# Type-I radio noise storms and Coronal Mass Ejections

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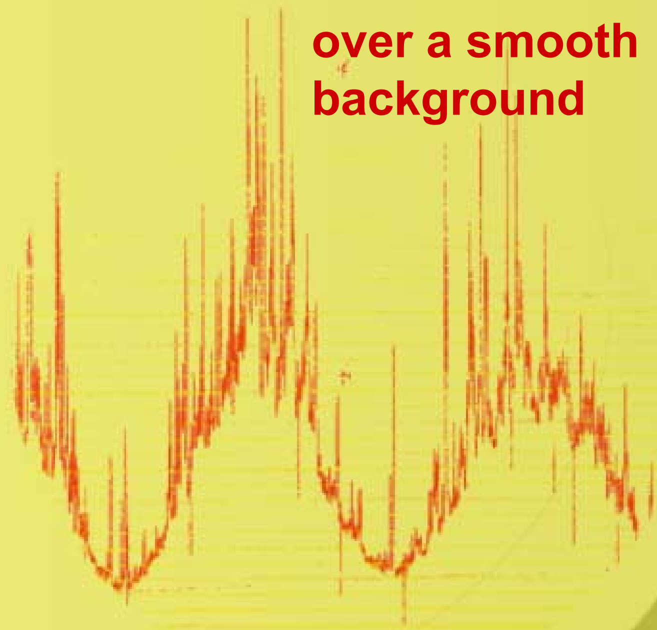
# About Type-I Noise storms

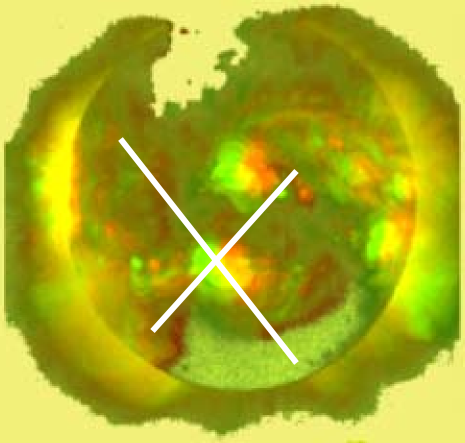
1. Frequently observed solar activity at meter wavelengths

2. Consist of occasional short-lived narrow band radio enhancements, superposed on often observed continuous, slowly varying, long-lasting broadband emission called noise storm continuum (Kai et al. 1985)

