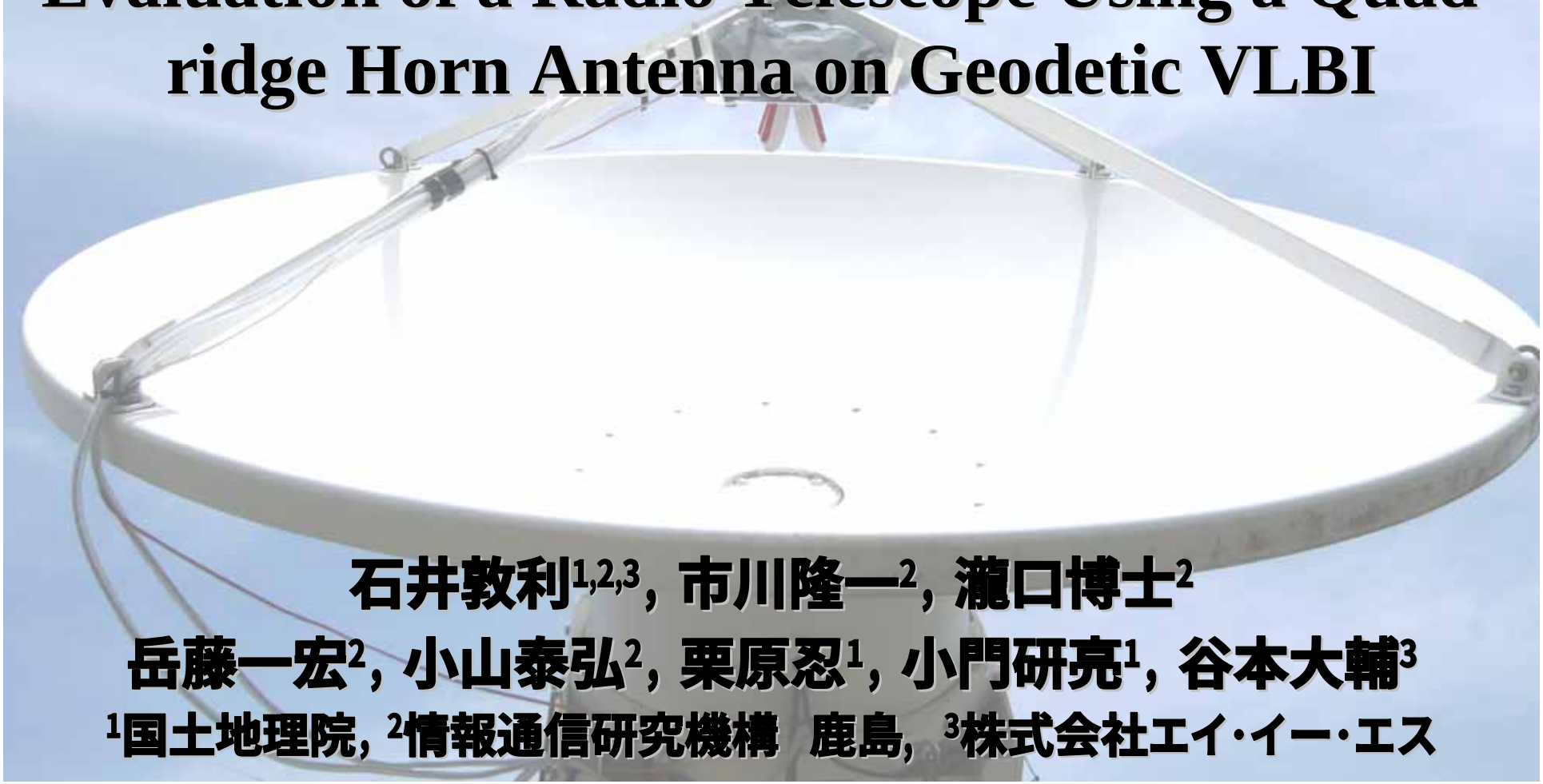
クワッドリッジホーンアンテナ (広帯域フィード) を用いた電波望遠鏡の測地VLBIにおける性能評価

