On the New Classifications of Solar Coronal Mass Ejections based on the Observations by LASCO/SOHO

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Abstract.

In this paper we present a new classification of solar coronal mass ejection (CME) based on initial speed of CMEs events observed by LASCO/ SOHO. As we know that for mass ejections from Sun's surface the required escape velocity is about 618 km/sec and as the height increases in the solar atmosphere the escape velocity of mass ejection decreases with height of solar atmosphere. Keeping this fact in mind, we have studied and classified the CMEs based on CMEs observations between 1996-2003. In classifying CMEs we assume that if the initial observed speed of CMEs material is less than the escape velocity at that solar atmospheric height then we call such CMEs as non-escape velocity-CMEs (NEV-CMEs) and if the initial speed of CMEs material is more than the escape velocity at that solar atmospheric height then we call such CMEs as escape velocity-CMEs (EV-CMEs). From the study of LASCO CMEs observed between 1996- 2003 we found that about 59 percent CMEs were EV-CMEs and 41 percent CMEs were NEV-CMEs.

CMEs data

The data used in the present study was observed by LASCO/ SOHO is taken from website created by NASA and its address http://*cdaw.gsfc.nasa.gov/**CME**_list/* -

To carry out this study we have calculated escape velocity at the time of first observations and from this we decide that whether the the CMEs is NEV-CMEs or EV CMEs. In figure 1 green cross (X) represent EV-CMEs and Blue star represent NEV-CMEs. The purple color line show plot height vs. Escape Velocity. Figures 1 to 8 clearly show that there are two types of CMEs:

1- Non Escape Velocity CMEs (NEV CMEs),
2- Escape Velocity CMEs (EV CMEs)

