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The Development of the X2-Class of flares with Presence of Type IV burst and Single Type III burst in Low Frequency (20-85 MHz) on 5th May 2015

S. N. U. Sabri[1], Z. S. Hamidi[1,*], N. N. M. Shariff[2], N. H. Zainol[2], Nabilah Ramli Syazwan[2], Marhana Omar Ali[2], Nurulhazwani Husien[2], C. Monstein[3]

[1]School of Physics and Material Sciences, Faculty of Sciences, MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia

[2]Academy of Contemporary Islamic Studies (ACIS), MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia

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

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

ABSTRACT

The plasma-magnetic field interaction in the solar corona is caused exploration of suprathermal electron population have been made to study about the phenomena solar radio burst. This burst only took about approximately 2 minutes to produce X2- class of solar flares which occurred at 22:10 UT till 22:11UT. The wave-wave interaction and wave-particle interaction influenced the characteristic structures of the emission. The CALLISTO spectrometer has been used to detect and record the Type IV and Type III occurred during 22:07UT till 22:11 UT and it only took about 3.30 minutes to occur. The range of frequency of this burst 20-85 MHz and data is from ROSWELL-NM observatory. With the presence of the data, we aim to determine the causes of the Solar Radio Burst Type IV produced Type III burst in several minutes and describe briefly about the formation and dynamics of solar radio burst type IV occurred on active region, AR2335 which also produced beta-gamma magnetic field. This event showed the strong pulsation and a broadband pattern with details about Type IV burst, then Type III burst present in fast drift. AR 2335 is the most active region and produced X2-class of solar flares which has solar wind speed about 361.6km/second and proton density about 4.3 protons/cm^3 in

the solar corona. AR 2335 harbor energy for X2-class from 6-H to 24-H observation on X-Ray solar flares have been recorded. The data showed that it has a strong energy electrons presence during the burst occurred in the active region and this class of solar flares are more powerful which has potential to cause radio blackout and long lasting space weather storms. As the conclusion, the sun activity showed on 5th May 2015 has quasi-periodic pulsation that has continuum and drift in lower frequency. The temperature that corona took to extend from the top of a narrow transition region still be as mysterious properties.

***Keywords*:** Sun; solar burst; III; IV; X-ray region; solar flare; Active Region 2335

1. INTRODUCTION

The nearest and active star with the energy that has been produced by nuclear reactions near its center known as the sun and it transported by photons from the inner region called a radioactive zone. Besides that, it's one of the strongest radio sources and observation side [1]. When photons are unable to transfer energy efficiently, it is called Convective zone, which allows all the unstable heat flow out to solar outer atmosphere known as a photosphere where will emit the solar light and decreased the temperature by radiation process.But,then the temperature will start rise to the wider layer known as the chromosphere about 2,000 km then moves rapidly to the transition region then proceed to interplanetary space where the solar wind produced. Solar corona has been found that has a high degree of ionization of iron and the temperature reached about 1 million Kelvin. From this finding, solar coronal heating problem is one of the issues because the temperature should be lower than chromosphere [2].

The sun also involved in Solar flare and Coronal Mass Ejection (CMEs) event which can be observed through the electromagnetic spectrum, which is gamma ray to radio waves [3]. The development, in the low corona, of large flare/CME events coincides with an extended opening of the magnetic field, accompanied by energetic particle acceleration and injection into interplanetary space and shocks. These are detectable, at metric and longer waves, by their radio signatures. Radio waves have longer wavelength, but lower in frequency. Although it has lower frequency, the signal or radiation waves still can be detected if it was at low-noise environment. Furthermore, plasma oscillation will excite and emit radiation at metric and decametric wavelength [4].

