UCSD Time-Dependent 3-D High-Resolution Reconstructions Providing Brightness and Polarization Brightness Analyses

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Time-Dependent 3-D High-Resolution Reconstructions

Introduction:

The UCSD time-dependent 3D reconstruction analysis – a Tutorial about how this works

Analysis modification to provide very high resolution Thomson scattering pseudo brightness and polarization brightness

Beneficial enhancements for future 3-D reconstruction analyses

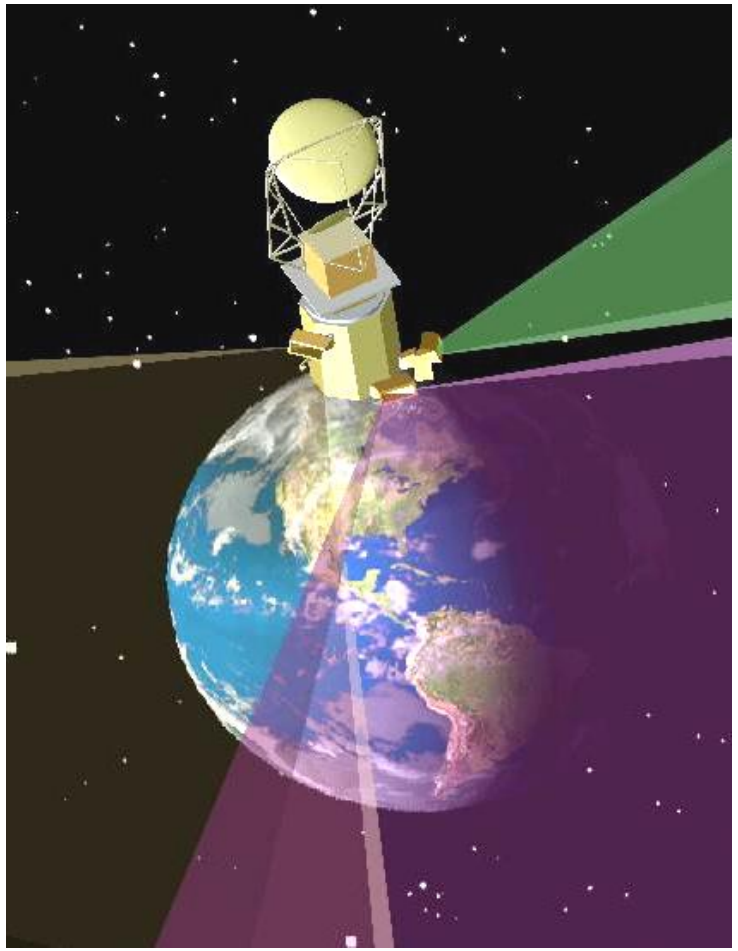
Time-Dependent 3-D High-Resolution Reconstructions

Thomson Scattering
B Analyses

Time-Dependent 3-D High-Resolution Reconstructions

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

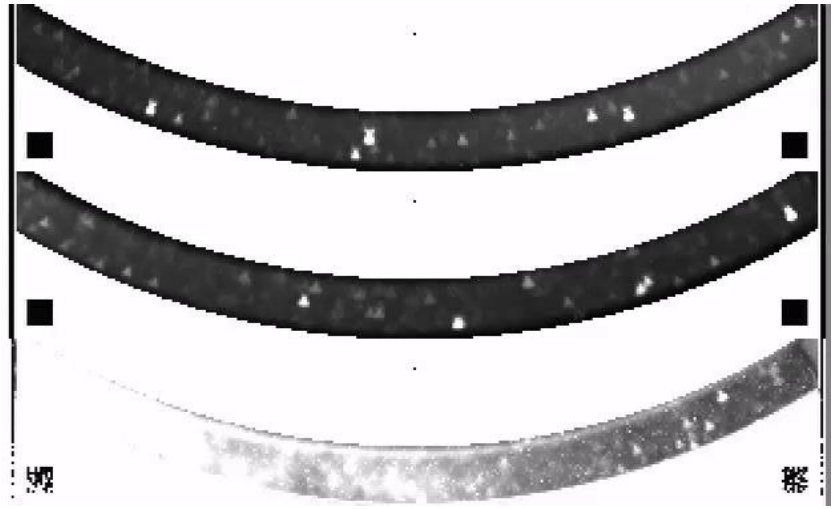
Launch 6 January 2003

← Sun

C1

C2

C3



Sun

↓ 1 gigabyte/day; total ~4 terabytes

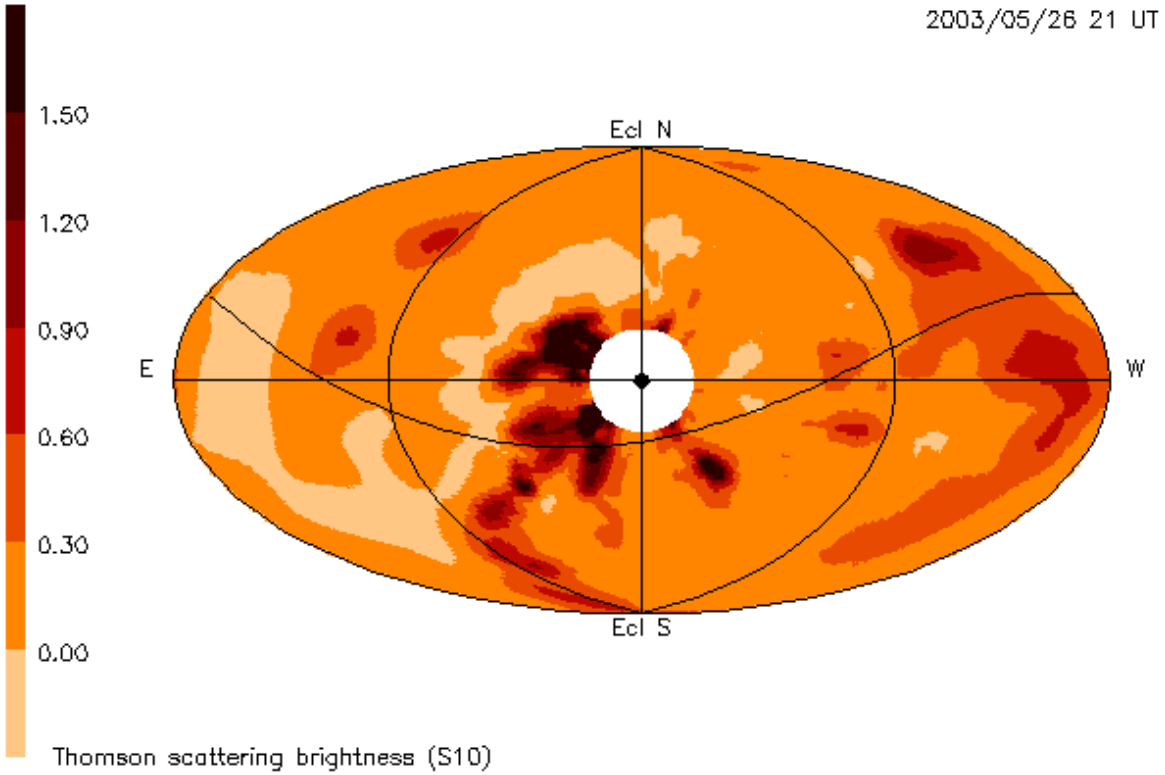
Simultaneous images from the three SMEI cameras.

A joint US Air Force - NASA Project

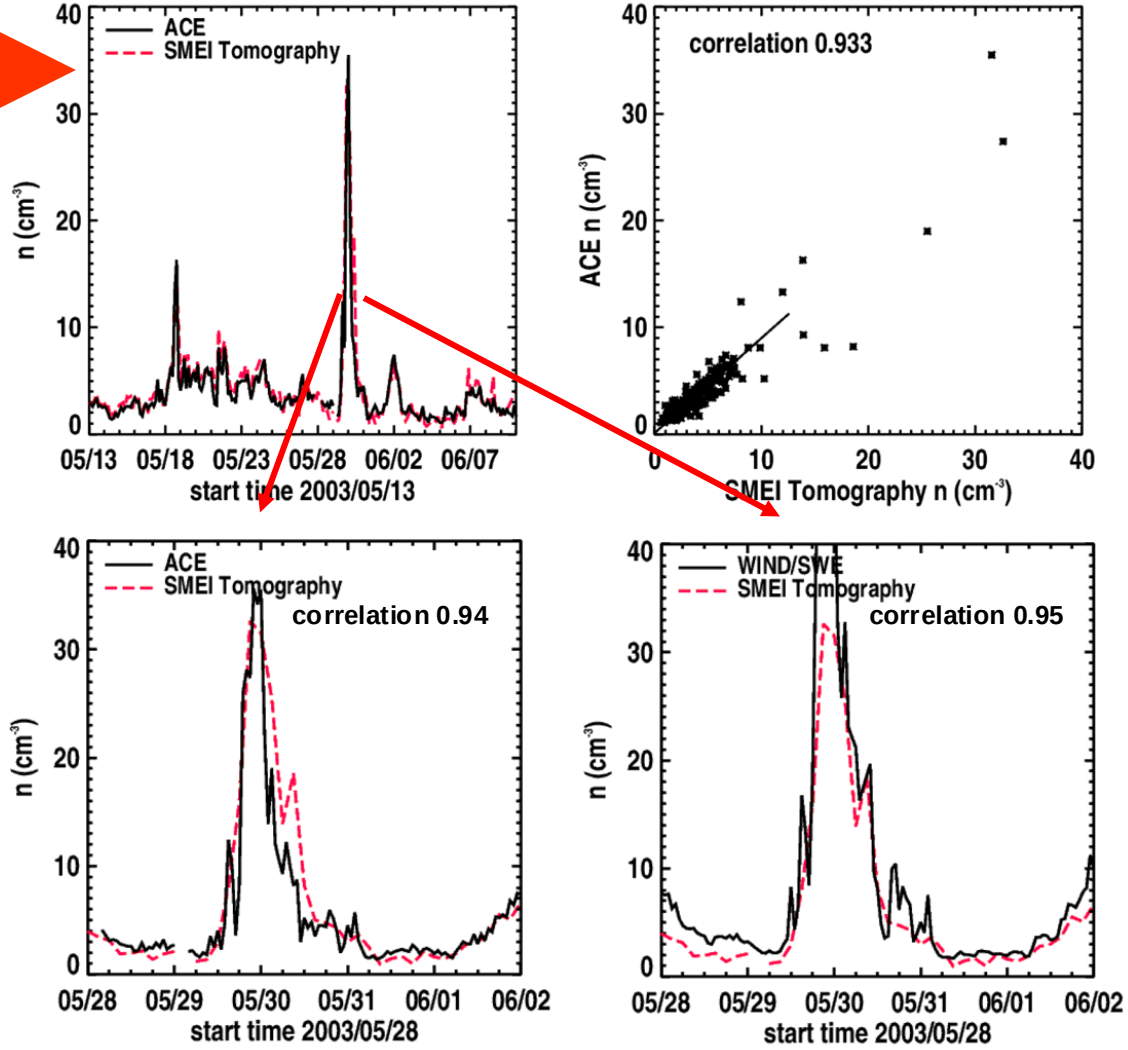
Time-Dependent 3-D High-Resolution Reconstructions

