Development of FOCAS IFU

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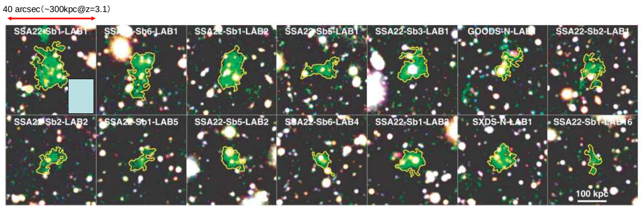
We are developing an integral field unit with an image slicer for the existing optical spectrograph FOCAS on Subaru telescope. Basic optical design has already finished. The slice width is 0.4 arcsec, the slice number is 24, and the field of view is 13.5 x 9.6 arcsec^2. We introduce our project in this poster.

Science cases

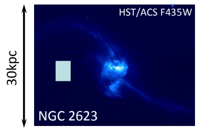
What evolutionary stage of Lyα blobs is?

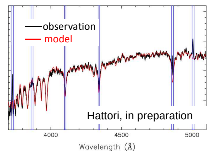
Many Lyα blobs have been detected by narrow-band imaging surveys. Much more Lyα blobs are expected to be found with Hyper Suprime-Cam. Those are supposed to evolve into massive galaxies, but evolutionary stage of Lyα blobs in galaxy evolution is not clear. We can get some clues from gas dynamics.

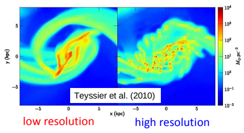


Lyα images of Lyα blobs taken with Suprime-Cam (Matsuda et al. 2011, MNRAS, 410, L13).
Rectangle in the figure shows the field of view of the FOCAS IFU.

How is star forming events going on in merging galaxies?

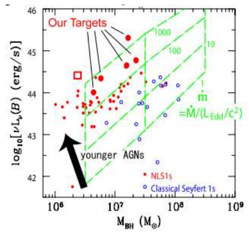






High-quality optical spectroscopy can reveal past (~10^8-10^9 years ago) star formation activity. in galaxies. Combined with radio/IR observation which traces current dusty star formation, we can reveal how stars are formed during galaxy interaction/merging. Because recent observations and high-resolution numerical simulations suggest the importance of spatially extended star formation in early stages of galaxy interaction, IFU is critical to such observation. Those knowledge will lead us to understand how star formation occurs in interacting/merging galaxies and how galaxies develop their structure and morphology.

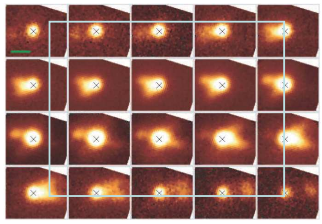
How does the co-evolution proceed?



Most galaxies are thought to have massive black holes, and many observational studies suggests co-evolution of galaxies and massive black holes. We are investigating the co-evolution model by using narrow-line Seyfert 1 galaxies which are supposed to be in early evolutionary phase of AGNs.

B-band luminosity of nearby active nuclei as a function of M_{BH} (Kawaguchi 2003, ApJ, 593, 69). Narrow-line Seyfert 1 galaxies (red symbols) have relatively larger mass accretion rate and smaller M_{BH}, which suggest early phase of AGN evolution.

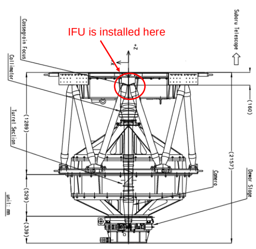
How large are impacts of AGN outflows on host galaxies?



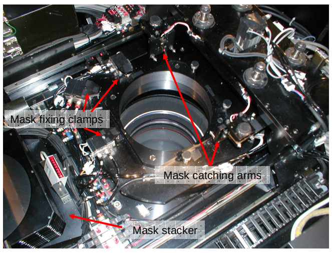
AGNs are supposed to affect host galaxy evolutions in some level. Distant AGNs which are in early phase of evolution are direct way to investigate AGN feedbacks, but those objects are difficult to observe. Some nearby AGNs showing outflow features are another probe to AGN feedback. For those objects, we can observe structures and hence study AGN outflow phenomena in more detail.

