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The Enlargement of Type II Burst After Type III at AR 12522 on 16th March 2016 In Conjunction With Flare-Related Coronal Mass Ejections Event

Nurulhazwani Husien[1], Z. S. Hamidi[1,4,*], N. N. M. Shariff[2,4], M. O. Ali[1], N. H. Zainol[1], S. N. U. Sabri[1], C. Monstein[3]

[1]School of Physics and Material Sciences, Faculty of Applied Sciences, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

[2]Academy of Contemporary Islamic Studies, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

[3]Institute of Astronomy, Wolfgang-Pauli-Strasse 27, Building HIT, Floor J, CH-8093 Zurich, Switzerland

[4]Institute of Science, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

*E-mail address: zetysh@salam.uitm.edu.my

ABSTRACT

On 16th March 2016 the solar radio burst type II is recorded to appear on spectrograph after the type III formation. These two bursts related to the Coronal Mass Ejections (CMEs) event that recorded by the SOHO spacecraft several minutes before the formation of Type III on the spectrograph. It has been reported that the Type III burst a fast drift compared to the Type II burst. In this paper, the calculation has been proved that the type III burst has a higher drift rate compared to Type II. These two events of Type II and III burst also has been contributing to the formation of C class flare with magnitude of C2.2 It is also proven that the type III burst has a fast drift rate compared to type II burst. In this case, the type III has a fast drift rate of 81% compared to the type II burst. During this event, the active region AR 12522 erupted the C-class X-ray emission with magnitude of C2.2 contribute to these type III and II burst.

***Keywords*:** Sun, Coronal Mass Ejections, X-ray emission

1. INTRODUCTION

In the 1960s, there were five types of solar radio burst that have been classified and all these types of burst have frequencies below a few hundred MHz [1,2]. It has been discussed that these types of bursts have their related events. Usually the type I and II are associated with solar storms and Coronal Mass Ejections (CMEs) respectively. While type III and IV normally caused by solar flare and formation of new sunspot. The type V event is very rare which can be observed after the type III formation [3,4].

The solar radio burst type II is well known as slow drift burst with the frequency range of 20 MHz until 150 MHz for fundamental and twice for harmonic structure [5,6,7]. The associated phenomena of type II burst including flares, proton emission, magnetohydrodynamic and shockwaves. Meanwhile, the type II is very differ to type III burst. The type III burst is a fast drift burst with frequency covers between 10 kHz until 1 GHz. There are three types of type III burst which are single burst, group and storm burst. These three types burst differ from their duration where the single burst has the shortest with one until three seconds, followed by group type by one until five minutes and the storm type has the longest duration which may occur in hours [8]. The related phenomena of type III burst are active regions and flares.

There are estimated to be over 30,000 events at any one time on the Sun. These activities generally believed occurred due to magnetic reconnection process takes place on the Sun. Magnetic reconnection is the process by which magnetic lines of force break and rejoin into a lower-energy configuration. The magnetic energy is then converted to plasma kinetic energy [9]. CMEs are defined as a massive burst of solar wind and magnetic fields rising above the solar corona that can trigger major disturbances in Earth's magnetosphere. It is considered as an important manifestation of solar activity that drives the space weather near Earth [10]. Normally the CMEs event related to the type II burst originated from the solar corona, expanding as they climb [11]. During the CMEs explosion, the solar plasma is heated to tens of million degrees, protons and electrons, with nuclei are accelerated to near speed of light [12]. CMEs are thought to explode just before the eruption of solar flares. However, both CMEs and solar flare events are associated with high energy particles and depend on the magnetic of the Sun.

There are two types of CMEs that has been classified (i) flare-related CMEs and (ii) CMEs associated with filament eruption [13]. CMEs can be observed during the solar flares. This is due to the magnetic flux in the active region. Usually the solar radio burst type II and III could be observed during this event [14]. However,the filament eruption also could form the CMEs based on the evolution of sunspot or active region behavior. But this process is very complicated and not easily to be understood.

2. METHODOLOGY

The Compound Astronomical Low-cost Low-frequency Instrument Spectroscopy and Transportable Observatory (CALLISTO) spectrometer is a solar dedicated spectrometer system that has been installed all over the world with the aim to monitor the Sun activity in 24 hours [15,16].

Since now, there are more than 116 instruments in more than 66 locations with users from more than 120 countries. This networking among other countries promotes collaboration which can provide monitoring the Sun activities within 24 hours per day.

