Overview and recent progress of JASMINE

—Japan Astrometry Satellite Mission for INfrared Exploration—

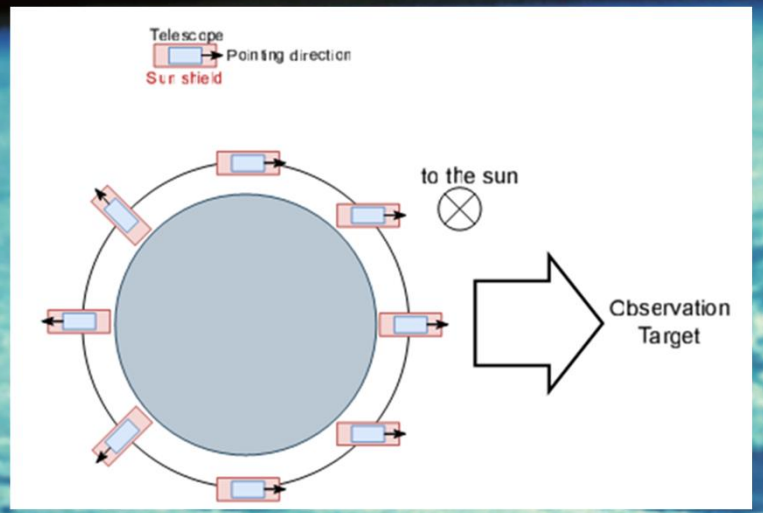
Naoteru Gouda(JASMINE Project Office/NAOJ) and JASMINE team

1. Mission concept of JASMINE

JASMINE：High-precision infrared astrometry satellite mission

Transit observation mission for the exploration of Earth-like planets

- highly thermal stable telescope
- Diameter of the primary mirror ～36cm
- Infrared sensor (InGaAs): 2k×2k×4
  - wavelength1.0-1.6μm
- Satellite weight ～600kg (wet)
- Launch by epsilon-s rocket (JAXA)
- science operation for 3 years (nominal)
- Sun-synchronized orbit・altitude ～600km



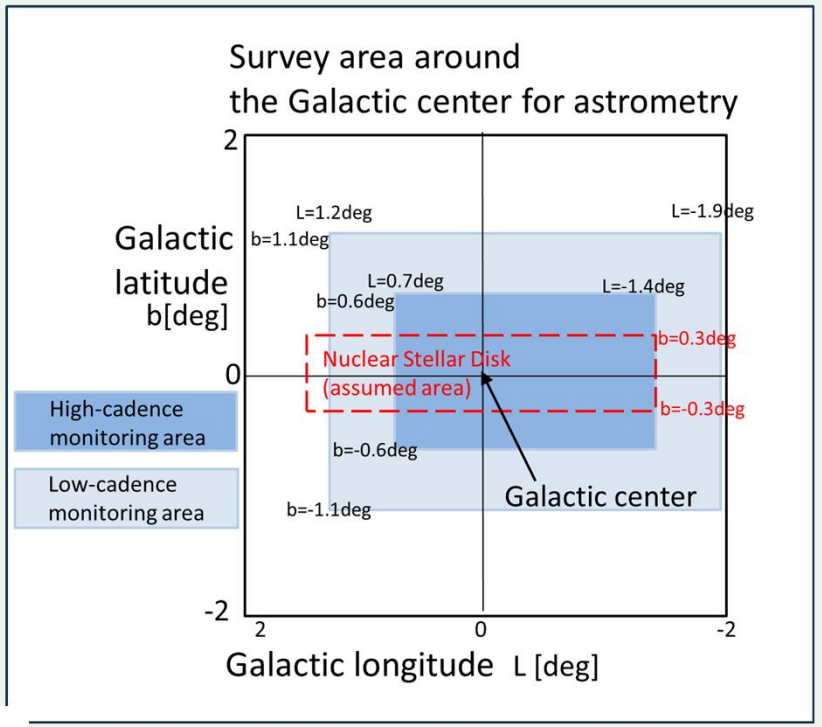
1. Mission concept of JASMINE（continued）

★Output data to be provided by JASMINE

Catalog：the annual parallaxes and proper motions of stars derived from the time-series data of the stellar positions on the celestial sphere observed in the direction of the Galactic nuclear region

：time-series photometry of exoplanet exploration objects

➔make the catalog available to researchers around the world.



Spring and Autumn：

Astrometric survey in the direction of the Galactic nuclear region

Stellar images are taken continuously every about 12.5 seconds(exposure time)

Hw-band: 1.0μm～1.6μm *Hw~0.9J+0.1H-0.06(J-H)^2

The magnitude range for the stars to be downloaded to the ground every exposure time➔

～10.0 mag< Hw <～14.5mag

➔ About 120,000 stars in the high-cadence monitoring area.

Full-frame of 1 field of view is planned to be downloaded every a few dozen exposure times. Full-frame downloads will become possible more frequently if the amount of communication data sent to the ground increases with the support of overseas stations.

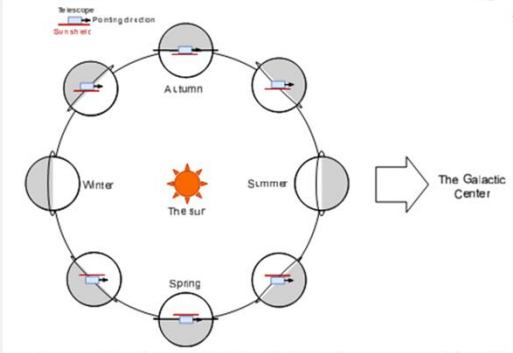
Precisions:

position, parallax：＜25μas～125μas

proper motion: ＜25μas/y～125μas/y

1~5km/s tangential velocity error at 8kpc

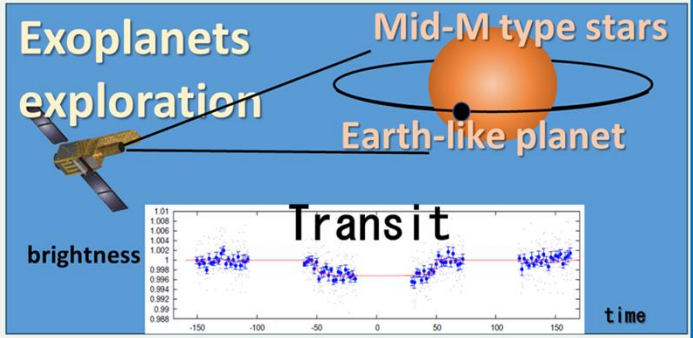
about 35μas（μas/y）～180μas（μas/y）for low-cadence area



Summer and Winter：

Transit observations of mid-M type stars to find Earth-like planets in the habitable zone

Time-series photometric data with photometric accuracy to detect 0.3% transit depth for 17 or more target objects (observation period of 2-5 weeks or more for one target)



