Solar wind propagation methods and their applicability including the magnetic lasso model

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Solar wind propagation

- Ballistic (with iteration)

- Magnetic lasso by Dosa

- 1D MHD + ballistic: Tao model

- 1D MHD + ballistic: mSwim (Zieger et al.)

- 3D MHD: ENLIL (Odstrcil et al.)

Input data: - any spacecraft in situ SW obs.

- remote obs. (Pinto talk)

Simple ballistic SW propagation

Earth to Mars propagation

$$\Delta t = \Delta t_1 + \Delta t_2$$

$$\Delta t_1 = \frac{r_{mars} - r_{earth}}{v}$$

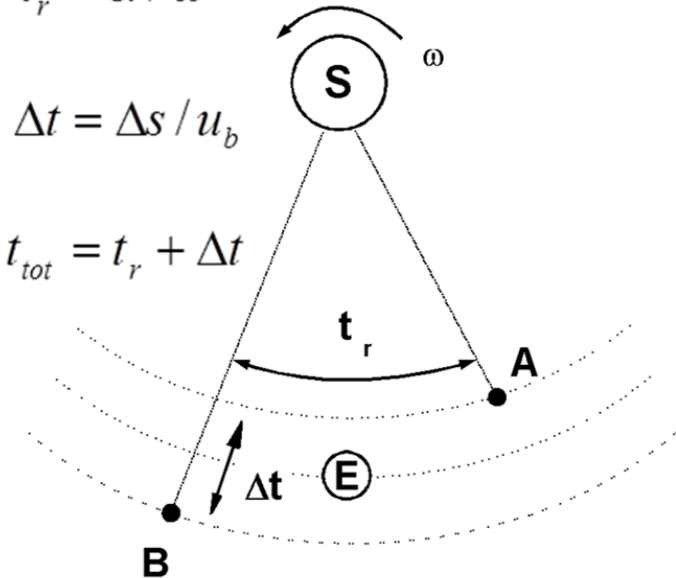$$\Delta t_2 = \frac{\phi_{mars} - \phi_{earth}}{\omega}$$

STEREO A and B comparison

$$t_r = \alpha / \omega$$

$$\Delta t = \Delta s / u_b$$

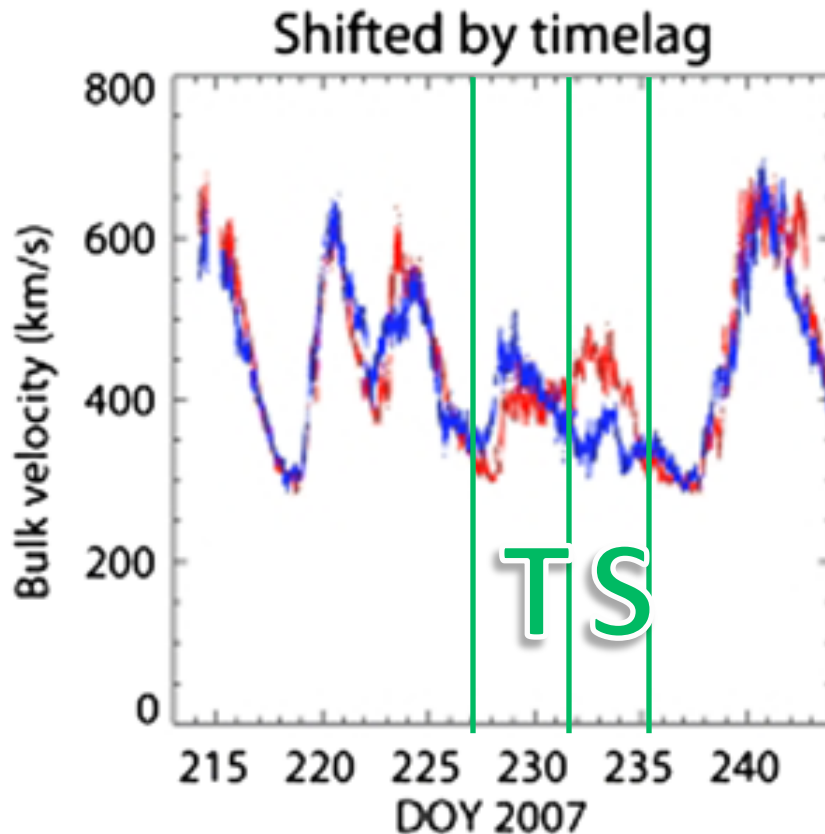$$t_{tot} = t_r + \Delta t$$

✍ **Vennerstrom et al. 2003 GRL**   ✍ **Opitz, Karrer et al. 2009 SolPhys**

+ Santos-Costa et al. 2008 (Jupiter) and Edberg et al. papers (Venus, Mars and Titan)

