

Our WISH: Feeding $z > 10$ Targets to ELTs

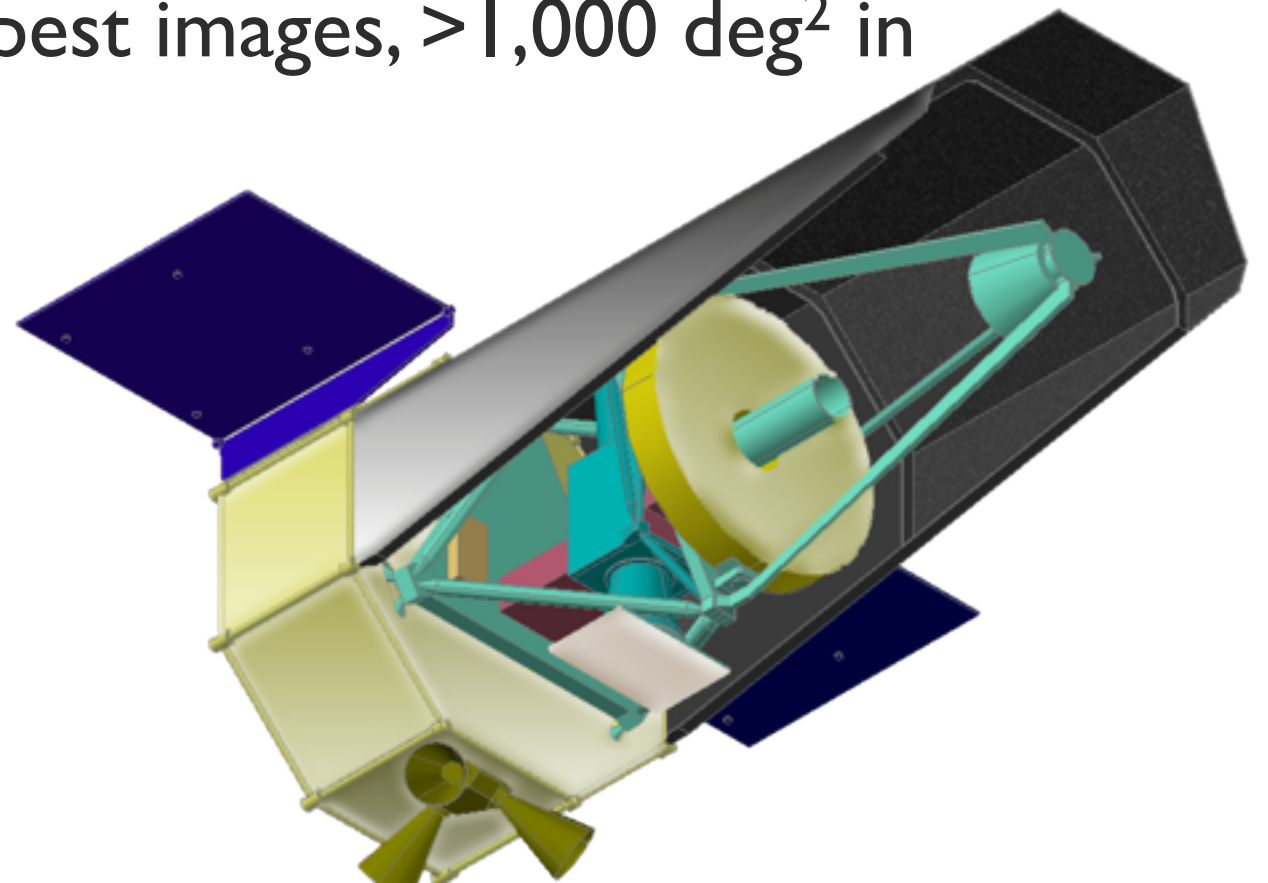
Ikuru Iwata

(National Astronomical Observatory of Japan)

<http://wishmission.org>

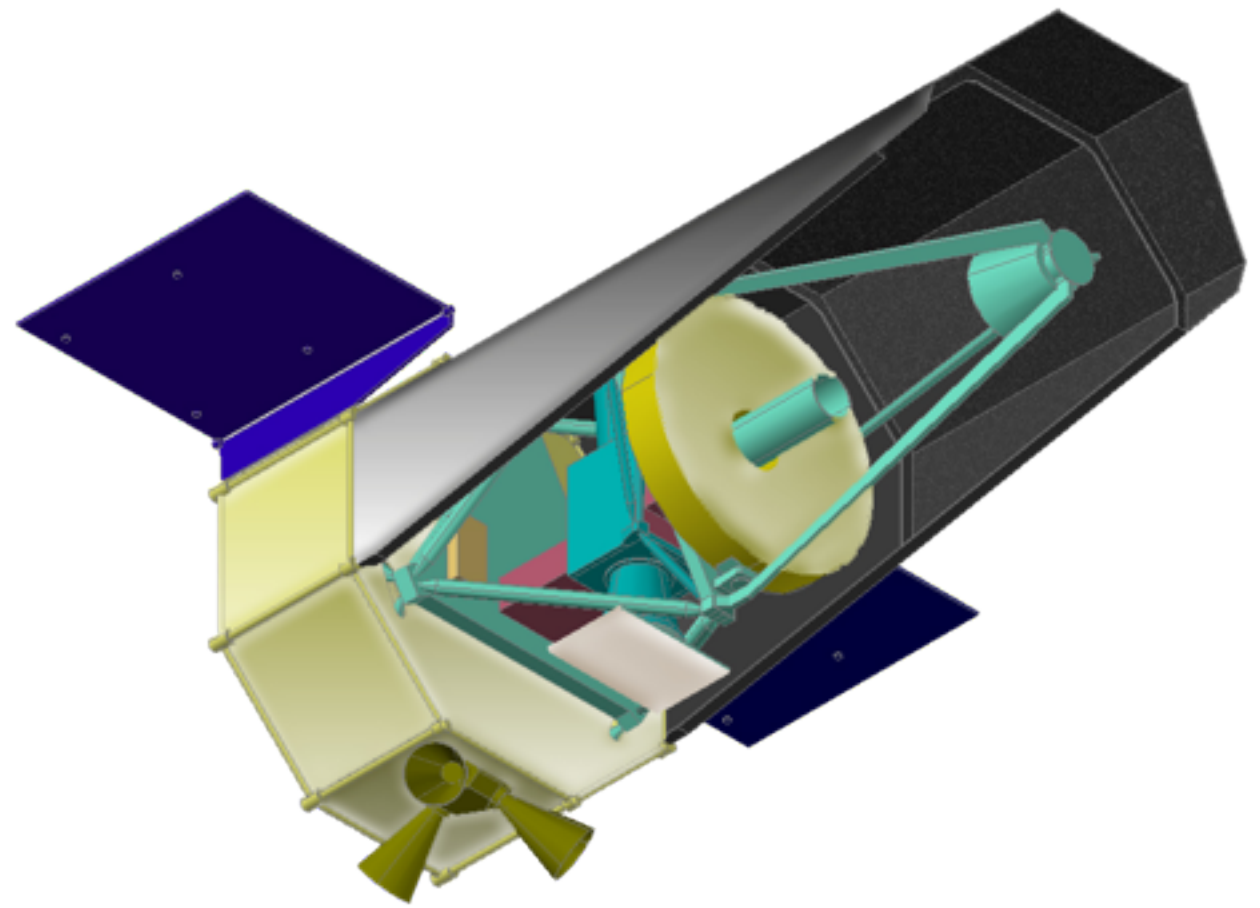
WISH: Wide-field Imaging Surveyor for High-redshift

- 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, $> 1,000 \text{ deg}^2$ in shallower surveys



WISH Working Group Members

- PI: Toru Yamada (Tohoku Univ.)
- NAOJ: I. Iwata, S. Tsuneta, T. Kodama, Y. Komiyama, M. Imanishi
- JAXA: H. Matsuhara, T. Wada, H. Sugita, Y. Sato, A. Okamoto
- Tohoku: Y. Katsuno, K. Mawatari, C. Tokoku (UC Riverside)
- Kyoto: K. Ohta, K. Yabe, R. Tsutui
- Tokyo: T. Morokuma, M. Doi, N. Yasuda
- S. Oyabu (Nagoya), N. Kawai (TITech), D. Yonetoku (Kanazawa), A. K. Inoue (Osaka-Sangyo), T. Goto (UH), Y. Ikeda (Photocoding / Kyoto-Sangyo), S. Iwamura (MRJ)

