

Determination of CME 3D Trajectories using Stereoscopy

STEREO CMES of 16Nov2007 and 31AUG2007

*Have previously demonstrated 3D trajectory determination
using synthetic white light data*

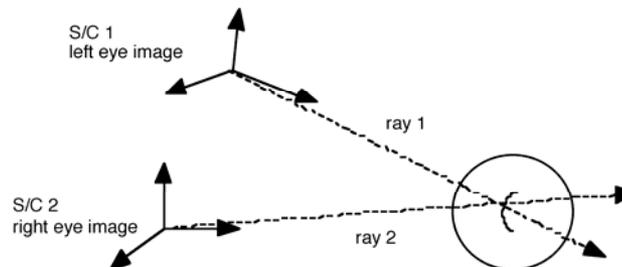
*Here, demonstrate 3D CME trajectory determination using
SECCHI AB pairs*

*P. C. Liewer, E. M. DeJong, J. R. Hall, JPL/Caltech;
R. A. Howard, NRL; W. Thompson, GSFC and the SECCHI Team*
STEREO SWG, Paris, April 2008



Stereoscopy and STEREO/SECCHI

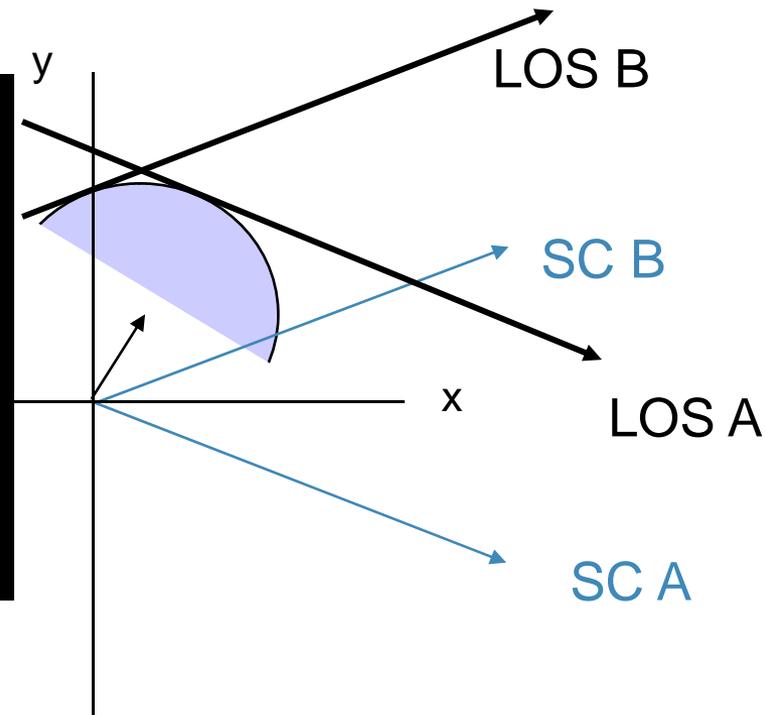
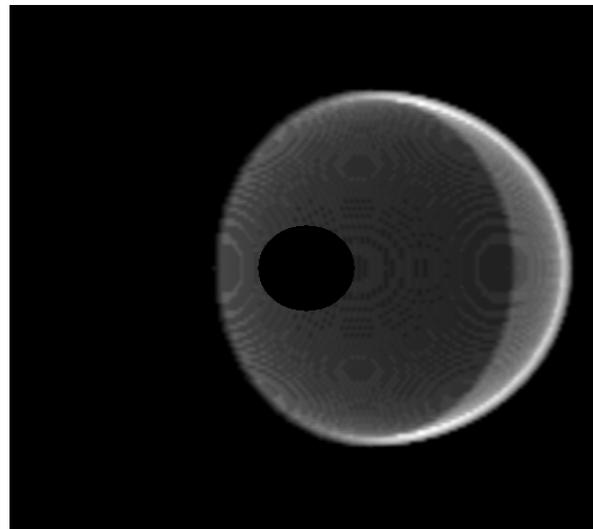
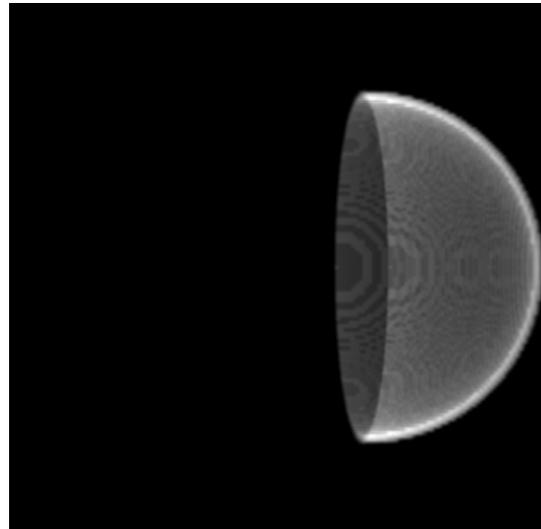
- SECCHI uses World Coordinate System (WCS) solar soft routines to relate image plane coordinates to heliocentric coordinate systems (see *W. Thompson, A & A, 2005, MS 4262thom*)
 - Need location of spacecraft A&B (from ephemeris), pixel size (arcsec), and pixel location of Sun-center ($x_{\text{SUN}}, y_{\text{SUN}}$).
- Each pixel defines a unique ray
 - In a single 2D image, feature can be anywhere along ray
 - In 3D, if perfect tiepointing, rays intersect at feature
- Triangulation program locates feature at point of closet approach of the two rays



Stereoscopy of CMEs vs Localized Structures

- Bright localized coronal structures (loops, filaments) can be reconstructed in 3D from SECCHI A+B image pairs using stereoscopy
- Because CMEs are so diffuse, stereoscopy on line-of-sight (LOS) coronagraph images gives approximate 3D location of CME “edges”

