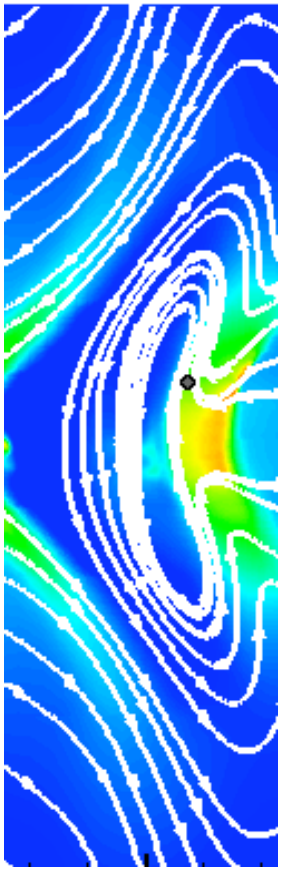

Signatures of fast CME Propagation near 1 AU

T. H. Zurbuchen, on behalf of

W. Manchester, J. Kota, I. Roussev, T. H. Zurbuchen, N. Lugaz, D. DeZeeuw, T. Gombosi, I. Sokolov, G. Toth

University of Michigan

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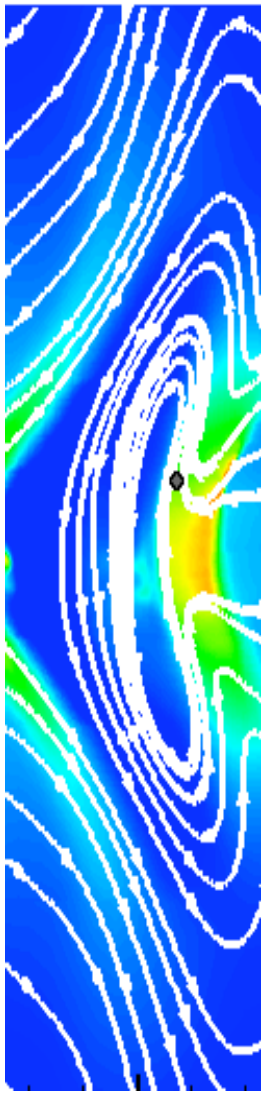
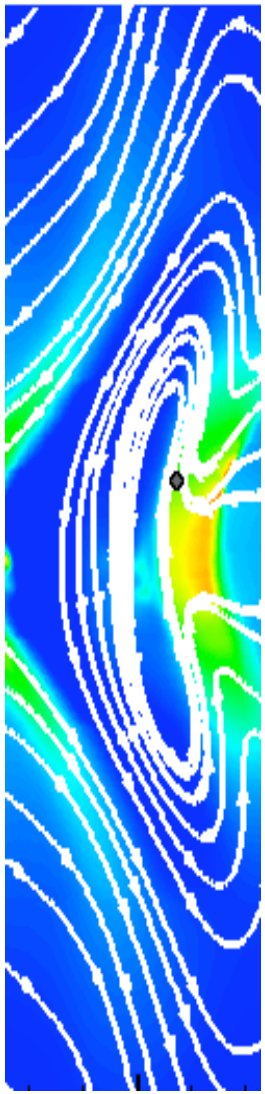


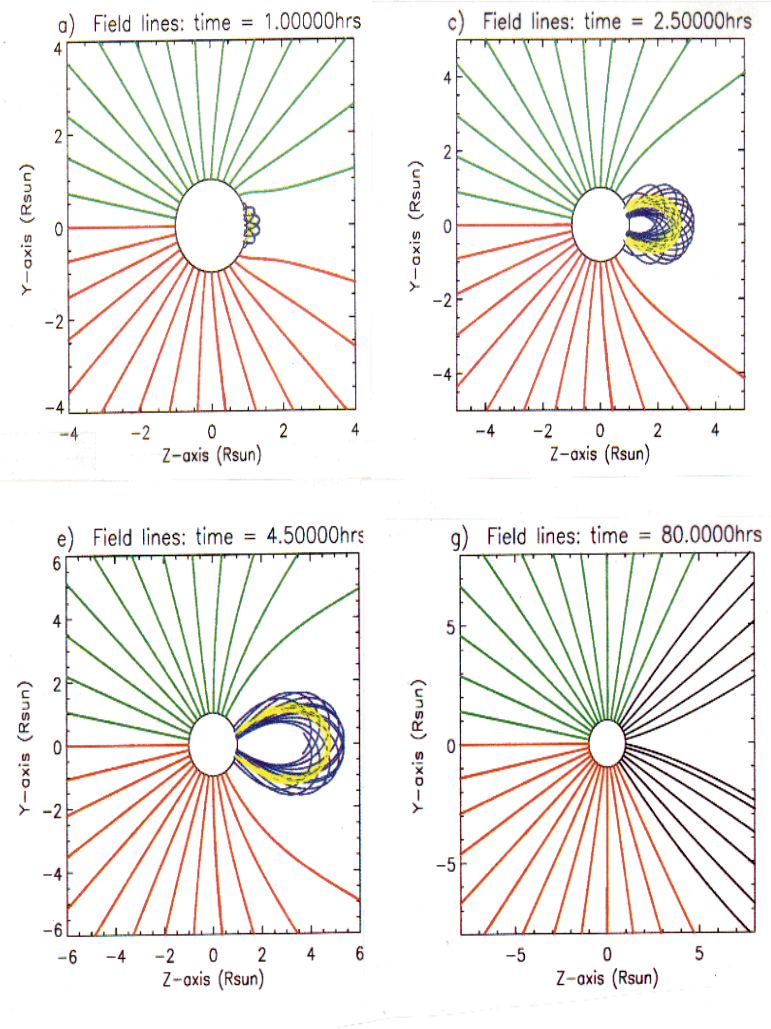
- Provide short description of CME model
- Use this model to derive eight testable predictions.

- Principle
  - Focus on CME propagation and interaction processes
  - Use simplest model we know – Gibson-Low.
  - Recognize that key results should be applicable to most CMEs.

