Space Weather STEREO SWG

Hamburg 2005

D.A. Biesecker

NOAA/SEC

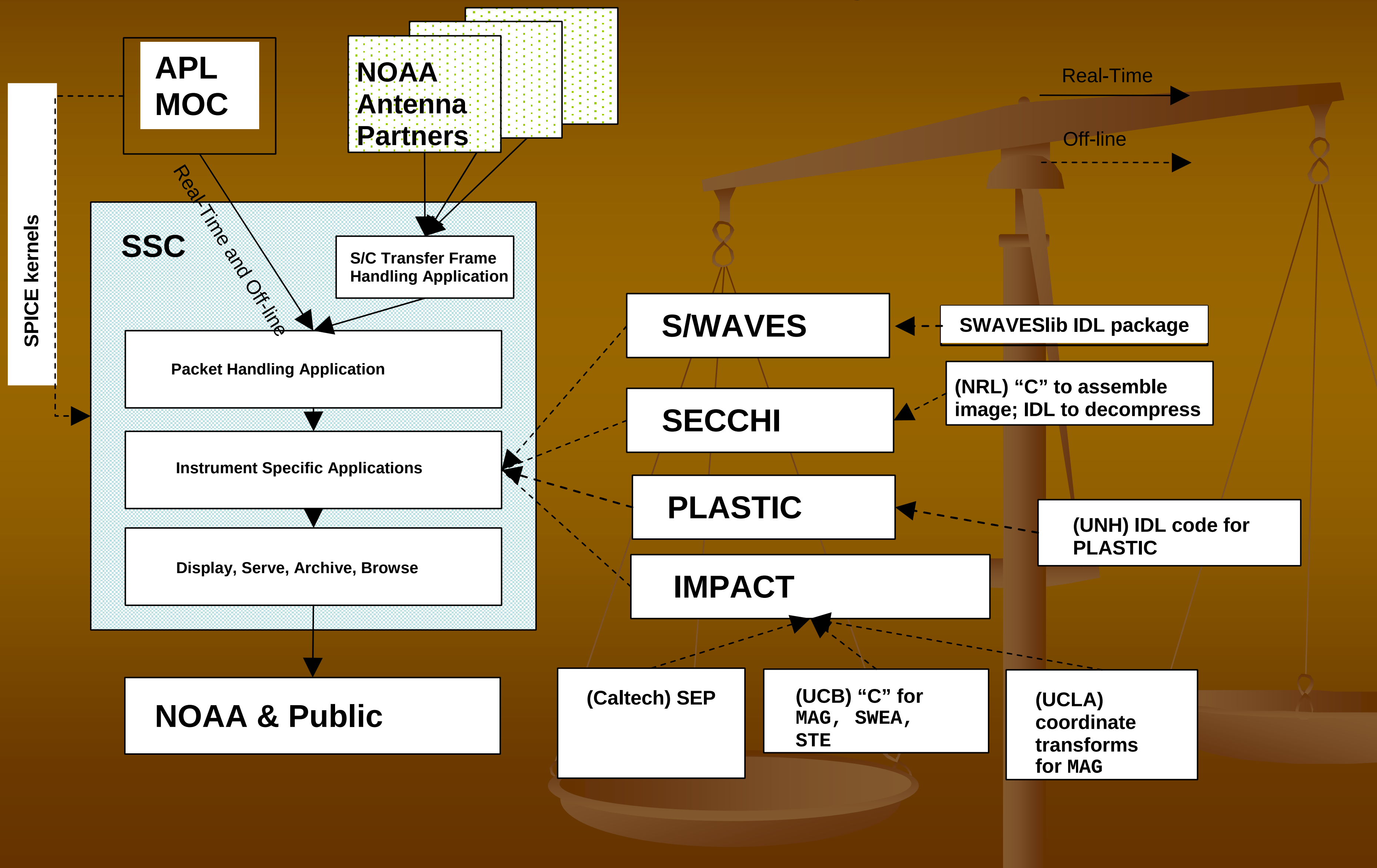
Agenda

- Current Beacon Status
- Presentations on ‘operational’ use of beacon
  - Data Viewers
    - Berghmans
    - Pick
    - Russell?
  - Automated Event Detection
    - Robbrecht – CME’s
    - Podladchikova – EUV dimmings
  - Modelling efforts
    - Biesecker – Geometric Localization
  - Others?
- Break?
- S/WAVES Space Weather Plan – M. Kaiser
- MuSTAnG Space Weather Muon Telescope – F. Jansen
- Round Table Discussion
  - Review SWx ideas already known (on STEREO SWx website)
  - What have we missed?
  - SWx chapter of STEREO book
  - Other Topics?

Outline

- Ground station network coming along
  - Turbo licensing issue almost resolved
- s/c beacon mode telecom testing
- Software to decode Viterbi and Turbo encoded data in work (Phil Karn)

Space Weather Beacon Processing



Ground Station Partners

- Primary network – gives us the 24/7 coverage we need
  - NOAA and CNES (France) are signed on
    - Letters in hand
    - Toulouse (1.5E); Wallops (75.5W); Fairbanks (147.8W)
  - CRL (Japan) is likely
    - NOAA has made a formal request through International Affairs Office
- We'd like redundancy where possible
  - Probable is RAL (UK)
  - Possible is USAF (California), ACRES (Australia)
  - Others?

Other details

- Beacon telemetry to begin after heliospheric orbits achieved
- Tested basic functional transfer of beacon telemetry packets from NOAA/SEC (representing ground stations) to SSC
  - Based on ACE real-time solar wind telemetry system
- ICD between NASA SSC and NOAA SEC almost finished?