2. JASMINE Current status

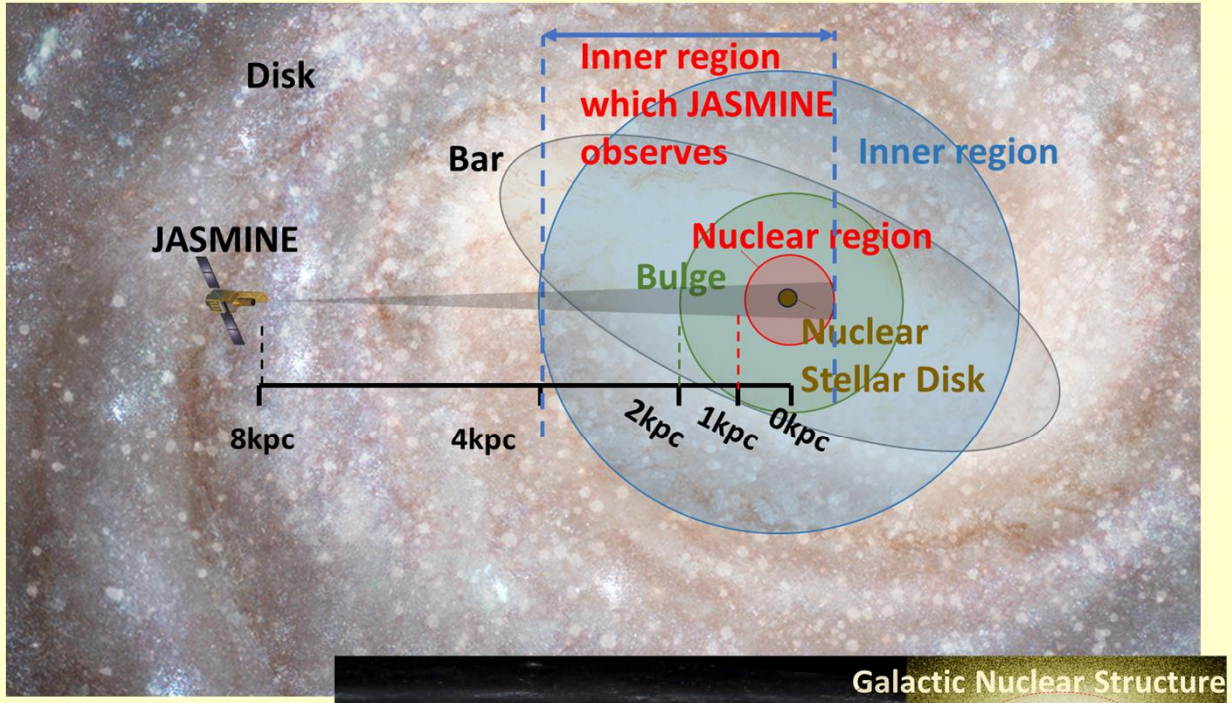
- ISAS/JAXA selected JASMINE as the 3rd Competitive Medium-class science satellite mission in May 2019
- We are promoting JASMINE with the aim of gradually improving the development stage at JAXA.
- JASMINE passed MDR(Mission Definition Review) in July of this year. ➔ Kataza
- The launch of JASMINE is scheduled tentatively for 2028
  in Space Basic Plan, Cabinet Office, GOJ.
  ＊Some delay in the launch year is anticipated due to external factors such as schedule adjustment of satellite manufacturing companies.
  In MDR, our JASMINE team showed the estimation that the launch will take place in FY2031 or FY2032.
- The program for infrared imaging sensor development has been going on well for completion in FY2024, while concept study for the infrared camera systems has started in the JASMINE project/NAOJ, the Advanced Technology Center/NAOJ and ISAS/JAXA, involving industry partner candidates.
- Conceptual studies for the mission instruments has been conducted with some companies in Japan. ➔ Kataza

3. Scientific Objectives

I. Astrometry

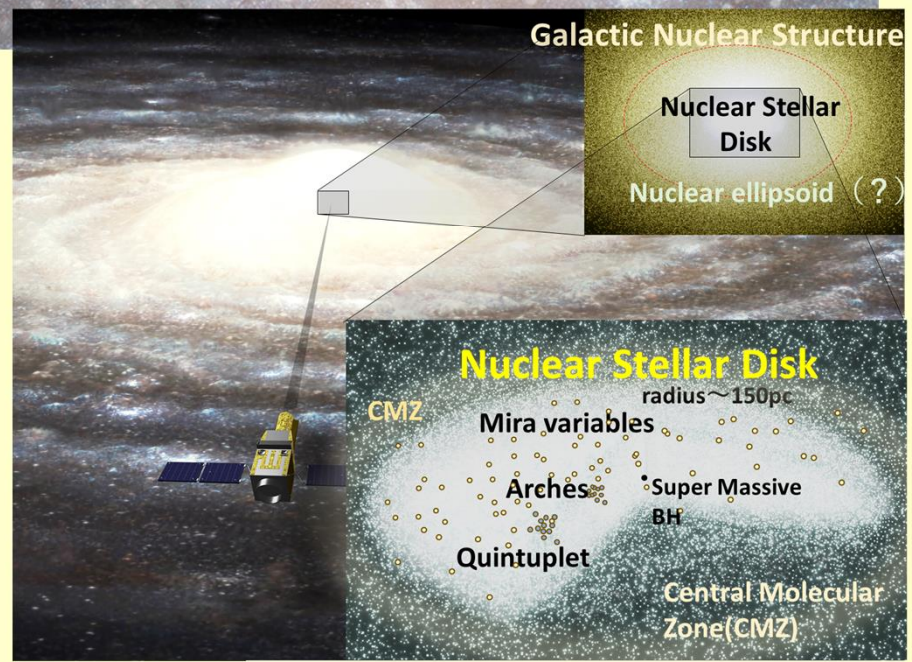
The target is the Galactic inner region along the Galactic plane around the center

★**Inner region:** Inside the radius of～4kpc along the Galactic plane from the center



This region is hard for astrometric measurements in optical bands

1 Nuclear Region inside the radius of ＜～1kpc from the center
- Nuclear stellar disk
- Nuclear ellipsoid (classical bulge ?)
- Nuclear star cluster



2 bulge/bar +long bar+ inner disk along the Galactic plane

The range of the radius of ～1kpc＜r＜～4kpc from the center

There are many unknowns in the inner region, and it is an important region where a lot of important information is hidden for astronomy and astrophysics.

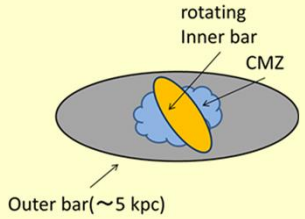
A. Galactic center archeology & Galactic inner structures

(1) Clarification of the Galactic Nuclear Stellar Disk(NSD) ➔ Friske

*orbit structures

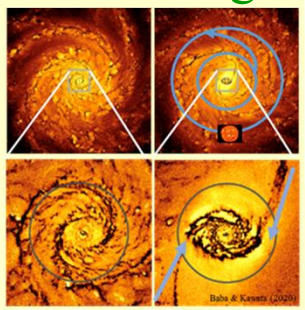
*the existence of an inner bar structure

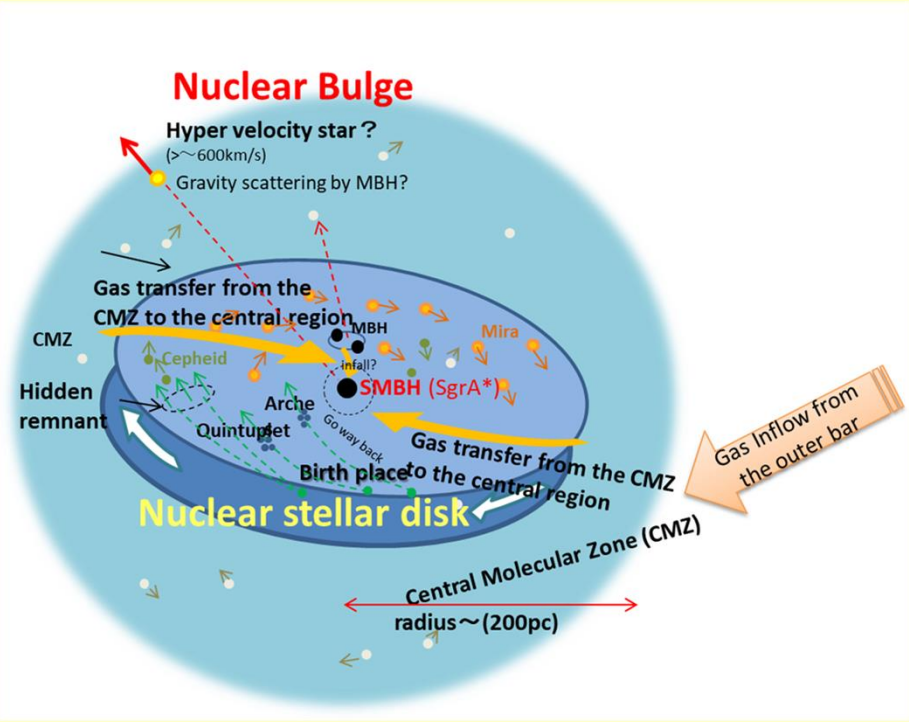
➔growth of SMBH and activity around the Galactic center.



*formation epoch of NSD ← Mira:good tracer ➔ Matsunaga

➔formation epoch of the outer long bar





(2) Clarification of “the Nuclear Ellipsoid”

relic of the classical bulge!? or kinematical relic of infall of supermassive BHs?

