New Instruments on the Subaru Telescope

Yosuke Minowa
(Subaru Telescope)

Subaru User's Meeting, 2017/01/10

New Visitor (PI-type) Instruments

NsIR

Kyoto3DII (~2017.2)

HiCIAO

AO188

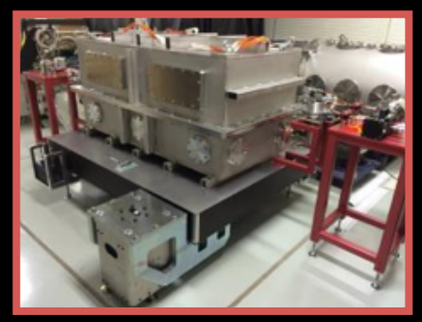
SCExAO

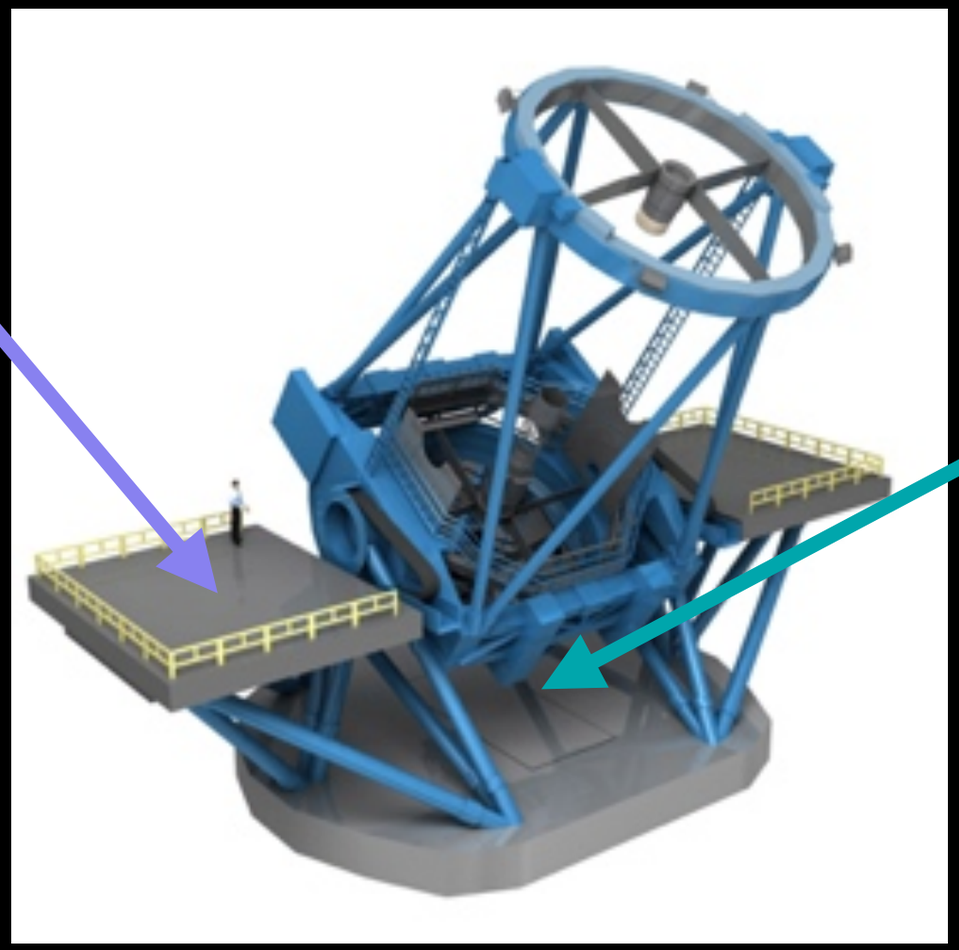
CHARIS (2016.7~)

MEC(TBD)

Coude

IRD(2017.2~)



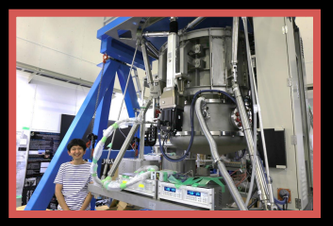


Accepted for commissioning

Cs

SWIMS

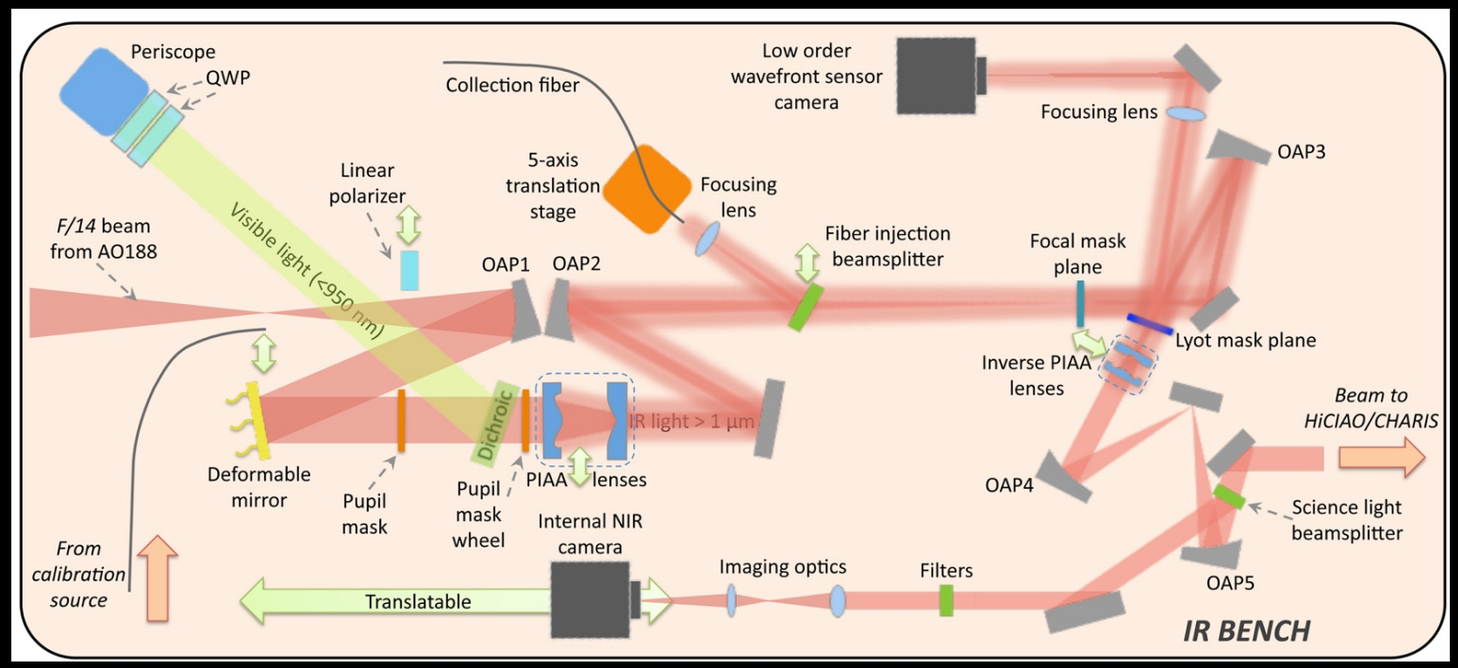
MIMIZUKU

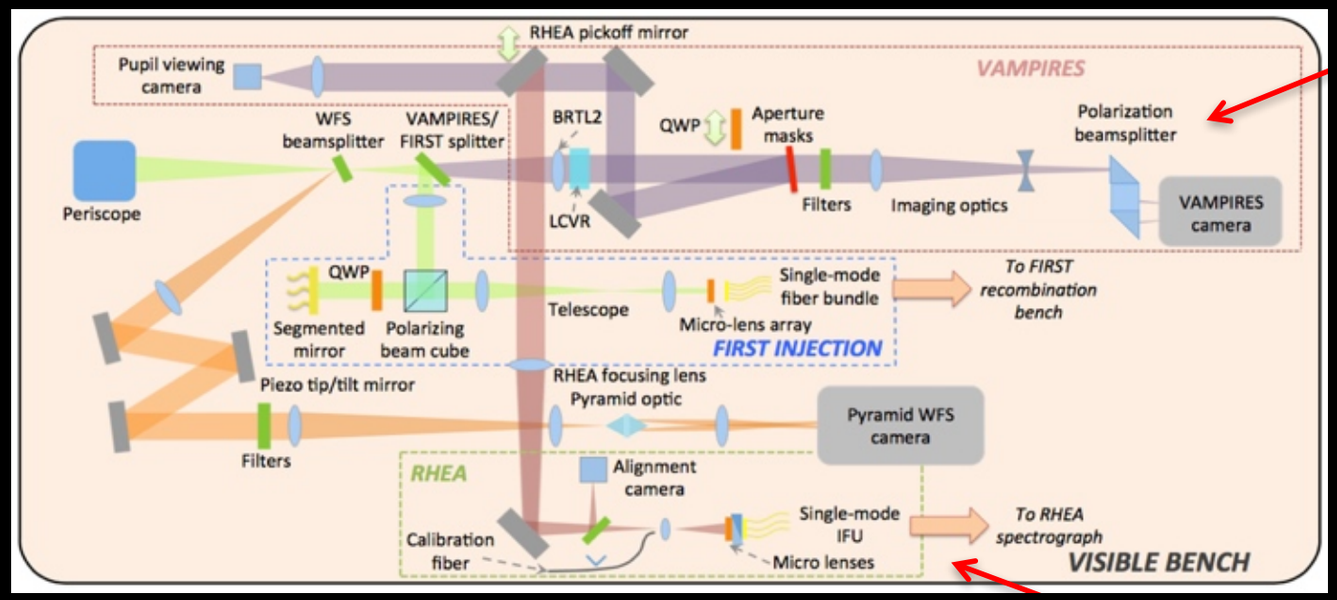


Short time-scale of Cycles (Development-Commissioning-Science) to catch-up this rapidly evolving research field

