Japanese Implication

Bun'ei Sato
Tokyo Institute of Technology

Introduction of my research and current (political) situation of Okayama Astrophysical Observatory (OAO)

People

Name	Institution	Research Fields
Shigeru Ida	ELSI, Tokyo Tech.	Planet formation, theory
Bun'ei Sato	Tokyo Tech.	Exoplanets, observation
Masahiro Ikoma	Univ. of Tokyo	Planet interior and atmosphere, theory
Kiyoshi Kuramoto	Hokkaido Univ.	Jovian atmosphere, theory
Yukihiro Takahashi	Hokkaido Univ.	Jovian atmosphere, observation
Hideyuki Izumiura	OAO, NAOJ	Stellar physics, observation and instrumentation
Eiji Kambe	OAO, NAOJ	Asteroseismology, observation and instrumentation
Hidekazu Hanayama	Ishigakijima Astro. Obs., NAOJ	
Few more people		

B. Sato

- Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology
- Associate Professor
  - 1 assistant professor and 8 graduate students in my group
- Research Fields
  - Detection and characterization of exoplanets
  - Doppler planet searches around evolved stars using 1.88m telescope at OAO, Subaru 8.2m telescope, etc. for ~15 years

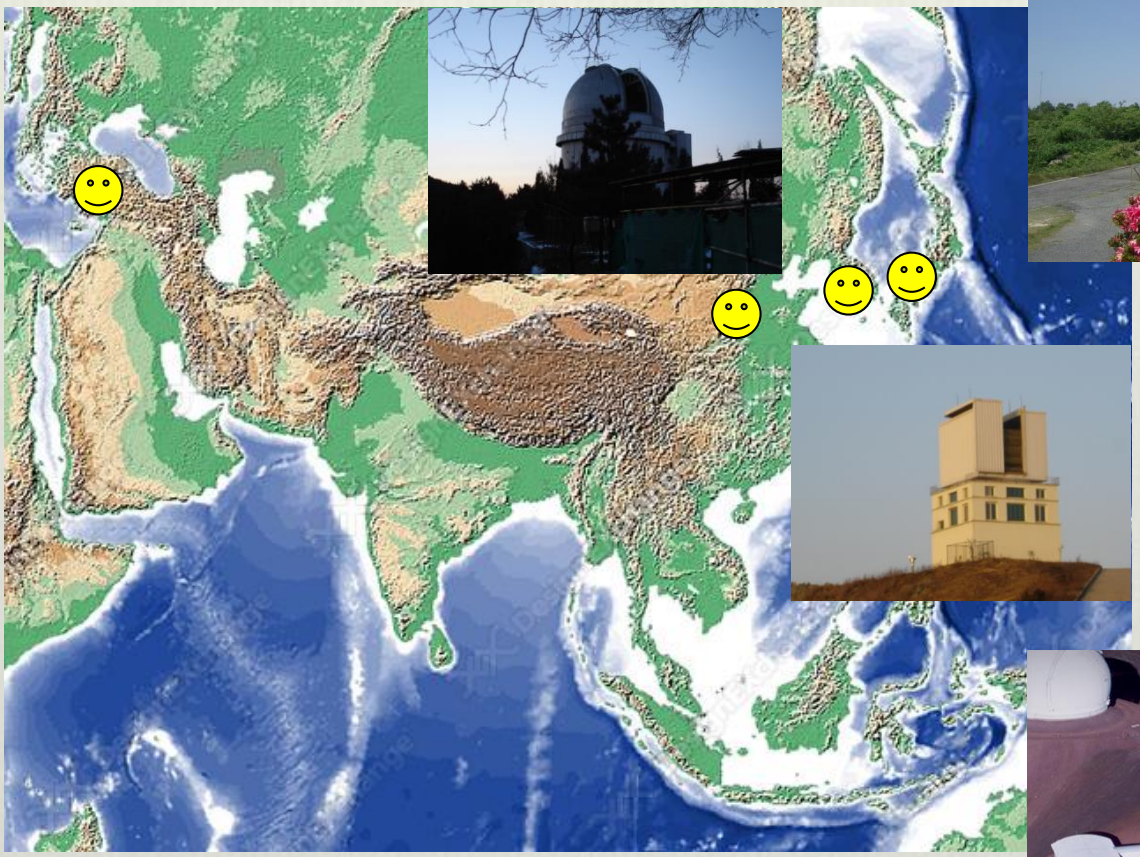
East-Asian Planet Search Network (EAPSNET)

Okayama (OAO) 1.88m

Xinglong/China 2.16m 2005~

Turkey 1.5m

2008~



2001~

Bohyunsan/ Korea 1.8m

2005~

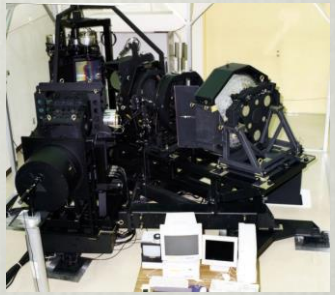
Subaru 8.2m 2006~

We discovered ~30 planets and brown dwarfs around evolved stars so far

Planet Hunting Machines

- Okayama 1.88m telescope and HIDES (HIgh Dispersion Echelle Spectrograph)
  - 3750-7500Å (5000-5800Å for RV)
  - R~70,000 (Max. 110,000)
  - Iodine cell for precise RV measurements
  - RV precision ~2 m/s
  - Fiber-feed and image slicer
  - Laser frequency comb is under development

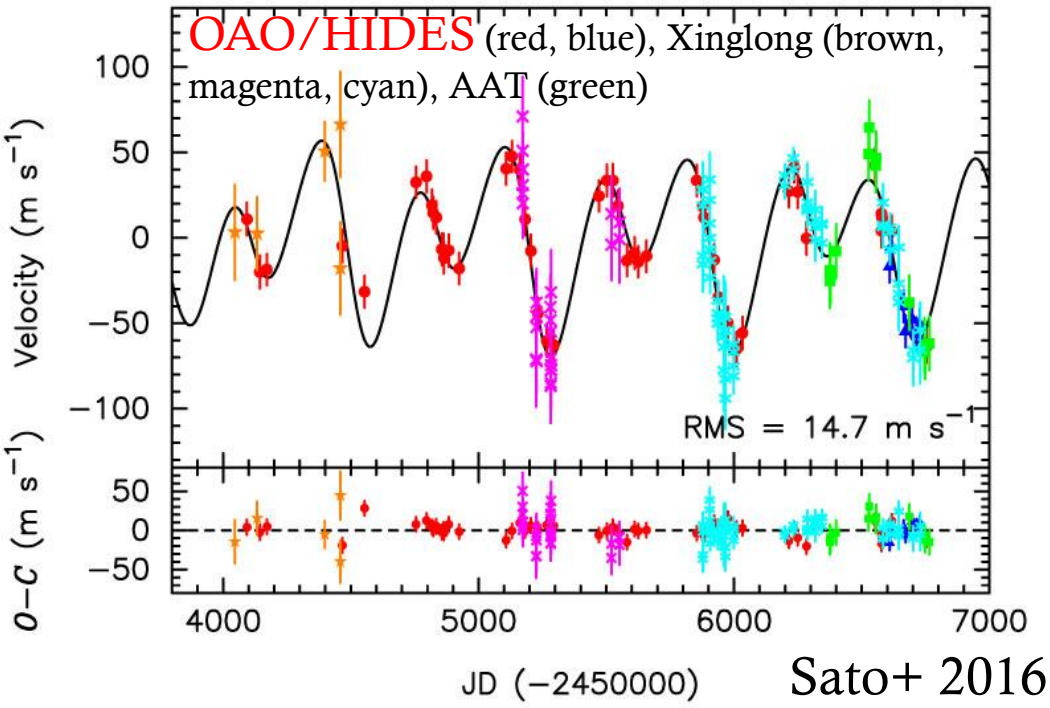
- Subaru 8.2m Telescope and HDS (High Dispersion Spectrograph)
  - 3500-6100Å (5000-5800Å for RV)
  - R~55,000 (Max. 150,000)
  - Iodine cell for precise RV measurements
  - RV precision ~2 m/s
  - Image slicer



Our latest result at OAO:

Multiple planets around HD 47366 (K1 III)

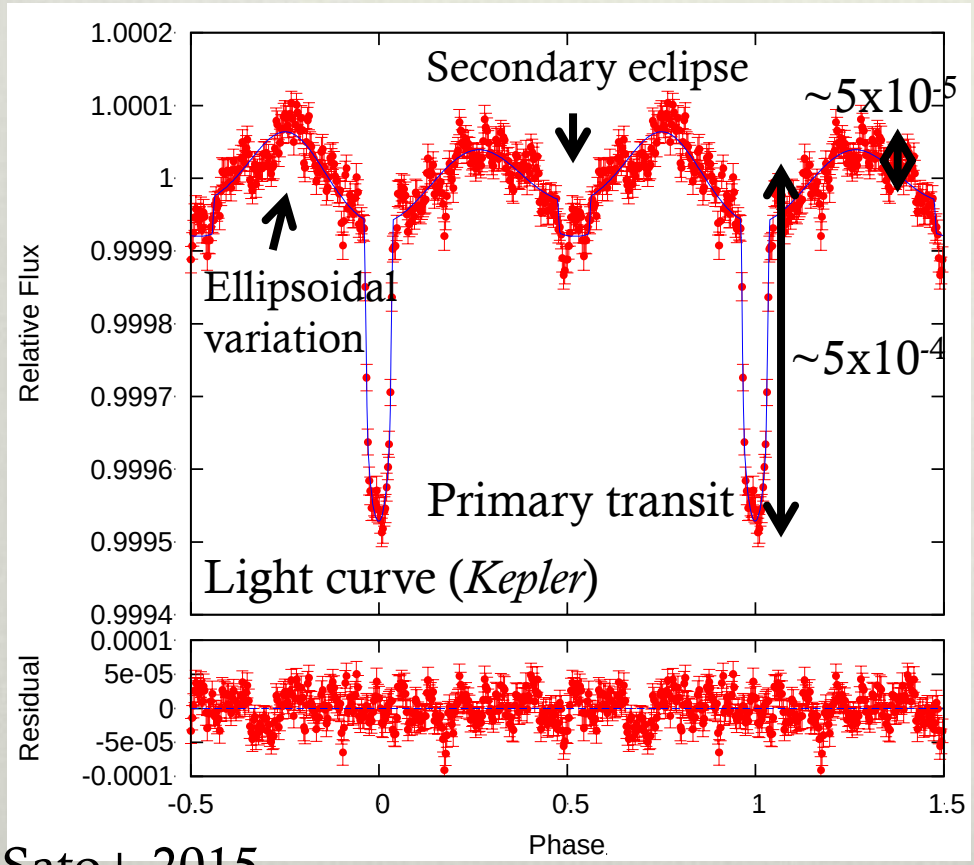
- ✓ Double Keplerian fitting
- ✓ Period ratio ~1.88
- ✓ Best-fit orbits to RVs are unstable (the orbits are almost crossing)

