

Toward WFOS IFU from FOCAS IFU

Shinobu Ozaki (NAOJ ATC)

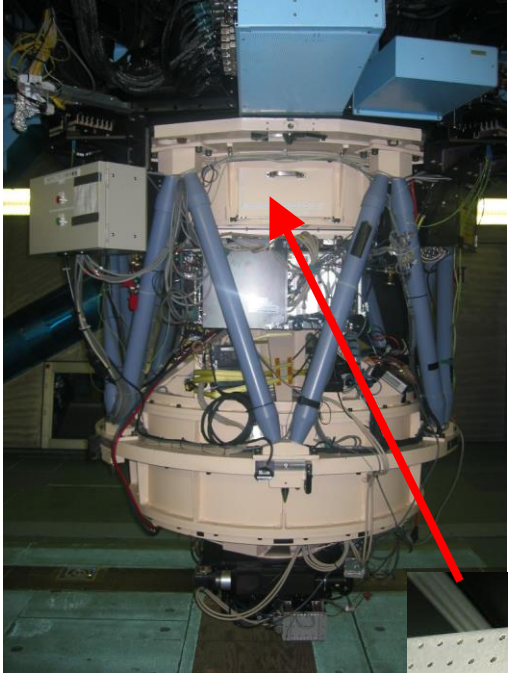
Collaborators so far:

Fukushima Mitsuhiro, Hikaru Iwashita, Kenji Mitsui, Toshihiro Tsuzuki, Norio Okada,
Yoshiyuki Obuchi, Bungo Ikenoue, Tomio Kanzawa (NAOJ ATC)
Takashi Hattori, Yoko Tanaka, Satoshi Miyazaki (NAOJ Subaru)
Tsuyoshi Ishigaki, Rin Sasaki (Iwate Univ.)
Takuya Yamashita (NAOJ TMT)

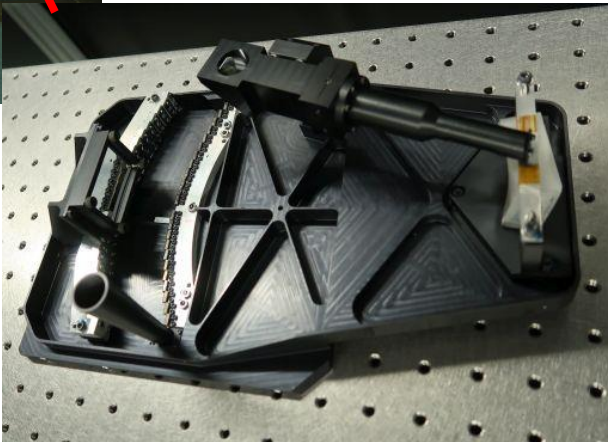


Our project overview

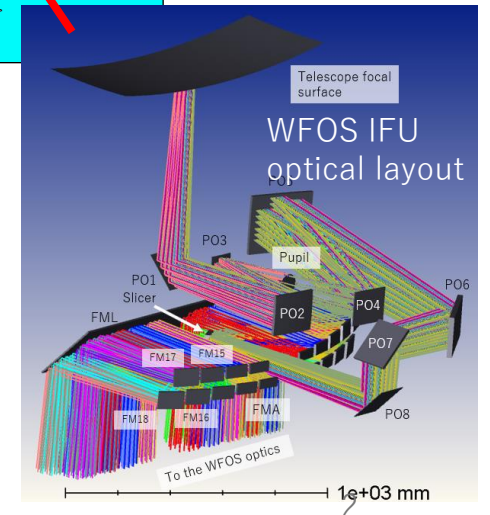
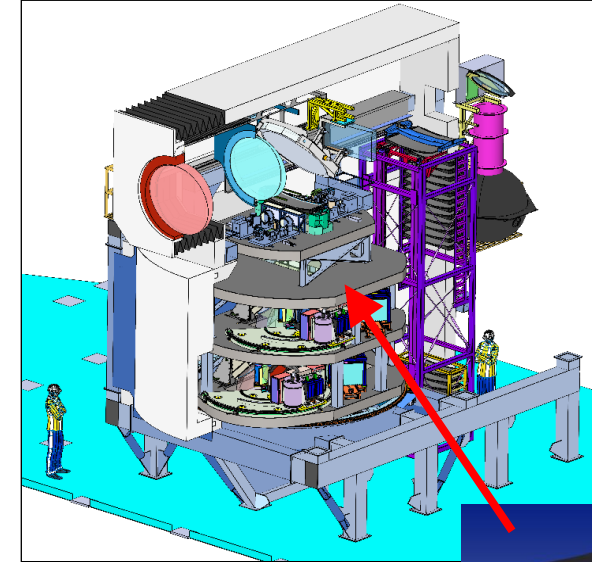
FOCAS@Subaru