Simple ballistic SW propagation

- Assumptions
  - constant bulk velocity during radial propagation
  - constant solar source for longitudinal separation
  - neglect latitudinal separation

- Validity
  - small radial distance depending on velocity gradient
  - only near ecliptic plane / solar equator plane

- Application
  - radial: only few AU ($V \leftarrow E \rightarrow M$)
  - longitudinal: Zieger 50°, Opitz 60°, Grison 45° (dep. persistence)

Solar wind variations
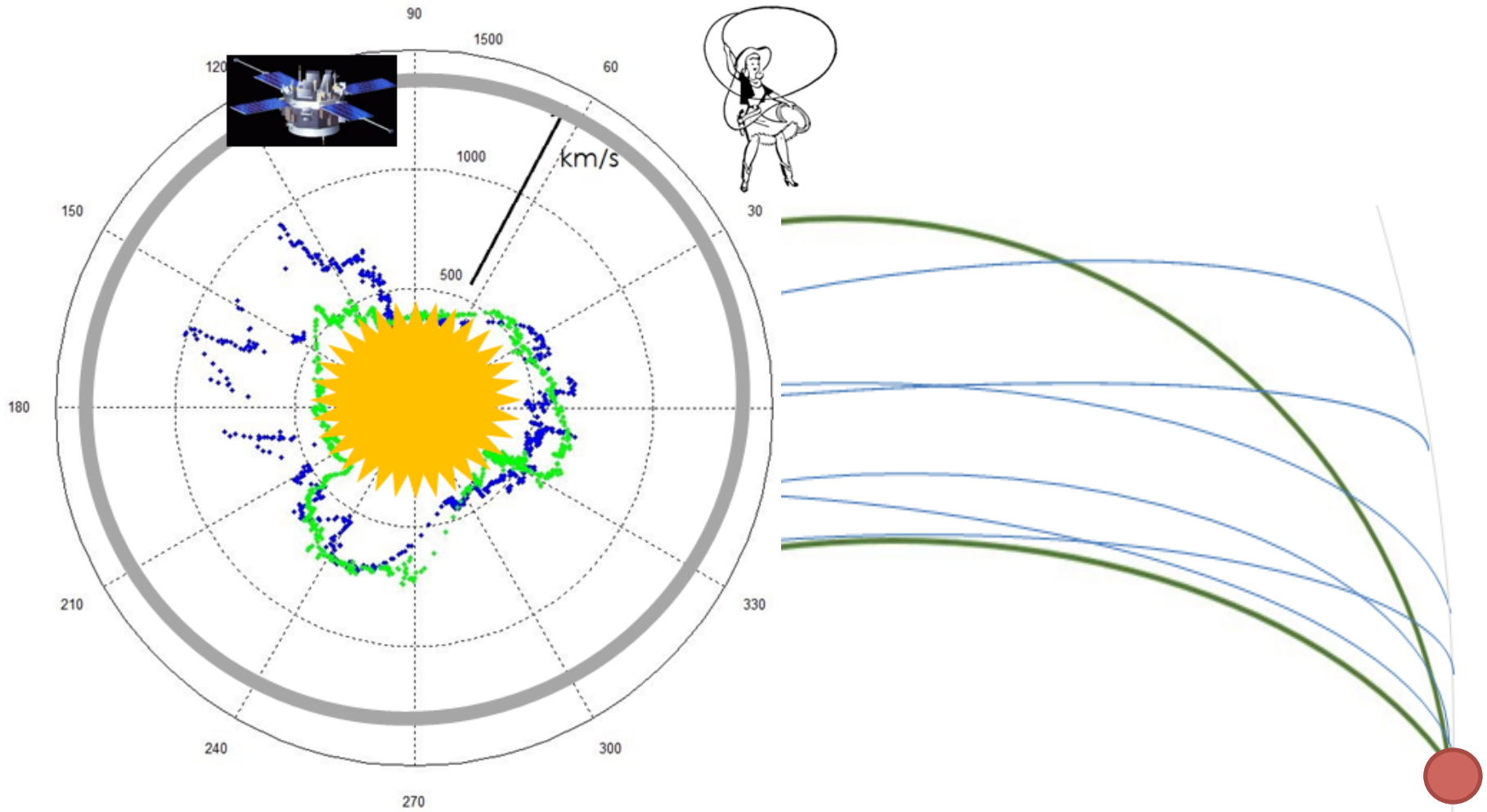

Shifted by timelag

T S

T: temporal evolution
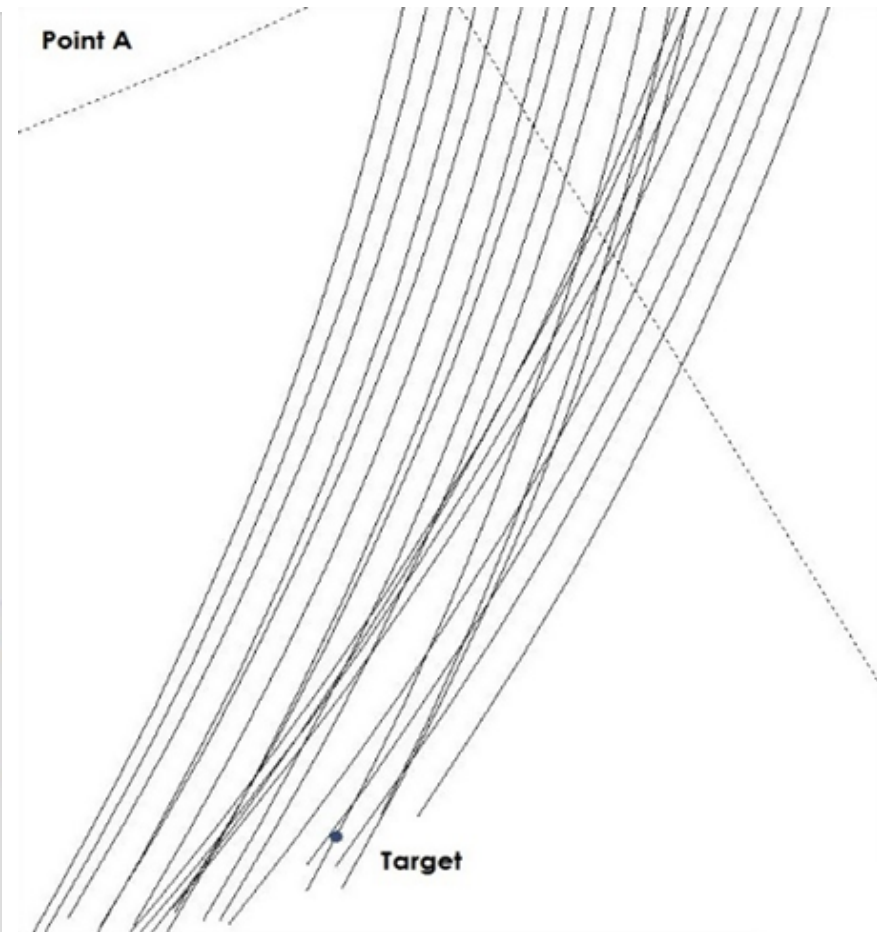solar wind source changed from STB to STA due to coronal hole closing

