# The effect of direction parameter on the classification of MC and EJ

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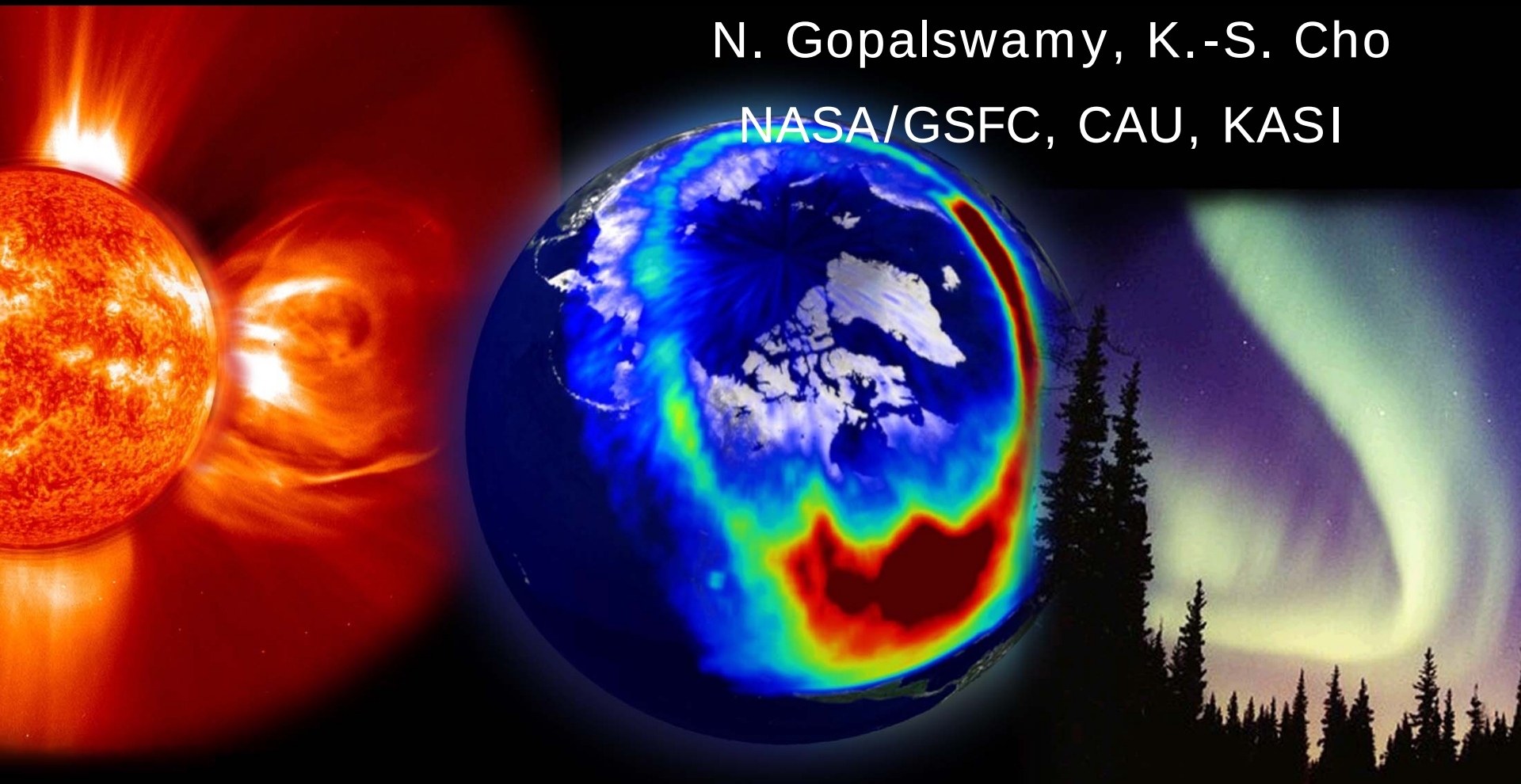
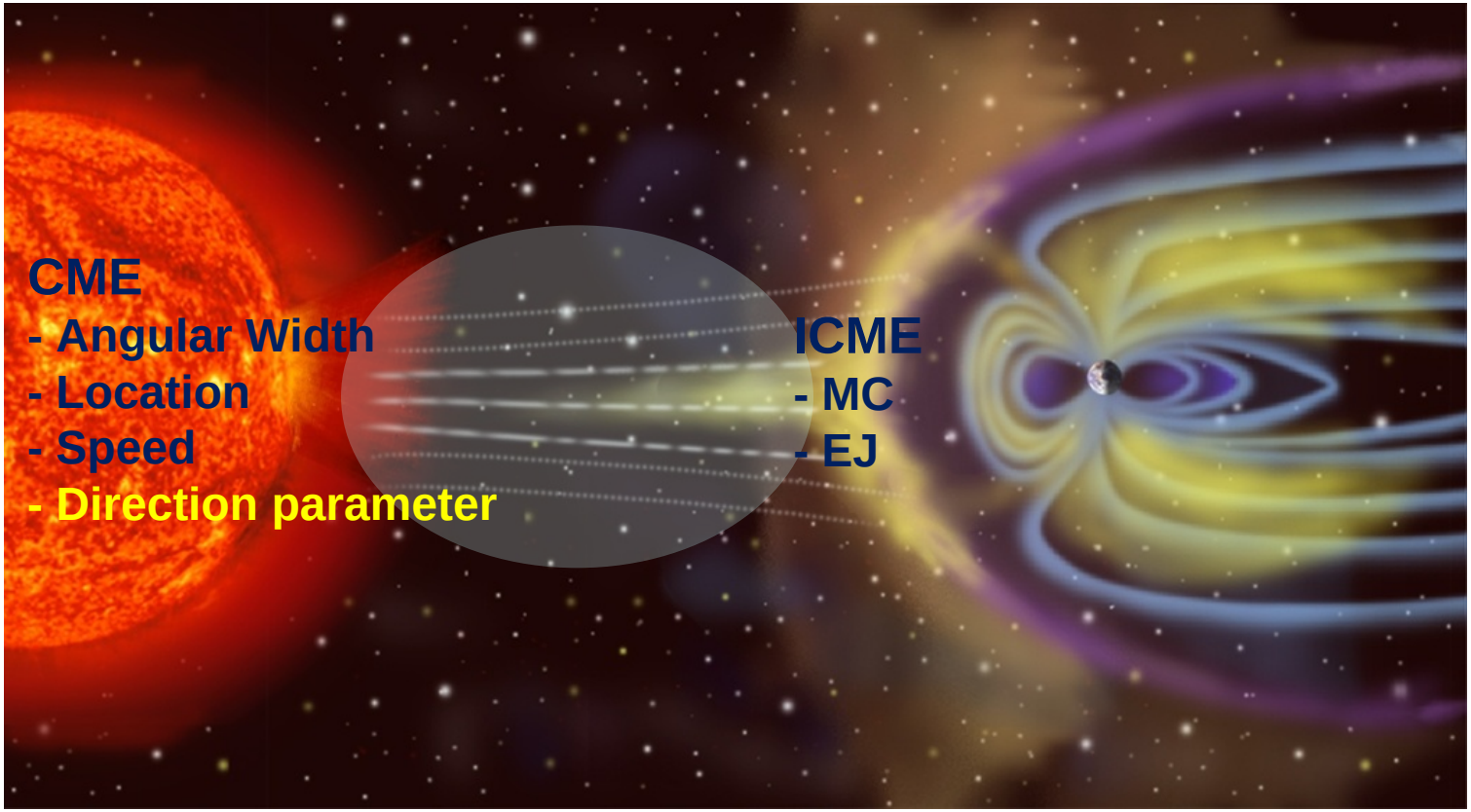


