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

Time-Dependent 3-D Reconstructions of B and pB

Interplanetary Scintillation (IPS) Analyses

Time-Dependent 3-D Reconstructions of B and pB

Interplanetary Scintillation Heliospheric Analyses from ISEE, Japan

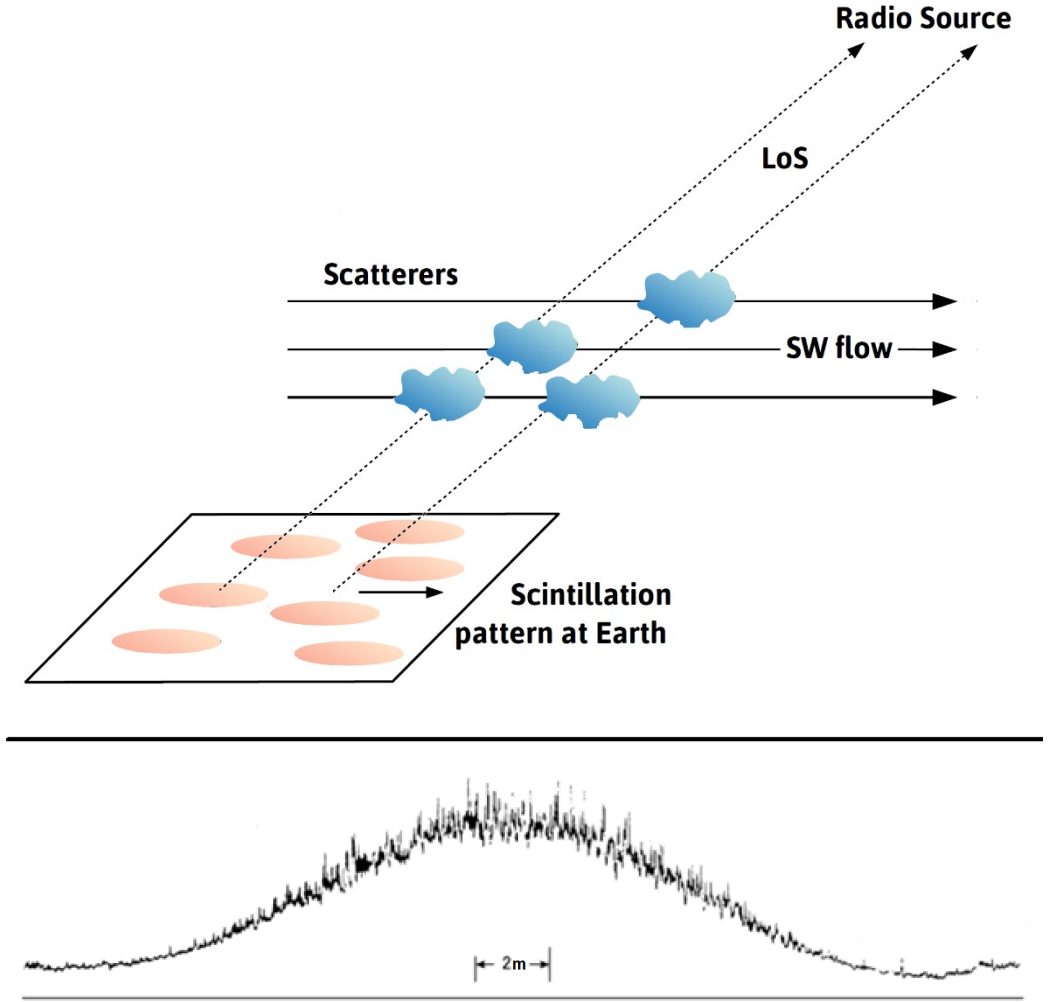
ISEE IPS array near Mt. Fuji

ISEE IPS array systems

Time-Dependent 3-D Reconstructions of B and pB

Most Are Guilty (Me too)

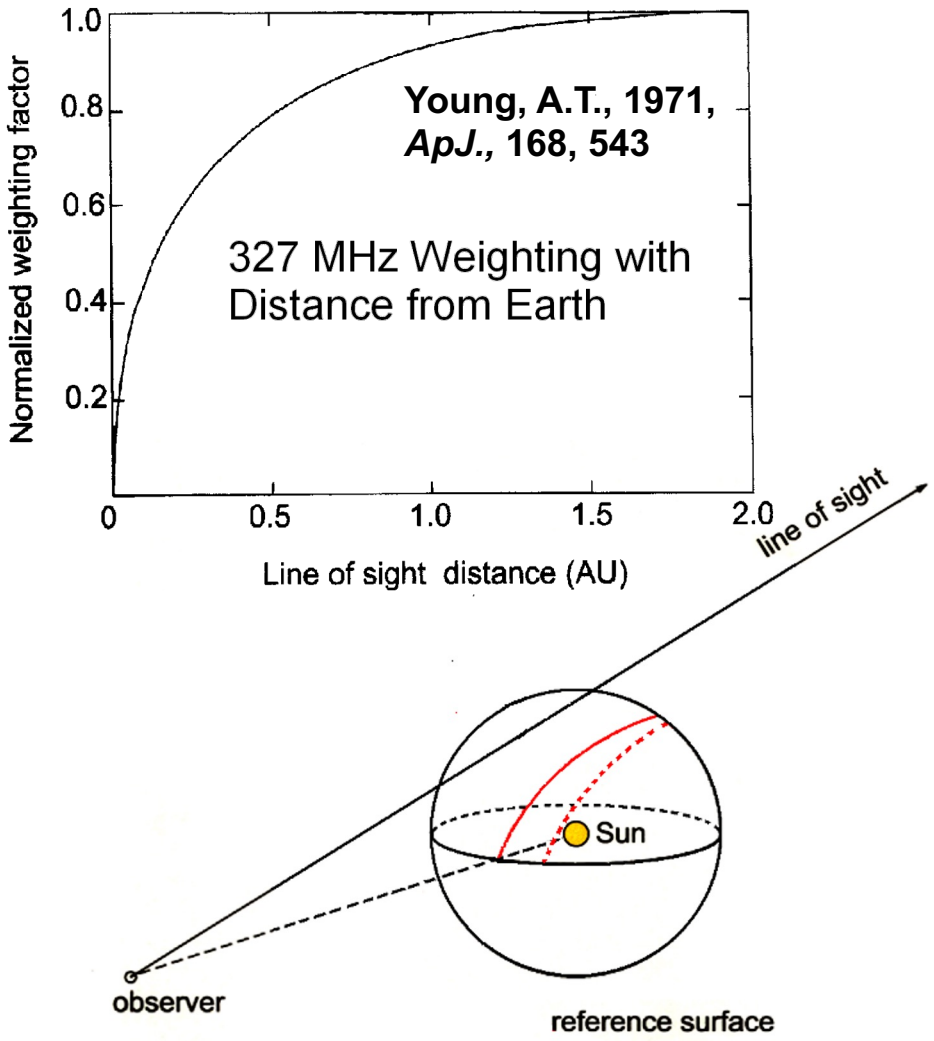
Interplanetary Scintillation Heliospheric Analyses from ISEE, Japan



ISEE IPS array systems

Time-Dependent 3-D Reconstructions of B and pB

Line-of-sight Response Interplanetary Scintillation

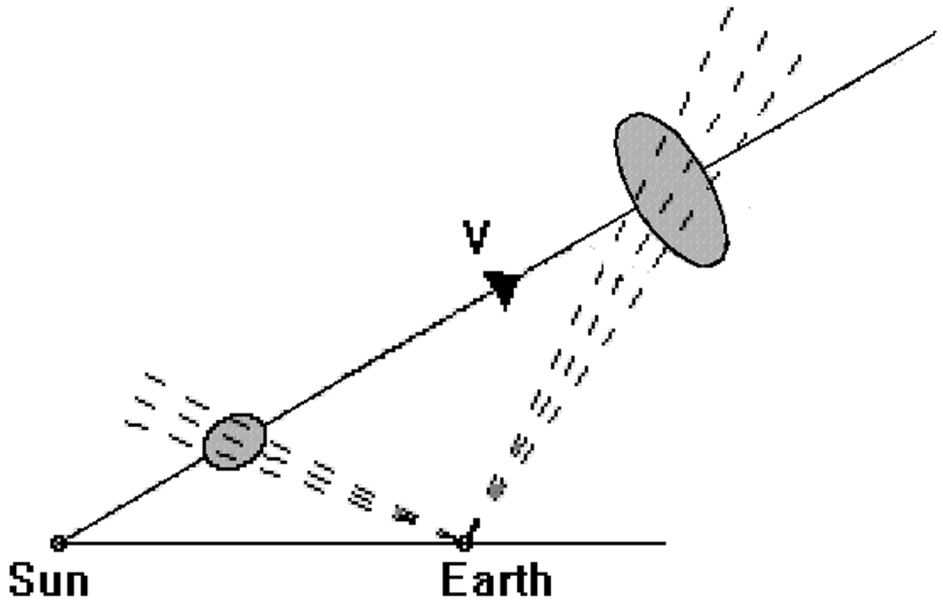


Jackson, B.V., *et al.*, 2008, *Adv. in Geosciences,* 21, 339

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

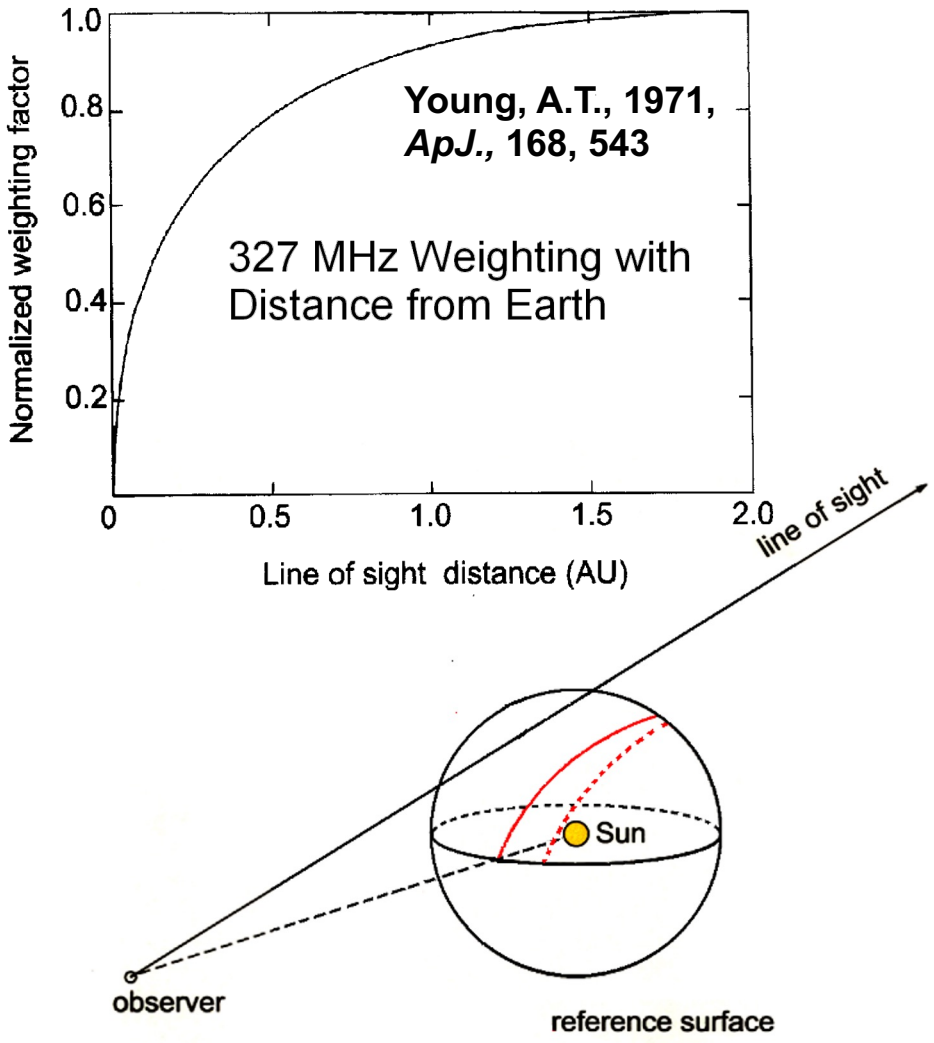
ISEE DATA

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.



Time-Dependent 3-D Reconstructions of B and pB

Line-of-sight Response Interplanetary Scintillation



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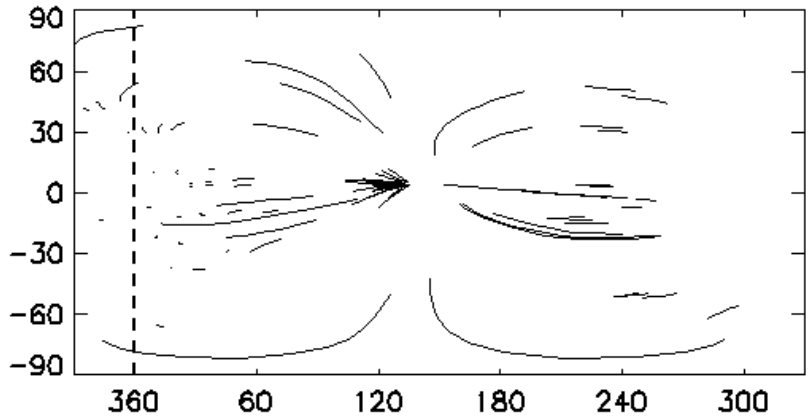
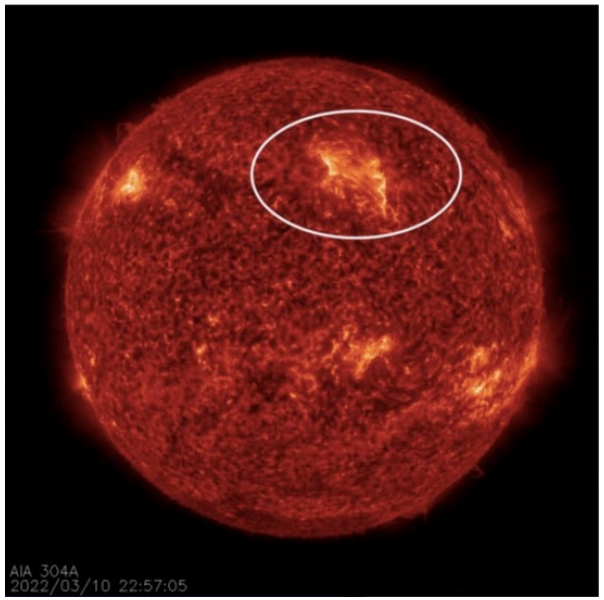
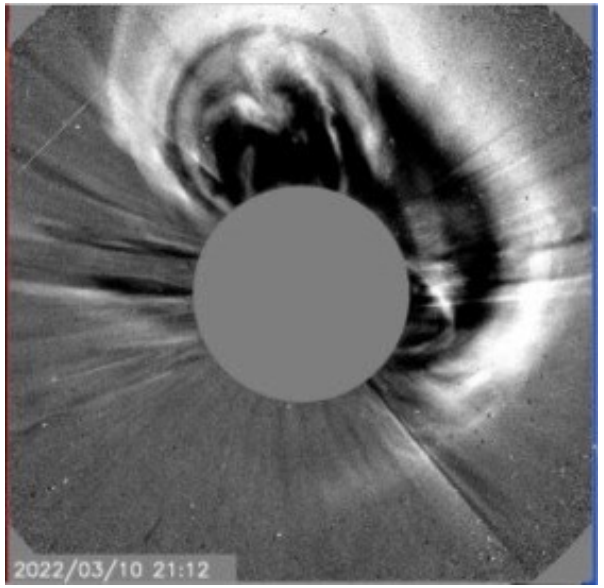


