A very small satellite for space astrometry: Nano-JASMINE

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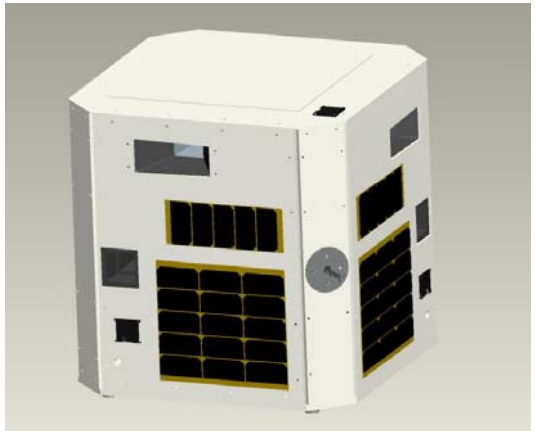
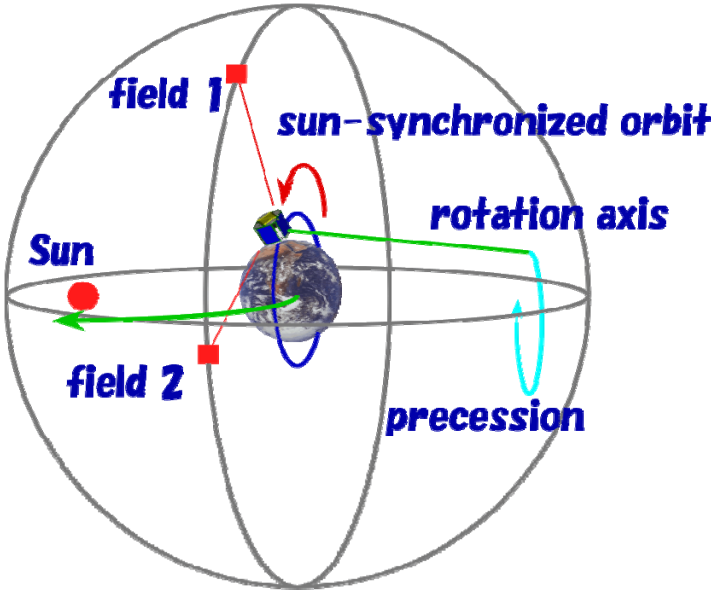
Nano-JASMINE project team

Nano-JASMINE





Mission: Astrometry

Size: Nano-size satellite (50 x 50 x 50 cm)

Mass: 25 kg

accuracy: 3 mas

Launch: 2010

Orbit: sun-synchronized orbit (500-800 km)

Mission life time: 1.5 years

Survey Area: whole sky

Spin Satellite

(Spin rate is synchronized to orbital period)

Motivation

First space astrometry mission in Japan

Challenge to observe astrometric parameter comparable to HIPPARCOS

(50 times lighter than HIPPARCS)

15 years passed since the end of the HIPPARCOS mission

↳ improve proper motions of stars

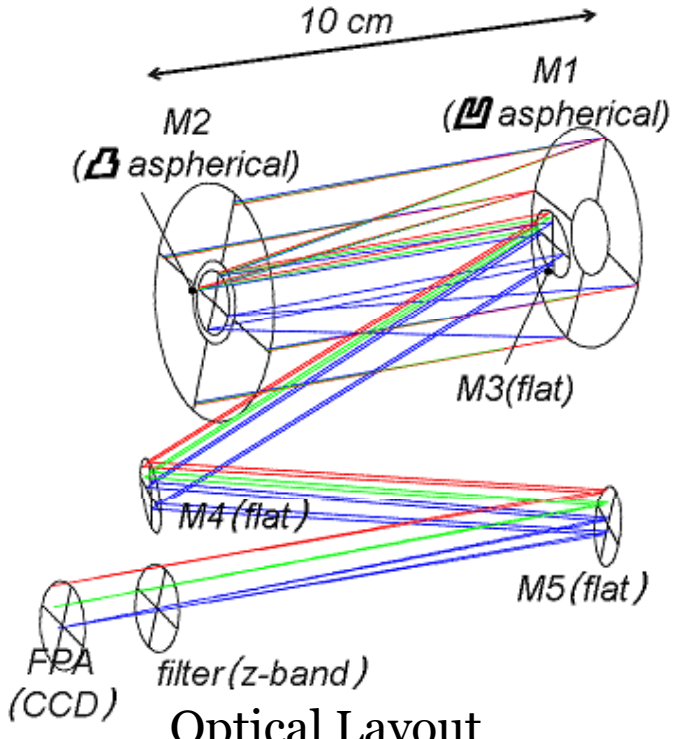
Technical demonstration for JASMINE

(First satellite of JASMINE series)

Features of Nano-JASMINE

- 5 cm reflecting telescope (focal length: 167 cm)
- HIPPARCOS type satellite (using beam-combiner)
- Drift scan (Time-Delayed Integration, TDI)
- Star Image Extractor (On-board data processing tool)
- Algorithm for centroid estimation (1/100 pixel)

Optical layout and Specification



Optical Layout

(Beam-combiner appear around M2)

