A deployable multi-object integral field unit for Ultimate-Subaru

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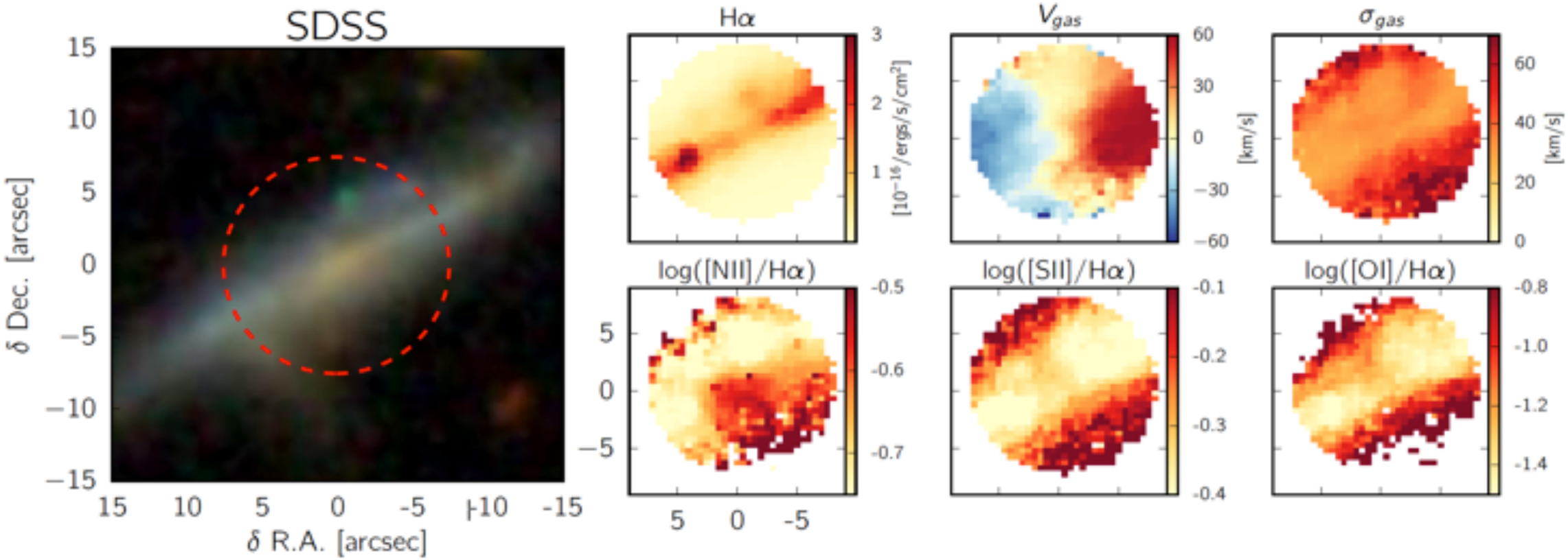
AAO

Galaxy evolution

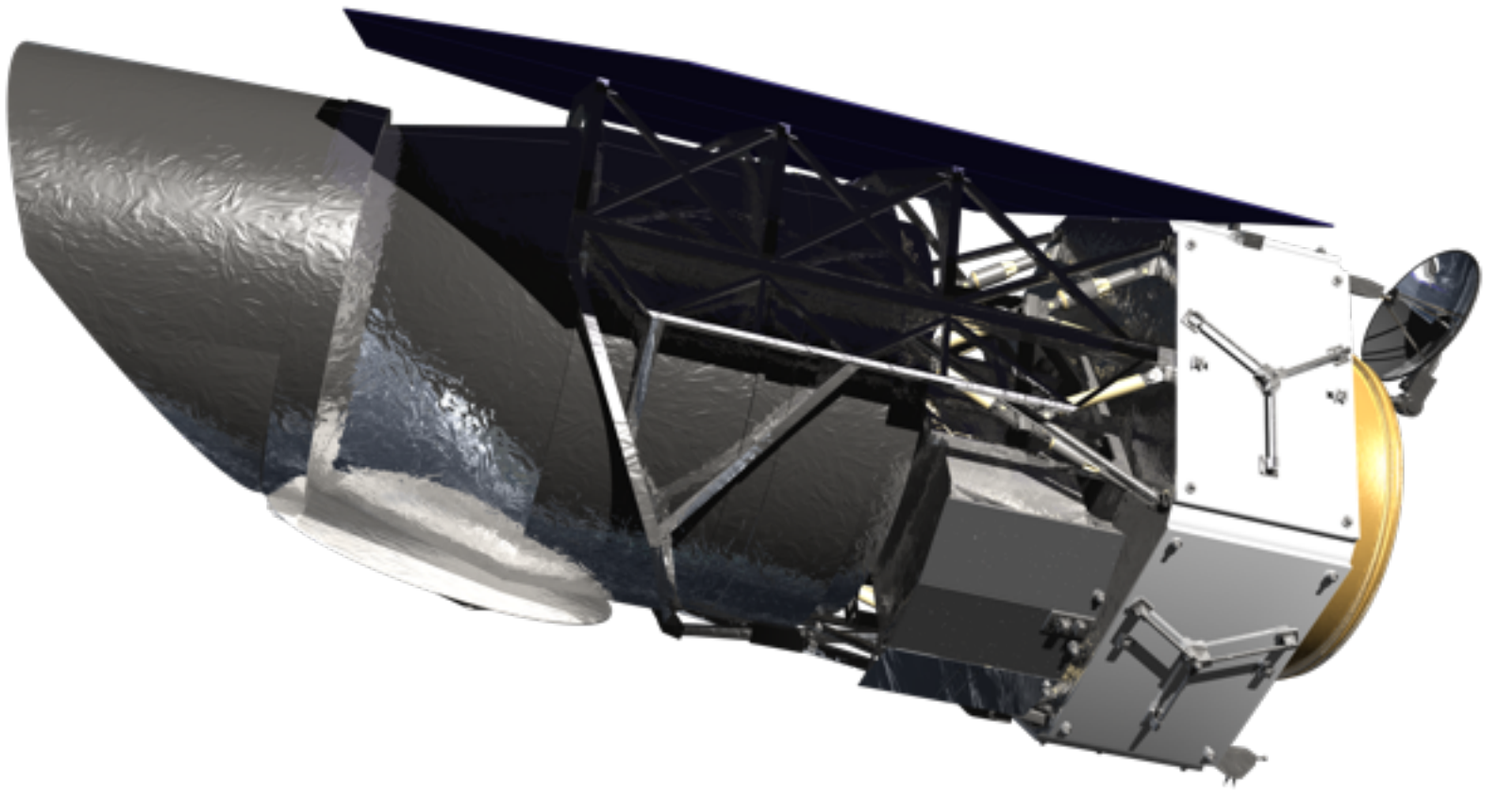
High redshift SAMI survey: 3000 galaxies at $z = 0.6, 1, 1.4$



To measure properties of galaxy evolution via emission lines:

- star formation rates from Hα
- feedback from winds, AGN, starburst from line ratios
- mergers from gas kinematics

Dark matter content of the inner Galaxy



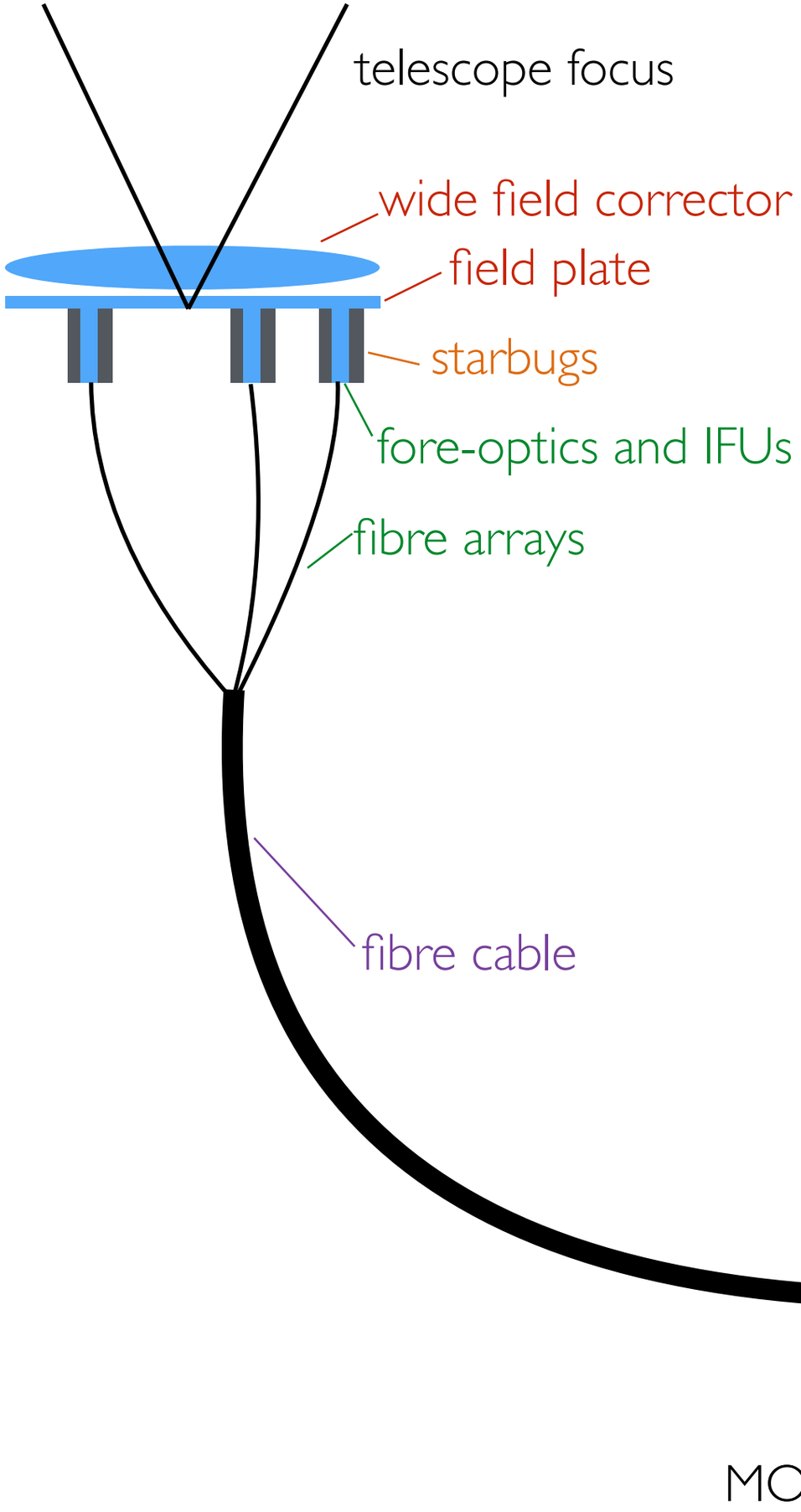
WFIRST Galactic bulge survey ⇒ parallax, proper motion, colour, asteroseismic mass, gravity

