光赤天連シンポジウム2019 @ 国立天文台三鷹 (2019/9/24)

ULTIMATE-SUBARU:

2030年代を見据えたすばる望遠鏡の挑戦

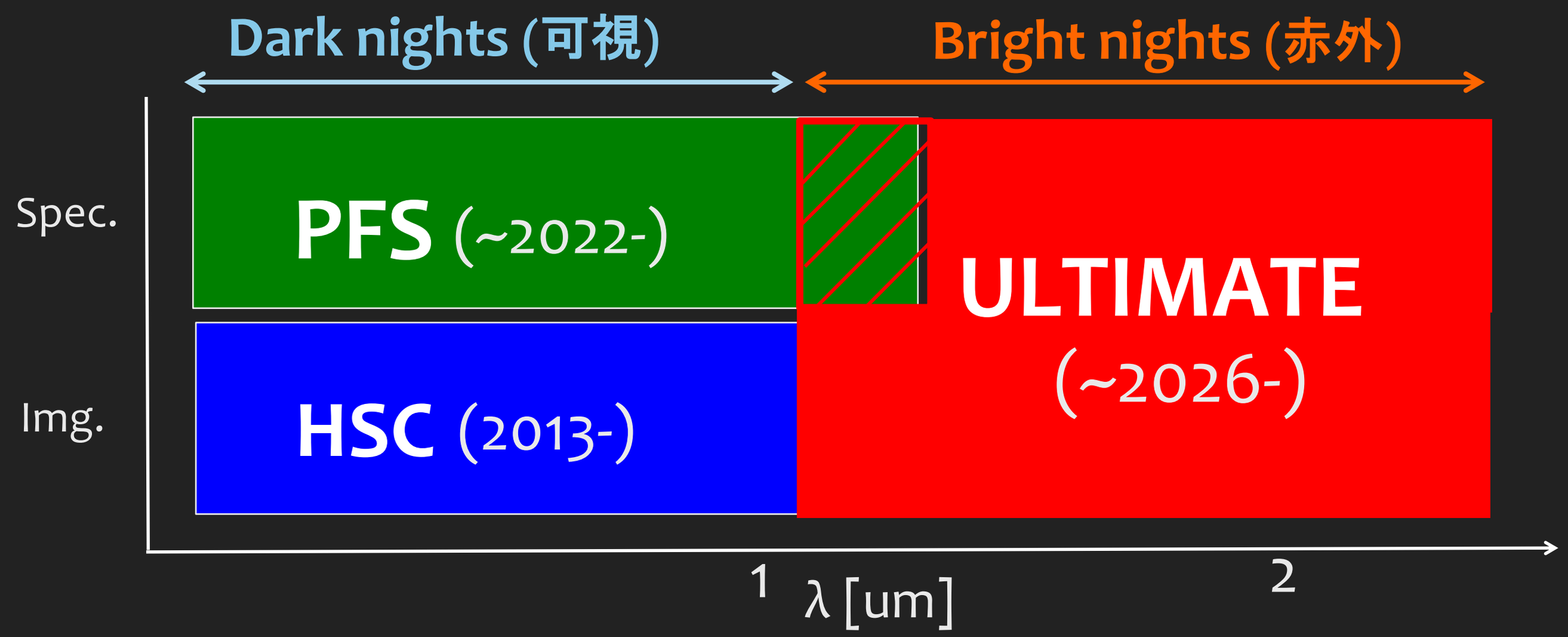
小山佑世（国立天文台ハワイ観測所）

美濃和陽典, 大野良人, 田中壱, 三枝悦子, 沖田博文, Christophe Clergeon, 服部尭, 早野裕, 岩田生, 吉田道利 (国立天文台), 秋山正幸, 児玉忠恭 (東北大学), 本原顕太郎, 小西真広 (東京大学), ULTIMATE-Subaruチーム

SUBARU STRATEGIC PLAN TOWARD 2030

Subaru is going to be a "wide-field survey oriented" telescope:

1. Very wide-field optical imager ---------- HSC (2013-)
2. Wide-field multi-object spectrograph ---------- PFS (2022-)
3. Wide-field NIR imager and MOS/IFU spectrograph w/ AO ------ ULTIMATE (2026-)

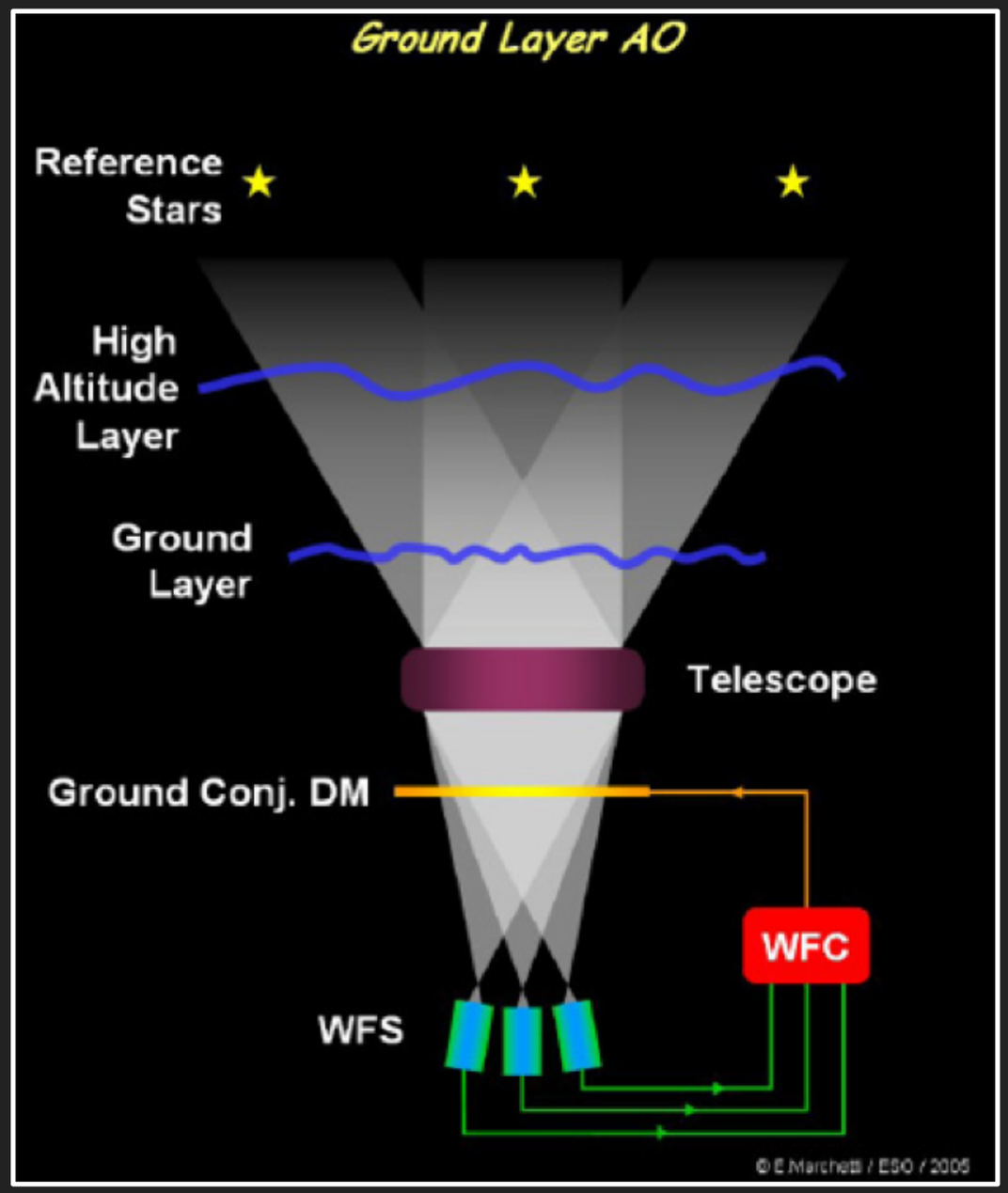


ULTIMATE = **U**LTRA-WIDE-FIELD **L**ASER **T**OMOGRAPHIC **I**MAGER and **M**OS with **A**O for **T**RANSCENDENT **E**XPLORATION by **SUBARU**

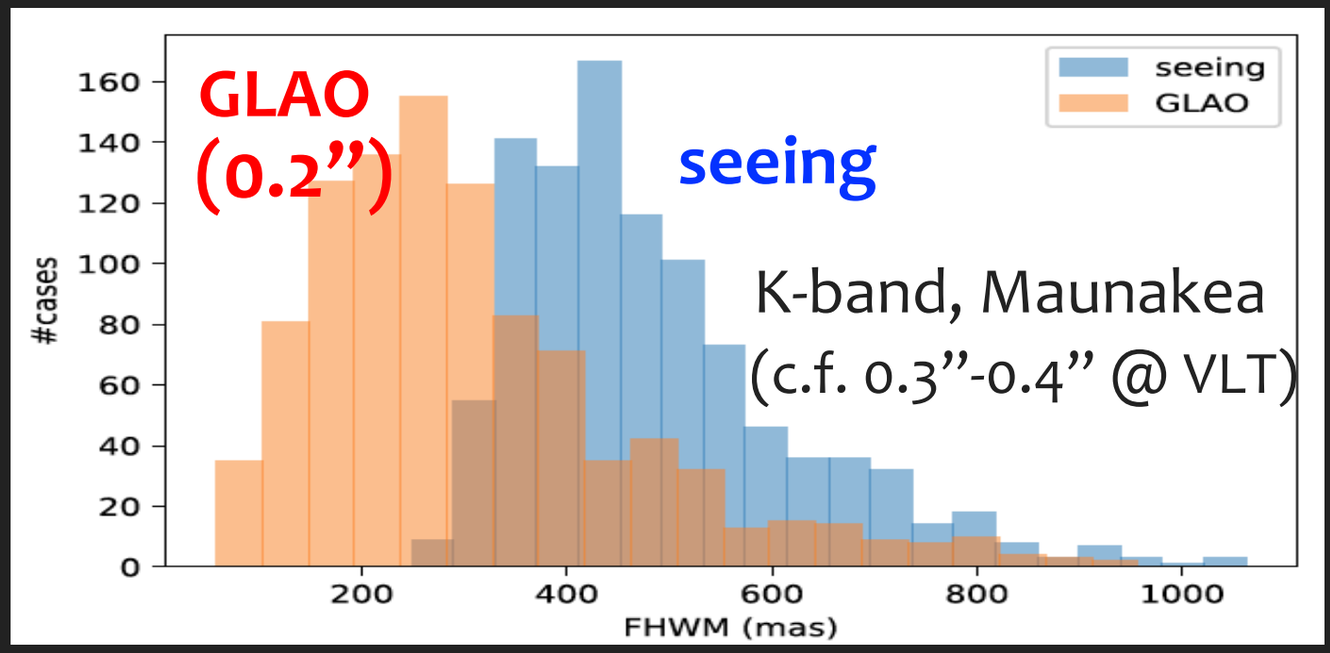
GLAO : WIDE-FIELD ADAPTIVE OPTICS ON SUBARU

