



# The Geometric Localization of STEREO CMEs

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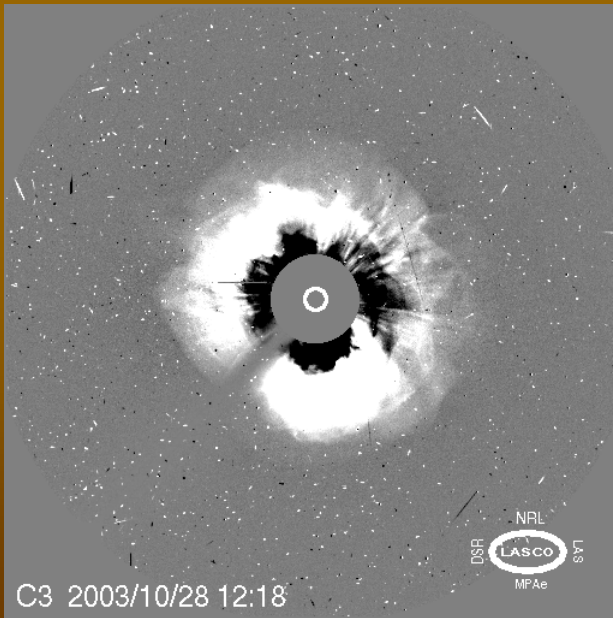


# Geometric Localization Technique

- What 'Geometric Localization' (GL) does
  - Given observations of any structure from 2 different places
    - at the same time if a transient structure
    - It works on 'any' structure for which an 'edge' is visible
  - *GL defines a volume which circumscribes that structure*

# WHY Concentrate upon CMEs?

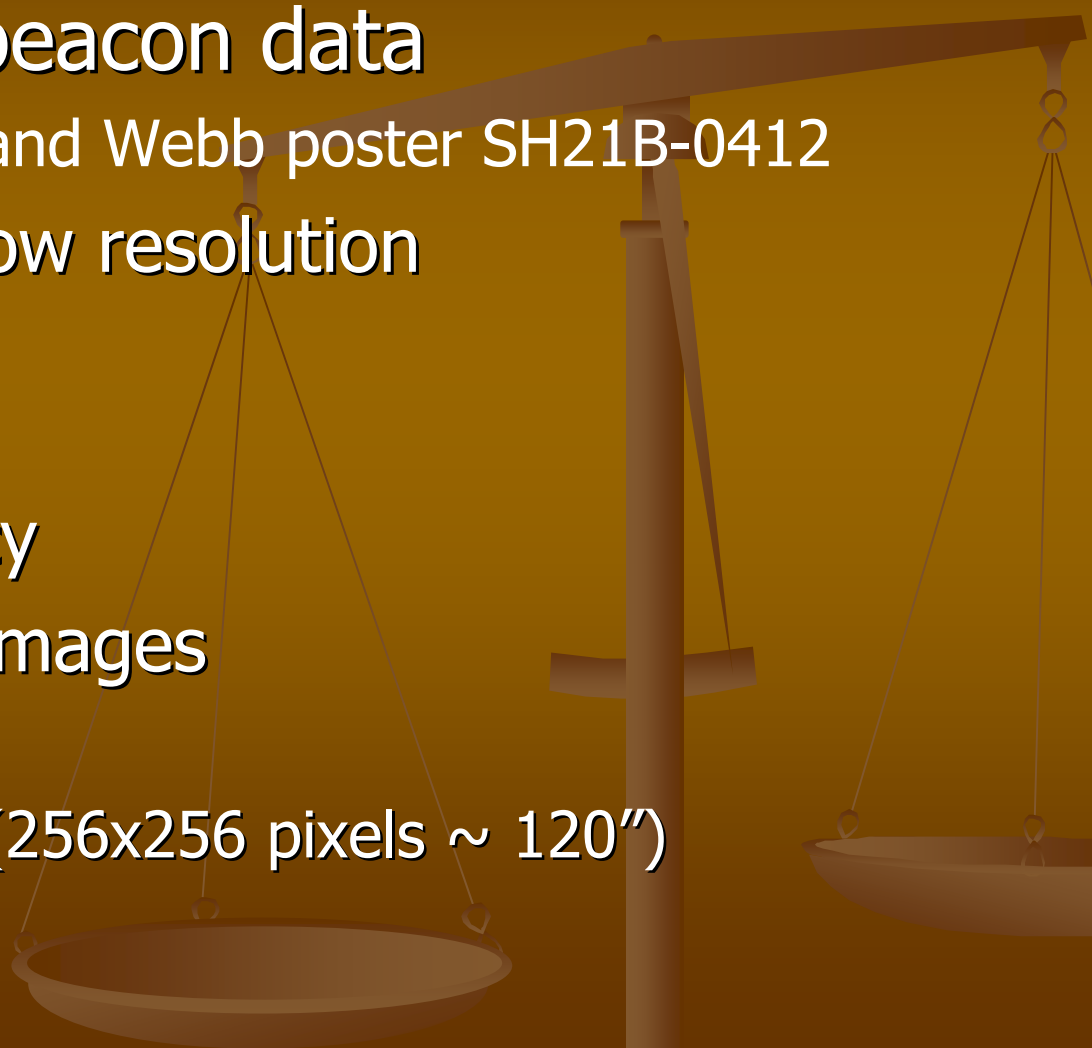
- Forecasting (Geomagnetic Storms)
  - currently use single observatory (halo/non-halo)
  - Estimate – if Earth impact; when; how strong?
- STEREO can improve this
  - Vastly improved estimate of Earth-directed CME properties → geomagnetic disturbances
  - Improved knowledge of coronal and interplanetary structures along E/S line