Turbo

- Telemetry encoding options in the beacon mode are rate 1/6 Viterbi, rate ½ Viterbi, and Turbo encoding.
- Turbo encoding (decoding) improves E_b/N_o
- Issues regarding Turbo were licensing and cost.
  - NOAA and France Telecom agree on wording of licensing agreement
    - Final draft not on the street, yet
  - Phil Karn (wrote decoder for ACE) will write Turbo decoder, free of charge

STEREO Science Center

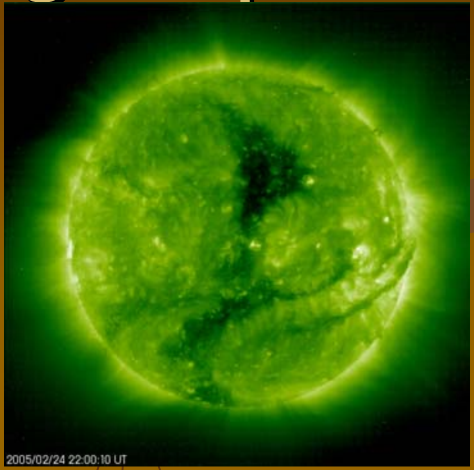
- Real-time data displays
  - Images
  - Where is STEREO?
  - Javascript movies w/selectable time range
- CME detection bit in real-time
  - One scheme is CACTUS http://sidc.oma.be/cactus/
  - Another is being developed by JPL
  - Automated e-mail alert? (current manual LASCO alert)

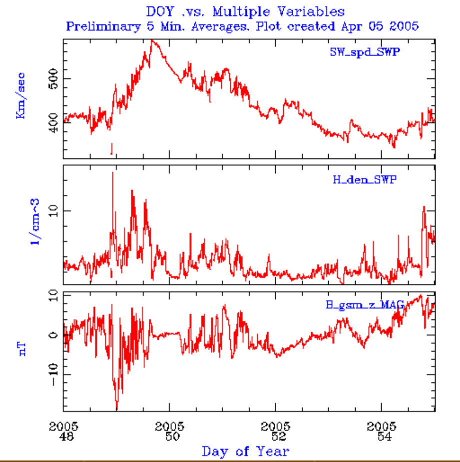
What do NOAA forecasters plan to do with STEREO?

- 3-d viewer or some way to display what's coming at us on the Sun-Earth line
  - SECCHI team
  - Others – Geometric Localization
- Predicting CME arrival – HI
- Anything that reliably and robustly describes some parameter of the data that doesn't require looking at the huge volume of data.

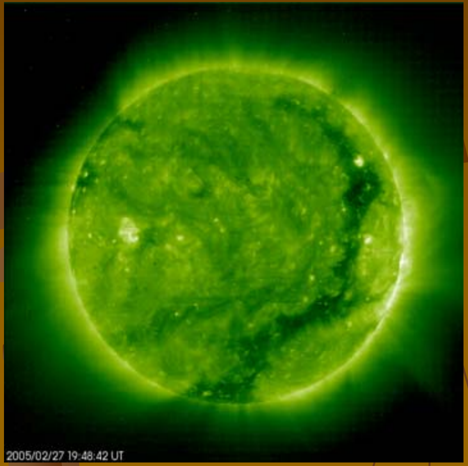
Coronal Hole/High Speed Stream

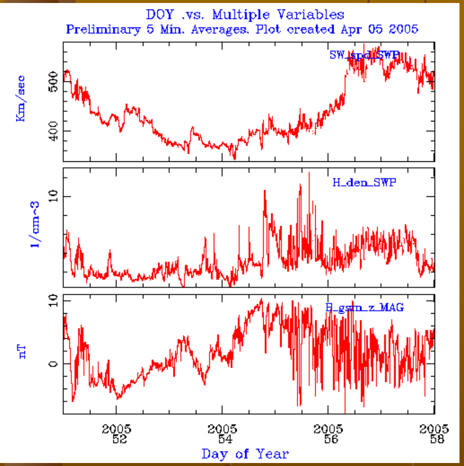
- Enhanced electrons
- Minor/Moderate geomagnetic storms
- Who cares
  - Satellite operators
  - …
- 1 year into mission
  - ~1.5 days lead time





