

Real-Time Forecasting with IPS 3D Modeling

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Real-Time Forecasting with IPS 3D Modeling

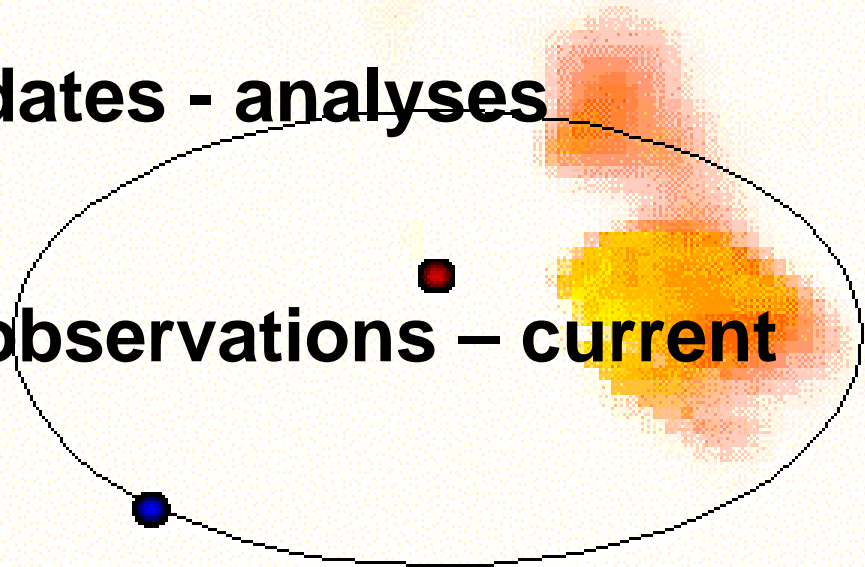
Introduction:

The observations: SMEI, IPS

SMEI updates - analyses

The IPS observations – current analyses

SMEI-Ulysses-STEREO Toyokawa
IPS Workshop, Japan



Real-Time Forecasting with IPS 3D Modeling

The Solar Mass Ejection Imager (SMEI) Mission, (*Solar Phys.* 225, 177)

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R.C. Altrock, S. Figueroa, P.E. Holladay, J.C. Johnston, S.W. Kahler, J.B. Mozer, S. Price, R.R. Radick, R. Sagalyn, D. Sinclair

Air Force Research Laboratory/Space Vehicles Directorate (AFRL/VS), Hanscom AFB, MA

G.M. Simnett, C.J. Eyles, M.P. Cooke, S.J. Tappin

School of Physics and Space Research, University of Birmingham, UK

T. Kuchar, D. Mizuno, D.F. Webb

ISR, Boston College, Newton Center, MA

P.A. Anderson

Boston University, Boston, MA

S.L. Keil

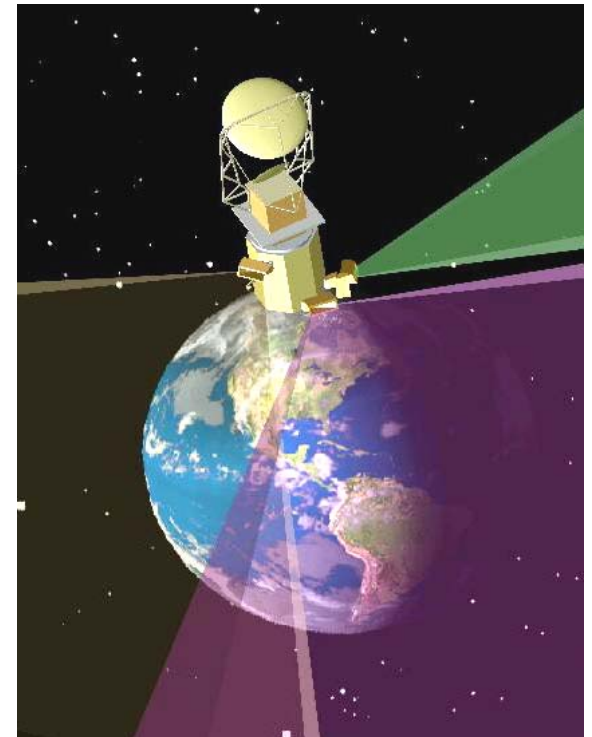
National Solar Observatory, Sunspot, NM

R.E. Gold

Johns Hopkins University/Applied Physics Laboratory, Laurel, MD

N.R. Waltham

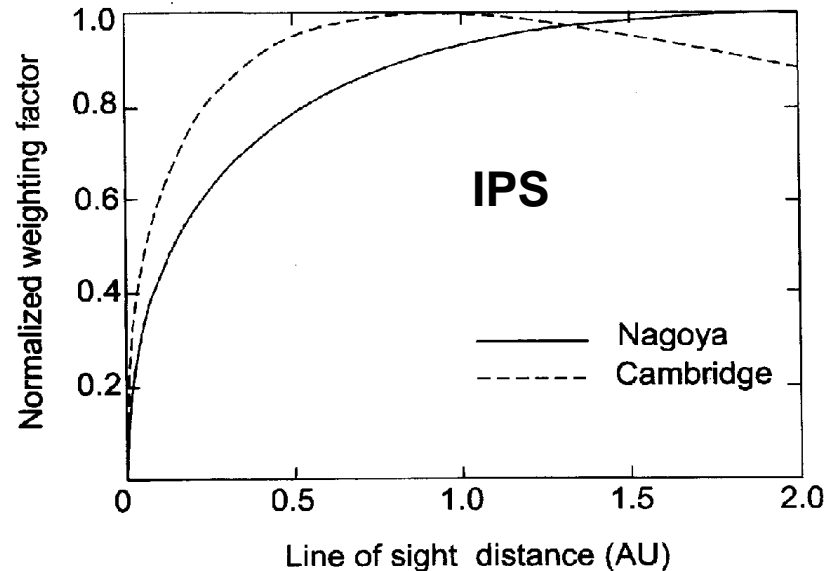
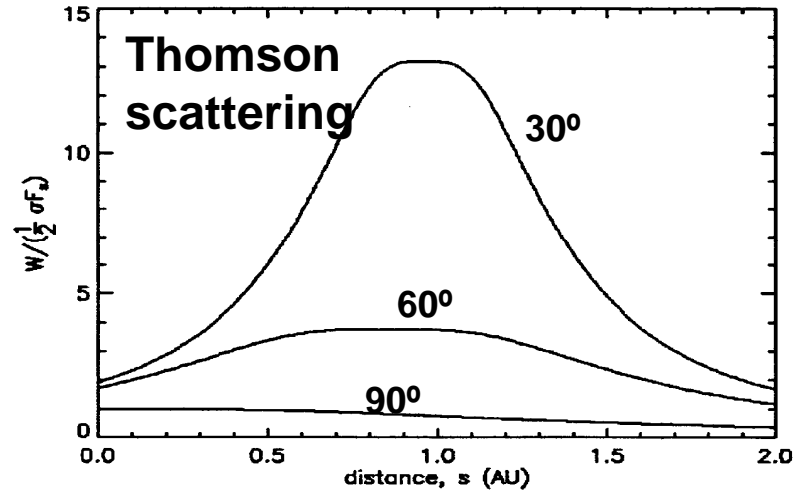
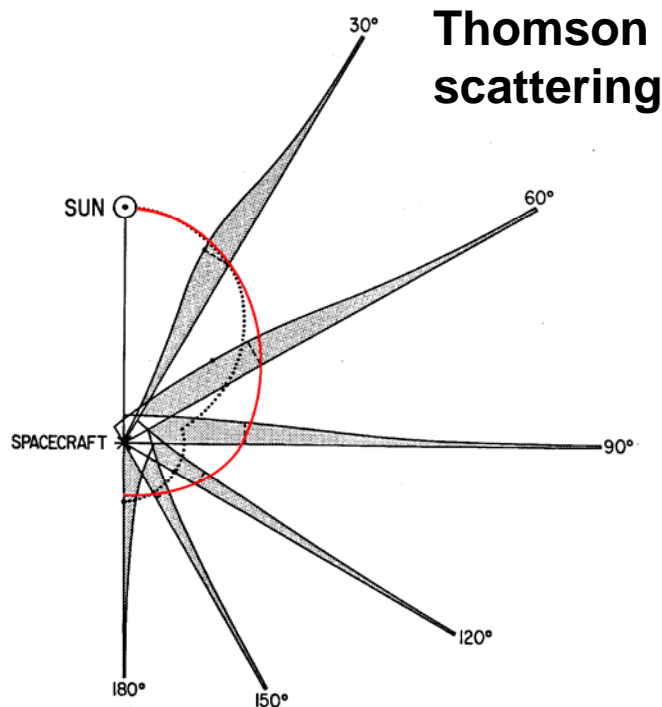
Space Science Dept., Rutherford-Appleton Laboratory, Chilton, UK



Real-Time Forecasting with IPS 3D Modeling

Heliospheric C.A.T. Analyses

Line of sight weighting values
for each sky location.



