Development of a Ranging System for the Forward Scattering Meteor Radio Echo Observation using a GPS-synchronized Multiple Receiving Stations. Takashi USUI[1], Hideto YOSHIDA[2], Hideaki MIYAMOTO[3], Noriyuki YAGUCHI[1], Toshio TERASAWA[3], Ichiro YOSHIKAWA[2] , [1]The Nippon Meteor Society (usui-t@nifty.com) , [2]The University of Tokyo (School of Sciences:yoshida@eps.s.u-tokyo.ac.jp), [3]The University of Tokyo (Institute for Cosmic Ray Research: terasawa@icrr.u-tokyo.ac.jp)

Introduction: We are developing an instrument for teaching purpose to determine the trajectory of a meteor with the Ham-band Radio Observations(HRO) [1]. In the current system, echo arrival times are measured and we need at least 6 different echoes from the same meteor trail in order to determine the trajectory. However, the probability of getting 6 clear echoes is low. And so, the number of available echoes for the analysis is small relative to all the received echoes. If we get ranging information, improvement of the number and accuracy of the trajectories are expected. So we have developed a new ranging system, and we have succeeded in getting ranging data with it. In this work, we describe the system and show some results.

The measurement setup: A signal source is transmitted from Nagano, Japan, with frequency of 53.8500MHz and output power at 200W. The signal is frequency modulated (FM) and the modulation signal is GPS-synchronized triangle wave with a period of 4ms. A bandwidth of the signal is about 30KHz (The accuracy of the ranging is 10km).

The receivers are set at Ebina-city, Bunkyo-ku, and Kimitsu-city, those are located in the nearly equilateral triangle in Tokyo and its nearby, about 50km of each side. The average distance from the transmission station is 192km. The configurations of the stations are almost same as [1].

We store the received signal and we use underdence echoes for the analysis. We calculate the correlation function between the received signal and the transmission signal (known waveforms). Then we measure the peak timing of the correlation by using PPS signal of GPS as a reference timing. Then we determine the traveling time of the received echo, finally we calculate the path length.

Data acquisition system: The receiver block diagram is shown in Fig.1. We use 2 elements yagi-antenna with the directivity of zenith. The output signals of the direct conversion receiver (I-ch, Q-ch) are digitized by two A/D converters with 200KSPS. The local oscillator of the receiver and A/D clock is disciplined by the GPS. The data is stored to HDD through USB interface. In the A/D unit, the time information is extracted from NMEA data from GPS receiver and stored it every second The acculacy of the PPS is 1micro second, and so, the precise sample timing can be known. The internal time delay in the transmitter and the receiver is measured in advance for the timing compensation. The clock of the personal computer is set by using the Network Time Protocol or GPS.

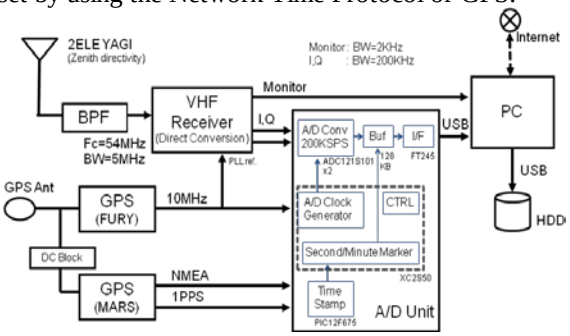

Fig.1 Data acquisition system

Observation results: The observation is done from July 30 to July 31, 2011. An example of the correlation result from the received echo is shown in Fig. 2. The peak timing is at 202samples from the reference marker in this case. The ranging result before compensation is 303.0km because 1 sample time is 5us. As the compensation value is 18km, the measured ranging result after the compensation is 285.0km.

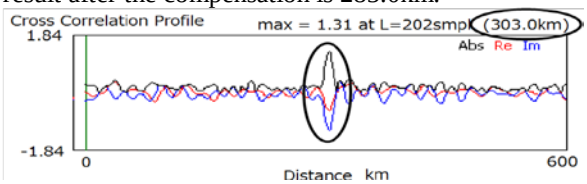

Fig.2 An example of the cross correlation result (Ranging value is before the compensation)

Table 1 Ranging results

Echo Time (JST)	Ebina-city	Bunkyo-ku	Kimitsu-city
Jul.30, 22h40m07s	285.0 km	309.0 km	334.5 km
Jul.31, 06h23m33s	330.0 km	331.5 km	375.0 km

We have analyzed two echoes. The results are shown in Table 1. Thus, we have succeeded in getting the ranging data of each echo. We are planning to discuss these results by comparing the results from our conventional method.

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References: [1] Yoshida, H. (2012) ACM2012.