Evaluation of a Radio Telescope Using a Quad-ridge Horn Antenna on Geodetic VLBI



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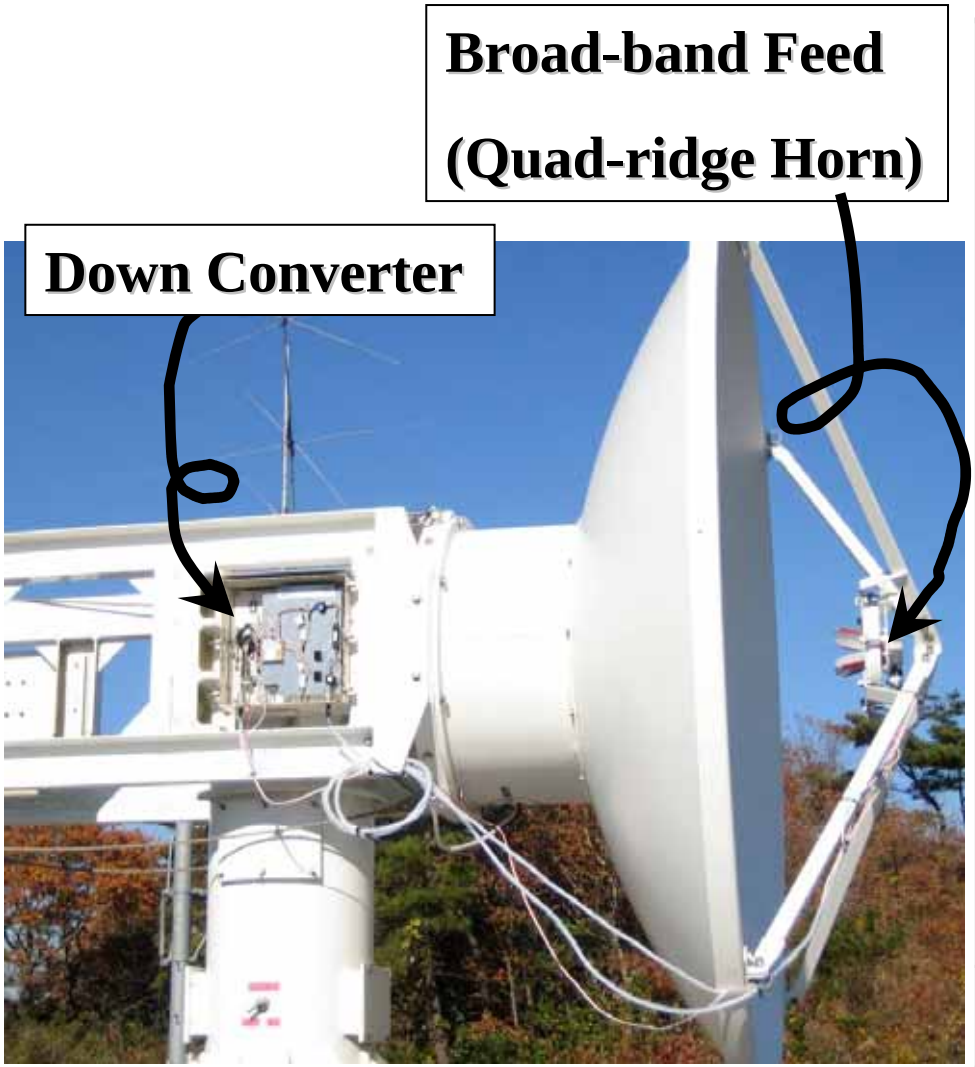
A Original Radio Telescope

CARAVAN2400

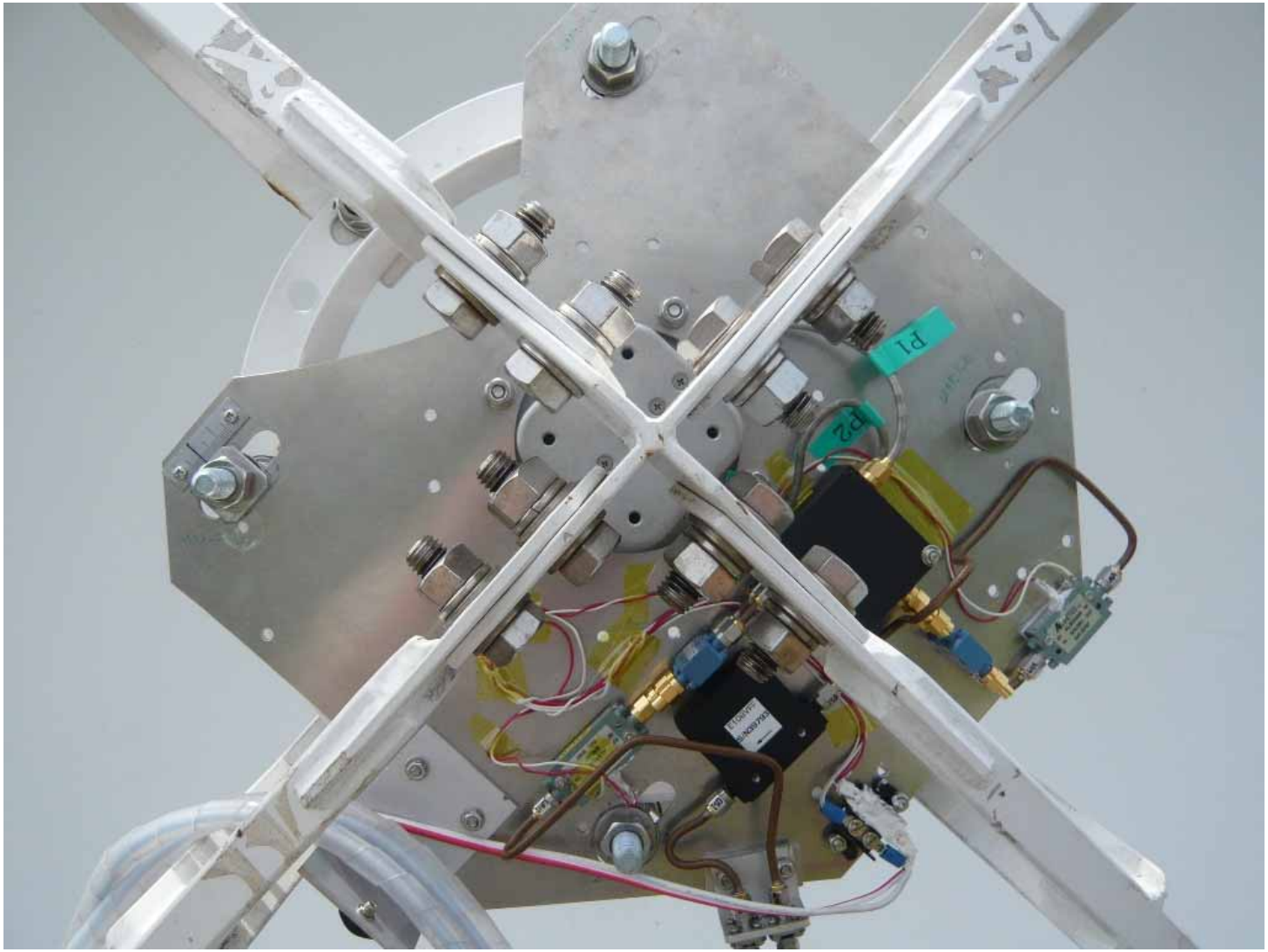
Diameter of Antenna	2.4m
Antenna Type	Cassegrain
Frequency	8180‐8600 MHz
Polarization	RHCP
Noise Temperature	System ：127 K Receiver：116 K
Aperture Efficiency	42%
Driving Speed	1°／sec