Real-Time Forecasting with IPS 3D Modeling

Jackson, B.V., P.L. Hick, M. Kojima, and A. Yokobe (1998), Heliospheric tomography using interplanetary scintillation observations, 1. Combined Nagoya and Cambridge observations, *J. Geophys. Res.*, 103, 12,049.

Jackson B.V. A. Buffington A., and P.P. Hick (2001), A heliospheric imager for solar orbiter, in Proc. of “Solar Encounter: The First Solar Orbiter Workshop, Puerto de la Cruz, Tenerife, Spain, 14-18 May 2001 (ESA SP-493), 251.

Jackson, B.V., P.P. Hick, and A. Buffington (2002), Time-dependent tomography of heliospheric features using interplanetary scintillation (IPS) remote-sensing observations’, *Solar Wind 10 Conference Proceedings*, Pisa, June 17-21, 31.

Jackson, B.V., P.P. Hick, and A. Buffington (2002), Time-dependent tomography of heliospheric features using the three-dimensional reconstruction techniques developed for the Solar Mass Ejection Imager (SMEI), *Proc. SPIE, Waikoloa*, 22-28 August 2002, 4853, 23.

Hick, P.P., and B.V. Jackson (2003), Heliospheric tomography: an algorithm for the reconstruction of the 3D solar wind from remote sensing observations, *Proc. SPIE, San Diego*, 7-8 August 2003, 5171, 287.

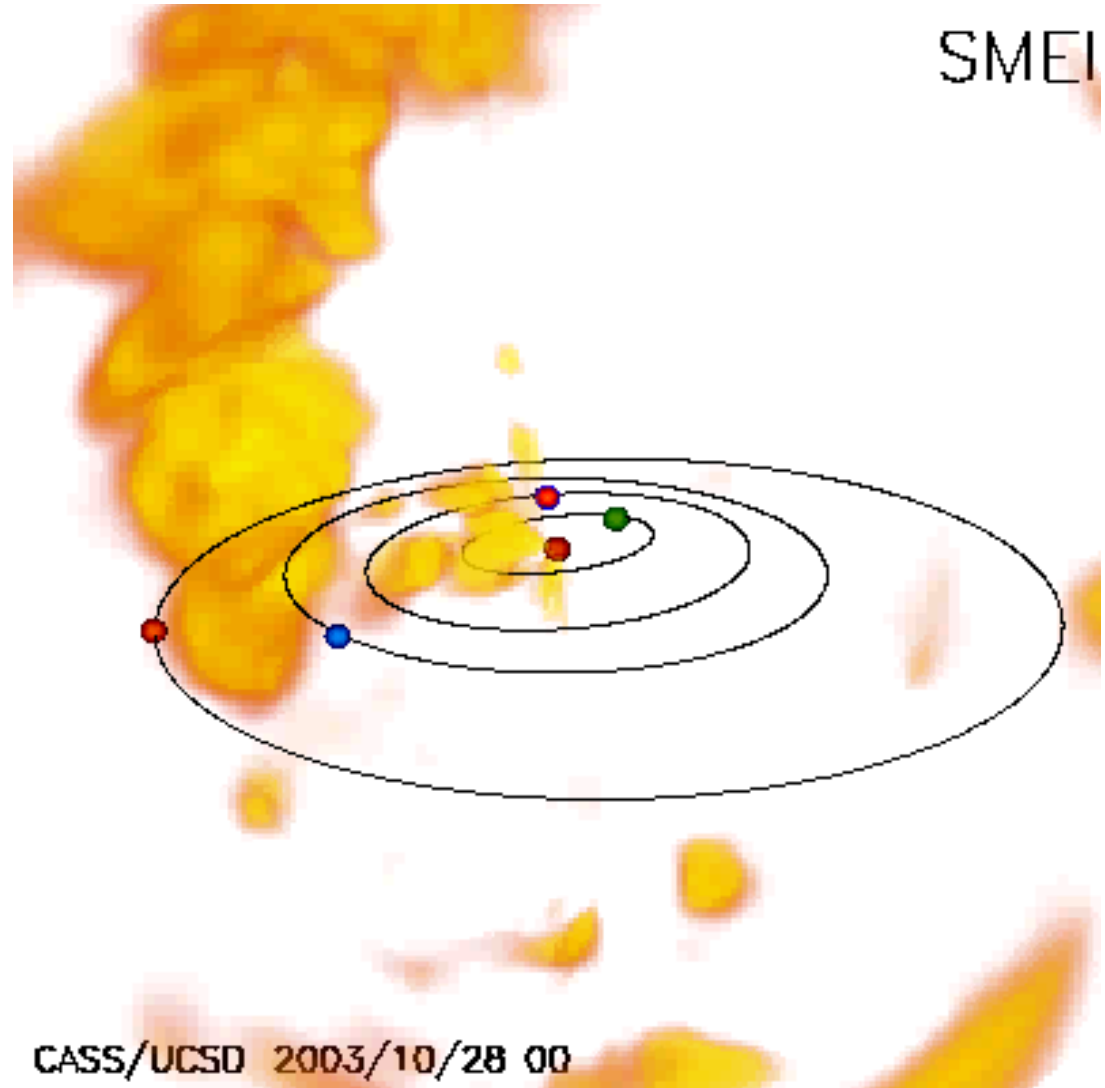
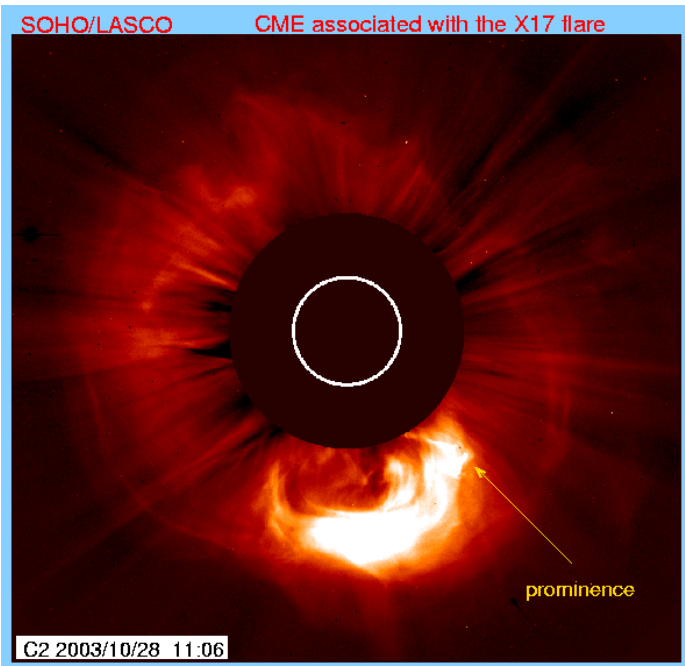
Jackson, B.V. and P.P. Hick (2004), Three-dimensional tomography of interplanetary disturbances, in: *Solar and Space Weather Radiophysics Current Status and Future Developments*, D.G. Gary and C.U. Keller (eds.), *ASSL 314*, Kluwer, The Netherlands, 355.

Jackson, B.V., A. Buffington, P.P. Hick, R.C. Altrock, S. Figueroa, P. Holladay, J.C. Johnston, S.W. Kahler, J. Mozer, S. Price, R.R. Radick, R. Sagalyn, D. Sinclair, G.M. Simnett, C.J. Eyles, M.P. Cooke, S. J. Tappin, T. Kuchar, D. Mizumo, D.F. Webb, P. Anderson, S.L. Keil, R. Gold, and N.R. Waltham (2004), The Solar Mass Ejection Imager (SMEI) mission, *Solar Phys.* 225, 177.

