

MEASURING SOLAR RADIO BURSTS IN THE 20-650MHz RANGE

The improved ARTEMIS IV multichannel solar radio spectrograph of the University of Athens

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Abstract- We present the improved solar radiospectrograph of the University of Athens operating at the Thermopylae Satellite Station. Observations now cover the frequency range from 20 to 650 MHz. The spectrograph has a 7-meter moving parabola feeding by a log-period antenna for 100 to 650MHz and a stationary inverted V fat dipole antenna for the 20 to 100 MHz. Two receivers are operating in parallel, one sweep frequency for the whole range (10 spectra/sec, 630 channels/spectrum) and one acousto-optical receiver for the range 270 to 450 MHz (100 spectra/sec, 128 channels/spectrum). The data acquisition system consists of two PCs (equipped with 12 bit, 225ksamples/sec DAC, one for every receiver). The daily operation is fully automated: receiving universal time from a GPS, pointing the antenna to the sun, system calibration, starting and stopping the observations at preset times, data acquisition, and archiving on DVD. We can also control the whole system through modem or Internet. The instrument can be used either by itself or in conjunction with other instruments to study the onset and evolution of solar radio bursts and associated interplanetary phenomena.

Key words: instrumentation, solar radio astronomy, solar radio bursts, radiospectrograph

Introduction

Radio Spectrography of the solar corona, at decimeter, meter and decameter wavelengths, provides basic information on the origin and early evolution of many phenomena which later extend and some of them reach the Earth. The Artemis IV solar radiospectrograph at Thermopylae is a complete system that receives and records the dynamic spectrum of solar radio bursts on a daily basis [1], [2]. It consists of: two antennas, two receivers and two PC with A/D converters. (Fig. 1)

The Two Antennas

The solar radiospectrograph has a parabolic and a dipole antenna (Fig. 2).

The parabolic antenna has a diameter of 7m and is feeding by a log period antenna for the 100-650MHz region. This antenna has a length of 2.25m and consists of 13 dipoles. Mean gain is 21db and mean half power beam width 6° . The antenna has a typical equatorial mounting and follows the sun. After collection the signal goes to band pass filters and multistage amplifiers. Every morning the system is self-calibrated by a noise generator and starts automatically the antenna movement (Fig. 3)..

The dipole antenna is a stationary very fat inverted V dipole, on the east-west plane. Every leg has a length of 3.5 m and a width of 1m. It is constructed by copper tube [3], [4]. The two legs form a 90° corner and its apex is 3.6m above ground. The antenna receives the sun radio signals during all the day and a lot of interfering signals because it is almost omni directional. After collection the signal goes through a floating band pass filter ($f_H=90$ MHz and $f_L=20$ MHz). Follows an active balun – broadband amplifier

A *combiner* combines the signals from the two antennas and drives them to the control room through a 50 Ohm, 70m long transmission line.

