

G3

美星スペースガードセンターにおけるデブリ光学観測活動 Optical Observations of Space Debris at the Bisei Spaceguard Center

○奥村真一郎 (JSGA)

○Shin-ichiro Okumura (JSGA)

美星スペースガードセンターはスペースデブリと地球接近小惑星の専用光学観測施設として2000年に岡山県美星町(現井原市美星町)に建設された、日本宇宙フォーラムが所有する観測施設である。

観測は1mと50cmの光学望遠鏡を使用し、主としてJAXAからの要求に従い、日本スペースガード協会のメンバーが日々の観測を請け負って実施している。

デブリ観測の主な対象は静止軌道物体の位置測定であり、軌道上で約40mの精度で位置を決定する事が出来る。

2台の光学望遠鏡は低軌道の高速移動物体を追尾する能力も有しており、低軌道デブリの観測にも成功している。

その他に研究的観測も実施しており、静止軌道物体の太陽位相角による光度変動の解析や短時間の光度変化からデブリの回転運動状態を議論する研究にも取り組んでいる。講演ではこれらの光学観測の活動について紹介する。

Bisei Spaceguard Center was built as a facility for the purpose of the optical observations of space debris and Near Earth Asteroids, in the Bisei town of Okayama Prefecture, in 2000.

It is an astronomical observation facility owned by the Japan Space Forum.

Daily observations are carried out by the members of the Japan Spaceguard Association, mainly according to the request from JAXA, using a 1-m and a 0.5-m optical telescopes.

The main target of the debris observation is the position measurement of the Geostationary Orbit (GEO) objects.

The accuracy of the measurement is about the distance of 40 m at the altitude of a GEO.

These telescopes have the tracking capability for high-speed moving objects at the low Earth orbit, and we have succeeded the observation of low orbit debris.

We are also working on research observations of space debris, for example, light-curve analysis depending on solar phase angle of the GEO object, or the analysis of the rotation/tumbling status from short-term light curve of debris.

In this presentation, I will introduce these observation activities.

The 7th space debris workshop

美星スペースガードセンターにおける デブリ光学観測活動

Optical Observations of Space Debris at the Bisei Spaceguard Center

○奥村真一郎

(日本スペースガード協会 (JSGA))

○Shin-ichiro Okumura

(Japan Spaceguard Association (JSGA))

Contents

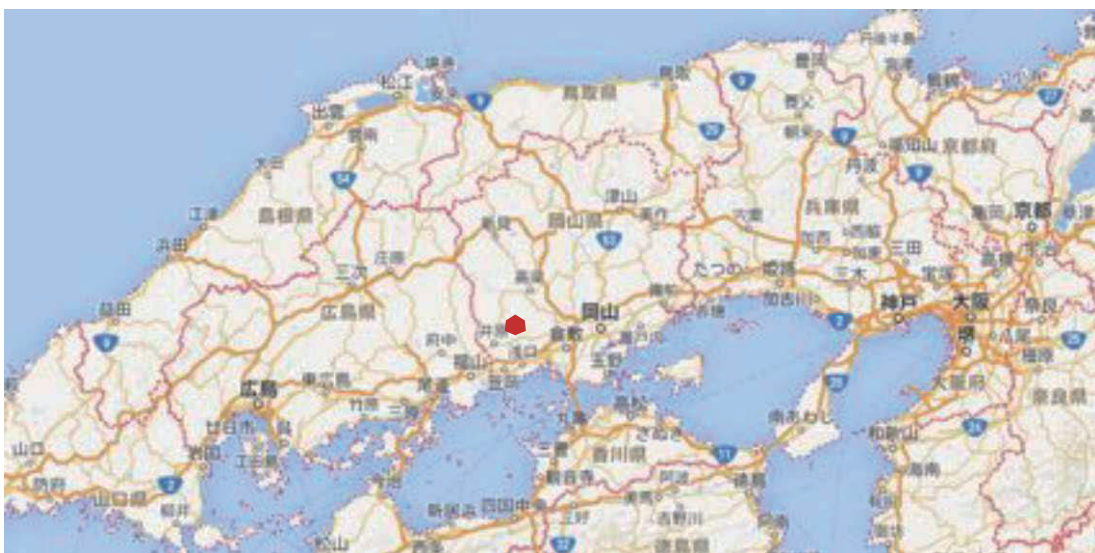
- ・ About the Bisei Spaceguard Center
- ・ Optical observations of space debris at the Bisei Spaceguard Center
 - Survey, follow-up
 - “Emergency” observations
 - Research activities

Bisei Spaceguard Center

- Construction began in 1998, with the cooperation of the Japan Space Forum (JSF), NASDA, and JSGA
- The first astronomical facility optimized for the observations of space debris and near Earth objects
- Constructed in 1999, 25cm and 50cm telescopes were installed and observations started from 2000
- 1m telescope and wide-field mosaic camera were installed in 2001
- Opening ceremony was held in 2002

