

# Characterization of Selected Solar Radio Bursts Based on Solar Activity Detected by e- CALLISTO (Malaysia)

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## ABSTRACT

One of the main reasons to study more about the dynamics of solar radio bursts is because solar these bursts can interfere with the Global Positioning System (GPS) and communications systems. More importantly, these bursts are a key to understand the space weather condition. Recent work on the interpretation of the low frequency region of a main solar burst is discussed. Continuum radio bursts are often related to the solar activities such as an indication of the formation of sunspot, impulsive phase of solar flares and Coronal Mass Ejections (CMEs) and their frequencies correspond to the densities supposed to exist in the primary energy release volume. Specifically, solar burst in low frequency play an important role in interpretation of Sun activities. In this work, we have selected few solar bursts that successfully detected by our station at the National Space Centre, Banting Selangor. Our objective is to correlate the solar burst with Sun activities by looking at the main sources that responsibility with the trigger of solar burst. It is found that type II burst is dominant with Coronal Mass Ejections (CMEs), type III burst associated with solar flare, IV burst with the formation of active region and type U burst high solar flare. We believed that this work is a good start to monitor Sun's activities in Malaysia as equatorial country.

**Keywords:** Sun; low frequency; solar radio; burst, type II; III;IV;V;U; e-CALLISTO

## 1. INTRODUCTION

The Sun is an active star that produces large-scale energetic events, such as solar flares and Coronal Mass Ejections (CMEs) which are observable across the electromagnetic spectrum, from gamma rays at hundreds of MeV to radio waves with wavelengths of tens of meters [1]. Solar radio bursts potentially describe possibilities of important phenomena in solar physics. The solar flare and Corona Mass Ejections (CMEs) are usually accompanied by

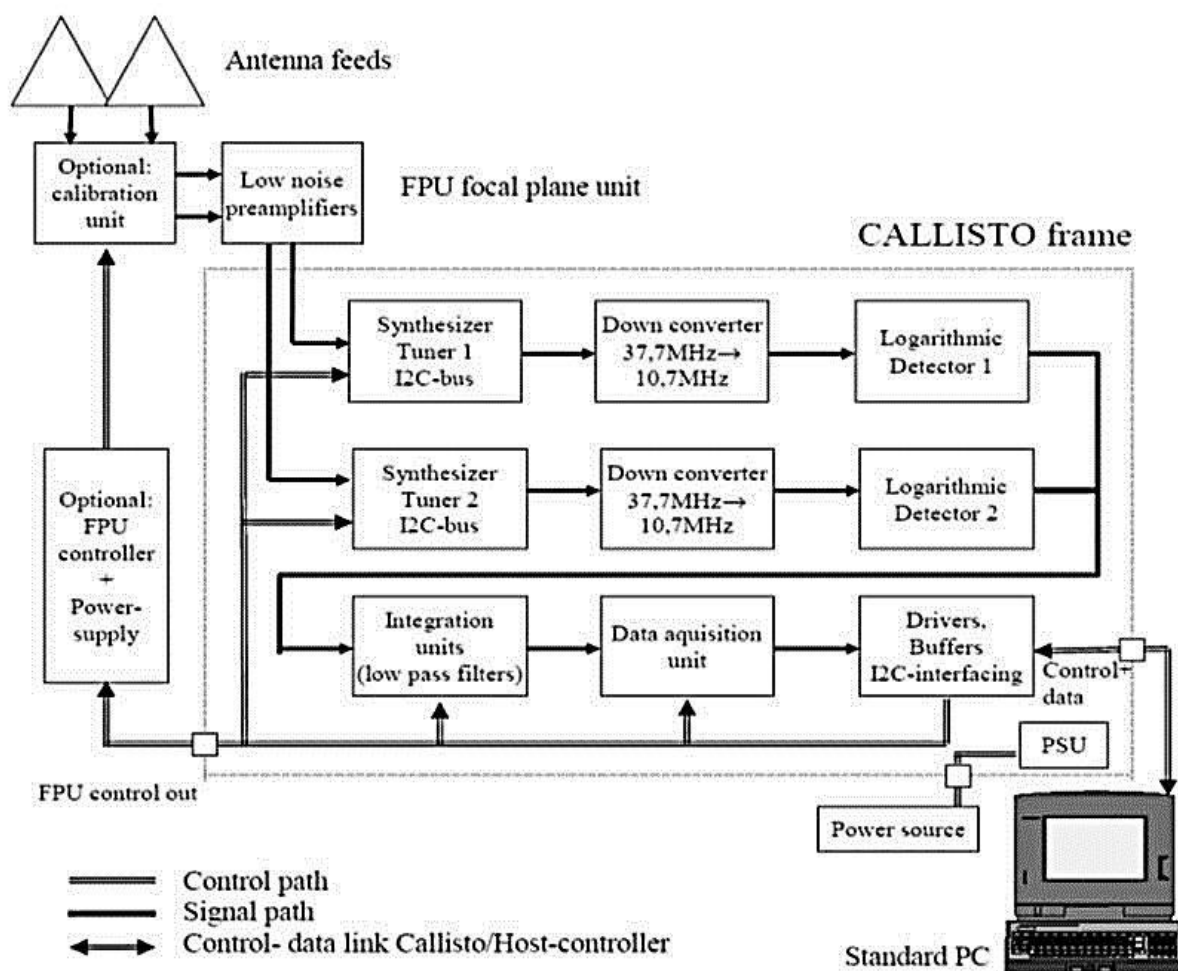
solar radio bursts and the signals are usually can be characterized by background levels of radiation upon which are superimposed bursts. Variation of radio signal fading events caused by ionospheric absorption should be studied for clearer picture because maximum flares can produce streams of highly energetic particles a solar proton event which can impact the Earth's magnetosphere especially in the performance of radio-communication systems and strongly influences the local space weather in the vicinity of the Earth. Solar flare and Coronal Mass Ejections (CMEs) monitoring in radio region is very important in order to identify the active flares sources based on their nature and emission mechanisms and to relate their properties with plasma parameters in flaring regions [2]. It is an ideal indicator on investigating acceleration processes which are responsible for higher excited velocities. Besides, it also can be used as natural plasma probes traversing the corona and the interplanetary space, thus providing various space plasma parameters due to the various wave-particle and wave-wave interactions.