The Gibson-Low Flux Rope

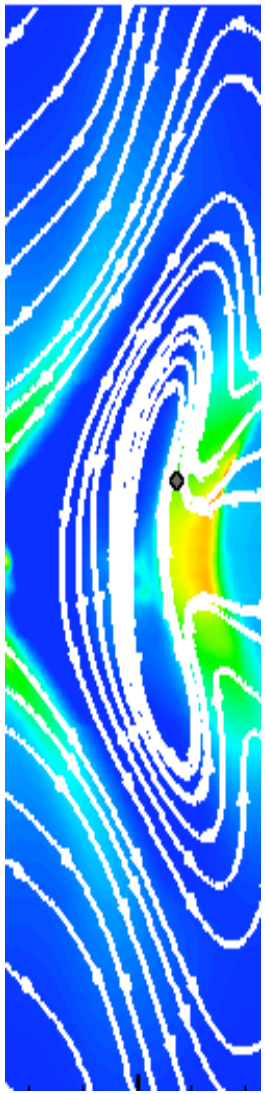


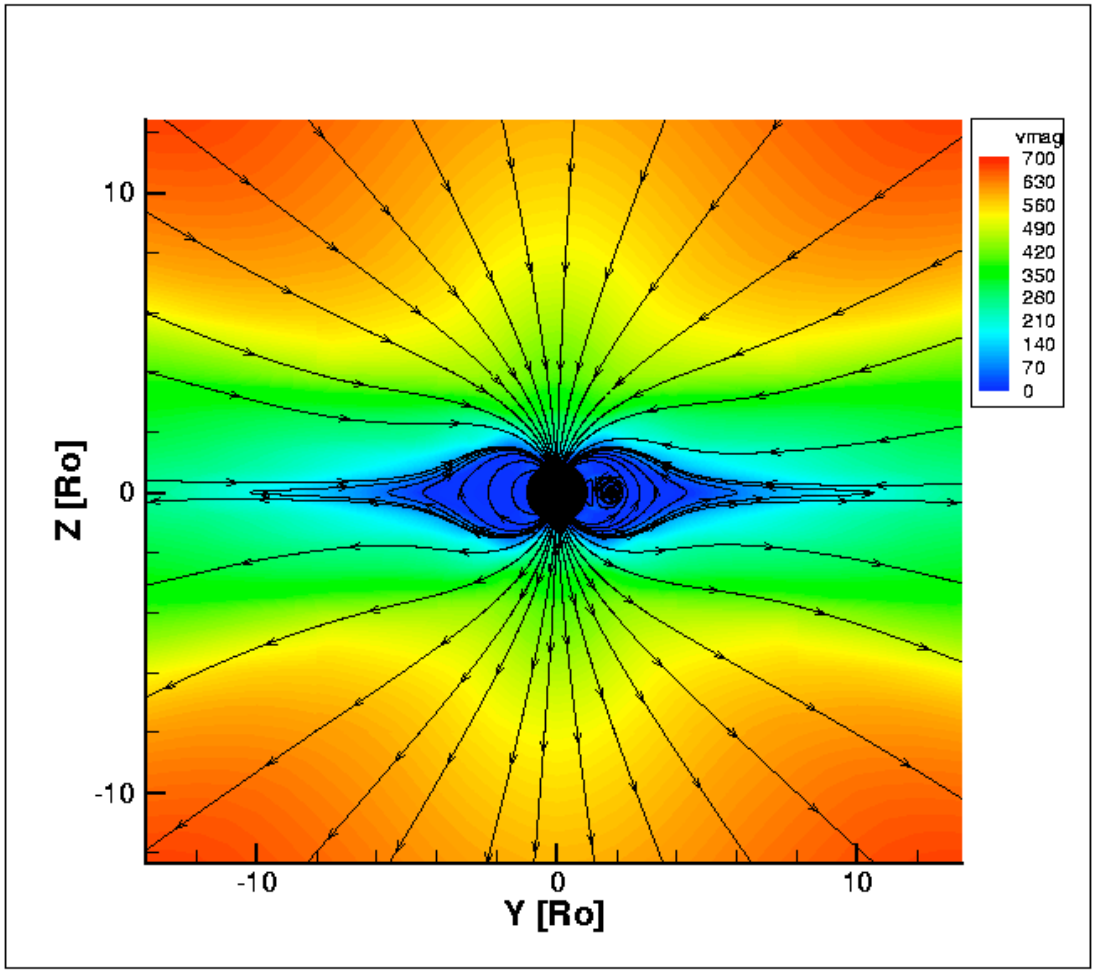
- Complex magnetic topology: spheromak flux rope distorted into a 3D tear drop shape
- Magnetic field supports the weight of the plasma: magnetic field possess significant free energy