13 July 2000

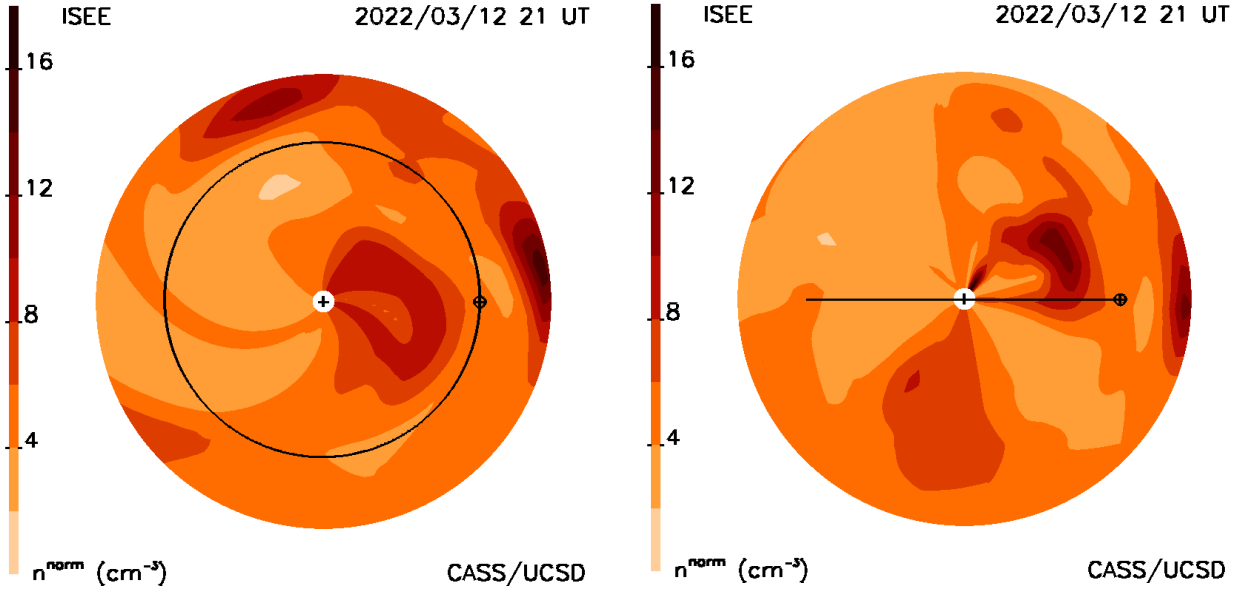
Time-Dependent 3-D Reconstructions of B and pB

2022/03/10 CME

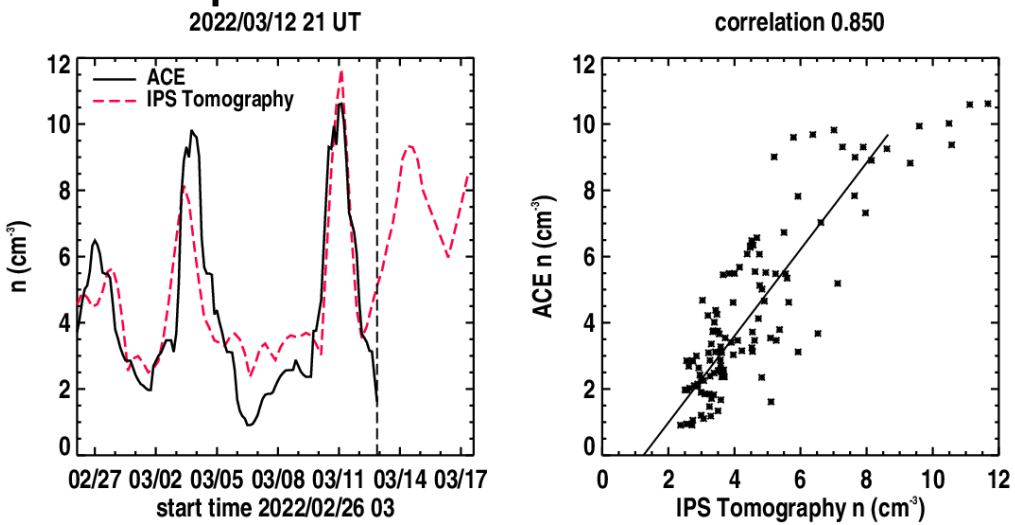




2022/03/12 21 UT



IPS Ecliptic Cut | **IPS Meridional Cut**



Time Series Comparison | **Pearson's "R" Correlation**

A Good Recent IPS CME Forecast

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

Time-Dependent 3-D Reconstructions of B and pB

2022/03/10 CME

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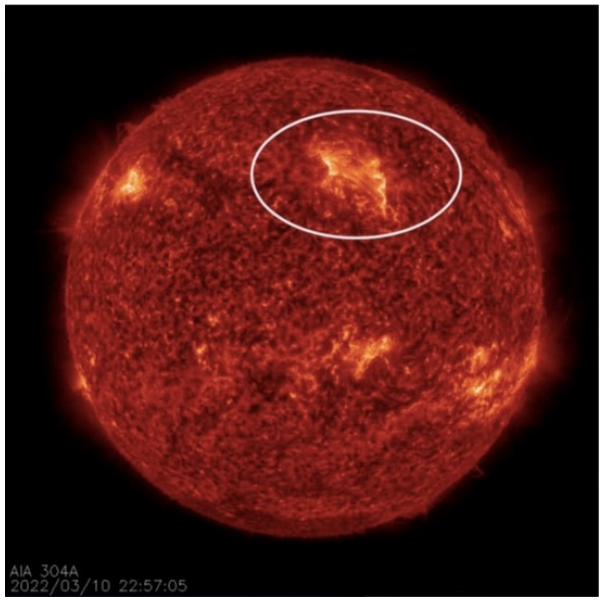
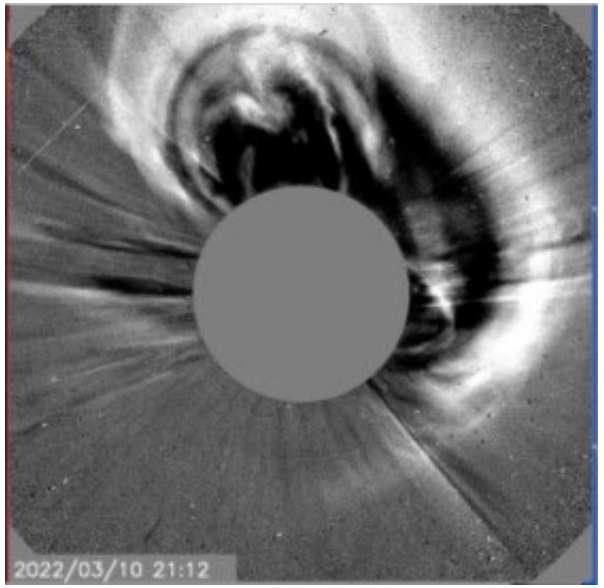
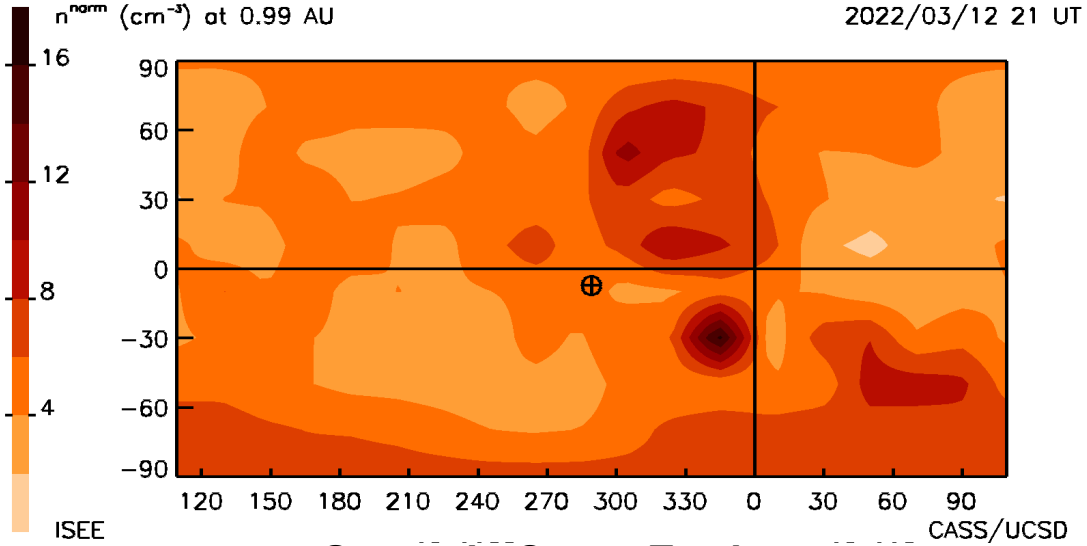
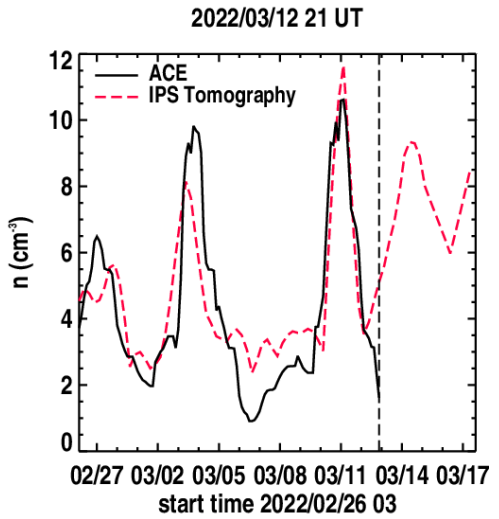






Synoptic Cut at Earth



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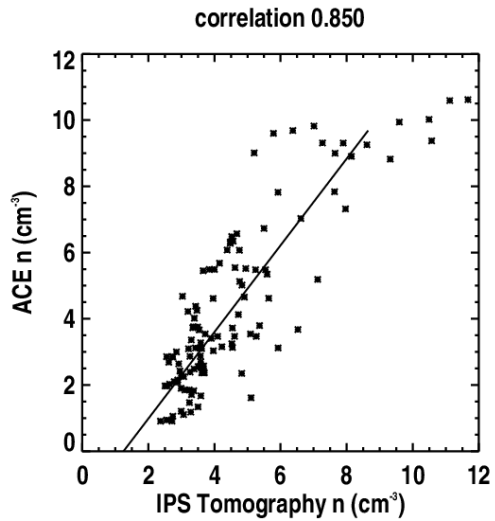

Pearson's "R" Correlation

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Time-Dependent 3-D Reconstructions of B and pB

2022/03/10 CME

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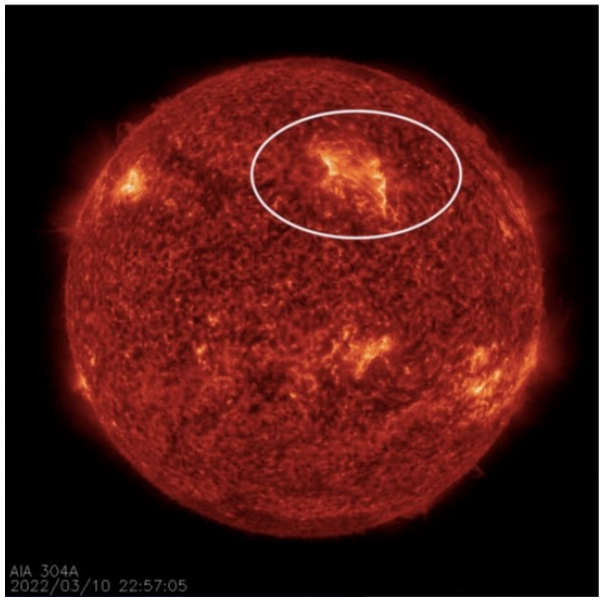

