UCSD Time-Dependent 3-D Reconstructions Modified to Provide Brightness and Polarization Brightness Analyses

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http://ips.ucsd.edu/   http://ips.ucsd.edu/stereo

Time-Dependent 3-D Reconstructions of B and pB

Introduction:

The UCSD time-dependent 3D reconstruction analysis – Current IPS and SMEI analyses

Analysis modification to provide Thomson scattering pseudo polarization brightness

Current tests of the modified B and pB analyses

Beneficial enhancement changes for future analyses

Interplanetary Scintillation (IPS) Analyses

Time-Dependent 3-D Reconstructions of B and pB

Interplanetary Scintillation Heliospheric Analyses from ISEE, Japan

ISEE IPS array near Mt. Fuji

ISEE IPS array systems

Time-Dependent 3-D Reconstructions of B and pB

Most Are Guilty (Me too)

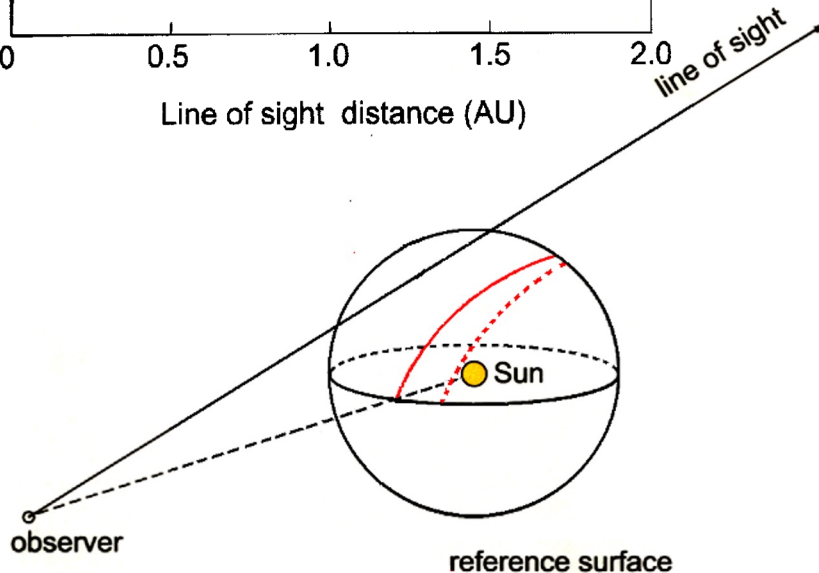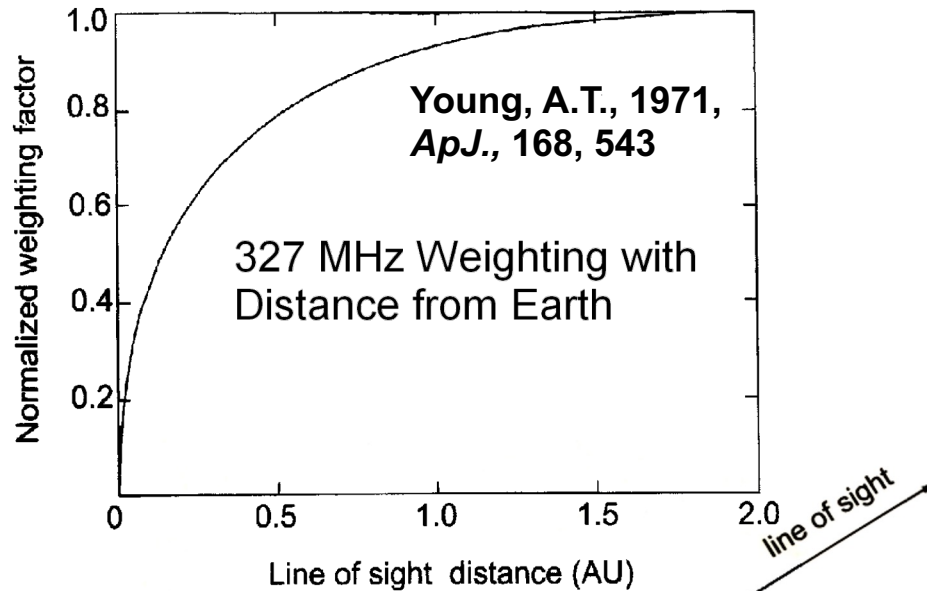## Interplanetary Scintillation Heliospheric Analyses from ISEE, Japan
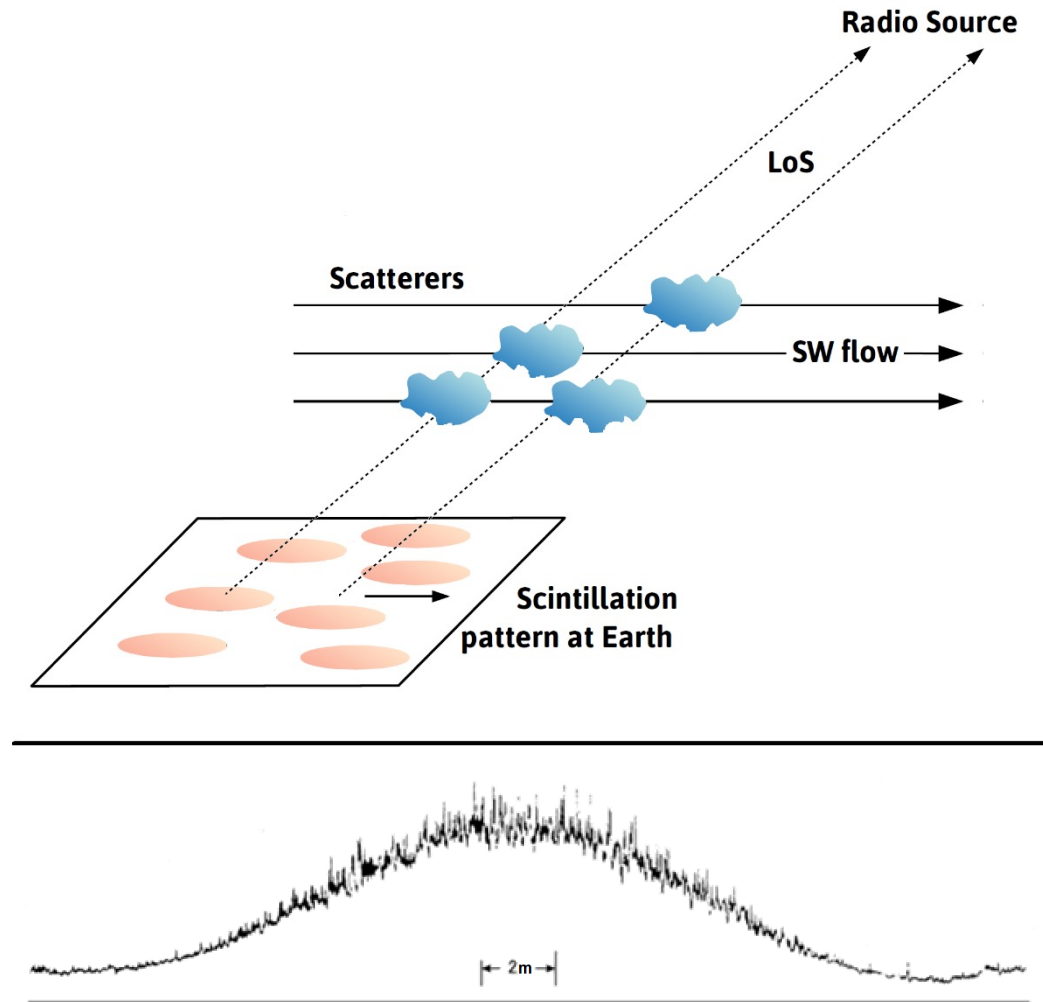
ISEE IPS array systems

Time-Dependent 3-D Reconstructions of B and pB
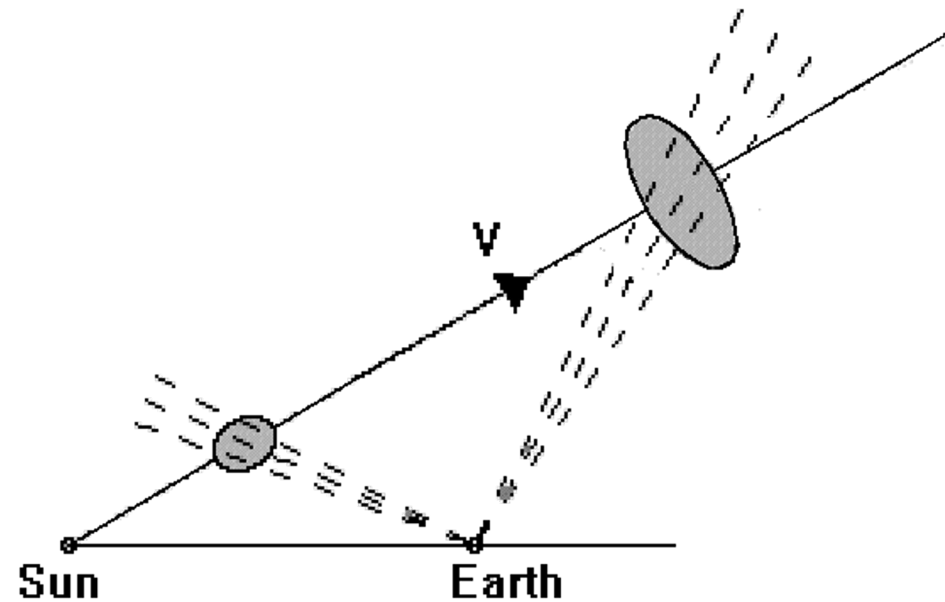
Line-of-sight Response

Interplanetary Scintillation

ISEE DATA

Heliospheric C.A.T. analyses: example line-of-sight distribution for each sky location to form the source surface weighting of the 3-D reconstruction.
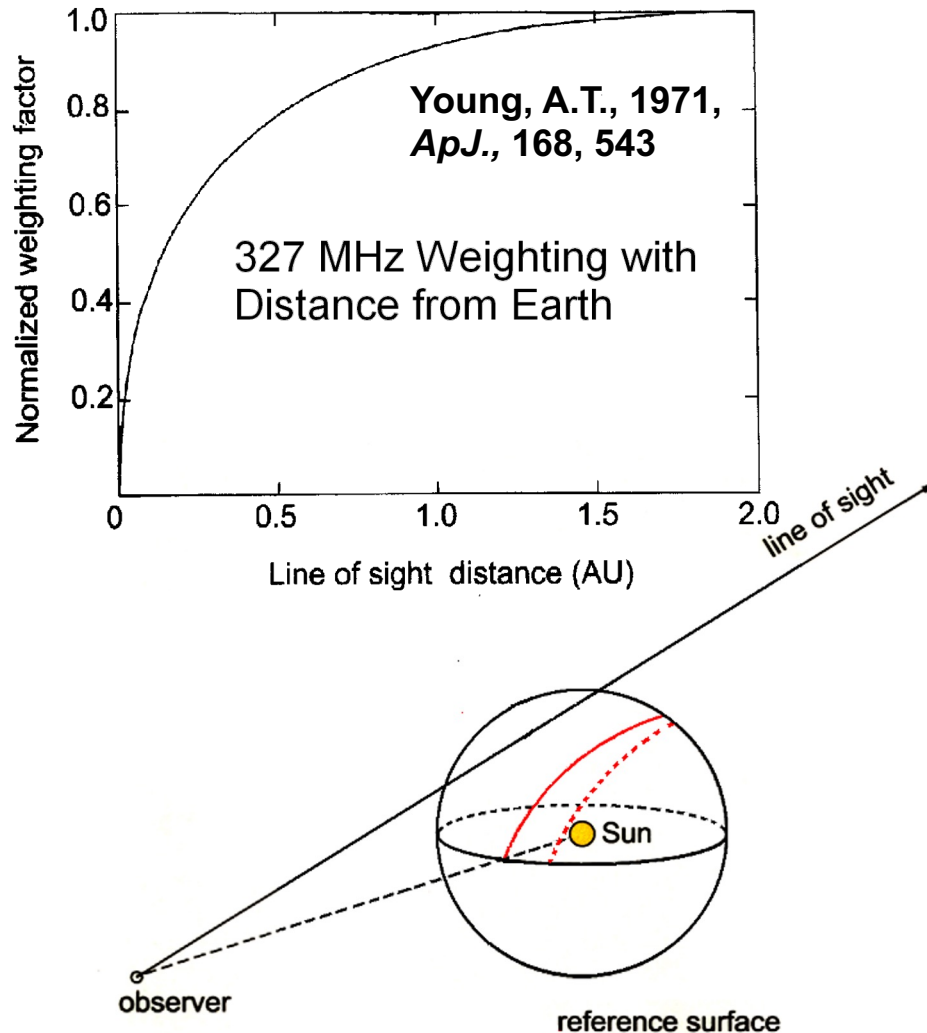