# Geometric Localization Technique

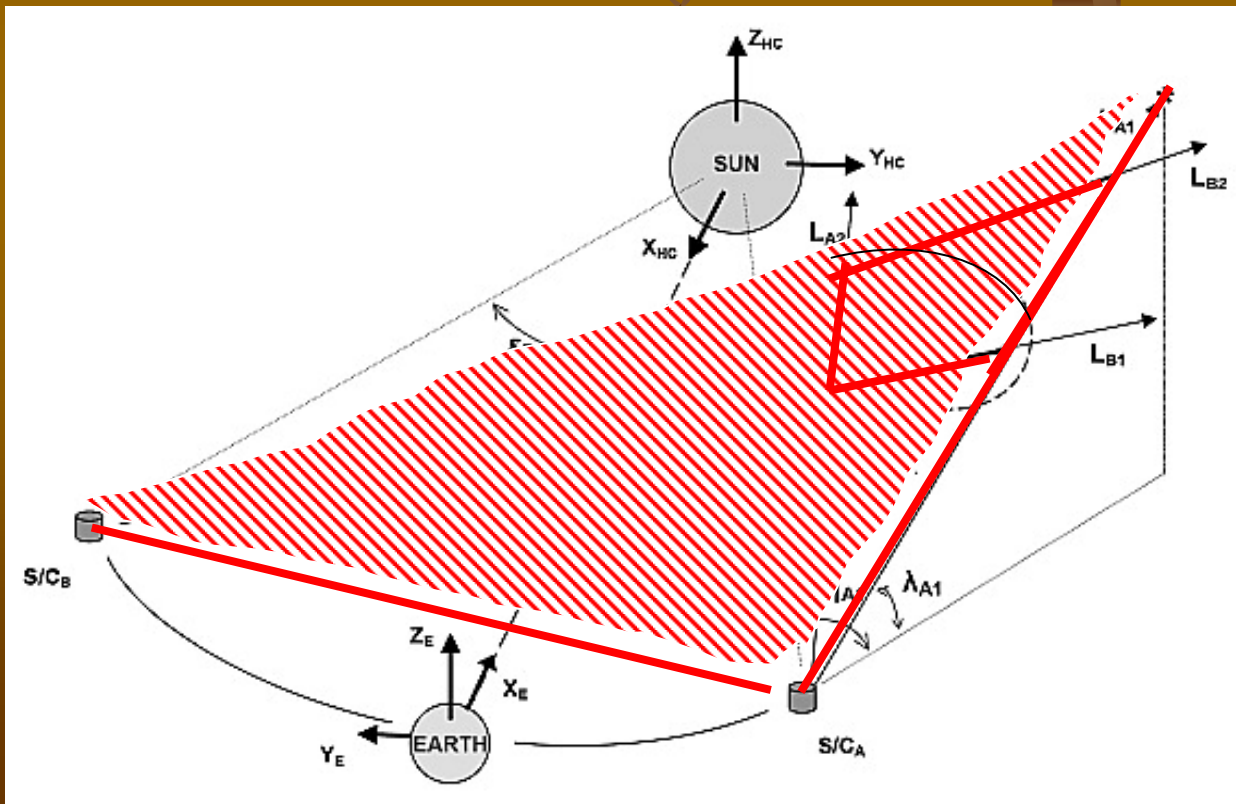
- How will this be implemented for STEREO?
  - Start by simulating STEREO data
    - 2 views of CME's don't yet exist
    - We generate CME model
      - Parameterized coronal background and transient
    - Apply our 'geometric' technique
      - Results in a set of stacked quadrilaterals that bound the CME
  - Compare results to input model

# STEREO Beacon Data

- 24/7 real-time beacon data
    - See Biesecker and Webb poster SH21B-0412
  - Low-cadence, low resolution
    - in-situ
    - imaging
  - 5-minute latency
  - SECCHI/COR2 images
    - 4x per hour
    - 1/8 resolution (256x256 pixels  $\sim$  120")
- 

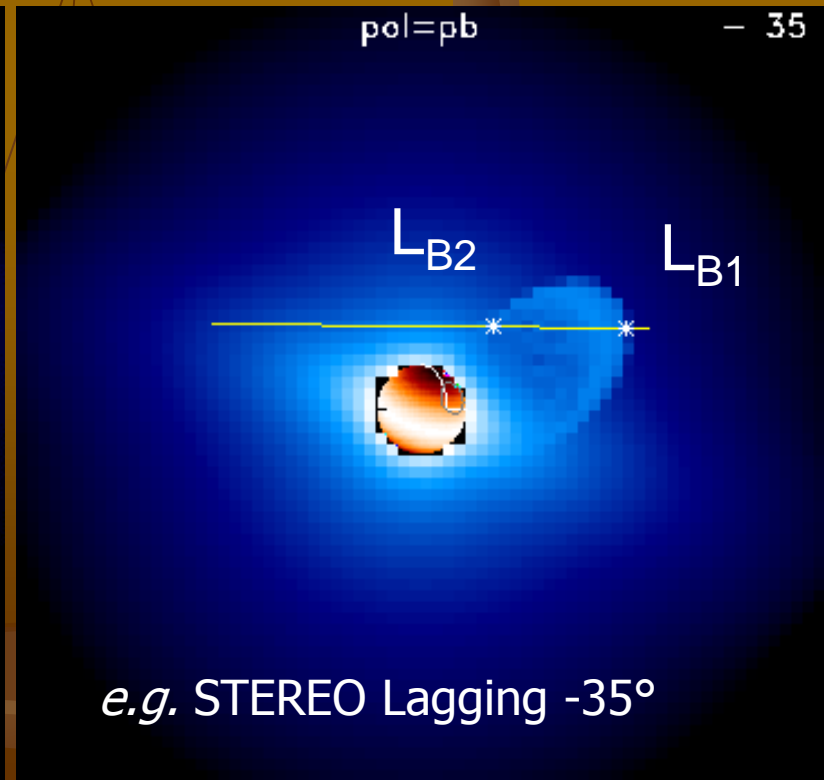
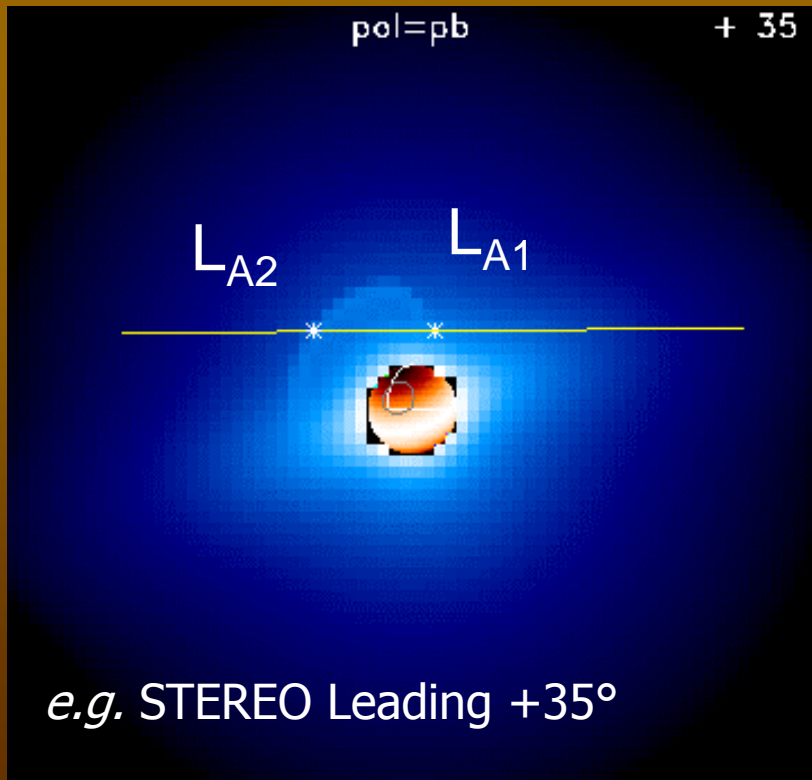
# Schematic of 'Geometric Localization' Technique

