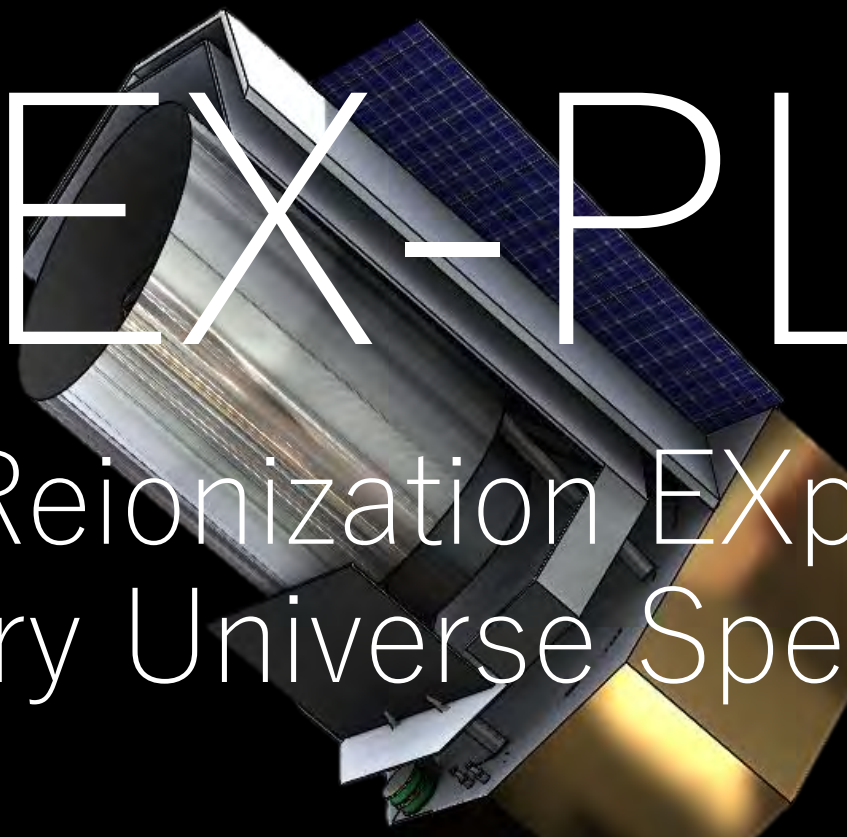
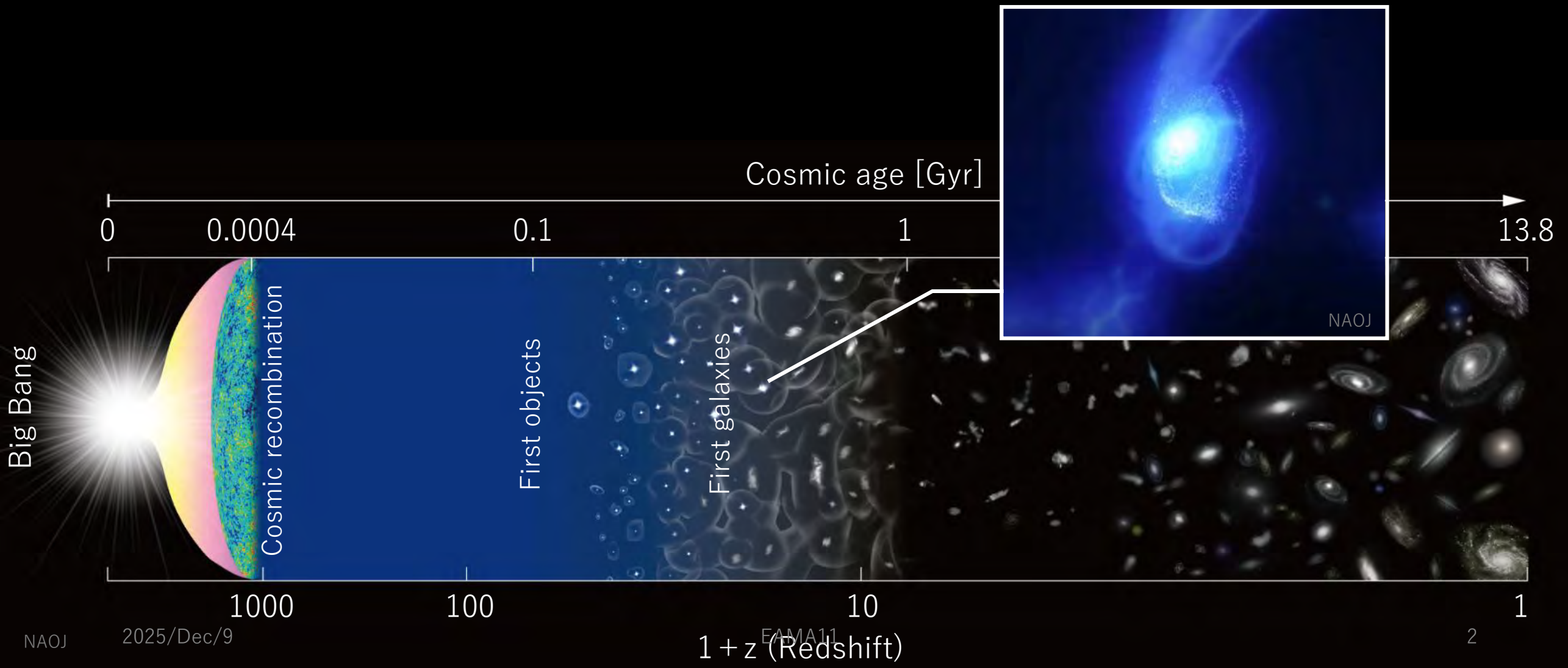
GREX-PLUS

Galaxy Reionization EXplorer and PLanetary Universe Spectrometer



Akio K. INOUE (Waseda U.)

