



Statistical Study of False Alarms of Geomagnetic Storms

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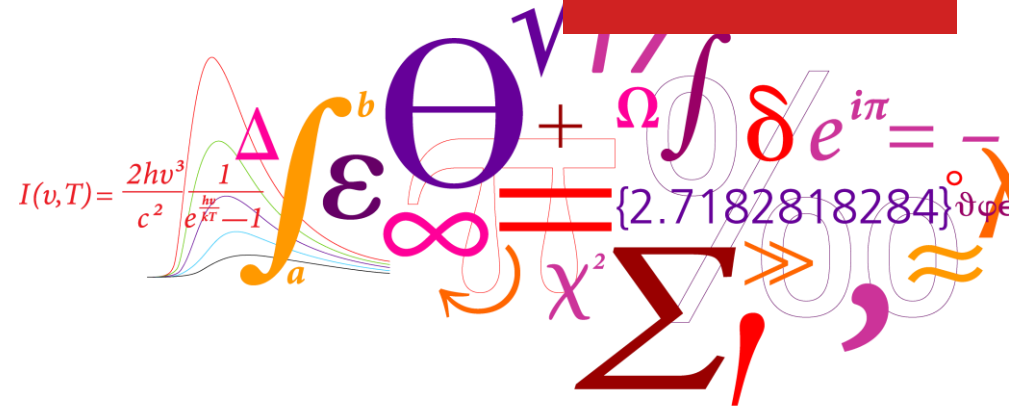
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Statistical Study of False Alarms of Geomagnetic Storms

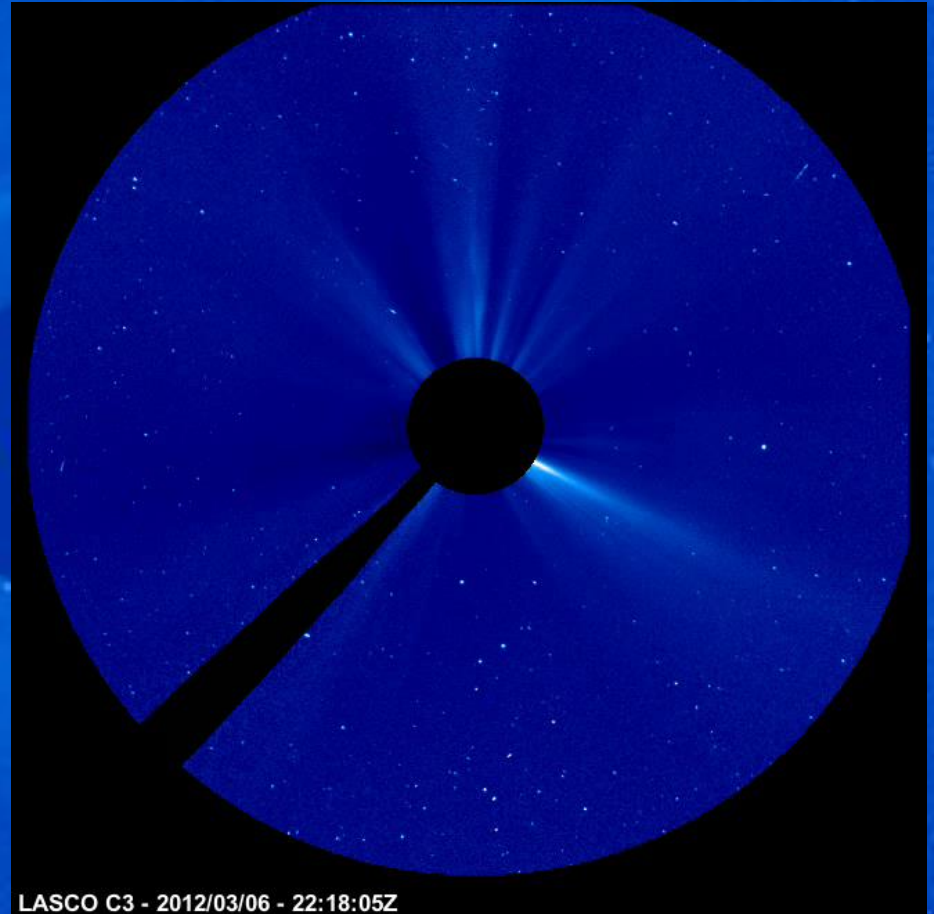
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- Coronal Mass Ejections are the main drivers of strong geomagnetic storms.
- Halo CMEs expected to be geoeffective

