

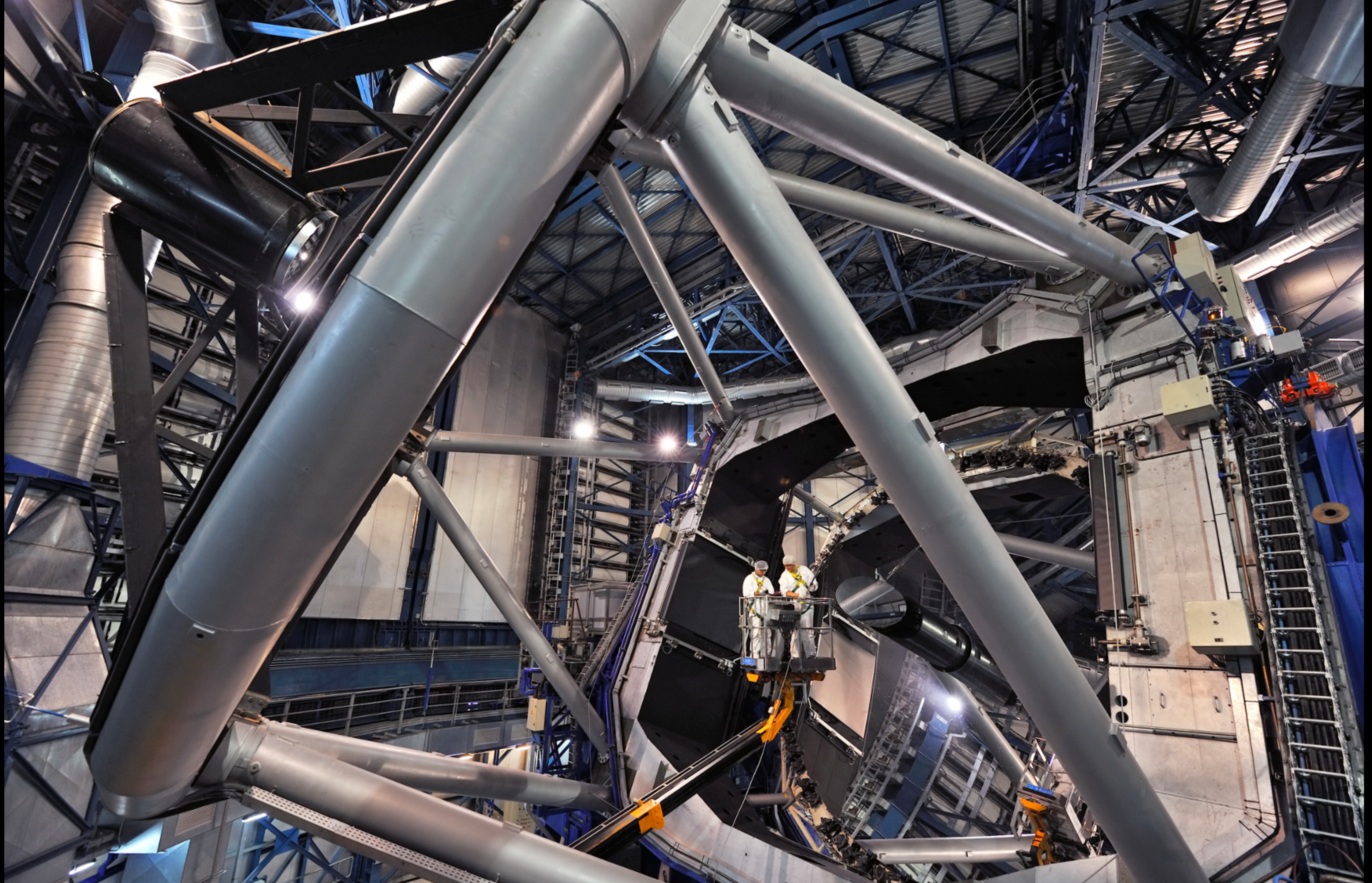


ESO Strategy for MM science

N&O P@@ - Nando Patat

European Southern Observatory - Observing Programmes Office





Instrument ▲	Type ◆	Wavelength range (nm) ◆	Resolution (arcsec) ◆	Spectral resolution ◆
ESPRESSO	Spectrometer	380–780	4	140000-180000
FLAMES	Multi-object spectrometer	370–950	n/a	7500–30000
FORS2	Imager/Spectrometer	330–1100	0.125	260–1600
GRAVITY	Imager	2000–2400	0.003	22,500,4500
HAWK-I	Near-IR Imager	900–2500	0.106	
KMOS	Near-IR Spectrometer	800–2500	0.2	1500–5000
MUSE	Integral-field Spectrometer	365–930	0.2	1700–3400
PIONIER	Imager	1500–2400	0.0025	
SINFONI	Near-IR IFU	1000–2500	0.05	1500–4000
SPHERE	AO	500–2320	0.02	30–350
UVES	UV/Vis Spectrometer	300–500,420–1100	0.16	80000–110000
X-SHOOTER	UV-NIR Spectrometer	300–2500		4000–17000



UT1 (Antu)

NACO
FORS2
KMOS

UT2 (Kueyen)

FLAMES
X-SHOOTER
UVES

UT3 (Melipal)

SPHERE
VISIR
CRIRES (2019)

UT4 (Yepun)