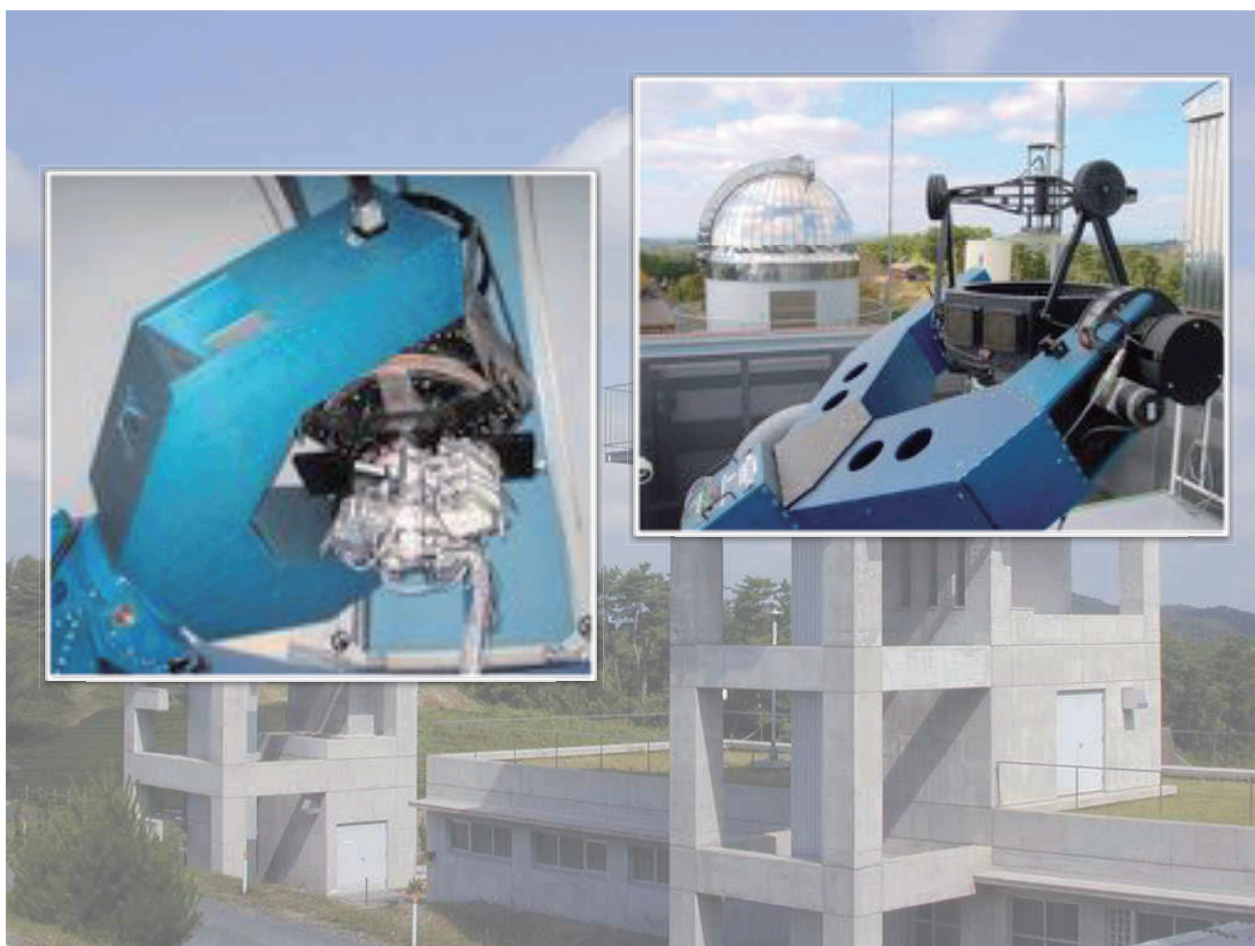
Bisei Spaceguard Center

“Western part” of Honshu



Bisei Spaceguard Center





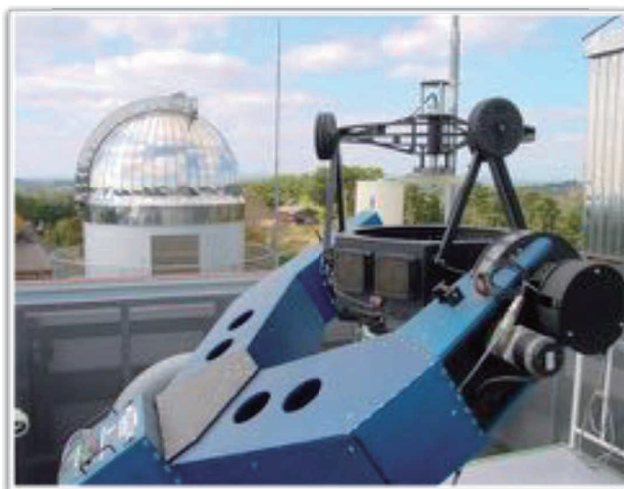
1 m Telescope



- Fork-mounted Equatorial
- Cassegrain focus
focal length: 3000mm (F3)
- Field of view $1.2^{\circ} \times 2.3^{\circ}$
- Maximum tracking speed $2.5^{\circ}/s$
- Limiting magnitude
18.7 (exp. of 2 min)
17.0 (exp. of 4 sec)

50cm Telescope

- Fork-mounted Equatorial
- Cassegrain
focal length: 1000mm (F2)
- Fields of view: $1.7^{\circ} \times 1.7^{\circ}$
- Maximum tracking speed $5^{\circ}/s$
- Limiting magnitude
17mag (exp. of 2min)



Bisei Spaceguard Center

- Building & telescopes are administered by JSF
Observations and research work by JSGA
- Discovery/followup/research observations of
artificial objects and near Earth objects
- Daily observation
 - two JSGA staffs (out of 6) are in shift every night
(スタッフ6人中毎晩2人が365日体制で夜勤務)
 - 255 days over a year in average
(365日のうち平均で年間255日の観測実績)

