



Collaborations between NCU and NAOJ

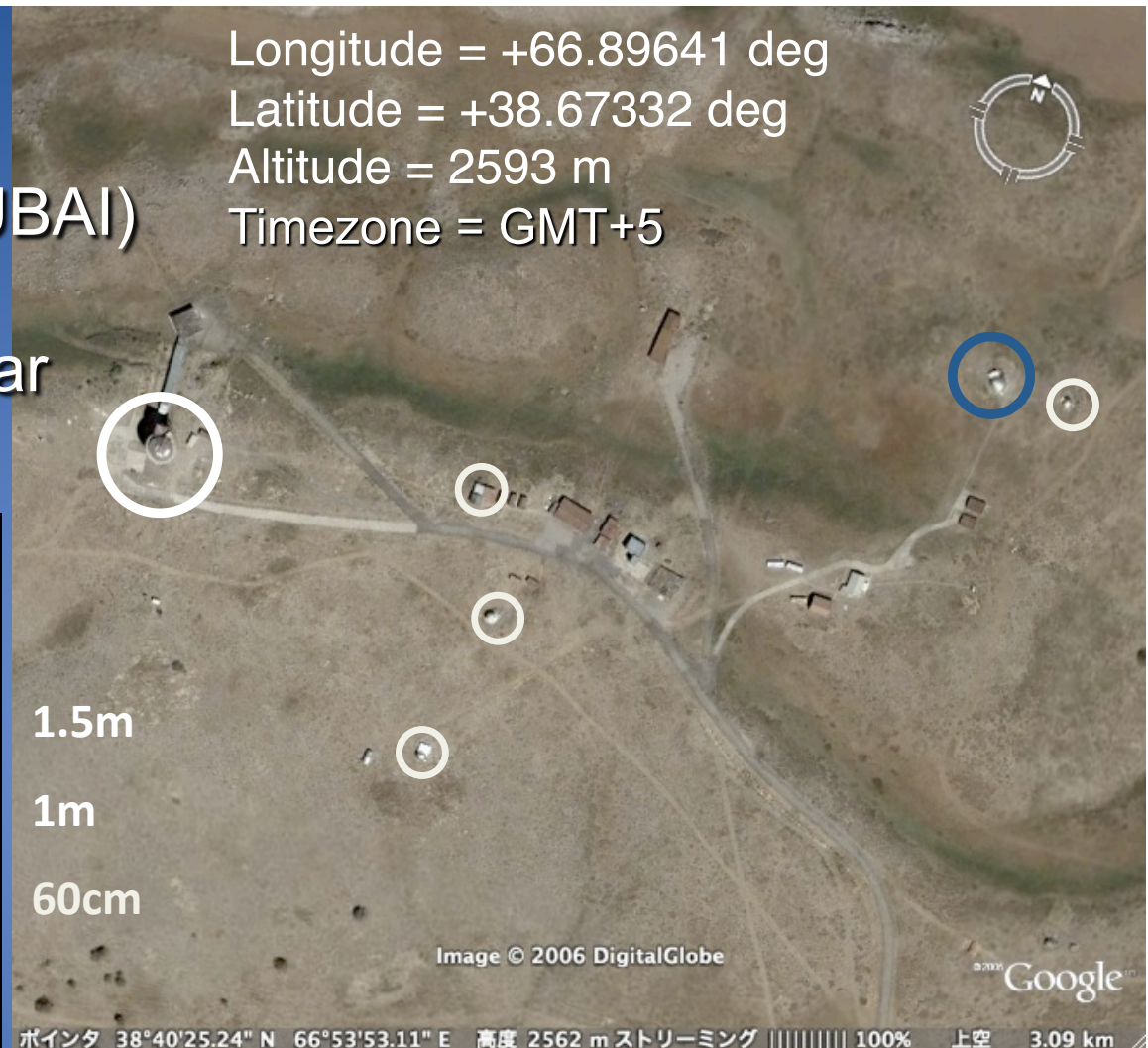
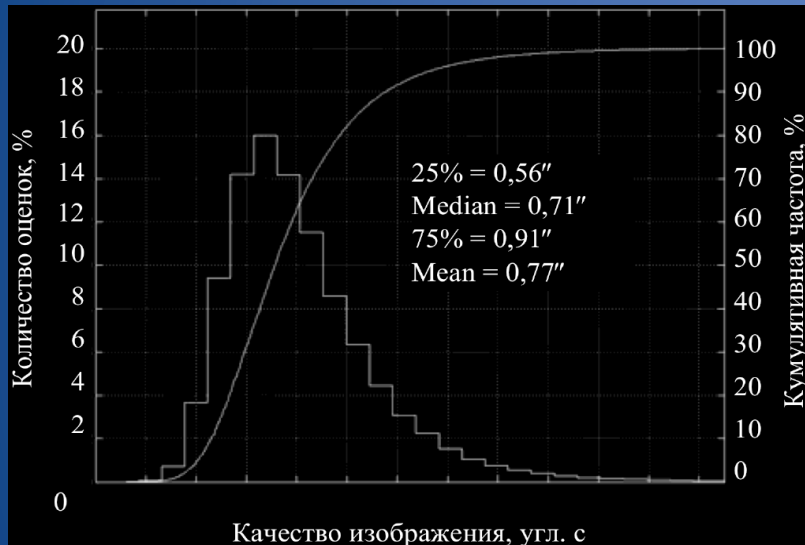
1. Improvements of the Maidanak observatory
2. The HSC survey for small solar system bodies