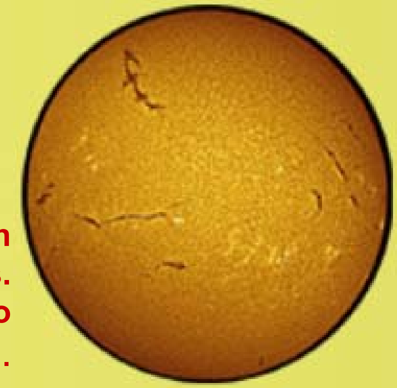


# Noise Storms & CMEs

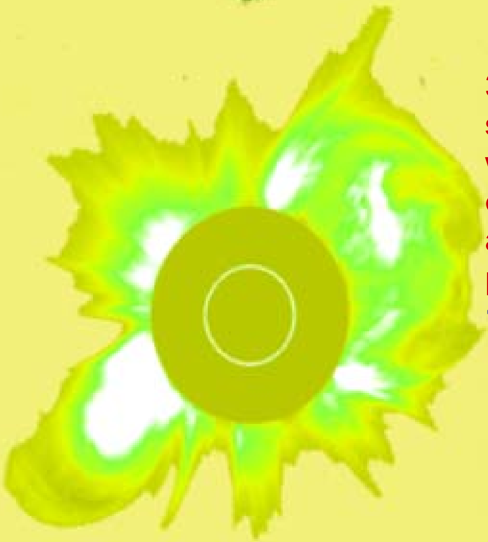
# Present Scenario



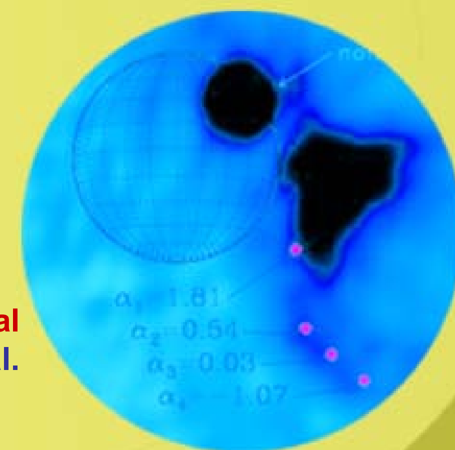
1. Early phase of noise storms – global soft X-ray brightening. But t not related to flare occuring anywhere on the Sun (Habbal 1989, Raulin & Klein 1994)



2. Benz et al. 2005 - week correlation between noise storms and X-ray flares. Similar result for H-α flares was also obtained by Elgaroy 1977 & Bohme 1993.



3. NS are systematically preceded, both spatially and temporally, by brightening in white-light coronagraph images - addition of new material to the corona in the aftermath of a CME – necessary precondition for NS onset (Benz & Wetzel 1981; Spicer et al. 1981)



4. CMEs also change the observational characteristics of pre-existing NS (Kahler et al. 1994; Chertok et al. 2001)

# Motivation for our work

**If we believe that CMEs and NS are related**

1. **what special characteristics CMEs must bear to have such a relationship with NS?**
2. **Can the onset of a NS be predicted with the help of CME parameters such as its speed, angular extent, position angle, mass, etc.?**
3. **What parameters of NS (like lifetime, angular extent over which the NS activity takes place, etc.) are related to CME parameters?**

