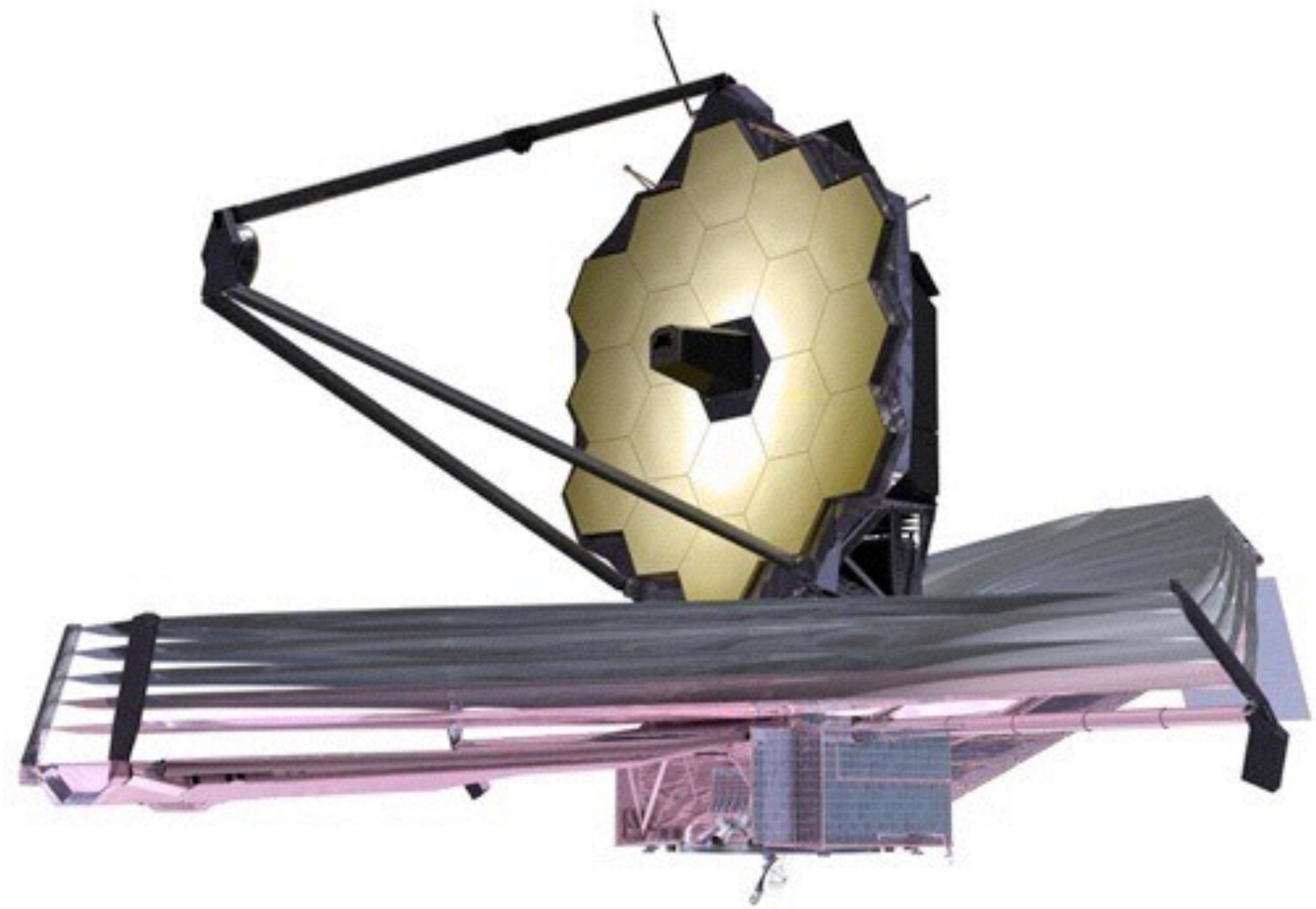
ULTIMATE-Subaru:
Comparisons with Space Missions

I. Iwata (Subaru Telescope)
2011/08/25
2013/05/28 small revisions
2013/06/04 include JWST/NIRISS
2016/06/16 revisions

Space Missions in Near-Future

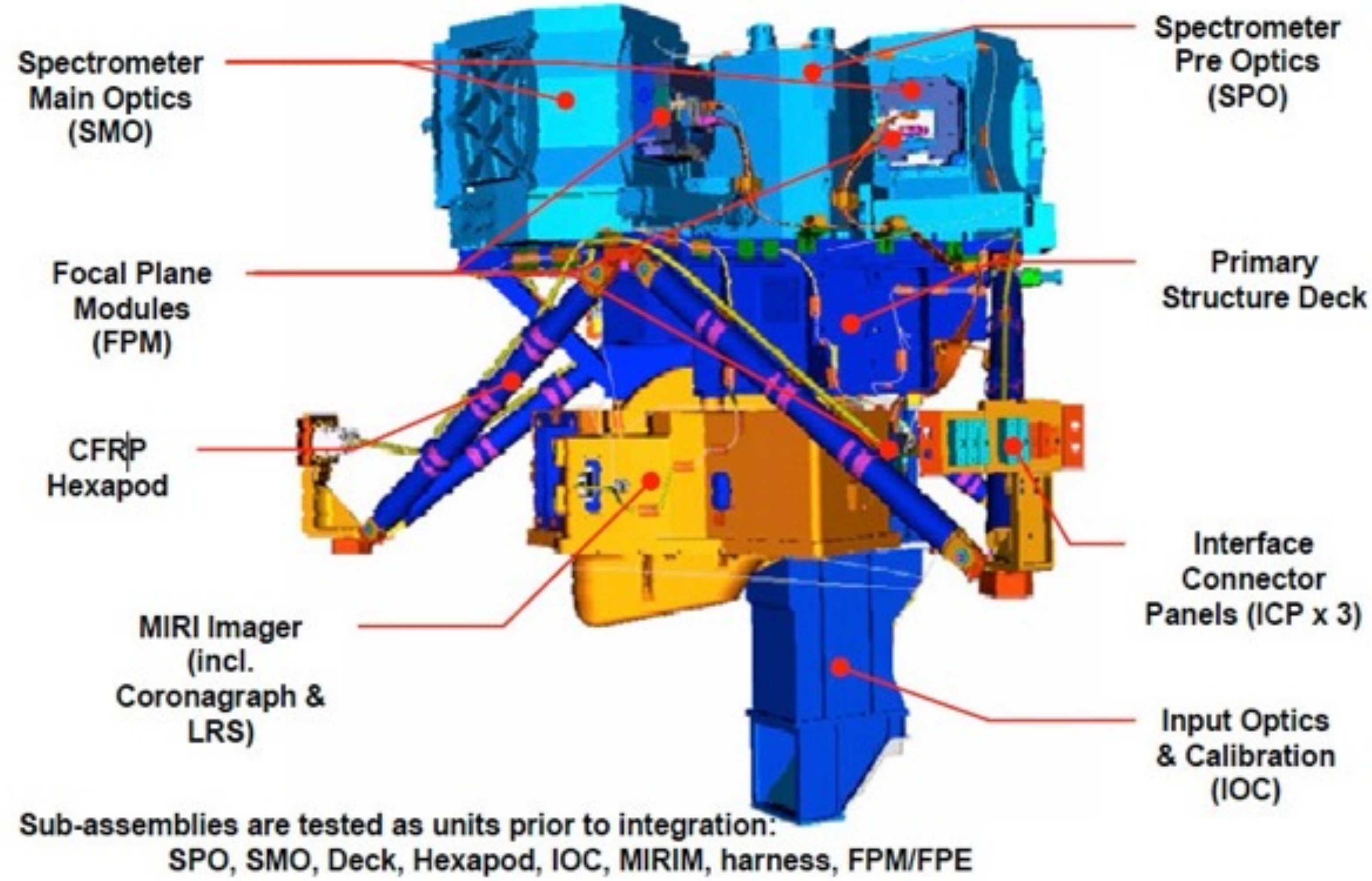
JWST

- 6.5m Deployable Mirror, Passive Cooling at S-E L2
- Four Science Instruments:
  - MIRI: Mid-IR (5 - 28μm)
  - NIRSpec
  - NIRCam
  - NIRISS