To know how the first objects and galaxies formed.



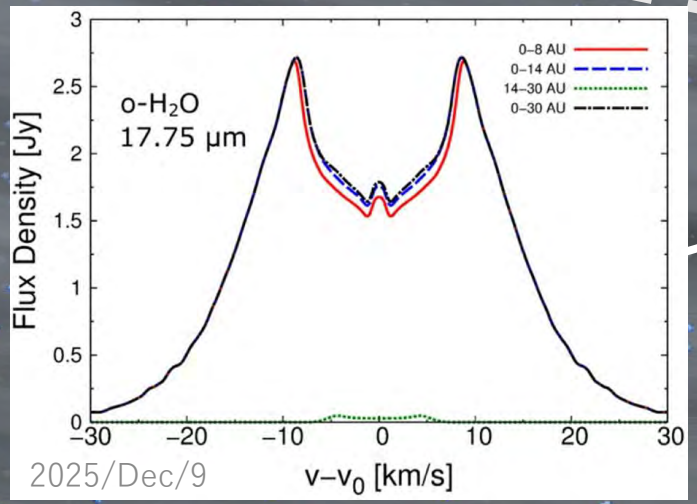
Galaxy Reionization EXplorer and PLanetary Universe Spectrometer (GREX-PLUS)

To know the origins of planets, ocean, and life.

