Available online at www.ilcpa.pl

International Letters of Chemistry, Physics and Astronomy

5 (2014) 32-42 ISSN 2299-3843

Chronology of Formation of Solar Radio Burst Types III and V Associated with Solar Flare Phenomenon on 19th September 2011

Z. S. Hamidi[1,*], N. N. M. Shariff [2,]**

[1]MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia

[2]Department of Science and Technology Studies, University of Malaya, 50603, Kuala Lumpur, Malaysia

*,**E-mail address: zetysh@salam.uitm.edu.my , nur.nafhatun@um.edu.my

ABSTRACT

The formation of two different solar bursts, type III and V in one solar flare event is presented. Both bursts are found on 19th September 2011 associated with C-class flares on active region 1295. From the observation, we believed that the mechanism of evolution the bursts play an important role in the event. It is found that type V burst appeared in five minutes after type III. There are a few active regions on the solar disk but most are magnetically simple and have remained rather quiet. An interpretation of this new result depends critically on the number of sunspots and the role of active region 1295. Sunspot number is increased up to 144 with seven sunspots can be observed. During that event, the speed of solar wind exceeds 433.8 km/second with 2.0 g/cm^3 density of protons in the solar corona. Currently, radio flux is also high up to 150 SFU. The solar flare type C6 is continuously being observed in the X-ray region for 24 hours since 1541 UT and a maximum C1 is detected on 1847 UT. Although the sources of both bursts are same, the direction and ejection explode differently. It is believed that the ejection of particles in a type III burst is higher than solar burst type V.

***Keywords*:** Solar radio burst; solar flare; type III; type V; CALLISTO

1. INTRODUCTION

An extensive experimental and theoretical work has succeeded in elucidating many observational and characteristics of radio bursts in understanding their physical nature. Radio observations have been carried out since 1944 when J.S Hey discovered that the Sun emits radio waves [1]. This method reveals us to study energy release, plasma heating, particle acceleration and particle transport in solar magnetized plasma. However, the dynamics of the solar corona is still not understood, and new phenomena are unveiled every year. This region covers from 15 MHz to 30 GHz. Thus, the radio spectrum is limited at the low frequency side of the ionosphere and at the high frequency region by the troposphere. Radio signatures generally guide us to the corona, since the opacity (and the minimum height of the formation of the emission) increases in height almost monotonically with wavelength [2].

Solar flare is one of an enormous explosion in the solar atmosphere. It results in sudden bursts of particle acceleration, heating of plasma to tens of millions of degrees, and the eruption of large amounts of solar mass. This phenomenon can be detected in the radio region as a solar burst characteristics. Statistical studies on detection of type III and V during solar flare proved that are generated from the same coronal structure from the same active region. Previous observations showed unique results instead of range of frequency, the type of solar flare, sunspot number during that particular event and the active region that responsible eject this phenomenon.

It is widely known that type III radio bursts originate from active regions. Accordingly, the type III burst occurrence rate can be used as an additional index of solar activity [3]. The theoretical basis for the plasma hypothesis of SRBT III was first introduced by [4] in the frequency range 500 MHz to 10 MHz. SRBT III, a fast drift burst is the most common of the metre wavelength bursts. It can be considered as a pre-flare stage that could be a signature of electron acceleration. It is well known that an isolated solar radio burst type III can exhibit a wide range of forms (T. Takakura, 1960). During the near maximum cycle, the average rate of occurrence growing up to 3 detections per hour with duration of individual times about 10 seconds. This type is associated with solar flares and usually occurs before optical events. Further evidence showed that type III are generated in a weak-field region comes from the absence or low degree of circular polarization of the bursts [5]. However, [6] against the theory and strongly agree that type III burst requires a very strong field to produce a fundamental and second harmonic of gyro frequency. The subject of nonlinear wave-wave interaction which involving interaction of electrostatic electron plasma that called as Langmuir waves active region radio emissions also have been studied [7-12] and the most recent and comprehensive ones can be found in a recent book dedicated to solar and space weather radiophysics [13].

Observations of low frequency solar type III radio bursts have long been of interest as it associated with the ejection of plasma oscillations localized disturbance due to excited in the plasma frequency incoherent radiations such as gyro synchrotron and free–free emissions [14]. In this case, radio wavelengths play a dominant role at the meter and decimeter wavelengths. Determination of solar burst this type could be interpreted as a very fast outward movement of the disturbance through the solar corona with could exceed from 3×10^4 to 10^5 km/sec based on the solar flare phenomenon [15]. Interestingly, this velocity represents one-third velocity of light [16]. Previous study also shown that this type of burst extends out to 1 AU with more than 20 keV electrons [17].

