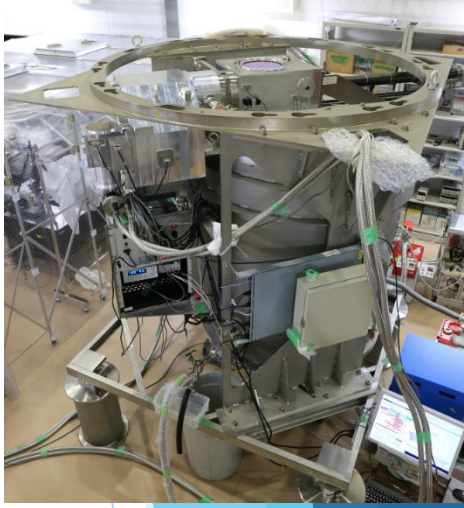


SWIMS-on-Subaru Overview

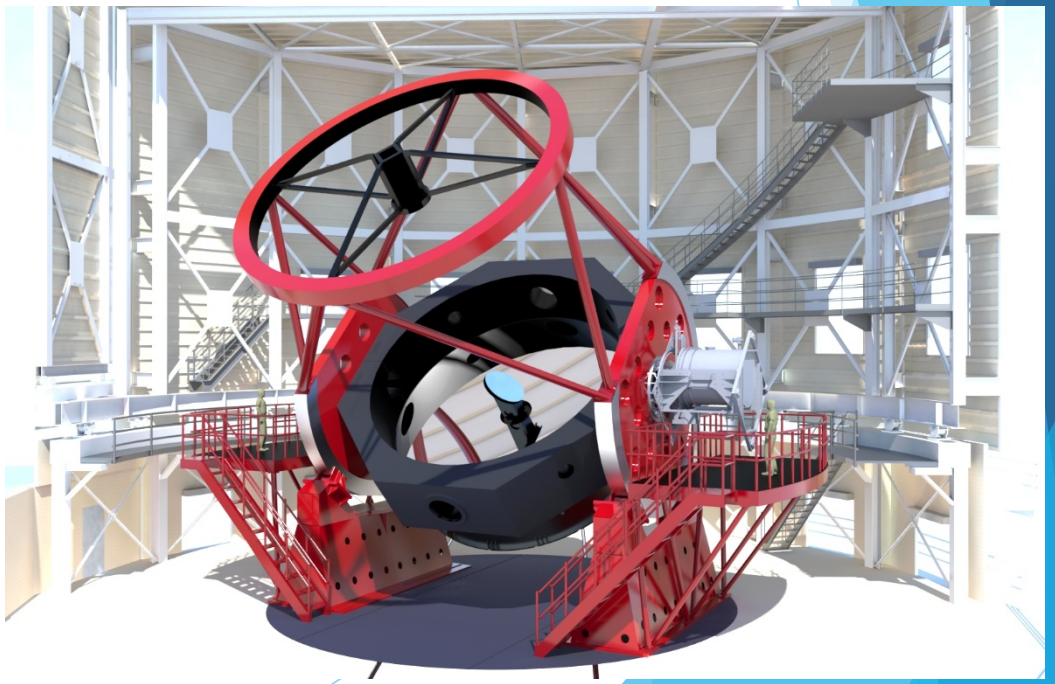
2020/7/27

K. Motohara (NAOJ), on behalf of SWIMS development team

TAO PROJECT
The University of Tokyo Atacama Observatory

SWIMS : Simultaneous-color Wide-field Infrared Multi-object Spectrograph

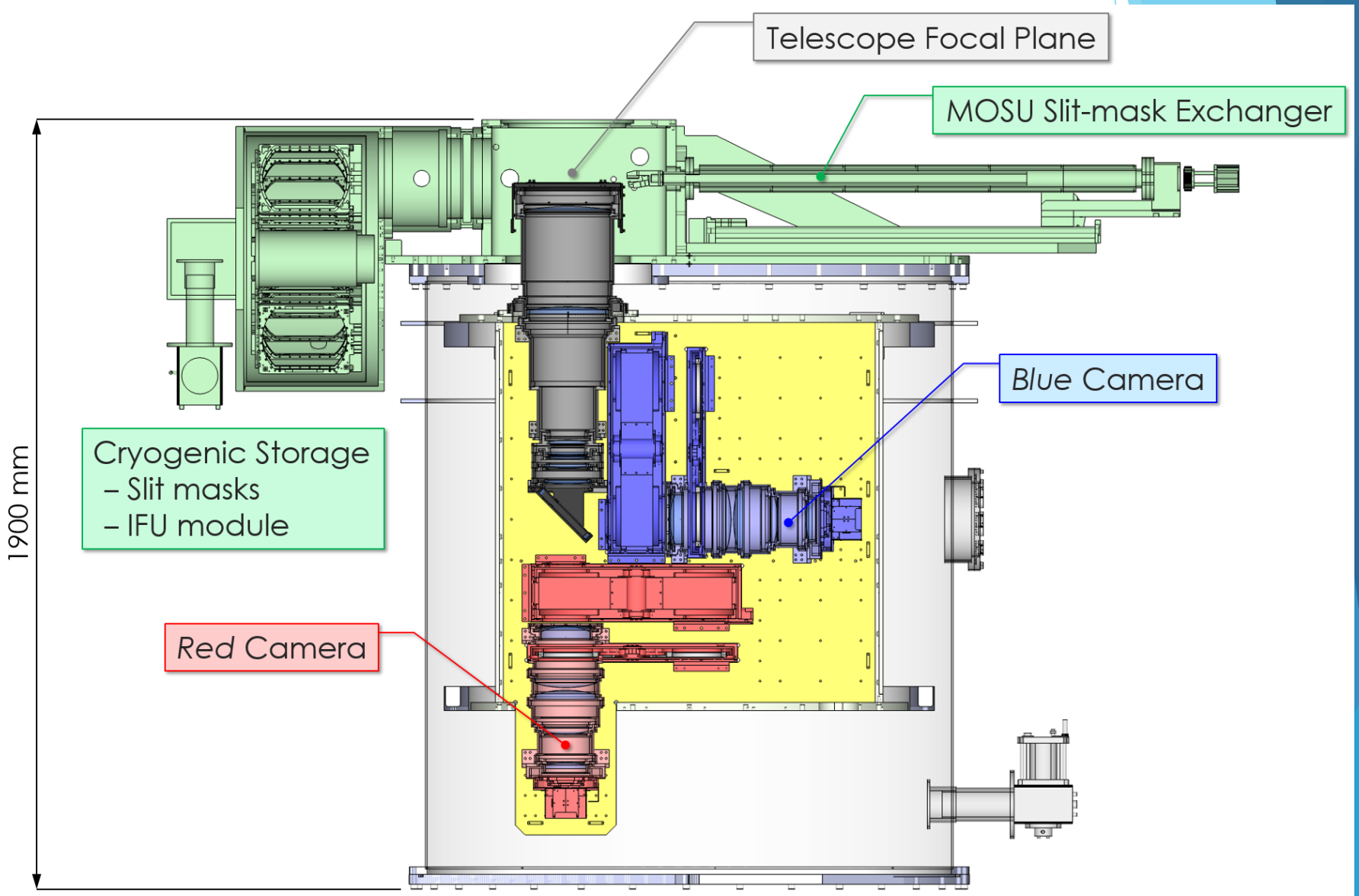
- Developed as a 1st gen facility instrument for TAO 6.5m telescope
- NIR (0.9um-2.5um) imager/MOS spectrograph



