WHY ONLY THE ELLIPTICAL CONE MODEL CAN BE USED TO ACCURATELY INFER THE 3-D CHARACTERISTICS OF HALO CMES

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CISM All Hands Meeting

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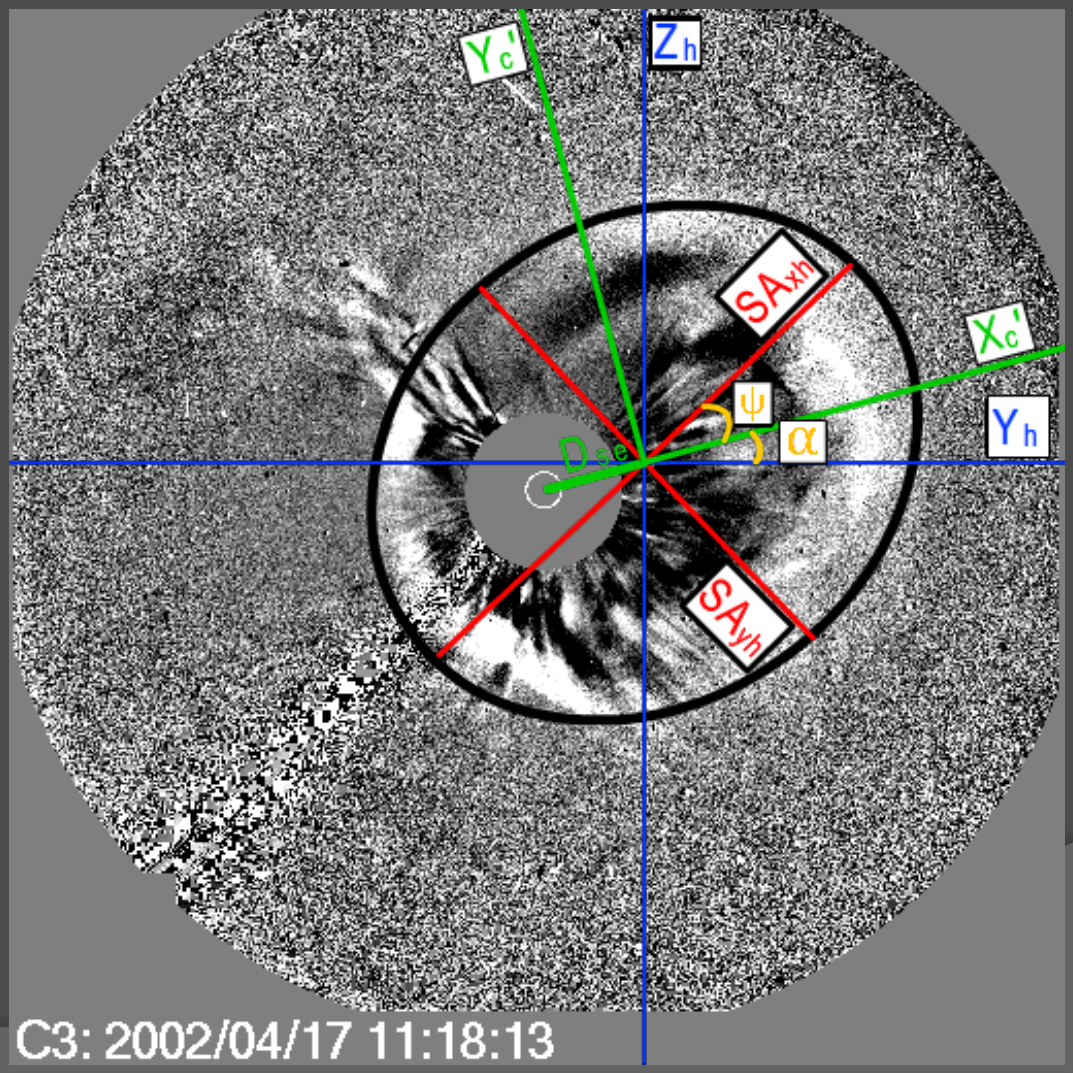
The Circular Cone Model (1/2)

- Widely used to invert 3D characteristics of halo CMEs
  - Relatively simple
  - Unique solution
- Results are trusted but not necessarily valid in most situations
  - ~10% of observed halo CMEs

The Circular Cone Model (2/2)

- Assumptions
  - Radial propagation direction, as a rule
    - Exceptions [Plunkett Et al. 1997; St. Cyr et al. 2000]
  - Constant angular width (ω_y, ω_z)
    - [Webb et al. 1997; Webb and Jackson 1990]

5 Halo Parameters: Geometry



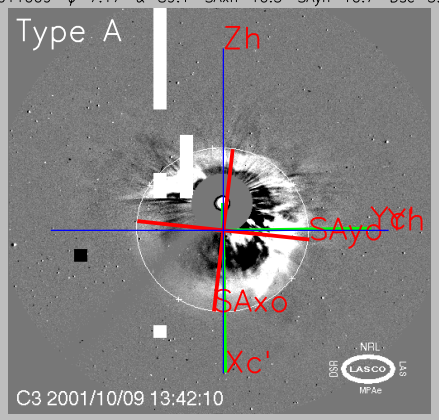
Types of Observed Halo CME

Type A	Type B	Type C
• $\lvert\psi\rvert < 10°$ • $SA_{xh} < Sa_{yh}$	• $\lvert\psi\rvert < 10°$ • $Sa_{xh} \geq Sa_{yh}$	• $10° \leq \lvert\psi\rvert \leq 45°$

