The Hunt for a Link : Quantitative Connections Between Magnetic Fields and EIT Coronal Wave/CME Properties

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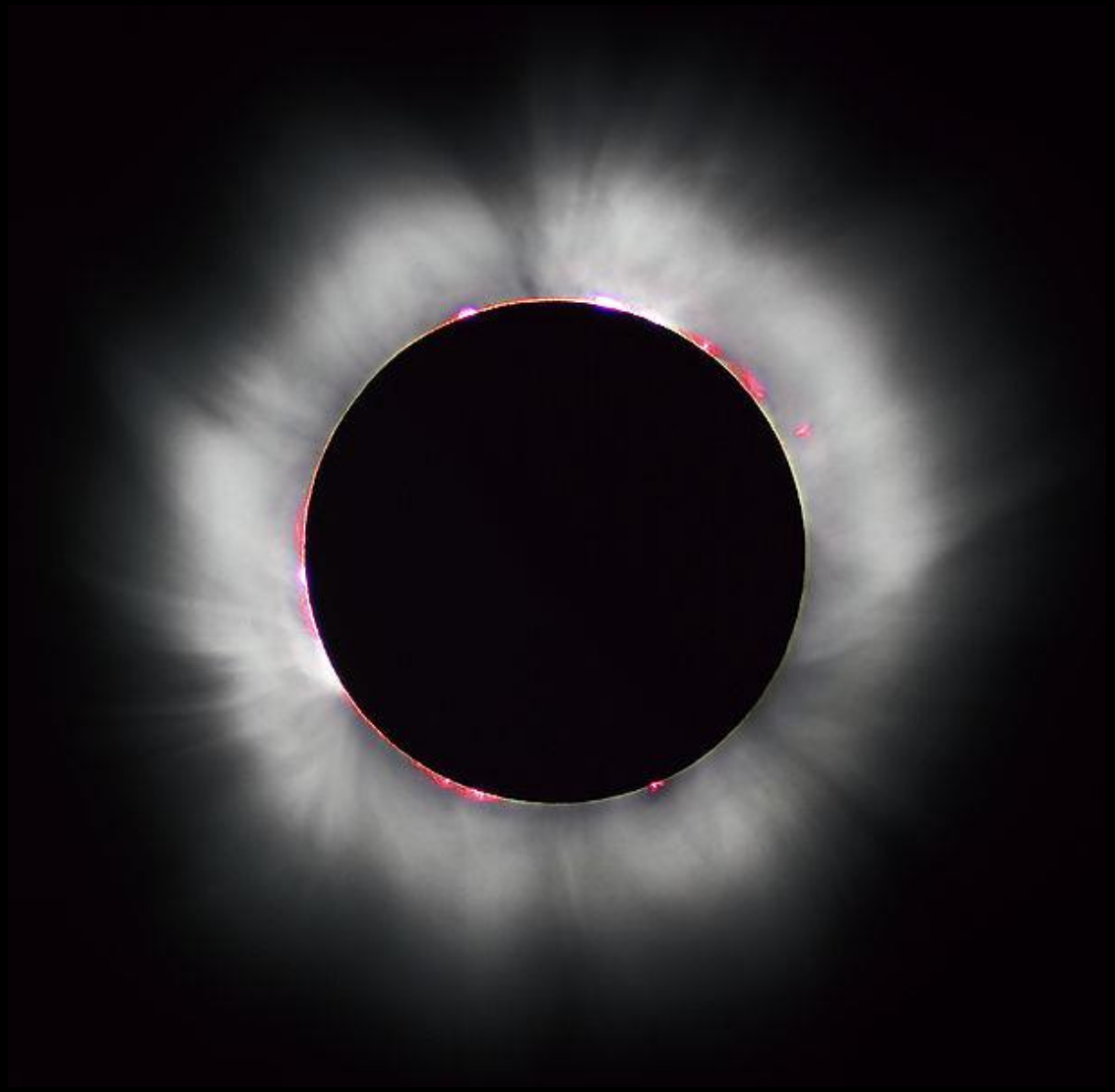
The Sun's Corona

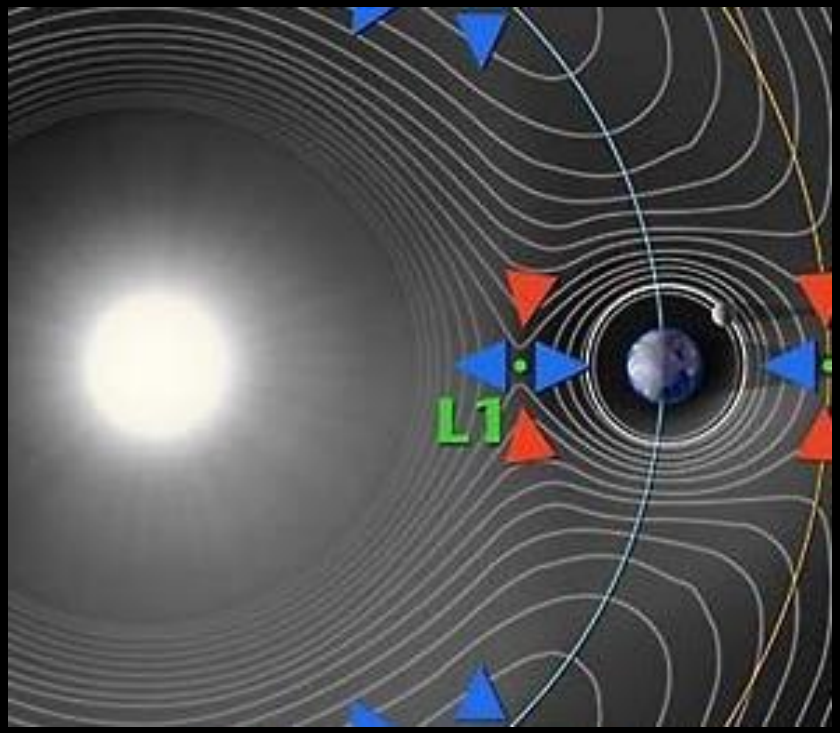
- Faint streamer-like part seen during a solar eclipse
- Very hot (millions of Kelvin)
- Very low density (e.g. 10^9 particles/cm^3)
- Plasma is "frozen" to the magnetic field.



How can we study the corona?

The Solar and Heliospheric Observatory (SOHO)

