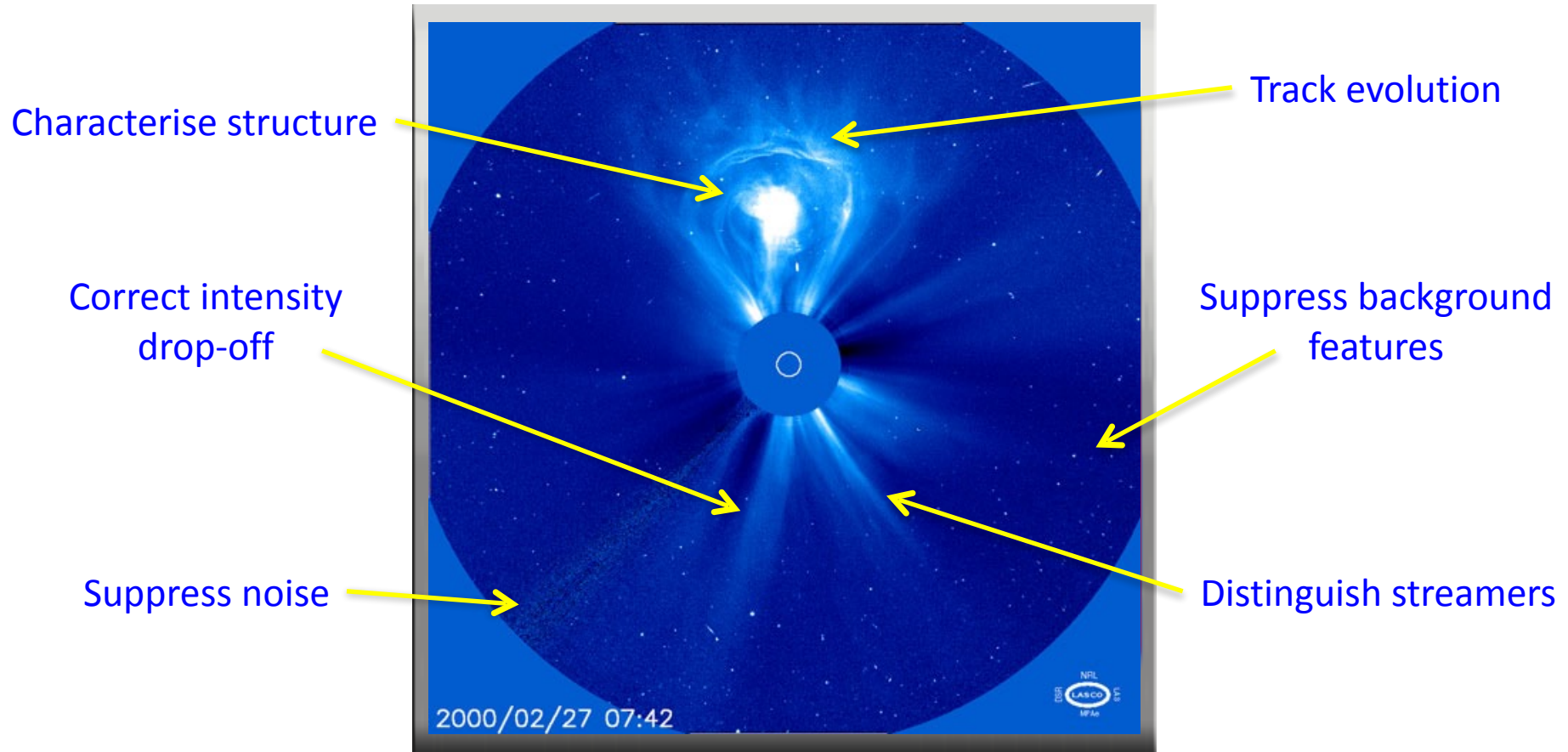


# The New CORIMP CME Catalogue & 3D Reconstructions

**Jason P. Byrne<sup>1</sup>**, Huw Morgan<sup>2</sup>, Peter T. Gallagher<sup>3</sup>, Shadia R. Habbal<sup>4</sup>

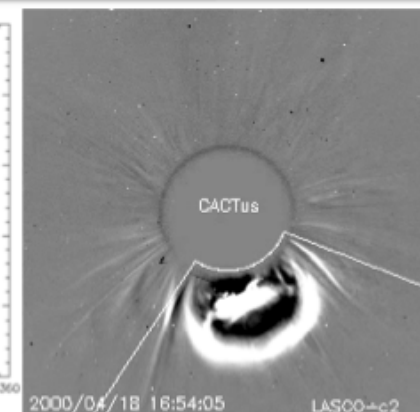
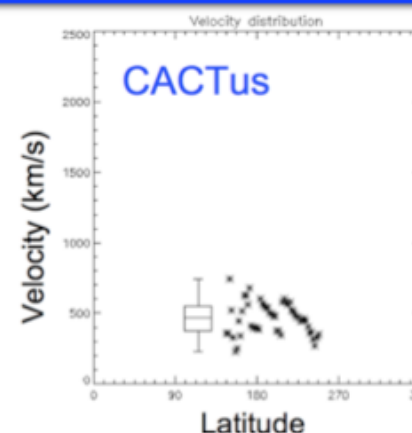
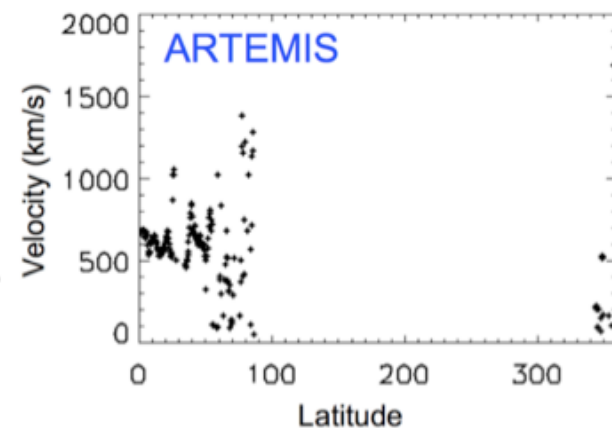
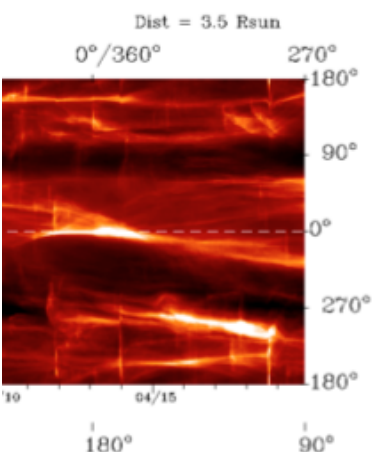
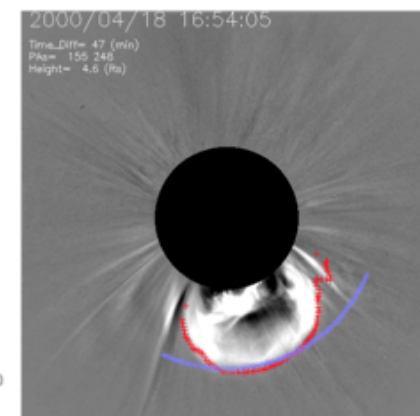
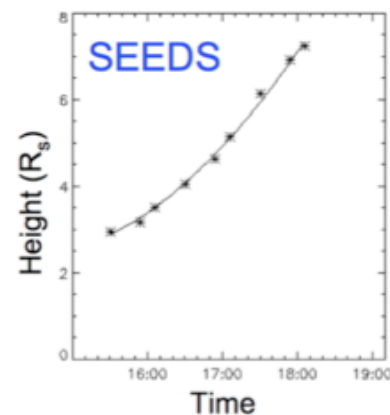
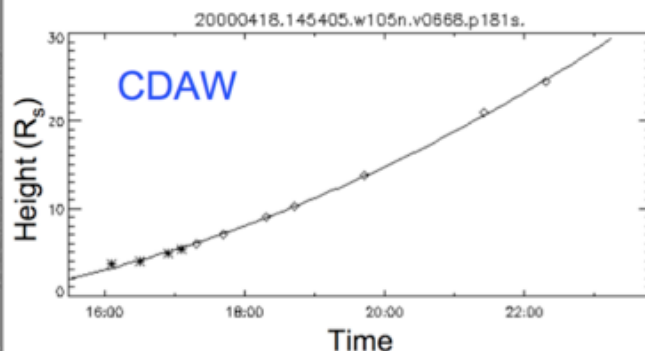
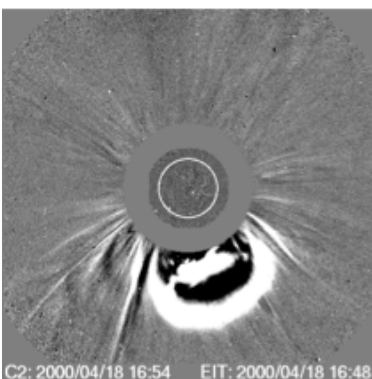
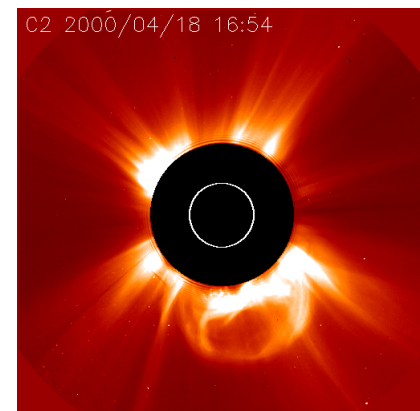
<sup>1</sup>RAL Space, UK | <sup>2</sup>Aberystwyth University, UK | <sup>3</sup>Trinity College Dublin, Ireland | <sup>4</sup>Institute for Astronomy, Hawaii

