# Development of wideband feed with sharp cut-off frequency OMT for RFI

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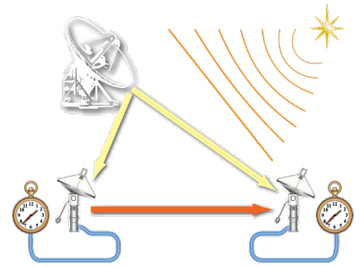
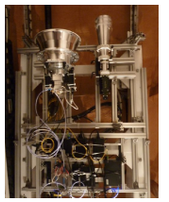
## 0. Development of Wideband feed in NICT Kashima VLBI group

For VLBI Time and Frequency Transfer Experiment(Gala-V), the next generation geodetic VLBI(VGOS) and radio astronomy.
•IGUANA-H feed(6.5-16GHz) : multimode horns derived from the horns of ASTRO-G/VSOP-2 VLBI satellite.
•NINJA feed(3.2-16GHz) : Axial corrugated horn using higher modes and dielectric lens.
They are the first wideband feeds with norrow beam for conventional Cassegrain antennas.




Kashima 34 antenna

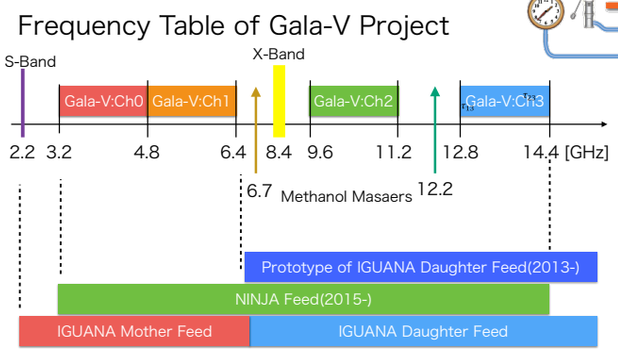


Wideband feeds in the 34m antenna

## 1. How to improve SNR in limited term and budget

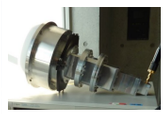
Sensitivity of a pair of VLBI antenna 1 and 2: $SNR = \frac{\pi S}{8k} D_1 D_2 \sqrt{\frac{\eta_1 \eta_2 B_w \tau}{T_{sys1} T_{sys2}}}$

•Tsys: 3-4 times better by cooled LNA, but expensive.
→LNF-LNR4-14B for room temperature used by the limitation of the budget.
•η: 20-50% is enough, for more effort will take more times.
•D: Dish of small stations(MARBLEs) were replaced from 1.5/1.6 m to 2.4 m.
•Bw: 10 times larger bandwidth than traditional S/X band VLBI.
→Development of wideband feed was the most cost effective way.

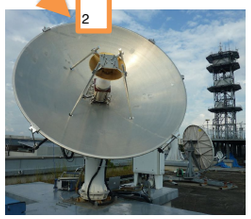



Frequency tables and developed feeds for Gala-V

MARBLE1 at Medicina Radio observatory in Italy



Wideband feed installed in MARBLEs

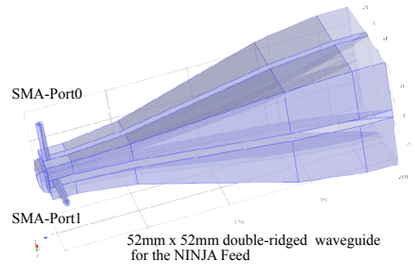


MARBLE2 at NICT Koganei HQ in Japan

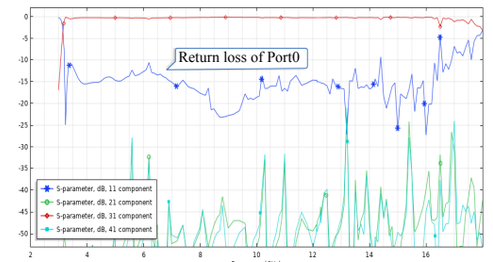
$\tau_{12}=\tau_{01}-\tau_{02}$

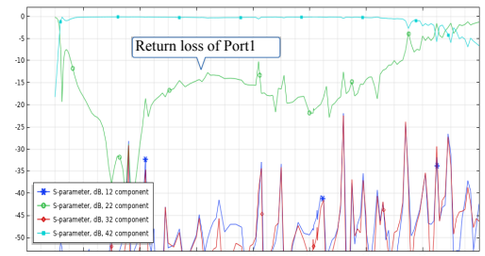
## 2. Wideband feeds and OMTs for Gala-V experiment

•Narrow beam width for Conventional radio telescopes of Cassegrain.
•Larger aperture size of the feed than VGOS or SKA feeds.
→more memories for simulations, longer time for development.
Thus feed and OMT(Orthogonal Mode Transducers) were developed separately.




