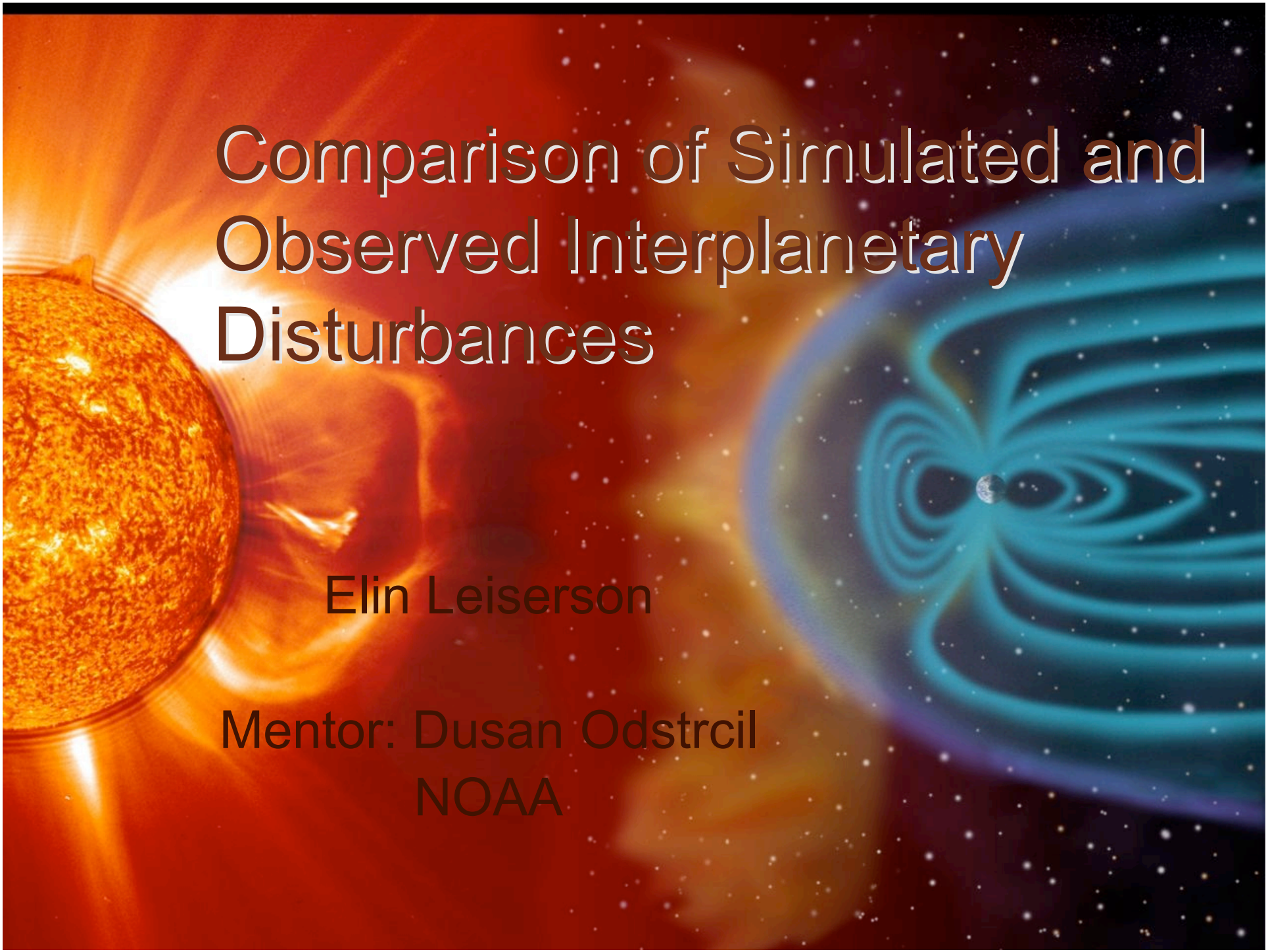

Comparison of Simulated and Observed Interplanetary Disturbances

Elin Leiserson

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NOAA

Outline

- Why use ICME models in space weather forecasting (esp. when they are still in the research phase)?
- ENLIL-modeling code
- Project and purpose
- Results thus far
- Goals (what is to come)

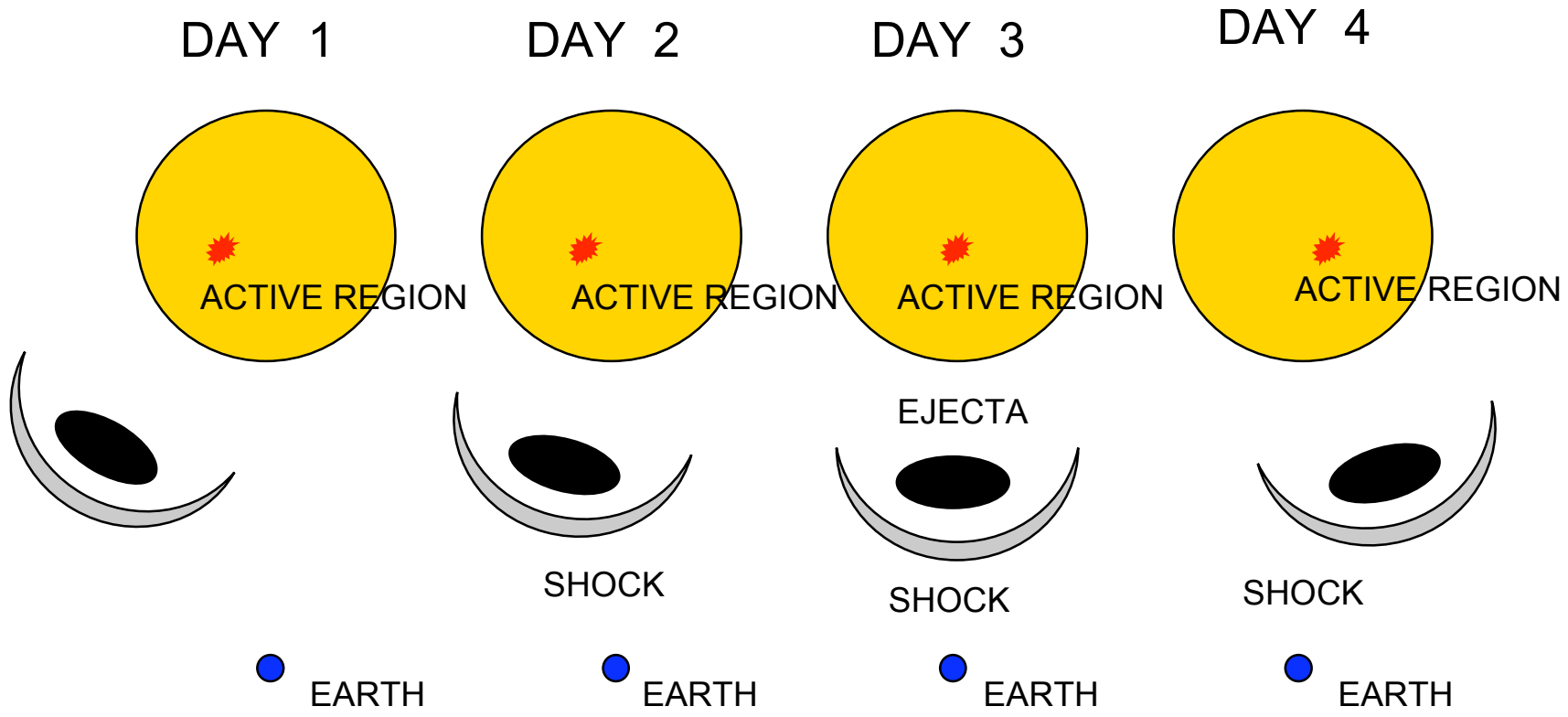
Why use ICME models for space weather forecasting?

- Interplanetary Coronal Mass Ejections (ICME's) can wreak havoc on our technological society
- For a 1000 km/s ICME, it only takes about 25 min for it to get to Earth from Lagrange Point 1
- Currently, when an ICME first goes off, it takes 12-40 hours to numerically compute the arrival time (depending on computer speed and access)
- Thus it is important to have a procedure or formula based off models as well as data to aid in estimating and predicting ICME potentials and arrival times

ENLIL— “Lord of the Air”

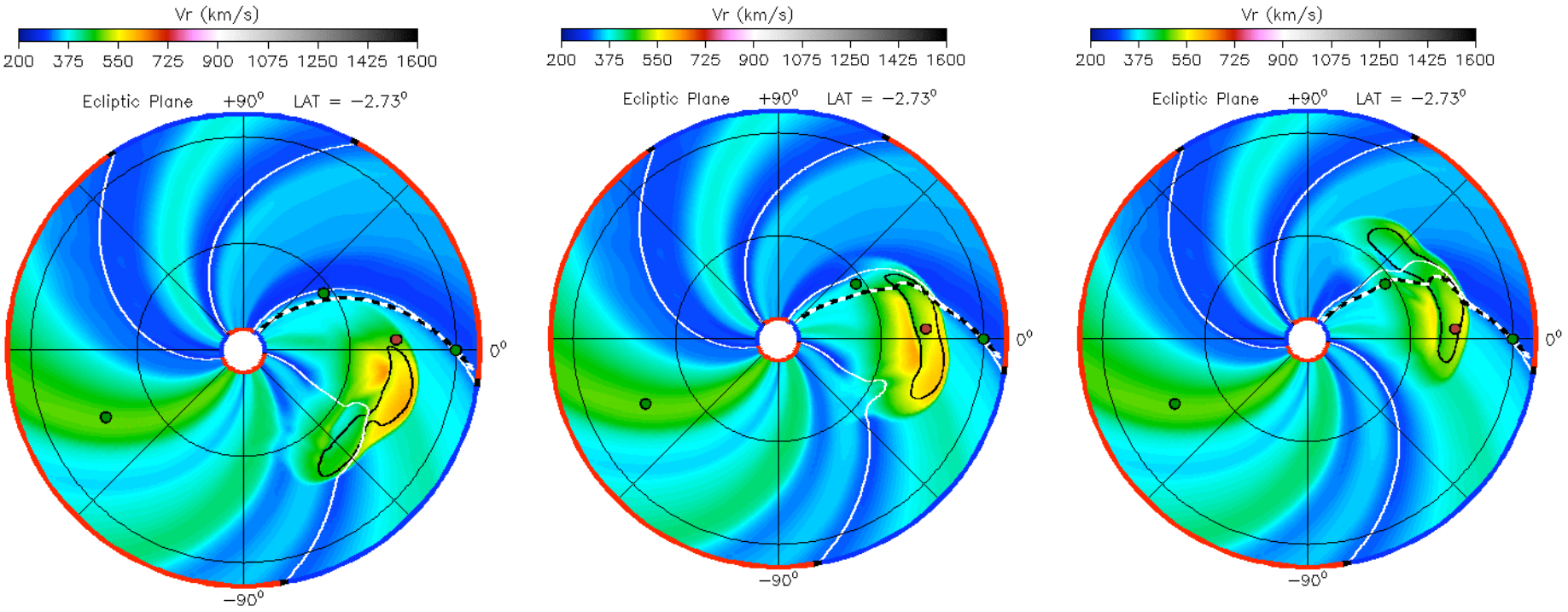
- 3D numerical magnetohydrodynamic code used to simulate ICME events.
- Solves equations for plasma mass, momentum, energy density, and magnetic field, using a Total-Variation-Diminishing Lax-Friedrichs (TVDLF) algorithm
  - TVDLF algorithm is an explicit scheme for solving Euler and hyperbolic equations for fluid dynamics
  - Useful for studying shocks