Goal:

- Investigate properties of false alarms
- Suggest how to handle false alarms in a forecasting perspective.
- Identify causes of false alarms



Definition of false alarm

Halo CME (front side only)

$V > 500$ km/s

$Dst > -50$ nT (4 days)

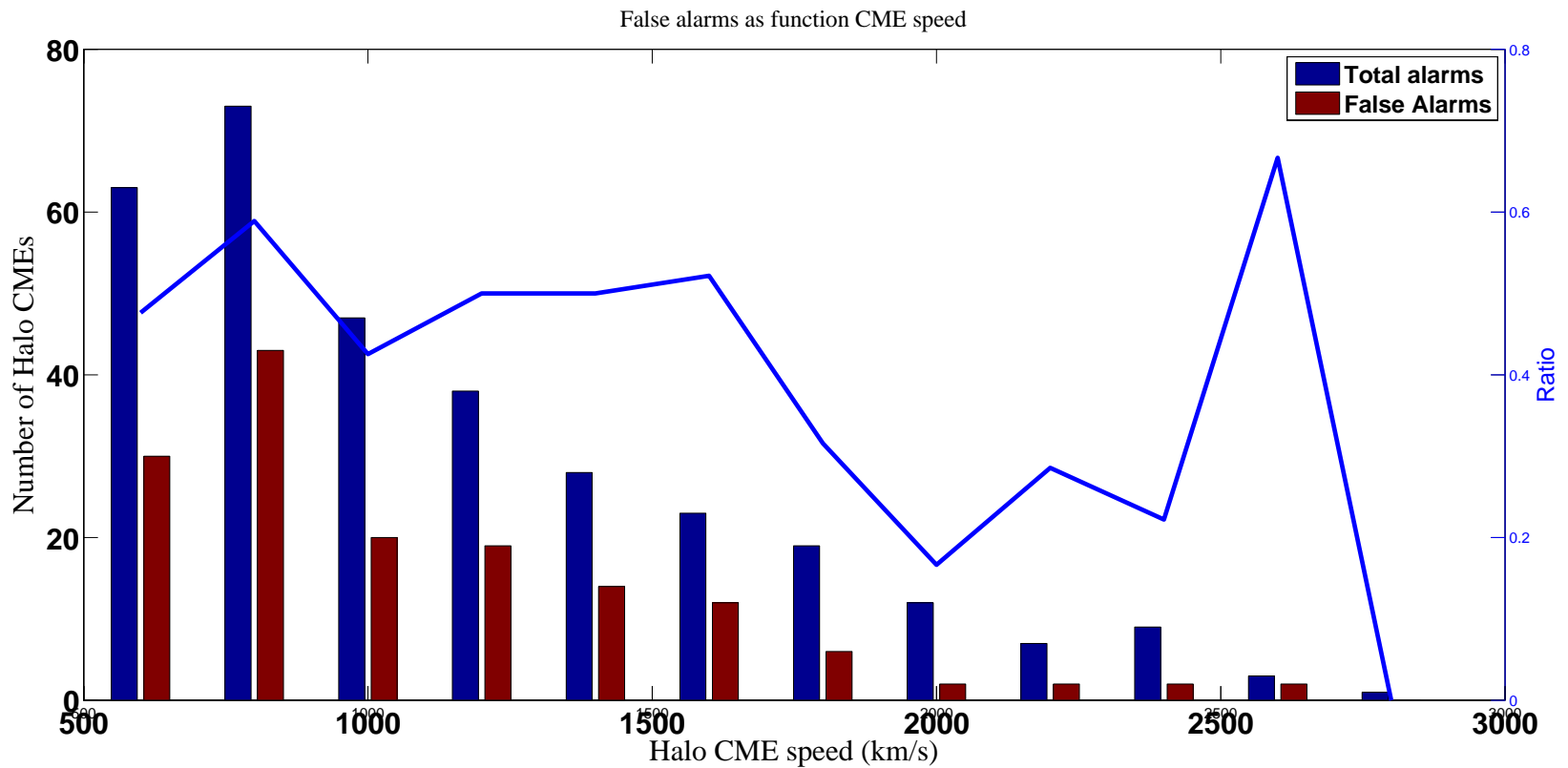
We use the SOHO/LASCO CME list at:
http://cdaw.gsfc.nasa.gov/CME_list/halo/halo.html

