ULTIMATE-SUBARU SCIENCE GOALS

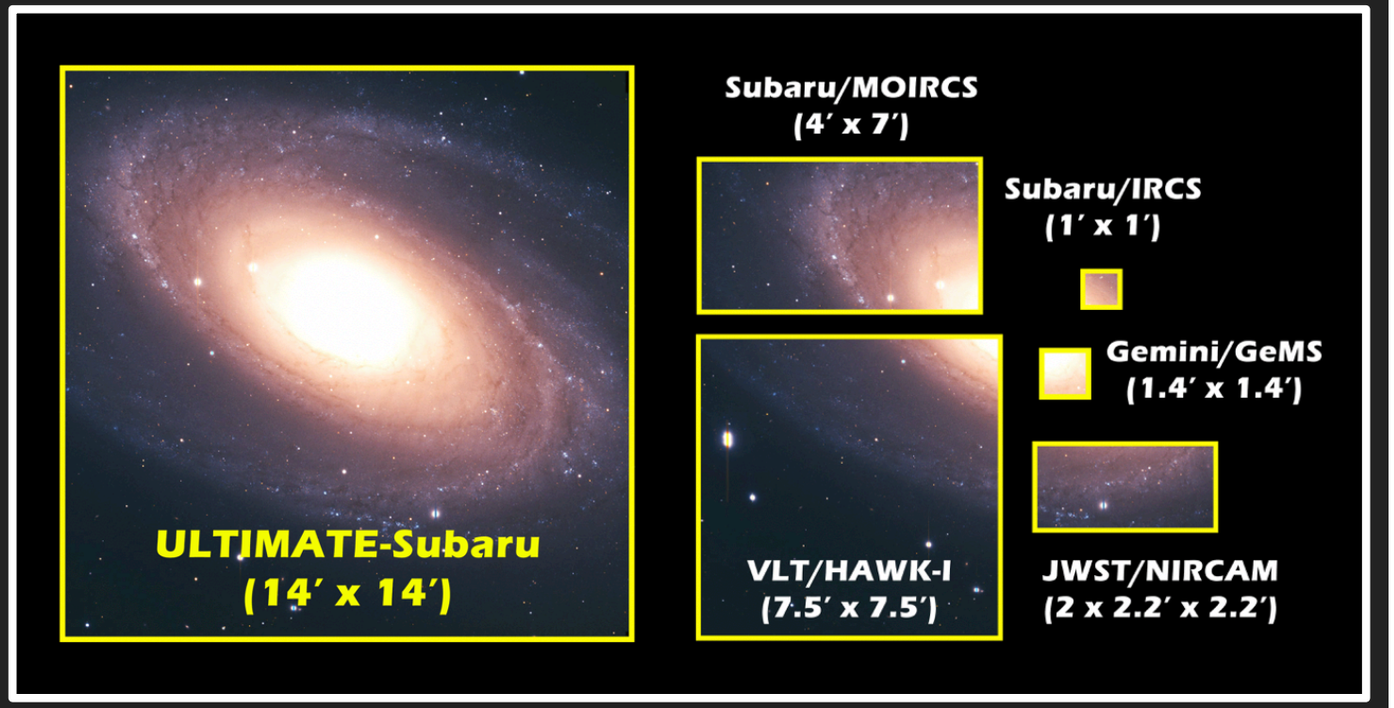
ULTIMATE Subaru

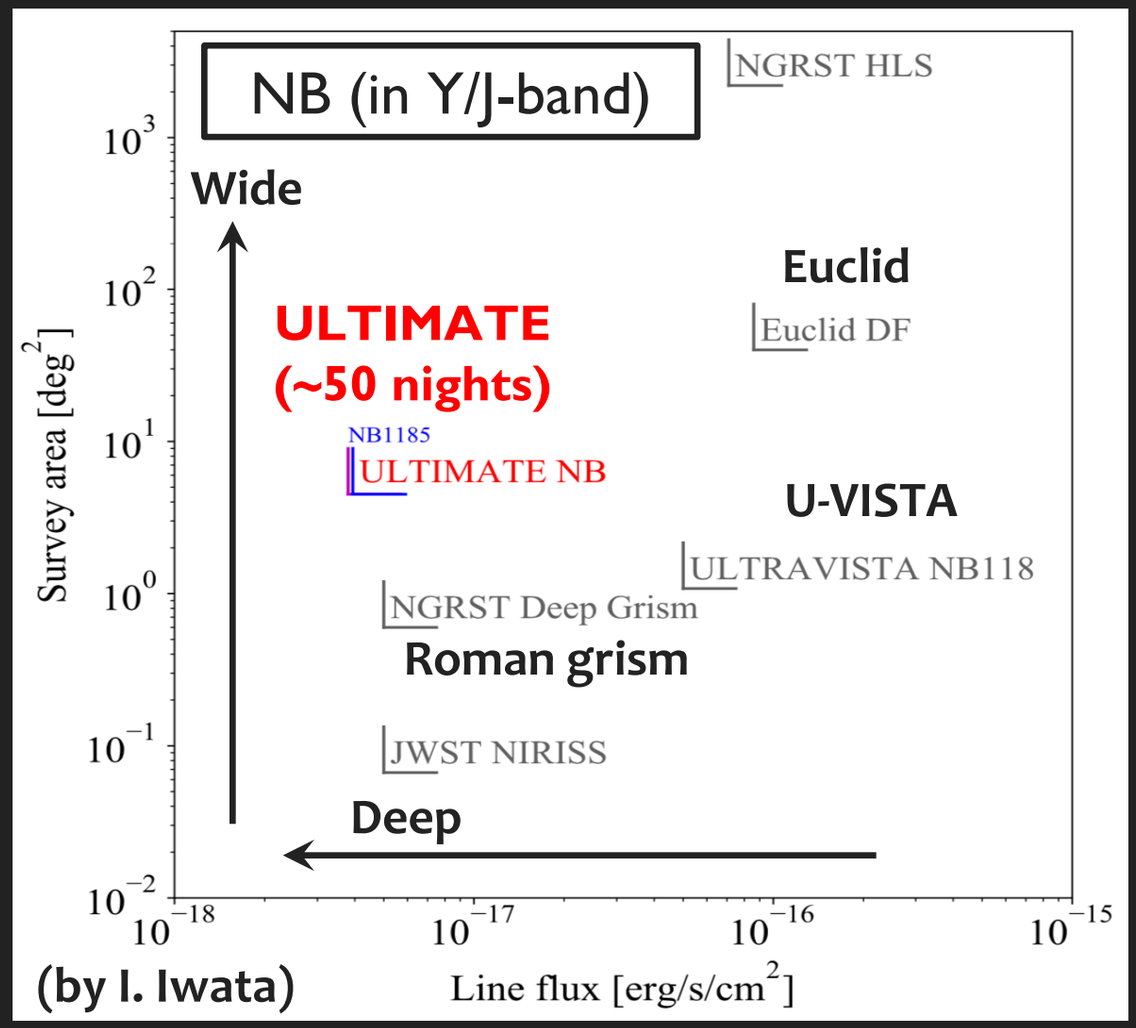
Yusei Koyama (Subaru Telescope)

ULTIMATE-Subaru Science Team

UNIQUE CAPABILITIES OF ULTIMATE-SUBARU

- Phase-1: GLAO+MOIRCS - high-resolution MOS spectroscopy at H+K
- Phase-1: LTAO mode - diffraction-limit image quality in optical-NIR
- Phase-2: GLAO+WFI - NB/MB/BB imaging (in Y/J/H/K, best performance in K)
- Phase-2: GLAO+WFI - long-term monitoring in crowded/obscured regions
- Phase-3: GLAO-assisted multi-object IFU at J + H (+ K ?)



