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Observation of Solar Radio Waves by CALLISTO Radio Spectrometer in Ibaraki University

Natsuki Tsuda　Satoshi Nozawa (Ibaraki Univ.)

1. Abstract

In the Sun, sudden explosion phenomena called solar flare occur and characteristic electromagnetic waves are emitted, but details of radiation mechanisms are not known. There are 5 types of solar radio bursts cause of solar flare, classified from time change of radio waves. Solar radio type-III bursts appear in several kilo hertz to several giga hertz frequencies and they are characterized by a rapid frequency drift from high to low frequencies. These radio waves are emitted by high energy electron streams accelerated by solar flare. In Ibaraki University, we observe solar radio waves by CALLISTO radio spectrometer and meter wave band log-periodic antenna to understand generating progress of high energy electrons from solar flare.

C8 class flare occurred in April 2nd, 2017 and we succeed in observation of solar radio type-III burst from this flare. This success of observation is the first observation with CALLISTO in Japan. Now we analyze the data and compare with other observatory's data.

2. Observations

Our CALLISTO radio spectrometer is used from e-CALLISTO worldwide network. Our location is at Mito, Ibaraki prefecture in Japan.

This is the change of observational instruments from April 2015:

・April – August 2015　Performance tests on the rooftop of G building in Ibaraki University (about 100km north of the Tokyo). We use TV antenna to test performance at that time.

・August 21 – 27 2015　Performance tests in Nobeyama radio observatory.

・September – November 2015　Setting up instruments on the rooftop of building in Ibaraki University.

・November 2015　Started automate observation. After adjusted amplifier and filter.

・August 2016-　Provided present instruments.

Present instruments

・Observation spot　Ibaraki University rooftop of building, 36.4 N° 140.44 E° altitude 32 m

・Observation time　1:00 - 6:00 (UT)

・Observation band　100 – 850 MHz　(attenuate TV frequency band 468 – 568 MHz)

・Time resolution　0.5 seconds

・Antenna　Log-periodic antenna　made by Creative Design Corp. CLP 5130-1

Frequency band　50 – 1300 MHz , non-rotated

・Filter　Notch Filter　made by Japan Correspondence Machines and Tools co.

Attenuate band　468 – 568 MHz

・Amplifier　Gain 30 dB　made by Mini-Circuits　ZRL-700+

・Attenuator　Attenuation 20 dB made by Mini-Circuits　UNAT-20+

Figure 1.　Instruments on rooftop

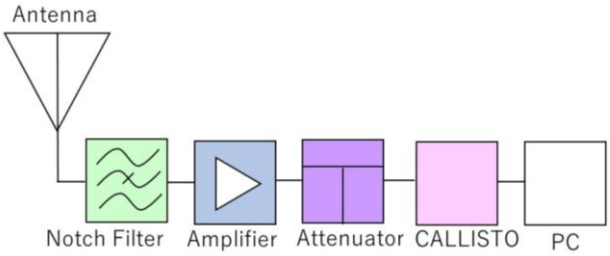

Figure 2.　Instruments schema

Figure 3.　Antenna

Figure 4.　PC and CALLISTO in cabin

3. Observational Results

This figure is result of observation in 2:31 – 2:45 (UT) April 2nd 2017. This data took difference between raw data of 2:31-2:45(UT) and averaged spectrum of 1:30 – 1:45 (UT) April 2nd 2017.