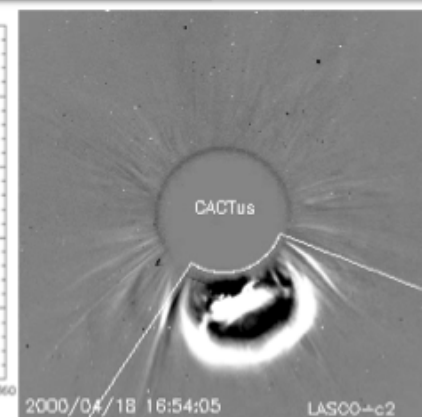
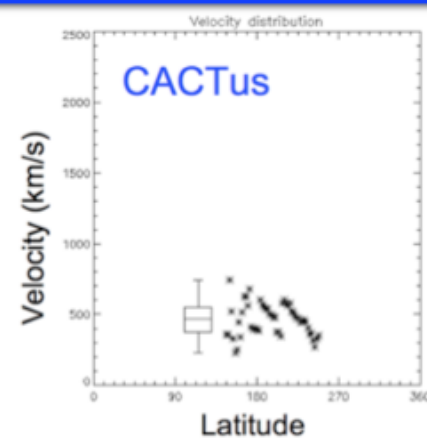
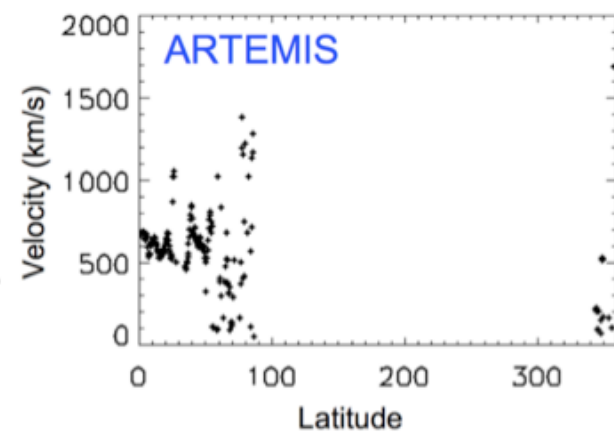
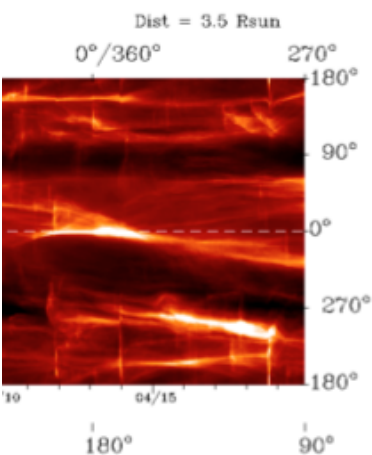
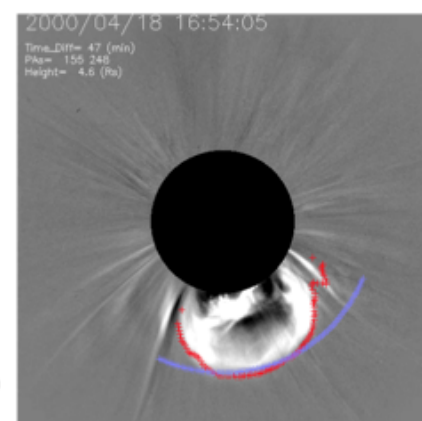
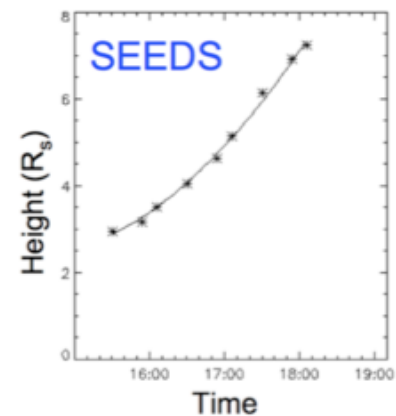
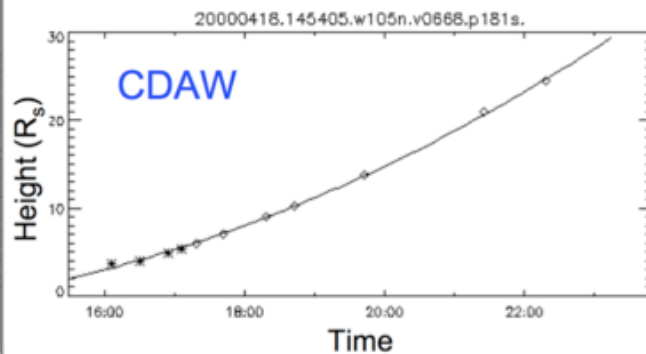
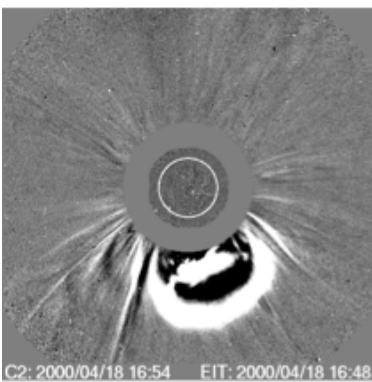


# CME Catalogues

**Aim:** To build a robust automated CME detection and characterisation algorithm, that determines CME kinematics and morphology with a high degree of accuracy and reliability.

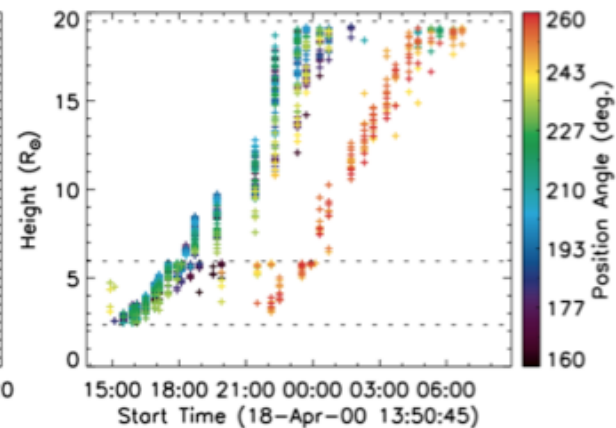
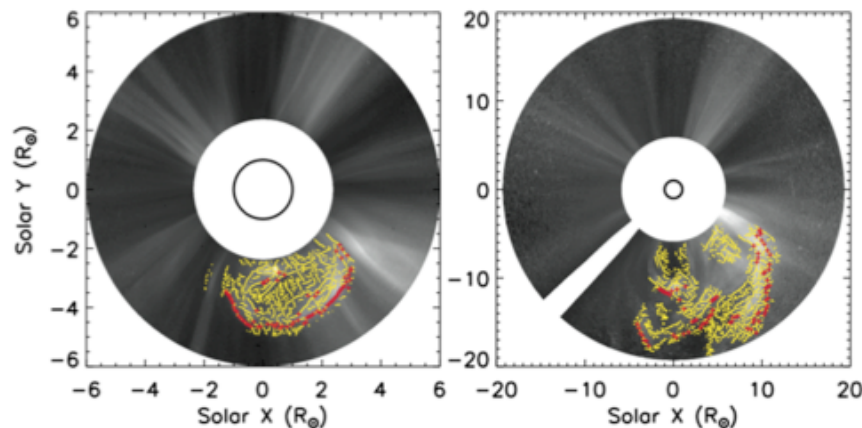
SOHO LASCO/C2  
2000/04/18 16:54



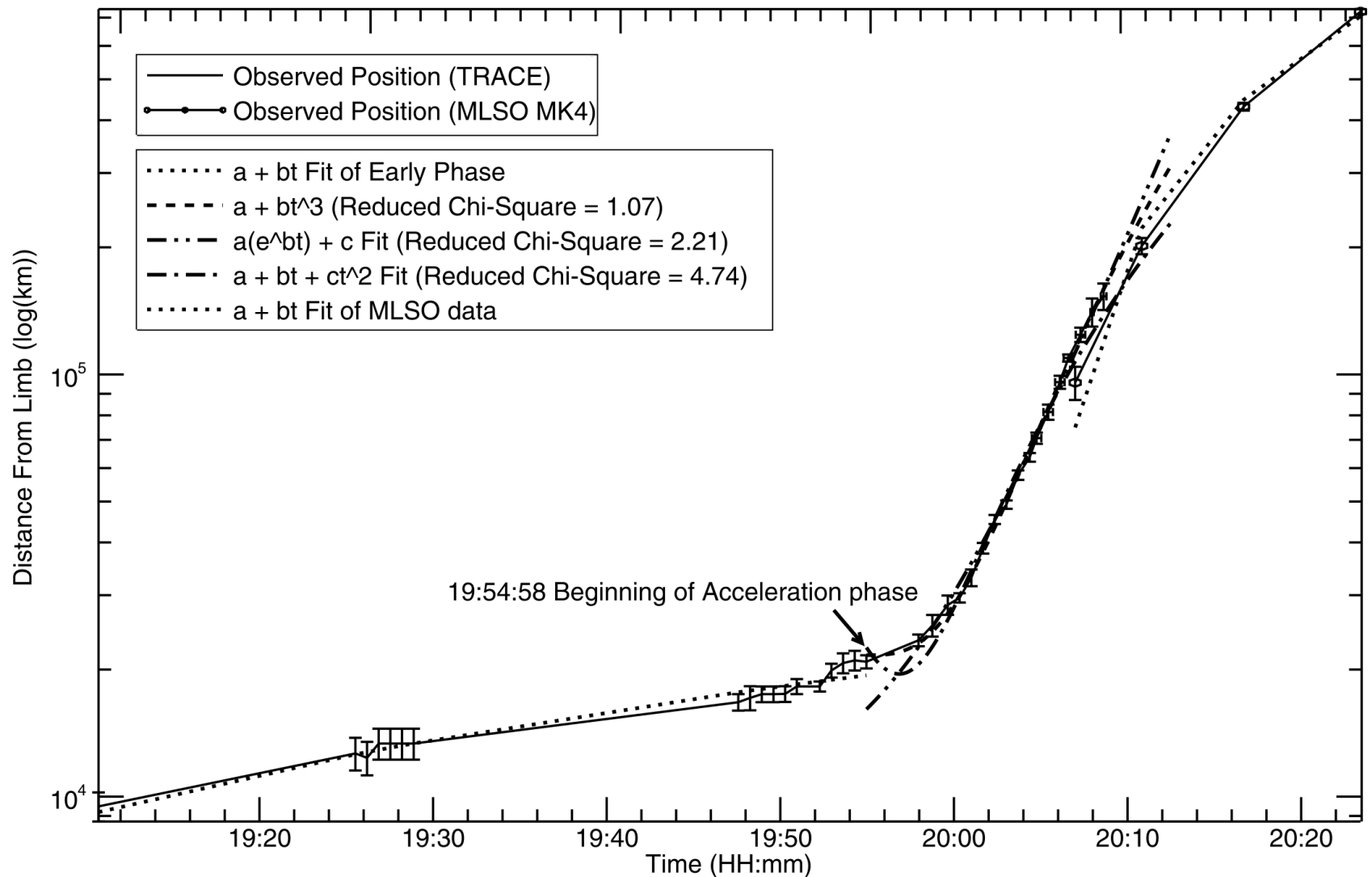


[alshamess.ifa.hawaii.edu/CORIMP](http://alshamess.ifa.hawaii.edu/CORIMP)