Status of the Space Debris Observations

- Survey and follow-up observations of the
geosynchronous Earth orbit (GEO) objects
- Follow-up observations of the
LEO (low Earth orbit) object
- “Emergency” observations (緊急観測)
- Research observations (研究観測)

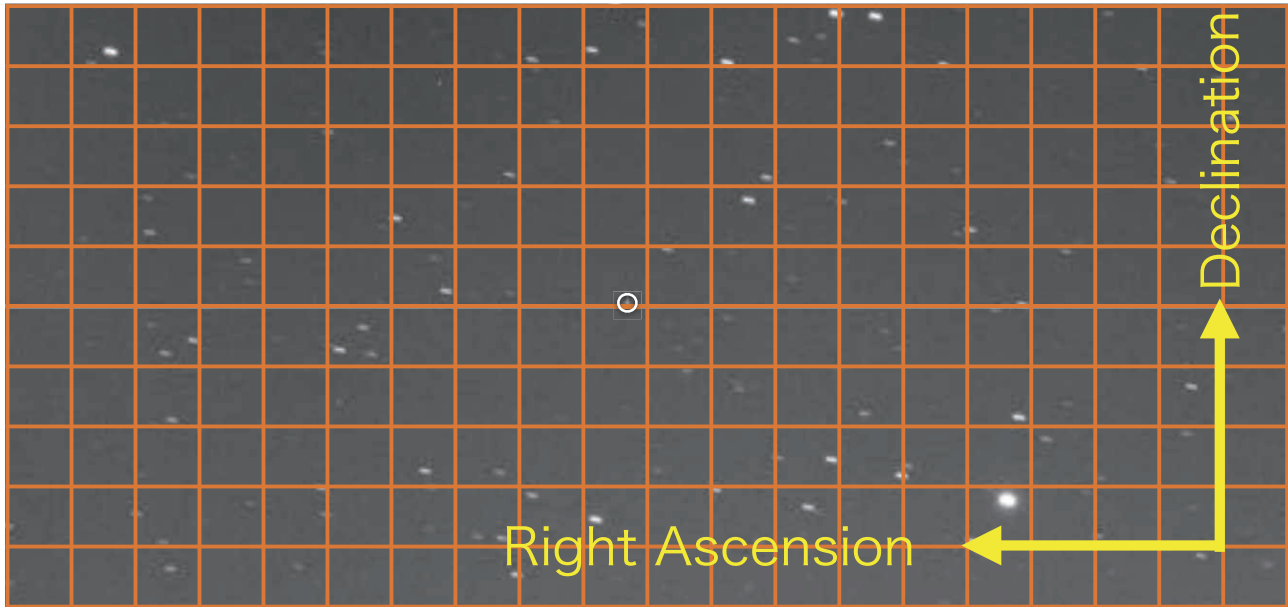
Status of the Space Debris Observations (GEO objects)

- Survey Observations
Survey observations of (65°E - 200°E) × 3 times
(observation area: 86°E -181°E(1m), 65°E - 200°E (0.5m))
- Follow-up Observations
Number of observations:
typically 800 objects / year
30000 data / year

Observation method (GEO object)



Observation method (GEO object)



Positional accuracy for the GEO objects...0.2-0.3 arcsec
(~ 40m@36000km (GEO))

Example image (GEO)



Example image (GEO)



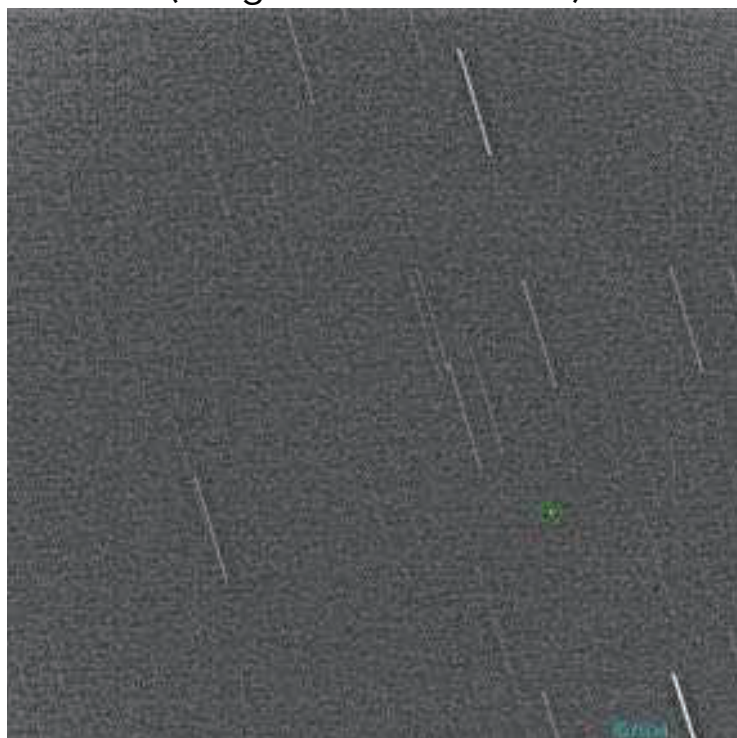
Status of the Space Debris Observations (LEO objects)

- LEO: altitude < 2000km,
T~100min@750km,
transverse velocity > 1° / sec
(*cf.* Maximum tracking speed: 2.5°/s (1m), 5.0°/s (0.5m))

