

# **Current Status of the Development of a Transportable and Compact VLBI System by NICT and GSI**

**Atsutoshi. Ishii<sup>1,2</sup>, R. Ichikawa<sup>2</sup>, H. Takiguchi<sup>2</sup>,  
K. Takefuji<sup>2</sup>, H. Ujihara<sup>2</sup>, Y. Koyama<sup>2</sup>, T. Kondo<sup>2,3</sup>,  
S. Kurihara<sup>4</sup>, Y. Miura<sup>4</sup>, S. Matsuzaka<sup>4</sup>, D. Tanimoto<sup>1,4</sup>**

<sup>1</sup>Advanced Engineering Services Co., Ltd (AES) (Assistant Researcher for GSI),

<sup>2</sup>National Institute of Information and Communications Technology (NICT) Japan

<sup>3</sup>Ajou University, <sup>4</sup>Geographical Survey Institute (GSI) Japan

# Contents

- **Introduction**
- **Applications**
- **Performance tests**
- **Summary & Outlook**



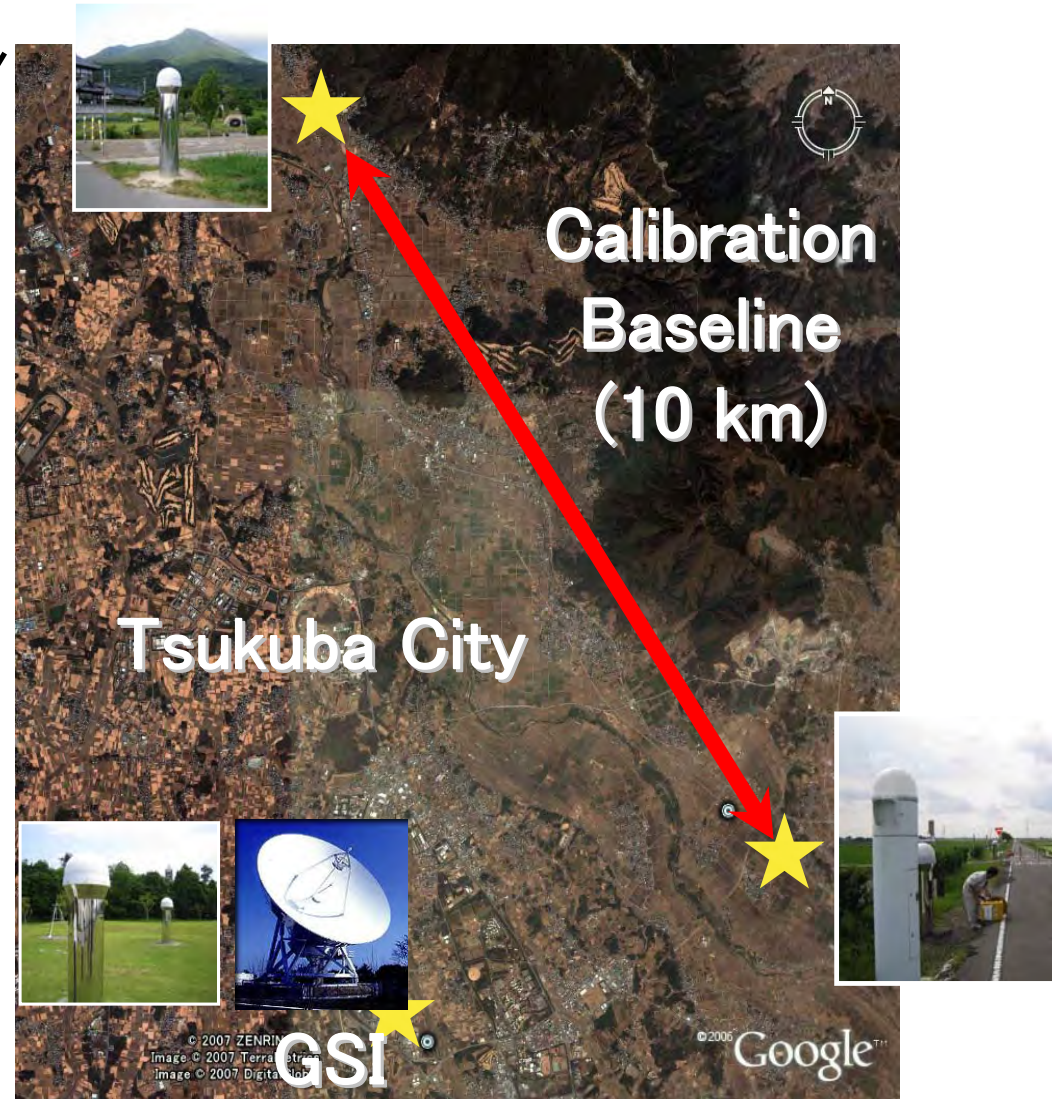
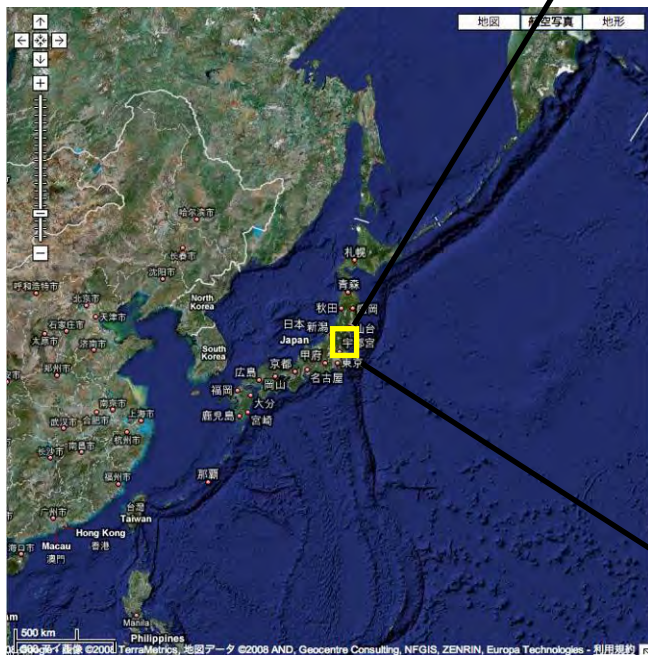
# **Introduction**

