - slowing solar wind.



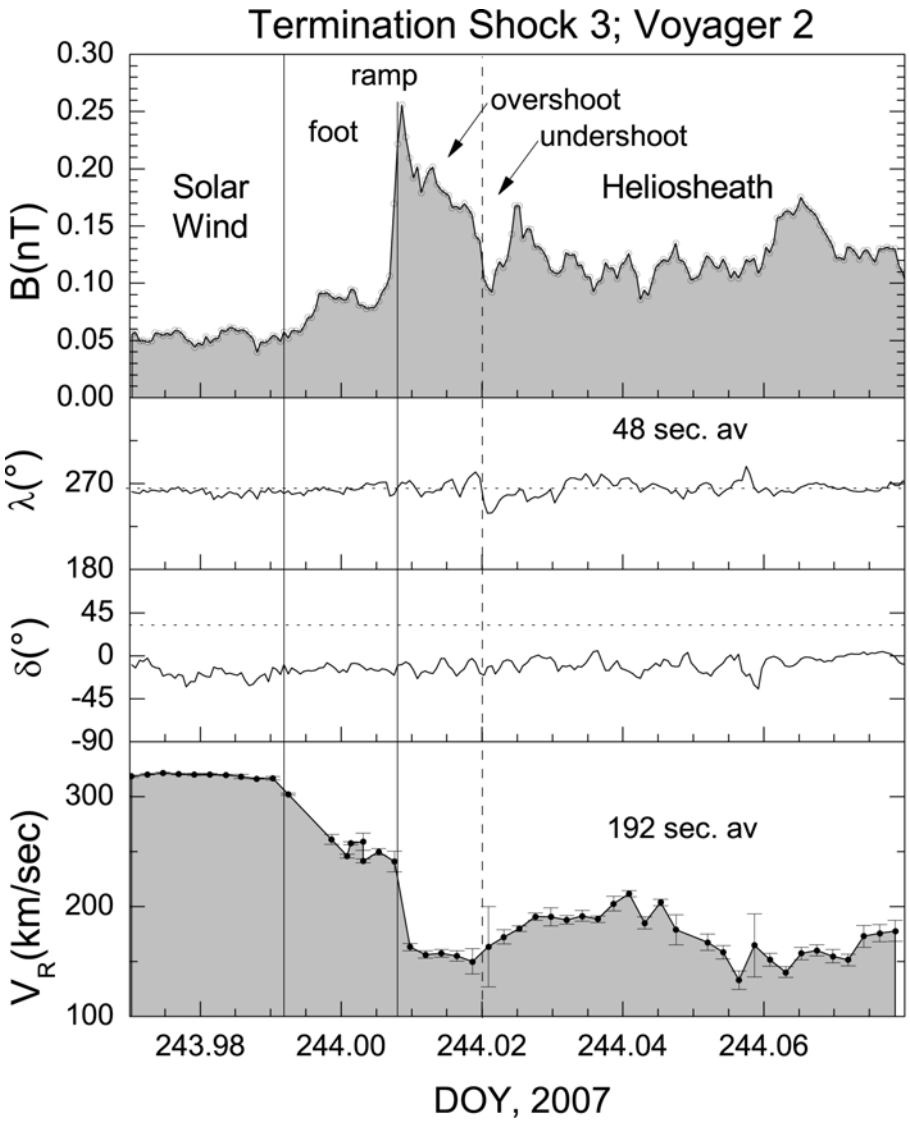

V2 encountered the TS at least 5 times in ~2 days, indicating motion of TS. (varying upstream conditions &/or ripples on TS surface?)




3 TS crossings. Separation: 3.9 & 2.7 hr (~14 $\Omega_{L,u}^{-1}$, & 10 $\Omega_{L,u}^{-1}$) (**shock ripples**?)

TS structure is variable from one crossing to the next (**reformation**?)

