# GLAO instrument specifications and sensitivities

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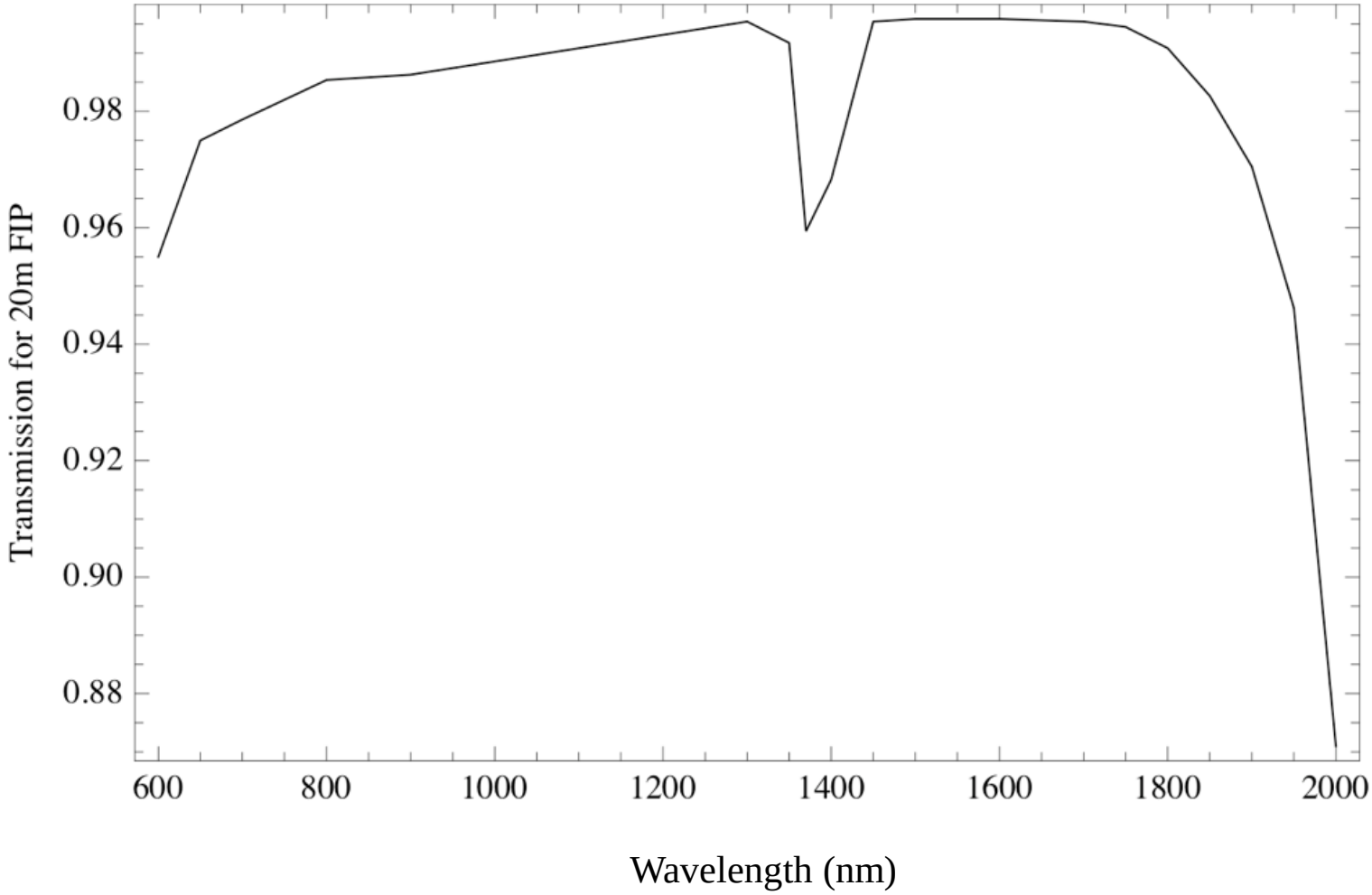
# Simulated instruments as of 2013

- Wide Field NIR imaging
  - Broad-band (BB) imaging
  - Narrow-band (NB) imaging
- Multi-Object Slit (MOS) spectroscopy
  - Emission line
  - Continuum
- KMOS type Multi-IFU spectroscopy
  - Emission line

# New Instrument Plan

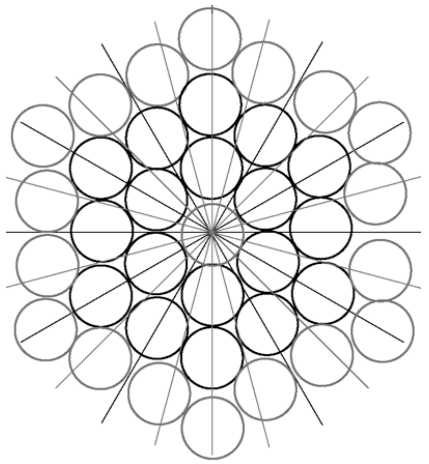
- Multi-object fiber IFU spectrograph
  - Fiber-bundle IFU system
  - Utilize “Starbugs” developed by AAO
  - Each bundle consists of 37, 19, 61 fibers within ϕ~1.4, 1.0, 1.8 arcsec FOV.arcminute$^2$ FOV.
  - Each fiber has 0.2 arcsec diameter.