## **(What is aim?)**

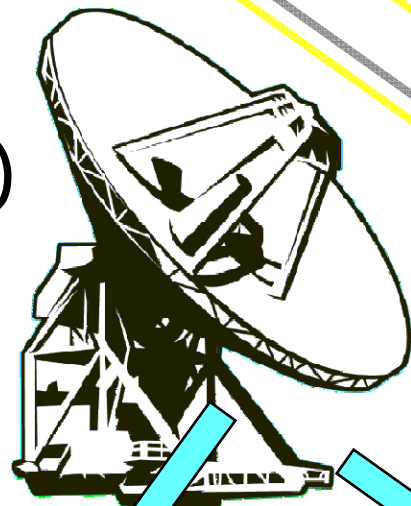
---

# To measure a calibration baseline

The calibration baseline :  
Facilities for check and validate  
surveying instruments  
(GPS, EDM, etc...)



Station R  
(Large Antenna)

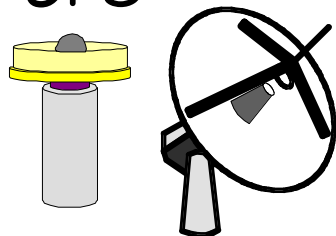


RX

RY

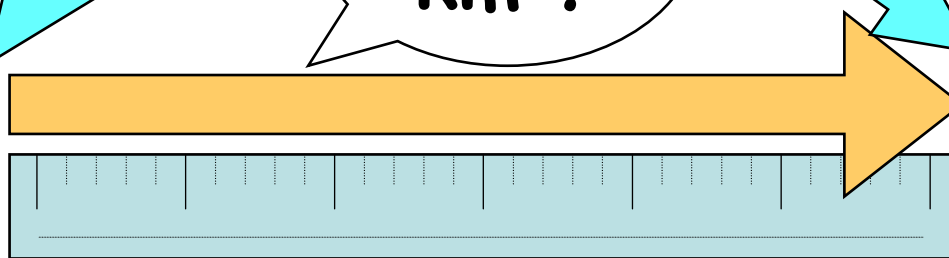
10  
km ?

GPS



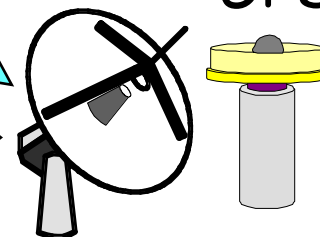
Station X

(Compact Antenna)