# A Supercritical Perpendicular Shock Crossing



# Shock Jump Parameters, TS-3

Moderate Shock Strength, ~ 1.6 ± 0.2 :

$B_d/B_u = 1.7 \pm 0.1$

$N_d/N_u = 1.4 \pm 0.2$

TS Speed:

$V_{TS} \sim 100$ km/sec

(*if shock normal & velocities are radial*)

TS-3 is Supercritical:

$M_{A,sh} = V_{TS} / V_{A,u} \sim 10$

# Other Shock Structure Parameters, TS-3

- Upstream solar wind

  $R_{L,Vu}$ = 51,000 km; $c/\omega_{pi,u}$ = 6,000 km;

  $V_{A,u}$ = 40 km/sec; $M_{A,u}$ = 7.9

  $\beta_p$ = 0.04 = O($\beta_{pp}$)? $V_{th}/V_{TS}$ = 0.1

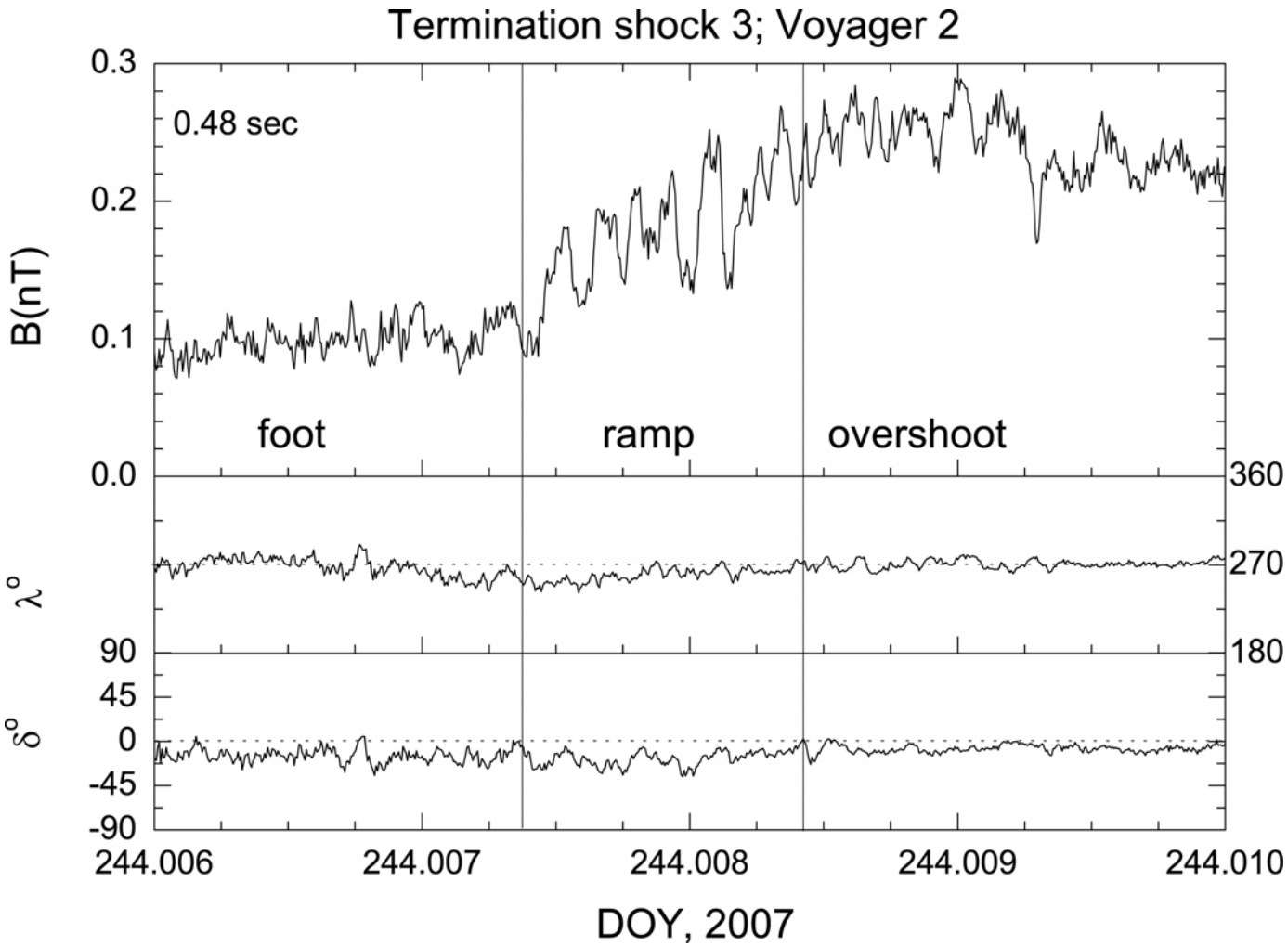
  $\Omega_{L,u}^{-1}$ = 17 min;