Meanwhile, the phenomenological continuum-like of type V bursts is misleading; physically it rather belongs to the class of drift bursts. It is believed that at least 2 MeV were required to account for the observed intensity. It is assumed, that this is emission of a part of the electrons, producing the type III burst, trapped in a magnetic loop. They occurred 10 percent of type III bursts and observed near radio limb. This type is due to synchrotron radiation from the same electron stream responsible for the type III plasma radiation. The pulses superimposed onto the broadband solar burst emission might be interpreted as a response to physical processes at the origin of the flare. Probably the best explanation for the long duration of the type V burst is that pitch-angle scattering removes electrons from the type III stream and slows down their propagation. Unfortunately, there are many factors of various radio emission are still largely unknown after more than 60 years. There is no evidence structured has been noted. However, in centimeter bursts an impulsive continuous radiation at centimeter wavelengths that lasts for just a few minutes above the tops of coronal loops potentially attributed to gyro synchrotron emission of high-speed electrons accelerated to energies of 100 to 1000 keV.

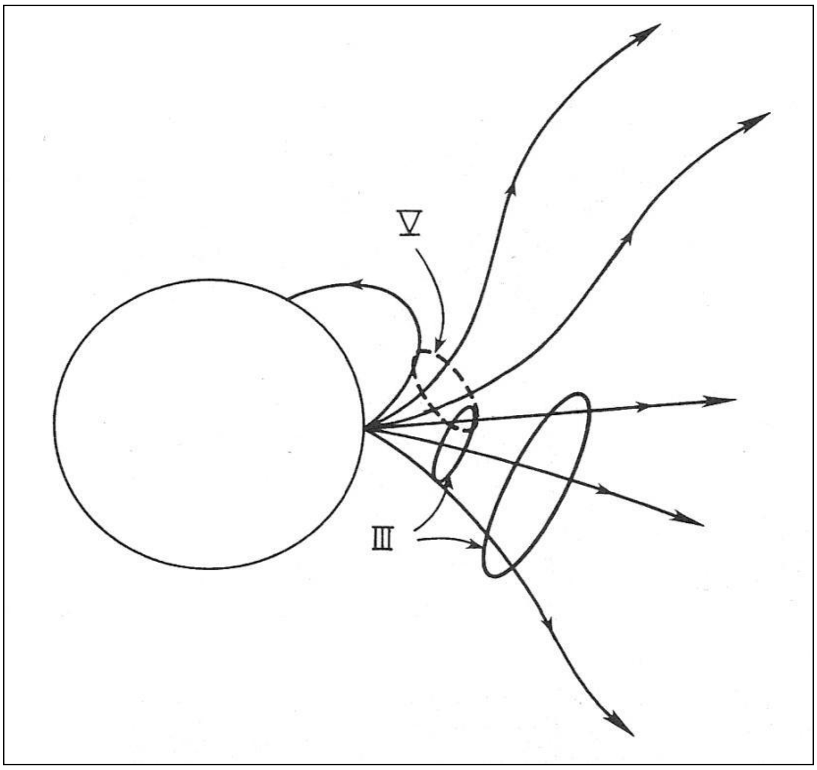

Figure 1. The illustration of formation of type III and V bursts on an open magnetic field line

This work focused on the formation of solar burst type III by looking at several parameters that might indicate a formation of type V burst. The data used in the study are described in Section 2. Detailed results and discussion is outlined in Section 3 and the conclusion is summarized in the last section.

2. SYSTEM CONFIGURATION AND OBSERVATION

In this work, we have selected archived solar radio spectra provided by e-Callisto network which provide a solar burst data in the low frequency region from different sites all over the world. The CALLISTO (Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory) spectrograph is a new concept for solar radio spectrographs, designed by ETH Zurich [18]. The objective is to monitor solar activities within 24 hours monitoring by considering the magnetic field of the Sun. This system can be used to study solar radio bursts and the response of the Earth's ionosphere and geomagnetic. Malaysia also started joining this research since February 2012 and routinely monitor 12 hours per day at National Space Centre, Selangor [19,20]. The spectrometer has 300 kHz bandwidth during a typical frequency sweep of 250 ms, and can be tuned by the control software in steps of 62.5 kHz to obtain a more detailed spectrum of the radio environment [21]. In order to compare with the X-ray region, the archive of the NOAA National Geophysical Data Center is used as a primary source of radio data [22].

3. RESULTS AND ANALYSIS

Results suggest that the energy released from accelerated particles from solar flare type M. The interpretation of this new result depends critically on the number of sunspots and the role of active region 1295. It is necessary to take into account that the bursts observed in the absence of active regions do not necessarily originate from quiet-Sun regions. Consequently, there are a few sunspot regions on the solar disk but most are magnetically simple and have remained rather quiet.