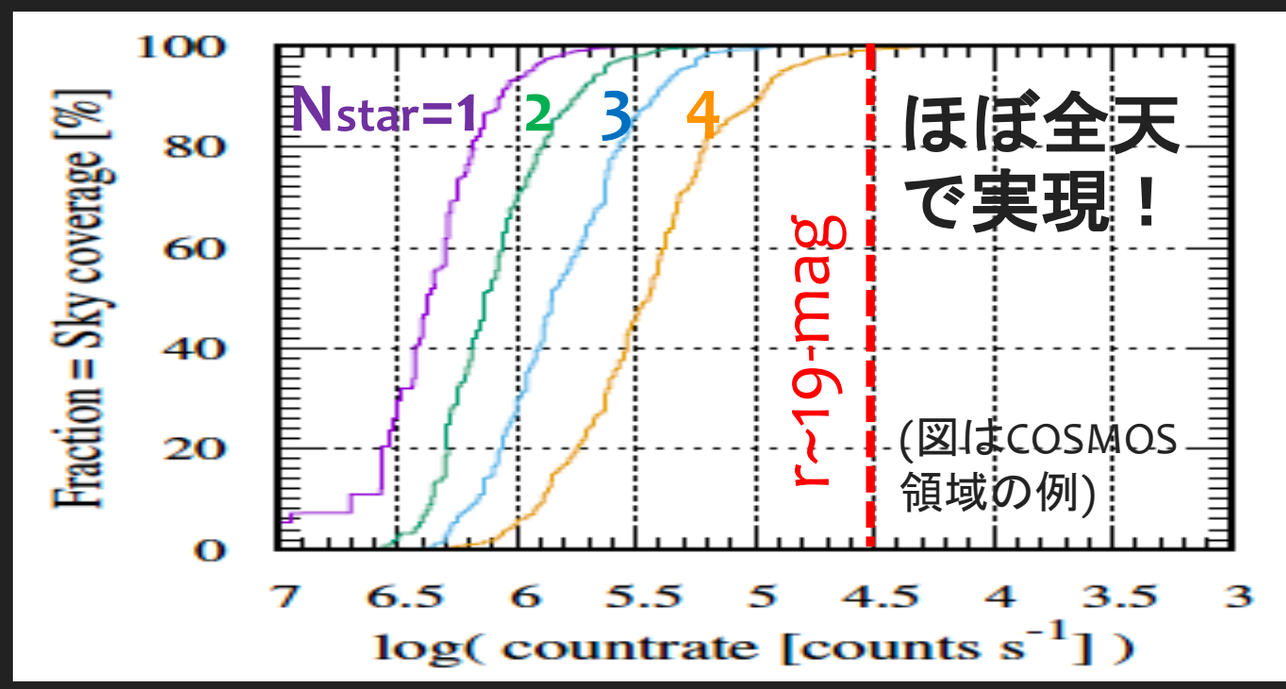
Improve image quality over ~20-arcmin at everywhere on sky

FWHM~0.2" @ K-band = resolution of HST/WFIRST @ Y,J,H



https://www.eso.org/sci/facilities/develop/ao/ao_modes/.html

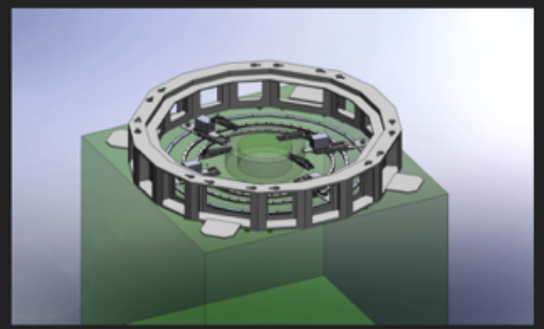




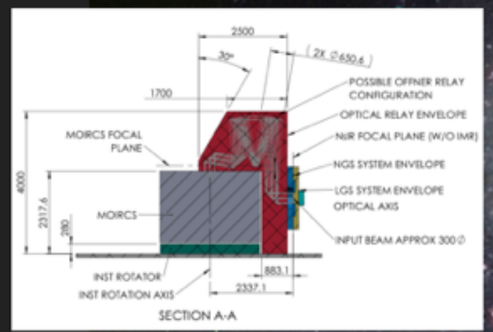
ULTIMATE-SUBARU KEY SUBSYSTEMS

3: Wavefront sensors

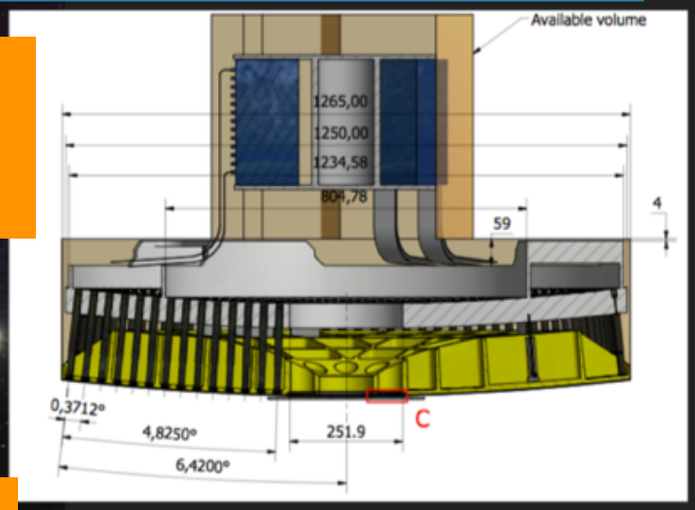
Cass. Focus
(FoV~20 arcmin ∅)



Nasmyth IR Focus
(FoV~14 arcmin ∅)



1: Adaptive Secondary Mirror



Preliminary Subaru ASM design by Adoptica

2019年度より
国立天文台Aプロとして発足
「すばるGLAOプロジェクト」

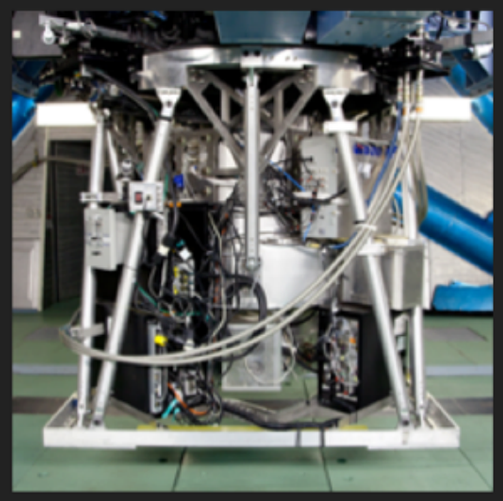
2017-2021年度 科研費基盤(S)
“ULTIMATE-START”
代表: 秋山正幸 [東北大]

2: Laser Guide Stars

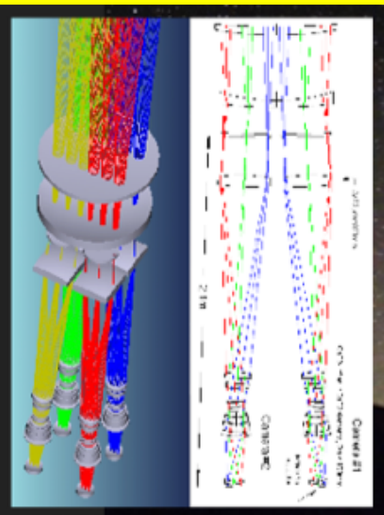
TOPICA fiber laser (589nm) x 2
Generate 4 laser guide stars

4: Wide-field NIR instruments

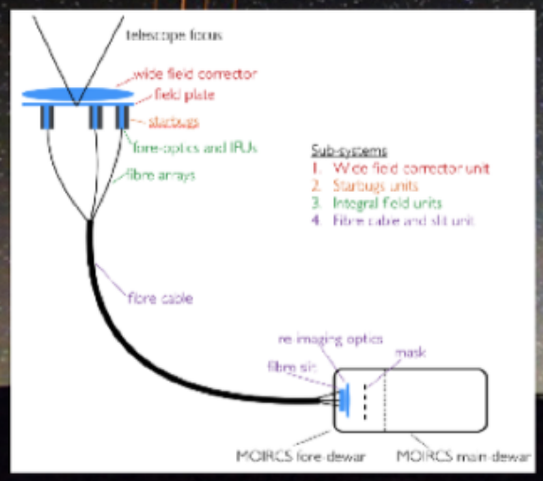
- Phase 1: Reuse MOIRCS at Ns. IR
- Phase 2: Wide-field imager (WFI) at Cs.
- Phase 3: Fiber-bundle multi-IFU at Cs.