# Fibre throughput model
# fibre only, no coupling losses or FRD



# Fibre Bundle Configuration (1)

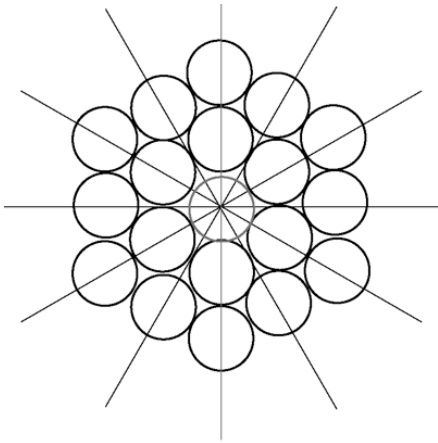
| | |
|---|---|
| Number of fibres | 37 (7 fibres on an axis) |
| Spatial sampling | 0.2 arcsec / fibre |
| Bundle sky diameter | 1.4 arcsec (point to pint) |
| Number of detector pixels per fiber | 4 |
| Number of pixels per bundle | 148 |
| Number of bundles per 2k detector | 13 (1924 pixels; plus sky fibers?) |
| Object Multiplicity (MOIRCS) | 26 |
| Sky Fibres/detector | 30 sky fibres with 1 fibre gap |



N=37 bundle

# Fibre Bundle Configuration (2)

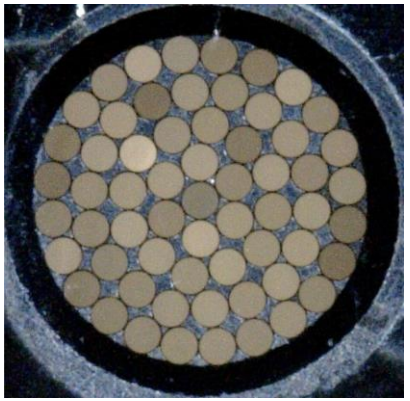
| | |
|---|---|
| Number of fibres | 19 (5 fibres on an axis) |
| Spatial sampling | 0.2 arcsec / fibre |
| Bundle sky diameter | 1.0 arcsec (point to pint) |
| Number of detector pixels per fiber | 4 |
| Number of pixels per bundle | 76 |
| Number of bundles per 2k detector | 26 (1976 pixels; plus sky fibers?) |
| Object Multiplicity (MOIRCS) | 52 (feasible??) |
| Sky fibres /detector | 17 sky fibres with a 1 fibre gap |



N=19 bundle

# Fibre Bundle Configuration (3)

| | |
|---|---|
| Number of fibres | 61 (9 fibres on an axis) |
| Spatial sampling | 0.2 arcsec / fibre |
| Bundle sky diameter | 1.8 arcsec (point to point) |
| Number of detector pixels per fiber | 4 |
| Number of pixels per bundle | 244 |
| Number of bundles per 2k detector | 8 (1952 pixels; plus sky fibers?) |
| Object Multiplicity (MOIRCS) | 16 |
| Sky fibres/detector | 23 sky fibres plus 1 fibre gap |



N=61 bundle (Bryant et al. 2014, MNRAS 438, 869)

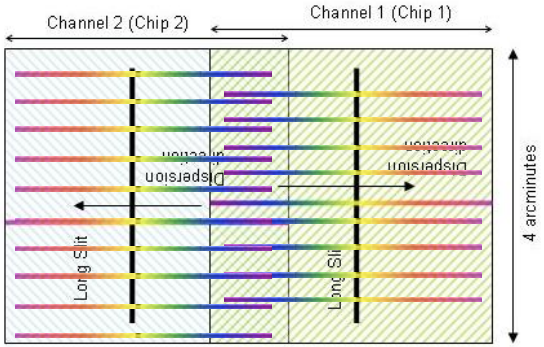
# Instrument setup

- Starbugs unit will be attached to the Cassegrain focus
- Spectrograph will be placed at the observation floor or at Nasmyth platform and connected to the starbugs with fibers.
  - F-conversion might be necessary to reduce the F# (12.4→→(e.g. 3.0) and avoid the effect of FRD(?)
  - Throughput of the fiber will be (e.g. 90%@NIR).
- Fiber will be connected to the fiber slit in the focal plane module, which is placed in the cryogenic condition.
  - Minimum spacing in between fiber centers should be 4 pixels or larger and the minimum spacing between the 90% EE diameter of each adjacent fiber should be 1 pixel or larger to avoid significant cross-talk and ensure the accuracy of the sky subtraction (<0.5%? based on PFS study).
  - F-conv. optics in side of the FP module might be necessary to change the F# back to the original (12.4) or to the optimum number for the spectrograph.

