Available online at www.worldscientificnews.com

World Scientific News

WSN 45(2) (2016) 80-91 EISSN 2392-2192

An Analysis of Active Regions 11036 Characteristics Leads To Solar Flare Class C7.2 Phenomena

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ABSTRACT

The solar flares are generated from electromagnetic radiation which is sudden oscillation of the stored energy in the magnetic field of the sun. Flares are categorized according to their brightness as C, M and X, where X is the brightest. The X class flares caused a long-time solar storm and ionospheric radio waves sparkling. The moderate level M class flares mostly effect polar cups and cause short-time radio sparkling. However, the C class flares are weaker than the X and M flares. In this work, we present an active region from the disturbance of magnetic field on the area of the Sun and may lead to powerful event if the magnetic field become stronger. The CALLISTO system network that has been installed in Gauri, India observed data that contain Solar Radio Burst Type II (SRBT II) occurred on 22nd December 2009 at 04:57 UT to 05:02 UT. Five active regions were obtained from online data via internet from the Space Weather website and the Solar Monitor website. All data and information from these sources assist in analyze of the phenomena. The magnetic field and X-ray flux, proton density increase the possibilities that SRBT II observed by CALLISTO network to generate powerful solar flare. When X-ray flux level was at maximum, then solar flare was at peak point. However, solar activity level was low because among of five active regions present, only one C-class flare event occurred. The most active region that contributes this event is an AR11036 with C-class flare.

***Keywords*:** Solar Radio Burst Type II; solar flare; Callisto network; active region

1. INTRODUCTION

Space weather is defined as the “conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-born and ground-based technological systems and can endanger human life or health [1]. There are two major types of energy which are continuously emitted from the Sun into space. There are electromagnetic (EM) radiation and corpuscular radiation. EM radiation consists of visible light, radio waves, microwaves, infrared, ultraviolet, X-ray, and gamma rays which are composed of electromagnetic spectrum. However, corpuscular radiation consists of solar wind, which is full of charged atoms and sub-atomic particles (mainly protons and electrons) which expand out to the solar system carrying the Sun’s magnetic field. The solar wind can cause changes to the upper atmosphere of the Earth which results in a natural coloured light appear in the sky near the northern and southern poles of Earth known as *aurorae* and carrying large electrical currents that can disrupt communication, power grids, and satellite navigations. These energies basically are associated with the solar flares and Coronal Mass Ejections (CMEs). Solar flares and CMEs are the most remarkable solar activities which create environment to the space weather and also affect the terrestrial environment. These two types of solar eruptions can expel huge amounts of radiation and charged particles into the space. In order to determine the solar wind and other parameters, space experiment was carried out by other researchers. Space experiment is intended for research of active non- stationary processes on the Sun, physical mechanisms and conditions of acceleration of electrons, protons and nucleus on various phases of solar flares progress [2]. The proton measurements from the GOES series of satellites provided valuable data for this work because of their geostationary location and the time span they cover [3]. The parameters that include such as solar wind, agnetic field, proton density, X-ray flux and other parameter are not easily measured. Then, because direct measurement of these parameters is a considerable challenge, in practise one has to use different tools to get a comprehensive picture of the atmosphere structure in active regions and processes therein [4]. These two phenomena cause powerful effects to our Earth environment. They occur in an area that we called as active regions.