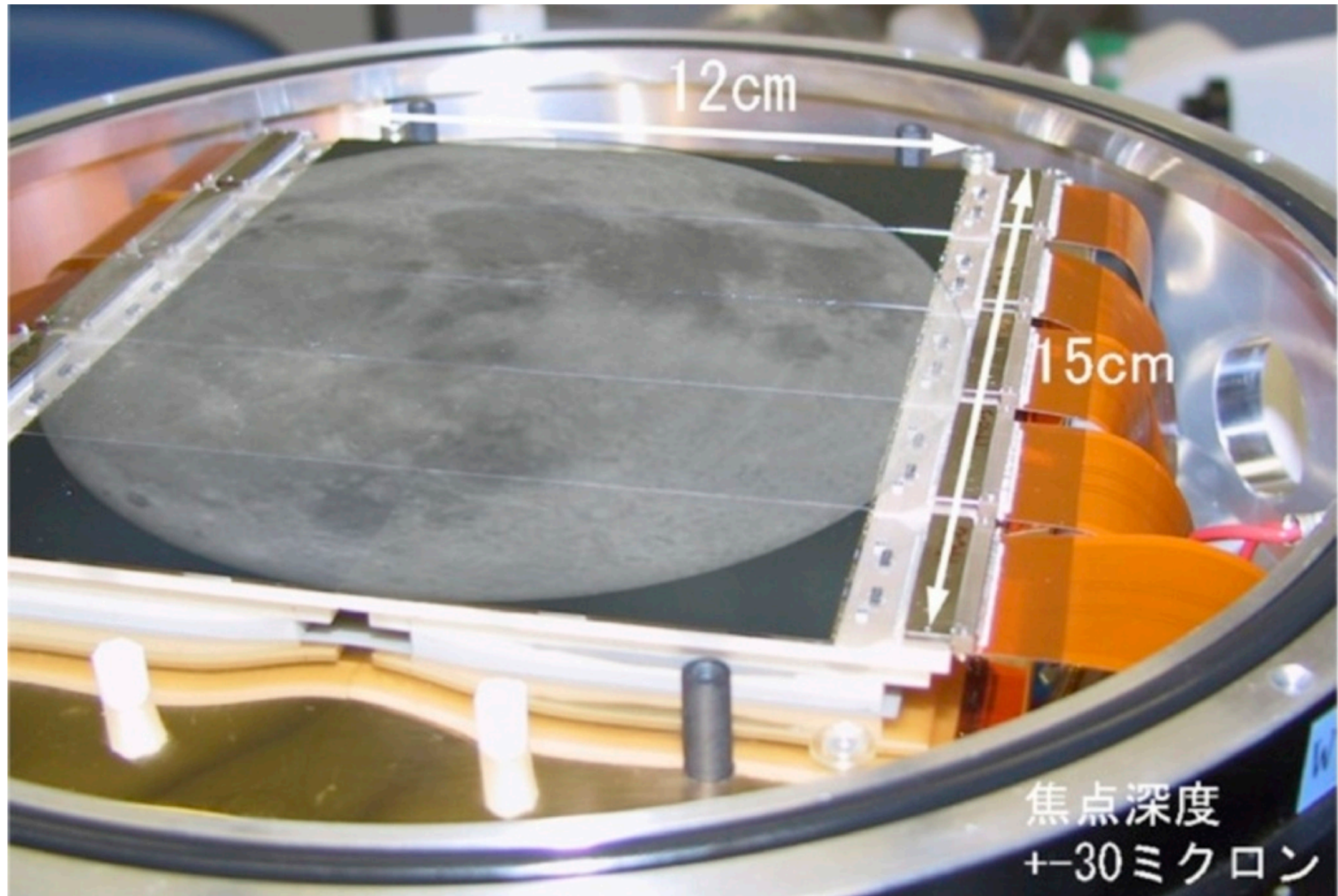


WISH: Scientific Objectives

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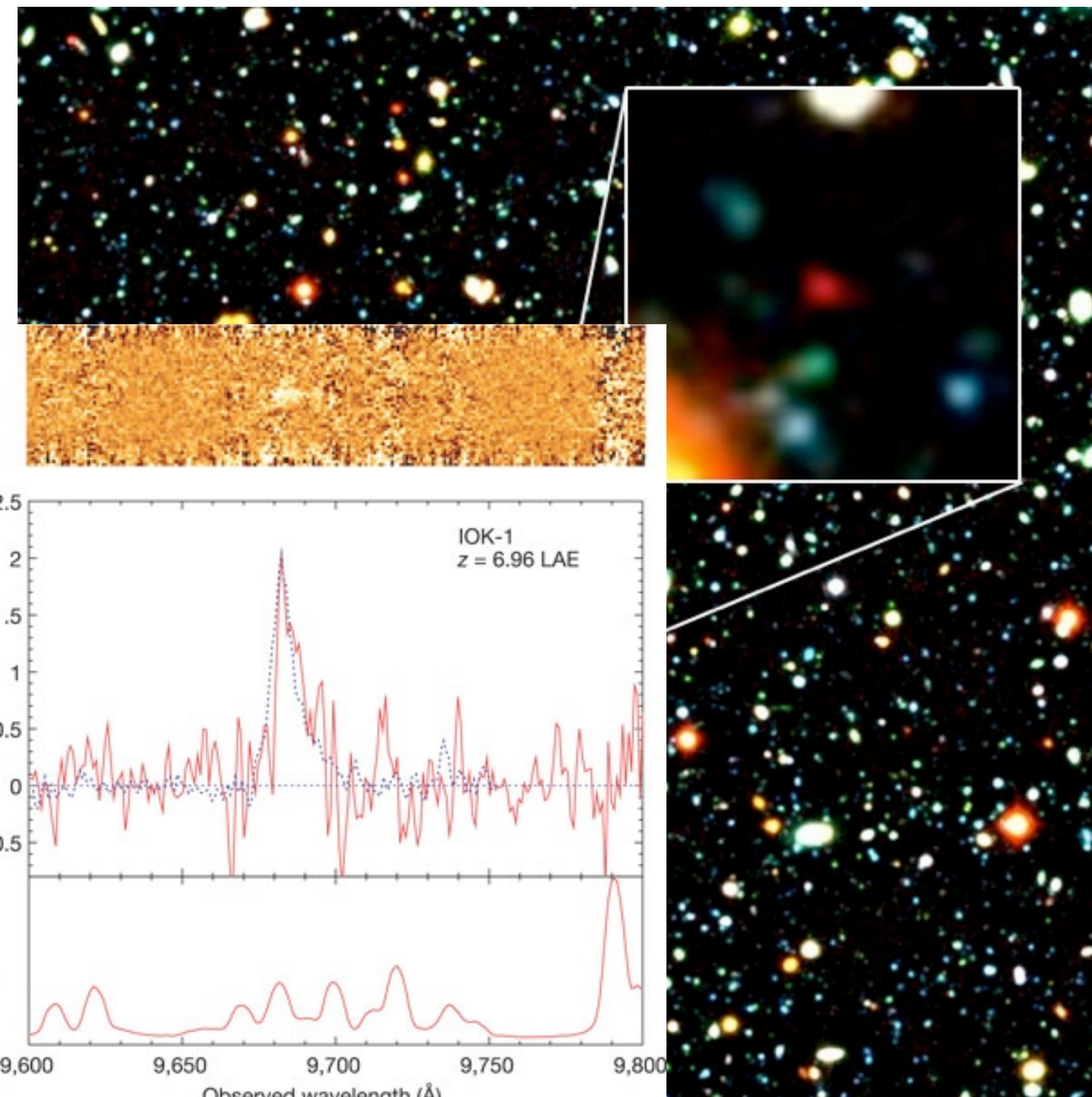
- Unveiling the First Epoch of Galaxy Formation:
 - Detections of Large Sample of First-Generation Galaxies ($7 < z < 15$)
 - Explorations of the Cosmic Reionization
- Constraining Dark Energy using Type Ia Supernovae
 - Detection and Light Curve in Rest-frame Near-IR
- Transient Objects such as Gamma-ray Bursts and Luminous Supernovae
- Legacy Near-IR Survey Data with Unprecedented Depth and Area
 - Galaxy Evolution, High- z AGN, Galaxy Stellar Population and more.

Subaru Suprime-Cam



FoV $\sim 30'$; Hyper Suprime-Cam (HSC) with 1.5 deg. in 2012

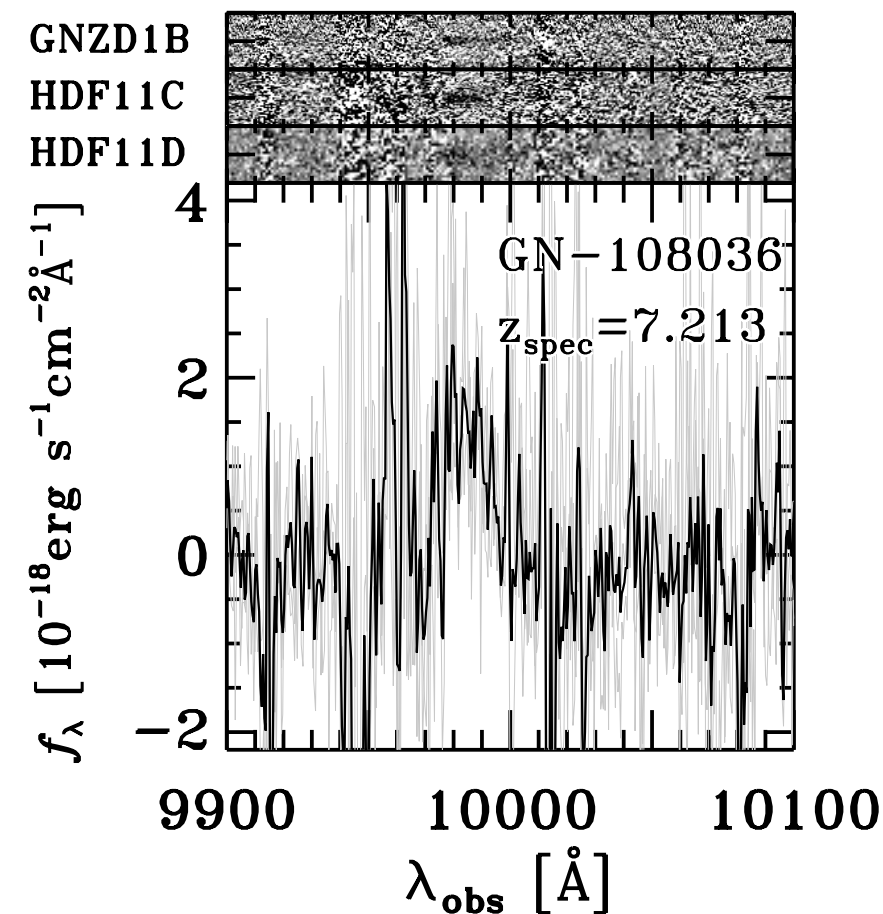
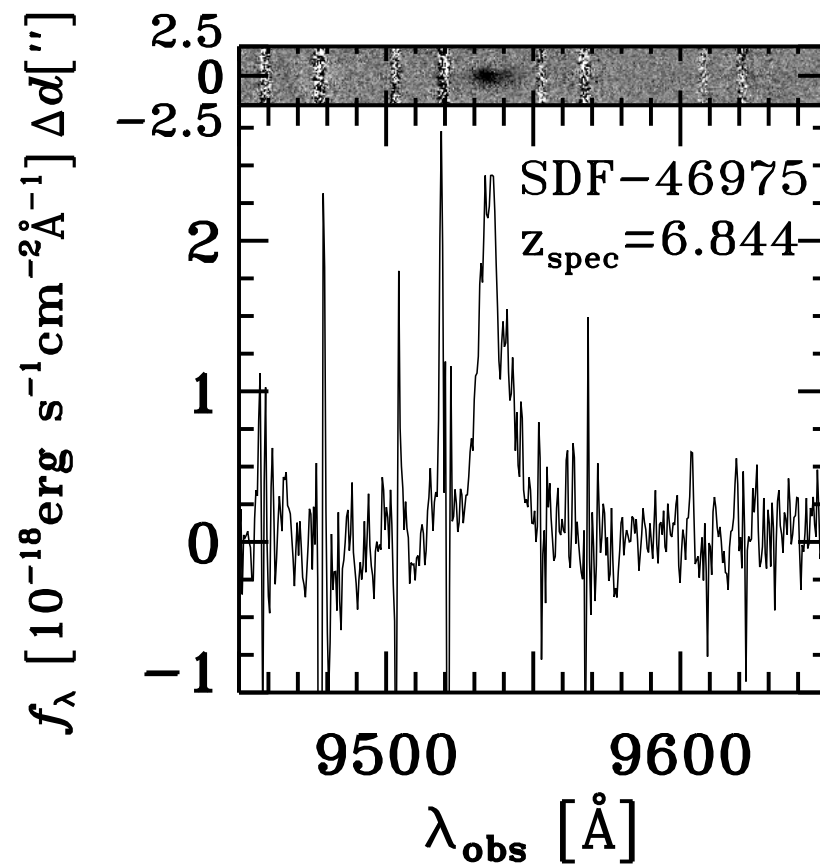
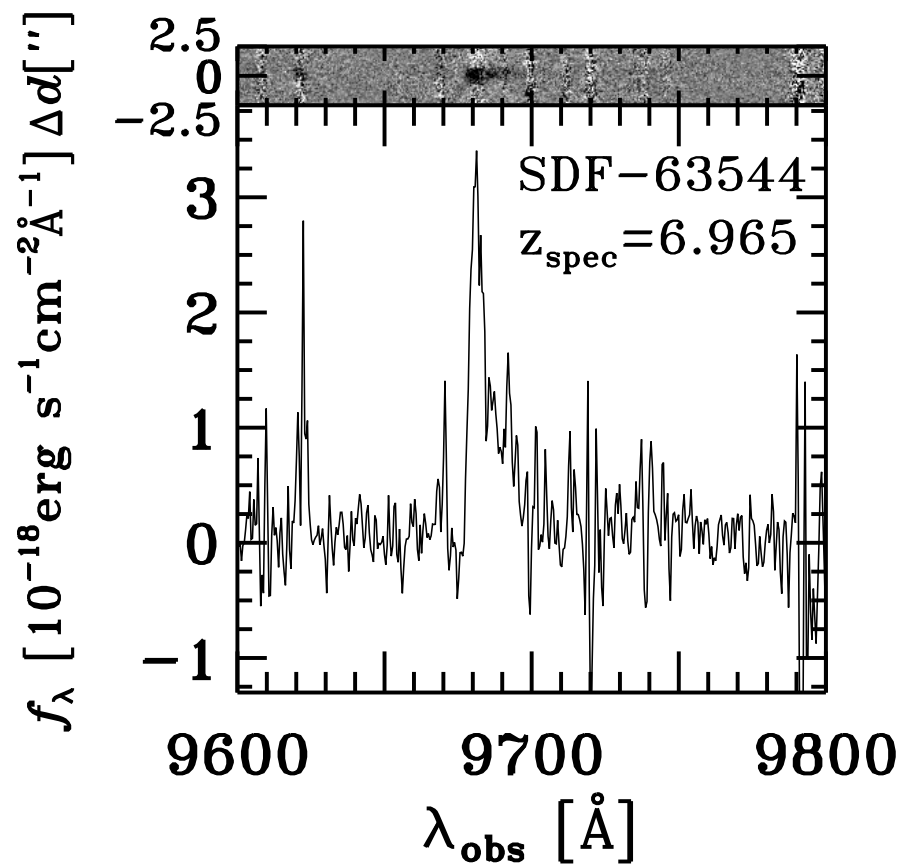
Achievements of Subaru Wide-field Imaging