One of the characteristic parameters of solar flares is its duration. It is found that during that day the sunspot number is increased up to 144 with seven sunspots can be observed during that period. The speed of solar wind exceeds 433.8 km/second with 2.0 g/cm^3 density of proton in the solar corona. Currently, radio flux is also high with 150 sfu. The solar flare type C6 is continuously being observed in the x-ray region for 24 hours since 1541 UT and a maximum C1 is detected on 1847 UT.

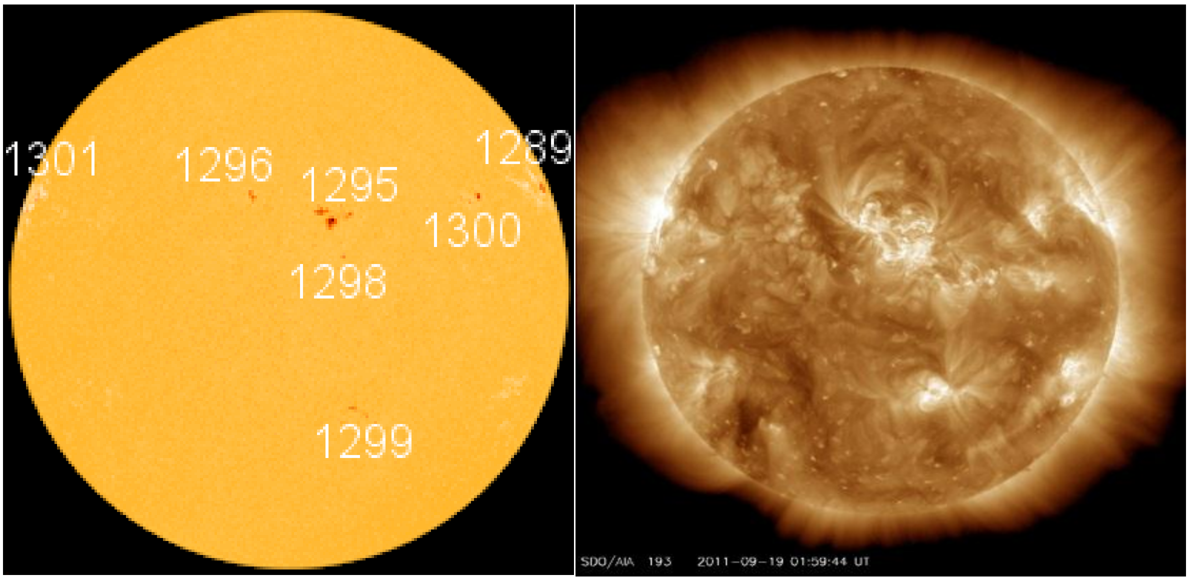

Figure 2. Active region (1295) in visible wavelength and the image of the Sun in X-ray region from Space Weather website.

There are seven sunspots directed to the Earth can be observed. However, there are no large coronal holes on the Earth-facing side of the Sun. In this case active region 1295 is responsible eject the solar flare which also corresponds to both solar bursts. As the probability of solar emissions are high only when a large sunspot group is present, our data collection dates were thus very subjective to the sun's present activity and are carried out based on forecasts made by a Space Weather monitoring agency. Figure 3 to 7 illustrate the chronology of formation type III and V solar burst.

