Nano-JASMINE

Use of AGIS for next astrometry satellite

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Naoteru Gouda and JASMINE Working Group
Nobutada Sako and Nano-JASMINE team

Contents

1. JASMINE series
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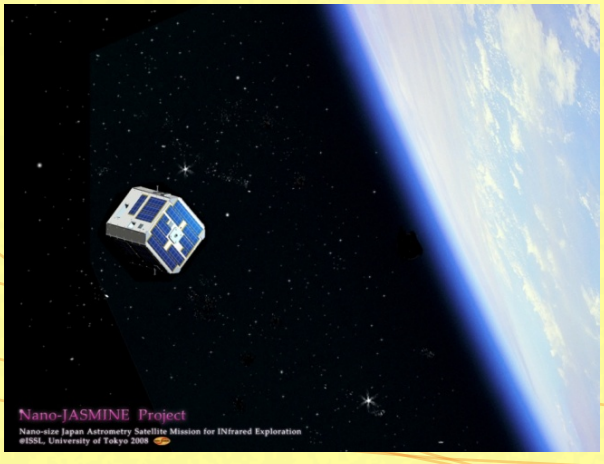
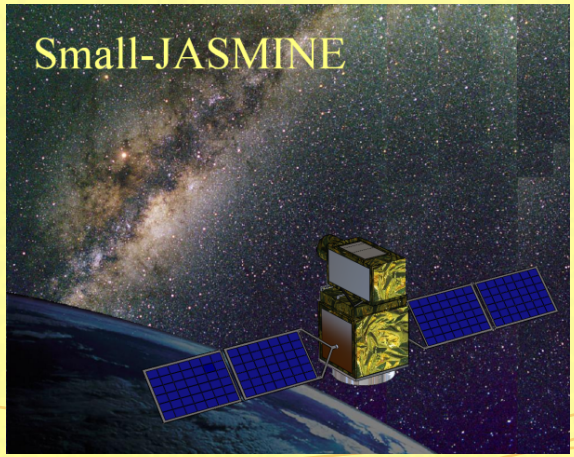
1.JASMINE Series

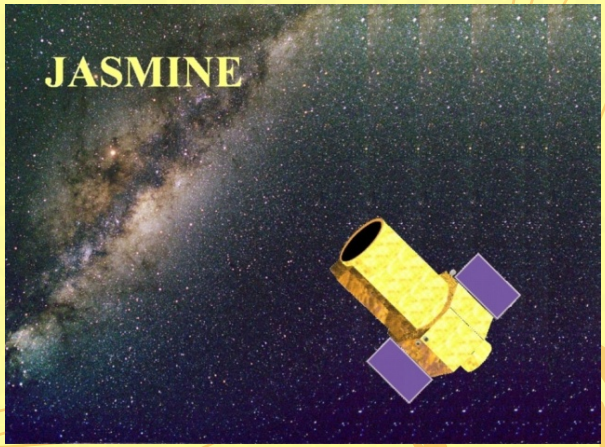
Japan Astrometry Satellite Mission for INfrared Exploration

See Gouda's poster

	Nano-JASMINE	Small JASMINE	JASMINE
D	5cm	30cm	1m class
Size/weight	$(50cm)^3$, 35kg	400kg	1500kg
accuracy	3mas@z<7.5	10μas @ K_W<11	10μas @ K_W < 11
survey	4πstr(whole sky)	Several sqr deg.	200 sqr deg.
operation	2011-2013	2016	2020's

