Multi-Spacecraft Observations of a New Double-Shock Type of High-Latitude ICME Driven by Interactions with two Solar Winds

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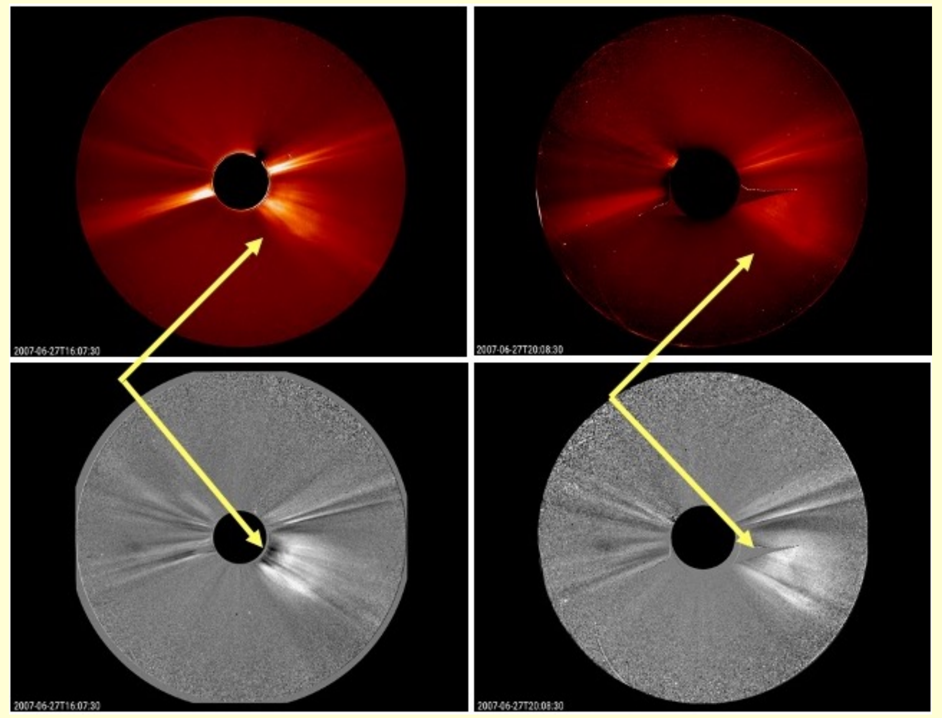
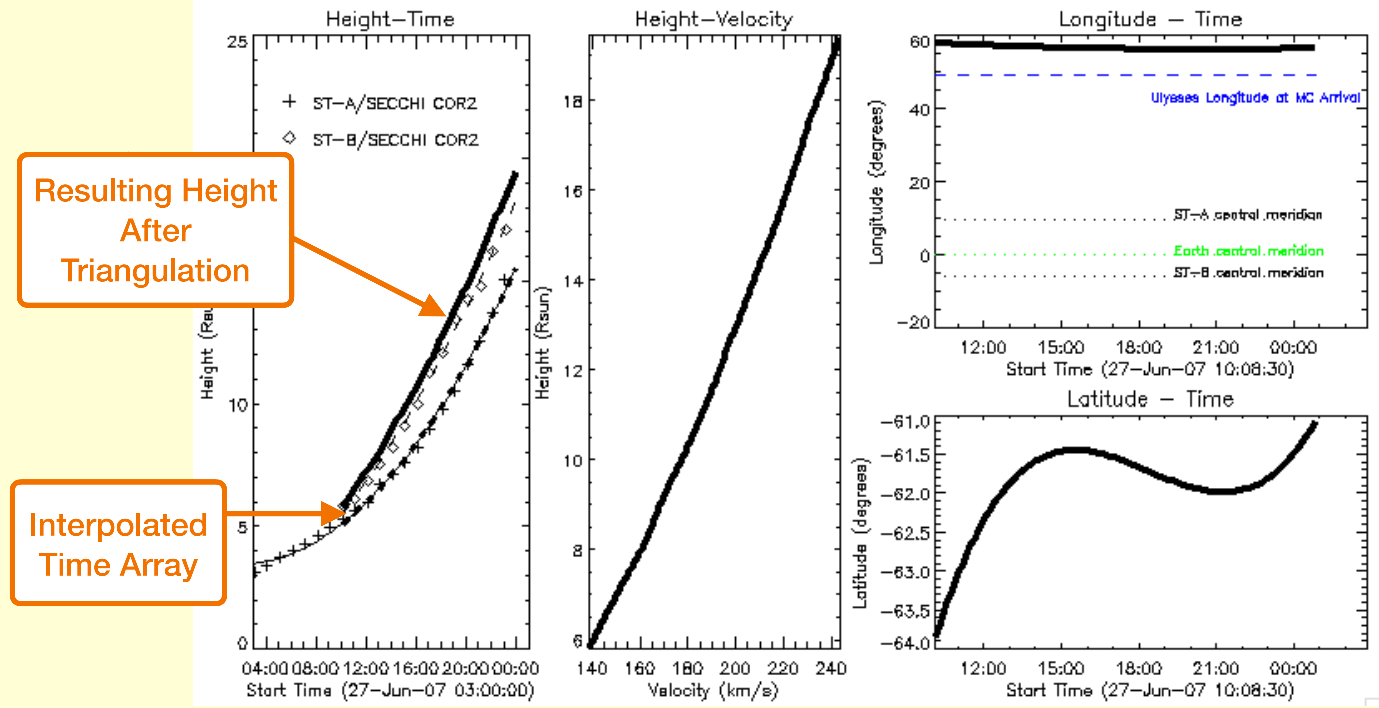
Introduction