Snow line

Water vaper

Water ice



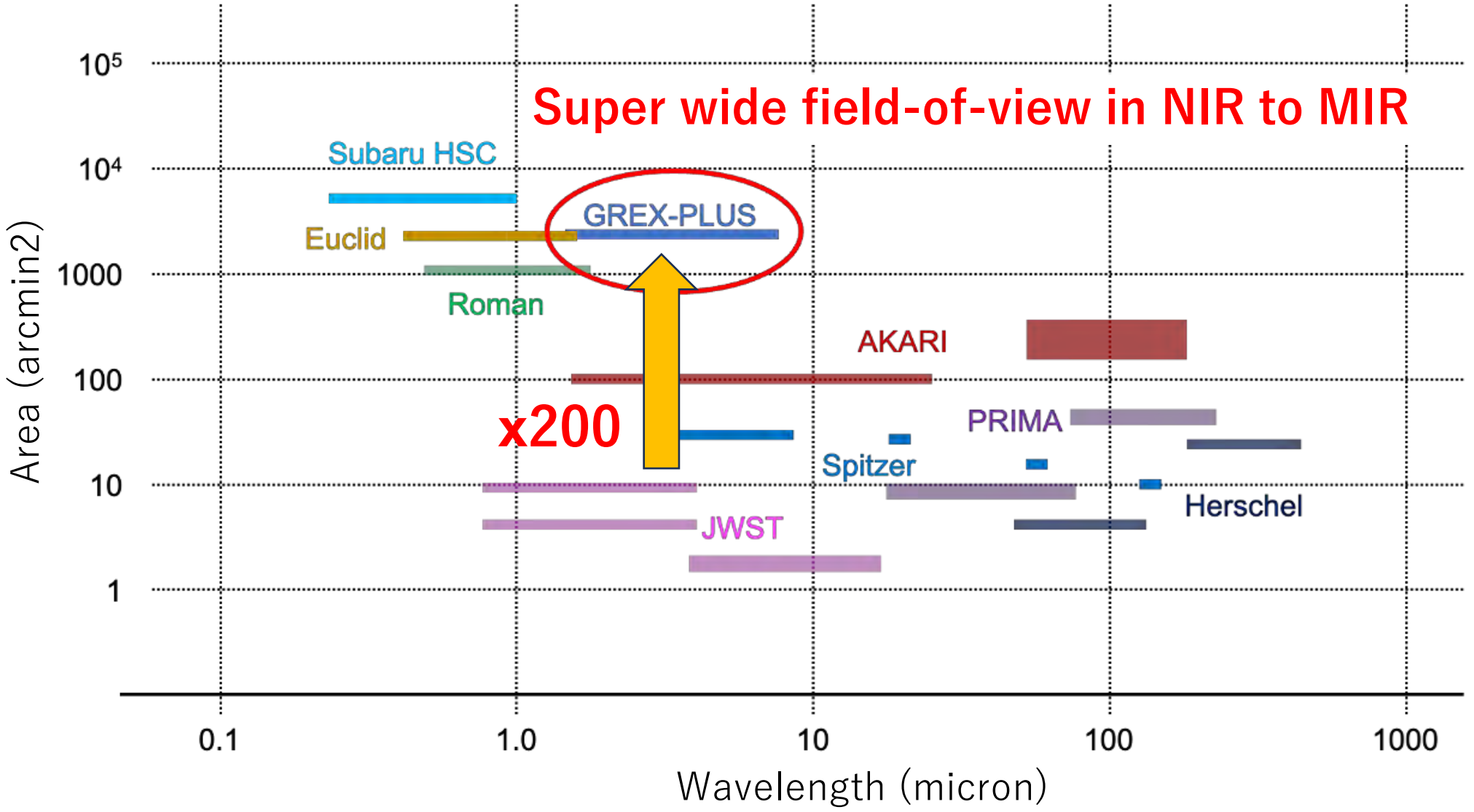
ESA/Hubble, M. Kornmesser

GREX-PLUS: A JAXA L-class mission candidate

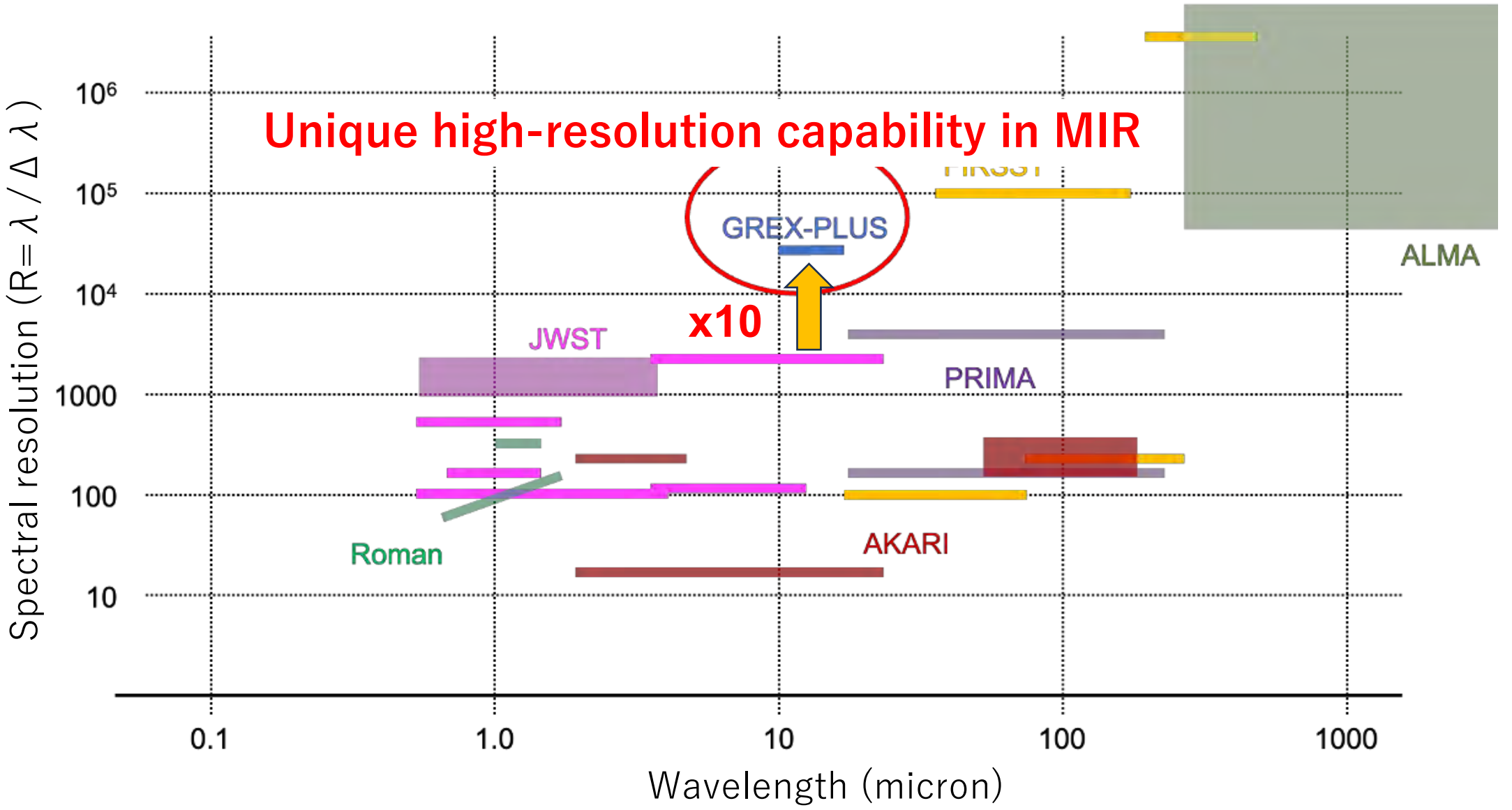
- Cryogenic space telescope (<50K)
  - Primary mirror diameter: 1.0m
  - Korsch 3-mirror optics
  - Cooling system from SPICA heritage
- Wide-Field Camera (WFC)
  - Field-of-view： 1,792 arcmin2
  - Division into 5 photometric bands
    - NIR (2-4.5 um) 3 bands, <55K
    - MIR (4.5-8 um) 2 bands, <42K
- (Option) High Res. Spec. (HRS)
  - R~30,000 (Δv~10 km/s) in 10-18 micron, <7K

- Pointing accuracy
  - Absolute accuracy: <1.0 arcsec (3σ)
  - Stability: <0.6 arcsec (300s, 3σ)
- Nominal lifetime: >5 years
- Orbit: Sun-Earth L2 Halo
- Launch: mid-2030s
- Status: Working Group for a JAXA L-class mission

