The Secret Behind the Nobeyama Radioheliograph's Excellent Performance

The Nobeyama Radioheliograph is a radio telescope for solar observation. “Helio” means the Sun, and “graph” means imaging instrument. The 84 parabolic antennas with diameters of 80 cm are arrayed in a T shape, 490 m east to west and 220 m north from the center of this line, to form an interferometeric array telescope. In 2015, management of the radioheliograph was reassigned to the Institute for Space-Earth Environment Research of Nagoya University, but it has persisted in conducting continuous observations of the Sun for 8 hours every day. Over the past 10 years, the operation rate is more than 99 %. This is the highest operation rate for an observational telescope in Japan.

The surface of the Sun looks calm, but strong activity occurs near the surface. High energy particles are produced by explosive phenomena around sunspots (solar flares). These spiral around the magnetic field lines of the sunspots and produce very strong radio waves. The radioheliograph catches these radio waves to ascertain the generation mechanisms for these high energy particles. Research into various phenomena happening on the surface of the Sun continues through cooperation with the Nobeyama Radio Polarimeters, the solar observation satellite “HINODE”, and solar telescopes located around the world including optical telescopes in Mitaka Campus.

Picture: Nobeyama Radioheliograph and 45-m Radio Telescope

Let's try to understand the structure of these radio telescopes and investigate the secrets behind their high accuracy and sensitivity by making a paper model of one of these telescopes.

Main Performance Specifications

Main reflector diameter: 80 cm
Number of antennas: 84
Deployment: T shape (490 m east to west, 220 m north to south)
Observational frequencies: 17 GHz (left-handed and right-handed circular polarization), 34 GHz (intensity only)
Field of view: Entire solar disk *The angular diameter of the Sun is about 1900 arcsec.
Angular resolution: 10 arcsec. (17 GHz), 5 arcsec (34 GHz)
Time resolution: 0.1 second (active periods), 1 second (quiet periods)