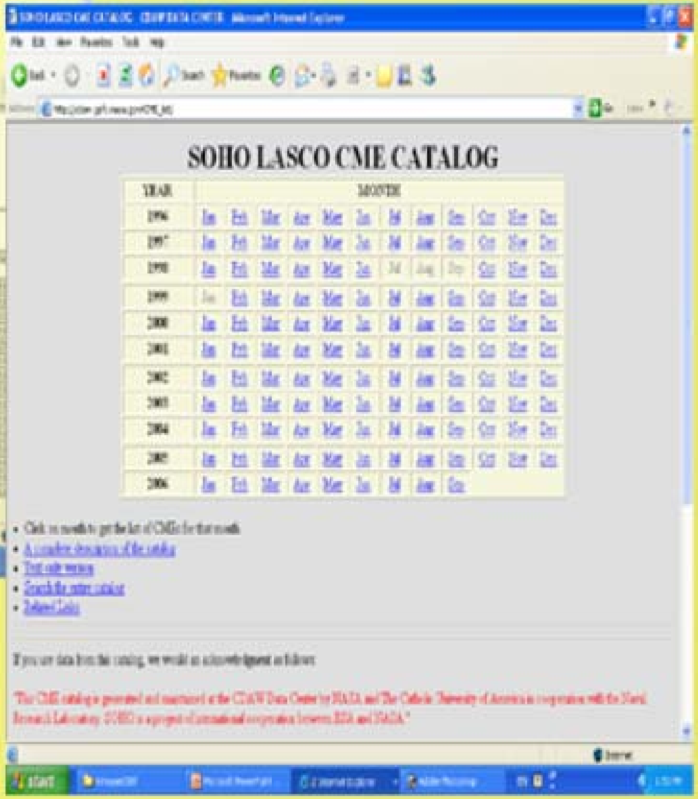
# Noise Storms & CMEs

# Data sources and selection


1. SGD (08:30-15:30 UT)
2. GRH (05:30-07:30 UT)

Year: 1996 - 2004

## 3. LASCO CME Catalog



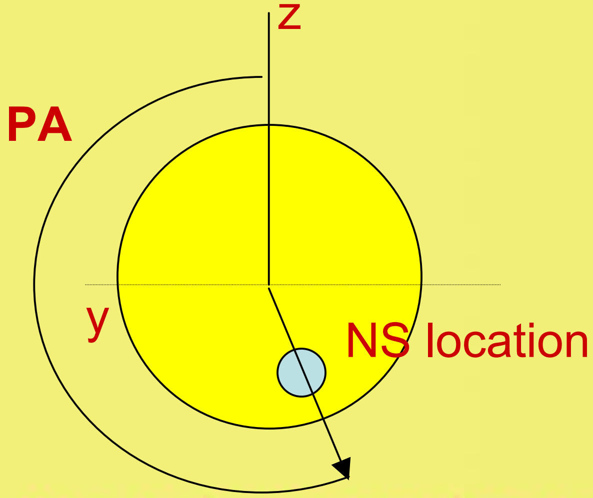

1. NS with known onset time = 340 events
2. CMEs erupt within 24 hr before NS onset

# Data sources and selection

**CME onset time selection**:

1. Radial distance of NS location from the center of the Sun is ≤ 0.5 Sol Radii, then the onset time from the first order fit with y-intercept is 0 sol.radii.
2. If the former is > 0.5 $R_S$, then the y-intercept is considered to be 1.0 $R_S$.
3. If the acceleration/deceleration of the CME > ± 25 m/s2 , then the onset time from the second order fit was taken.

**Conversion of NS co-ordinates to corresponding PA**:




$$
\begin{aligned}
PA &= 0^\circ + \tan^{-1}(y/z)\ ;\ y < 0\ \&\ z \geq 0 \\
&= 90^\circ + \tan^{-1}(z/y)\ ;\ y < 0\ \&\ z < 0 \\
&= 180^\circ + \tan^{-1}(y/z)\ ;\ y \geq 0\ \&\ z < 0 \\
&= 270^\circ + \tan^{-1}(z/y);\ y \geq 0\ \&\ z \geq 0
\end{aligned}
$$

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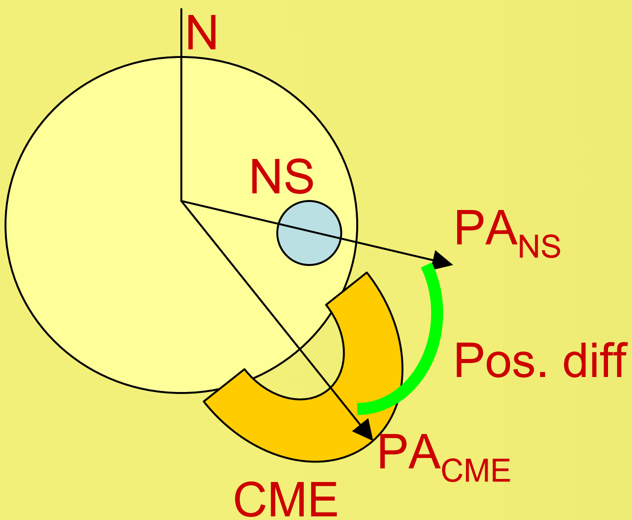
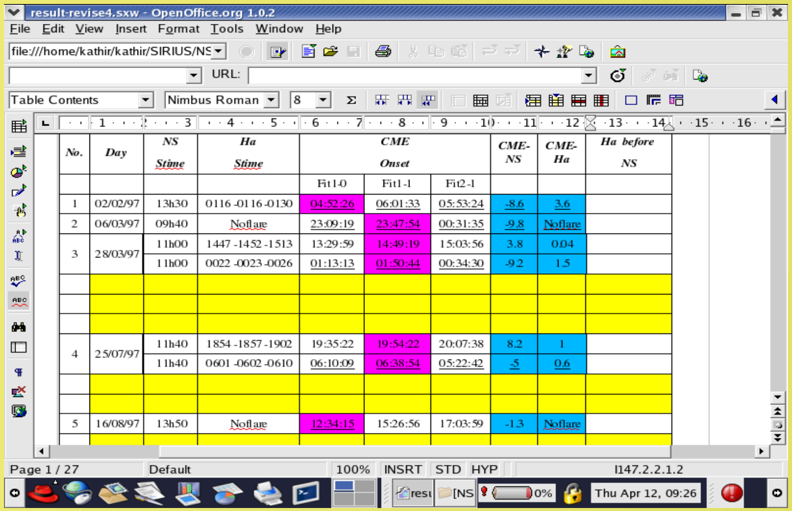
# Analysis methodology

