



# Environmental testing of an InGaAs infrared detector for the JASMINE mission

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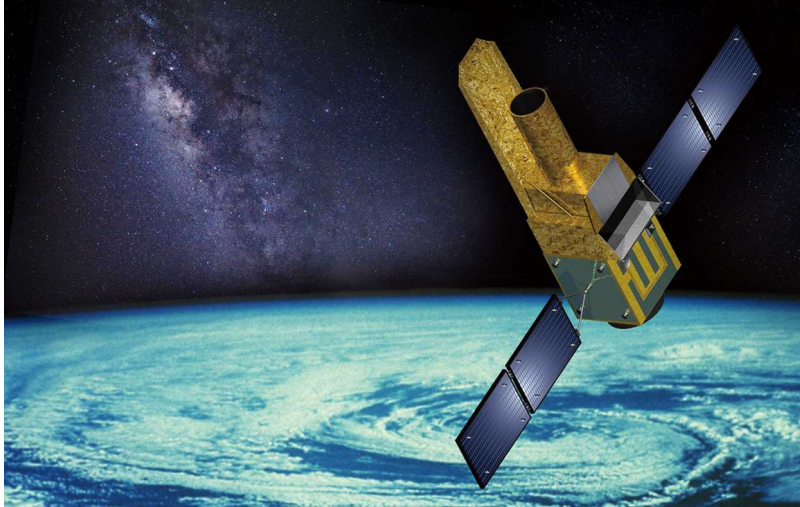
Takayuki Kotani (ABC, NAOJ, SOKENDAI), Yuji Sakamoto (UTokyo)

and JASMINE team

# JASMINE

## Japan Astrometry Satellite Mission for INfrared Exploration

### Satellite



JASMINE White paper (Kawata+ 2024)

### JAXA's M-class science space mission

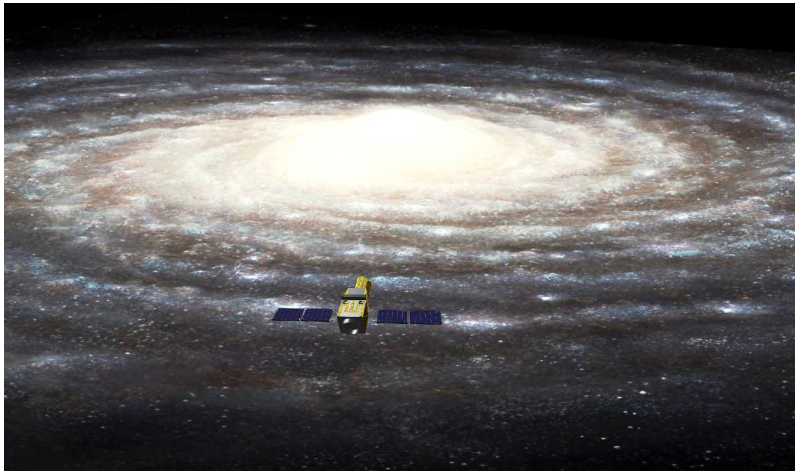
- The launch is planned for 2032

- Diameter of the primary mirror  $\approx 36$  cm
- Satellite weight  $\approx 540$  kg (wet)
- Size  $\approx 1$  m  $\times$  1 m  $\times$  3.6 m
- **InGaAs** Infrared sensor:
  - 2k $\times$ 2k pixels  $\times$  4
  - Wavelength: 0.9 – 1.6  $\mu$ m
- Sun-synchronous polar orbit
  - Altitude  $\approx 550$  – 600 km
- Science operations for 3 years

