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# Geo-effective Disturbances from the "Beta-Gamma-Delta" Magnetic Fields on Active Region AR 2403

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**ABSTRACT**

This moving solar radio burst type IV, which lies in between 980 – 1260 MHZ was observed using Compound Astronomical Low-Cost Low- Frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO) spectrometer and will discussed in detail. CALLISTO system was used and the data were recorded. From BLEN5M's Radio Flux Density data, it shown that a brief description of the formation of a dynamic formation of solar radio burst type IV due to an active region, AR 2403. This event proved that solar radio burst type IV has a broadband continuum features and has strong pulsations in some range of time. In this event it was took about 8 minutes and it can be high in possibility solar flare and CMEs event followed due to this event. AR 2403 remained active and produced an X- class solar flares and it showed "Beta- Gamma-Delta" magnetic field that gives solar flares which can make geo-effective disturbance to our earth satellite and we have to investigate how plasma – magnetic field in the solar corona which can produce suprathermal electron pulsation about 8 minutes. In this event, it has solar wind speed in 364.8 km/sec and solar wind density in 11.0 protons/cm$^3$.

***Keywords*****:** Sun; Solar Radio Burst Type IV; X-ray region; Solar flare; active region AR 2403

## 1. INTRODUCTION

Radio observation usually can be seen in low region and it serves with Sun activities such as the Coronal Mass Ejections (CMEs), evolution of sunspots, solar flare and unpredicted phenomena [1]. These observations are particularly useful for temperature measurements as a function of optical depth because higher frequencies arise from lower layers of the solar atmosphere. Radio waves of a certain frequency can only be observed from regions where the local electron plasma frequency νp is equal to or lower than the radio frequency ν.

