

# Tomo-e Gozen 科学試験観測クイックサマリ

大澤亮

# Outline

1. Summaries of Observations with Tomo-e Gozen Q0 & Q1
  1. Observation run in 2017.10
  2. Observation run in 2018.02–06
2. Featured Observations
  1. Survey experiments
  2. Targeted observations: the Solar System
  3. Targeted observations: the Milky Way
  4. Targeted observations: extragalactic objects

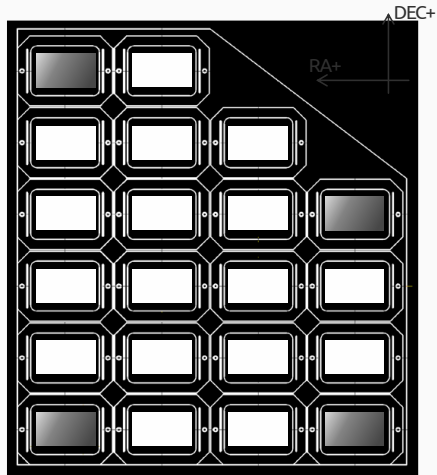
# Overview

experimental observation run in 2017.10

- › Observations with **4** image sensors
- › **10** days in between 2017-10-03 and 2017-10-27
- › about **41** observations carried out

**2012 TC4 (NEO)**, 3C 84 (AGN), ASAS J2059 (ACep), ASASSN-17mz (SN candidate), **Crab pulsar**, Cygnus region, FRB 121102, high declination test, IC 10 (galaxy), IC 1590 (open cluster), M 101 (galaxy), M 13 (globular cluster), M 31 (galaxy), M 33 (galaxy), M 39 (open cluster), **MonR2 IRS3**, NGC 147 (galaxy), NGC 185 (galaxy), NGC 188 (open cluster), NGC 628 (galaxy), NGC 6440 (globular cluster), **NGC 6891 (planetary nebula)**, NGC 6946 (galaxy), NGC 7009 (planetary nebula), NGC 7331 (galaxy), NGC 7640 (galaxy), NGC 891 (galaxy), Perseus cluster (open cluster), PN Hb12 (planetary nebula), **QSO J0509+0541 (ice cube blazar)**, SN2017eaw (SN), SN2017glg (SN), SN2017grm (SN), Swift J0243.8+6124 (accreting NS), **Taurus region**, **V1217 Her (RRab)**, **white dwarfs**, zenith (meteors)

- › some objects observed through a transparent grating



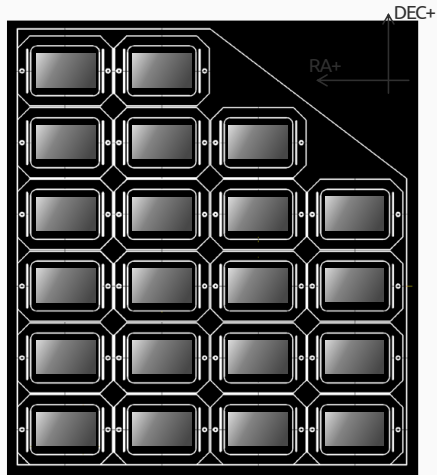
# Overview

experimental observation run in 2018.02

- › Observations with **21** image sensors
- › **47** days in between 2018-02-19 and 2018-06-13
- › about **73** observations carried out

2005 SE71 (NEO), 2008 TZ3 (NEO), **2010 WC9 (NEO)**, 2017 VR12 (NEO), 2018 BY2 (NEO), 2018 GG (NEO), **2018 GP (NEO)**, 2018 JX (NEO), **2018 LV3 (NEO)**, 3C 279 (AGN), AA Tau (YSO), Asteroid Survey, Bernerd 33 (dark cloud), Crab pulsar, DG Tau (YSO), Gemini region, GM Aur (YSO), GS 1826-24 (2Hz monitoring), HD 34282 (YSO), Her X-1 (IMXB), HIP 57548 (flare star), HSC18dzf (SN candidate), IC 4592 (reflection nebula), JCSAT-2 (satellite), JNS006 (NEO candidate), M 101 (galaxy), M 104 (galaxy), M 105 (galaxy), M 106 (galaxy), M 10 (globular cluster), M 14 (globular cluster), M 38 (open cluster), M 42 (reflection nebula), M 42 (reflection nebula), M 44 (open cluster), M 51 (galaxy), M 63 (galaxy), M 81 (galaxy), M 82 (galaxy), M 86, M 94 (galaxy), **MAXI J1820+070 (BB)**, Meteor observations with MU radar, Moon (stray light test), NGC 2068 (reflection nebula), NGC 2146 (galaxy), NGC 3147 (galaxy), NGC 4242 (galaxy), NGC 4725 (galaxy), NGC 5472 (galaxy), NGC 5474 (galaxy), NGC 7023 (iris nebula), NGC 7023 (reflection nebula), occultation by Gratia, occultation by Palma, Ophiuchus region, RW Tau (YSO), RY Tau (YSO), **S5 0716+714 (blazer)**, SA 98 (calibration region), Sco X-1 (LMXB), SN2018aca, SN2018aki, survey test, Swift J0243.6+6124 (high-speed monitoring), Taurus region, **Tiangong 1 (falling satellite)**, VW Lyn (YSO), **WD 1145+017**, zenith (meteors)