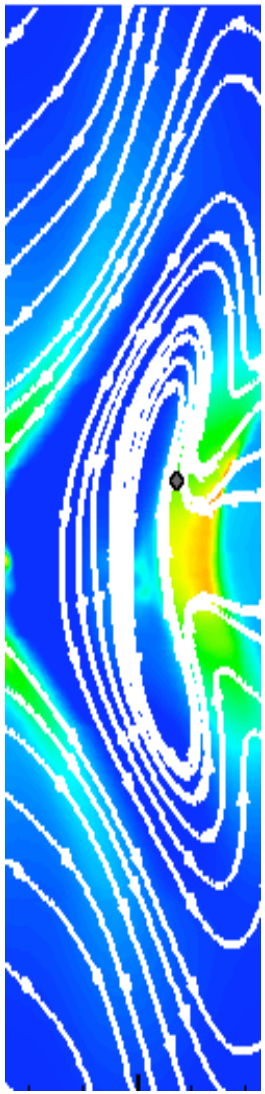
Gibson & Low, ApJ 493, 460, 1998

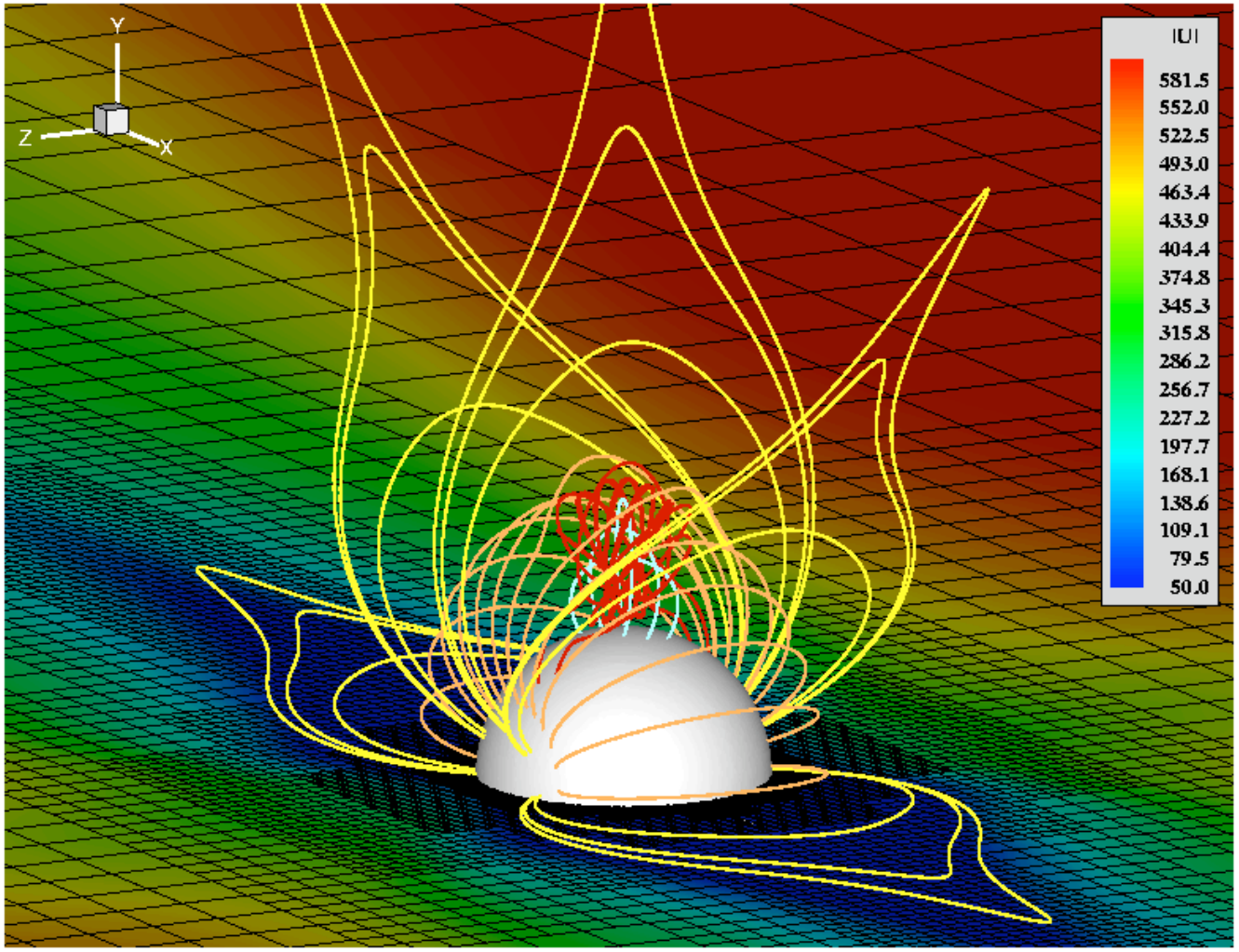
The Ambient Solar Wind





3D View of the flux rope in the corona





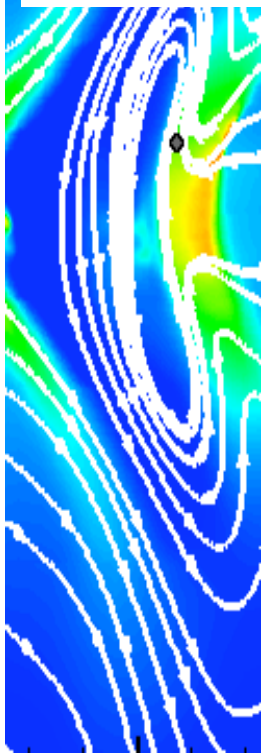
The CME in 3D

CME Properties

Peak velocity > 1000 km/s

Flux rope mass = 1.0×10^{15} grams

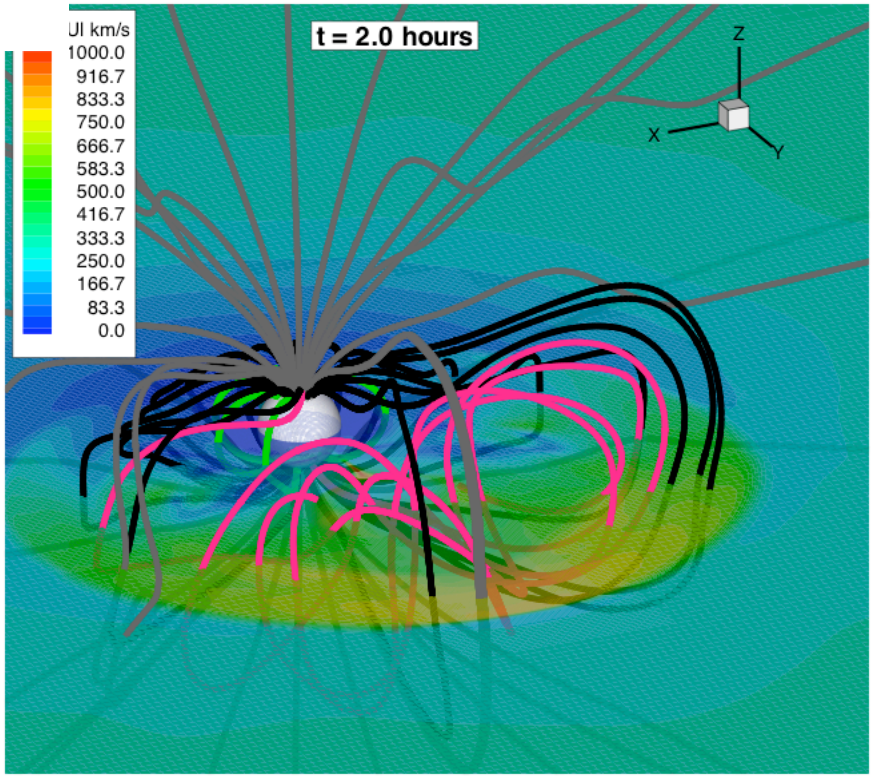
Kinetic Energy = 4.0×10^{31} ergs



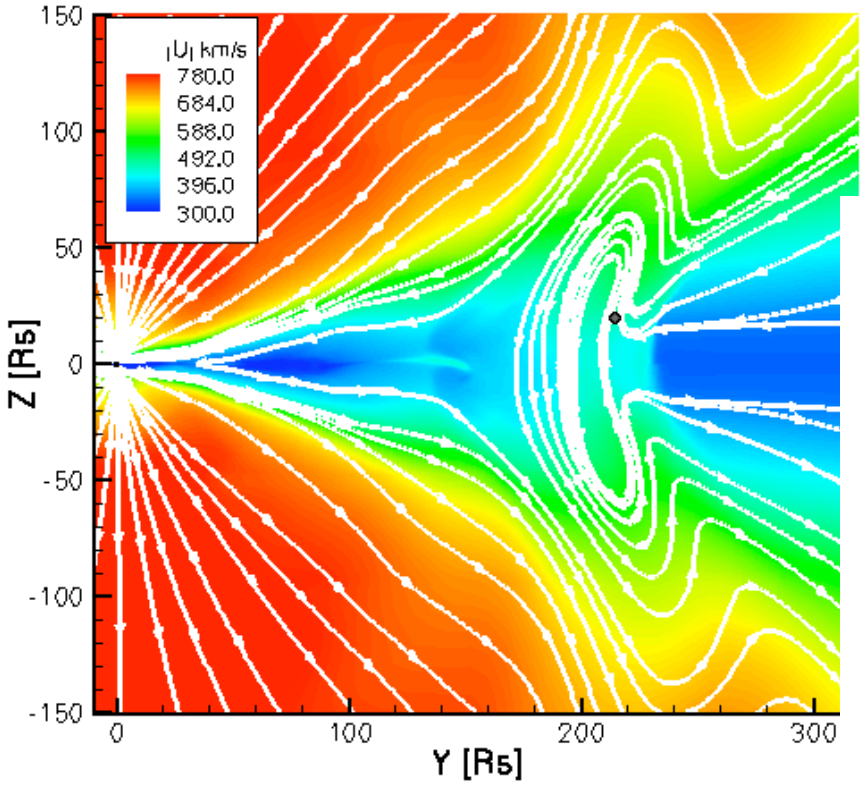
Magenta: magnetic lines of the flux rope

