Subaru instruments and capabilities

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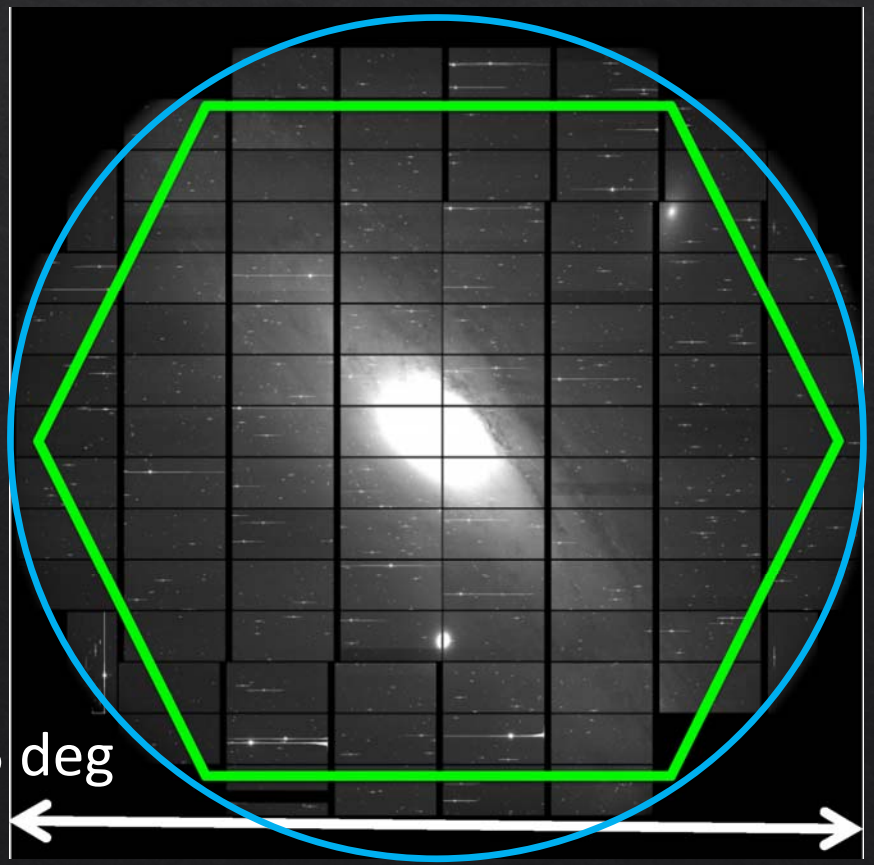
2. Instrument Plan
3. Instrument Line-up

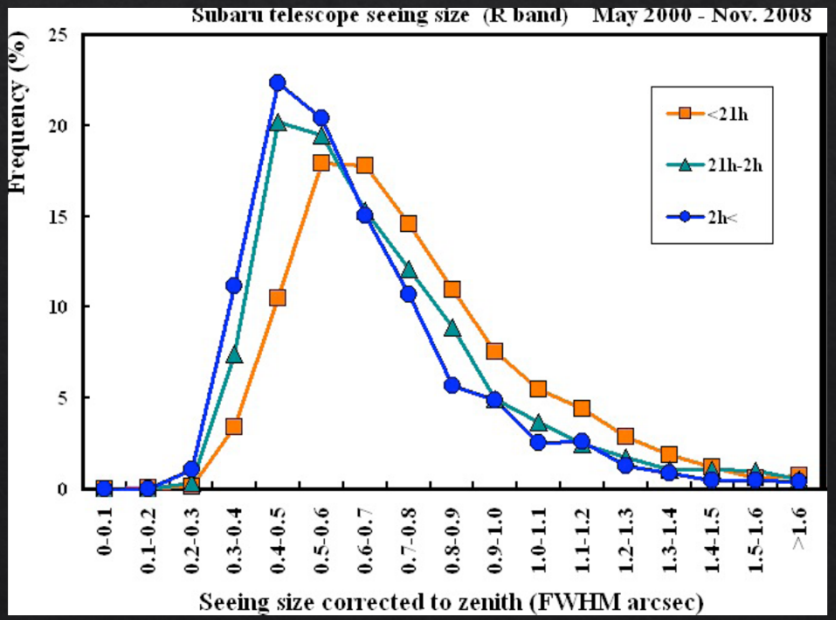
Subaru Telescope

- Large field of view with prime-focus instruments



Subaru Telescope

- Image quality
  - good seeing at Maunakea
  - active mirror support
  - enclosure designed for thermal control and smooth air flow

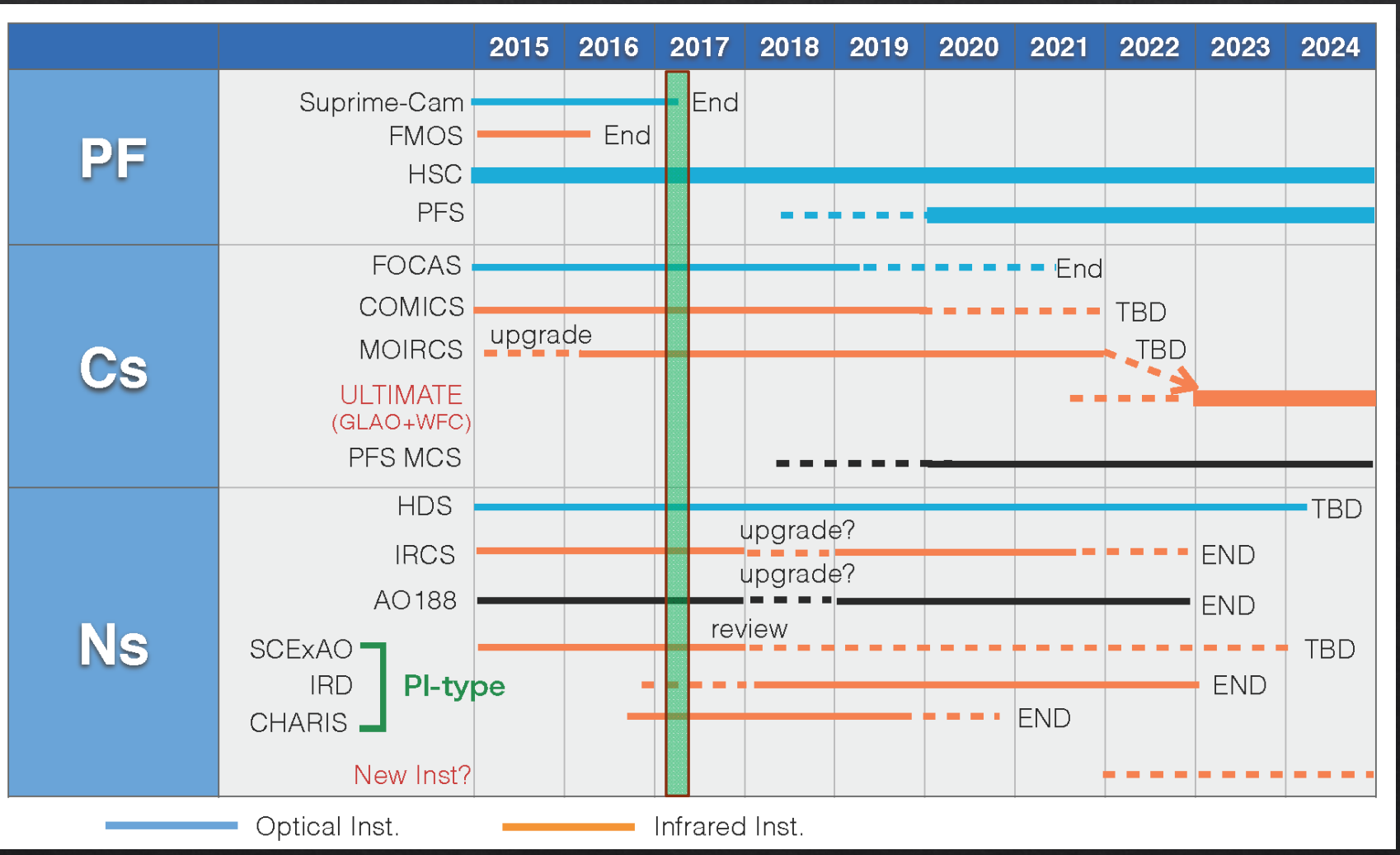


median = 0”.64

Subaru Telescope

- Dedicated support by experienced SAs
  - maybe my personal view
  - planning, observation, analysis
  - one primary SA for each instrument
  - it is recommended to contact the SA well before the observation and keep close communication