Findings

- From the LASCO catalogue in 1998-2012 there was found 367 front side halo CMEs with speed larger than 500 km/s
- 197 of these were associated with geomagnetic storm next 4 days
- 170 had no geo-impact (False Alarms)

More or less 50/50 chance of predicting false alarm

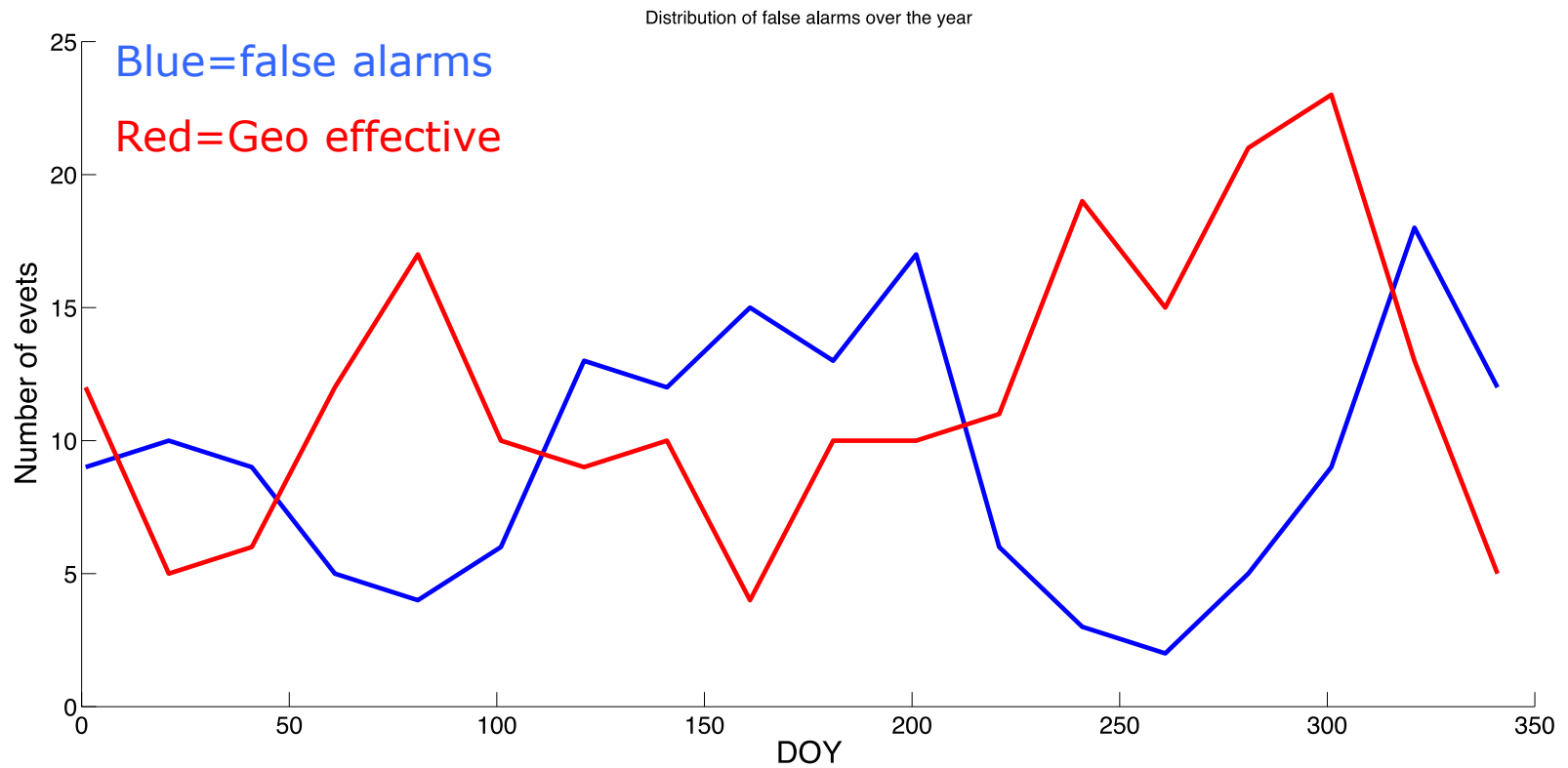
Is CME speed a signature of false alarm?



