# PyIRD: A Python-Based Data Reduction Pipeline for Subaru/IRD and REACH, with Applications to Brown Dwarf Observations

- Data reduction pipeline for IRD and REACH
- Open-source code developing on GitHub

Come visit **Poster P01**!

- ✓ Simple Tutorial
- ✓ Applications to Real-world Data
- ✓ Future Development Plan

## Key Features

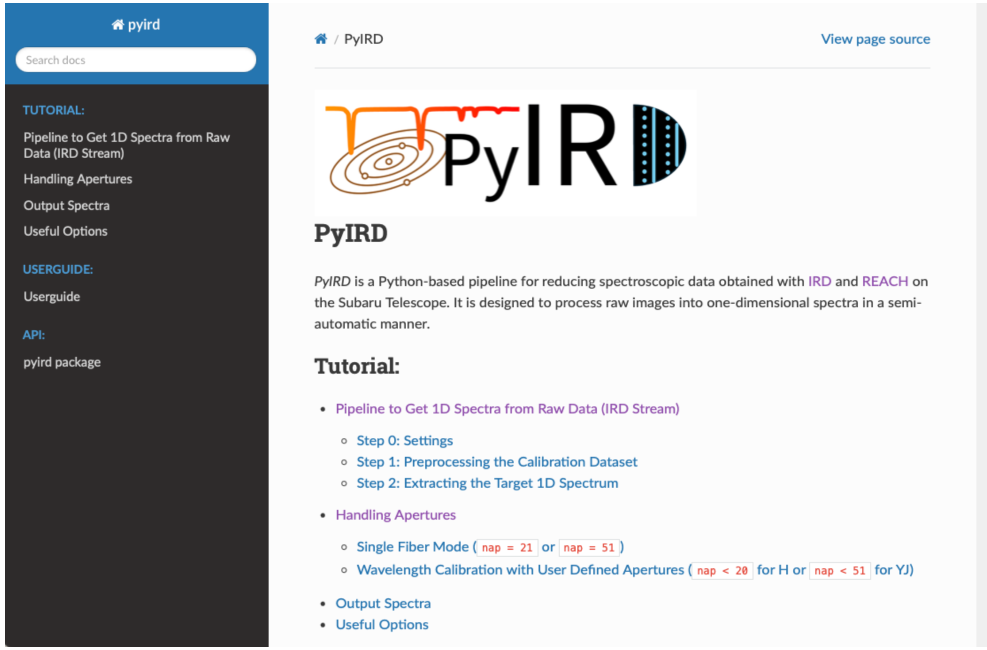
1. **Fully Python-Based** Pipeline
2. Enhanced **Readout Noise Pattern Removal**
3. **Automated Wavelength Calibration** Using Th-Ar Lines

PyIRD

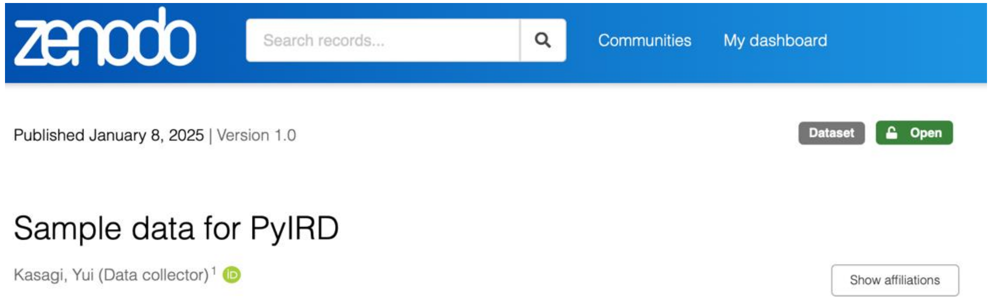
Yui Kasagi (ISAS/JAXA),
Hajime Kawahara (ISAS/JAXA, UTokyo), Ziying Gu (UTokyo), Teruyuki Hirano, Takayuki Kotani (ABC/NAOJ/SOKENDAI), Masayuki Kuzuhara (ABC/NAOJ), Kento Masuda (UOsaka)

# ➢ User Support Updated in the Latest Release (v1.1)

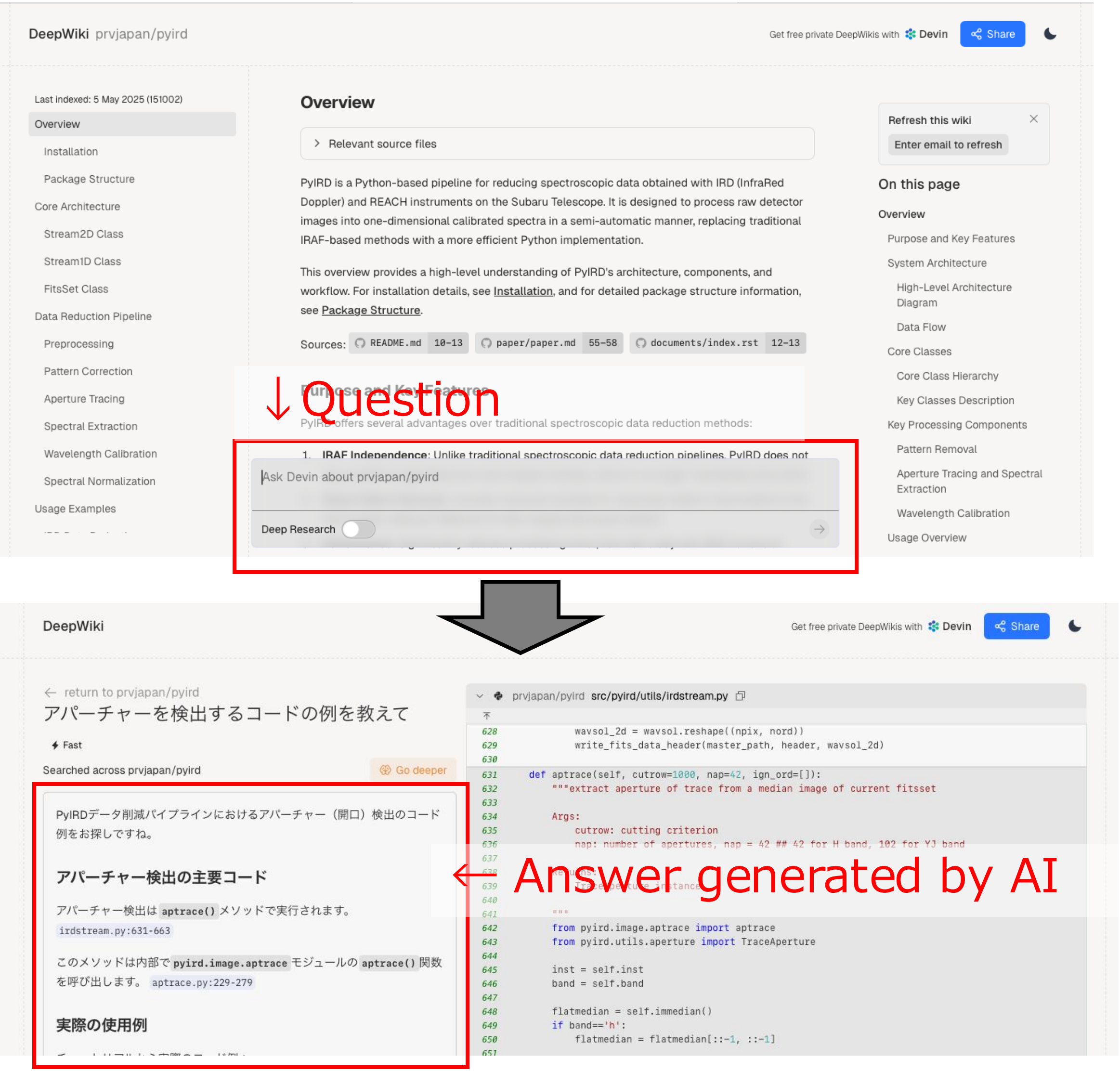
## ■ Document
https://secondearths.sakura.ne.jp/pyird/




## ■ Sample Data for Tutorial
https://zenodo.org/records/14614004



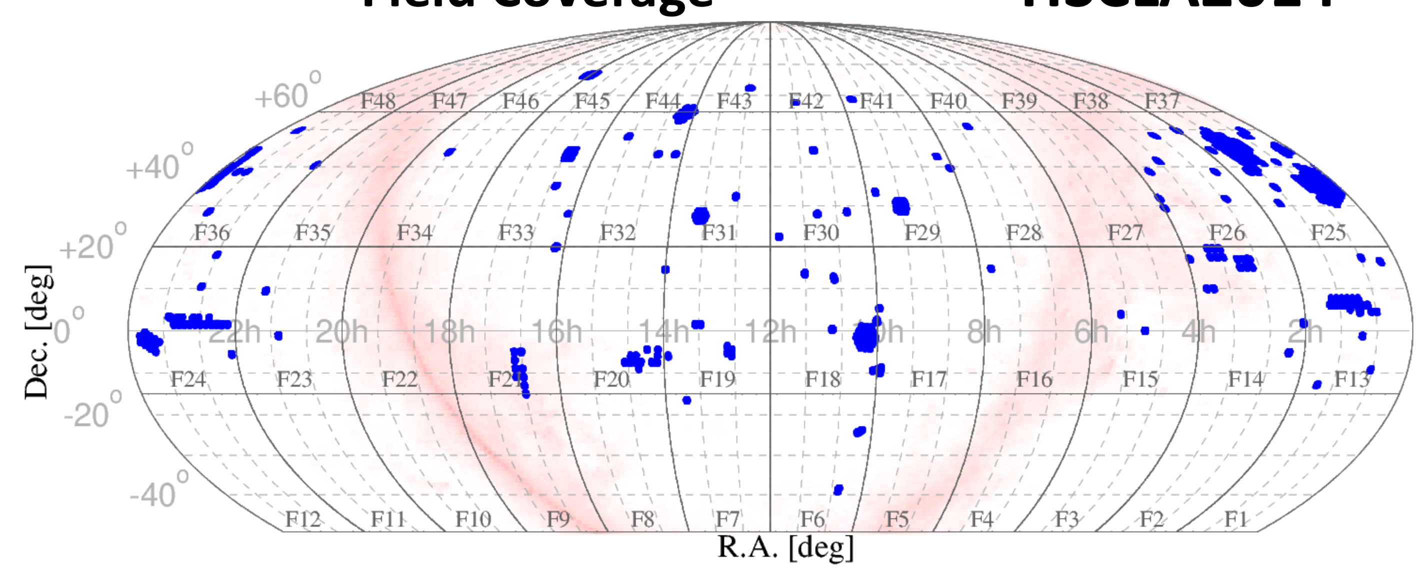

## ■ DeepWiki
https://deepwiki.com/prvjapan/pyird



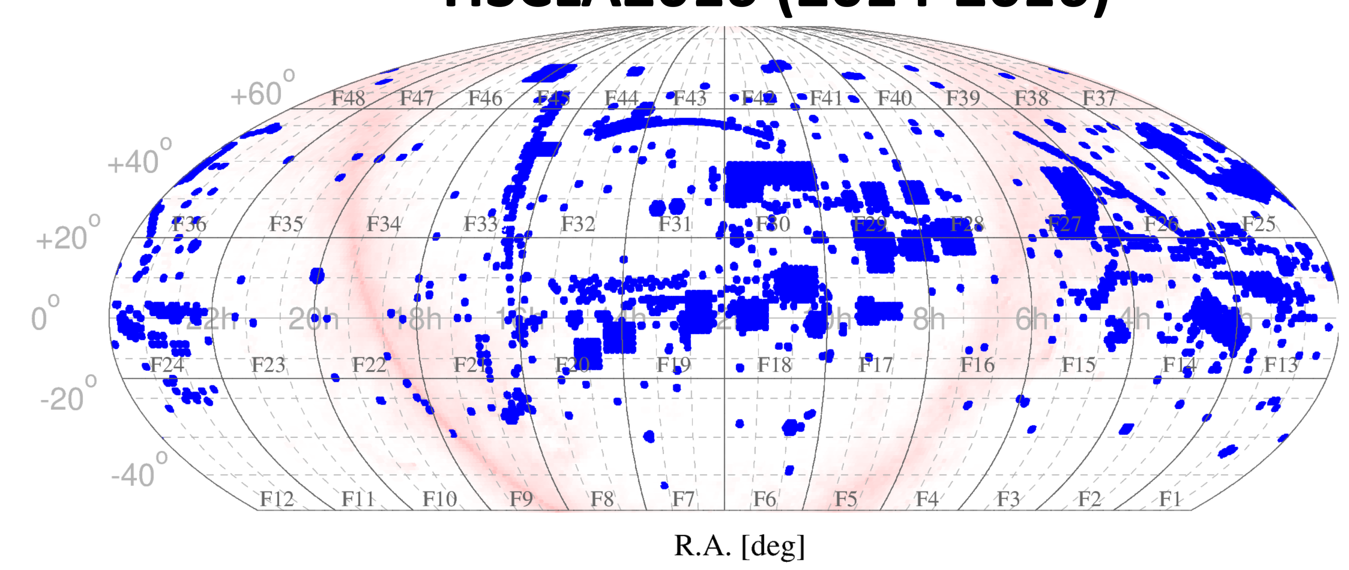
# The Hyper Suprime-Cam Legacy Archive: Expanding Access to Science-Ready Data from 2014–2020

Field Coverage

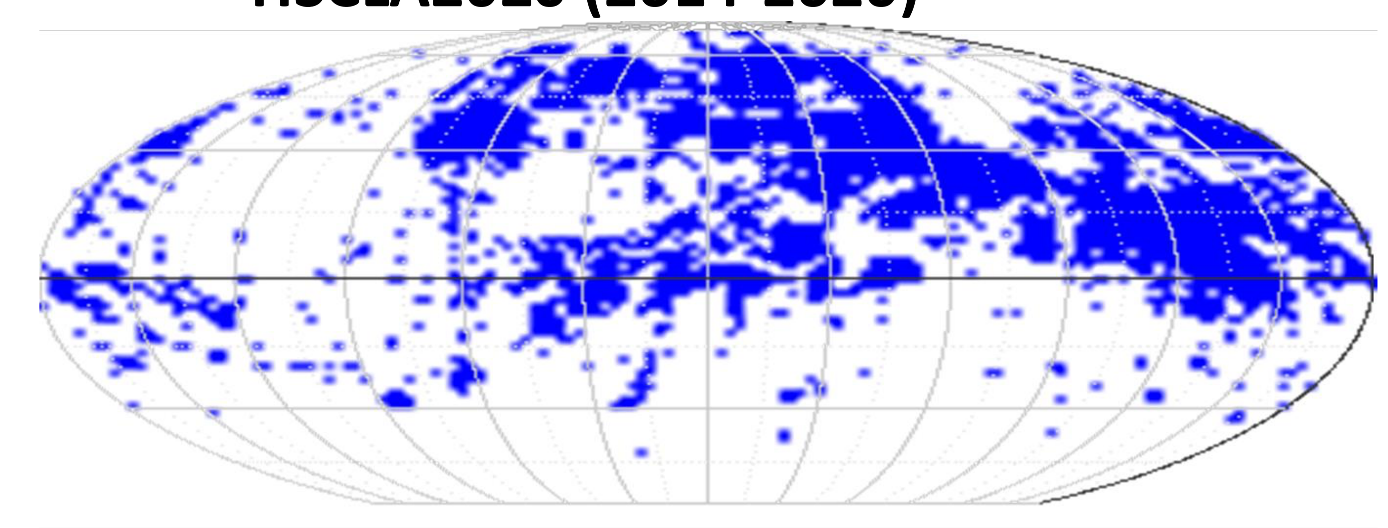
HSCLA2014



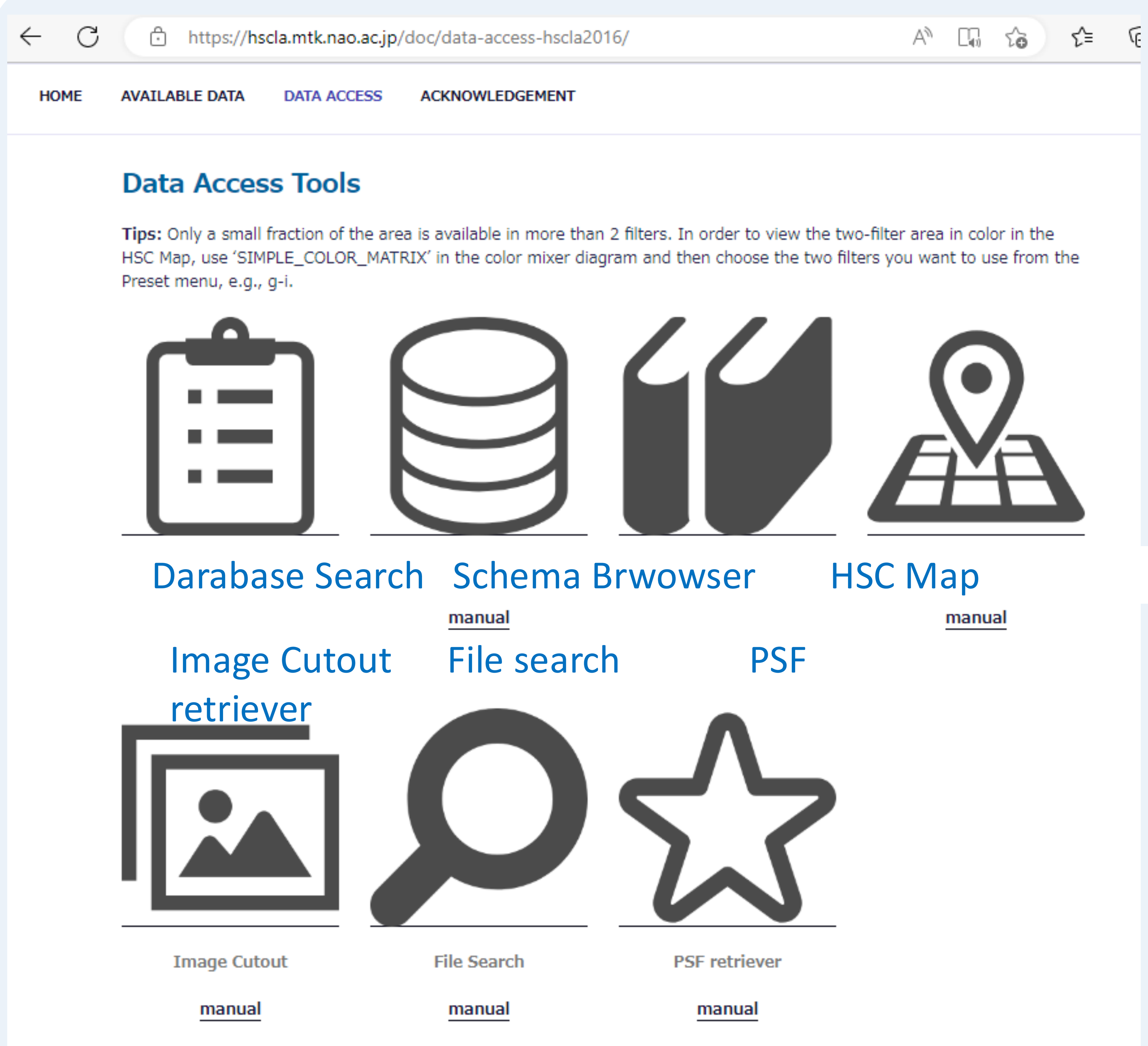

HSCLA2016 (2014-2016)

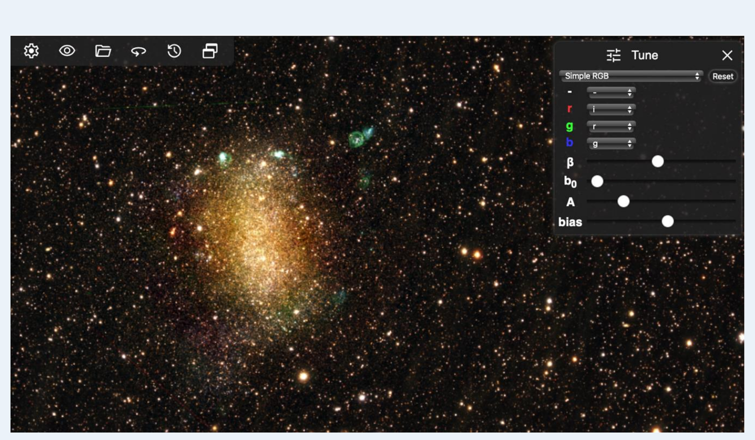


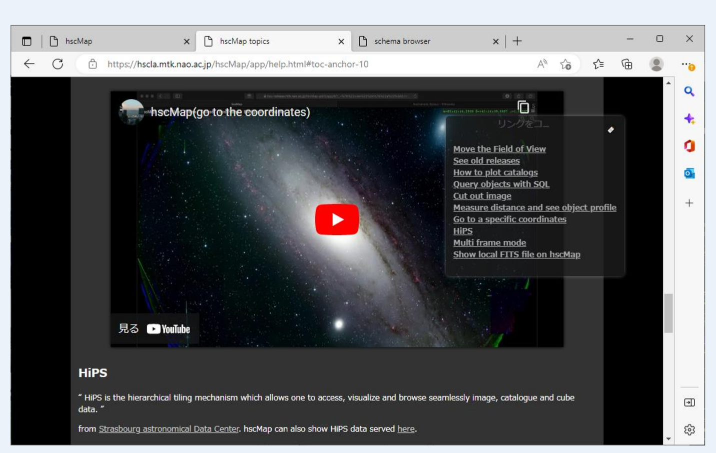

HSCLA2020 (2014-2020)



There are several tools to access HSCLA data.



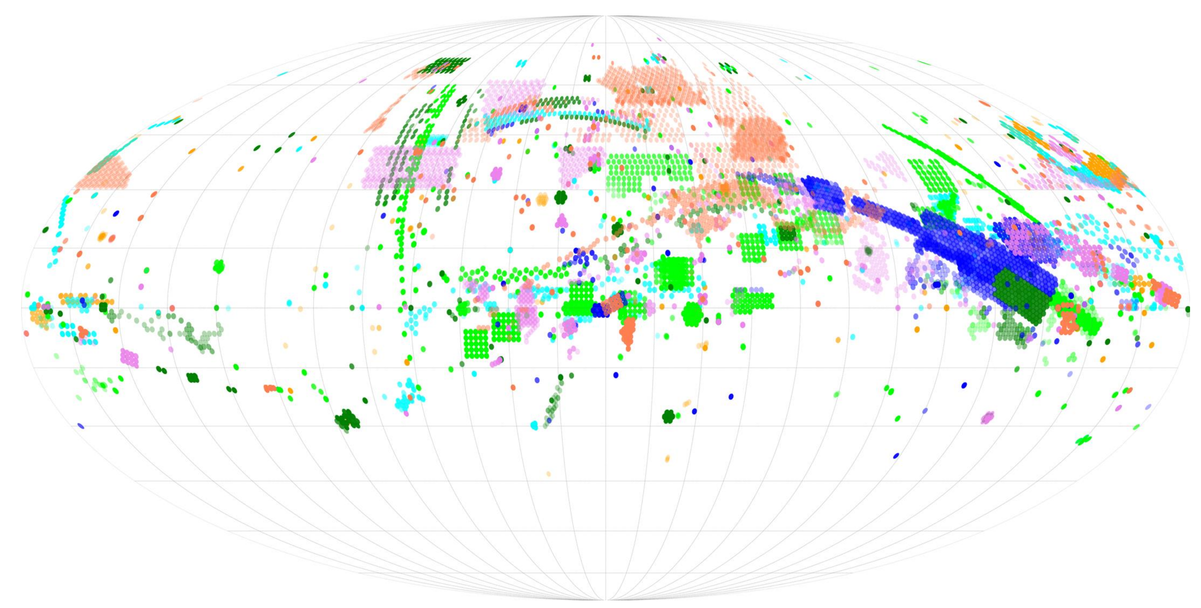



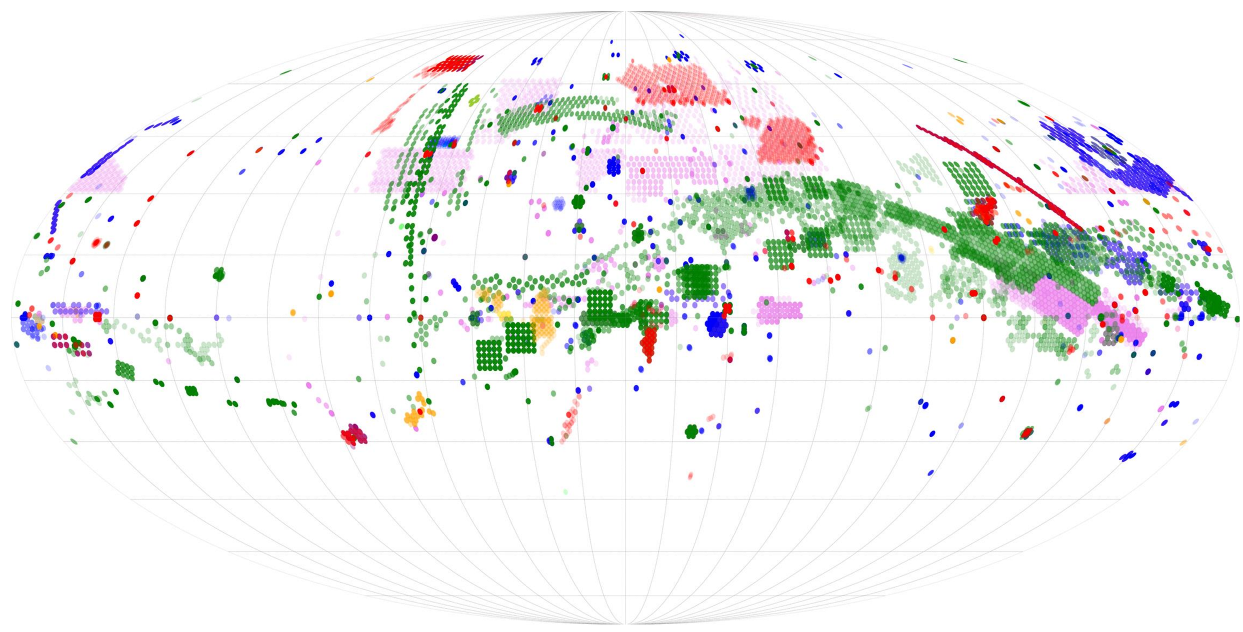
**HSCMAP**
(https://hscla.mtk.nao.ac.jp/hscMap/)is a very user-friendly tool to access data.
You could access the data through HSCMAP.
There are 10 movies to explain how to get HSCLA data from HSCMAP

## Comparison

| The Number of | HSCLA 2014 | HSCLA 2014-2016 | HSCLA2020 |
|---|---|---|---|
| **visits** | 3065 | 18769 | 38817 |
| **tracts** | 772 | 3654 | 6003 |
| **area** (deg^2) | 580 | 3400 | 7300 |
| **Objects** (isPrimary) | 152190170 | 767558512 | 1513917679 |
| **hours** | 149hrs. | 789hrs. | 1655hrs. |
| **pipeline** | v6 | v8.4 | v8.4 |

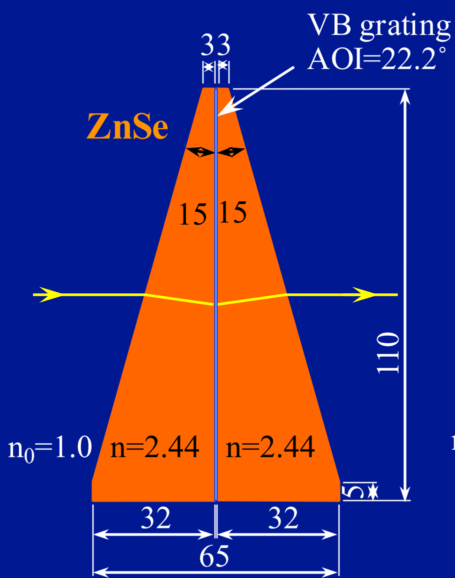
| year | visit |
|---|---|
| 2020 | 6153 |
| 2019 | 5342 |
| 2018 | 3249 |
| 2017 | 5422 |
| 2016 | 9599 |
| 2015 | 5680 |
| 2014 | 3372 |



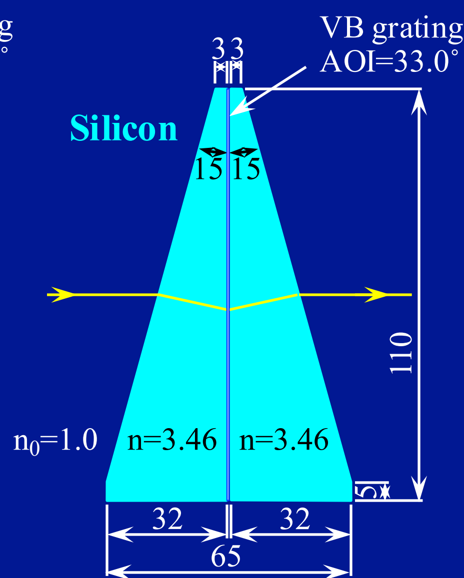
| filter | visit |
|---|---|
| IB0945 | 58 |
| NB0387 | 90 |
| NB0400 | 39 |
| NB0468 | 142 |
| NB0515 | 489 |
| NB0527 | 69 |
| NB0656 | 21 |
| NB0718 | 63 |
| NB0816 | 437 |
| NB0921 | 510 |
| NB0926 | 90 |
| NB0973 | 57 |
| HSC-G | 10183 |
| HSC-I | 7140 |
| HSC-R | 13763 |
| HSC-Y | 1414 |
| HSC-Z | 4252 |

# P4 Novel Transmission Gratings with High-dispersion, High-efficiency and Wide Bandwidth III

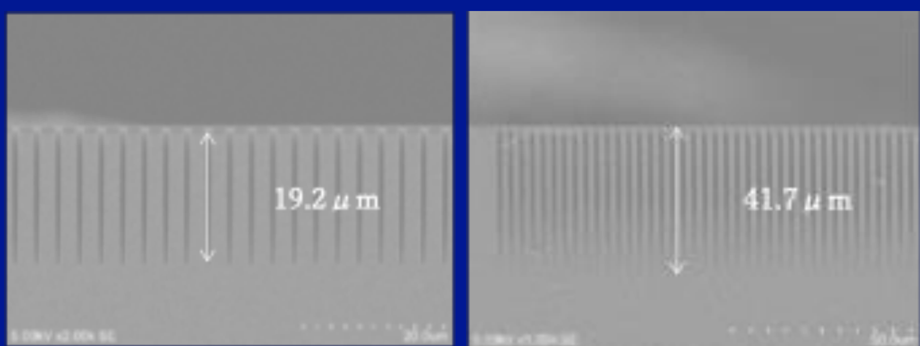
## Silicon VB Grating for H-K Band Grism of SWIMS



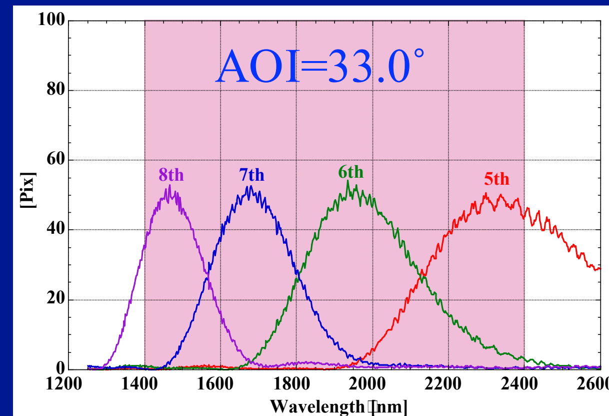

R=3,430

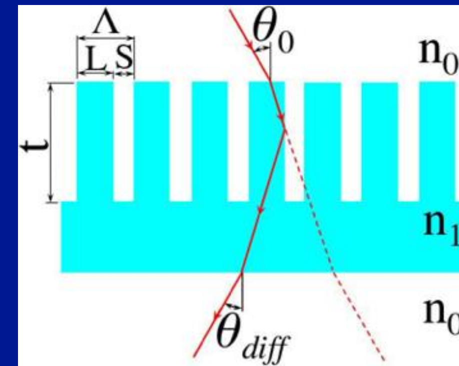



R=5,300



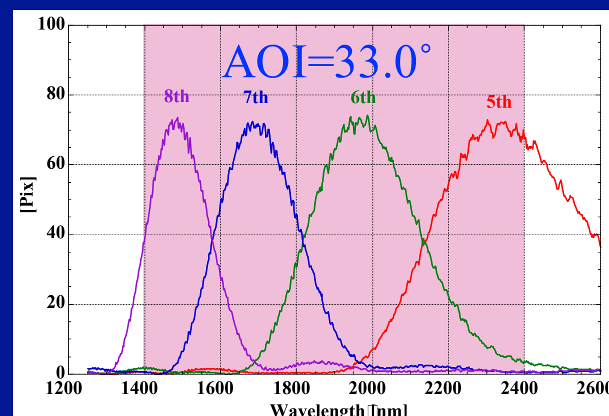

SEM photograph of cross section of test fabrication of VB grating processed by silicon deep RIE.