Specification

Aperture (M1) : φ5cm

Focal length : 167cm

Type : Ritchey-Chretien type

2 aspherical mirrors & 3 folding mirrors

FOV : 0.5 x 0.5 deg

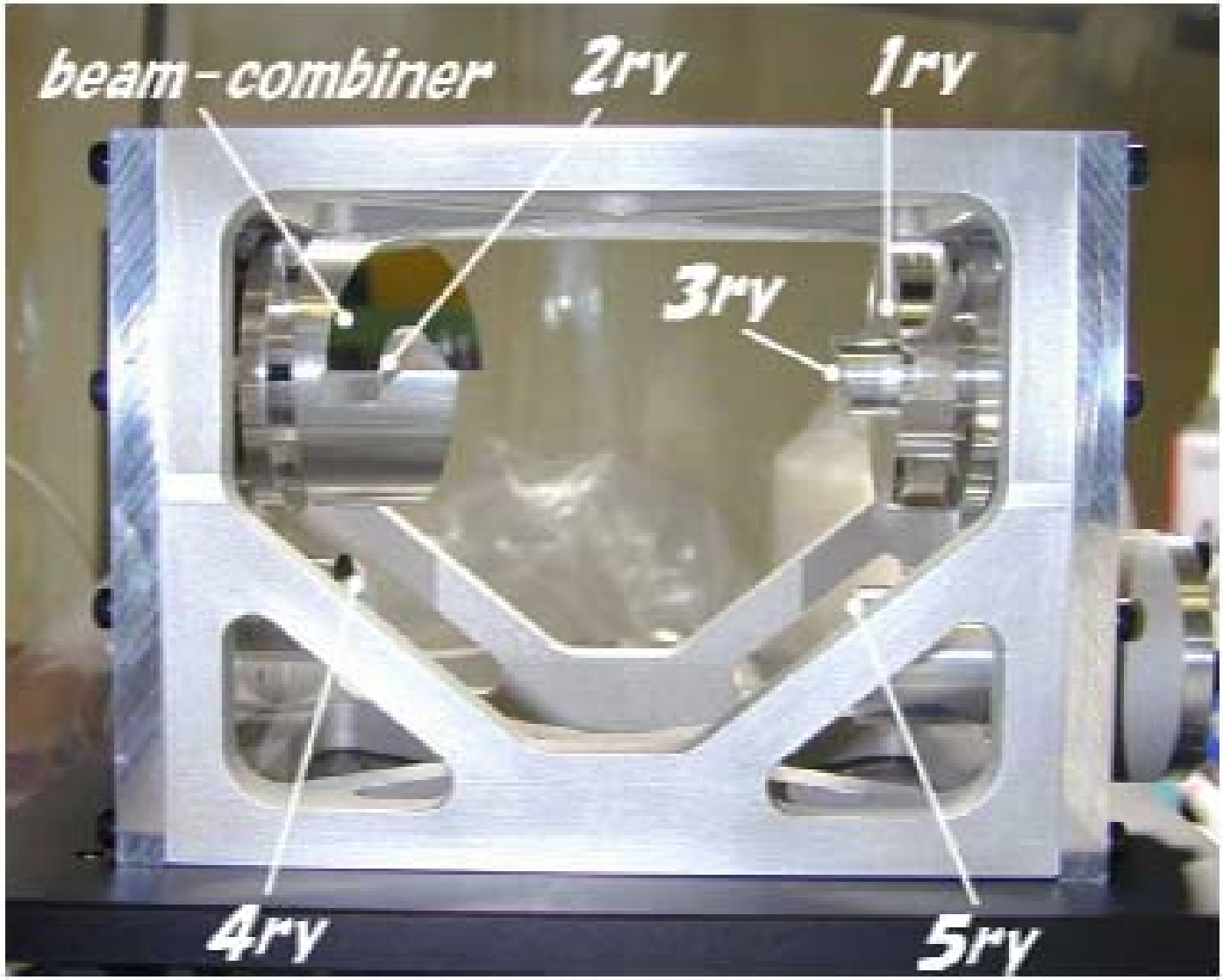
Wavelength : λ～0.9μm (z-band)

CCD : 2k x 1k (Full-depletion)

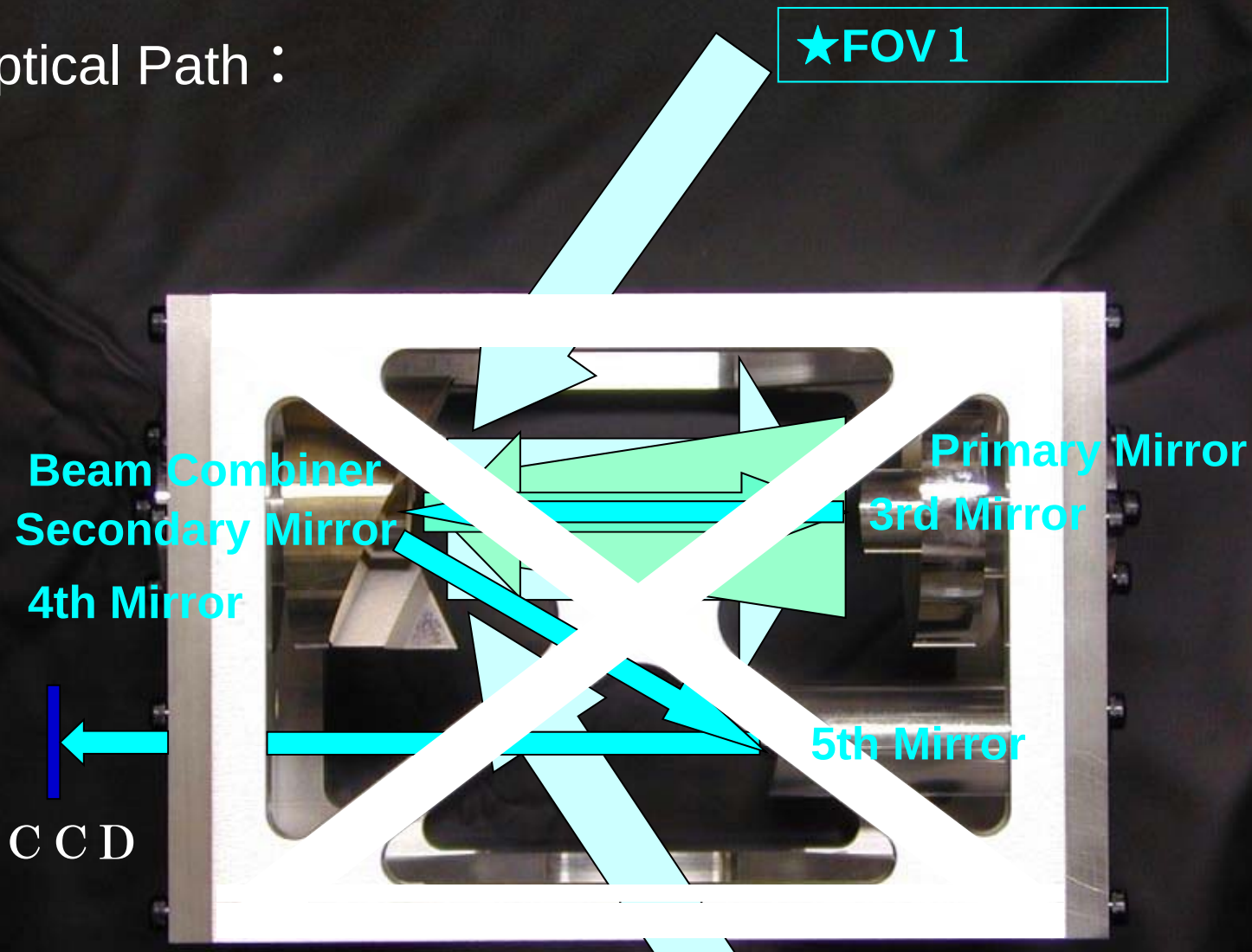
Relative angle of Beam combiner : 99.5deg

