

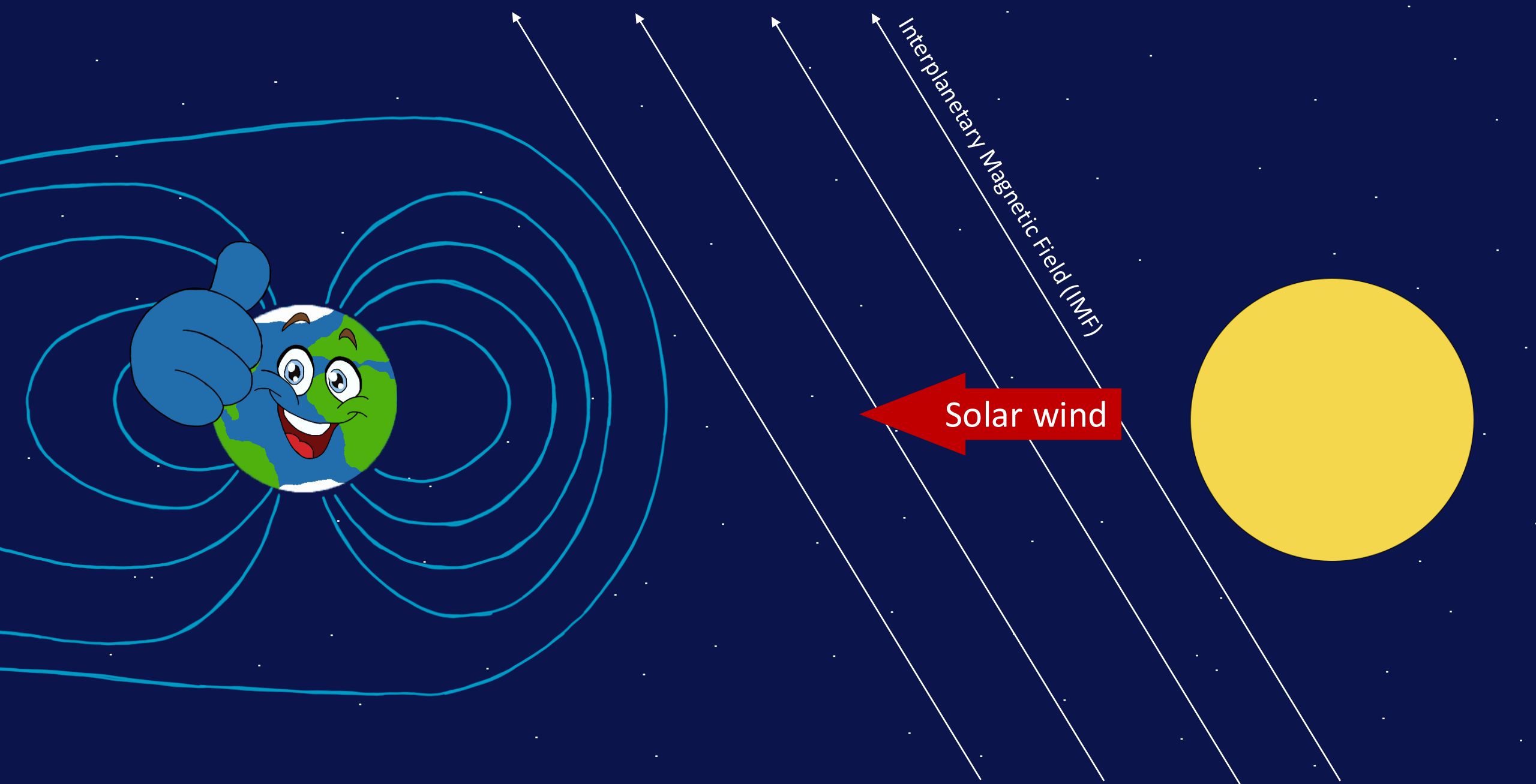


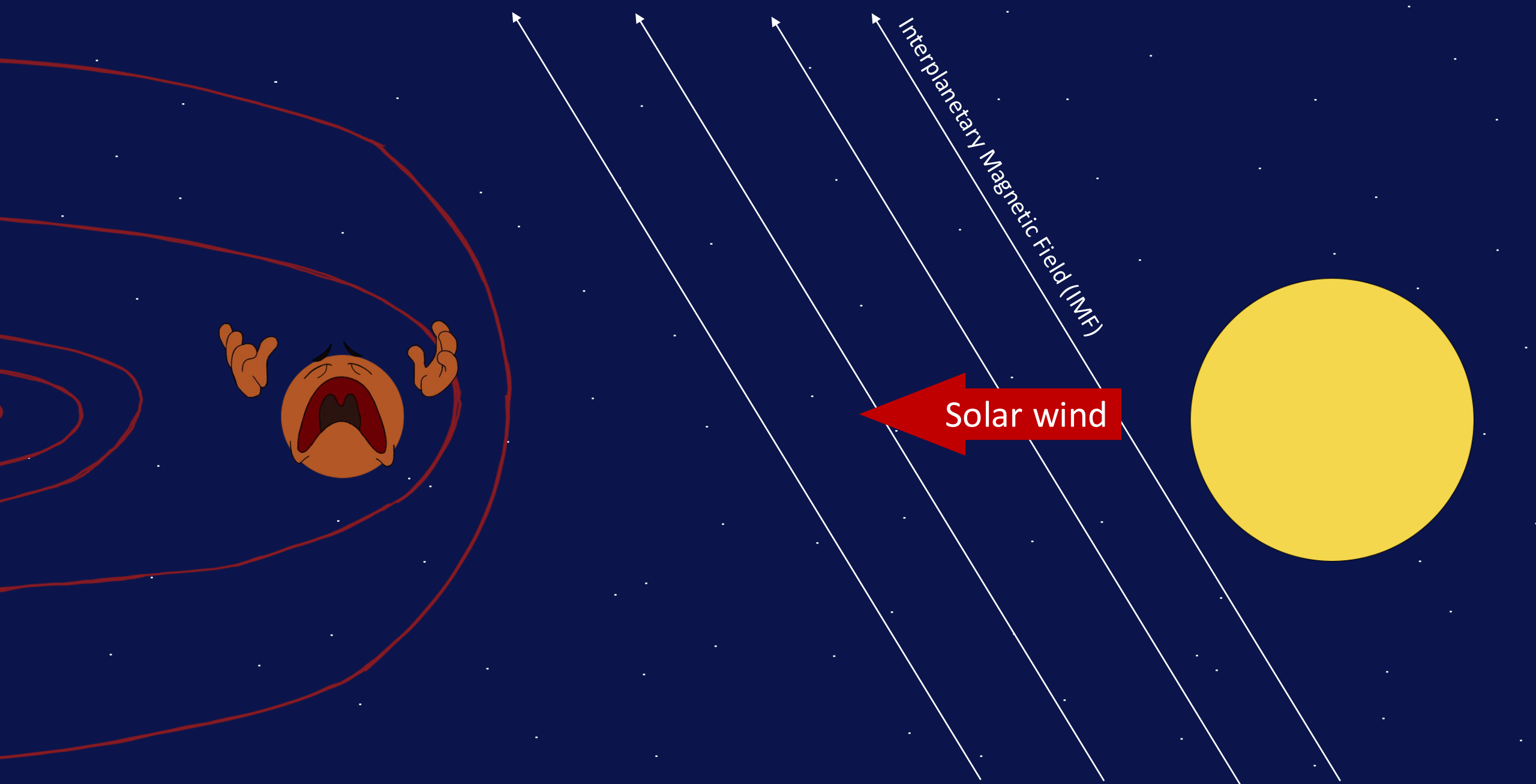
# Data-Model Comparison of Multispecies MHD and MAVEN Observations at the Mars Magnetotail Current Sheet