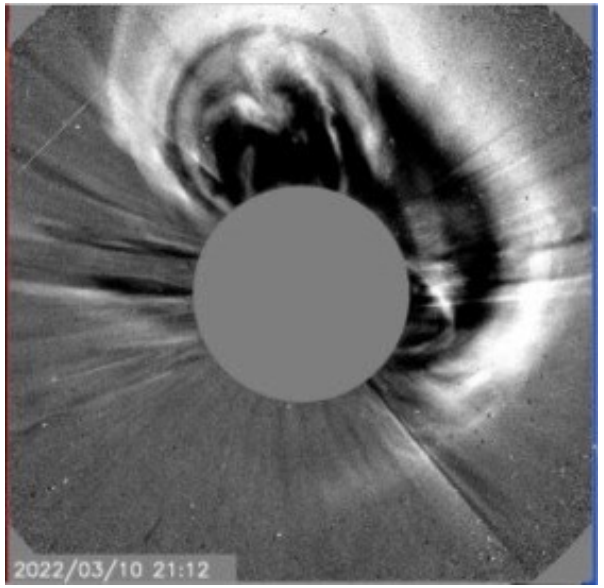

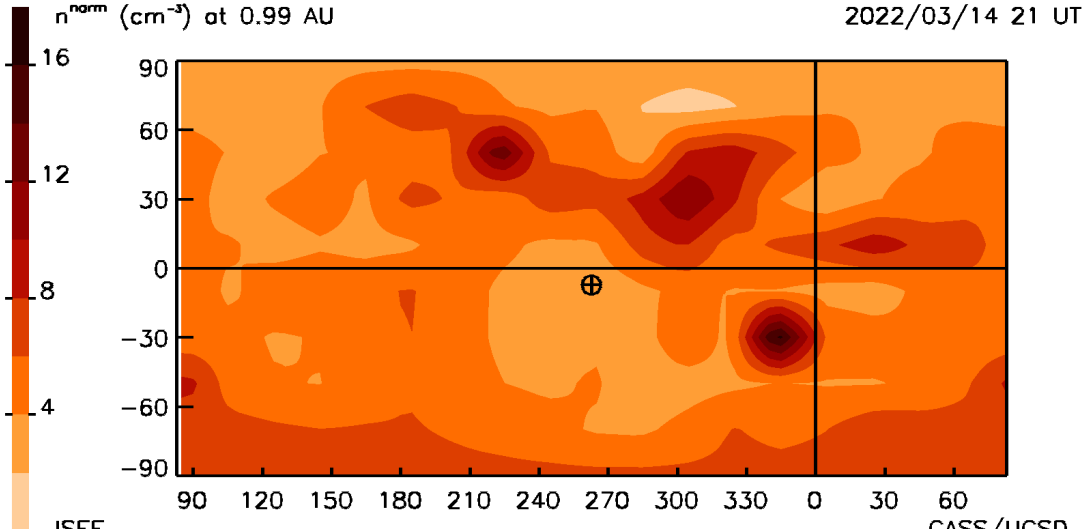

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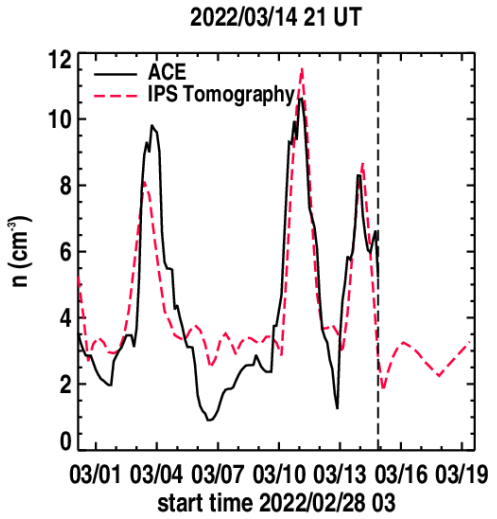
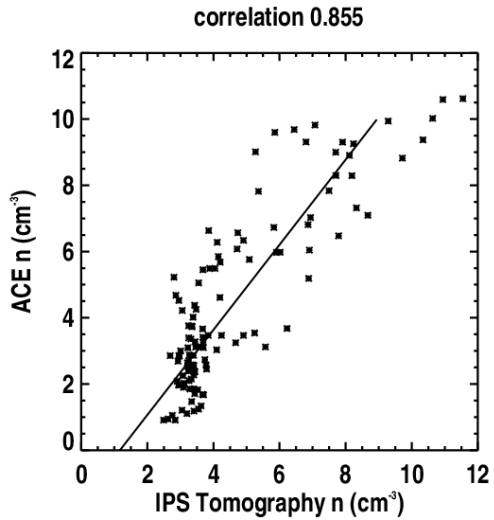


Time Series Comparison



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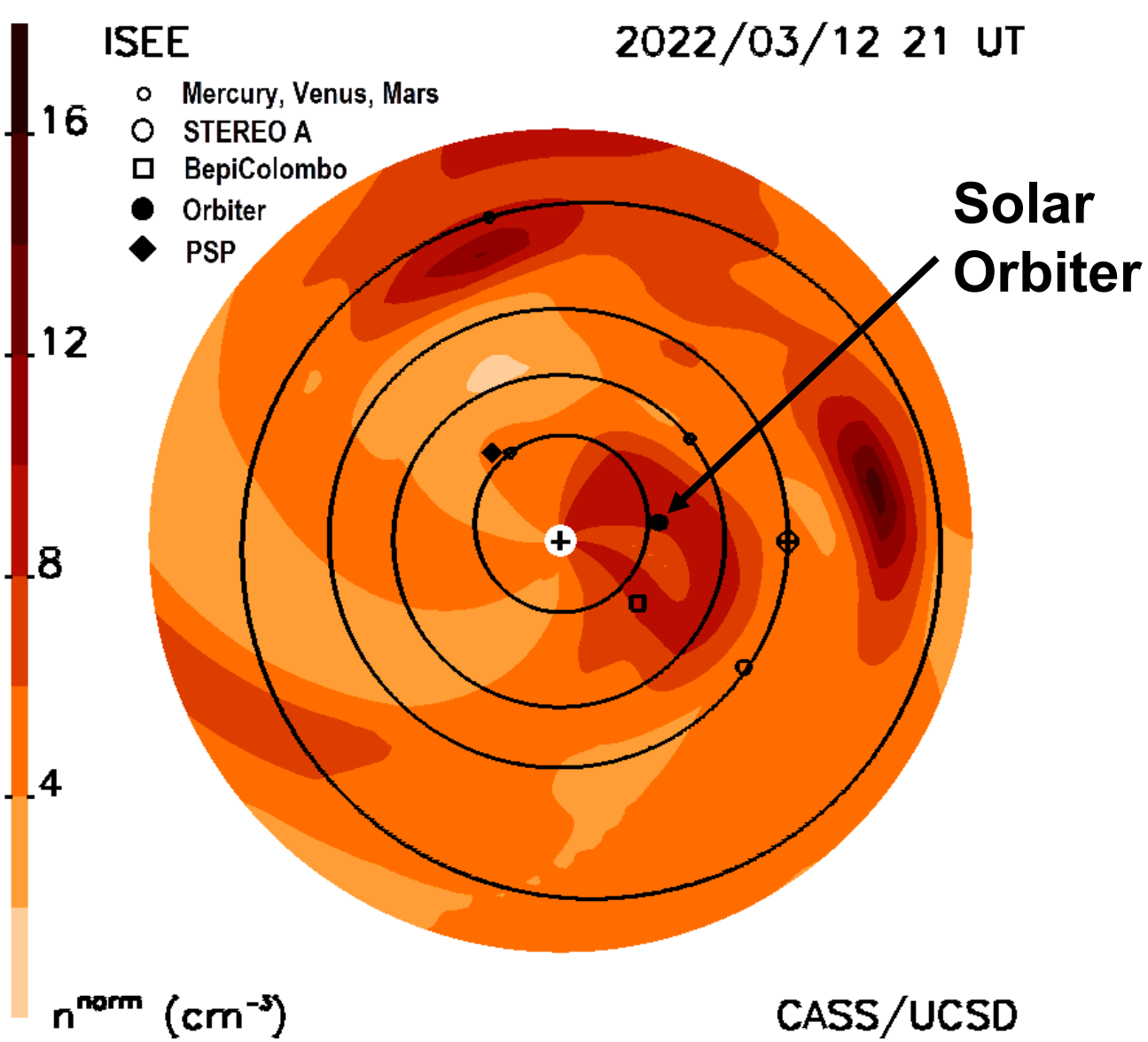
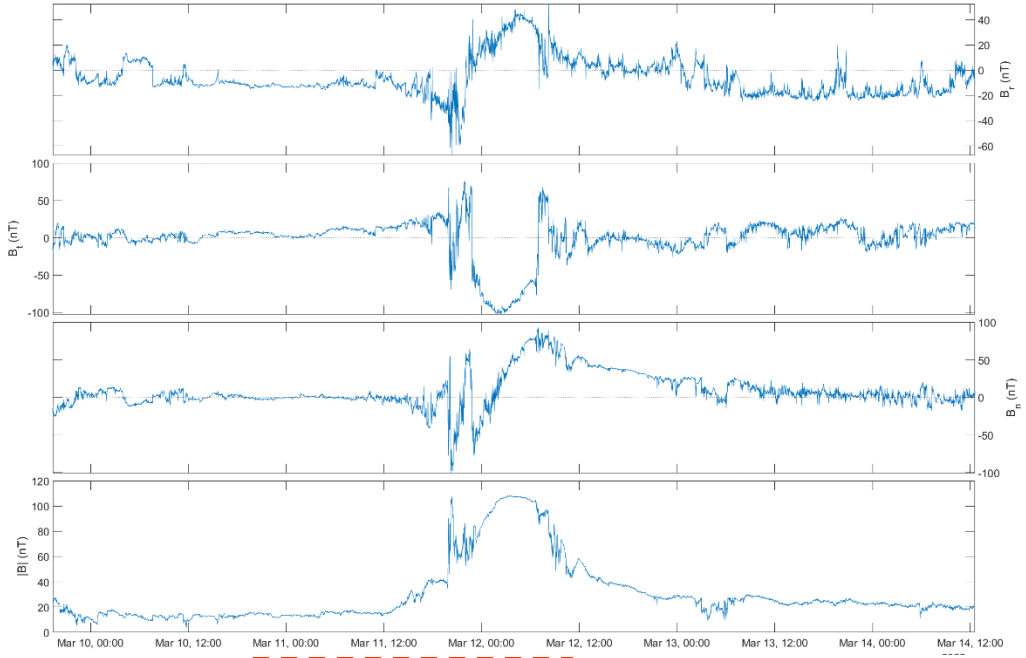
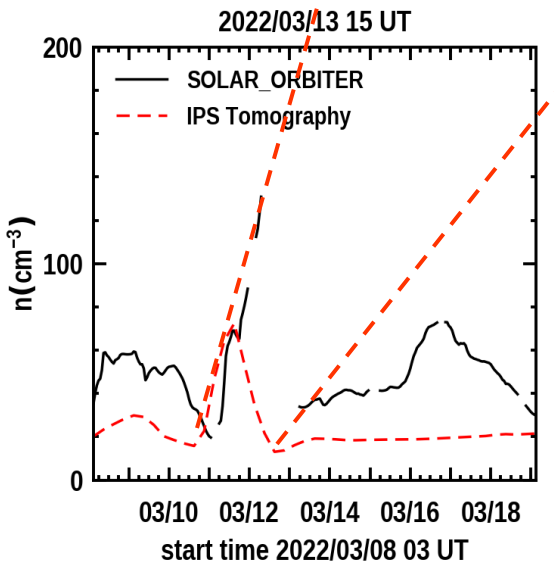
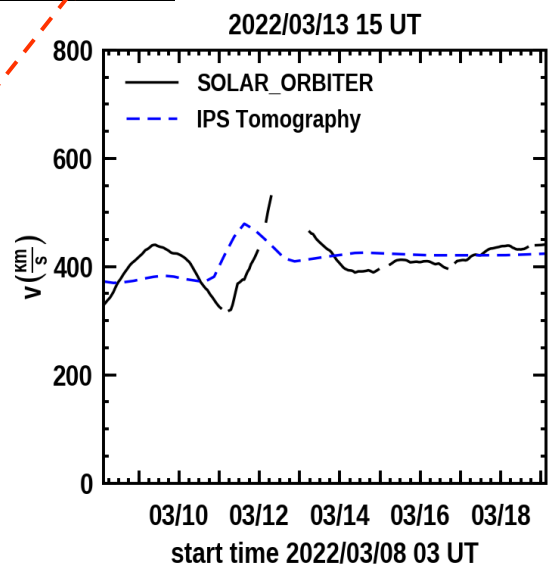
Time-Dependent 3-D Reconstructions of B and pB









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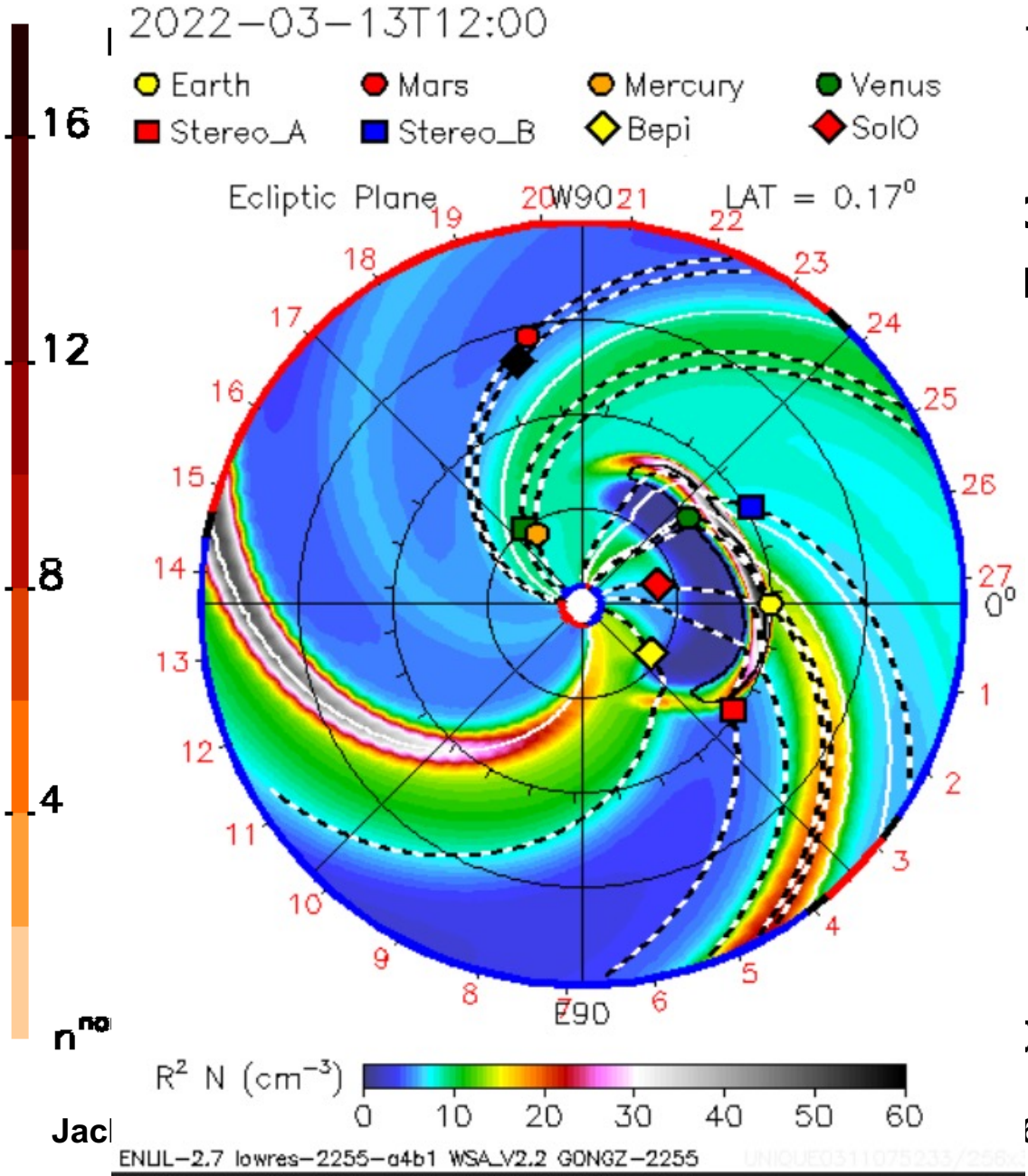
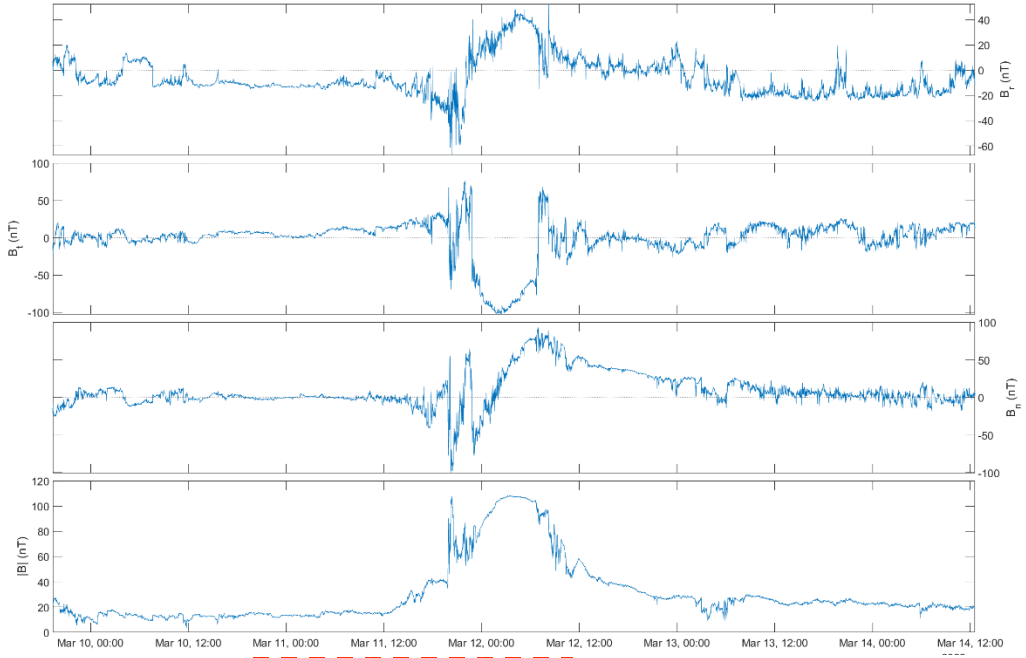
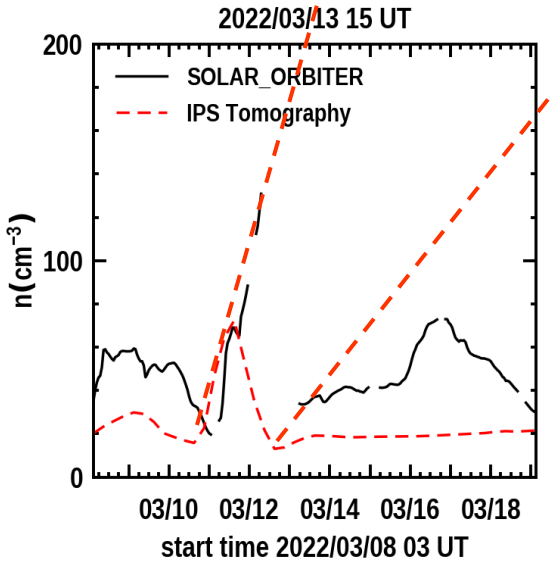
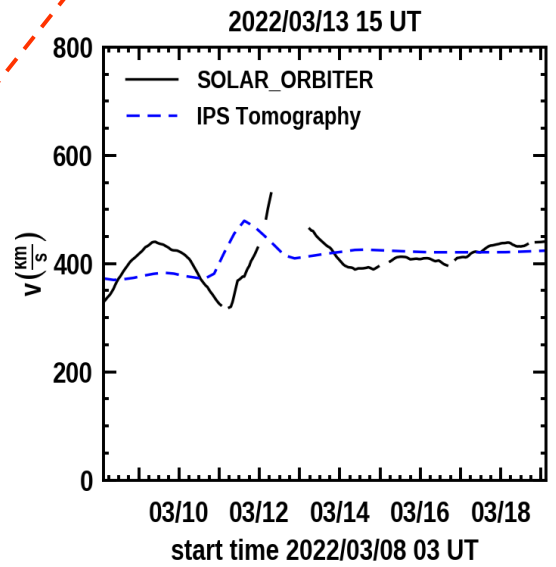