Young, A.T., 1971, *ApJ.,* 168, 543

327 MHz Weighting with Distance from Earth

Line-of-sight Response
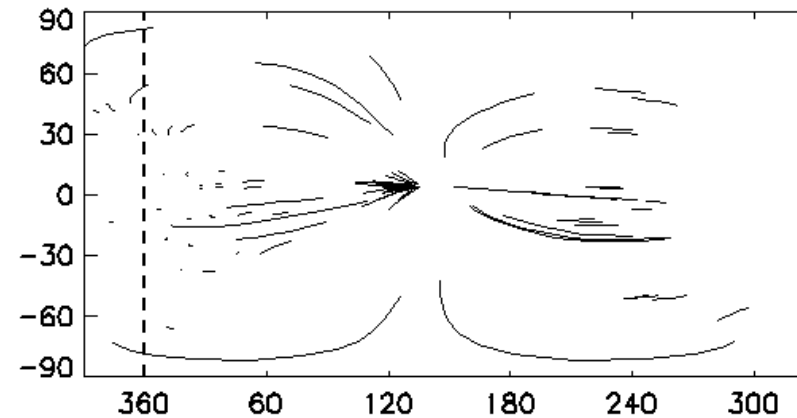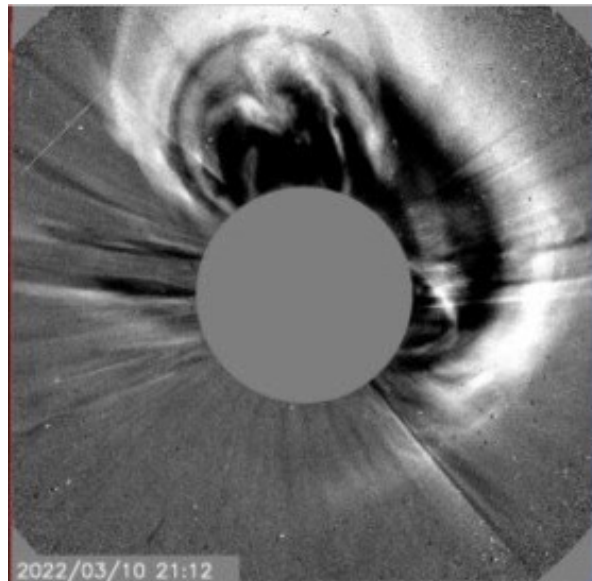
Interplanetary Scintillation

Jackson, B.V., *et al.*, 2008, *Adv. in Geosciences,* 21, 339

Jackson *et al.*, 2020, *Frontiers in Astronomy and Space Sci.*, doi: 10.3389/fspas.2020.568429

ISEE DATA

Heliospheric C.A.T. analyses: example line-of-sight distribution for each sky location to form the source surface weighting of the 3-D reconstruction.
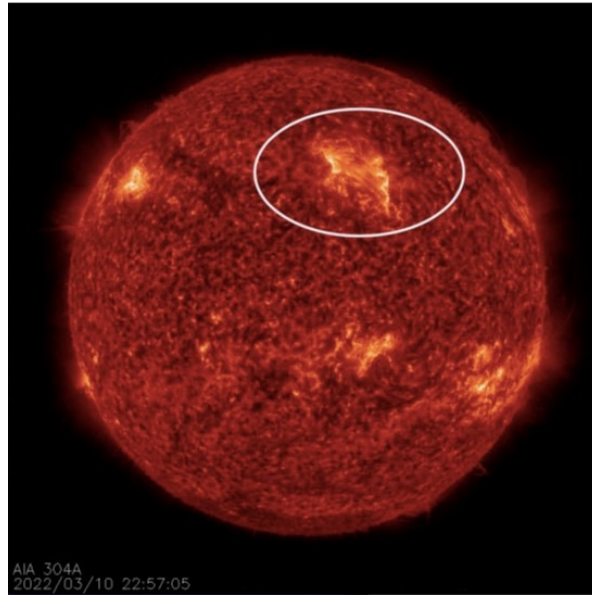

Young, A.T., 1971, *ApJ.,* 168, 543

327 MHz Weighting with Distance from Earth

Normalized weighting factor

Line of sight distance (AU)

line of sight

observer

Sun

reference surface

13 July 2000

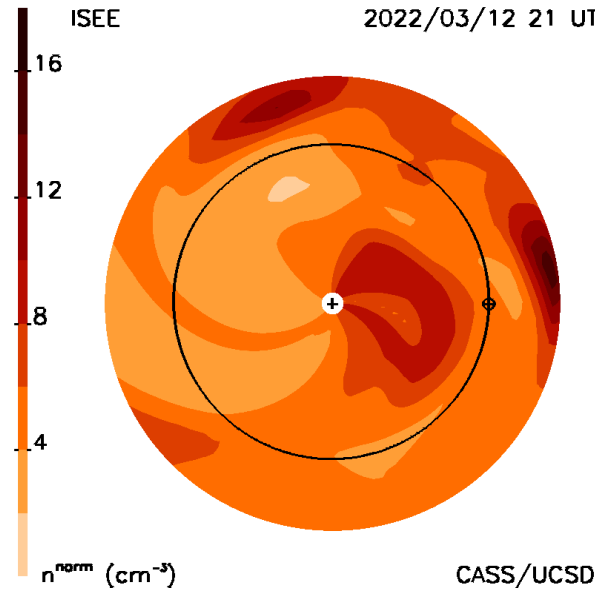# Time-Dependent 3-D Reconstructions of B and pB

2022/03/10 CME

2022/03/12 21 UT

A Good Recent IPS CME Forecast

Jackson, B.V., 2023,
Solar Phys.,
doi:10.1007/s11207-023-02169-8.

IPS Ecliptic Cut
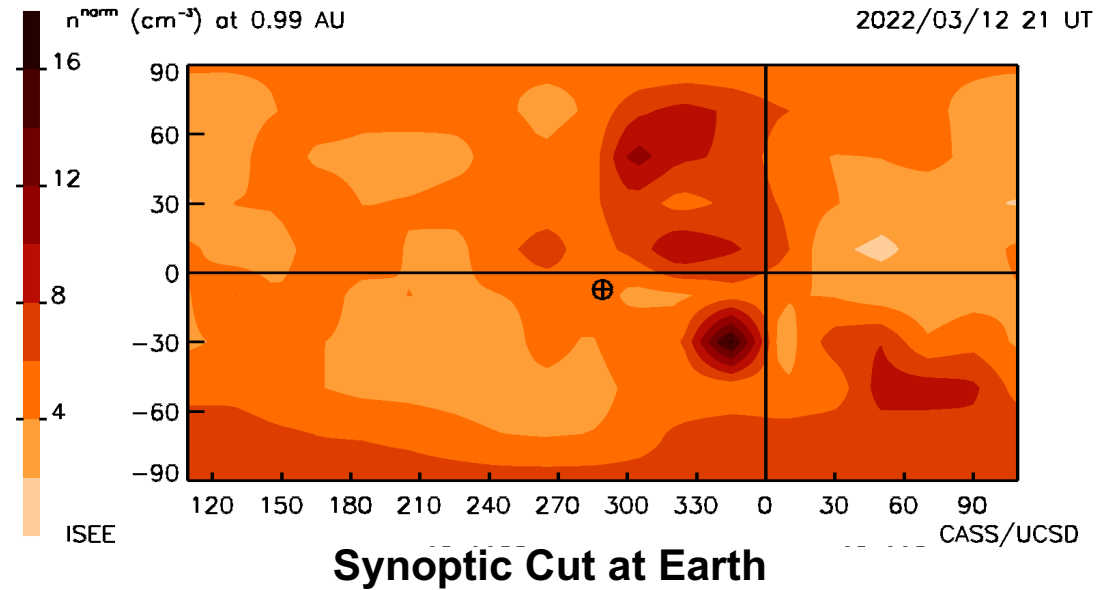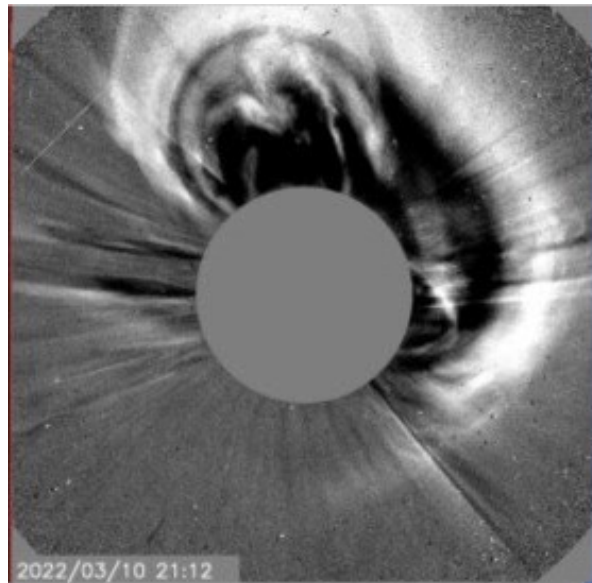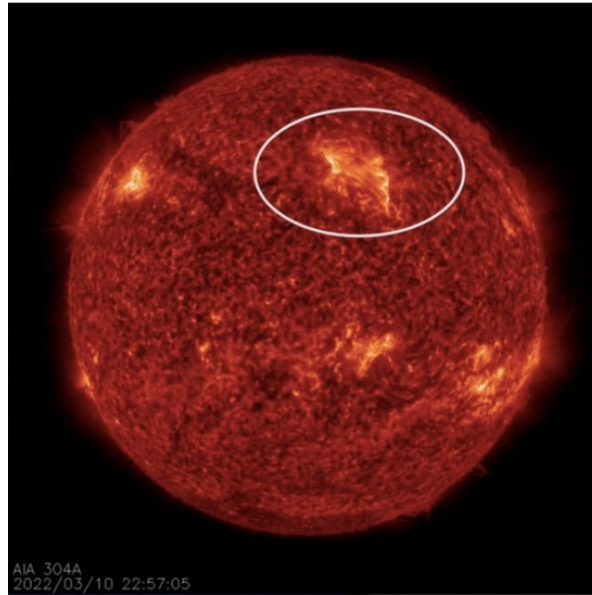
IPS Meridional Cut