Larger Lead Time of Geoeffectivity Predictions



- Probabilities of the solar eruption (A%), interplanetary shock (B%), and ejecta (C%), and geo-effectivity (D%) before the actual eruption
- Pre-computed scenarios ready if actual eruption happens

Global Properties of Transient Disturbances



High-resolution parameterized study needed to determine:

- Probability of interplanetary shock hitting geospace
- Probability of coronal ejecta hitting geospace

And derive empirical formulae for various scenarios

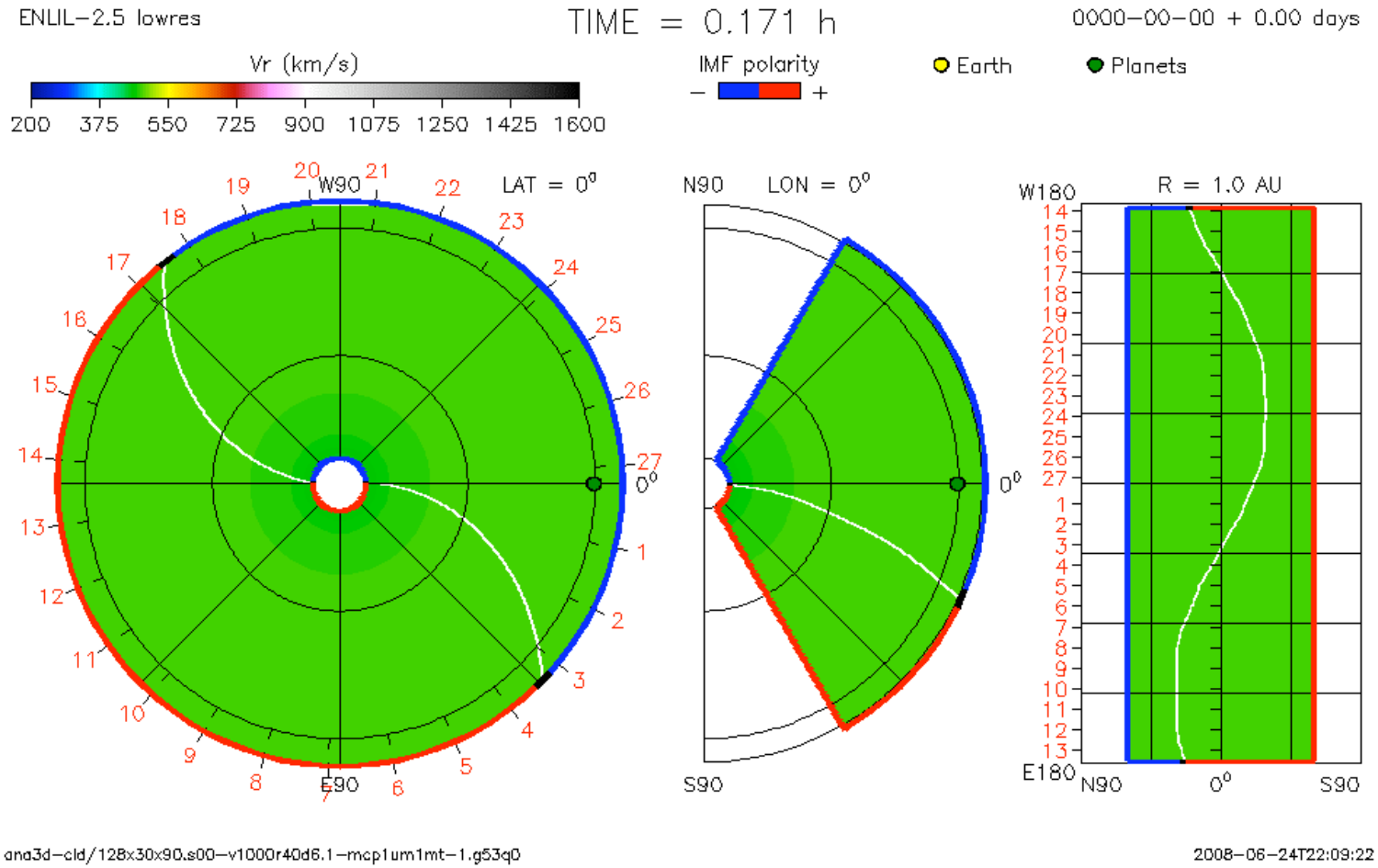
Project Goals

- Complete parametric study with various ejecta
- Compare with spacecraft observations of real events
- Determine the values of free parameters providing the best match for each specific event
- Verify whether the same values of the free parameters can be used for all events.

Parameters of Study

- Free parameters of ejecta
  - Initial Velocity Range (500-2000 km/s)
  - Angular width Range (40-180 degrees)
    - *input as “radius,” which is half the angular width
  - Density Enhancement (2-8 x solar wind density)
- Free parameters of background
  - Solar wind velocity

