

# STEREO Space Weather

Beacon:

March 2004

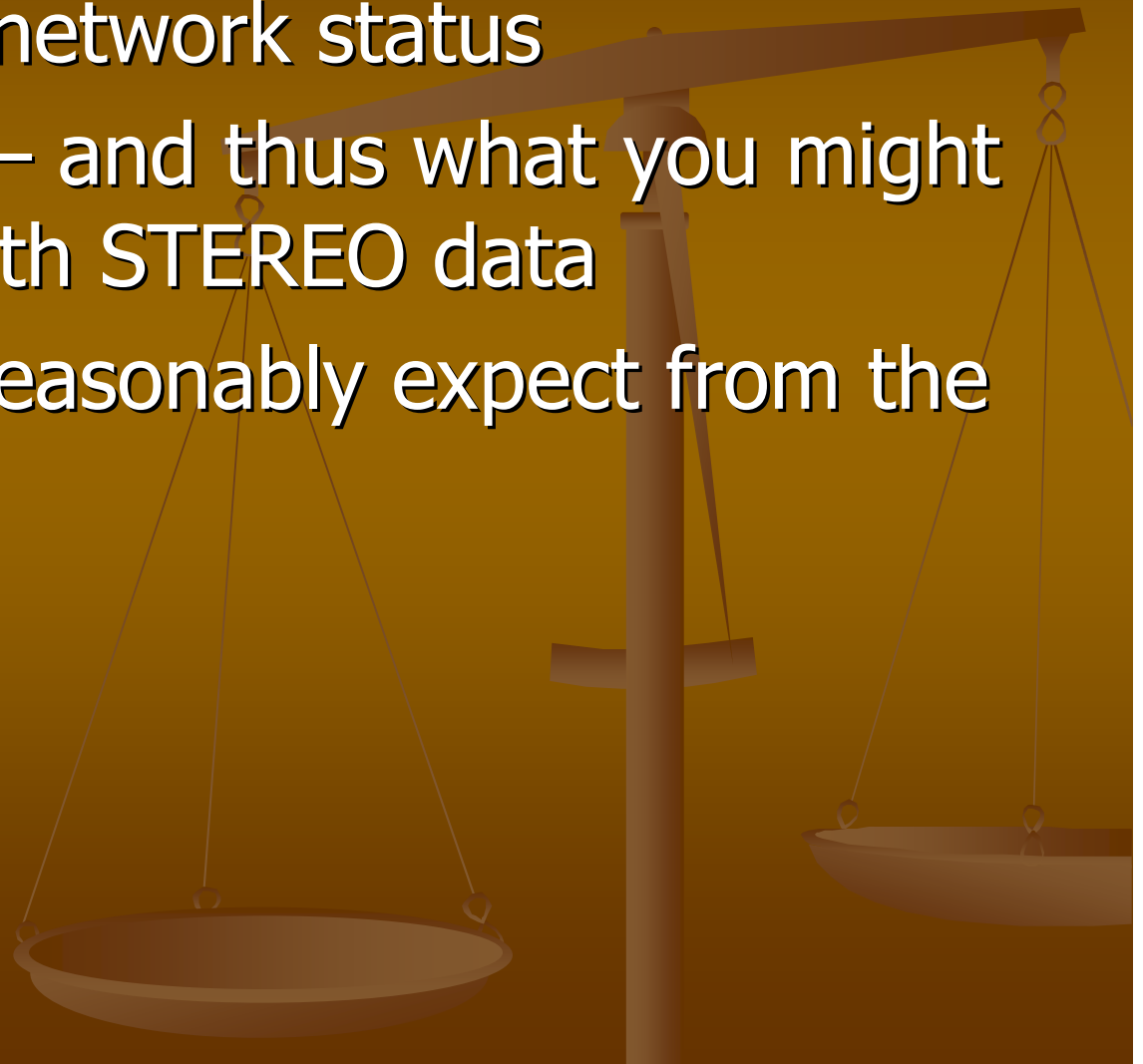
D.A. Biesecker

*NOAA/SEC*



# Outline

- n Ground station network status
- n SEC's priorities – and thus what you might choose to do with STEREO data
- n What SEC can reasonably expect from the STEREO data



# Ground Station Partners

- n Earliest Beacon Mode operation April, 2006
  - n End of phasing for 'B' s/c ~ 60 days after launch
- n None have yet signed on the bottom line
  - n Moving along nicely
    - n Probables would give us the coverage we need
    - n Looking for redundancy wherever possible
  - n Probables are NOAA (Fairbanks), NOAA (Wallops)\*, RAL\* (UK), CNES (France), and CRL (Japan)
  - n Possible is USAF (California), ACRES (Australia), NOAA (Boulder)\*
  - n Others?
  - n \* primary tracking target is ACE

# Ground Station Particulars

- n NOAA/Wallops and NOAA/Fairbanks (13m)
  - n Formal request not yet made – needs to be a high priority
  - n Informal contacts indicate antenna availability likely
- n CNES (9m near Toulouse)
  - n Should receive confirmation soon
  - n Performance of antenna recently tested and additional upgrades being considered to increase link margin
  - n Technical exchange on-going
- n RAL (12m, 2.4m and 3.7m)
  - n ACE is primary here – use smaller dishes for ACE?
- n CRL (6m) – now 7m
  - n Expect decision on funding on April 1, 04. Preliminary word is favorable
  - n Valley Forge (PA) Composite Technologies building new antenna
    - n Technical exchange to start when budget approved

# Other beacon issues



- n MOU with NASA

- n Draft received from NASA in December
  - n Still needs action by SEC
  - n Formalizes the roles of SEC and SSC

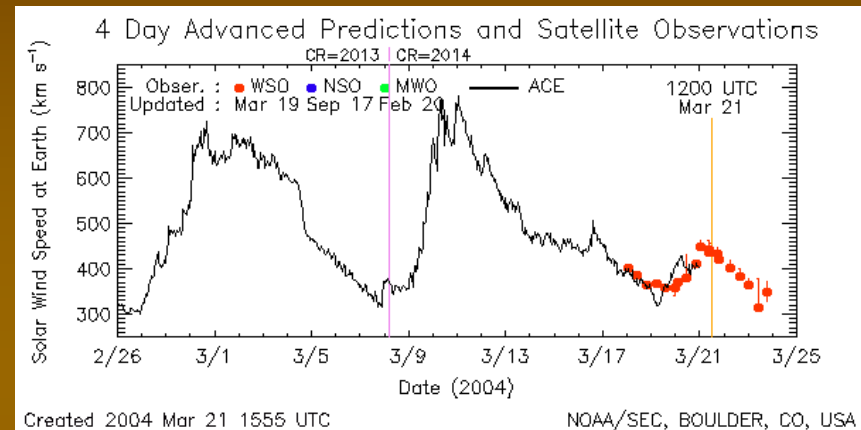
- n Software to decode Viterbi encoded data in test (Phil Karn)

- n Performance 'slightly' less than expected?
- n Might force use of Turbo encoding earlier in the mission
- n Still need actual s/c data for testing

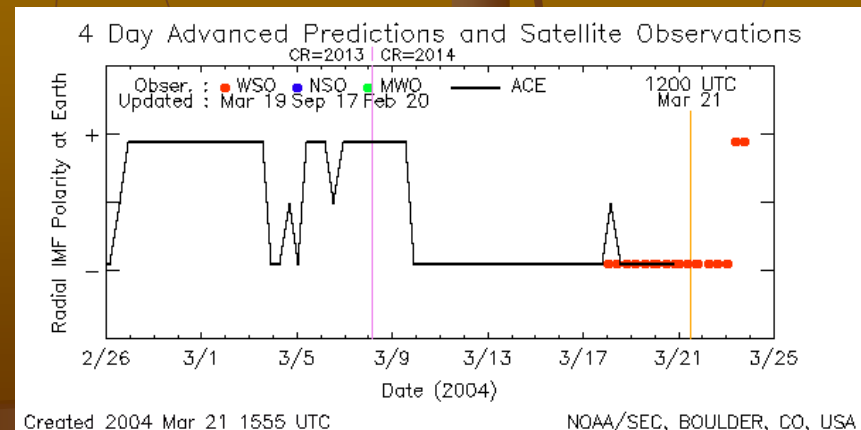
# N. Arge promises the following from Wang-Sheeley work

- n Given the s/c position in heliographic coord.
- n Solar wind and IMF radial polarity (Bx) forecasts (1-7 days)
- n In time for STEREO?
- n  $|B|$ , density, other B components

