10 August 2009, Commission 8 Science meeting @IAU-GA

Series of JASMINE projects

---Exploration of the Galactic bulge ---

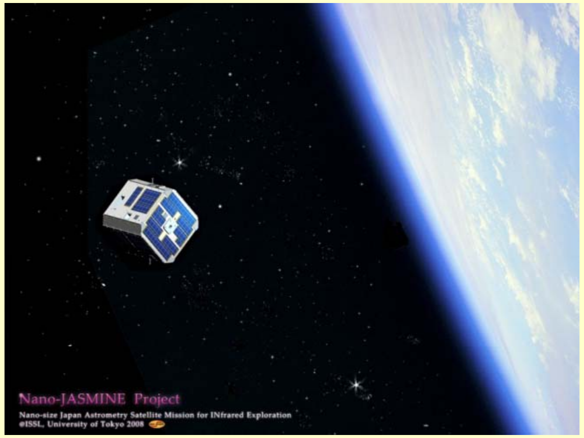
N.Gouda[1)] and JASMINE Working Group

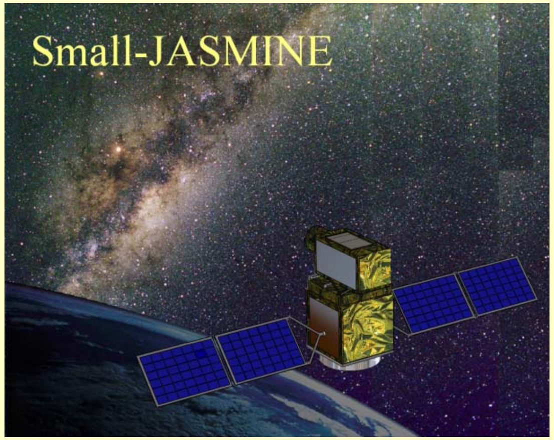
1:National Astronomical Observatory of Japan

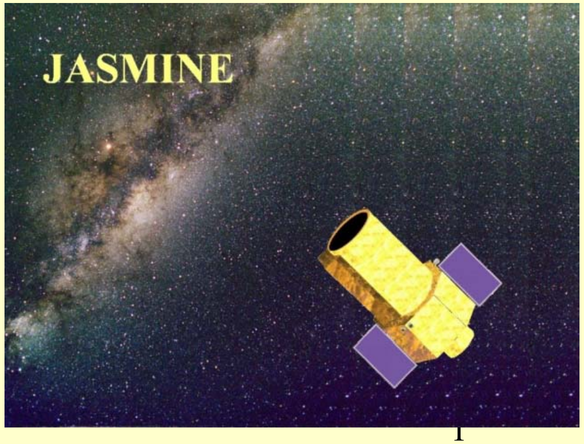
JASMINE

---Japan Astrometry Satellite Mission for INfrared Exploration---

Nano-JASMINE | Small-JASMINE | JASMINE





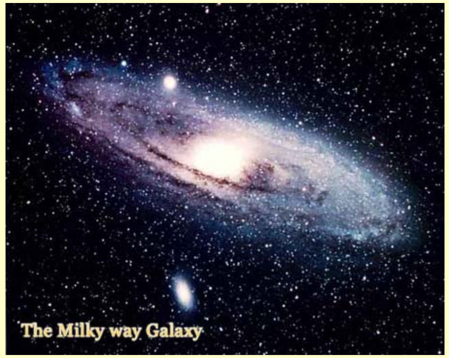


Hop: Nano-JASMINE launch date: July 2010

very small nano-satellite: 25kg, 50^3cm^3

the diameter of a primary mirror: 5cm

the first space astrometry in Japan



Step: Small-JASMINE target launch date : ~2015

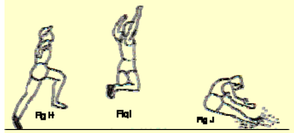
step -by-step approach to JASMINE for both science and techniques

