PO-17P

IFU for Wide Field Optical Spectrograph (WFOS) on TMT

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We present the conceptual design of the integral field unit (IFU) for Wide Field Optical Spectrograph (WFOS)[1], one of the first-generation instruments on TMT. WFOS is a multi-purpose imaging spectrograph covering a UV/optical range (0.31 - 1.0 μm) with high throughput. Although the IFU is not a baseline of WFOS, it is a promising upgrade path of WFOS.

Concept

The IFU will be installed between the telescope focal surface and the first collimator mirror of WFOS. WFOS has a dedicated bench for the IFU (Fig. 1). The slicer slices a relayed image and reflected each sliced image to the relevant folded mirror. The folded mirror reflects the light to the WFOS optics. Seeing from WFOS, the virtual pseudo slits are created at the telescope focal surface.

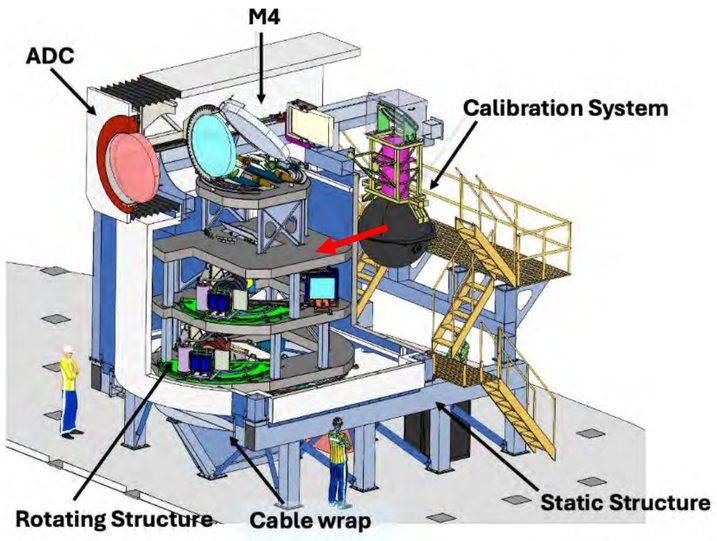


Fig. 1 WFOS structure. It has a dedicated bench for the IFU (red arrow).

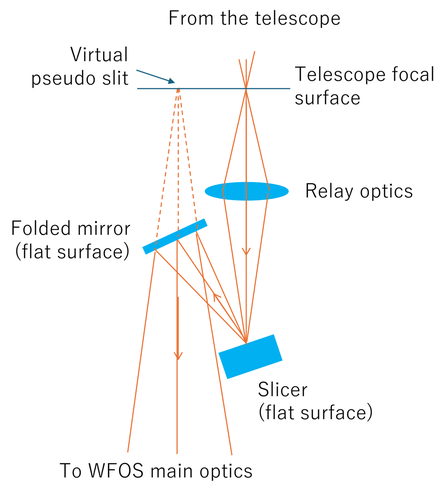


Fig. 2. Schematic diagram of the optical layout. Only one channel is shown.

Optical Layout

The relay optics (PO1-8) reimages an object image on the slicer. The IFU has 4 slicers with different slice widths, offering different field-of-views and different spectral resolutions (Table. 1).

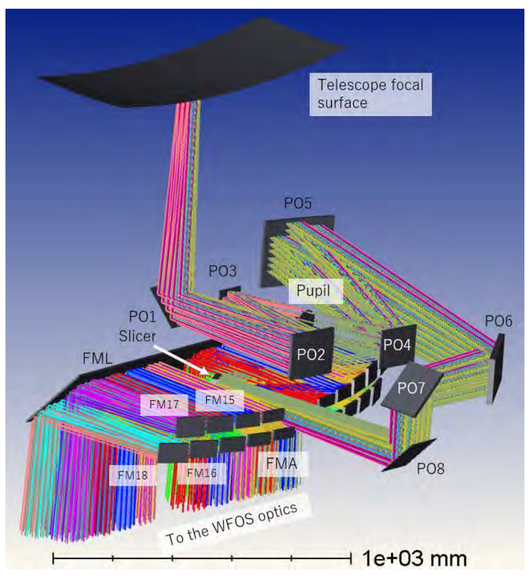


Fig. 3 Optical layout of WFOS IFU.

Tab. 1 Parameters of WFOS IFU

Number of slices	18			
Magnification factor of relay optics	1.1			
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 has 3 gratings (R=1500, 3500, 5000 for a 0.75-arcsec slit). The expected spectral resolutions for each grating are simply calculated from the physical pseudo slit width seen from the instrument.