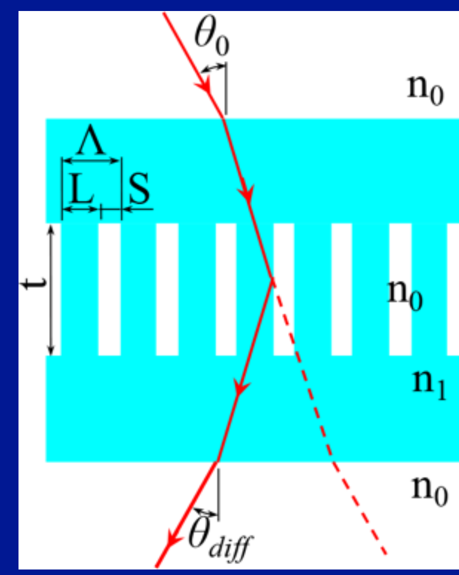



Open type Si VB grating

$n_1$=3.455@1.9 μm, Λ=10.75μm (93.0 lp/mm)
L&S=19:1, t=60 μm, Aspect ratio=1:111.6



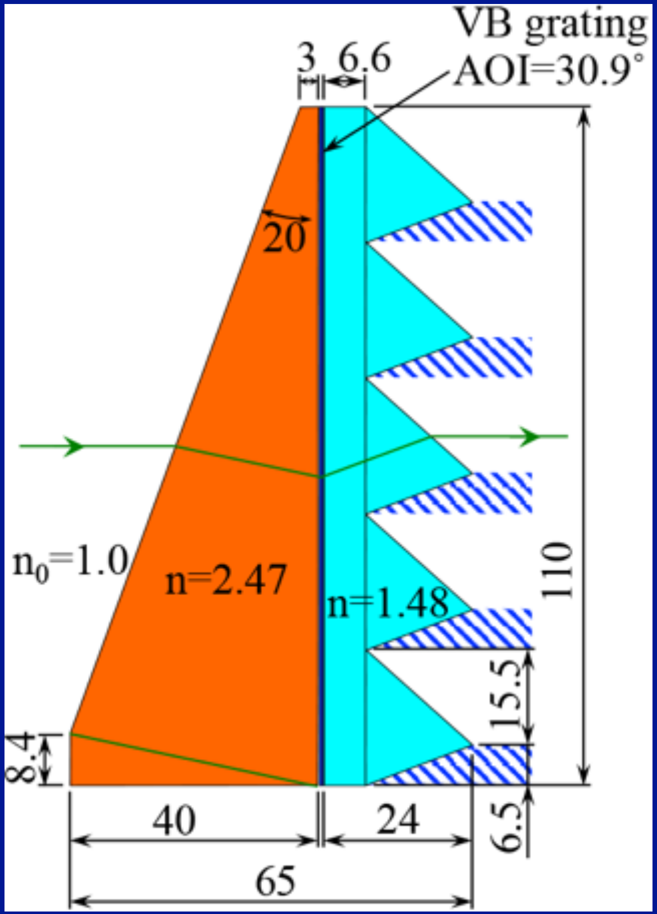




Closed type Si VB grating

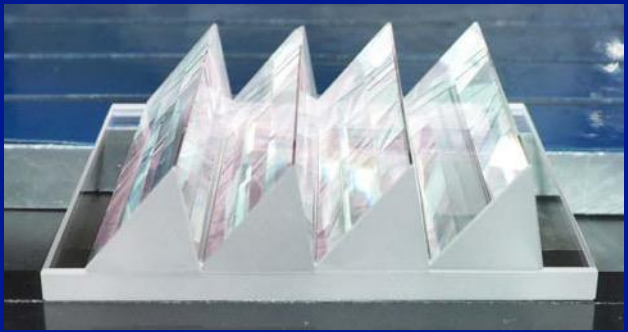
$n_1$=3.455@1.9 μm, Λ=10.75μm (93.0 lp/mm)
L&S=19:1, t=58 μm, Aspect ratio=1:107.9

# Prism Array for Grism

To reduce the thickness of grism of SWIMS z-J band, we are developing a prism array for the grism.

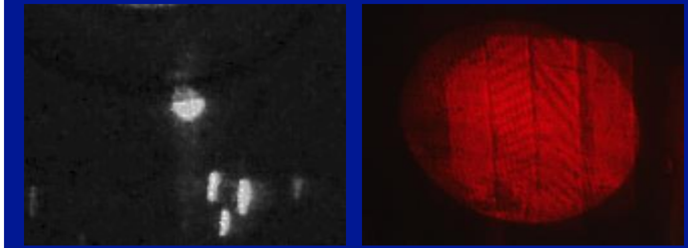


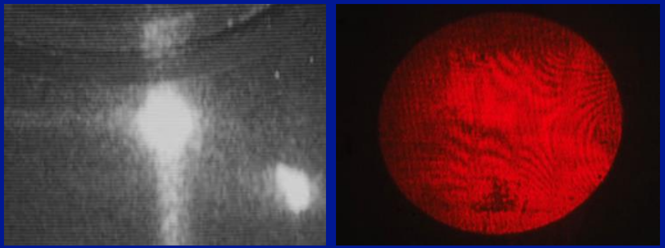

VB grism with ZnSe prism and prism array for exit side. AOI of the VB grating is 30.9°. This value is sufficient for z-J band grism of SWIMS.



Prism array for exit side.

Jig with a tilt adjustment mechanism for prism arrays bonding.



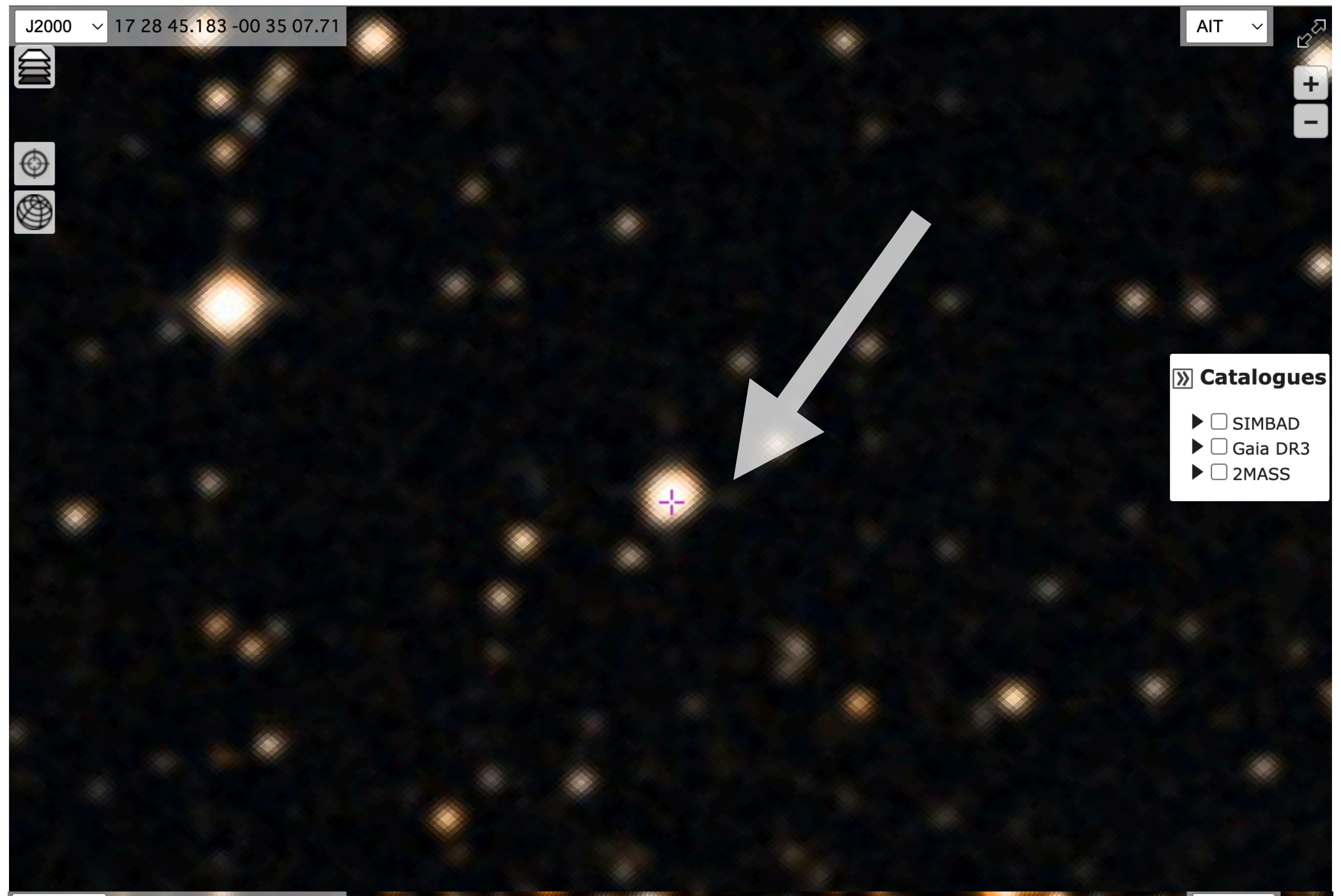


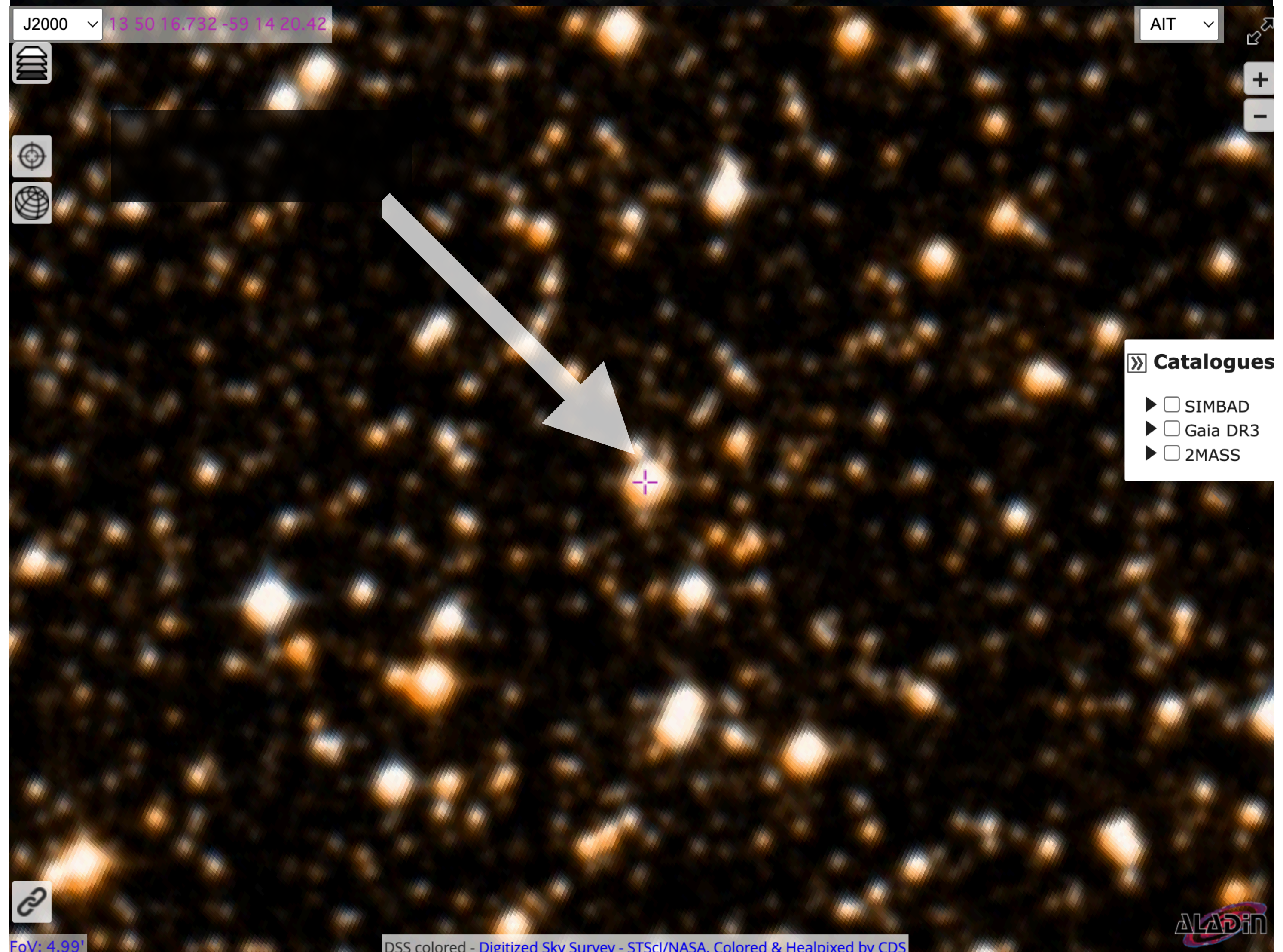
Experiment on bonding prism arrays using a jig with a tilt adjustment mechanism.

Left: Simply attaching the prism rods to the glass substrate with matching oil allows for adjustment of the wavefront parallel to the prism rods, but not in the perpendicular direction.

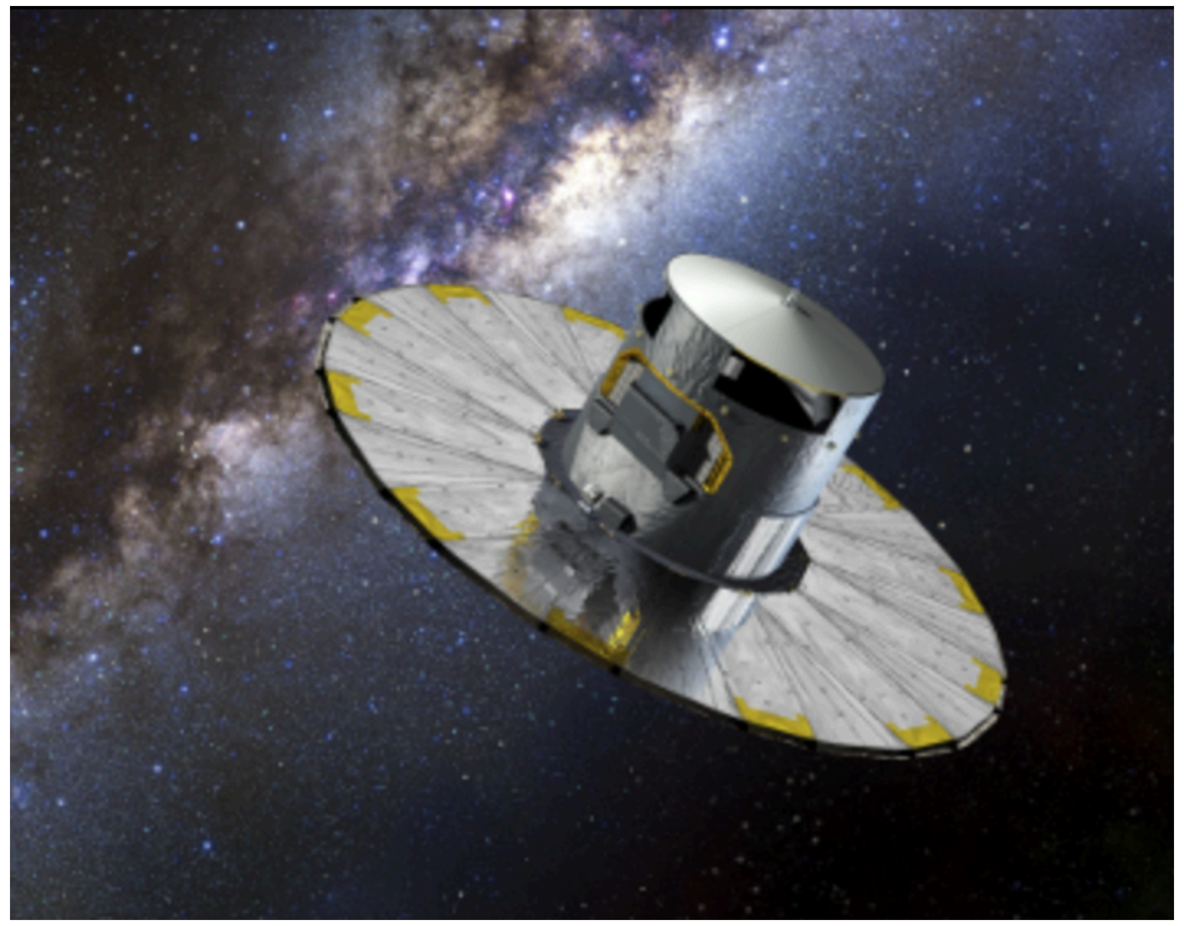
Right: By attaching a piece of plastic wrap (approximately 2mm wide, t~11μm) to the edge of the glass substrate with UV-curing resin, adjustment in the perpendicular direction became possible, and the wavefronts of the four prism rods could be made almost parallel.

# Search for long-period binary stars with compact objects

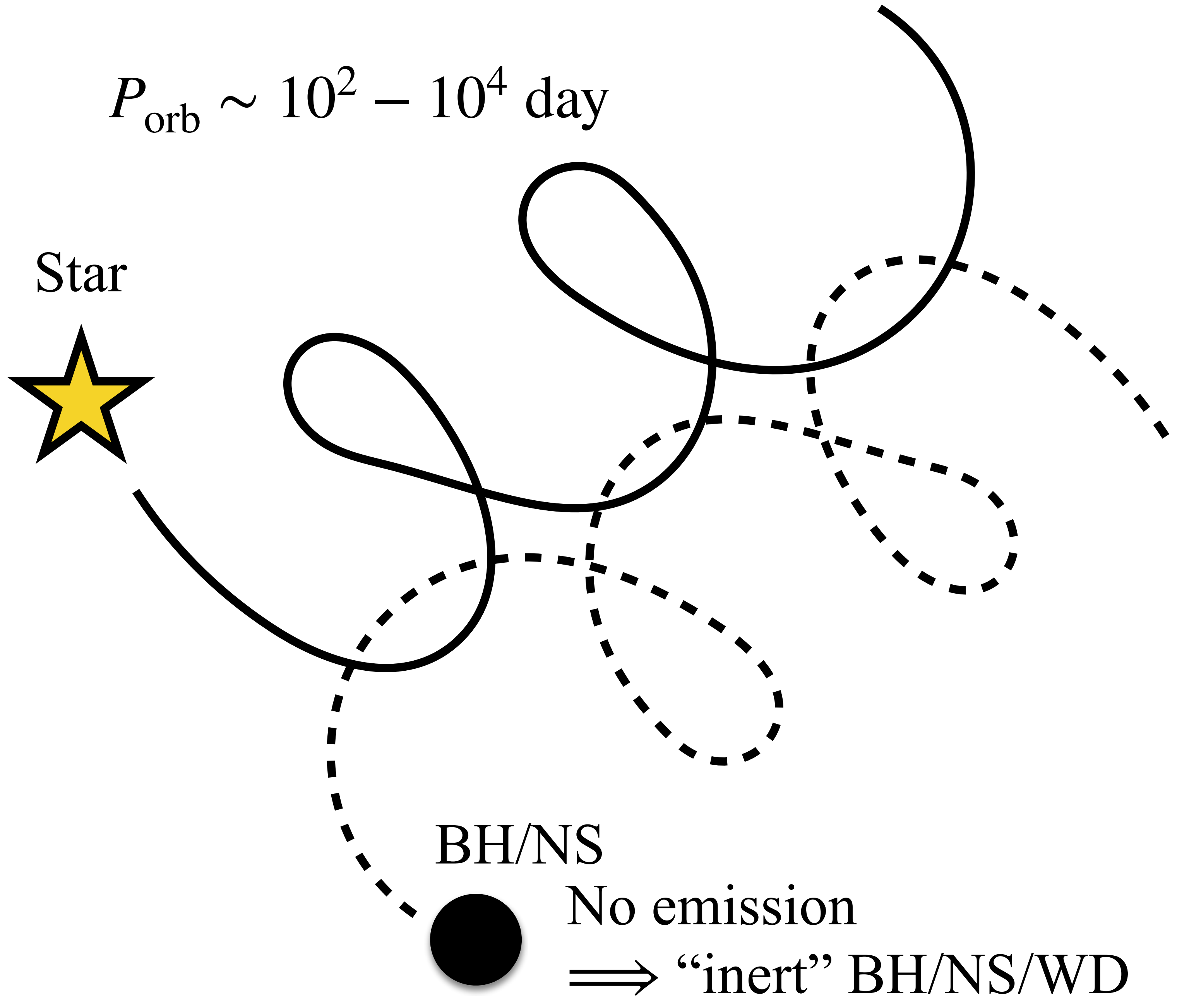


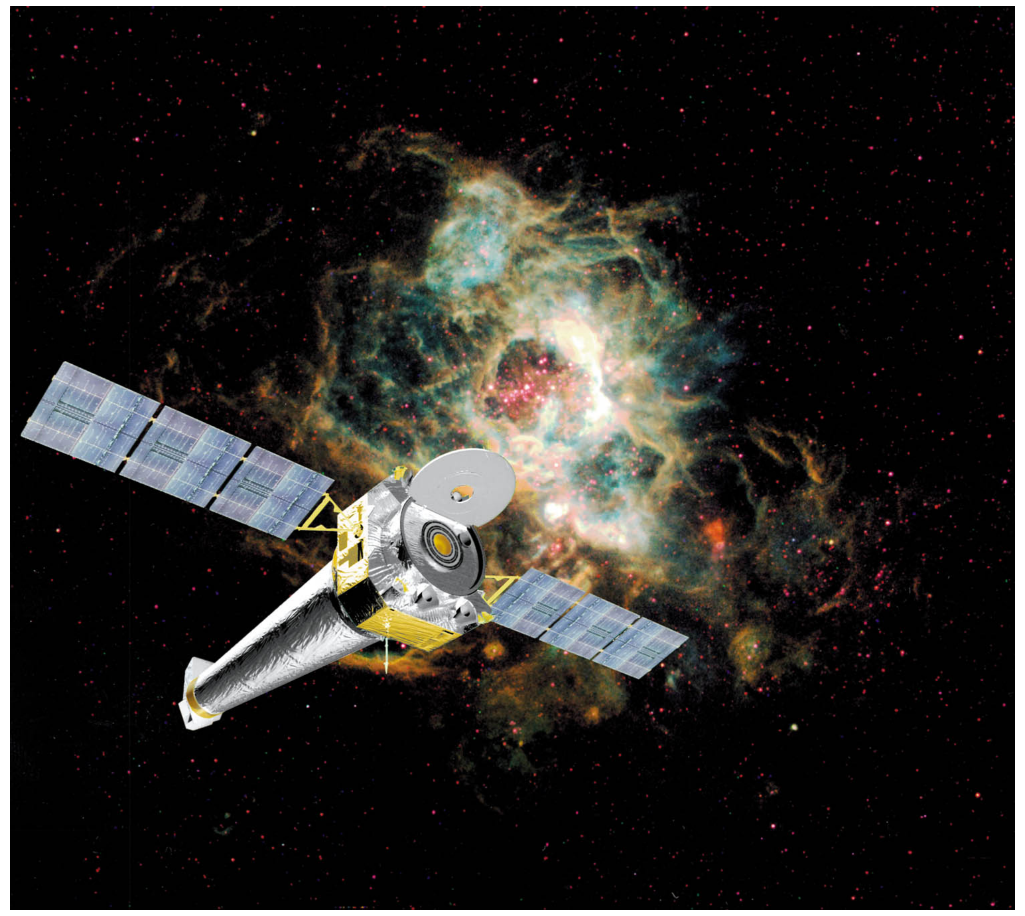

Astrometry telescope “Gaia”