SWIMS Development Team

- Instrument Team
  - PI : K. Motohara (NAOJ)
  - M. Konishi (U.Tokyo)
  - H. Takahashi (U.Tokyo)
  - N. Kato (U.Tokyo)
  - K. Kushibiki (U.Tokyo / D1)
  - H. Nakamura (U.Tokyo / M2)
  - N. Chen (U.Tokyo / M1)
- IFU Development Team
  - S. Ozaki (NAOJ)
  - Y. Yamagata (Riken)
  - T. Hosobata (Riken)
  - M. Takeda (Riken)
  - S. Morita (Tokyo Denki U.)
- SWIMS-18 Filter Team
  - T. Kodama (Tohoku U.)
  - Y. Koyama (NAOJ)
  - M. Hayashi (NAOJ)
  - K. Tadaki (NAOJ)
  - T. Suzuki (Tohoku U.)
  - T. Asano (U. Tokyo / M2)

Hardware Structure



Specifications

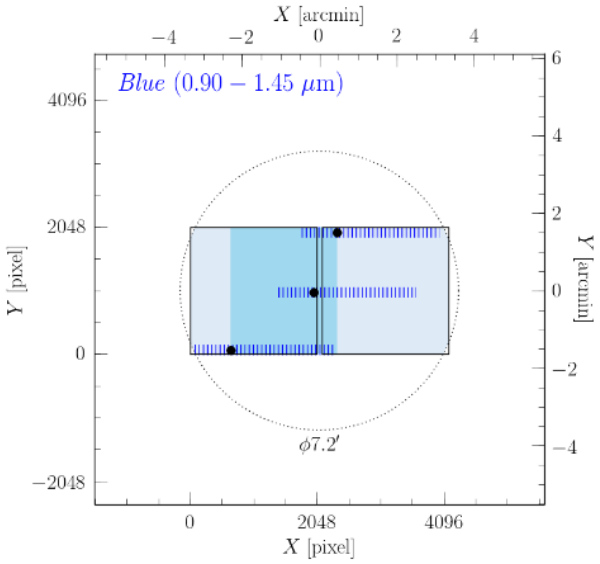
- 2-color Simultaneous imaging/spectroscopy
  - 0.9-1.4 μm
  - 1.4-2.5 μm
- Wide-Field Imaging
  - 6.6’ x 3.3’ with 2k x 4k pixels
  - 0.095"/pix
  - 22 filters
- Multi-object spectroscopy
  - ~30 objects
  - R~1000
  - 0.9-2.5 μm spectroscopy with a single exposure
- IFU under development : Not available at the moment
- Summary available at :

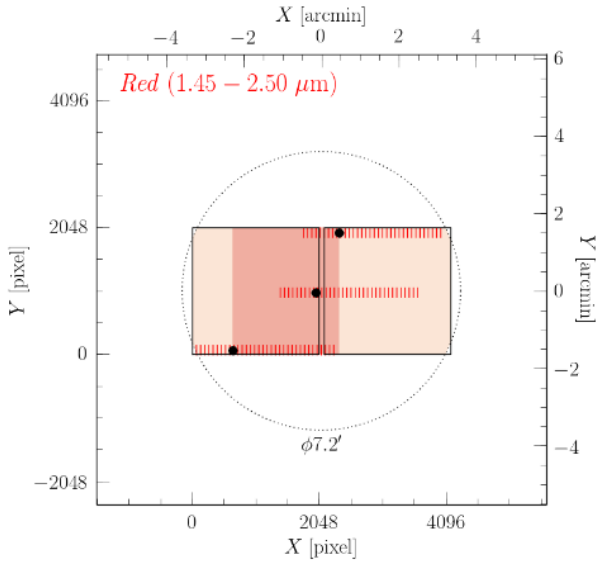
  http://www.ioa.s.u-tokyo.ac.jp/TAO/swims/?Summary_for_Subaru_S21A_CfP

  (for S21A)

Field of View and Detectors

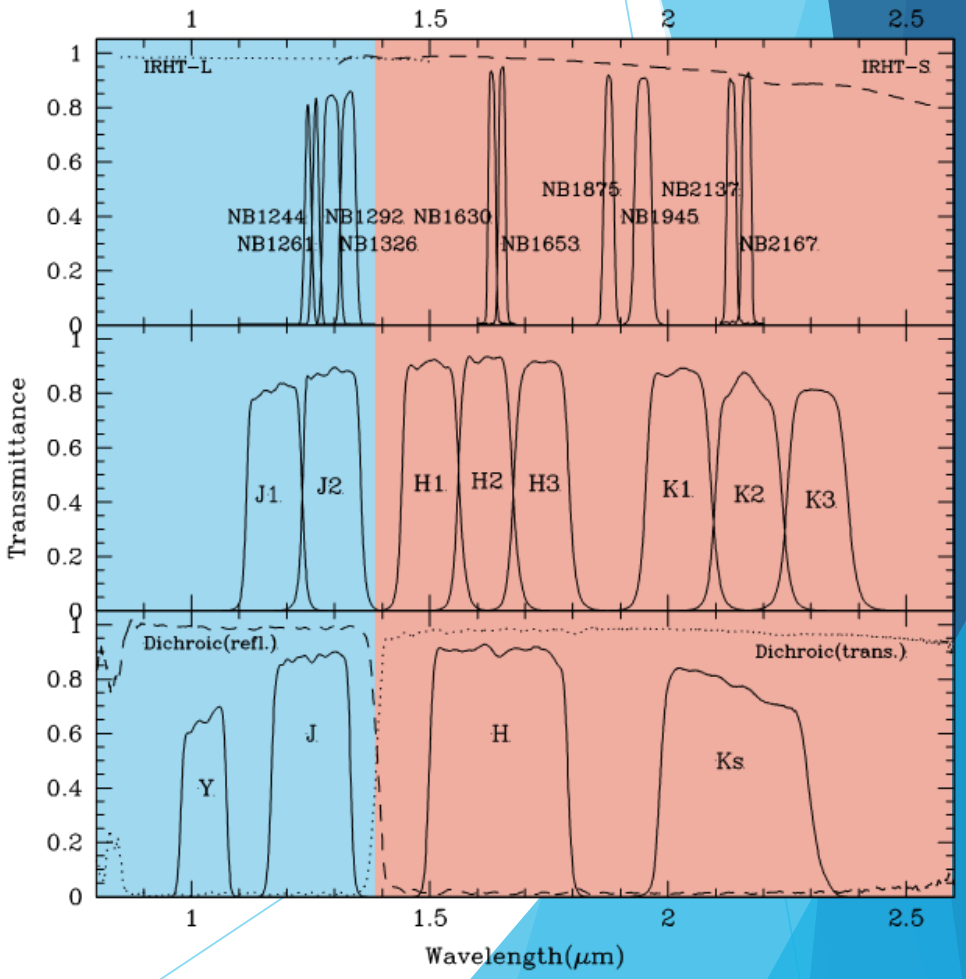
- 3.3'×6.6' on Subaru
  - Two H2RGs for each channel
  - 0.095" / pix
  - Gap between the arrays is ~13"
- In Spectroscopy, effective FoV to cover full spectral range is smaller