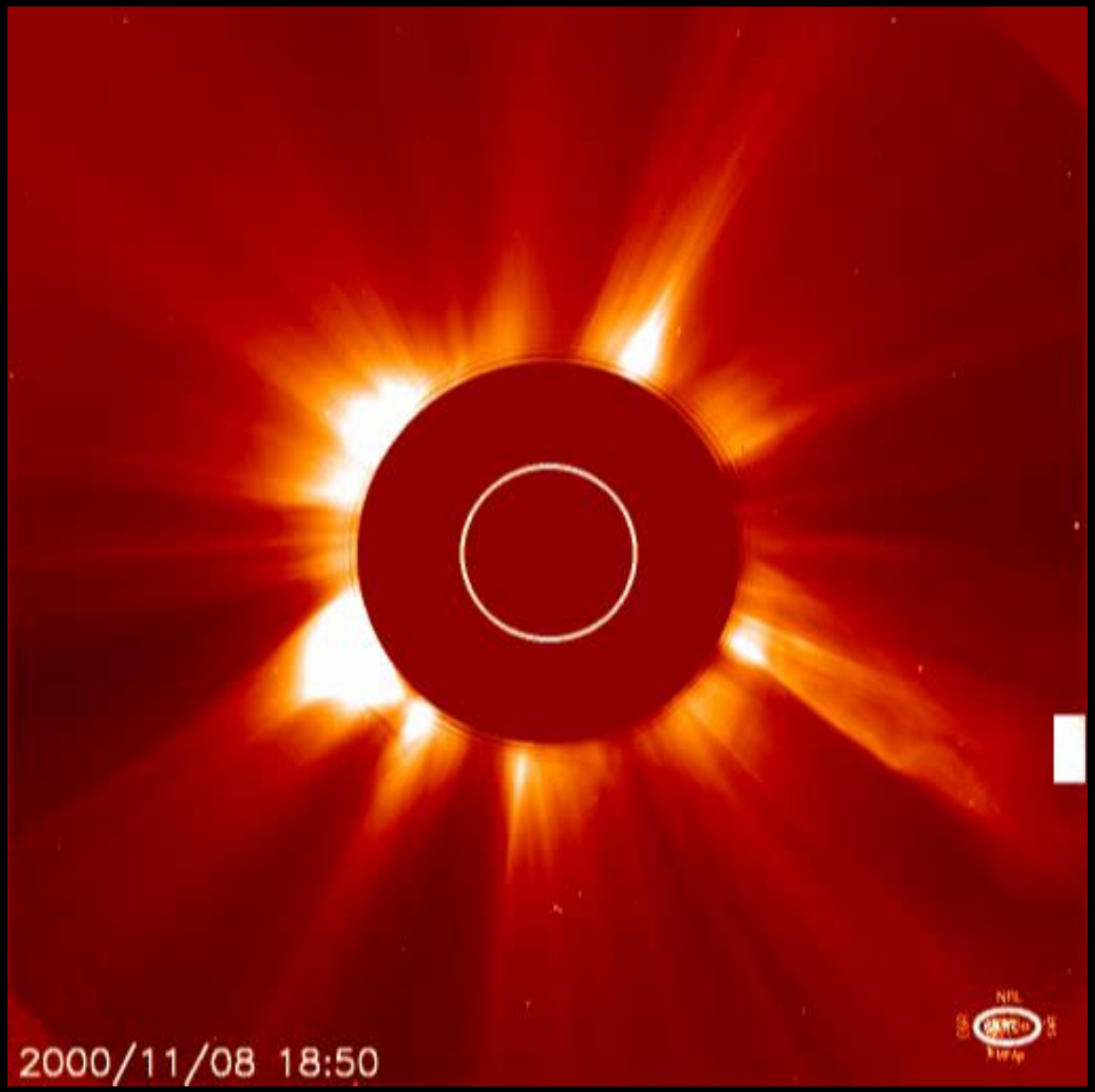
- Orbits L_1.
- Can continuously observe the Sun.



Three important instruments

- LASCO – Large Angle and Spectrometric Coronagraph
- EIT - Extreme ultraviolet Imaging Telescope
- MDI - Michelson Doppler Imager

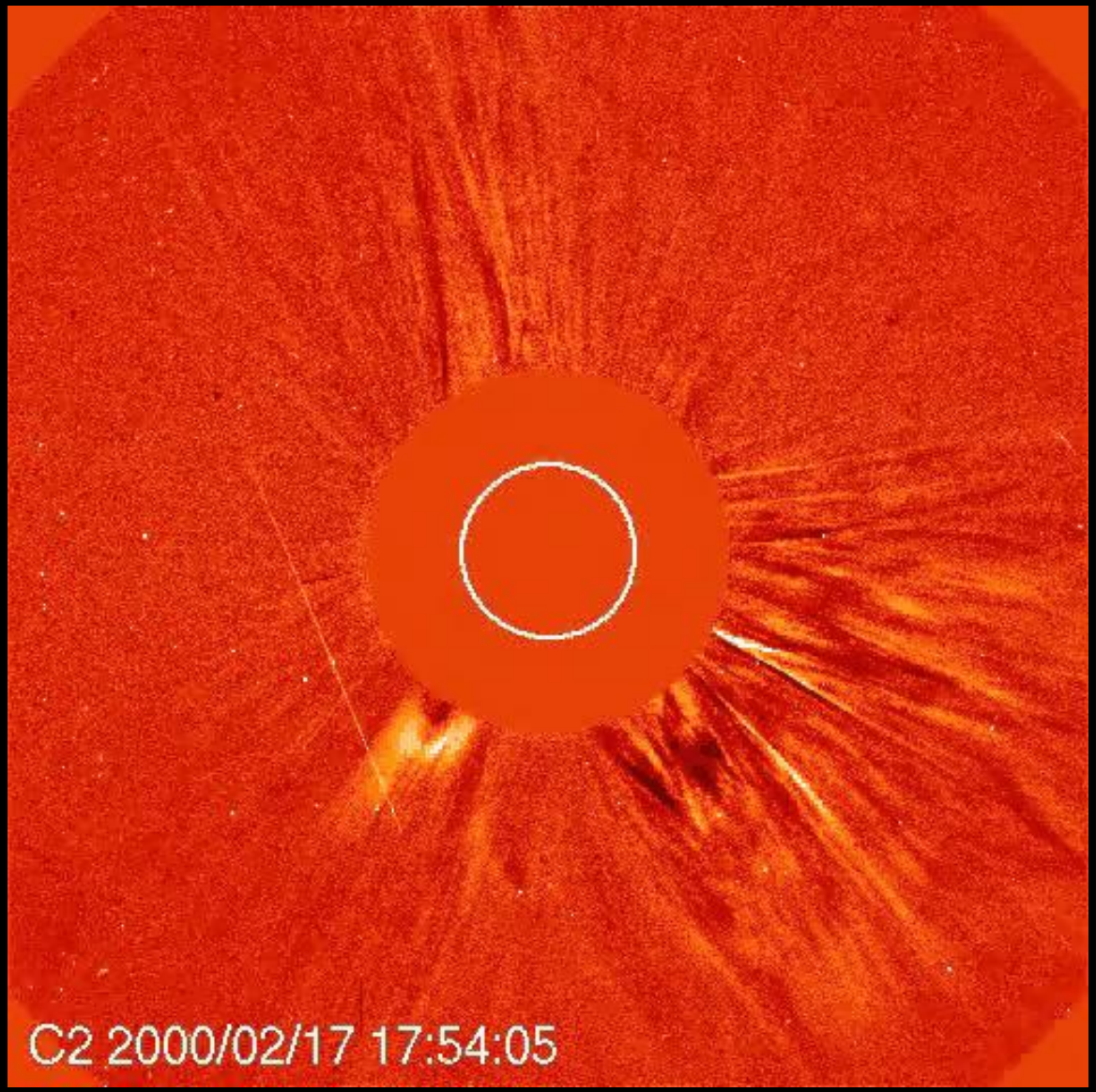
CMEs



- As seen in LASCO C2
- White light image

Movie created by NASA, taken from Best of SOHO observations http://sohowww.nascom.nasa.gov/bestofsoho/Movies/movies2.html