Operating temperature : 170K ～ 220K

Optical System (assembled telescope)



■Optical Path：

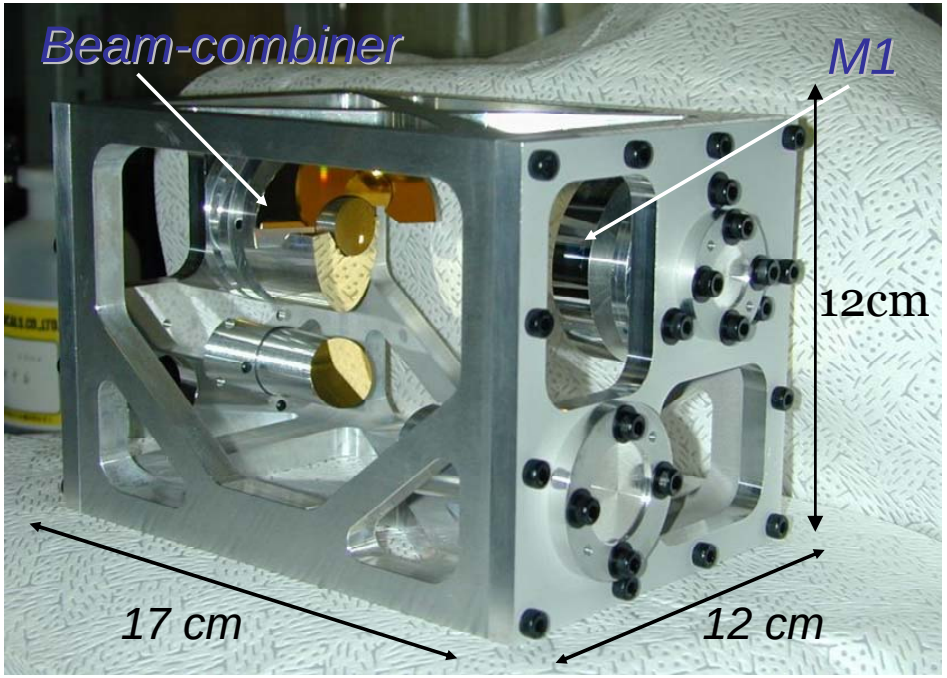


Fabrication of telescope

All mirrors and their structural supports are shaped out of aluminum alloys

All reflecting surfaces were fabricated with diamond turning machine

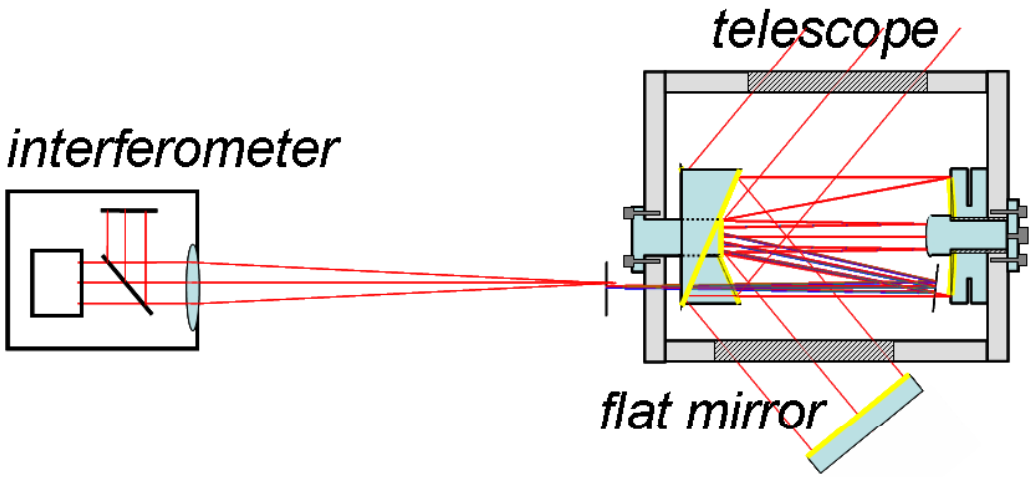
Optical component
(deposited by Cr and Au)