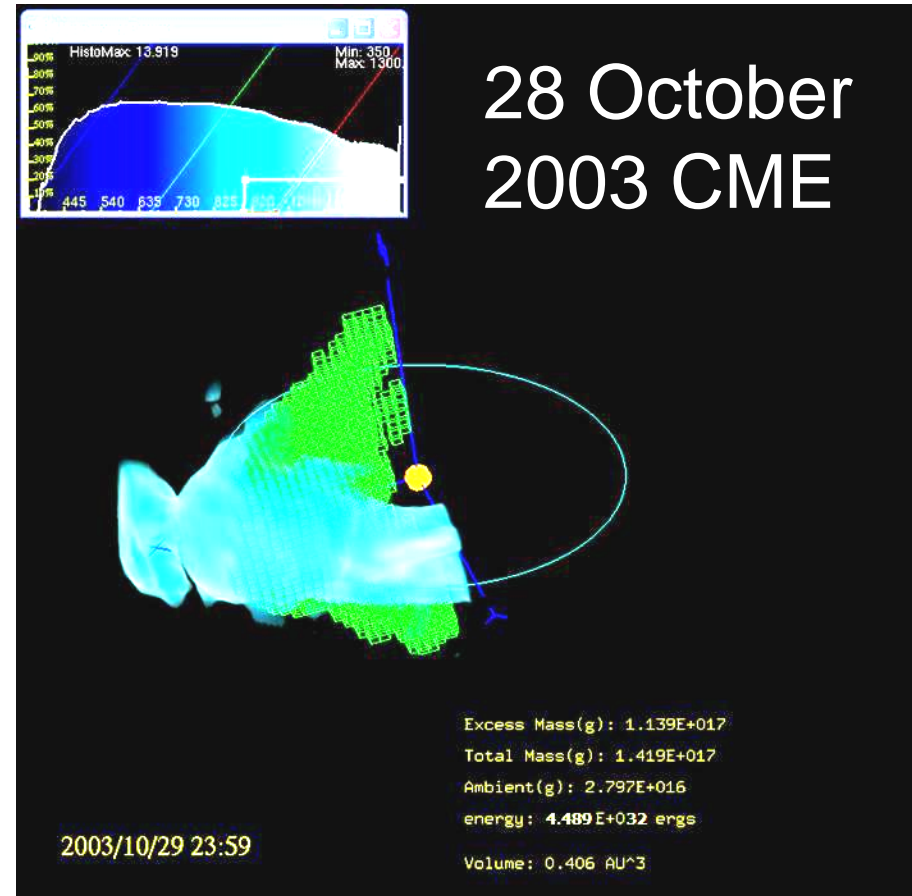
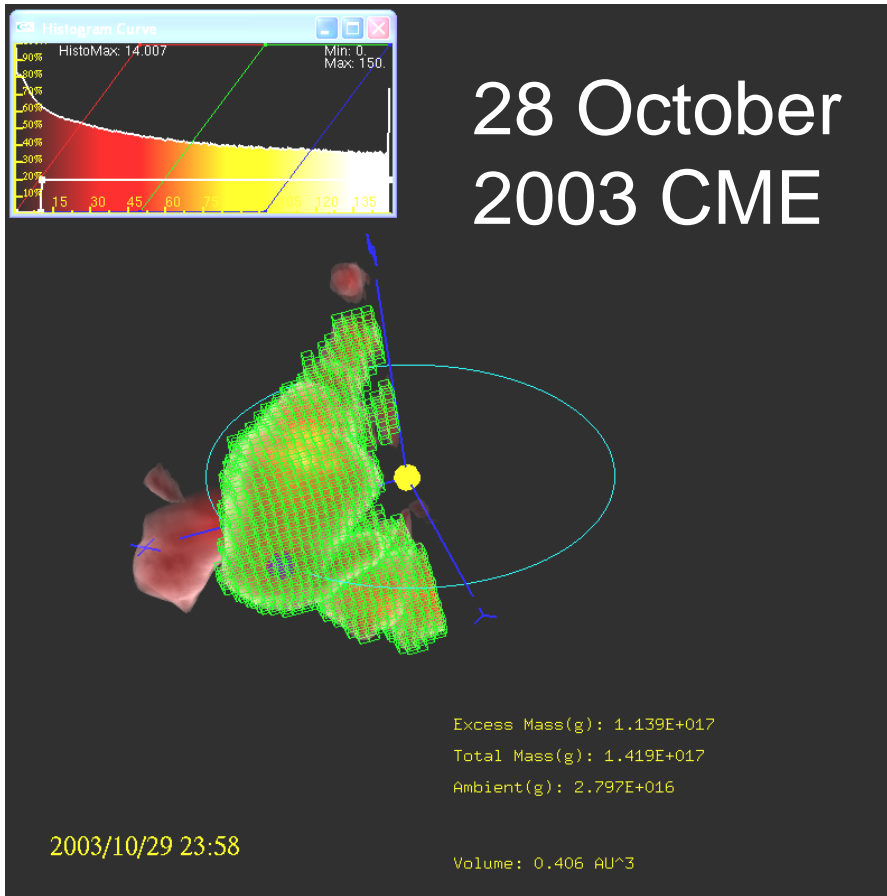
Jackson, B. V., A. Buffington, P. P. Hick, X. Wang, and D. Webb (2006), Preliminary three-dimensional analysis of the heliospheric response to the 28 October 2003 CME using SMEI white-light observations, *J. Geophys. Res.*, 111, A04S91, doi:10.1029/2004JA010942.

Real-Time Forecasting with IPS 3D Modeling

SMEI 3D reconstruction of the 28 October 2003 CME.



Real-Time Forecasting with IPS 3D Modeling



**SMEI reconstructed density on
October 30 at 0 UT $>10 \text{ e}^- \text{ cm}^{-3}$**

Total Mass = $1.4 \times 10^{17} \text{ g}$

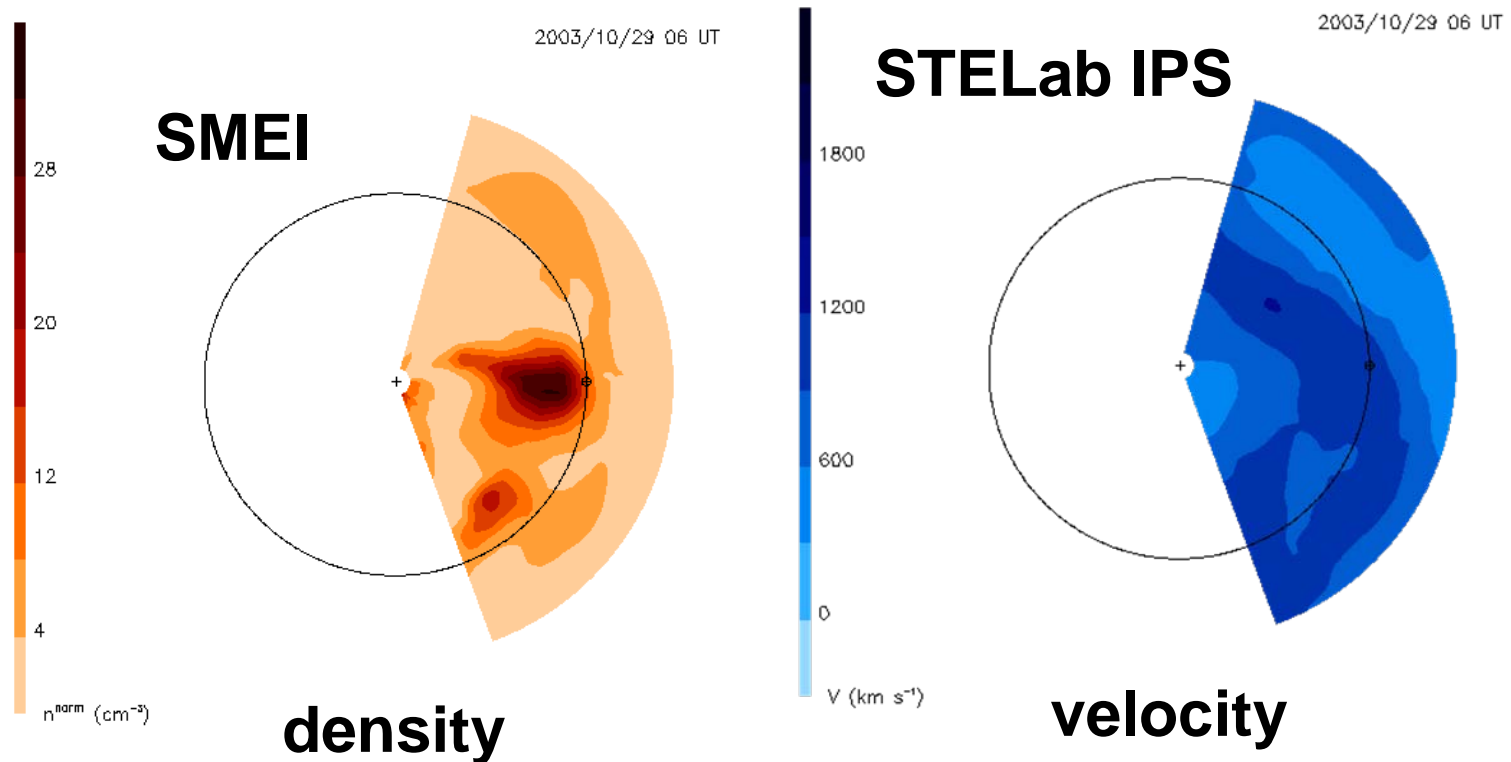
Excess Mass = $1.1 \times 10^{17} \text{ g}$

Volume = 0.4 AU^3

**IPS UCSD reconstructed velocity at 3D
density time viewed above $\sim 900 \text{ km s}^{-1}$.
Material highlighted by density used to
determine kinetic energy = $4.5 \times 10^{32} \text{ ergs}$.**

Real-Time Forecasting with IPS 3D Modeling

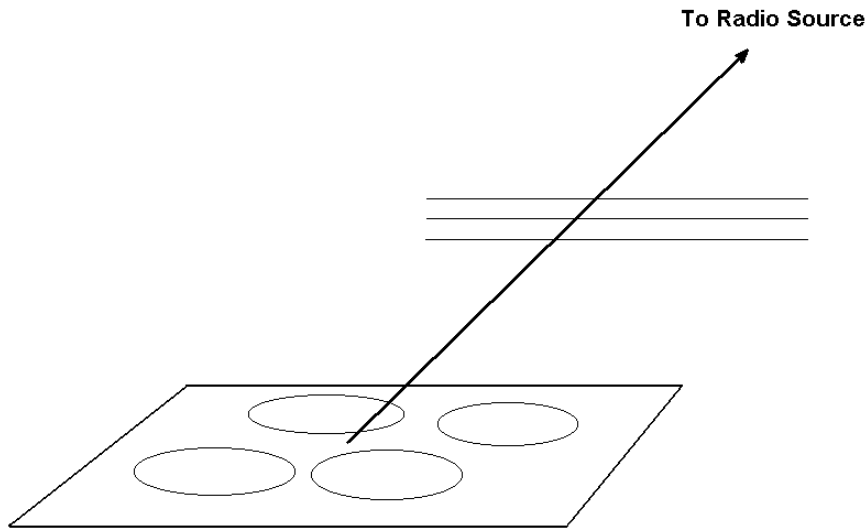
**28 October 2003 CME
ecliptic planar cut**



Real-Time Forecasting with IPS 3D Modeling

Current STELab IPS Heliospheric Analyses

STELab IPS array near Fuji.