AOF
HAWK-I
SINFONI
MUSE

LGSF

4LGSF

VST

OmegaCAM

VISTA

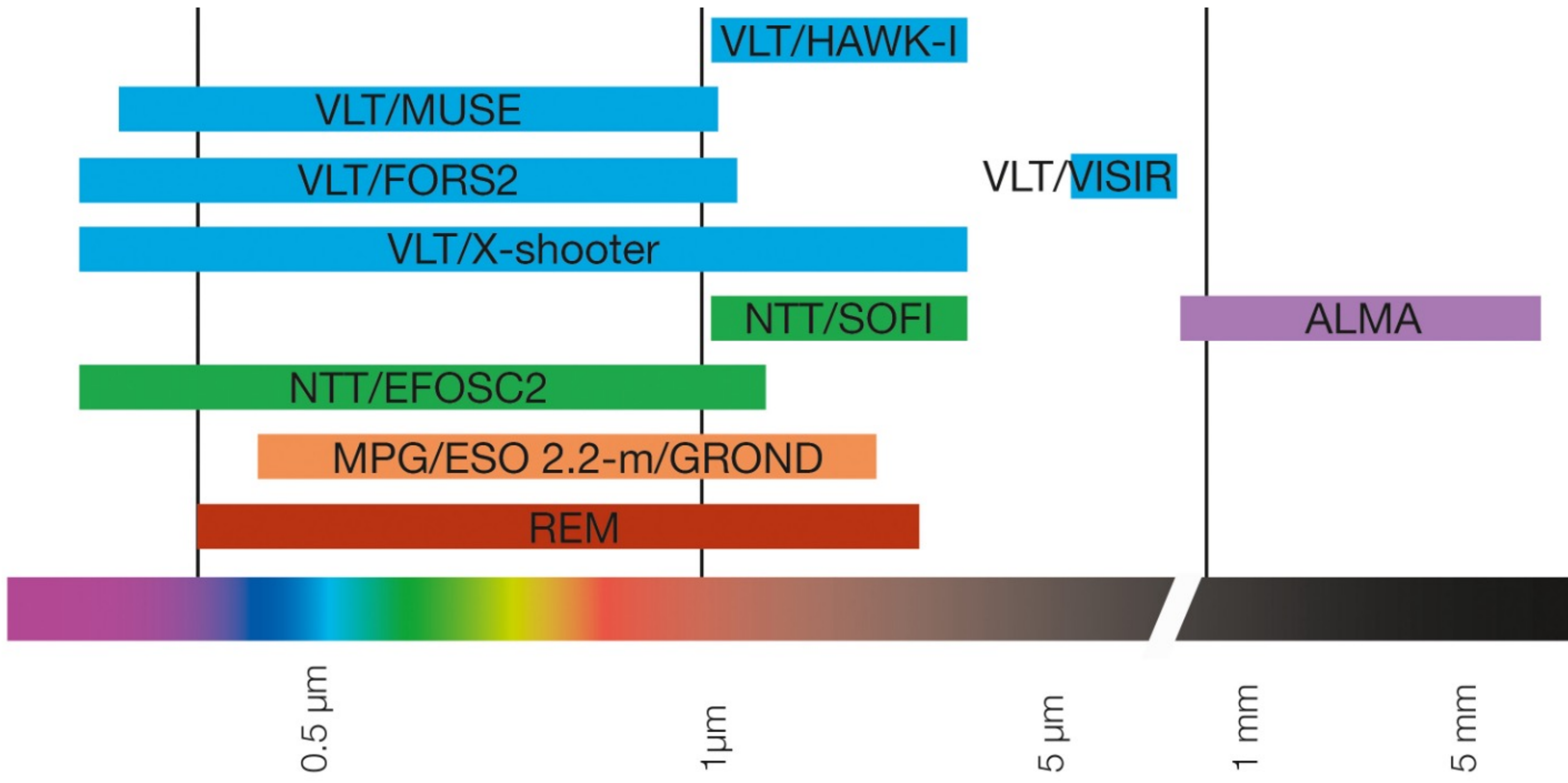
VIRCAM

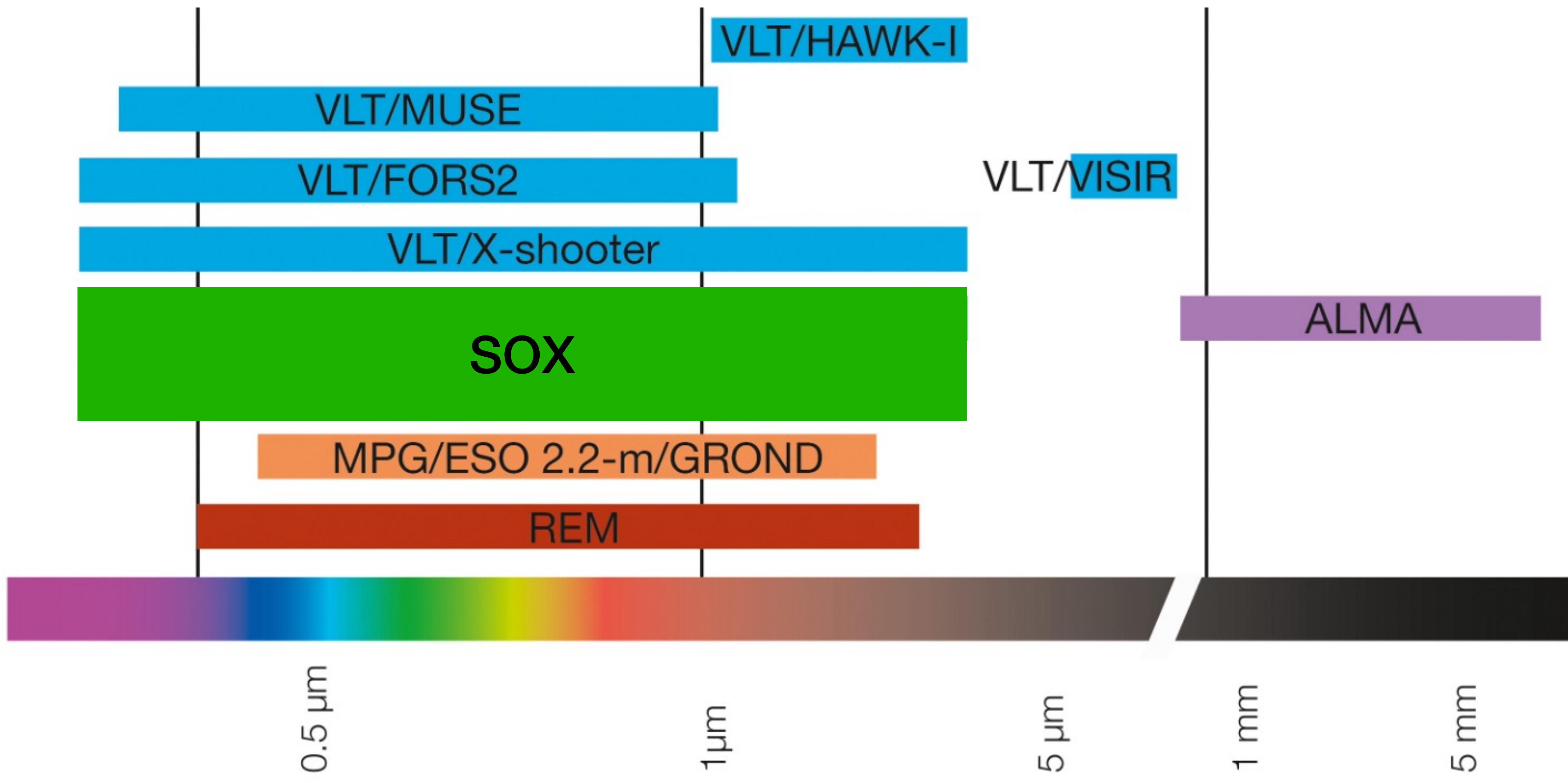
VLT

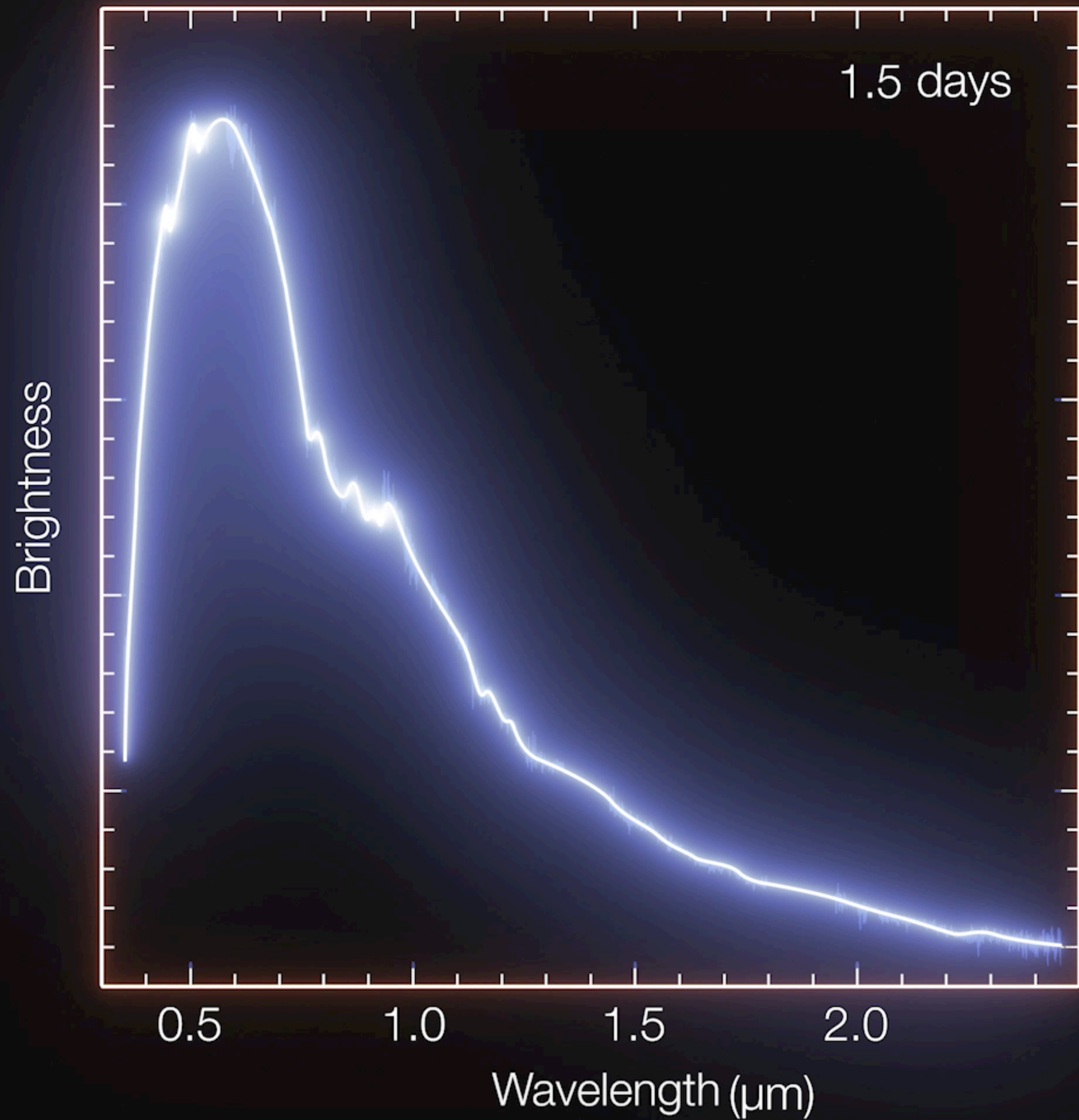
Incoherent combined
Coudé focus:
ESPRESSO