Fumi Yoshida
NAOJ

Maidanak Observatory, Uzbekistan



- Belonging to Ulugh Beg Astronomical Institute (UBAI)
- Median seeing = 0.71"
- Photometric > 270n / year
- Light pollution ~ none



- -1980s : An astronomy center of CCCP
- 1990s- : No budget, no astronomer
- 2000s- : Collaboration with east Asia
 - 2001 with NCU Taiwan (W.P. Chen)
 - 2003 with SNU Korea (M. Im), NAOJ Japan (F. Yoshida) →

Multiple photometry of
 Young asteroid
 families

Fragment size
 Surface material
 Fragment shape
 Spin state etc.

History of a research collaboration between NAOJ and Maidanak

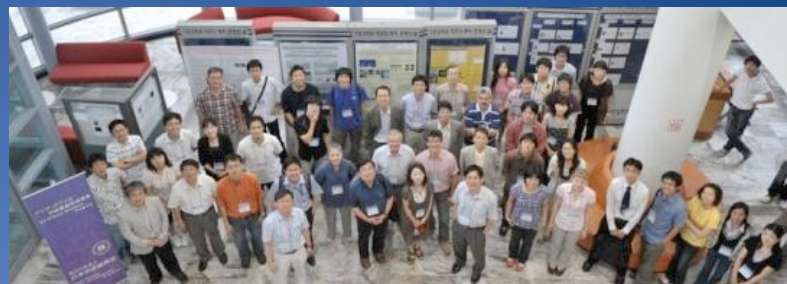
- **2003.08:** Asteroids observation with the 1.5 m telescope *Personal collaboration started (F. Yoshida & S. Takahashi)*
- **2004.12:** Agreement of research collaboration between NAOJ and UBAI (PI. T. Nakamura) *Official collaboration started*
- **2005.03:** Equipped a CCD camera to the 60 cm telescope
- **2006.04 – 2009.03** This research was funded by Grant-in-Aid (MEXT) to a great deal (PI. F. Yoshida)
- **2009.04 (till 2012.03)** This research will covered by JSPS fund partly (PI. T. Ito).

Regular asteroid observation using 50% of the 60 cm telescope time has been continued until now.



This year (2009)

(1) 1st Maidanak users meeting in Seoul on June 30



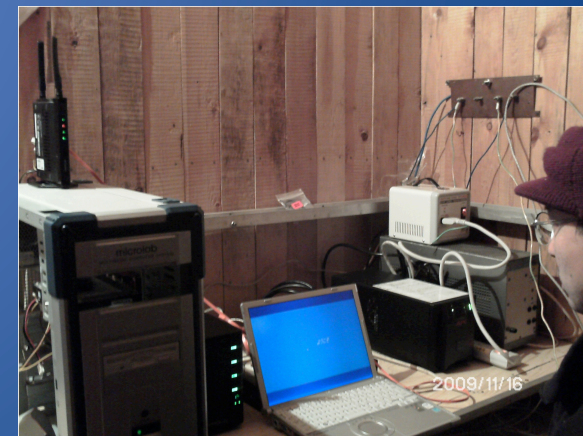
(2) Cleaning 60cm mirror



(3) Set up data storage system

(4) Send the 60cm mirror to Okayama

(5) Training/experience at NAOJ and JAXA in Feb.