XY

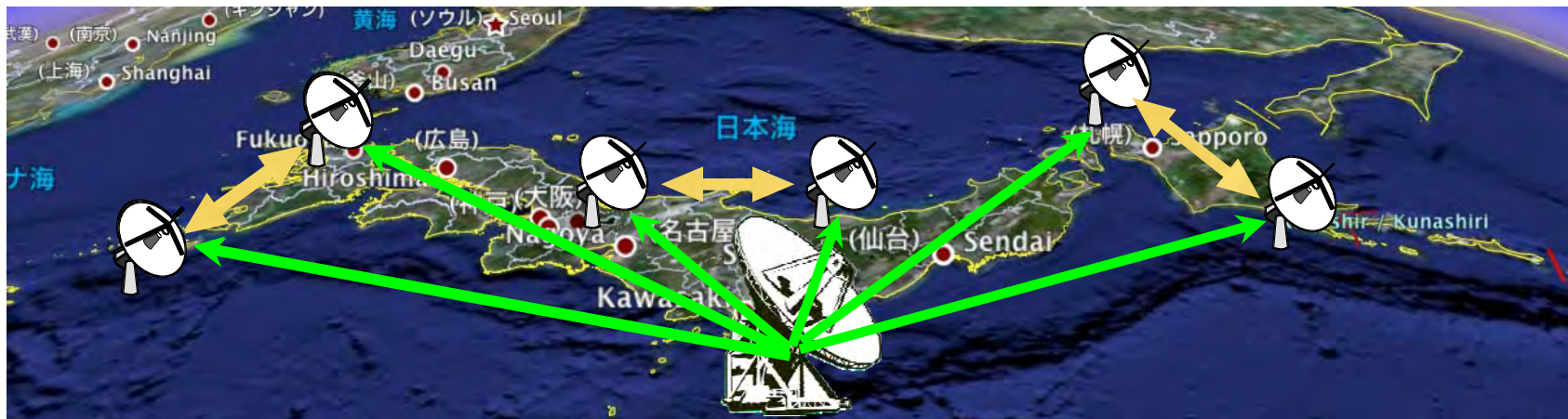
GPS



Station Y

(Compact Antenna)

Multiple Antenna Radio-interferometer  
for  
Baseline Length Evaluation  
**MARBLE**  
System



# **Introduction of a transportable VLBI system**

---

# Timeline of development

**2006** We started development of a compact VLBI system collaborate with GSI and NICT.

**2006 ~ 2007**

**Feasibility Study and Design**

**Compact frequency standard was tested on VLBI.**

**2008** 1st prototype of compact antenna was made.

**First light on 1st prototype**

**2009** We performed geodetic VLBI exp. using 1st prototype.

**2nd prototype of compact antenna was made.**

**We performed geodetic VLBI exp. using two prototypes.**



## First Prototype

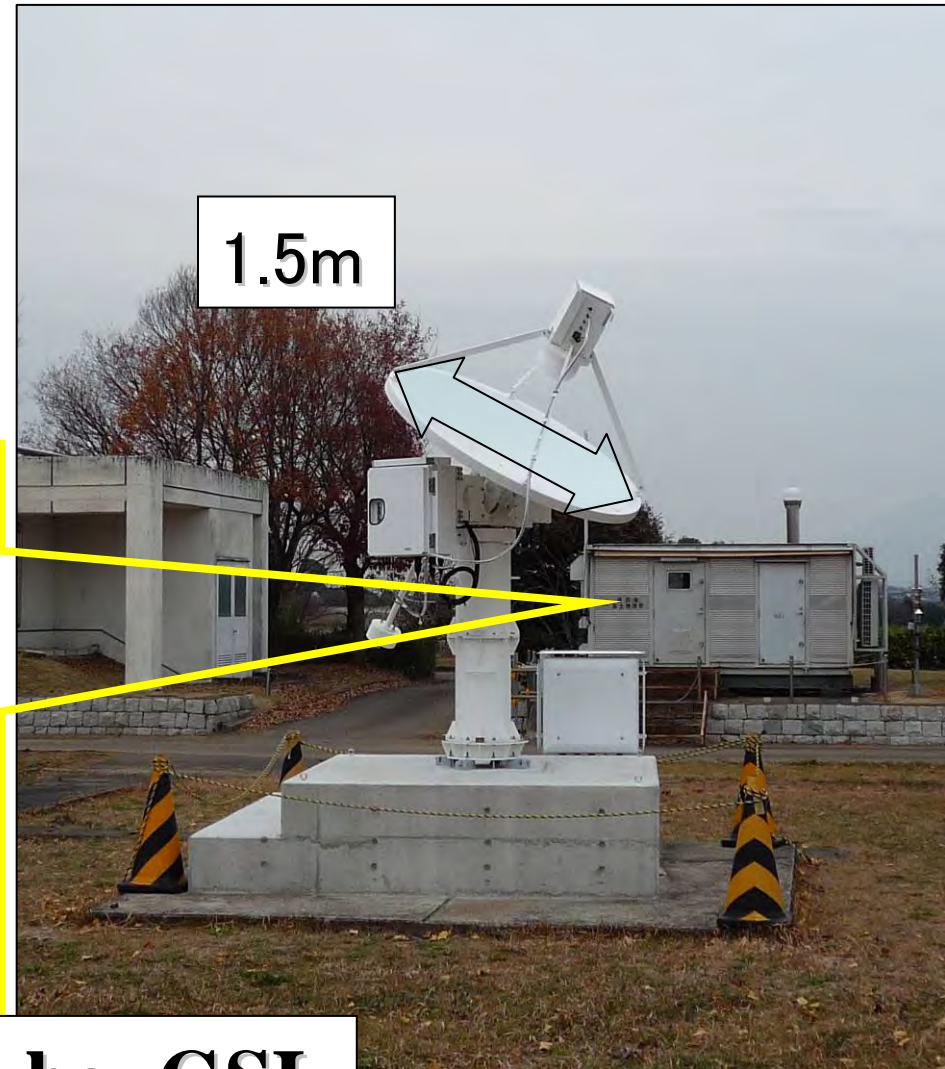
- Driving Speed 5 deg./sec
- S/X-band
- Tsys ~ 140 K (X)  
~ 180 K (S)
- Broad-Band Feed