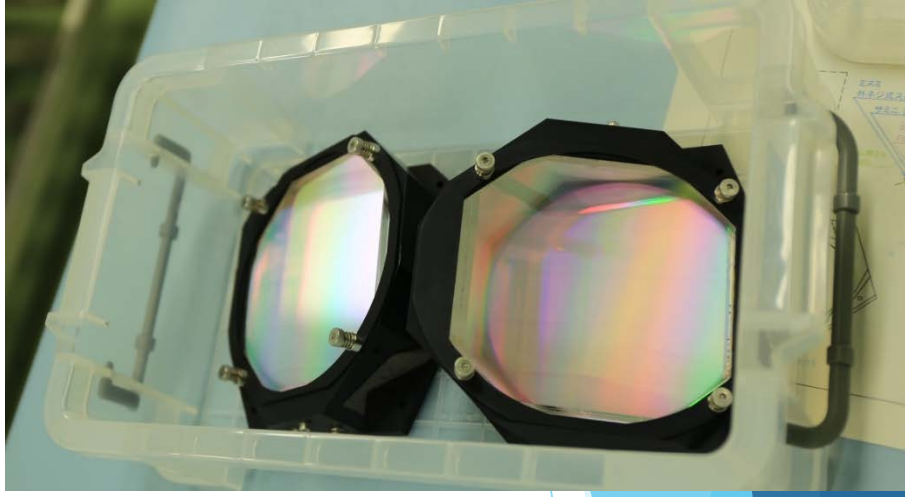


Filters

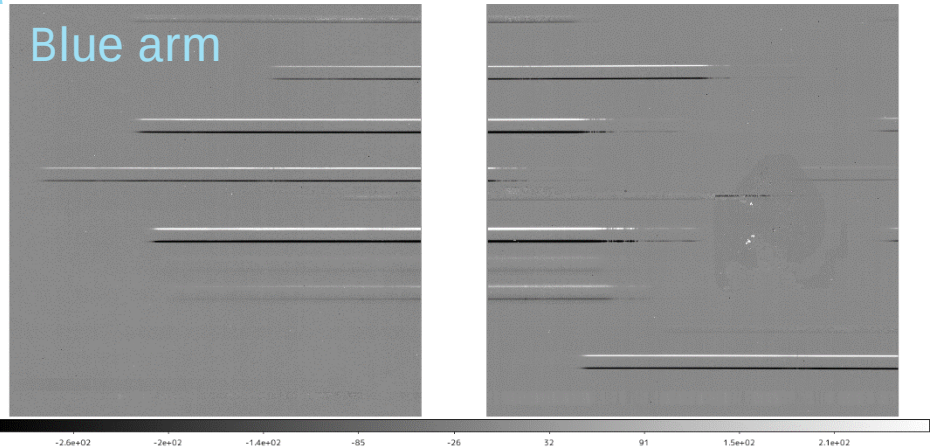
- 3 Wheels for each arm
  - 4 BBFs : Mauna Kea Filter sets
  - 8 MBFs : “SWIMS-18” filter set (Kodama-san’s talk)
  - 10 NBFs : “SWIMS-18” filter set + Paschen-α ON/OFF (1.875 / 1.945μm) and Paschen-β ON/OFF (1.292 / 1.326μm)

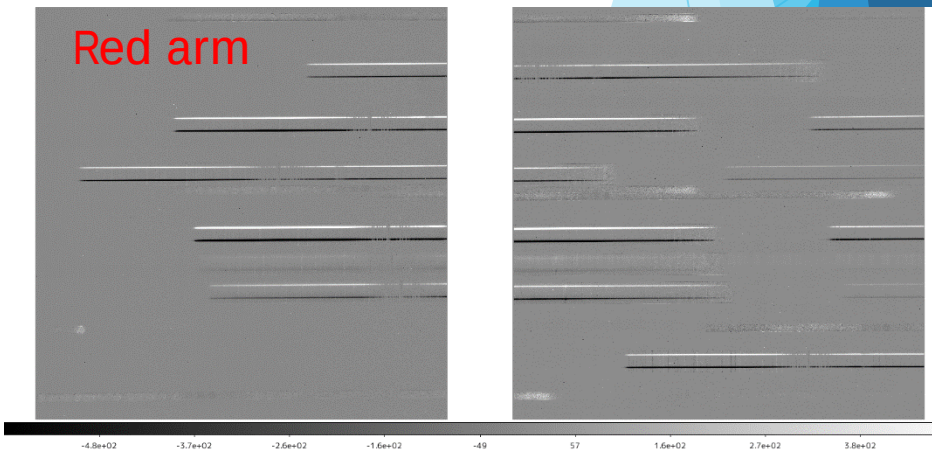


Spectroscopy



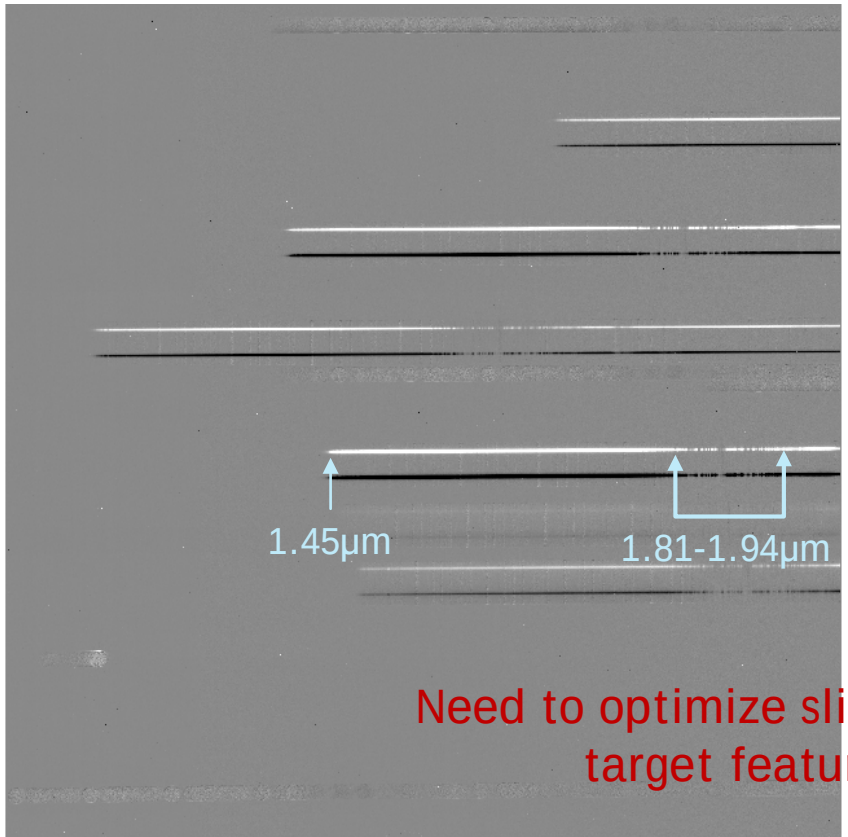
- Spectral Coverage
  - Blue arm : 0.86-1.38μm
  - Red arm : 1.44-2.47μm
- Wavelength Resolution
  - Blue arm : 0.24nm/pix → R=700-1200 (0.5”slit)
  - Red arm : 0.457nm/pix → R=600-1000 (0.5”slit)
- 0.9-2.5μm spectra can be obtained with a single exposure

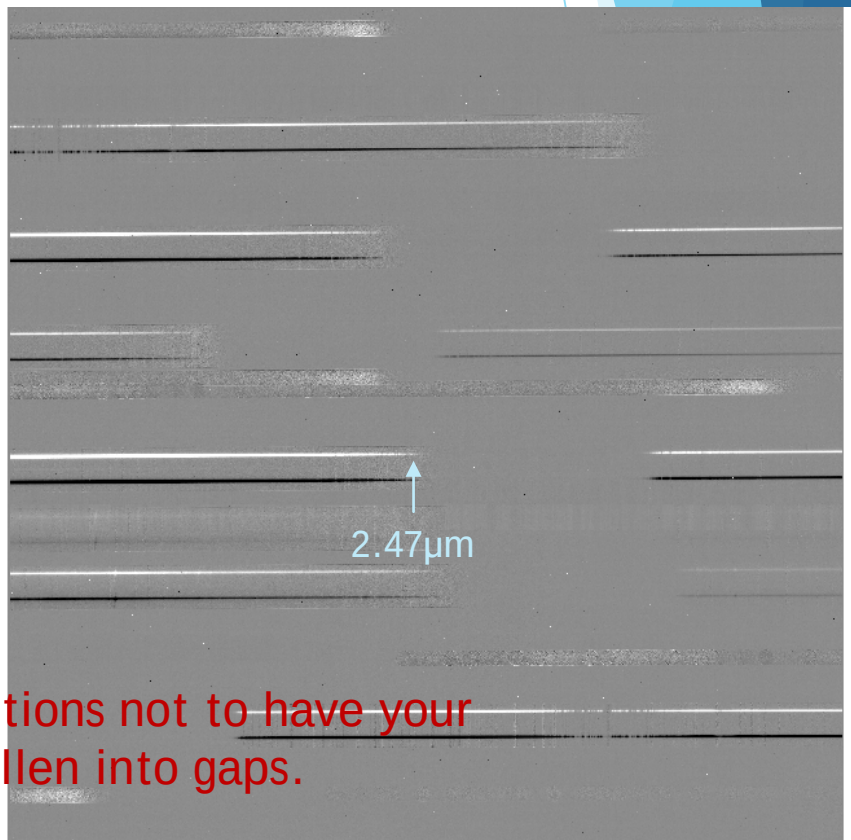




Limitation of Spectroscopy

- Atmospheric absorptions between H/K (~1.81-1.94μm) cause wavelength loss
- Detector gap causes additional loss of ~31nm (blue) / ~59nm(red), whose wavelengths depend on slit positions.

