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Study Of Symmetric And Asymmetric Short Term Cosmic Ray Intensity Decreases From 1997 To 2013

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Abstract
For this work we have to consider oulu super neutron monitor data of cosmic ray intensity decreases. For this period 47 symmetric cosmic intensity decreases and 74 asymmetric cosmic ray intensity decreases have been found. Now we have found that out of these events we have no data of CMEs for 5 symmetric and 7 asymmetric cosmic ray events for association with coronal mass ejections (CMEs). Again we found that these cosmic ray intensity decreases are well correlated with x-ray solar flares of different categories. Most of the asymmetric cosmic ray intensity decreases are found to be associated with M class x-ray solar flare and most of the symmetric cosmic ray intensity decreases are found to be associated with C class x-ray solar flares. Further we analyze that asymmetric cosmic ray intensity decreases are well correlated with geomagnetic storms and interplanetary shocks as compared to symmetric cosmic ray intensity decreases. The associated interplanetary shocks are forward shocks.

***Keywords: -** Cosmic ray intensity, Interplanetary shocks, Solar flares.*

1- INTRODUCTION

The cosmic-ray intensity has its minimum at the maximum of the sunspot cycle. Generally, this variation is explained in terms of gradient and curvature particle drifts in the large-scale field of the heliosphere (Jokipii,Levy,and Hubbard1977) and diffusion/convection of cosmic rays (Morrison 1956;Burlaga et al 1984; Perko;&Burlaga 1992) in the solar wind (for recent reviews see McDonald 1998;Potgieter 1998, Burger 2000) Coronal mass ejections (CMEs), large-scale eruptions of magnetized plasma from the Sun (Hundhausen 1993,199), are related to very strong, short-lived (Forbush) decreases of cosmic-ray intensity at Earth and are considered to be the building blocks of global merged interaction regions (GMIRs) in the outer heliosphere(Burlaga,McDonald,&Ness 1993) which are associated with the extended Forbush-type decreases .There (Webber,Lockwood, & Jokipii 1986) Newkrik, Hundhausen, & Pizzo(1981) were among the first to suggest that CMEs might play a role in long-term modulation of cosmic rays. In the past years, much of the debate and research on cosmic-ray modulation has focused on the relative importance of drifts and diffusion/convection.

The consensus that has emerged is that drifts are more important at solar minimum, when the large-scale heliospheric field is relatively well ordered; and diffusion/convection modulation is dominant at solar maximum (Jokipii & Wibberenz 1998). At solar maximum, the CME rate, which tracks the sunspot number (Webb & Howard 1994), is high, and CMEs are observed at all latitudes, consistent with the closed shell of the GMIR picture (McDonald, Lal, & McGuire 1993), in which modulation proceeds as a series of steps. Cane, Wibberenz, and colleagues have prompted a rethinking of the causes of cosmic-ray modulation.

The interplanetary medium is permeated by the continuous expansion of the solar corona, the solar wind, which carries outward the solar magnetic field. As the solar wind is very rarefied, ordinary collisions are replaced by long-range Coulombian forces in terms of particle interactions. Thus the solar wind is a colissionless magnetized plasma where the steepening of nonlinear waves can occur and generate shocks. Interplanetary shocks can be classified according to their propagation relative to the Sun: if its propagation is toward the Sun, its called a reverse shock, if its propagation is away from the Sun it is called a forward shock (Stone et al.,1998 , ECHER, E.,et al 2003,Echer, E. et al 2010,Tsurutani, B.T. et al 2011). The relationship between the decrease in cosmic ray intensity due to the shock and the one due to the magnetic cloud has been investigated (Cane et al. 1995, 1996; Wibberenz et al. 1997, 1998), and there is some evidence that they can contribute in roughly equal proportions, to the overall magnitude of the decrease, although the individual time profiles of the decrease due to these two effects can be quite different (Wibberenz et al. 1997).