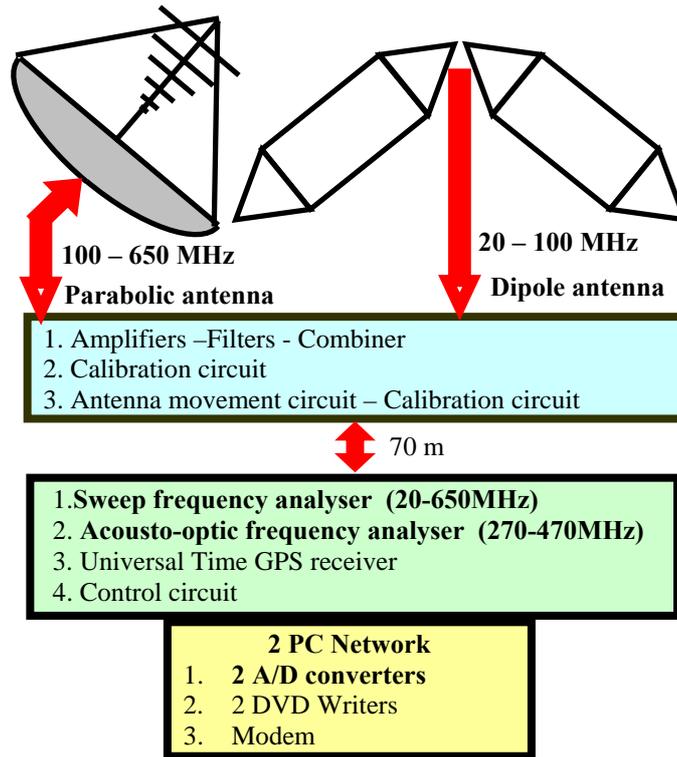


Figure 1. ARTEMIS IV solar radiospectrograph block diagram



Figure 2. The two antennas at Thermopylae

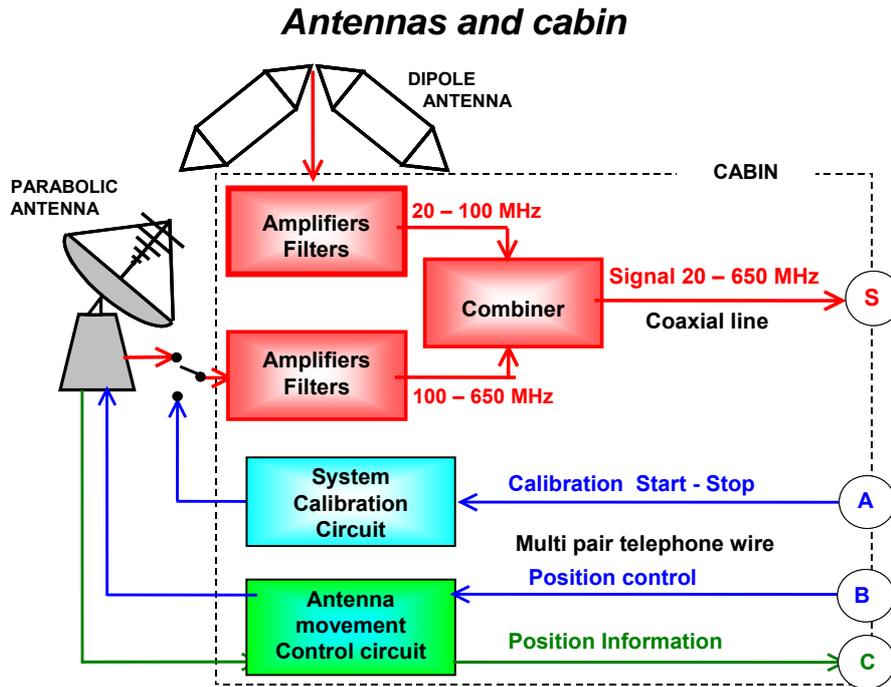


Figure 3. Antennas and cabin block diagram

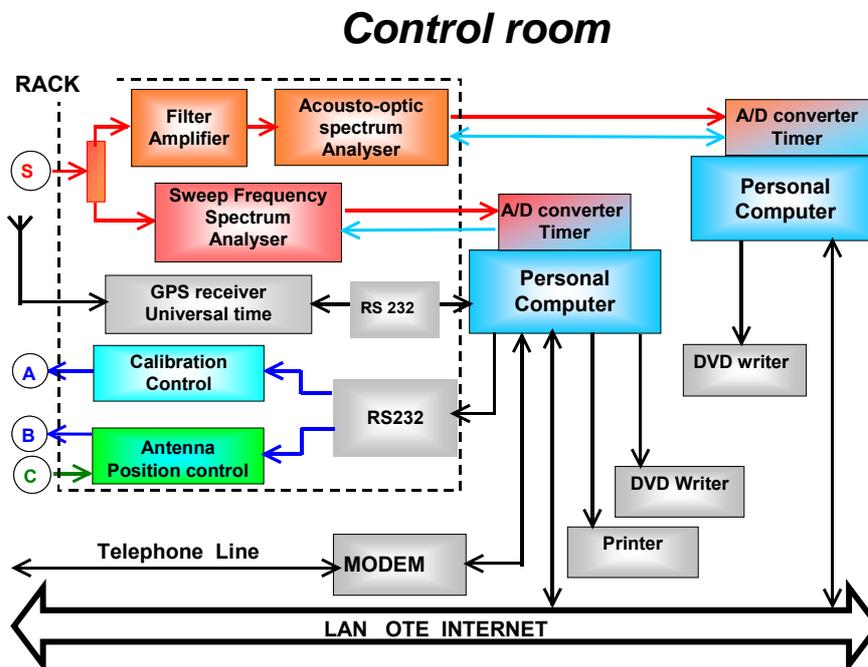


Figure 4. The control room block diagram

The Two Receivers and Data Acquisition

The signal enters into the control room through the transmission line. A splitter splits the signal in two ways.

First way (Fig. 4).. It includes a classical sweep frequency analyzer (Analyseur de Spectre Global or ASG) which covers the whole range from 20 to 650MHz at 10 sweeps/sec with instantaneous bandwidth 1MHz and dynamic range of 70 db.