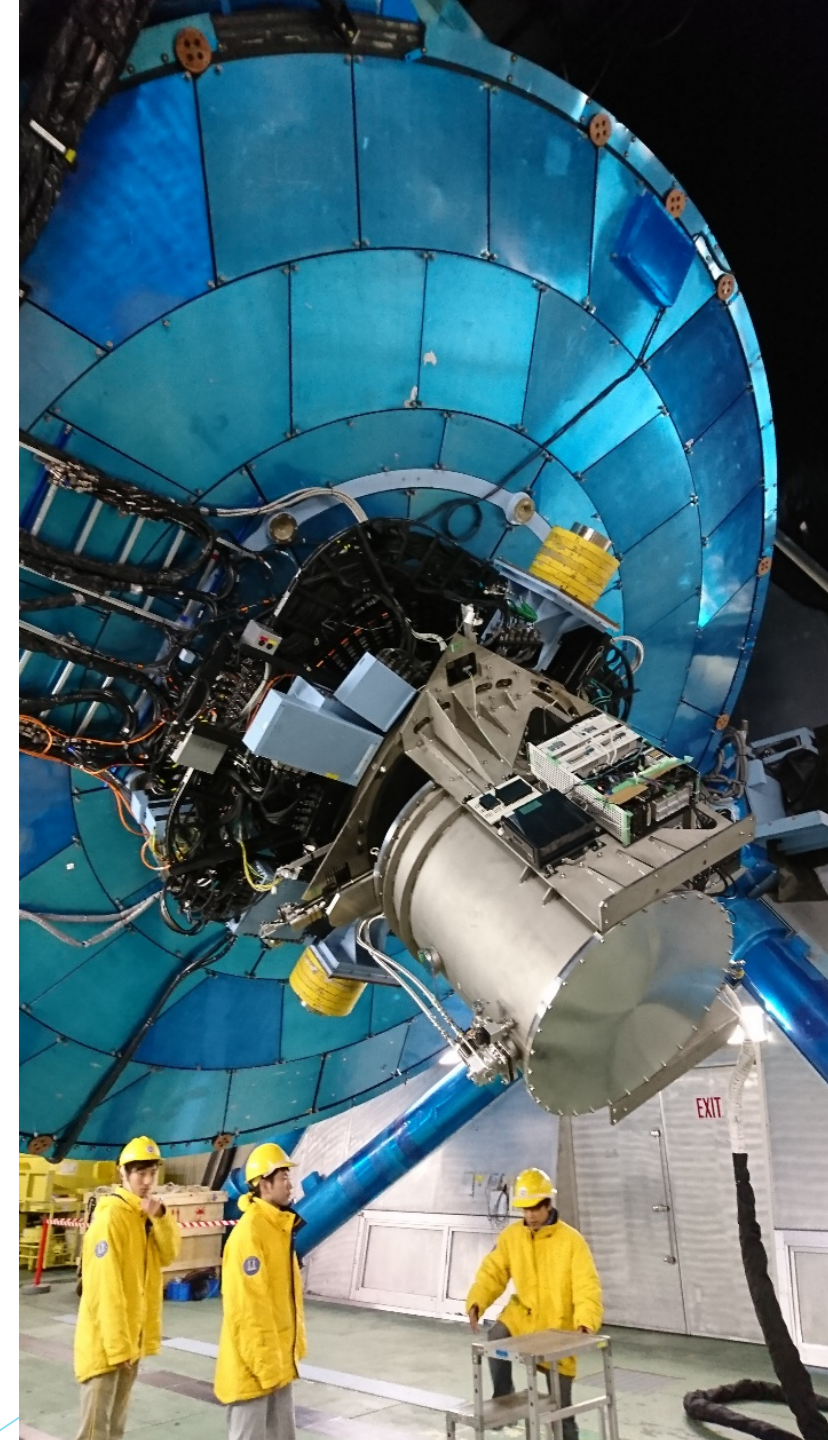




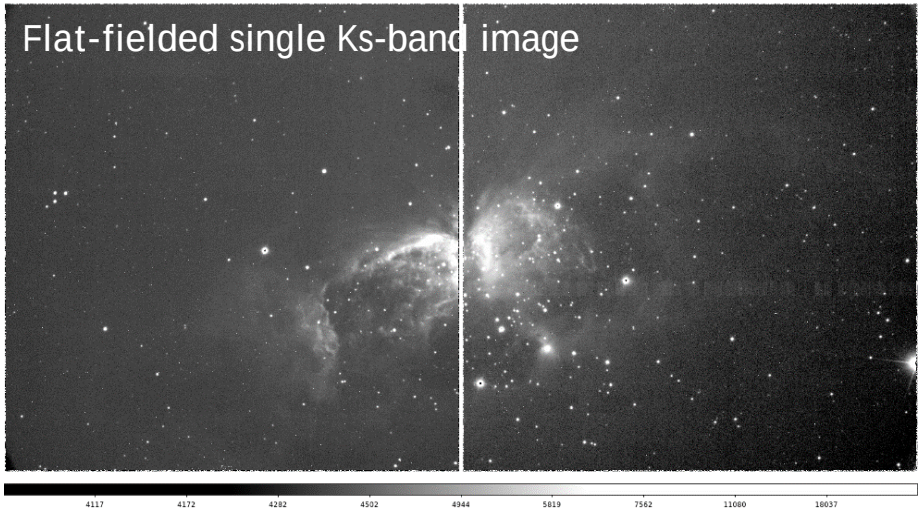
Need to optimize slit positions not to have your target features fallen into gaps.

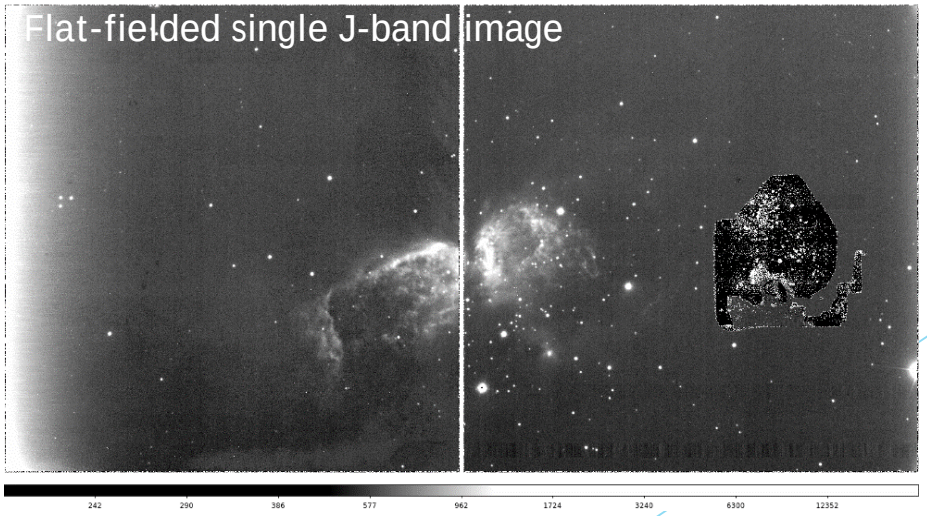
Commissioning on Subaru

- Two Test Runs completed, and another to come
- 2018/5/29-6/1
  - First Light!
  - Filter wheel trouble
  - Minimum test of imaging completed
- 2019/1/22-24,26
  - No major problem
  - Almost all engineering observation completed
    - Standard Star Observation in All filters
    - Deep imaging
    - MOS spectroscopy
- 2020/10/3, 4
  - ?