Comparison with other optical IFUs on ELTs

On GMT, the fiber feed module, MANIFEST[2] provides an IFU capability to GMACS[3]. It focuses on a multi-object spectroscopy, and hence the FoV for one IFU is narrow (1.0 – 1.5 arcsec in diameter).

On E-ELT, there is HARMONI[4], which is basically a near-IR integral field spectrograph but has the sensitivity down to 460 nm only for the R~3,000 grating. HARMONI adopts very fine sampling, and hence its FoV is very small.

WFOS occupies complemental parameter space; wide FoV but modest sampling.

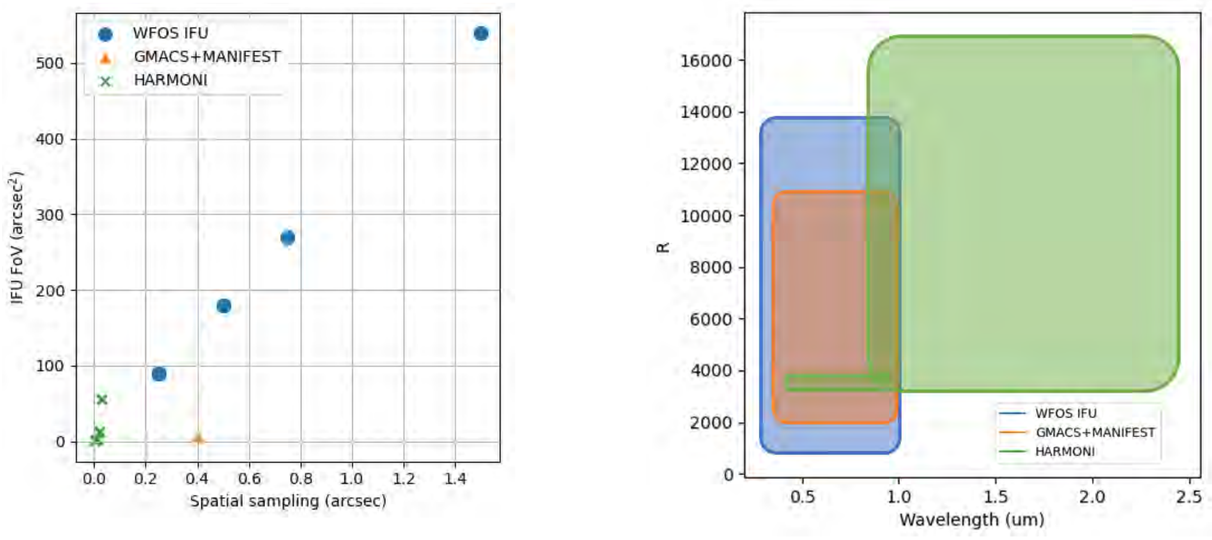


Fig.4 Comparison between WFOS IFU, GMACS+MANIFEST and HARMONI.

Expected sensitivity

1-sigma detection limit for a 10-hour exposure is expected to be ~$10^{-19.5}$ erg/s/cm^2/arcsec^2 (Fig. 5). This sensitivity can detect Lyα emission from the intergalactic medium even at z~6 (Fig. 6). In this estimation, integrated space in a data cube is 1.5” x 1.42” x 12.5Å (440km/s). Entire emission line flux is assumed to be included in the 12.5-Å width.

