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# PARTICLE ACCELERATION IN SHOCK-SHOCK INTERACTION – MULTI-SPACECRAFT *IN SITU* OBSERVATIONS

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## ABSTRACT

We use detailed multi-spacecraft observations to study the interaction of an interplanetary (IP) shock with the bow shock of the Earth on August 9-10, 1998. We can distinguish four different phases of particle acceleration in the shock-shock interaction:

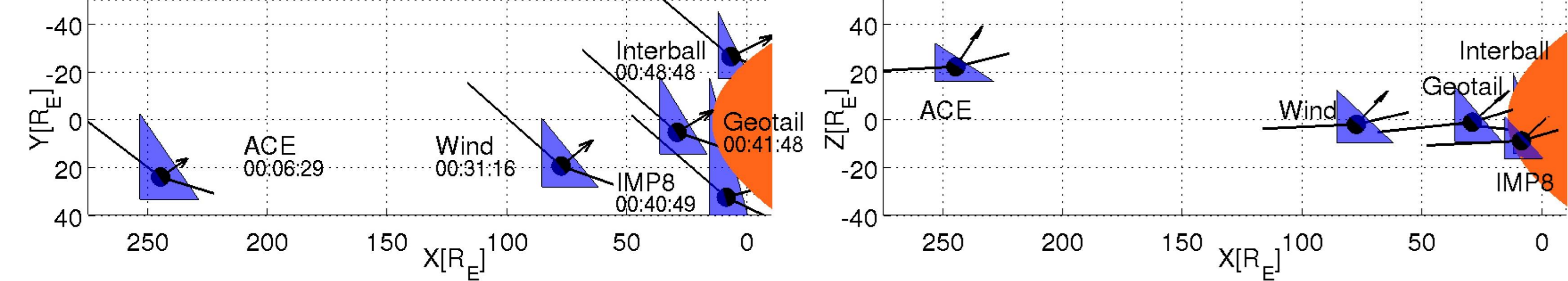
1. formation of magnetic contact with the IP shock and the seed population of energetic particles accelerated by it,
2. reacceleration of this population by the bow shock (BS),
3. first order Fermi acceleration as the shocks approach each other, and
4. particle acceleration and release as the shocks collide.

Such a detailed analysis was made possible by the particularly advantageous quasi-radial interplanetary magnetic field (IMF) configuration. To our knowledge, this is the first time the last phase of acceleration at a shock-shock collision has been reported using *in situ* space plasma observations.