Real Data from Test Observations in 2018-2019





System Efficiency (Imaging)

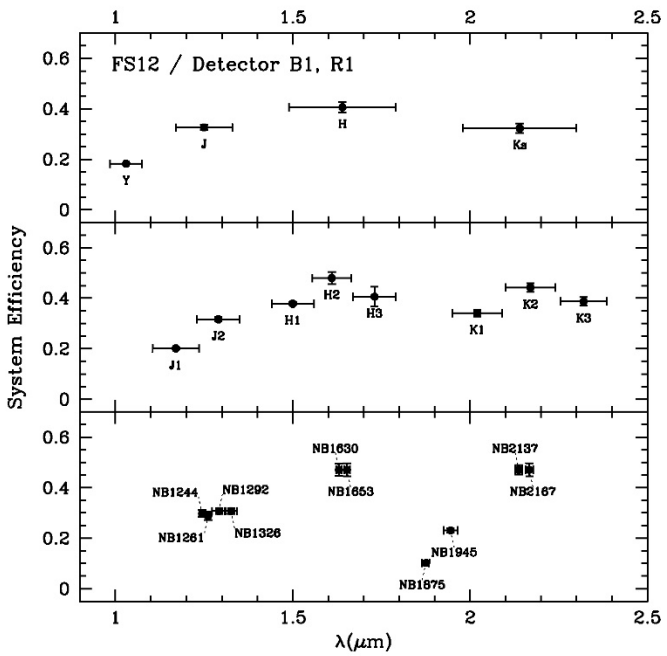
Efficiency including the instrument, telescope and Earth atmosphere

- Red Arm : 32~48%
- Blue Arm : 20~35%

Almost consistent with expected value

Comparable to those of MOIRCS

→ Limiting magnitude is same as that of MOIRCS



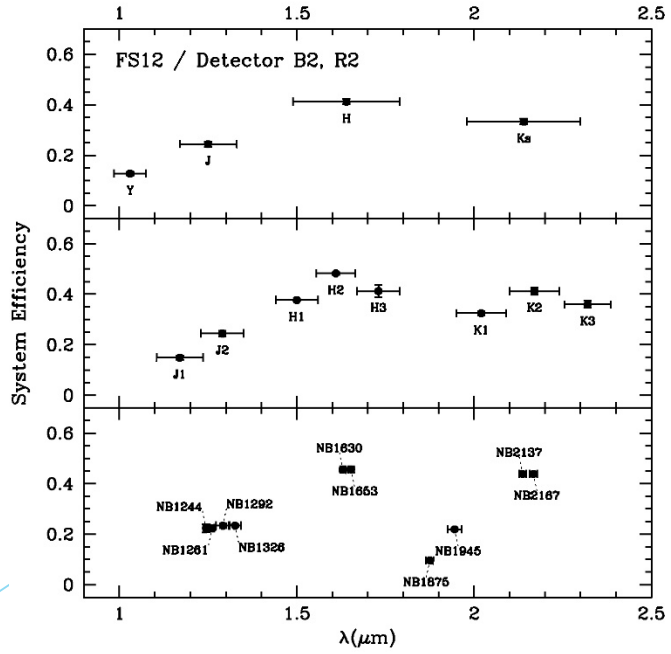
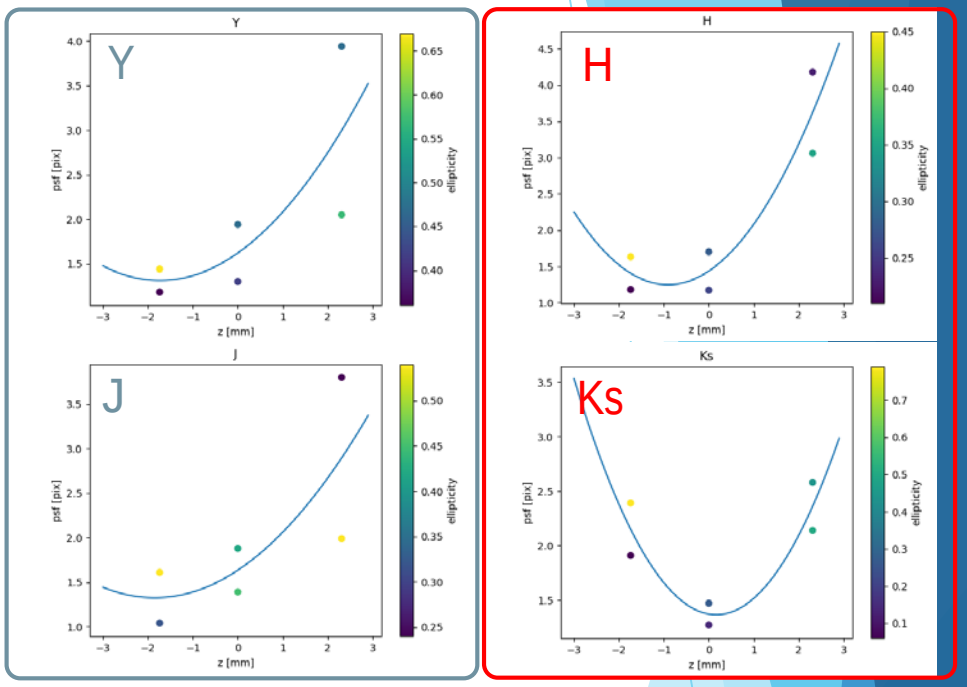
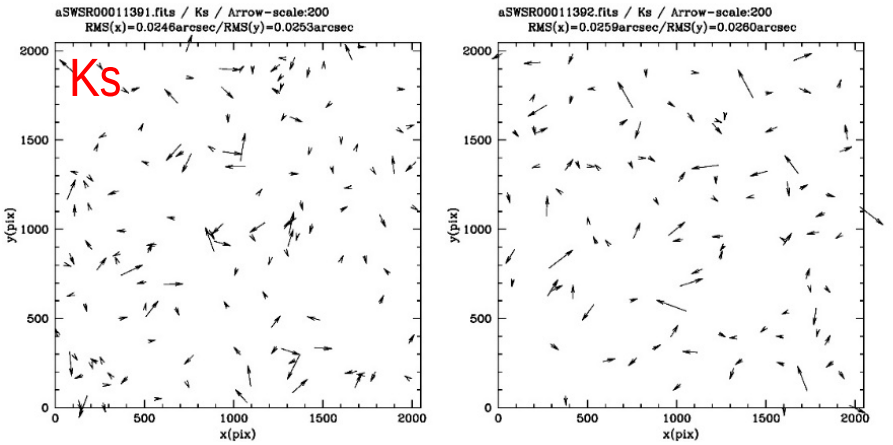


Image Quality

- Point Spread Function
  - BBF, MBF : FWHM<2pix(0.2”) for pinhole images
  - NBF : some have larger FWHM (MAX ~10pix max)
    - Probably due to focus offset
    - No problem under seeing limited condition
- Distortion
  - No distortion found down to 0.025arcsec rms in both the red and the blue arms