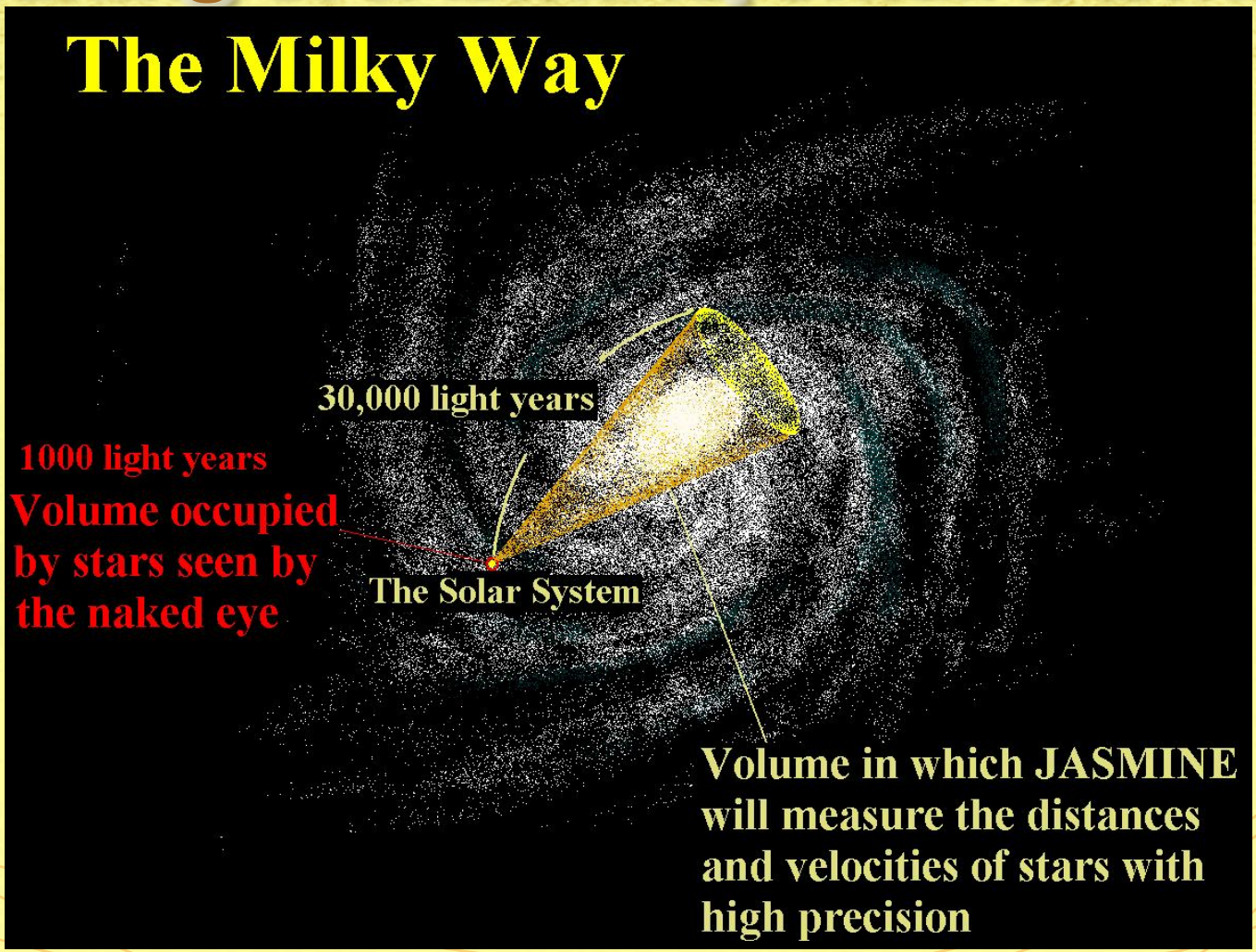






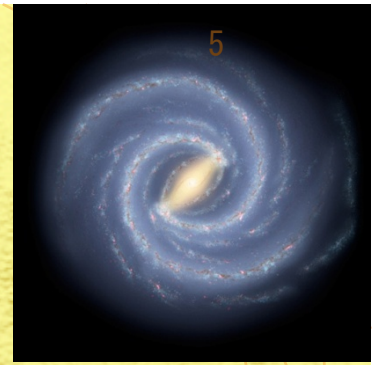
Japanese space astrometry program

IR Astrometry
meaning of JASMINE/Small JASMINE



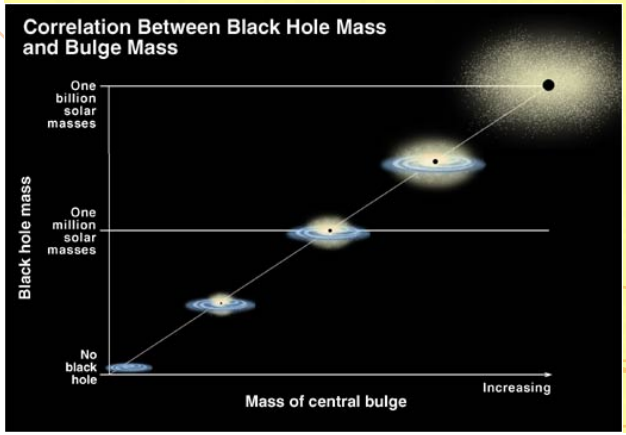
Bulge becomes interesting!

See Yano's poster



Scientific Targets of Small-JASMINE

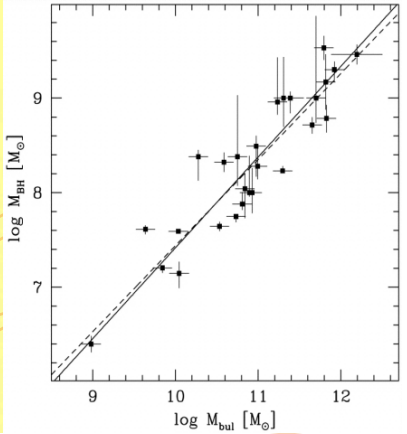
- Structure, Kinematics of the Galactic Bulge and Co-evolution of the Supper Massive BH and the bulge
  - galactic bulges=>key to study the galaxy formations and evolutions
  - the Growth of bulges=> Evolution of the Hubble type
- Supper massive BH at the galactic center =>Activity of the galaxy
- Co-evolutions of super massive BH s and bulges



(STScI/NASA)

Magorrian relation

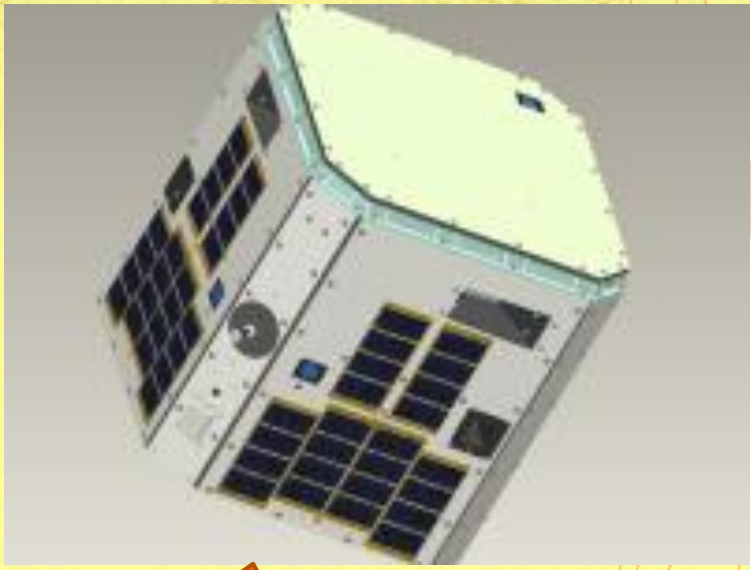
(Marconi & Hunt 2003, ApJ, 589, L21)



See Tsujimoto's poster

2.Nano JASMINE

All sky Astrometric Measurement in z_w-band (0.8 μm +/− 0.2μm)



- Made by universities/ observatory laboratories! not by a national space agency (like JAXA/ESA/ NASA).

Development and Launch

Launch date: AUG 2011

- Concluding launch contract
  - Launcher: Cyclone4(Yuzhnoye: Ukraine) from Brazil,
- EM testing phase ends and FM building phase starts
- Collaboration on N-J data analysis with GAIA data analysis team is ongoing.