the diameter of a primary mirror: 30cm

weight of a satellite: ~400kg

survey toward the restriced regions of the Galactic bulge

Jump: JASMINE target launch date: the first half of 2020's



the diameter of a primary mirror: 80cm

weight of a satellite: ~1500kg

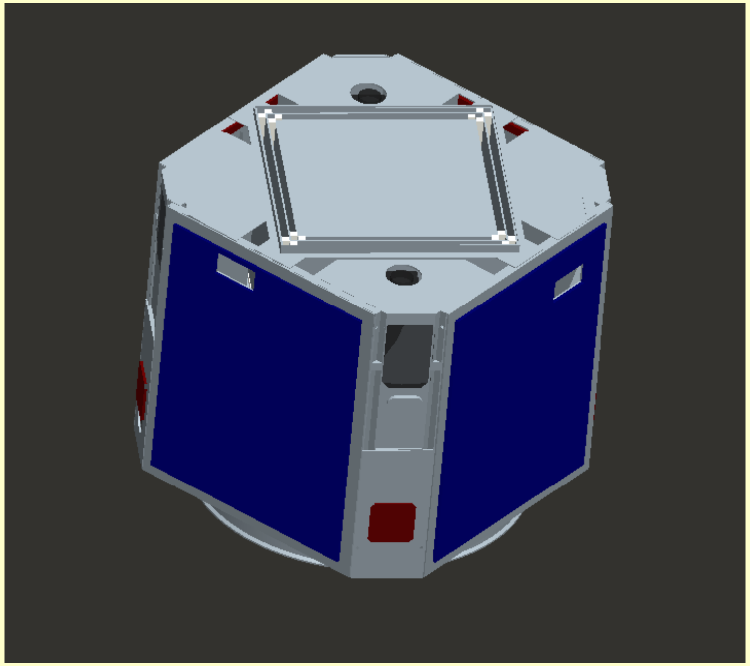
survey toward the whole region of the Galactic bulge

1 Nano-JASMINE

First space astrometry in Japan

use of a very small satellite (nano-satellite)

Nano-JASMINE satellite:



- size~$50^3 cm^3$
- weight~25 kg
- 5cm diameter
  of a primary mirror with
  a focal length of ~1.7m
- Target accuracy of parallaxes:
  ~3mas at z=7.5mag, operation in z-band(~0.9 micron)
- Orbit: sun-synchronized orbit
- Observing strategy :Hipparcos and GAIA type

◎Objectives of Nano-JASMINE

*first demonstration of space astrometry in JAPAN
We can experience almost the same process from the preliminary design, development to the operation as that in a big satellite.

*Examinations of technical issues for Small-JASMINE and JASMINE

- on-board processing: stellar image extractor
- feed back of stellar images to attitude control

*To get proper motions with high accuracies combining a Nano-JASMINE catalogue with the Hipparcos catalogue

◎ Launch: July 2010

Launcher:

*<u>Cyclone4(Yuzhnoye: Ukraine)</u>

Development of spacecraft bus system

Prof.Nakasuka's laboratory at the University of Tokyo

Spaceport@Alcantara, Brazil

Please refer to Hatsutori's presentation

2. Small-JASMINE (tentative name) & (JASMINE)

Astrometric Measurement in Kw-band
(central wavelength: 2.0 μm, bandwidth: 1.0μm(1.5μm~2.5μm)
Infrared astrometry missions have advantage in surveying the Galactic bulge, hidden by interstellar dust in optical bands!