What we see at Earth

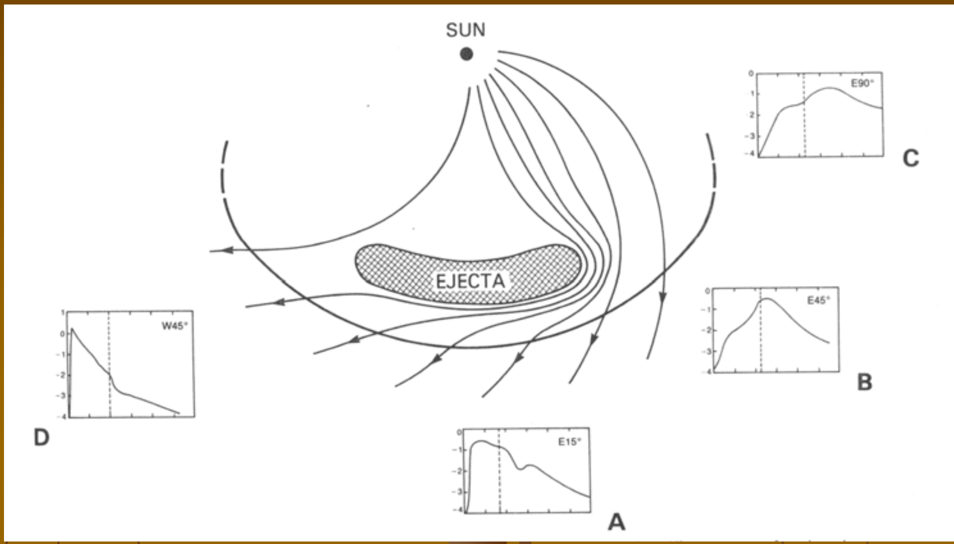


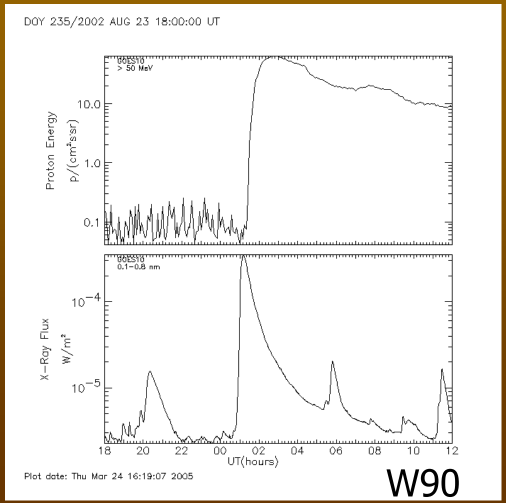


What STEREO-B sees

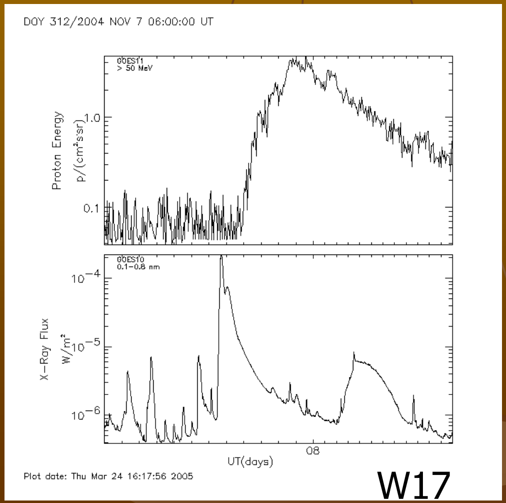
SEP events

- Event profile depends on observer position relative to event source
  - Radiation Storm
- Who cares:
  - Launch providers
  - Satellite operators
  - Astronauts
  - Airline pilots/stewards

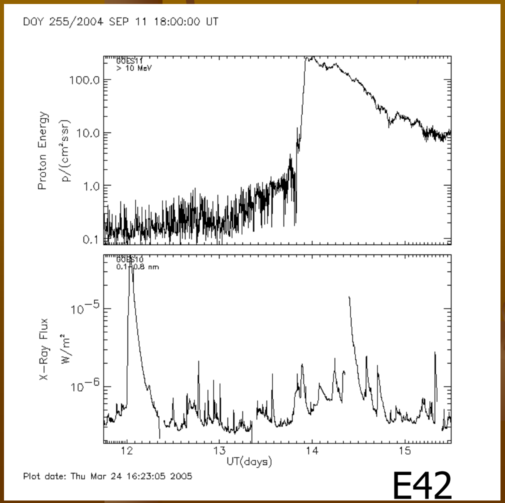




STEREO LAGGING



EARTH



STEREO LEADING

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

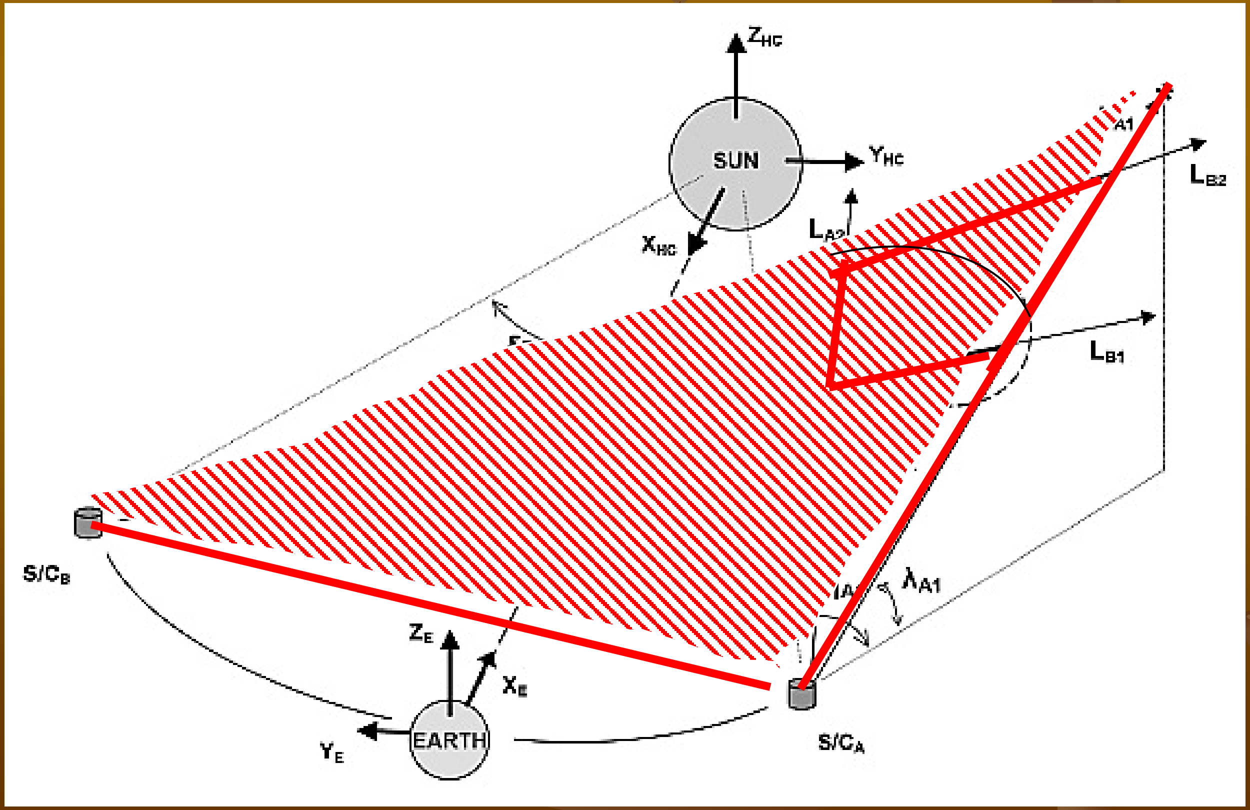
  - *GL defines a volume which circumscribes that structure*

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 ~ 120")