Blue kilonova – FORS2, X-shooter
Red kilonova – HAWK-I, NACO, X-shooter
GRB afterglow – FORS, X-shooter
Kilonova polarimetry – FORS

Counterpart discovery: VST, VISTA
(collaborations with ENGRAVE)
Also: ATLAS, BlackGEM, GOTO, PS1, ZTF





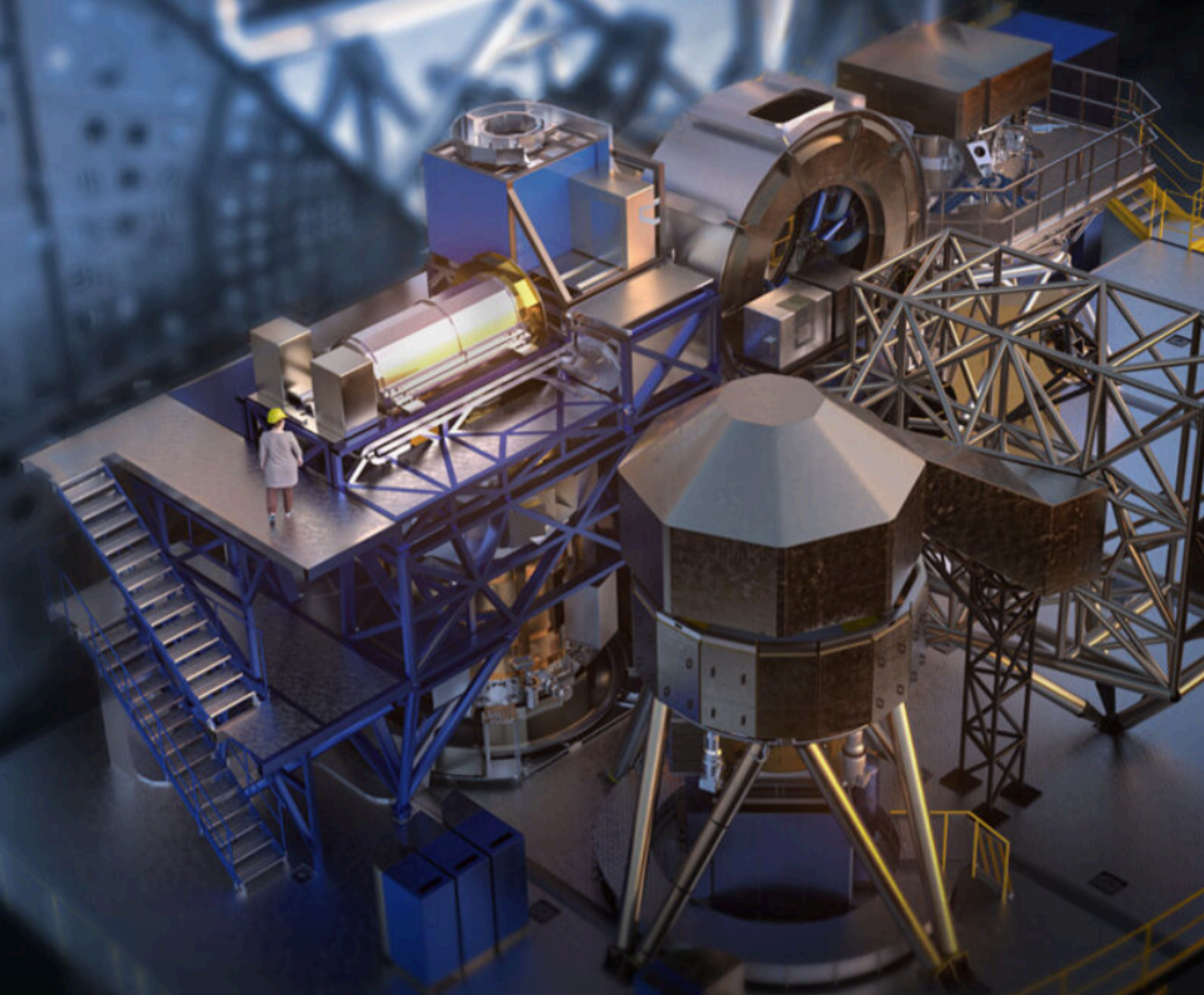


ELT first light: 2028



European
Southern
Observatory

The Extremely Large Telescope

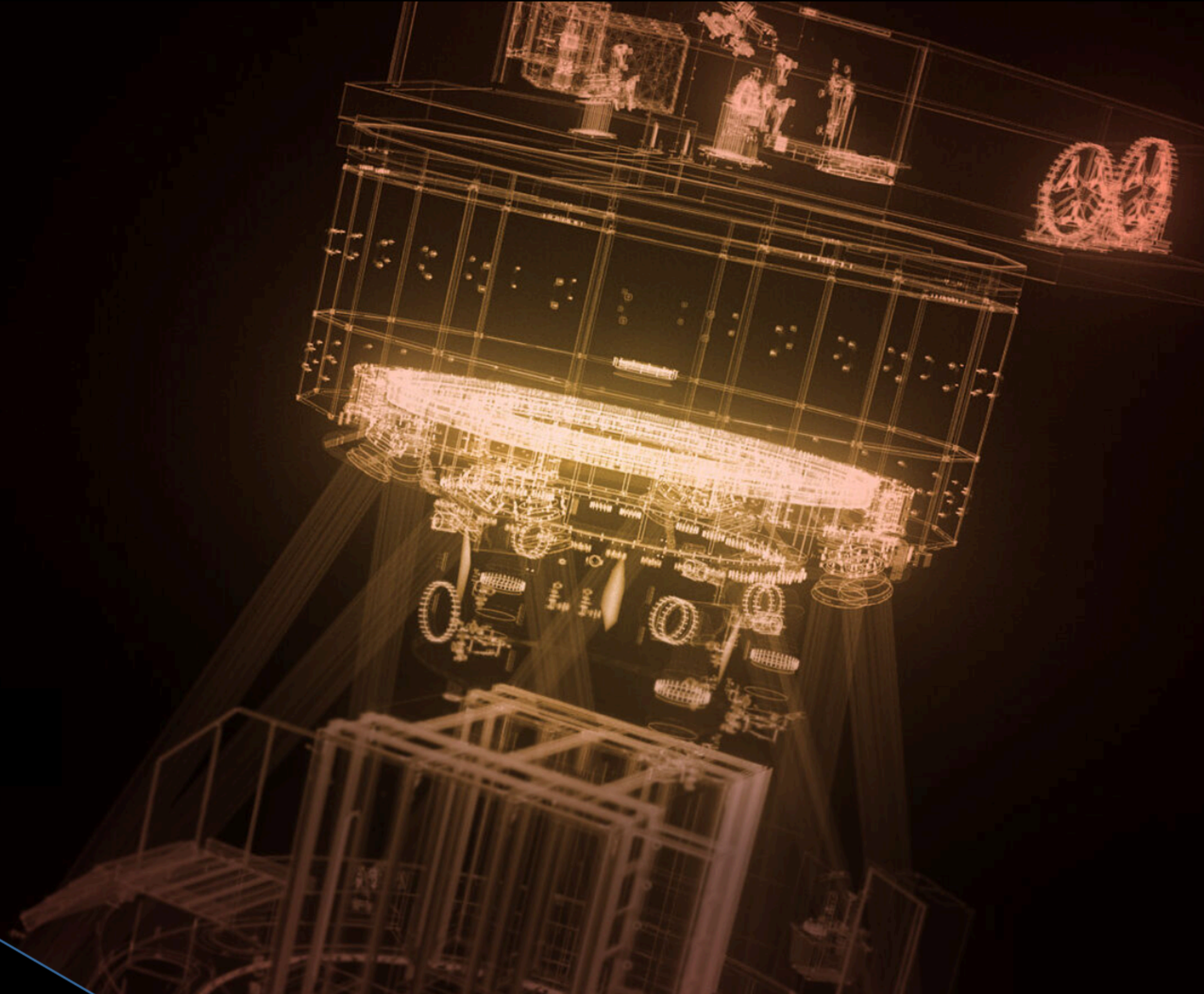


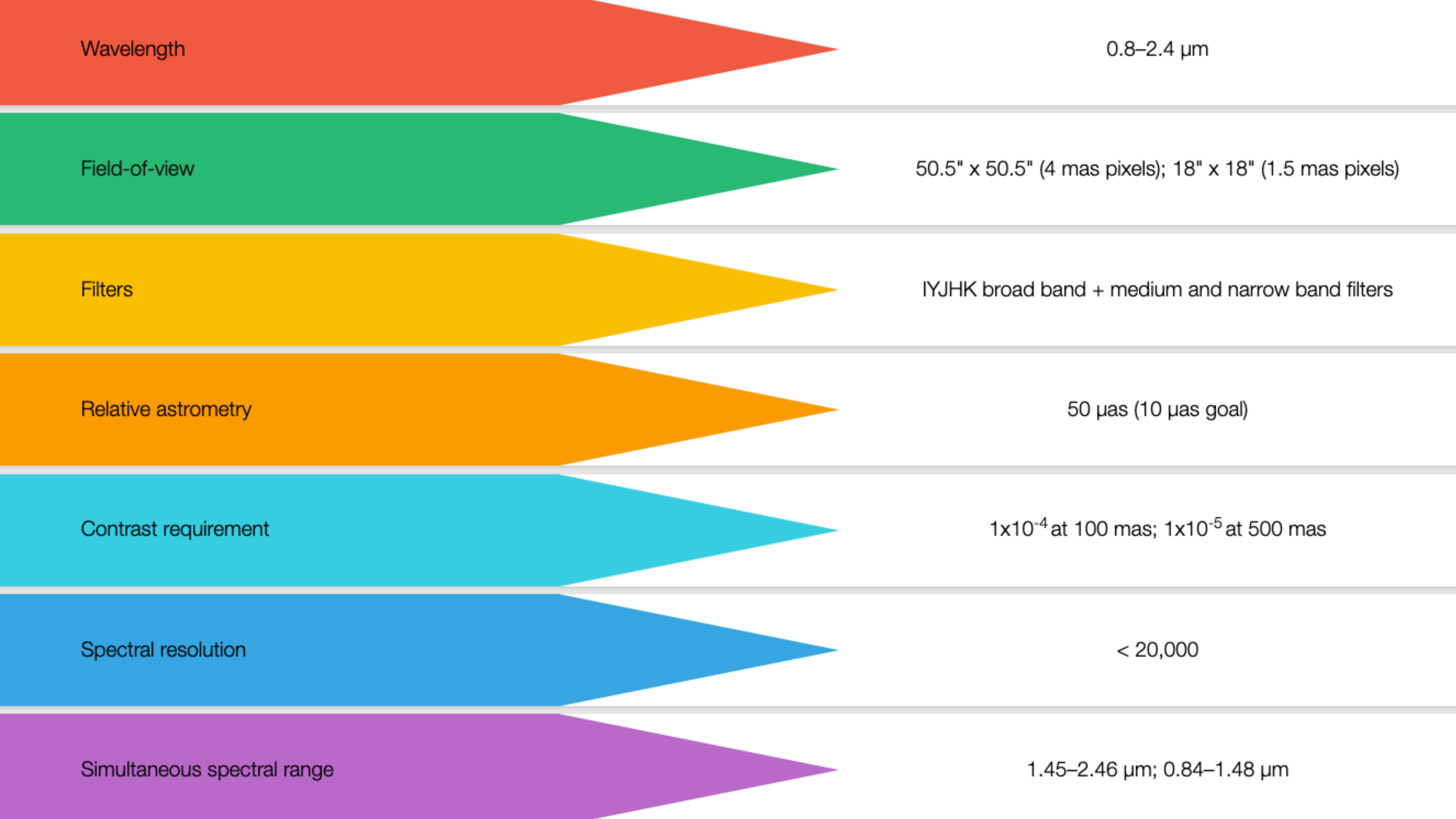
Instruments Overview

MICADO

Multi-AO Imaging Camera for Deep Observations

MICADO
First light instrument





Wavelength

0.8–2.4 μm

Field-of-view

50.5" x 50.5" (4 mas pixels); 18" x 18" (1.5 mas pixels)

Filters

IYJHK broad band + medium and narrow band filters

Relative astrometry

50 μas (10 μas goal)

