

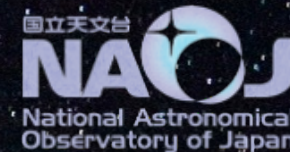
Subaru Users Meeting FY2023 (2024/1/23-25)

ULTIMATE-Subaru

Science Team Activity Report

<https://ultimate.naoj.org/index.html>

Yusei Koyama (Subaru Telescope)
on behalf of ULTIMATE collaboration



ULTIMATE
Subaru



SUPER
IRNET



ULTIMATE-Subaru : science team members

すばる広視野補償光学プロジェクト

ULTIMATE project office
(project management team)

Project scientist
(Yusei Koyama)



ULTIMATE-Subaru
science team
(Jan 22 2024)

A. High-redshift Universe

Masayuki Akiyama	Yen-Ting Lin*	Takatoshi Shibuya
Yuichi Harikane	Yuichi Matsuda	Rhythm Shimakawa
Takuya Hashimoto	Yoshiki Matsuoka	Tomoko Suzuki
Akio Inoue	Yosuke Minowa	Ken-ichi Tadaki
Daichi Kashino	Takahiro Morishita	Ichi Tanaka
Satoshi Kikuta	Rieko Momose	Masayuki Tanaka
Tadayuki Kodama	Tohru Nagao	Jun Toshikawa
Kotaro Kohno	Kimihiko Nakajima	Yoshiki Toba
Yusei Koyama	Kazuyuki Ogura	Hideki Umehata
Mariko Kubo	Masato Onodera	<i>Katherine Whitaker</i>
Haruka Kusakabe	Christian Rusu	Kiyoto Yabe

Multi-object IFU

F. Bian	S. Croom	L. Kewley
J. Bryant	S. Leslie	I. T. Ho
J. Bloom	C. Lidman	A. Shaefer
A. Casey	D. Nataf	T. Yuan
		T. Zafar

B. Local Universe

Nearby galaxies
Milky Way, Solar System

<i>Daniela Calzetti</i>	Kosuke Kushibiki	Kazuo Sorai
Masashi Chiba	Patryk S. Lykawka	Daisuke Suzuki
Olivier Guyon	Yen-Ting Lin	Masahiro Takada
Arika Higuchi	Noriyuki Matsunaga	Yuhei Takagi
Daisuke Iono	Tomonori Michiyama	Shunya Takekawa
Miho Ishigaki	Rie Miura	Tsutomu T. Takeuchi
Takashi Ito	Yusuke Miyamoto	Tsuyoshi Terai
Takafumi Kamizuka	Kumiko Morihana	Kazufumi Torii
Hiroyuki Kaneko	Kentaro Motohara	Junko Ueda
Daisuke Kawata	Takayuki Muto	Chikako Yasui
Ji Hoon Kim	Yoshikazu Nakada	Fumi Yoshida
Masato Kobayashi	Shogo Nishiyama	
Jin Koda	Yumiko Oasa	
Takuma Kokusho	Keiji Ohtsuki	
Shinya Komugi	Sakurako Okamoto	
Yukihiro Kono	Hiroki Onozato	
Shuhei Koyama	<i>Eric Peng</i>	
Yusei Koyama*	Tae-Soo Pyo	
	Toshiki Saito	
	Satoko Sorahana	

C. Time Domain science

Akihiko Fukui	Masamune Oguri
Naoaki Koshimoto	Daisuke Suzuki*
Yusei Koyama*	Takahiro Sumi
Chien-Hsiu Lee	Masaomi Tanaka
Keiichi Maeda	Kenneth C. Wong
Tomoki Morokuma	
Takashi Moriya	
Chow-Choong Ngeow	

NINJA / LTAO

Yusei Koyama*	Shinobu Ozaki
Yoshiki Matsuoka*	Masaomi Tanaka*
Takashi Moriya	Masayuki Tanaka*
Kentaro Motohara*	Chihiro Tokoku
Yosuke Minowa*	Koki Terao
Tohru Nagao*	Nozomu Tominaga
Yoshito Ono	Kenshi Yanagisawa
Masami Ouchi	Michitoshi Yoshida



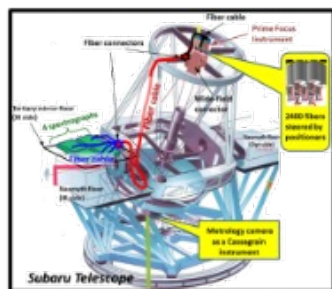
ULTIMATE-Subaru

すばる広視野補償光学プロジェクト

Instruments
for dark nights

Instruments
for bright nights

Imaging Spectroscopy



PFS
(2025-)



HSC
(2013-)



ULTIMATE
(~2028-)

1
 λ [μm]

2

Great synergy with future
space telescopes



Excellent target provider
for 30m -class telescopes





ULTIMATE-Subaru : history (1)

すばる広視野補償光学プロジェクト

Science/Community meetings organized by ULTIMATE project:

- FY2011: Subaru Next-generation AO workshop (Osaka)
- FY2012: GLAO science workshop 2012 (Hawaii)
- FY2013: GLAO science workshop 2013 (Hokkaido)
- **FY2014: ULTIMATE-Subaru** Science WS (NAOJ)
- FY2016: ULTIMATE-Subaru Science WS (NAOJ)
- FY2017: Mini-workshop for ULTIMATE in Taipei (Taipei)
- FY2018: ULTIMATE-Subaru Collaboration Meeting (NAOJ)
- FY2019: Wide-field IR Astronomy Workshop (domestic, NAOJ)
- FY2019: ULTIMATE session in Subaru 20th conference (Hawaii)
- FY2021: SUPER-IRNET online seminar series
- FY2022: SUPER-IRNET in-person Workshop (NAOJ)