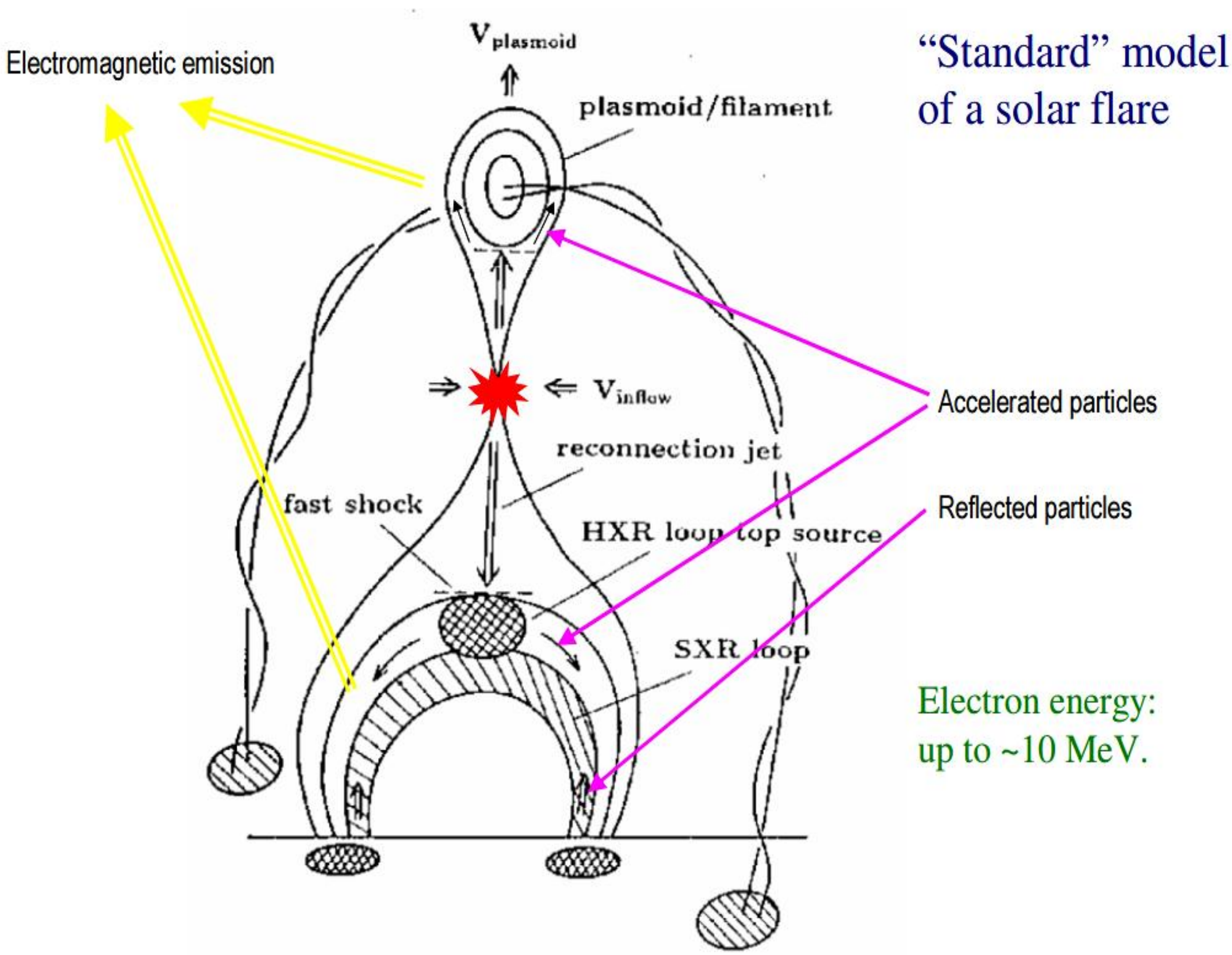


**Figure 1.** "Standard" model of a solar flare.

The mechanism of energy release, plasma heating, the particle acceleration and how magnetized plasmas work plays an important role in solar radio emission [2,3]. It has a low frequency in rage because an originate in the same layers of the solar atmosphere where the energy is released in solar flares where energetic particles accelerated and the place Coronal Mass Ejections (CMEs) are launched [4,5] it showed this event in a fine structure and has dynamical process when the burst of flares [6].

It is important to study this region because it allow us to study the parameters of magnetic field and plasma in the solar corona, where observations at other wavelengths usually fail due to low plasma density.

There are three (3) components of solar radio emission (1). Emission of the quiet Sun which co nsists a free-free emission of thermal electrons (T ~ $10^6$ K). Studying the quiet Sun has advantages over trying to grasp the complex phenomena in active regions because one deals with less complex magnetic field topologies and a supposedly simpler structure of the stratified atmosphere.

Since the quiet Sun contains a large number of sources that vary on time scales of minutes, many baselines and therefore many antennas are needed. The slowly-varying component is produced due to cyclotron radiation of thermal electrons in strong magnetic fields of the active regions; and idemonstrates a very good correlation with the sunspot number. The last component of solar radio eission is a sporadic radio emission which is associated with flares and produced by nonthermal electrons. The standard model of solar flare can be represented in Figure 1 as below.

The type IV burst usually in broadband quasi- continuum features and associated with the decay phase of solar flares due electrons trapped in closed field lines in the post- flare arcades produced by flares [5]. Type IV burst can be divided into two structure, fine structure and zebra structure.

Besides that, the type IV event has high associated with long-duration flares where the most energetic particle event sources present in the solar wind. The given frequency is depending on the direction of the sources which usually are perpendicular between broadband radio pulsations (BBP) and zebra patterns (ZP) sources [2,7]. In some cases of BBP, frequency drift (~250 $MHzs^{-1}$) can be achieved [8].

## 2. EXPERIMENTAL SETUP AND METHODOLOGY

In this data, CALLISTO system has been used which connected to BLEN5M (Switzerland) and one of the low cost radio spectrometer that used to monitor metric radio burst [9, 10]. In Malaysia, a crossed log-periodic antenna is used to collect the radio emission coming from the outer part of the solar atmosphere, i.e. solar corona, in the frequency range from 45 MHz to 870 MHz [11,12]. The antenna is connected to a CALLISTO receiver which has a frequency bandwidth of 12.5 MHz For this event, we select the range of frequency from 980-1260 MHz. T

This range is in the BLEN5M observatory site, but most CALLISTO sites are focused the frequency range from 45 MHz to 900 MHz region seems the best range with a very minimum of Radio Frequency Interference (RFI) [13]. But it still can be function in 980- 1260 MHz. The next section we will discuss more on solar flares in an X-ray and radio region to evaluate the distribution of high and low energy.