Contrast requirement

1×10^{-4} at 100 mas; 1×10^{-5} at 500 mas

Spectral resolution

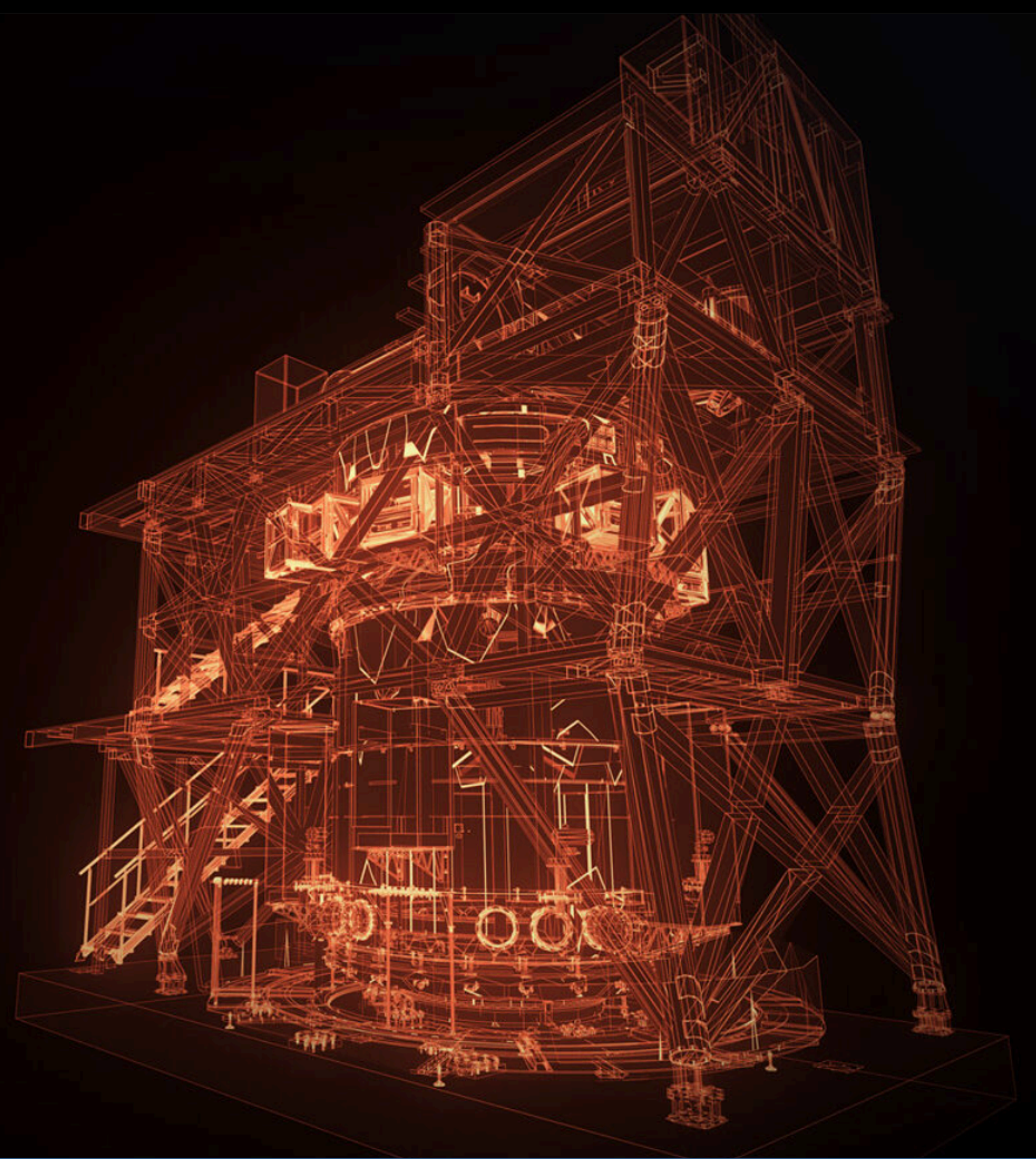
< 20,000

Simultaneous spectral range

1.45–2.46 μm ; 0.84–1.48 μm

HARMONI

High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph



HARMONI



Wavelength

0.47—2.45 μm

Spectral resolution

~3,500, 7,500, and 18,000 in the NIR and ~3,500 in the VIS bands

Simultaneous spectral range

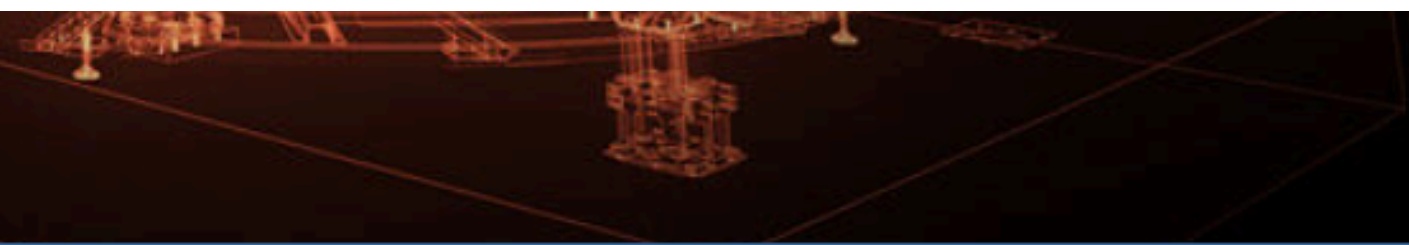
at least one band at a time R~7,500 (i, z, J, H, K), two at R~3,500