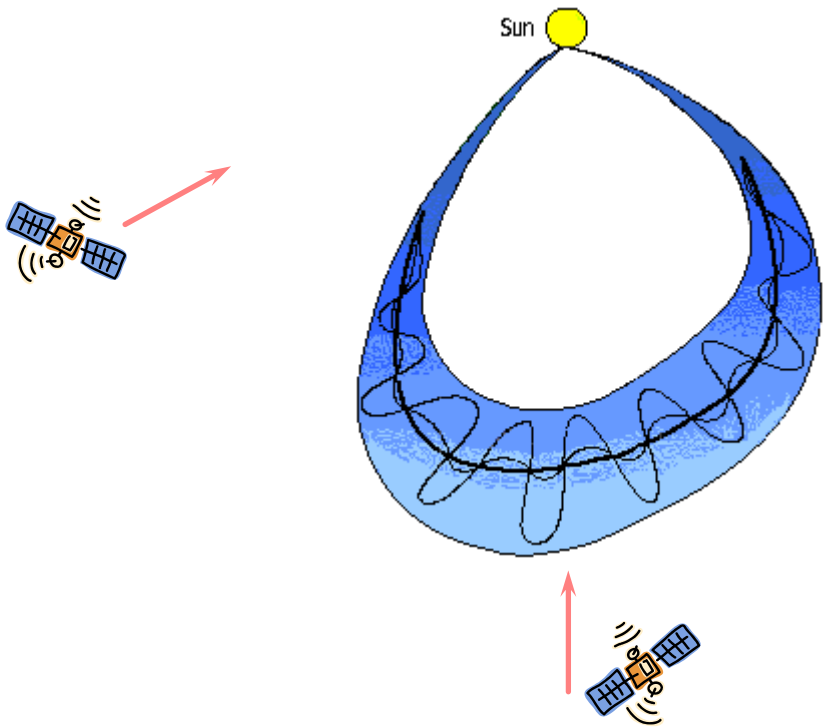
# Classification of ICME Type

- Magnetic cloud and Ejecta
  - We examined the direction parameter of CME.
  - Direction parameter is related with the direction of ICME to the space observation.



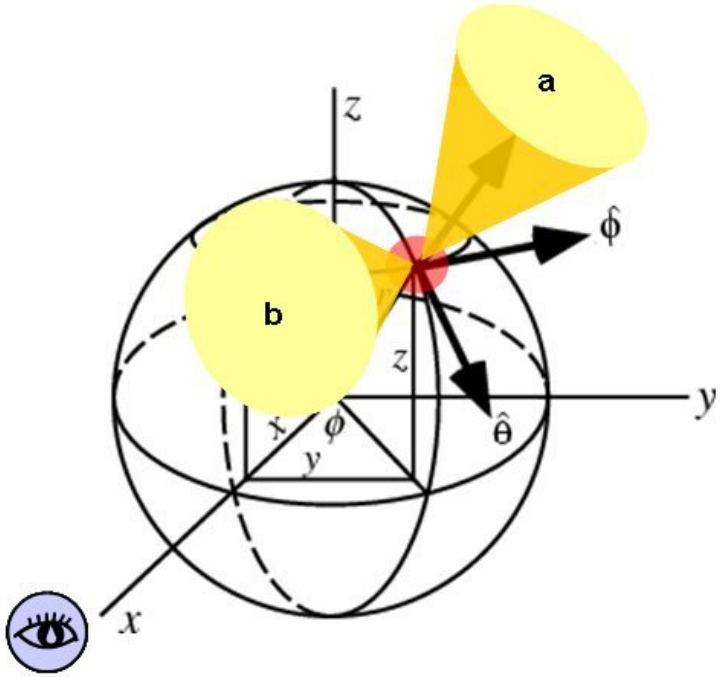
# The geometry of ICME

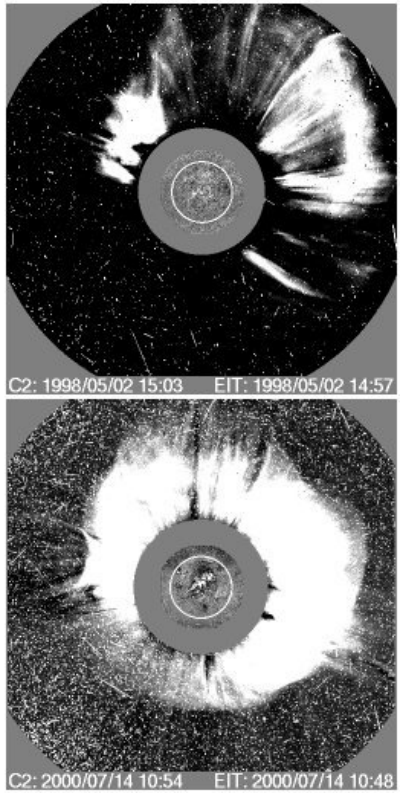
- Can the observing position control the ICME type?