(3) Discovery of unknown star clusters in the inner region by detection of parallel movement of the stellar proper motion

(4) Dynamical structures along the Galactic plane in the region of ～1kpc＜r＜～4kpc

B. Physics hidden in the inner region
Hunt of：

(1)dark matters DM on the inner disk/long bar ←kinematic information

➔ Kohri, Abe

(2) Black Holes ➔ Kawanaka, Tanikawa

＊Black Hole-star binaries ←orbital analysis of stars

＊Intermediate Massive Black Holes ←gravitational lens effects

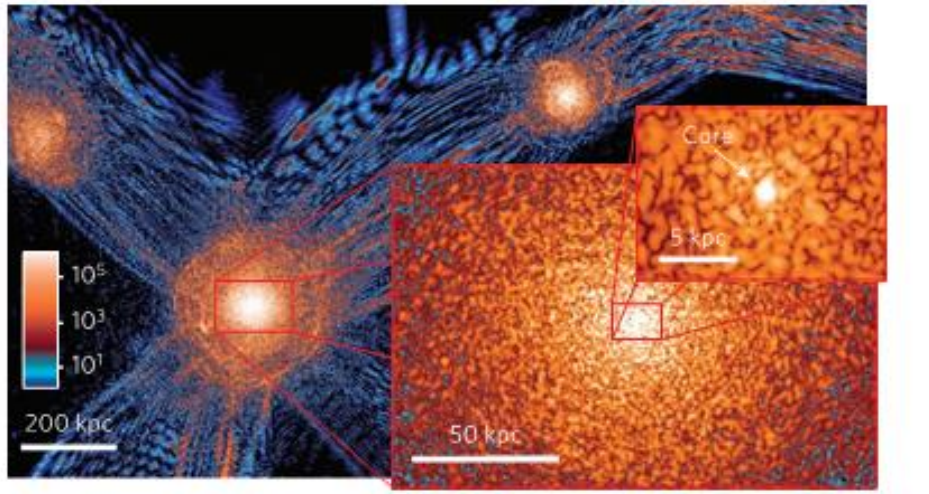
(3)Orbital analysis of X-ray binaries ➔ compact objects

(4) Stellar physics, star formation, 3-dimensional distribution of inter-stellar dust, magnetic field

⋮

➔ Kakiucih, Kawabata, Hori, Maruta, Jo, Doi

➔ Ogami



Schive, et al. Nature Physics 2014


JASMINE: Near-Infrared Astrometry and Time Series Photometry Science

Daisuke Kawata, Hajime Kawahara, Naoteru Gouda, Nathan J. Secrest, Ryouhei Kano, Hirokazu Kataza, Naoki Isobe, Ryou Ohsawa, Fumihiko Usui, Yoshiyuki Yamada, Alister W. Graham, Alex R. Pettitt, Hideki Asada, Junichi Baba, Kenji Bekki, Bryan N. Dorland, Michiko Fujii, Akihiko Fukui, Kohei Hattori, Teruyuki Hirano, Takafumi Kamizuka, Shingo Kashima, Norita Kawanaka, Yui Kawashima, Sergei A. Klioner, Takanori Kodama, Naoki Koshimoto, Takayuki Kotani, Masayuki Kuzuhara, Stephen E. Levine, Steven R. Majewski, Kento Masuda, Noriyuki Matsunaga, Kohei Miyakawa, Makoko Miyoshi, Kumiko Morihana, Ryoichi Nishi, Yuta Notsu, Masashi Omiya, Jason Sanders, Ataru Tanikawa, Masahiro Tsujimoto, Taihei Yano, Masataka Aizawa, Ko Arimatsu, Michael Biermann, Celine Boehm, Masashi Chiba, Victor P. Debattista, Ortwin Gerhard, Masayuki Hirabayashi, David Hobbs, Bungo Ikenoue, Hideyuki Izumiura, Carme Jordi, Naoki Kohara, Wolfgang Löffler, Xavier Luri, Ichiro Mase, Andrea Miglio, Kazuhisa Mitsuda, Trent Newswander, Shogo Nishiyama, Yoshiyuki Obuchi, Takafumi Ootsubo, Masami Ouchi, Masanobu Ozaki, Michael Perryman, Timo Prusti, Pau Ramos, Justin I. Read, R. Michael Rich, Ralph Schönrich, Minori Shikauchi, Risa Shimizu, Yoshinori Suematsu, Shotaro Tada, Aoi Takahashi, Takayuki Tatekawa, Daisuke Tatsumi, Takuji Tsujimoto, Toshihiro Tsuzuki, Seitaro Urakawa, Fumihiro Uraguchi, Shin Utsunomiya, Vincent Van Eylen, Floor van Leeuwen, Takehiko Wada and Nicholas A. Walton

National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK
Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa, 252-5210, Japan
Astronomical Science Program, Graduate Institute for Advanced Studies, SOKENDAI, 2-21-1 Osawa, Mitaka, Tokyo, 181-1855 Japan
U.S. Naval Observatory, 3450 Massachusetts Ave NW, Washington, DC 20392-5420, USA
Department of Physics, Kyoto University, Kitashirakawa-oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
Centre for Astrophysics and Supercomputing, Swinburne University of Technology, Hawthorn, VIC 3122, Australia
Department of Physics and Astronomy, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819-6041, USA

Publ. Astron. Soc. Japan (2023) 00(0), 1–50
doi: 10.1093/pasj/xxx000

Please refer to JASMINE White Paper

**(Kawata, D. et al.,
Publications of the Astronomical Society of Japan, Advance Access Pub Date: April 2024)**

★Cooperation with other observation projects for the Galactic nuclear region

*Photometry+Astrometry: VVV, GALACTICNUCLEUS, Ultimate-Subaru, ROMAN,JWST, GREX+,GaiaNIR ,… (for faint stars) → Koyama → Inoue

*Catalogue of Mira variables: PRIME → Suzuki, Matsunaga

*Techniques: HiZ-GUNDUM → Tsumura

*Spectroscopy: Subaru-PFS, APOGEE-2,MOONS, Milky Way Mapper, … → Ishigaki

*Observations with other wavelengths: JEDI, ALMA, SKA, ngVLA, … → Tsuboi

Subaru-PFS (spectral observation) can measure the radial velocity (+metals) of all stars targeted by JASMINE before JASMINE's launch. → Nisihyama

The stars targeted by JASMINE can have six-dimensional phase space information. They will be very unique and valuable information in the Galactic nuclear region.

Telescope/Instrument	Aperture of the primary mirror	Field of view [square degrees]	Number of the fibers	Observation wavelength range	Wavelength resolution (λ/Δλ)
Subaru/PFS	8.2 m	1.25	2,400	0.38-1.26	4300@<1.26μm

Comparison with other astrometric observation projects in the Galactic Center (no dedicated astrometric projects)

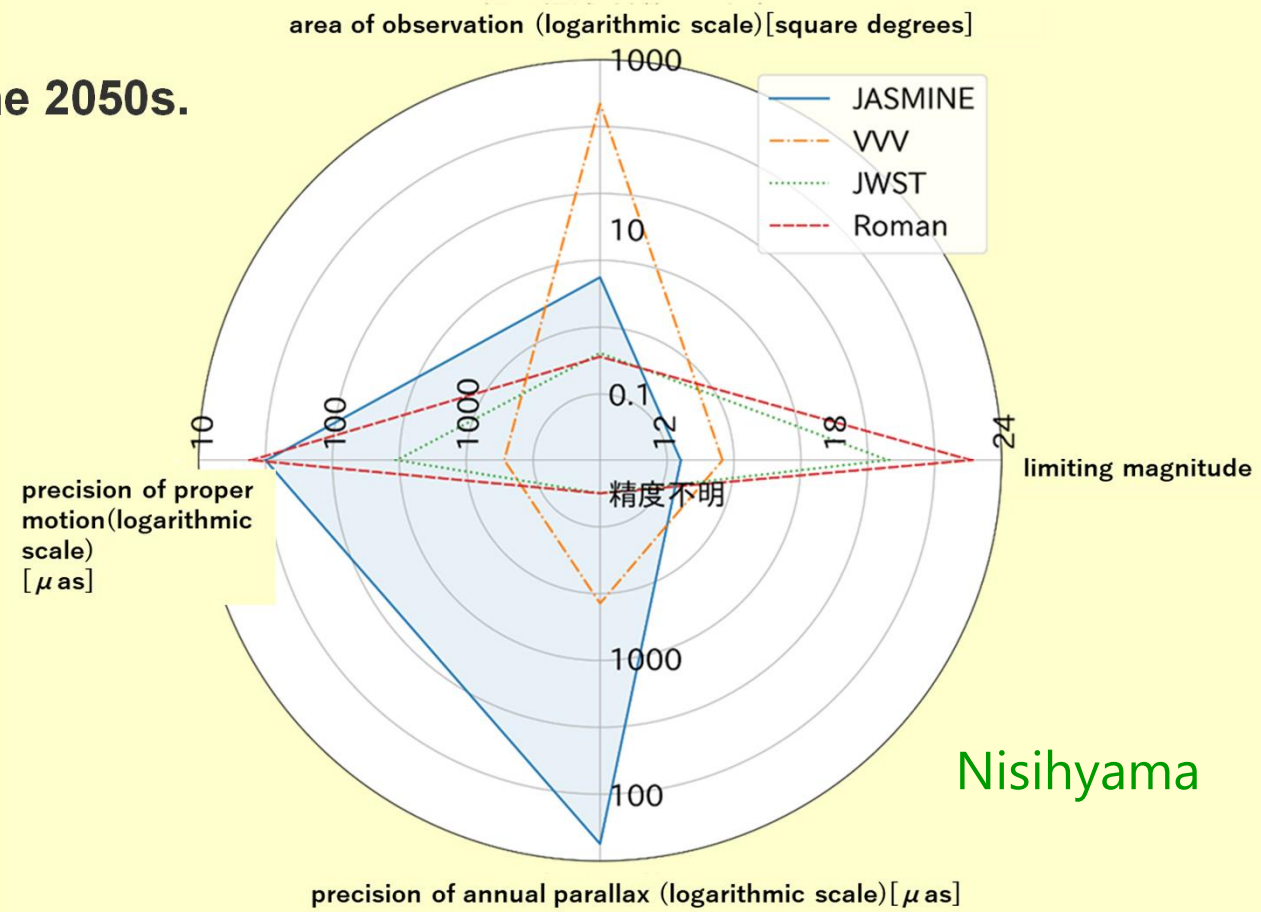
＊GaiaNIR is excluded because it will be launched in the 2050s.