Time diff = CME onset – NS onset
Pos. diff = CME PA – NS PA = ± 45˚




**196/340 NS found to have an association with CMEs satisfying the aforesaid conditions/criteria.**



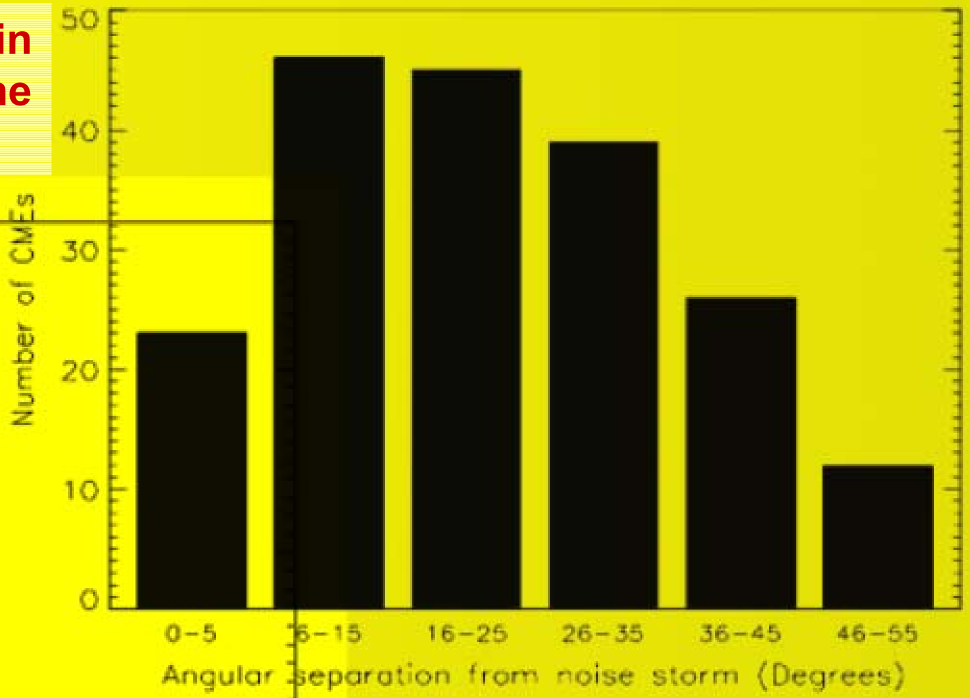
| No. | Day | NS Stime | Ha Stime | CME Onset | | | CME-NS | CME-Ha | Ha before NS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Fit1-0 | Fit1-1 | Fit2-1 | | | |
| 1 | 02/02/97 | 13h30 | 0116 -0116 -0130 | 04:52:26 | 06:01:33 | 05:53:24 | -8.6 | 3.6 | |
| 2 | 06/03/97 | 09h40 | Noflare | 23:09:19 | 23:47:54 | 00:31:35 | -9.8 | Noflare | |
| 3 | 28/03/97 | 11h00 | 1447 -1452 -1513 | 13:29:59 | 14:49:19 | 15:03:56 | 3.8 | 0.04 | |
| | | 11h00 | 0022 -0023 -0026 | 01:13:13 | 01:50:44 | 00:34:30 | -9.2 | 1.5 | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| 4 | 25/07/97 | 11h40 | 1854 -1857 -1902 | 19:35:22 | 19:54:22 | 20:07:38 | 8.2 | 1 | |
| | | 11h40 | 0601 -0602 -0610 | 06:10:09 | 06:38:54 | 05:22:42 | -5 | 0.6 | |
| | | | | | | | | | |
| | | | | | | | | | |
| 5 | 16/08/97 | 13h50 | Noflare | 12:34:15 | 15:26:56 | 17:03:59 | -1.3 | Noflare | |