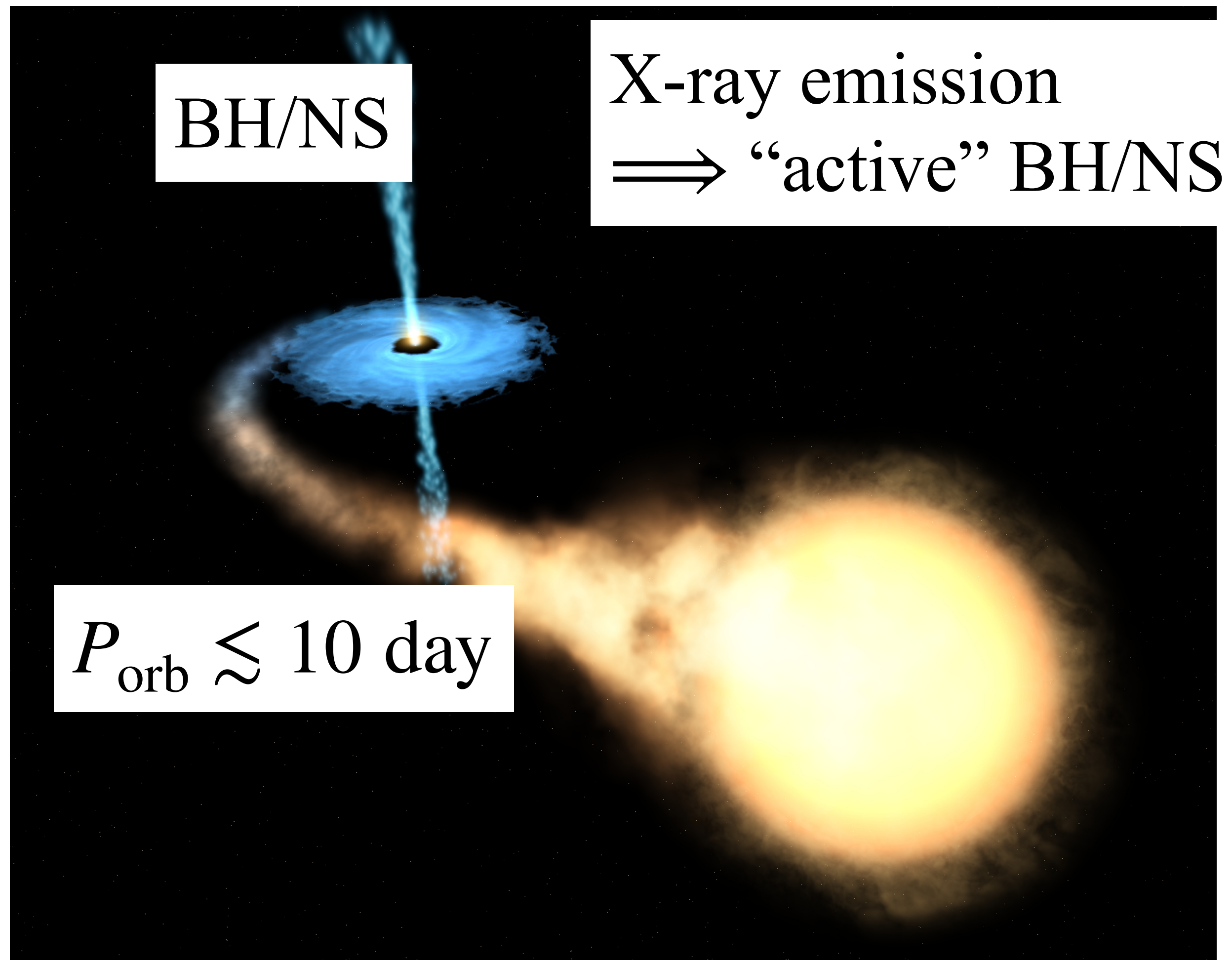
Observation




X-ray observertory “Chandra”



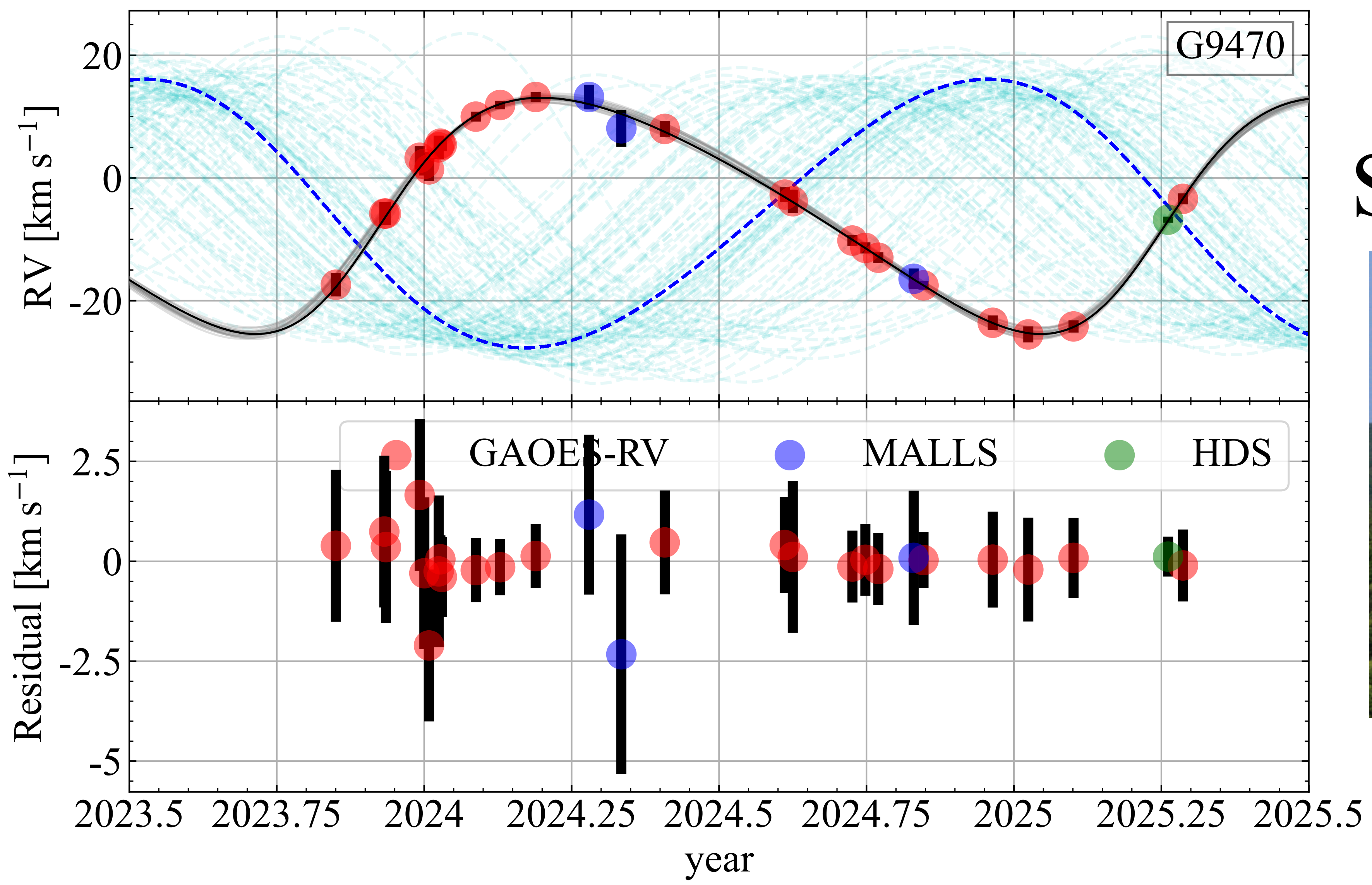
Observation

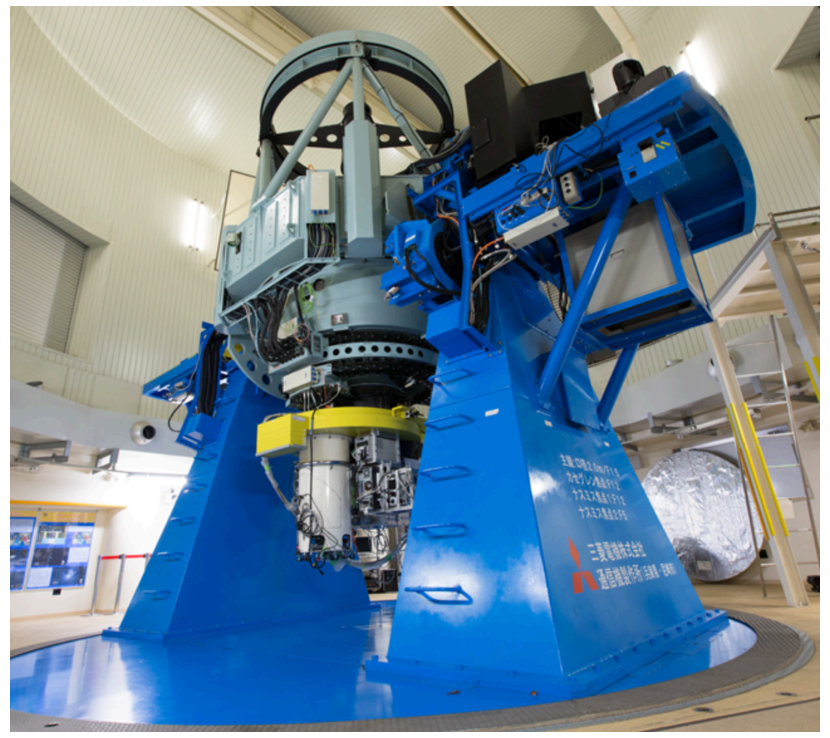


# Selecting candidates from Gaia DR3

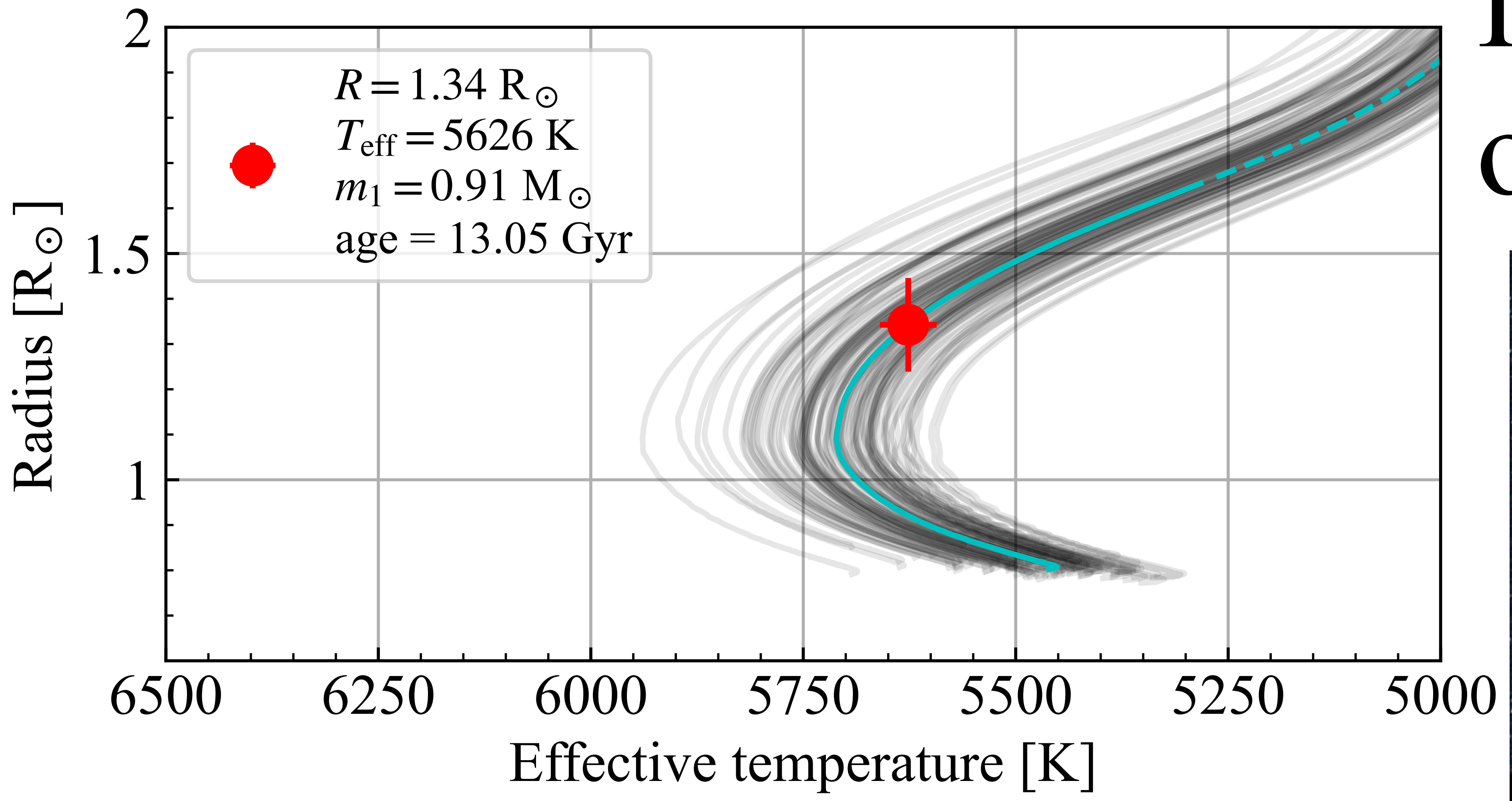
## Radial velocity monitoring by

Seimei GAOES-RV NAYUTA MALLS



## Isochrone fitting to weigh primary star based on observation of Subaru HDS




Two massive WD candidates

| $f_\mathrm{m}$ [$\mathrm{M}_\odot$] | $m_1$ [$\mathrm{M}_\odot$] | $m_{2,\mathrm{min}}$ [$\mathrm{M}_\odot$] |
|---|---|---|
| $0.431^{+0.033}_{-0.031}$ | $0.87^{+0.03}_{-0.02}$ | $1.24^{+0.07}_{-0.06}$ |
| $0.351^{+0.024}_{-0.024}$ | $1.00^{+0.03}_{-0.03}$ | $1.19^{+0.06}_{-0.06}$ |

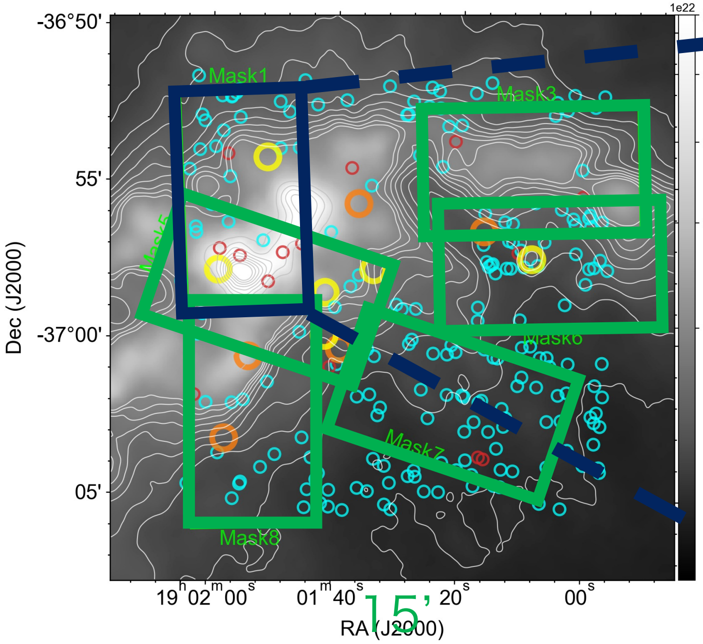
# Subaru/MOIRCS Wide-field Multi-object Spectroscopy of Very Low-mass Objects in the R CrA region

Takahiro KANAI, Yumiko Oasa (Saitama Univ.) P06

Very low-mass objects: brown dwarfs(<0.08$M_\odot$) and planetary-mass objects(<0.013$M_\odot$).
NIR photometric/spectroscopic surveys in various star forming regions
→ reveal IMFs and formation process of VLMOs.

## UKIRT/WFCAM JHK Photometric Survey

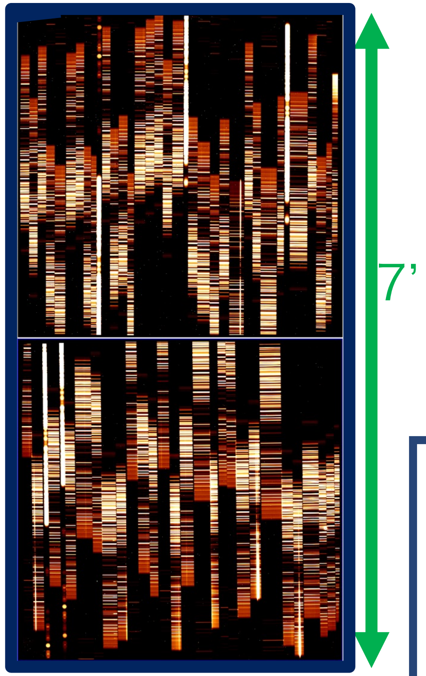
**Identify VLMO candidates**

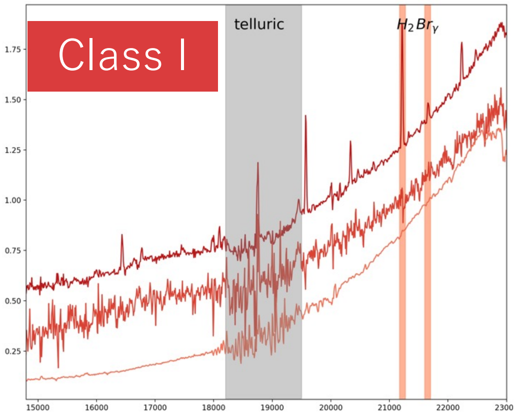


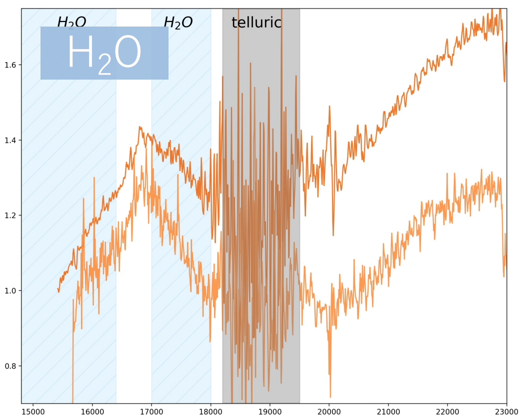

~ 200 VLMO candidates were identified in the R CrA region (Kanai & Oasa 2025)

## Subaru/MOIRCS Follow-up Spectroscopy

**Confirm young VLMOs**




Obtained ~300 spectra including ~100 VLMO candidates using MOIRCS

Water absorption bands were detected that are features of cool stars

# Initial Analysis Results of Subaru/HSC Observations of TNOs for New Horizons Navigation Support (P.7)

Neo YAMASHITA (KWANSEI GAKUIN UNIVERSITY )

## Purpose

**Understanding the structure of the outer solar system!**

↓

The New Horizons mission

**To study the unexplored regions of the solar system**

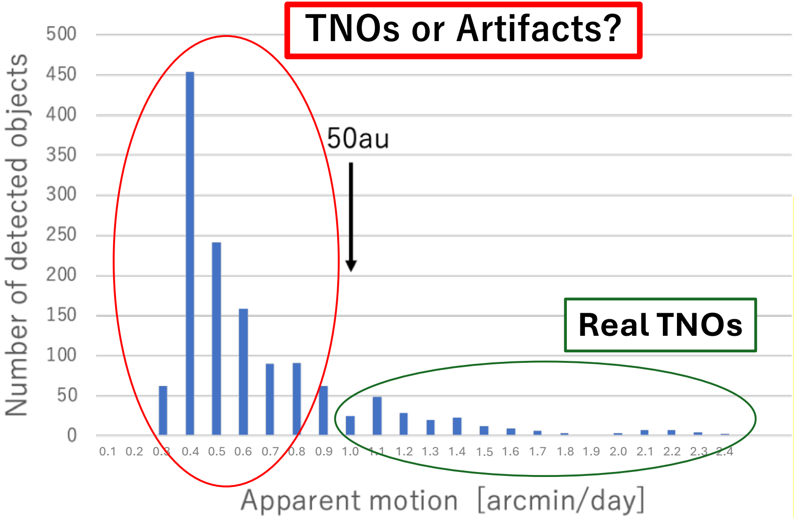
↓

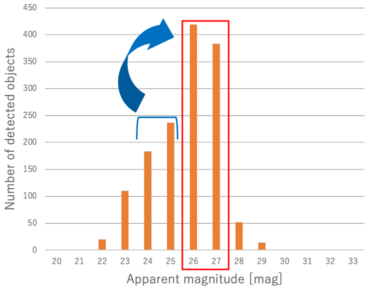
Using the Subaru Telescope and HSC

**Discover KBOs that the NH spacecraft can flyby.**

# Detected many TNO candidates,

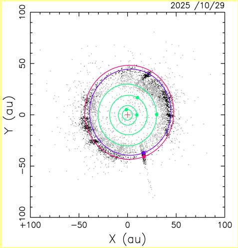
**with a detection limit of 26-27 mag in the 2024 data.**




## Two new TNOs

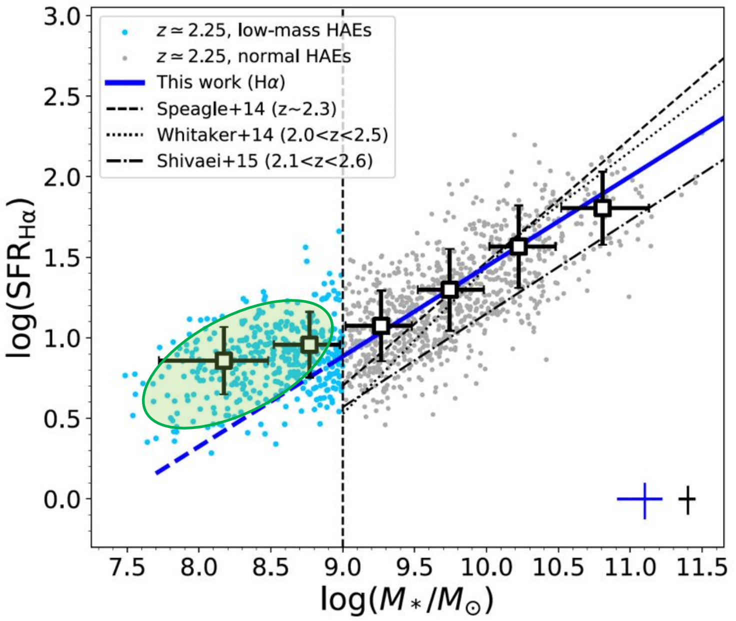
were found in the 2020 data.

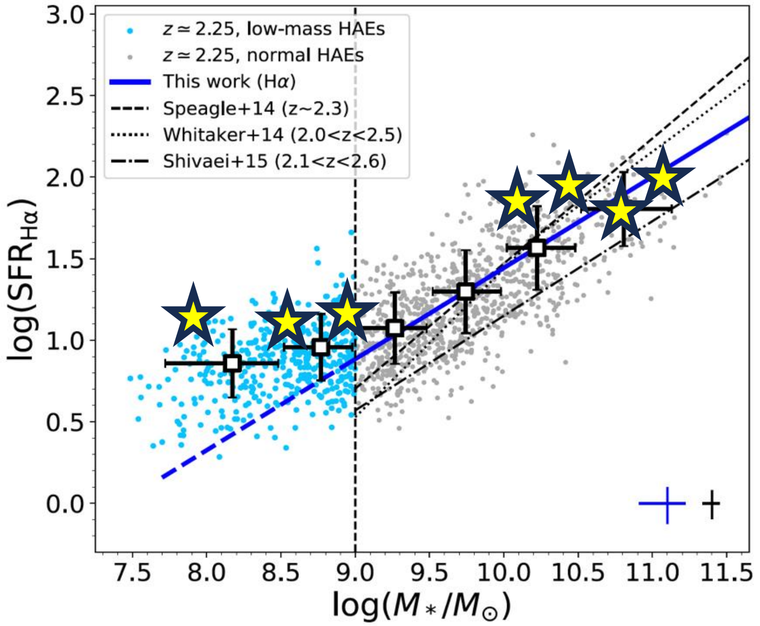


# Low-mass with high-SFR Hα emitters at z ~ 2 in ZFOURGE-COSMOS field

Authors: Jeung Yun[(1)], Kentaro Motohara[(1),(2)], Kosuke Kushibiki[(2)], Nuo Chen[(3)], Masahiro Konishi[(1)], Tomoya Yukino[(1)], Shuhei Koyama[(2)]

(1): The University of Tokyo, (2): NAOJ, (3): Tohoku University




### Select Hα emitter at z ~ 2

- ZFOURGE-COSMOS field survey data
- Use Ks-filter flux excess method
- Low-mass galaxies ($M_* < 10^9 M_\odot$) : SFR > main sequence

### Research goal

- Verify Ks-filter excess method
- Find features of low-mass with high SFR galaxies

### Observation

- Telescope: Subaru telescope with SWIMS
- Total exposure time: ~ 250 minutes
- Spectral resolution: R ~ 1000
- Slit width and length: 0.5″ , 10″
- Multi object spectroscopy

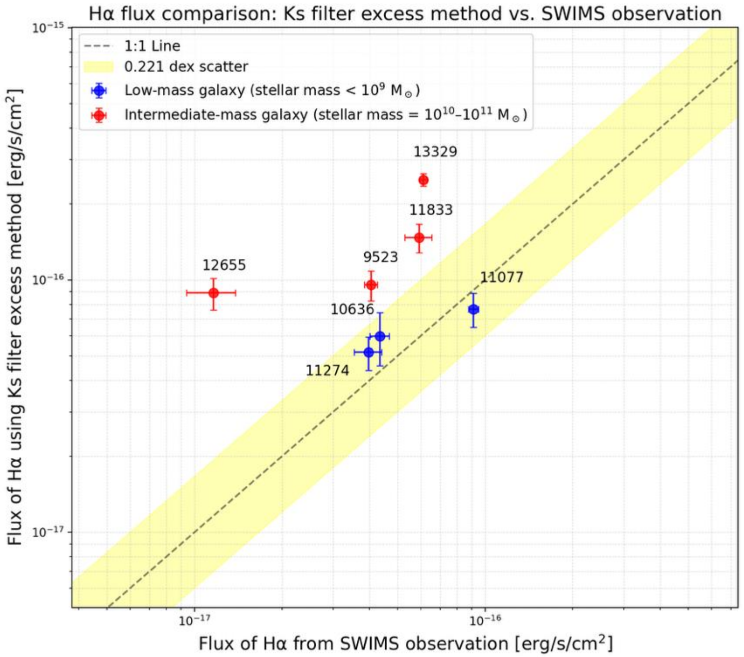
# Result

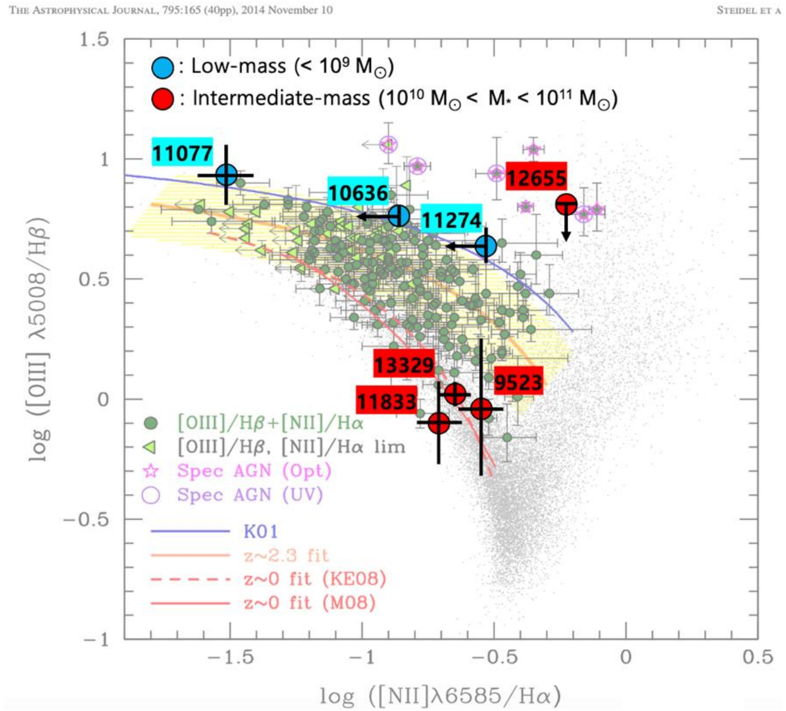
## 1. Comparison of Ks-filter excess method with spectroscopic observation

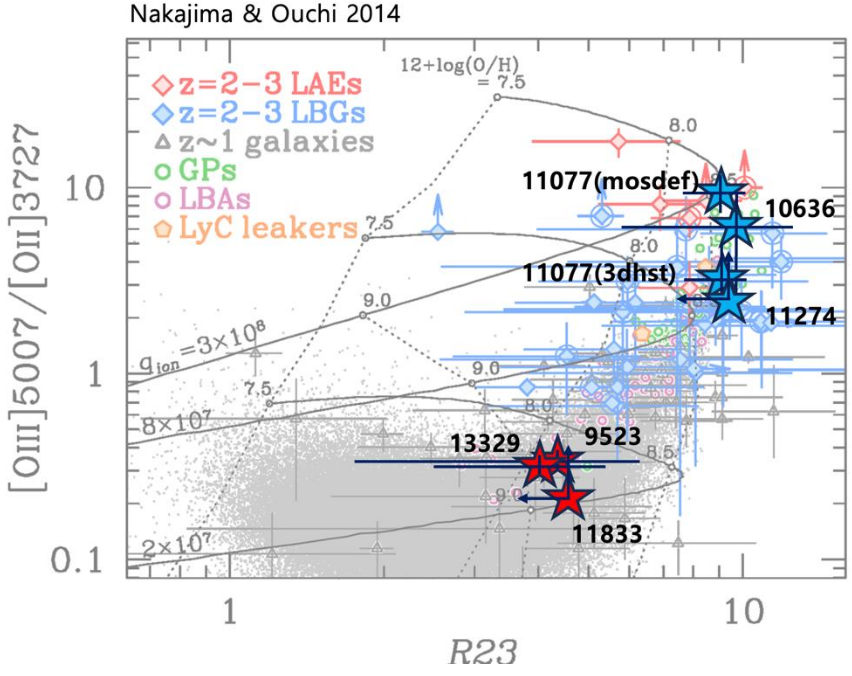
- Low-mass: near the 1:1 line
- Intermediate-mass: far from the 1:1 line
- Slit-loss effect
    - Low-mass: star formation distribution is small
      → easy to fit galaxy within slit
    - High-mass: star formation distribution is large
      → difficult to fit galaxy within slit