# JASMINE: Science Objectives

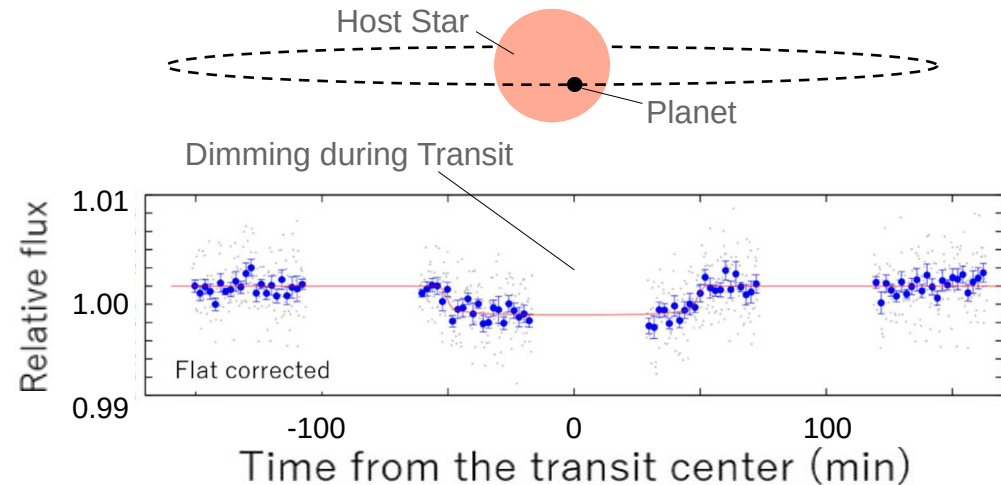
## Galactic Center Survey

- High-precision infrared **astrometry** of the Galactic nuclear region
- Position, Parallax: 25 - 125  $\mu\text{as}$
- Proper Motion: 25 - 125  $\mu\text{as/y}$

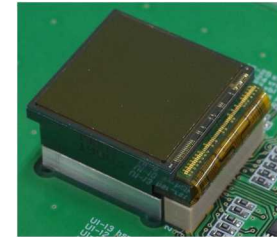


## Exoplanet Survey

- **Transit observations** to find Earth-like planets in the habitable zone
- Primary targets: mid-M-type stars
  - Transit Signal  $\approx 0.3\%$



# InGaAs Infrared Detector for JASMINE

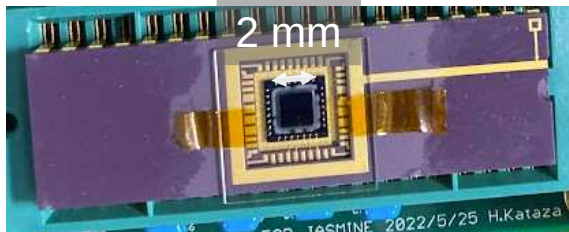


- InGaAs infrared detectors for ground-based astronomy have been developed by NAOJ and Hamamatsu Photonics K.K.

(Nakaya+16, JSPS KAKENHI 26247029 (FY2014-2016), 17H01117(FY2017-2019))

- JASMINE team started development for **space applications** with Hamamatsu in 2021
  - Larger format, improved radiation tolerance, AR coating, ...

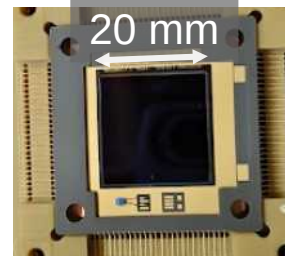
Prototype: 128×128 format  
Pixel pitch: 15  $\mu\text{m}$



Details → Miyakawa+2024 (SPIE)

## Today's focus

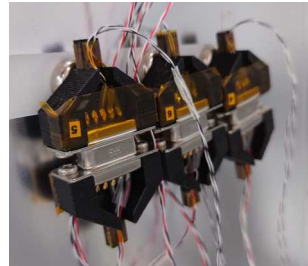
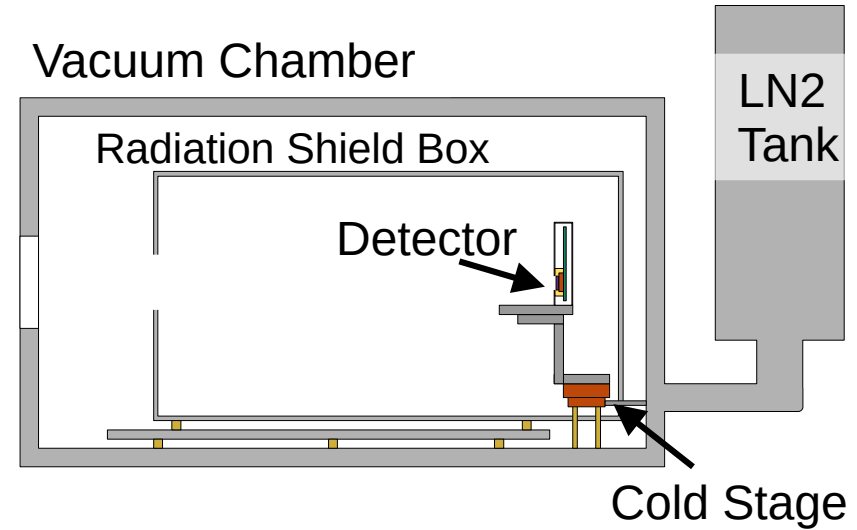
1952×1952 format  
Pixel pitch: 10  $\mu\text{m}$