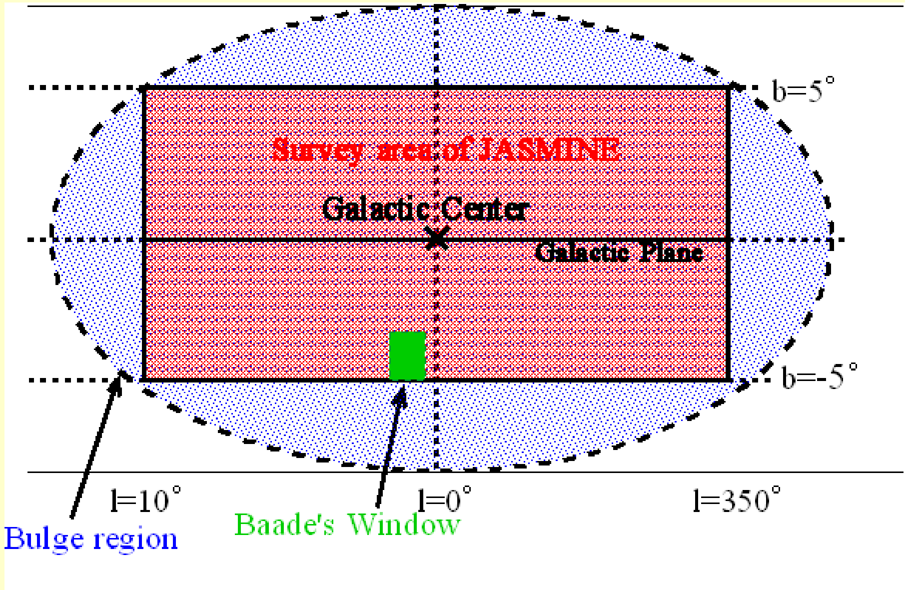
Accuracy:

parallax:
~10 μ as for Kw<11mag

proper motion:
~8 μ as/yr for Kw<11mag
(~4 μ as/yr for Kw<11mag)

position:
~7 μ as for Kw<11mag

Survey Area:
3 regions with 1 square degree
(l=350 degree~10 degree
|b|<10 degree)



The Number of Objects:

about several tens of thousands in the Galactic bulge

(about ten million stars around the bulge)

Observing strategy : Frames –Link Method

The target launch date is around ~2015 (the first half of 2020's)

Mission life: ~2 years (~5years)

Orbits: sun synchronized orbit (L2-Lissajous, HCPO, etc.)

Launcher: solid rocket under development by JAXA

(H-IIA (dual launch))

Small JASMINE(& JASMINE)

⇩

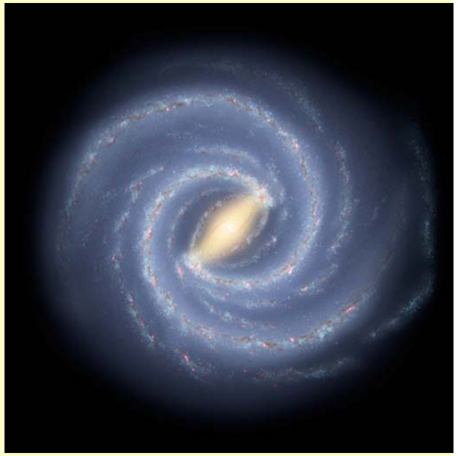
Development effort of NAOJ

with JAXA (Japan Aerospace eXploration Agency)

and universities in Japan

Scientific targets of Small-JASMINE and JASMINE

◎ Structure, Kinematics and Dynamics of the Galactic Bulge



*galactic bulges=>key to study the galaxy formations and evolutions

⇩

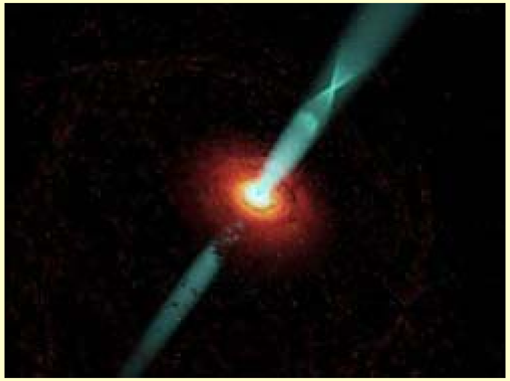
The Galactic bulge➔recent star formations

The Growth of bulges➔Evolution of the Hubble type

⇩

Supper massive BH at a galactic center➔ Activity of the galaxy

Co-evolutions of super massive BH s and bulges



The origins and evolutions of bulges

Three types of bulges

Similar to elliptical galaxies

origin : merging of galaxies!?

classical

Our Galactic bulge??