＊At present, JASMINE boasts the highest precision in measuring annual parallaxes.

＊JASMINE has the unique feature that, although its limiting magnitude is shallow (note), it is a project that can achieve astronomical observations of a wide area of the nuclear region at a very high position with high precision.

(Note) JASMINE is unique in that it can observe stars that are too bright to be fully observed by other astronomical observations, such as Mira-type variable stars, which are good tracers for the search for the central disk.

➔ Matsunaga



Nisihyama

Radar Chart of the Galactic nuclear region astrometric observations based on JASMINE(blue solid line)、VVV(orange dash-dotted line)、JWST(green dotted lie)、Roman(red dash line). Clockwise from the top are the area of observation (logarithmic scale), limiting magnitude, precision of annual parallax (logarithmic scale), and precision of proper motion (logarithmic scale). The blue shading represents JASMINE.

Comparison with other astrometric observation projects in the Galactic Center (no dedicated astrometric projects)

＊GaiaNIR is excluded because it will be launched in the 2050s.

Comparison table of Galactic Center Near Infrared Astronomical Observation Project

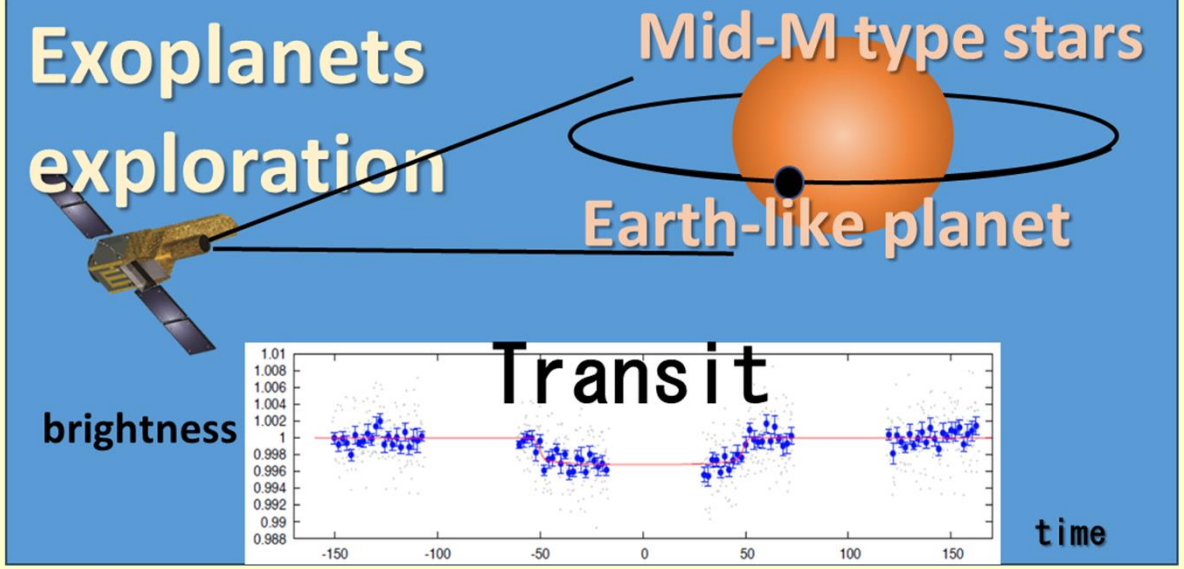
Nisihyama

	aperture size [m]	pixel angular scale [arcsec]	angular resolution [arcsec]	filter	field of view [square degree]	observation area [square degree]	Limiting magnitude [mag]	精度 (固有運動) [μas/yr]	precision (annual parallax) [μas]
JASMINE	0.36	0.53	1.06	Hw	0.30	2.5	12.5	40(25)-125	40(25)
VVV (VIRAC)	4.1	0.34	0.75	Ks	0.9	300	14	670	1100
GNS	8.2	0.106	0.2	H	0.016	0.25	21		
GNS+HST						0.16	16	500	
JWST	6.5	0.031	0.07	F210M	0.003	0.31	20	150	
Roman	2.4	0.105	0.15?	F146	0.281	0.28	23-24	15-25 (note1)	(note1)
ULTIMATE	8.2		~0.3	H/K	0.054	6.0	~18	300	
PRIME	1.8	0.5	1.4?	H	1.56	176			

Note 1: The white paper claims that optimal (high frequency) observations including Sgr A* would enable the proper motion to be measured at 2.5-3.5 μas/y and the annual parallax to be measured at an accuracy of 3 μas (Terry, et al. 2023). However, this is still a proposal at this stage, and there is no guarantee that optimal observations will be made. In addition, the calculations only consider statistical errors, and do not take into account systematic errors. Since Roman's observation proposal does not assume an observation mode suitable for astrometry, such as HST, it is thought that it may be difficult to achieve such accuracy.

II. Photometry

Transit observation of mid M-type stars to find Earth-like planets in the habitable zone



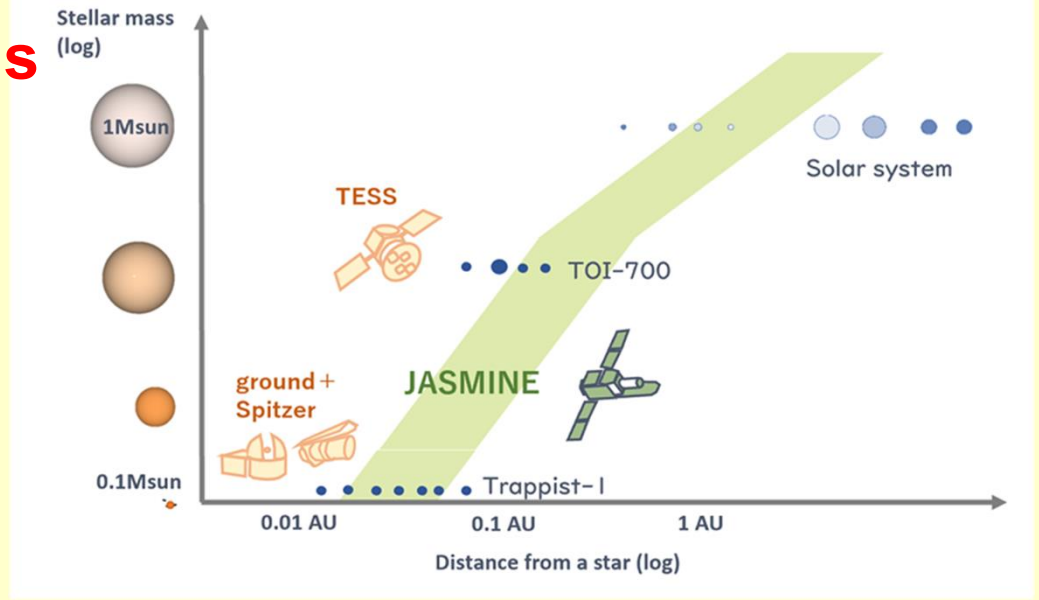
JASMINE will carry out transit observations during the periods when JASMINE cannot observe toward the Galactic nuclear region, utilizing the continuous photometric observations, taking advantage of its capability of high-precision photometric and highly frequent observations in the near-infrared region.

