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Solar Burst Type IV Signature Associated with Solar Prominences on 20th January 2016

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ABSTRACT

Proceeding from close association between solar eruptions, flare and CMEs, we analyze between burst at 980 MHz to 1270 MHz, recorded at the Blein, Switzerland on 20th January 2016. This burst indicates the emission radiation from the Sun from numerous high energy electrons in active region AR2484 and AR2487 forming a large prominence in that particular area. Solar prominences usually occur in loop shape and can last for weeks or months. This event allows us to investigate the electron density and drift rate of solar burst type IV During that time the Sun has the moderate number of sunspots with 55.The radio sources responsibly for IV appear to expand spherically through the solar corona after eject on y solar flare. This event shows a strong radiation in radio region, but not in X-ray region. This burst intense radio phenomena that follow with solar flares. It has a wide band and fine structure. It can be considered as an intermediate fast drift burst (IMDs). This fiber burst has a negative drift rate where the drift is interpreted by the group velocity of the whistler-mode waves. This burst appears is single SRBT III for approximately within 7 minutes with starting time is 8.23 UT. This burst duration is longer compared to the other events. It can be considered as a IV because it begins at the same time as the explosive phase of solar flare. The solar optical, radio and X-ray emission associated with these various energetic particle emissions as well as the propagation characteristics of each particle species are examined in order to study the particle acceleration and emission mechanisms in a solar flare. At the same time, the number of particles traveled a given path in reconnecting area falls exponentially with the increase of this path because of losses owing to a leaving of particles the acceleration volume due to drift.

***Keywords*:** Sun, solar burst, type IV radio region, X-ray region, solar flare, Coronal Mass Ejections (CMEs)

1. INTRODUCTION

The increasing solar activities will give impact to the magnetic field of the earth. The magnetization of the earth, also known as the geomagnetic field, is the magnetic field that extends from the Earth's interior out into space, where it meets the solar wind, a stream of charged particles emanating from the Sun [1,2]. The magnetic field of the earth was used to deflect most of the solar wind, whose charged particles would otherwise strip away the ozone layer that protects the Earth from harmful ultraviolet radiation [3]. Other than that, increasing solar activities also will give impact on the satellites; the satellites will damage due to geomagnetic storm [4].

Electric current inside the sun create a magnetic field and the strength of the magnetic field of the sun is just about twice as strong as Earth's field for the most part. Nonetheless, it is profoundly moving in little areas, which sees up to 3000 more than expected. These kinks and twist in the magnetic field create in light of the fact that the sun quicker at the equator turns as in the higher scopes and in light of the fact that the inward parts of the Sun pivot speedier than the surface. These bends make highlights running from sunspots to dynamite emissions known as flares and coronal mass ejection. Flares are the most vicious ejections in the solar system, while coronal mass ejections are less brutal yet include remarkable measures of matter - a single emission around 20 billion tons of matter into space spout [5] .

Among of this type of solar radio burst; type I, type II, type III, type IV and type V, type IV are the only one that takes a longer duration present of solar burst [6-8]. Solar burst type IV occurs due to synchrotron emission by the flare electrons [9].They are generated attributed to trap electrons in closed field lines in the post- flare arcades produced by flares [10,11]. The frequency is more than 20 MHz [12]. Although they are not as common as Type II and III bursts, and there has been somewhat less work on their properties [13,14]. Type IV bursts have long been of interest in Space Weather studies because they have a high degree of association with solar energetic particle events .

Type IV burst is confined to frequencies ≤ 1000 MHz, and can divide into 2 categories (i) a moving burst and (ii) static type IV bust [15,16]. This burst bursts characteristically happen at around the time of the soft X–ray peak in a solar flare and are identified by a slow drift to lower frequencies with time in dynamic spectra. [17-19]. It is related to the generation of solar cosmic rays and plasma clouds that related to the mechanism of solar particles [19,20].