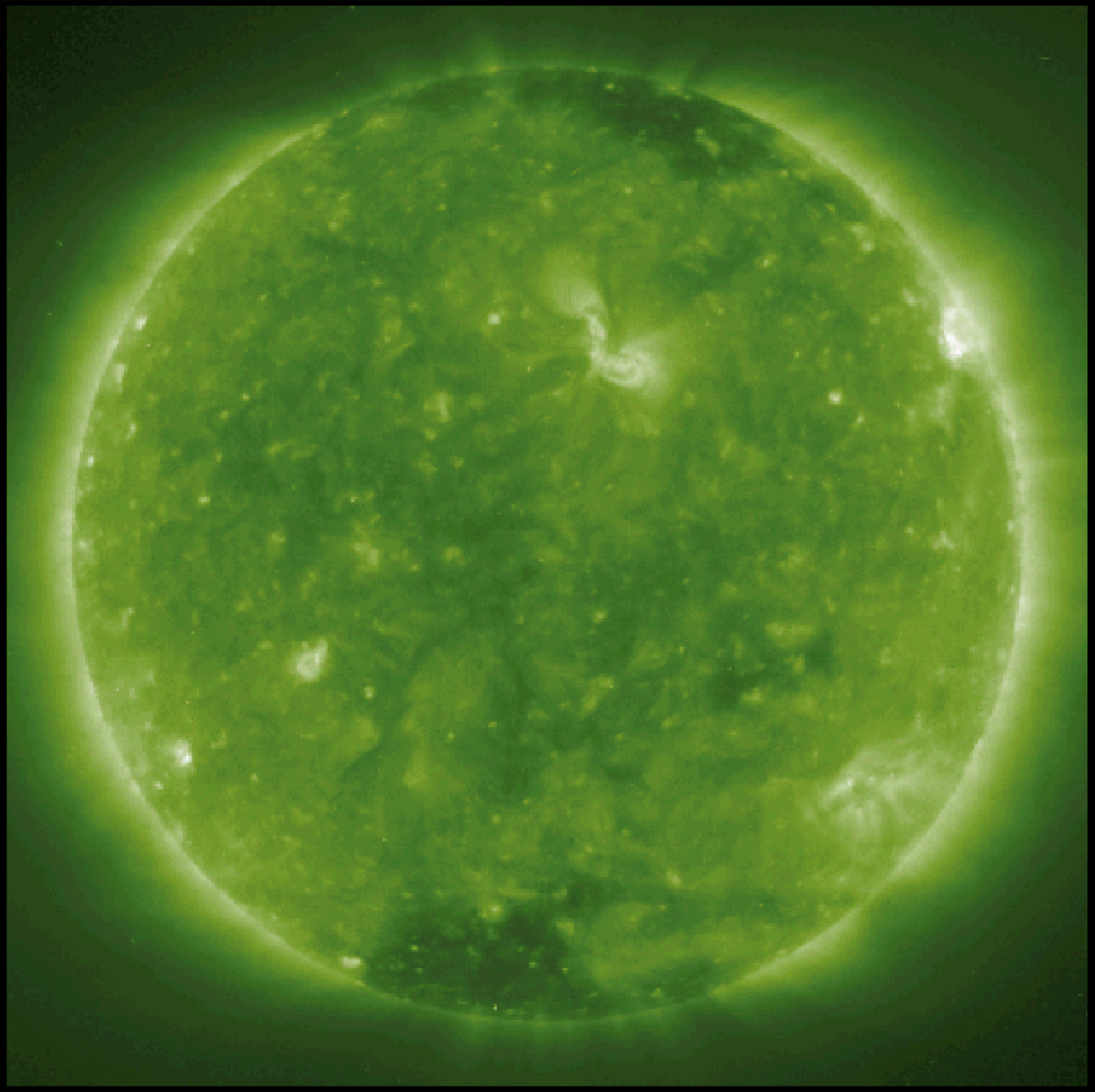
Halo CMEs



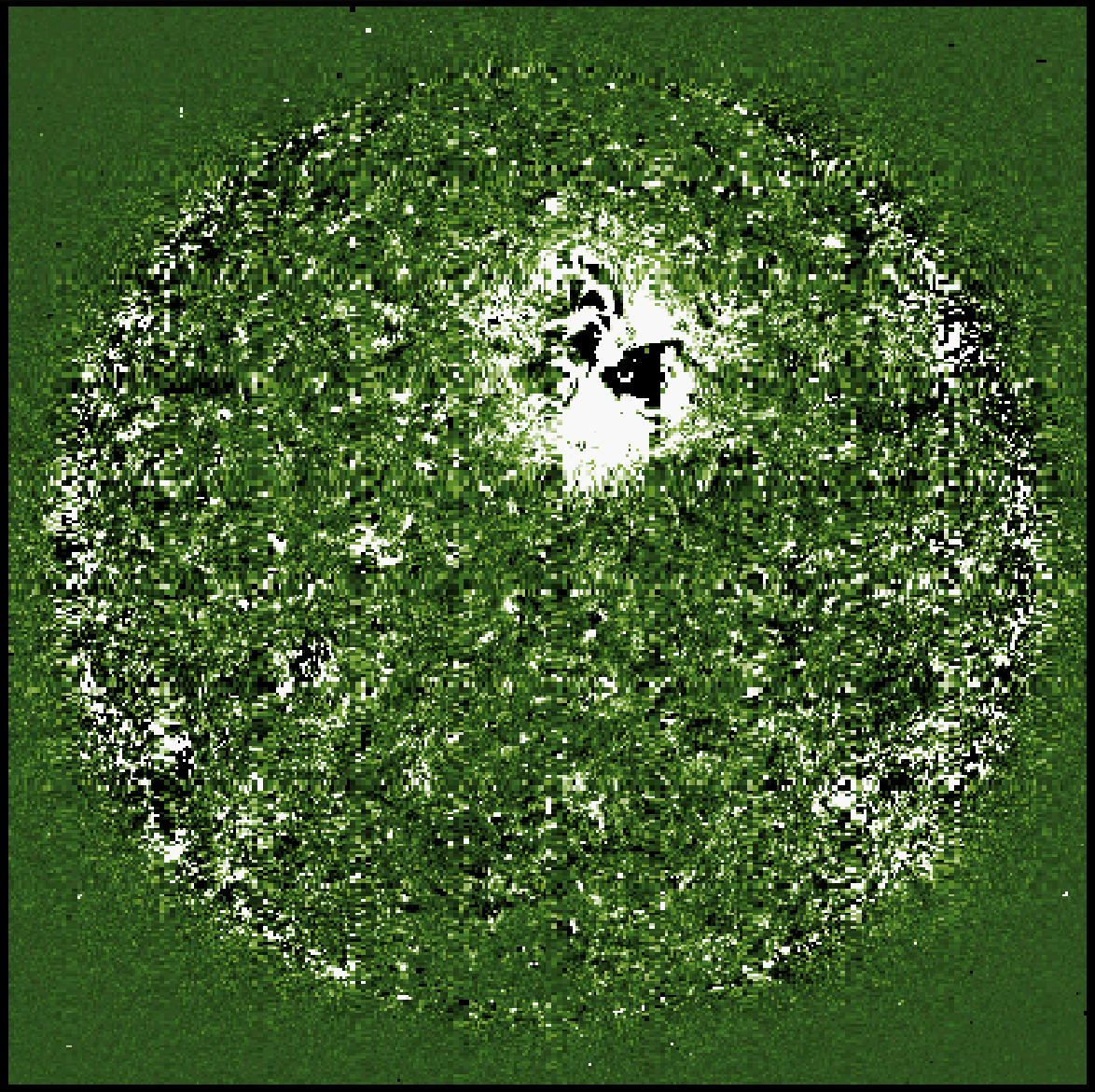
- As seen in LASCO C2
- White light image
- Running Difference

Movie created by NASA, taken from Best of SOHO observations http://sohowww.nascom.nasa.gov/bestofsoho/Movies/movies2.html

EIT Waves / Coronal Waves



EIT Waves / Coronal Waves Running difference



Relations/Causes

Relations

- **Biesecker et *al*. 2002, and Chen *et al*. 2006** - showed that EIT waves are strongly associated with CMEs, rather than flares.
- **Cliver *et al.* 2005** - conclude that the special condition required for a coronal wave is a CME.