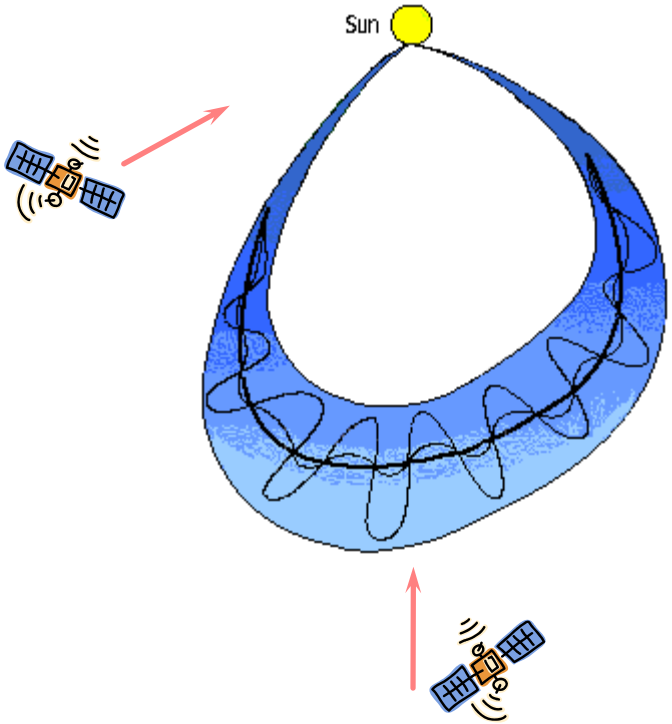


# Direction Parameter (D)

- CME's direction of propagation
  - Two CMEs ejected at the same region might be propagated to different directions according to the their ambience configurations.
  - The shape of CME's front edge could be used to trace CME propagating direction.

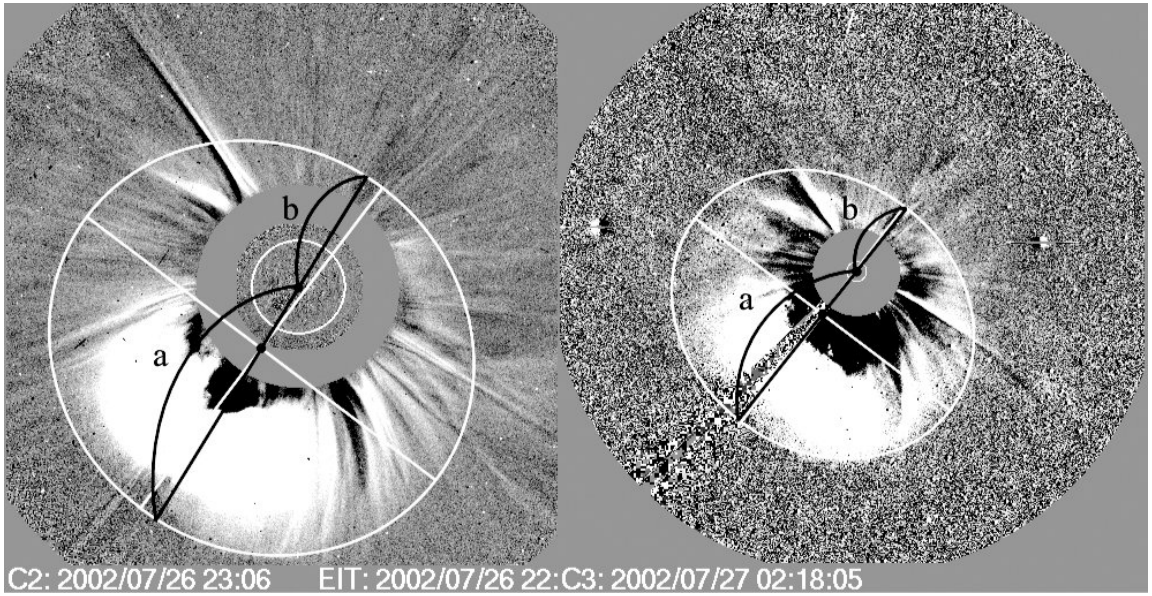


# Direction Parameter (D)

- Definition and Measurement
  - The ratio of the distance between the shorter CME front and the solar center (b) to that of the longer one (a).
  - An ellipse is plotted to follow the CME front in the SOHO/LASCO running difference image.
  - a and b are measured along a line passing through centers of the Sun and the ellipse.
  - D=b/a ($0 \leq D \leq 1$)



# Direction Parameter (D)

- Advantages
  - The direction parameter can be directly estimated from the coronagraph images.
  - It includes both the CME propagation direction and angular effect of the cone model (Xie et al. 2004, Moon et al. 2009).