Time Series Comparison

Pearson's "R" Correlation

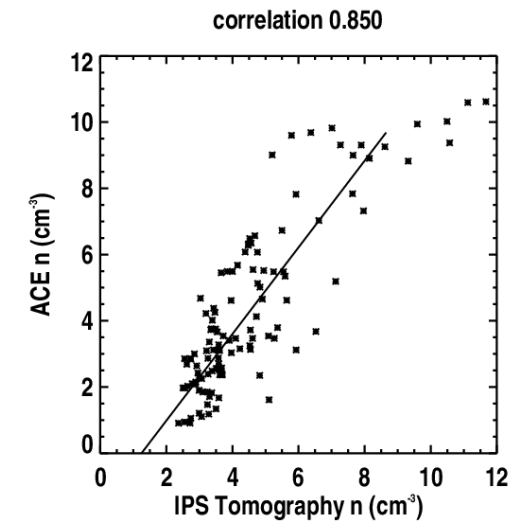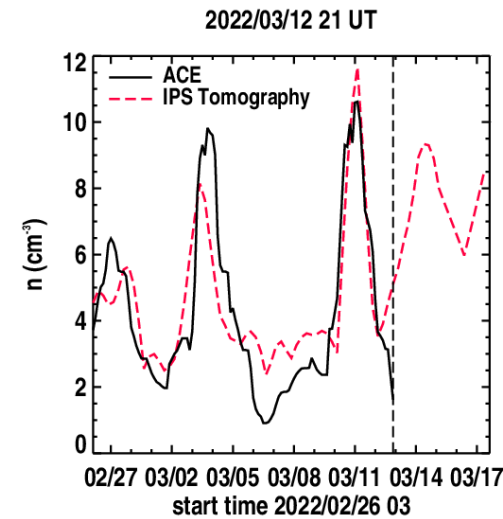# Time-Dependent 3-D Reconstructions of B and pB

2022/03/10 CME

2022/03/12 21 UT

A Good Recent IPS CME Forecast

Jackson, B.V., 2023,
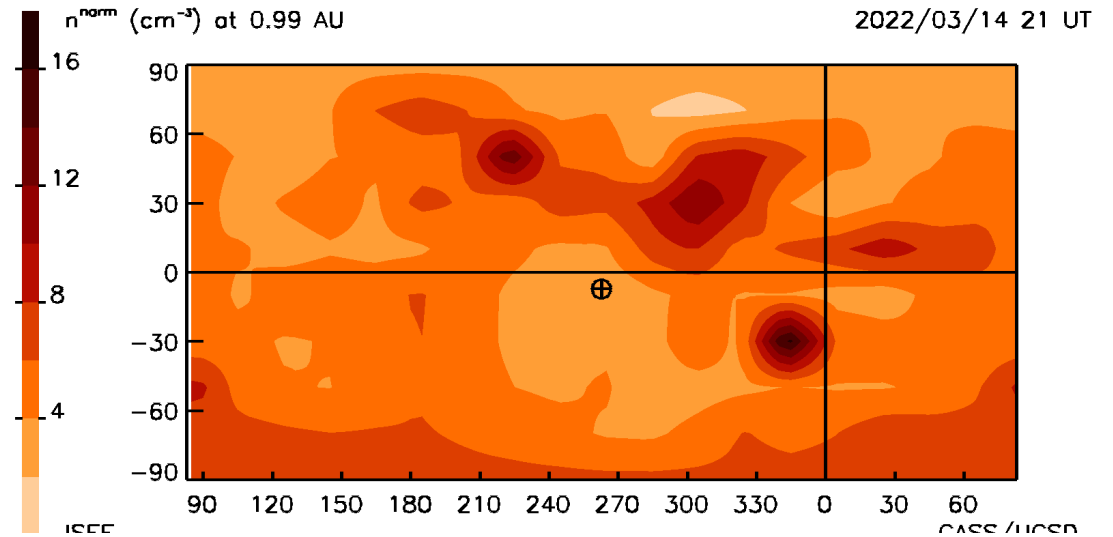*Solar Phys*.,
doi:10.1007/s11207-023-02169-8.

AIA 304A
2022/03/10 22:57:05

2022/03/10 21:12

n^{norm} (cm^{-3}) at 0.99 AU   2022/03/12 21 UT

ISEE   CASS/UCSD

Synoptic Cut at Earth

2022/03/12 21 UT

ACE
IPS Tomography

n (cm^{-3})

02/27 03/02 03/05 03/08 03/11 03/14 03/17
start time 2022/02/26 03

Time Series Comparison

correlation 0.850

ACE n (cm^{-3})

IPS Tomography n (cm^{-3})
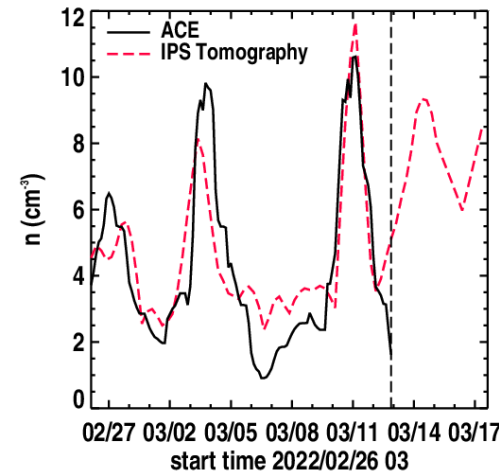
Pearson's "R" Correlation

Time-Dependent 3-D Reconstructions of B and pB

2022/03/10 CME

2022/03/14 21 UT

A Good Recent IPS CME Forecast

Jackson, B.V., 2023, *Solar Phys*., doi:10.1007/s11207-023-02169-8.
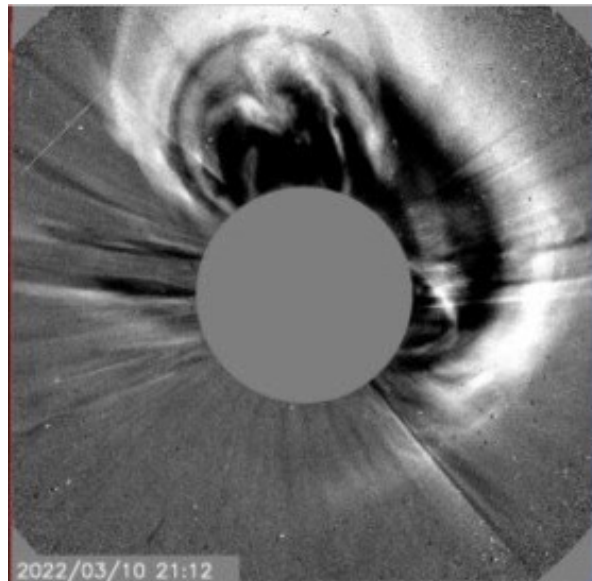
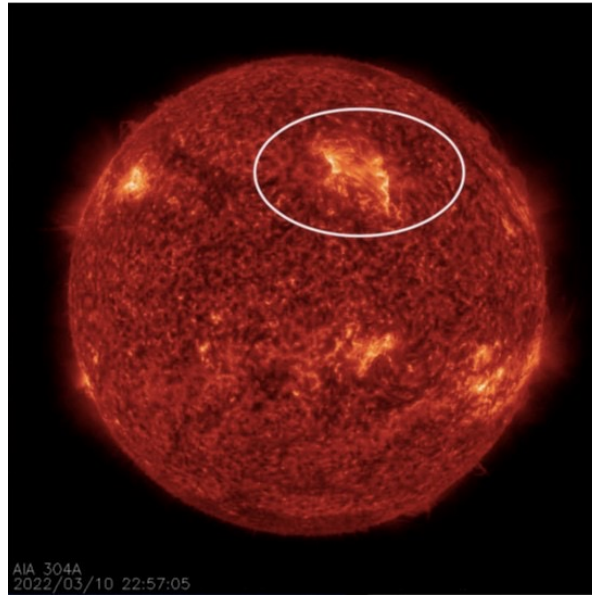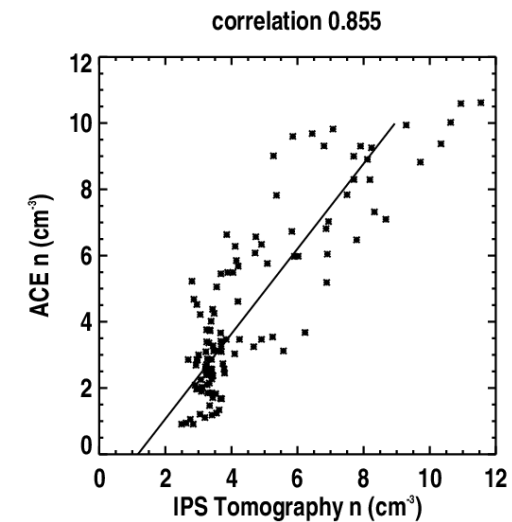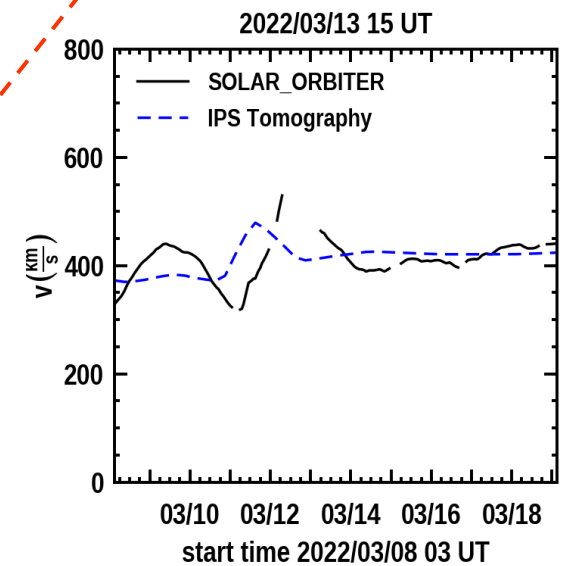**Synoptic Cut at Earth**

Time Series Comparison

Pearson's "R" Correlation

Time-Dependent 3-D Reconstructions of B and pB

Jackson, B.V., 2023, *Solar Phys*., doi:10.1007/s11207-023-02169-8.