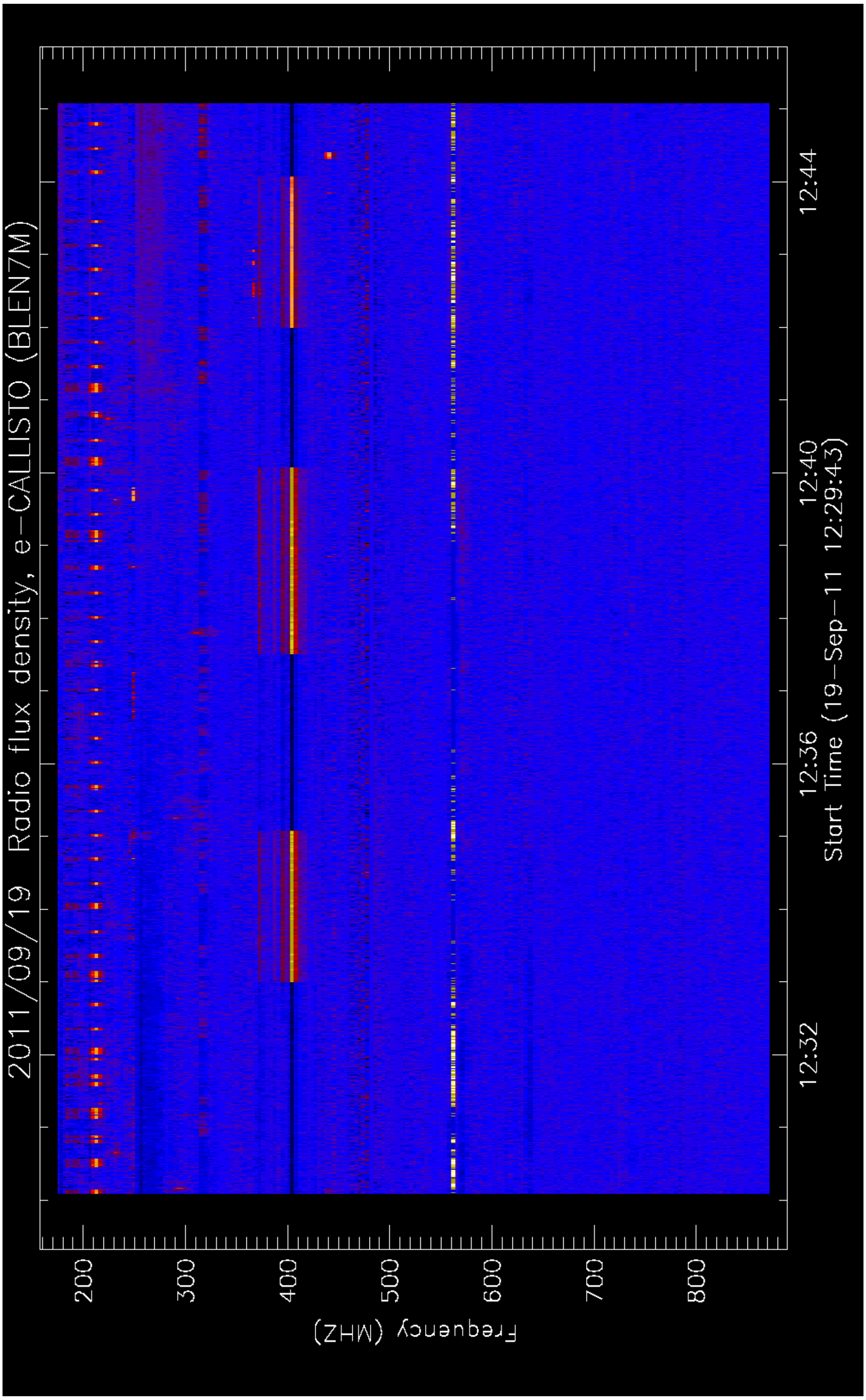

Figure 3. A formation of type III burst at 12:41UT. (Credited to the Institute of Astrophysics, ETH Zurich Switzerland)**.**