## 2. Features of low mass with high SFR galaxies:

- Coexistence of Hα and [O III]
- Flux of [O III]5007 > Flux of Hα
- Not detected [O II] and [N II] emission lines
- Compact star-forming regions
- High [O III]5007/Hβ ratio
- High ionization parameter (U)
- Low metallicity
- Locating at the boundary between star-forming and AGN on the BPT diagram
- Lyman-α emitters (LAEs)



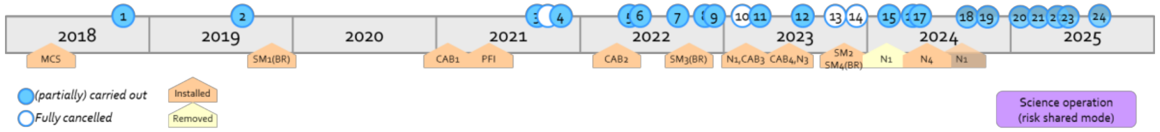



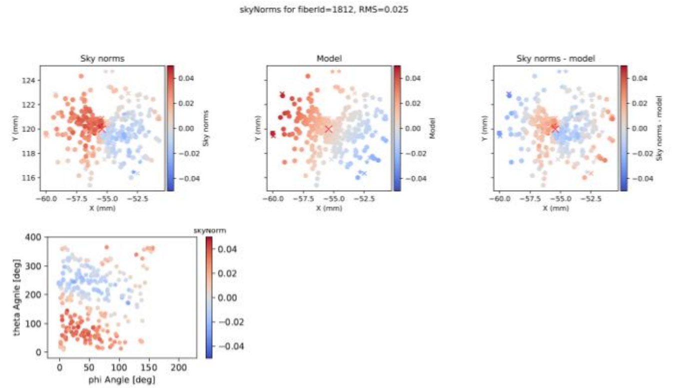
# Instrument Performance verified through the PFS engineering observations

Yuki Moritani[1,2], Kiyoto Yabe[1,2], Shintaro Koshida[1], Satoshi Kawanomoto[1], Robert Lupton[3], Craig Loomis[3], Arnaud Le Fur[3], Chi-Hung Yan[4], Jennfier Karr[4], Masayuki Tanakai[1] , Miho N. Ishigaki[1], Wanqiu He[1] , Arai Akira[1] , Vera M. Passegger[1] , Ichi Tanaka[1], Jim Gunn[3], Naoyuki Tamuara[1,2], and PFS development team. (1: Subaru Telescope, 2: Kali IPMU, 3: Princeton University, 4: ASIAA )

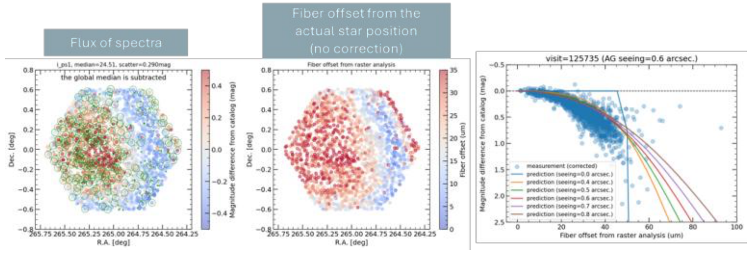
- Prime Focus Spectrograph:
  - Wide field (~1.25 deg2), High multiplexity (2394 reconfigurable fibers), Wide waveband (380nm-1260nm with three channels)
  - Science operation started in March 2025.
  - Commissioning is in the last phase: Stabilizing and Optimizing the instrument performance



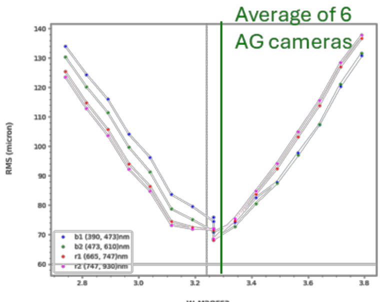

- The instrument performance
  - Throughput: comparable to expected model using the optics measurements and analysis.
  - A-few-hour variation was suppressed by applying the index matching gel on the fiber connectors.
  - Variation in the fiber patrol region is being modeled individually.




- Fiber configuration
  - Total configuration error is 20-50um (95%-tile. Higher at lower elevation.)
  - Fiber misalignment correlates with relative flux in FoV.
  - Software to measure the fiber position is being updated to improve the error.
  - Degradation of the fiber convergence started in 2025. The positioners are being full recalibrated.



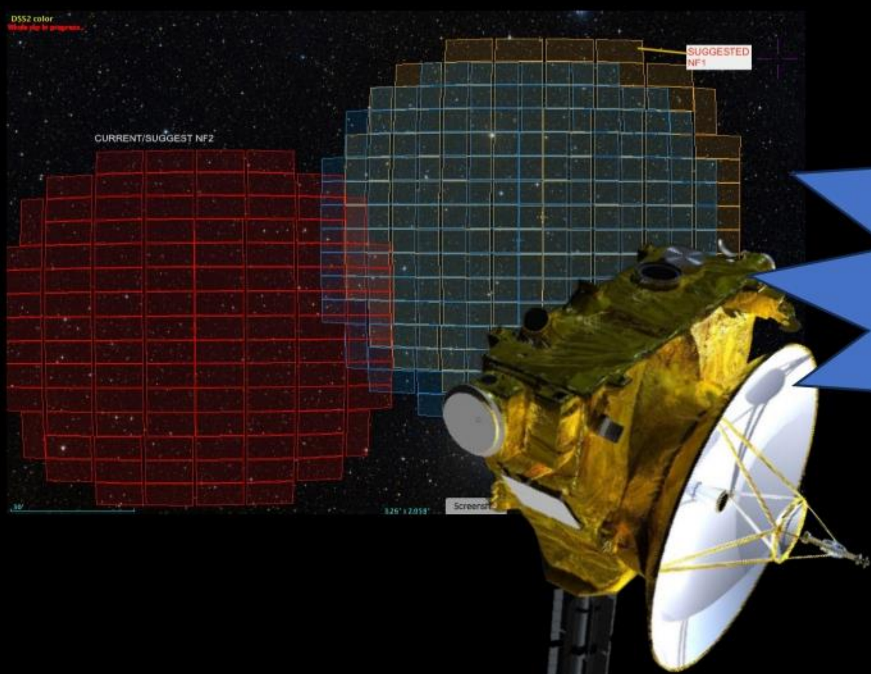

- Auto Guide cameras
  - Focus position is consistent with the fiber focus position.
  - Guide performance good, but guide error is large at few-star field.
  - Instability of the camera mount may affect the measurement.




- Remaining issues
  - Improve fiber configuration accuracy and guide performance at few-star field.
  - Hardware upgrade: SM2 detector replacement, AG support modification.

# Multi-Input Convolutional Neural Networks with Attention for Faint Moving Object Detection

**Masato SHIBUKAWA**
(SOKENDAI)




Analyzing HSC Data with Machine Learning

**Find KBOs!!**

**Collaborators:** Fumi YOSHIDA (University of Occupational and Environmental Health・Chiba Institute of Technology University), Toshifumi YANAGISAWA (Star Signal Solutions Co., Ltd.), Takashi ITO (NAOJ), Hirohisa KUROSAKI (JAXA), Neo YAMASHITA (KWANSEI GAKUIN UNIVERSITY), Makoto YOSHIKAWA(JAXA), O Hosei(The University of Tokyo), Akira Hatakeyama(SOKENDAI), Naoya Ozaki(JAXA)

## Background

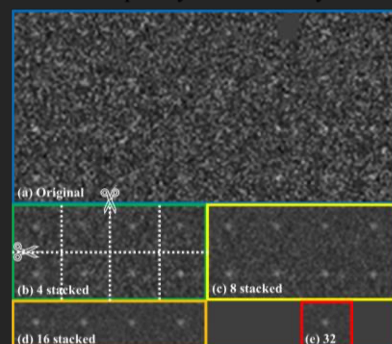
We are searching for **faint Kuiper Belt objects** by stacking images acquired with HSC.

## Method

### (i) Observation with Hyper Suprime Cam

Hyper Suprime Cam

JAXA System

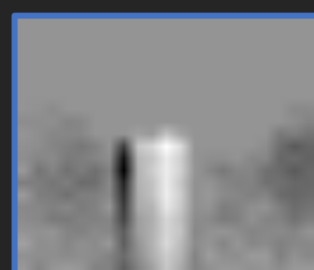



Output Images

### (ii) Machine Learning Classification

**CNN based Model (Our proposal)**

**Object**



**Noise**

## Result

ML performance

- **AUC > 0.99**
- **ACC > 98%**
- **Error < 2%**

## Task reduction

- **99% reduction**

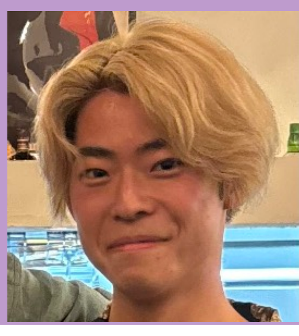
Contribution

- Analysis for deep stacked images
- Analysis for multiple images
  - Time series images
  - Multi-modal observation data

# The Origin of Phosphorus-rich Stars

P12


**Ryota Hatami** (SOKENDAI/NAOJ), Nozomu Tominaga, Koh Takahashi (NAOJ),
Noriyuki Matsunaga (U. Tokyo), Daisuke Taniguchi (TMU), Wako Aoki, Takuji Tsujimoto (NAOJ)


## Abstract

Precise measurements of phosphorus abundance in stars contribute not only to understanding chemical evolution of the universe but also to the origin of life because P is one of the most essential elements for earthly life. Available phosphorus absorption lines do not exist in the optical wavelength range, requiring observations in the near infrared (NIR) or ultraviolet, and until recently, such measurements were scarce. In recent years, observations by The Apache Point Observatory Galactic Evolution Experiment (APOGEE) have measured the P abundance of numerous stars using two absorption lines in the H band. Among these, P-rich stars with [P/Fe] > +1.0 have been discovered. Despite having [Fe/H] ~ -1.0, these P-rich stars contain almost equivalent P abundance of Sun. Furthermore, not only P but also elements surrounding P, such as Al, Mg, and Si, as well as s-process elements like Ce, are enhanced. Thus, their high P composition must be reproduced by simulations, including correlations with these elements. Therefore, the aim of this study is to confirm the chemical composition, including P, of the P-rich stars measured by APOGEE using Subaru/IRD. APOGEE only used the H band, but since four more usable P absorption lines exist in the Y band, Subaru/IRD allows for precise measurement using all available six lines in NIR. In the future, we will compare the confirmed abundances of these P-rich stars with results of the simulations of stellar and supernova nucleosynthesis to discuss whether the models can reproduce the observational abundances or not.


## 1.Introduction

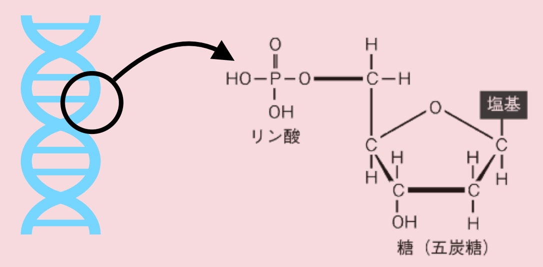
**<Phosphorus in the Universe>**

Components of DNA/RNA, ATP, and Phospholipid

→ Essential elements for earthly life

P synthesis site is not fully understood

DNA



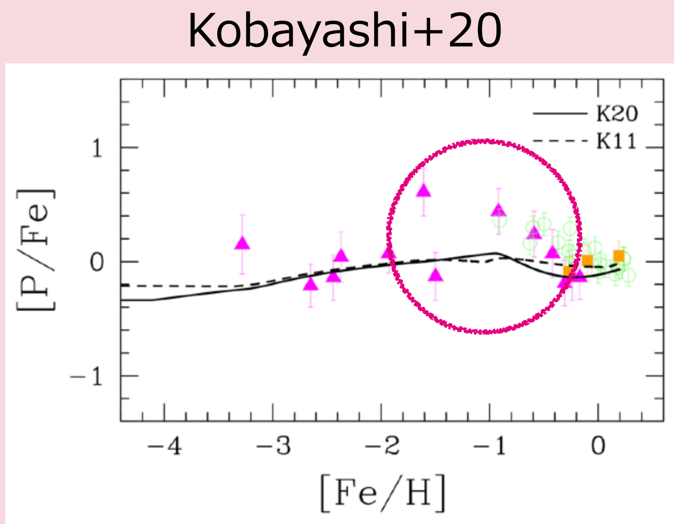
**<Phosphorus Synthesis and Evolution>**

P synthesis site …?

- Massive Nova (Bekki & Tsujimoto+24)
- Explosive Nucleosynthesis (Nomoto+13)
- C-O shell merger (Ritter+18)

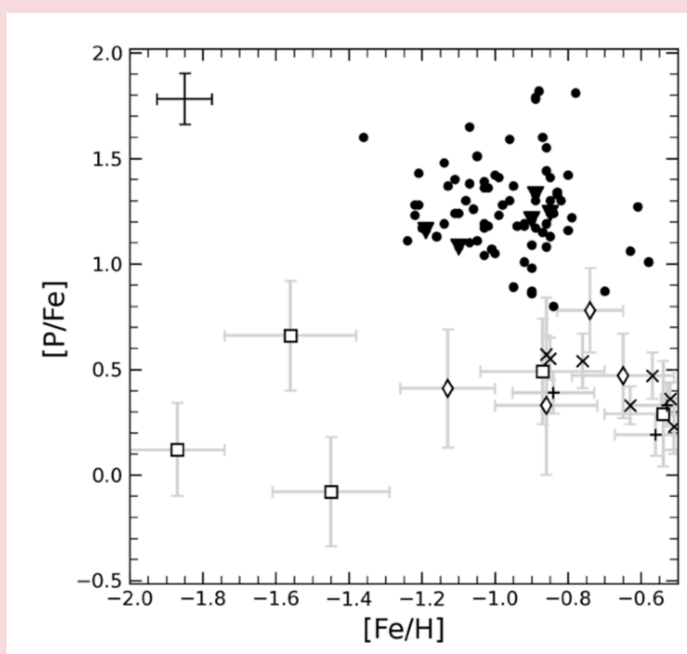
etc.

Kobayashi+20




Phosphorus abundance and its time evolution can't be reproduced by simulations around [Fe/H] ~ -1

Brauner+23




**<P-rich Stars>**

Even though P-normal stars abundance haven't been reproduced…

Recent observations revealed

**P-rich stars w/ [P/Fe]>+1.0**

(Masseron+20, Brauner+23)

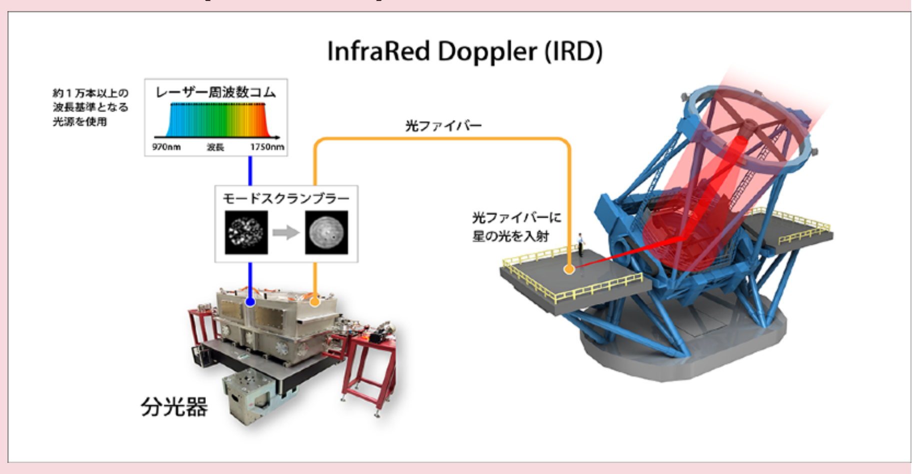
=＞Synthesis of P and other elements around P should be investigated!!

**<P Measurement w/ Subaru/IRD>**

P absorption lines are available in NIR or UV

- P-rich stars are observed only by APOGEE (H band)
- 2 available lines in H band
- 4 additional lines in Y band

=＞Using Subaru/IRD, we can measure P abundance more precisely




**<Aims>**

**Goal 1:Confirm the P abundance in P-rich stars**

**Goal 2:Reveal/Identify the origin of high-P abundance**

Step 1. Observe P-rich stars and measure the chemical abundances not only P but also other elements (e.g. Mg, Al, Si, K, Sc etc. …)

**Step 2**. Calculate nucleosynthesis in massive stars and compare with observational abundances (This Poster)

## 2.Observations

**<Observed P-rich Stars>**

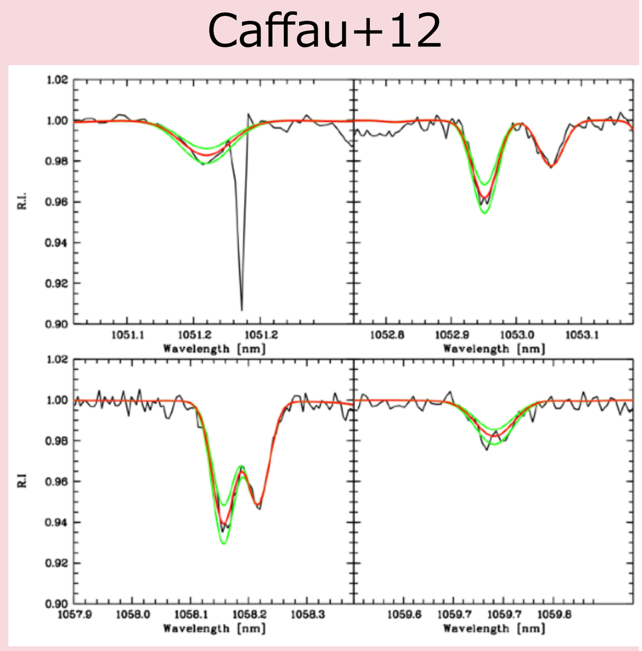
We have already observed 12 P-rich stars w/ Subaru/IRD and analysis is in progress……

**<Using Absorption Lines>**

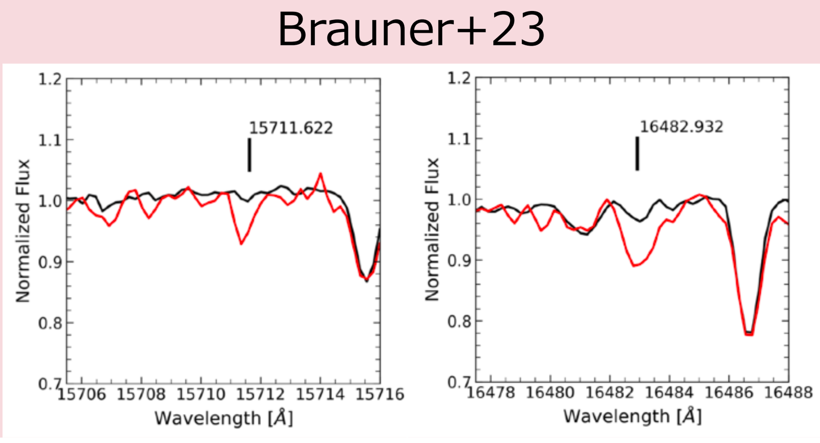
Y band (μm): 1051.2, 1053.0, 1058.2, 1059.7

H band (μm): 1571.1, 1648.3

Caffau+12



Brauner+23




## 3.P Synthesis in Massive Stars

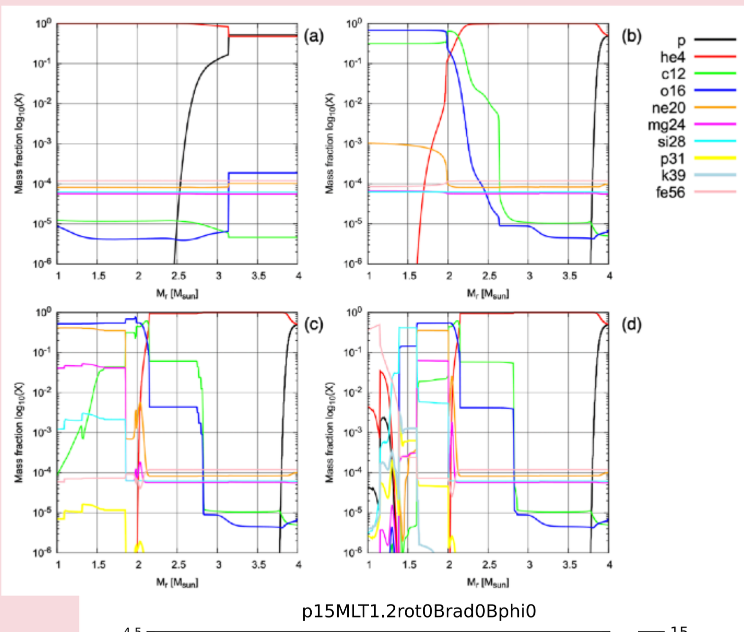
**<Stellar Nucleosynthesis>**

Calculation Code: HOSHI (Takahashi+18)

Parameters: $M_{\rm ZAMS}$, $Z$, $\alpha_{\rm MLT}$, $f_{\rm ov}$, $\omega/\omega_{\rm Kep}$

- Mass: 10, 13, 15, 18, 20, 25, 30, 40 ($M_\odot$)
- Metallicity: 0, $10^{-4}$, $10^{-3}$, $10^{-2}$, $10^{-1}$, 1 ($Z_\odot$)
- MLT parameter: 1.2, 1.5, 1.7, 2.0
- Overshoot: 0.001, 0.005, 0.01, 0.02, 0.05, 0.1
- Rotation: 0, 0.2, 0.3, 0.5, 0.6

Nuclear Network: 300 species (p~$^{79}$Br)



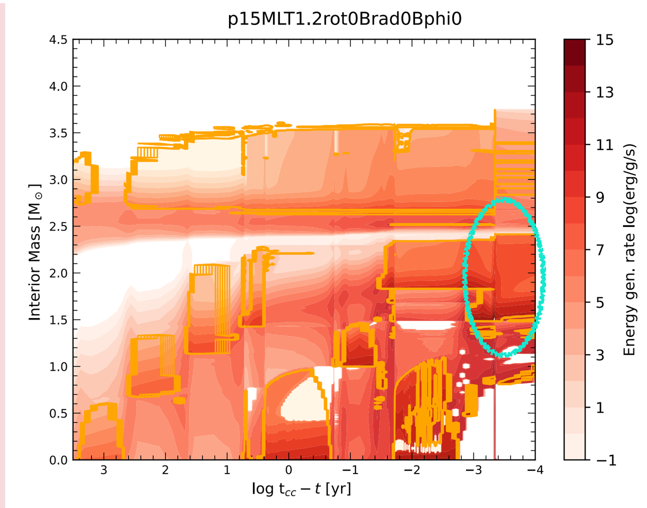
**<C-O Shell Merger>**

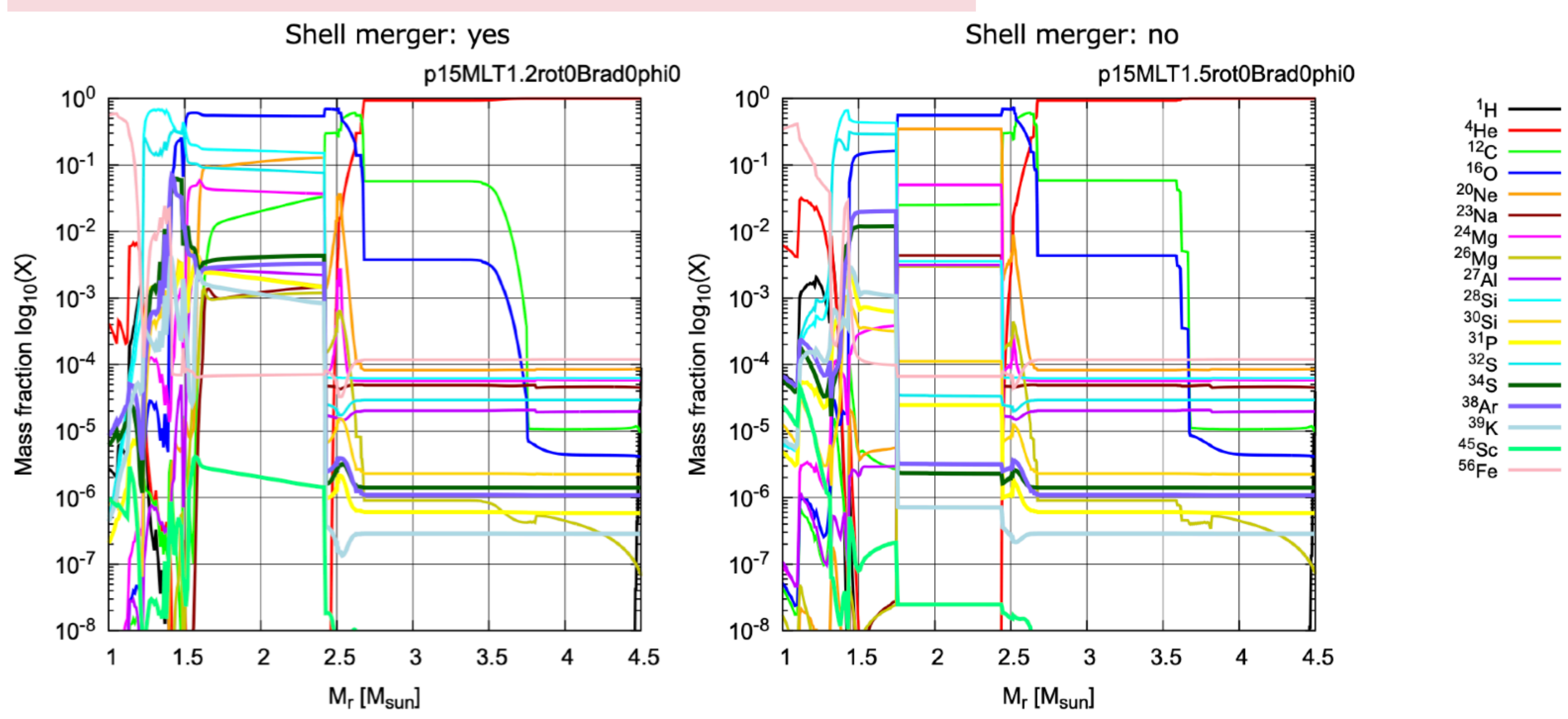
A few days~hours before collapse,

**O burning shell** and **C burning shell** might mix and merge (**C-O shell merger**)

→ Odd-Z elements (P, Cl, K, Sc) are enhanced

In some model, C-O shell merger successfully occur and P is enhanced




Although P is enhanced by C-O shell merger, the abundance is not sufficient to reproduce P-rich star

→ It could be reproduced by combining C-O shell merger with neutrino process in CCSN…?

## 4.Summary/Future work

**<Summary>**

- Our goals are
  1. Confirm the P abundance in P-rich star candidates reported as P-rich star by APOGEE observations
  2. Reveal the origin of high-P abundance by calculating stellar and supernova nucleosynthesis
- We observed 12 P-rich star candidates and analysis is in progress
- We calculated more than 500 stellar models, C-O shell merger occurs in some models
- Although there are C-O shell merger occurring model, the P abundance is insufficient to reproduce P-rich star

**<Future Work>**

- Confirm the elemental abundance of P-rich stars
- Combining supernova nucleosynthesis, investigate whether the abundance could be reproduced or not and identify the origin of P enhancement

## Reference


[1] Bekki, K., & Tsujimoto, T., 2024, ApJL [2] Nomoto, K., et al., 2013, Annual Review of Astronomy and Astrophysics, 51, 457 [3] Ritter, C., et al. 2018, MNRAS, 474, L1 [4] Kobayashi, C., et al., 2020, ApJ, 900, 179 [5] Masseron, T., et al. 2020, Nat.Commun., 11, 3759 [6] Brauner, M., et al. 2023, A&A, 673, A123 [7] Caffau, E., el al, 2011, A&A, 532, A98 [8] Takahashi, K., 2018, ApJ, 857, 111

# Unravelling star formation history in the Andromeda galaxy halo(Subaru/HSC)

T Ito, Y Komiyama, M Tanaka(Hosei Univ), M Yagi(NAOJ), K Sato(SOKENDAI/NAOJ)

## 1.Purpose & Background

M31 halo：Lots of old and low-metallicity stars
➡Stars of halo retain information of galaxy formation in early time.

Importance to study genuine halo without contaminations of accretions (galaxy/globular cluster)

Unraveling star formation history(SFH) in early time by analysing DEEP_FIELD1 region.