6:Spaceport@Alcantara, Brazil

Nano-JASMINE

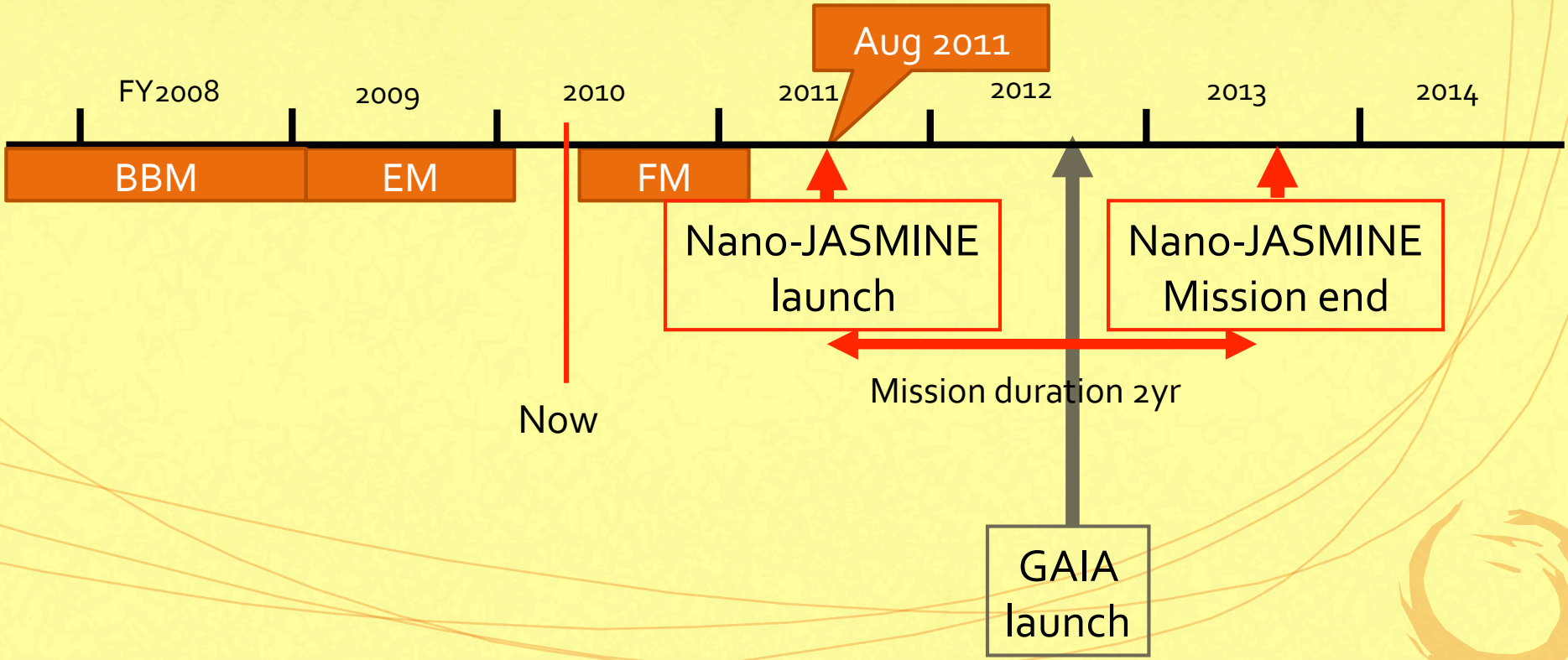
	Specification
Size	$(50cm)^3$
weight	35kg
Diameter of the primary mirror	5cm
Optical system	Ritchey-Chretien, f=1.67m, F=33
band	0.6 ～ 1.0μm
FOV	0.5 x 0.5(deg^2)
accuracy	3mas @ z < 7.5
Orbit	Sun synchronous orbit, LTAN(～6h), height are TBD(～700km)
Observing strategy	Same as HIPPARCOS and GAIA
Attitude control	3 axis
Telemetry	S-band, 100 kbps
Mission duration	2 years

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

Schedule and current status

- 2003/04:concept study starts
- 2005/07: design starts
- EM testing phase terminates. / FM building starts.
- FM assemble starts at 2010/07.

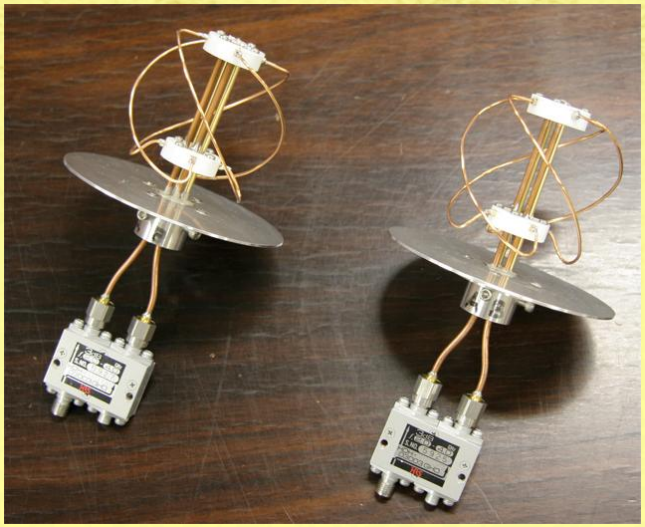


members

- Data reduction and on-board processing
  - Kyoto University
- Mission part (Payload module)
  - National Astronomical Observatory Japan
- Bus system (Service module)
  - University of Tokyo
  - Some other Universities
- About 20 people.

Antennas

Swedish Space Corporation
Kiruna, Sweden



Nano-JASMINE on board

Mizusawa 10m
NAOJ

University of Tokyo, 3m

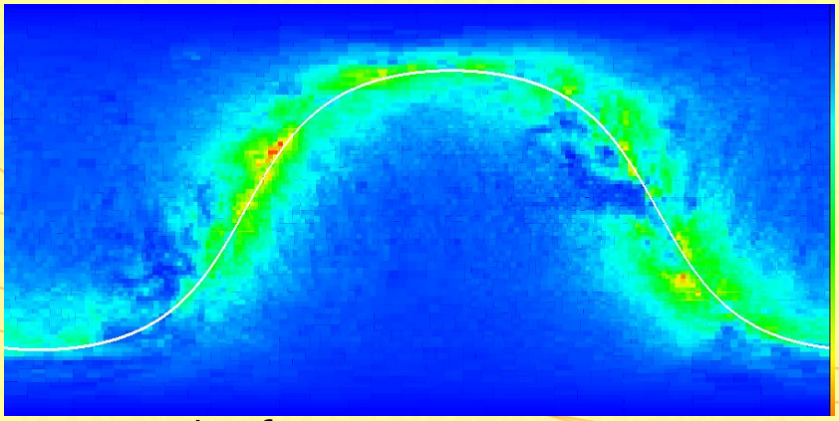
Telemetry

estimate

- S band (100 kbps)/ 3% visible
- Generated data volume(50MB/day) is enough smaller than storage size (1GB)
- Variability of data rate due to the non uniformity of the stellar distribution is OK (max 20 days data can be stored)
- Stored and selected downlink of stars brighter than 10mag

Survey times	2period×6times
Bus data / day	7.5[MB]
Downlink / day*	**19.9[MB]**

*30min / day communication



Sample of scan

Generated data including Bus data.

	average	maximum
Stored volume[brighter than 9mag]	**13.8[MB]**	**23.6[MB]**
Stored volume[brighter than 10 mag]	**24.4[MB]**	**50.7[MB]**

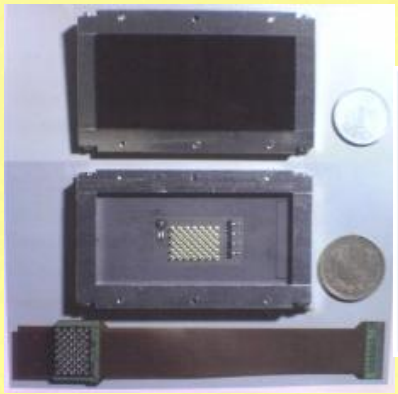
NJ OBC and storage

SEU rate: 1 times / 93day

HIMAC@National Institute of Radiological Science

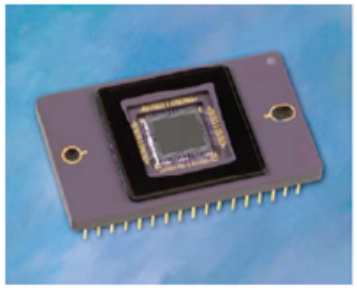
Virtex5

TANDEM van de Graaff @ Japan Atomic Energy Agency Tokai Research and Development Center