- › some objects observed in the SDSS-g, -r, -i, or -H $\alpha$  filters



# Featured Observations

## Survey Experiments

1. Dithering Test
2.  $\geq 8,000$  deg<sup>2</sup> Wide Field Survey
3. Asteroid Survey (see, Kojima-san's talk)
4. Supernova Survey Experiment (see, Morokuma-san's talk)
5. Survey with colored filters

# Dithering Test in Virgo region

2018-02-21



# Dithering Test in Virgo region

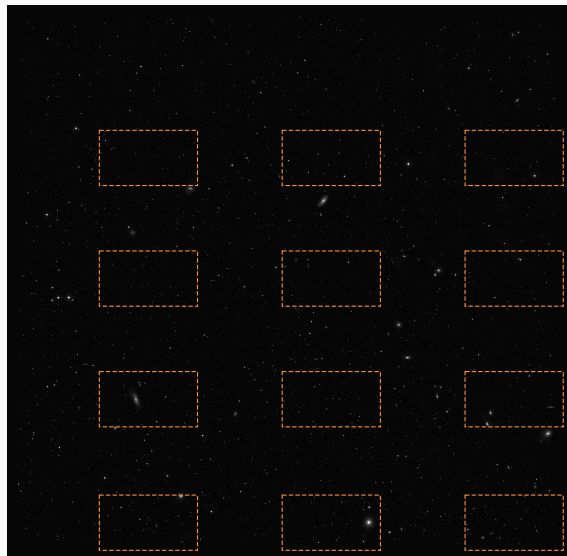
2018-02-21

First survey experiment with Q1

Tiling observation using 12 sensors

Dithering Pattern:  $2 \times 3$

Covering about  $4^\circ \times 4^\circ$  area



# Wide Field Survey

2018-03-24

Second survey experiment with Q1

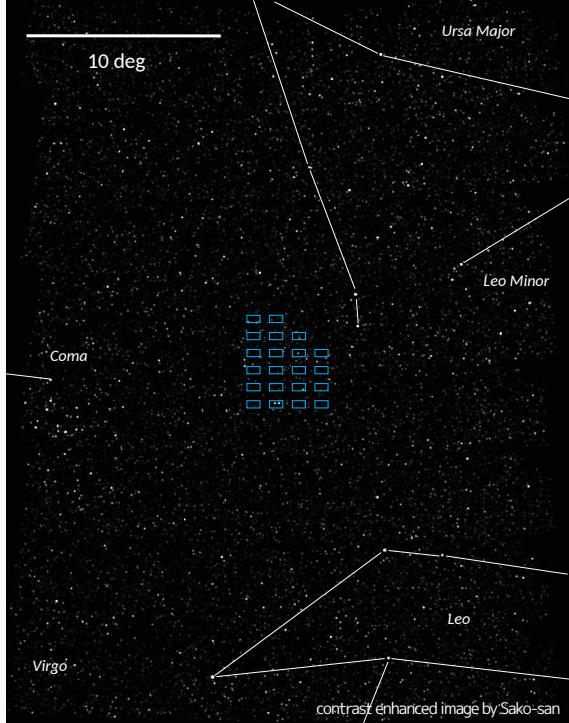
Exposure: 0.5s × 12 frames/visit

Survey Pattern:

Dithering: 2×2, Pointing: 8×8

Survey Period: ~1 hour

Covering about 1,000 deg<sup>2</sup>





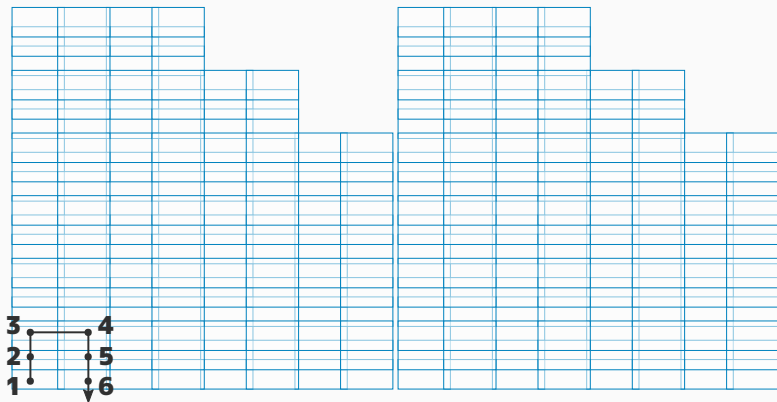
# Asteroid Survey

2018-02-22, 26

Survey experiment for moving objects

5 visits, 2 pointing, 2×3 dithering, and exposures of 5s × 12 frame

For details, see Kojima-san's talk

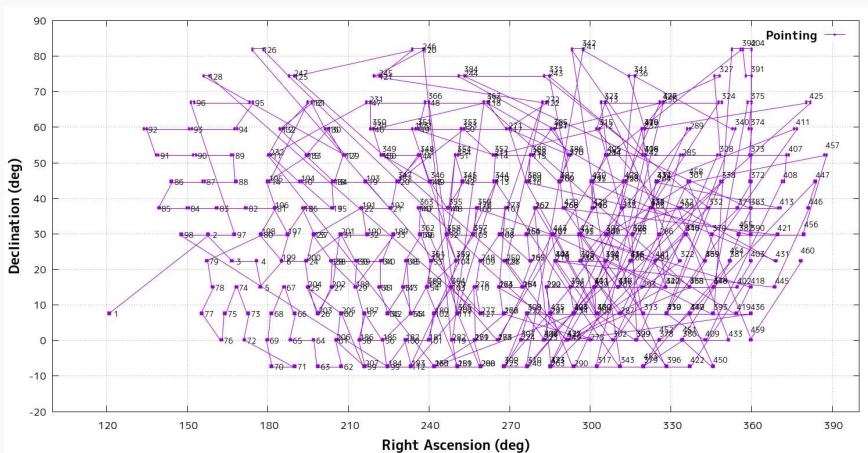


# Supernova Survey Experiment

2018-05-28

Telescope Pointing Experiment (totally clouded)

2x2 dithering, 16x 0.5s exposures  $\Rightarrow$  460 pointings/night



# Survey with SDSS filters

2018-03-28



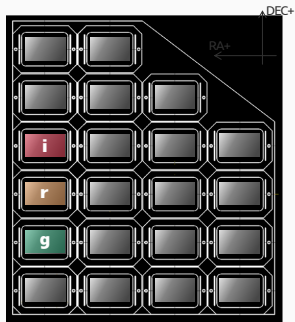
# Survey with SDSS filters

2018-03-28

Raster scan survey with SDSS-g, -r, & -i

Exposure: 10× 5s

~24 deg<sup>2</sup> area covered in the three colors



# Featured Observations

## Targeted Observations: the Solar System

### 1. Near Earth Asteroids

- **2012 TC<sub>4</sub>**, 2005 SE<sub>71</sub>, 2008 TZ<sub>3</sub>, 2010 WC<sub>9</sub>, 2017 VR<sub>12</sub>, 2018 BY<sub>2</sub>, 2018 GG, **2018 GP**, 2018 JX, 2018 LV<sub>3</sub>, **JNS006**

### 2. Asteroid occultations

- Gratia (non-detection), **Palma** (detection)