2- DATA SOURCES

In this work monthly and hourly data of oulu super neutron monitor have been used to determine symmetric and asymmetric cosmic ray intensity decreases. The data of coronal mass ejections (CMEs) will be taken from SOHO – large angle spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. The data of interplanetary shocks have been taken from shocks arrival derived by WIND group from WIND observations, ACE list of transient and disturbances.

3- RESULT AND DISCUSSION

1- We have associated asymmetric cosmic ray intensity decreases observed during the period of 1997 to 2013 at Oulu super neutron monitor with Coronal mass ejections. Out of 74 asymmetric cosmic ray intensity decreases (Fds) we have no data of CMEs for 7 events. The available data of CMEs for association are 67 events and out of these 67 events 62 (92.54%) asymmetric cosmic ray intensity decreases (Fds) have been found to be associated with coronal mass ejections. The majority of associated CMEs are halo CMEs (Figure-1). Again magnitude of asymmetric cosmic ray intensity decreases (Fds) is dependent on associated CMEs a scatter plot has been plotted between magnitude of asymmetric cosmic ray decreases and speed of associated CMEs and found the correlation coefficient is 0.46 between them(Figure-2). While we have found total 47 symmetric cosmic ray intensity decreases for this period, we have no data of CMEs for 5 events for association. We have available data of CMEs are 42 events and out of these 42 events 27 (64.28%) symmetric cosmic ray intensity decreases have been found to be associated with coronal mass ejections . The association rate of H Type and P types CMEs have been found 13 (48.15%) and 14 (51.85 %) respectively(Figuee-3).now we draw a scatter plot between magnitude of symmetric cosmic ray intensity decreases and speed of associated CMEs and the correlation coefficient between these parameters is 0.19(Figure-4). We have concluded that asymmetric cosmic ray intensity decreases are well correlated with CMEs.

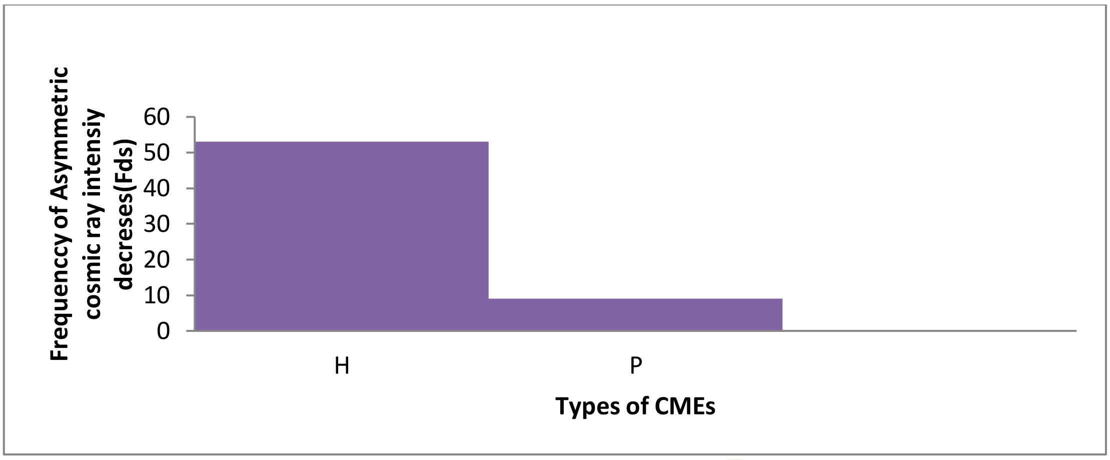

Figure-1- Bar diagram of asymmetric cosmic ray intensity decreases (Fds) and types of associated CMEs for the period of 1997-2013.