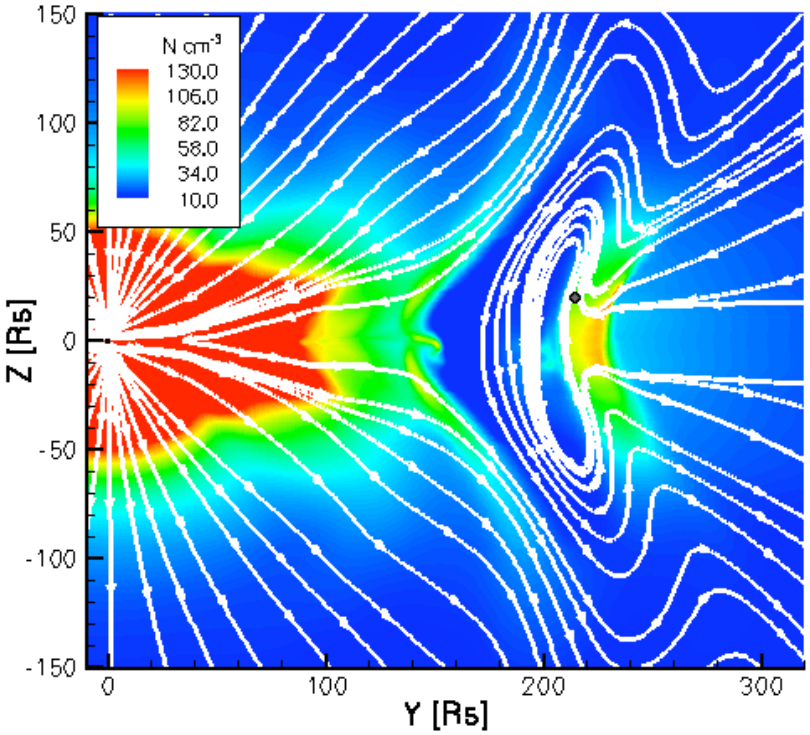
Black and green lines: magnetic lines of the helmet streamer.

Grey: open field lines.



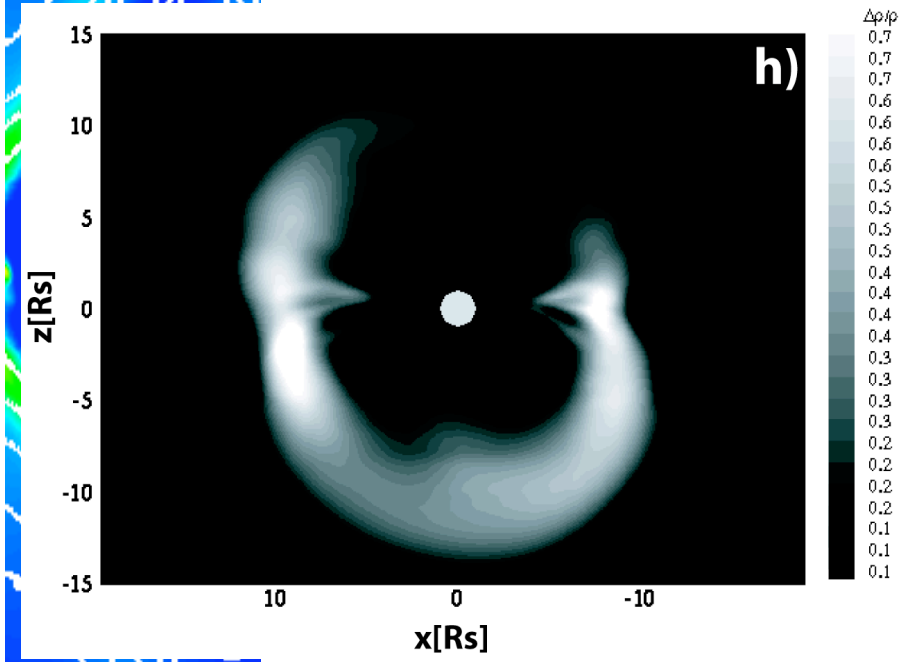
Prediction 1: Shock is deformed around slow solar wind band. High latitudes advance faster.



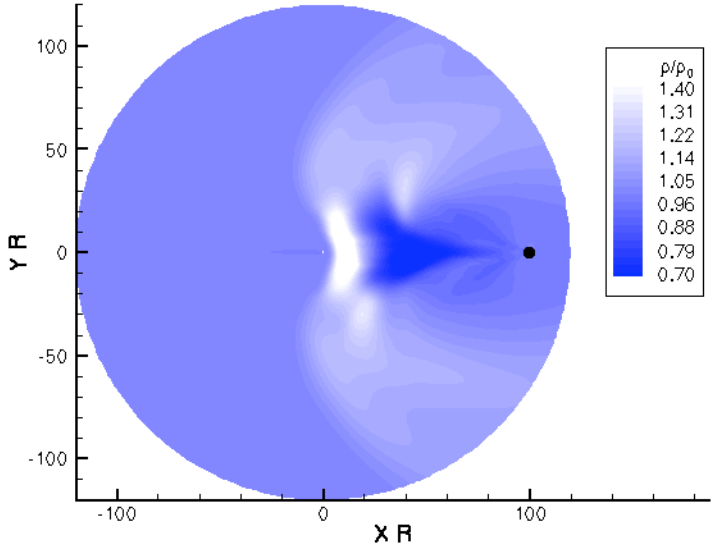


Prediction 2: Indentation of shock front near current sheet seen by coronagraphs and heliospheric imagers.