Predicted Solar Wind Speed at Earth



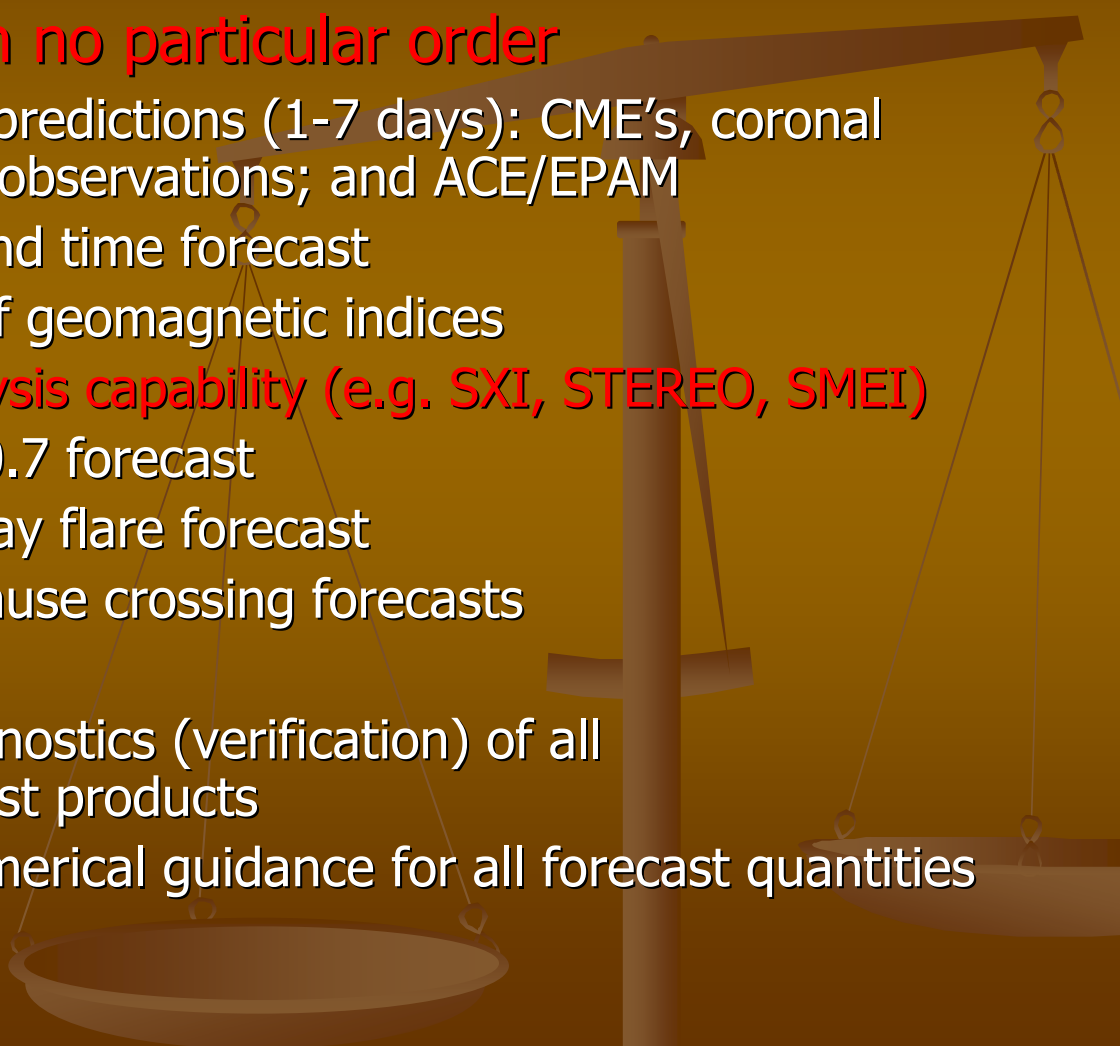
Predicted IMF Polarity at Earth



# SEC's Identified Needs: I

- n Highest priority – in no particular order
  - n SEP event forecasts – start, peak, & end times; peak flux, spectrum, fluence, probability of SEP
  - n Energetic electron flux prediction for ISS
  - n Regional geomagnetic nowcasts and forecasts (e.g. Auroral electrojet maps)
  - n Ionospheric maps of TEC and scintillation (nowcasts and forecasts)
  - n Geomagnetic index forecasts (A, K, Dst) and probability forecast

# SEC's Identified Needs: II

- n **High Priority – in no particular order**
    - n Geomagnetic activity predictions (1-7 days): CME's, coronal holes, solar magnetic observations; and ACE/EPAM
    - n Geomagnetic storm end time forecast
    - n Real-time estimates of geomagnetic indices
    - n **Improved image analysis capability (e.g. SXI, STEREO, SMEI)**
    - n Short-term (days) F10.7 forecast
    - n Short-term (days) X-ray flare forecast
    - n Geosynch. magnetopause crossing forecasts
    - n EUV index
    - n Real-time quality diagnostics (verification) of all warning/watch/forecast products
    - n Routine statistical/numerical guidance for all forecast quantities
- 

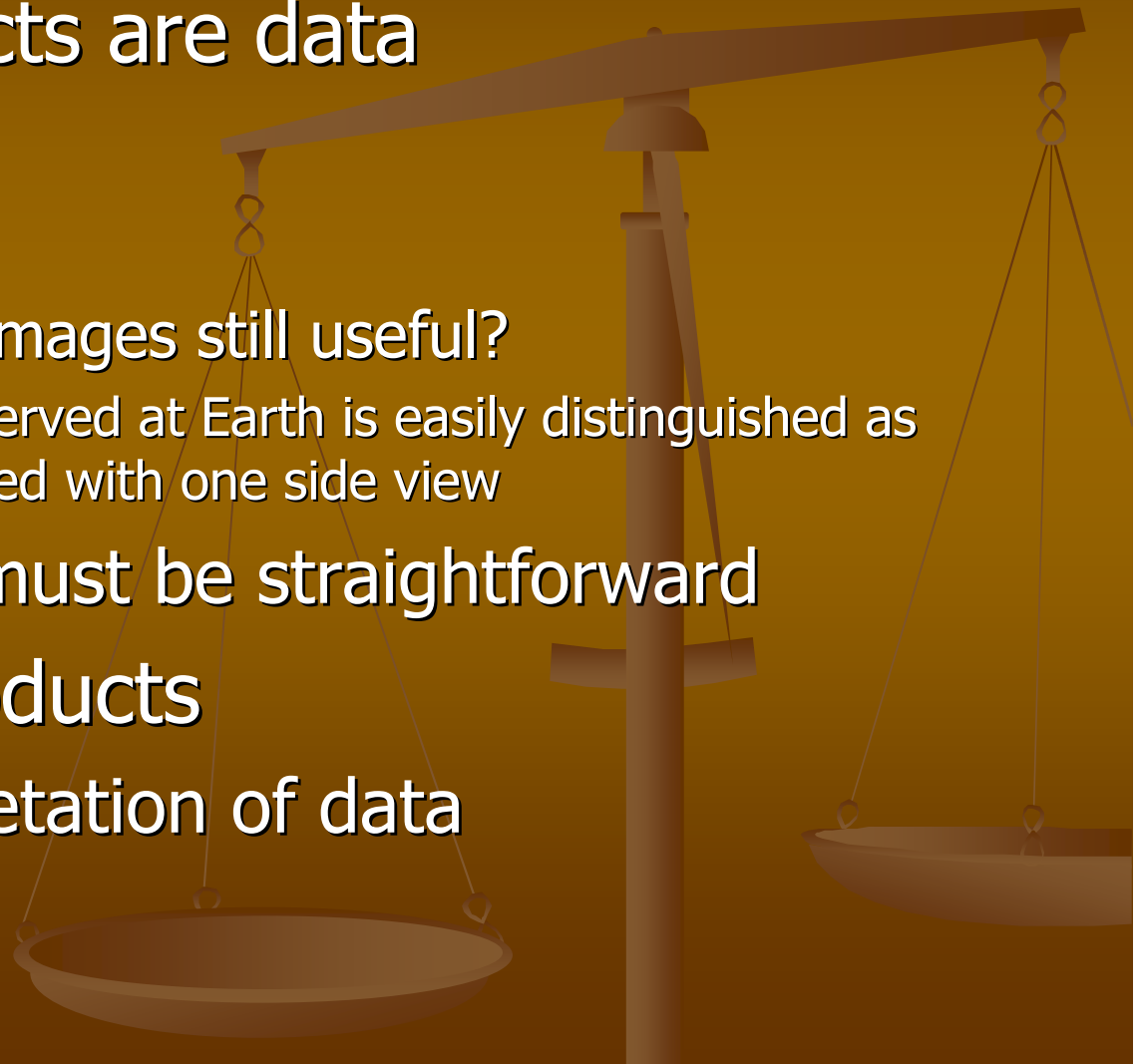


# NOAA/SEC use of STEREO

- n Based on success of transitioning missions such as ACE and SOHO into operations; expectations are high
  - n Most important lesson is probably the time it took to integrate into forecast center
  - n Expect STEREO to be faster just because we'll receive beacon data from start
    - n It needs to be faster due to changing geometry and thus changing capabilities