CORIMP



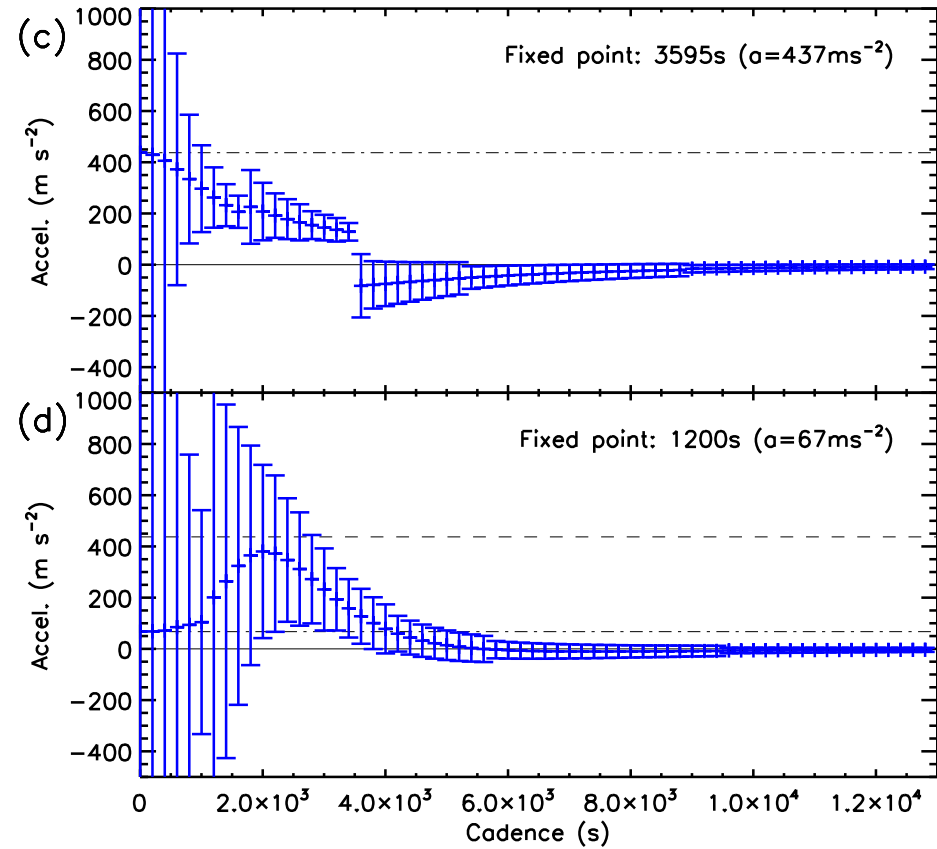
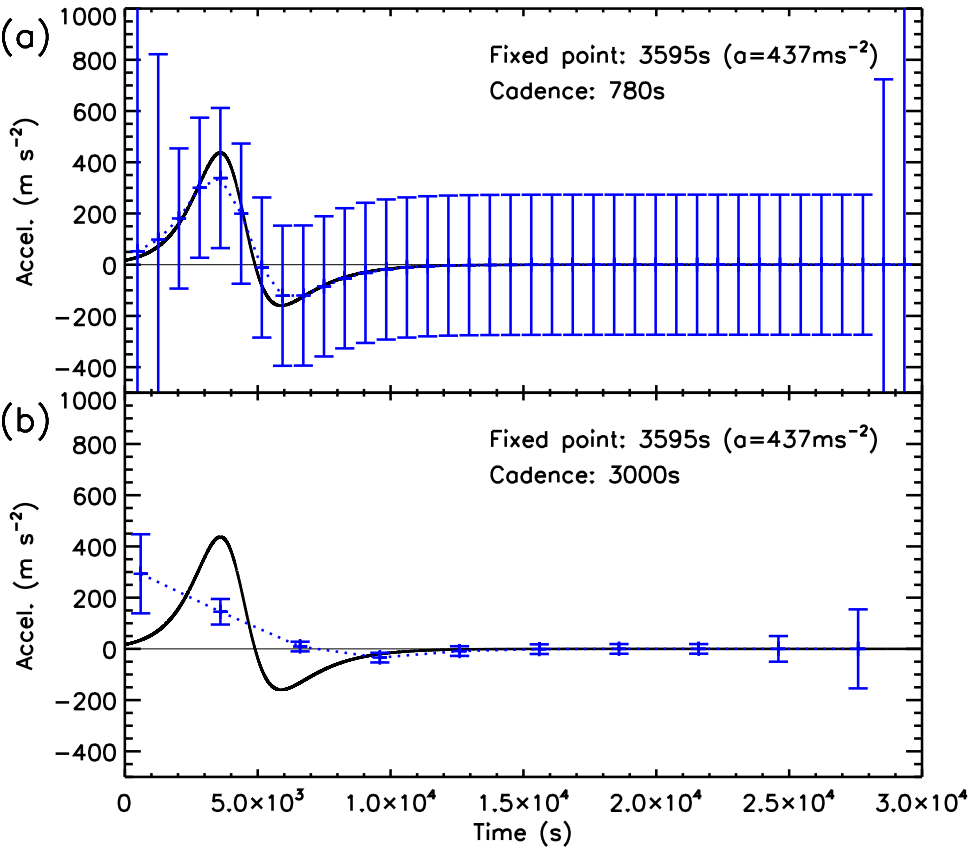
# CME Kinematics



(Schrijver *et al.*, *Astrophys. J.*, 2008)

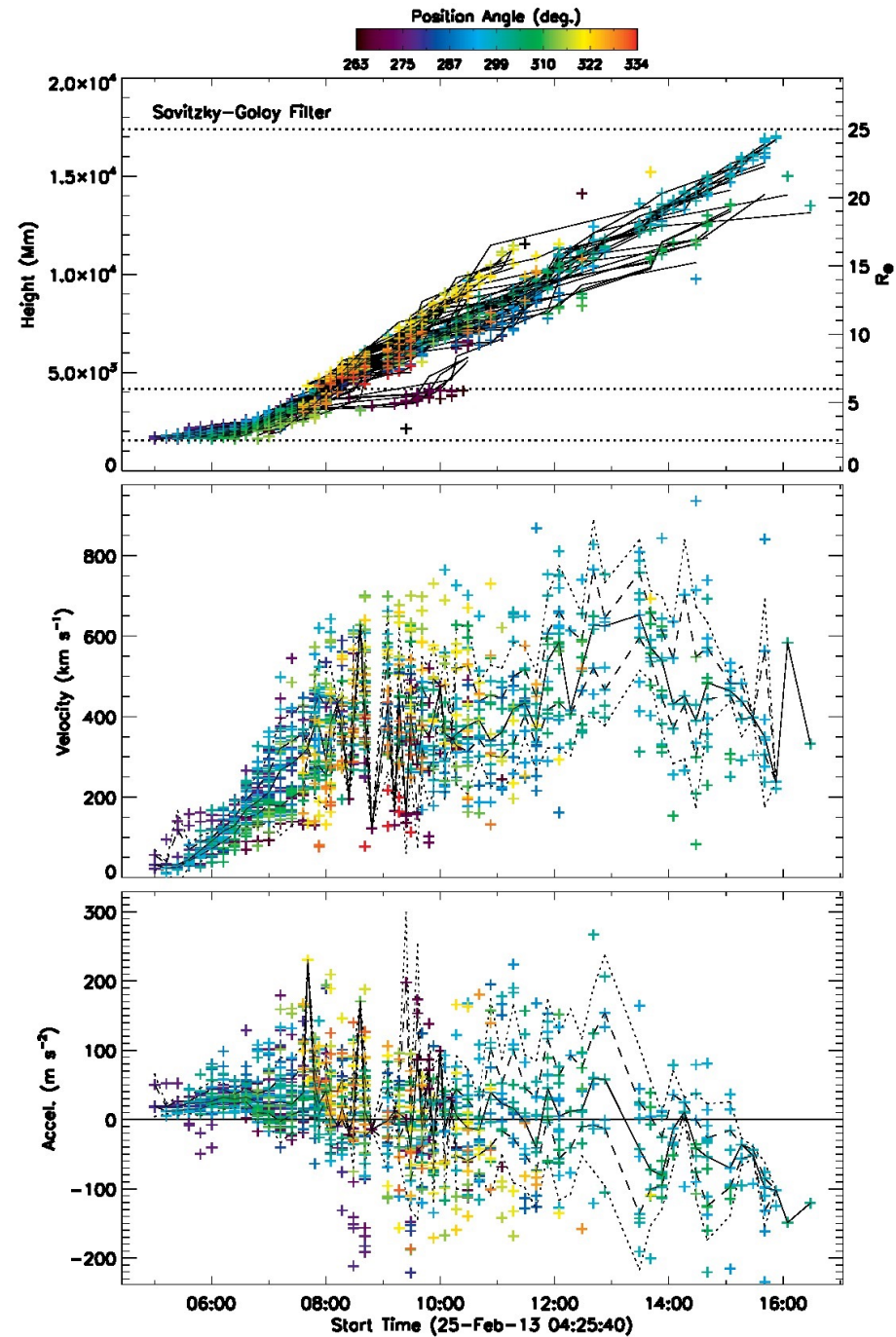
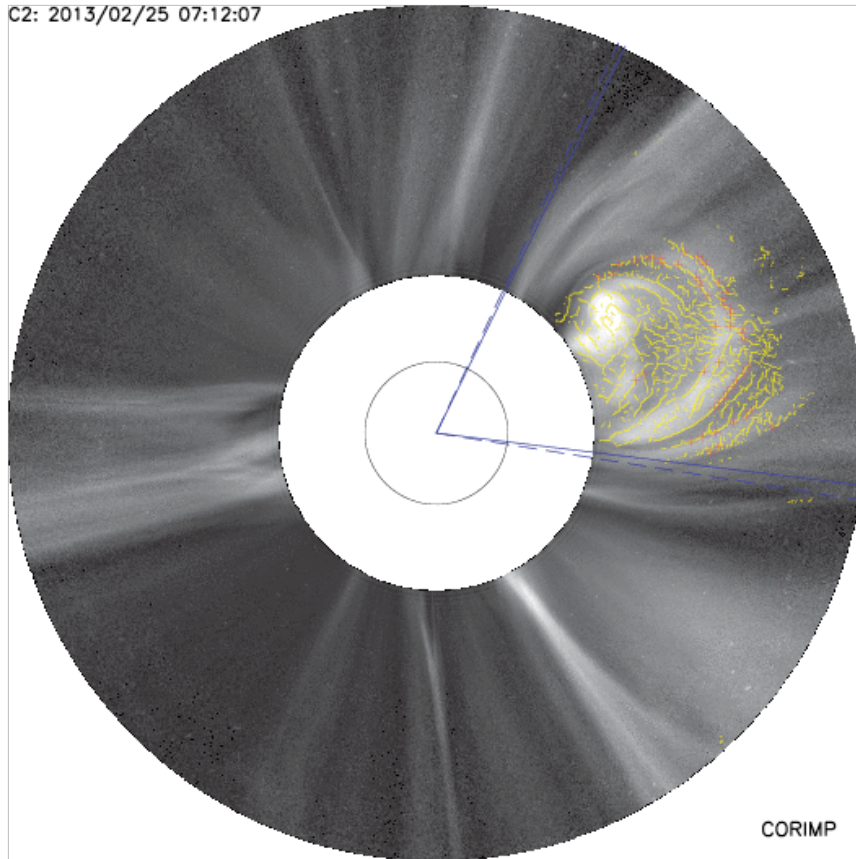