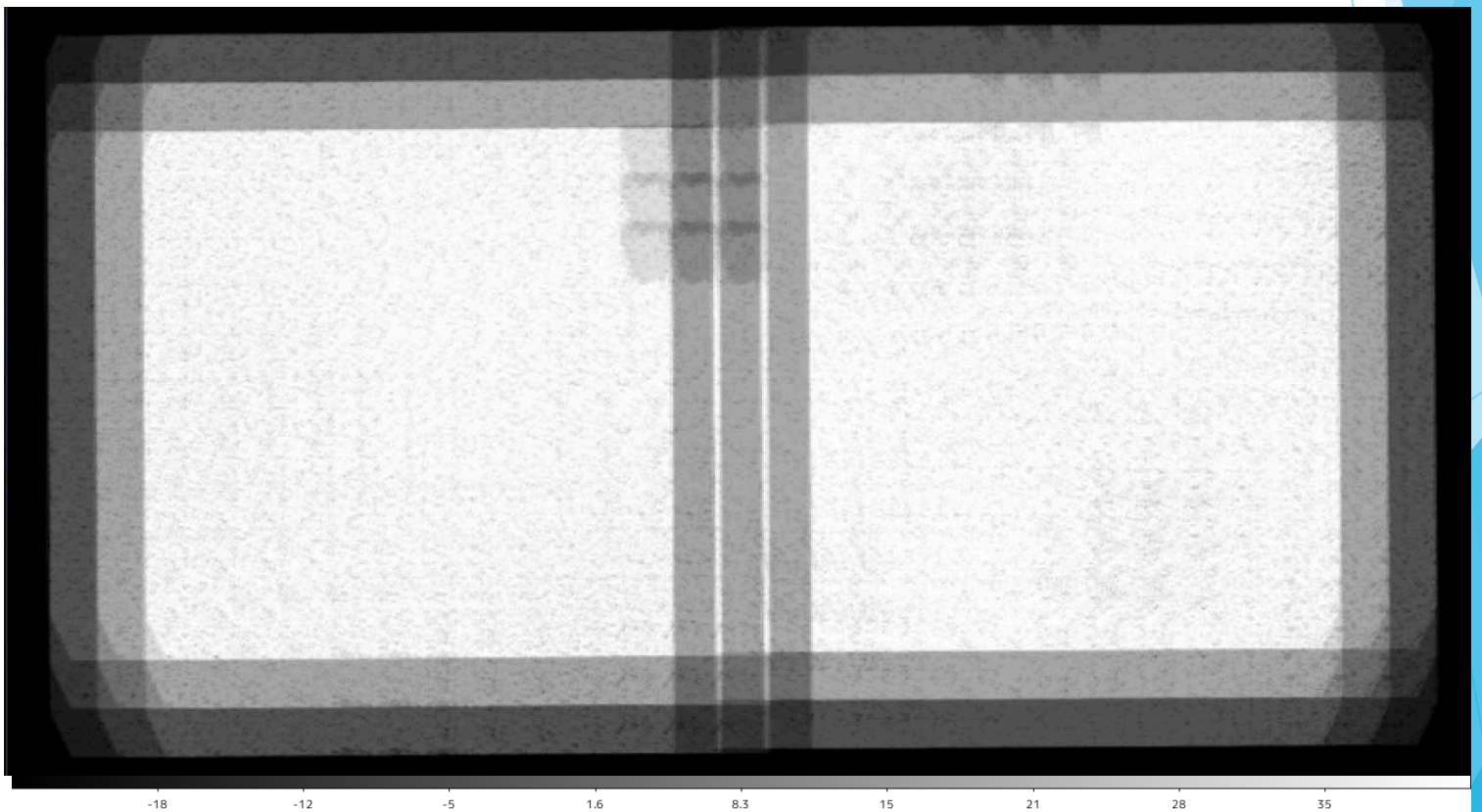




Chen

Performance of Deep Imaging

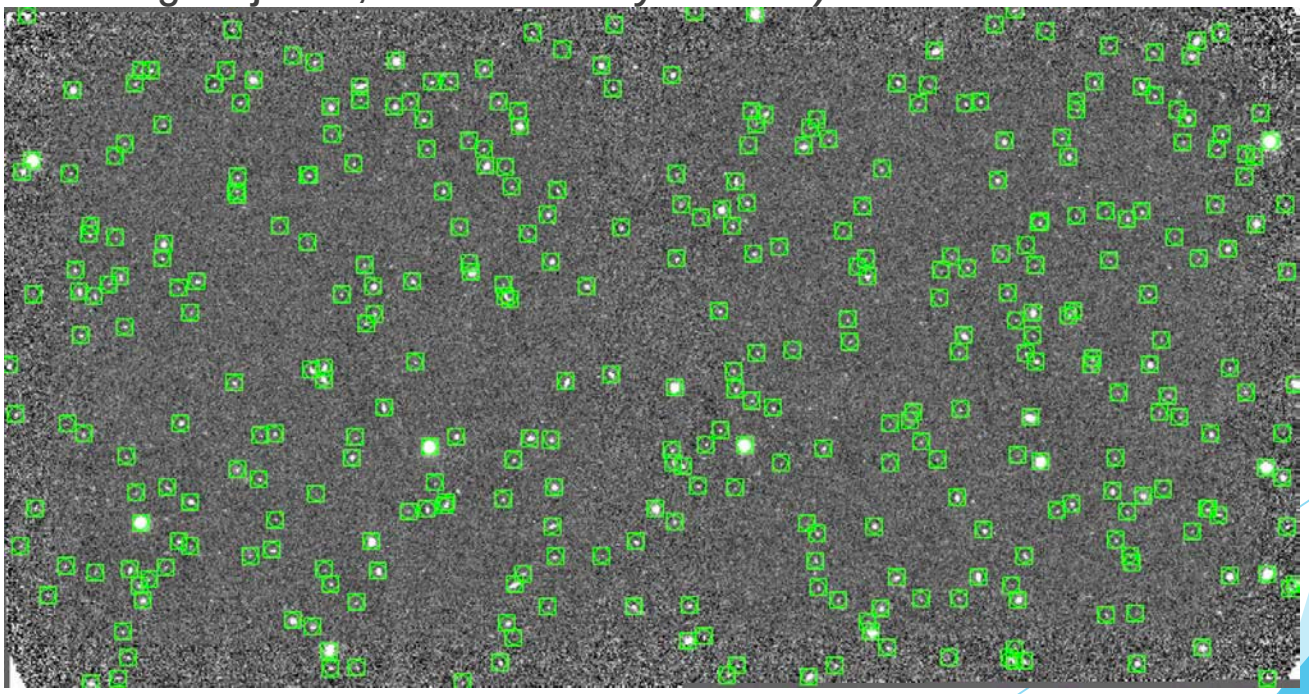
- ZFOURGE-COSMOS Field
- K2-band / 90min integration



Chen

Imaging Sensitivity (K2 Filter) from Observations

- Limiting Magnitude : 24.3AB (1” aperture, 5σ)
- Sextractor : 358 Detection (355 match with ZFOURGE catalog objects, 3 cosmic-ray events)



Imaging Sensitivity (as of 2020.Jul.26 / Preliminary)

- Based on
  - K2 deep imaging (Red Arm)
  - NB1261 deep imaging (Blue Arm)
- AB / 3600sec / 5σ / 1” aperture

	λ (μm)	Δλ (μm)	Sky Background (AB/ □”)	Expected Limiting Magnitude
Y	1.03	0.09	17.7	25.2
J	1.25	0.16	15.9	24.9
J1	1.17	0.13	17.2	25.2
J2	1.29	0.12	15.9	24.7
NB1244	1.244	0.012	17.5	24.2
NB1261	1.261	0.012	15.5	23.2
NB1292	1.292	0.04	16.0	24.1
NB1326	1.326	0.034	17.4	24.7