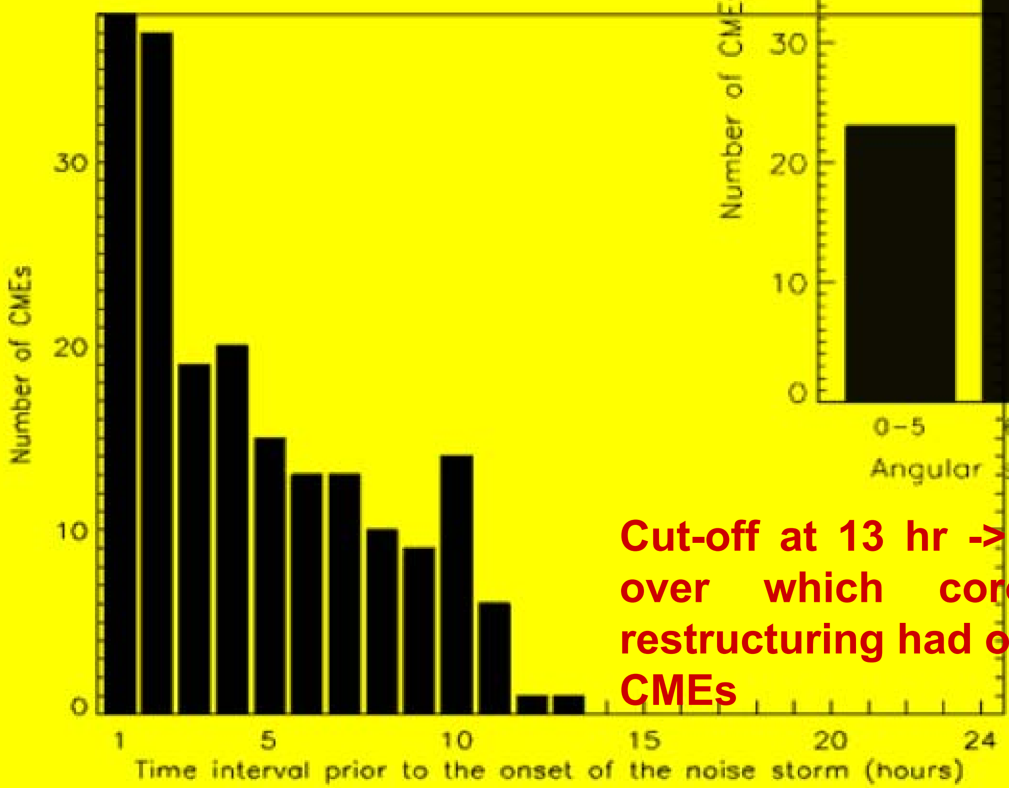
- Average width of CMEs = 45–55˚ (Yashiro et al. 2004).
- Activity occuring in association with magnetic field changes can be noticed even at an angular distance of 30˚ away (Bruzek 1952; Wang & Sheeley 1999).
- Location of NS can be close to the footpoints of CMEs (Lantos 1981, Willson 2005).

# Noise Storms & CMEs

# Results and Conclusions

**About 70% of NS are triggered within 35˚ from the CME central PA and the weighted mean value is close to 25˚**




**Cut-off at 13 hr -> Upper limit of the time scale over which coronal plasma-magnetic field restructuring had occurred in the aftermath of 196 CMEs**

