イメージスライサー型可視光面分光ユニットの開発

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

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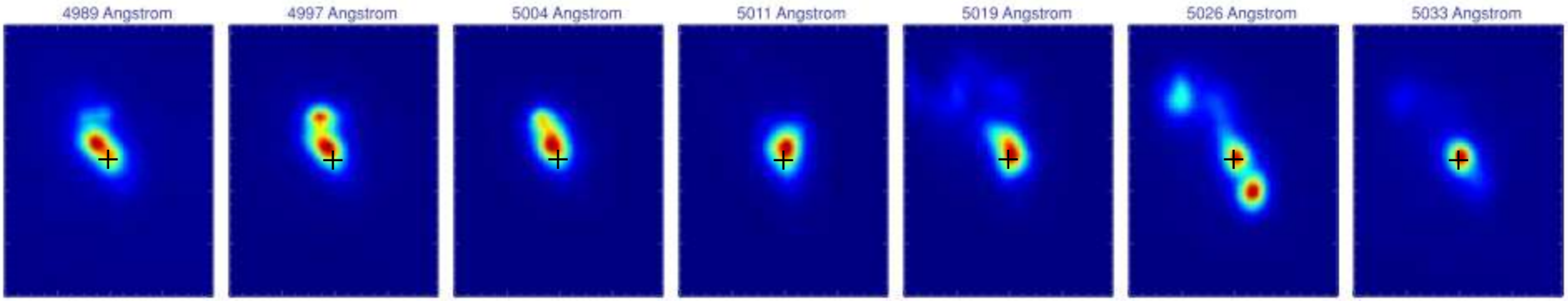
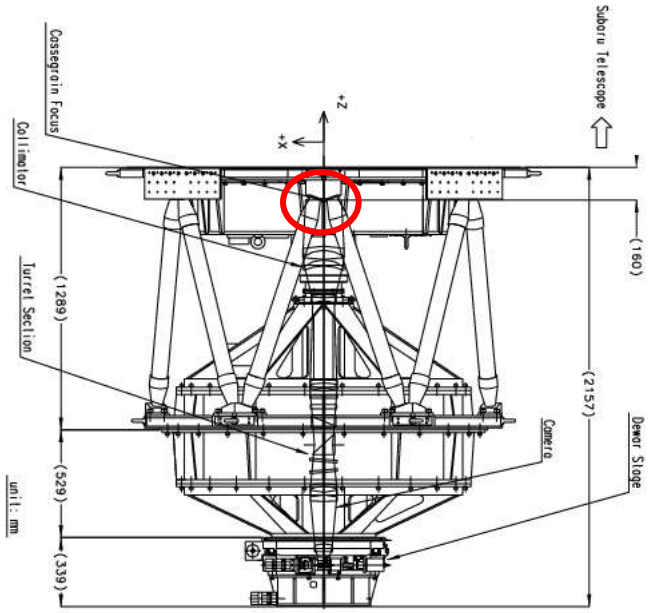
Integral Field Spectroscopy is a powerful tool

- 3D data (XY+λ) is simultaneously obtained.
- Science example
  - Detailed studies of AGN emission line regions
    - Velocity structure
    - Excitation structure

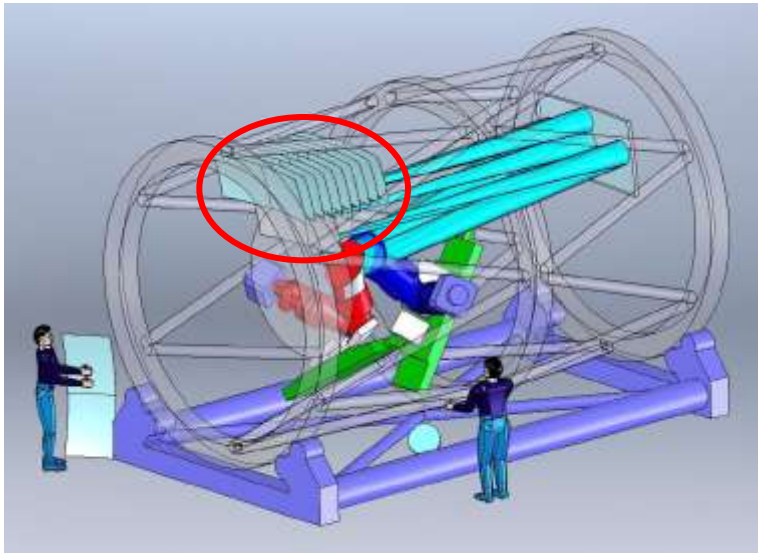


NGC1068 [OIII]λ5007 channel map (Gerssen et al. 2006)

