STEREO Science Working Group Meeting, Dec 15-16, 2003
Space Science Laboratory (SSL), University of Berkeley

Session 2: Issues for Discussion

3-D Imaging with STEREO

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http://secchi.lmsal.com/Science/

1) How does Science drive the STEREO 3D Imaging & Analysis ?

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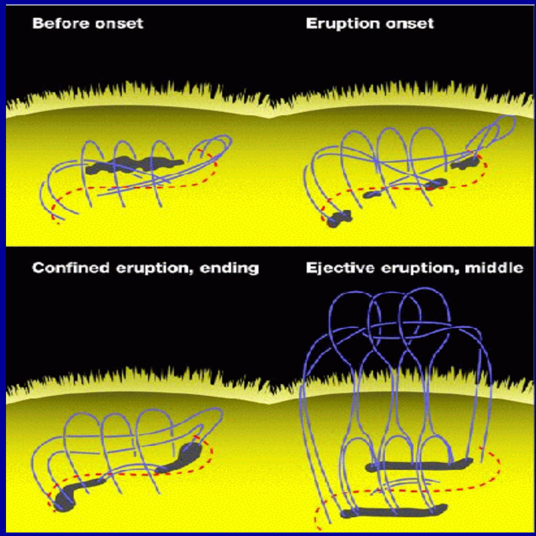
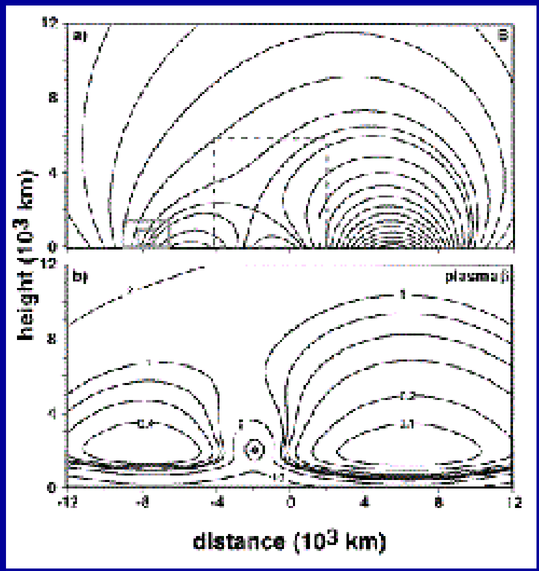
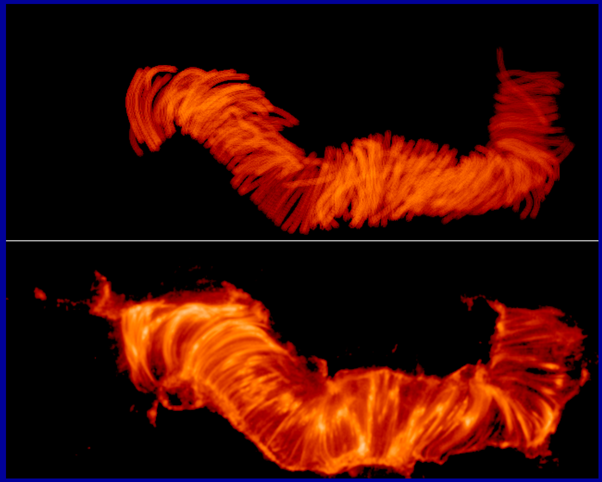




Theoretical concept or model



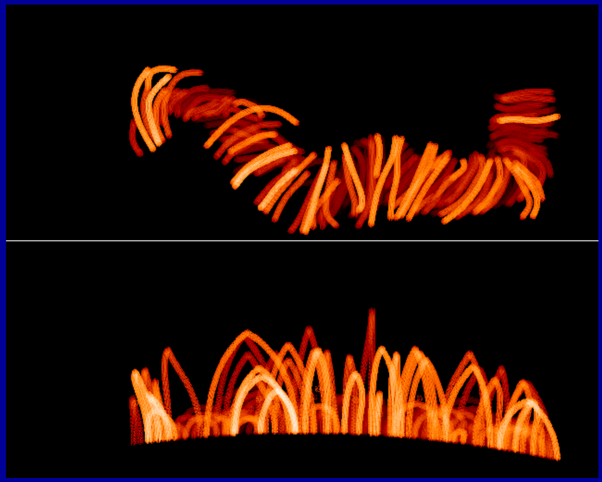


Image analyis, modeling, fitting

Philosophy:

1) Scientific question expressed by quantifyable observables
2) Development of data analysis tools that quantify observables and are sensible to answer the question
3) YES/NO answer would ideally confirm/disprove model