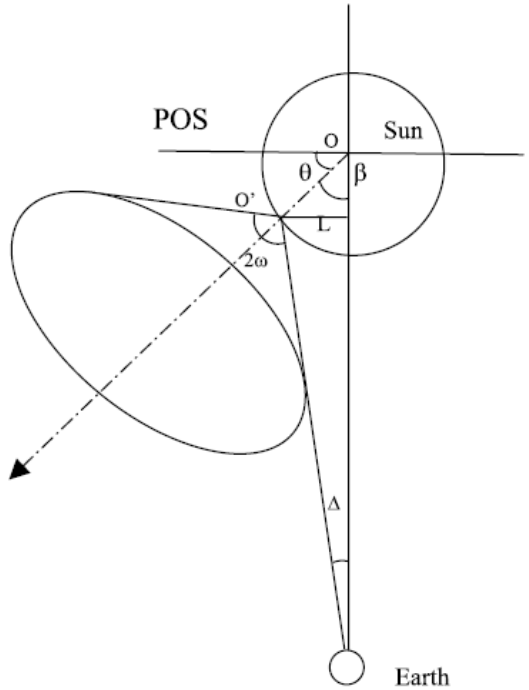



Figure 9. Illustration of the constraint relation between angular width and orientation for a front-side CME to encounter the Earth.

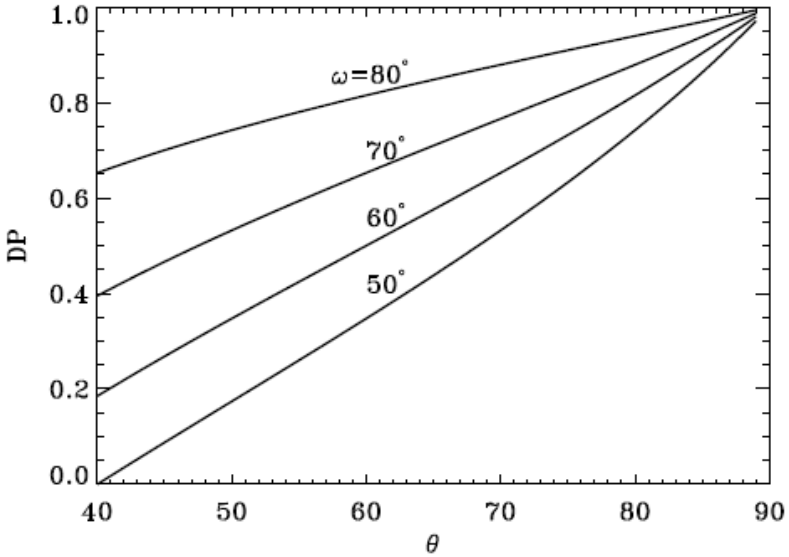
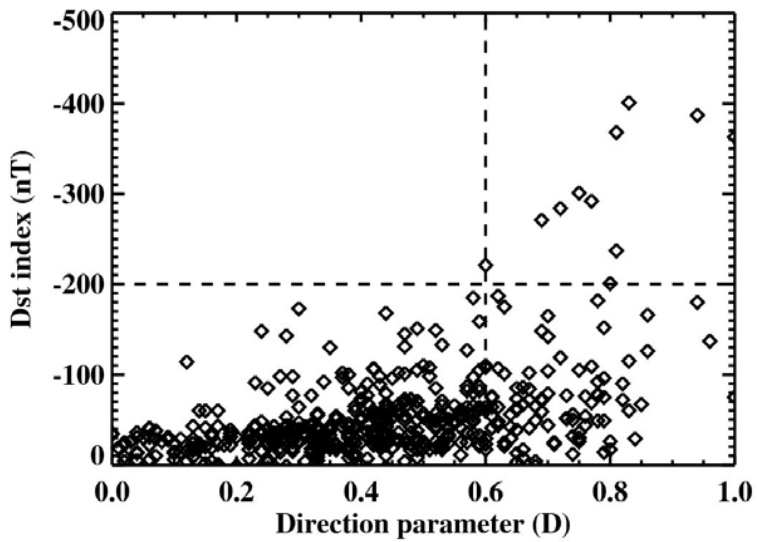
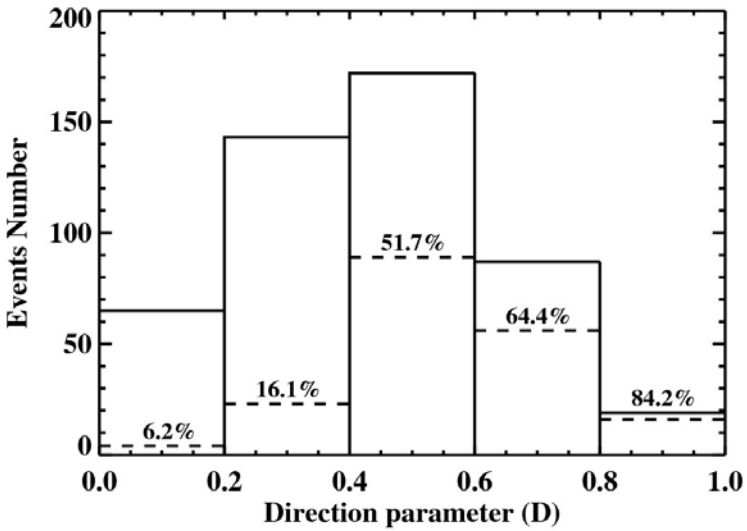



Fig. 3.— Relationship between the earthward direction parameter DP and the cone model parameters, $\omega$ and $\theta$.

# Geoeffectiveness of Direction Parameter

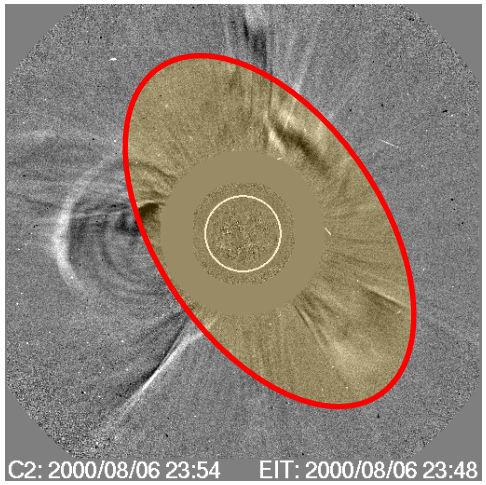
- Distribution and probability
  - Direction parameter has a good correlation with storm strength.
  - All CMEs associated with strong geomagnetic storms (Dst ≤ -200 nT) have large direction parameters (D ≥ 0.6).
  - Probability of geoeffective CME rises from 52% to 84% as the direction parameter increases from 0.4 to 1.0.

