To editor:

We made a major revision with three new figures (Fig 3, Fig 6, and Fig A2) and revised all the other figures. We appreciate very much to botThe main point was also slightly changed as:

We compared the speeds between the interplanetary (IP) shock propagation and the solar wind, which is expected to be different but actual statistics lacks.

(1) As expected from simple shock models, a majority of IP shock arrives at the Earth about 0-10 min earlier than the predicted arrival time that is derived from the solar wind velocity. actual arrival time of the IP shock to the Earth (represented by the geomagnetic SC) is earlier than the predicted arrival time of the shocked solar wind by 0-10 min.

(2) The speed difference between the shock propagation and solar wind is about 10%, which is in the same order of magnitude as that expected from the 1D shock model with typical solar wind parameters across the shock.

(3) The distribution of the velocity ratio between the shock propagation and the solar wind is slightly asymmetric toward higher ratio (faster propagation) with respect to the center of the distribution.

For the Reply to reviewer #1, it is unchanged from the interactive discussion, in which we took all comment to improve the text (except the last one on name of Table A1-A4). The reply to reviewer #2 is updated from the interactive discussion.

Reply to reviewer #2

Thank you for many interactive comments that really improved the paper. Here is the list of how we improved the paper by taking your original comments.

Major Comment: The theoretical discussion of the shock has some issues, although they can be fixed. No distinction is made between normal speed and speed. Usually the shock speed is defined to be normal to the shock front, which is clearly what is assumed in the Appendix. But the L1 speed is usually taken in the GSE X direction or simply it is the total speed. Neither of these speeds correspond to the normal speed in general. As long as the velocity vectors ahead and behind the shock front are roughly parallel, there is a simple proportionality between the normal and X directional/total speeds. I recommend that the authors create a new figure that depicts the geometry. The same figure can be used to explain the impact of the spacecraft not being on the Sun-Earth line.

A: Thank you for pointing out insufficient explanation. We add a new figure (new panels in Fig A1) to show the oblique shock configuration together with both spacecraft location. We also describe why we use two spacecraft timing instead of the local velocity local ratio.

Major Comment: For the example event shown in Figure 1, the authors argue that the 1D shock model is failing as it predicts much slower speed than found empirically. The shock model relies on mass conservation that is certainly true. A likely explanation for the discrepancy is that the shock normal is not aligned with the X direction and/or the shock is not planar. The authors try the Parker spiral direction for the shock front (which would be reasonable for a CIR but not for a CME) and find that it does not work. But there are many other possibilities. In fact the Z component of the velocity jumps from ~0 to ~50 km/s according to both ACE and WIND measurements. This is comparable the jump of the velocity in the X direction (50-70 km/s), which suggests that the shock normal was tilted close to 45 degrees in the X-Z plane (and much less in the X-Y plane). This large tilt reduces (although does not fully eliminate) the discrepancy in the arrival times. ACE was at around Z=1.29e5 km, while SOHO was at Z=6.7e4km, so projecting to the Sun-Earth line reduces the distances to around 1.19e6 km for SOHO and 1.31e6 km for ACE. This gives 646km/s (SOHO) and 624km/s (ACE) observed shock speeds. These are consistent with each other, suggesting that the 45 degree tilt in the X-Z plane is plausible. According to the authors the 1D shock model gives around 540 km/s (SOHO) and 600km/s (ACE) speeds, which are still smaller for SOHO, but consistent for ACE. Given that the compression ratios at ACE and SOHO are drastically different (4 vs 2), there is certainly some non-uniformity in the transverse direction, so the planar shock assumption is probably not valid.

A: Thank you very much for pointing out possibility for Z tilt. For Fig 1 case, the angle estimate in the X-Z direction is 33 ± 40 degrees (velocity 730 ± 100 km/s) instead of -45 degree (velocity 660 km for SOHO and 630 km for ACE). The large error bar comes from relative Z location of the spacecraft (we need extrapolate in the z direction instead of interpolate in the y direction). We add these explanations.

We also added explanations why we assumed the tilt direction in the Y direction rather than in the Z direction in statistics. In appendix A, we also checked if the result is affected by possible tilt in the Z direction in Figure A2.