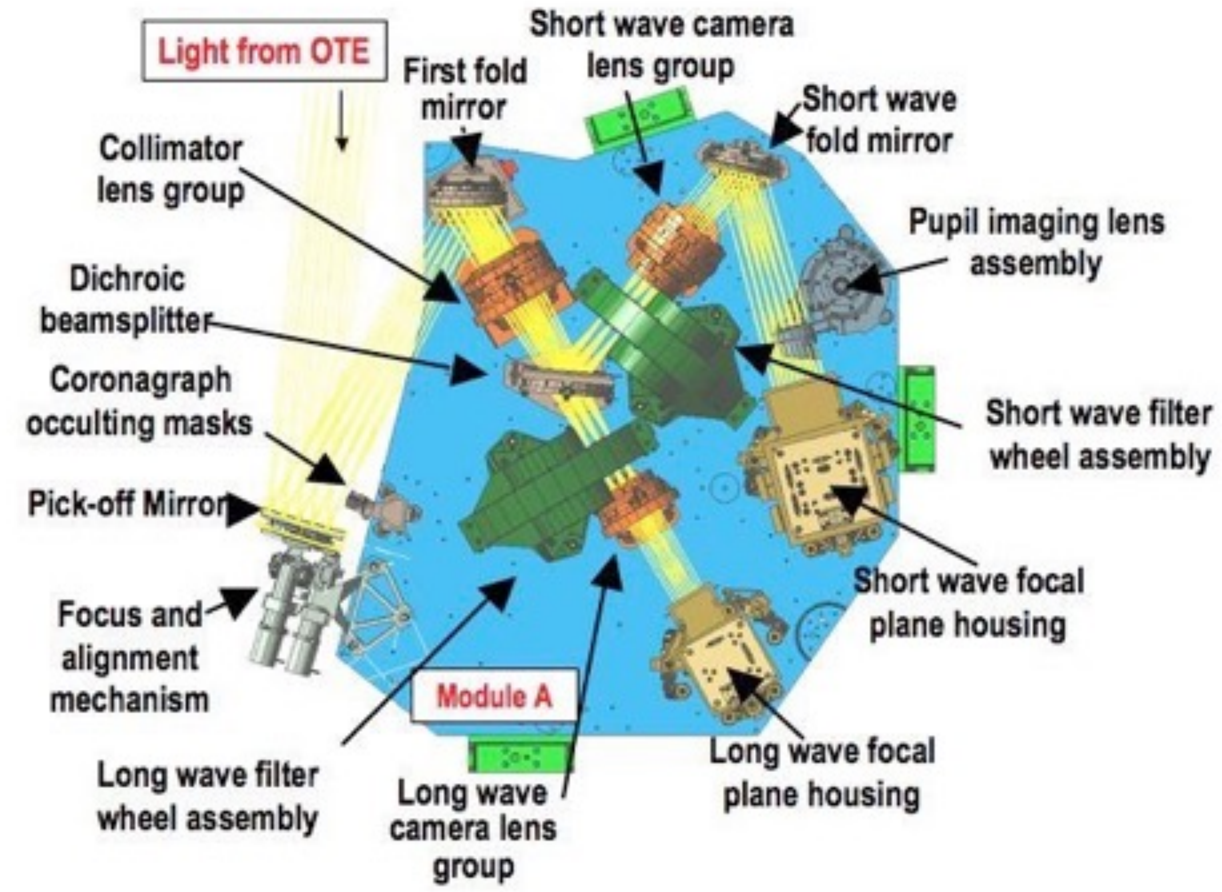
JWST MIRI

- Imaging 5 - 28.3μm, FoV 1.25’ x 1.88’
- Coronagraph
- R=1,000 - 3,000 Spec

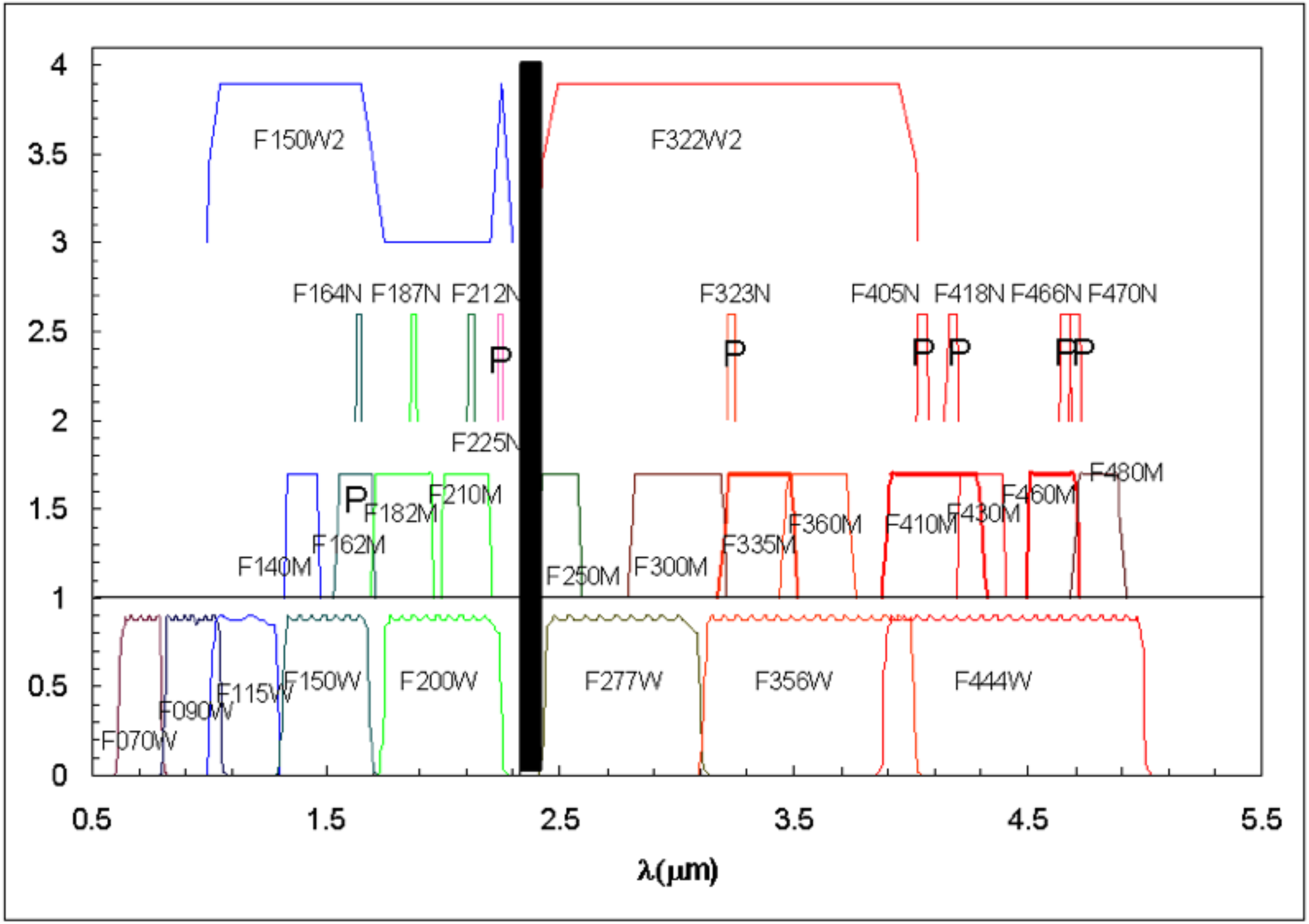


JWST NIRCam

- Two Channels, both 2.2' x 4.4'
  - Short: 0.5 - 2.3 μm, 32 mas (8 H2RGs)
  - Long: 2.5 - 5.0 μm, 64 mas (2 H2RGs)
- Coronagraphic High Contrast Imag
- Slitless Grism Spectroscopy R~180