Time-Dependent 3-D Reconstructions of B and pB
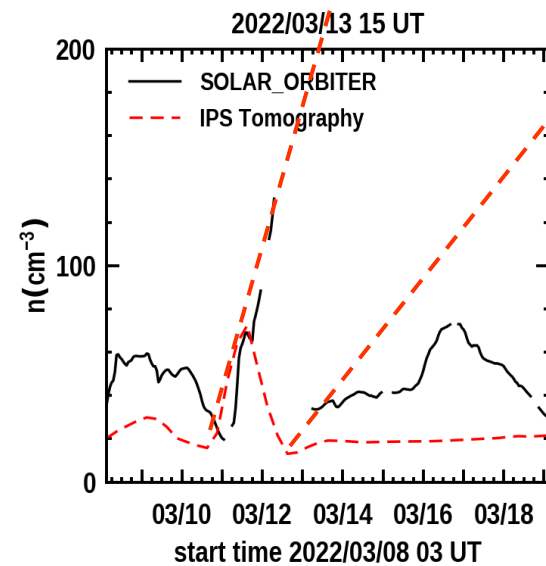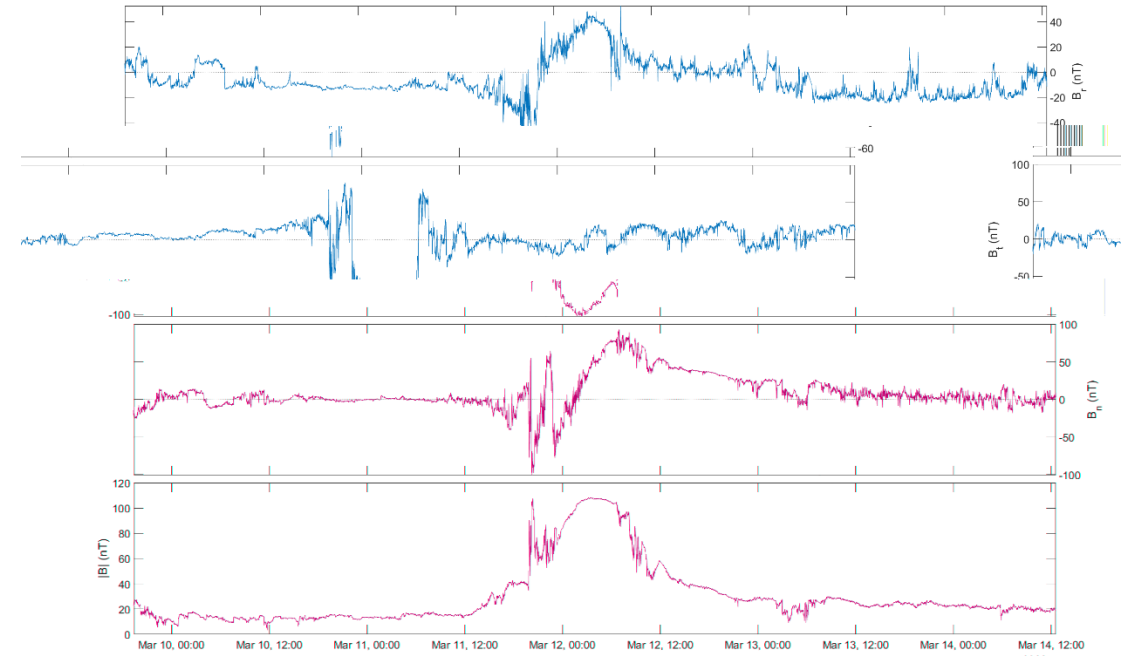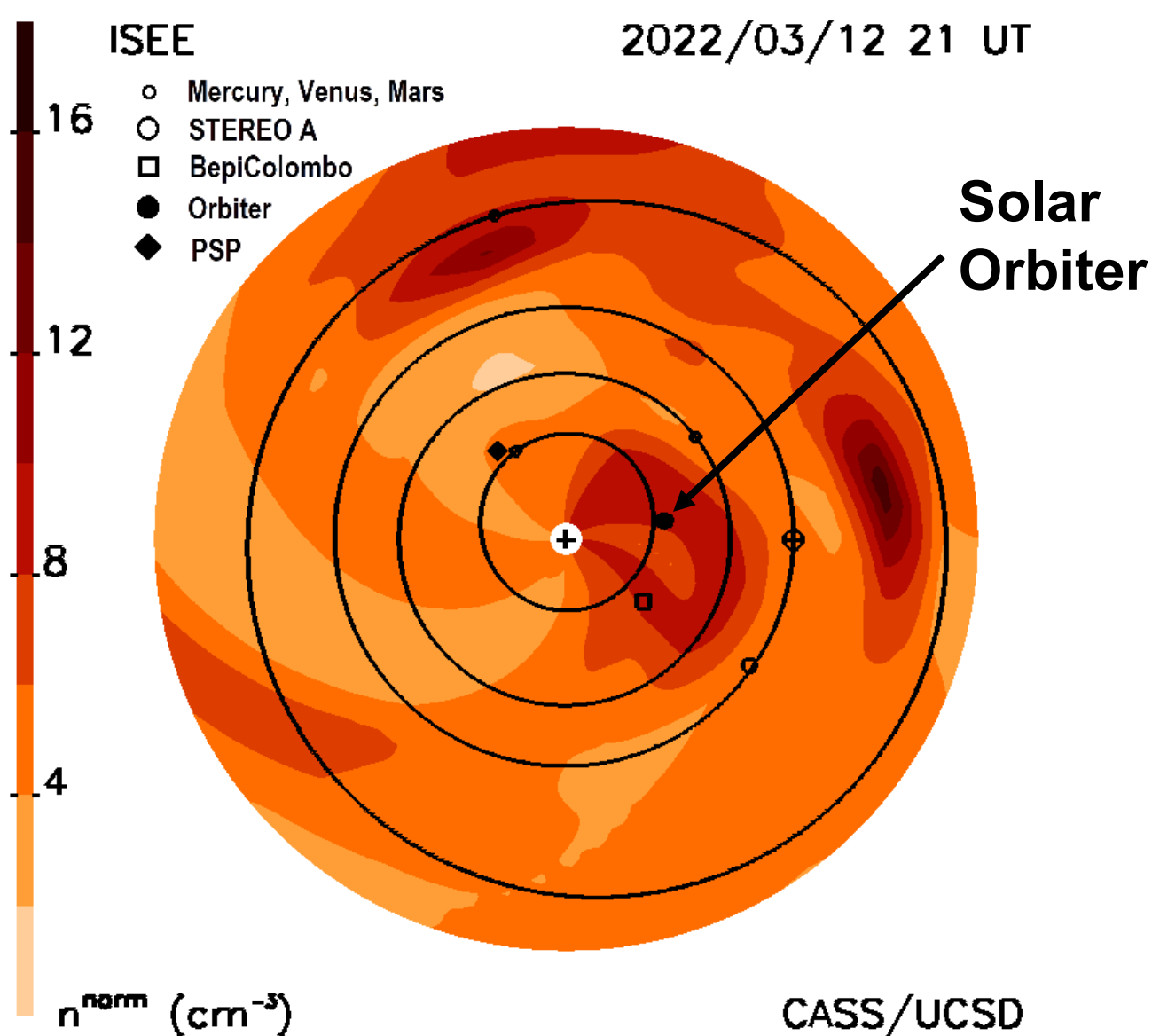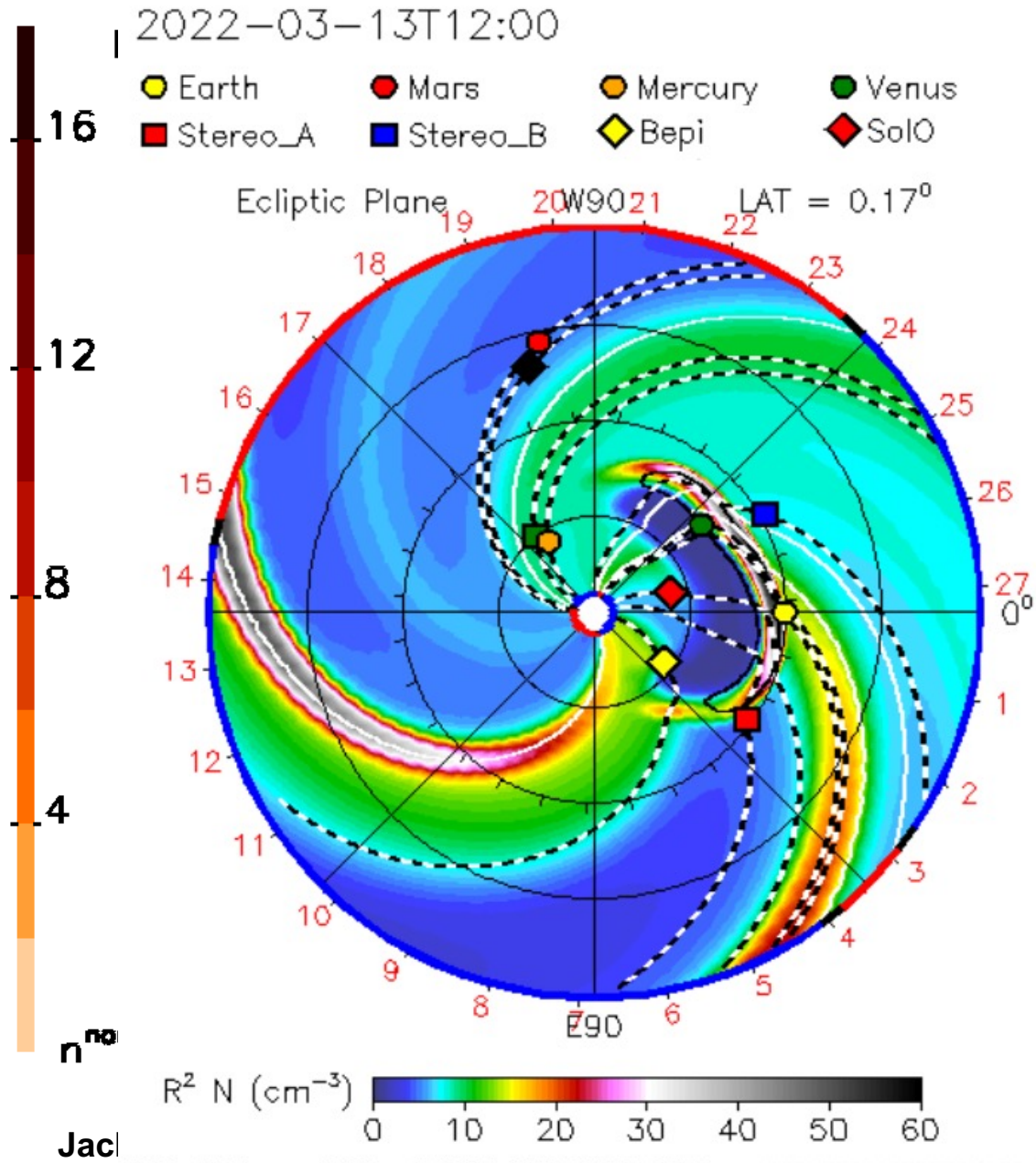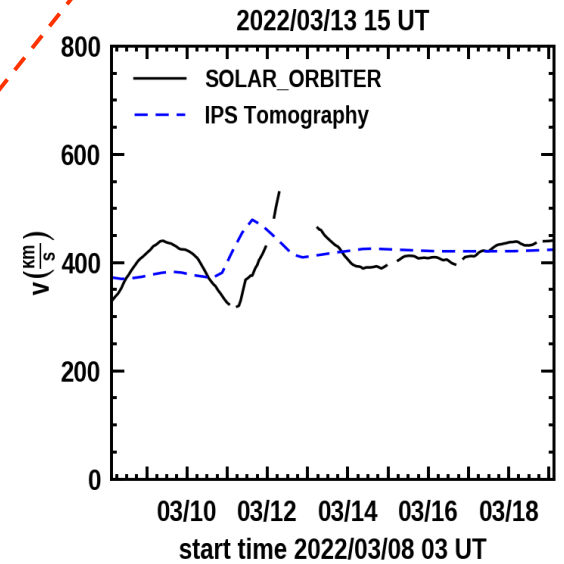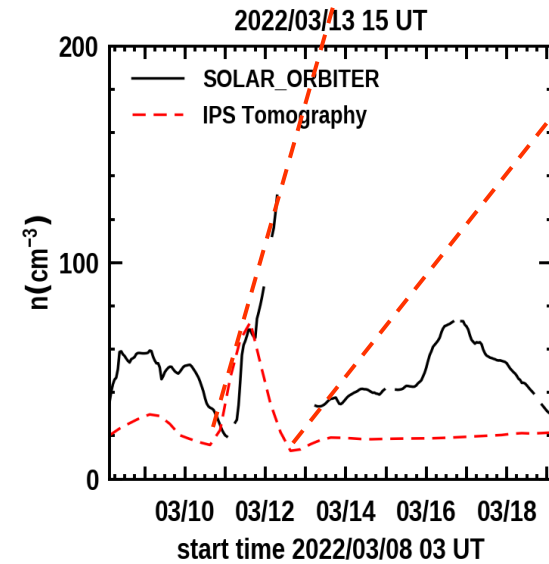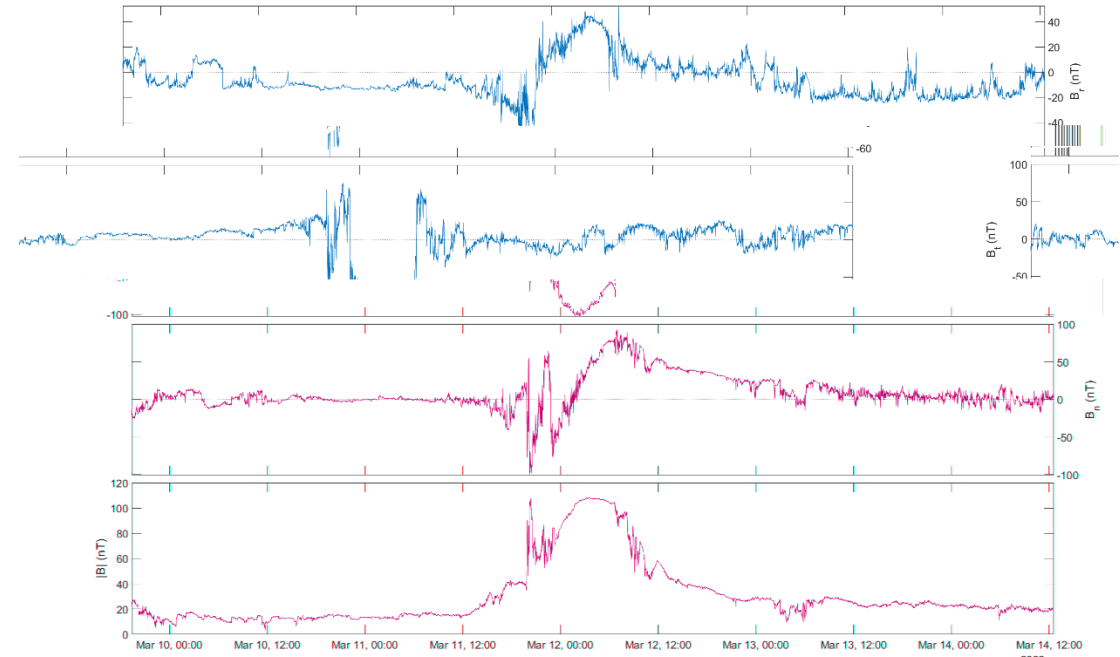
Thomson Scattering
B Analyses