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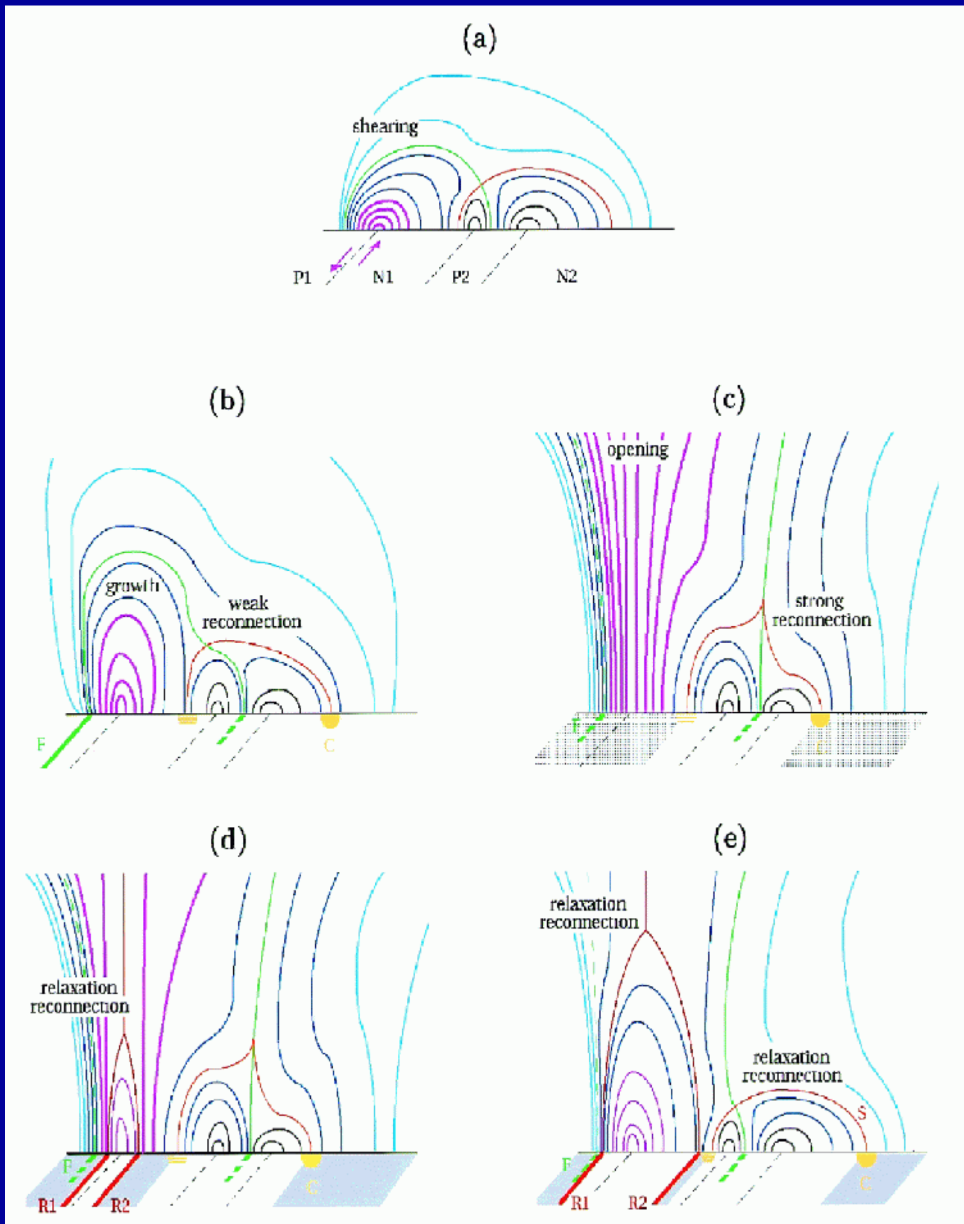
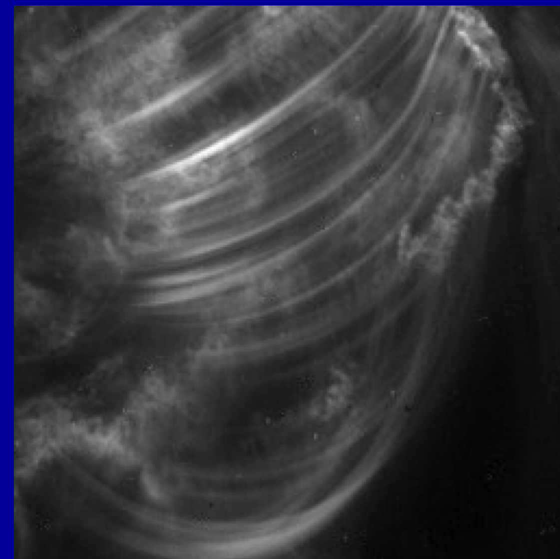
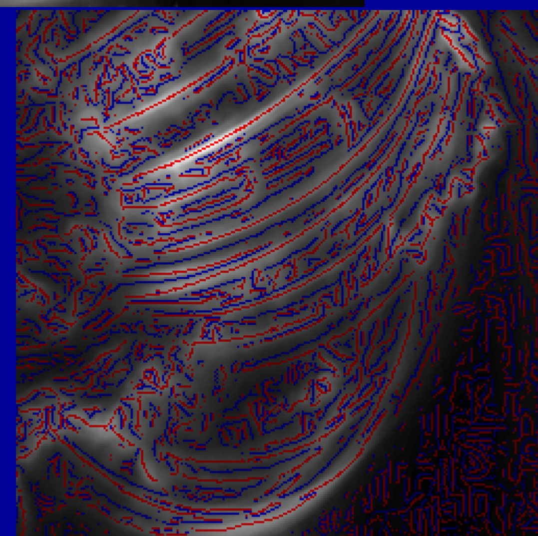
Example:

1) Does “Magnetic Break-out” or “loss-of-equilibrium” model trigger eruption of filament and lead to a CME ?
2) Develop tool to derive 3D magnetic field from STEREO data and forward-fit 3D evolution with MHD codes.
3) None, one, or both models yield a good fit to data,
   à disproves both models, confirms one model, or ambiguous choice



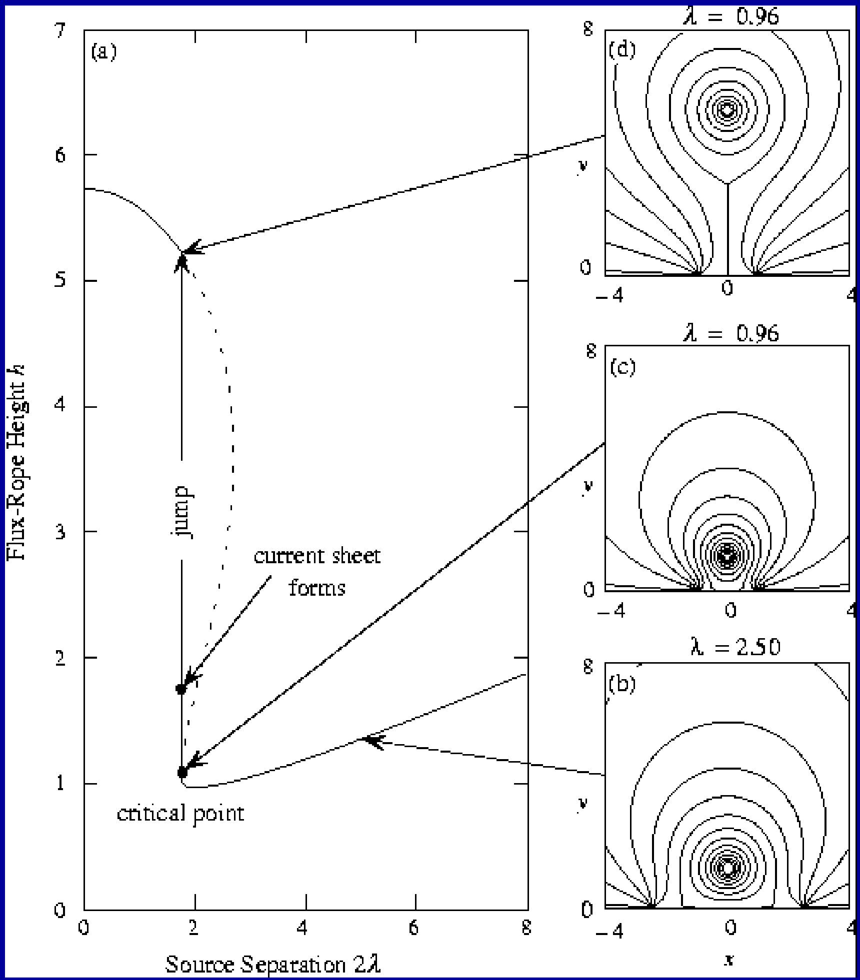
Magnetic breakout model (Antiochos 99)

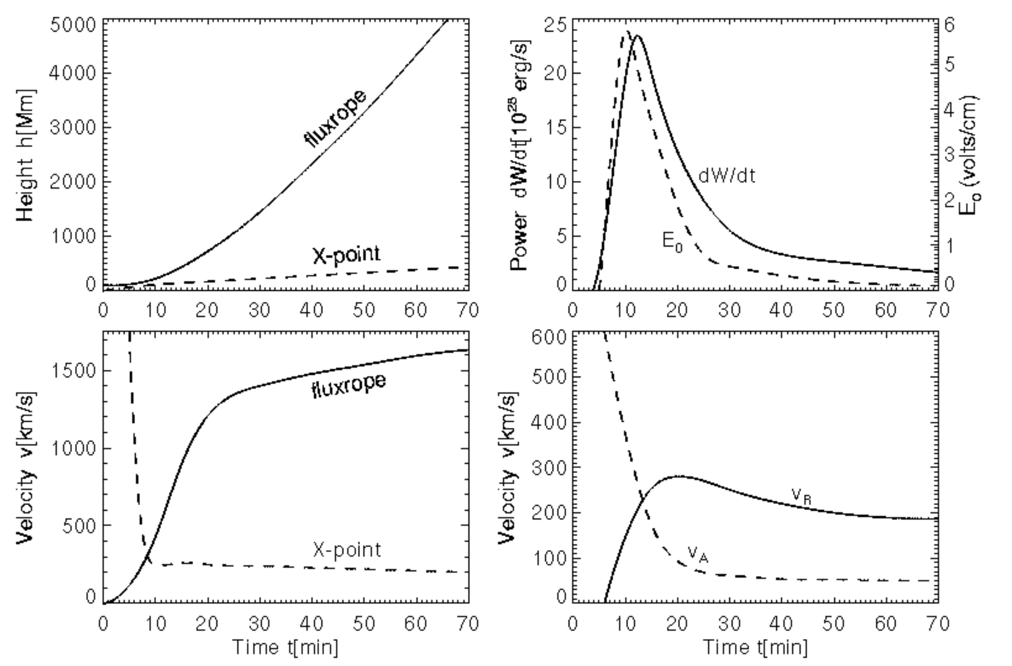




Data modeling:

1) pattern recognition ("finger-printing")
2) 3D-parameterization of field lines
3) Reconstruct time evolution B(x,y,z,t)





"loss-of-equilibrium" model
(Forbes & Priest 1995)

Data Analysis:

(1) Measure footpoint convergence (driver ?)

(2) Measure vertical motion [h(t), v(t), a(t)]

(3) Fit theoretical model of h(t) to data.

Required Data Analysis Tools:

1) Automated pattern recognition for curvi-linear structures (2D parameterization of magnetic field lines)

2) Tie-point finding algorithm of individual field Lines in two STEREO images

3) Combining 2D projections from 2 STEREO images into 3D coordinate of field lines

4) Volumetric modeling of CMEs by tomography, algebraic backprojection, or geometric forward-fitting

2) Methodology, Strategy, and Approach of 3D Imaging Data Analysis

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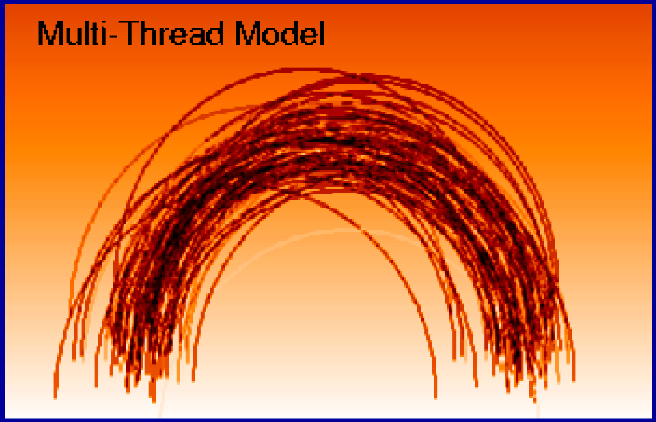
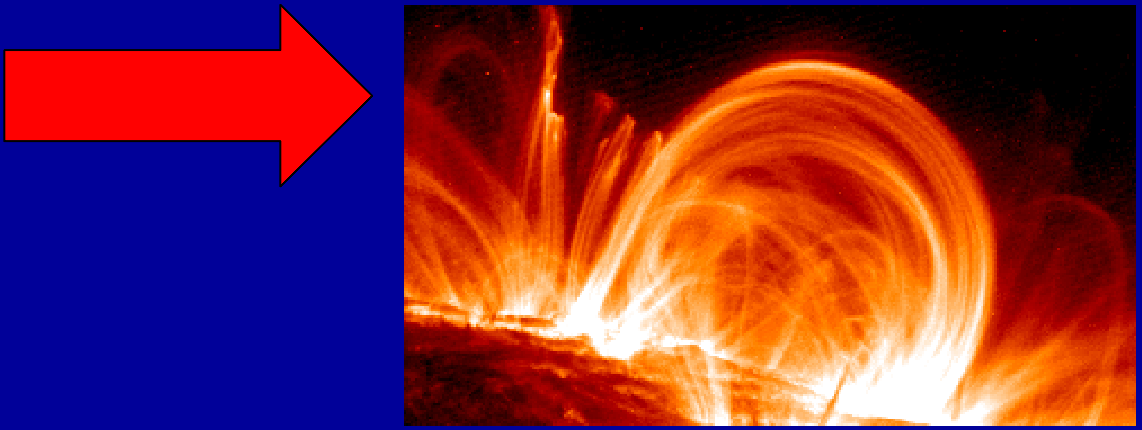
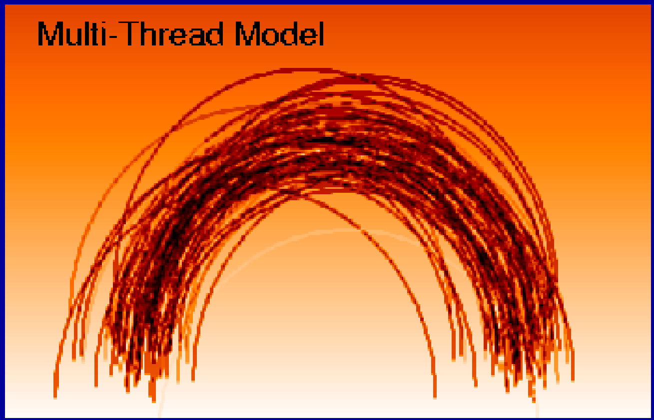


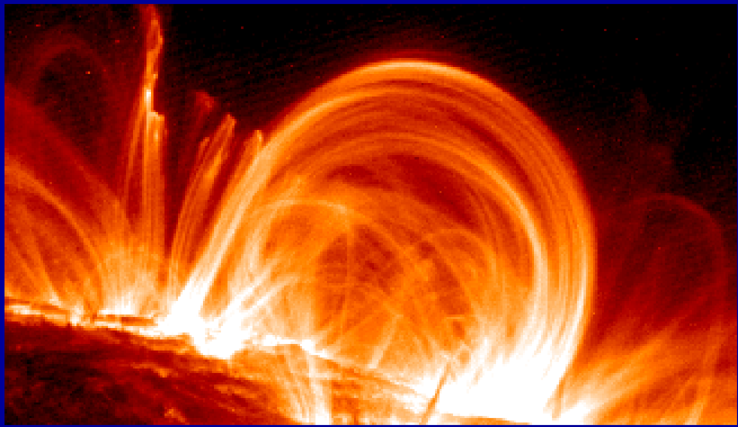
Forward-Fitting



2) Methodology, Strategy, Approach of 3D Imaging Data Analysis

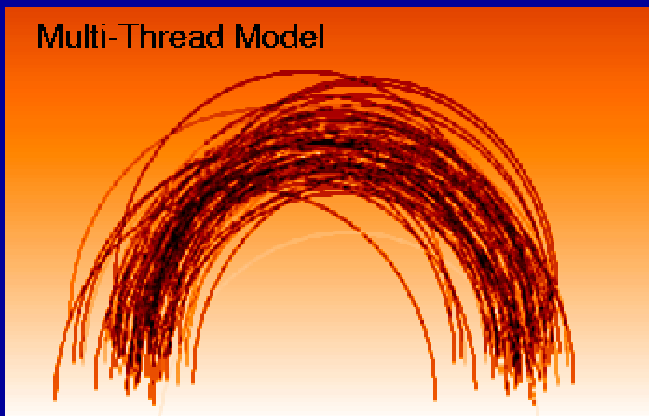


Forward-Fitting



-Requires parameterization of model
-Number of parameters could be large
-2D projection is given, only 3D coordinates need to be constrained by 2nd STEREO image
-Strategy: develop tool with automated 2D-parameterization of curvi-linear features (loops, filaments, fluxropes, sigmoids, postflare loops, etc.)
-3D coordinate can be first constrained by a-priori model (potential field, force-free, simple geometries, and then iteratively refined with projections from 2nd image, starting with the most unique and unambigous tie-points.