The dominant radio emission mechanism during impulsive flares depends on the wavelength observed and local conditions in the flaring source [3]. Coronal Mass Ejections (CMEs) are the most important manifestation of solar activity that drives the space weather near Earth [4,5]. In the meter wavelength range, 5 types of radio emissions are distinguished (review by [6] and at decimeter wavelengths there is a similar number [7] and [8]. It is well known that the radiations are caused coherently by electron beamed, shocks, possibly trapped electrons, and high-frequency waves in the plasma [9]. In this section, some main characteristics of each type will be explained. Type I solar burst is normally associated with storm burst in a very short period (1 to 20 s) and potentially lasting from hours to days. This burst is considered as short-duration narrow band burst features that are associated with active regions [10]. Meanwhile, type II burst accompanying flares and lasting some minutes in which features drift gradually towards lower frequencies associated with CMEs. It is thought to be excited by magnetohydrodynamic (MHD) shockwaves associated with CMEs [11]. Only the CME driven shocks are expected to propagate into interplanetary space; the blast-waves are damped with distance and, probably, rarely escape the lower corona [12,13]. It is well known that there is a connection between some enhancements of solar radio waves and some solar flares. It seems probable that the first solar radio waves observed, but not recognized at the time as of solar origin, were of this class. One interesting fact about type III is it results from energetic particles escaping along open magnetic field lines [14]. This burst is a short-lived (a few seconds), broadband ( $\approx 100$  MHz) burst in which the frequency of maximum intensity drifts rapidly towards the lower frequencies due to solar flare event. It is now widely recognized that solar burst type IV always related to the development of sunspot groups and show broad continuum emission with rapidly-varying fine structures [15,16]. On the other hand, type V burst appearances a smooth short-lived continuum and formed after type III [17]. One of the main reasons to study more about the dynamics of solar radio bursts is because solar these bursts can interfere with GPS and communications systems [18]. More importantly, these bursts are a key to understand the space weather condition [19].