Simulated CME— velocity=1000 km/s, radius=40, density=6



Simulated CME—
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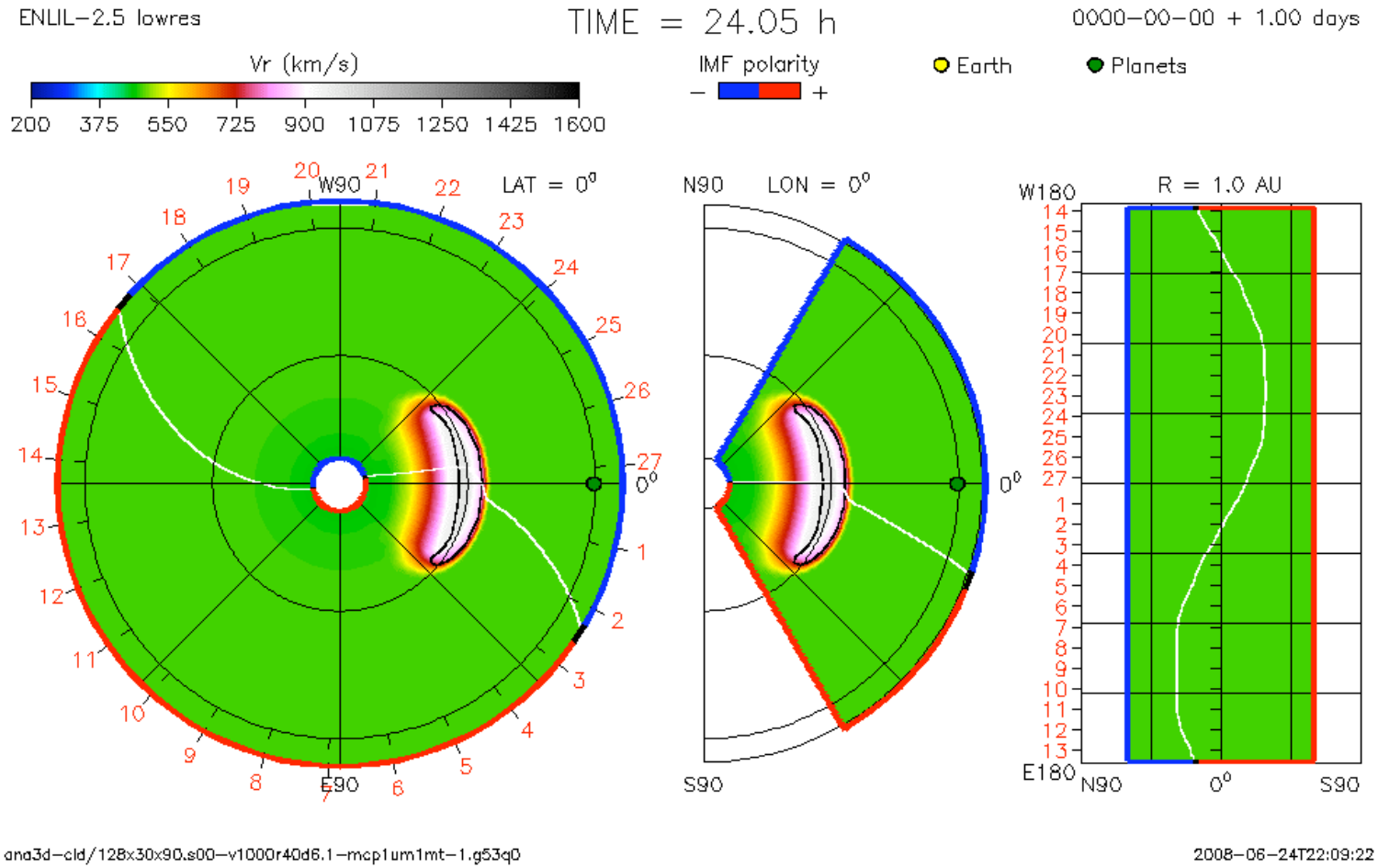
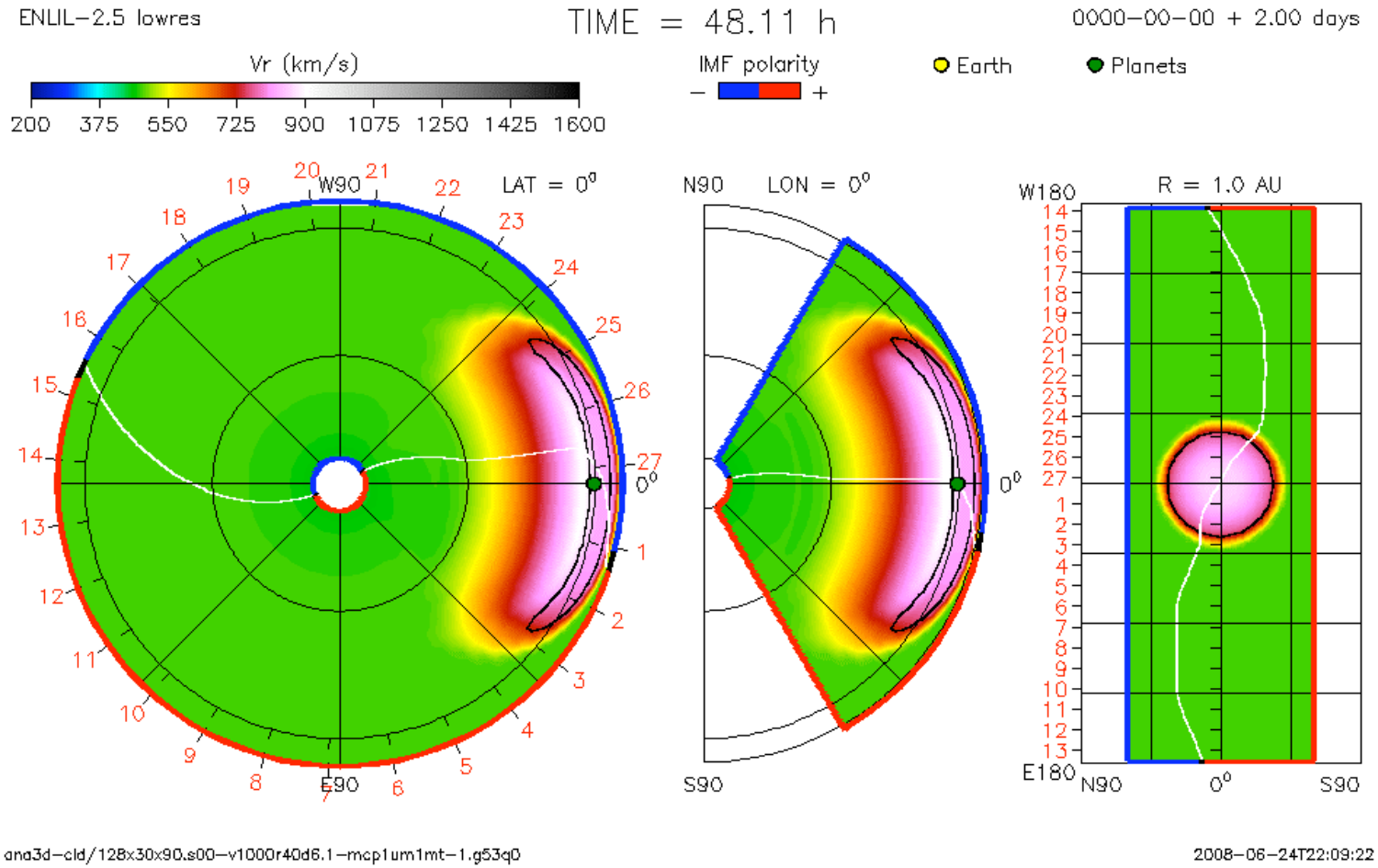
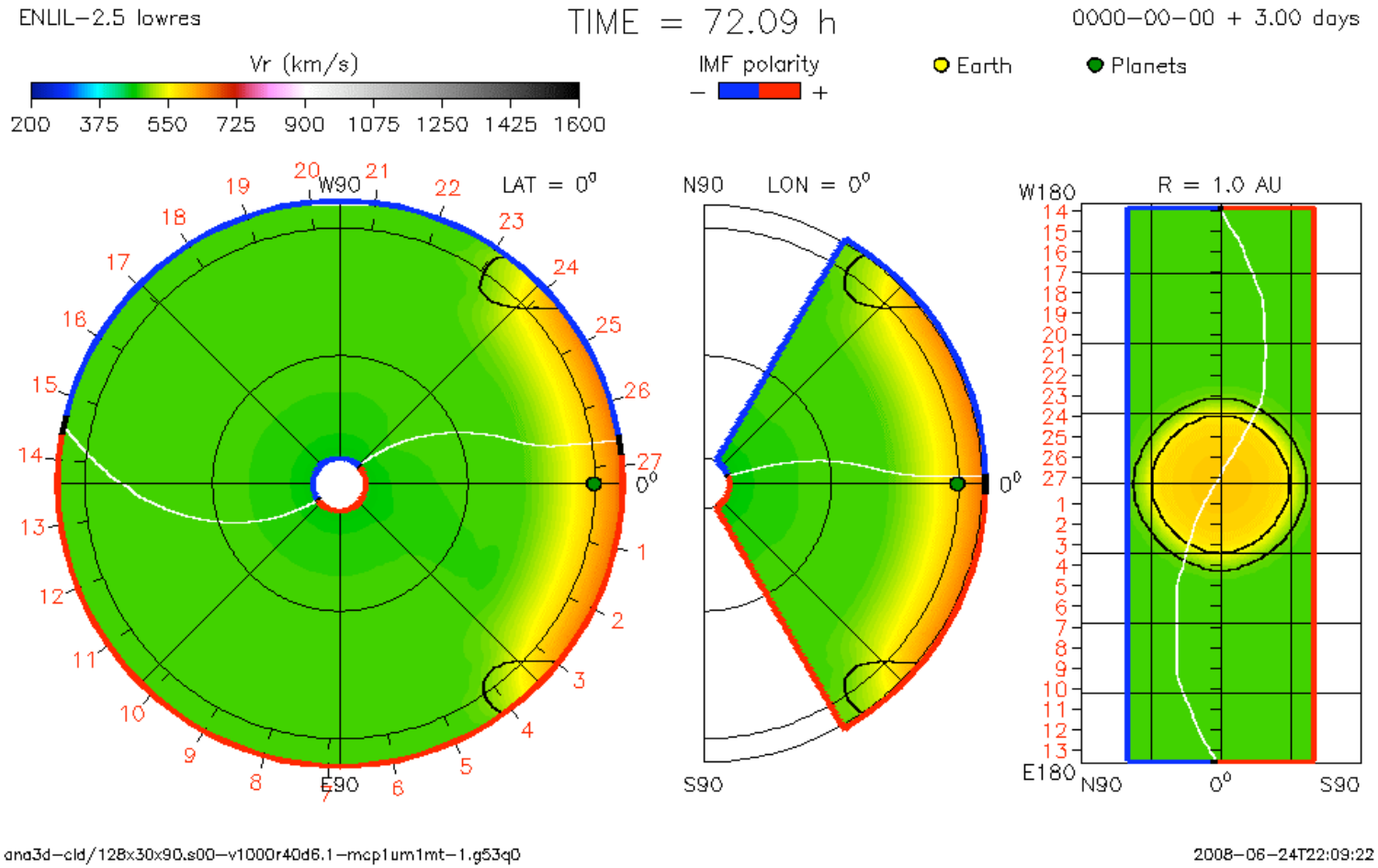


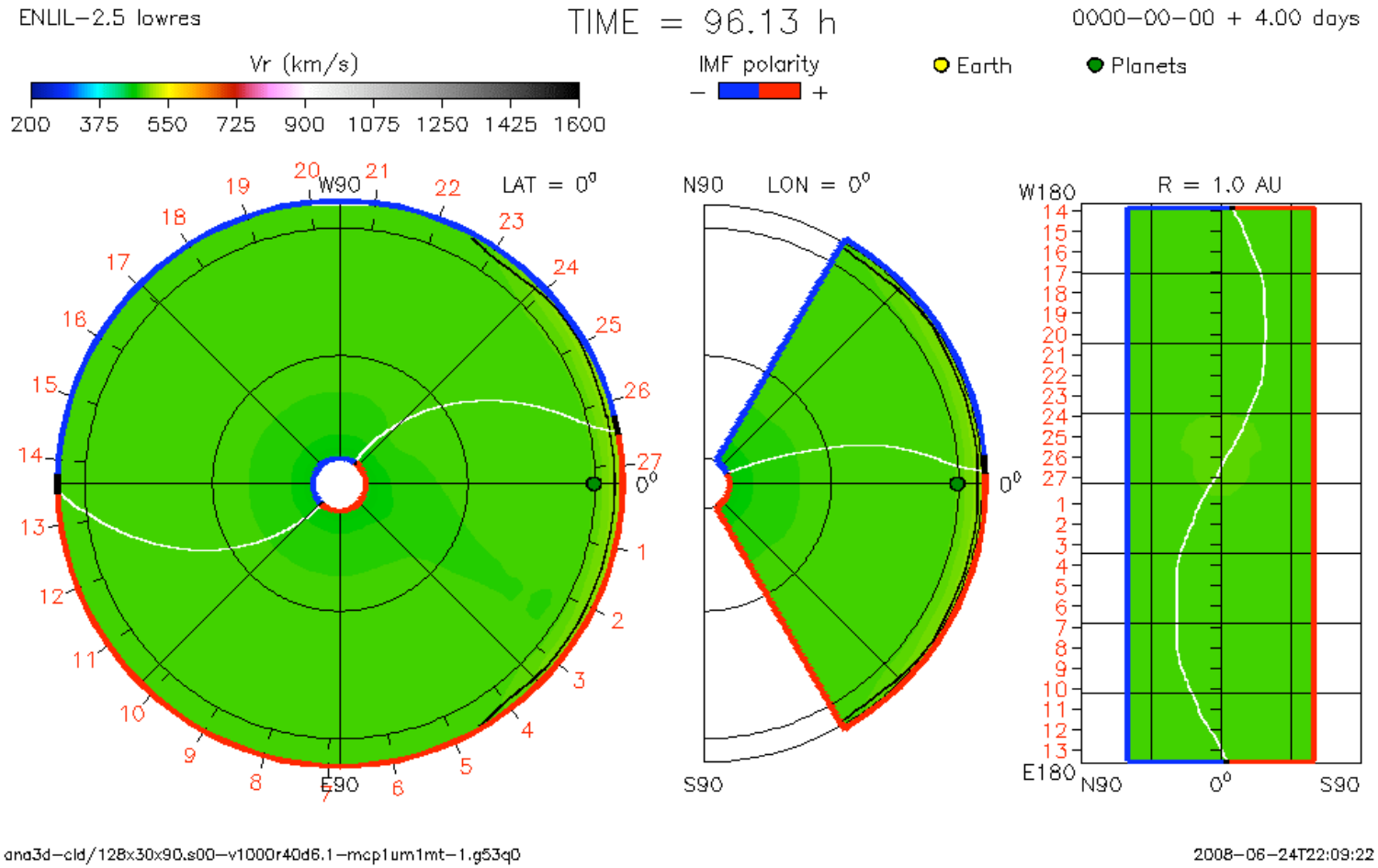
Simulated CME— velocity=1000 km/s, radius=40, density=6