Figure1: Plot of Height of CMEs vs. Initial Velocity of CMEs for 1996

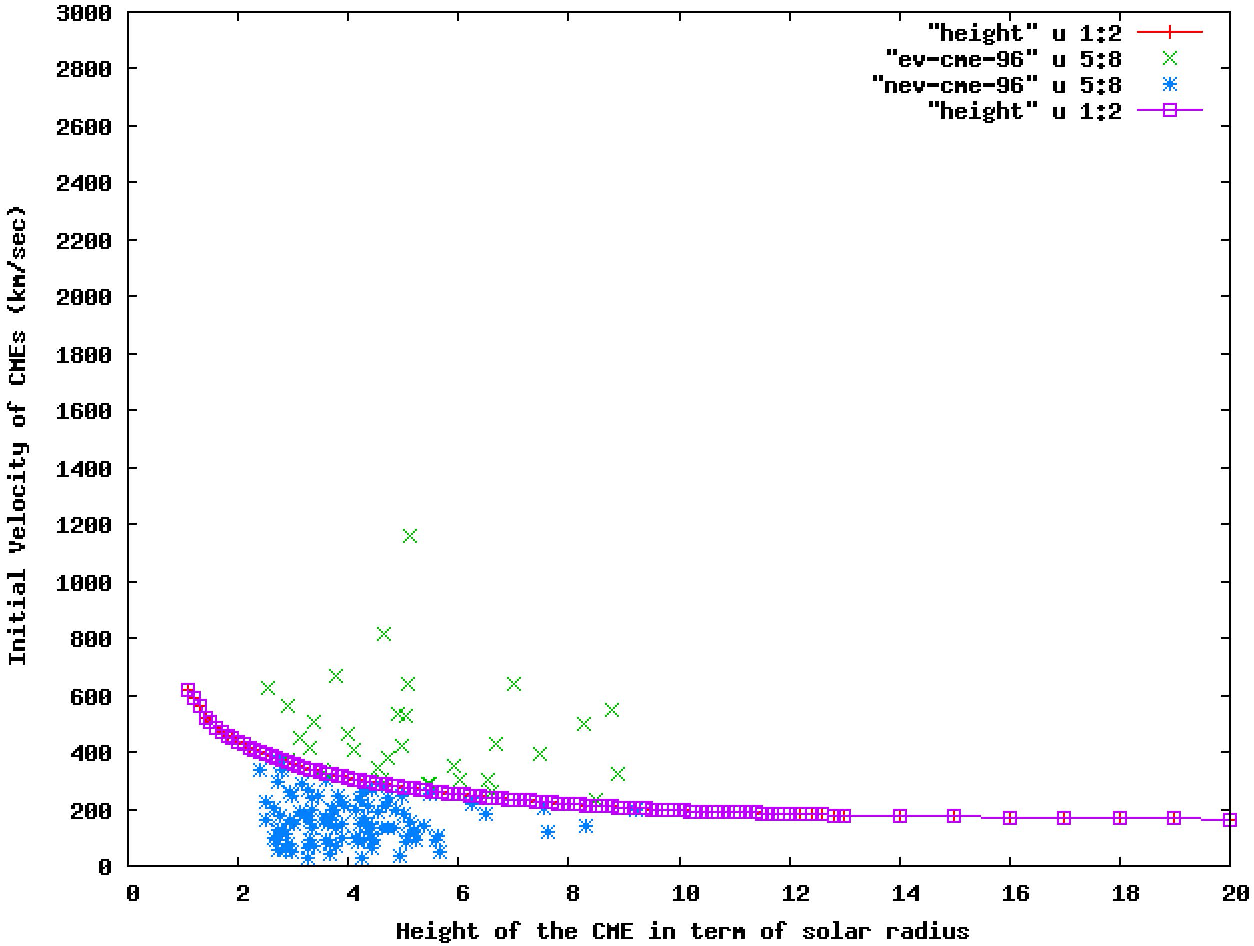


Figure 2: Plot of Height vs. Initial Velocity of CMEs for year 1997

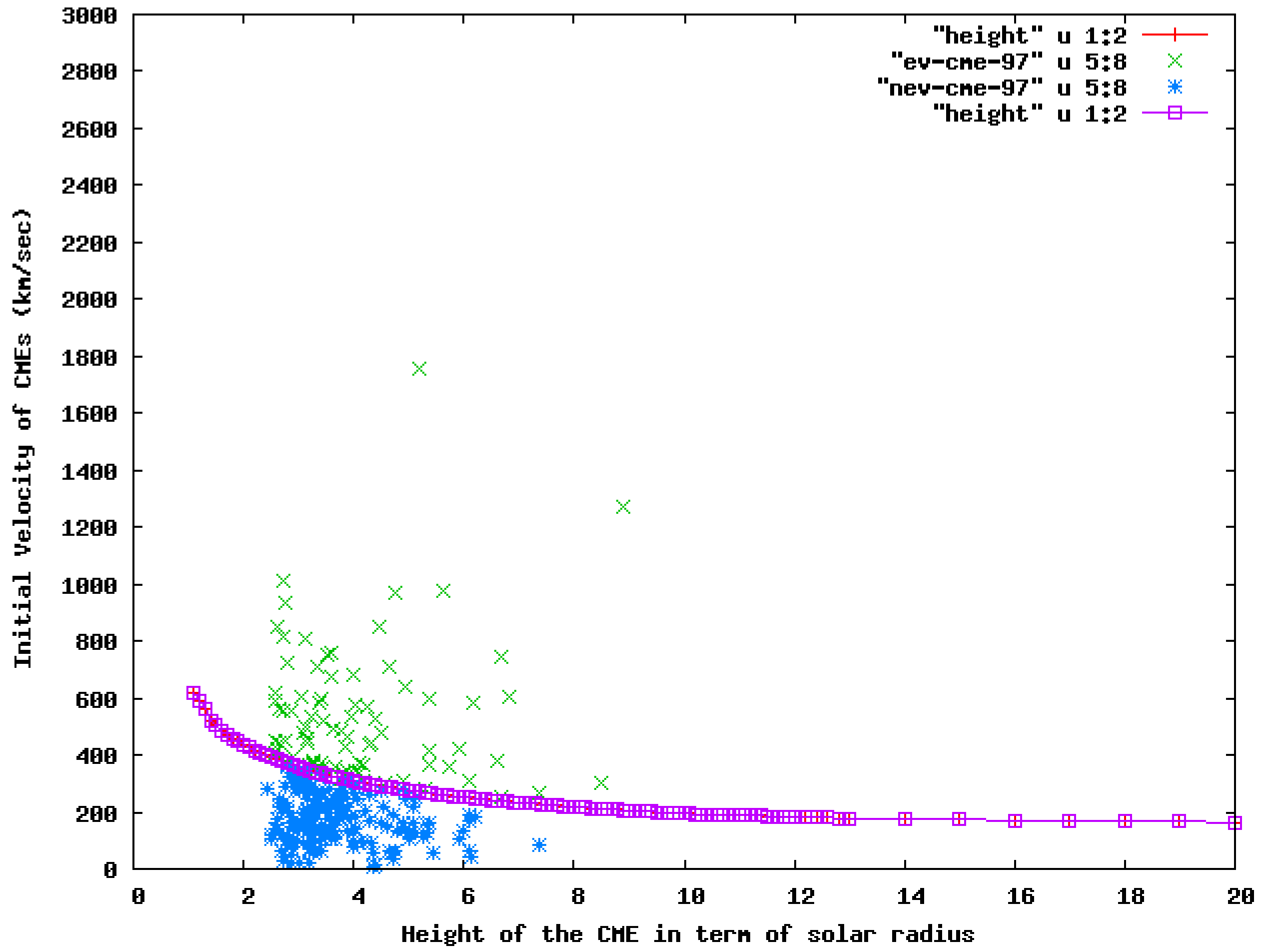


Figure 3: Plot of Height vs. Initial Velocity of CMEs for year 1998

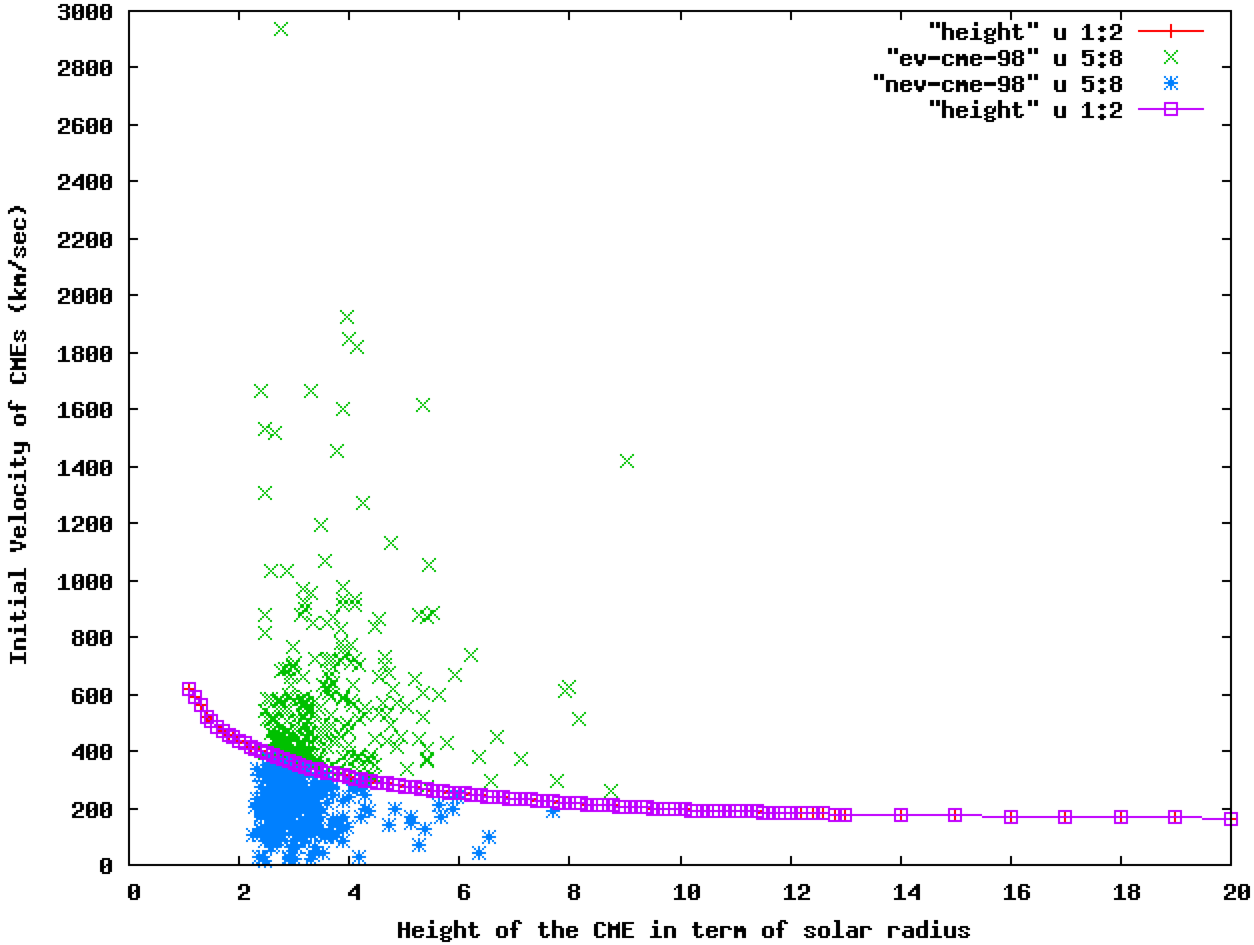


Figure 4: Plot of Height vs. Initial Velocity of CMEs for year 1999

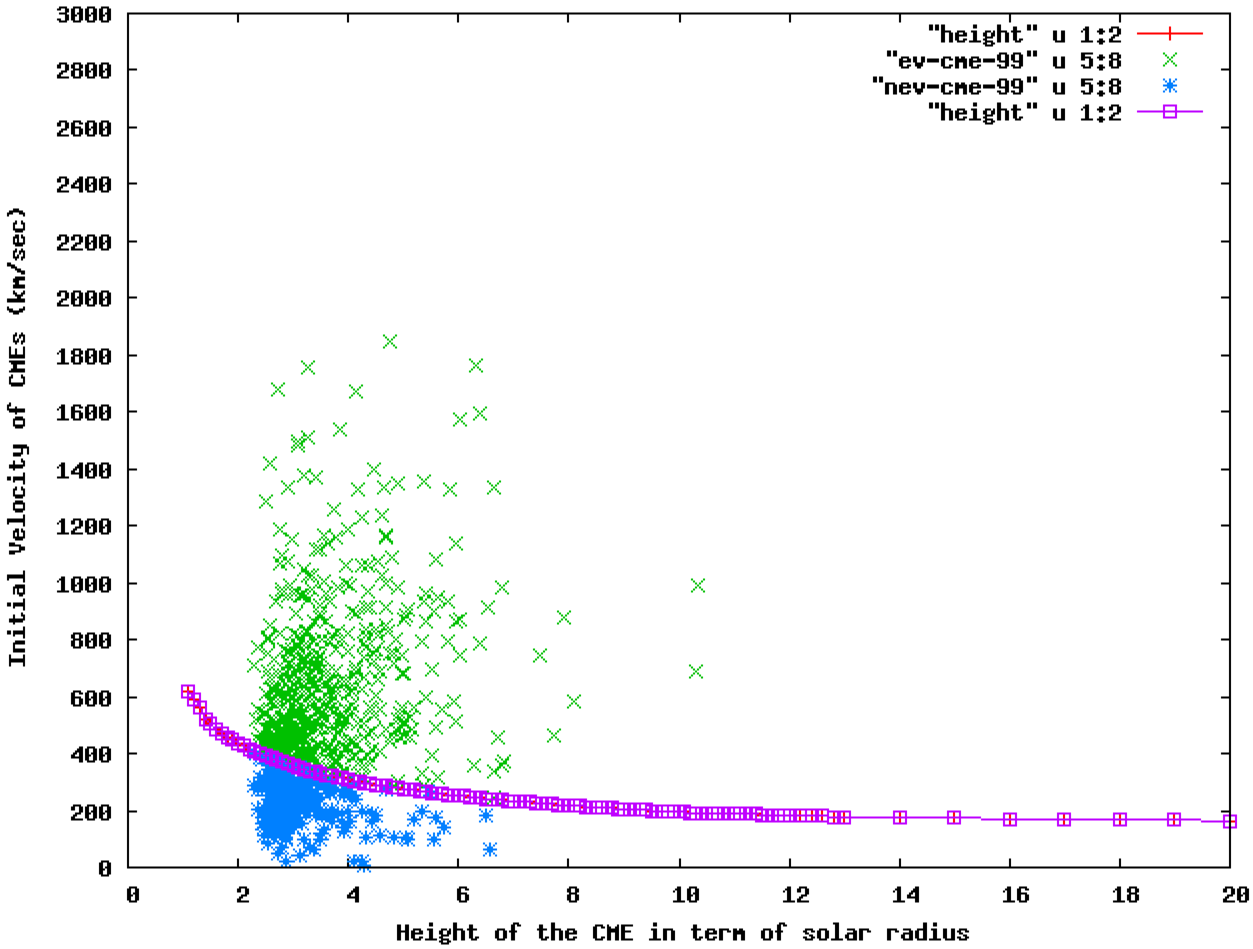


Figure 5: Plot of Height vs. Initial Velocity of CMEs for year 2000

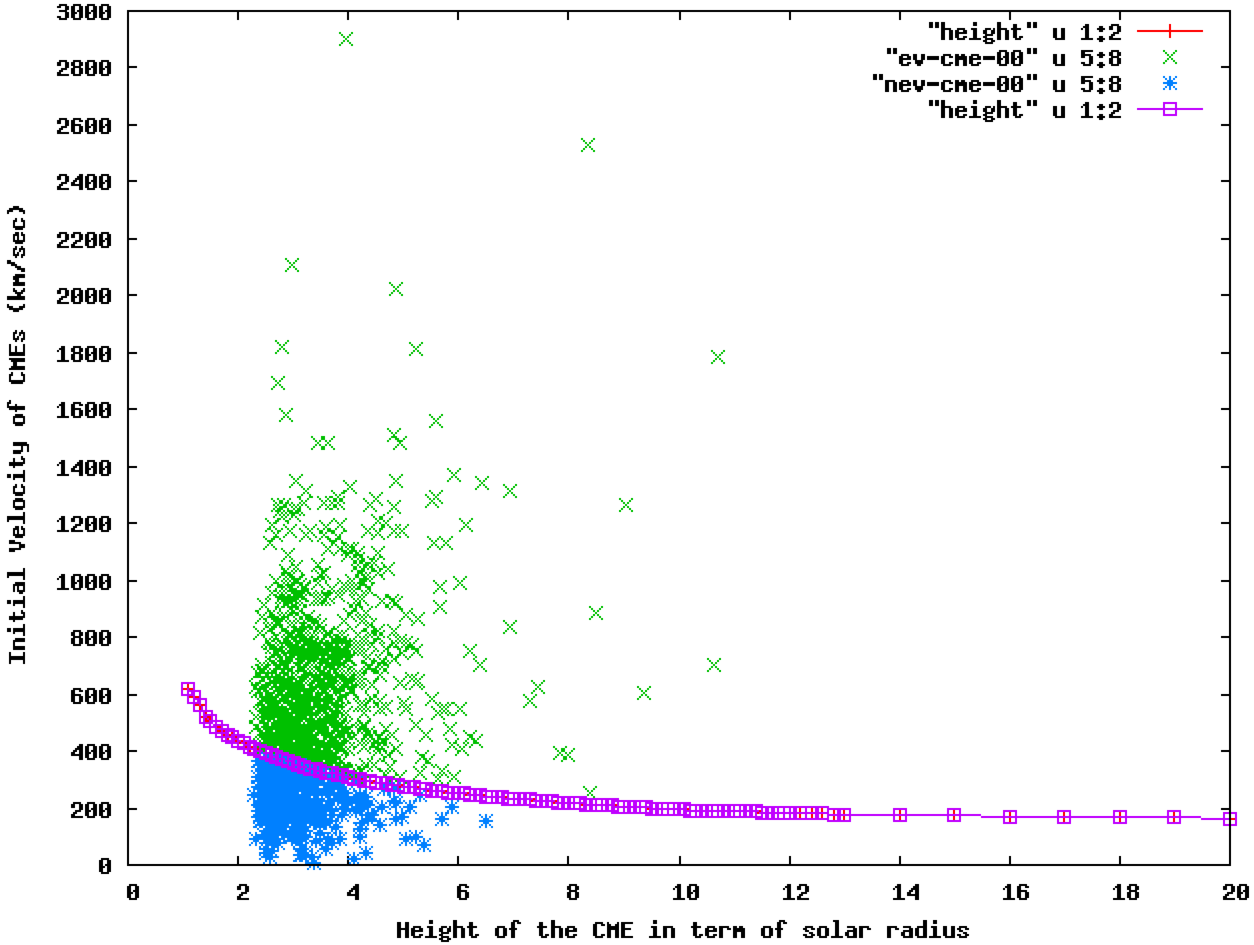


Figure 6: Plot of Height vs. Initial Velocity of CMEs for year 2001

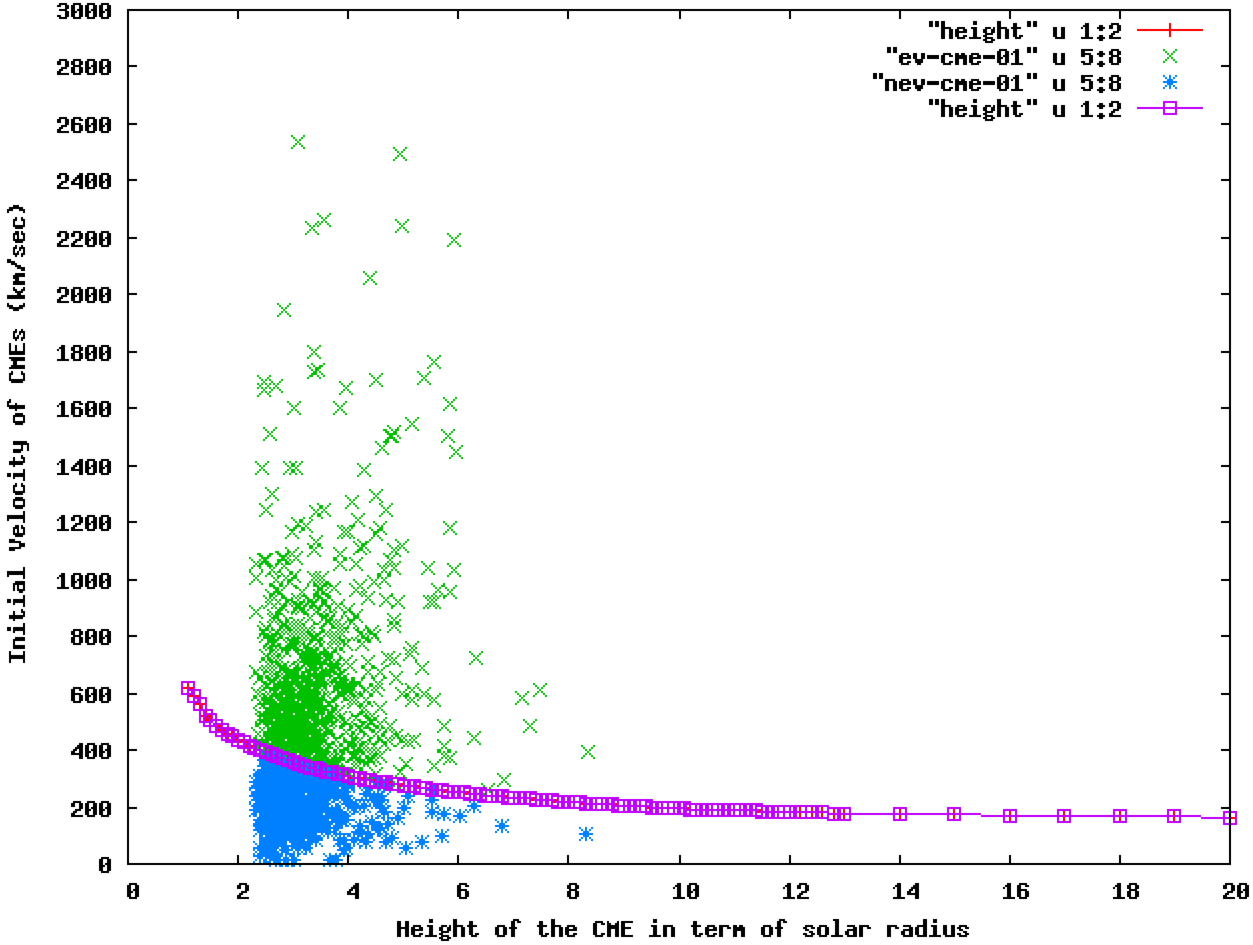


Figure 7: Plot of Height vs. Initial Velocity of CMEs for year 2002

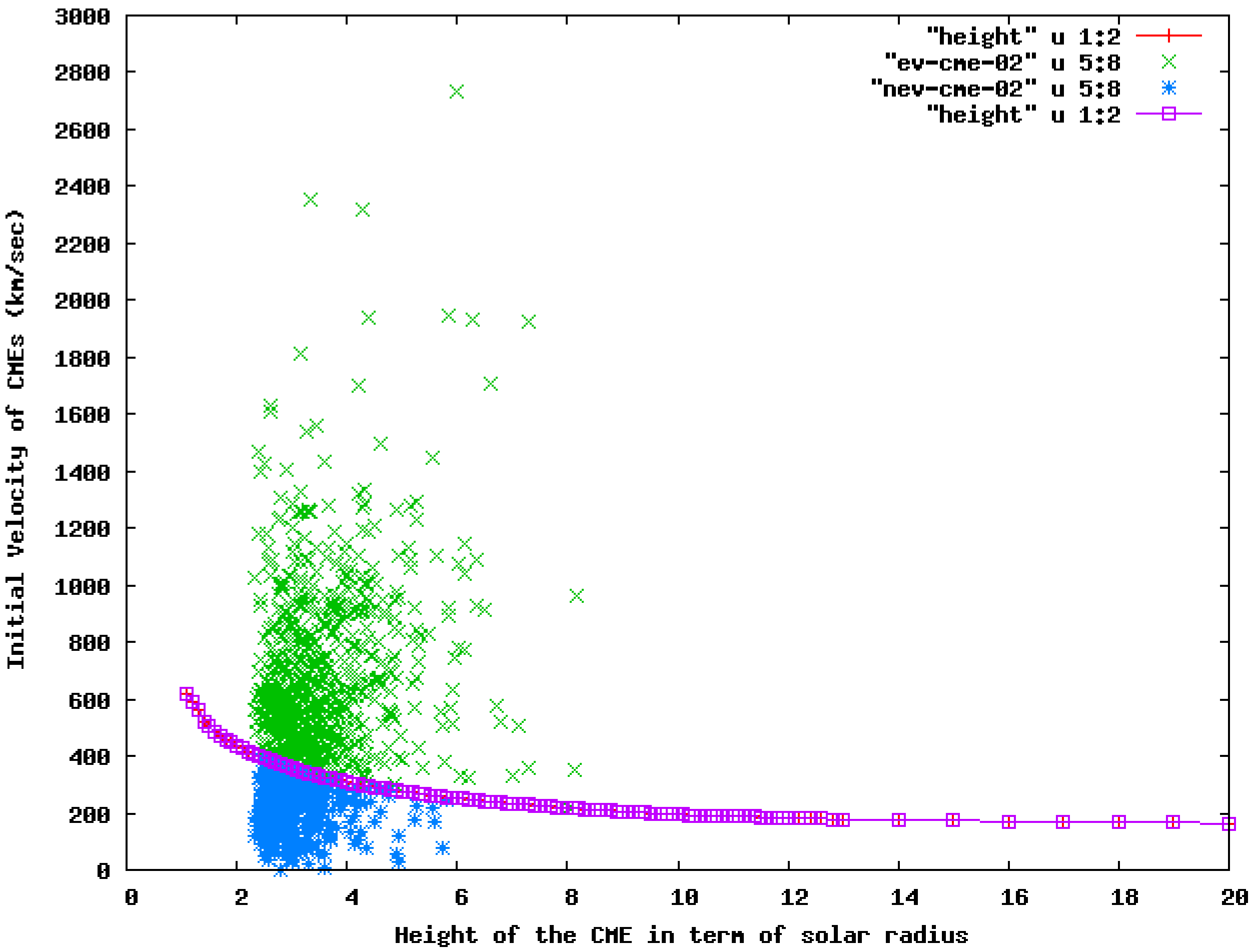
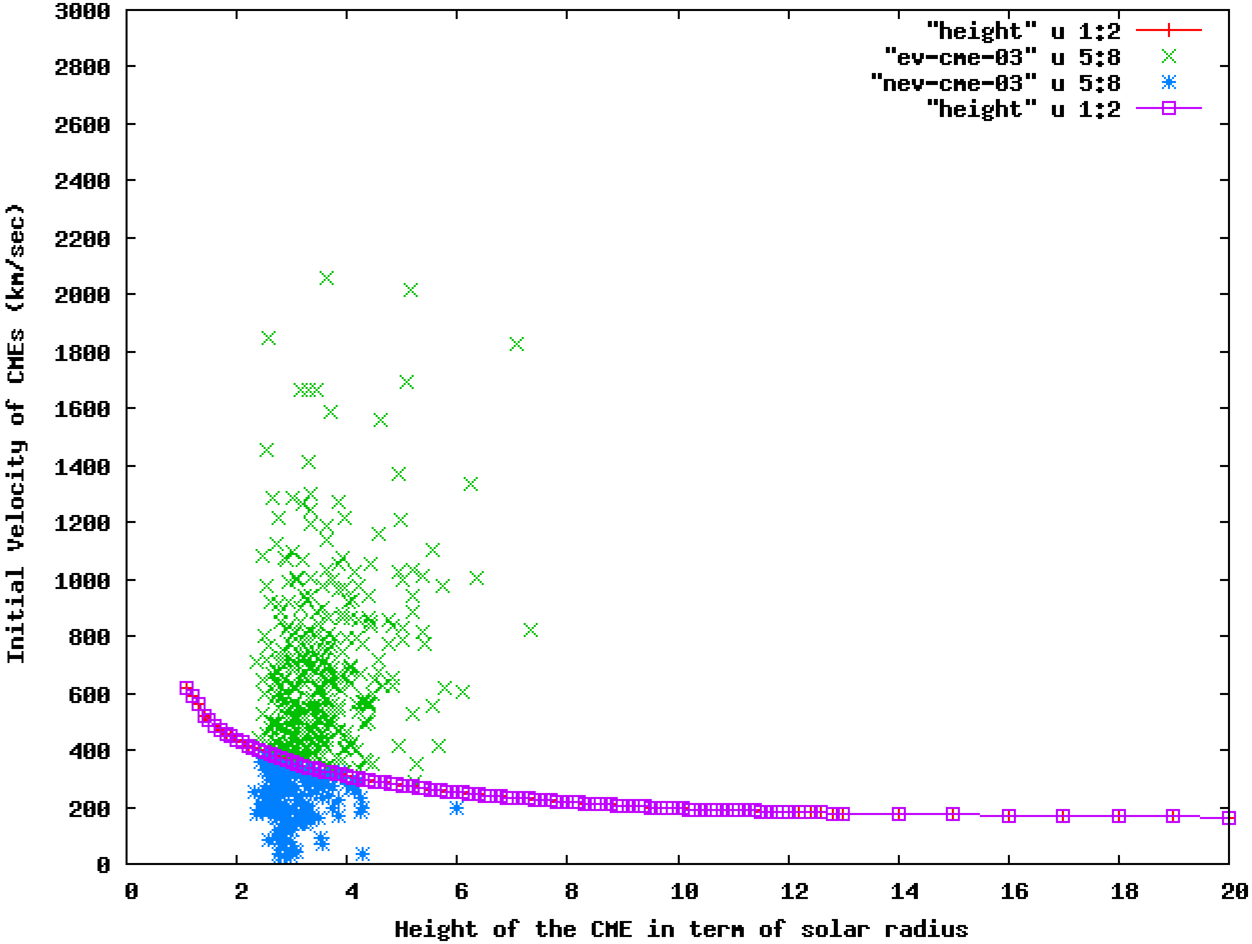


Figure 8: Plot of Height vs. Initial Velocity of CMEs for year 2003



Acceleration of CMEs

We found that there are two classes of CMEs.

1- NEV-CMEs (41%): The majority NEV-CMEs class of CMEs show positive accelerations and this is clear from Figures 9 to16.

2- EV-CMEs (59%): About 45.5% EV-CMEs show positive acceleration and about 54.5% of EV-CMEs show negative acceleration as it is clear from Figures 9(1996) to 16(2003).

3- Over all 68% CMEs show positive acceleration and 32% CMEs show negative acceleration.

Table 1: Yearly number of Flares, CMEs, EV-CMEs and NEV-CMEs for 1996-2003

S.No.	Year	Flares	CMEs	EV-CME	NEV-CME
1	1996	280	132	034	098
2	1997	790	263	085	178
3	1998	2423	537	267	270
4	1999	3963	756	502	254
5	2000	4474	1176	778	396
6	2001	3597	1175	639	536
7	2002	3223	1194	753	441
8	2003	1552	530	363	167
	Total	20302	5383	3371	2340