## **2. CALLISTO SYSTEM CONFIGURATION EXPERIMENTAL SETUP**

The CALLISTO system consists of the Log Periodic Dipole Antenna (LPDA), preamplifier, and spectrometer, which operating from 45 MHz to 870 MHz [20]. The e-CALLISTO network aims at 24 h coverage of the radio emission of the Sun [21]. It consist CALLISTO (Compound Astronomical Low-cost Low-frequency Instrument for

Spectroscopy in Transportable Observatory) spectrometers, designed and built by electronics engineer Christian Monstein of the Institute for Astronomy of the Swiss Federal Institute of Technology Zurich (ETH Zurich), record the intensity of electromagnetic radiation at radio frequencies. The channel resolution is 62.5 kHz; while the radiometric bandwidth is about 300 KHz with sampling time is exactly 1.25 ms per frequency-pixel. In principle, data that obtained from the CALLISTO can be transferred to a computer and saved locally via a R232 cable in FIT files [22]. Current solar observatories, it provides a (wealth of data at high spectral, temporal, and spatial resolutions with the specification of the 0.25 second time resolution. All data are stored with a scale factor and an offset applied so that the measured ADC digits range fits into the byte data range (0 – 255). The antenna has a boom length 5.45 meters with gain 7 dBi [23]. Meanwhile, Low Noise Preamplifier is connected to maximize a gain more than 10 dB [24]. Within this range, it could be possible to detect solar activities specifically solar flare and Coronal Mass Ejections (CMEs). This system has been successfully installed at National Space Centre; Banting Selangor located (3°5'00"N 101°32'00"E) [25]. Daily observations were performed for almost 12 hours [26]. Schematic diagram of the CALLISTO system is illustrated as in Figure 1.



**Figure 1.** Schematic diagram of experimental setup of CALLISTO.

Up to date, the system which objective was designed to observe solar flares in 24 hours monitoring has been distributed to 19 sites. While in previous work we focused on the construction of the antenna and the system, now, we are looking at the behavior of each burst due to the data that successfully obtained from our site [27].

A part of calibration process, we have subtracted the pre-burst visibilities from the CALLISTO data in order to remove the signal from a quiet Sun. We also have checked the flux calibration by comparing the CALLISTO and relative amplitude of solar burst. In this work, we analyze the data obtained from our site using CALLISTO spectrometer. In this work, we have selected a few data that represent each burst. The significance of chosen the data will be explained in the next section [28-42].

### 3. RESULTS AND DISCUSSION

In order to provide an analytical description of each type of the burst, we listed the parameter that might influence the formations and the evolution of the burst such as sunspot number, radio flux and the active region that trigger the burst. We also focused on the specific range of frequency in order to observe the potential location that might need to be highlighted. This is very important because when there is expected any event of solar activities we are already targeting the range of frequencies.

For the spectra described in this paper, a complete wavelength was accomplished in 15 minutes. Due to constrain of the interference factors, the range of 150 MHz till 400 MHz had been chosen as selected data.