Solar Radio Burst can be classified into 5 types which has a low range of frequency. Type III burst which has fast drift in frequency versus time due the ability to convert ambient coronal density with time from high to low. Sometimes it can reach from hours till a few days and from KHz to GHz [5]. The Type II bursts at metre wavelengths, however, are interpreted either as a flare blast wave. Metric bursts of the Type III family generally consist of groups of individual bursts. The drift rate of higher frequency are faster due smaller the density scale of height and it generated by energy released in flares.With the presences of flares, there are possible strong burst Type III to be observed with the broad frequency range due conversion of Langmuir waves to electromagnetic waves.

The instability of the electron-beam current makes it to be excited while forward and backward reaction of Langmuir wave can cause the second harmonic of Type III burst to occur.Meanwhile, Type IV burst has broadband quasi-continuum features that associated with solar flares. The continuum emission of metric and decametric type IV radio emission is

usually connected with electrostatic loss-cone and Cherenkov instabilities of highly energetic electrons, and their subsequent transformation into electromagnetic (transverse "t") waves. This burst has been interest because the degree association with the energetic particles event is high. Type IV burst usually related to the development of sunspot and high possibility followed by geomagnetic storm [4,6]. Zebra patterns are more complicated structures, with many different mechanisms proposed and The majority of these models are based on electrostatic emission at the double plasma resonance. Hence a widely accepted theory of zebra pattern has not yet emerged. An important point missing in previous theories is that a loss-cone distribution generates whistlers which in turn affect the electron velocity distribution. The continua during periods of activity, represent the radiation of energetic electrons trapped within magnetic structures and plasmoids, and they are known under the names of Type IV bursts and "Flare Continua".

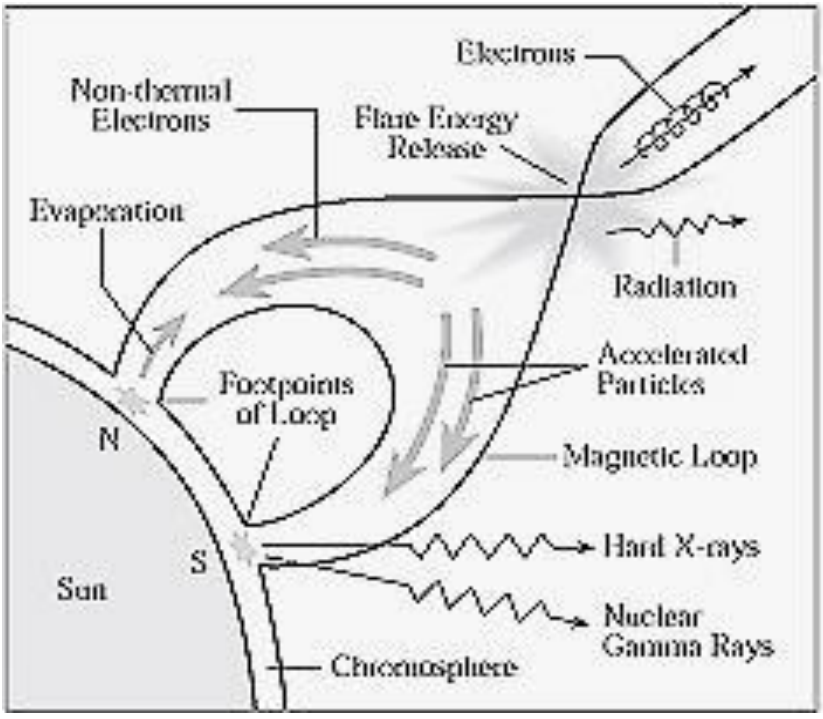

Figure 1. The Schematic diagram of the magnetic reconnection of the burst.

Long-lasting metric continuum radiation, like noise storms and certain species of type IV bursts, are signatures of coronal particle acceleration which often occurs without conspicuous H alpha or microwave signatures in the underlying atmosphere.Whistler wave packets or whistler solve one of the alternative theories that propagated across or along the region where the placed electrons trapped in emitted inertial kinetic Alfve'n waves for Type IV burst.The injection of the large fluxes of medium energetic electrons into a coronal loop also related. The emission trip can achieve up x 10^4 km in source drift over distance with 10^5 kms^{-1} apparent velocities. The direction of the source motion in a given frequency is found to be perpendicular zebra patterns (ZP) and Broadband pulsations(BBP) sources and this type of burst usually presents a few days before solar flare and CMEs. [3,7]. It is generally believed

that type IV radio burst fine structures are caused by particle injections into a magnetic trap and formation of a loss-cone distribution, giving rise to different plasma instabilities.