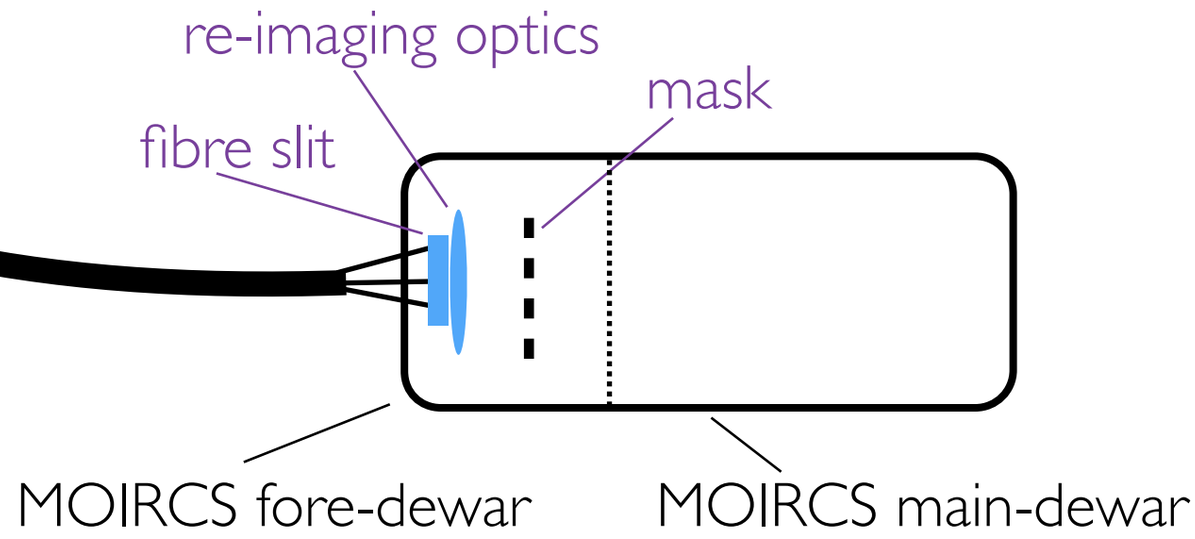
ULTIMATE ⇒ radial velocities

Together ⇒ map dark matter potential

Can be done without GLAO

ULTIMATE - IFU





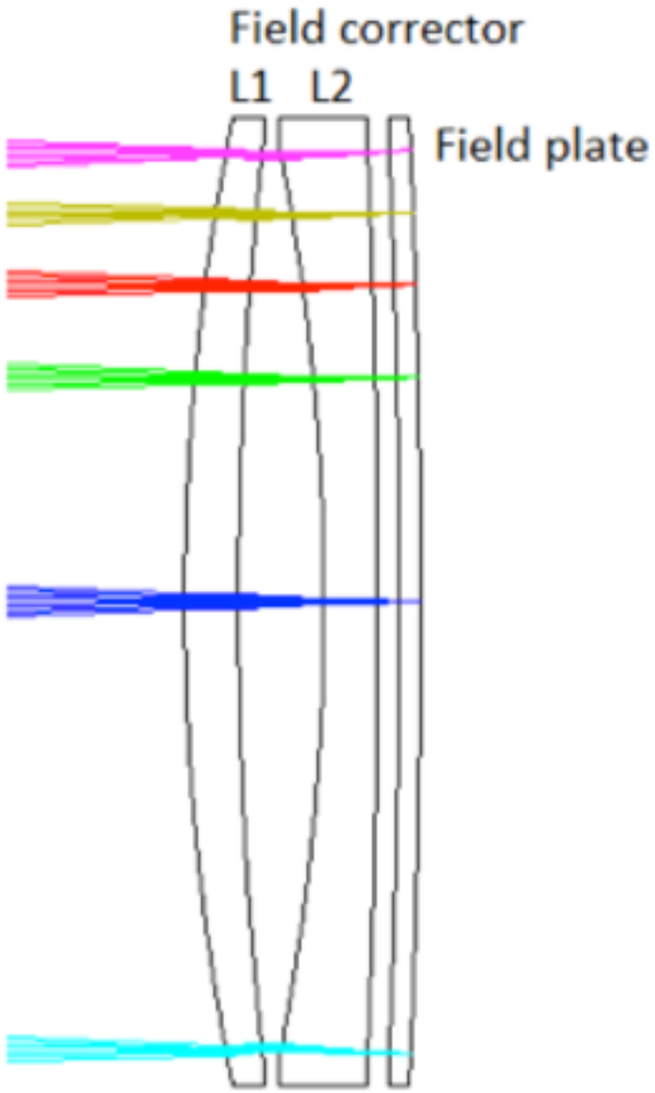
Sub-systems

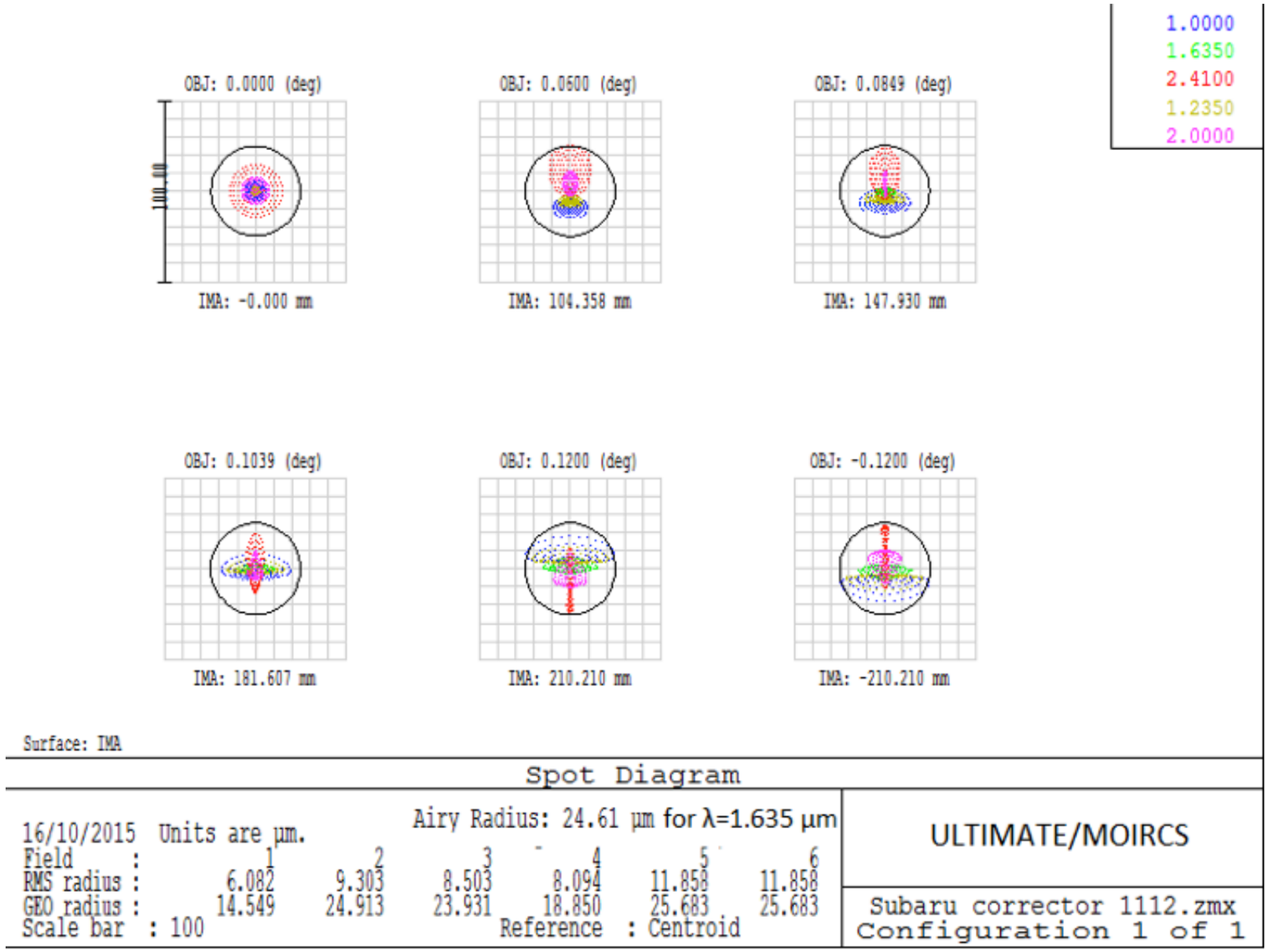
1. Wide field corrector unit
2. Starbugs units
3. Integral field units
4. Fibre cable and slit unit

Main instrument parameters

IFUs	
Number of IFUs	8 - 13
Number of elements per IFU	61 hexagonally packed
Spatial sampling per element	0.15 arcsec
Total field of view per IFU	1.18 square arcsec
Total patrol area	14 x 8 arcmin
Minimum separation between IFUs	20 arcsec
Spectrograph	
Wavelength coverage	0.9 – 1.8 μm
Spectral resolving power	500 – 3000
Dispersion	1.6 Å per pix (J), 2.1 Å per pix (H)
Sampling	2 - 5 pixels FWHM
Combined properties	
Total efficiency	9 % (J), 12 %(H)

Wide field corrector

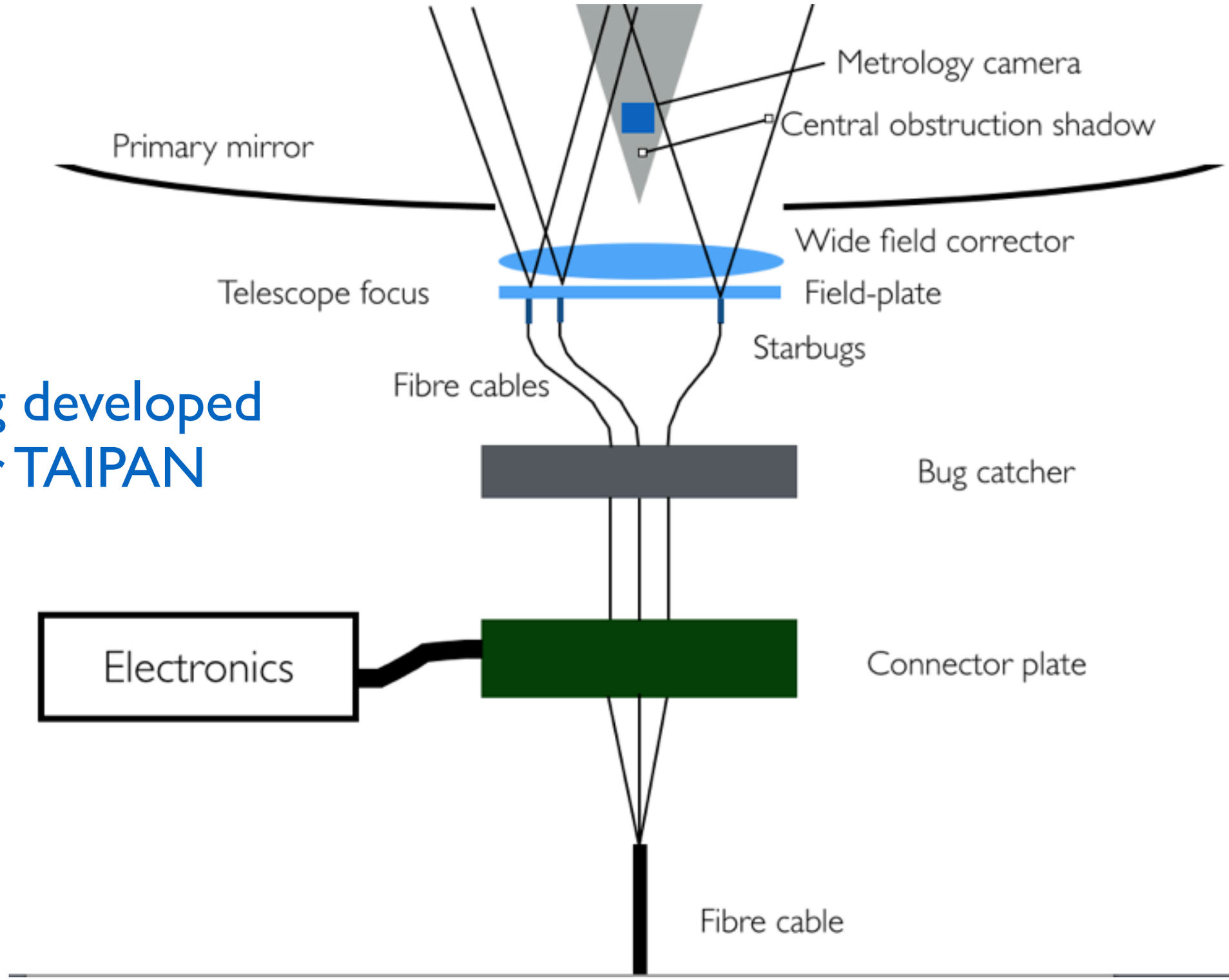




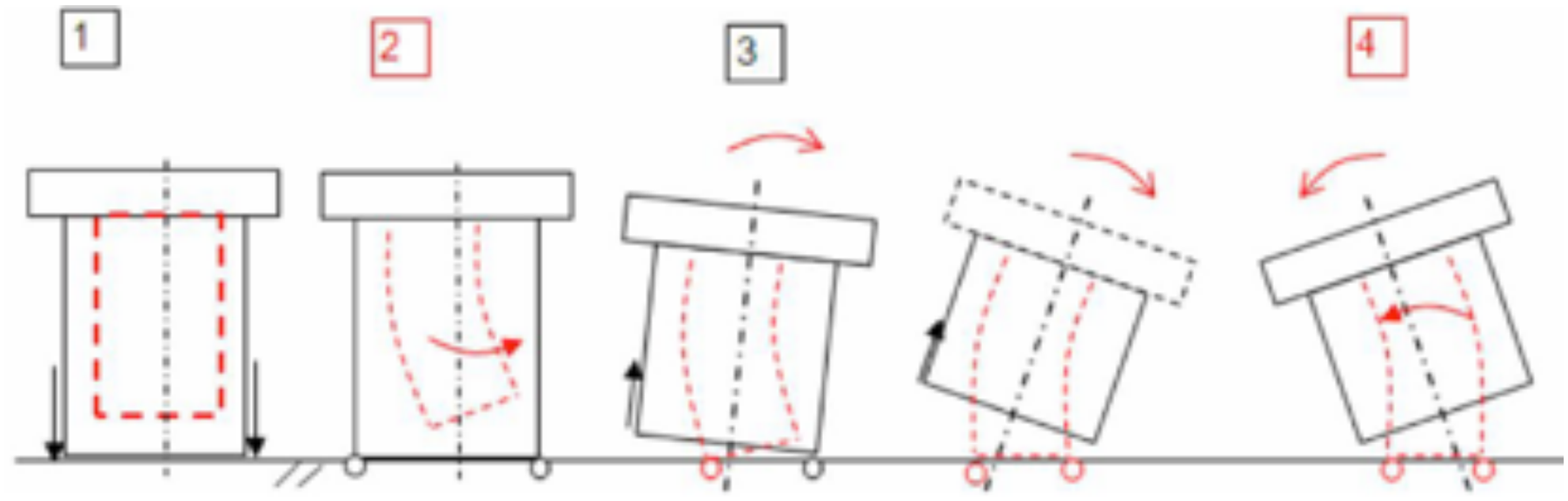
λ µm	Dispersion (arcsec)
0.9 – 1.15	0.17 arcsec
1.15 – 1.35	0.07 arcsec
1.35 – 1.8	0.12 arcsec