Hamamatsu Photonics FDCCD(NJ telescope)

KAI 01050 (Star Tracker)



TANDEM van de Graaff @ Kyoto University

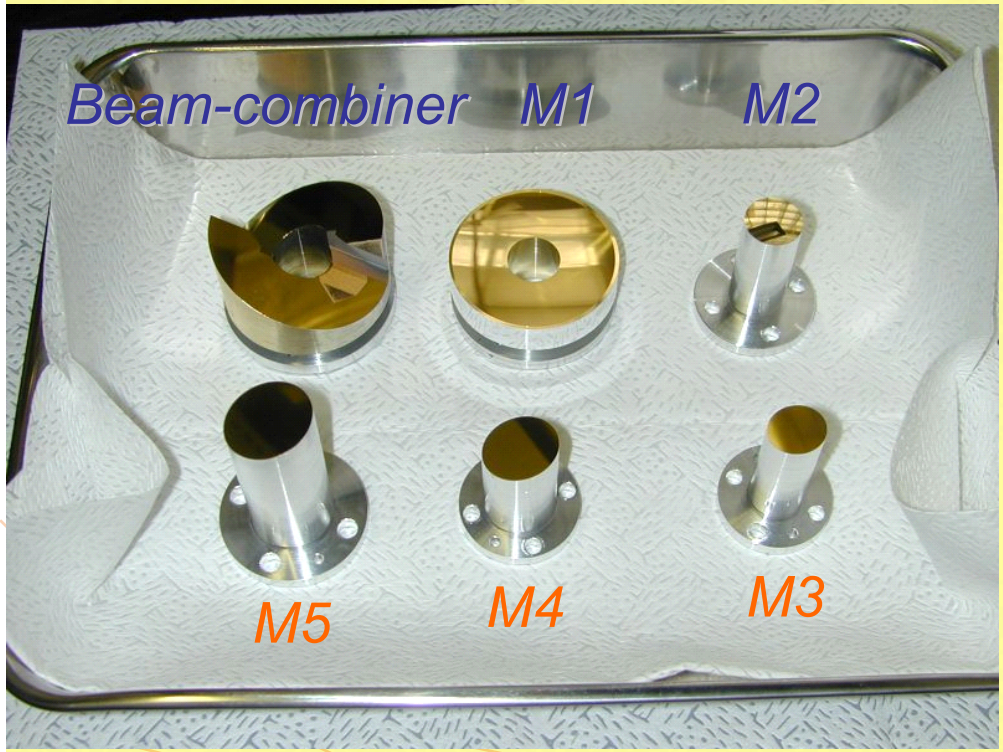
Surrey satellite technology already used the same designed GPS receiver.

GPS

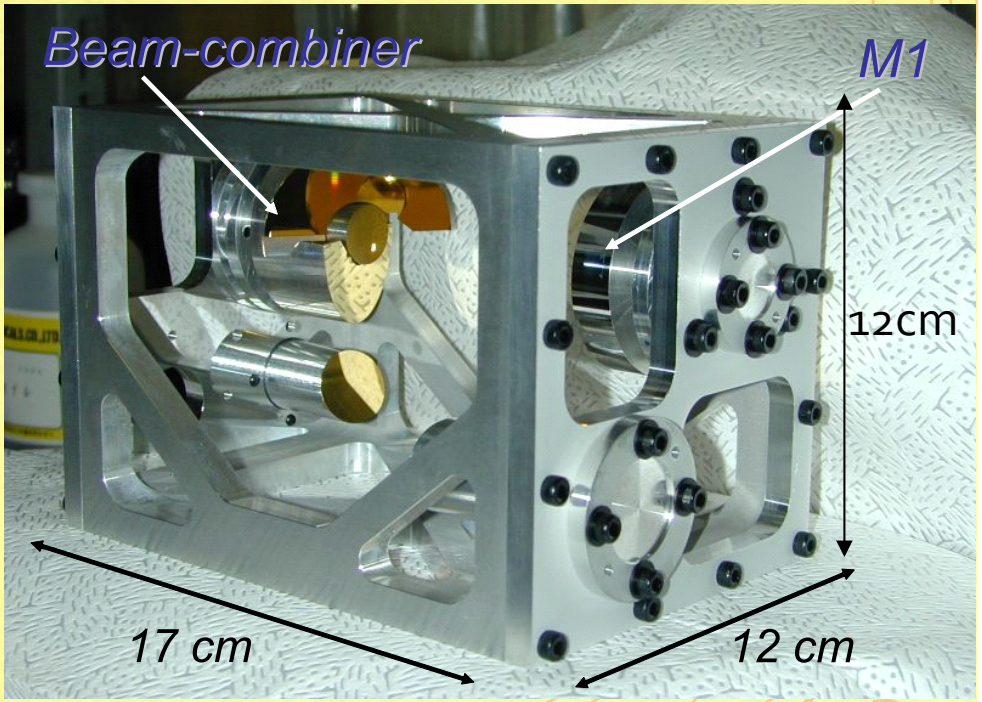
Fabrication of telescope

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)