At Kashima, NICT

## Second Prototype

- Driving Speed 5 deg./sec
- S/X-band
- Tsys ~ 160 K (X)  
~ 200 K (S)
- Broad-Band Feed



At Tsukuba, GSI

# Feature : **Easy to transport by (only) man-power**



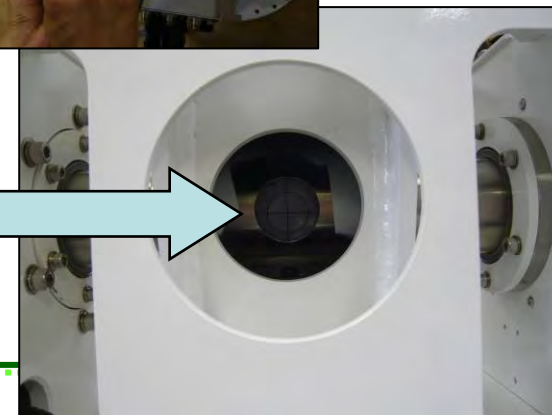
# Feature : Easy to mount other survey instruments



**GPS**

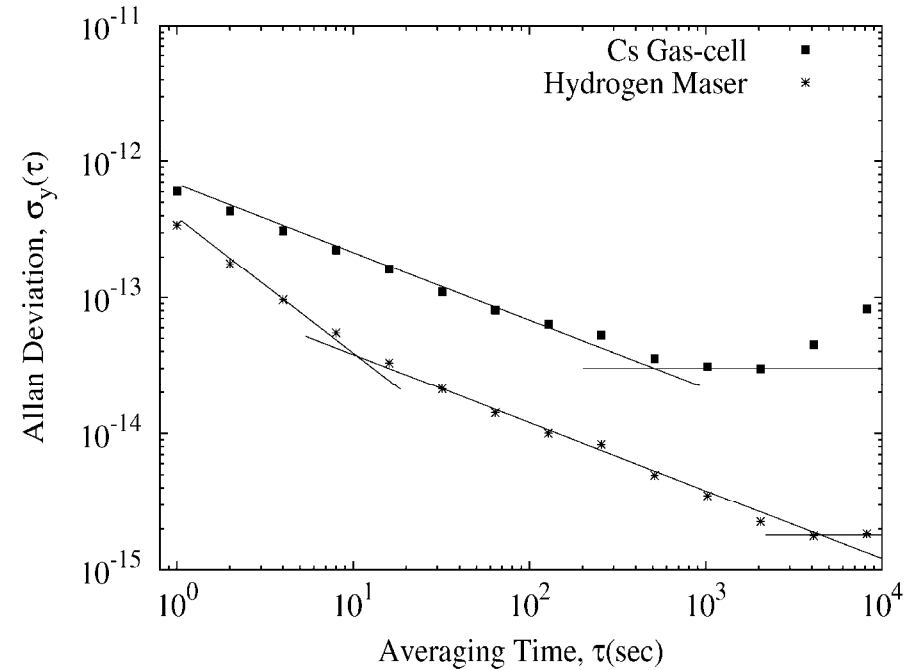


**VLBI  
reference  
point**



# Frequency Standard

## Laser-pumped Cs Gas-cell Frequency Standard



**It has been confirmed to  
use on geodetic VLBI !**