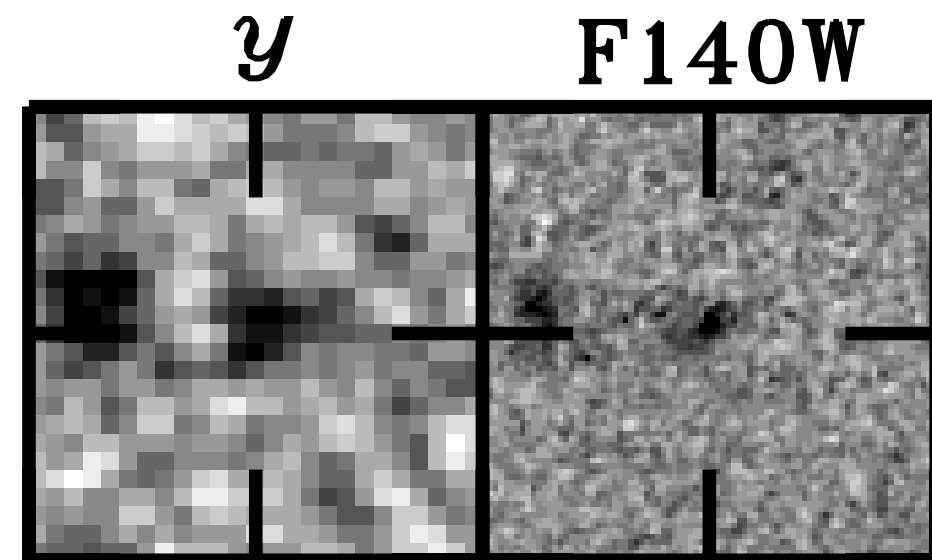
Iye et al. 2006
 $z=6.964$
(Cosmic age=
750 Million years)

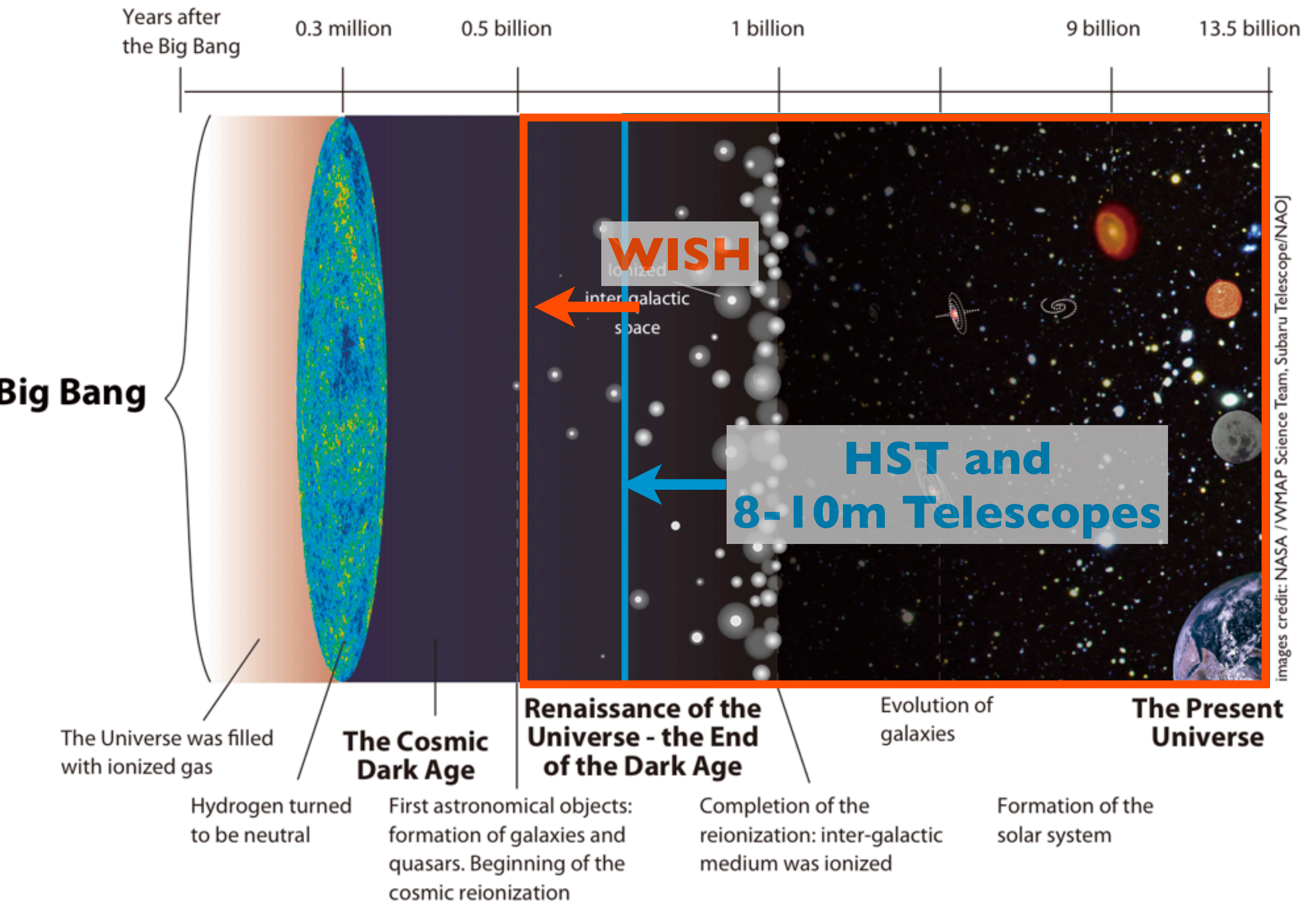
$\text{Ly}\alpha$ at $0.97\mu\text{m}$

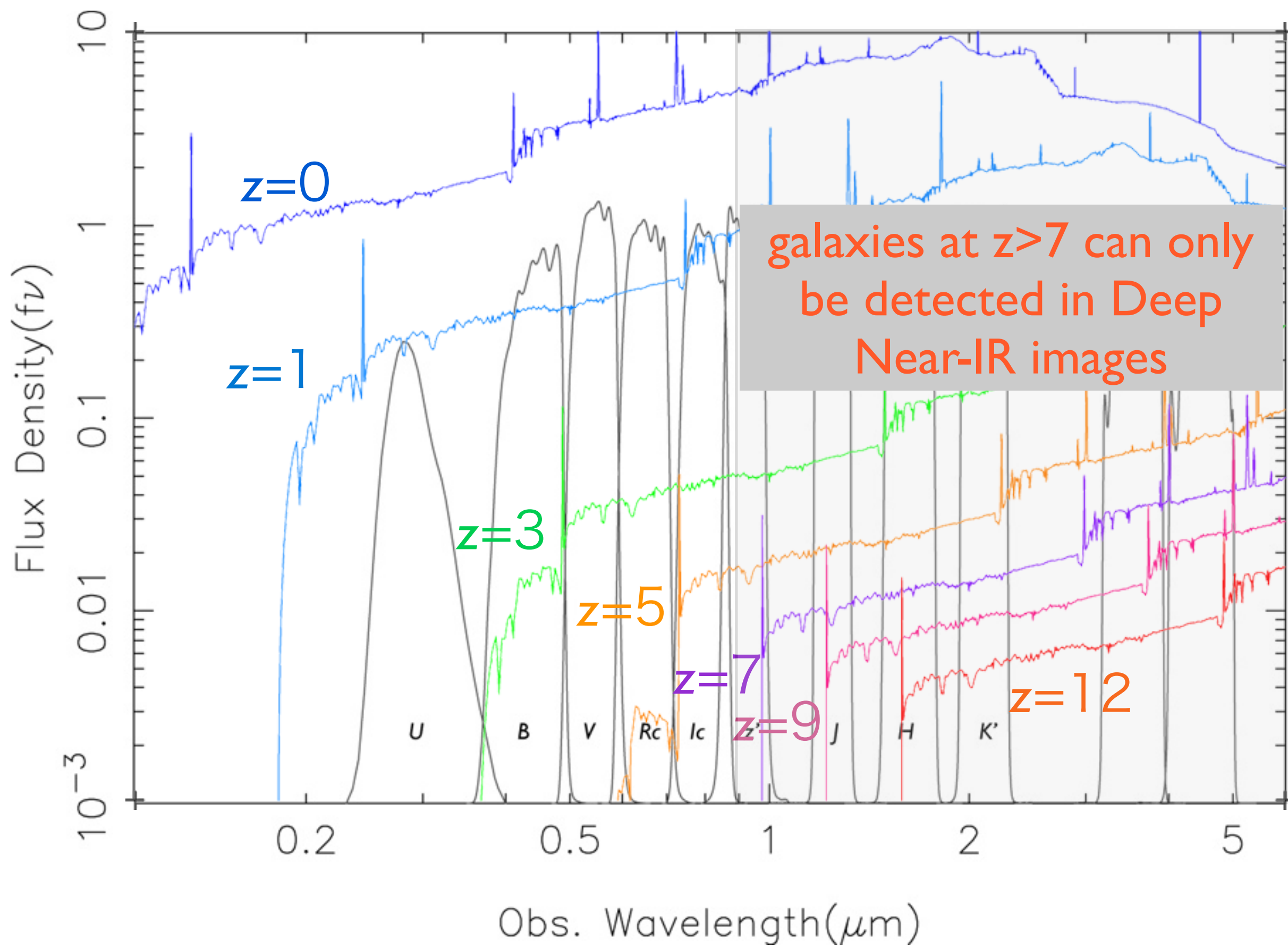
Achievements of Subaru Wide-field Imaging



Ono et al. 2011
z-dropouts







ELTs Should Make Spectroscopy of 'First Galaxies'. But Who can Provide the Targets?



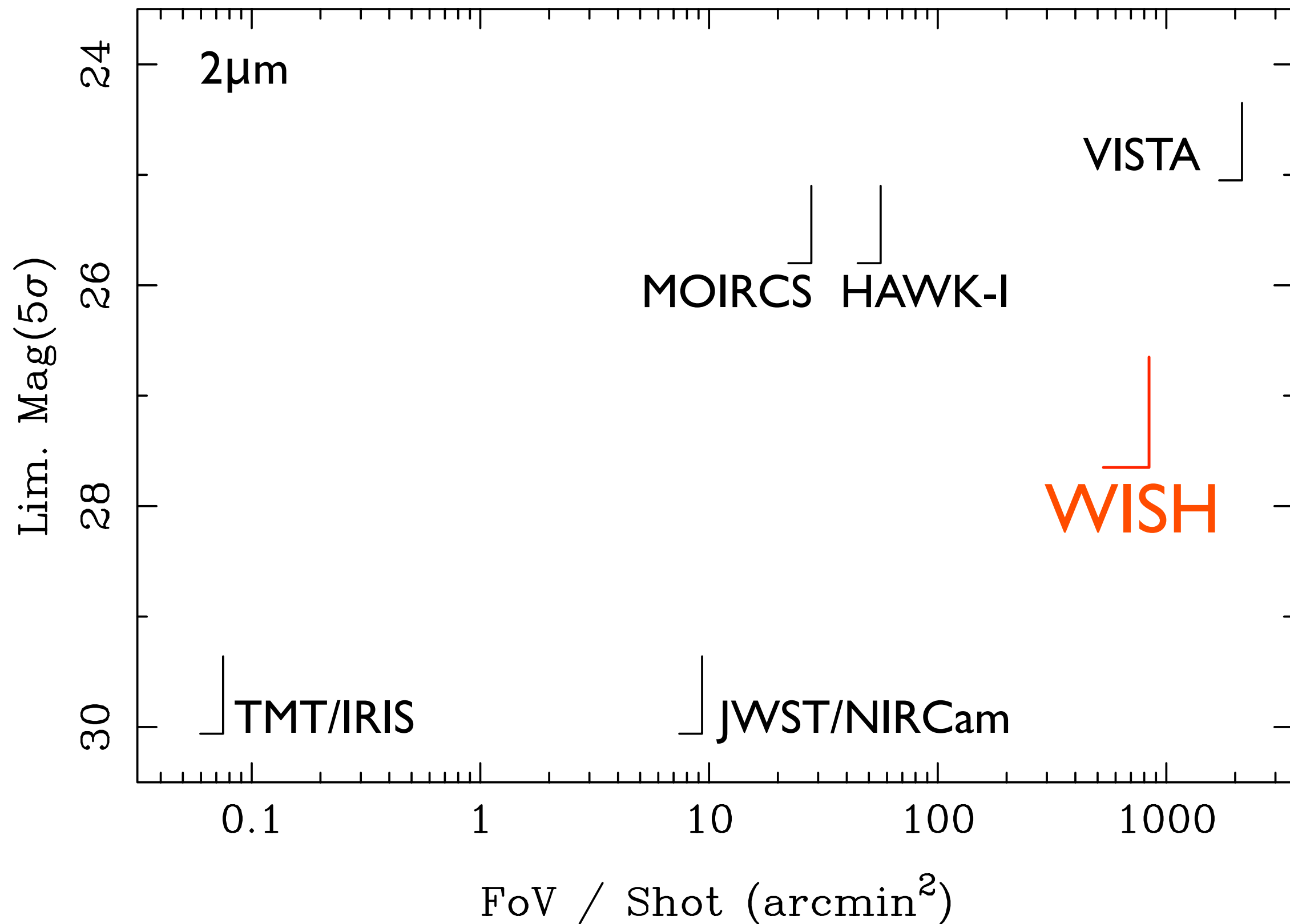
Ground-based Telescopes Can't Find 'First' Galaxies

In Near-IR, the Depth of the Broad-band Images is Determined by the Background Radiation. Thermal Noises Prevent Us to Reach >27 AB Mag.