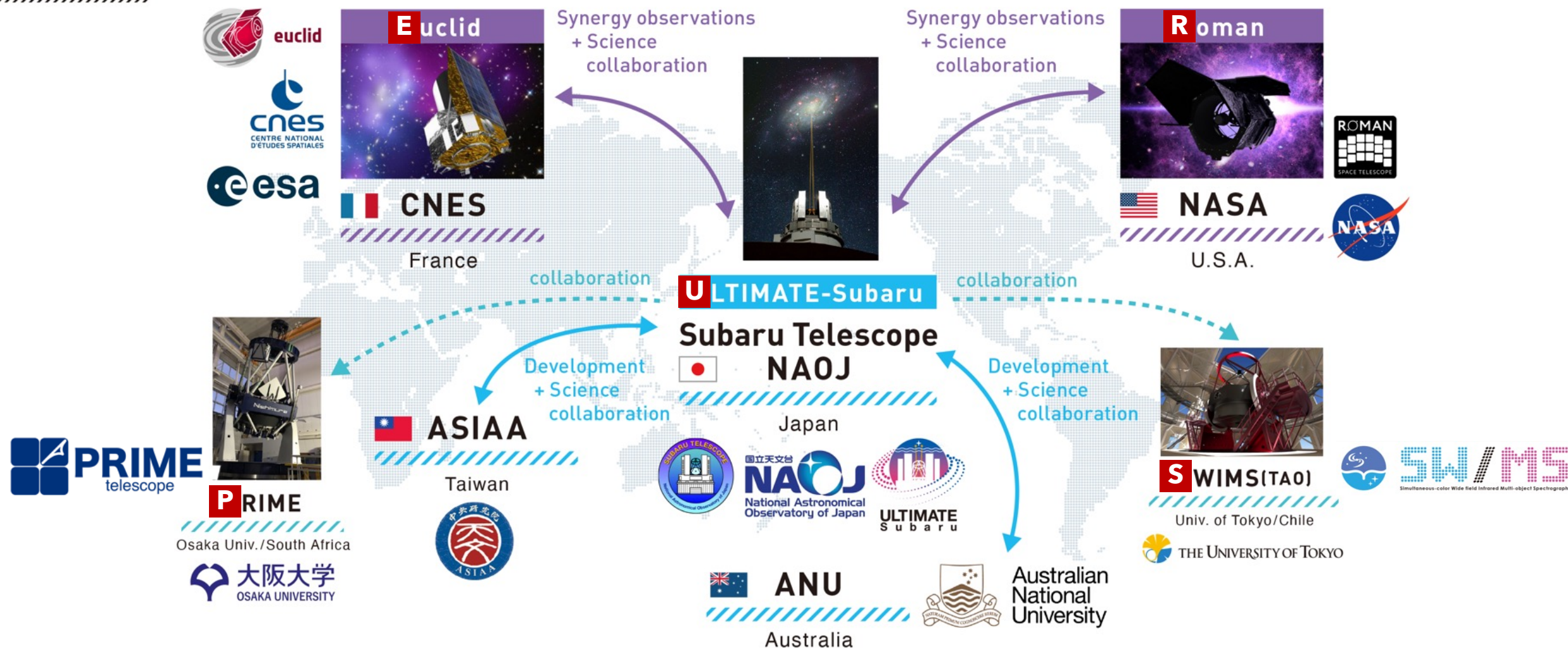
SUPER-IRNET: JSPS Core-to-Core Program

FY2021-FY2025, PI: M. Yoshida (NAOJ)

- Online seminar series in FY2021-FY2022 (during pandemic)
- 1st in-person meeting in March 2023 @ NAOJ
- 2nd meeting in July 2024 @ Beppu/Oita

Organizers:

- M. Yoshida (NAOJ)
- Y. Koyama (Subaru/NAOJ)
- H. Miyatake (Nagoya)
- T. Moriya (NAOJ)
- D. Suzuki (Osaka)





SUPER-IRNET

FY2021-FY2025, PI

- Online seminar series
- 1st in-person meeting
- 2nd meeting in July 2024

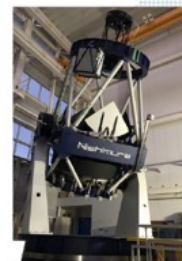
SUPER IRNET



euclid



CNES
France



PRIME

Osaka Univ./South Africa



ASIA

Taiwan



SUPER IRNET

The Second SUPER-IRNET Workshop:
Sparkling Our Collaboration at the Cosmic Gate

July 23 - 26, 2024

@ B-Con Plaza, Beppu/Oita, Japan

Core Program

Organizers:

M. Yoshida (NAOJ)
Y. Koyama (Subaru/NAOJ)
H. Miyatake (Nagoya)
T. Moriya (NAOJ)
D. Suzuki (Osaka)

Participants



NASA

U.S.A.



Collaboration

Development
Collaboration



SWIRMS(TAO)

Univ. of Tokyo/Chile



THE UNIVERSITY OF TOKYO



SWIRMS
Simultaneous-color Wide Field Infrared Multi-object Spectrograph

Australian
National
University

Australia

Australia-Japan Foundation Grant

Australia-Japan Foundation grant recipients, 2010-11				
Australia-Japan Foundation grant recipients, 2009-10	Scientific Innovation	Australian Academy of Technological Sciences and Engineering	Australia-Japan Emerging Leaders in STEM	\$30,000.00
Australia-Japan Foundation grant recipients, 2008-09	Scientific Innovation	The University of Western Australia	Advancing Australia-Japan knowledge exchanges on hydrogen	\$25,000.00
Australia-Japan Foundation grant recipients, 2007-08	Scientific Innovation	ULTIMATE-Subaru collaboration, Subaru Telescope, National Astronomical Observatory of Japan	ULTIMATE - Australia-Japan collaboration for a brighter future at Subaru Telescope	Year 1: \$30,000.00 Year 2: \$16,600.00
	Scientific Innovation	University of New South Wales	Sustainable material futures: computational design for timber architecture	\$45,000.00
	Society, Culture and Sport	Agency Projects	Cultural explorations in materiality and design	\$43,253.08
	Society, Culture and Sport	Arao City Culture Centre (Chuo-Setsubi Stage Labo Collaborative)	A staged reading of the play "Counting & Cracking" in Kyushu, Japan	\$40,000.00
	Society, Culture and Sport	Art Front Gallery Co. Ltd.	Artwork by Abdul Rahman Abdullah at Hyakunengo Art Festival	\$10,000.00
	Society, Culture and Sport	Australian Art Orchestra	The Australian Art Orchestra Inter-Cultural Music Exchange	\$30,000.00

2-yrs program to extend our existing AU-JP collaboration (mainly in AO development) to full community scale!



ULTIMATE-Subaru : history (2)

すばる広視野補償光学プロジェクト

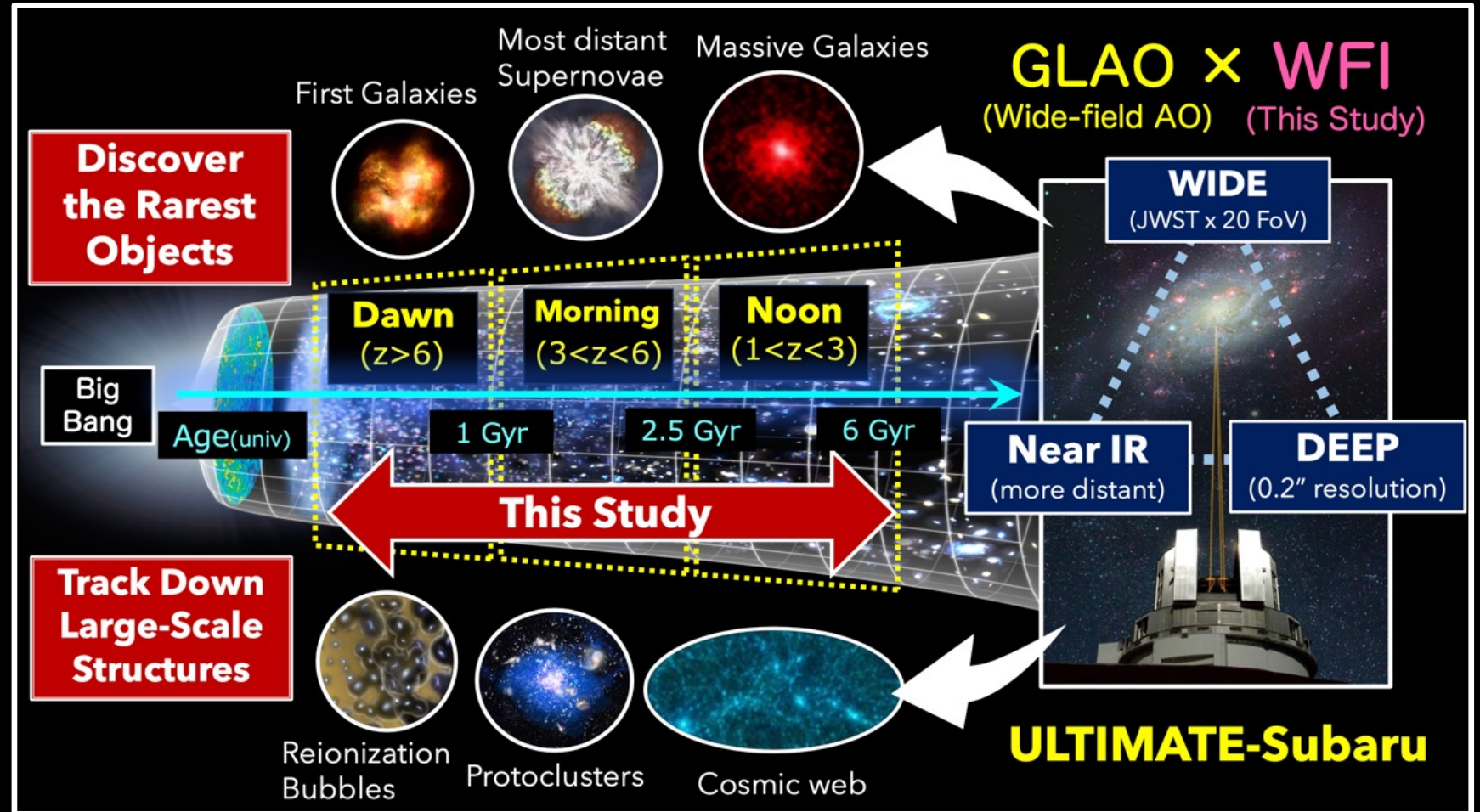
Project status and funding history:

- FY2017: "ULTIMATE-START" started (with Kakenhi/Kiban-S, PI: Akiyama)
- FY2018: GLAO system Conceptual Design Review
- FY2019: Start of NAOJ's official support as A-project ("Subaru GLAO Project")
- FY2021: Start of SUPER-IRNET, NINJA (both with PI: M. Yoshida)
- FY2021: ULTIMATE Instruments Conceptual Design Review
- FY2022: Start of "Subaru-2.0" as MEXT Frontier Program
- FY2022: GLAO system Preliminary Design Review
- FY2022: Start of Kakenhi/国際先導研究 (ILR, PI: Miyazaki)
- **FY2024: Start of Kakenhi/特別推進 to develop ULTIMATE-WFI (PI: T. Kodama)**

JSPS Kakenhi Tokubetsu-suishin - starting from FY2024 (7 years)

PI: T. Kodama (Tohoku Univ)

- K. Nagamine (Osaka)
- H. Yajima (Tsukuba)
- K. Sugimura (Hokkaido)
- T. Moriya (NAOJ)
- A. Inoue (Waseda)
- M Kubo (Tohoku)
- Y. Koyama (Subaru/NAOJ)
- K. Motohara (NAOJ)
- M. Akiyama (Tohoku)
- Y. Minowa (Subaru/NAOJ)



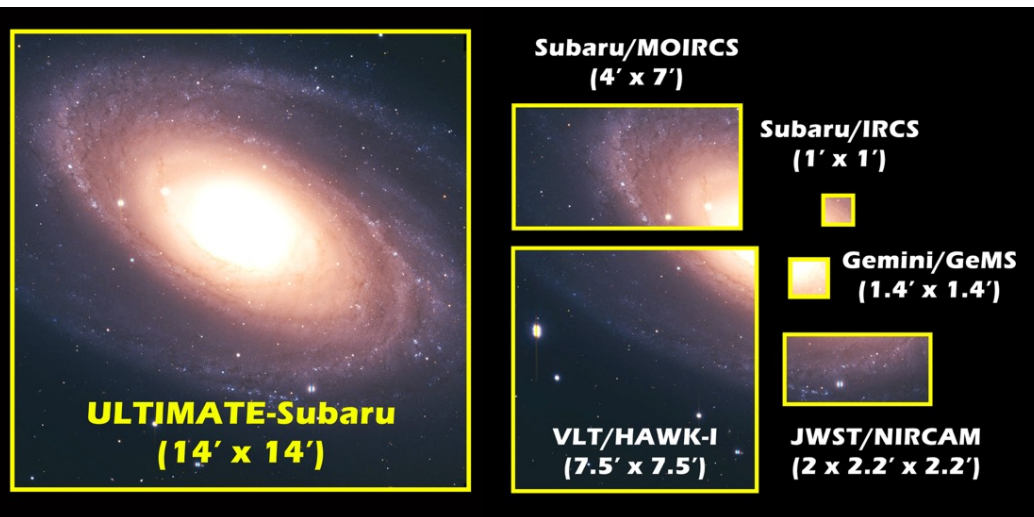
BREAKING NEWS : ULTIMATE-WFI Funded !!



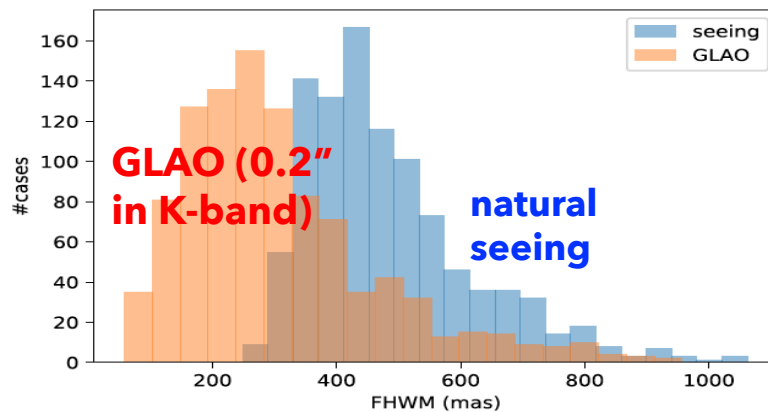
ULTIMATE-Subaru : unique science capabilities

すばる広視野補償光学プロジェクト

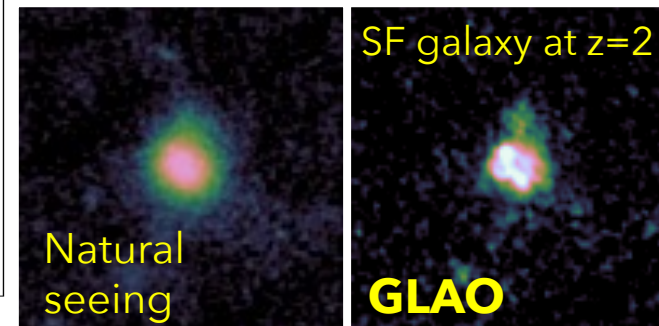
① Widest AO imaging on 8-10m telescope



② Space telescope image quality



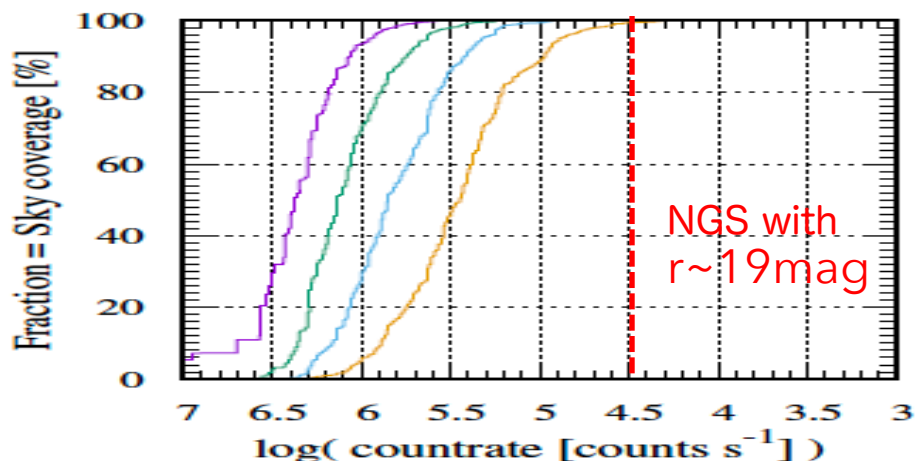
Comparable to HST/Roman, higher image quality than existing GLAO on VLT