COR2 - SC A at -20° COR2 - SC B at $+20^\circ$



*Synthetic image pair from hemisphere shell
CME model*

STEREO CME November 16, 2007 COR2

LASCO CME 20072226.092608 - Behind limb for all 3 SC

Nov 16, 2007
08:37:54

Nov 16, 2007
08:37:54

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

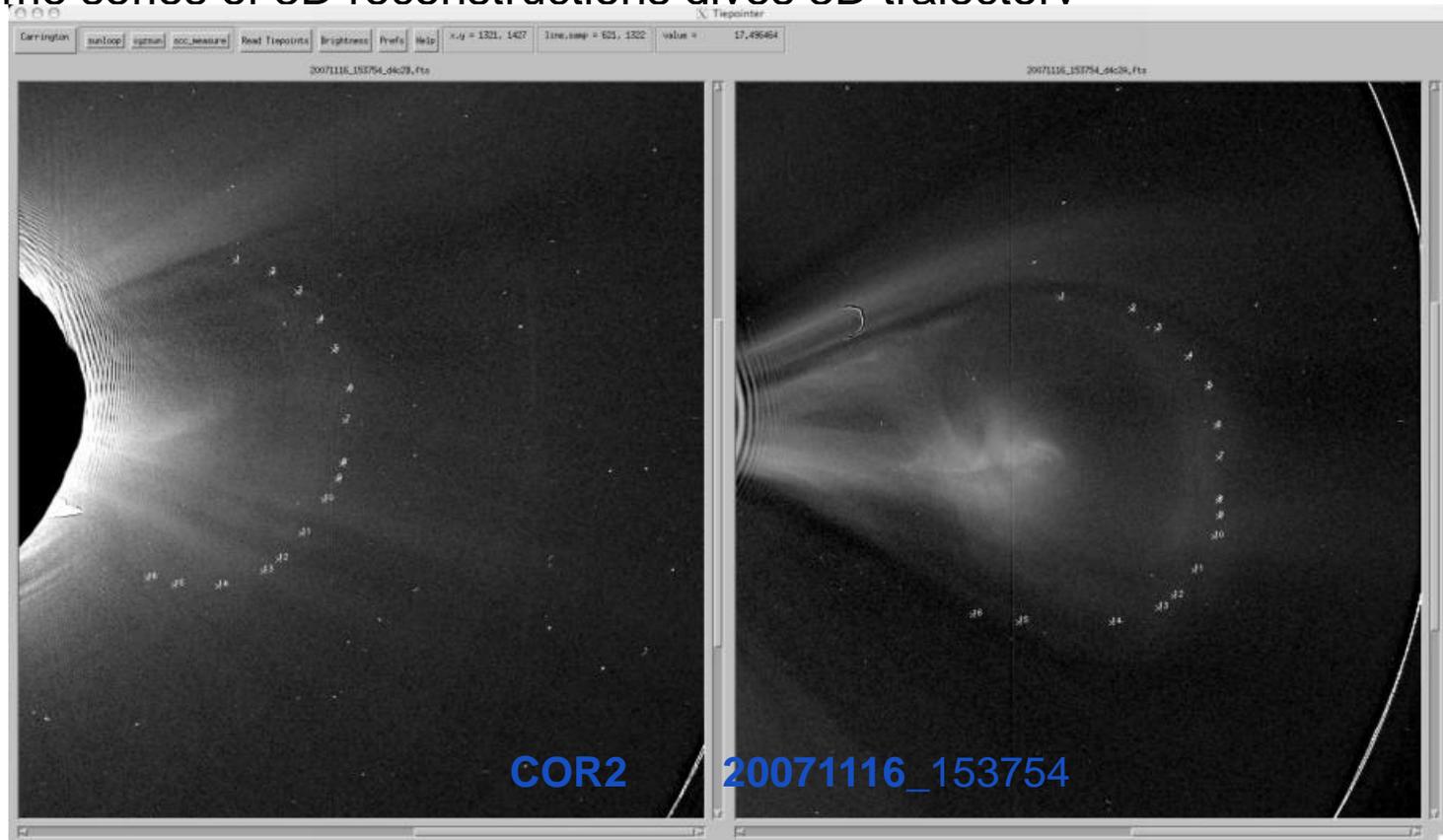
QuickTime™ and a
H.264 decompressor
are needed to see this picture.