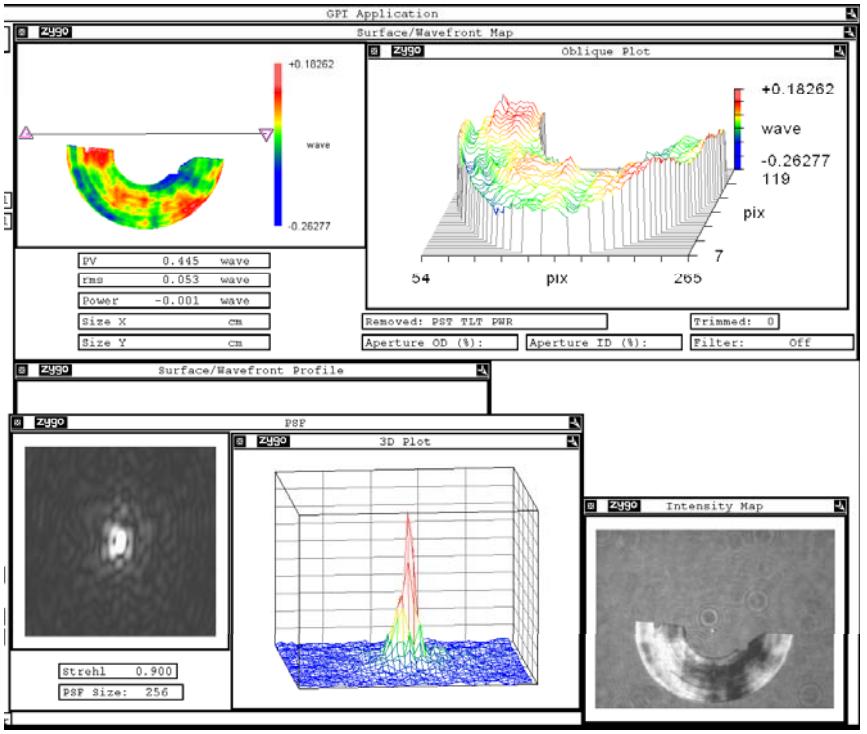


Assembled telescope
Totally weigh: 1.7kg

Performance Test

Wavefront error is measured through the whole optics of the telescope





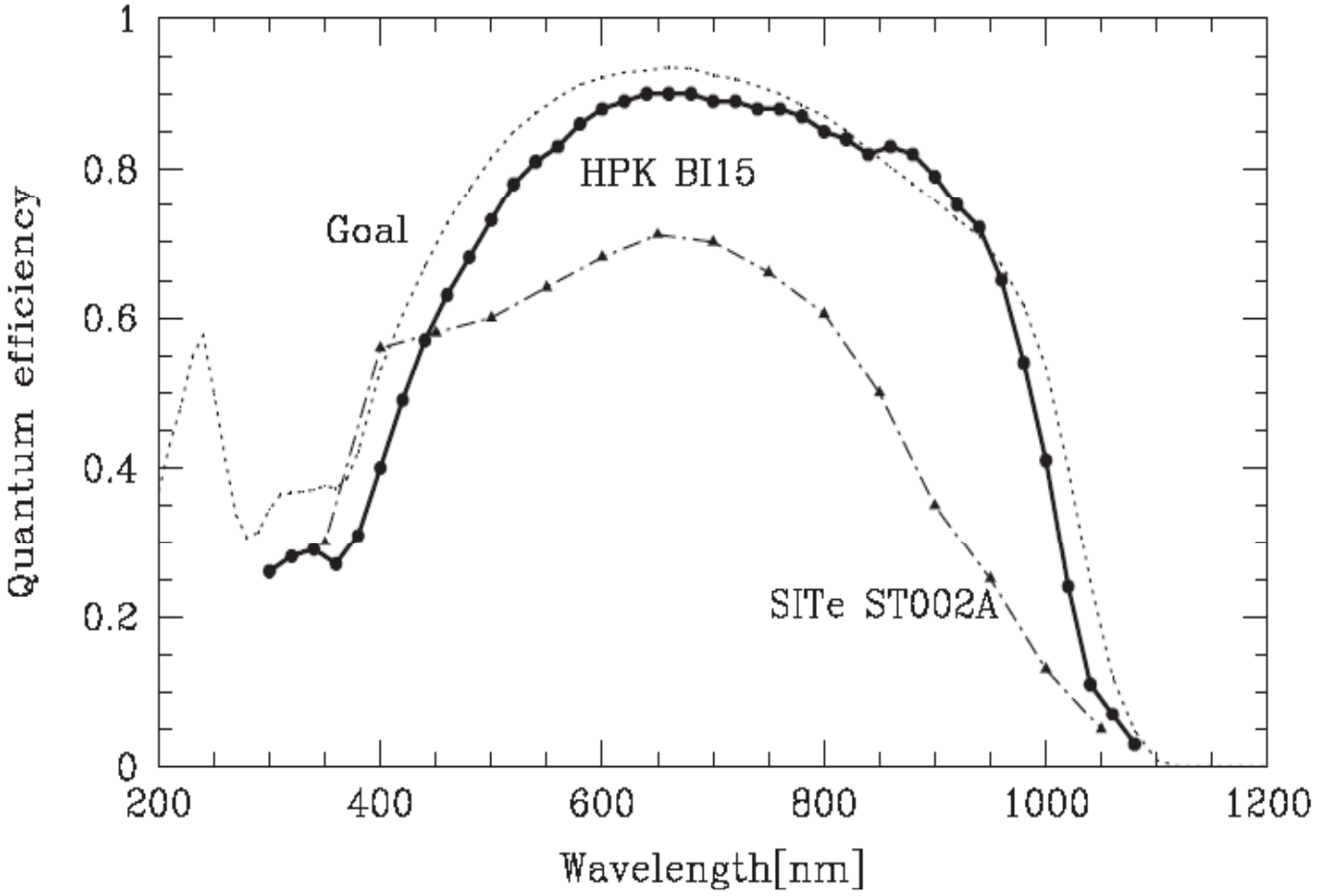
Total wavefront error

Wavefront error of each mirror

Surface	Shape RMS (nm)	Wavefront RMS (nm)	wavefront RMS (λ/σ at $\lambda = 800$nm)
beam-combiner	15	30	$\lambda/27$
1ry	15	30	$\lambda/27$
2ry	9	18	$\lambda/44$
3ry	10	20	$\lambda/40$
4ry	11	22	$\lambda/36$
5ry	8	16	$\lambda/50$
RSS total	29	57	$\lambda/14$