Solar burst type IV has three characteristics which are moving burst, stationary burst and flare continua burst [21]. For moving burst, the burst is broadband, slow frequency drift and smooth continuum. The range for this burst is between 20 MHz – 400 MHz and the durations is between 30 hours to 2 hours. This burst also will produce eruptive prominences, magneto hydrodynamic shock waves. For stationary burst, the burst is a broadband continuum with fine structure . The range for this burst is between 20 MHz – 4 GHz and it can take days to hours to complete the burst. This burst also will produce flares and proton emission. For flare continua burst the burst is broadband and smooth continuum. The range for this burst is between 25 MHz – 200 MHz and the durations is between 3 minutes to 45 minutes. This burst also will produce flares and proton emission [22].

Solar burst type IV can be divided into two groups which is zebra burst and fibre burst. The main characteristic of fibre burst is: (i) their drift rate as usually negative, (ii) the drift / frequency ratio (df/dt) is on the order of 0.04 to -0.1s-1 (iii) their instantaneous bandwidth is approximately 2% of the emission frequency (Benz,Mann,1998) and (iv) they are accompanied a parallel drift absorption band in the background continuum radiation (Chenov,2006). Even though the drift rate can be negative but sometimes it can also be positive (Bouratzis et al., 2016). However, for zebra burst, the characteristic is the appearance in zebra stripe on the dynamic spectrogram. Zebra burst also consists of a series of spectral bands and spacing between the bands is approximately constant (LaBelle et al., 2003).

In this study we want to determine the physical properties (moving or stationary) of Solar Radio Burst Type IV and to analyze the sunspot evolution of the X-ray and optical data.

2. OPTICAL RADIO AND X-RAY OBSERVATION

By using this software and instrument the sunspot was observed on 20th January 2016 in the active region 2484, 2485,2486 and 2487 , which is seen at the solar disk, was recorded by Geostationary Operational Environmental Satellite (GOES) [23,24,25]. The optical data was taken form Balai Cerap, Teluk Kemang, Negeri Sembilan Malaysia to observe the prominences and sunspot evolution.

3. RESULTS AND ANALYSIS

During the impulsive phase of the flare (from 08:23 UT to 08:30 UT), there were two groups of active regions on the sun (i) 2484 (ii) 2487 (respectively. But this sunspot appears to be passive in this day . In this case, the range of 250 MHz to 350 MHz is selected [26]. Detailed there were fiber structure pattern are shown. It was found that a significant solar burst happened starting from 8.23 UT to 8.30 UT. But unfortunately, the continuous detailed data could not be taken due to limitation in period of observations. The details of the selected solar burst shown at Table 1.

Table 1. Data for Solar Activity during 20th January 2016

Time UT	8.23 UT
Active Region (AR)	2484,2485,2486,2487
Sunspot Number	55

The Radio Sun	10.7 cm flux: 98 sfu
Solar Wind	speed: 380.8 km/sec density: 21.8 protons/cm3
X-ray Solar Flare	6-hr max: B4 1709 UT Jan20 24-hr: C1 0734 UT Jan20
Planetary K-index	Now: Kp = 5 storm 24-hr max: Kp = 5 storm
Interplanetary Magnetic Field	Btotal: 14.9 nT Bz: 1.5 nT north

Table 2. Data energy emitted in Solar Radio Burst Type IV

Date	Burst Duration (minutes)	Average Low Frequency (MHz)	Photon Energy (MeV)	Average High Frequency (MHz)	Photon Energy (MeV)
20/1/2016	7	980	4.058×10^{-12}	1260	5.218×10^{-12}

On 20th January 2016, the Solar Burst Type IV lasts long within 7 minutes with starting time is 8.23 UT; starting frequency is 980 MHz and ending with a frequency of 1260 MHz. This burst is stationary burst which broadband continuum with fine structure. During that period, the solar wind speed is exceed up to 380.8 km/second and this solar wind will give 30% chance of minor geomagnetic storms due to coronal hole that happen in southern of the sun. Coronal holes are placed in the sun's atmosphere where the magnetic field opens up and allows the solar wind to get away. The density of protons is 21.8 protons/cm3. The active region for this solar burst is 2484,2485,2486,2487 while the sunspot number is 55.