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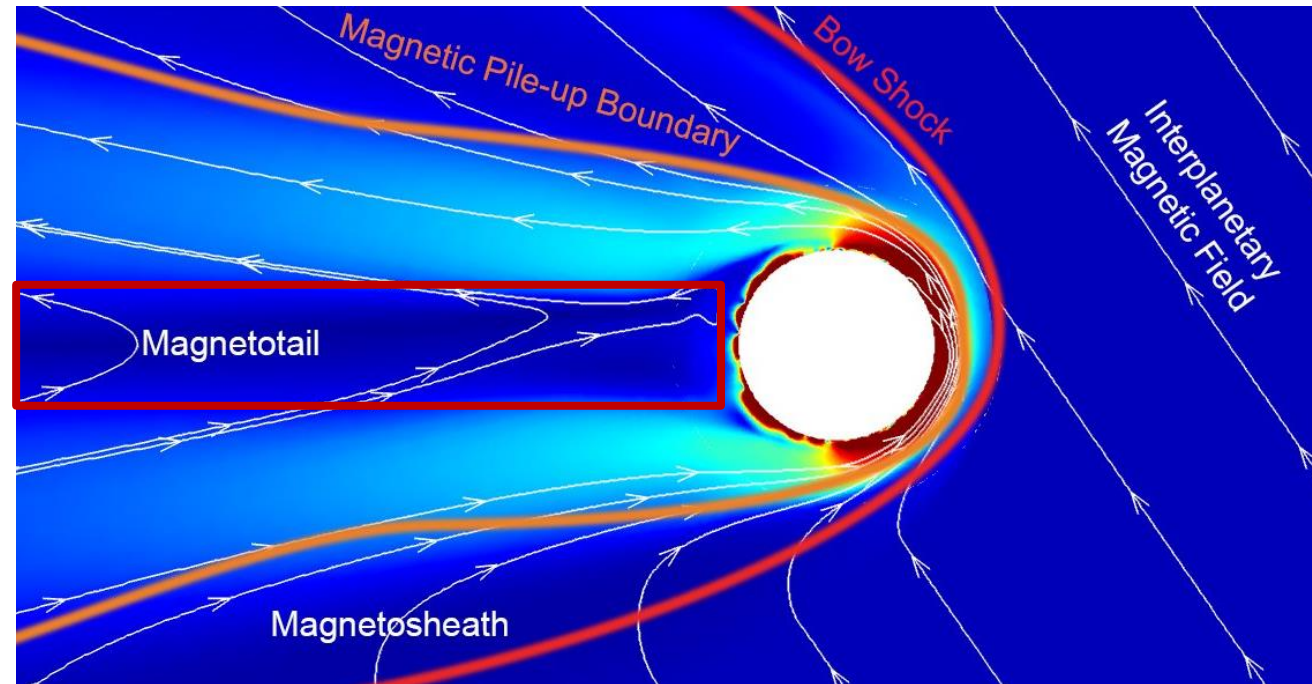
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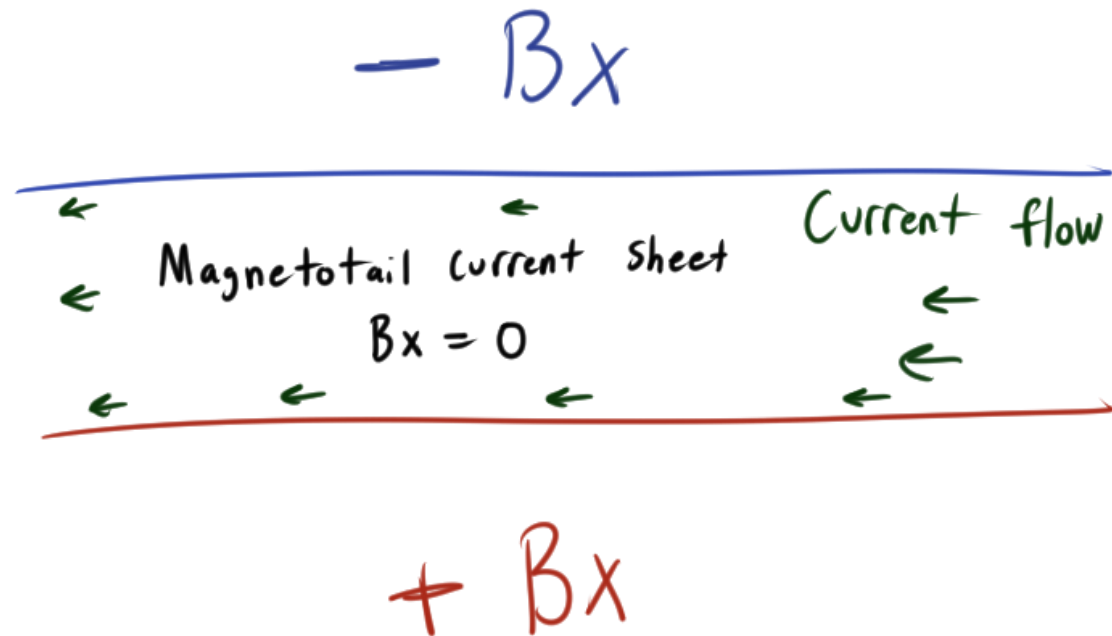
# Martian Magnetotail

- Key region of interest for atmospheric ion escape
- Primary focus: magnetotail current sheet



# Magnetotail Current Sheet

- Thin layer in the magnetotail where the magnetic field flips and currents flow
- Exhibits a dawn-dusk asymmetry



# How We Investigate It

- Spacecraft observations
  - Detailed measurements at specific locations
  - Sparse spatial coverage
- Numerical simulations
  - Entire magnetosphere can be studied
  - Sensitive to model parameters
- Data-model comparisons have been largely limited to global magnetic field configurations
- What about a comparison at the magnetotail current sheet?

