GLAO Instrument from MOIRCS Perspective

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Preface

Question: “How you want to use 8-m Telescope in 2020s when TMT/GMT/JWST/WISH etc are there?”

“Attraction” of the instrument itself is the key for success.

Attractive = Challenging (no counterpart). If overcome, great idea will follow (I believe).

「人に使ってみたくさせる様な、魅力的な装置」をいかに (経済的に) 作るか。進化の可能性を維持する事ができるか。

MOIRCS

• FL ... Sep 2004 (imag) & 2005 (MOS).
• Open-use started from S06A.
• The First NIR MOS open-use instrument among large telescopes.
• The First Wide-Area NIR instrument for large telescopes until arrival of HAWK-I

• Imaging: 4’x7’ FOV by 2 H2. YJHK & many NBs
• MOS/long slit. R500, R1300, VPH(YJHK).
MOIRCS

SIDE VIEW

FRONT VIEW
MOIRCS: Pros

• Cs instrument ➔ Better background performance in K than Ns (cf. HAWK-I).
• 3 Filter/Grism/Stop Turrets (total 36 ports) ➔ Many Filter Ports available for user filters & grisms.
• 0.117”/pix ➔ Good sampling for good condition. ~3 pix condition is not so rare. ➔ Good choice.
• 2 independent channel ... Die Hard to trouble (half-channel operation possible). Complicated operation (e.g., ch1->sp, ch2->im) is also possible.
MOIRCS: Cons

- Flexure ... Large line residual after sky subtraction (Sp.). Shift of the spectra. Fringe on imaging data.
- Poor Align of Cold Stop. No way to fine adjust.
- Large overheads: Too slow detector readout. Slow MOS alignment time.
- R500...too many OH lines. R1300...very low sensitivity for YJ. Image degradation by grism itself. VPH...Peak efficiency wavelength shift: very difficult to use for MOS.
- Frequent focus change (telescope). AG does not help for check due to the focus mismatch.
Fringe Residual (H2 filter)

Degradation for spatial direction

Degradation for spatial direction (R1300)

Peaky & Large Tc shift for VPH Grism
MOIRCS: Scientifically...

• Good Imaging Performance. But studies for morphology are limited. Mostly just photometric use.
• Deep obs ... condition averaged out -> degrade.
• Deep Imaging Data...follow-up impossible? (But All visible objects will be spectroscopic targets for TMT !!)

• Many users went for field galaxy studies. → “Main” targets are not so rich in the MOIRCS FOV. Many are just filler objects. (cf. FMOS)
• Limit of photo-z and instrument sensitivity: >50% success rate for spec-z is a hard task (partly due to fillers).
• Spec data is quite sensitive to seeing under 0.8”-width slits. Slit loss is a serious issue.
  ● Narrower slit is preferred to avoid OH lines.
  ● But NOT all galaxies are compact enough to confidently use 0.2”-0.4” slits. Extended galaxies might also be morphologically complex.
→Extragalactic People may choose wider slits after all (more photon is preferred)? e.g. 0.6” slit for 0.06”/pix => 10pix profile!

Cf.) oversampling problem on FOCAS (Dr.Ohyama’s review 2005).

Is simple MOS still attractive for 2020 era? But MOSFIRE type/microshutter technology may worth trying.
FOCAS進化論(FOCAS Instrument Review) by Dr. Y. Ohyama (2005)

- FOCAS: Subaru optical MOS Spectrograph.
- Dr. Ohyama --- 1st FOCAS SA.
- His Review --- Suggestive to NGAO Instrument.

http://optik2.mtk.nao.ac.jp/~cyoshida/SACsympo/
νMOIRCS: MOIRCS upgrade (2012~)

- **H2 → H2RG+ASIC**: much better overhead & less cosmetics, good noise level expected.
- **IFUs**: 4 IFU arms will be added. Other options (MLA mode etc) are also on work.
- Instrument Improvement: Efforts for flexure suppression etc.

MOIRCS could be a 1st light GLAO instrument depending on the condition.
νMOIRCS “Wing Box”

- Two wing boxes. 2 IFUs for each.
- If 4 IFUs are combined, it works as a large single IFU.
- Flexibility for Other Applications (test bench).
- Modification: just replacement of Focal Plane Box.

Same box can come here too.

Great Idea for NGAO Instrument
JWST, EUCLID (and I wish WISH too) will already be there.

TMT comes soon. GMT may already be there (FL late 2019). E-ELT will be soon (early 2020s).