Associated flare class

Flare class	False alarms (%)	Geo-effective(%)
B and C	55	45
M	39	61
X	22	78

Distribution over the year



Combining flare and DOY

- DOY and associated flare class are strong signatures of false alarms. How can we combine these two?
- Using Bayes' theorem we can find P - probability of false alarm for a given time of year

$$P = \frac{FA * f}{FA * f + Geo * (1 - f)}$$

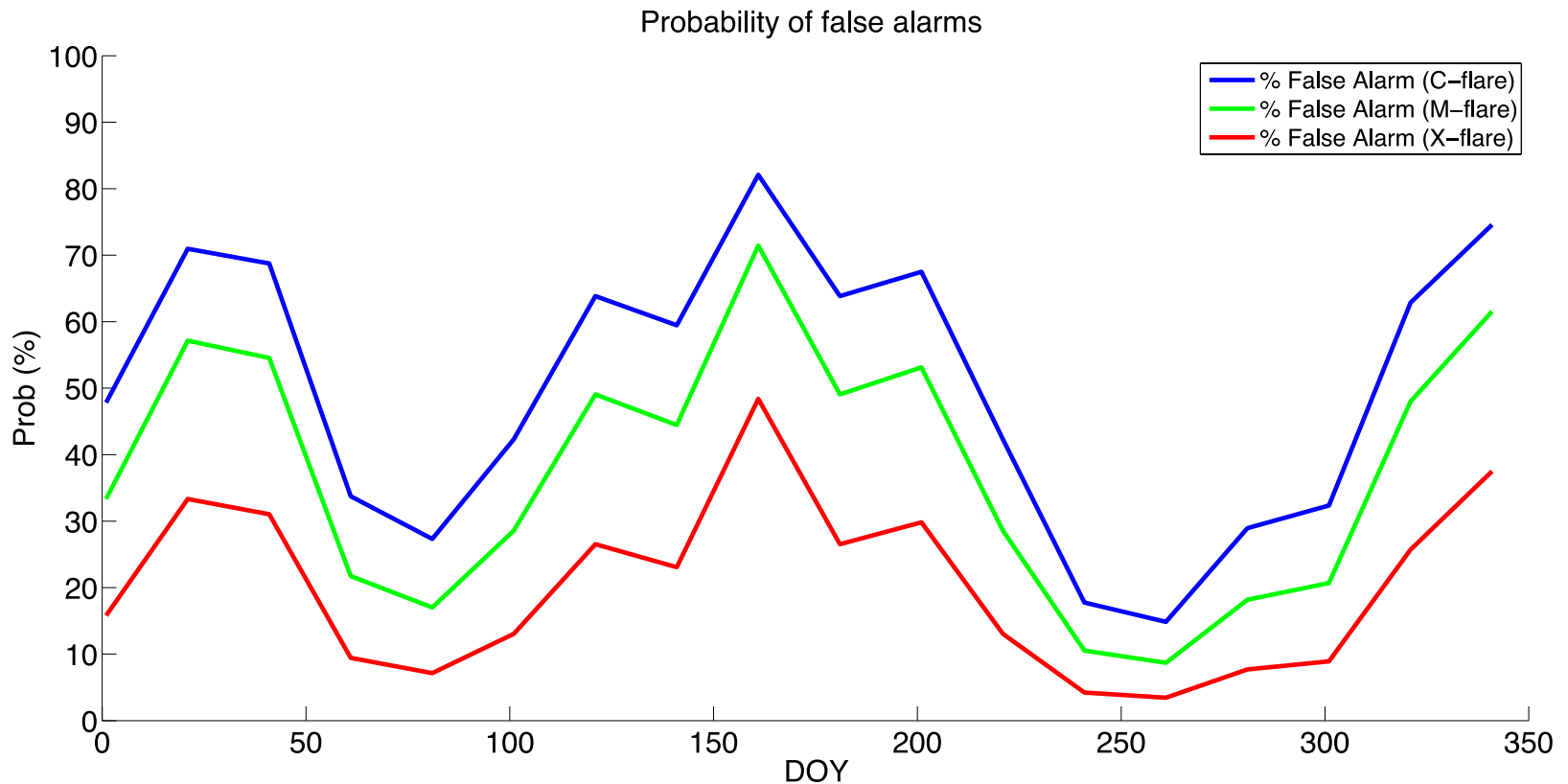
Where FA = number of false alarms in time bin, Geo is number of false alarms in time bin and f is the probability of false alarm as function of flare class.

