

STEREO Observations of Interplanetary Shocks

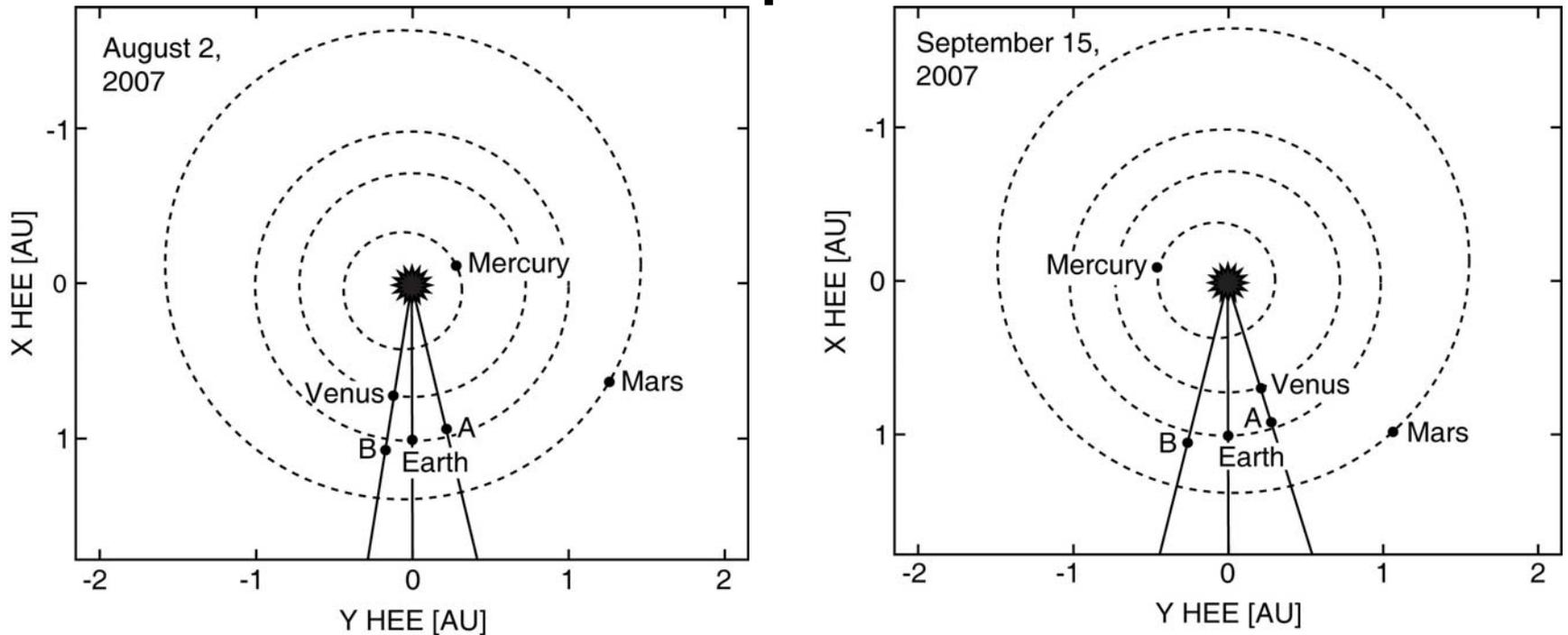
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18th STEREO Science Working Group

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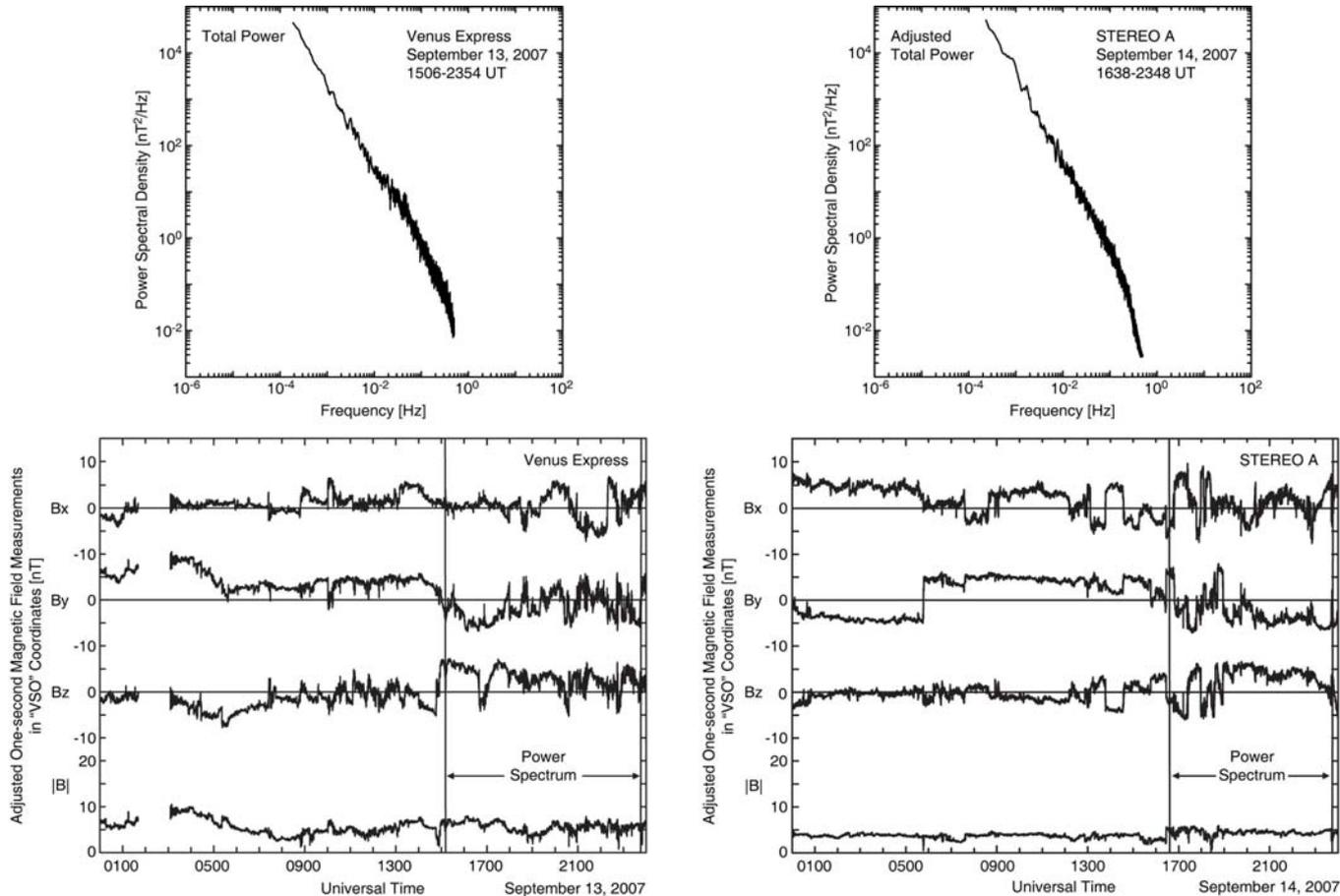
Meudon, France