- Need location of 2 spacecraft
  - Defines a plane
- Need location of 'edges' of CME
  - Defines a quadrilateral circumscribing CME



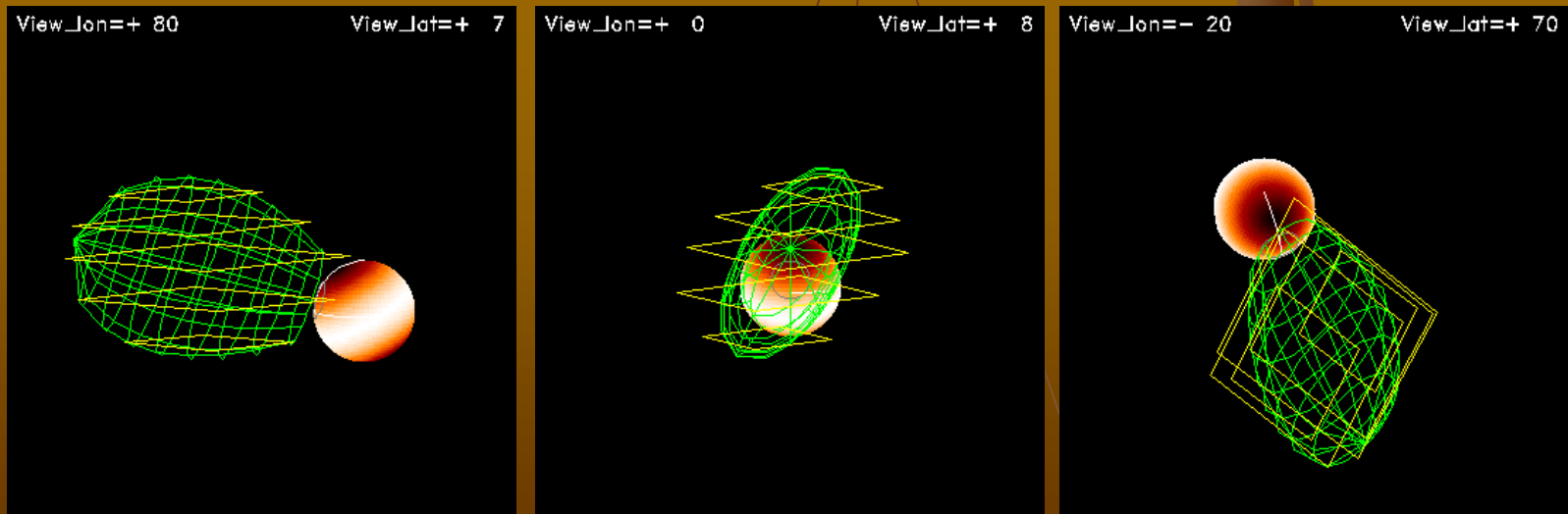
# Applying the technique

- Mark one edge –  $L_{A1}$ 
  - s/c – s/c – Sun plane: defines a line
  - Mark  $L_{A2}$ ; and then in other s/c image mark  $L_{B1}$  &  $L_{B2}$
- Choose a succession of starting points – thin slices



# The Resulting Localization

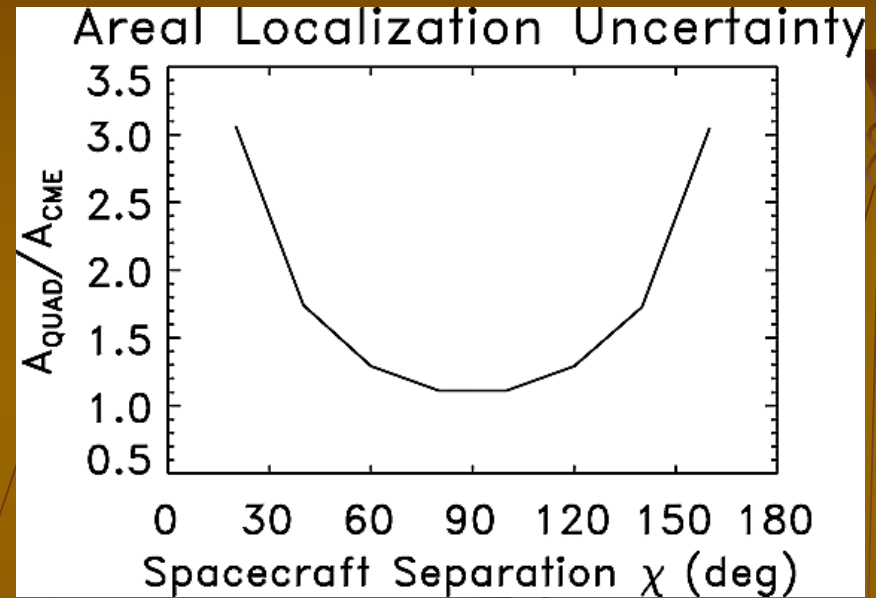
- Comparison of localization model to input CME
  - 3 perspectives
  - Geometric Localization circumscribes input CME