The active regions are the regions on the Sun which usually form with sunspot groups. Sunspots are one of the components of active regions that are studied in order to forecast solar activity. Solar active regions are associated with particularly powerful and complex magnetic fields which create suitable conditions for the release of enormous amounts of energy in the form of solar flares. This energy can lead to the acceleration of atomic particles which may increase its energetic status and make it capable of affecting terrestrial systems and orbiting satellites. Understanding this energy is important as it aids our ability to predict solar eruptions, such as solar flares as well as CMEs. Flares are sudden, rapid, and intense variations in brightness that occur when the magnetic energy that has built up in the solar atmosphere is suddenly released, over a period lasting from minutes to hours. Flares emit strong radiations such as radio waves, X-rays and gamma rays, releasing very large amounts of energy. The solar flares regularly occur in active regions where sunspots exist because the magnetic fields there are always stronger. However, flares could occur even when spots are not present in the region. They are most frequent during the rapid growth stage of an active region's development. Numerous small flares often occur during the initial formation stage of a sunspot group, while in other small regions they might not occur until after a sunspot has already formed. This is because each sunspot region is different and has its own identity. Flares are created through the sudden release of a massive amount of energy. The solar flare phenomenon is important to understand inner dynamics of the Sun [5]. It is not easy to determine solar flare. There are many modes of observations depending on the exposure time, resolution, signal-to-noise ratio, etc. [6]. Evidently, in addition to depending strongly on the active region's free energy, an active region's flare productivity also depends significantly on the complexity of the active region's field configuration, on the rate of evolution of the configuration, and on the occurrence of emergence and cancellation of flux in the active region [7]. Automatic solar flare detection plays a key role in real-time space weather monitoring. Another type of observing solar flares was by using Hα to form clear image. The classification rate is more than ***95%*** and running time is less than ***0.3*** second using this method [8].

2. METHODOLOGY

The CALLISTO spectrometer is portable equipment and can be installed in many suitable observatories. CALLISTO spectrometer system equipment is similar to other radio-telescope modules. It includes an antenna, a preamplifier, a super heterodyne receiver with spectroscopic capability (the CALLISTO spectrometer itself), and a data-recording device. It has been operated with a log-periodic antenna (gain 6 db) in the full frequency range at the Blein Radio Observatory which about 50 km west of Zurich [9]. The basic diagram is shown schematically in Figure 1. The signals obtained from two feeds LPDA (two modes of polarization) are fed into two receivers (top row and middle row). A preamplifier was mounted between the Log Periodic Dipole Antenna (LPDA) with long cable directly to CALLISTO spectrometer [10]. There are many applications are using Log Periodic Dipole Antenna (LPDA) as it originates as broadband antennas. These coplanar linear arrays of unequal and unequally spaced parallel linear dipoles are fed by a twisted balanced transmission line. However, there are some parameters that should be taken into account in order for LPDA to perform well in its performance. Log Periodic Dipole Antenna (LPDA) is frequency independent in that the electrical properties such as the mean resistance level *R0*, characteristic impedance of the feed line *Z0* and driving-point admittance *Y0*, vary periodically with the logarithm of the frequency [11]. Generally, signal from the antenna is directed to the (Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy in Transportable Observatory) CALLISTO spectrometer, which is housed in a steel case, via a low loss coaxial cable [12]. Radio observations system consists of log periodic dipole antenna (LPDA), CALLISTO spectrometer and Windows computer connected to the internet. The data will be saved based on the duration of period of daylight in Universal Time (UT) and compile every 15 minutes [13]. Every spectrum data file and the tracking log file stored by CALLISTO software and tracking software are transferred to the data acquisition server to process, analyze and display data and current tracking status in the Space Weather Monitoring Laboratory (SWML) in real time. Come out data should be in a low interference to get the best result in order to carry out the analysis from data obtained. Thus, it is easier to determine type of burst occur at that time. However, the data can also be compared with the National Oceanic and Atmospheric Administration (NOAA) list is in an updated state. Data archive allows to store up to 10 TeraBytes of FIT-files. The archive is physically located at FHNW (Fachhochschule Nordwestschweiz) and managed from ETH (Eidgenössisch Technisch Hochschule in Zurich) [14].