Target fixed star: 0.2 Rsol, 3000K, 16-25pc
Target planet: Earth-like planet in habitable zone
Period of revolution: 14 days – 30 days
The depth of the transit: 0.25%

Observation period: 14 – 35 days/each target
Target : planetary systems whose inner planets and/or gas planets are found by TESS/RV survey (>17 objects)

JASMINE has an advantage over other missions for explorations of this type of exo-planets.

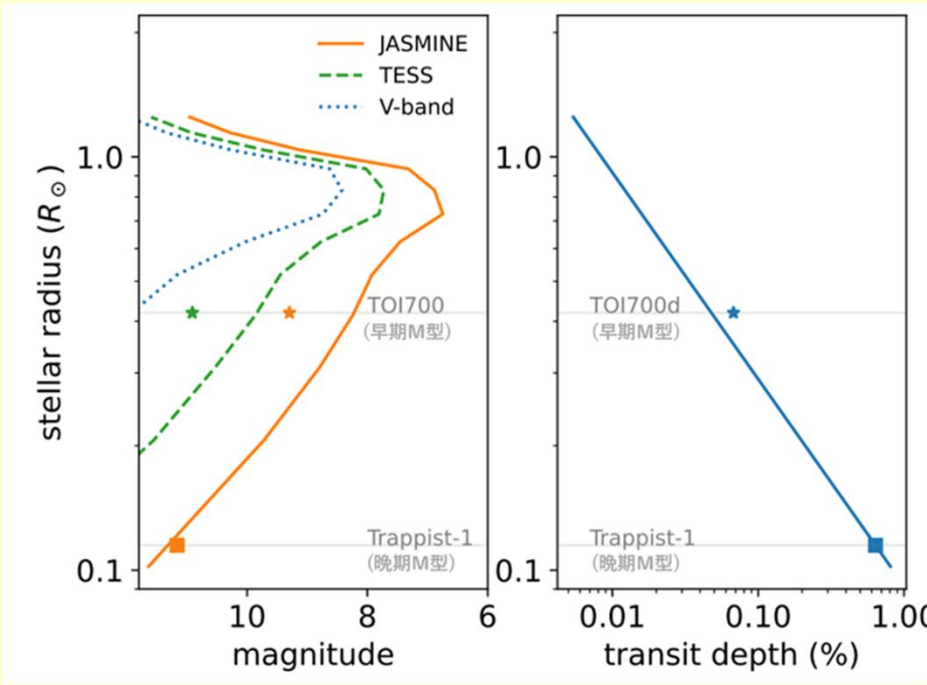
Around early M-type stars, the depth (rate of dimming) of the transit signal (the characteristic light curve of a star due to transit) is smaller, but they are relatively bright and therefore easy to discover with a 10 cm aperture TESS.
Conversely, around late M-type stars, the stars are fainter, but the transit signal is deeper, so although the photometric accuracy is lower, they are advantageous for large-aperture ground-based telescopes.

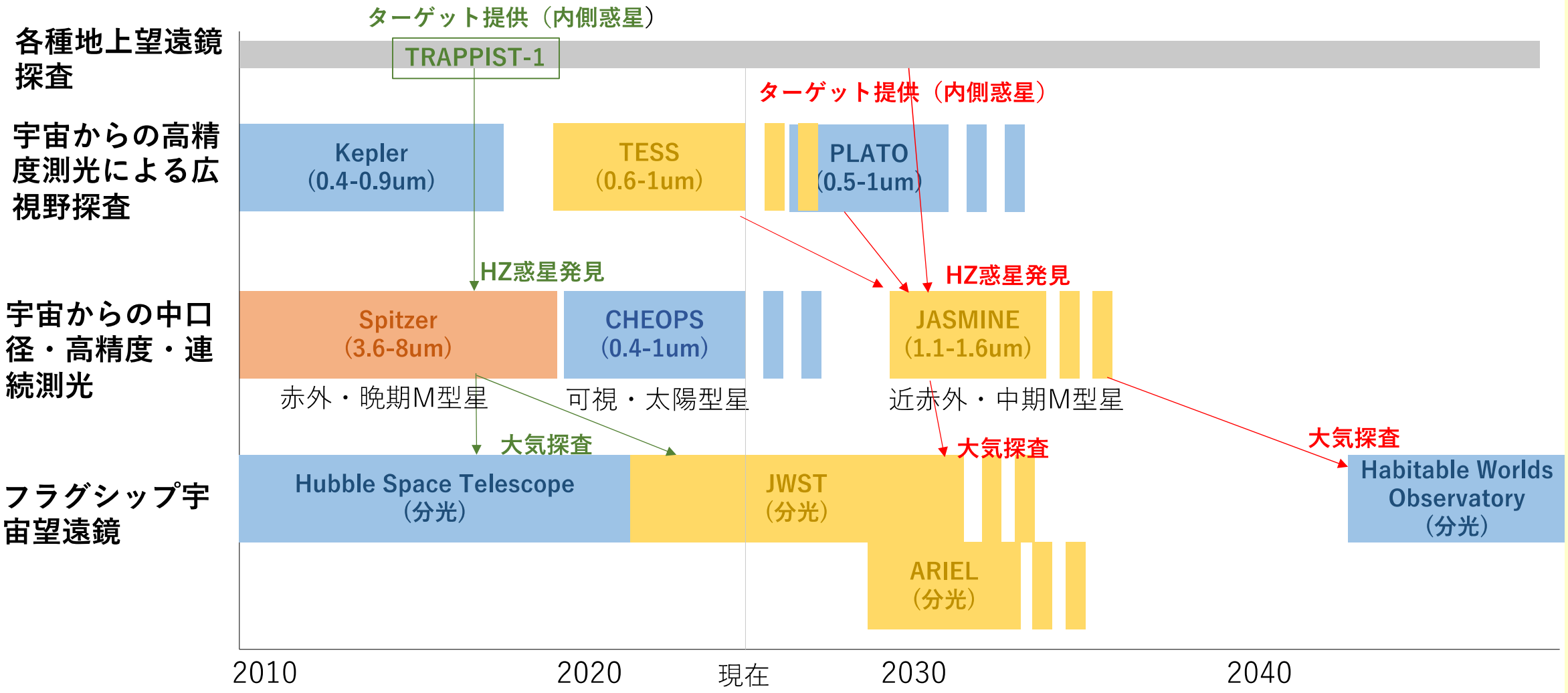


On the other hand,

the mid-M type stars in this intermediate region require medium-diameter observations from space, and JASMINE is well suited to this.

*JASMINE has 20 times light-gathering power than that of TESS
*JASMINE has good enough photometric sensitivity to detect the transit depth of the earth-like planets around mid-M type stars. The ground-based observations cannot provide this photometric sensitivity.





Relationship between JASMINE and other projects, division of roles and age

Kawahara

★Science objectives in the exoplanets

➔ Hirano, Kasagi, Tada, Kodama

(1) Follow-up observations of transiting and microlensing planet candidates discovered by other observations

(2) Exploration of young planets in star cluster regions

(3) Luminosity variation of brown dwarfs

(4) Fluctuations of rotation speed of stars in clusters

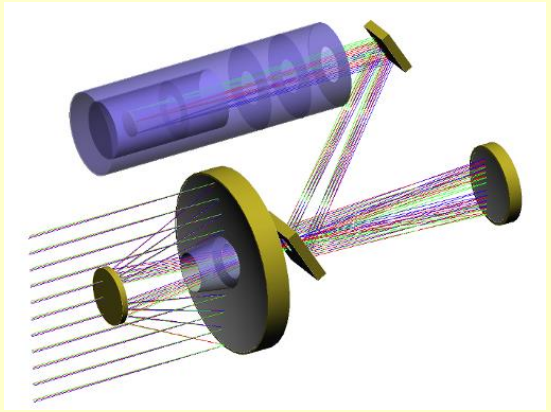
(5) Exploration of supergiant-neutron star binaries and Be X-ray binaries by continuous photometry

◎Astrometric exoplanets exploration

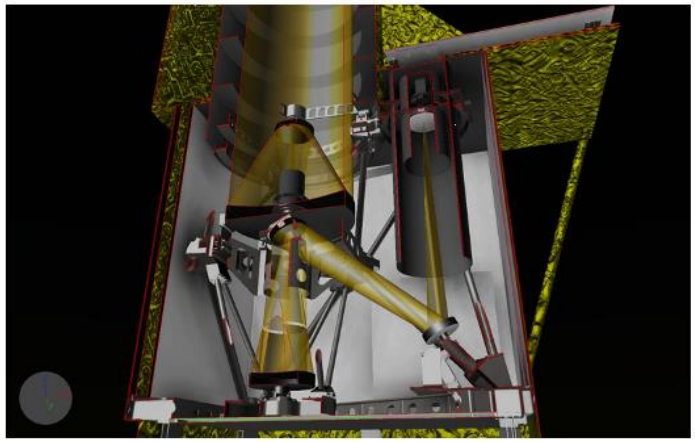
4. Mission instruments ➔ Kataza and poster presentations