Real-Time Forecasting with IPS 3D Modeling

<http://ips.ucsd.edu> (CASS - STELab joint cooperative agreement)

The screenshot displays a web application interface for space weather forecasting. At the top left, a digital clock shows '18:22 UT' and the date '13-11-2002'. The top right features the CASS logo (UCSD Center for Astrophysics & Space Sciences, Solar-Terrestrial Environment Laboratory (Japan)) and the STELab logo (STEREO). The main content area has a dark starry background with the title 'Space Weather Forecasting with Interplanetary Scintillation Data' in yellow and white text. A central inset shows a 3D model of the solar wind with a yellow and orange structure and a blue dot representing Earth's orbit. A left sidebar contains a menu with links for 'Space Weather Links', 'Public Introduction', 'Science Introduction', 'Corotating', 'Remote View', 'Synoptic Map', 'Sky Map', 'Sky Sweep', 'Time Series', 'Correlations', and a 'Time-Dependent' section with similar links.

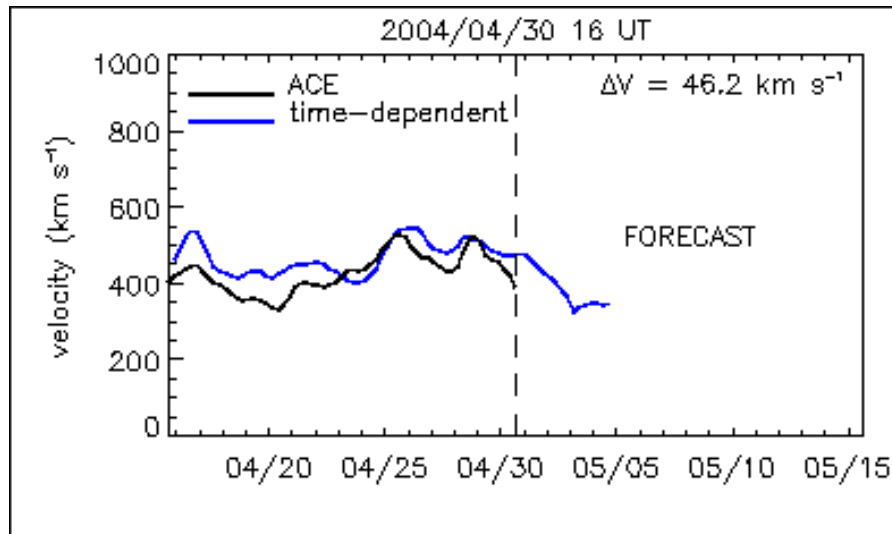
Web Analysis Runs Automatically Using RedHat Linux on a P.C.

Real-Time Forecasting with IPS 3D Modeling

UCSD time-dependent IPS model

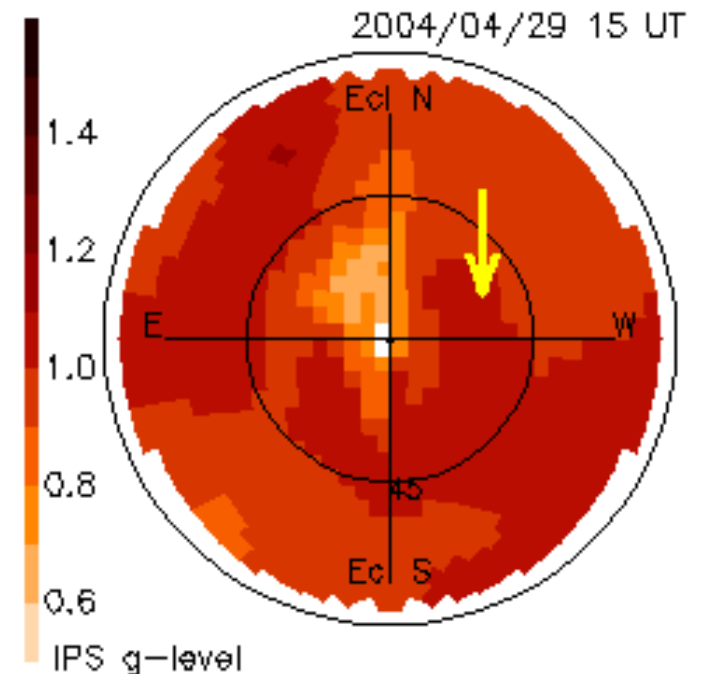
<http://ips.ucsd.edu/>

Velocity model time-series



Real-time tomographic analysis of the solar wind on 29-30 April, 2004 showing a halo CME response in the interplanetary medium.

G-level sky map



Web Analysis Runs Automatically.

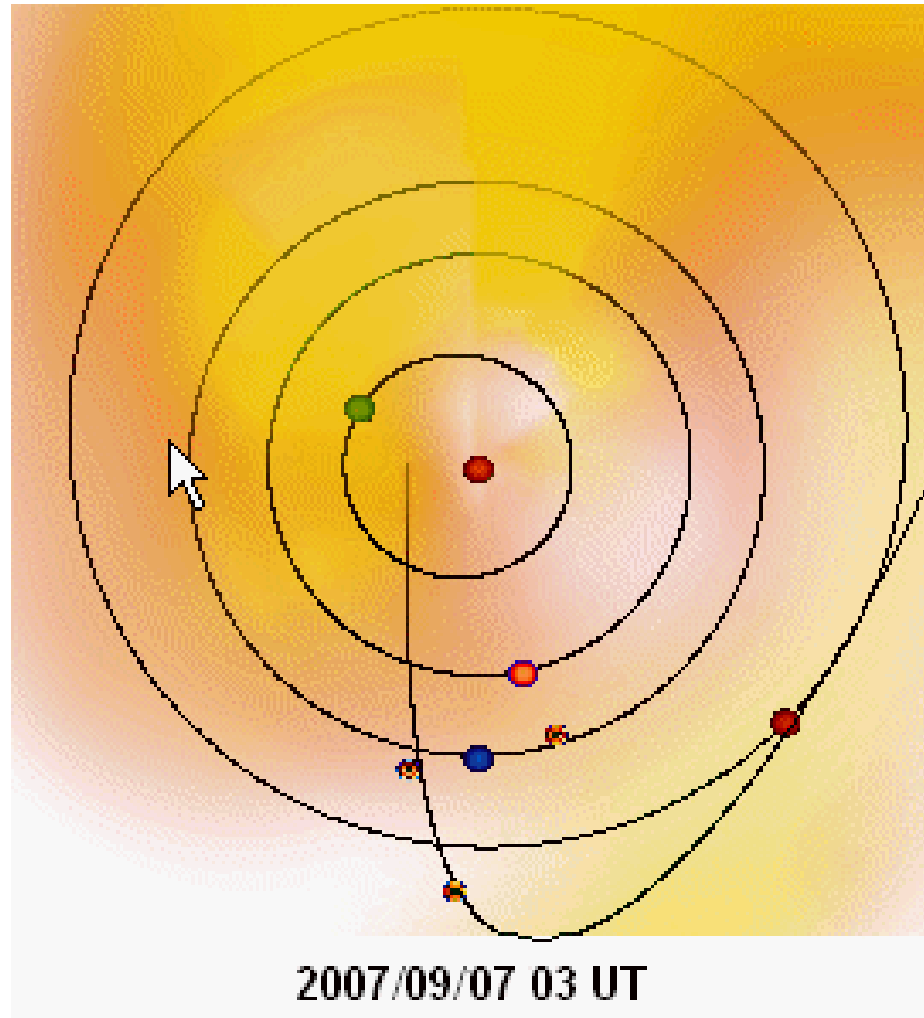
Real-Time Forecasting with IPS 3D Modeling