MOIRCS



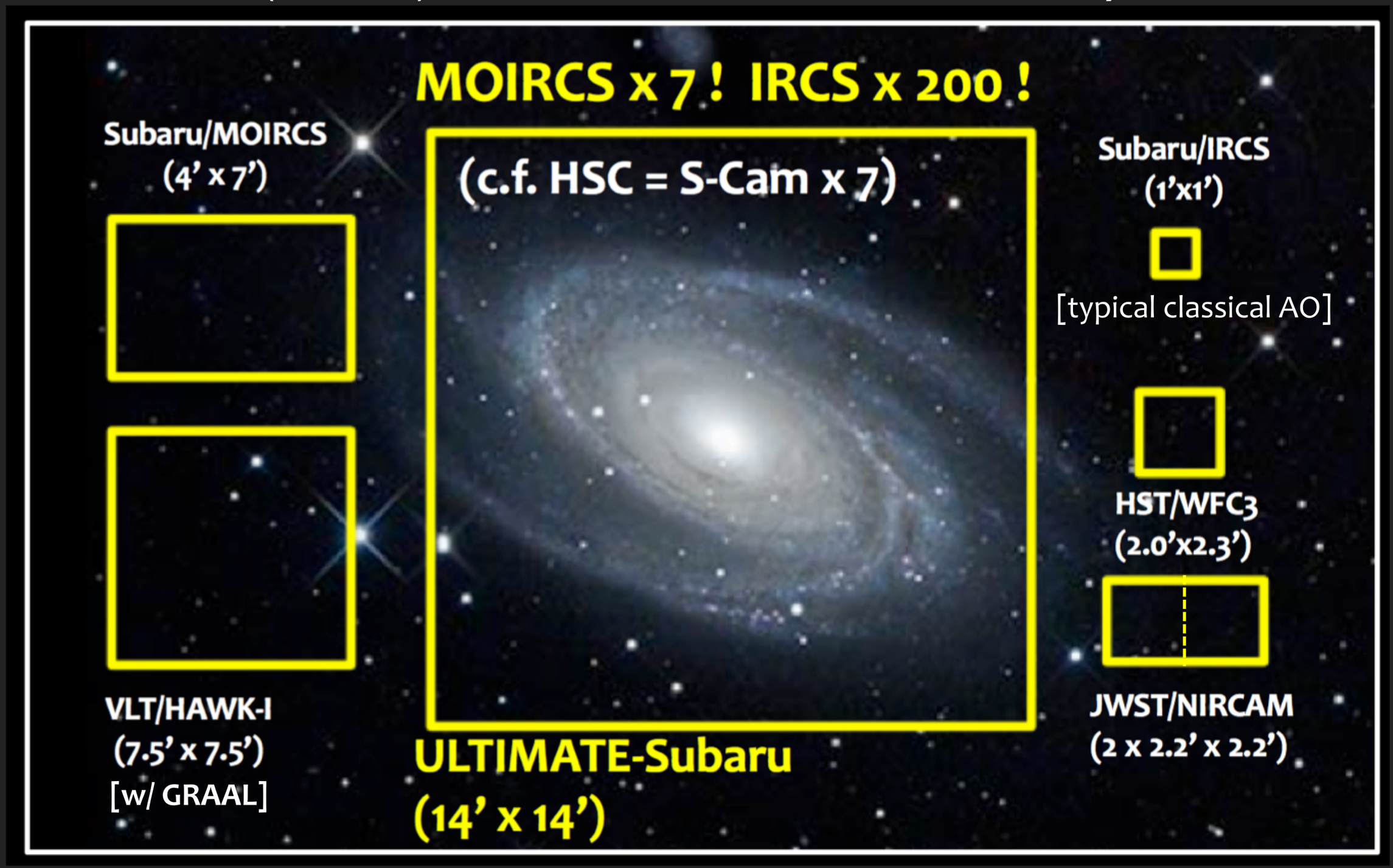
WFI concept



Multi-IFU concept

ULTIMATE-SUBARU = GLAO + NEW IR INSTRUMENT

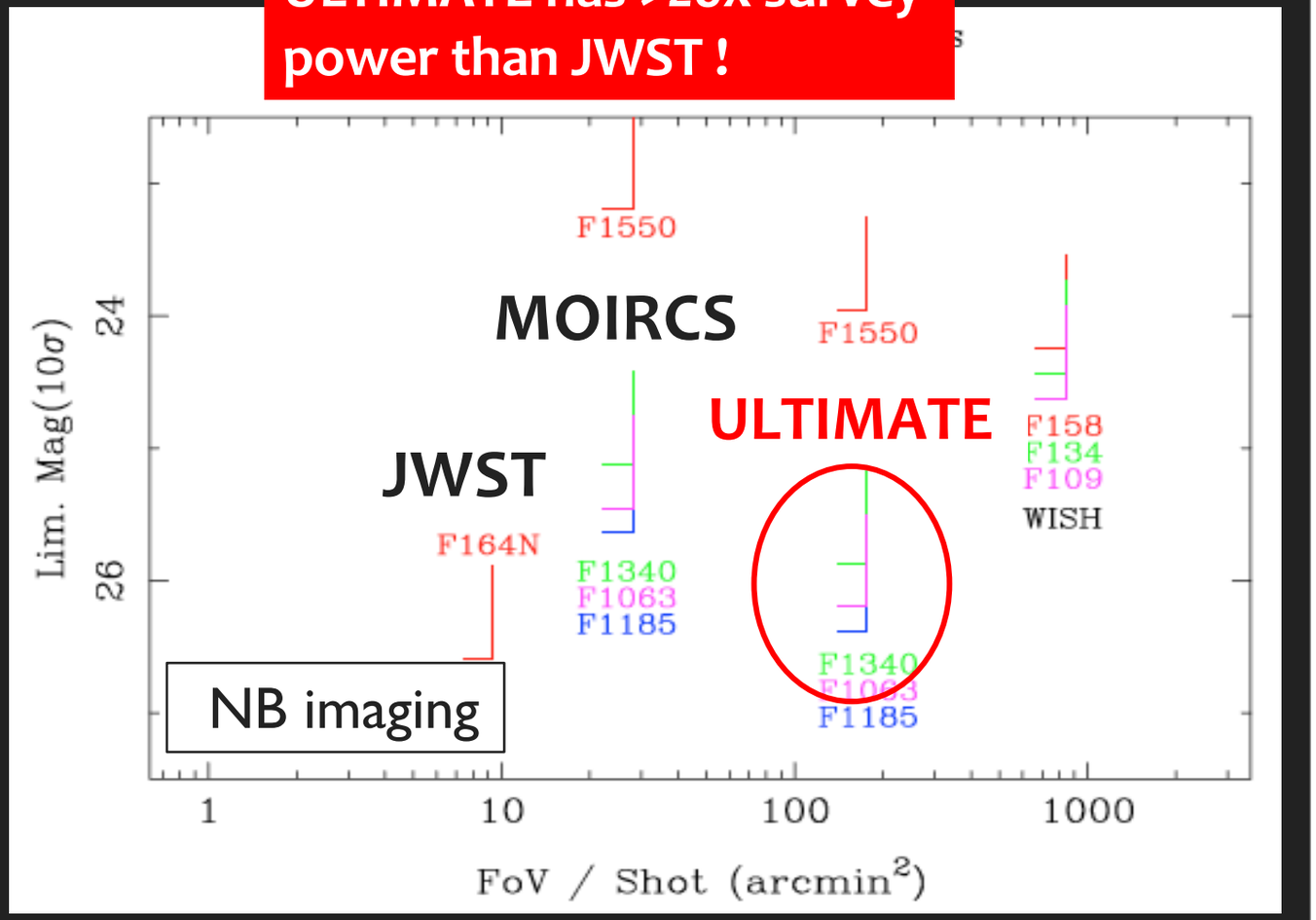
NIR (K-band) facilities available in 2020s and beyond.

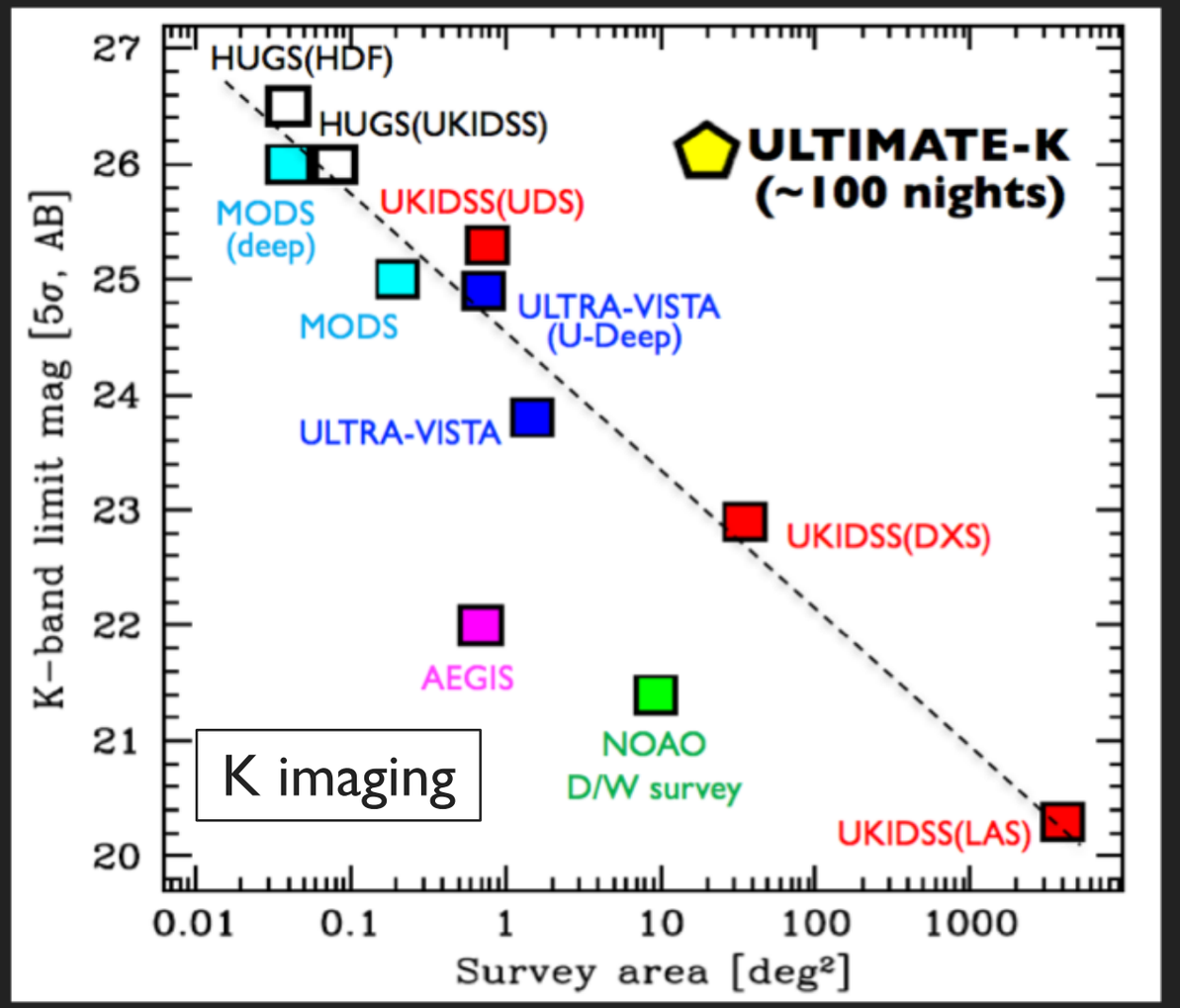


UNIQUE CAPABILITIES OF ULTIMATE-SUBARU

- Narrow- & medium-band imaging (1.0<λ<2.3um)
- Broad-band imaging at K-band
- High-resolution MOS spectroscopy at H+K (Phase-I w/ MOIRCS)
- AO-assisted multi-object IFU at J + H (+ K) (Phase-3)

ULTIMATE has >20x survey power than JWST !