FOCAS IFU



WFOS@TMT

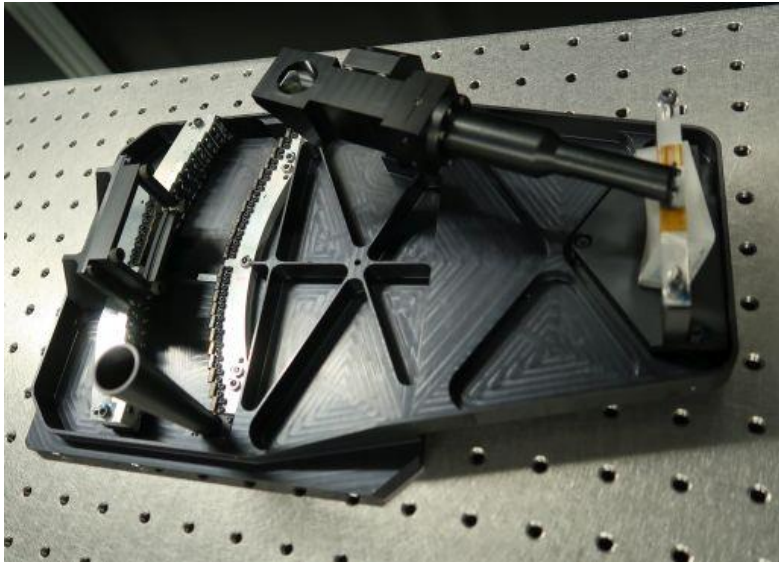


2025/01/30

Subaru UM 2024

FOCAS IFU

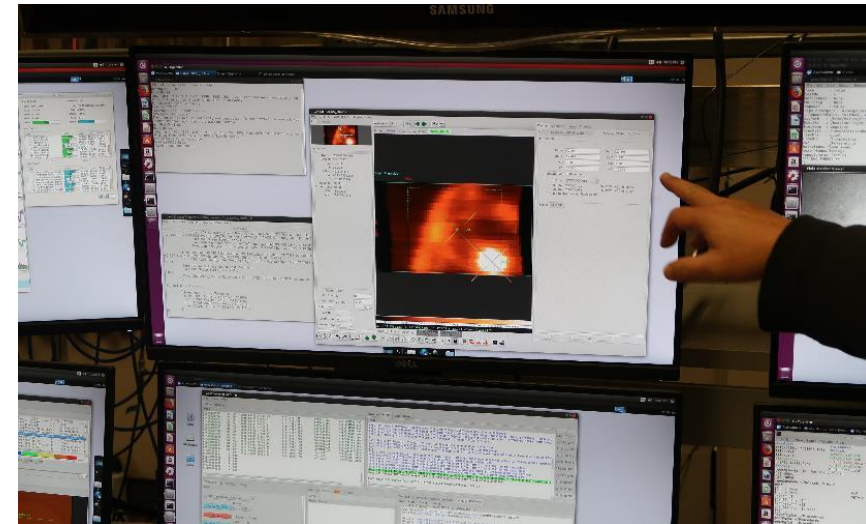
- FOCAS is an optical imaging spectrograph on the Subaru telescope.
- Development of FOCAS IFU was started in 2010 and completed in 2018.
- FOCAS IFU has been open for common use since 2019.
- This development was supported by
 - TMT strategic R&D fund (TMT戦略基礎開発経費) (FY2012, FY2013, FY2014, FY2016, FY2017) and,
 - KAKENHI Grant-in-Aid for Scientific Research (C) (科研費基盤C) (FY2014-FY2016).



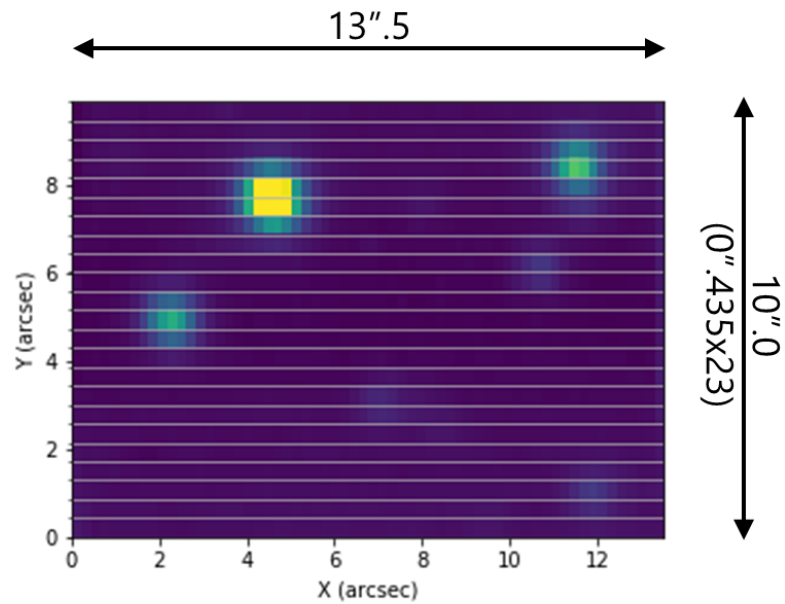
2025/01/30



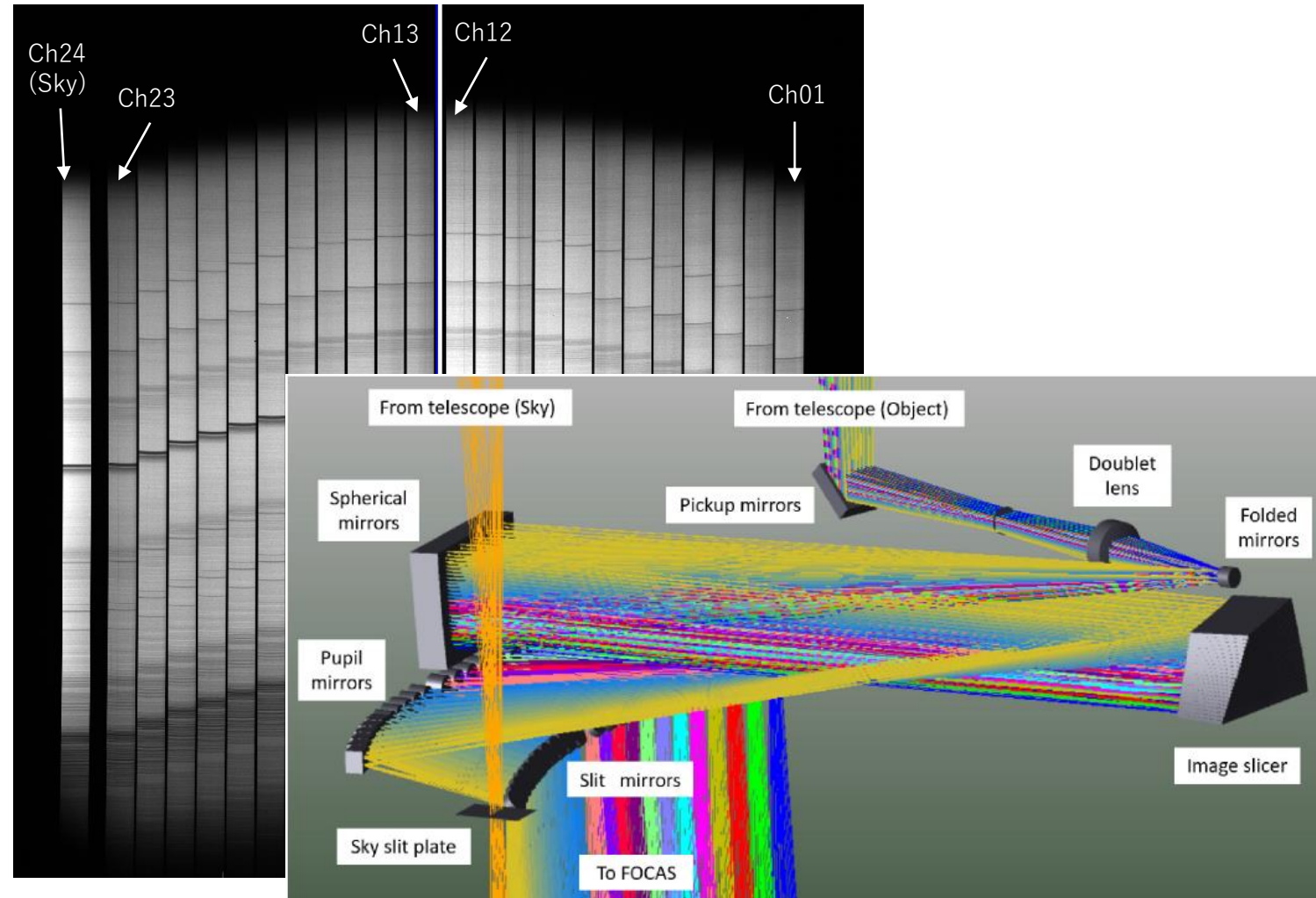
Subaru UM 2024



FOCAS IFU parameters



Slice number	23
Slice width	0.435"
Slice length	13.5"
Field of View	13.5" x 10.0"