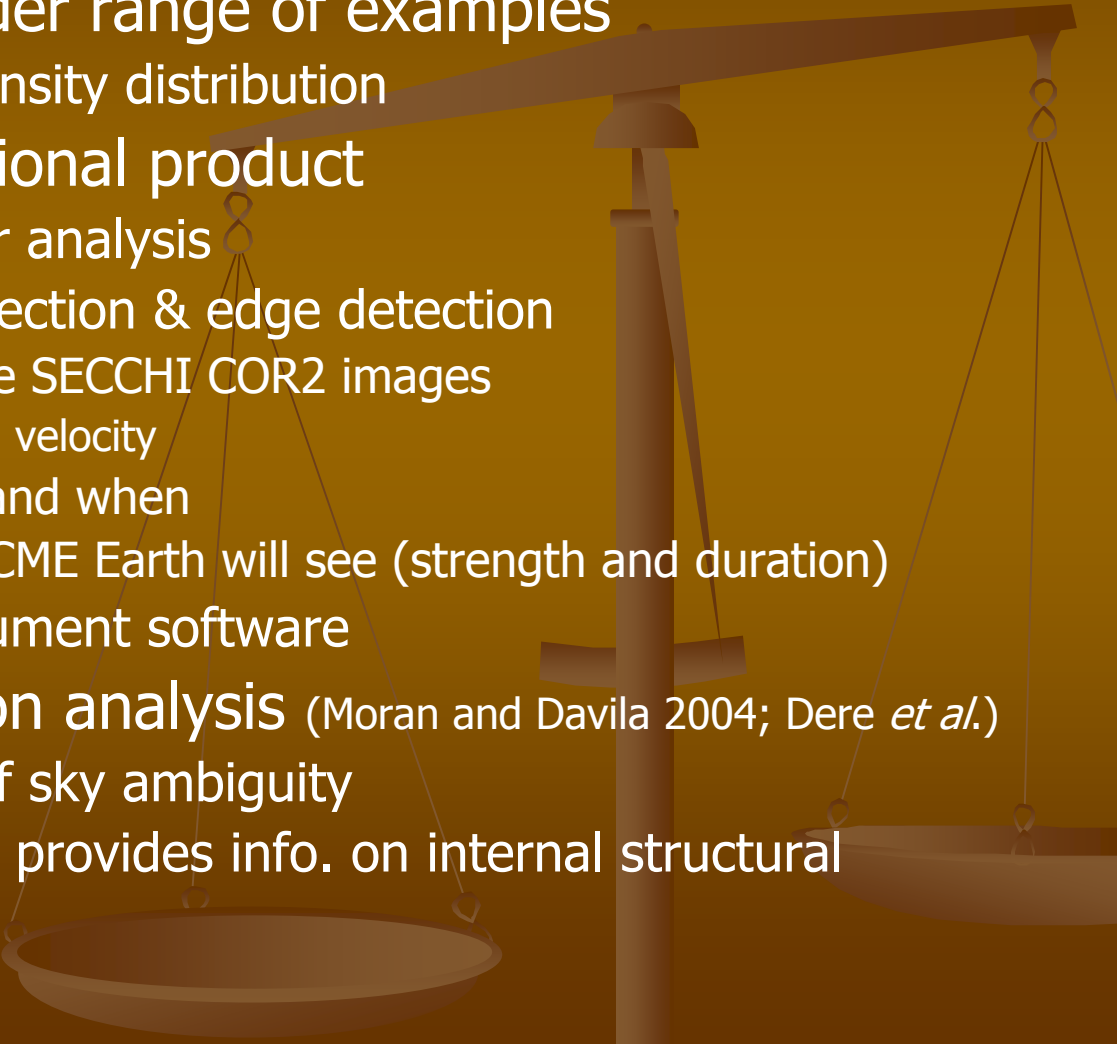
# How well does it work?

- One measure of error
  - Ratio of area determined by GL to area of input CME  $\sim f(X)$
  - Quantifiable – critical for forecasters
- Ideal separation  $90^\circ$ 
  - Two years into mission
- Reasonable uncertainty (<50%)
  - Year 1 to Year 3