Field(s)-of-view

four, corresponding to different spaxel scales

AO

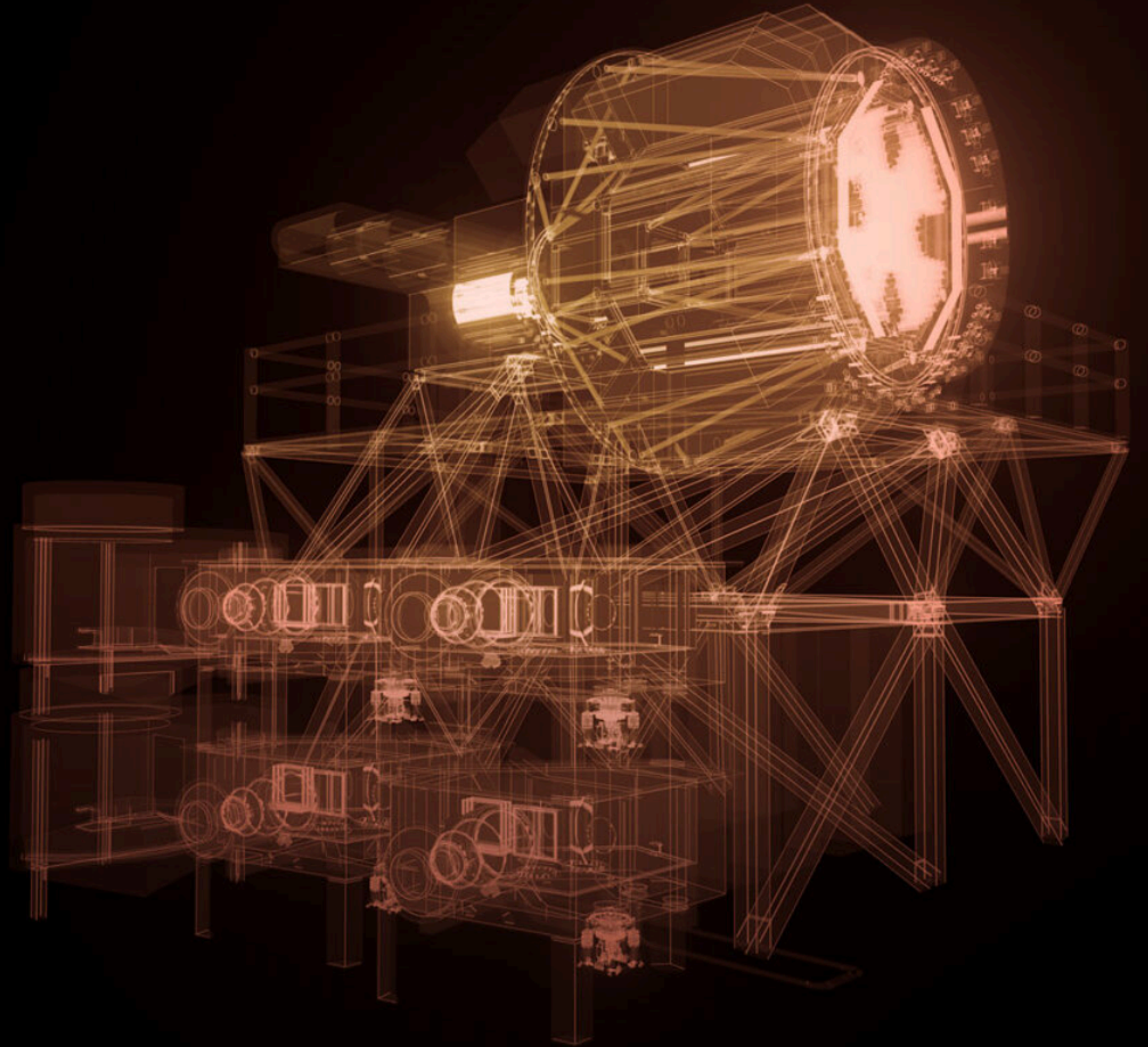
LTAO and SCAO



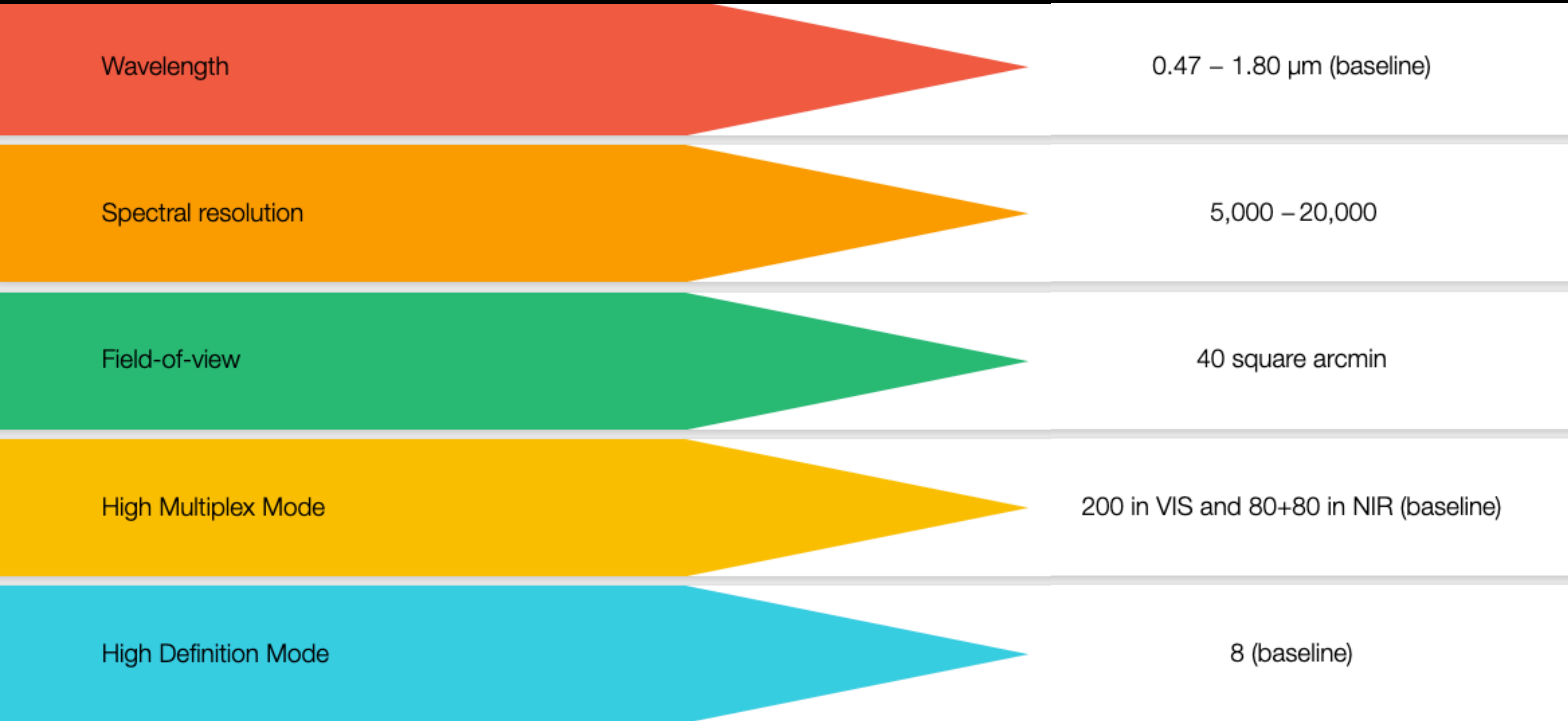
Scale (mas)	Field of View	Comments
60x30	9.1"x6.1"	For non-AO visible observations
20x20	3.0"x4.1"	For optimal sensitivity (faint targets)
10x10	1.5"x2.1"	Best combination sensitivity/spatial resolution
4x4	0.6"x0.8"	Highest spatial resolution (diffraction limited)