- **Cryogenic test and detector characterization**
  - Quantum efficiency has been measured
- **Heavy-ion irradiation test**
- **Vibration test**

# Cryogenic Test

- Performance evaluation at 140 - 200 K
  - Operation temperature on JASMINE: 170 K



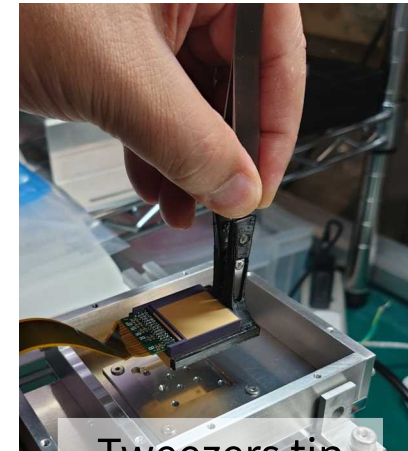
Dsub connector covers  
with magnets  
Made by Kataza-san



Cup



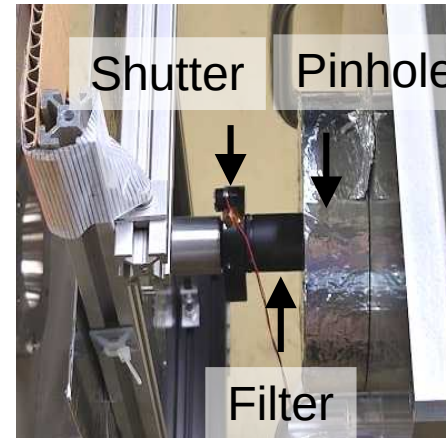
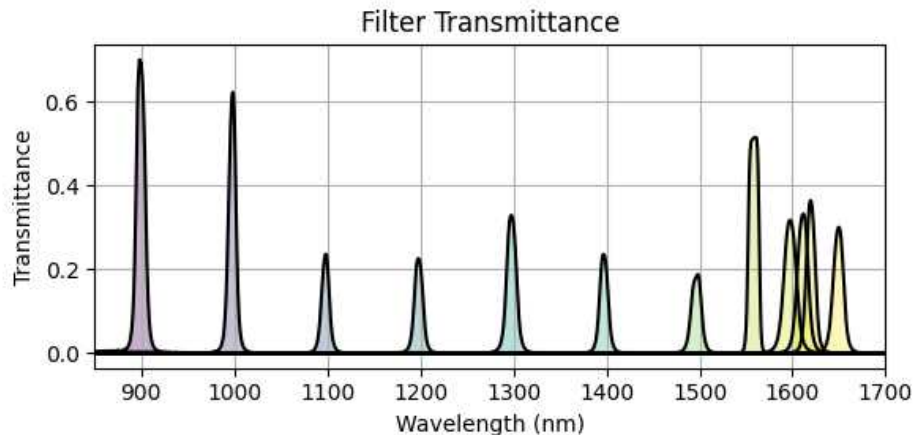
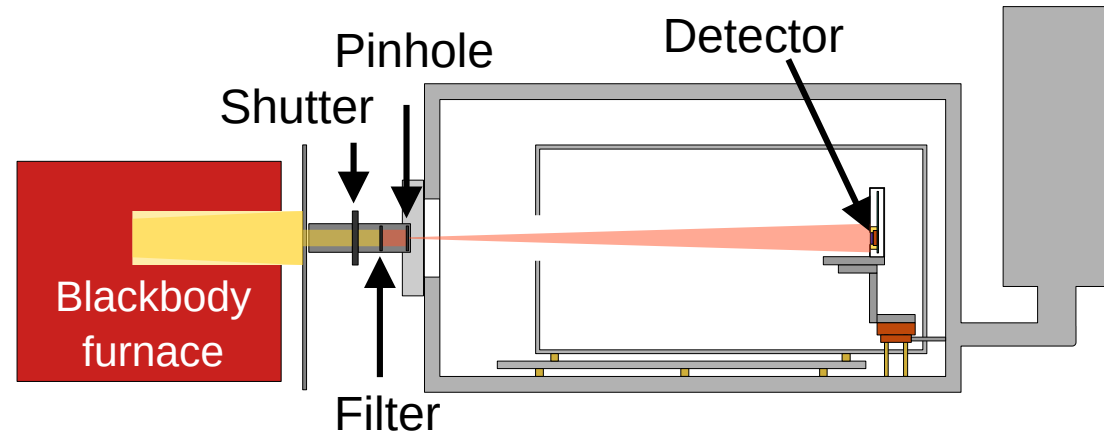
Cold gas guide tube