<http://ips.ucsd.edu>

**IPS exploration
of CME and
Corotating
Structure**

**7 September
2007 STEREO-
Ulysses
configuration**

**(UCSD real-time IPS
analysis)**



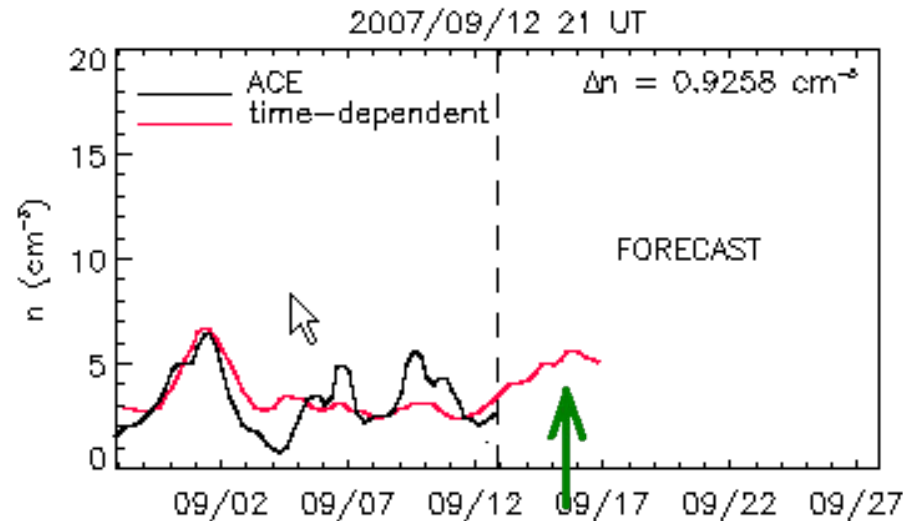
Real-Time Forecasting with IPS 3D Modeling

<http://ips.ucsd.edu>

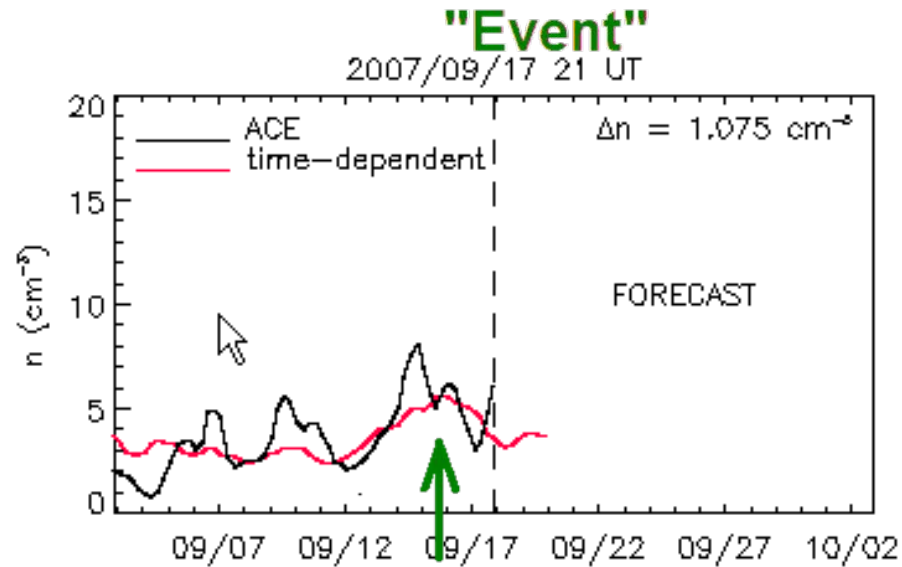
IPS exploration of CME and Corotating Structure

(UCSD real-time IPS analysis)

“Event” on ~09/15/2007



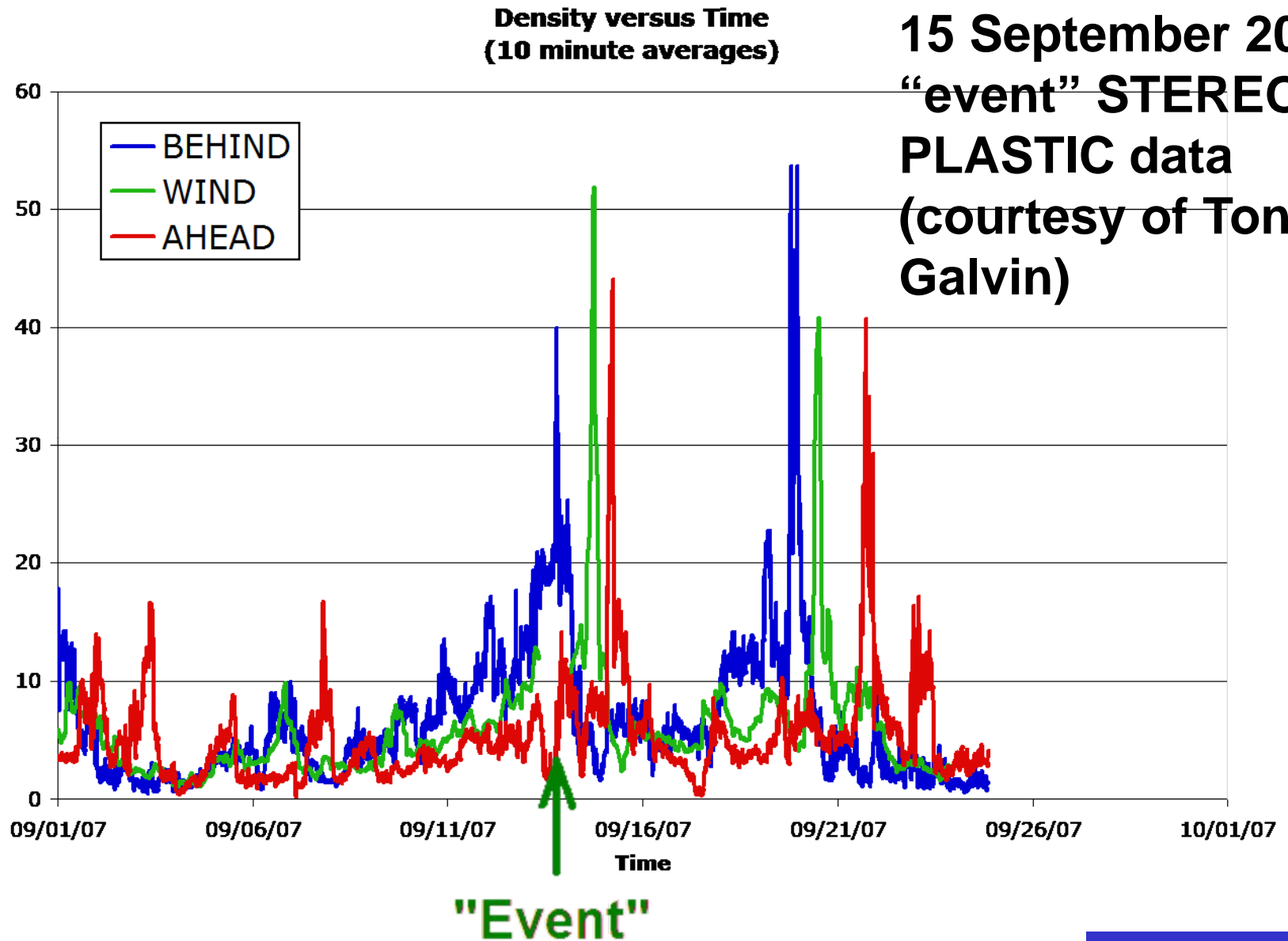
21 UT
09/12/2007



Five days
later

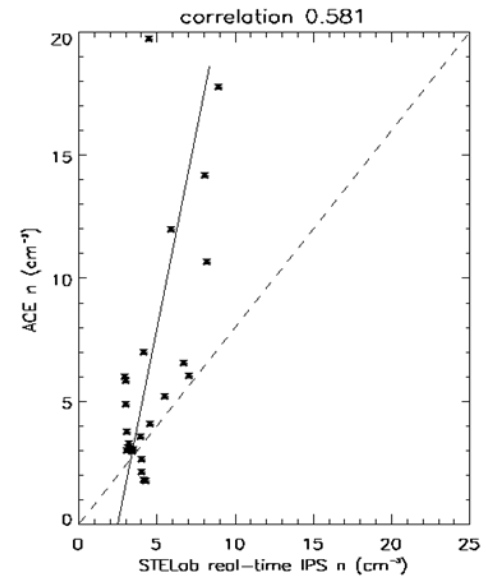
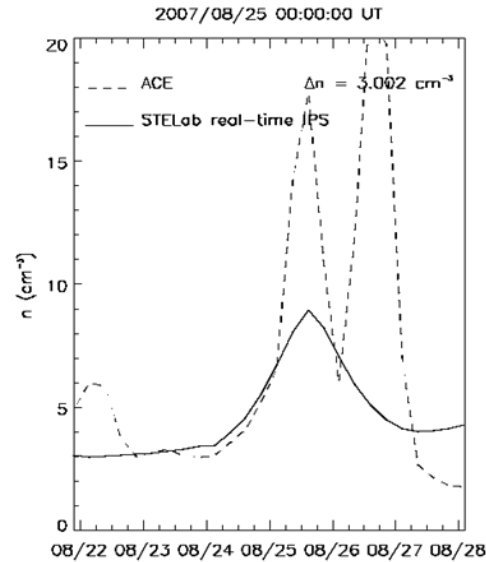
“Event”