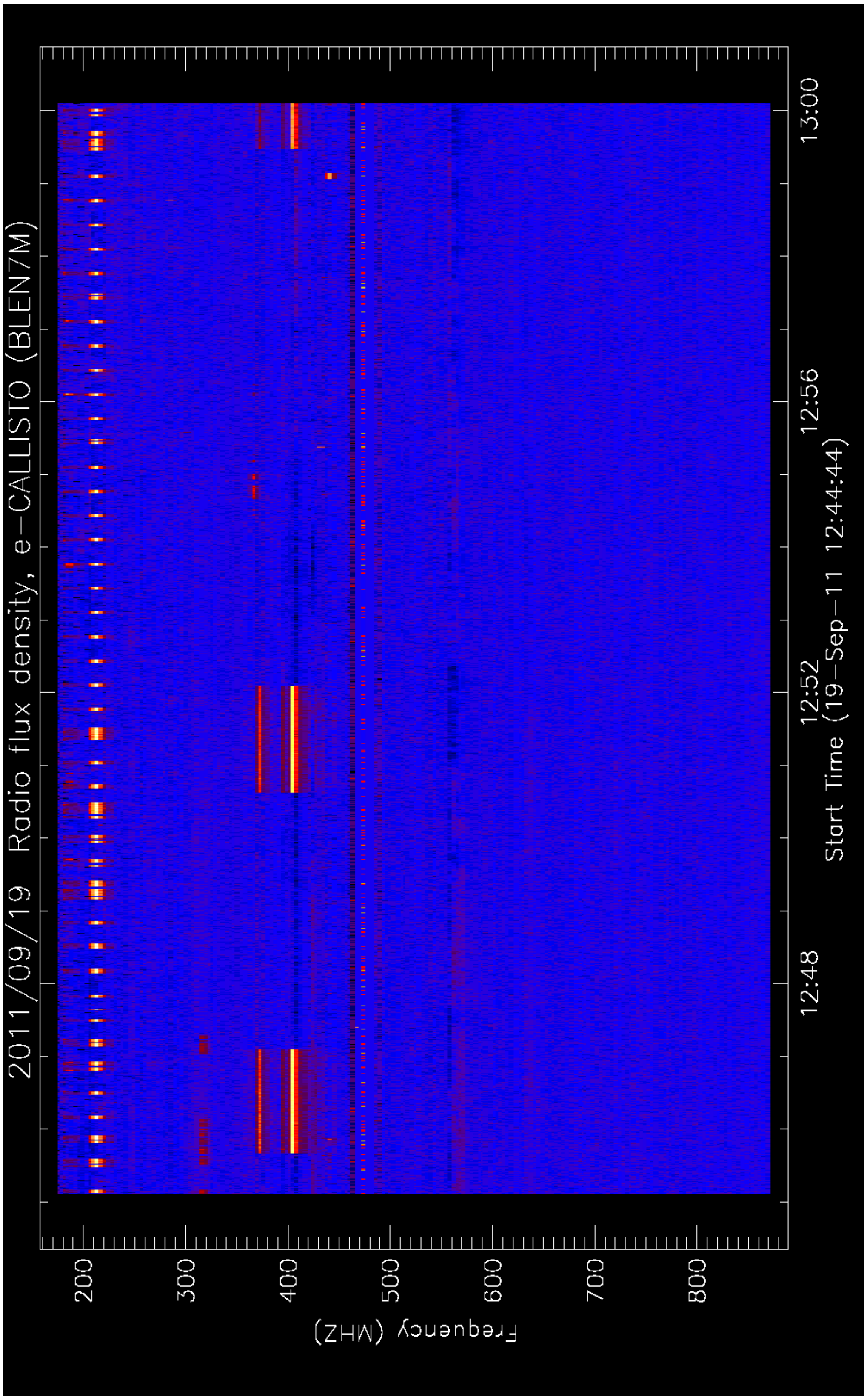

Figure 4. A continuity of type III burst. (Credited to the Institute of Astrophysics, ETH Zurich Switzerland)**.**