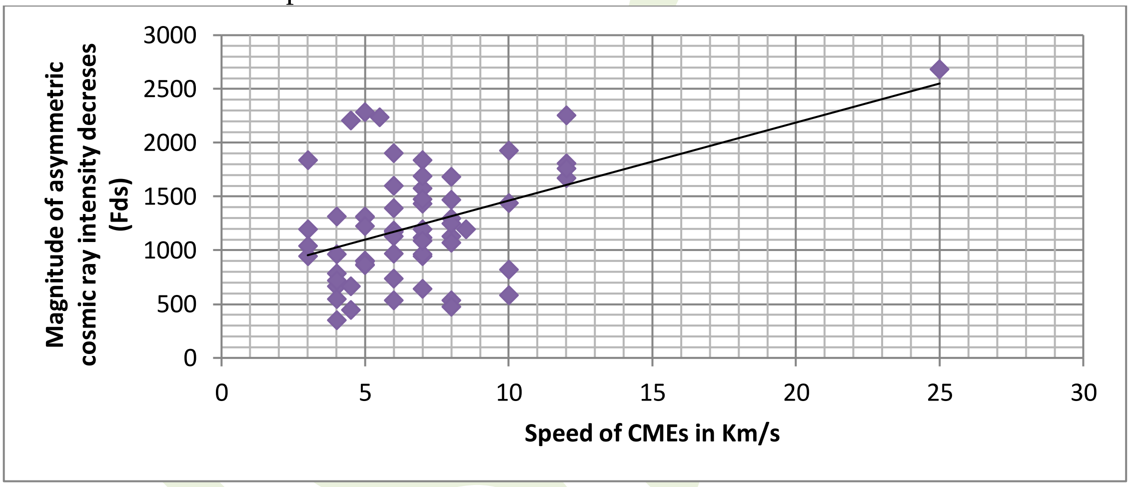

Figure-2-Scatter plot between magnitude of asymmetric cosmic ray intensity decreases (Fds) and speed of associated CMEs for the period of 1997-2013 showing positive correlation with correlation coefficient 0.46.

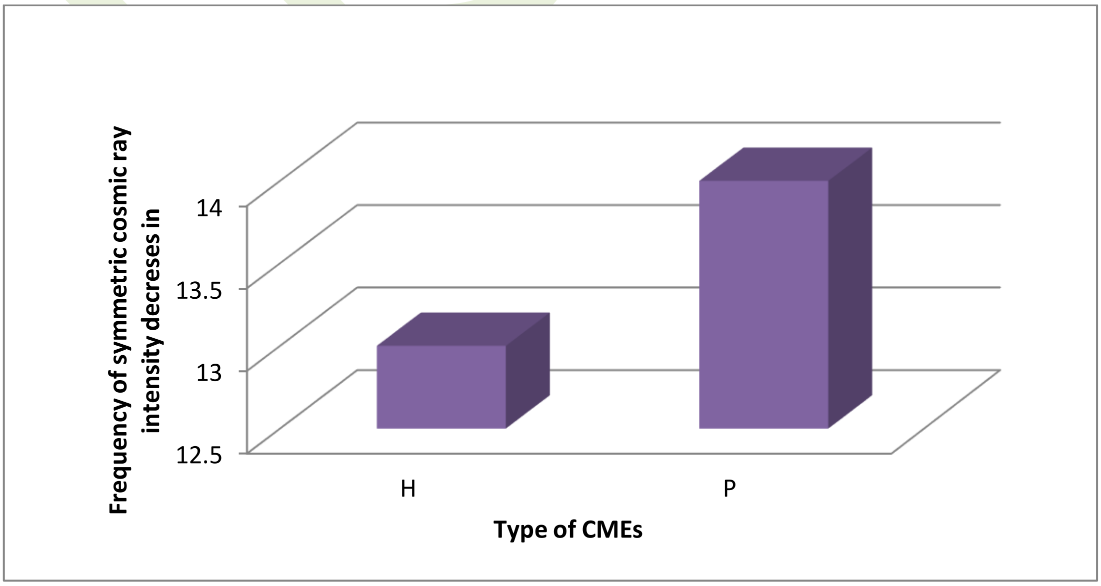

Figure-3- Bar diagram of symmetric cosmic ray decreases in cosmic ray intensity and types of associated CMEs for the period of 1997-2013.