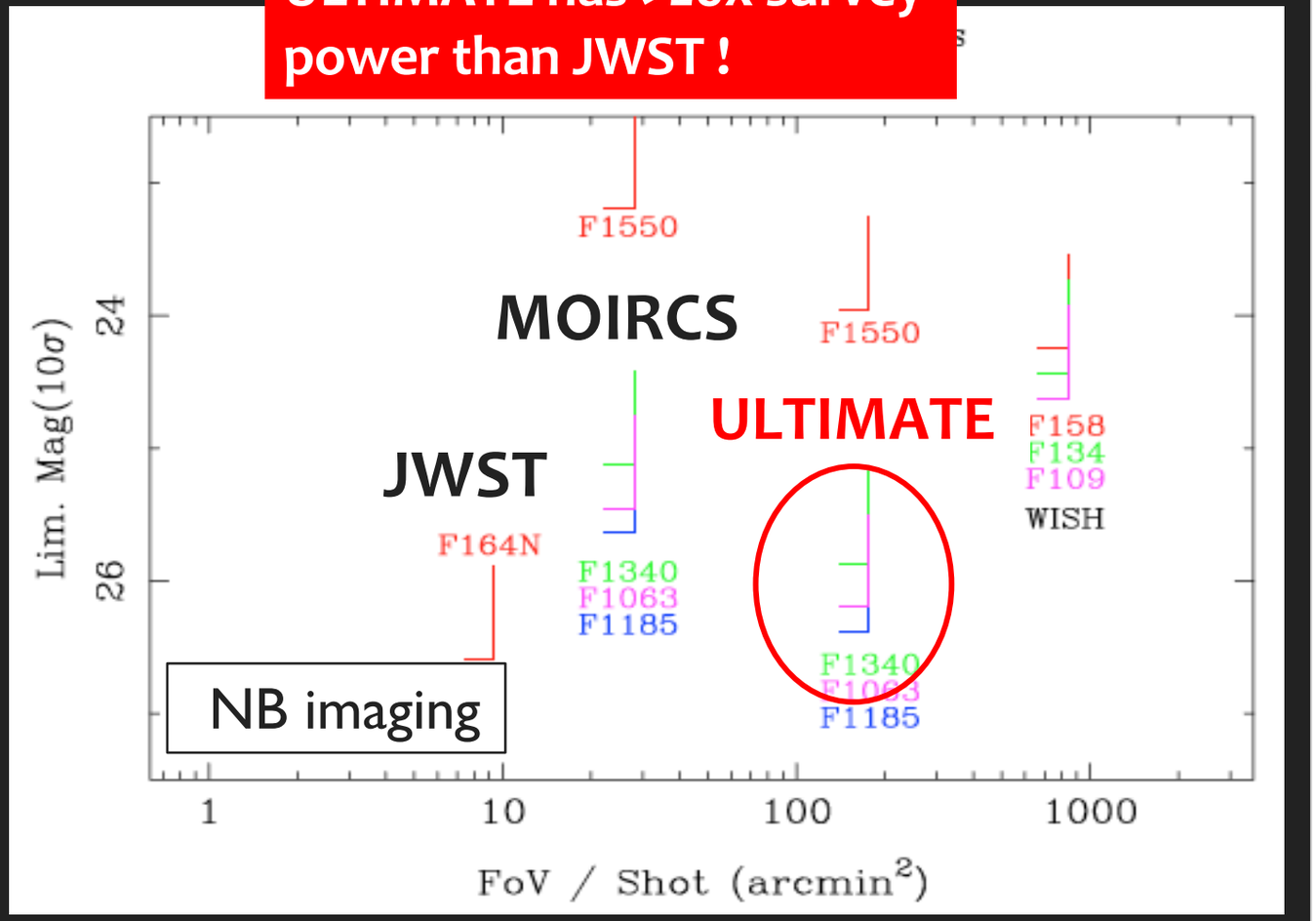


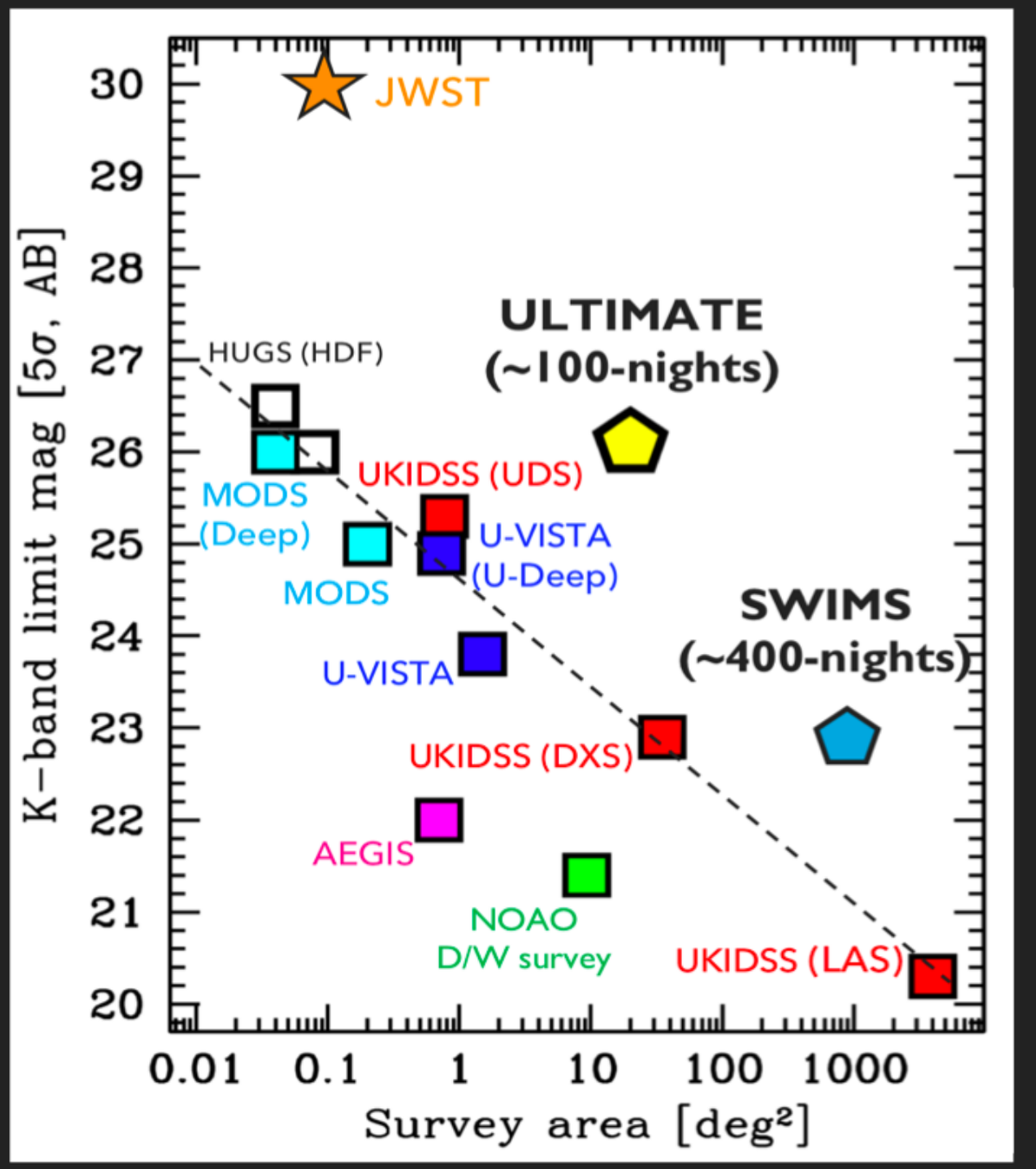


UNIQUE CAPABILITIES OF ULTIMATE-SUBARU

- Narrow- & medium-band imaging (1.0<λ<2.3um)
- Broad-band imaging at K-band
- High-resolution MOS spectroscopy
- AO-assisted multi-object IFU at J +

ULTIMATE has >20x survey power than JWST !





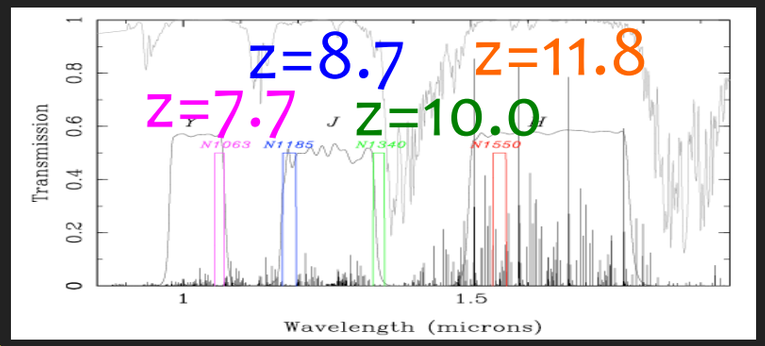
ULTIMATE-SUBARU SCIENCE TEAM (>70 SCIENTISTS)

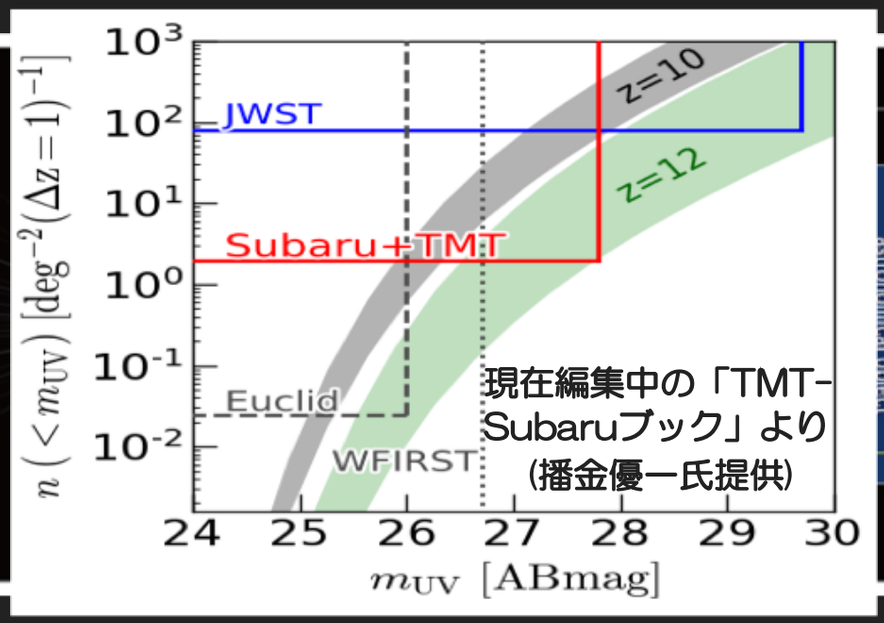
Masayuki Akiyama (Tohoku)
Fuyan Bian (ANU)
Jessica Bloom (Sydney)
Julia Bryant (AAO)
D. Calzetti (Massachusetts)
Andy Casey (ANU)
Masashi Chiba (Tohoku)
Scott Croom (Sydney)
Akihiko Fukui (NAOJ)
Olivier Guyon (Subaru)
Daisuke Iono (NAOJ)
Masatoshi Imanishi (NAOJ)
Ikuru Iwata (Subaru)
Yuichi Harikane (NAOJ)
Masao Hayashi (NAOJ)
I-Ting Ho (ANU)
Akio Inoue (Waseda)
Hiroyuki Kaneko (NAOJ)
Lisa Kewley (ANU)
Satoshi Kikuta (SOKENDAI)
Ji-Hoon Kim (Subaru)
Jin Koda (Stony Brook)
Tadayuki Kodama (Tohoku)
Kotaro Kohno (IoA, Tokyo)
Naoki Koshimoto (Osaka)
Yusei Koyama (Subaru)
Toshiki Saito (MPIA)
Sarah Leslie (ANU)
Chien-Hsiu Lee (Subaru/NOAO)
Chris Lidman (AAO)
Yen-Ting Lin (ASIAA)
Yuichi Matsuda (NAOJ)
Noriyuki Matsunaga (Tokyo)
Yoshiki Matsuoka (Ehime)
Yosuke Minowa (Subaru)
Takashi Moriya (NAOJ)
Kentaro Motohara (Tokyo)
Tohru Nagao (Ehime)
Kimihiko Nakajima (NAOJ)
David Nataf (ANU)
Chow-Choong Ngeow (NCU)
Shogo Nishiyama (Miyagi Educ.)
Yumiko Oasa (Saitama)
Kazuyuki Ogura (Bunkyo)
Masamune Oguri (IPMU)
Sakurako Okamoto (Subaru)
Masato Onodera (Subaru)
Tae-soo Pyo (Subaru)
Christian E. Rusu (Subaru)
Toshiki Saito (MPIA)
Adam Schaefer (ANU)
Takatoshi Shibuya (Kitami Inst. Tec.)
Rhythm Shimakawa (Subaru)
Kazuo Sorai (Hokkaido)
Takahiro Sumi (Osaka)
Daisuke Suzuki (JAXA)
Tomoko Suzuki (Tohoku)
Ken-ichi Tadaki (NAOJ)
Tsutomu T. Takeuchi (Nagoya)
Ichi Tanaka (Subaru)
Masaomi Tanaka (Tohoku)
Masayuki Tanaka (NAOJ)
Tsuyoshi Terai (Subaru)
Yoshiki Toba (Kyoto)
Kazufumi Torii (NAOJ)
Junko Ueda (NAOJ)
Kenneth C. Wong (NAOJ)
Takuji Yamashita (Ehime)
Kiyoto Yabe (IPMU)
Chikako Yasui (NAOJ)
Tiantian Yuan (ANU)
Tayyaba Zafar (Macquarie)

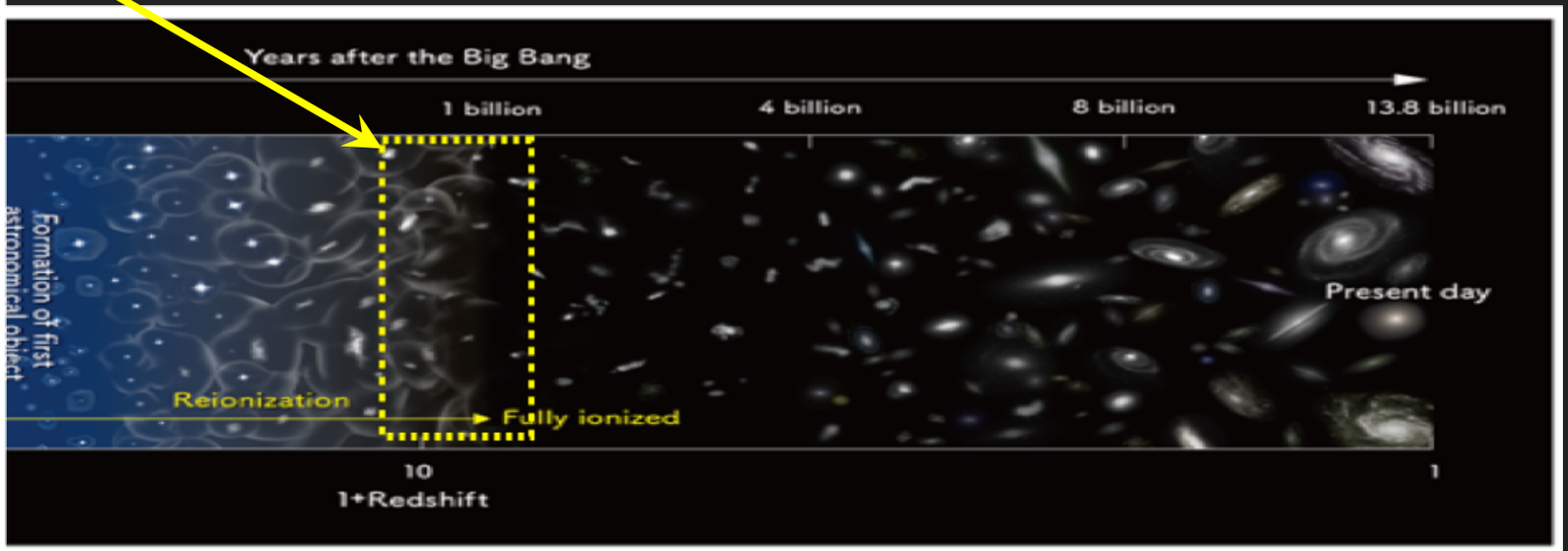
KEY SCIENCE: "BIRTH", "GROWTH", "DEATH" OF GALAXIES IN THE CRADLE OF COSMIC STRUCTURE