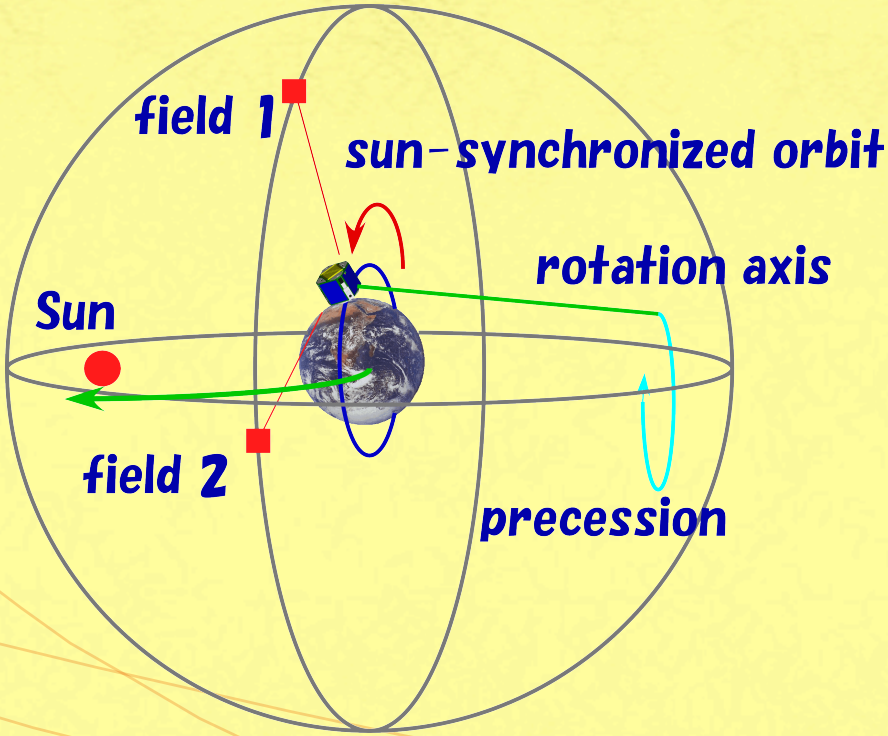


Assembled telescope Totally weigh: 1.7kg

See Hatsutori's Poster

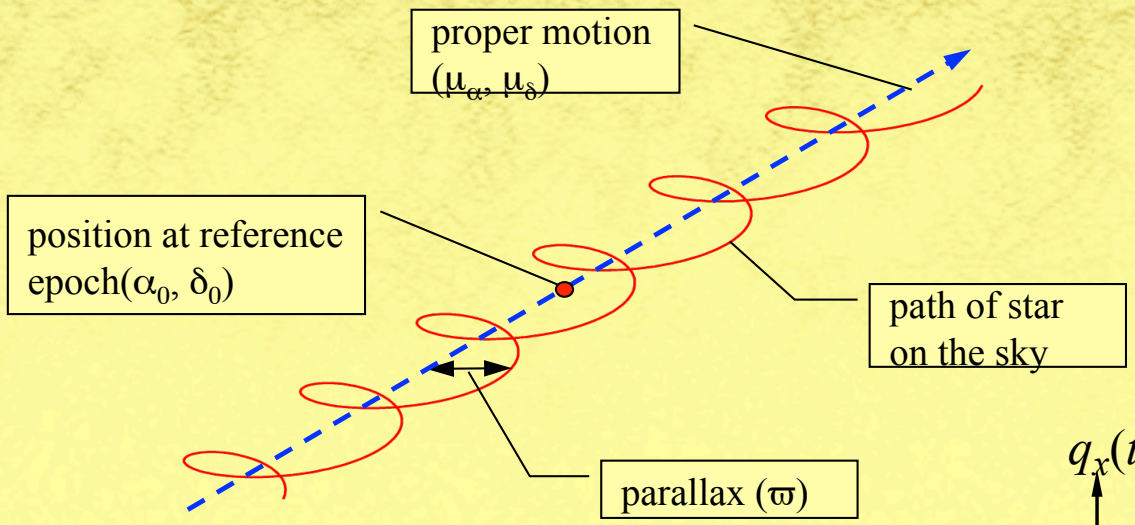
3.Applying GAIA code is available!

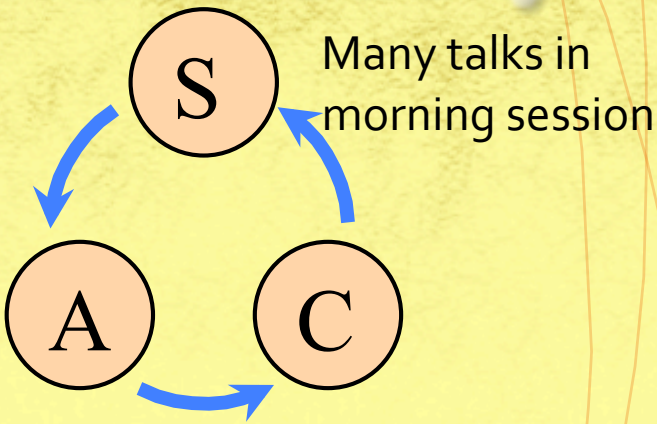
NJ observational strategy is similar to GAIA

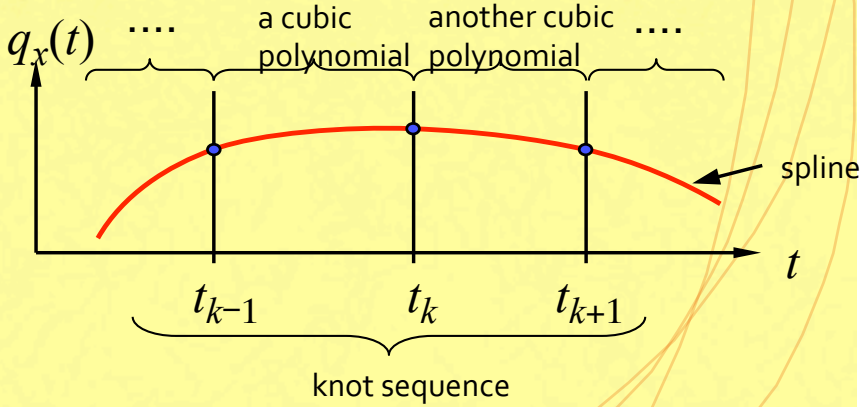


- Use beam combiner
  - Observe 2 FOVs simultaneously
- Angle of spin axis and the Sun is fixed(45 deg) and precession
- Use TDI operation of CCD
- Centroiding with 1/100 pixel accuracy

AGIS
(Astrometric Global Iterative Solution)

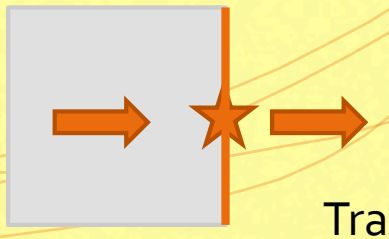






$$\chi(\mathbf{s},\mathbf{a},\mathbf{c}) = \sum_L \left(\frac{t_L - f_L^{(\mathrm{AL})}(\mathbf{s}_i, \mathbf{a}_j, \mathbf{c}_k, \mathrm{aux})}{\sigma_L} \right)^2$$