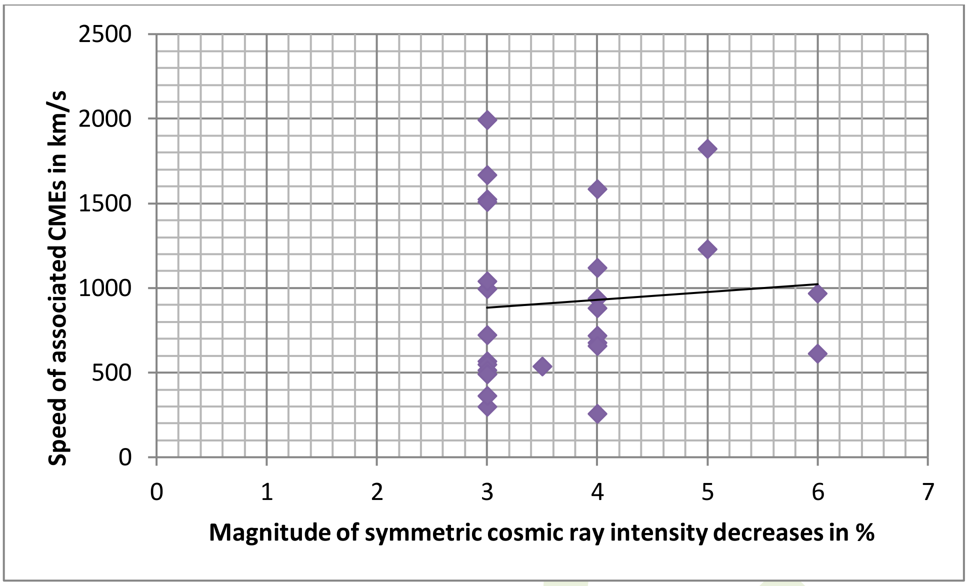

Figure-4-Scatter plot between magnitude of symmetric cosmic ray intensity decreases and speed of associated CMEs for the period of 1997-2013, showing positive correlation with correlation coefficient 0.19.

2- Out of 74 asymmetric cosmic ray intensity decreases, 69 (93.24%) asymmetric cosmic ray intensity decreases (Fds) have been identified as being associated with X ray solar flares of different categories and majority of the associated solar flares are M-Class solar flares. Out of 69 asymmetric cosmic ray intensity decreases (Fds), 16 (23.19%) asymmetric cosmic ray intensity decreases (Fds) are found to be associated with X class X-ray solar flares, 36(52.17%) are found to be associated with M class X-ray solar flares,(18.84%) are found to be associated with C class X-ray solar flares and 04(5.7%) are found to be associated with B class X-ray solar flares. The bar diagram between types of X-ray solar flares and frequency of associated asymmetric cosmic ray intensity decreases (Fds) are shown in Figure-5**.** While 42(89.36%) Symmetric cosmic ray intensity decreases are found to be associated with X ray solar flares of different categories and majority of the associated solar flares are C-Class solar flares. 01(2.38%) symmetric cosmic ray intensity decreases are found to be associated with X class X-ray solar flares, 18(42.86%) are found to be associated with M class X-ray solar flares ,19(45.24%) are found to be associated with C class X-ray solar flares and 04(9.52%) are found to be associated with B class X-ray solar flares(Figure-6). From these results it is concluded that most asymmetric and symmetric cosmic ray intensity decreases (Fds) are associated with M class and C class solar flares.