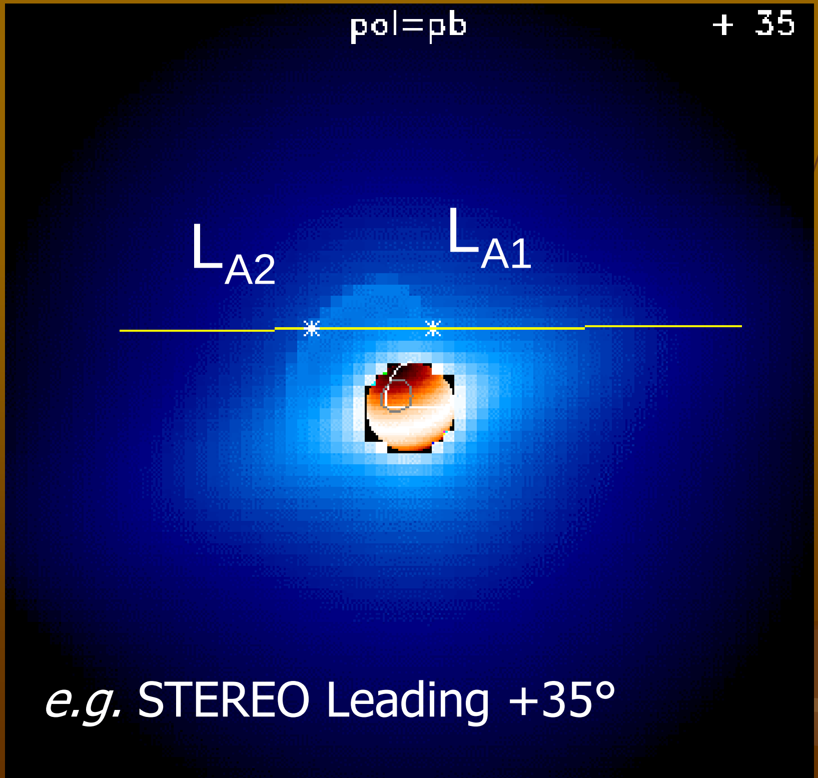
Schematic of ‘Geometric Localization’ Technique