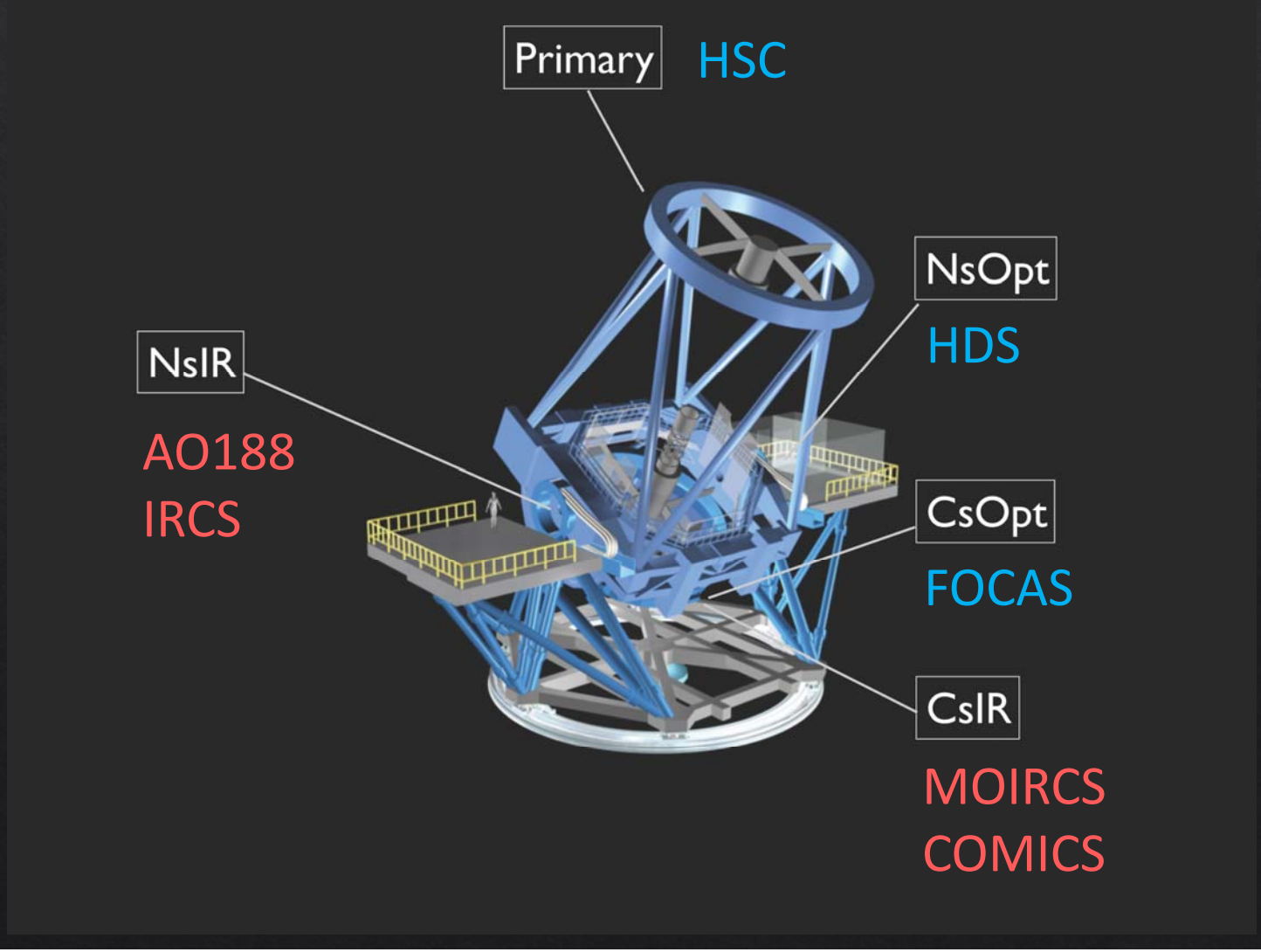
Instrument Plan



Koyama (Dec. 2016)

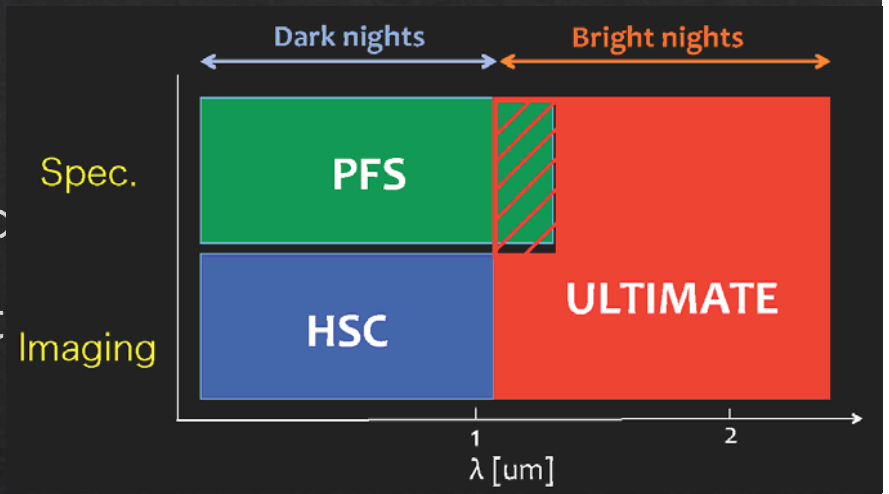
Instrument Plan

- facility instruments (current)



Instrument Plan

- facility instruments (in 2020s)
  1. Prime Focus : HSC, PFS
  2. Cs : ULTIMATE-Subaru
     - based on SAC recommenc
     - NIR wide-field instrument
  3. NsOpt : HDS?
     - based on discussions in “instrument planning task force” (2014)
     - very stable, low operation cost, unique performance, efficient publication record
  4. NsIR : platform for new instruments

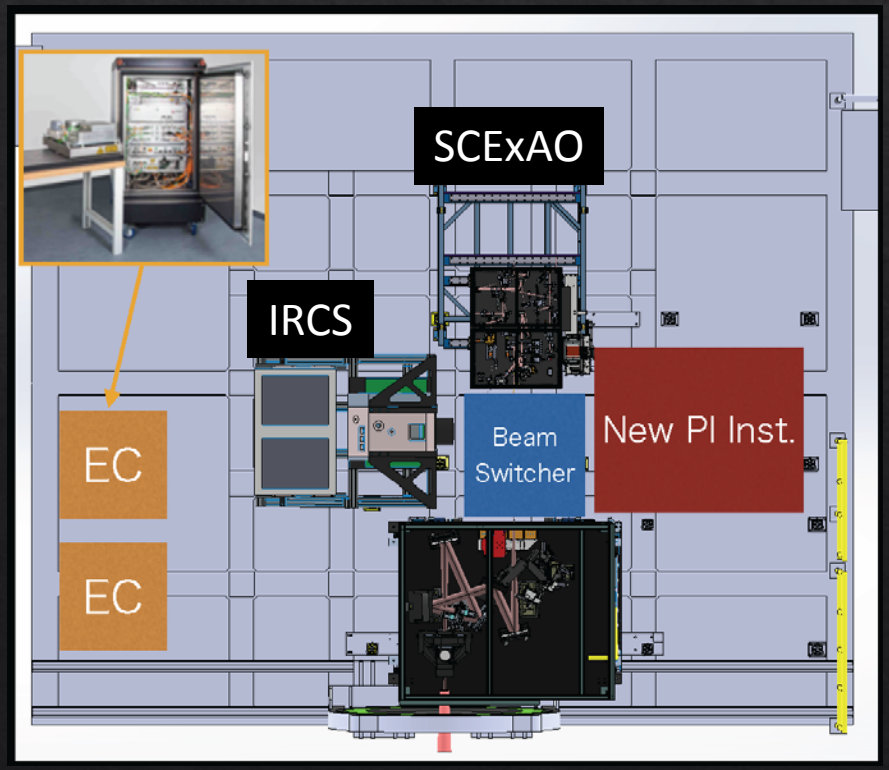


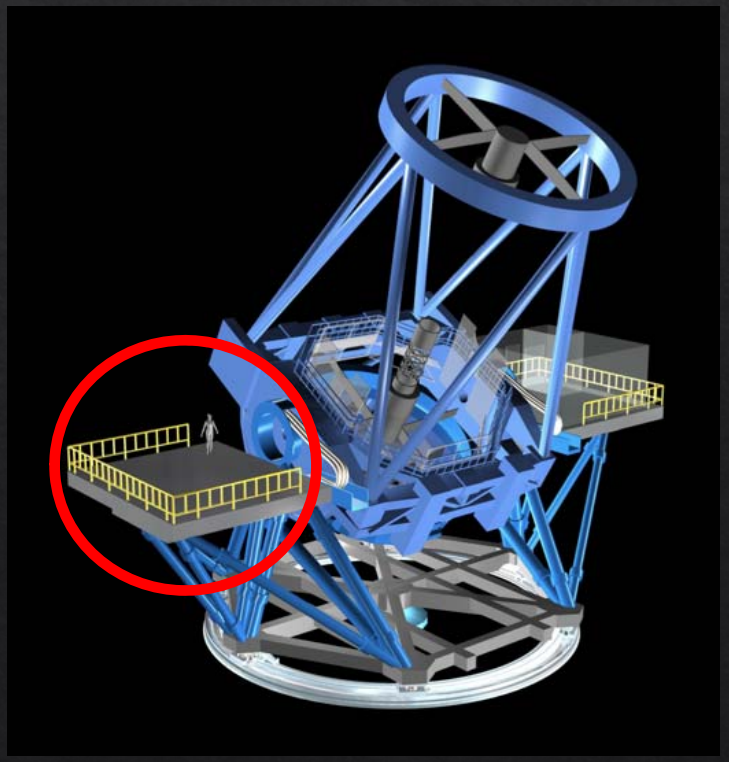
Instrument Plan

1. PI Instruments
   - Subaru encourages to carry in visitor instruments
   - variety of PI instruments in the past
   - current and planned instruments
     - NsIR : SCExAO, CHARIS, HiCIAO, MEC
     - Cassegrain : SWIMS, MIMIZUKU (only for engineering)
     - Coude : IRD
   - nominal operation period : 3 years