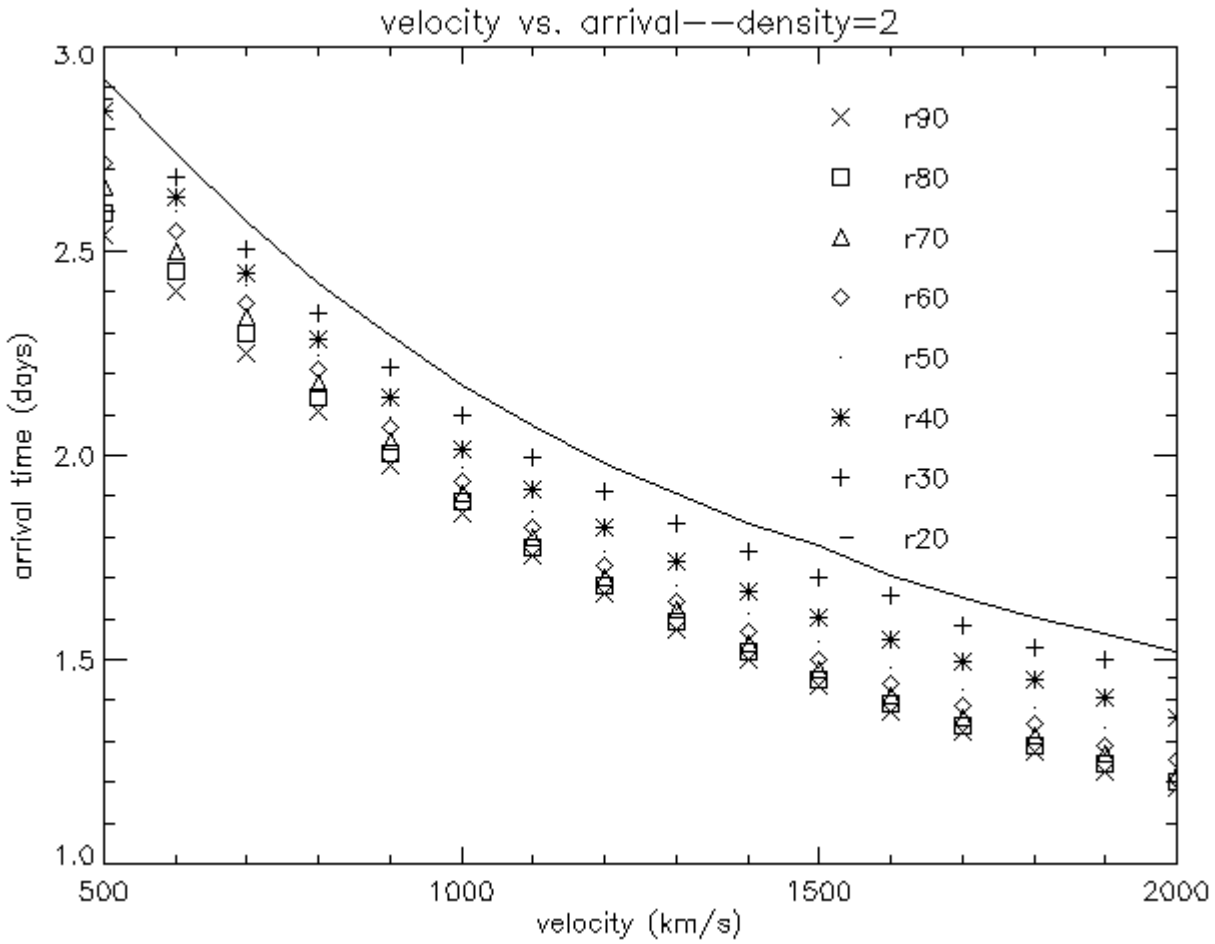
Simulated CME— velocity=1000 km/s, radius=40, density=6



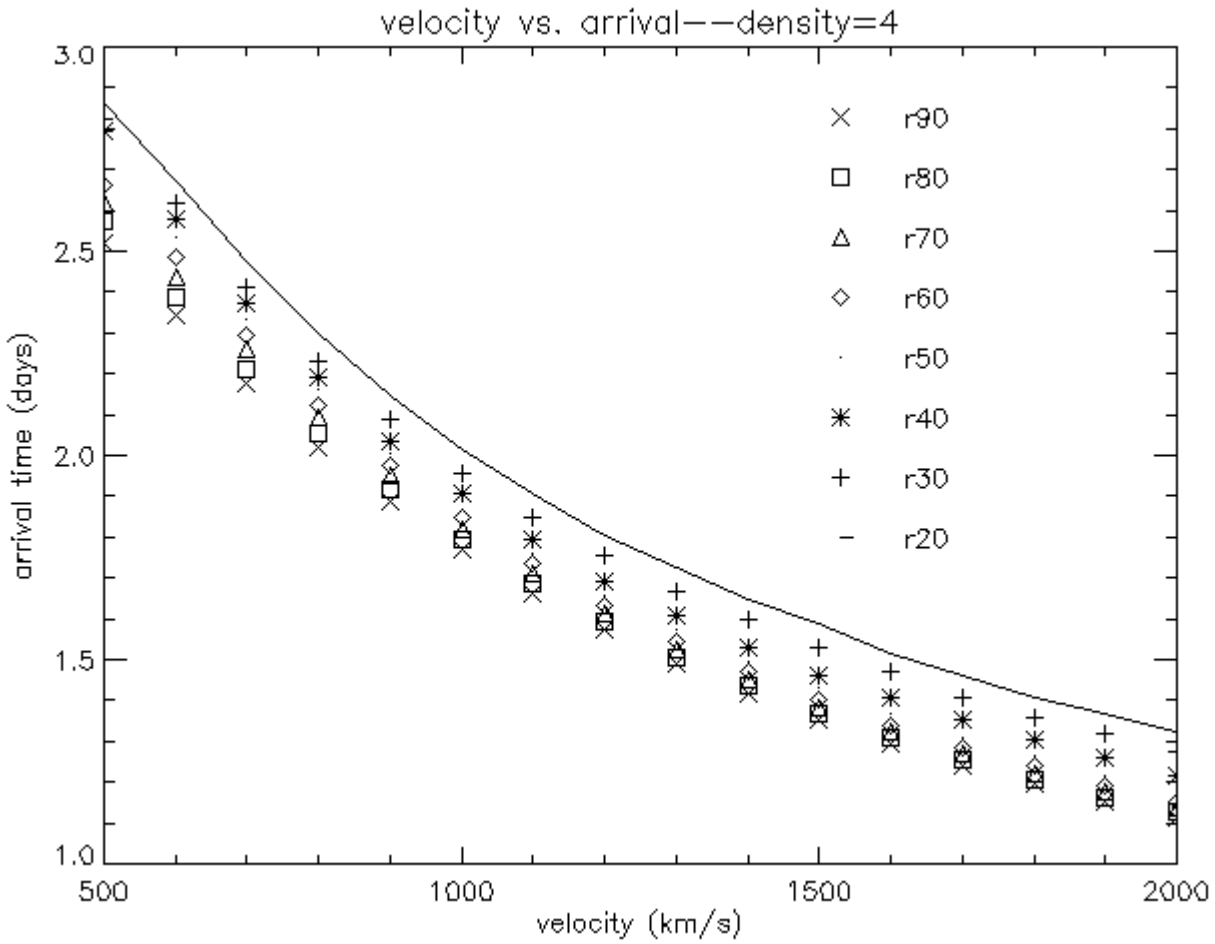
Simulated CME— velocity=1000 km/s, radius=40, density=6