Real-Time Forecasting with IPS 3D Modeling

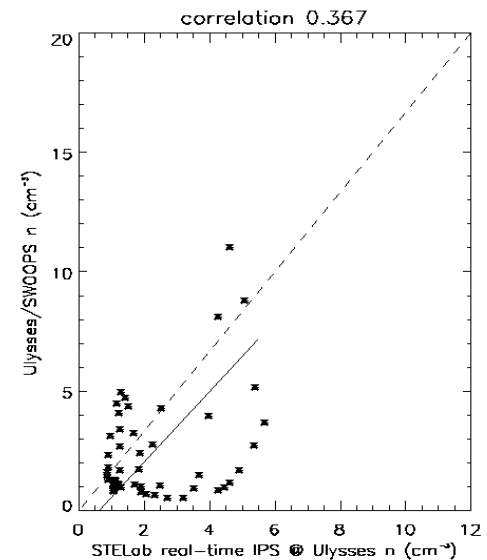
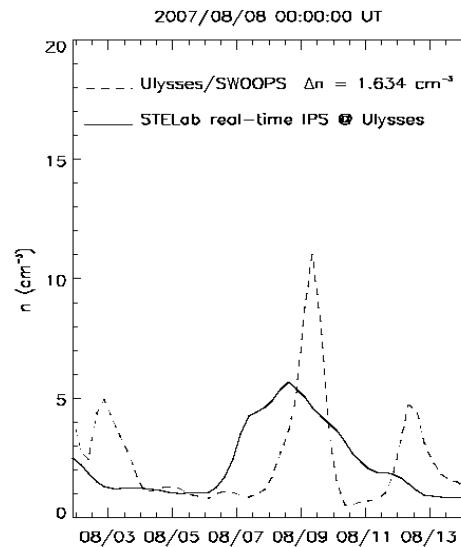


Real-Time Forecasting with IPS 3D Modeling

**August 2007 STEREO
PLASTIC data
(courtesy of Toni
Galvin)**



**August 2007 Ulysses
SWOOPS data
(courtesy of Alex
Ruzmaikin, Joan
Feynman)**



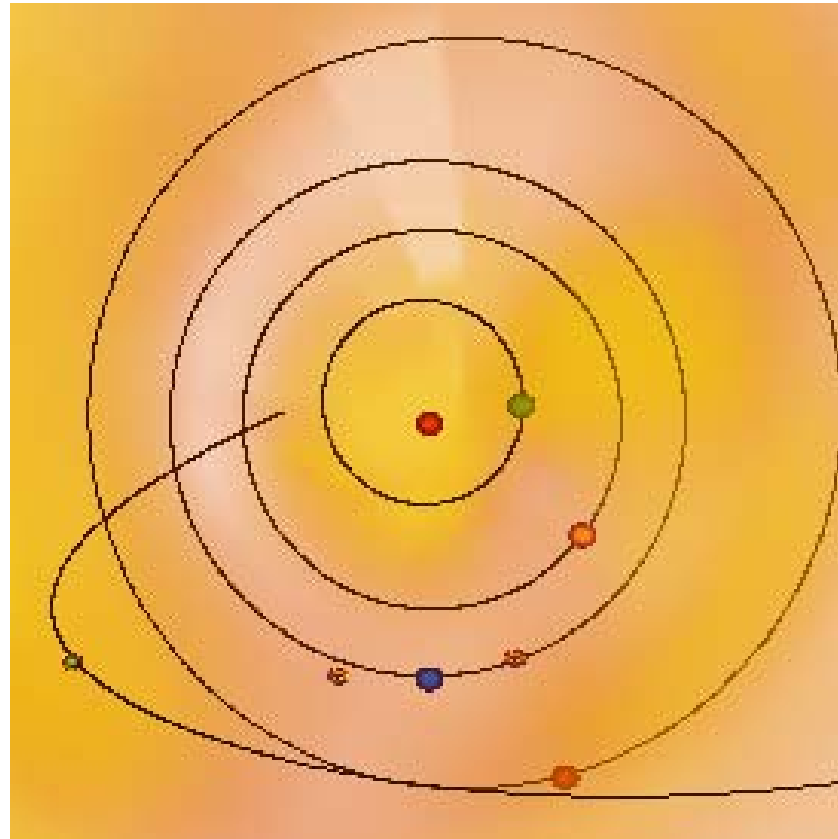
Real-Time Forecasting with IPS 3D Modeling

<http://ips.ucsd.edu>

**IPS exploration
of CME and
Corotating
Structure**

**14 November
2007 STEREO-
Ulysses
configuration**

**(UCSD real-time IPS
analysis)**

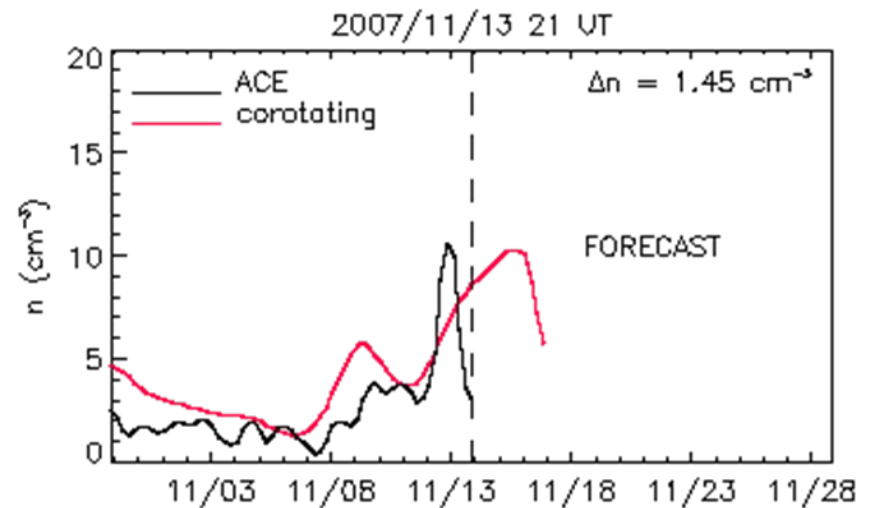
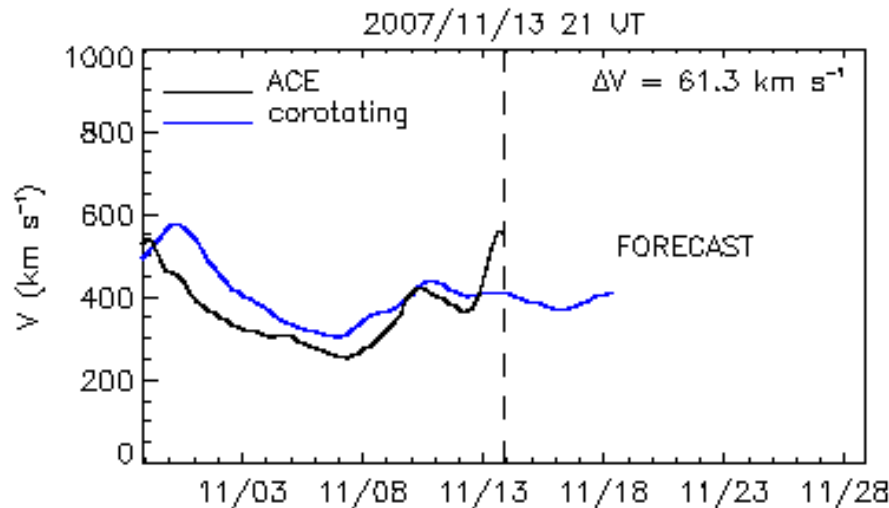