Solar Orbiter presents a unique opportunity to view and measure Coronal Mass Ejections (CMEs) and their interplanetary counterparts (ICMEs) from above the Sun's poles, the only regions in which **'over-expanding'** ICMEs [1] have been observed. We examine a **high-latitude** CME and its subsequent ICME using data from **STEREO**, ***Ulysses***, and **OMNI**.

Remote Sensing

The CME's motion is tracked in difference images through the fields of **STEREO SECCHI's COR2 (outer) coronagraphs** with a separation angle of ~15°.

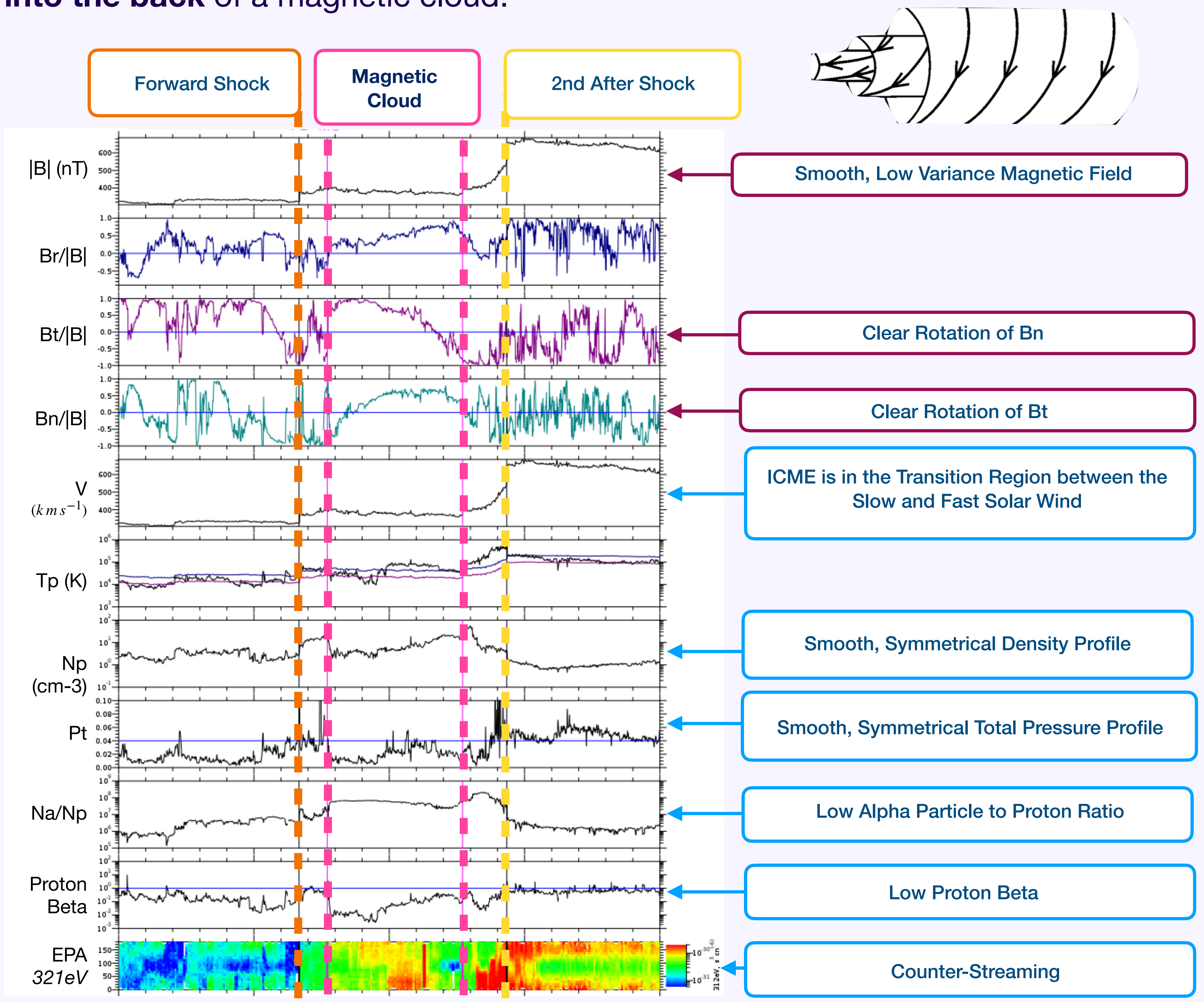