■ NAOJ provides:

- CCD cameras
- Data storage system (2009)
- Expense for employment
 - 2 fulltime local observers
- Observing plan (every month)
- Education of students related to our observation
- Cleaning of 60cm mirror (2009)
- Re-aluminizing mirror at Okayama Observatory (2009-2010)

■ UBAI provides:

- Human resource for observing
- Local expense
- >50% of a 0.6-m telescope

Next year (2010)

(1) Set up the re-aluminized mirror

(2) 2nd Maidanak users meeting

(3) Digitalize the driving gear of 60cm telescope ← If we get the Grant-in-Aid fund.

(4) Introduction of a new generator (?) ← Money from NCU also?

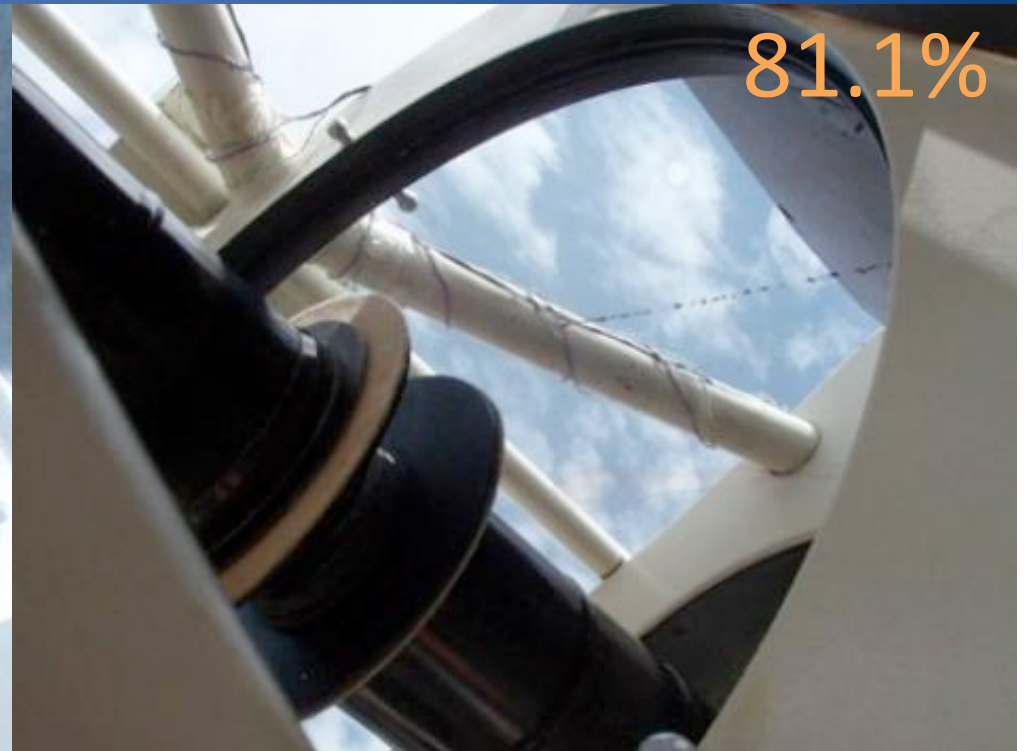
Cleaning of the 60cm mirror in Aug. 2009

Before

After

Reflectance 67.7%

81.1%



Scatterometer



clean water, alcohol, and cotton



wipe with cotton soaked with alcohol



Observations (>17.5 mag), some results

2006

Iannini family (5)
Karin family (2)
Veritas family (15)