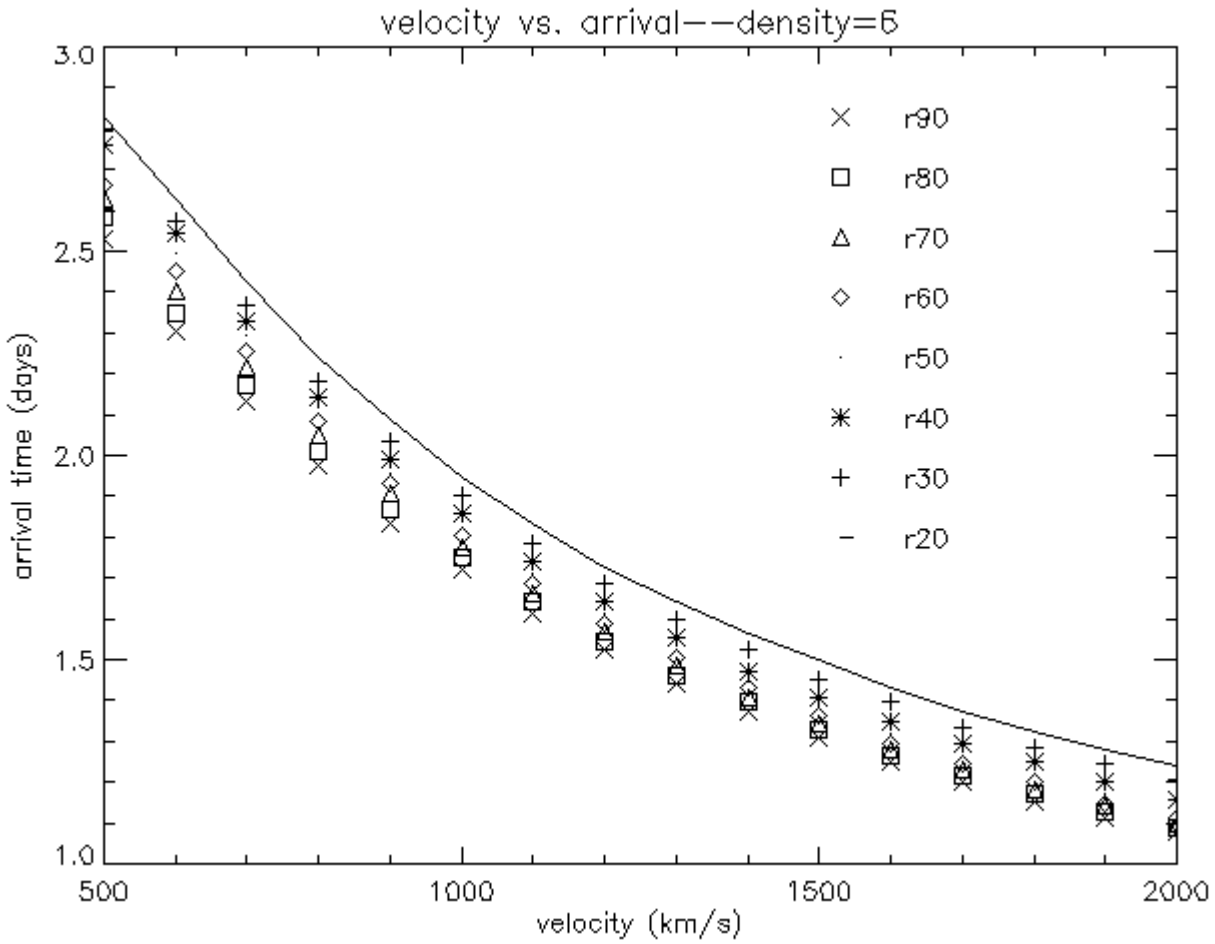
Initial Velocity vs. time



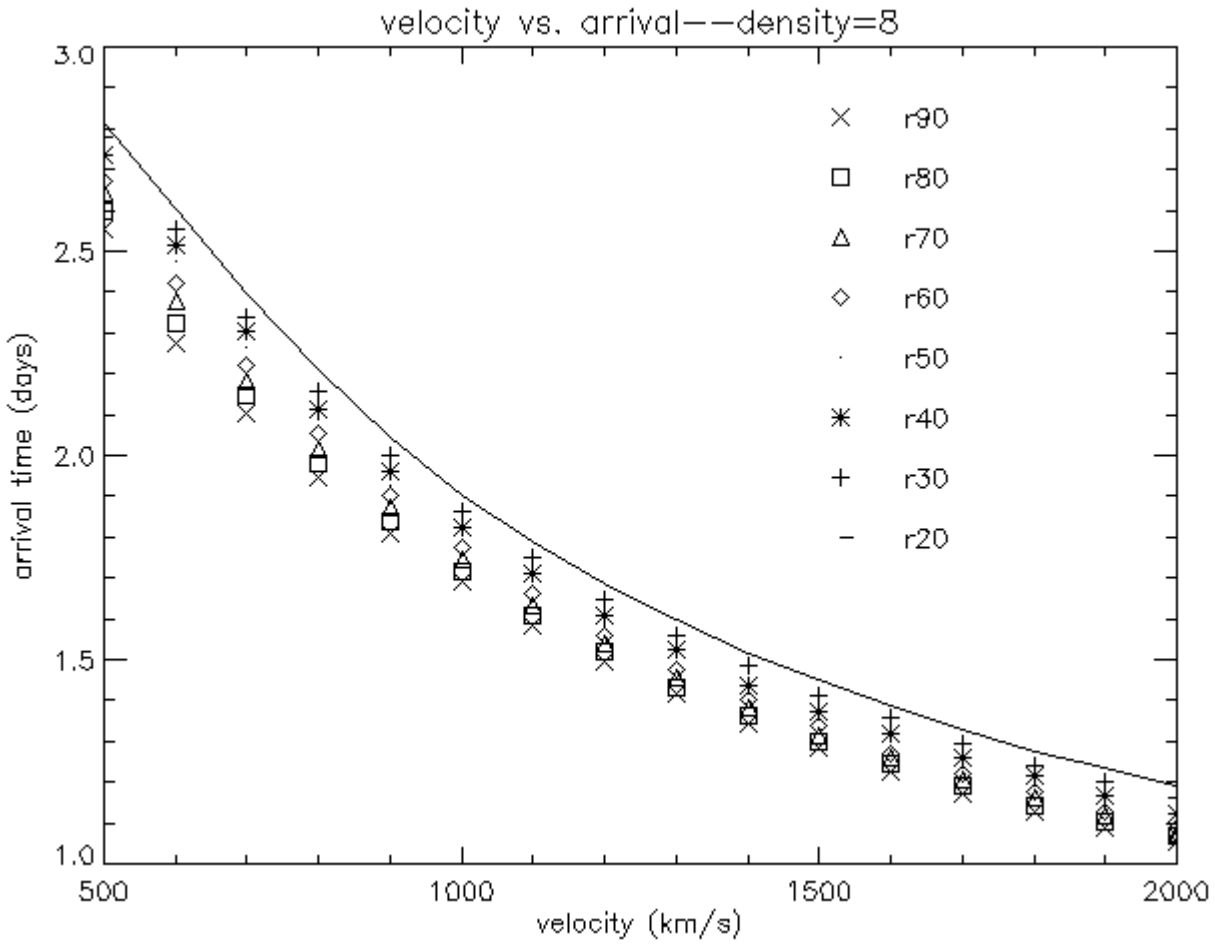
Initial Velocity vs. time



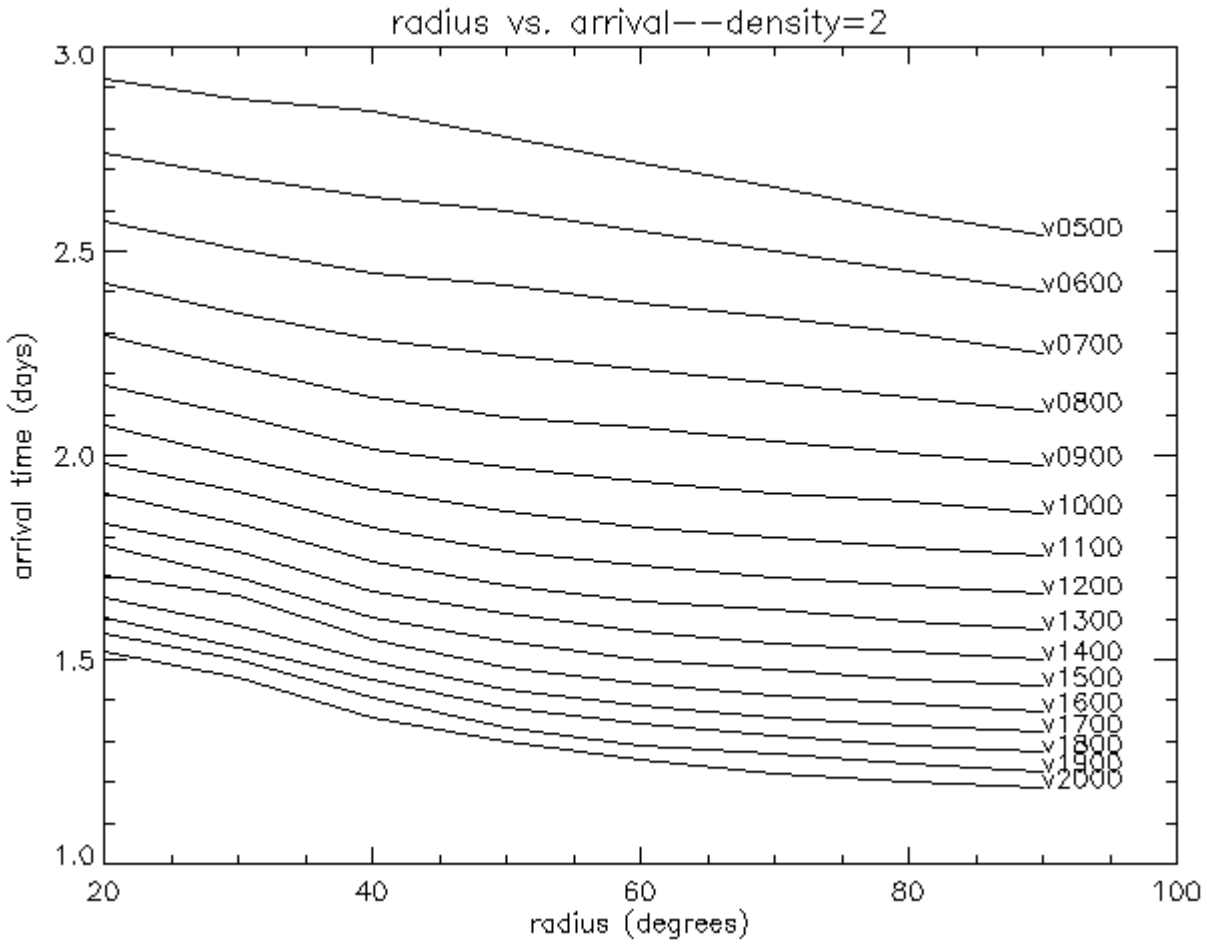
Initial Velocity vs. time



