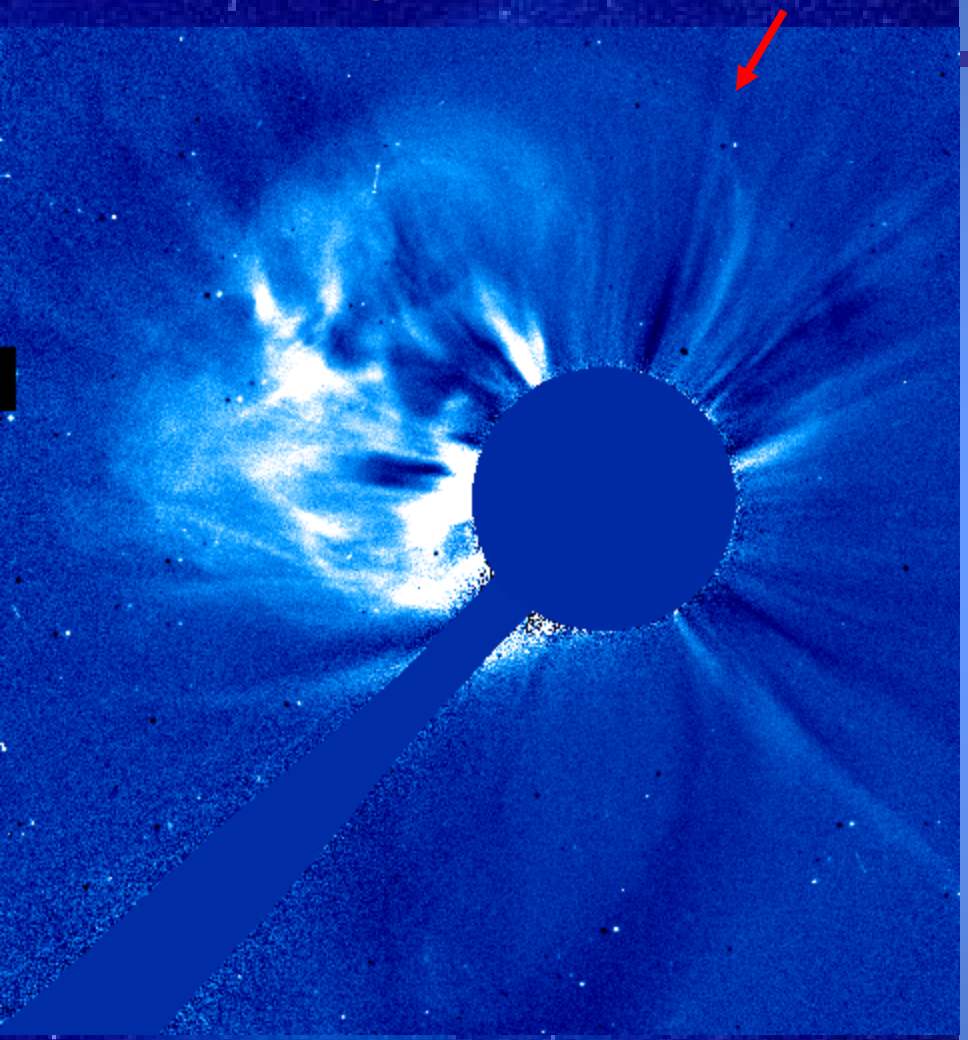
CME-driven Shocks in White Light Observations



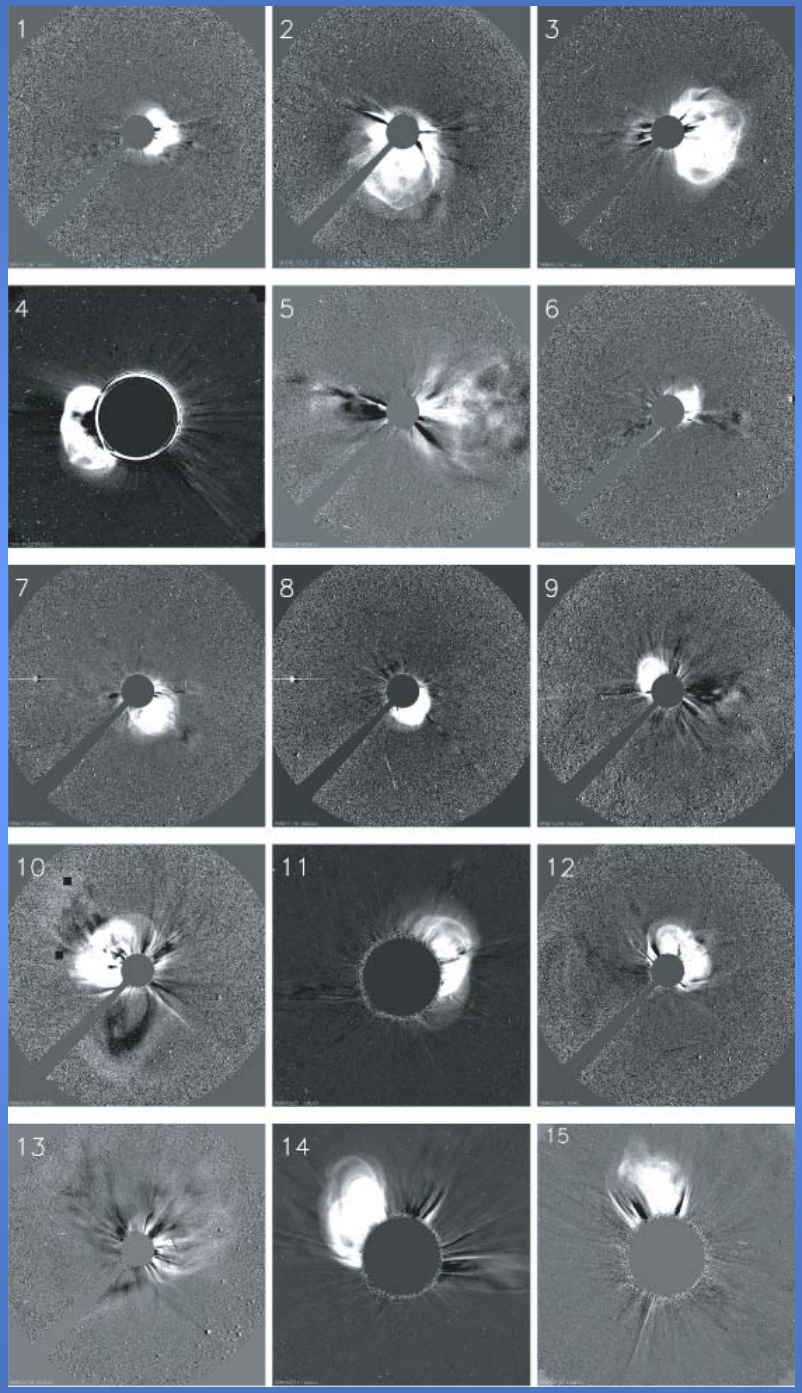
SOHO/LASCO C3 – CME May 5th, 1999

We demonstrate that CME-driven shocks:

(1) can be detected in white light coronagraph images.

(2) can have some of their properties measured (i.e., shock strength).

(3) their propagation direction can be deduced via simple modeling.



Our Data

Events between 1996-1999

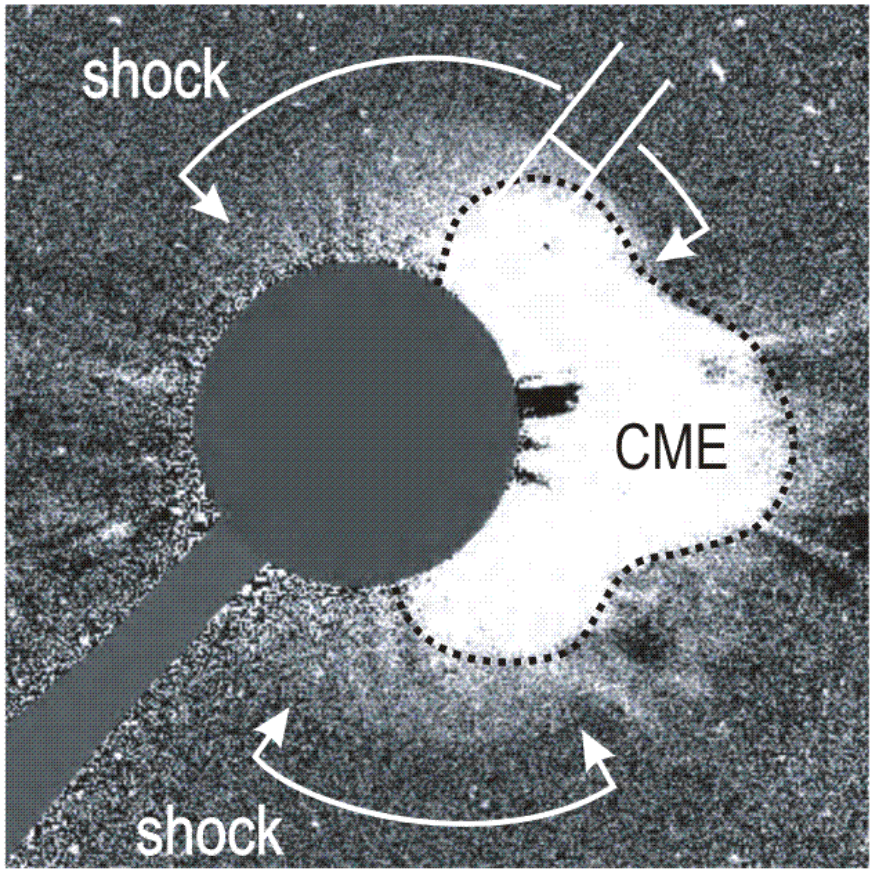
The overall morphology of the white light corona is simple.