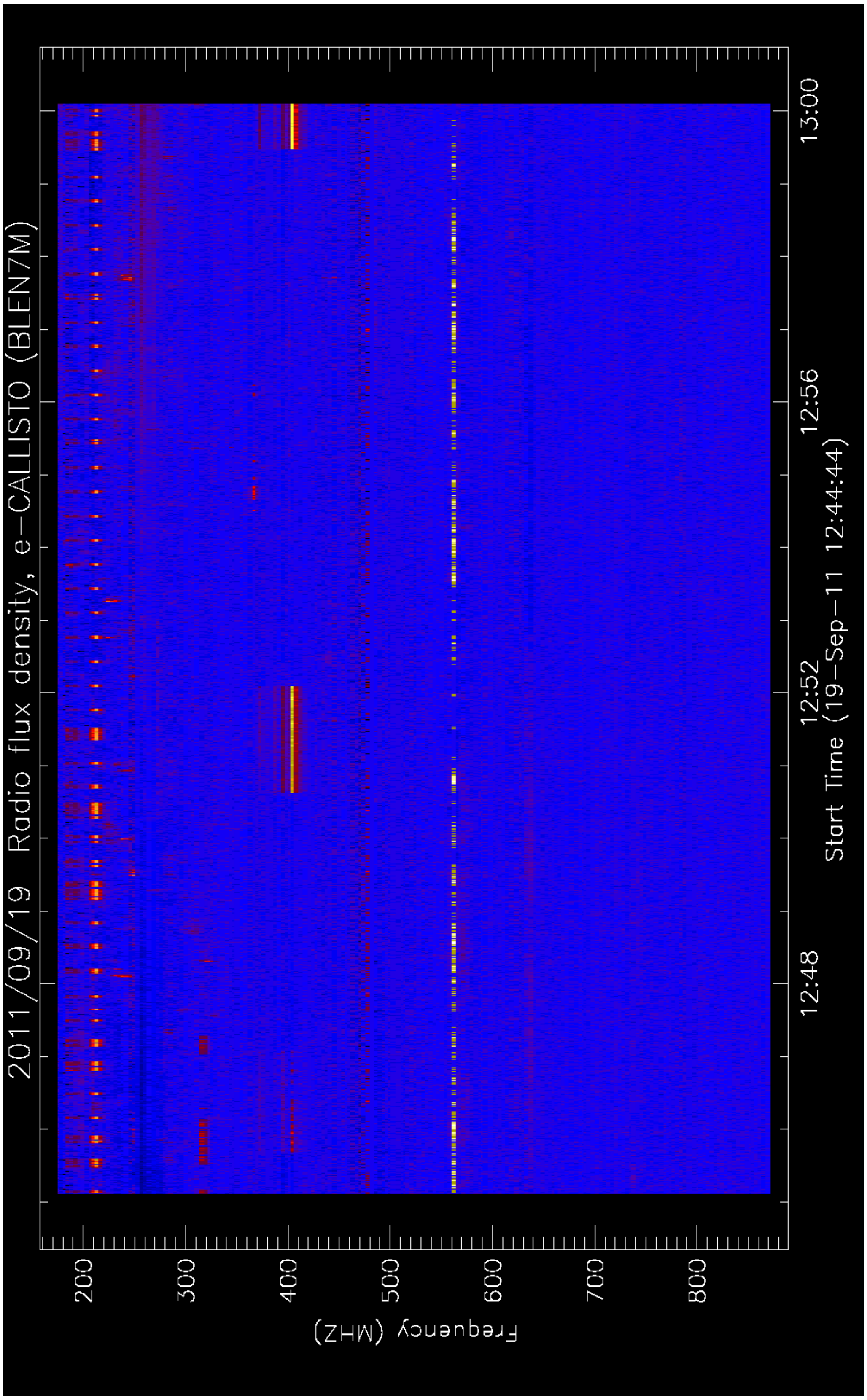

Figure 5. A continuity of type III burst. (Credited to the Institute of Astrophysics, ETH Zurich Switzerland)**.**

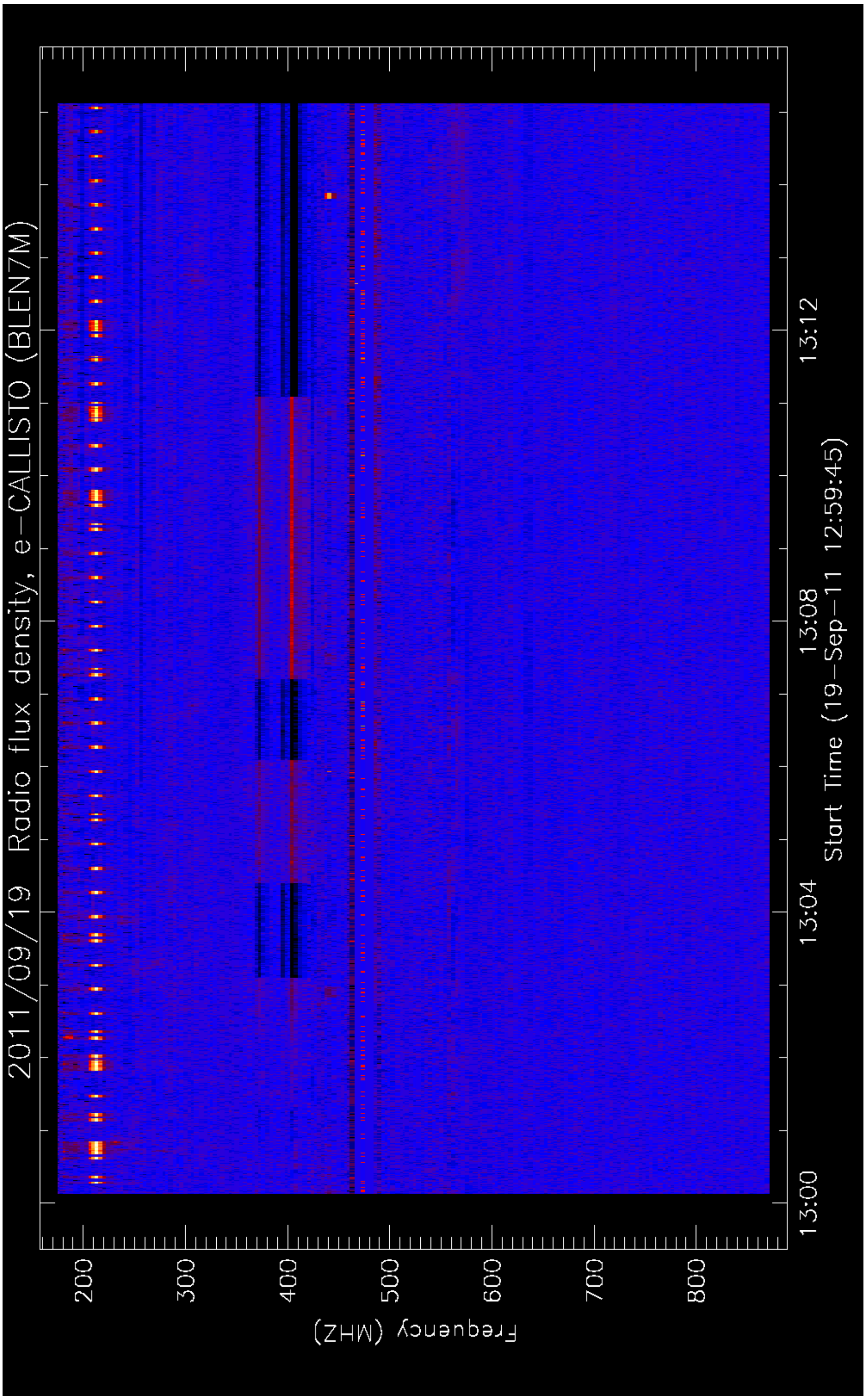

Figure 6. A continuity of type III burst. (Credited to the Institute of Astrophysics, ETH Zurich Switzerland).