Subaru Coronagraphic Extreme Adaptive Optics

PI: Olivier Guyon (Subaru)





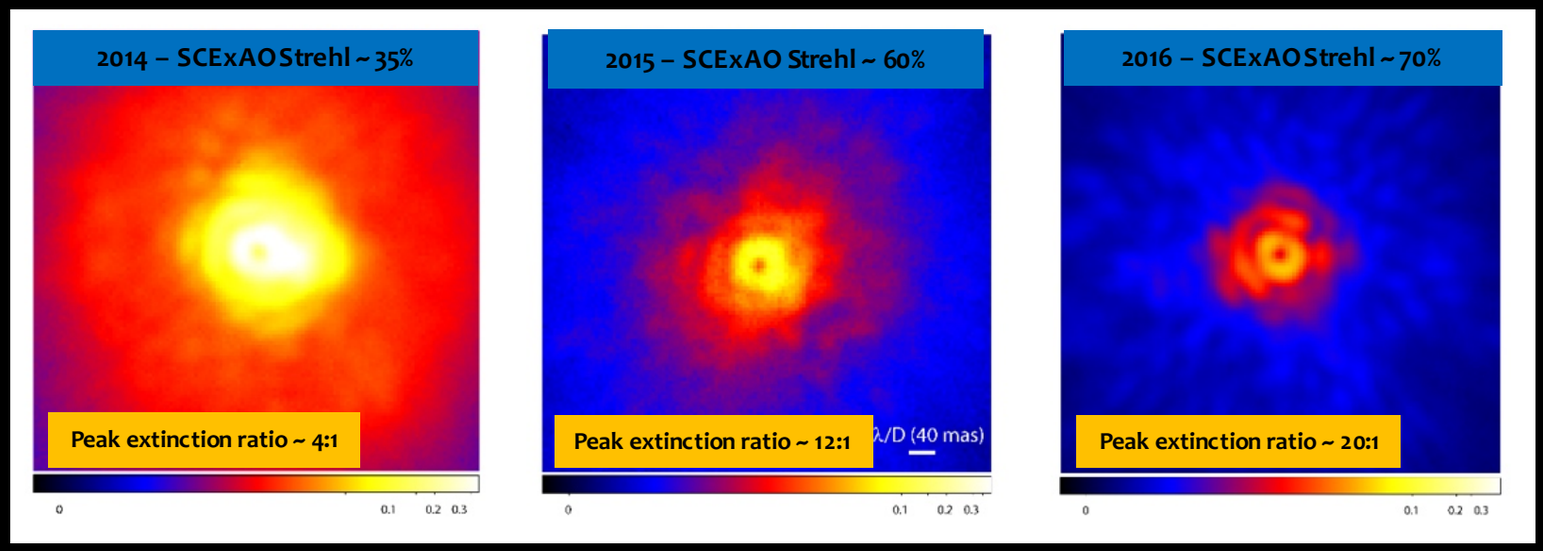
Jovanovic et al. 2015

Visitor modules on the visible bench

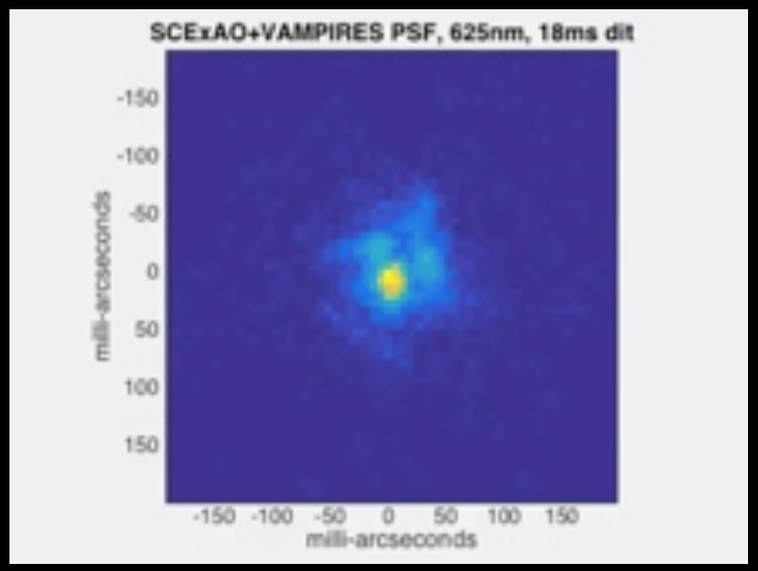
- VAMPIRES (open to the community)
  - polarimetric instrument using non-redundant pupil mask
- FIRST (commissioning phase)
  - interferometer and spectrometer using non-redundant pupil remapping with single-mode fibers
- RHEA (commissioning phase)
  - 9 element IFU spectrograph with single-mode fiber injection on the focal plane
- NULLER (commissioning phase)
  - Nulling interferometer using single mode fiber injection

Subaru Coronagraphic Extreme Adaptive Optics

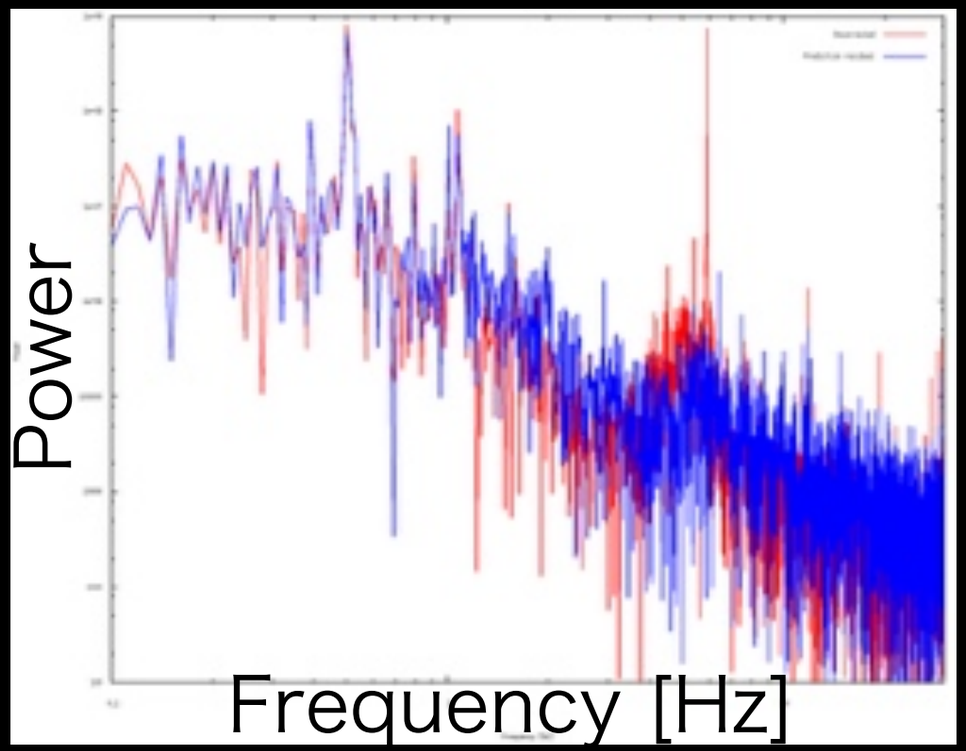
Phase 2 (pyramid WFS) commissioning has been started since 2014.
Most of the issues solved, except for vibration during transit.



Figures from M. Ireland



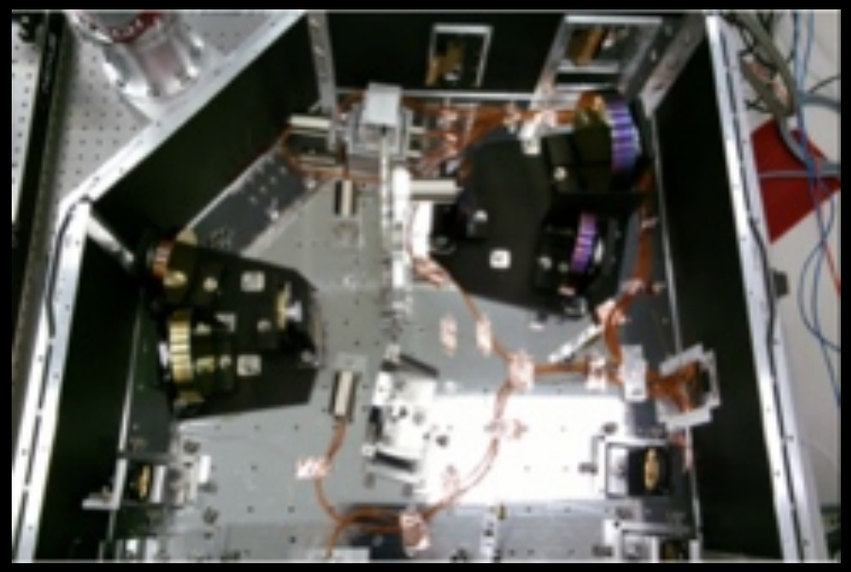
Movie from B. Norris

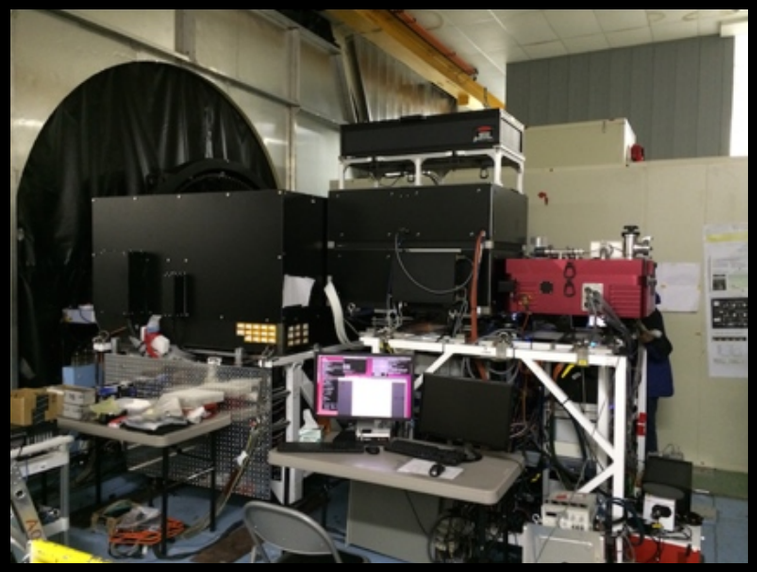


- Several accelerometers have been installed to telescope to measure the vibration.
- Trying to mitigate the 5Hz vibration by introducing a feed-foward correction from accelerometer measurement to AO188 Tip/Tilt mount.
- This will potentially improve the PSF not only for SCExAO, but also for all instruments.