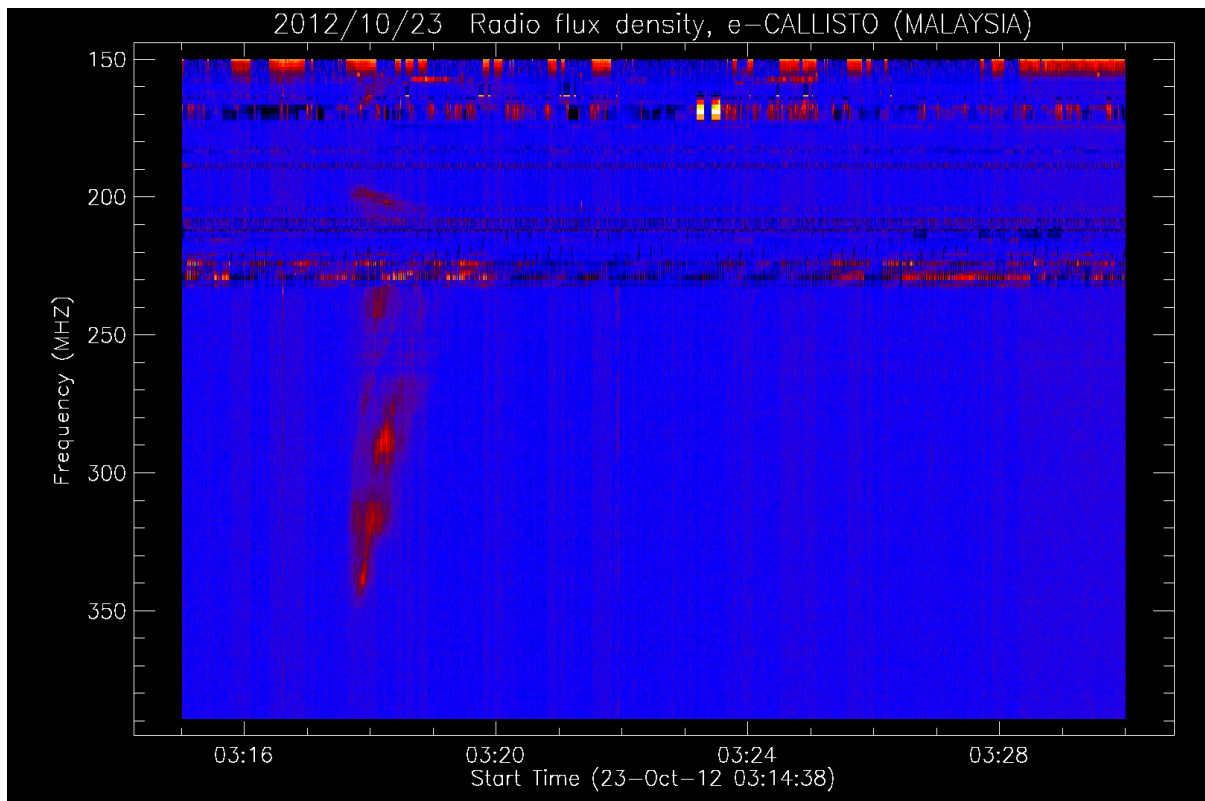
In this section, we present the results of several type bursts which can be detected successfully and related to solar events. Our current contribution to this effort is an observational study that begins to test the CALLISTO system. Detailed description of our own observations is given in Table 1.

**Table 1.** Solar radio burst parameters.

<b>Type</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>U</b>
<b>Date</b>	23rd October 2012	9th March 2012	5th March 2012	9th March 2012
<b>Time (UT)</b>	3:17-3:19	4:23-4:26	4:14-4:19	4:12:05-4:12:06
<b>Range of frequency (MHz)</b>	200-350	150-400	282-400	311-383
<b>Active Region</b>	1598	1429	1429	1429
<b>Sunspot number</b>	86	86	70	86
<b>Radio flux (sfu)</b>	144	140	120	140
<b>Event</b>	Coronal Mass Ejections (CMEs)	Solar Flare type M 7.9	New active region	Solar Flare type M7.9
<b>Duration</b>	2 minutes	3 minutes	5 minutes	1 minute

Coronal Mass Ejections (CMEs) will form type II bursts originated from the solar corona, expanding as they climb. Nevertheless, this burst of solar plasma being hurled from the eastern limb of the Sun is more like an explosion potentially release up to 100 billion kg of material with and the speed of the ejection exceeds 1000 km/second. Generally, the solar plasma is heated to tens of millions of degrees, protons and electrons, with nuclei are accelerated potentially closed to the speed of light.

