On Chinese Solar Radioheliograph in Centermetric to Decimetric Wave Range

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ABSTRACT

The imaging of solar radio emissions at dm-cm wave range is important to understand the energy release, converter and transmission processes in the solar atmosphere. It has long been expected to build a radioheliograph in China and a new Chinese radioheliograph project (CSRH) at multiple frequencies in the dm-cm wave range with 100 antennas of 2-3m is proposed. A prototype study of 2-element interferometer has been built and tested for overall design since 2004. The prototype system includes 2 4.5m antennas, feed and LNA (low noise amplifier), optical transmitter, optical fibril, optical receiver, RF (radio frequency) receiver, and digital correlator receiver. The site survey for future location of the CSRH array is carried out and a radio quiet region in Inner Mongolia appears promising. The progress about the project is introduced in the present work.

1.INSTRUCTION

Imaging spectroscopy over cm- and dm-wavelength range are important for addressing fundamental problems of energy release, particle acceleration and particle transport (Bastian, et al., 1998), and the American FASR project has been proposed to meet this end (Gary & Keller, 2004).

The Chinese solar physics community had long been wishing to build a radioheliograph. Some pre-studies were carried out on proposals for radioheliograph in either cm-band or mm-band, but none of these had been implemented (Jin et al. 1996; Fu et al 1996). Following these lines, it was suggested to build a Chinese Spectral Radioheliograph (CSRH) in the cm-dm wave range with a limited budget in the next few years (Yan et al. 2003, 2004). A prototype study of 2-element interferometer has been built and tested for overall design since 2004. The prototype system includes two 4.5m antennas, feeds and LNA (low noise amplifier), optical transmitter, optical fibril, optical receiver, RF (radio frequency) receiver, and digital correlator receiver. The site survey for future location of the CSRH array is carried out and a radio quiet region in Inner Mongolia appears promising.

2.CSRH SPECIFICATIONS

The proposed preliminary specifications for the CSRH, as driven by science requirements, are shown in Table1. The CSRH project is open for international cooperation and the parameters are not fixed yet (Yan et al. 2003, 2004).

3. SYSTEM BLOCK DIAGRAM

Due to the budget limitation, it is not possible to implement all these channels simultaneously and our strategy is to make full use of the scaning filter-bank technique that had been successfully employed in the Chinese 0.7-7.6 GHz broadband spectro-polarimeters (e.g., Ji et al 2003). The system block diagram is shown in Figure 1

Table1 preliminary specifications of CSRH

Number of antennas	~100	Frequency range	~0.4 –15 GHz
Number of baselines	~5000	Frequency resolution	50MHz, 0.4-2 GHz
Antenna size	2.4-6m		150MHz, 2-10 GHz
Polarizations	Dual circular		300MHz, 10-15 GHz
Maximum base line	3000m	Time resolution	<100ms, 1-4 GHz
Field of view	0.5° -7°		<0.5s, 4-15 GHz
Imaging dynamic range	20dB	Spatial resolution	1.38”-20”