boxy/peanut-shaped

Disk-like profile

Origin : vertical bar instability

secular evolution owing to bar structures of bulges

pseudo

old population

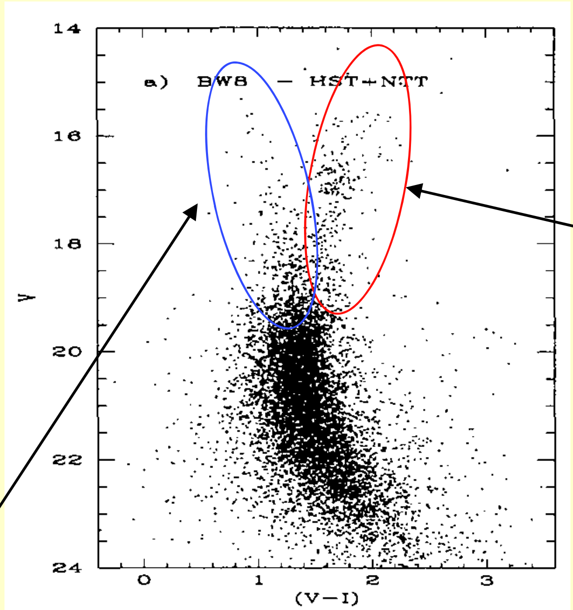
Star formations during long period

Science targets of Small-JASMINE:

Which type of the bulge does our Galaxy have?

Star Fomation History➔CM relations (+chemical compositions)

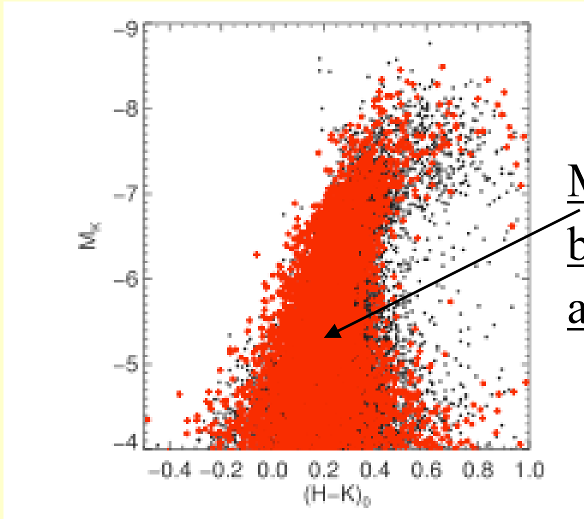
Baade window



old population

young population

M31



Mixture of bulge stars and disk star

The fact that successive star formations has been occurred until a few billion years ago is suggested (Olsen+ 2006)

disk component?

or

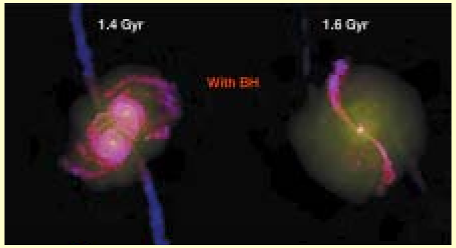
disk+bulge components?

Remark: CM diagrams =>bulge stars + disk stars

Separation between bulge stars and disk stars is a difficul task.

Accurate distances of stars +kinematics of stars➔ necessary for discriminating bulge stars from disk stars

Determination of Structure Formation Model of the Galactic bulge by using kinematics of bulge stars



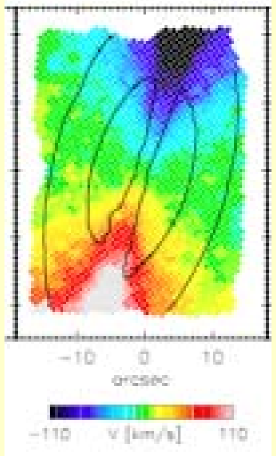
di Matteo + 2005

Gradient of rotation velocity along the vertical direction to the galactic plane

Merging vs. Bar instability

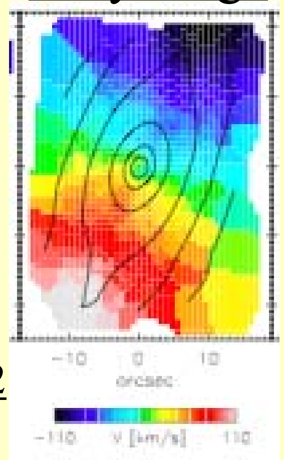
Sauron survey (Falcon-Barroso + 2004)