Status of the Space Debris Observations ("Emergency" objects)

- Special observations according to events/accidents

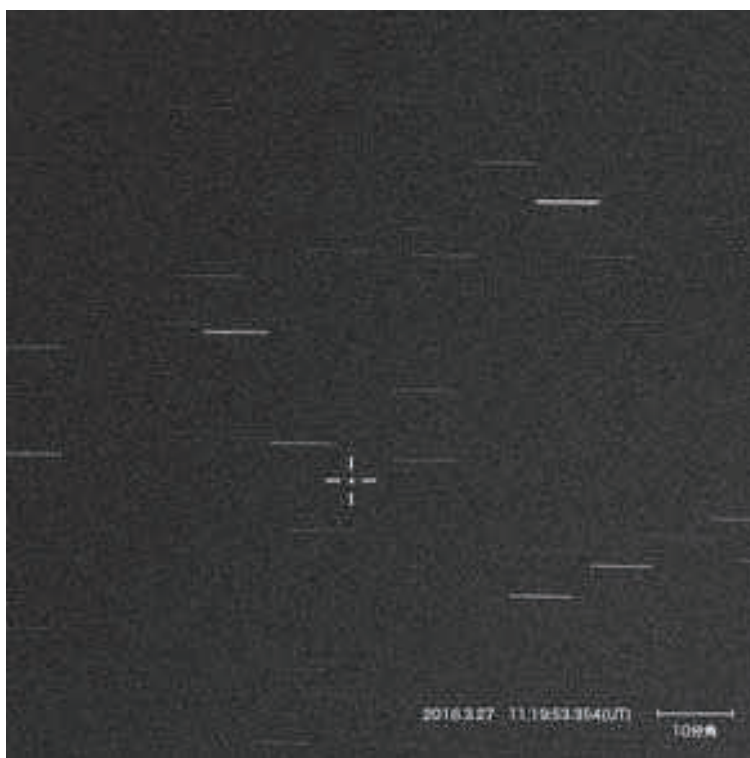
Example (LEO/Emergency)
1999-025AK (FENGYUN 1C debris)
(range:1000-4000km)



Observations of Astro-H

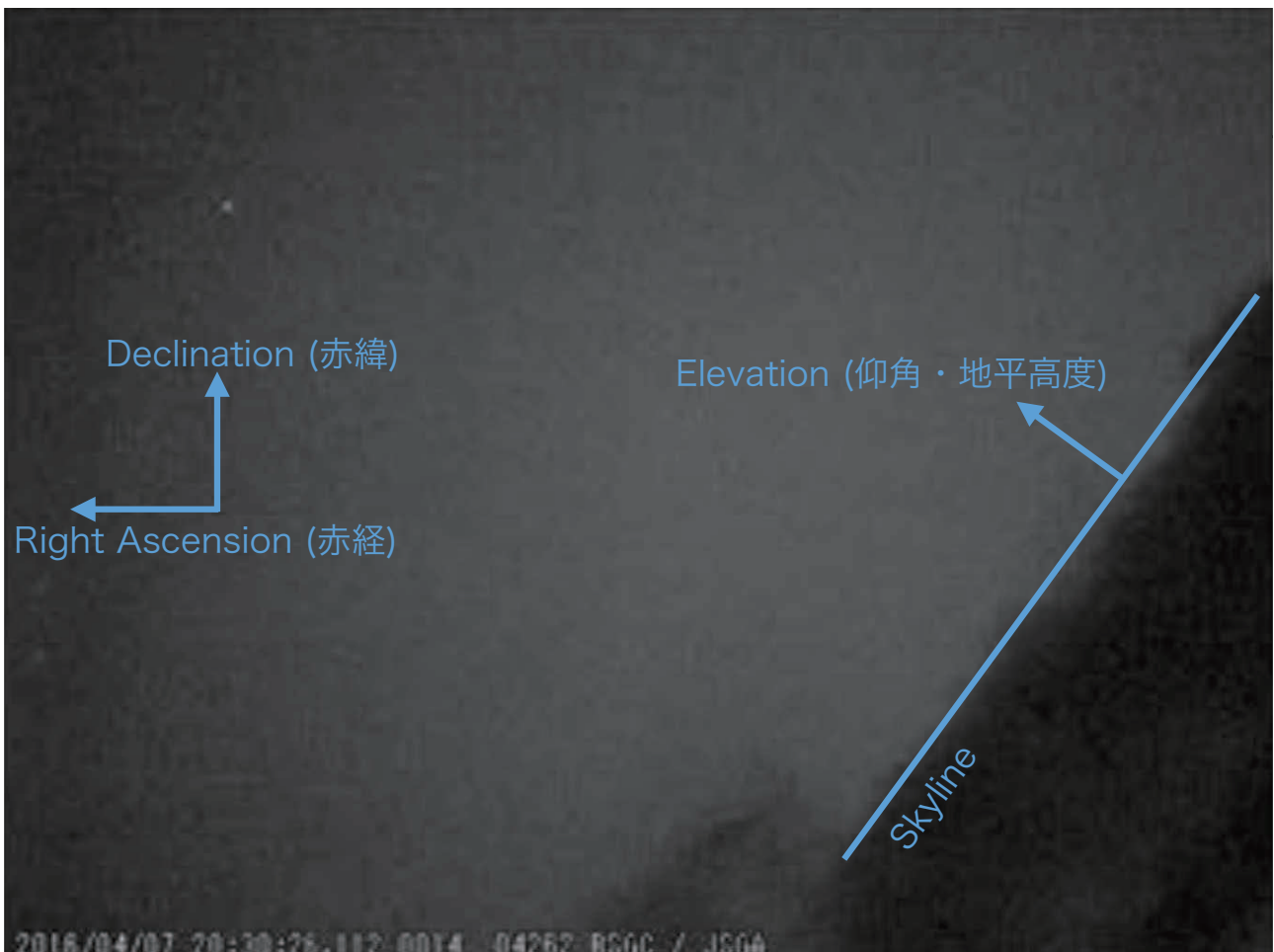
- Astro-H (Hitomi):
an X-ray astronomy satellite, altitude of 575 km
- Emergency observation request from JAXA
on March 27, 2016
- Observations were carried out on
March 27- April 11 and April 25 - May 7