2007/11/13 21 UT

Real-Time Forecasting with IPS 3D Modeling

IPS exploration of CME and Corotating Structure

<http://ips.ucsd.edu>



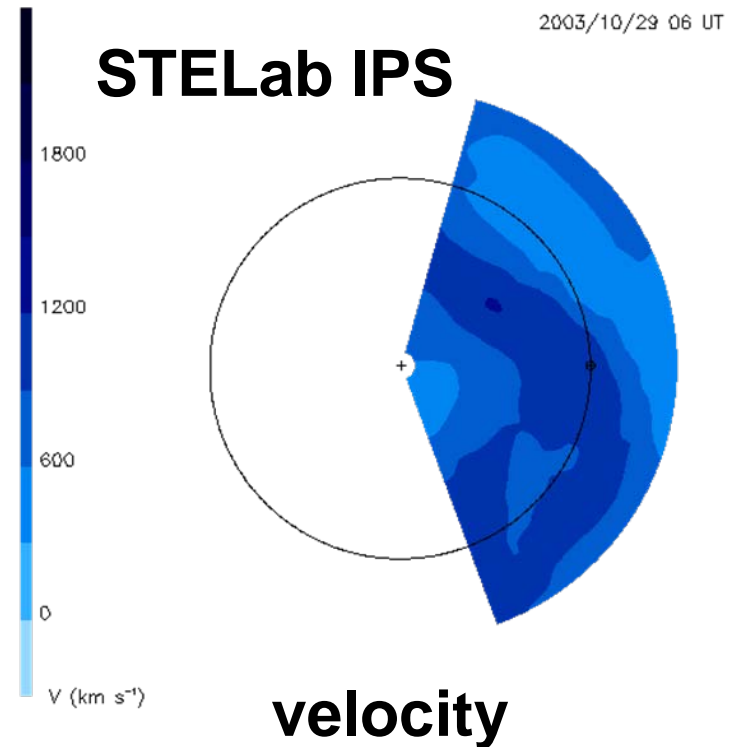
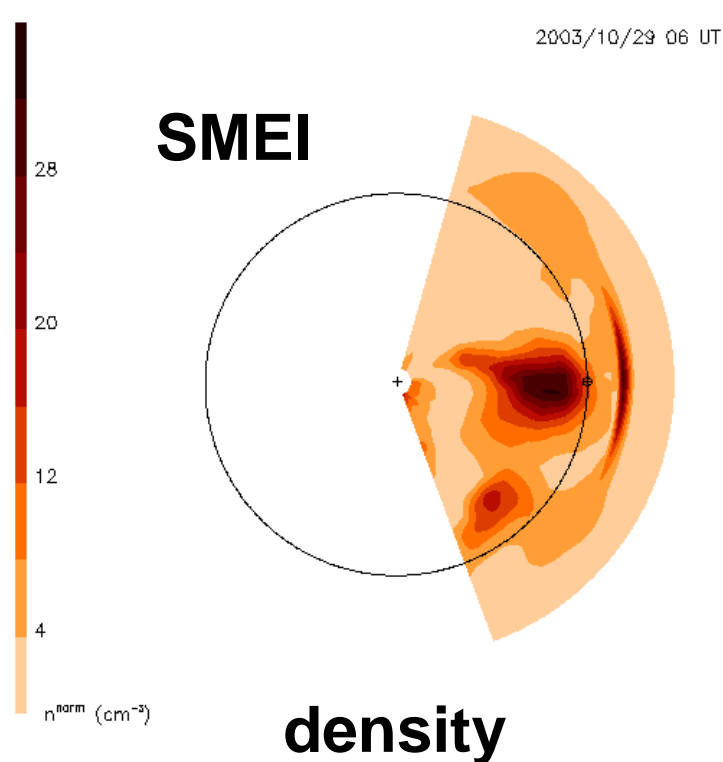
(UCSD real-time IPS analysis – er, yesterday)

Real-Time Forecasting with IPS 3D Modeling

28 October 2003 CME
ecliptic planar cut

How about
providing a
higher-resolution
reconstruction?

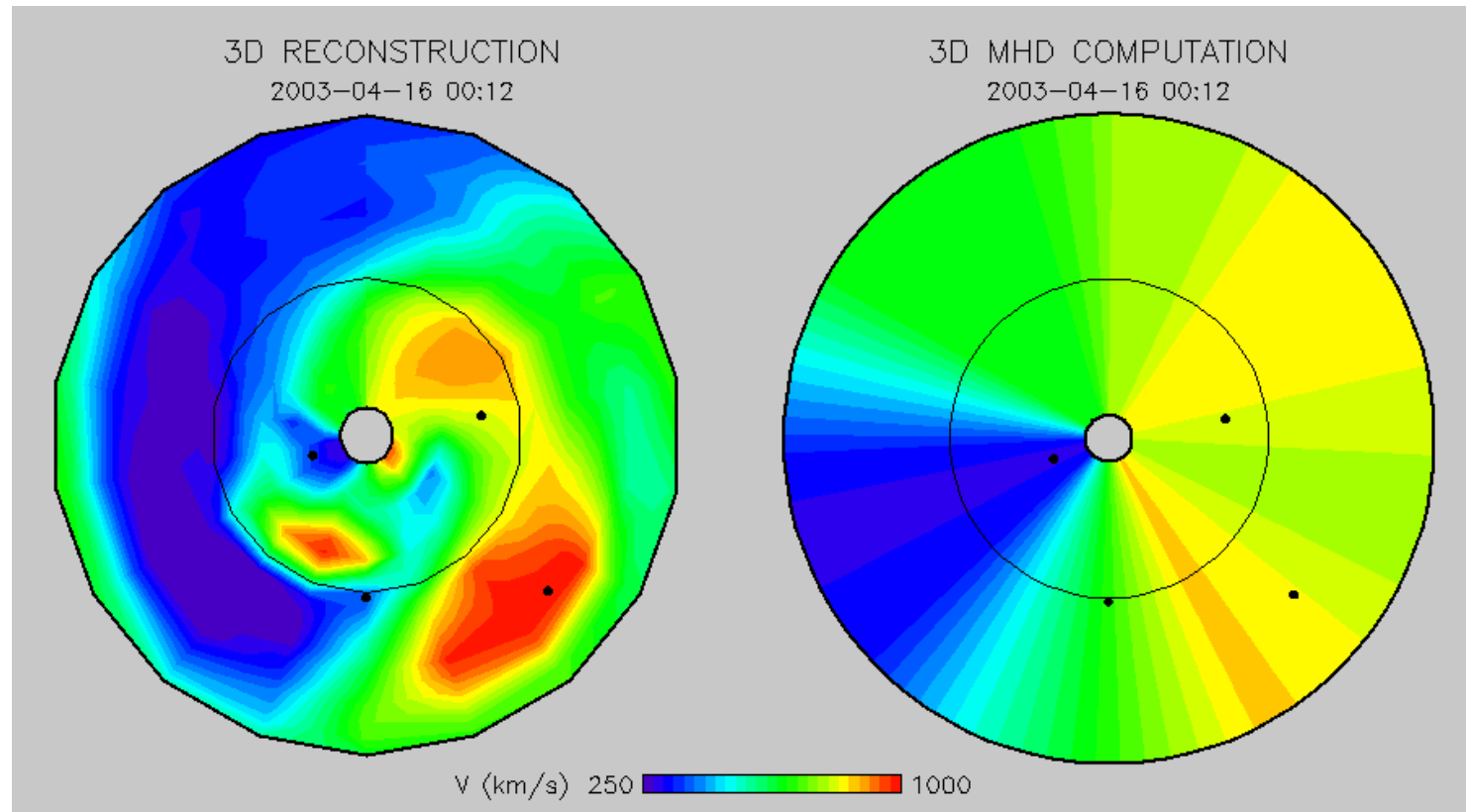
UCSD SMEI Update – Future Hope



Real-Time Forecasting with IPS 3D Modeling

How about this simple kinematic solar wind model we have been using?

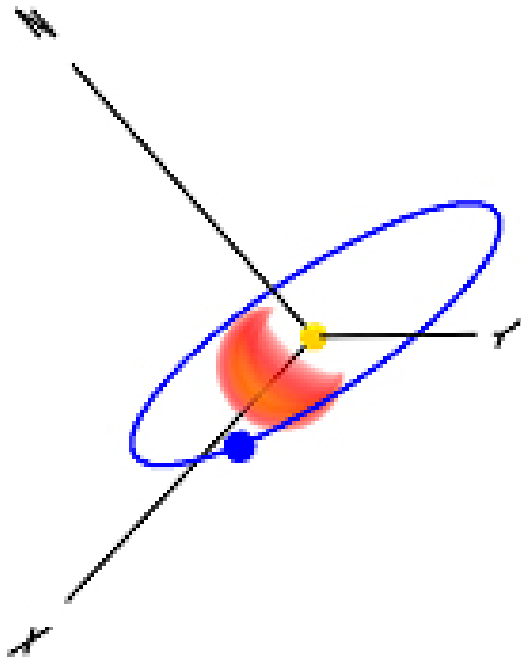
How about using 3D-MHD?



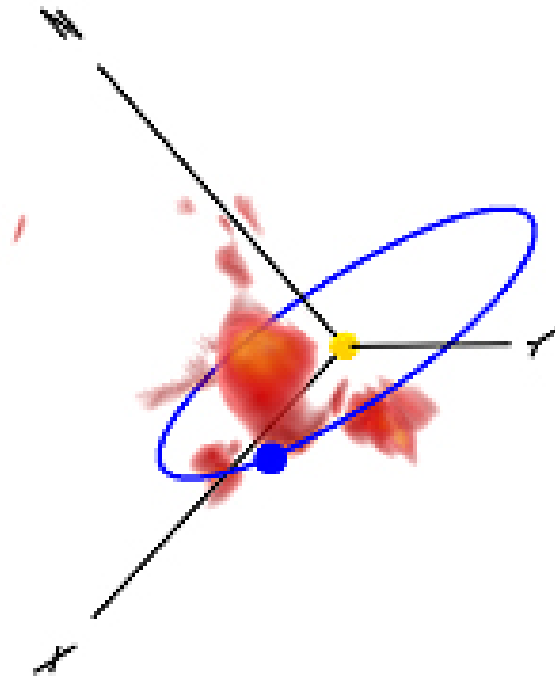
3D-MHD reconstruction courtesy of Dusan Odstrcil, SWW Boulder