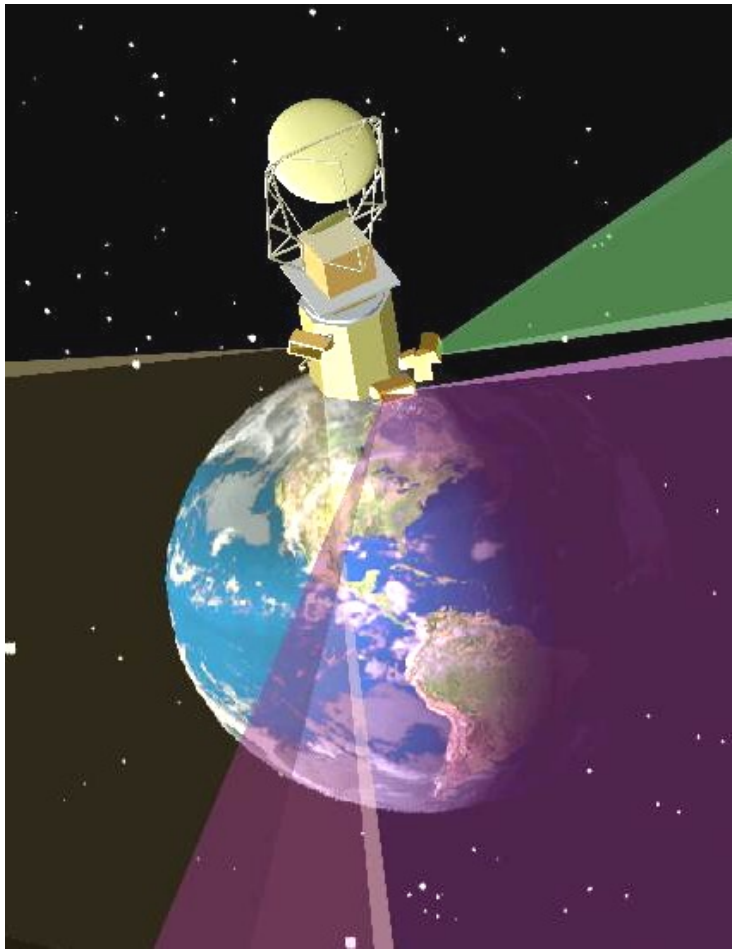
Time-Dependent 3-D Reconstructions of B and pB

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)



A joint US Air Force - NASA Project

Jackson, B.V., et al., 2004, *Solar Phys.*, 225, 177

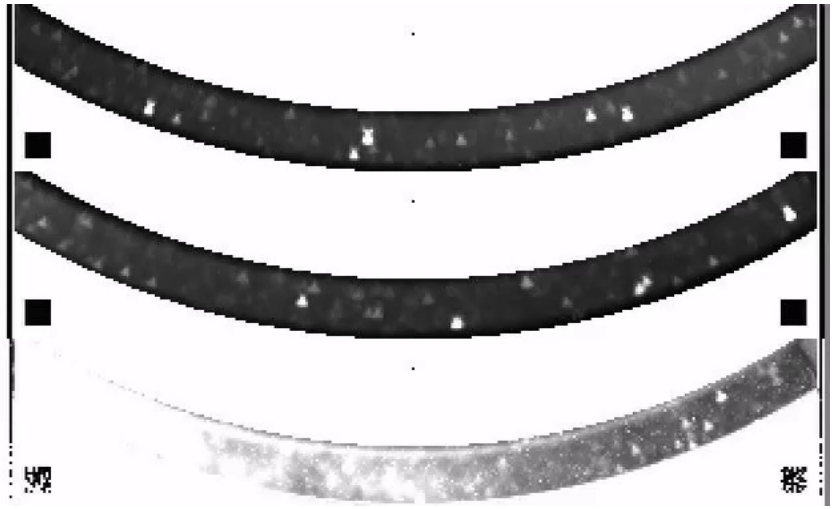
Launch 6 January 2003

← Sun

C1

C2

C3



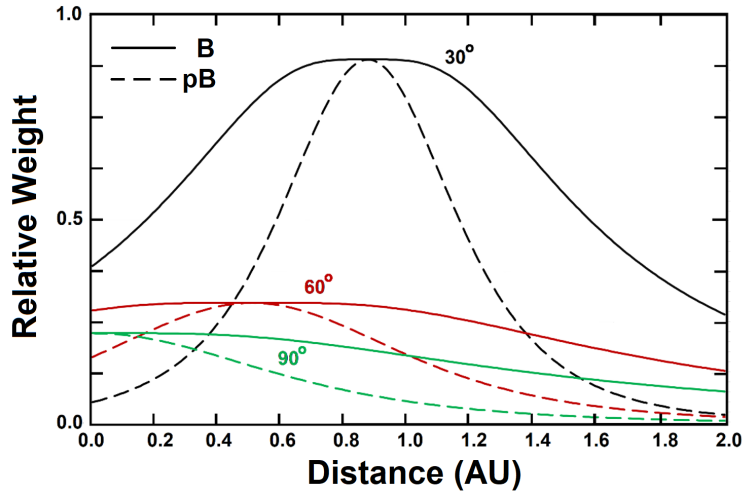
Sun

↓ 1 gigabyte/day; total ~4 terabytes

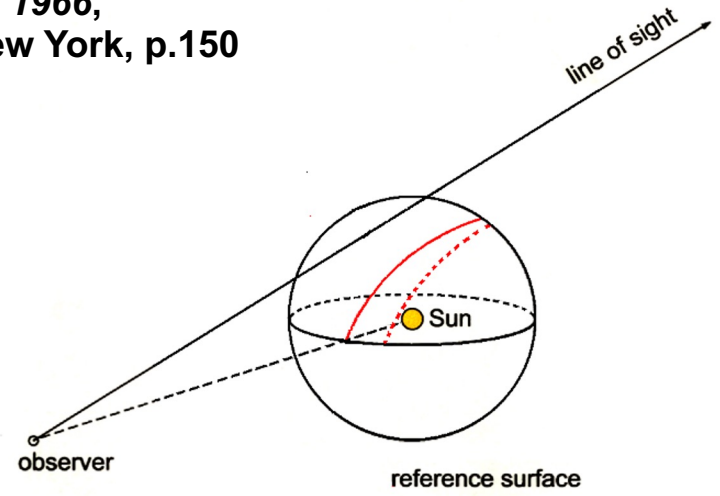
Simultaneous images from the three SMEI cameras.

Time-Dependent 3-D Reconstructions of B and pB

Thomson-Scattering B & pB Line-of-Sight Response



Billings, D.E., *1966*, *Academic,* New York, p.150



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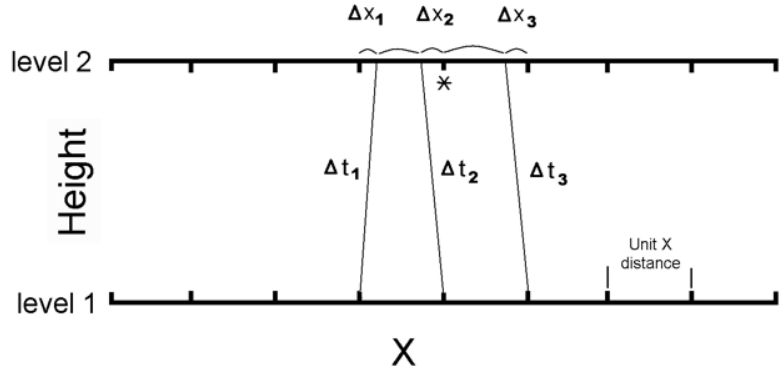
Heliospheric C.A.T. analyses:

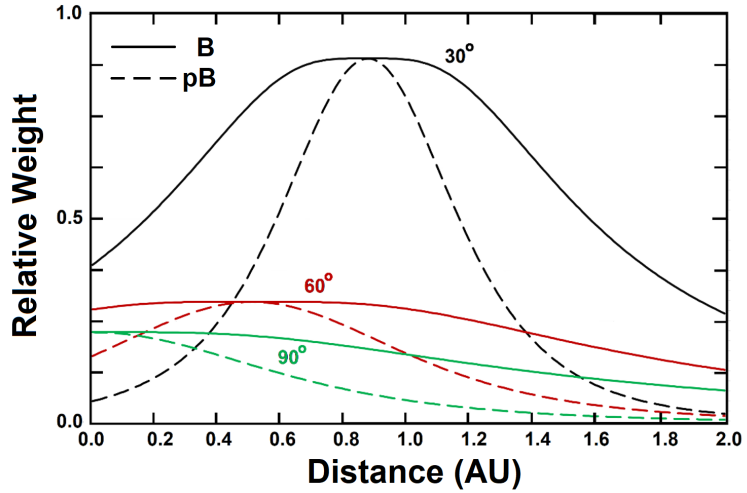
"Traceback" Matrix Concept



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 Δx2 and the unit x distance – Δx3 distance or (1 – Δx3). 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 ΣΔx, ΣΔy, ΣΔt, ΣΔv, and ΣΔm 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



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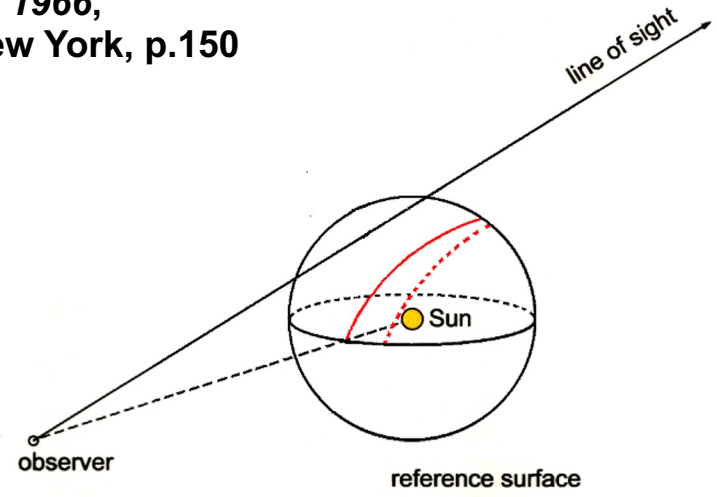

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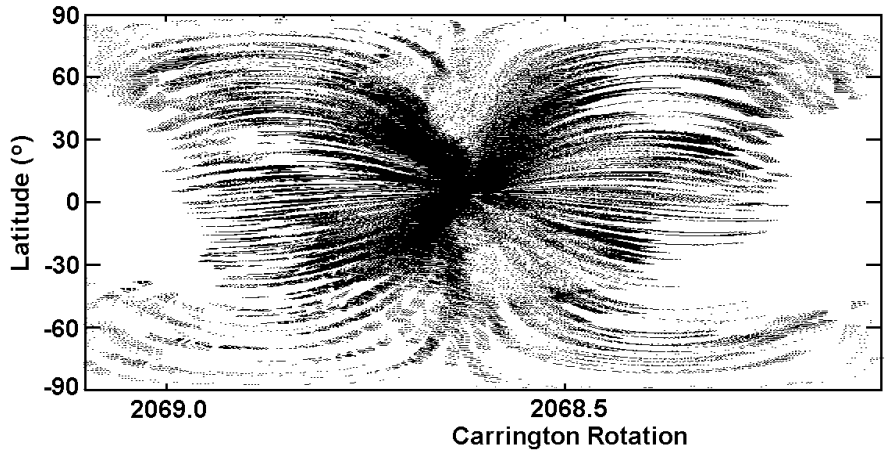
Heliospheric C.A.T. analyses: example line-of-sight distribution for each sky location to form the source surface weighting of the 3-D reconstruction.