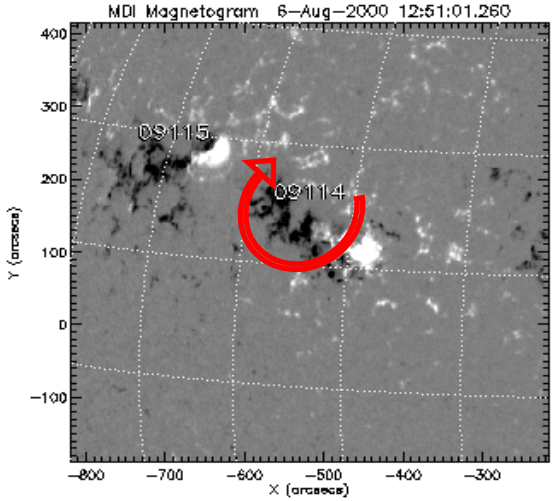


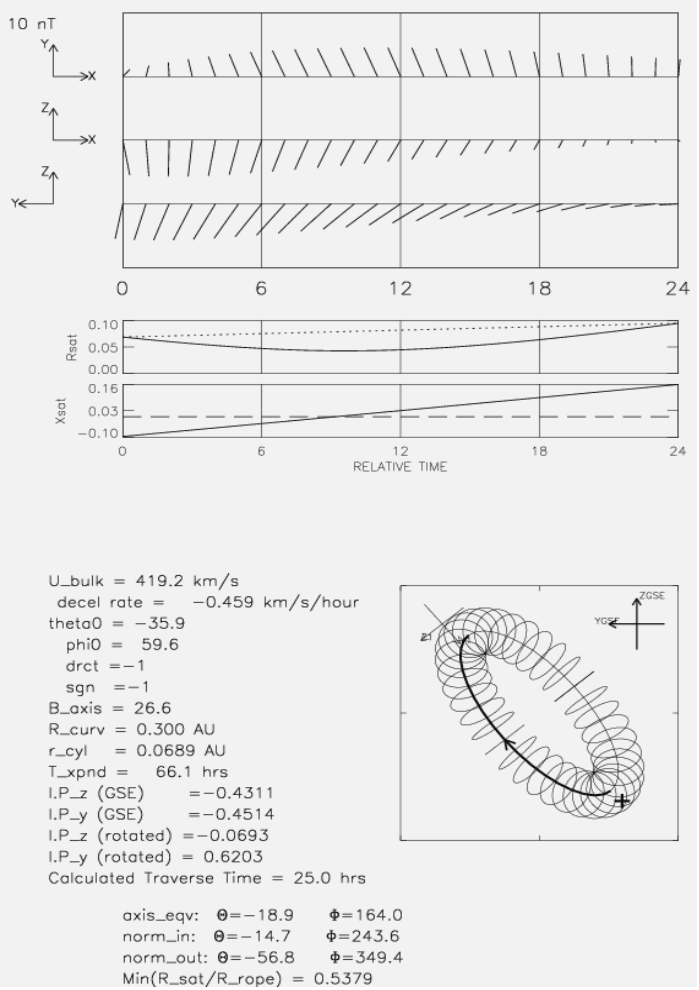



# CME and ICME pair identification

- Magnetic flux rope and CME direction parameter
  - Event #: 22 (EJ)
  - D=0.44

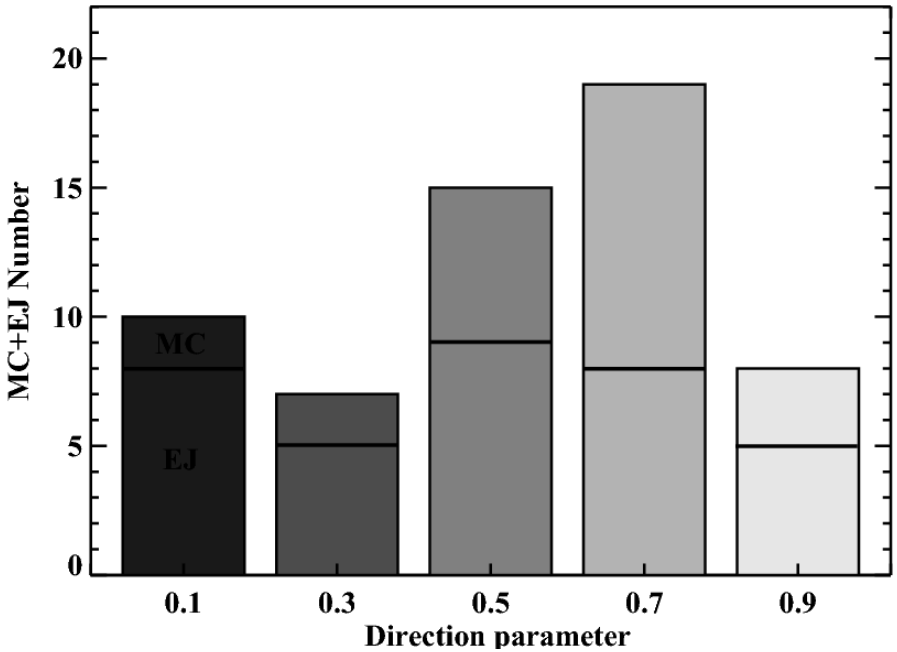


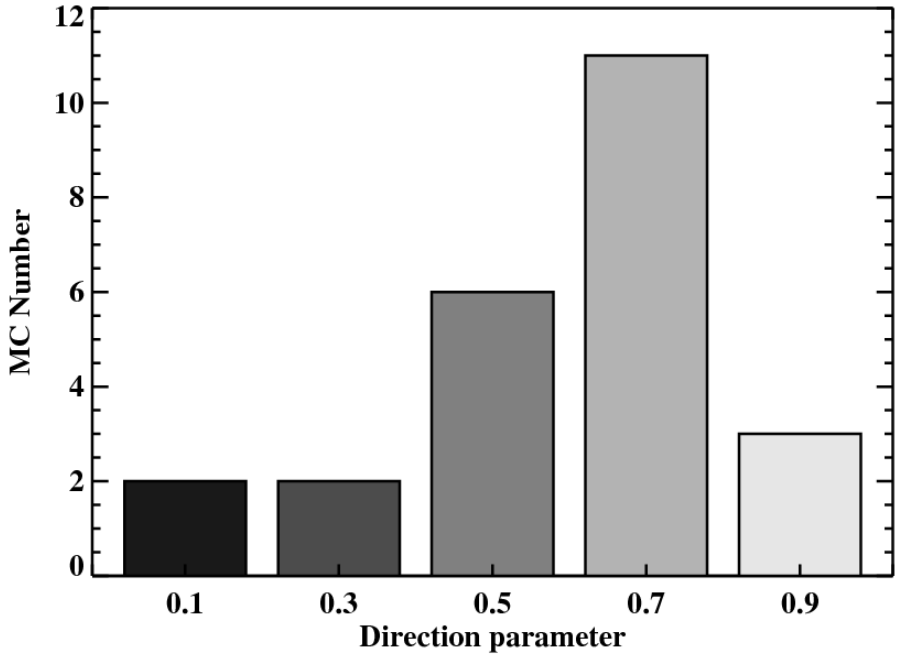
# Direction parameter of MC and EJ

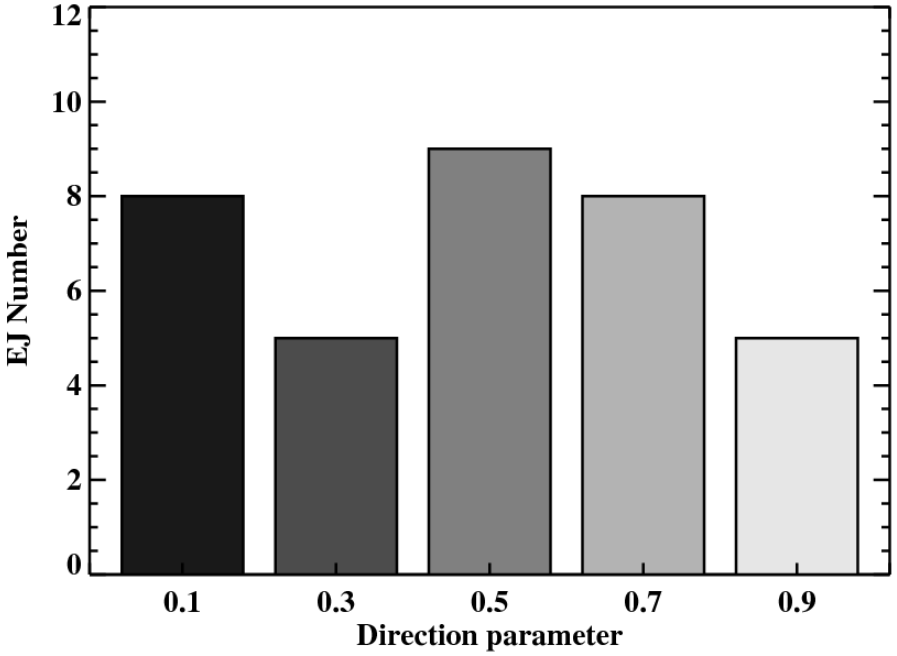