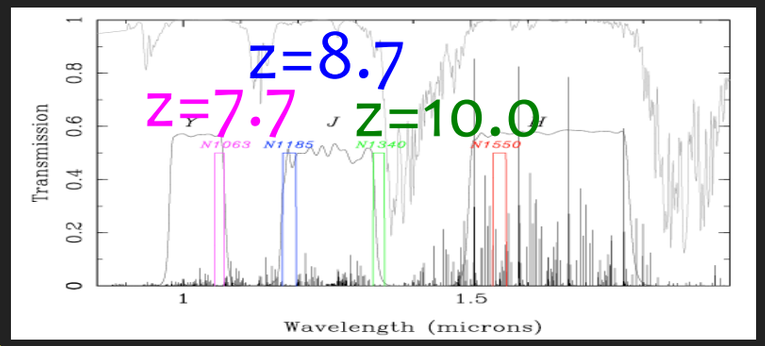


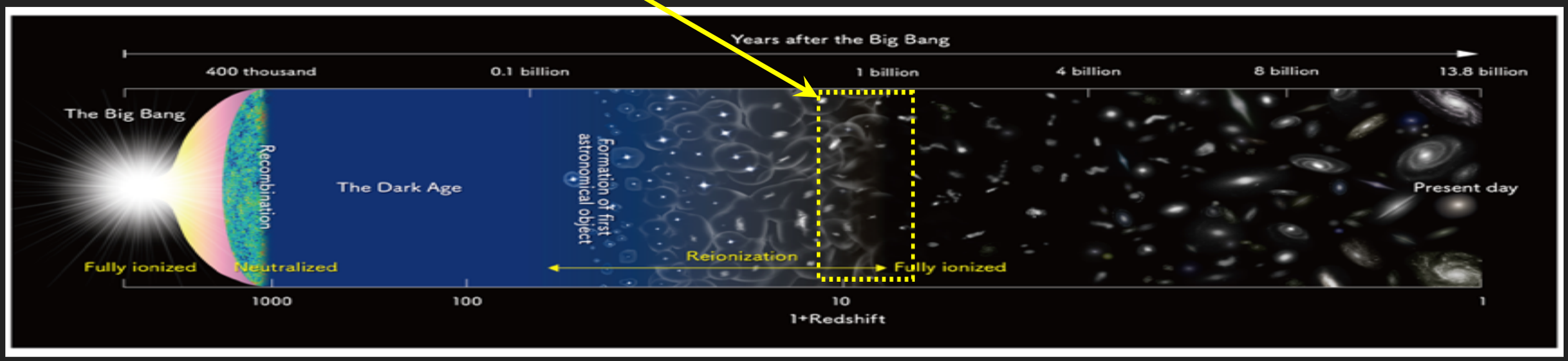
Please see ULTIMATE session in Day-3

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

1. First galaxies (birth)

- Detect LAEs (+LBGs) in the epoch of reionization (z>>7) with ultra-deep NB(+BB) NIR imaging





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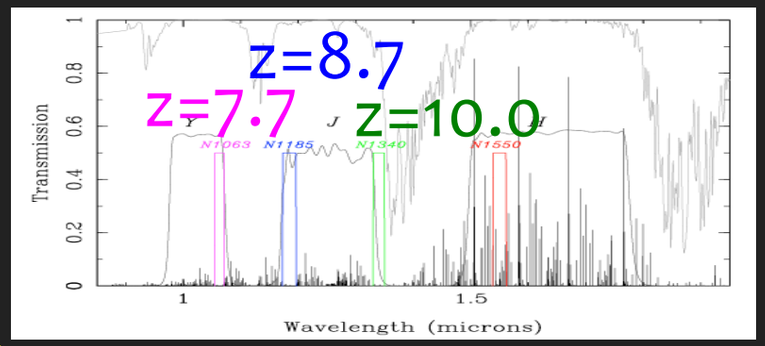
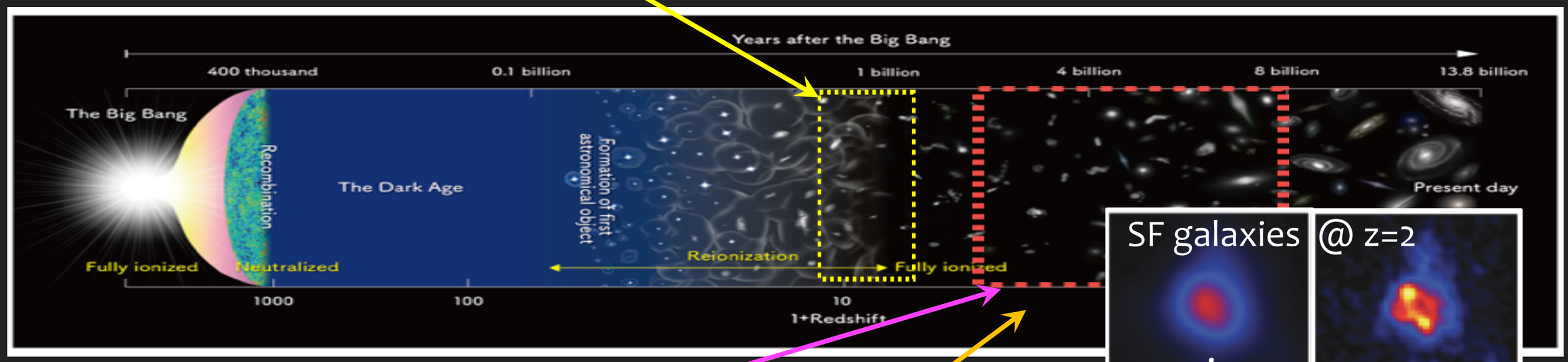


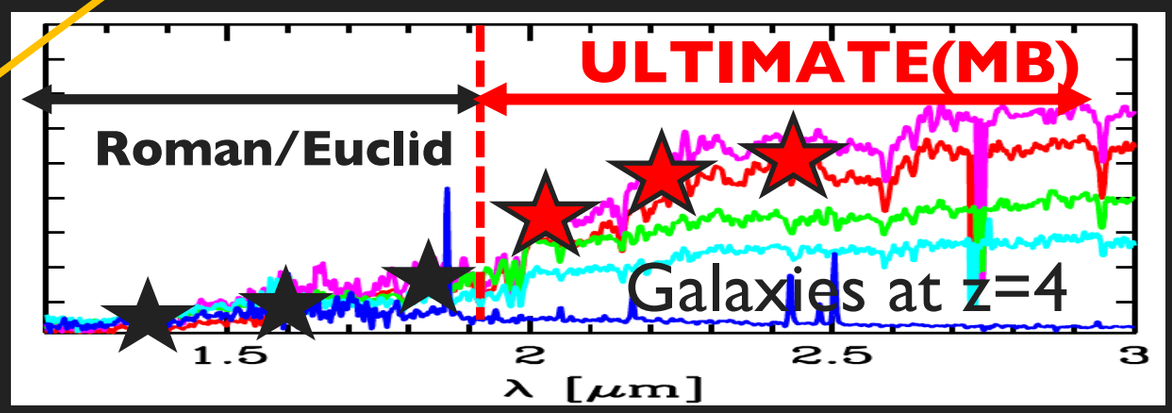


2. Stellar build-up (growth)

- 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).