Starbugs Unit

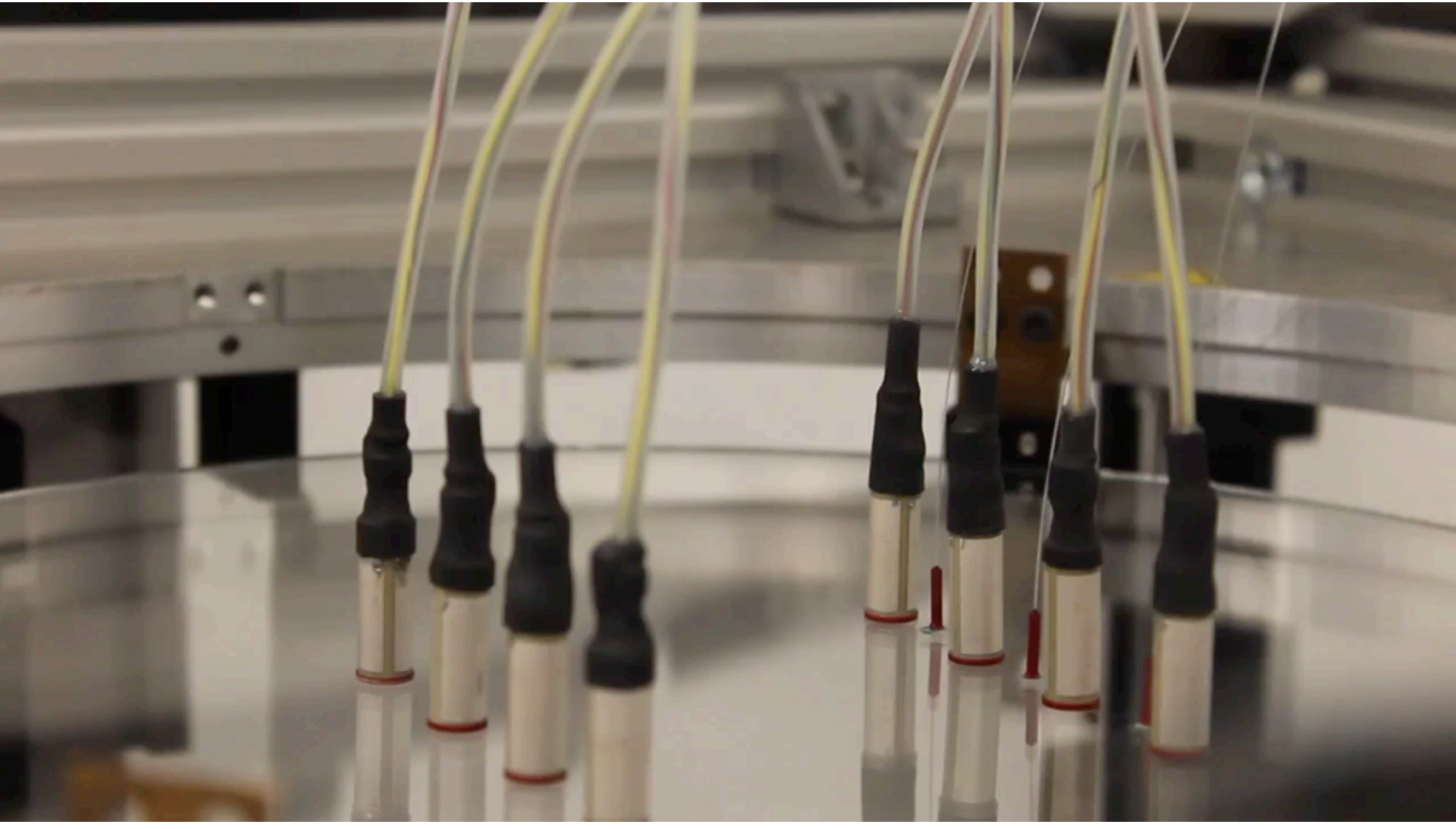
Being developed for TAIPAN



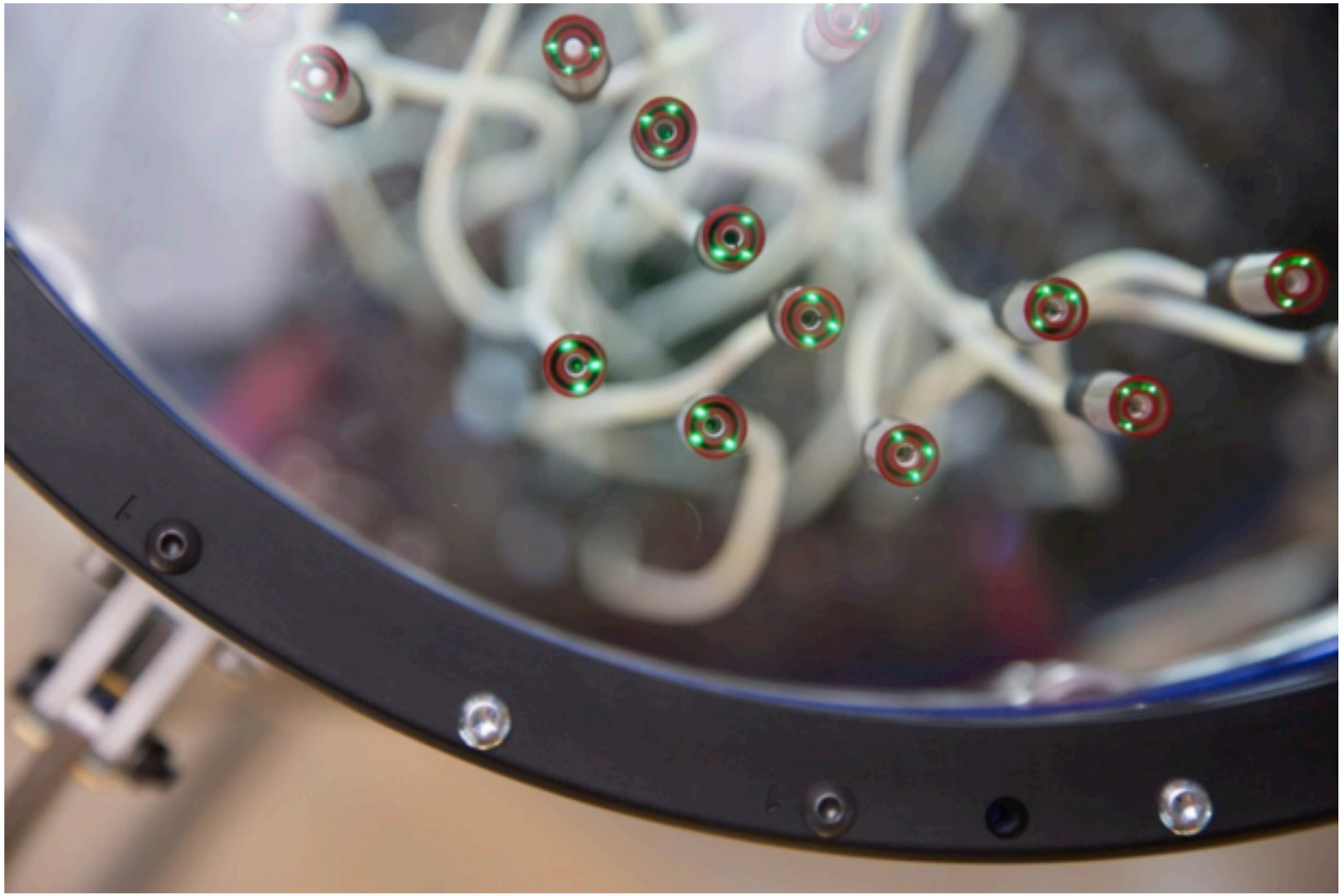
Starbugs

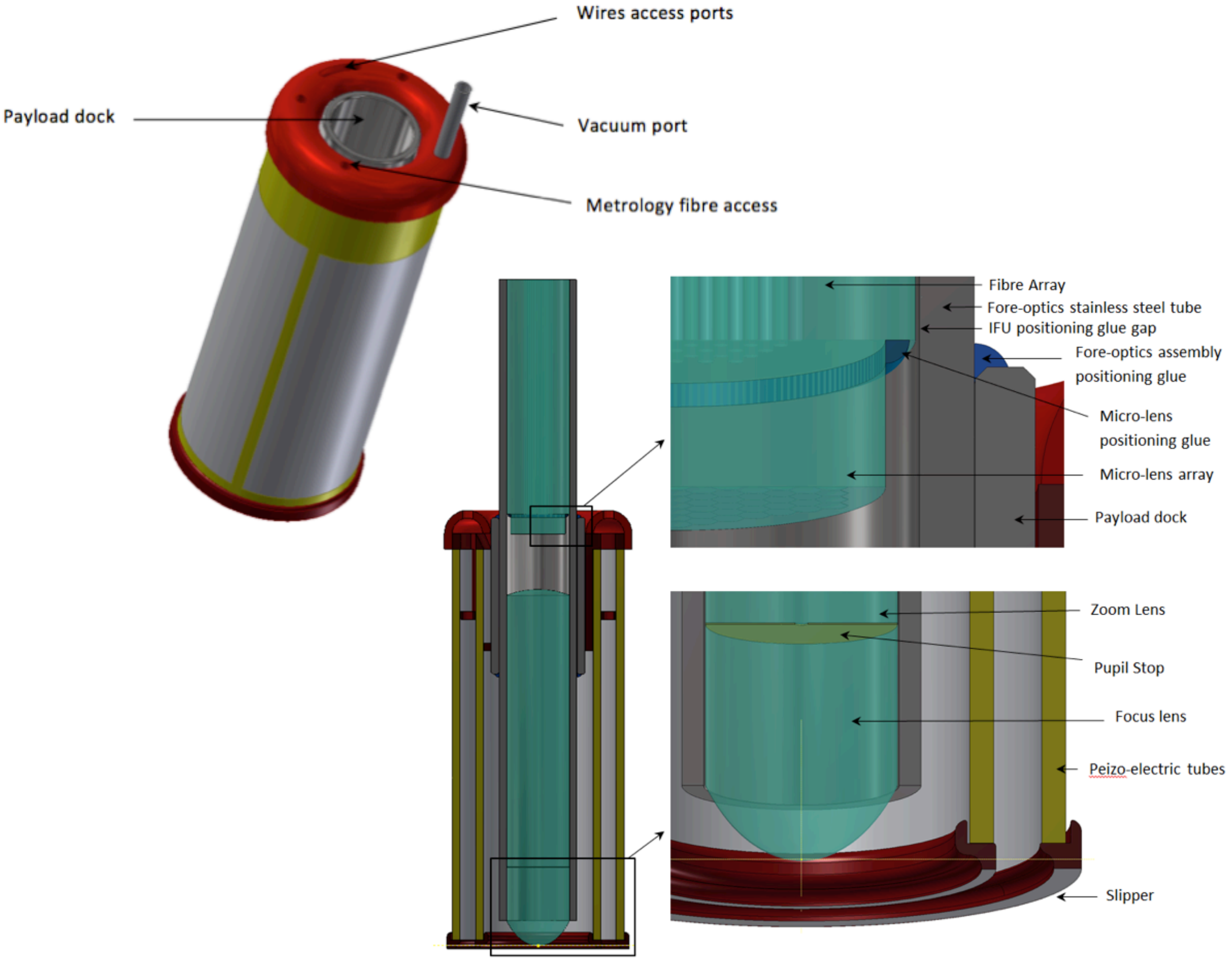


Starbugs

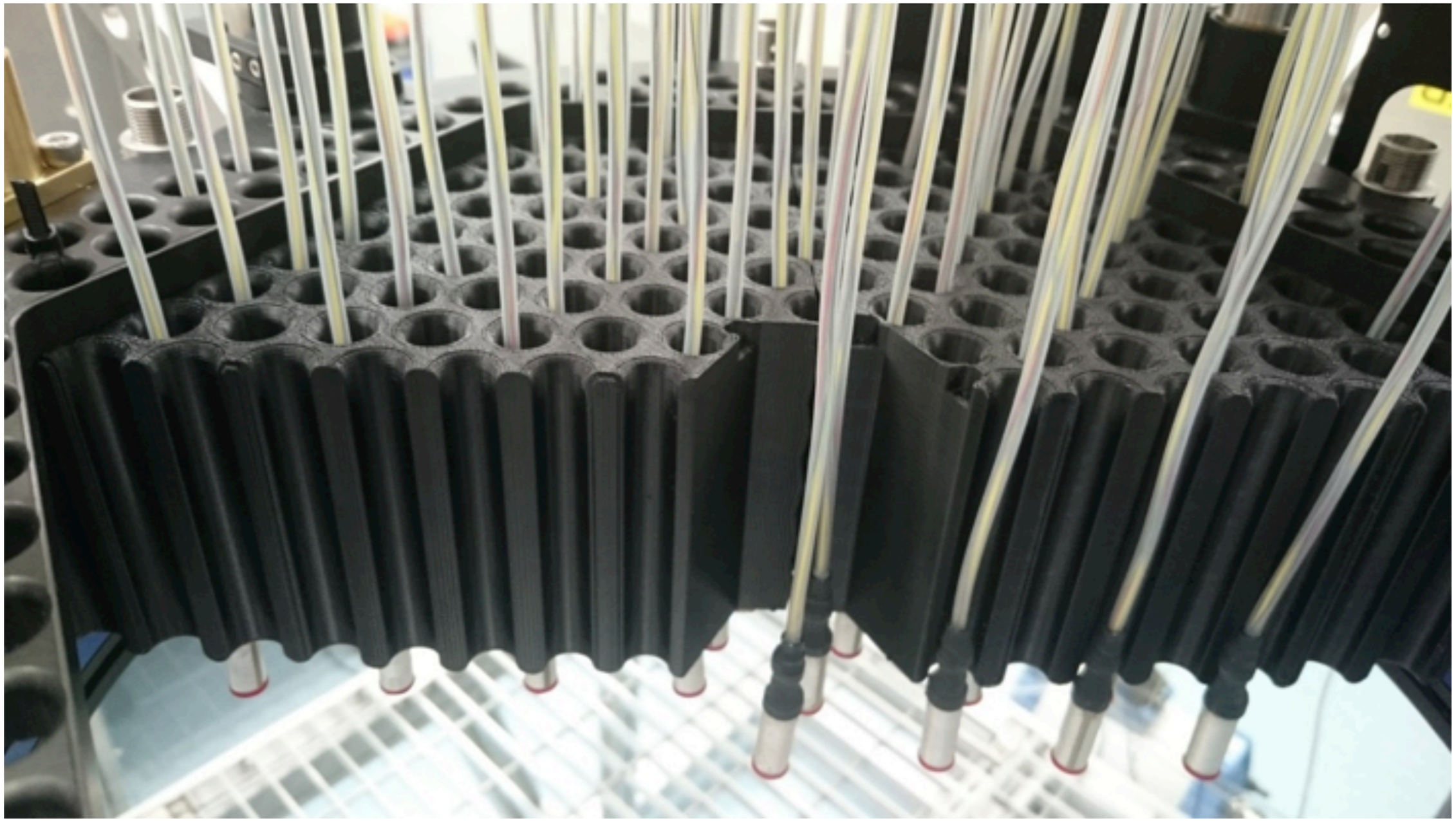


Starbugs Unit

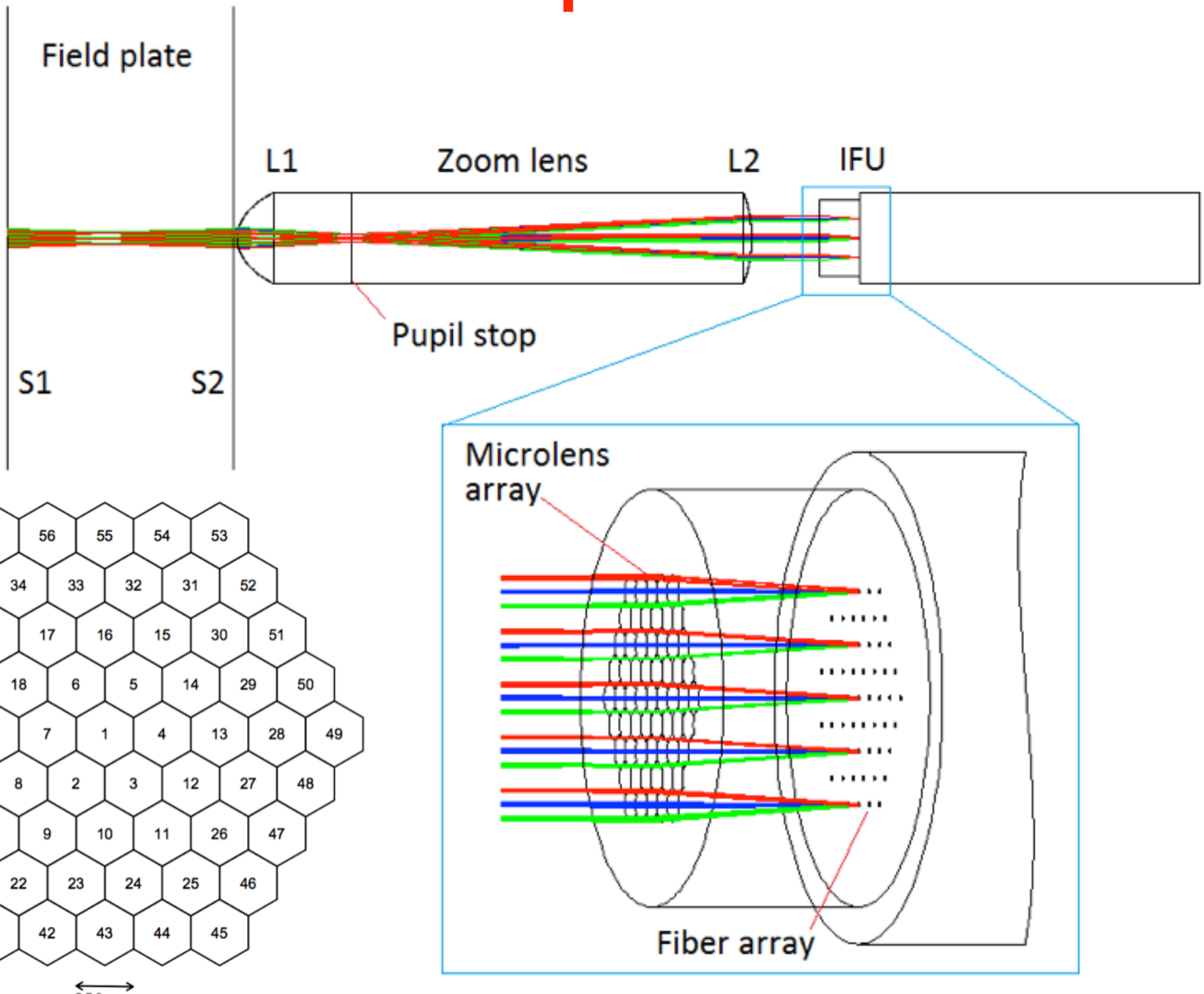



Wires access ports
Payload dock
Vacuum port
Metrology fibre access
Fibre Array
Fore-optics stainless steel tube
IFU positioning glue gap
Fore-optics assembly positioning glue
Micro-lens positioning glue