The receiver provides a dynamic spectrum which represents the variation of the solar radio emission versus time and frequency. These emissions are associated with solar radio bursts generated by electron beams propagating along open magnetic field lines. Magnetic fields are considered to be the most likely channels for transporting the energy from the photosphere through the chromosphere and the transition region into the corona. The system at the BLEIN site is illustrated in Figure 2.

**Figure 2.** A 7 meter dish with a CALLISTO system at BLEIN site.

## 3. RESULTS AND ANALYSIS

The CALLISTO data investigates in particular the fine structures, like drift-pairs, observed during solar radio flares and Coronal Mass Ejections (CMEs). The space-based observations are combined with NOAA experiment observations on board of the SOHO satellite. We will discuss more about the event that occurred on 26th August 2015 with its unique features.

Based on the observation, there are two active regions during this period. These active regions have high possibility to create a large formation of solar flare. At high frequency, it has noise persisted on the event between 980-1260 MHz. The emission maps out of location and the loop motion through out of the solar corona.

Radio emission of solar flares is produced by the high-energy electrons that are the key factor in development of the flares. Therefore, radio observations allow us to study the parameters of these electrons.

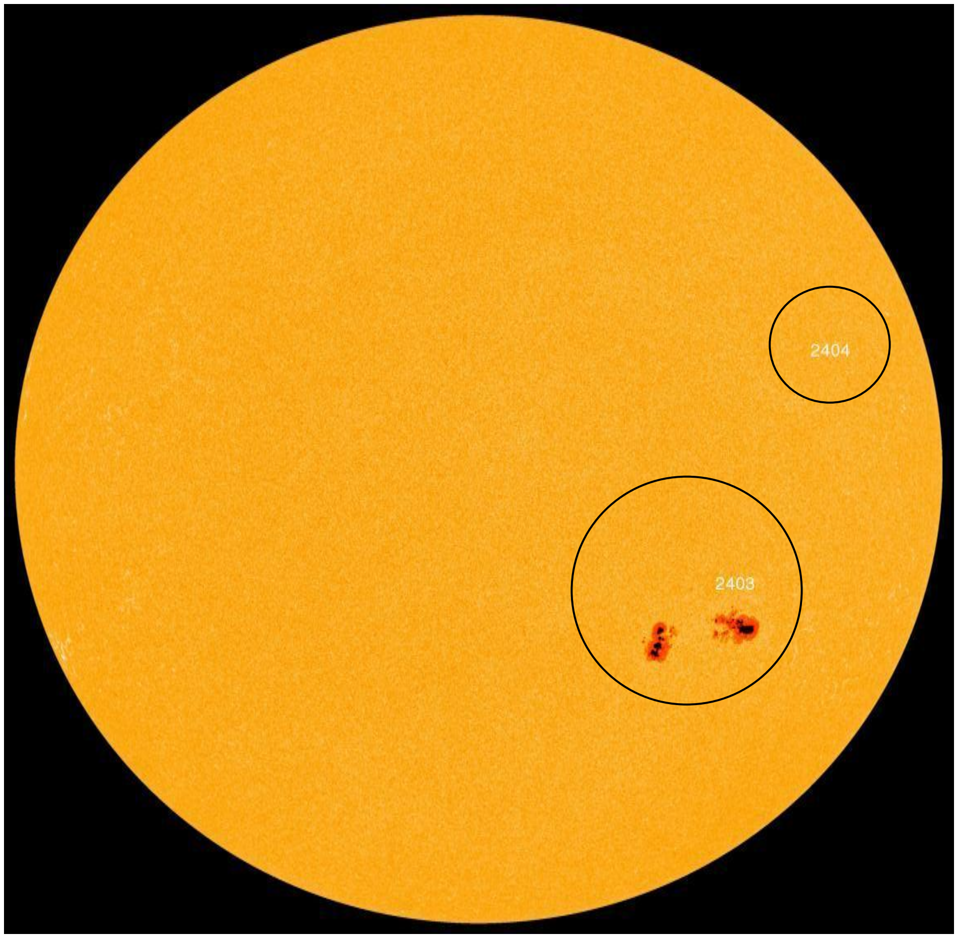


**Figure 3.** The Active Region, AR 2403 and Active region , AR2404 in 26th August 2015 from CALLISTO software.

Spectra of moving the burst Type IV have been detected at BLEN5M observatory and the data in Figure 4. From this observation, it can conclude that, the strong burst was started at 07:15 UT and it can be considered as a broadband continuum of burst due to difference in in electron density and spectral expansion, it produced differences in emission. It is limiting average procedure which only can be saved in data based form and due to non-axis symmetric harmonics, it quit difficult to be interpreted. However, the emission mechanisms are rather complicated and the spatial resolution is usually low because a big challenge for us to analyze in detailed. The lack of significant spectral lines is no surprise because the emission of plasma waves by atoms is more effective than the emission of ordinary photons in a turbulent plasma. From the results, it is also that the emission is produced by trapped electrons in closed magnetic configurations.