Assembled telescope achieves diffraction-limited performance

Full Depletion CCD

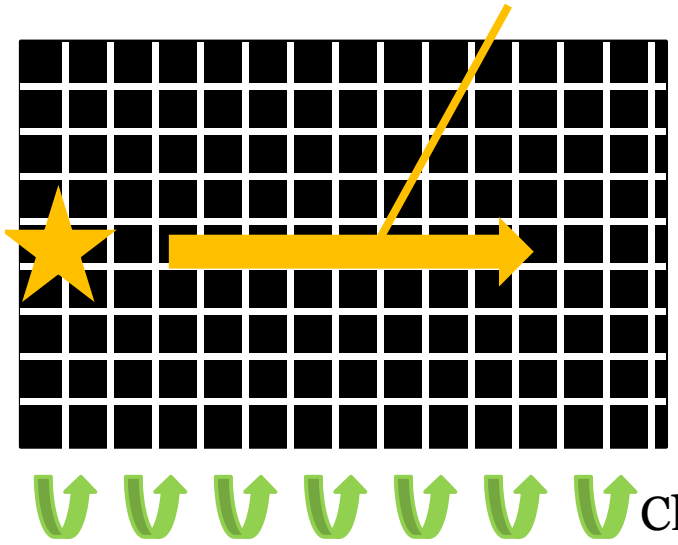


Large quantum efficiency in near infrared range

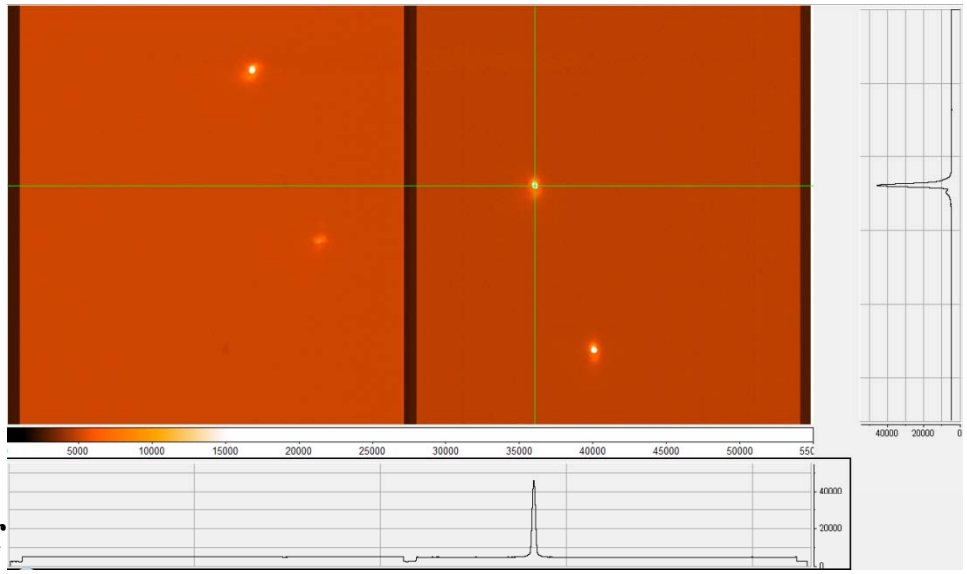
Developed by NAOJ and Hamamatsu Photonics

Drift Scan (Time-Delayed Integration)

Observed stars move with satellite spin



Charge transfer



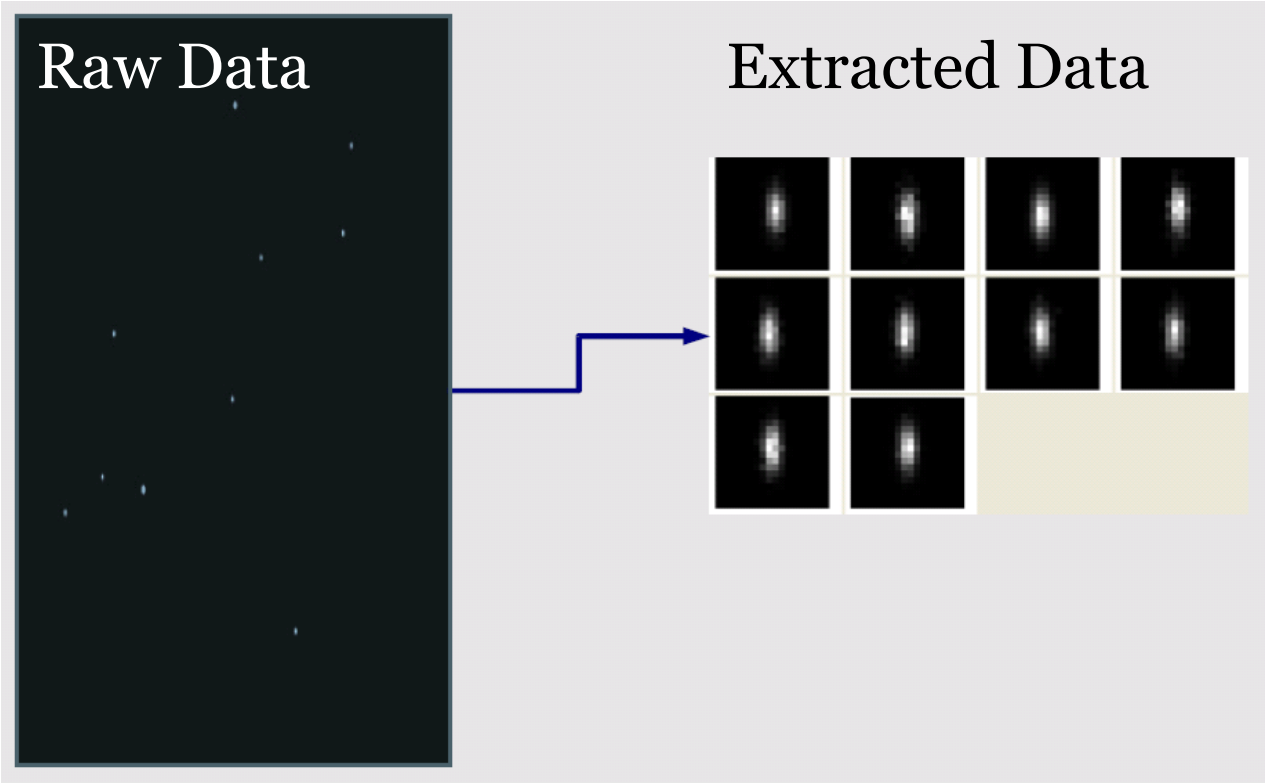
Charge transfer is synchronized with satellite motion

- Each star is exposed about 8 sec.
- Endless stripes of an image is produced.