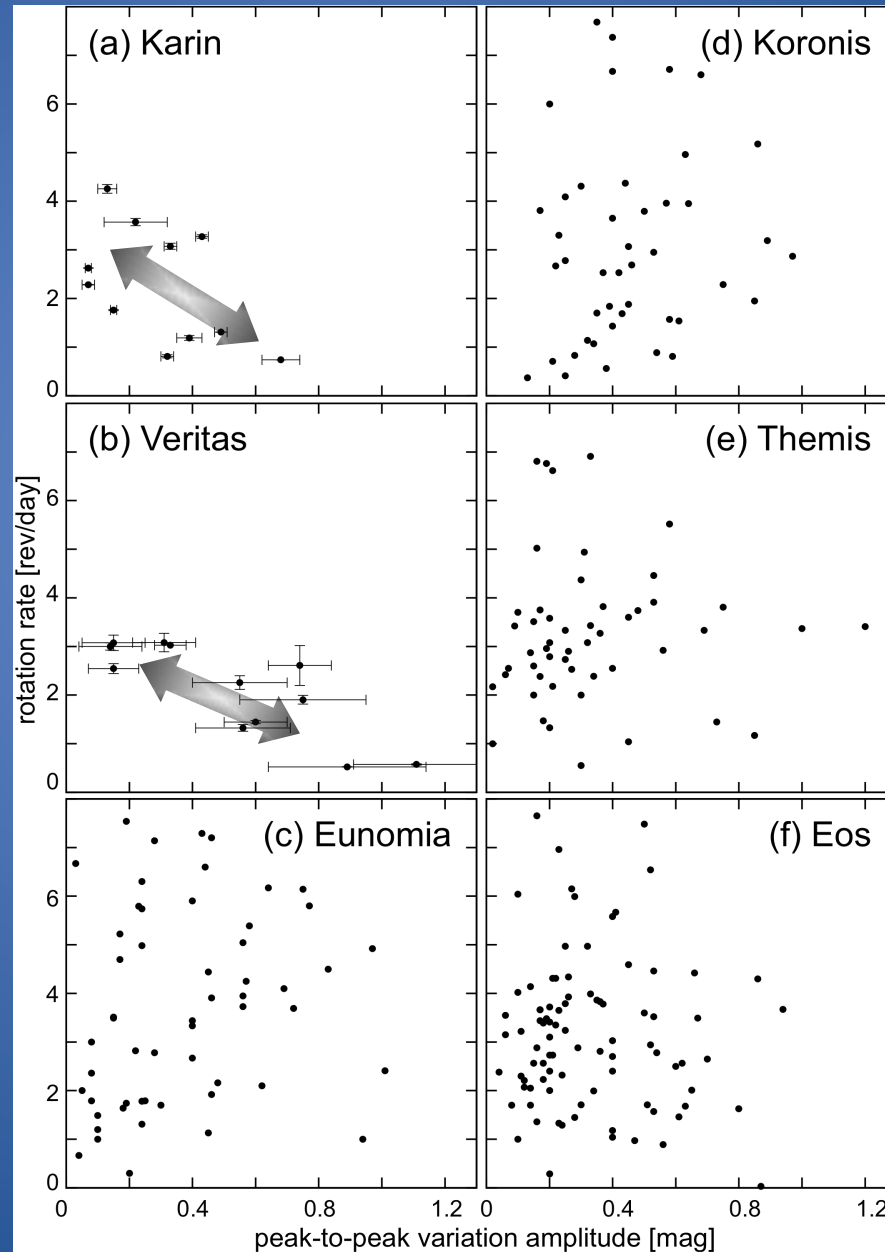
2007

Iannini family (2)
Karin family (3)
Veritas family (15)

2008

Iannini family (1)
Veritas family (15)