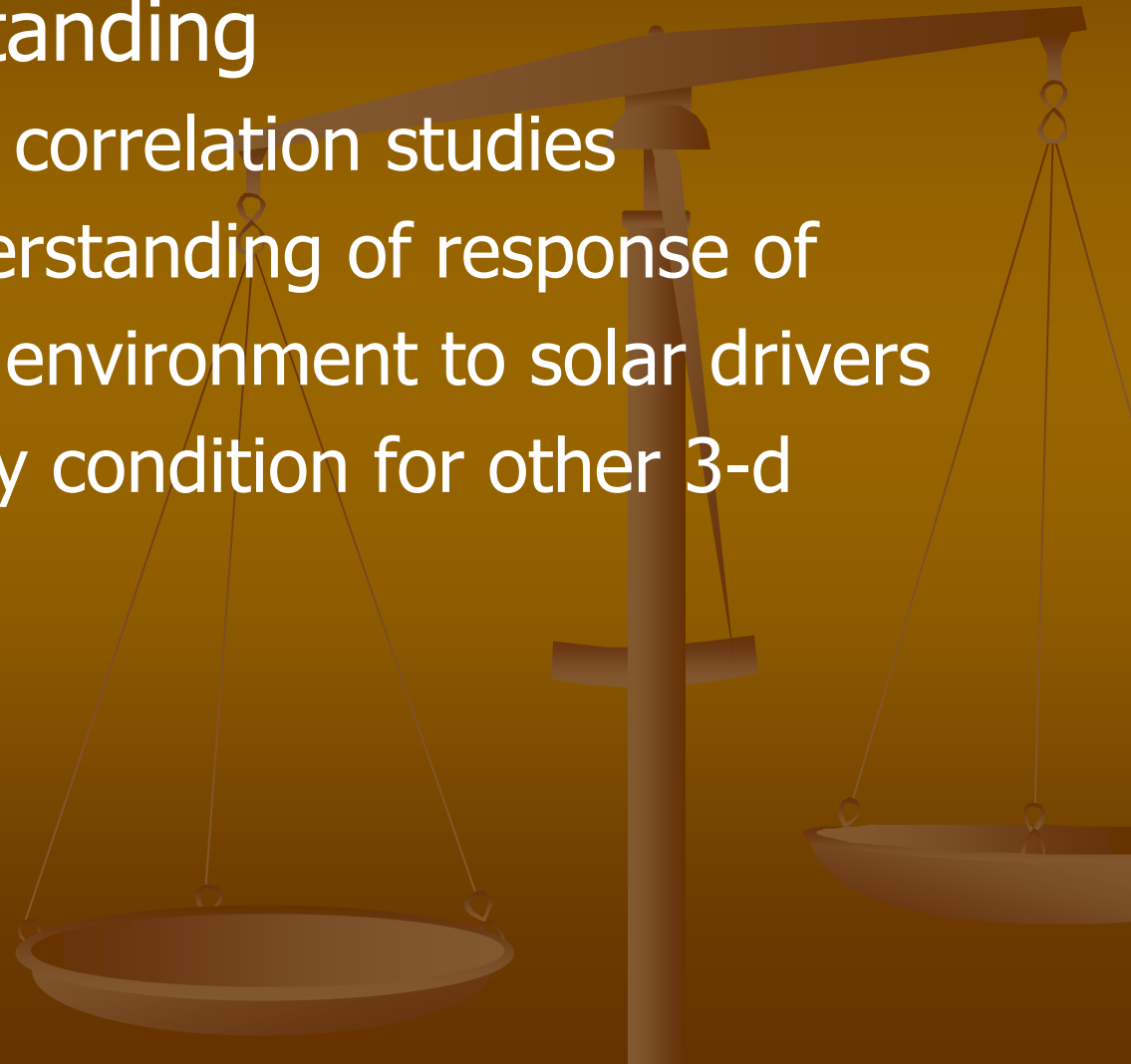
Comparing area of cross-section of model to cross-section of CME

# Planned additional work

- Explore much broader range of examples
    - Vary CME shape, density distribution
  - Making it an operational product
    - Improve/refine error analysis
    - Automated CME detection & edge detection
      - Apply to successive SECCHI COR2 images
        - Location, extent, velocity
      - If CME will arrive and when
      - How much of the CME Earth will see (strength and duration)
    - Streamline and document software
  - Relate to polarization analysis (Moran and Davila 2004; Dere *et al.*)
    - GL removes plane of sky ambiguity
    - Polarization analysis provides info. on internal structural
- 

# Additional work - continued

- Science/understanding
  - Major boost to correlation studies
  - Improved understanding of response of interplanetary environment to solar drivers
  - Input/boundary condition for other 3-d techniques



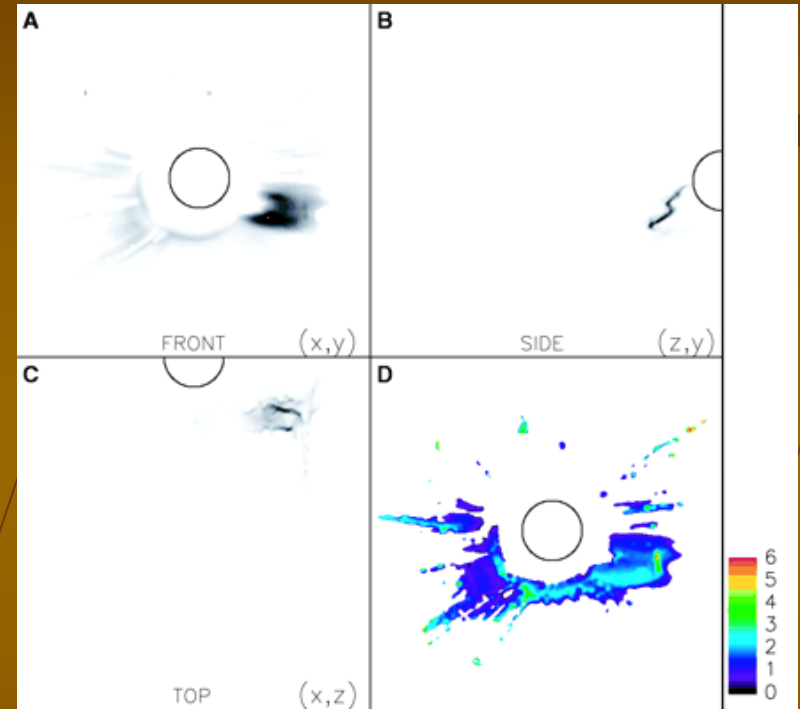
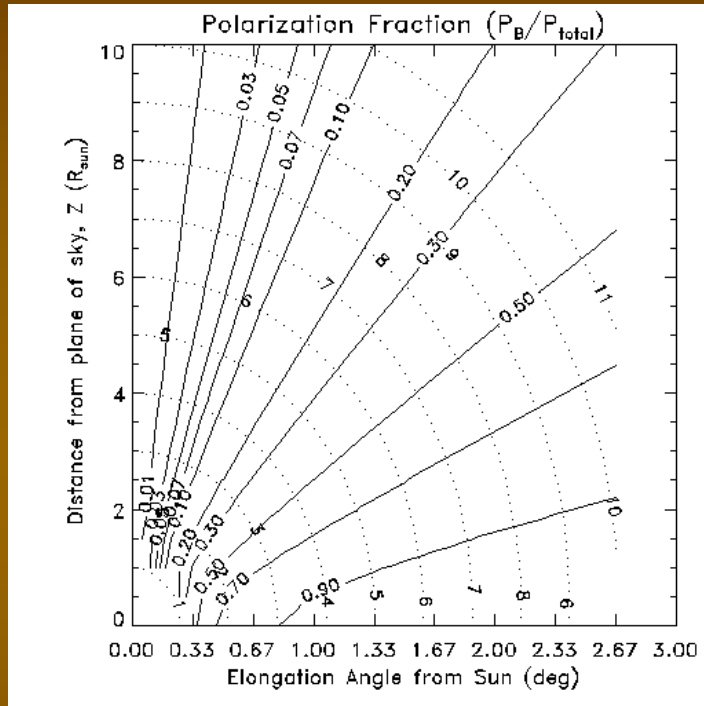
# Summary