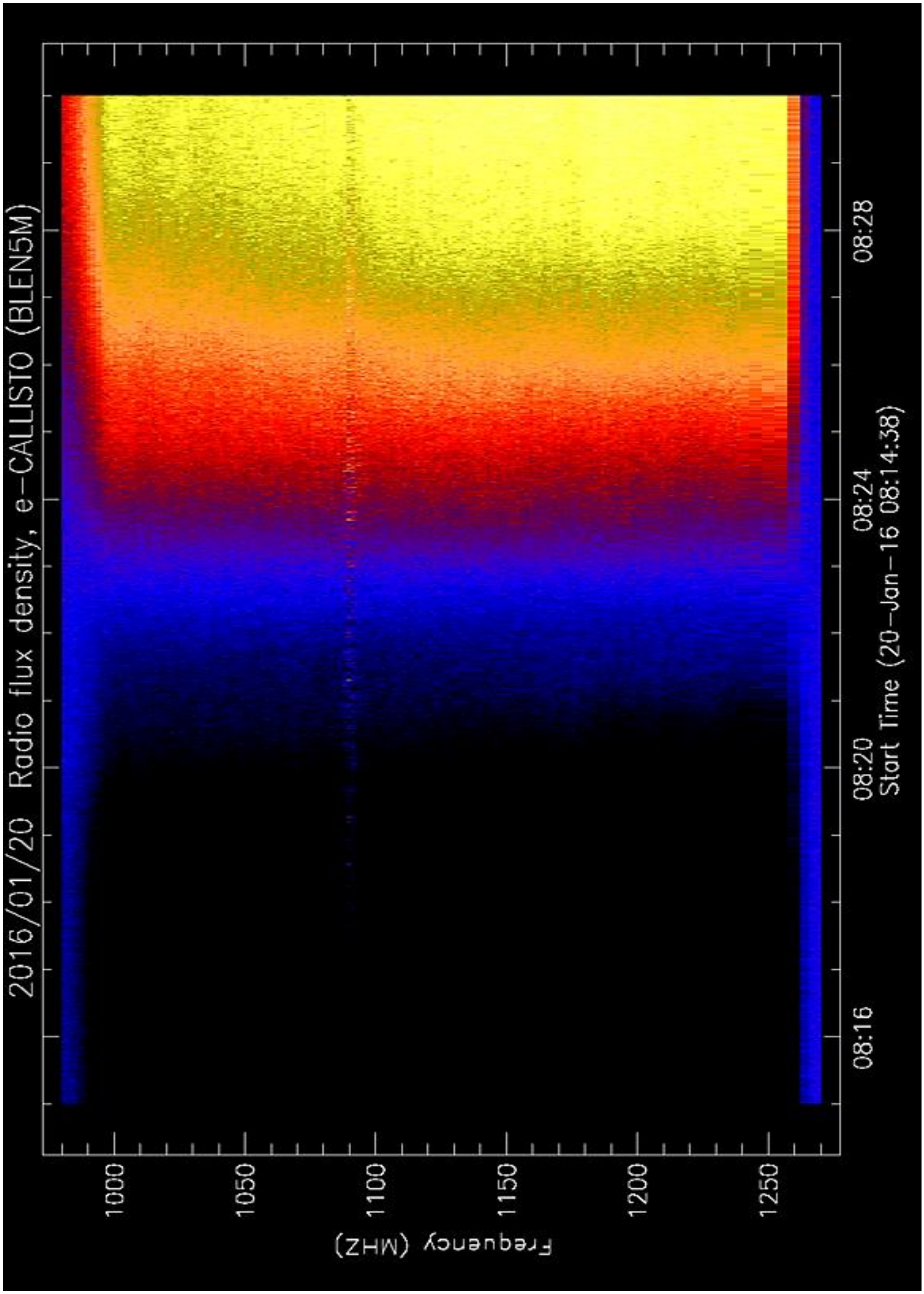

Figure 1. Solar Radio Burst Type IV at Blein, Switzerland

The formation Solar Burst Type IV comes from non-thermal electron that trapped in moving or stationary structure that will produce long lasting continuum emission. This burst produced during an explosive phase of solar flares or showing up with some delay after such a flare, and it is arranged over the related flare area. Solar burst type IV has three characteristics which are moving burst, stationary burst and flare continua burst. However, all the data that have been analysed is stationary burst with duration 3 minutes to 10 minutes and with the frequency from 980 MHz to 1270 MHz. The burst is a broadband continuum with fine structure.