Project outline

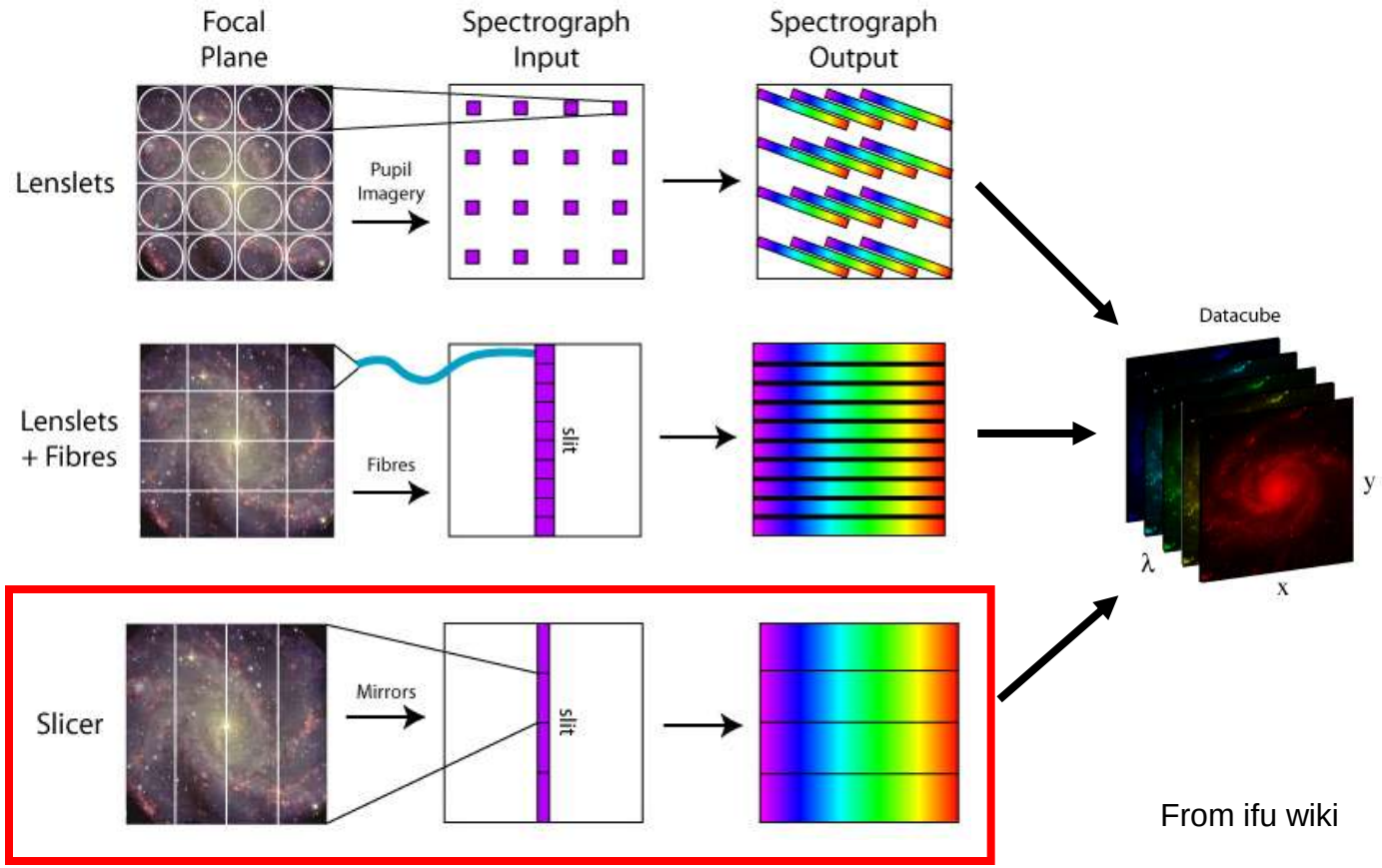


FOCAS @ Subaru



WFOS @ TMT

Why image slicer type IFU?