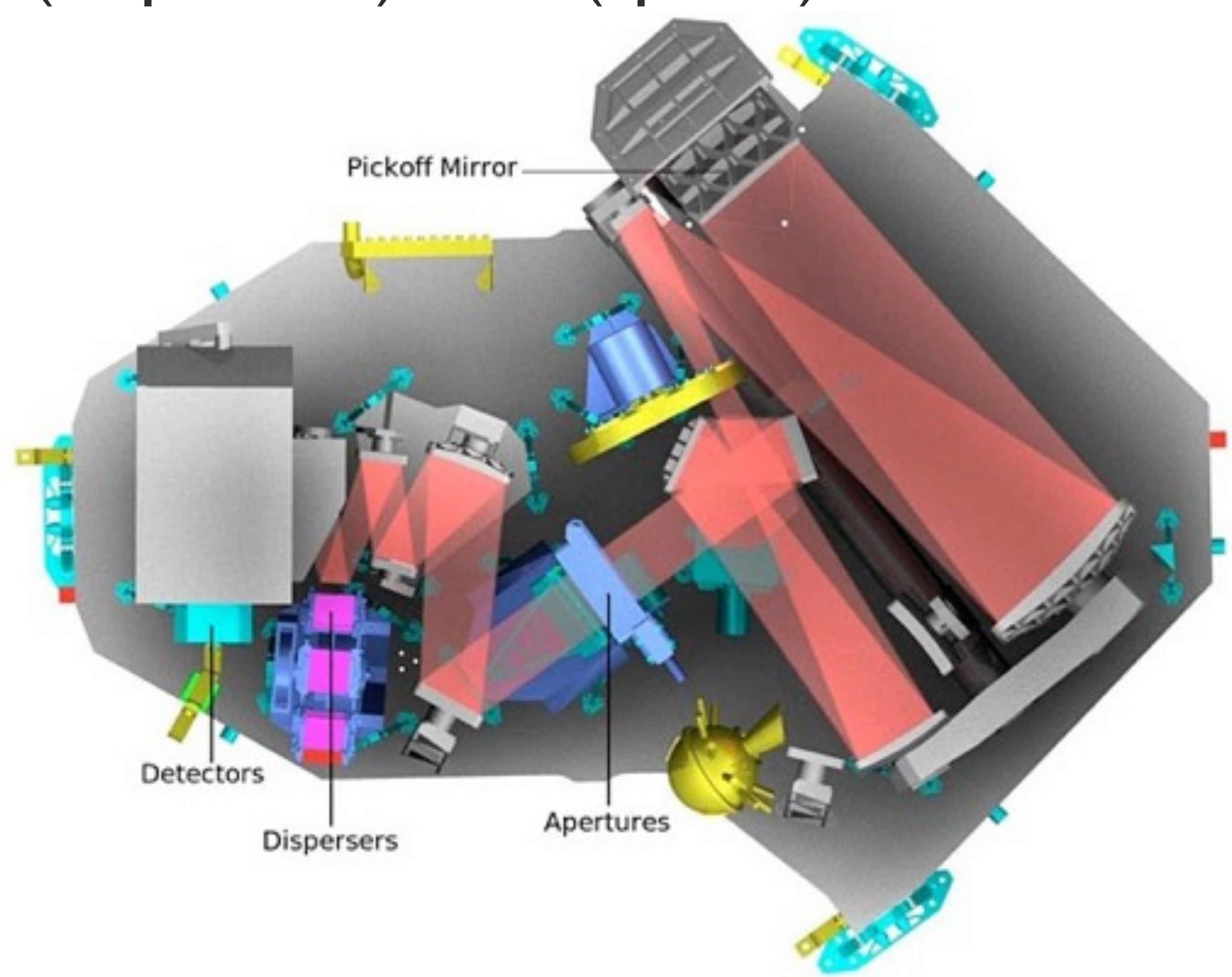


NIRCam Filters



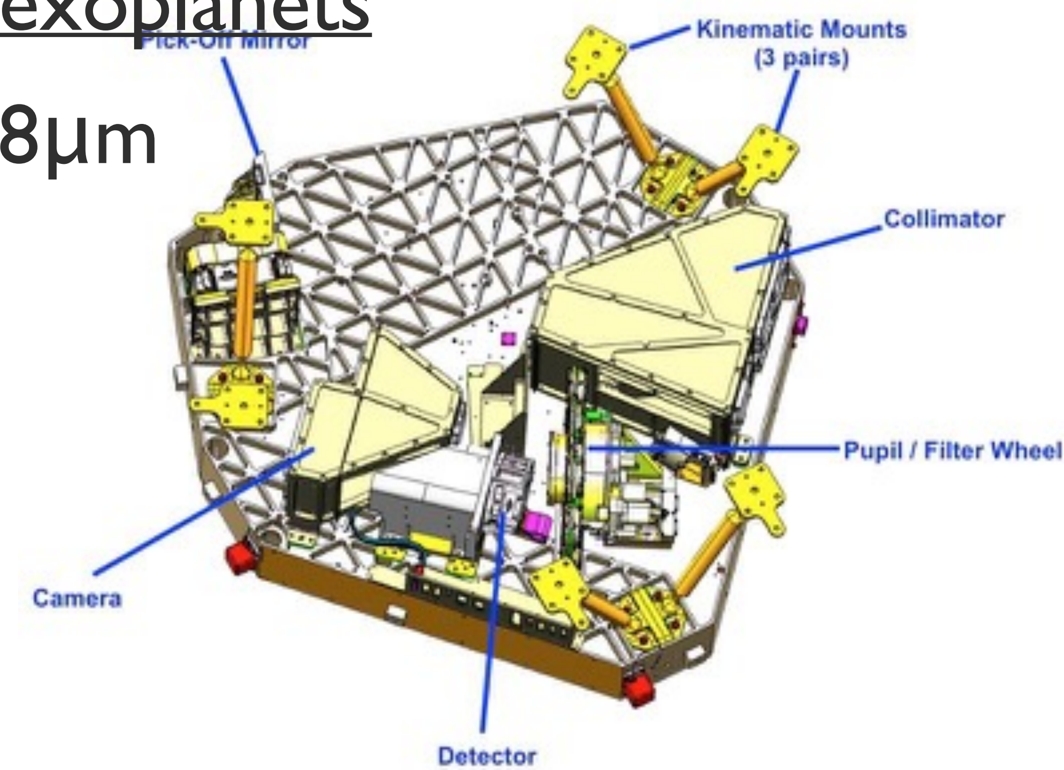
JWST NIRSpec

- 3.6’ x 3.4’ FOV
- Micro-Shutter Assembly: 0.2” x 0.46” Micro-Shutters
- Fixed Slits: 0.4”x3.8”, 0.2”x3.3”, 1.6”x1.6”
- IFU: 3”x3” FOV, 30 Slices, 0.1”(dispersion) x 3” (spatial)
- R = 100, 1000, 2700
- 2 x H2RG



JWST NIRISS (Near-IR Imager and Slitless Spectrograph)

- http://www.stsci.edu/jwst/instruments/niriss
- 1x H2RG 5.3µm cutoff, 0.065”/pix, 2.2’ x 2.2’ FoV
- Wide-Field Slitless Spectroscopy: 1.0-2.5µm, R~150 optimized for z>10 LAEs
- Single-Object Slitless Spectroscopy: R~700 (0.6-2.5µm) using cross-disperser optimized for transiting exoplanets
- Aperture Masking Interferometry: 3.8-4.8µm
- Imaging: 0.9-5.0µm



WFIRST-AFTA

WFIRST-2.4 Design Reference Mission Capabilities						
Imaging Capability	0.281 deg^2		0.11 arcsec/pix		0.6 – 2.0 μm	
Filters	Z087	Y106	J129	H158	F184	W149
Wavelength (μm)	0.760-0.977	0.927-1.192	1.131-1.454	1.380-1.774	1.683-2.000	0.927-2.000
PSF EE50 (arcsec)	0.11	0.12	0.12	0.14	0.14	0.13
Spectroscopic Capability	Grism (0.281 deg^2)				IFU (3.00 x 3.15 arcsec)	
	1.35 – 1.95 μm, R = 550-800				0.6 – 2.0 μm, R = ~100	

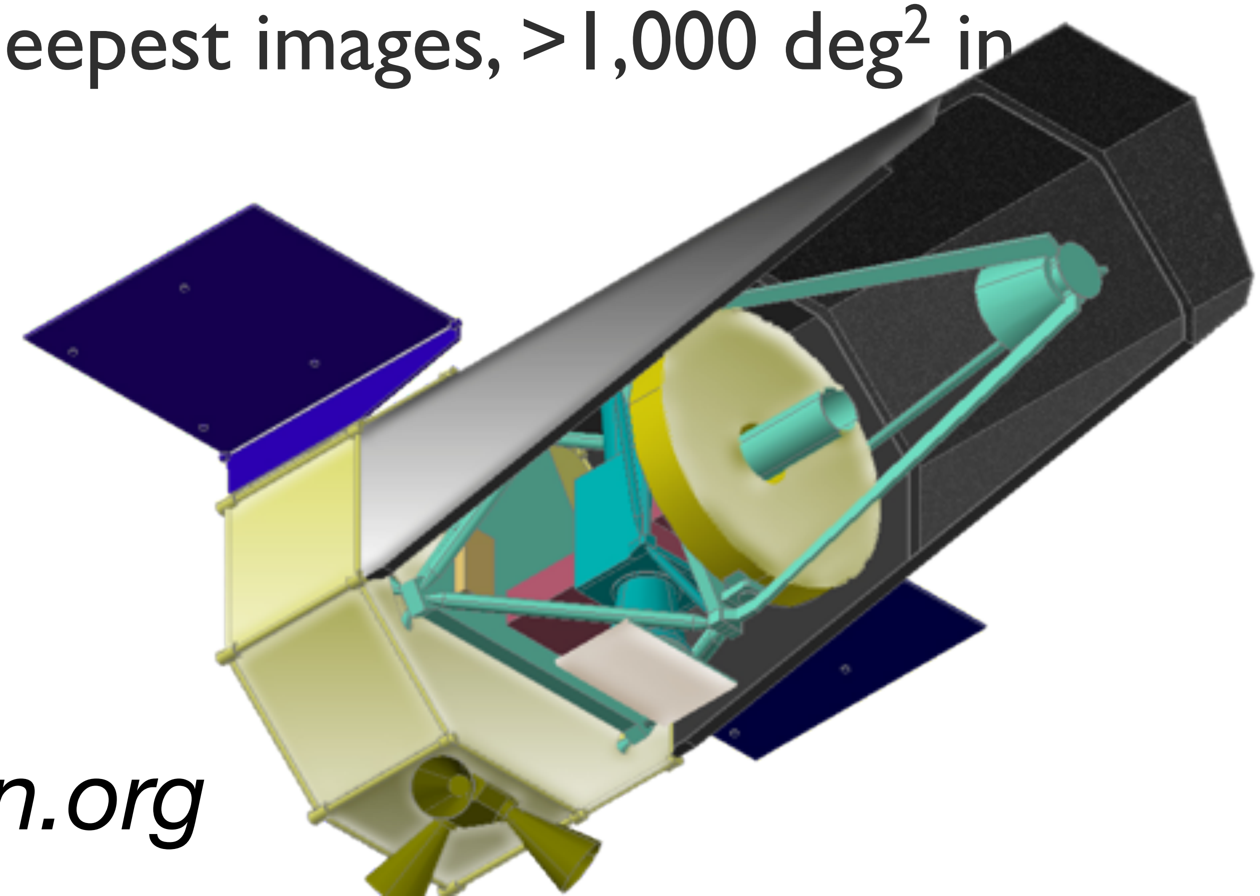
Baseline Survey Characteristics					
Survey	Bandpass	Area (deg^2)	Depth	Duration	Cadence
Exoplanet Microlensing	Z, W	2.81	n/a	6 x 72 days	W: 15 min Z: 12 hrs
HLS Imaging	Y, J, H, F184	2000	Y = 26.7, J = 26.9 H = 26.7, F184 = 26.2	1.3 years	n/a
HLS Spectroscopy	1.35 – 1.95 μm	2000	0.5×10^{-16} erg/s/cm^2 @ 1.65 μm	0.6 years	n/a
SN Survey				0.5 years (in a 2-yr interval)	5 days
Wide	Y, J	27.44	Y = 27.1, J = 27.5		
Medium	J, H	8.96	J = 27.6, H = 28.1		
Deep	J, H	5.04	J = 29.3, H = 29.4		
IFU Spec	7 exposures with S/N=3/pix, 1 near peak with S/N=10/pix, 1 post-SN reference with S/N=6/pix Parallel imaging during deep tier IFU spectroscopy: Z, Y, J, H ~29.5, F184 ~29.0				