Instrument Plan

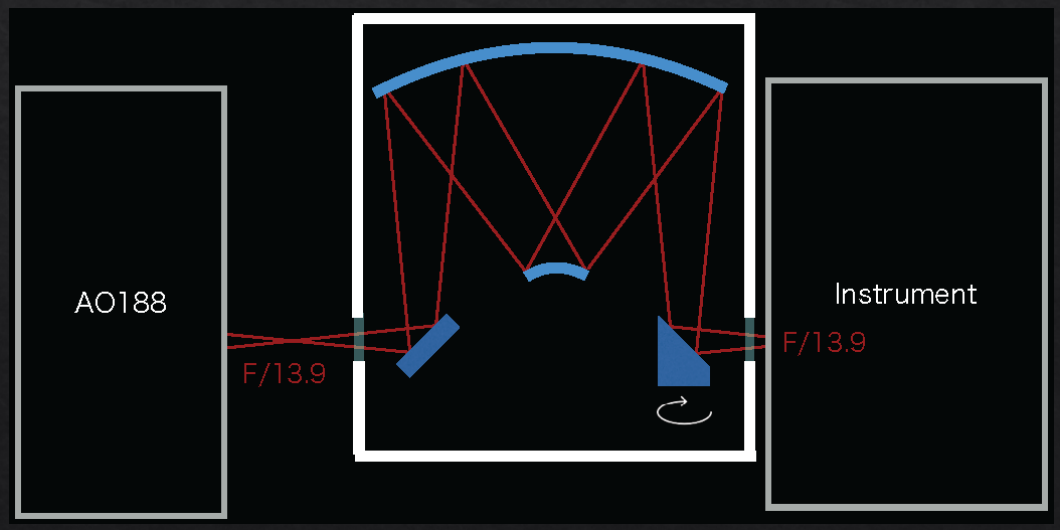
1. PI Instruments
   - NsIR as a platform for new instruments





Instrument Plan

1. PI Instruments
   - NsIR as a platform for new instruments
     - beam-switcher for instrument switching
     - with AO188 and upgraded LGS
     - with Adaptive Secondary

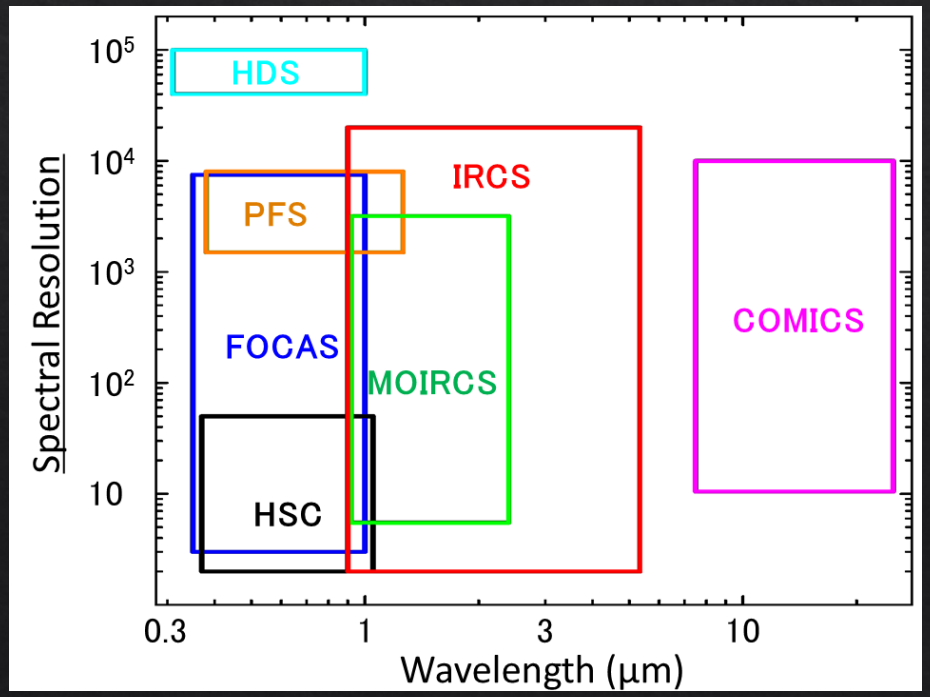


side-view

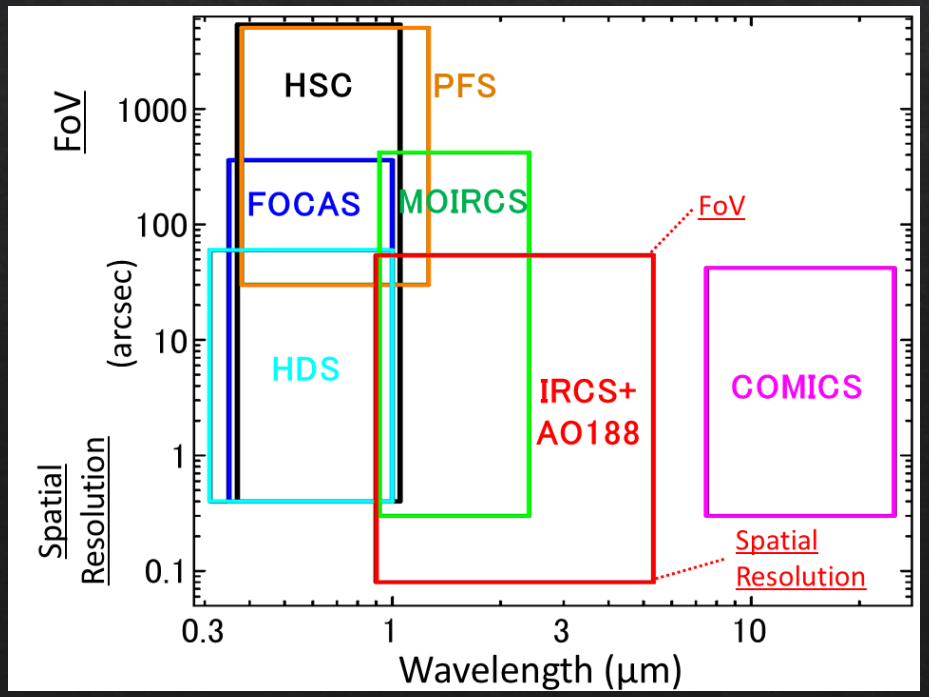
Instrument Line-up

- facility instruments

spectral-resolution

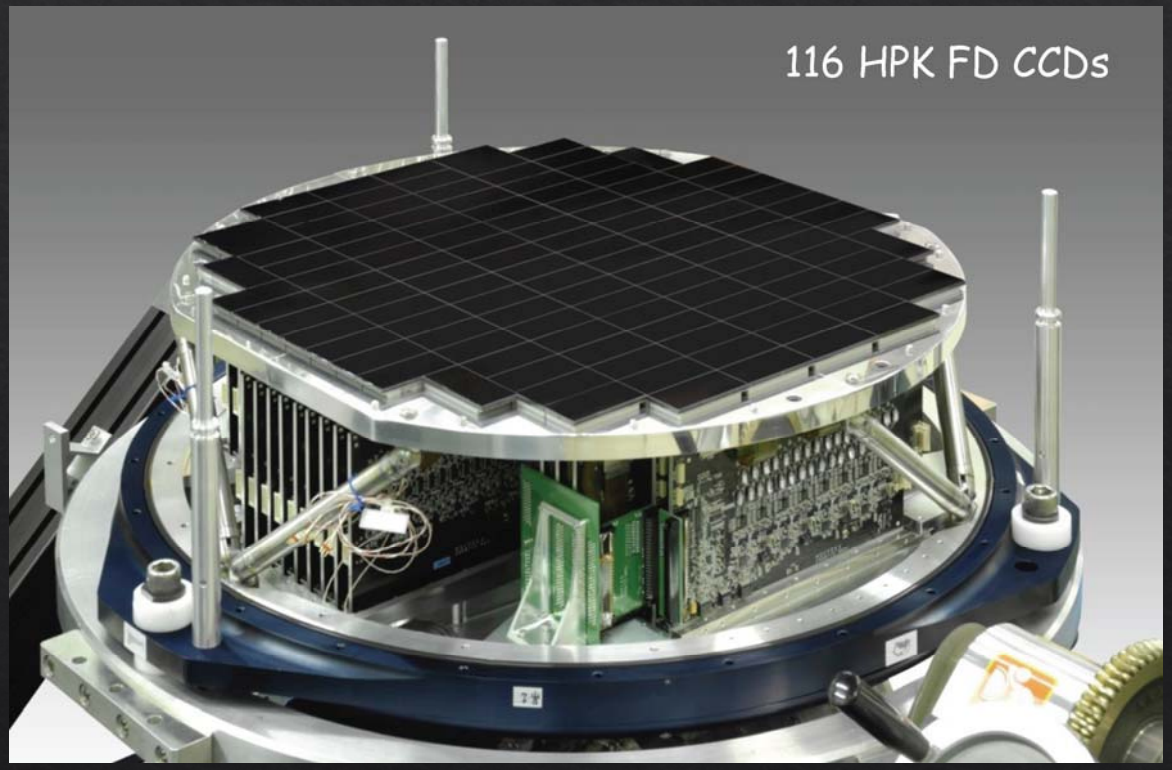


FoV/spatial-resolution



HSC (Hyper Suprime-Cam)