1. First galaxies (birth)

- Explore the LAE/LBG world toward the frontier redshifts (z>>7) with ultra-deep NB/BB imaging in NIR



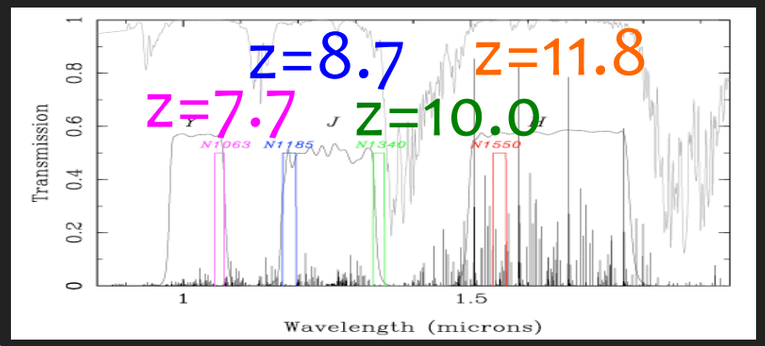


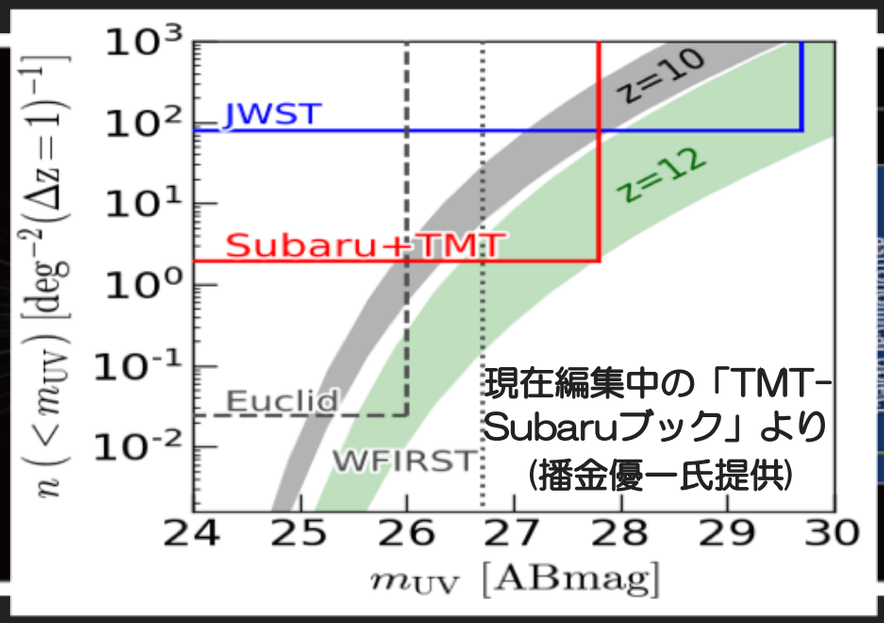


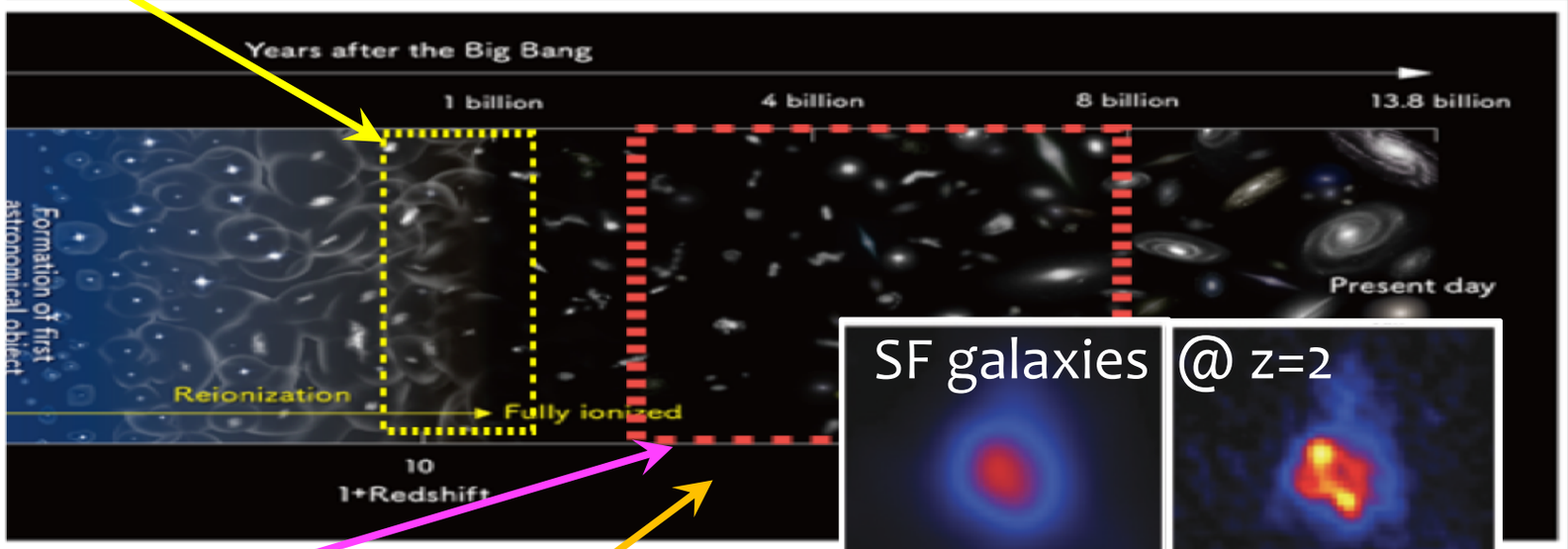
KEY SCIENCE: "BIRTH", "GROWTH", "DEATH" OF GALAXIES IN THE CRADLE OF COSMIC STRUCTURE

1. First galaxies (birth)

- Explore the LAE/LBG world toward the frontier redshifts (z>>7) with ultra-deep NB/BB imaging in NIR





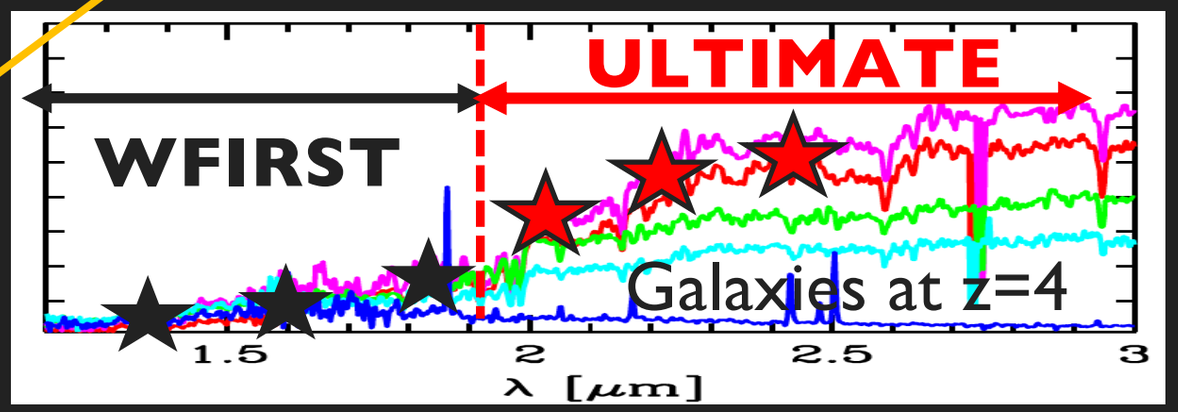


2. Stellar build-up (growth)

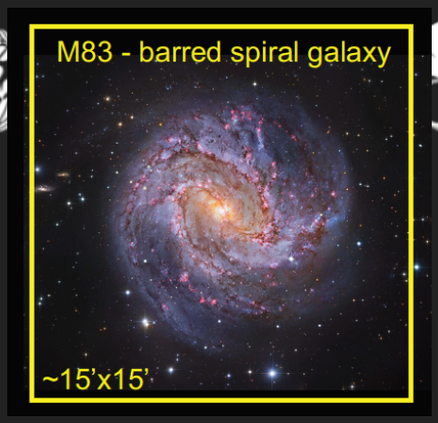
- Deep & sharp & panoramic NB Hα/[OIII] imaging galaxies at "cosmic noon"(z=0.5-3.5)

3. Quenching (death)

- Tracking down the rest-optical SEDs of galaxies @ z~5 with BB/MB imaging (in K-band).

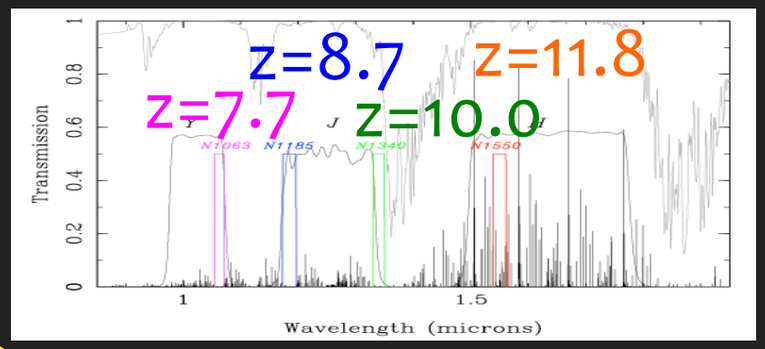


KEY SCIENCE: "BIRTH", "GROWTH", "DEATH" OF GALAXIES IN THE CRADLE OF COSMIC STRUCTURE



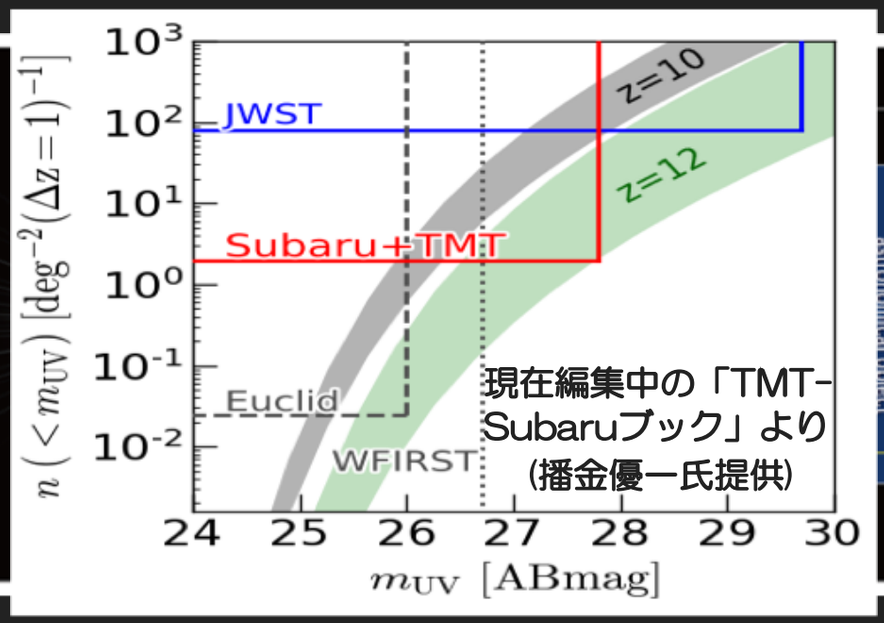
1. First galaxies (birth)