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

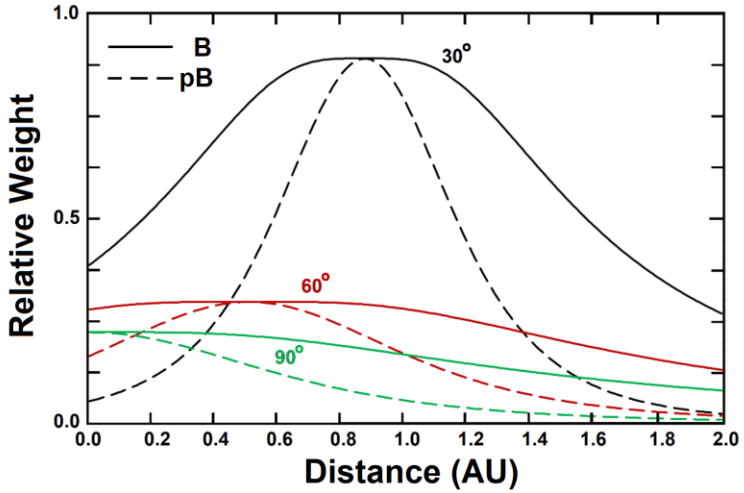


SMEI Analysis

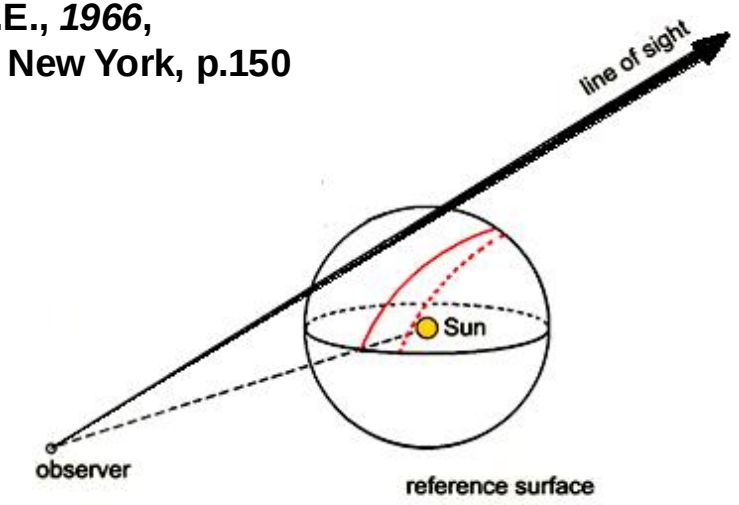


Time-Dependent 3-D High-Resolution Reconstructions

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



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

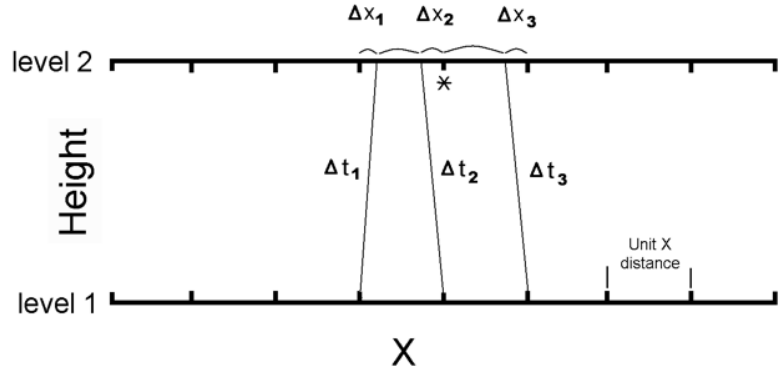


Jackson, B.V., *et al*., 2008, *Adv. in Geosciences* 21, 339

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

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 High-Resolution Reconstructions

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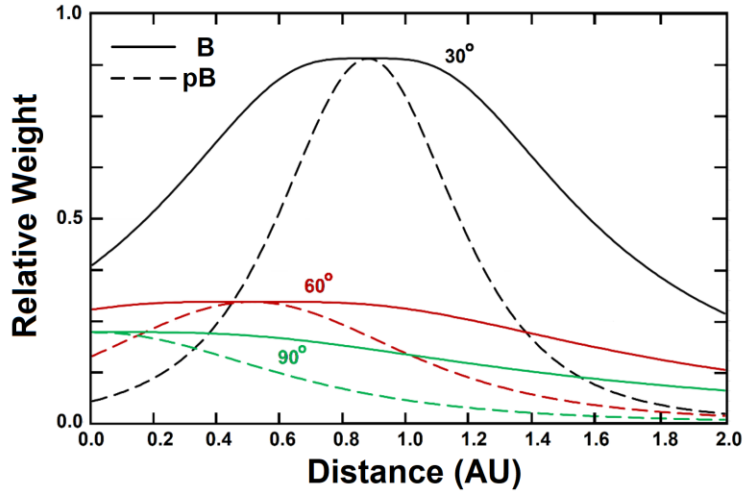

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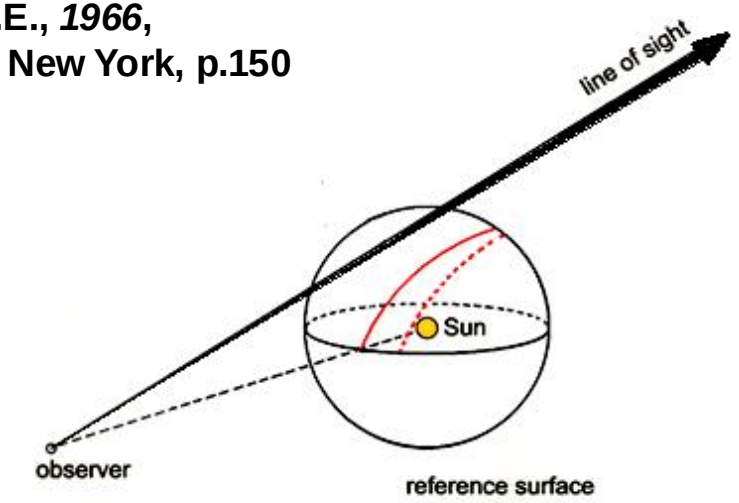

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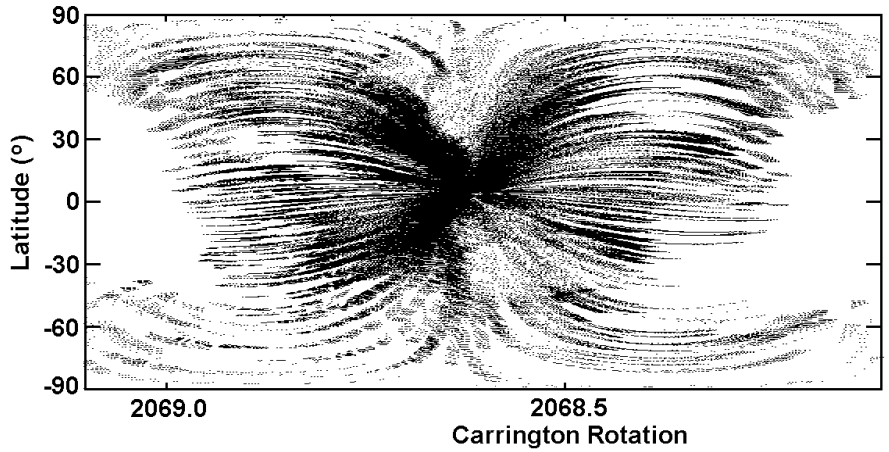
Jackson *et al*., 2020, *Frontiers in Astronomy and Space Sci*., doi: 10.3389/fspas.2020.568429

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 High-Resolution Reconstructions

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

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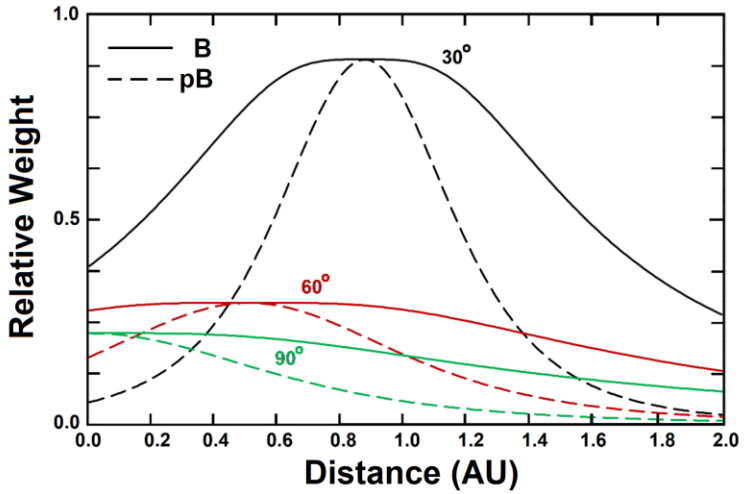

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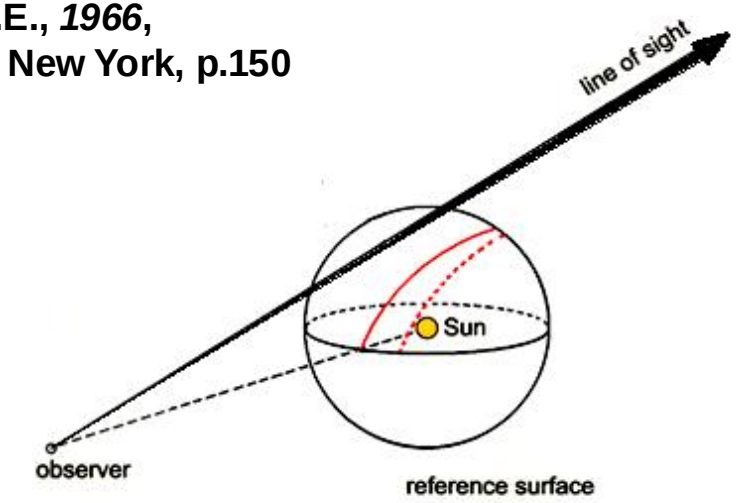


The B or pB values of each electron (left) get folded into each segment's Ne, its distance from the Sun, its distance from the observer, and are summed to provide the image brightness

What does this mean for tracking LoS segments?