# CME Kinematics



# CME Kinematics

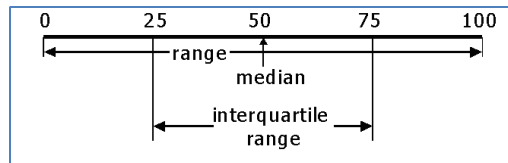
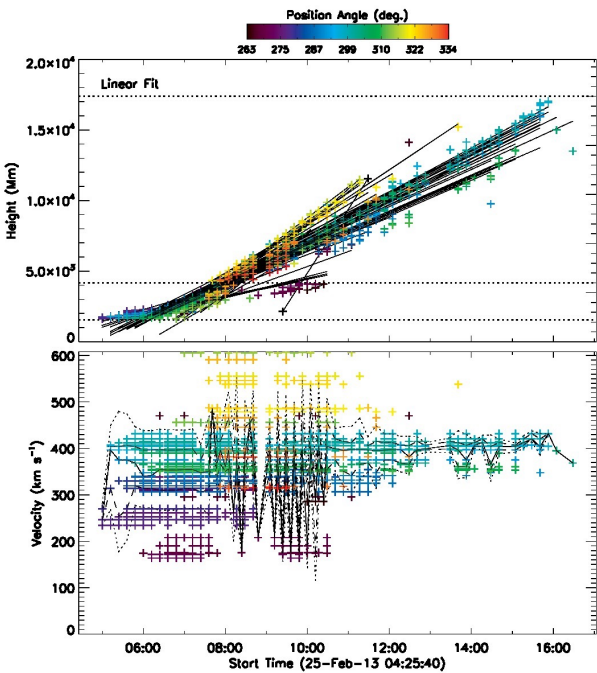
C2: 2013/02/25 07:12:07



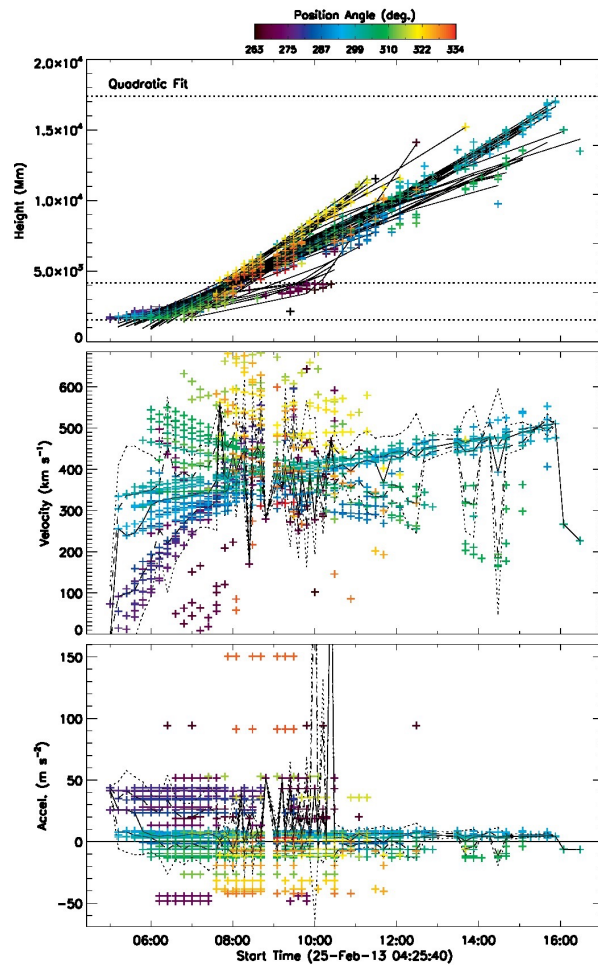
(Byrne *et al.*, Astron. & Astrophys., 2013)

# CME Kinematics

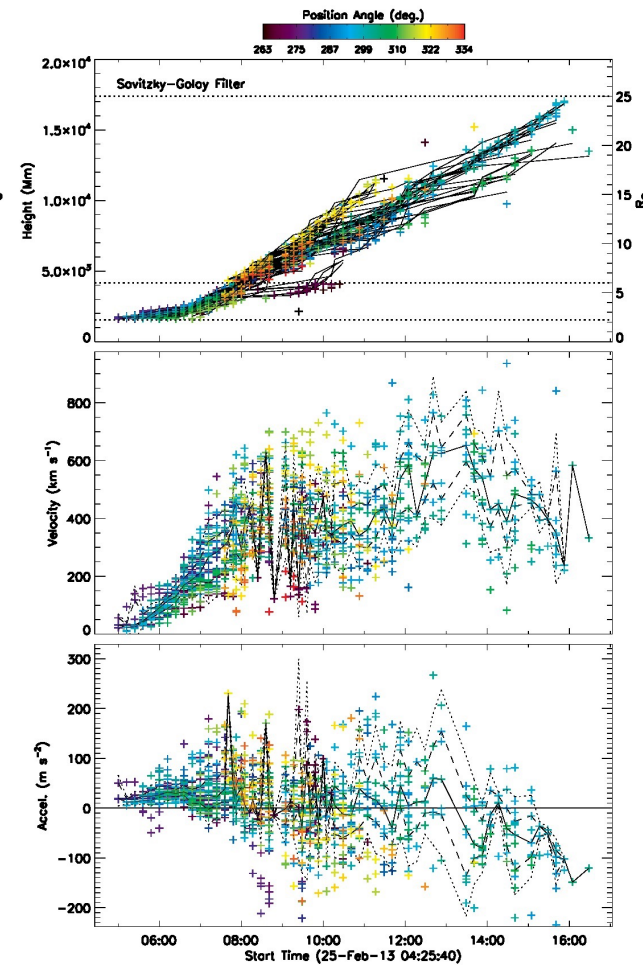
Linear fits

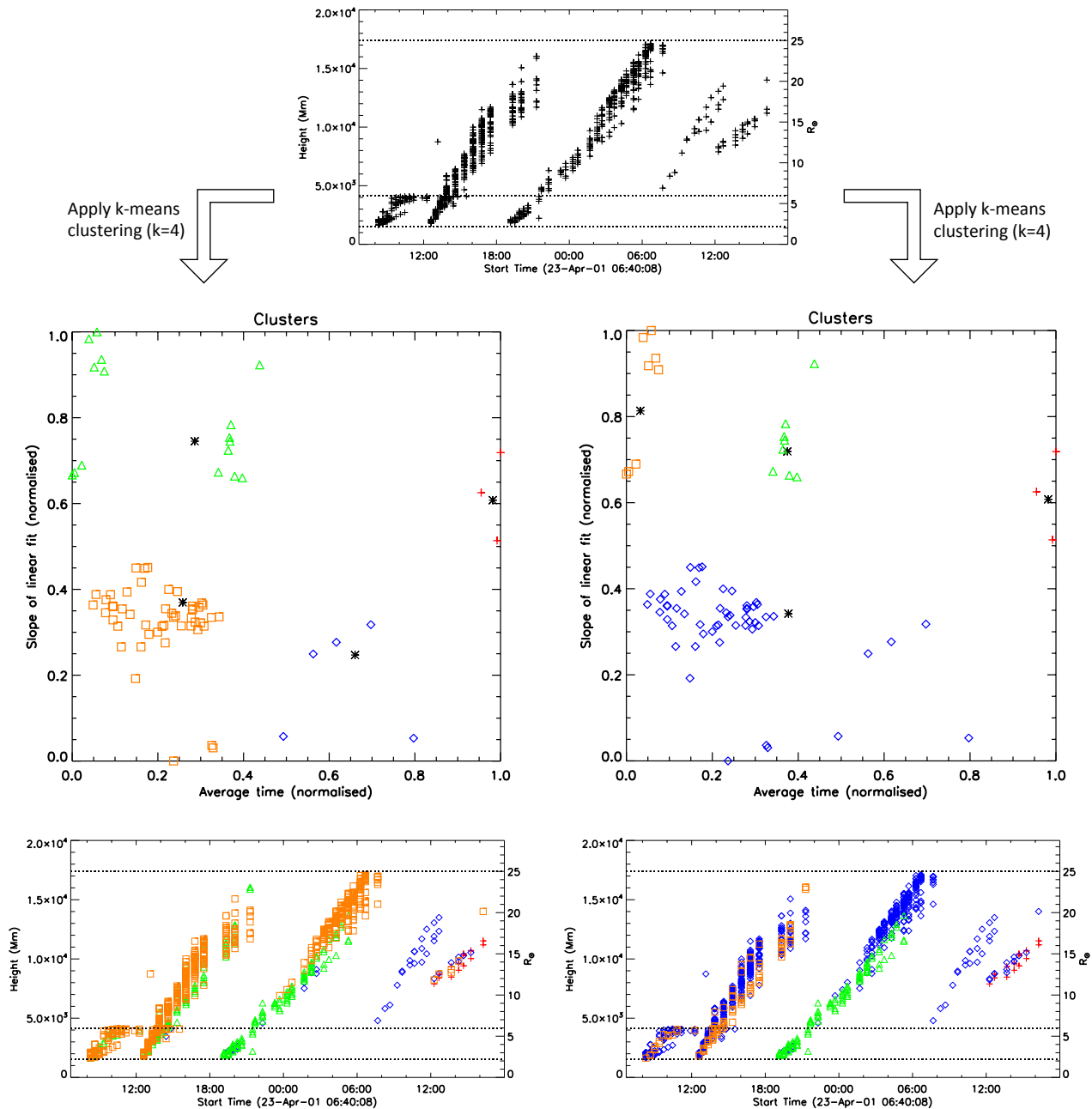


Quadratic fits



Savitzky-Golay filter

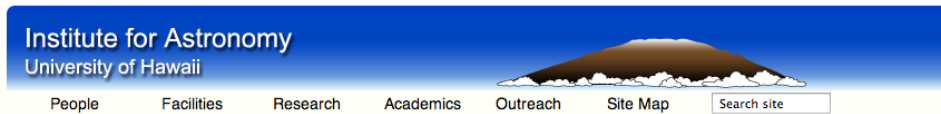




# CME Catalog

<http://alshamess.ifa.hawaii.edu/CORIMP>

twitter: @CMEcatalog



## CORIMP CME Catalog

SOHO / LASCO (under construction)

[Realtime CME detections \(latest available data\)](#)

[Weekly CME detections \(past 7 days\)](#)

| Year | Month |     |     |     |      |      |      |     |     |     |     |     |
|------|-------|-----|-----|-----|------|------|------|-----|-----|-----|-----|-----|
| 2014 | Jan   | Feb | Mar | Apr | May* | Jun* | Jul* |     |     |     |     |     |
| 2013 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2012 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2011 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2010 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2009 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2008 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2007 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2006 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2005 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2004 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2003 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2002 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2001 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2000 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |

\*Italic detections populated from realtime data.  
(Missing detections currently being processed.)