(Observation Duty: 95%)

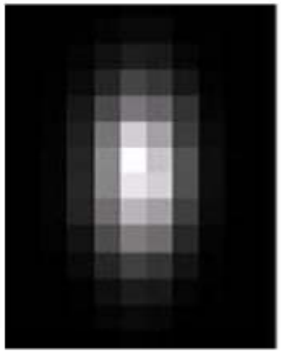
Star Image Extractor

Data rate of raw data: 2Mbps
Down link rate: 100kbps (visibility: 5%)

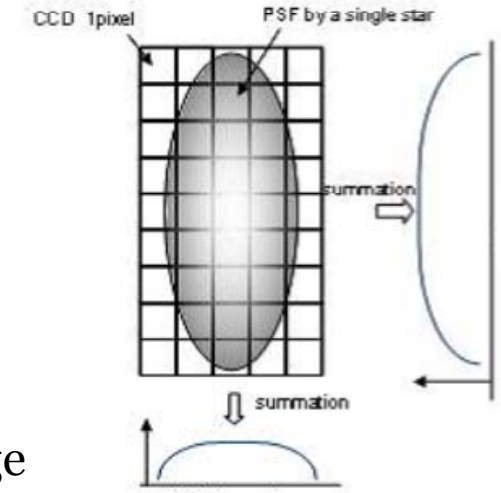


5×9pixel image around each stars is extracted

Attitude Control



Extracted Image



LSF for z axis

LSF for xy axis

Extracted images are
feed-backed to the controller

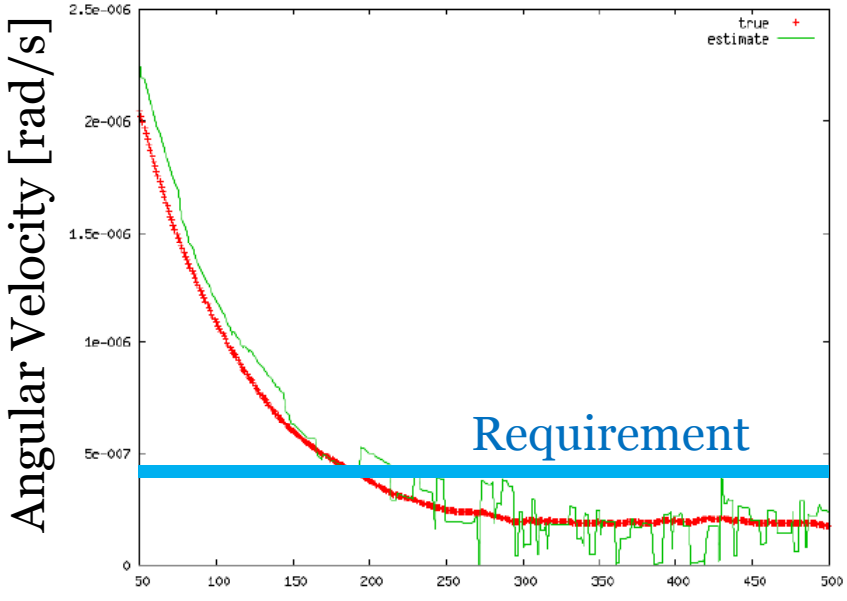
Instruments for Attitude control

Sensor

- •Star Tracker (STT)
- •Fiber Optical Gyro (FOG)
- •Mission Telescope

Actuator

- •Reaction Wheel (RW)
- •Magnetic Torquer (MTQ)

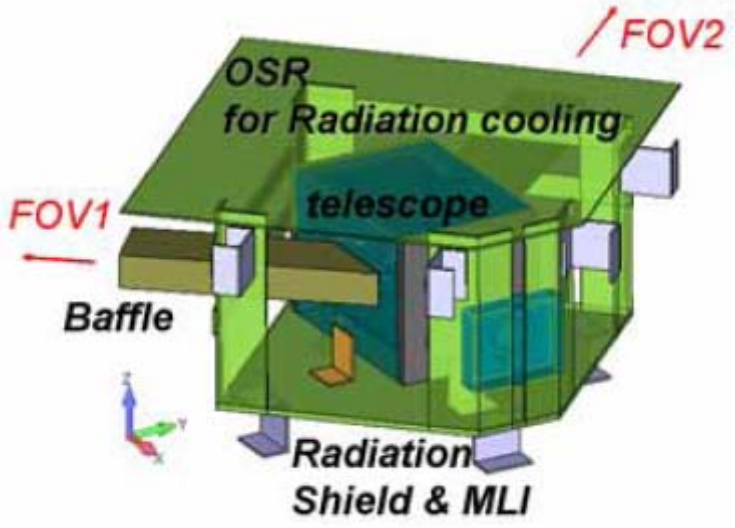


Result of numerical analysis

Thermal Analysis

variation of relative angle affects position determination accuracy

relative angle of beam-combiner should be kept within 1 milli-arc-sec



Thermal Shield for telescope

Requirement

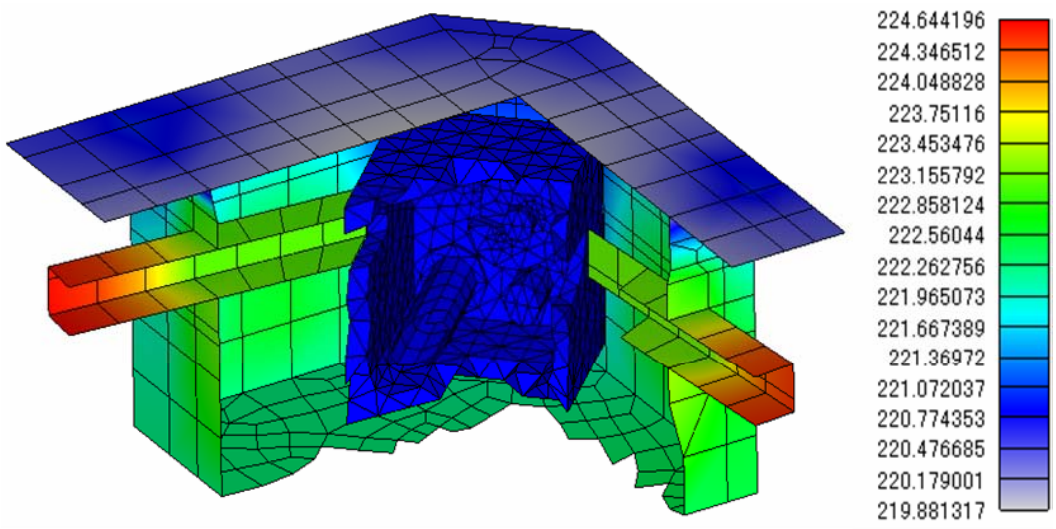
Operating temperature : 170K～220K

(Dark noise of CCD)