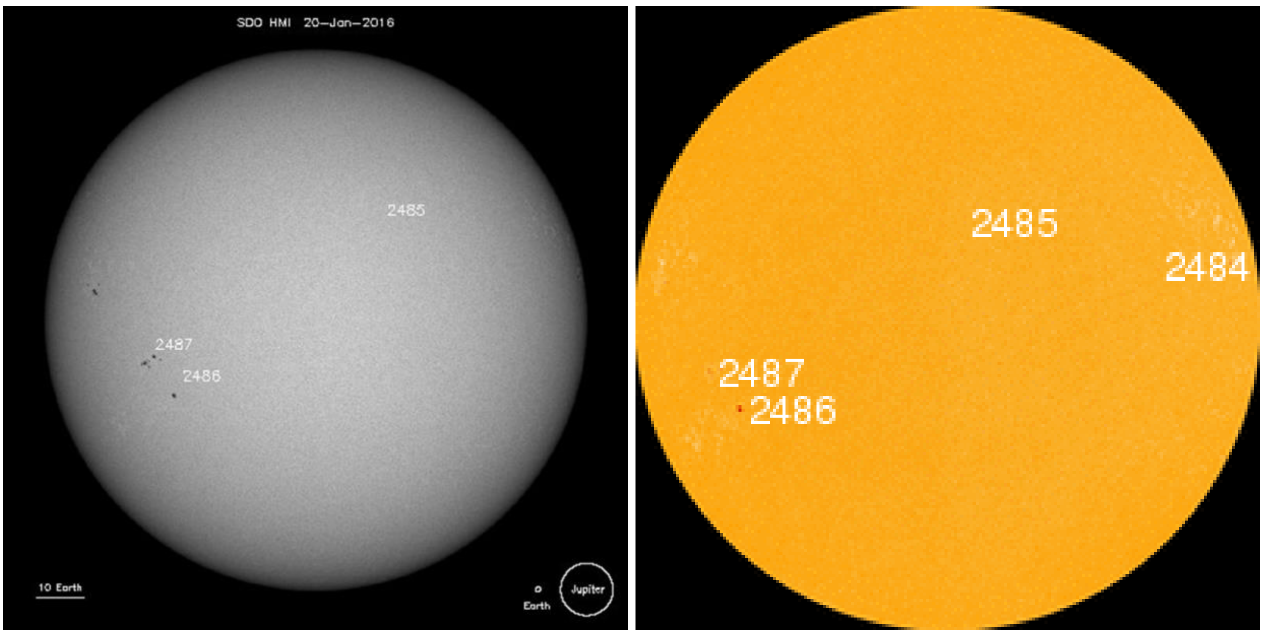

Figure 2. Sunspot number (Active region, AR 2484 and 2487)

According to Figure 2, the active region (AR) for sunspot number is 2486 and 2487. At this AR, the sunspot has a beta group sunspot classification with no penumbra and it is a bipolar spot configuration. This group sunspot classification was classified using Modified Zurich Class. From this sunspot is also a source of solar flare. From Solar Monitor's flare prediction system's (FPS) through the NOAA Space Weather Prediction Centre, it has predicted that the solar flare type C1 will occur at this sunspot. This information can be confirmed using Figure 3.

In this Figure, the graph of X-ray Flux from the GOES shows that the highest point is at C region and it is shown that solar flare type C1 will occur which is less noticeable on Earth and it can direct make an observation of the sun and monitor of its X-ray emission. More solar activity type C is likely throughout the following 24 hours at a sunspot number of 2487 keeps on hinting at flux emergence and spot development. The distribution of flux and electron flux in X-ray region is illustrated in Figure 3 and 4.