Main optical components in FOCAS IFU

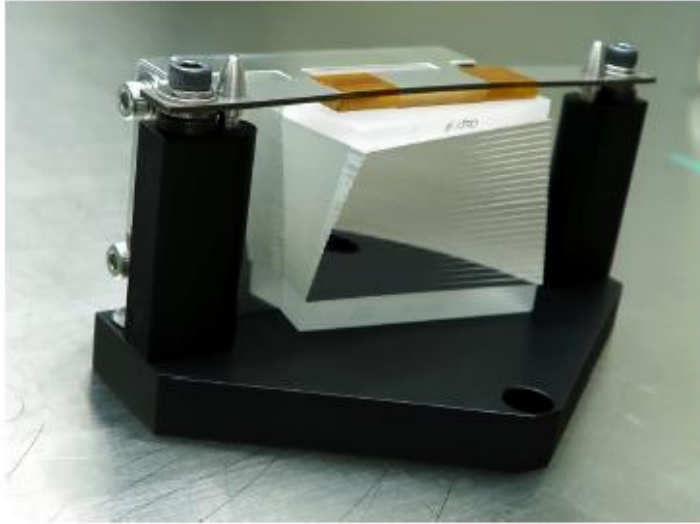
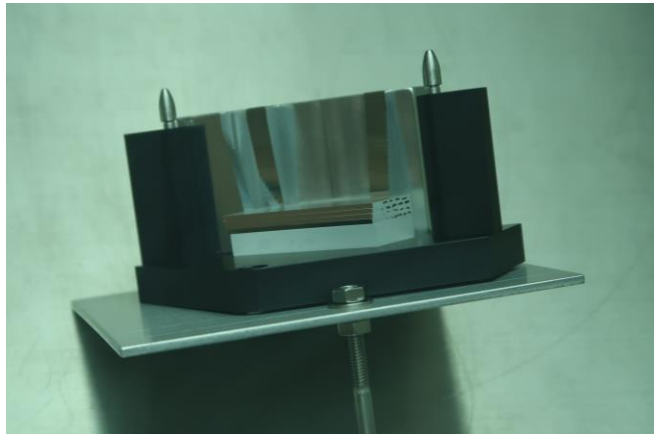


Image slicer



Pupil mirror array



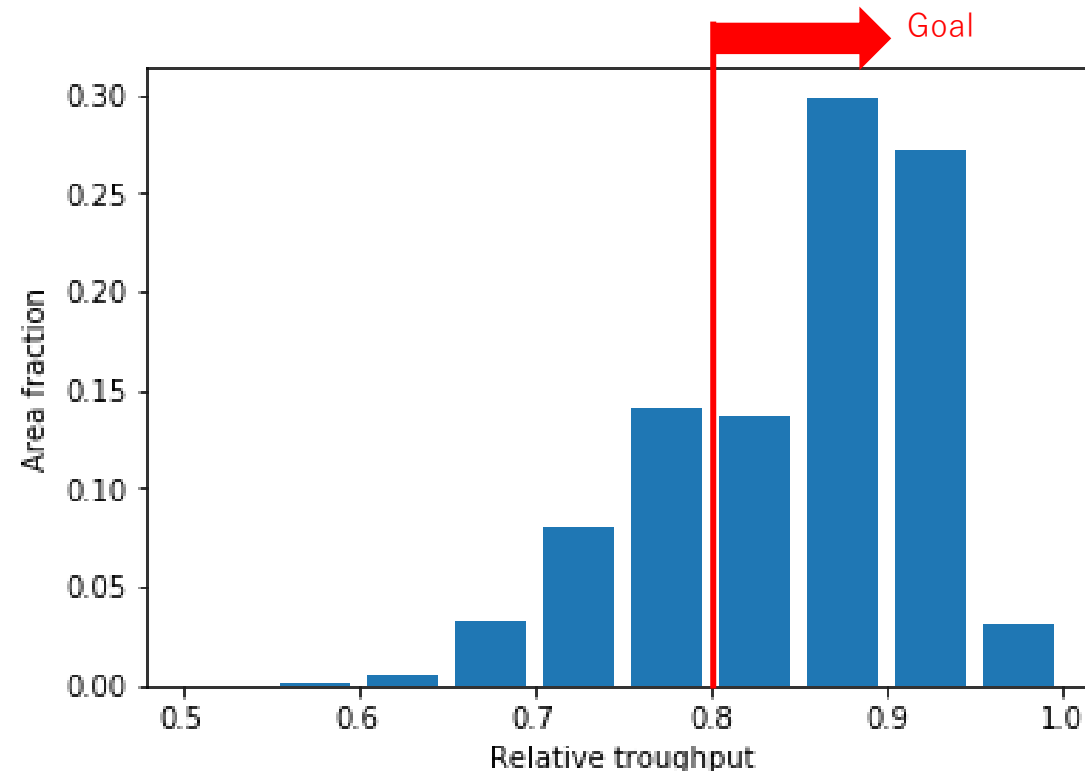
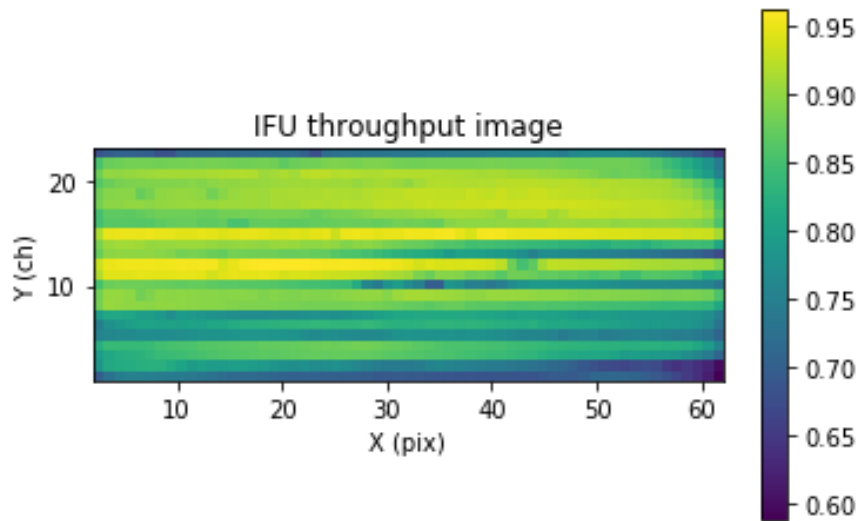
These opt-mechanics were fabricated in NAOJ ATC, and these components were assembled in NAOJ ATC.