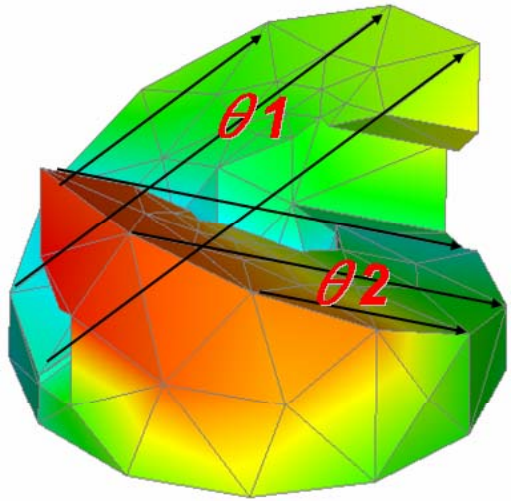
Stability of beam combiner : 1mas

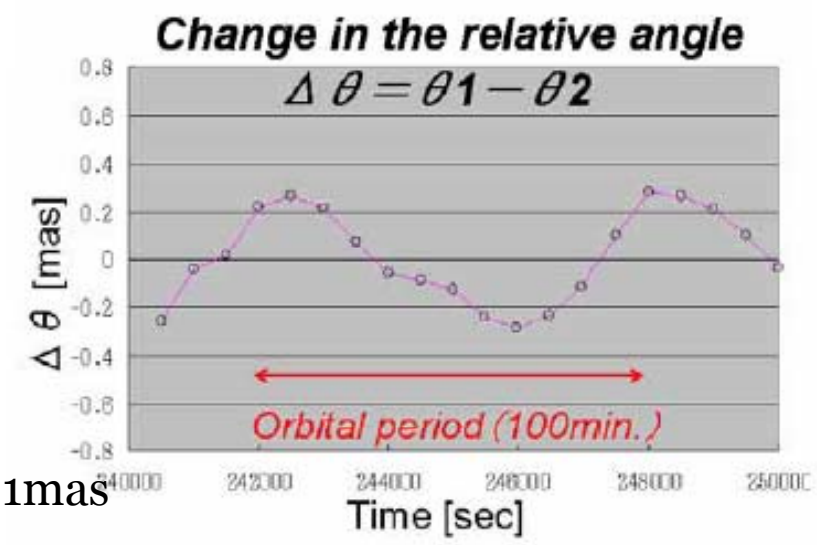
Thermal Analysis is needed

Thermal Control



Results of thermal analysis

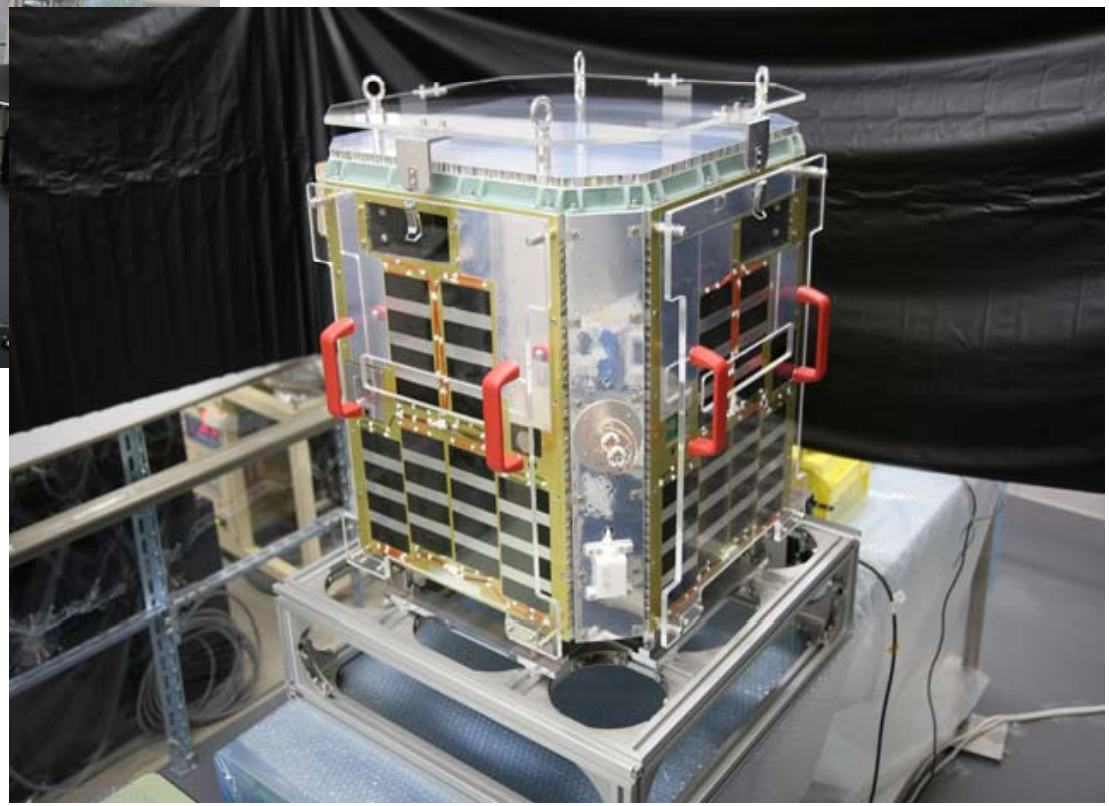




Radiation shield and cooling (passive control)