Other Solar Observation Instruments in Nobeyama

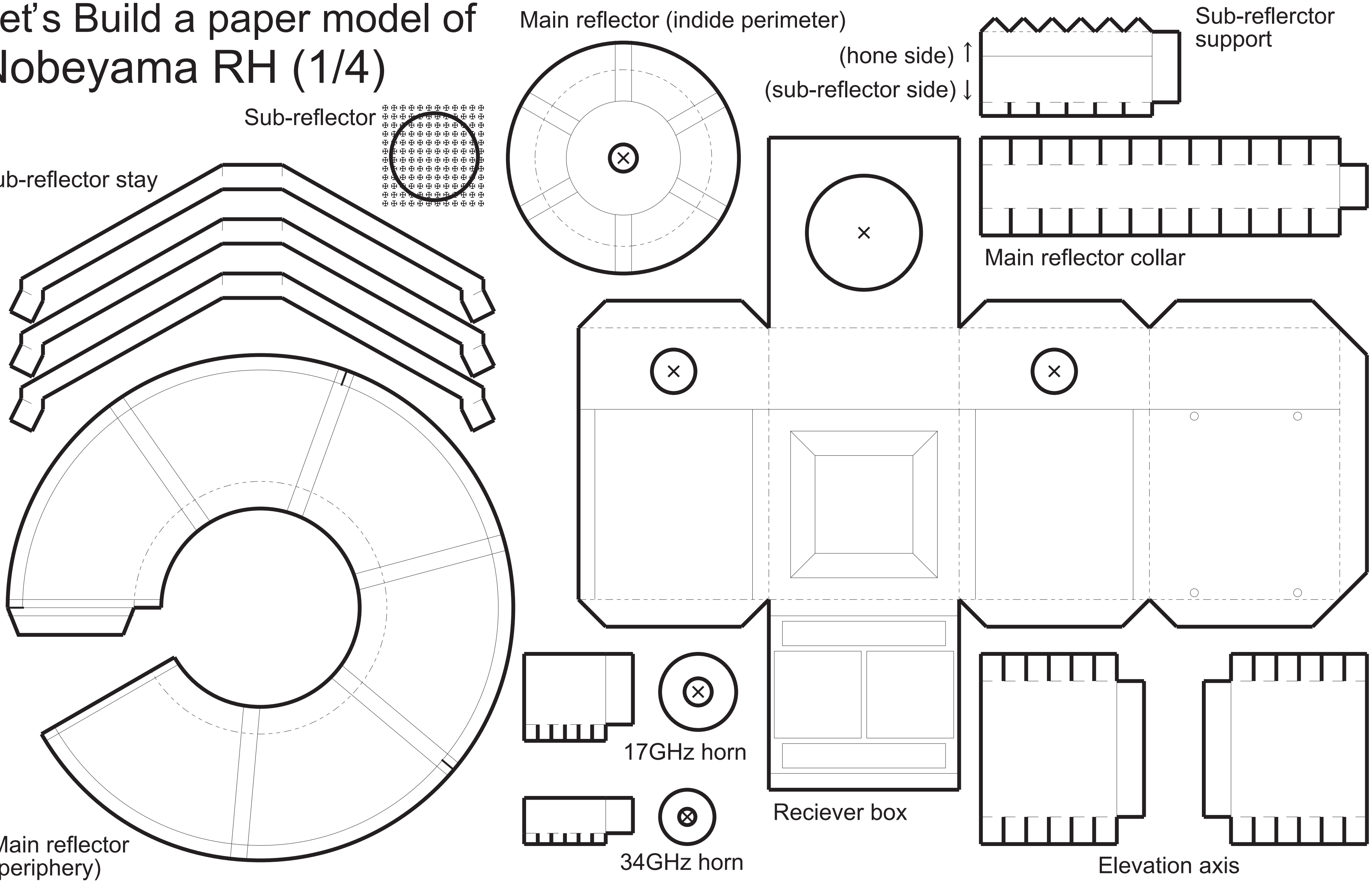
Nobeyama Radio Polarimeters

These observe the Sun at multiple frequencies in the microwave range, such as 1, 2, 3.75, 9.4, 17, 35, and 80 GHz. They can discern the total incoming flux and the degree of circular-polarization to investigate solar activity. In particular, 3.75 GHz band observations have continued for over 60 years since 1951.