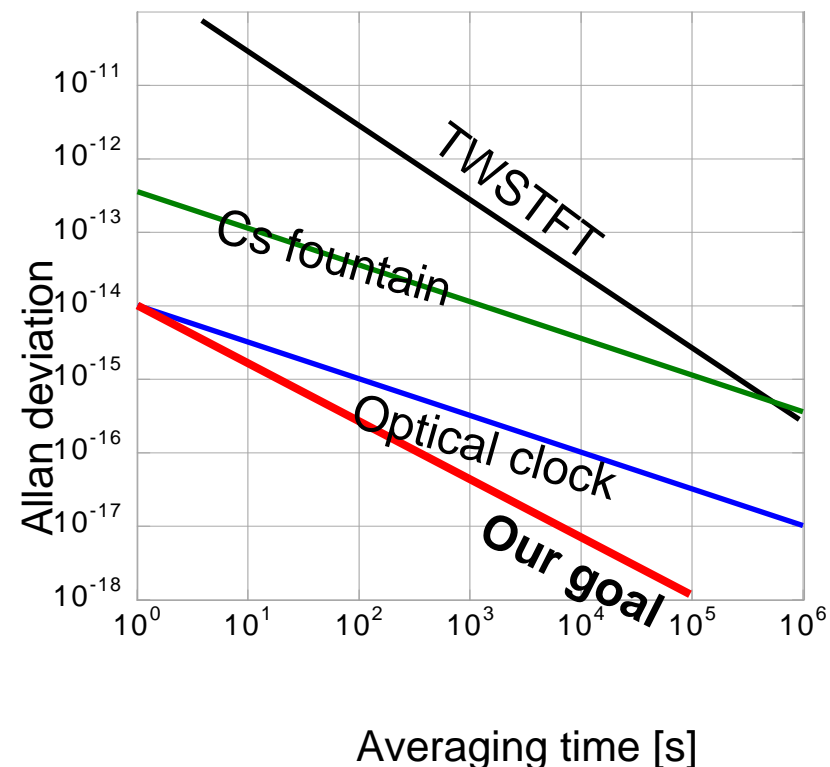
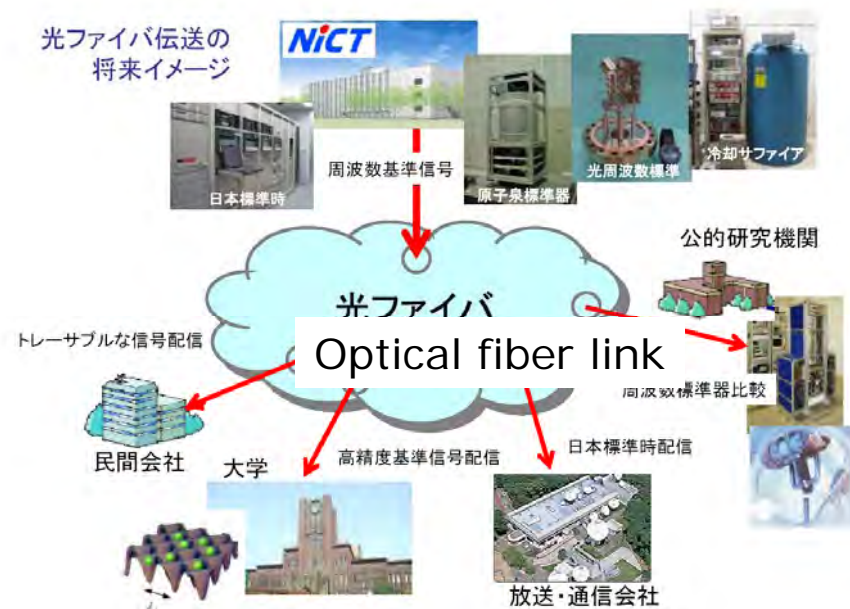
**(Ishii et al 2008, J. Geod, Soc. Japan)**

# Frequency Standard (Planned)

## RF distribution using optical fibers

To distribute precise and accurate RF signal to remote users

To be used as a mean of optical clock comparison



## Costs

- **Antenna and mount : \$ 140 thousand USD**
  - **Receiver : \$ 50 thousand USD**
  - **Back-end (K5) : \$ 100 thousand USD**
  - **Cs-Gas Cell Std. : \$ 120 thousand USD**
-