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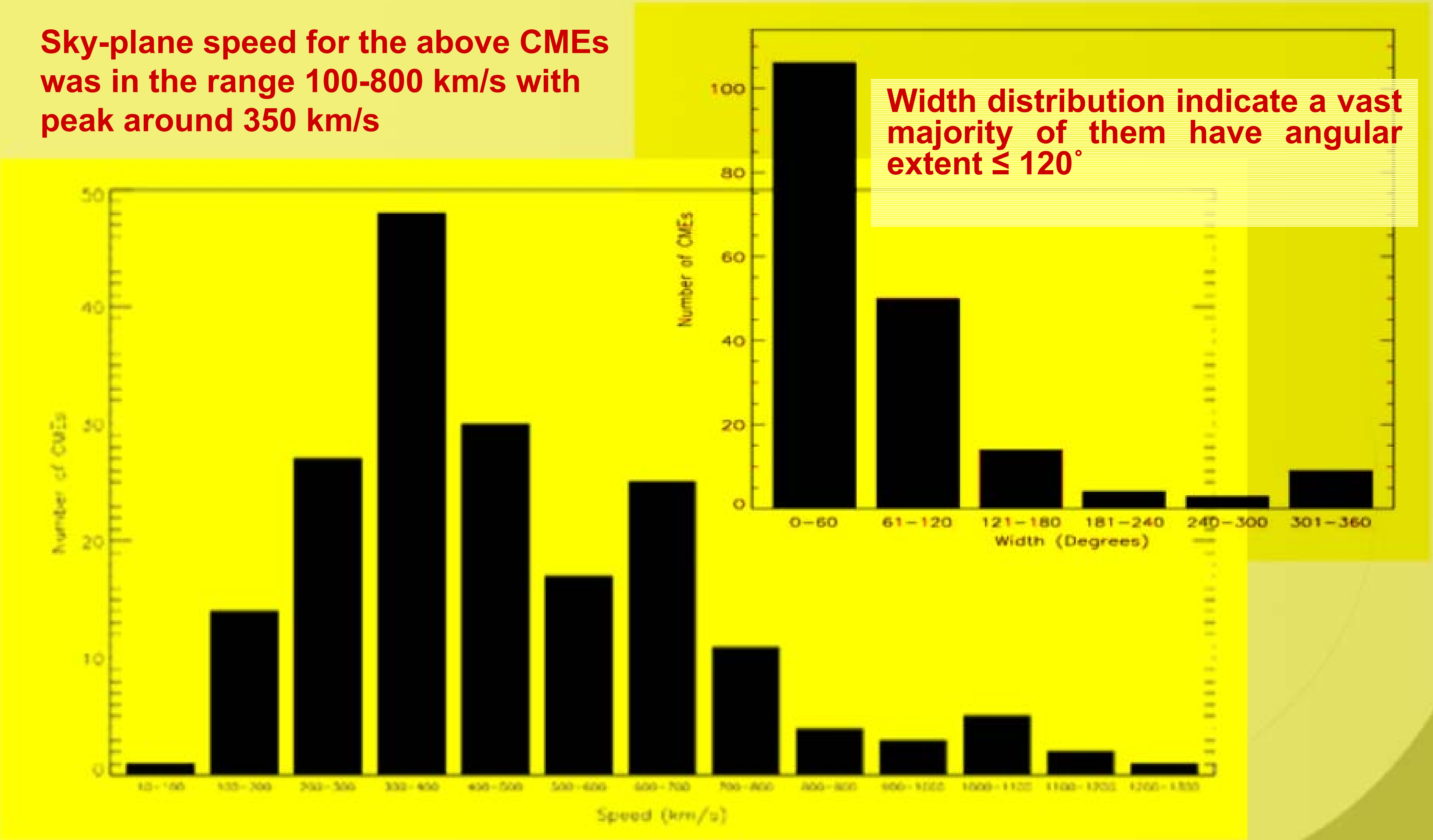
# Results and Conclusions