④ Variety of NB/MB filters + flexible observations

③ All-sky coverage

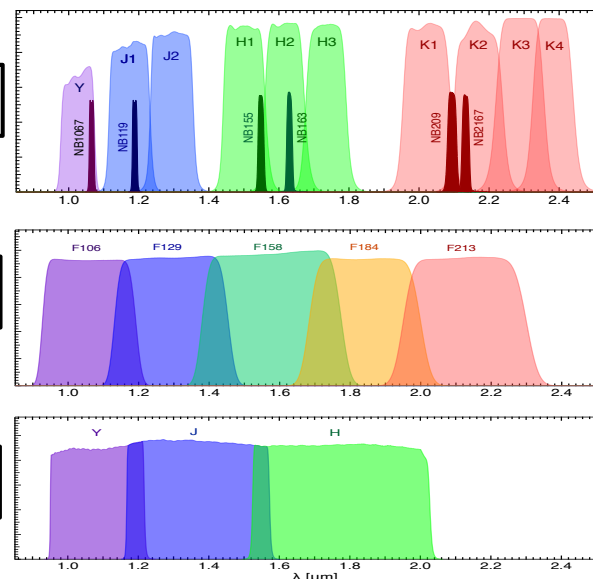
Full performance everywhere - no worry about guide star availability



ULTIMATE

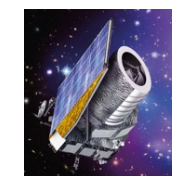
Roman

Euclid



Roman

Expecting great synergy with space missions.



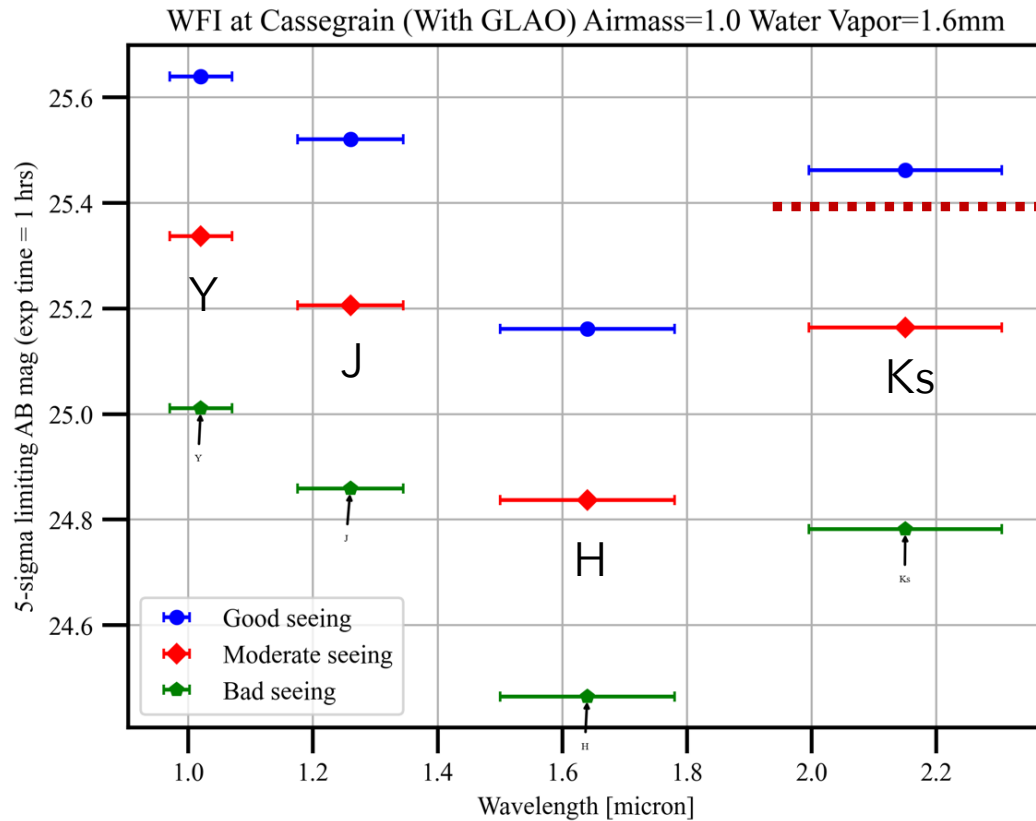
Euclid



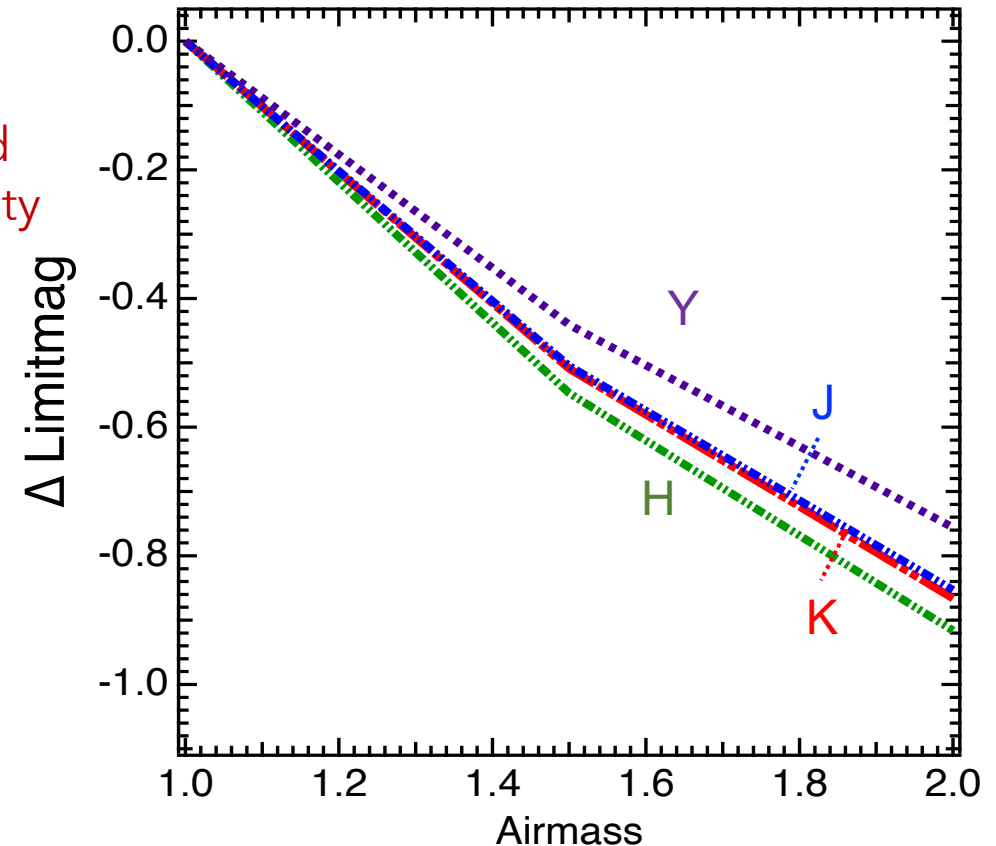
Sensitivity - GLAO + WFI (broad-bands)

See poster (S. Ali et al.) for more details

- We can reach ~25-26 mag (AB) with reasonable observing time.
- ~0.5 mag higher sensitivity than no-AO cases in K-band (~0.3-0.5 mag in Y/J/H).