S: spatial variation
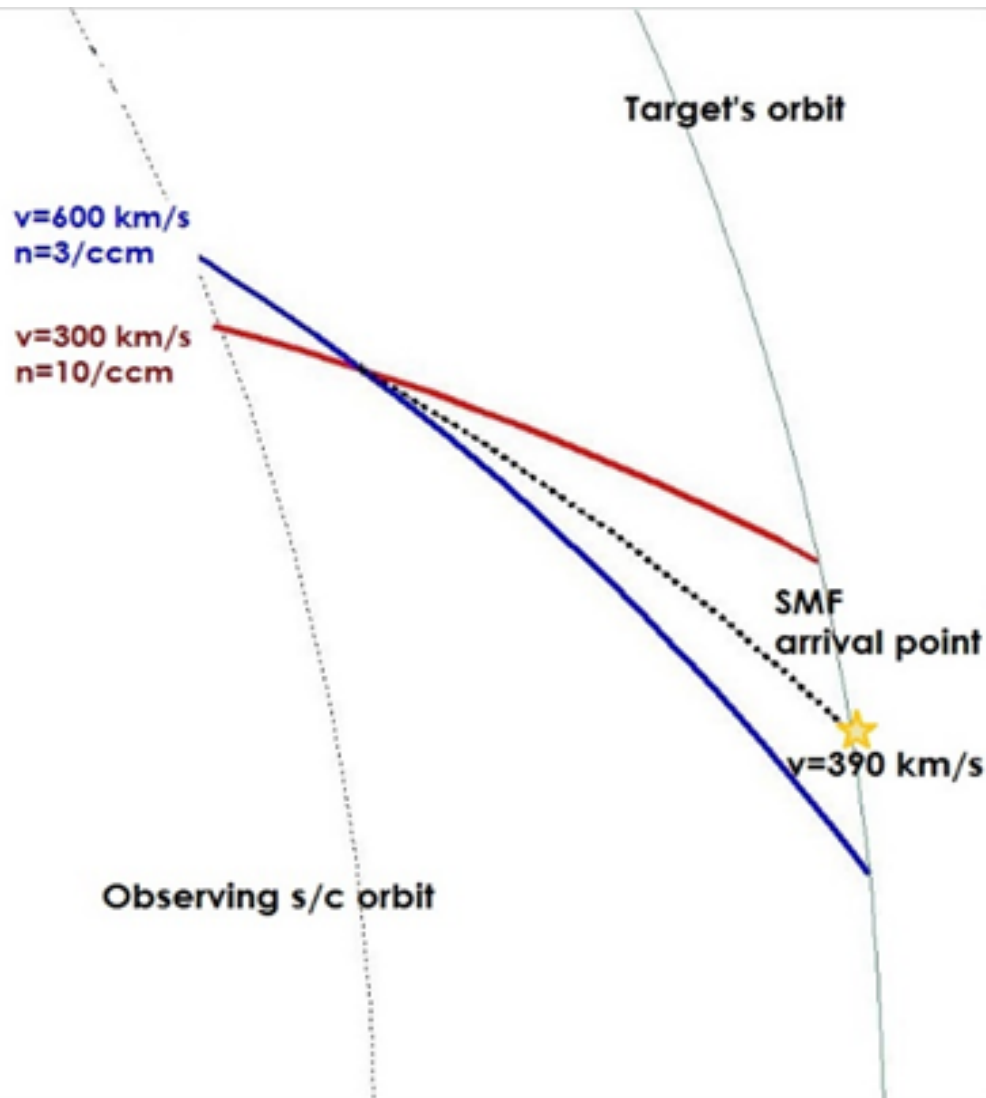exceptionally high latitudinal velocity gradient along the 2.2° latitudinal difference between STB