COR2 B

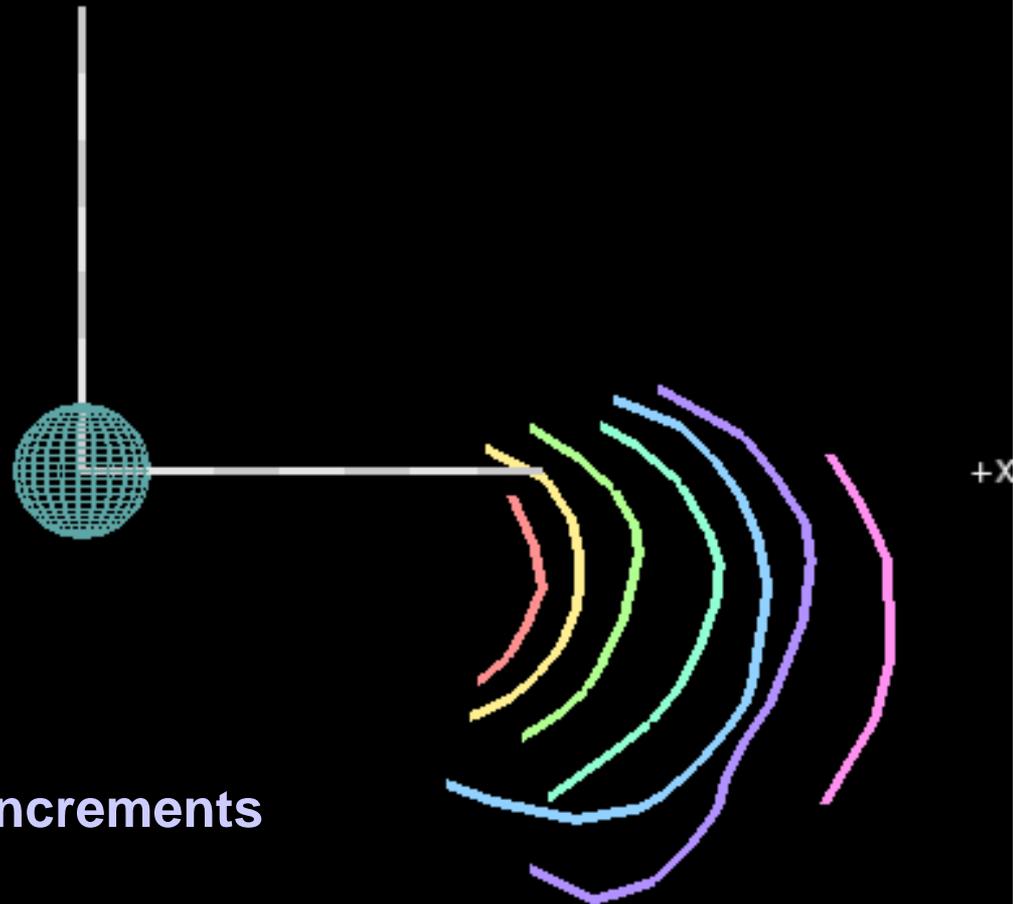
COR2 A

Determination of 3D CME Trajectories

- CME visible in both STEREO A & B with obvious difference in height
 - $\sim 40.4^\circ$ separation between A&B on November 16, 2007
- User marks same features on CME in both images of COR2 AB pair
 - Tiepoints are constrained to lie in epipolar line
 - Here, tiepointing the leading edge of CME only
- Triangulation program finds 3D coordinates in heliocentric system
- Time series of 3D reconstructions gives 3D trajectory