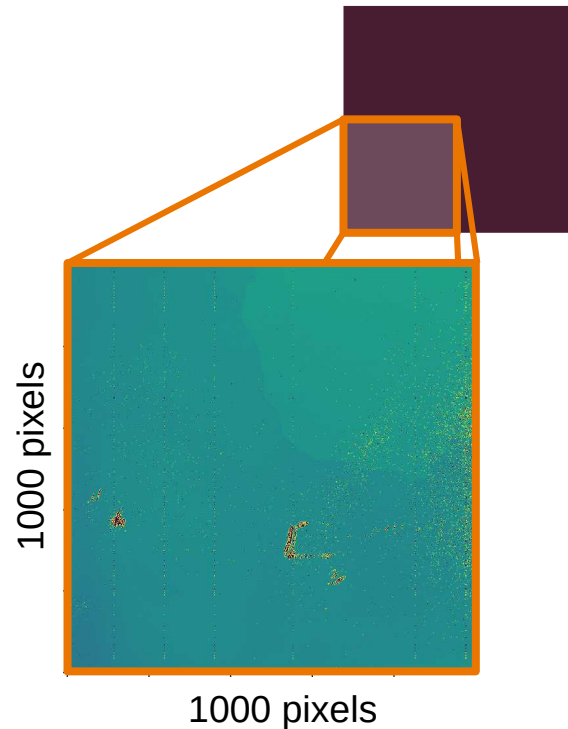
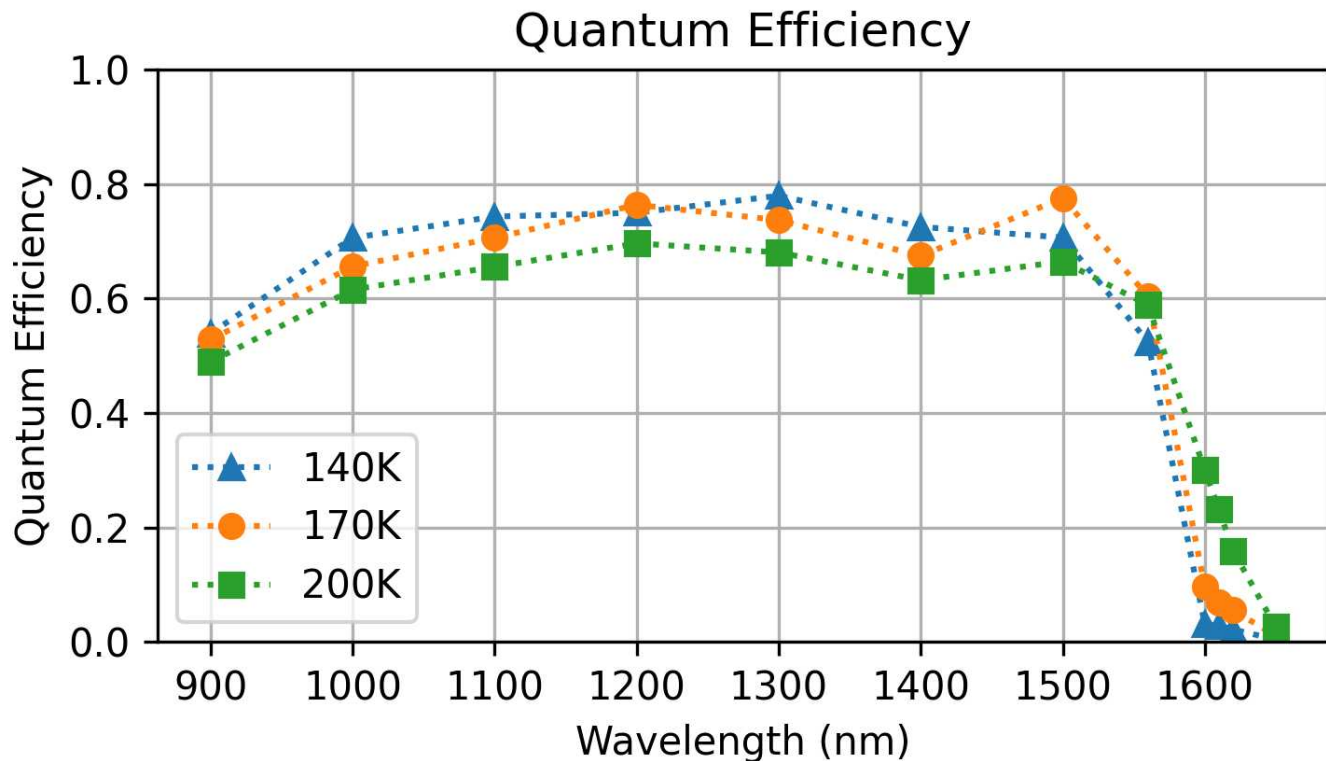
Tweezers tip  
attachment