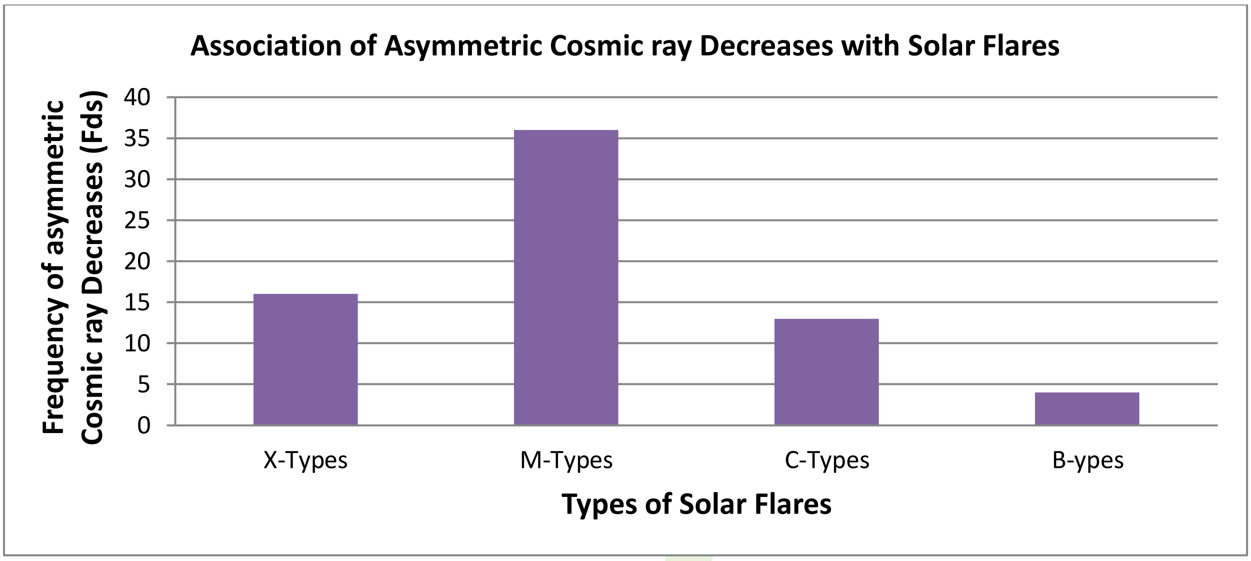

Figure-5-Bar diagram between different types of solar flares and frequency of associated asymmetric cosmic ray intensity decreases (Fds) for the period of 1997-2013.

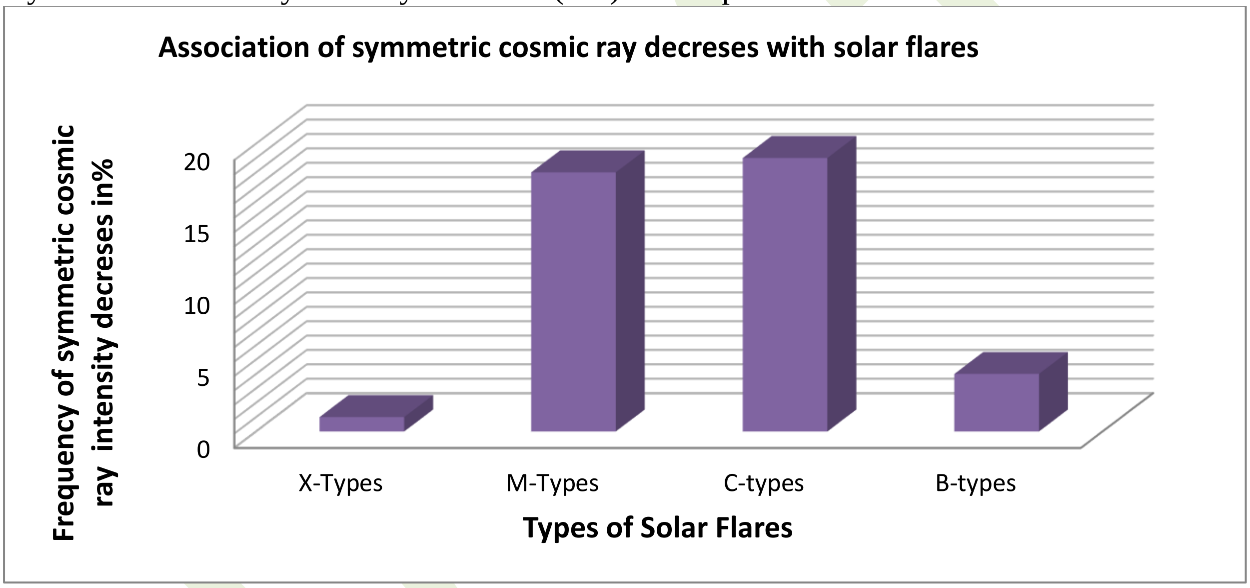

Figure-6- Bar Diagram between Different types of Solar flares and frequency of associated symmetric cosmic ray intensity decreases for the period of 1997-2013.