# Transition to operations

- n 'Easiest' products are data
- n How to display
  - n 3-d graphics
  - n Single s/c 2-d images still useful?
    - n Halo CME observed at Earth is easily distinguished as front/back sided with one side view
  - n Interpretation must be straightforward
- n Higher level products
  - n Require interpretation of data



# Coronal Mass Ejections

## n Currently – SOHO/LASCO

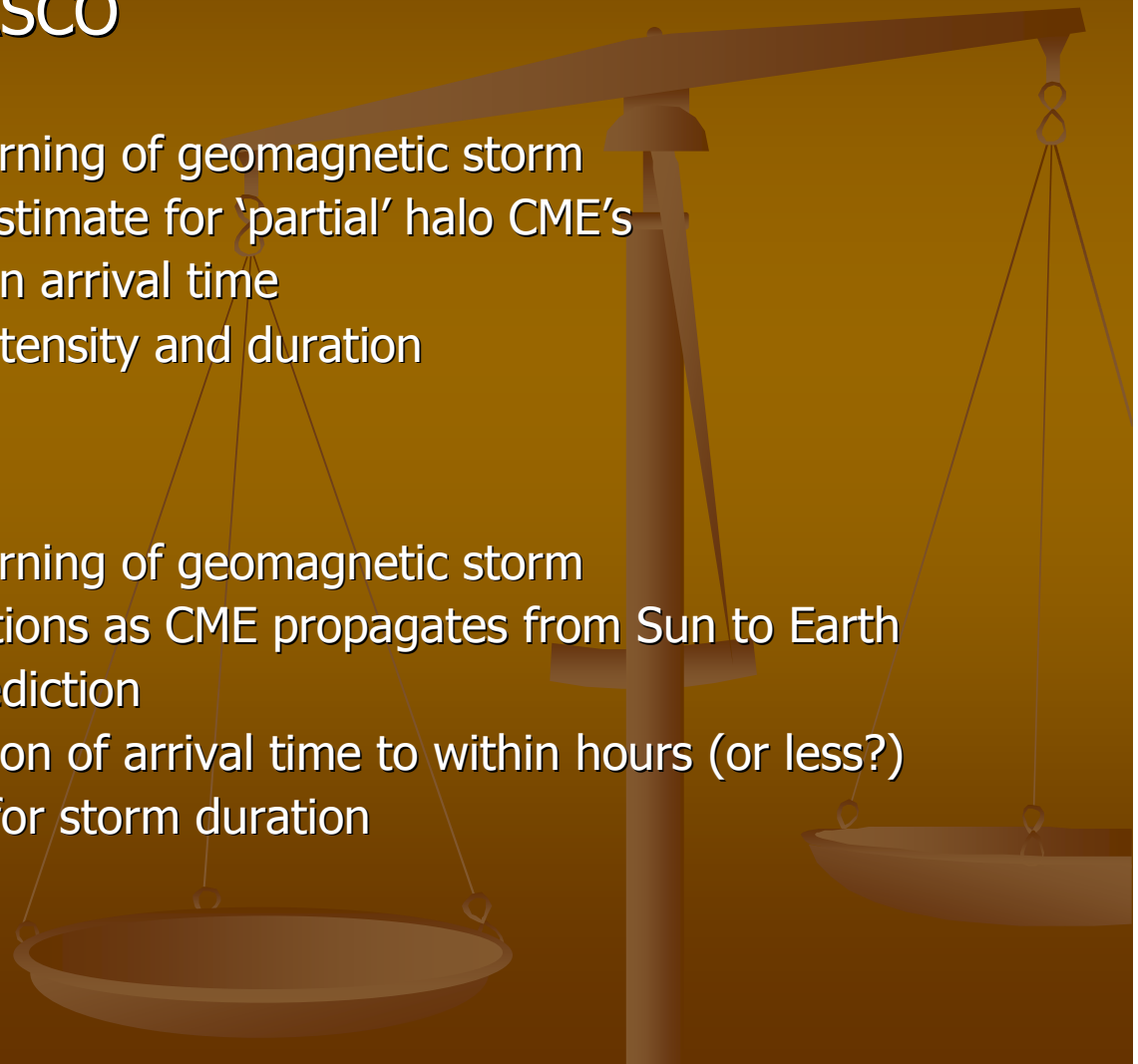
### n Halo CME's

- n 1-3 day advance warning of geomagnetic storm
- n Uncertain hit/miss estimate for 'partial' halo CME's
- n error of  $\pm 11$  hours in arrival time
- n rough estimate of intensity and duration

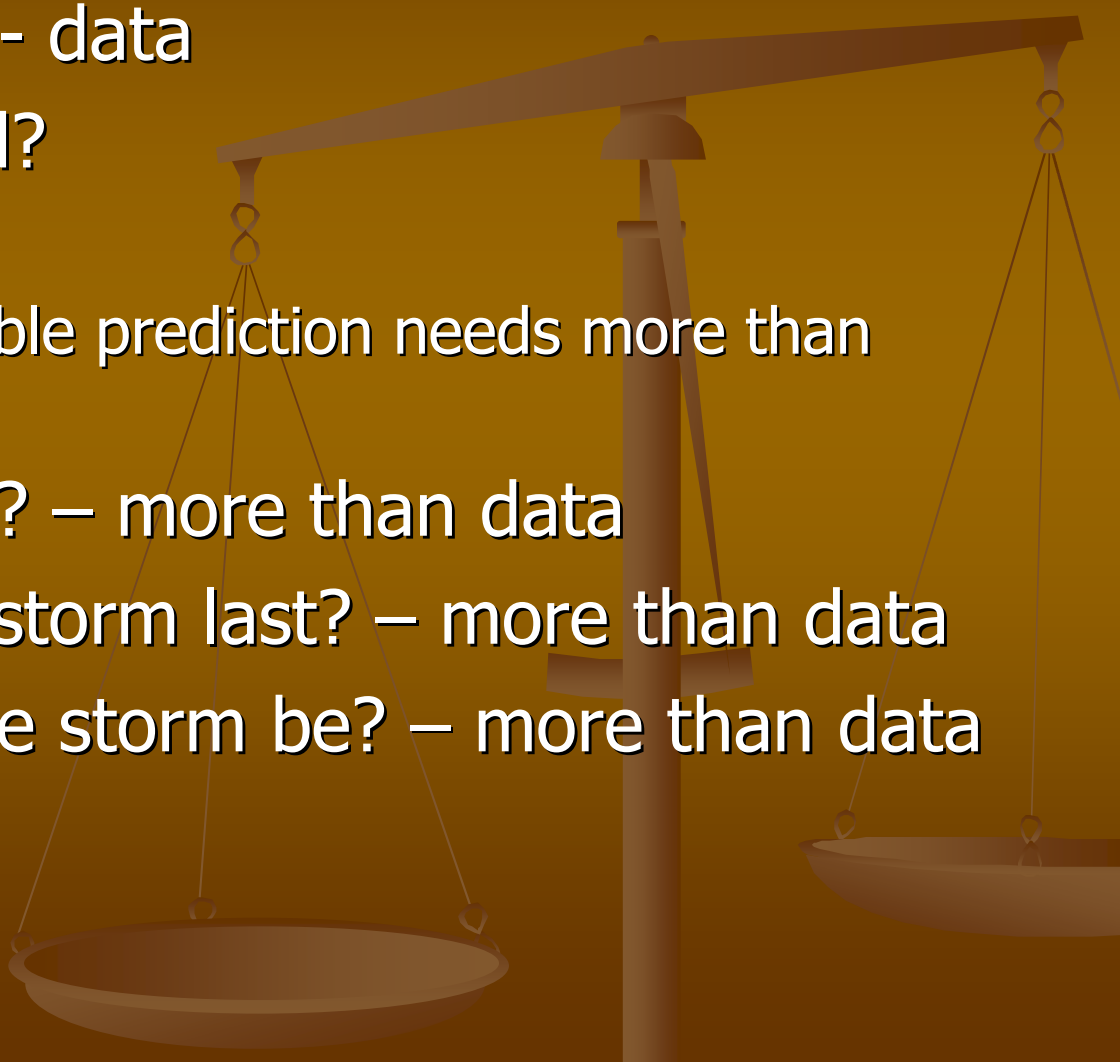
## n STEREO

### n 3-d views of CME's

- n 1-3 day advance warning of geomagnetic storm
- n Continuous observations as CME propagates from Sun to Earth
- n Reliable hit/miss prediction
- n Potential for prediction of arrival time to within hours (or less?)
- n Improved estimate for storm duration