2. SOLAR BURST OBSERVATION

During a major space event, there are possibility to detect the variety of solar radio burst from ROSWELL-NM site which used to monitor the solar burst [8,9]. In this event, a Log-Periodic Dipole Antenna (LPDA) has been constructed with broadband, multi-element, unidirectional and narrow-beam antenna. Besides that, it also has impedance and radiation characteristics that repeat regularly which can be a logarithmic function of the excitation frequency [10]. The LPDA was set up to have a frequency range from 45-870MHz which connected with CALLISTO spectrometer. A CALLISTO is Compound Astronomical Low Cost Low Frequency Instrument for Spectroscopy and Transportable Observatory, which used to monitor metric radio burst with low-cost radio spectrometer [3,11]. We usually detect solar burst in the range of 240 MHz till 360 MHz for data, but in this event it lies below than 100 MHz. It still can be detected, but is usually associated with Type II [12-14]. Most of the CALLISTO is focuses on the frequency range from 45 MHz till 900 MHz and seems to be the best range if associates with minimum Radio Frequency Interference (RFI) [15-19].

3. RESULTS AND ANALYSIS.

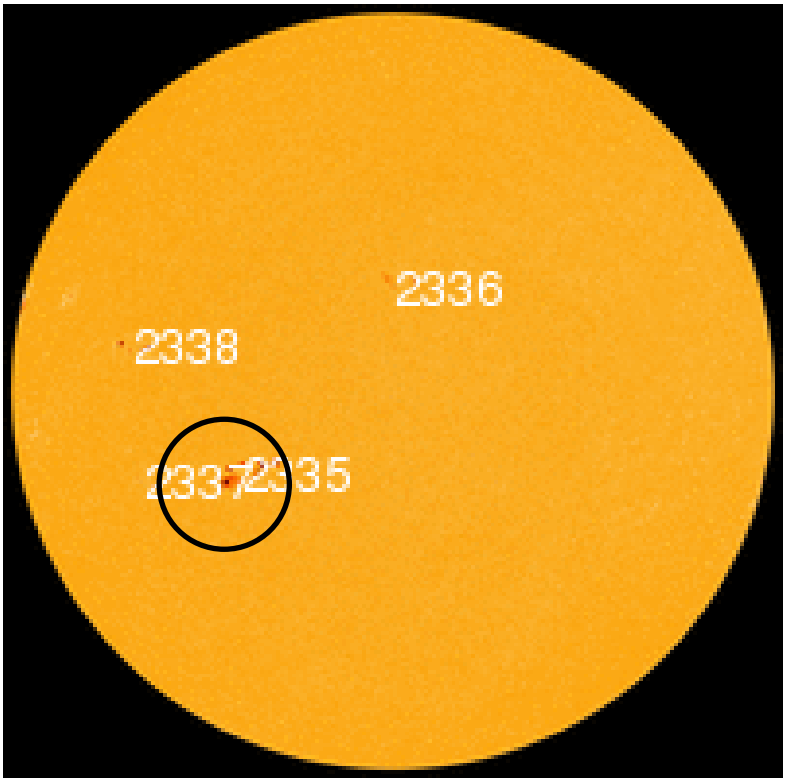

Figure 2. The location of the active region (AR2335)
Credited to: Solar Dynamic Observatory (SDO)

In this section, we will focus on the active region structure that located at the sun's corona. There are four of active regions in this event which are AR 2336, AR2337, AR2338 but the most active region was AR2335. In Sect. 3, we will describe the event, with emphasis on the features never seen before. An overview of the entire event is given in Figure. 2.