CALLISTO provides good quality data for scientific purposes with a remarkably low cost. This system of the spectrometer was championed by one co-author, Christian Monstein and the result is a global network system of solar monitoring research [2],[3]. Usually the antenna used for this system covers the frequency range between 45MHz until 870MHz. The CALLISTO software produces several output files. The most important are the data files, which use the Flexible Image Transport System (FITS) file format.

This type of file, are typically produced at 15 minutes intervals throughout the specified observation period. The instruments of this system automatically collect the data and then they are gathered in a database and send to the internet [17]. All these data can be archived by browsing the link http://www.e-callisto.org/

The data also obtained from other website which is SOHO websites. This website is well known for obtaining the data for Coronal Mass Ejections (CMEs).

Same as e CALLISTO websites, it also can be archived through the link http://sohowww.nascom.nasa.gov/about/about.html SOHO itself stands for Solar & Heliospheric Observatory. This is one of the collaboration project between NASA and ESA with the aim to study the Sun from its deep core to the outer corona and solar wind. SOHO spacecraft was built in Europe by an industry team led by prime contractor Matra Marconi Space (now EADS Astrium) under overall management by ESA. This spacecraft was successfully launched on 2nd December 1995.

2. RESULT AND DISCUSSION

The Figure 1 and 2 above showed the solar radio burst type III occurred on 16th March 2016. This is a brief complex type III burst which started to emerge at 06:37 UT until 06:39 UT. The complex radio burst type III occurred in conjunction with CMEs [18]. During this event, the CMEs recorded by the SOHO space craft occurred several hours before type III emerged on spectrograph which at 03:48 UT. This CMEs is a flare-related CMEs due to magnetic flux in the active region and it contributes to the solar radio burst type II and III. It was proven as the type III and II burst could be observed several hours later. The type II burst also started to appear on the spectrograph at 06:46 UT until 07:00 UT.

It has been reported that more than 60 percent of all solar radio burst type II are preceded with type III burst. The time delay between type III group and the start of type II burst lies between 1 and 18 minutes [12]. In this case, the time delay of type III until the formation of type II is about 5 minutes. The compound type III- type II burst can be explained as due to the ejection of two sets of disturbances from a single explosion occurring low in the solar atmosphere at the time of the type III event [12].

It is well known the main differences of these two bursts are their drift rate, for the type III burst, it is fast drift burst while type II is slow drift burst. So to prove this kind of theory, here I would like to compare the result of the drift rates for both type III and type II burst.