DEEP_FIELD1

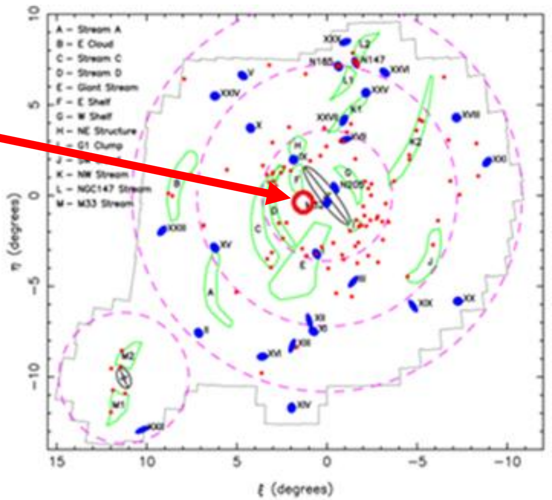


Fig.1 Observed field in M31 Halo

## 2.Data

Table1 Data Set

| Filter | Exposure time[sec] |
|---|---|
| HSC-G | 6×400, 4×30 |
| HSC-I2 | 28×240, 4×30 |

## 3.Result
## Color-Magnitude Diagram and Stellar Density

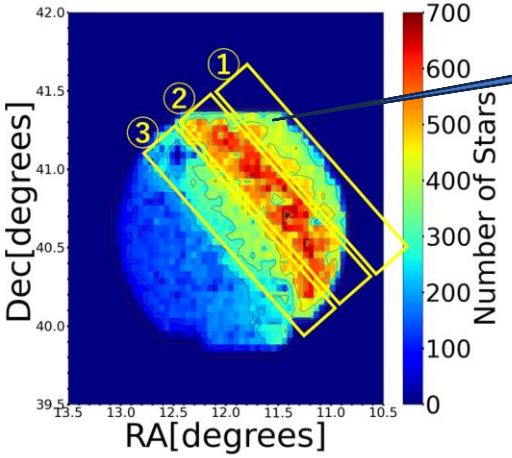



Fig.2 Stellar Density

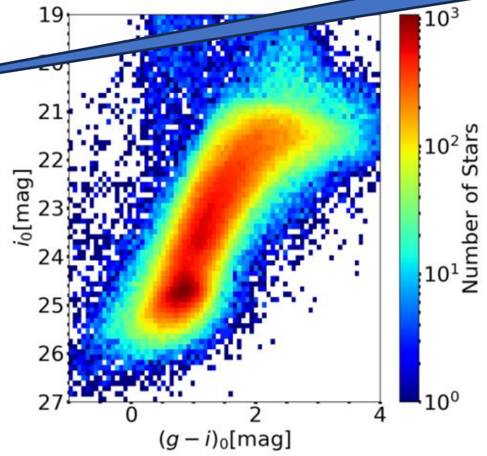



Fig.3 ① Region

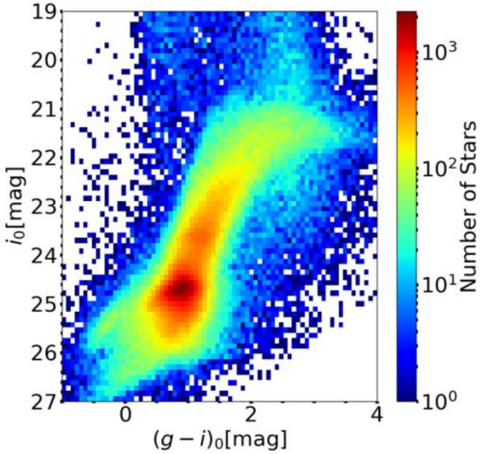



Fig.4 ② Region

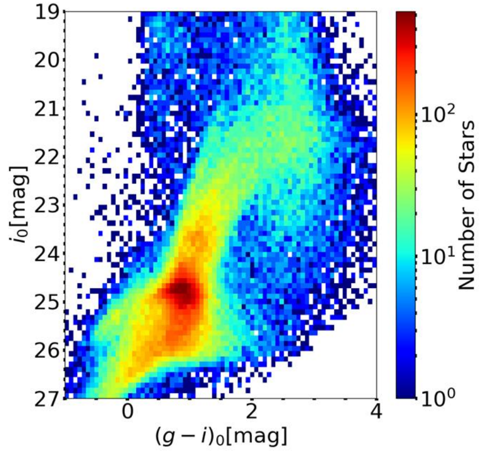



Fig.5 ③ Region

- NW region：Shallow detection
- Red Clump stars are clearly seen

in all regions.➡Possibility to determine SFH

**Estimation age and metallicity**

Various ages and metallicities(5~13Gyr and [Fe/H]=-3.20～-1.05)

➡Low metallicity and old stars dominate in DEEP_FIELD1.

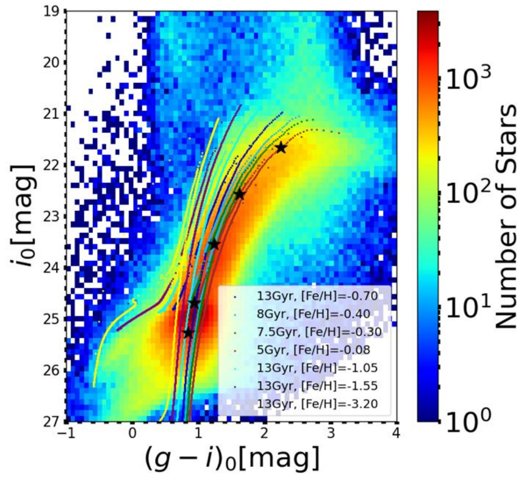
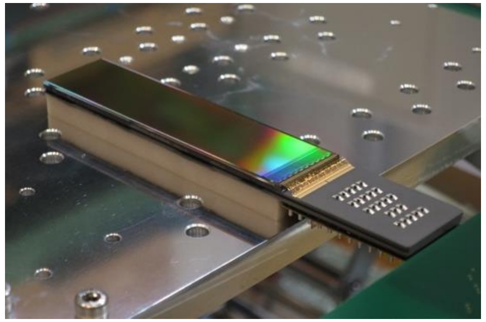



Fig.6 Estimation age and metallicity

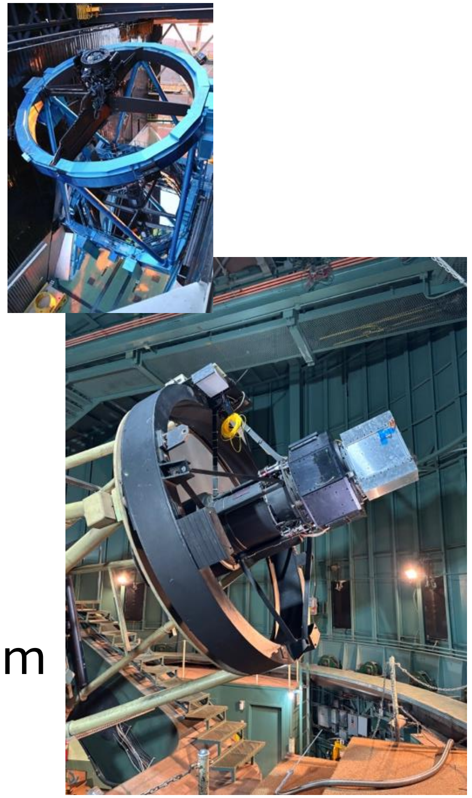
# First Light of a Wide-Field, High-Speed CMOS Camera for the 90-Inch Telescope at Steward Observatory

## New CMOS Sensor

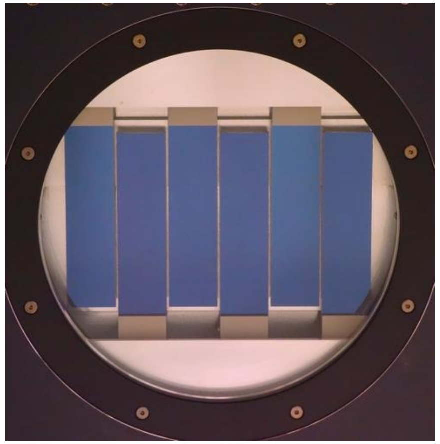


developed by NAOJ & Hamamatsu Photonics

- ✓ high sensitivity
- ✓ high-speed readout
- ✓ large format



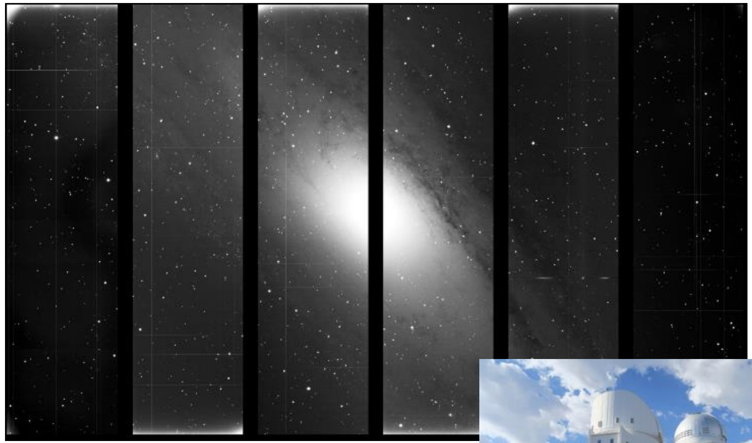
## Test Observations at 90-Inch Telescope



- ✓ mechanical system
  - dewar
  - electronics
- ✓ software
  - readout / monitor system

## First Light

- ✓ We plan to continue test observations to further evaluate the camera’s performance and pursue scientific discoveries.

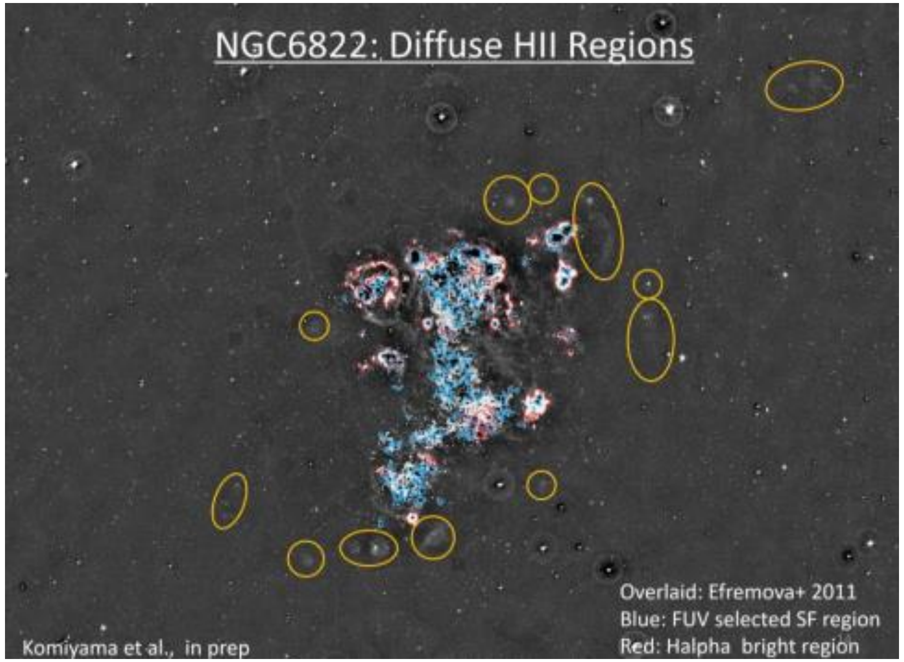


Mihiro Takahashi, Kotaro Tsuchiya, Mai Murakami (Hosei University)

Yutaka Komiyama (Hosei University), Yukiko Kamata, Satoshi Kawanomoto, Michitaro Koike, Satoshi Miyazaki (NAOJ), Eiichi Egami (the University of Arizona), Yutaka Fujita (Tokyo Metropolitan University), Masamune Oguri (Chiba University), Yuki Imai, Tasuku Joboji, Yukinobu Sugiyama (Hamamatsu Photonics K. K.), Fumio Hodoshima (Shimafuji Electric Incorporated)

# Star-forming regions in the outer part of the dwarf irregular galaxy NGC 6822

Taiga Sato, Yutaka Komiyama, Mikito Tanaka (Hosei University), Masafumi Yagi (NAOJ)



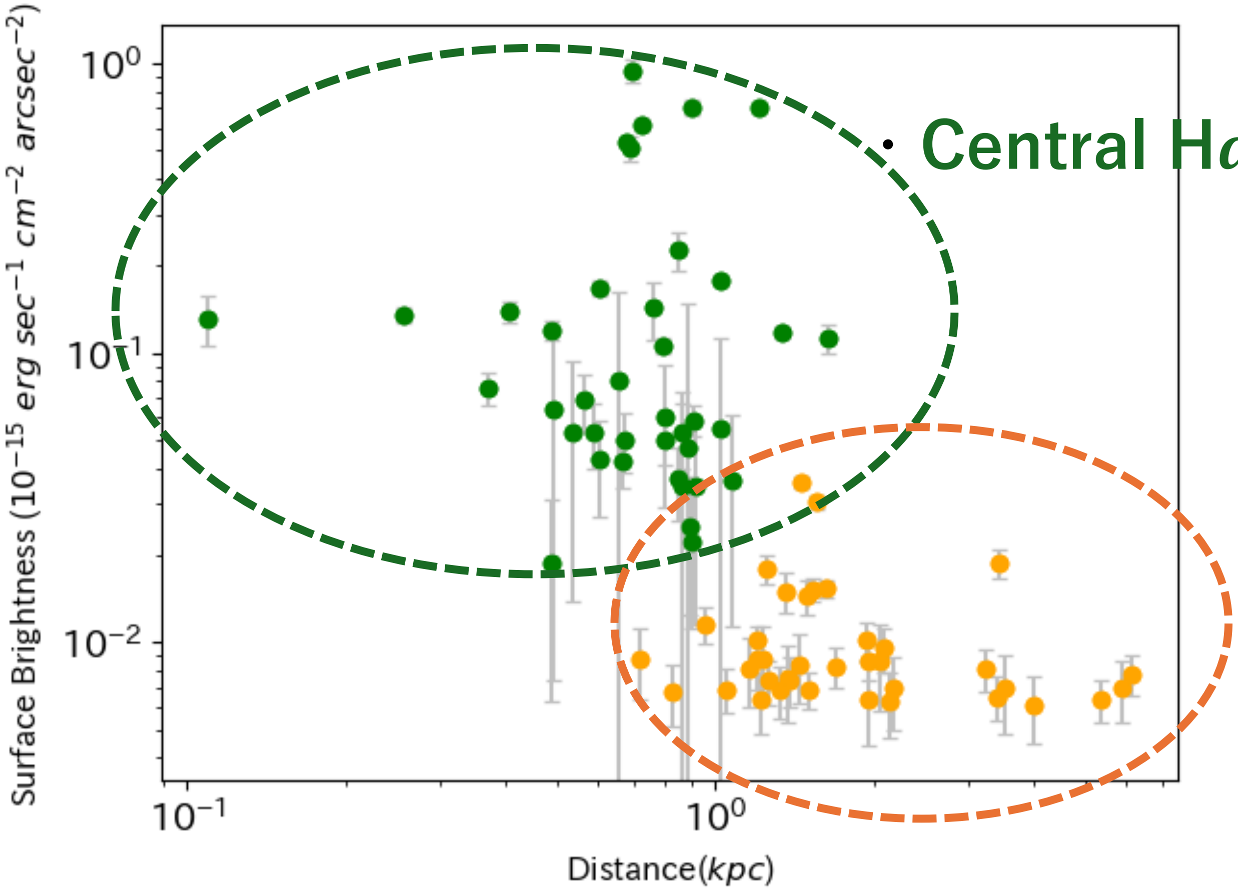

Diffuse H$\alpha$ emission regions in the outer part of NGC 6822. (yellow circle)

- Narrow-band observations by **Hyper Suprime-Cam (HSC)**

- We identified **extremely diffuse** H$\alpha$ emitting regions in the outer part

- How they differ from previously studied star-forming regions and whether they represent noteworthy objects??

# Result




Relationship between Distance and Surface Brightness (Comparing within the galaxy).

・**Central Hα Emission Regions**

・**Outer Hα Emission Regions**
⇒**extremely lower surface brightness !?**

# [P16] Progress and Challenges in Planning for Subaru PFS Open-Use Programs

Wanqiu He, Masayuki Tanaka, Miho N. Ishigaki, Masato Onodera, Kiyoto Yabe, Eric Jeschke,
Yuki Moritani, Naoyuki Tamura (NAOJ) & obsproc members

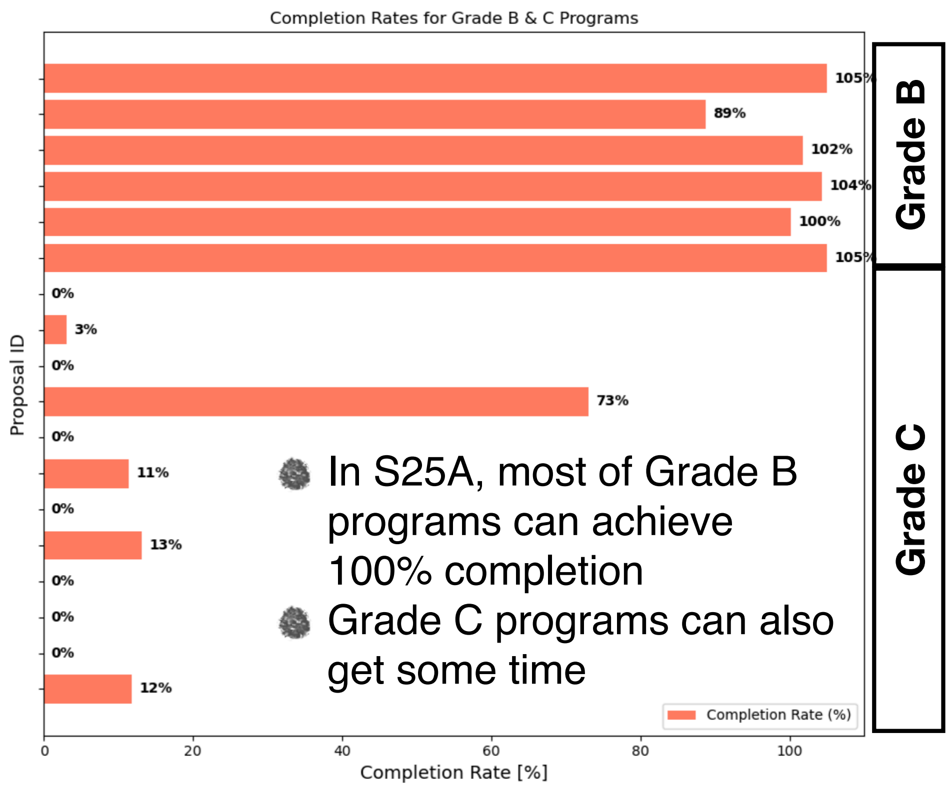
- We have developed the PFS Pointing Planner (PPP), an algorithm that balances target priorities and allocation efficiency to optimize fiber assignment across different programs.
- Planning for queue, classic and SSP observations have been carried out successfully in S25A and S25B
- Remaining challenges:
  - optimization of prioritization among filler programs
  - Further validation of duplication checks among programs, including observatory fillers
  - Careful reduction of the fraction of partially observed targets

## The general flow-chart of generation of design files

1. **Query targets, update exptime with EET*, and remove complete targets & programs**

   * EET: effective exposure time
2. **PPP: determine pointing centers**
3. **QPlan: schedule pointings**
4. **Add fillers, fluxstd, sky & guide stars**
5. **Generate design&ope files**

**Now automated!**



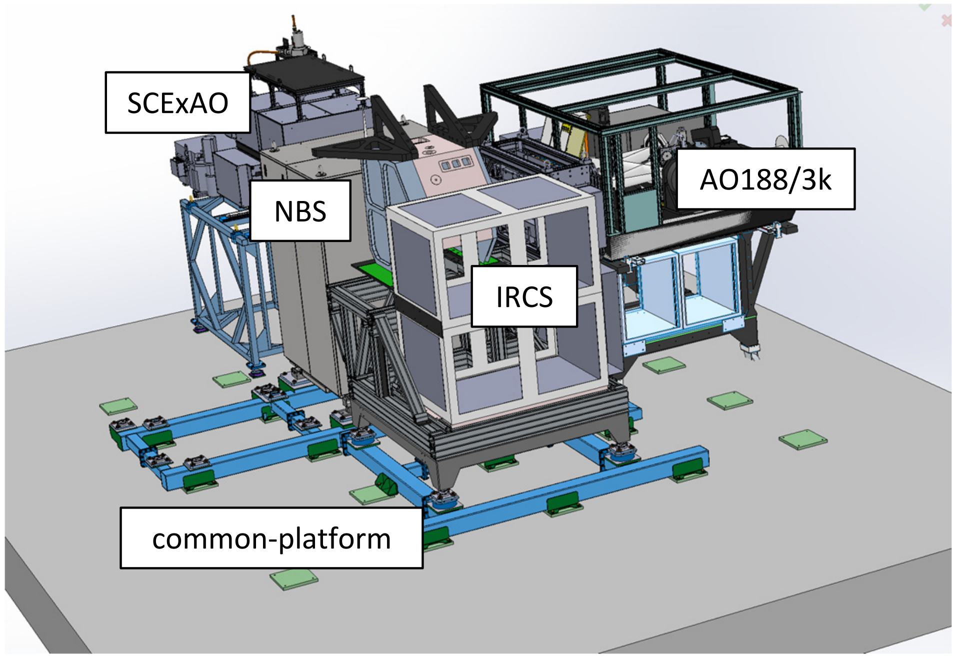

- In S25A, most of Grade B programs can achieve 100% completion
- Grade C programs can also get some time

P 17

# Subaru Nasmyth Beam Switcher: Commissioning Status

Takashi Hattori; Takamasa Bando; Yoshiyuki Doi; Julien Lozi;
Yosuke Minowa; Yuhei Takagi; Matthew Wung (Subaru Telescope)

- AIT in 2025
  - May-June : NBS assembly at Hilo base, FARO measurement of common-platform
  - July : common-platform
  - August : LTAO-WFS and NIRWFSv2
  - September : Nasmyth Beam Switcher (NBS), IRCS, SCExAO
  - October : engineering observation with NBS+IRCS/SCExAO

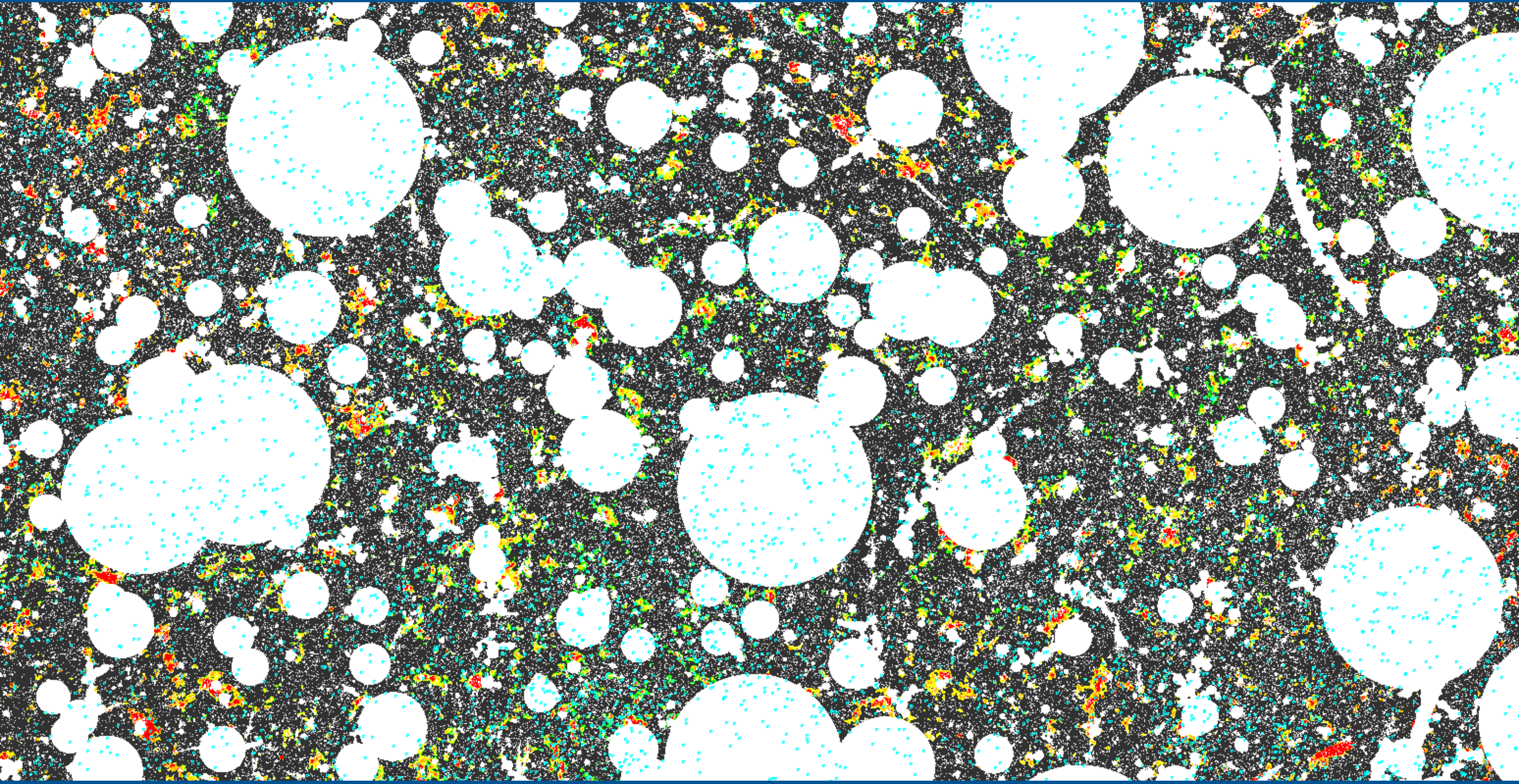




NsIR WebCam 2025/10/24

P18

# MIRACLES. Subaru HSC Ultra Deep Narrow-band Survey Data for Direct Detection of the Cosmic Web



Satoshi Yamanaka[1], Ken Mawatari[2],

Yuichi Matsuda[3], Satoshi Kikuta[4], Mariko Kubo[5], Hideki Umehata[6], Scott C. Chapman[7], George Wang[8], Yuma Sugahara[2], Akio K. Inoue[2], Toru Yamada[9], Takuya Hashimoto[10], Hidenobu Yajima[10], Masami Ouchi[3,4], Kentaro Nagamine[11], and MIRACLES team

[1]NIT Toba College, [2]Waseda University, [3]NAOJ, [4]The University of Tokyo, [5]Kwansei Gakuin University, [6]Nagoya University, [7]Dalhousie University, [8]University of British Columbia, [9]JAXA, [10]University of Tsukuba, [11]The University of Osaka