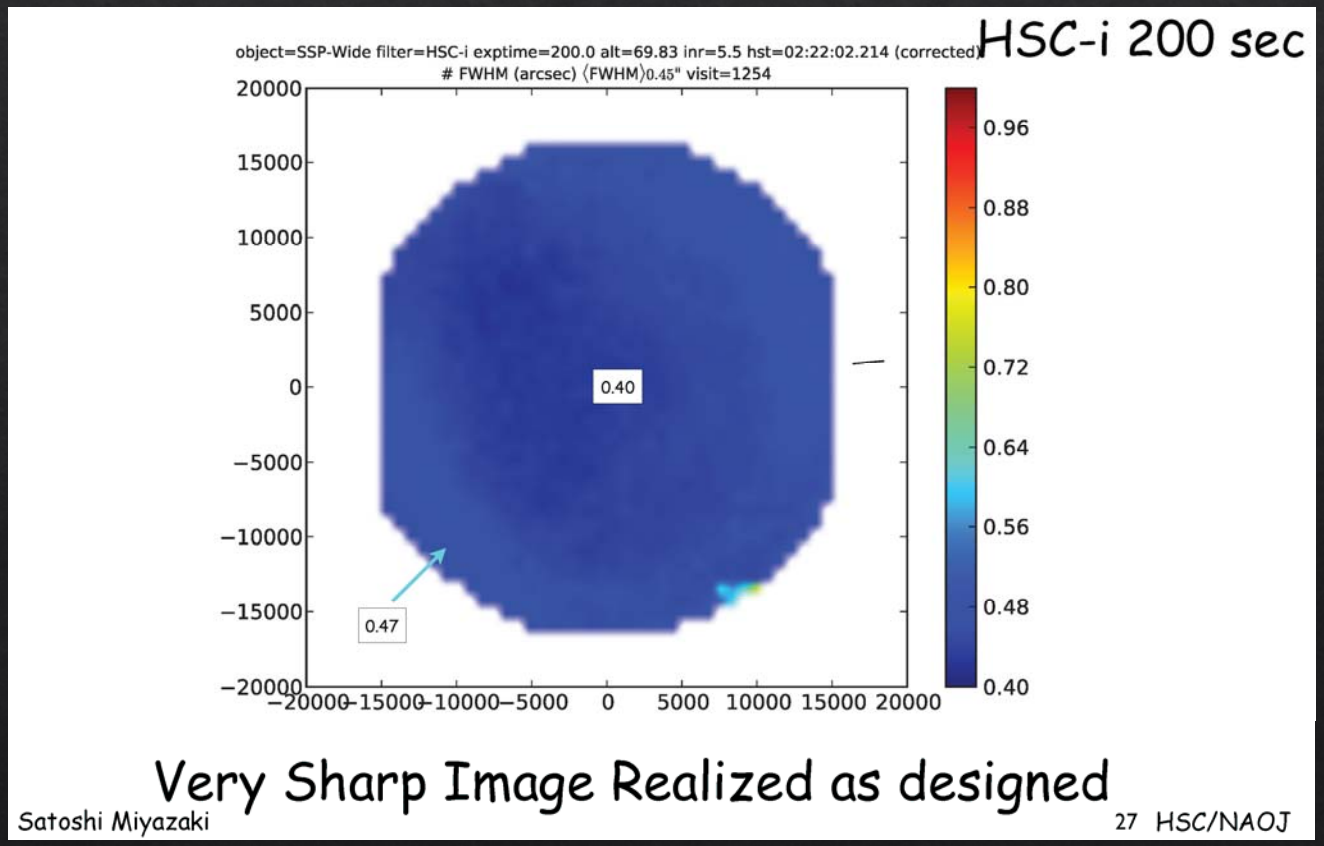
- wide field : ~1.5 deg. diameter



Slide by S. Miyazaki (2015)

HSC (Hyper Suprime-Cam)

- good and uniform image quality

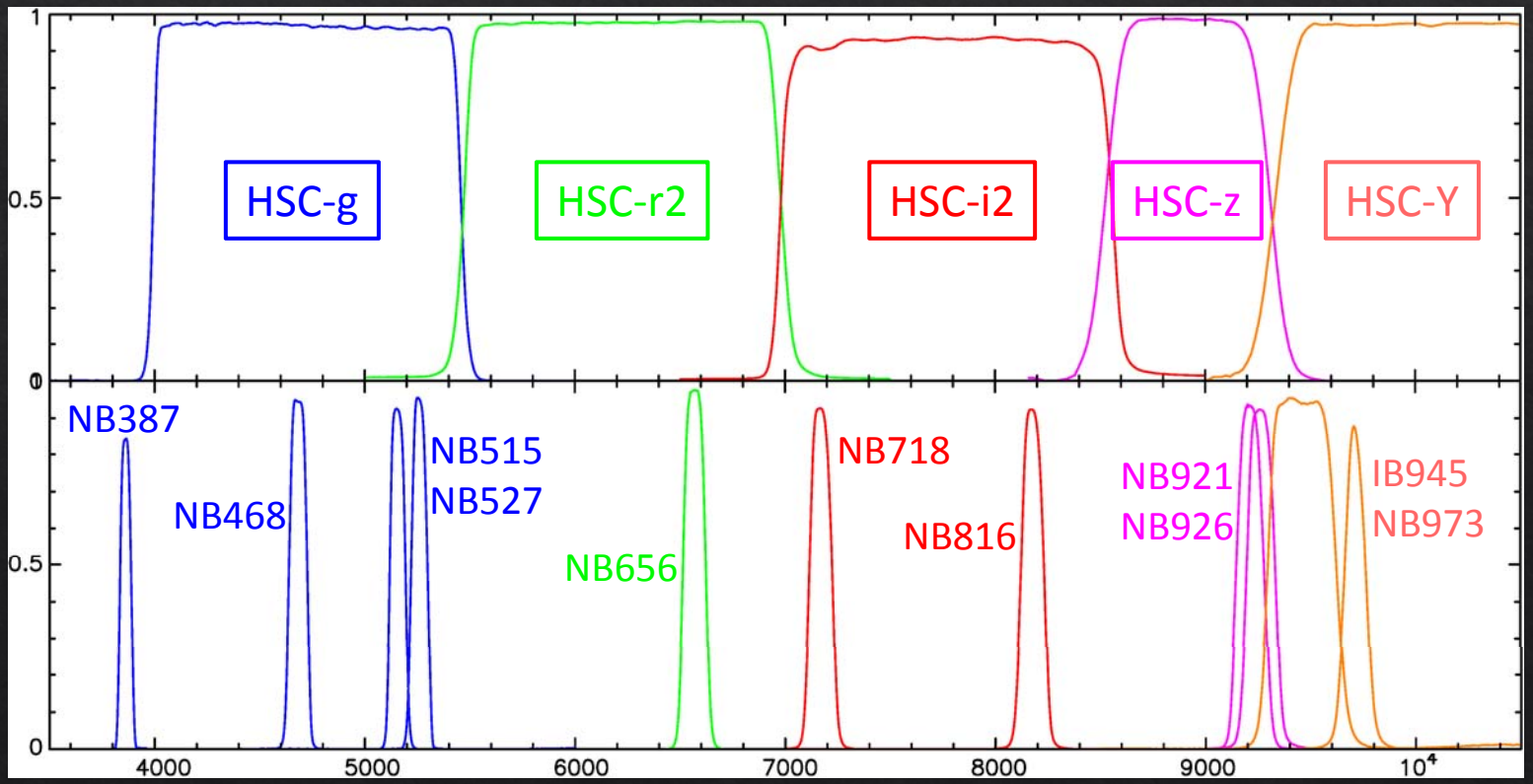


on-site analysis system

Slide by S. Miyazaki (2015)

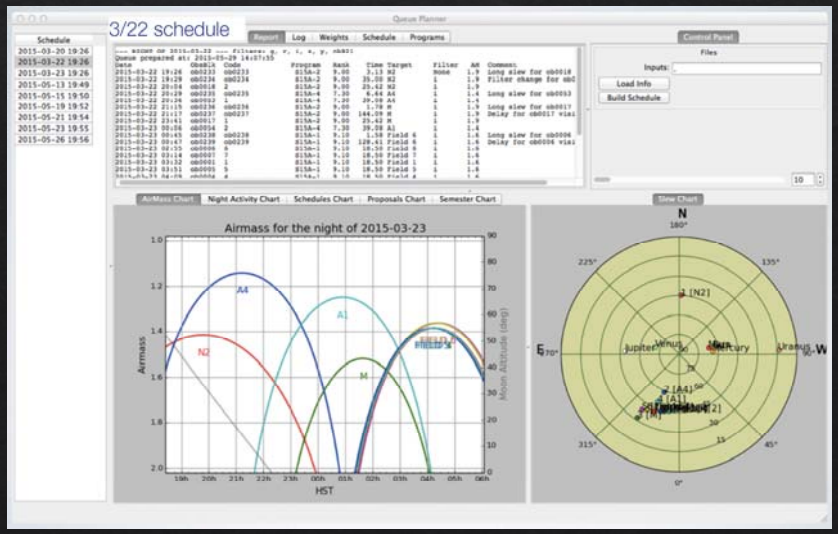
HSC (Hyper Suprime-Cam)

- variety of filters



HSC (Hyper Suprime-Cam)