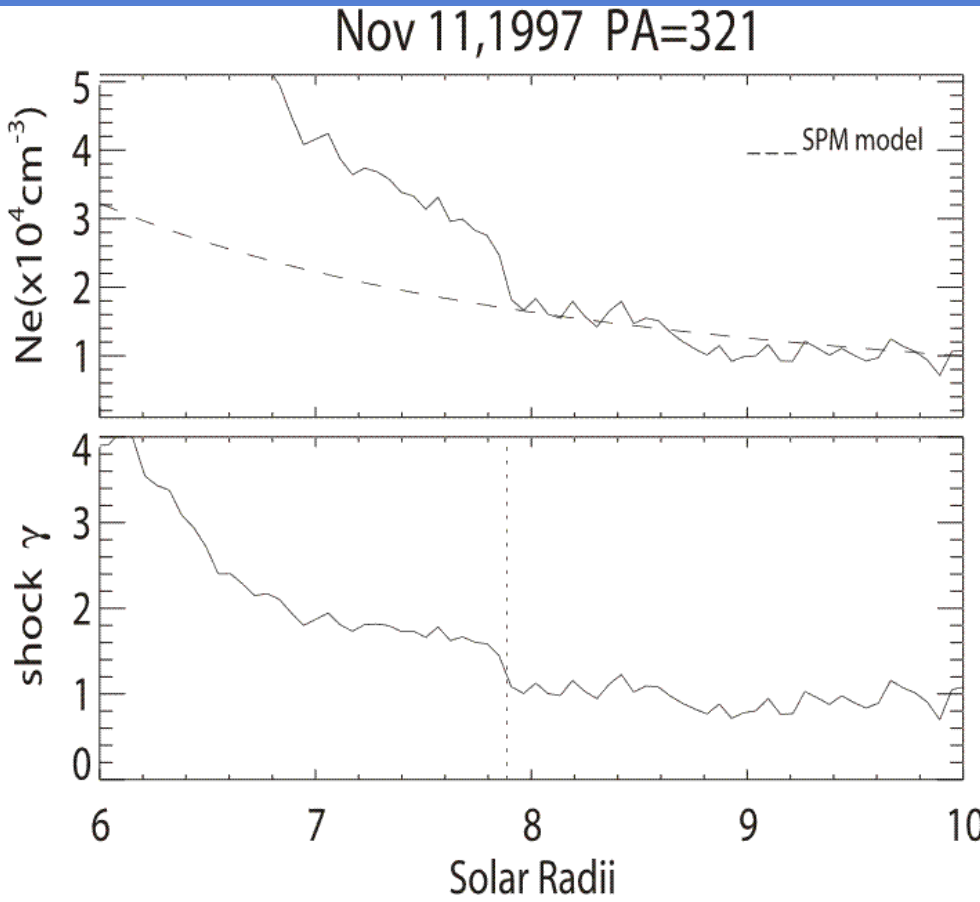
ALL FAST CMEs

V>1500 km/s

Events that will be good candidates to drive a shock.