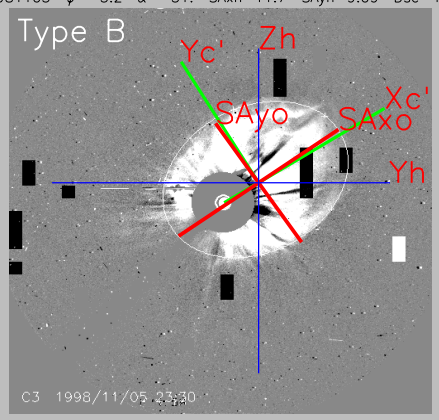
- From 30 event table [Cremades 2005, Tbl. 3]
  - 3 Type A
  - 7 Type B
  - 20 Type C
- Circular Cone Model only works for Type A
  - ***ONLY ~10% OF ALL OBSERVED EVENTS!***

Examples of 3 Types

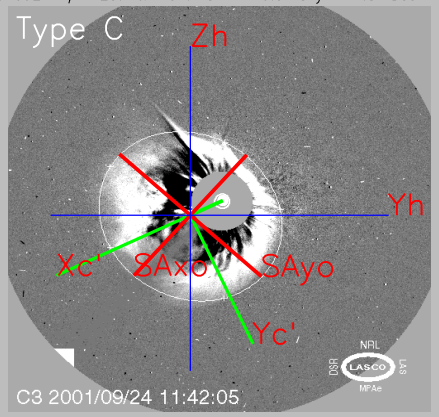
20011009 ψ=7.17 α=89.1 SAxh=10.5 SAyh=10.7 Dse=3.54



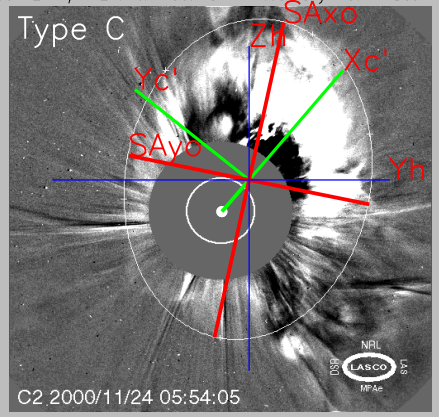
19981105 ψ=−3.2 α=−31. SAxh=11.7 SAyh=9.09 Dse=4.85



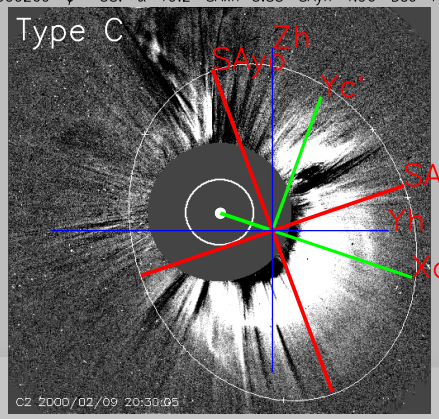
20010924 ψ=−23. α=154. SAxh=10.5 SAyh=11.8 Dse=4.48



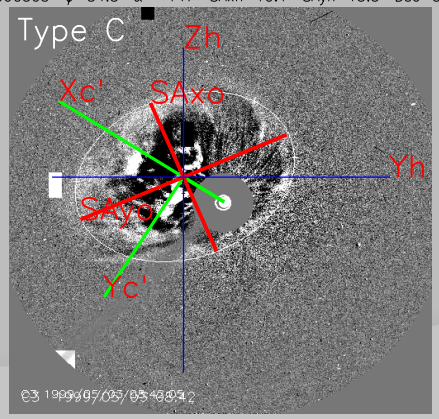
20001124 ψ=−27. α=−50. SAxh=4.65 SAyh=3.41 Dse=1.19



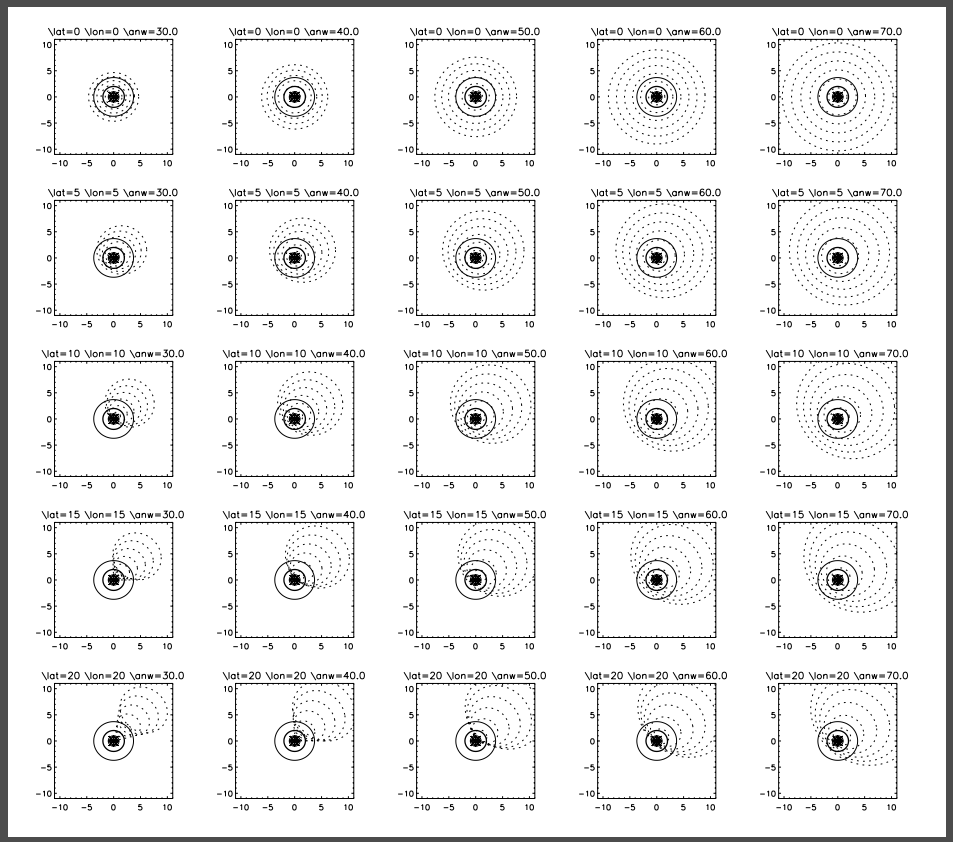
20000209 ψ=−38. α=19.2 SAxh=3.88 SAyh=4.96 Dse=1.53