- Thickness:

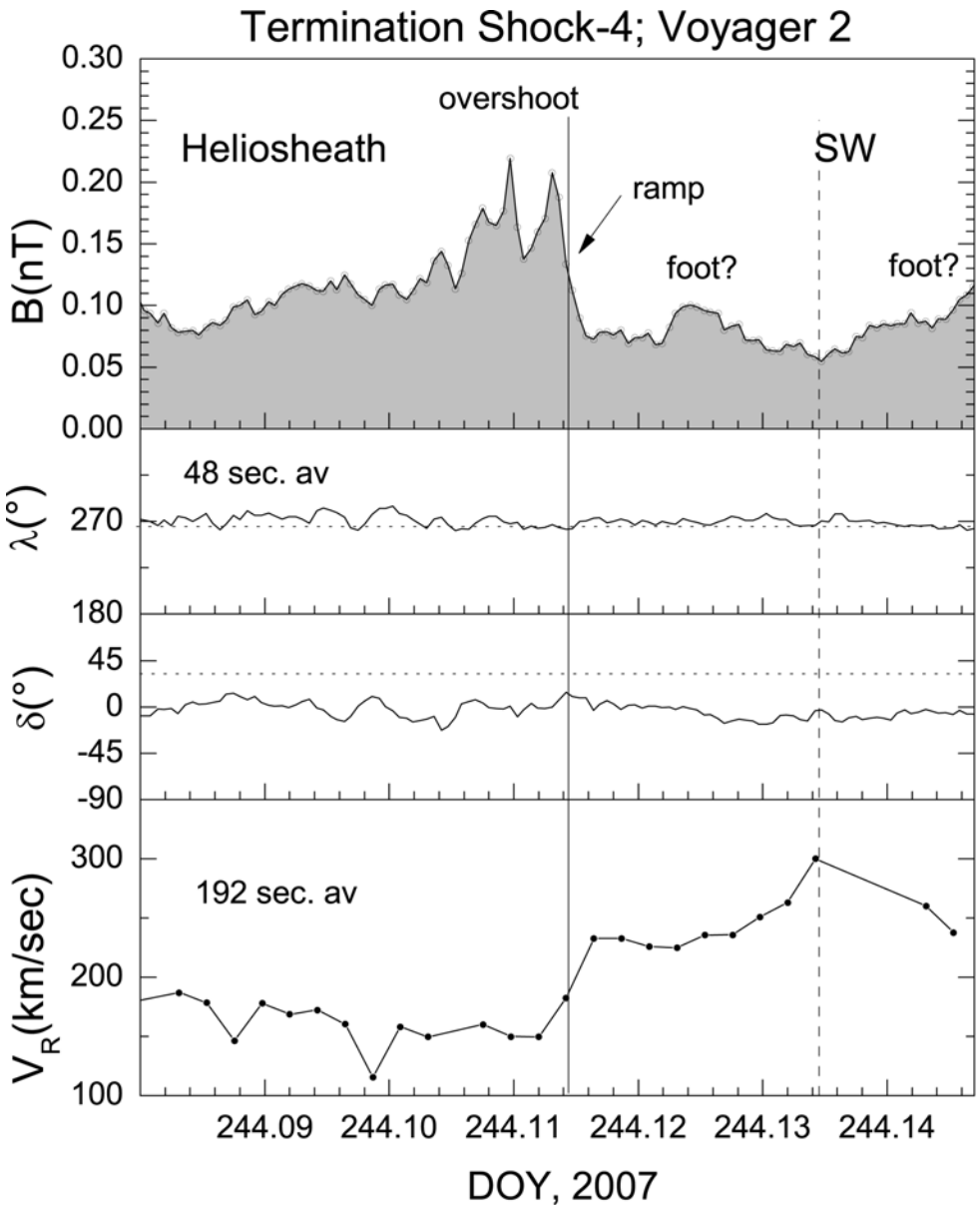
  foot: (23 min); 320,000 km = 6 $R_{L,Vu}$