# e.g. CME related geomag storm

- n Did a CME occur? - data
  - n Is it Earth directed?
    - n Halo – data
    - n Partial halo – reliable prediction needs more than data
  - n When will it arrive? – more than data
  - n How long will the storm last? – more than data
  - n How strong will the storm be? – more than data
- 

# STEREO beacon CME detection

## OVERVIEW

### Objective:

Use near-real-time STEREO beacon data to infer direction, speed, extent, and mass of Earth-directed CMEs

### Application:

Advance warning of oncoming CMEs affecting geospace

### Forecast Gain:

Immediate, High

## APPROACH

### Strategy:

Forward modeling study to develop understanding of stereo images, then construction of ops analysis tools

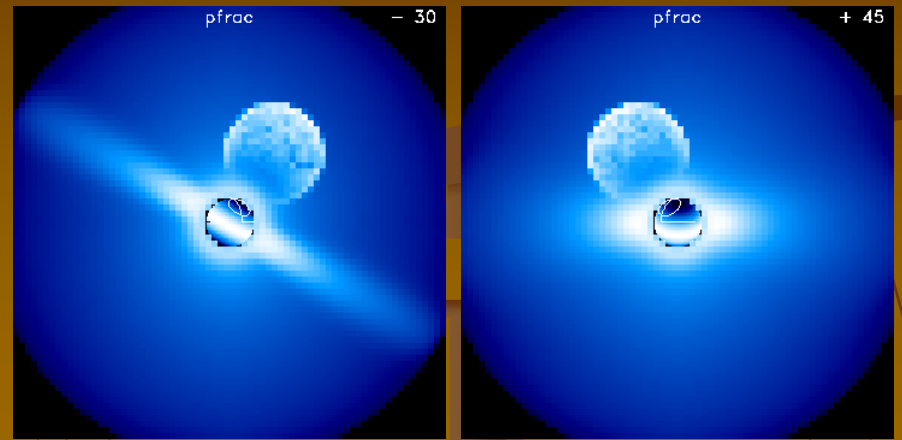
### Uniqueness:

Only N-R-T beacon analysis underway, is based upon triangulation

### Context:

Complements tomographic approaches

## GRAPHIC



## PROGRAMMATICS

### Resources Needed:

0.2 FTE level of effort

### Development Time:

2-3 years at 0.2 FTE

**Current Status:** Basic LOS routines done, analysis not yet started

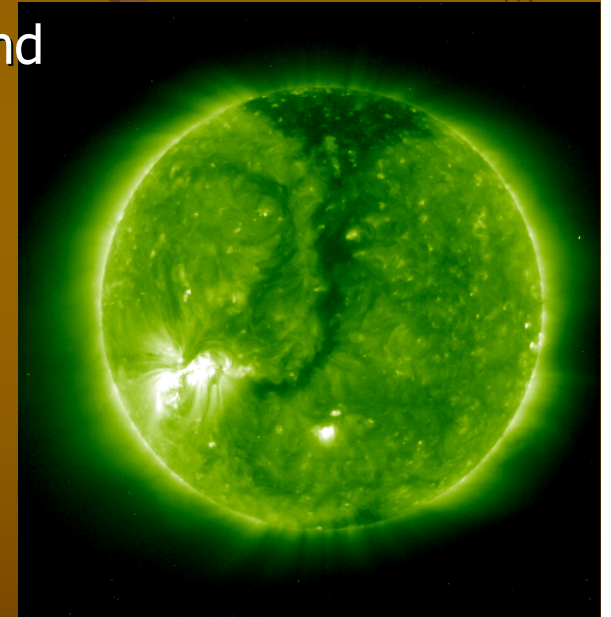
# Recurring Solar Wind Streams

## n Currently

- n For first time stream – estimate from longitude
- n Recurring stream – use previous occurrence and changes in coronal hole since then – 27 days

## n STEREO – Lagging spacecraft

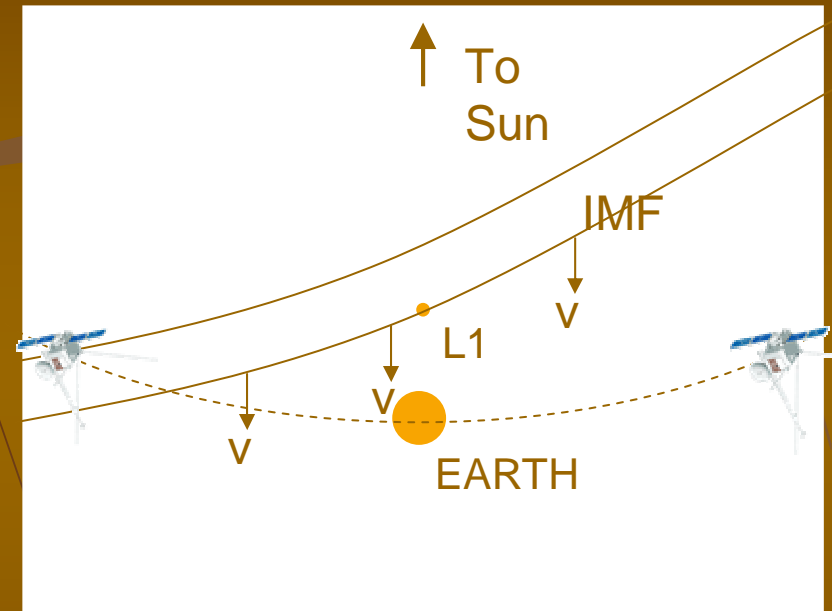
- n Use actual observation from ~few days earlier
- n Improved start time of high speed wind
- n Improved end time of high speed wind
- n Determination of high speed wind properties (*e.g.* velocity)



# Solar Wind Discontinuities (and more)

## n Currently

- n In-situ observation at L1
- n ~1 hour warning of  
n, V, B

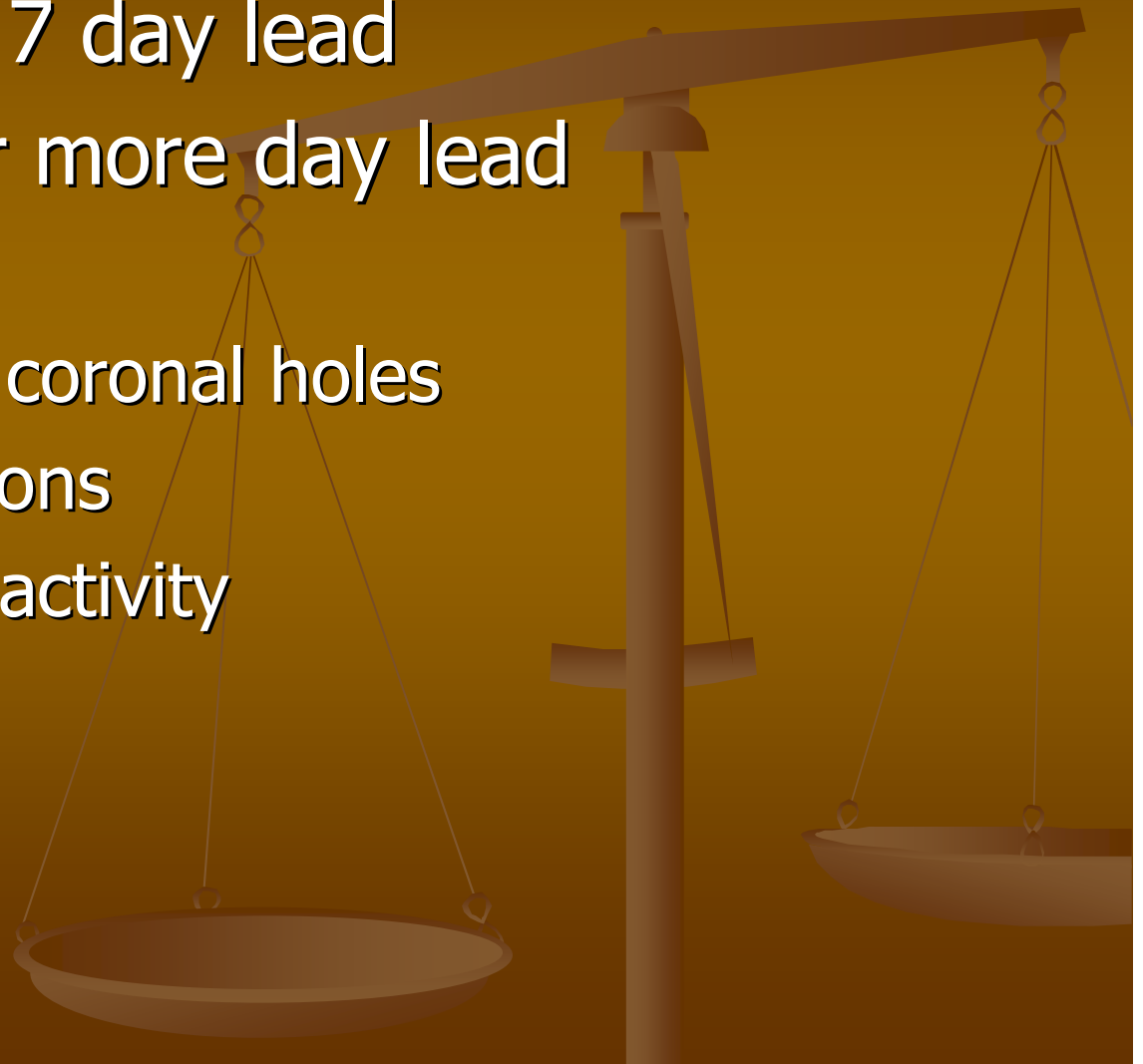


## n STEREO

- n Either spacecraft, depending on heliosphere
    - n May potentially provide ~ 1 day warning of V, B
- Weimer *et al.* (2003)