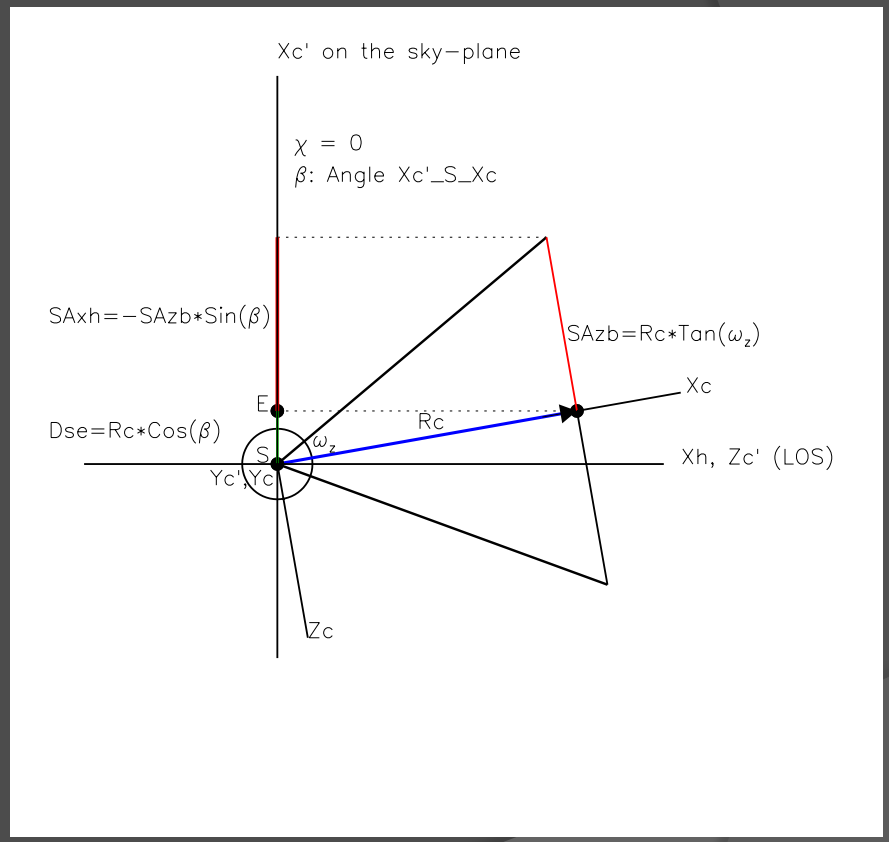


19990503 ψ=34.3 α=−147 SAxh=10.1 SAyh=13.5 Dse=5.84



The CC Model: Limitations (1/2)