Lightcurves & colors



peak-to-peak
vs. P^{-1}

Young families
Old families

Related publications

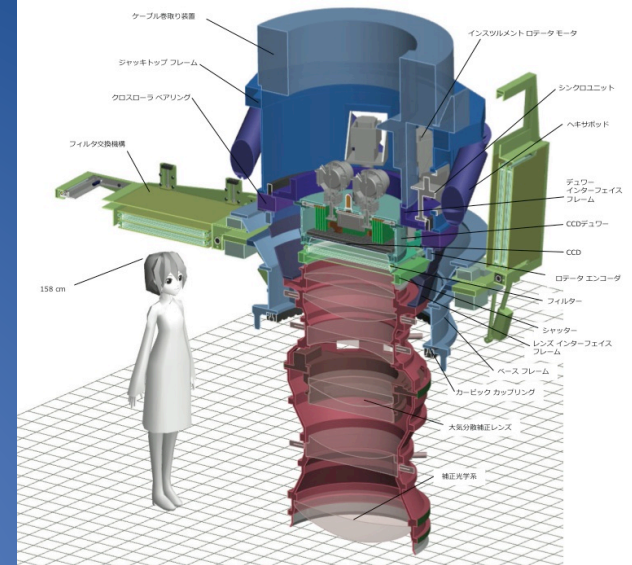
- **Using the data from Maidanak**
 - Yoshida, Ito, Takahashi, Mansur, Nastya et al. (2009)
"Photometric observation of young asteroid families at Maidanak observatories", *Advances in Geosciences*, in press.
- **The same topic with other observatory's data**
 - Ito & Yoshida (2007) *Publ. Astron. Soc. Japan*, **59**, 269.
 - Ito & Yoshida (2006) *Adv. Geosci.*, **3**, 317.
 - Sasaki, Yoshida, Ito, et al. (2006), *Adv. Geosci*, **3**, 311(?)
 - Sasaki, Yoshida, Ito, et al. (2006), *Adv. Space Rev.*, **38**, 1995.
 - Yoshida, Ito, et al. (2004), *Publ. Astron. Soc. Japan*, **56**, 1105.
 - Sasaki, Yoshida, Ito, et al. (2004), *Astrophys. J.*, **615**, L161.

Hyper Suprime-Cam (HSC) survey in 2012-2016

- HSC survey is not an all sky survey
- Time allocation : 300 days / 5 years (not fixed yet)

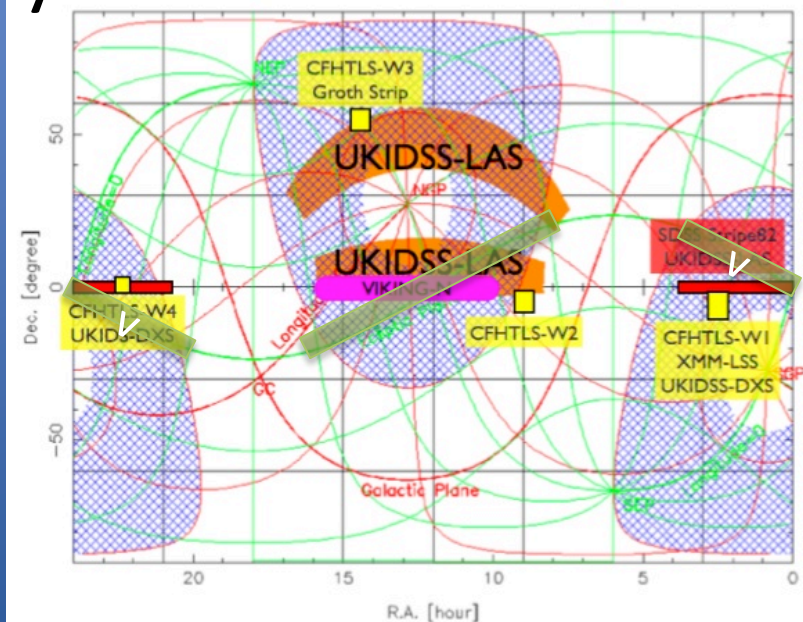
Major science of the HSC survey

- Understanding the nature of **dark energy**
- Exploring the **large-scale structure**
- Studying the **galaxy formation** process
- Understanding the nature of **AGNs**
- Exploring the transient and variable objects (**SNs, GRBs** etc.)
- Understanding the **planetary formation history** of the **Solar System**