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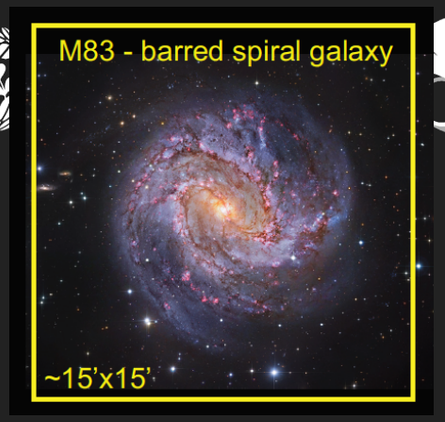

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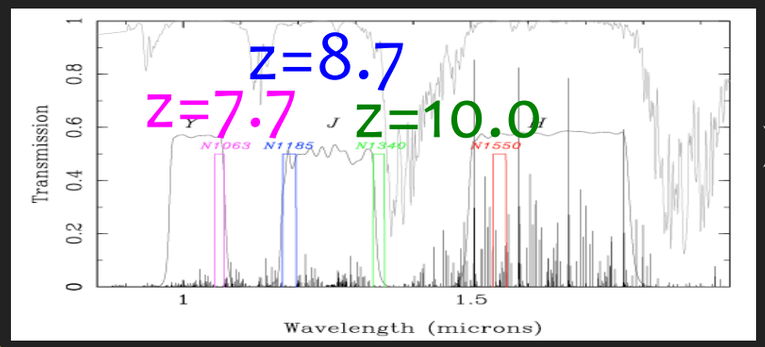
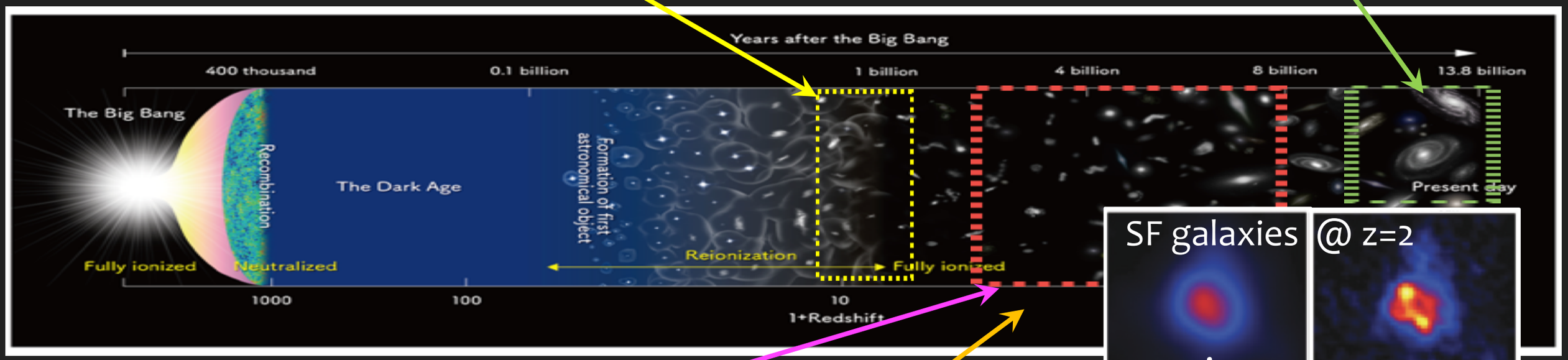


4. End products

- Dissecting nearby galaxies @ D<100Mpc with BB+NB to GMC scale.



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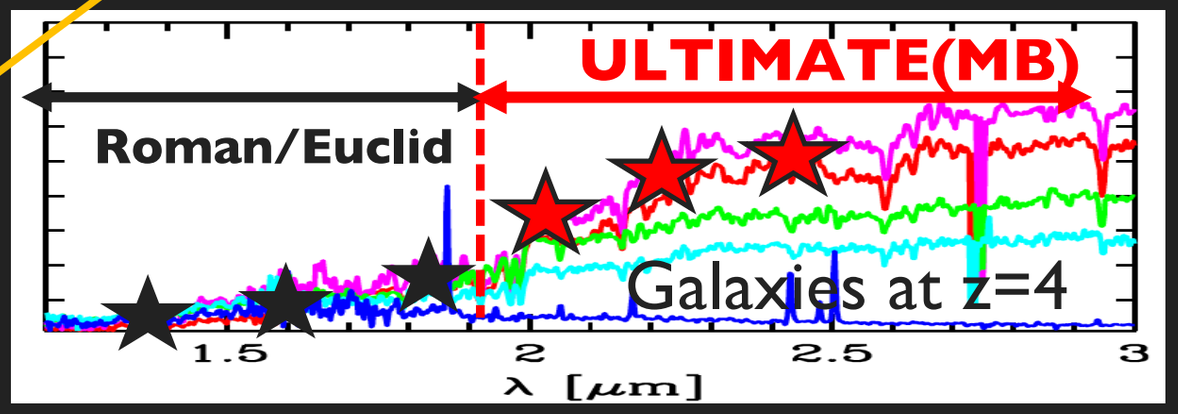
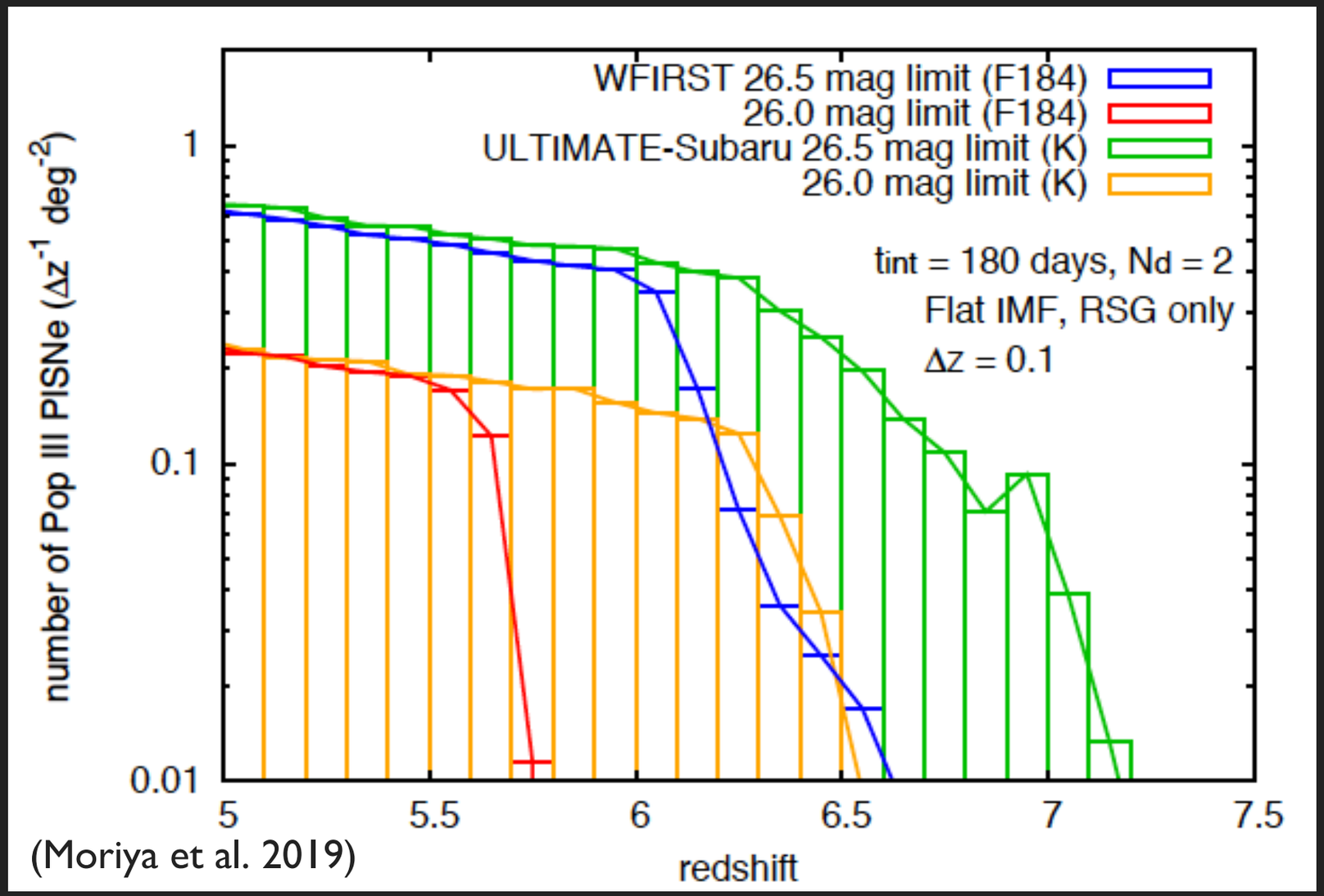
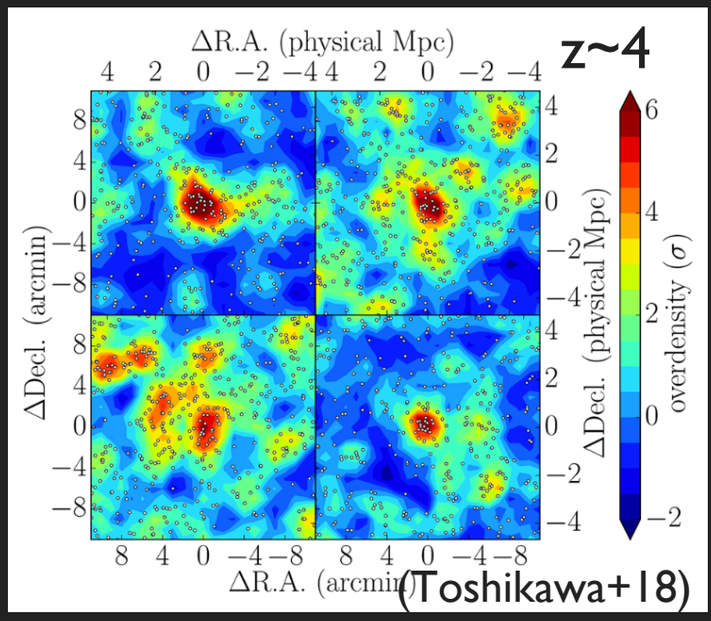


