Evolution of CMEs in the Heliosphere

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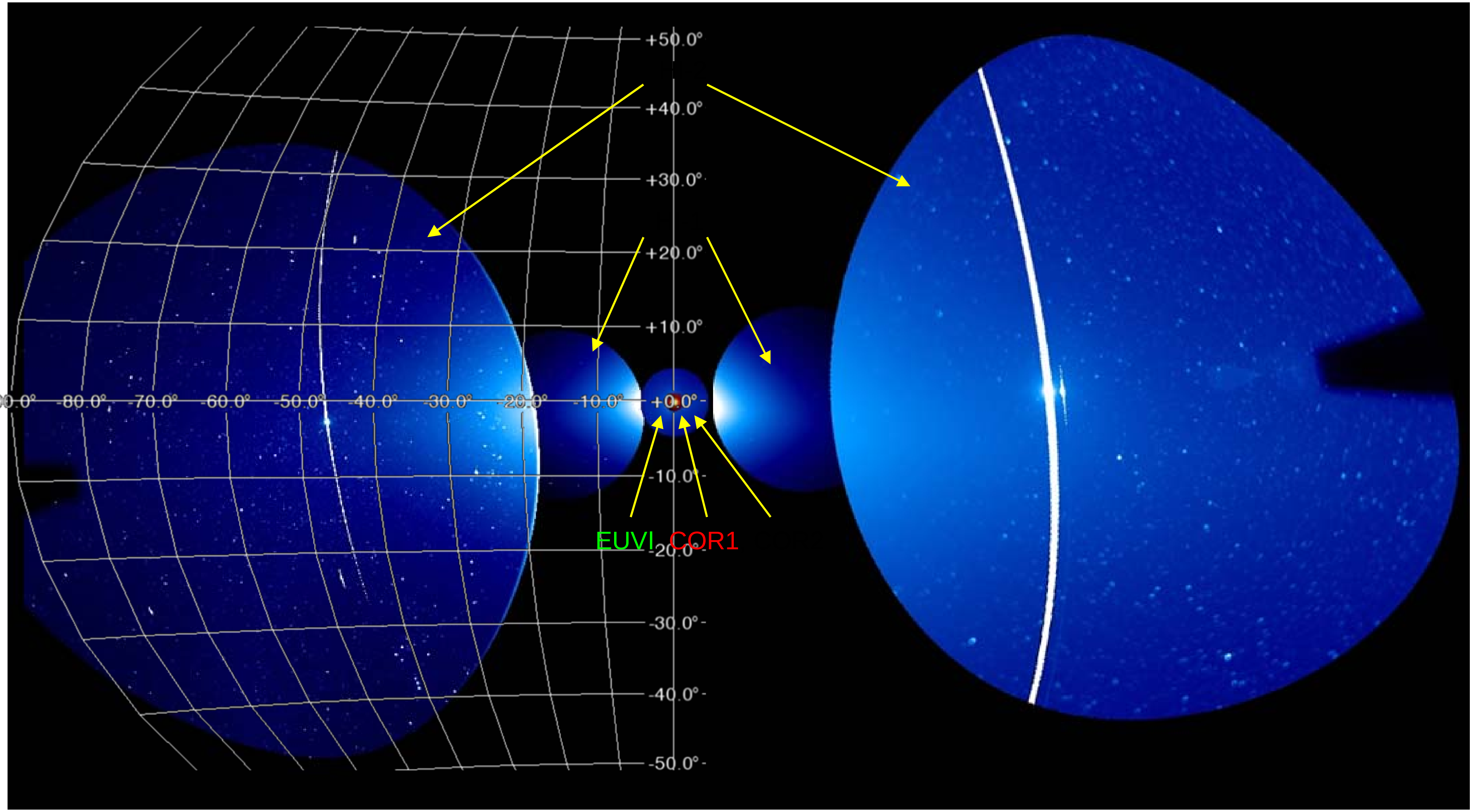
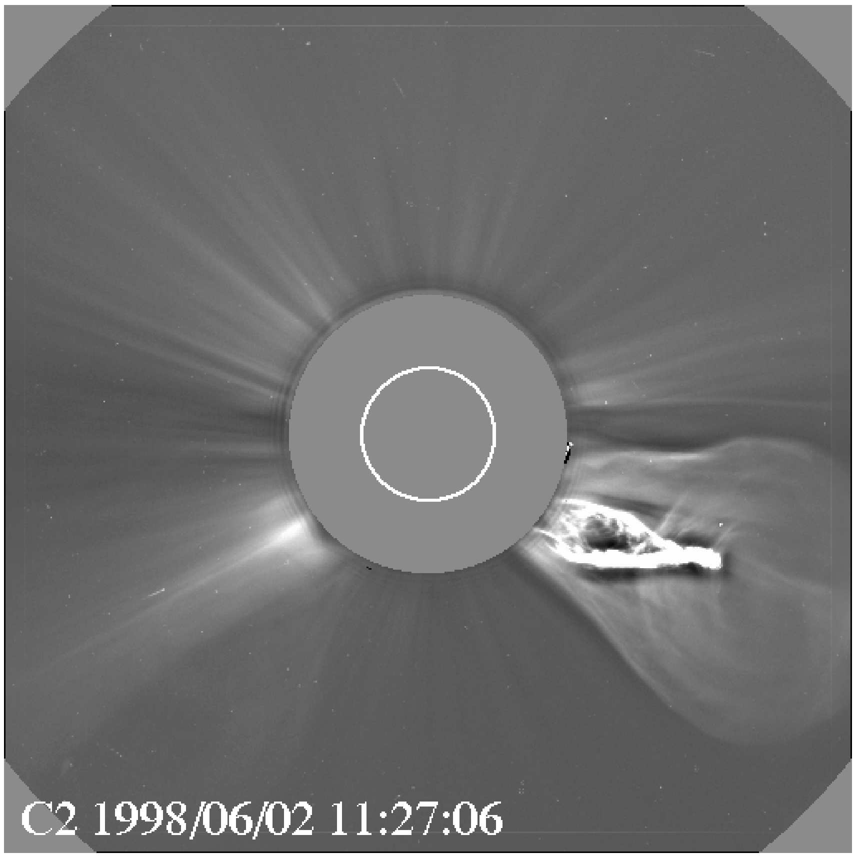
SECCHI Panoramic View of the Heliosphere