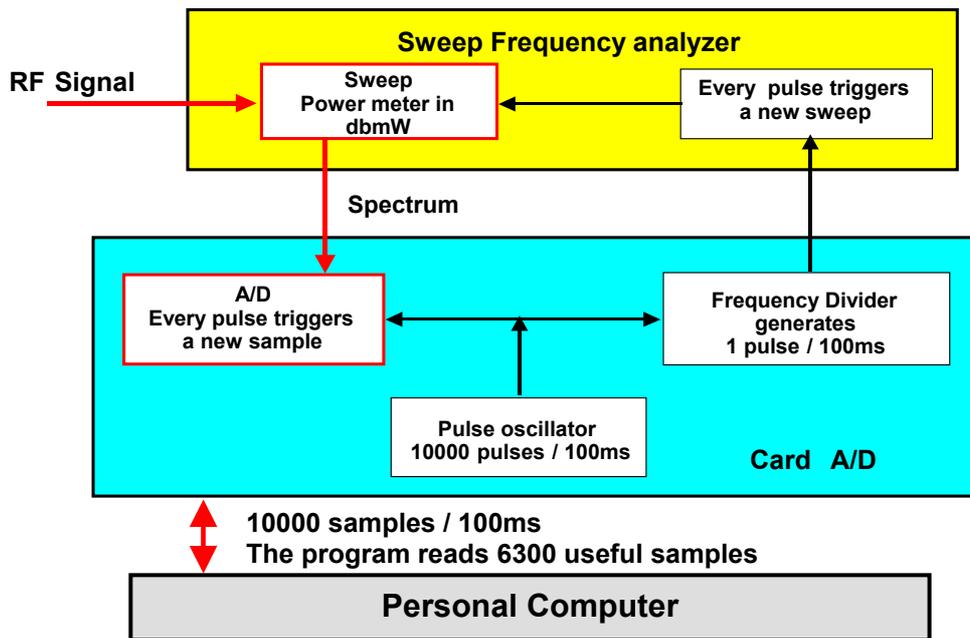


Figure 5. Timing the A/D converter and sweep analyzer

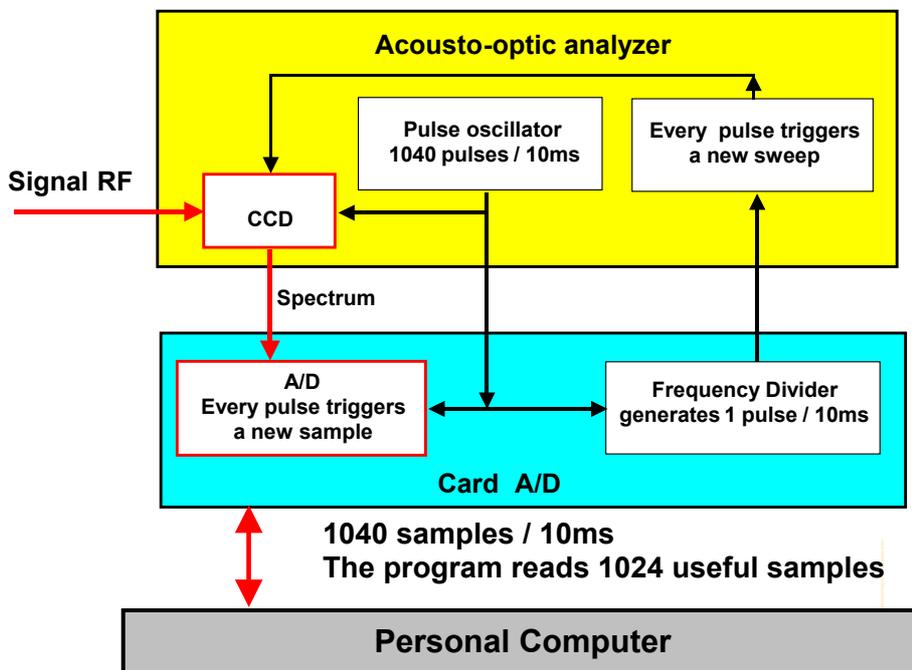


Figure 6. Timing the A/D