1) If many LoS structures are present you must track all

2) To know where any one LoS segment is located you must solve all

3) This implies the background can be as important as the one LOS place of interest you are trying to track

Time-Dependent 3-D High-Resolution Reconstructions

Examples
B and pB Analyses

Time-Dependent 3-D High-Resolution Reconstructions

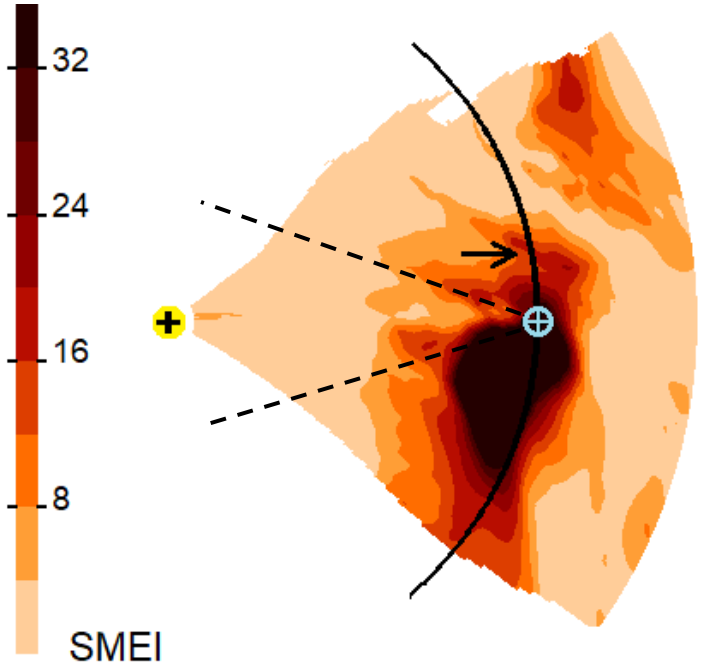
Jackson et al., 2020 doi: 10.3389/fspas.2020.568429

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

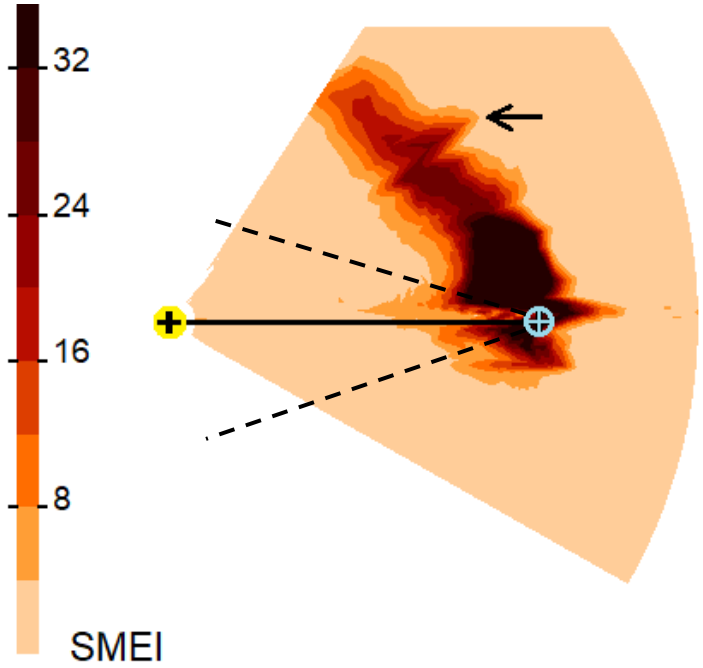
SMEI Analysis

2003 May 27-28 CME events

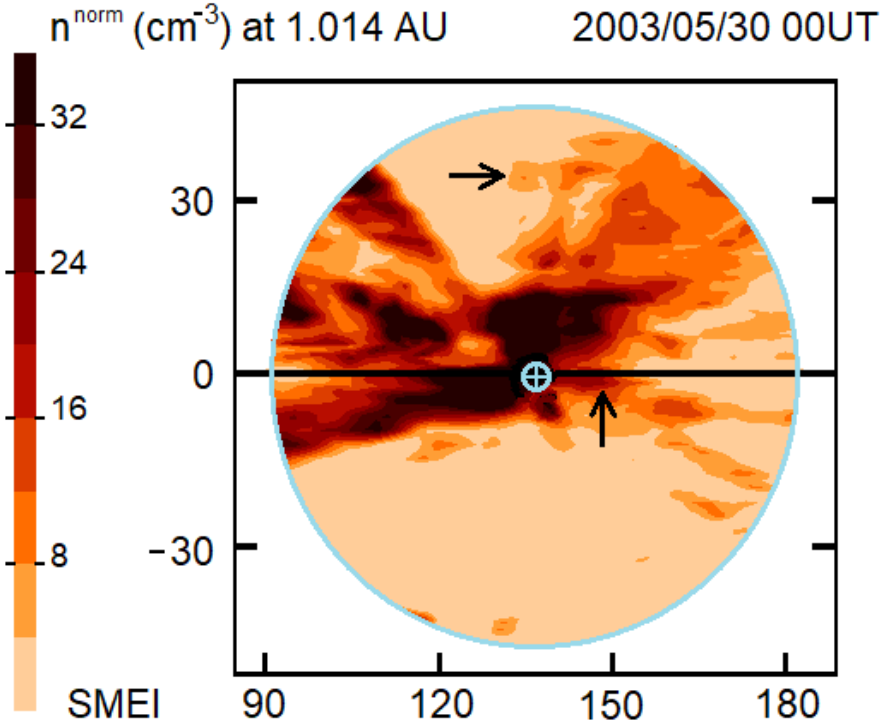
High Res Analyses show CMEs corrugated and spotty!



Ecliptic Cut



Meridional Cut



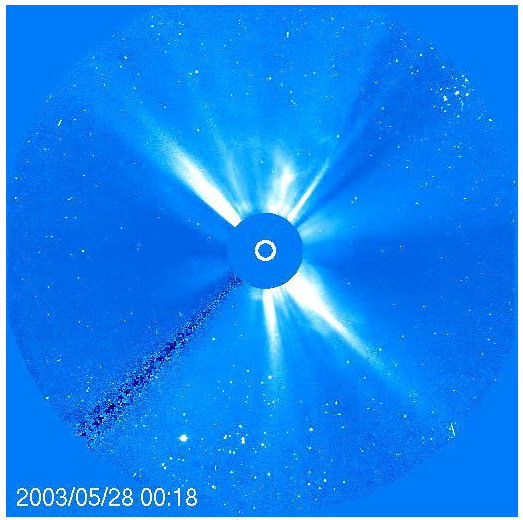
Synoptic Cut

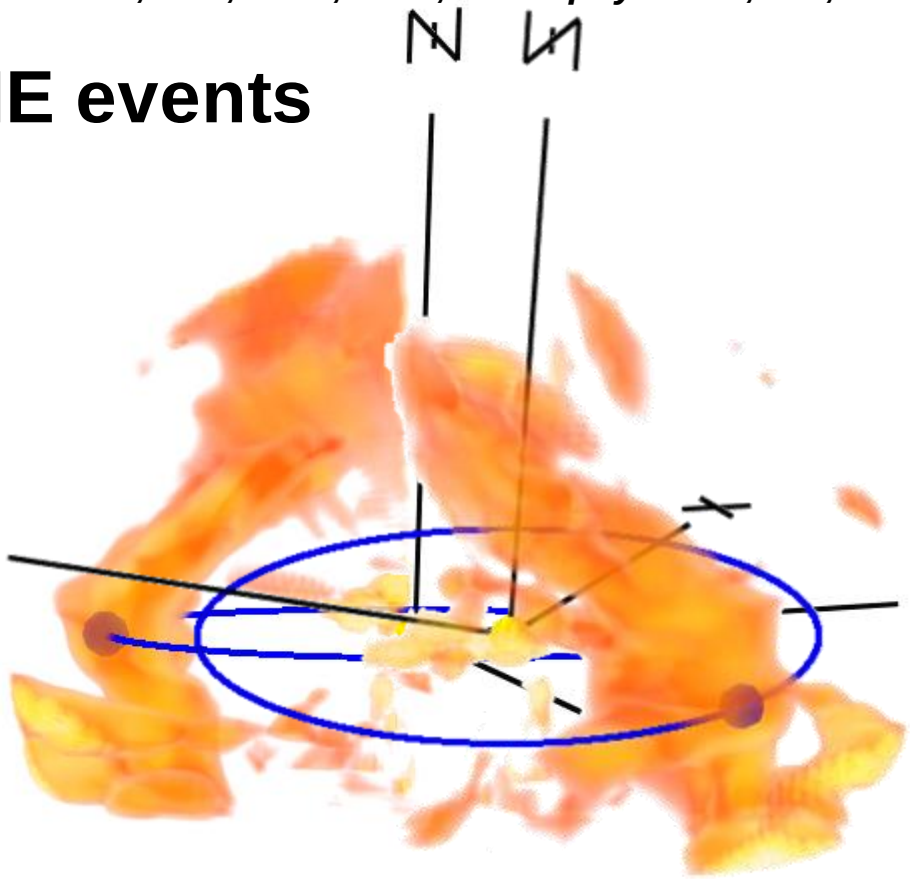
Time-Dependent 3-D High-Resolution Reconstructions

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.