- Statistical result for 59 CDAW events
  - D ≥ 0.4
    - ✓ MC: 48%, EJ: 52%
  - D < 0.4
    - ✓ MC: 24%, EJ: 76%



# Direction parameter of MC and EJ

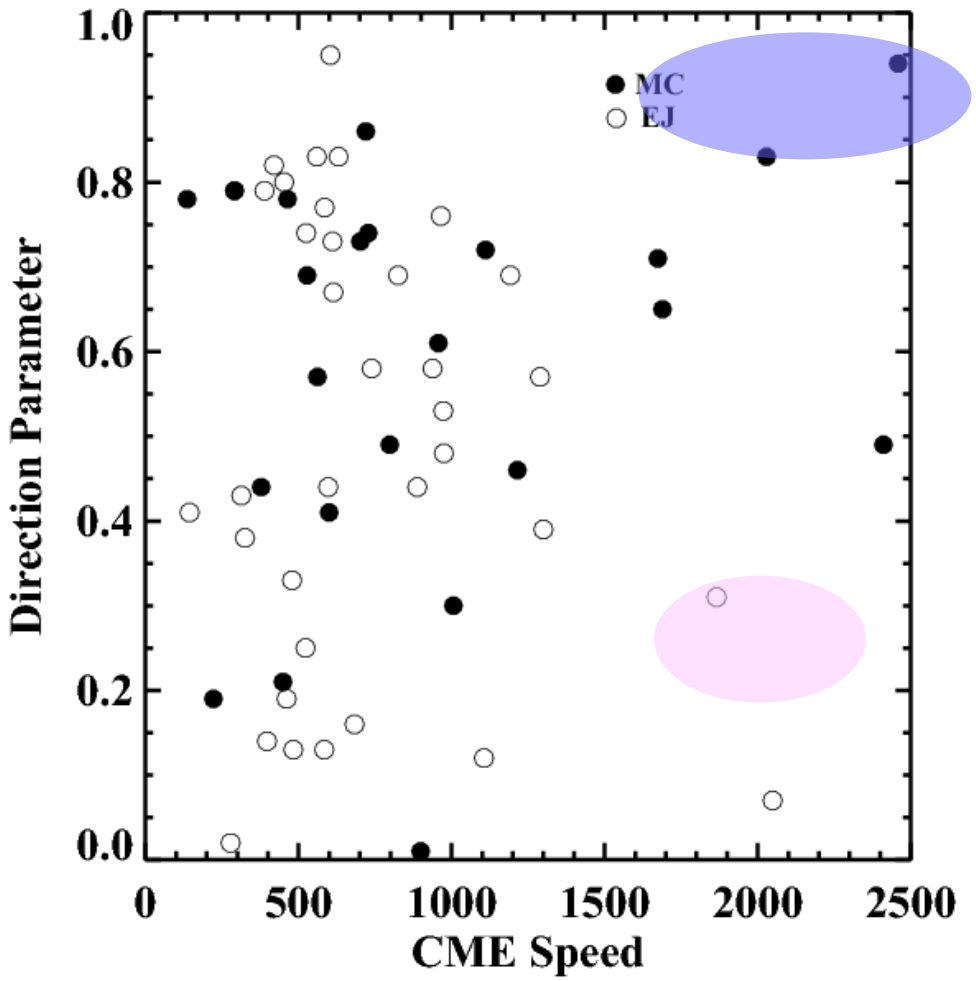
- Statistical result for 59 CDAW list events
  - MC tends to have larger direction parameter than EJ.
    - ✓ Mean D for MC: 0.60
      EJ : 0.49