STEREO Alignments with Venus Express



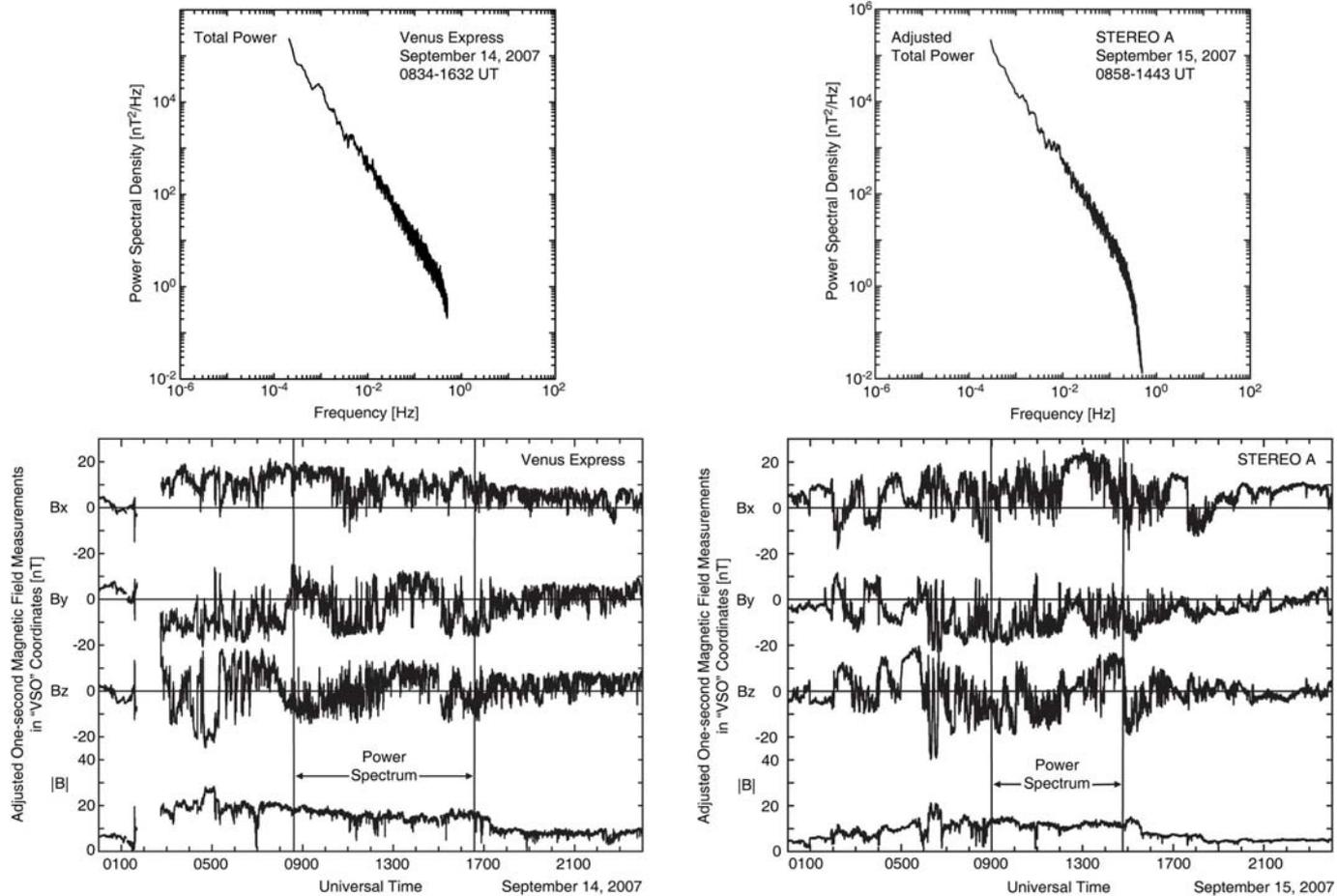
- Venus has a synodic period with the Earth of close to 19 months and now has passed STEREO B, Earth and STEREO A in the course of its travels.
- A search for shocks appearing first at Venus and then at STEREO was undertaken around the times of these conjunctions.
- Many shocks were seen at STEREO; none were seen at Venus using similar resolution magnetic field data.