and STA due to a nearby coronal hole
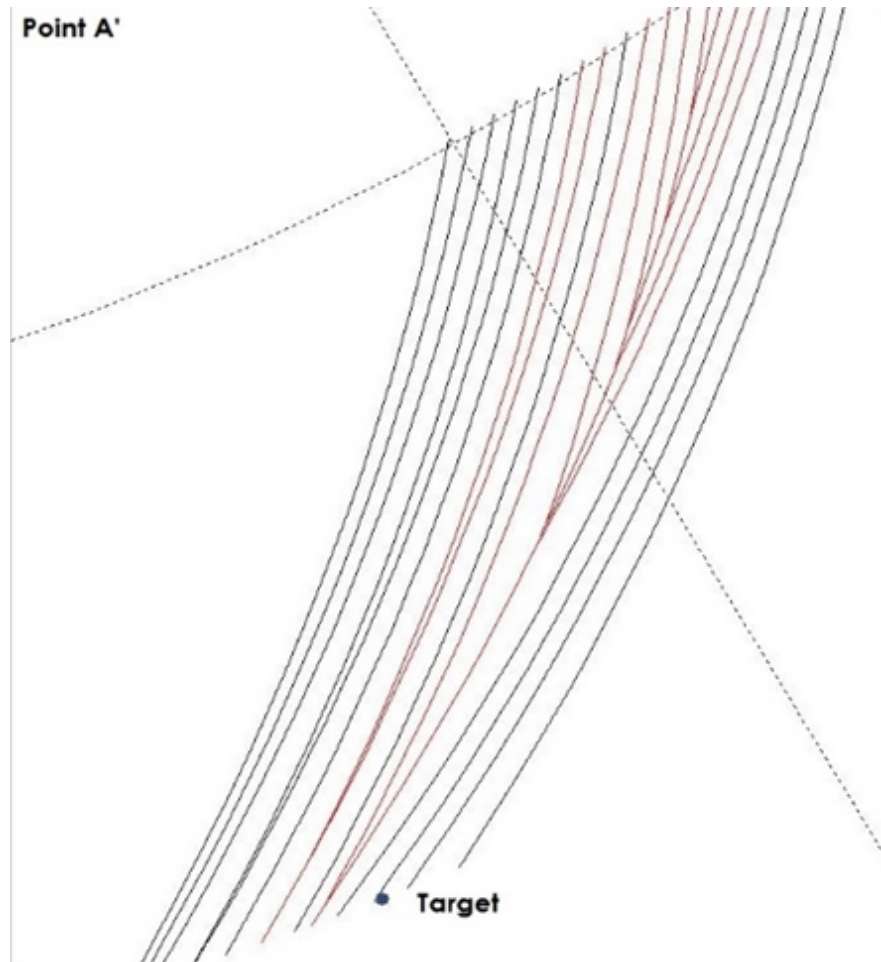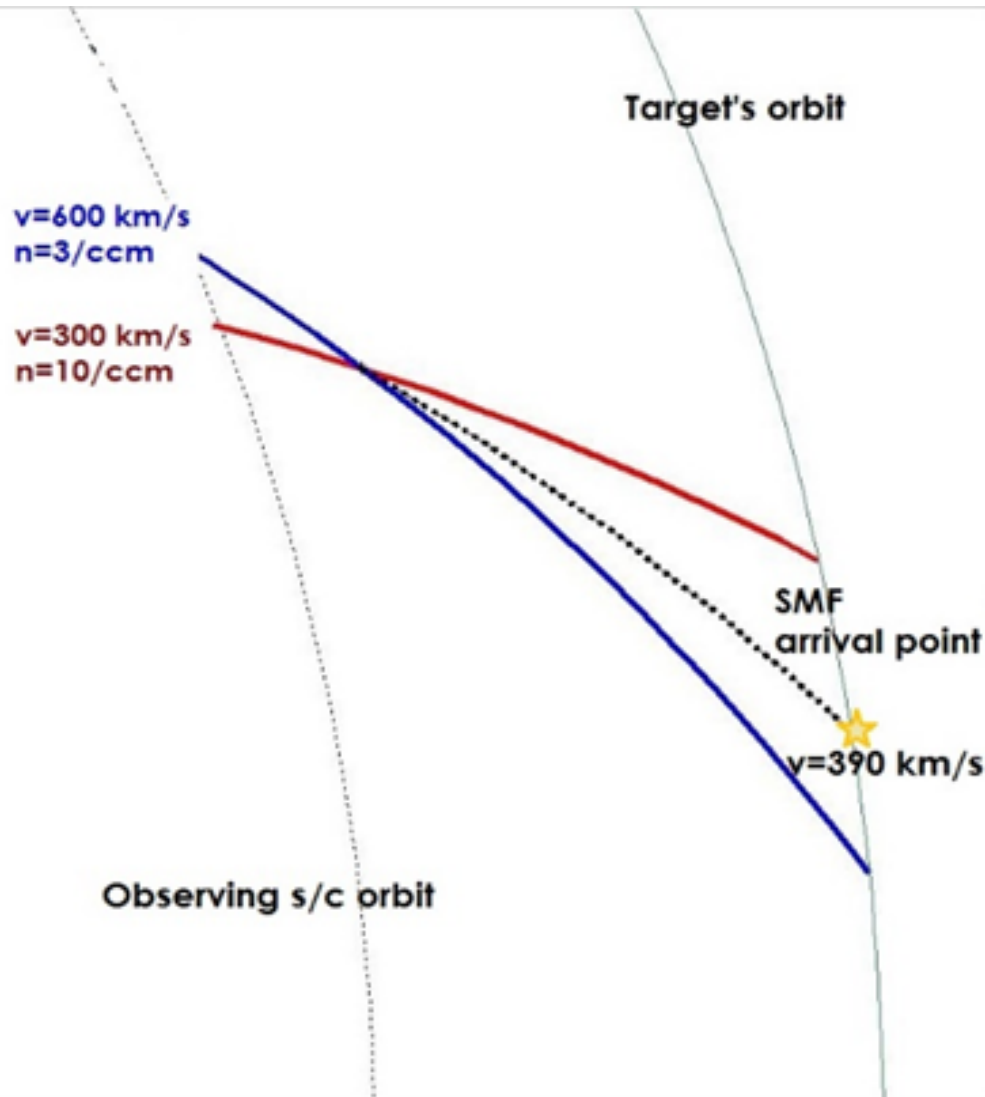
✍ Opitz, Karrer, Wurz et al. 2009 SolPhys