# Quantum Efficiency Measurement: Method

- Light source:
  - Blackbody furnace (1673 K)
  - + Narrow band filter
  - + Pinhole
- Measured at 140, 170, 200 K



# Quantum Efficiency Measurement: Result

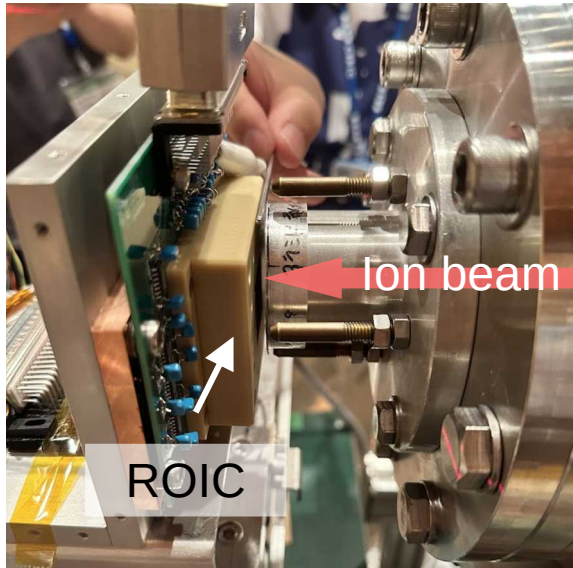


Cropped 1000 × 1000 pixels from the 1400 nm image

- **QE  $\approx$  70%** at 1.0 - 1.6  $\mu\text{m}$
- Cutoff wavelength varies with temperature

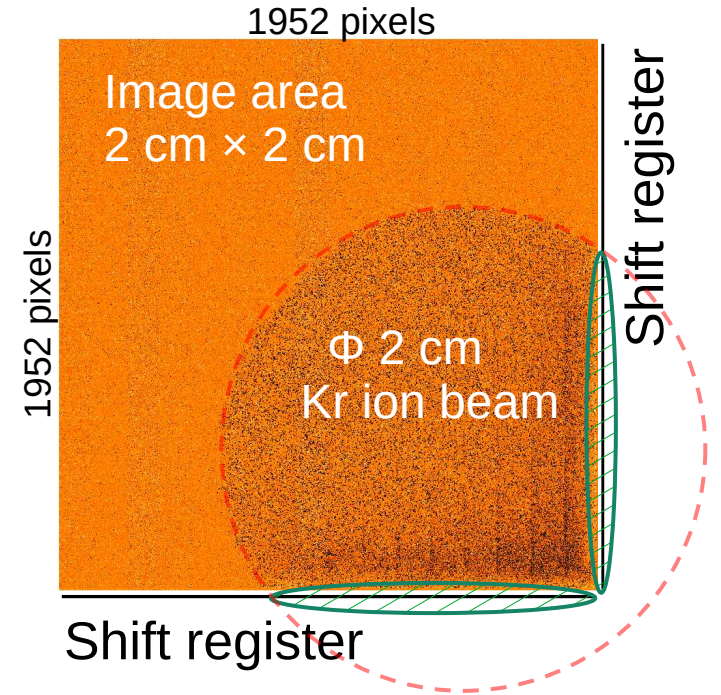
# Heavy-ion Irradiation Test

- Investigation of occurrence frequency of **SEL** and **SEU** (Single-Event Latchup/Upset)
- Testing of Readout IC (ROIC, without InGaAs)