TIME DOMAIN ASTRONOMY IN ULTIMATE ERA

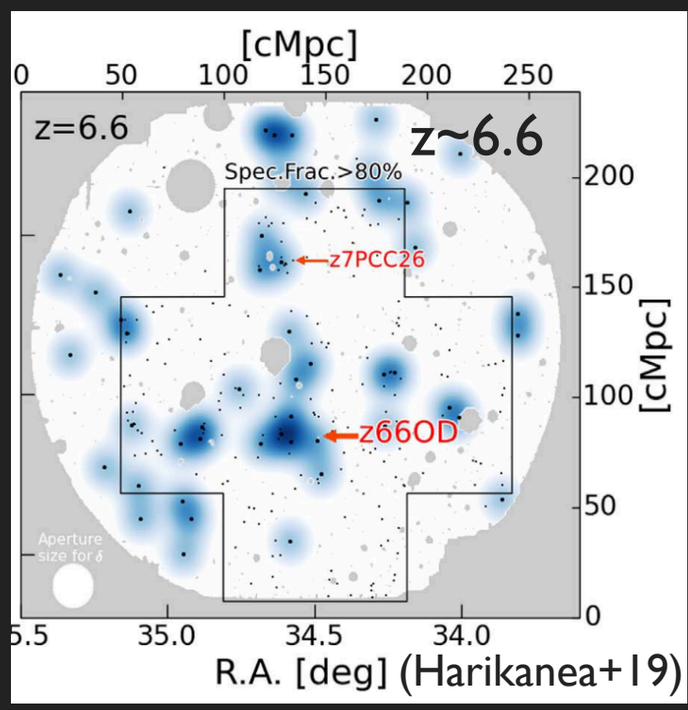
Supernovae search at z>6 – visiting ~1-deg^2 every 180-days down to K > 26 mag (AB) will allow us to detect PopIII pair-instability SNe at 6<z<7.



(Moriya et al. 2019)



(Toshikawa+18)

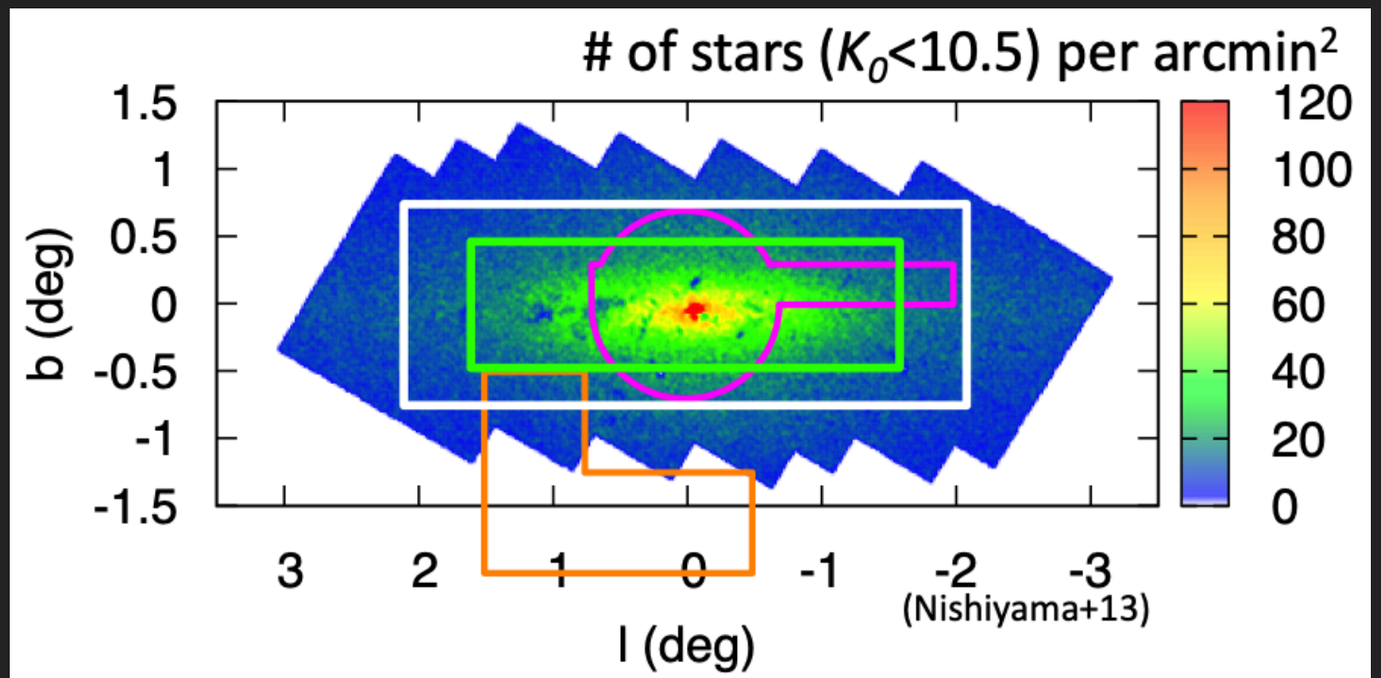


(Harikanea+19)

Note: Roman can do the same job as they recently decided to install Ks-band - but we will enhance the efficiency by targeting overdense/proto-cluster regions discovered by HSC, Euclid, Roman.