Wave Power Alignment Study: 1



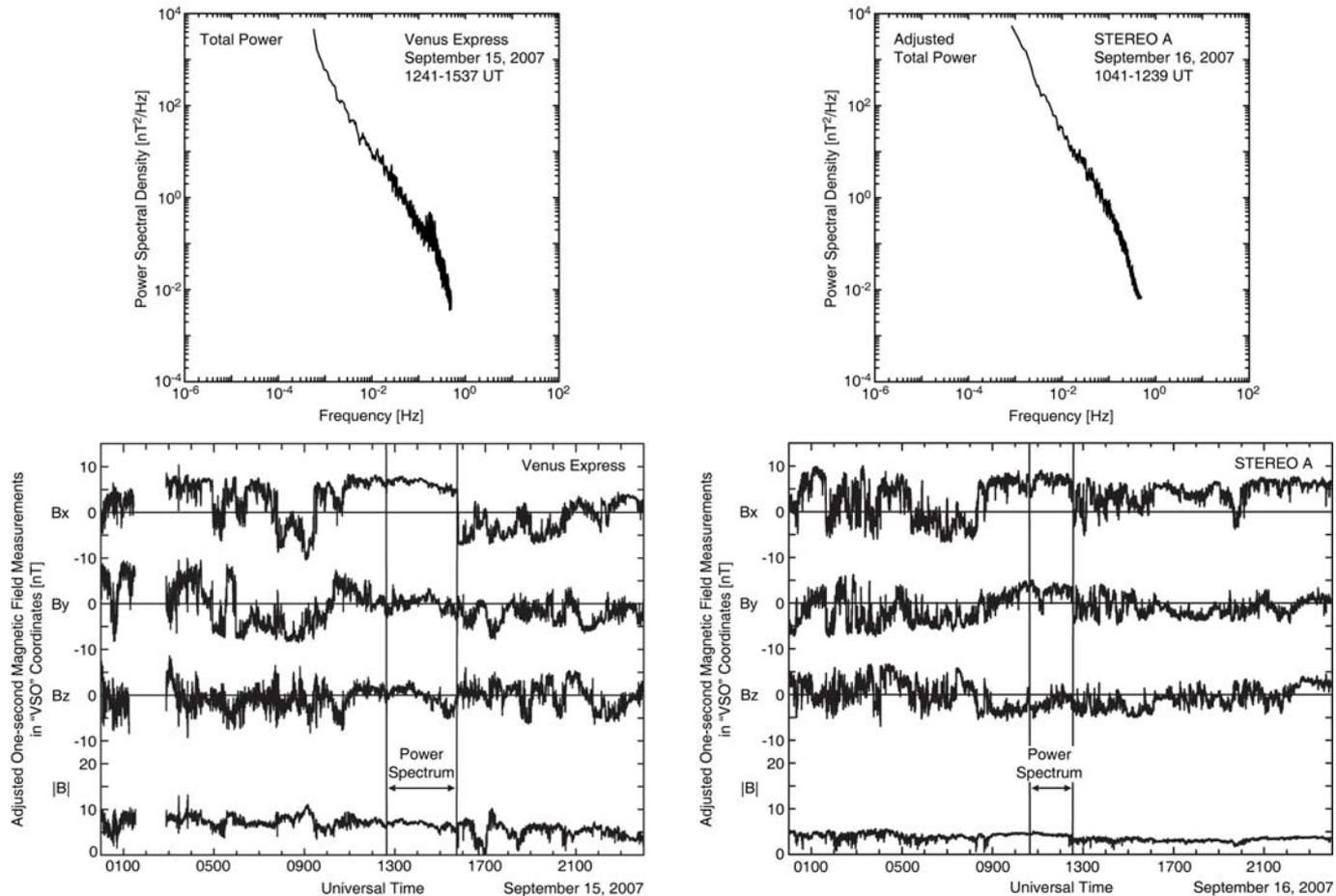
- At the median solar wind velocity of 440 km/s it takes 1.1 days to travel from 0.72 AU (Venus) to 1 Au (STEREO).
- Looked for two regions with similar appearance separated by about 1 day.
- Adjusted radial field by 2 and tangential field by 1.4 at STEREO.
- Total field was not adjusted nor compared.
- Compared wave power.

Wave Power Alignment Study: 2



- Did not keep regions the same dimensions as Earth and Venus were at slightly different latitudes.
- Visually the nature of the fluctuations seemed to be the same at the two locations.
- Wave power at the two locations were very similar as adjusted.

