Development of an integral field unit (IFU) with an image slicer

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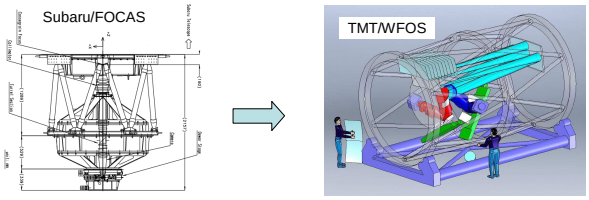
We are developing an integral field unit (IFU) with an image slicer for TMT. The prototype IFU will be installed into the optical imaging spectrograph FOCAS on the Subaru telescope to verify the performance and to carry out some science projects. We have finished the basic investigations, and the parameters of the prototype IFU for FOCAS are as follows; Field of view is 13.5 x 10.0 arcsec^2. Slice width is 0.4 arcsec. Number of slices is 25. We are planning to make test fabrications for the slicer and the pupil mirror array. First light is expected in 2012. Based on the results, we are keen to develop the IFU for WFOS/MOBIE to enhance its versatility. In this poster, we will show the IFU layout, the parameters, and the current status.

1, Our plan



First, we develop the IFU for the optical imaging spectrograph, FOCAS, on the Subaru telescope. Then, we will start to investigate the IFU for WFOS on TMT.

2, Why image slicer type IFU

An image slicer type IFU can use most efficiently detector imaging area than other type IFUs. We can cover wider field of view or wider wavelength range.

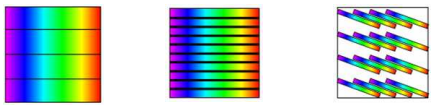
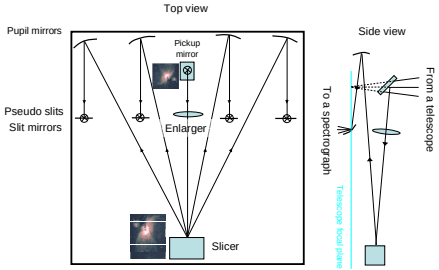


Image slicer type | Fiber type | Lenslet array type

Figures are from IFS wiki (http://ifs.wikidot.com/).

3, Optical layout

We referred and modified the optical layout of the GNIRS IFU (Allington-Smith et al., 2006, MNRAS, 371, 380) at the Gemini telescope.



1, Light from the telescope is reflected by the pickup mirror.
2, Then, the enlarger creates the magnified image on the slicer.
3, The slicer slices the image and delivers the light to each pupil mirror.
4, Pupil mirrors create pseudo slits with the same F ratio as the telescope.
5, Slit mirrors reflect the light to the spectrograph and make the IFU exit pupils at infinity.

4, Parameters

	FOCAS / Subaru	MOBIE / TMT†
Slice width (arcsec) *	0.4	0.4
FOV (arcsec^2)**	13.5 x 10	17 x 12
Number of slices	25	30
Fore-optics magnification	3.8	3.8
Slice dimension (mm x mm)	24.9 x 0.737	140.9 x 3.32
Pupil mirror size (mm)	~6	TBD
Slit mirror size (mm)	~7	TBD

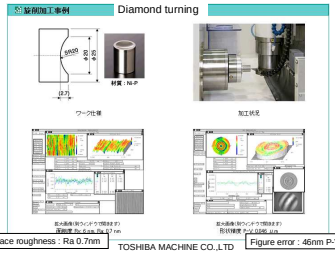
* : Fixed parameter

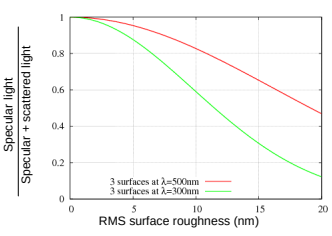
**: Aspect ratio of FOV is fixed to be about 1.4.

†: The values for MOBIE are preliminary.