Figure 9: Plot of Initial Velocity of CMEs for 1996 vs. Acceleration

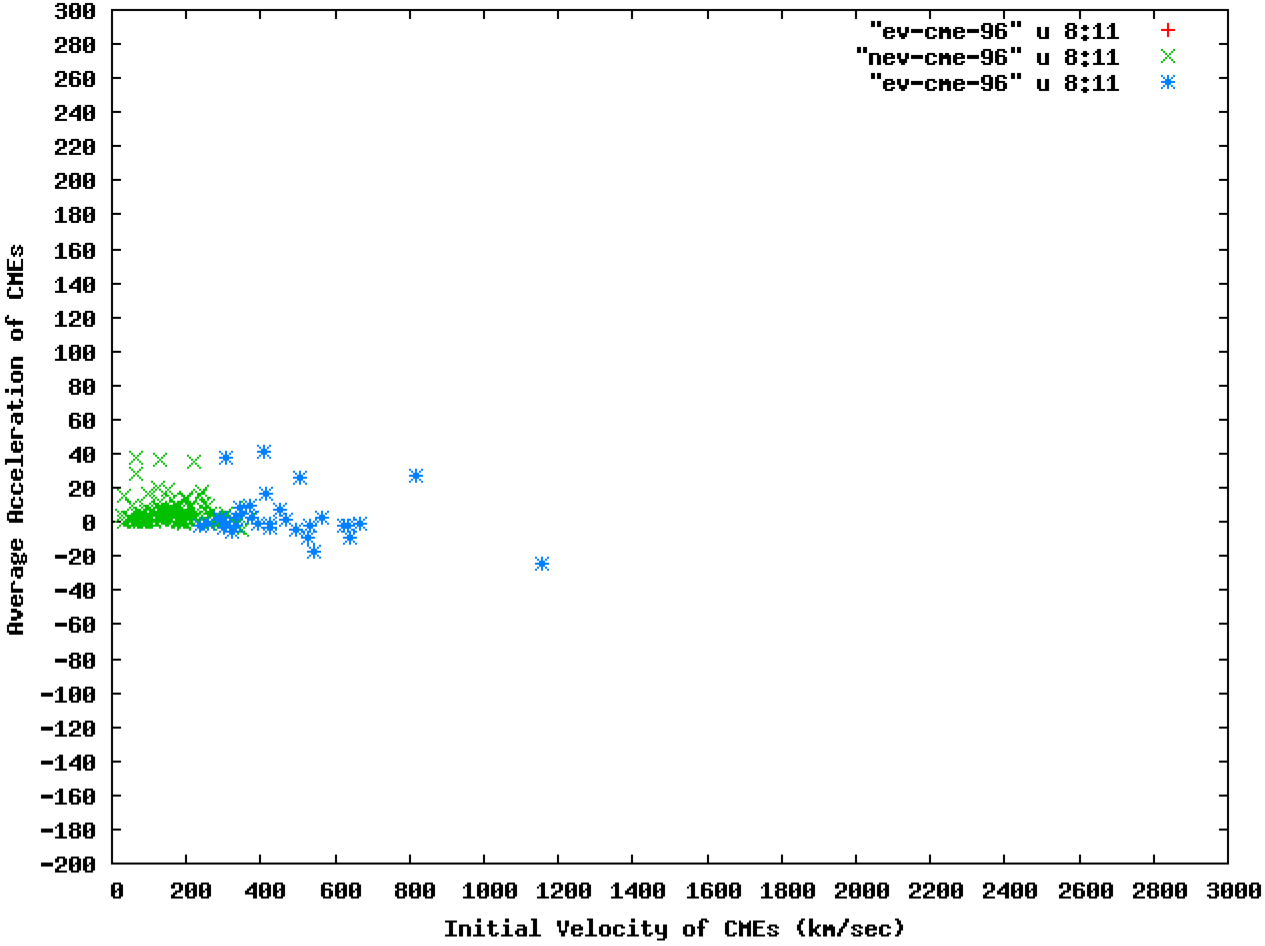


Figure 10: Plot Initial Velocity of CMEs for 1997 vs. Acceleration

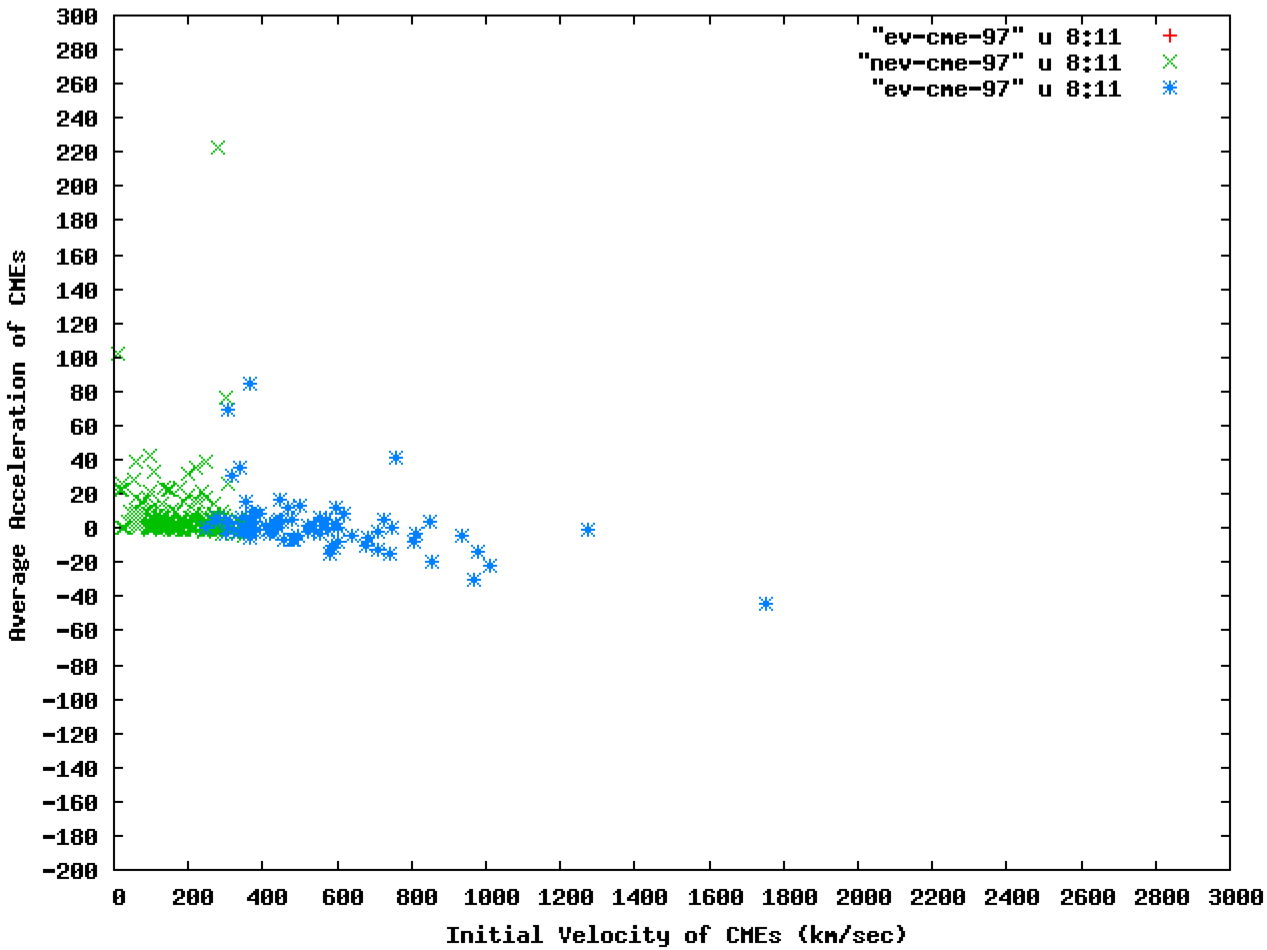


Figure 11: Plot of Initial Velocity of CMEs for 1998 vs. Acceleration

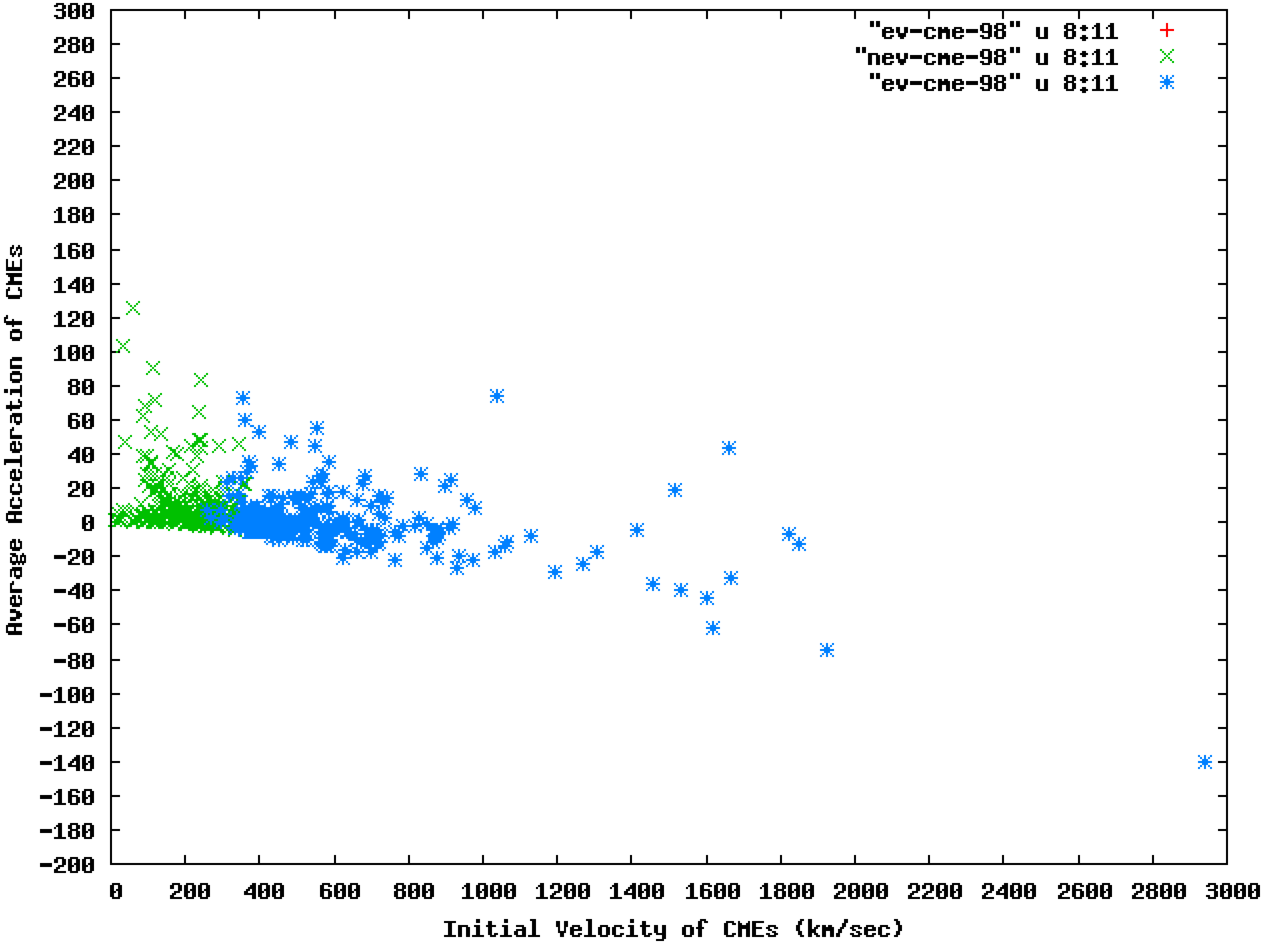


Figure 12: Plot of Initial Velocity of CMEs for 1999 vs. Acceleration

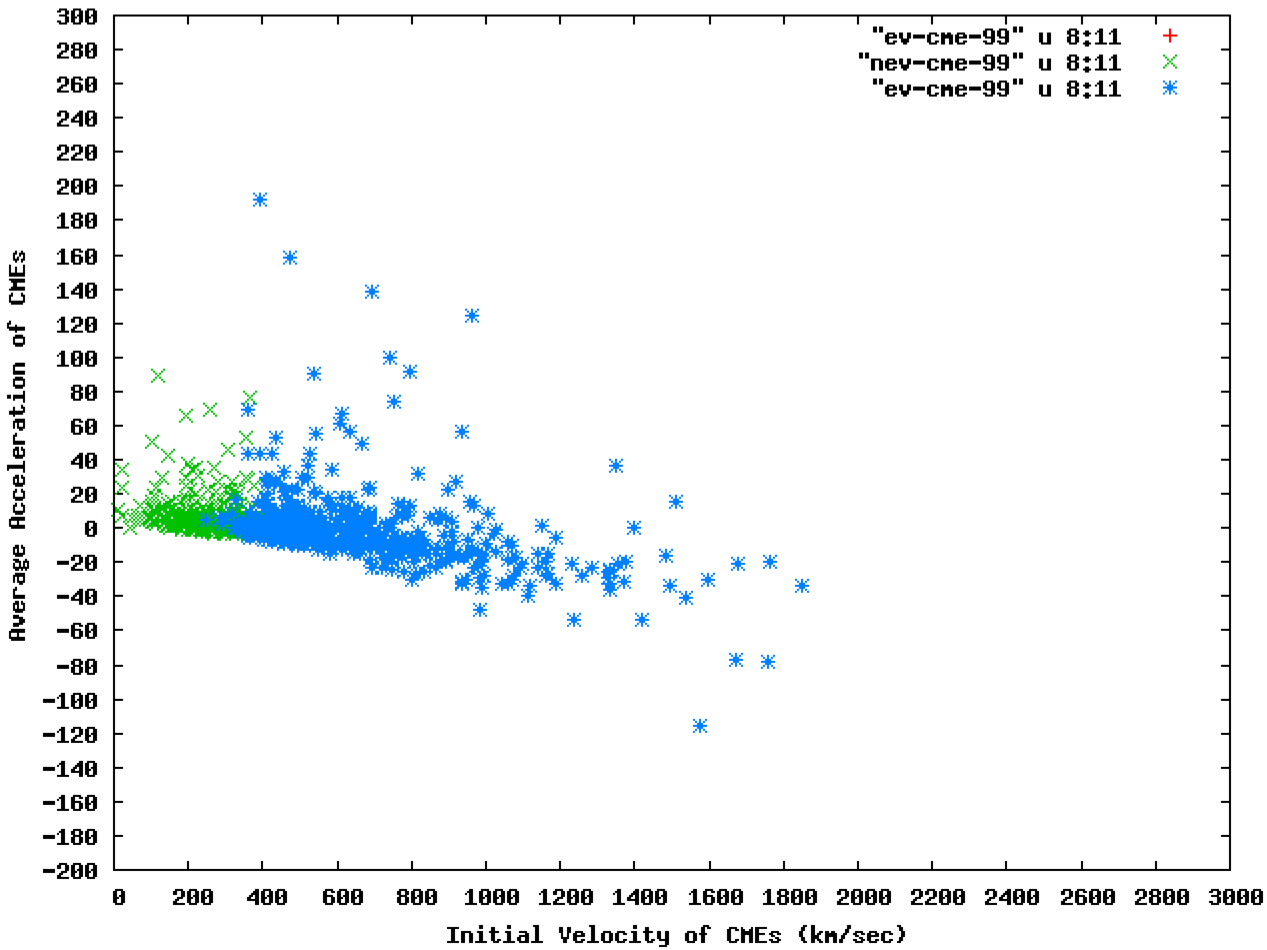


Figure 13: Plot of Initial Velocity of CMEs for 2000 vs. Acceleration

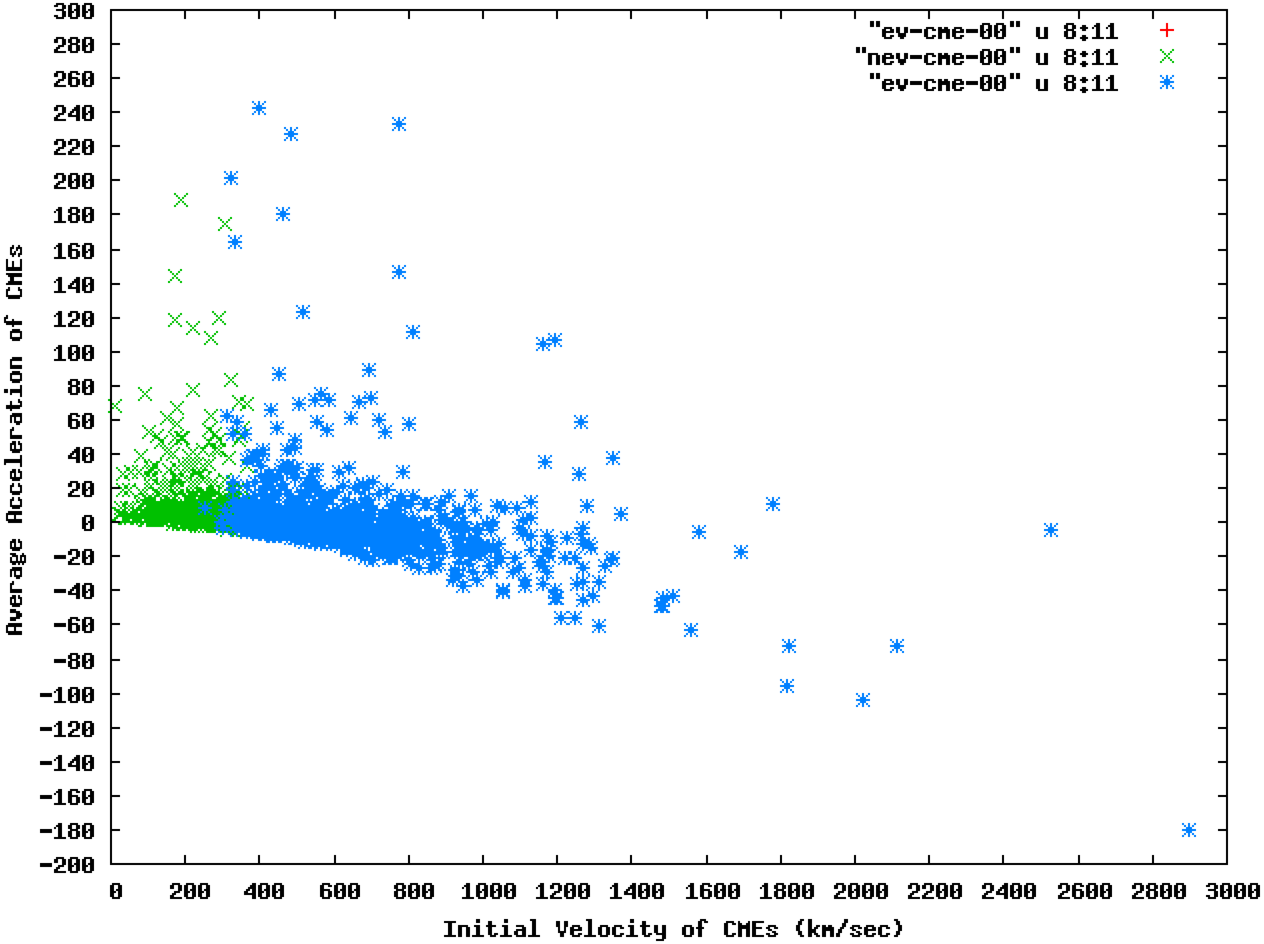


Figure 14: Plot Initial Velocity of CMEs for 2001 vs. Acceleration

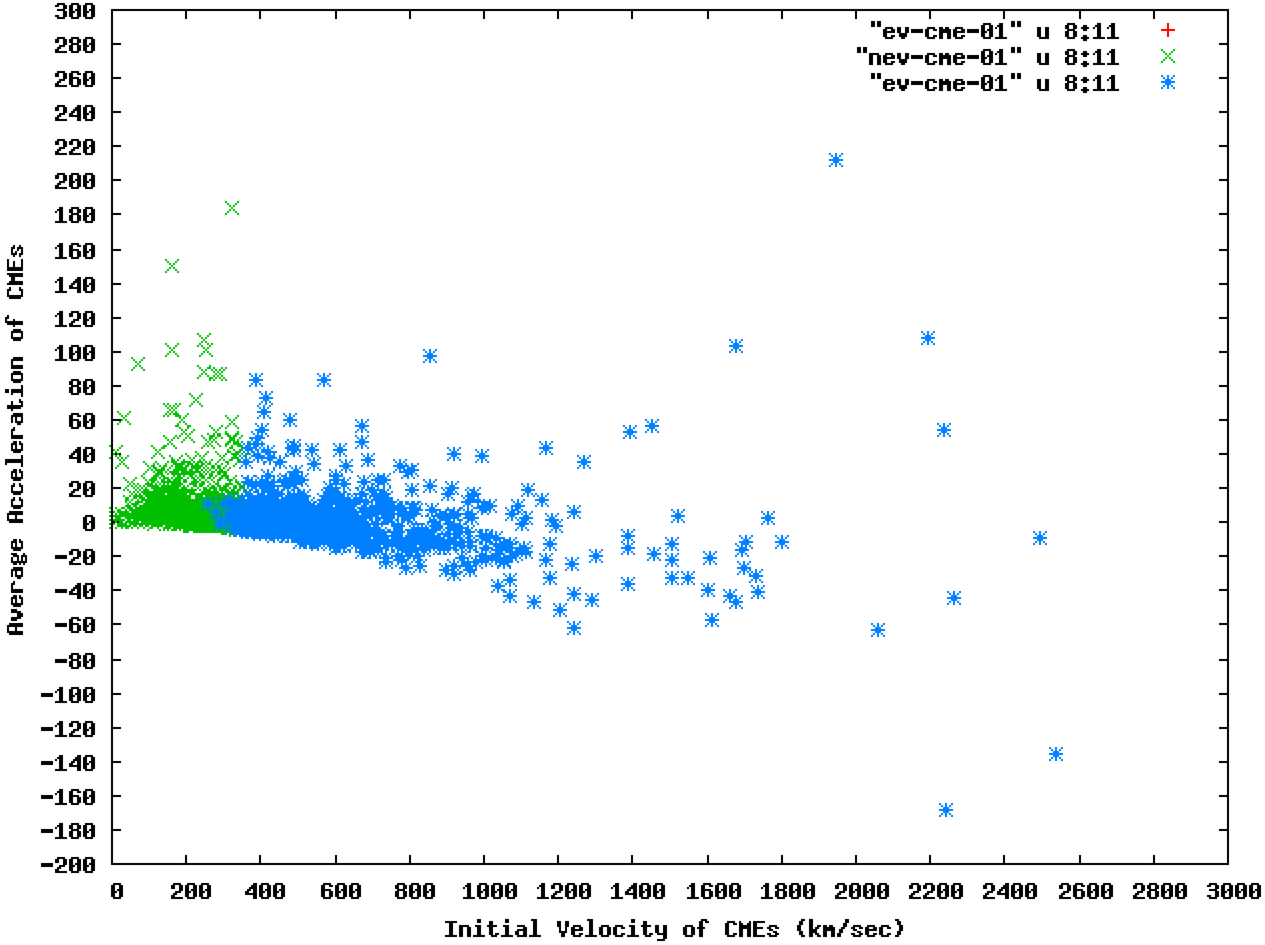