3- Again we found that 62 (83.87 %) asymmetric cosmic rays intensity decreases have been found to be associated with geomagnetic storms. while 29 (61.7%) symmetric cosmic rays intensity decreases have been found to be associated with geomagnetic storms. Further we have plotted a scatter diagram between magnitude of asymmetric and symmetric cosmic ray intensity decreases with magnitude of associated geomagnetic storms. Positive co-relation with co-relation coefficient 0.60 has been found between magnitudes of asymmetric cosmic ray decreases and magnitude associated geomagnetic storms (Figure-7) and Positive co-relation with co-relation with correlation coefficient 0.09 has been found between magnitudes of symmetric cosmic ray intensity decreases and magnitude associated geomagnetic storms (Figure-8). From these results we have concluded that the association rate of asymmetric cosmic ray intensity decreases with geomagnetic storms is good.

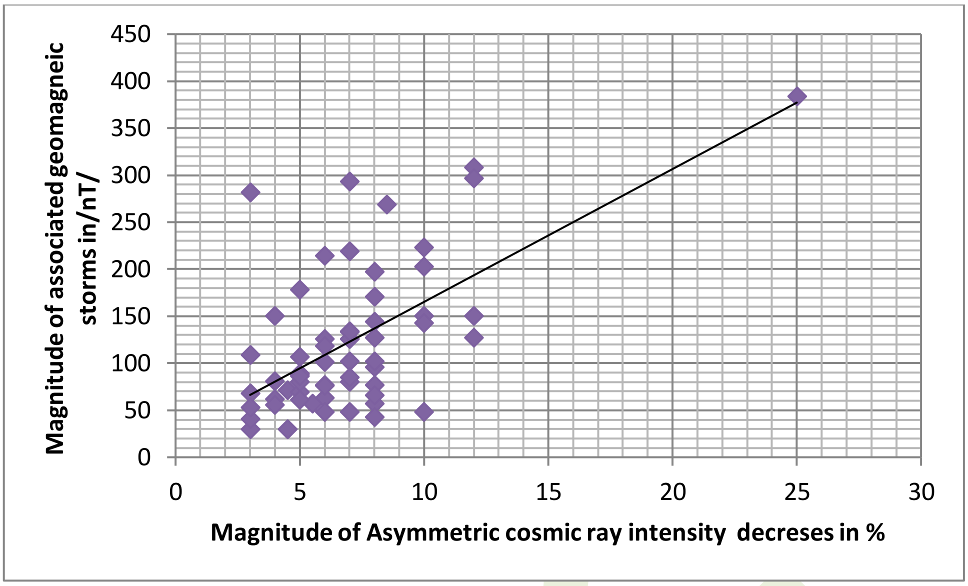

Figure-7- Scatter plot between magnitude of asymmetric cosmic ray intensity decreases (Fds) and magnitude of associated geomagnetic storms for the period of 1997-2013 showing positive correlation with correlation coefficient 0.60.