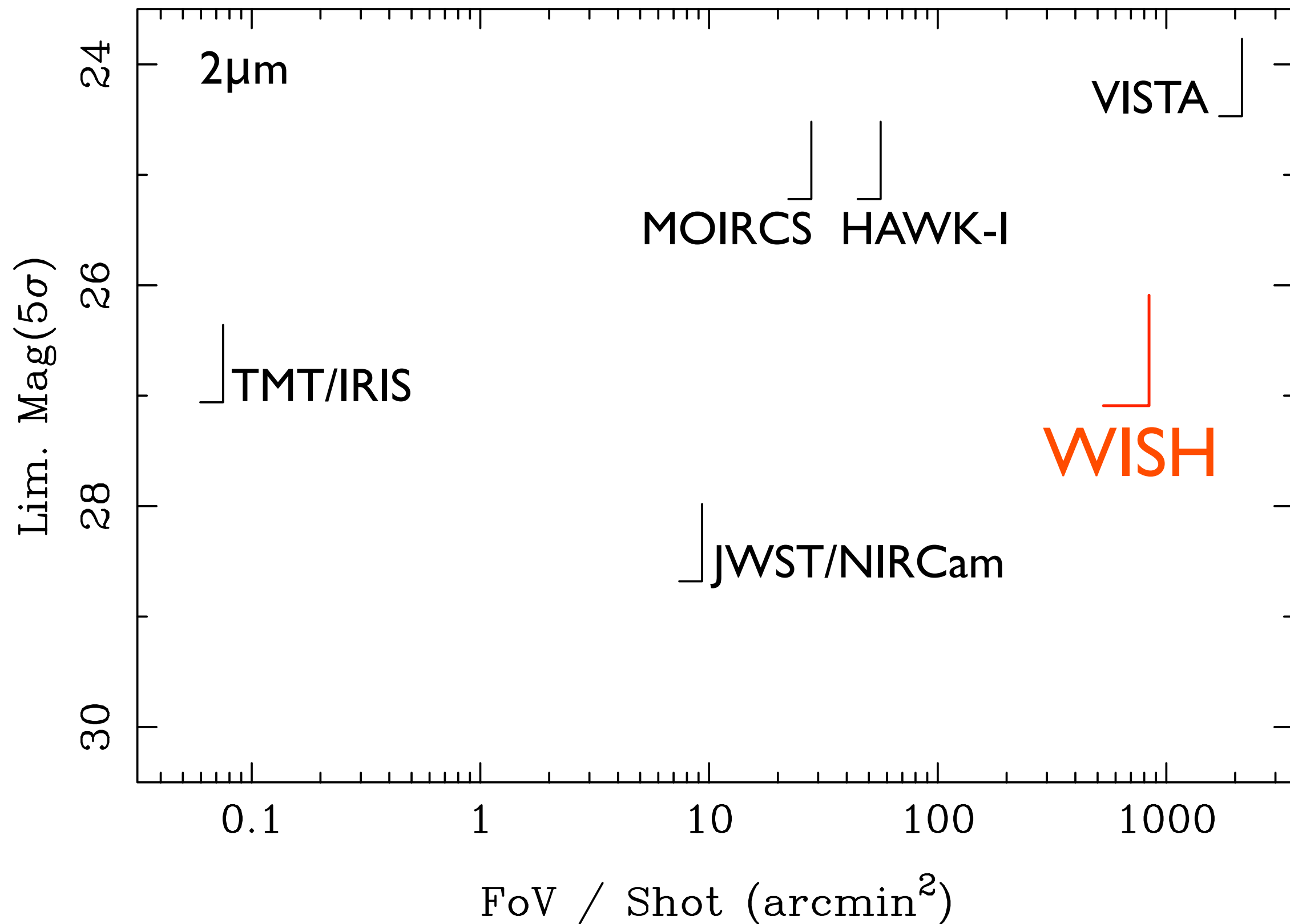
Cooled Space Telescope is Required.

Depth + **Survey Area** are the Keys.