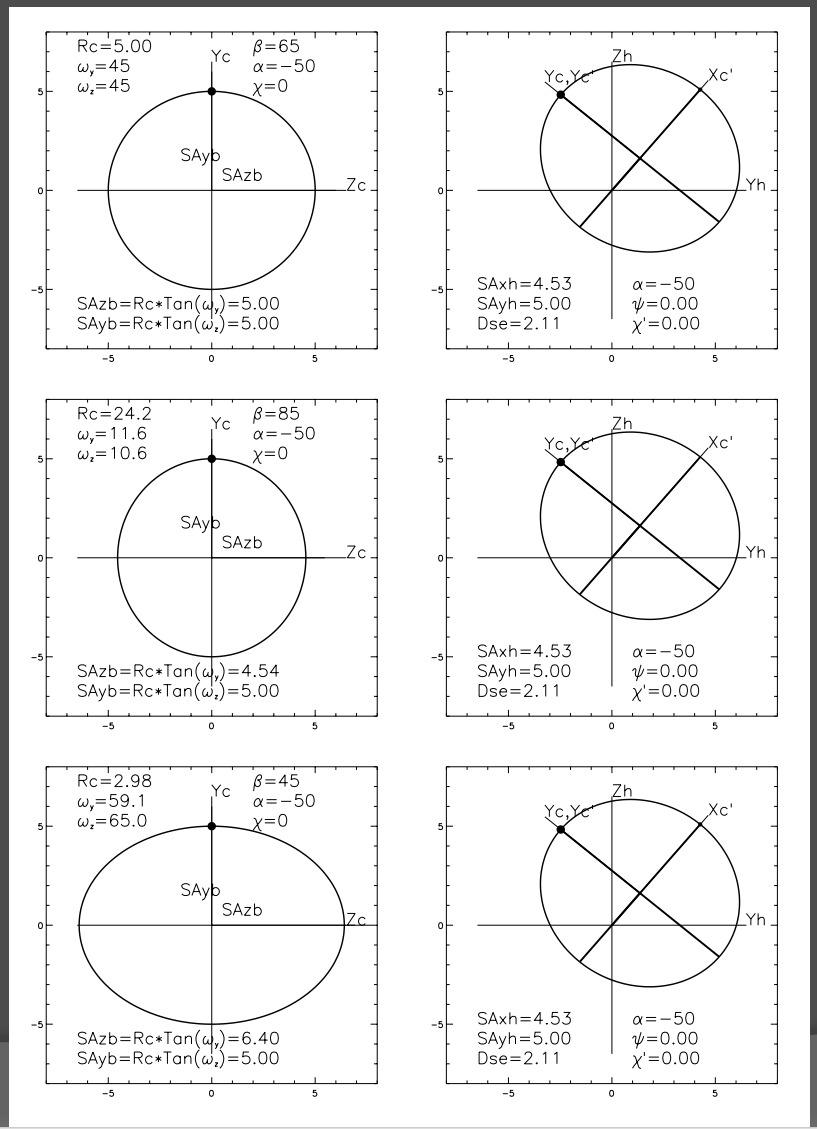




CC MODEL MINOR AXES MUST PASS THROUGH SOLAR DISK CENTER

ONLY ~10% OF ALL OBSERVED EVENTS!

The CC Model Limitations (2/2)



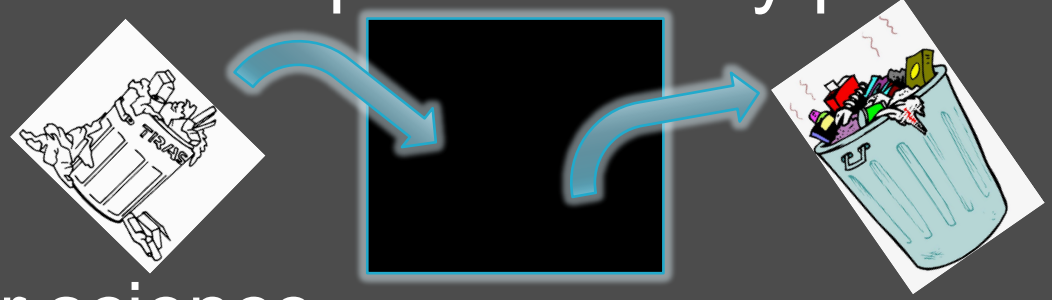
3 different sets of model parameters (left column)

Identical halo parameters for given β (right column)

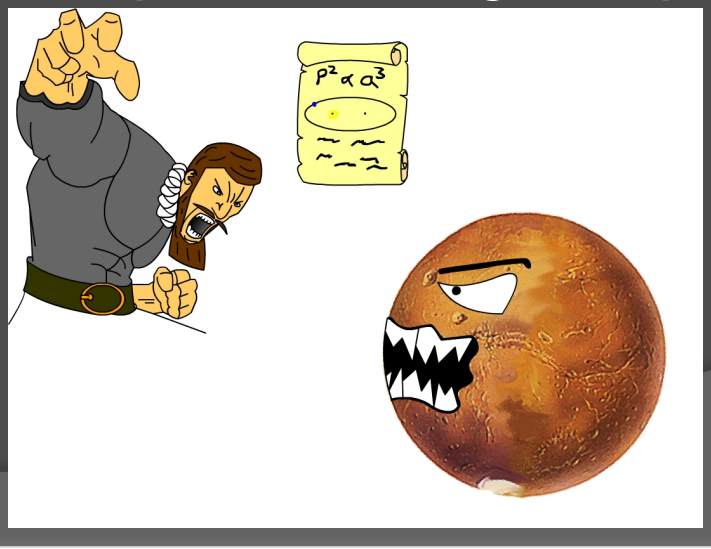
CC Model solutions not necessarily unique