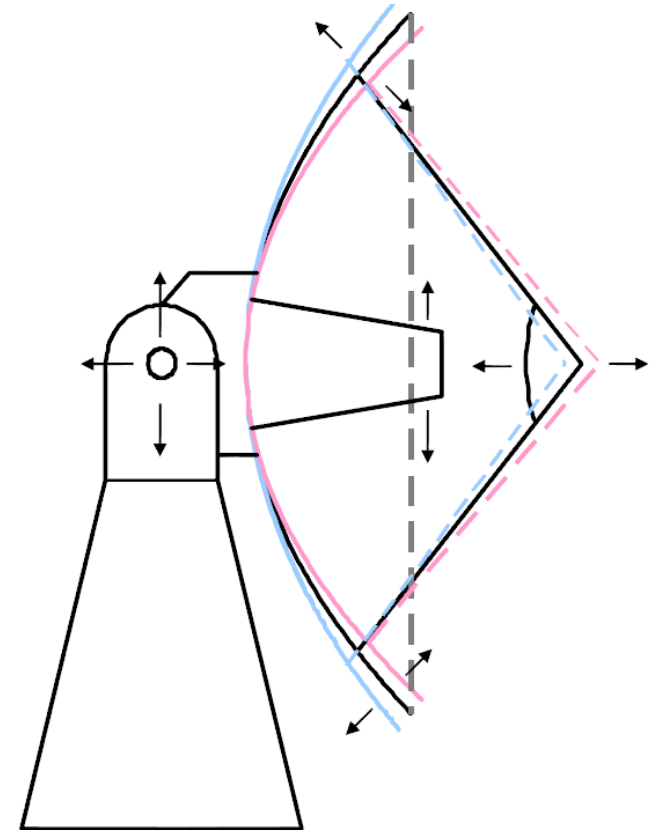
# Applications

---



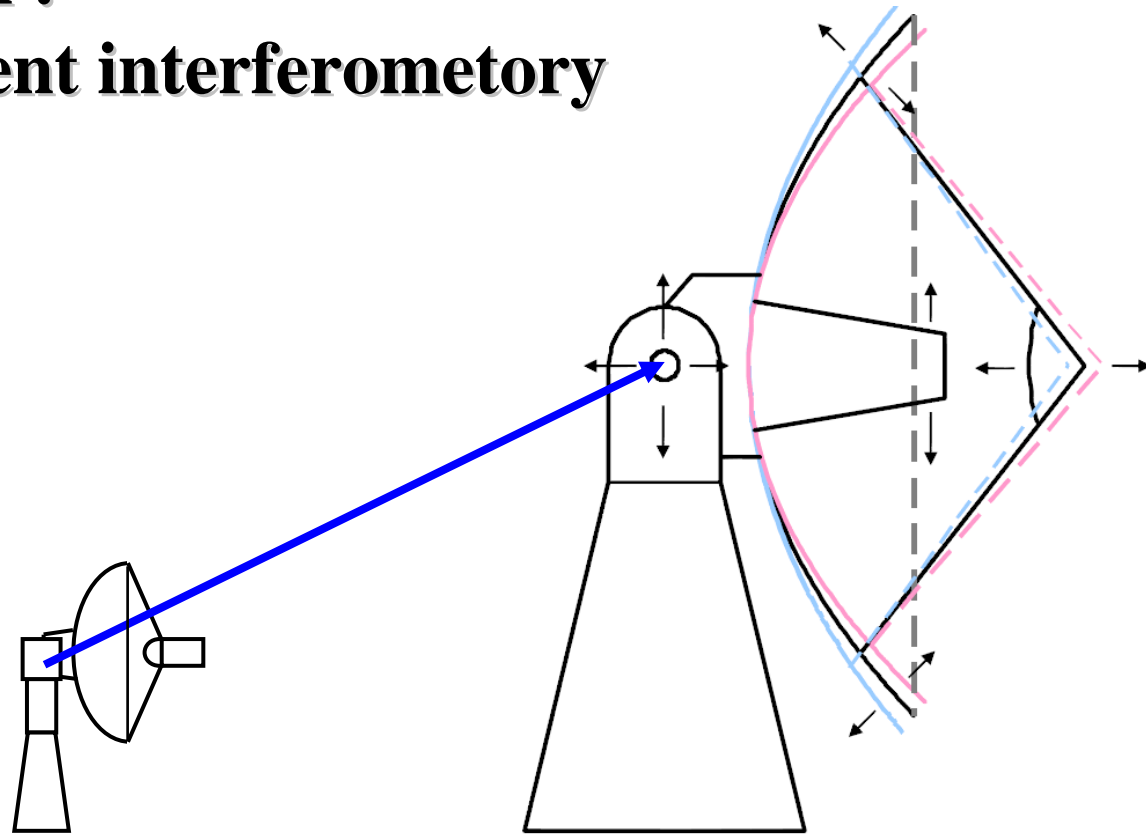
## For VLBI2010

- **To achieve the challenging measurement precision of VLBI2010.  
(1 mm position accuracy)**
- **We have to deal with the problem of antenna deformation.  
(Thermal and gravitational)**