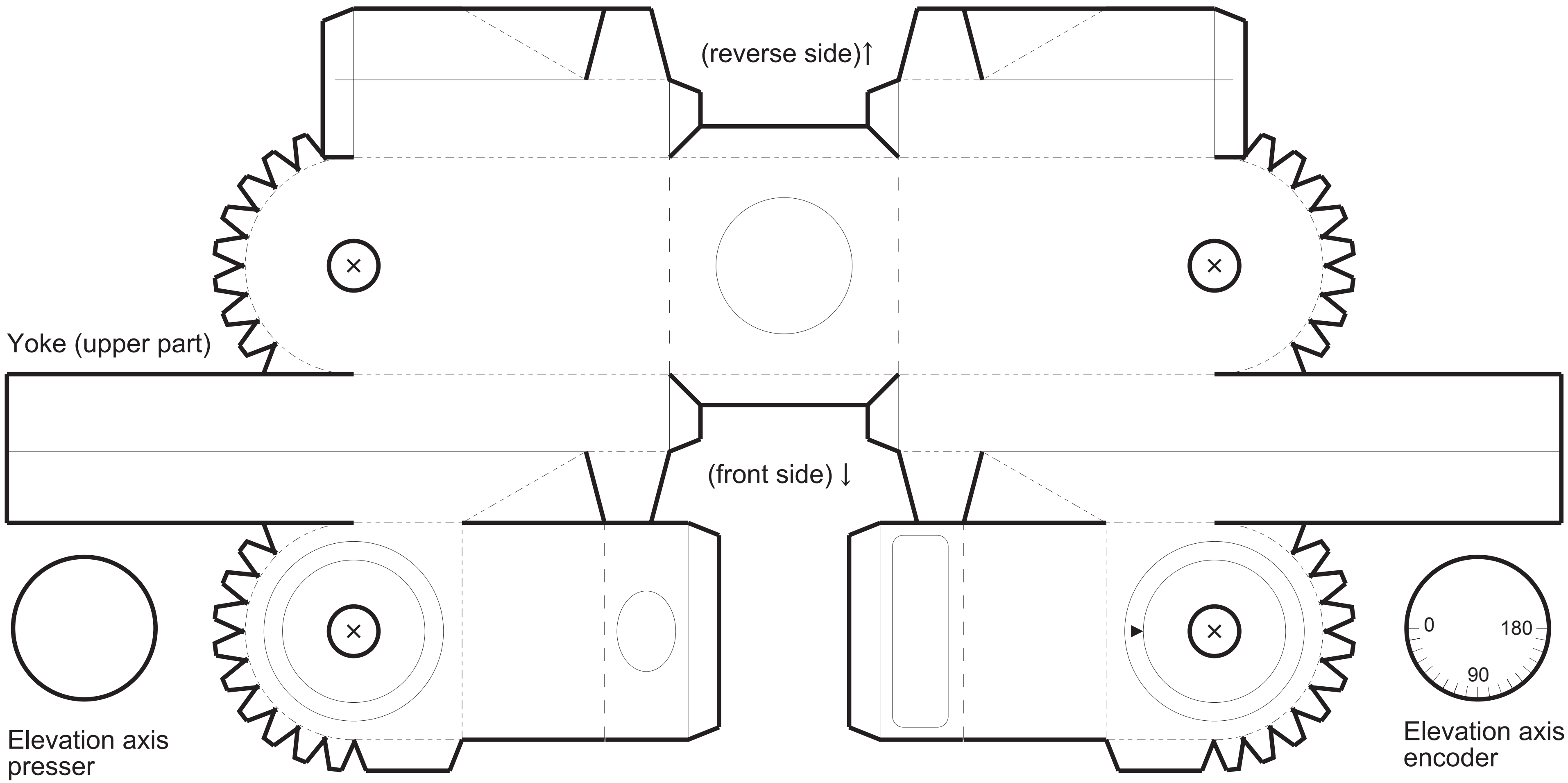
Nobeyama Interferometers

The red antennas in the background observed 160 MHz (1970-1989), and the antenna in the foreground observed 17 GHz (1971-1992). Now, these have finished observations and have been removed. But they're still being put to use for parabola demonstrations; the 160 MHz antennas were taken to the Nishi-Harima and Misato Observatories, and the 17 GHz antennas are now in Nobeyama, Mitaka, etc.

Let’s Build a paper model of Nobeyama RH (1/4)

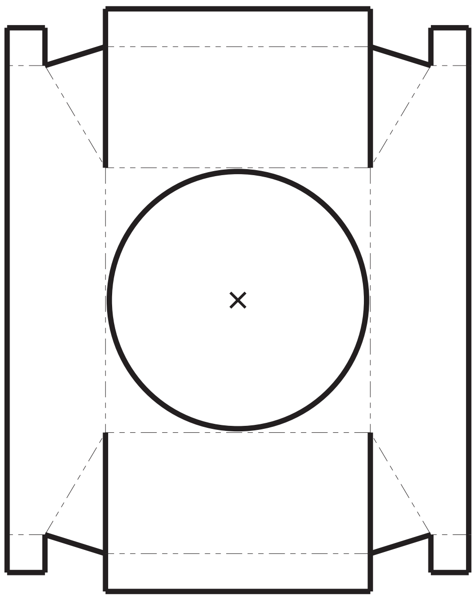


Let’s Build a paper model of
Nobeyama RH (2/4)

