

Space Weather: The Significance of e-CALLISTO (Malaysia) As One of Contributor of Solar Radio Burst Due To Solar Activity

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ABSTRACT

The impact of solar activities indirectly affected the conditions of earth's climate and space weather in general. In this work, we will highlight a low cost project, however, potentially gives a high impact through a dedicated long-term and one of the most successful space weather project. This research is a part of an initiative of the United Nations together with NASA in order to support developing countries participating in 'Western Science' research. At the beginning of 2007, the objective to monitor the solar activities (solar flares and Coronal Mass Ejections) within 24 hours all over the world has positively turned to reality. Realize how important for us to keep doing a research about the solar bursts, by using the new radio spectrometer, CALLISTO. This research is not only hoping to give a knowledge to the people about how the solar bursts are produced, the characteristics of every type of solar burst at the wide range (45 MHz to 870 MHz) but also the effect of the solar burst toward the Earth. By using the same CALLISTO spectrometer within the 45-870 MHz, designing and leading by Christian Monstein from ETH Zurich, Switzerland, this research project is the one of successful project under ISWI program. Malaysia becomes the 19th countries that involve this research. One of the advantages to start the solar monitoring in Malaysia is because our strategic location as equator country that makes possible to observing a Sun for 12 hours daily throughout a year. We strongly believe that Malaysia as one of contributor of solar activity data through E-CALLISTO network. This is a very good start for developing a radio astronomy in Malaysia.

Keywords: Sun; radio emission; solar radio burst; Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy in Transportable Observatories (CALLISTO); solar flares; Coronal Mass Ejections (CMEs); space weather

1. INTRODUCTION

The investigation of the solar radio burst has made great progress in more than a decade beginning with ground observation and become one of the most significant current discussions on space weather issue. The study of space weather generally covers the conditions in the solar flare and CMEs (Coronal Mass Ejections) that can affect life on the surface of the Earth, particularly the increasingly technologically sophisticated devices that are part of modern life [1]. These phenomena can also be detected from ground-based telescope observations by using radio telescopes. The radio observations have been carried out since 1944 when J. S Hey discovered that the Sun emits radio waves [2]. 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 side by the troposphere

It is widely accepted that the Coronal Mass Ejections (CMEs) and solar flares of explosions provide powerful insight into the nature of their progenitors. It is well known as one of the most enormous eruptions of magnetized plasma expelled from the Sun into the interplanetary space, which potentially create major disturbances in the interplanetary medium and trigger severe magnetic storms when they collide with the Earth's magnetosphere.

As indicated with radio signatures so-called type II and III bursts it also divided by sub-type of burst depending on the physical characteristics and different mechanisms. The impact of solar activities indirectly affected the conditions of earth weather. Interestingly, in some cases, the solar flares may be only a minor part of a much larger destabilization of the corona, when the magnetic confinement of a considerable part of the corona is broken up. It expands and is expelled by magnetic forces in a Coronal Mass Ejections (CMEs). CMEs have been studied extensively since 1970s. The CME phenomenon was discovered only in 1971 [3] but has become the most important form of solar activity because it is the most energetic phenomena on the Sun with a wide range influence throughout the heliosphere. The front speeds could exceed up to 3000 km/s [4-6]. This phenomenon can exhibit a variety of forms, some having the classical "three-part" structure [7].

Meanwhile, solar flares are considered the highly energetic and complicated phenomena in which mass eruptions occur, energetic particles are generated and highly energy radiations are emitted. During a solar flare, large quantities of energy are transferred between the corona and chromosphere through thermal conduction, non-thermal particle beams, radiation transport, and mass motions. These eruptive phenomena are due to instabilities of equilibrium of coronal magnetic field. Electrons located near the loop apex are accelerated to high energies and travel downward through the atmosphere, depositing energy and producing a hard X-ray which is also known as a Bremsstrahlung radiation. Since the magnetic force is much stronger than other forces in the corona, any coronal structure is mainly controlled by magnetic field.