GALACTIC CENTER – ULTIMATE-K + NB IMAGING SURVEY

(S. Nishiyama, D. Suzuki, et al.)



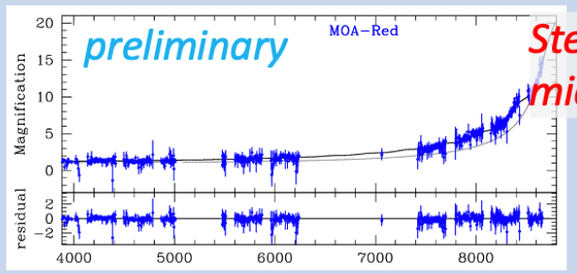
- ULTIMATE low cadence (1/month) 6 deg^2
- ULTIMATE high cadence (3/month) 3 deg^2
- Roman microlensing survey field
- JASMINE survey field

➢Synergy with Roman

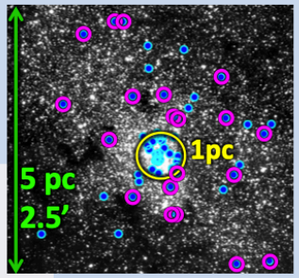
Simultaneous observation to measure the free-floating planet mass function

Please see ULTIMATE session in Day-3

To reveal ***hidden objects*** toward the Galactic center

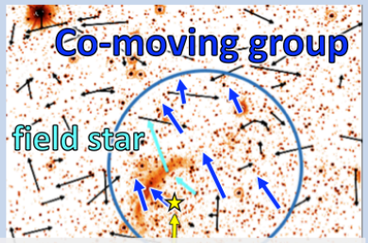


Stellar mass BH microlensing events



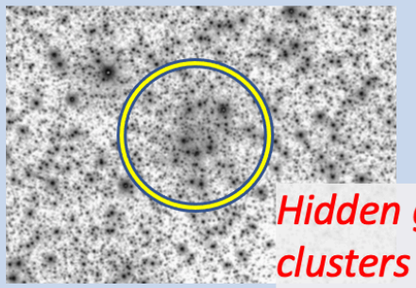
Intermediate-age Population in the Nuclear Star Cluster

Nishiyama & Schödel 13, Nishiyama+16



Hidden star clusters with IMBHs

Shahzamanian+19



Hidden globular clusters in the bulge

Moni Bidin+11

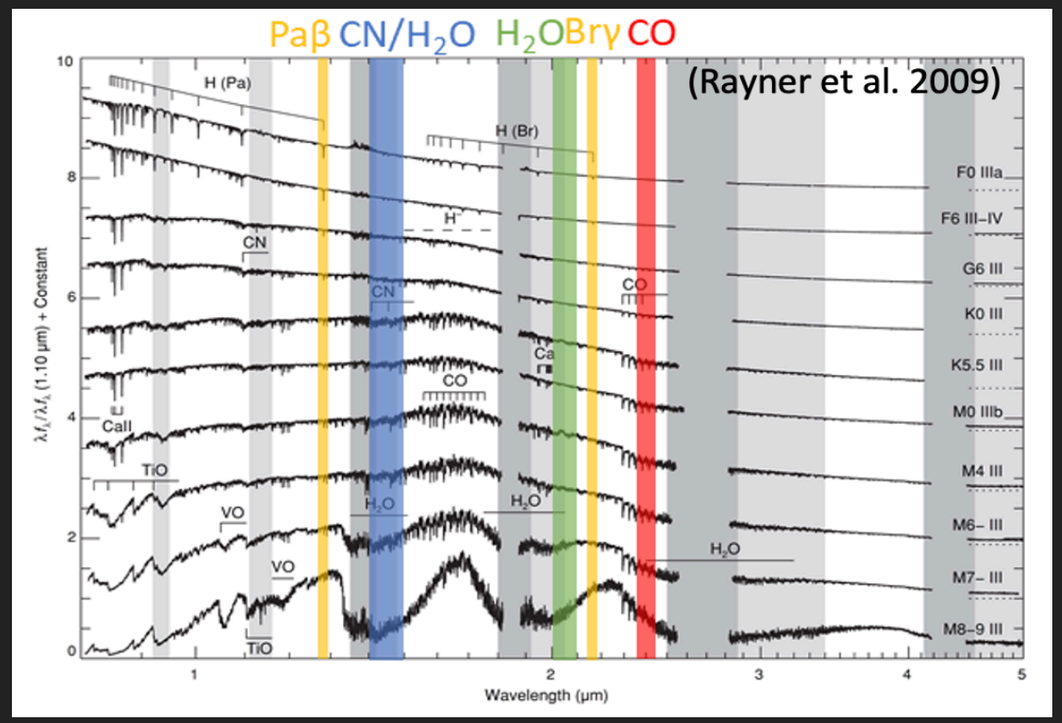
- ✓Photometry (*K*+NB) and Astrometry survey
- ✓Requires GLAO, wide FOV, Fast-AO setting for large airmass
- ✓Complementary to the space missions
- ✓Confusion limit for GC
- ✓Assuming Subaru Intensive program

ULTIMATE GALACTIC PLANE SURVEY

(T. Kamizuka, K. Morihana,
H. Onozato, Y. Nakada et al.)

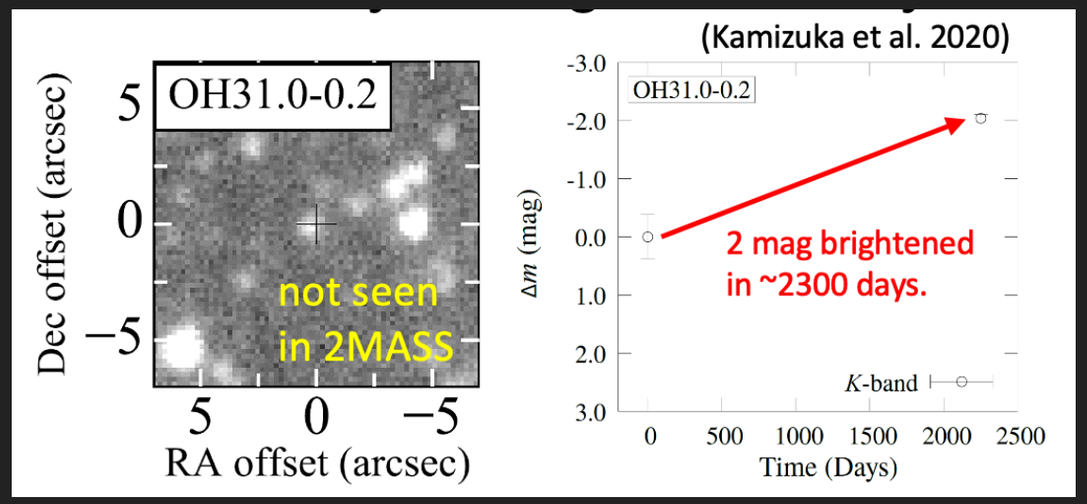
Revealing the Milky Way structure and hidden stellar evolution

1. Stellar classification & distribution census in the MW w/ MB (CO, H2O) & NB (Paβ, Brγ)



NIR spectra of giant stars and MB/NB filters.