3D Reconstruction of CME Leading Edge



7 times - half hour time increments

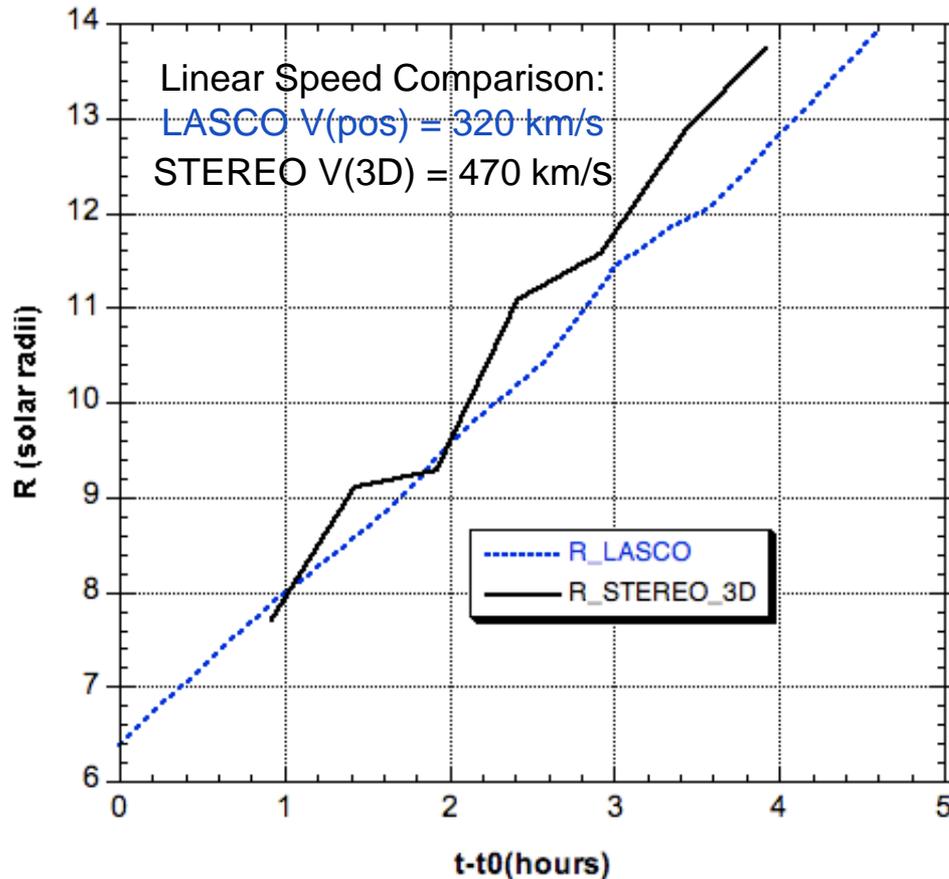


3D Reconstruction of CME Leading Edge

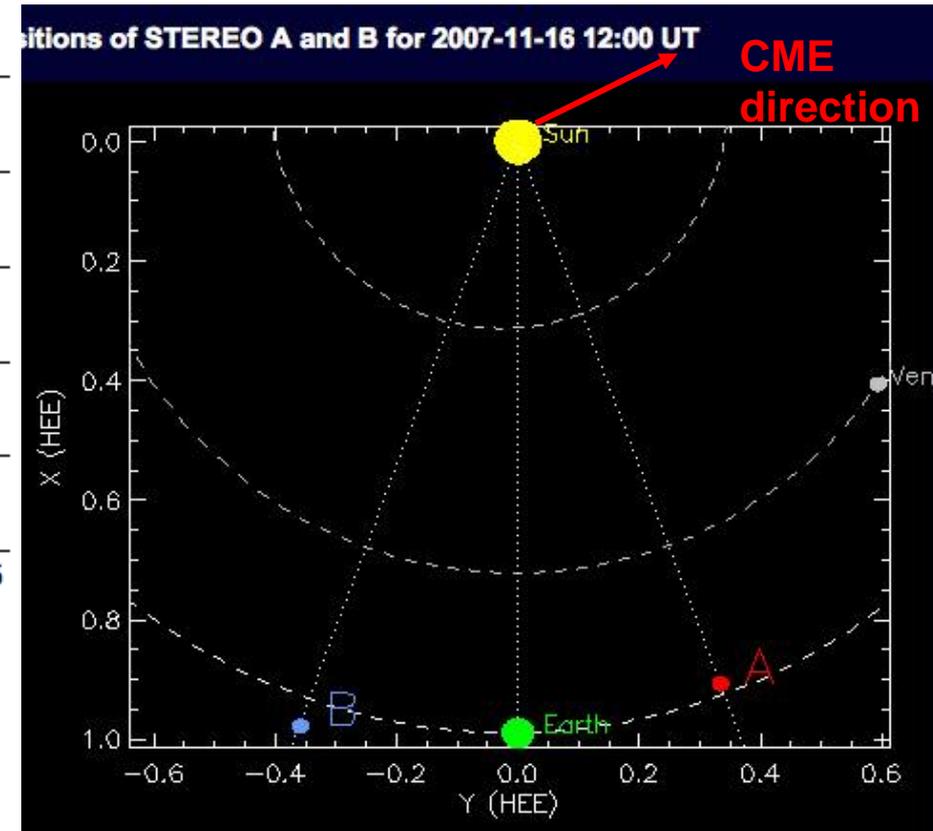
QuickTime™ and a
decompressor
are needed to see this picture.

CME Trajectory and Comparison with LASCO

Comparison of LASCO & STEREO-3D Height-Time for 16Nov2007 CME



Carrington longitudes
 B = 181° Earth = 201° A = 221°
 CME = 315°
 CME in A's Plane of Sky!



STEREO Prominence & CME August 31, 2007

LASCO data gap: only caught trailing end

Aug 31, 2007
18:06:15

Aug 31, 2007
18:06:15

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

EUVI 304 B

EUVI 304 A

STEREO Prominence & CME August 31, 2007

LASCO data gap: only caught trailing end

Aug 31, 2007
20:00:00

Aug 31, 2007
20:00:00

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

COR1 B

COR1 A

STEREO CME August 31- September 1, 2007

LASCO data gap: only caught trailing end

Aug 31, 2007
20:37:30

Aug 31, 2007
20:37:30

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

COR2 B

COR2 A

3D Reconstruction of Erupting Prominence

August 31, 2007

EUVI 304 data from
A + B

**Long filament:
pre-eruption**

Every 2.5 mins
during eruption

CR Lat = -30°
CR Long = 194°

B = 131°
Earth = 143°
A = 159°

QuickTime™ and a
decompressor
are needed to see this picture.