Slit mirror array

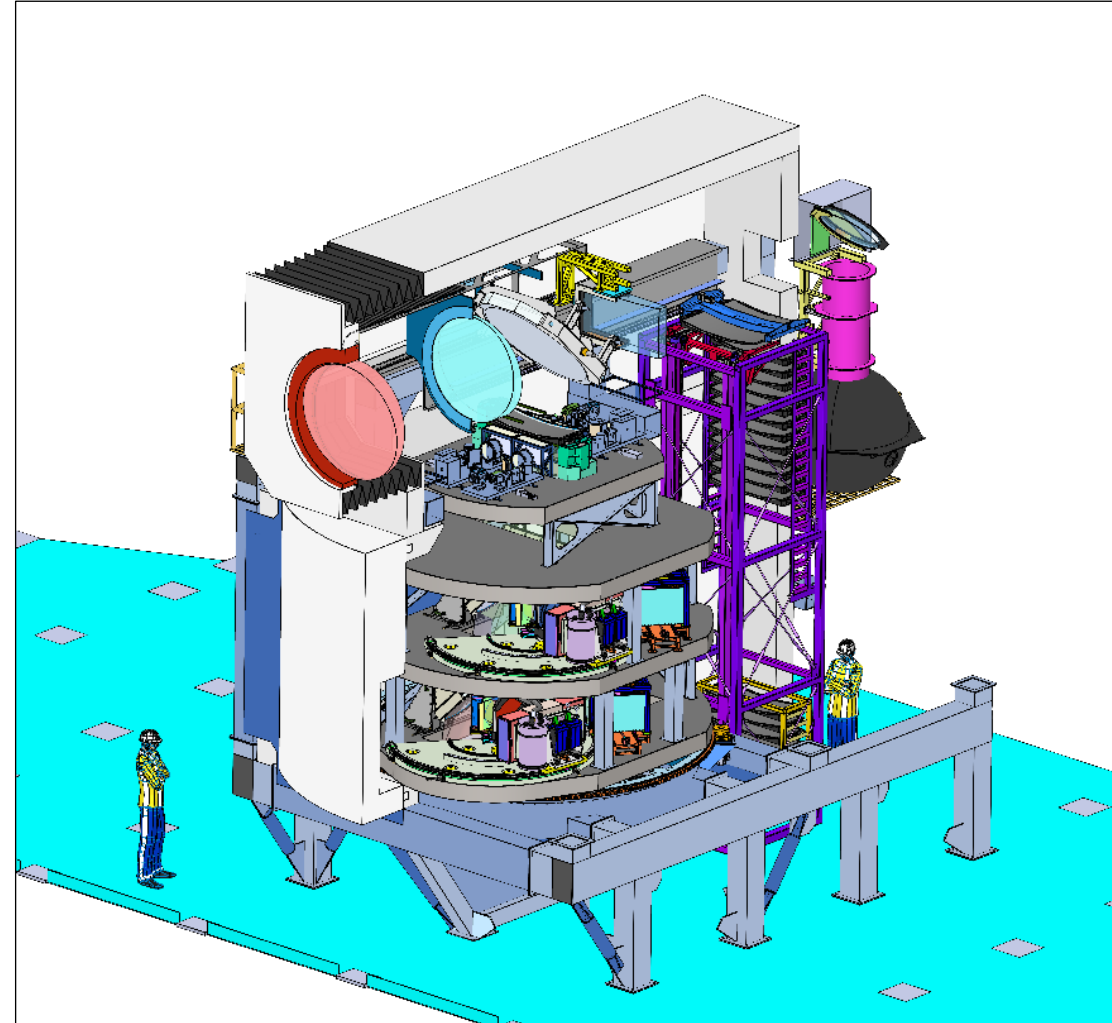
Vignetting of FOCAS IFU

- The vignetting was mainly caused by the assembling error of the slicer due to tight tolerance.
- We started R&Ds toward WFOS IFU right after the completion of FOCAS IFU.



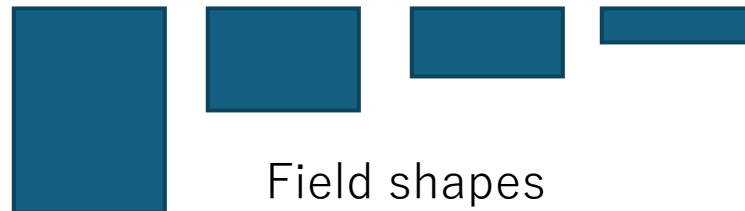
Wide Field Optical Spectrograph (WFOS)

- The development is led by Caltech.
- Observing modes:
 - Imaging
 - Multi-slit spectroscopy
 - (Integral field spectroscopy)
- FoV = 8.3 arcmin $\times$ 3 arcmin
- R~1500, 3500, 5000@0.75" slit
 - R~4500, 10500, 15000@0.25" slit

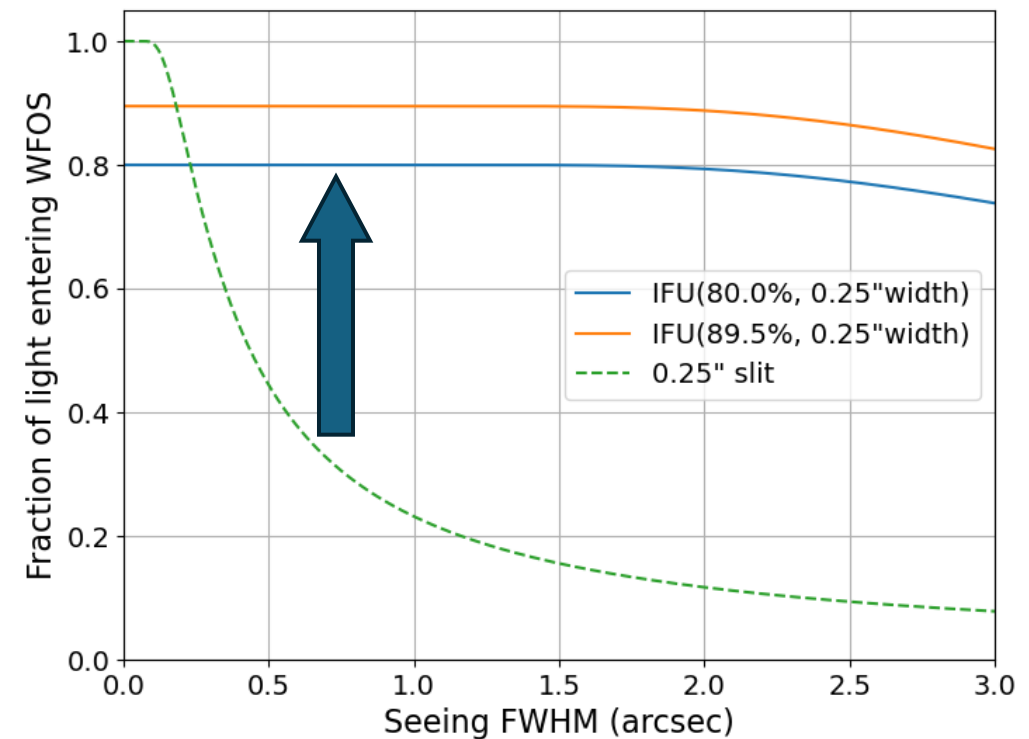


WFOS IFU parameters

Number of slices	18			
Slice length (arcsec)	20			
Slice width (arcsec)	1.5	0.75	0.5	0.25
FoV (arcsec x arcsec)	20 x 27	20 x 13.5	20 x 9	20 x 4.5
Spectral resolution (R) for each grating in the IFU mode*				
R=1500 grating	682	1364	2046	4092
R=3500 grating	1591	3182	4773	9546
R=5000 grating (goal)	2273	4545	6819	13635



Considering a slit loss, IFU has great advantage against the slit spectroscopy.