Quantifying





Ontiveros & Vourlidas, 2008, ApJ Submitted

Quantifying

G1

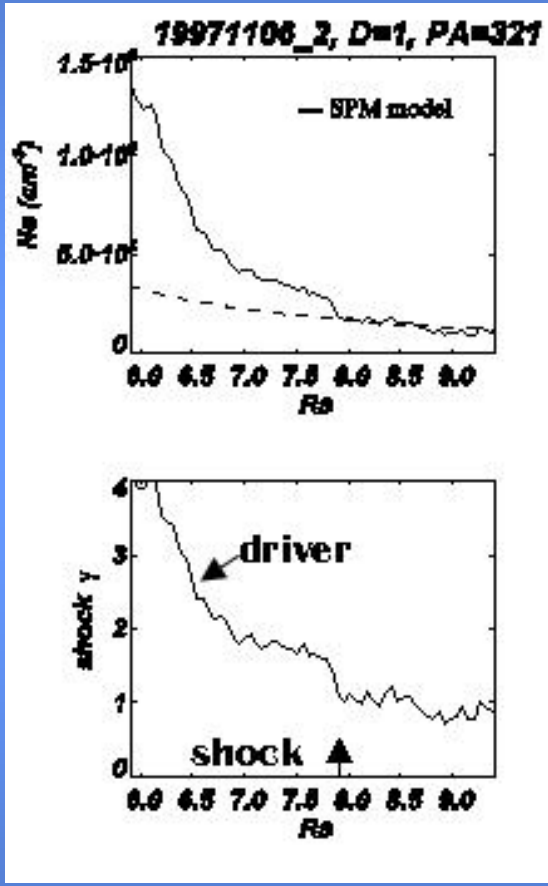


Image ☺ measurement ☺

G2

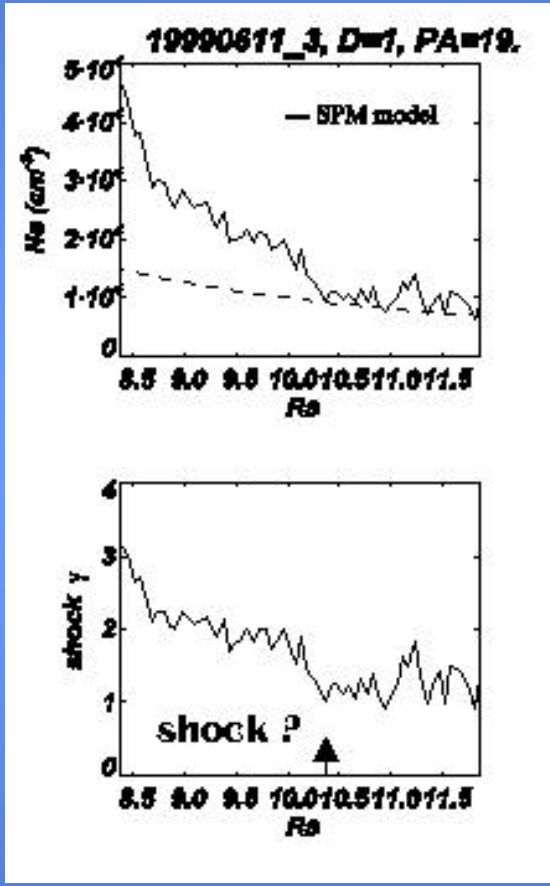


Image ☺ measurement **?**

G3

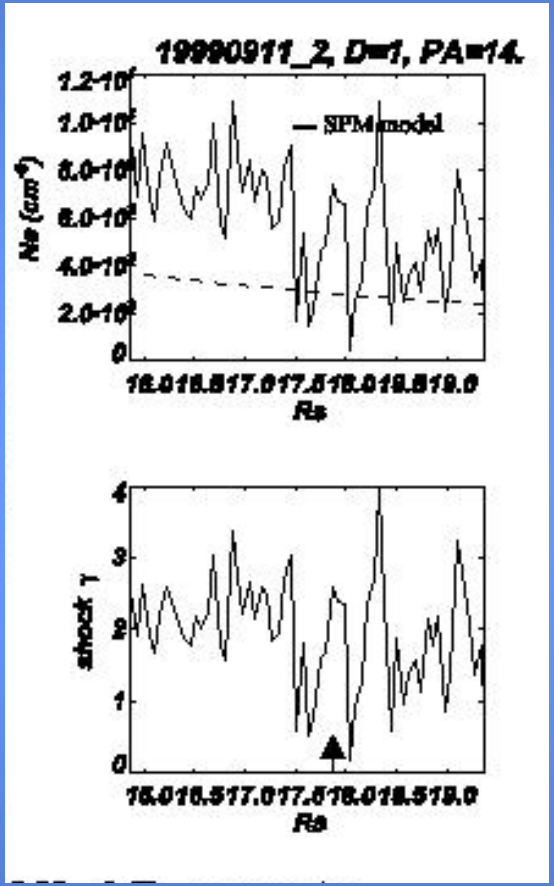
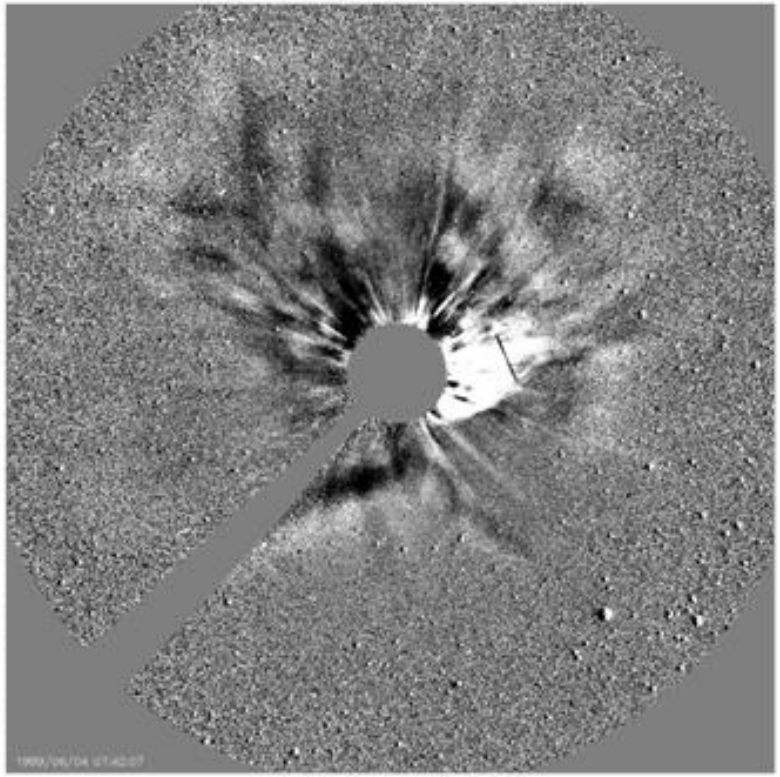


Image ☺ measurement ⊘

Quantifying

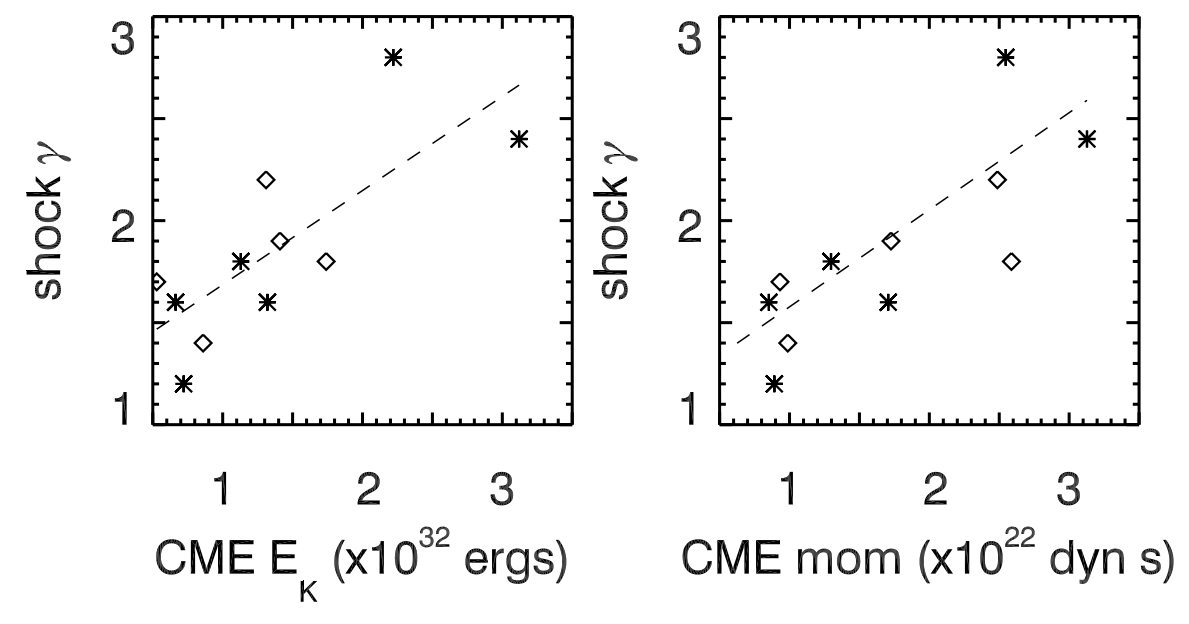
Group 4: no clear white light shock signature



All 15 events

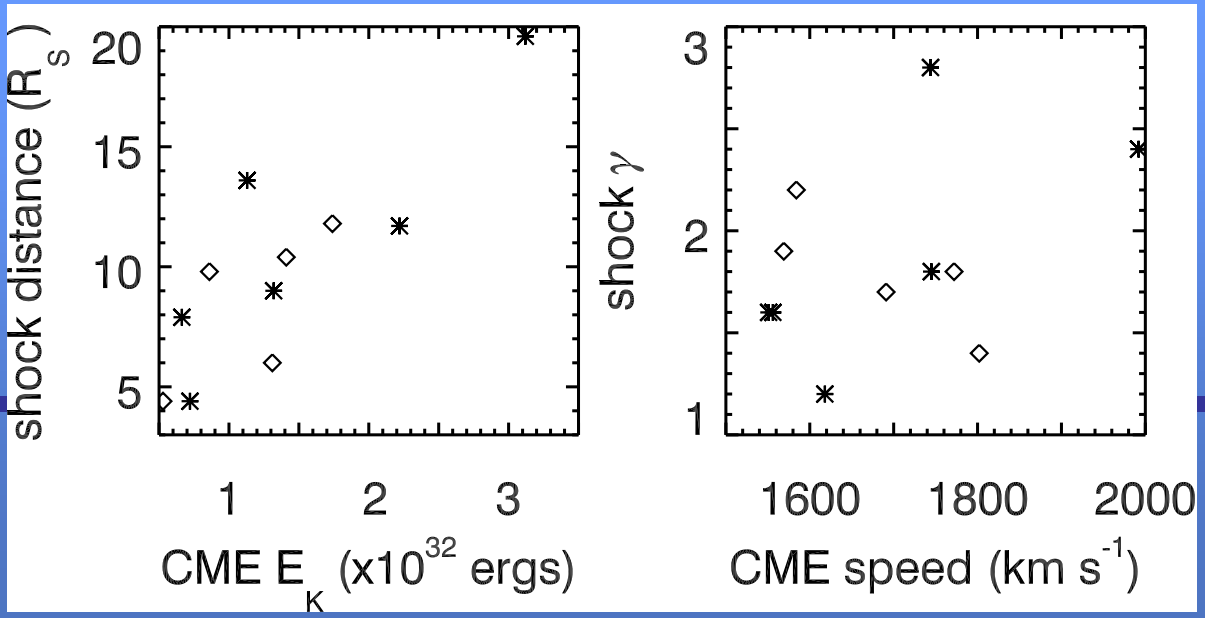
GP	DATE	VEL km/s	AW	HEIGHT Rs	γ	MASS gr (e15)	KIN EN erg(e31)
1	19971106	1556	halo	7.9	1.6	5.5	6.6
1	19980331	1992	halo	19.6	2.4	15.7	31.2
3	19980420	1863	165	23.7		23.5	40.8
1	19980423	1618	halo	4.4	1.2	5.5	7.2
4	19980509	2331	178			8.1	21.9
2	19980604	1802	halo	9.8	1.4	5.3	8.6
1	19981124	1744	halo	11.7	2.8	14.6	22.2
1	19981126	1551	halo	9.0	1.6	11.0	13.2
1	19981218	1745	halo	13.6	1.8	7.4	11.3
2	19990503	1584	halo	6.0	2.2	10.4	13.1
2	19990527	1691	halo	4.4	1.7	3.7	5.2
2	19990601	1772	halo	11.8	1.8	11.1	17.4
4	19990604	2230	150			2.6	6.5
2	19990611	1569	181	10.4	1.9	11.4	14.1
3	19990911	1680	120	17.9		2.6	3.6