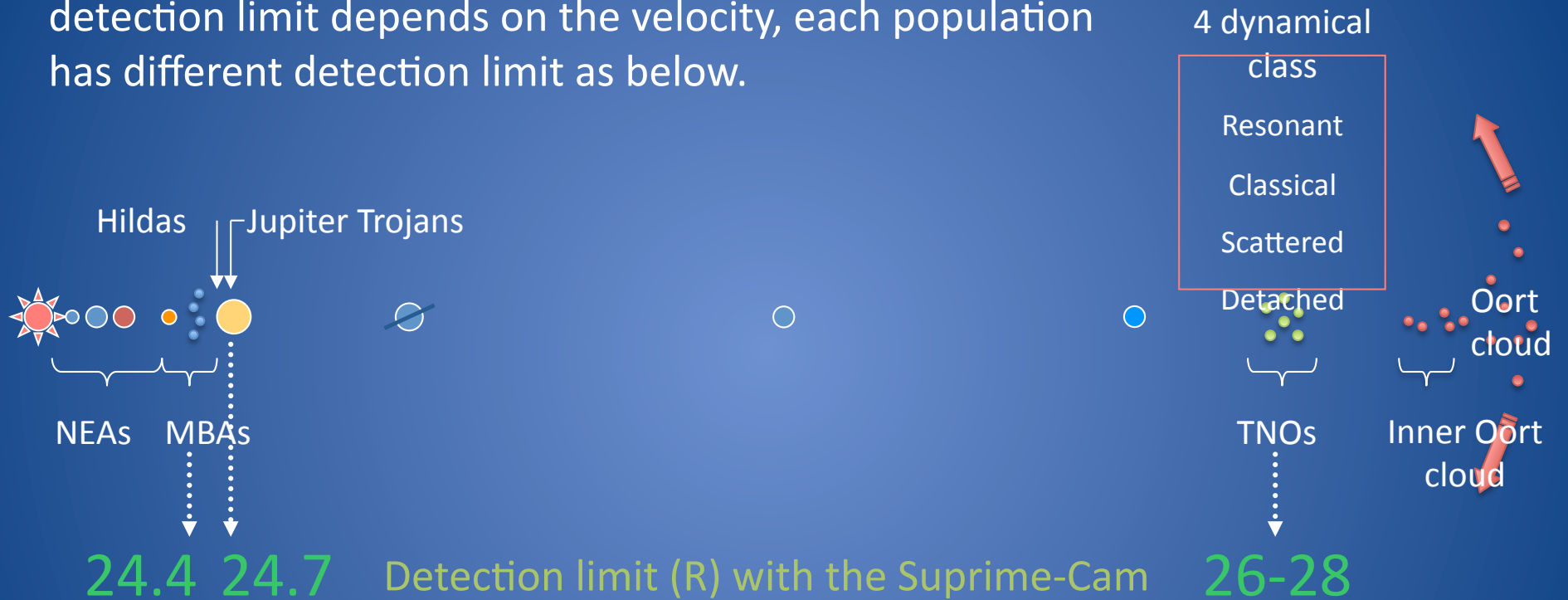
Hyper Suprime-Cam

- FOV : 1.5 deg^2
(cf. FOV of Suprime-Cam: 0.25 deg^2)



Detection limit of Small Solar System Bodies

Small solar system bodies are always moving. Since the detection limit depends on the velocity, each population has different detection limit as below.



❖ Pan-STARRS < 24mag

❖ LSST 24.7 mag (deep survey (limited area) 27.5 mag)

In the case that we use many images and stack them along TNO's movement.

HSC is the most suitable tool to explore outer solar system

Solar System Science

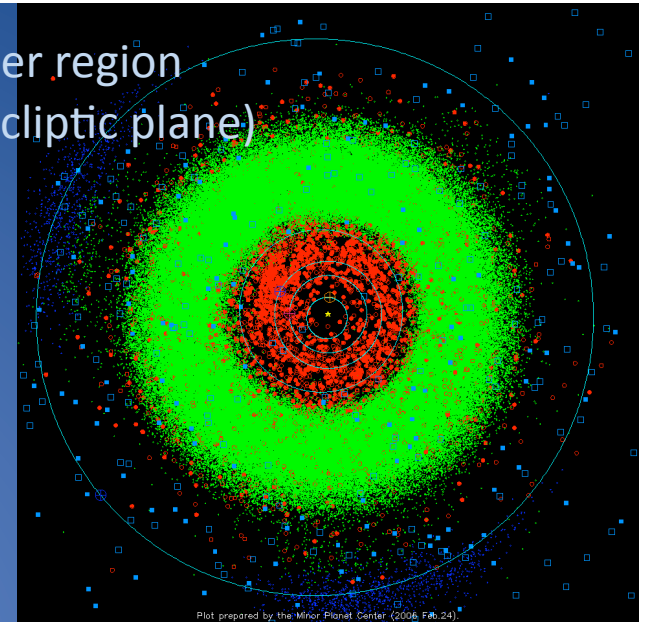
Various sciences from NEAs to inner Oort cloud