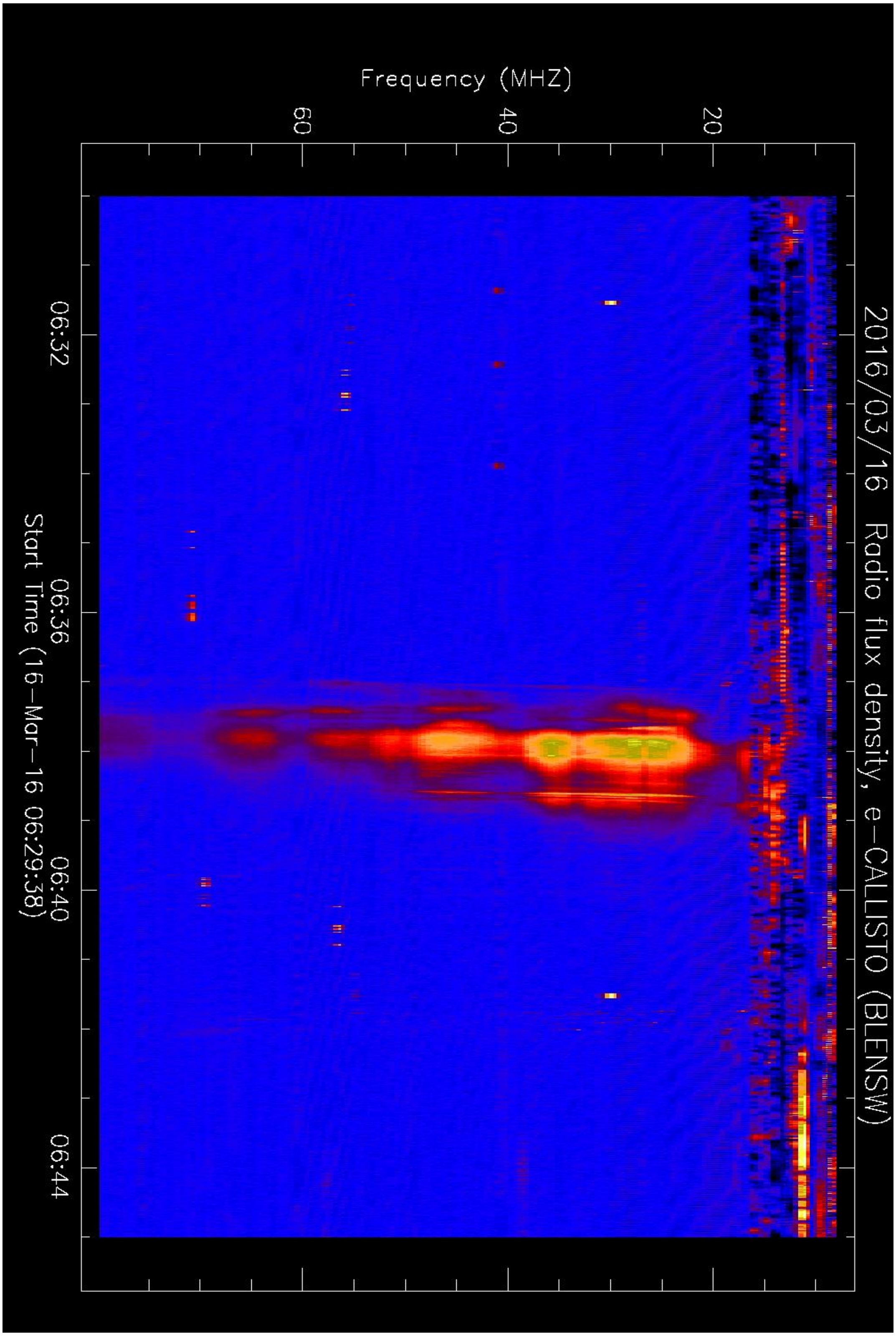

Figure 1. Type III burst

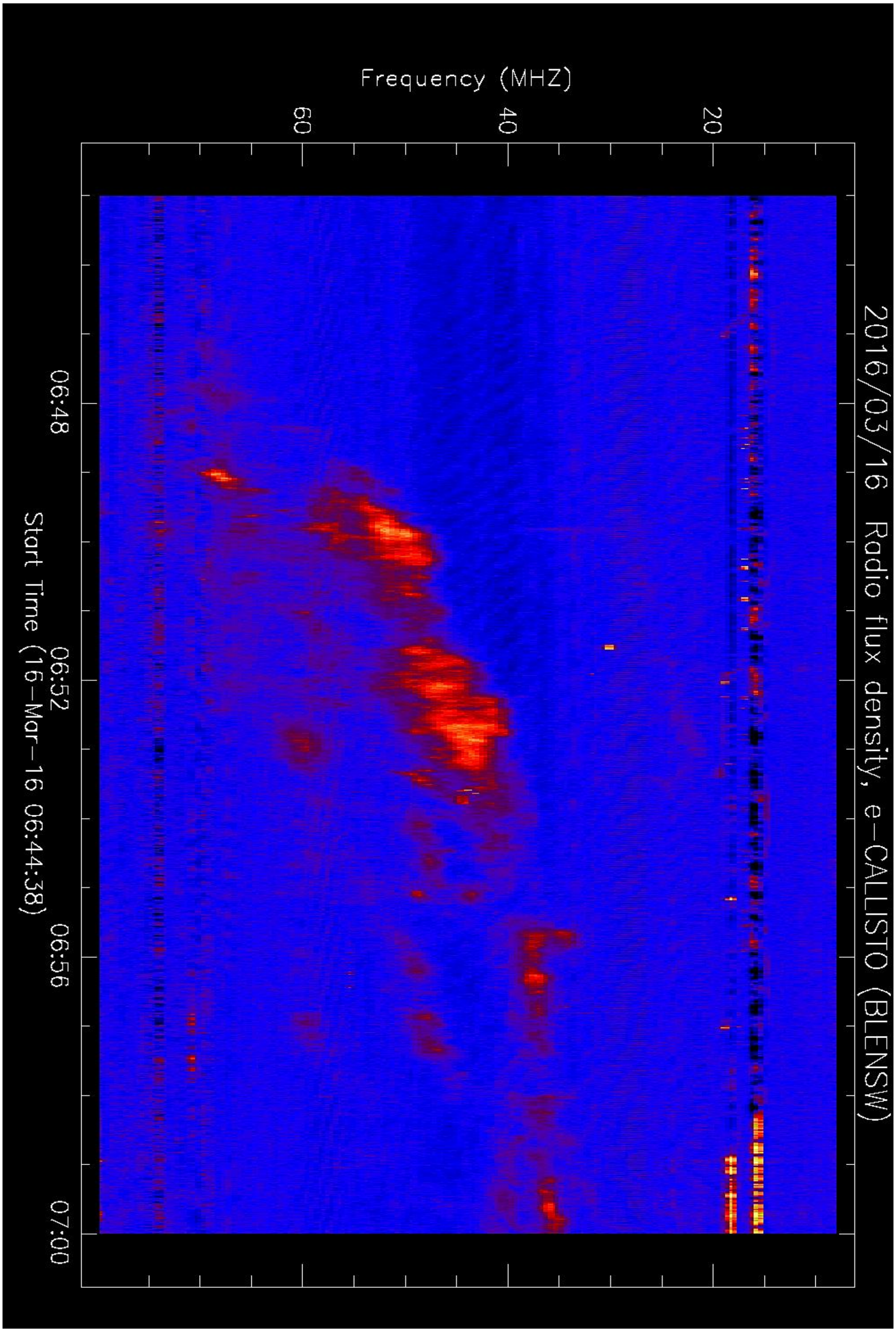

Figure 2. Type II burst occurred 9 minutes after the formation of type III

The formula used to calculate the drift rate:

$$-D = (f_{min} - f_{max})MHz/(t_2 - t_1)s \tag{1}$$

where:

f_{min} = minimum frequency of the burst (MHz)
f_{max} = maximum frequency of the burst (MHz)
t_2-t_1 = duration of the burst (s)

The calculation of drift rate for solar radio burst type III on 6th March 2016:

$$-D = (f_{min} - f_{max})MHz/(t_2 - t_1)s \tag{2}$$

$$-D = (15 - 80)MHz/120s$$

$$D = 0.54MHz/s$$

The calculation of drift rate for solar radio burst type II on the same date occurred five minutes later:

$$-D = (f_{min} - f_{max})MHz/(t_2 - t_1)s \tag{3}$$

$$-D = (30 - 80)MHz/1020s$$

$$D = 0.04902MH/s$$

From the calculation above, we can conclude that the drift rate of type III burst is faster compared to type II burst which is about 81%. Logically, it is acceptable as we can compare the feature of type III and type II burst shown in spectrograph that the type III burst showed an almost straight line shape compared to type II burst which is bent.

The solar X-ray emission is generated by solar corona. It carries the important information about the composition, structure and state of the corona. Not only that,it is also gives the information about the physical processes which occur within it.

The study about the X-ray emission is very important because his type of radiation are partly responsible for the formation of the ionosphere and for disturbances in its lower-lying layers and take part in 'Sun-Earth' problem [19].

During the event on 16th March 2016 it was recorded that the active region AR 12522 contribute to this burst as it erupted the C- type class of flare with magnitude C2.2 begin at 06:34 UT ended at 06:57 UT.

Although it is not the most dangerous type of flare, it is still can affect the Earth as their energetic particle can pass through the Earth's atmosphere. The energetic protons streaming past Earth are slightly elevated as a result of the blast.