P18

# MIRACLES. Subaru HSC Ultra Deep Narrow-band Survey Data for Direct Detection of the Cosmic Web

## MIRACLES project

**The overview is introduced in Matsuda-san's talk (10/31)**

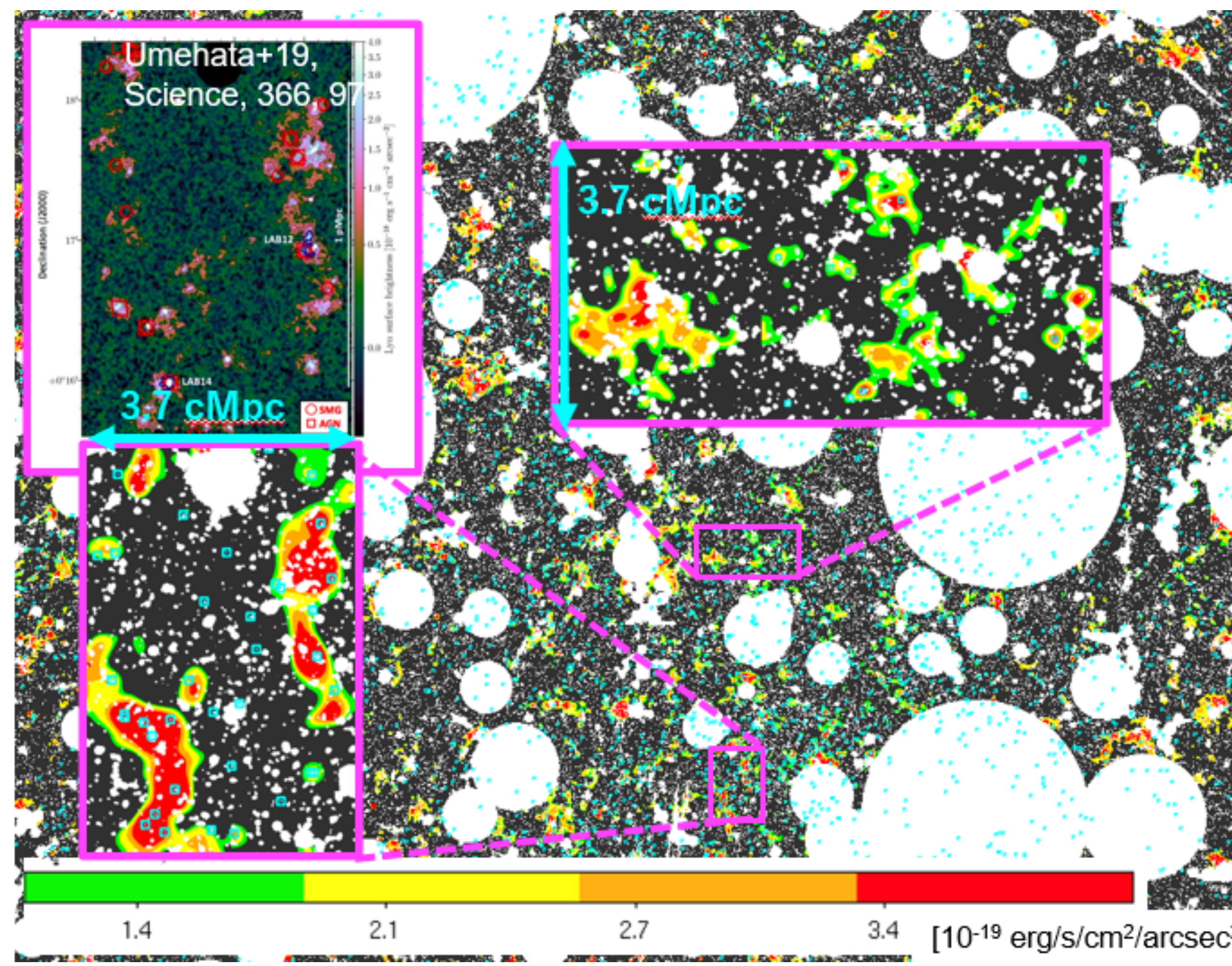
- HSC intensive program
- Direct detection of Lya filaments
- Ultra deep NB497 survey for SSA22 proto-cluster field at z=3.1
- **~50hrs exposure in NB497**

| | | Area (deg²) | Exp. Time (hours) | PSF* (arcsec) | Lim. mag.* (5σ, 2"ϕ) |
|---|---|---|---|---|---|
| HSC | g | 5.81 | 12.6 | 0.71 | 26.83 |
| | r2 | 5.91 | 13.4 | 0.62 | 26.59 |
| | i2 | 5.80 | 4.6 | 0.52 | 25.56 |
| | N497 | 5.88 | 53.2 | 0.71 | 26.08 |
| | N527 | 2.92 | 5.6 | 0.69 | 25.45 |
| CFHT | u | 1.11 | | 0.96 | 26.98 |

*median

## Lya emission map

- (NB497 – g) image = Lya@z=3.1 map
- Careful sky subtraction / noise estimation
- MUSE Lya filaments are well reproduced (Umehata et al.2019, Science 366, 97)



# Latest Report on Synergistic Observations with Subaru for the Nancy Grace Roman Space Telescope

NANCY GRACE ROMAN SPACE TELESCOPE

**ISAS - Roman J Team :** Kazuki Daikuhara[1] Shota Miyazaki[1] Naoshi Murakami[2] Yasuhiro Murata[3] Motohide Tamura[2] Takayuki Tamura[1] Atsushi Tomiki[1] Takahiro Sumi[4] Daisuke Suzuki[4] Toru Yamada[1]

* 1. ISAS/JAXA, 2. Astrobiology Center/NAOJ 3. Fukui University of Technology 4. The University of Osaka

## Roman-Subaru Synergistic Observations

**Subaru telescope provide 100 nights from 2027 to enhance Roman science**

- **7 proposal submitted (~240 nights requested)**

  1) Subaru PFS/NINJA Roman Investigation of Neutral-hydrogen and Galaxies (SPRING)
  2) Roman/Subaru Synergistic Follow-up of RAPID-discovered transients
  3) Advancing Supernova Ia Cosmology and Time DomainStudies
  4) Dark Matter on small scales: Precise dynamical analysis of dwarf spheroidal galaxies with Roman and Subaru-PFS
  5) The Subaru-PFS/Roman (SuPR) Deep Survey: Redshifts for Roman Cosmology
  6) The Exciting Opportunity of Subaru High-Contrast Observations for the Roman Coronagraphic Mission
  7) Roman-Subaru/HSC Concurrent Observations for Rogue Planet Mass Measurements

- Steering Group

  Yusei Koyama (NAOJ), Yoshiki Matsuoka (Ehime University), Julie McEnery (NASA GSFC), Jason Rhodes (NASA JPL), Takahiro Sumi (The University of Osaka), David Weinberg (Ohio State University), Toru Yamada (JAXA)

  ISAS Roman team member: Kazuki Daikuhara (JAXA)

# Latest Report on Synergistic Observations with Subaru for the Nancy Grace Roman Space Telescope

| Date | Action | |
|---|---|---|
| Sep 2024 | Call for White paper | Community input into themes for programs |
| Dec 16-18, 2024 | 6th Workshop for Roman-Subaru Synergitic obs. | Presentations, Discussions, Teaming |
| Mar 14, 2025 | Due date of White paper submission | SG has internal/external reviews for White Papers |
| Fall 2025 (~November) | **Open the prioritized themes** | SG shows the prioritized themes |
| Fall 2025 (~November) | Call for proposal on the selected themes | Detailed observational proposals for the selected themes |
| Spring (Mar, TBC) 2026 | 7th Workshop for Roman-Subaru Synergitic obs. | Discussions selected themes |
| May 2026 | **Due date of final proposals** | Proposal development |
| Early summer 2026 | Program identification & comsolidation | |

# Resurrection of Subaru+COMICS for the study of solar system objects with ground-based MIR observations III

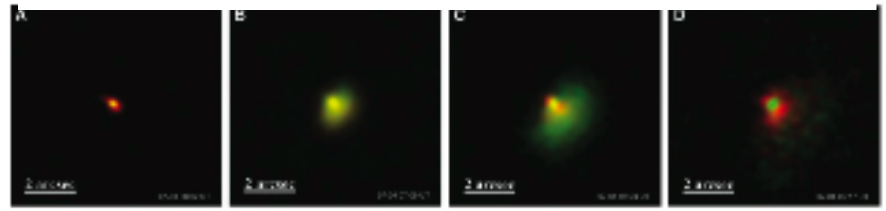
Takafumi Ootsubo, Hideyo Kawakita, Yoshiharu Shinnaka, Jun-ichi Watanabe, Takuya Fujiyoshi

P20

**Cooled Mid-Infrared Camera and Spectrometer**

- **7.5 – 25 μm (N and Q-bands)**
- **Imaging**
- **Spectroscopy**

Deep Impact on 9P/Tempel (2005)



- **This is the final year of the (initial) 3-year project.**
- **COMICS** operated for nearly **20 years** at Subaru Telescope **until S20B**.
- Many results for **Solar System objects** were acquired with COMICS, but COMICS was **decommissioned**.
- Restarting **COMICS is still the most reliable and efficient** way to study Solar System objects in mid-IR!
- We are currently checking the performance of COMICS at the summit.

- **No hardware issues with COMICS have been encountered so far.**
- We welcome collaborations and contributions from **anyone in the wider astronomical community!**

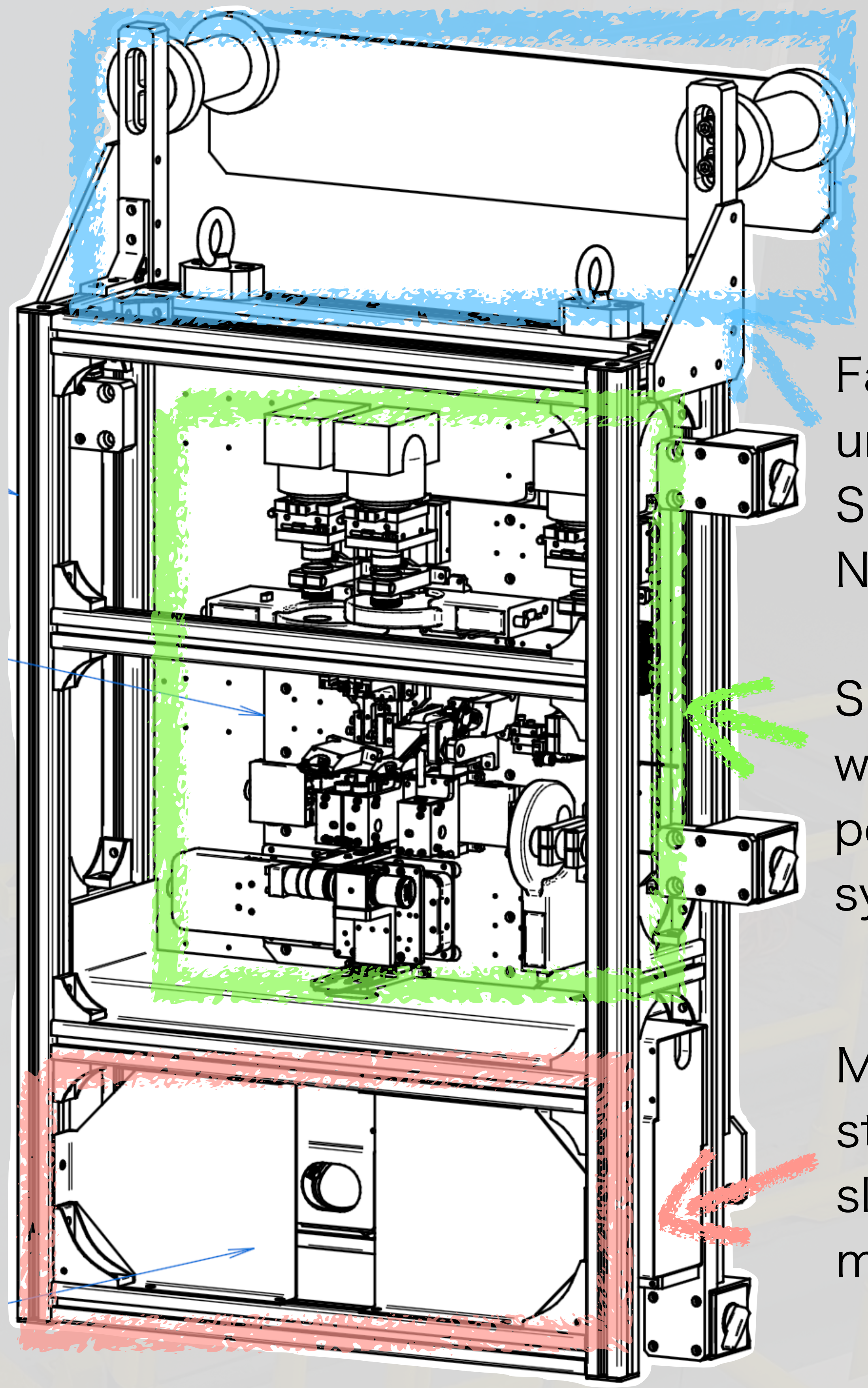
Subaru Users Meeting FY2025, October 29 - 31, 2025 JST @ NAOJ Mitaka campus

# Astrocomb and Fiber Feed Module for HDS

Masashi Omiya (ABC/NAOJ), Hajime Inaba (AIST), Wako Aoki (NAOJ), Tomonori Usuda (NAOJ), Sho Okubo (AIST), Ken Kashiwagi (AIST), Akito Tajitsu (NAOJ), Eiji Kembe (NAOJ), Jun Nishikawa (NAOJ/SOKENDAI/ABC), Akira Arai (NAOJ), Yuki Moritani (NAOJ/SOKENDAI), Hideyuki Izumiura (NAOJ/SOKENDAI), Bun'ei Sato (TITECH), Toru Misawa (Shinshuu Univ.)

- **“HDS comb” = Astrocomb for HDS ==> Precise wavelength calibration**
  - Generates **many emission lines** at suitable uniform frequency intervals
  - Spacing frequency ： 30GHz (plan) ~ **0.25Å@500nm** (line spacing)
- **Fiber-Feed Module (FFM)**
  - **Object, Sky and Comb** lights are injected into HDS simultaneously.
  - Injection system is installed **on the AG/SH flange of NsOpt. focus**
  - Fiber output optics is installed in front of the HDS slit.
- **Set-ups of HDS and HDS comb ==> RV precision ~0.8 m/s**
  - Resolution : **>36,000 (variable)** # Determined by the slit width
  - Wavelength coverages : **390 - 555 nm, 439 - 606 nm, 650 - 900 nm etc.**
- Install in **FY2025**, Engineering observations in **S26B-**
  - Submitted the proposal document on this August
  - The comb and FFM will be **ready by the end of this year**.

## Injection system of the FFM on NsOpt. focus

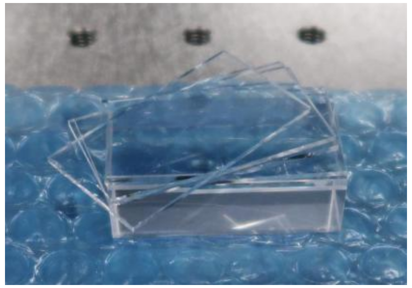


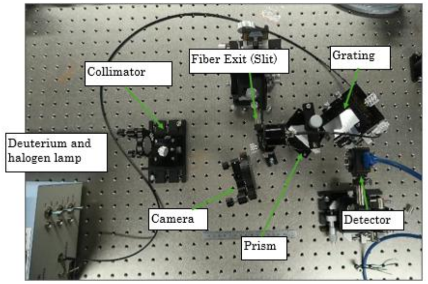

~240 lines in an echelle order → ~ 8000 lines in 2 CCD frames of HDS → comb precision ~ 10 cm/s

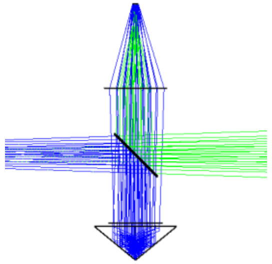
# Tech. IFU:

## Technology verification for WFOS IFU

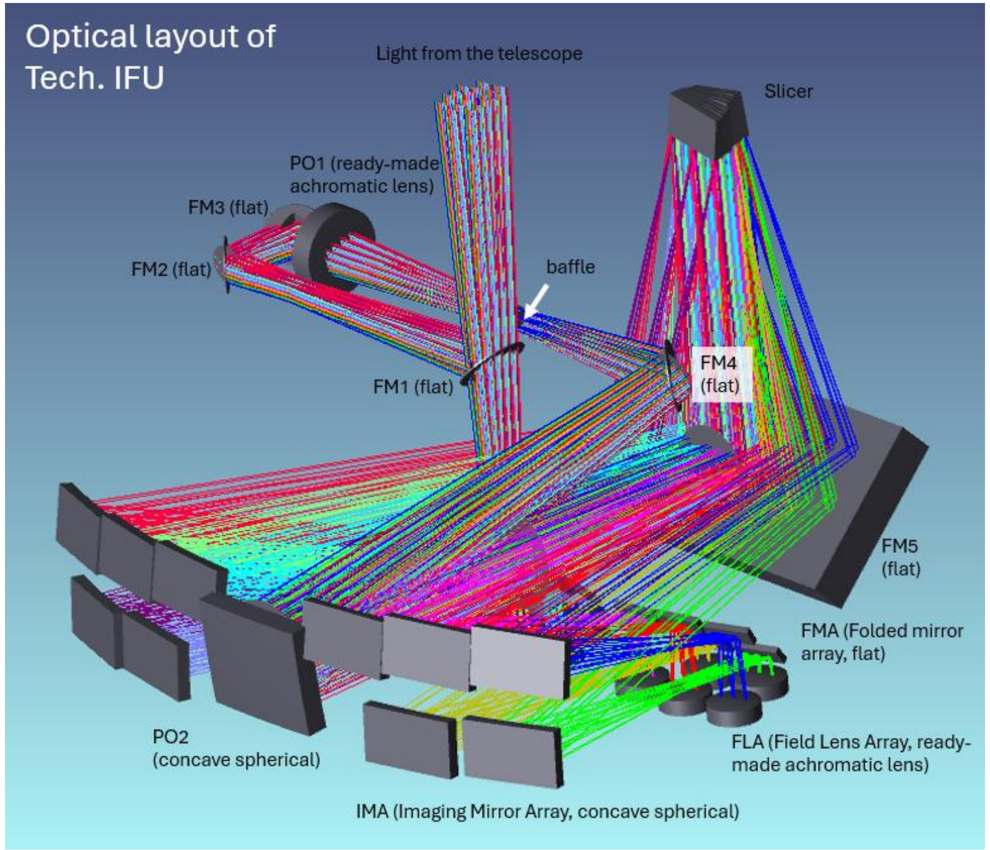
Shinobu Ozaki, Yoko Tanaka, Tomio Kanzawa, Takashi Hattori (NAOJ),
Tsuyoshi Ishigaki, Aika Kabe (Iwate University)





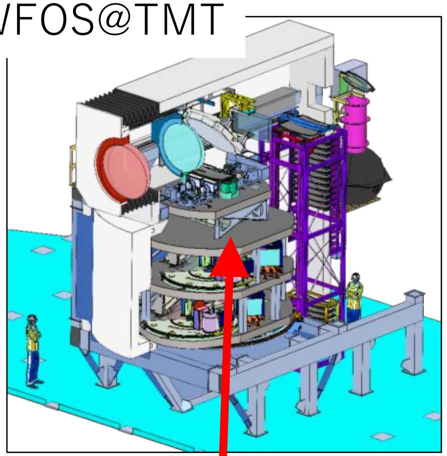



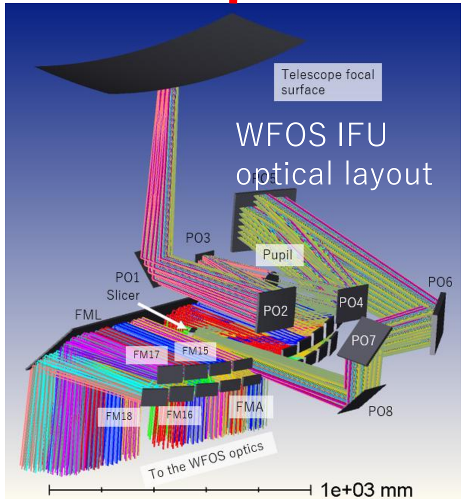
Some R&Ds




Tech. IFU will be installed in FOCAS.

WFOS@TMT

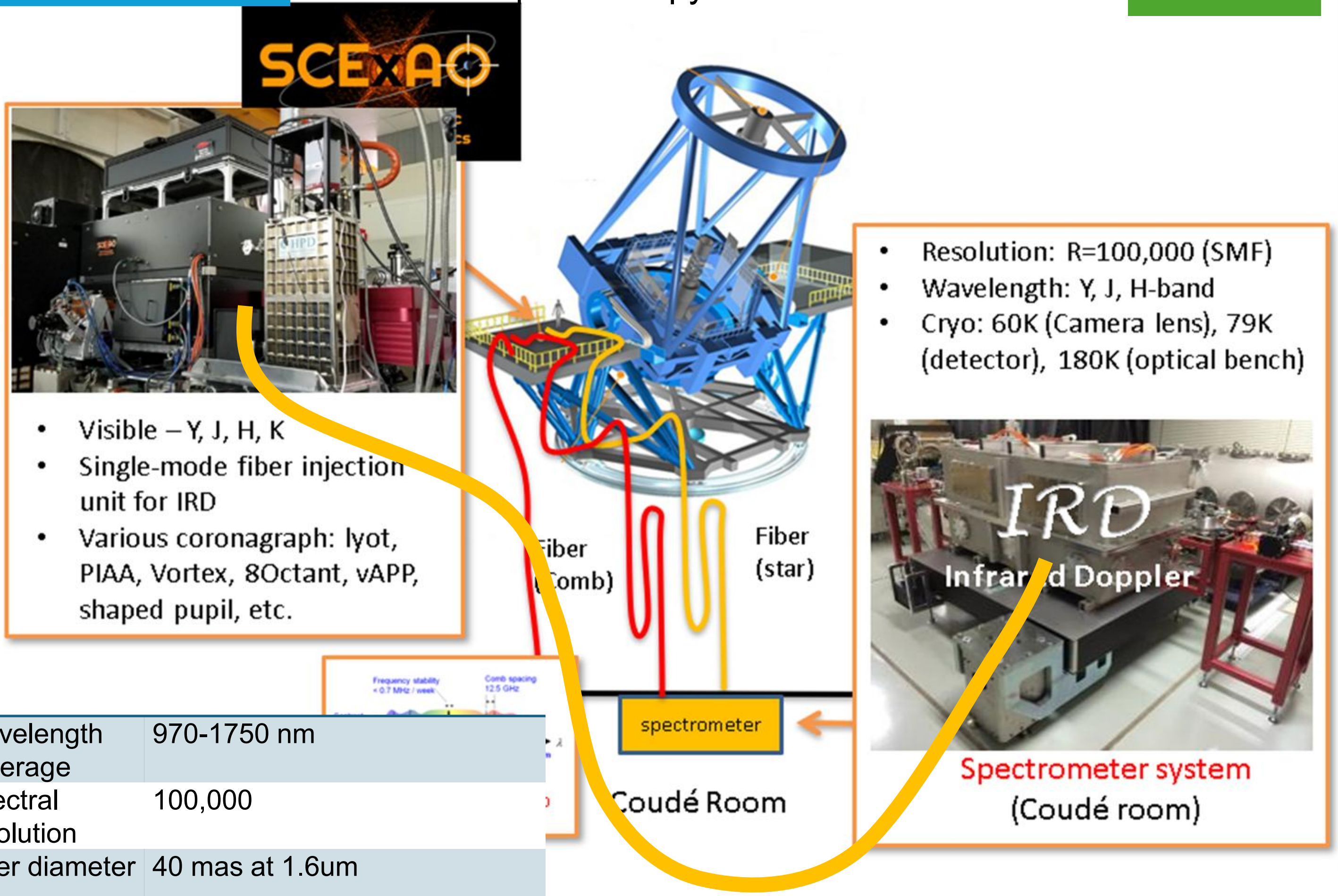




# IRD, REACH, and K-REACH: Current Status and Upgrade Plans for Near-Infrared High-Dispersion Spectrometer

## REACH

Combination of IRD and SCExAO for high-contrast and high-resolution spectroscopy

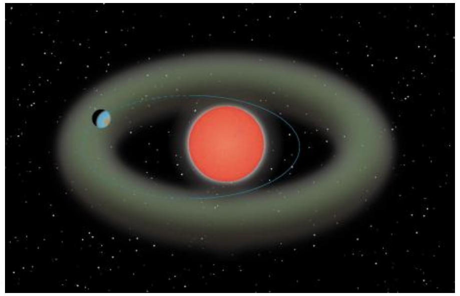


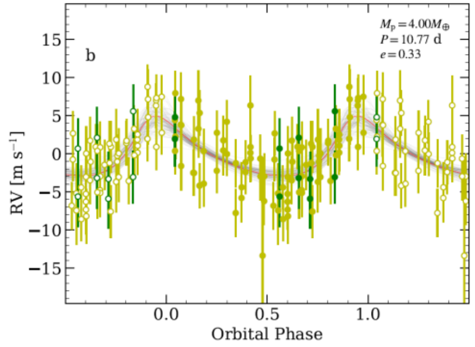

| | |
|---|---|
| Wavelength coverage | 970-1750 nm |
| Spectral resolution | 100,000 |
| Fiber diameter | 40 mas at 1.6um |
| Throughput | 2% at ~1520 nm at 0.6arcsec seeing condition |
| Operation | From 2020 |

## IRD

YJH-band, R=70,000 high-resolution spectrometer for highly stable radial velocity measurement

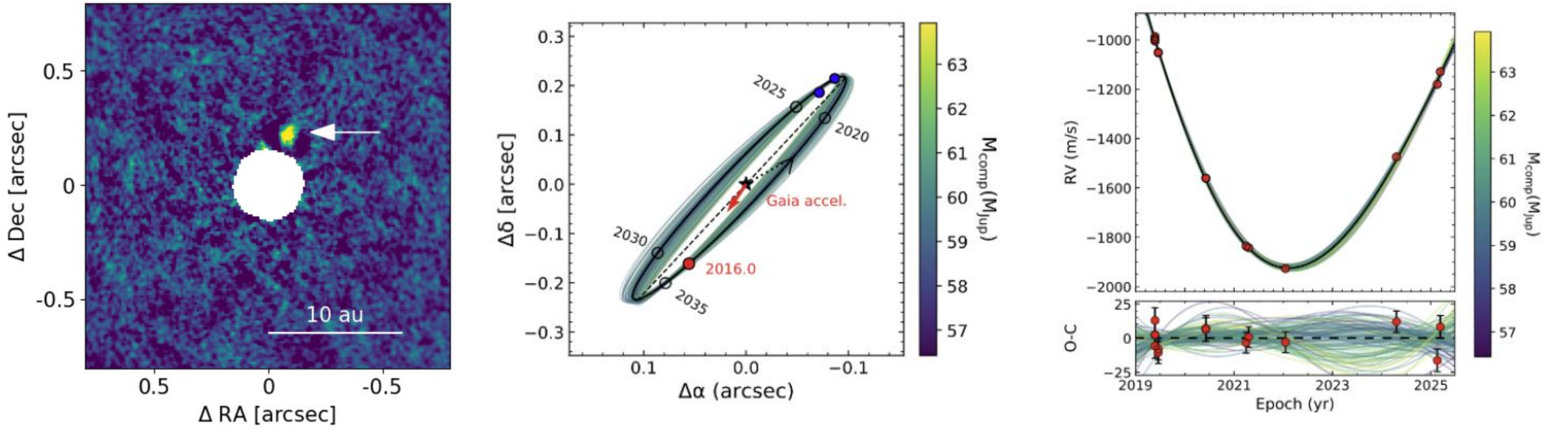
| | |
|---|---|
| Wavelength coverage | 970-1750 nm |
| Spectral resolution | 70,000 max (Multi-mode fiber), 100,000 (Single-mode fiber) |
| Fiber diameter | 60 mm, 0.48 arcsec (MMF: OFS F8950), 7.5 mm MFD@1550nm (SMF: OFS BF05635-02) |
| Wavelength reference | Laser frequency comb, ThAr lamp |
| Throughput | 2.3% at ~1000nm, 3.9% at ~1520 nm |
| Radia velocity measurement stability | 2 m/s |
| Operation | From 2018 |





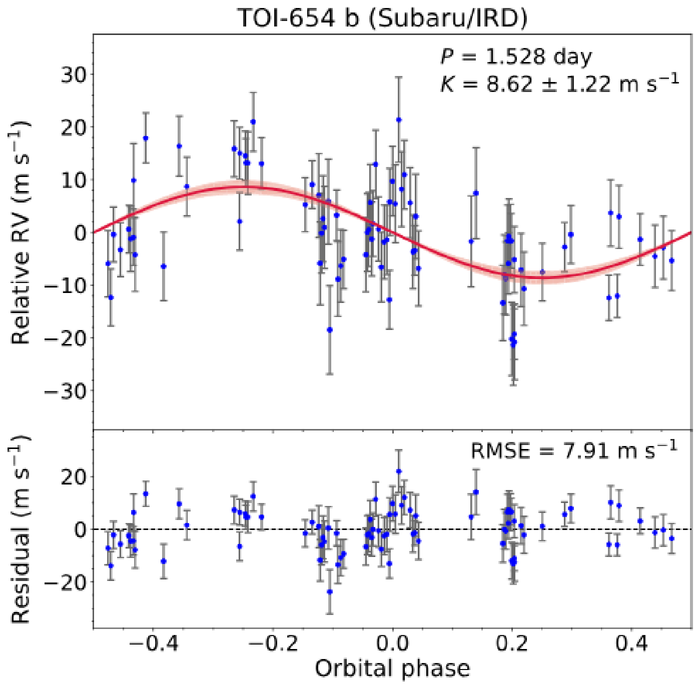

4 $M_{Earth}$ planet near the habitable zone (Harakawa et al. 2022,PASJ, 74,904)