International competitiveness: Field-of-View

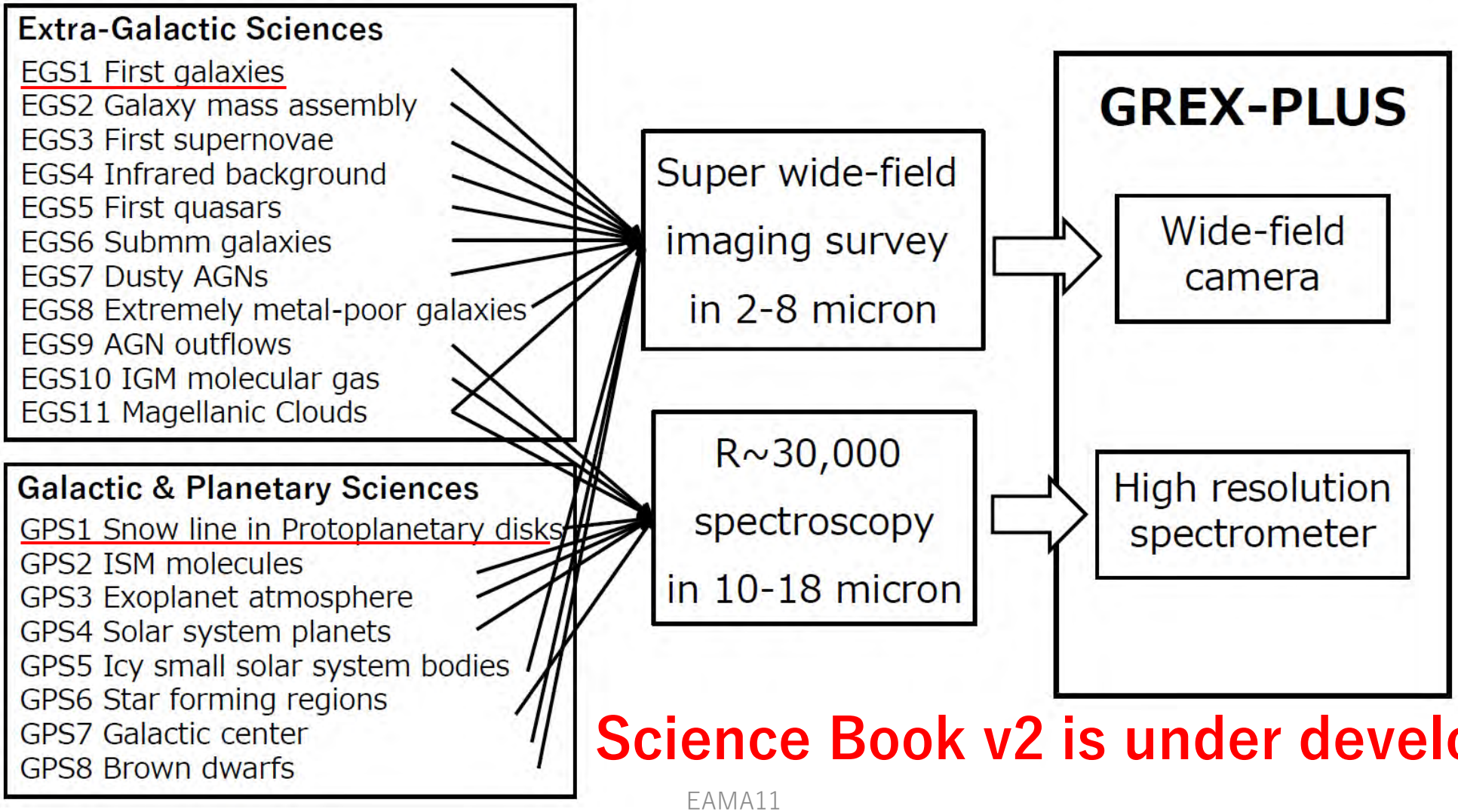


International competitiveness: Spectral resolution



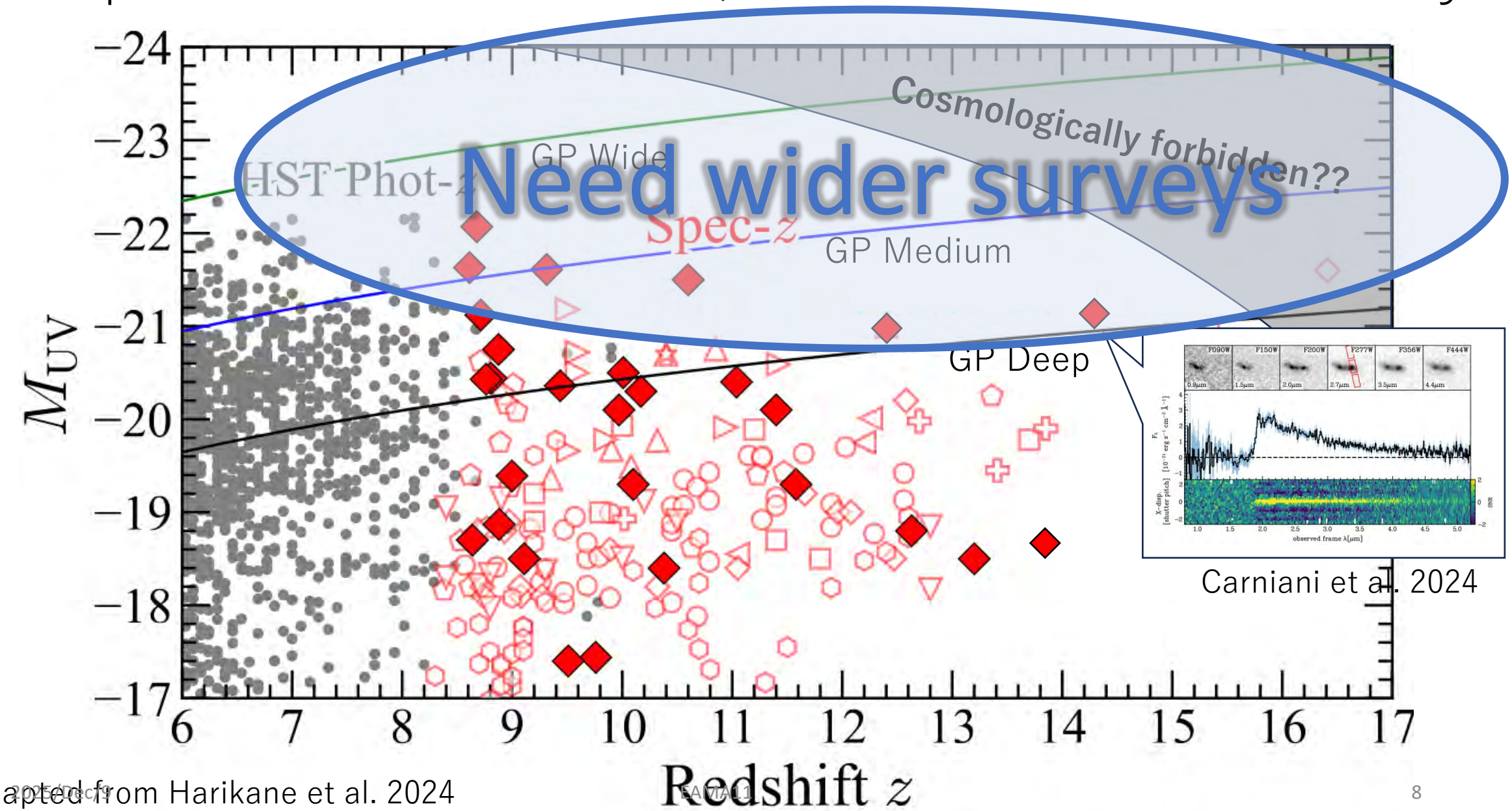
GREX-PLUS: Galaxy Reionization EXplorer and PLanetary Universe Spectrometer
Science Goals, Required Observations and Instruments