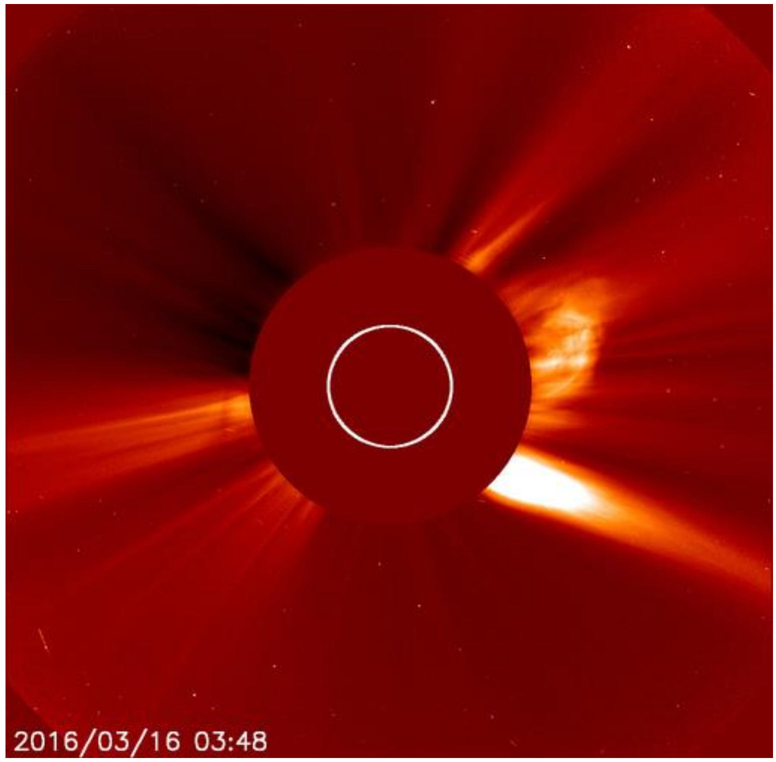

Figure 3. The Coronal Mass Ejections conjunction with complex type III and II.

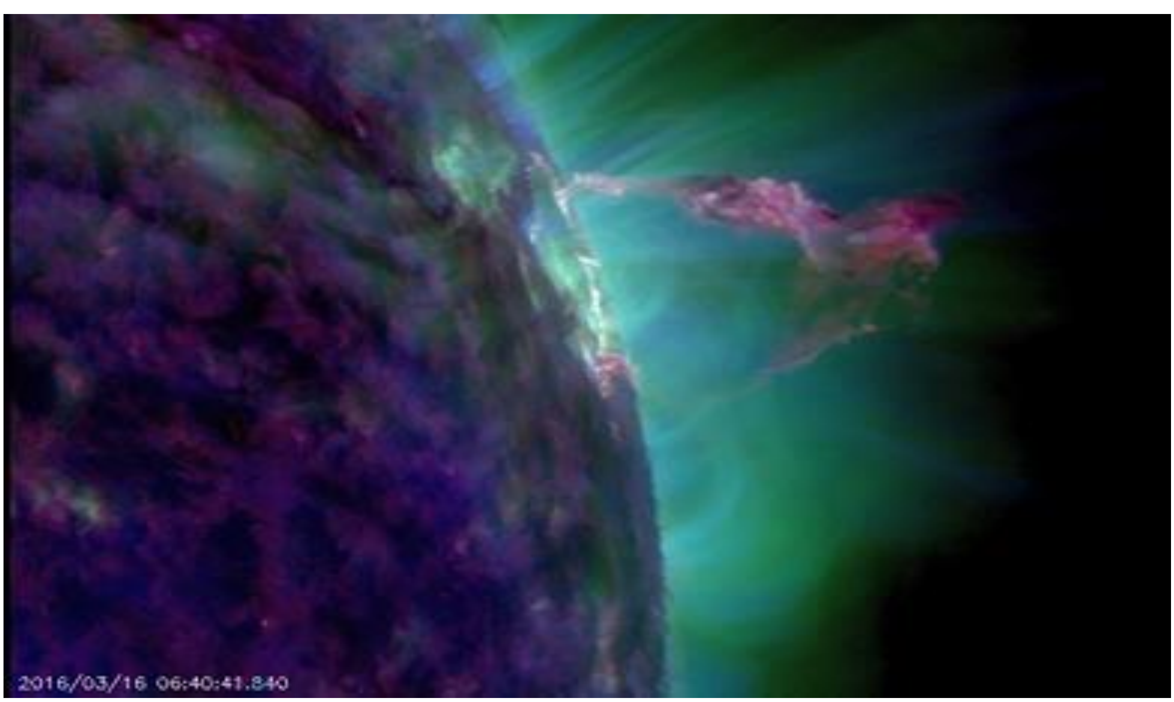

Figure 4. The blast erupted by sunspot AR2522 at 06:40 UT on 16th March 2016 recorded by NASA/SDO.