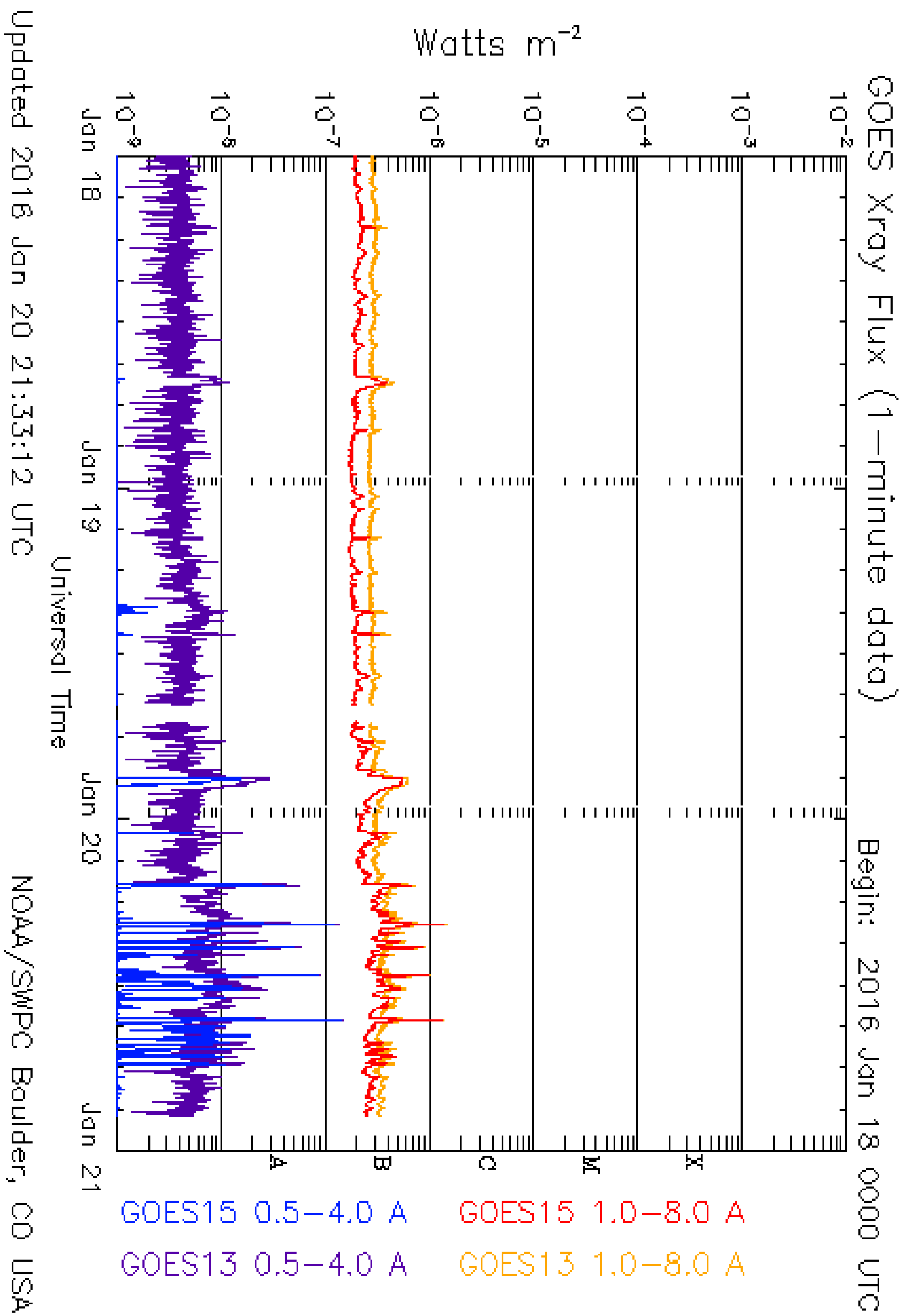

Figure 3. X-ray Flux from GOES (solar monitor software)