Figure 15: Plot of Initial Velocity of CMEs for 2002 vs. Acceleration

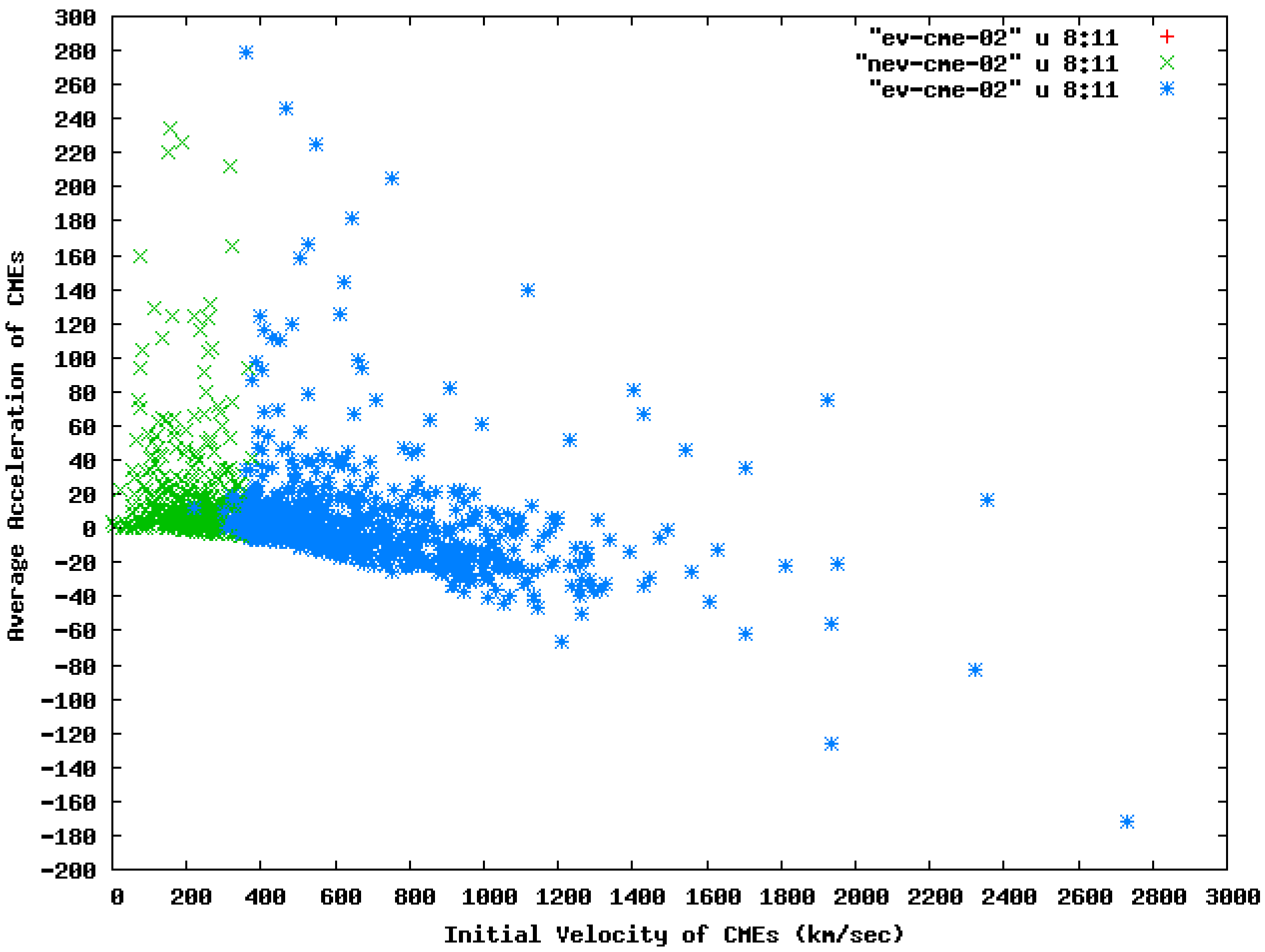
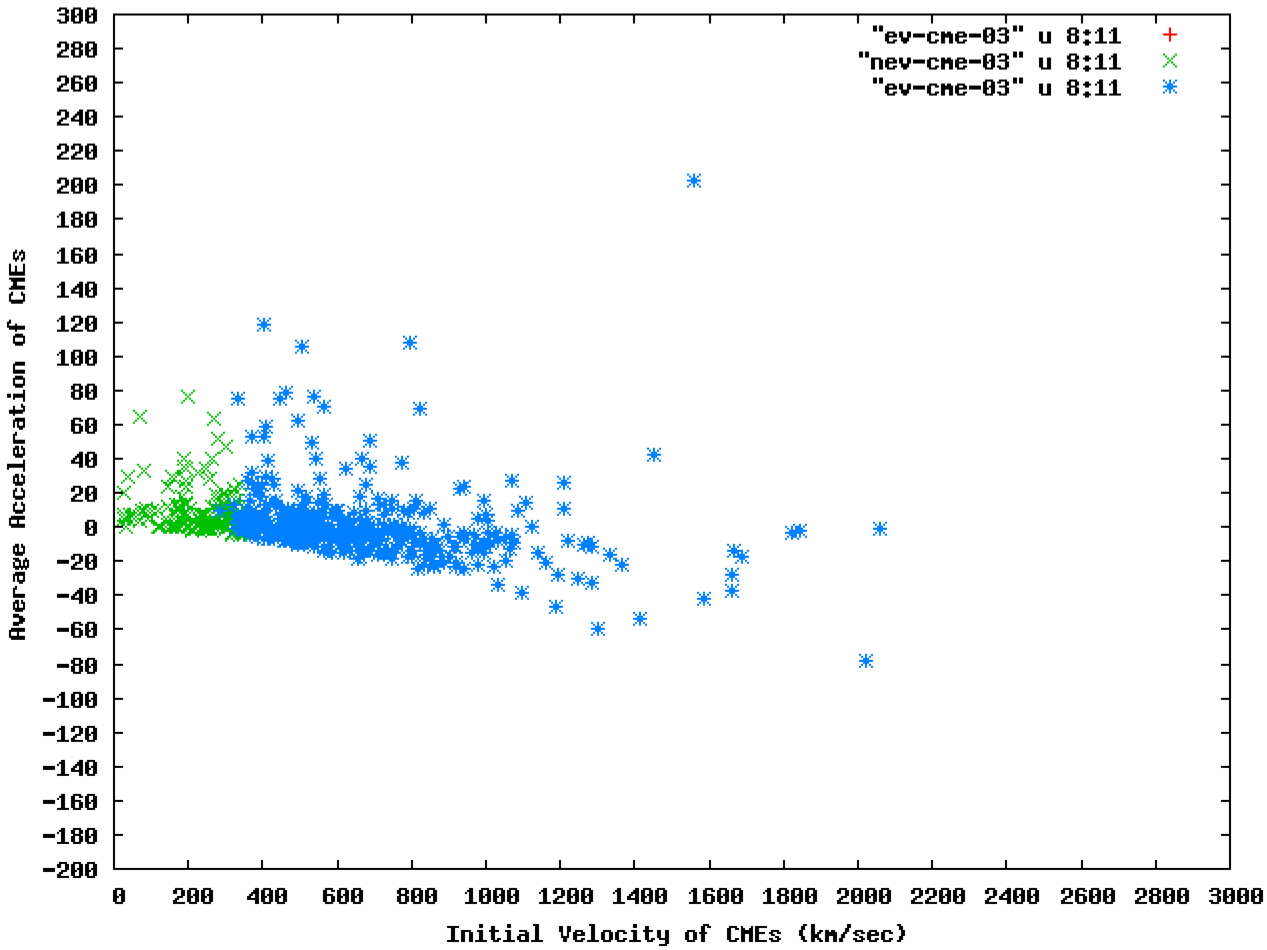


Figure 16: Plot of Initial Velocity of CMEs for 2003 vs. Acceleration



Relation between Initial Velocity and Velocity of CMEs at 20 Radii

We have also studied the relation between initial velocity of CMEs and velocity of CMEs at 20 solar radii. It is found that 5-10% NEV-CMEs do not go beyond 20 solar radii and 15-20% of EV-CMEs do not go beyond 20 solar radii because there velocity become zero. Figures 17(1996) to 24(2003) show the plot of initial velocity of CMEs and velocity of CMEs at 20 solar radii for both the class.

