IFU for Technology Verification (Tech. IFU)

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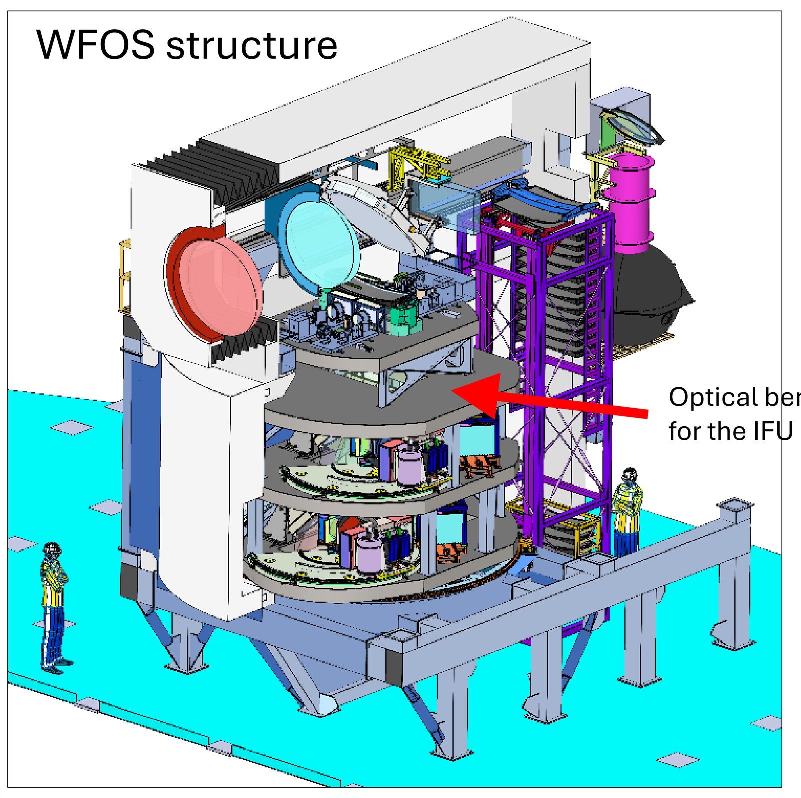
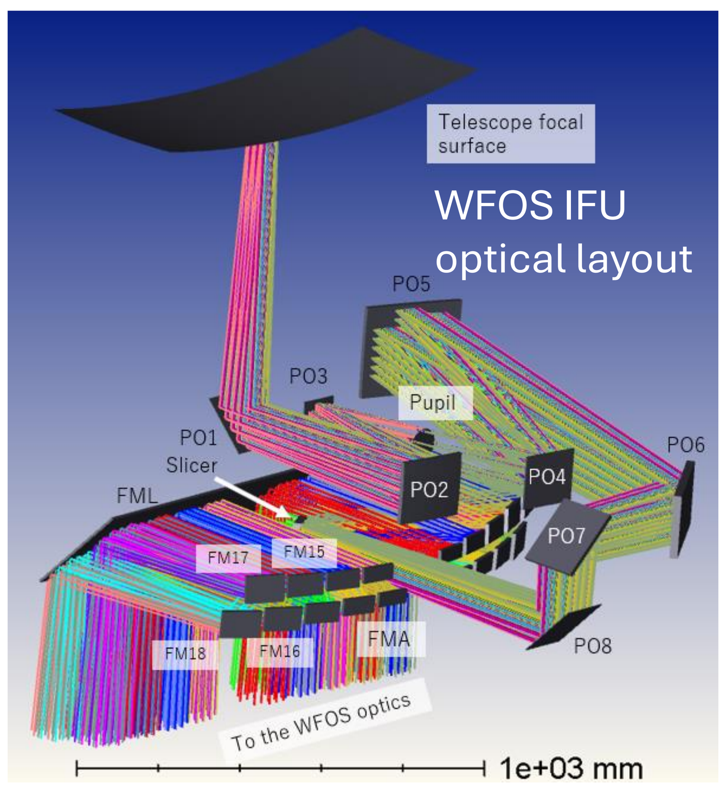
We are aiming to develop an IFU for Wide Field Optical Spectrograph (WFOS), one of the first-generation instruments of TMT, and now conducting some R&Ds on basic technologies for developing the IFU. To verify the technologies, we will develop an IFU (Tech. IFU) installed in Faint Object Camera and Spectrograph (FOCAS). In this presentation, we introduce our activities and the IFU for technology verification.