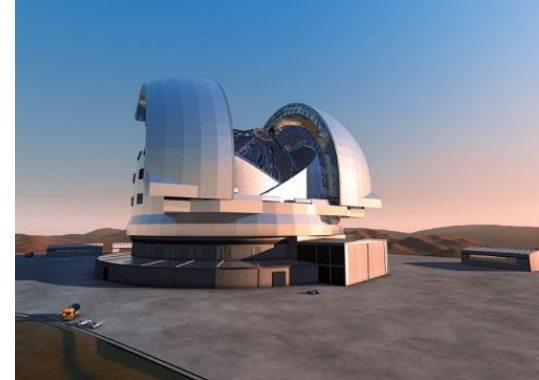


Optical IFUs on other ELTs

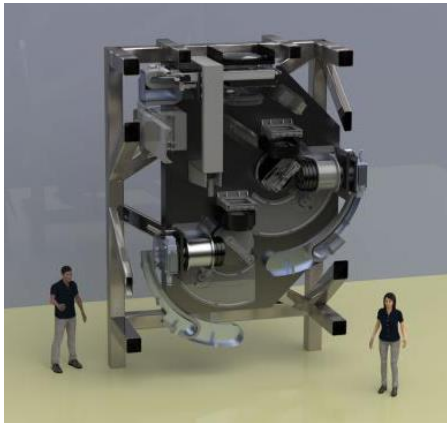
GMT



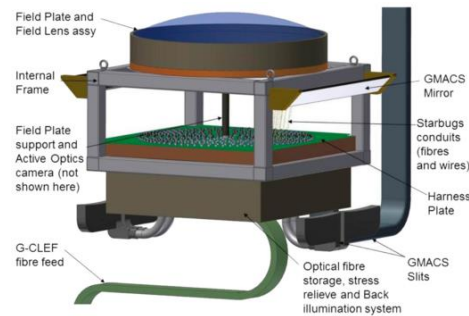
E-ELT



GMACS

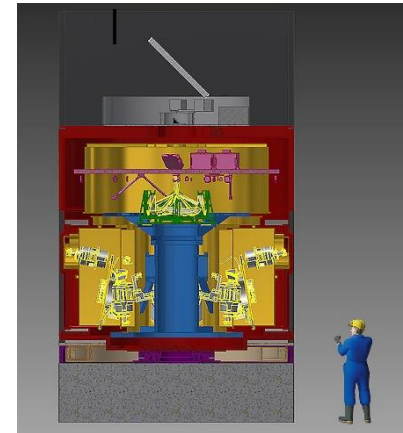


MANIFEST



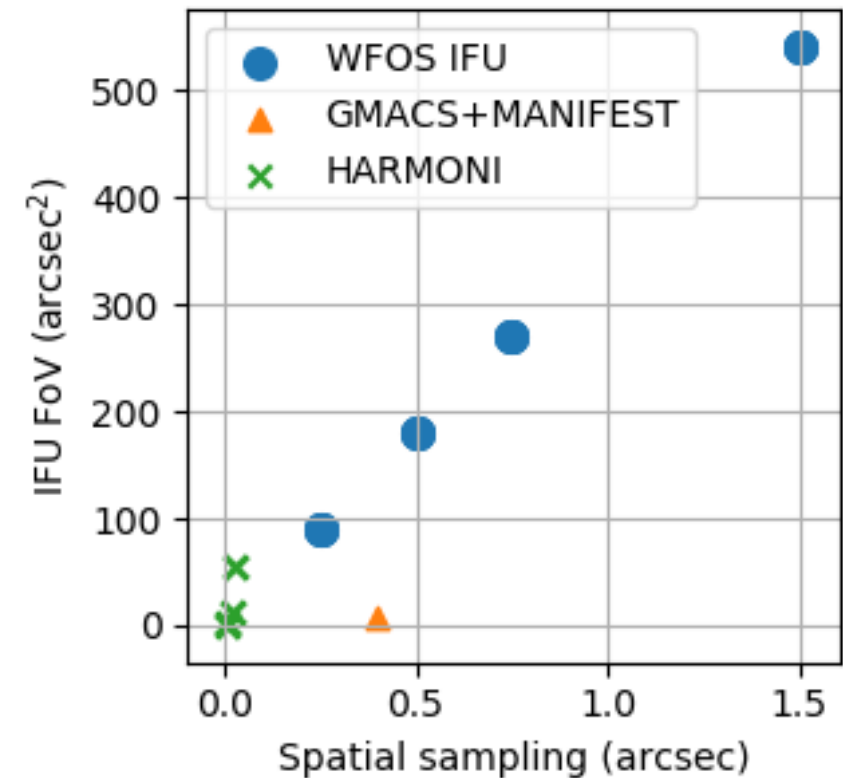
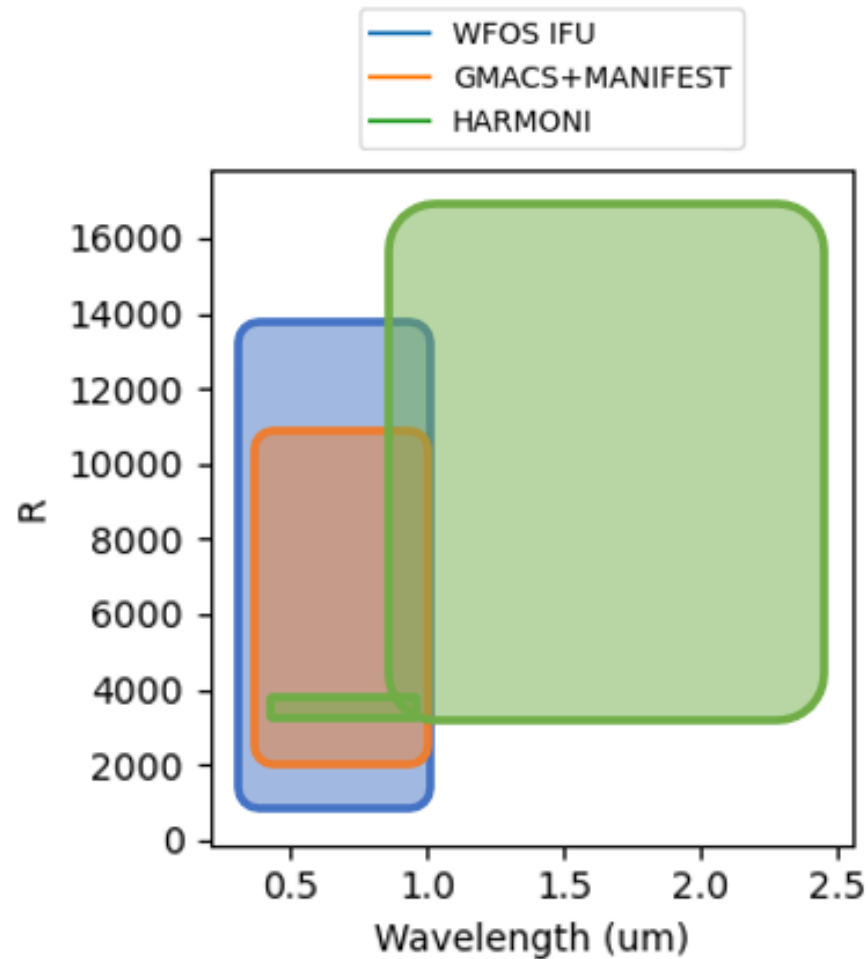
MANIFEST is a fiber feeding module and provides an IFU capability for GMACS.