Micro-lens array
Payload dock
Zoom Lens
Pupil Stop
Focus lens
Peizo-electric tubes
Slipper

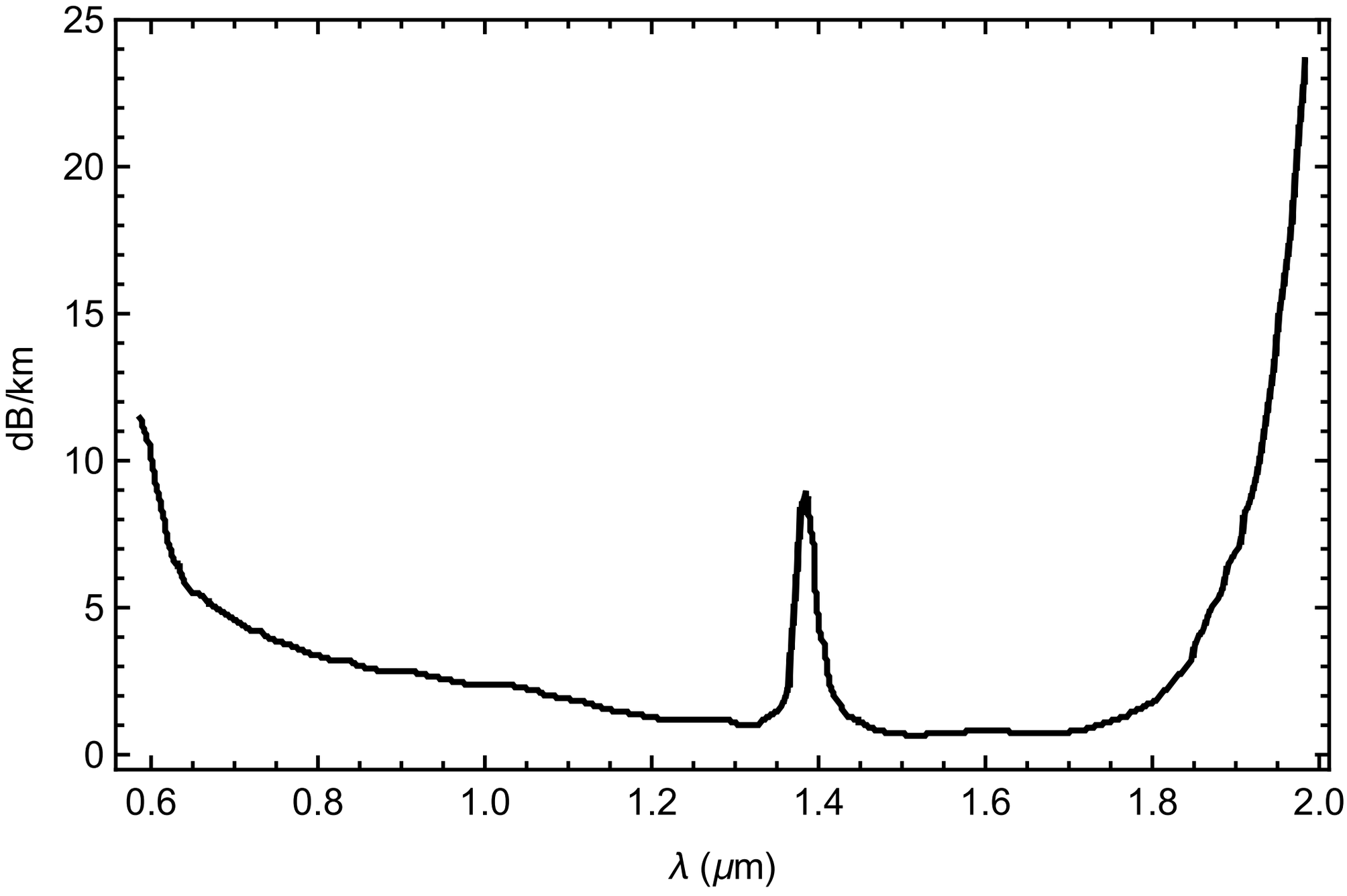
Starbugs Unit



Fore optics

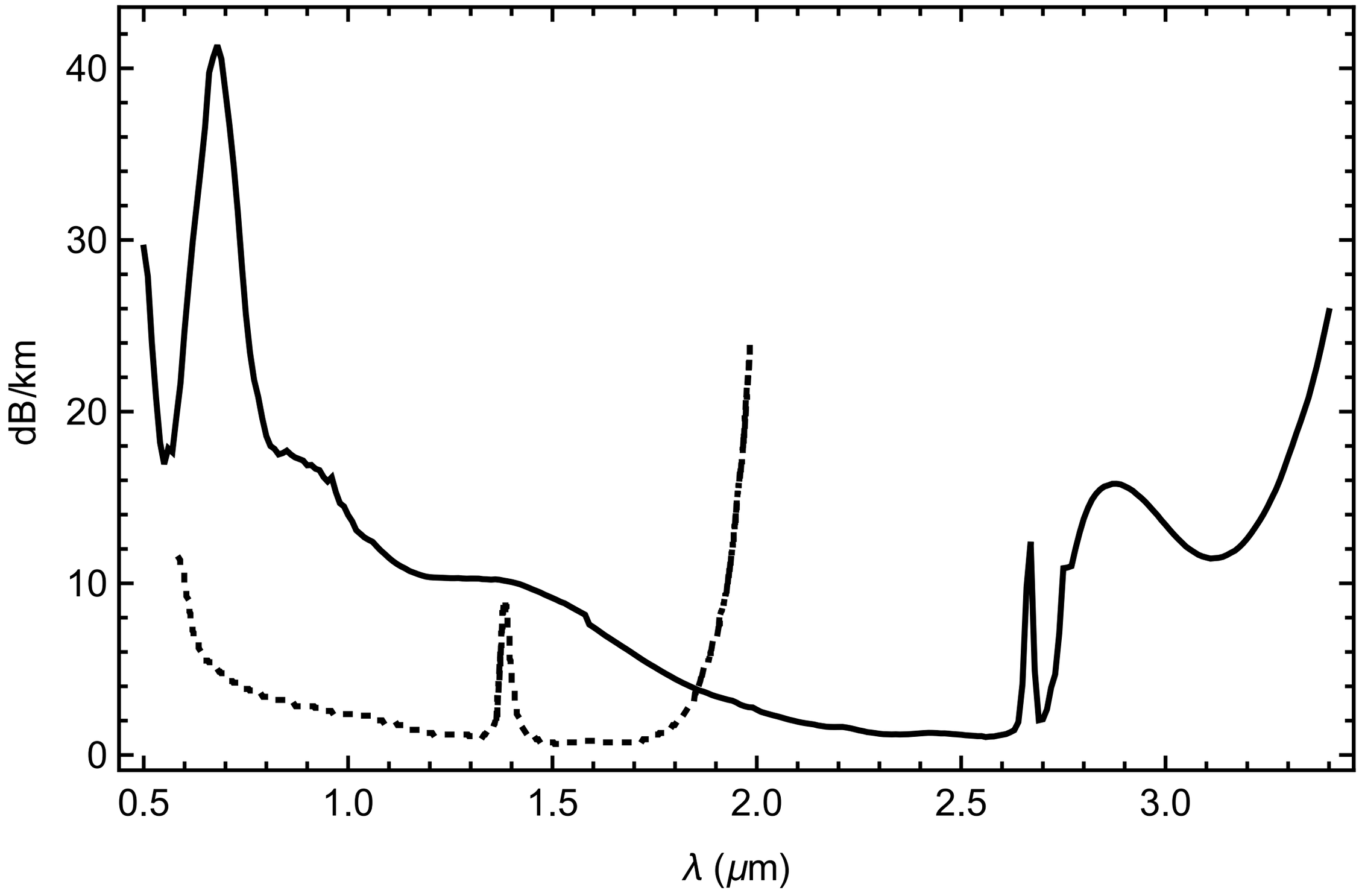

Field plate
L1
Zoom lens
L2
IFU
Pupil stop
S1
S2
Microlens array
Fiber array
57 56 55 54 53
58 34 33 32 31 52
59 35 17 16 15 30 51
60 36 18 6 5 14 29 50
61 37 19 7 1 4 13 28 49
38 20 8 2 3 12 27 48
39 21 9 10 11 26 47
40 22 23 24 25 46
41 42 43 44 45
250 μm
0.15"
1.35"