Optical design: Modified Korsch System with 3mirrors and two folding flats to fit the focal length

- **Aperture size: 0.36m** T～278K
- **Focal length: 4.37m**
- **Field of view: 0.55° × 0.55 °**
- **Detector: 4× domestic CMOS sensors**
  InGaAs (2k × 2k)
  Hw-band:1.0～1.6μm
  operating temperature: < ~ 173K



Preliminary optical design (Kawata et al.2024)



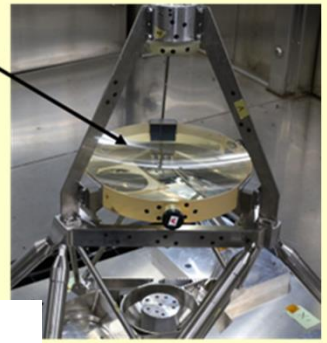
An example of schematic view of the payload layout

Telescope structure with little thermal structure time-variation

CTE: $0 \pm 1 \times 10^{-8}\ K^{-1}$

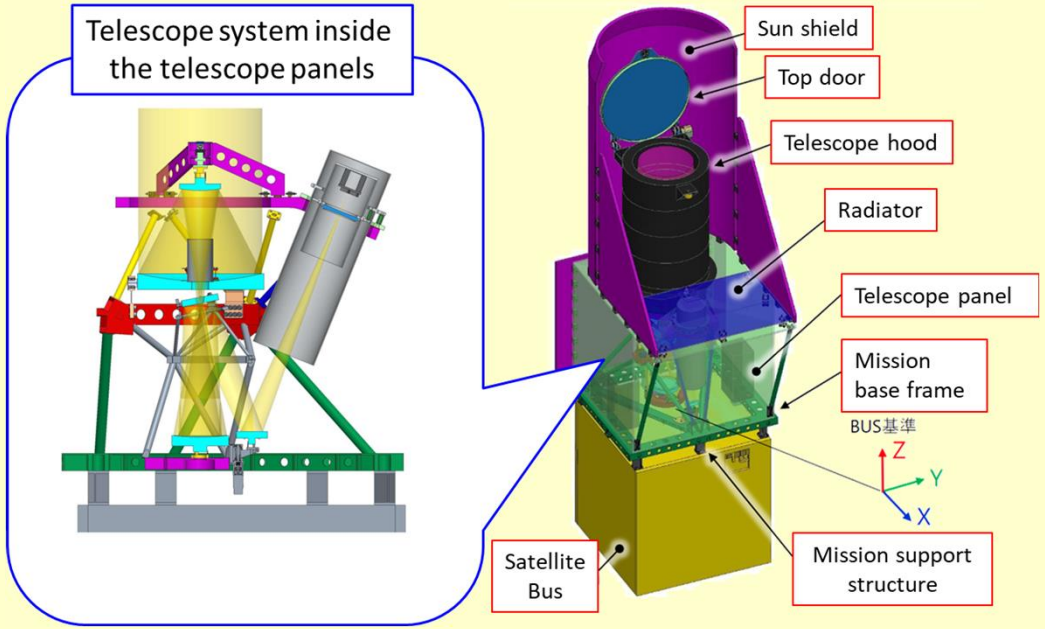
T～278±5K

CLEARCERAM®
-Z EX



low-temperature (low-T)
zero-expansion invar alloy

CTE:
$0 \pm 5 \times 10^{-8}\ K^{-1}$

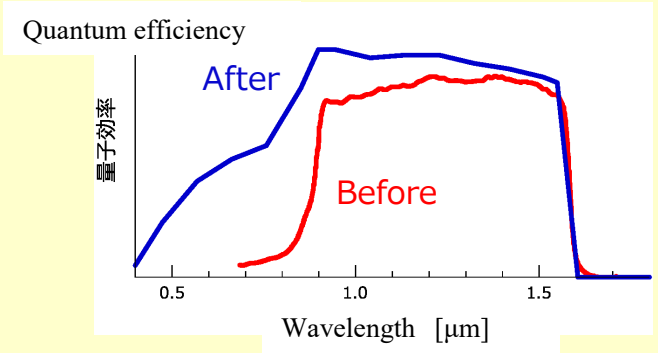


★Overview and progress of infrared camera development

Imaging

- detector: InGaAs (1952×1952 pixels) ×4
- wavelength: 1.0 ~ 1.6μm
- field of view: ~ 0.55 degree×0.55 degree
- pixel: ~ 0.5 arcseconds
- exposure time: ~ 12.5 seconds
- read time: ~ 1 second

The infrared detector that we plan to install on the JASMINE satellite is a domestic InGaAs detector. Our institute, NAOJ, has developed InGaAs CMOS infrared detectors suitable for ground-based astronomy. JAXA started developing this domestic detector to use in space, in collaboration with NAOJ, and various Japanese companies.



Cooling

- operating temperature: < ~ 173K
- cooling method : heat sink + Peltier (TEC)

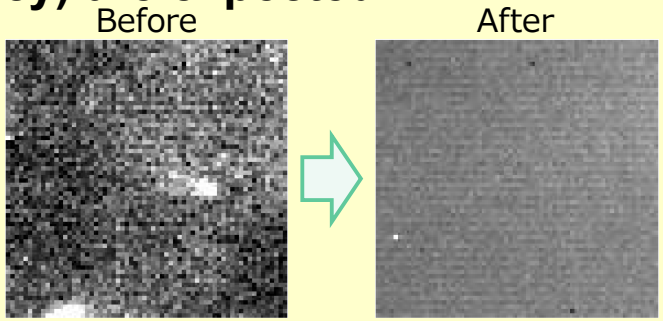
Progress:

Small format (128 × 128) sensor prototyped in 2021,and large format (2k × 2k) sensor in FY2022

➔ In-house tests for the cooling performance evaluation were prepared and the tests were conducted.

Confirmed that the InP substrate was removed and the anti-reflection coating was uniformly applied.

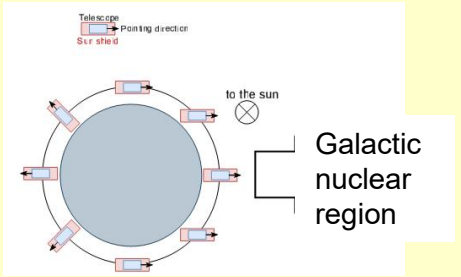
➔ Reduction of noise caused by cosmic rays and improvement of sensitivity (quantum efficiency) are expected.

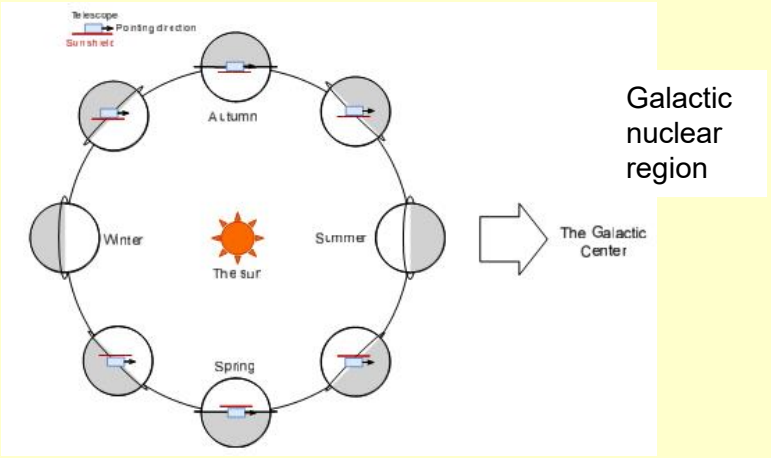


5. Outline and progress of usage and operation concept

○Orbit

・Sun-synchronous polar orbit, altitude ～600 km
・Scientific operation (nominal) ~ 3 years
　・Orbit insertion by Epsilon-S rocket





○Operation sequence

• Spring/Autumn: Astrometric measurements of the Galactic nuclear region
・Summer/Winter: Transit observations of mid M-type stars

○Examination of ground system for realization of observation

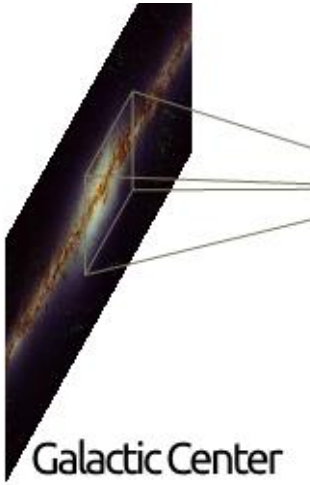
・Progress with the cooperation of the Scientific Satellite Operation and Data Utilization Unit (C-SODA) of the Institute of Space and Astronautical Science. In addition to JAXA, we are considering using the ground stations of overseas organizations and private companies.