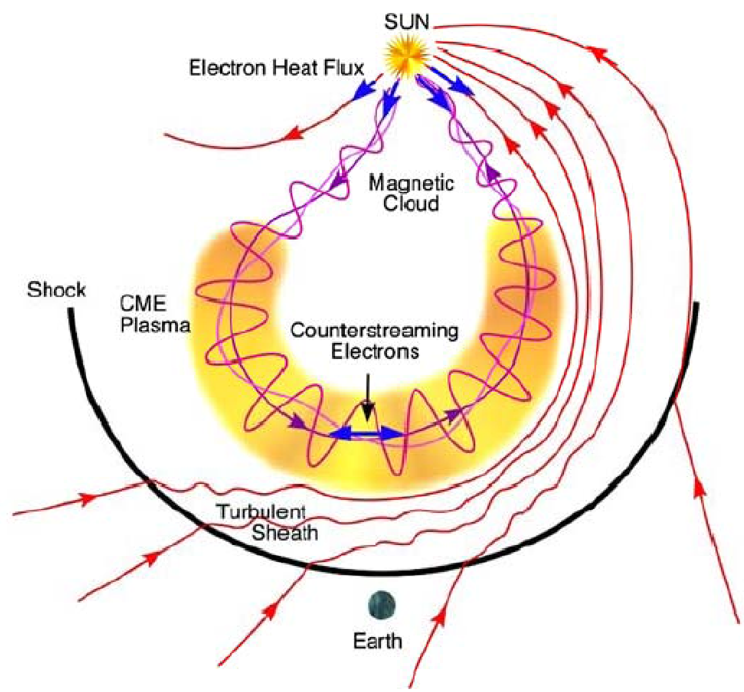


Science Objectives

- How does the structure of CMEs evolve as they propagate through the inner heliosphere?
- How do the features of ICMEs observed in-situ reflect their solar origins and the appearance of CMEs in remotely sensed imaging data?
- How are CMEs accelerated and/or decelerated as they propagate from the Sun to 1 AU and beyond?
- We intend to address these questions using a combination of remote sensing (SECCHI) and in-situ (IMPACT/PLASTIC/ACE) observations and MHD modeling (MAS/ENLIL)