The coronal image processing (CORIMP) CME catalog is generated from the automatic detection and tracking of CMEs in images from the Solar & Heliospheric Observatory (SOHO) Large Angle & Spectrometric Coronagraph experiment (LASCO). The catalog utilises a normalising radial-graded filter (NRGF) that removes the steep gradient in coronal brightness. A deconvolution technique is used to remove the static background, separating dynamic and quiescent structures. A multiscale decomposition then results in a number of scales upon which the images can be automatically inspected for curvilinear features. Detection masks are generated to isolate CME structure, and a sequence of observations then reveal the changing CME kinematics and morphology. (STEREO / SECCHI coming soon)

Note: A list of known bugs is compiled [here](#). Please contact us if you find another.

[A guide to using the catalog can be found here.](#)

Details available in the following publications (please cite these if using the catalog):

- Byrne, Morgan, Habbal & Gallagher, *ApJ* (2012)
- Morgan, Byrne & Habbal, *ApJ* (2012)

LASCO data currently; SECCHI imminent.

Realtime implementation.

Event list mirrors current catalogs: dividing data by Year & Month.

Catalog description

List of known bugs.

Relevant publications.



# CME Catalog

Institute for Astronomy  
University of Hawaii



People Facilities Research Academics Outreach Site Map Search site

## CORIMP CME Catalog

SOHO / LASCO (under construction)

[Realtime CME detections \(latest available data\)](#)

[Weekly CME detections \(past 7 days\)](#)

| Year | Month |     |     |     |      |      |      |     |     |     |     |     |
|------|-------|-----|-----|-----|------|------|------|-----|-----|-----|-----|-----|
| 2014 | Jan   | Feb | Mar | Apr | May* | Jun* | Jul* |     |     |     |     |     |
| 2013 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2012 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2011 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2010 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2009 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2008 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2007 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2006 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2005 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2004 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2003 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2002 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2001 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |
| 2000 | Jan   | Feb | Mar | Apr | May  | Jun  | Jul  | Aug | Sep | Oct | Nov | Dec |

\*Italic detections populated from realtime data.  
(Missing detections currently being processed.)

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Note: A list of known bugs is compiled [here](#). Please contact us if you find another.

[A guide to using the catalog can be found here.](#)

Details available in the following publications (please cite these if using the catalog):

- Byrne, Morgan, Habbal & Gallagher, *ApJ* (2012)
- Morgan, Byrne & Habbal, *ApJ* (2012)

## Guide to using the catalog

The CORIMP catalog presents the results of the CME detections in a row/column format, as shown in the image below. The default catalog displays the kinematics derived using a Savitzky-Golay filter on the height-time data (see Byrne et al. 2013). The top links provide access to the kinematics derived from either quadratic fits or linear fits to the height-time profiles.

| << CORIMP        |              |                        | Savitsky-Golay filter     |                           |                        | Quadratic fits                          |                                      | Linear fits                          |             |                                |
|------------------|--------------|------------------------|---------------------------|---------------------------|------------------------|---|--------------------------------------|--------------------------------------|-------------|--------------------------------|
| Date<br>yy/mm/dd | Time<br>[UT] | Central<br>PA<br>[deg] | Angular<br>Width<br>[deg] | Median<br>Speed<br>[km/s] | Max<br>Speed<br>[km/s] | Median<br>Accel.<br>[m/s <sup>2</sup> ] | Max<br>Accel.<br>[m/s <sup>2</sup> ] | Min<br>Accel.<br>[m/s <sup>2</sup> ] | Mass<br>[g] | Movie &<br>Image Links         |
| 2011/10/01       | 01:36:25     | 302                    | 29 (36)                   | 143                       | 279                    | 54                                      | 128                                  | -87                                  |             | C3 (dyn) (ms)<br>C2 (dyn) (ms) |
| 2011/10/01       | 03:42:07     | 246                    | 47 (47)                   | 262                       | 466                    | 14                                      | 57                                   | -53                                  |             | C3 (dyn) (ms)<br>C2 (dyn) (ms) |
| 2011/10/01       | 08:48:08     | 296                    | 87 (87)                   | 82                        | 149                    | 1                                       | 6                                    | -5                                   |             | C3 (dyn) (ms)<br>C2 (dyn) (ms) |
| 2011/10/01       | 10:54:07     | 235                    | 132 (132)                 | 175                       | 504                    | 6                                       | 36                                   | -36                                  |             | C3 (dyn) (ms)<br>C2 (dyn) (ms) |
| 2011/10/01       | 14:24:07     | 21                     | 25 (26)                   | 178                       | -                      | -                                       | -                                    | -                                    |             | C3 (dyn) (ms)<br>C2 (dyn) (ms) |

The columns are divided as follows:

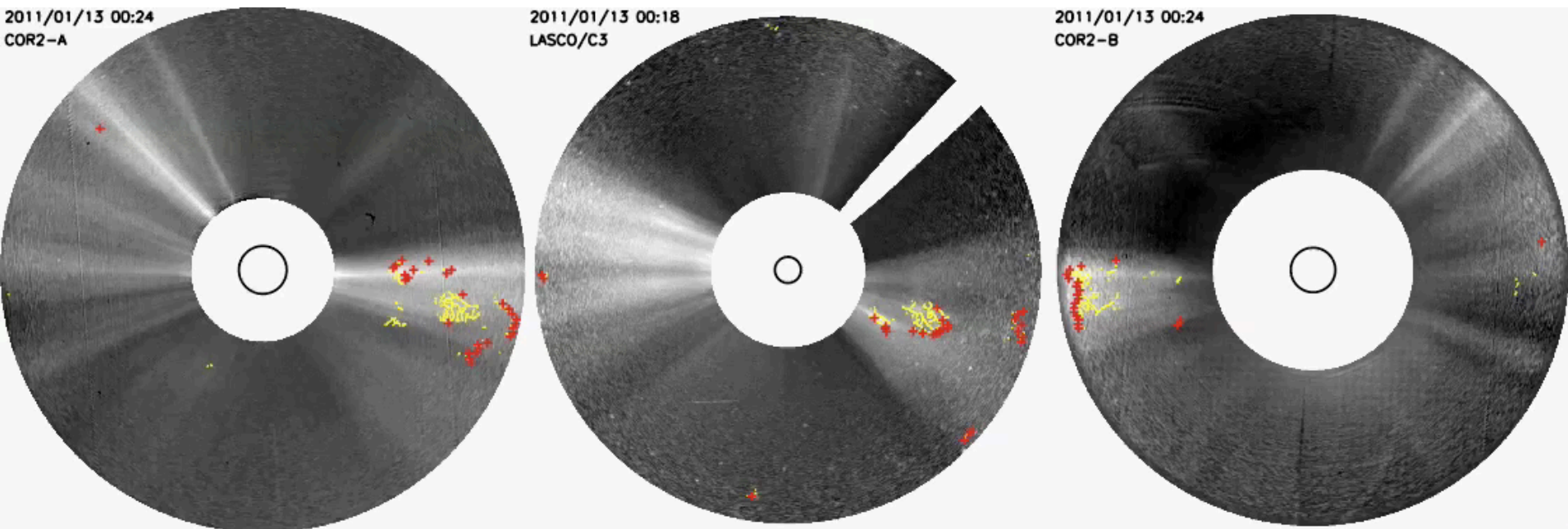
|  |  |
|--|--|
| <b>Date</b><br>[yy/mm/dd]:                   | The date of first detection of the CME.  |
| <b>Time</b><br>[UT]:                         | The time of first detection of the CME.  |
| <b>Central PA</b><br>[deg]:                  | The central position angle of the detected CME, measured counter-clockwise from solar north.   |
| <b>Angular Width</b><br>[deg]:               | The angular width (and upper limit) of the detected CME.   |
| <b>Median Speed</b><br>[km/s]:               | The median of all 'upper quartile' values in the derived distribution of CME speed.  |
| <b>Max Speed</b><br>[km/s]:                  | The value that is two median-absolute-deviations above the median of all 'upper fence' values in the derived distribution of CME speed.        |
| <b>Median Accel.</b><br>[m/s <sup>2</sup> ]: | The median of all 'upper quartile' values in the derived distribution of CME acceleration.   |
| <b>Max Accel.</b><br>[m/s <sup>2</sup> ]:    | The value that is two median-absolute-deviations above the median of all 'upper fence' values in the derived distribution of CME acceleration. |
| <b>Min Accel.</b><br>[m/s <sup>2</sup> ]:    | The value that is two median-absolute-deviations below the median of all 'upper fence' values in the derived distribution of CME acceleration. |
| <b>Mass</b><br>[g]:                          | The derived mass of the detected CME, at each corresponding position angle and totalled across its angular span.                               |
| <b>Movie &amp; Image Links</b>               | Links to the C2 and C3 movies & images, for both the processed original images and dynamic separated images.                                   |

- Clicking on any particular 'Date' will bring up a movie of the event.
- Clicking on any particular 'Time' will show the text file containing the event information.
- Clicking on any of the derived CME parameters will bring up the kinematic plots, or the clicking the mass will show the mass plot.

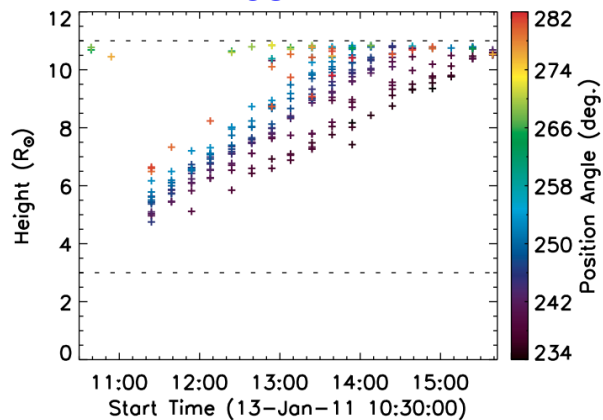
The rows corresponding to each event are color-coded as follows:

|            |  |
|------------|--|
| Red        | Red events have a substantial number of detections that span greater than 90°.                 |
| Orange     | Orange events have a substantial number of detections that span between 60° and 90°.           |
| Yellow     | Yellow events have a substantial number of detections that span between 30° and 60°.           |
| White      | White events do not have a substantial number of detections, regardless of their angular span. |
| Light-gray | Light-gray events do not have a substantial number of detections, and span less than 30°.      |
| Dark-gray  | Dark-gray events are the weakest detections, with potentially untrustworthy kinematics.        |