classical bulge

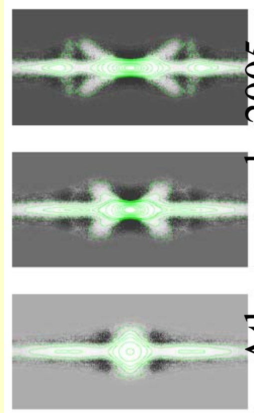


NGC 5866

boxy bulge



NGC 7332



Athanassoula 2005

cylindrical rotation

Constant rotation velocity along the vertical direction to the galactic plane

Collaboration with other science teams

Proper motion+ distance

+radial velocity+chemical component

➔clarification of the origin of the Galactic bulge structure

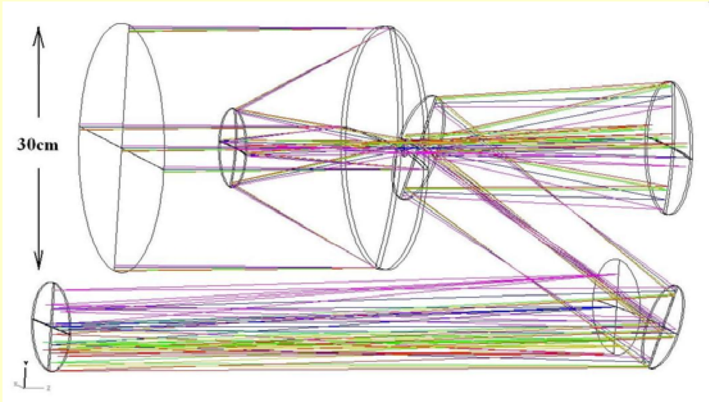
Observations of radial velocitis and chemical components in some ares within the Galactic bulge

Other scientific targets in Small-JASMINE:

- Stellar evolutions in the Bulge
- Dust information
- Gravitational lens effect caused by disk stars

Preliminary design of Small-JASMINE instrument

- Optics design: Modified Korsch System (3mirrors)
- Material: Synthetic Silica (a candidate)
- Aperture size: 0.3m
- Focal length: 4.9m
- Field of view: 0.87 degree × 0.87 degree
- Detector:



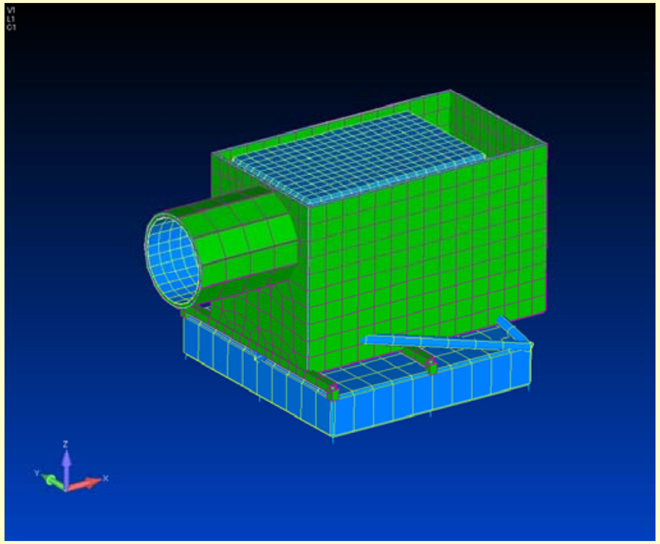
Kw-band: HgCdTe, Number of detectors: 4(2 × 2)

pixel size:18μm

the number of pixels:2048 × 2048

potential well:150,000

read-out noise :18e



Structure model of
the mission system (JAXA)