Guest Observer Capabilities						
1.4 years of the 5 year prime mission						
	Z087	Y106	J129	H158	F184	W149
Imaging depth in	27.15	27.13	27.14	27.12	26.15	27.67

WISH: Wide-field Imaging Surveyor for High-redshift

- Space Telescope Mission with 1.5m Diameter Aperture
- Wide-Field Near-Infrared Camera (0.9 - 5 μm)
- (Passively) Cooled Mission with Sun - Earth L2 Orbit

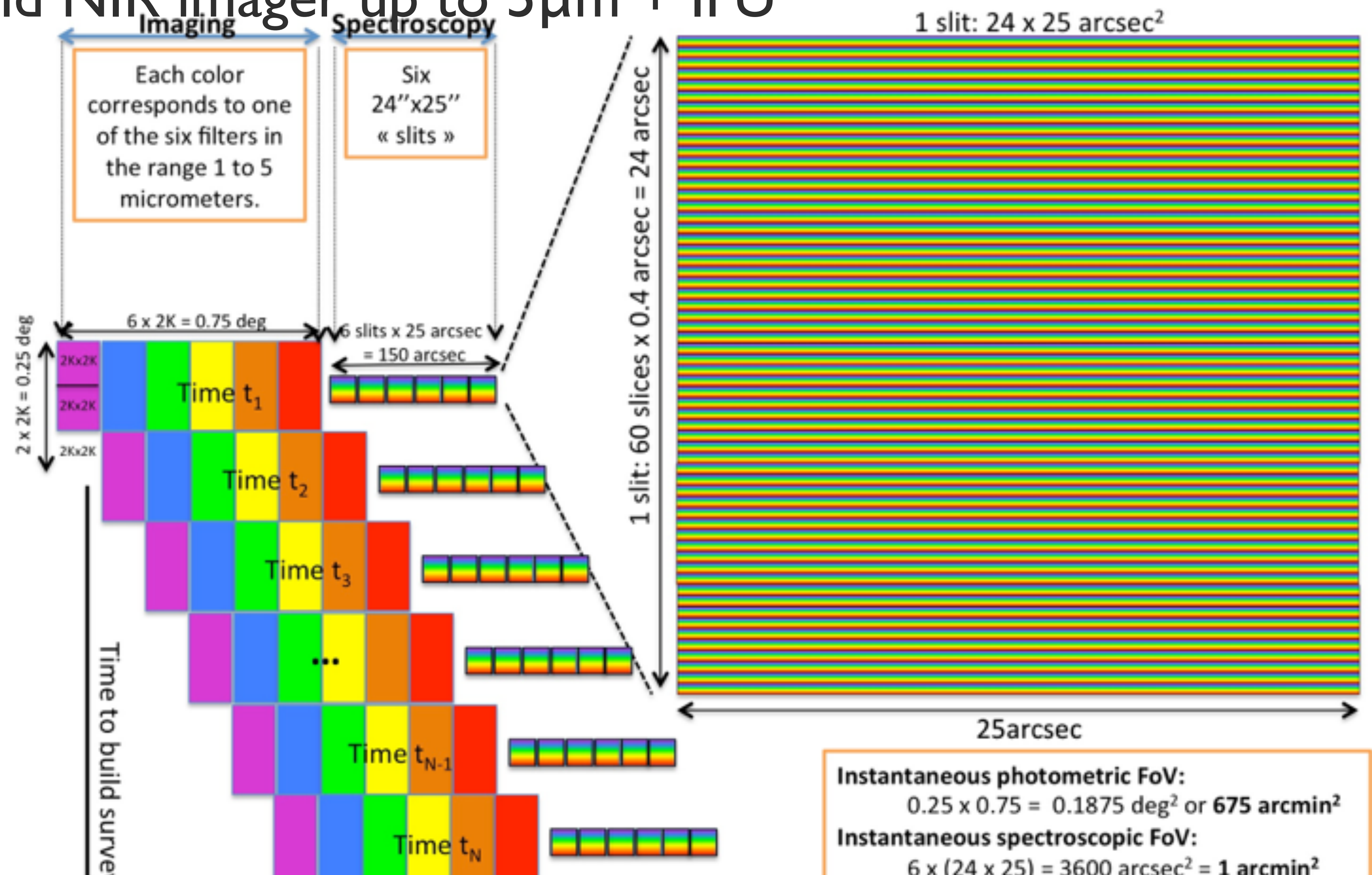
- Depth - deeper than images with any ground-based telescopes
- Width - 100 square degrees in deepest images, >1,000 deg^2 in shallower surveys



http://wishmission.org

FLARE

- http://mission.lam.fr/flare/
- to be proposed for ESA M5
- 2m-class Wide-field NIR imager up to 5µm + IFU