Furthermore, it can be classified as moving burst due to the short period of the time variability in the emission and because having the range of frequency 980-1270 MHz, it would be associates with post-flare loop due to low spatial resolution typical of the long waves. It is expected to have large solar flares in the next few days. The plasma radiation mechanism dominates an unstable electron beam which will potentially produced a plasma waves radio emission.

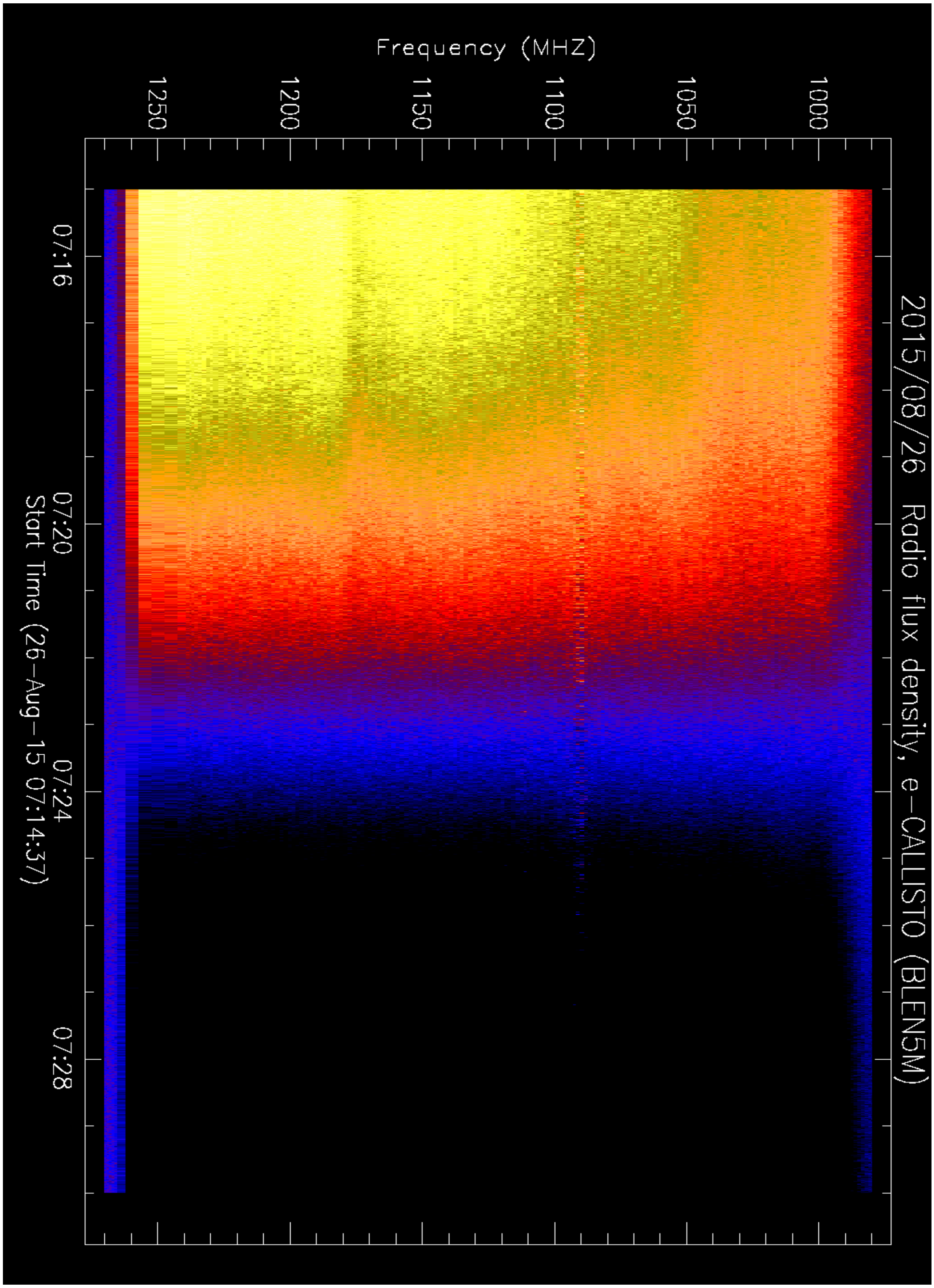


**Figure 4 .** The light curve associated with a C1 type of solar flare on 26 August 2015 at BLEN5M (Switzerland) observatory.