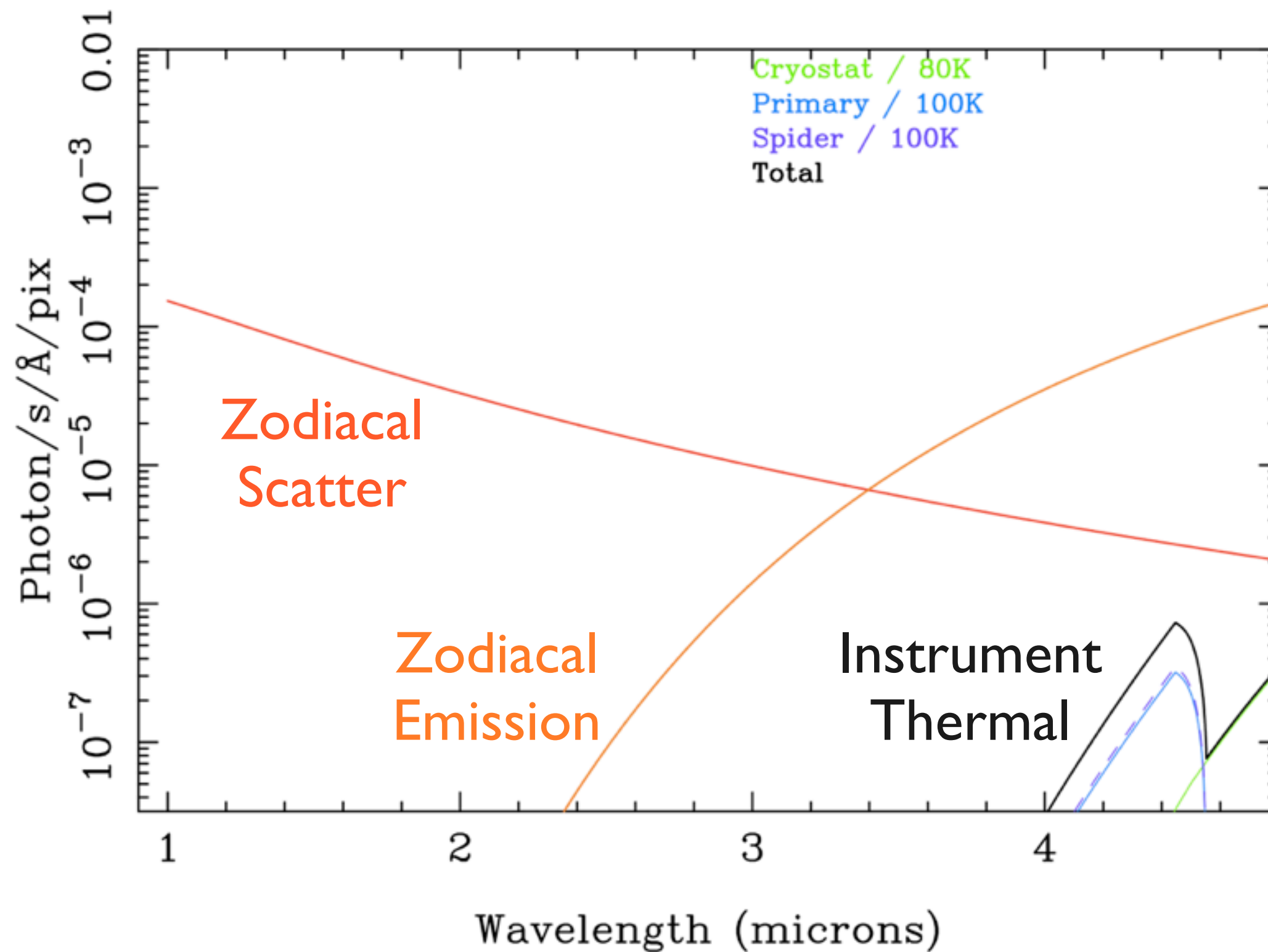
Point Source, 10^4 sec

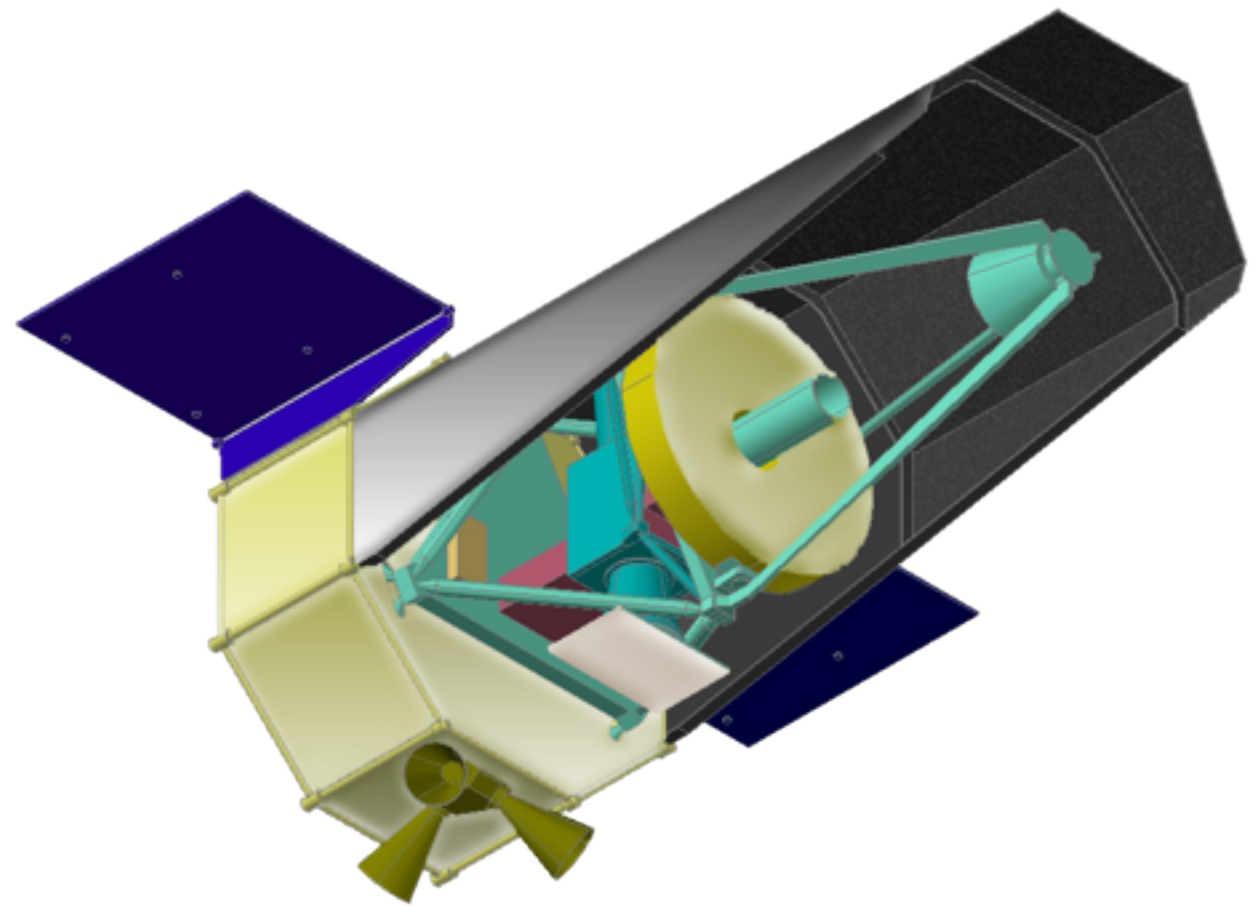


0.5'' Extended Source, 10^4 sec



Filter5 CRYO=80K MIRROR=100K



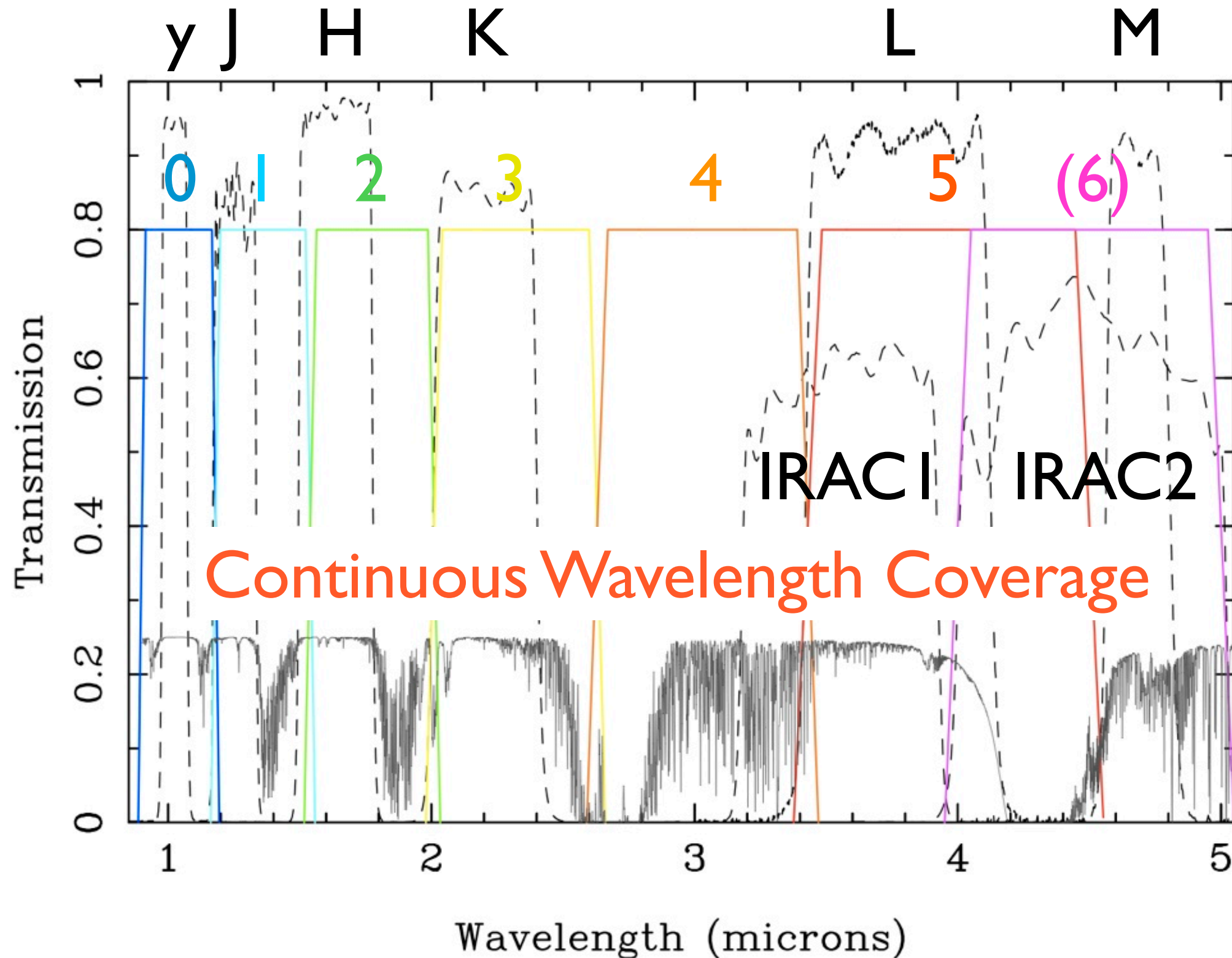


WISH: Expected Number of High- z Galaxies

WISH Survey Plan

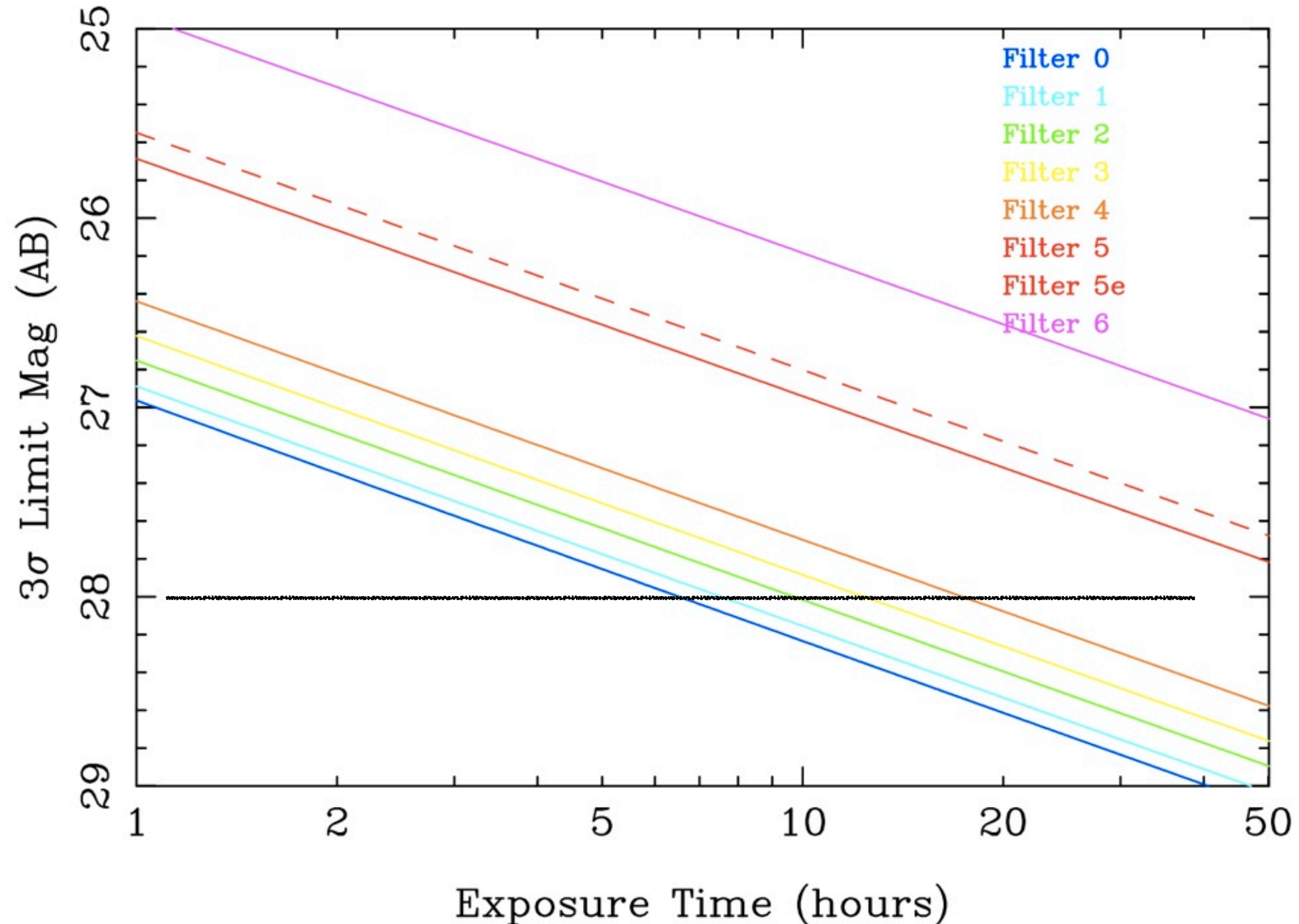
	Depth [AB mag.]	Area [sq. deg]	Days
Ultra Deep Survey	28.0	100	1,500
Ultra Wide Survey	25.0	1,000	50-100
Extreme Survey	~29.5	~1	<100

WISH Broad-band Filter Set

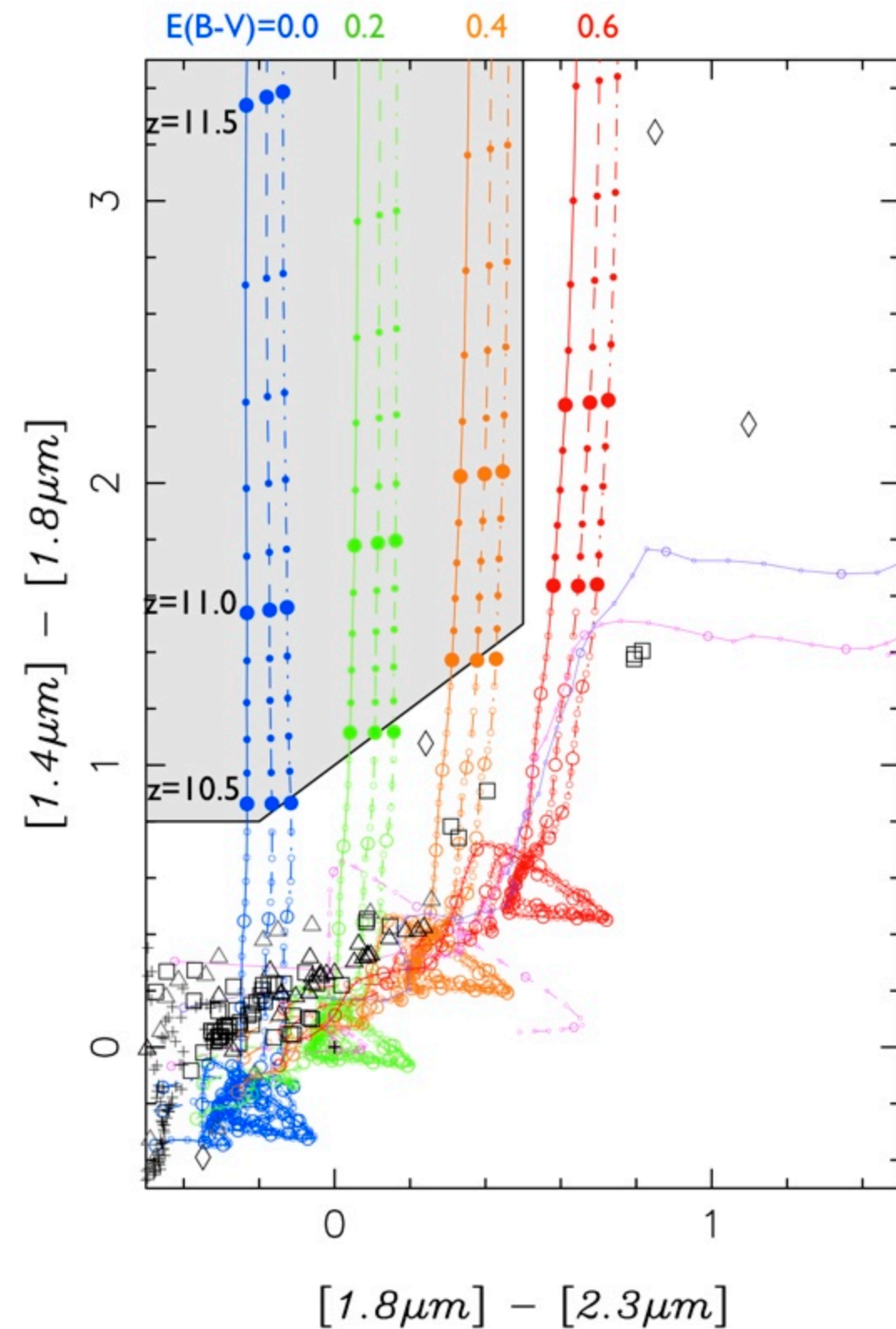
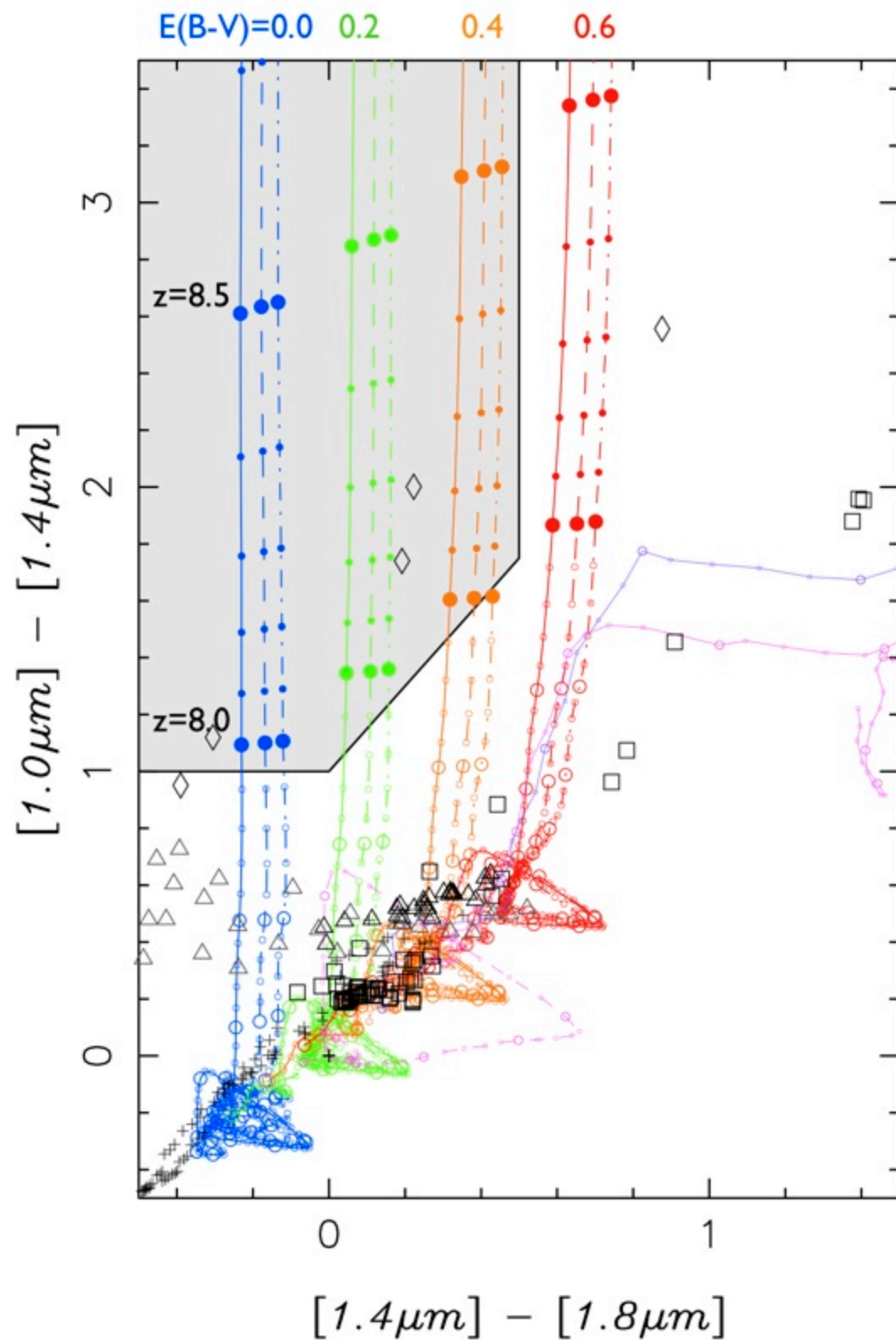