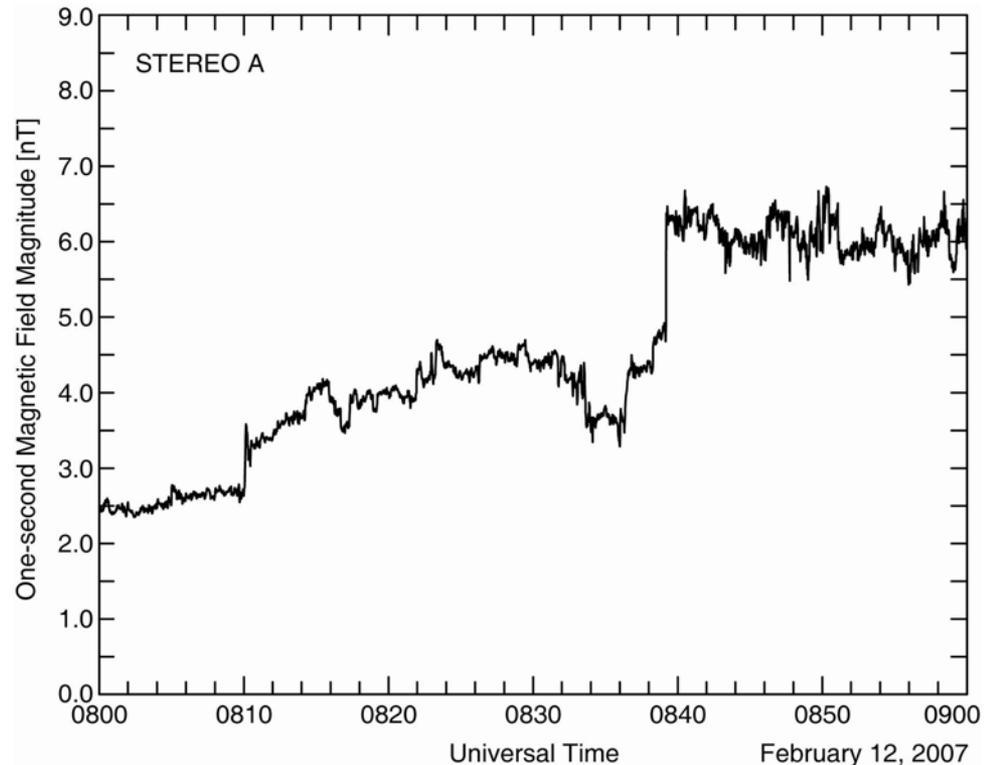
Wave Power Alignment Study: 3



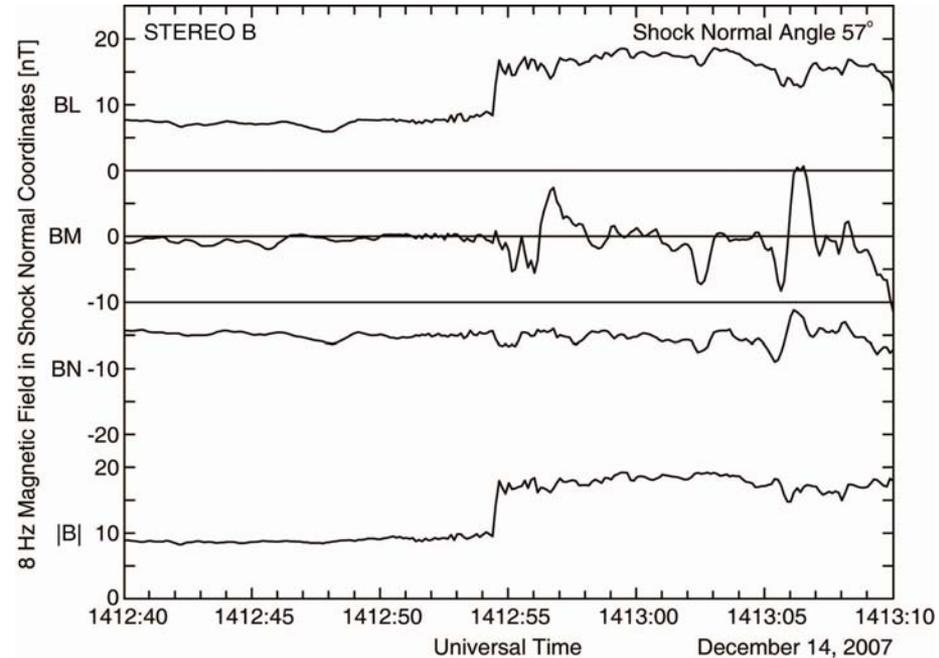
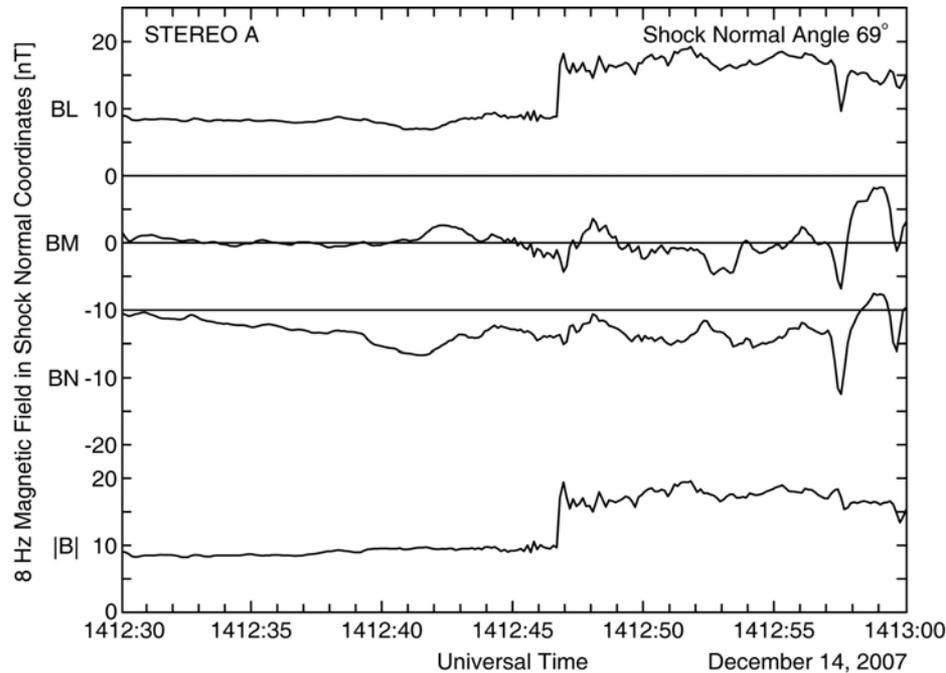
- Power varied over an order of magnitude from day to day but adjusted power was the same well within a factor of 2 over the entire band.
- Very little amplification or diminution of wave power from Venus to Earth.

Shock Formation

- The alignment study demonstrated that almost all shocks seen at STEREO originated between 0.7 AU and 1 AU.
- As to be expected, the majority of shocks observed were very weak.
- There were about 50 interplanetary shocks observed in the study (up to January 31, 2008).
- The shock strengthening paradigm is that overtaking weak shocks form a stronger shock. Here is one of several examples of this.