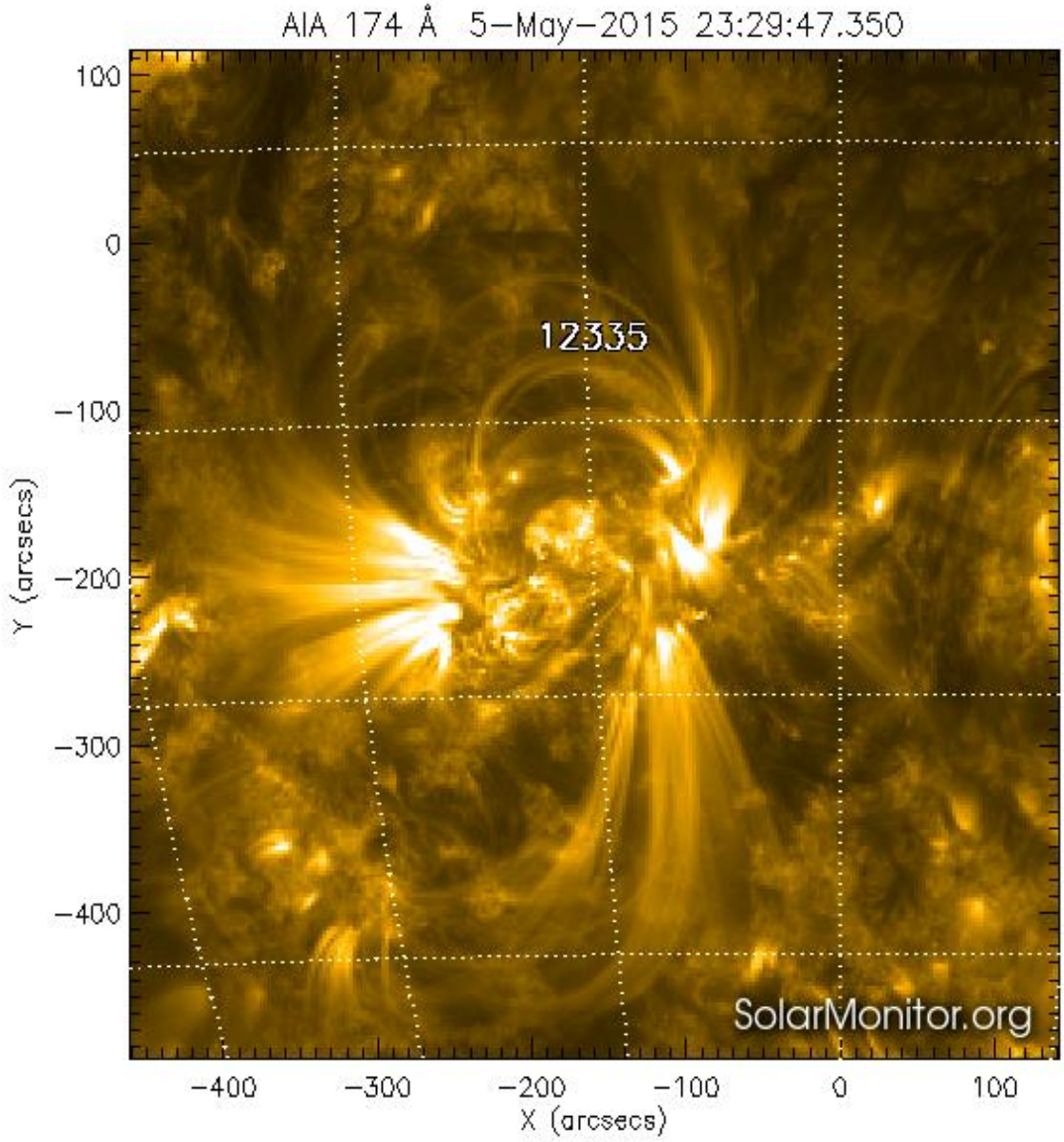

Figure 3. The coronal loops can be seen from AR2335 using SDO short wave (Credited to: Solar monitor.org website)

According to the CALLISTO network, this event is related to evolution of Type IV burst, then followed by Type III and it can be seen from solar Radio Flux Density data. This event was occurring started from 22:07UT (06:07 am) till a few minutes. The explosion ionized the upper layers of Earth's atmosphere produced extreme ultraviolet radiation and

caused HF radio effects on the day side on Earth. When the frequency below 100 MHz, there will be notice from ham radio operators and mariners about blackout signal, thus will affect our satellite system and communication satellites.