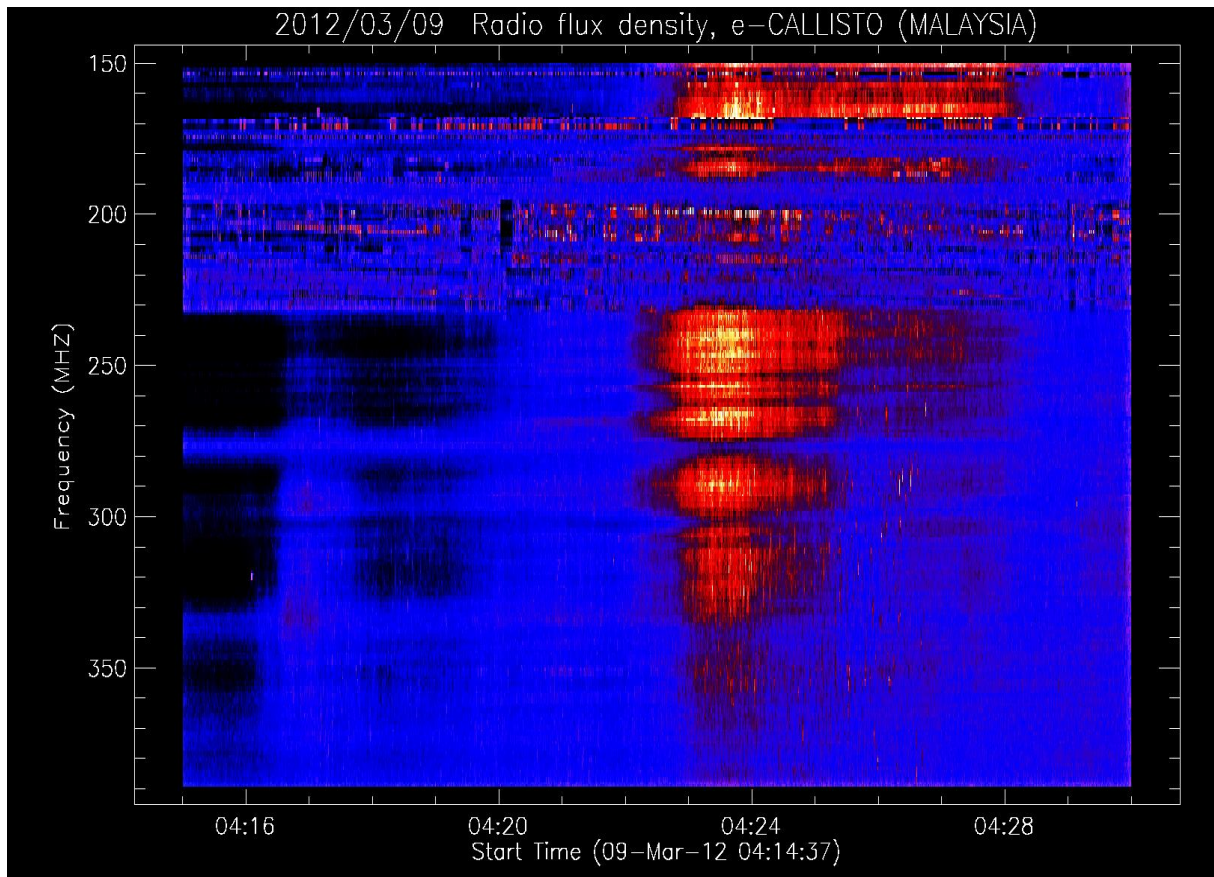
In this case, the super-heated electrons from CMEs move along the magnetic field lines faster than the solar wind can flow. As a consequence, rearrangement of the magnetic field and solar flares possibly will result in the configuration of a shock that accelerates particles ahead of the CME loop. The observation of solar radio burst during CMEs requires high resolution in frequency. For this event, we considered a time window over 3 hours (360 minutes) covering the phases of impulsive courses (waveforms) and background signals. Figure 2 shows the solar radio burst type II on 23<sup>rd</sup> October 2012.



**Figure 2.** Solar radio burst type II on 23rd October 2012.

The type III solar radio bursts, which are generated when high-energy electrons are ejected from the Sun, are characterized by a rapid drift in frequency from hundreds of megahertz to tens of kHz. It is believed that the process of producing type III solar radio bursts is associated with the excitation of Langmuir waves, which are oscillations in the electron density in a plasma, followed by the conversion of these waves into radio emissions. During solar flares there may be large increases (bursts) in radio emission lasting anywhere from a few seconds to several hours.

In order to understand the possible mechanism of dynamical structure of the burst, we have investigated relationships and time integrations of the bursts with soft/hard as well as solar flares. It is clearly seen an impulsive lace burst were detected at 4:24 UT and it is more plausible that the energies are confined to the top of the loop and it is confined with an X-ray results. The burst is now at the end of the phase where we can observe it is now decreased till 4:52 UT. Figure 3 illustrate the solar radio burst type III with a high energetic particles.



**Figure 3.** Solar radio burst type III on 12<sup>th</sup> March 2012

Solar burst type IV always related to the development of sunspot groups. This first light curve associated with a class M 2.0 solar flare on 5th March 2012 also successfully detected at the National Space Centre, Banting. Here we consider the range that almost free from interference from 240 MHz till 380 MHz, see Figure 4. Time variations in the emission may due to the changes in the electron density. However, these variations mainly proceed slowly and due to the change in the local ionization temperatures.