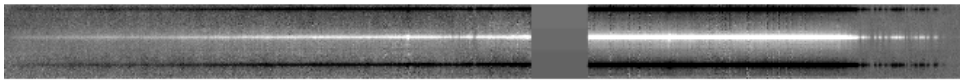
	λ (μm)	Δλ (μm)	Sky Background (AB/ □”)	Expected Limiting Magnitude
H	1.64	0.3	15.2	24.2
Ks	2.14	0.32	15.8	24.4
H1	1.5	0.12	15.3	23.7
H2	1.61	0.11	15.2	23.7
H3	1.73	0.12	15.3	23.7
K1	2.02	0.14	15.6	23.8
K2	2.17	0.14	15.9	24.1
K3	2.32	0.13	15.7	23.9
NB1630	1.63	0.016	15.4	22.8
NB1653	1.653	0.016	15.7	22.9
NB1875	1.875	0.02	15.6	22.1
NB1945	1.945	0.04	15.9	23.1
NB2137	2.137	0.021	16.5	23.4
NB2167	2.167	0.021	16.2	23.3

Kushibiki

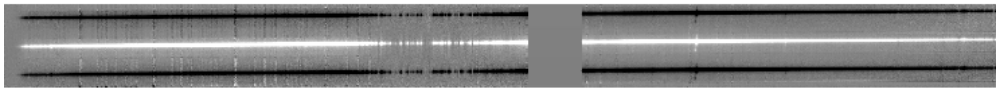
Real Data from Commissioning Run : Multi-object Spectroscopy

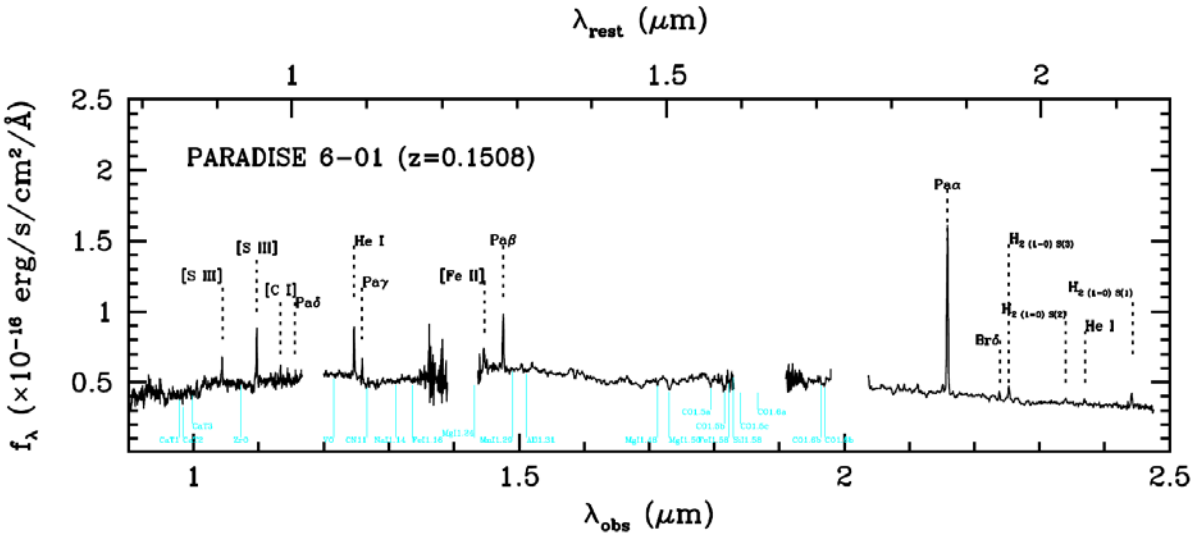
- Z=0.15 LIRG spectrum

Blue-arm



Red-arm

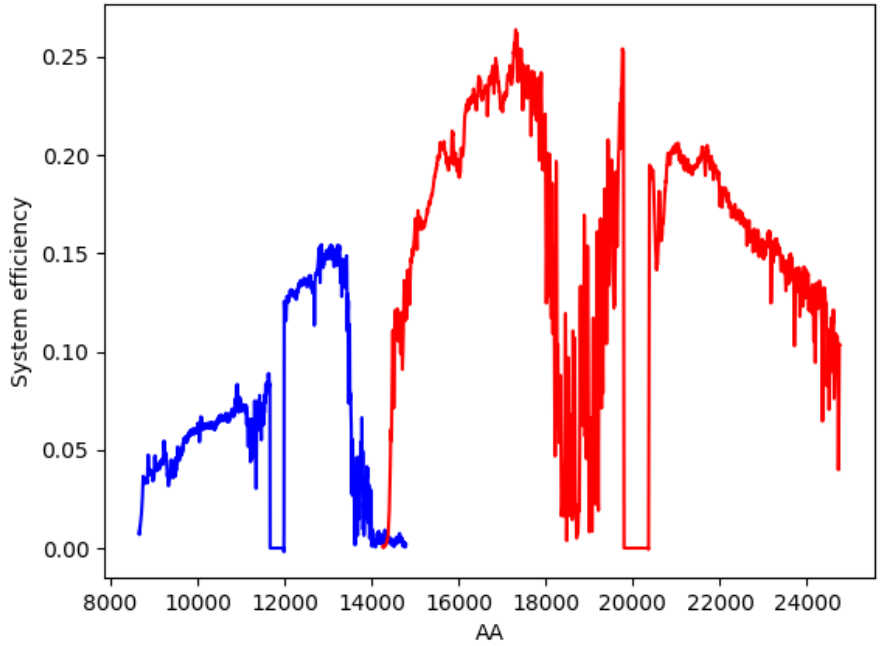




Kushibiki

System Efficiency (Spectroscopy)

- Measured from standard star spectra
- Lower than expected (30%)
- Resulted in lower sensitivity
- Due to IRM2 recoating, we may have higher efficiency by factor of ~1.2 in the blue-arm

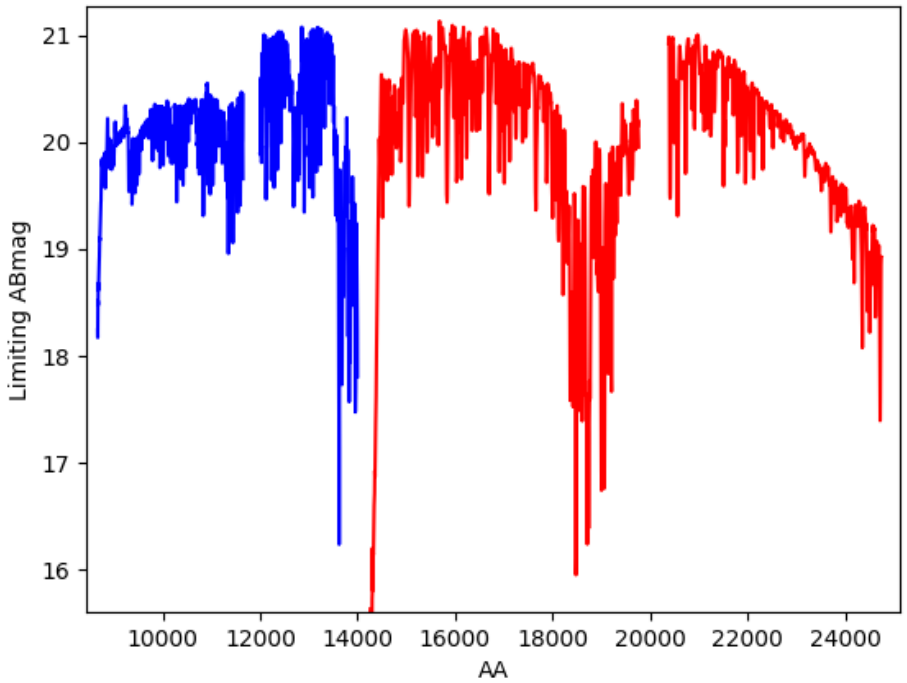


Kushibiki

Spectroscopic Sensitivity from Observations

- 3600sec / 5σ
- 0.4” slit
- 0.6”(J) / 0.5” (K) Seeing

Band	AB-Mag	Initial Estimate (0.5” slit, 0.5” seeing)
J	20.5	21.1
H	20.5	20.7
Ks	20.4	20.9