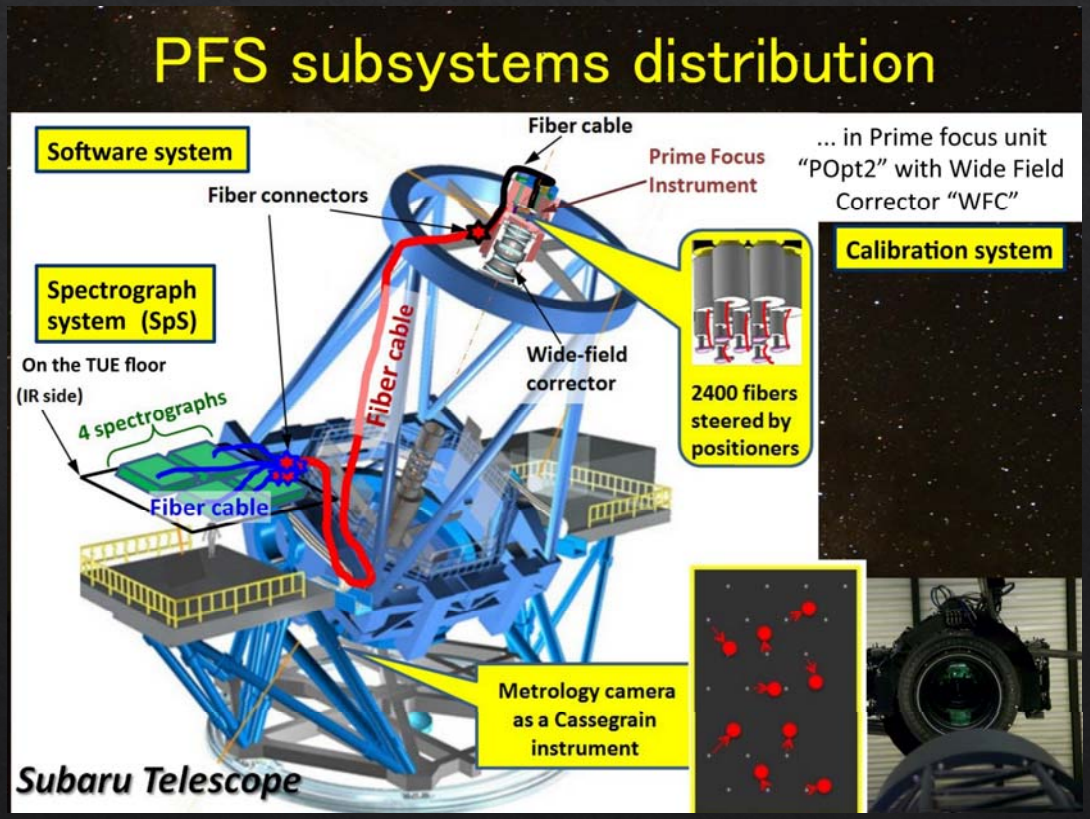
- queue mode observation
  - implementation plan
    - from 2016
    - ~50% in S17B, ~80% in S18AB
  - on-site analysis system
    - in a few minutes
    - seeing, transparency, etc.



Slide by Pyo and Yeh (2015, queue WS)

PFS (Prime Focus Spectrograph)

- delivery of subsystems starts 2017
- science operation is planned to start early 2020 (~3 years from now)



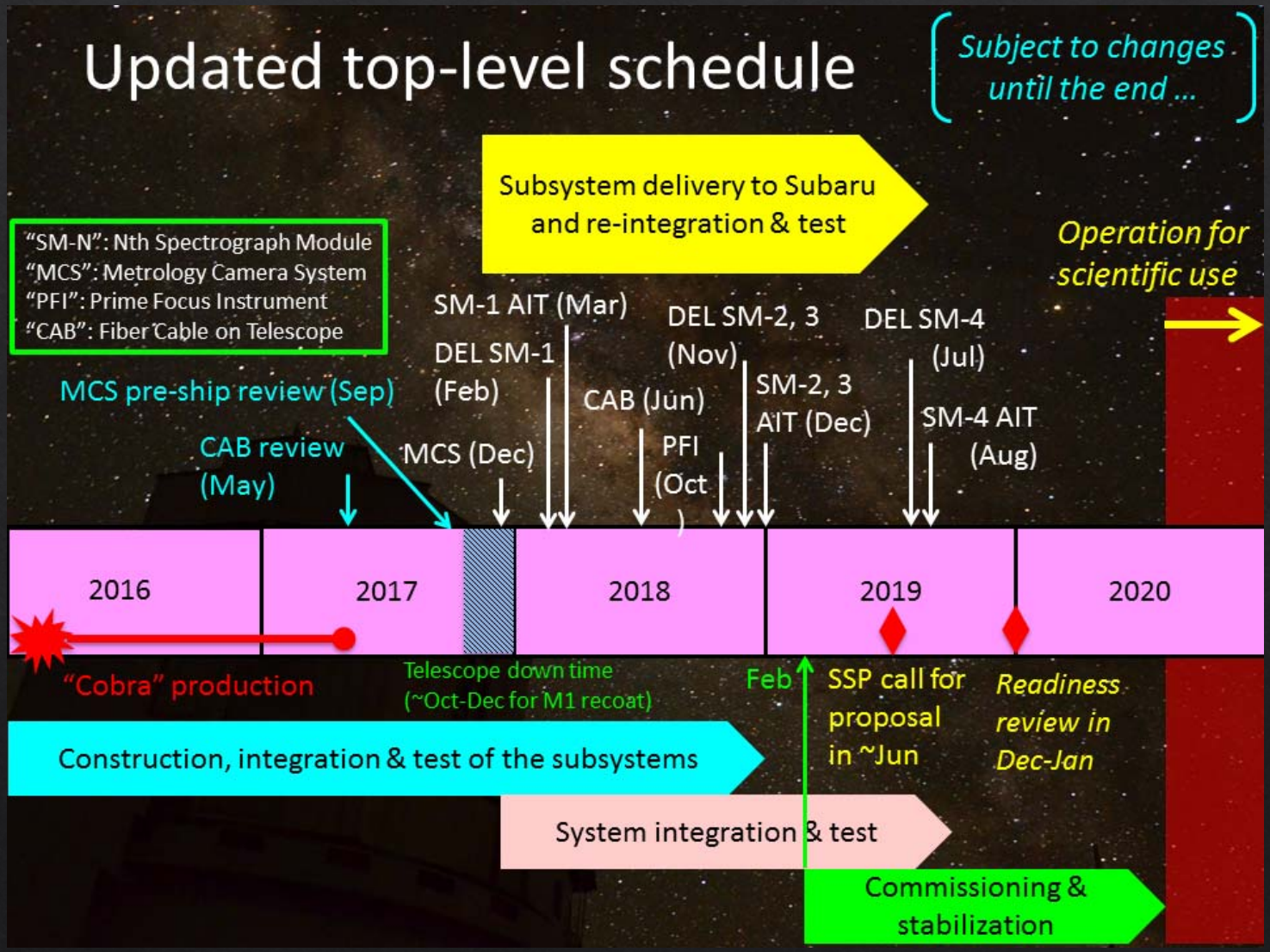
Slide by N. Tamura (2017, Subaru UM)

PFS (Prime Focus Spectrograph)

- wide field : **~1.4 deg. diameter**
- high multiplicity : **2394 fibers**
  - fiber diameter : ~1.05”
  - fiber positioner pitch : ~85”
  - minimum fiber separation : ~30”
- quick fiber reconfiguration : 60-120 sec (TBC)
- VIS-NIR coverage : **380-1260nm simultaneously**
  - low-resolution mode : ~2.5A resolution
  - medium-resolution mode (around ~800nm) : ~1.6A resolution

Slide by N. Tamura (2017, Subaru UM)

PFS (Prime Focus Spectrograph)



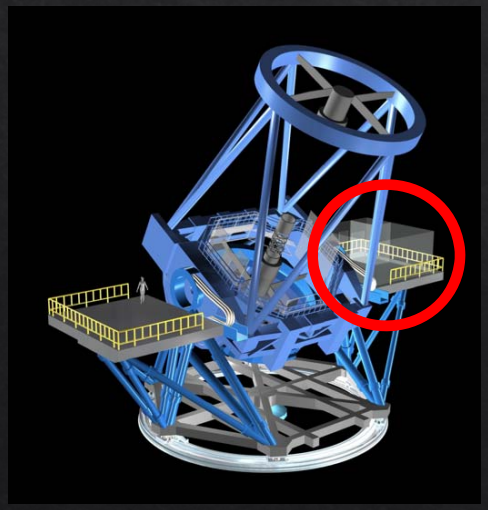
Slide by N. Tamura (2017)