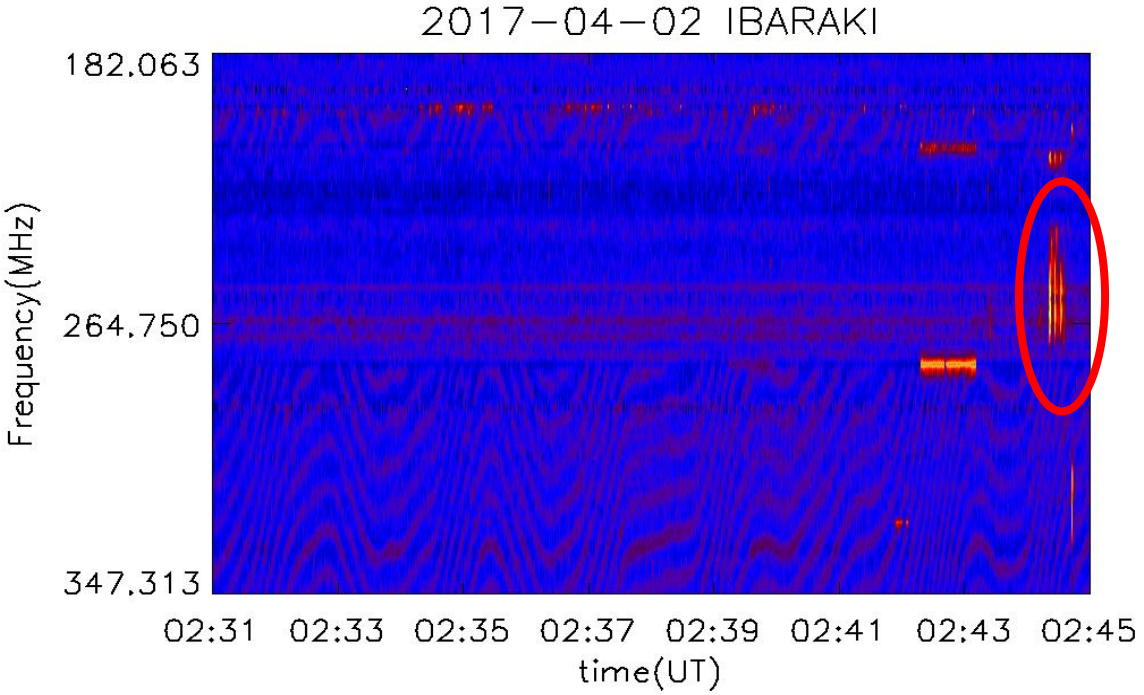

Figure 5. Result of observation in 2:31 – 2:45 (UT) April 2nd 2017 in Ibaraki Univ.

In this figure, about 2:44, about 250 MHz band intensity is high. These are radio waves of C8 class flare occurred April 2nd .

This figure is result of observation in 2:44 – 2:45 (UT)

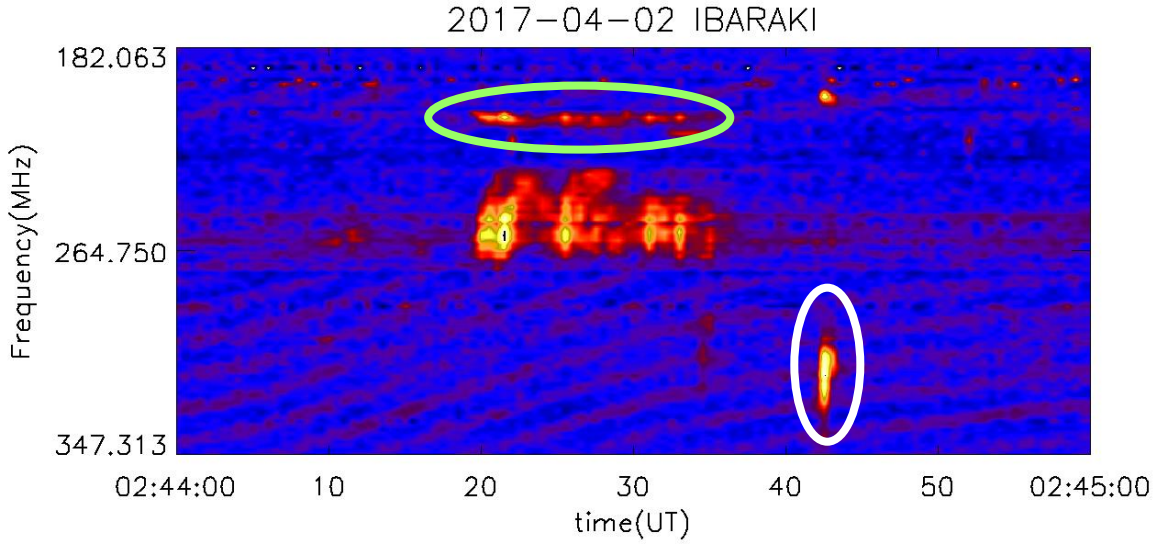

Figure 6. Result of observation in 2:44 – 2:45 (UT)

4. Comparison with other observatory's CALLISTO

These two figures are data of other observatory's CALLISTO.