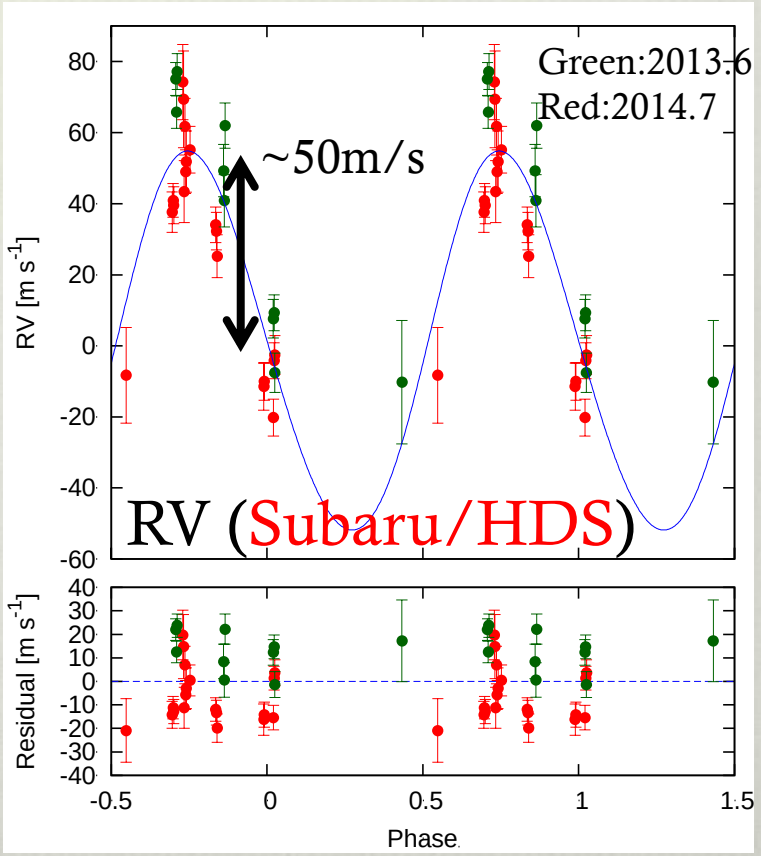


Parameter	HD 47366 b	HD 47366 c
Period P (days)	$363.3^{+2.5}_{-2.4}$	$684.7^{+5.0}_{-4.9}$
RV semiamplitude K_1 (m s^{-1})	$33.6^{+3.6}_{-2.8}$	$30.1^{+2.1}_{-2.0}$
Eccentricity e	$0.089^{+0.079}_{-0.060}$	$0.278^{+0.067}_{-0.094}$
Longitude of periastron ω (deg)	100^{+100}_{-71}	132^{+17}_{-20}
Periastron passage T_p (JD−2450000)	122^{+71}_{-55}	445^{+55}_{-62}
Minimum mass $m_2 \sin i$ (M_J)	$1.75^{+0.20}_{-0.17}$	$1.86^{+0.16}_{-0.15}$
Semimajor axis a (AU)	$1.214^{+0.030}_{-0.029}$	$1.853^{+0.045}_{-0.045}$
Semimajor axis ratio a_b/a_c	$0.6555^{+0.0041}_{-0.0043}$	

Our latest result at Subaru: Kepler-91

- Stellar properties (Huber+ 2013; Lillo-Box+ 2014)
  T_{eff} = 4550±75K, log g = 2.85 cgs, $M_\star$ = 1.31±0.10$M_\odot$, $R_\star$ = 6.30±0.16$R_\odot$
- Planet properties (this study)
  (P=6.24668005d) M_p=0.66±0.06M_{JUP}, R_p=1.40±0.04R_{JUP}, $a/R_\star$=2.253±0.045





Sato+ 2015

A Multisite Campaign to Measure Solar-like Oscillations in Procyon

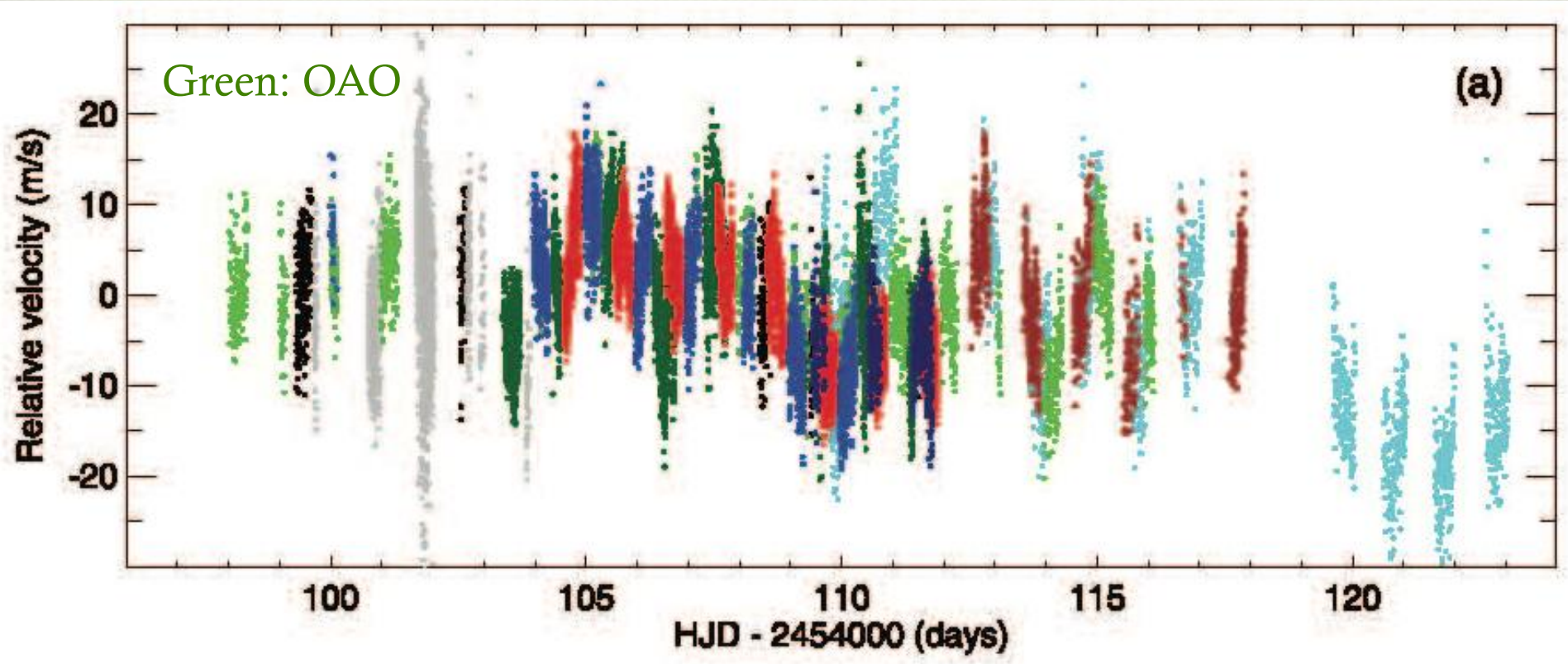
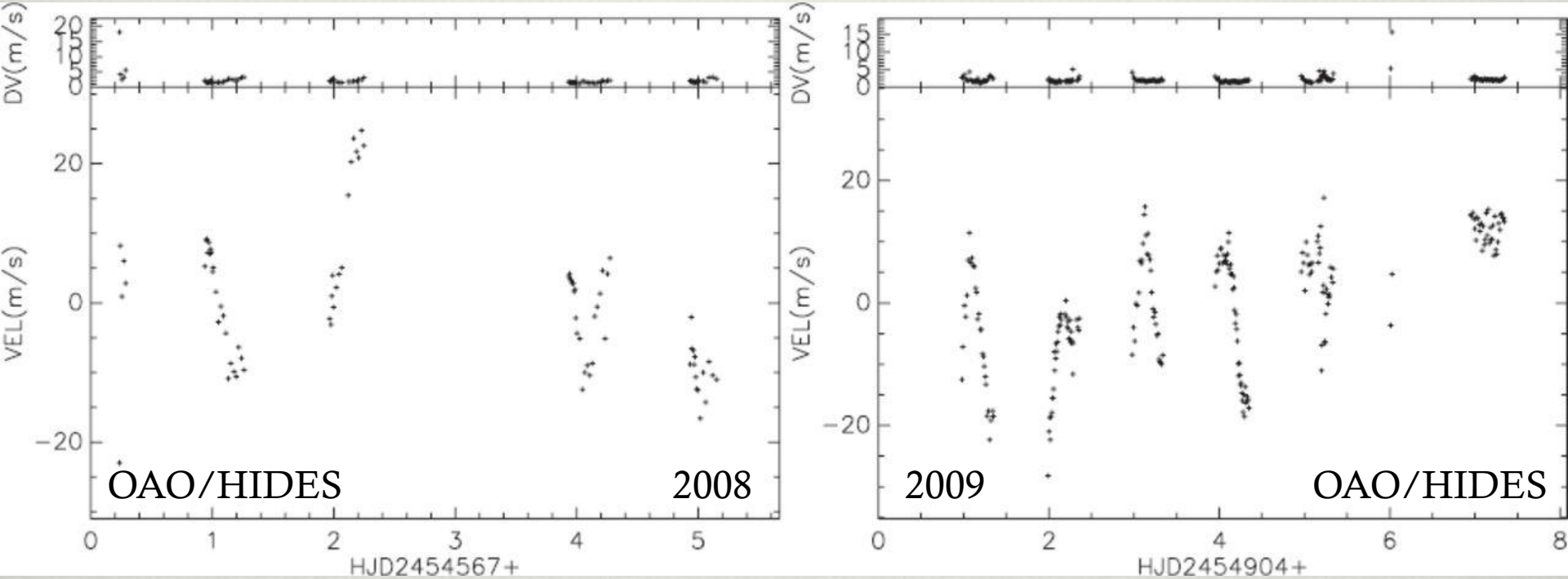


FIG. 1.—Velocity measurements of Procyon, color coded as follows. HARPS: red; CORALIE: brown; McDonald: gray; Lick: cyan; UCLES: blue; Okayama: green; Tautenburg: black; SOPHIE: dark green; SARG: dark blue; FIES: magenta; EMILIE: yellow. (*a*) Full time series, before any removal of slow trends (EMILIE and FIES are not shown). (*b*) Close-up of the central 10 days (FIES not shown). (*c*) Close-up of a 5 hr segment during which three spectrographs observed simultaneously: HARPS (*red circles*), SOPHIE (*dark green squares*), and SARG (*dark blue triangles*). All three series have been high-pass filtered to remove slow trends and the SOPHIE and SARG data have been smoothed slightly (using a boxcar with a width of three data points). (*d*) Time series of the final noise-optimized uncertainties, showing all 11 telescopes.

Arentoft+ 2008 (OAO observations were led by Eiji Kambe)

Stellar oscillation in evolved stars

11 Com (G8 II-III)



Ando+ 2010

Okayama Astrophysical Observatory, National Astronomical Observatory of Japan

C Projects

Nine Observatories as Main Driving Force of NAOJ

The C projects group consists of the six observatories and three projects, such as Subaru Telescope, ALMA (NAOJ Chile Observatory), "HINODE" and Nobeyama Radio Observatory, which have been completed as NAOJ facilities and are operating. This project group is the main driving force of NAOJ actively supporting leading edge observations and research.

Mizusawa VLBI Observatory

Observing the position of stars accuracy by dedicated 4 radio telescopes. And, measuring the distance of stars from the Earth.

Nobeyama Radio Observatory

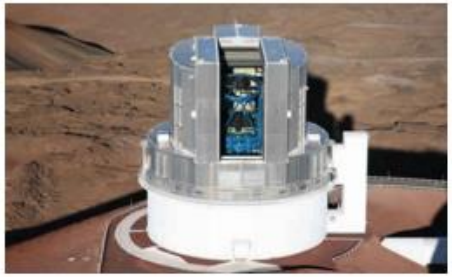
It is the world class large telescope that opened untouched millimeter wavelength astronomy field.