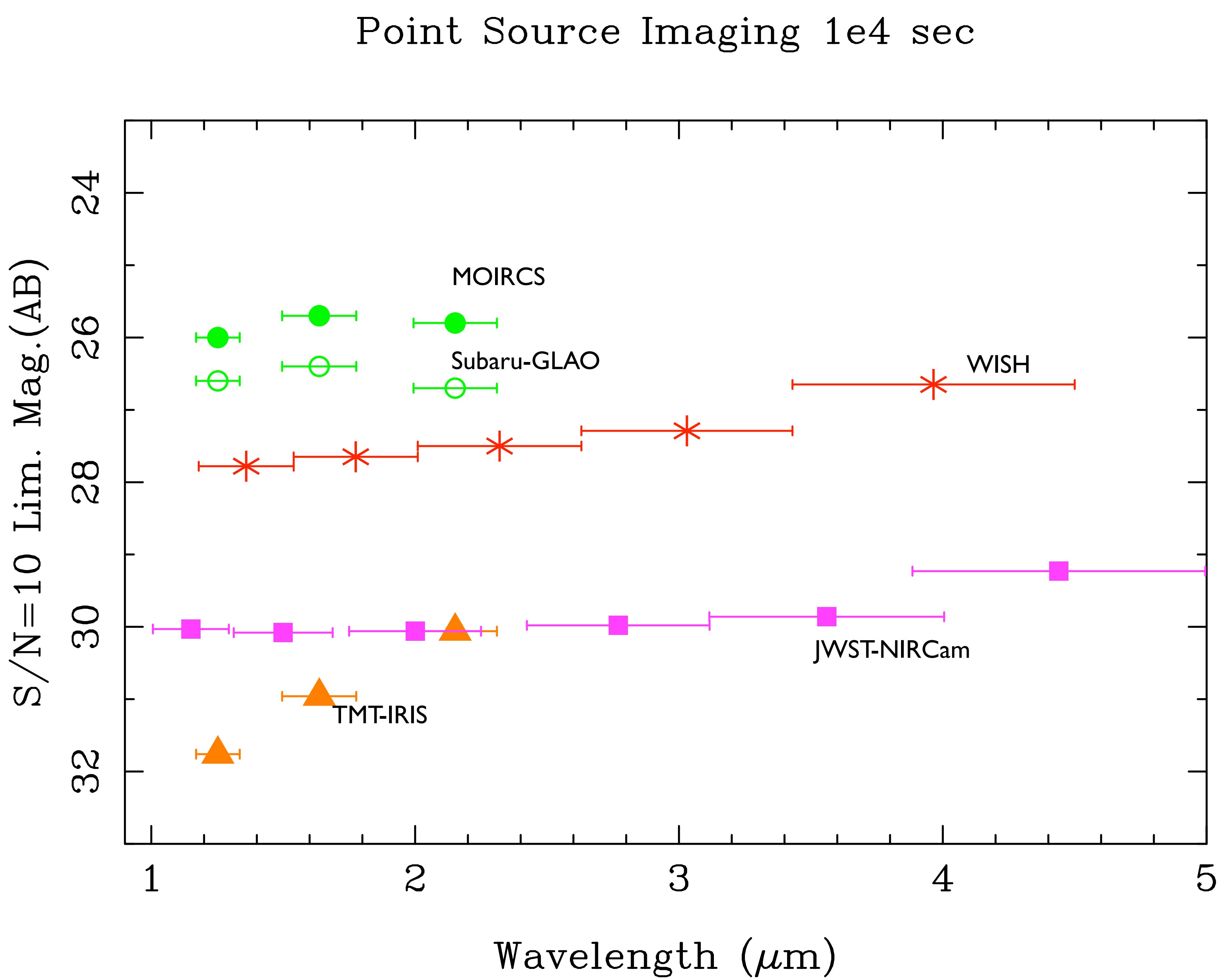


Euclid and WFIRST

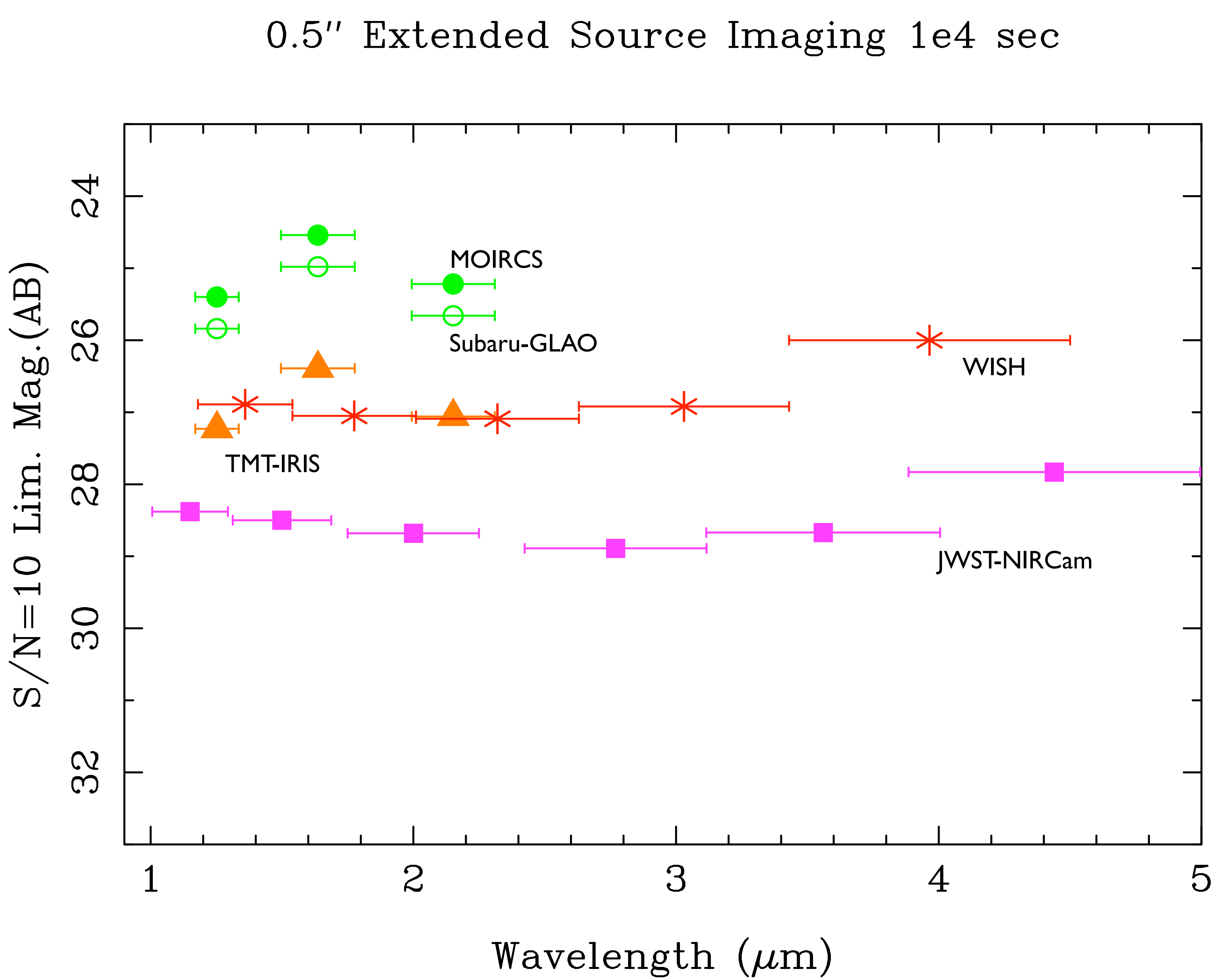
	Euclid	WFIRST-AFTA
Mirror	1.2m	2.4m
FoV	0.5 deg^2	0.3deg^2
Visual Imager	RIz	↓
NIR Imager	YJH	0.7-2.0μm
Lim. Mag.	24AB	26.7AB
Survey Area	20,000 deg^2	2,200 deg^2 (HLS)
Primary Science	Dark Energy	DE, Exoplanet, GO
Expected Operations	2020- (6 years)	2024? (5 years)