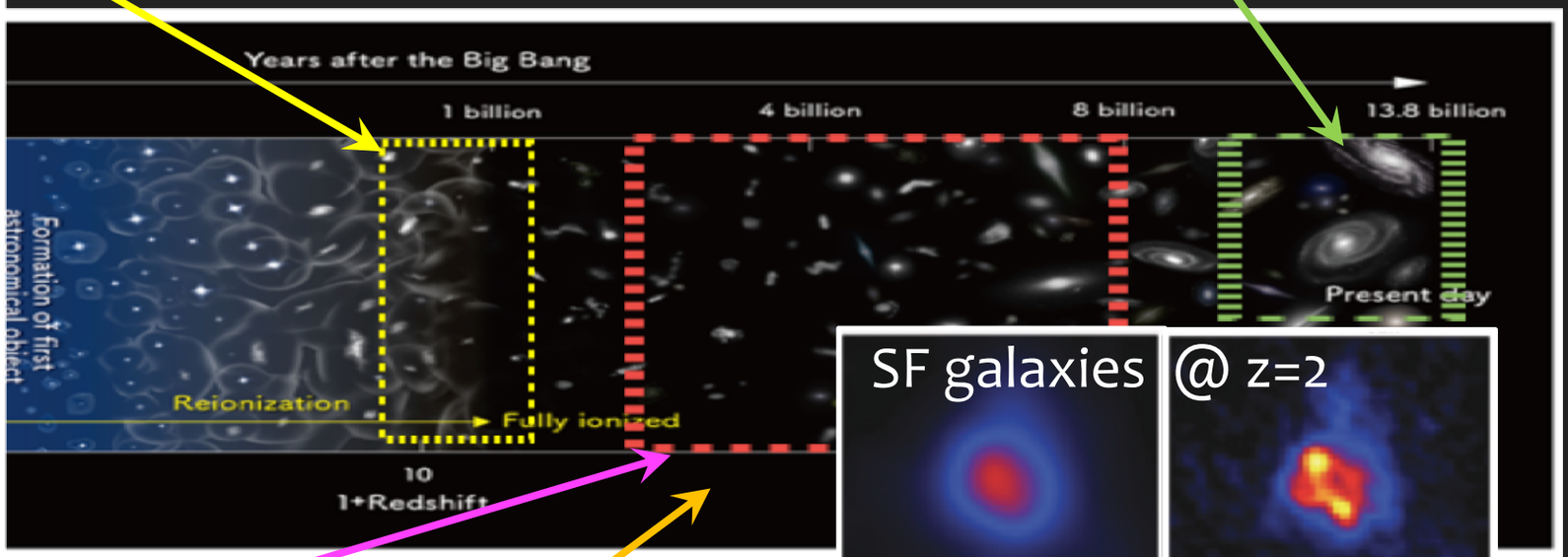
- Explore the LAE/LBG world toward the frontier redshifts (z>>7) with ultra-deep NB/BB imaging in NIR



4. End products

- Complete census of ~60 nearby galaxies @ D<11Mpc with BB+NB.



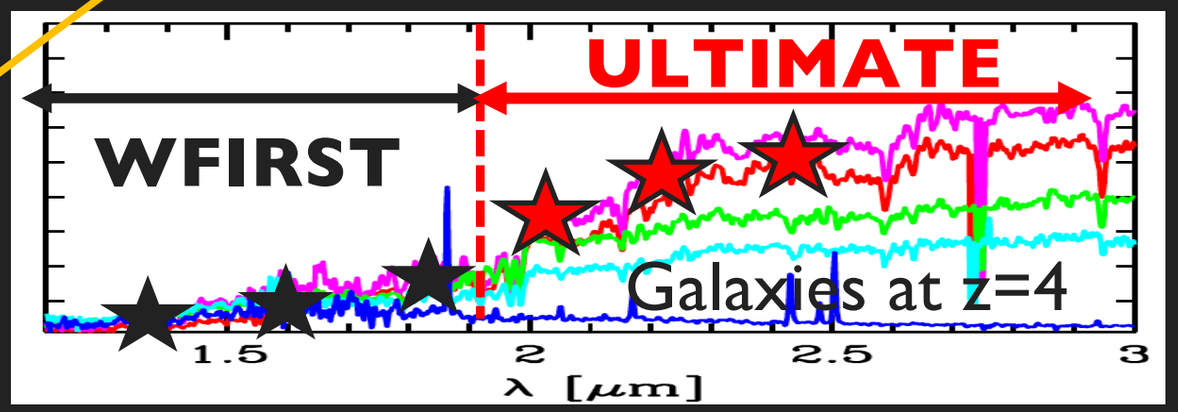


2. Stellar build-up (growth)

- Deep & sharp & panoramic NB Hα/[OIII] imaging galaxies at "cosmic noon"(z=0.5-3.5)

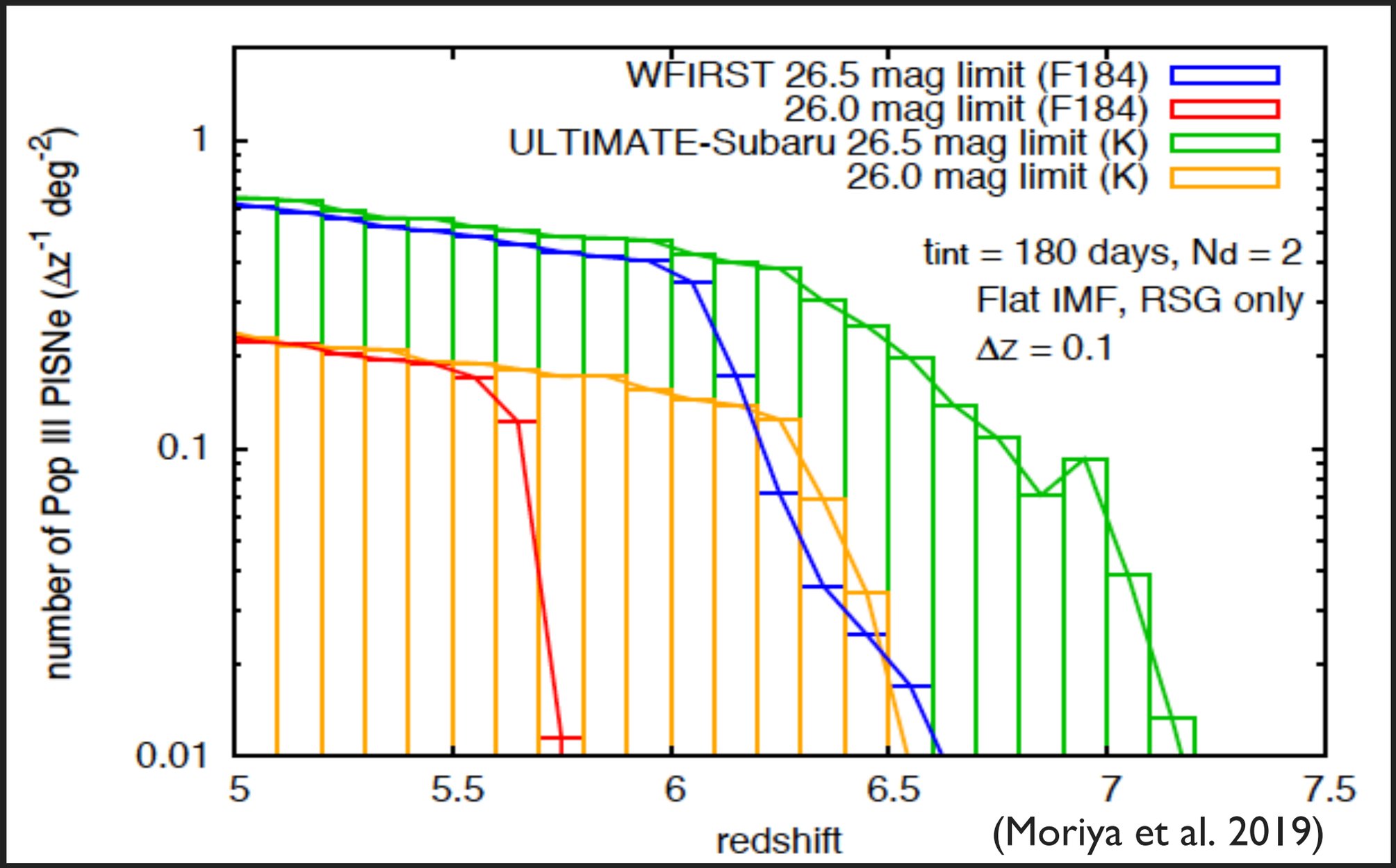
3. Quenching (death)

- Tracking down the rest-optical SEDs of galaxies @ z~5 with BB/MB imaging (in K-band).



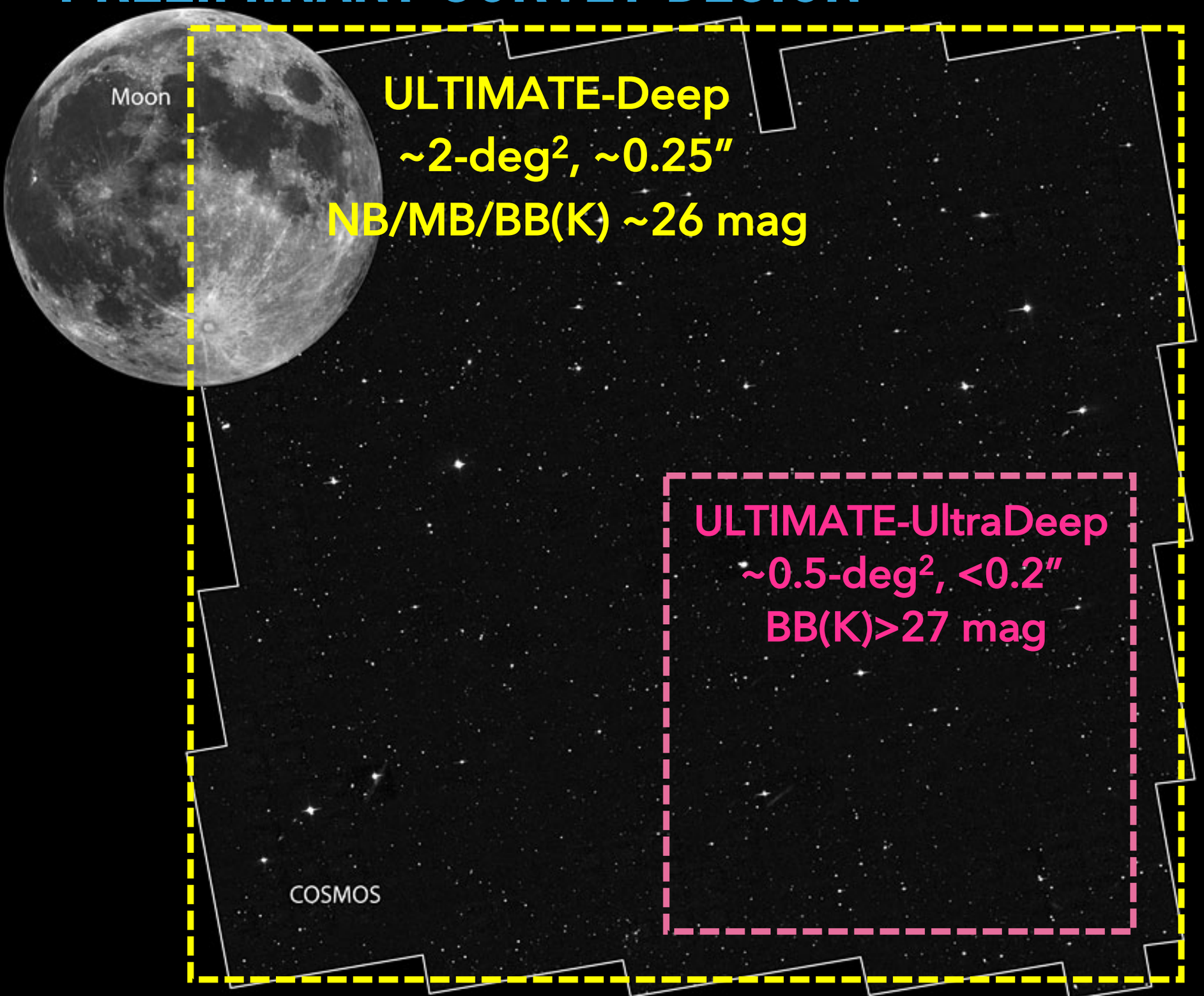
TIME DOMAIN ASTRONOMY IN ULTIMATE ERA

Supernovae search at z>6 – visiting ~1-deg^2 every 180-days down to K > 26 mag (AB) will allow us to detect PopIII pair-instability SNe at 6<z<7.