Solar Observatory

Challenging the mystery of the most closest star "Sun" by using magnetic field observation.

Okayama Astrophysical Observatory

188-cm telescope is the symbol of optical/infrared observation in Japan.

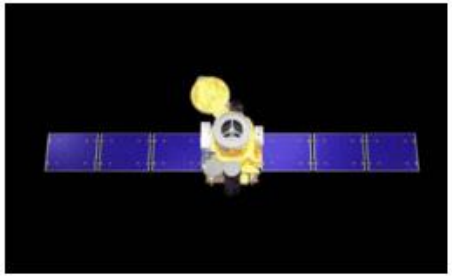


Subaru Telescope

Subaru Telescope continues to talk to the Universe.

Center for Computational Astrophysics

Proceeding the third astronomy that reproduce the Universe in the computer.



Hinode Science Center

This is the hub station of observation and data analysis of solar orbital astronomical observatory "Hinode" satellite.

NAOJ Chile Observatory

ALMA is the state-of-the-art telescope to investigate the cool universe, operated by NAOJ and international partners.

Okayama Astrophysical Observatory

North

East

Okayama Astrophysical Observatory

Since 1960

Longitude E133° 35’ 47”
Latitude +34° 34’ 26”
Altitude 372m

Possible candidate of a host telescope of JOVIAL

New 3.8m telescope of Kyoto Univ.

(Partially) Start operation in 2018
A half of the telescope time is for open-use

A big issue on the 1.88m telescope

- The 1.88m telescope is now fully operated by NAOJ as an open-use telescope.
- NAOJ will shut down operation of the 1.88m telescope by the end of March 2018.
  - New Kyoto 3.8m telescope will partially start operation as an open-use telescope in April 2018.
- If we want to use the 1.88m telescope after April 2018, we need funds to operate the telescope.
  - If we have more funds, we may have chances to get more observing time.
  - A total cost (including labor cost) would be ~0.3M$/yr. To share the cost with other groups is possible (~50K$/yr for each?).
  - A back-up plan is necessary? (Ishigaki?)

Funds … nothing at this moment

- Japan
  - Applying for competitive research funds
    - KAKENHI grants (Japan Society for the Promotion of Science; JSPS)
      - Deadline: late October
    - Others
- France?

Thank you

Okayama Astrophysical Observatory

Bun'ei Sato
Tokyo Institute of Technology

Okayama Astrophysical Observatory

North

East

1.88m telescope

Since 1960

Longitude E133° 35’ 47”
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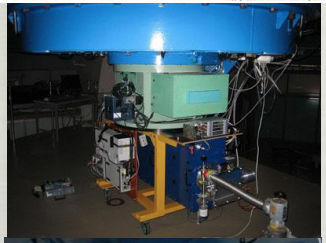
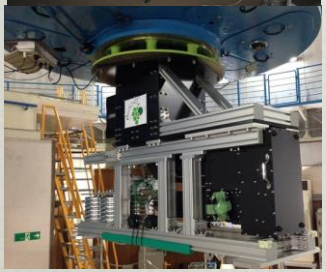
Possible candidate of a host telescope of JOVIAL

Instruments





- Coude focus
  - High Dispersion Echelle Spectrograph (HIDES)
- Cassegrain focus
  - Near-infrared imager and low-dispersion spectrograph (ISLE)
  - Kyoto-Okayama Optical Low-dispersion Spectrograph (KOOLS)
  - Multi-color Simultaneous Camera for studying Atmosphere of Transiting exoplanets (MuSCAT)

http://www.oao.nao.ac.jp/en/telescope/

http://esppro.mtk.nao.ac.jp/MuSCAT/observing.html

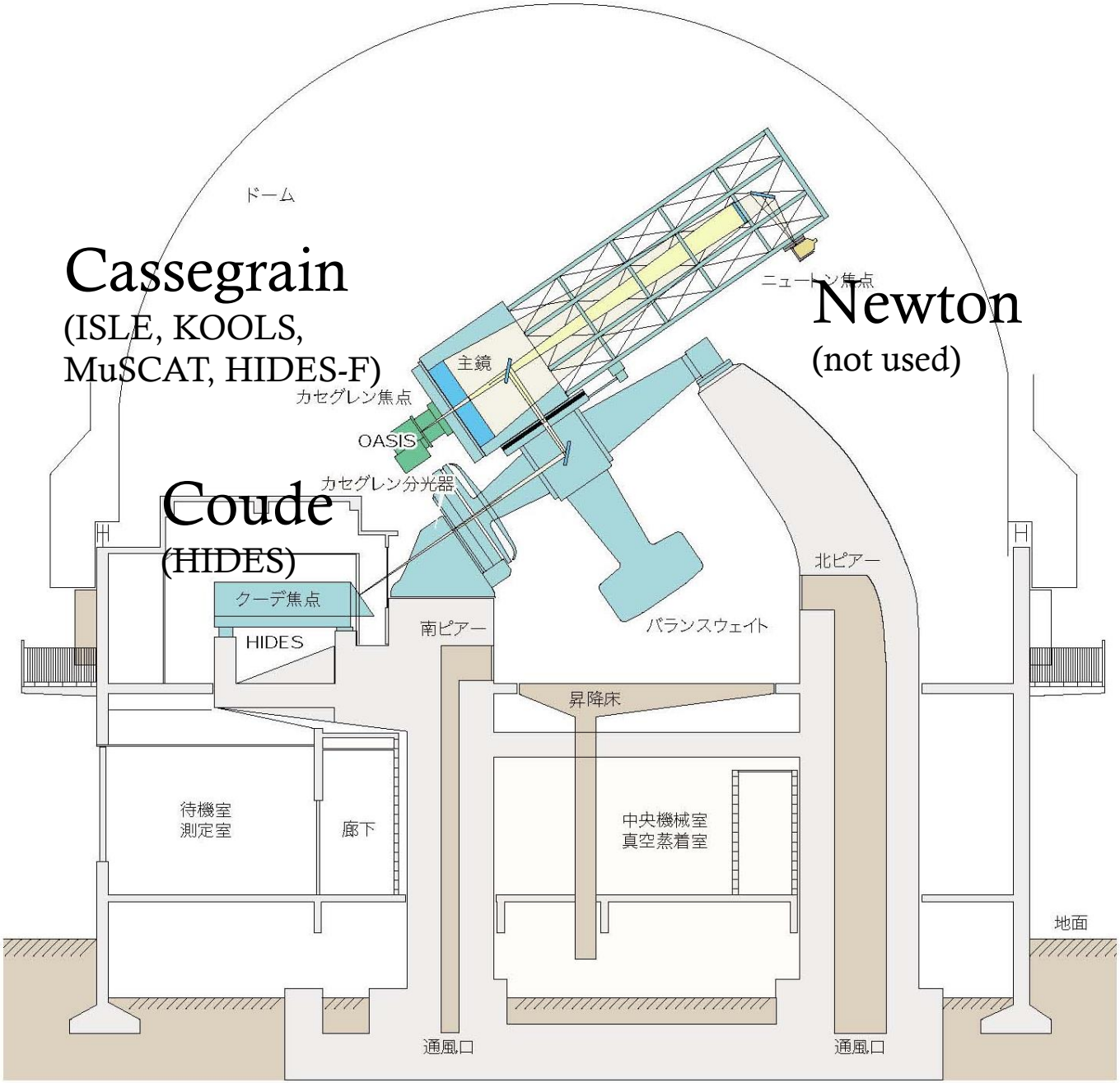
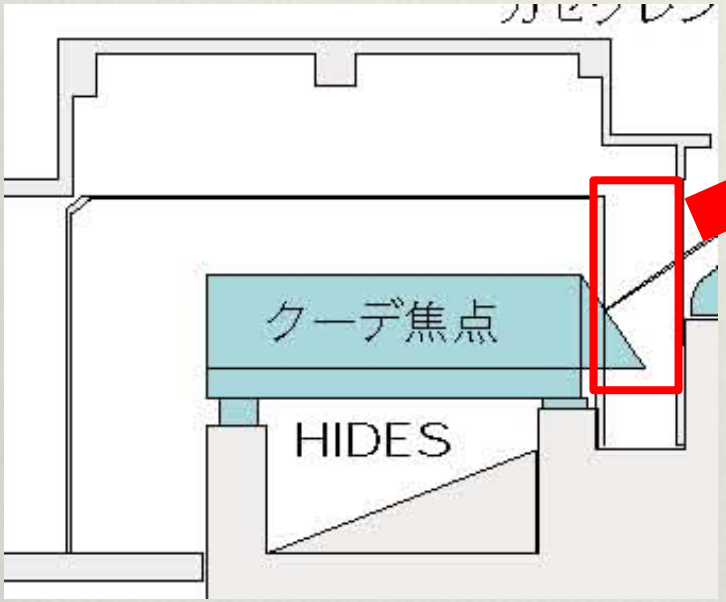
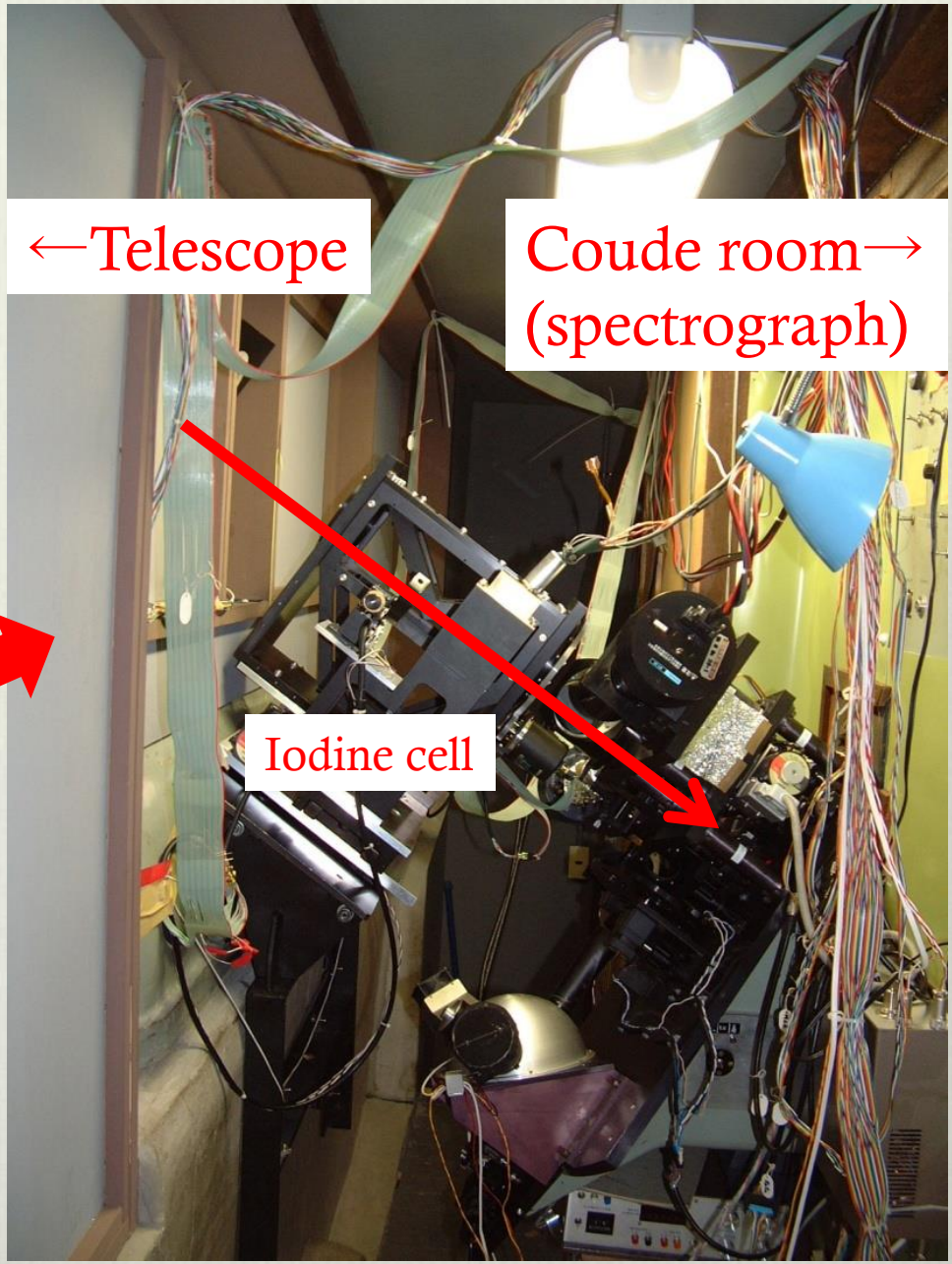