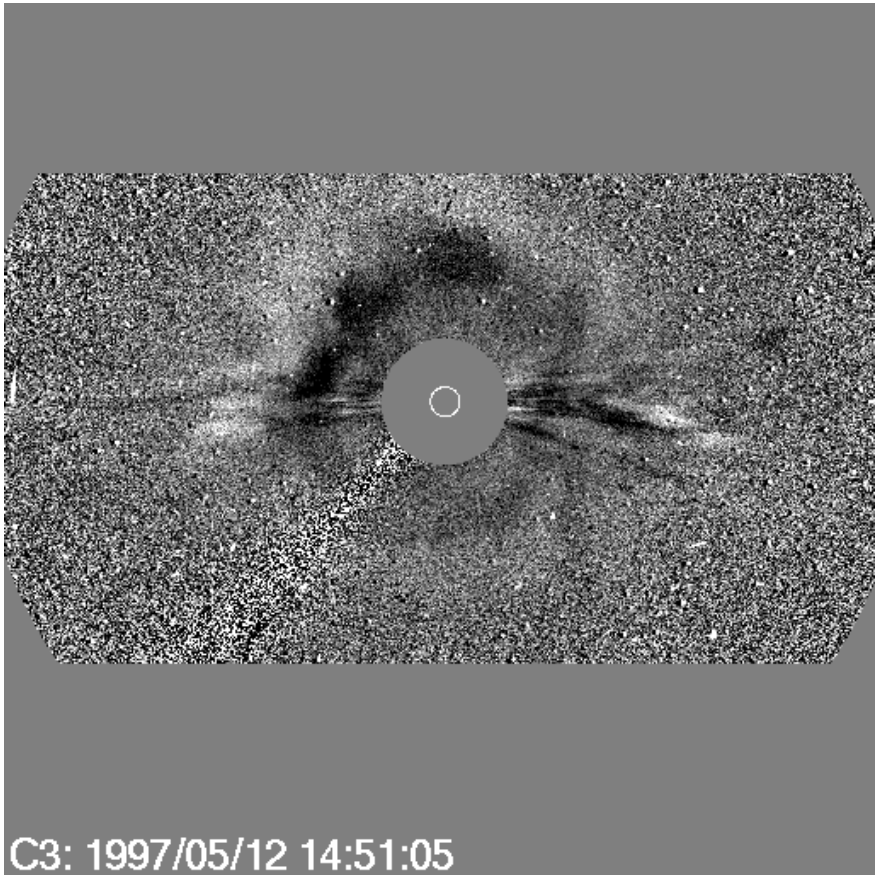
# The combination effect of D and Speed

- For very fast CMEs (V ≥ 1500 km/s)
  - If the CME has large D,
    → MC
  - If the CME has small D,
    → EJ



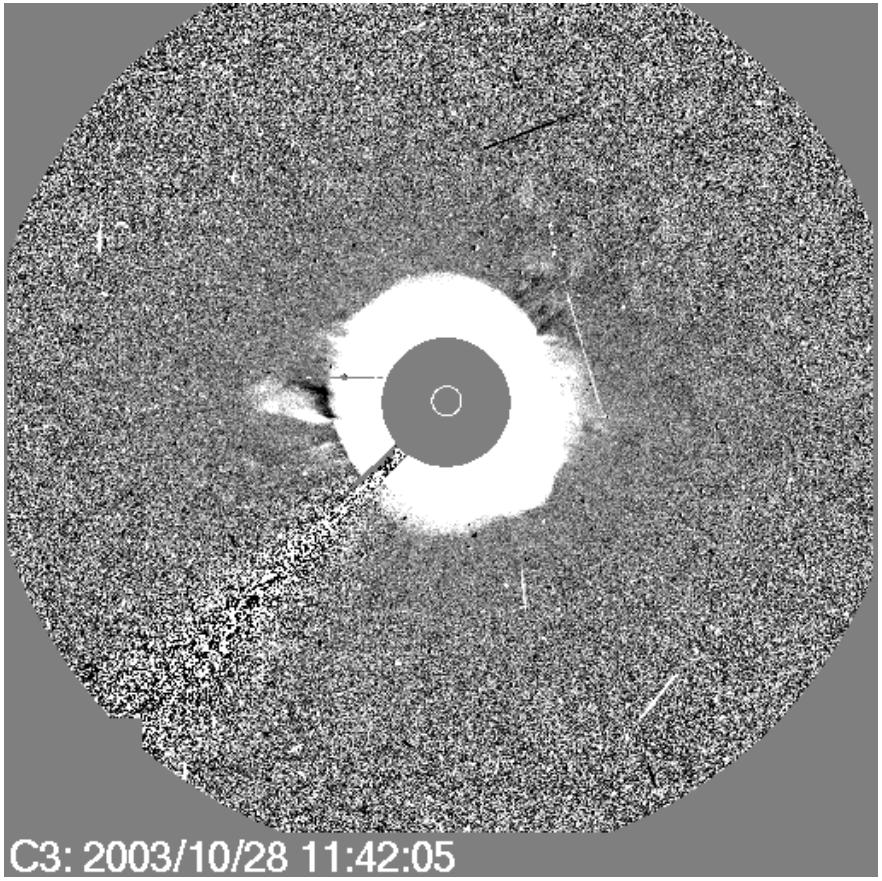
# Case Study

- MC (#2)
  - CME speed: 464 km/s
  - Flare class: C1.3
  - Flare location: N21W08
  - D: 0.83