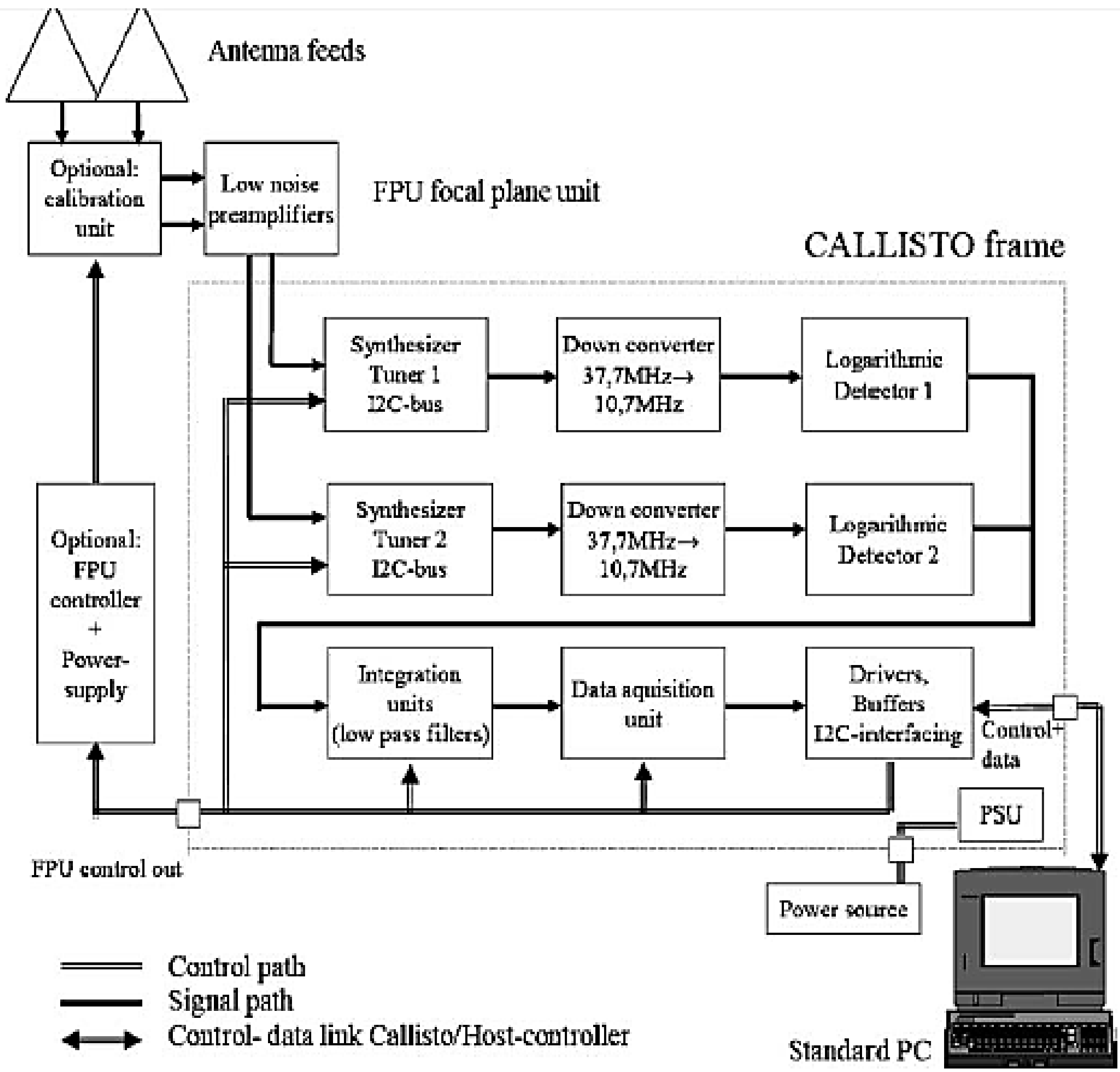

Figure 1. Basic design of solar radio spectrometer in radio observation

Based on intensive study, some flares exhibit as ‘explosive phase’ during the maximum cycle which is associated with hydrodynamic effects. In this scenario, an optical continuum reaches a peak increase of several per cent, which is in solar white-light flares based on the radiative hydrodynamic s models [15]. The previous data showed two different kind of spike event; (i) spike clusters which originating in post-flare phase [16] and (ii) originates from the main flare phase and well originate with non-thermal flare emission [17]. It is widely accepted that the solar flare is related with the relatively strongest magnetic field [18] found that the variability under magnetic condition in electron density, N_e, ion temperature T_i and electron temperature T_e, respectively changed with local time and height due to day to day flares monitoring.