Retrofitted CARAVAN2400



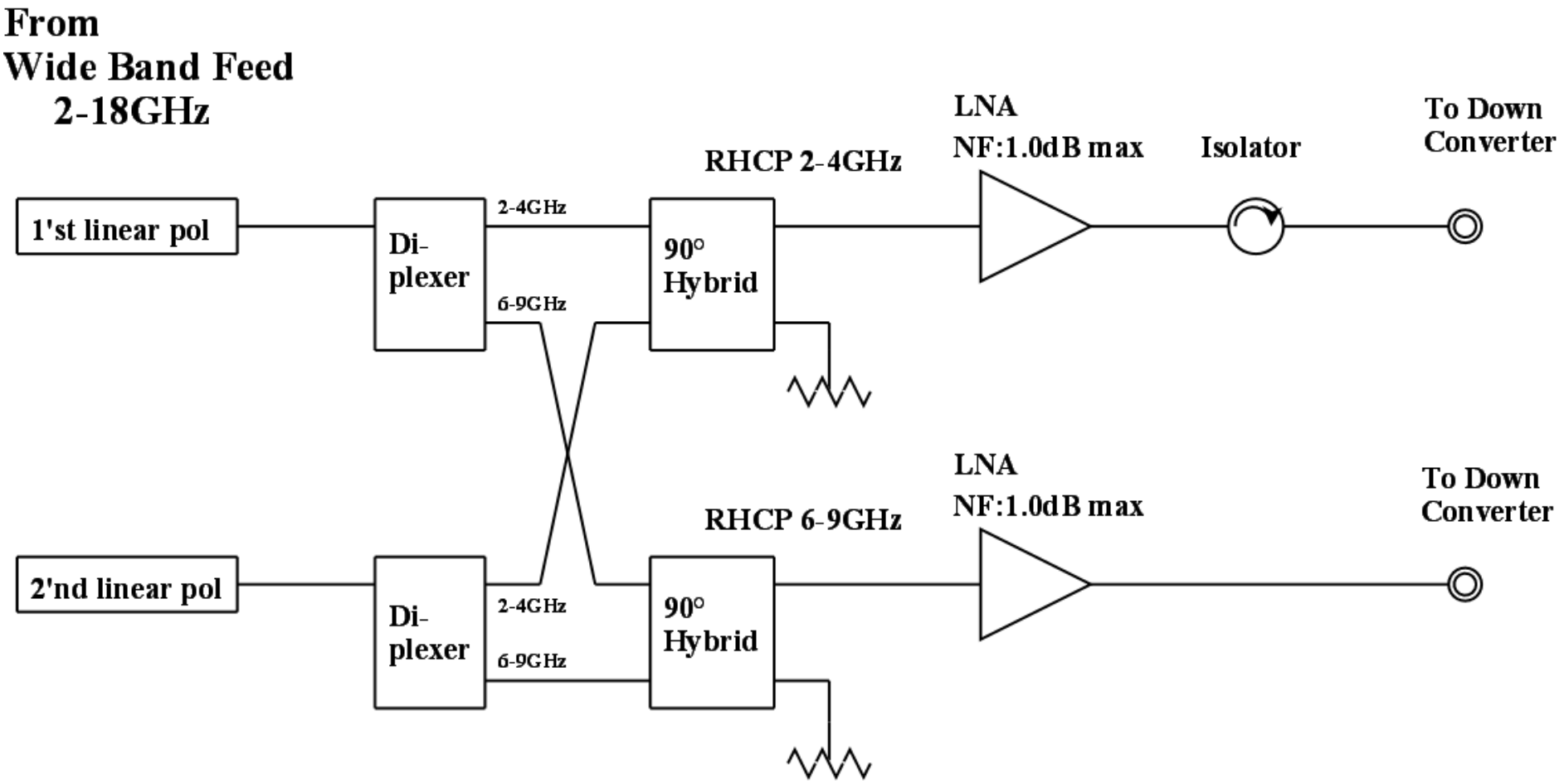
Diameter of Antenna	2.4m
Antenna Type	Front-fed Paraboloid
Receiving Frequency	S-band X-band
Polarization	RHCP or LHCP
Receiver Noise Temperature	S-band：86K X-band：170K
Driving Speed	1°／sec