We want to know the history and dynamical evolution from planetary formation up to now .

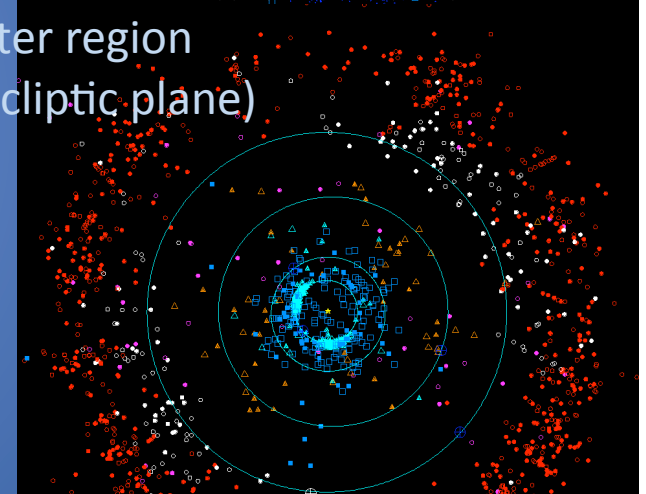
Science proposals

1. Exploring source of NEAs in the MBAs
2. Investigating TNO dynamical classes
3. Exploring evidence of giant planet migration
4. Exploring new Binary TNOs
5. Exploring “Planet X”, eccentric large TNOs, inner-Oort cloud objects
6. Investigating origin of meteorites
7. Exploring origin of Jupiter Family Comets
8. Investigating characteristic of fast rotators

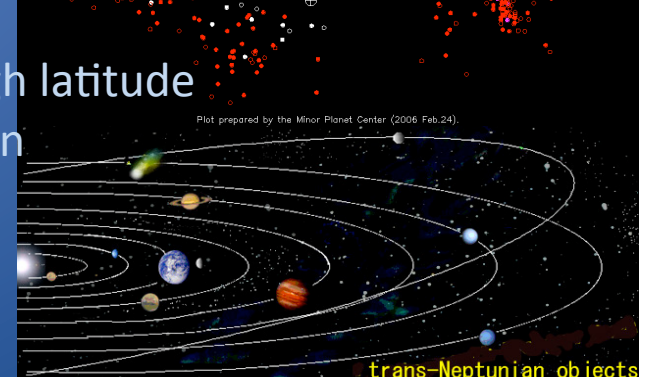
➤ Inner region
(on ecliptic plane)



➤ Outer region
(on ecliptic plane)



➤ High latitude
region



trans-Neptunian objects

The HSC Solar System Science Group

- NAOJ/NINS
 - Fumi Yoshida
 - Takashi Ito
 - Shigeru Takahashi
 - ISAS/JAXA
 - Toshifumi Yanagisawa
 - Hirohisa Kurosaki
 - Makoto Yoshikawa
 - Kobe University
 - Tsuyoshi Terai
 - Kinki Univ.
 - Patryk Lykawka
 - JSGA
 - Seitaro Urakawa
 - TITec
 - Arika Higuchi
- ◇ NCU
 - Wing-Huen Ip
 - Shinsuke Abe
 - Daisuke Kinoshita
 - Hsin-Wen Lin
 - Ying-Tong Chen
 - Chan-Kao Chang
 - ◇ Princeton University
 - Ed Turner
 - Amaya Moro-Martín
 - Steve Bickerton

Why only Japan, Taiwan and Princeton ?
Because their institutes contributed a large amount of budget to the HSC production.

Thank you very much