Results



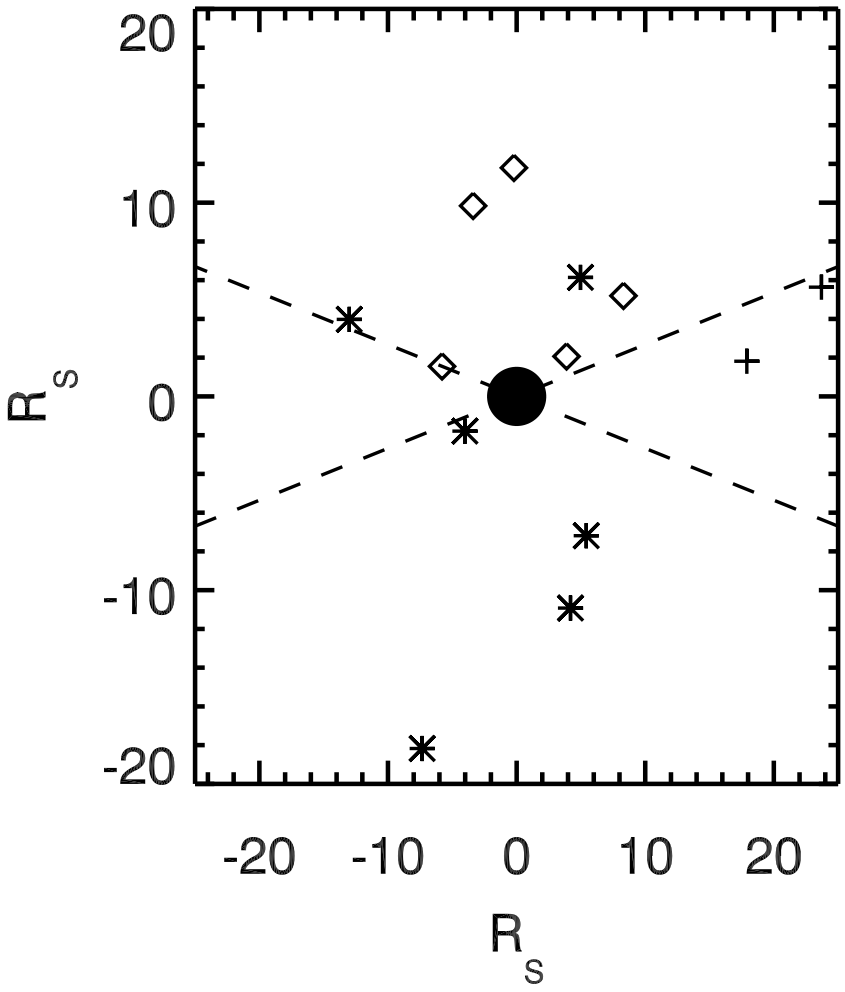
Kinetic Energy
CC=0.7

Momentum
CC=0.8



Speed high enough to create a shock, but not the best correlated parameter

Results



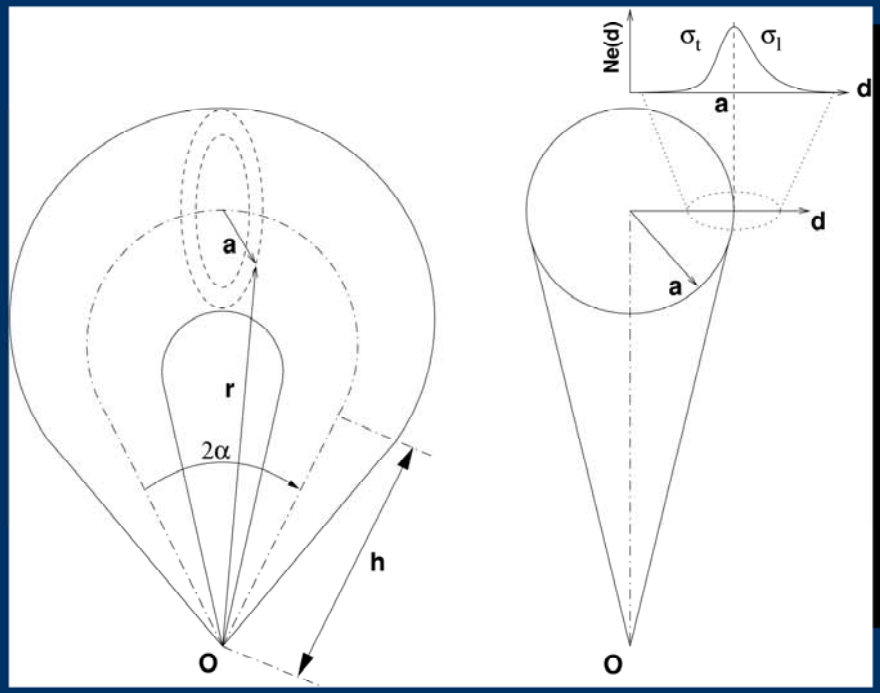
WHERE IS EASIER TO OBSERVE THE SHOCK SIGNATURE?

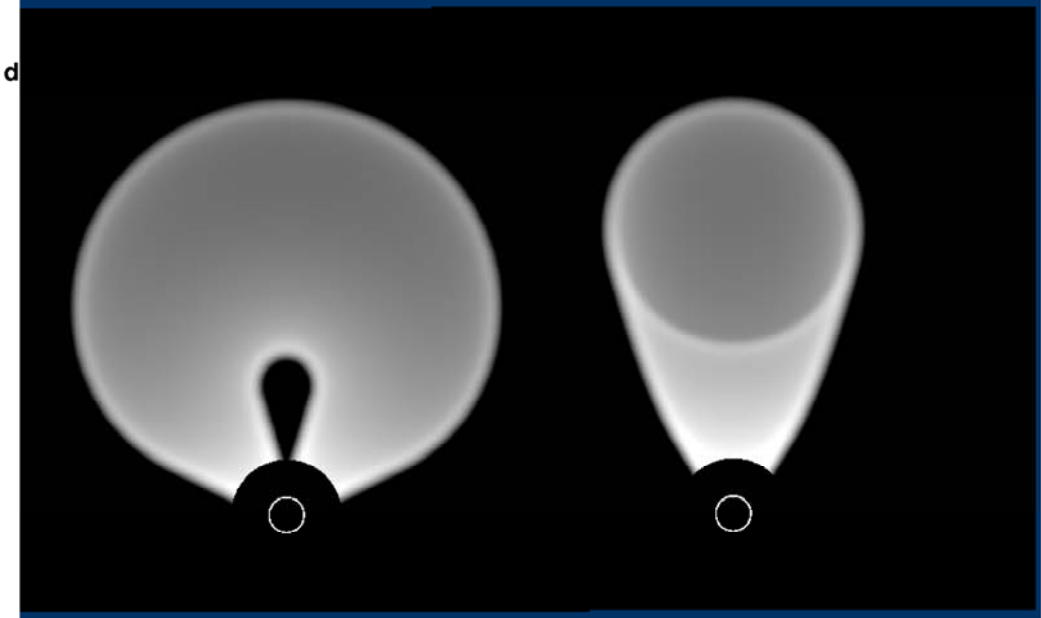
15 degrees above or below the Solar Equator