2) Methodology, Strategy, Approach of 3D Imaging Data Analysis



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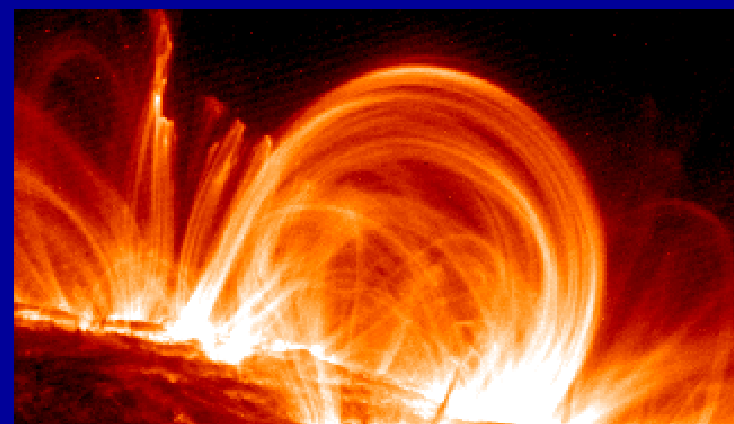
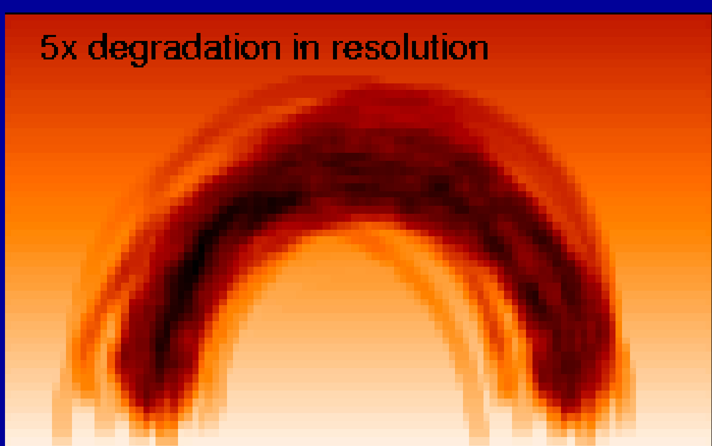


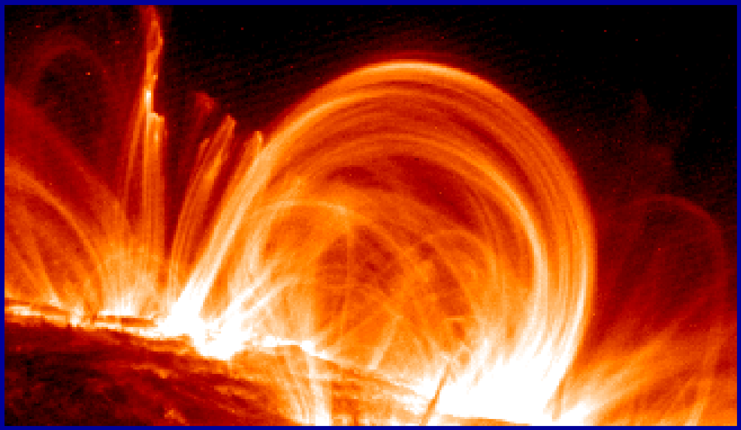
Inversion



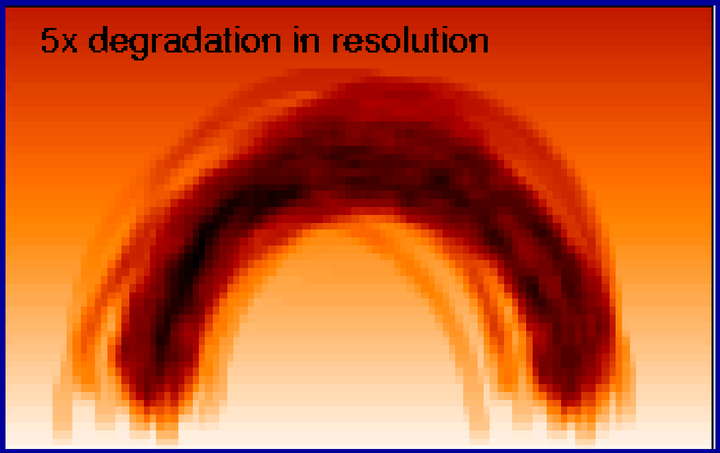
2) Methodology, Strategy, Approach of 3D Imaging Data Analysis

Inversions generally are coarse because of data noise, ambiguities, non-uniquneness
Advantage of inversions: they are model-independent
Inversion methods for STEREO images: e.g.

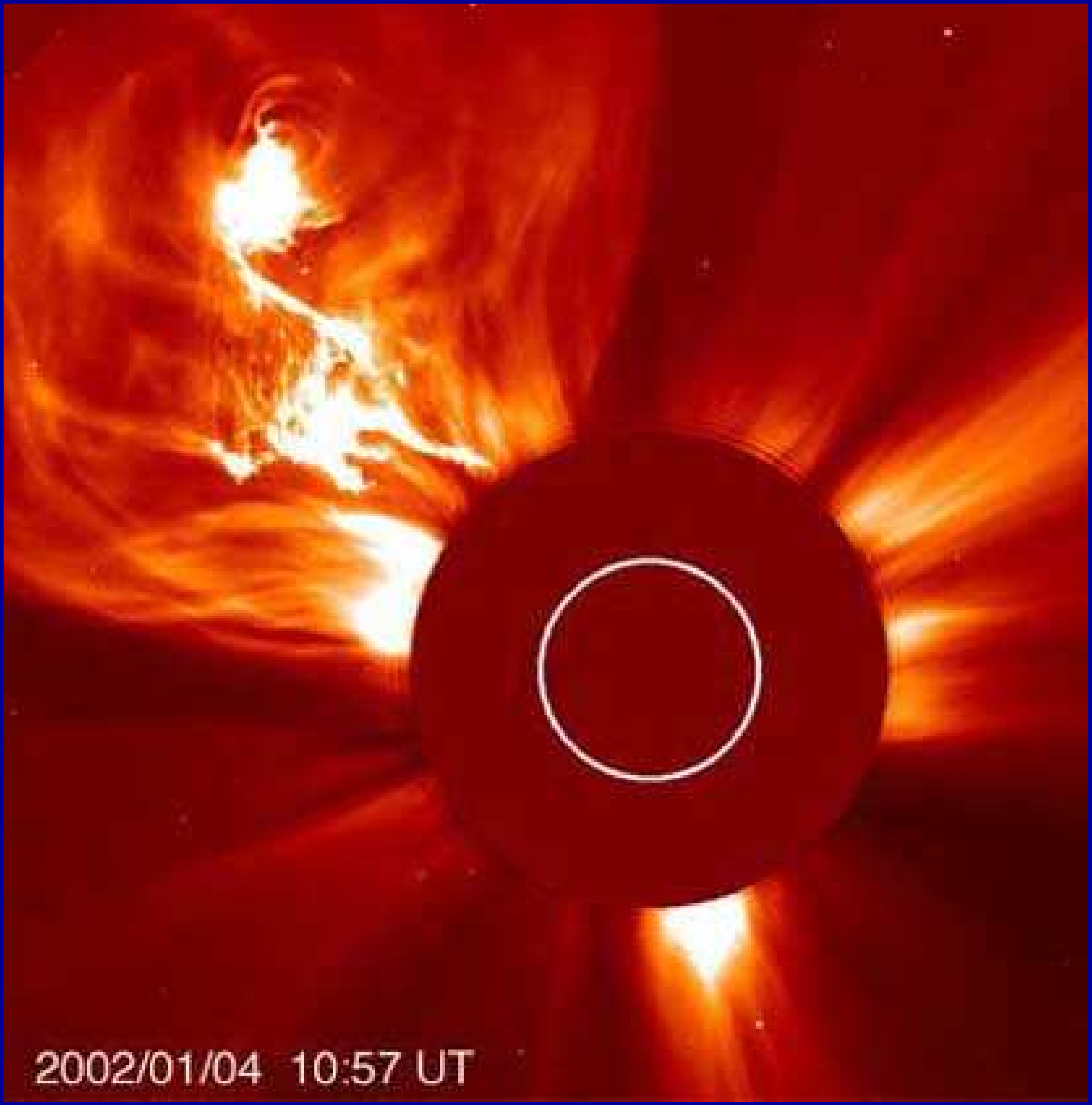
- 3D tomography (SMIE, Bernie Jackson)
- 3D Pixon reconstruction (SECCHI, John Cook; commercially available)