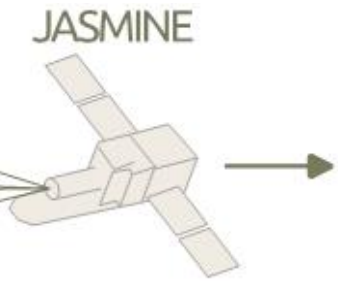
○ Data catalog creation and preparation for publication

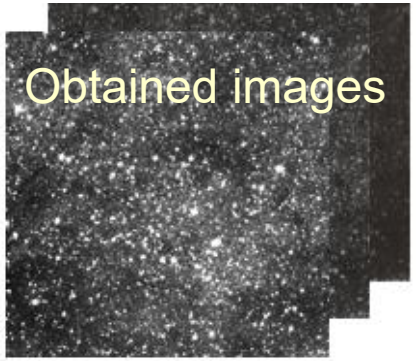
・With the cooperation of the Astronomical Data Center (ADC) of NAOJ, the ADC plans to open an observation data catalog. We have started discussions with the ADC and hold regular meetings.
・In order to meet the needs of the researcher community as much as possible, the transparency and reliability of the data will be improved, and **the data will be divided into several stages by performance level and prepared so that it can be used effectively in a timely manner.** ➔ Discussion in JC
The aim is to publish the data as quickly as possible.

6.Dataflow of JASMINE mission ➔ Ohsawa

“The point and stare” strategy: The whole survey region will be mapped to observe all the stars in this region for a similar number of times for three years and detect each star at the different positions within the detector, to randomize the noise and reduce systematic biases.



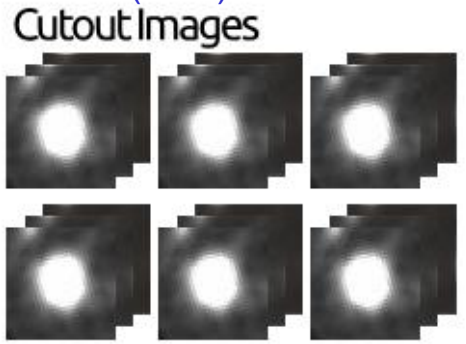




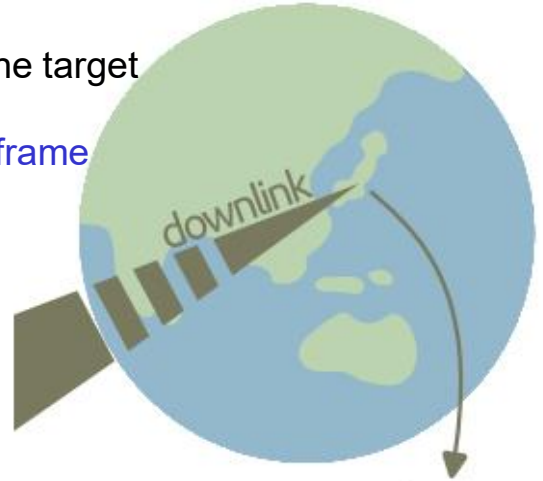
At each pointing of a single field of view of 0.55◦ × 0.55◦, JASMINE takes 12.5 sec exposure around 46 times

the data of 9 × 9 pixels around the target stars

In addition, downlink of one full-frame sometimes(TBD)



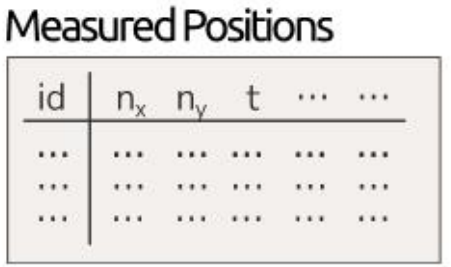
Background subtraction
Star image extraction

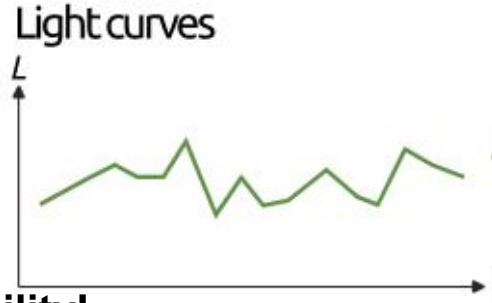


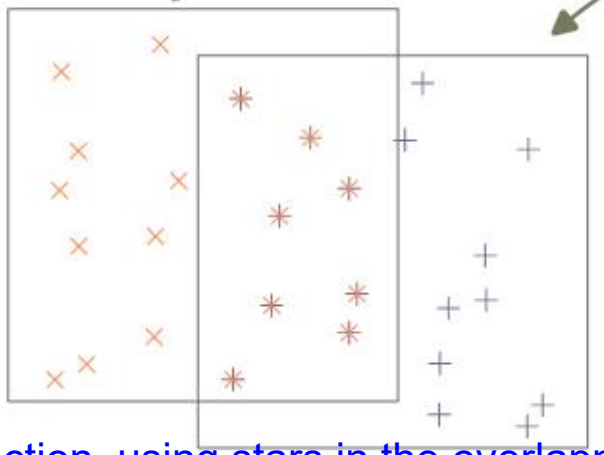
Build ePSF
Centroid estimates
~4 mas

ePSF optimal stellar-image model (instrumental PSF+ intra-pixel flat pattern)..
(Anderson & King, 2000)

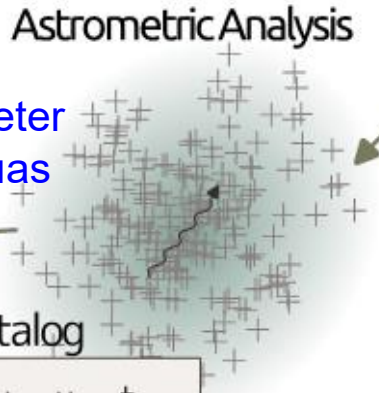
The ePSF can be estimated from a collection of stellar images



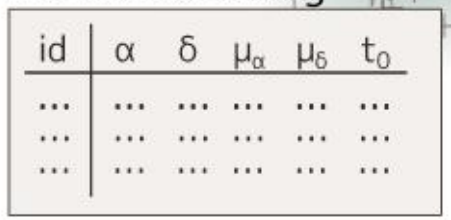




Distortion correction, using stars in the overlapped frames and Gaia references. **Thermal structure stability!**



Astrometry Parameter
$(\alpha,\delta,\pi,\mu_\alpha,\mu_\delta)$~25 μas



End-to-End simulation (E2E)

Dataflow of JASMINE simulation

implementation examples

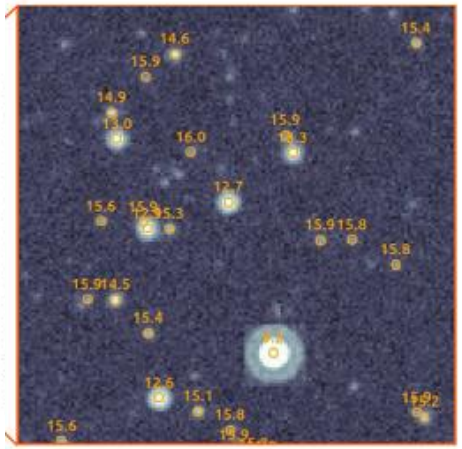
➔ Ohsawa

Mock Catalog ➔ Ramos

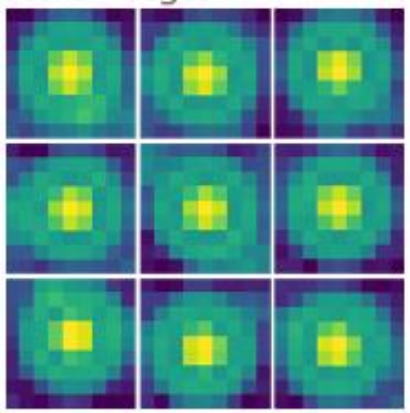
id	α	δ	μ_α	μ_δ	t_0
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...