Initial Velocity vs. time



Radius vs. time



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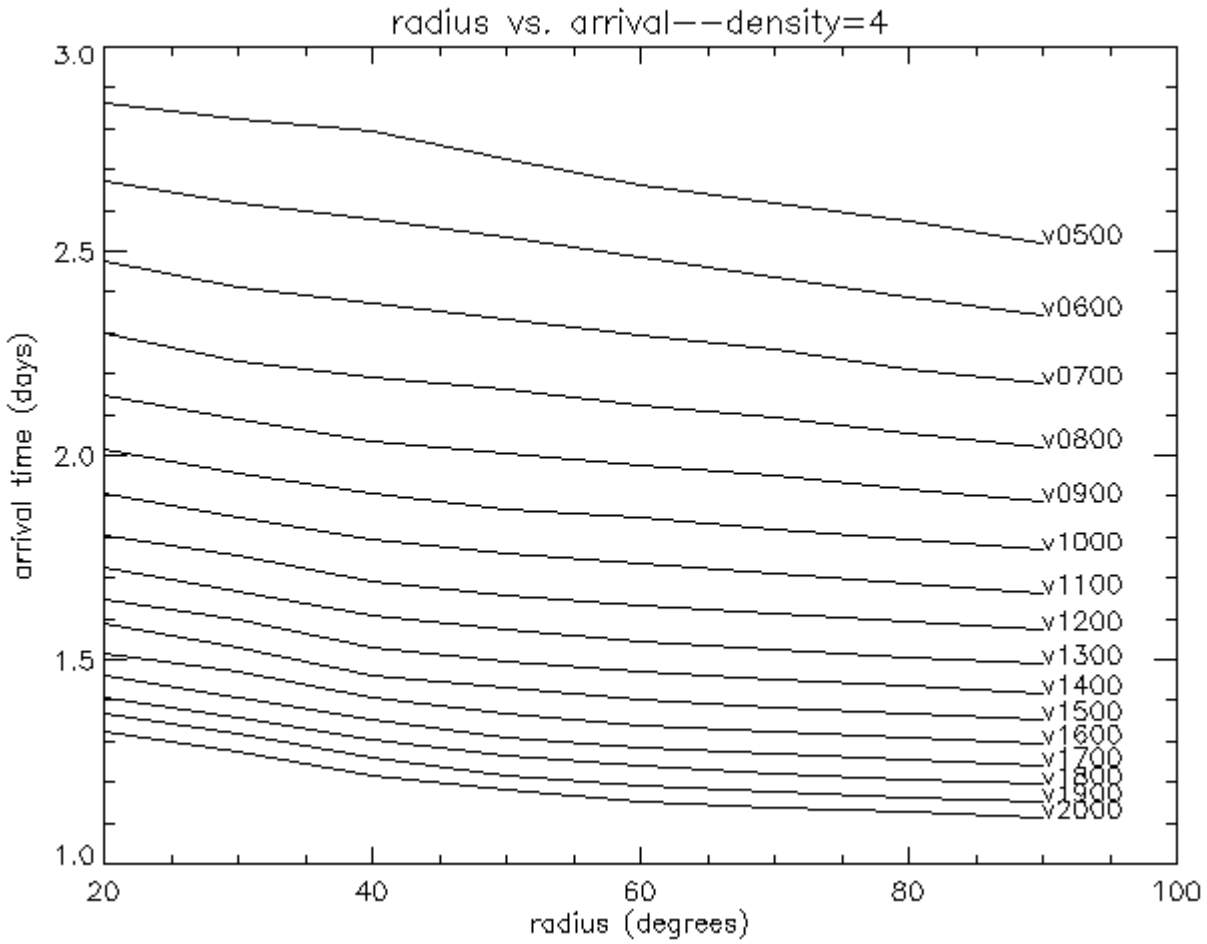
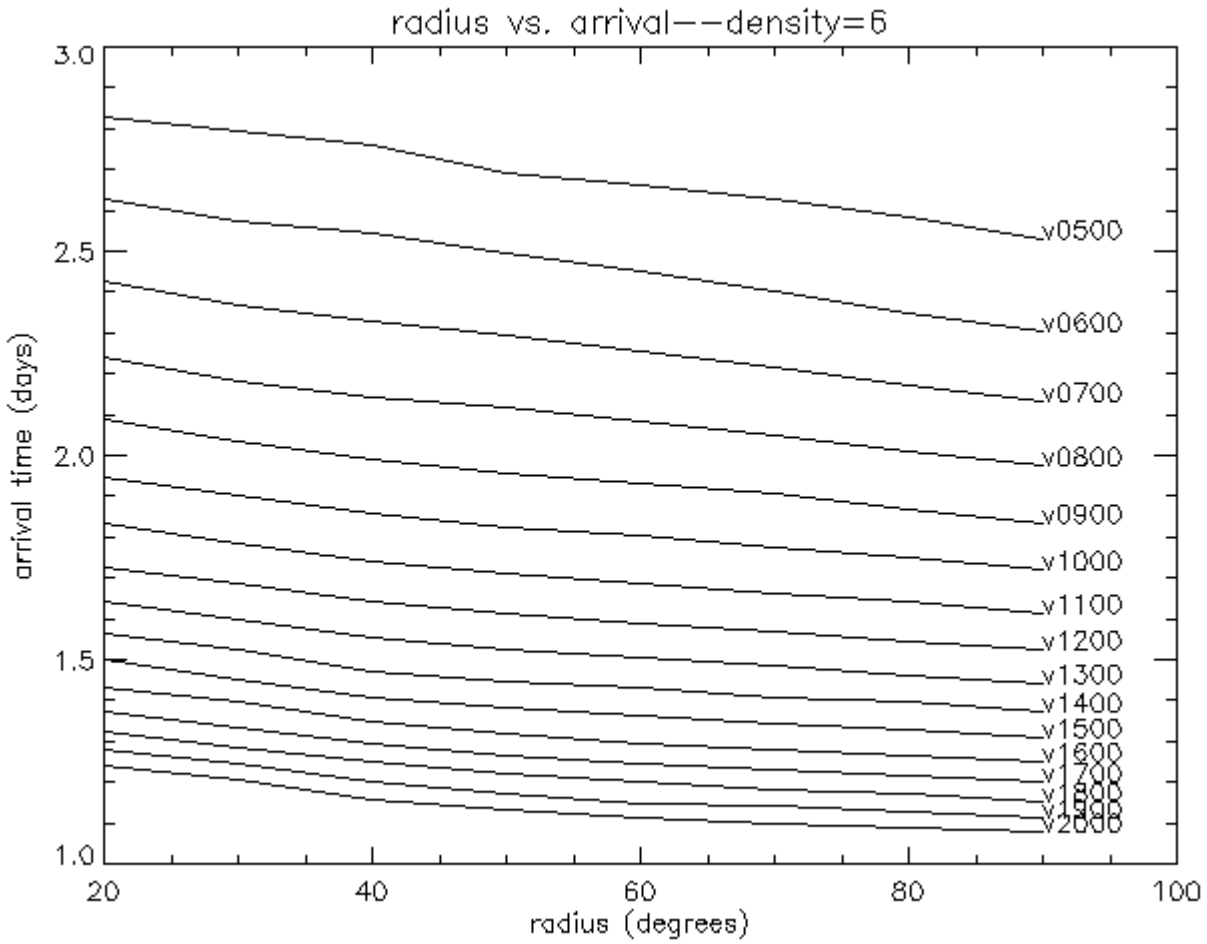
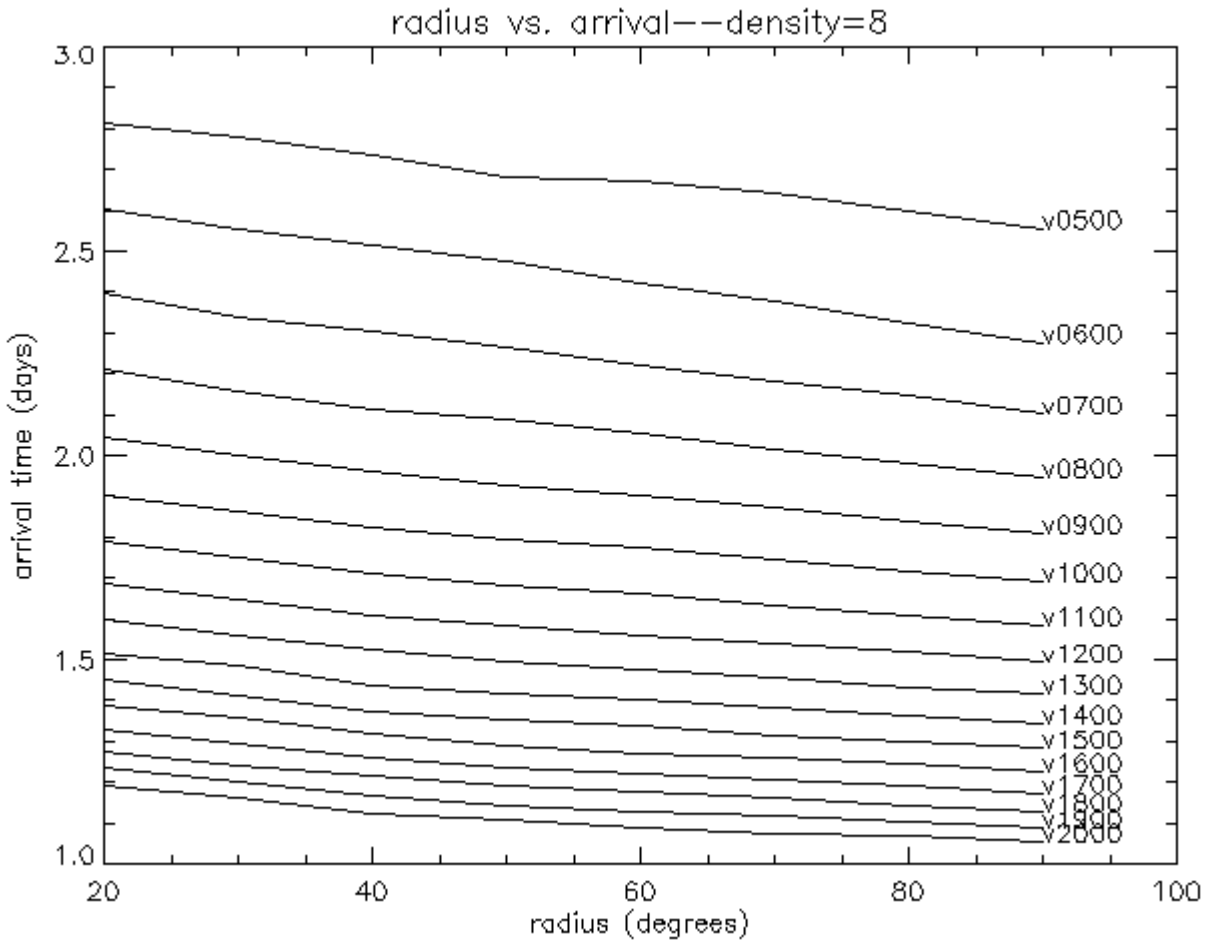