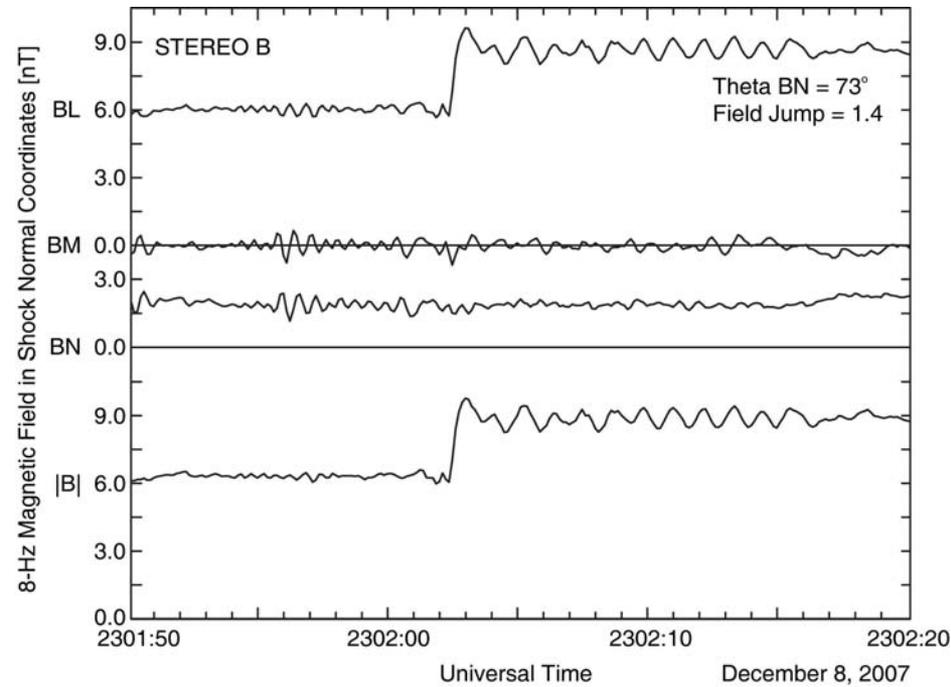
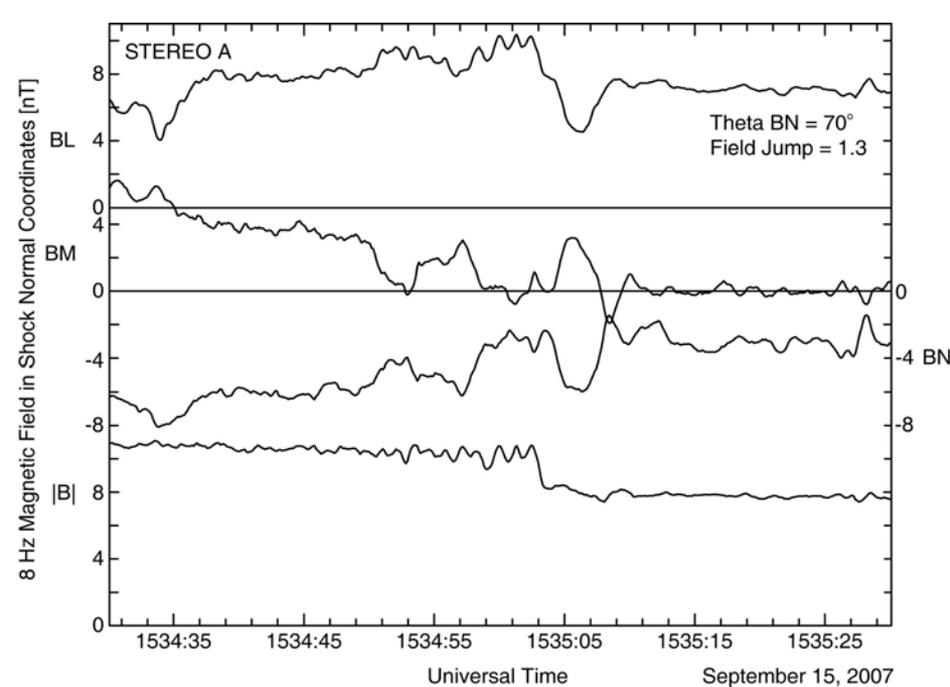