HARMON



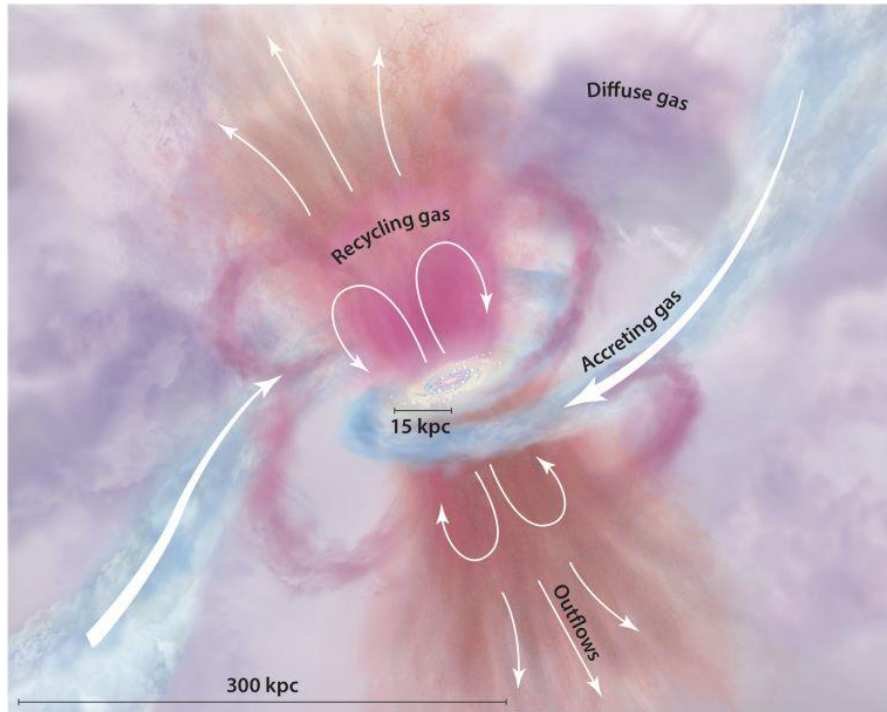
HRMONI for ELT is mainly for near IR, but its sensitivity extends to optical range.

Comparison with other IFUs on ELTs

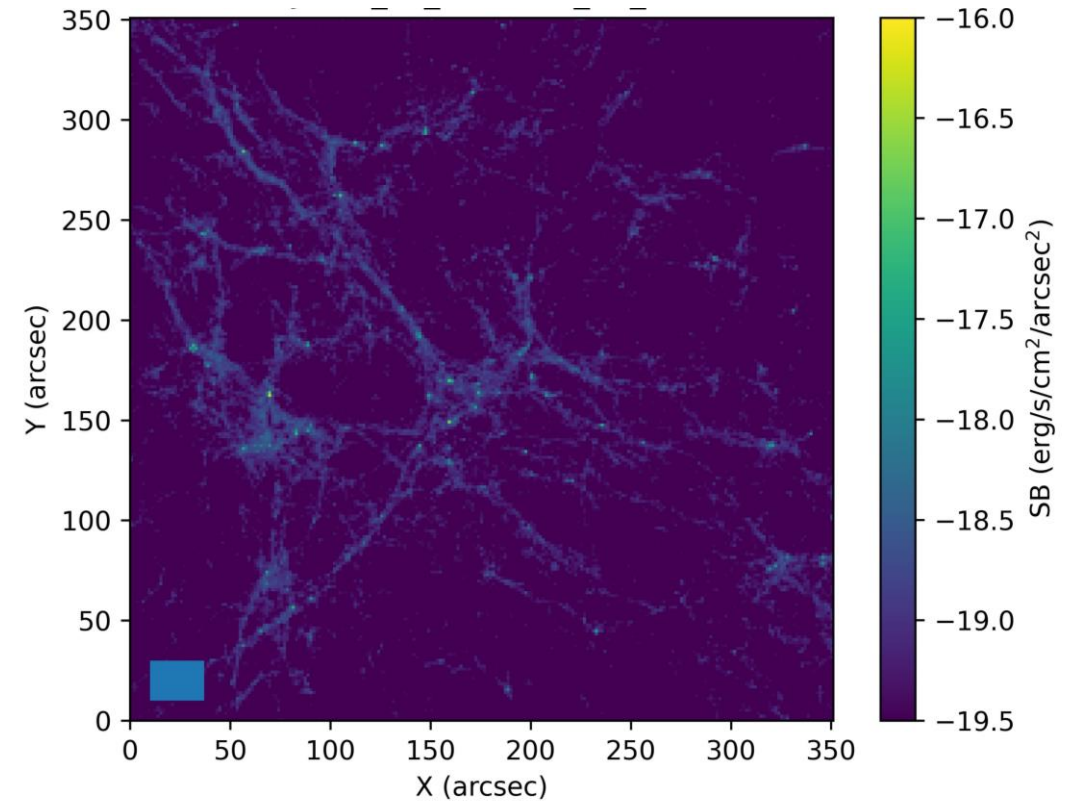


Science cases

- Cosmic web
- Circum-galactic medium (CGM)