Brown dwarf companion around M4.5 star

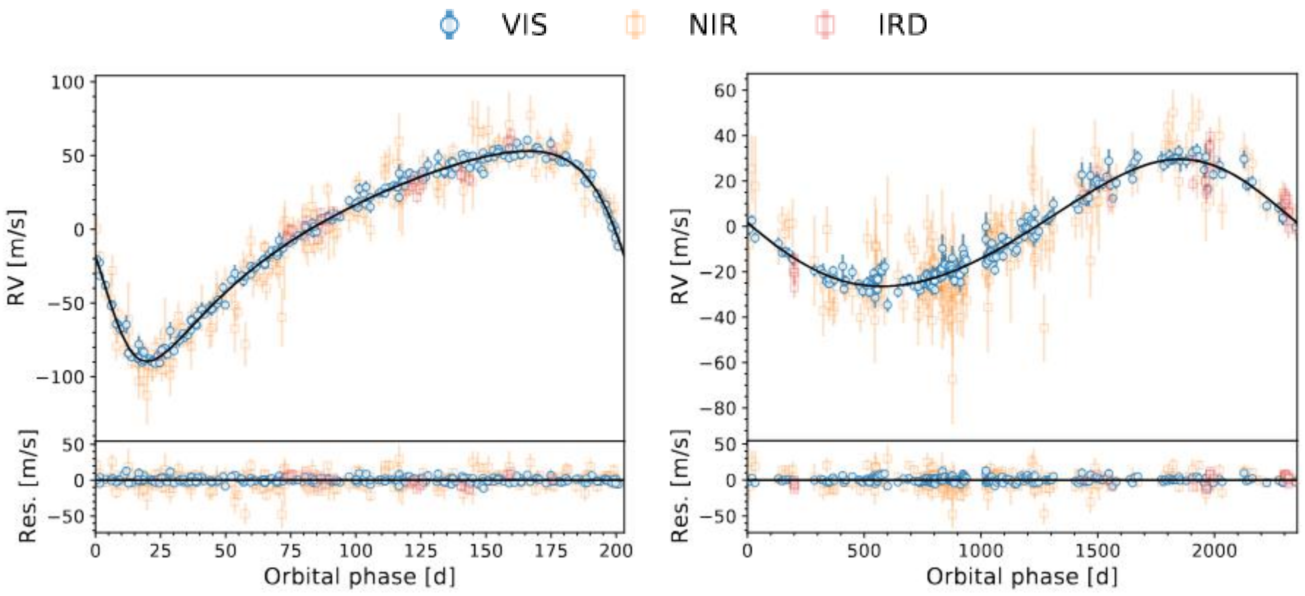



Uyama et al., 2025, AJ,170,272

Short period sub-Neptune (8.7 $M_{Earth}$)



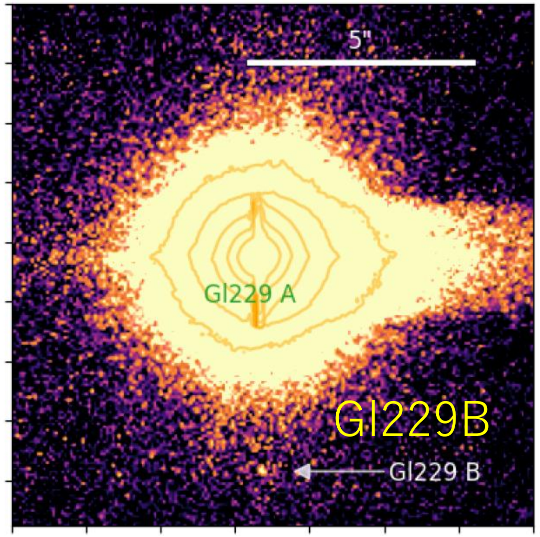

Two 0.45 $M_{jup}$ mass planet orbiting M5.5 star

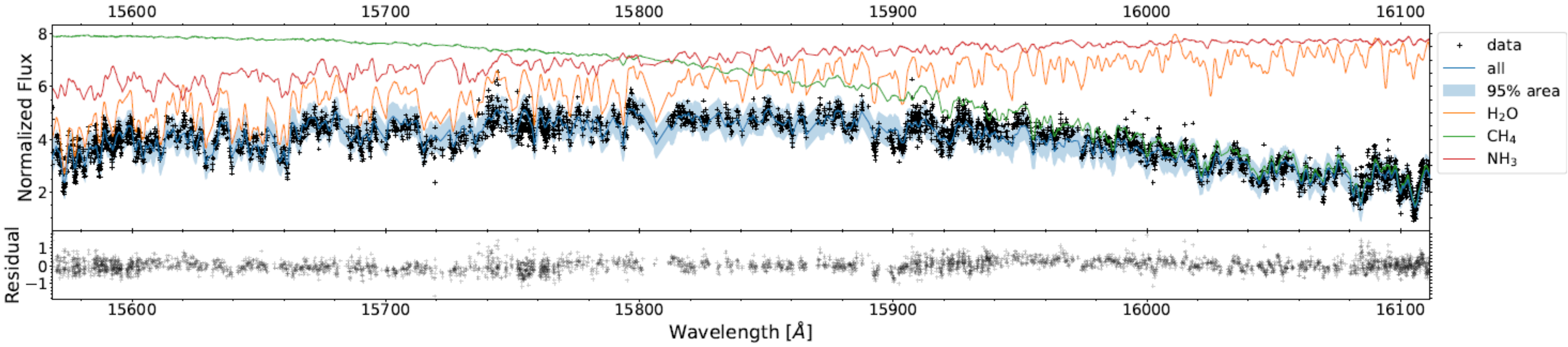



Morales et al. 2025A&A, 700, 242

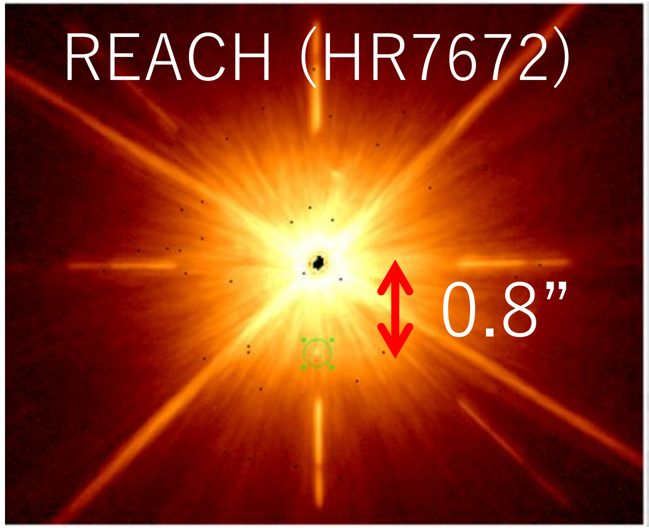
Ikuta et al. 2025PASJ,77,1101I

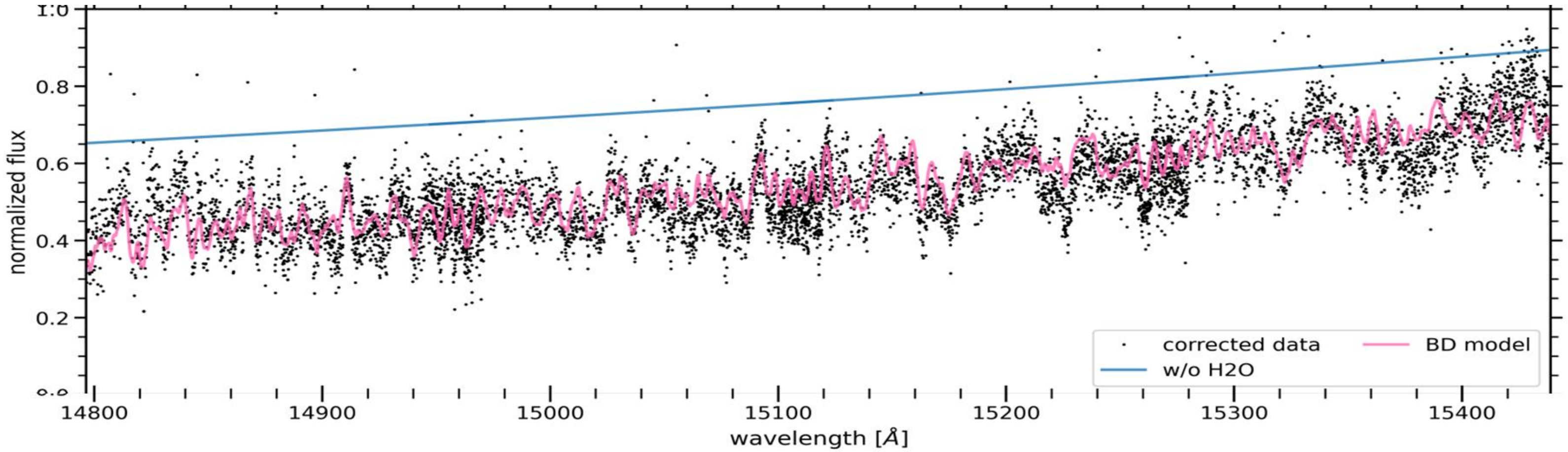
# NIR high-resolution spectroscopy of exoplanet/brown dwarf atmosphere




Kawashima et al. 2025, ApJ, 988, 53



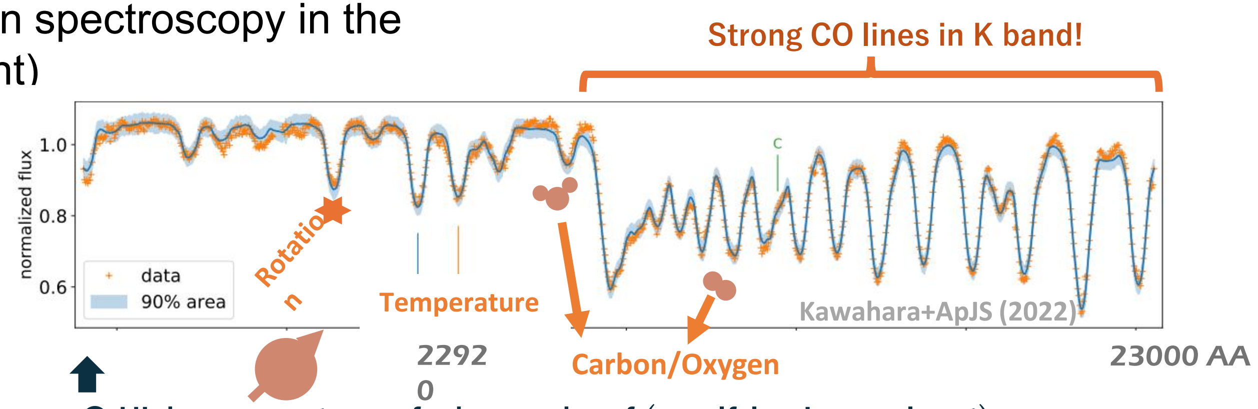




Kasagi et al. 2025, AJ, 170, 211

- Precise atmospheric characterization of brown dwarfs and exoplanets
- REACH can probe a region < 1 arcsec from a primary star with very high-contrast
- IRD+AO188 has an advantage to study well separated objects (<5 arcsec) with a moderate contrast

# K-REACH

Combination of IRCS and SCExAO for high-contrast and high-resolution spectroscopy in the K-band (under development)

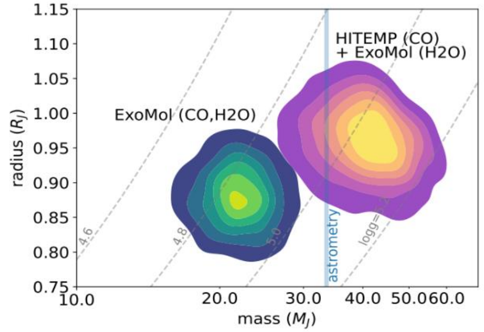



● High-res spectrum of a brown dwarf (~ self-luminous planet)

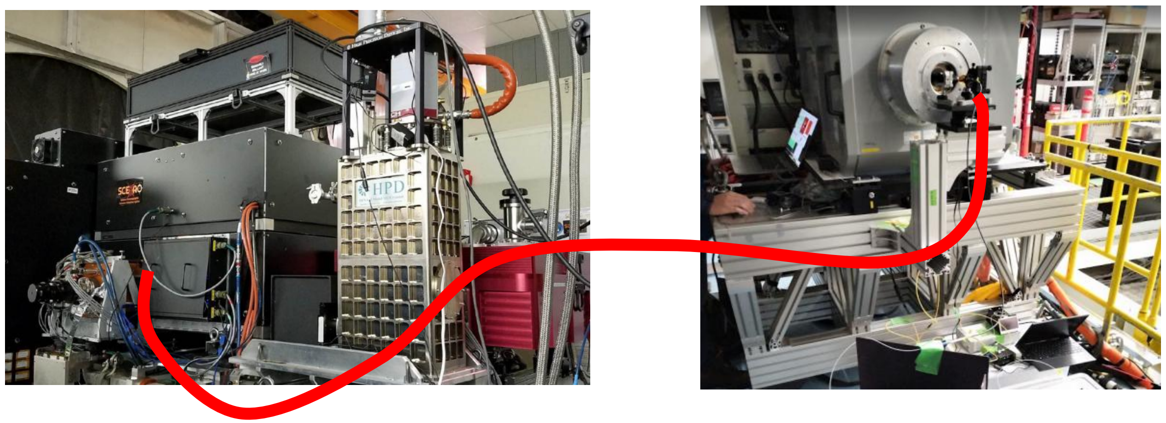
| | |
|---|---|
| Spectral resolution | 18,300 – 22,300 |
| Spectral coverage | 1.9-2.4 um |
| Expected throughput | 2.4% (K-REACH)<br>(10% IRCS+AO188) |
| Raw contrast | 1e-3 @100 mas<br>1e-4 @500 mas<br>1e-5 @ 1000 mas |
| Operation | From S26B at the earliest |

CO (and H2O) lines provide
- Carbon/Oxygen ratio, the tracer where a planet was born
- Gravity (i.e. planet mass) from the spectroscopy only

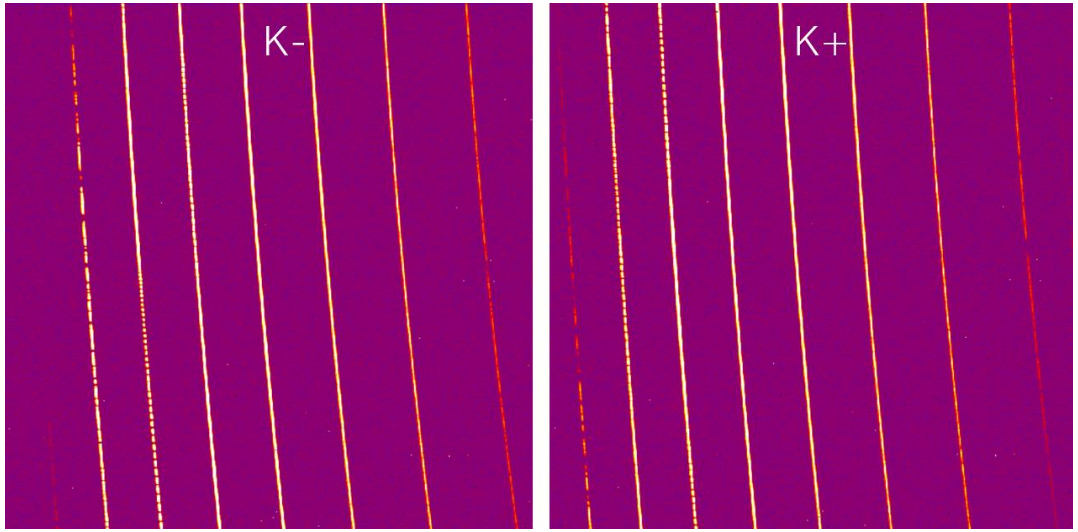
● Brown dwarf mass inferred from CO high-res line shape

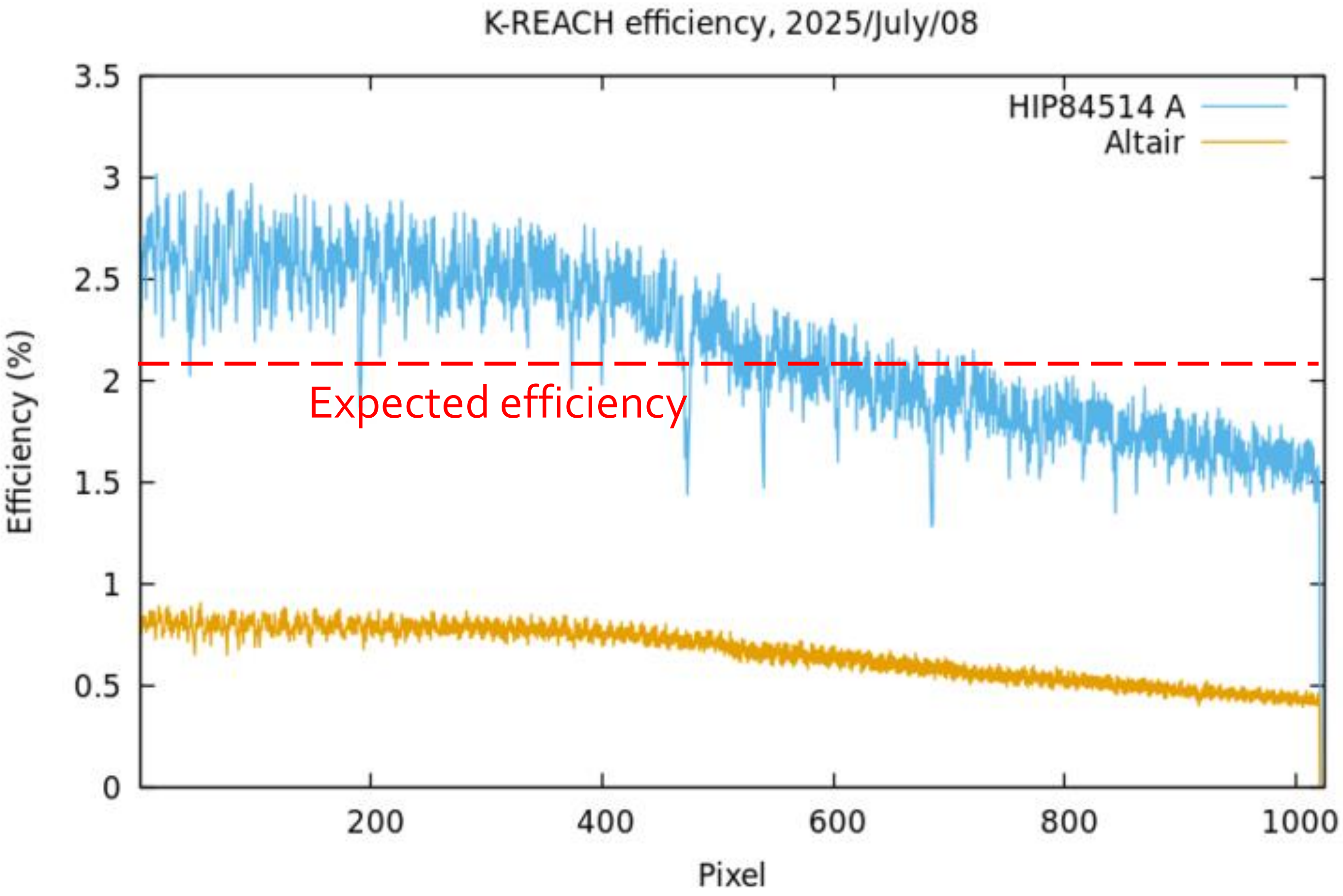



Kawahara, Kawashima, Masuda+2022

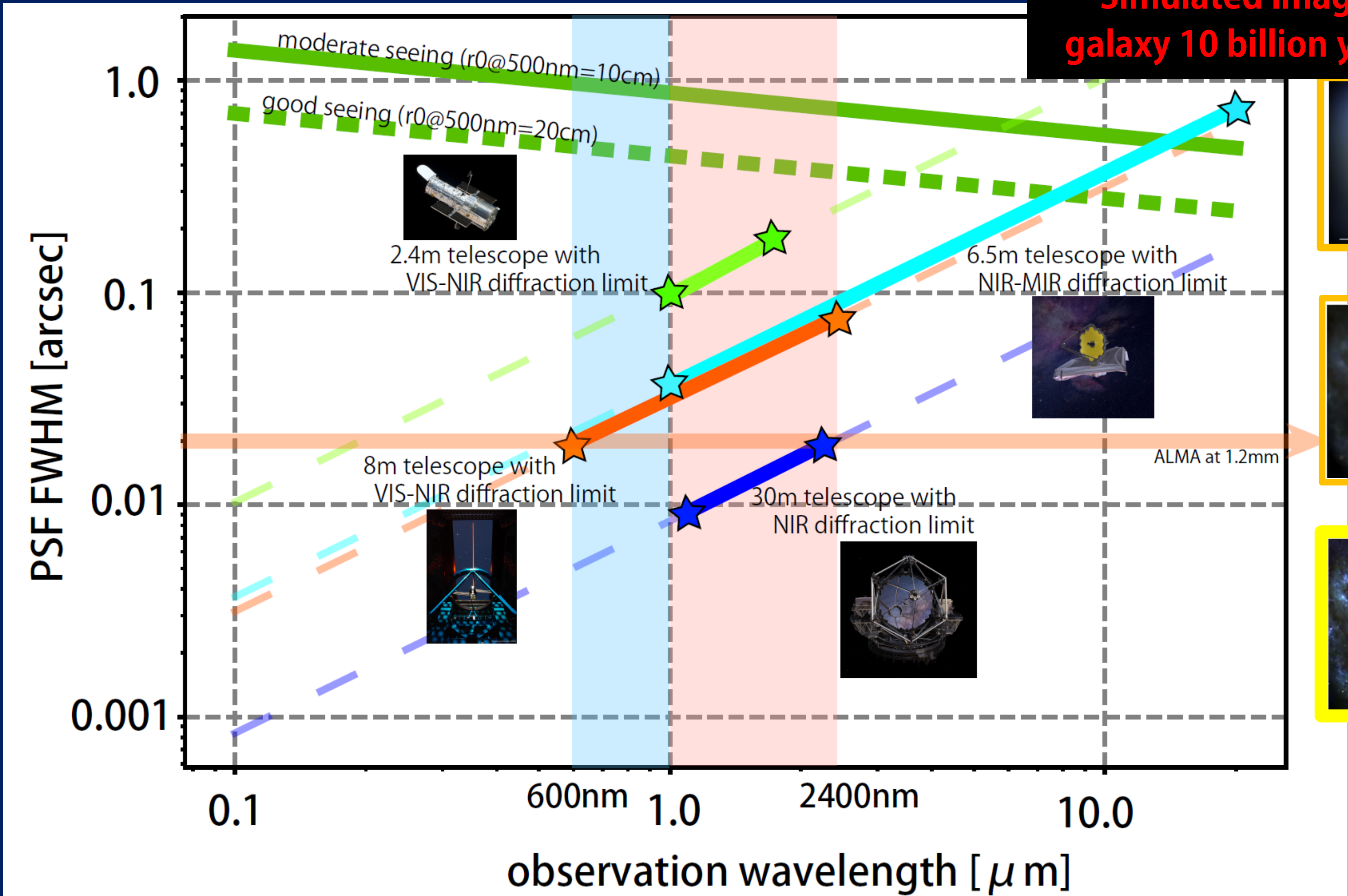


# K-REACH First light (2025/July/08)



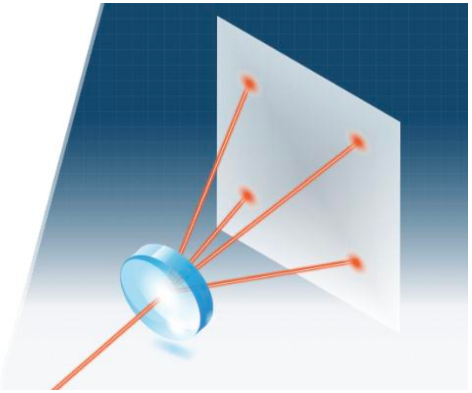
# ULTIMATE-START : LTAO for Subaru
# Make Subaru as sharp as ELTs
# with laser tomography AO



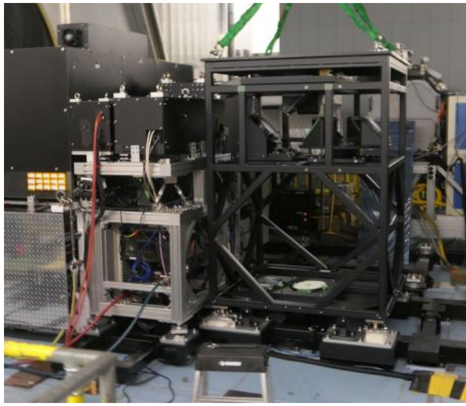

Simulated images of a galaxy 10 billion years ago

# We are ready for the engineering first light in Dec. !

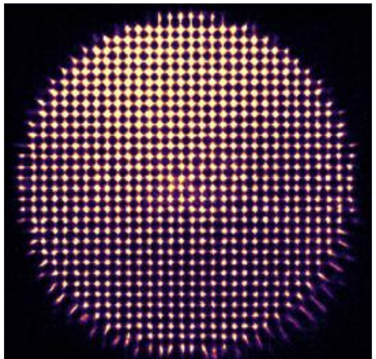
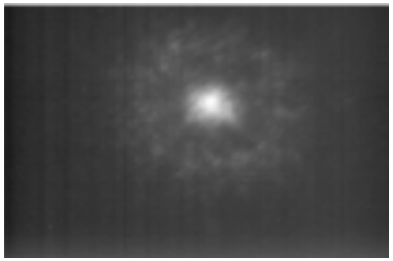
- ✓ 4 LGSs successfully formed on-sky with the diffractive optics element ! : Mar. 2025



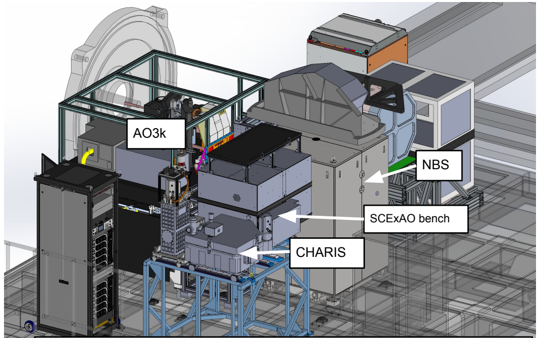

- ✓ Tomography wavefront sensing unit is successfully installed on NsIR platform ! : Aug. 2025
- ✓ Beam switching optics is also installed !

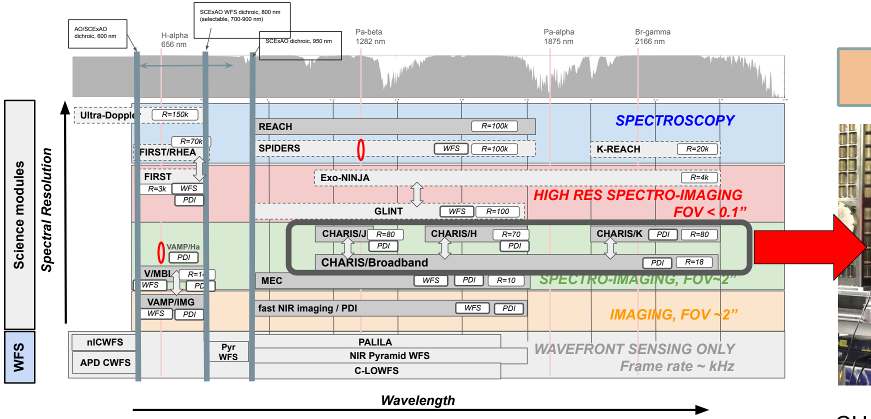
- ✓ AO loop is closed successfully with AO3K DM and the truth WFS !

# P25 Exoplanet and Circumstellar Disks Observations with SCExAO/CHARIS

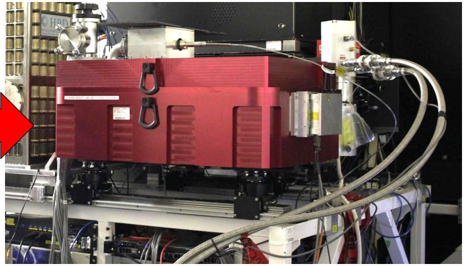



Instrument configuration on the Nasmyth-IR platform. Light enters from the telescope on the left. AO3k performs the initial AO correction. Light is then sent to SCExAO for 2nd-stage AO correction and starlight suppression, before entering CHARIS




Current and future instrument modules, as a function of wavelength (x-axis) and spectral resolution (y-axis). Many modules can operate simultaneously. See posters P26, P27, P28 and P29 for details.