- Geometric localization provides a 'simple to use' technique
  - Potential for automation
  - Application to CME's aids in forecasting geomagnetic storms
    - From length of cut through CME on Sun-Earth line
      - Improved prediction of if/when CME will hit Earth
      - Information on storm strength/duration
    - Quantifiable error estimates
      - Adding a 3<sup>rd</sup> view helps significantly (*e.g.* SOHO/LASCO)
    - Implementation in time for start of STEREO mission expected
- **Therefore, ideal for forecasting!**
- Useful for collaborative scientific investigation
  - *e.g.* Polarization Analysis

# Backup slides

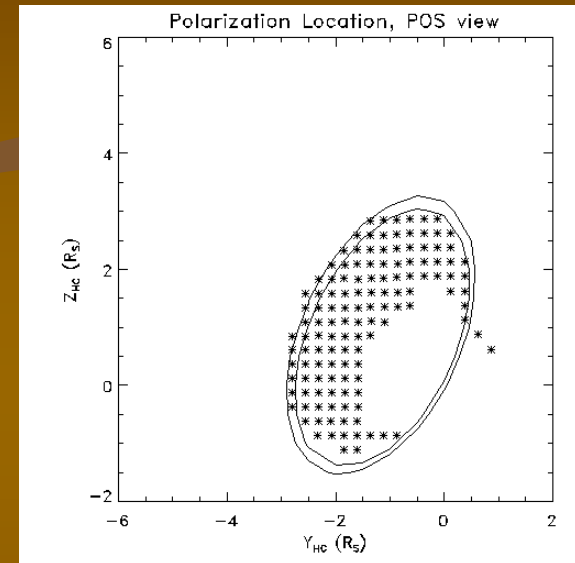
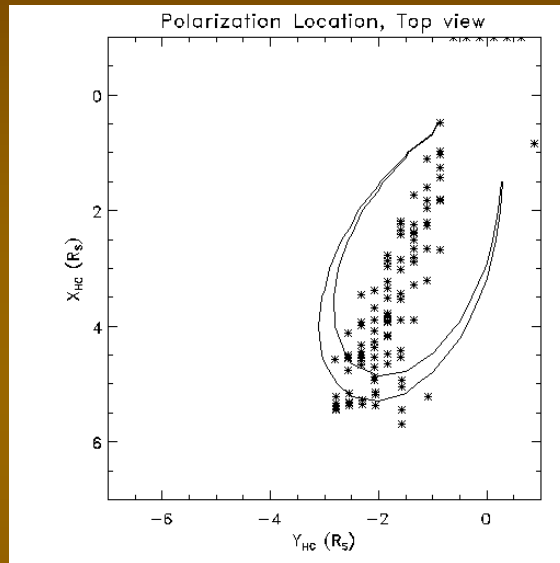