# For VLBI2010 Contd.

- **One of the solution :**  
**Connected-element interferometry**



**Compact "reference" antenna**

**VLBI2010 antenna**



# Time & Frequency Transfer

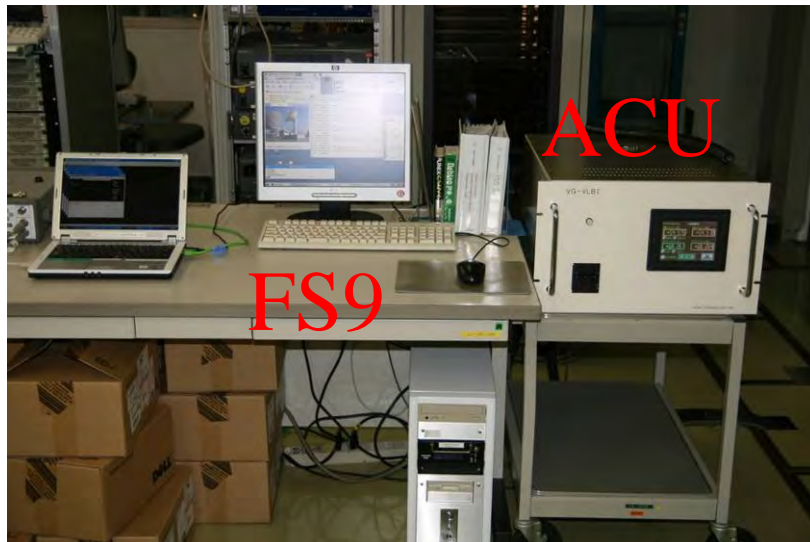


# Performance tests

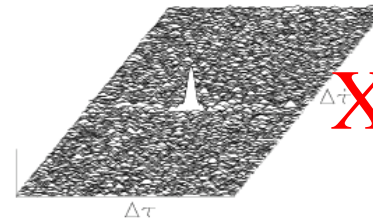
---

# Fringe detection test for 1st prototype

## Feb. 12, 2009

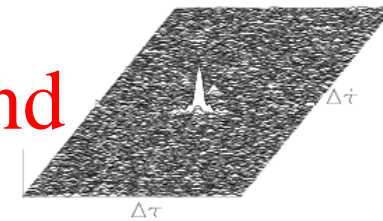


KASHIM34 - MARBLE1  
CH#:1 8184.99MHz U 1bit 32MHz sampling  
Source : 3CB4, Integ(sec)=240.0, PRT:2009/043 05:32:30  
Amp = 0.000584, SNR = 51.2 (no amp correction)  
Delay Res (sec) : -2.874e-08 Rate Res(s/s) : -6.640e-12

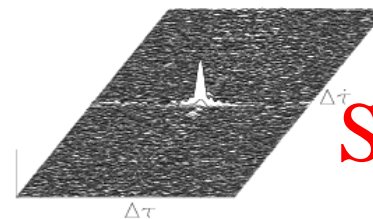


X-band

KASHIM34 - MARBLE1  
CH#:2 8659.99MHz U 1bit 32MHz sampling  
Source : 3CB4, Integ(sec)=240.0, PRT:2009/043 05:32:30  
Amp = 0.000953, SNR = 83.5 (no amp correction)  
Delay Res (sec) : -9.837e-09 Rate Res(s/s) : -6.621e-12

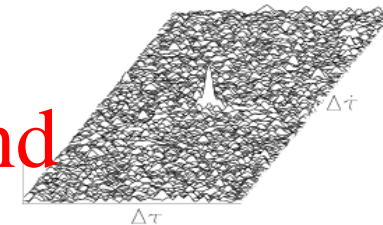


KASHIM34 - MARBLE1  
CH#:3 2219.99MHz U 1bit 32MHz sampling  
Source : 3CB4, Integ(sec)=240.0, PRT:2009/043 05:32:30  
Amp = 0.001461, SNR = 128.1 (no amp correction)  
Delay Res (sec) : 2.243e-09 Rate Res(s/s) : -6.647e-12