Example

- Given there were 10 false alarms and 15 geo-effective halo CME in a given time bin.
- If an X-flare is observed in this time bin, the probability of false alarm is (f=22%):

- $$P = \frac{10 \cdot 0.22}{10 \cdot 0.22 + 15 \cdot (1 - 0.22)} = 16\%$$

Probability of false alarms



Causes of false alarms

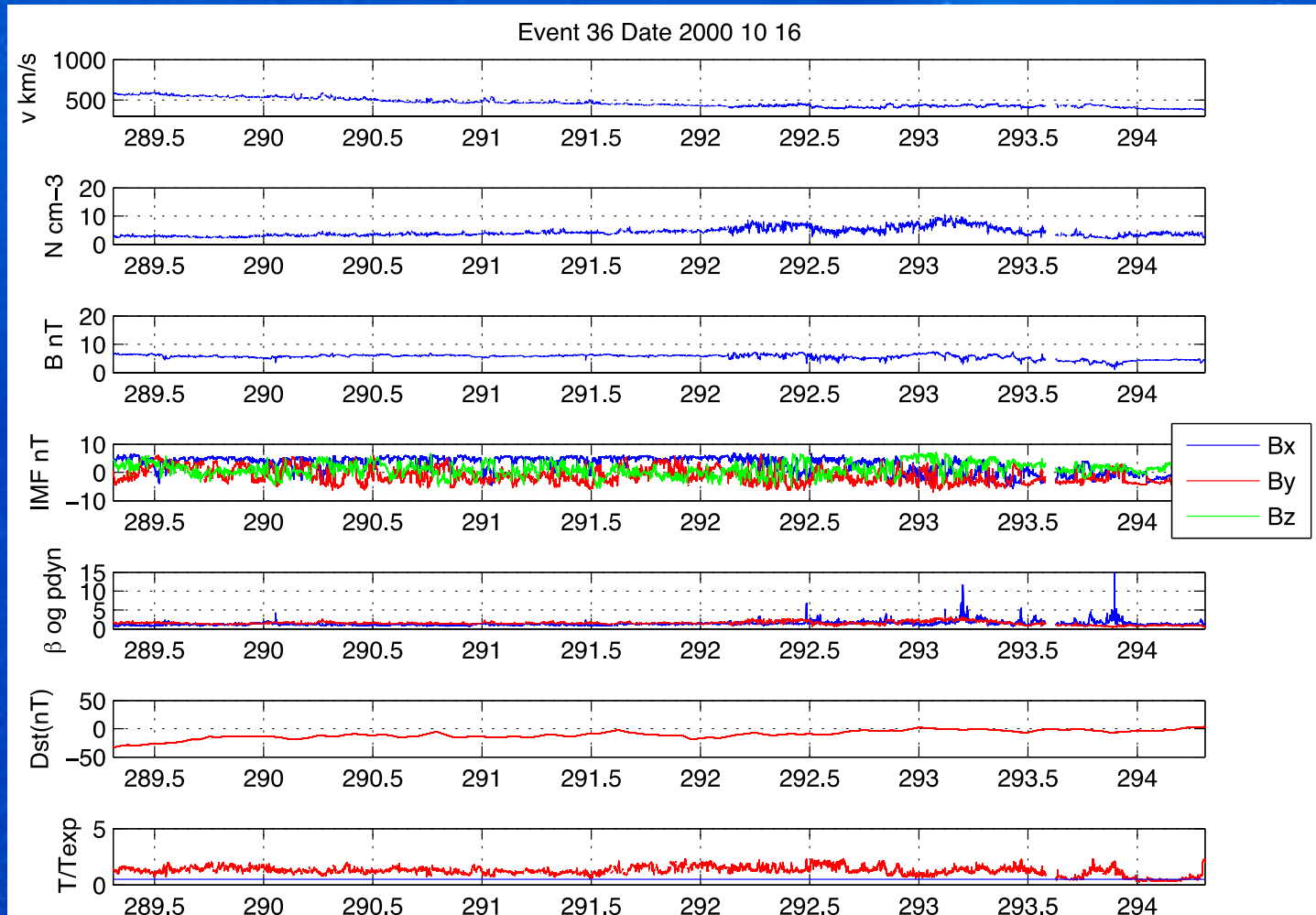
- There are two main causes we can think of:
 1. The CME didn't hit the Earth (miss event)
 2. B_s was small

Ace data was used to determine causes. 142 events from 1998-2011 was examined.

Miss events defined by three rules:

- the maximum gradient of B is less than 2 nT/min
- the maximum gradient of N is less than 4 particles/min
- B didn't exceed 10 nT.