Here, we focus on radio region at low frequency that covers from 45 MHz till 870 MHz. The main objective is to monitor the solar activities (solar flares and CMEs) within 24 hours all over the world has positively turned to reality [8]. The objective of this research is to advance the space weather science by a combination of instrument deployment, analysis and interpretation of space weather data from the deployed instruments in conjunction with space data, and communicate the results to the public [9]. One of the strategies is to develop the scientific insight necessary to understand the science, and to reconstruct and forecast near-Earth

space weather. This includes instrumentation, data analysis, modeling, education, training, and public outreach.

2. STRATEGIC PLANNING AND SCIENTIFIC ACTIVITIES

2. 1. Strategic Planning

The CALLISTO (Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy in Transportable Observatories) spectrometer is a heterodyne receiver designing and leading by Christian Monstein and Radio and Plasma Physics Group from ETH Zurich, Switzerland [9]. There are a few designs of a frequency-agile or swept-frequency spectrometers, which are currently in operation in several places, including China [10] Hiraio [11], Ondrejov [12], Sao Paolo [13] and Tremsdorf [14]. ETH Zurich also operates broadband spectrometers since many years.

To date, there are 28 stations around the world that actively observe the Sun routinely. Up to date, this project has successfully achieved more than 90 percent target in order to monitor the Sun within 24 hours. Figure 3 shows the coverage of the maps and duration of monitoring the Sun recently. There are still a few hours need to be covered and it will be better if we possible to fulfill the gap between 16:00-18:00 UT from December to February and October till December. Due to 12 hours monitoring, Malaysia almost covered fifty per cent of the CALLISTO data [15]. This should make our data should be reliable and consistent. It is also an advantage for us to observe solar activities, especially solar flare and Coronal Mass Ejection (CMEs) phenomena in a long term period. So far, there are 25 sites that are confirmed to obtain a daily data from CALLISTO network.

Meanwhile, the development solar radio astronomy in Malaysia is not only from scientific aspects, it is also covered from antenna design to communication and radar technologies [16-19]. Malaysia becomes the 19th countries that involve this research. We started by proposing this research in early 2011, through the National Space Agency of Malaysia (ANGKASA), University of Malaya (UM), National University of Malaysia (UKM) and the MARA University of Technology (UiTM). Previous studies conducted by Zamri et al. (2009) investigated the radio frequency interference (RFI) [20,21] that future Very Long Baseline Interferometer (VLBI) observations in Malaysia may encounter [22]. By 2011, we have constructed 6 meters Log Periodic Dipole Antenna (LPDA) and successfully set-up the CALLISTO system at National Space Centre, Banting Selangor on 20th February 2012 [23-27]. Start from that, a daily data beginning from 07.30 am to 19.30 pm is automatically stored. This data also accessible on CALLISTO website: <http://www.e-callisto.org/> and can be compared with other sites. As can be seen from Figure 1, we highlight the duration period of solar burst monitoring in Malaysia within 24 hours throughout the year.

Until now, the number of people interested to pursue research in this field is increasing. The data of solar activity associated with solar burst also become much more relevant. Especially toward 24th year cycle, there are more sun activities that will be observed. In this case, the role of radio region monitoring is very important. We could possible to detect a large flare and Coronal Mass Ejections (CMEs) for instance if we alert on it. Therefore a 24 hour solar monitoring is very significant to fulfill this work. In addition, with international collaboration, there are many advantages that we could gain. We can compare the data, and choose a high quality data if there are a site that polluted by interference for instance. The CALLISTO system and the Log Periodic Dipole Antenna are shown in Figure 2.