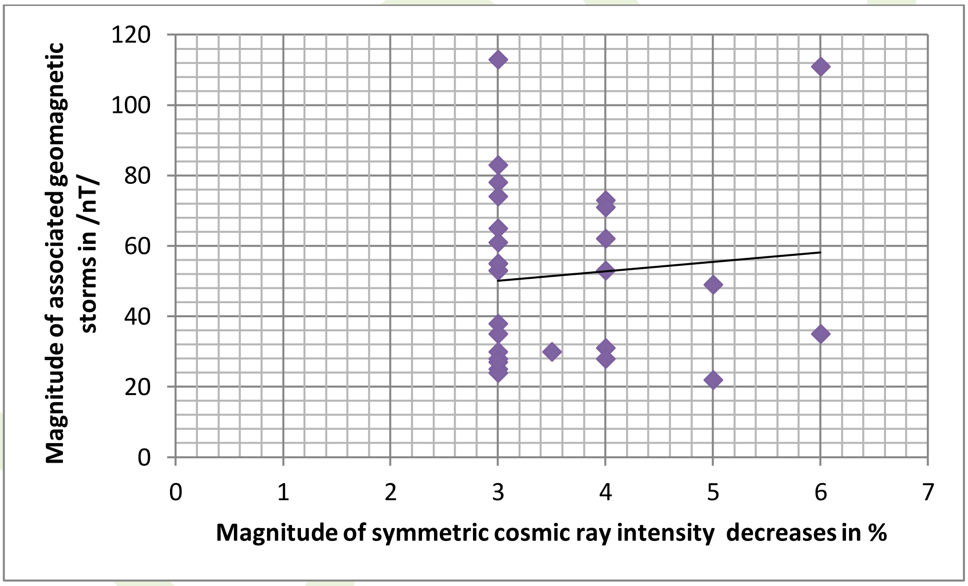

Figure-8- Scatter plot between magnitude of symmetric cosmic ray intensity decreases and magnitude of associated geomagnetic storms for the period of 1997-2013 showing positive correlation with correlation coefficient 0.09.

4- From the data analysis we have found that out of 74 asymmetric cosmic ray intensity decreases (Fds) ,60 (81.08%) asymmetric cosmic rays intensity decreases (Fds) have been found to be associated interplanetary shocks. The associated interplanetary shocks are forward shocks. From the further analysis it is observed that majority of interplanetary shocks following the onset of asymmetric cosmic ray intensity decreases (Fds). We have 60 asymmetric cosmic ray intensity decreases which are associated with interplanetary shocks out which arrival time of 37(61.66%) interplanetary shocks have been found after the onset time of asymmetric cosmic ray intensity decreases (Fds), The arrival time of 20(33.33%) interplanetary shocks have been found before the onset time of asymmetric cosmic ray intensity decreases (Fds) and onset time of 03(5%) asymmetric cosmic ray intensity decreases are common to arrival time of interplanetary shocks(Figure-9).

Again out of 47 symmetric cosmic ray intensity decreases 22 (46.81%) symmetric cosmic rays intensity decreases have been found to be associated interplanetary shocks .The associated interplanetary shocks are forward shocks. We have 22 symmetric cosmic ray intensity decreases which are associated with interplanetary shocks out which arrival time of 17(77.27%) interplanetary shocks have been found after the onset time of symmetric cosmic ray intensity decreases, The arrival time of 05(22.72%) interplanetary shocks have been found before the onset time of symmetric cosmic ray intensity decreases. There are no common symmetric cosmic ray intensity decreases to arrival time of interplanetary shocks (Figure-10). Finally we have concluded that asymmetric cosmic ray intensity decreases are well correlated with all the parameters which we have considered then symmetric cosmic ray intensity decreases.