It could not be denied that the analysis and interpretation of observations in different wavelengths are required to discover out which the flare are triggering mechanisms. While this process has become generally accepted as the trigger, it is still controversial how it converts a considerable fraction of the energy into non-thermal particles [19]. It was observed that the interaction between coronal structures can generate the circumstances for reconnection and the consequent energy release. This interaction can be forced either by flux emergence or by rapid motions of photosphere structures [20].

As it gives also access to the highest energy particles accelerated during flares, since high frequency radio diagnostics are more sensitive to these particles than are hard X-rays produced by non-thermal bremsstrahlung. During this stage, the Sun’s radio emission can increase up to a million times the normal intensity just a few seconds. Based on the SOHO /LASCO data from 2004-2009 there were nine events which is about 14% of the type II solar radio burst after the X-ray flares event not followed CME in the region of 20-70 MHz [21].

The general instrumental parameters used in CALLISTO were stated in the Table 1 below.

Table 1. The parameter of the CALLISTO system.

Parameter	Specification
Frequency range	45.0 MHz to 870 MHz
Frequency resolution	62.5KHz
Radiometric bandwidth	300KHz/-3Db
Dynamic range	-120dBm to -20dBm (depending on gain voltage)
Sensitivity	25Mv/Db +/-1Mv/dB
Noise figure	<10dBm
Sampling frequency	Internal clock 800 s/sec max, external clock 1000 s/sec max
Number of channels	1 to 500, nominal 200 frequency per sweep
Supply	12V +/- 2V / 225Ma

Weight	~800 grams
Dimensions	110mm x 80mm x 205mm
Input	3 configuration files (config, frequency, scheduler)
Output	2 files (FITS-file and logfile)

3. RESULT AND ANALYSIS

An active region on the Sun is an area that was disturbed. Active regions on the Sun are places where the Sun's magnetic field is especially strong. These regions frequently spawn various types of solar activity, including explosive "solar storms" such as solar flares and coronal mass ejections (CME). There are five active regions presented on the particular day. There are AR 11034, AR 11035, AR 11036, AR 11037 and AR 11038. However, among these five active regions, only one active regions was discovered to have explosion of C-class flare. Figure 1 show five active regions detected during that day by Global High-Resolution Hydrogen Alpha Network (GHN Hα). AR 11036 shows the brightest image as flare present in this active region. However, other active regions has bright spot that represent existence of strong magnetic field but still did not produced any flare or solar phenomena. GHN Hα detected AR 11036 occured with solar flare C-class. Other active regions did not have any obvious solar activity present. The target region, NOAA 11036, was the source of the C7.2 event at 22nd December 2009 at 04:56 [UT] Flare of C-class has high background but low flare formation. AR 11036 developed mixed polarities within its trailing portion. There is a slight chance of an isolated low-level M-class event if AR 11036 develops additional magnetic complexity. Based on method of this project, CALLISTO system that used produced a data as shown in Figure 2. The result was illustrated in spectrogram diagram. As shown in Figure 2, flare present in AR 11036 related to Solar Radio Burst Type (SRBT) II event appears in spectrogram. This shows that SRBT II occurs due to solar flare phenomena. The fast SRBT II occurs from 04:57 [UT] until 05:02 [UT] that can still be observed.