TAO will be soon (SWIMS could also be a FL instr for GLAO).
JWST (Imaging)

- NIRcam can go extreme depth.
- **Wide-area shallow** (still deep) scan should also be an easy task.
- Pressure for COSMOS-Like Legacy Data $\rightarrow$ deg$^2$-scale survey likely to be executed. But $10^2$ scale would be too time-consuming for JWST.

- Wide FOV of **NGAO Inst.** can make the data with **10-100 sq.deg** with reasonable time. We may keep some niche, until WISH comes.
- Any NB deep & wide-area survey would keep its own niche until WFIRST comes (next).

- **K-band wide and deep** would be attractive for EUCLID Deep Field (and WFIRST).
• 1st-ranked space mission by Decadal Survey 2010.
• Significant revision in 2013: 1.3m → 2.4m. Two Mirrors and optics system are already in NASA (given from NRO)!
• 18 H4RG. FOV=0.281 deg² (0.11”/pix). 0.76-2.0um (no K).
• Slitless Grism (R~700)+ 3.0”x3.1” IFU(R~100).
• Imaging (YJH~<26.7) and Spectroscopy (7s to 5e⁻¹⁷erg) for ~2000deg²!
• If started next year, Launch will be ~2022.
• For GLAO Inst...only K-band (NB, BB) is the niche. Early start is advantage.
GMT NIRMOS: Potential Threat?

• GMT ... FL goal is **end of 2019**. Construction started, 2 mirrors already done (3rd in Aug?).
• NIRMOS ... 1st generation proposed instrument. GLAO-assisted **6.5’x6.5’** NIR imager/MOS (CfA).
• 3x2 H4RG.

• MOS mask or MOS robot.
• CoDR review approved. Actively seeking funding.
• Filter space is currently quite limited.
• NGAO Instr....NB/IB only?
JWST: NIRISS

- Space ... Power of slitless spectroscopy.
- JWST NIRISS: R\~150 slitless spec. across \~2’x2’ FOV. Instrument is already in GSFC for test.
- Extreme sensitivity: best for faint z>7 LAEs.

- Narrow FOV? Survey volume of slitless spectroscopy is large (6<z<17). They will do Legacy-class survey anyway (deg$^2$)?.

- Subaru NGAO inst. may still have a niche in targeted wide-FOV NB business. For K-band region we have.
What our NGAO Instrument would be...

- We want everything (Imaging, MOS, IFUs)!
- But budget is limited. Weight limitation is also tight.

nuMOIRCS Approach might be a solution...
1. Making Imager First.
   – High Throughput. Simple Design.
   – Wide Fov, optimized to K band.
   – The Design for future addition of spec. function (=MOS/IFU etc) must already taken into account.

2. Making Unitized Additional Components
   – MOS Robot Unit (MOSFIRE-type)?
   – IFU(s)
   – Near-Focal Plane NB Filters w/stacker?
   – Is High Throughput “Giant” NIR-FP possible?
   – Easy Convertibility --- they should be detachable with small downtime (~1 mo).

Unitization has advantage on risk/cost/manpower management.
Example of development case...


Got Grant!

Imager Part
Development: NAOJ+collaborators

Got Grant!

MOS Part
Got Grant!

Operation

Got Grant!

IFU Part
Development: A Institute.

Got Grant!

MOS Robot
Development: B Univ.

Got Grant!
A Further MOIRCS Update Project

Option 0’: “Cheapest” IFU option?

Upgrade:
- 2 more H2RG for spectral data.
- Change of Whole camera section & bottom dewar part.
  1. Afford more IFU spaxel.

Change to more smart IFU arms? Larger IFU pick?

2 IFUs arms → 4 IFU arms or 2 Larger-format IFUs

Project: “νMOIRCS” → “FνMOIRCS?”
Summary

• NGAO Instrument ... Starting from Imager may be a realistic option.
• Unitized Design for further update (νMOIRCS-like approach) could be the solution for collaboration and difficult budget situation.
• FνMOIRCS? Good timing for it? As SWIMS comes to Subaru as a guest instrument.

(For me) manpower appears potentially the most serious issue for the project. How the project is going for realization??
Omake Idea...
(Based on a word from Y.Tanaka)

If 2-m limit causes more number of lenses, degraded pupil, etc... Let’s seriously think about using whole bottom of telescope.

Lightweight design of the dewar is also the key! Honeycomb-like wall?