Thomson Scattering CAT Analysis



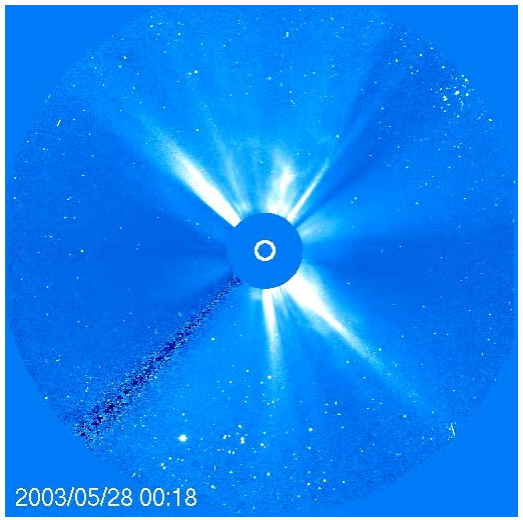
From SMEI (6 hr difference- 1/25 # of LOS) 3-5 Million LoS in a one-month interval

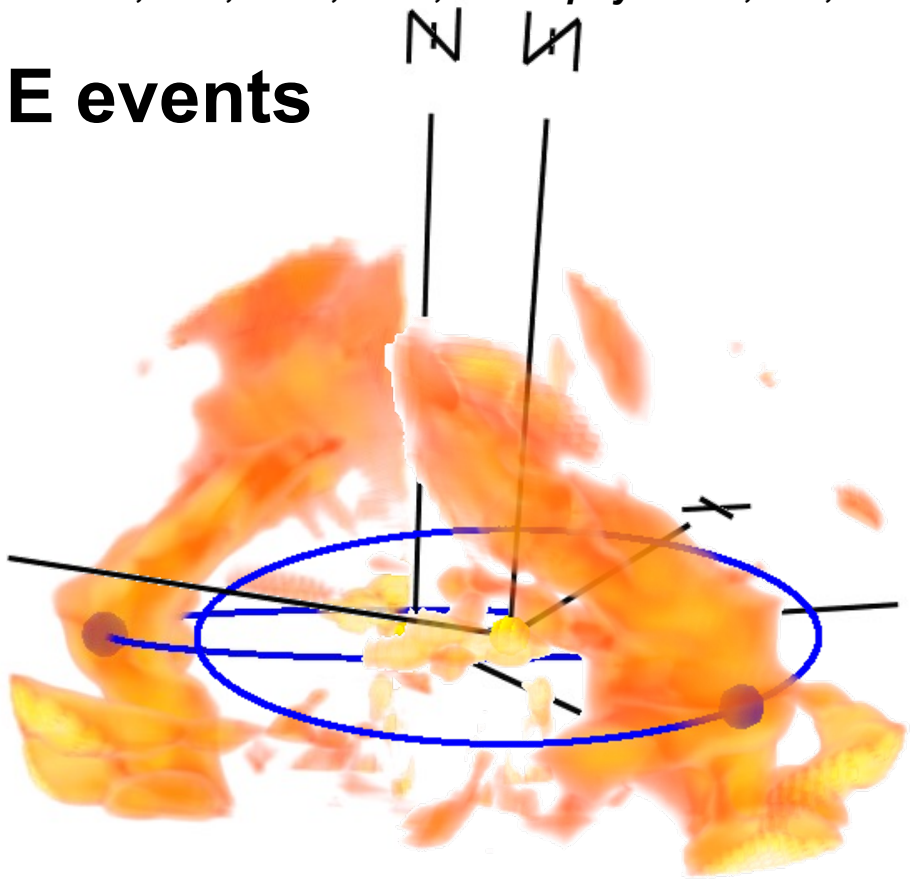
Time-Dependent 3-D Reconstructions of B and pB

Jackson, B.V., et al., 2008, *J. Geophys Res.*, 113, A00A15, doi:10.1029/2008JA013224

2003 May 27-28 CME events

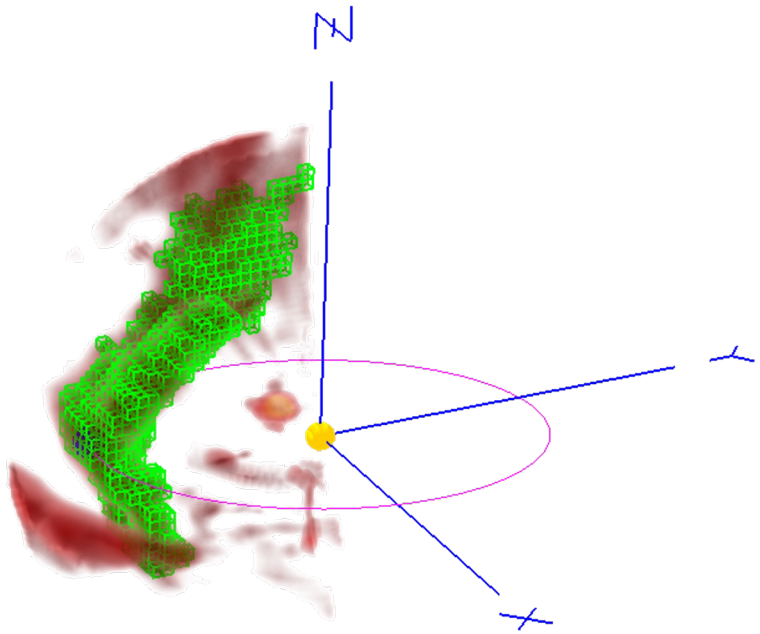
SMEI density 3D reconstruction of the 28 May 2003 halo CME as viewed from 15º above the ecliptic plane about 30º east of the Sun-Earth line.





SMEI density (remote observer view) of the 28 May 2003 halo CME

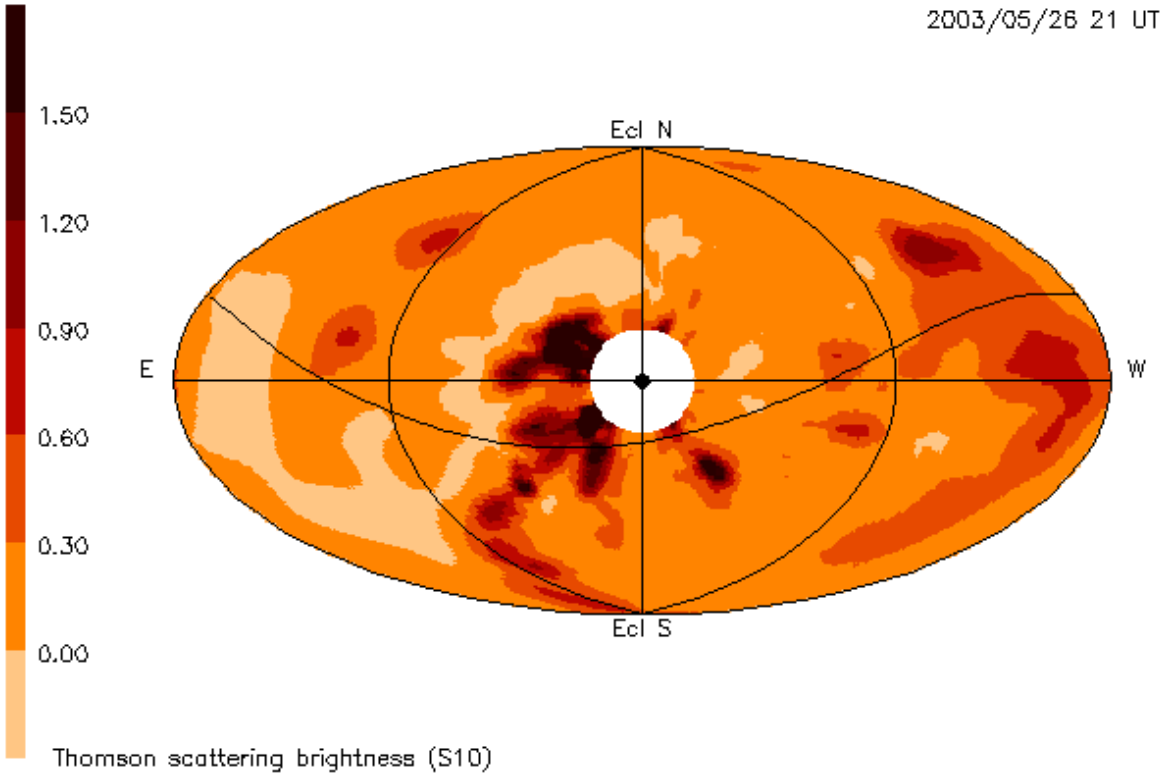
SMEI Analysis
CME mass



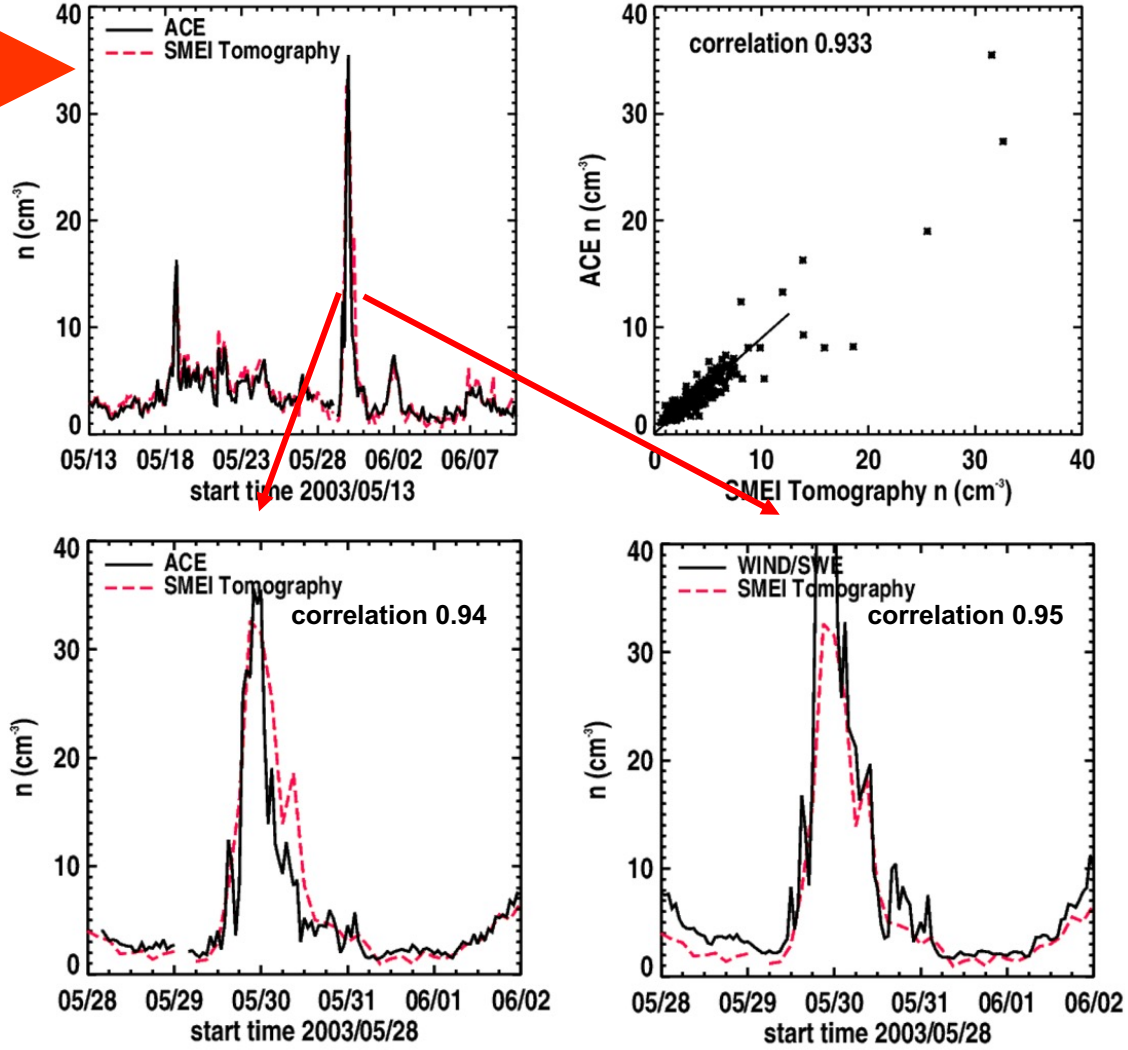
Time-Dependent 3-D Reconstructions of B and pB

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

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



SMEI Analysis



Time-Dependent 3-D Reconstructions of B and pB

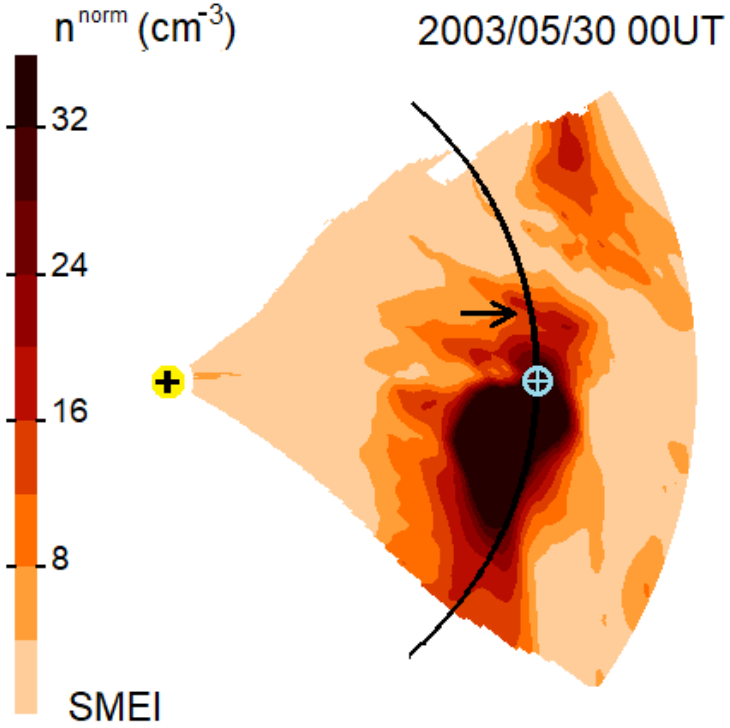
Jackson et al., 2020 doi: 10.3389/fspas.2020.568429

SMEI Analysis

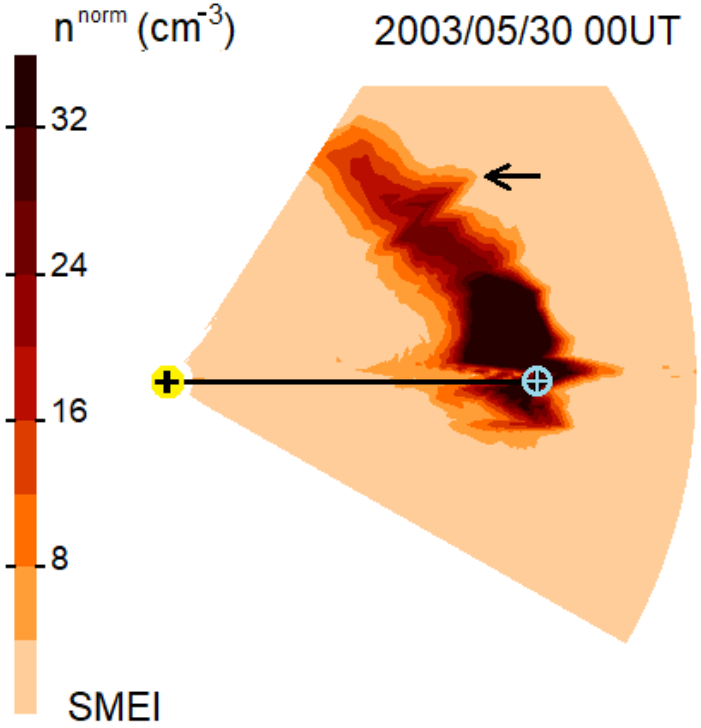
2003 May 27-28 CME events

High Res Analyses show CMEs corrugated and spotty!