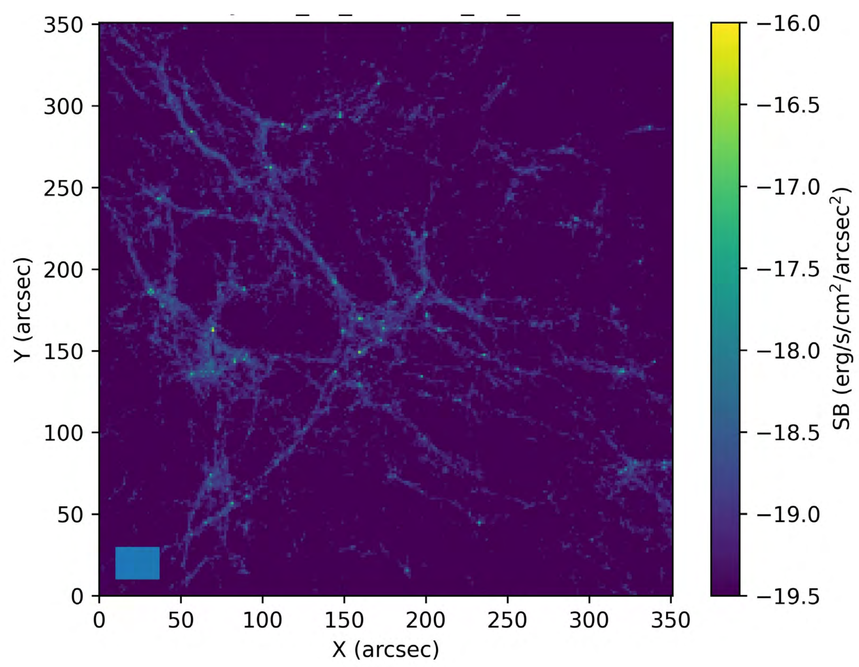


Fig. 6 Expected Lyα surface brightness at z=6 [5]. The box at the bottom left shows the largest WOFS IFU field (20 x 27 arcsec^2).

Current status

WFOS IFU is in the conceptual design phase. Figure 7 shows the conceptual IFU structure. The main flame (purple) of the IFU is mounted on the IFU bench with the three leveling blocks (green). The IFU can be deployed using two linear guides (blue).

We are also conducting some R&Ds for the slicer-type IFU. One major item is to establish a manufacturing method of a slicer (Figure 8).

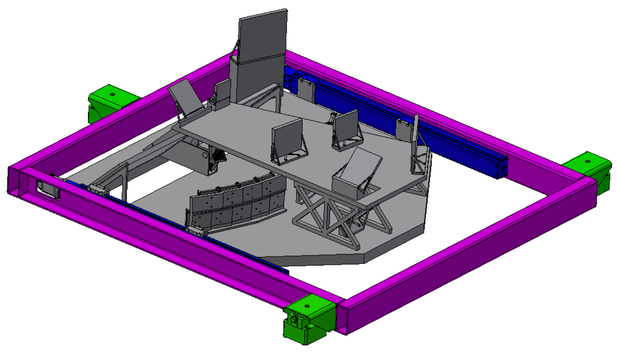


Fig. 7 Conceptual IFU structure.

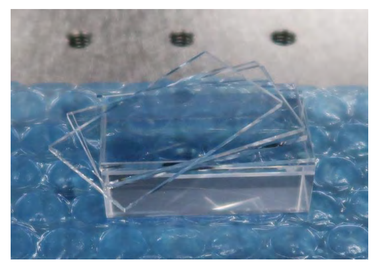
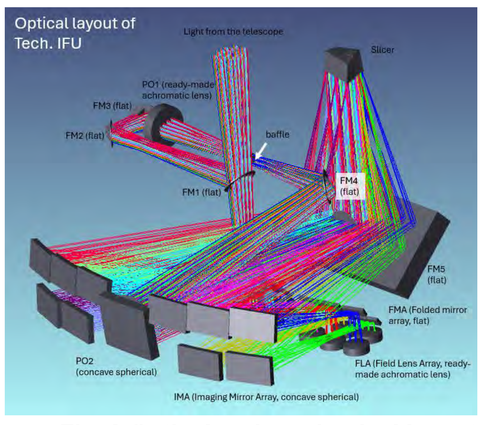


Fig. 8 Assembly test of a slicer.

To verify technologies obtained from the R&Ds, we will develop a technology verification IFU (Figure 9) and install it to the optical spectrograph, FOCAS, on the Subaru telescope.



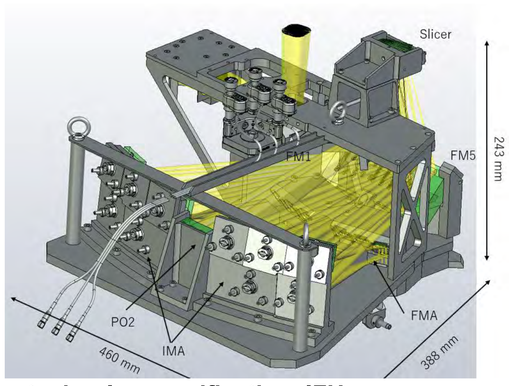


Fig. 9 Optical and mechanical layouts of the technology verification IFU.

[1] Steidel et al., 2022, Proc. SPIE, 12184, 1218423
[2] Zafar et al., 2022, Proc.SPIE, 12184, 1218417
[3] DePoy et al., 2018, Proc. SPIE, 10702, 107021X
[4] Thatte et al., 2020, Proc. SPIE, 11447, 114471W
[5] Yajima et al. 2022, MNRAS, 509, 4037