GREX-PLUS Science Book arXiv:2304.08104



Science Book v2 is under development!

JWST pushes the frontier, but need wider surveys



Carniani et al. 2024

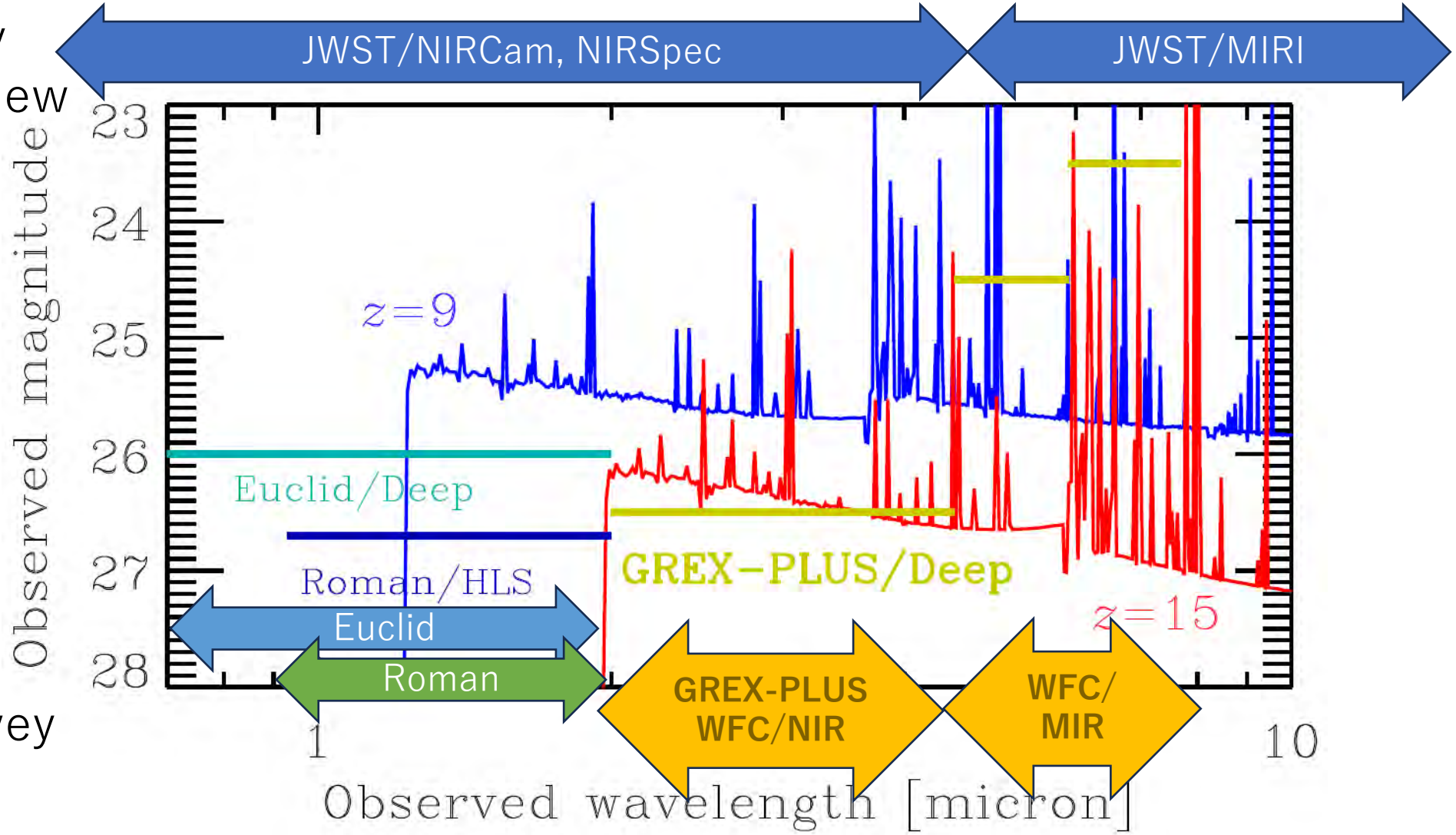
Adapted from Harikane et al. 2024

Importance of wide-field surveys at $\lambda > 2$ μm

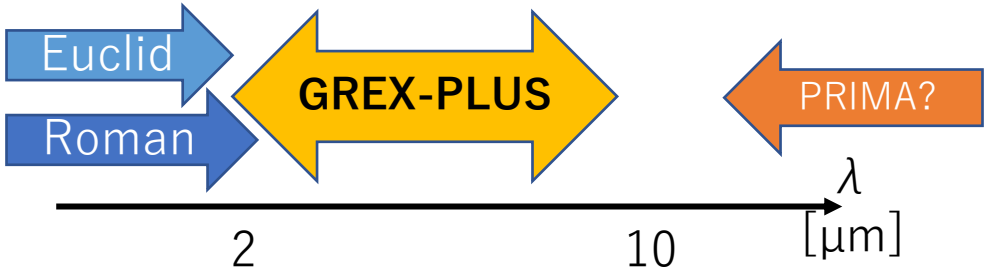
Super high sensitivity
but narrow field-of-view

To find rare bright,
massive galaxies

Super wide-field survey



GP WFC Science



- **Extremely versatile images at 2—8 μm**
  - "Roman-drop" objects
    - z>15 galaxies and AGNs (SMBHs) ~10 or more (Harikane+22)
    - z>6 matured, passive (Balmer-break) galaxies ~10k (Mawatari+20)
    - z>3 Dust-obscured galaxies and AGNs (SMBHs) ~100-400 (Y. Toba)
    - z>8 Most distant supernovae (SLSNe, PISNe) ~10 or more (T. Moriya)
    - etc. including new populations such as LRDs and further unknown populations
    - These objects will be excellent targets for ALMA, JWST, ELTs
  - Infrared background measurements
  - Nearby galaxies including Magellanic Clouds
  - Galactic plane survey
  - Solar system small bodies (photometric 3 μm water ice survey)
  - Base images for transient objects and multi-messenger astronomy