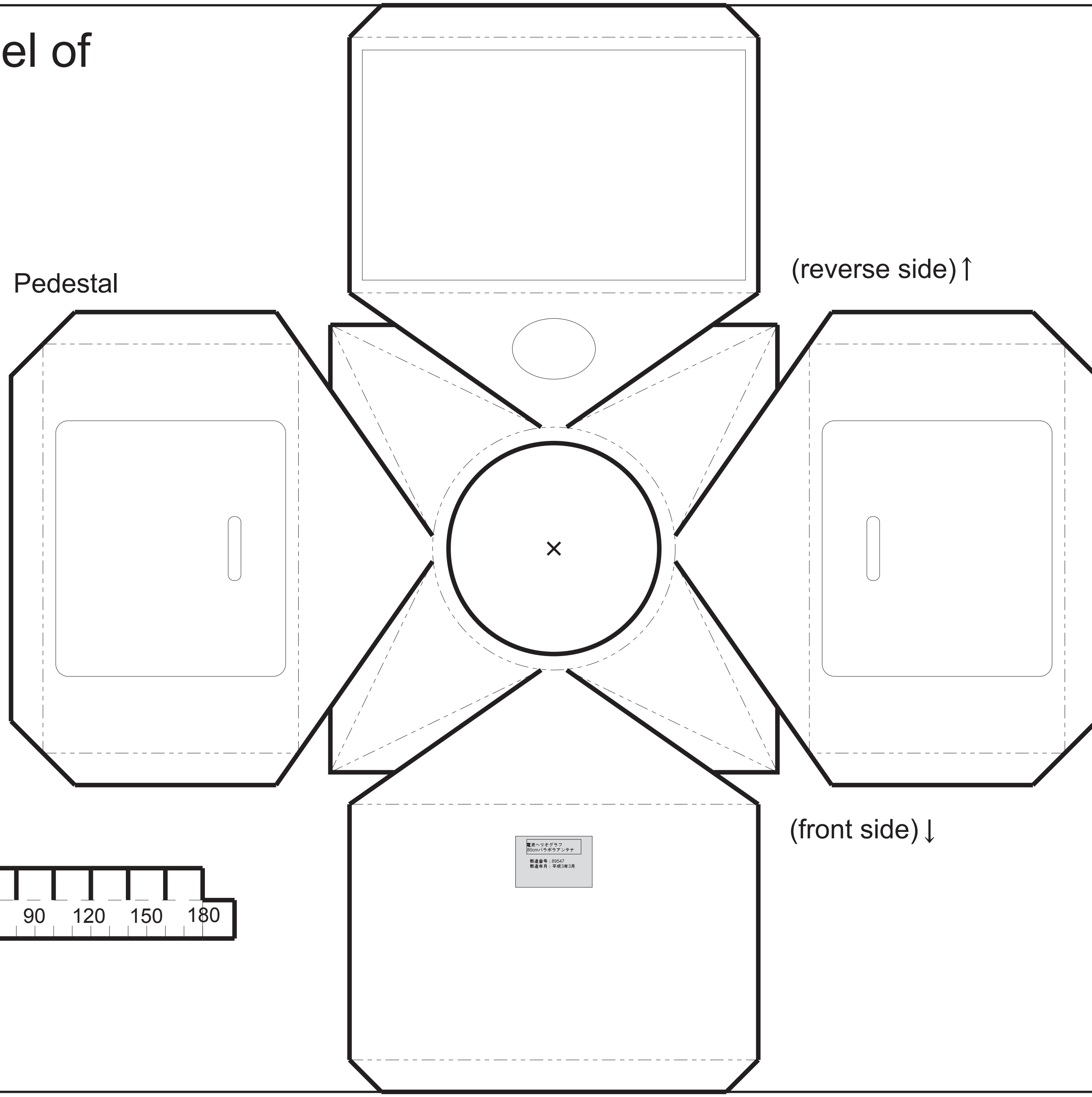


Let's Build a paper model of
Nobeyama RH (3/4)

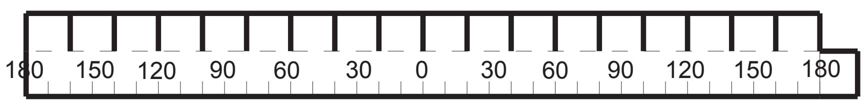
Yoke (lower part)