# Project Objective

- Determine how well idealized BATS-R-US simulations reproduce MAVEN current sheet crossings on 28 May 2017

# Methodology: Numerical Model

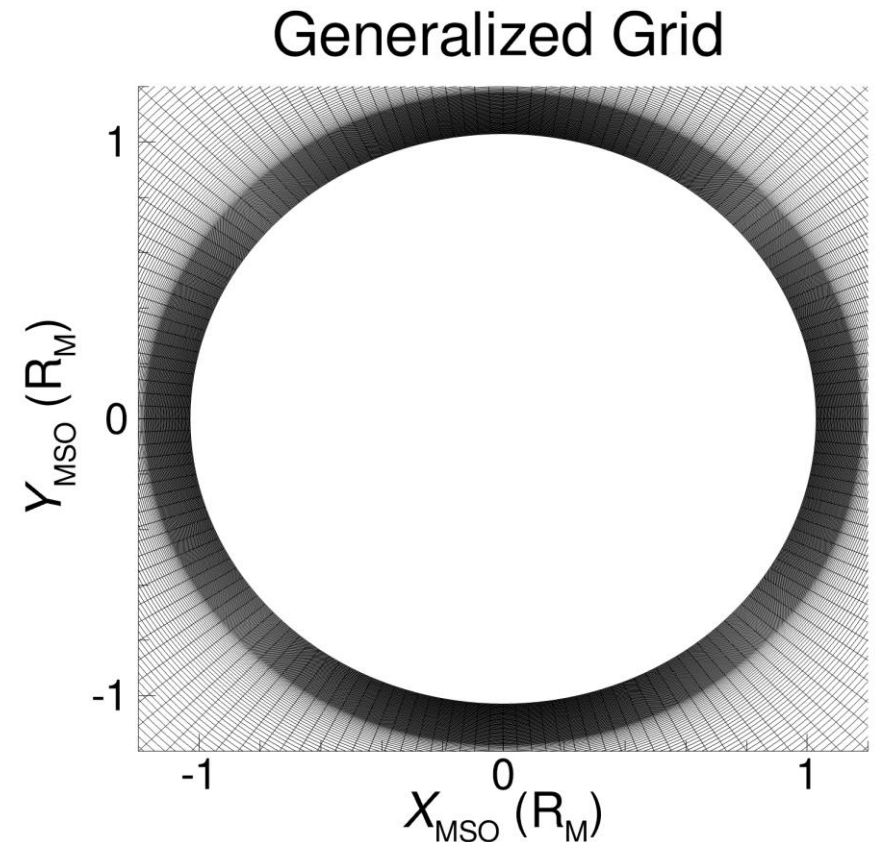
- **BATS-R-US:** Block Adaptive Tree Solar wind Roe-type Upwind Scheme
- Multispecies MHD code
  - Atmospheric ions ( $H^+$ ,  $O_2^+$ ,  $O^+$ ,  $CO_2^+$ ) have their own densities
  - Ion species share a single velocity
  - Ion species share a single temperature
- Model outputs are 3D, results shown in 2D



# Grid Configuration

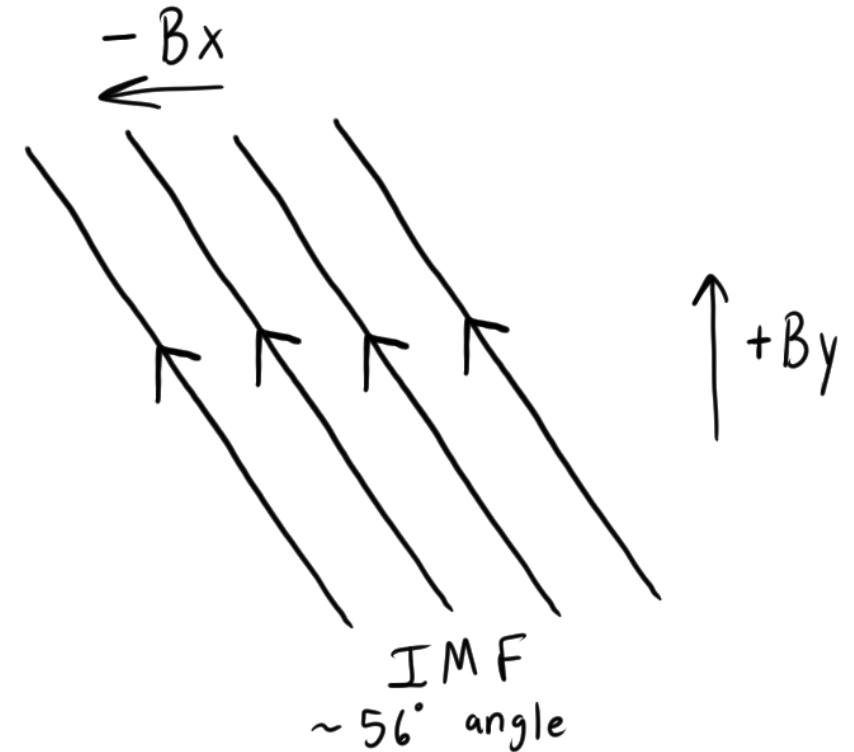
- Simulation domain:
  - $-24 \leq X_{\text{MSO}} \leq 8 R_{\text{M}}$
  - $-16 \leq Y_{\text{MSO}} \leq 16 R_{\text{M}}$
  - $-16 \leq Z_{\text{MSO}} \leq 16 R_{\text{M}}$
- Fine resolution at the inner boundary