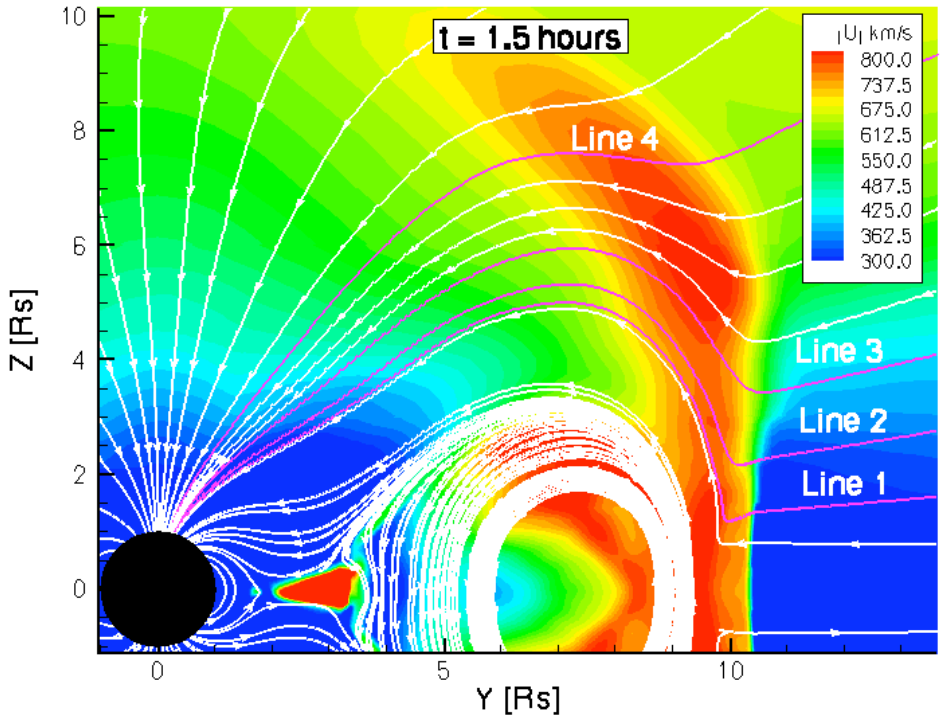
2 hours

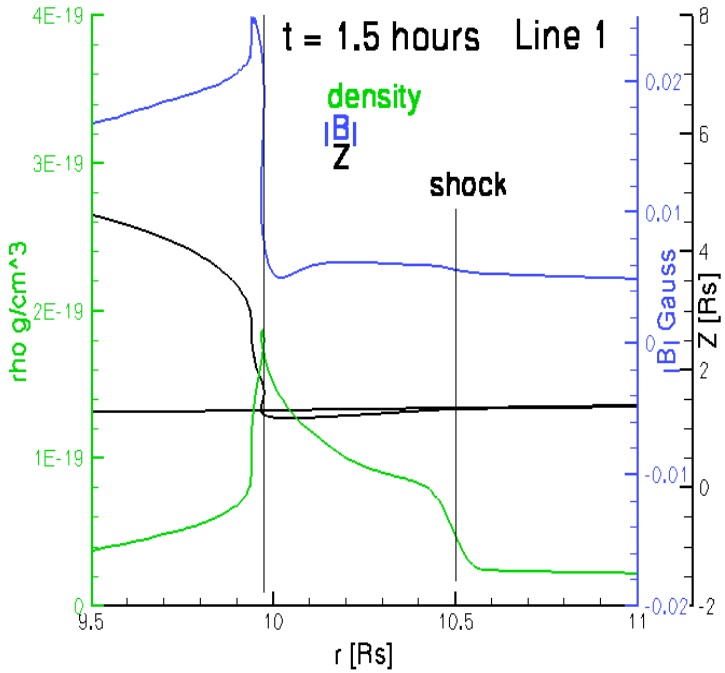


24 hours

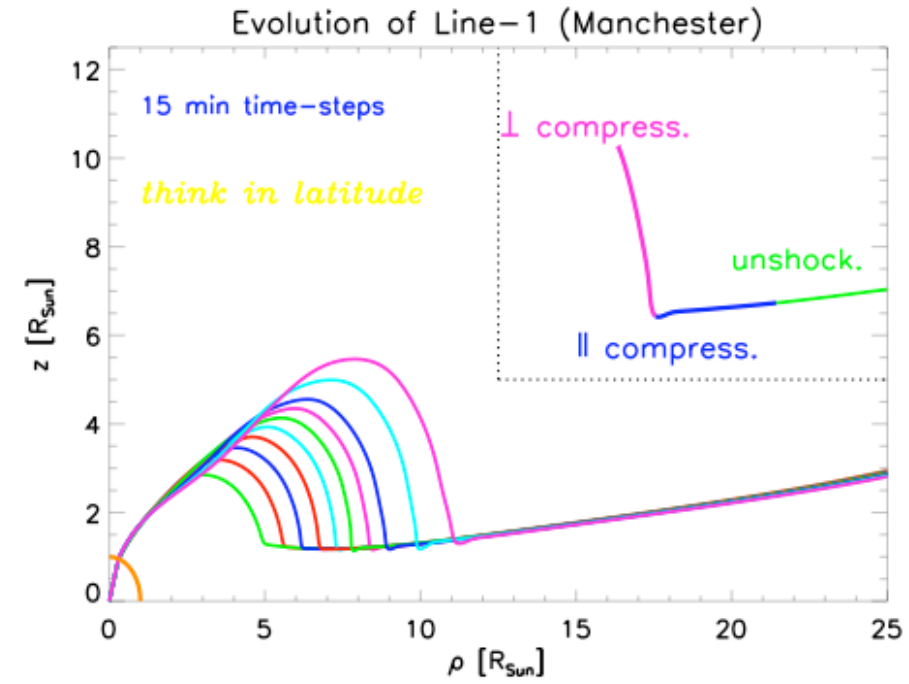


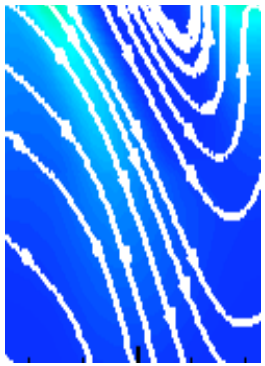
Prediction 3: Post Shock compressions form behind the shock indentation close to the Sun.