Evolution of CME Structure

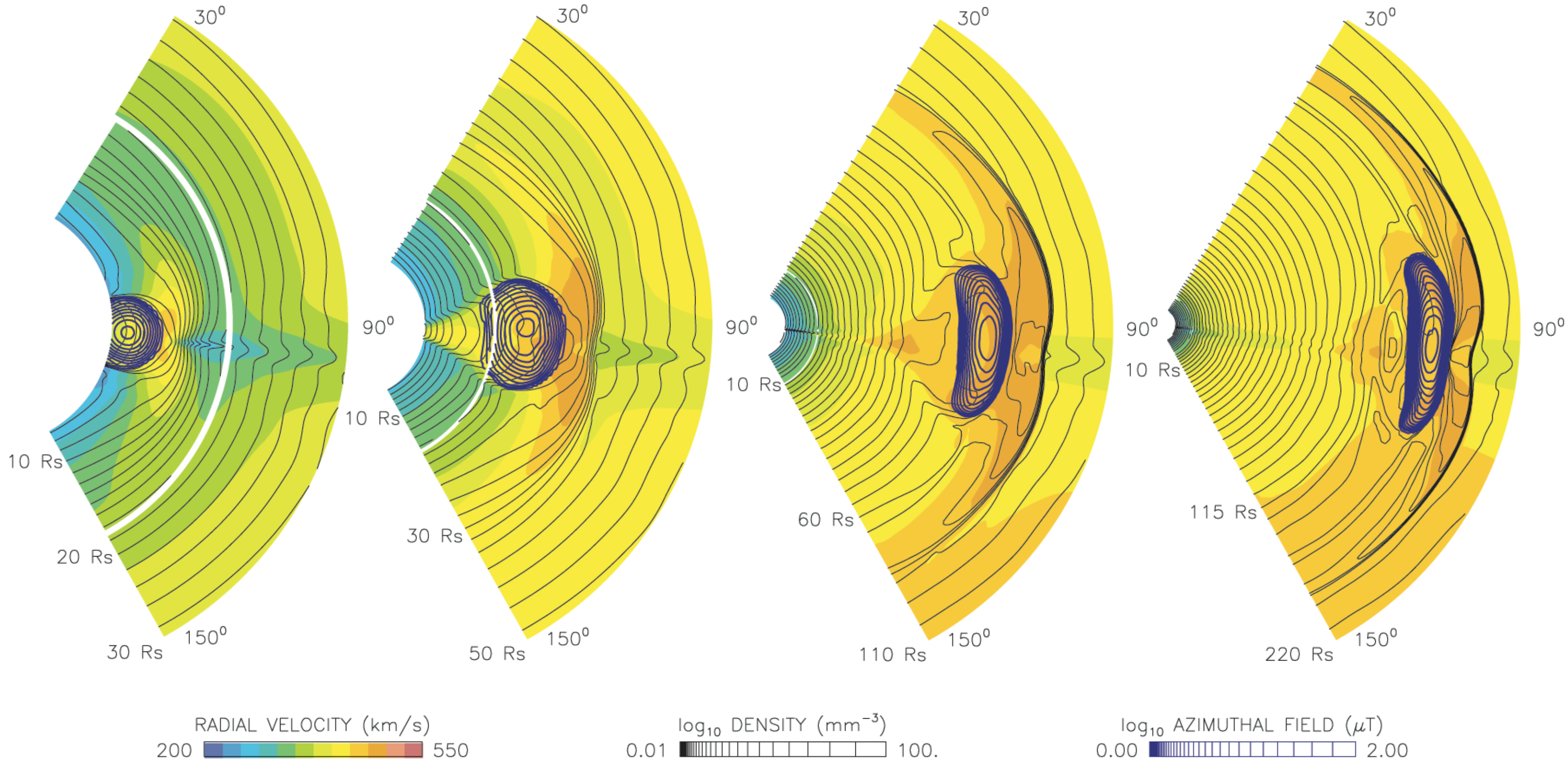




Zurbuchen & Richardson (2006)