Example (LEO/Emergency) 2016-012A (Astro-H)



Example (LEO/Emergency) 2016-012A (Astro-H)

- ・ ビデオ観測を実施（市販のビデオカメラを50cm望遠鏡に同架）



Status of the Space Debris Observations (Research)

- Luminosity vs Phase angle with the Sun
- Estimation of shape or motion from its light curve
- Short-period light curve by the application of TDI mode
- ...

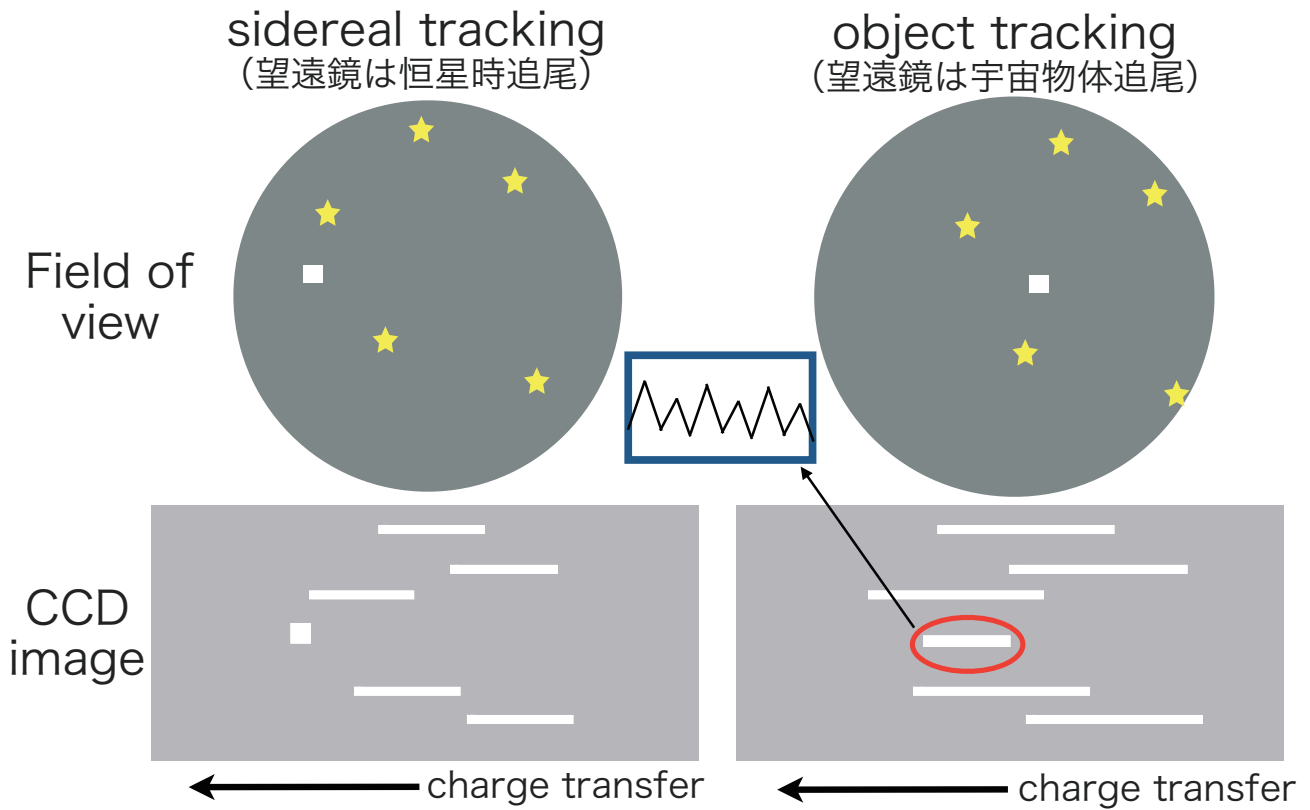
TDI (Time Delay Integration)

TDI (drift scan) method :

An exposure made by shifting electrical charge with a mechanical shutter open.

露出をしながら（シャッターを開いた状態で）
電荷転送を行う、CCDの読み出し手法

TDI (Time Delay Integration)



Short-period light curve by TDI mode



30 sec exposure, the telescope tracking for a GEO object.