Pedestal

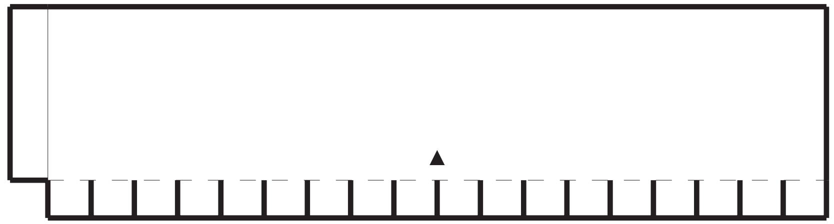


Azimuth axis encoder

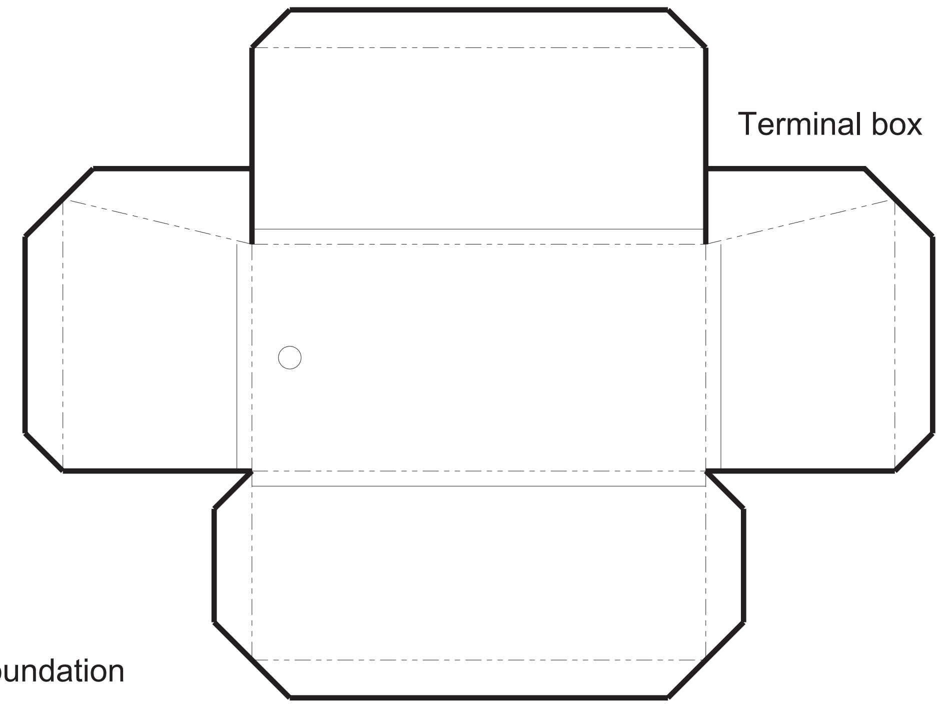


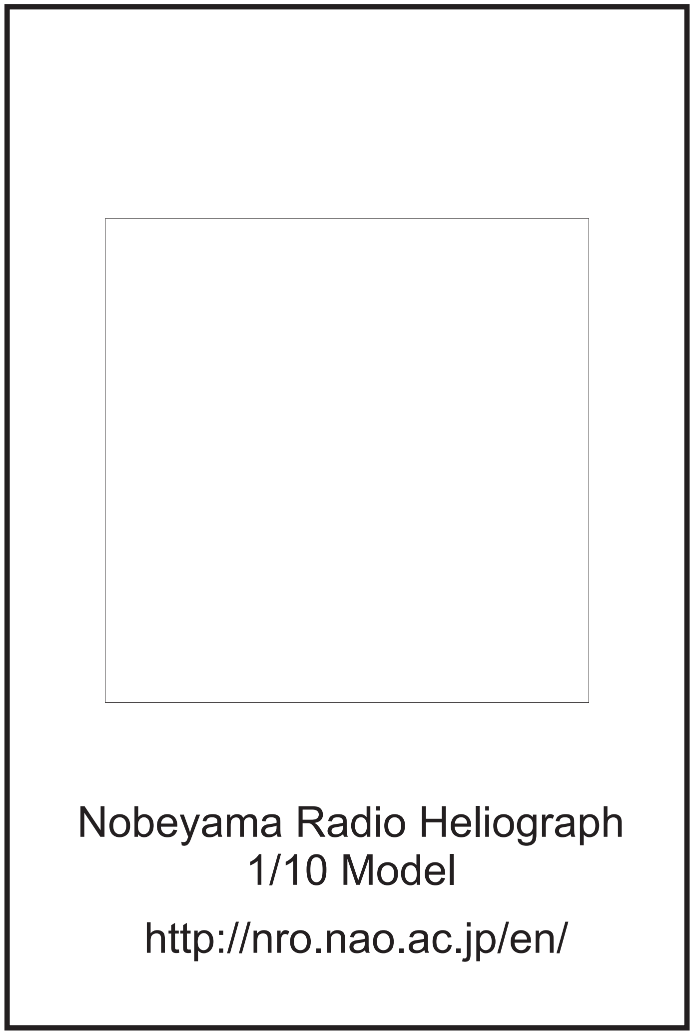
Let's Build a paper model of
Nobeyama RH (4/4)

Azimuth drive



Terminal box





Foundation

Let’s Build a paper model of Nobeyama RH (Instractions-1)

Material and tools: paper cutter, glue

1. Preparation: Copy the drawings (1/4, 2/4, 3/4, 4/4) on sheets of paper thick like Kent paper so that the outer frame forms 17 cm x 26.5 cm rectangle. Cut out all the 24 componetns along the thick lines. Snick or hole where you have thick lines on the components. Mountaion fold chain double-dashed lines and valley fold dashed lines.