# Polarization Analysis

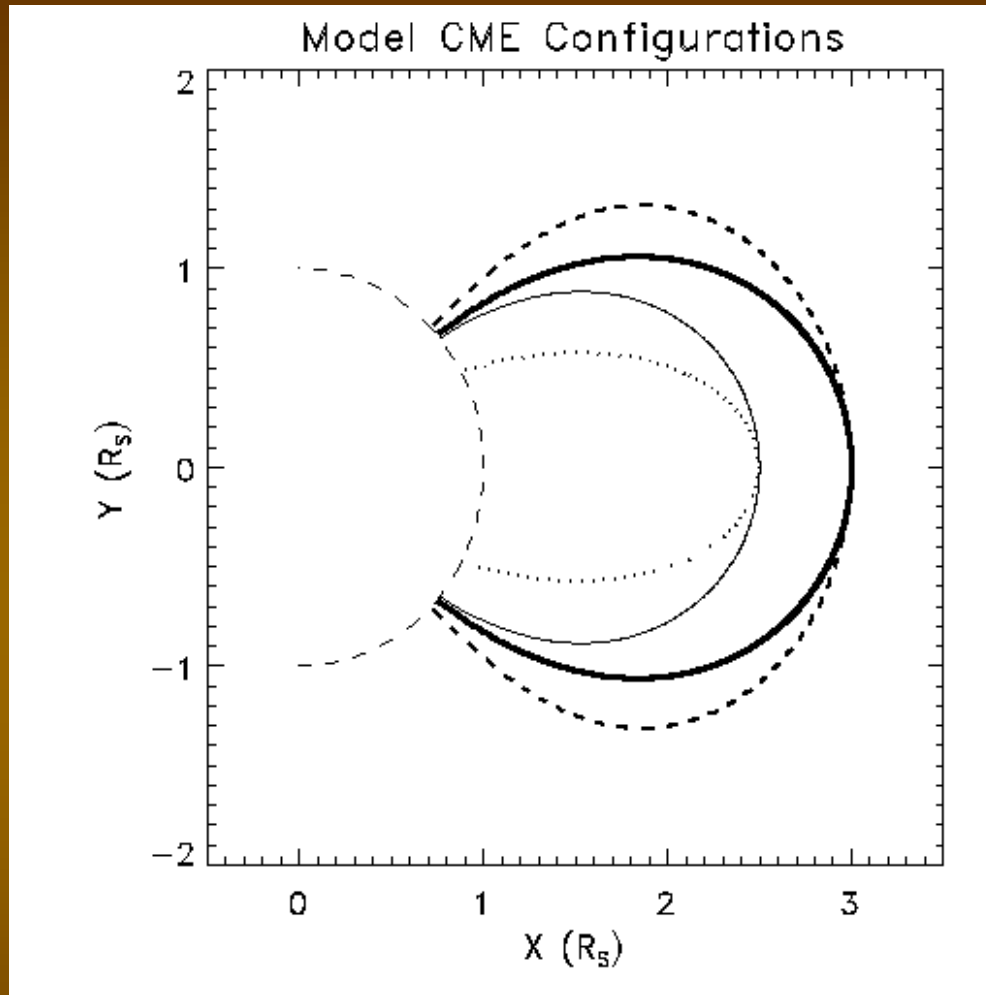


- On a pixel by pixel basis – finds C.O.M. along a line of sight
  - Collapses a 3-d structure into  $\sim 2.5$ -d
  - Gives spatial information

# Polarization Analysis + Geometric Localization



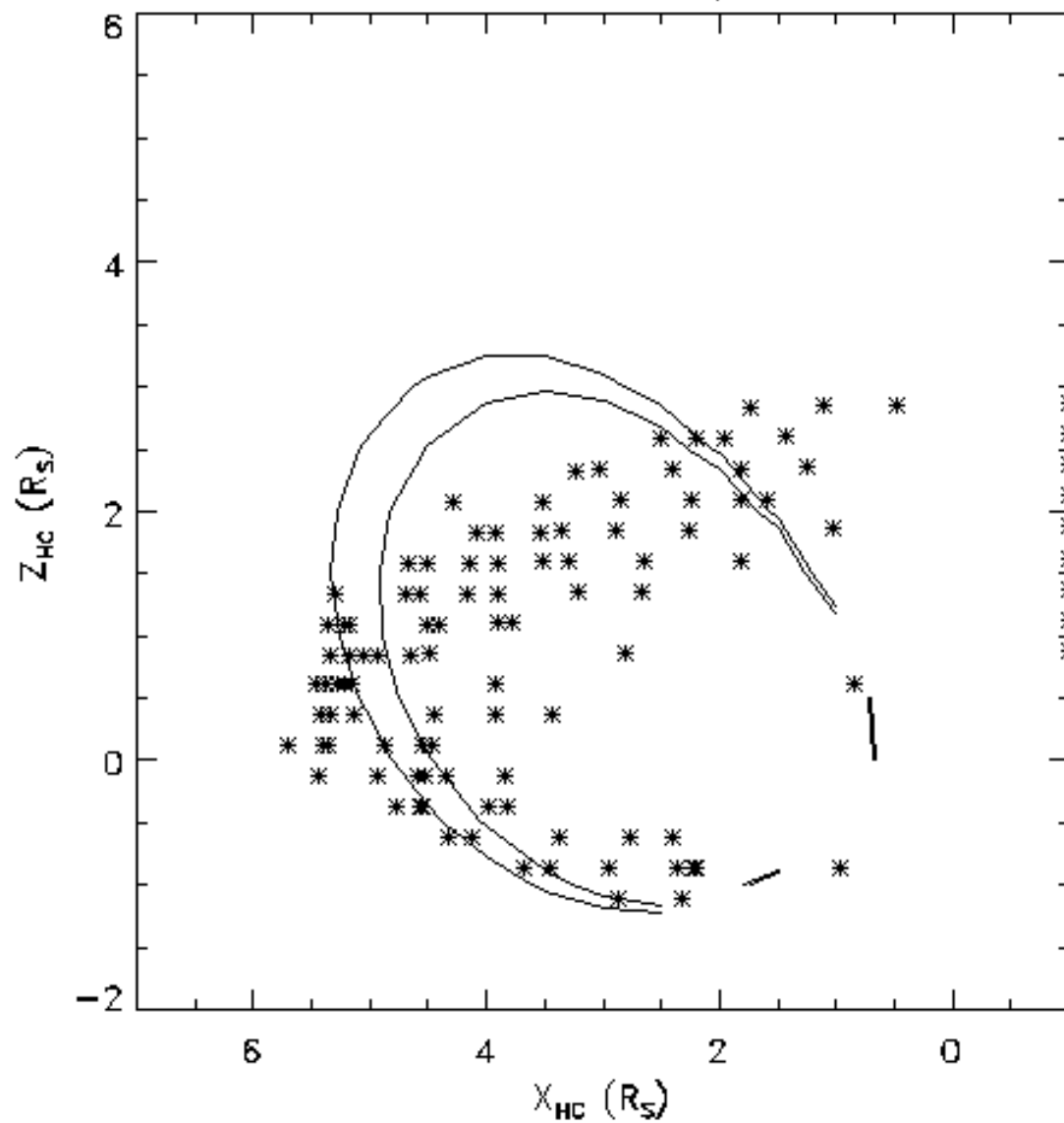
- Polarization Analysis and Geometric Localization are complementary
  - Geometric Localization resolves plane-of-sky ambiguities inherent in polarization analysis
  - Polarization analysis can provide more information about CME structure (*i.e.* mass distribution)



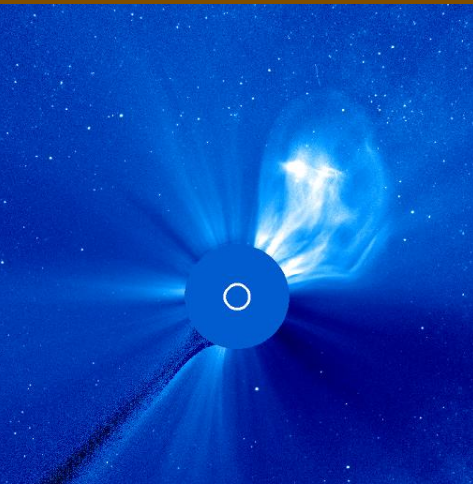
$$\psi(\rho, \zeta) = (1 / \rho) \times \cos^{(p/2)}(2\zeta)$$