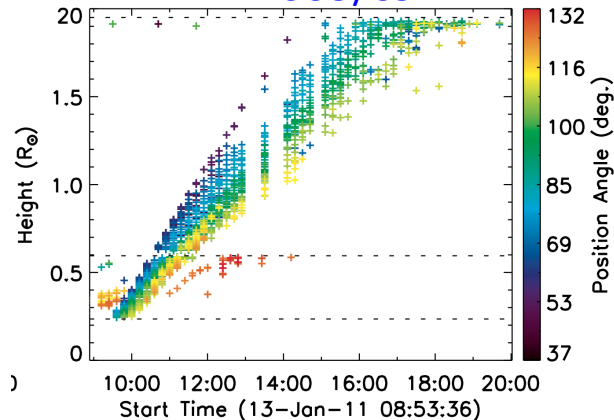
# STEREO Observations



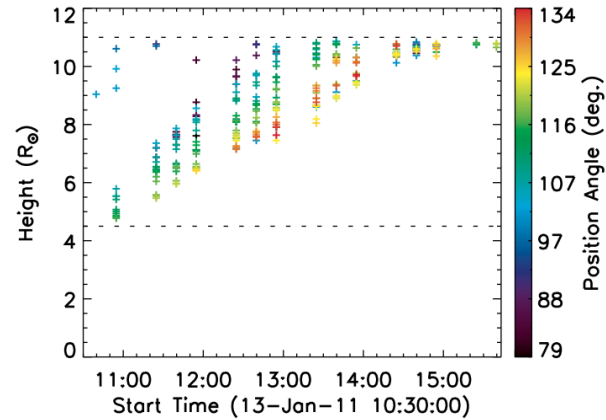
COR2-A



LASCO/C3



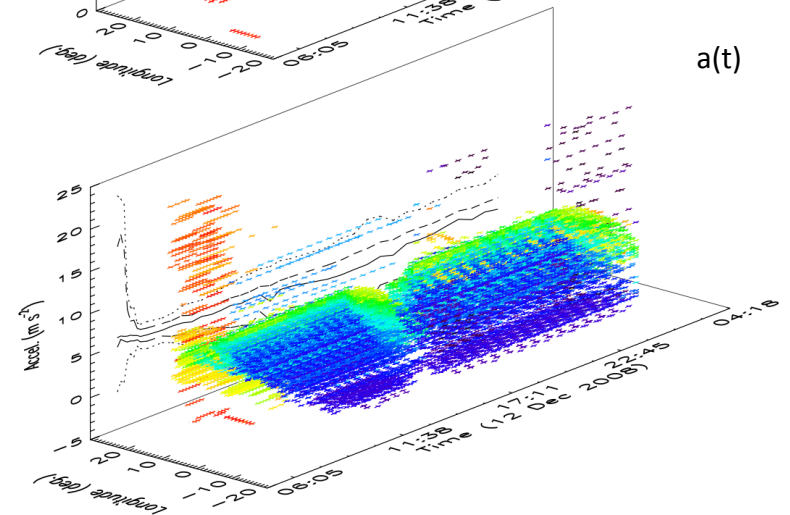
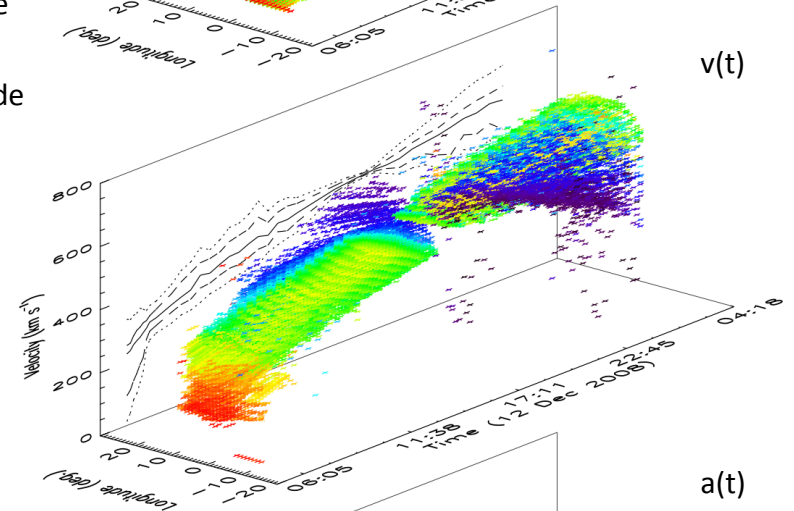
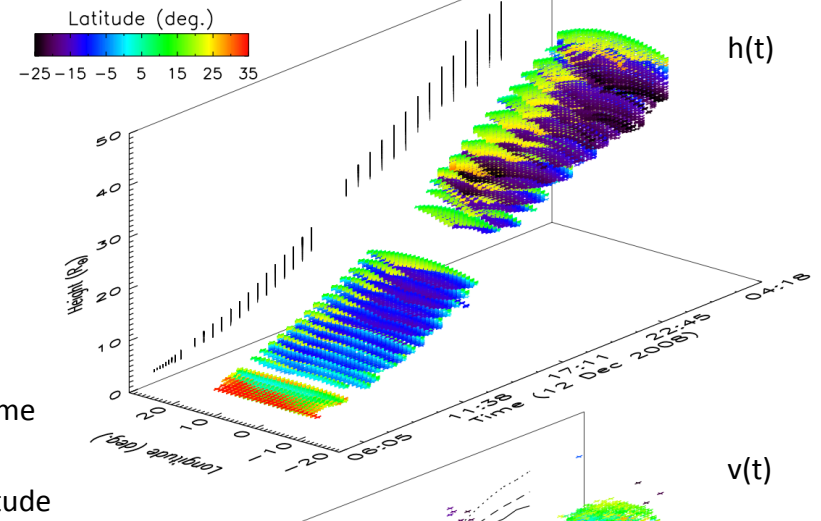
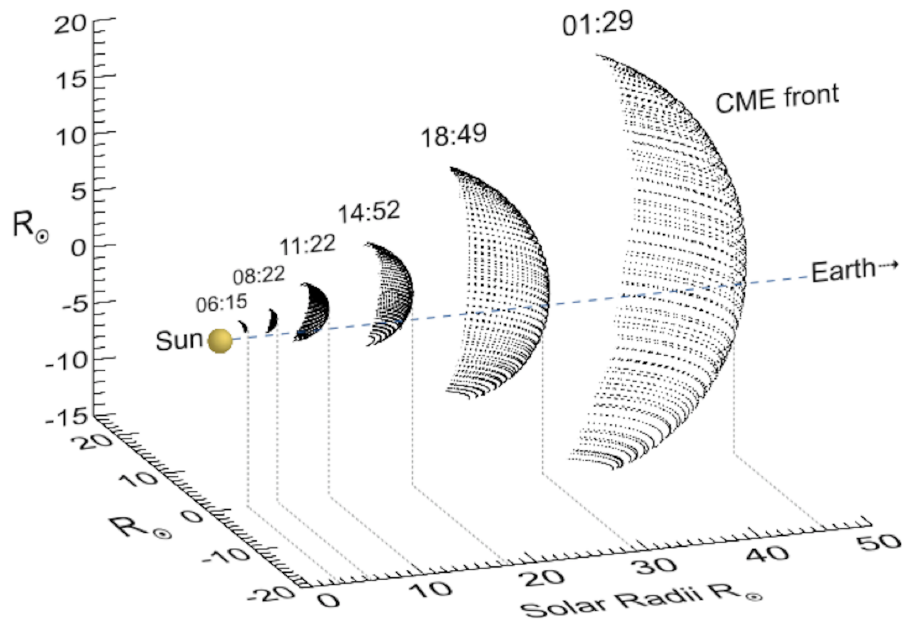
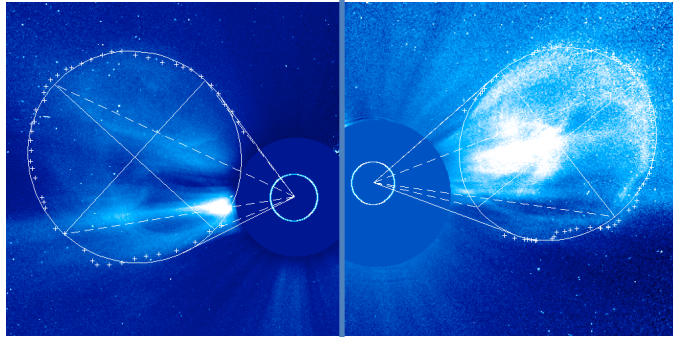
COR2-B



# STEREO Observations

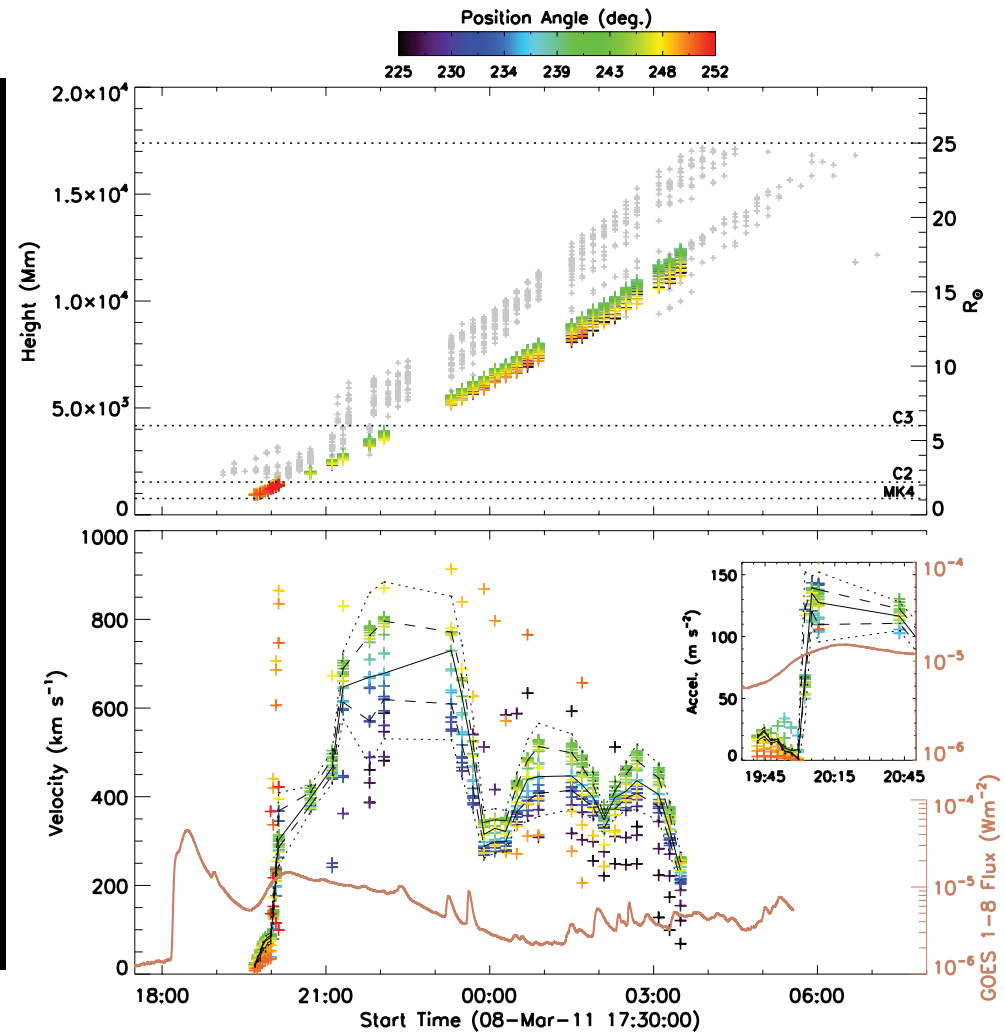
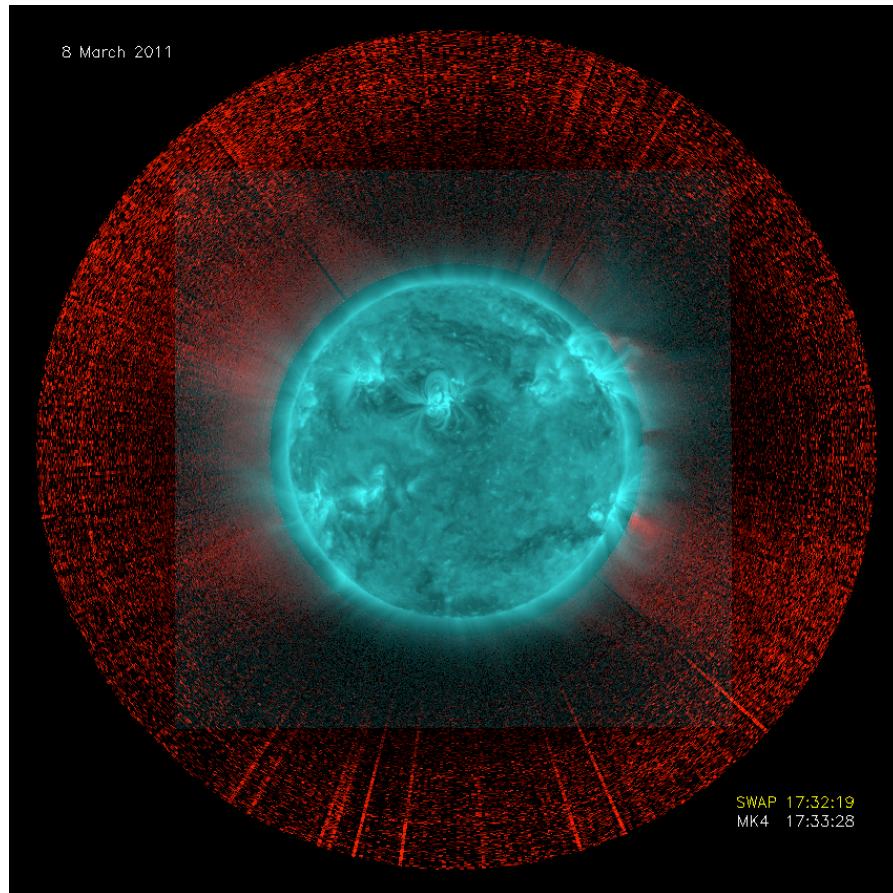
COR2-A