All the components in the can!

2. Main refrector: Glue the ends of the main refrector periphery to make a cone (printed surface is the outside of it) and mountain fold the inner side slightly. Glue the inside perimerter on the concave side of the main reflector periphery. See to it that all the printed surfaces come to the reverse side. Make up the 17 GHz horn cylinder by curling up the component, thrust it into the disc hole and glue the nicked end on the non-printed side of the disc, now, glue this unit from the concave side, on the center of the inner perimeter.

3. Sub-reflector: Rub the sub-reflector surface with your fingernail unit it becomes convex. Prepare the 34 GHz horn by curling its component as well as the sub-reflector support. Attach the sub-reflector so that one can see the printed surface. On another end of the sub-reflector support, attach the 34 GHz horn in the way it hides itself behind the sub-reflevtor. Finally, wrap around the sub-reflector support with 6 sub-reflector stay ends (stays should be interfolded beforehand) and fix them by gluing as to make up a tripod, Glue down the tripod's legs on the main reflector (gluing points are marked on the reverse side).

4. Reciever box: Assemble the reciever box by mountain foldinig and gluing, except the face with a large hole, and glue the main reflector collar on the edge fo the large hole. At this stage the favce with the main mirror collar should not be glued.

5. Elevation axis: Curl and make up the two axes. Glue the elevation axis encorder on an end of the axis and a presser on an end of the remaining axis. Then leave them for the moment.

Now we have almost completed the sections!

6. Reciver box: Shape the upper part of the yoke. Insert the elevatioin axis from the outside hole of the yoke's upper part and through the hole of the receiver box, glue the parts as you prceed steo by step. Glue the ends on the inner walls of the receiver box. Use the axis with encorder on the yoke marked with ▲, and set the encoder's 90 ° to meet the mark ▲. Finally glue the face with main reflector collar to complete a box.

Let’s Build a paper model of Nobeyama RH (Instractions-2)

7. Yoke: When you finished assembling the lowe part of the yoke, glue the azimuth encoder on the base of the yoke so that the 0 ° faces the front face.

8. Main reflector: Arrange the three sub-reflector stays to form an inversed Y when you mount the main reflector on the main reflector collar.

9. Pedestal: Make a box by folding the faces of pedestal and mout the azimuth drive on the top, ▲ mark should point the front side (the face with plate), then glue it. Now glue the pedestal onto the foundation.

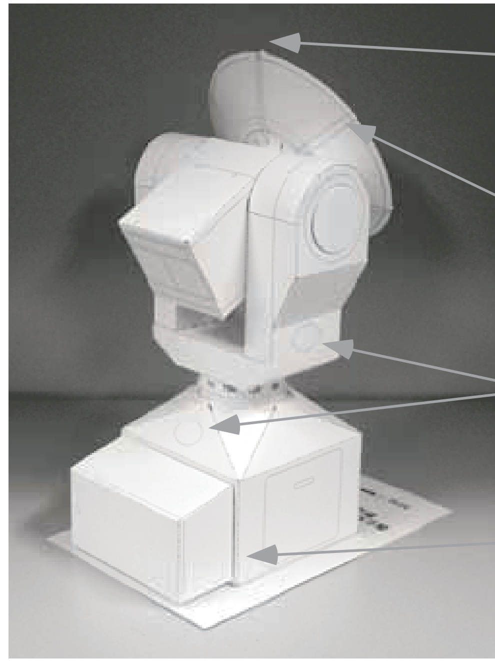
Sub-reflector stays form an inversed Y when seen head-on.

34 GHz horn hides itself behind the sub-reflector.

Front side of the reciever box has squares on its surface.

front side of the pedestal has a plate.

10. Terminal box: Make it by folding and gluing and attach it on the far side of the pedestal.



Sub-reflector stays should be mounted on the marked pointd on the reverse side of the main reflector.

Far side of the main reflector.

Fill in antenna ID such as W-22 in the ellipse.

Array configuration of the Nobeyama Radio Heliograph and its numbering