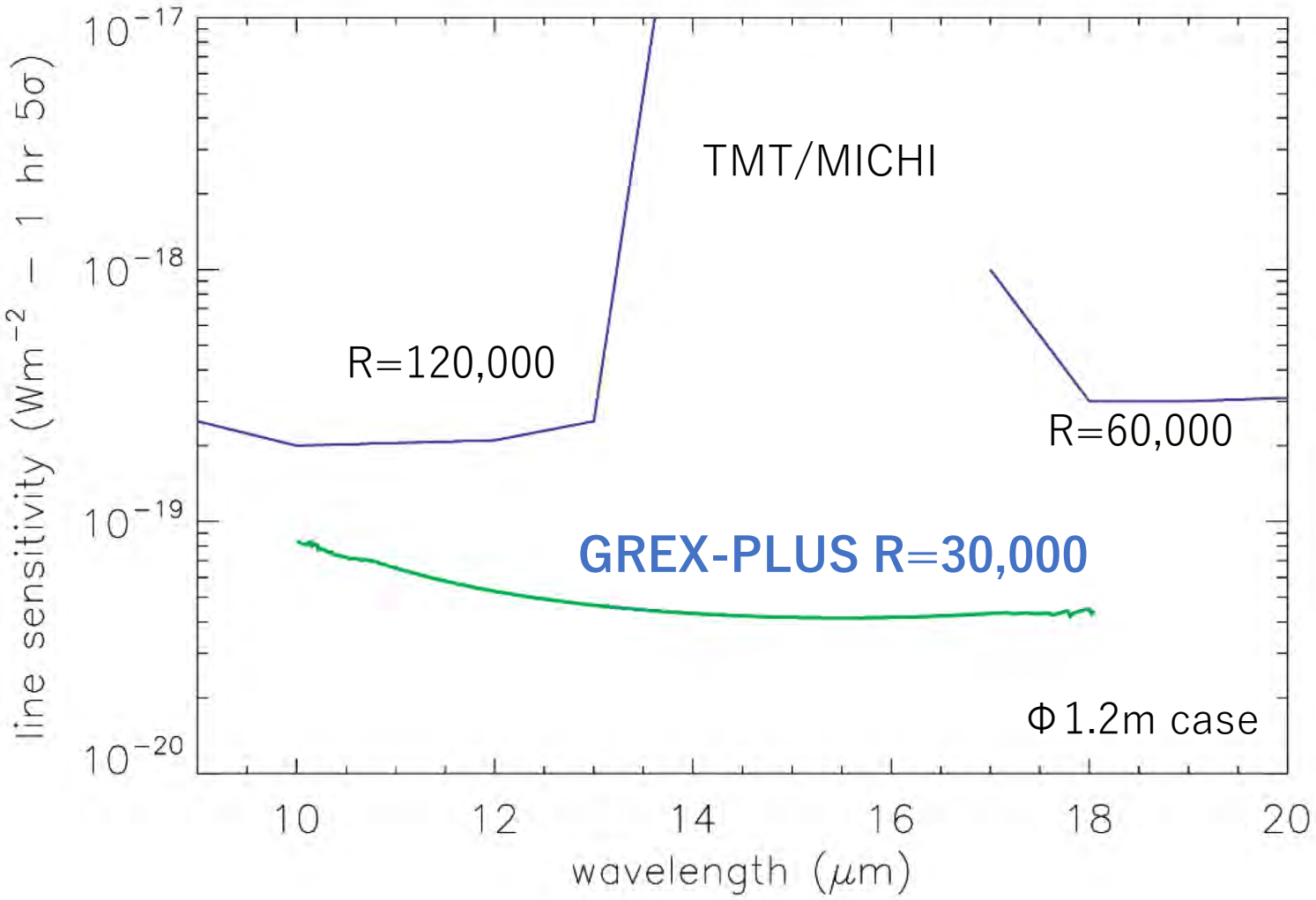
GREX-PLUS Science Book arXiv:2304.08104

GREX-PLUS High-Resolution Spectrometer (HRS)

- **Resolving power: 30,000**

- One order of magnitude higher than JWST R~3,000

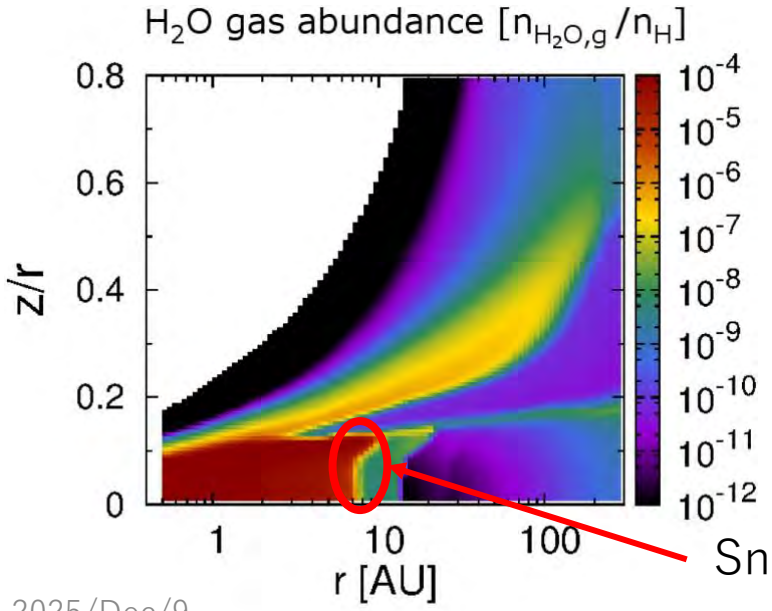
- Several times better sensitivity than ELTs
- <u>Continuous wavelength coverage</u>

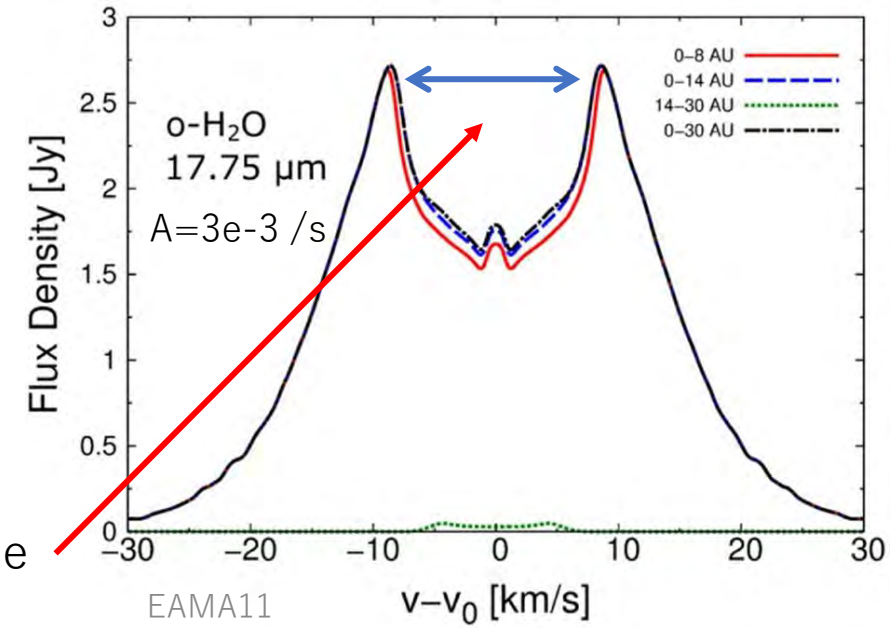


GREX-PLUS HRS Sciences

GREX-PLUS Science Book
arXiv:2304.08104

- **Uniqueness of Mid-IR, R=30,000 on a space telescope**
  - λ =10-20 μm: "Finger-print domain" for molecular spectroscopy
  - Resolving the **water snowline in ~100 PPDs** and examining its evolution
  - Probing the organic molecule formation in PPDs
  - Transit spectroscopy of the exoplanet atmosphere
  - Atmosphere on the Solar system planets
  - Interstellar chemistry to understand the organic molecule formation
  - AGN molecular outflows kinematics and understanding AGN feedback
  - Molecular absorption in damped Ly α system in the intergalactic medium





Resolve Keplerian motion at the snow line with Δ v=10 km/s (R=30,000).