3D Reconstruction of CME Leading Edge

August 31 - September 1, 2007

COR2 data, A + B

~30 min increments

**COR1 - only lowest
reconstruction**

CR Lat = -20°

CR Long = 210°

B = 131°

Earth = 143°

A = 159°

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

20070831_220500 to
20070901_033730

3D Reconstruction of Cavity Leading Edge

August 31, 2007

COR1 data, A + B

**5 minutes
increment**

About 1 hr total

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

20070831_204500 to
20070831_215000

3D Reconstructions of Prominence + Leading Edges of both Dark Cavity and CME

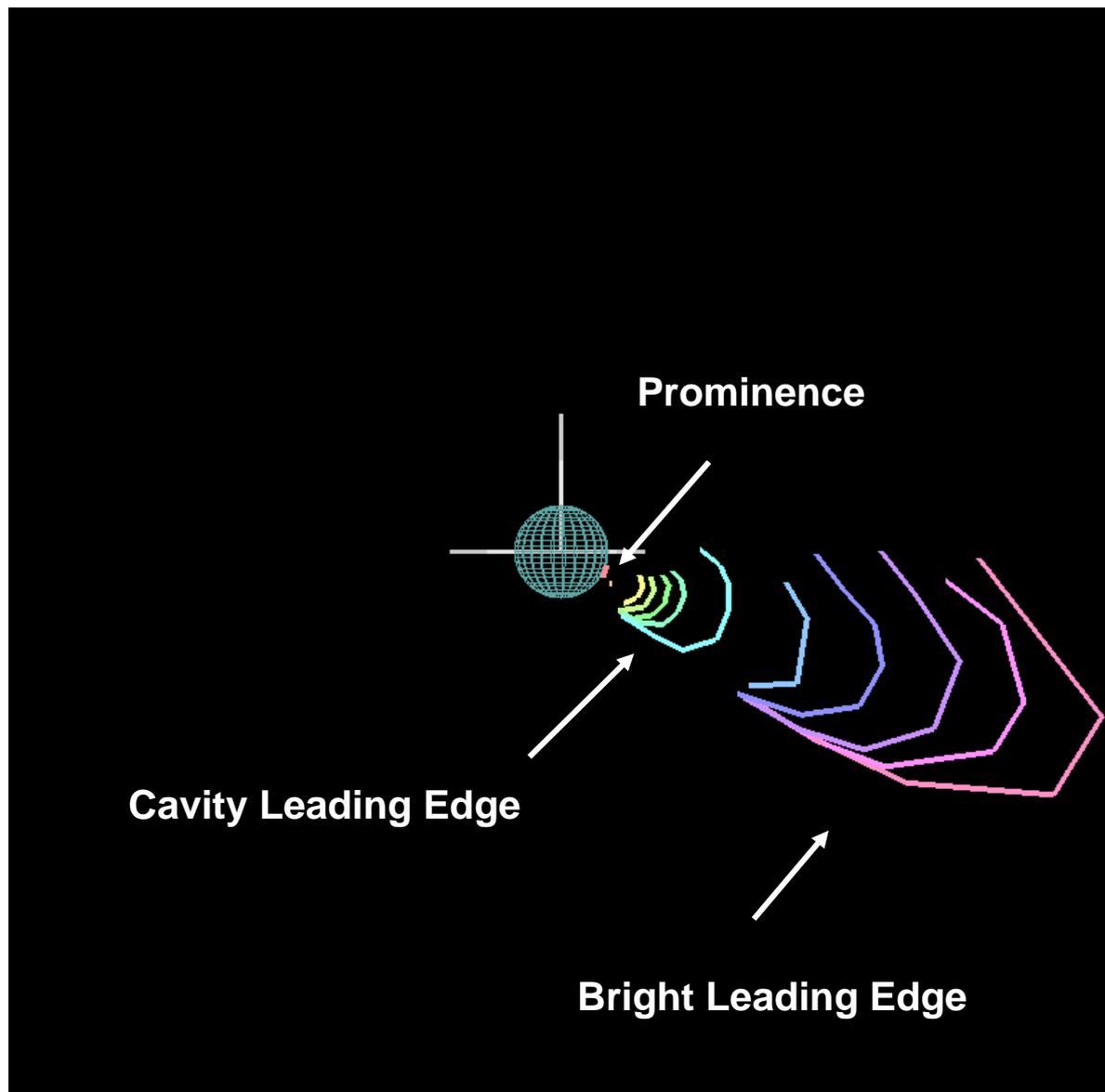
August 31, 2007

EUV 304, COR1,
COR2 data, A + B

Various times
covering 7 hours

Software works
across multiple
FOVs!

20070831_161615 to 20070901_030730



3D Reconstructions of Prominence + Leading Edges of both Dark Cavity and CME

August 31, 2007

**EUV 304, COR1,
COR2 data, A + B**

**Various times
covering 7 hours**

Note all line up!

QuickTime™ and a
decompressor
are needed to see this picture.

20070831_161615 to 20070901_030730

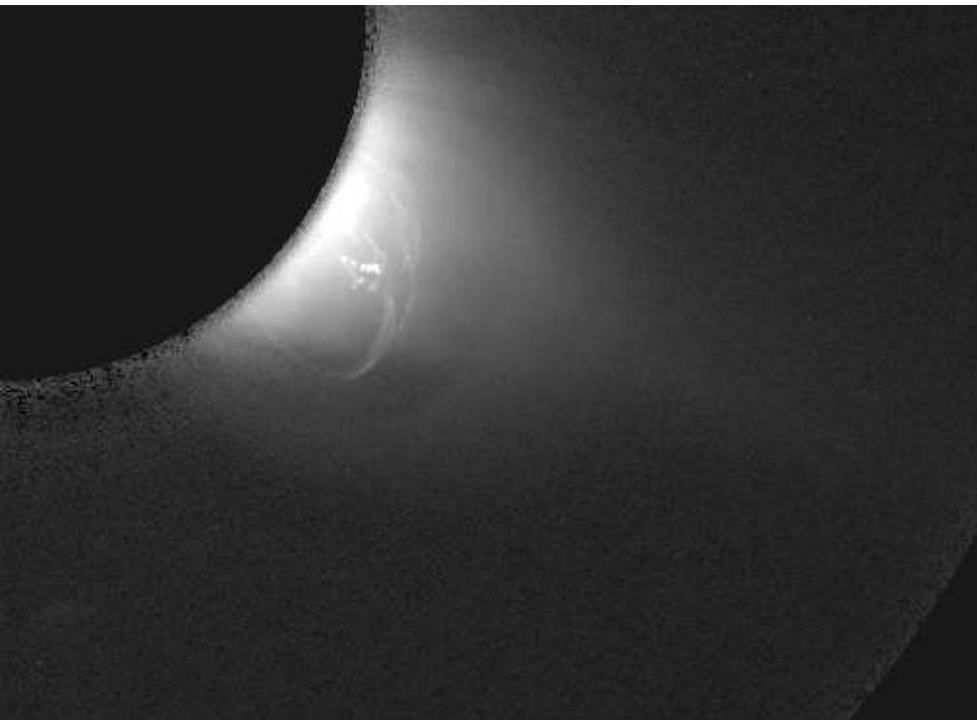
3D Reconstructions of Prominence and Leading Edge of Dark Cavity

August 31, 2007

21:25:00

COR1 A + B

Shows relation of
filament to dark
cavity in 3D



QuickTime™ and a
decompressor
are needed to see this picture.