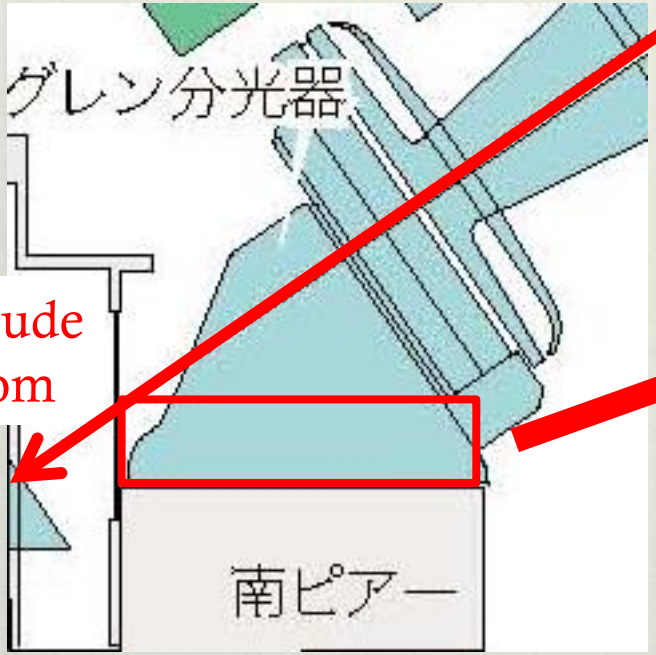
図2－1　188cm反射望遠鏡ドーム概略図

Coude room

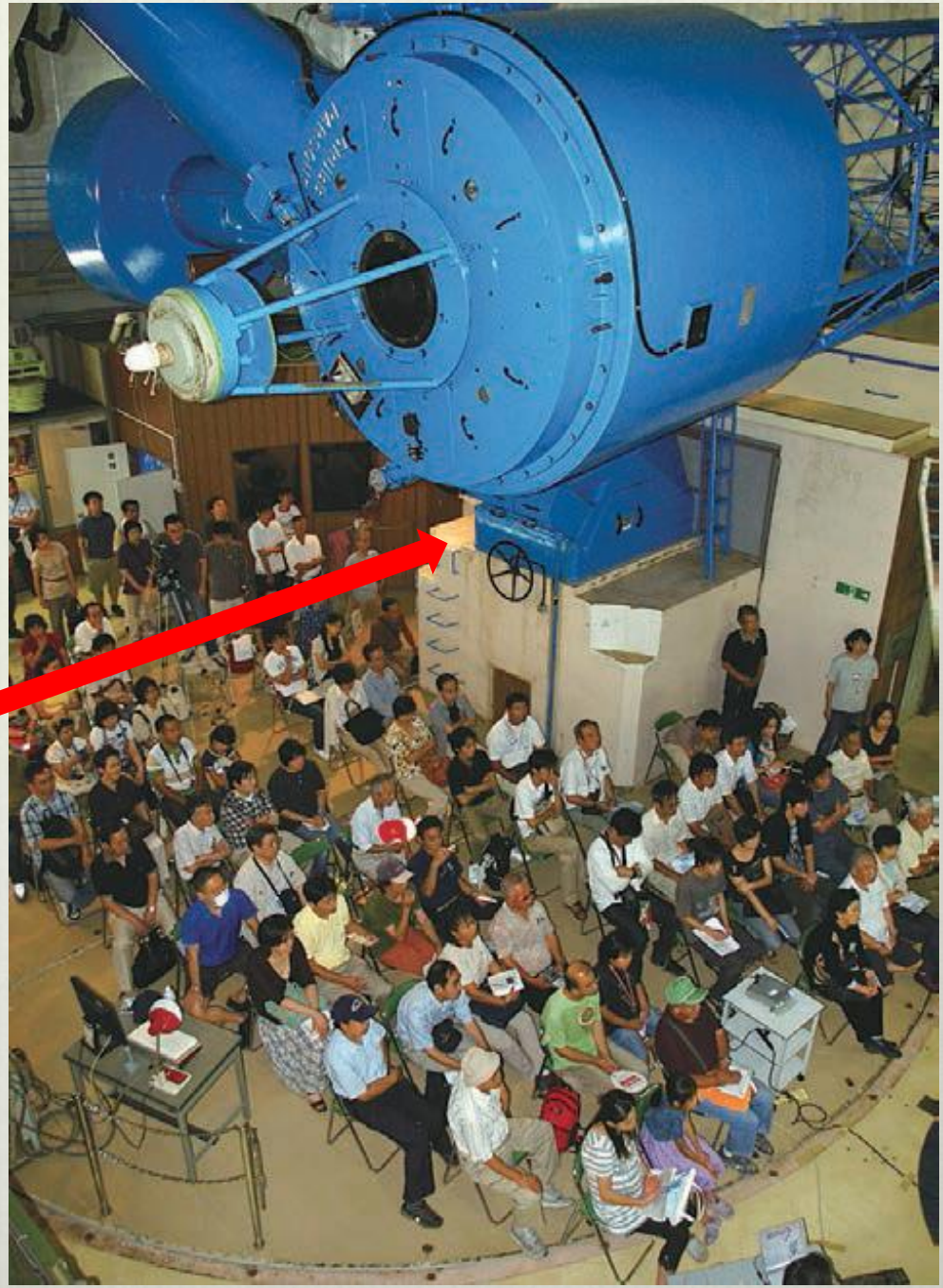

クーデ焦点
HIDES


←Telescope
Coude room→
(spectrograph)
Iodine cell

Telescope



Coude room



http://www.oao.nao.ac.jp/en/telescope/abouttel188/

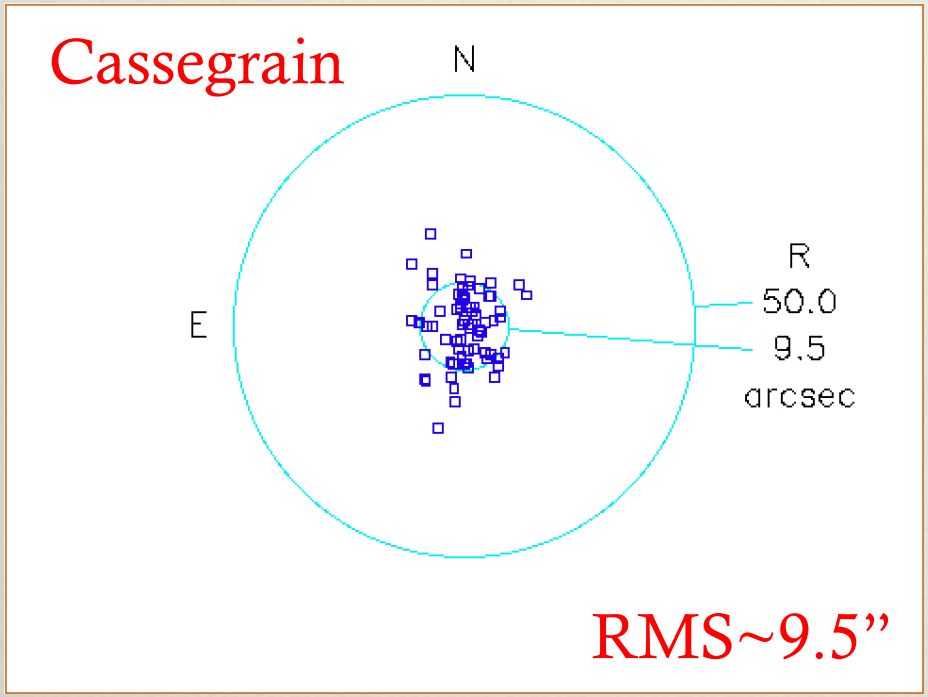
Basic spesifications

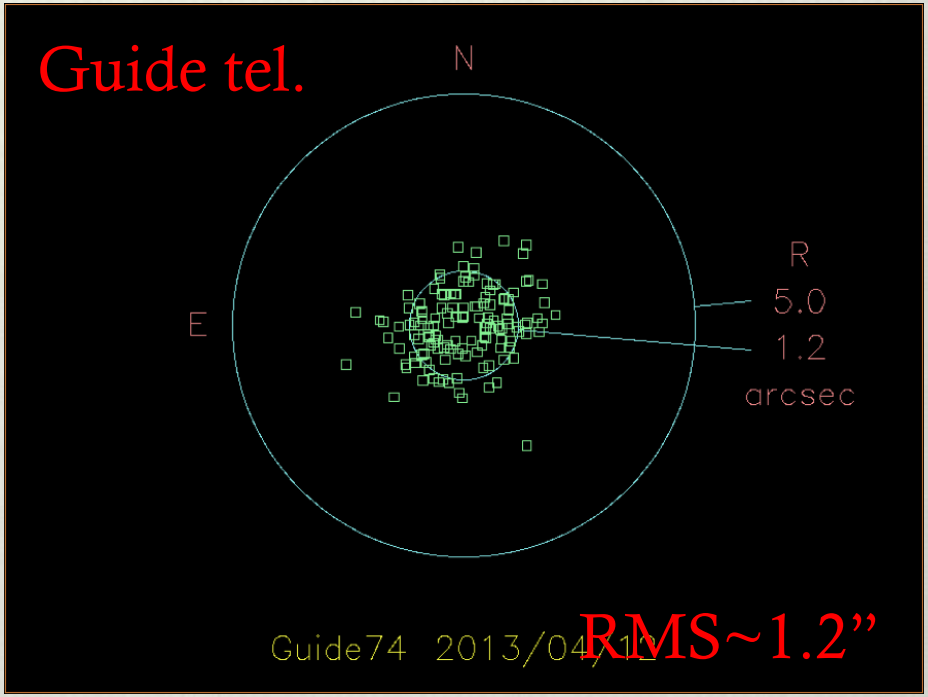
Latitude	+34° 34′ 37.47″ N
Longitude	133°35′38.24″ E
Altitude	372m
Telescope type	Classical Type Cassegrain (constructed by Grabb Persons Inc., UK in 1960)
Mounting	British-type equatorially mounting
Weight	50t
Length	9m (center piece + octagonal torus)
Haltmann constant	about 0.23
Pointing accuracy	about 20 arcsec

Focus

	Focal length [m]	Focal ratio	Plate scale[“/mm]
Newton	9.15	4.9	22.5
Cassegrain	33.85	18	6.09
Coude	54.29	29	3.80

Pointing accuracy (Cassegrain)