A **triangulation method** [2] and second-order polynomial fits to each of the two sets of observations, overlapping in time are applied to determine the 3-D propagation direction of the ejecta.

In-Situ at *Ulysses*

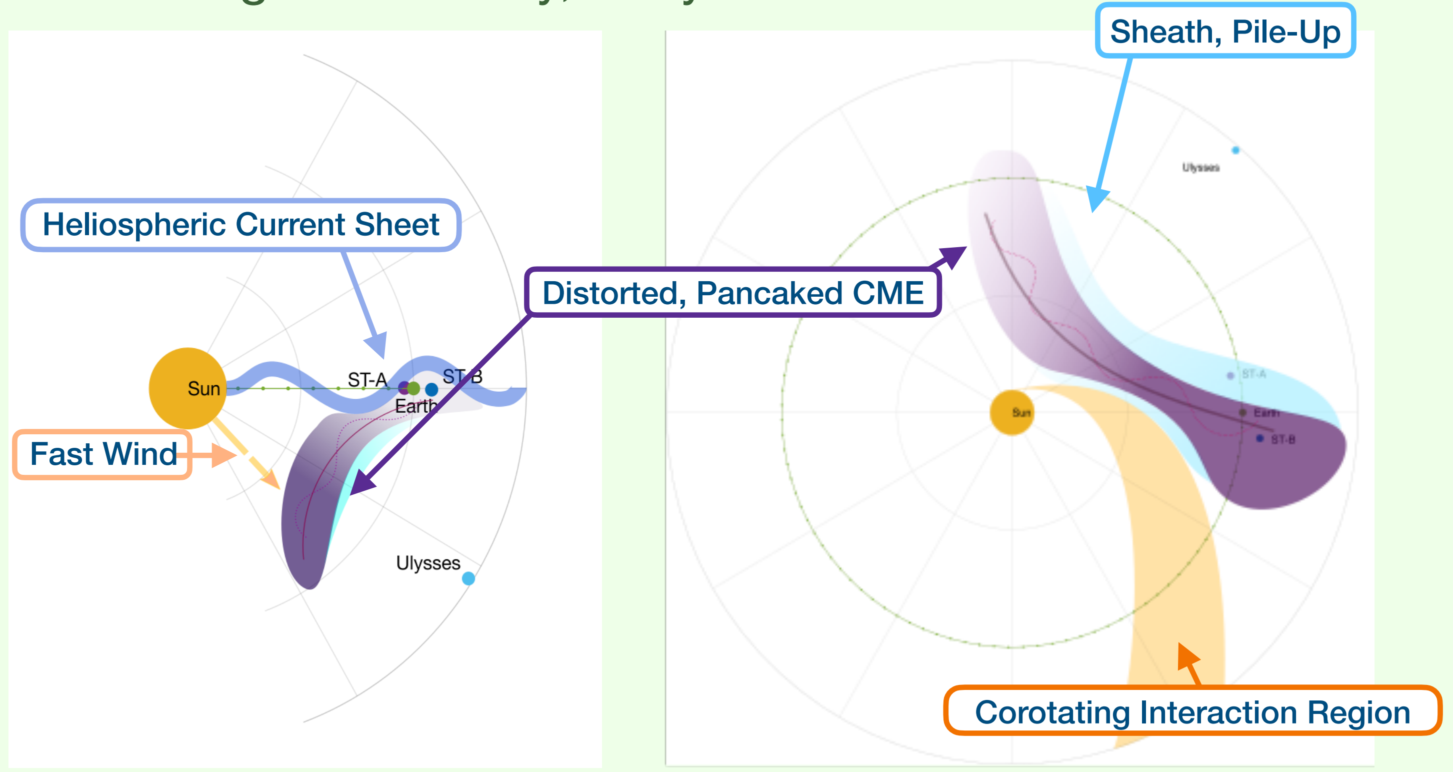
Ulysses has the clearest structure and is closest to the direction of propagation of the ICME indicated by the triangulation. We observe a **forward shock** preceding the magnetic cloud as a result of it propagating faster than the slow solar wind ahead and **two after shocks** due to the succeeding fast solar wind **propagating into the back** of a magnetic cloud.