Importance of Generalizing the Cone Model

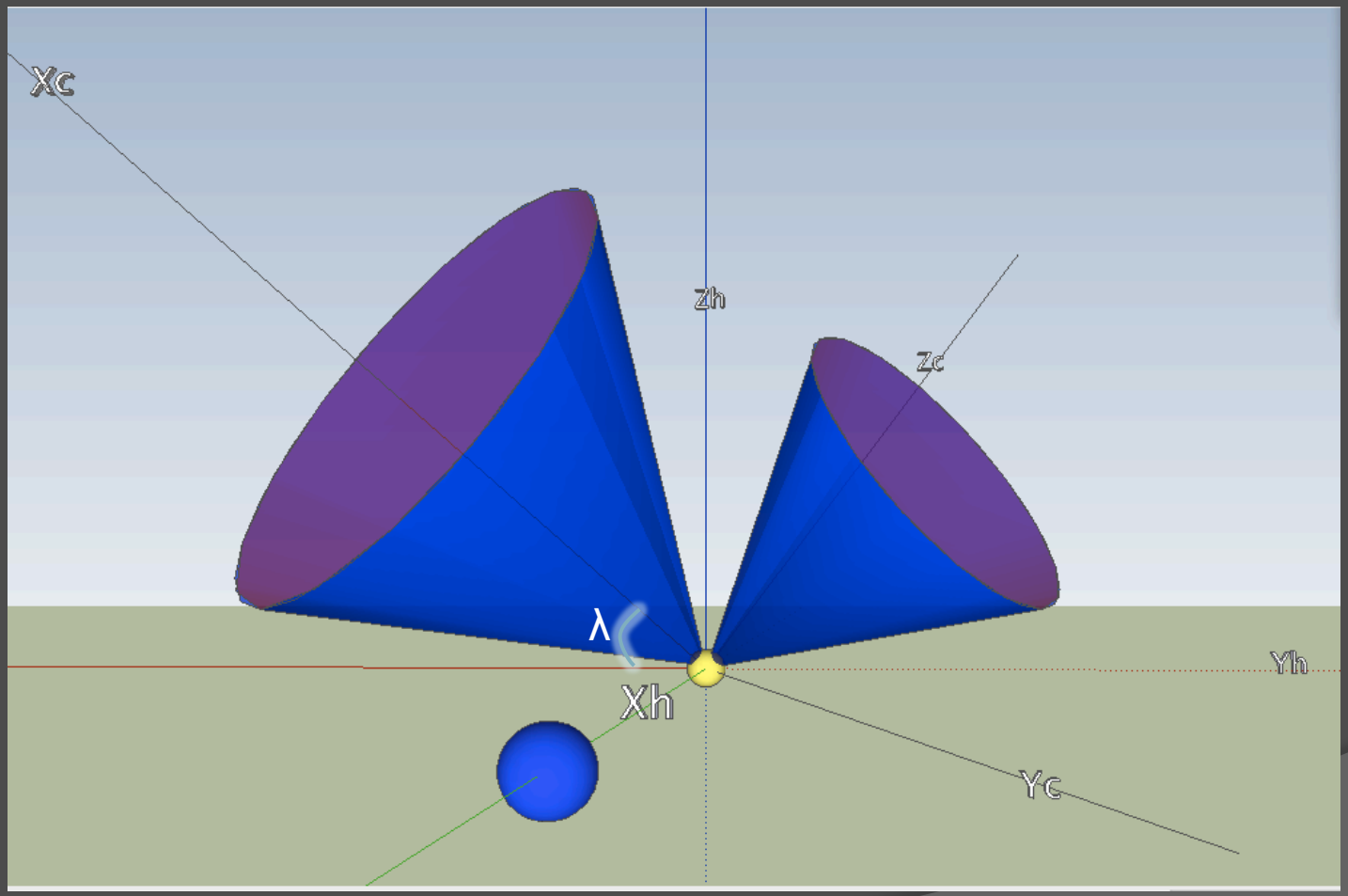
- MHD codes for Solar Wind use Cone Model as an input/boundary parameter



- Better science
  - Johannes Kepler had to give up circles too



The Zhao Elliptic Cone (ZEC) Model (1/2)



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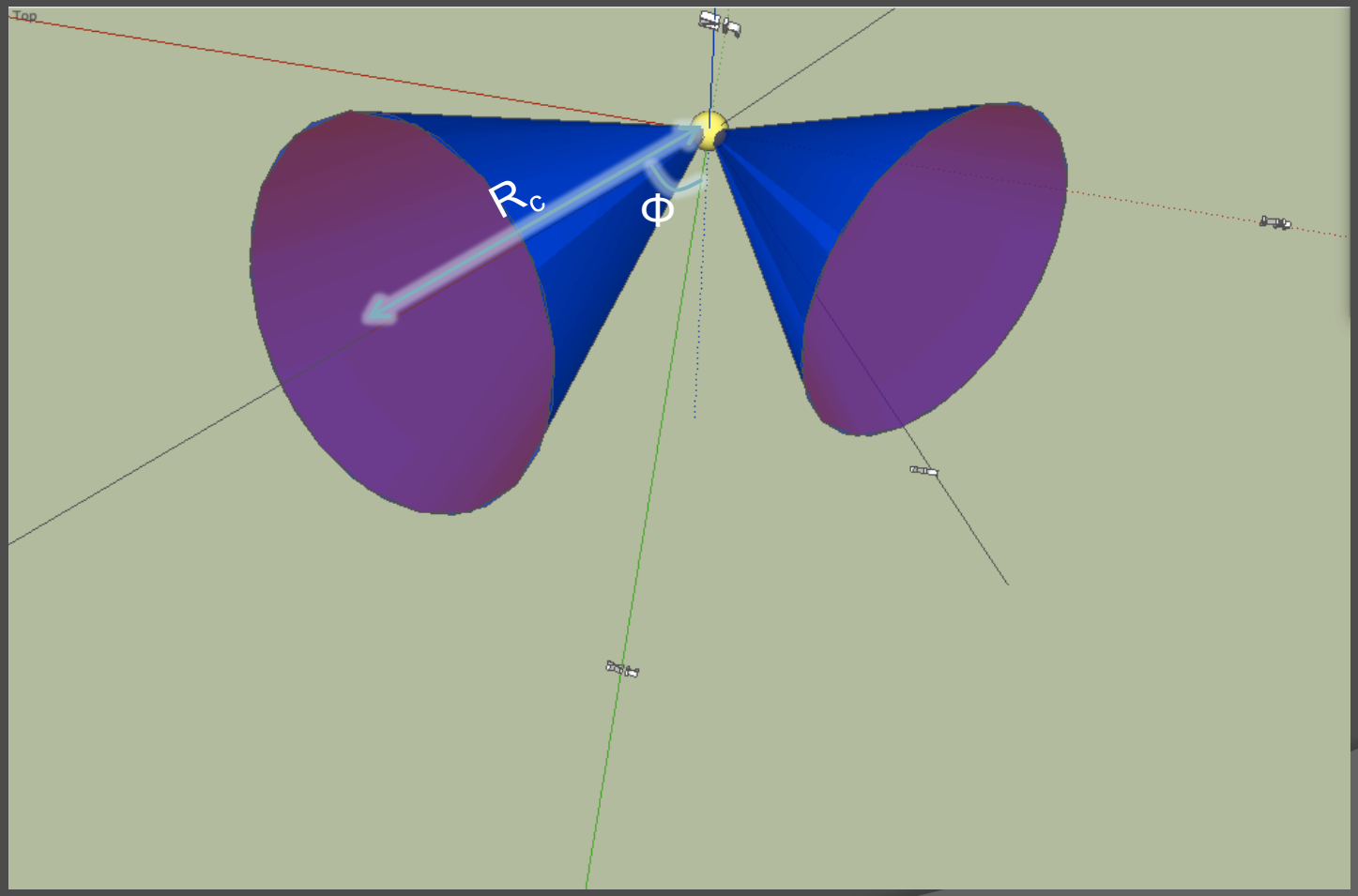