WISH: Expected Sensitivity

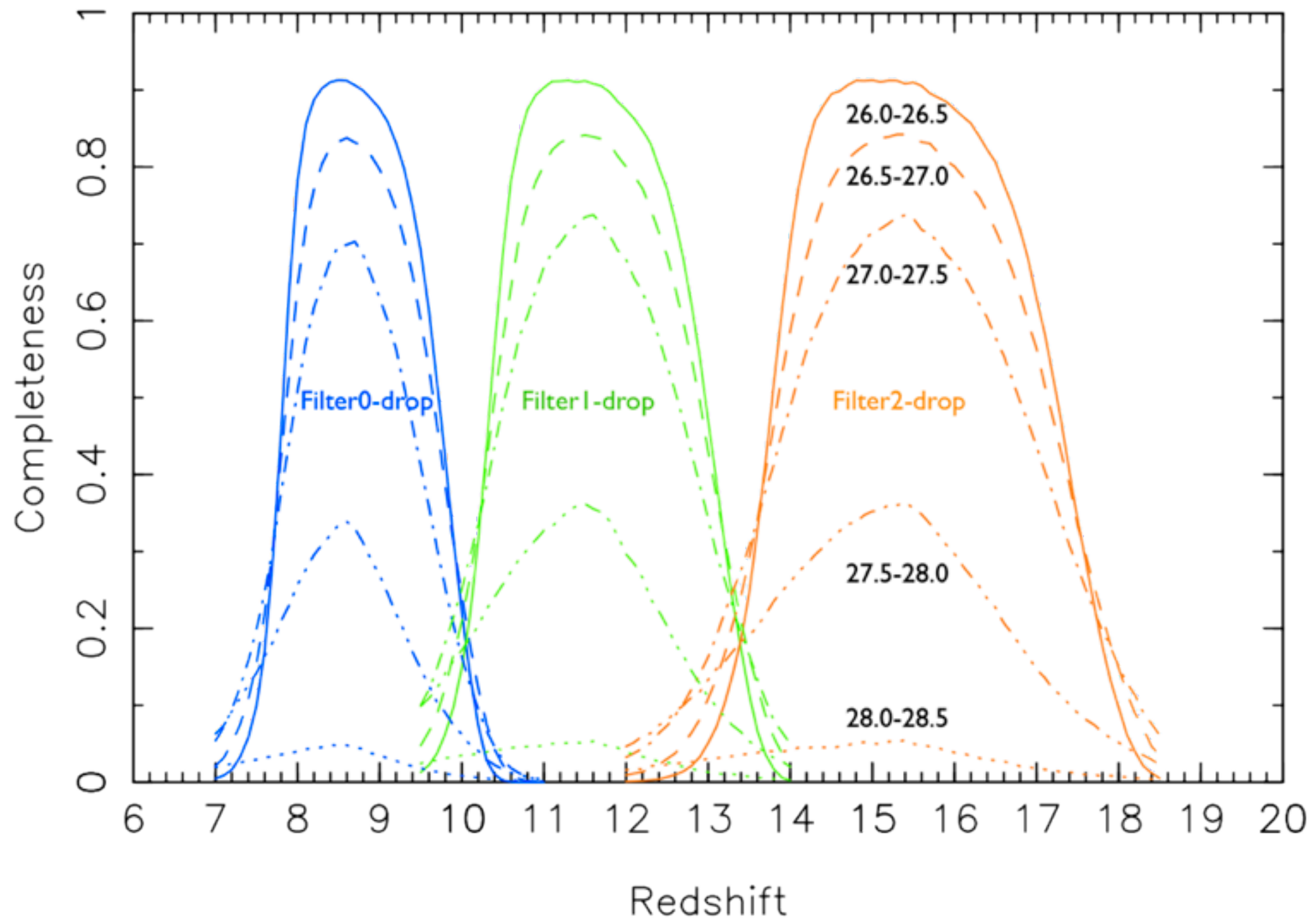
Zodiacal Light = 3x Ecliptic Pole



Selection of High-z Galaxies with Two-Colors



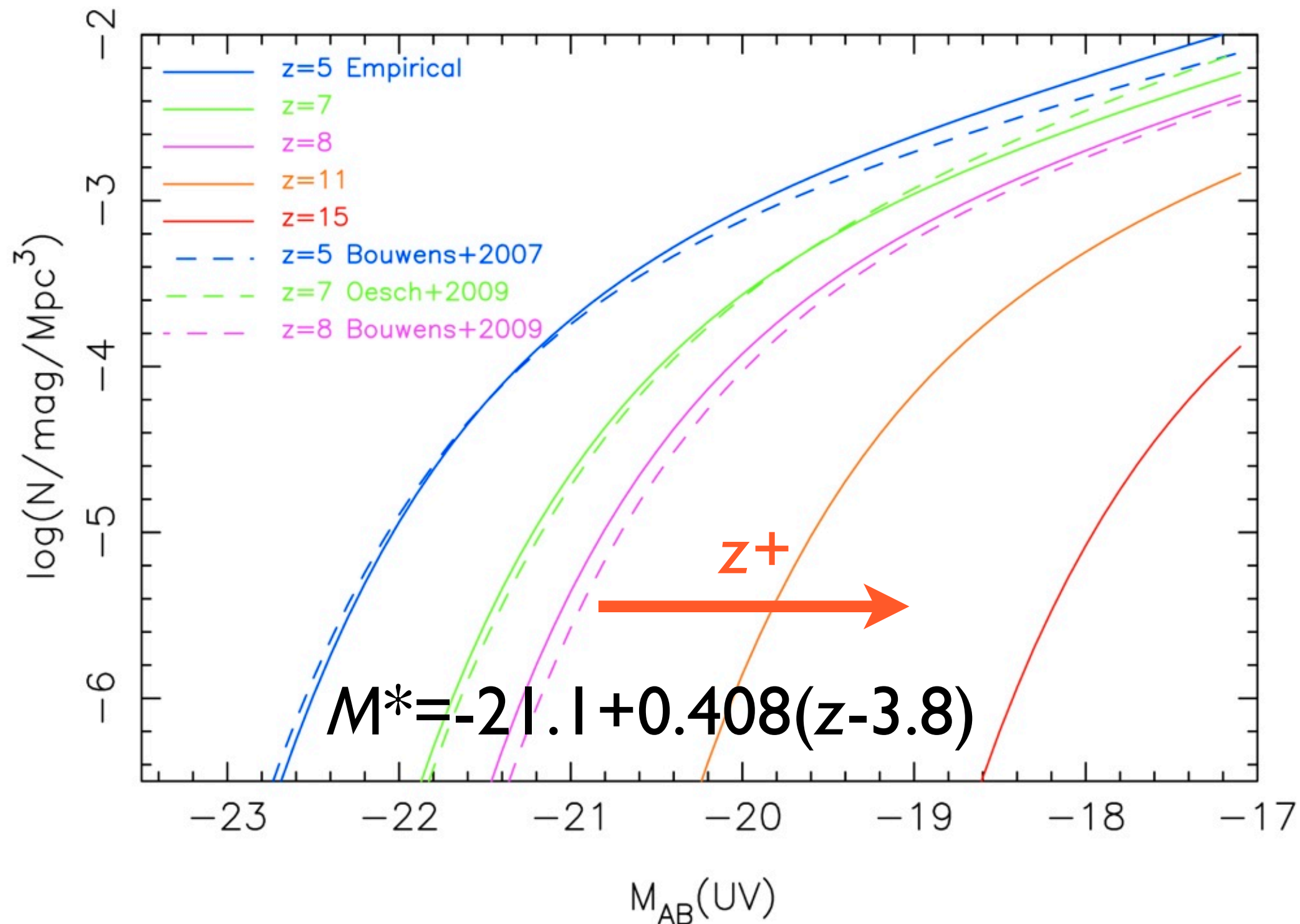
Completeness Estimates



for the case of WISH (Lim. Mag. = 28AB)