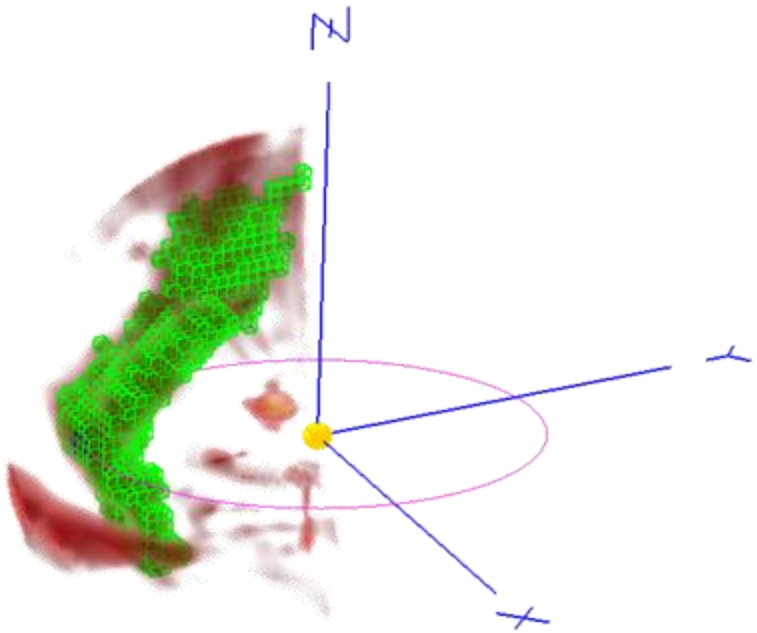




SMEI density (remote observer view) of the 28 May 2003 halo CME

SMEI Analysis

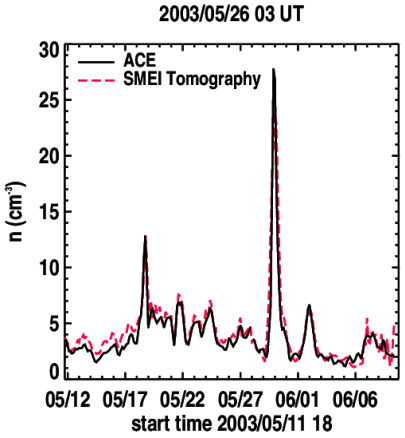
CME mass

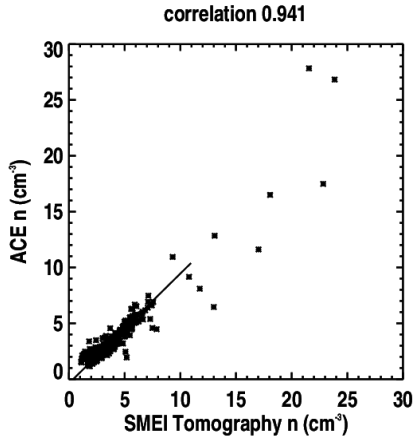


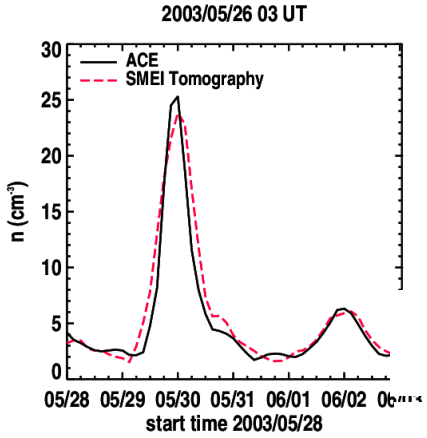
Time-Dependent 3-D High-Resolution Reconstructions

Thomson Scattering
B & pB Analyses

Time-Dependent 3-D High-Resolution Reconstructions







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

SMEI Low Res B Analysis

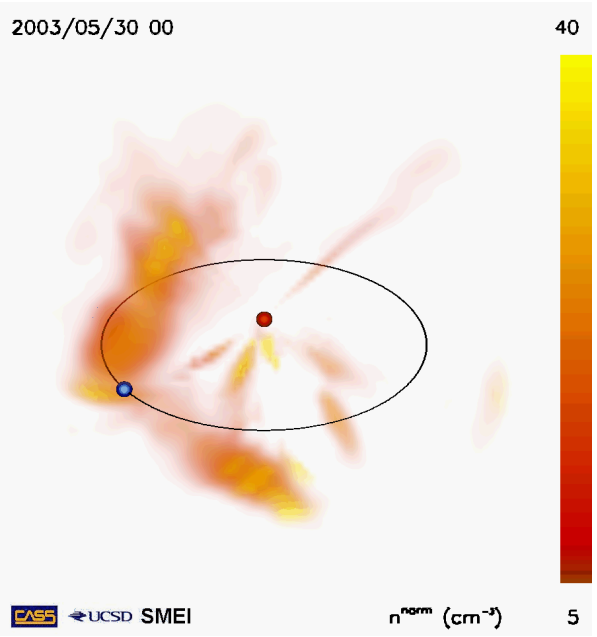
2003 May 27-28 CME events

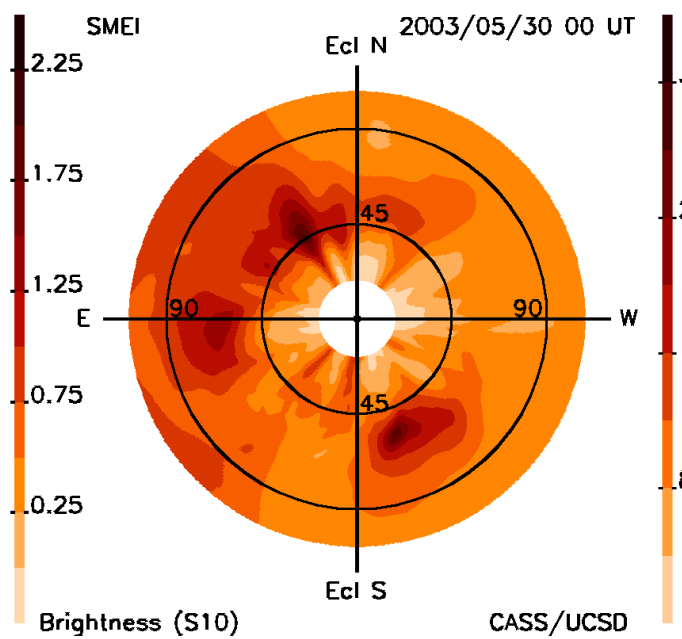
12-Hour 3-D Reconstructions

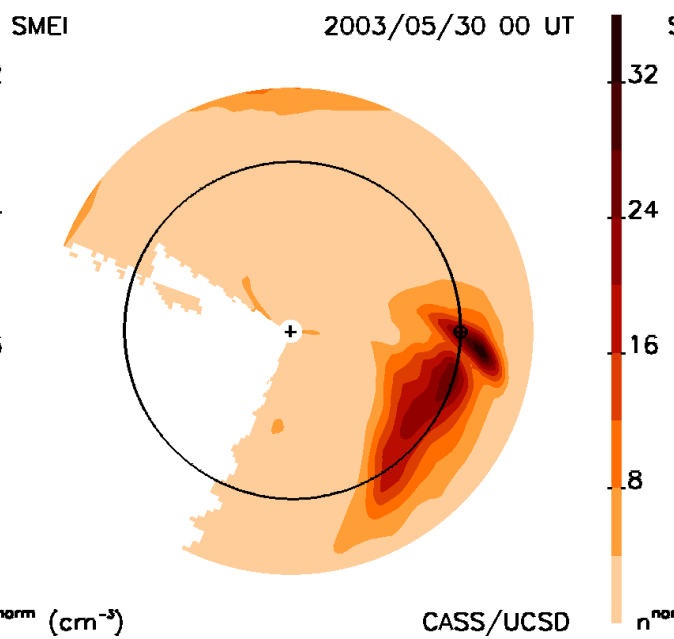
Sample CME Views

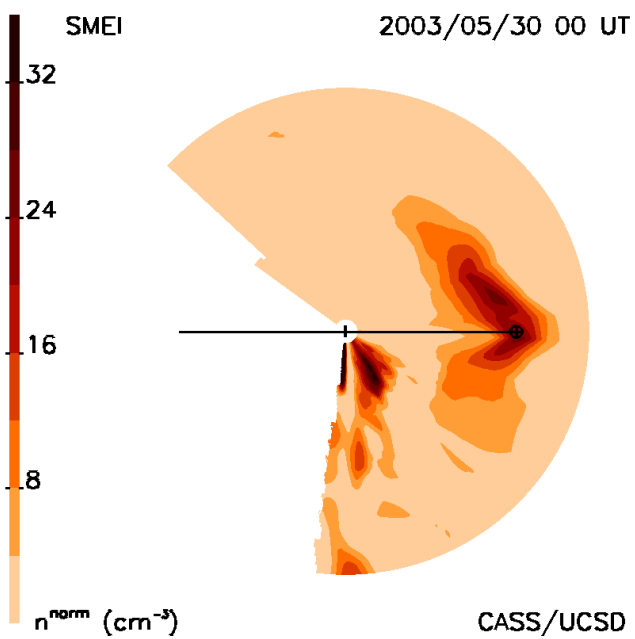
Month-long Time Series

6-days CME









Remote View

Skymap

Ecliptic Cut

Meridional

Time-Dependent 3-D High-Resolution Reconstructions

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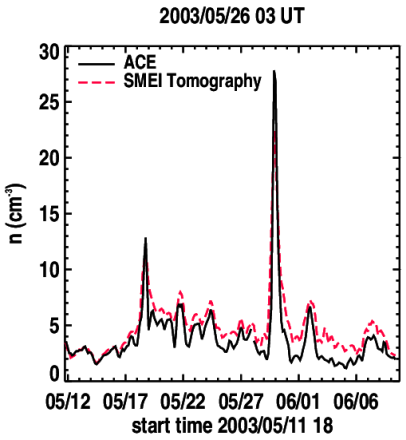
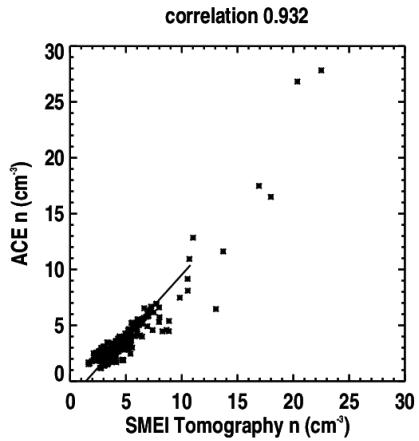
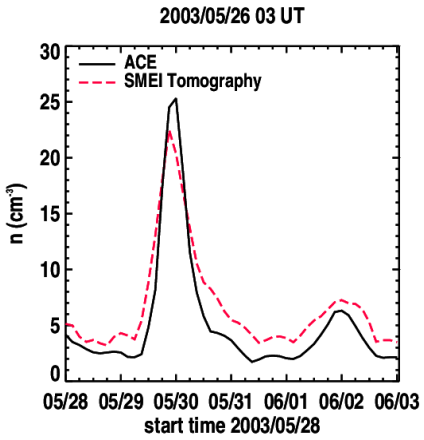
SMEI LR Pseudo B Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views