CHARIS
(Coronagraphic High Angular Resolution Imaging Spectrograph)

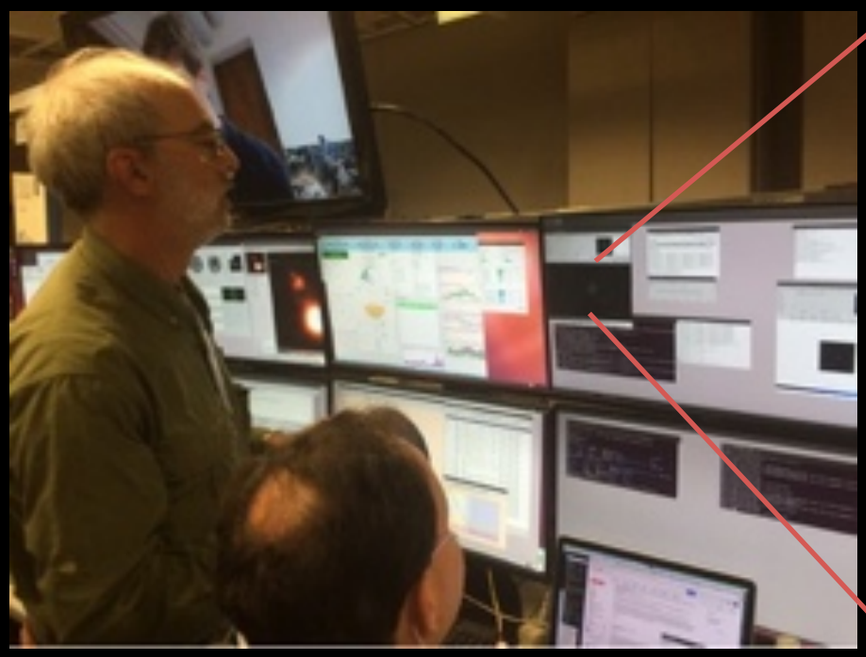
PI: Jeremy Kasdin (Princeton Univ.), funded by NAOJ (PI: M. Hayashi)

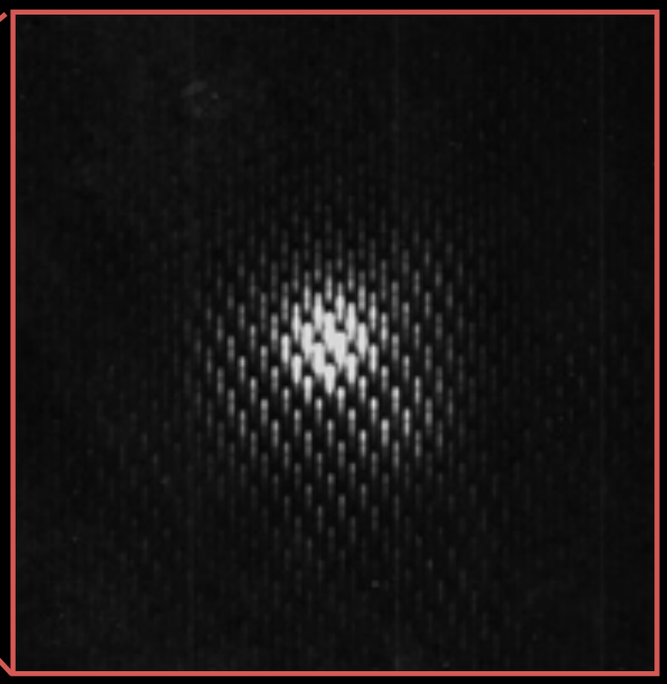




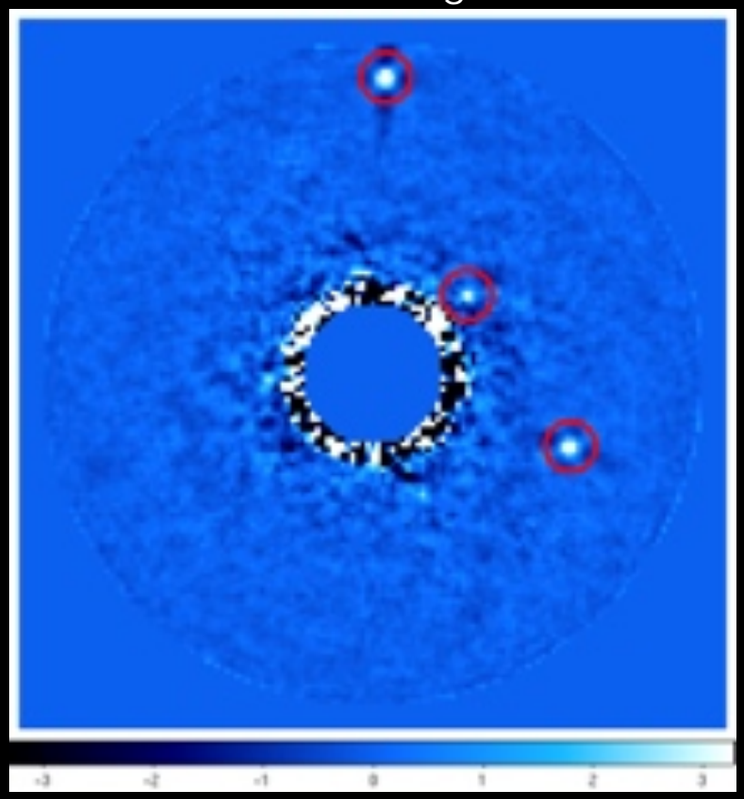
- Commissioning started since July, 2016
- Science operation will start from S17A (opened to the community in a shared-risk)

CHARIS First Light image





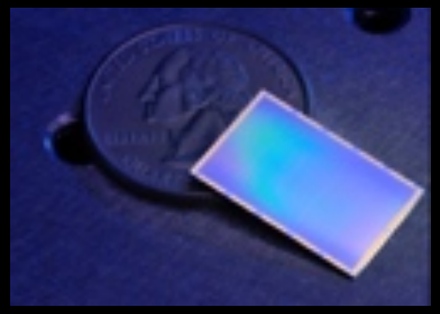
SCExAO+CHARIS image of HR8799



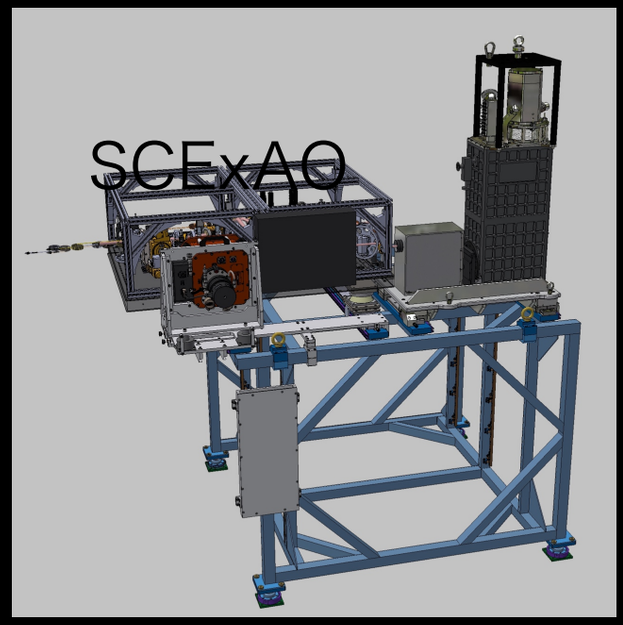
http://scholar.princeton.edu/charis

MEC (MKIDs Exoplanet Camera)

- Fast photon-counting, energy resolving IFS based on Microwave Kinetic Inductance Detectors (MKIDs)