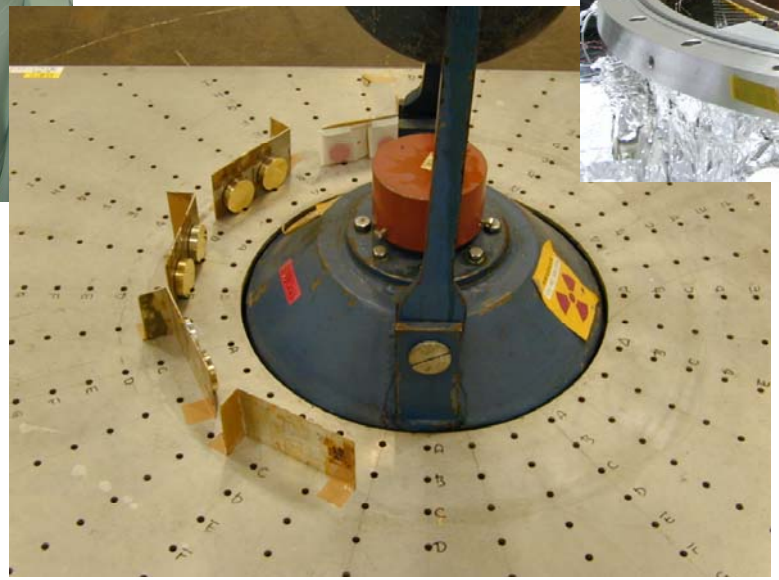
- Optical system is cool-downed under220K
- Relative angle of beam combiner is kept within 1mas

Engineering Model

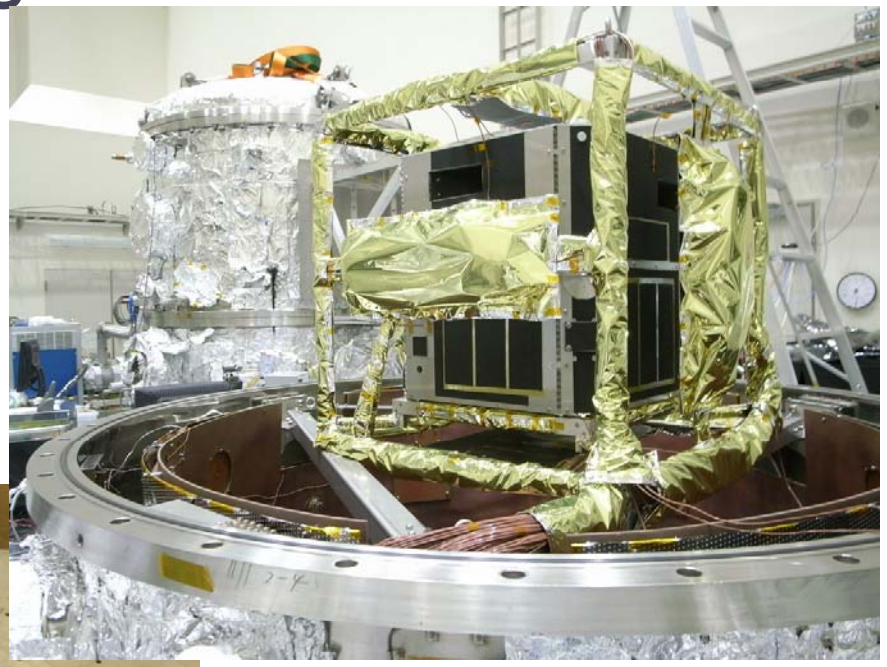


Environmental tests

Vibration test



Radiation test



Thermal vacuum test

Ground Station

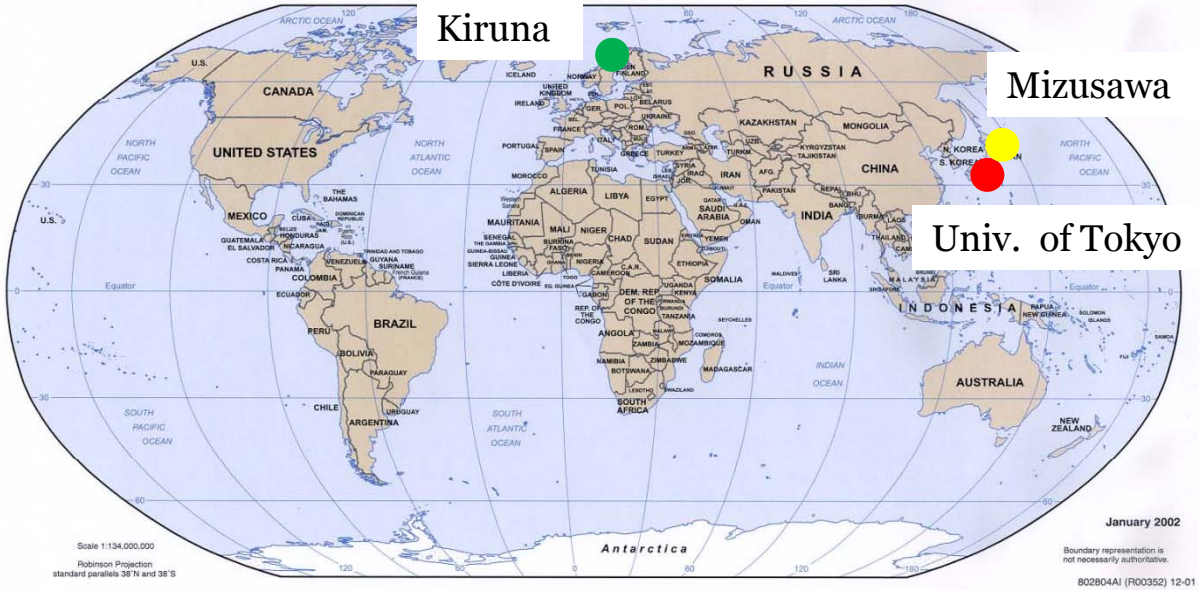
10m radio antenna
@NAOJ

Uplink and Downlink station

- 3m radio antenna (University of Tokyo, Japan)

Downlink station

- 10m radio antenna (Mizusawa branch of NAOJ)
- Kiruna Tracking Station (Sweden) - TBD



Launch

NAOJ, University of Tokyo, Alcantara Cyclone Space and SDO Yuzhnoye have signed the memorandum of understanding (MOU) to launch Nano-JASMINE by Cyclone-4 rocket from Brazil in 2010.

Cyclone-4 rocket
© SDO Yuzhnoye

Summary

Nano-JASMINE is a first astrometry satellite in Japan

First satellite of JASMINE series

Engineering model passed some environmental tests

Nano-JASMINE will be launched from Brazil in 2010