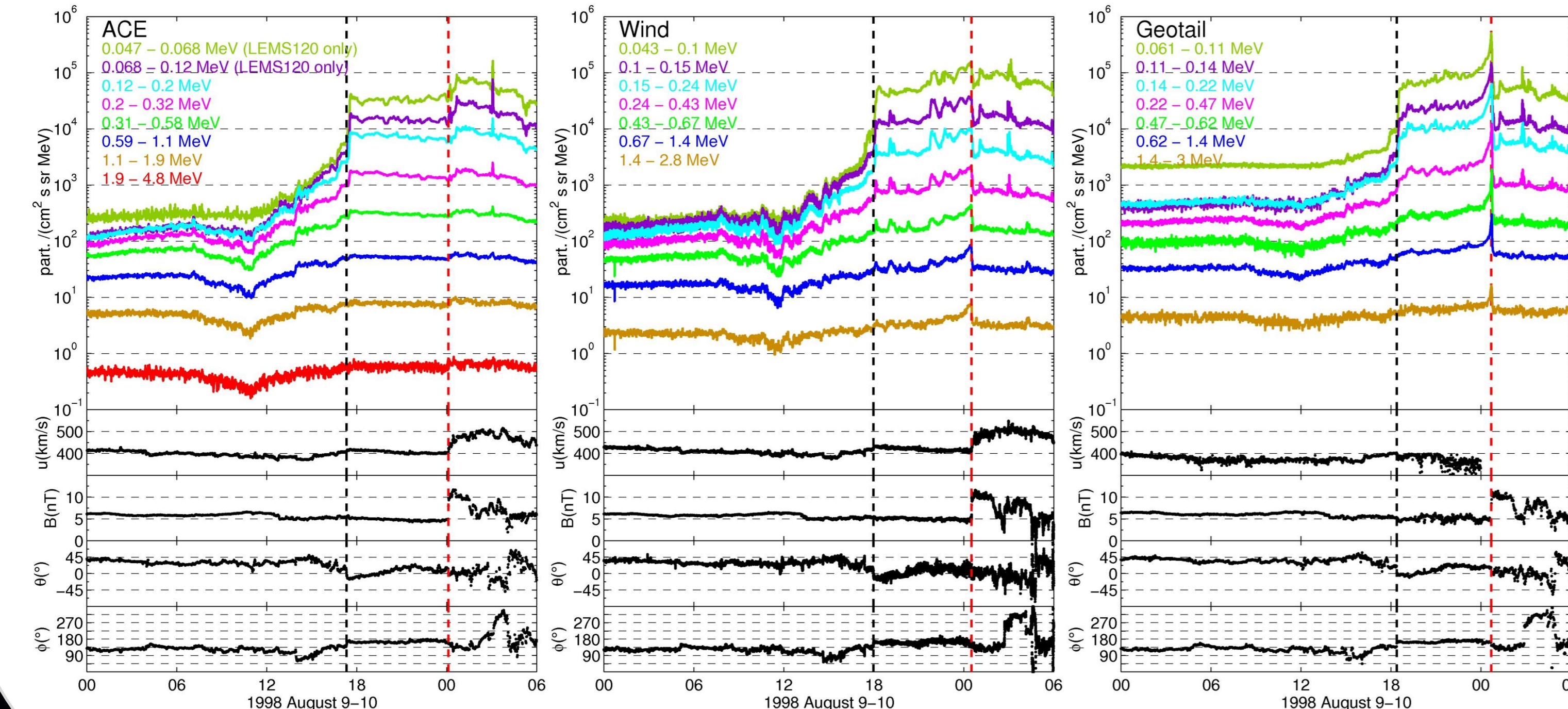
## I MOTIVATION

A well-established acceleration mechanism, but difficult to identify from observations.

## II EVENT OVERVIEW



Locations of the spacecraft on August 10, 1998. Blue triangles show the calculated shock fronts with shock normal vectors. Black lines show the direction of the magnetic field upstream and downstream of the shock ( $B_x < 0$ ). The orange ellipsoid represents the model bow shock.