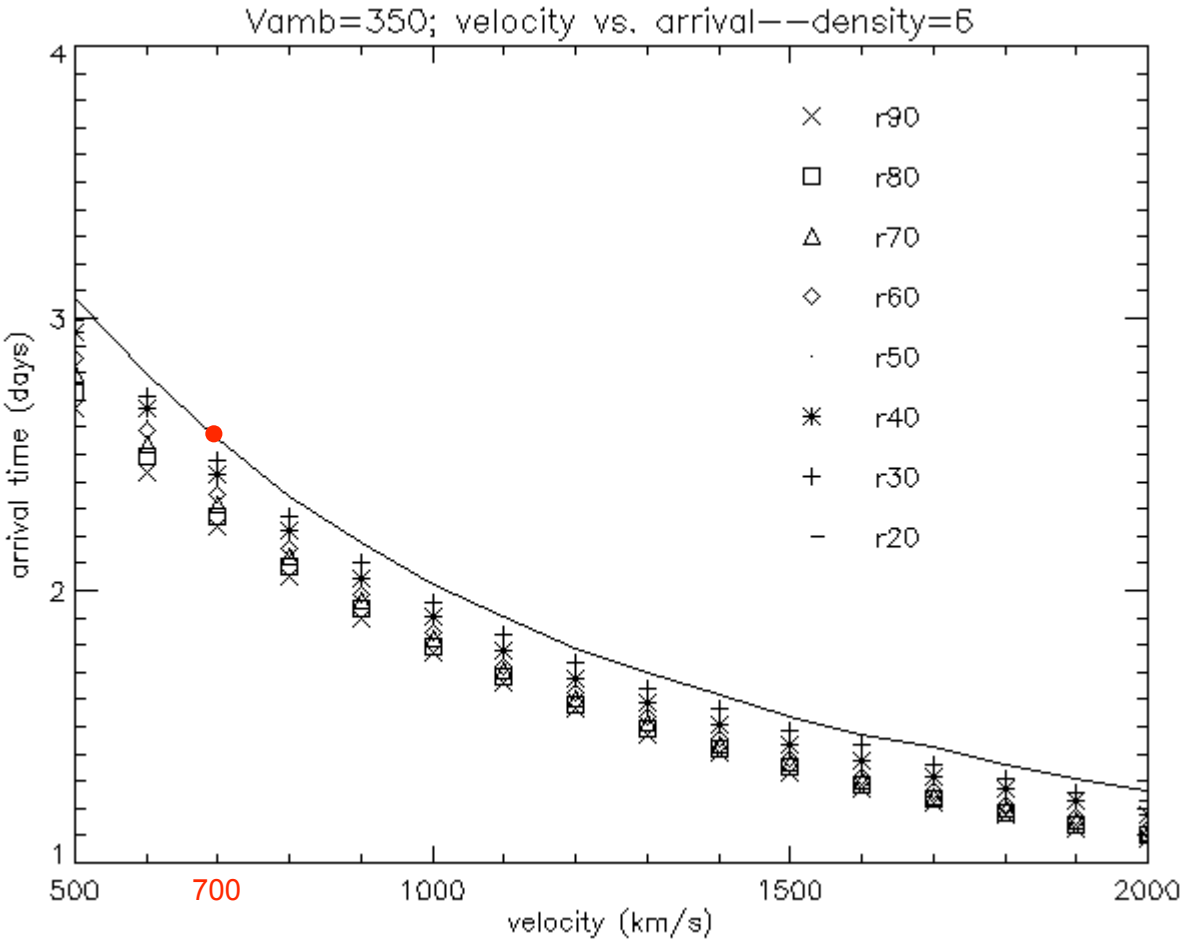
Radius vs. time



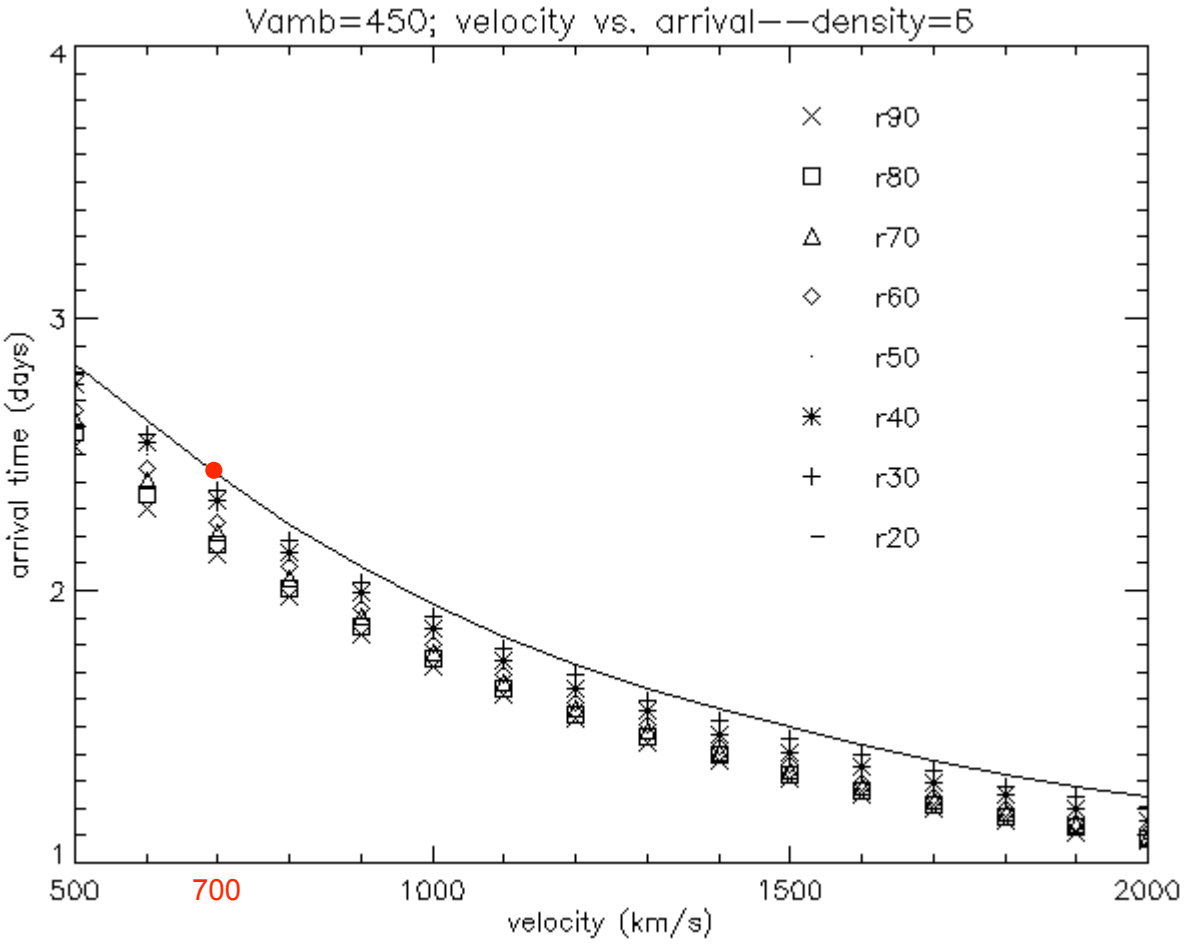
Radius vs. time



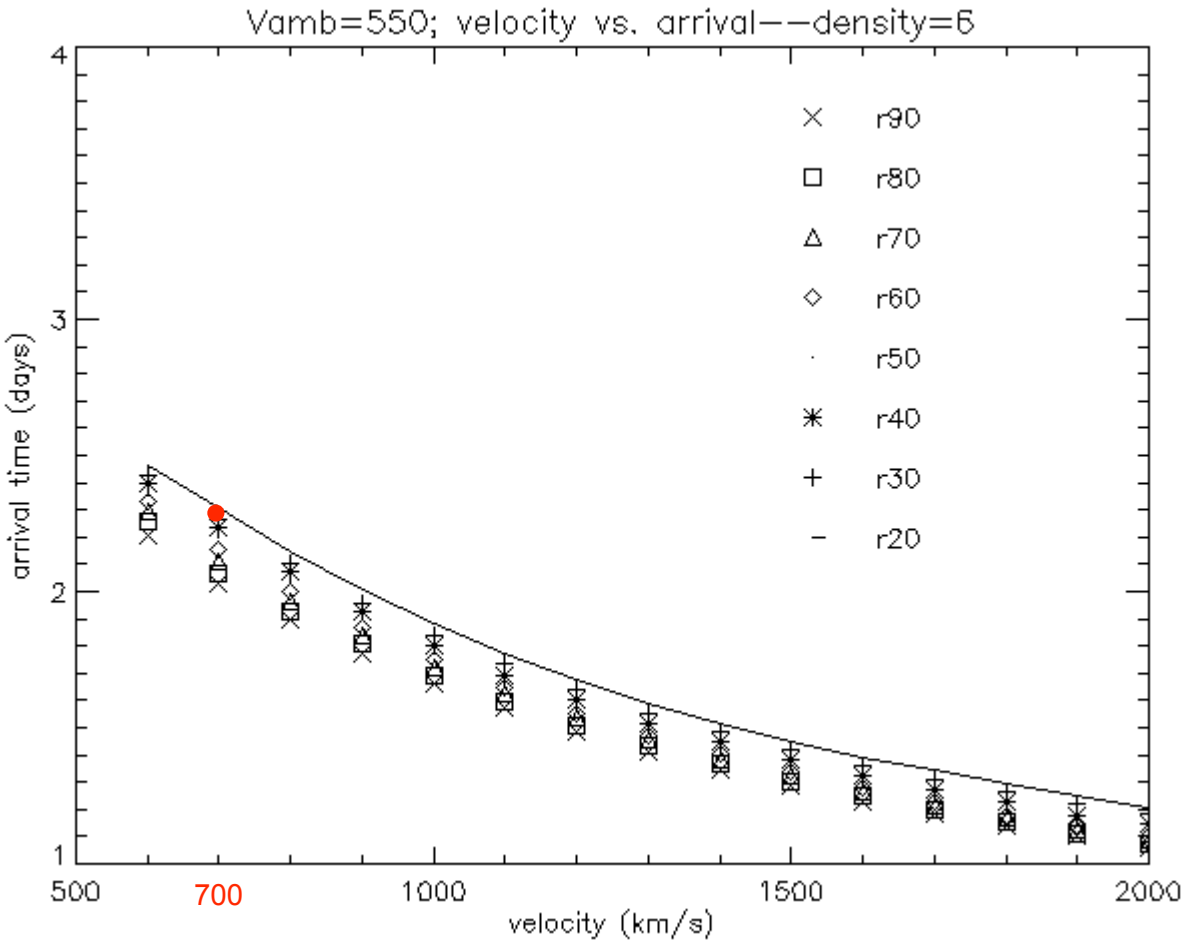
Varying the solar wind velocity (Vamb)
Vamb=350 km/s; arrival time ≈ 2.6 days