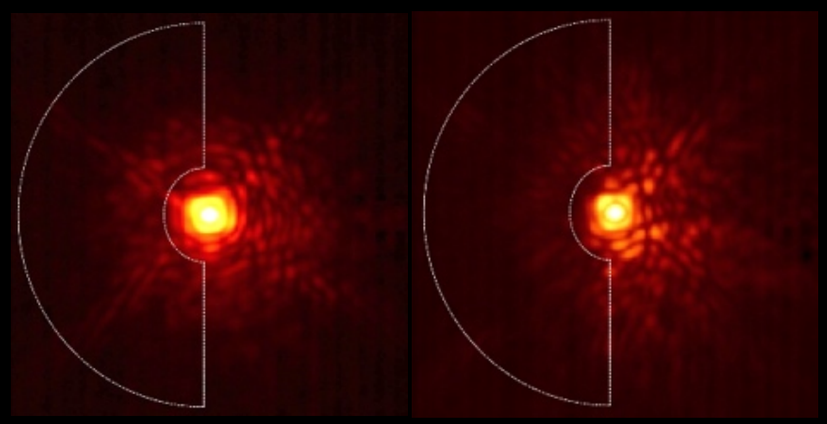


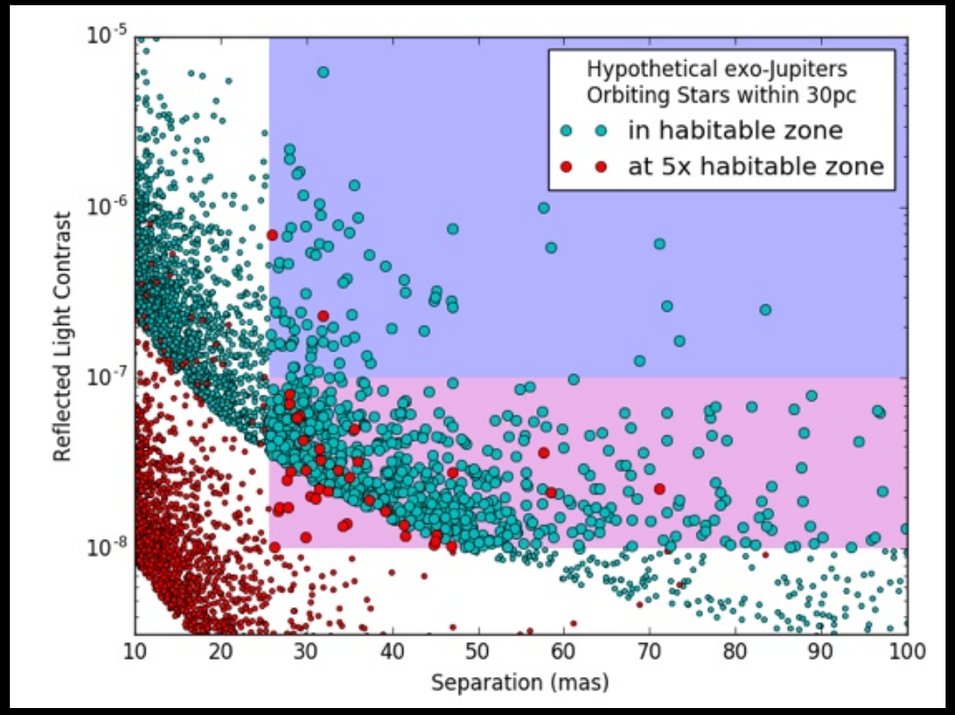
- Funded by JSPS Grant-in-Aid (PI: Guyon), being developed by UCSB (PI: B. Mazin).



- Specification:
  - 140 x 146 MKID array, covering 1".4x1".46 FoV with 0."01/pixel
  - Wavelength coverage: 800-1400nm
  - Spectral resolutin~ 10
  - Total throughput (fore-optics+detector) ~ 10-20%

- Active speckle control utilizing unique fat and monochromatic detector.



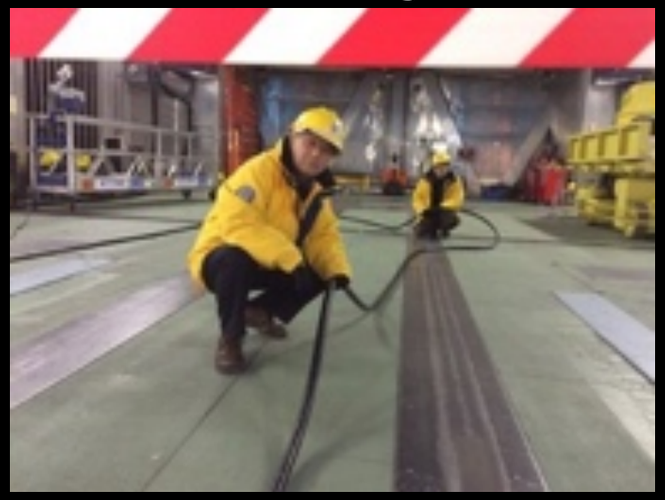


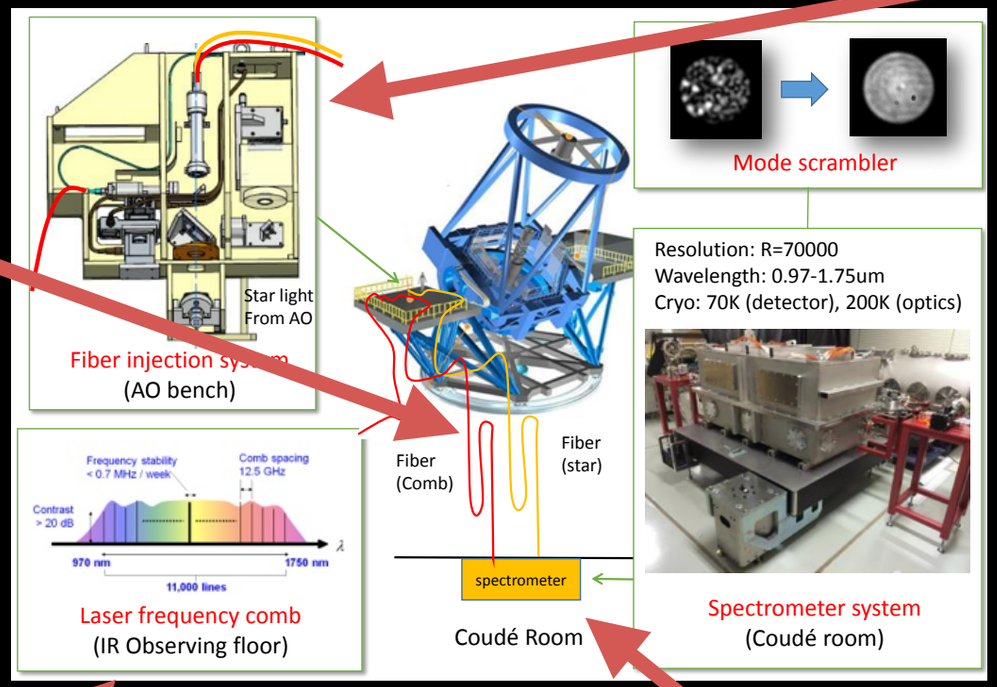
Carry-in proposal has been received from UCSB.
Review process is on-going.

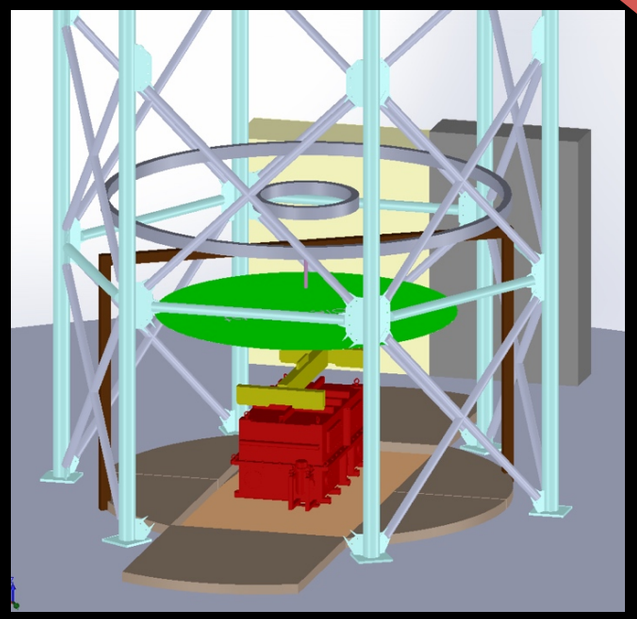
IRD

PI: Motohide Tamura (Univ. of Tokyo)

- Detect Earth-mass planets around late M-type stars with ~1m/s RV resolution
- NIR (YJH, 1-1.8μm) echelle spectrograph with laser frequency comb
- Spectral resolution: R~70,000
- Commissioning will start from S17A
- SSP survey with 120 nights from S18A is being planned.







SWIMS/MIMIZUKU

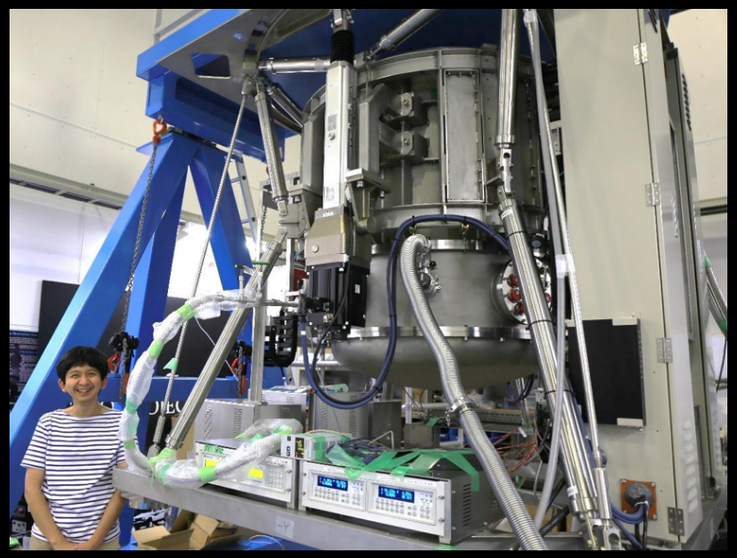
TAO 6.5m telescope's facility instruments.