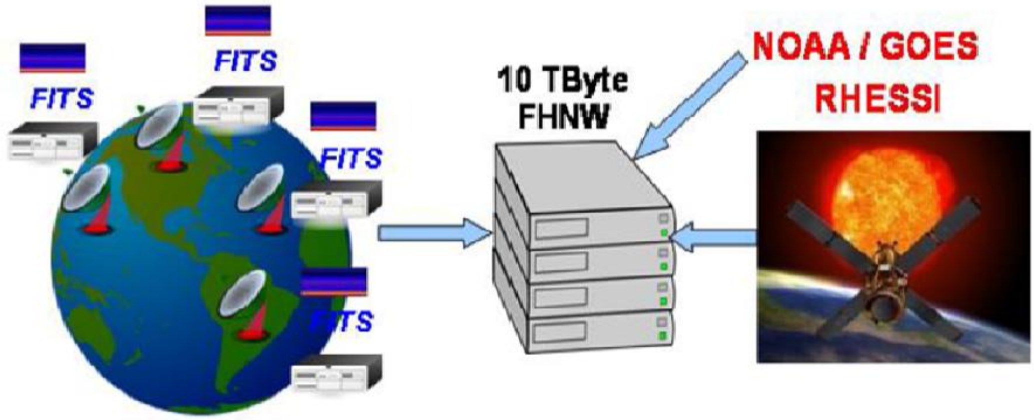

Figure 2. Dataflow from the sites to the achieve (Credited to C.Monstein, ETH, Switzerland)