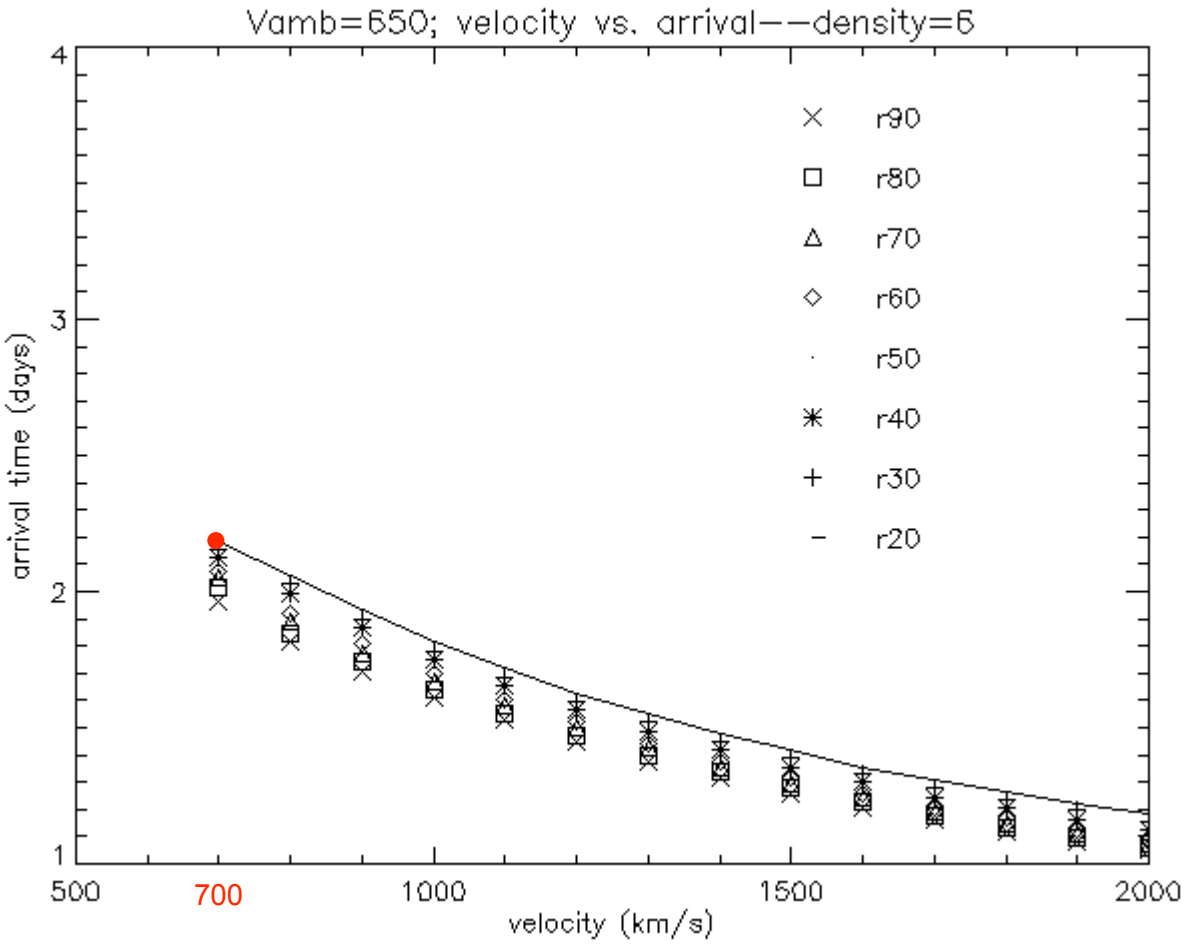
Varying the solar wind velocity (Vamb)
Vamb=450 km/s; arrival time ≈ 2.45 days



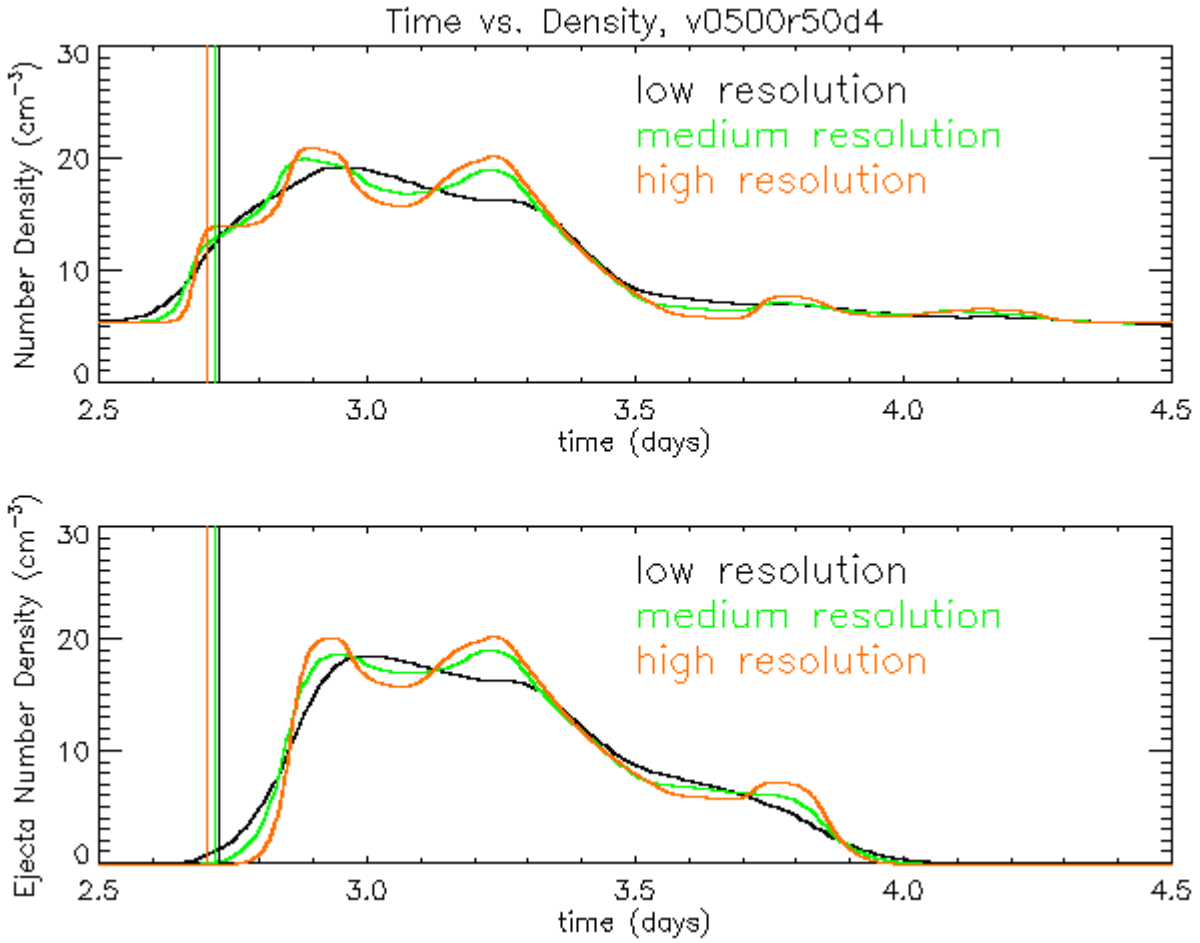
Varying the solar wind velocity (Vamb)
Vamb=550 km/s; arrival time ≈ 2.3 days



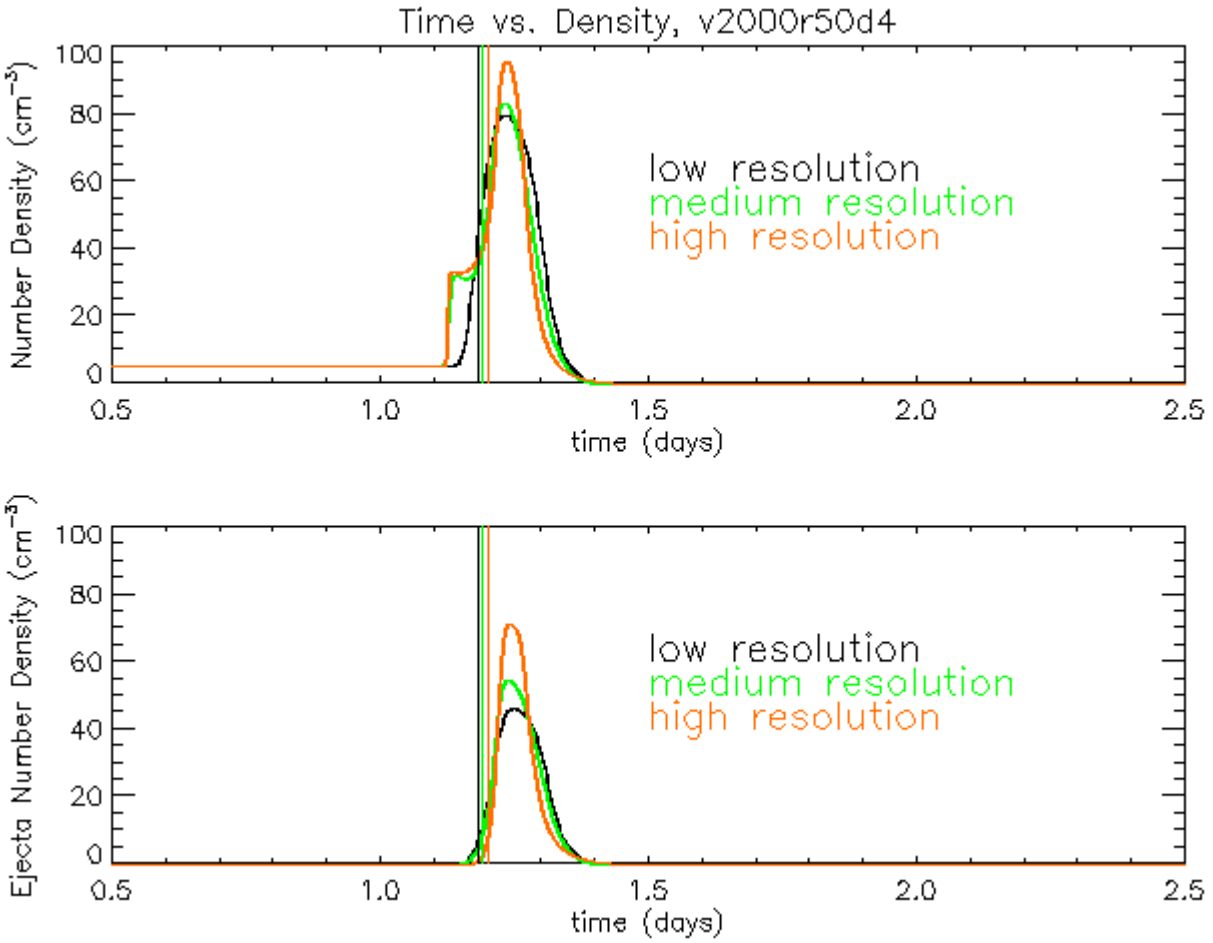
Varying the solar wind velocity (Vamb)
Vamb=650 km/s; arrival time ≈ 2.2 days



Time vs. Density—varying resolutions



Time vs. Density—varying resolutions



Future goals

- Compare results with observed data
- Derive an empirical forecasting model in which given a known density, radius, and velocity, arrival time can be predicted