# Long-term Forecasts

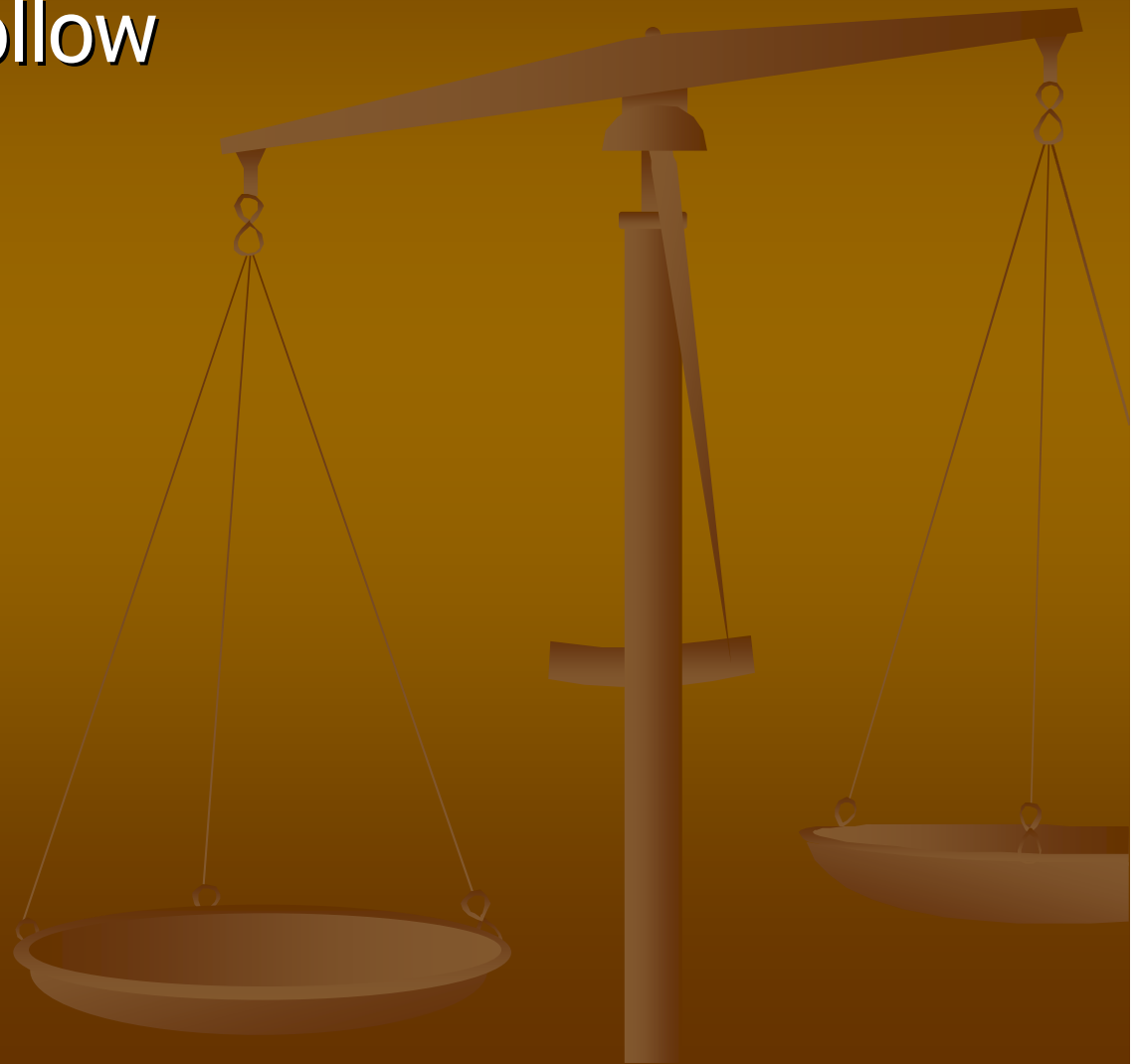
- n Current – up to 7 day lead
- n STEREO – 14 or more day lead
  - n EUV Flux
  - n New equatorial coronal holes
  - n New active regions
  - n Level of flaring activity