Conclusions

- Demonstrated that stereoscopy can be used to track CME propagation in 3D
- Determined approximate 3D trajectory of 2 STEREO CMEs
 - Validated software by comparison with LASCO height-time results
 - Plan further tests by comparison with 3D forward modeling CME reconstruction of Thorneisen et al.
- Reconstructed three parts of 2007/08/31 STEREO CME
 - Bright Leading Edge, Dark Cavity Leading Edge, Prominence
- Demonstrated ability to track CME through 3 FOVs - EUVI, COR1, COR2

HD SECCHI A & B Daily Quicktime Movies



<http://solarmuse.jpl.nasa.gov>

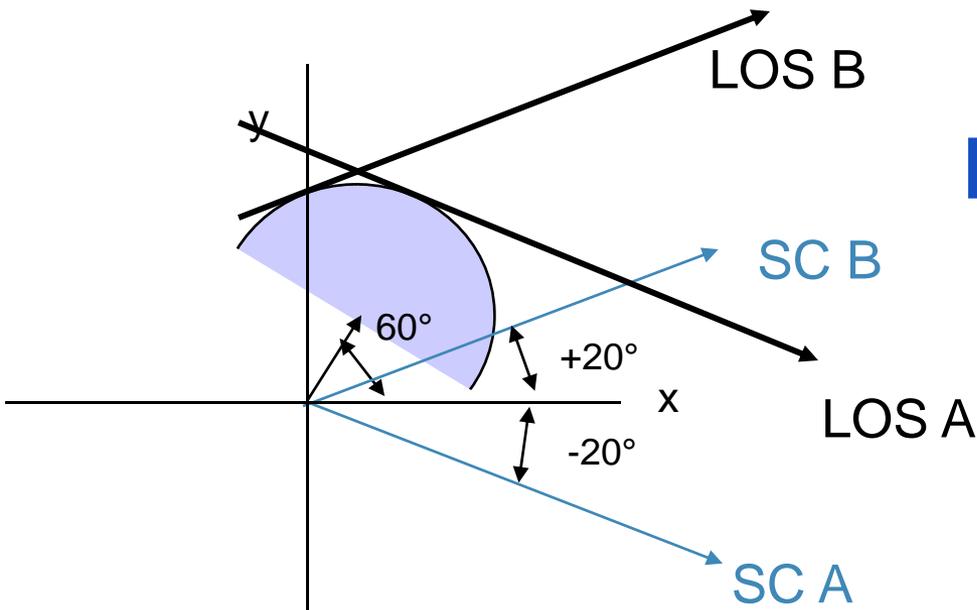
– Now EUVI 1K by 1K available

User: Science_Team Pass:secchi07

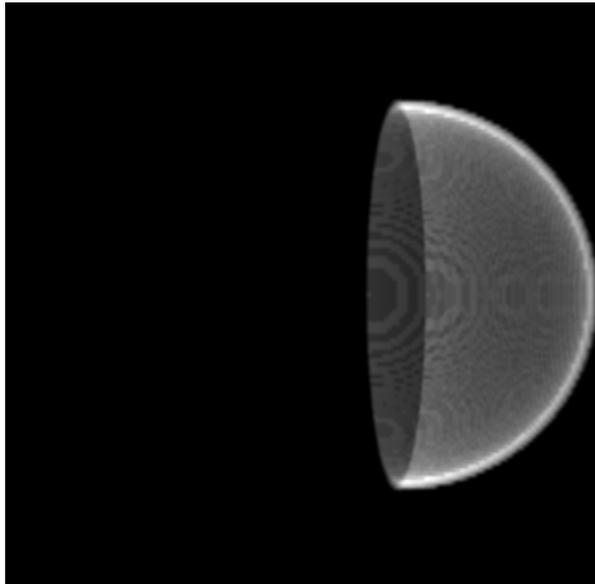
In Beta test - All telescopes

Backup Slides

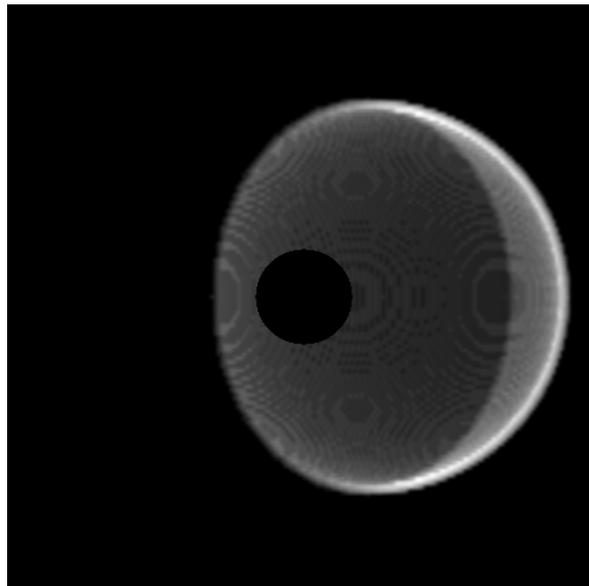
Early Test on hemisphere CME for Tiepointing Bright Leading Edge