Roman
Ks-band
sensitivity

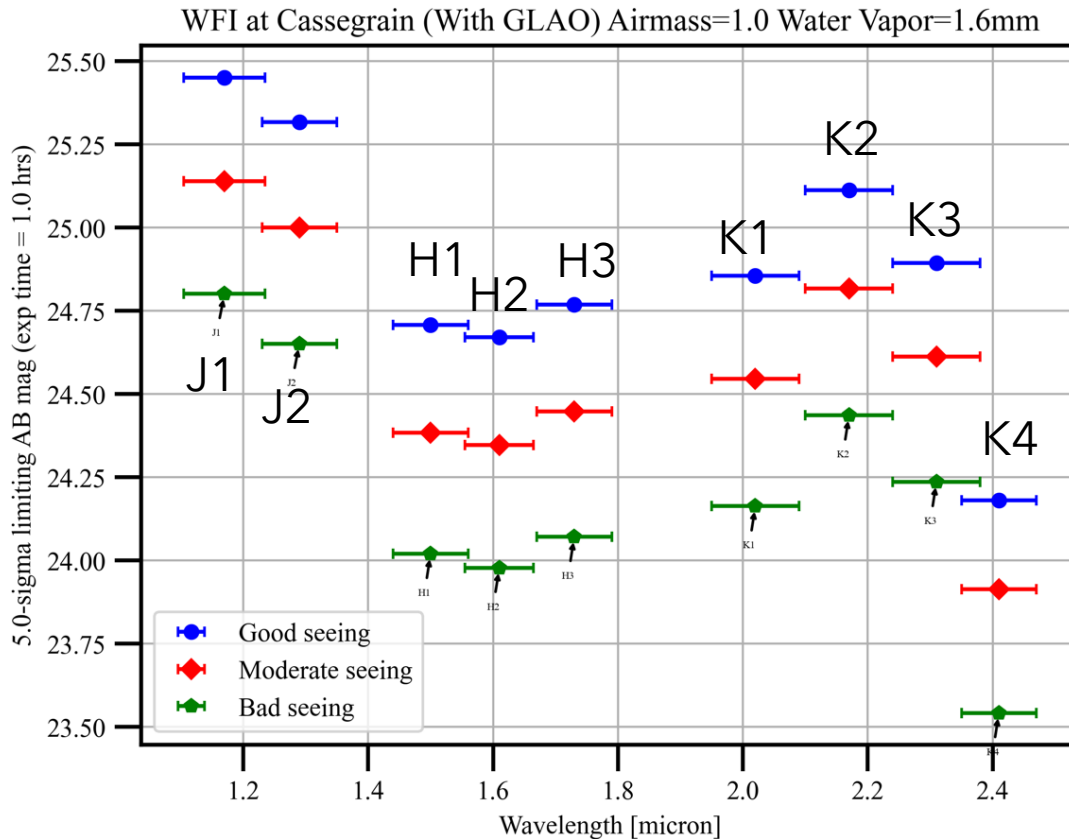


Sensitivity - GLAO + WFI (MBs/NBs)

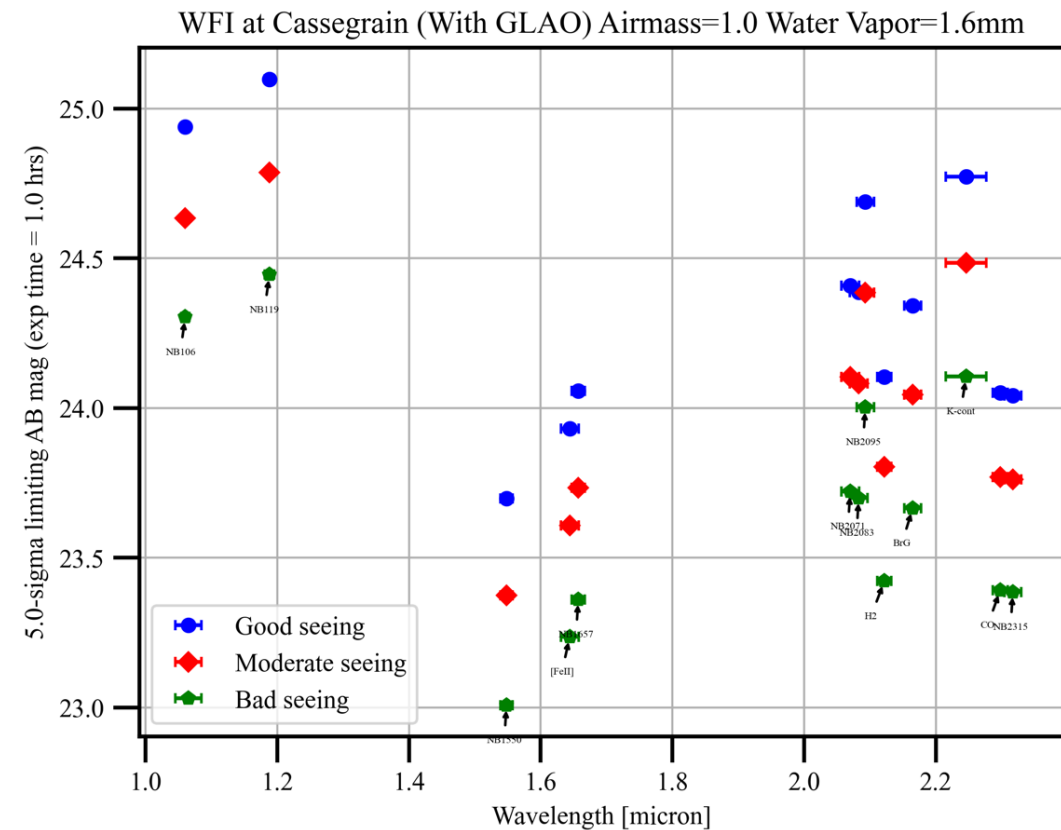
- We can reach ~24-25 mag (AB) in MBs/NBs.
- Filter set is still under discussion.

See poster (S. Ali et al.) for more details

MBs **Funded by Kakenhi (ILR)**
(PI: S. Miyazaki)



NBs (assume MOIRCS NBs)



We encourage everyone to carry in your custom filters !

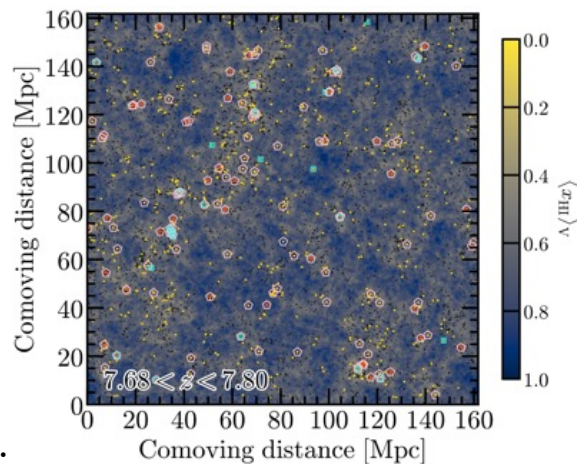
ULTIMATE to explore the *Deep* Universe

A) High-redshift universe

1) Cosmic Reionization Bubble

Deep & Wide NB

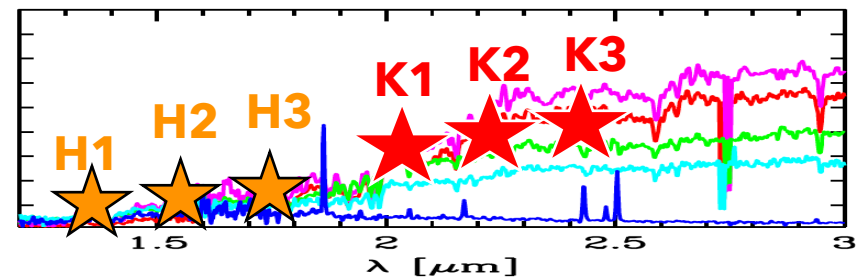
Unprecedentedly deep and wide NB imaging to search Ly α emitters in the epoch of cosmic reionization (at $z \gg 7$), to identify ionized bubbles in the very early universe.