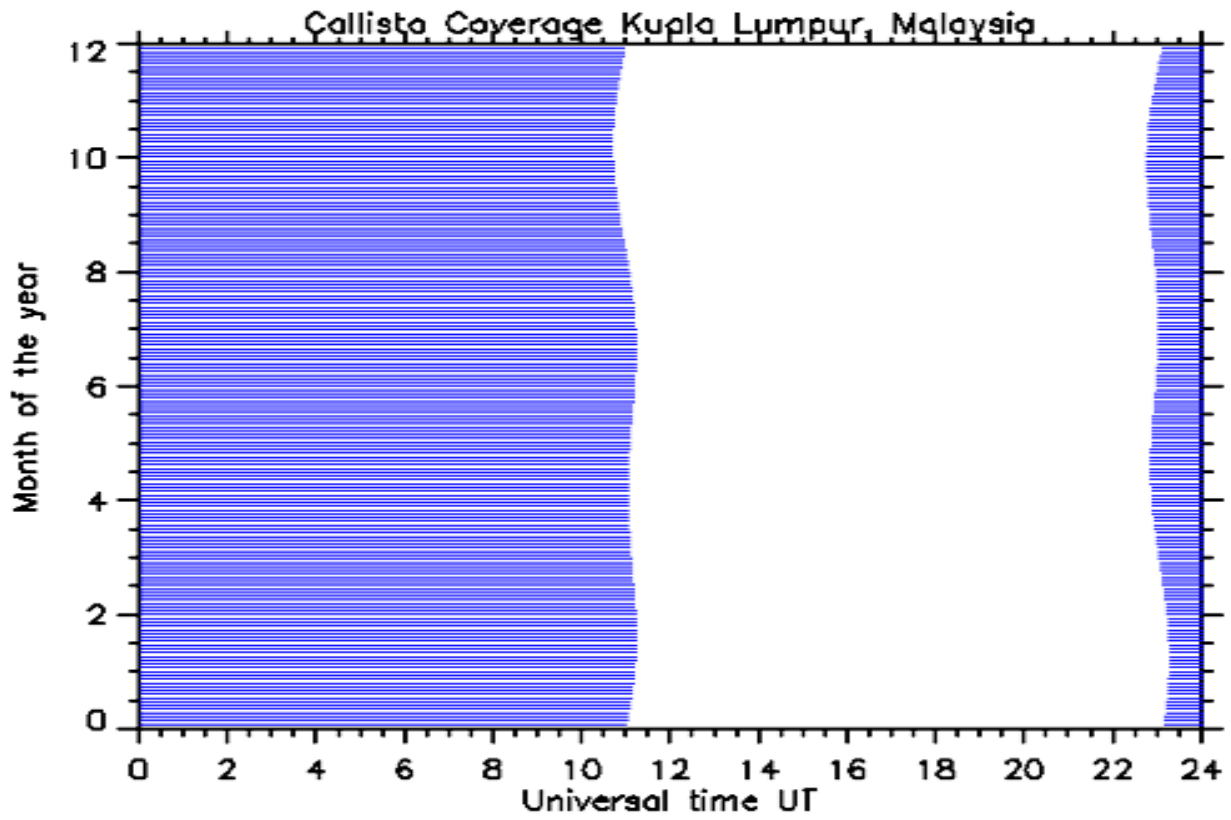


Figure 1. The coverage of solar burst monitoring in Malaysia.



Figure 2. The Log Periodic Dipole Antenna (LPDA) at National Space Centre Banting Selangor.

2. 2. Scientific Activities

Our first light detection of solar bursts occurred on 5th March 2012 associated with solar flare type M 2.0. We also successfully detected a few solar bursts such as type II, type U and type III associated with solar flares and Coronal Mass Ejections. Routinely, once per day a cron-job (PERL) gets in contact with the instrument holder, reads the directory, selects files of interest and uploads them to the main server in Switzerland. Data will be saved based on the duration of period of daylight in Universal Time (UT) and compile every 15 minutes. All data can be achieved from the e-CALLISTO websites initiated by Institute of Astrophysics, Switzerland. This observational data are limited only a good range of frequency with minimum interference. In order to keep data only with high probability of containing solar radio flares, a filter method also be used from time to time. This 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 Technische Hochschule in Zurich). A free-software can be used to transfer the data, such as FTP-watchdog could replace a function of FTP server and make the process of the data can be automatically transferred into a table based on the timing of the solar activities. For the basic data reduction purpose, we can use JAVA software to subtract the data from background noise. All data can be analyzed in detail with IDL (Interactive Data Language) program.