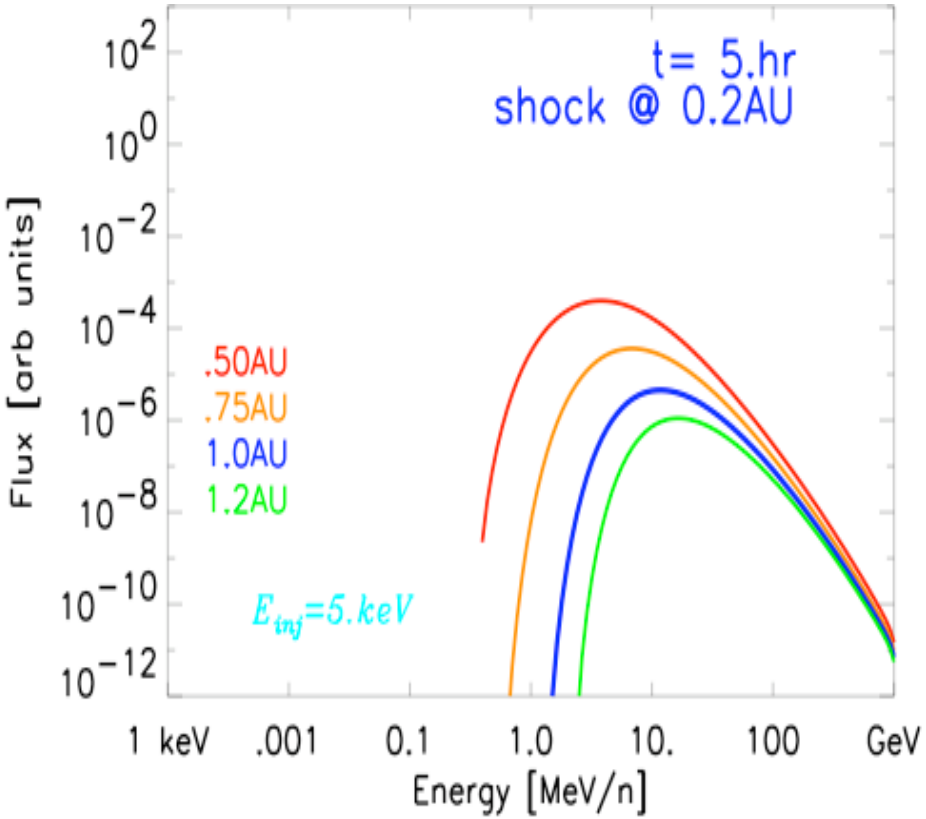




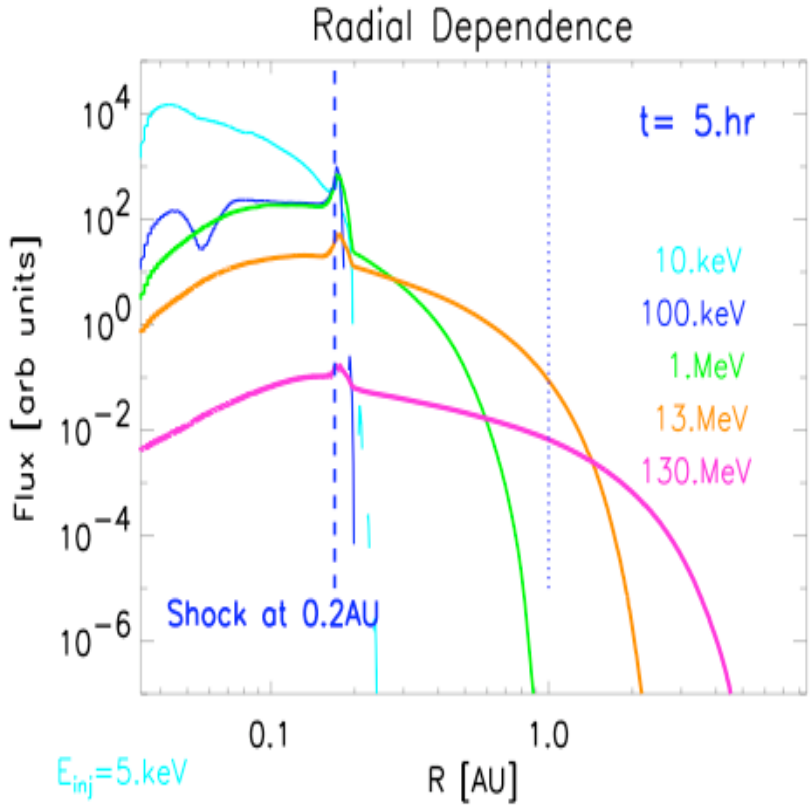
Prediction 4: Particle acceleration is effective throughout corona and into heliosphere at the shock and post-shock compressions.

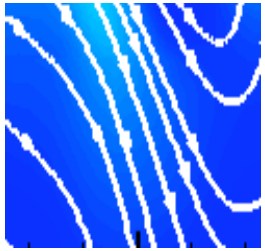


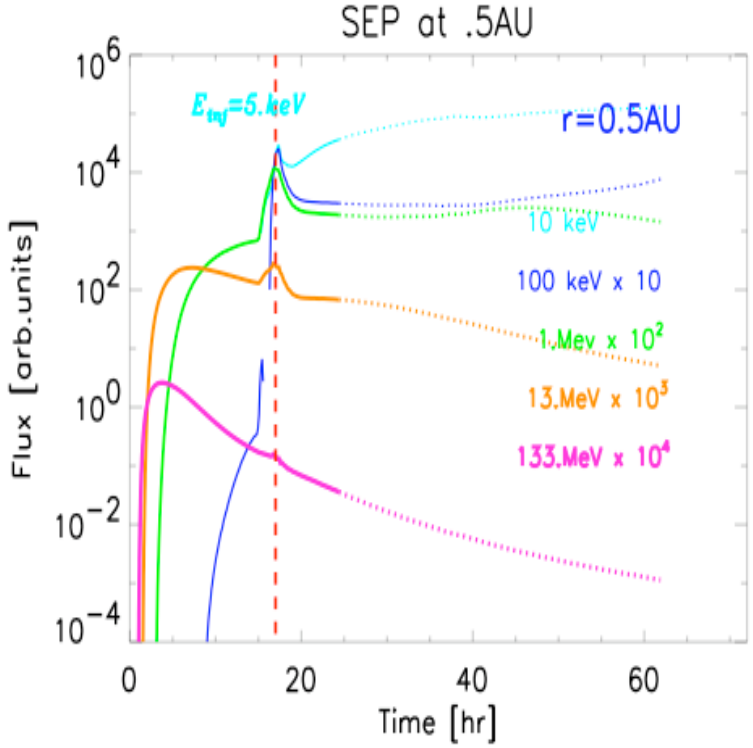




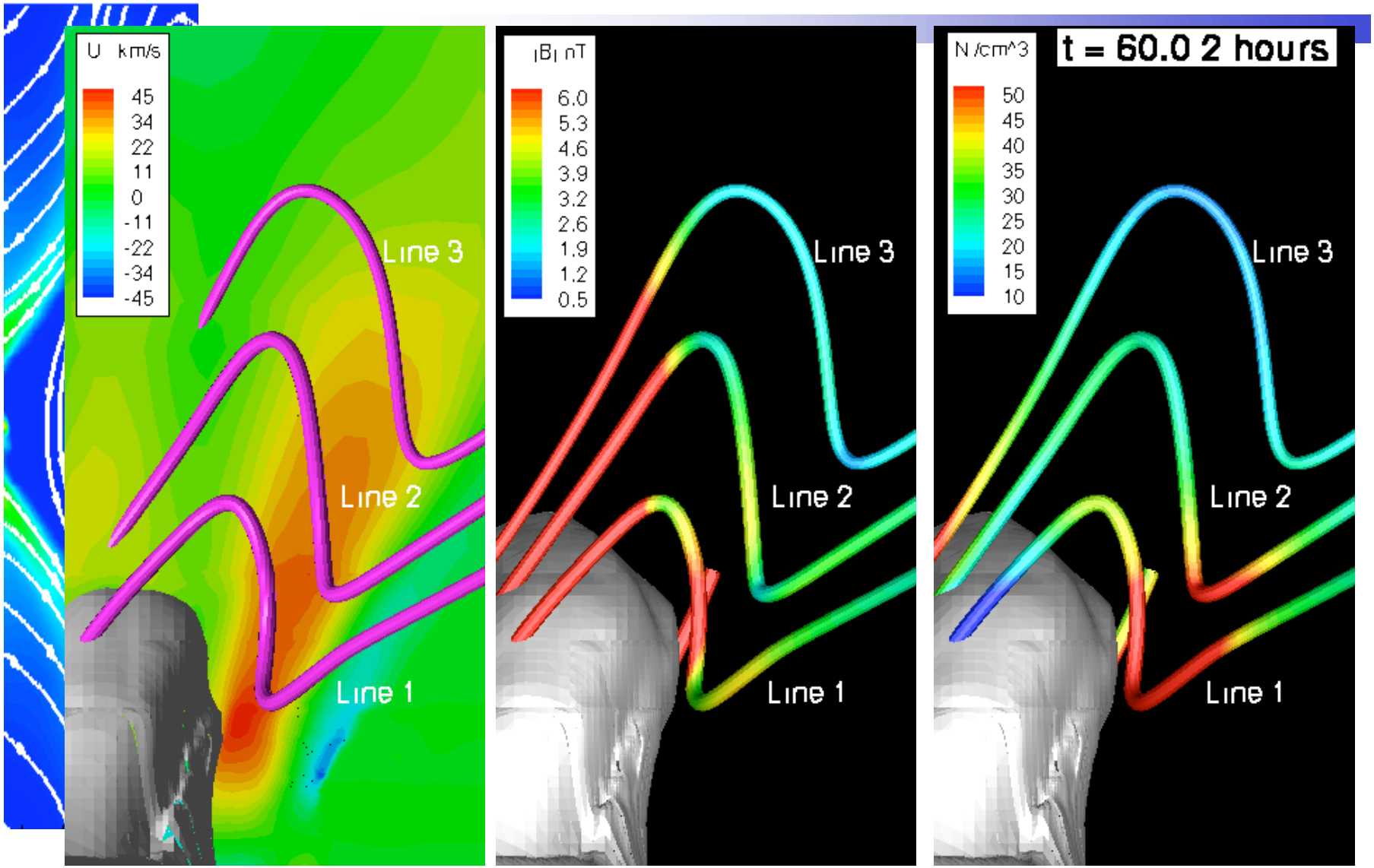
Fermi Acceleration of SEPs at the Shock, by J. Kota