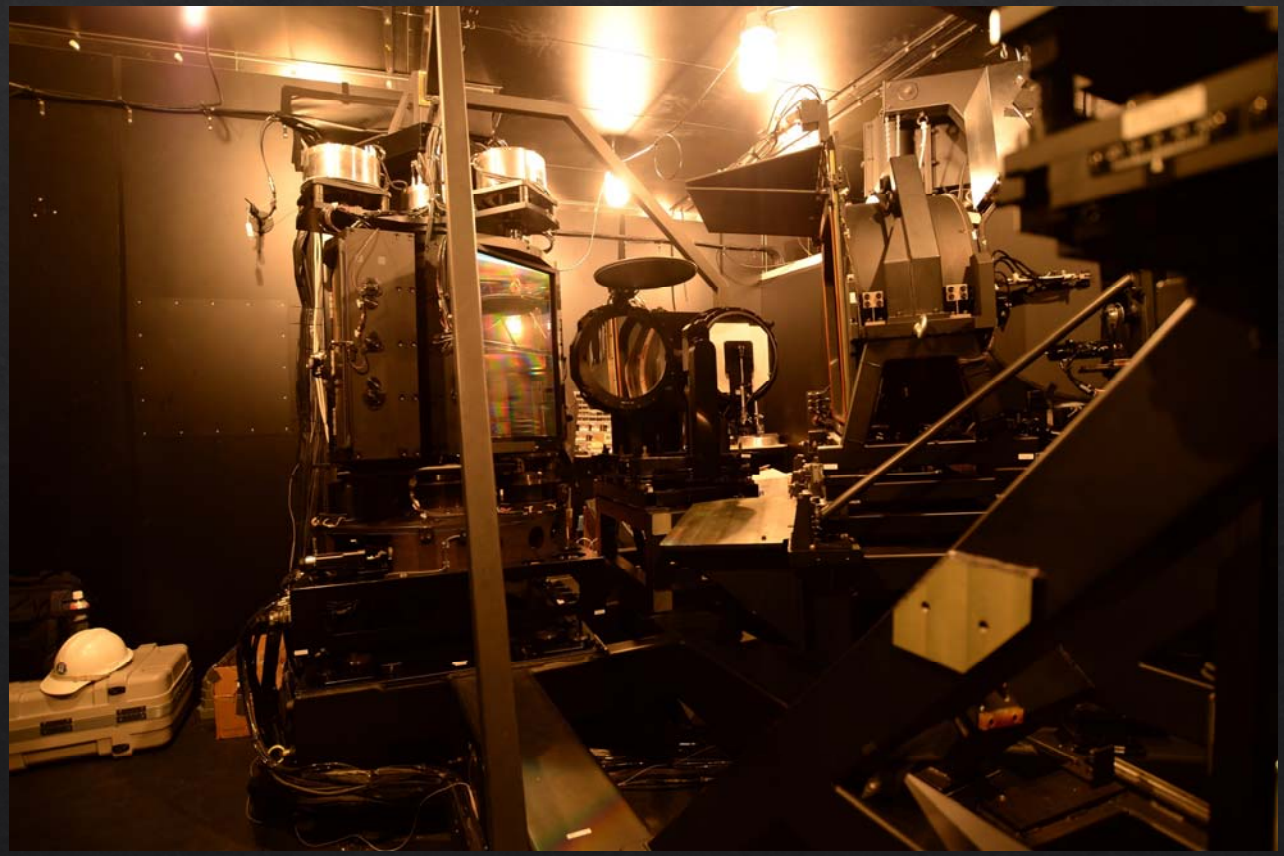
PFS (Prime Focus Spectrograph)

- open-use observation with PFS
  - still TBD
  - but queue-mode observation will be necessary for efficient use of the telescope time

HDS (High Dispersion Spectrograph)

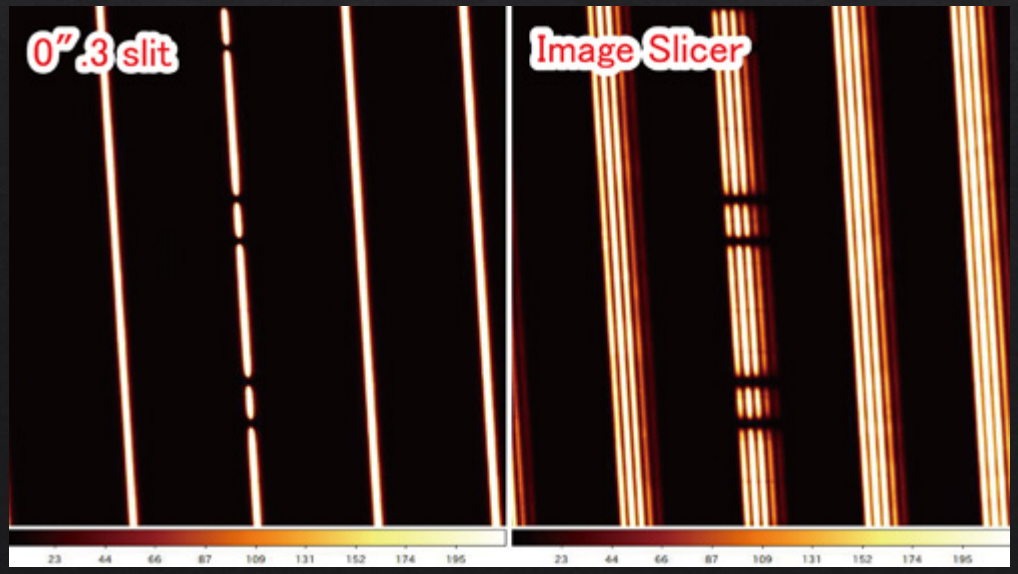
- optical high dispersion spectrograph

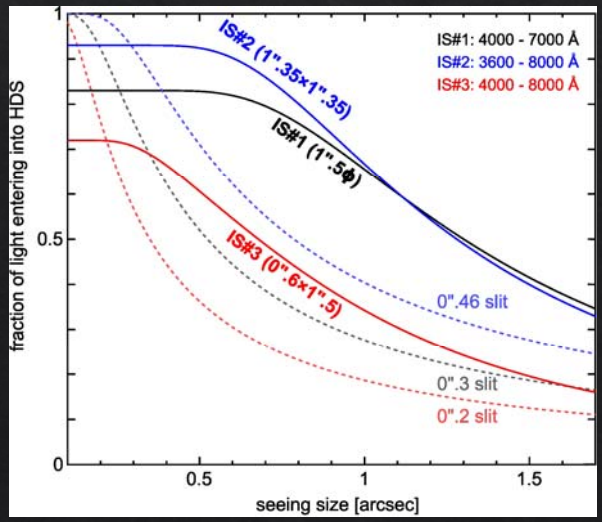




HDS (High Dispersion Spectrograph)

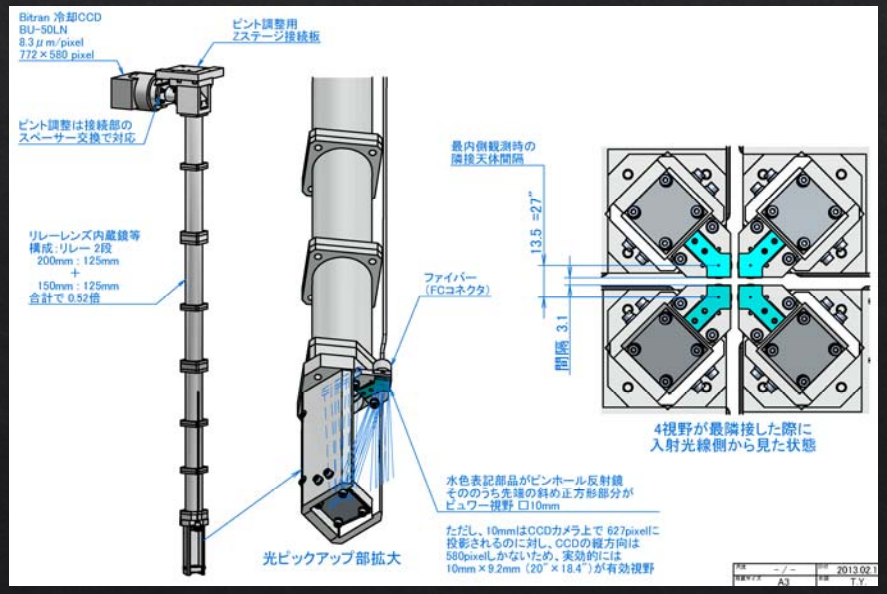
- high spectral resolution
  - up to R=165,000
  - variety of image slicers (better efficiency at high spectral resolution)

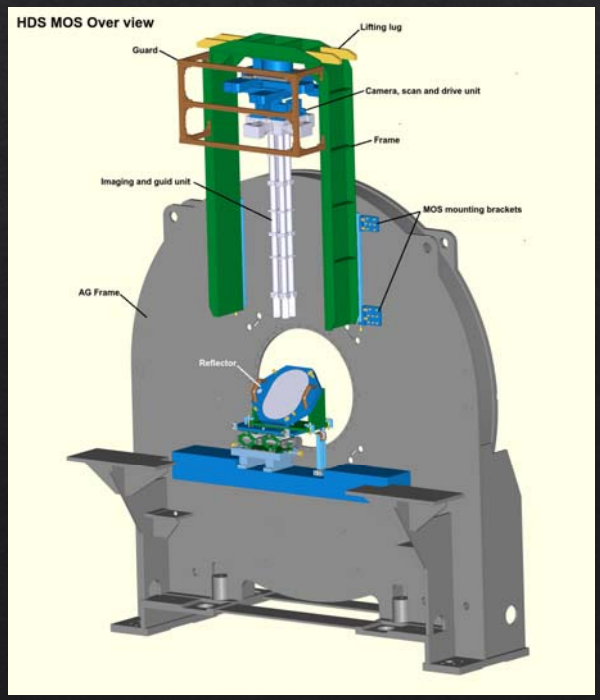




HDS (High Dispersion Spectrograph)

- high efficiency at blue side (down to ~3000A)
- I2-cell for radial velocity measurement (a few m/s)
- fiber-MOS unit in near future