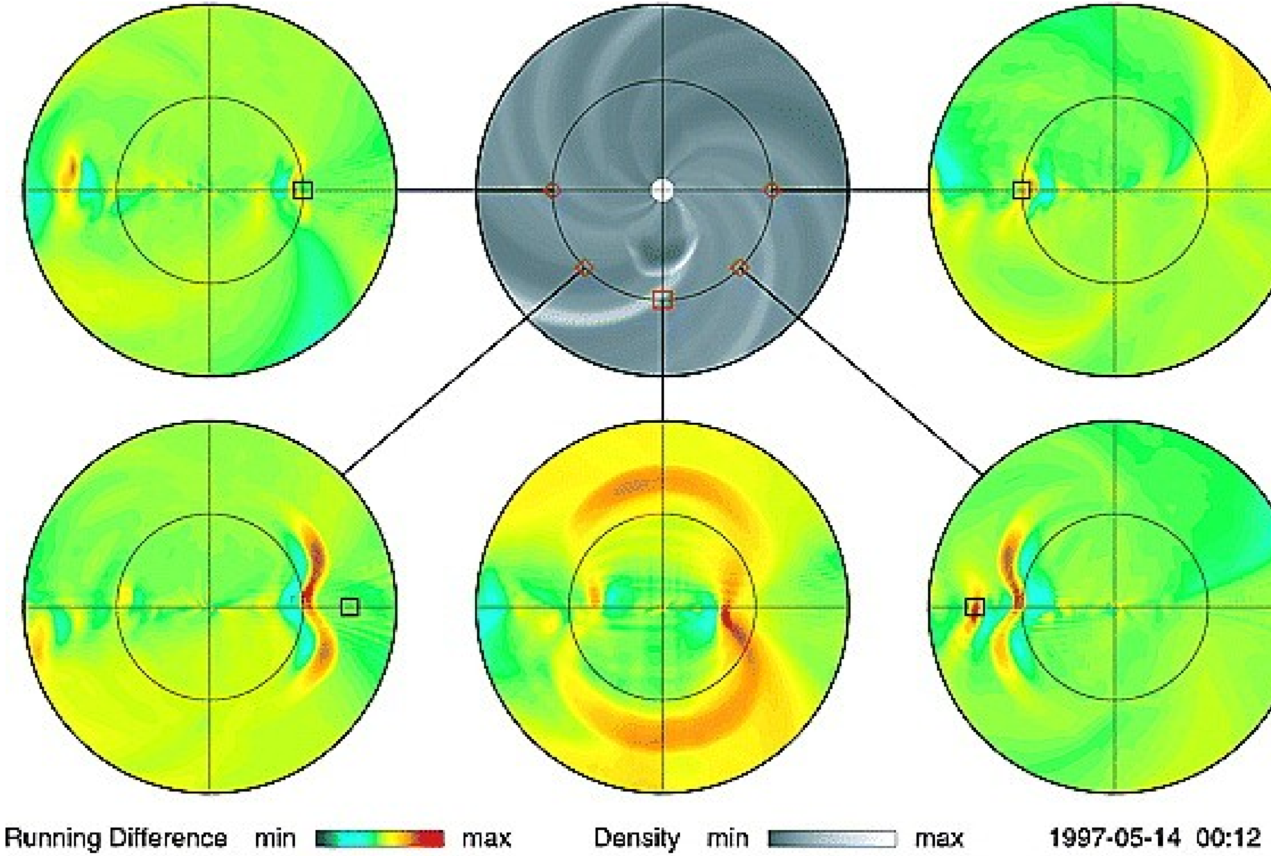
How does this……………………….………….become this?

Coupled Coronal and Heliospheric Codes



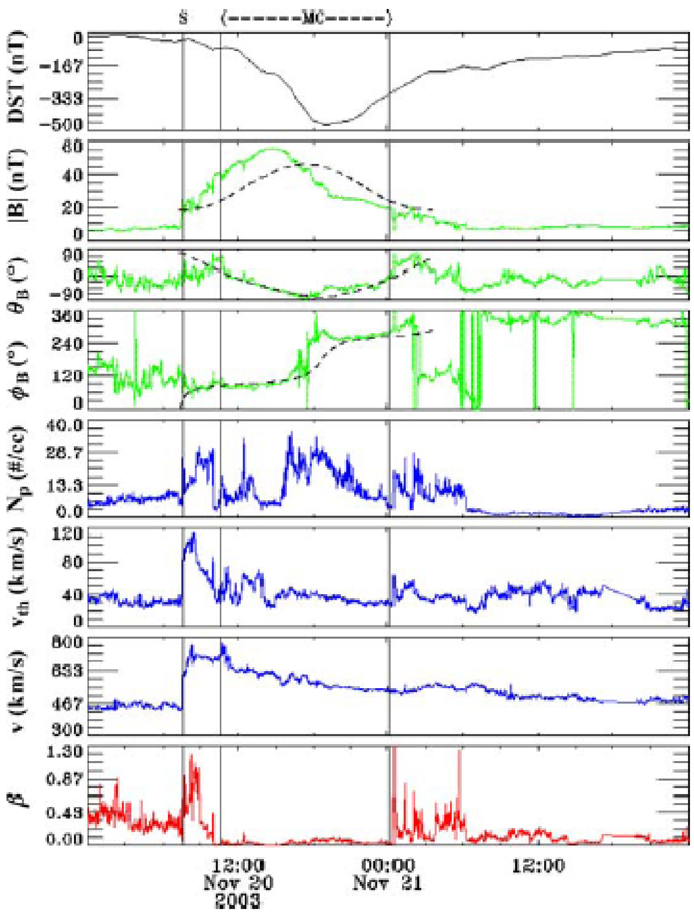
Propagation of an idealized flux rope through the coronal model and into the heliospheric model. The initially simple, circular flux rope structure has been distorted by 1 AU, and a pressure wave ahead of the flux rope has steepened into a shock (Riley et al 2003).