**Sky-plane speed for the above CMEs was in the range 100-800 km/s with peak around 350 km/s**




**Width distribution indicate a vast majority of them have angular extent ≤ 120˚**

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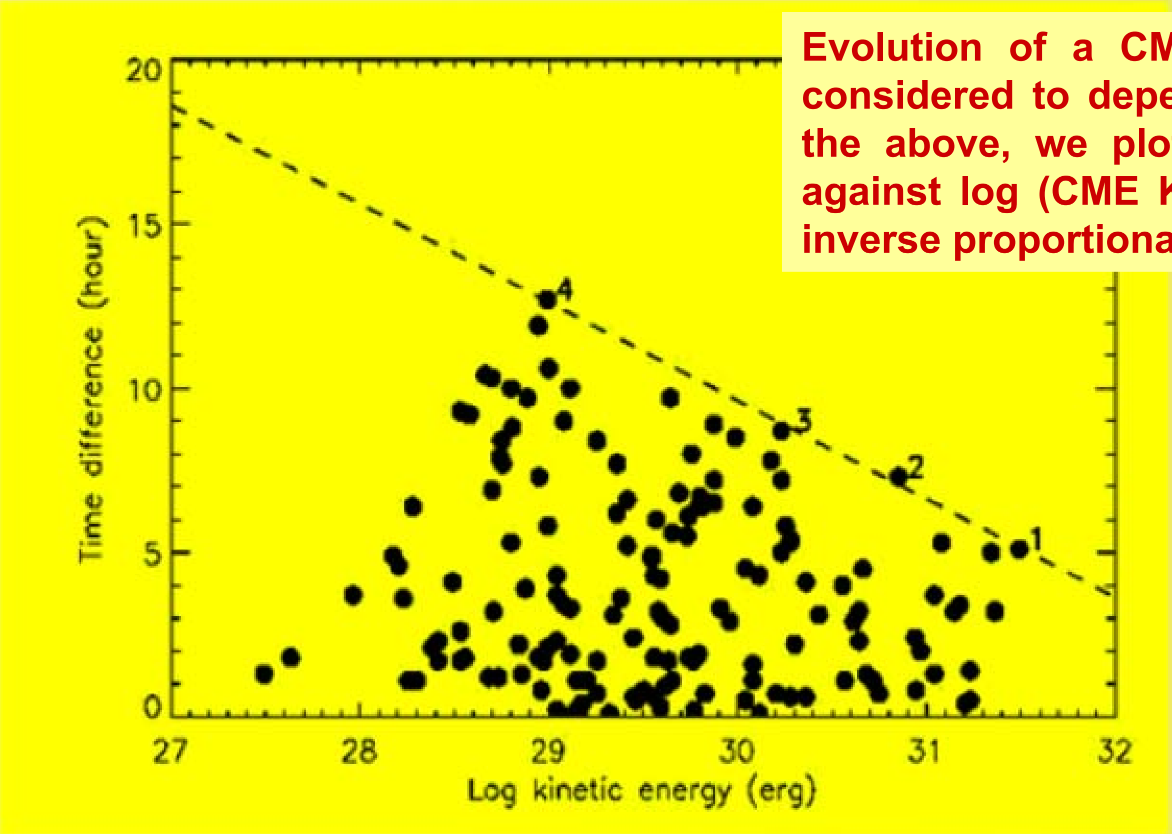
# Results and Conclusions




**Evolution of a CME in the solar atmosphere is considered to depend on its kinematics. To verify the above, we plotted the above time difference against log (CME K.E). It appears that there is an inverse proportionality between the two.**

## Cut-off line

- **All the data points should lie below the line.**
- **It should pass through as many maxima points as possible.**

**The dotted line in this figure shows the best fit and is given by**

$$t_{diff} = -2.99 \log KE(CME) + 99.5$$

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CMEs

# Results and Conclusions

- The scatter in the time interval could be due to differences in either the angular extent or speed of the corresponding set of CMEs.
- On extrapolation, we found that the aforementioned cut-off is approximately 4 and 19 hr for CMEs with K.E. $10^{32}$ and $10^{27}$ ergs respectively. Hansen et al. 1974, Hiei et al. 1993 reported white-light observations of coronal helemt streamer reformation over a period of 5 and 18 hr respectively, at the CME location. This indicates that structural changes in the post-CME corona and subsequent noise storm activity are related to energetics of associated CMEs. Similar observations of post-CME coronal activity at 34.5 MHz was published by Ramesh & Sastry 2000, quote a CME of mass $10^{29}$ ergs. Using the above empirical relationship one can expect a restructuring time limit should be within 13 hr. X-ray flares reported in the above 13 hr time interval confirms the same.

We would like to hint here that the NS that do not have any CME association could probably be due to:

1. Weak/faint CMEs that are difficult to detect
2. The conditions that we have set in selecting the CMEs
3. Gaps in the LASCO data
4. Magnetic surges in the absence of CMEs
5. Emergence of new magnetic flux without any CME association, etc.