2) First Massive Galaxies

Deep & Wide MB

Understand the nature and environment of massive (quenched) galaxies by detecting the most massive galaxies at $z \sim 4-5$ with deep/wide MB(K) imaging.

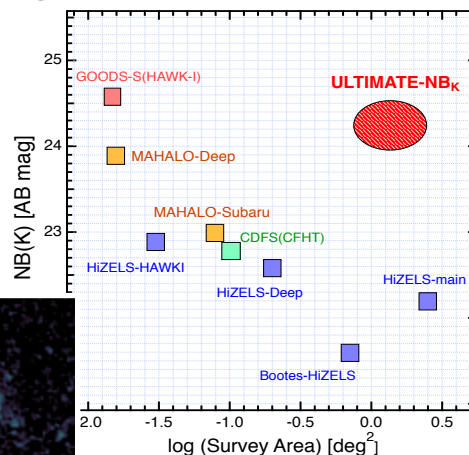


SEDs of $z=4$ galaxy

3) Early Galaxy Morphologies

Sharp & Wide NB

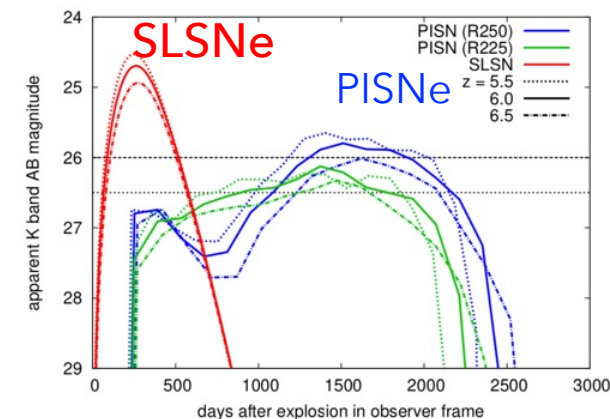
Stellar build-up inside the galaxies at the cosmic noon ($z \sim 2-3$) epoch with deep and sharp NB(H α /[OIII]) imaging in K-band.



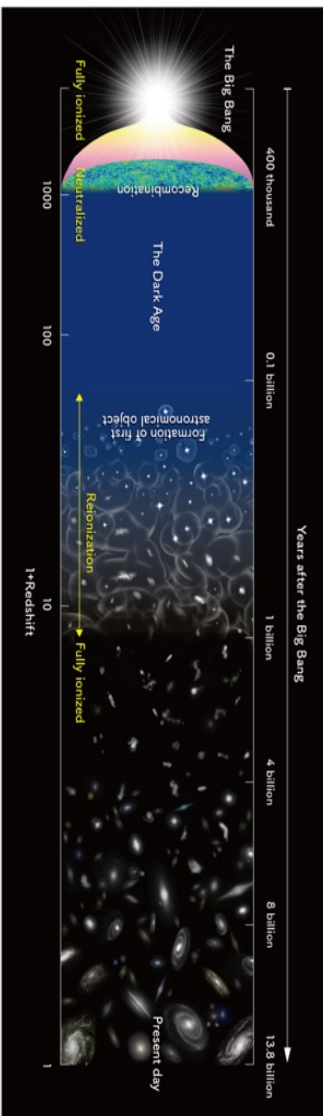
4) Supernovae Explosion of First Stars

Deep & Wide K/MB

SNe search at $z > 6$ by visiting $\sim 1\text{-deg}^2$ every 180-days down to $K > 26$ mag will allow us to detect SNe at $z > 6$.



(Moriya+2019)



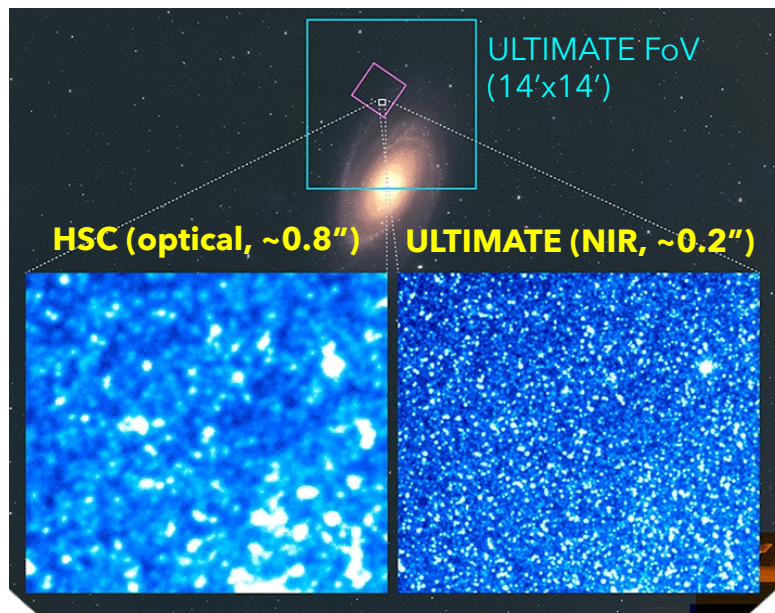
ULTIMATE to explore the *Deep* Universe

B) Dense/Obscured Regions in the Local Universe

1) Nearby Galaxies

Sharp & Wide JHK + NB

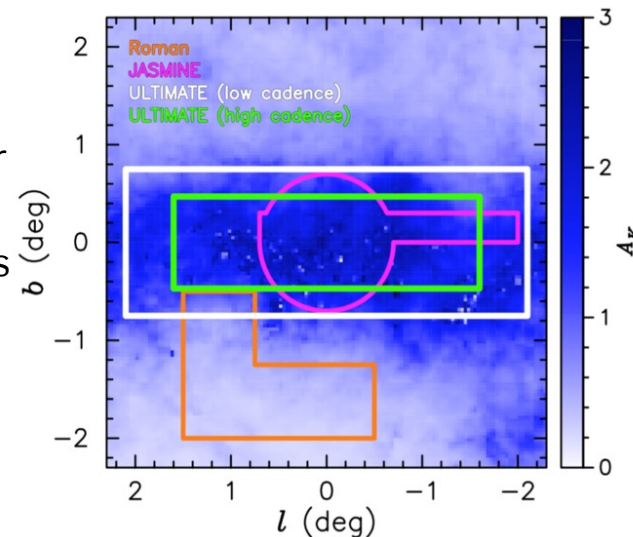
Spatially resolve nearby galaxies ($D < 10 \text{ Mpc}$) into individual stars and star-forming regions, to study galaxy formation history (galactic archaeology) and ISM physics.