COR2-B



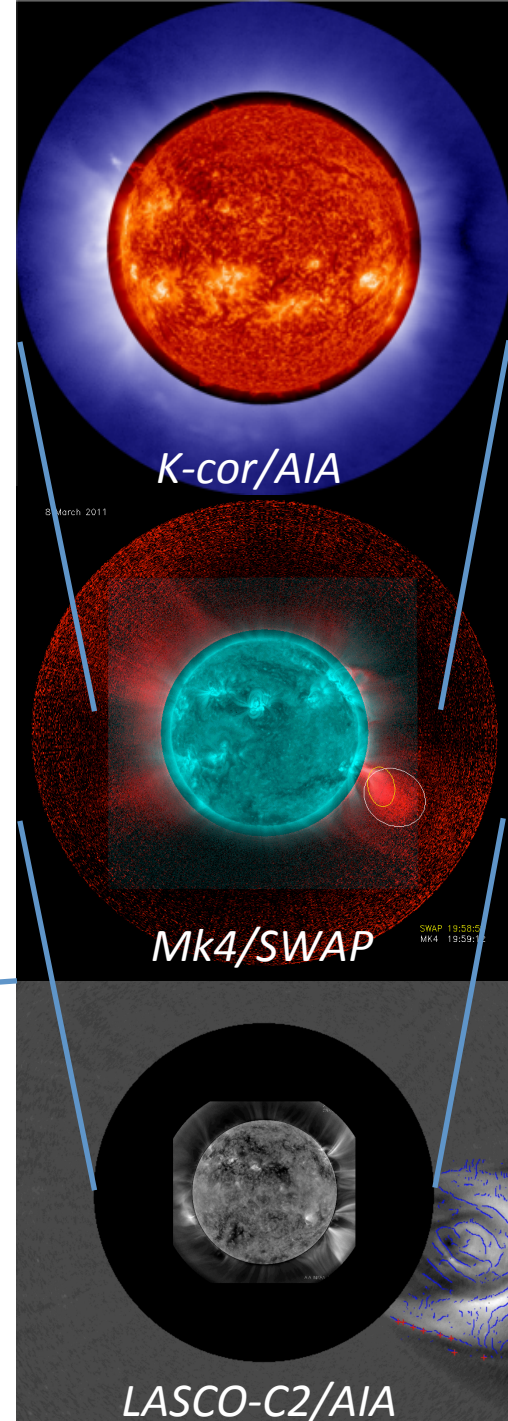
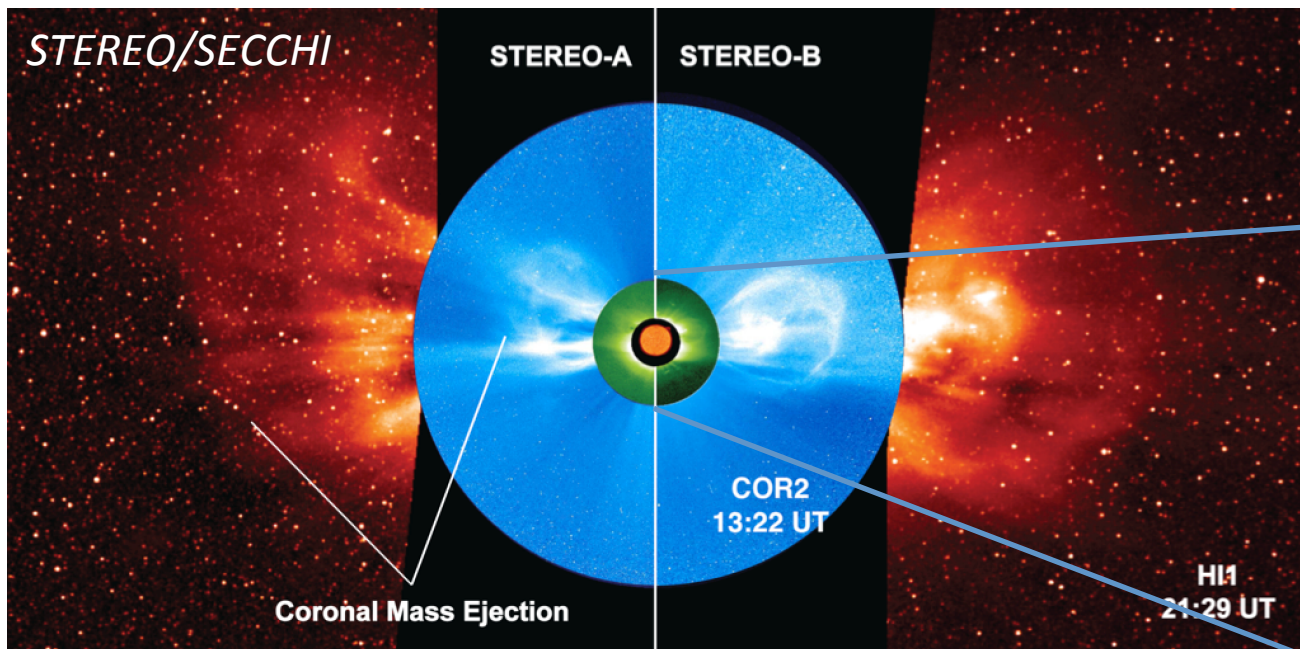


# Combined Observations



# Ongoing & Future Work

- CORIMP catalogue & realtime detections  
*Database of high-fidelity CME measurements & statistics.*  
<http://alshamess.ifa.hawaii.edu/CORIMP>
- Investigate true CME kinematics & morphology  
*Across the entire STEREO mission dataset.*
- Overlap with other instrument observations  
*Ranging from the Heliospheric Imagers down to K-cor.*







# In conclusion... observational science goals

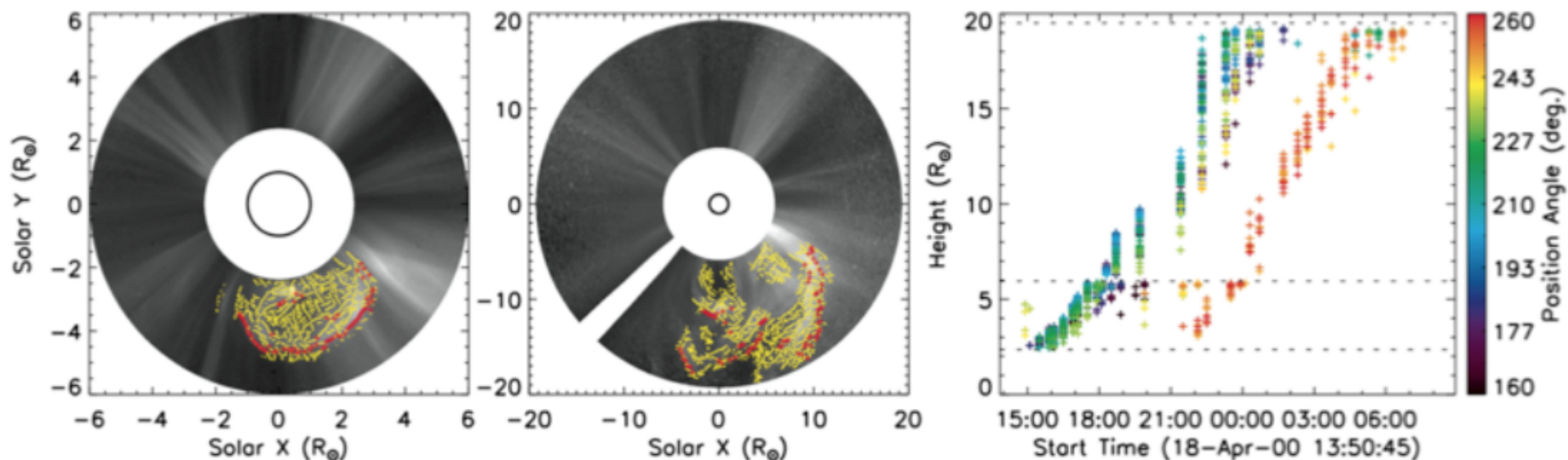
What is the physics governing:

- 1) CME trajectories?
- 2) CME kinematics?
- 3) CME evolution?