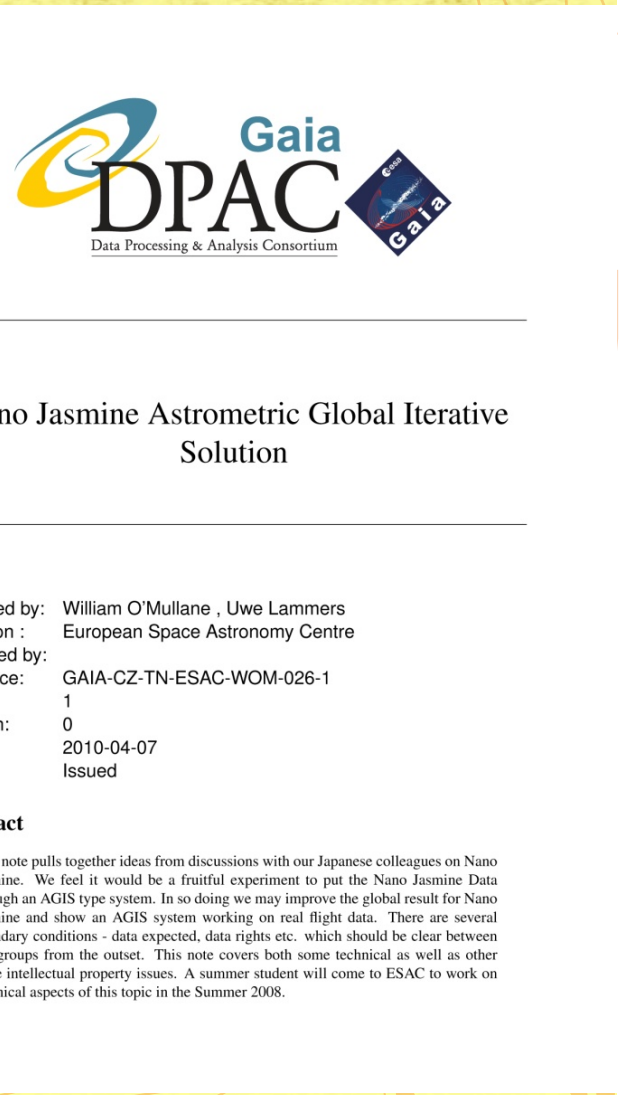
$$\begin{pmatrix} \boldsymbol{S} & \boldsymbol{U}^{\mathrm{T}} & \boldsymbol{V}^{\mathrm{T}} \\ \boldsymbol{U} & \boldsymbol{A} & \boldsymbol{W}^{\mathrm{T}} \\ \boldsymbol{V} & \boldsymbol{W} & \boldsymbol{C} \end{pmatrix} \begin{pmatrix} \Delta\boldsymbol{s} \\ \Delta\boldsymbol{a} \\ \Delta\boldsymbol{c} \end{pmatrix} = \begin{pmatrix} \boldsymbol{b}_s \\ \boldsymbol{b}_a \\ \boldsymbol{b}_c \end{pmatrix}$$



Transit time t_L

Application of AGIS to NJ

- AGIS aplicable
  - Similarity of two missions.
- Uwe Lammers' proposal at Shanghai IAU 248(2007)
  - NJ will be the test bench for Gaia AGIS
  - NJ team can use well designed and well tested software for analysis.
  - Using software by two projects is challenge!
- Cost for software will be not negligible in future projects.



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Data Processing & Analysis Consortium

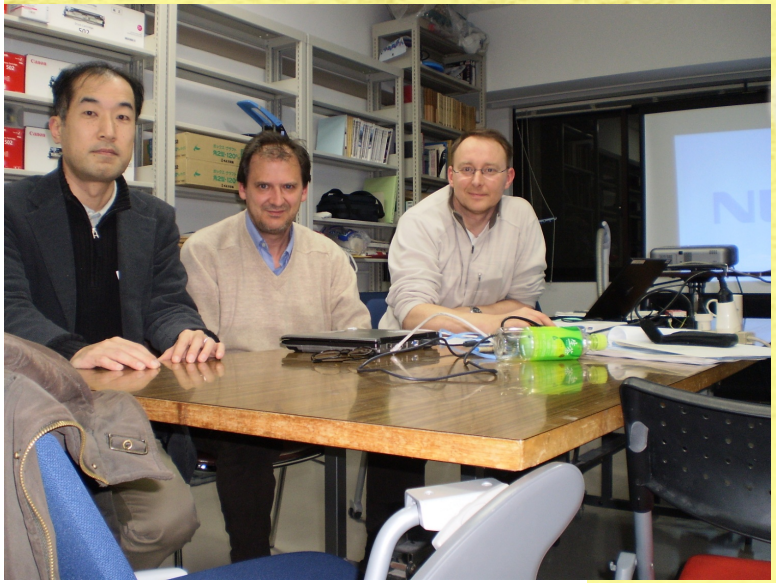
Nano Jasmine Astrometric Global Iterative Solution

prepared by: William O'Mullane , Uwe Lammers
affiliation : European Space Astronomy Centre
approved by:
reference: GAIA-CZ-TN-ESAC-WOM-026-1
issue: 1
revision: 0
date: 2010-04-07
status: Issued

Abstract

This note pulls together ideas from discussions with our Japanese colleagues on Nano Jasmine. We feel it would be a fruitful experiment to put the Nano Jasmine Data through an AGIS type system. In so doing we may improve the global result for Nano Jasmine and show an AGIS system working on real flight data. There are several boundary conditions - data expected, data rights etc. which should be clear between our groups from the outset. This note covers both some technical as well as other more intellectual property issues. A summer student will come to ESAC to work on technical aspects of this topic in the Summer 2008.

GAIA-CZ-TN-ESAC-WOM-026-01



GAIA members of NJ/AGIS

- Uwe Lammers
- Jose Hernandez
- Daniel Michelik
- Xaviel Luri
- Yago Isashi
- William O'Mullane

- 2008/11 Quebec ADASS
- 2009/09 Heidelberg Milky way
- 2009/10 Sapporo ADASS
- 2010/03 Kyoto
- 2010/06 Sevres ELSA