2) Galactic Center

Sharp & Wide JHK + NB

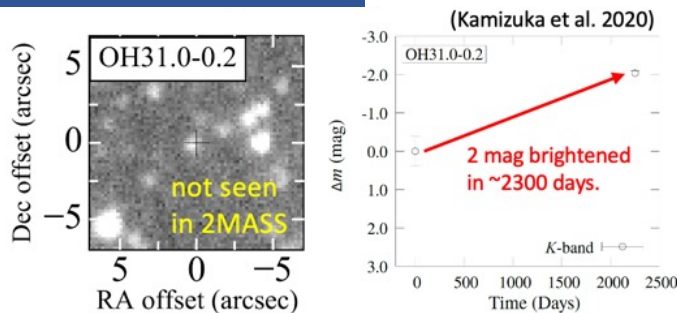
High/low cadence survey toward the Galactic Center with ULTIMATE, to reveal hidden objects (blackholes and free-floating planets) in the Galactic Center with microlensing and astrometric approach.



3) Galactic Plane

Poster by Morihana et al.

- Revealing the Milky Way structure and hidden stellar evolution (e.g. OH/IR stars).
- Pa β /Br γ imaging for cataclysmic variables, to reveal the Galactic Diffuse X-ray Emission

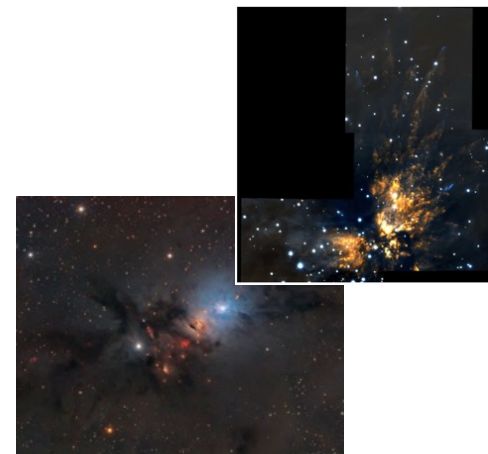


Sharp & Wide NB/MB

4) Star Forming Regions

Sharp & Deep JHK + NB

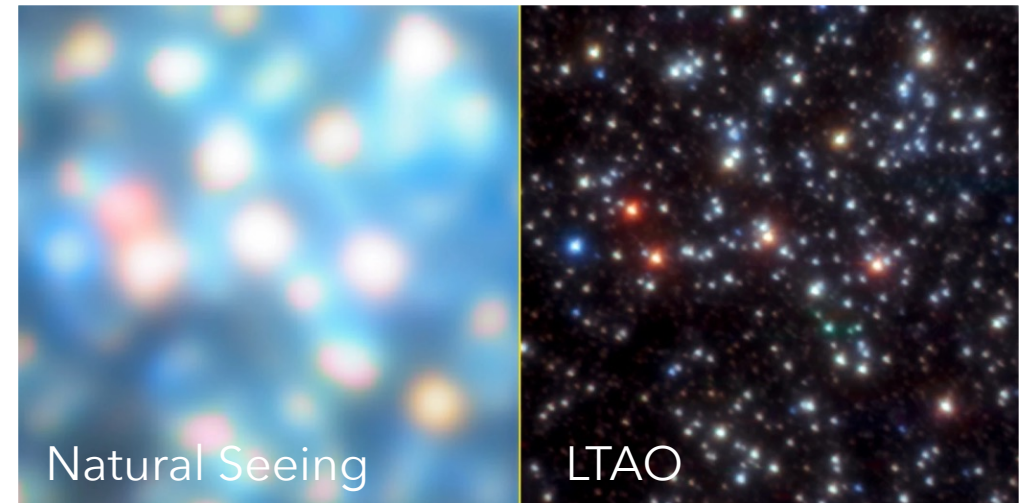
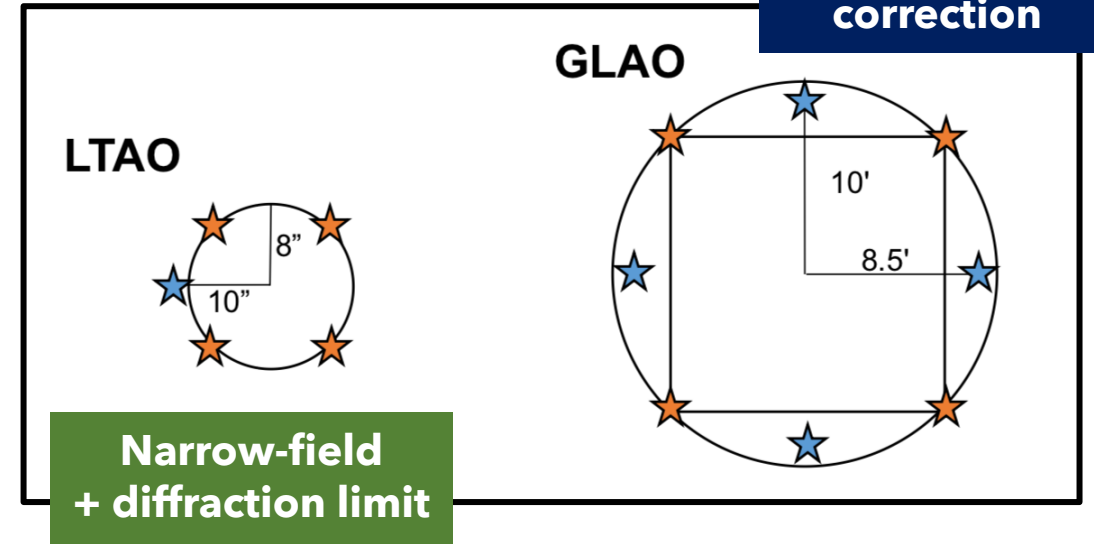
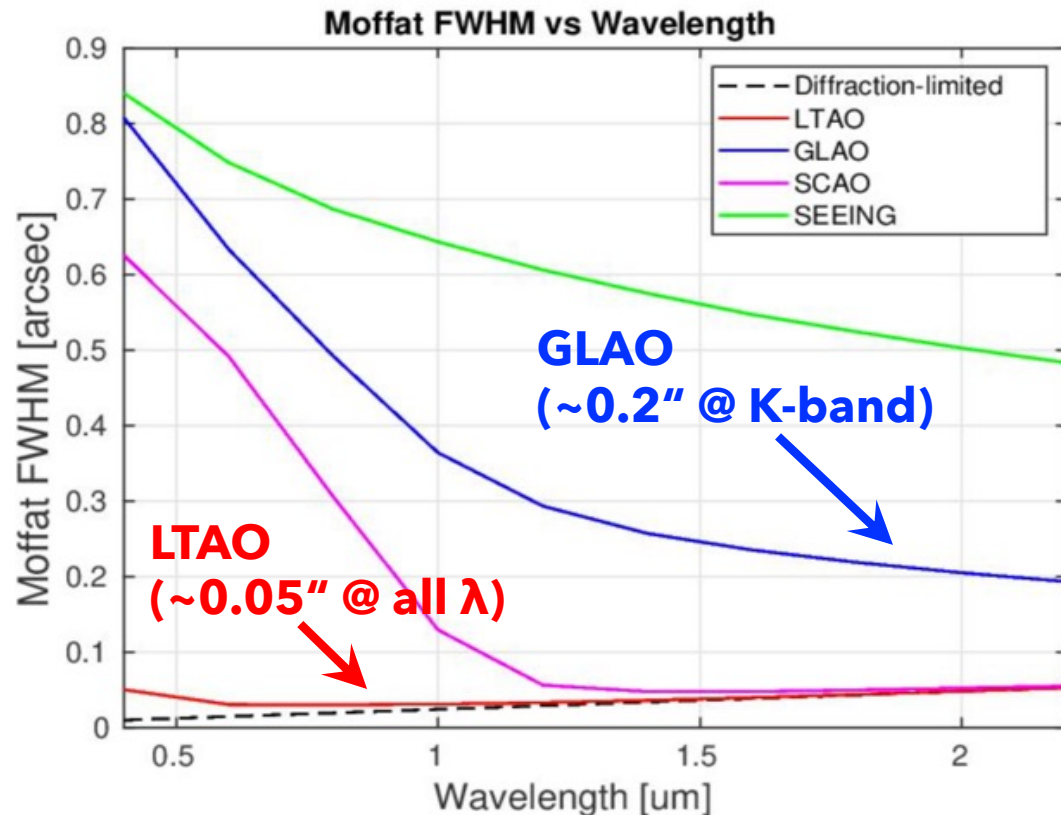
Sharp/deep imaging of SF regions in a variety of environment within the Milky Way to study the variety/universality of IMF.