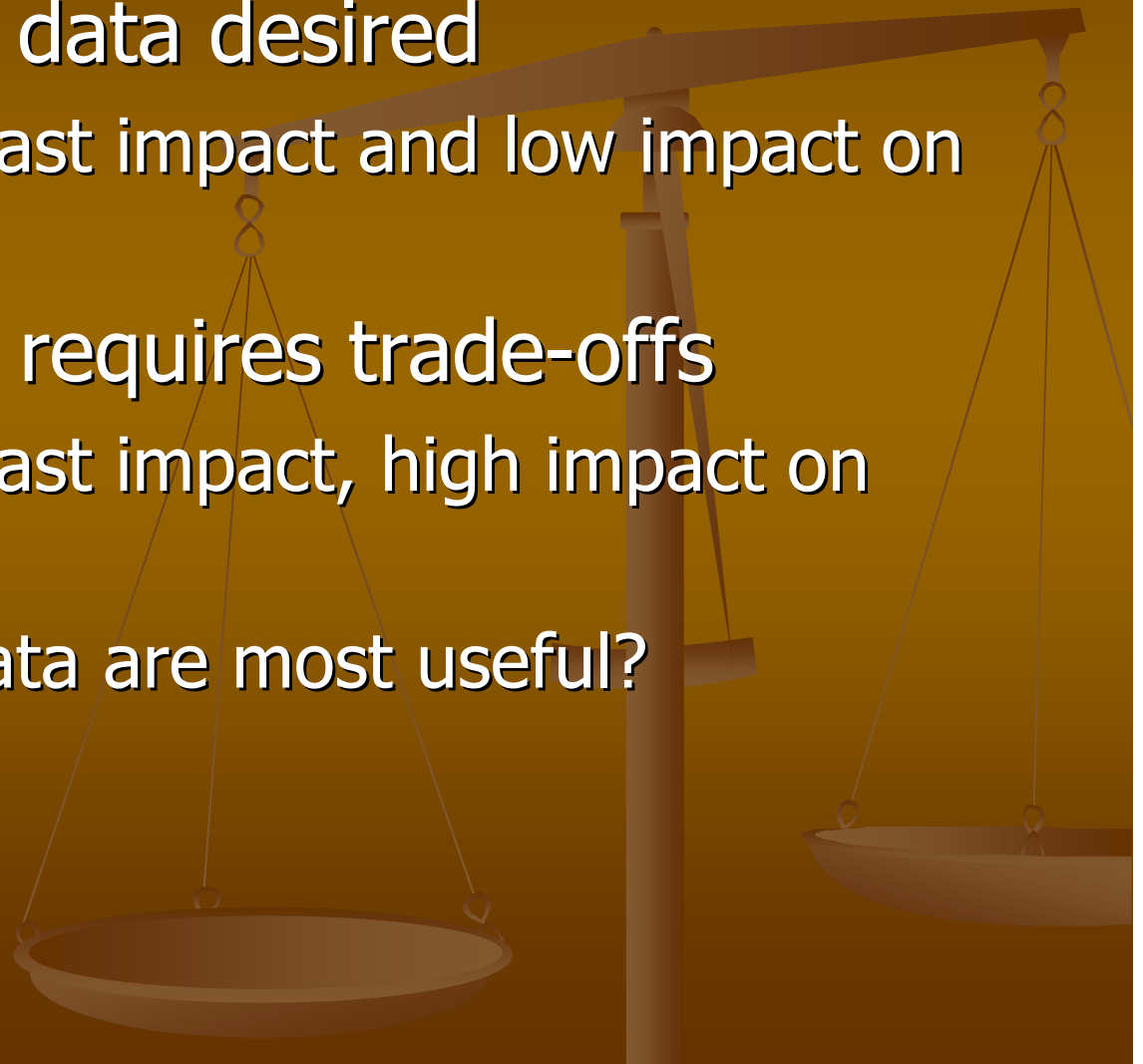
# Done

n Backup slides follow



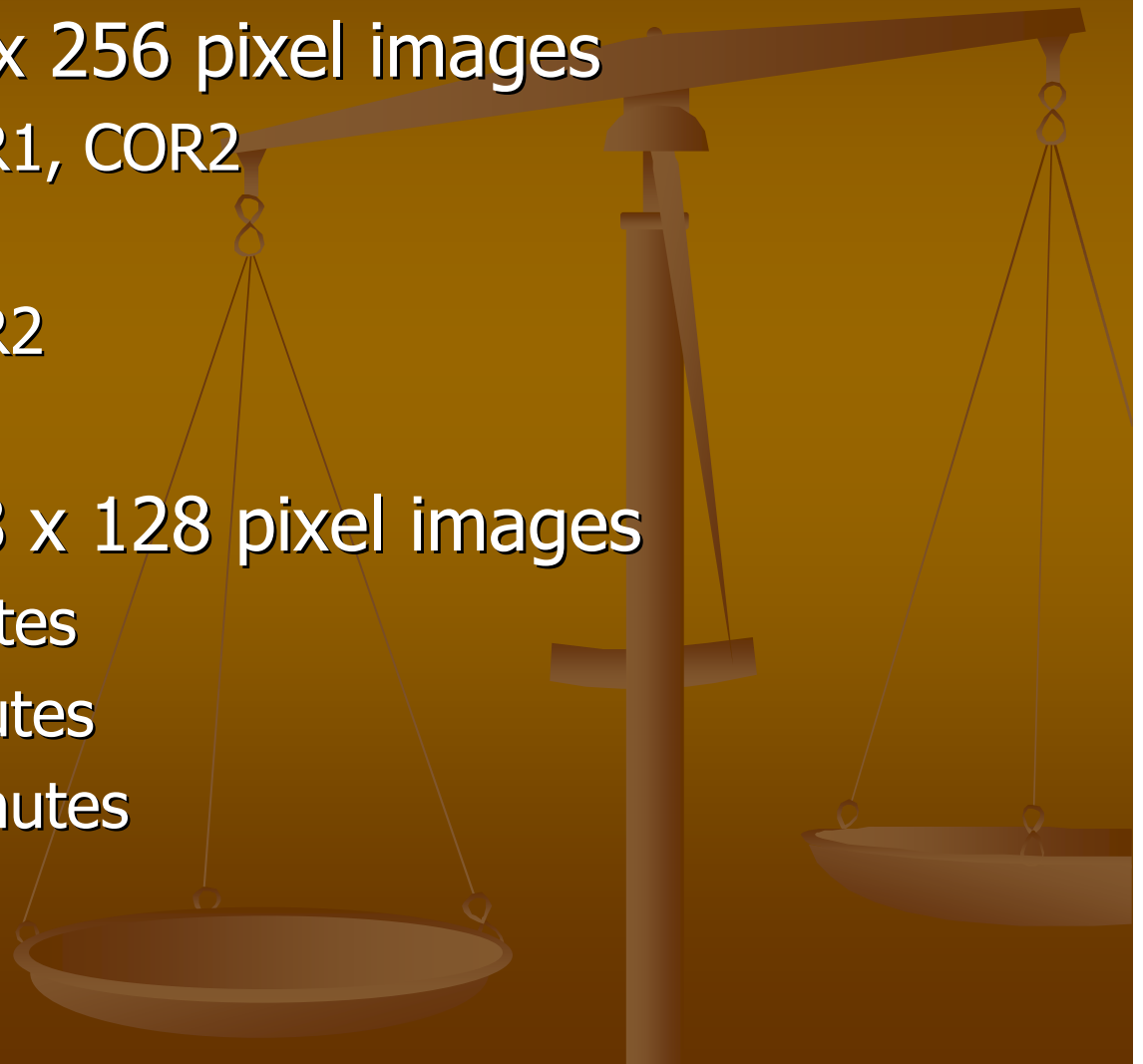
# Space Weather Beacon Data

- n All non-imaging data desired
  - n High SWx forecast impact and low impact on telemetry
- n The image data requires trade-offs
  - n High SWx forecast impact, high impact on telemetry
  - n Which image data are most useful?



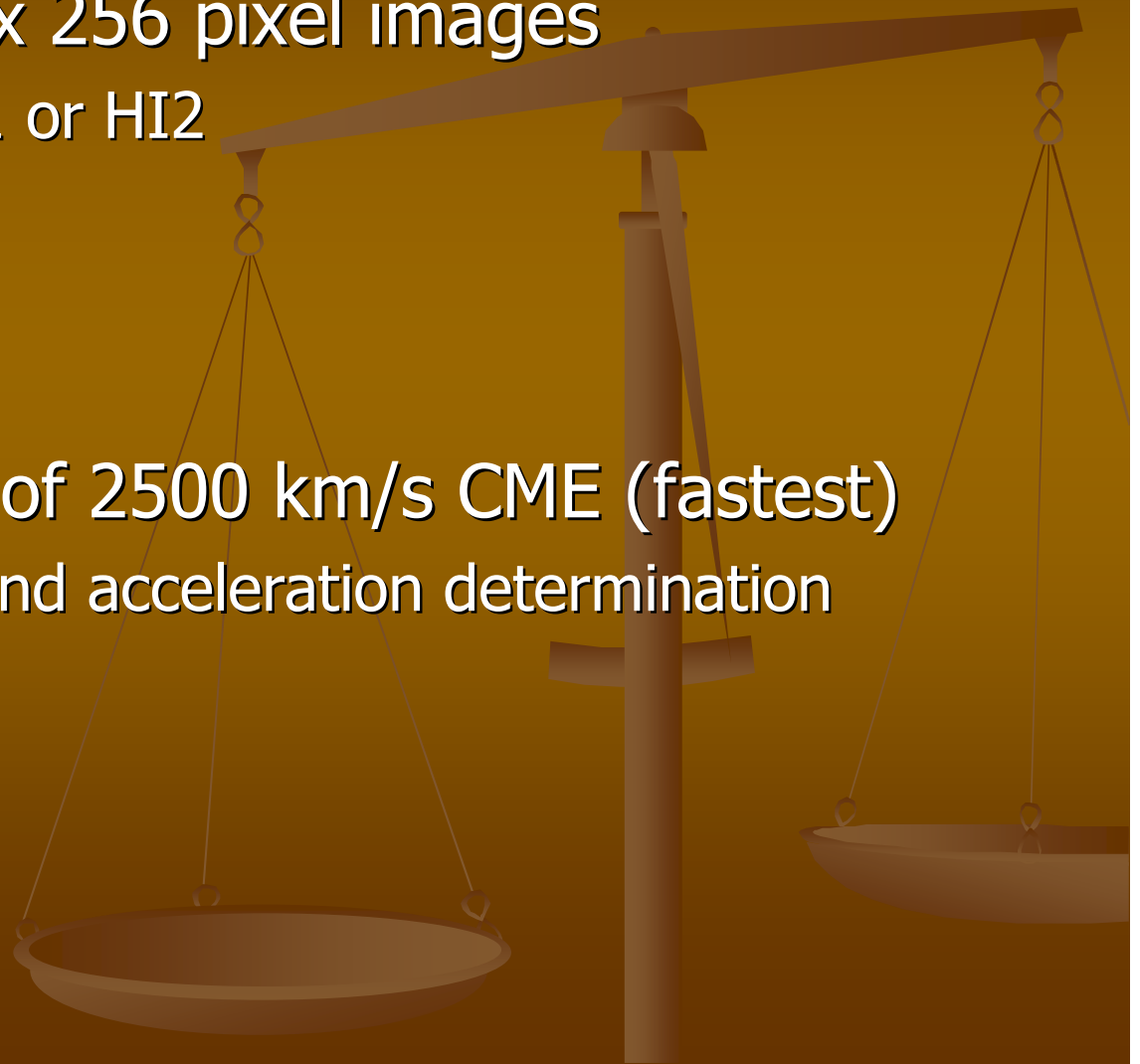
# SECCHI Draft Observing Plans

- n Hourly Plan 7 256 x 256 pixel images
  - n 00 mins EUVI, COR1, COR2
  - n 15 mins COR2
  - n 30 mins EUVI, COR2
  - n 45 mins COR2
- n Hourly Plan 28 128 x 128 pixel images
  - n EUVI every 5 minutes
  - n COR1 every 6 minutes
  - n COR2 every 10 minutes