3. Observing strategy and data reduction

3-1. Two types of observing strategy

HIPPARCOS, GAIA

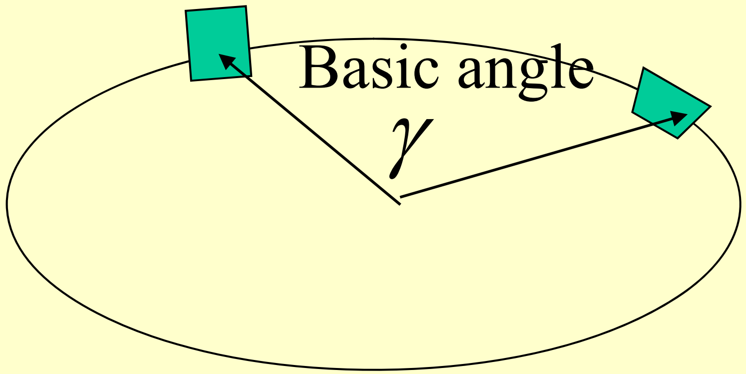
Nano-JASMINE

Small-JASMINE, JASMINE

Astrometry (absolute parallax, proper motion)

All sky survey

Partly a few stars



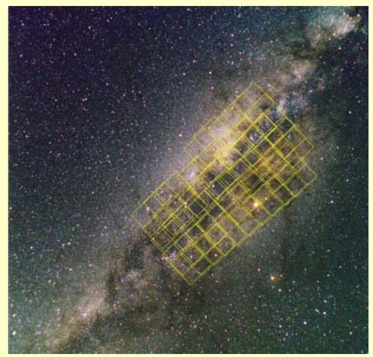
local survey (bulge)

many stars anywhere + calibration

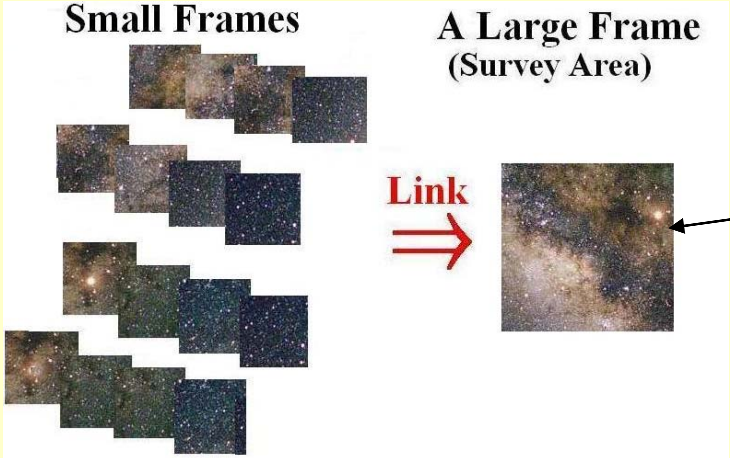
astronomical objects

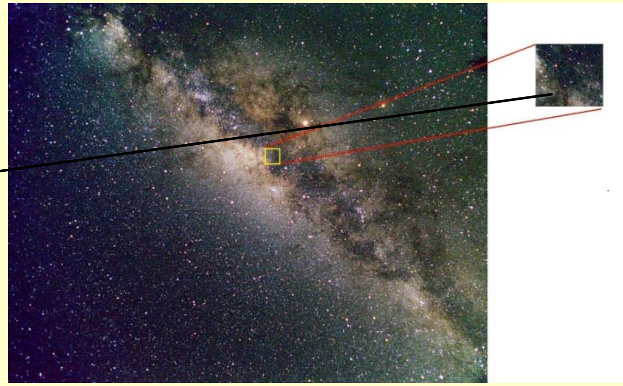
Frames-Link method

The whole survey region is composed by combining the small fields by using many stars in an overlap region between two consecutively observed adjacent small-fields. This method is applicable only to survey of the Galactic bulge because there is a sufficient number of stars to link small-fields with good accuracy.



3-2.Outline of Frames-Link method for Small-JASMINE





Survey area :

1.7° × 1.7 °

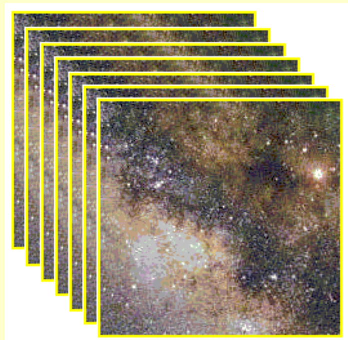
(which consists of 2 or 3 sub-areas) toward the Galactic bulge

Field of view: 0.9 degree × 0.9 degree

Stage 1: Stellar images on this field of view will be taken with an integration time of 3 seconds. 16 sets of stellar images exposed successively 16 times on a field of view is termed ``a small-frame''.