Imagesim

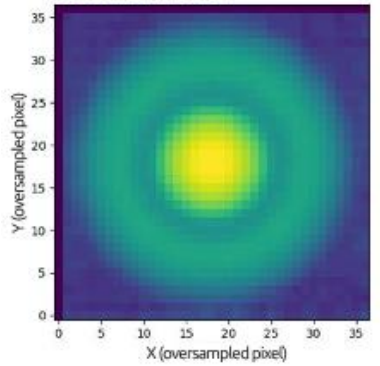
Simulated Images



stellar images



estimated ePSF



Observation Schedule

id	α	δ	θ	t	⋯
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...

By using an appropriate reference star catalog, image distortion analysis could be performed self-consistently. The time series transition of the estimated coordinates reproduced the proper motion and annual parallax of the celestial body.

Astrometric Analysis

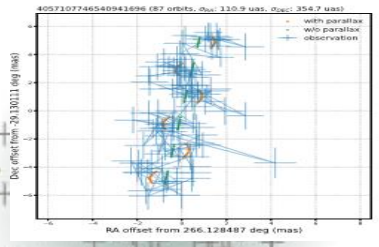
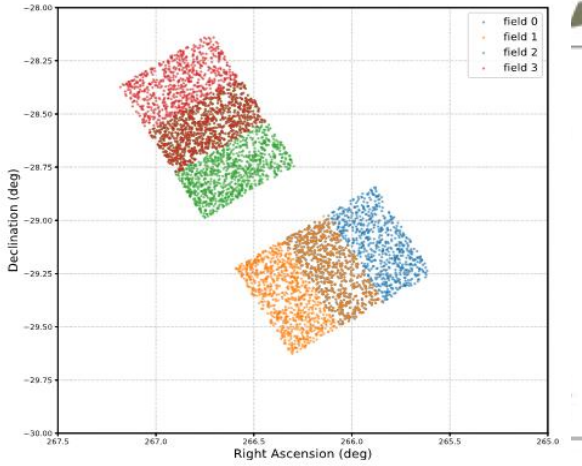


Plate Analysis



Measured Positions

id	n_x	n_y	t	⋯	⋯
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...

Light curves

Estimated Catalog

id	α	δ	μ_α	μ_δ	t_0
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...

7. 推進体制(Promotion Structure)

JAXA宇宙科学研究所
片坐宏一(プリプロジェクト候補チーム長)、河原創、臼井文彦、磯部直樹、近藤依央菜、鹿野良平(クロアポ)、高橋 葵、 笠木 結、宮川浩平、峯杉賢治、太刀川純孝

国立天文台 JASMINEプロジェクト
プロジェクト長:郷田直輝
鹿野良平、和田武彦、辻本拓司、矢野太平、上田暁俊、辰巳大輔、三好真、大澤亮、鹿島伸悟、宇都宮真、間瀬一郎、Ramos, Pau、片坐宏一(クロアポ)

E2Eシミュレーショングループ(データ解析WG)
大澤亮(代表), 河田大介(UCL)、山田良透(京都大学)
上塚貴史、福井暁彦(東京大学)、平野照幸、大宮正士(ABC)、逢澤正嵩(SJTU)、鈴木大介(阪大)、泉浦秀行、津久井尊史(国立天文台)、服部公平(統数研)、立川崇之(高知工専)、吉岡諭(東京海洋大)
+ISAS/JASMINEメンバー+NAOJ/JASMINEメンバー

国立天文台 先端技術センター
技術主幹:鵜澤佳徳
センター長・技師長:平林誠之、
満田和久(スペースラボ)、尾崎正伸(エレキ)
末松芳法&都築俊宏&小原直樹(光学)、大渕喜之&
浦口史寛&
清水莉沙&池之上文吾&森田正規(熱構造)
東谷 千比呂(衛星システム)

国立天文台天文データセンター
小杉城治(センター長)、
髙田唯史、古澤久徳、白崎裕治

位置天文サイエンスコアチーム
西山正吾(チーム長:宮城教育大)、松永典之(東大)、川中宣太(都立大)、河田大介(UCL)、郡 和範、矢野太平、郷田直輝(NAOJ)

系外惑星探査チーム(トランジット観測による地球型惑星探査等)
河原 創(チーム長:ISAS)、増田賢人(阪大)、小玉貴則、福井暁彦(東大)、葛原昌行、大宮正士、小谷隆行、平野 照幸(ABC/NAOJ)、山田亨(ISAS)、他

JASMINE Consortium
WG-A(Data Analysis)、WG-B(Science Validation and Preparation)、WG-C(Outreach)
リーダー:河田大介 (MSSL/UCL)、国内外60名の研究者(2021年4月現在)

データ解析

3人の 専門員雇用(2023.4~)

ARI Heidelberg University
Michael Biermman, Wolfgang Löffler

国際協力

Technische Universität Dresden
Sergei Klioner

地上局

ESA

★Launch of the Astrometry Science Core Team

member：西山（チーム長:宮城教育大）、河田(UCL)、松永(東大)、
川中(都立大)、郡、矢野、郷田(NAOJ)
observer：河原（他にも必要に応じて招聘）

○Scientific review and strengthening/expansion of scientific outputs by JASMINE

○Strengthening collaboration with other observation projects（＊）

○Consideration and preparation of science data validation methods
- ＊Advance validation of the science case＜＝＝mock catalogue
- ＊After analyzing the actual data, prepare and consider how to verify that the data performance is as required.

○Nurturing young people and expanding the community

（＊）Photometry+Astrometry: Ultimate-Subaru, ROMAN, JWST, GREX+, VVV. GN,…
Catalogue of Mira variables: PRIME, Techniques: HiZ-GUNDUM
Spectroscopy: Subaru-PFS, MOONS, Milky Way Mapper, …
Observation at other wavelengths: JEDI, ALMA, SKA, ng VLA…

★JASMINE Joint Scientific Research Program (NAOJ)
(JASMINE 共同科学研究事業(国立天文台))

＊The primary purpose of this program is to promote researchers at Japanese universities to carry out preparatory research to produce scientific results on the Galactic center region using JASMINE's astrometric data, which is expected in the future.
＊Successful applicant (PI) is required to lead strong a research project by supervising a dedicated researcher who will produce journal articles and presentations and organize the JASMINE Consortium meeting.

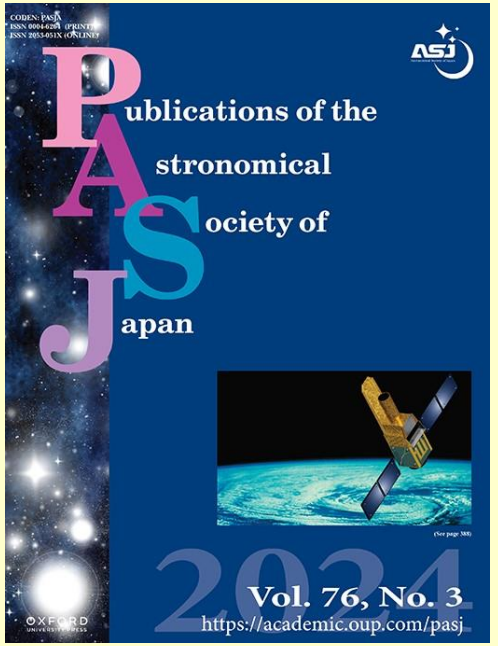
*PI of a selected research project will be supported for three consecutive years with the following grant:
One Project Researcher (postdoc) + Research Grant 1,000,000 yen / year

The JASMINE Project of NAOJ solicited applications for the JASMINE Joint Scientific Research Program.

PI: 松永典之 Noriyuki Matsunaga	東京大学 The University of Tokyo	JASMINE 観測領域に存在するミラ型変光星の研究 Studies on Mira variable stars in the JASMINE observation area

http://jasmine.nao.ac.jp/grant/JASMINE_grant_approved.html

8. International Collaboration



○ **Investigations of scientific outputs to be expected by JASMINE**
***We published the White Paper in PASJ by international collaboration**

○**The ARI (Astronomisches Rechen-Institut) group at the Heidelberg University in Germany has already started on the collaboration of the data analysis of JASMINE. We have regular joint meetings. ➔ Wolfgang Furthermore, the group at Technische Universität Dresden is considering the collaboration on the data analysis.**

○**Scientific cooperation with other observations for measurements of radial velocities, chemical compositions and photometry is very strong synergy for studies of the Galactic nuclear region.**
e.g. APOGEE2, VVV, GALACTICNUCLEOUS, MWM, MOONS, Roman, JWST, Theia, GaiaNIR, ...

○ **Collaboration in the downlink of scientific data**

***ESA is now considering the support of ground stations for the down link of scientific data to be provided by JASMINE. ISAS/JAXA will start to negotiate with ESA.**

Jasmine

Thank you for your support!