### 3. Artificial Satellites

- Tiangong 1, **JCSAT-2**

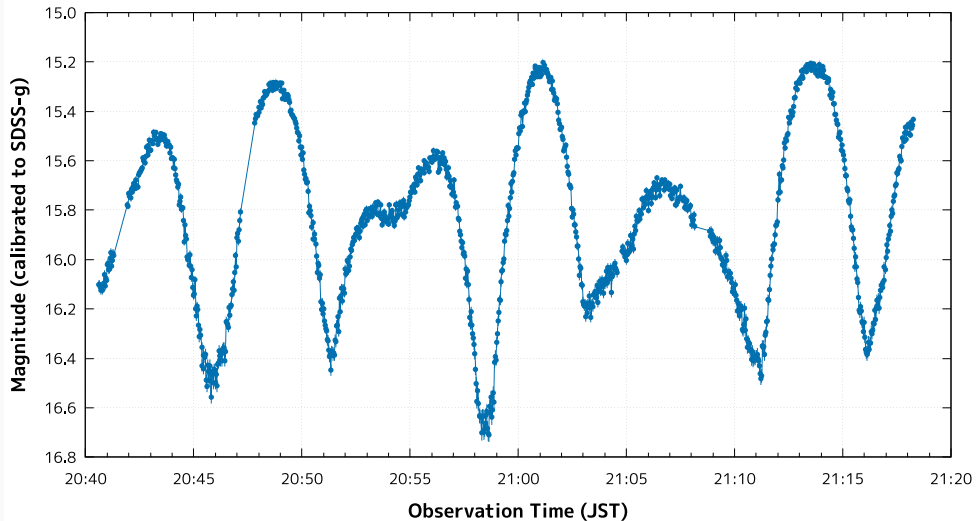
### 4. Meteors

2012 TC<sub>4</sub>



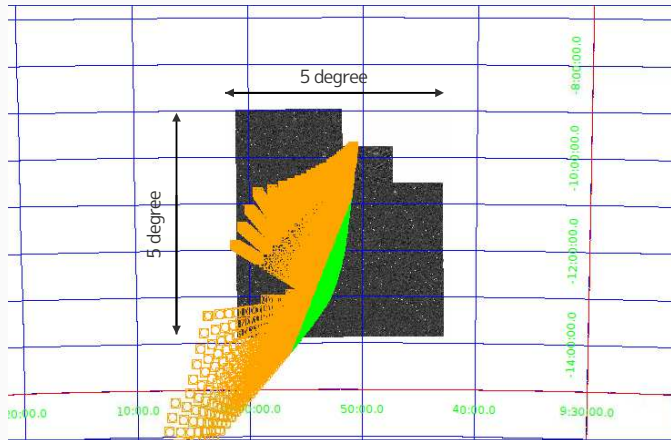
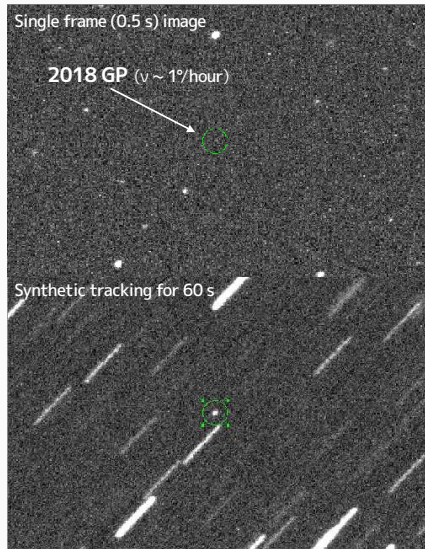
0.5 Hz observation, 200x time lapse video

# Tomo-e Q0: 2012 TC<sub>4</sub>



Data from Urakawa et al., in prep.

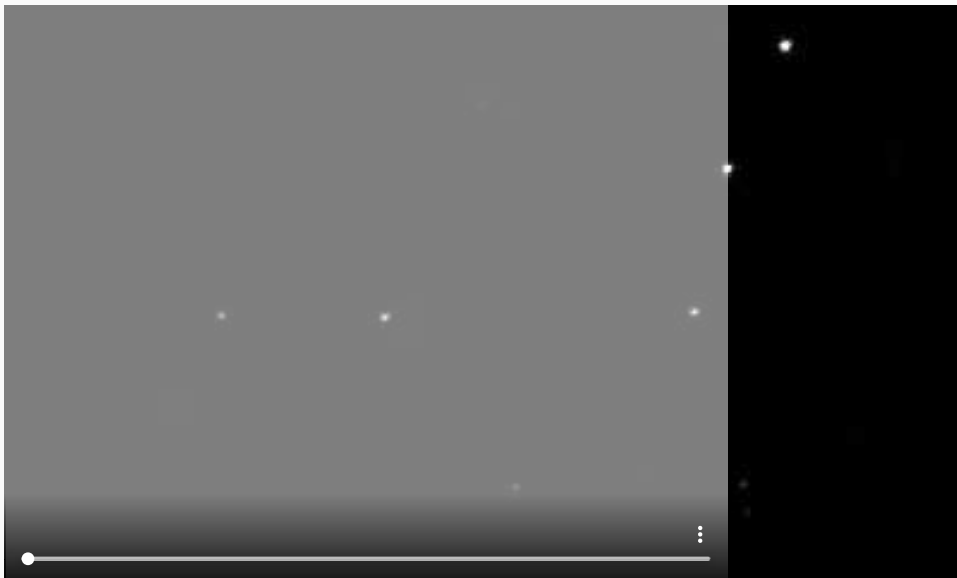
# Tomo-e Q1 : NEA observations



(left) Follow-up observation of NEA 2018 GP.  
(right) Follow-up observation of an NEA candidate.