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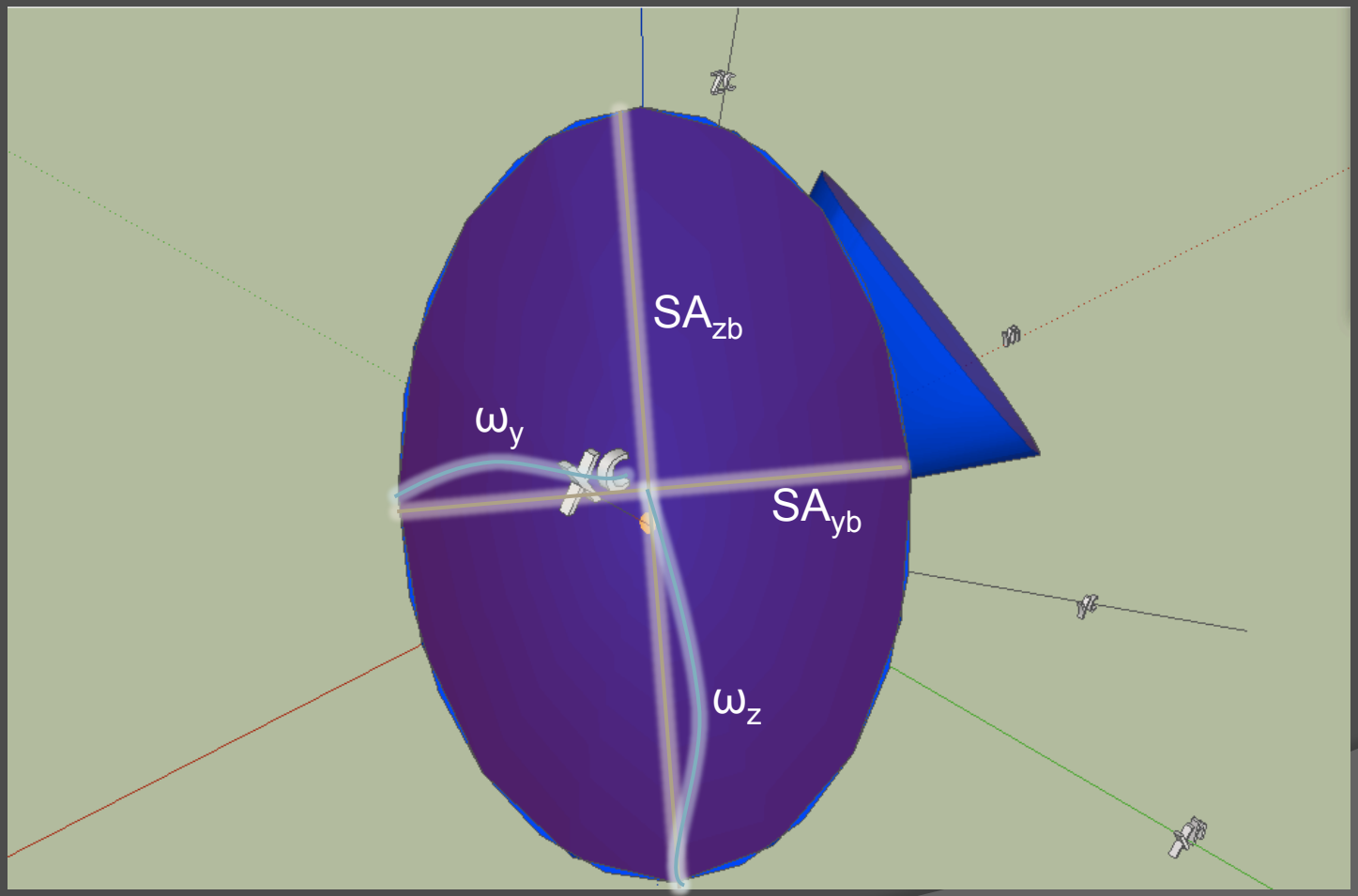