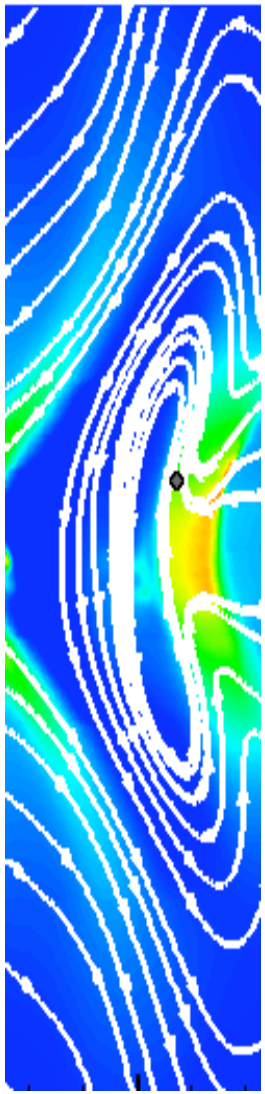


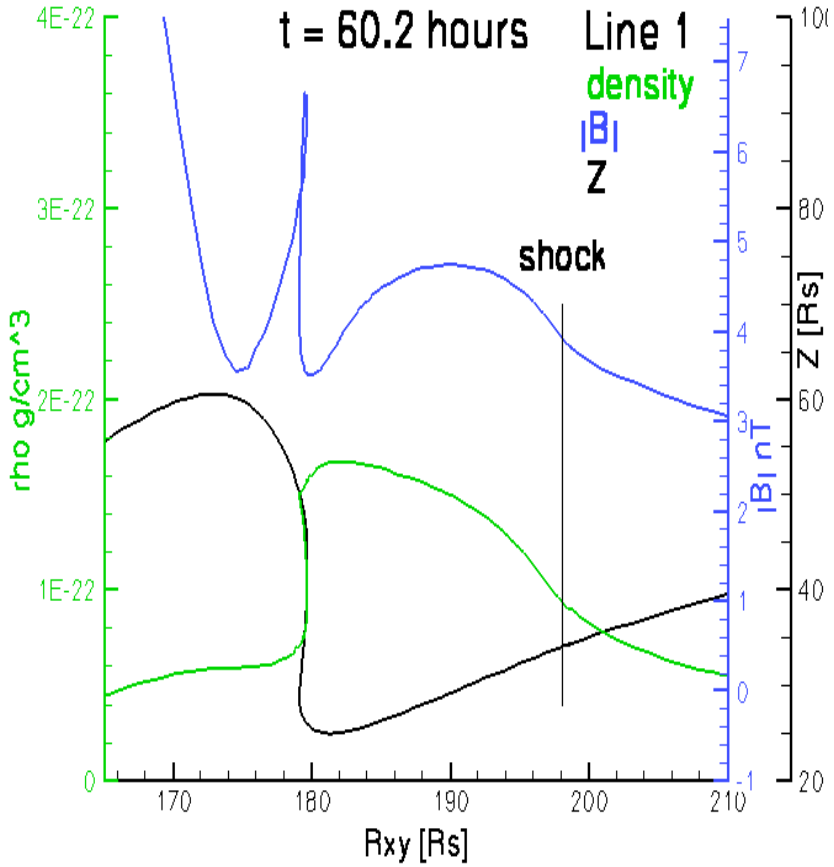


Prediction 5: Post-shock compressions persist to 1 AU.



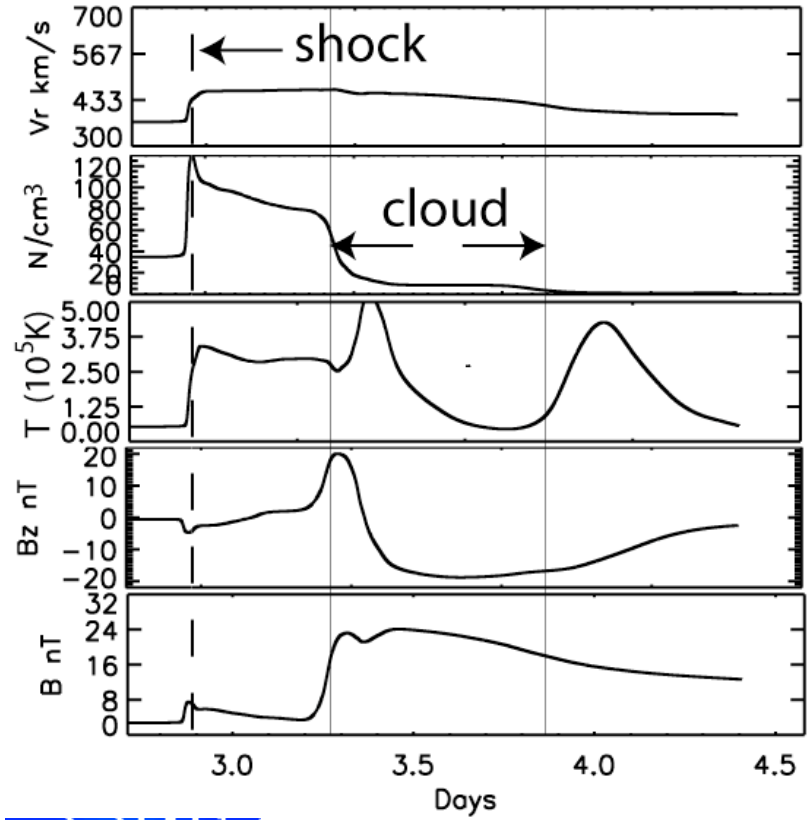
Prediction 6: In the inner heliosphere, there are B-field enhancement at the back-side of the CME