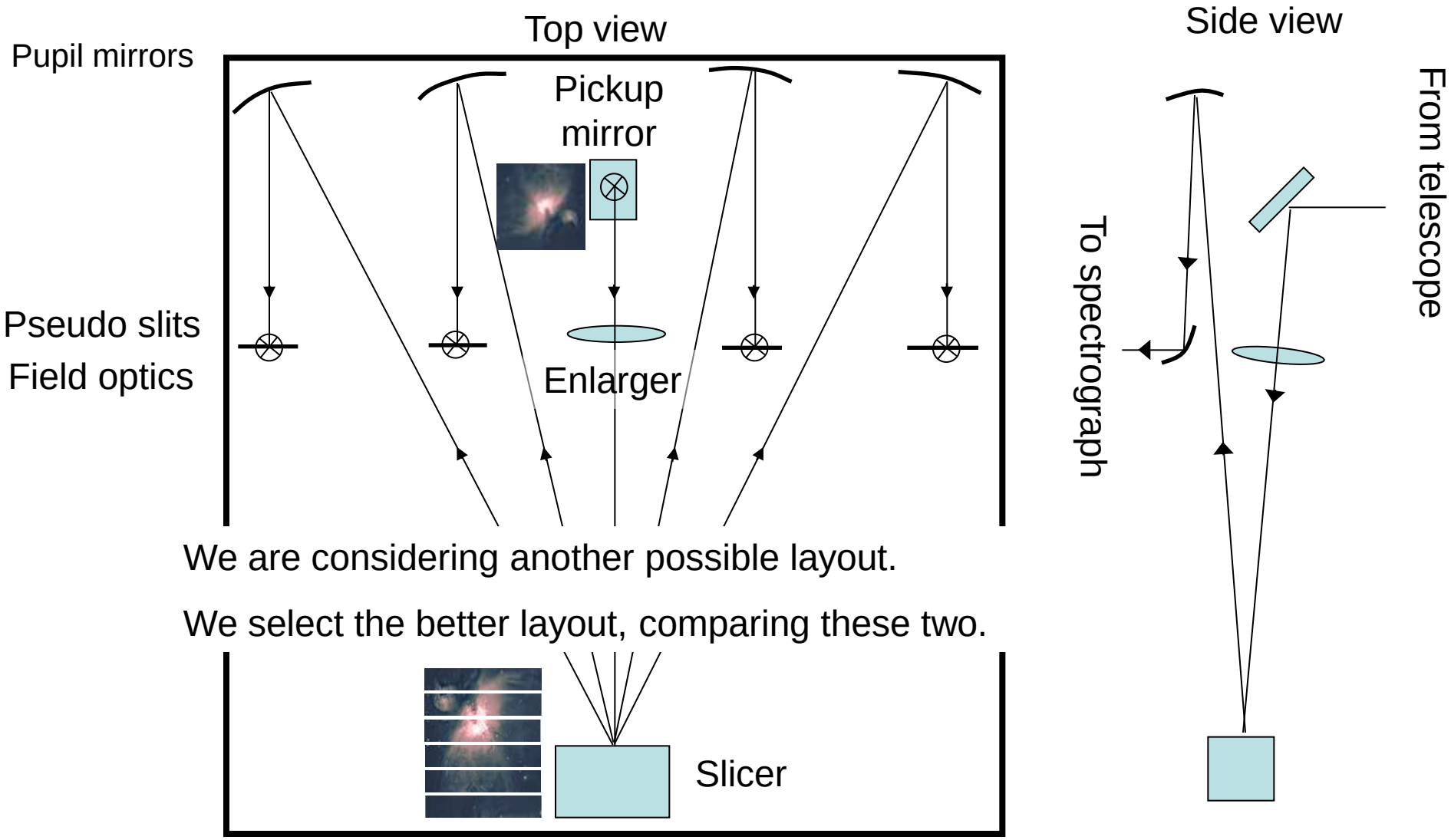


From ifu wiki

- Advantage
  - Dead space on a detector is the smallest.
- Drawback
  - Difficulty of fabrication. ← Diminishing thanks to technology progress

IFU optical layout

Based on GNIRS at Gemini observatory.



We are considering another possible layout.

We select the better layout, comparing these two.

IFU parameters

	FOCAS@Subaru	WFOS@TMT
Slice width (arcsec)	0.3	
FOV (arcsec^2)*	12.0 x 8.4	14 x 11
Number of slices	28	35
Fore-optics magnification	3.7	
Slice dimension (mm x mm)	22.2 x 0.54	113.0 x 2.42
Throughput	>80%	

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

Manufacturing methods for mirrors

- High precision machining for metal
  - Advantage
    - Fast fabrication speed
    - Easy to fabricate an aspheric surface
    - Can make monolithic module
  - Drawback
    - Only a few experiences in astronomical instrumentation

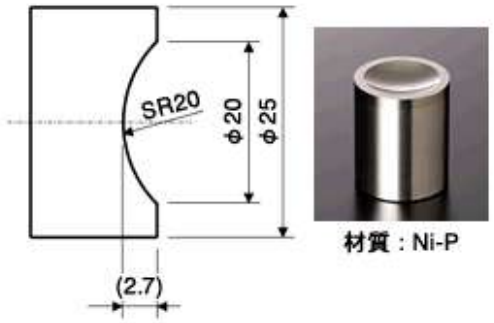
- Polishing for glass
  - Advantage
    - Achievable low surface roughness
  - Drawback
    - Slow fabrication speed
    - Difficult to fabricate an aspheric surface
    - Cannot make monolithic module

Manufacturing methods are closely coupled with optical layout.