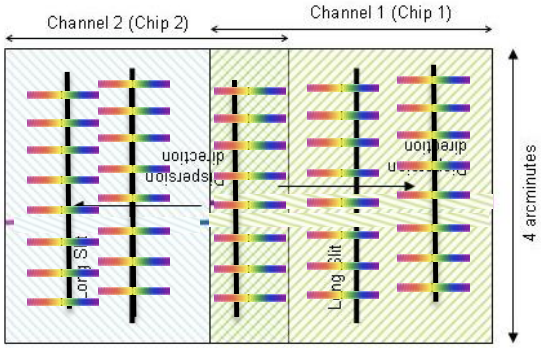
# Phase-I: Starbug+ New MOIRCS

- First light instrument for GLAO
  - Commissioning obs. will start from around 2017?
  - Observations with OH suppression 2020?.
- Number of bundles:
  - (1) HK500, zJ500, R1300+BB(JHK), VPH: 26 (config 1); 52 (config 2); 16 (config 3)
  - (2) R1300 or VPH + Narrow-band or Intermediate band filters: 78 (config 1); 156 (config 2); 48 (config 3)

(1)




(2)




- Sensitivity: 60-70% of MOSFIRE/Keck (MOIRCS VPH only)
- Sensitivity:  75- 85% of KMOS/VLT (MOIRCS VPH only)
- Need to multiply by 70-80% efficency for fiber system
- MOIRCS will be moved to the observation floor or Nasmyth platform and connected to the starbugs with fibers.
- Focal plane unit of MOIRCS will be modified so as to feed the light into slits from fibers.

# Phase-II: Starbug +new dedicated instrument

- First light will be several years after GLAO commissioning
- Number of bundles:
  - 52 (config 1); 104 (config 2); 32 (config 3) for each spectrograph!
  - Φ13’.5 FOV
- Sensitivity: 70-80% of MOSFIRE/Keck
  - Sensitivity of the spectrograph should be same as or higher than MOSFIRE.
  - Only difference is throughput and emissivity due to the fibers.
  - Not including telescope diameter difference
- New instrument will be placed on the observation floor or Nasmyth platform and connected to the starbugs with fibers.

# Sensitivity comparison with MOSFIRE

| | MOIRCS | | MOSFIRE |
|---|---|---|---|
| | Current | New | |
| FOV | 4'x7' | | 6'.1x6'.1 |
| Imaging throughput (atm+Telescope+Instrument) | 0.23(J), 0.34(H),0.30(K) | | 0.54(J),0.56(H),0.50(K) |
| Spectral resolution | 500, 1300, ~3000(VPH)* | | 3500 |
| Grating diffraction efficiency | HK500, zJ500: 0.8(J), 0.78(H), 0.65(K)<br>R1300: 0.2(J), 0.3(H), 0.5(K)<br>VPH: ~0.75(J), ~0.7(H) 0.80(K) | | 0.60(J), 0.65(H),0.70(K) |
| Spec. throughput (atm+Telescope+Instrument) | HK500, zJ500: 0.18(J), 0.26(H), 0.20(K)<br>R1300: 0.05(J), 0.10(H), 0.15(K)<br>VPH: ~0.15(J), ~0.20(H), ~0.26(K) | | 0.325(J), 0.361(H), 0.350(K) |
| Detector | HAWAII-2 | HAWAII-2RG | HAWAII-2RG |
| QE | ~80%(JHK) | | ~80%(JHK) |
| Read-out noise | 15e rms (16NDR) | 5e rms (16NDR) | 5e rms (16NDR) |

* For 0.5" slit. Using a fiber with 0.2" spatial sampling, resolutions are 2.5 times higher.

# Sensitivity Improvement of MOIRCS

- HAWAII2 => H2RG
  - Readout noise: 15e- => 5e-
- Grism replacement
  - System throughput: 15%(R1300) => 25%(R2000)
- Sharp and stable image with GLAO
- Improvement of emission line sensitivity
  - Point source: >1.2 mag. (>3x)
  - Extended source: ~0.5 mag. (~1.6x)

# Sensitivity comparison with MOSFIRE

- Current MOIRCS sensitivity is 4~7 times lower than MOSFIRE (difference in the telescope diameter is not taken into account).
- If the new MOIRCS can successfully reduce the RO-noise down to 5e-, the sensitivity difference is about 1.4(VPH)~2.3(R1300).
- This difference can not be reduced without changing the optical coating.
  - MOSFIRE has 31 surfaces
  - Average throughput in each surface is about 0.992.
  - Total throughput of the optical coating is about 0.78
  - MOIRCS has 24 surfaces.
  - Average throughput of the coating is 0.983.
  - Total throughput of the coating is 0.64.