Magnetic lasso

✎ Dósa, Opitz et al., SolPhys
nearly submitted

Stream interaction

v=600 km/s
n=3/ccm

v=300 km/s
n=10/ccm

Target's orbit

SMF
arrival point

v=390 km/s

Observing s/c orbit

Point A

Target

Stream interaction

Target's orbit

v=600 km/s
n=3/ccm

v=300 km/s
n=10/ccm

SMF arrival point
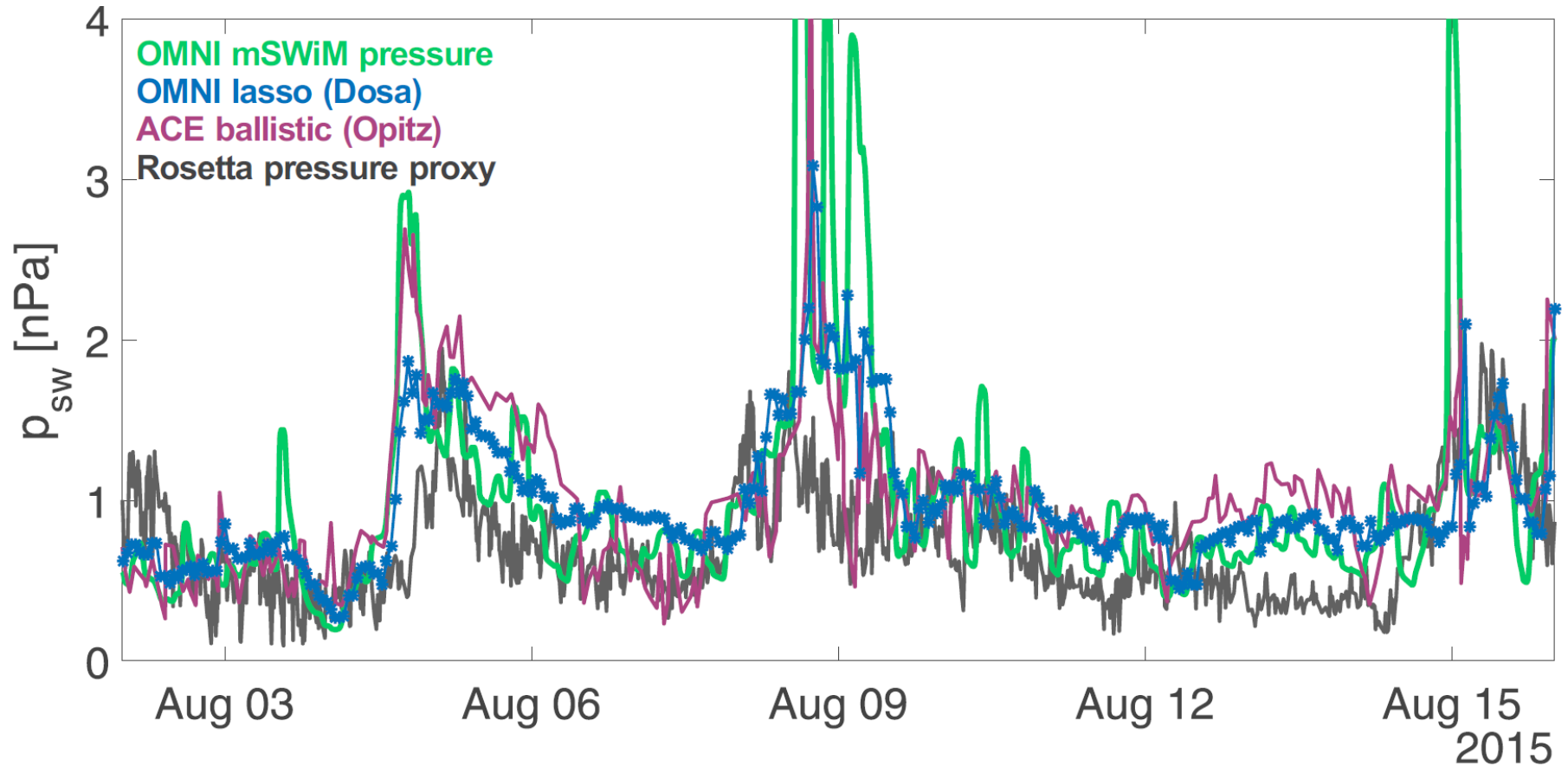
v=390 km/s

Observing s/c orbit

Point A'

Target

✎ **Dósa, Opitz et al., SolPhys nearly submitted**

Radial 1D MHD + ballistic

- Tao model: Tao et al. 2005
  - 2 components (X, Y) of B and V
  - Jupiter: Tao et al. 2005