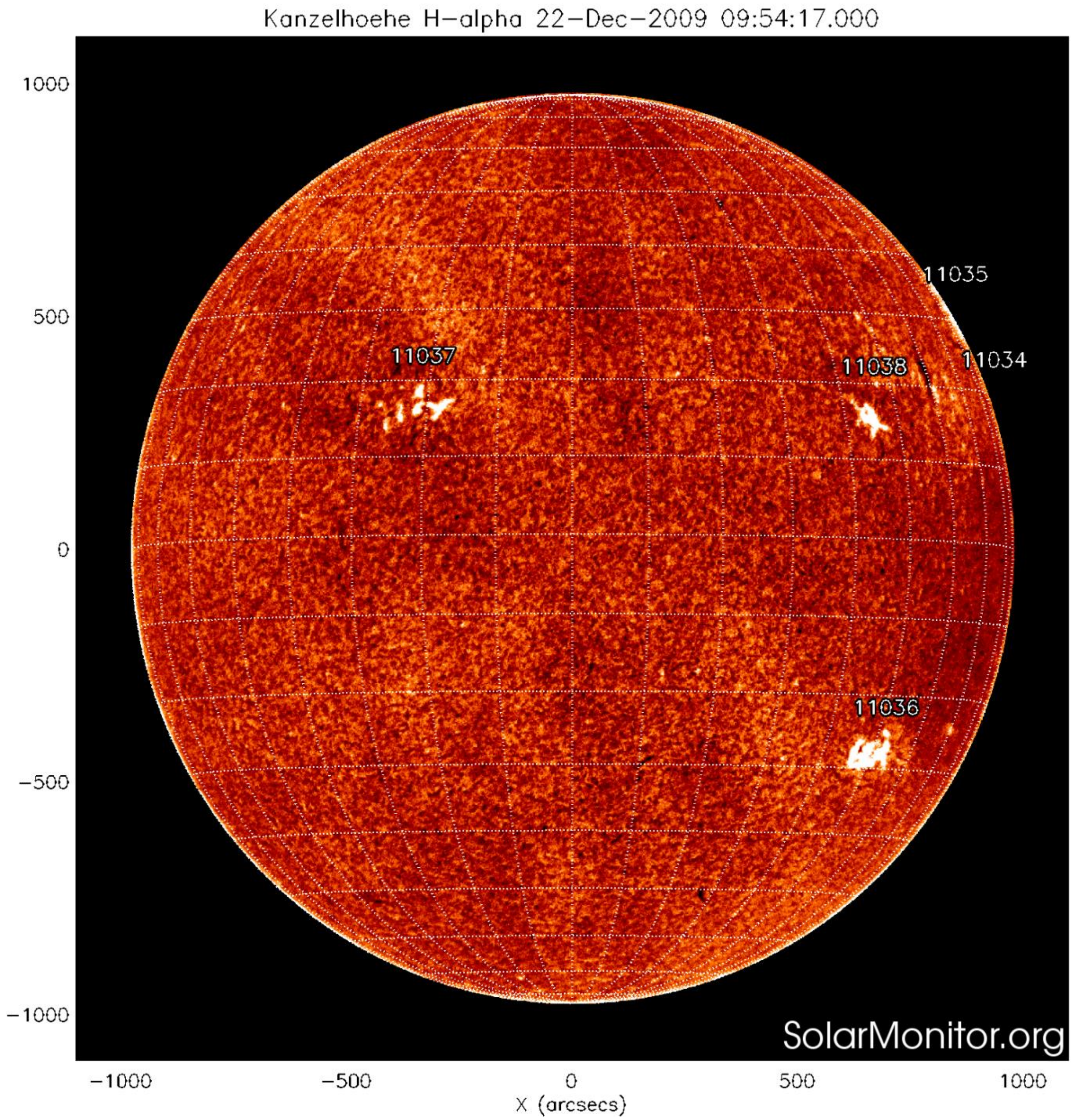

Figure 3. Five active regions AR 11034, AR 11035, AR 11036, AR 11037, and AR 11038 detected during 22nd December 2009 (Credited: Solar Monitor website)

In particular, an observed random variable may be represented as instability of the magnetic field of the active region. There was a flare event that has been detected at 05:54 [UT] from the LASCO data. The speed of the event was about 340.5 km/sec with proton density of 6.1 protons/cm^3. This proved that the flare occurred in a meter solar radio burst will take a long period to decay after its explosion. The GOES X-ray plots functions to trace solar activity and solar flares.