Imaging Sensitivity

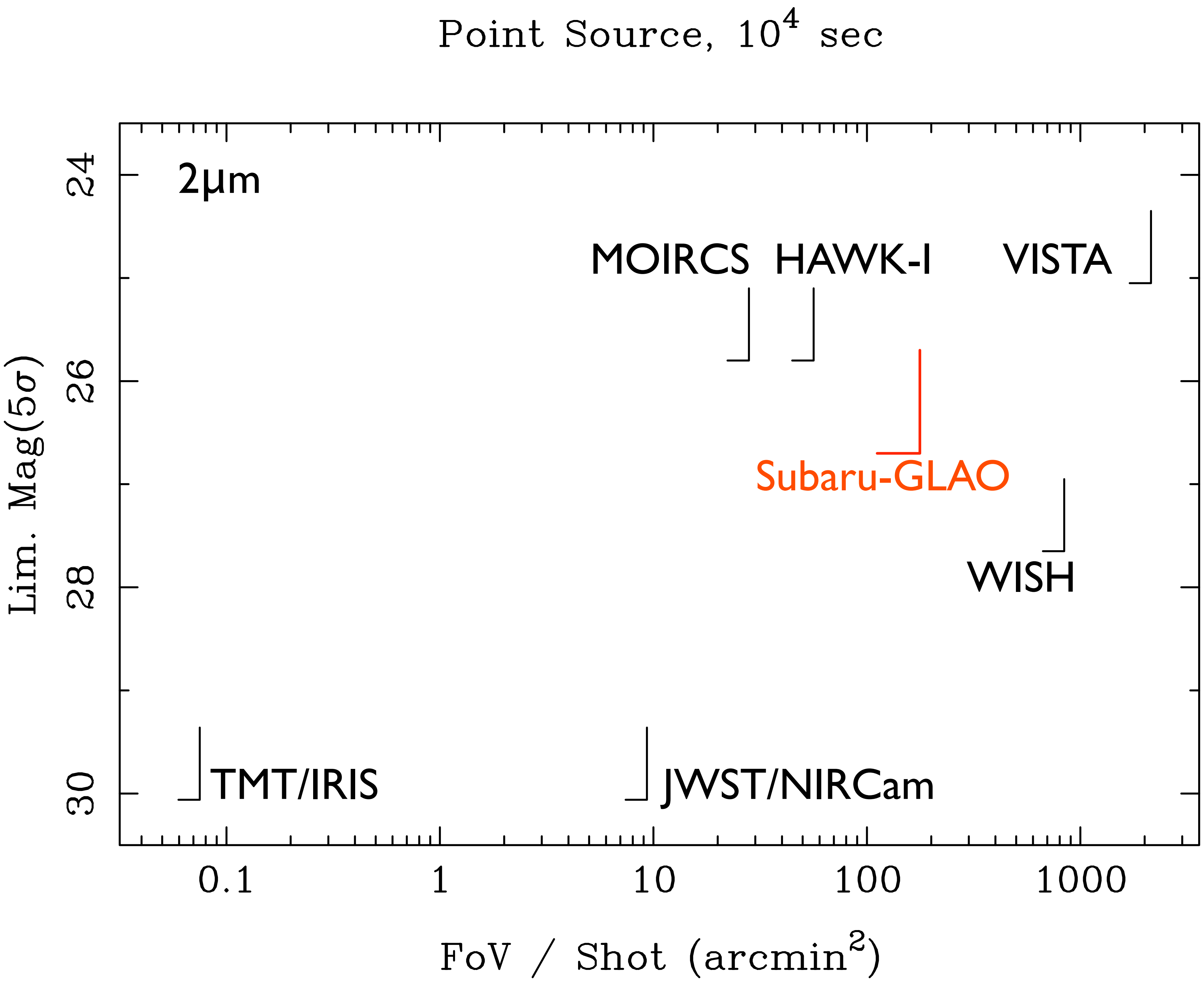
Imaging: Sensitivity for Point Sources



Imaging: Sensitivities for Extended Sources



Imaging: Sensitivity and Field-of-View



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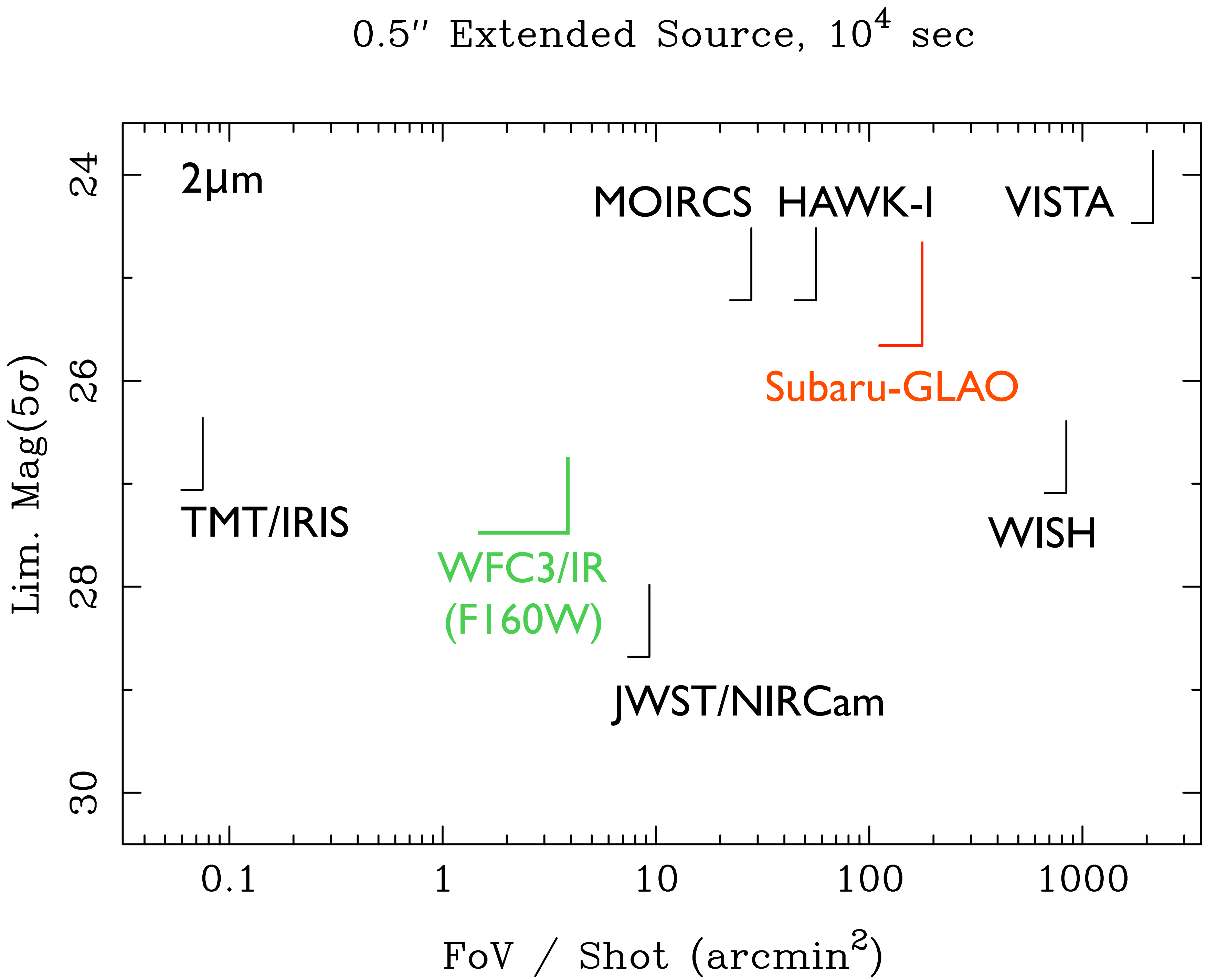
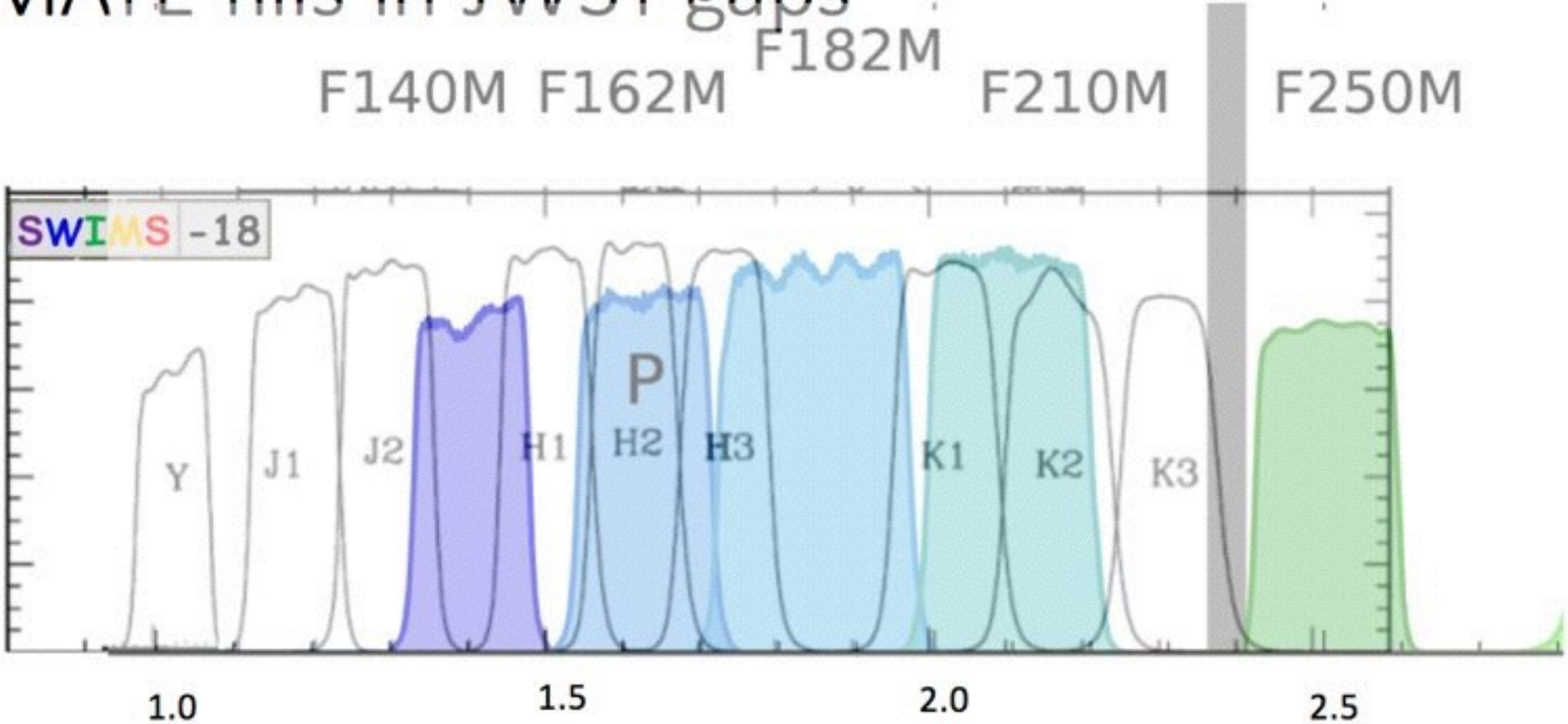