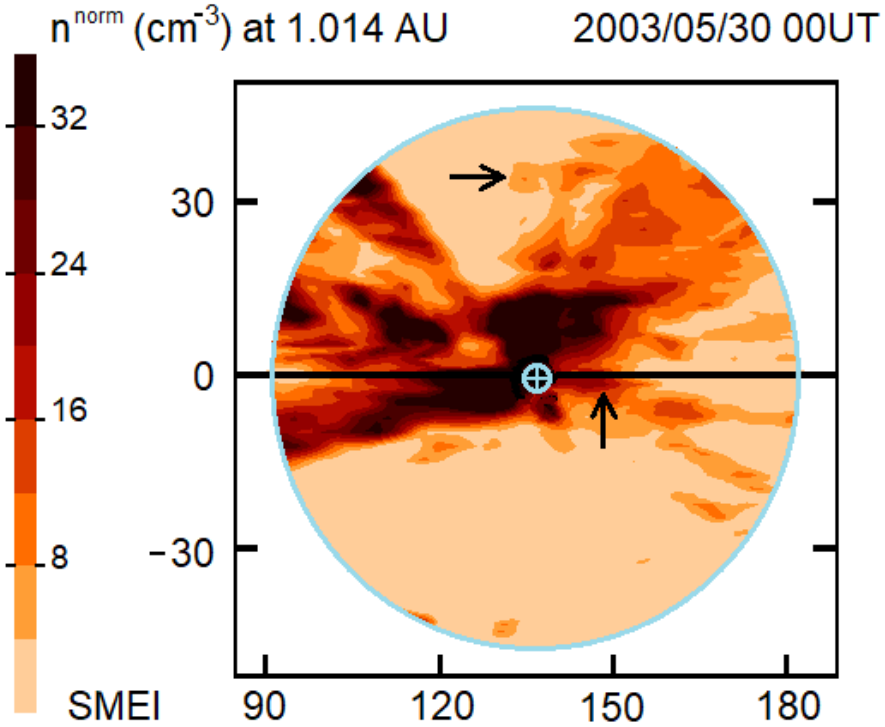
Ecliptic, Earth Meridional, and Synoptic Cuts at 1.5-Hour Cadence Resolution



Ecliptic Cut



Meridional Cut

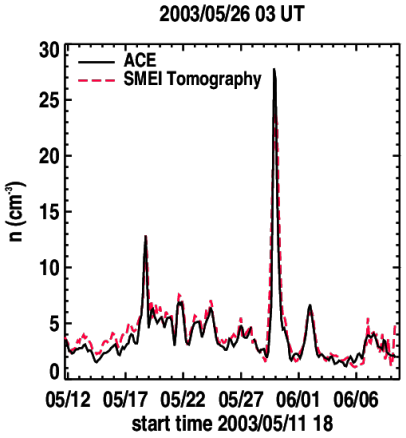


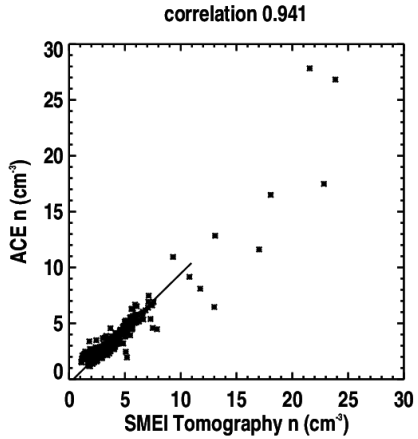
Synoptic Cut

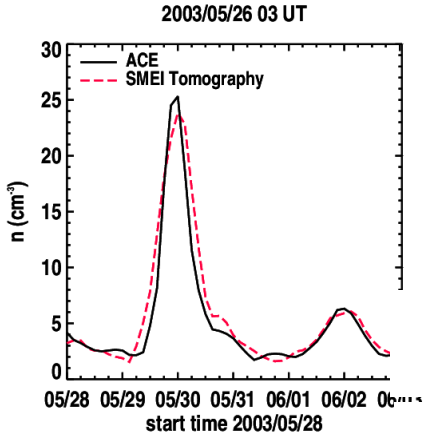
Time-Dependent 3-D Reconstructions of B and pB

Thomson Scattering B & pB Analyses

Time-Dependent 3-D Reconstructions of B and pB



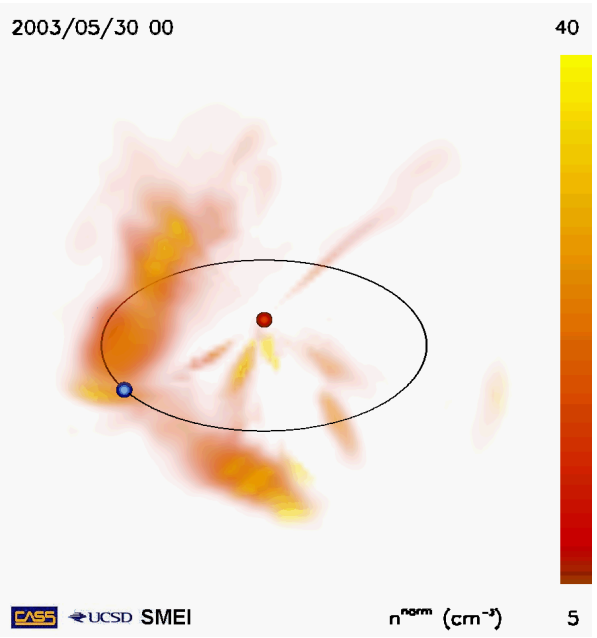


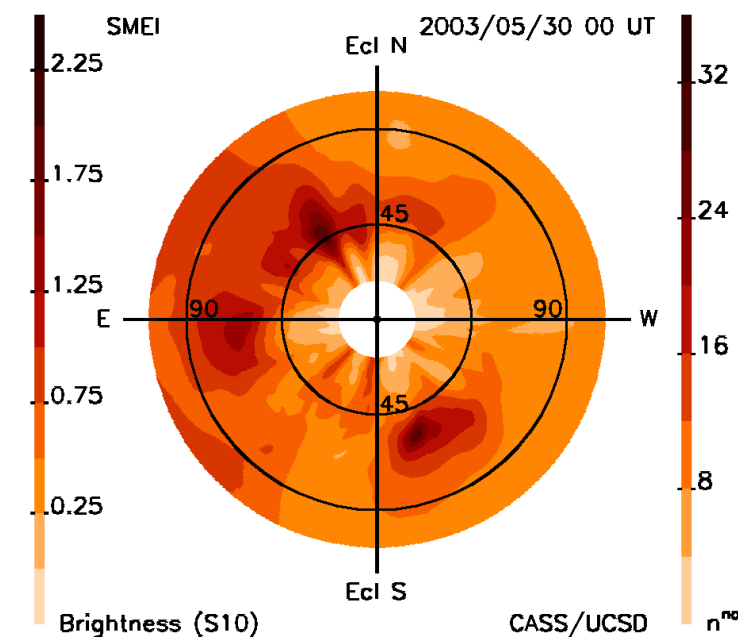


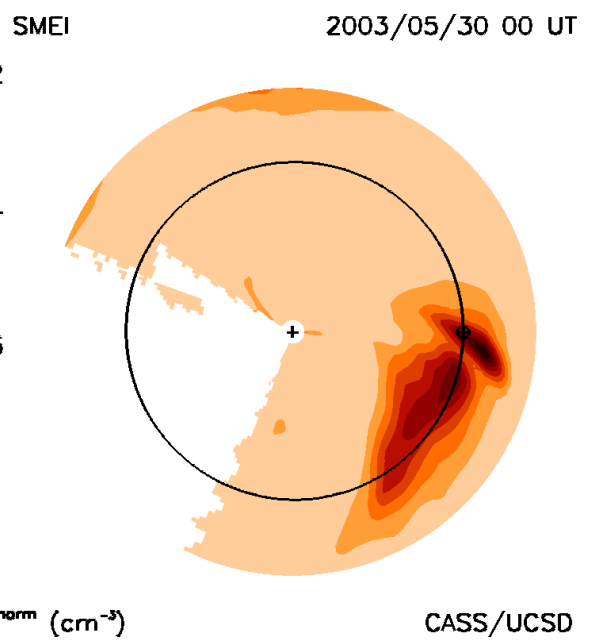
Jackson et al., 2020 doi: 10.3389/fspas.2020.568429

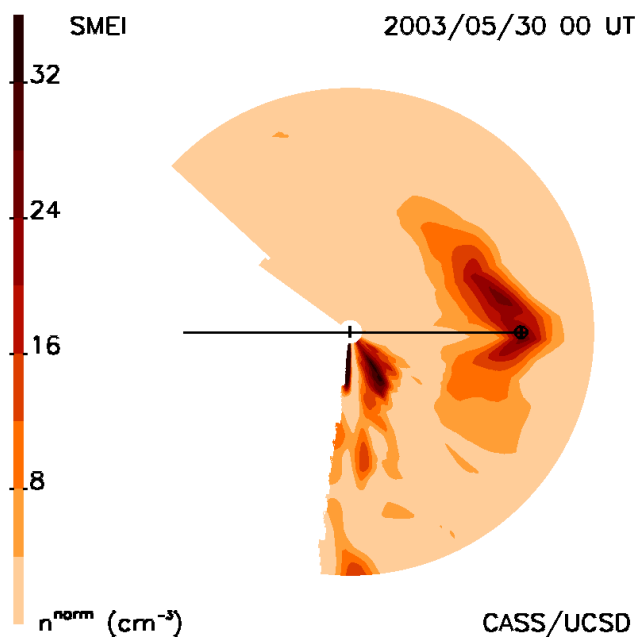
SMEI Regular B Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views