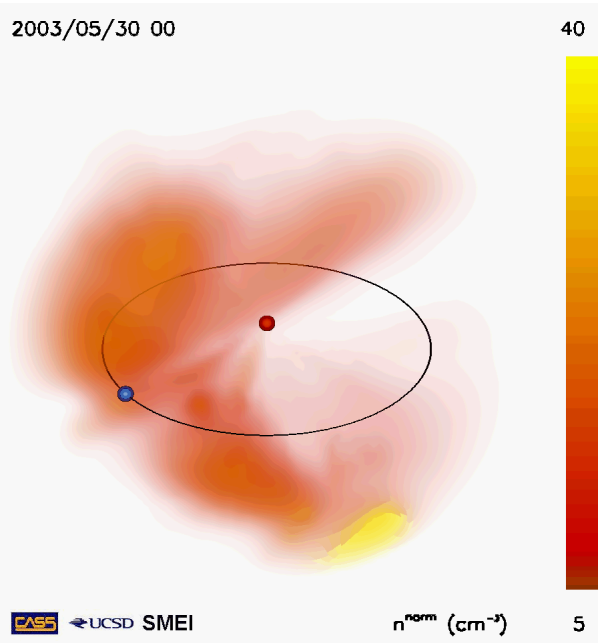


Month-long Time Series

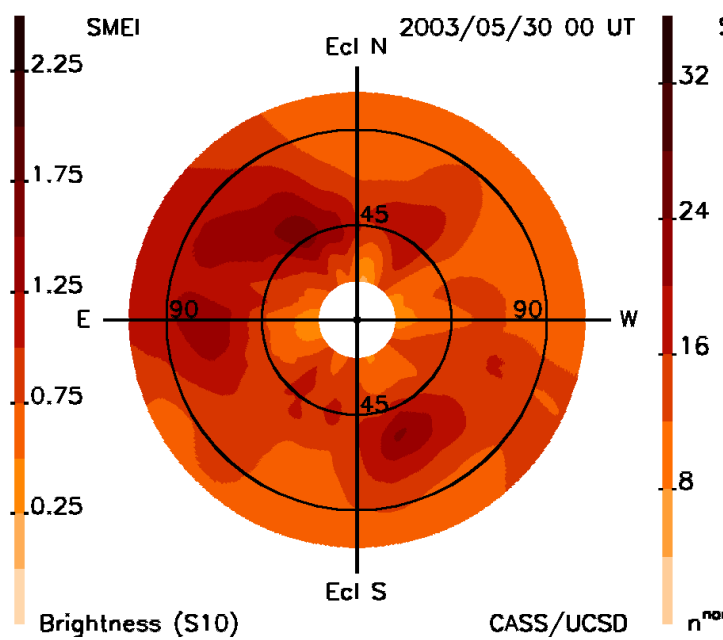




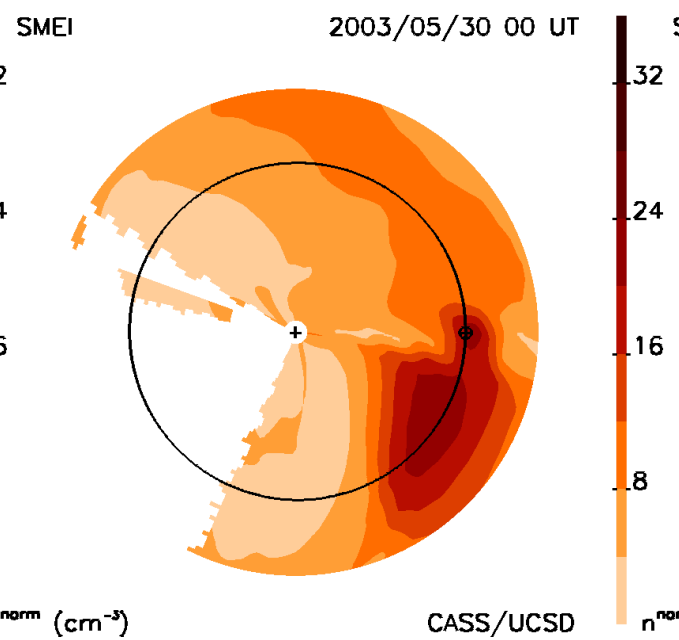
6-days CME



Remote View



Skymap



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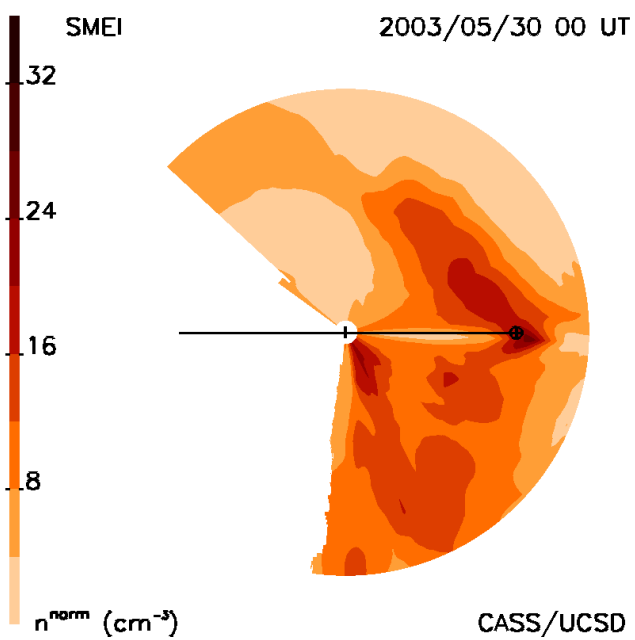

Meridional

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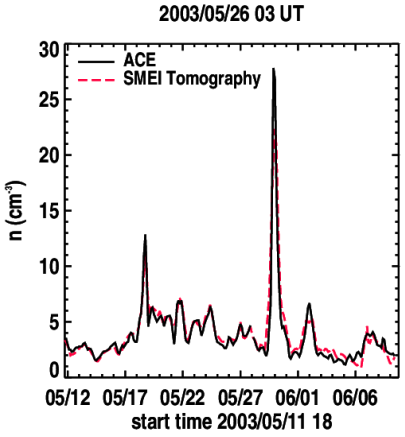
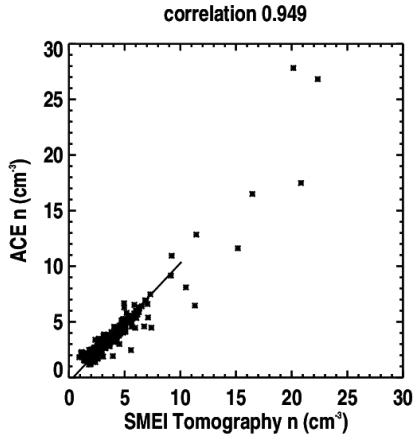
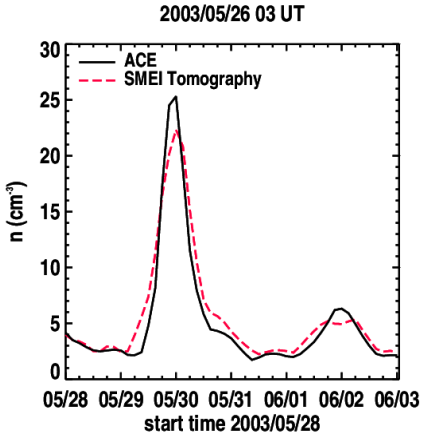
SMEI LR Pseudo pB Analysis
2003 May 27-28 CME events
12-Hour 3-D Reconstructions
Sample CME Views