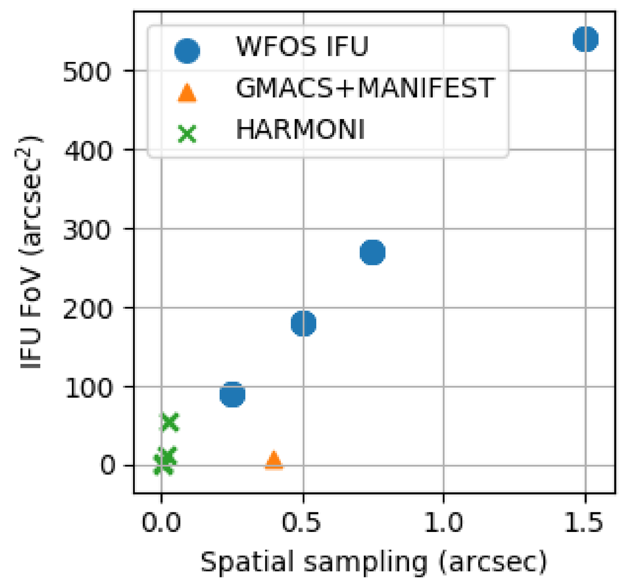
WFOS IFU

WFOS IFU is not a baseline feature of WFOS. However, considering its scientific benefit, we are aiming to develop the IFU as an upgrade. For the upgrade, the current WFOS structure has an optical bench dedicated for the IFU.





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



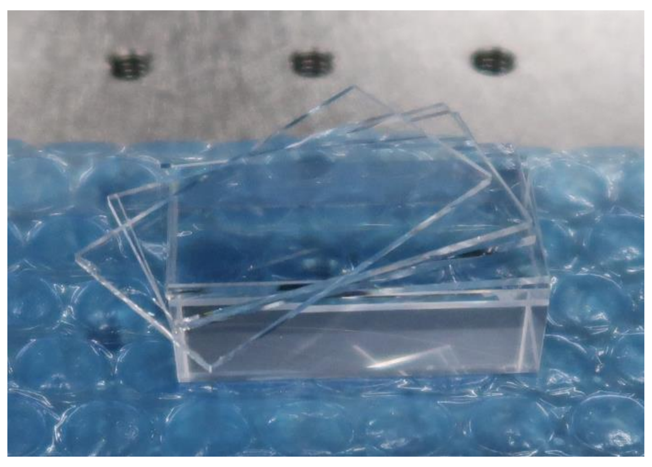
WFOS IFU has 4 slicers which have different slice widths. The wider width modes have outstandingly wider field comparing other IFUs on extremely large telescopes. In the narrowest width mode, the spectral resolution reaches R=13,635 without slit loss.

R&Ds for WFOS IFU

We developed FOCAS IFU for the Subaru telescope. Based on the experience, we identified some technical issues and have conducted R&D efforts for them.

R&D #1. Improving assembling accuracy of a slicer

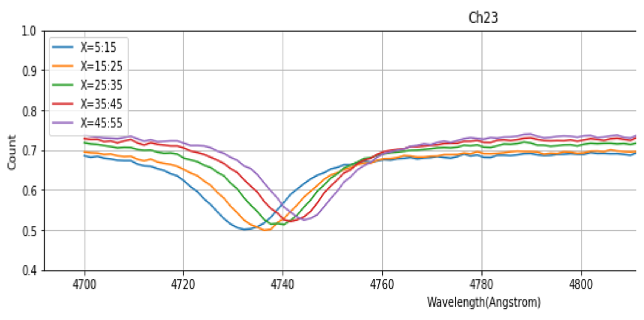
To achieve higher throughput, we adopt high reflective multilayer dielectric coat for all reflective surfaces. However, In FOCAS IFU, we found significant assembling error of the slicer due to deformation of slice mirror substrates caused by large stress of the coat. We are improving the assembling accuracy in collaboration of a company.