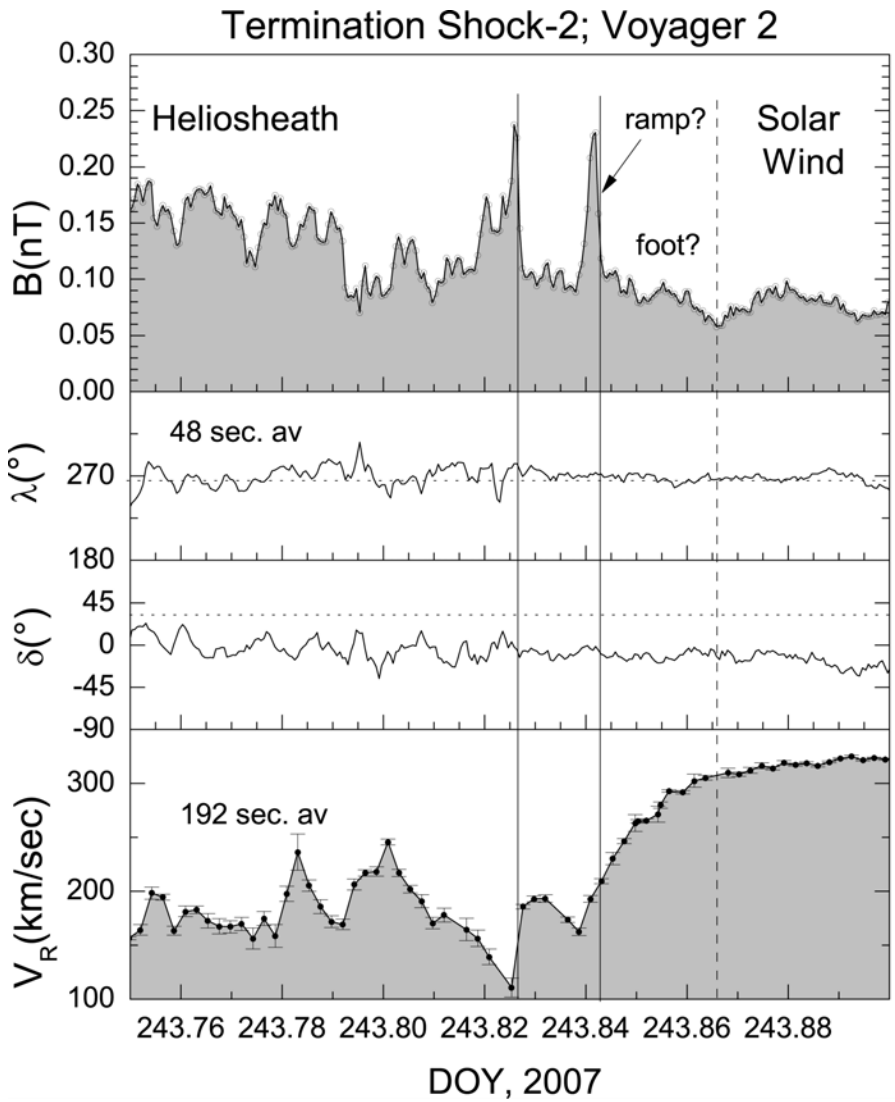
  ramp: ( 1.5 min); 22,000 km = 4 $c/\omega_{pi,u}$