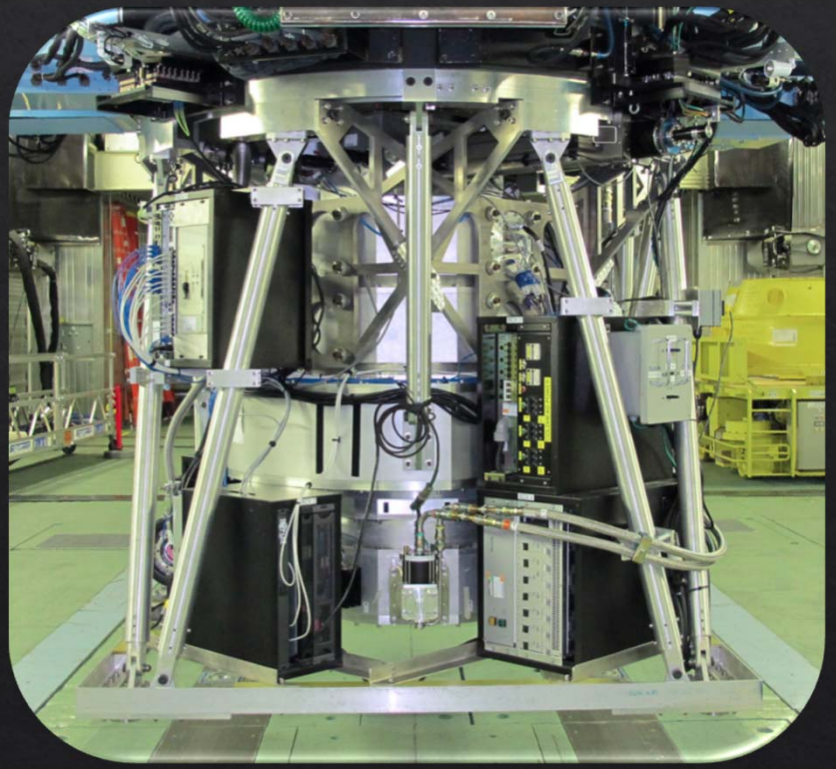
OptCraft (2013)

MOIRCS

(Multi-Object Infrared Camera and Spectrograph)

- wide-field NIR imaging and multi-object spectroscopy
  - FoV 4'x7'
  - R=500-3000
  - good image quality

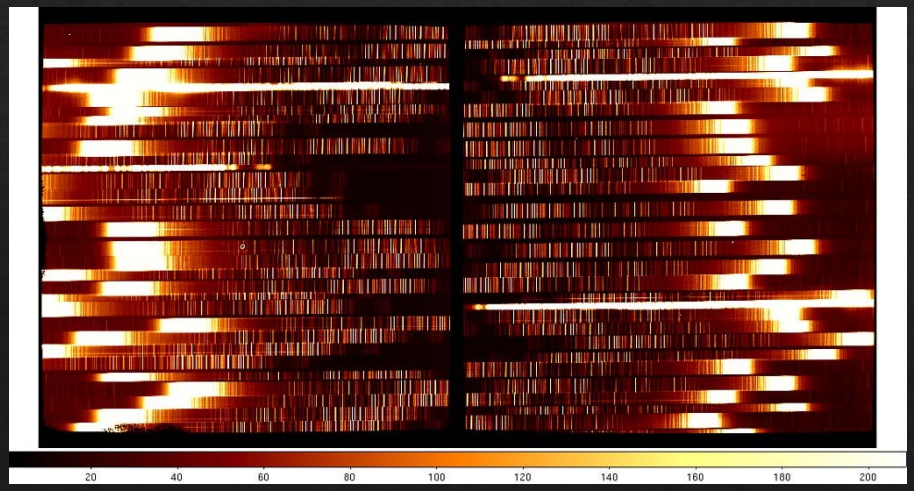
FWHM=0".18

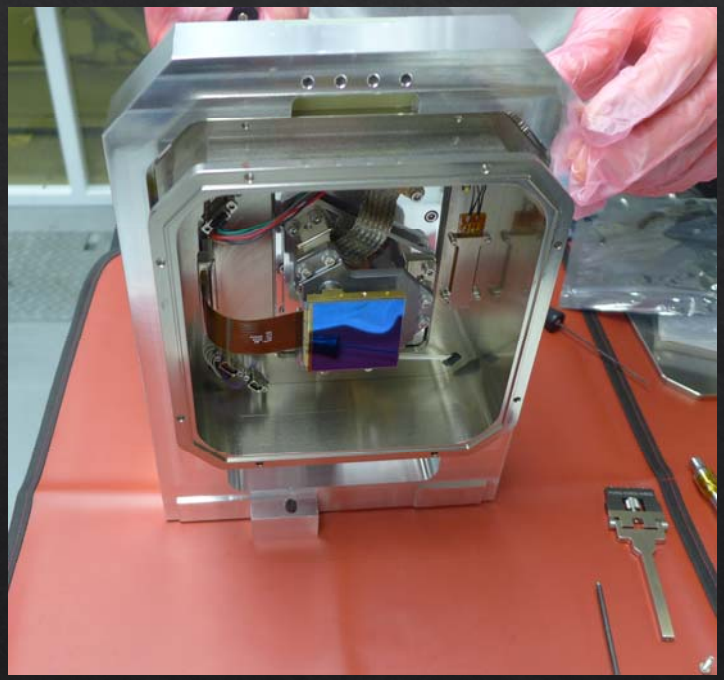


MOIRCS

(Multi-Object Infrared Camera and Spectrograph)

- wide-field NIR imaging and multi-object spectroscopy
  - detectors : two H2RG
  - multi-object spectroscopy



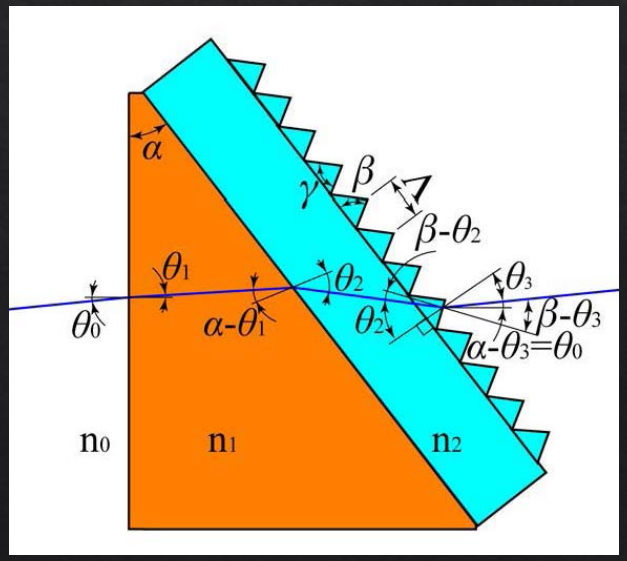


~60 slits with HK500 grism
(by Ichi Tanaka)

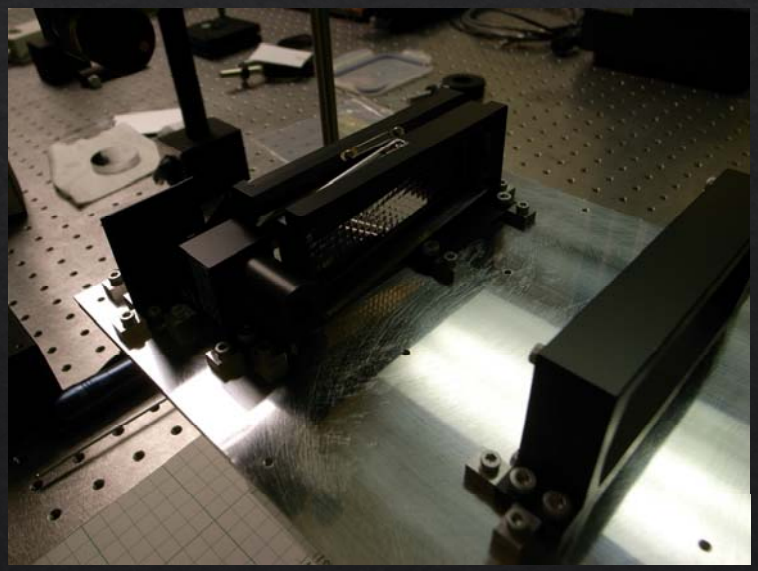
MOIRCS

(Multi-Object Infrared Camera and Spectrograph)

- upgrade projects
  - microlens-array IFU is being developed (Ishigaki)
  - hybrid grism for R~1500 spectroscopy (Ebizuka)
  - proposal for Echelle spectroscopy mode (AAO)



hybrid-grism design (Ebizuka 2016)



MLA-IFU optics test (Ishigaki 2016)

IRCS+AO188

- work horse instrument with AO
  - wide wavelength coverage : 0.9-5.6um
  - multi observing modes
    - imaging (FoV 20” or 54”)
    - grism spectroscopy
    - Echelle spectroscopy (up to R~20,000)
    - linear polarimetry (imaging and grism-spec in NIR)

IRCS+AO188

- work horse instrument with AO
  - upgrading projects
    - thermal infrared and circular polarimetry are being tested and will be opened soon
    - detector upgrade in consideration
    - MOS capability with digital-micromirror-device in near future

COMICS

- only mid-infrared facility instrument in Maunakea
  - wavelength coverage : 7.5-25um
  - low to medium resolution spectroscopy : R=250-10000
  - imaging FoV 42”x32”
  - diffraction limited image quality (~0”.3) and wide FoV (60” chopping capability)
    - big advantage for extended objects

