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DEVELOPMENT OF SCANNING-BEAM VHF AURORAL RADAR SYSTEM (EXTENDED ABSTRACT)

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VHF radar observations at Syowa Station have been continued since 1966 as one of the routine ionospheric observations. The first observation with 112.2 MHz auroral radar was carried out by the PPI (plan position indication) method; radio auroral echo returns were recorded on 16 mm film (HASEGAWA and SHIRO, 1970). The second auroral radar had four frequencies, 50, 65, 80, and 112 MHz, and investigated the frequency dependence of radio auroral echoes. This radar was modified in order to measure the Doppler spectrum of backscattered echoes in 1978 (IGARASHI *et al.*, 1981). In 1981 a new VHF Doppler radar was developed by IGARASHI *et al.* (1982). Since then continuous Doppler measurements of backscattered echoes at two frequencies, 50 MHz and 112 MHz, have been conducted along two fixed beam directions by coaxial collinear antennas with about 4 degree beam width.

In order to cover the whole echo region we have developed a new 50 MHz scanning-beam VHF auroral radar with two sets of array antennas. This radar is capable of observing the whole region of radio auroral echoes which is generated by *E*-region irregularities. A plasma drift velocity map is available every several minutes. We aim to conduct simultaneous observations with the HF radar which will be installed at Syowa Station. It is possible to compare the *E*-region and *F*-region plasma drift velocities simultaneously. Four observation modes are available, including meteor echo observation mode.

Radio auroral echoes are caused by field aligned irregularities in the polar *E*-region. So the radar echoes show strong aspect sensitivity. Figure 1 shows a typical example of a radio aurora recorded by PPI display. The strong echo region appears in the geomagnetic south direction. The echo range appears from about 230 km to 1000 km. Auroral echoes are mostly observed from the region within ± 80 degrees, centering on geomagnetic south.

The typical parameters of this radar system are shown in Table 1. The block diagram of scanning-beam VHF auroral radar is shown in Fig. 2. One of the important functions of this system is to regularly observe the plasma convection pattern from the Doppler measurements of radio auroral echoes in the *E*-region.

Five transmitting antennas, each having an azimuthal beam width of about 30 degrees, cover a wide area of about 160 degrees in azimuth. The outputs from four

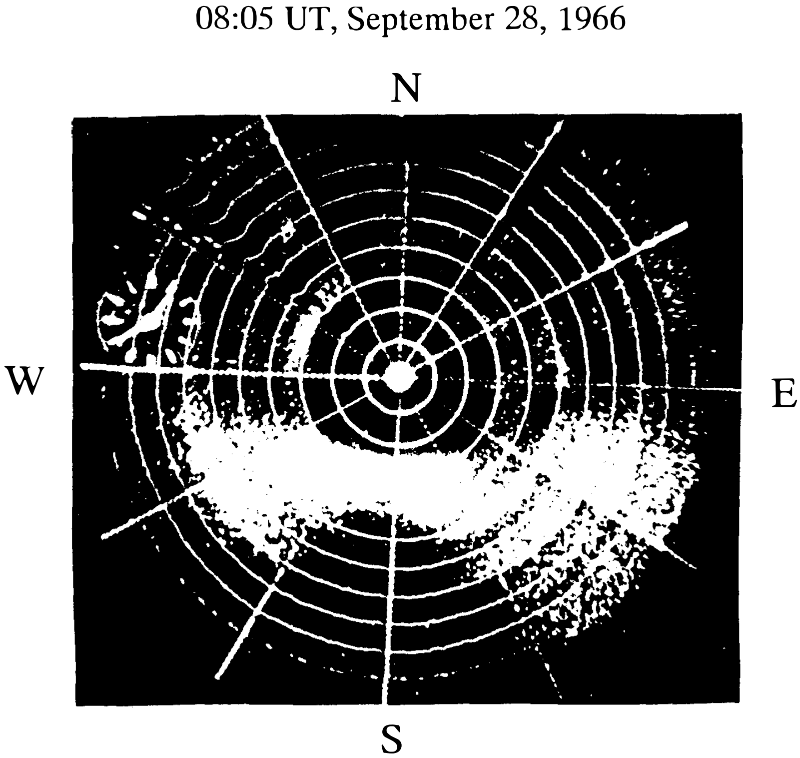

Fig. 1. PPI record of 112.2 MHz auroral radar backscattered echo obtained at 0805 UT September 28, 1966 at Syowa Station. S indicates the geomagnetic south direction. Circular range marks on axes are every 100 km.

Table 1. Specifications of scanning-beam VHF auroral radar.