COR2 - SC A at -20°



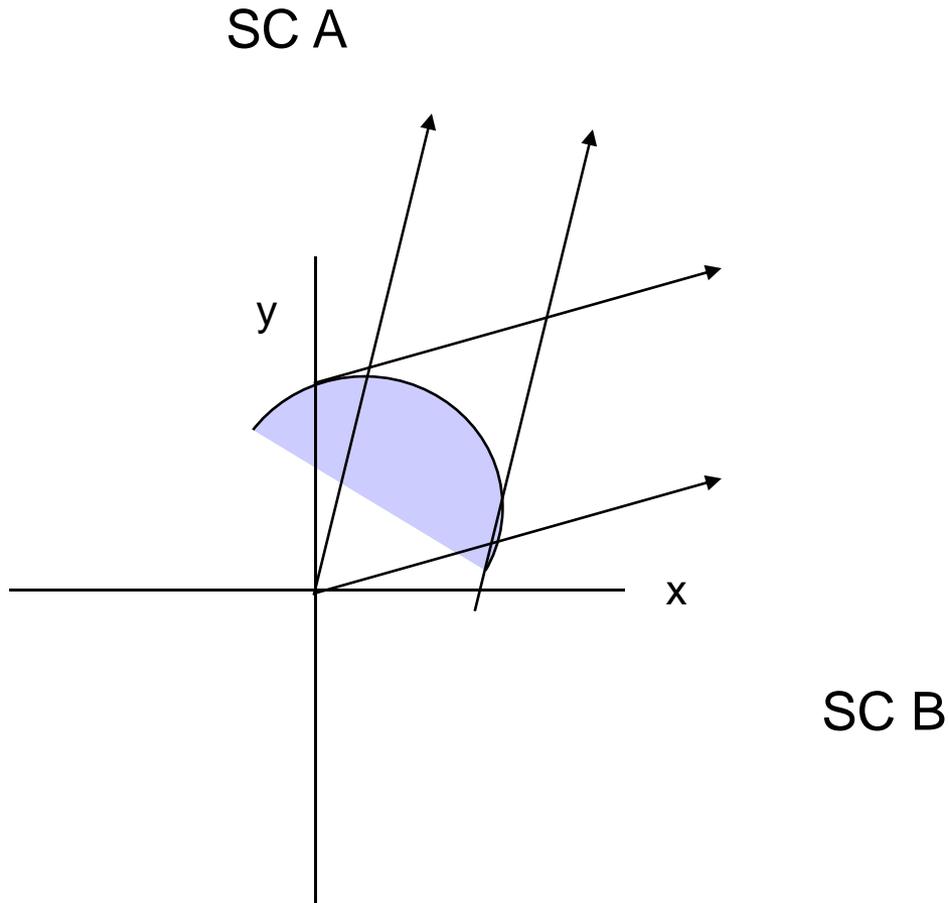
COR2 - SC B at $+20^\circ$



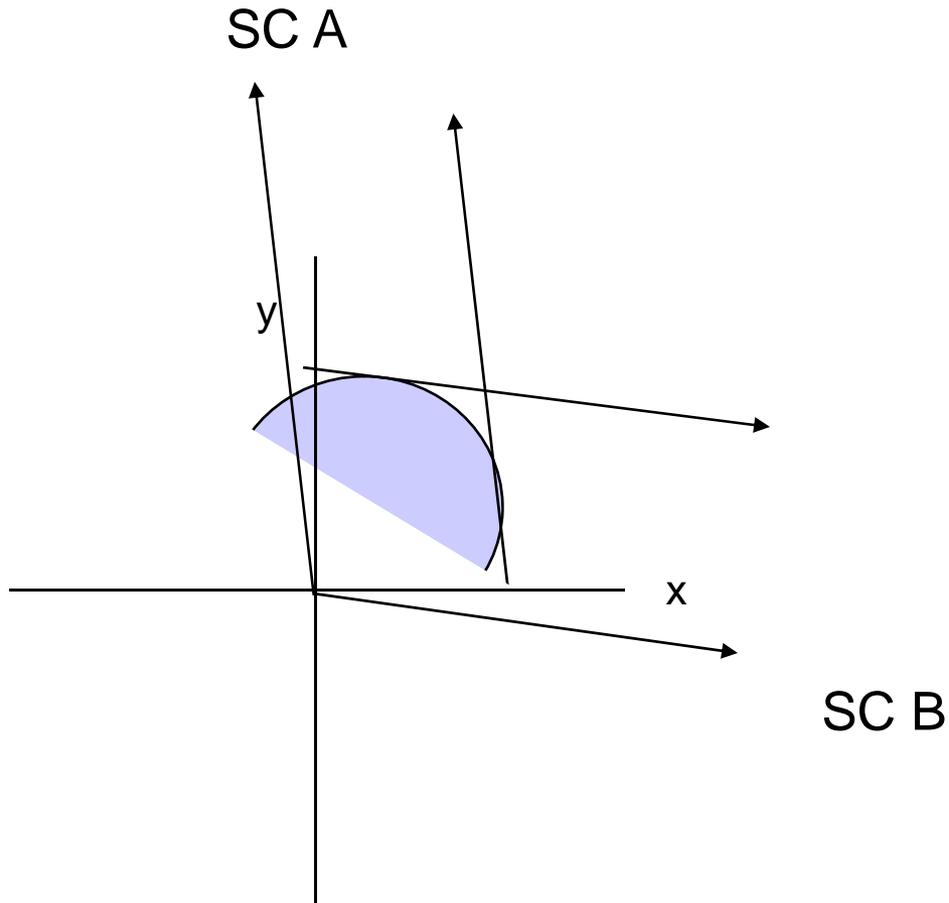
Result:

- Leading Edge at $15.1 R_{\text{sun}}$ vs actual $15 R_{\text{sun}}$
- Angle of 72° vs actual 60°