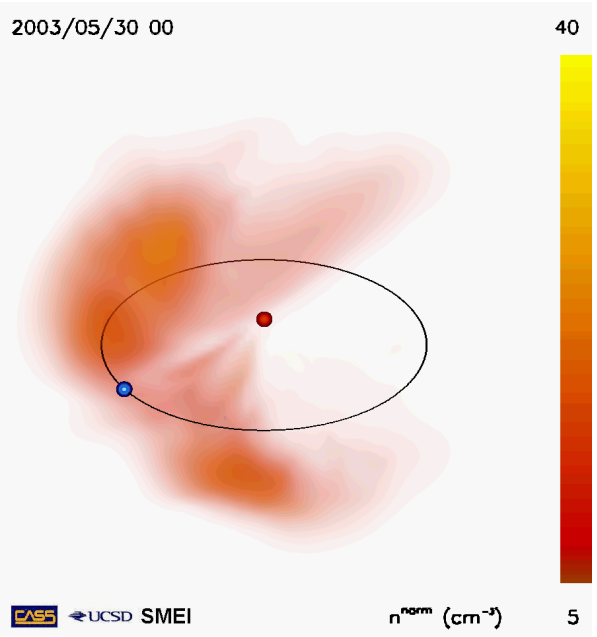


Month-long Time Series

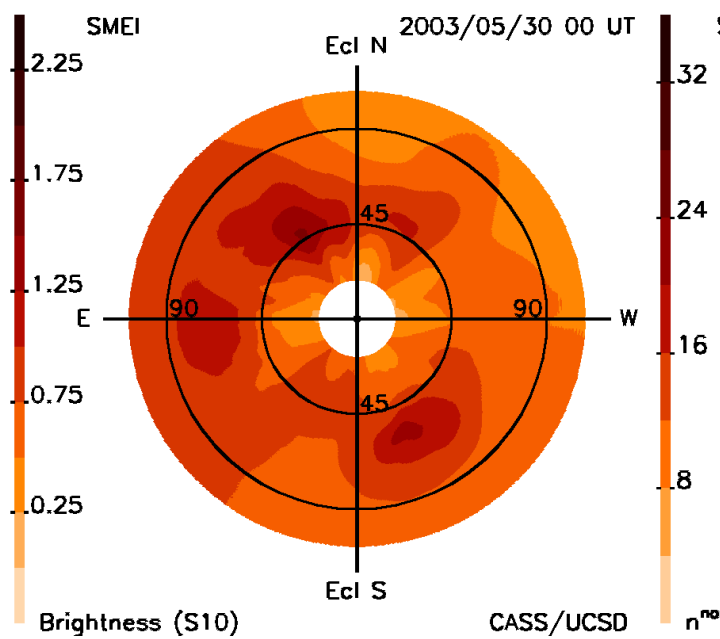




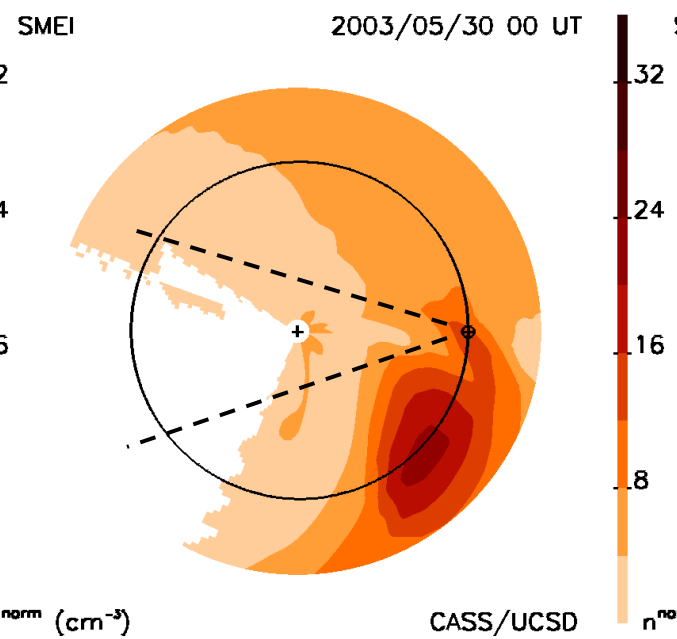
6-days CME



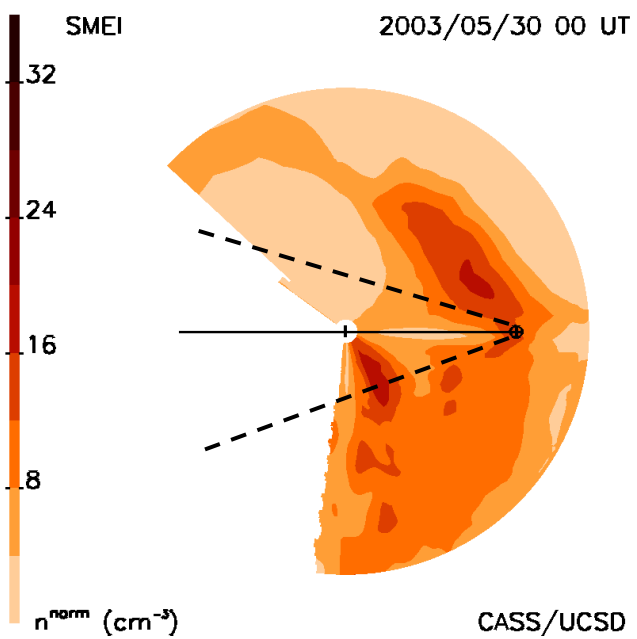
Remote View



Skymap



Ecliptic Cut



Meridional

Time-Dependent 3-D High-Resolution Reconstructions

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 High-Resolution Reconstructions

Higher Resolution and Closer to the Sun PUNCH practice

Time-Dependent 3-D High-Resolution Reconstructions

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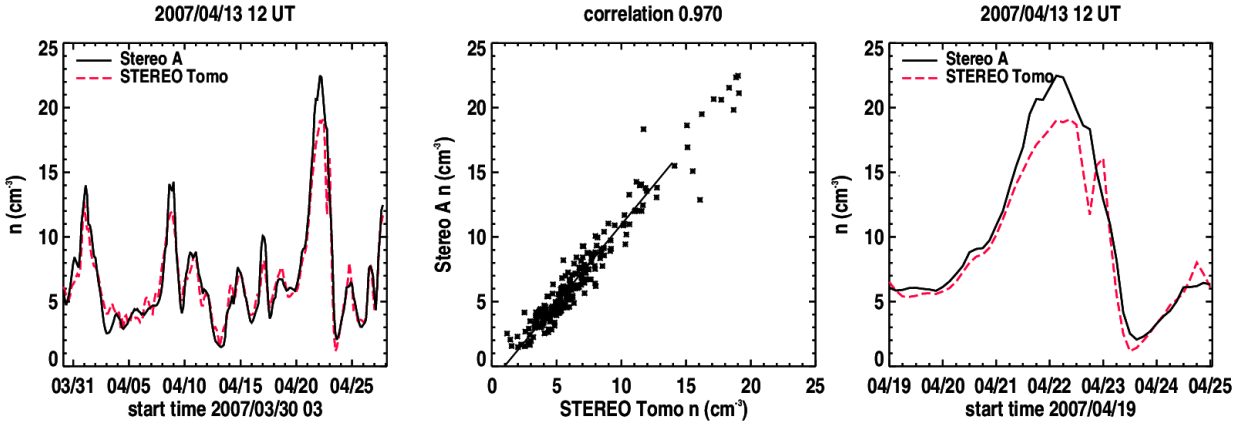


Month-long Time Series

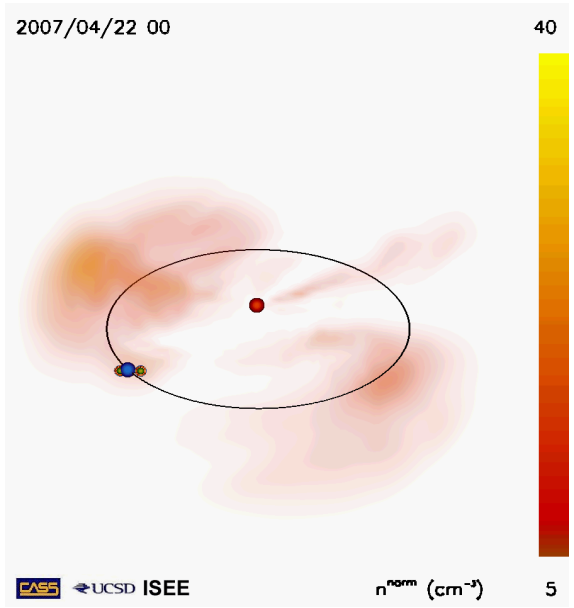
6-days CME

STEREO A&B HI 1 Low Res B

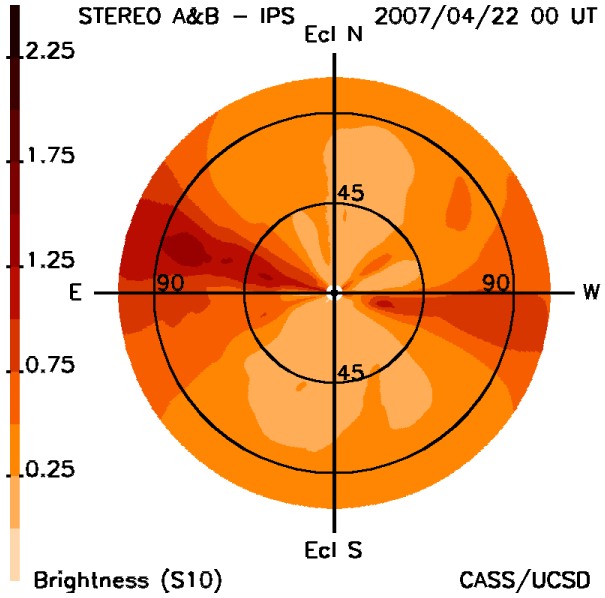
2007 March 31- April 28 events

12-Hour 3-D Reconstructions

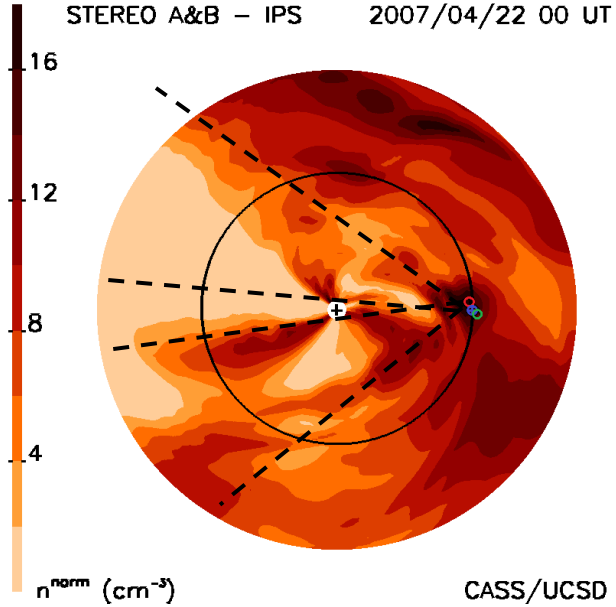
Sample Structure Views



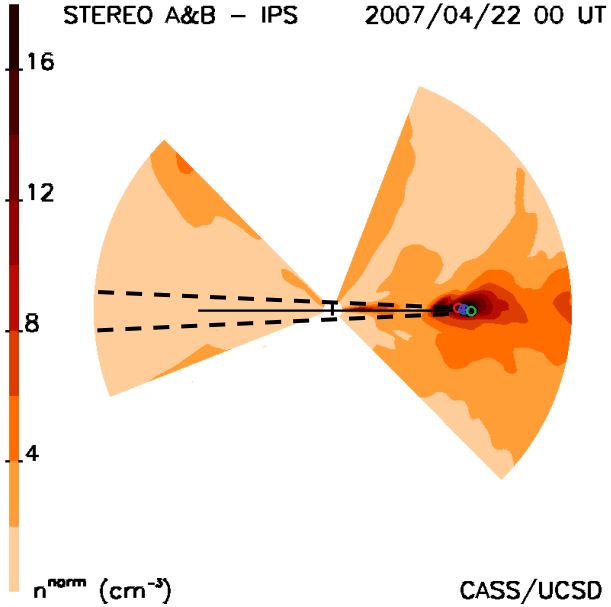
Remote View



Skymap



Ecliptic Cut



Meridional

Time-Dependent 3-D High-Resolution Reconstructions

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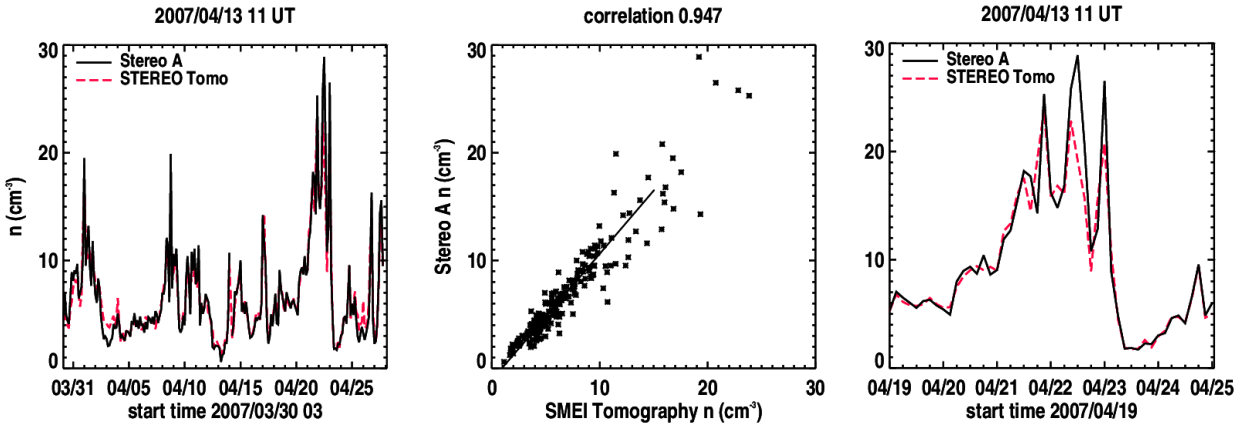