Fibre cable

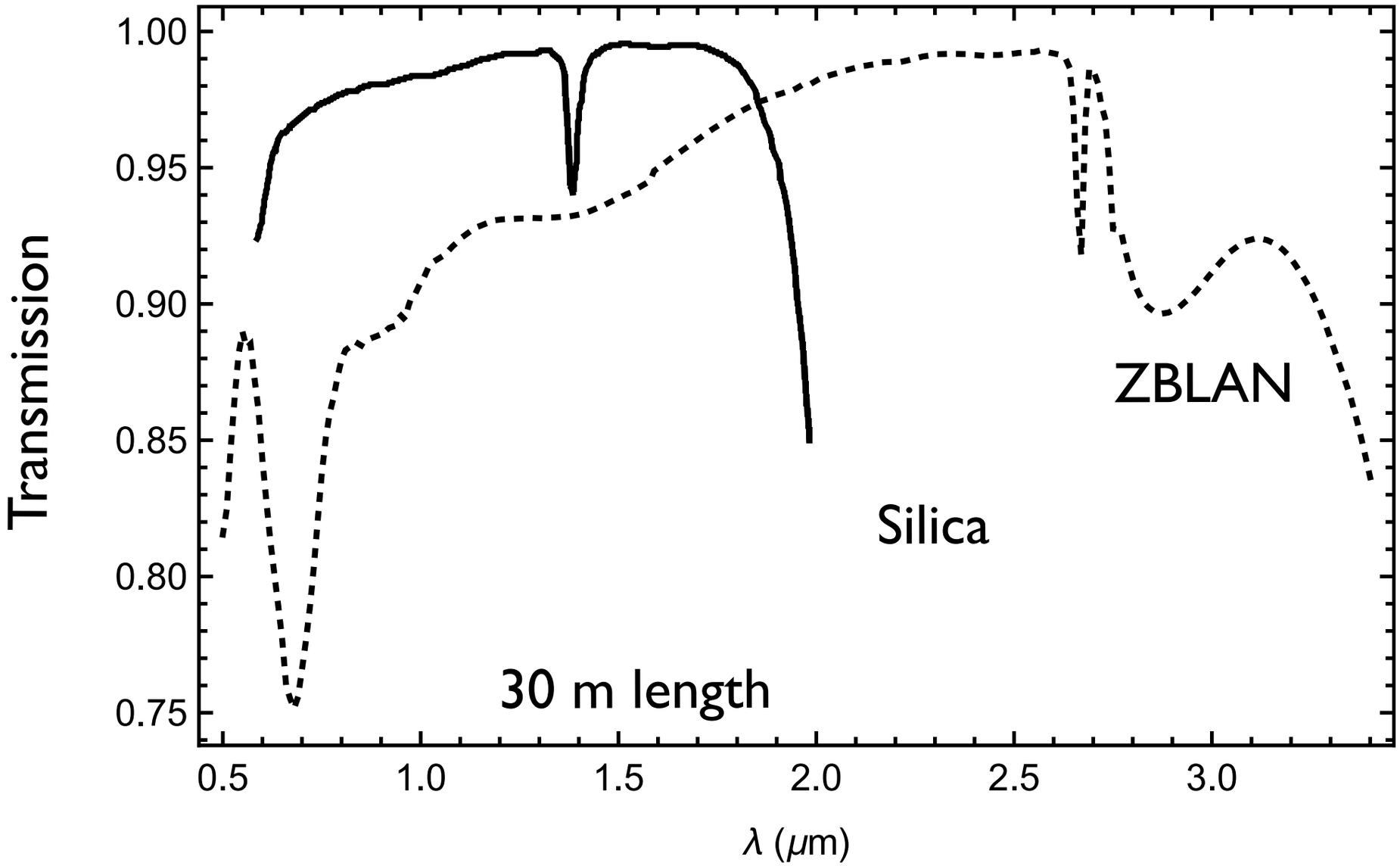


Low OH fibre for good NIR throughput, e.g. Polymicro FI

ZBLAN fibres



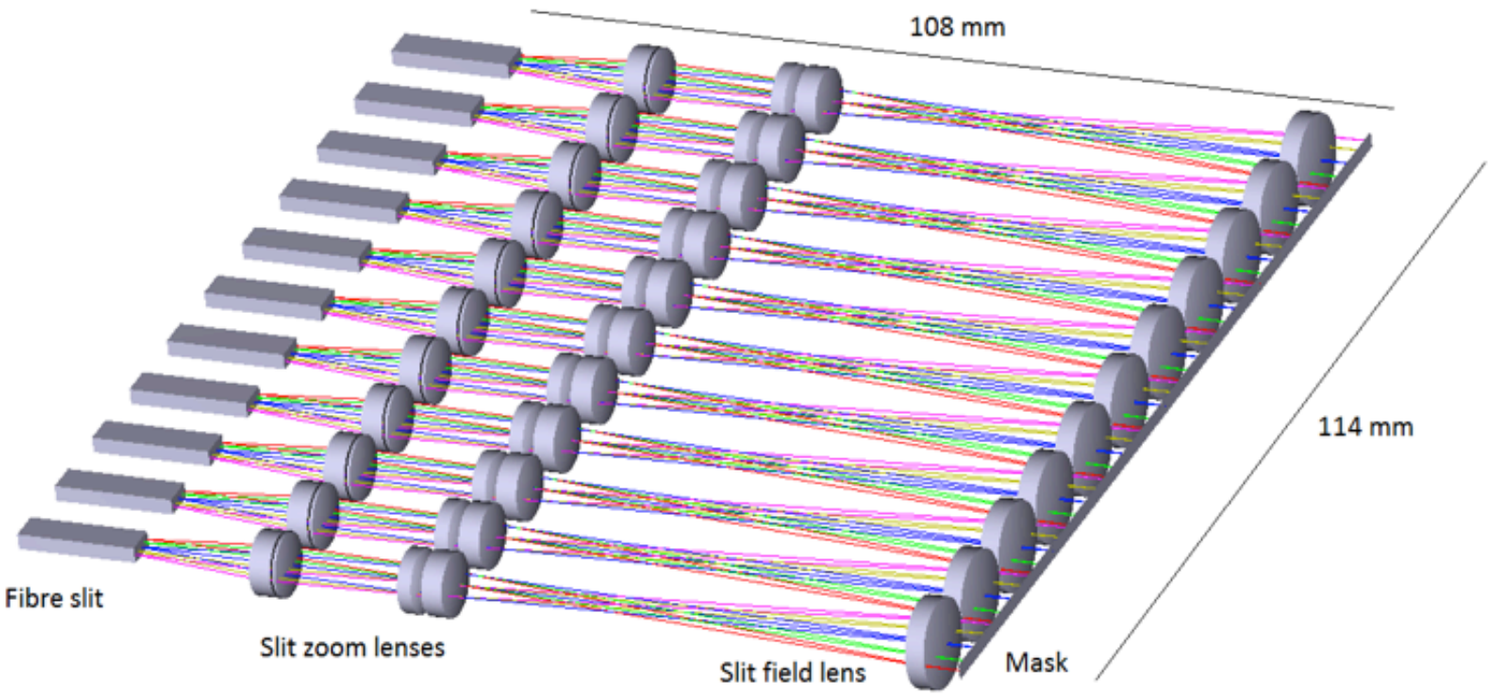
ZBLAN fibres

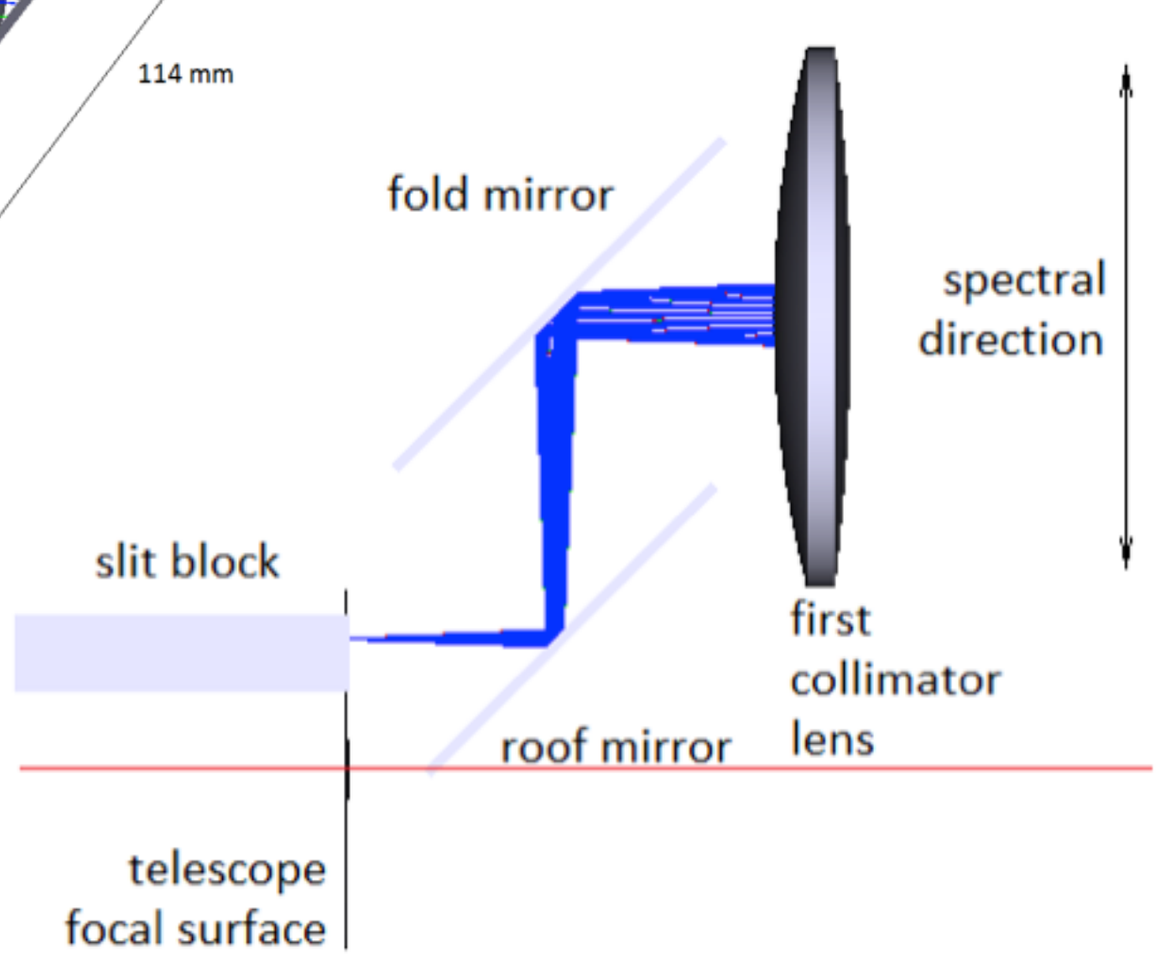


Excellent transmission. Good FRD. In use by Spirou and OHANA.

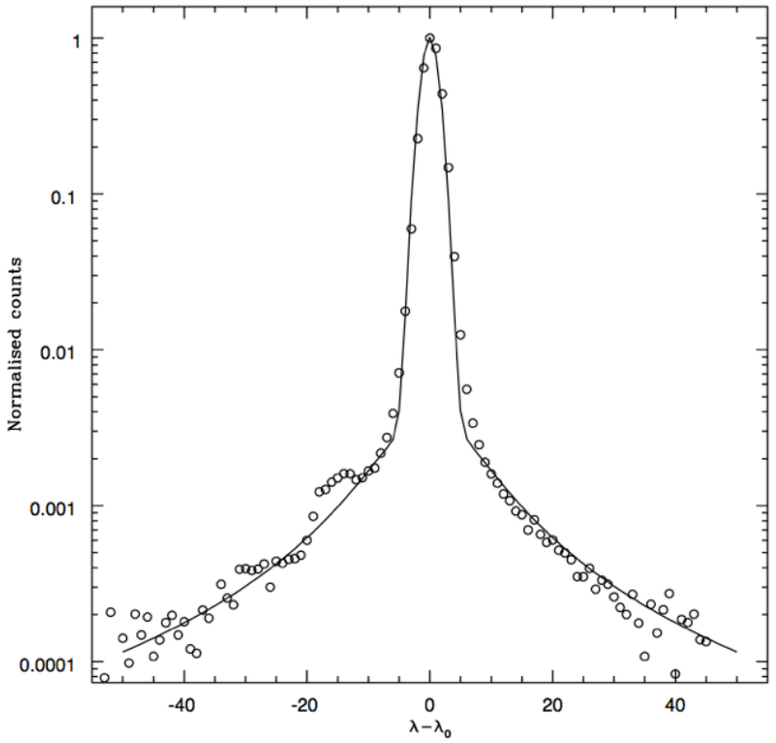
Handling? Polishing? Lab tests necessary.