Causes

- **Wills-Davey & Attrill, 2009 submitted** - describes **seven** different theories that attempt to describe the nature of EIT waves
- **Klimchuk *et al*. 2001** - explains **five** potential models for CME initiation.
- **Forbes *et al*. 2006** - details several theories that aim to explain the process that initiates CMEs and account for their evolution and propagation.

New relationships, what to look for?

Source region properties

- Total magnetic flux of source region (usually an AR)
- Total magnetic flux of a 300 X 300 arc second box around source region.
- Total magnetic flux of a 300 X 300 arc second box in quiet sun
- Total magnetic flux of the Post-Eruptive Arcade (PEA)

EIT wave properties

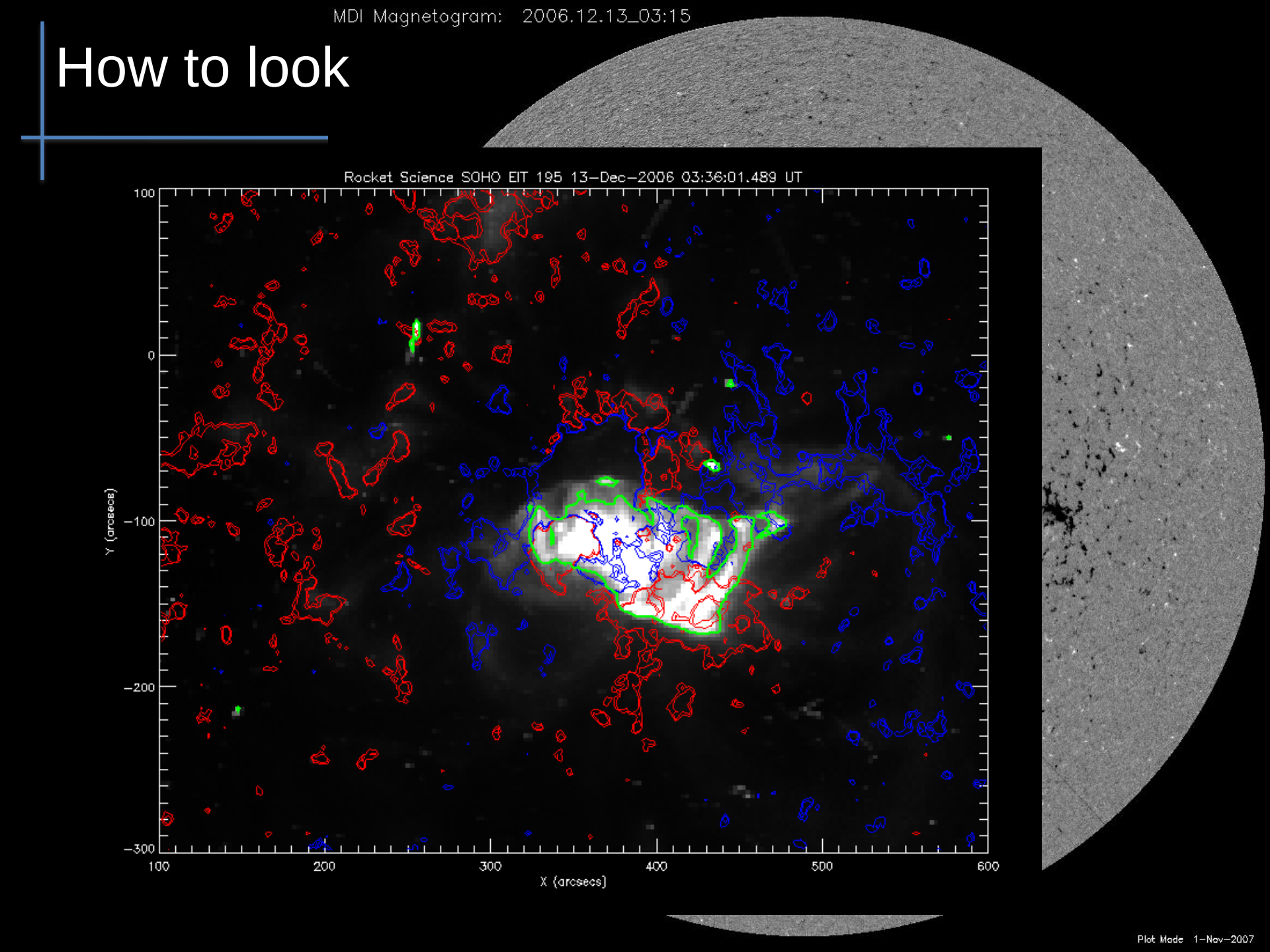
- Final lateral extent
- Average velocity

Science question: what determines the EIT wave's propagation speed and its final lateral extent.