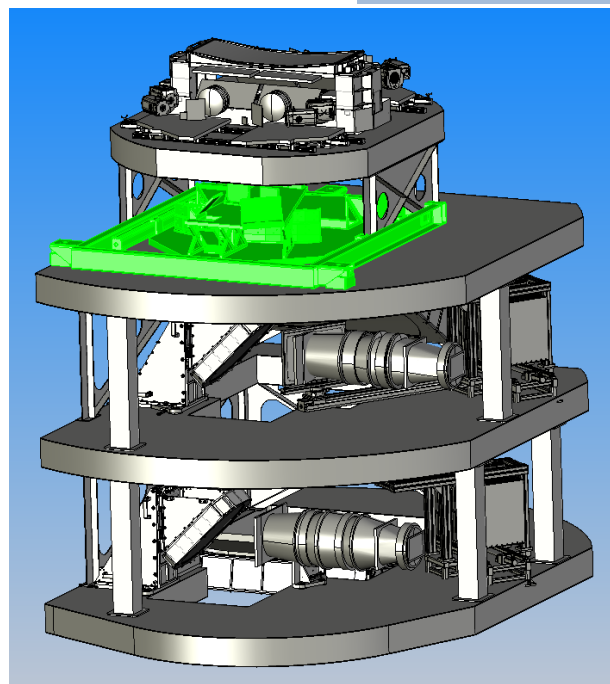
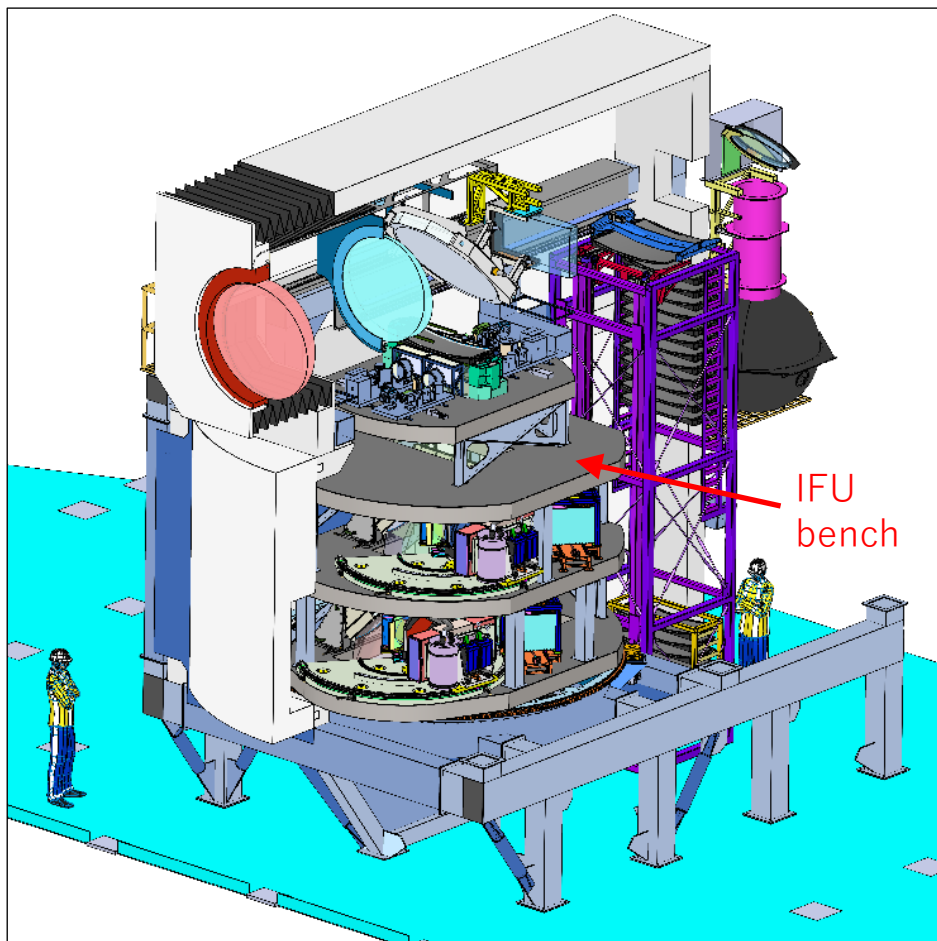
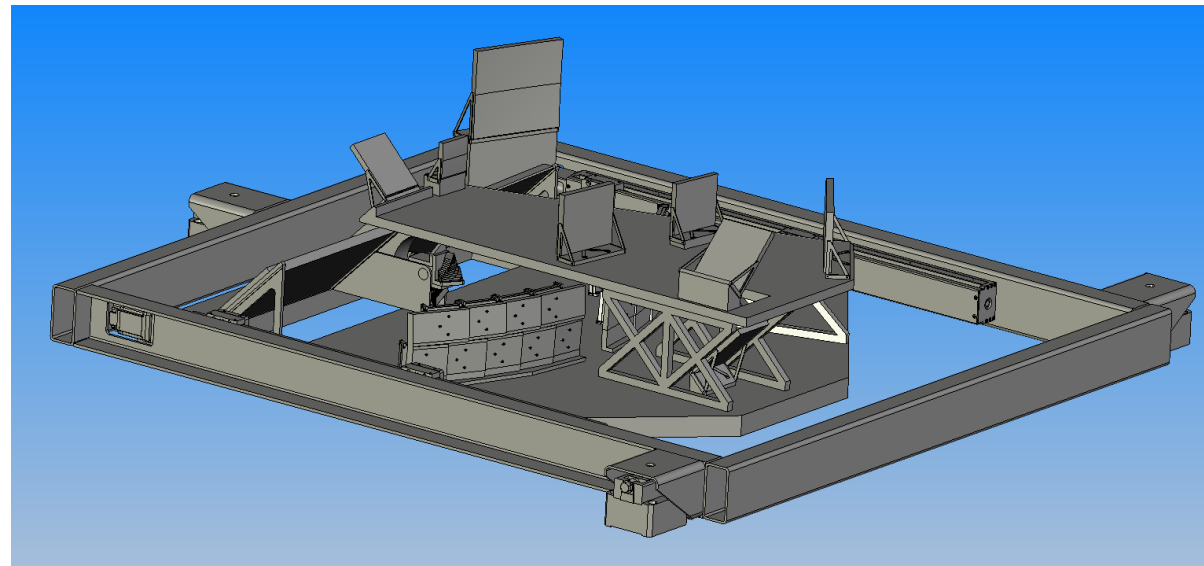


Tumlinson et al. (2017, ARA&A, 55, 389)