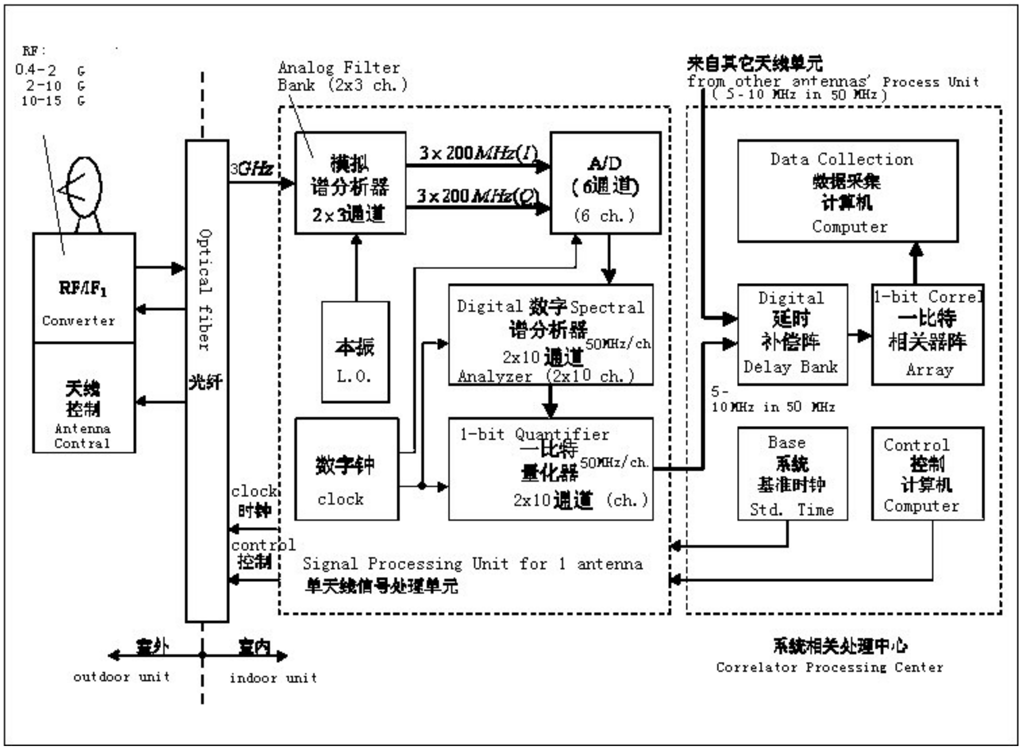

Figure 1. System block diagram.

It is tentatively considered that the RF signal in 0.4-15 GHz will be converted into 0.4-2 GHz, 2-10 GHz and 10-15 GHz bands. The bands are then transmitted to the indoor unit by optical fibers. The signal of each band will be processed digitally. We plan to use a filter bank of 3×200MHz=600MHz range for analog/digital converting. The sampled signal then go through a digital spectral analyzer of 5 channels with 40 MHz being bandwidth of each channel. Then we will correlate signals at a frequency point within each channel. For whole frequency coverage we will repeat above procedure. Therefore we have repeating times and the whole channels. The signal from each 40 MHz but at a point frequency (~5MHz) will be correlated with signals from other antennas. The delay compensation bank is estimated to be in the range of 10^4 with step of 1 ns. The number of complex correlators is 100(ant.) × 99/2 ×10(ch.) = 49500. The prototype for digital correlators of two elements is developed. We have analyzed the blocking effect when two antennas are aligned in either east-west or north-south direction. The change in a year’s time is also analyzed. It can be expected that about 8-10 hours can be elapsed for observations in a day.

4. PROTOTYPE STUDY AND SITE SURVEY

The prototype system includes two 4.5m antennas, feeds and LNA (low noise amplifier), optical transmitter, optical fibril, optical receiver, RF (radio frequency) receiver, and digital correlator receiver. The prototype system is shown in Figure 2.

Figure 2. Two element prototype experimentalat 1.2-1.8GHz. Right panel: outdoor equipments including two 4.5m mesh antenna, 2 feeds in 1.2-1.8GHz range, LNA, optical transmitters, optical fibrils of 200m long, and antenna control and driving system. Upper-left panel: optical receivers, and analogous receiver. Lower-left panel: digital correlator and computer.

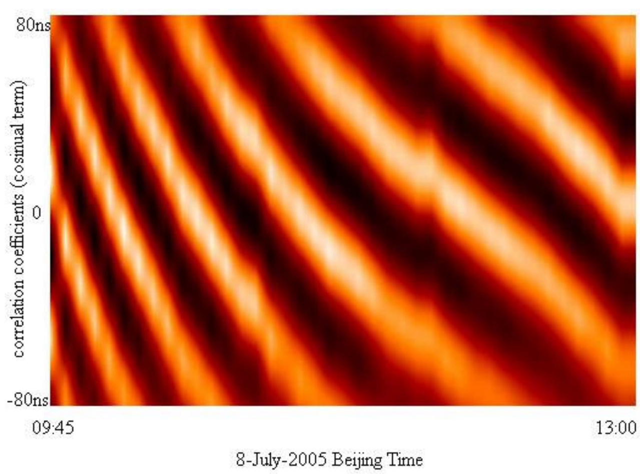

Figure 3. Observed fringe variation during 09:45 to 13:00 local time on 8 July 2005 at an interval of 5 minutes when two antennas were pointing at the Sun during the whole process. The data were actual sampled at 2.5ns cadence and correlated with 5MHz band lasted for 0.08ms duration time

The experiment for short baseline of 8 meter has been done at Miyun Radio Astronomical Station of NAOC and several case studies have been carried out in order to verify the design parameters. Figure 3 shows fringe variation obtained by the prototype experiment on 8 July 2005 when observing the Sun. For the experiment we have simultaneous 64 delay channel outputs with plus and minus 80 ns shift in order to analyze the results. It can be seen that the observed results are very promising.

The site survey for future location of the CSRH array is carried out and a radio quiet region in Inner Mongolia has been monitored. At moment the radio interference at the site is very low and it is expected to be protected for the CSRH project. Figure 4 shows the route map and site picture.

Figure 4. A radio quiet area in Inner Mongolia about 400km northwest to Beijing.

5. Summary

A radio heliograph with high temporal, spectral and spatial resolutions have been proposed and the brief description for this instrument is introduced. It will play an important role in solar physics when it is built in the near future.

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