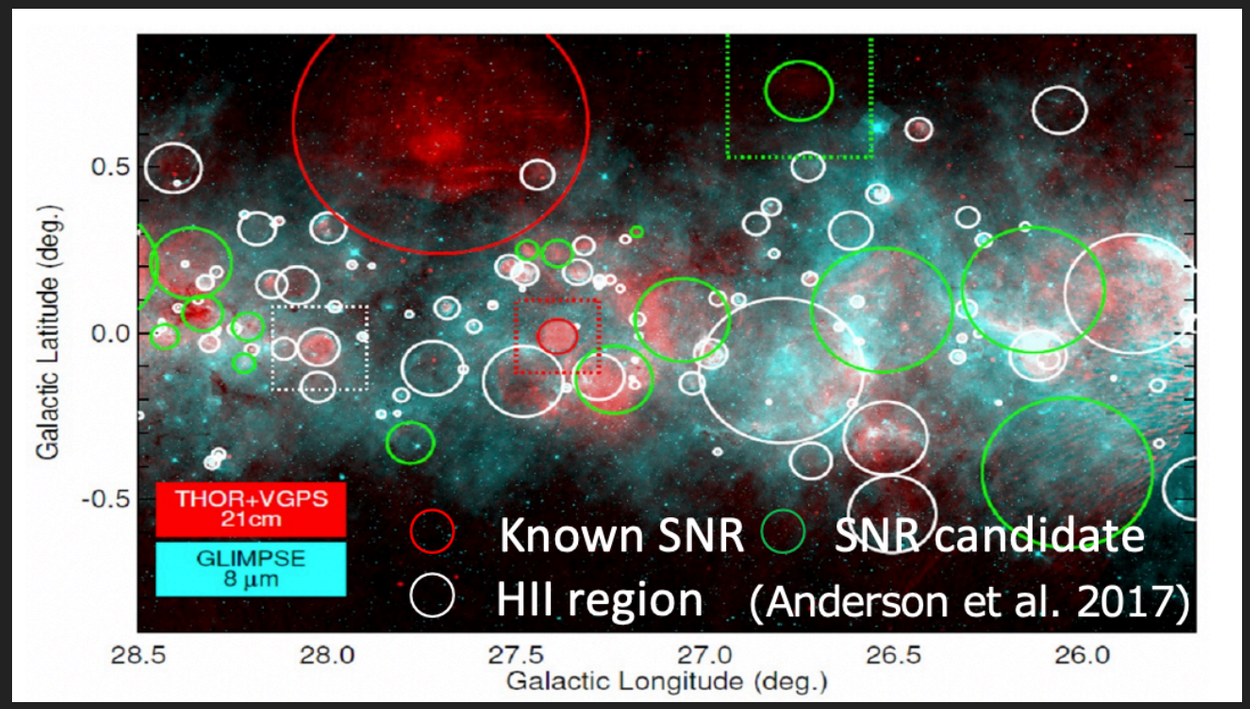
2. Finding & monitoring OH/IR stars – to investigate their evolution & mass-loss activity through variability.



Unexpected brightening of a non-variable OH/IR star from UKIDSS-GPS survey.

3. Cataclysmic Variable Survey with NB imaging (Paβ, Brγ).

4. Galactic Supernovae Remnant Survey with [FeII] & H2 NB imaging.

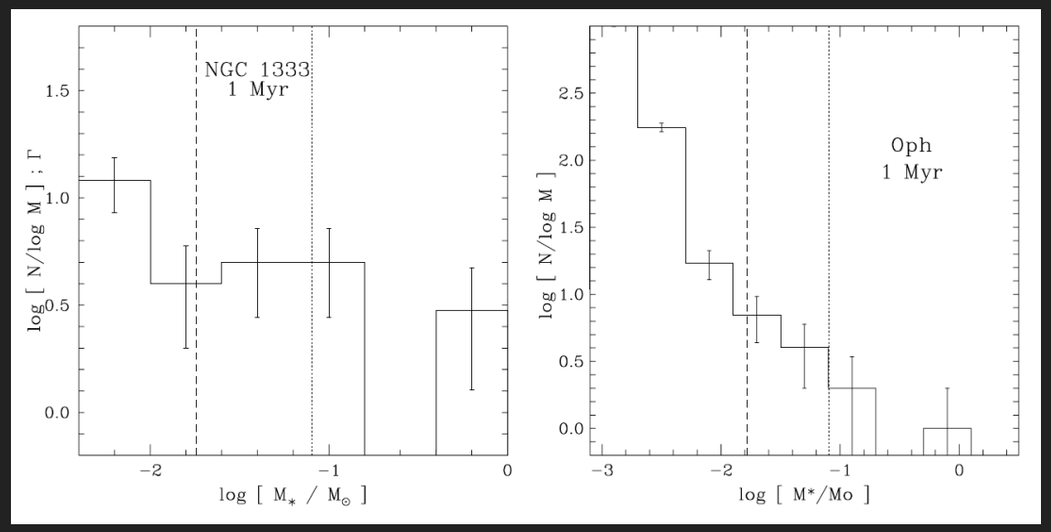


STAR FORMATION SCIENCE WITH ULTIMATE

(Y. Takagi et al.)

- **Initial Mass Function (IMF)**

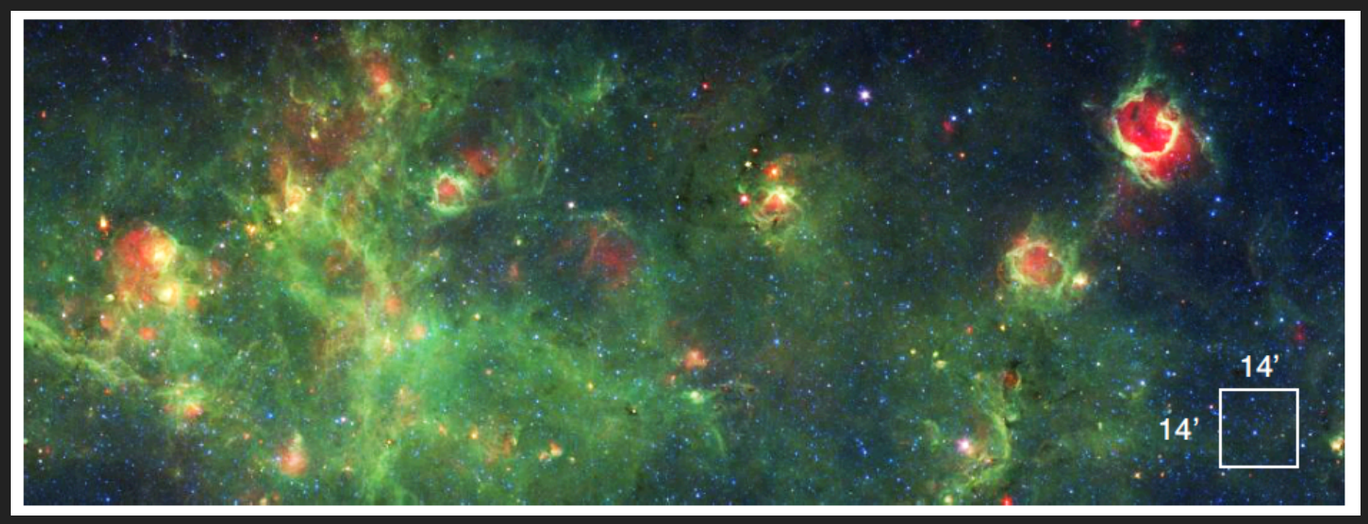
  High-resolution deep imaging of massive star forming regions (SFR) and low-metallicity distant SFRs are essential to clarify the universality and variety of IMFs



IMF of NGC1333 and Oph (Oasa+ 2006, 2008)