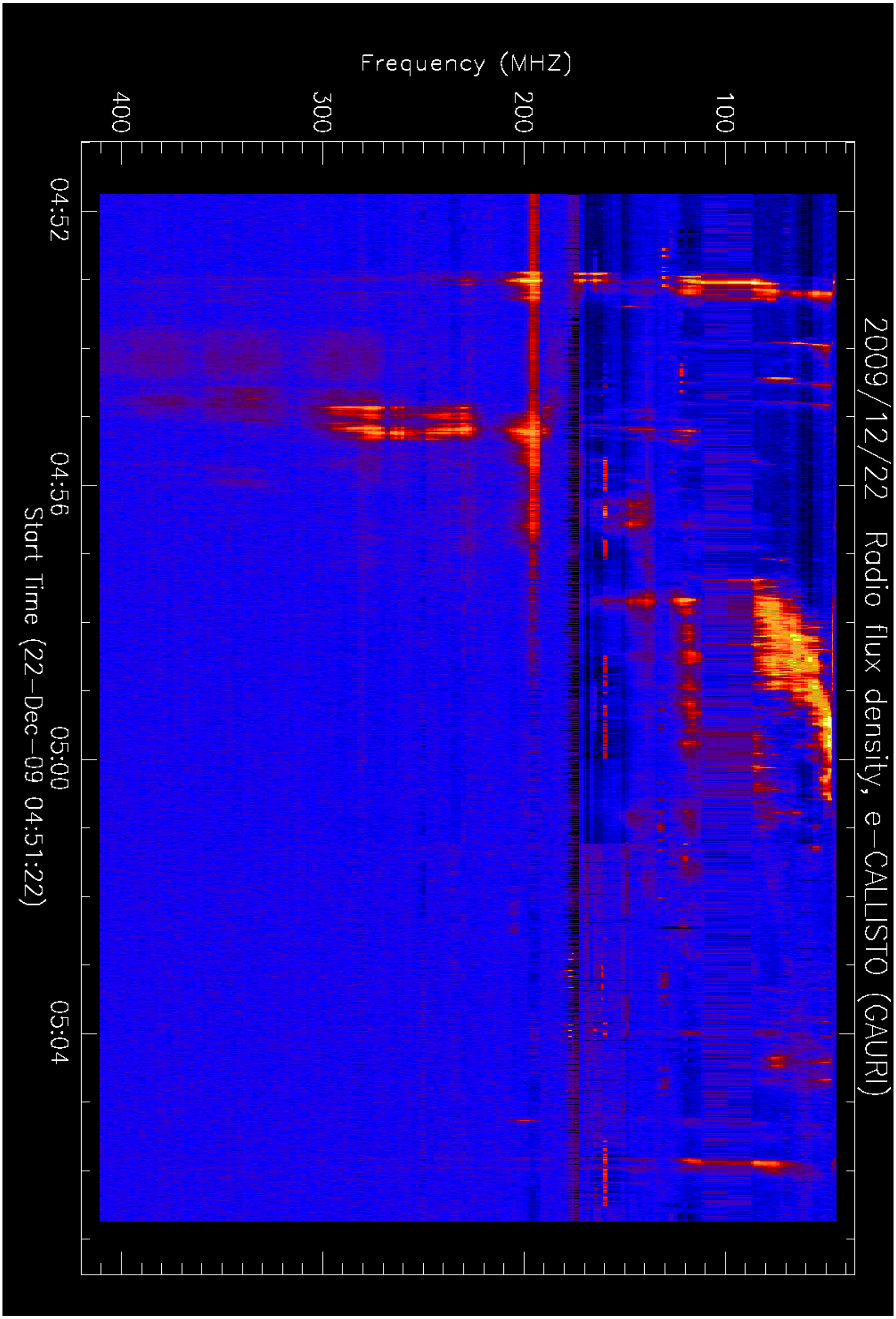

Figure 4. Selected event on 22nd December 2009 during 04:57[UT] to 05:02[UT] in Gauri, India (Credited: e-CALLISTO website)

The solar X-ray flux arises from two factors. Firstly, there is flux coming from sunspot regions and other features - the background flux - and this varies slowly from day to day. Secondly, solar flares produce large amounts of X-ray flux, but this is concentrated to the duration of the flare which is usually from minutes to several hours. In this particular event, the dynamic spectra of the X-ray region begin from 04:55 UT till 05:05 UT. As can be seen the X-ray flux is approximately from 10^{-6} W/m^2 to 10^{-5} W/m^2 during 05:00 UT. This is the highest point within six hours period of time. The sun remains active with two solar flares C-class can be detected within 3 days starts from 20 December 2009 to 23 December 2009.

Based on GOES X-Ray flux figure , probabilities for the flare event to occur in these three days was 20% for C-class flare, M-class flare about 4% and 0% for X-class flare. On previous day (21st December 2009), the graph shows that Sun begin to active with low C-class. After it reach certain level, Sun begin to increase its activation until it reach maximum or peak X-ray flux level with 7.2×10^{-6} W/m^2. At this point, solar flare formation is also at peak point.