- Provide opportunities for initial instrument test
- Promote instrument development activity at Japanese community

SWIMS – NIR wide field multi-color imager and MOS muti-color

(PI: K. Motohara at Univ. of Tokyo)

- 3'.3 x 6'.6 FOV at Subaru
- Simultaneous two-band imaging at NIR (zJ and HK)
- Wider spectral coverage than MOIRCS
- Proposed to ship the instrument to Subaru on July.
- Proposed First light wll be at the end of 2016.



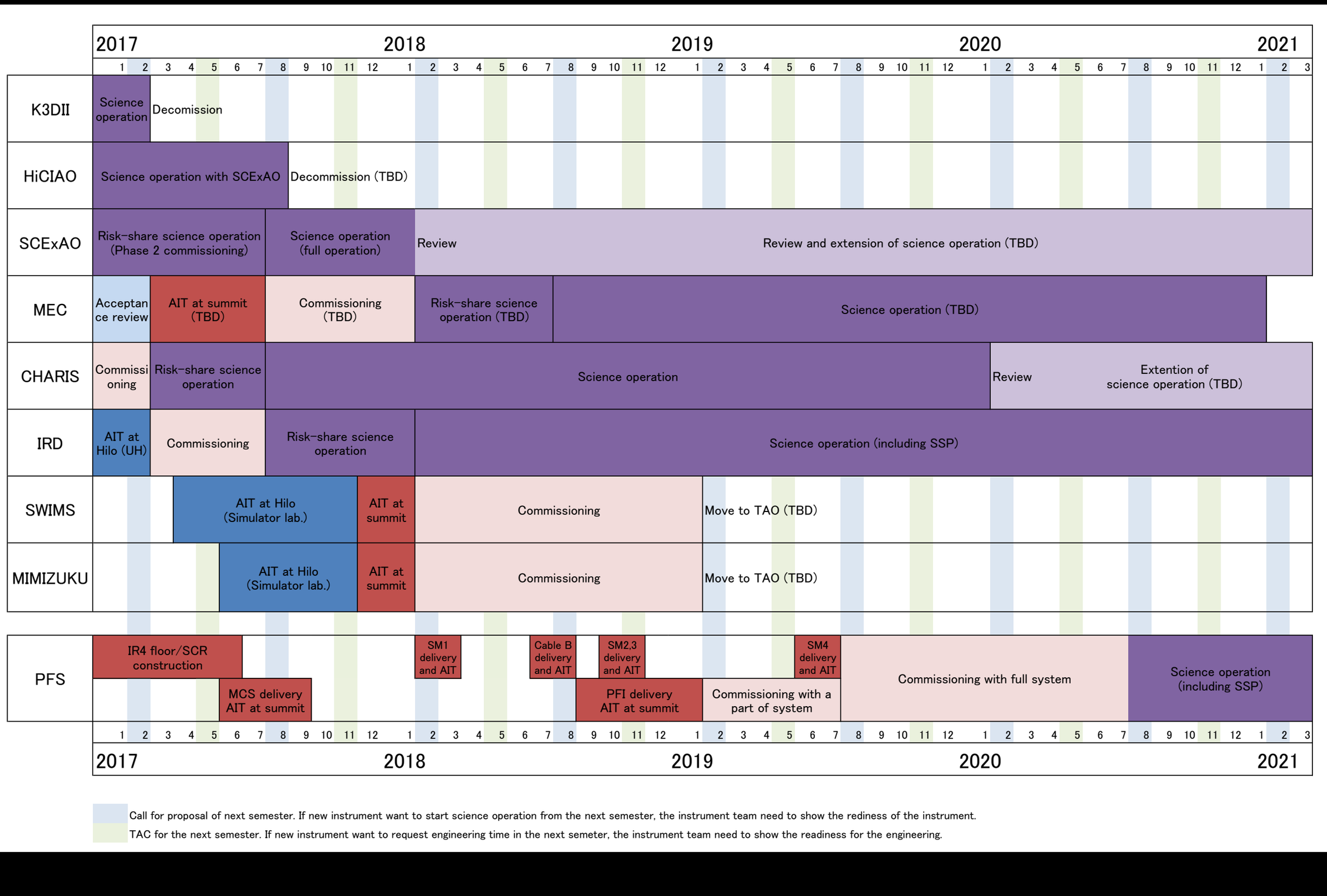
MIMIZUKU – MIR multi-filed imager and spectrograph

(PI: T. Miyata at Univ. of Tokyo)

- Wider wavelength coverage than COMICS: 2-26 micron
- Field stacker enables precise photometry in mid-infrared by simultaneously observing science and reference objects in the discrete two fields

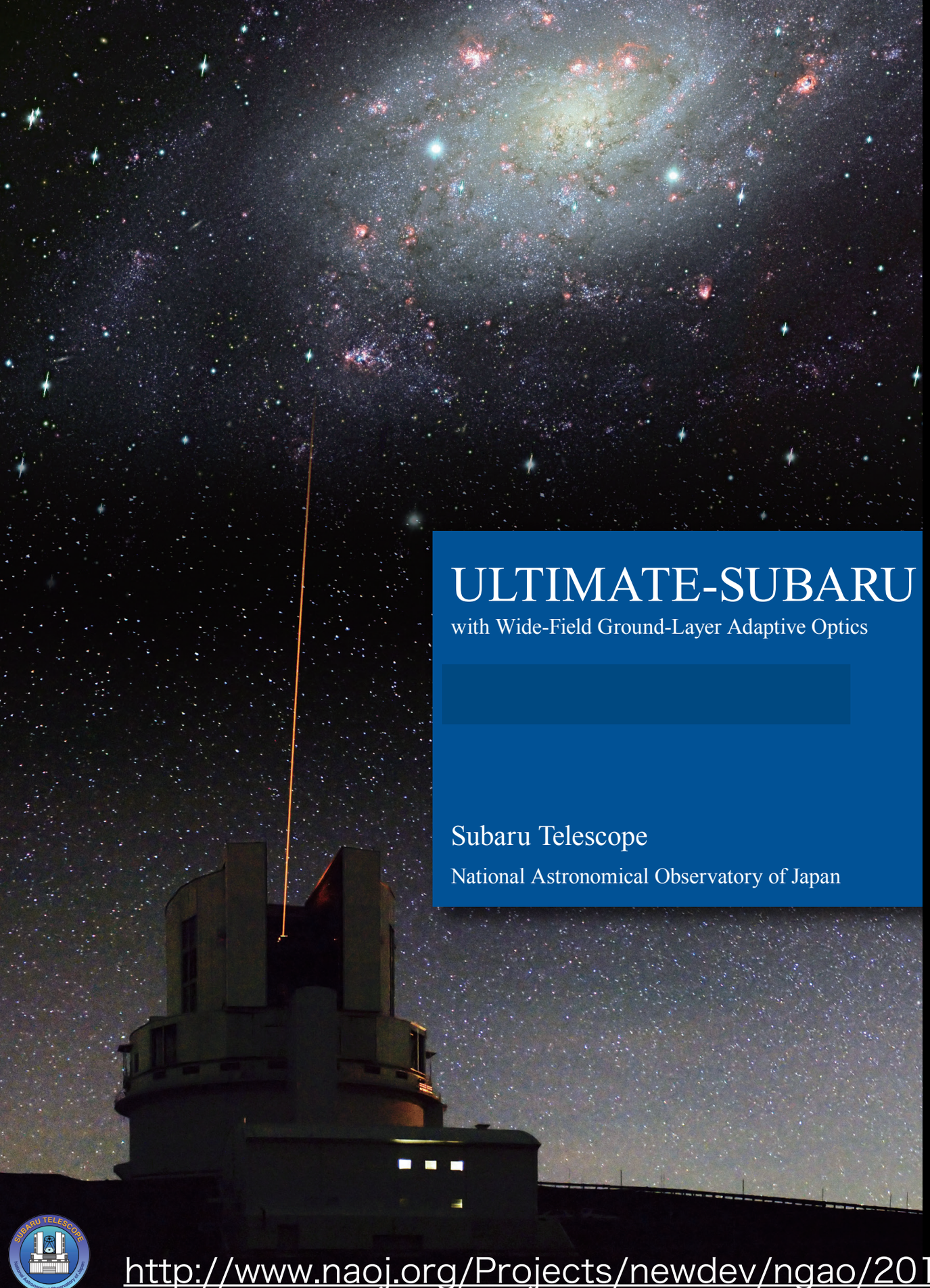
- Accepted instruments carry-in only for commissioning at 2017-2018
- No science operation is planned

New Instruments activities toward 2020



Call for proposal of next semester. If new instrument want to start science operation from the next semester, the instrument team need to show the rediness of the instrument.

TAC for the next semester. If new instrument want to request engineering time in the next semeter, the instrument team need to show the readiness for the engineering.