During 9<sup>th</sup> March 2012, a strong M 7.9 class of solar flare was recorded from solar Active Region AR1429. It is clearly seen an inverted type U burst occurs between 310 MHz till 384 MHz within 1 minute. In this event, an M6 solar flare occurred in the active region AR 1429 starting at 3:32 UT and ending at 05:00 UT, with the peak at 4:12 UT. If one looks very closely, before type U burst form, there is a group of ten of solar burst types III occurred from 4:06-4:10 UT.

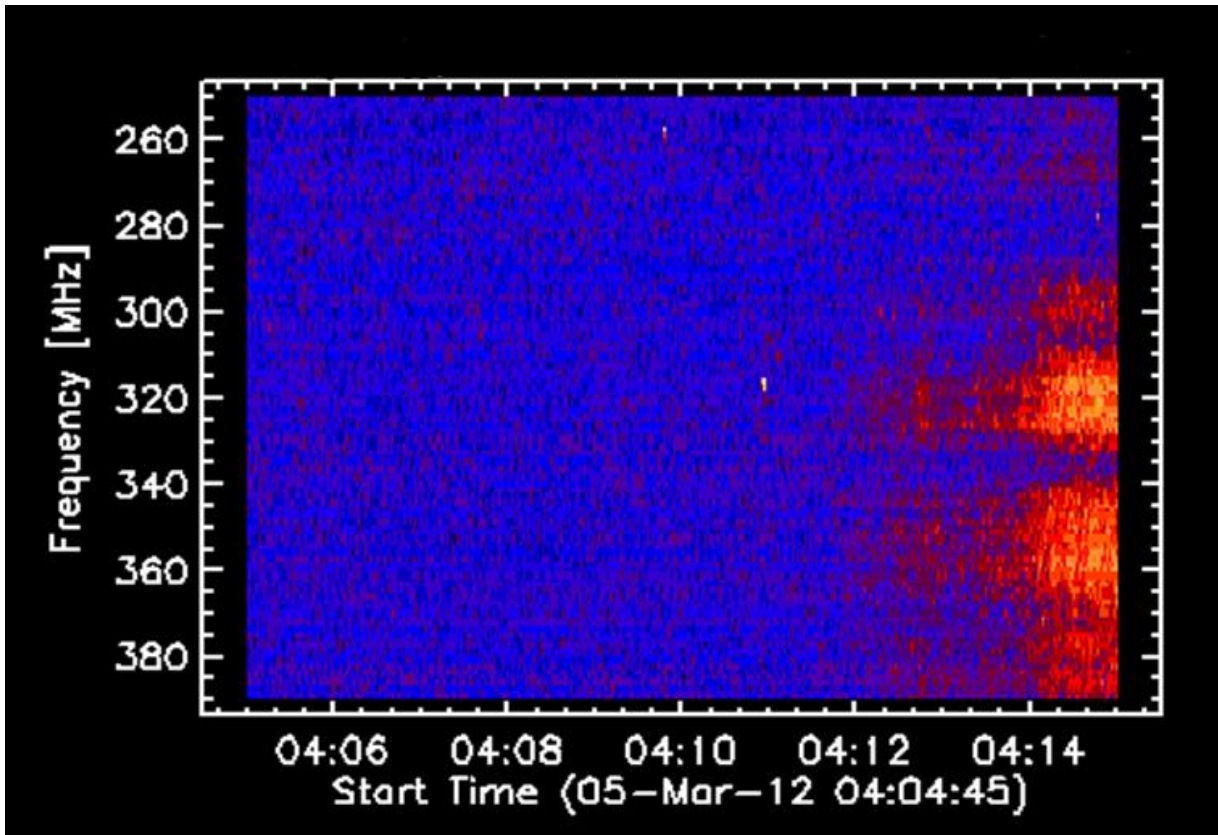


Figure 4. Solar radio burst type IV on 5<sup>th</sup> March 2012.