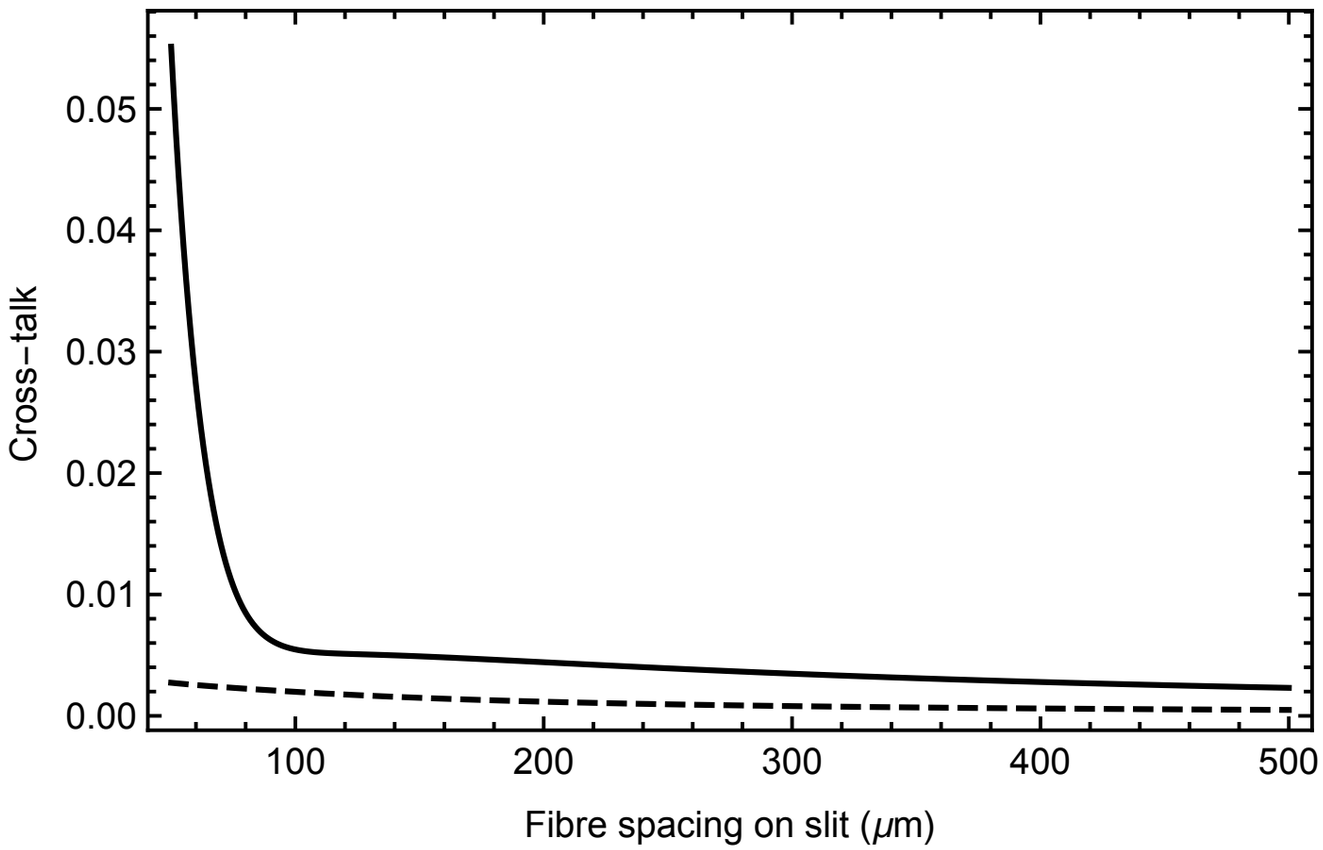
Slit unit


108 mm
114 mm
Fibre slit
Slit zoom lenses
Slit field lens
Mask


fold mirror
spectral direction
slit block
first collimator lens
roof mirror
telescope focal surface

Slit unit

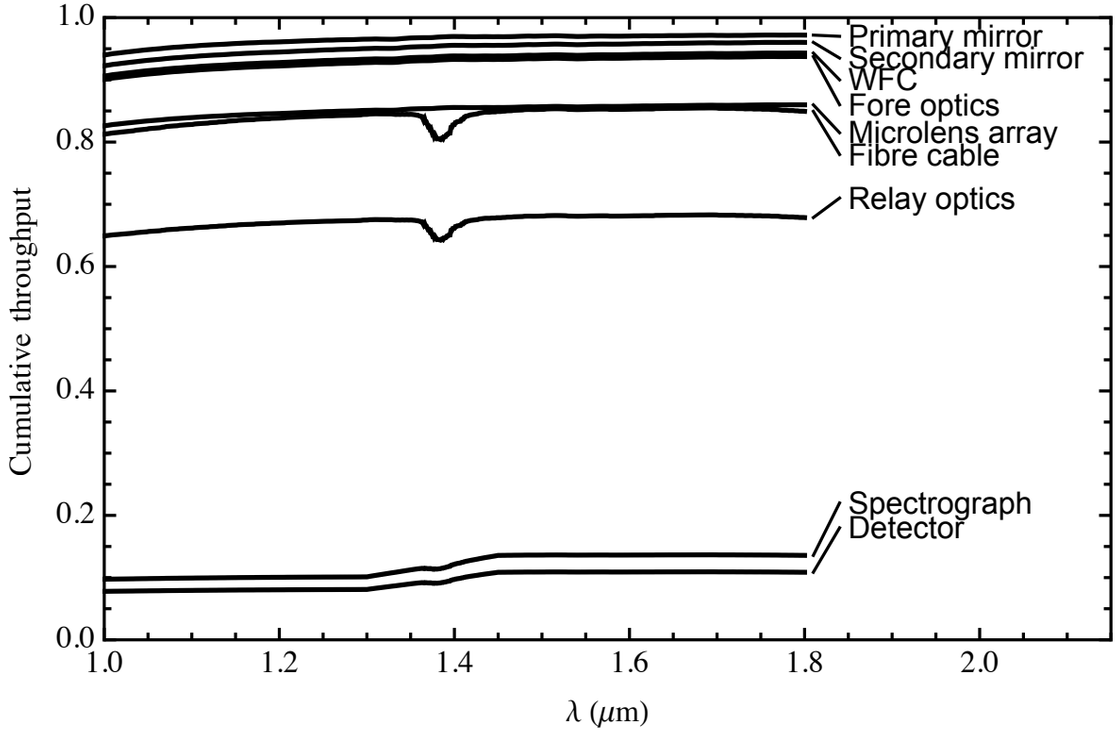




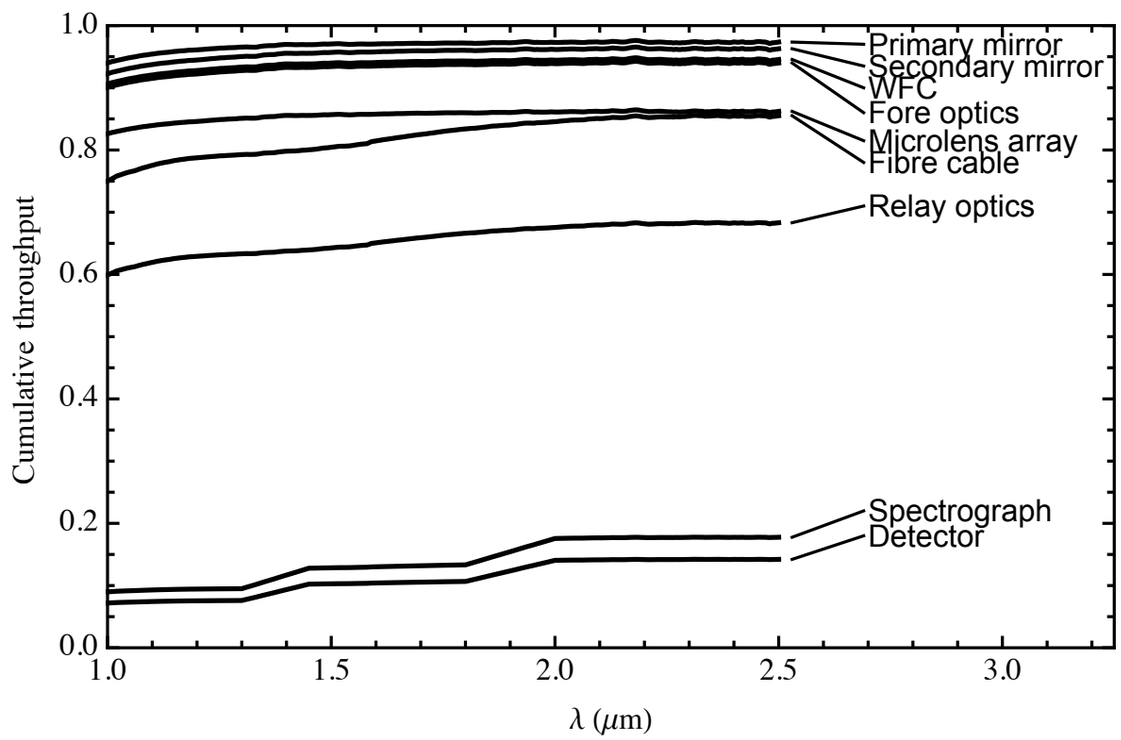
Cladding diameter	Spectral element separation		Number of spectral elements on both 2K x 2K CCD's	Number of 61 element Starbug units
	Mask	CCD		
88 μm	0.279 mm	5 pixels	819	13

Throughput

Silica



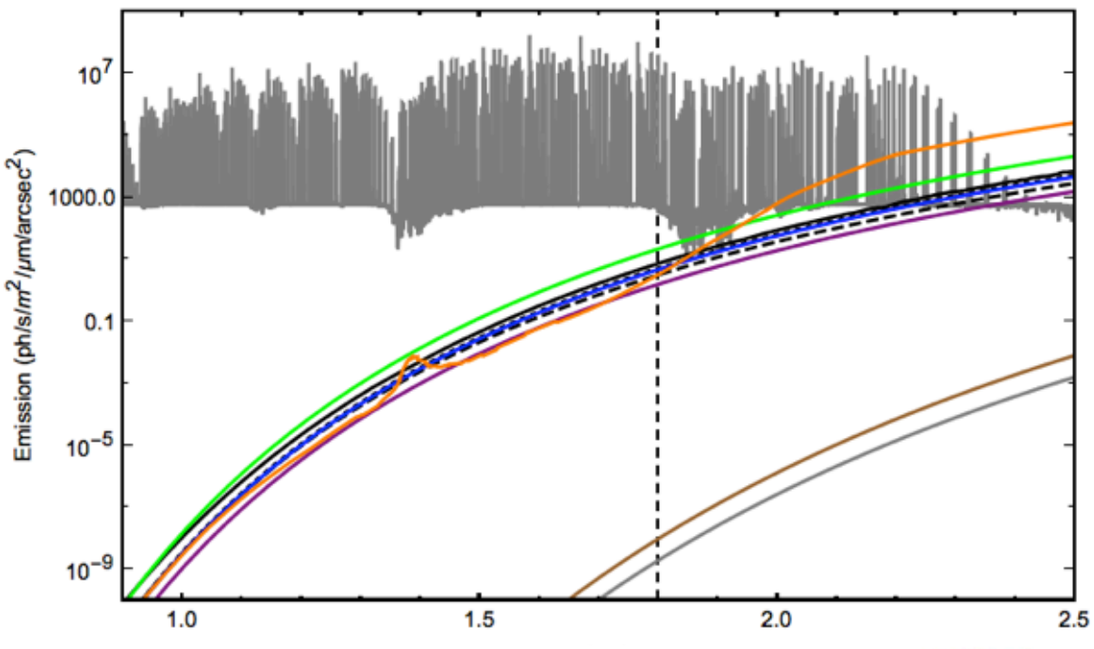
ZBLAN



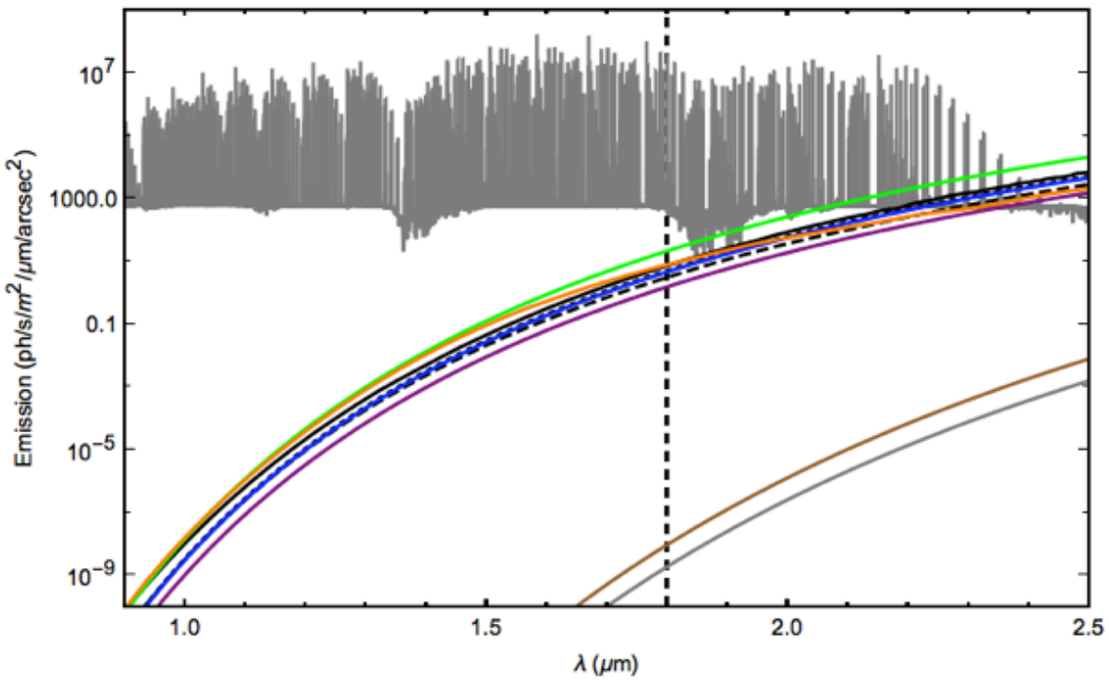
Wavelength (μm)	Silica fibre %	ZBLAN fibre %
1.2	9	8
1.6	12	11
2.2	0	15