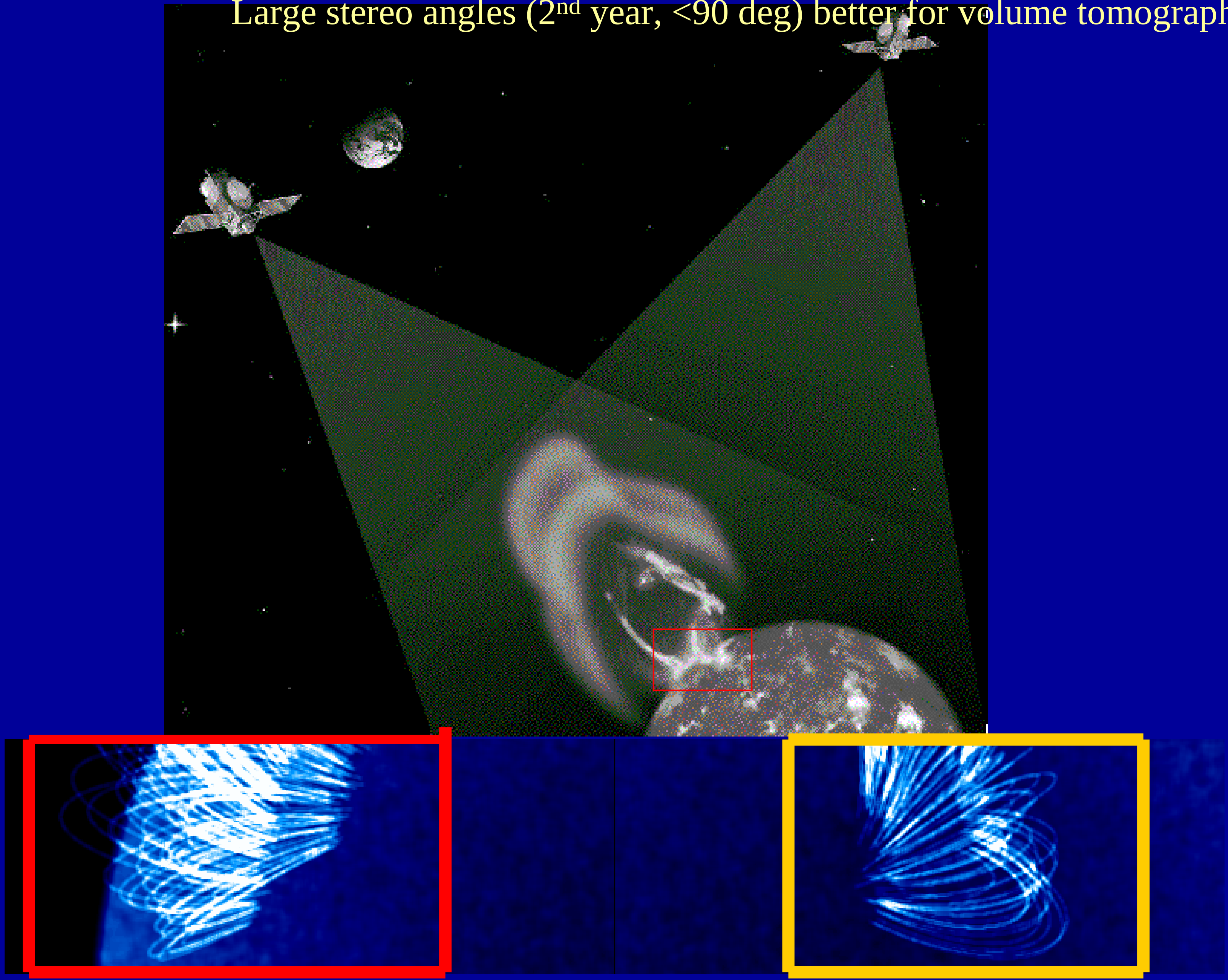
Inversion



Choise of 3D-modeling method:
Tomography, 3D-Pixon, Forward-Modeling ?



STEREO Timing: Small stereo angles (1st year, <45 deg) most suitable for stereoscopy
Large stereo angles (2nd year, <90 deg) better for volume tomography



Forward-fit Algorithm for Stereo Image Pair:

1. Selection of structure-rich multi-wavelength image from TRACE, EIT, and/or Yohkoh database (with filament, flare, CME, fluxropes, etc.)