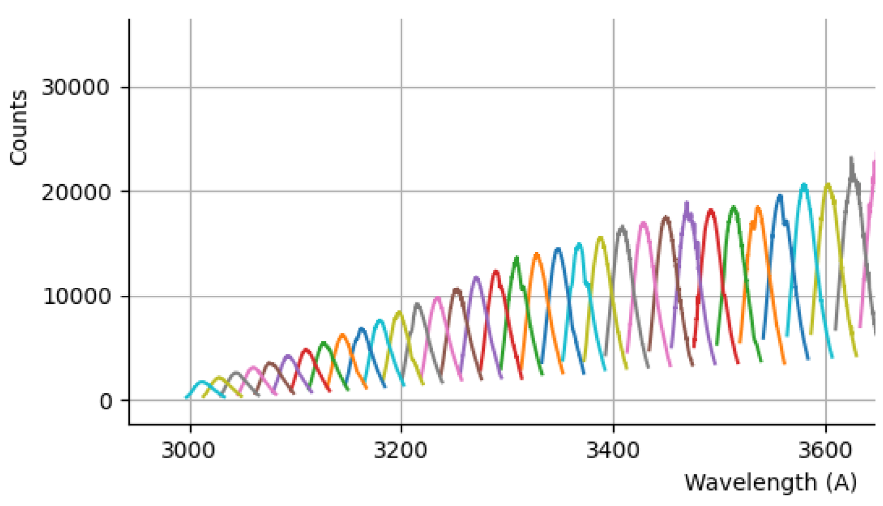
Assembling test result.

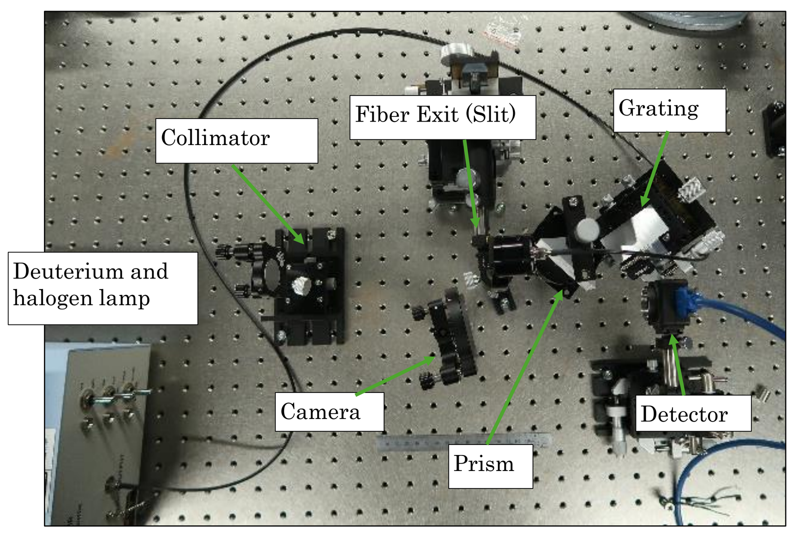
R&D #2. Reflectivity measurement system

The high reflective coat tend to have unexpected absorption features due to coating process error. For the countermeasure, we tune the coat design in which the undesirable features are hard to occur. In addition, we develop a reflectivity measurement system capable of covering the wavelength range of 300 - 1,000 nm with R~14,000 and use it for quality assurance.



Observed unexpected absorption feature in FOCAS IFU.