Month-long Time Series **6-days CME**



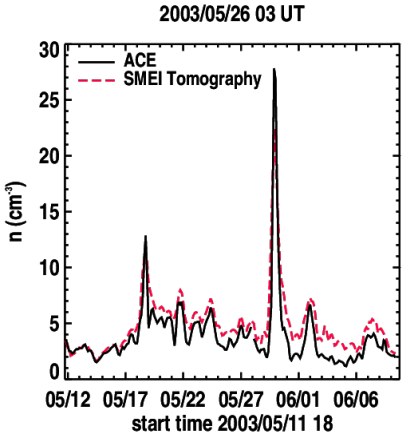


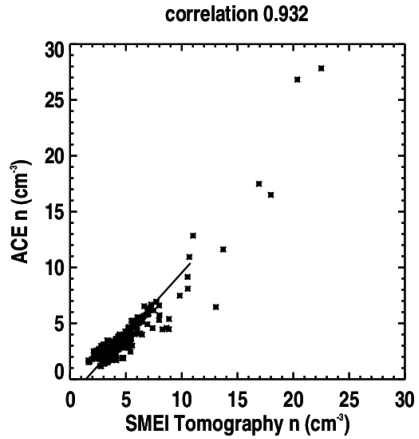


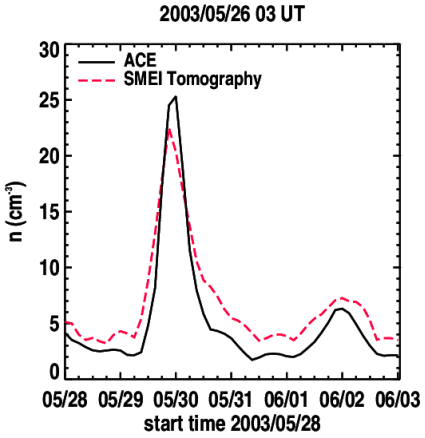


Remote View **Skymap** **Ecliptic Cut** **Meridional**

Time-Dependent 3-D Reconstructions of B and pB



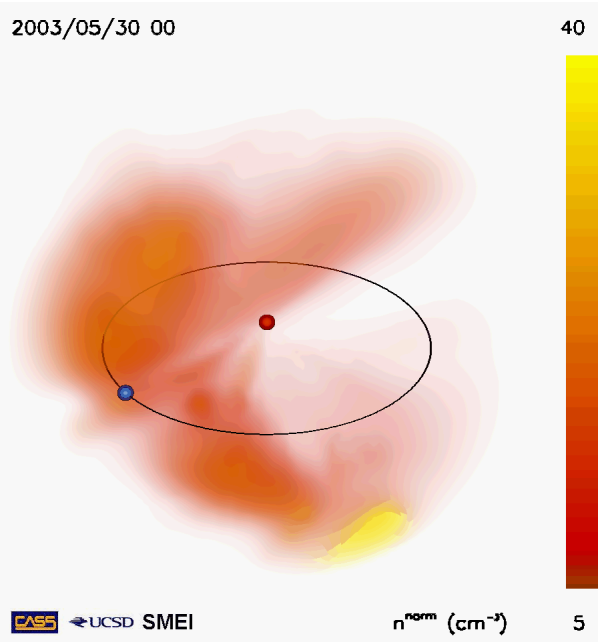


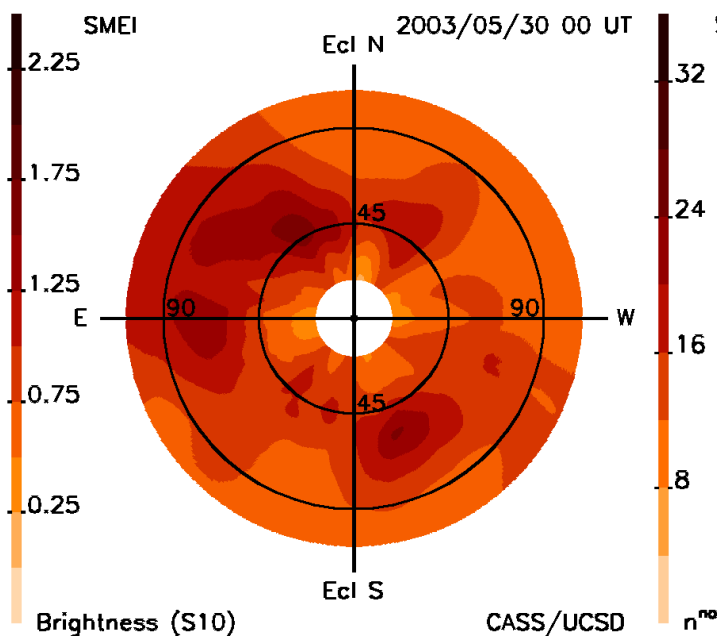


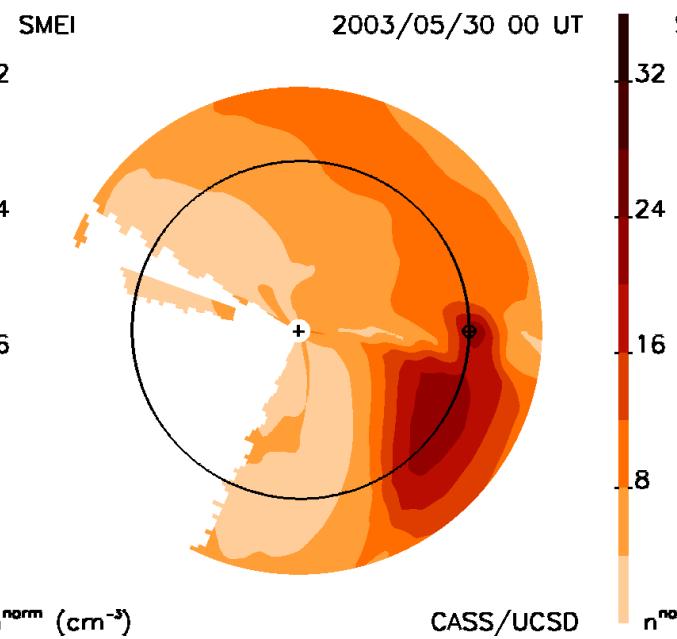
Jackson et al., 2020 doi: 10.3389/fspas.2020.568429

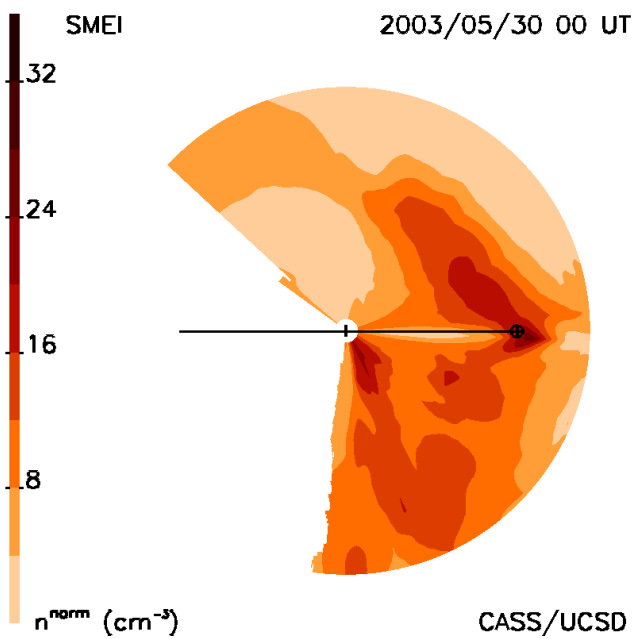
SMEI Pseudo B Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views

Month-long Time Series **6-days CME**









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

Time-Dependent 3-D Reconstructions of B and pB

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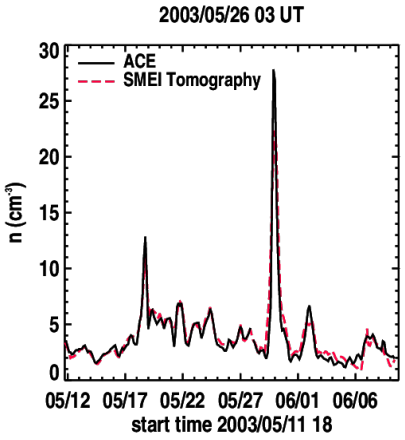

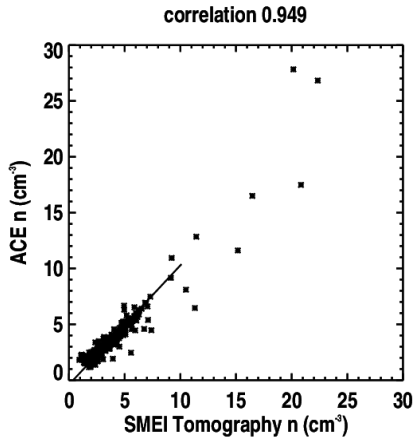

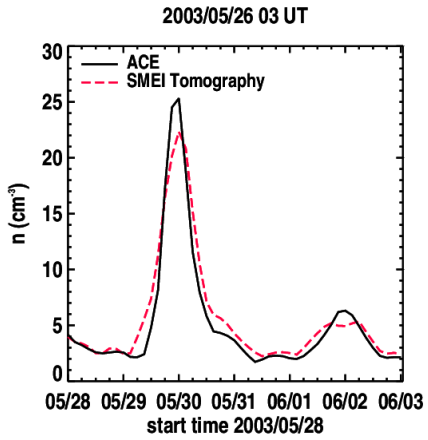

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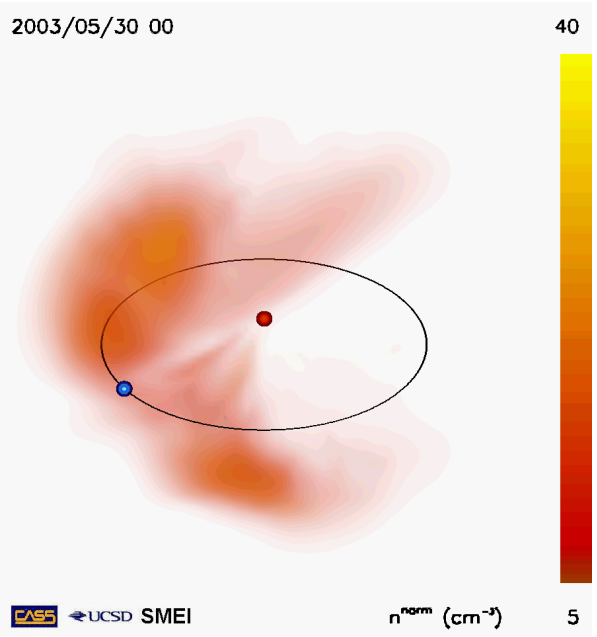
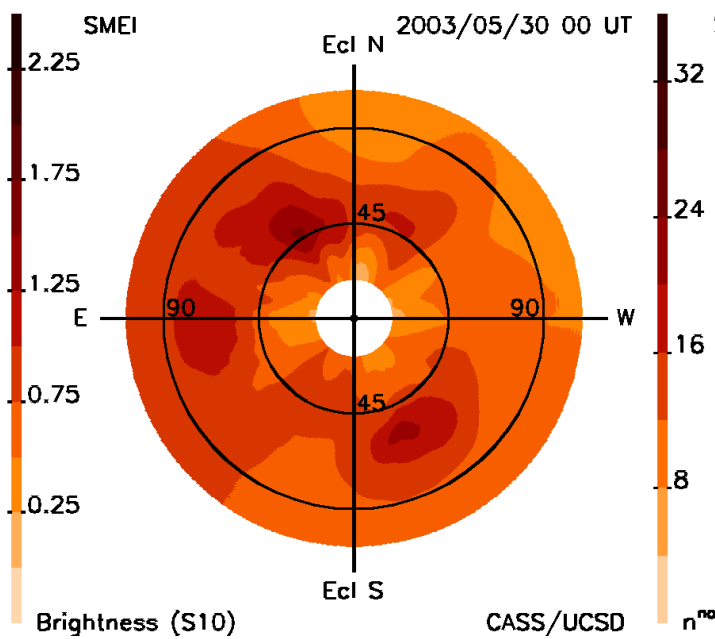
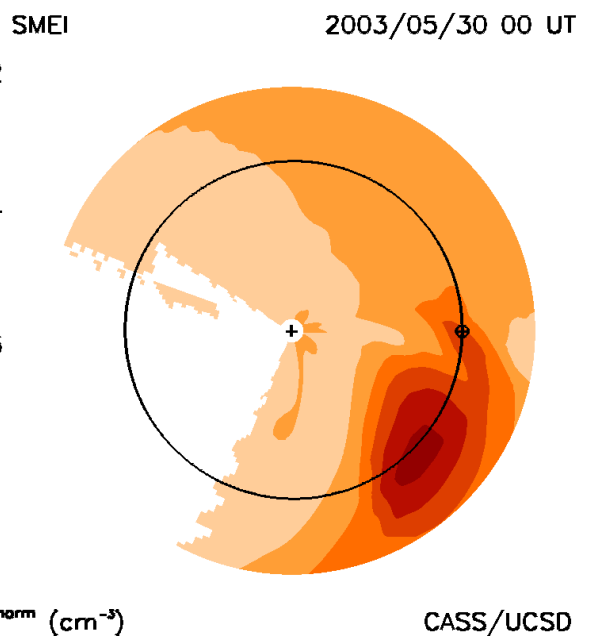
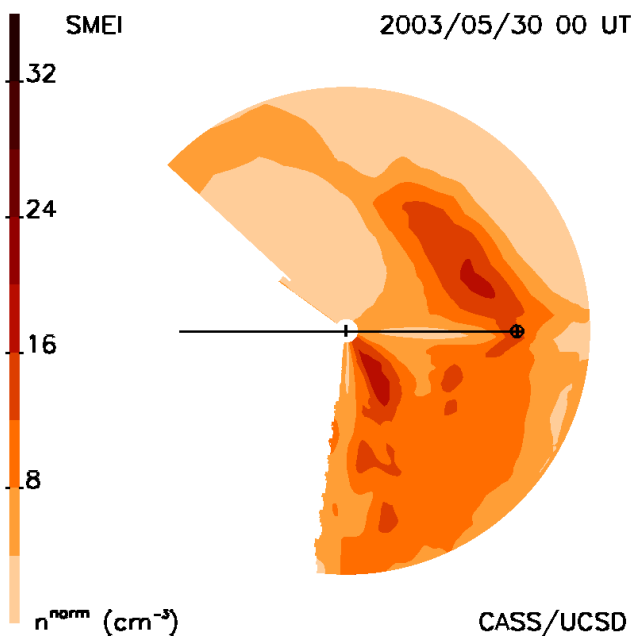








Remote View

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.

Time-Dependent 3-D Reconstructions of B and pB

Future Work That Must Happen

Time-Dependent 3-D Reconstructions of B and pB

Future Work:

Provide pB with these immediate analyses and others at higher resolution and with less smoothing (provide in multi-node)

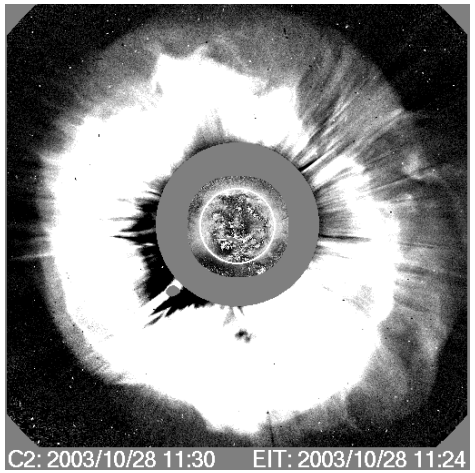
Raster-scan volumes in both B and pB at PUNCH locations with random outage line-of- sight locations

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

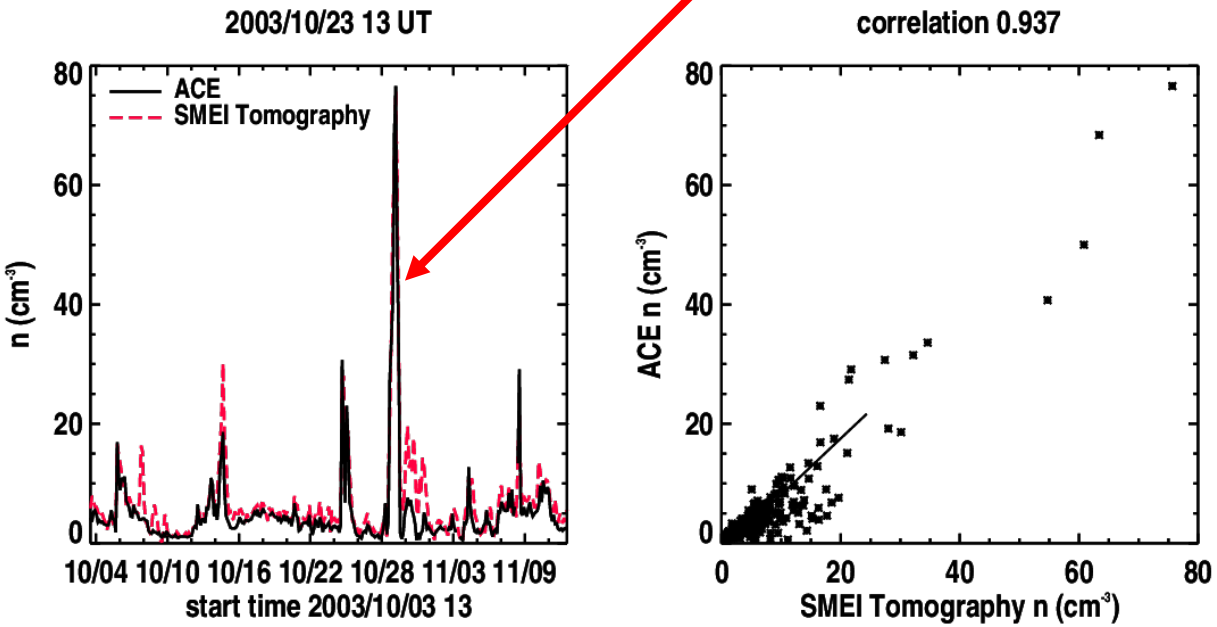
Ecliptic, Earth Meridional, and Synoptic Cuts at 1.5-Hour Cadence Resolution



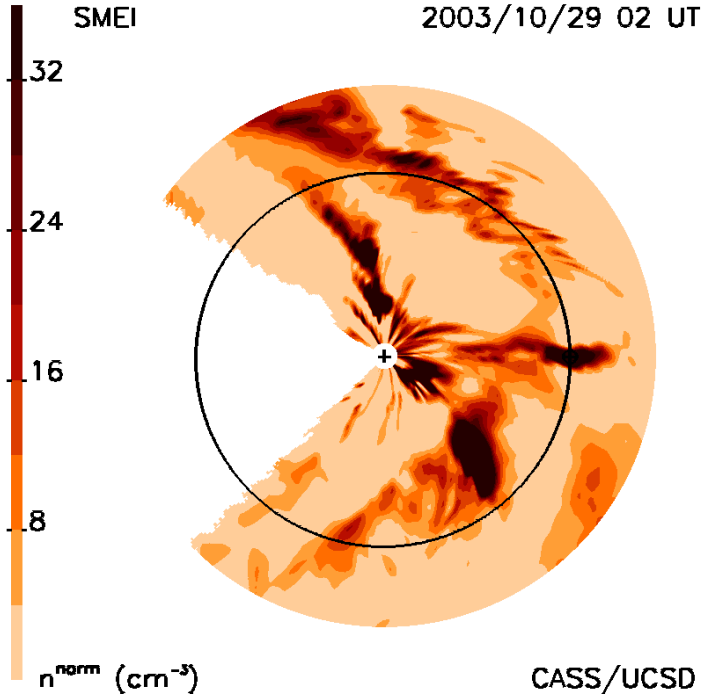
SMEI Analysis

2003 Oct 28 CME event

CME shock sheaths are corrugated and spotty!