2. Tracing linear features (loops, filaments, fluxropes) in 2D: s(x,y)

3. Inflation from 2D to 3D with prescription z(x,y)
   s(x,y) -> s(x,y,z)

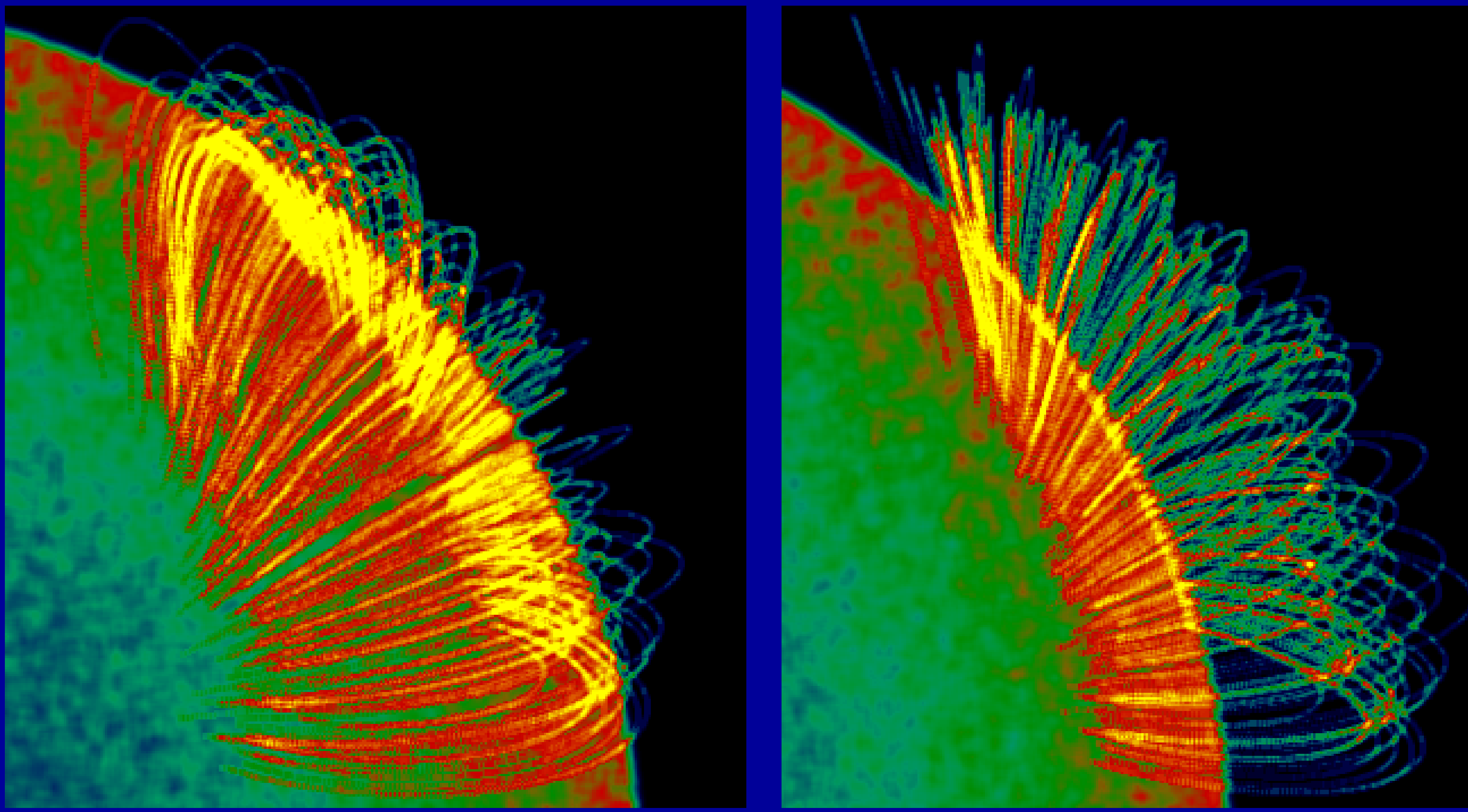
4. Physical model of structures: T(s), n(s), p(s), EM(s)

5. Geometric rotation to different stereo angles
   EM(x,y,z) -> EM(x',y',z')

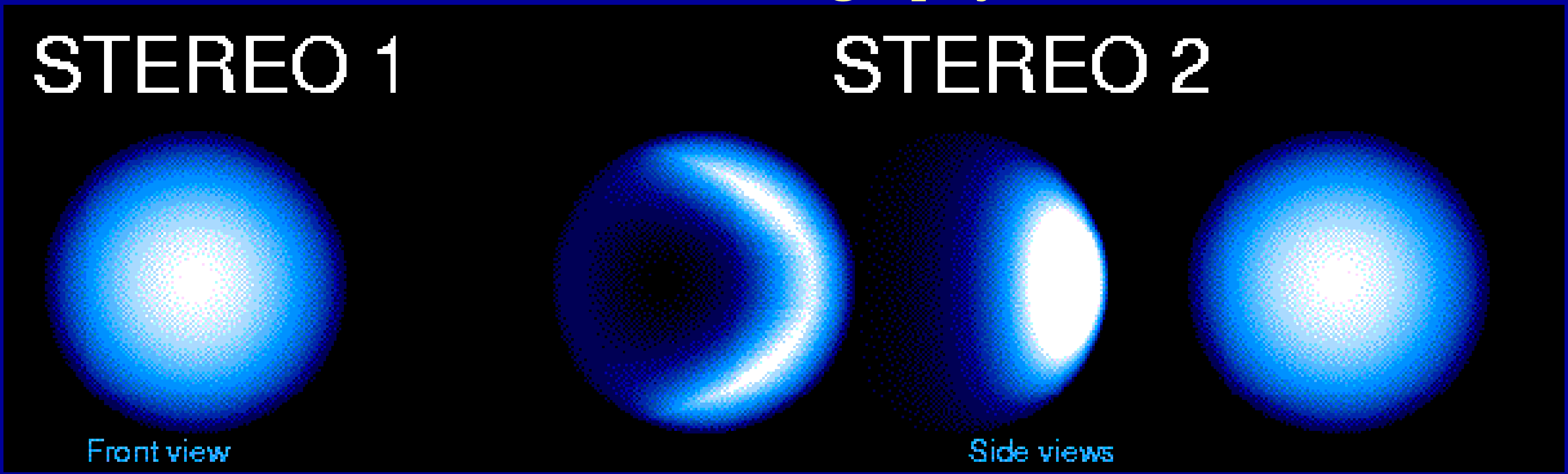
6. Line-of-sight integration $EM(x',y')=\int EM(x',y',z')dz'$ and convolution with instrumental response function

→ http://www.lmsal.com/~aschwand/ppt/2002_Paris_stereo.ppt

Simulation of STEREO images at different stereo angles



Volumetric Forward-Modeling of Stereo images versus Inversion with tomography



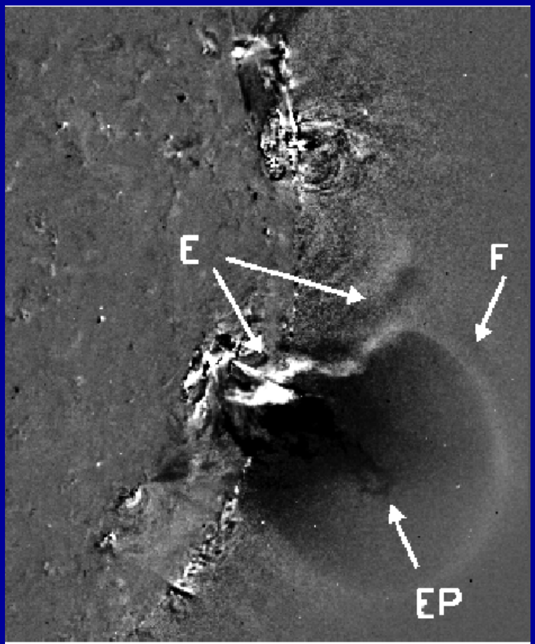
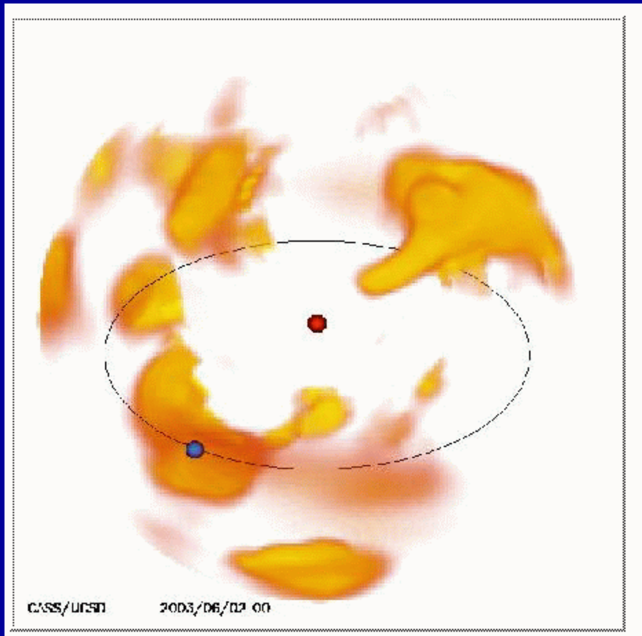