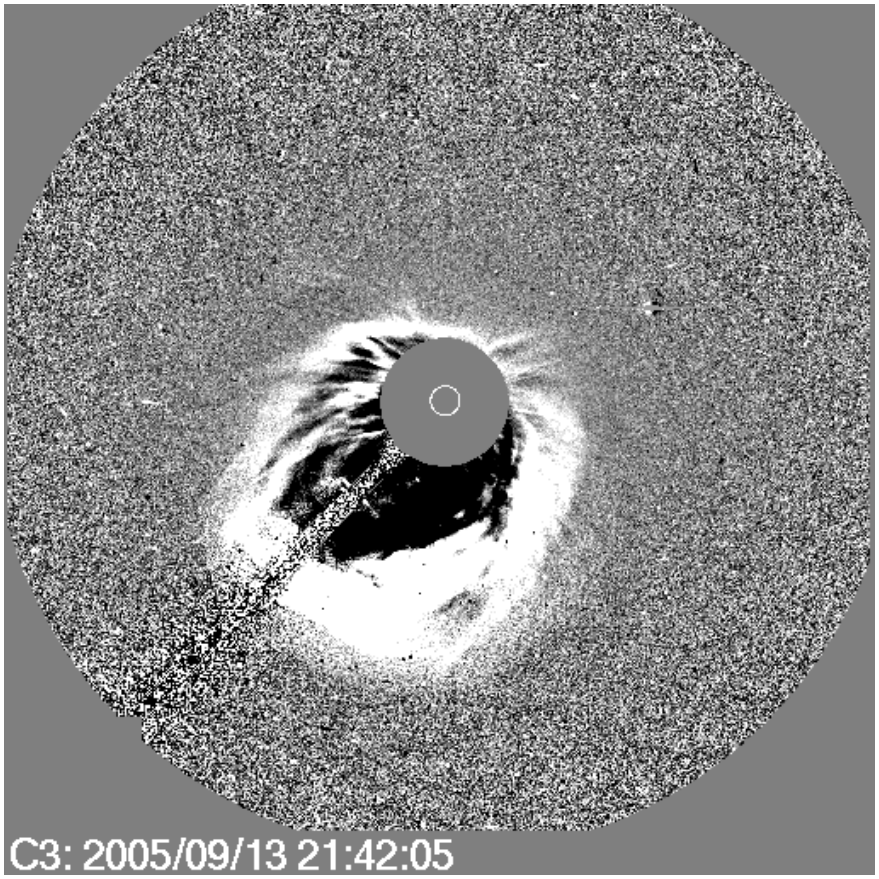
# Case Study

- MC (#45)
  - CME speed: 2459 km/s
  - Flare class: X17.2
  - Location: S16E08
  - D: 0.94



# Case Study

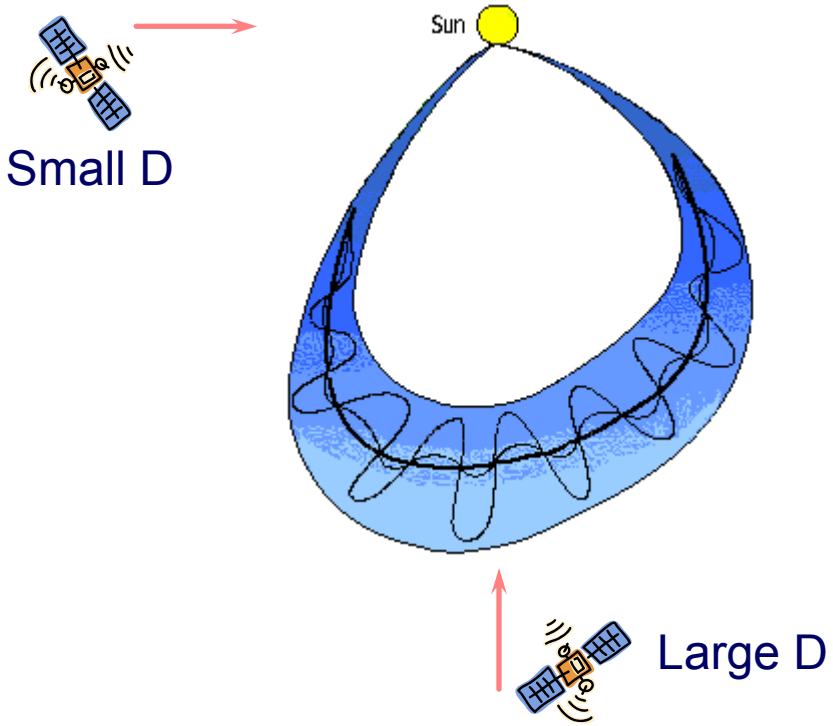
- EJ (#58)
  - CME speed: 1866 km/s
  - Flare class: X1.5
  - Flare location: S09E10
  - D: 0.31



# Conclusions

- If the direction parameter is
  - Larger than 0.4: MC: 48%, EJ: 52%
  - Small than 0.4: MC: 24%, EJ: 76%

  →MC tends to have larger direction parameter than EJ



# Conclusions

- Combination effect with CME speed
  - For fast CMEs (V ≥ 1500 km/s) ,
    - ✓ If the D ≥ 0.4 → MC
    - ✓ If the D < 0.4 → EJ
  - For slow CME,
    - ✓ We have to examine the combination effect with other CME parameters or other process.