FOCAS

- work horse optical instrument
- multi observing modes
  - imaging (FoV ϕ6')
  - single- and multi-object spectroscopy R=250-7500
  - imaging- and spectro-polarimetry
- heavily used for HSC follow-up spectroscopy
- planned to be decommissioned after PFS commissioning (schedule is TBD)

SCExAO+CHARIS/HiCIAO/MEC

New Visitor (PI-type) Instruments

NsIR

Kyoto3DII (~2017.2)

AO188

HiCIAO

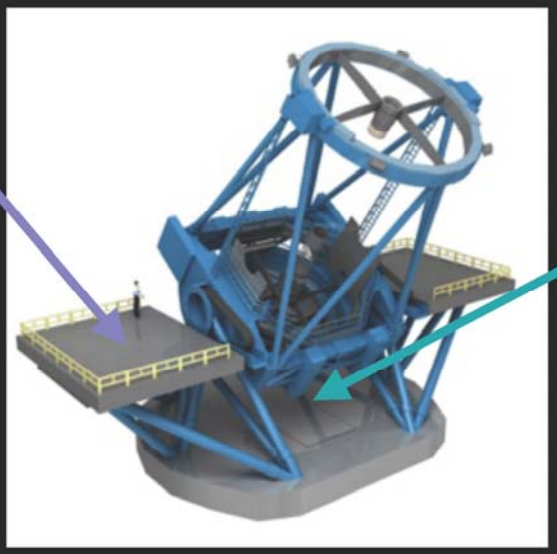
SCExAO

CHARIS (2016.7~)

MEC(TBD)

Coude

IRD(2017.2~)



Accepted for commissioning

Cs

SWIMS

MIMIZUKU

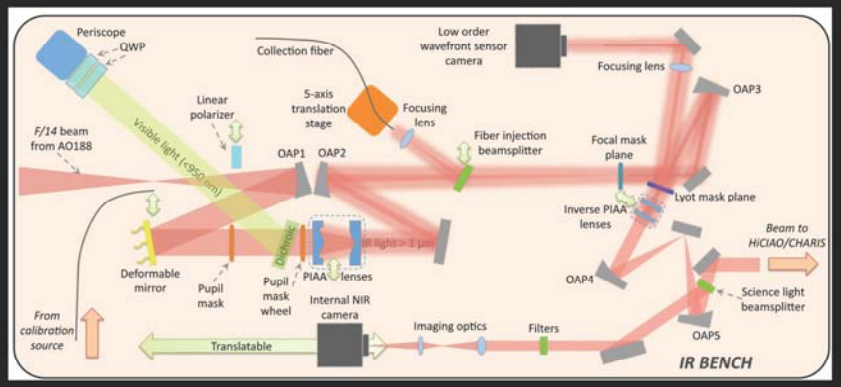
Short time-scale of Cycles (Development-Commissioning-Science) to catch-up this rapidly evolving research field

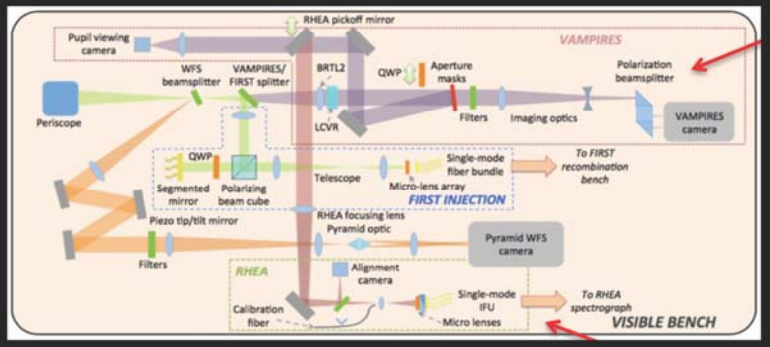
Slide by Y. Minowa (2017)

SCExAO+CHARIS/HiCIAO/MEC

SCExAO Subaru Coronagraphic Extreme Adaptive Optics

PI: Olivier Guyon (Subaru)





Jovanovic et al. 2015

Visitor modules on the visible bench

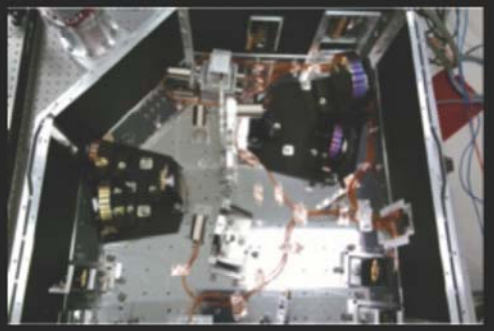
- VAMPIRES (open to the community)
  - polarimetric instrument using non-redundant pupil mask
- FIRST (commissioning phase)
  - interferometer and spectrometer using non-redundant pupil remapping with single-mode fibers
- RHEA (commissioning phase)
  - 9 element IFU spectrograph with single-mode fiber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

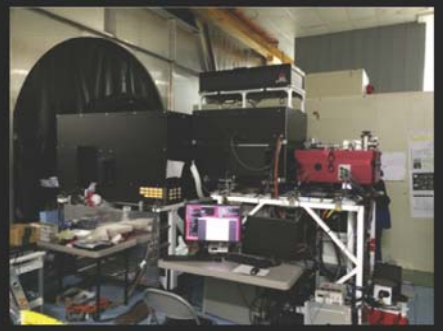
Slide by Y. Minowa (2017)

SCExAO+CHARIS/HiCIAO/MEC

CHARIS
(Coronagraphic High Angular Resolution Imaging Spectrograph)

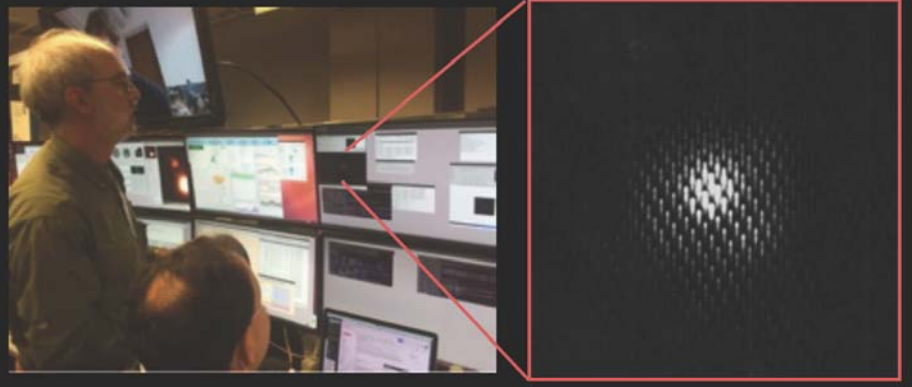
PI: Jeremy Kasdin (Princeton Univ.), funded by NAOJ (PI: M. Hayashi)



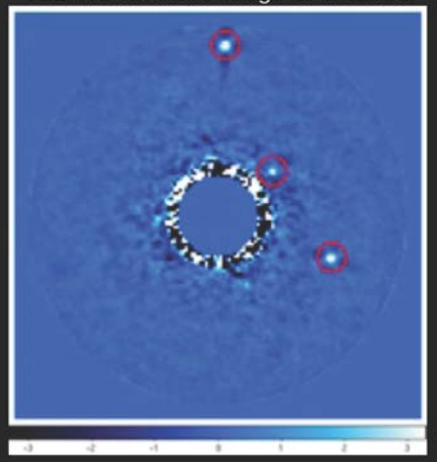


- Commissioning started since July, 2016
- Science operation will start from S17A (opened to the community in a shared-risk)

CHARIS First Light image



SCExAO+CHARIS image of HR8799



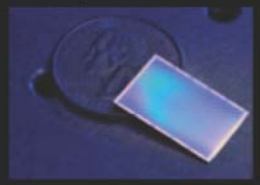
http://scholar.princeton.edu/charis

Slide by Y. Minowa (2017)

SCExAO+CHARIS/HiCIAO/MEC

MEC (MKIDs Exoplanet Camera)

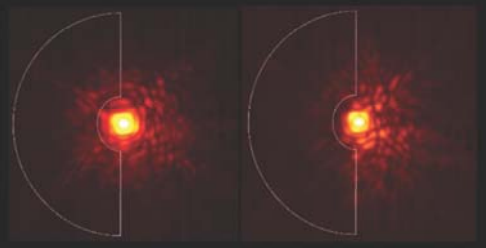
- Fast photon-counting, energy resolving IFS based on Microwave Kinetic Inductance Detectors (MKIDs)

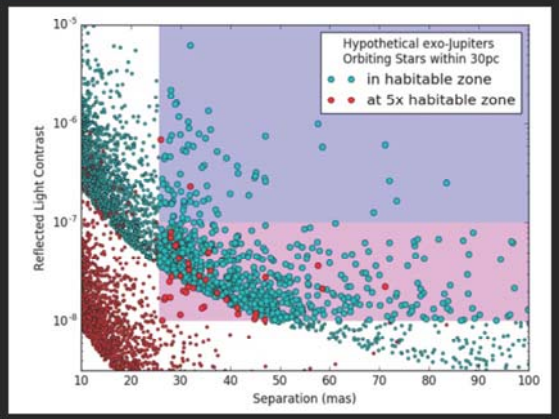


- Funded by JSPS Grant-in-Aid (PI: Guyon), being developed by UCSB (PI: B. Mazin).

- 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.

Slide by Y. Minowa (2017)