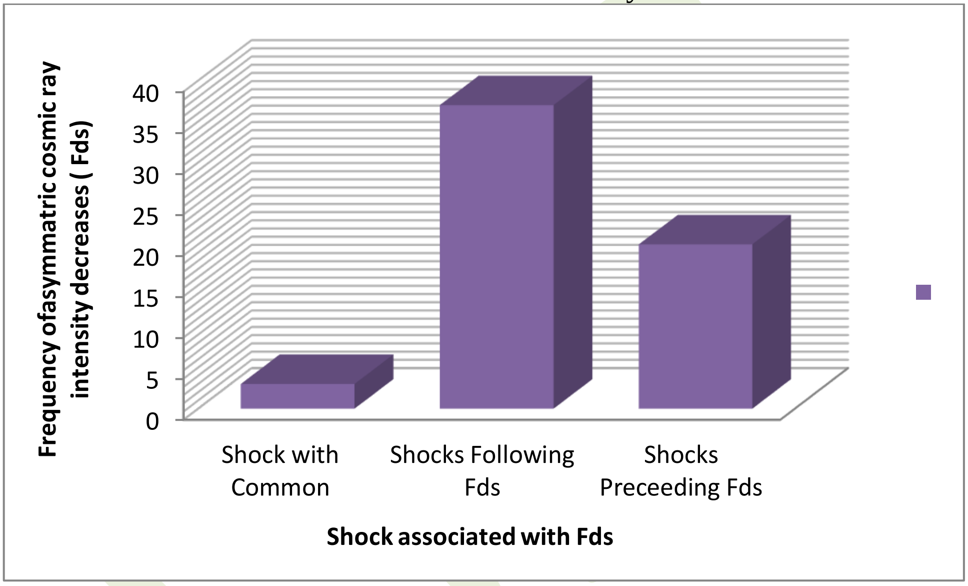

Figure-9-Shows Frequency of asymmetric cosmic ray intensity decreases (Fds) associated with common onset, preceding and following the onset time of asymmetric cosmic ray intensity deceases (Fds).

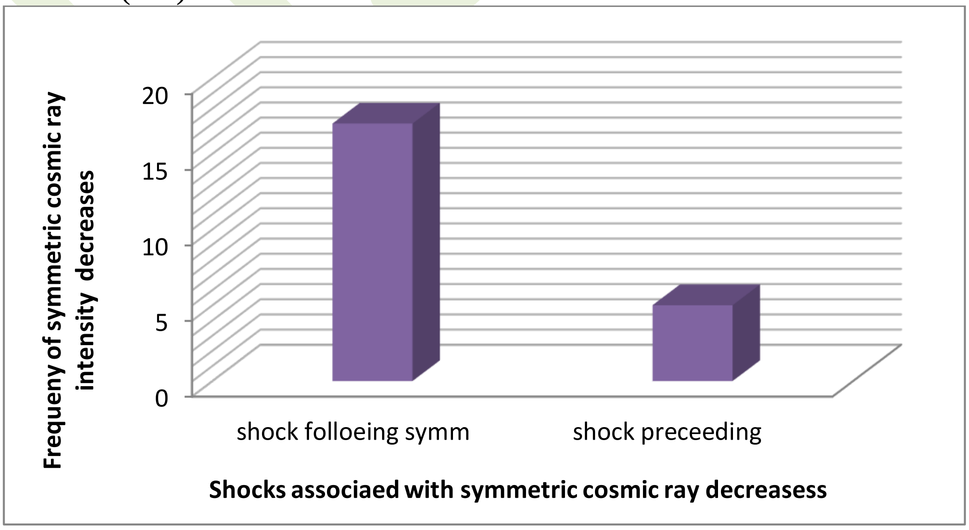

Figure-10- Shows Frequency of symmetric cosmic ray intensity decreases (Fds) associated with common onset, preceding and following the onset time of symmetric cosmic ray intensity deceases.

4- CONCLUSION

For this work we have to take oulu neutron mentor data of cosmic ray intensity decreases during the period 1997-2013 to study with different parameters like CMEs, flares, geomagnetic storms, and interplanetary shocks. We have found that in all the parameters asymmetric cosmic ray intensity decreases are well correlated as compare to symmetric cosmic ray intensity decreases. In both decreases the interplanetary shocks are forward shocks. Some cosmic ray intensity decreases have no data for correlation with coronal mass ejections (CMEs). We concluded that asymmetric cosmic ray intensity decreases are mostly related with halo coronal mass ejections and also with geomagnetic storms with correlation coefficients 0.60 and correlation coefficient of geomagnetic storms with symmetric cosmic ray intensity decreases is 0.09 which shows symmetric cosmic ray intensity decreases are not well correlated with geomagnetic storms.

5- ACKNOWLEDGEMENT

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