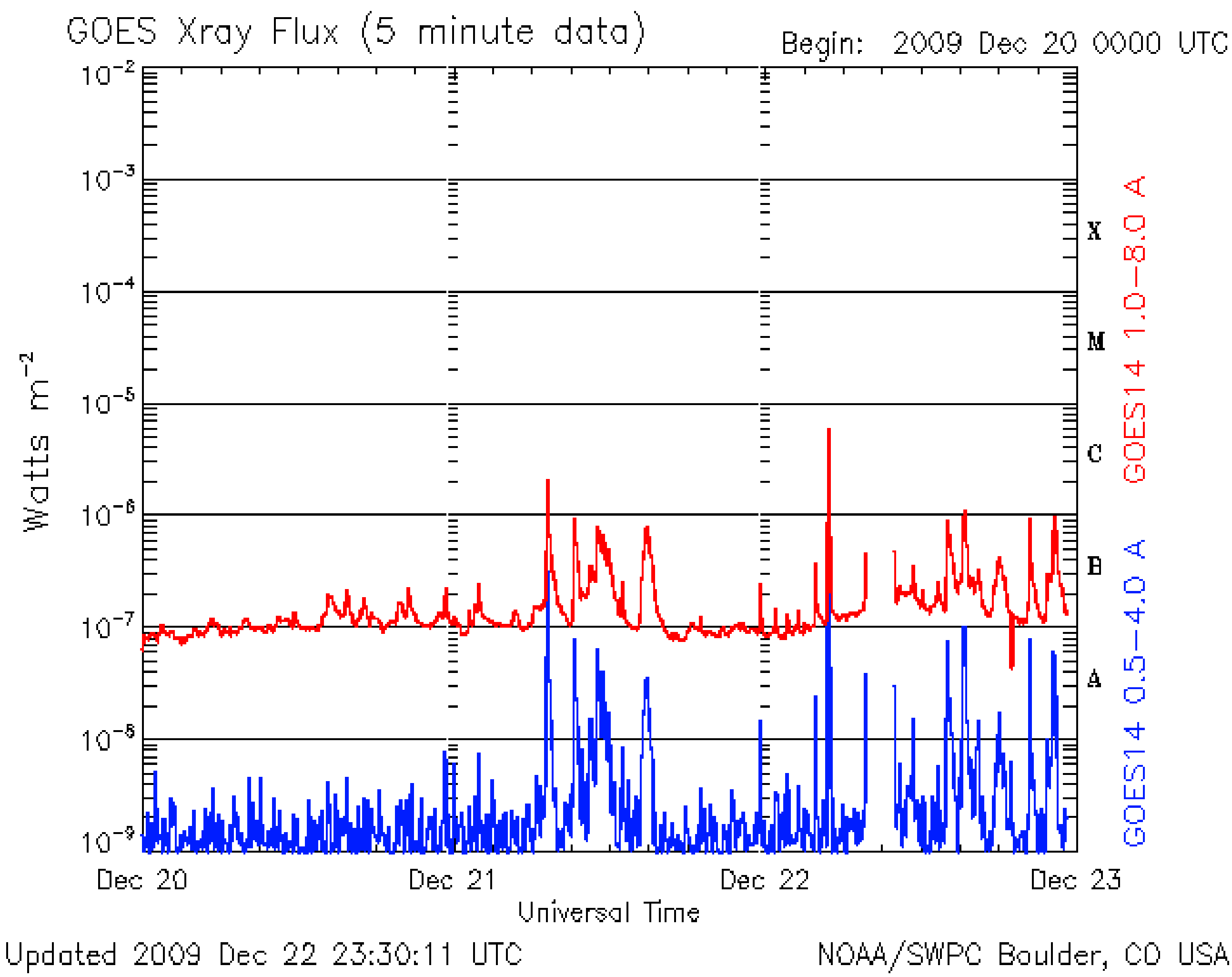

Figure 5. Dynamic spectrum of CMEs detected using X-ray region for three days from 20 December 2009 to 23 December 2009 (Credited: Solar Monitor website)

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4. CONCLUSION

Overall, solar activity level during this event was low. This is because among of five active regions present, only one C-class flare event occurred. The most active region was AR11036 with C-class flare. The active region was associated with an emerging flux. As flare causes many disturbance to Earth environment, there is needed to determine and make some research on it in order to get overview about the causes and effects of it. Therefore, it is essential to be able to predict these violent eruptions prior to their occurance to mitigate their consequences.

ACKNOWLEDGMENT

We are grateful to CALLISTO network, STEREO, LASCO, SDO/AIA, NOAA, SOHO, SolarMonitor and SWPC make their data available online. This work was partially supported by the 600-RMI/FRGS 5/3 (135/2014) and 600-RMI/RAGS 5/3 (121/2014) UiTM grants and Kementerian Pengajian Tinggi Malaysia. Special thanks to the National Space Agency and the National Space Centre for giving us a site to set up this project and support this project. Solar burst monitoring is a project of cooperation between the Institute of Astronomy, ETH Zurich, and FHNW Windisch, Switzerland, Universiti Teknologi MARA and University of Malaya. This paper also used NOAA Space Weather Prediction Centre (SWPC) for the sunspot, radio flux and solar flare data for comparison purpose. The research has made use of the National Space Centre Facility and a part of an initiative of the International Space Weather Initiative (ISWI) program. We are also thanks to Perpustakaan Tun Abdul Razak 1, UiTM Shah Alam, for giving us the facility to book and use the discussion room to complete this paper.

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(Received 10 March 2016; accepted 24 March 2016)