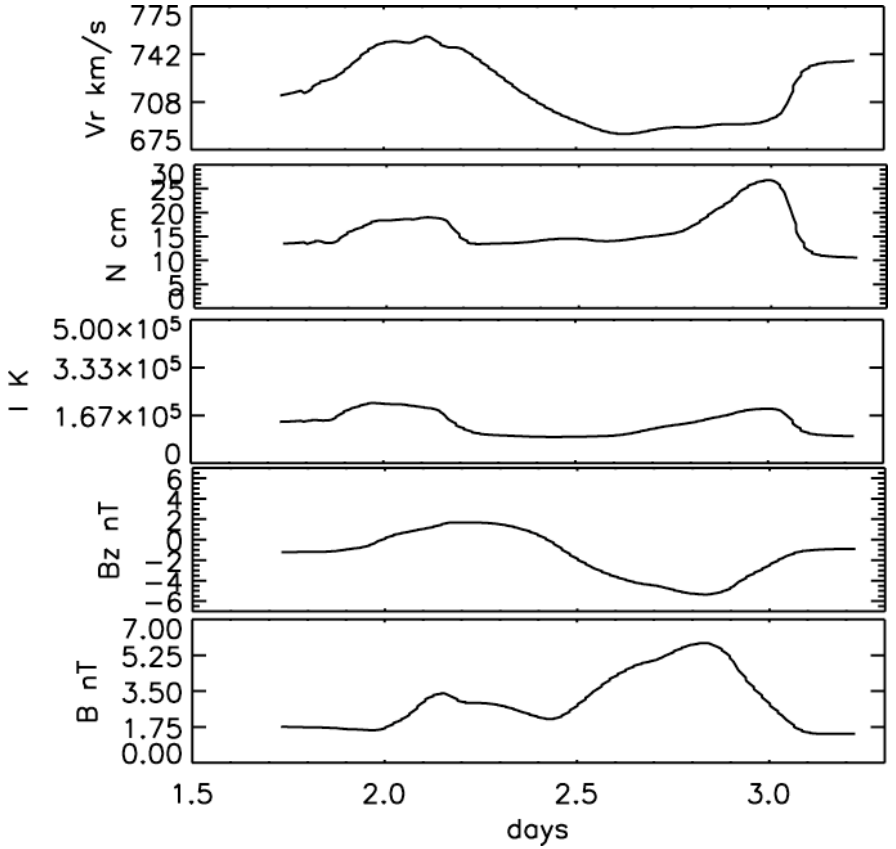


Prediction 7: CME disturbance expands far beyond CME ejecta.

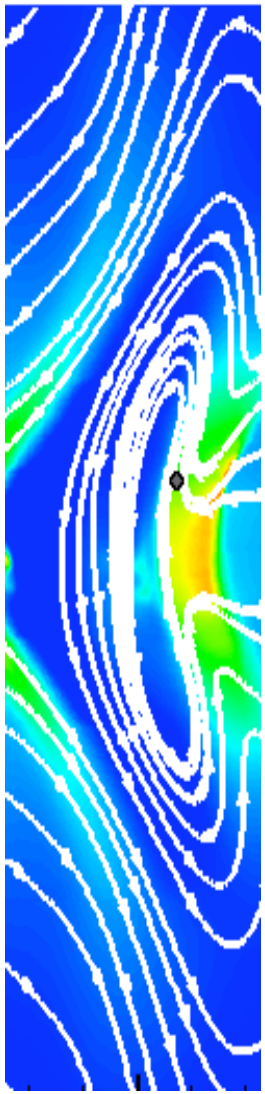
Z = 20

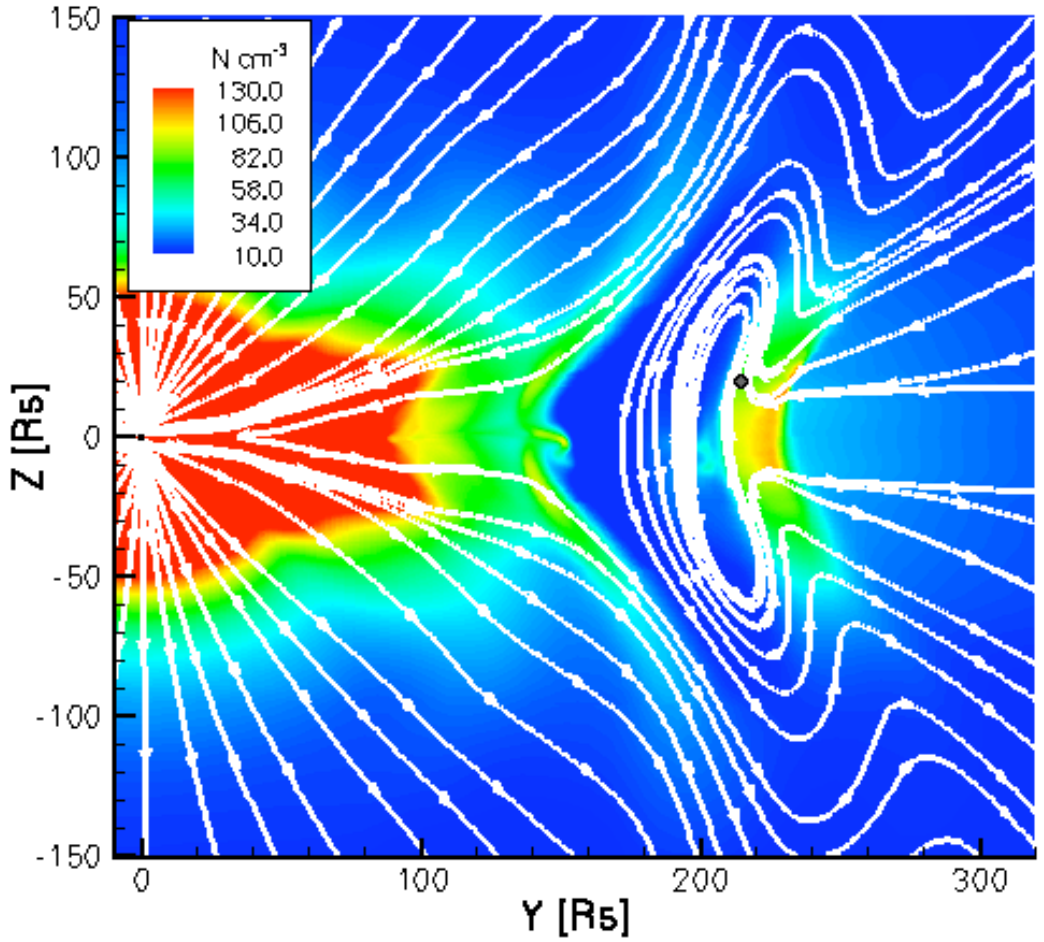


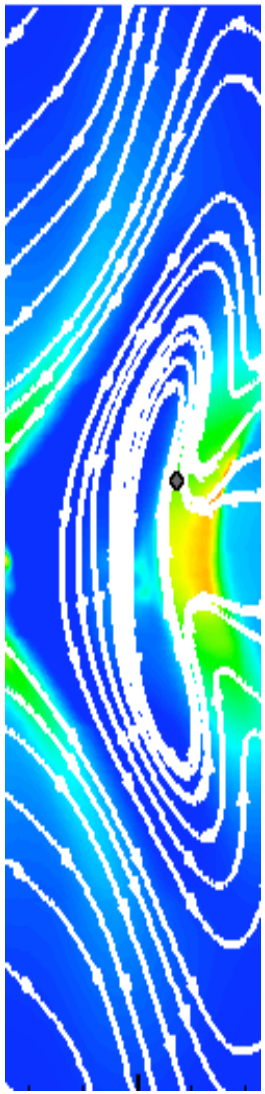
Z = 120



Prediction 8: CME field lines are disconnected within 1 AU.







Summary: Predictions at 1 AU

- 3D flux rope embedded in the steamer with a 3 part density structure
- Shock formation and interaction with the bi-modal solar wind deforms the shock front forming a large indentation also bends the cloud forward at high latitude
- Large post-shock compressions behind shock indentation
- High latitude signatures of CMEs (out side the ejecta) resemble low latitude CMEs with reduced amplitude in B
- SEP acceleration at the shock and post-shock compression
  - ⇨The most energetic particles are accelerated close to the Sun