Gaia DPAC Data Processing & Analysis Consortium

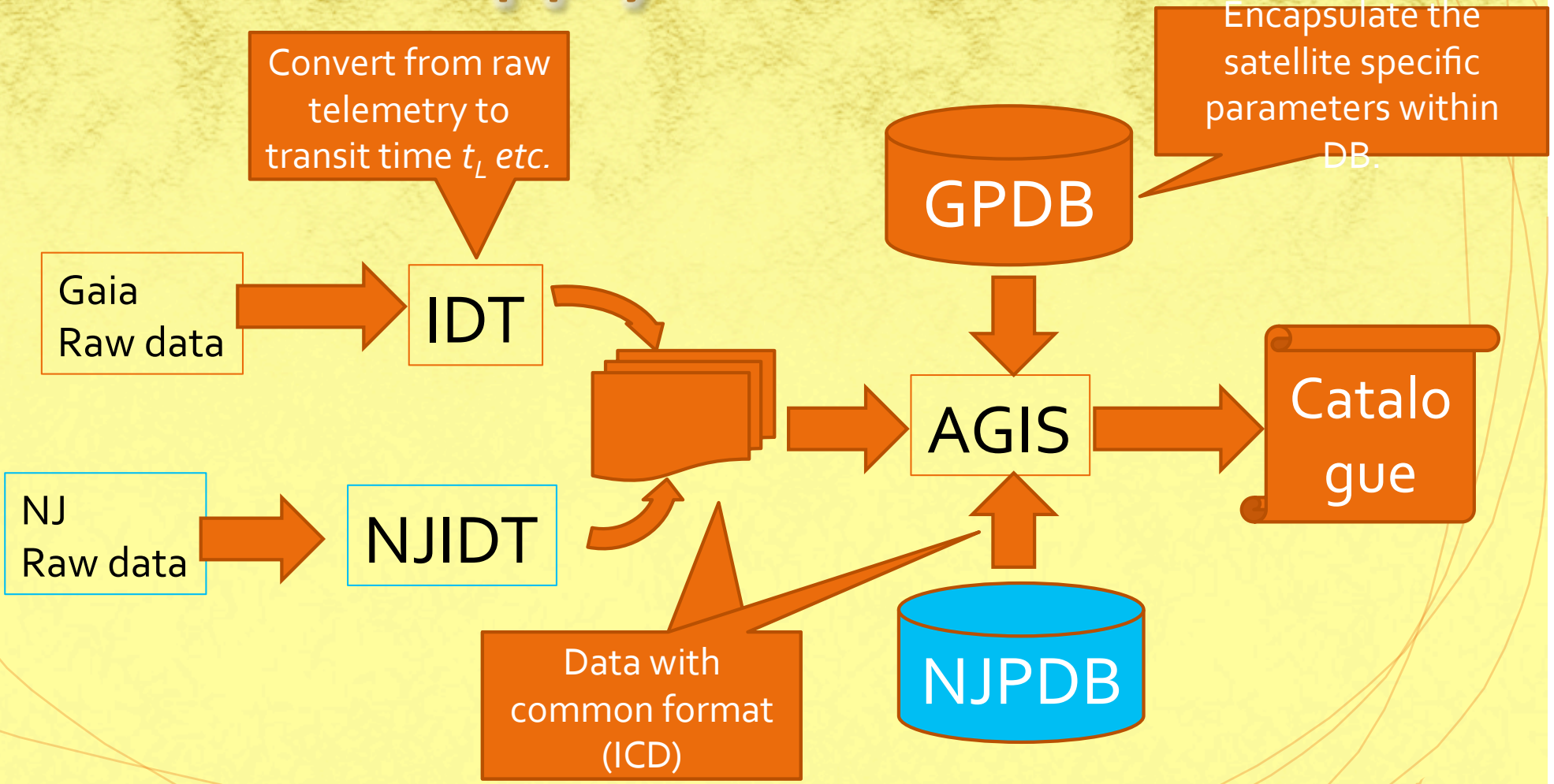
Minutes of March 2010
AGIS/NanoJasmine Working Visit #1

Department of Physics, Kyoto University, Kyoto, 23–25 March 2010

prepared by: U. Lammers
reference: GAIA-CZ-MN-ESAC-UL-043-01
issue: 01
revision: 0
date: 2010-04-07
status: Issued

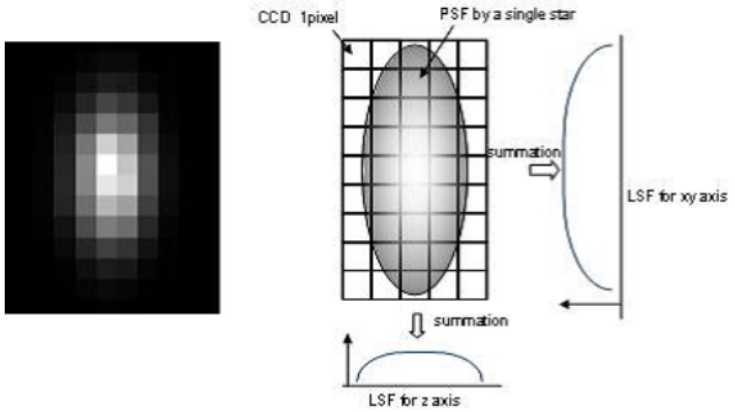
GAIA-CZ-MN-ESAC-UL-043-01

How apply AGIS to NJ?



NJ raw data

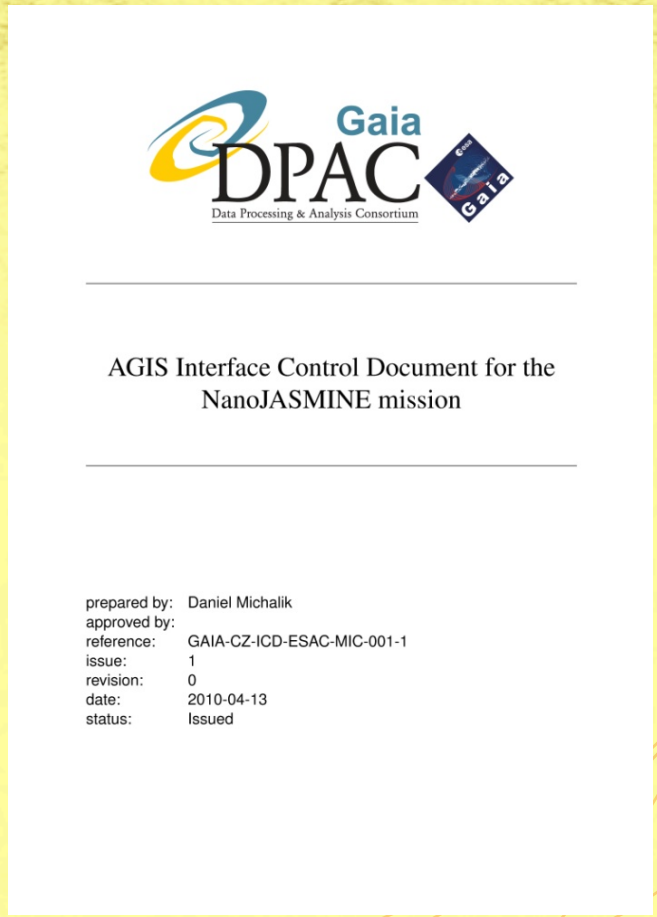
- Always 2D image with 5 x 9 pixels
- Stars observed by NJ
  - GSC2.3 sub catalogue is prepared.
  - About 1M stars may be observed
  - About 10000 stars has 10 % accurate parallax data.



See Kobayashi's poster

NJ ICD Plan

- Transit time data
  - ICD was written by Daniel.
- Attitude model
  - Spline knots Interval should be considered
- GaiaParams class for NJ
  - Maintain NJ parameters
- How to fix the coordinate?
  - What objects can be used as 'QSO'?