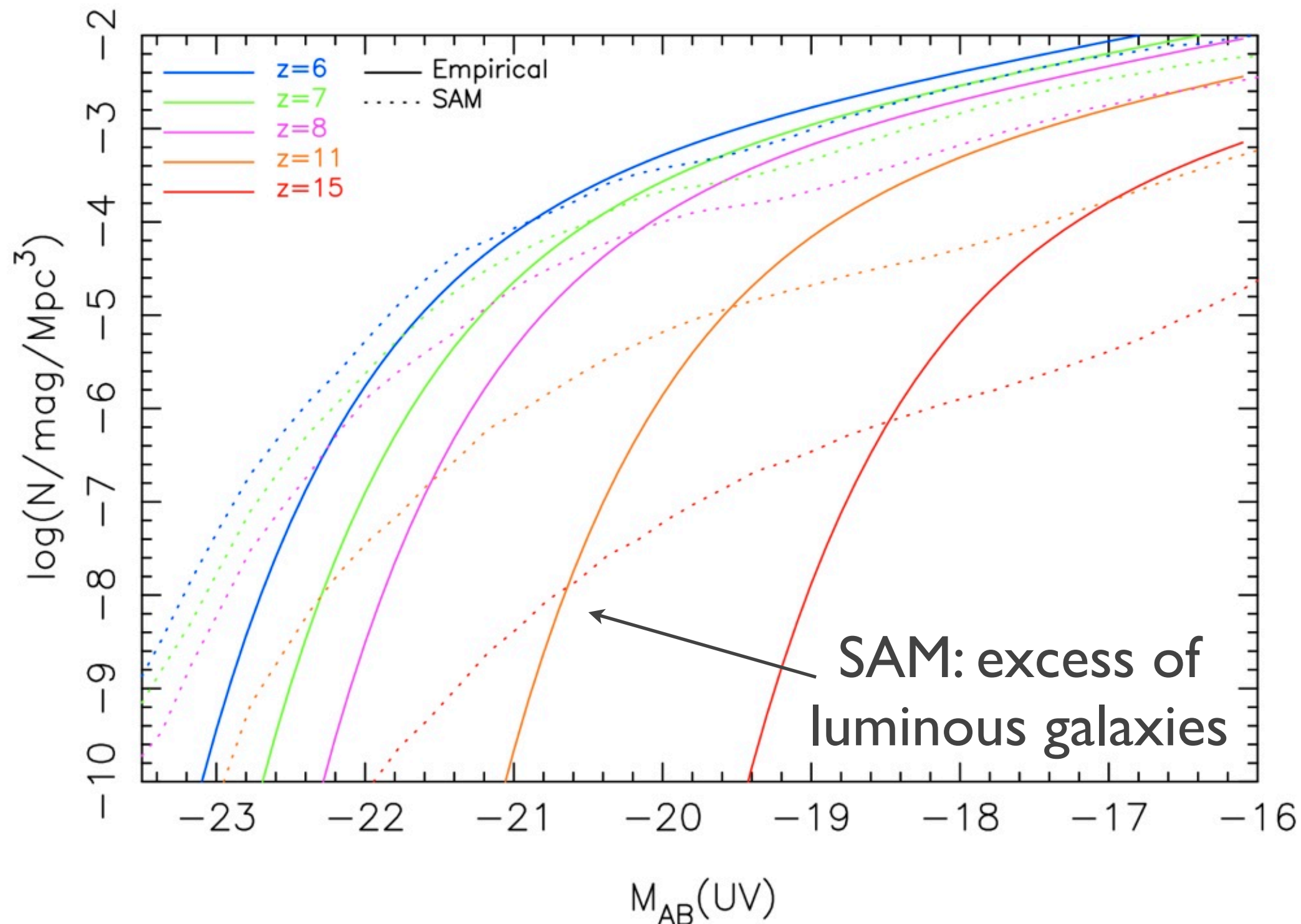
Assumption on Evolution of Luminosity Function(I)

Empirical Evolution



Assumption on Evolution of Luminosity Function(2)

Semi-Analytic Model by Kobayashi et al.



Expected Numbers with **WISH** Ultra-deep Survey

- **100 sq. deg** survey with 5 filters from 1.0 μ m to 3.0 μ m
 - Limiting magnitudes 28AB (point source, 3σ)
 - Total 1,500 days

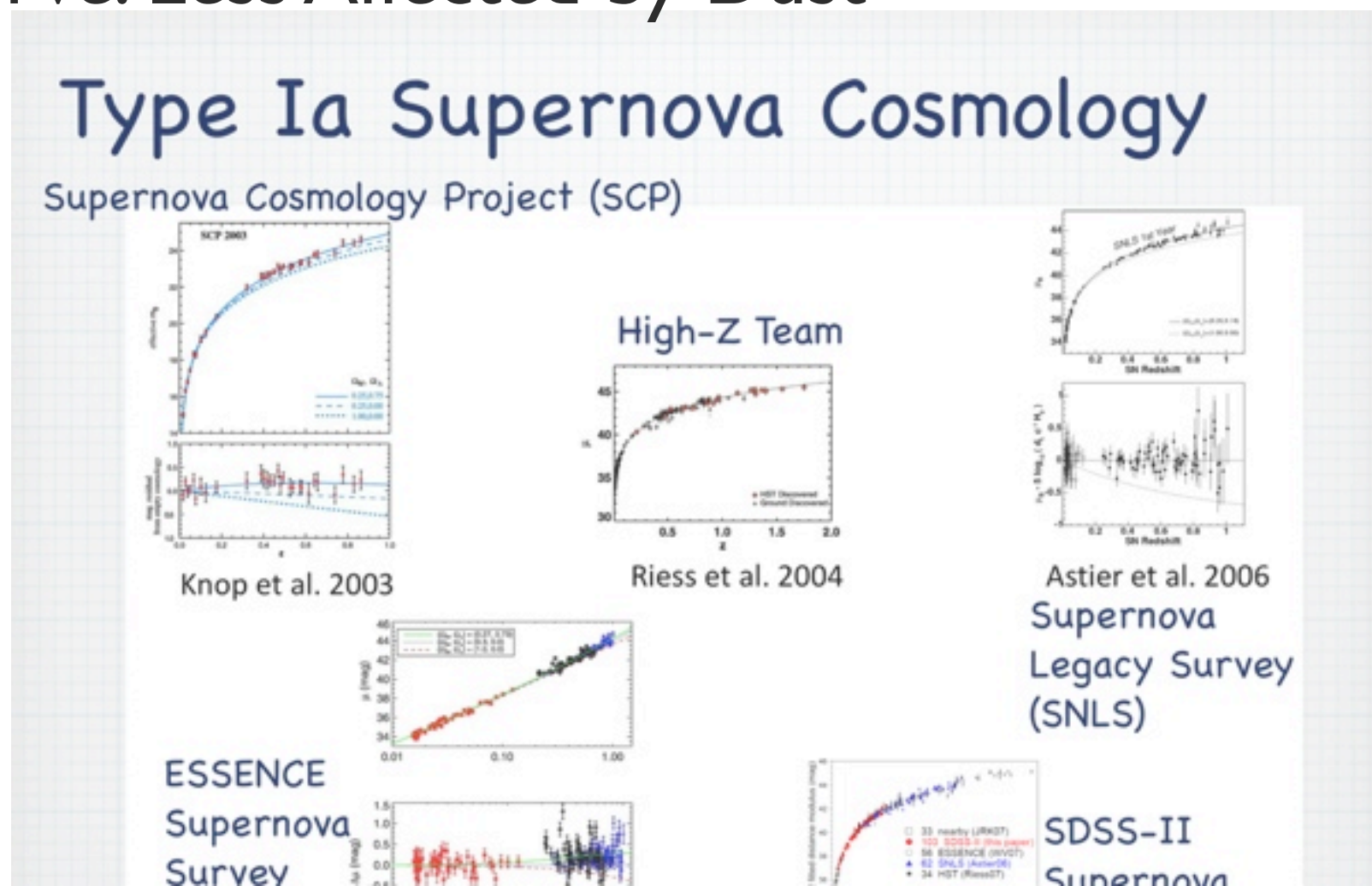
	z=8-9	z=10-12	z=13-17
Empirical Ev.	169,000	10,420	72
SAM	63,120	4,970	107

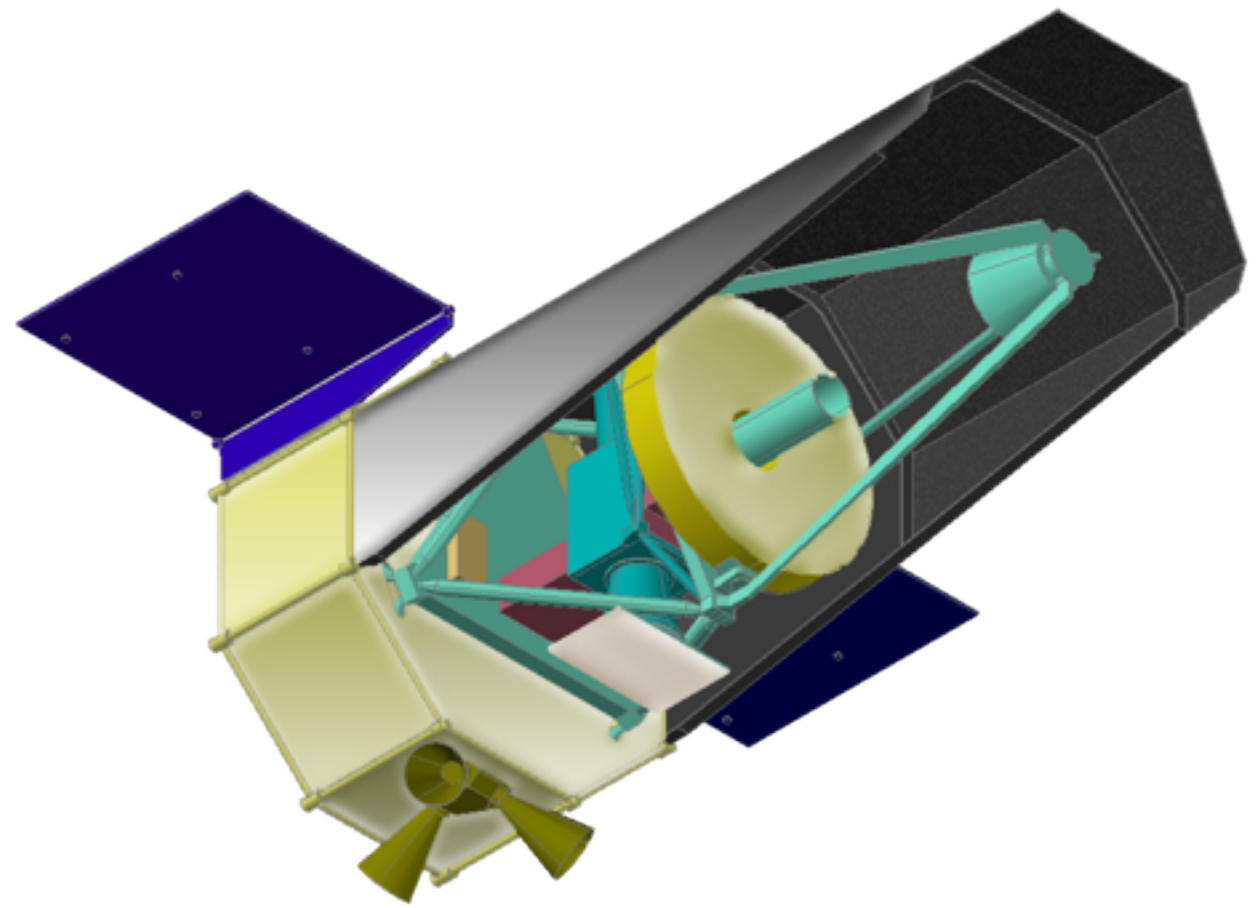
WISH can provide large number of targets to ELTs.