Retrofitted CARAVAN2400 (Front-end)



Retrofitted CARAVAN2400

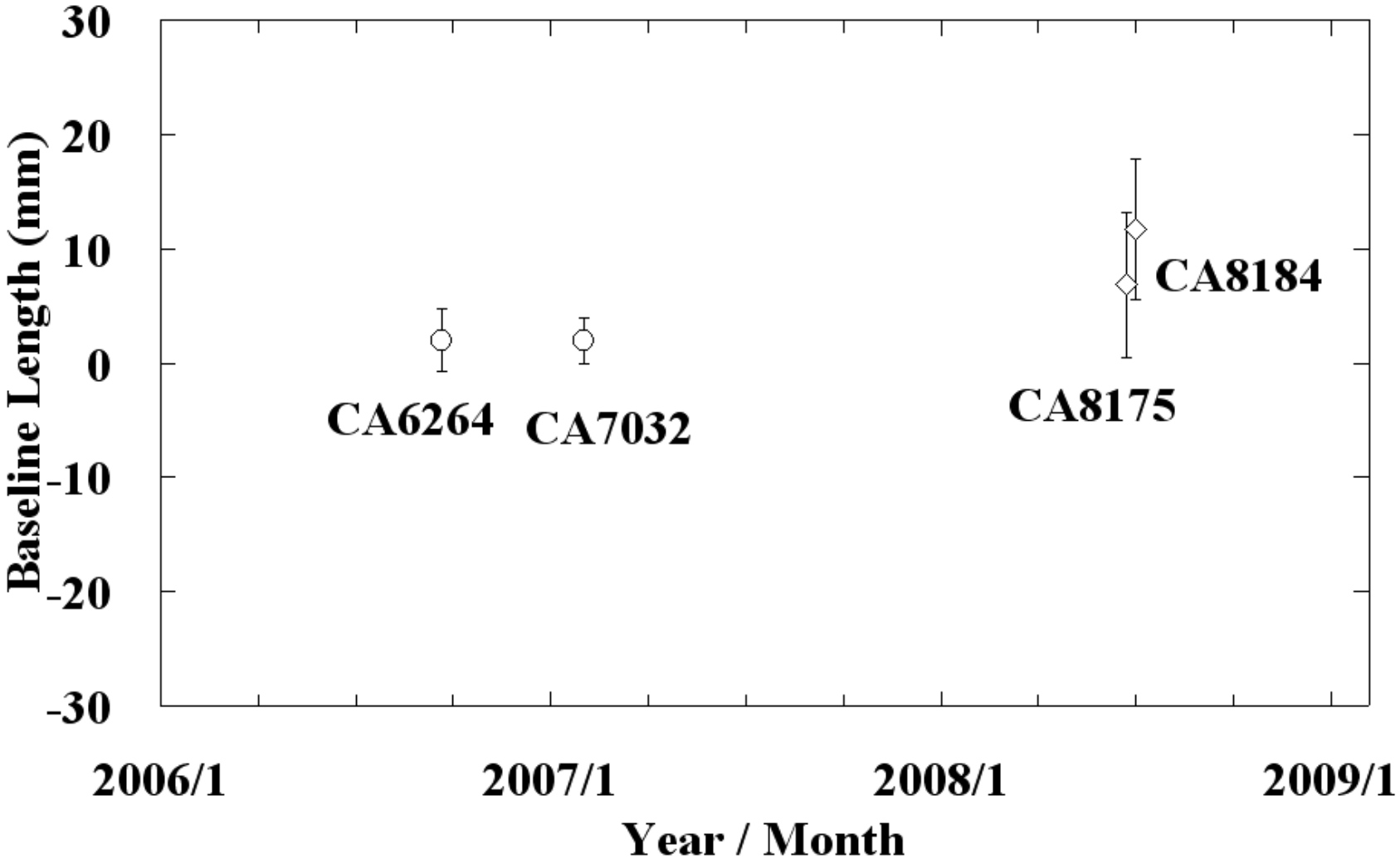
(Block Diagram of the Front-end)



Geodetic VLBI Experiments

	Experiment Name			
	CA6264	CA7032	CA8175	CA8184
Date	2006 / 9 / 21	2007 / 2 / 1	2008 / 6 / 23	2008 / 7 / 2
Station	CARAVAN2400 Tsukuba 32m		Retrofitted CARAVAN Tsukuba 32m	
Frequency	X-band 8 ch		X-band 10ch, S-band 6ch	
Sampling parameter	16 MHz / ch, 1-bit sampling (Using K5)			
Number of observations	275	375	220	188
Actual duration	24.0 h	24.2 h	24.0 h	24.0 h

Geodetic VLBI Experiments contd.