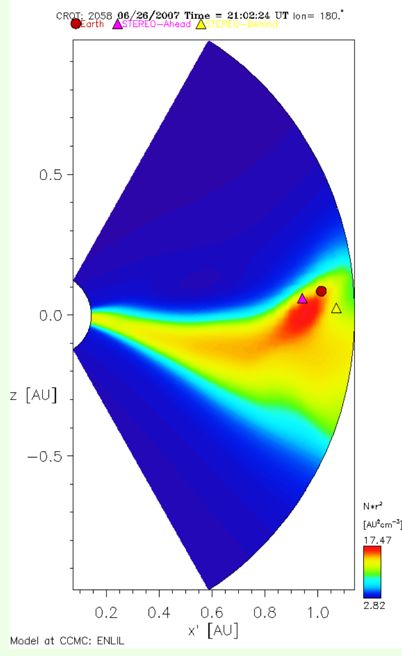
We performed a **length scale analysis** which showed the **sheath regions are thinner at *Ulysses***, towards the nose of the ICME; than at the flank of the ICME, closer to OMNI and STEREO-B. It expanded between STEREO-B and *Ulysses*, but **does not exhibit** the expected **monotonically decreasing speed** we tend to observe in 'over-expanding' ICMEs.

Topology and Geometry

The magnetic cloud may be interpreted as a **flux-rope.** At *Ulysses* the cloud has an **East-North-West** orientation [3,4], suggesting that the flux-rope is locally **highly-inclined** in comparison to the ecliptic with negative helicity, likely due to its **latitude**.



The ICME has also been **distorted** by its interaction with the surrounding complex solar wind environment, the particularly near Earth and the **multi-spacecraft observations presented were key** to disentangling this event from the surrounding features in the solar wind. The ENLIL [5] time-dependent 3D MHD model of the heliosphere at this point shows the deflection of the ICME near the ecliptic.



Conclusions

This event is a **unique high-latitude ICME** that straddles a region between slow and fast solar winds. Implying the existence of a **new type of double-shock ICME** driven dynamic plasma interaction observed in the solar high-latitudes. This study shows the importance of ICME **case studies** in addition to statistical studies as we see the **local solar wind environment** has a large impact on ICMEs.

References:
[1] Gosling et al. 1998
[2] Mierla et al 2008
[3] Foullon et al, 2007
[4] Bothmer and Schwenn, 1998
[5] Odstrcil D. 2003