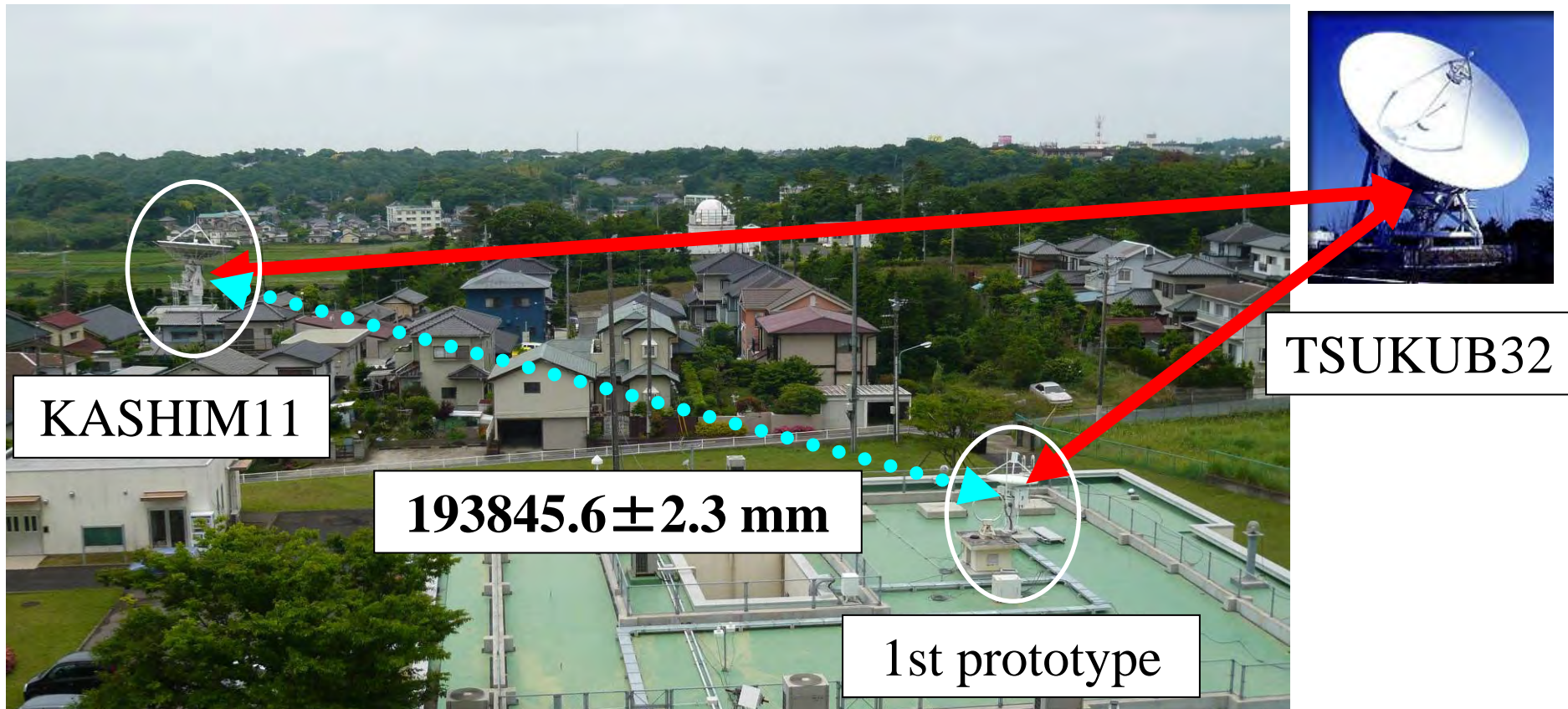
S-band

KASHIM34 - MARBLE1  
CH#:4 2349.99MHz U 1bit 32MHz sampling  
Source : 3CB4, Integ(sec)=240.0, PRT:2009/043 05:32:30  
Amp = 0.000250, SNR = 21.9 (no amp correction)  
Delay Res (sec) : 1.856e-08 Rate Res(s/s) : -6.771e-12



# Geodetic VLBI exp. using 1st prototype

Jun. 25-26, 2009



**We got a baseline length around 200 m !**

# Geodetic VLBI exp. using two prototypes

Dec. 24-25, 2009

TSUKUBA32

2nd prototype



$54184878.6 \pm 2.7$  mm



1st prototype

**We got a baseline length around 54 km !**

# Summary

- **We designed and made the two prototypes of transportable VLBI system.**
  - **We made some performance tests for these prototypes.**
  - **We confirmed that these prototypes can be used on geodetic VLBI.**
-



# Outlook

➤ **We are going to examine the antenna efficiency in anechoic chamber using a near-field measurement system.**

➤ **We are going to upgrade and modify**

**Antenna : Two reflectors (ring-focus design?)**

**Front-end : Cooling? (LNA and Feed?)**

**Back-end : Higher Speed Sampler (ADS3000+)**



# Thank you for your attention !

- These prototypes of compact antennas was made by VEGA TECHNOLOGY INC.

<http://www.vegatechnology.co.jp/kaihatsu.html>

- This work was supported by a Grant-in-Aid for scientific research (KAKENHI, No.212410043)
-