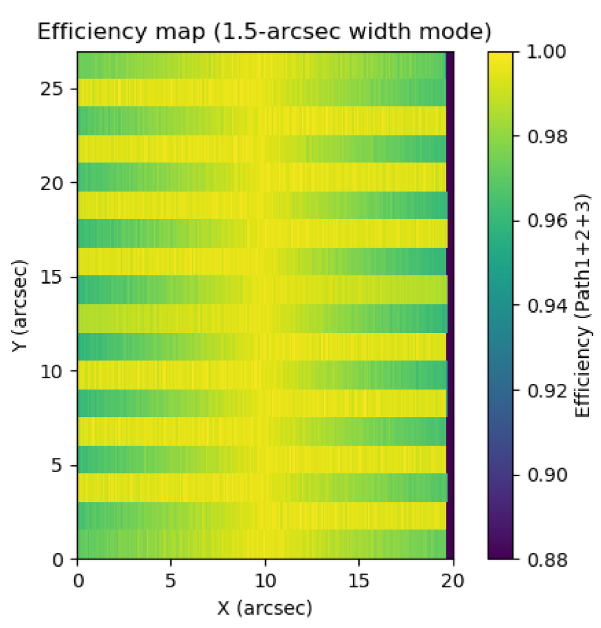




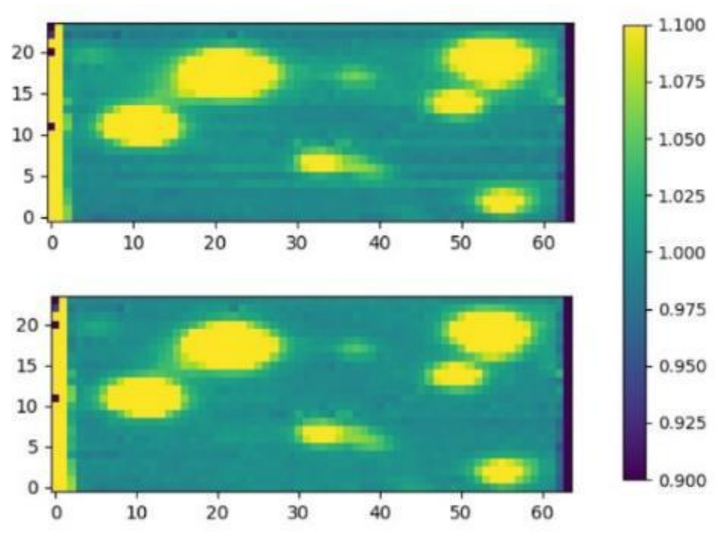
Echelle spectrograph part of the reflectivity measurement system (right) and obtained data (left).

R&D #3. Field flatness correction software

We cannot avoid slight vignetting originating from slicer's step-like structure. It causes systematic error in a flat fielding process. We are developing the correction software.



Estimated vignetting of WFOS IFU



Observed systematic error in FOCAS IFU (top), and preliminary result of the correction software (bottom).

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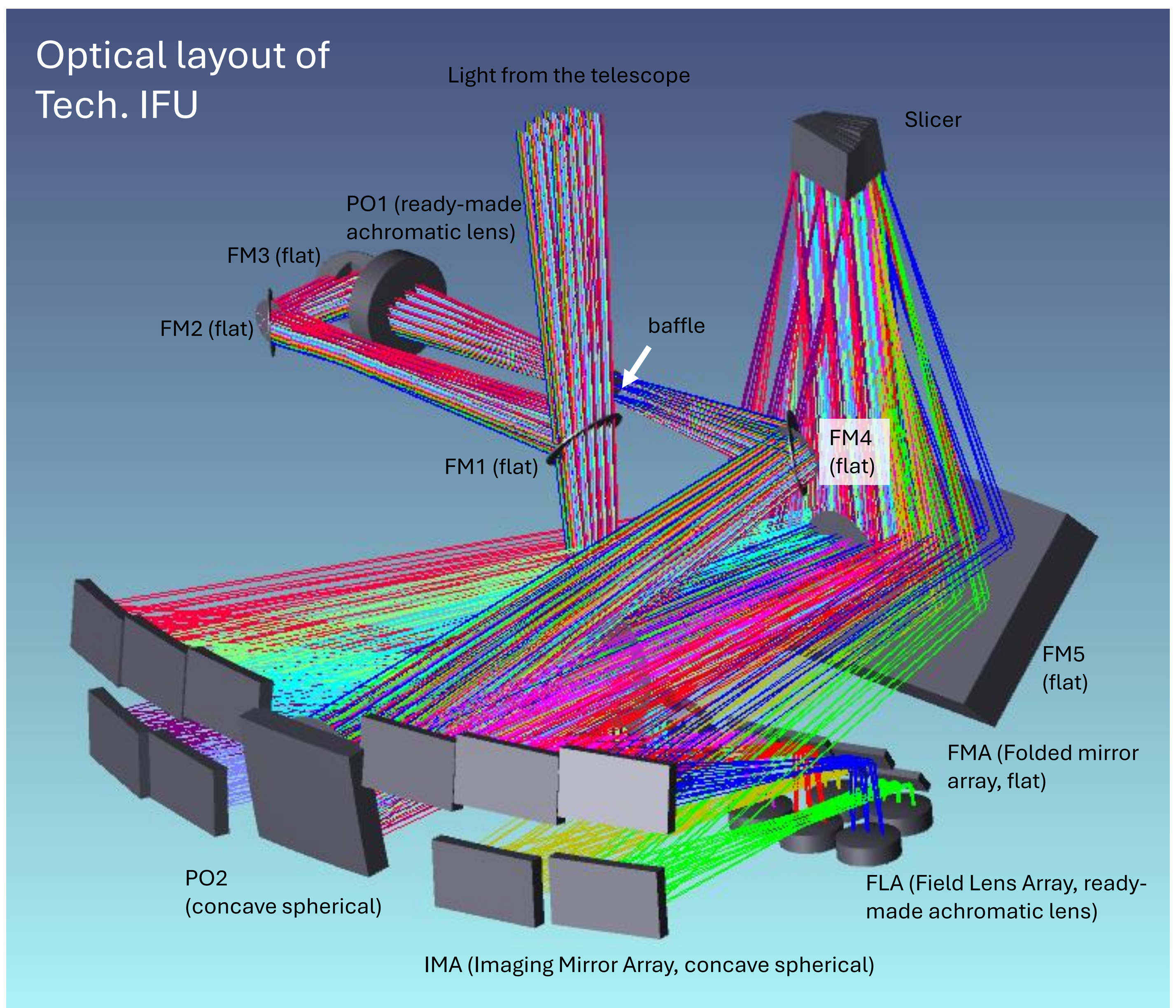