# Noise Storms & CMEs

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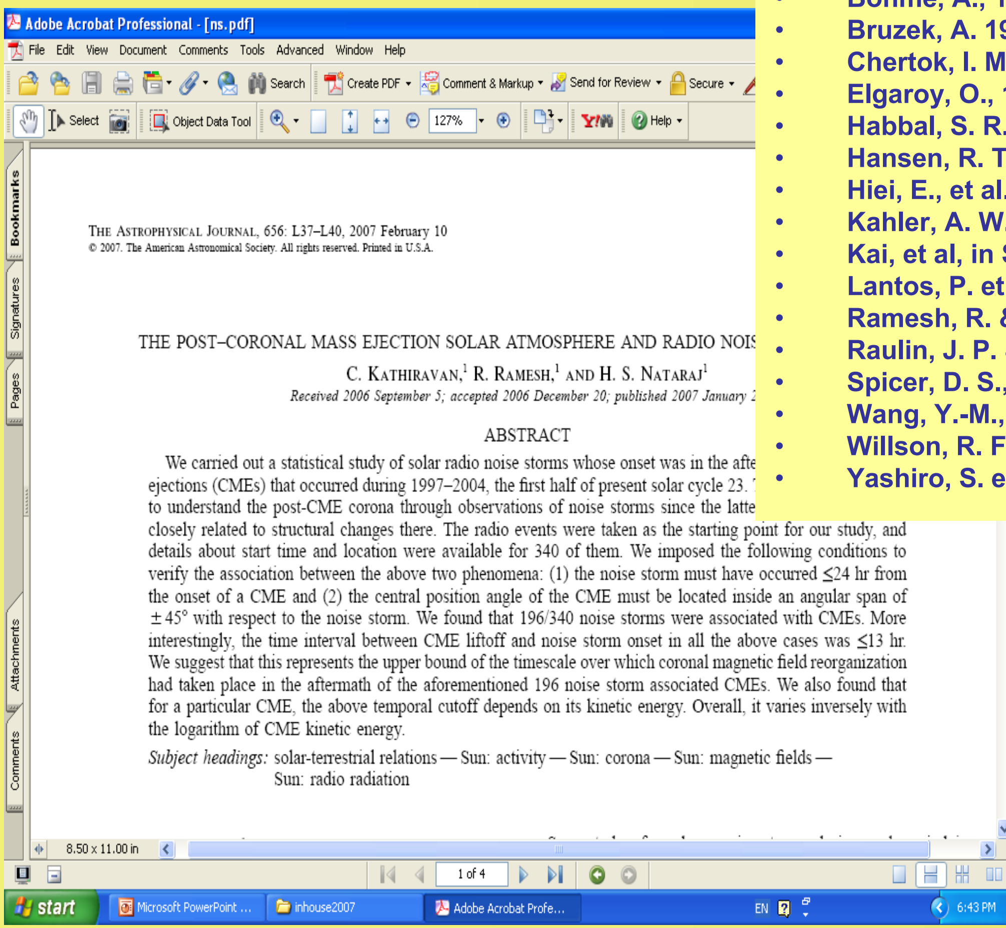


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THE POST–CORONAL MASS EJECTION SOLAR ATMOSPHERE AND RADIO NOIS

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ABSTRACT

We carried out a statistical study of solar radio noise storms whose onset was in the afte ejections (CMEs) that occurred during 1997–2004, the first half of present solar cycle 23. to understand the post-CME corona through observations of noise storms since the latte closely related to structural changes there. The radio events were taken as the starting point for our study, and details about start time and location were available for 340 of them. We imposed the following conditions to verify the association between the above two phenomena: (1) the noise storm must have occurred ≤24 hr from the onset of a CME and (2) the central position angle of the CME must be located inside an angular span of ±45° with respect to the noise storm. We found that 196/340 noise storms were associated with CMEs. More interestingly, the time interval between CME liftoff and noise storm onset in all the above cases was ≤13 hr. We suggest that this represents the upper bound of the timescale over which coronal magnetic field reorganization had taken place in the aftermath of the aforementioned 196 noise storm associated CMEs. We also found that for a particular CME, the above temporal cutoff depends on its kinetic energy. Overall, it varies inversely with the logarithm of CME kinetic energy.

*Subject headings:* solar-terrestrial relations — Sun: activity — Sun: corona — Sun: magnetic fields — Sun: radio radiation