Figure 2. EIT Observations of a CME With 3-Part Structure on 21 Dec 1996

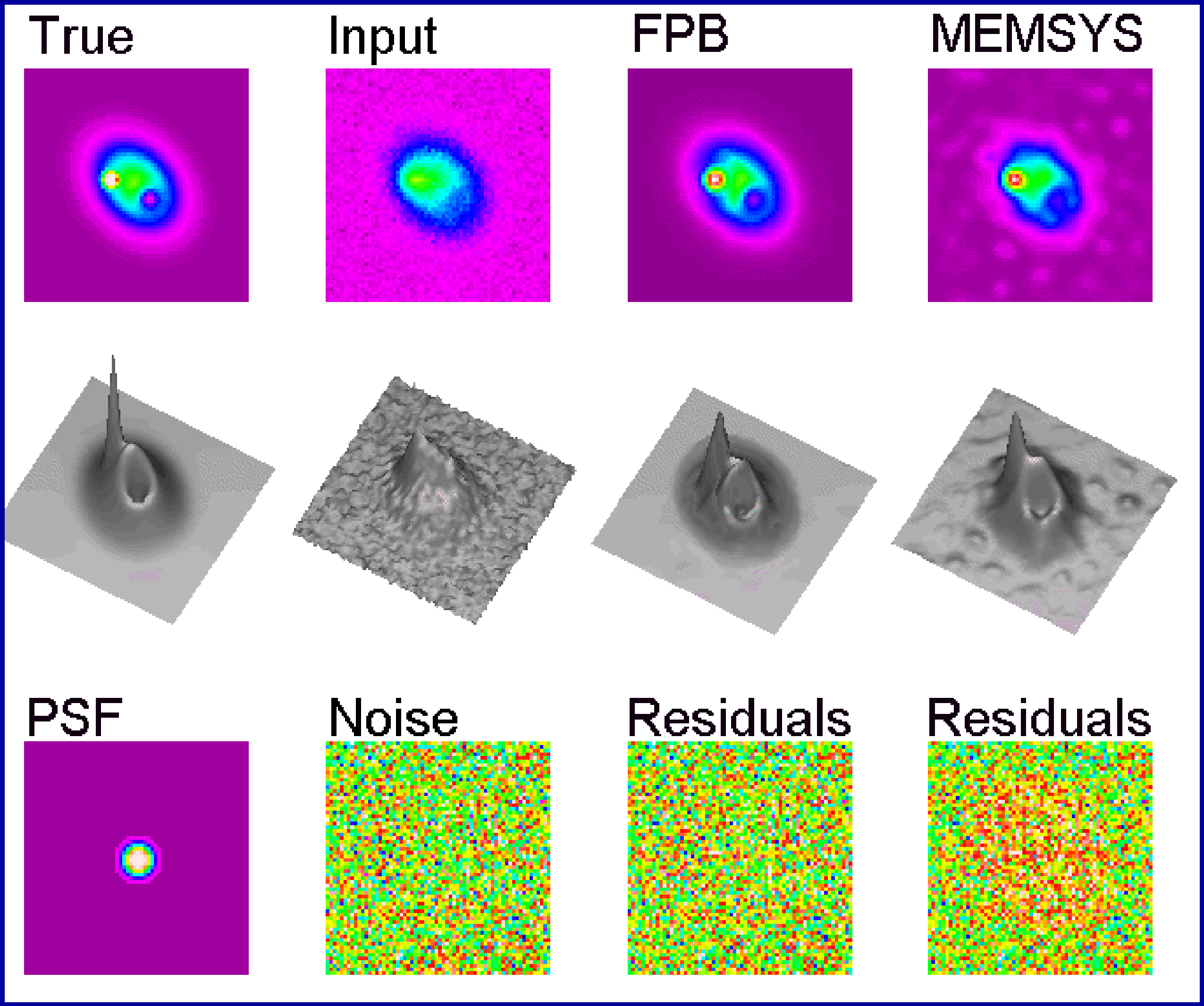
EIT

SMIE

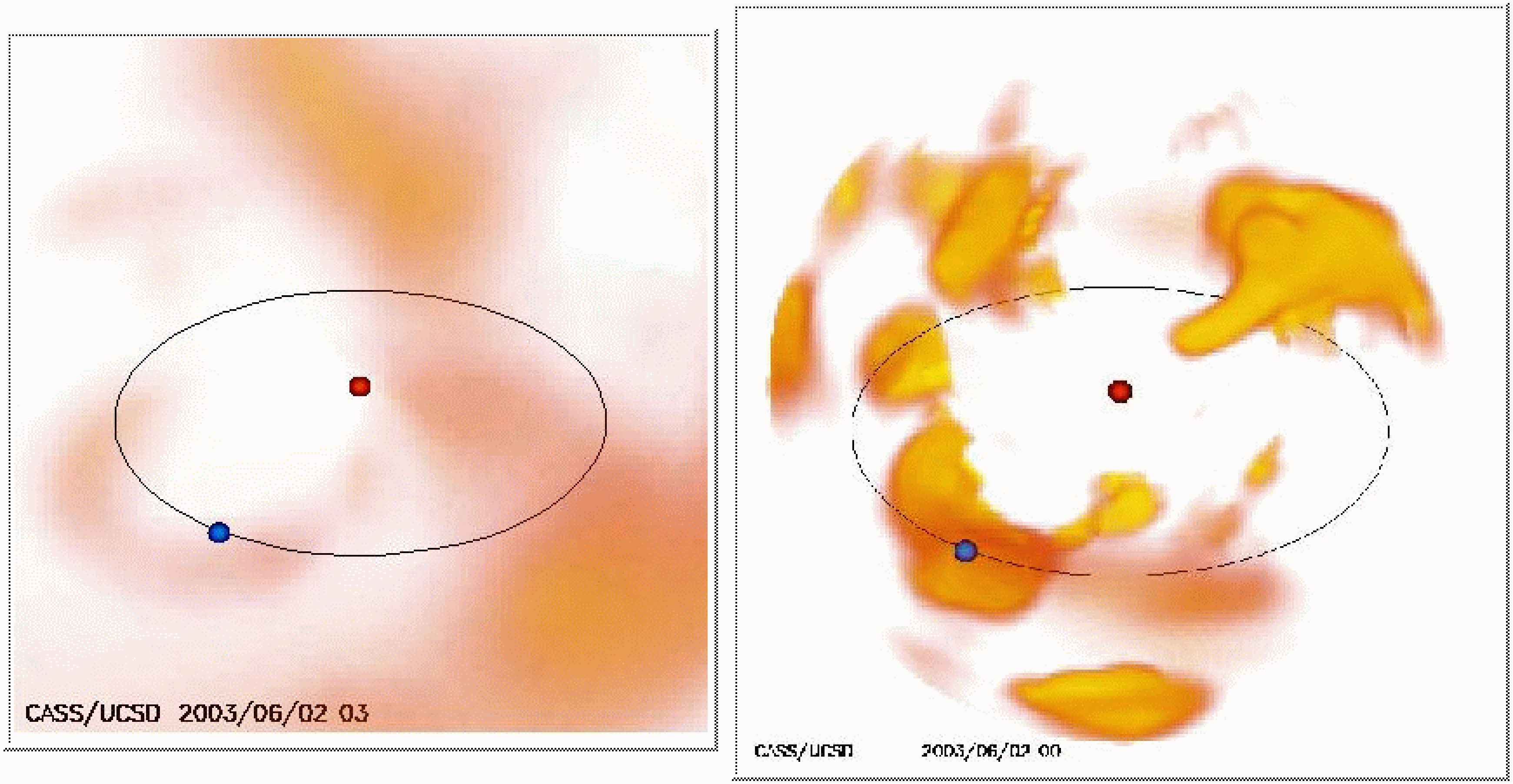


ion tomography of May 29, 2003 halo CME.

Pixon reconstruction of CME structures in STEREO images:



3D tomography reconstruction of SMIE data



IPS (left) and SMEI (right) low resolution tomography of May 29, 2003 halo CME.

http://cassfos02.ucsd.edu/solar/smei_new/analysis.html
(Bernie Jackson)

3) Interfacing 3D Imaging: SECCHI – HI – SMEI – SDO - …

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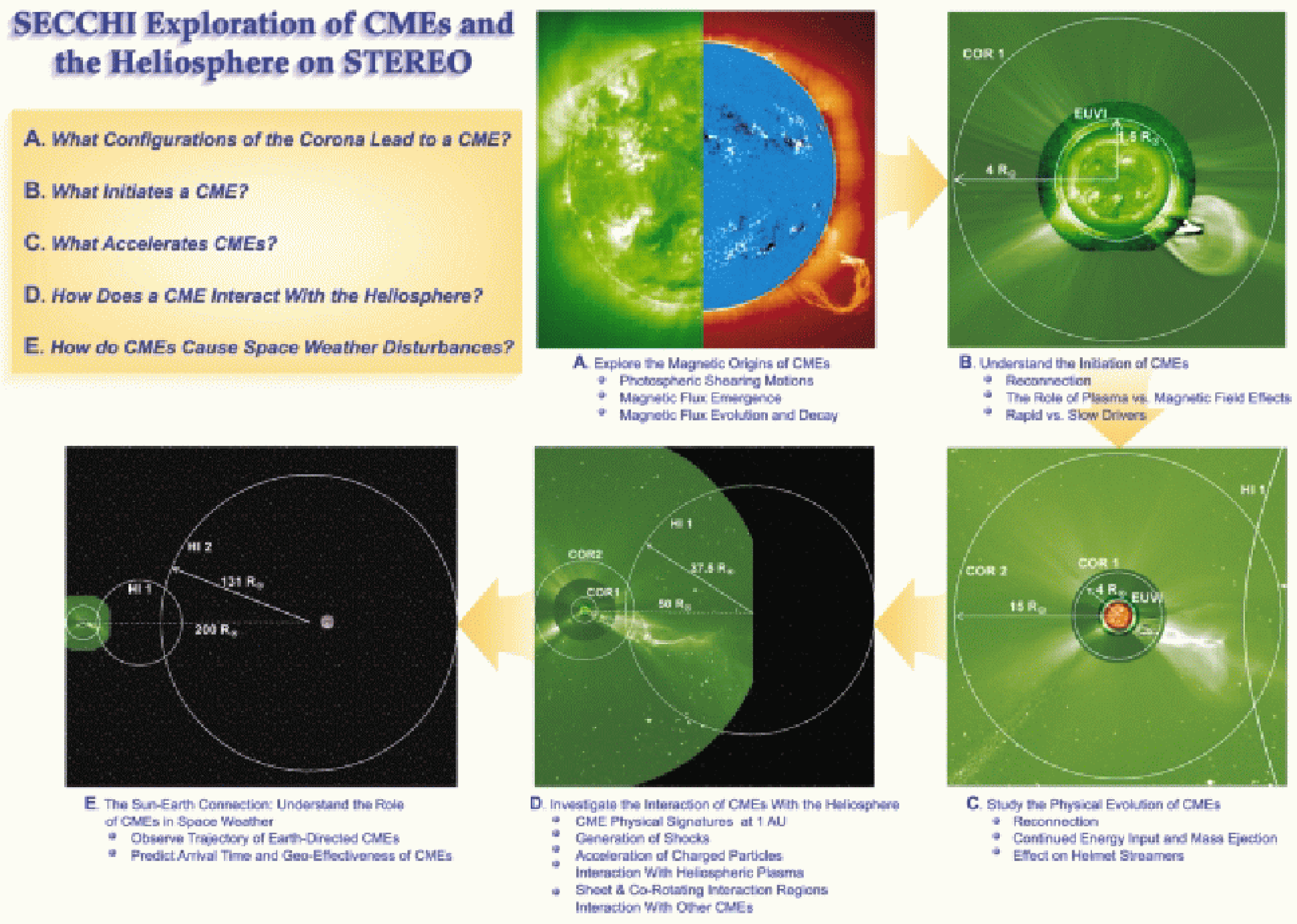

Discussion – Session 2:

à HI Image Simulation – Chris Davis

à HI Operations – Davis Neudegg

à HI/SECCHI – Sarah Matthews

à SMEI – Dave Webb, Bernie Jackson

(accomplished tomography at low resolution)

à VSO (Virtual Solar Observatory) – Bill Thompson

Other Input:

à SECCHI high/low telemetry rate vs. stereo separation angle (Wuelser)

à Automated Detection and 3D Reconstr. EUV Prominences (Claire Fullon)
à LASCO, Automated detection of CMEs (David Berghmans)

à SECCHI White-light Coronograph 3D heliospheric reconstruction/pixon
(Reiser, Cook, Newmark, Crane, Yahil, Gosnell, Puetter)

à Image tomography based on magnetic field input
(Bernd Inhester, Maxim Kramer; Stereo meeting 2002)

à Automated pattern recognition used for finding tie-points
(Paulett Liewer and Eric de Jong)

à Multiscale Vision Model à multi-scale tie-points ?
global matching, local w. epipolar lines (Fabrice Portier-Fozzani, 2001)
optical flow methods (T.Papadopoulo et al. 2000) –
(Thierry Dudok de Wit, Image processing meeting 2003)

Web-sites related to STEREO 3D Imaging:

http://stereo.nrl.navy.mil/html/3dindex.html
http://sol.oma.be/SECCHI/
http://sol.oma.be/SIRW/
http://secchi.lmsal.com/Science/
http://stereo.jhuapl.edu/
http://stp.gsfc.nasa.gov/missions/stereo/stereo.htm
http://star.mpae.gwdg.de/secchi/index.html