ULTIMATE-Subaru

Study Report 2016

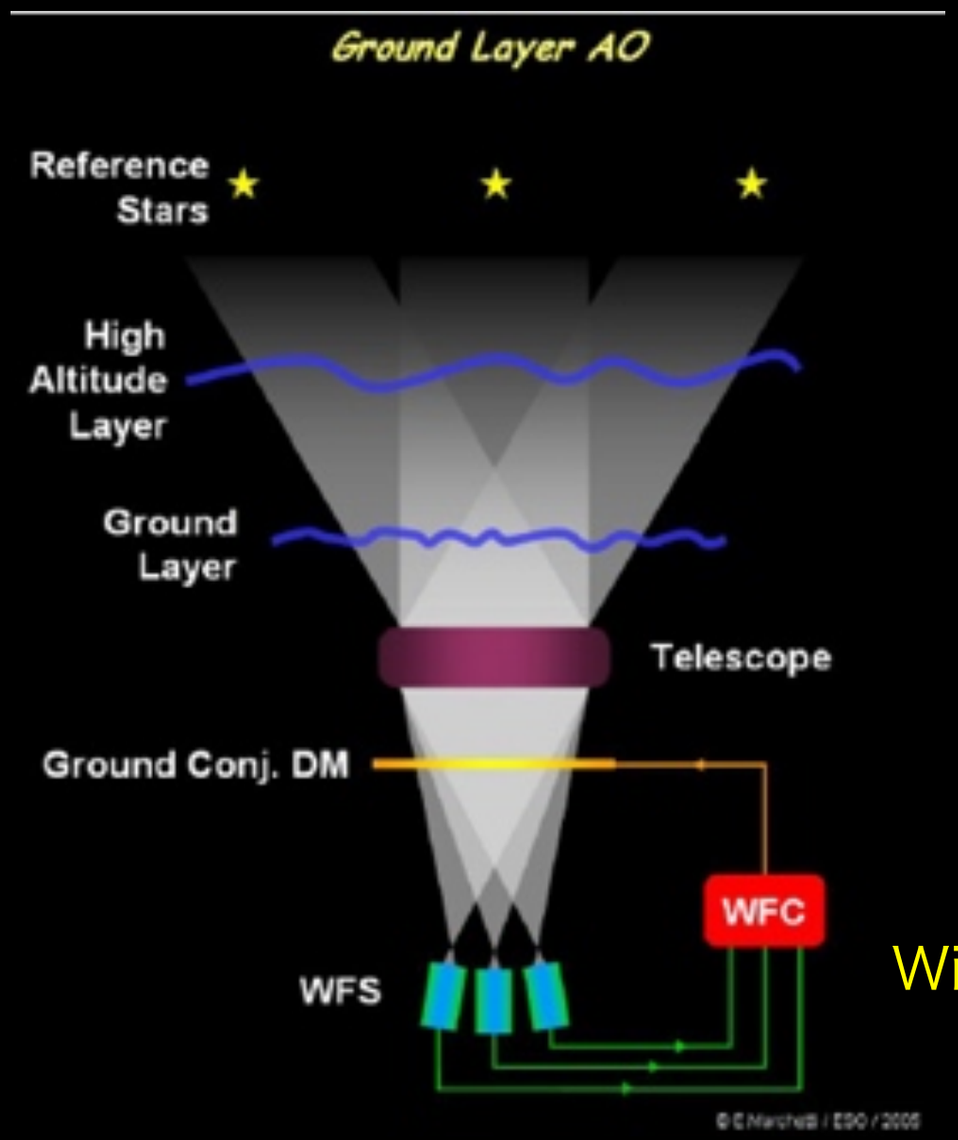
- Science Case
  - High-z galaxies **(Key Science)**
  - Low-z galaxies
  - Galactic
- Adaptive Optics
  - Performance modeling
  - System modeling
  - Interface with telescope
- Instruments
  - Wide-Field imager
  - Multi-Object Slit spectrograph
  - Multi-Object IFU spectrograph
- Development Plan
  - Team organization
  - Budget
  - Timeline

http://www.naoj.org/Projects/newdev/ngao/20160113/ULTIMATE-SUBARU_SR20160113.pdf

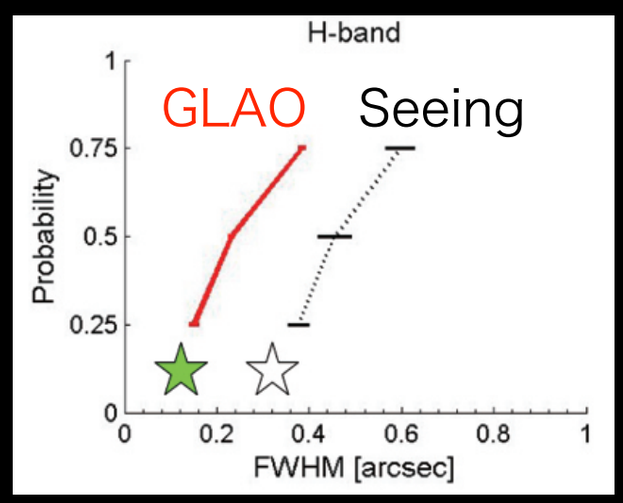
Subaru's Next Facility Instrument Plan

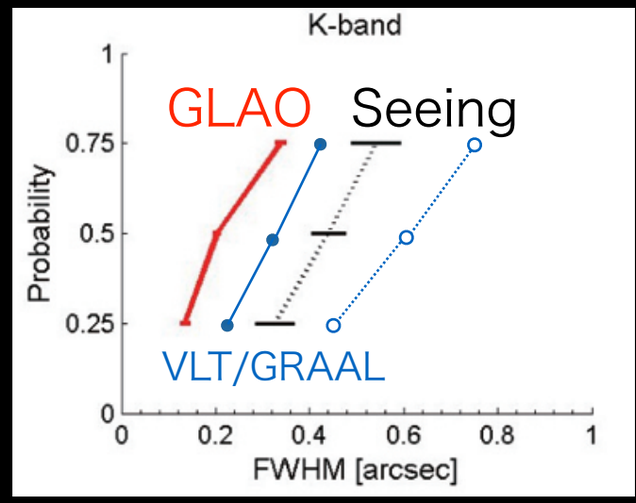
ULTIMATE-Subaru

Ground-Layer Adaptive Optics
x
Wide-Field near-infrared instrument



GLAO performance simulation at Subaru





☆On-sky performance verification with RAVEN

(Oya et al. 2014)

- Uniform seeing improvement over ~20 arcmin FoV
- FWHM < 0".2 at K-band

Wider FoV and better image quality than VLT GLAO

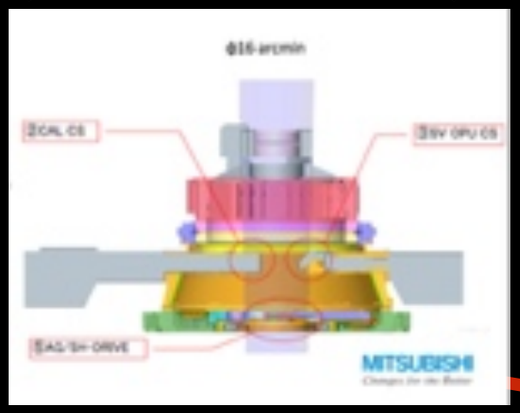
(Seeing 0".6 —> GLAO 0".32 at K, FoV~7'.5)

ULTIMATE-Subaru: System Overview

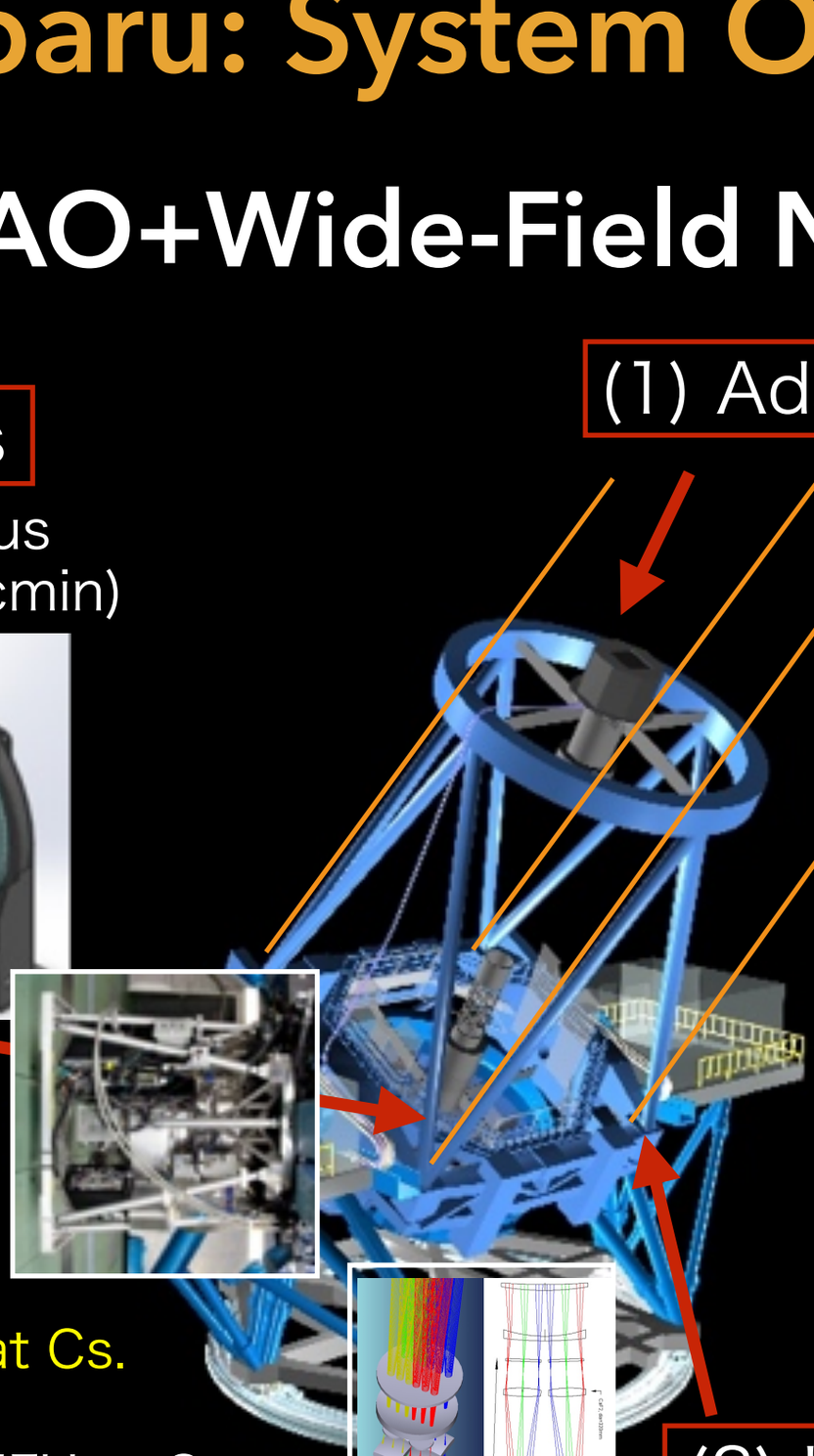
Ground-Layer AO+Wide-Field NIR instruments