Figure 4 shows that it is Moving Type IV burst which has fast frequency drift and has smooth continued with 20- 85 MHz range in frequency with the presence of solar flares (Type III burst) which eruptive prominence and magneto-hydronamic shock waves has a high possibility to be happening. It shows the dynamic spectrum recorded by CALLISTO system, and plotted on a contracted time scale over the full 20–100 MHz frequency range of the instrument.

There are difference in the emission because of changes in electron density and spectral expansion.Furthermore, the magnetic reconnection and disruption of the loop during solar flares can be the main factor for the formation. Trapping electron in the emission influenced by electron density and it depends on the broadband of frequency (45-870 MHz). The Type III burst showed a fast - drift and it was generated by the energy released in flares due the electron beams propagate out to regions of low density and it showed a single burst of Type III because it was less than 3 seconds of duration.

Table 1. The condition of the sun during 5th May 2015.

Parameter	Value
Solar Wind Speed	361.6 km/ second
Density	4.3 protons /cm^3
Sunspot Number	85
10.7 cm flux	125sfu
6-hour max	22:11UT (X2-class Solar Flares)
24-hour	22:11UT (X2-class of Solar Flares)

Table 1 shows the condition of the Sun during that day. Within 24 hours, there are a few peaks of solar flares can detect on 5th May 2015.GOES 15-0.5-4.0 A showed 5 classes of solar flares fluctuated formed during this period. At the same period, there are also the presence of GOES 15 1.0-8.0A that showed the significant peak at C-class peak at the beginning and increased vigorously to the M–class then the final peak was at X2-class. Table 1 showed the detail information about active region that have been observed and recorded on 5th May 2015. There are four active regions and be considered as active. Some of the active region also constantly exploded a huge particle and has potential to eject the solar flares. Alternative interpretations include limit cycles of nonlinear wave–particle interactions in coronal loops or quasiperiodic particle acceleration episodes during the magnetic reconnection in a large-scale current sheet.