  overshoot: (17 min); 145,000 km = 3 $R_{L,Vu}$

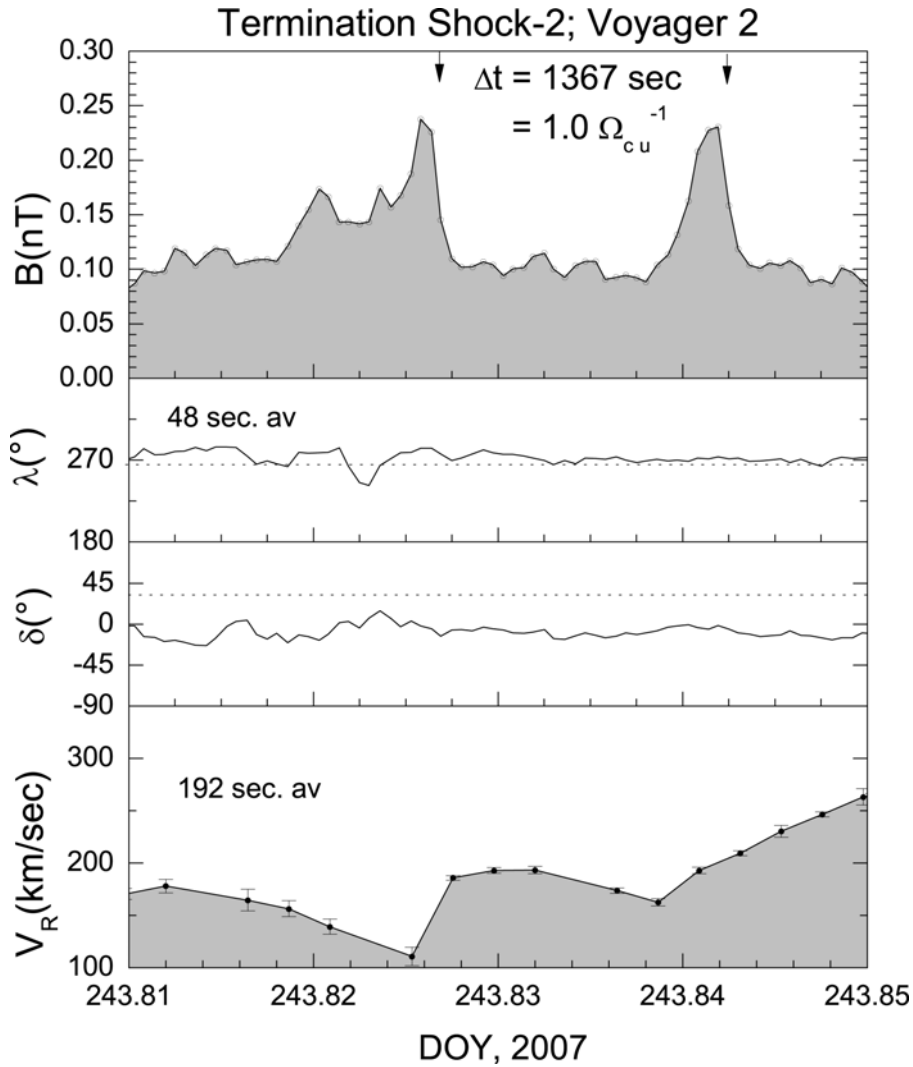



- **Ramp:** scale. $\tau \sim 90$ sec; $\lambda \sim 22{,}000$ km = $4\ c/\omega_{pi,u} = 0.4\ R_{L,Vu}$
- **Substructure:** scale: $\tau \sim 12.3$ sec; $\lambda \sim 3{,}000$ km = $0.5\ c/\omega_{pi,u}$


Termination Shock-4; Voyager 2
overshoot
Heliosheath
SW
ramp
foot?
foot?
B(nT)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
48 sec. av
λ(°)
270
180
δ(°)
45
0
-45
-90
192 sec. av
$V_R$(km/sec)
300
200
100
244.09
244.10
244.11
244.12
244.13
244.14
DOY, 2007




This TS crossing shows complex, variable structure




- Reformation? Two soliton-like structures separated by ~ 1 $\Omega_{L,u}^{-1}$, the reformation scale for a perpendicular shock.
- "ramp" thickness; $\Delta t \sim 85$ sec; L ~15,000 km ~ 2.5 $c/\omega_{pi,u}$

# Summary

- The TS moved past V2 ≥ 5 times in ~ 2 days
  - due to variations in TS speed &/or ripples on shock?
- The structure of the TS was observed in 3 crossings
  - All 3 TS were quasi-perpendicular.
  - The shock structure was variable on scales 0.1 – 15 $\Omega_{L,u}^{-1}$
  - Evidence for reformation during one crossing.
- One crossing had foot, ramp, & overshoot structure
  - Supercritical shock: $M_{A,TS}$ ~ 10
  - Moderate strength: $B_d/B_u \sim N_d/N_u \sim V_u/V_d \sim 1.6 \pm 0.2$
  - Scales: foot ~ 6 $R_{L,Vu}$; ramp ~ 4 $c/\omega_{pi,u}$ ; overshoot ~3 $R_{L,Vu}$
  - Oscillations in ramp: scale ~ 0.5 $c/\omega_{pi,u}$