Short-period light curve by TDI mode

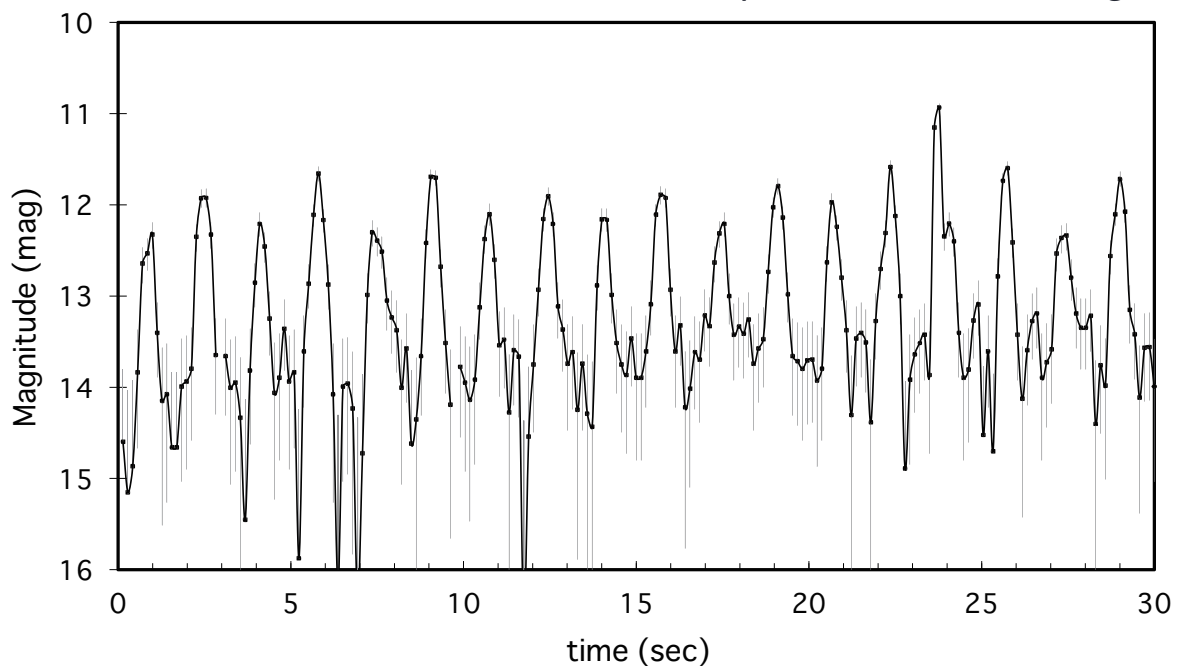


30 sec exposure, the telescope tracking for a GEO object.

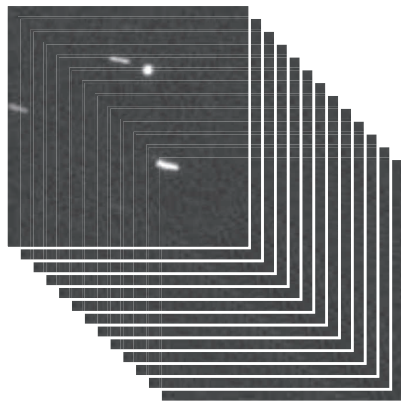
Short-period light curve by TDI mode

sampling interval : 0.1415 sec

time resolution : ~ 0.24sec (depends on the seeing size)