at RARiS, Tohoku University

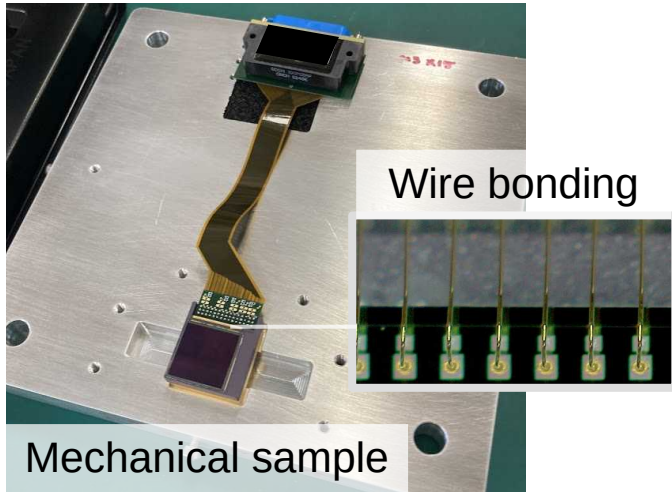
## Integrated Image



- **No SEL or SEU was observed**
  - LET (Si): 41 MeV·cm<sup>2</sup>/mg
  - Total fluence (Kr): 1.1×10<sup>5</sup> cm<sup>-2</sup>
- **Meets JASMINE's requirements**

# Vibration Test

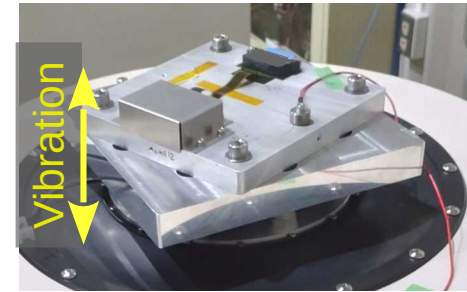
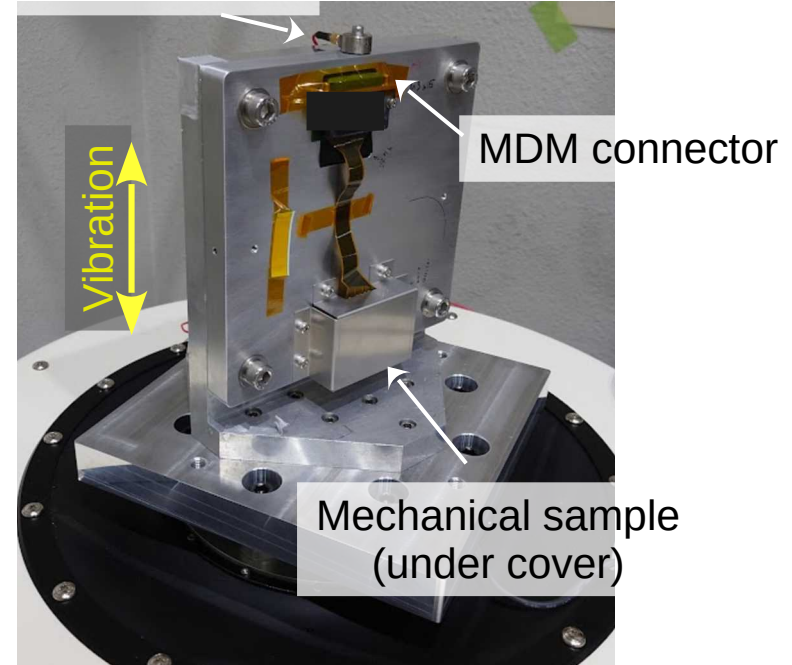
- Testing resistance to launch conditions



- 20 G Sine-Sweep, 20 - 2000 Hz  
(MIL-STD-883, Test Method 2007, Test Condition: A)

- **No damage was observed**

Accelerometer



The results were obtained using  
Space Chamber Laboratory of ISAS, JAXA. 9

# Upcoming Plans

- **Further performance evaluation**
  - Noise, dark current, non-linearity, persistence, ...
- **Testing of updated sensors (from 2026)**
  - Rolling shutter → Global shutter compatibility
  - Adjusting InP layer thickness
    - Balance between optical blocking and reduction of cosmic-ray-induced luminescence

# Summary

- We are developing an InGaAs infrared detector for the JASMINE mission
- We are testing and characterizing 2k×2k detectors
  - Cryogenic testing and detector characterization
    - The detector achieves  $\approx$  **70 % quantum efficiency** between 1.0 and 1.6  $\mu\text{m}$
  - Heavy-ion irradiation test (LET: 41 MeV·cm<sup>2</sup>/mg)
    - **No SEU or SEL** was observed
  - Vibration test (20 G, 20 – 2000 Hz)
    - **No damage** was observed