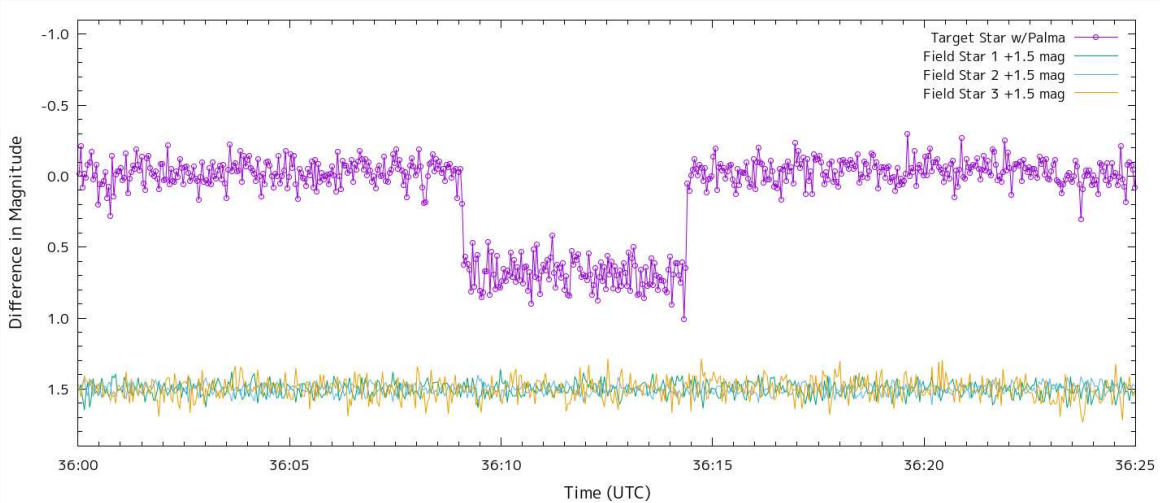


# Occultation by Palma

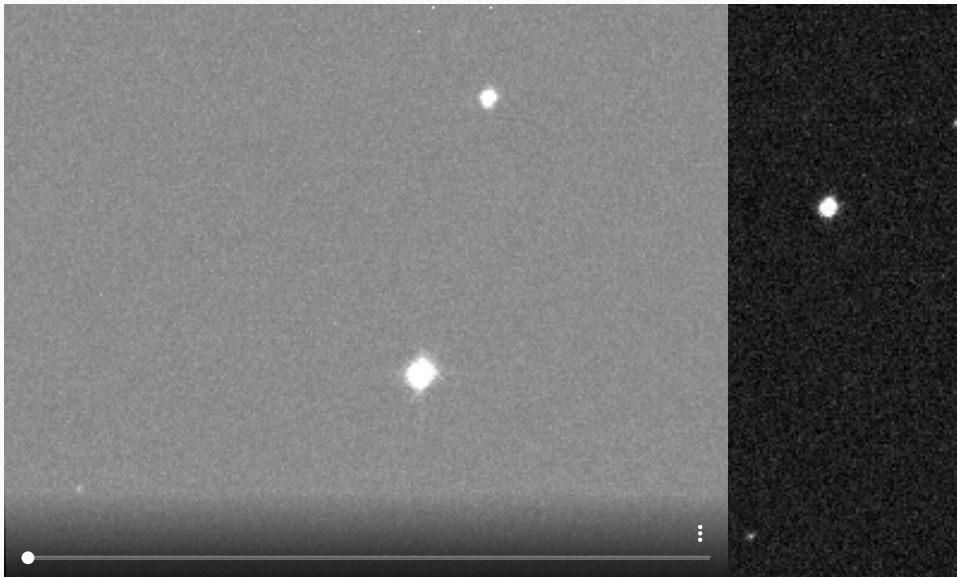


24 Hz observation, real-speed video

# Occultation by Palma

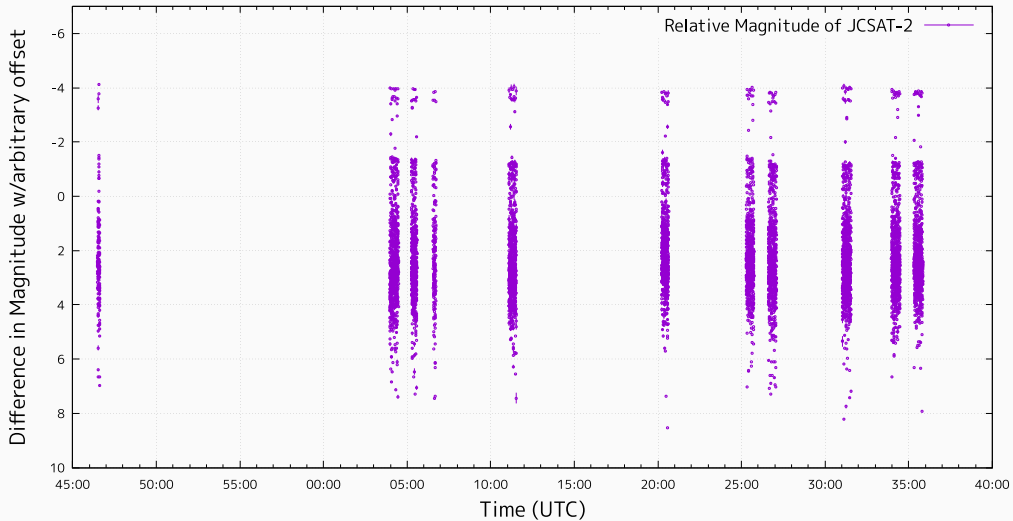


# JCSAT-2

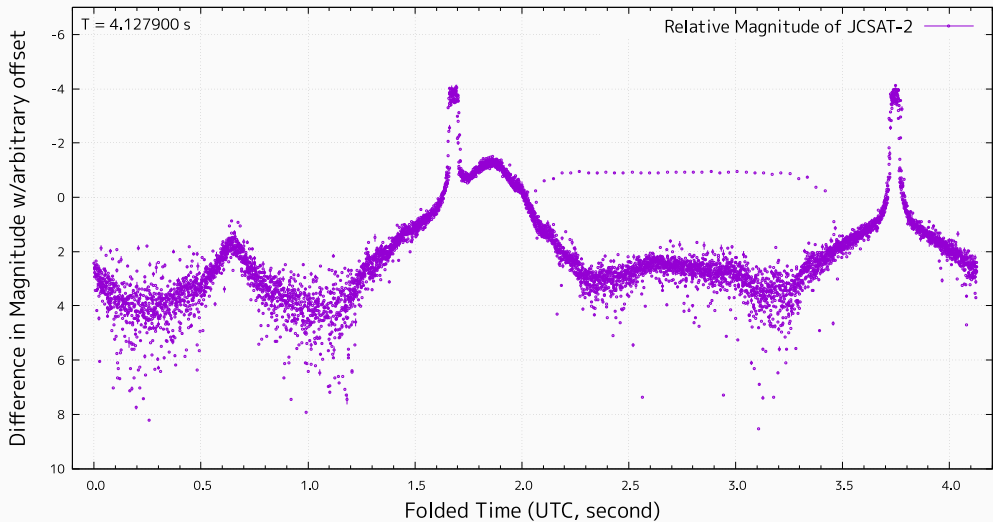


24 Hz observation, real-speed video

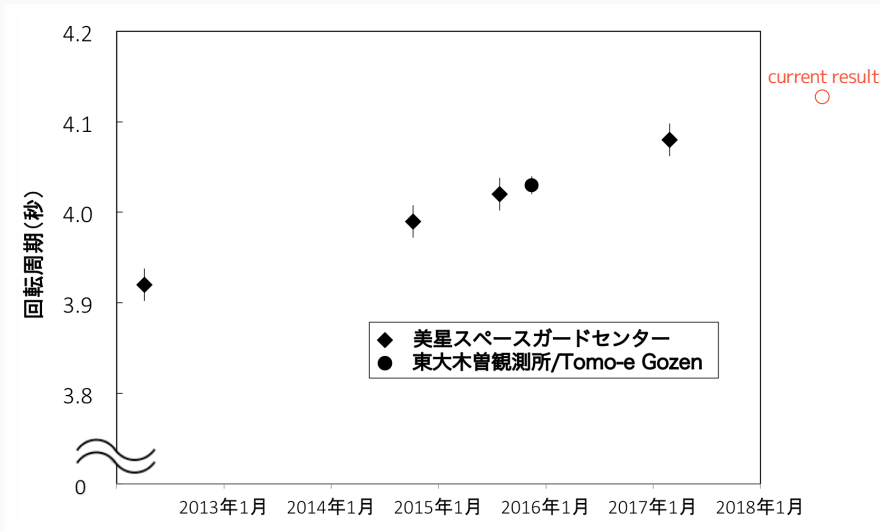
# JCSAT-2



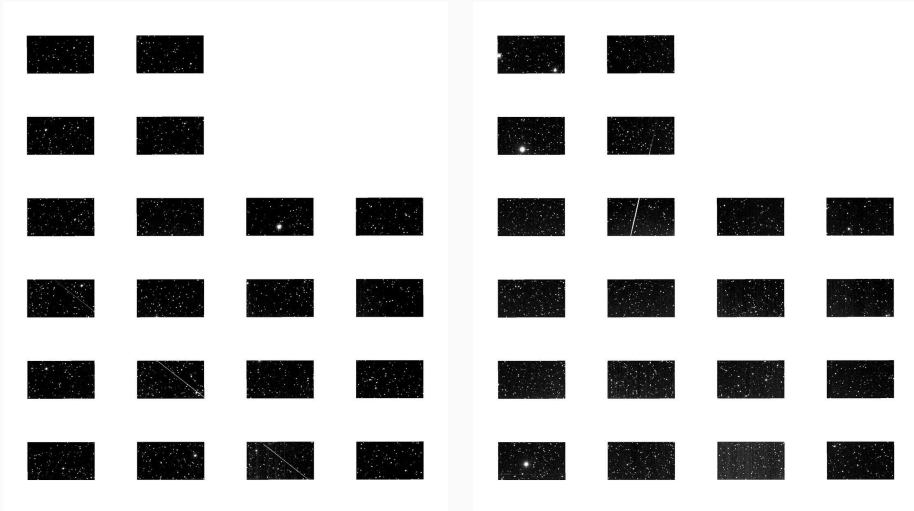
# JCSAT-2



# JCSAT-2



# Meteors



Meteors detected in the collaboration with Kyoto U. RISH MU-radar (Hirota-san's talk)

# Collaboration with MU radar

- › determine ~1,000 meteor orbits and sizes per night
- › investigate ~100 meteor spectra per night
- › connect radar and optical observations

The first collaboration successfully conducted in April, 2018.

## Optical Observation:

brightness (size) distribution  
elemental abundance by spectroscopy (optional)



Kiso Schmidt telescope

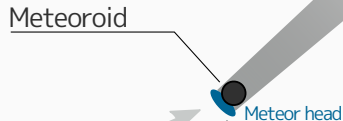
## Radar Observation:

direct measurements of meteor motion  
accurate time stamps



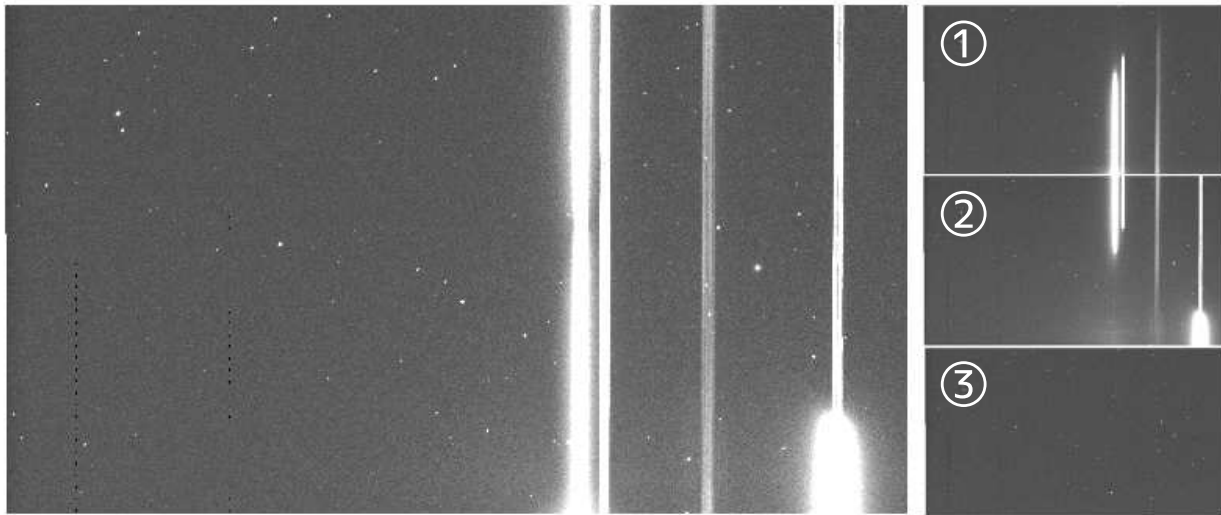
Kyoto Univ. MU Radar

Distance ~ 173 km





# Faint Meteors



Meteors obtained on 2018-03-27  
3 consecutive frames composed in lighten mode

# Featured Observations

## Targeted Observations: the Milky Way

### 1. Young Stellar Objects & Star Forming Region

- Taurus region, Ophiuchus region, Gemini region, M44, Mon R2 IRS3, AA Tau, DG Tau, RW Tau, RY Tau, VW Lyn, GM Aur, HD 34282, HIP 57548