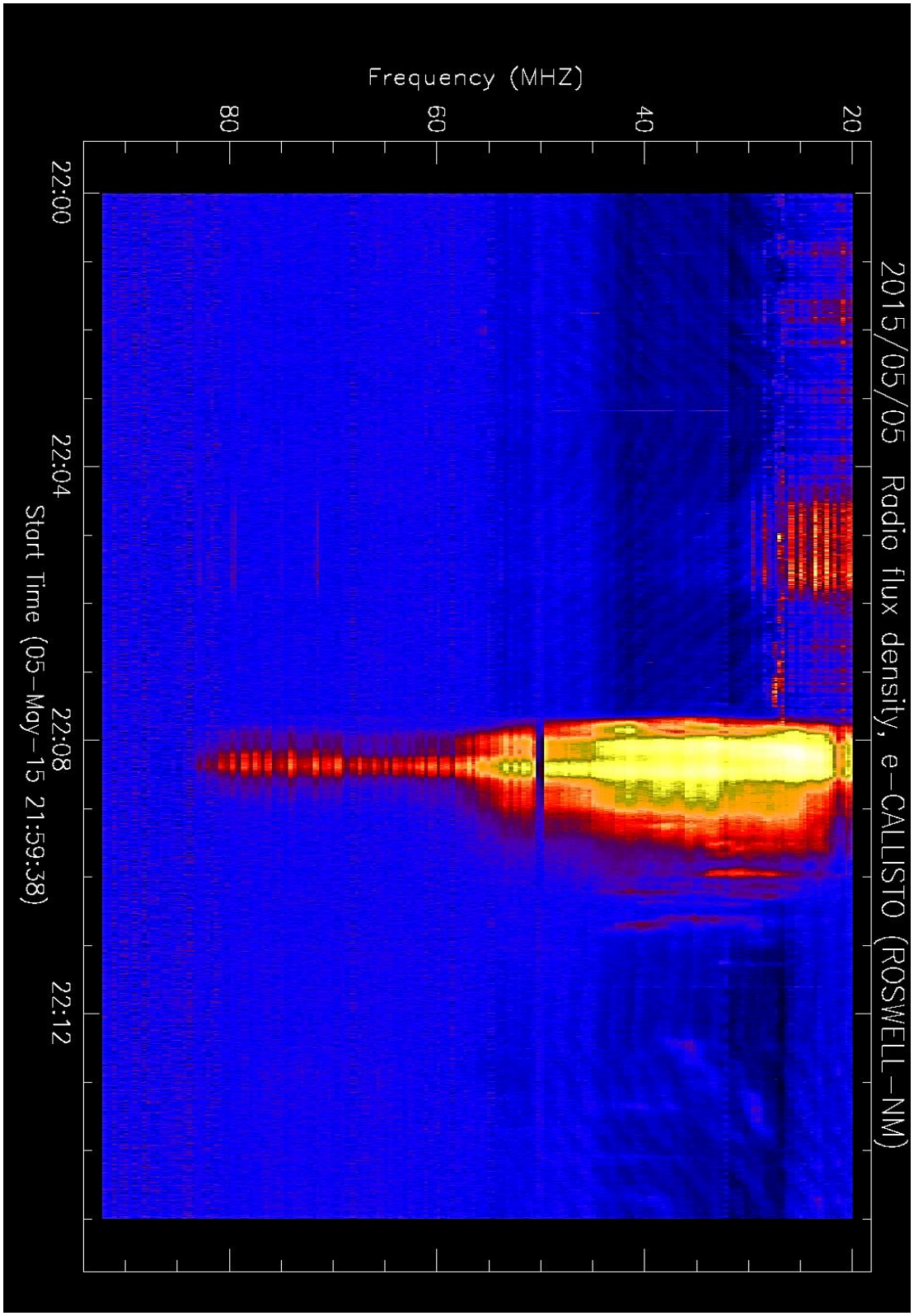

Figure 4. Solar Radio Burst Type IV and III from 22:07 UT till 22:11UT from ROSWELL-NM Observatory (Credited to : e-CALLSTO software)