MOSAIC

Multi-Object Spectrograph



MOSAIC

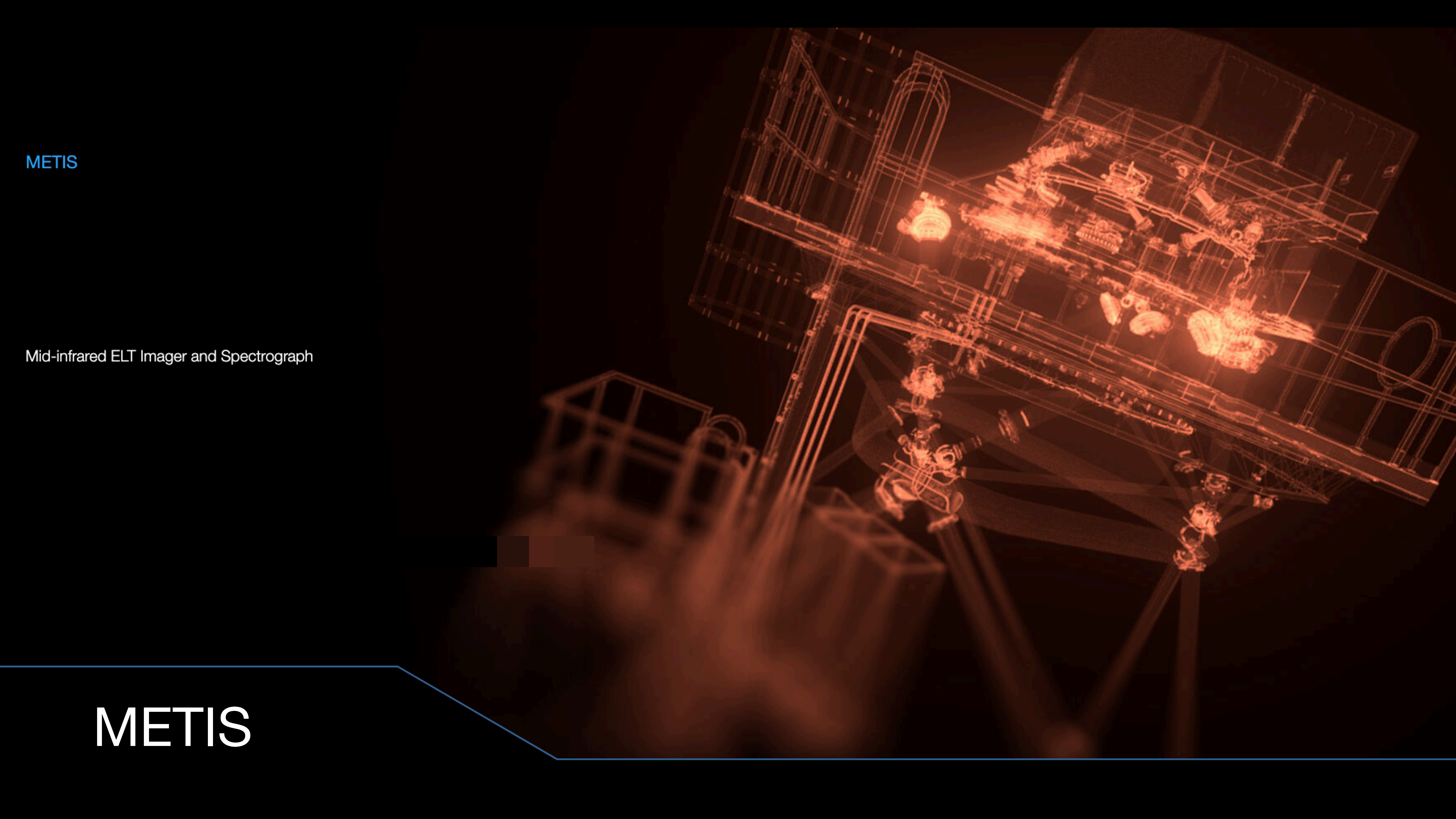


MOSAIC

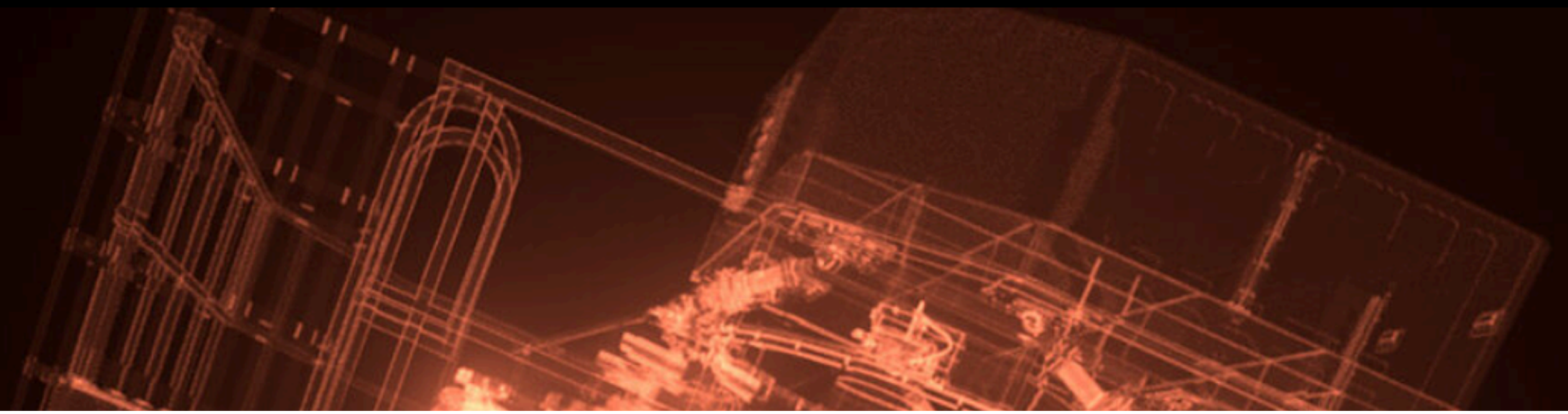
METIS

Mid-infrared ELT Imager and Spectrograph

METIS



METIS



Wavelength coverage

3 – 13 μm (imaging); the imager includes low-resolution slit spectroscopy and coronagraphy
3 – 5 μm IFU spectroscopy

Spectral resolution

Low-resolution, long-slit $R\sim 400$ (N-band), $R\sim 1500$ (L-band), $R\sim 1900$ (M-band)
High-resolution, IFU $R\sim 100,000$ (L,M bands)

Field-of-view

$\sim 10''$ (imager), $< 1''$ (high resolution IFU spectroscopy)

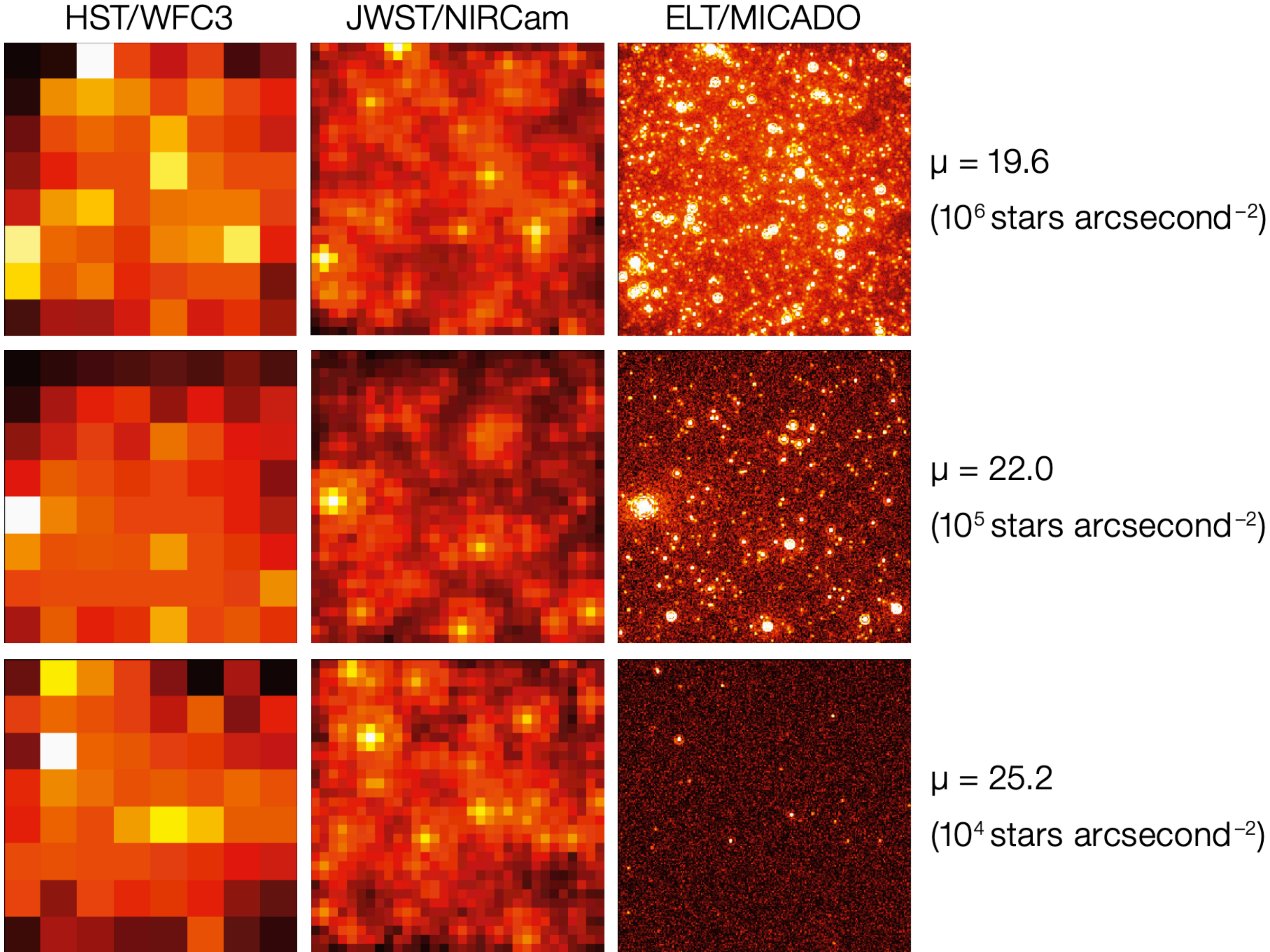
AO

all observing modes work at the diffraction limit with a single conjugate AO system

METIS

Instrument	Main specifications			Schedule				
	Field of view/slit length/ pixel scale	Spectral resolution	Wavelength coverage (μm)	Phase A	Project start	PDR	FDR	First light
MICADO	Imager (with coronagraph) 50.5" \times 50.5" at 4 mas/pix 19" \times 19" at 1.5 mas/pix	<i>I, Z, Y, J, H, K</i> + narrowbands	0.8–2.45	2010	2015	2019	2023	2028?