Time-Dependent 3-D Reconstructions of B and pB

Titan II launch from Vandenberg AFB 6 January 2003.

The Solar Mass Ejection Imager (SMEI)
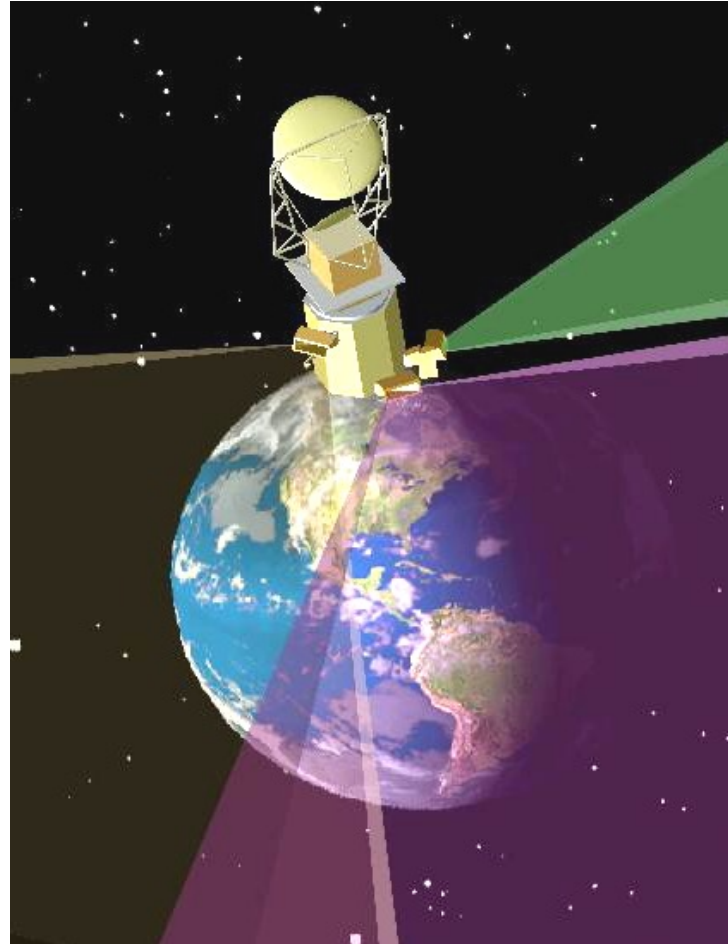
Jackson, B.V., et al., 2004, *Solar Phys.,* 225, 177

Launch 6 January 2003
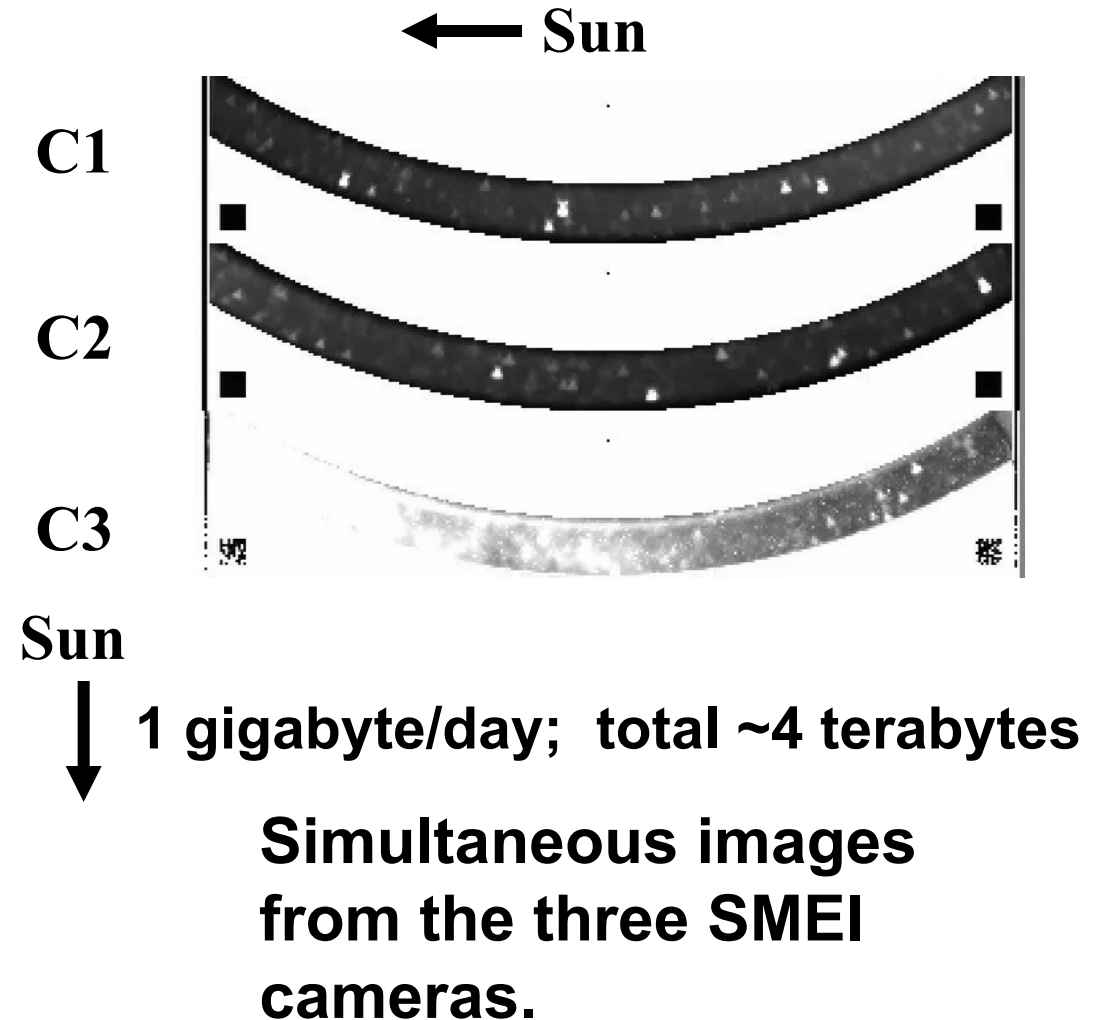
← Sun

C1

C2

C3

Sun

1 gigabyte/day; total ~4 terabytes

Simultaneous images from the three SMEI cameras.

A joint US Air Force - NASA Project

Time-Dependent 3-D Reconstructions of B and pB

Thomson-Scattering B & pB Line-of-Sight Response
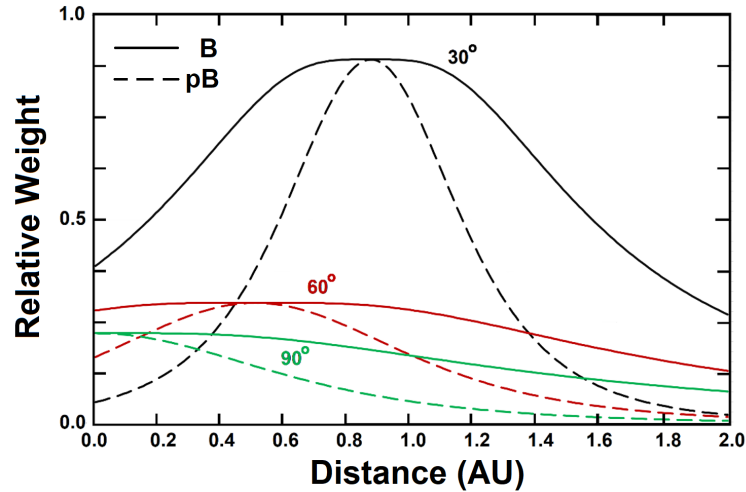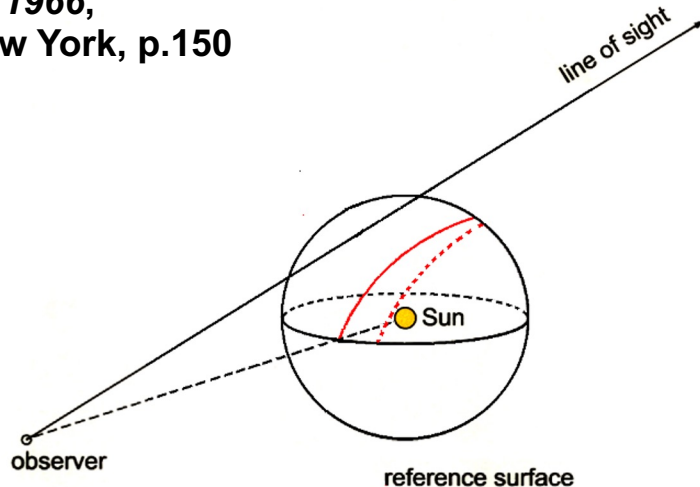
Heliospheric C.A.T. analyses:

"Traceback" Matrix Concept

Billings, D.E., *1966, Academic,* New York, p.150
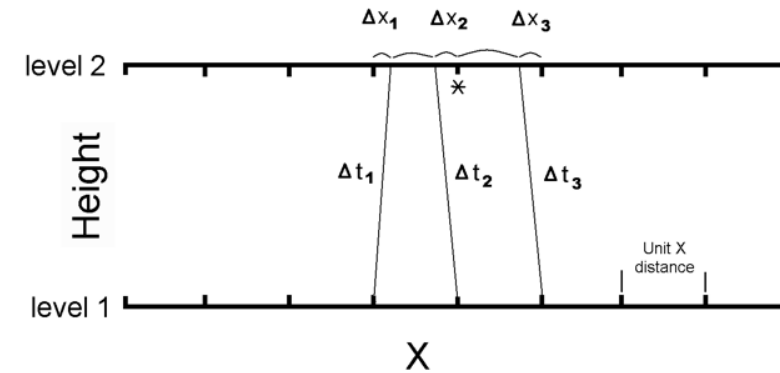
The "traceback matrix" (any solar wind model works)
In the traceback matrix the location of the upper level data point (starred) is an interpolation in x of $\Delta x2$ and the unit x distance – $\Delta x3$ distance or $(1 - \Delta x3)$. Similarly, the value of Δt at the starred point is interpolated by the same *spatial* distance. Each 3D traceback matrix contains a regular grid of values $\Sigma\Delta x$, $\Sigma\Delta y$, $\Sigma\Delta t$, $\Sigma\Delta v$, and $\Sigma\Delta m$ that locates the origin of each point in the grid at each time and its change in velocity and density from the heliospheric model.

Time-Dependent 3-D Reconstructions of B and pB
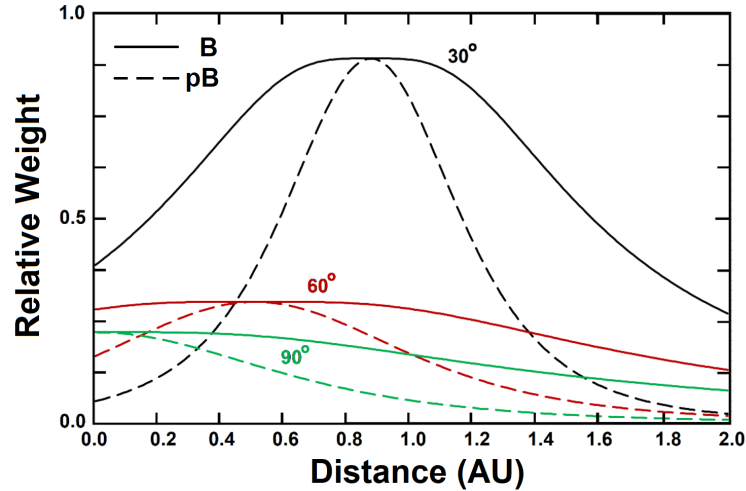
Thomson-Scattering B & pB Line-of-Sight Response

Heliospheric C.A.T. analyses: example line-of-sight distribution for each sky location to form the source surface weighting of the 3-D reconstruction.

Billings, D.E., *1966, Academic,* New York, p.150
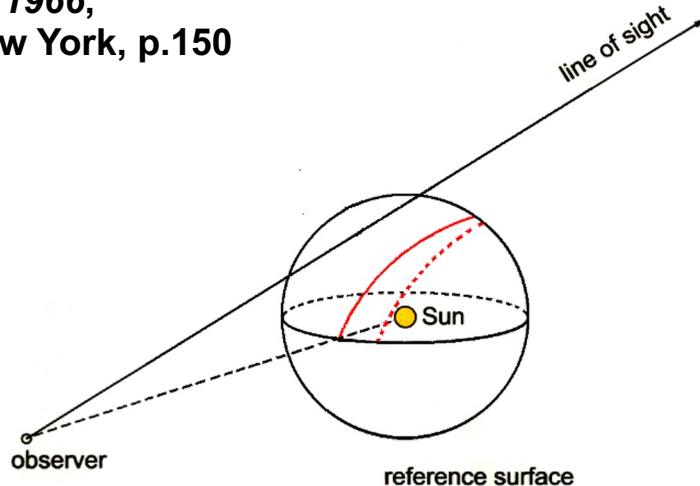
Thomson Scattering CAT Analysis
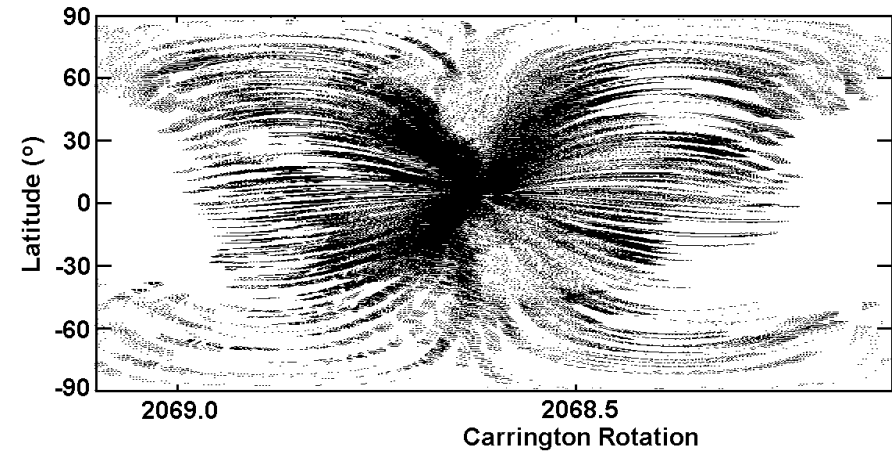
From SMEI (6 hr difference- 1/25 # of LOS) 3-5 Million LoS in a one-month interval

Time-Dependent 3-D Reconstructions of B and pB

2003 May 27-28 CME events

SMEI density 3D reconstruction of the 28 May 2003 halo CME as viewed from 15º above the ecliptic plane about 30º east of the Sun-Earth line.

SMEI Analysis
CME mass

2003/05/28 00:18

2003/05/30 00:00 UT

SMEI density (remote observer view) of the 28 May 2003 halo CME
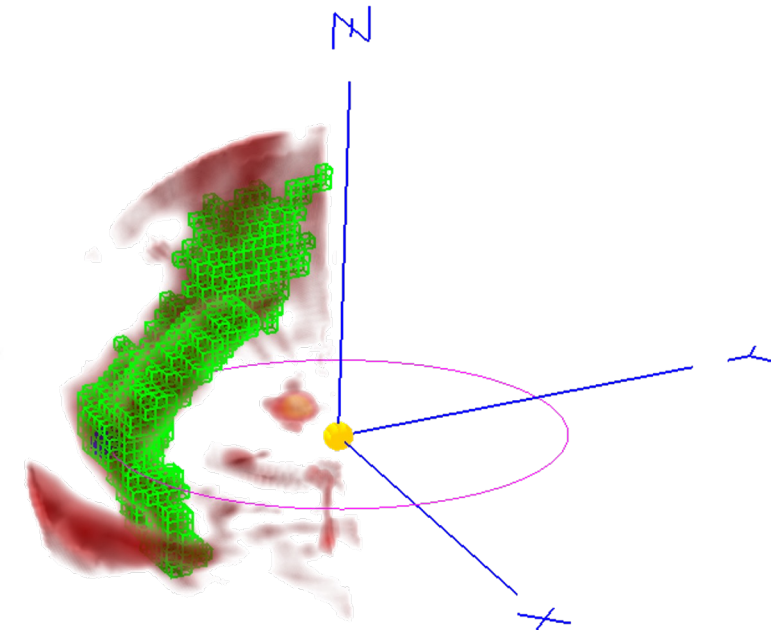
Excess Mass(g): 1.844E+016
Total Mass(g): 2.491E+016
Ambient (g):   6.470E+015
Energy (ergs): 3.448E+031

2003/05/30 00:00 UT

Volume: 0.144 AU^3

Time-Dependent 3-D Reconstructions of B and pB
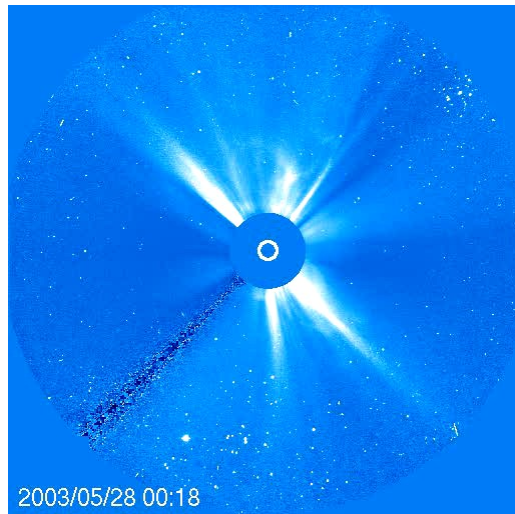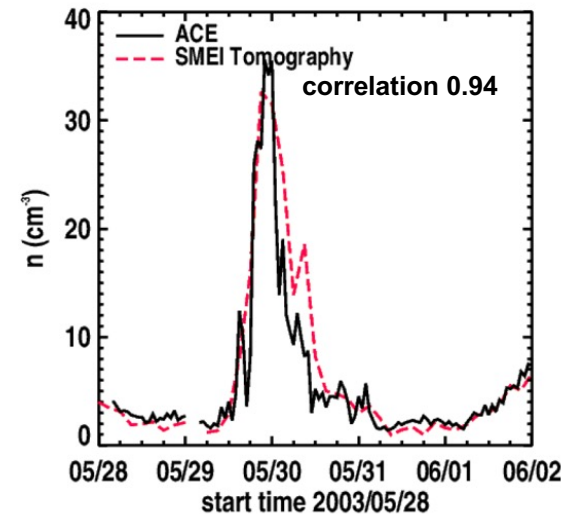
Jackson et al., 2020, *Frontiers in Astronomy and Space Sci.*, doi: 10.3389/fspas.2020.568429

SMEI Analysis

3,000,000 LoS in one month, 1.5- Hour Cadence Resolution

Time-Dependent 3-D Reconstructions of B and pB

Ecliptic, Earth Meridional, and Synoptic Cuts at 1.5-Hour Cadence Resolution

SMEI Analysis

2003 May 27-28 CME events

High Res Analyses show CMEs corrugated and spotty!