Gaia DPAC
Data Processing & Analysis Consortium

AGIS Interface Control Document for the NanoJASMINE mission

prepared by: Daniel Michalik
approved by:
reference: GAIA-CZ-ICD-ESAC-MIC-001-1
issue: 1
revision: 0
date: 2010-04-13
status: Issued

GAIA-CZ-ICD-ESAC-MIC-001

IDT software implementation Plan

- Centroiding
  - CCD radiation test: done
  - Apply deformation model of PSF(charge distortion model)
  - Images has time information from on-board GPS. GPS time should be converted to T_{CB}
- Attitude /orbit model
  - Attitude are estimated from the star tracker data as AGIS initial data. Detail attitude are solved by AGIS.
  - Orbit (positions and velocities) is estimated from the GPS data.
  - Time / space coordinate of both data should be converted.
- Identification of objects
  - Which FOV? ⇒ catalogue cross match
  - Is there unknown objects?
- Color information: from catalogue
  - List of NJ visible stars <= checked from GSC 2.3
  - Do enough number (as primary star)of stars have color information?

cu1.params.GaiaParams class

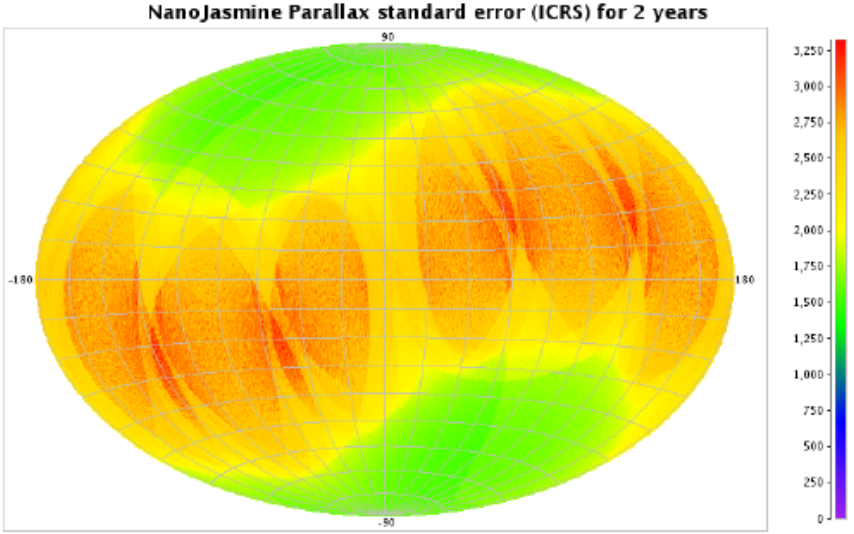
	GAIA	NJ
LIFETIME_OPERATIONALPHASE_NOMINAL	6 years	2 years
Nature category	common	
AF.CCD_NUMBER/CCD_NUMBER_AL	62/9	1/ 1
AF.CCD_POSITION_NOMINALX / Y		
AF.FOV_AL	0.71973 deg	0.5
BASICANGLE_DEGREE	106.??	99.5
BP. CCD_NUMBER/CCD_NUMBER_AL	7/1	0/0
CCD_*		
FOV_*		
SCANPERIOD_NOMINAL/SCANRATE	6 hour	90 min
SM.*		
TELESCOPE_FOCALLENGTH/_NUMBER	35m	1.67m

Only 33 parameters should be maintained

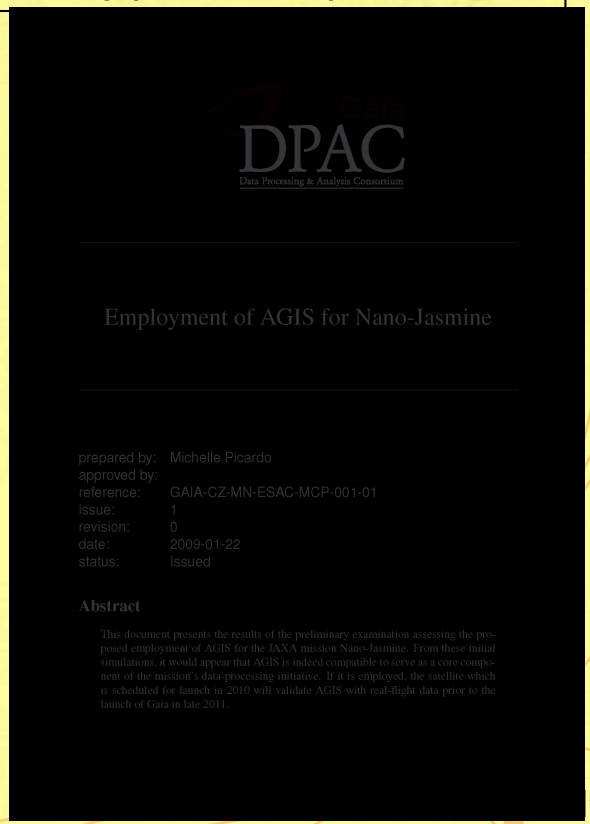
accuracy assessment

Standard error	
parallax	2306.89 uas
Alpha o *	5436.67 uas
Delta o	4396.60 uas
Mu alpha *	3.420 mas/yr
Mu delta	2.735 mas/yr

Convergence test(10^6stars)=>done
Accuracy=>done
NJ Parameter applicability => done



Plot 3. - Standard Error Plot for the Parallax


DPAC
Data Processing & Analysis Consortium

Employment of AGIS for Nano-Jasmine

prepared by: Michelle Picardo
approved by:
reference: GAIA-CZ-MN-ESAC-MCP-001-01
issue: 1
revision: 0
date: 2009-01-22
status: Issued

Abstract

This document presents the results of the preliminary examination assessing the proposed employment of AGIS for the JAXA mission Nano-Jasmine. From these initial simulations, it would appear that AGIS is indeed compatible to serve as a core component of the mission's data-processing initiative. If it is employed, the satellite which is scheduled for launch in 2010 will validate AGIS with real-flight data prior to the launch of Gaia in late 2011.

's work

GAIA-C3-TN-ESAC-MCP-001-01

Future work (1/2)

- Implement IDT software at Kyoto Univ.
  - Conversion of time and space coordinate
  - Attitude / orbit modeling (knod interval)
  - centroiding
- Pseudo input catalogue for AGIS (NAOJ)
  - File format will be shown by ESAC.
  - GSC 2.3 sub catalogue will be converted to the format.
- Implement NJSS (similar to GASS) by ESAC.
- Check convergence, accuracy etc. in NJ situation (mainly in Japan)
  - Blade server (IBM TRL)
  - update calibration models if necessary

Future work(2/2)

- We are welcome to scientific collaboration with European community using NJ data!

- AGIS becomes more general astrometry (astronomical) application Ex. JASMINE

Thank you

http://www.jasmine-galaxy.org/index.html