Why is wide-band feed adopted?

Why is wide-band feed adopted?

We are developing a new small radio telescope for geodetic VLBI.

= MARBLE Compact VLBI System

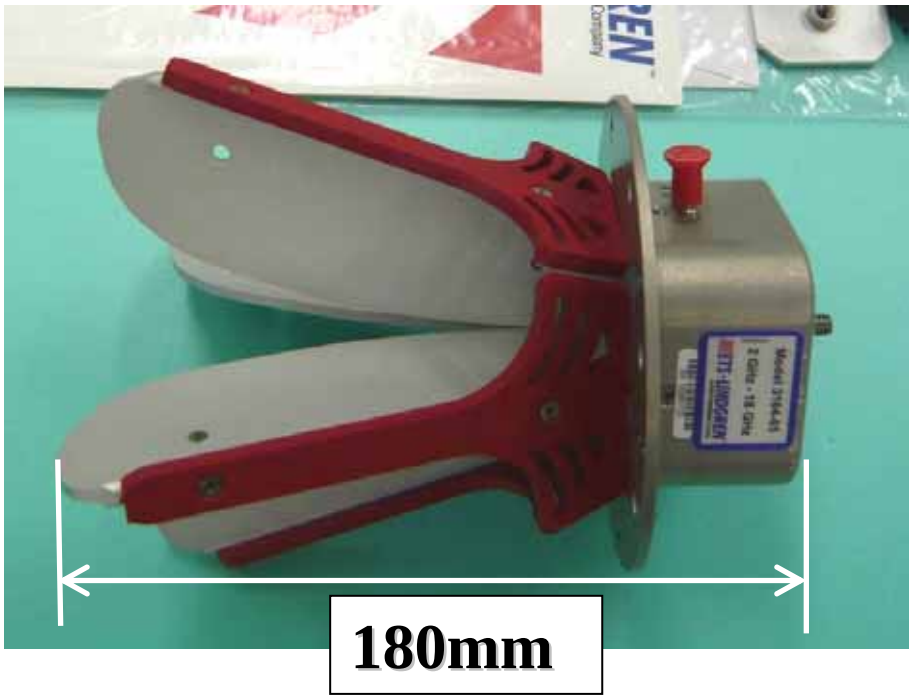
< One of a development task >

S/X band receiving simultaneously

< Requirements of the task >

1) Compact
2) Simple
3) Inexpensive
4) RHCP and LHCP

Quad-ridge Horn Antenna (QRHA)



Advantage

- Wideband

  That cover multi-octave.
- Compact and light
- Dual liner polarization

Disadvantage

- Beam width depend on frequency
- Phase center depend on frequency
- The beam pattern is not symmetry in E-plane and H-plane.

Evaluation of Retrofitted CARAVAN2400

Performance of Retrofitted CARAVAN

System noise temperature (R-Sky method)

Measured System noise temperature

S-band：280 K (EL = 90 deg), X-band：245 K (EL = 90 deg)

Performance of Retrofitted CARAVAN contd.

Aperture efficiency measurement using the moon

Ideal measured temperature

$$T_{a\_ide} = 1/2 \cdot A \cdot S / k \cdot L_a \cdot L_m$$

- Loss factor of atmosphere
- The shape factor
- Area of dish
- Boltzmann's constant
- Flux density of moon

Measured temperature

$$T_{a\_meas} = P_{on} / P_{off} \cdot T_{sys}$$

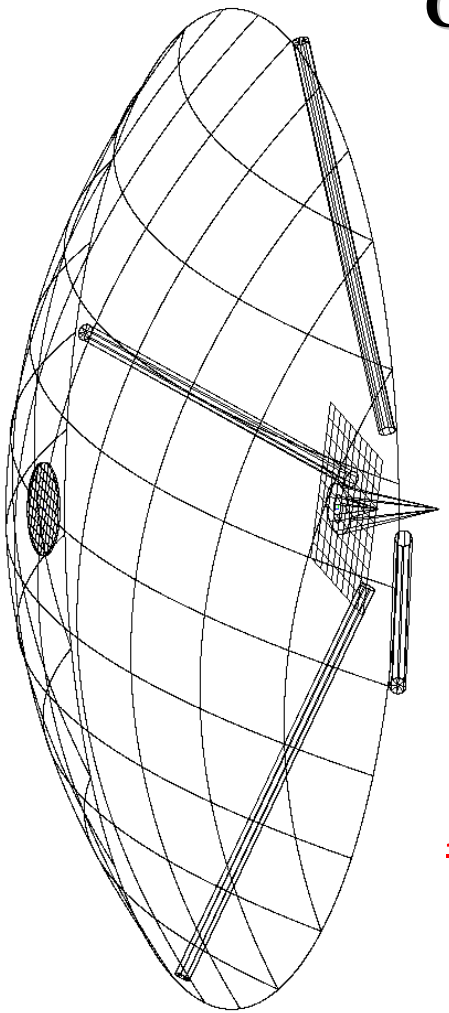
- System noise temperature
- Receiving Power from moon
- Power of background noise