Setting	Default
Grid geometry	Spherical generalized grid
Radial resolution $\Delta r$ (km)	8
Longitudinal resolution $\Delta \phi$ ( $^\circ$ )	2
Latitudinal resolution $\Delta \theta$ ( $^\circ$ )	2
Initial refinement levels	0
Global refinement levels	0
Inner boundary refinement levels	1



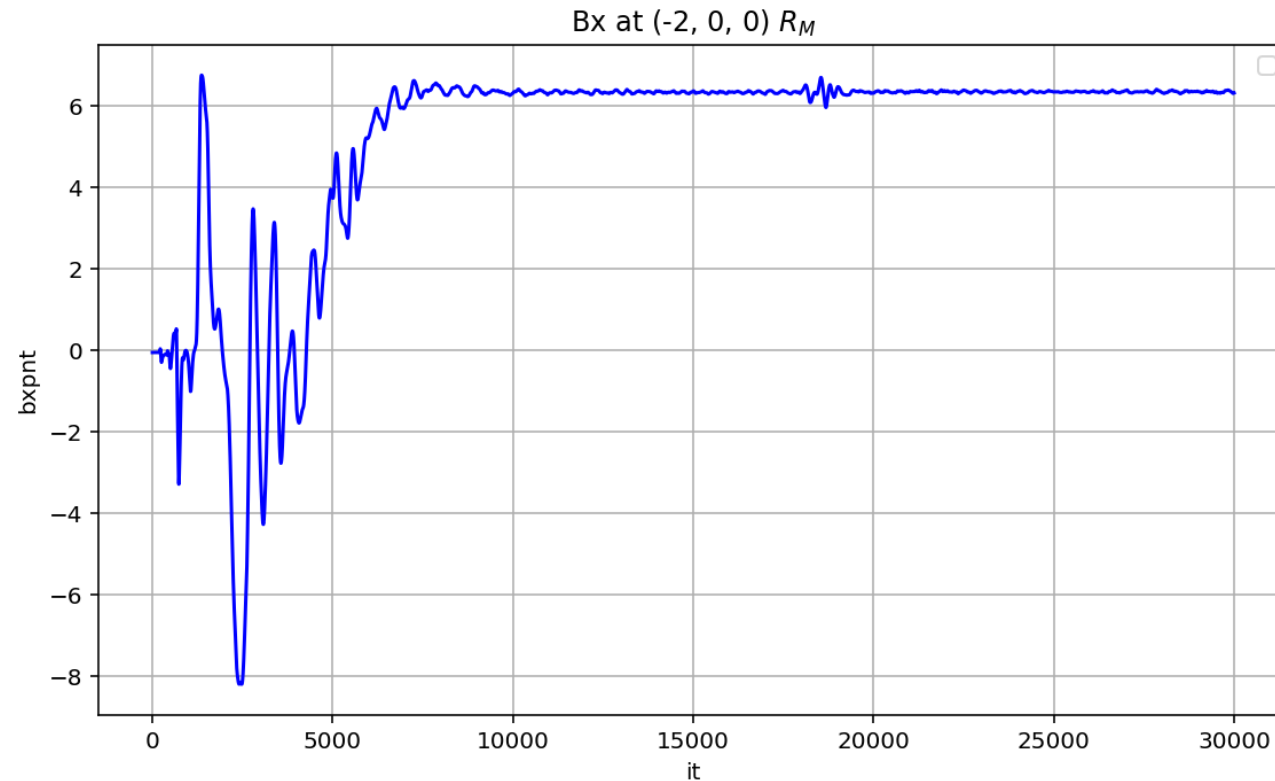
# Solar Wind Conditions

- **IMF: 3 nT away sector Parker spiral**
  - $(-1.67, 2.48, 0)$  nT
  - $\sim 56^\circ$  angle
- Density:  $4 \text{ cm}^{-3}$
- Velocity:  $-400 \text{ km/s}$  (x-direction, towards Mars)
- Temperature:  $3.5 \times 10^5 \text{ K}$



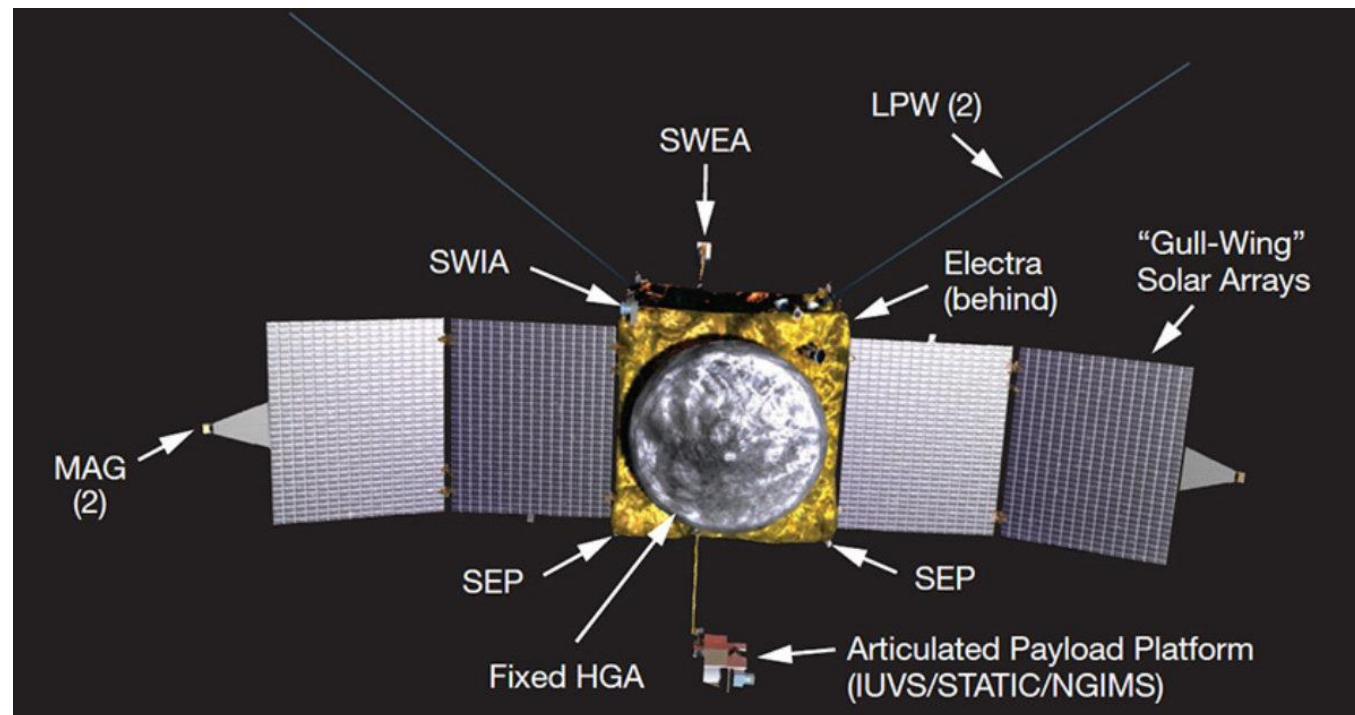
# Simulation Runtime

- Simulations are steady-state (Mars is not rotating)
- Run for 30,000 iterations