Note: the finally combined image from this survey will reach K>27.5 (AB mag) .

PRELIMINARY SURVEY DESIGN

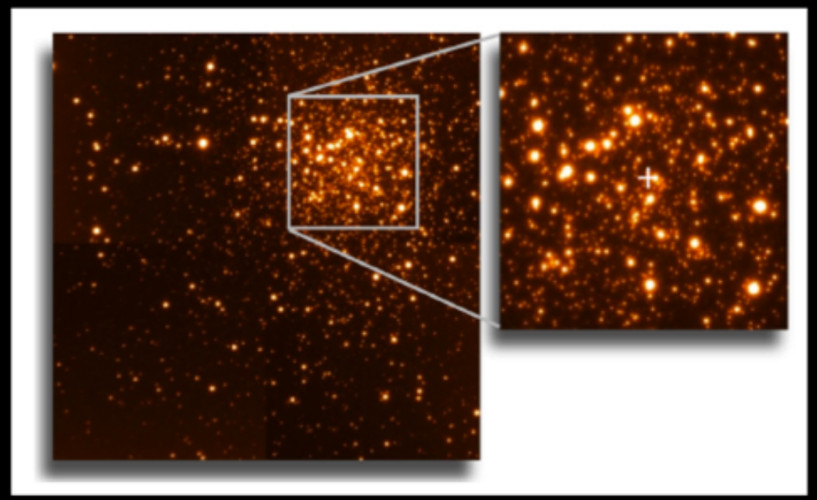


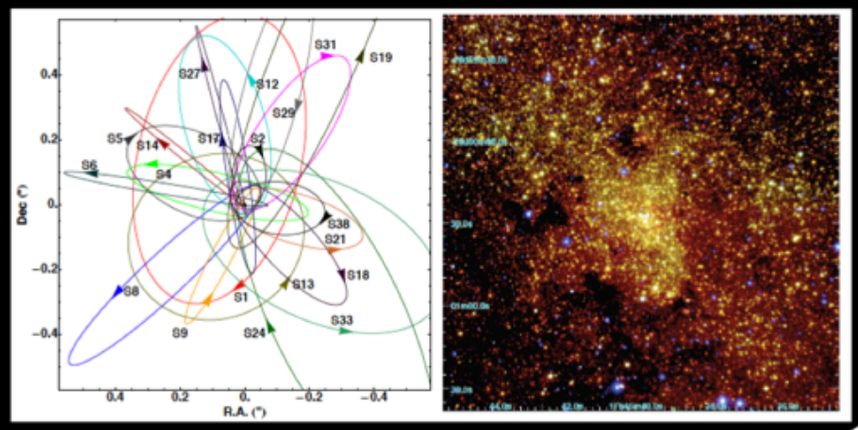
"PREMIUMS"
Panoramic REsearch with Multi-band Imaging by ULTIMATE Machine on Subaru

Please give us your inputs to maximize the legacy value of ULTIMATE-Subaru, and to provide our best sample for TMT.

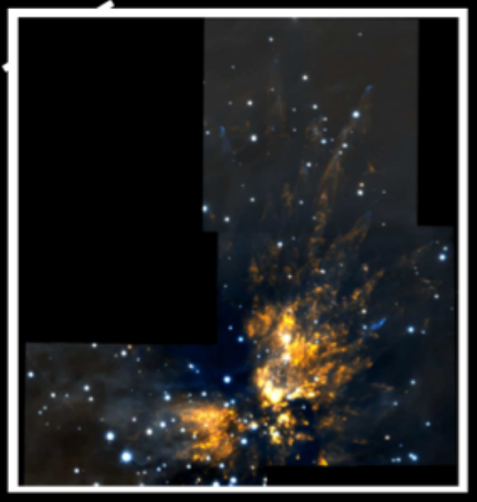
http://candels-collaboration.blogspot.com/2012/07/cosmos-cosmic-evolution-survey.html © NASA/ESA/Z. Levay

ULTIMATE FOR A VARIETY OF SCIENCE IN OUR GALAXY: GALACTIC CENTER & STAR-FORMING REGIONS



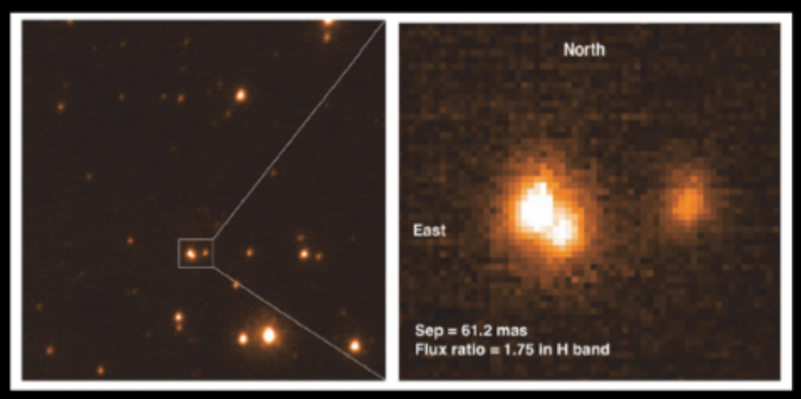


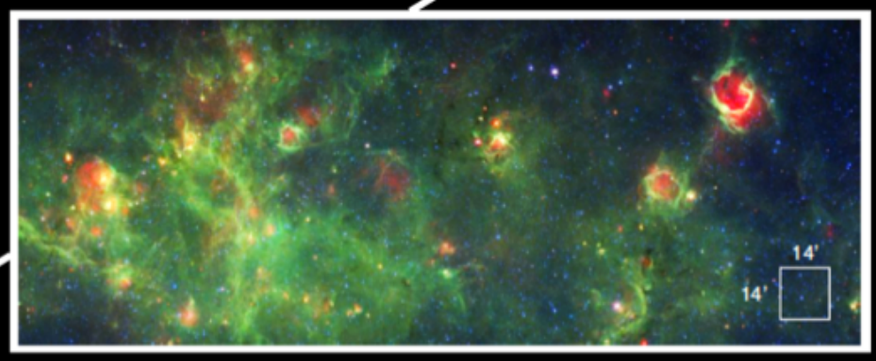
Astrometry of Galactic central stars
(S. Nishiyama)



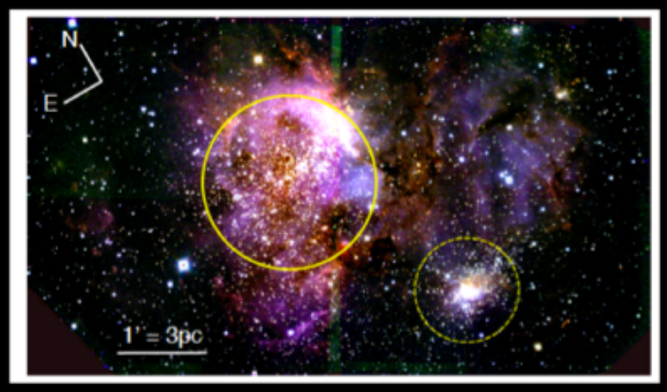
Jet/shock surey of SF regions
(T. Pyo)

Globular cluster in Galactic bulge
(M. Chiba)



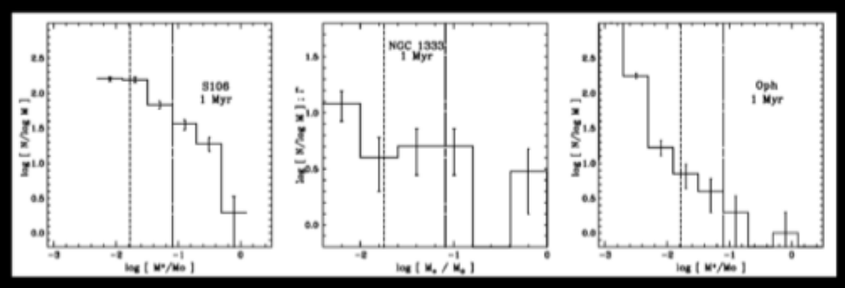


"Spitzer bubble" in the Galactic plane
(K. Torii)



Star formation and IMF in the extreme outer Galaxy (C. Yasui)

Microlensing exoplanet survey toward the Galactic bulge
(C.H. Lee, D.Suzuki)



(Y. Oasa)

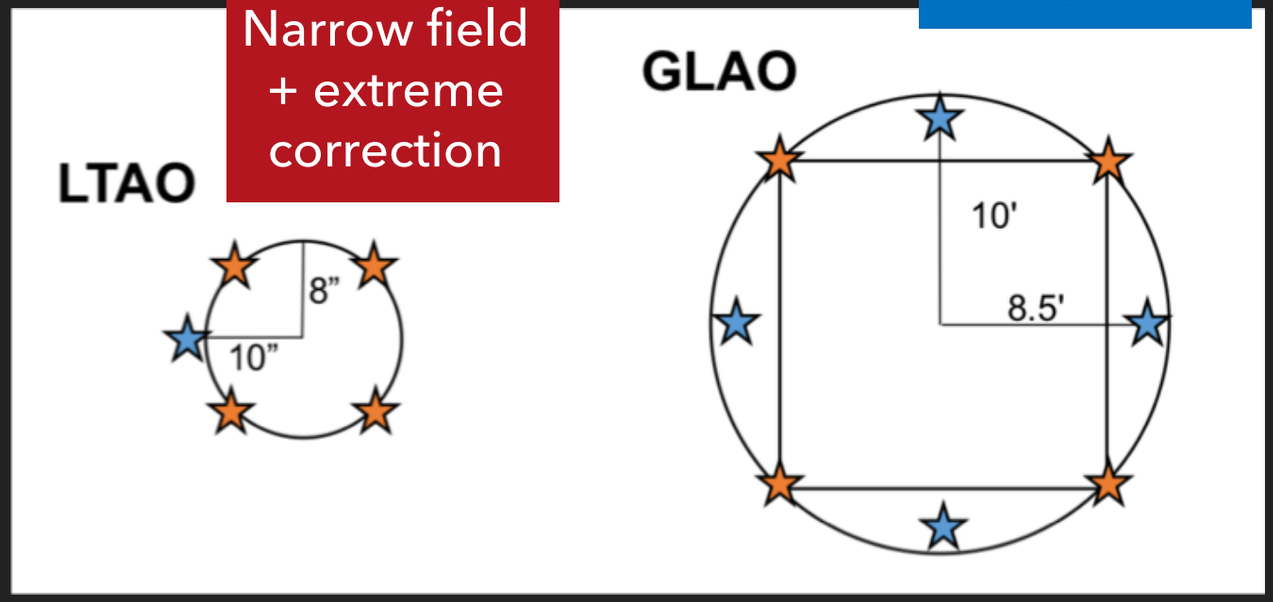
"substellar" IMFs down to brown dwarfs & planetary mass