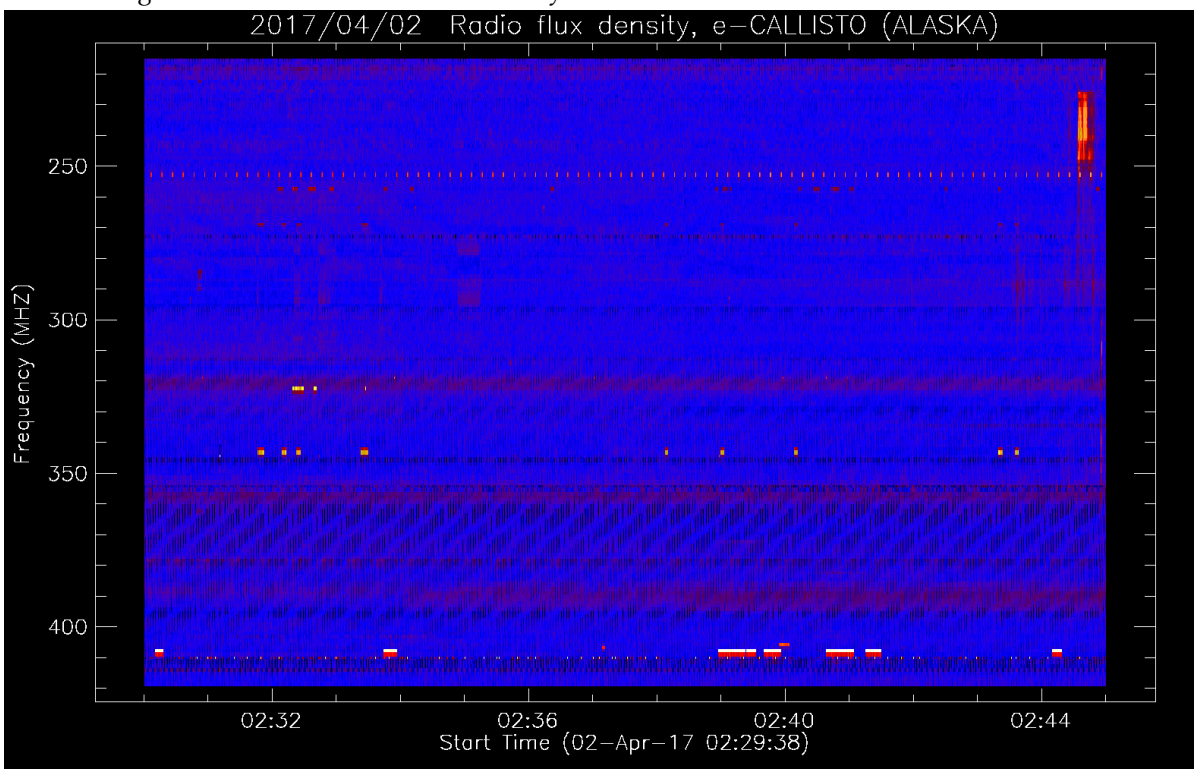

Figure 7. Data of observation in 2:30 – 2:45 (UT) April 2nd 2017 in ALASKA

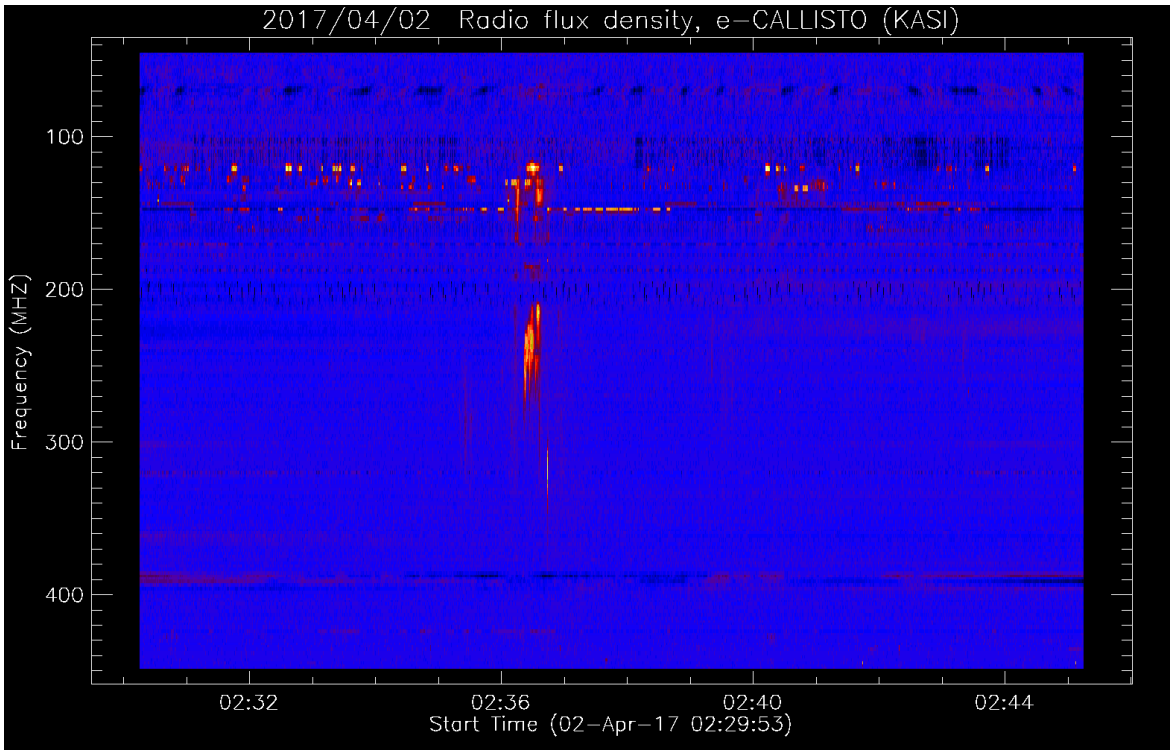

Figure 8. Data of observation in 2:30 – 2:45 (UT) April 2nd 2017 in KASI

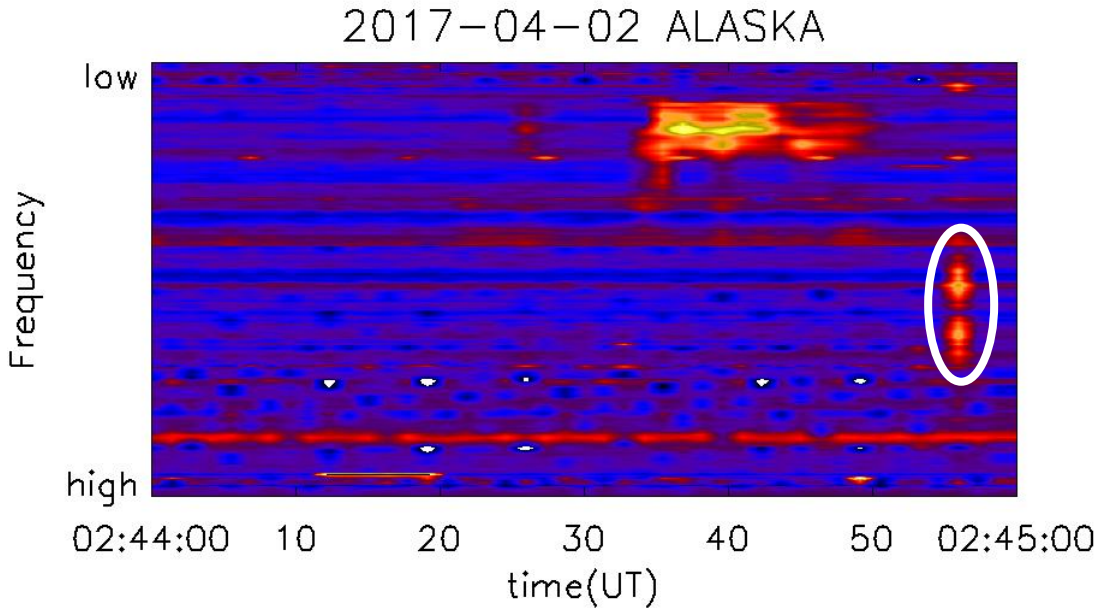

Figure 9. Data of observation in 2:44 - 2:45 (UT) in ALASKA

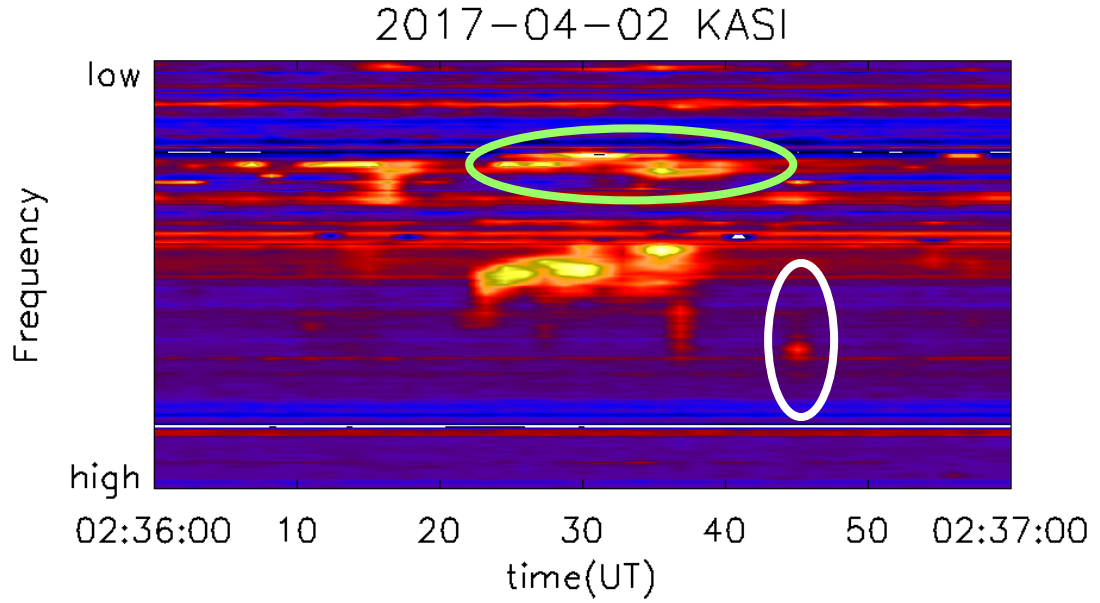

Figure 10. Data of observation in 2:36 - 2:37 (UT) in KASI

Comparing Figure 5, 7, 8, the start time of burst in ALASKA and Ibaraki Univ. is same time, but in KASI, burst start 8 minutes earlier than other observatory. According to Dr. Kim Sujin in KASI, the clock was clashed so it is hard to know correct start time in KASI.

Comparing Figure 6, 9, 10, the result of Ibaraki Univ. , the start time of burst is 15 seconds earlier than ALASKA. This difference of 15 seconds is under investigation, which is assumed uncollected time of our PC's clock.

There are some same points in Figure 6, 9, 10. The strong radio waves in white circle in 3 figures appeared about 5 seconds after first radio waves disappeared. And in Ibaraki Univ. and KASI, the strong radio waves of green circle appeared.