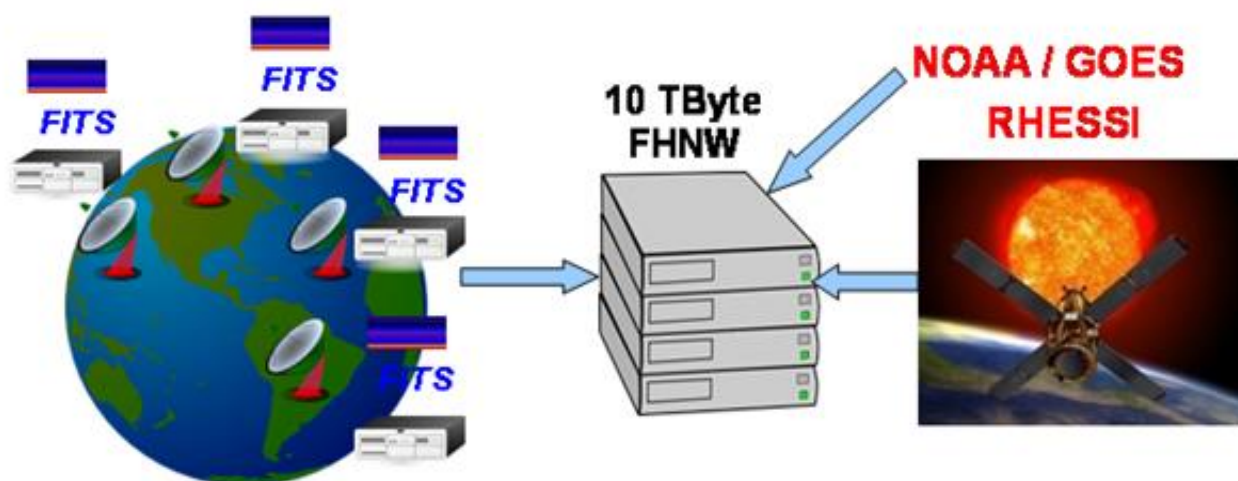


Figure 3. The Dataflow from observatories to the archive (Credited to C.Monstein, ETH Zurich, Switzerland).

However, as more and more diverse uses for the radio spectrum emerge, the number of signals that may potentially cause interference inexorably increases. The increasing of technological applications exponentially affected the range that is suitable for solar observations. Moreover, the sensitivity of equipment and other ground based noise also produce some minor impact of the noise level. In addition, population density and site of observations also need to be considered. Nevertheless, the growing demand on electromagnetic spectrum, especially in the radio wavelength cannot be neglected.

This scenario has happened all over the world. The aims in this paper are based mainly focus on the role of Malaysia as one of significant contributors o solar radio burst data. One of the advantages of solar monitoring in Malaysia is due to our strategic location as equator country that makes possible to observing a Sun for 12 hours daily throughout a year. This makes our data much more consistent with a long duration compared other countries. As an active member of the Working Group of Radio Astronomy in South East Asian Astronomical Network (SEAAN), we are committed to the mission and vision of the group in order to establish effective mechanisms for nurturing and sharing the development and experiences in astronomy research and education among South-East Asian countries.

3. CONCLUSIONS

In this work, we highlighted the potential role of Malaysia as one of the candidate sites that possible gives a good data and focusing on a few aspects such as optimization, and performance evaluation data and visualization. As a conclusion, we strongly believe that Malaysia can be one of a main contributor of solar activity data through the e-CALLISTO network. This is a very good start for developing a radio astronomy in our country. Therefore, the National Space Centre, Sg. Lang, Selangor is one of the prime candidate sites for the first radio astronomy research. However, there are many aspects need to be considered. Further actions need to be taken to prove solar monitoring studies are very important and should be extended. Besides, collaboration both nationally and internationally is really recommended. In general, this field encompasses many science, engineering and mathematics disciplines. We hope that we can contribute a very relevant data that might possible to answer the dynamical behavior and structure of the Sun. Although the solar activities have experienced rapid growth recently, high-level management of the CALLISTO system has remained successfully manage the storage of data. Further actions need to be taken to prove solar monitoring studies are very important and should be extended. As sensing and monitoring technology continues to improve, there is an opportunity to deploy sensors in this system in order to improve their management. It is also not easy to maintain the future data seems the numbers of sites are also growing from time to time.

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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.

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C. Monstein is an engineer at Institute of Astrophysics, ETH, Switzerland that develop the e-CALLISTO network.

Zainol Abidin Ibrahim currently is a Professor at Dept. of Physics, Faculty of Science, University of Malaya, Malaysia.

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