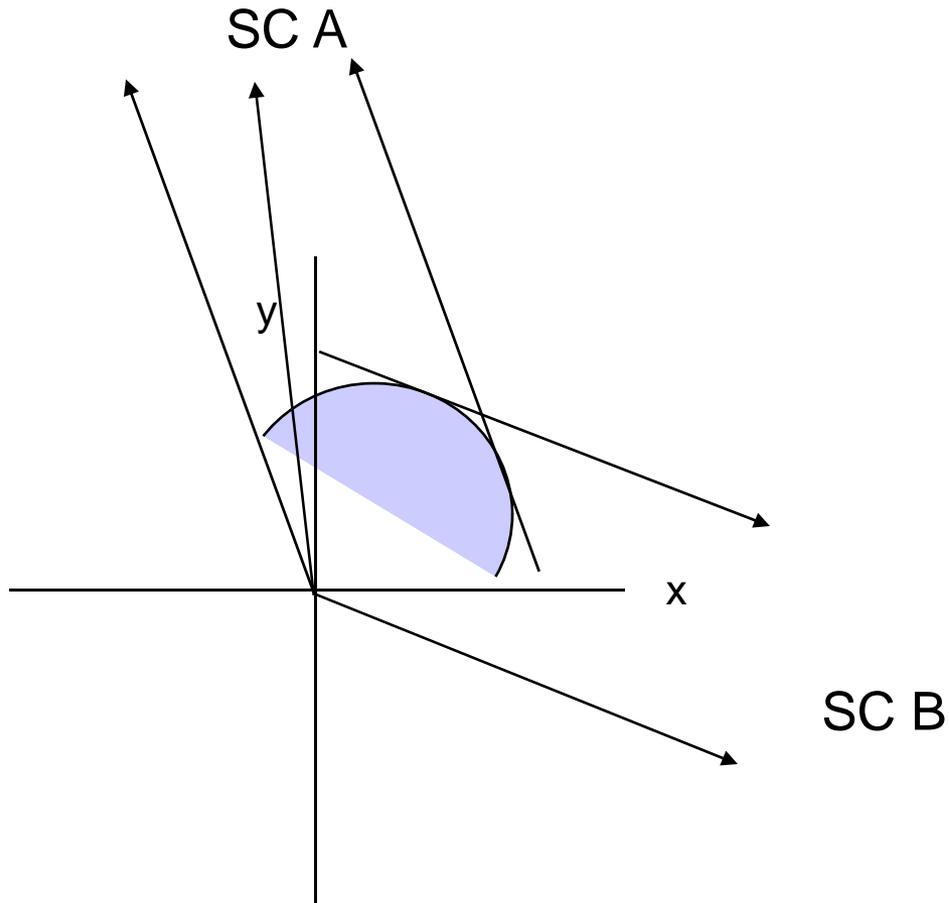
Consider Increasing SC Separations with CME in between A&B



Consider Increasing SC Separations with CME in between A&B



Consider Increasing SC Separations with CME in between A&B



Nov 16, 2007 Prom and CME

- Limb event for STEREO A - Behind the limb event for LASCO & STEREO B
- COR1A shows clear deflection of CME towards equator

Nov 16, 2007
00:06:15

Nov 16, 2007
03:45:00

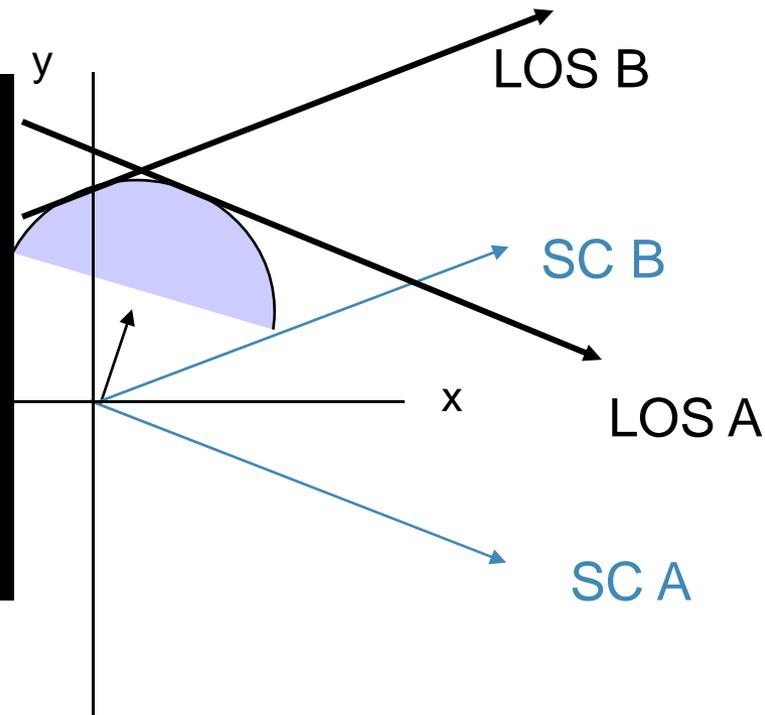
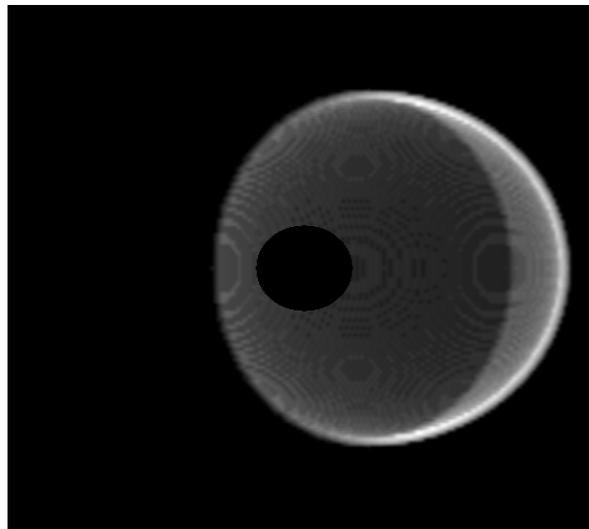
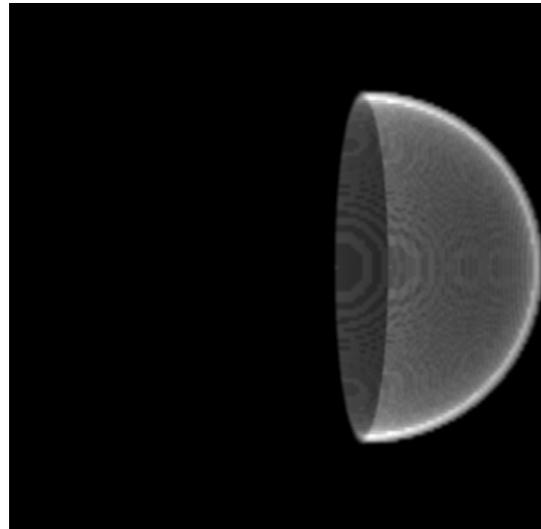
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