5. Comparison with the data of NICT Yamagawa radio observatory

This figure is the data of NICT Yamagawa observatory in 2:44-2:45 (UT).

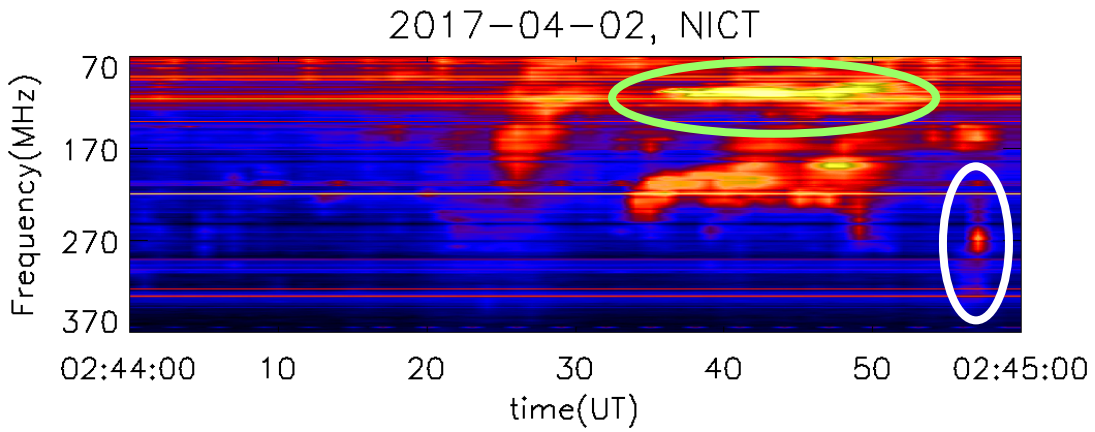

Figure 11. Data of observation in 2:44 - 2:45 (UT) in NICT

Comparing figure 6 and figure 11, there are same points in white circle and green circle. And the start time of Ibaraki Univ. is 15 seconds earlier than NICT. According to Dr. Kazumasa Iwai in Nagoya University, it is hard to consider the difference of 15 seconds because of difference of observatory.

6. Comparison with GOES X-ray flux and SMART Hα in Hida observatories of Kyoto University

These figures are superposition data of intensity of 263 MHz radio wave observed in Ibaraki Univ. and GOES X-ray flux and intensity of Hida observatories SMART Hα intensity.