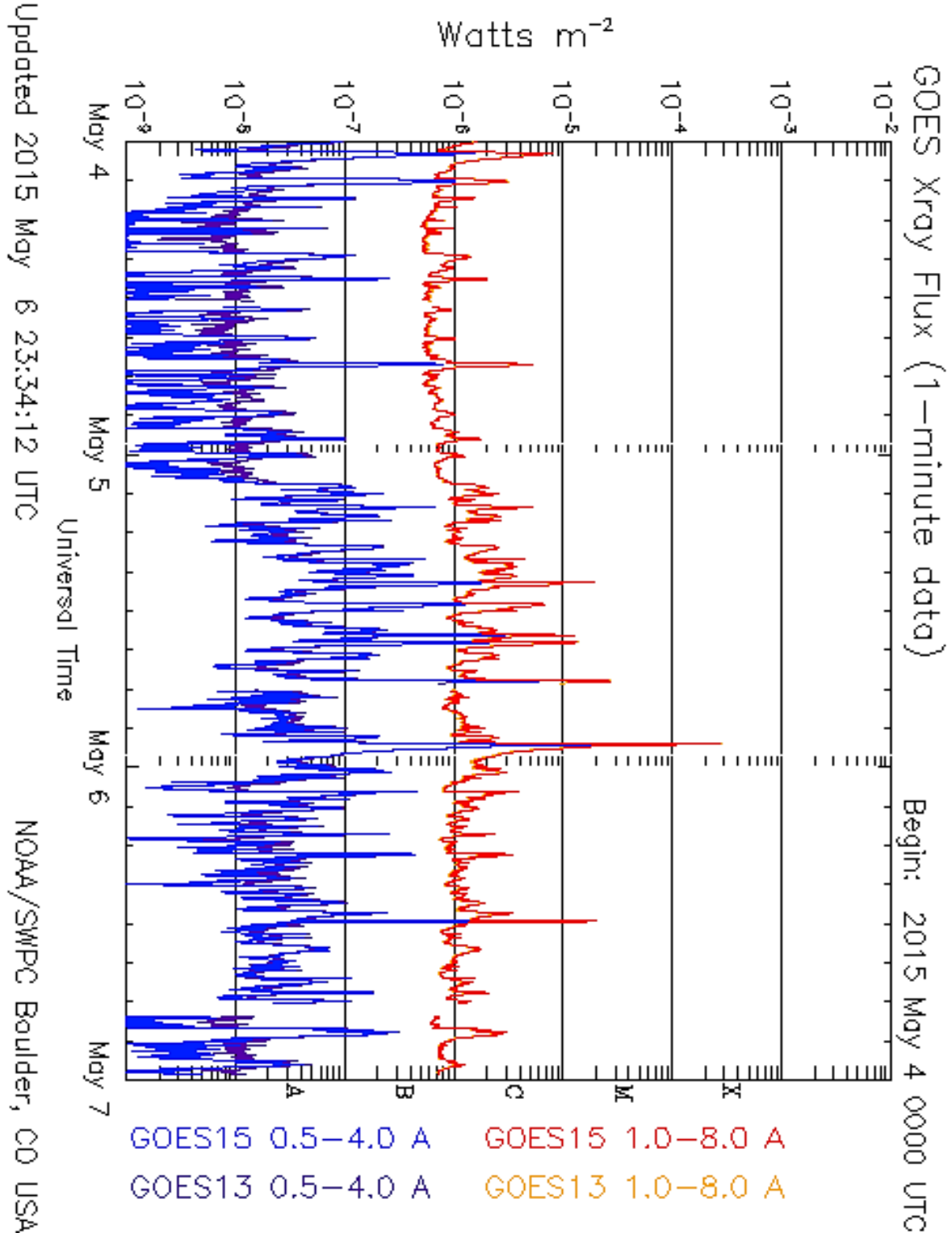

Figure 5. GOES X-ray Flux profile showed X-2 flares on 5th May 2015.
(Credit to: NOAA website)

The source of the solar storm energy comes from the solar magnetic field that produced from convection zone and from the results, it showed that it has broadband and non-drifting nature caused by the electron trap in closed magnetic field and a single burst of Type III occurred approximately in 3 minutes. The burst has low frequency and has been recorded and observed using Space Weather which will affect the sun's atmosphere basically. As plasma emission depends on electron density, which in turn may be converted to coronal height using density models, we may calculate estimates for the radio source heights and speeds from the dynamic spectra. This analysis will be done in the next project.

4. CONCLUDING REMARKS

Active Region AR2335 have unstable "beta-gamma" magnetic fields give out energy a continuous and fast drifting toward lower frequencies. It has solar wind speed about 361.6 km/second and proton density 4.3 protons/cm^3. There are 50 percent chance of M-class flares and only 5 percent for X-class flares for 24-H till 48-H. This showed that the burst happened when all of the observatories shut down their system except data recorded from ROSWELL-NM Observatory during at that time.

The corona extends the temperature from top of transition region to Earth and the temperature reached millions of degrees which still be a mysterious issue until now. Radio and X-Rays are dominant on the analysis of observation, but cannot confirm directly that there is only the possibility, we also need to consider the other aspect such as detailed injection, energy loss and the process of acceleration of the particles.

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