	Single slit	$R \sim 20\,000$						
MORFEO	AO Module SCAO – MCAO		0.8–2.45	2010	2015	2023		
HARMONI + LTAO	IFU 4 spaxel scales from: 0.8" \times 0.6" at 4 mas/pix to 6.1" \times 9.1" at 30 \times 60 mas/pix (with coronagraph)	$R \sim 3\,200$ $R \sim 7\,100$ $R \sim 17\,000$	0.47–2.45	2010	2015	2018		
METIS	Imager (with coronagraph) 10.5" \times 10.5" at 5 mas/pix in <i>L, M</i> 13.5" \times 13.5" at 7 mas/pix in <i>N</i>	<i>L, M, N</i> + narrowbands	3–13	2010	2015	2019		
	Single slit	$R \sim 1\,400$ in <i>L</i> $R \sim 1\,900$ in <i>M</i> $R \sim 400$ in <i>N</i>						
	IFU 0.6" \times 0.9" at 8 mas/pix (with coronagraph)	<i>L, M</i> bands $R \sim 100\,000$						
ANDES	Single object	$R \sim 100\,000$	0.4–1.8 simultaneously	2018				
	IFU (SCAO)							
	Multi object (TBC)							
MOSAIC	~ 7 -arcminute FoV ~ 200 objects (TBC)	$R \sim 5\,000$ – $20\,000$	0.45–1.8 (TBC)	2018				
	~ 8 IFUs (TBC)	$R \sim 5\,000$ – $20\,000$	0.8–1.8 (TBC)					
PCS	Extreme AO camera and spectrograph	TBC	TBC					