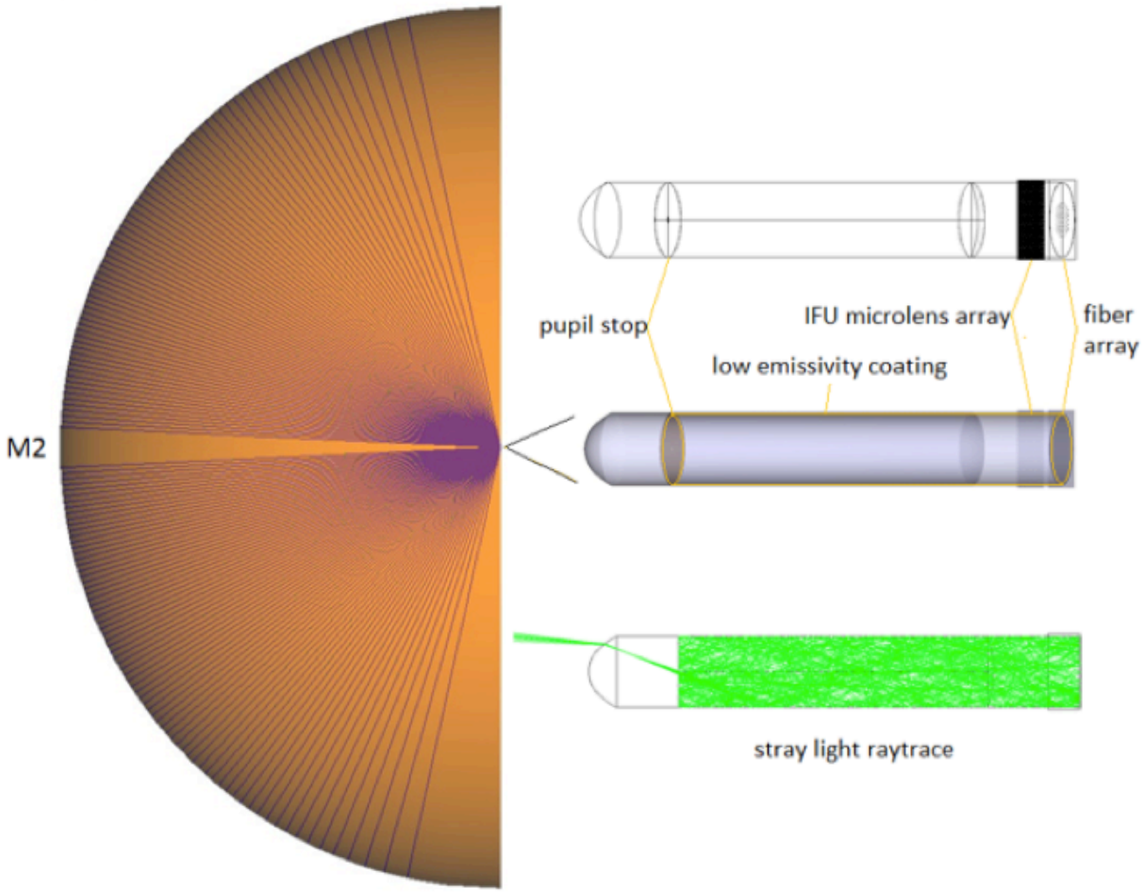
Background emission

Silica



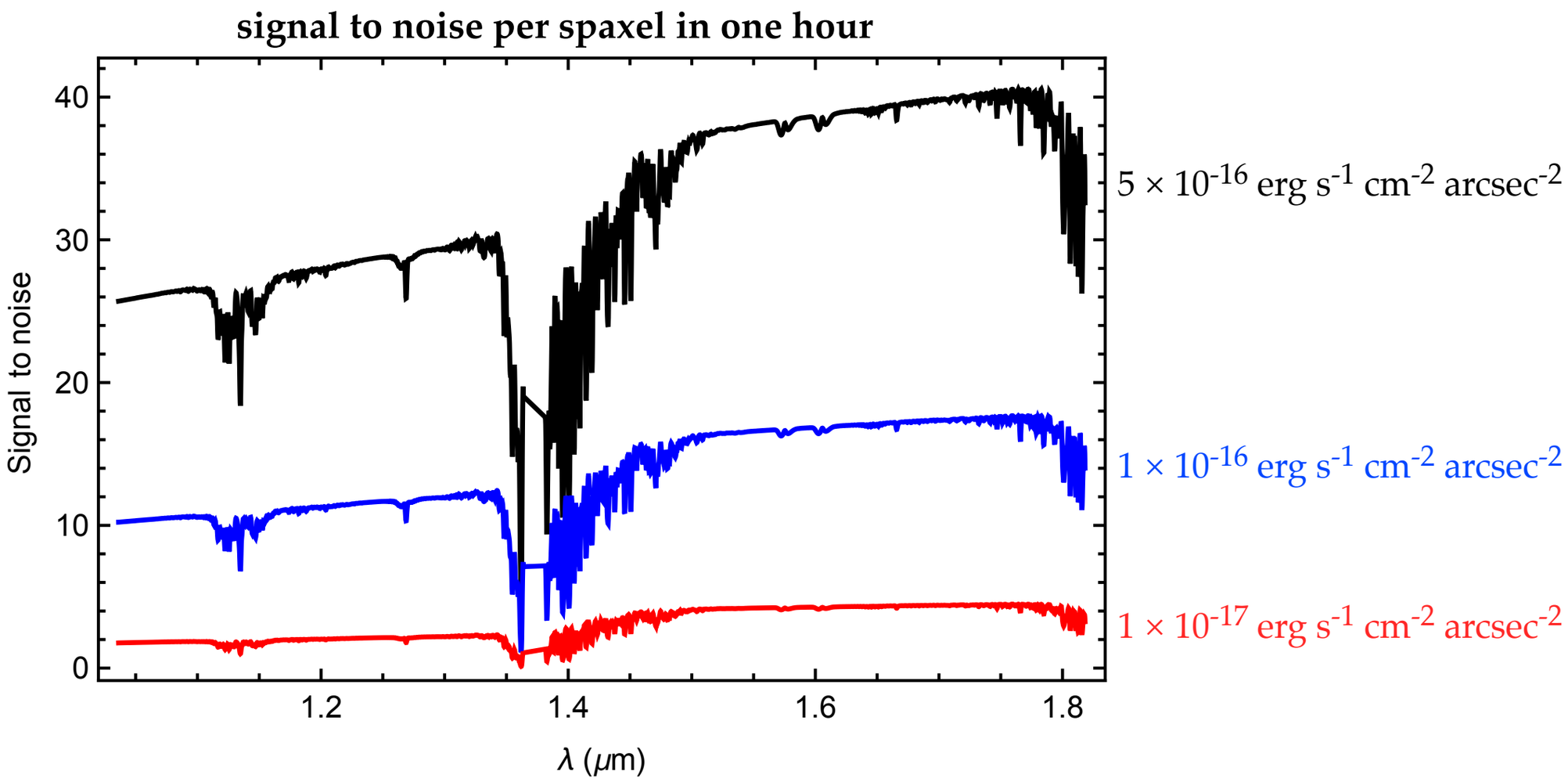
ZBLAN





stray-light contributes 12 % of the thermal emission from M2.

Signal to noise



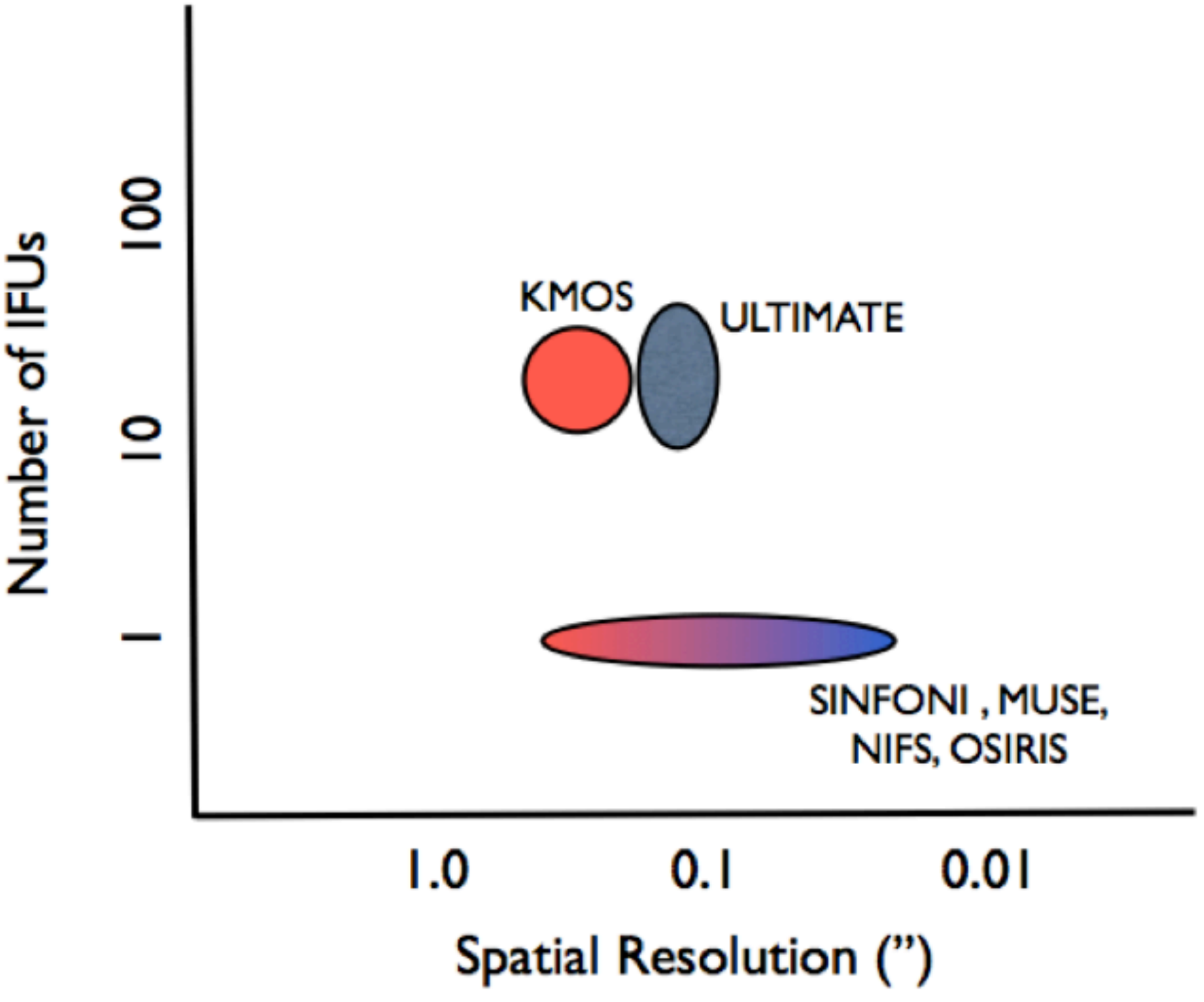
Signal to noise estimates for 1 hour observations of the H alpha line in a galaxy with a star-formation rate of 10 solar masses per year, uniformly distributed over a galaxy disc of radius 8 kpc.