Typical miss event



Shock

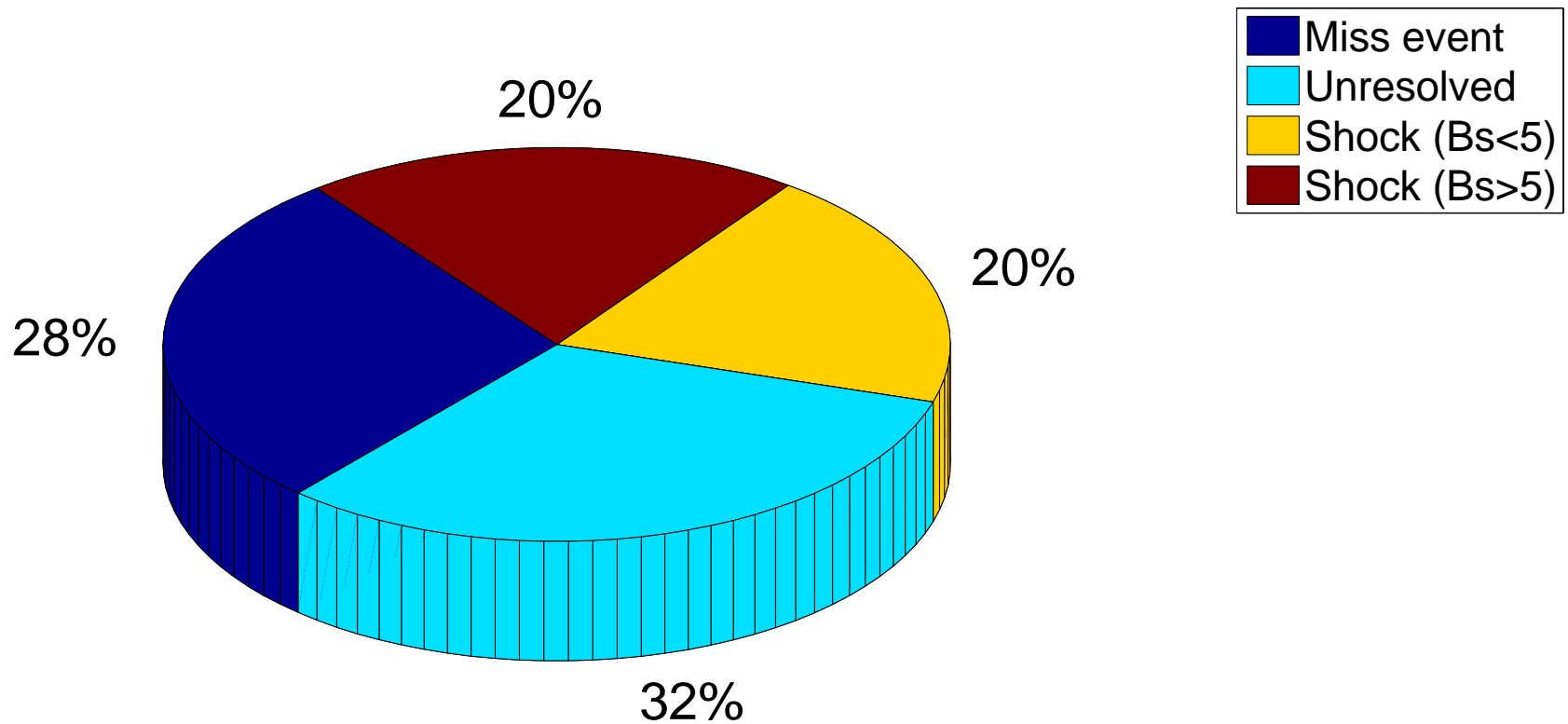
Shock in ACE data are collected on:

http://www.ssg.sr.unh.edu/mag/ace/ACElists/obs_list.html#1999

60 shock related events were found – these events did indeed hit the Earth.

It was examined if $B_s > 5$ nT for at least two hours. (Gonzales et al. 1994)

Causes of false alarms



Conclusion

- False alarms in the Soho era have been studied.
- No definite signature of false alarm was found, however it was showed how time of year and associated flare in high degree indicates the probability of false alarm.
- Causes were investigated and it was found that 28% false alarms are cause by miss of CME. 40 % of the CME produced a shock, half of these had a very small B_s . The remaining 32% are not fully resolved.

Bonus slides

C-flares – observations and calculated