- mSWIM (UoMichigan): Zieger and Hansen 2008
  - 3 components (X, Y, Z) of B and V
  - Saturn: Zieger and Hansen 2008 JGR
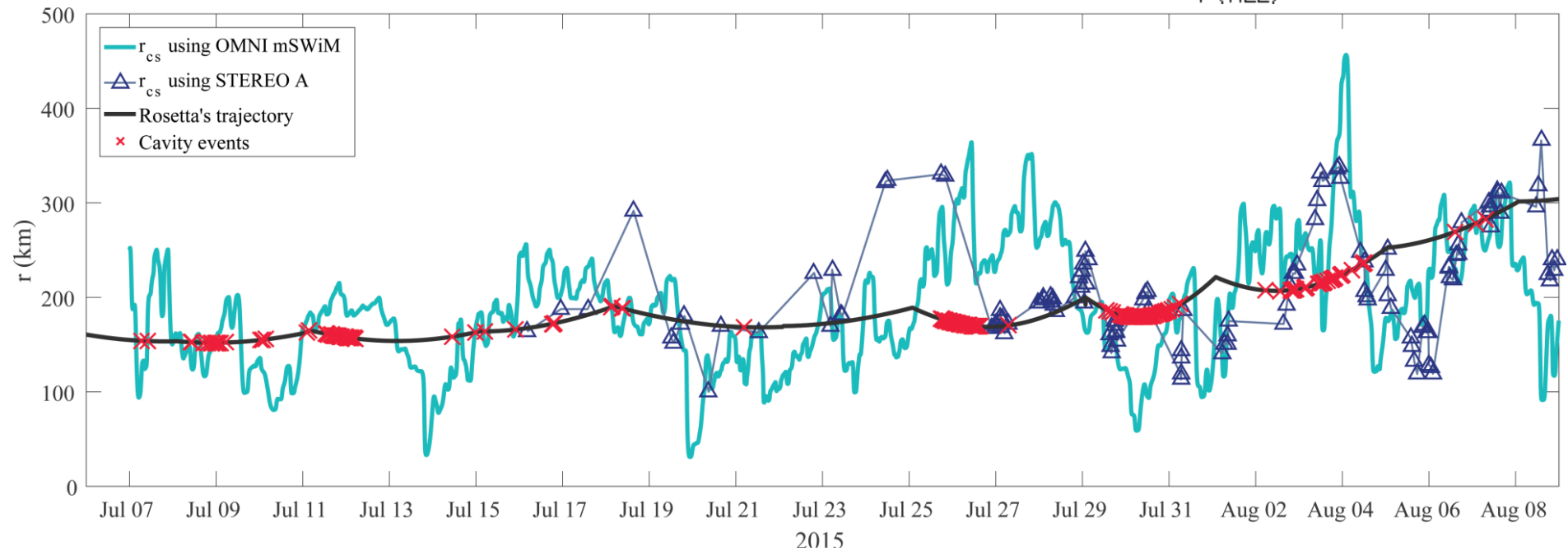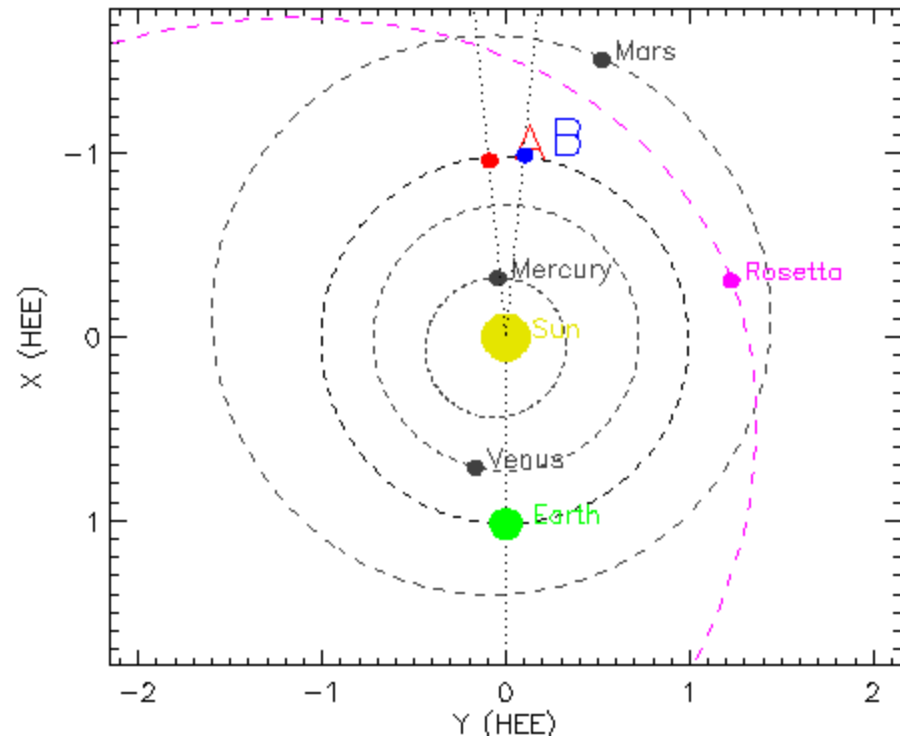 - Mercury: Zieger et al. 2009 GRL
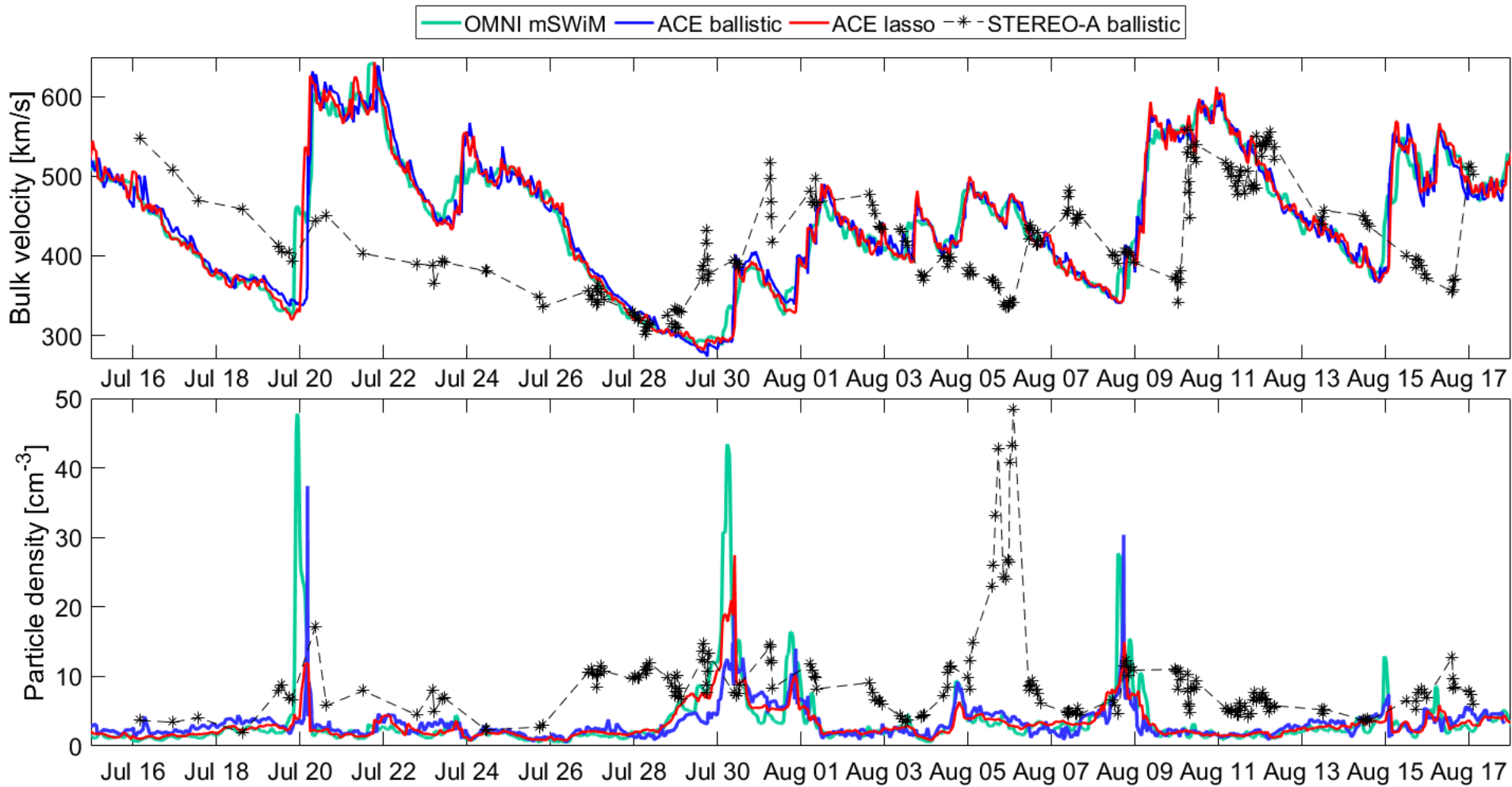
SW dyn. pressure proxy at comets

OMNI mSWiM pressure
OMNI lasso (Dosa)
ACE ballistic (Opitz)
Rosetta pressure proxy

from Timár Talk

SW prediction to Comet 67P

from Timár Talk

SW prediction to Comet 67P

2015

SW prediction to Comet 67P

Dayside excursion: 2015 September 22 - October 11.

Prediction one week in advance was possible due to favorable constellation.

But ICME datagap!

→ STEREO-A / Mars