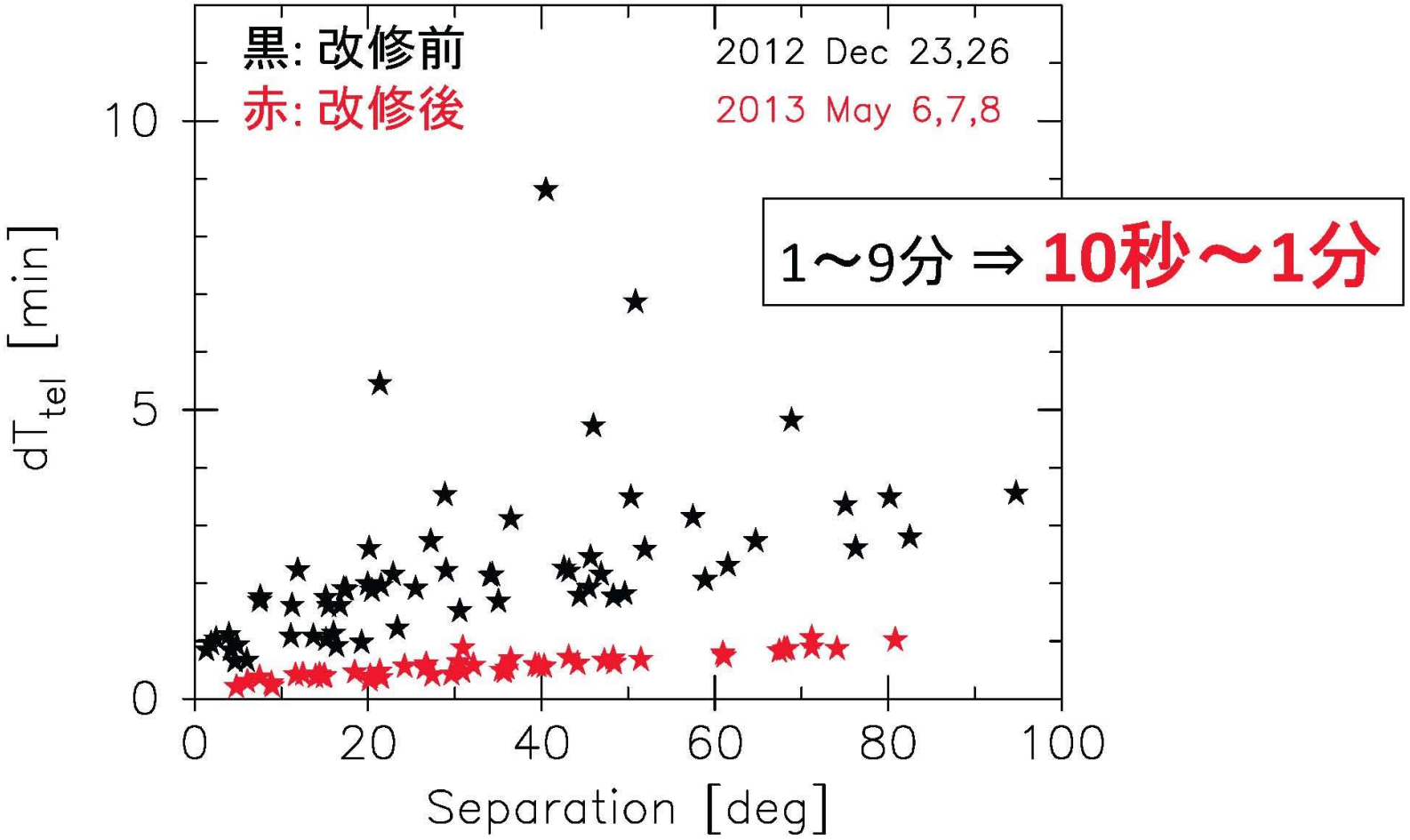




http://www.oao.nao.ac.jp/stockroom/extra_content/um13/O08_Fukui.pdf

Slew speed

- 望遠鏡の指向時間 (指向開始から終了までの時間) を改修前後で比較
  - HIDESスリットによる共同利用観測(視線速度探索)時のログを調査



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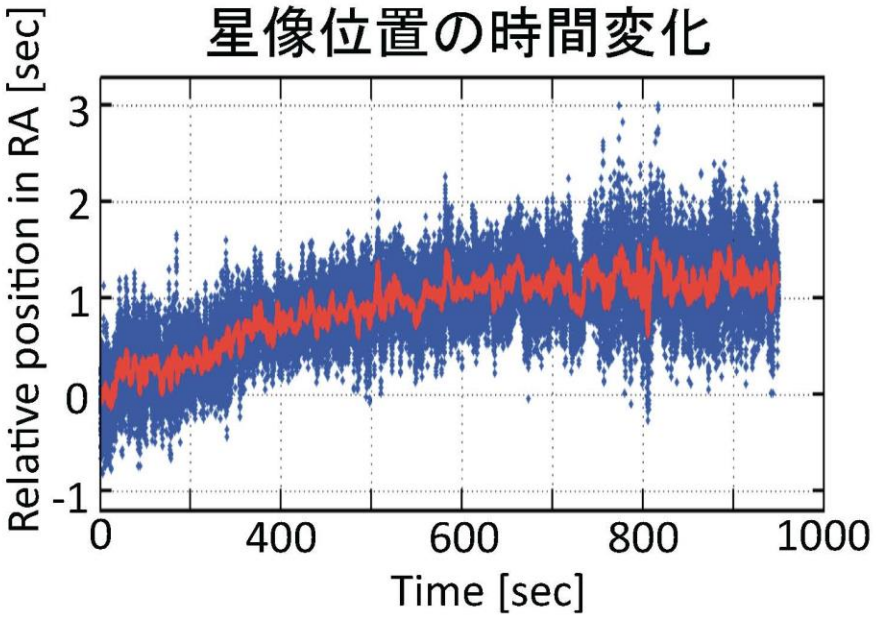
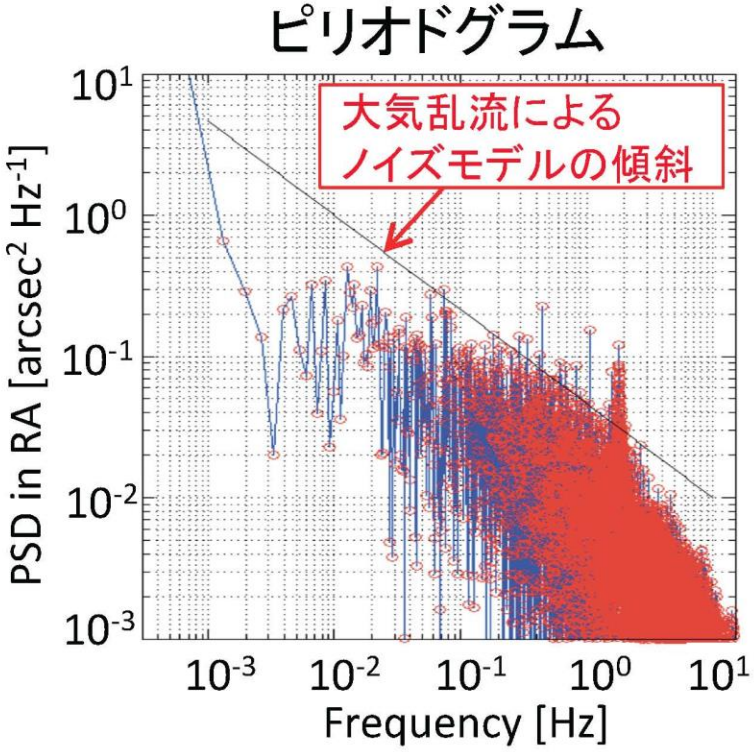
Tracking accuracy

改修後 **RA方向**





- RA方向の周期的な誤差が無くなり、追尾がスムーズに
- ドリフト（～1.2”/15分）が見られる

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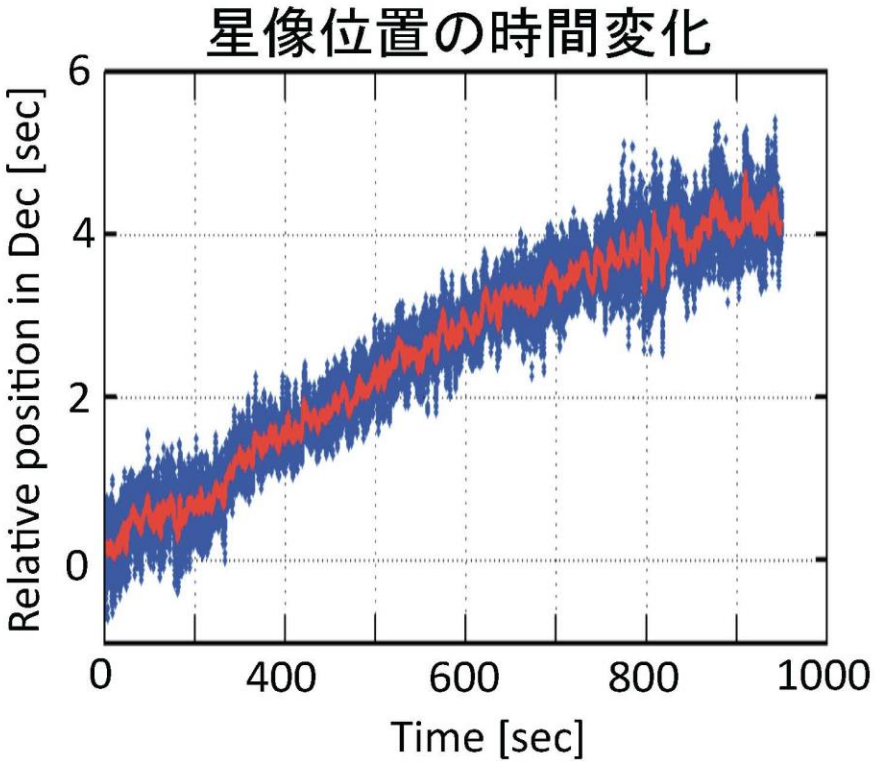
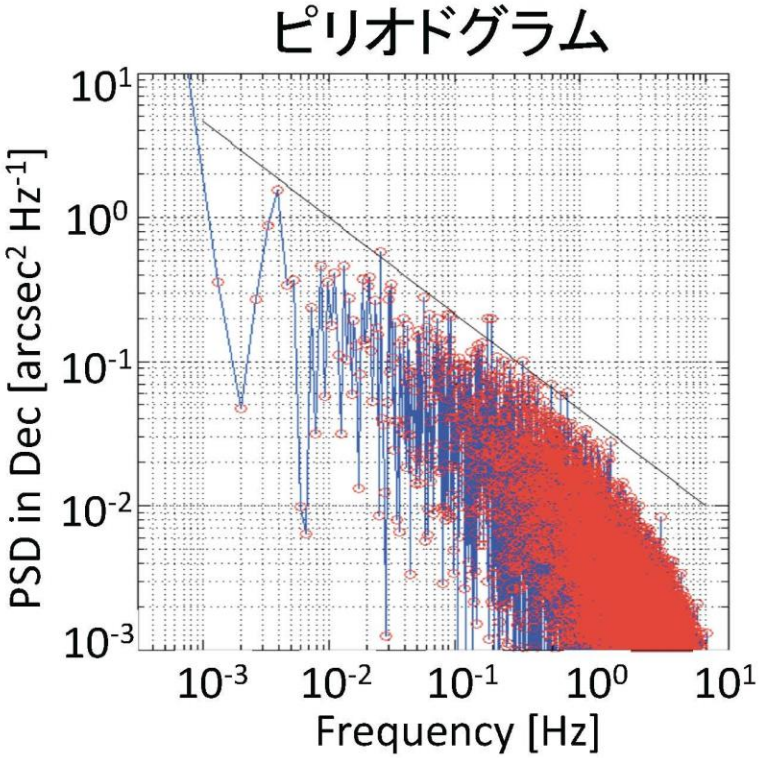
Tracking accuracy