Real-Time Forecasting with IPS 3D Modeling

IPS or SMEI 3D reconstruction of the 28 October 2003 CME



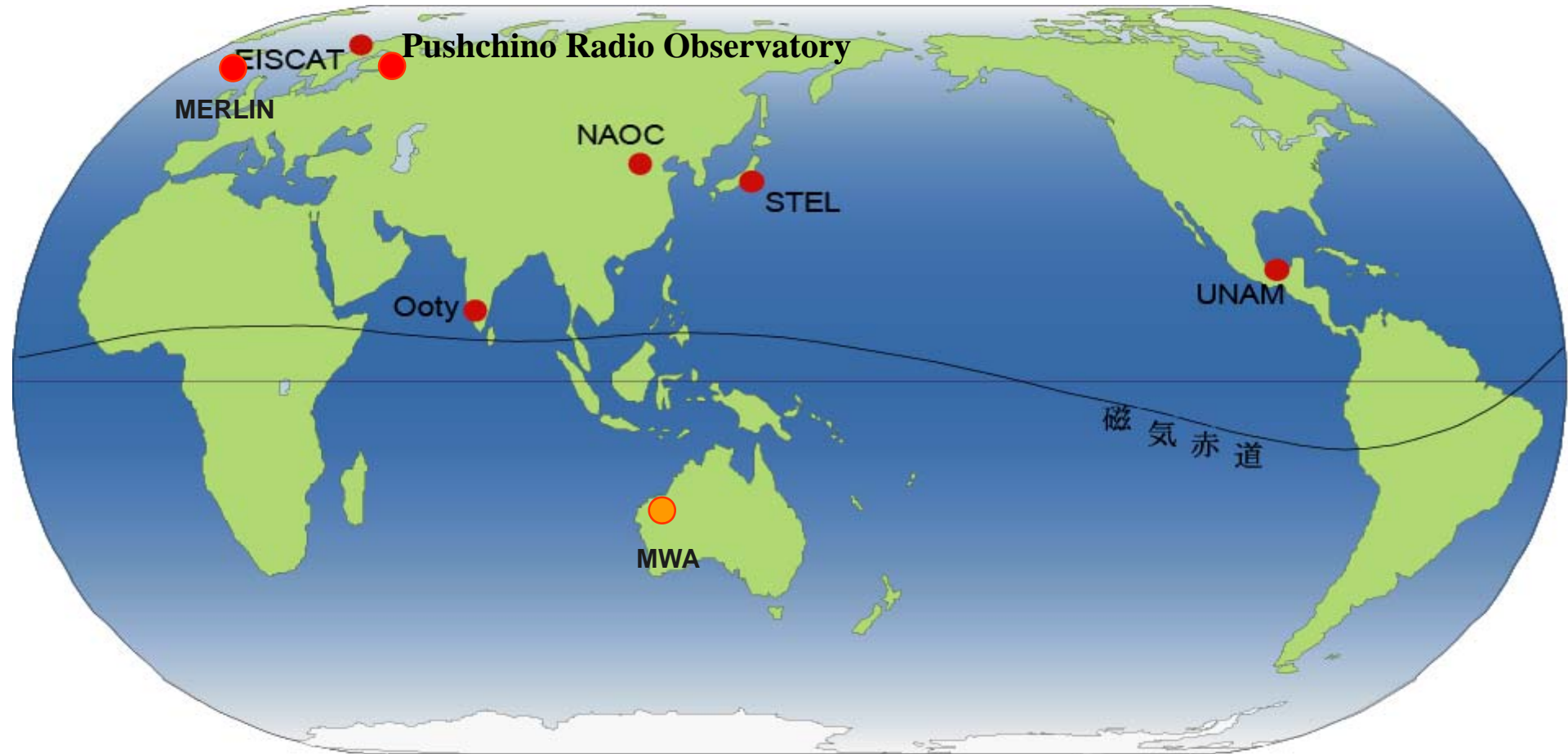
IPS g-level data reconstruction from data obtained between 22UT 28 and 7 UT 29 October. The reconstruction time is ~ 3 UT. Mass $\sim 6 \times 10^{16}$ g



Reconstruction from SMEI data on 29 October 29 03 UT. Mass $\sim 7 \times 10^{16}$ g for the event northward portion

Real-Time Forecasting with IPS 3D Modeling

IPS Observation Network



How about providing more data?

Real-Time Forecasting with IPS 3D Modeling

IHY - Other Current IPS Radio Systems



The Pushchino Radio Observatory 70,000 m² 110 MHz array, Russia (summer 2006)



The Ootacamund (Ooty) off-axis parabolic cylinder 530 m long and 30 m wide (15,900 m²) operating at a nominal frequency of 326.5 MHz

Real-Time Forecasting with IPS 3D Modeling

SMEI-Ulysses-STEREO Toyokawa IPS Workshop, Japan

(CAWSES, Nagoya University, STELab, US NSF sponsored)



New STELab IPS array at Toyokawa (photograph, 18 February 2007)

Real-Time Forecasting with IPS 3D Modeling

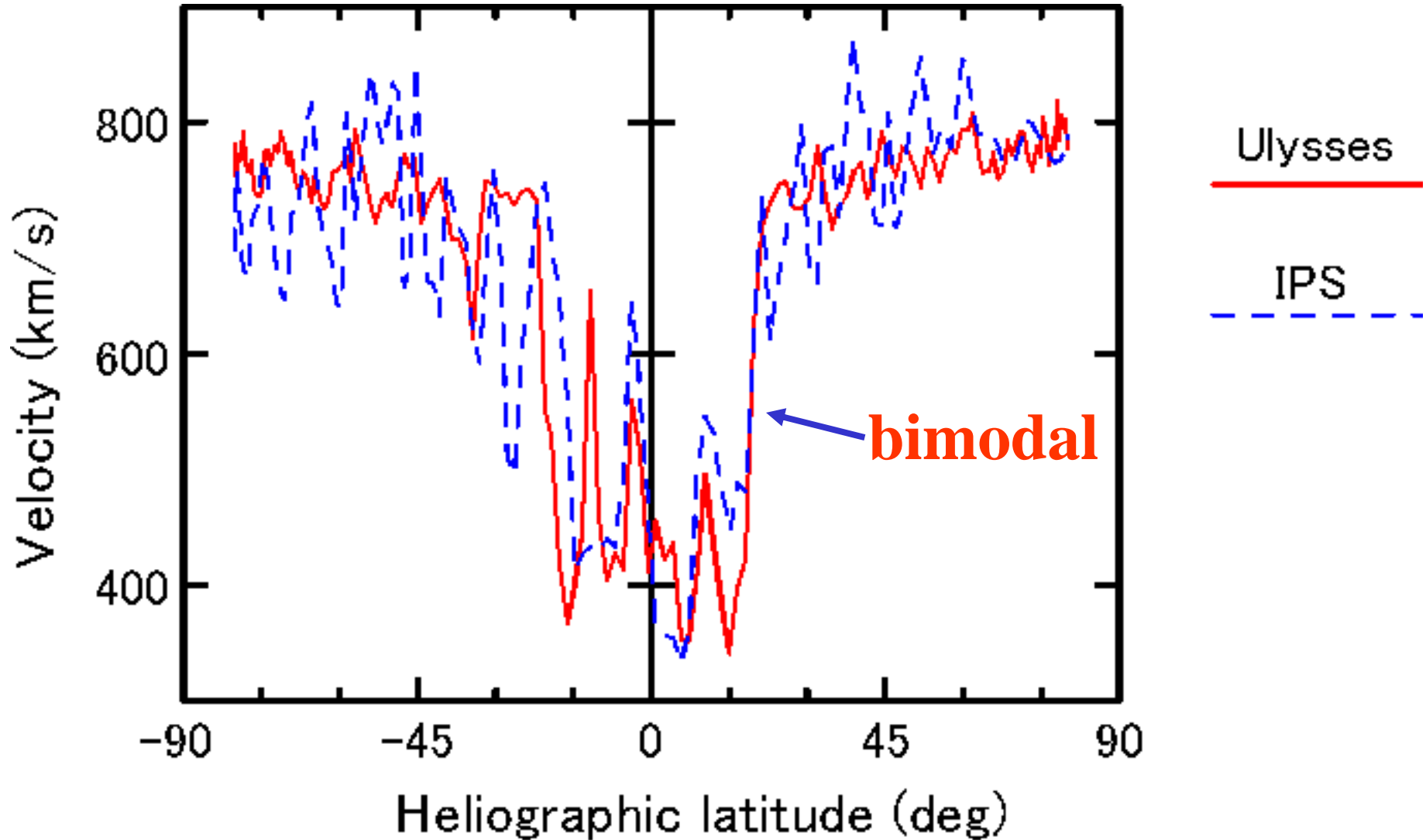
SMEI-Ulysses-STEREO Toyokawa IPS Workshop, Japan

(CAWSES, Nagoya University, STELab, US NSF sponsored)



New STELab IPS array at Toyokawa (photograph, 31 October 2007)

Real-Time Forecasting with IPS 3D Modeling



Real-Time Forecasting with IPS 3D Modeling

Summary:

- 1) We are pretty good but we aren't perfect, and we would like to know why.**
- 2) Because of the Ulysses close pass and the availability of STEREO data, much of the remote-sensing-type analyses that are done using these techniques can now be checked.**