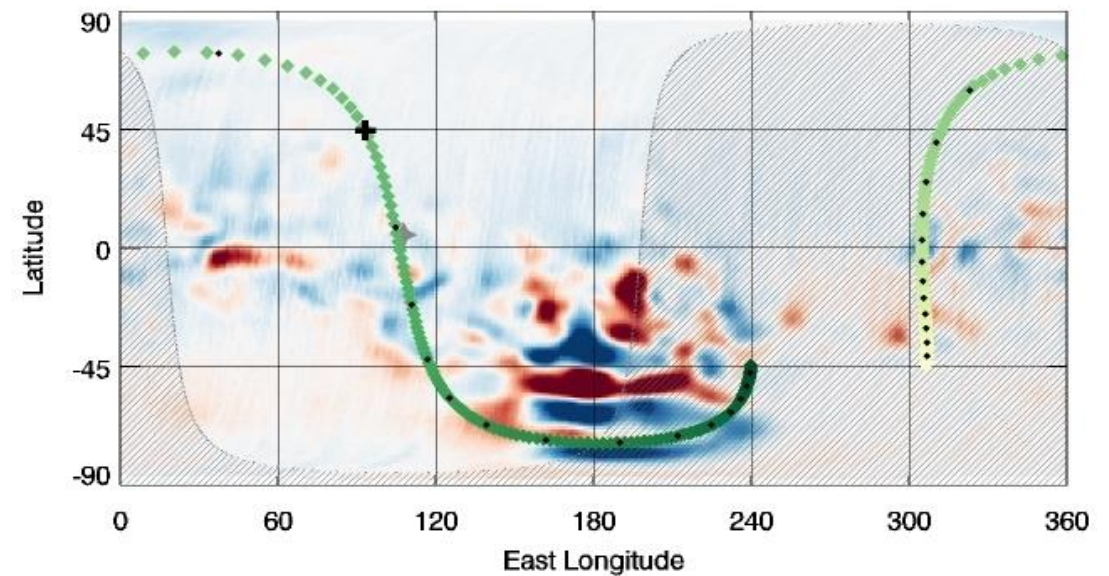
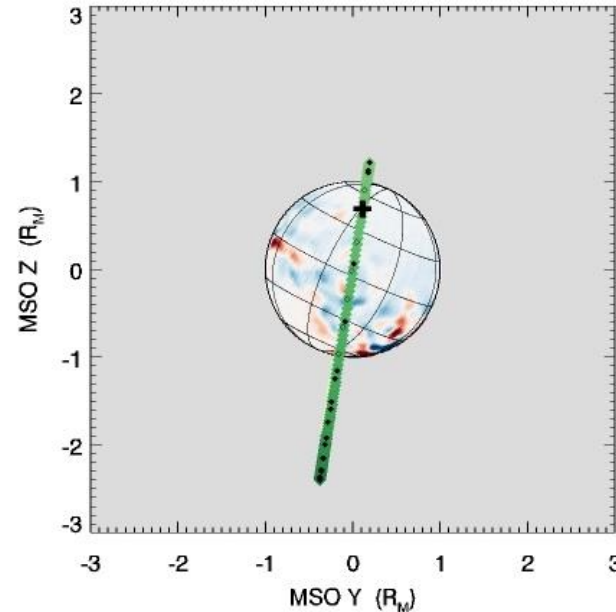
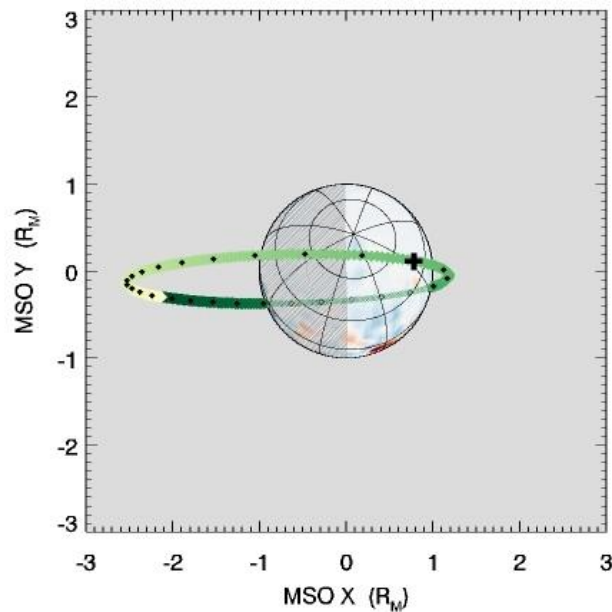
# Methodology: MAVEN Spacecraft

- Mars Atmosphere and Volatile Evolution (**MAVEN**) Magnetometer (**MAG**)
- Measures the strength and direction of the magnetic field on Mars