(3) Wavefront Sensors

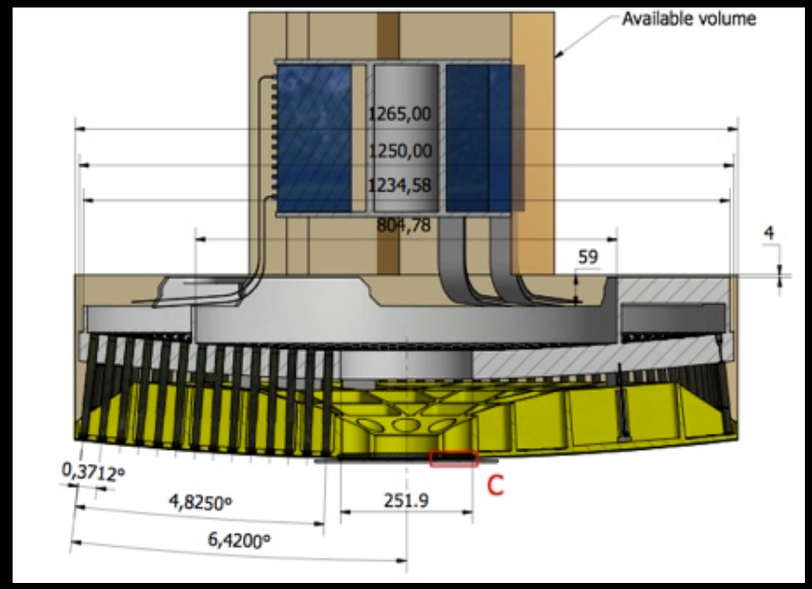
Cs. Focus
(FoV~20 arcmin)



Ns. Focus
(FoV~6 arcmin)



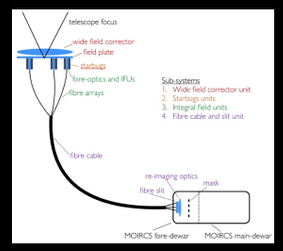
(1) Adaptive Secondary Mirror

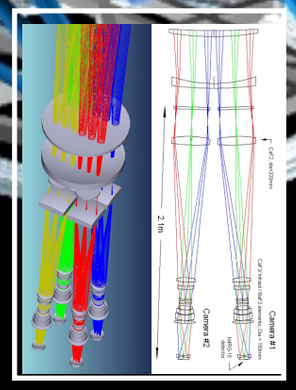


Preliminary Subaru ASM
design by Microgate ADS

(4) Wide-field NIR instruments

- New wide-field imager (WFI) at Cs.
- Reuse MOIRCS at Ns. IR
- (Optional) Fiber-bundle multi-IFU at Cs. proposed by AAO, Australia