We choose the method after the decision of the optical layout.

Fabrication sample of high precision machining

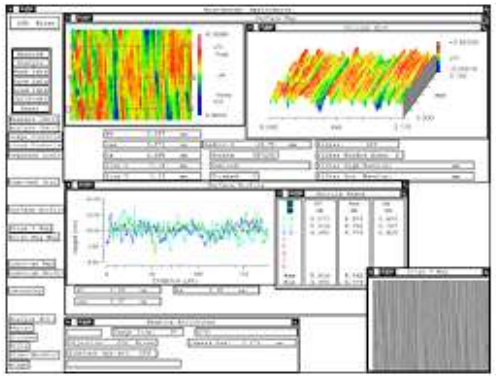
旋削加工事例 Diamond turning



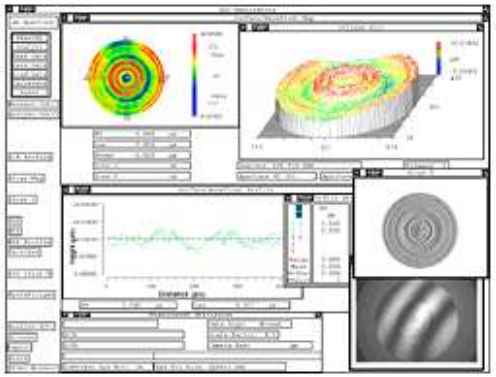
材質：Ni-P

ワーク仕様

加工状況



拡大画像(別ウィンドウで開きます)
面粗度 Ry: 6 nm, Ra: 0.7 nm



拡大画像(別ウィンドウで開きます)
形状精度 P-V: 0.046 μm

Surface roughness : Ra 0.7nm

Comparison with other instruments

	VIMOS+IFU @VLT	GMOS+IFU @ Gemini	Kyoto3DII + IFU	FCOAS＋IFU
IFU type	Fiber	Fiber	Lenslet	Slicer
FoV	54” x 54” 27” x 27” 13” x 13”	7” x 5”(object) + 5” x 3.5”(sky) 5” x 3.5”(object) + 3.5” x 1.75”(sky)	3.6” x 2.8”(object) + 3.6” x 0.6”(sky)	12” x 8”
Spatial sampling	0.67” 0.33”	0.2”	0.096”	0.3”
R	220 – 3,100	1,018 – 7,090	1,200	333 - 10,000
λ range	395 – 1,015 nm	360 – 1,100nm	360-900 nm	370-1,000 nm
# of Spectrograph	4	1	1	1
Spectrograph	Multipurpose	Multipurpose	Multipurpose	Multipurpose
CCD format	2k x 4k x 4	4k x 6k	2k x 2k	4k x 4k
Information amount *	1.64×10^6	1.1×10^6	0.24×10^6	1.60×10^6

* (Information amount) = (Spatial element #) x (Spectral element #)

Comparison with future instruments

	MUSE @ VLT	KCWI @ Keck	FCOAS＋IFU
IFU type	Slicer	Slicer	Slicer
FoV	60” x 60” (7.5” x 7.5”)	20” x 8.4”, 16.8”, 33.6”	12” x 8”
Slice width	0.2” (0.025”)	0.35”, 0.7”, 1.4”	0.3”
R	1,750 – 3,750	1,000 - 20,000	333 - 10,000
λ range	4,650 – 9,300 Å	3,500 – 10,000 Å	3,700-10,000 Å
# of Spectrograph	24	1 (2 channels for red and blue)	1
Spectrograph	Dedicated	Dedicated	Multipurpose
CCD format	4k x 4k x 24	4k x 4k x 2	4k x 4k
Information amount *	200×10^6	?	1.6×10^6

* (Information amount) = (Spatial element #) x (Spectral element #)

Schedule

- FY2010
  - Parameter search (Done)
  - Decision on optical layout (till end of Jan.)
  - Test fabrications of each modules (from Feb.)
- FY2011
  - IFU for FOCAS
    - Detailed design
    - Fabrications
    - Assemble
    - Performance verifications
- FY2012
  - Test observations with FOCAS+IFU
  - Start developing the IFU for TMT/WFOS

Budgets

- Applied for Grants-in-Aid for Scientific Research (Kiban-B)
- Applied for NAOJ internal budget

Summary

- We are developing the slicer type optical IFU.
  - 1st step: IFU for FOCAS/Subaru
  - 2nd step: IFU for WFOS/TMT

- FY2012: First light of IFU for FOCAS