52mm x 52mm double-ridged waveguide for the NINJA Feed

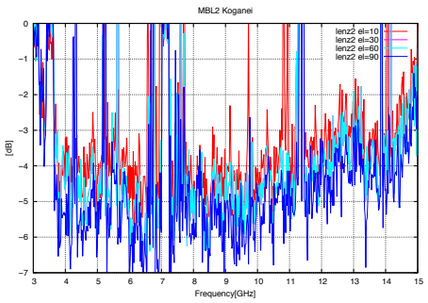


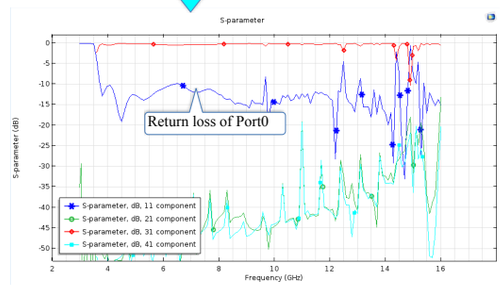

Simulation result of wideband OMT for 3.2-14.4/16GHz NINJA Feed.

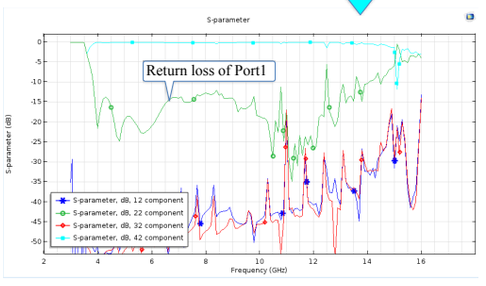
## 3. RFI suppression

• Before the 1st LNA
RFI < 3.2 GHz : cut by quad-ridged OMT with sharp cut-off
• After the 1st LNA
at 3.5 GHz : BEF
at 14 GHz(from a nearby satellite communication antenna in Koganei) : LPF and filter banks




RFIs observed by a 3.2-16GHz NINJA feed on the 2.4m dish at Koganei

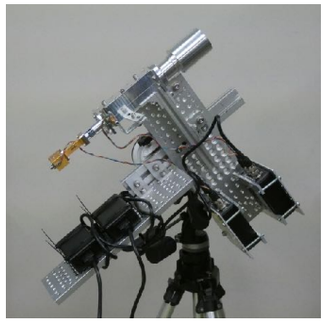


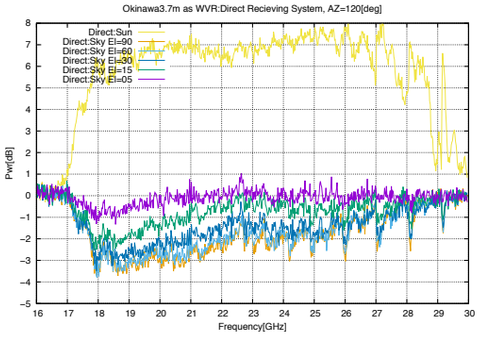

Simulation result of wideband OMT for 3.8-14.4/16GHz NINJA Feed.

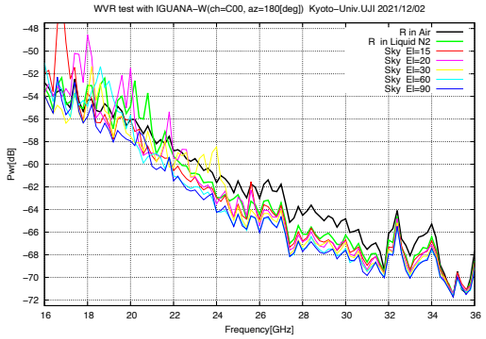
## 4. Development of Next Generation Radiometer

•Wideband feeds developed for 16-64 GHz to observe all of water vapor(16-26 GHz), Oxygen(50-64GHz) and water in clouds(28-34 GHz).
•900mm or more large dish will be used used for high resolution.
Thus more precious observation realized from the zenith to nearby horizon.
• Previous OMTs will be replaced with 3.5GHz cut-off to reduce the intermodulation noise of the 1st LNA.



16-64GHz IGUANA-H feed for the next generation radiometer




Water vapor observations by wideband feed
Left: at NICT Okinawa, using 3.7m dish. Right: at the roof top of Kyoto University, Uji, without dish

Acknowledgement:
· Bandwidth extension of IGUANA feed for methanol masers(6.7GHz and 12.2GHz) was achieved using the grant of Joint Development Research supported by the Research Coordination Committee, National Astronomical Observatory of Japan (NAOJ).
· NINJA Feed for 3.2-14.4/16GHz were developed using the incentive fund of NICT in FY2013.
· All of wideband feeds were made in the Workshop of NICT and measured in METLAB of RISH in Kyoto University.
· Development of the next generation radiometers are supported by JSPS KAKENHI grant number JP18H03828 and JP21H04524.

## References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