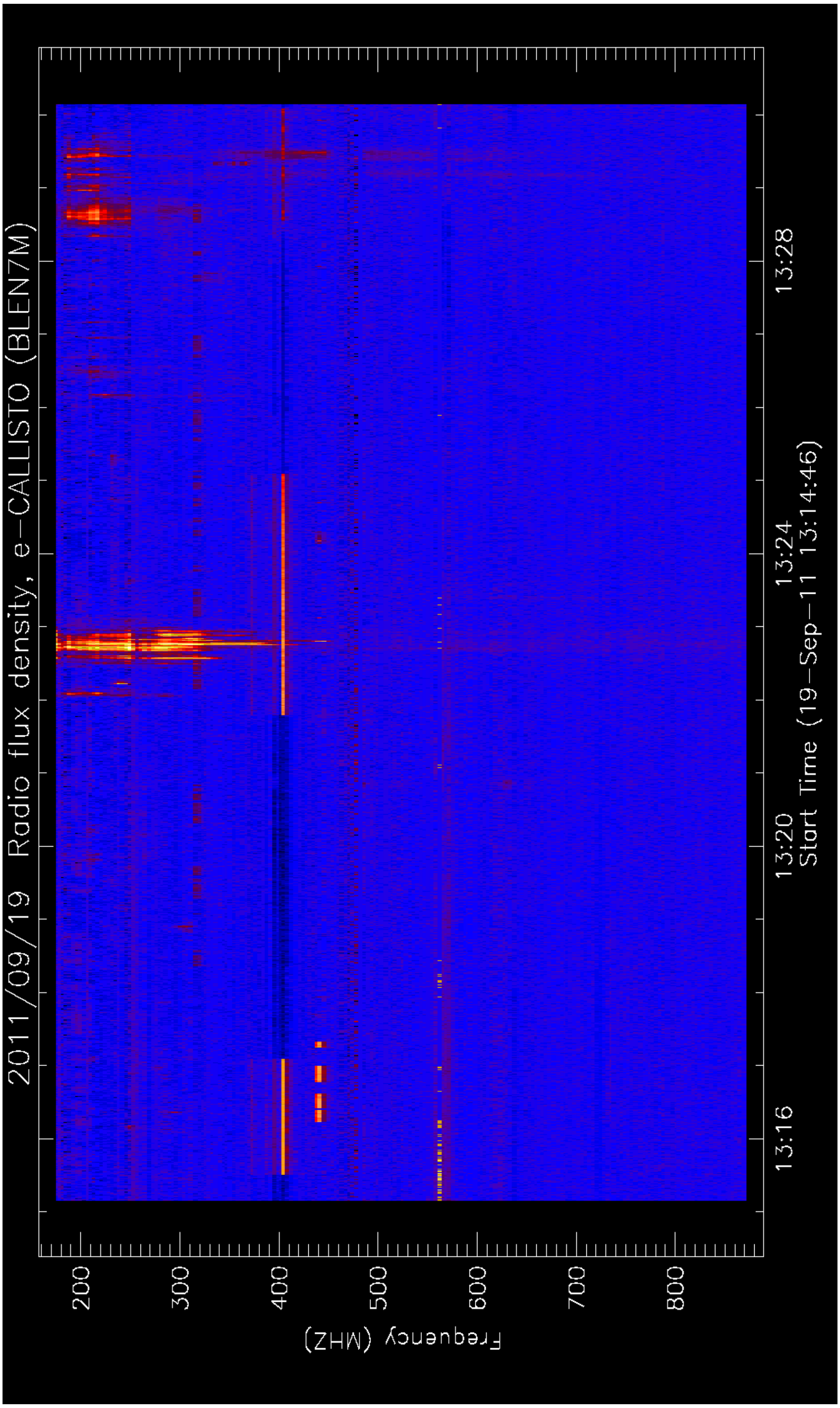

Figure 7. Solar radio burst type III and V (Credited to the Institute of Astrophysics, ETH Zurich Switzerland).