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

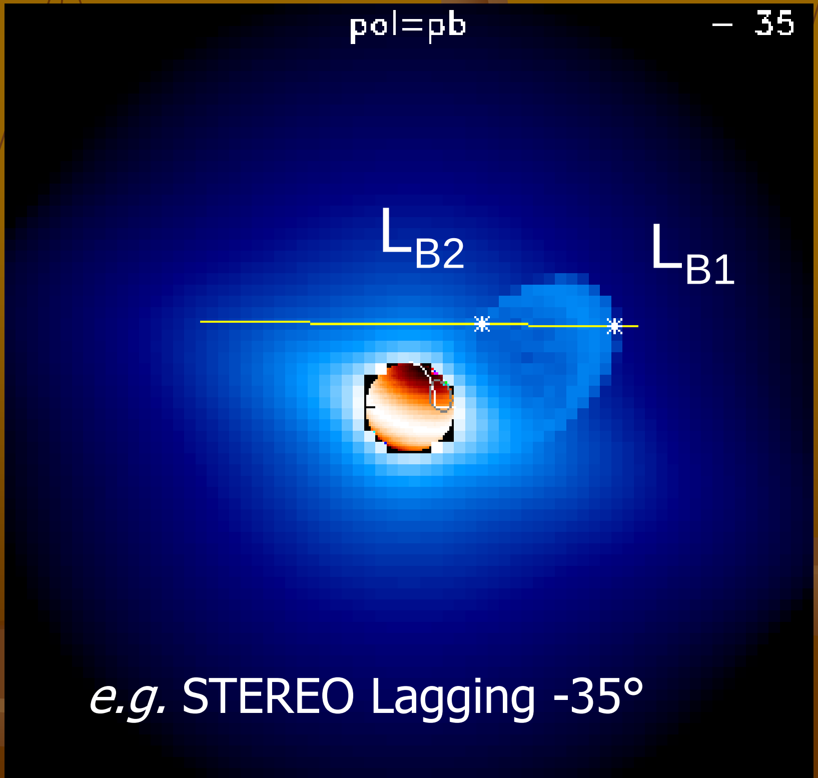


Geometric Localization

- 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



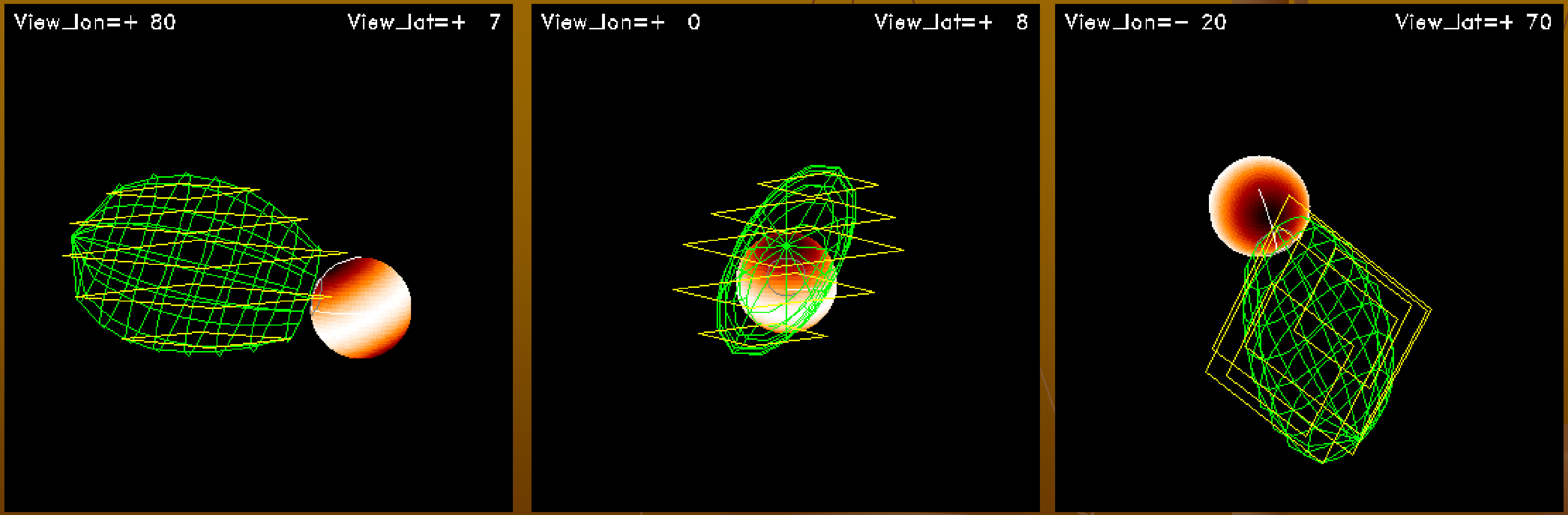
e.g. STEREO Leading +35°



e.g. STEREO Lagging -35°

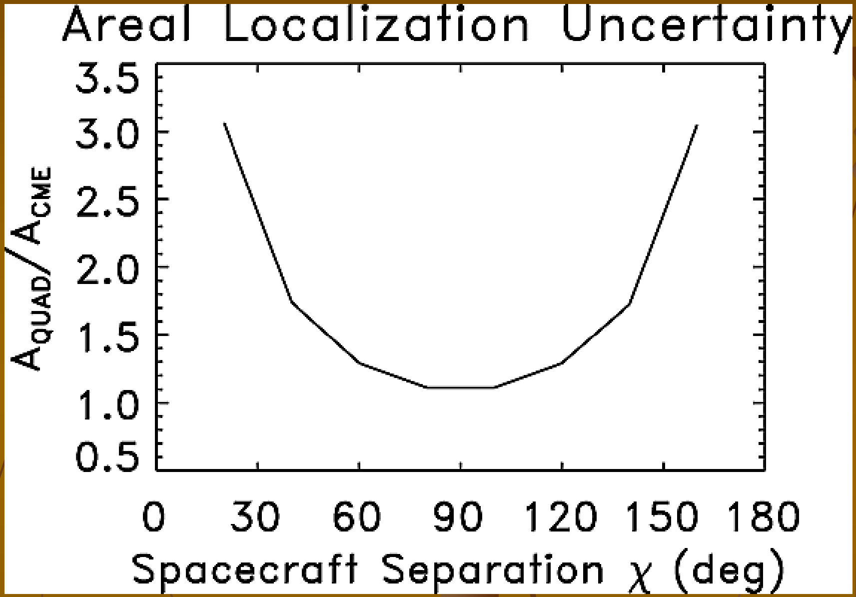
The Resulting Localization

- 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 ~ *f(X)*
  - Quantifiable – critical for forecasters
- Ideal separation 90°
  - Two years into mission
- Reasonable uncertainty (<50%)
  - Year 1 to Year 3

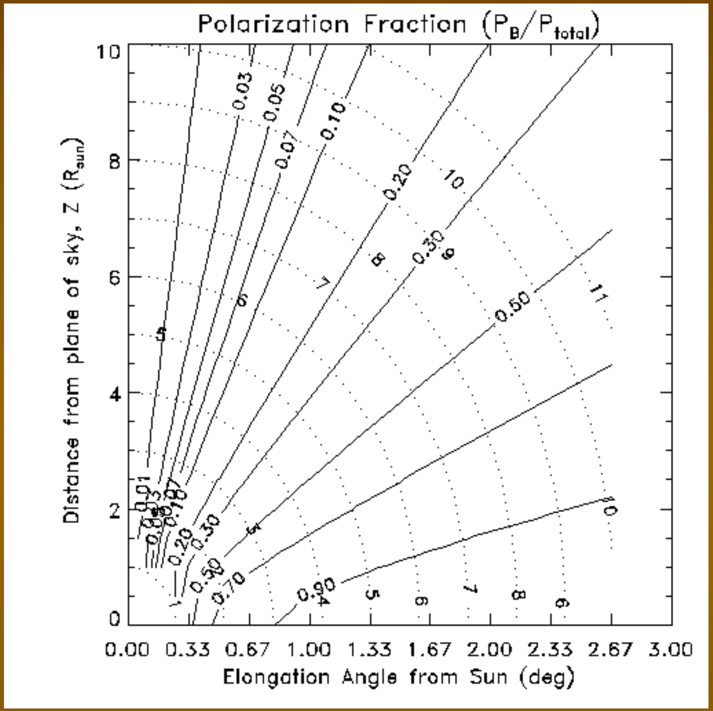


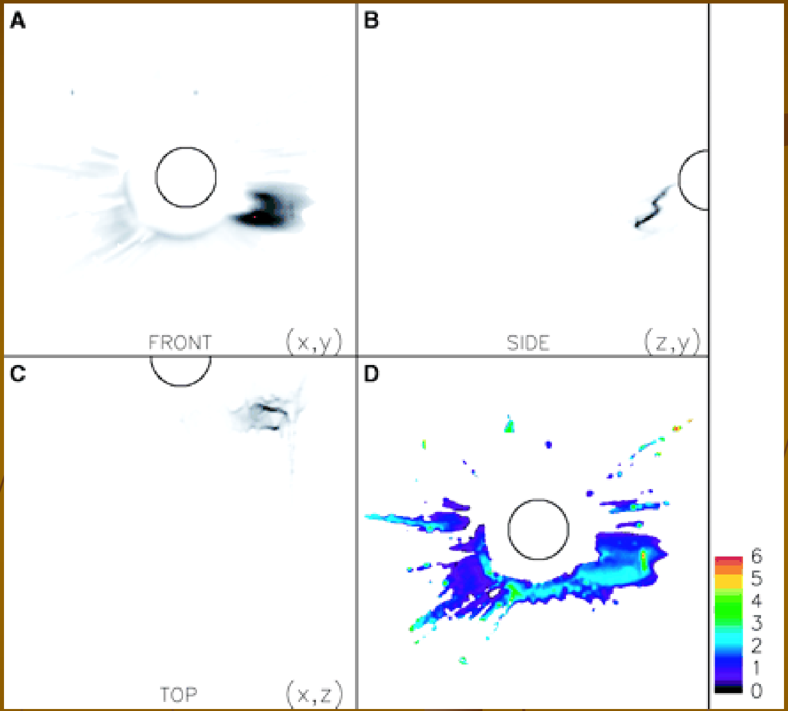
Comparing area of cross-section of model to cross-section of CME