5, Possible fabrication methods

Method	High precision machining	Polishing
Material	Metal	Glass
Fabrication speed	○	△
Aspheric surface	○	△
Monolithic fabrication	○	×
Surface roughness	△	○

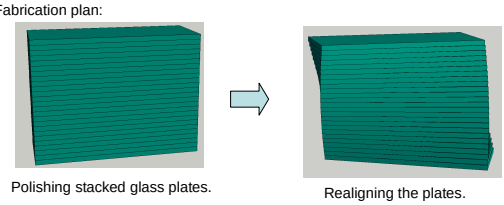




5, Slicer

Because slicer surface has curvature, it is very difficult to be fabricated with high precision machining. Polishing method is adopted for slicer fabrication.

Fabrication plan:



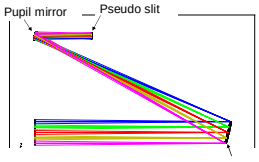
Polishing stacked glass plates. | Realigning the plates.

We are planning to prototype a slicer with 5 or 6 slice mirrors.

6, Pupil mirrors

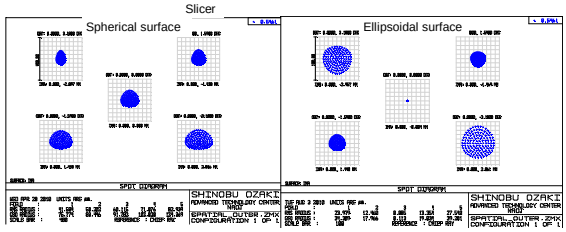
Spherical surface causes large aberration due to large angle in the edge channels.

Ellipsoidal surface is adopted for pupil mirrors because of smaller aberration.

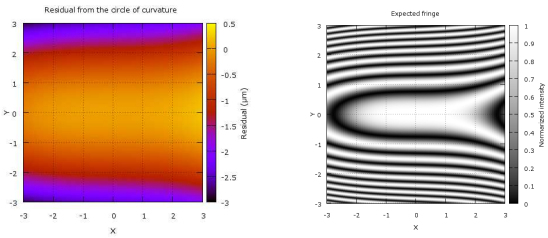


Comparison of the spot diagrams. Slicer and pupil mirror are only considered. The other optical components are assumed to be ideal lens.

0.1 arcsec FWHM ~ 20.6μm rms radius



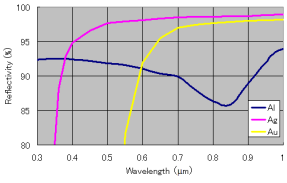
We are planning to make test fabrications with both high precision machining and polishing methods. After comparing between two methods, we decided a fabrication method.



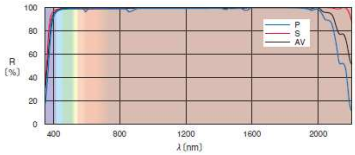
Residual from the circle of curvature (left), and expected fringe pattern observed with an interferometer (right). We can measure these ellipsoidal surfaces.

7, Coating for the mirrors

The IFU has many mirror surfaces, so high reflectivity is required for the mirrors.
We will apply broadband multi-layer dielectric mirror coatings.
These coatings are usually made on glass base plates. We have to check the performances of the coating on metal surface (e.g. durability).



Reflectivity of the metal coatings.



Example of the broadband multi-layer dielectric mirror coatings. (From Sigma Koki web page http://www.sigma-koki.com/)

8, Future works

- Detailed optical design and tolerance analysis. (in progress)
- Test fabrications (2011)
  - Slicer with polishing
  - Pupil mirror with both high precision machining and polishing
  - Dielectric coating on metal surface
- Mechanical designs, fabrications, and performance verifications of the IFU for FOCAS. (2011-2012)
- Installation to FOCAS and commissioning observations on the Subaru telescope. (2012)
- Start investigations for the IFU for WFOS/MOBIE. (from 2013)