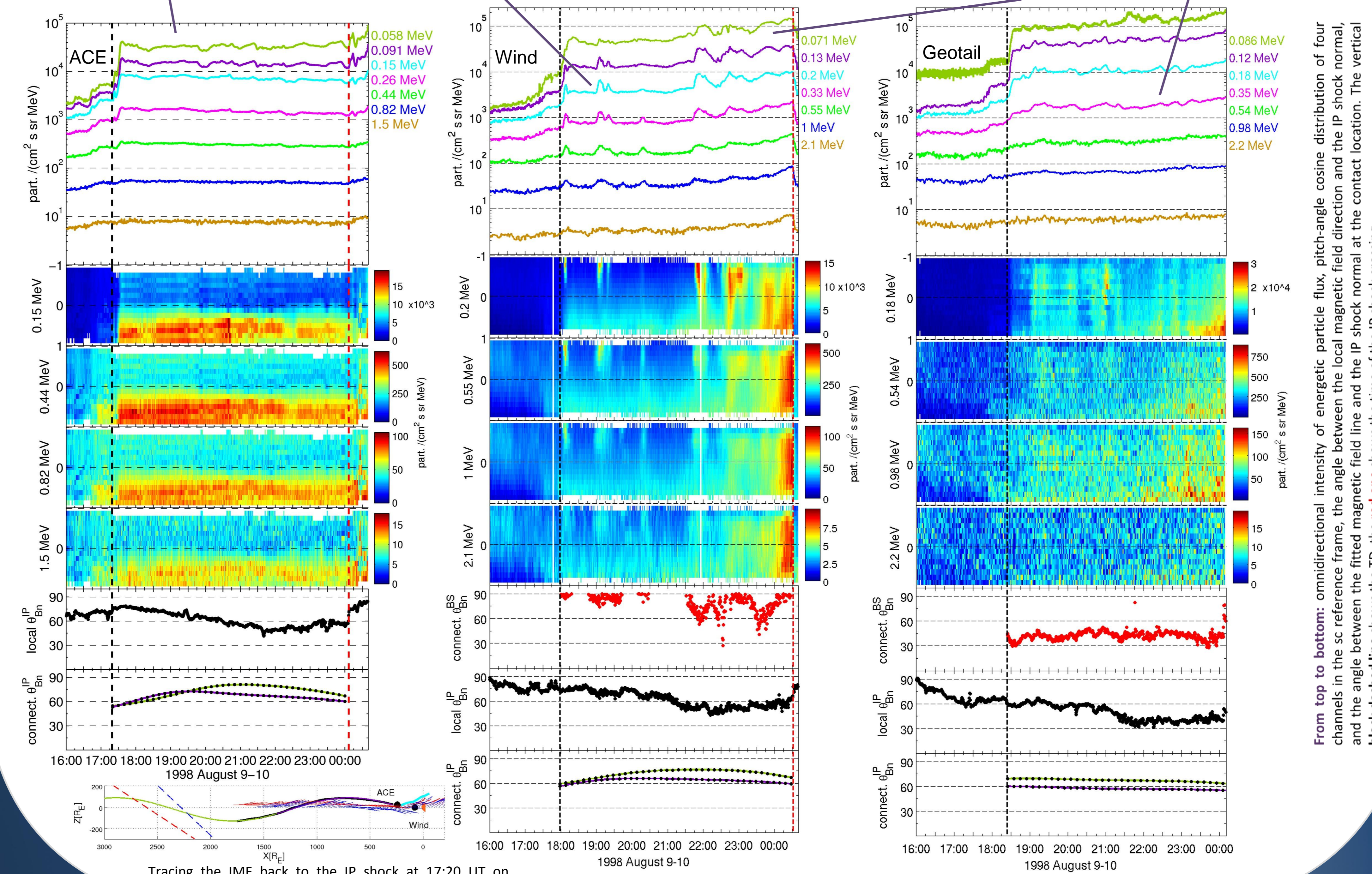
From top to bottom: the intensity of omnidirectional energetic particle flux in different energy channels, the solar wind speed, and the interplanetary magnetic field. The black dashed line shows the beginning of the radial IMF, and the red dashed line shows the IP shock passage.