A Strong Interplanetary Shock



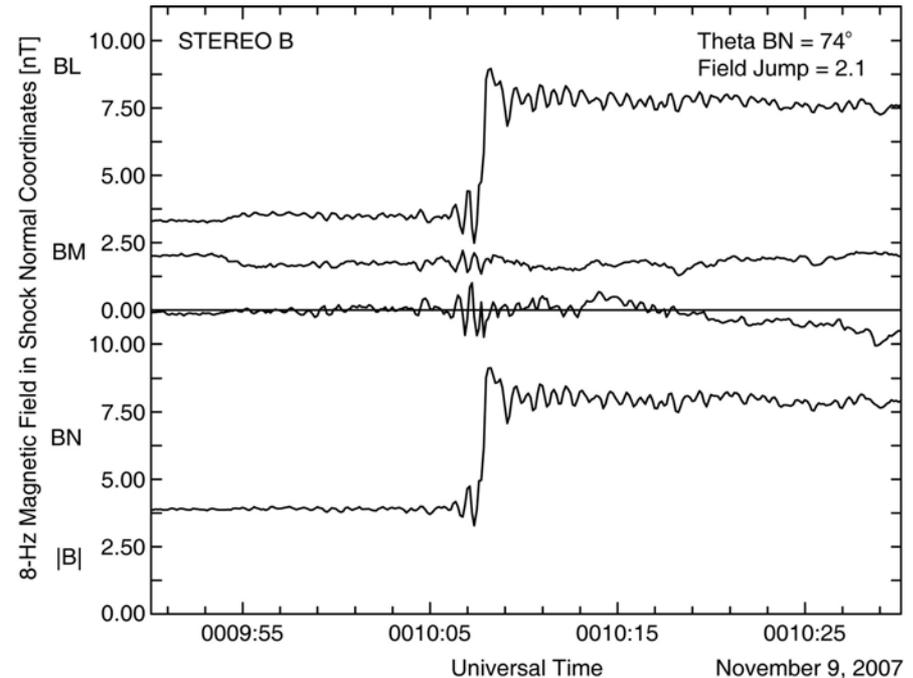
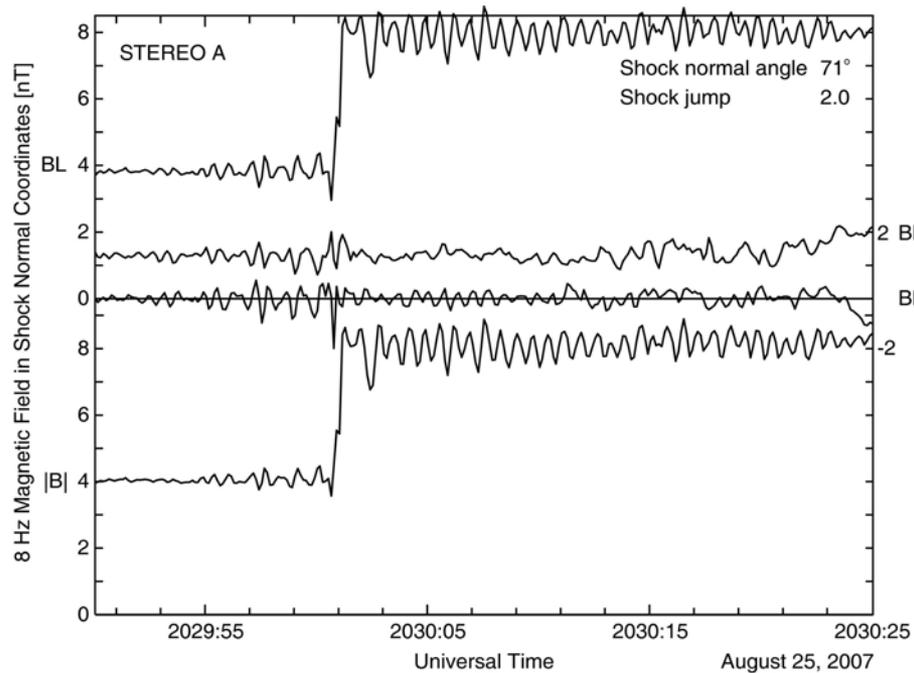
- One strong interplanetary shock was seen on December 14, 2006, when a strong old cycle ICME passed STEREO A and B.
- The normal instrument cadence of 8 Hz is insufficient to capture the structure of such fast, strong shocks.

Interplanetary Shocks in 2007 Weak on Average



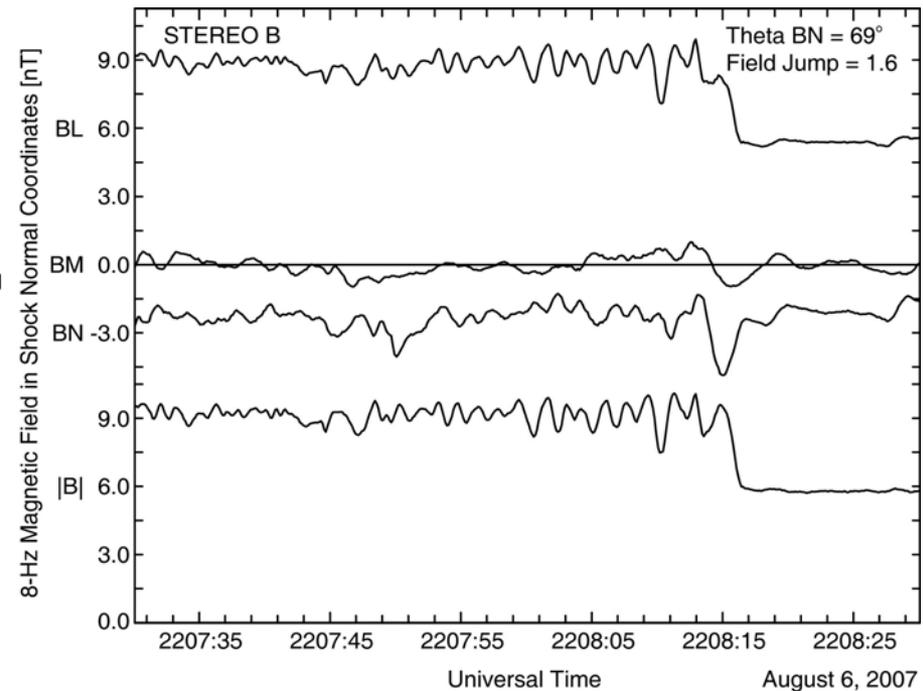
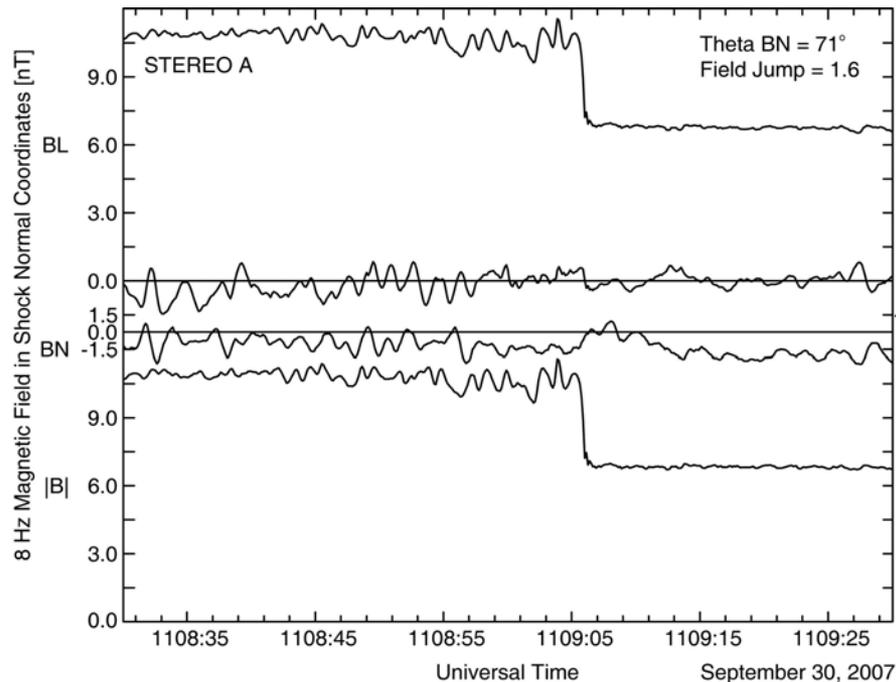
- There were few ICME-driven shocks in 2007 and even these were weak.
- The stream interaction shocks were also very weak.