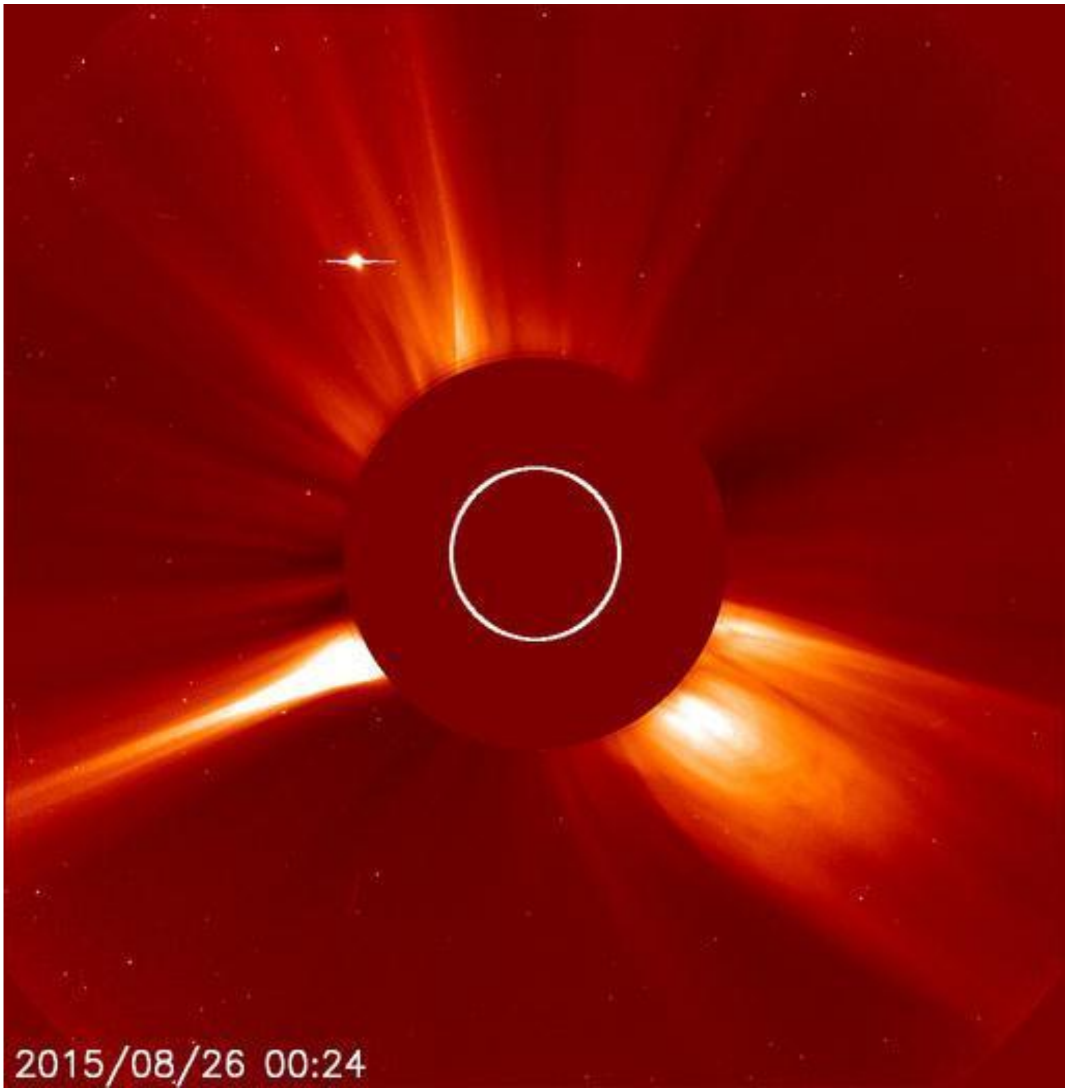


**Figure 5.** The Active Region 2403 possess a threat for the C- class of solar flares at 00:24 UT. Credit to : LASCO 2 Coronagraph.