Location	Syowa Station (69°00′S, 39°35′E in geographic coordinates; −70.0°, 80.2° in geomagnetic coordinates)
Transmitting frequency	50.0 MHz
Peak transmitting power	20 kW/(combined with four 5 kW solid state power amplifier)
Pulse width	10–190 μs every 10 μs
Pulse repetition frequency	5–1,275 Hz (variable in 5 Hz steps)
Transmitting pulse pattern	Single pulse, double pulse, multi-pulse
Phase coding	No coding on 13 bit Barker code
Receiver bandwidth	10–100 kHz (dependent on pulse width)
Transmitting antenna	5 sets of 8 element Yagi antenna
Receiving antenna	Two sets of sixteen Yagi array antennas
Receiving beam width	5 degrees
Beam cover region	±80 degrees in azimuth, directed toward geomagnetic south
Signal processing	Intel 386 (16 MHz) class PC with DSP board

5 kW solid-state power amplifiers are combined so that finally 20 kW peak power is available. Five Yagi antennas are switched, depending on the covered region of transmitting beam pattern. The receiving beam direction is scanned in 2.5 degree steps (minimum step) by using two sets of array antennas with beam width of about five degrees. The beam direction and observation region can be varied from one observed object to another. A plasma convection pattern is available every several minutes.

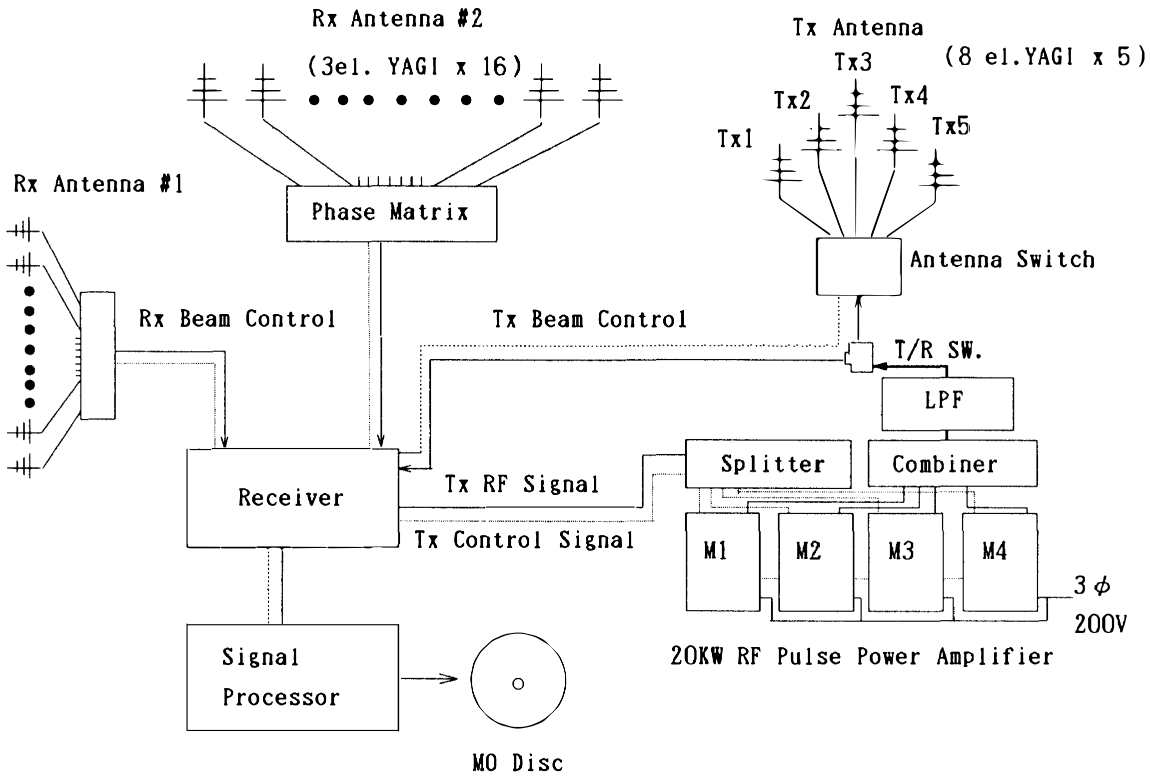

Fig. 2. Block diagram of the scanning-beam VHF auroral radar system.

Fig. 3. Scanning-beam VHF auroral radar system showing four power amplifiers, a receiver and a signal processing PC.