- **Formation of massive stars**

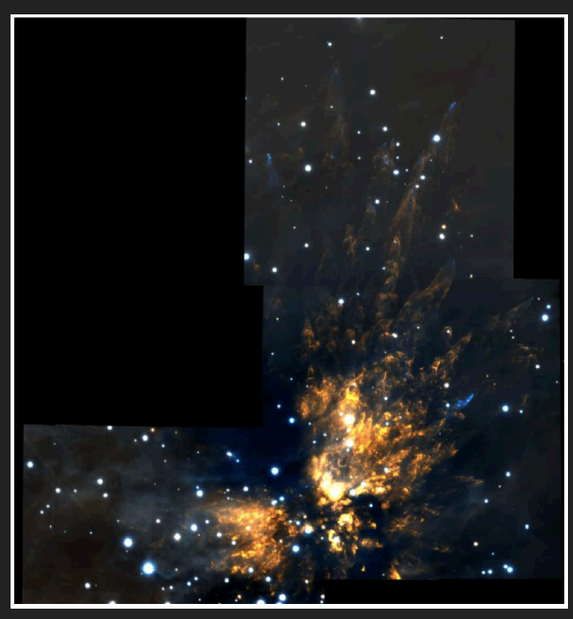
  Understanding the formation of massive star by revealing massive YSOs and HII regions with NB(Paβ, Br γ)



Churchwell et al. 2006

- **Jet & Outflow**

  NB ([FeII], H_2) observations of both jets and outflows to understand the formation history of molecular clouds and stars



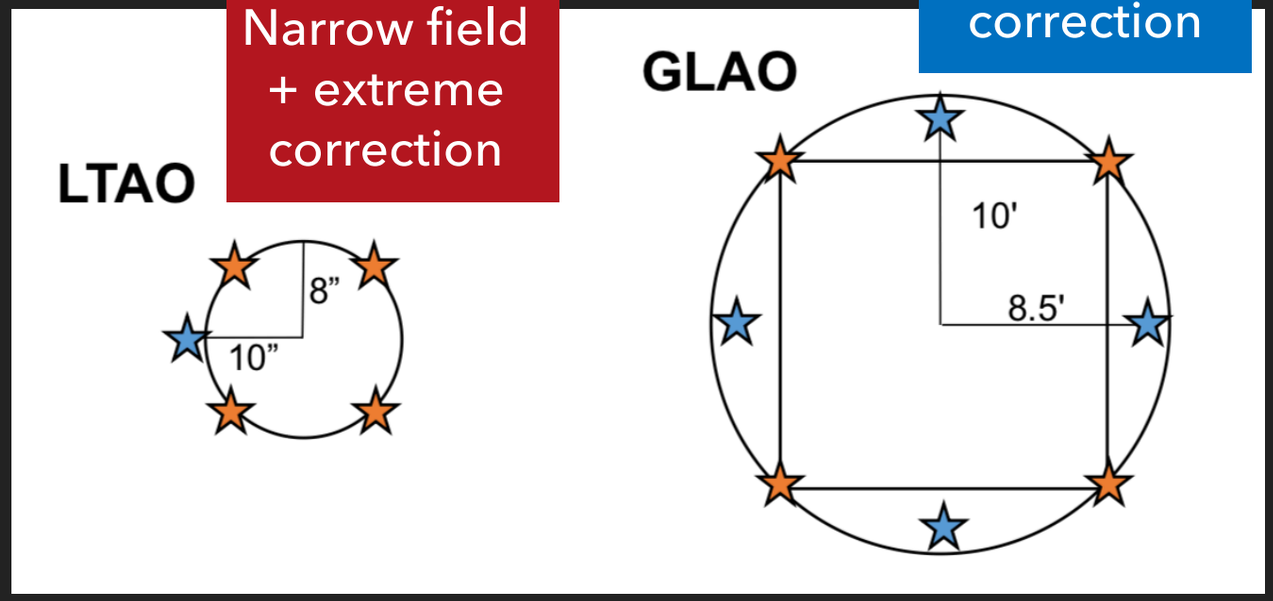
Wide field imaging of H_2 (orange) and [Fe II] (cyan) with AO (Bally et al. 2015)