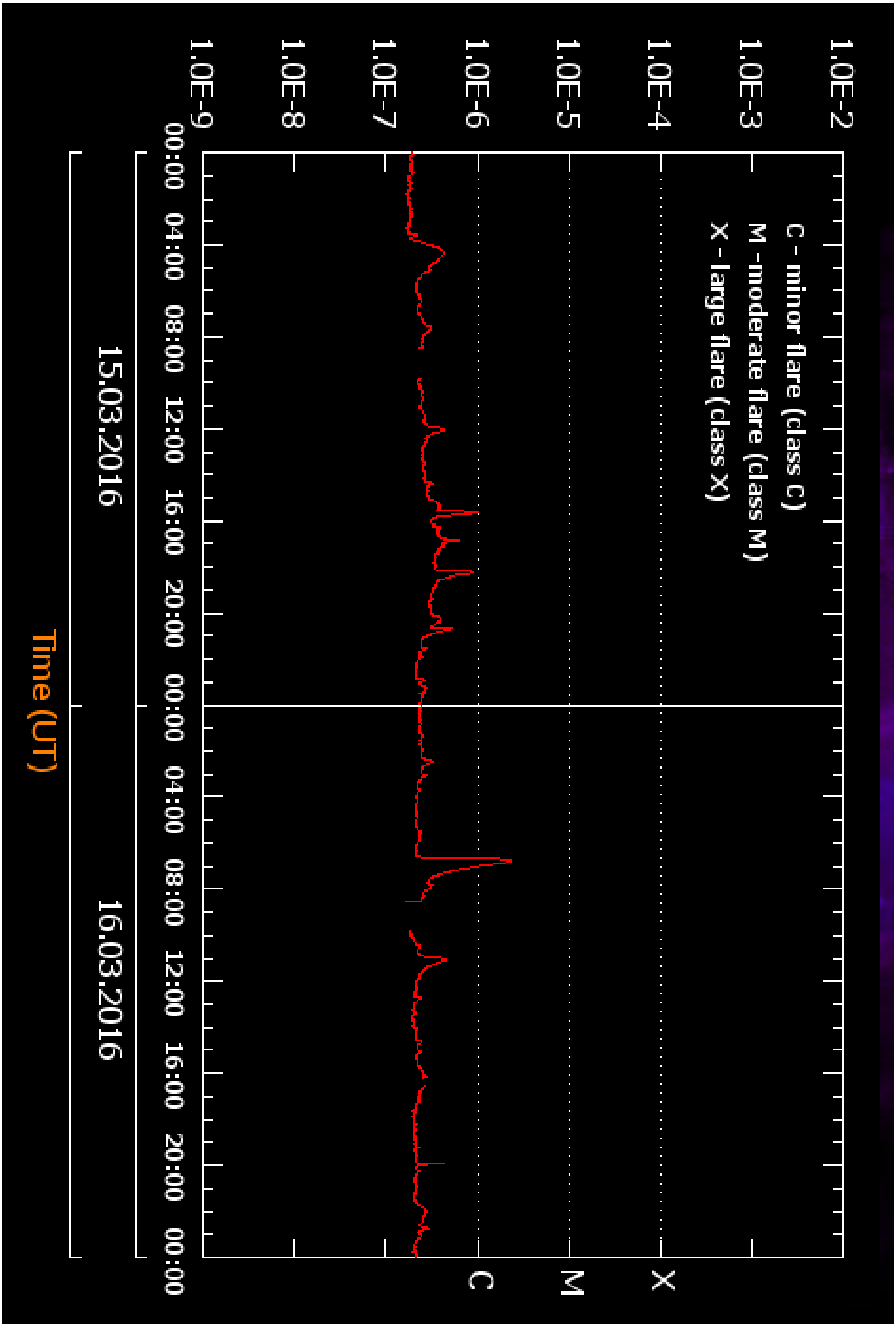

Figure 5. The graph of X-ray emission of the Sun from 15th March 2016 to 16th March 2016 recorded by GOES satellite.

3. CONCLUSIONS

The events on 16th March 2016 showed the related between the type III burst with a type II burst which have time relay five minutes. The CMEs also showed the relation between these two events which reported to occur at 03:48 UT, several hours before the type III burst emerged on the spectrograph. It is also proven that the type III burst has a fast drift rate compared to type II burst. In this case, the type III has a fast drift rate of 81% compared to the type II burst. During this event, the active region AR 12522 erupted the C-class X-ray emission with magnitude of C2.2 contribute to these type III and II burst. Actually the X-ray emission and radio emission can be only detected in the area of the corona which is the outer layer of the Sun.

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