“usual” method

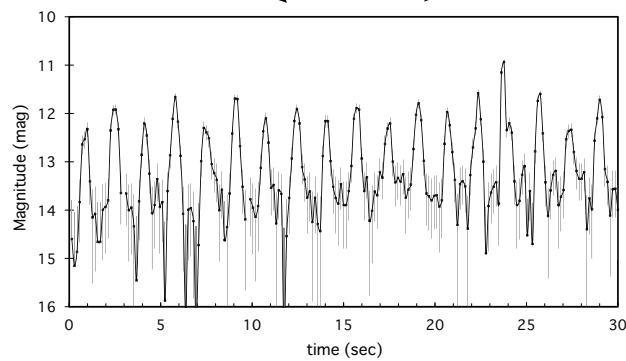


many frames

TDI method



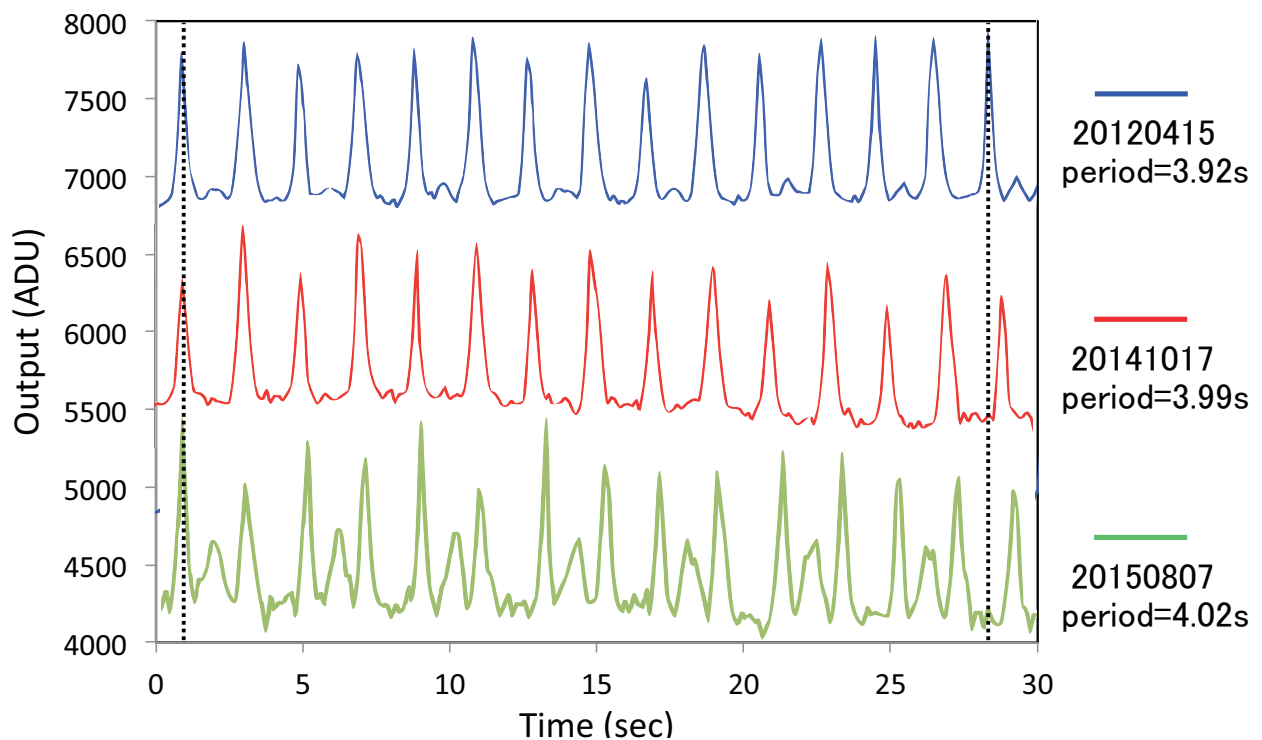
single frame



light curve

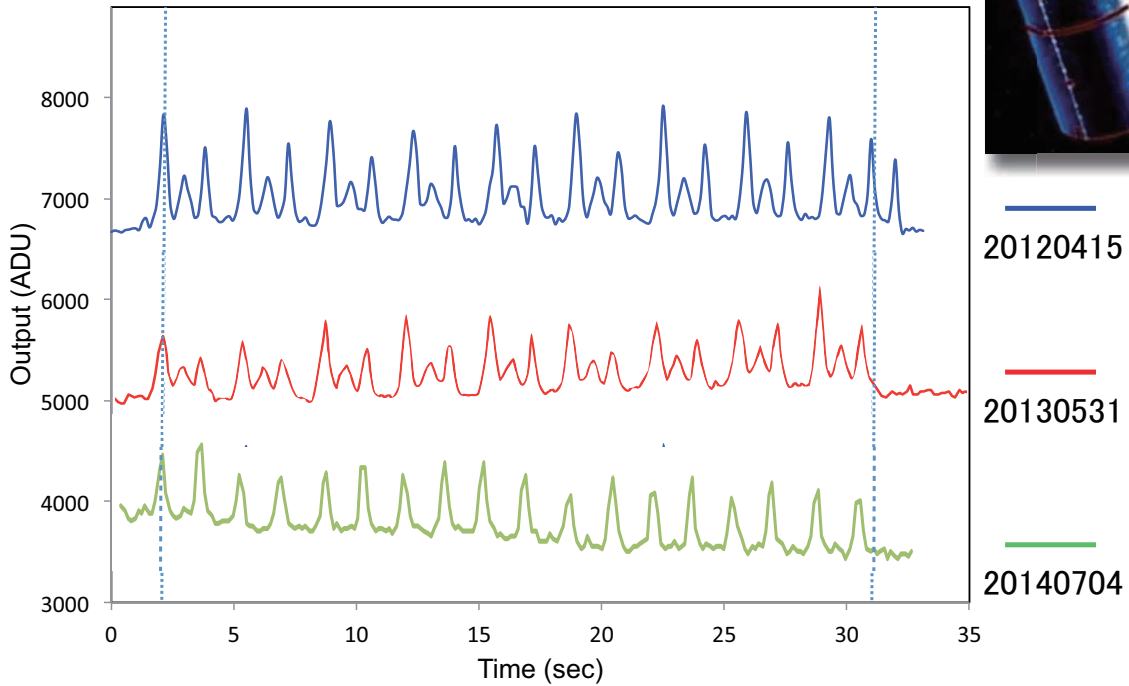
Example : Short-period light curve

1990-001B (JCSAT-2)
(Decommissioned on July, 2002)