JWST fills in the opaque windows
ULTIMATE fills in JWST gaps

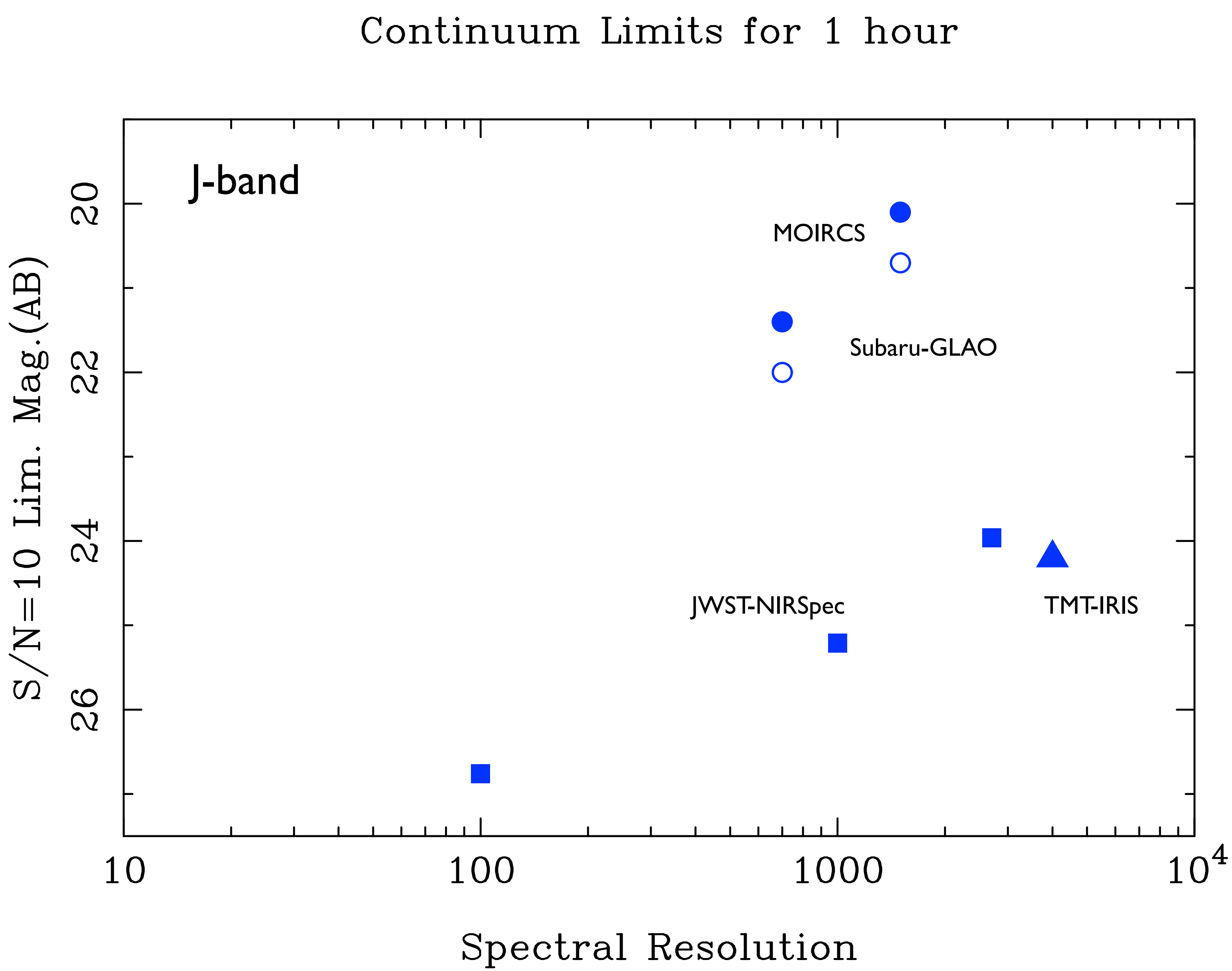


Possible ULTIMATE filterset = black outline, JWST/NIRCam = color filters

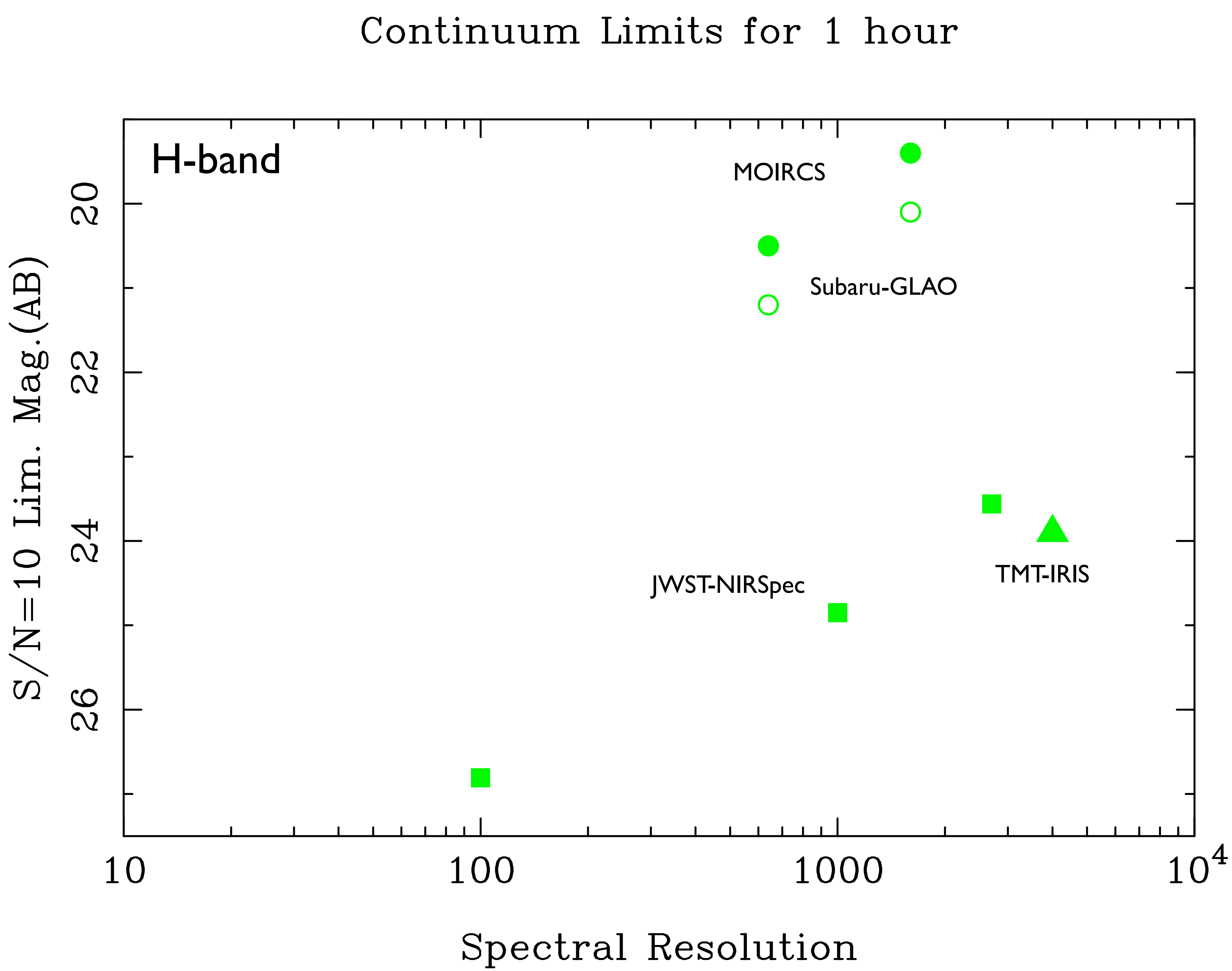
Lee Spitler, this WS

Spectroscopic Sensitivity

Spectroscopy: Continuum Sensitivity (Point Sources)



Spectroscopy: Continuum Sensitivity (Point Sources)