One Carrington interval



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

Ecliptic Cut

Time-Dependent 3-D Reconstructions of B and pB

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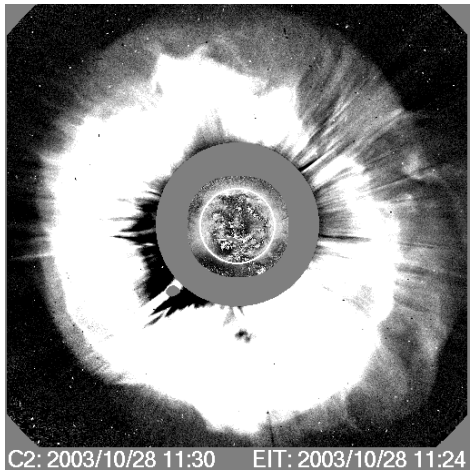

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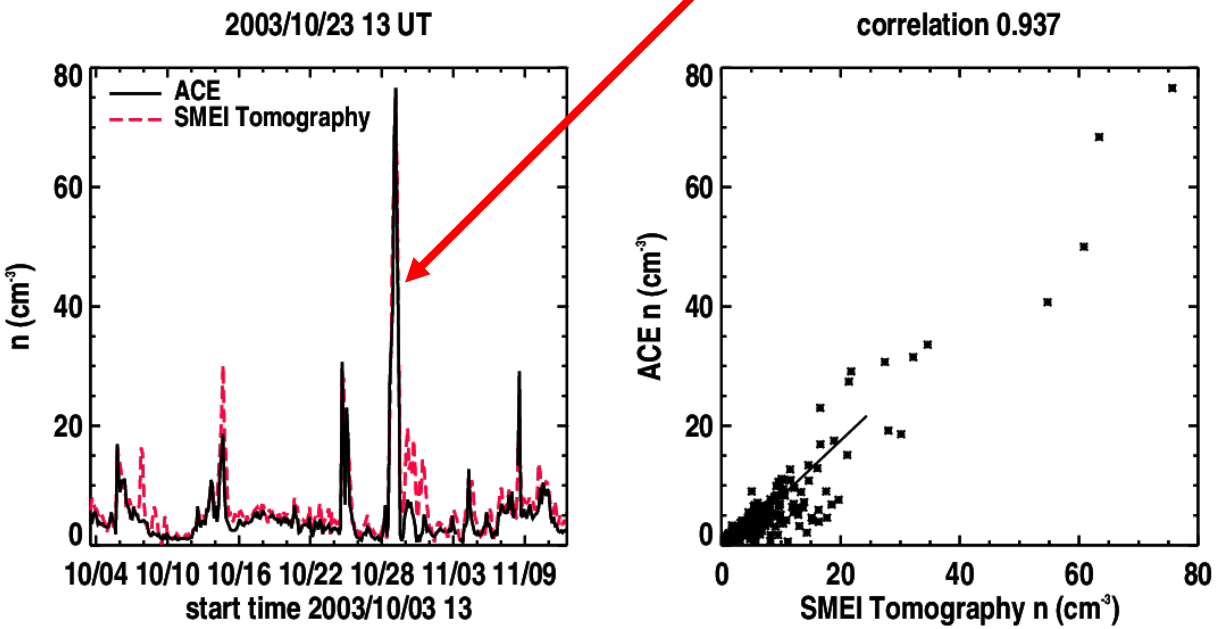

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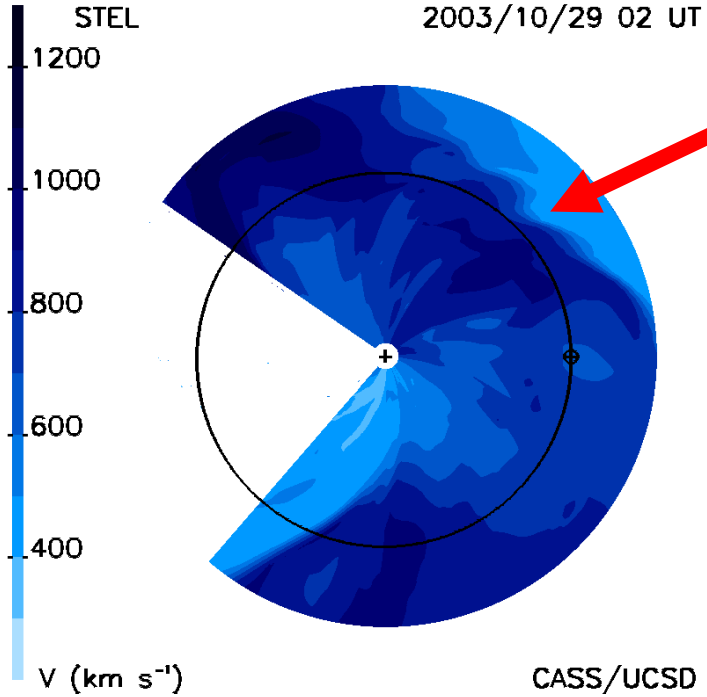

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Low Res IPS V Ecliptic Cut

Time-Dependent 3-D Reconstructions of B and pB

Conclusions:

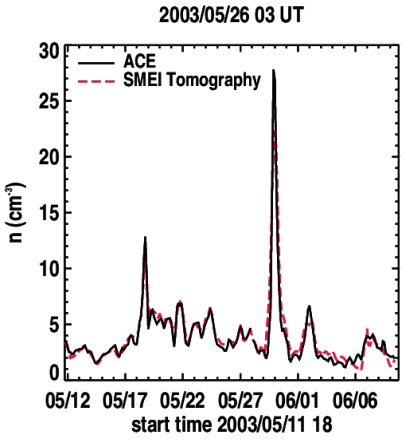
The UCSD time-dependent 3D reconstruction analysis –
Current IPS and SMEI white-light analyses work pretty well

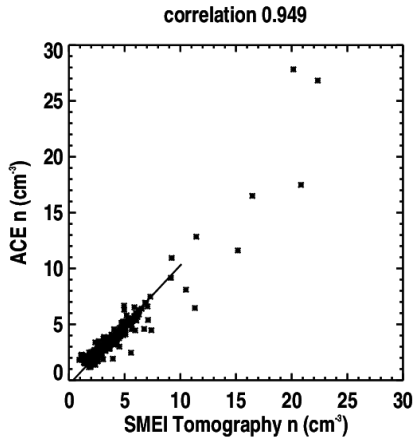
Analysis modification to provide density results from Thomson scattering polarization brightness (pB) now gives results

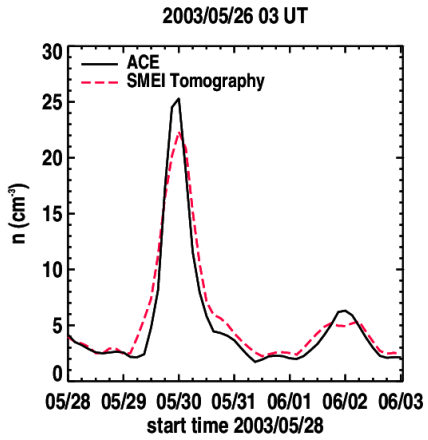
Current tests of the pseudo B and pB analyses give essentially the same results

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







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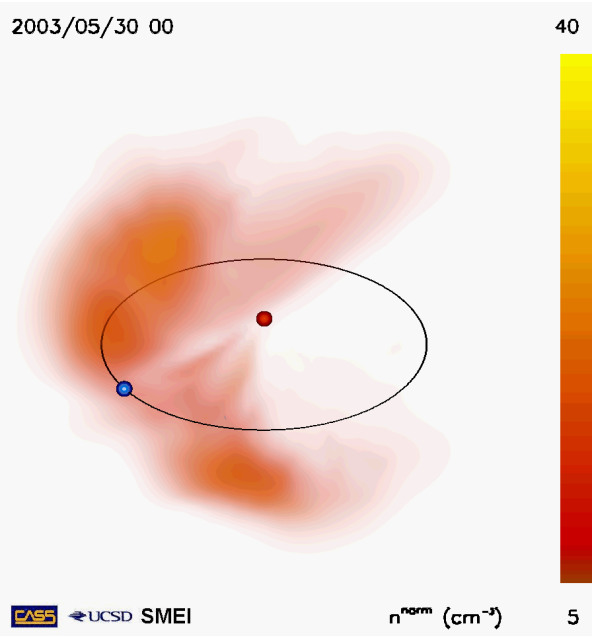
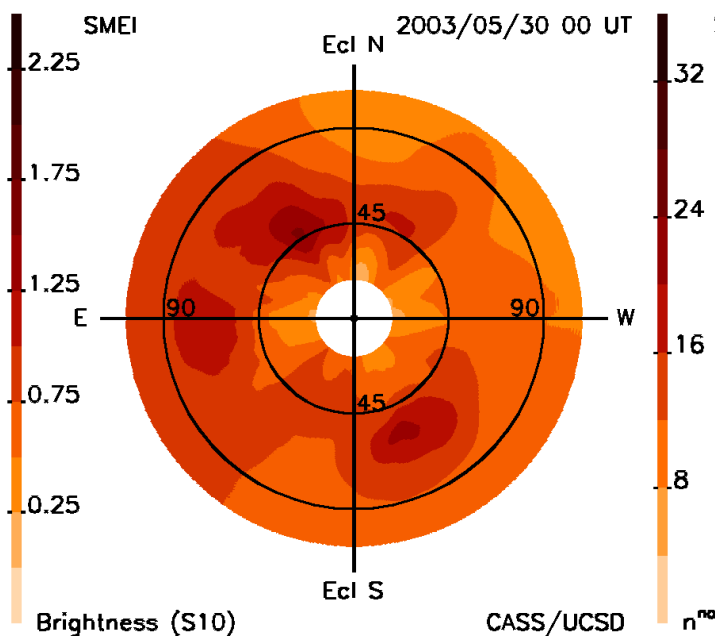
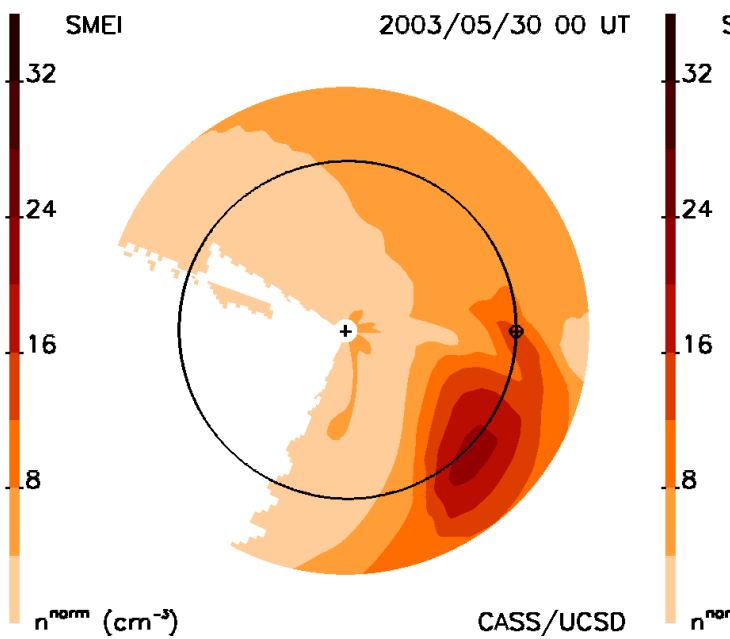
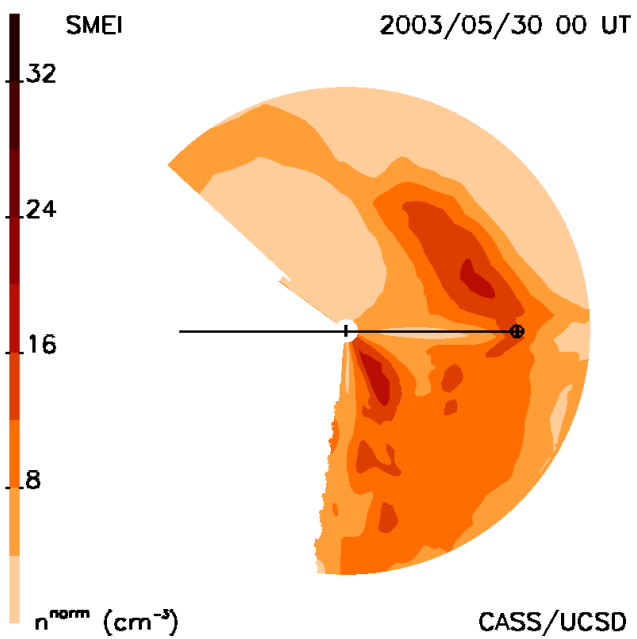
CME









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