streamers make difficult the shock observation

A Geometric Flux Rope Model

The Hollow Croissant Model

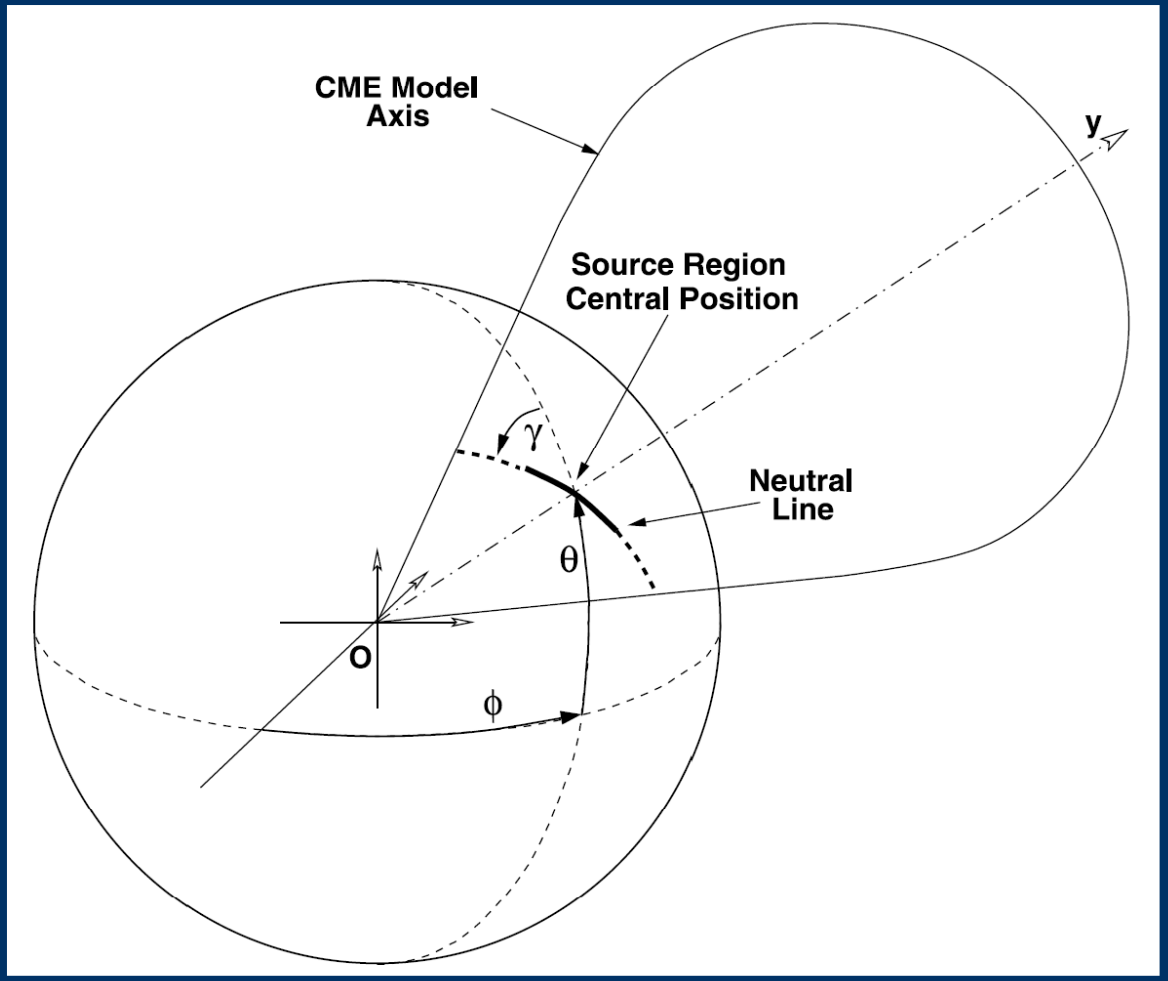




Slides courtesy of A. Thernisien

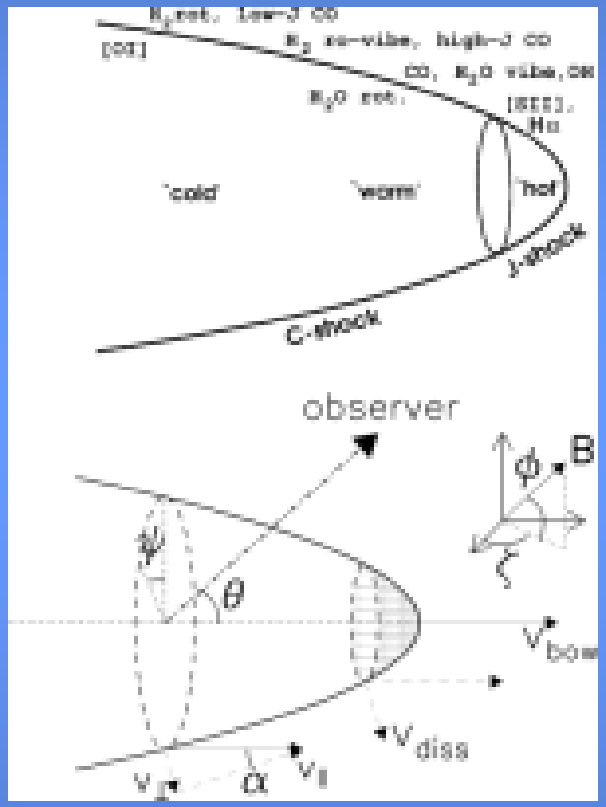
Positioning the Model

Using one view



Use position the SR detected by EIT: it has to be visible !

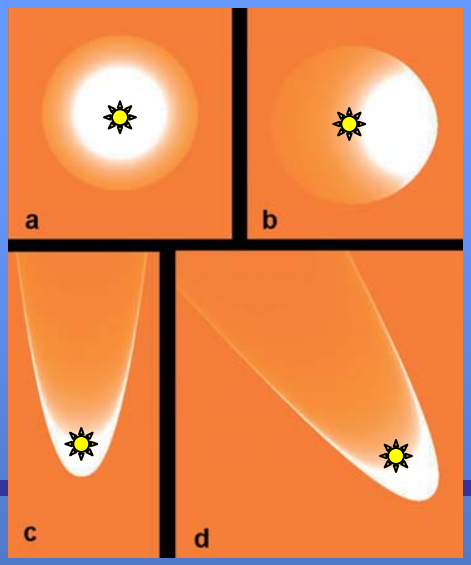
Bow-shock model (Smith et al 2003)