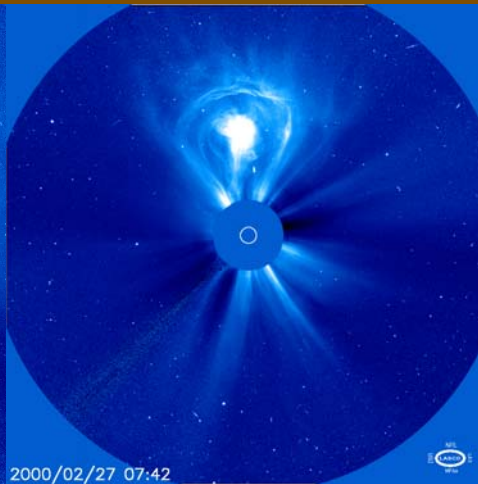
Polarization Location, Side view



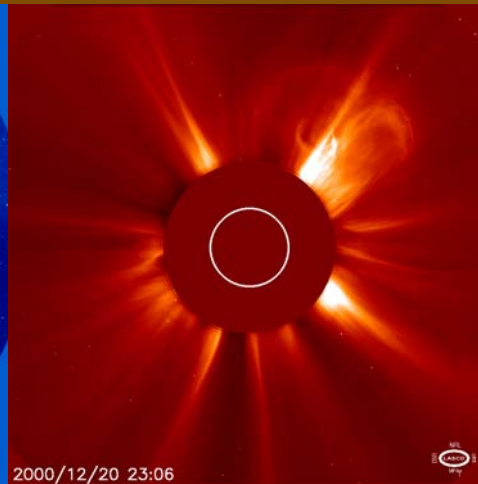
# SOHO/LASCO CMEs



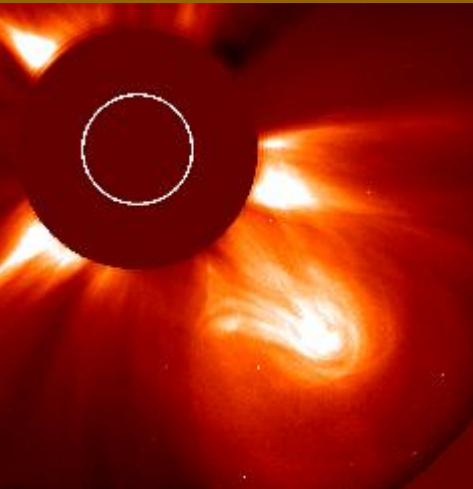
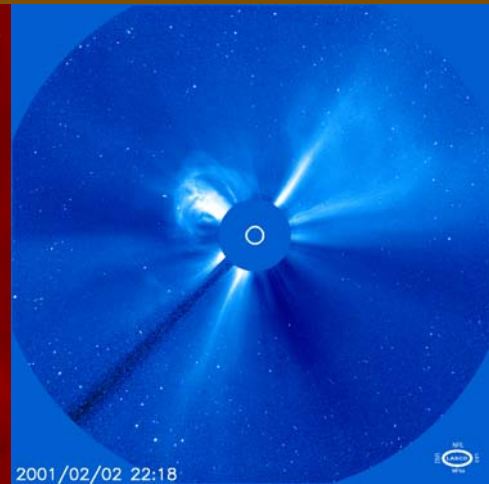
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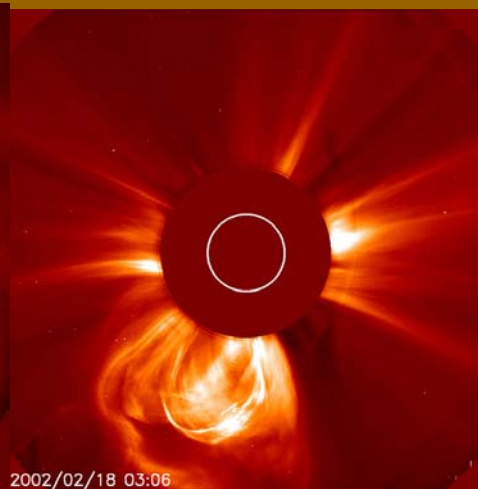
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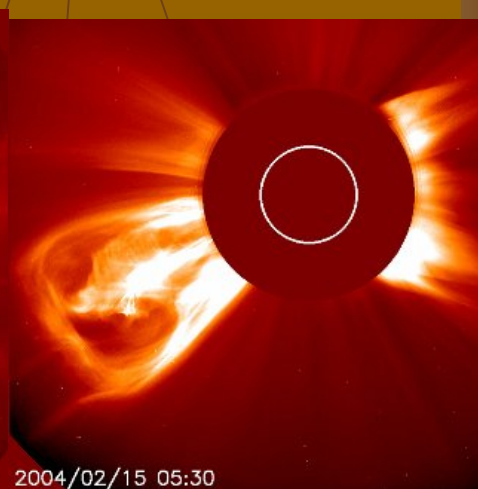
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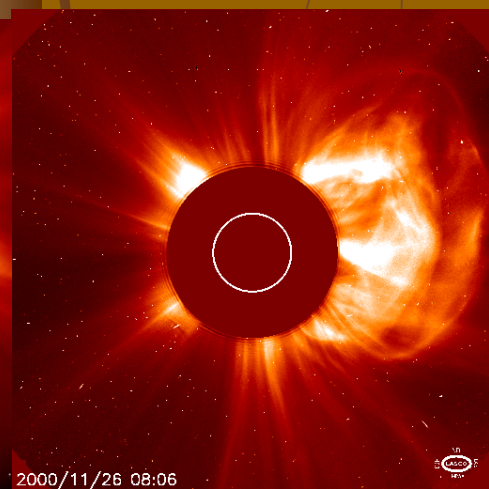
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SOHO