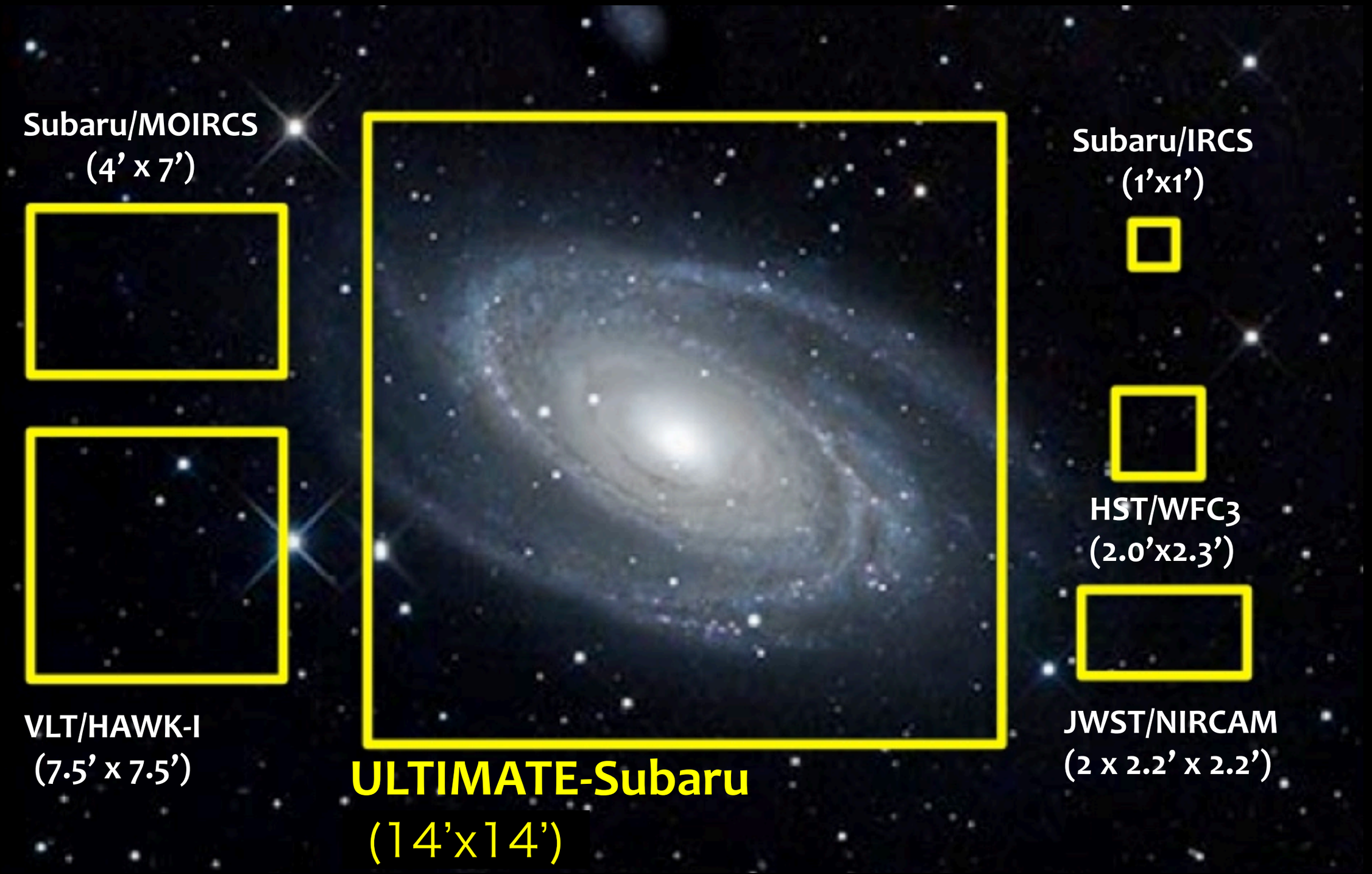


(2) Laser Guide Star system

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

ULTIMATE-WFI: Uniqueness

Widest FoV among NIR facilities in 2020s available at λ>2.0μm

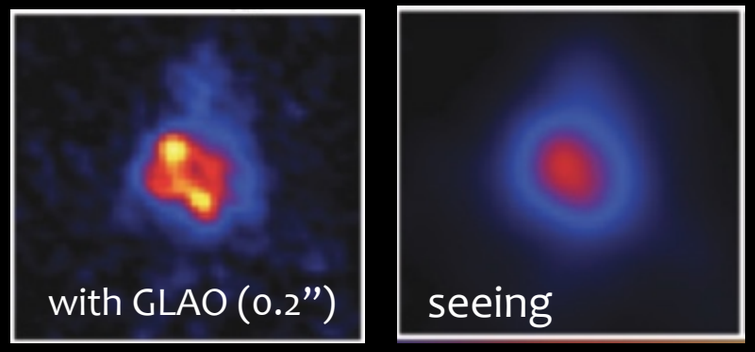


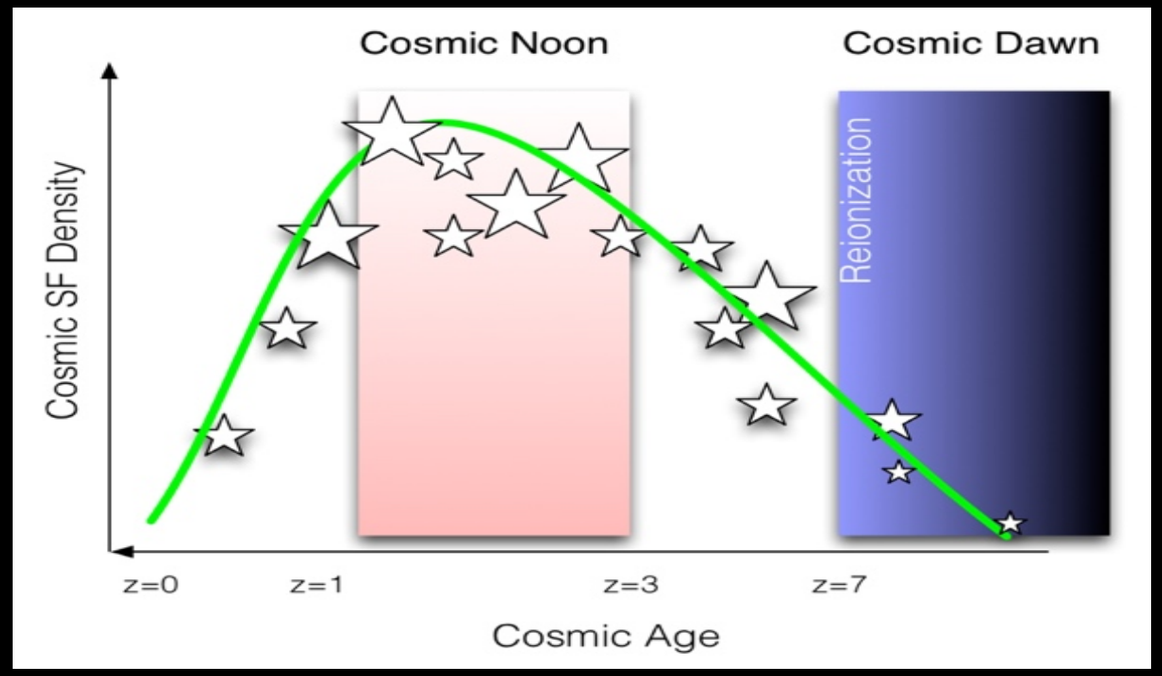
ULTIMATE-WFI: Key Science Case

Wide-field, high-resolution narrow-band imaging survey

(1) Complete census of galaxy evolution

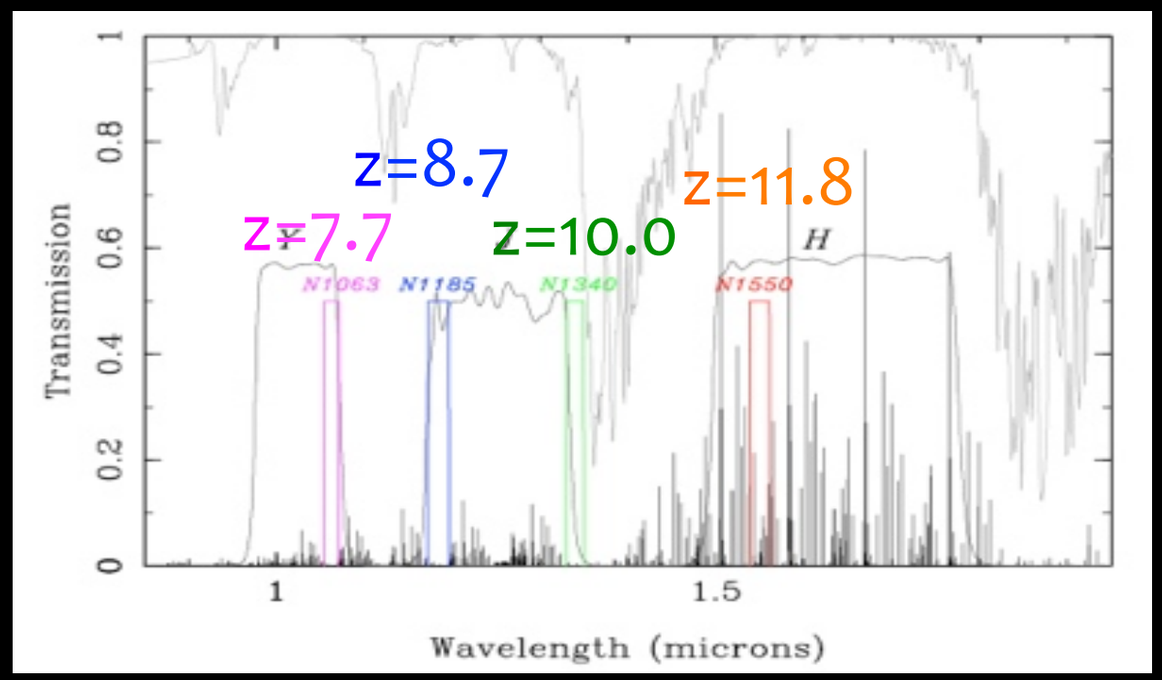
- Hα/[OIII] emission line survey at z=2-3 down to 10^9 M_{sun} in stellar mass.
- MB imaging survey for galaxies at z>5
- Stellar build-up history
- Quenching mechanism
- Mass and environmental dependency





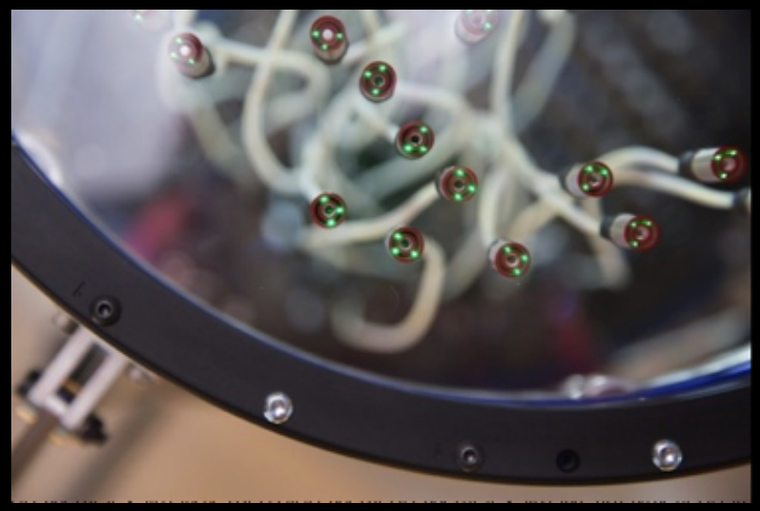
(2) Exploring very high-z galaxies

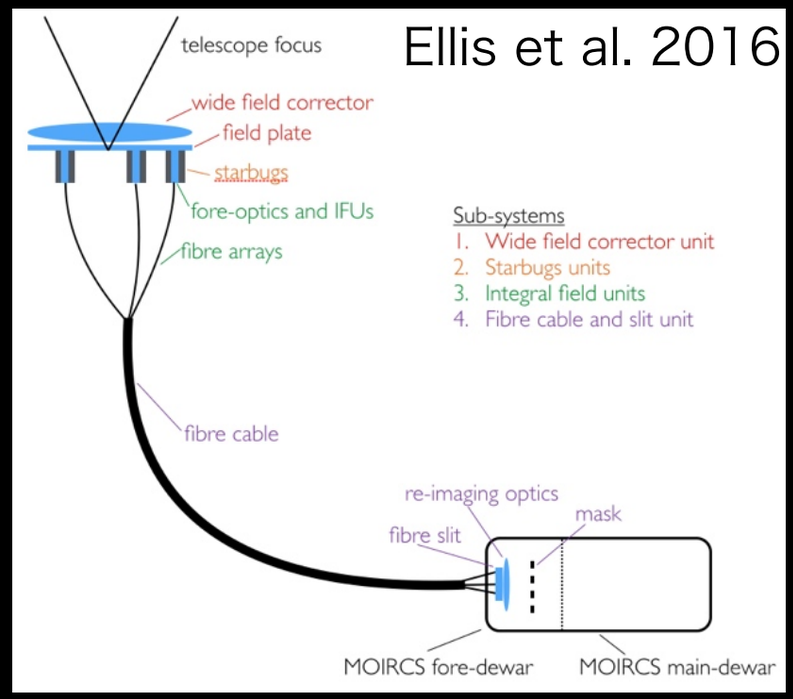
- Lyα emission line survey at z=8, 9, 10…
- History of cosmic re-ionization
- Sensitivity of ULTIMATE-WFI in J-band NB is comparable to the JWST NIRCAM NB imaging.



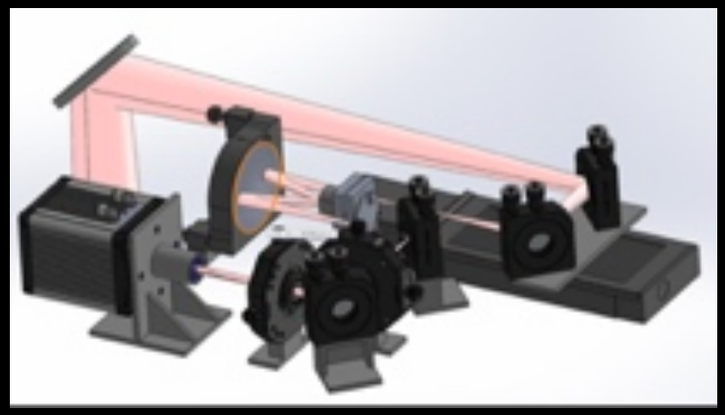
Japan-Australia collaboration on ULTIMATE

- AAO (A. Sheinis et al.) proposed Starbug based fiber bundle multi-object IFU system for ULTIMATE





- Subaru, Australia (F. Rigaut et al. from ANU), and Tohoku Univ. (Akiyama-san) are going to start collaboration on GLAO WFS and LGS system design and feasibility study based on the small project agreement between Subaru and AAL.



WFS conceptual design

ULTIMATE-Subaru: Summary

- ULTIMATE-Subaru is a Subaru's next generation facility instrument plan after PFS.
- ULTIMATE-Subaru will develop a ground-layer AO system and wide-field near-infrared imager, which provide ~14x14 arcmin^2 FoV with 0".2 spatial resolution in K-band.
- Conceptual design of the GLAO and imager is ongoing in collaboration with Australia, will be reviewed at the end of 2017. Expected first light of GLAO is 2023.
- Multi-Object fiber-bundle IFU spectrograph (M-IFS) is being planned in collaboration with Australia. Instrument concept is designed by AAO.
- Not only high-z science, we are collecting various science cases such as local star-forming region, galactic archaeology, and near-by galaxies.
- Any kind of participation in the ULTIMATE-Subaru project, Science case, Instrument development, is very welcome.