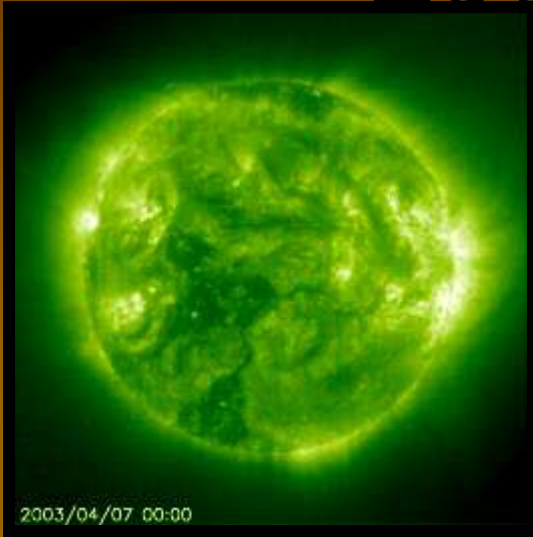


# SEC Preferred Observing Plans

- n Hourly Plan 7 256 x 256 pixel images
  - n 00 mins COR2, HI1 or HI2
  - n 15 mins COR2
  - n 30 mins COR2
  - n 45 mins COR2
- n Provides 4 images of 2500 km/s CME (fastest)
  - n 'Reliable' velocity and acceleration determination