## III RESULTS AND INTERPRETATION

phase 1 :  
seed population

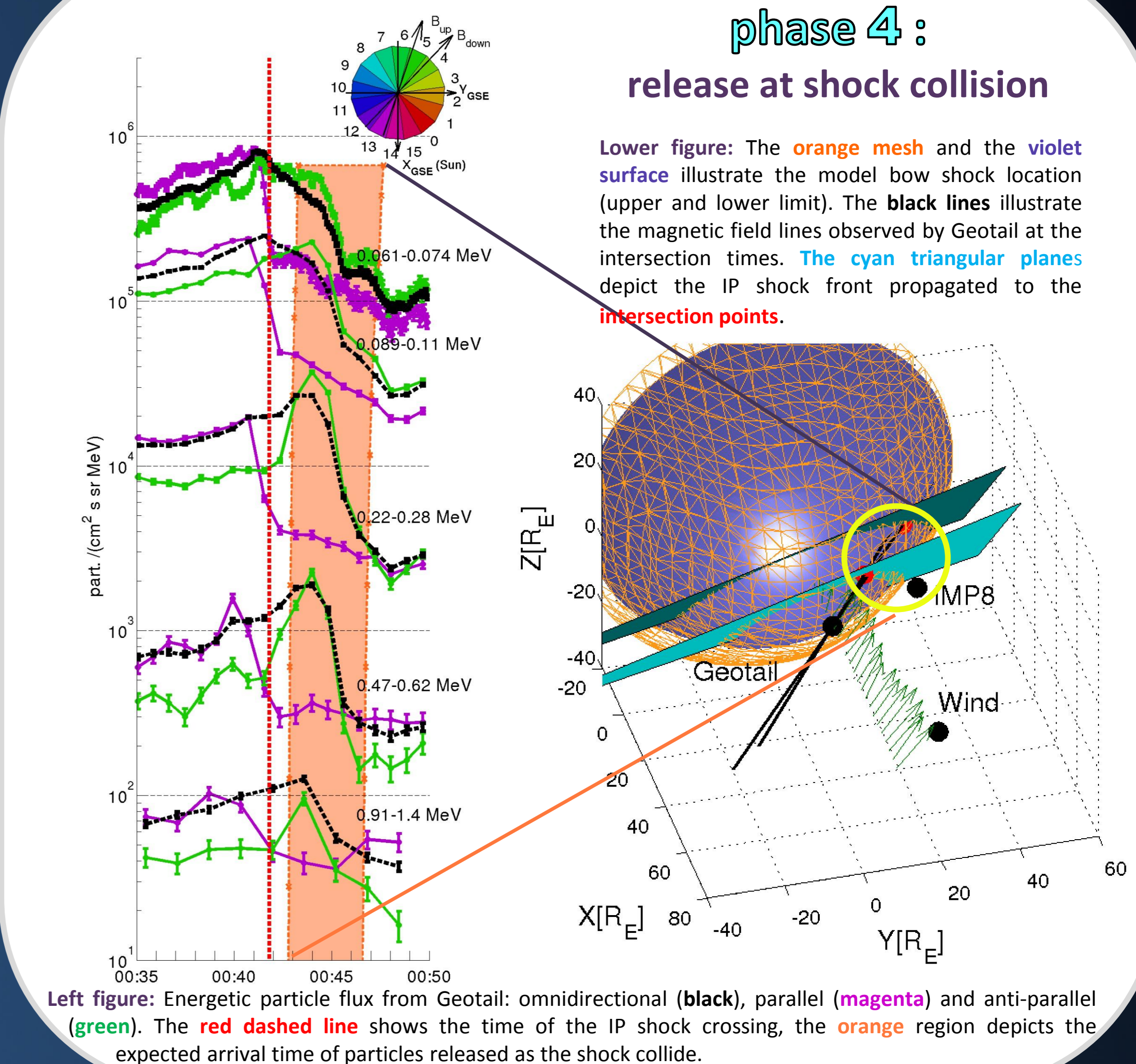
phase 2 :  
reacceleration by BS

phase 3 :  
acceleration of trapped particles



Tracing the IMF back to the IP shock at 17:20 UT on August 9 using 'frozen-in' magnetic field measurements.

Schematic picture of the event: The black lines depict the IMF. The red ellipsoid represents the bow shock (BS) of the Earth, and the pink region its foreshock. The red line represents the IP shock, and the magenta spiraling arrows propagating energetic particles. The red dashed line indicates the position of the IP shock when it hit the bow shock (phase 4).



Left figure: Energetic particle flux from Geotail: omnidirectional (black), parallel (magenta) and anti-parallel (green). The red dashed line shows the time of the IP shock crossing, the orange region depicts the expected arrival time of particles released as the shock collide.

## IV CONCLUSIONS

First *in situ* observations of the last phase!

## ACKNOWLEDGEMENTS

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## RELATED LITERATURE

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