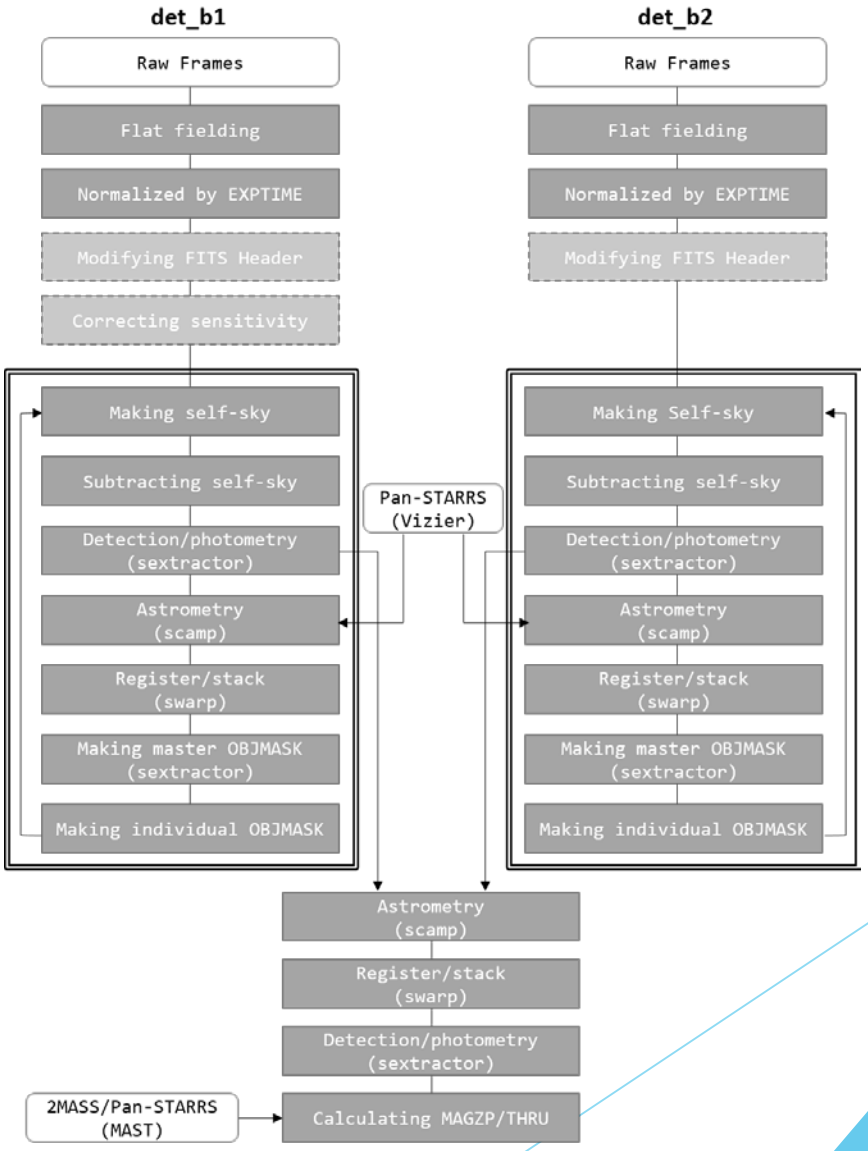


- Emission-line : $0.5 \sim 1 \times 10^{-16}\ \mathrm{erg/s/cm^2}$ (5σ)

Konishi

Reduction Pipeline (Imaging)

- SWSRED
  - Python
  - NO IRAF

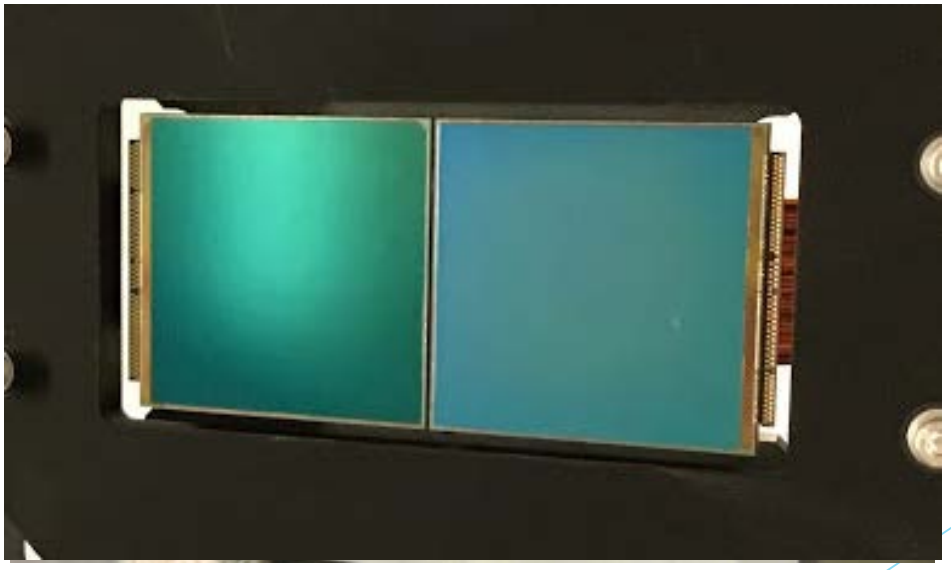


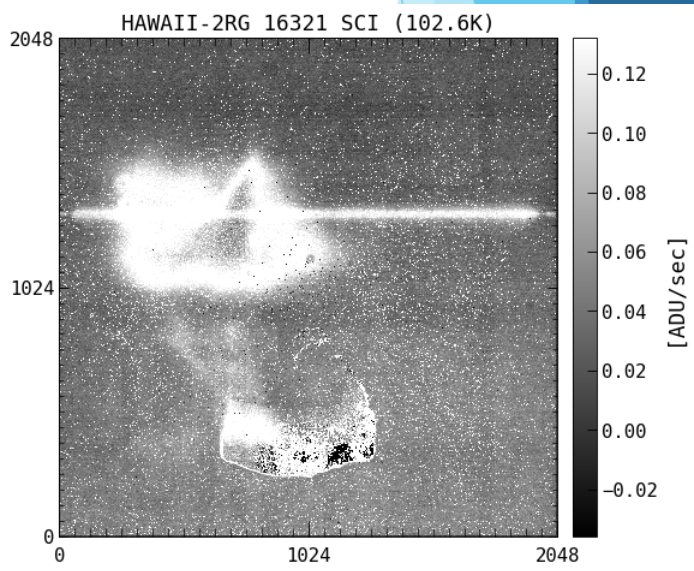
SWIMS-on-Subaru

- S21A-S22B (4 semesters)
- Open as a PI Instrument
- Several Notices :
  - Limited # of MOS masks : Only four slit-masks will be available per run
  - Risk-Shared Operation

Current Status at Subaru

- Stand-by at Hilo Base Facility
- Recent Update : March 2020
  - Detector Blue-1 replacement
    H2RG 1.7um cutoff (Engineering Grade)
    => H2RG 2.5um cutoff (Science Grade / Subaru Property)





Current Status at Subaru (cont'd)

- Maintenance required
  - Detector Power Supply failure
  - MOSU Vacuum Pump Controller failure
  - Replace precool line inside the dewar
- The maintenance works are expected in the beginning of September
  - Motohara will visit Hilo (?!)
  - If this doesn't happen, all S21A observations will be cancelled.

More Questions ?

1. Is the thickness of NB filters is correct? Differences may cause focus shift
   => yes, we have checked the thickness, surface figure, and surface roughness and no problem was found.
2. What is the small shaded region in the left-side detector?
   => it is the region with unstable bias level, and decided to maks it out
3. Can exposure time of blue and red be controlled independently?
   => Yes, for example, we can make a single longer exposure in the blue-arm with several shorter exposure in red.