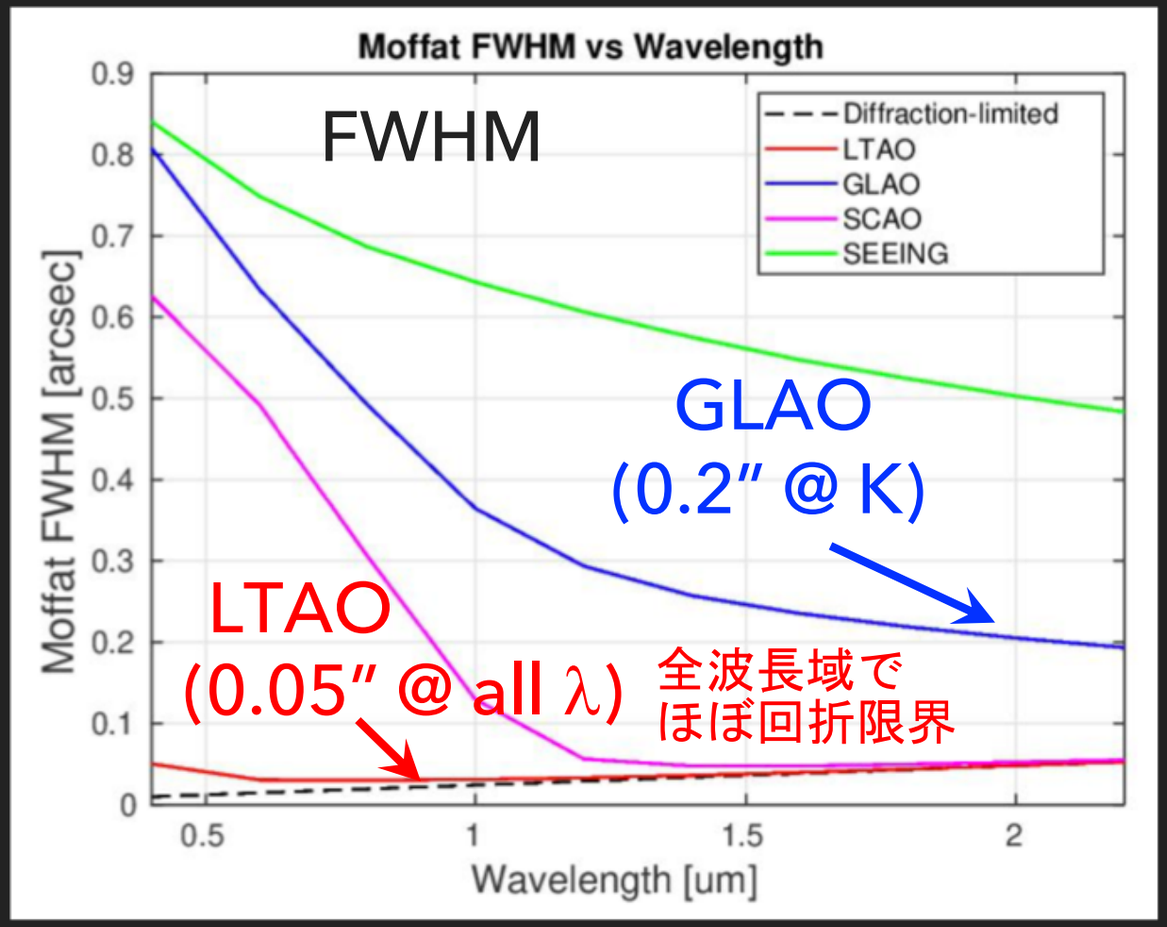
ULTIMATE IS NOT ONLY FOR WIDE-FIELD AO

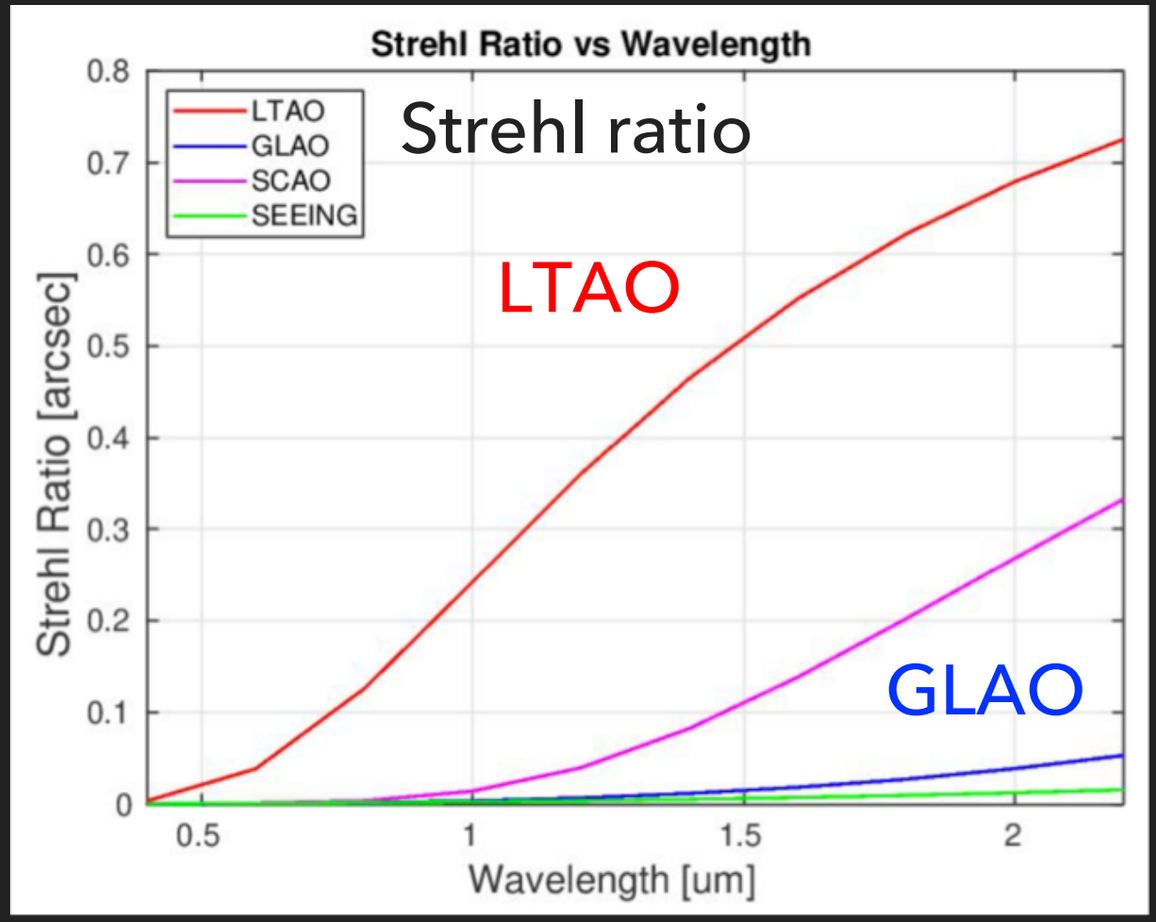
- Please also recognize our “narrow-mode” capability.
- Our LTAO mode can deliver ultimately high spatial resolution and high sensitivity to your favorite target!

Wide field + moderate correction

Narrow field + extreme correction





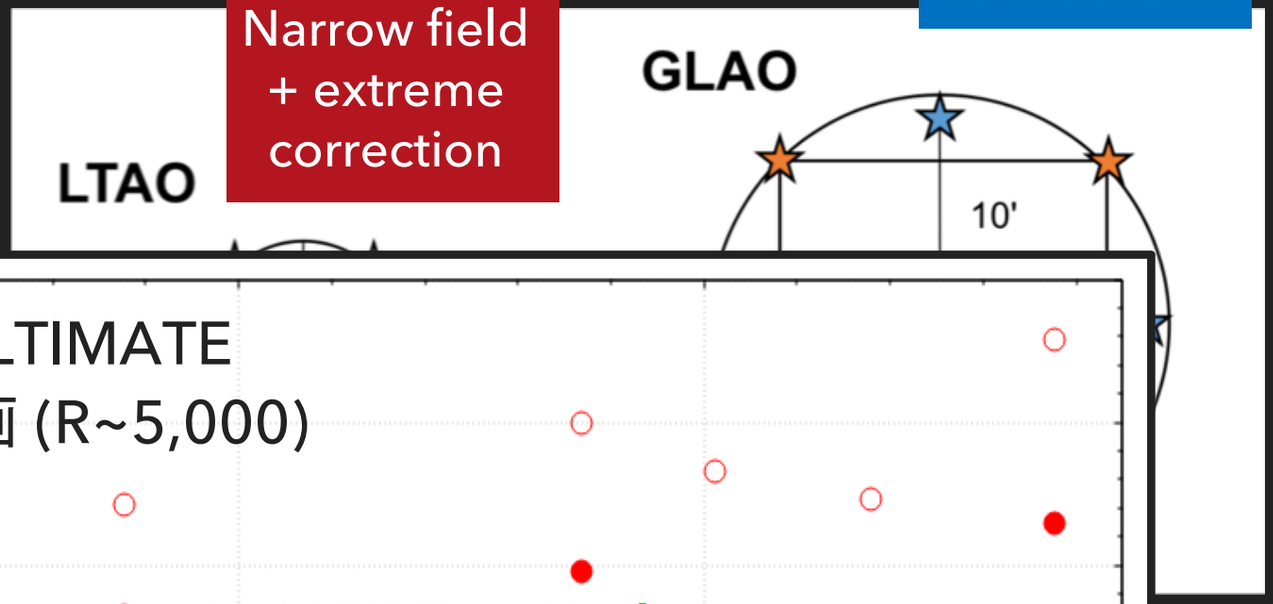


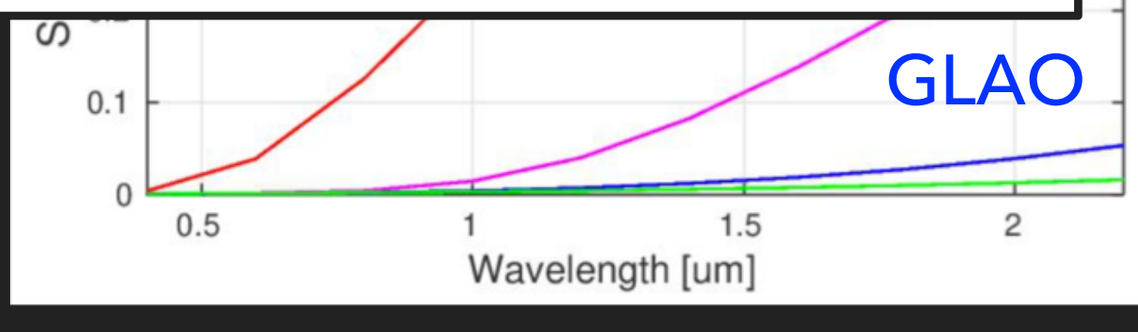
ULTIMATE IS NOT ONLY FOR WIDE-FIELD AO

Wide field + moderate correction

Narrow field + extreme correction

- Please also recognize our "narrow-mode" capability.
- Our LTAO mode can deliver





SUMMARY

ULTIMATE-Subaru

2030年代に向けたすばるの機能アップグレード
「すばる２」 = HSC/PFS (暗夜) + ULTIMATE (明夜)

広視野モード(GLAO)

- FWHM=0.2" @ K-band
- 20-arcmin FoV (diameter)
- 宇宙望遠鏡との高い親和性を生かしたKバンド帯を中心とする平方度スケールのサーベイでTMTにターゲット供給

狭視野モード(LTAO)

- FWHM=0.05" @ all opt-NIR
- A few to ~10-arcsec FoV
- HSC/PFS等の超広視野サーベイの究極フォローアップ装置として、TMT時代を前に８メートルの限界に挑戦

科学検討/開発検討チームへの参加、サーベイデザインへのインプット、ULTIMATEの特長を生かした新規装置開発/持込みの提案など歓迎！！