Model and Data Comparisons



Synthetic running difference images of white light brightness for the May 12, 1997 event, showing how the event would appear when viewed from spacecraft at five different locations at 1 AU in the ecliptic plane (Odstrcil et al 2005).

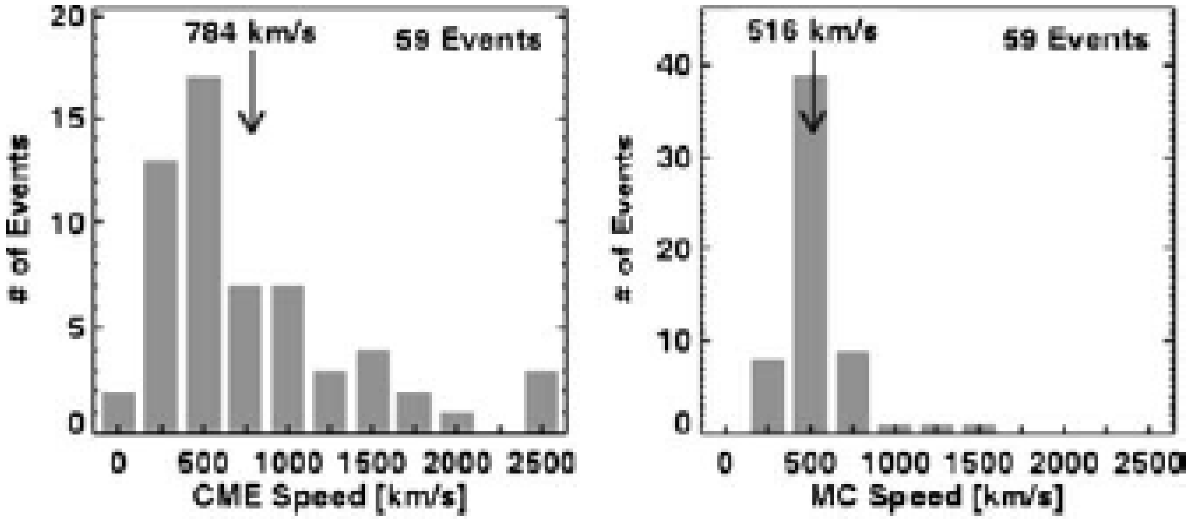
In-Situ vs Remote Sensing Observations



Gopalswamy (2006)

- How do in-situ plasma and magnetic field signatures relate to CME structure from remote sensing observations?
  - Which part of the CME corresponds to the magnetic cloud?
  - Why is the bright prominence core rarely seen at 1 AU?
  - How can multi-point in-situ measurements of different parts of the ICME structure be understood?