converter and acousto-optic analyzer

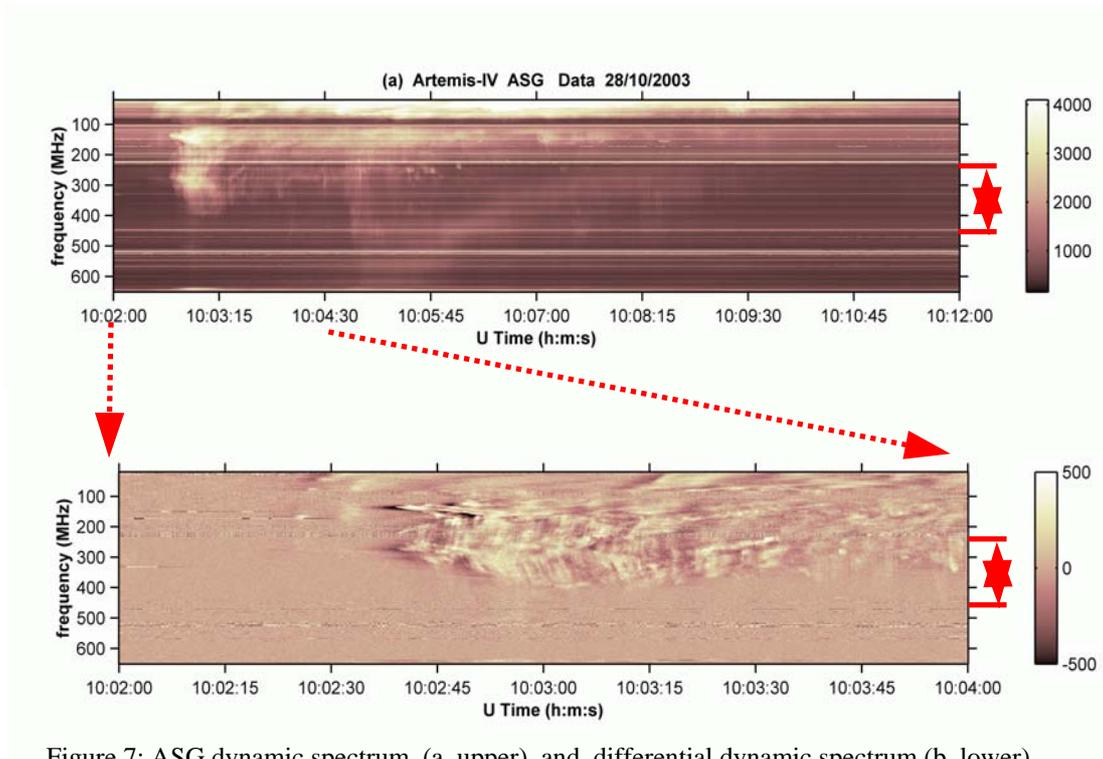


Figure 7: ASG dynamic spectrum (a, upper) and differential dynamic spectrum (b, lower)