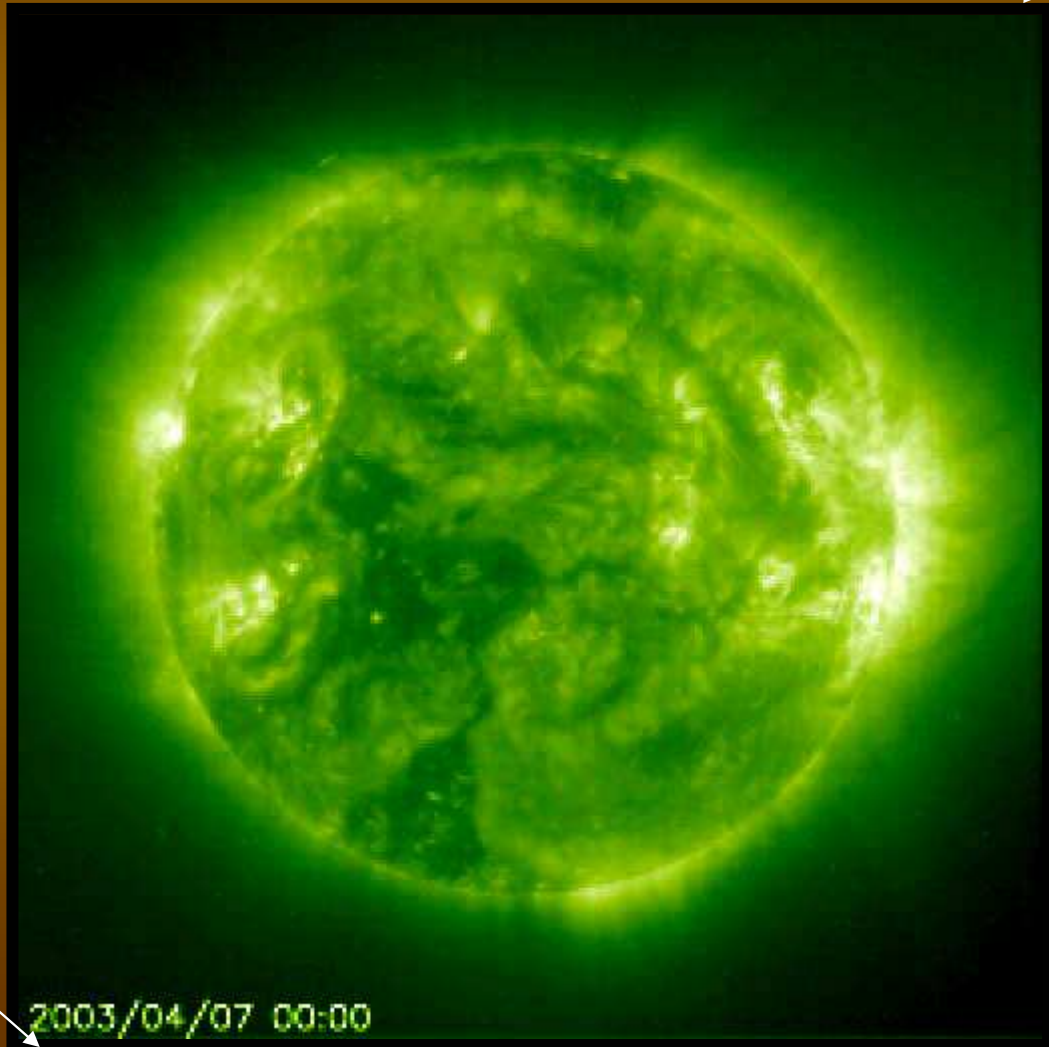


# 256 x 256 EIT Images

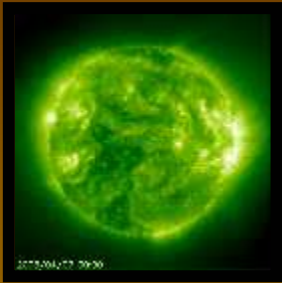


12 min cadence  
10.4"/pixel

2x Enlargement

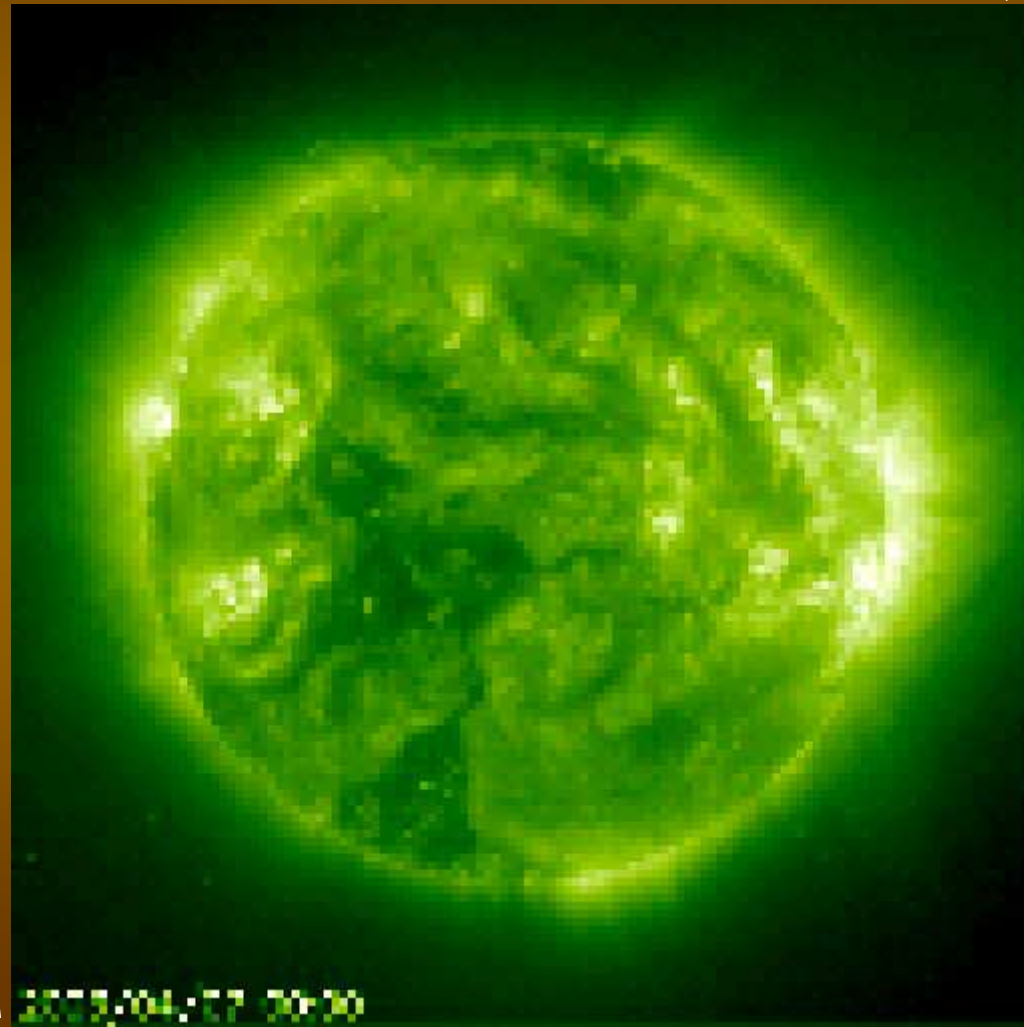


# 128 x 128 EIT Images

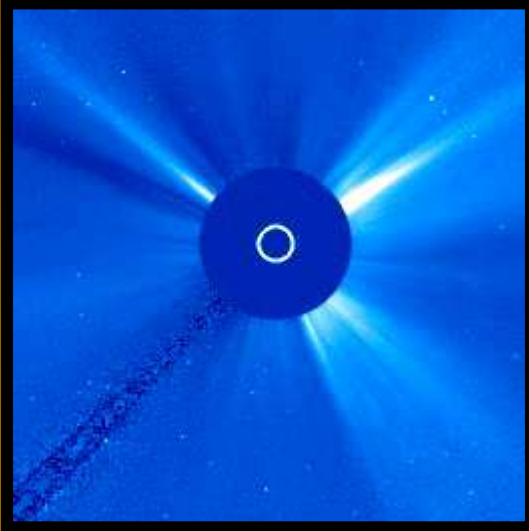


12 min cadence  
20.8"/pixel

4x enlargement

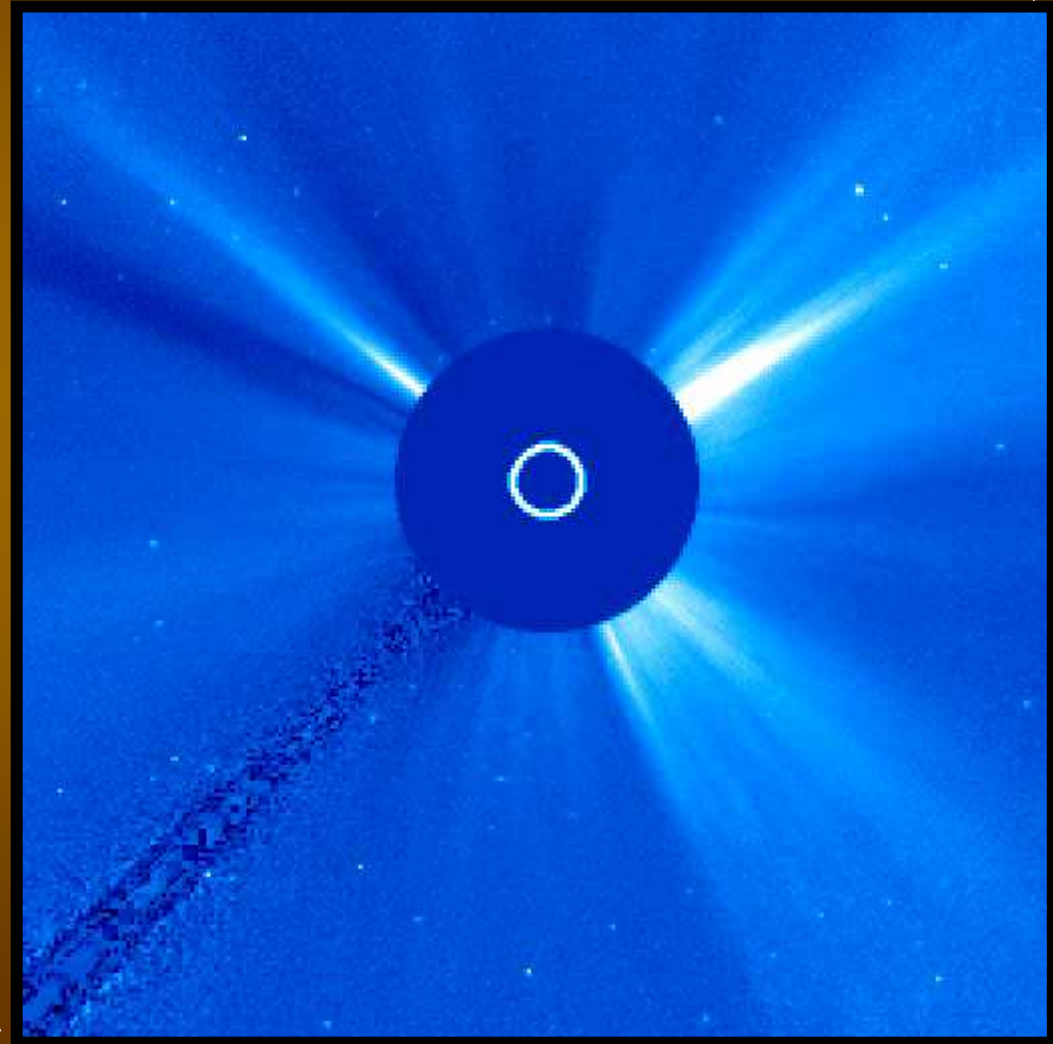


# 256 x 256 LASCO C3 Images



~30 min cadence  
224"/pixel

2x Enlargement

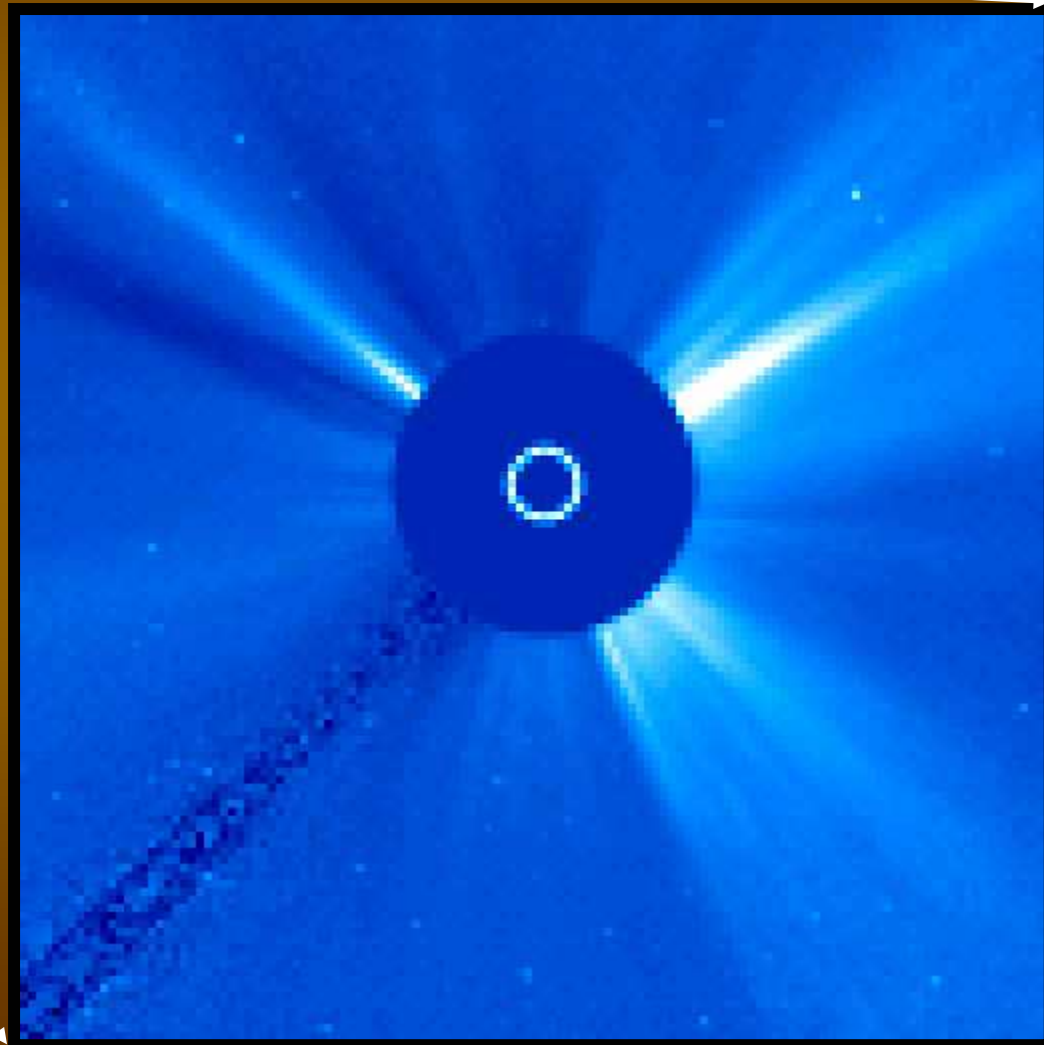


# 128 x 128 LASCO C3 Images



~30 min cadence  
448"/pixel

4x enlargement





# Space Weather Beacon Questions

## n Observing plan

- n Piggyback on full resolution observing plan or some space weather beacon only images?
- n Brightness or polarized images?
- n EUVI wavelength scan?
- n HI-1 or HI-2 data?

## n Non-image data?

- n Brightest pixel in each 64 x 64 pixel block (32 x 32 pixel image)
- n Cosmic Ray Counts from HI Scrubbing

## n Do we generate SW Beacon images when we don't know someone is listening ?