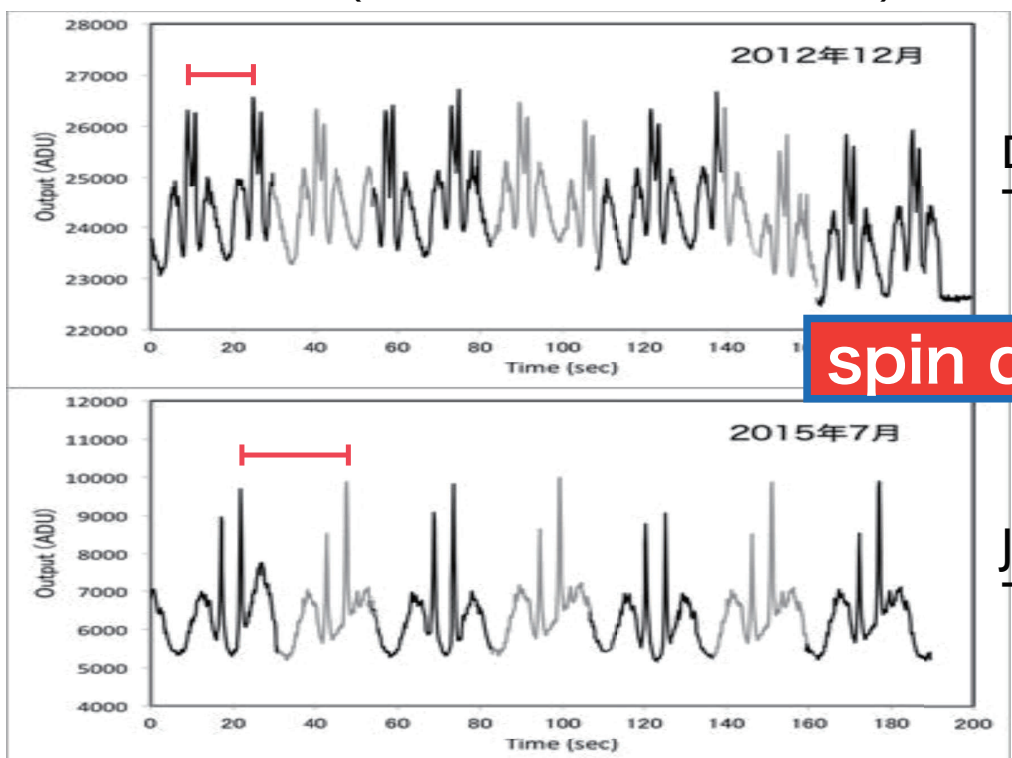
Example : Short-period light curve

1989-020A (JCSAT-1) (Decommissioned on July, 1998)



Example : Short-period light curve

H-IIA R/B (2008-007B) (launched on Feb. 2008)

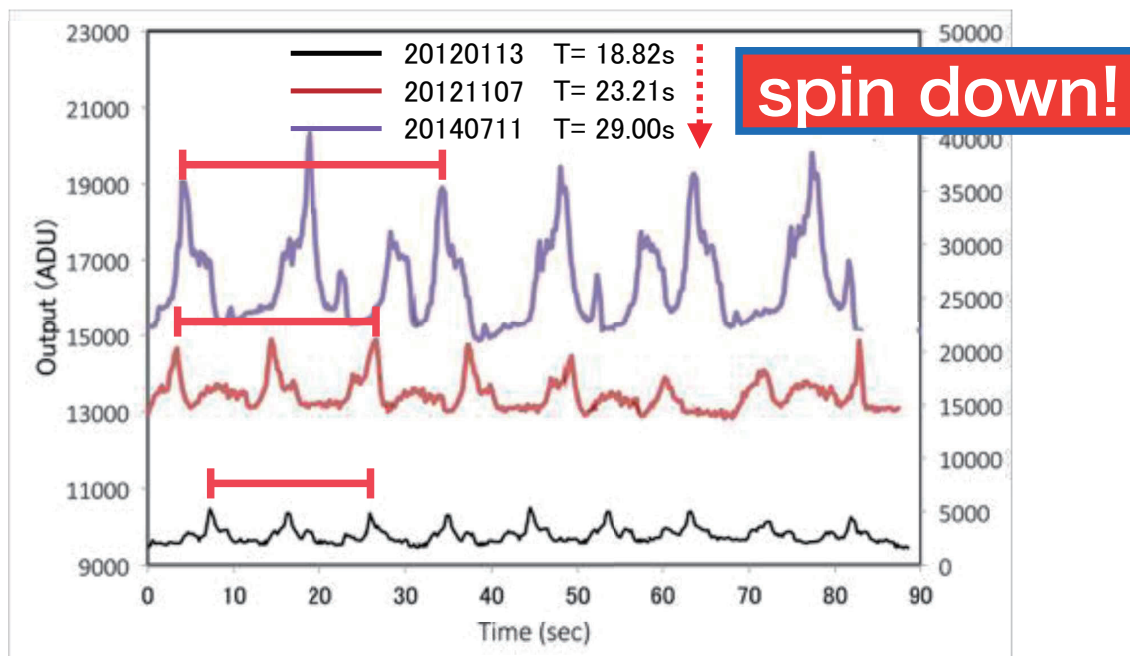


spin down!

Dec. 2012
T = 16.0s

July 2015
T = 25.9s

Example : Short-period light curve
H-I R/B(1) (1989-070B)
 (launched on Sep. 1989)



Objects	Change rate of rotation periods	Semi-major axis	Apogee	Perigee
JCSAT-2 (1990-001B)	+0.003 sec/yr (+0.75%/yr)	42658km	36544km	36016km
JCSAT-1 (1989-020A)	-0.056 sec/yr (-1.7%/yr)	42372km	36023km	35965km
H-IIA R/B (2008-007B)	+3.83 sec/yr (+24%/yr)	22346km	31683km	253km
H-I R/B(1) (1989-070B)	+4.07 sec/yr (+21%/yr)	12377km	11492km	505km

Summary

- ・ Bisei Spaceguard Center
 - ✓ The first facility for the observations of space debris and near Earth objects
- ・ Status of the space debris observations
 - Survey and follow-up observations of GEO objects
 - Follow-up observations of LEO objects
 - Emergency observations
 - Research observations
 - ✓ Light curve taken with the TDI mode

Acknowledgment

国立研究開発法人宇宙航空研究開発機構
追跡ネットワーク技術センターには、観測の機会
および多くの有用なコメントをいただきました。
また、美星スペースガードセンターは
一般財団法人日本宇宙フォーラムにより建設され
管理・運用されています。