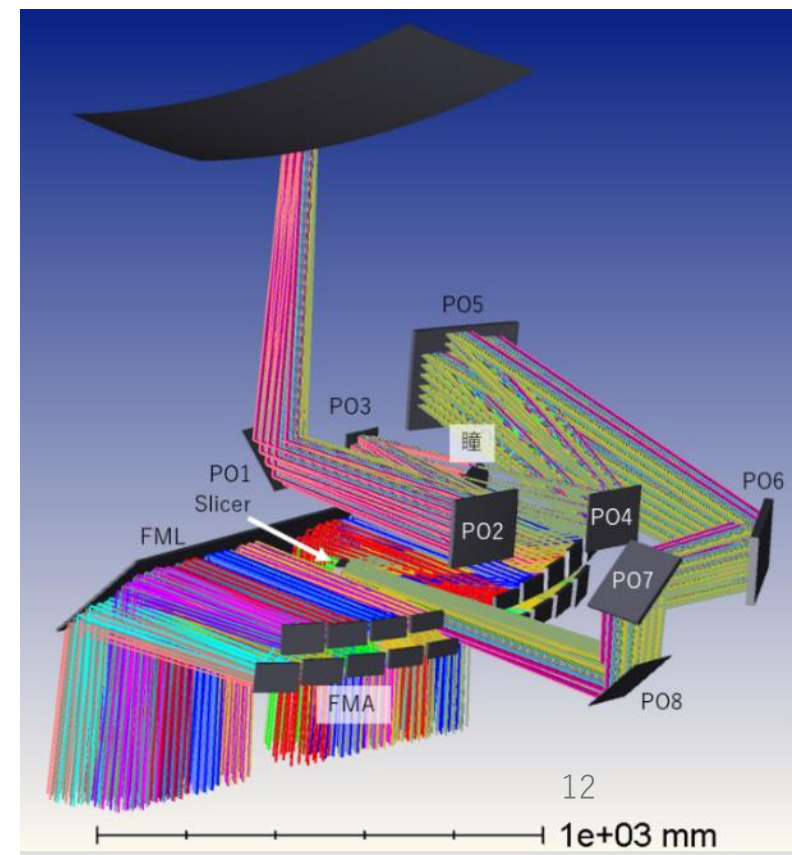


Expected Ly α surface brightness (Yajima et al. 2020)
Lowest level: 1σ detection limit for 10-hour exposure
 $\sim 3 \times 10^{-20} \text{ erg/s/cm}^2/\text{arcsec}^2$

WFOS IFU status

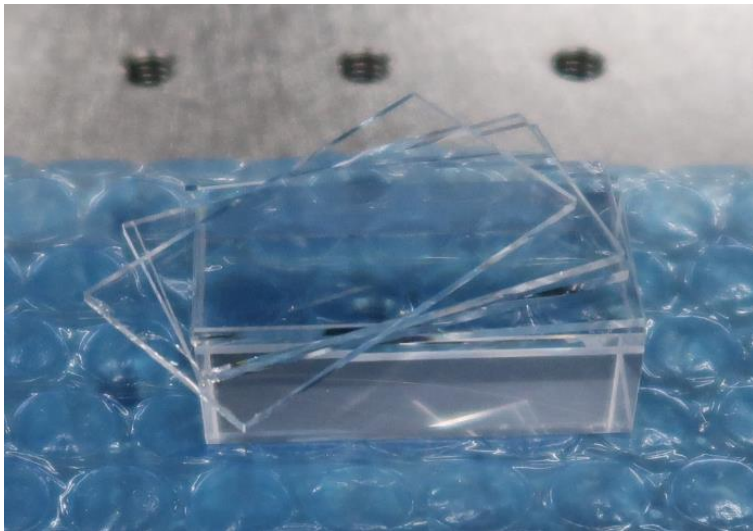


Rotating structure in WFOS

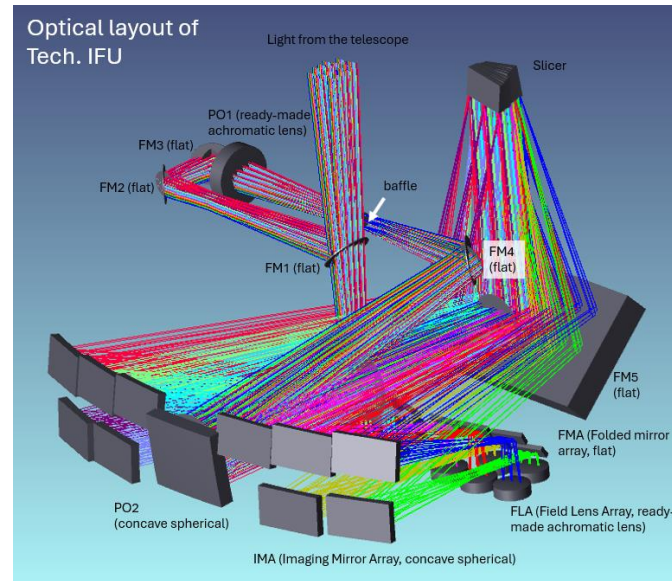


R&D efforts toward WFOS IFU

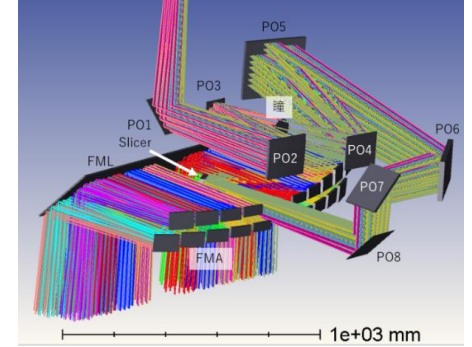
- TMT strategic R&D fund (TMT戦略基礎開発経費) (FY2019, FY2022, FY2023)
- NAOJ Leadership fund (国立天文台リーダーシップ経費) (FY2020, FY2022)
- KAKENHI Grant-in-Aid for Scientific Research (B) (科研費基盤B) (FY2024-FY2027).



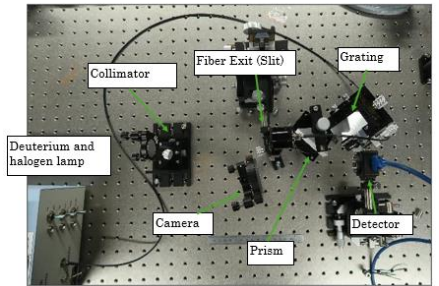
Improvement of the slicer assembling accuracy.



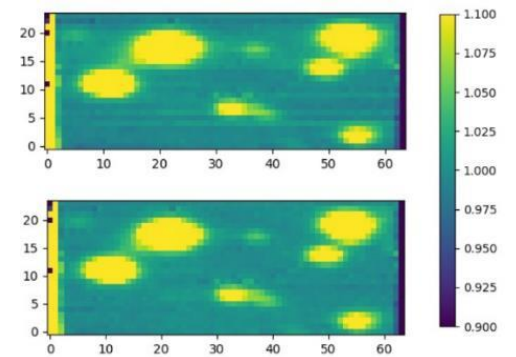
Technology verification IFU (Tech. IFU) (See P20)



Optical layout with loose-tolerance



Reflectivity measurement system



Flat-fielding error correction

Summary

- We developed FOACS IFU.
- Based on the experiences, we are conducting some R&D efforts toward WFOS IFU.
- Our activity has been supported by **TMT strategic R&D fund**, KAKENHI and NAOJ Leadership fund.
- I am very happy if TMT strategic R&D fund supports us continuously!

Acknowledgement

- These developments have been supported by TMT strategic R&D fund, KAKENHI, NAOJ Leadership fund.
- We thank the staff of ATC, TMT-J and Subaru.