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

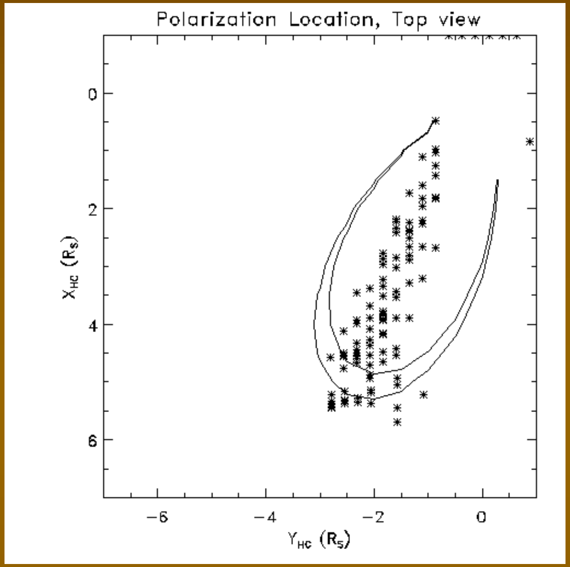
Polarization Analysis

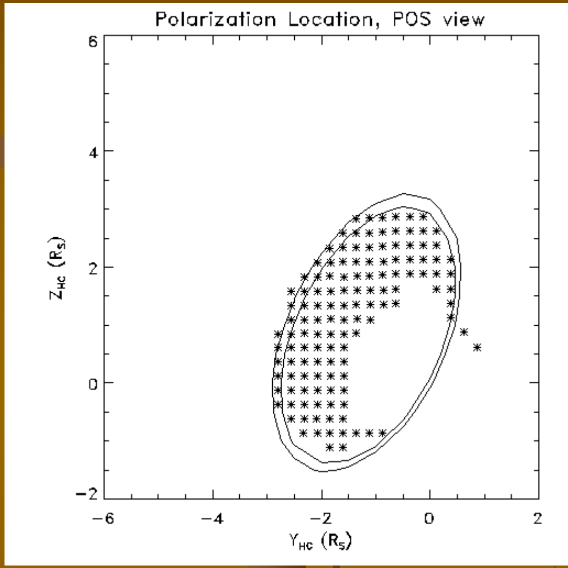




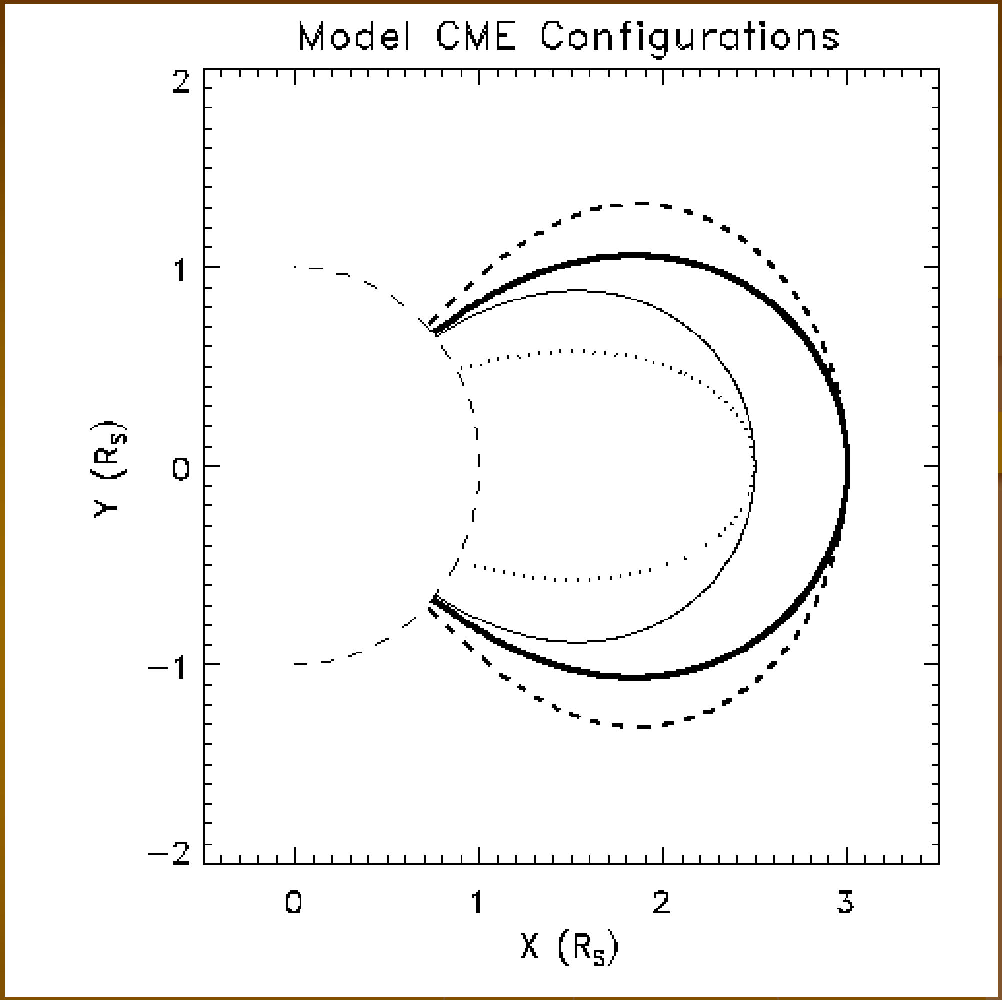
- On a pixel by pixel basis – finds C.O.M. along a line of sight
  - Collapses a 3-d structure into ~2.5-d
  - Gives spatial information