[OIII]5007 velocity channel map of NGC 1052 (Sugai et al., 2005, ApJ, 629, 131). Green line shows 1 arcsec scale. Spatial resolution is ~0.4" and R~1200. Large rectangle in the figure shows the field of view of the FOCAS IFU.

Project outline

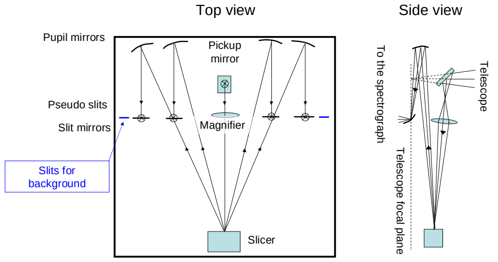


FOCAS/Subaru



FOCAS mask exchanging system

Our IFU is installed into the mask exchanging system. The IFU is stored in the mask stacker as one of mask plates. The mask catching arms pick it up and put on the mask stage at the focal plane, and the mask fixing clamps fix it.



FOCAS IFU parameters

FoV	13.5" x 9.6"
Slice width	0.4"
Slice number	24
IFU throughput	> 80%
Size	300 x 210 x ~70 mm
Mass	~ 1kg

1, Light from the telescope is reflected by a pickup mirror.

2, A magnifier reimages on a slicer with a proper magnification factor.

3, The slicer slices the image and delivers light to corresponding pupil mirrors.

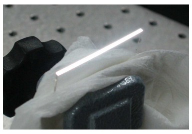
4, The pupil mirrors match the F ratio to the telescope and make pseudo slits.

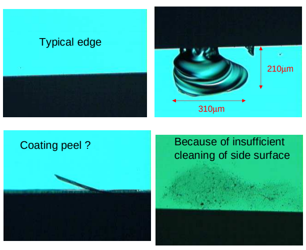
5, Slit mirrors match the exit pupil place to the telescope and deliver the light to the spectrograph.

Current status

Slice mirror test fabrication

Specifications
- Thickness 1.04mm
- Length 41mm
- Number 24
- Curvature radius 500mm
- Wavelength range 370-1,000nm
- Reflectivity >98%





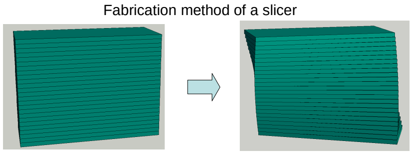
Only three edge chips larger than 100μm among all slice mirrors.

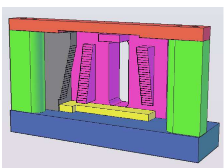
4% light loss

There were some defects, but those are not significant for the expected performance.

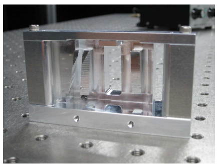
Test fabrication of a slice mirror alignment jig

Fabrication method of a slicer





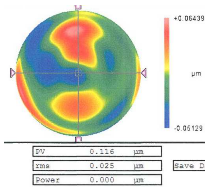
3D model of the jig

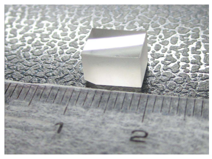


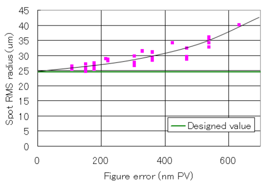
The jig manufactured at NAOJ/ATC

Slice mirrors are aligned by piling them and attaching those rear and side surfaces to steps of the jig.

Test fabrication of a off-axis ellipsoidal surface







Polishing was made with a magnetorheological finishing (MRF) machine produced by QED technologies. Deviation from the designed surface is 116 nm PV. This value is confirmed to be good enough from ZEMAX simulations.

Future works

1, Test assembly of a slicer with the prototype jig.

2, Design of a pupil mirror array and a slit mirror array.

Each mirror array has 24 small mirrors. Each mirrors must be aligned with high accuracy.

3, Establishing alignment procedure of each component.

Pickup mirror, magnifier, slicer, pupil mirror array and slit mirror array

4, Manufacturing FOCAS IFU.

First light will be in 2013.

Please contact me (shinobu.ozaki@nao.ac.jp) if you are interested in this project (science, instrumentation or anything).