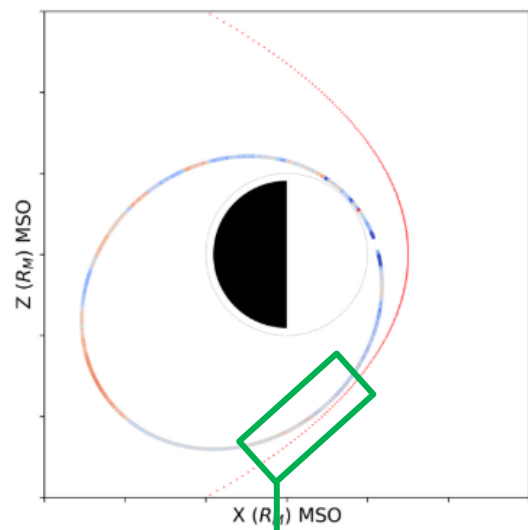


# MAVEN Orbit Geometry (28 May 2017)

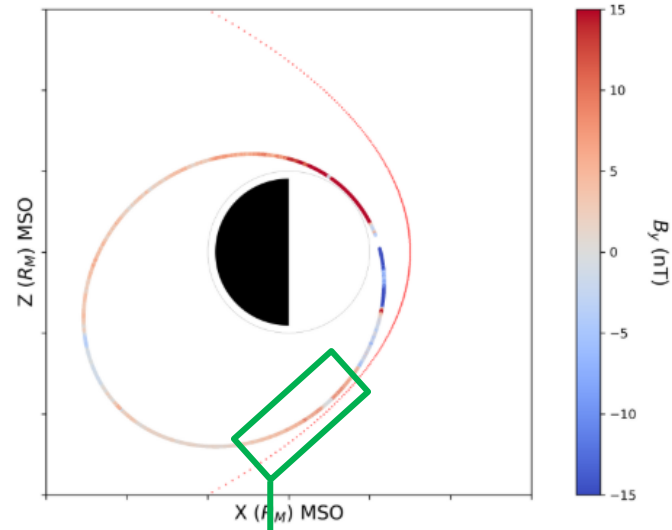
- Time – 04:22 UTC
- Why this date: apoapsis is almost directly behind Mars
- Spacecraft passes near the current sheet



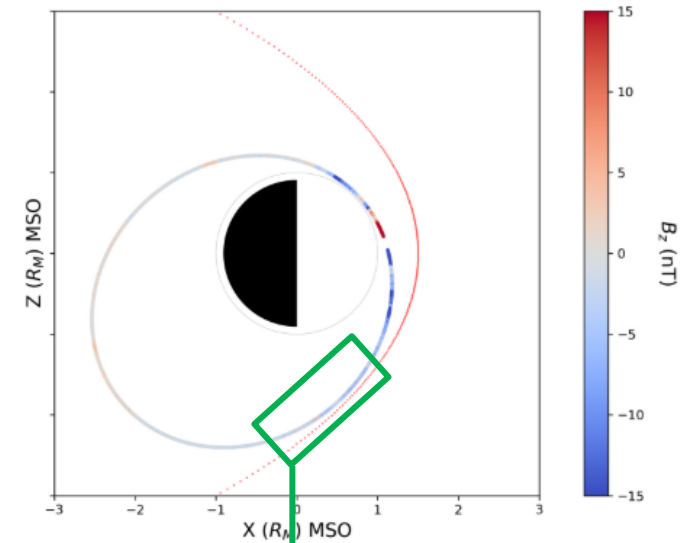
# Away sector IMF conditions ( $-B_x, +B_y, \sim 0 B_z$ )



Negative  $B_x$  (blue)