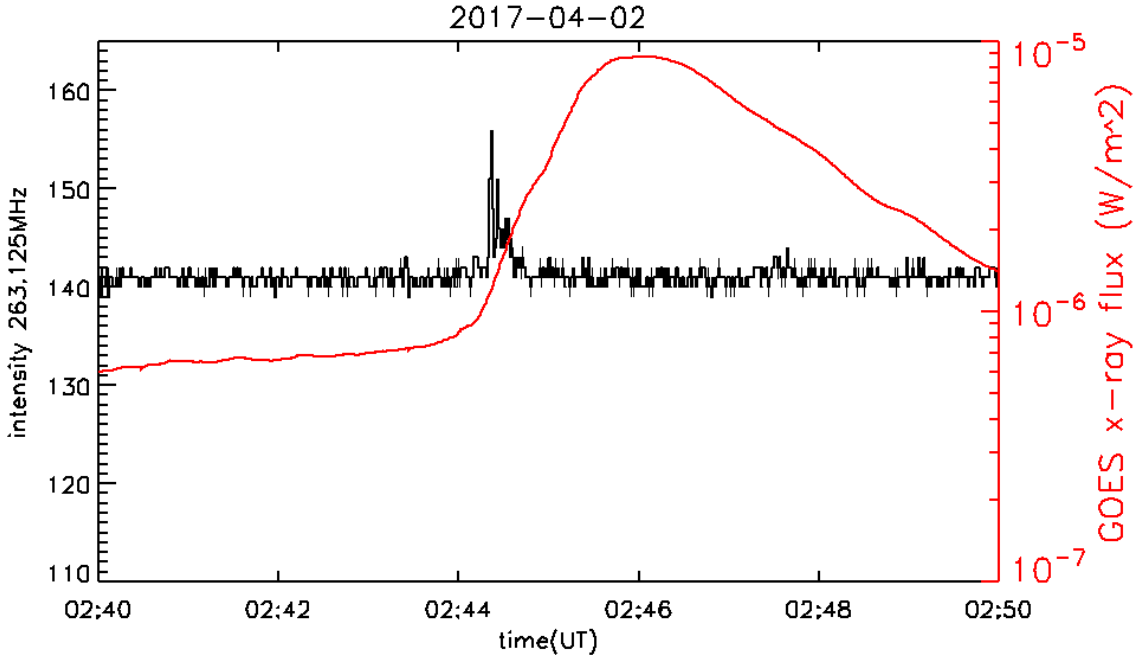

Figure 12. 263 MHz radio wave intensity and GOES X-ray flux in 2:40-2:50 (UT)

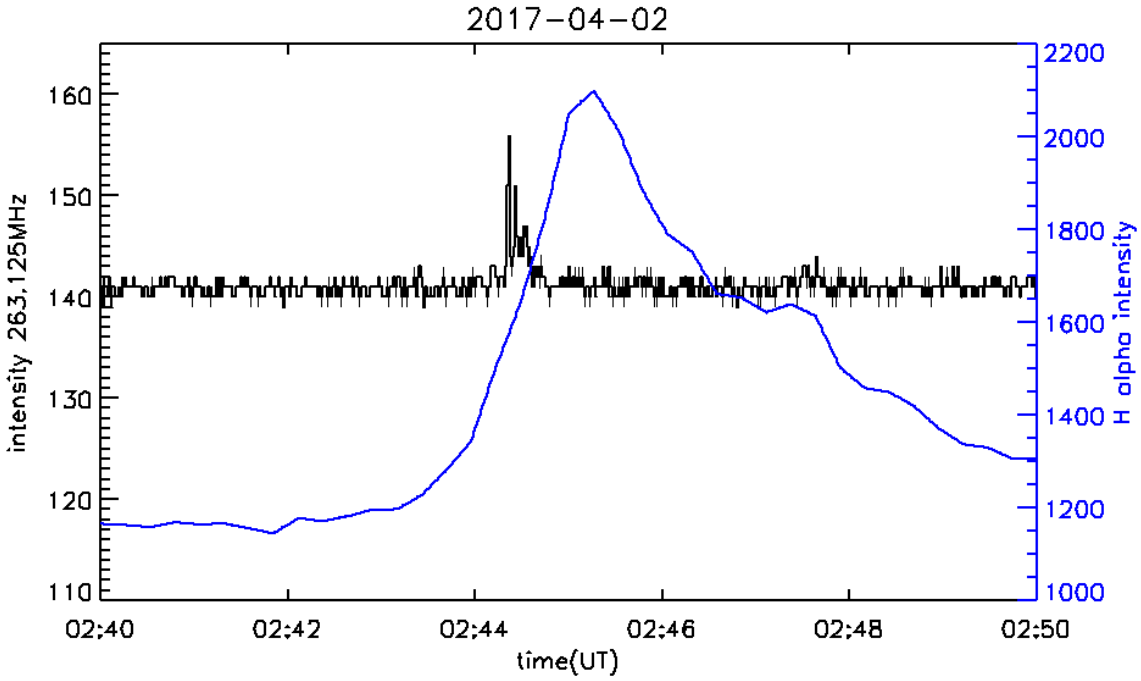

Figure 13.　263 MHz radio wave intensity and SMART H α　intensity in 2:40 - 2:50 (UT)

Emission of electromagnetic waves in solar flare, peaks of X-ray and H α　appear soon after solar radio type-III burst appeared. In figure 12 and 13, there is correlations of electromagnetic waves.

7.　Future schedule

In the future, we will investigate the difference of 15 seconds and calibrate observation data. And we will offer and open data of Ibaraki Univ. to e-CALLISTO.