All data are taken from Blein, Switzerland site by using CALLISTO spectrometer. The flare originated from sunspot group 1295 and was again identified to be a type III solar burst. The particular frequencies range shown here are correspond to the detection solar burst type III at 13.23 UT from 393 MHz to 170 MHz. Later it was found that a solar burst type V is produced within five minutes after the type III burst. In the case of type V, the emission fast drifts from 230 to 180 MHz in frequency. Our analysis also showed that an intensity of the bursts is 53 SFU and 51 SFU respectively. There is also dominant radio frequency interference at 330 MHz caused by radio navigation. It should be noted that as the degree of X-ray radiation produced by a solar flare increased, the greater was the intensity of radio interference from the Sun. It was identified by GOES as an M class flare with a record the X-ray flux density of at least 2.8 $x10^{-4}$ Wm^{-2}. However, it does not affect too much on the data.

4. CONCLUSION

Type III and V are not always can be detected in radio region. The formation is very rare and occur during a high activity of the Sun. It depends on the number of active regions and the magnetic reconnection of the active regions. By investigating the types of solar radio burst, this will provide a better understanding of the space weather. Although the sources of both bursts are same, the direction and ejection explode differently. It is believed that the particles in a type III burst are higher than type V solar burst.

Acknowledgement

This work was partially supported by the PPP UM PV071/2011B grants. Special thanks to C. Monstein from ETH Zurich, Switzerland who set up and gives us training on analyzing the data. Also to National Space Agency and 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, MARA University of Technology 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.

Biography

Zety Sharizat Hamidi is currently a PhD candidate and study in Solar Astrophysics specifically in radio astrophysics at the University of Malaya. Involve a project under the International Space Weather Initiative (ISWI) and also a lecturer in School of Physics and Material Science, at MARA University of Technology, Shah Alam Selangor.

N.N.M..Shariff Her current research is communicating sustainability. She is looking forward for cross-field research i.e. solar astrophysics, light pollution measurement (mapping) and application of technology on sustainability.

References

[1] J. S. Hey, S. J. Parsons, J. W. Phillips, *Monthly Notices of the Royal Astronomical Society* 108 (1948) 354-371.

[2] S. M. White, *Asian Journal of Physics* 16 (2007) 189-207.

[3] P. A. Robinson, *Sol. Phys.* 134 (1991).

[4] J. P. Wild , Smerd S. F., Weiss, A. A., *Ann. Rev. Astron. Astrophysics* 1 (1963) 291-366.

[5] K. Kai, *Sol. Phys.* 11 (1970).

[6] A. F. Kuckes, Sudan, *R. N Sol. Phys.* 17 (1971).

[7] E. Y. Zlotnik, *Soviet Astron.* 12 (1968).

[8] V. V. Zheleznyakov, *Radio Emission of the Sun and Planets* (1970).

[9] P. Lantos, *Sol. Phys.* 22 (1972).

[10] G. B. A. L. Gelfreikh, B. I., *Soviet Astron.* 23 (1979).

[11] A. Vourlidas, Bastian T. S., Nitta N., Aschwanden M. J., *Sol. Phys.* 163 (1996).

[12] S. M. A. K. White, M. R., *Sol. Phys.* 174 (1997).

[13] D. E. K. Gary, C. U., *Solar and Space Weather Radiophysics*, Current Status and Future Developments Dordrecht: Kluwer, 2004.

[14] N. Gopalswamy, *Geophys. Res. Lett* 27 (2000).

[15] N. Gopalswamy, *Journal of Astrophysics and Astronomy* 27 (2006) 243-254.

[16] N. Gopalswamy, S. Akiyama, S. Yashiro, P. Makela, *Coronal mass ejections from sunspot and non-sunspot regions*, in: S.S. Hasan, Rutten, R.J. (Ed.), Astrophysics and Space Science, pringer, Berlin; Heidelberg, 2010a, pp. 289-307.

[17] A. Vourlidas, D. Buzasi, R. A. A. E. Howard, E., *Mass and energy properties of LASCO CMEs*, in: A. Wilson (Ed.), ESA Conference Proceedings, 2002a, pp. 91-94.

[18] A. O. Benz, C. Monstein, A. H. Meyer, *Solar Phys.* 226 (2005) 143-151.

[19] Z. S. Hamidi, et al., *International Journal of Fundamental Physical Sciences* 2(4) (2012) 72.

[20] Z. Hamidi, Z. Ibrahim, Z. Abidin, M. Maulud, N. Radzin, N. Hamzan, N. Anim, N. Shariff, *International Journal of Applied Physics and Mathematics* 2(3) (2012) 140-142.

[21] Benz A. O., C. Monstein, H. Meyer, *CALLISTO, A New Concept for Solar Radio Spectrometers*, Kluwer Academic Publishers, 2004.

[22] Z. S. Hamidi, N. N. M. Shariff, *International Letters of Chemistry, Physics and Astronomy* 4 (2014) 29-36.

(Received 08 December 2013; accepted 14 December 2013)