Aperture efficiency

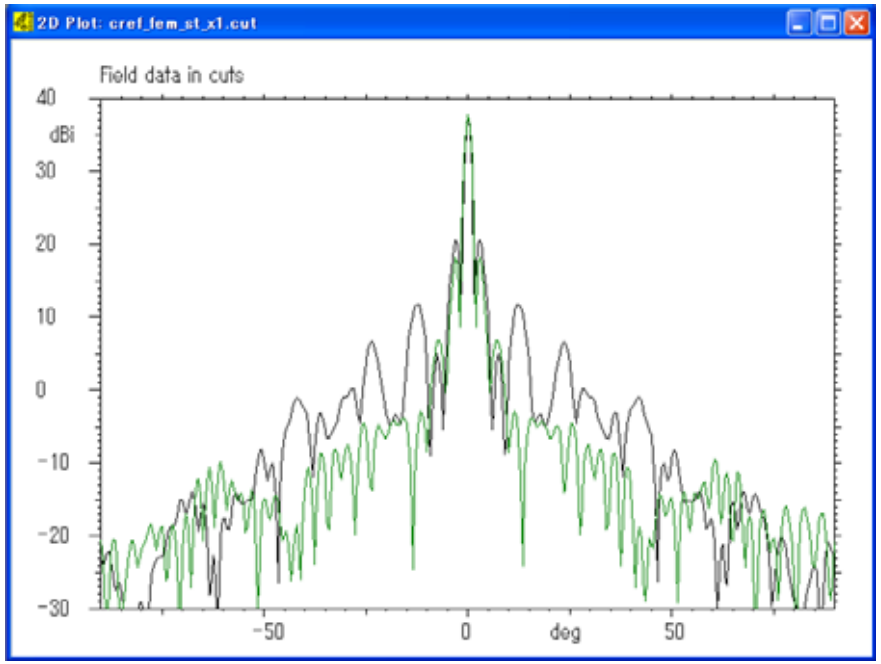
$$\eta = T_{a\_meas} / T_{a\_ide}$$

= 6.3 ± 1.0 % (X-band)

Performance of Retrofitted CARAVAN contd.



Calculated by reflector antenna analysis program GRASP8

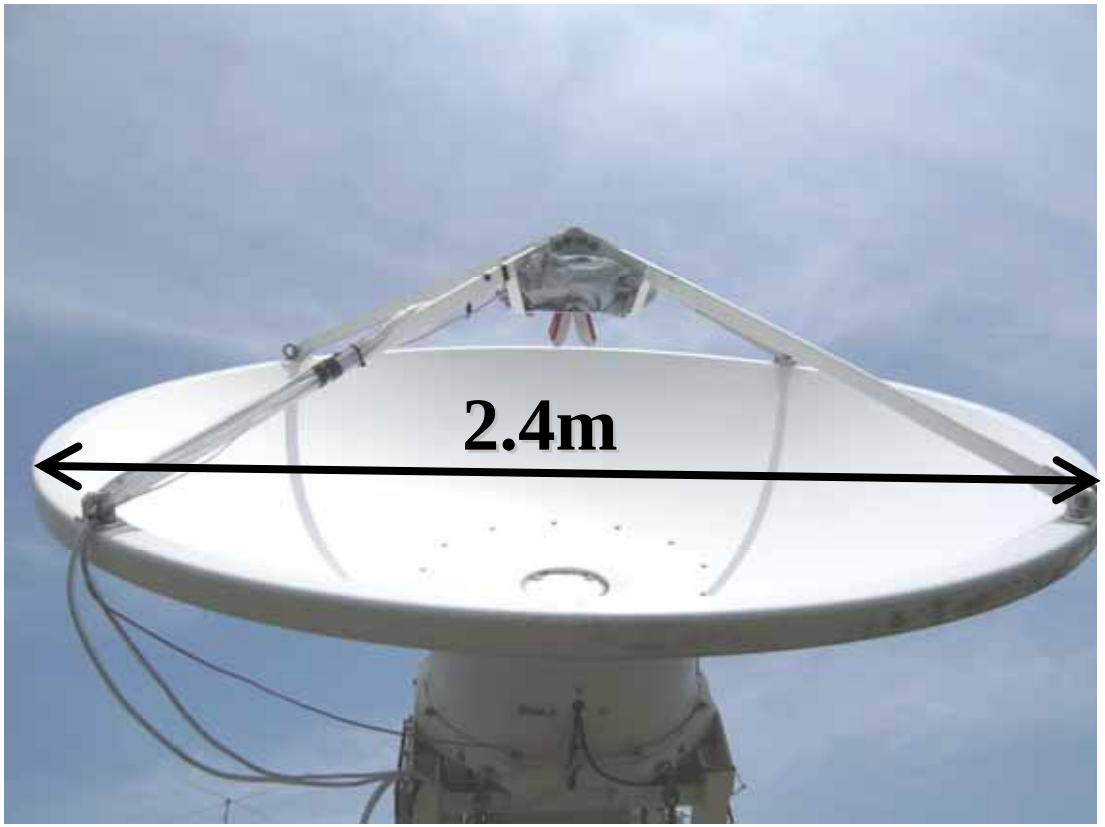


Aperture efficiency

37.7 dBi (Calculated gain) - 46.5 dBi (Ideal gain) =
−8.8 dB = **13 % (X-band)**

Aperture efficiency of Retrofitted CARAVAN

$$(2.4\text{m}/2)^2\pi \times 6\ \% \quad = (0.83\text{m}/2)^2\pi \times 50\ \%$$