The radar echo signal processing uses a Digital Signal Processing (DSP) board. There are three observation modes for radio aurora; (1) single pulse, (2) double pulse, (3) multi-pulse (*e.g.* FARLEY, 1972). This radar has a meteor radar mode for observing the neutral wind velocity at an altitude of around 90 km too. The picture

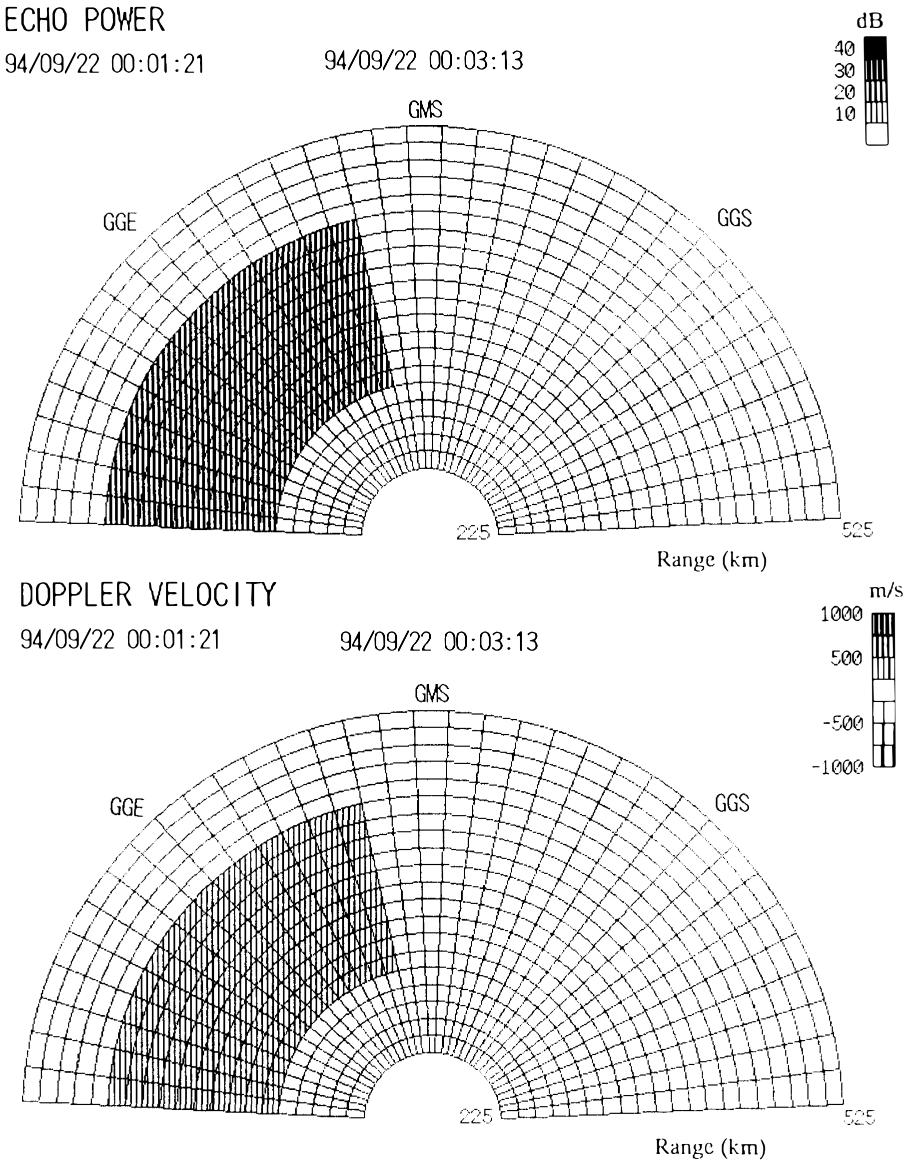

Fig. 4. Example of the quick-look displays showing the echo power and Doppler velocity which is obtained for double pulse mode observation. Displayed range is variable. GMS, GGS and GGE mean geomagnetic south, geographic south and geographic east directions from Syowa Station, respectively.

of this radar system is shown in Fig. 3. Figure 4 shows an example of a quick look display simulated with the double pulse mode observation method by using a calibrated radio aurora test signal appearing in the geographic east direction.

A simultaneous observation with a new Syowa Station HF radar will be done in 1995 (YAMAGISHI *et al.*, 1994). This experiment is unique in that it compares the *E*-region and *F*-region plasma drifts on the same field line simultaneously. This upgraded VHF radar covers the region over 10^6 km^2. It is also possible to perform coordinated experiments with satellites, optical equipment, radar measurements of mesospheric wind and so on.

Acknowledgments

The new array antenna was installed at Syowa Station for testing in 1994 by the 35th wintering party. We would like to thank especially N. OBARA and K. IWASAKI for their efforts in successful construction of this large antenna system.

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