Ecliptic Cut

Meridional Cut

Synoptic Cut
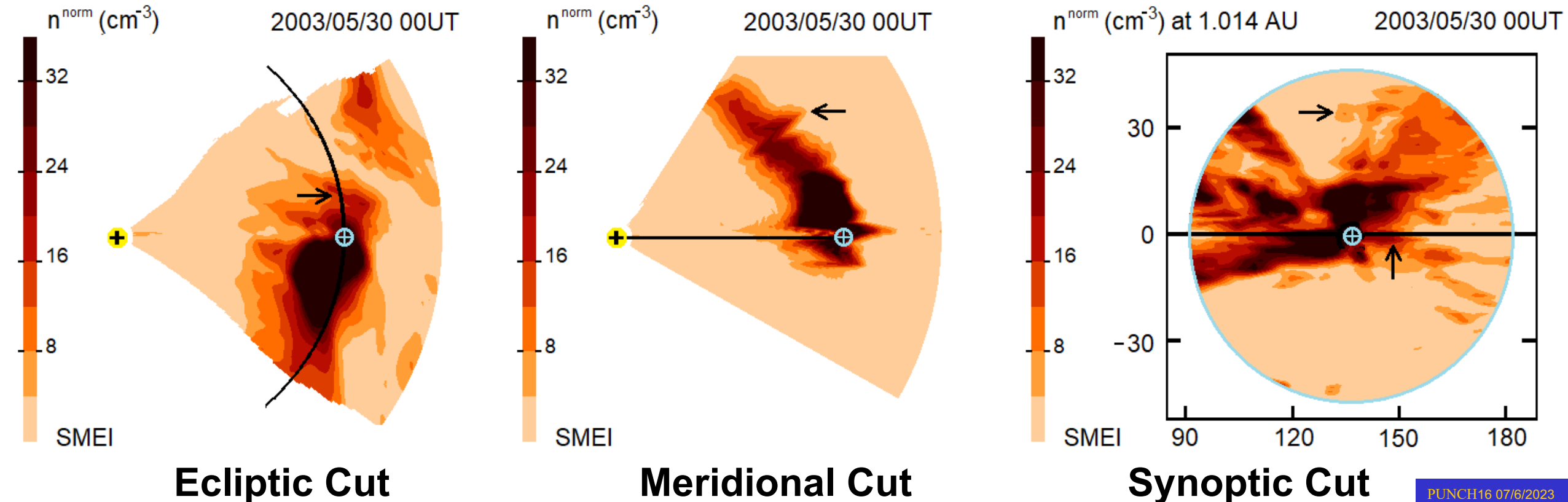
Thomson Scattering B & pB Analyses

Time-Dependent 3-D Reconstructions of B and pB

SMEI Regular B Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views
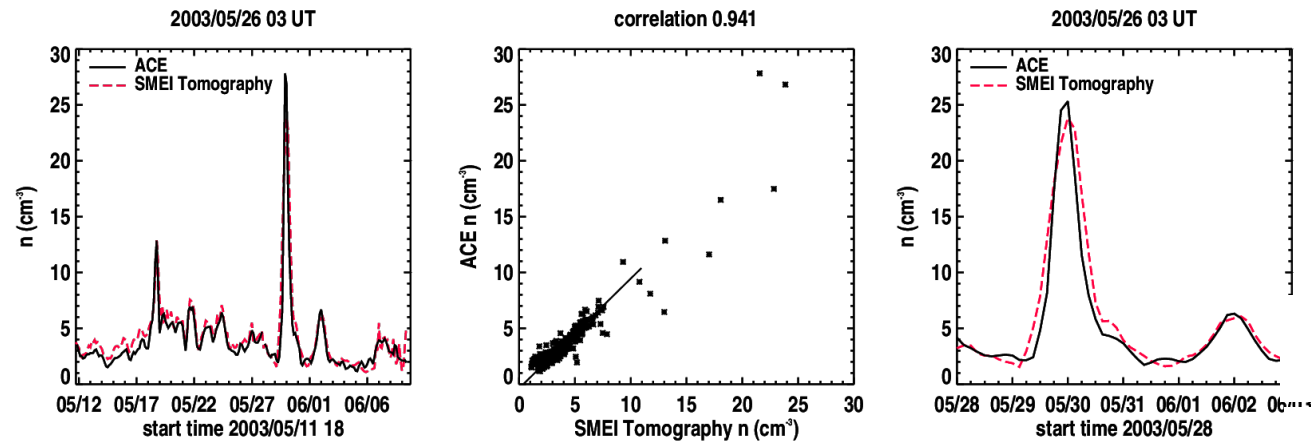
Month-long Time Series

6-days CME

Remote View

Skymap

Ecliptic Cut

Meridional

Time-Dependent 3-D Reconstructions of B and pB

Month-long Time Series

6-days CME

SMEI Pseudo B Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views

Remote View

Skymap

Ecliptic Cut

Meridional

Time-Dependent 3-D Reconstructions of B and pB

2003/05/26 03 UT — ACE / SMEI Tomography — Month-long Time Series

correlation 0.949

2003/05/26 03 UT — ACE / SMEI Tomography — 6-days CME

SMEI Pseudo pB Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views
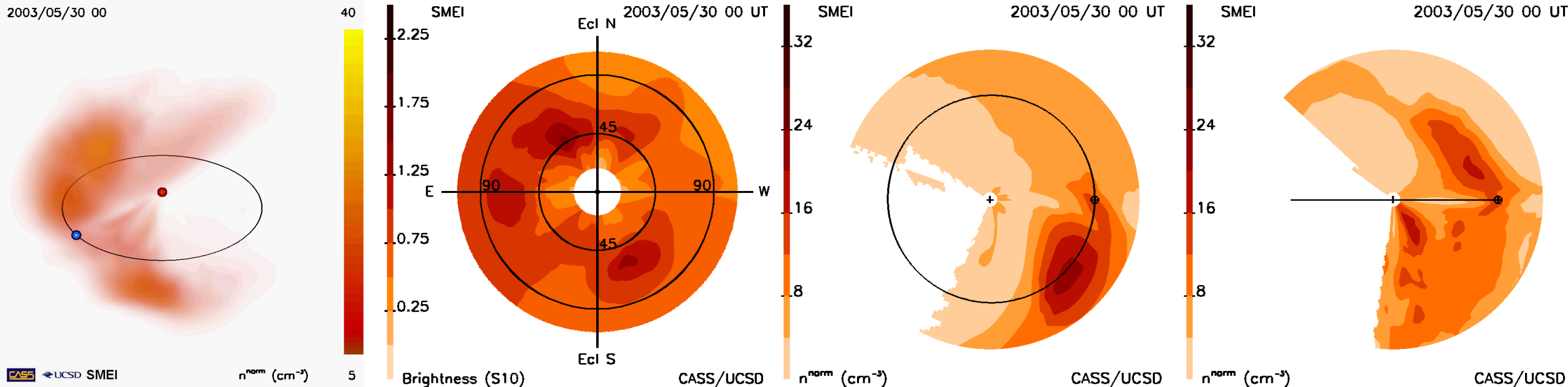
Remote View

Skymap

Ecliptic Cut

Meridional

Time-Dependent 3-D Reconstructions of B and pB

Caveats:

The analyses show images interpolated to a given instant in time, not how the data were actually obtained over a period of a few minutes, with each LoS different from one another from the IPS or SMEI data.

To be expedient I used the LoS only from density proxy observations, not the proxy speeds, and gave these times of the LoS, not the actual images. These were made into data files and re-read into the program.

The images show volumes where data were sufficient to make an accurate 3-D reconstruction, but to provide the pseudo LoS, each volume was filled completely and then that pseudo observation used.

Future Work That Must Happen

Future Work:

Provide pB with these immediate analyses and others at higher resolution and with less smoothing (provide in multi-node)
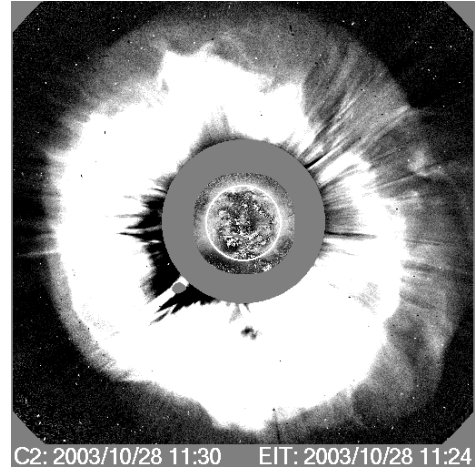
Raster-scan volumes in both B and pB at PUNCH locations with random outage line-of- sight locations

Correlation tracking velocities would be good to attempt from STEREO data to compare with inner heliospheric spacecraft or SMEI pseudo skymaps
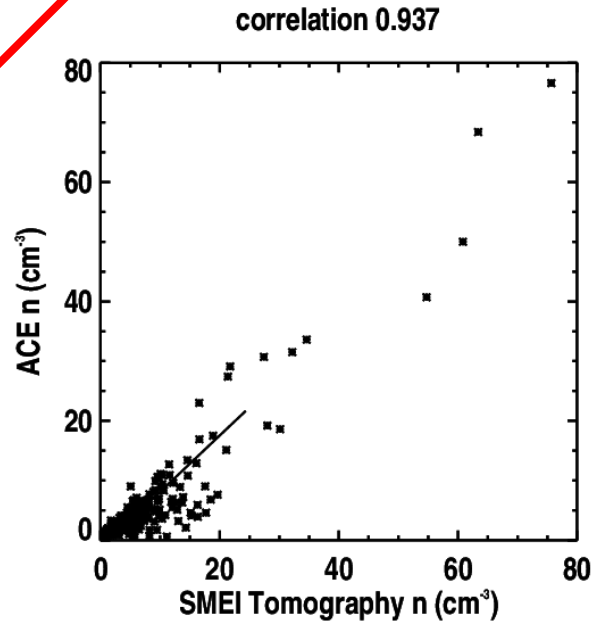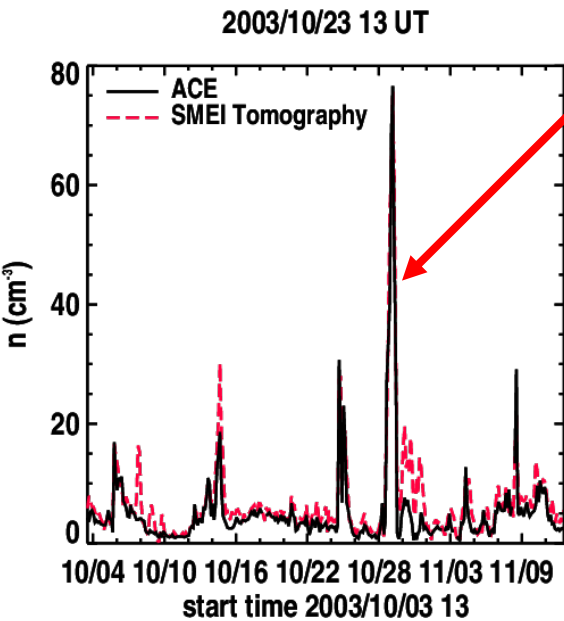
Compare correlation-tracking with IPS velocities
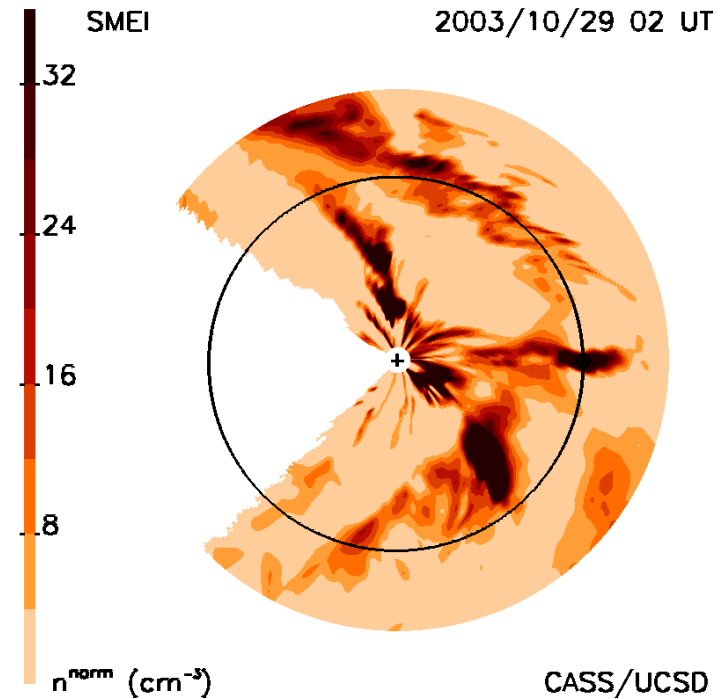
Time-Dependent 3-D Reconstructions of B and pB

Ecliptic, Earth Meridional, and Synoptic Cuts at 1.5-Hour Cadence Resolution

C2: 2003/10/28 11:30   EIT: 2003/10/28 11:24

SMEI Analysis
2003 Oct 28 CME event
CME shock sheaths are corrugated and spotty!