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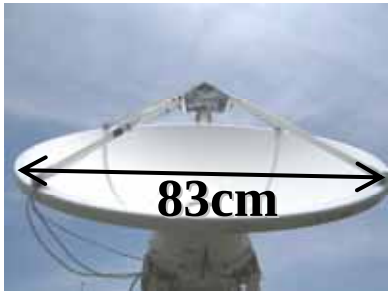
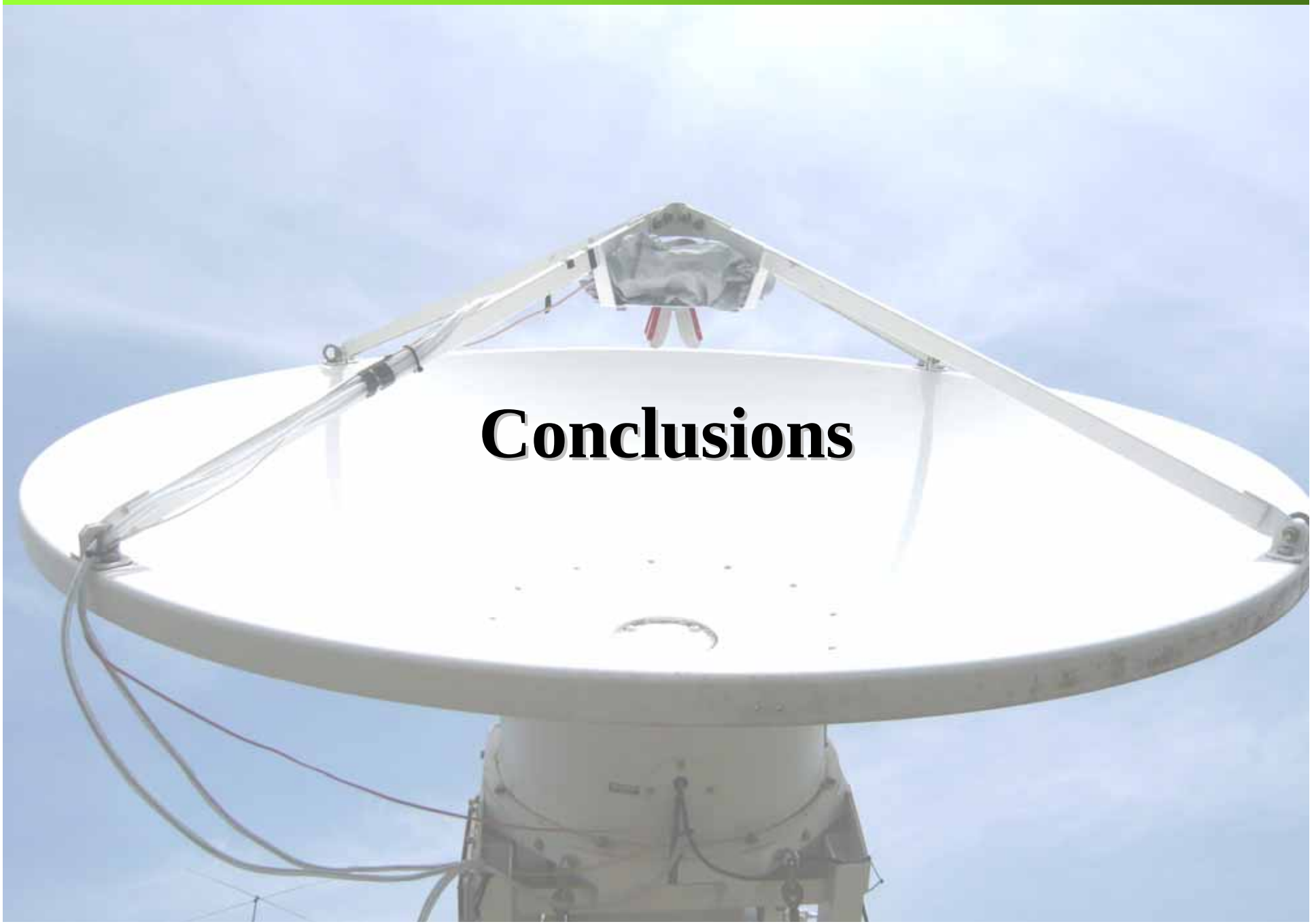




Conclusions

Conclusions

- We designed novel wideband radio telescope.
  It adopted wideband feed of simple and compact.
- This radio telescope was confirmed to be able to apply to geodetic VLBI.