改修後　**Dec方向**





- Dec方向にも大きなドリフト（～4”/15分）

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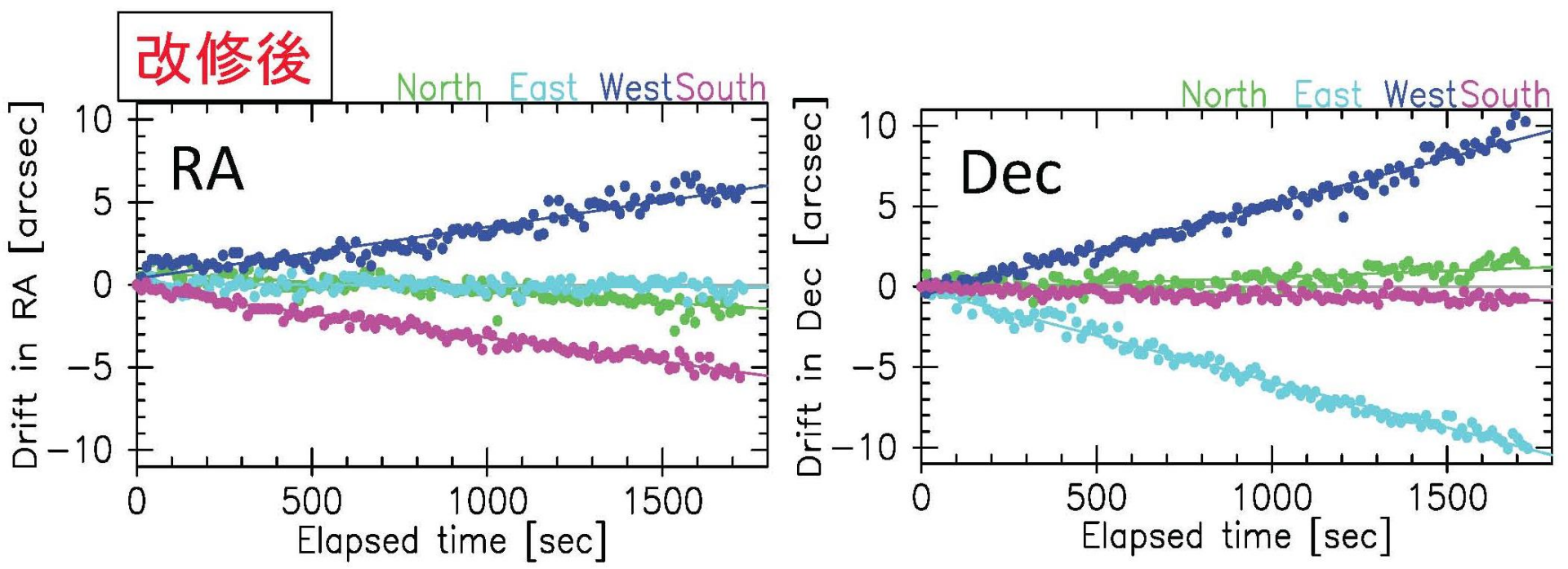
Tracking accuracy

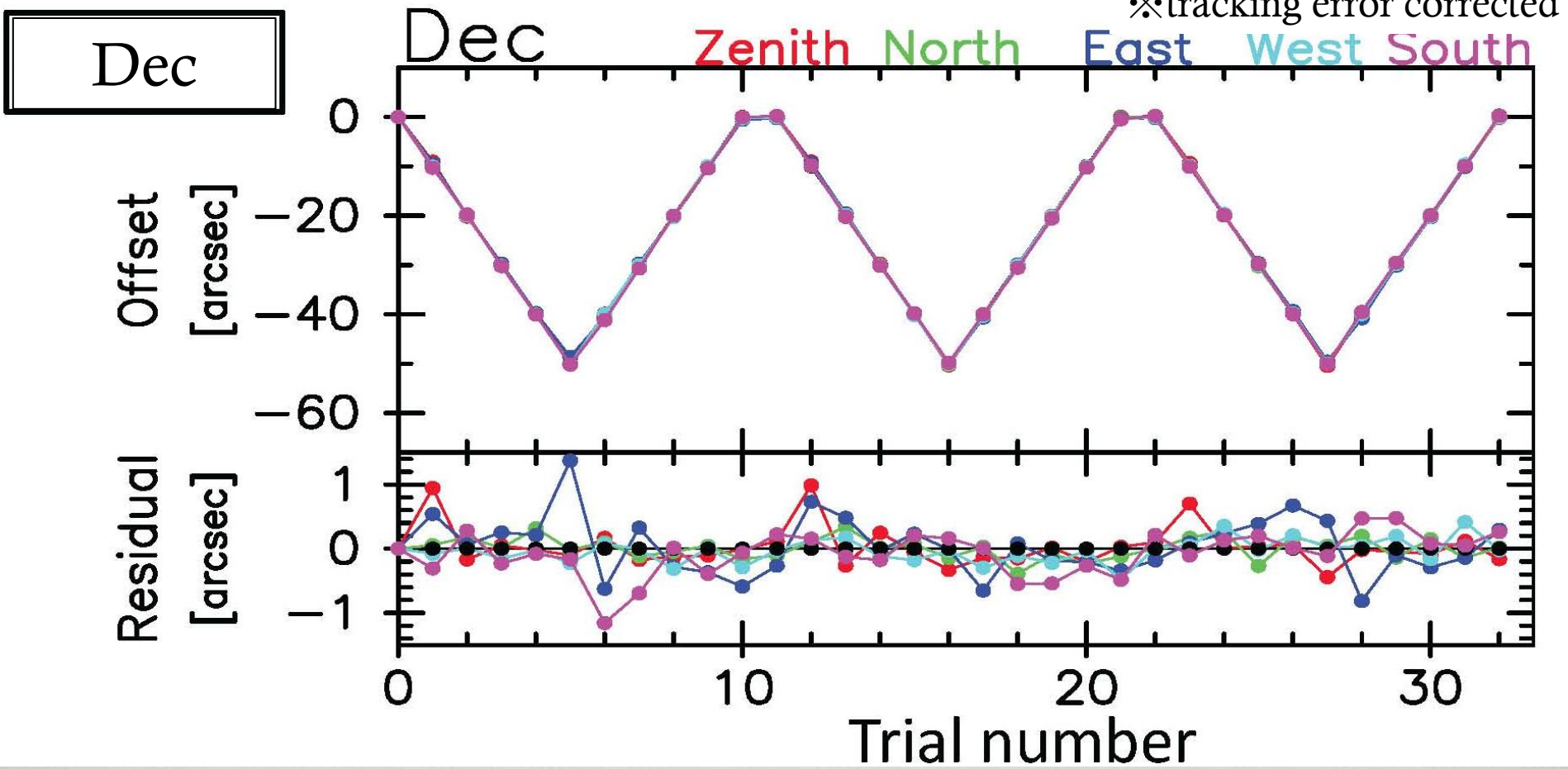


Drift < 10”/30min

http://www.oao.nao.ac.jp/stockroom/extra_content/um13/O08_Fukui.pdf

Small angle motion

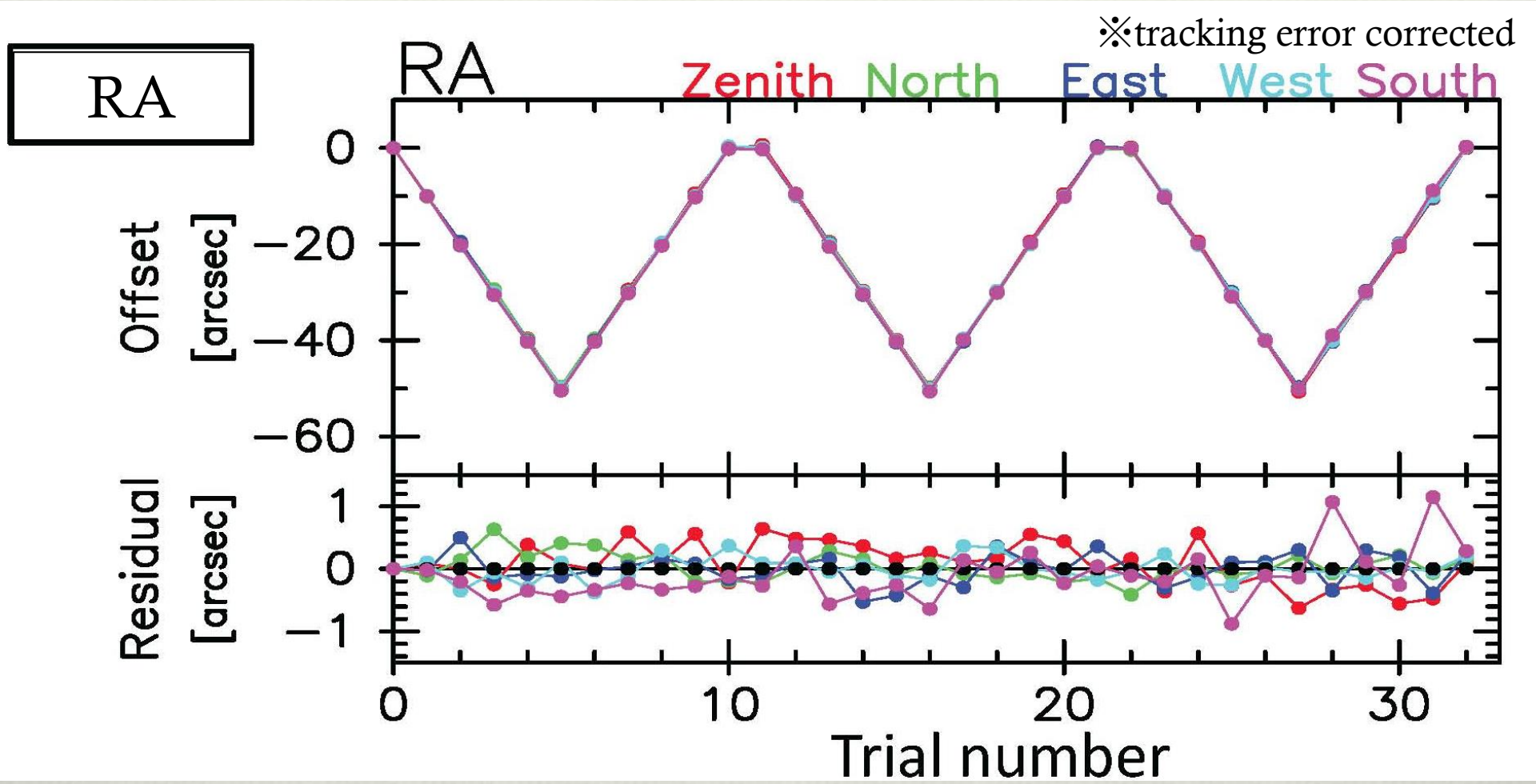
※tracking error corrected



RMS~0.3”