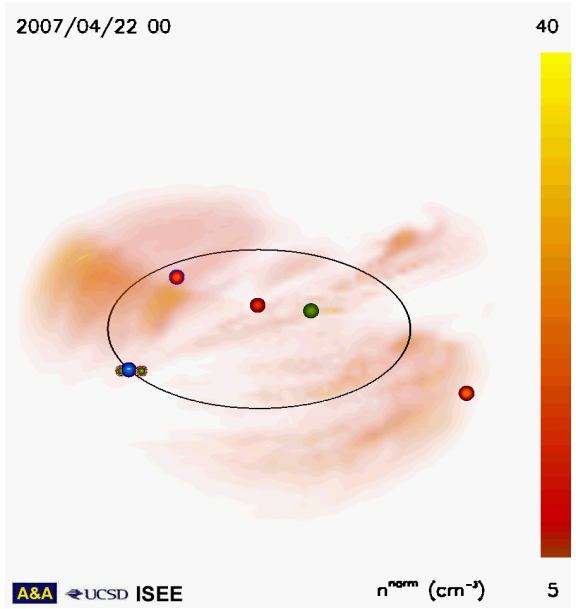
Month-long Time Series **6-days CME**

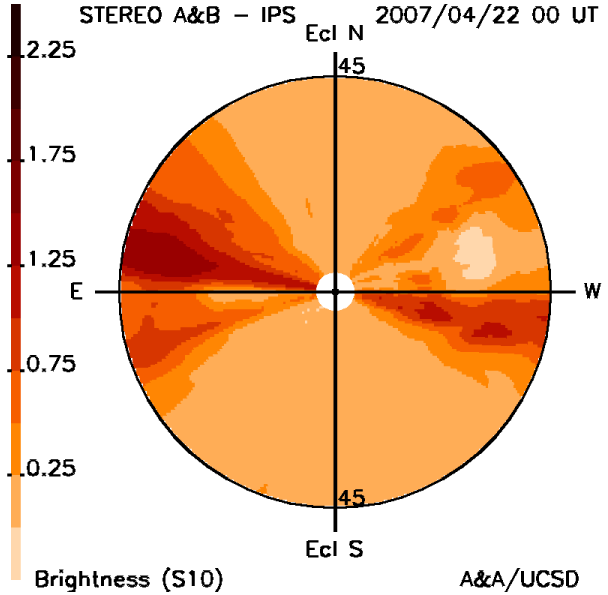
STEREO A&B HI 1 High Res B

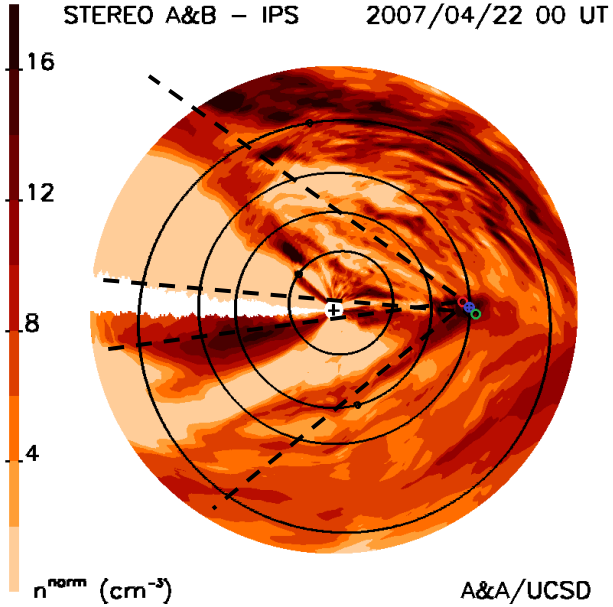
2007 March 31- April 28 events

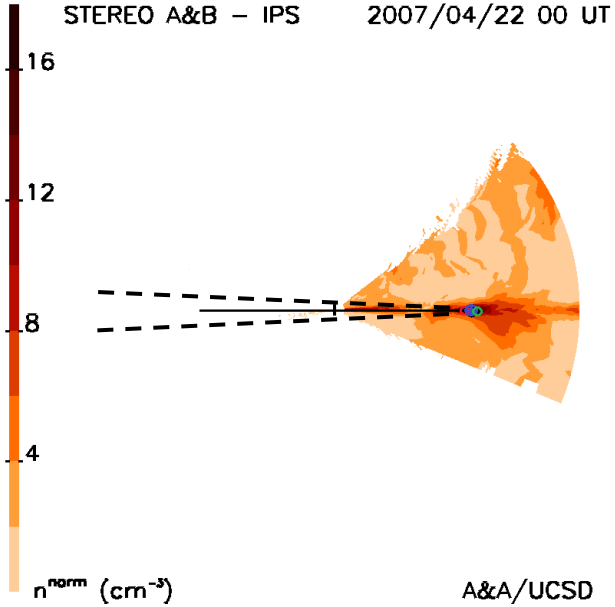
12-Hour 3-D Reconstructions

Sample Structure Views





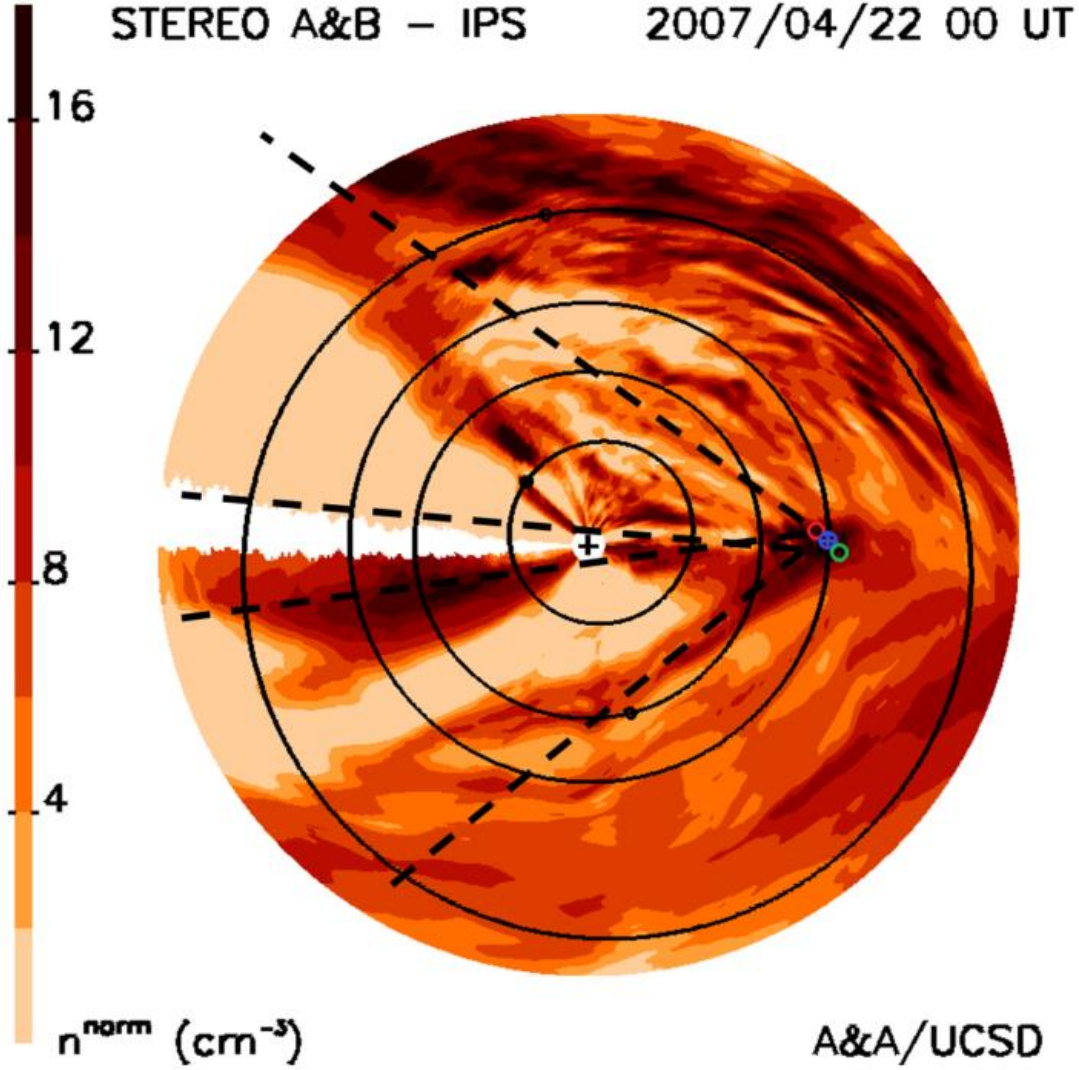


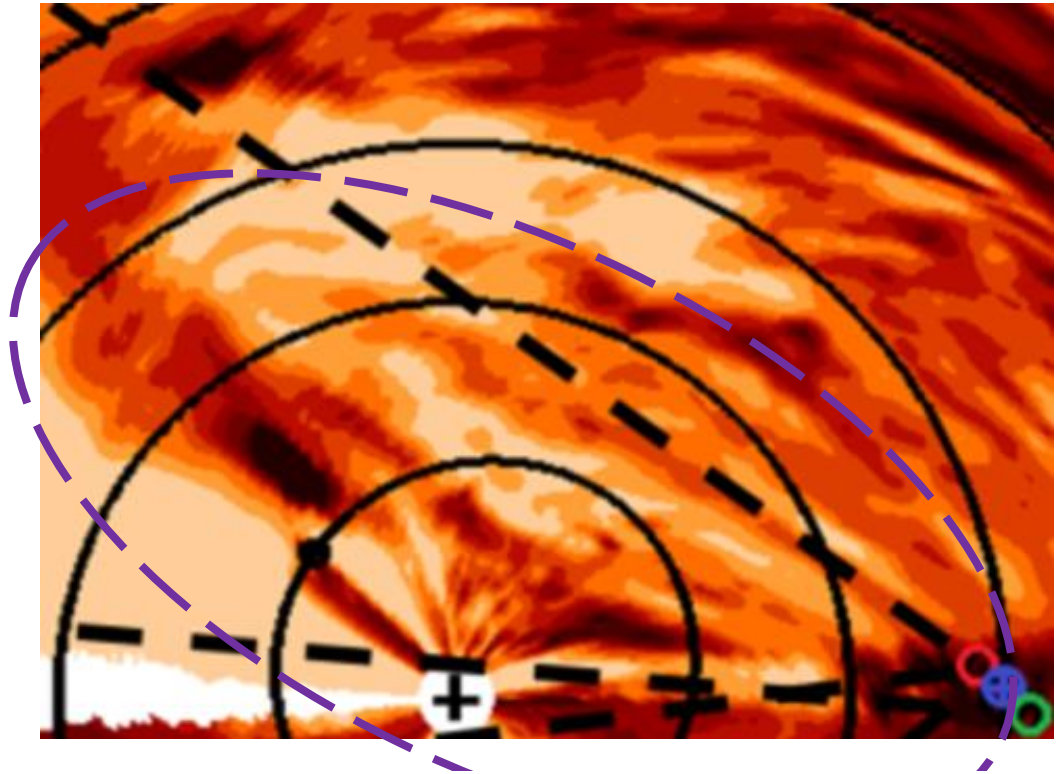


Remote View **Skymap** **Ecliptic Cut** **Meridional**

Time-Dependent 3-D High-Resolution Reconstructions

2007 March 31- April 28 High Resolution Analyses Closer Look

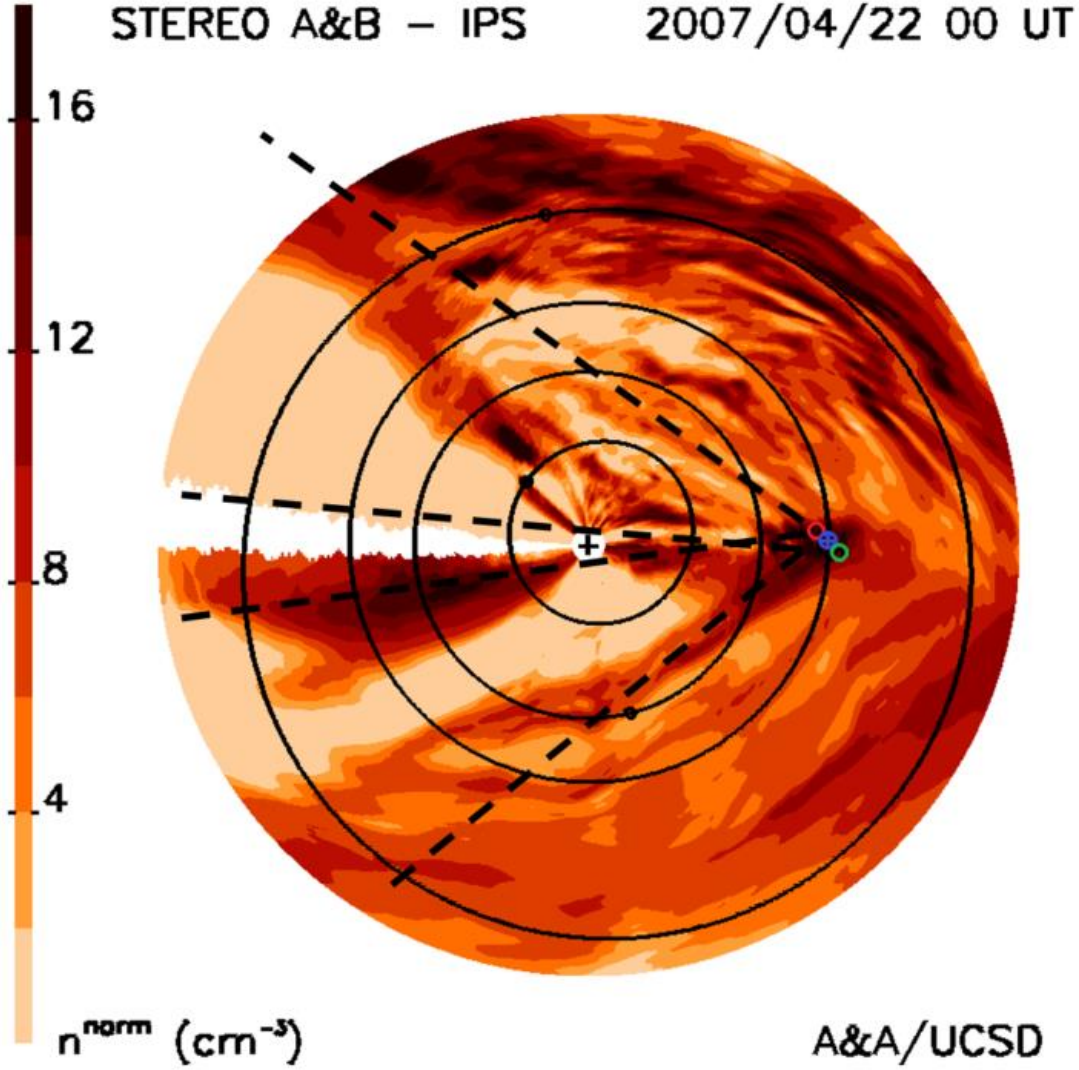


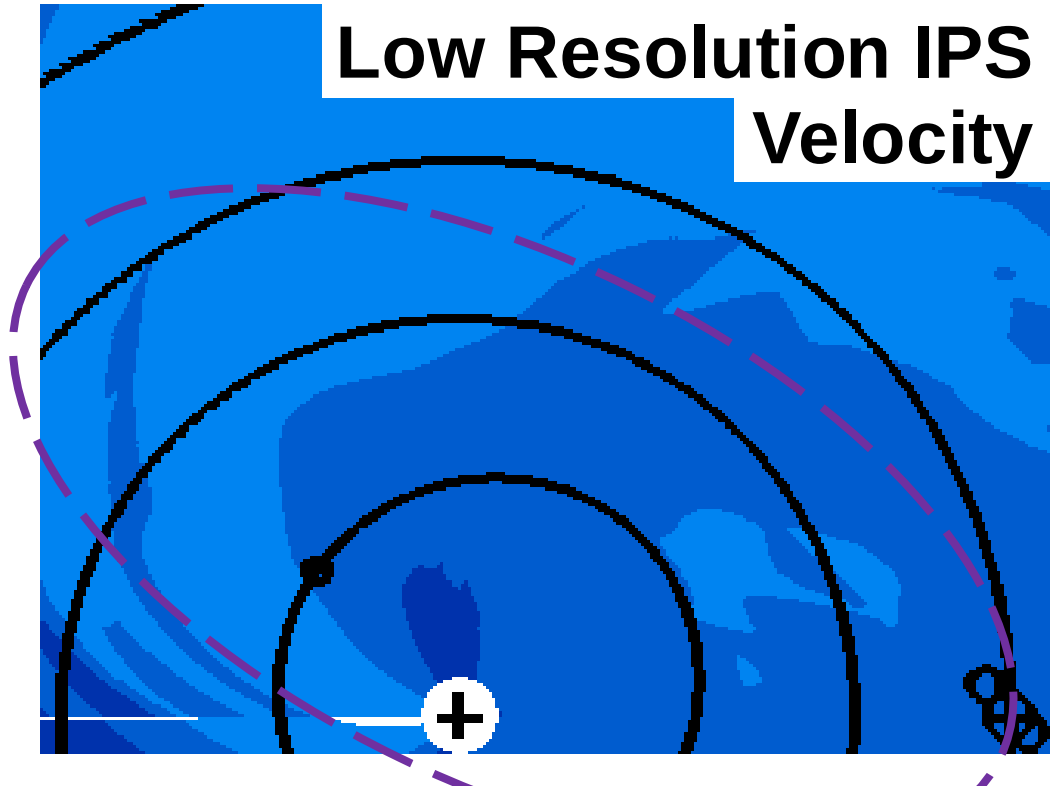


The only near-Sun location that can be 3-D reconstructed directly with PUNCH is inside the dashed lines. Everything else is an extrapolation.

Time-Dependent 3-D High-Resolution Reconstructions

2007 March 31- April 28 High Resolution Analyses Closer Look





The only near-Sun location that can be 3-D reconstructed directly with PUNCH is inside the dashed lines. Everything else is an extrapolation.

Time-Dependent 3-D High-Resolution Reconstructions

Future Work That Must Happen

Time-Dependent 3-D High-Resolution Reconstructions

Future Work:

Some work can be done already by subdividing the STEREO regions into different angular portions to designate inner and outer flow locations and reconstruct them. It would be best to provide this using multi-node processing.

A better way than IPS currently used to determine the flow in the region viewed by PUNCH would certainly be good to have → correlation tracking!

Both B and good pB PUNCH data will certainly refine the 3-D positions of structures without as much need for flow tracking over large distances.

Time-Dependent 3-D High-Resolution Reconstructions

Conclusions:

I've briefly given a tutorial about how the UCSD time-dependent 3D reconstruction analysis works and the need for the LoS determination of both the background and specific LoS locations

I've mentioned the analysis modifications currently available to provide very high resolution Thomson scattering pseudo brightness and polarization brightness

Some (and hopefully soon available) changes are needed for future analyses including correlation tracking to provide higher resolution velocity resolutions