ULTIMATE “narrow-field (LTAO)” mode

- ULTIMATE is **not only** for wide-field science.
- Our “LTAO” mode can deliver ultimately high spatial resolution and high sensitivity for your favorite target!

**Discussion session tomorrow
(future of Subaru NslR)**

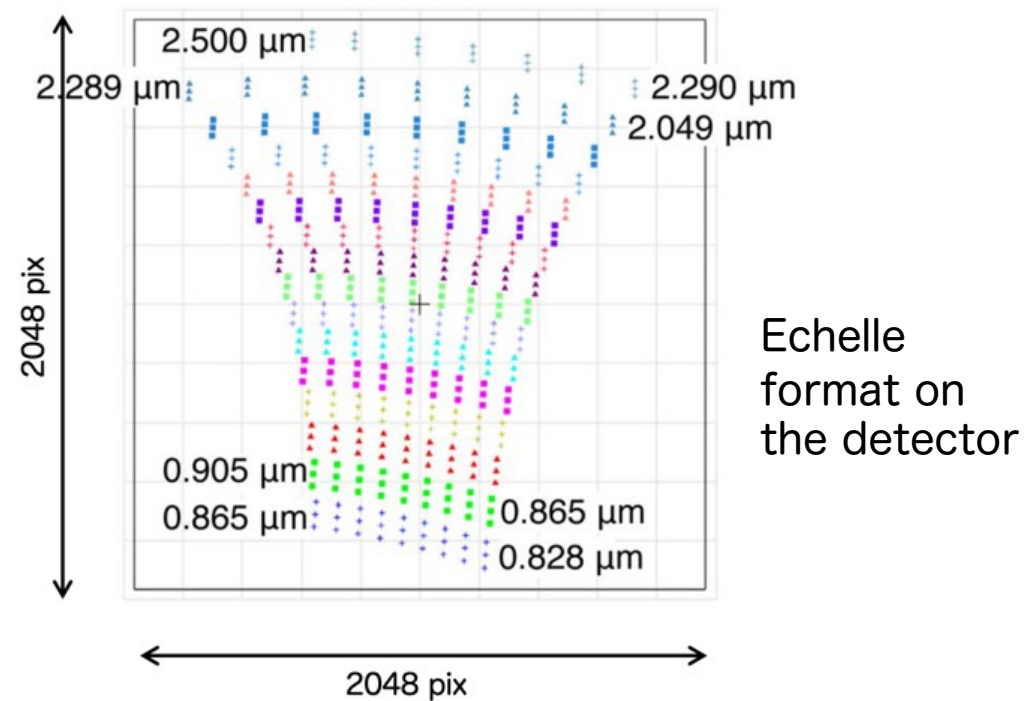
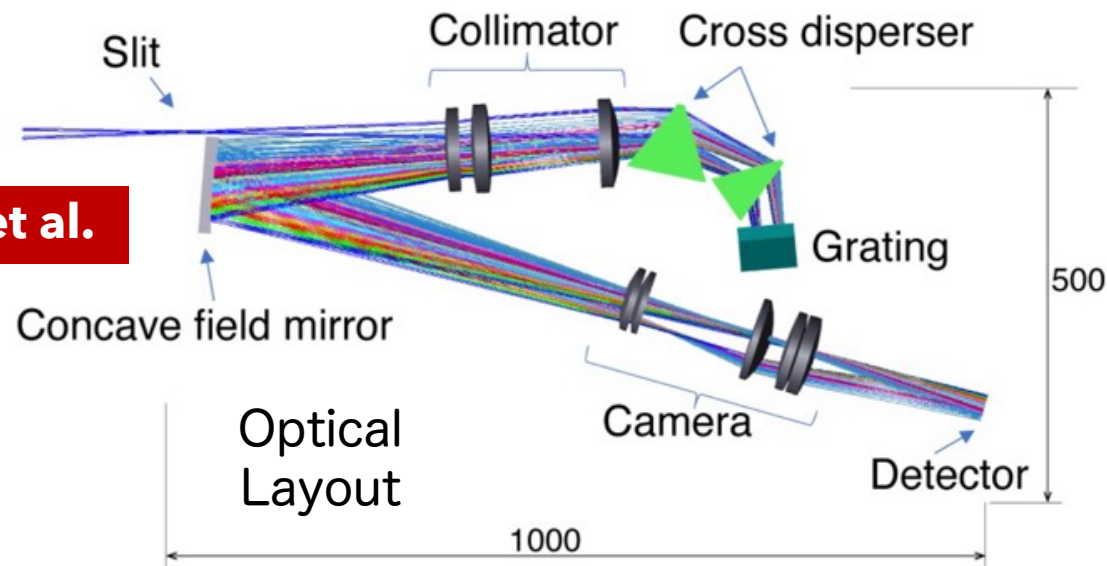


NINJA Near-**I**nfrared and optical **J**oint Spectrograph with **A**daptive optics

See poster by Tokoku et al.

- **Kakenhi Kiban-S (PI: M. Yoshida)**
- LTAO-assisted, high sensitivity spectrograph
- Wide wavelength coverage, potential extension to visible.
- Start science operation as PI-type instrument from FY2026.

波長範囲	0.83 – 2.5 μm
F比	13.9
スリット幅	0.35" (0.19 mm) (TBD)
スリット長	5" (2.7 mm)
コリメータ焦点距離	597.7 mm
瞳径	43.0 mm
グレーティング溝密度	56 lines/mm
グレーティングブレード角	33 degrees
検出器	HAWAII-2RG 1枚
検出器画素数	2048 x 2048 pix
検出器画素サイズ	18 $\mu\text{m}/\text{pix}$
サンプリング(0.35"スリット)	3.3 pix
波長分解能	R~3300



NINJA team: C. Tokoku, M. Yoshida, T. Moriya, K. Motohara, S. Ozaki, K. Yanagisawa, Y. Ono, Y. Minowa, K. Terao, Y. Hayano, Y. Koyama, N. Tominaga, M. Ouchi, M. Tanaka (NAOJ), M. Tanaka, M. Akiyama (Tohoku), T. Nagao, Y. Matsuoka (Ehime), K. Kushibiki, A. Yasuda, T. Yukino (Tokyo)

Tokoku et al. (2022)

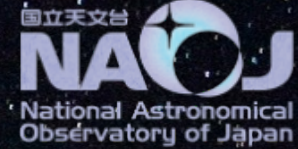


Summary

ULTIMATE is
NOT a dream.

ULTIMATE is
our REAL future!

It's time to seriously
consider your science
with ULTIMATE.



TOHOKU
UNIVERSITY



Australian
National
University



東京大学
THE UNIVERSITY OF TOKYO



SUPER
IRNET



ULTIMATE
Subaru



Australian Government



Australia-Japan
Economic Partnership