Shocks with Same Parameters Resembled Each Other



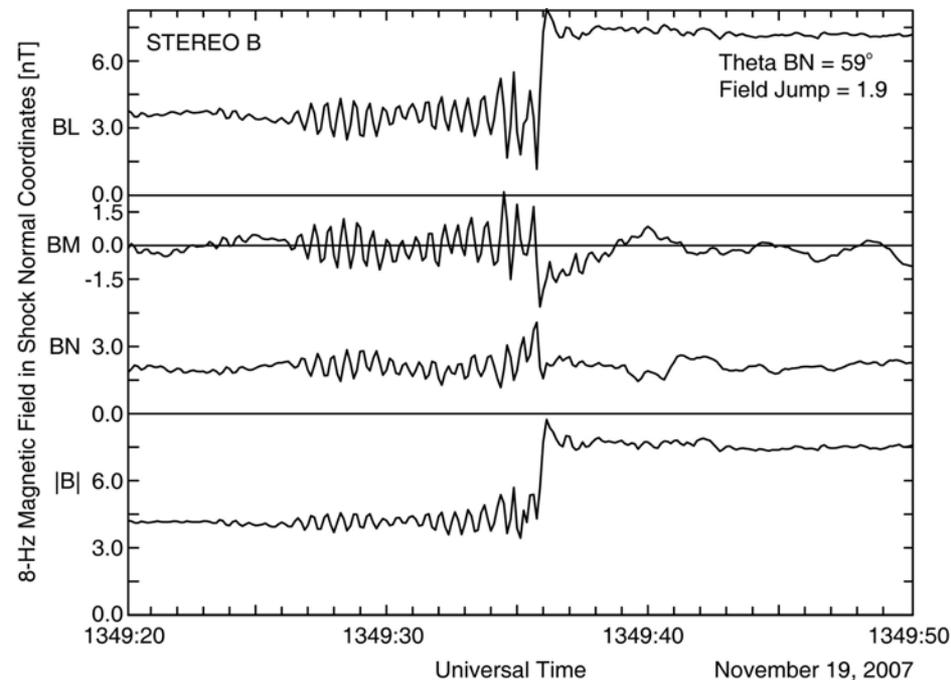
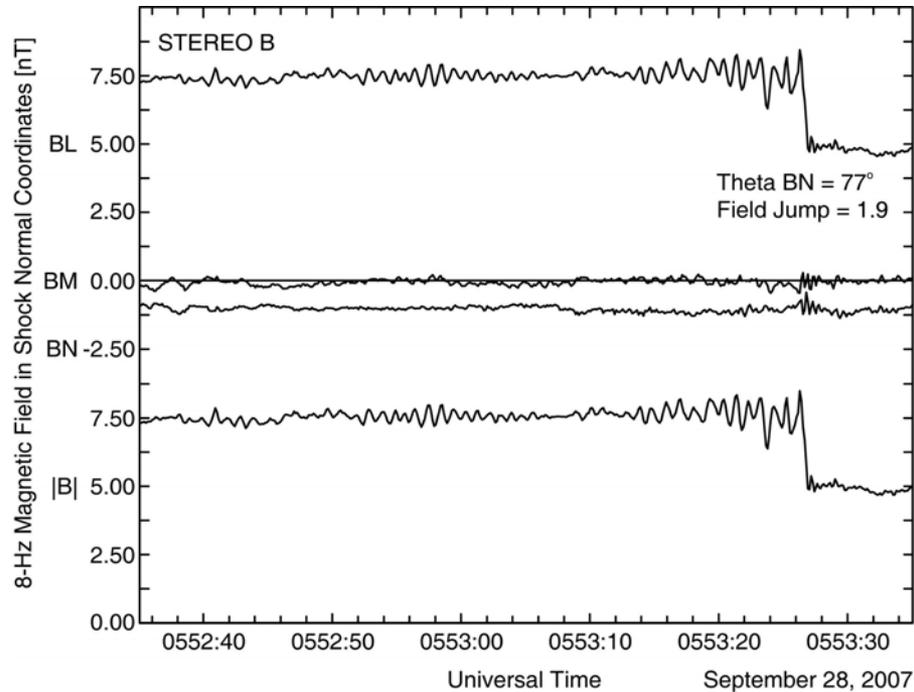
- Shocks with similar strength and θ_{b_n} usually resembled each other.
- θ_{b_n} was usually around 70° in these shocks. Quasi-parallel and nearly perpendicular shocks are rare.