Major Comment: At line 160-165 the authors decided to remove the "backward" propagating shocks. This will only remove shocks that happen to be tilted beyond the tilt of the line connecting the two spacecraft, but does not limit tilts in the other way. A more neutral way would look at the discrepancy of the propagation speeds obtained by the two spacecraft and limit it to stay within some range (say +-10%).

A: As the reviewer suggested, we also use the estimated tilt angle for filtering, as shown in new Figure 3 (this is posted in the last answer to reviewer 1).

Major Comment: The authors consistently talk about tilt in the X-Y plane as the only possibility, but in reality the tilt can be in any direction. A major missing information is comparing the observed speed with the 1D shock model. The authors keep refering to the one and only example (which is not even analyzed correctly) why the 1D shock model is not reliable. But what about actually doing the analysis on all the events? There should be plots of the difference between the predicted travel time from the 1D shock model and the observed travel time.

A: Detailed analyses of "unexpected" cases will be made in the next paper. On the other hand, we showed the simple 1D shock generally makes good job by comparing the model with the observation (V_propagation/V_SW) in Figure A2c. Since Figure A2 may include large error due to instrument saturation after the shock (this problem is described in section 2), we took only the general agreement (order of magnitude in %) in the main text, whereas we kept this figure in the Appendix to prevent possible exaggeration of this figure by wide readers.

Major Comment: Is the distribution symmetric or is there still some bias? What is the spread compared to the spread using the upstream velocity? Smaller? Larger? The same? Is there some trend as a function of shock speed or as a function of the assumed tilt angle?

A: In new Figure 6, the asymmetry with respect to the center of the distribution is reduced significantly, but we still see some asymmetry, particularly for the extreme values. This is the topic for the next paper.

Minor issues:

Line 96: 700+-30 km ... 690+-20 km -> 700+-30 km/s shock speed ... 690+-20 km/s.

Line 100-105: It should be clarified that the 570+-20 km/s (not km) and 960+-30 km/s speeds are _not_ the normal shock speed, but the speed along the X direction.

Line 169: as short as 1s... Maybe 1 minute?

Line 4 and 24: assumed to be the same as the measured solar wind (proton) speed Add: "after the shock". All reasonable approximations discard the plasma elements overtaken by later ones, which in effect means that the higher speed behind the shock is used to propagate the shock.

Line 38: from the different reasons -> from other reasons.

Line 43: the symmetric orbit -> symmetric orbits

Line 48: ACE is at most 3e5 km away from the Sun-Earth line, while SOHO is up to 6e5 km. But always much less than 1e6 km.

Line 66: The size of Earth is not 0.06e5 km. The radius of Earth is around 6800km, so a reasonable rounding is 7000km. The size of Earth is not well defined. Radius or diameter are.

Line 101: Projecting these directions -> Projecting these directions along the shock front

Line 158: velocity profile -> velocity profiles

Line 306: All shocks are "compressional". There are radially outward propagating shocks where n_b is smaller than n_a, and reverse shocks where n_b is larger than n_a.

Line 307: It should be mentioned that epsilon is the inverse of the shock compression ratio for outward propagating shocks.

Line 336: diseased -> deceased

Figure A1: Spacecrft -> Spacecraft

Table A1-A4: There are no "rarefied shocks". They are reverse shocks.

all fixed

Line 163: tilted in the Y direction -> tilted There is absolutely no reason to assume that shocks can only be tilted in the Y direction.

Lines 250-260: It is incorrect to assume that the shock is always tilting in the X-Y plane. The whole discussion needs to be changed to be general.

A: Entire paragraphs were rewritten. Point is that "in statistics", we expect the source of CME is extended more east-west than north-south (on the solar surface).

Figure 1: The ACE speed jumps to 480 km/s as the density increases by about a factor of 2. It is unclear why the later increase of the velocity to 520km/s is taken as the upstream speed, while the density hardly changes. Is this based on the assumption that ACE does not actually measure the speed accurately?

A: In addition to the uncertainty of the measurement, we took the value that can give the highest propagation speed in the model (which is still slower than the observation), because it is to show the difference between the model and observation.

Tables A1-A4: Since these belong to Appendix B, maybe they should be B1-B4.

A: Journal's LaTex package automatically assign Table A1, A2,,,, (A means Appendix, but not A).