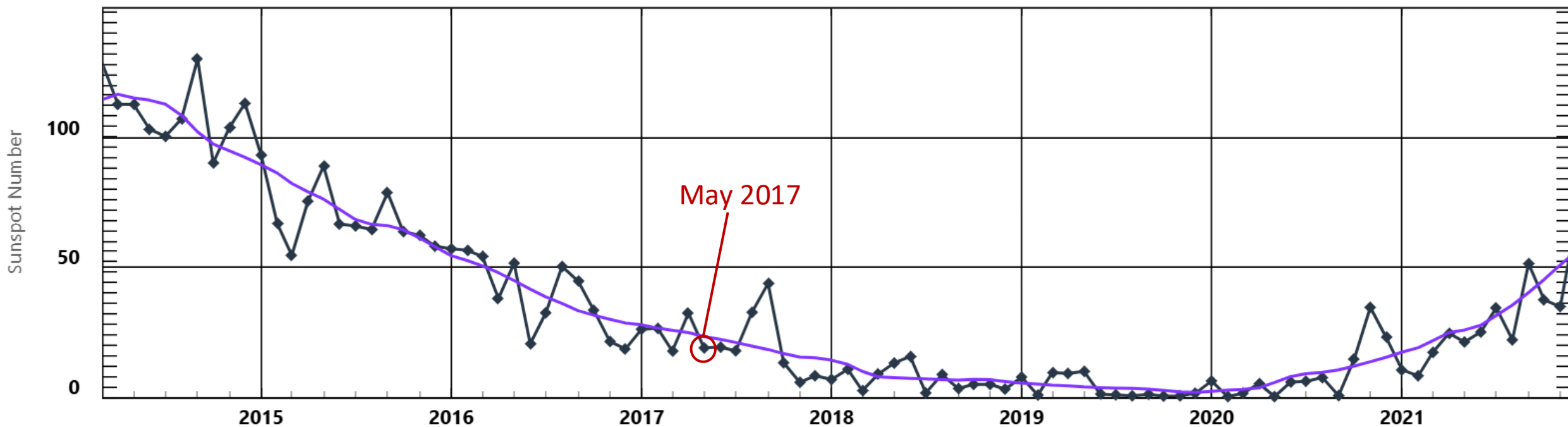


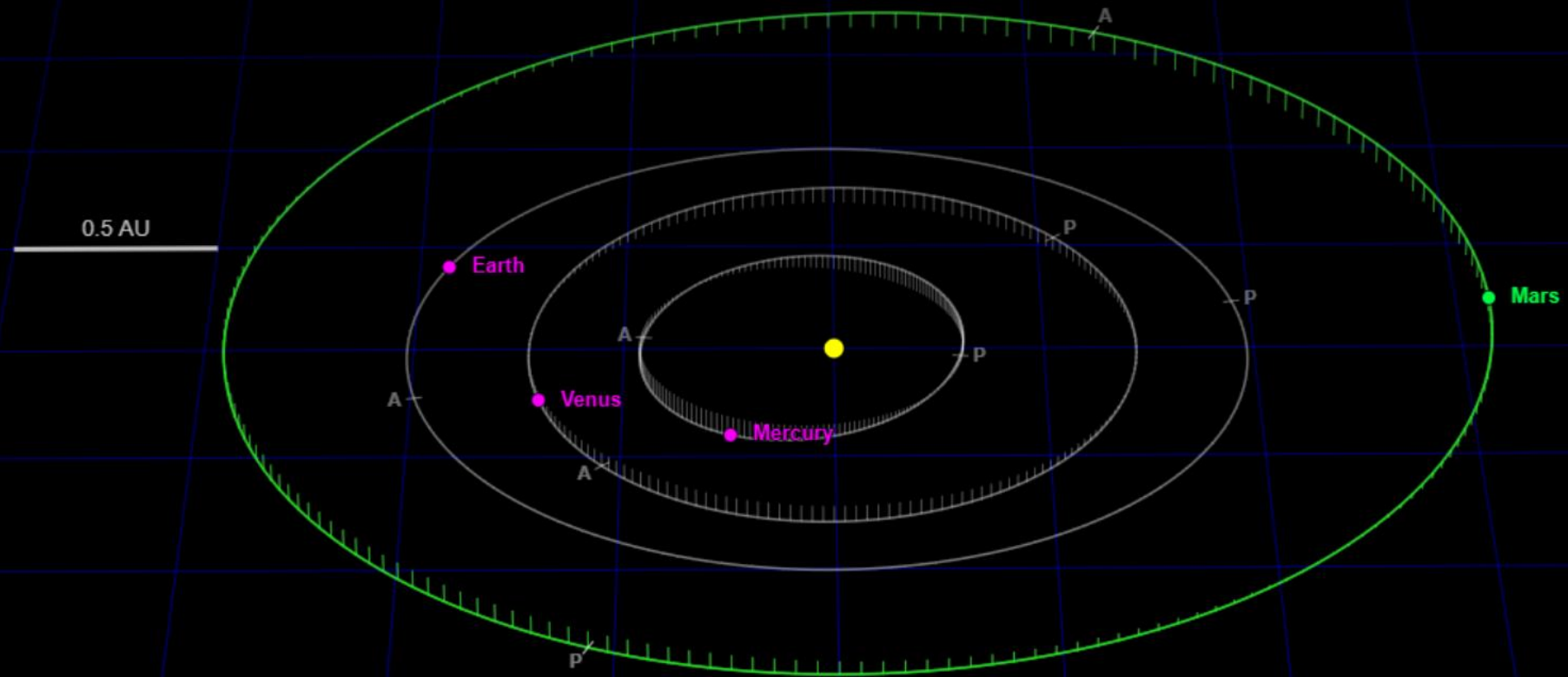
Positive  $B_y$  (red)



Near zero  $B_z$  (light blue)