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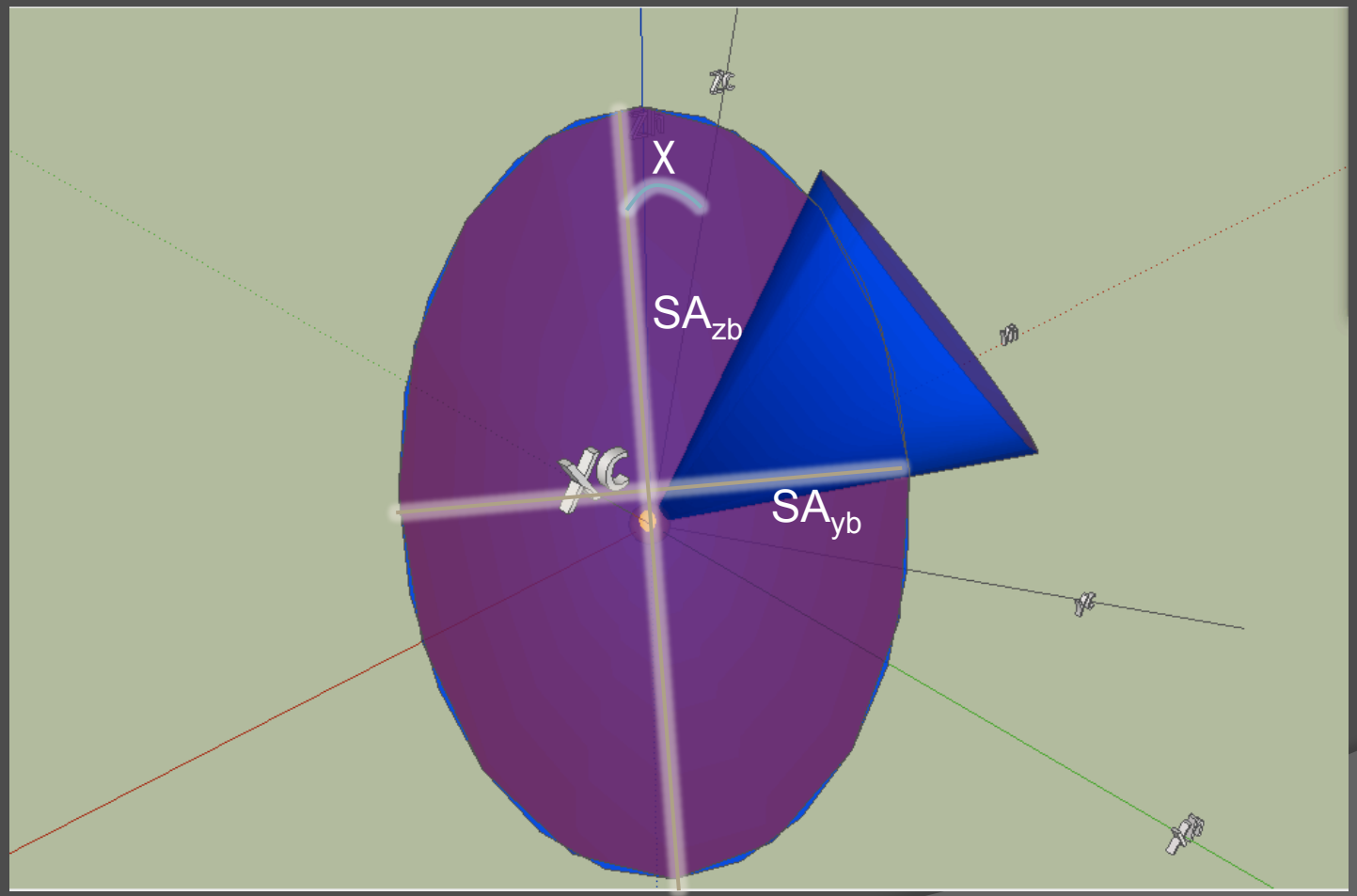
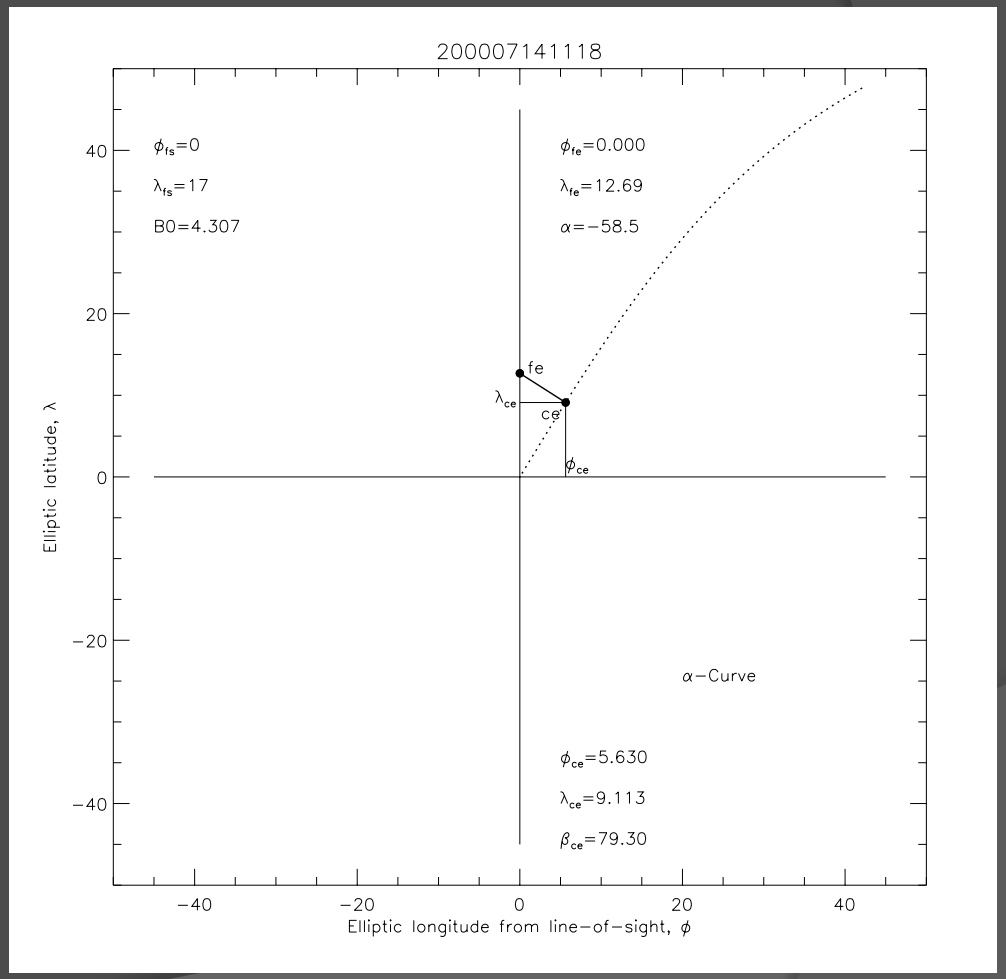