Figure 17: Plot of Initial Velocity vs. Velocity of CMEs at 20 Solar Radii

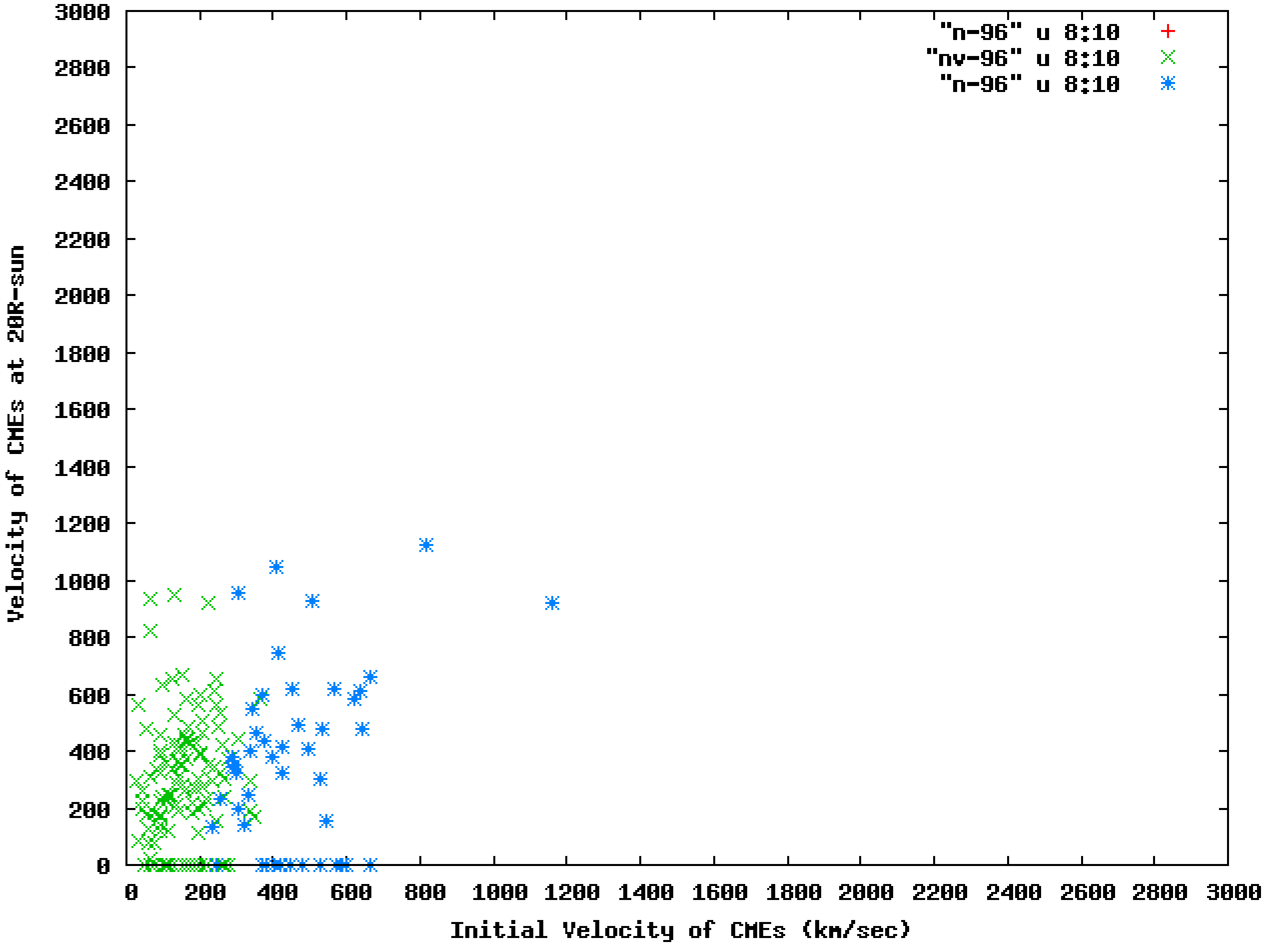


Figure 18: Plot of initial velocity vs. velocity of CMEs at 20 Solar Radii

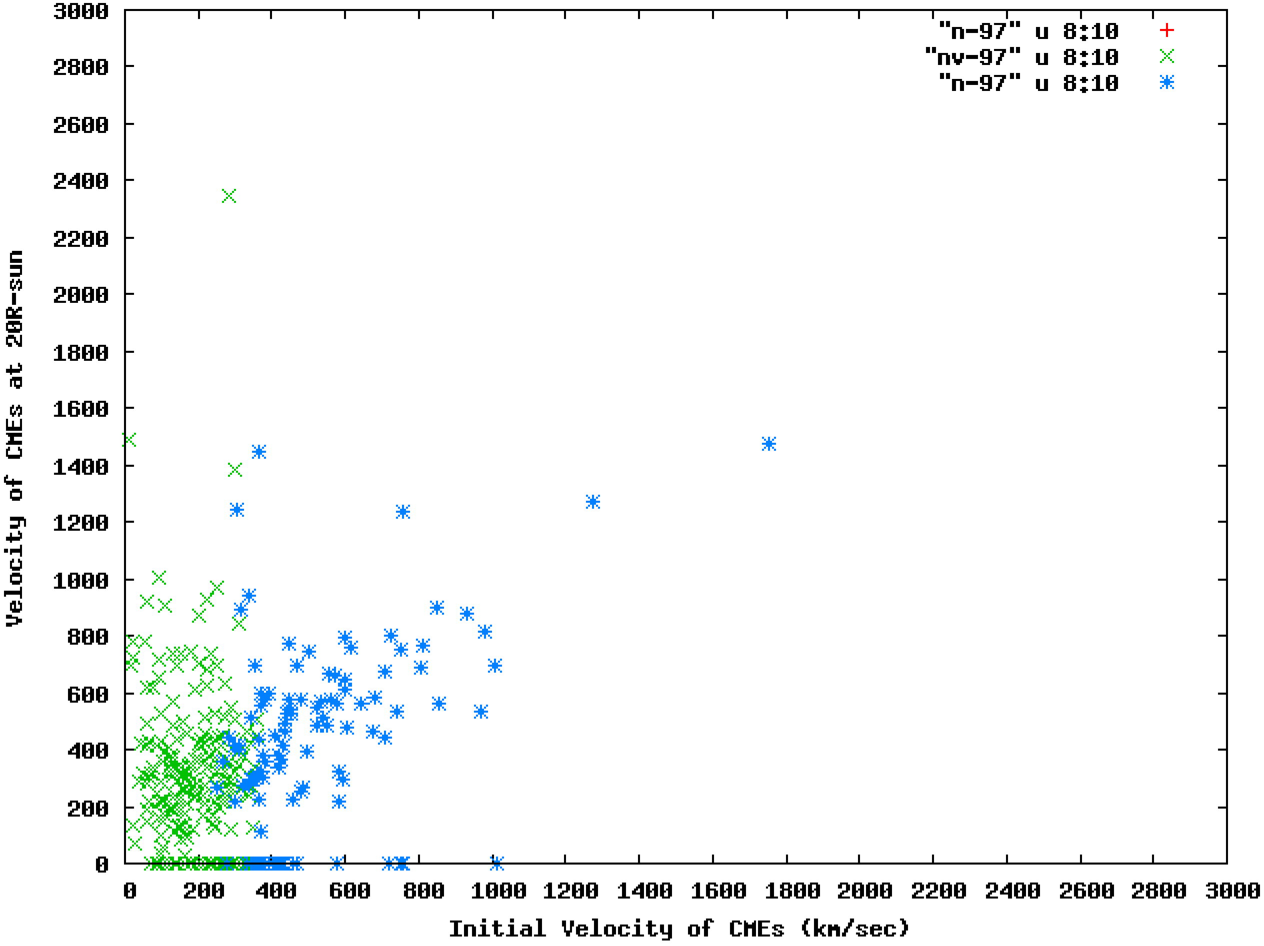


Figure 19: Plot of Initial Velocity vs. Velocity of CMEs at 20 Solar Radii

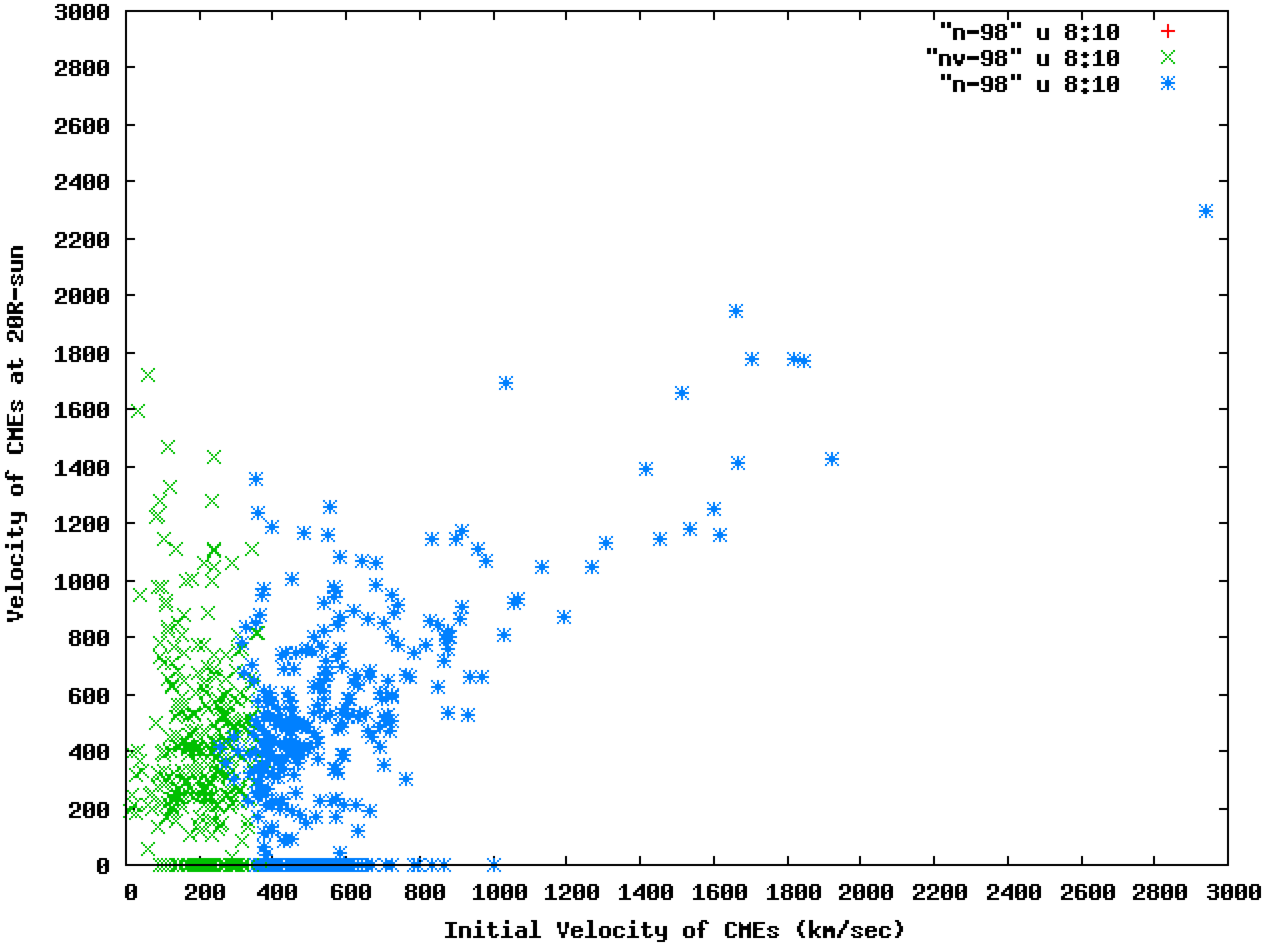


Figure 20: Plot of Initial Velocity vs. Velocity of CMEs at 20 Solar Radii

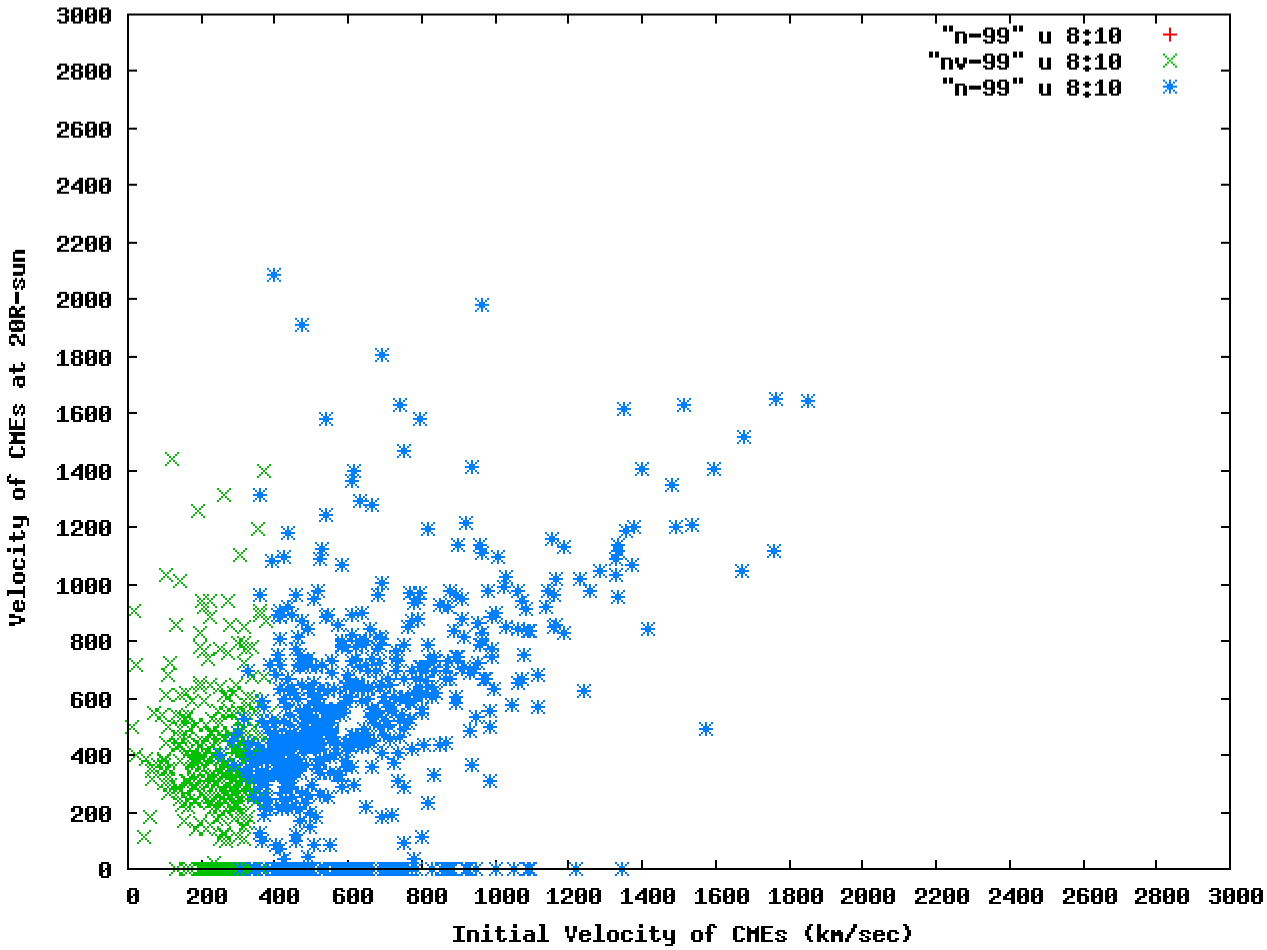


Figure 21: Plot of Initial Velocity vs. Velocity of CMEs at 20 Solar Radii

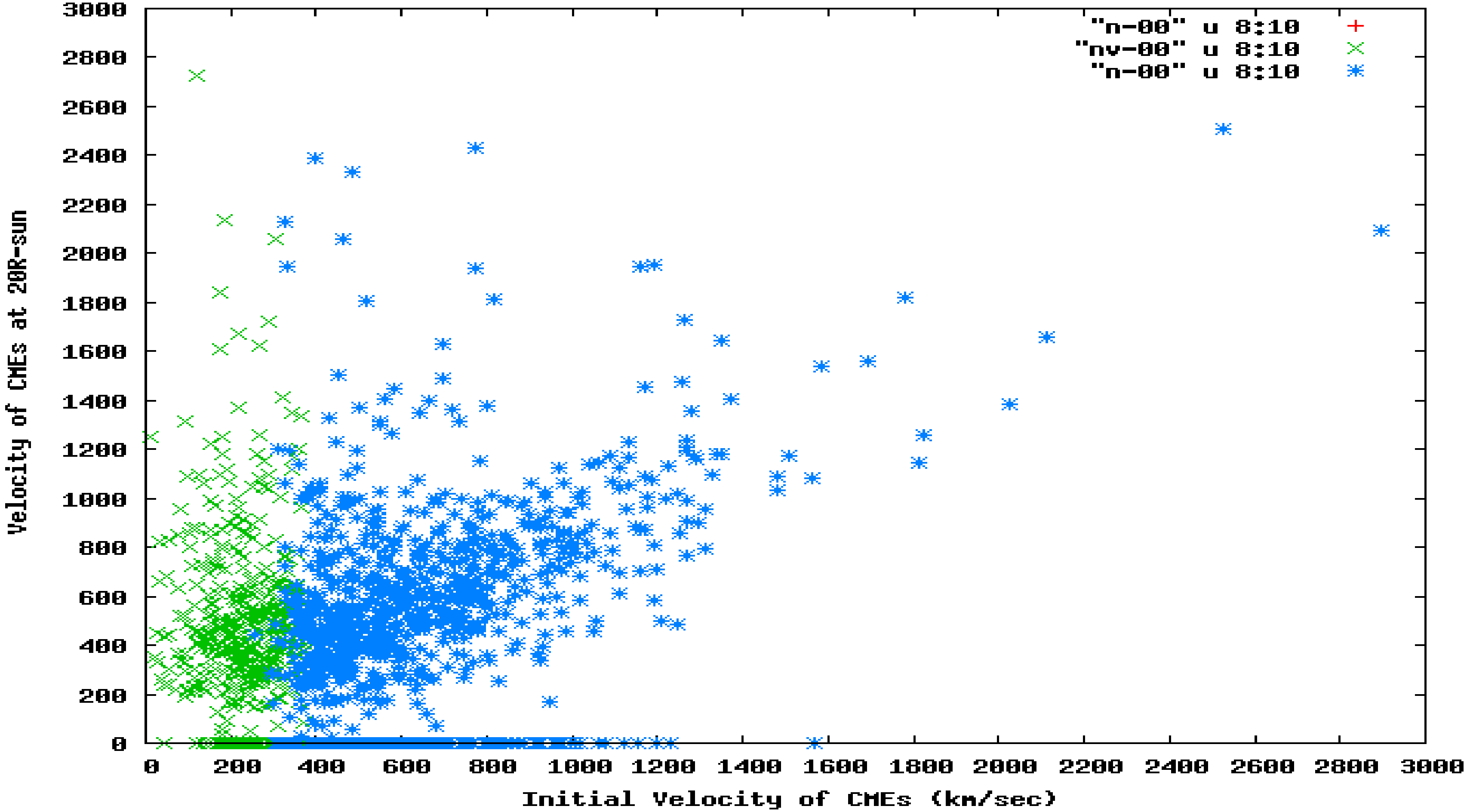


Figure 22: Plot of Initial Velocity vs. Velocity of CMEs at 20 Solar Radii

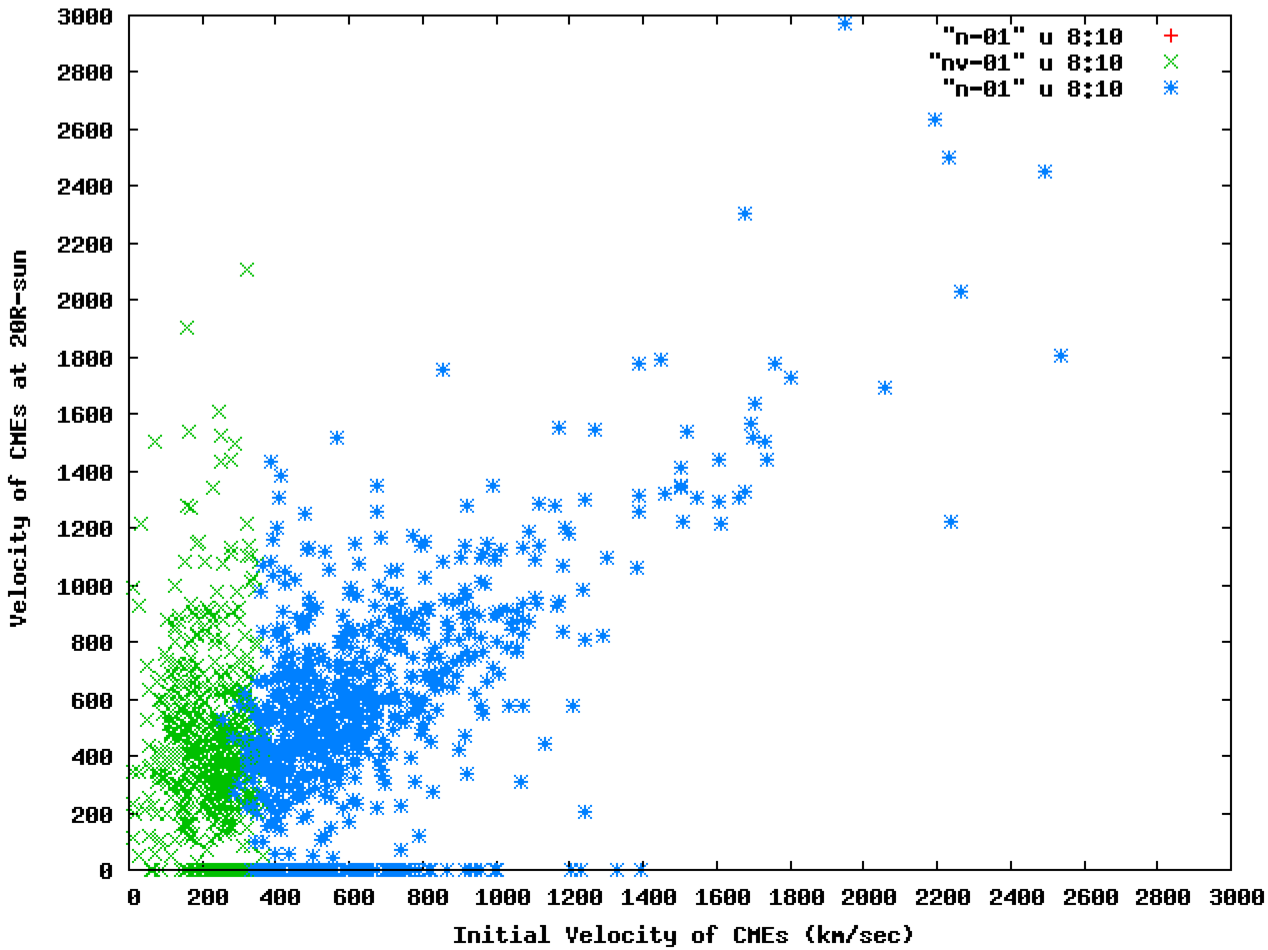


Figure 23: Plot of Initial Velocity vs. Velocity of CMEs at 20 Solar Radii

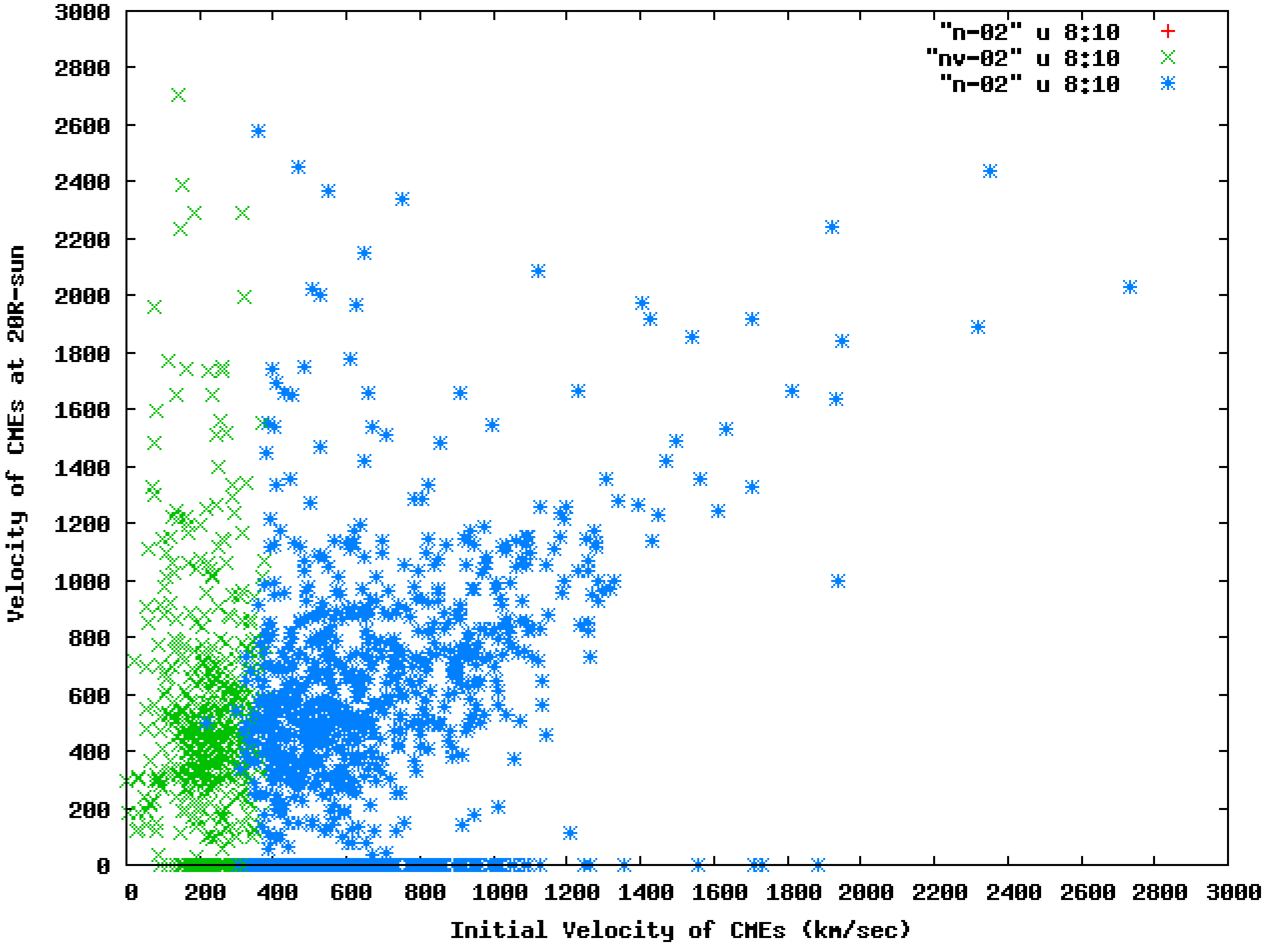
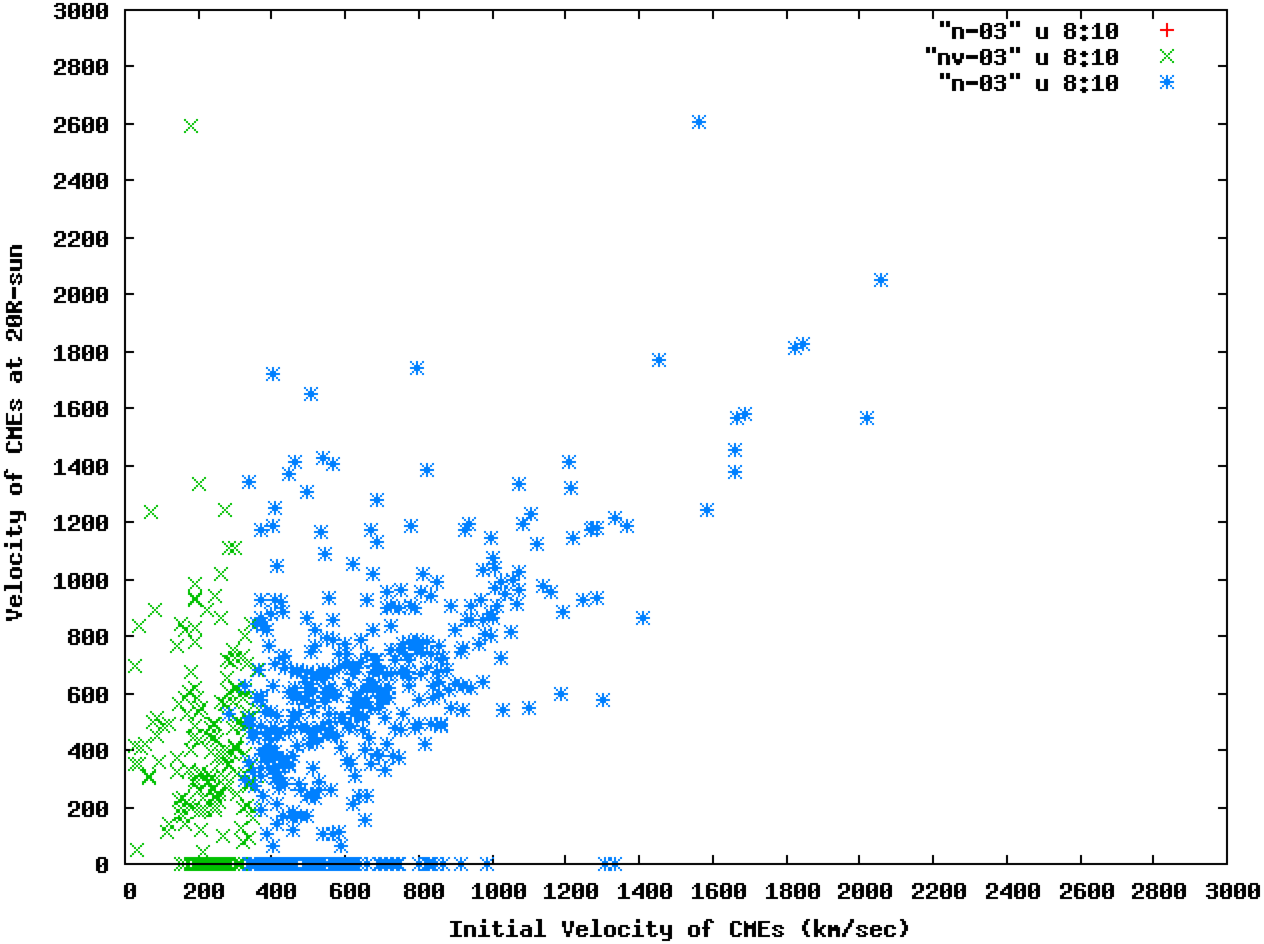


Figure 24: Plot of Initial Velocity vs. Velocity of CMEs at 20 Solar Radii



Results: This study shows that there are two classes of CMEs.