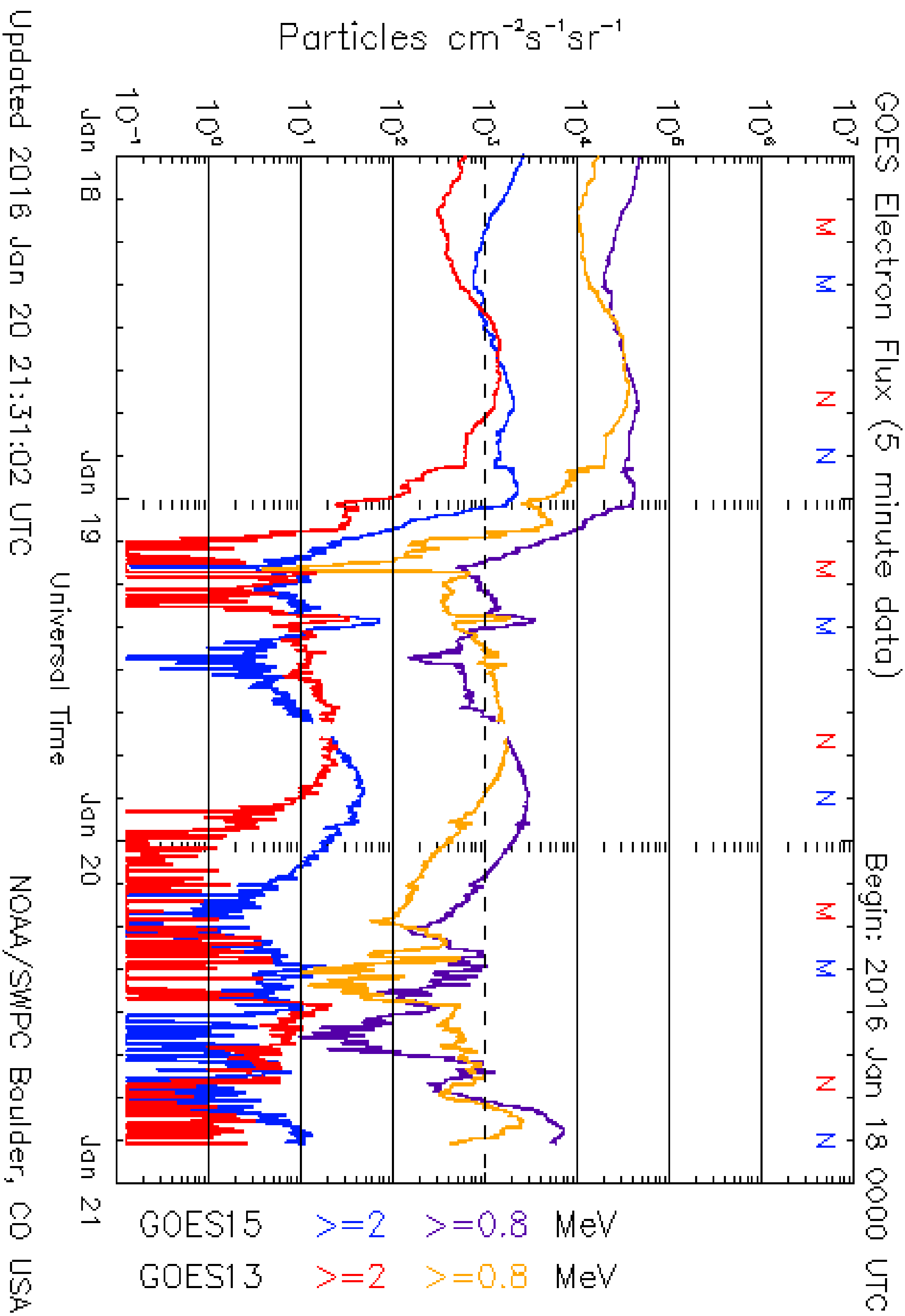

Figure 4. Electron Flux from GOES (solar monitor software)

The evolution of the sunspot is very important because from the sunspot we can know the active region of the sun. This active region will give the information about the solar flare. The solar flares are regularly connected with coronal mass ejections; the ejections of electrons, protons and ions from the Sun. These charged particles have some different impacts on Earth, which is related to communications and radio transmissions. From the data that have been analysed, the solar burst on 17th February 2016 and 22th March 2016 give M-class solar flare and solar burst on 20th January 2016 and 20th January 2016 give C-class solar flare.

4. CONCLUDING REMARKS

The radio sources responsible for IVm appears to expand spherically through the solar corona after ejection of solar flare. This event shows a strong radiation in radio region, but not in X-ray region. This burst intense radio phenomena that follow with the solar flare. It has a wide band structure from 1412- 1428 MHz. It can be considered as an intermediate drift burst (IMDs). This fiber burst has a negative drift rate where the drift is interpreted by the group velocity of the whistler-mode waves. Their bandwidth is approximately 2% of the emission frequency. It is believed that this burst consisting an interaction of a Langmuir and whistler-mode wave where it produce a left-handed polarized ordinary (L-O) mode wave that can escape from the emission region.

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