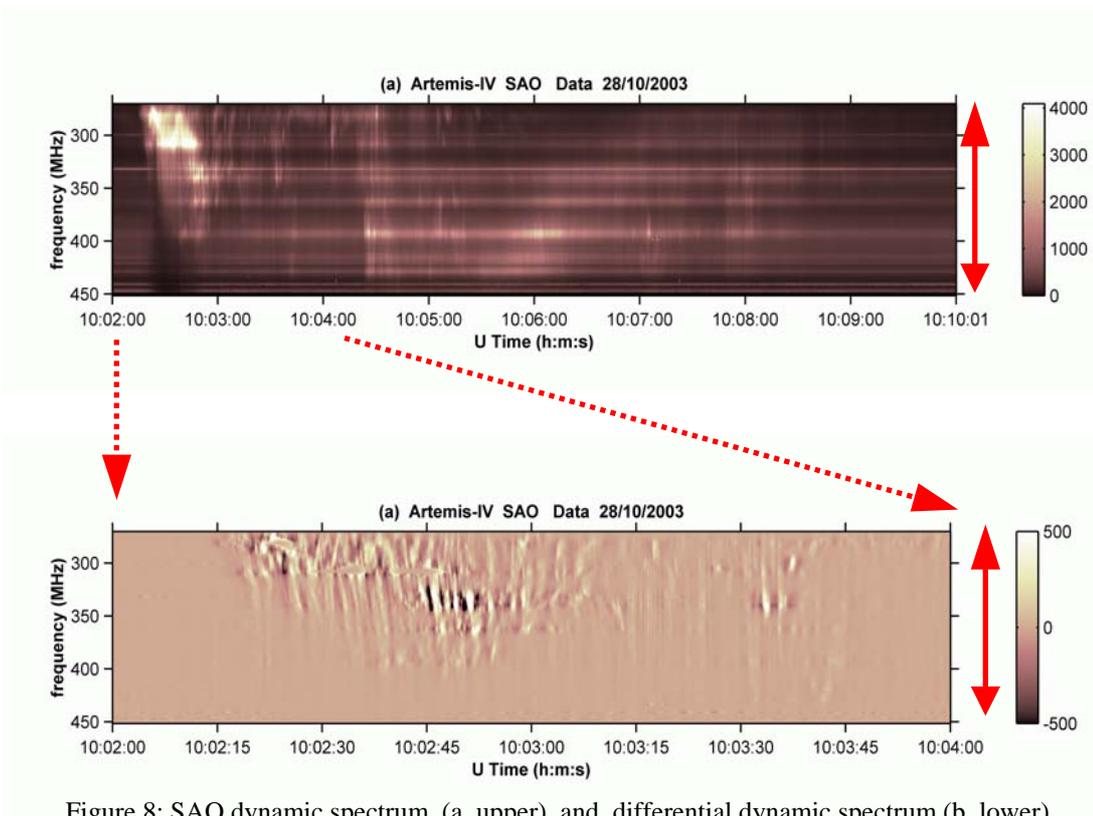


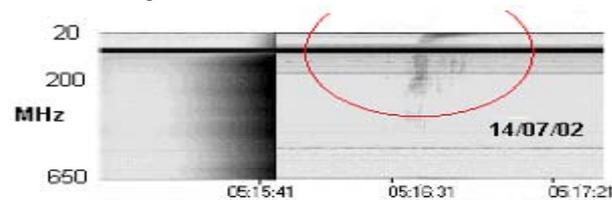
Figure 8: SAO dynamic spectrum (a, upper) and differential dynamic spectrum (b, lower)

A pulse from a timer on the ADC card triggers every sweep (Fig. (5)). The analog output from the ASG drives a 12 bit ADC card on a PC. It takes 6300 samples/sweep [5]. The samples are averaged by ten so we divide the whole spectrum (20 to 630MHz) into 630 channels with resolution bandwidth 1MHz. We also take care to avoid strong FM radio and TV interference. Every 5 sweeps the data are transferred to the hard disk with a universal time stamp. Simultaneously we see the dynamic spectrum on the PC screen. At the end of the day or later we can take the daily activity and storage it on a DVD. The daily data are about 0.5Gbyte. Every day, before starting measurements, this PC receives the Universal Time from a GPS, controls the calibration and the antenna movement.

This PC is equipped with a telephone line modem for telemetry purposes. Also there is an Ethernet connection with the other PC.

Second way (Fig 4): It includes a pass band filter, RF amplifier, and finally an acousto-optic frequency analyzer (Spectrograph Acousto-Optic, SAO) [6] for 270-450 MHz with low dynamic linear range (20db), very good frequency resolution at 176kHz and very fast frame rate at 100Hz. Every 10msec the ADC takes 1024 samples with a resolution of 12bit (Fig. 6) [5]. The samples are averaged by eight, so we have 128 channels with resolution bandwidth 1.4MHz. This arrangement leads to a high signal to noise ratio. Every 50 sweeps the data are transferred to the hard disk with a universal time stamp. Simultaneously we see the dynamic spectrum on the PC screen. At the end of the day or later we can take the daily activity and storage it on a DVD. The daily data are about 1Gbyte. The Universal Time is received every morning from the other PC through the Ethernet.

Figure below shows first experiments with ASG dynamic spectrum (black color indicates strong signal and white weak). On the left we see the calibration signal and on the right (in the circle) a solar radio event. Horizontal lines indicate strong FM radio and TV interference.



Conclusions and perspectives

This instrument has a very high time and frequency resolution from decimeter to decameter wavelengths with a very good signal to noise ratio which permits fine structure detecting [7].

Fig 7.a shows the dynamic spectra of 10min large solar radio event on 28/10/2004 recorded by ARTEMIS IV ASG solar radiospectrograph. Colorbar on the right shows the signal intensity in arbitrary units. Fig. 7.b is a 2min small part of the above event, it shows the differential dynamic spectrum derived after special 2D filtering where we can distinguish fine structure which indicates ascending and descending electron beams in the solar corona. Fig. 8 shows the same event as recorded by SAO in the 270-450MHz band where more details are distinguished in the frequency domain.

Future perspectives are the use of the old and construction of new antenna to make polarimetric measurements and extension of the SAO frequency range.

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