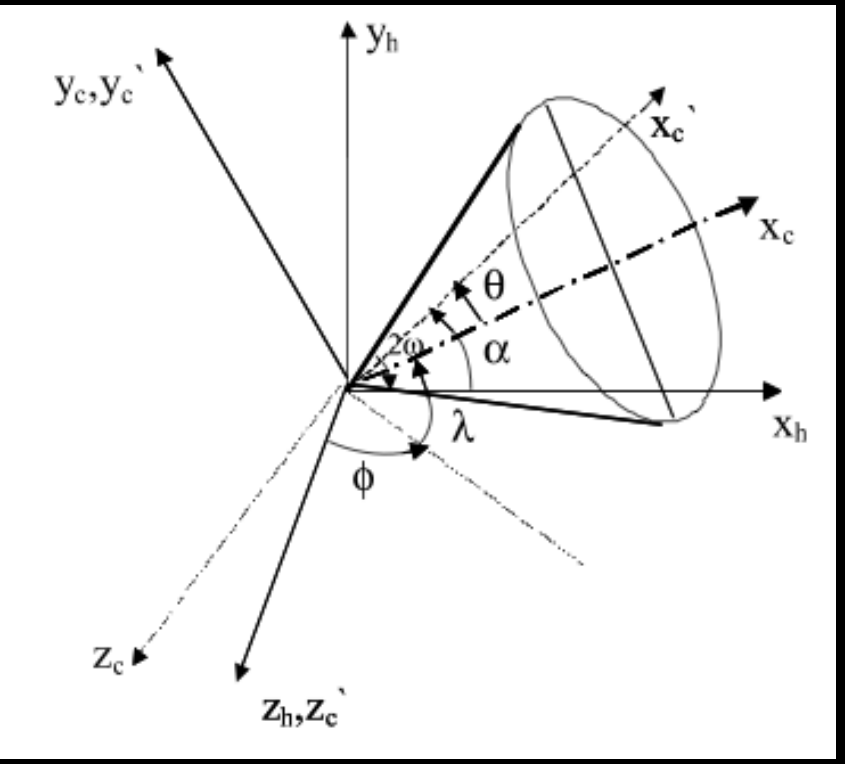
CME property

- Average radial velocity

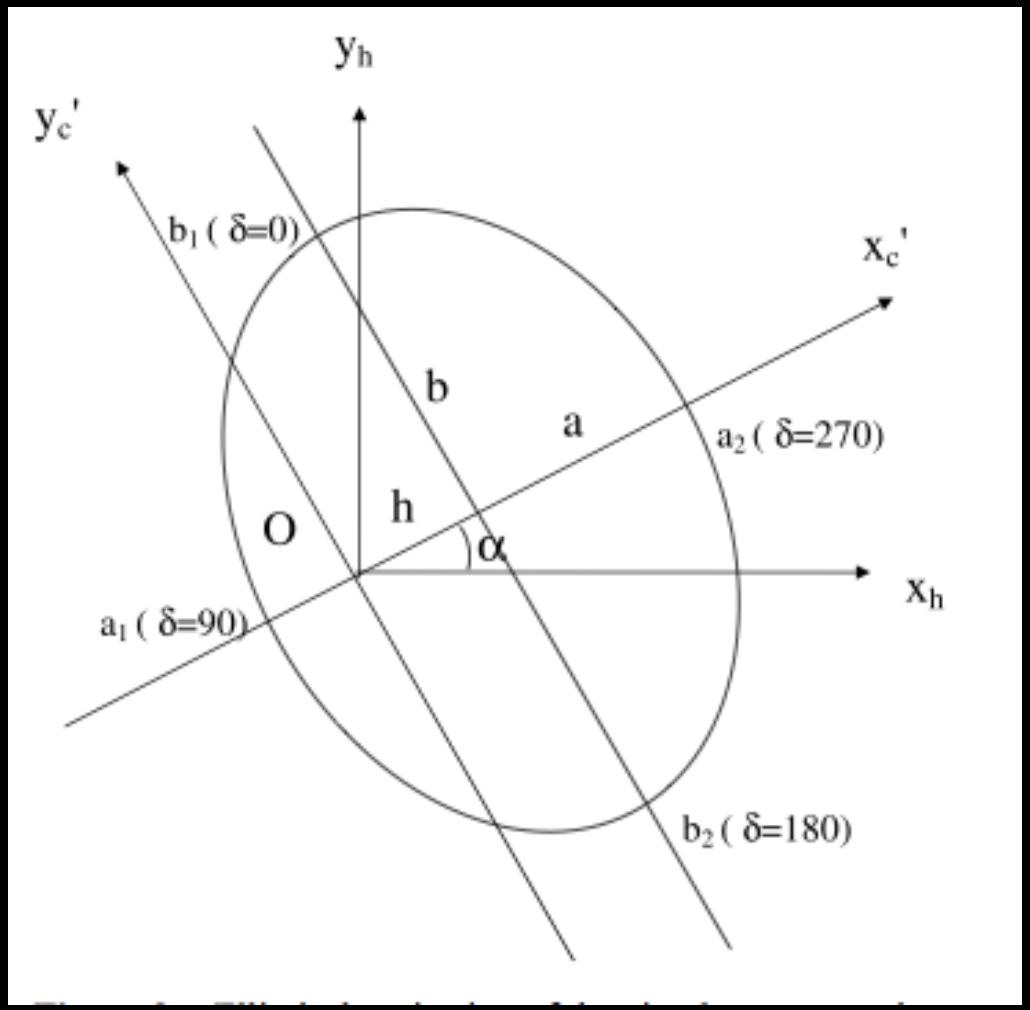
How to look


MDI Magnetogram: 2006.12.13_03:15
Rocket Science SOHO EIT 195 13-Dec-2006 03:36:01.489 UT
100
0
-100
-200
-300
Y (arcsecs)
100
200
300
400
500
600
X (arcsecs)
Plot Made 1-Nov-2007