### Solar Cycle Sunspot Number Progression



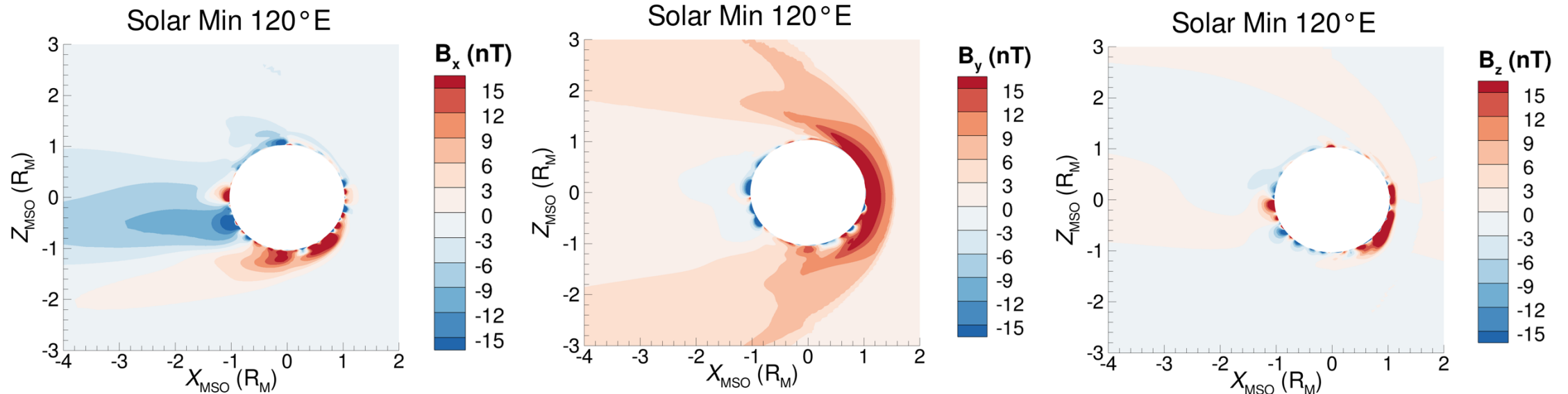


# BATS-R-US solar condition: Solar Minimum

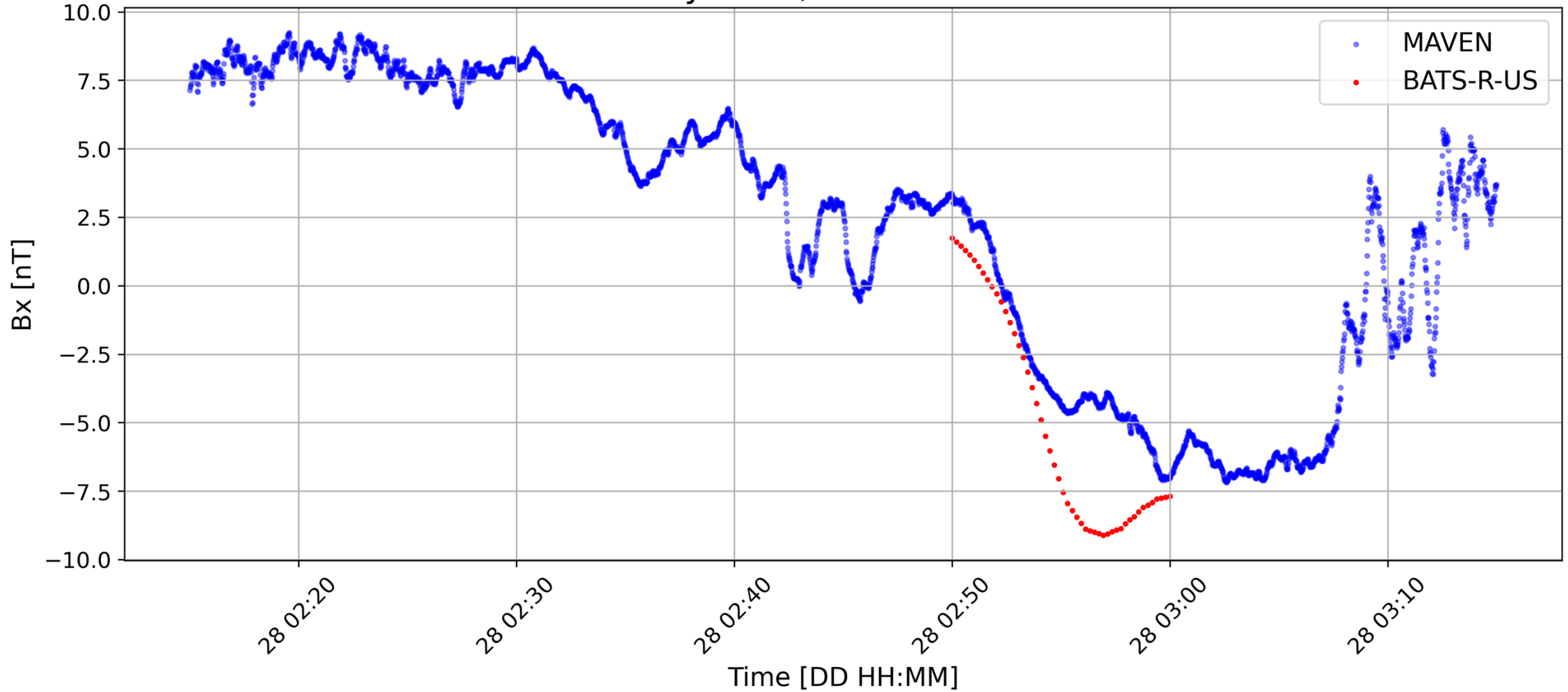
<https://in-the-sky.org>

# BATS-R-US Configuration

- Subsolar longitude:  $120^\circ\text{E}$ ,  $0^\circ\text{N}$ 
  - This translates to 16 hours local time
  - Strongest crustal fields are at  $120^\circ\text{E}$ ,  $0^\circ\text{N}$
- Region of interest: **current sheet crossing** (where  $B_x$  changes sign)
- Time independent, so we assume a 10-minute interval

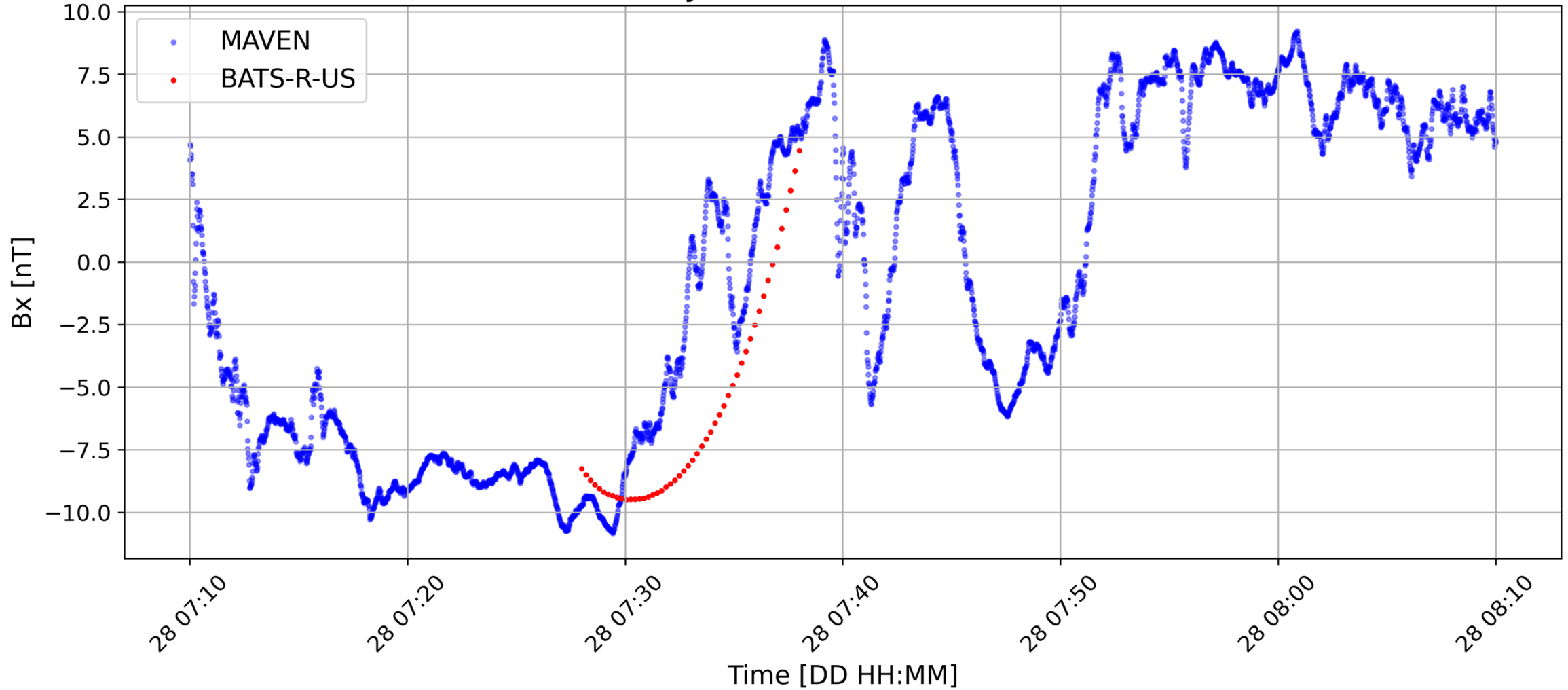


### Bx vs MAVEN Orbit Time 28 May 2017, 02:15-03:15 UTC



# Bx vs MAVEN Orbit Time

28 May 2017, 07:10-08:10 UTC



# Data/Model Limitations

- Single event selection
  - What about other days that exhibit similar conditions?
- BATS-R-US interval selection
  - Steady-state has no time so we're assuming it's a 10-minute interval
- Steady-state assumption
  - Mars is not rotating
  - IMF doesn't vary with time

# Summary

- Current sheet crossing comparison between MAVEN and BATS-R-US shows encouraging signs of agreement
- BATS-R-US configuration reproduces key magnetotail features despite even in steady-state

# Future Work

- Validate BATS-R-US magnetotail current sheet configuration with multiple MAVEN crossings
- Potentially test other model conditions
  - IMF orientation
  - Solar wind speed
  - Extreme space weather scenarios

# Thank You!

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