Polarization Analysis + Geometric Localization

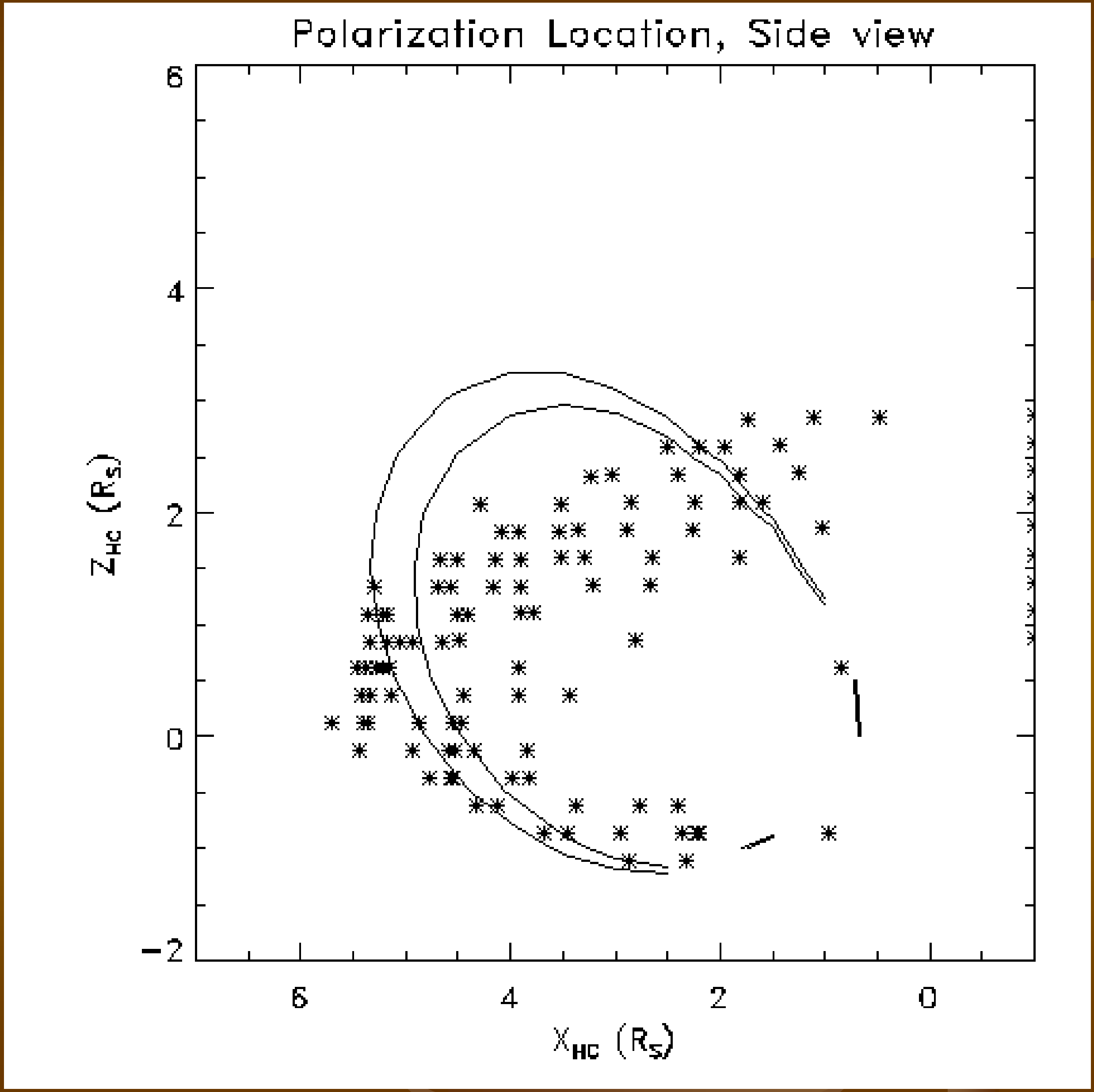




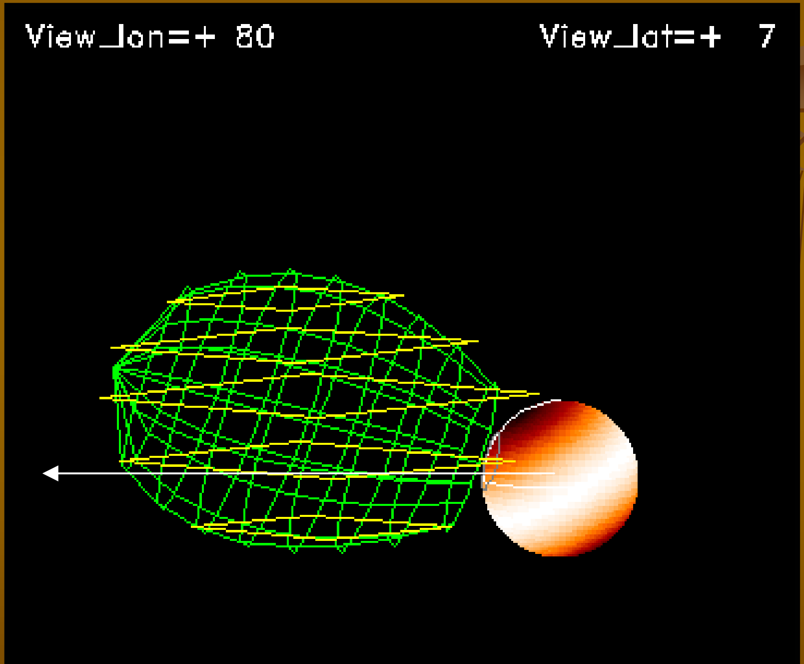
- Polarization Analysis and Geometric Localization are complementary
  - Geometric Localization resolves plane-of-sky ambiguities inherent in polarization analysis
  - Polarization analysis can provide more information about CME structure (*i.e.* mass distribution)



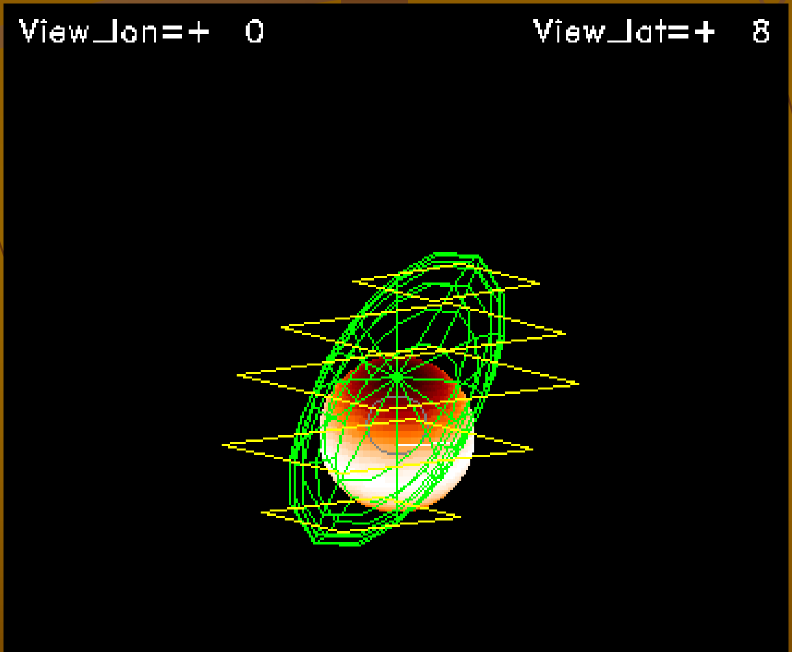
$$\psi(\rho, \zeta) = (1 / \rho) \times \cos^{(p/2)}(2\zeta)$$