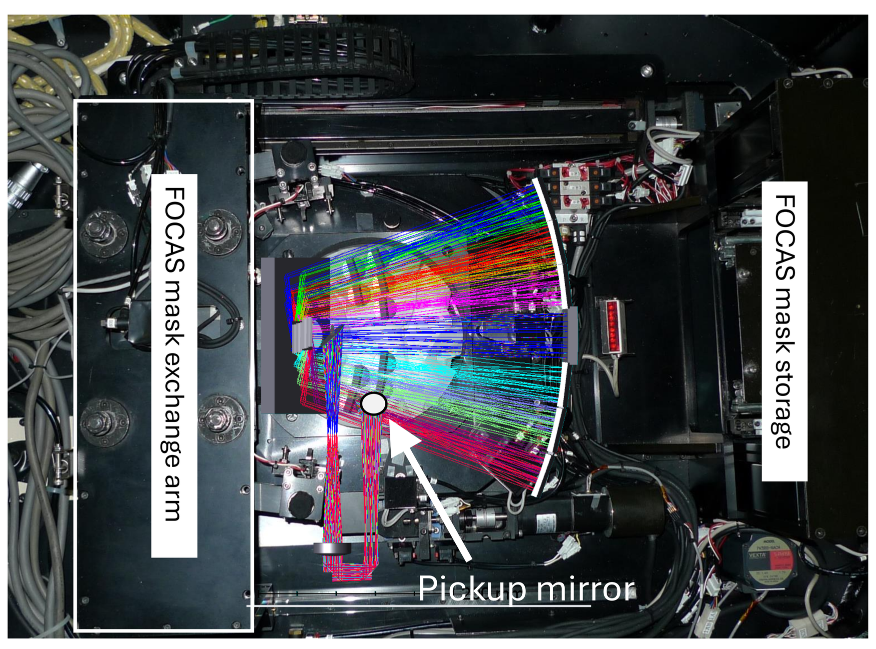
To verify technologies throughout IFU development, we are developing an IFU called as Tech. IFU. Items to be verified are below.

- End-to-end fabrication process of the slicer
- High reflective multilayer dielectric coat without unexpected absorption features
- Development process of the IFU
    - ➢ Designing, tolerance analysis, fabrication, assembly/alignment, optical testing
- Optical alignment process
    - ➢ Each Imaging Mirror have alignment mechanism. Combining with a pupil monitor system, we align the telescope exit pupil, the baffle in the IFU and the baffle in the spectrograph.
- Validity of the field flatness correction software

Tech. IFU focuses on the technology verification and uses ready-made products for non-essential parts. Tech. IFU is close to the end of the conceptual design phase and will complete by FY2026.

Parameters of Tech. IFU

Number of slices	10
Slice width	1.8 arcsec
Slice length	20 arcsec
FoV	20 x 18 arcsec^2
R@VPH680	1389



Tech. IFU in FOCAS