1- NEV-CMEs (41%): The majority NEV-CMEs class of CMEs show positive accelerations and this is clear from Figures 9 to16.

2- EV-CMEs (59%): About 45.5% EV-CMEs show positive accelerations and about 54.5% of EV-CMEs show negative accelerations as it is clear from Figures 9(1996) to 16(2003).

This study also shows that over all 68% CMEs show positive acceleration and 32% CMEs show negative acceleration. The negative acceleration of EV CMEs is the natural phenomena because once a mass is ejected from the sun (source of CMEs: flares or active prominences or active filaments) its velocity will get decrease as its moves away from the Sun. Now the question arises how the NEV-CMEs materials maintains the positive acceleration when its move away from the Sun.

Results: Continued

We are of the view that the NEV and EV Class of CMEs with positive accelerations (68% CMEs) are perhaps have been produced by some mechanism, in which the mass ejected by some solar flares or active prominences, gets connected with the open magnetic lines of CHs (source of high speed solar wind streams) and moves along them to appear as CMEs as suggested earlier by Verma and Pande(1989), Verma (1992), Verma(1998) and Verma (2002). The recent papers by Asai et al(2008, 2009) supports the view of presence of CHs close to the active region involved in the coronal mass ejections and approved the scenario suggested by Verma(1998) which is shown in Fig.25.

Figure 25 Shows the CMEs origin scenario proposed by Verma(1998)

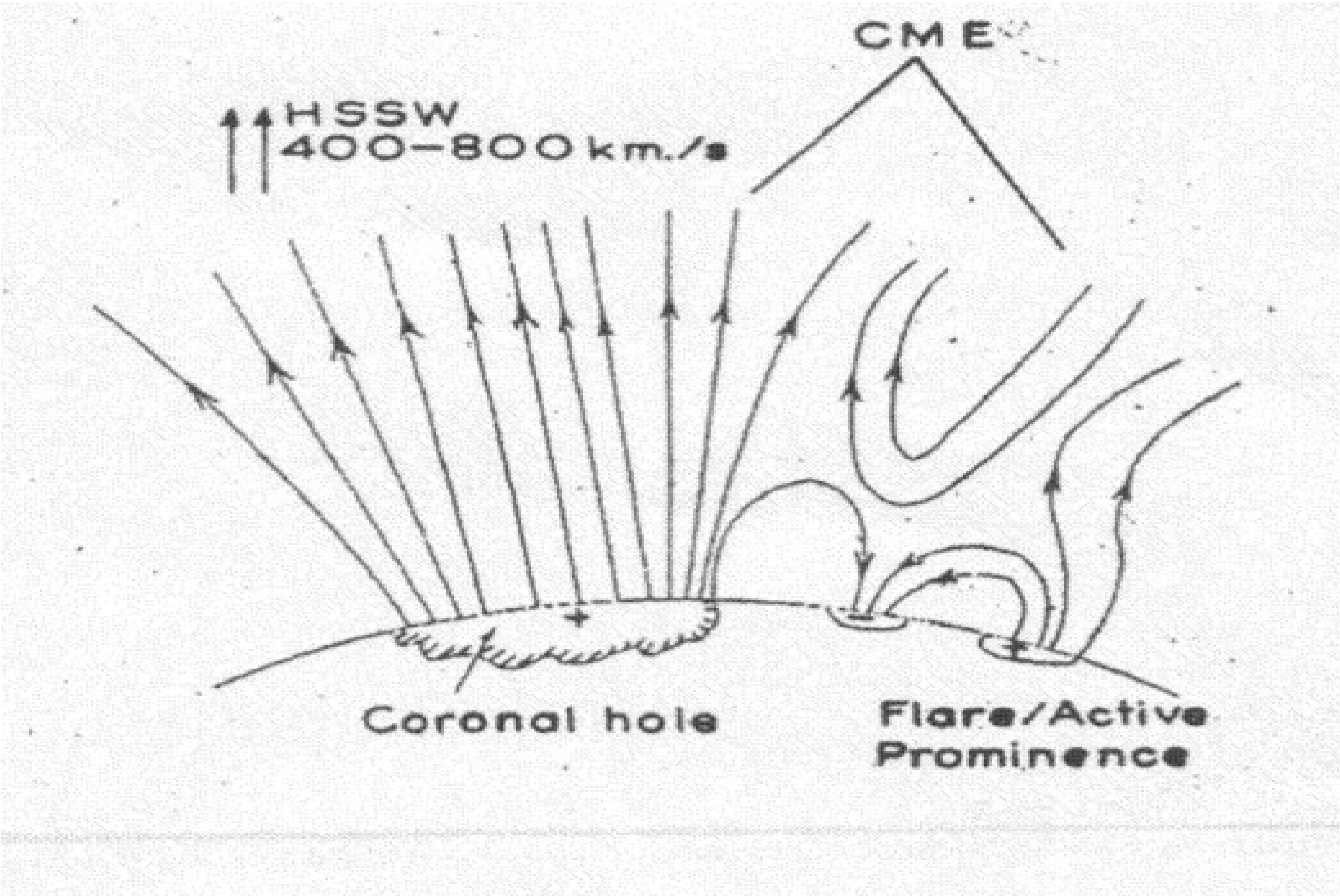


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Table 2: Max and Min. Masses and related Energies for both Classes of CMEs

Table 2

S.No.	EV-CME Mass (Energy)	NEV-CME Mass (Energy)
1- Mass Min	1.6e+13 gm(5.0e+27 erg)	4.1e+11 gm(6.3e+25 erg)
2- Mass Max	8.2e+15 gm(5.5e+30 erg)	8.3e+15 gm(2.7e+30 erg)
3- Energy Min	5.0e+27 erg(1.6e+13 gm)	6.3E+25 erg(4.1e+11 gm)
4- Energy Max	1.9e+31 erg(4.0e+15 gm)	2.7e+30 erg(8.3e+15 gm)