Status and timeline

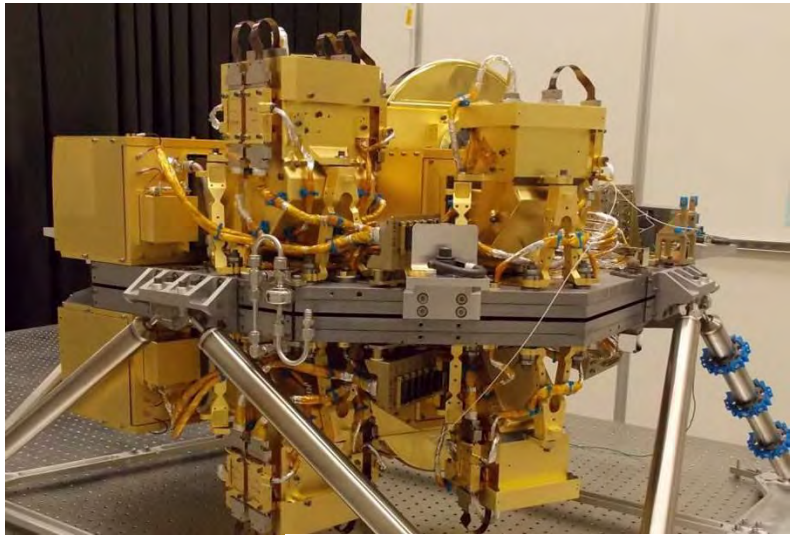
- ISAS/JAXA Working Group
  - Concept study funded by ISAS/JAXA
  - One of the two final candidates for the 2030s

- 2027, Mission proposal submission → Selection
- 2029, Mission Definition Review (MDR)

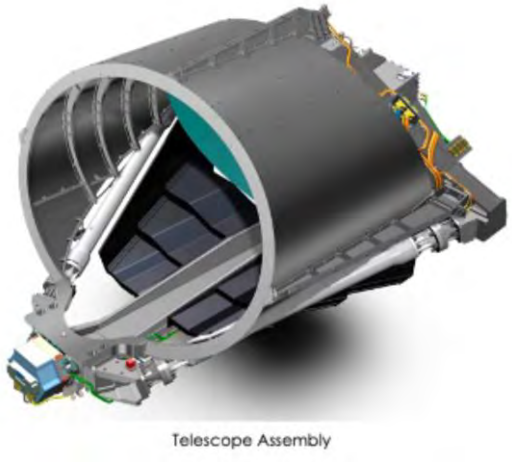
- ~2037, Launch
- Nominal 5 years operation + possible extension

International collaboration

- US
  - US GREX-PLUS Team
    - Steward Observatory, Arizona University (Lead)
    - Harvard Smithsonian Observatory
  - WFC development through NASA funding
    - Great heritages of JWST/NIRCam and Spitzer/IRAC
- EU
  - EU GREX-PLUS consortium?
    - Kick off meeting in February 2025 in Brussels
    - The second workshop in November 2025 in Bologna
  - ASI, Italy?
    - Telescope development based on the heritage of ARIEL telescope?
- Others
  - ASIAA, Taiwan? KASI, Korea? Australia? And more?



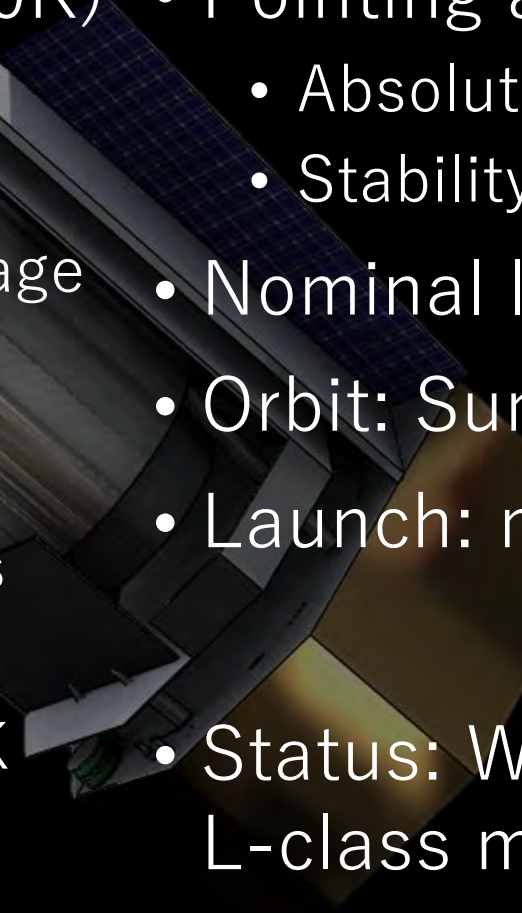
Arizona U.



Pace et al. (2024)

GREX-PLUS: A JAXA L-class mission candidate

- Cryogenic space telescope (<50K)
  - Primary mirror diameter: 1.0m
  - Korsch 3-mirror optics
  - Cooling system from SPICA heritage
- Wide-Field Camera (WFC)
  - Field-of-view： 1,792 arcmin2
  - Division into 5 photometric bands
    - NIR (2-4.5 um) 3 bands, <55K
    - MIR (4.5-8 um) 2 bands, <42K
- (Option) High Res. Spec. (HRS)
  - R~30,000 (Δv~10 km/s) in 10-18 micron, <7K



- Pointing accuracy
  - Absolute accuracy: <1.0 arcsec (3σ)
  - Stability: <0.6 arcsec (300s, 3σ)
- Nominal lifetime: >5 years
- Orbit: Sun-Earth L2 Halo
- Launch: mid-2030s
- Status: Working Group for a JAXA L-class mission

What kind of international collaborations are welcome!