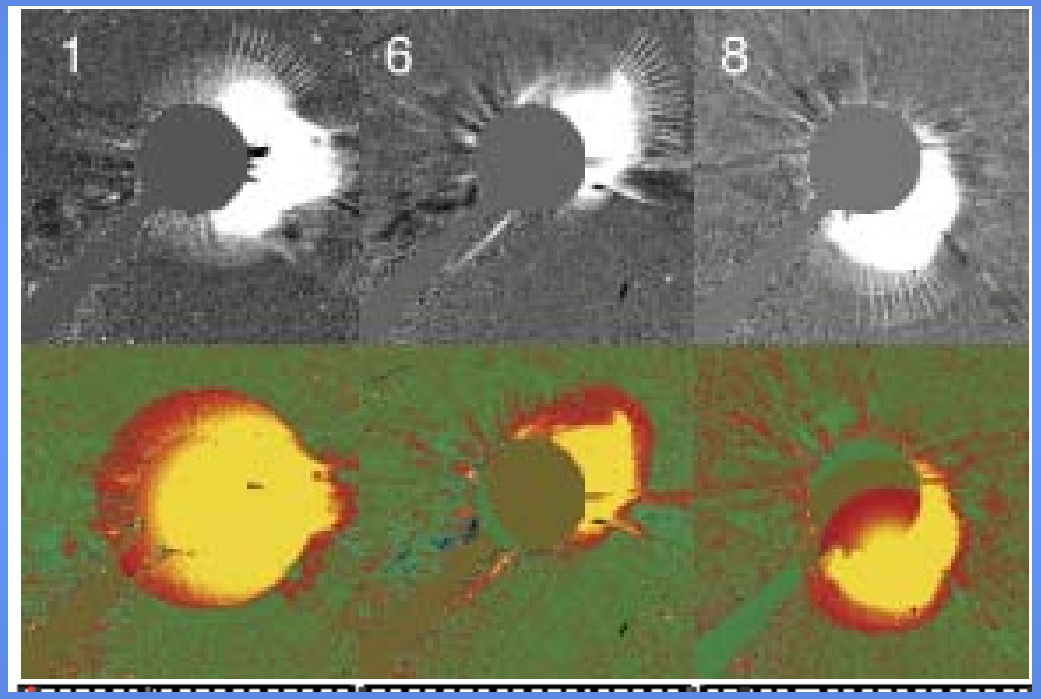


$$\frac{z}{d} = \frac{1}{s}\left(\frac{R}{d}\right)^{s}$$

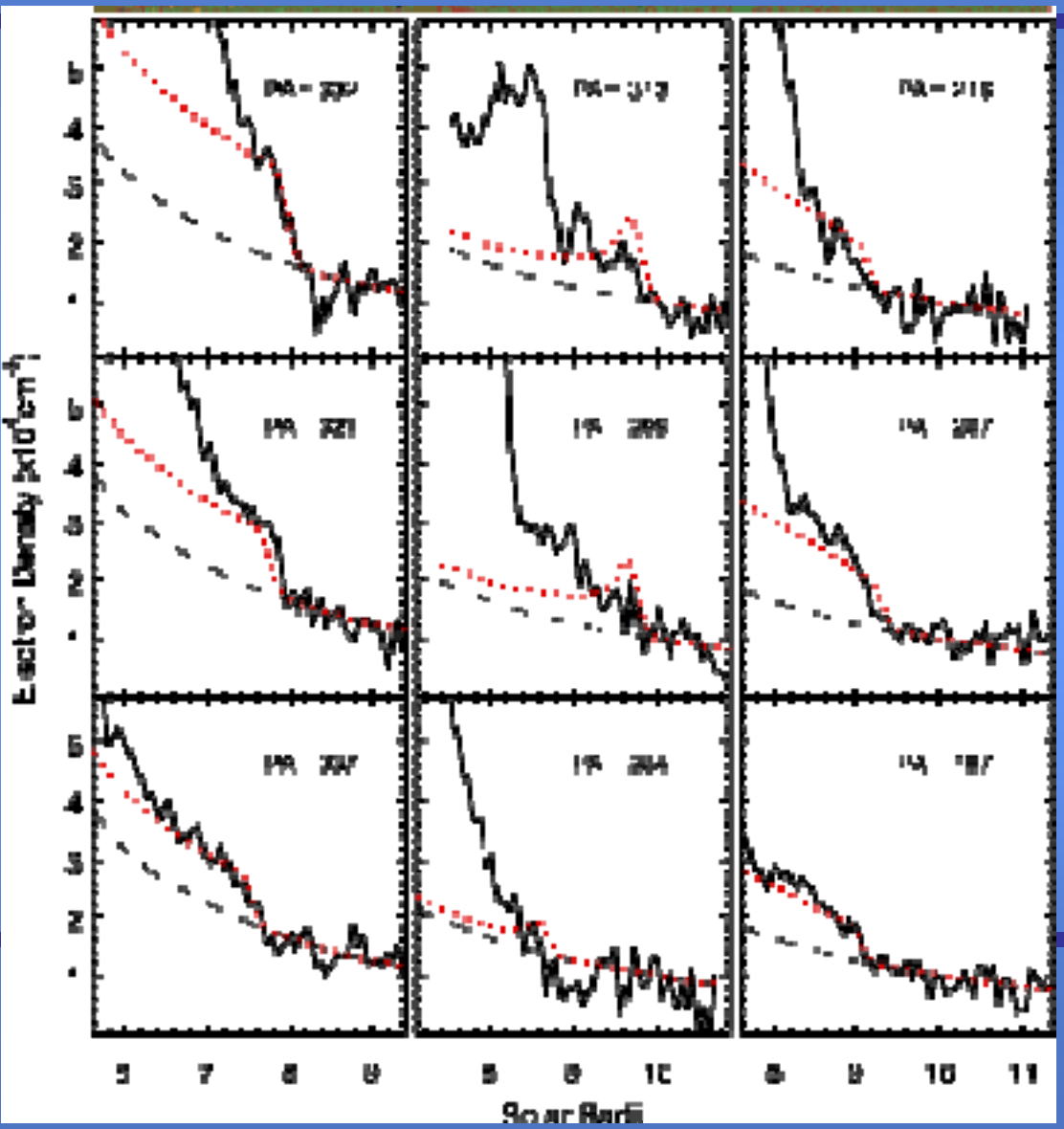
Solar Corona Raytrace

Simulated white light images for a bow-shock model observed through different lines of sight.
(a) Along the Sun-Earth line
(b) 10◦ west
(c) 90 ◦ south
(d) 45◦ west, 45◦south





Solar Corona Raytrace



Comparison of Modeled Shock Orientation and CME Source Regions

event	shock nose	source region
971106	S13W56	S18W63
980604	N47W138	N43W107
981126	S38W108	S26W134

Discrepancy

latitude <12 deg
longitude < 31 deg

Ontiveros & Vourlidas, 2008, ApJ Submitted

Summary and Conclusions

• 13/15 of these events exhibited a sharp but faint brightness enhancement ahead or at the flanks of the CME over a large area, which we interpret as the white light counterpart of the CME-driven shock.

• All halo CMEs (10 events) have at least one location with such a shock signature. This is consistent with a shock draping all around the CME driver.

• The clearest white light signatures were found 15 deg above or below the solar equator, irrespective of heliocentric distance.

Summary and Conclusions

• We found only a weak dependence between the shock strength (γ) and the CME speed.

• We found stronger correlations between the density jump and the kinetic energy (cc=0.77) and between density jump and the momentum (cc=0.80).

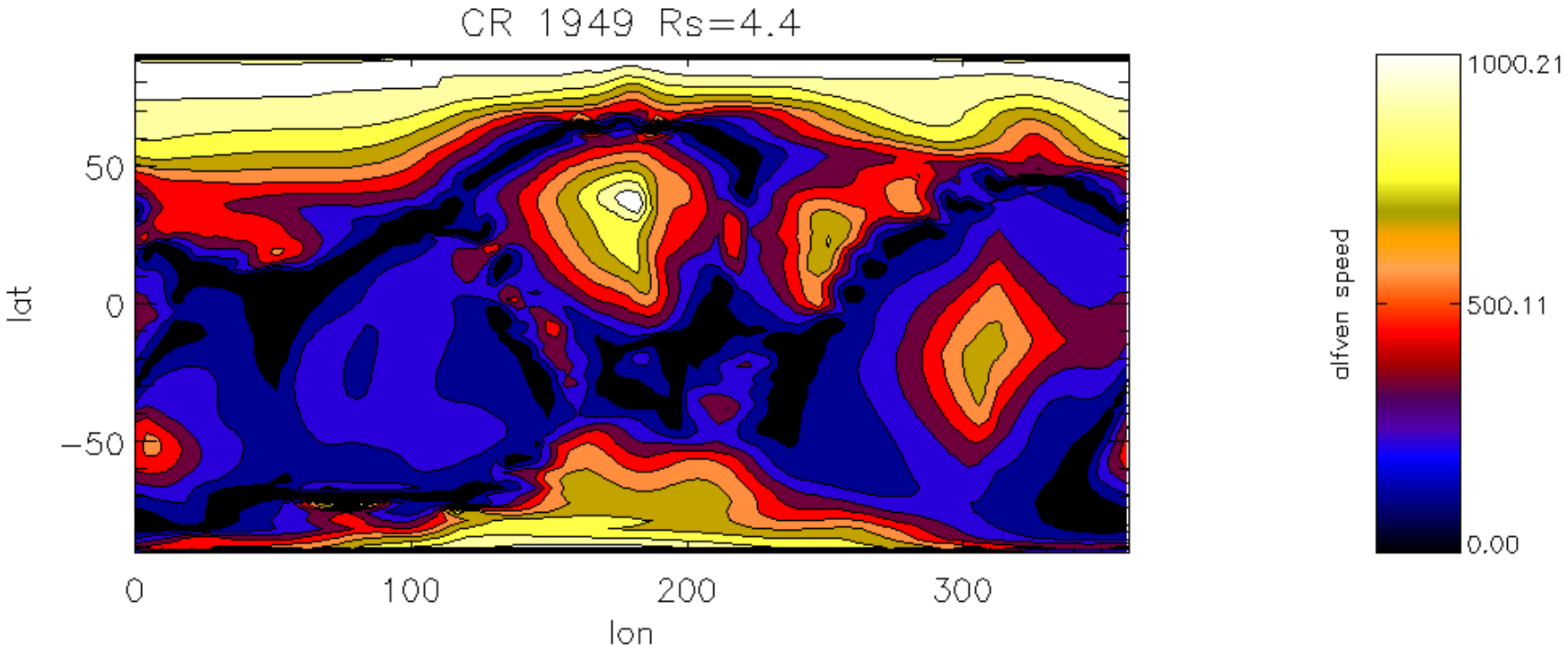
• The observed density profiles are the result of line-of-sight integration through a thin shock and sheath and not with a step jump as the observed shocks from in-situ measurements.

•We also found that our modeled 3D shock direction is in very good agreement with the expected direction of the CME assuming radial propagation from the source region.

Future Directions

- Coronal Alfvén speed maps (w/ Riley)
- Forward-model fitting of both CME (driver) and shock
- Investigate spatial relation between shock/source region

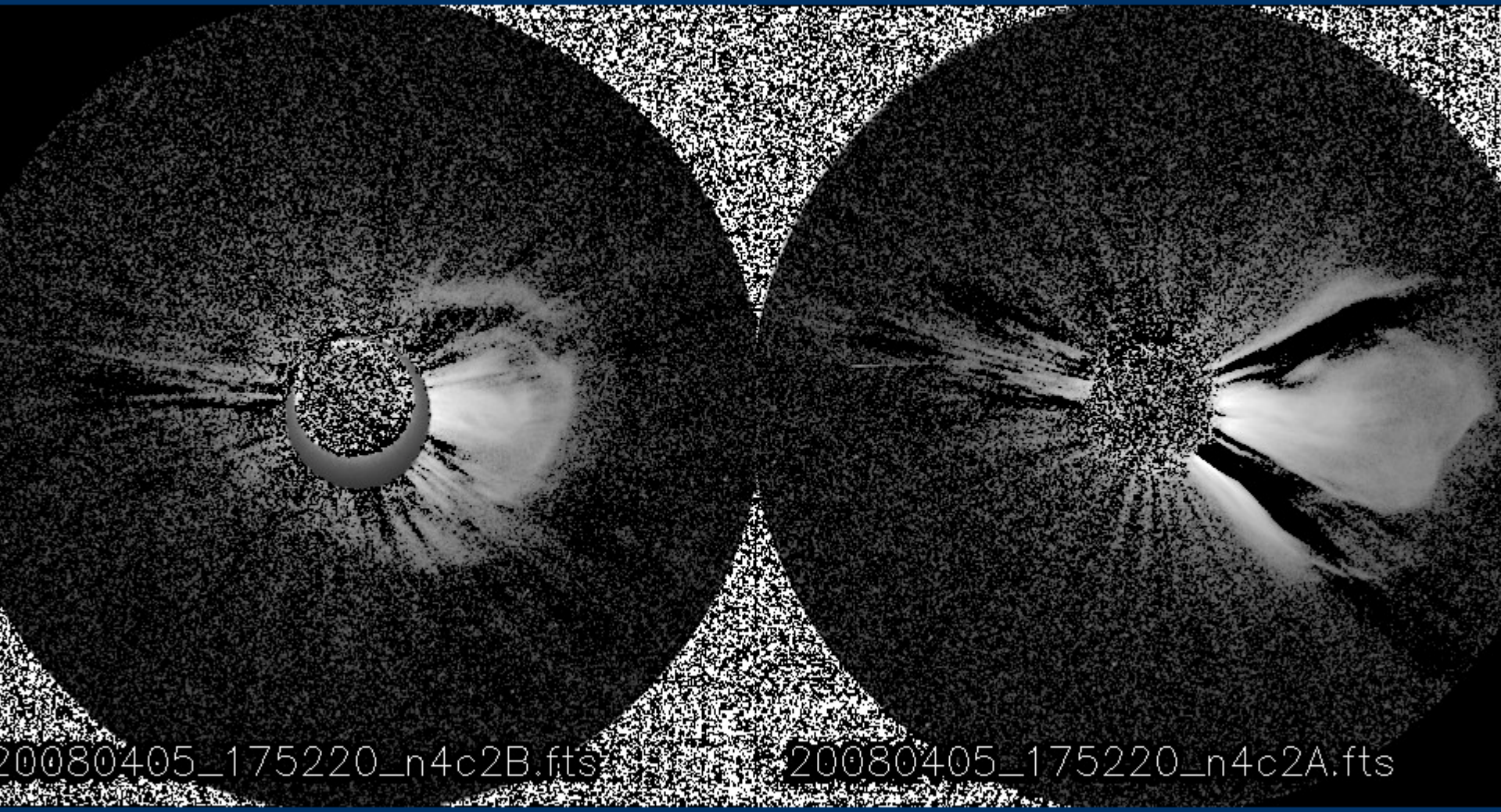
Where?