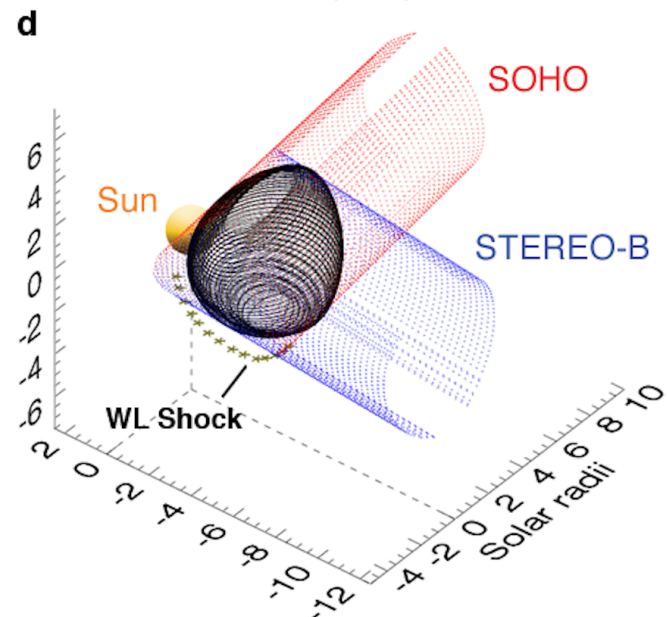
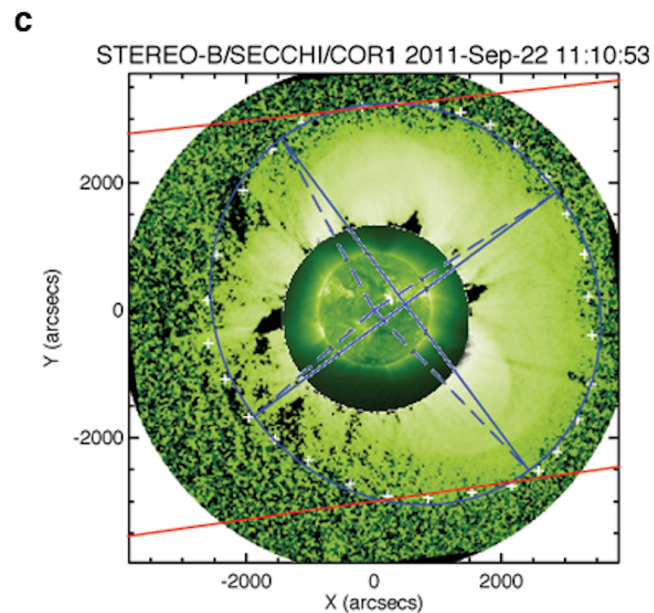
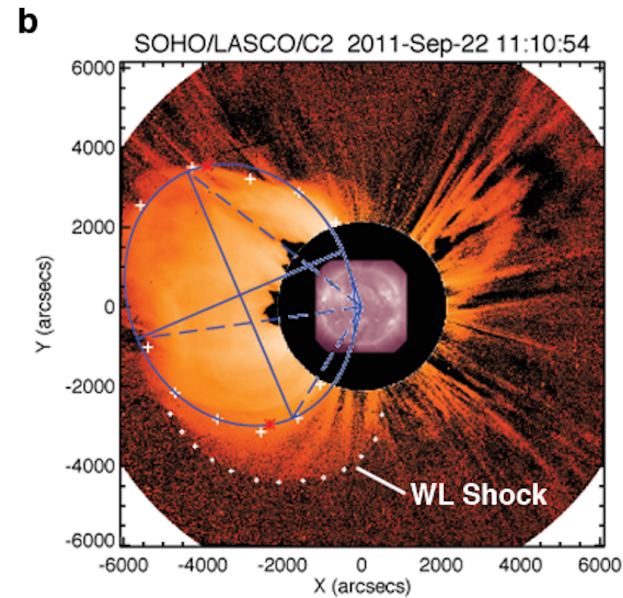
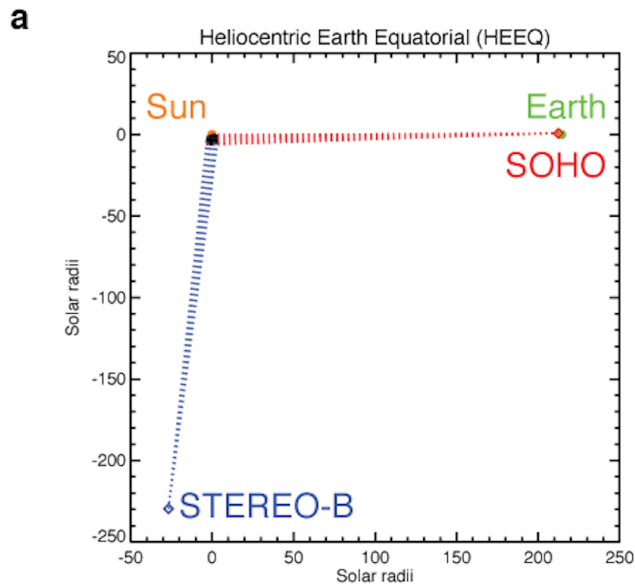
How can we improve methods of:

- 1) detecting and tracking CMEs?
- 2) deriving CME velocity/acceleration?
- 3) measuring true CME geometries?

## CORIMP



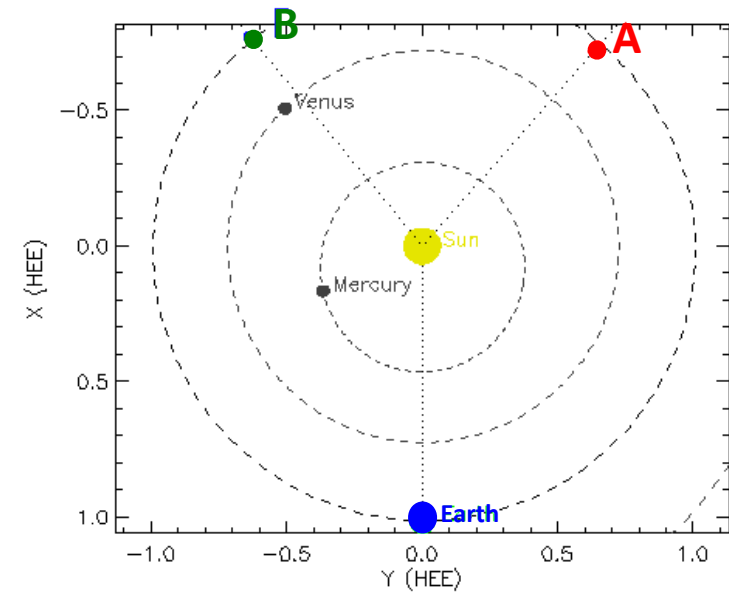
# CME Shock Observations



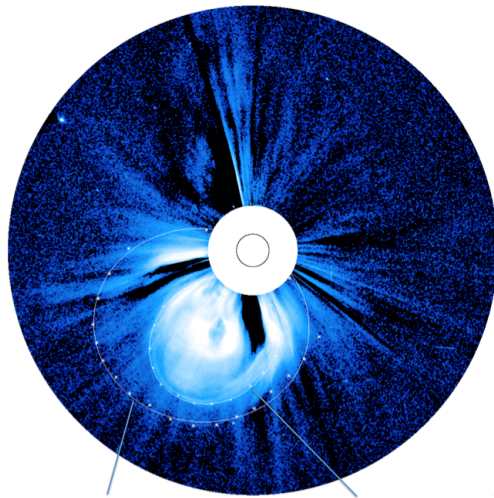
(Carley, Long, Byrne *et al.*, Nat. Phys., 2013)

# CME Shock Observations

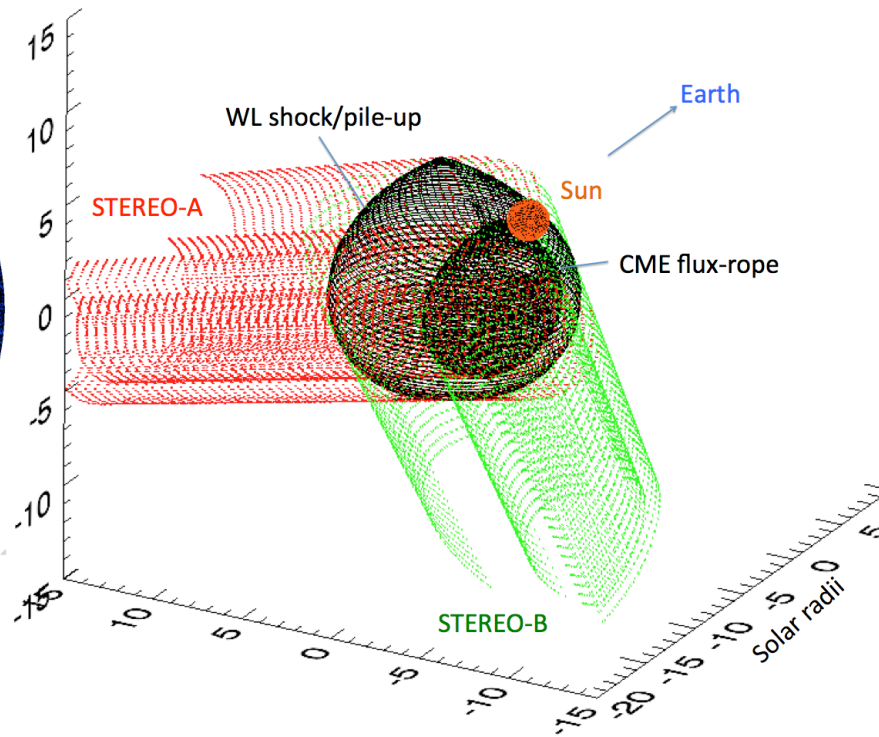
- Example: 7 June 2013 (~quadrature)
- CME with white-light shock/pile-up
- 3D reconstruction: elliptical tie-pointing



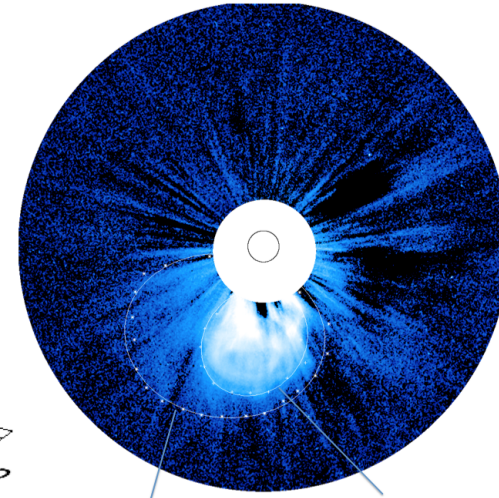
STEREO-A/COR2



WL shock/pile-up CME flux-rope



STEREO-B/COR2



WL shock/pile-up CME flux-rope



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