Stage 2: The telescope moves toward another adjacent field of view (small-frame) overlapping the previous small-frame (overlapping area is about a half of the frame). In about 20 minutes, the telescope takes the stellar images over the whole survey region, covering it by 16 small-frames.

Stage 3: We repeat the procedure at the stage 1 and 2 during the whole mission life and finally about 26,000 large- frames will be observed. Combining these large- frames allows determining the astrometric parameters using calibration stars whose astrometric parameters have been already determined accurately. Linear and annual variation of size, location, orientation, distortions of each large-frame can be fixed by calibration stars.

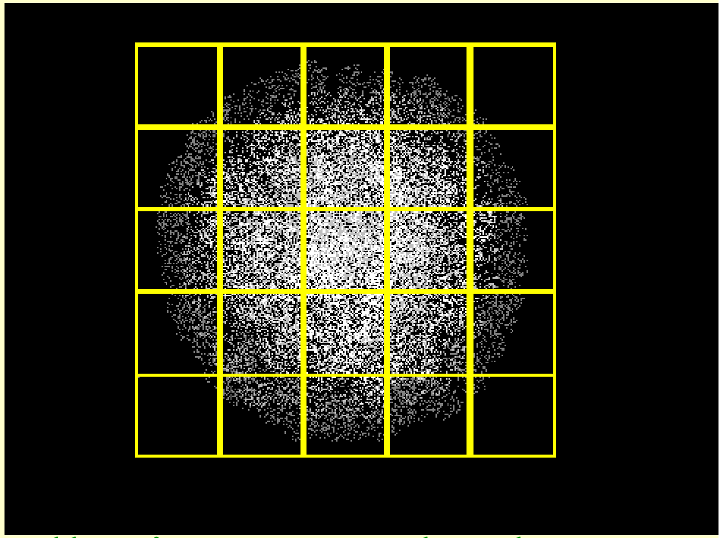


4. Critical error sources and requirements to a satellite system

(1) Random noise

e.g.

* photon number noise $\sigma \sim \lambda / \left(D \sqrt{N}\right)$



Stellar image on the detector

* linking of the small-frames

There is a sufficient number of stars in the overlapping region of two adjacent small-fields to decrease the errors

*smearing of stellar images due to fluctuations of the telescope pointing ⇨ stability of the telescope pointing

the specification of the size of the mirror, the size of the field of the view and the mission life is determined to attain ~7μas random errors of parallaxes at the final stage.

○Stability of the telescope pointing and the attitude control

Requirements:

○Pointing stability in the Small-JASMINE mission:

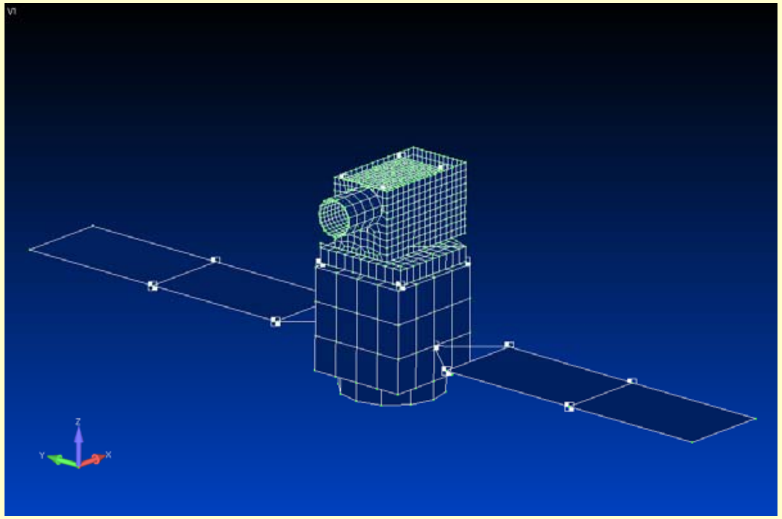
280 mas/3 sec ⟹ Tip Tilt Mirror

○Consumed Time for

Attitude Maneuver + relaxation to a state of rest: ~30 sec

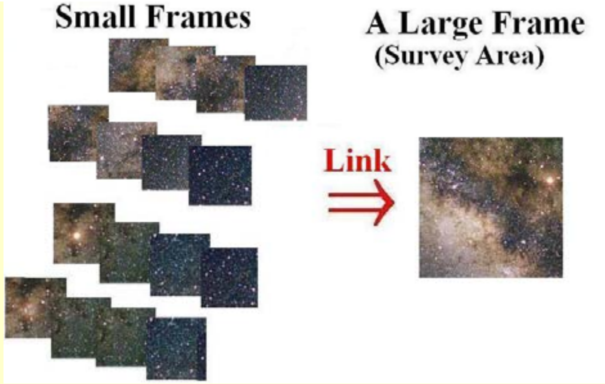
○ absolute pointing: ~0.1°

Engineers at JAXA are investigating detailed methods in real situations.



Structure model of
the Small-JASMINE satellite (JAXA)

(2) Systematic noise
At stage2:



Critical Systematic Error sources:

small-frames may have different sizes and distortions caused by the change of the telescope geometry according to temperature time variations

⇩

This fact requires very small temperature variations around the telescope and also the small change of the telescope geometry

⇩

Small-JASMINE :

Within ~10nm/20minutes variations of telescope geometry

⇩

Ultra low expansion telescope, structure of the satellite achievable to highly stability of temperature around the telescope

○Thermal stability of instruments

Low CTE materials should be used for the mirrors and the strucuture of the telescope:

e.g. Synthetic Silica

CTE :~10^{-7}@180K

about 0.4K time-variations of temperature should be attained within around   20 minutes for Small-JASMINE.

Engineers at JAXA are investigating detailed methods in real situations.

Small-JASMINE and JASMINE (STEP➔JUMP)

Science	Small-JASMINE	JASMINE
Dynamical structure of the bulge	Kinematics in only restricted regions (discriminating bulge stars from disk stars)	Phase space density of all matter in the bulge, reconstruction of the gravitational field
Formation of the bulge	Determination of a structure formation scenario (among 2 major scenarios)	Best choice among many scenarios
Star formation history	Histories in 2 or 3 regions	Dependence of histories on the regions in the bulge

Techniques	Small-JASMINE	JASMINE
Diameter of the primary mirror	**30cm**	**80cm**
Orbit	**Sun synchronized**	**L2-Lissajous**
Pointing stability	**280mas/3sec**	**100mas/2.2sec**
Thermal stability	**0.4K/20 minutes**	**4mK/10 hours**

Small-JASMINE:

Significant mission to get a number of the Galactic bulge stars with good astrometric accuracies as a step to the JASMINE mission.

Reason:

Earlier realization of infrared astrometry measurements in the Galactic bulge is required

(GAIA data, and sufficient data of radial velocity and chemical components in the Galactic bulge will be provided in around 2017)

* JASMINE: Getting budget and overcoming techniques ➔ long time

*Small-JASMINE: budget is not so expensive, requirements to the satellite system are not so severe

➔necessary and required as a step to the JASMINE mission

We hope that Small-JASMINE will be realized as soon as possible as a step to the JASMINE mission.

We need your strong support for Small-JASMINE.

5 Management and Schedule

- JASMINE project office at NAOJ 2004.4~
- JASMINE working group at JAXA 2008.3~
- Small-JASMINE working group at JAXA 2009.1~
- Launch of Nano-JASMINE ~ 2010
  (data release ~2012)
- Proposal of Small-JASMINE mission to JAXA ~2010(target)
- Launch of Small-JASMINE ~2015(target)
- Operation ~2 years
- Data release ~2018(target)
- Target Launch of JASMINE ~(2020 ~2024)

Jasmine

We would like to ask you for your continuous cooperation and encouragement