SOHO/LASCO C3 – CME May 5th, 1999

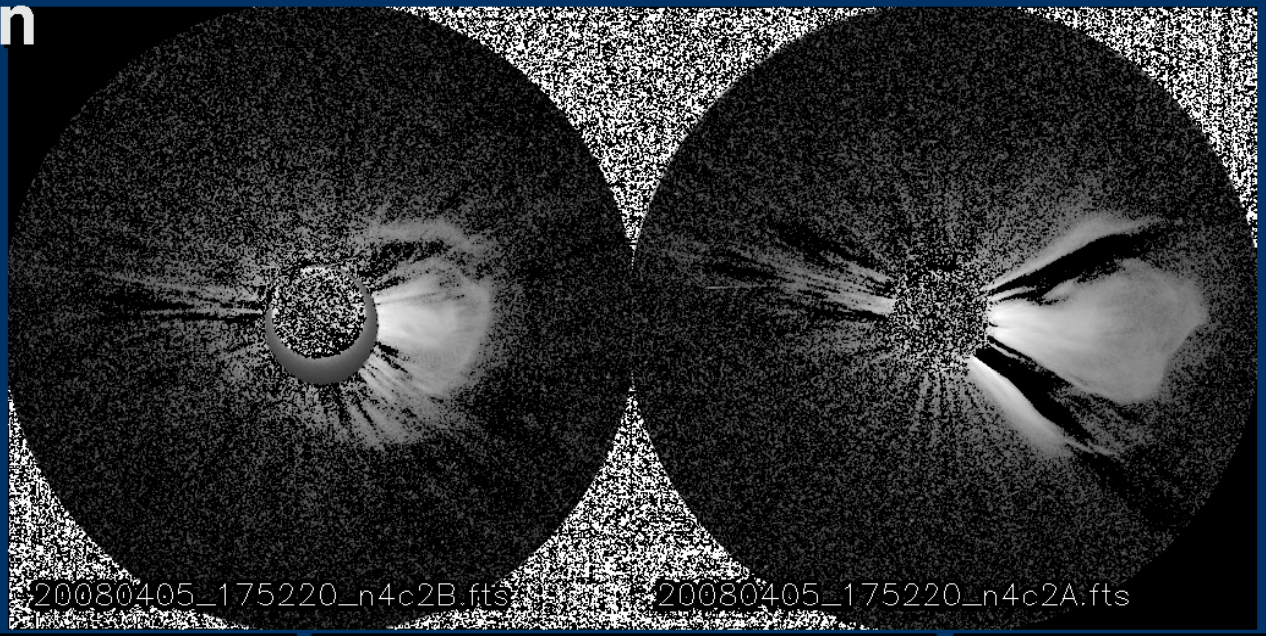
Event of 2008 Apr 05

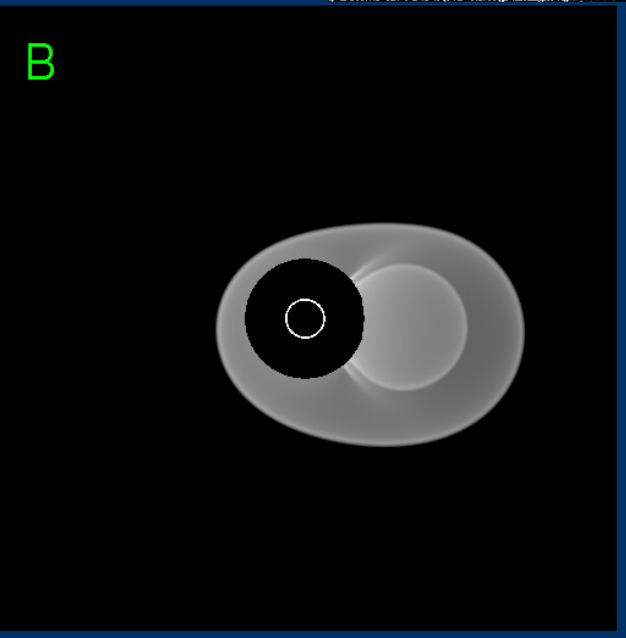
Movie

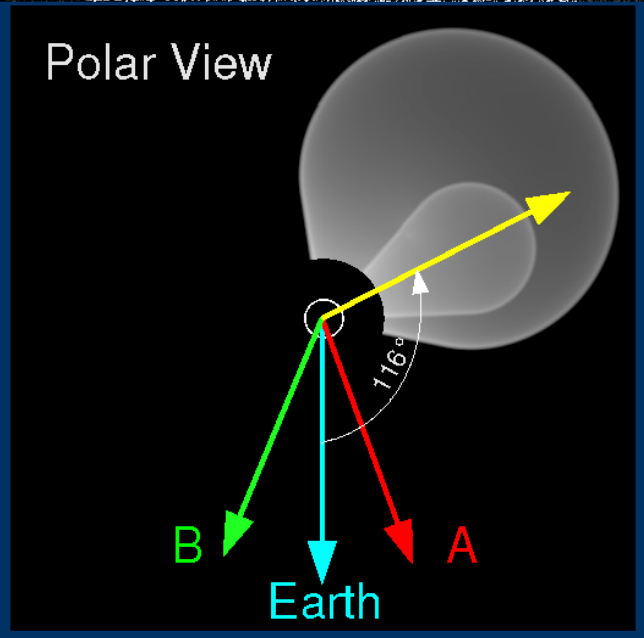


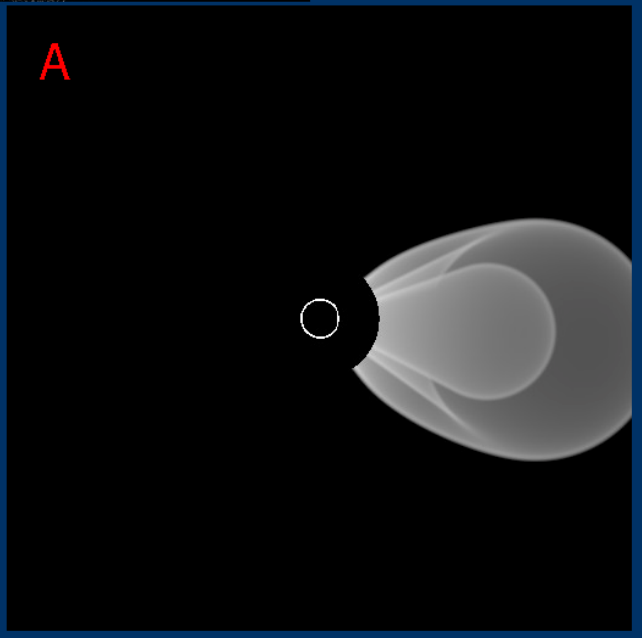
Event of 2008 Apr 05

Direction