http://www.oao.nao.ac.jp/stockroom/extra_content/um13/O08_Fukui.pdf

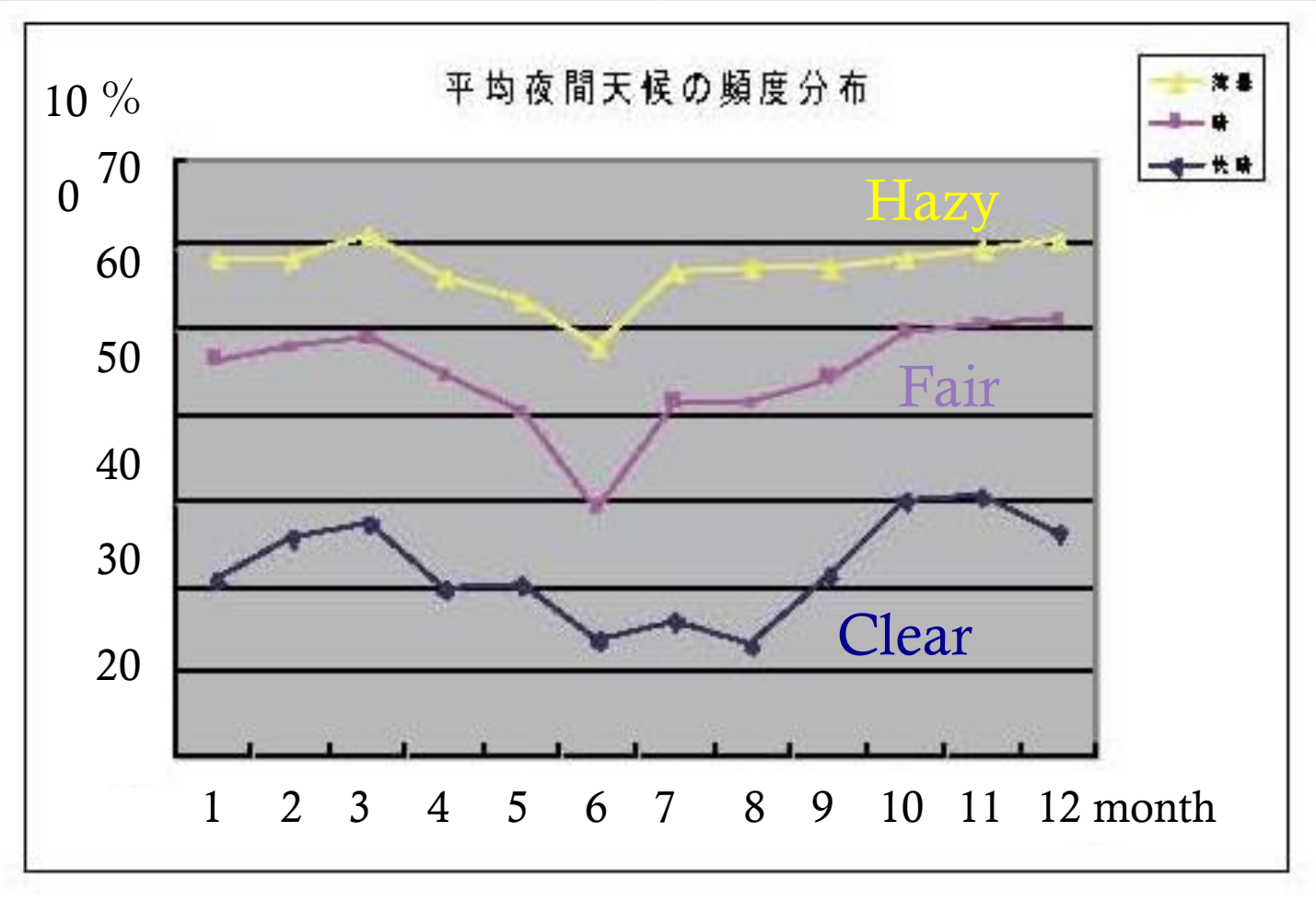
Small angle motion



RMS~0.3”

http://www.oao.nao.ac.jp/stockroom/extra_content/um13/O08_Fukui.pdf

Night weather (typical)



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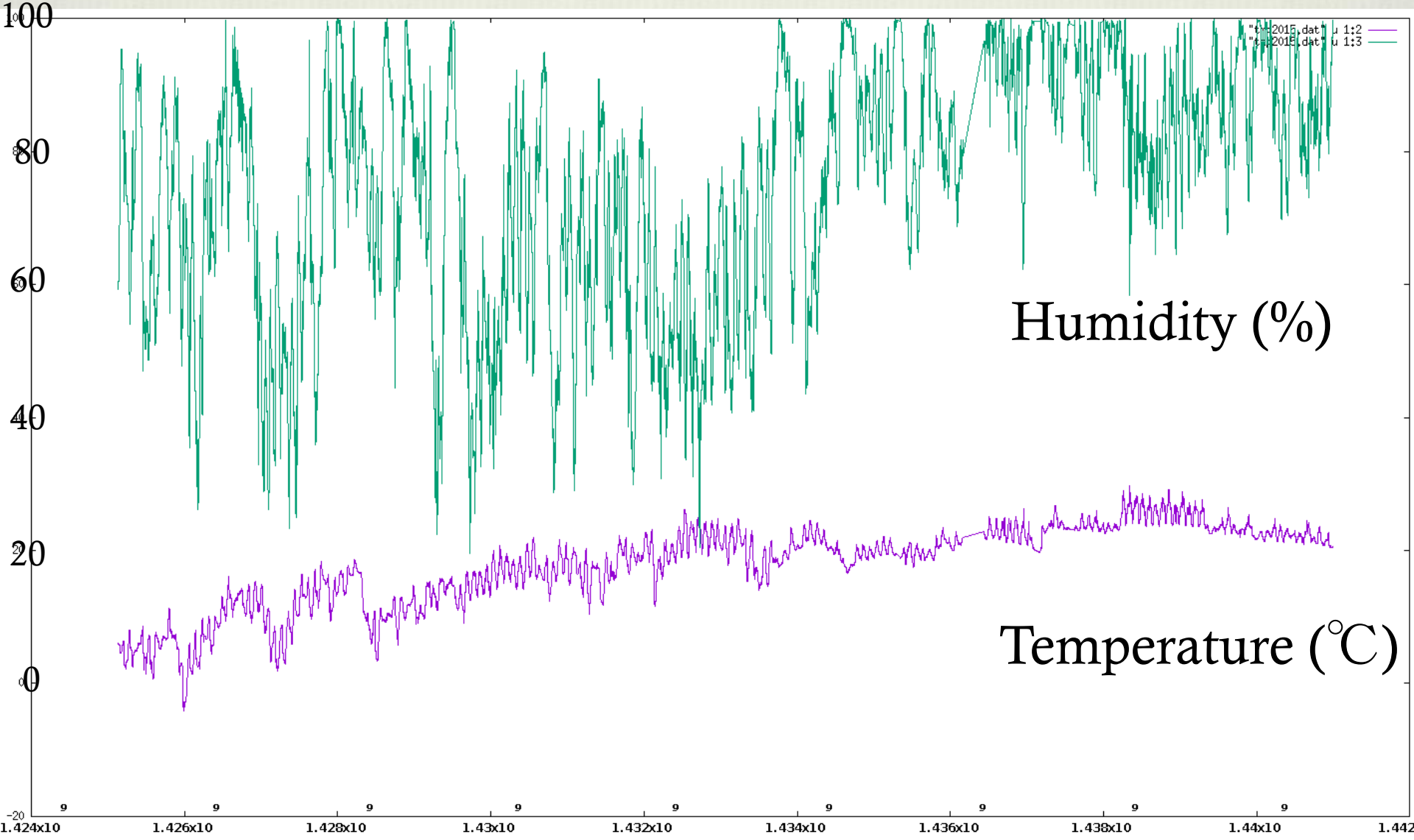
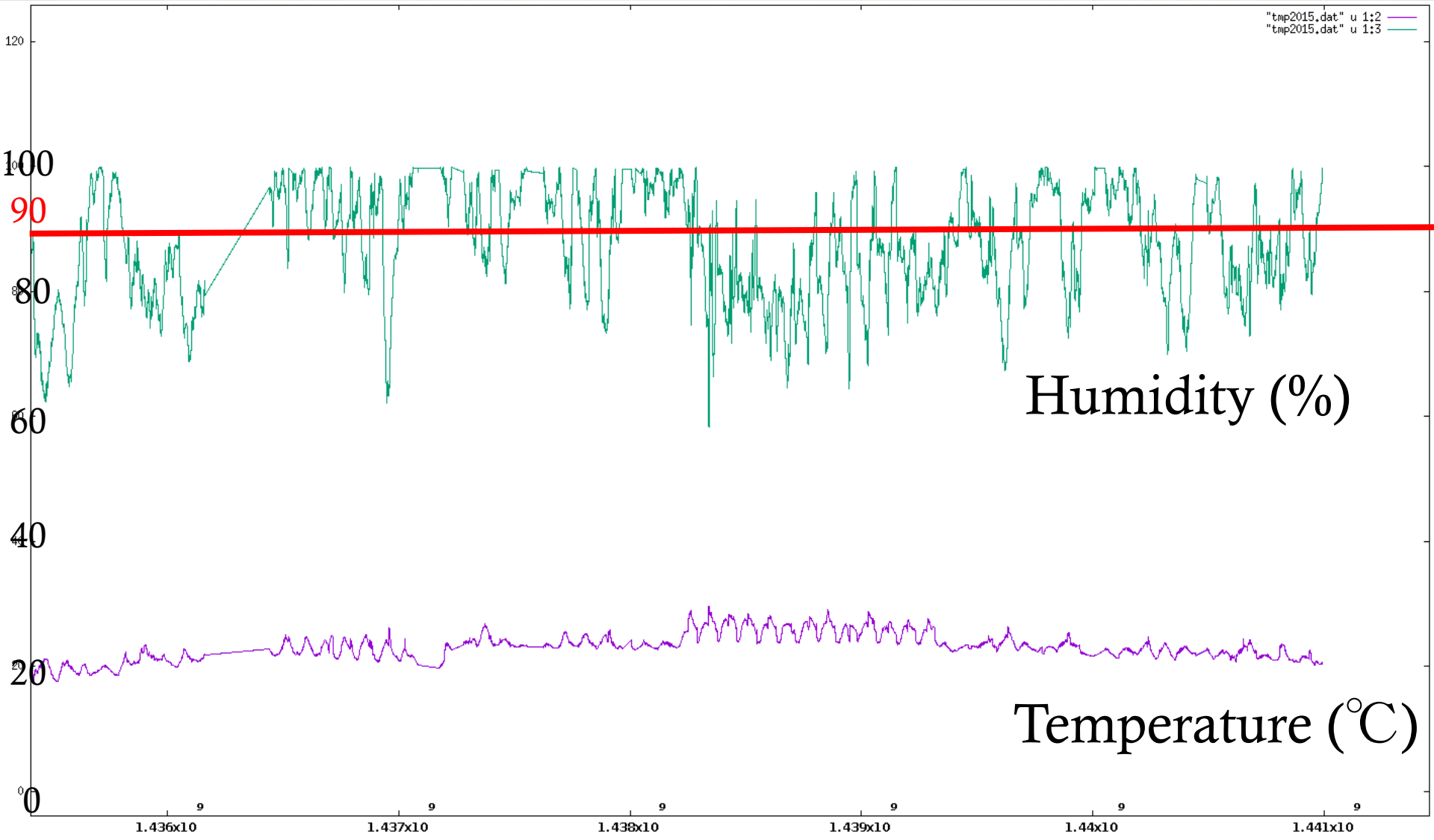
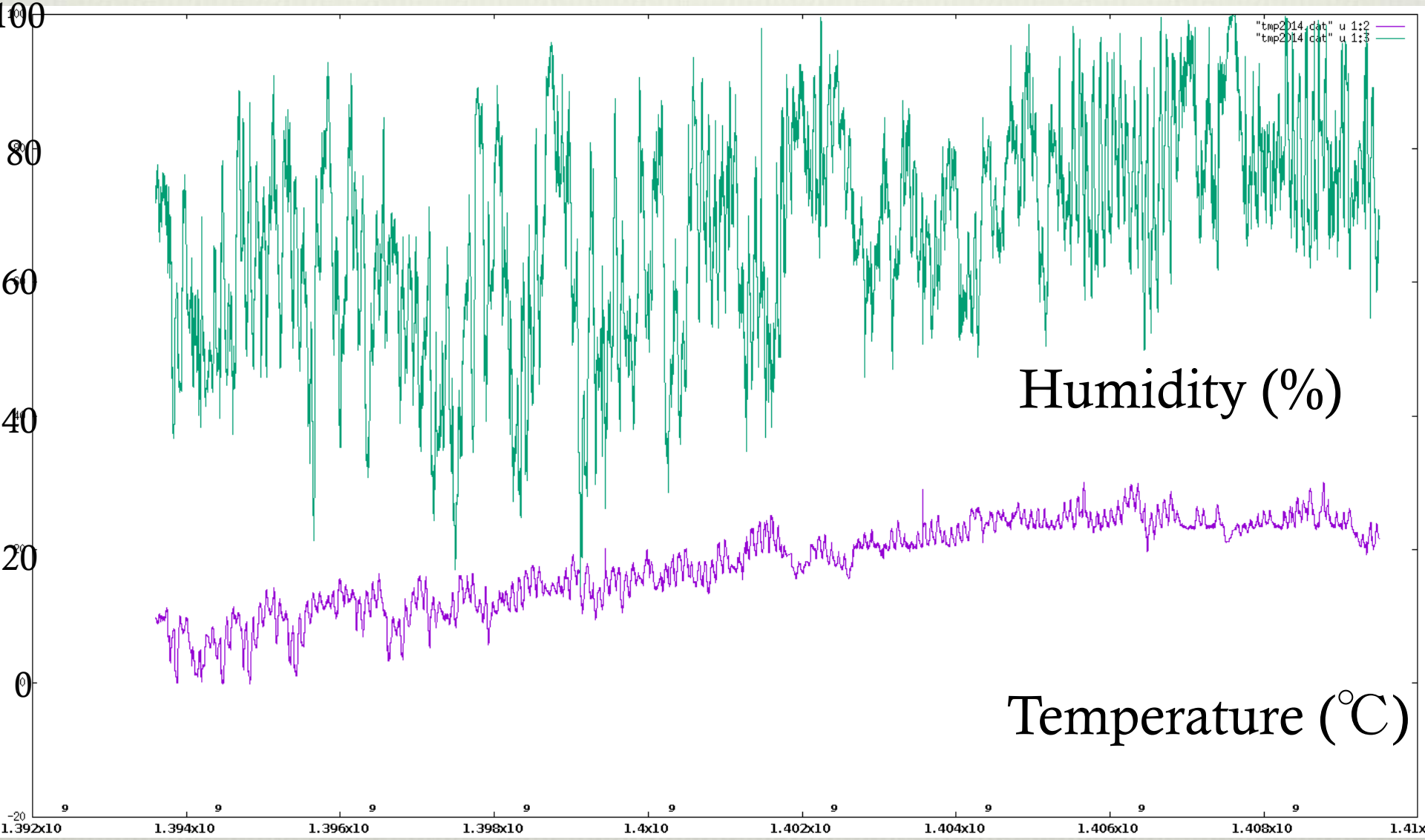
Inside dome 2015 Mar.-Aug.