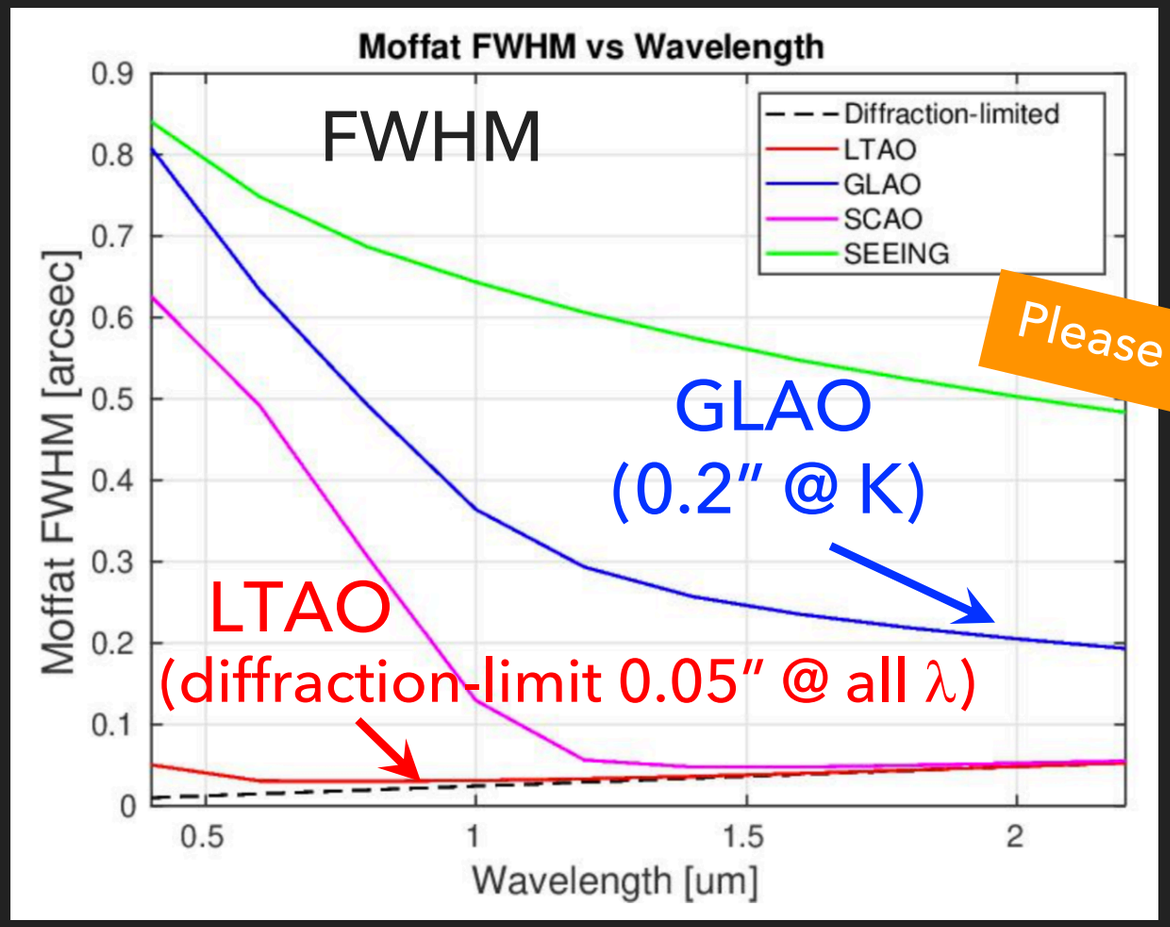
ULTIMATE IS NOT ONLY FOR WIDE-FIELD AO

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

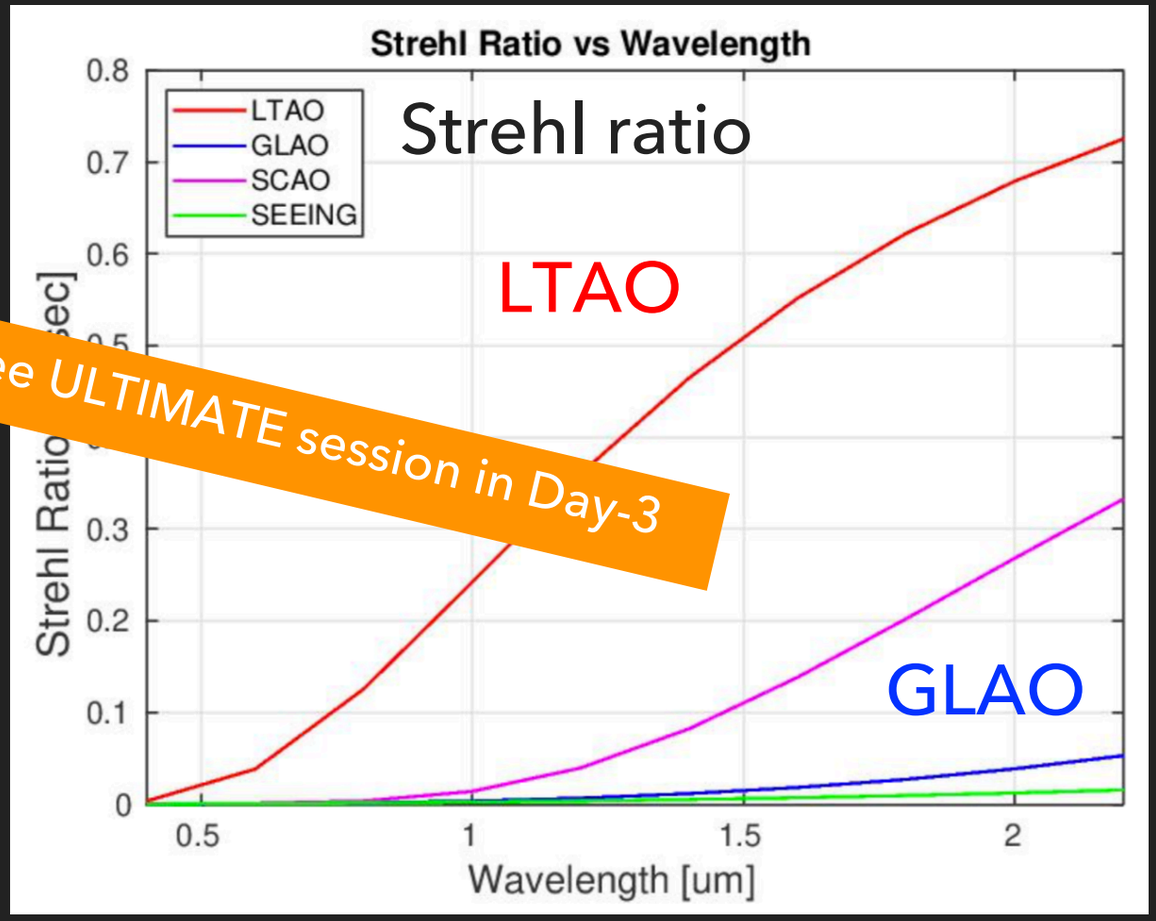
Narrow field + extreme correction

Wide field + moderate correction





Please see ULTIMATE session in Day-3



Development Team
(AO & instruments)

ULTIMATE core
(project management team)

Project scientist
(Y. Koyama)

ULTIMATE science team (ver. March 3rd 2021)











A. High-redshift Universe
(T. Kodama / I. Iwata / A. Inoue / K. Tadaki / T. Suzuki)

M. Akiyama
T. Hashimoto
Y. Harikane
M. Hayashi
A. Inoue
I. Iwata
S. Kikuta
T. Kodama
K. Kohno
Y. Koyama
M. Kubo
Y. T. Lin
Y. Matsuda
Y. Matsuoka
Y. Minowa
T. Morishita
R. Momose
T. Nagao
K. Nakajima
K. Ogura
M. Onodera
C. Rusu
T. Shibuya
R. Shimakawa
D. Sobral
T. Suzuki
K. Tadaki
*I. Tanaka
M. Tanaka
J. Toshikawa
Y. Toba
K. Yabe
F. Bian
J. Bryant
J. Bloom
A. Casey
S. Croom
S. Leslie
C. Lidman
L. Lin
D. Nataf
L. Kewley
I. T. Ho
A. Shaefer
T. Yuan
T. Zafar

B. Local Universe & Milky Way
(T. Yamashita / S. Okamoto / S. Nishiyama / D. Suzuki / K. Morihana / T. Kamizuka / Y. Takagi)

D. Calzetti
M. Chiba
A.Fukui
O. Guyon
D. Iono
K. Ito
T. Kamizuka
H. Kaneko
J. H. Kim
J. Koda
T. Kokusho
S. Komugi
Y. Kono
N. Koshimoto
*Y. Koyama
C. H. Lee
*Y. T. Lin
N. Matsunaga
T. Michiyama
Y. Miyamoto
K. Morihana
T. Muto
Y. Nakada
S. Nishiyama
C.C. Ngeow
Y. Oasa
S. Okamoto
H. Onozato
T. Pyo
T. Saito
S. Sorahana
K. Sorai
T. Sumi
D. Suzuki
Y. Takagi
T. T. Takeuchi
T. Terai
K. Torii
J. Ueda
T. Yamashita
C. Yasui

C. Time Domain science
(T. Moriya)

T. Morokuma
Masaomi Tanaka
*C. H. Lee
K. Maeda
T. Moriya
C. C. Ngeow
M. Oguri
K. C. Wong

D-SHOOTER/LTAO

M. Ouchi, *T. Moriya,
*Masaomi Tanaka,
N. Tominaga, M. Yoshida
S. Ozaki , *Y. Minowa
N. Takato, *Y. Koyama

JSPS CORE-TO-CORE PROGRAM (研究拠点形成事業)

*"International research network toward the era of **deep and wide NIR survey of the universe** with space and ground-based telescopes"* - **Approved for FY2021-2025 !**

Philippe Laudet

esa cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

France/CNES

Euclid-Subaru synergy obs.

Michitoshi Yoshida

Japan/NAOJ

国立天文台 NAOJ National Astronomical Observatory of Japan

Roman-Subaru synergy obs.

NASA

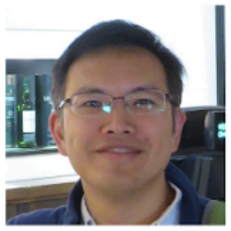
Julie McEnery

USA/NASA

SUBARU TELESCOPE National Astronomical Observatory of Japan

Subaru

ULTIMATE Subaru (2026-)



Shiang-Yu Wang

Taiwan/ASIAA

中央研究院 ASIAA

collaboration in ULTIMATE

collaboration in ULTIMATE

Australia/ANU

Australian National University

Celine d'Orgeville

SUMMARY

ULTIMATE-Subaru

Next-generation AO + IR instrument to maximize Subaru capabilities (in bright nights) toward 2030s.

Wide-field mode (GLAO)

- FWHM=0.2" @ K-band
- 20-arcmin FoV (diameter)
- Great synergy with future space missions (e.g. Euclid/Roman/ JASMINE) with deep/wide/ sharp/long-period survey.

Narrow-field mode (LTAO)

- FWHM=0.05" @ all opt-NIR
- A few to ~10-arcsec FoV
- Best follow-up tool for your favorite targets (discovered by e.g. HSC/PFS) as a preparation work toward the TMT era.

Please join ULTIMATE session in Day-3 (March 5th 10:00-10:30, JST)