2003/10/23 13 UT

correlation 0.937

One Carrington interval

SMEI   2003/10/29 02 UT

Shock! (The CME reached Earth 18 hours after the X17 solar flare)

n^{norm} (cm^{-3})   CASS/UCSD

Ecliptic Cut

Time-Dependent 3-D Reconstructions of B and pB

Ecliptic, Earth Meridional, and Synoptic Cuts at 1.5-Hour Cadence Resolution

C2: 2003/10/28 11:30   EIT: 2003/10/28 11:24

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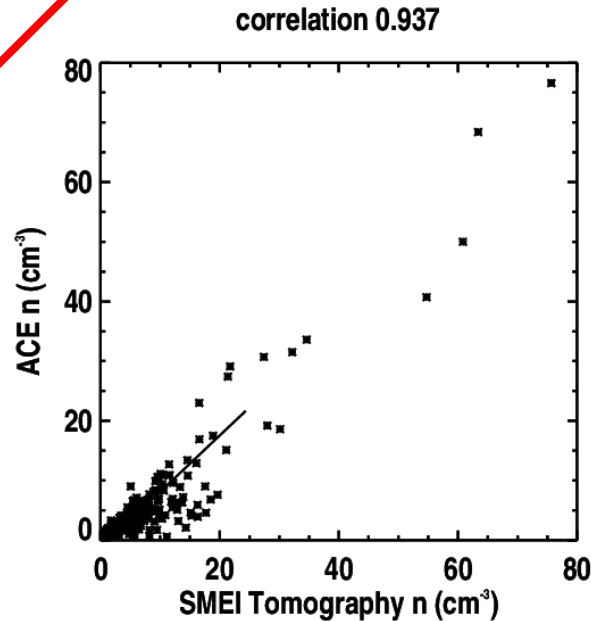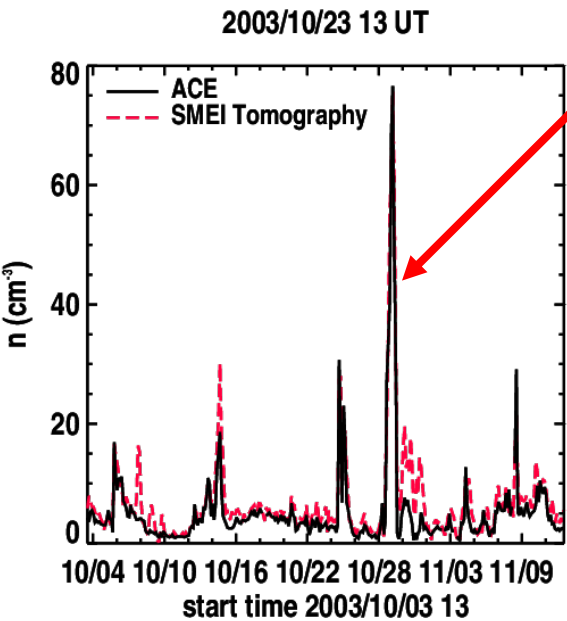2003/10/23 13 UT

correlation 0.937

One Carrington interval

STEL   2003/10/29 02 UT

Shock! (The CME reached Earth 18 hours after the X17 solar flare)

V (km s⁻¹)   CASS/UCSD
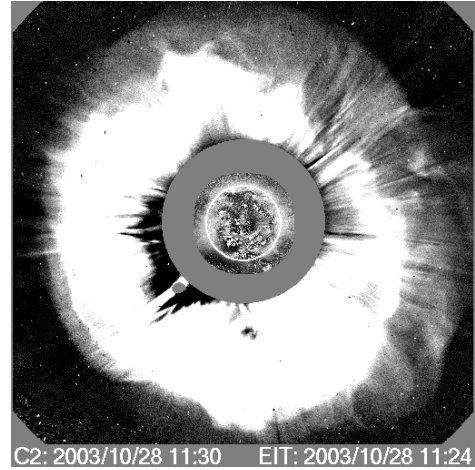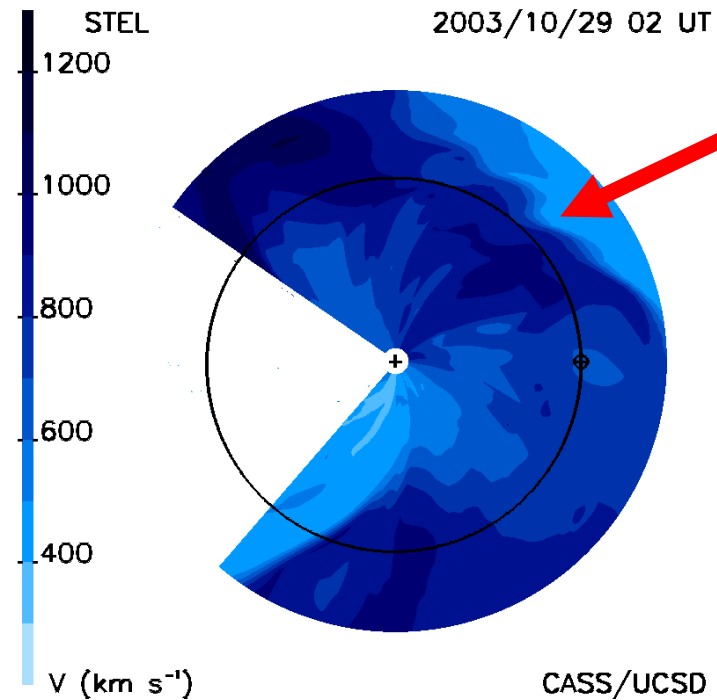
Low Res IPS V Ecliptic Cut

Conclusions:

The UCSD time-dependent 3D reconstruction analysis –
Current IPS and SMEI white-light analyses work pretty well

Analysis modification to provide density results from Thomson
scattering polarization brightness (pB) now gives results

Current tests of the pseudo B and pB analyses give essentially
the same results

Enhancements for better future results should include more multi-
node processing and image brightness correlation tracking
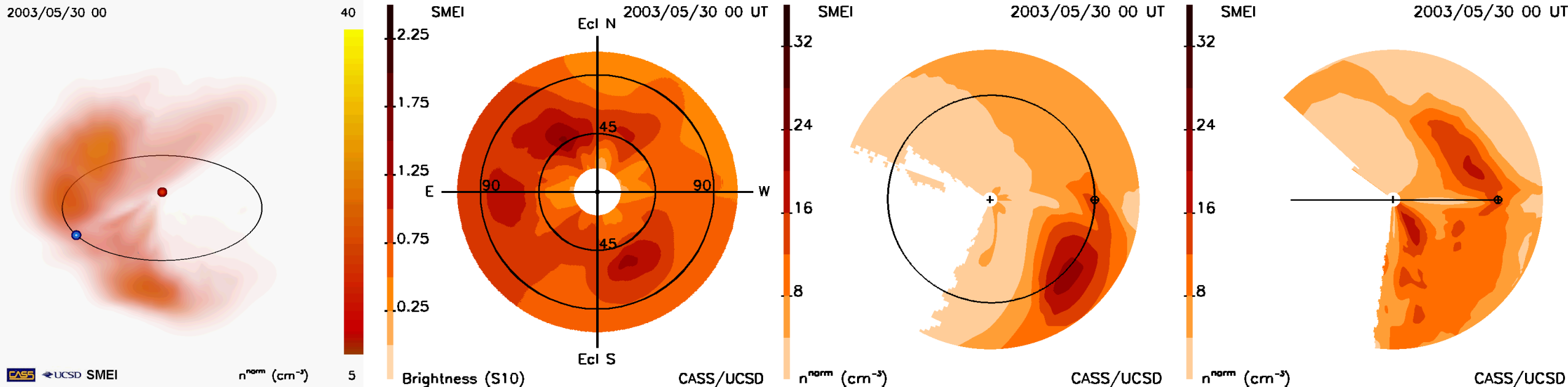
Time-Dependent 3-D Reconstructions of B and pB

SMEI Ratio Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views
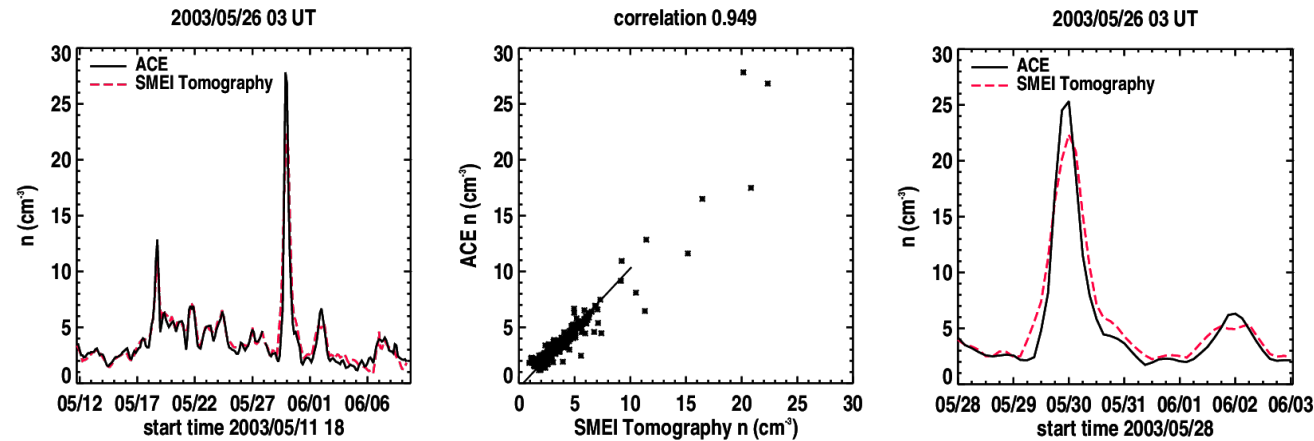
Month-long Time Series   **CME**

Remote View   **Skymap**   **Ecliptic Cut**   **Meridional**

PUNCH16 07/6/2023