CME cone model



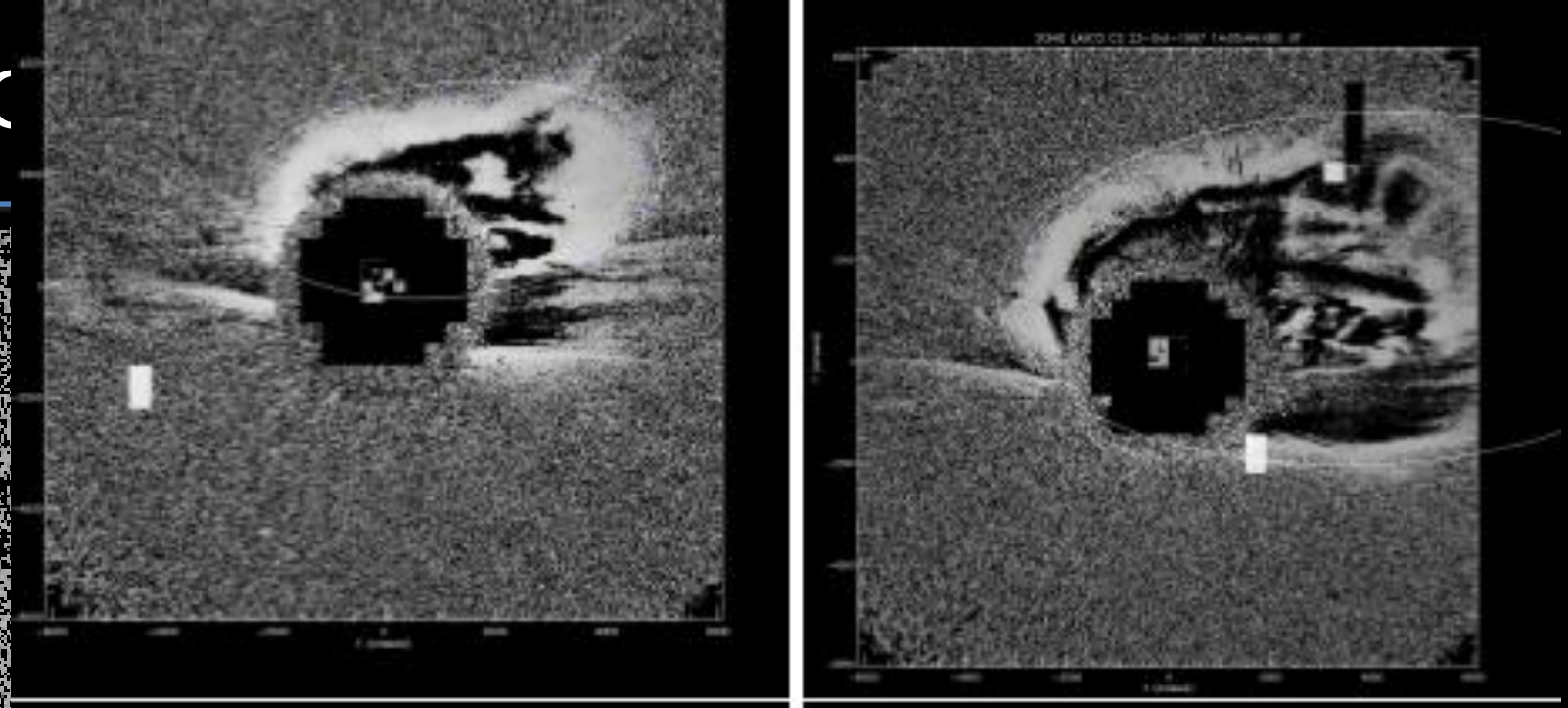
CME as a cone, origin is center of sun

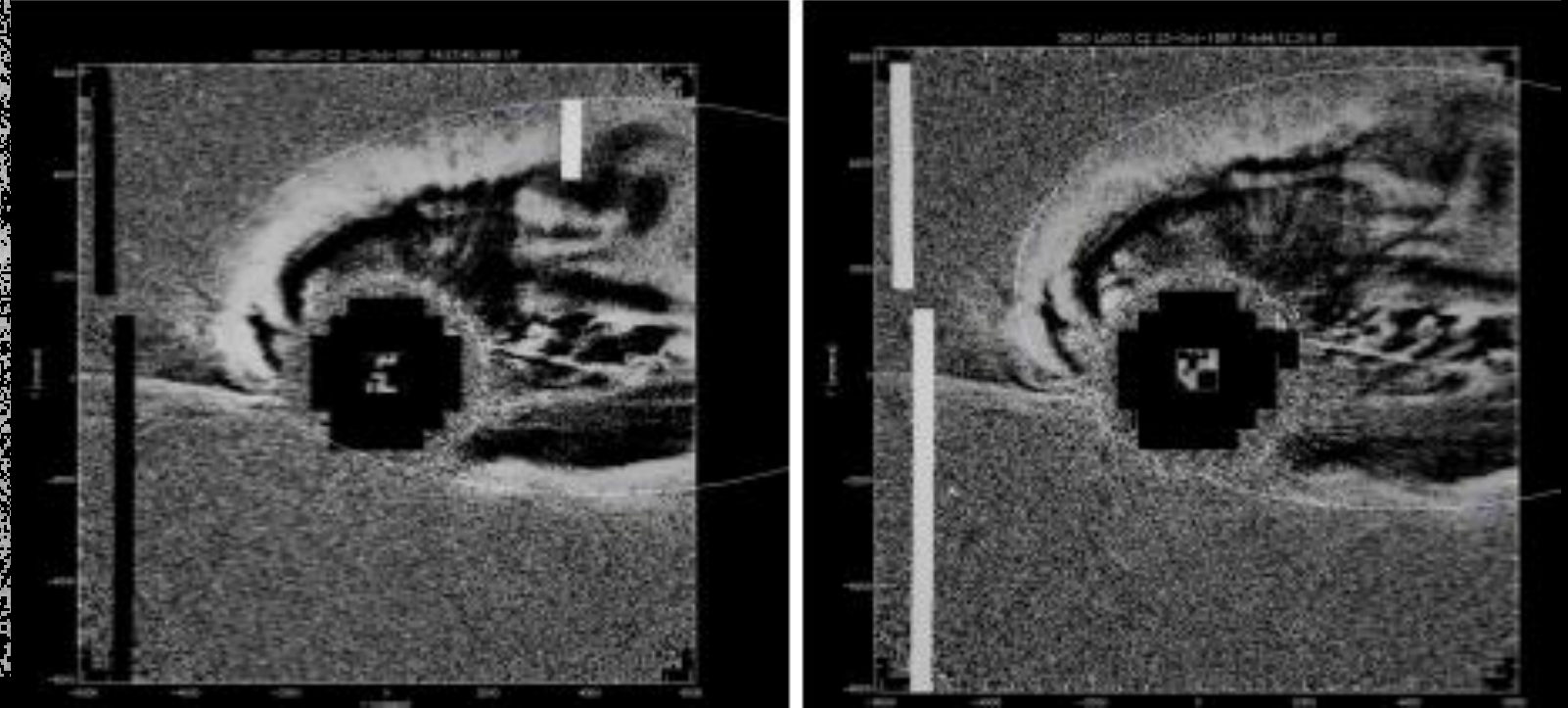


Elliptical projection on to the plane of sky

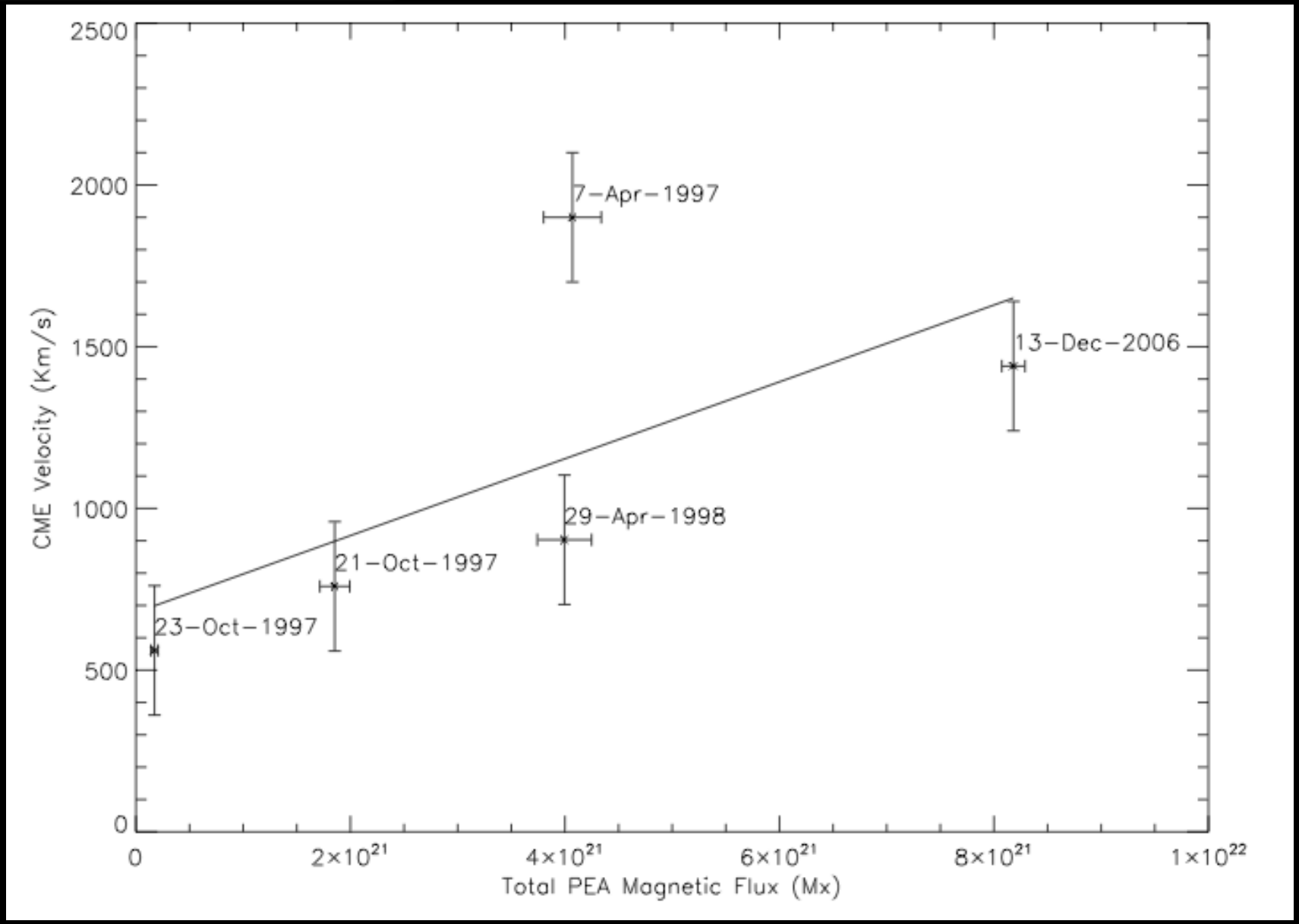
Figures from Xie *et al*. 2004

C

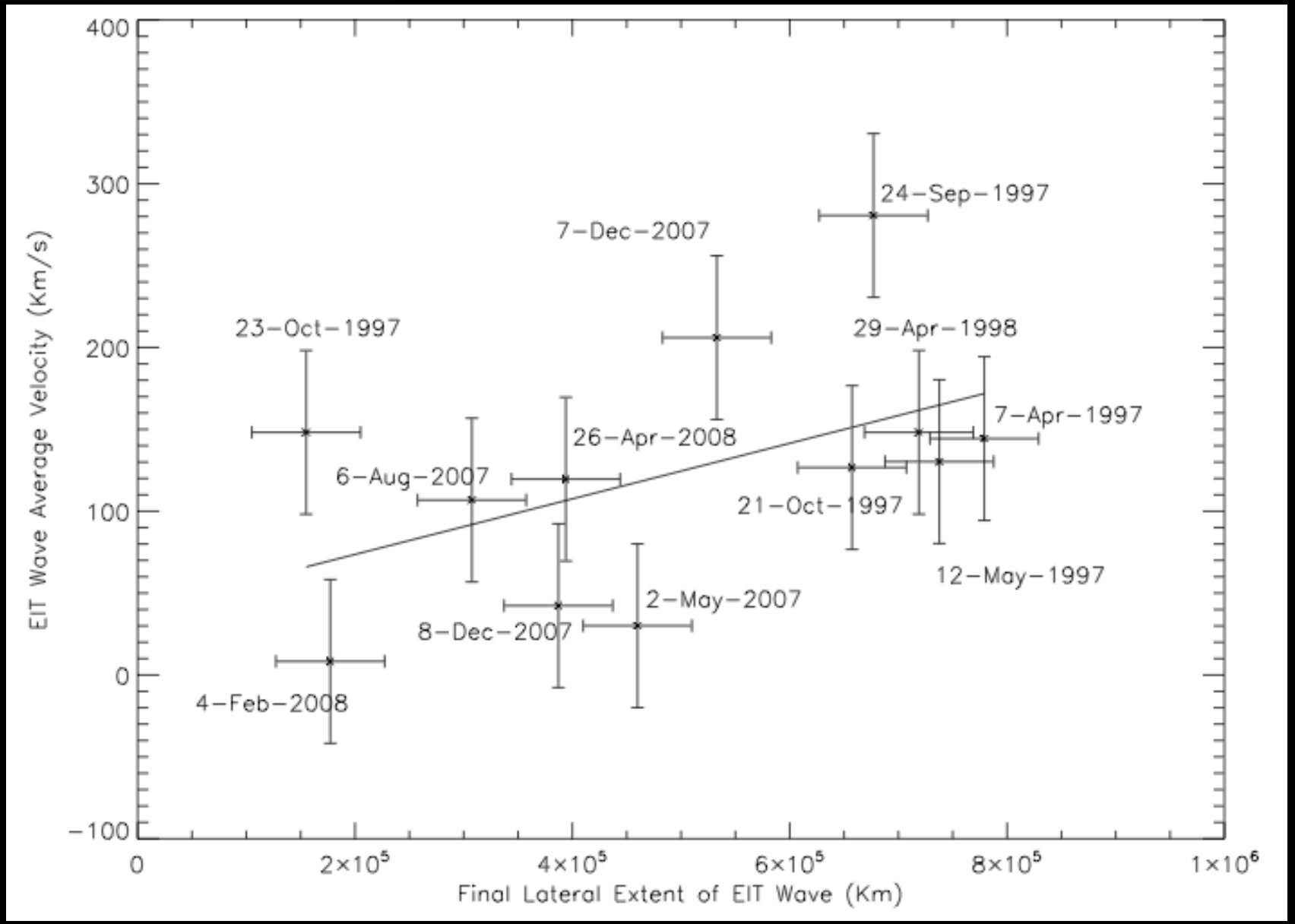




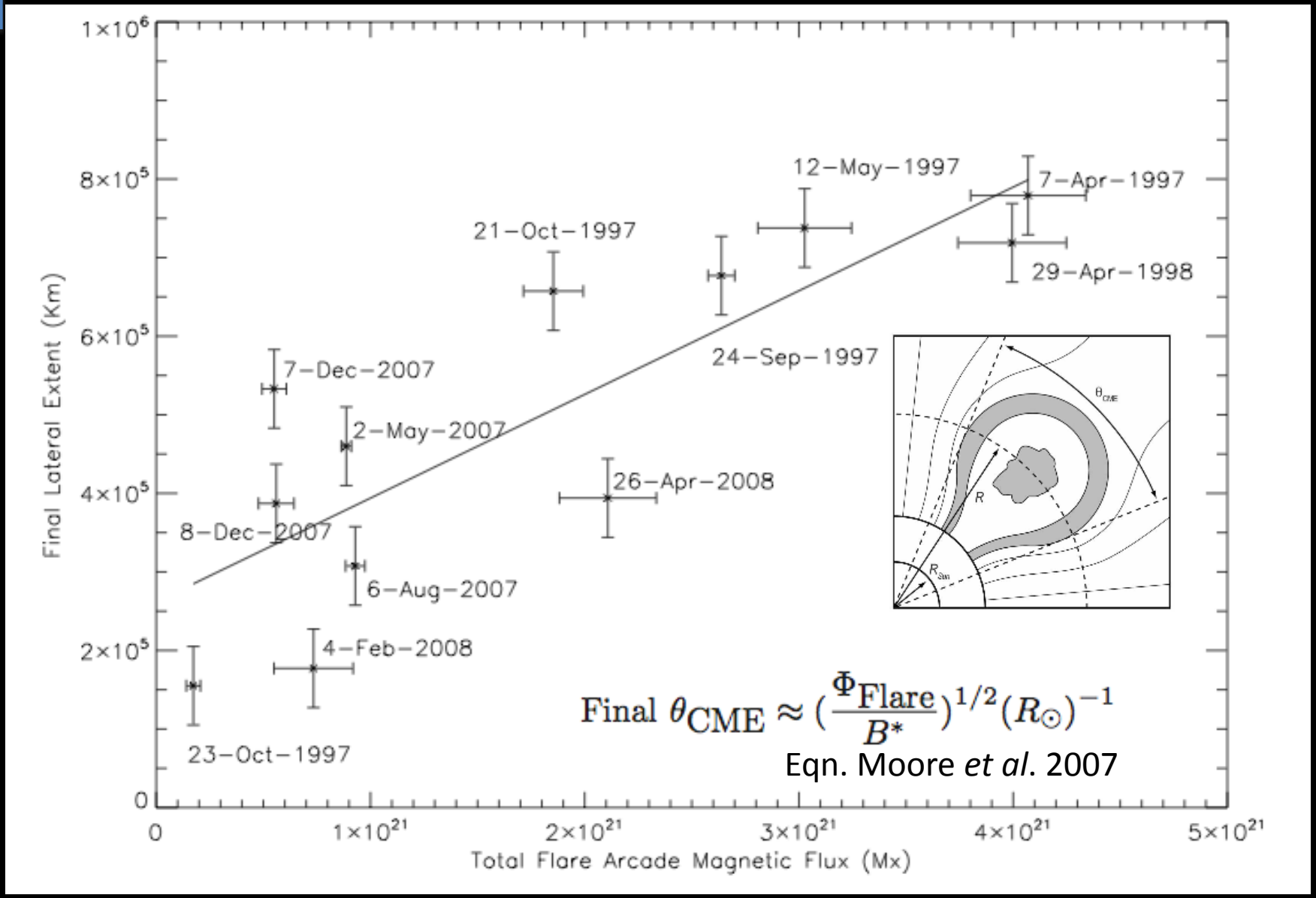
CME Velocity per PEA flux



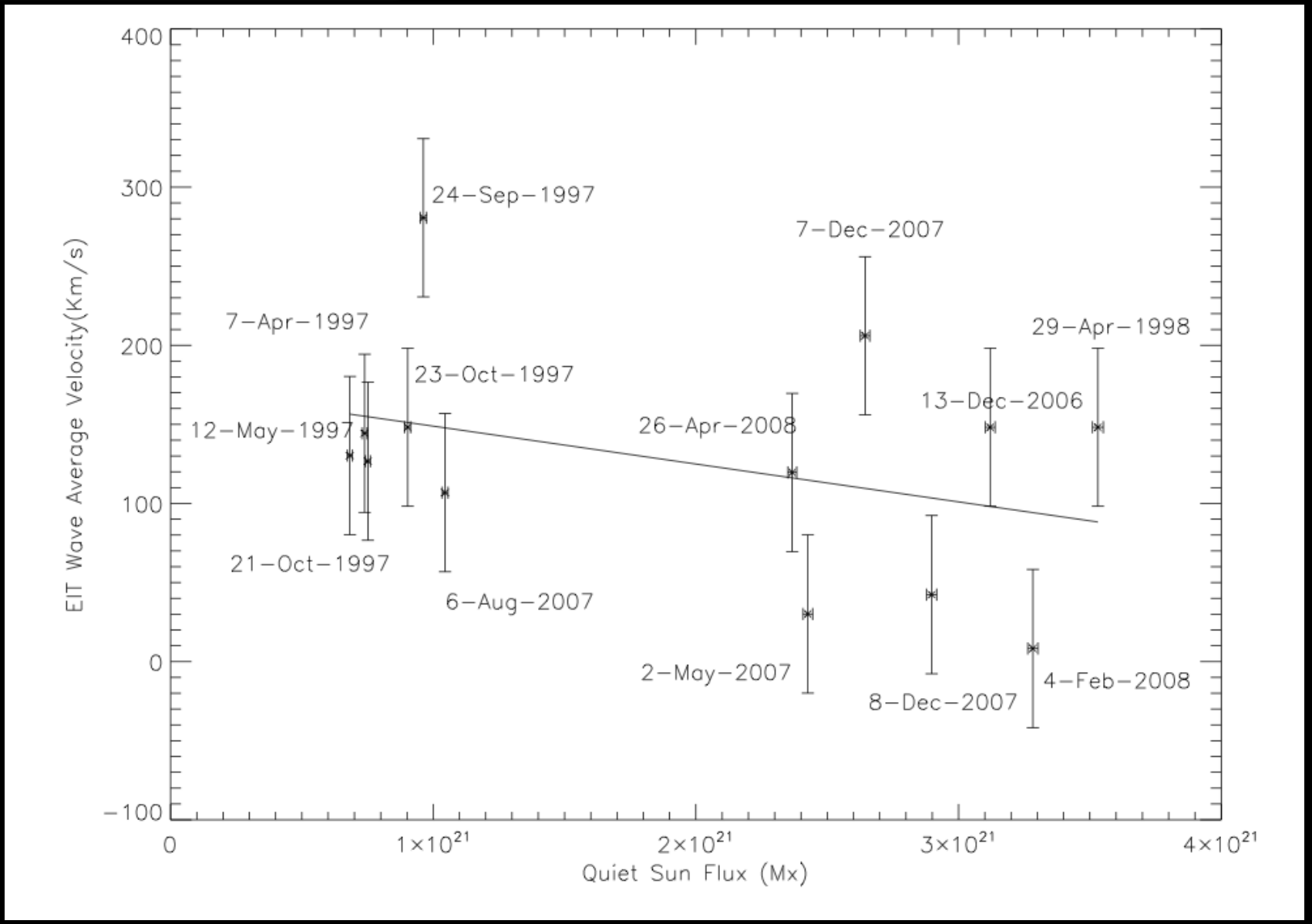
EIT Wave Velocity per Final Lateral Extent



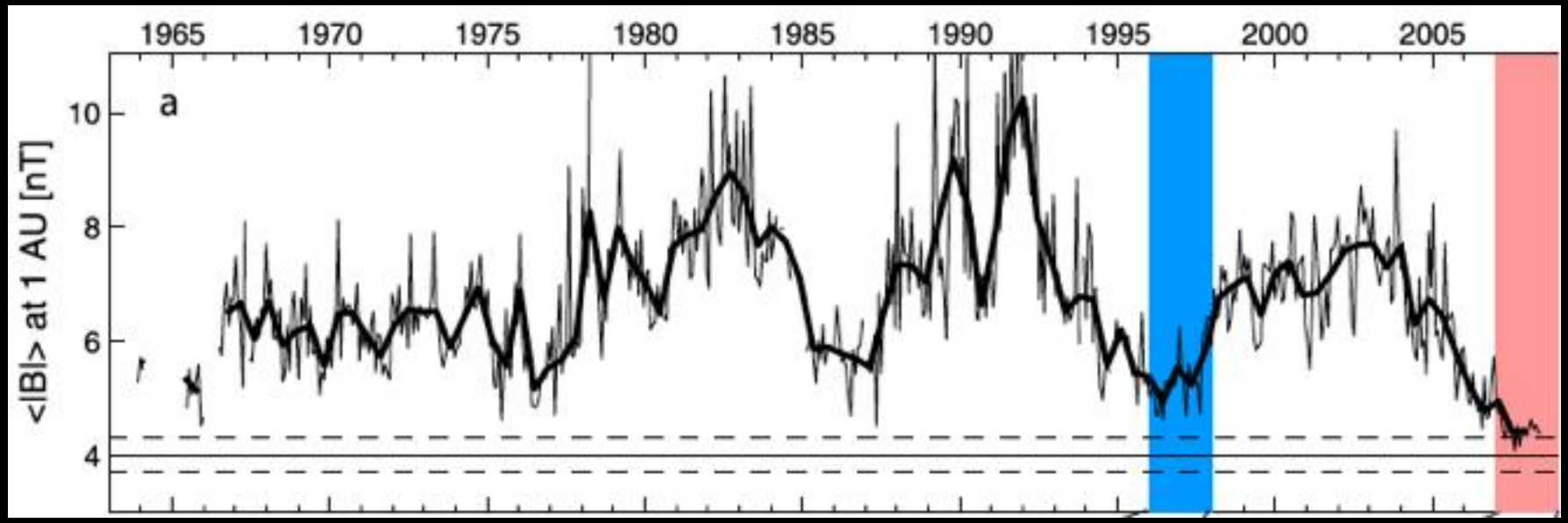
EIT wave Final Lateral Extent per PEA Flux



EIT Wave Average Velocity per Quiet Sun Flux



Field at 1 AU Fluctuations



Results from Owens et al., (2008) as presented by Schwadron at SHINE

Summary/Conclusions

- Further work is needed with the cone model to explore the relation between CME radial velocity and PEA flux.
- The average velocity and final lateral extent of an EIT wave are linked.
- A PEA with a high flux corresponds to an EIT wave with a larger final extent.
- A high quiet Sun flux is associated with EIT waves with a smaller final extent.
- Further study of the background magnetic field between this solar minimum and last is necessary.

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• SOHO is a project of international cooperation between ESA and NASA.
• The CDAW CME catalog is generated and maintained at the CDAW Data Center by NASA and The Catholic University of America in cooperation with the Naval Research Laboratory.

CME Velocity per EIT Wave velocity