Polarization Location, Side view
Z_{HC} (R_S)
X_{HC} (R_S)
6
4
2
0
−2
6
4
2
0

A pathetic attempt at demonstrating a visualization tool



View from the side



View straight down the barrel

What’s still missing?

- What info didn’t I present that FAB wants?
- What needs to be done before launch
  - Do we do lots of work to be ready for data?
  - Do we wait to see what we end up getting and using?
- Transition process?

Data Browsers and Viewers

- **SSC Beacon Data pages**
  - http://stereo-ssc.nascom.nasa.gov/mockup/latest_mockup.shtml
- **Solar Weather Browser** B. Nicula, D. Berghmans, R. van der Linden ROB
  - User-friendly browser tool for finding & displaying solar data & (SWB) context information.
  - Test version available at http://sidc.oma.be/SWB/.
- **STEREO Key Parameters** *C. Russell & IMPACT, PLASTIC & SWAVES teams UCLA*
  - An easily browseable Merged Key Parameter data display including the in-situ & SWAVE radio data from STEREO.
- **Carrington Rotation In-situ Browser** *J. Luhmann, P. Schroeder UCB*
  - Browser for identifying in-situ events & their solar sources at CR-time scales.
  - Includes near-Earth (ACE) data sets for third point views & image movies from SECCHI & near-Earth (SOHO).
  - See: http://sprg.ssl.berkeley.edu/impact/data_browser/index.html.
- **JAVA-3D Synoptic Information Viewer** *J. Luhmann, P. Schroeder UCB*
  - JAVA-3D applet for viewing 3D Sun & solar wind sources based on synoptic solar maps & potential field models of the coronal magnetic field.
- **Radio and CME data pages** ***M. Pick, M. Maksimovic, J.L. Bougeret, et al.***
  - Ground radio imaging and spectra; movies; S/WAVES

3-D Imaging Tools

- **Tie Point Tool** *E. DeJong, P. Liewer, J. Hall, J. Lorre JPL*
  - **Manually create tiepoints between features in SECCHI image pair & solve for 3D location in heliographic coordinates.**
- **Geometric Localization Of CMEs** *V. Pizzo, D. Biesecker NOAA*
  - **Tool utilizing a series of LOS's from two views to define the location, shape, size and velocity of a CME.**
  - **To be automated & used to decide whether and when a CME will impact Earth.**
- **3D Structure of CMEs** *V. Bothmer, H. Cremades, D. Tripathi MPI, Ger.*
  - **Program to compare analysis of SECCHI images on the internal magnetic field configuration & near-Sun evolution of CMEs with models based on SOHO observations.**
  - **Forecast flux rope structure; 3D visualization of CMEs.**

Automated Detection and Identification

- **Computer Aided CME Tracking (CACTus)** *E. Robbrecht, D. Berghmans, et al.*
  - **Near-realtime tool for detecting CMEs in SECCHI images.**
    - **Outputs: QL CME catalog w/measures of time, width, speed; NRT CME warnings.**
  - **Successfully tested on SOHO LASCO CMEs.**
  - **Test version available at http://sidc.oma.be/cactus.**
- **Computer Aided EUVI Wave & Dimming Detection** *O. Podladchikova, D. Berghmans, A. Zhukov ROB*
  - **NRT tool for detecting EUV waves & dimming regions.**
  - **To be tested on SOHO EIT images.**
- **Velocity Map Construction** *J. Hochedez, S. Gissot ROB*
  - **Program to analyze velocity flows on SECCHI images; detect CME onsets & EUV waves; NRT warnings of fast CMEs; reconstruct 3D velocity maps of CMEs from 2D maps from each STEREO.**
- **Automatic Solar Feature** *D. Rust, P. Bernasconi, B. LaBonte, JHU/APL*
  - **Tool for detecting and characterizing solar filaments and sigmoids Recognition & Classification in solar images. Goal is to meas. magnetic helicity parameters & forecast eruptions using filaments & sigmoids.**

Heliospheric Studies

- **WSA Model Predictions** *N. Arge, J. Luhmann, D. Biesecker AFRL, UCB, NOAA*
  - **The Wang-Sheeley-Arge and ENLIL 3D MHD solar wind models will be integrated**
  - **Provide routine predictions of vector s.w. velocity, polarity, s.w. density & temp. anywhere you like**
- **Identifying & Tracking CMEs with the Heliospheric Imagers** *R. Harrison, C. Davis RAL*
  - **Produce simulations to show model CMEs can be identified & tracked with the HIs.**
  - **Use triangulation to measure speed & direction of CMEs & forecast their Earth arrival.**
- **Structural Context of Heliosphere Using SMEI Data** *D. Webb, B. Jackson BC/AFRL, UCSD*
  - **Use analyses of SMEI images to provide structural context of the heliosphere for STEREO HI**
  - **Also provide complementary observations of transient disturbances.**
- **Interplanetary Acceleration of ICME's** *M. Owens BU*
  - **Construct acceleration profiles of fast ICMEs over a large heliocentric range using multi-point HI to understand the forces acting on ejecta.**
  - **Improve predictions of arrival times of ICMEs at Earth.**
- **Relationship between CMEs and Magnetic Clouds** *S. Matthews, MSSL*
  - **Assess the potential geoeffectiveness of CMEs based their association with magnetic clouds.**
  - **What particular characteristics lead to production of a magnetic cloud?**