But…

- Low Aperture Efficiency
- High Noise Temperature

Outlook

A Prototype of MARBLE Compact VLBI System

1) Using a optimum designed dish

Aperture efficiency ~40% (X-band, Predicted)

$(2.4m/2)^2 \pi \times 6\% < (1.65m/2)^2 \pi \times 40\%$

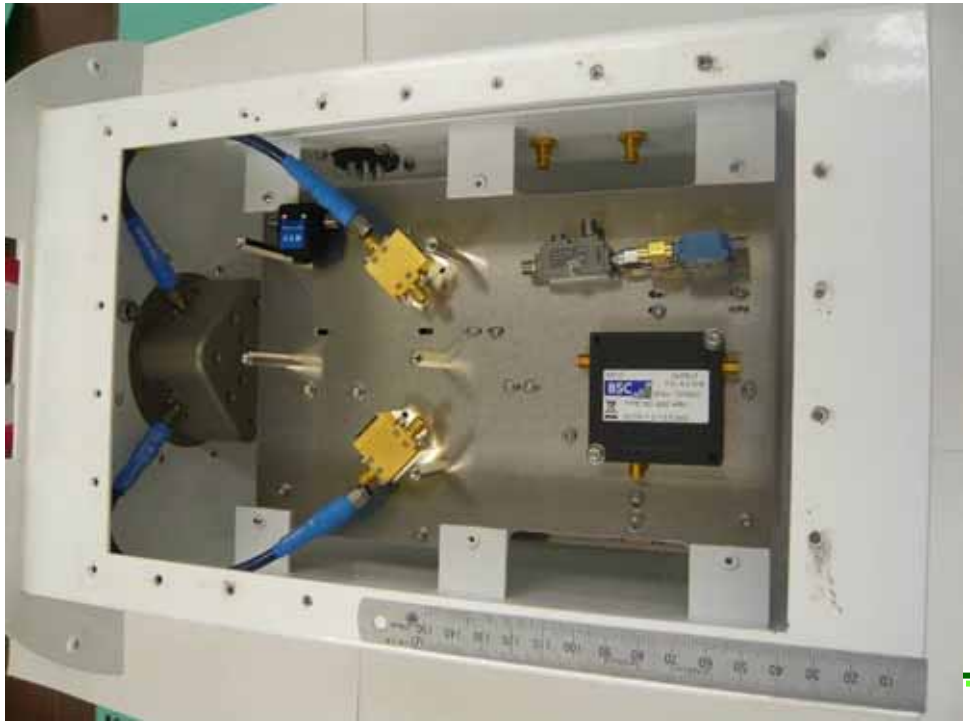
Outlook contd.

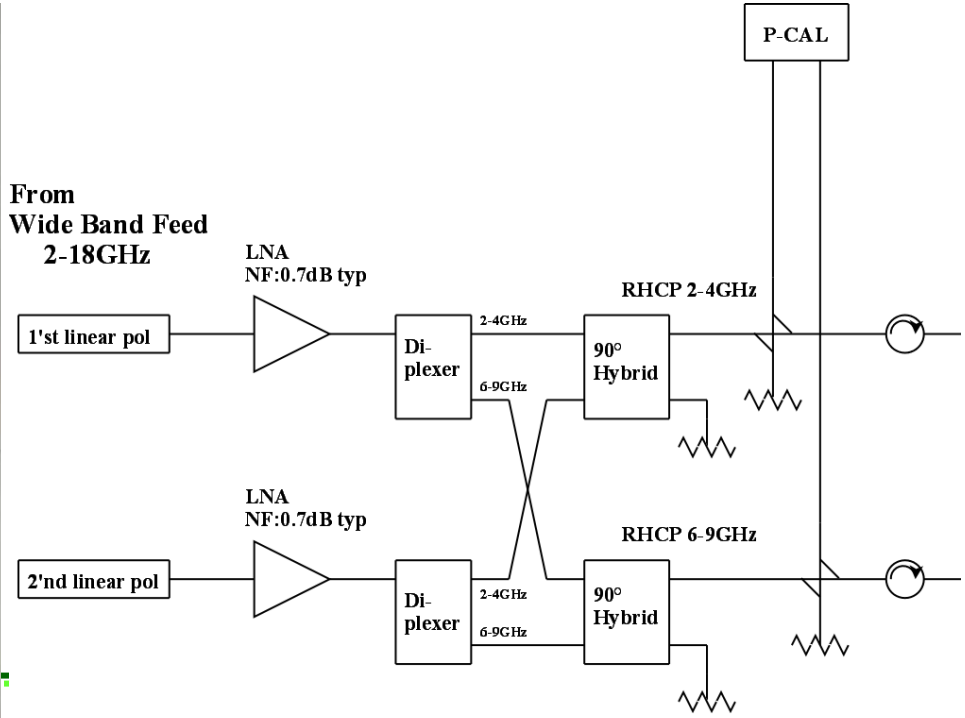
A Prototype of MARBLE Compact VLBI System

2) Using a wideband low noise amplifier

S-band Trx：86K → 65K

X-band Trx：170K → 65K





Outlook contd.

A Prototype of MARBLE Compact VLBI System