Survey	S/N over 1 square arc-second	S/N per spaxel (0.15”)	KMOS (0.2” by 0.2”)
ULTIMATE @ z=0.6	108	15.1	10.0 (0.165 nm bin)
ULTIMATE @ z=0.9	80	11.3	7.4 (0.165 nm bin)
ULTIMATE @ z=1.4	69	9.6	2.8 (0.2 nm bin)

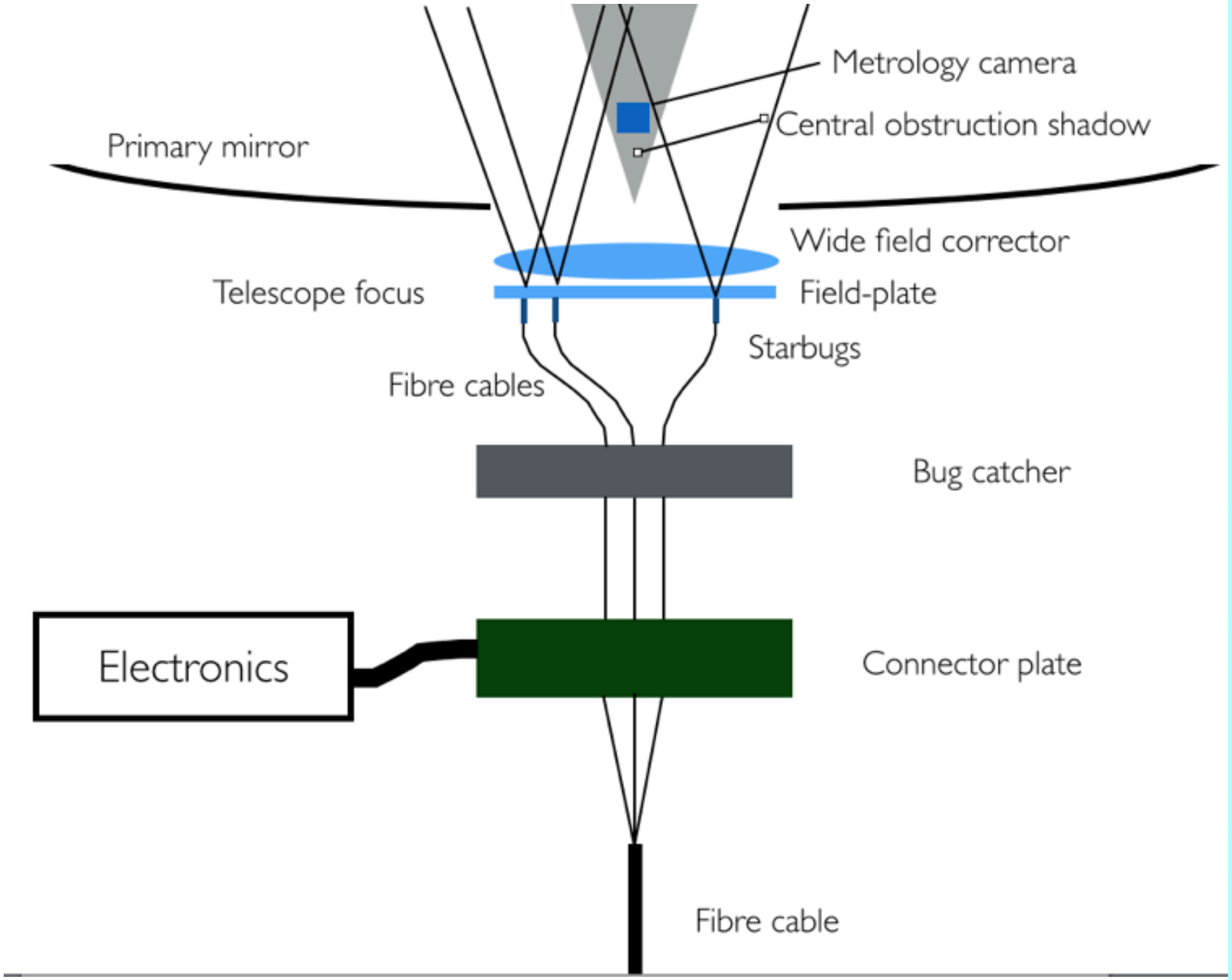
Comparison of ULTIMATE to existing and planned integral field spectrographs

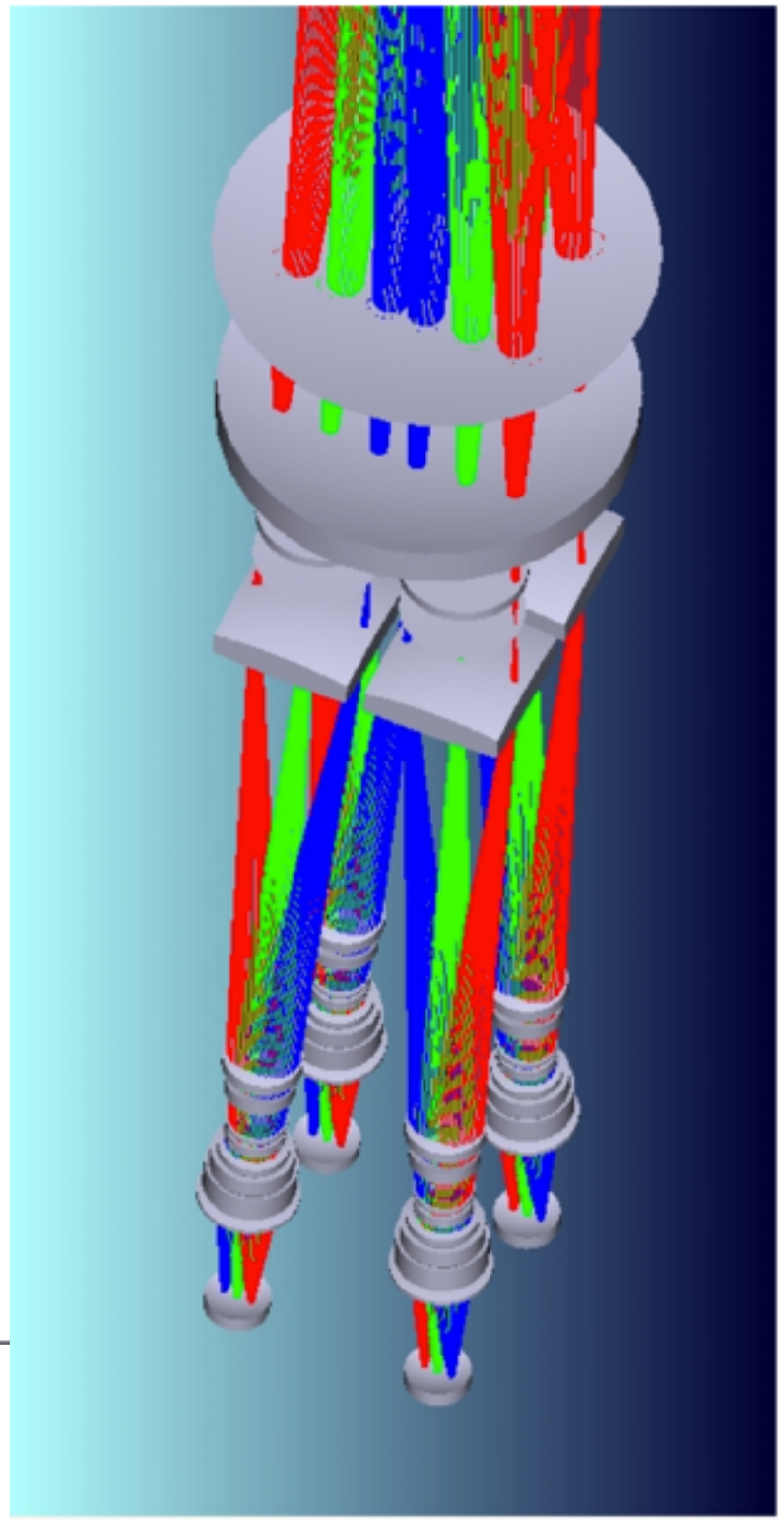
Instrument	AO	# of IFUs	Spaxel (“)	IFU FoV	Number or Elements	Spectral coverage (nm)	Resolution
ULTIMATE / Subaru	GLAO	8-13	0.15	1.19	61	380-1800	500-3000
KMOS / VLT	non AO	24	0.2	7.84	14x6	800-2500	2800-4500
OSIRIS / Keck	NGSAO, LGSAO	1	0.02-0.10	0.32x1.28, 4.8x6.4	16x64, 48x64	1000-2400	4000
SINFONI / VLT	non AO, NGSAO, LGSAO	1	0.025, 0.1, 0.25 (AO and non AO)	0.64, 9, 64 (AO and non AO)	32x16	1100-2450	1500-4000
NIFS /Gemini	SCAO, LGSAO	1	0.04	9	30x30	900-2400	5000
MUSE/VLT	non AO and GLAO	1	0.025, 0.2 (AO and non AO)	56, 3600 (AO and non AO)	300x120	470-930	1700-3500
GMTIFS / GMT	GLAO,NGSAO,LTAO	1	0.006 to 0.05	0.25x0.5 to 2.1x4.2 (NGSAO and GLAO)	40x20 and 20x10 (LTAO and GLAO)	1000-2400	5000-10000
HECTOR/ AAT	non AO	100	1.6	15-28.5” diameter	61(?)	372-776	3000-5000

Comparison of ULTIMATE to existing and planned integral field spectrographs



Compatibility with WFC





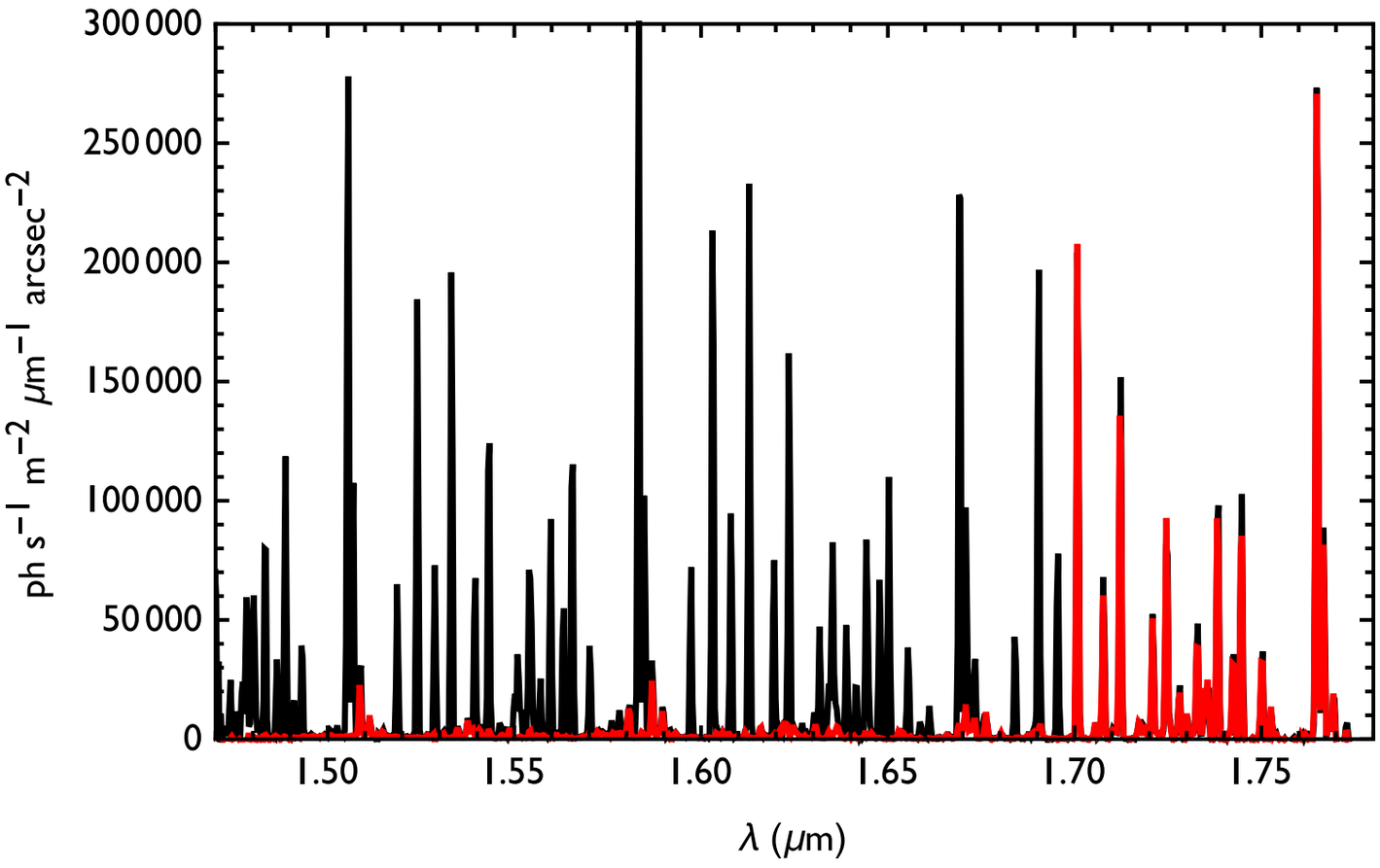
Phased approach

Without GLAO

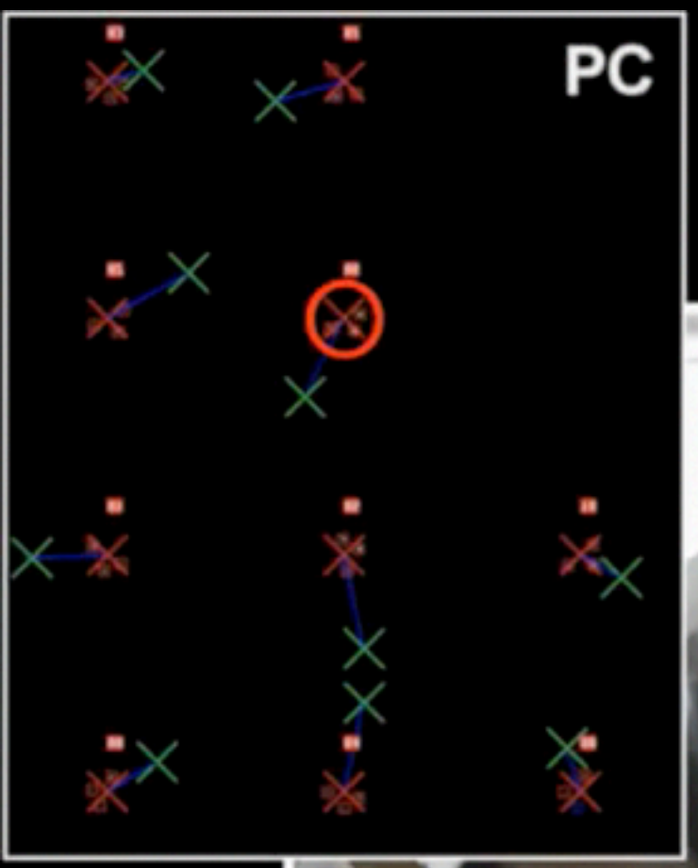
With GLAO

New spectrographs - more IFUs

OH suppression



Starbugs



Each Starbug will move from its home position (red cross)