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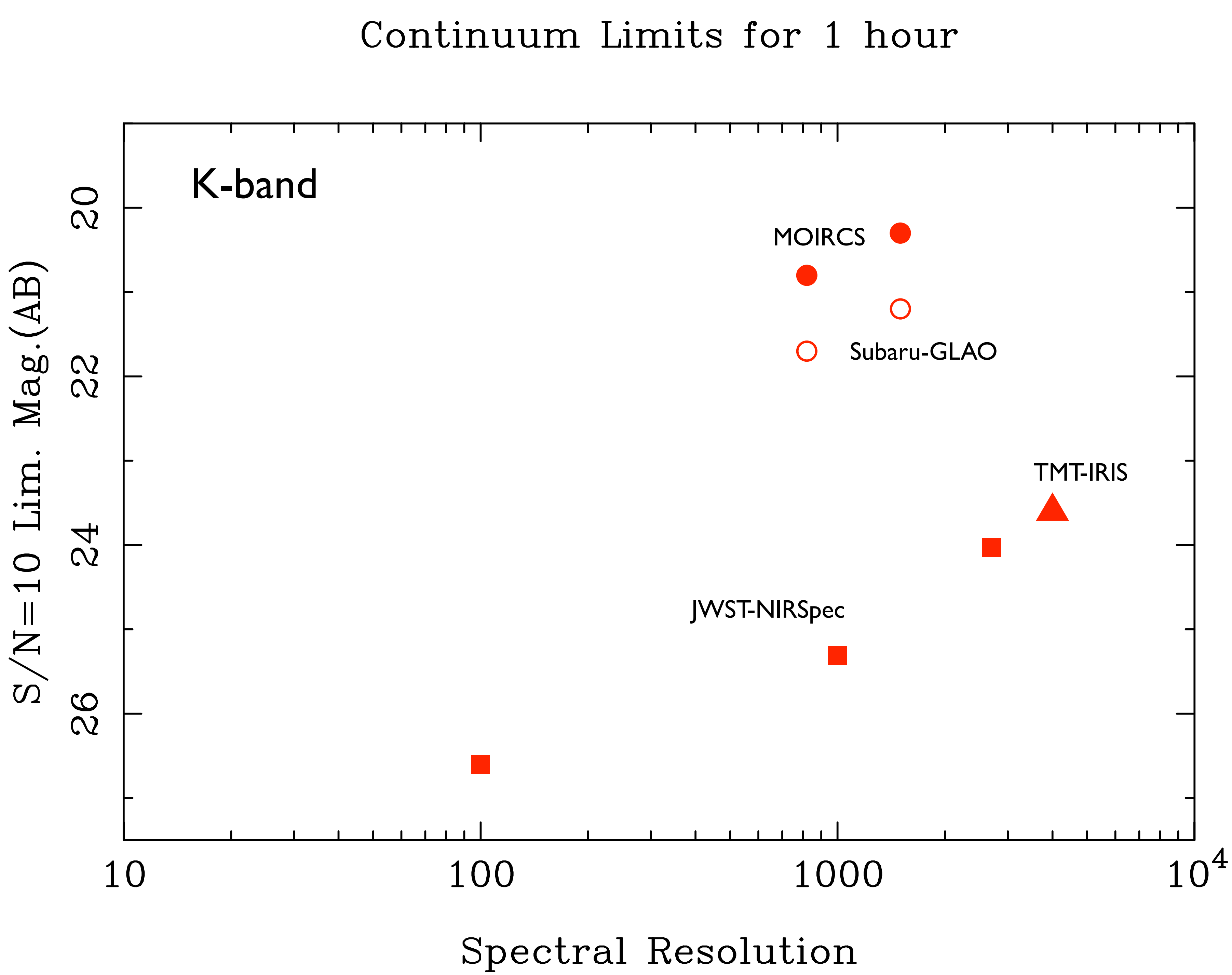
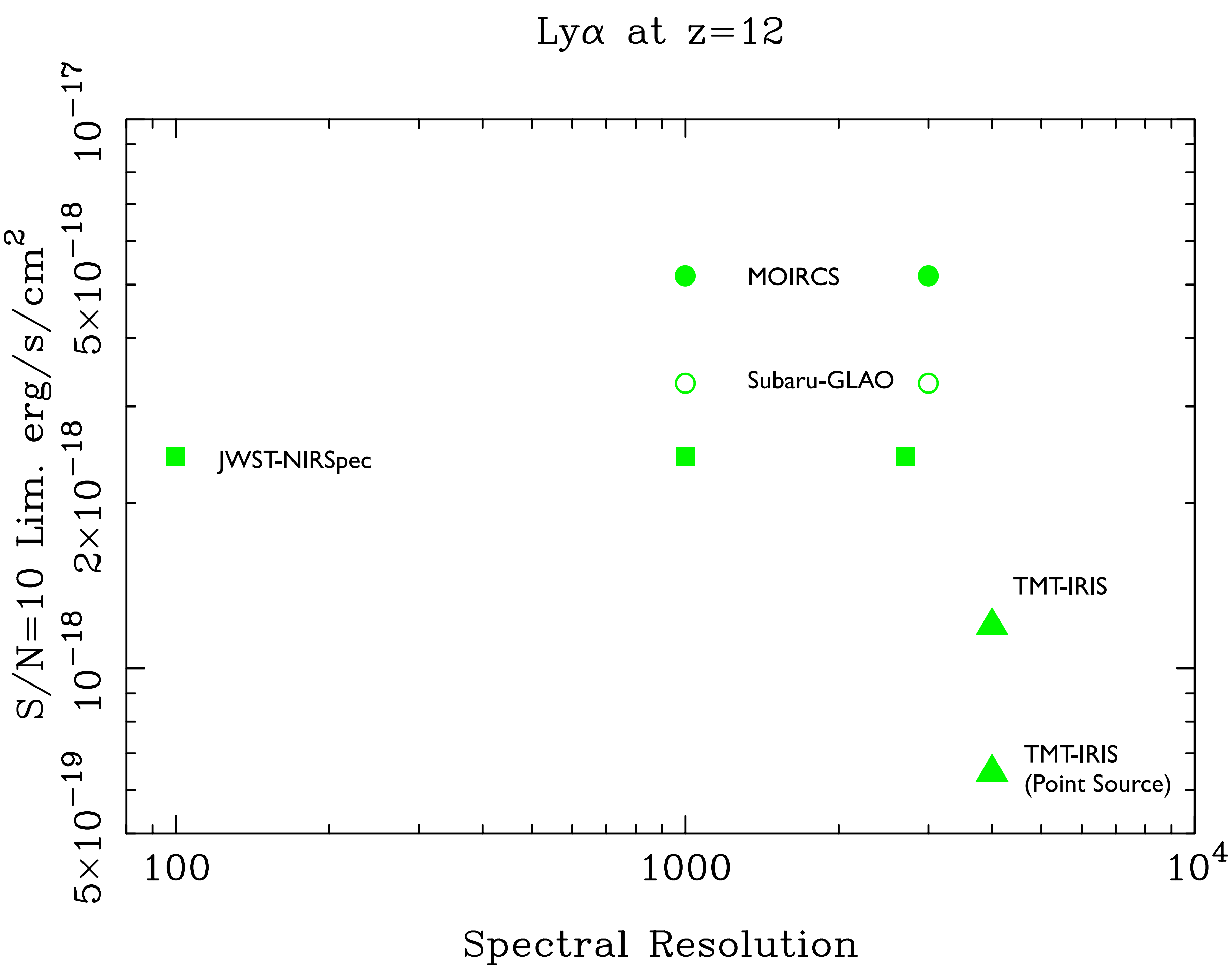


Spectroscopy: Sensitivity for Emission Lines

1 hours, ~0.25" extended source



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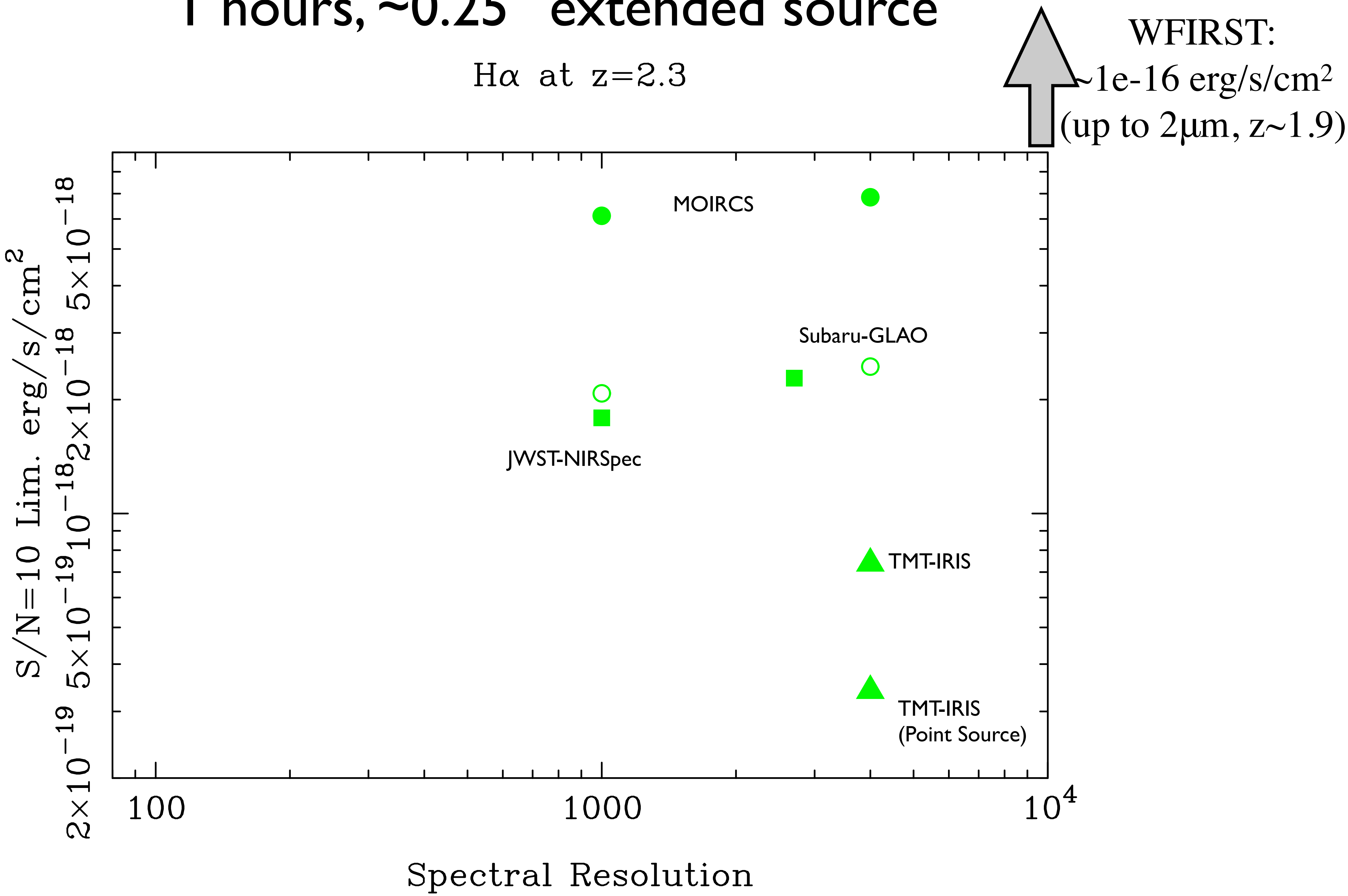

Summary

- Imaging: Space Missions have significant advantages
  - Narrow-band imaging capability is more suited for ground-based telescopes
- Spectroscopy:
  - Sensitivity gain can be as much as ~2x with GLAO
  - For extended sources difference between ground-based and space telescopes becomes smaller.
  - The most sensitive observations will be realized by TMT.
  - Reducing Read-out Noise is important.

Niches for ULTIMATE-Subaru

- Imaging:
  - JWST: More sensitive but limited in FoV and set of filters
  - WFIRST: up to 2μm, Broad-band filter only
  - → K-band and NB/MB filters
- Spectroscopy:
  - JWST: More sensitive but limited in FoV
  - WFIRST: More efficient but limited in sensitivity
  - → Multi-object (Integral-field) Spectroscopy
    - High spectral resolution >4,000?