The ZEC Model (2/2)

- Assumptions & Ambiguities
  - Same assumptions as CCM (Radial Propagation + constant angular width)
  - Need a method to determine propagation direction (β-angle between X_c and X'_c) in order to uniquely solve inversion equations
    - 1 point: Associated flare location
    - 2 point: Two simultaneous images from different points in the ecliptic (STEREO)

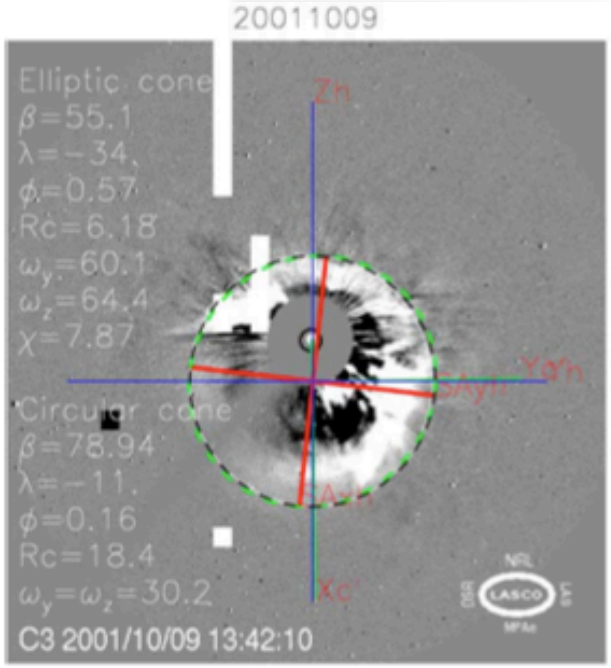
Determination of Propagation Direction (1-point Approach)

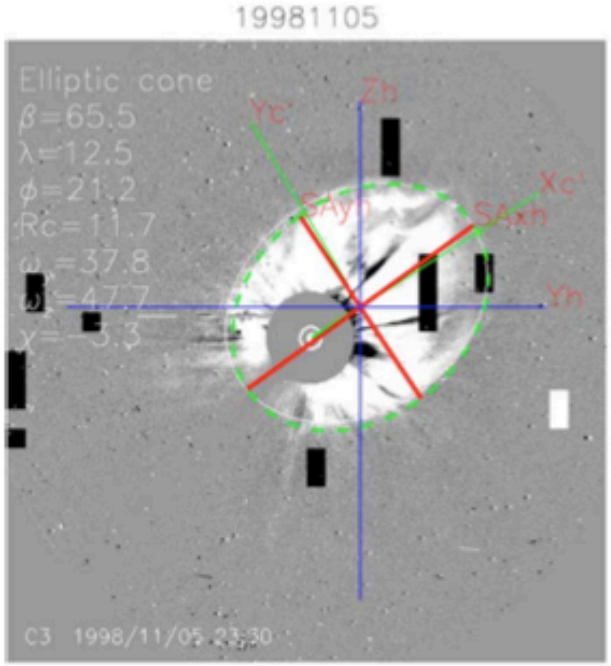
- Specified α narrows possible (λ,φ) from entire plane to a line
- Point represents spatial location of associated flare
- Optimal β = minimum distance between point and curve (after correcting B0)



Validation of 1-point Approach

- Overlay calculated cone projection onto observed CME image
- Generally good agreement





- All figures from Zhao 2008, Journal of Geophysical Research, Vol. 113