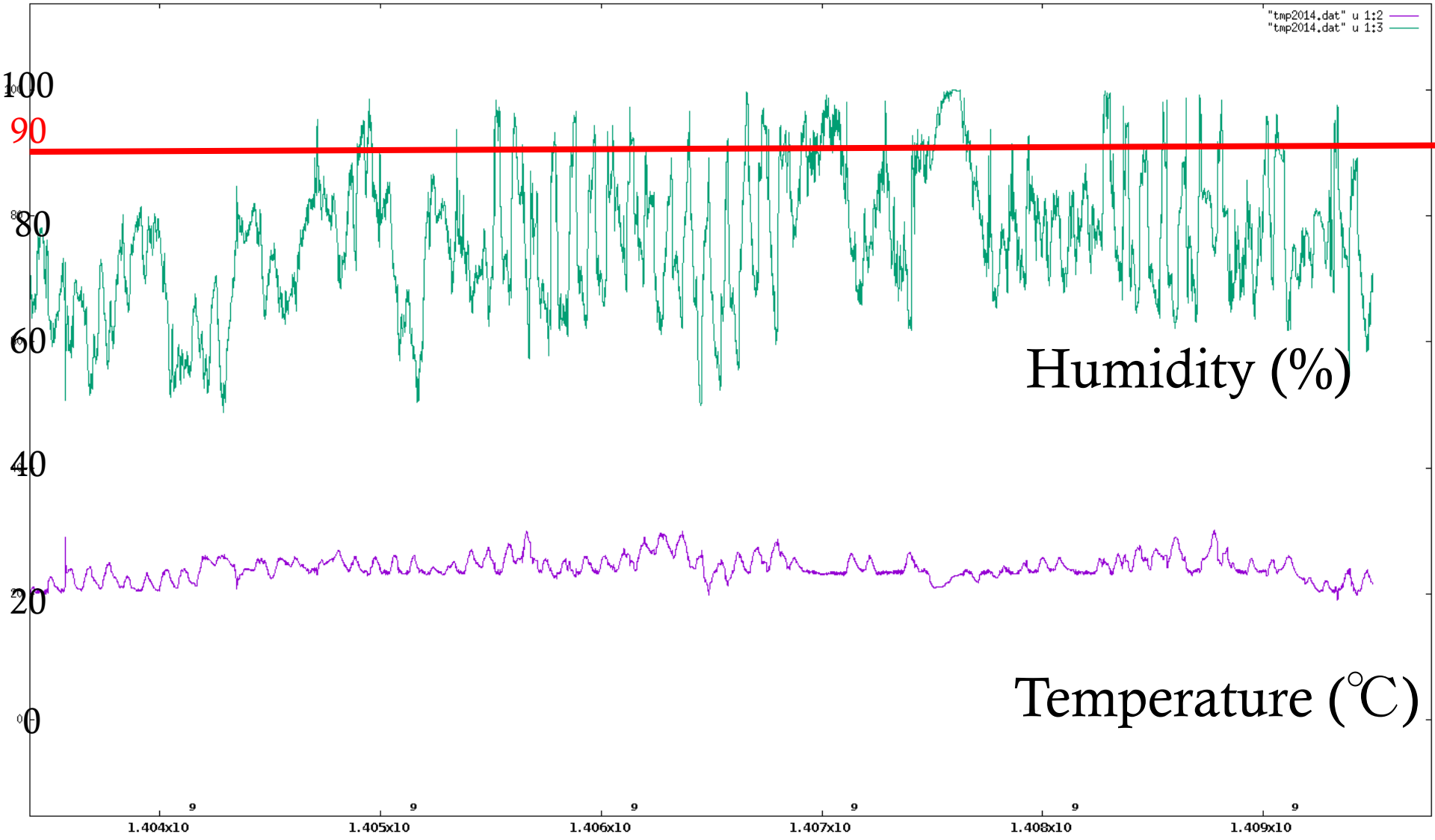
Inside dome 2015 Jul.-Aug.



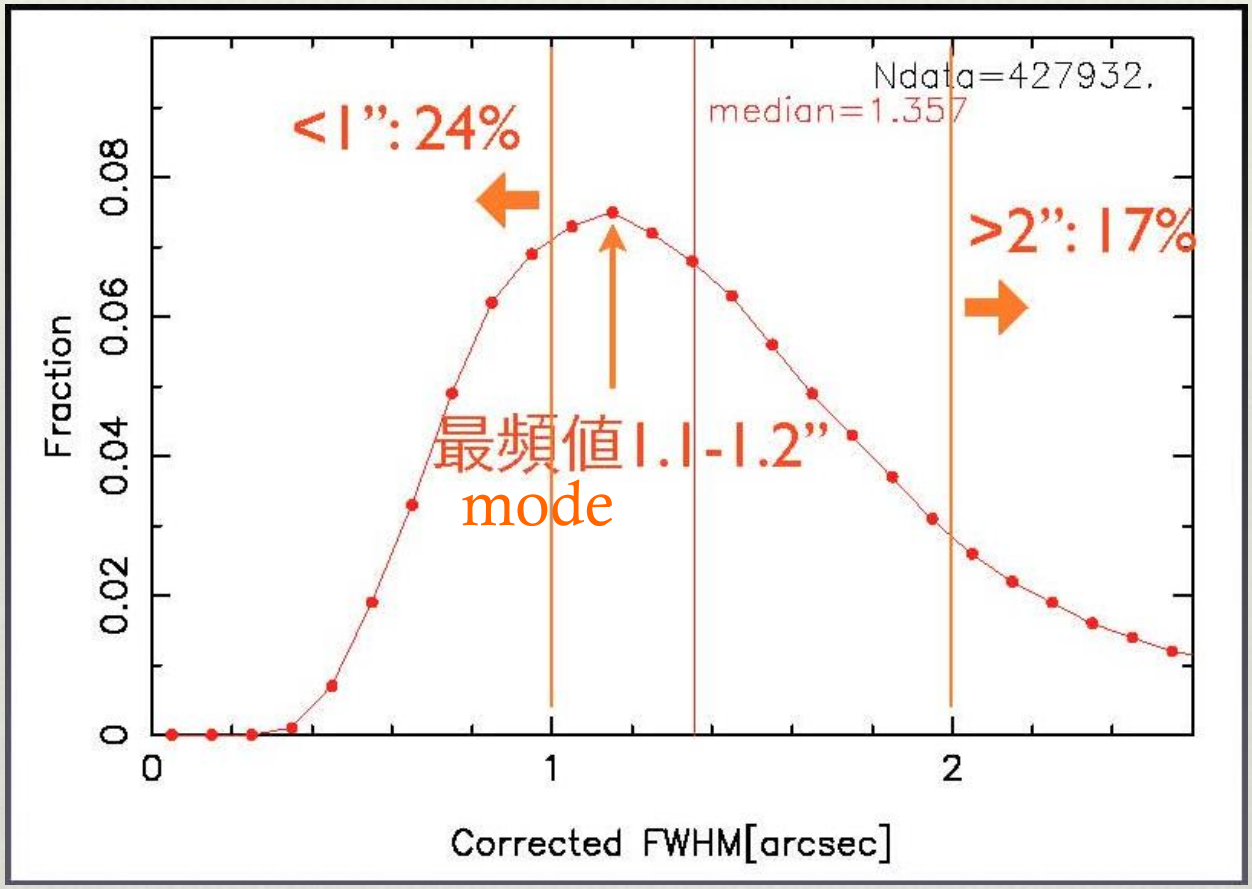
Inside dome 2014 Mar.-Aug.



Inside dome 2014 Jul.-Aug.



Natural Seeing



Inside the 1.88m tel. dome ➔~1.5"

http://www.oao.nao.ac.jp/stockroom/extra_content/com50pdf/OAO50th.pdf

Thank you