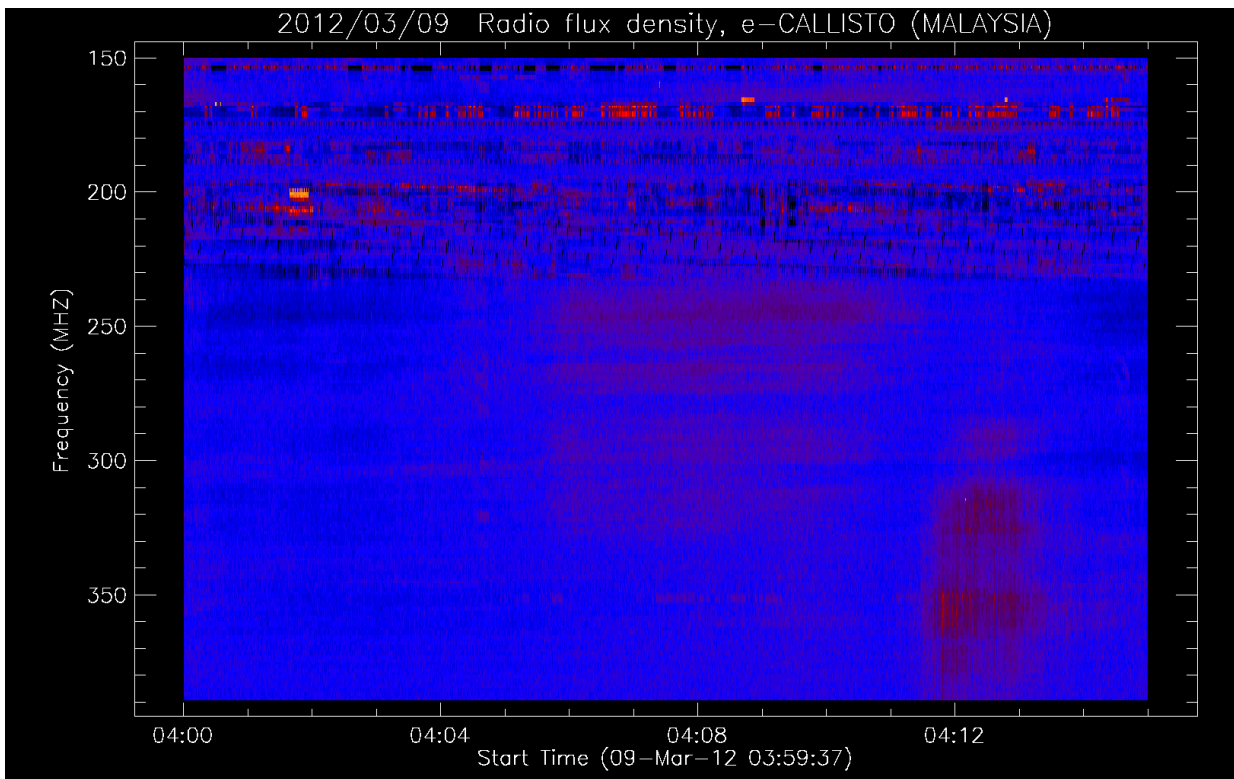


Figure 5. Solar radio burst type U on 9<sup>th</sup> March 2012.

During 9<sup>th</sup> March 2012, a strong M 7.9 class of solar flare was recorded from solar Active Region AR1429. It is clearly seen an inverted type U burst occurs between 310 MHz till 384 MHz within 1 minute. In this event, an M6 solar flare occurred in the active region AR 1429 starting at 3:32 UT and ending at 05:00 UT, with the peak at 4:12 UT. If one looks very closely, before type U burst form, there is a group of ten of solar burst types III occurred from 4:06-4:10 UT.

#### **4. CONCLUSIONS**

There is a growing interest in observing solar burst in low frequency of the radio region due to the increasing number of solar activities towards 24<sup>th</sup> solar cycle. In this article, a comprehensive analysis of variation of solar burst has been presented. There is a growing interest in observing solar burst in low frequency of radio region. It could not be doubted that e-CALLISTO network plays a dominant and important database on the target monitoring solar activities in 24 hours. The results presented in this paper point to the importance of observing Sun activities in radio region. Still our data show hints of possible solar activities that can be detected in this lower region. Our radio observations were carried out simultaneously with the CALLISTO spectrometer is could contribute a good data due to our advantages, which made daily observation for 12 hours throughout the years and the different perspective seems our location as an equatorial site. This factor may be important for observation of burst with long duration. It is hoped that we could possible to gain a better data that can be used as a reference.

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#### **BIOGRAPHY**

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