Diffraction limit resolution: 4-12 mas



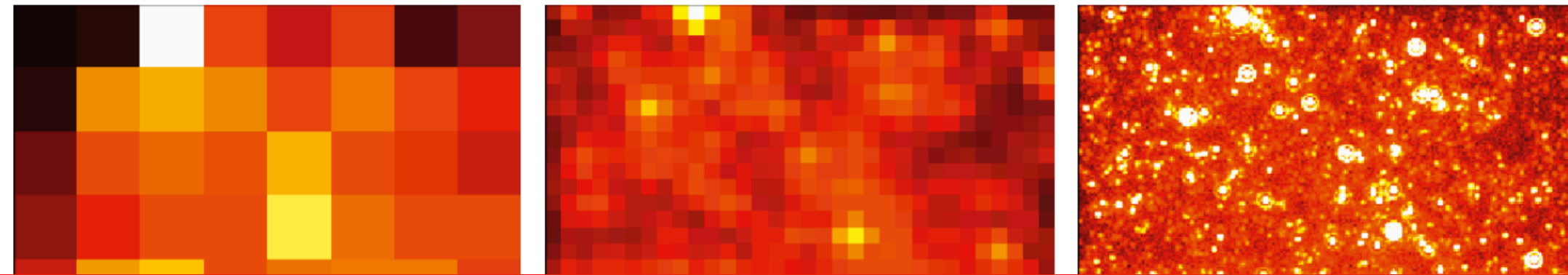
Davies et al (2021)

Diffraction limit resolution: 4-12 mas

HST/WFC3

JWST/NIRCam

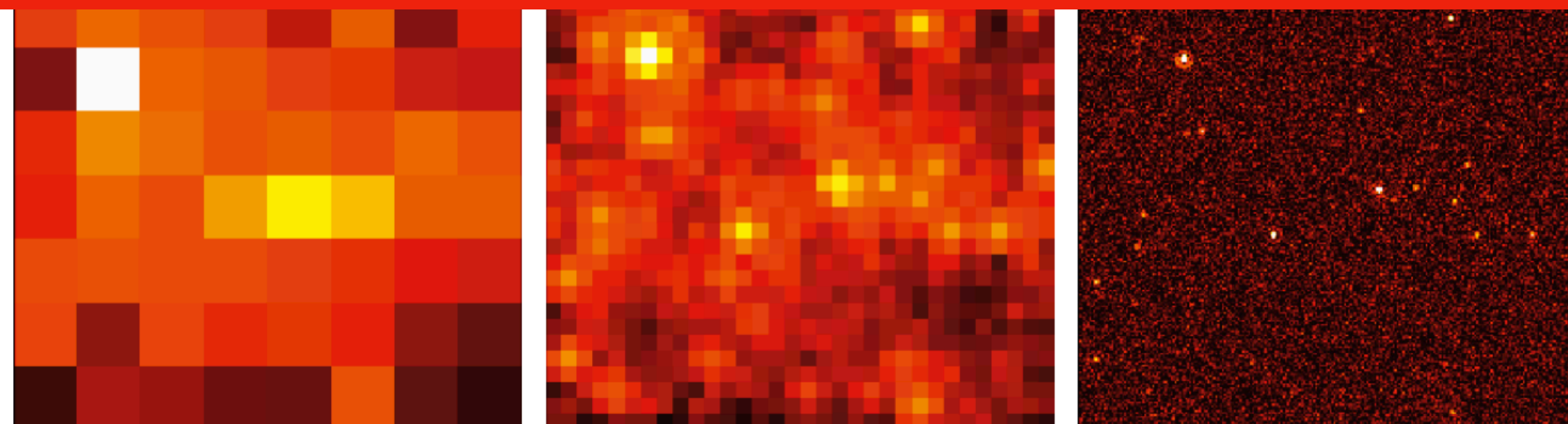
ELT/MICADO



$\mu = 19.6$

<p>Imaging (MICADO + AO)</p>	<p>R=3100 HARMONI+ AO 10mas spaxels</p>	<p>R=7000 HARMONI + AO 10mas spaxels</p>	<p>R= 17000 HARMONI + AO 10mas spaxels</p>
<p>$H_{AB} = 29.5$</p>	<p>$H_{AB} = 27.2$</p>	<p>$H_{AB} = 26.4$</p>	<p>$H_{AB} = 25.3$</p>

5-sigma, 5 hours integration time

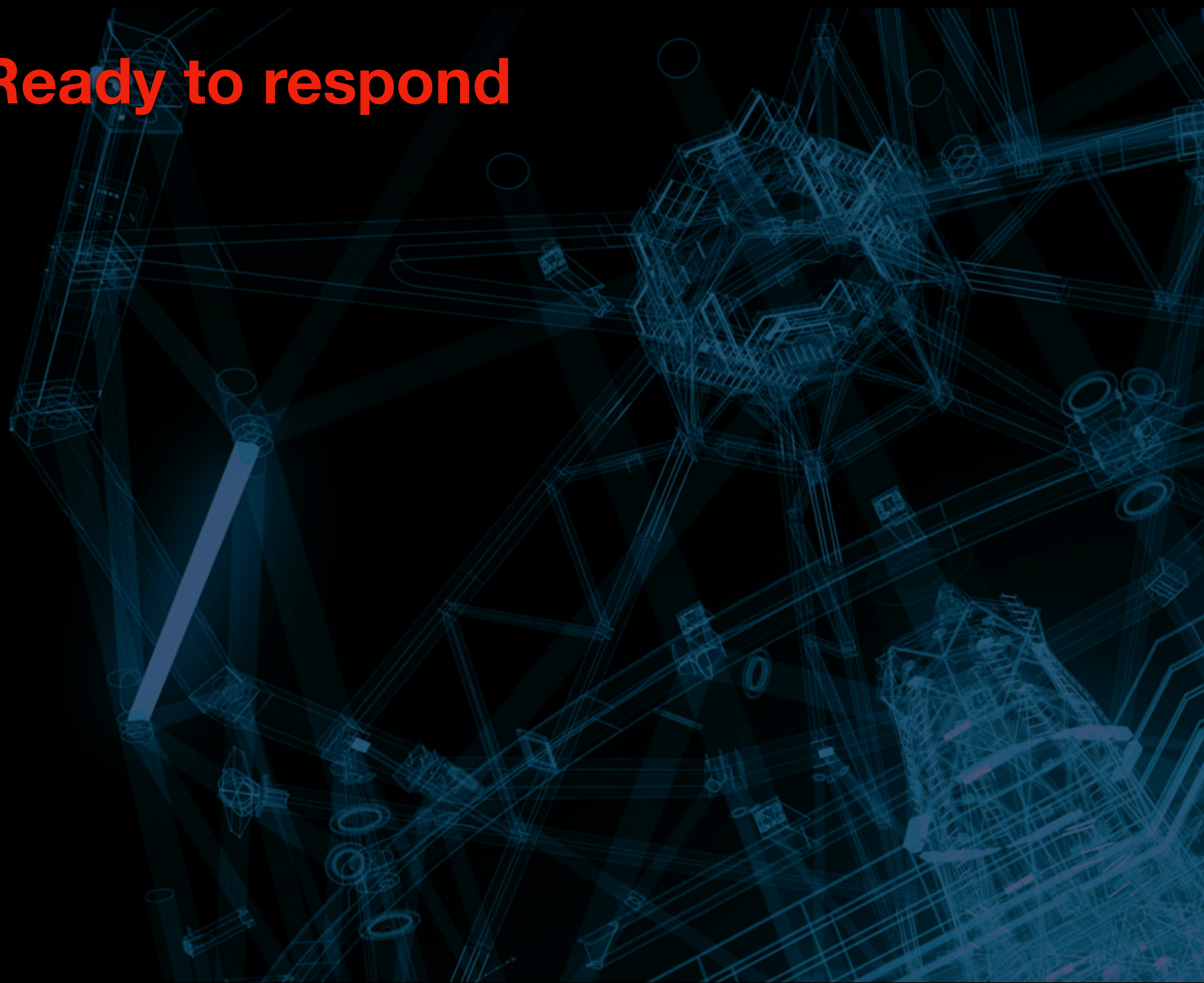


$\mu = 25.2$

(10^4 stars arcsecond⁻²)

Davies et al (2021)

ELT (and ESO) Ready to respond



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- **Following the ENGRAVE example, ESO will foster international collaborations to cover MM science cases**