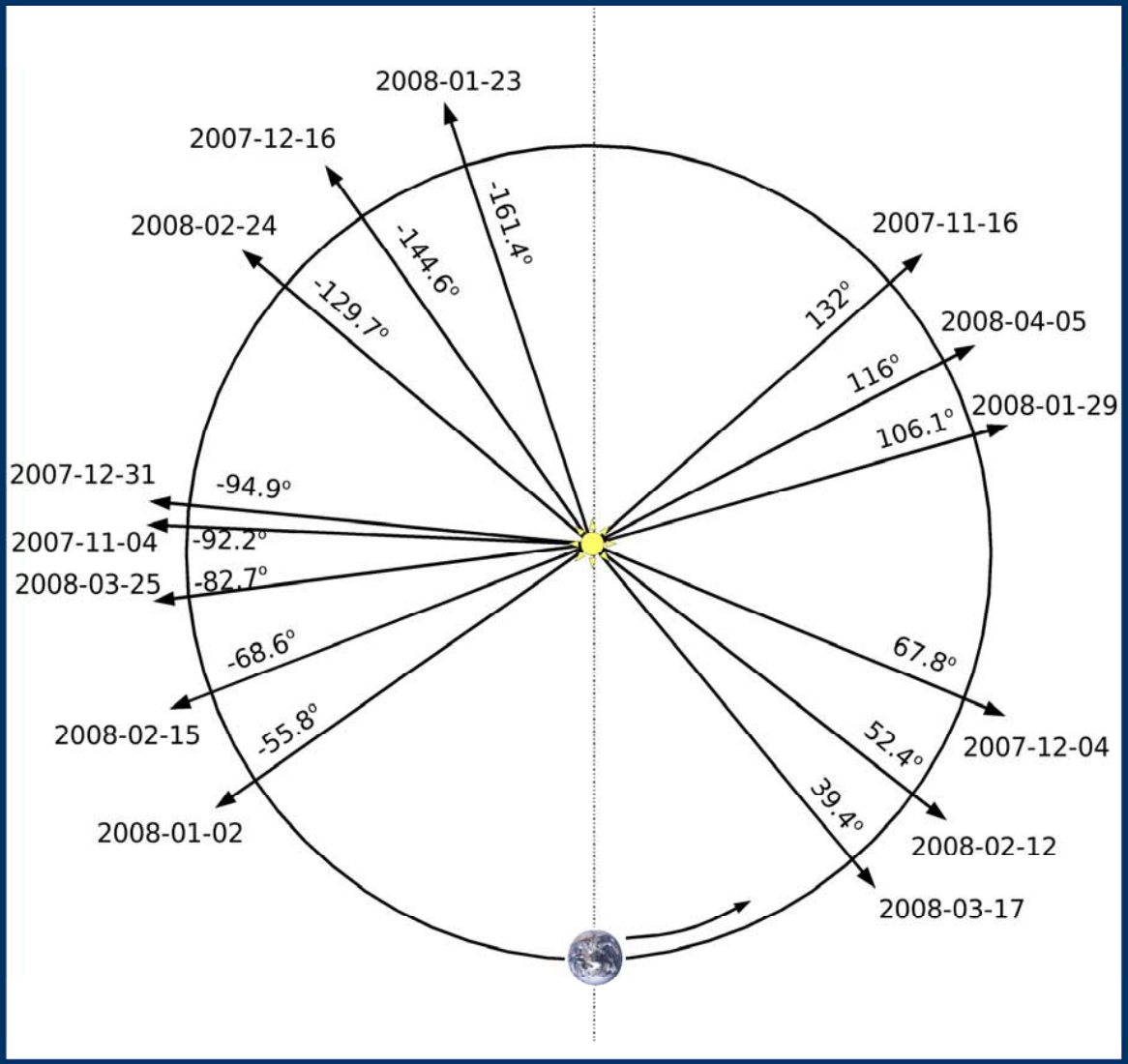




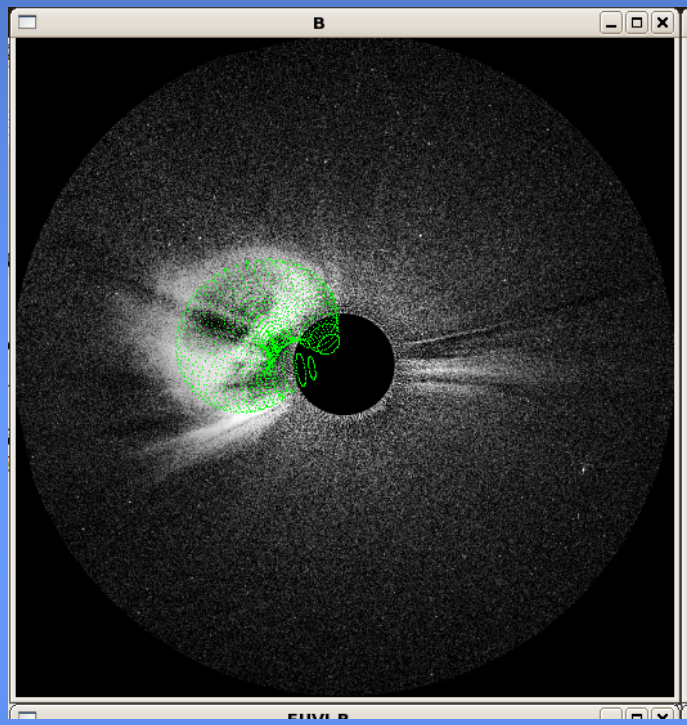




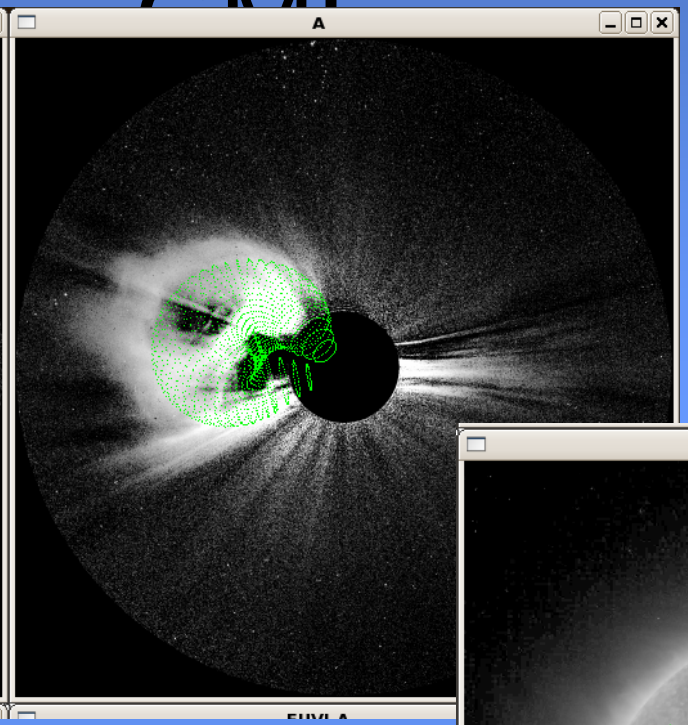
Summary for the 14 studied CMEs



Localizing the source of the CME

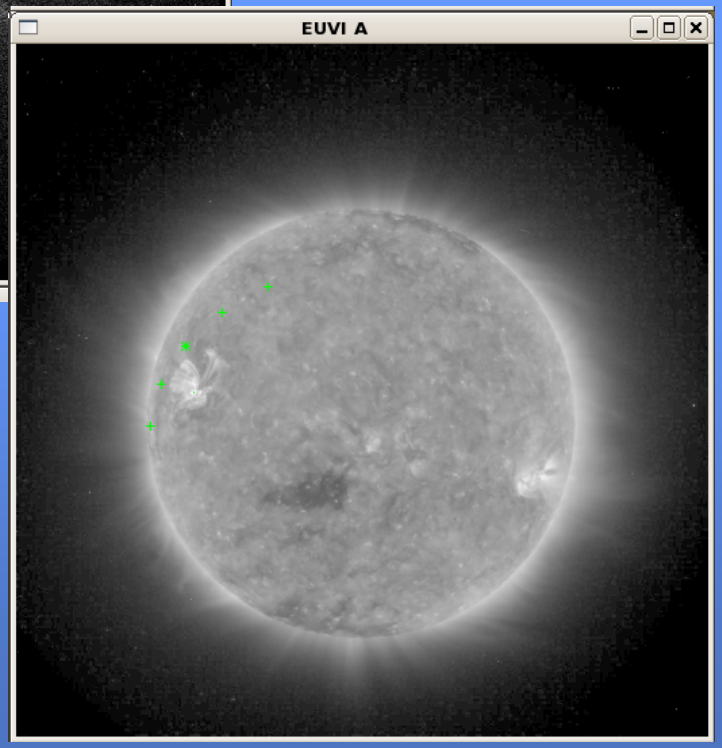


COR2B



COR2A

EUVI



Thernisien et al, work in progress