During the observation, we can see that there are possibility to create a plasma eruption and a large solar flare. This event are classified as Solar radio Burst Type IV which has duration 8 minutes and in 980-1260 MHz range in frequency. This type of event has C2 class of flares and has 60% possibility to become M-Class and only 10 % to become X- flares within 24 hours and 24-48 hours, the possibility to form M-class solar flare 55% compare turn to X- class only 10%. This is moving burst and electromagnetic radiation took about 8 minutes to reach our earth and it can be seen it was the highest point on that day.

From data that we received, it can be analyzed that the possible reason for this formation is because of magnetic reconnection and disruption of the loops during solar flares. When there are disturbance, the burst are located at the same layer as solar corona is and it was affected due to electrons were trapped in the emission and they are changed in electron density due to high in the broadband frequency range.

It also act as an indicator of corpuscular emission from the sun because has low energy of protons and has distinct and attenuation components. This event has large variations in intensity and high degree of polarization which usually occurred at meter wavelength.

The speed of the solar wind exceeds 364.8 km/sec with 11.0 g/cm$^3$ density of proton in solar corona. The most stable density of proton usually lies on 1.0-2.0 g/cm$^3$. It can be concluding that during this event, this event produced high density of proton and it can be the factor the C-class of solar flares tends to occur and increased in intensity of. It has two active regions, AR 2403 and AR 2404 in M-class solar flares. It has continued in C2 class in 6 hours started at 17:06 UT and changed within 24 hour periods at C9 class at 13:53 UT. Figure 4 will show the variability in X-ray flux from 24 August 2015 till 27$^{th}$ August 2015.