CME/ICME Speeds



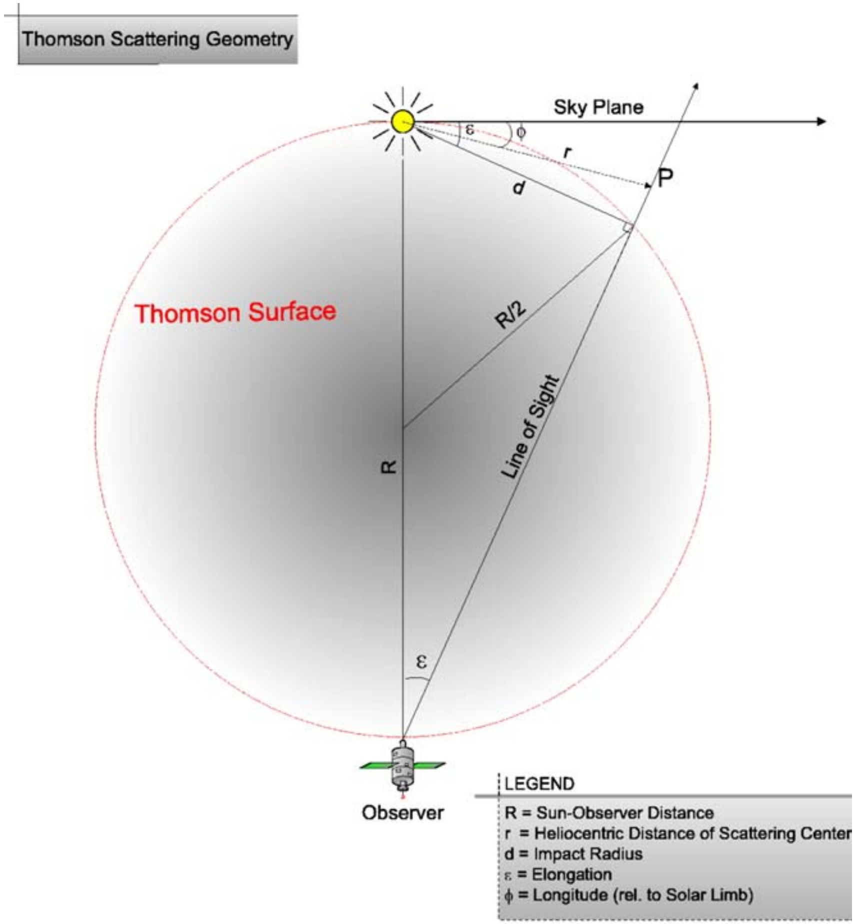
Gopalswamy (2006)

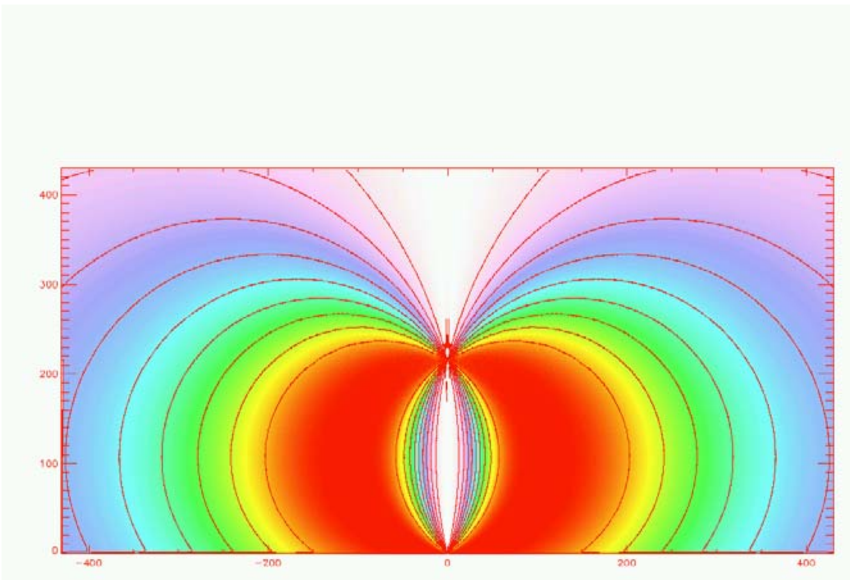
- It is well known that fast CMEs tend to decelerate and slow CMEs tend to accelerate towards the asymptotic solar wind speed.
- However, the velocity and acceleration profiles of CMEs beyond about 30 $R_\odot$ are not well understood.
  - Empirical models for predicting arrival of ICMEs at 1 AU based on near-Sun observations have accuracies of $\pm$ 12 hours at best.

Data Selection and Analysis

1. Select CMEs that are well-observed by SECCHI, particularly HI, and that occur in spatial and temporal isolation from other CMEs.
2. Identify CMEs with three-part structure in SECCHI coronagraphs.
3. Select events with a clear magnetic cloud or flux rope signature from *in situ* data.
4. Expect about 30 events per year on the Earthward side of the Sun.
5. Select up to 5 events per year for detailed analysis and modeling.
   i. Focus on Earth-directed events viewed broadside by both STEREO spacecraft at moderate separations.
      a. Multi-point remote and in-situ observations of the same event
      b. Combine STEREO, ACE and WIND observations.
   ii. Focus on events observed in near-quadrature at larger separations.
      a. Broadside and head-on remote observations of the same event from two STEREO spacecraft.
      b. Remote observations of event from one STEREO spacecraft as it passes over the other spacecraft.

Thomson Sphere: Visibility Effects





Scattering efficiency contours for total B, Ranging from 10% (white) to 90% (red).

SECCHI HI-1A Observations: April 2007