Weaker Shocks are Generally More Unsteady



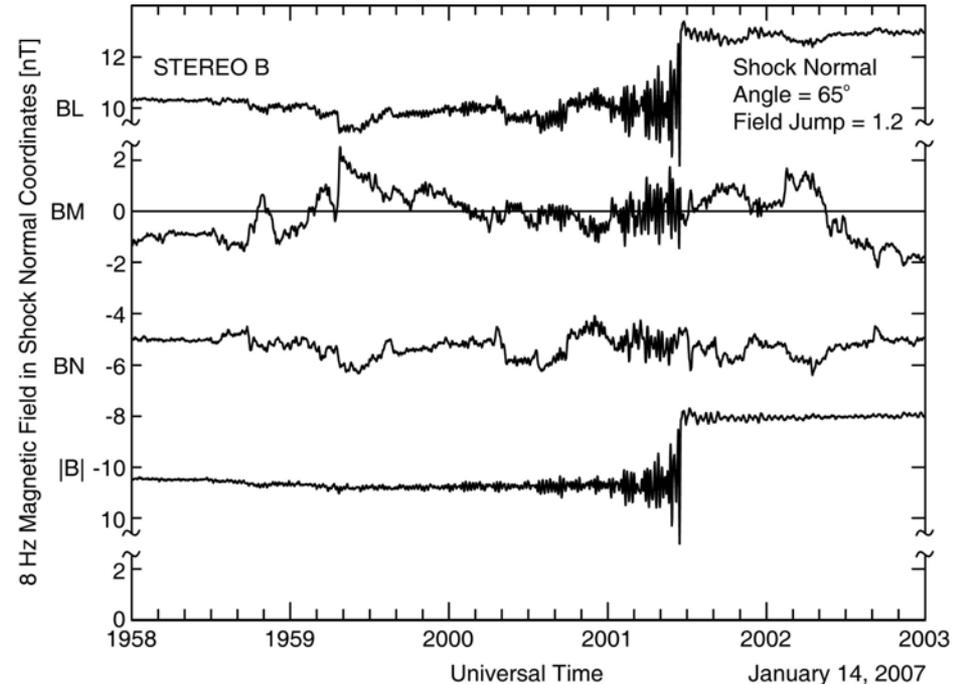
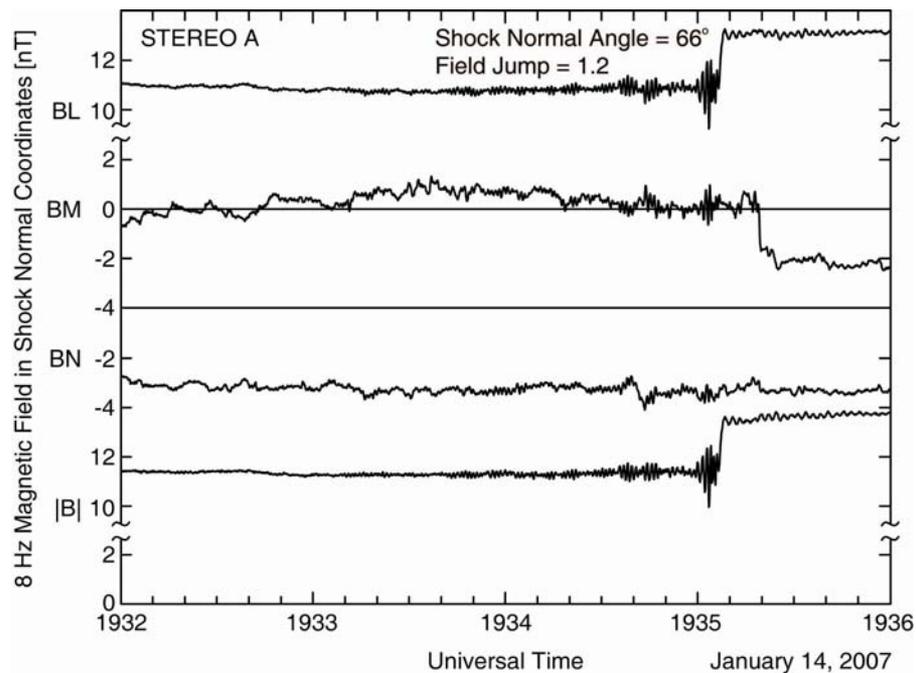
- These two shocks with a field jump of 1.6 are very similar.
- They also are not as steady as stronger shocks.

Dependence on Theta BN



- These shocks differ only in the angle of the field to the shock normal.
- The quasi-perpendicular shock as a strong downstream wave train; the more quasi-parallel shock has an upstream wave train.

Very Weak Quasi-perpendicular shocks



- When the quasi-perpendicular shock is very weak, the shock associated wave extends upstream and not downstream.

Summary

- Shocks seen at 1 AU generally arise between 0.7 and 1.0 AU.
- There does not appear to be much change in the current sheet structure over this range of distances.
- Shocks appear to strengthen by overtaking of successive shocks.
- Few strong interplanetary shocks have been seen but STEREO B has observed hundreds of strong bow shocks.
- Shocks with similar strength and shock normal angle do look the same in the STEREO data.
- Weaker shocks appear to be more unsteady.
- Upstream wave trains appear for weaker shocks and for more parallel shocks; otherwise the wave trains are downstream.
- The number of interplanetary shocks observed is unexpectedly high. Forty percent of stream interactions are associated with shocks.
- We are making lists and will put them on the web.