## CHARIS



CHARIS is the main SCExAO science instrument, operating in nearIR at spectral resolution ranging from 20 to 70.
FOV 2.07" x 2.07%

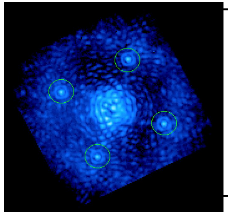
### Spectroscopy

**LOW RESOLUTION MODE:**

- R~19, J+H+K Band
- 65-70% instrument throughput
- 10-15% from atmosphere to detector

**HIGH RESOLUTION MODE:**

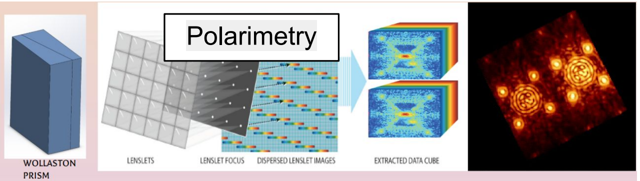
- R~70-90: J, H, and K Bands
- 55-60% instrument throughput
- ~15% from atmosphere to detector



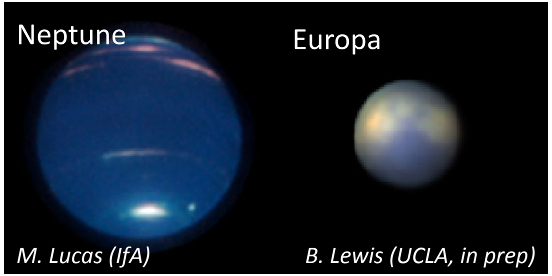
### Coronagraphy

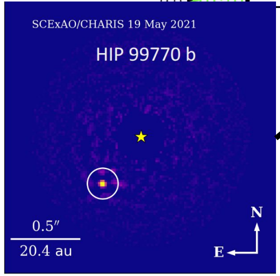
- Selectable Lyot focal plane mask
- Optional astrogrid for PSF referencing

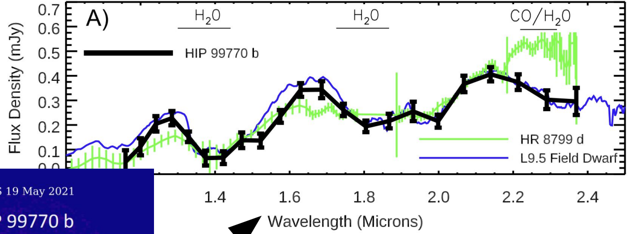
### Polarimetry



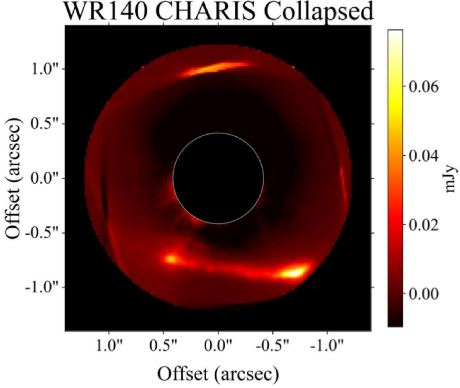
# CHARIS SCIENCE MEASUREMENTS



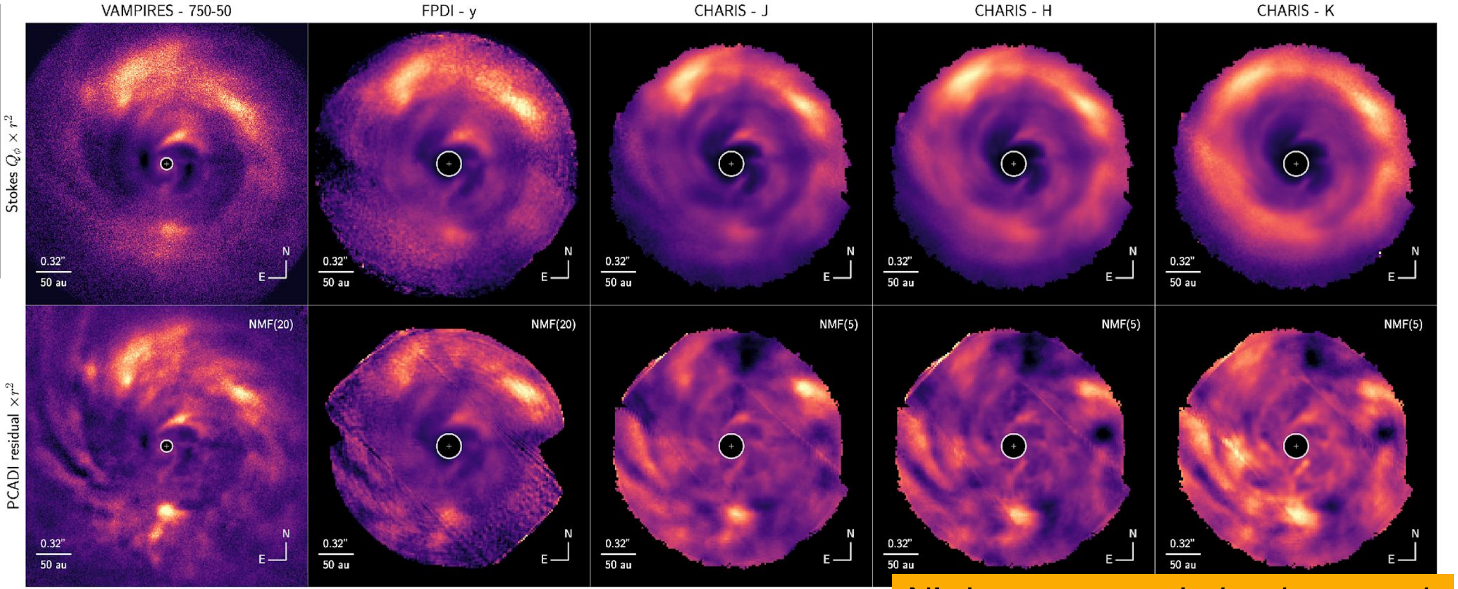

Currie et al. Science (2023)




*R. Lau, ApJ, 2023*

Polarized light component

Total Intensity



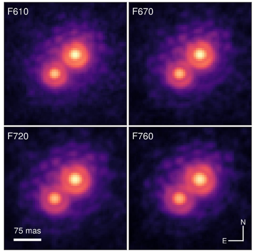

AB Aur, data reduction: M. Lucas

All data captured *simultaneously*

# P26 Visible-light High Contrast Observations with SCExAO/VAMPIRES

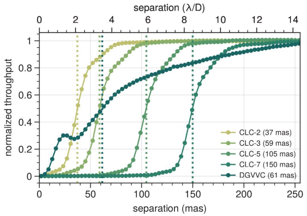
**VAMPIRES' FIVE (5) MEASUREMENT MODES; CAN BE COMBINED**

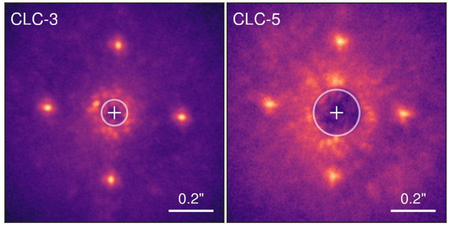
## MBI




75mas binary (detail). Full frame is 3x3".

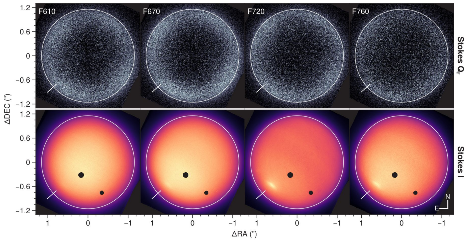
## Coronagraphy

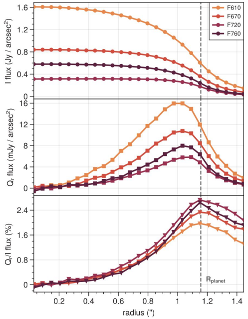



Selectable Lyot-type coronagraph masks (4 Lyot + vector vortex) . (left) Throughput curves for available masks. (right) Example on-sky frames.

## Polarimetric Imaging



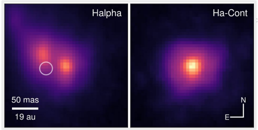



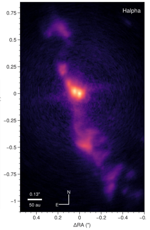

Neptune PDI: (left) Limb polarization; (right) Radial profiles show wavelength dependent intensity and scattering

## H-alpha

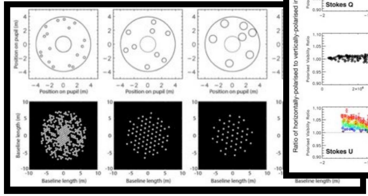
Simultaneous imaging of Ha and nearby continuum

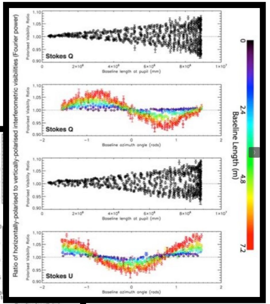
R Aqr symbiotic star




## Aperture Masking




NRM mask (left) allows for independent measurement of baselines complex visibilities. (right) NRM+PDI

# Fast, low noise detector

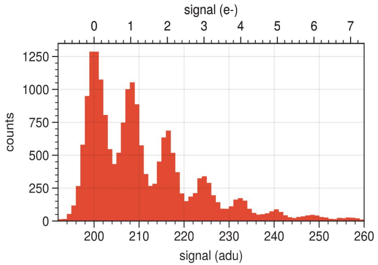
Two (2x) low-noise visible cameras, providing the sub-e- readout noise 0.2e- to 0.4e-).QE is 60% average in the VAMPIRES bands.

Camera Modes and Performance

VAMPIRES Camera Modes

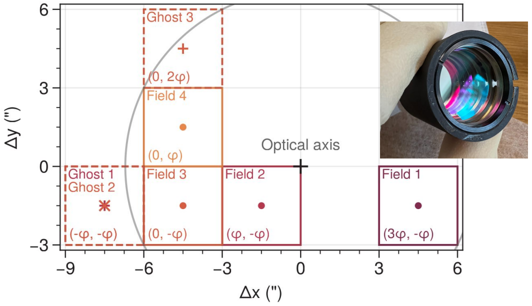
| Camera Mode | Frame Size (px) | Readout Mode | Max. Framerate (Hz) |
|---|---|---|---|
| standard | 536 x 536 | fast | 516 |
| | | slow | 16 |
| MBI | 2244 x 1108 | fast | 244 |
| | | slow | 7 |
| MBIR* | 2244 x 592 | fast | 489 |
| | | slow | 15 |

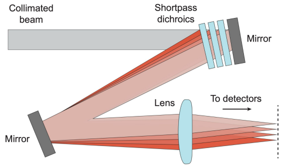
*: MBI-reduced (MBIR) mode crops out the F610 field for faster readout speeds.




# Multi-band Imaging (MBI)

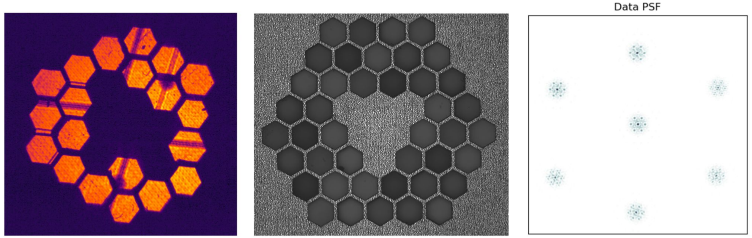
In MBI mode, four 50nm-wide bands are simultaneously acquired




# Aperture Masking -> JEWELS

JEWELS replaces the aperture mask with a tiling of prism for greater efficiency and better (u,v) plane coverage. This will bring >10x boost in efficiency and sensitivity.




(Left) Jewel 4x5 mask currently installed on VAMPIRES. (Center) new Jewel 7x6. (Right) A rosette of Interferograms taken with a 633nm laser in an optical testbed illustrating the entire PSF of the new 7x6 mask.

# P27 Super-Resolution Spectro-Imaging with SCExAO/ Photonic Lanterns

## Modal Decomposition of light with a Photonic Lantern (PL)

In a PL, light transitions adiabatically (no loss) from the MMF input to multiple SMF outputs. **The PL performs a modal decomposition of the input electric field** over a small FOV.

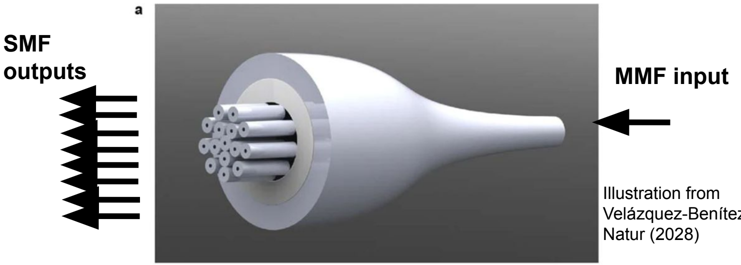
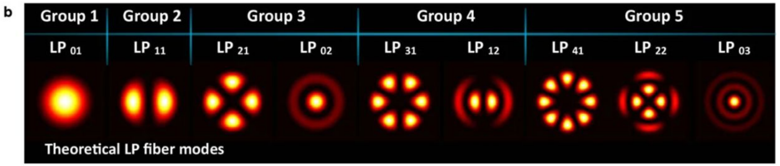
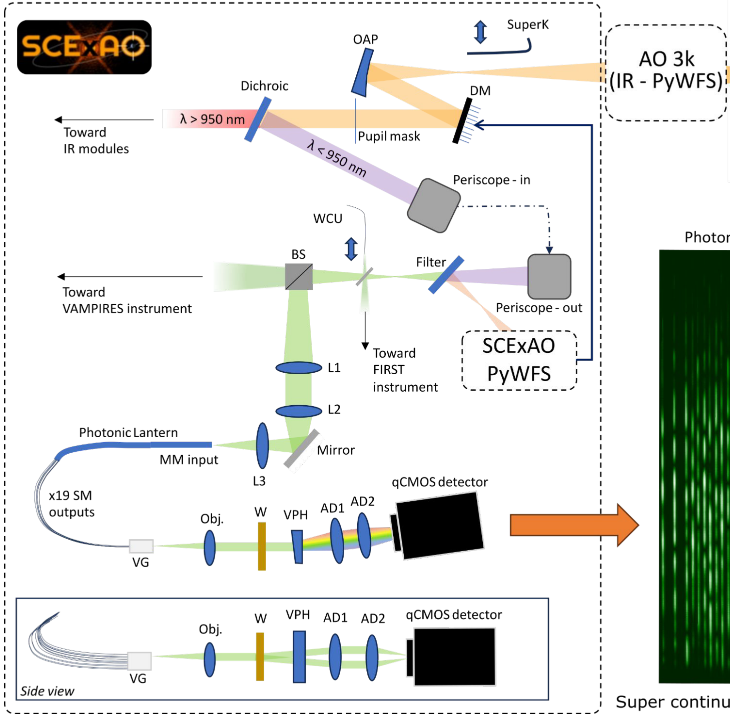
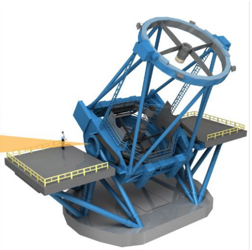



Illustration from Velázquez-Benítez et al. Natur (2028)

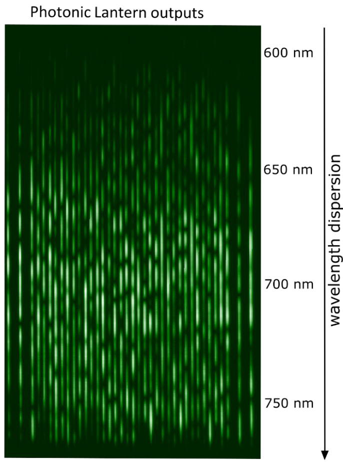



All-fibre photonic lantern. (**a**) Illustration of a photonic lantern fabricated using 15 fibres, and (**b**) theoretical LP fibre modes attainable with this device.



Subaru Telescope

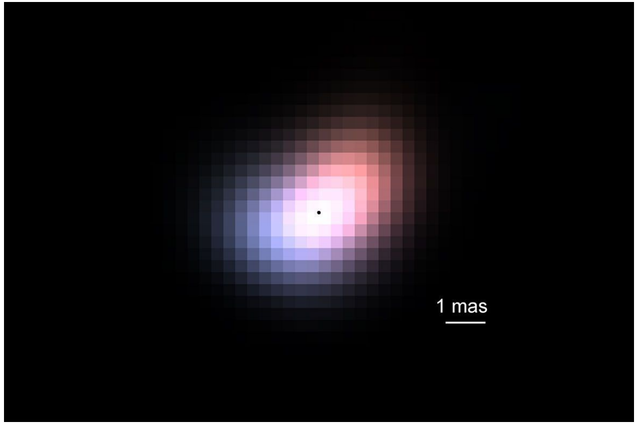


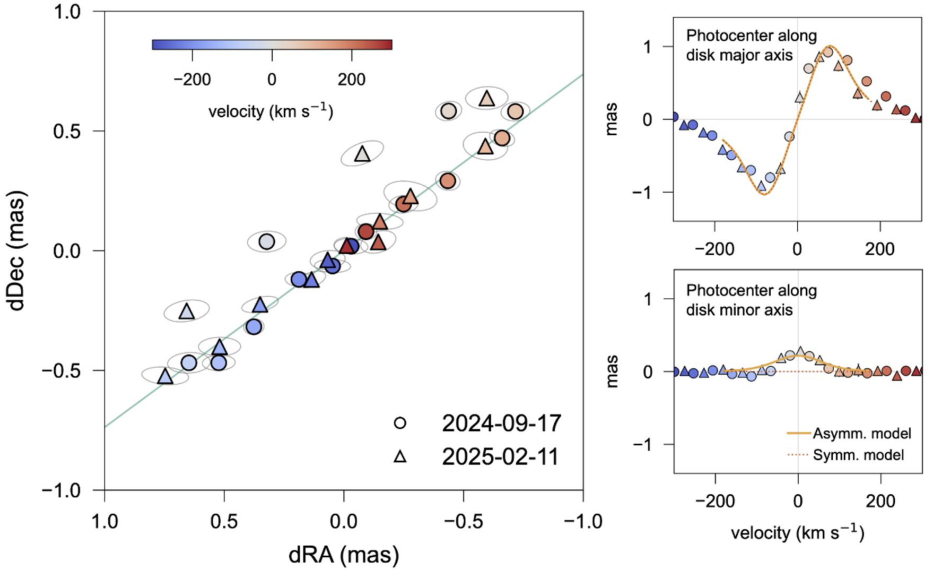

Super continuum calibration laser image

## Observation of β-CMi

(work led by Yoo Jung Kim @ UCLA)

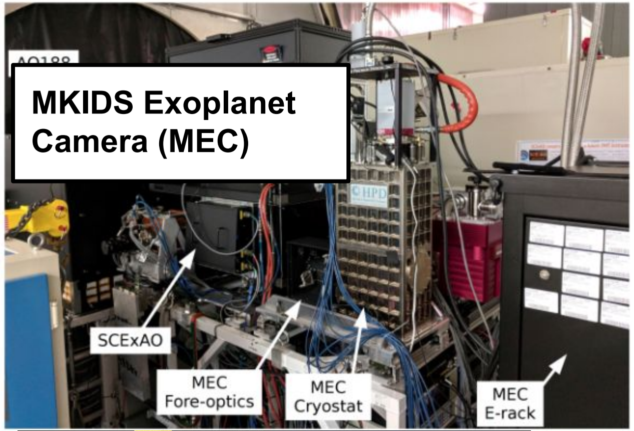
- **β-CMi** is a Be star with an Hα decretion disk
- Spectro-astrometry well below the diffraction limit of the Subaru Telescope (~20 mas at 656 nm)
- Disk asymmetry shown for the first time

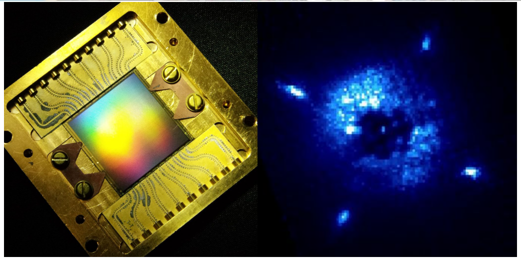


# P28 Enabling Deep Contrast Exoplanet Observations at the Diffraction Limit with New Technologies

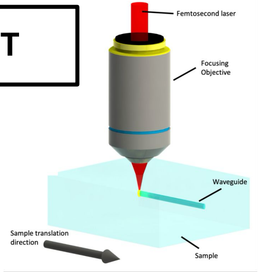
## DETECTORS

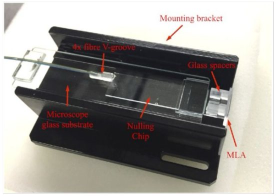


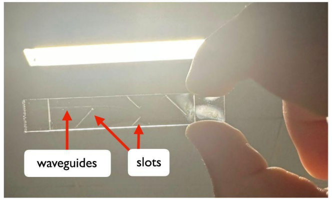
## ASTROPHOTONICS

GLINT

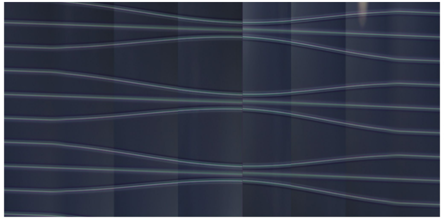


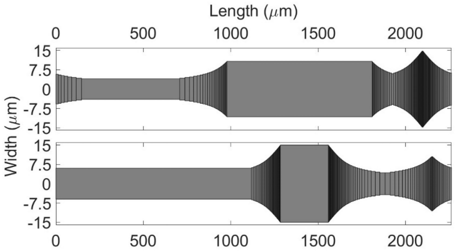

Arcadi, E.




E. Arcadi, Norris+ 2020 *MNRAS*



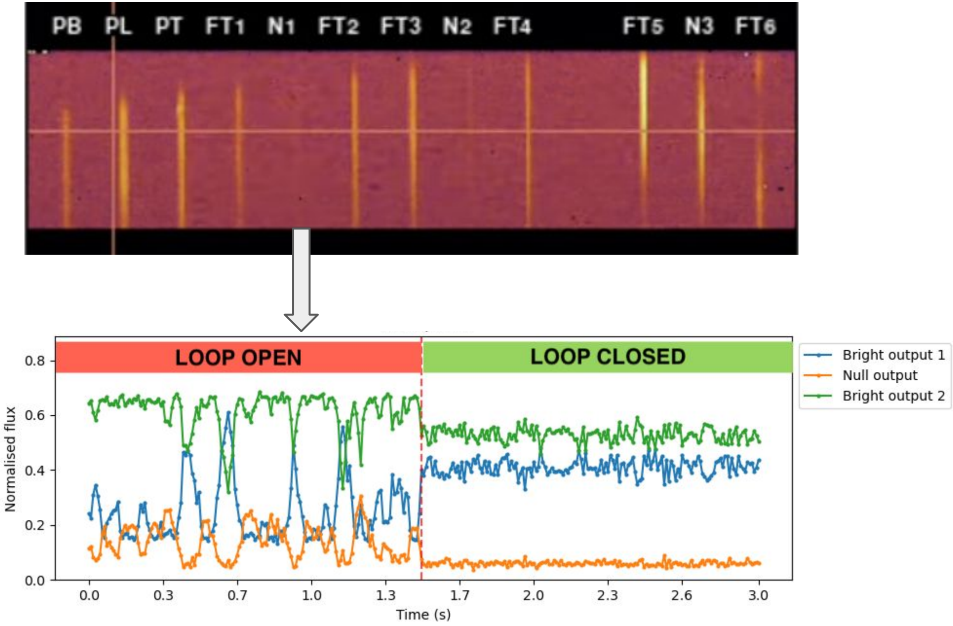
Waveguides arranged as tricouplers to enable phase control




Waveguides have achromatic phase shifters for a more broadband null

# WAVEFRONT / SPECKLE CONTROL

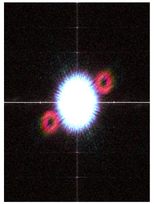
## GLINT



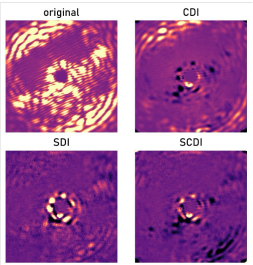

*GLINT on-sky Nulling (May 2025)*
*(Rossini-Bryson et al. 2025, in prep)*

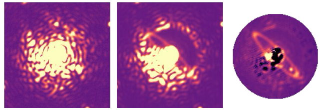
## SPIDERS

### Spectro-Coherent Differential Imaging

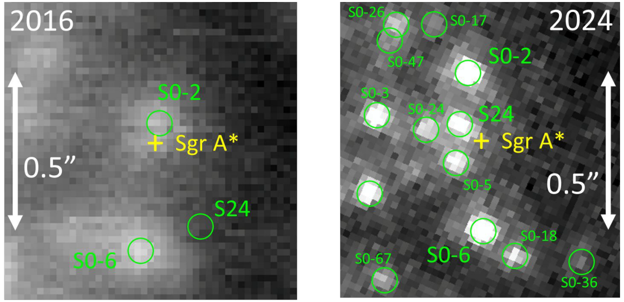


- Suppress speckles using DM at one wavelength
- Record fringed images at all wavelengths
- Use spectral differential imaging and coherent differential imaging on the same dataset

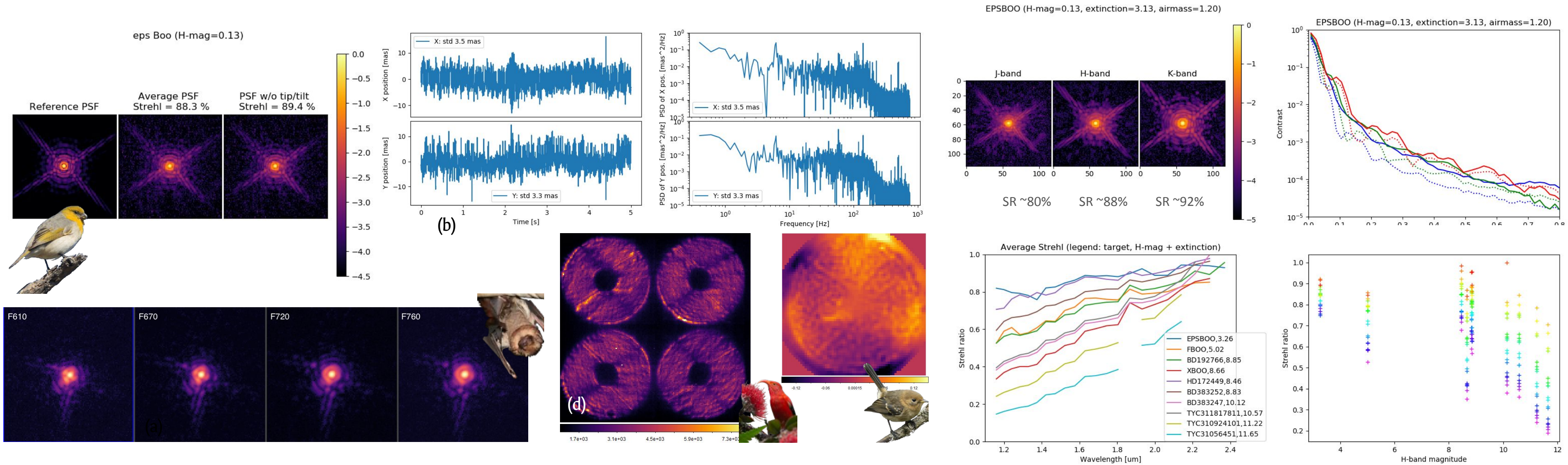


# P29 Updates on AO3k's new modules



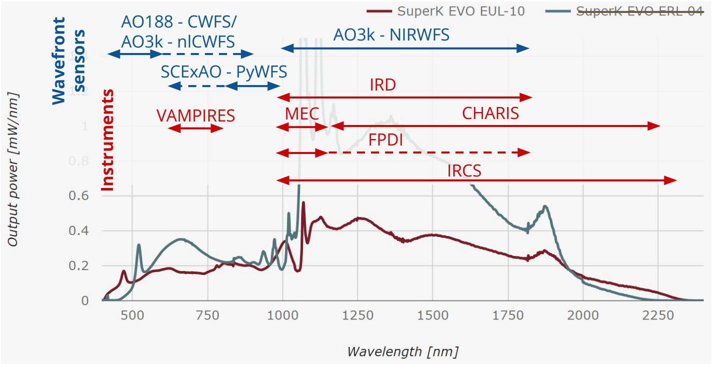

*Comparison of the galactic center observations in AO188 - LGS mode in 2016, and AO3k - NIRWFS mode in 2024. (Nishiyama et al.)*

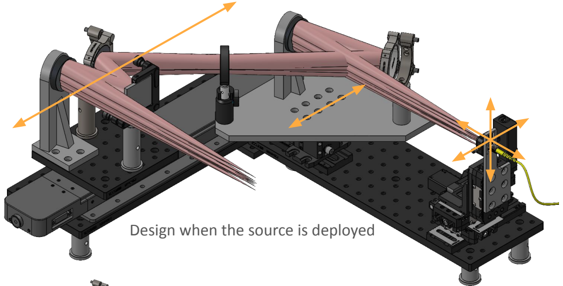


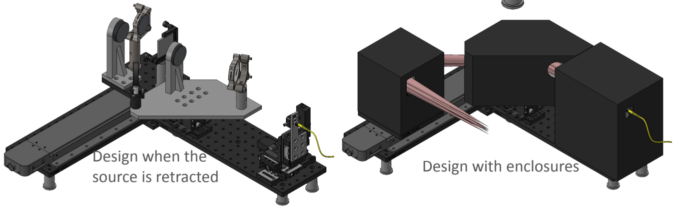

*a) Palila camera images (H-band) showing high Strehl compared to the reference PSF. b) Temporal data and PSDs of the tip/tilt showing a residual of ~3 mas RMS, mostly from a few mechanical vibrations. c) VAMPIRES images in multi-band imaging mode. d) Pyramid mode of the NIRWFS used for wavefront correction. e) DM3k command applied. f) CHARIS data with AO3k - NIRWFS and SCExAO - PyWFS loops closed.*

*g) CHARIS measurements with the AO3k-NIRWFS loop only. h) and i) Strehl measurements for various stellar magnitudes.*

# New light source




# Non-linear CWFS