### 2. White Dwarfs

- **WD 1145+017**, IR bright white dwarfs, NGC 6891

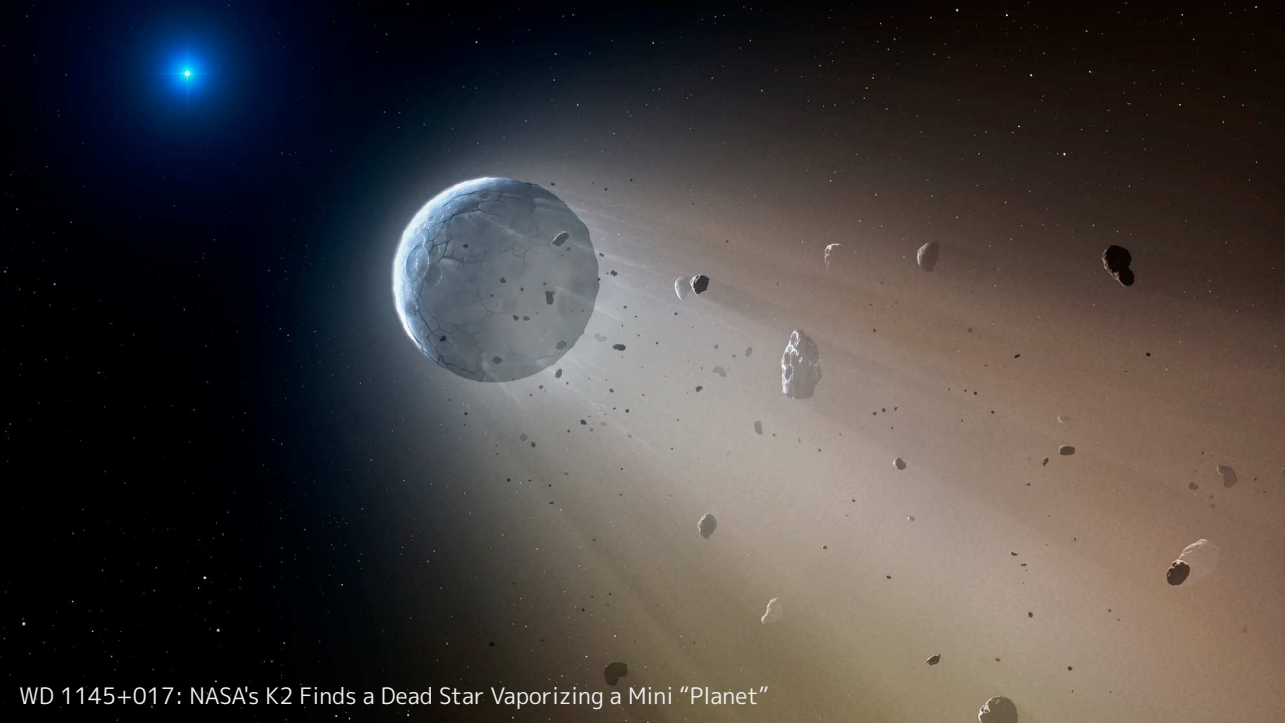
### 3. Variable Stars

- ASAS J2059, V1217 Her

### 4. X-ray binary

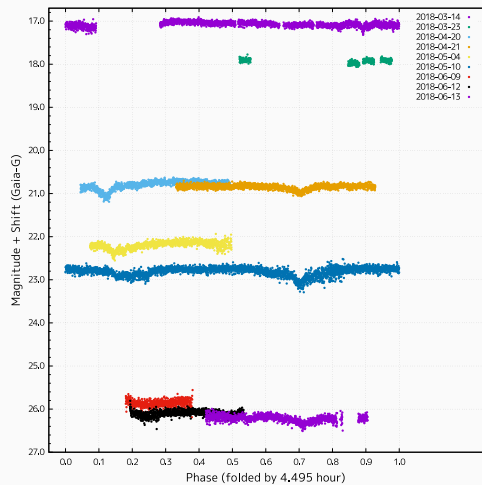
- **MAXI J1820+070**, Sco X-1

### 5. Crab pulsar (see, Ichiki-san's talk)



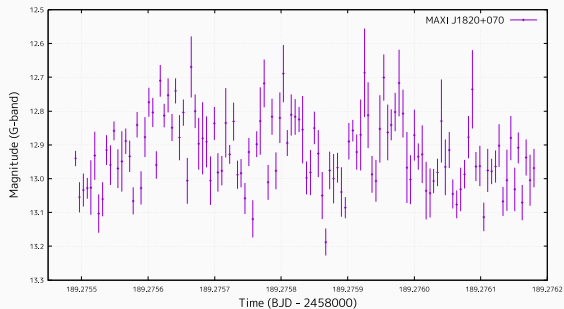
WD 1145+017: NASA's K2 Finds a Dead Star Vaporizing a Mini "Planet"

# WD 1145+017

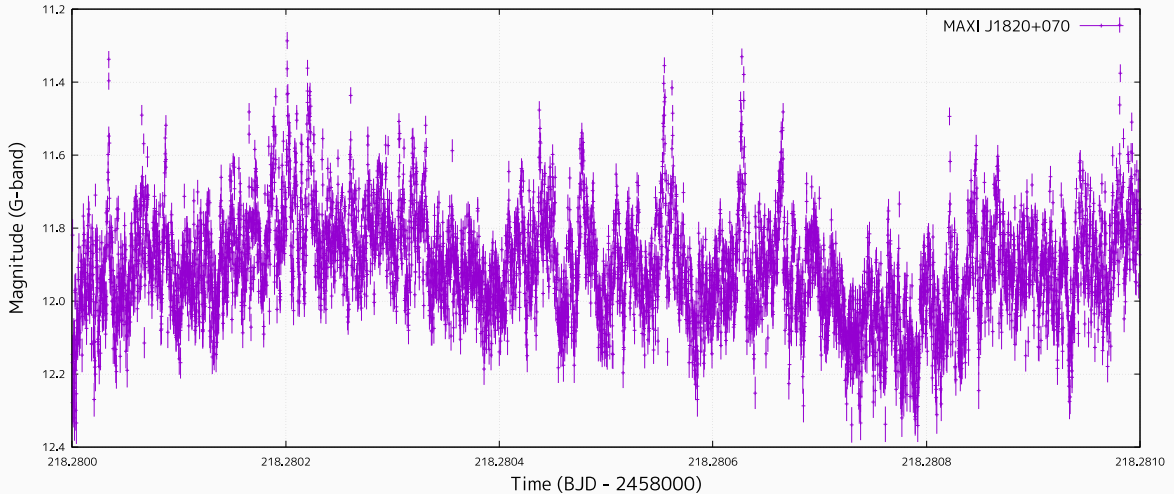


# MAXI J1820+070

- › ATel #11399 published in 16:41 UT 2018-03-11
- › Tomo-e Q1 observation in 18:37 UT 2018-03-11
  - 120× 0.5s exposures, 2×6 dithering ×2
  - survey + 2 Hz lightcurve
  - significant variability detected in 2 Hz resolution



# MAXI J1820+070



67 Hz observation on 2018-04-09

30 / 34

# Featured Observations

Targeted Observations: extragalactic objects

1. Repeating Fast Radio Burst (FRB 121102)
2. Blazar
  - S5 0716+714, QSO J0509+0541
3. Supernovae & Supernova candidates
  - ASASSN-17mz, SN2017eaw, SN2017glg, SN2017grn, **SN2018zd**, SN2018aca, SN2018aki, **HSC18dzef**

# SN2018zd





# HSC18dzef



# Summary

Run	2017.10	2018.02-06
# of Days	10	47
# of Objects	41	73

- Survey Experiments
  - Wide Field Survey, Asteroid Survey
- Targeted Observations
  - Solar System objects: *Near Earth Asteroids, Asteroid occultations, Satellites, Meteors*
  - Milky Way objects: *Young Stellar Objects & Star Forming Region, White Dwarfs, Variable Stars, X-ray binary, Crab pulsar*
  - Extragalactic objects: *Repeating FRB (FRB 121102), Blazar, SNe & SN candidates*