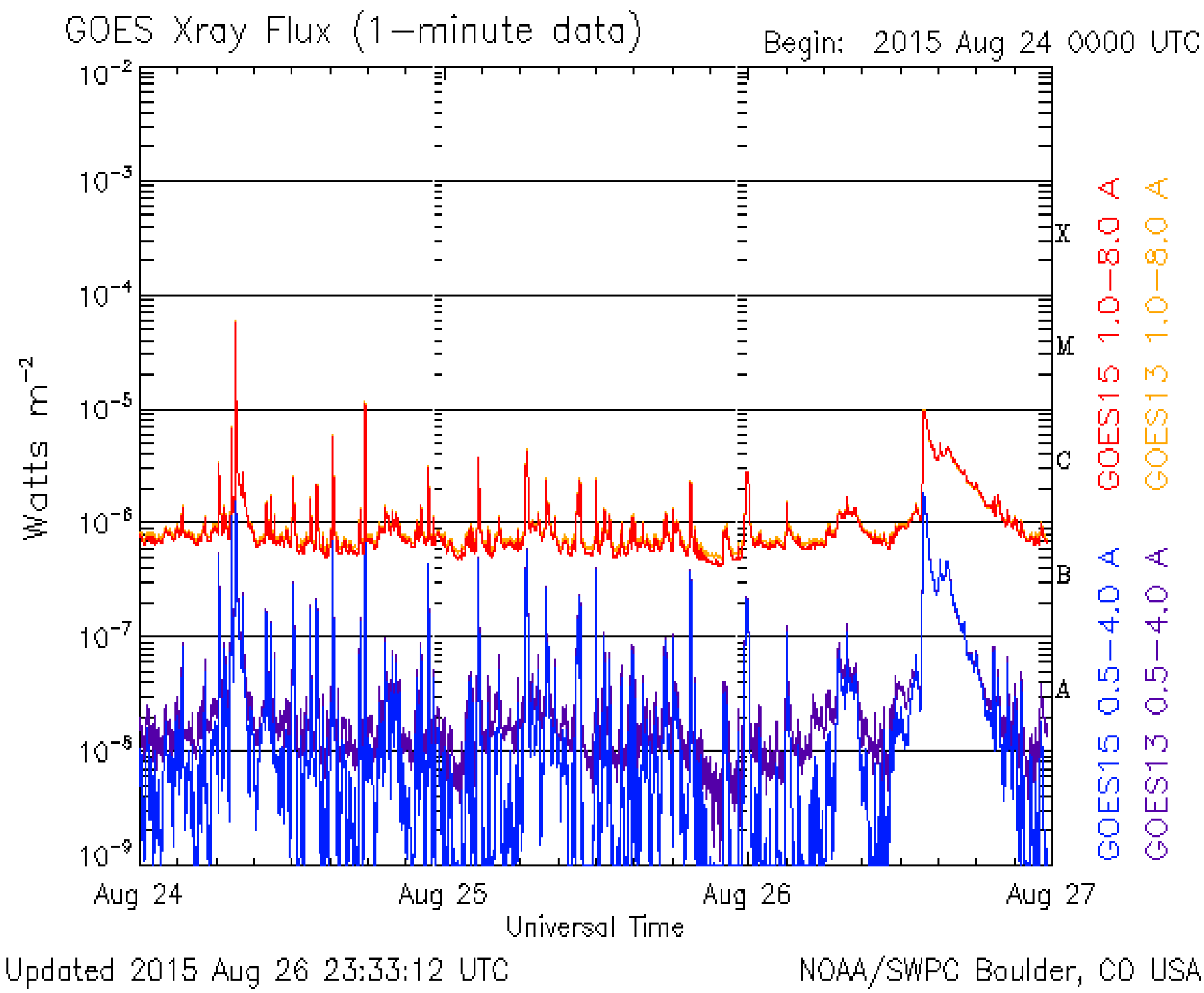


**Figure 6.** The variability of X-ray flux from 24 – 27 August 2015.
(Credit to NOAA Space Environment Centre).

This event allows us to investigate the plasma-magnetic fields interaction in the solar corona which basically can produce suprathermal electron populations over the period from tens of minutes up to several hours and the characteristic of the fine structure depends on wave-wave interaction and wave- particle interaction. The burst was occurred at high frequency compared to previous events and much longer than the previous duration of time. The solar wind and density were influenced by plasma frequency. The higher the plasma frequency, the higher the solar wind while the density of protons will influence the speed of solar wind. The higher the density of proton, the slower the speed of solar wind.

**Table 1.** The details about Active Region (AR2403) on 26th August 2015.

| Parameter | Value |
|---|---|
| Solar Wind (Density)(proton/cm) | 11.0 (proton/cm) |
| Solar Wind (Speed) ( km/sec) | 364.8 (km/sec) |
| Active Region (AR) | 2403 |
| Class Magnetic Fields | Beta-Gamma-Delta |
| Sunspot Number | 61 |
| The Radio Sun (10.7 cm Flux) | 121 sfu |

## 4. CONCLUDING REMARKS

Active region, AR 2403 have unstable “Beta- Gamma-Delta” magnetic fields as it has increased the size of sunspot and it can be classified due to its sizes that gives out energy to produce C-class of solar flares and has possibility to give X-class of solar flares. Besides that, this will implies acceleration possibly at the top of the loops. It has highest interest in space weather study because have high degree association with solar energetic particles. The electrons that trapped in closed magnetic fields was gave broadband and non-drifting nature of Type IV emission. The solar radio burst that can be presents burst characteristics in high frequency sometimes with presence of solar flares or Coronal Mass ejection (CMEs) have been proved. This event showed fine structure of Solar Burst Type IV. As it was in “Beta-Gamma-Delta” magnetic fields, it is believed it also gave some effect to the size of sunspot which caused the changes in solar flares classes and magnetic field thus tend to formed huge geo-effective disturbance to our earth and our satellite system especially.

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**Biography**

Siti Nur Umairah Sabri is an undergraduate Physics student at The School of Physics and Material Sciences, Faculty of Sciences, MARA University of Technology, 40450, Shah Alam , Selangor, Malaysia.

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Dr Nur Nafhatun Md Shariff is a senior lecturer in Academy of Contemporary Islamic Studies (ACIS), MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia. Her current research is more on sustainability; environmental aspect. She is looking forward for cross-field research, i.e. solar astrophysics, light pollution measurement (mapping) and religious studies.

C.Monstein is a senior Engineer at Institute of Astronomy, Wolfgang- Pauli-Strasse 27, Building HIT, Floor J, CH-8093 Zurich, Switzerland and one of the researcher who initiated the CALLISTO system around the world.

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