Supernova Survey

- Repeat Observations → Find Transient Objects
- Type-Ia SN Search can be made Simultaneously.
- ~2,000 Type Ia SNe ($0 < z < 2-3$) are expected
- Rest-frame IR Light Curve: Less Affected by Dust

Slide by
T. Morokuma

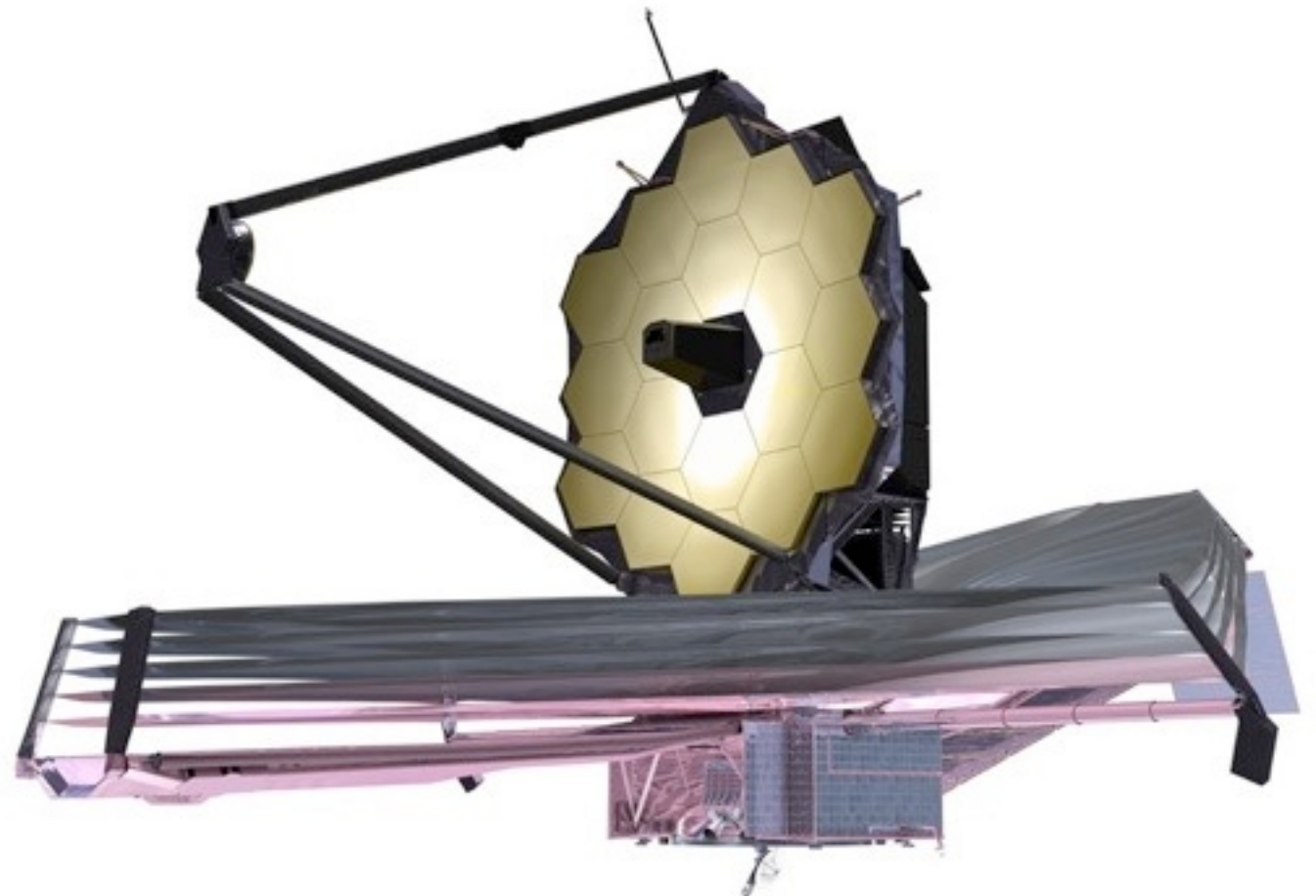




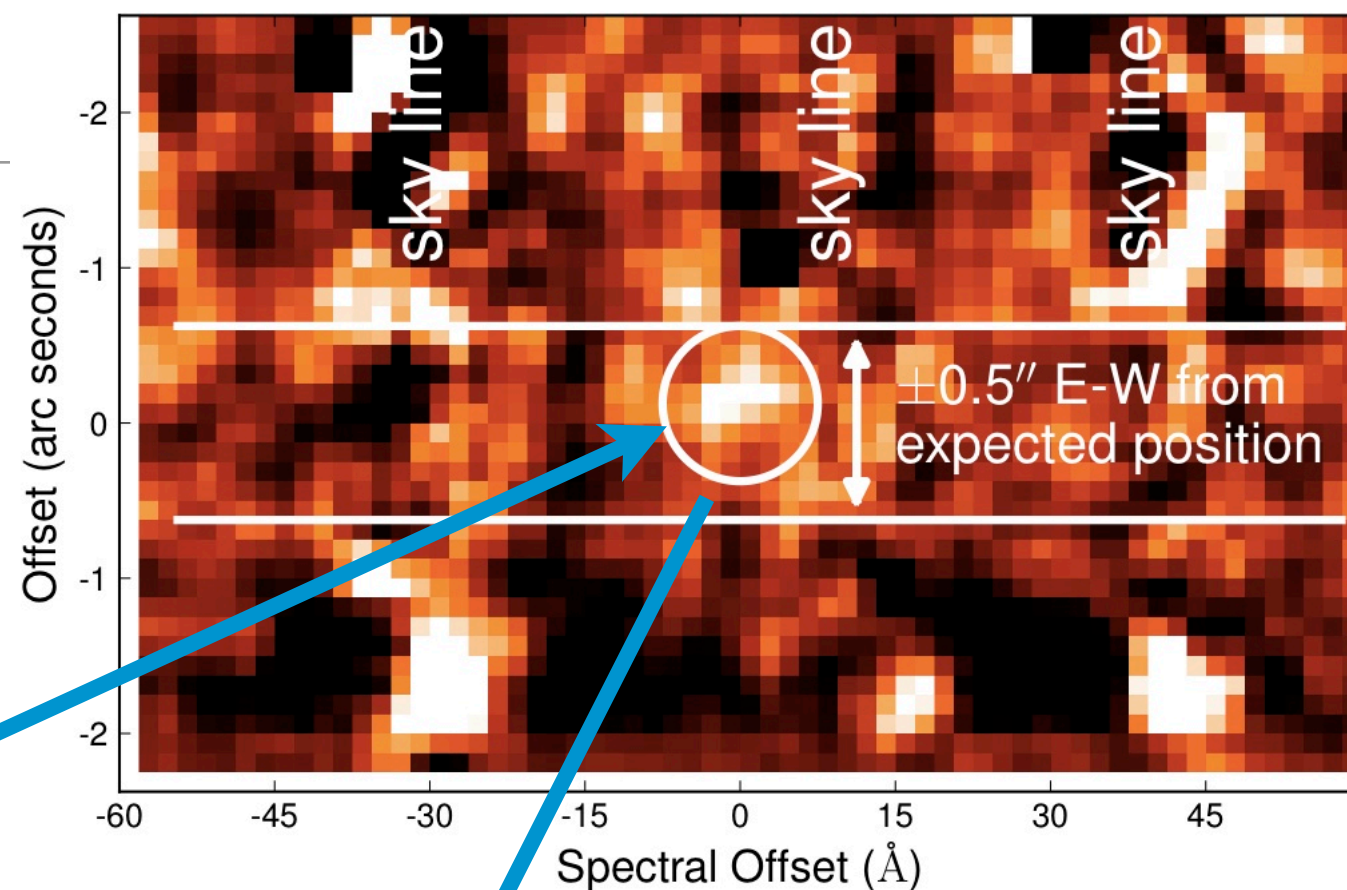
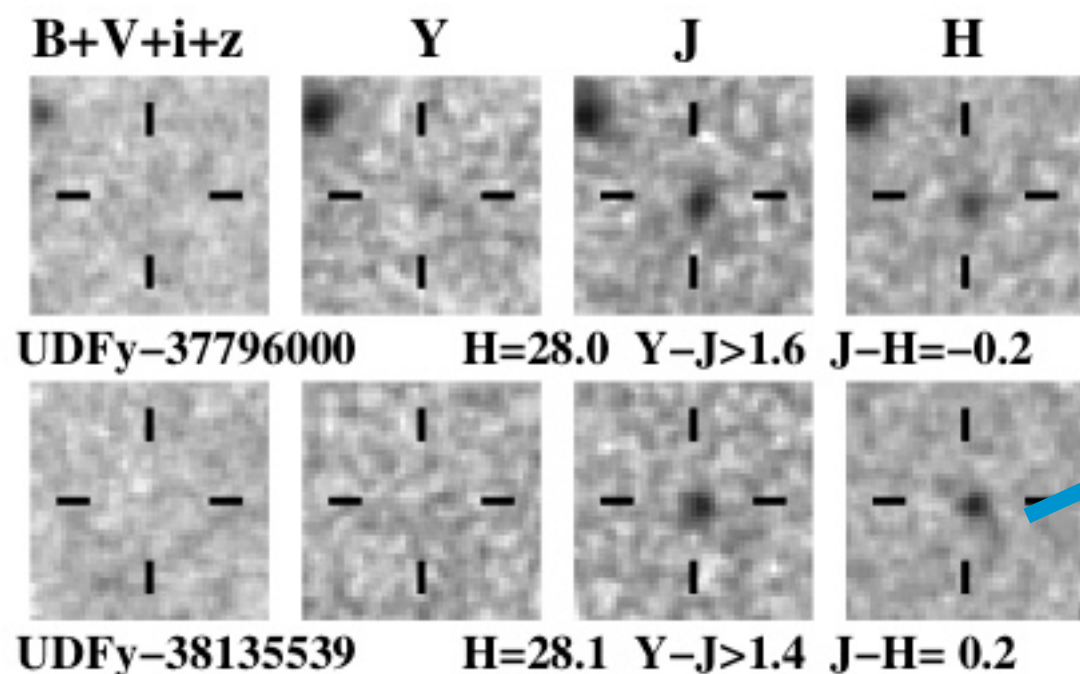
Why WISH is Indispensable

JWST

- 6.5m Deployable Mirror, Passive Cooling at S-E L2
- Four Science Instruments:
 - MIRI: Mid-IR (5 - 28 μ m)
 - NIRSpec
 - NIRCam
 - TFI: Tunable Filter Imager

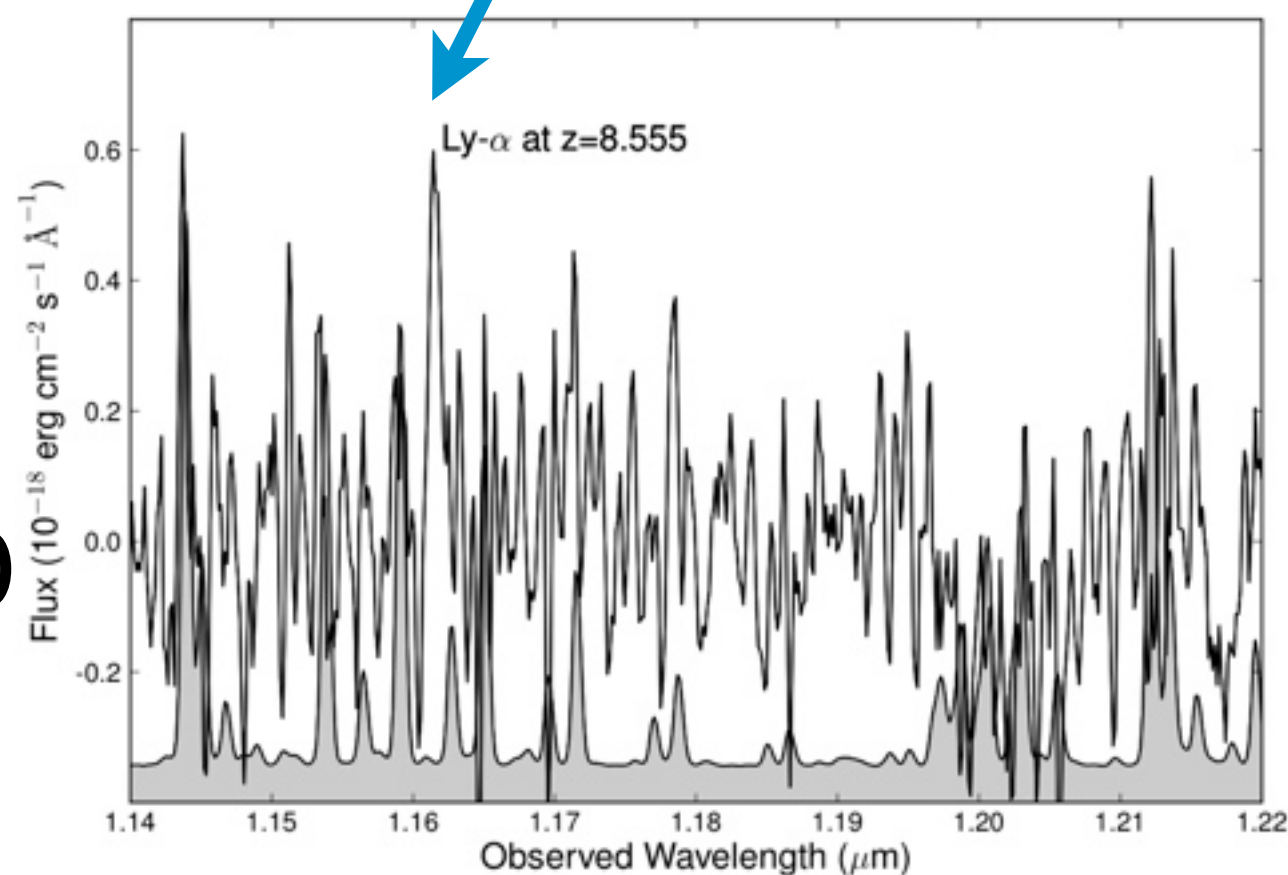


HST/WFC3

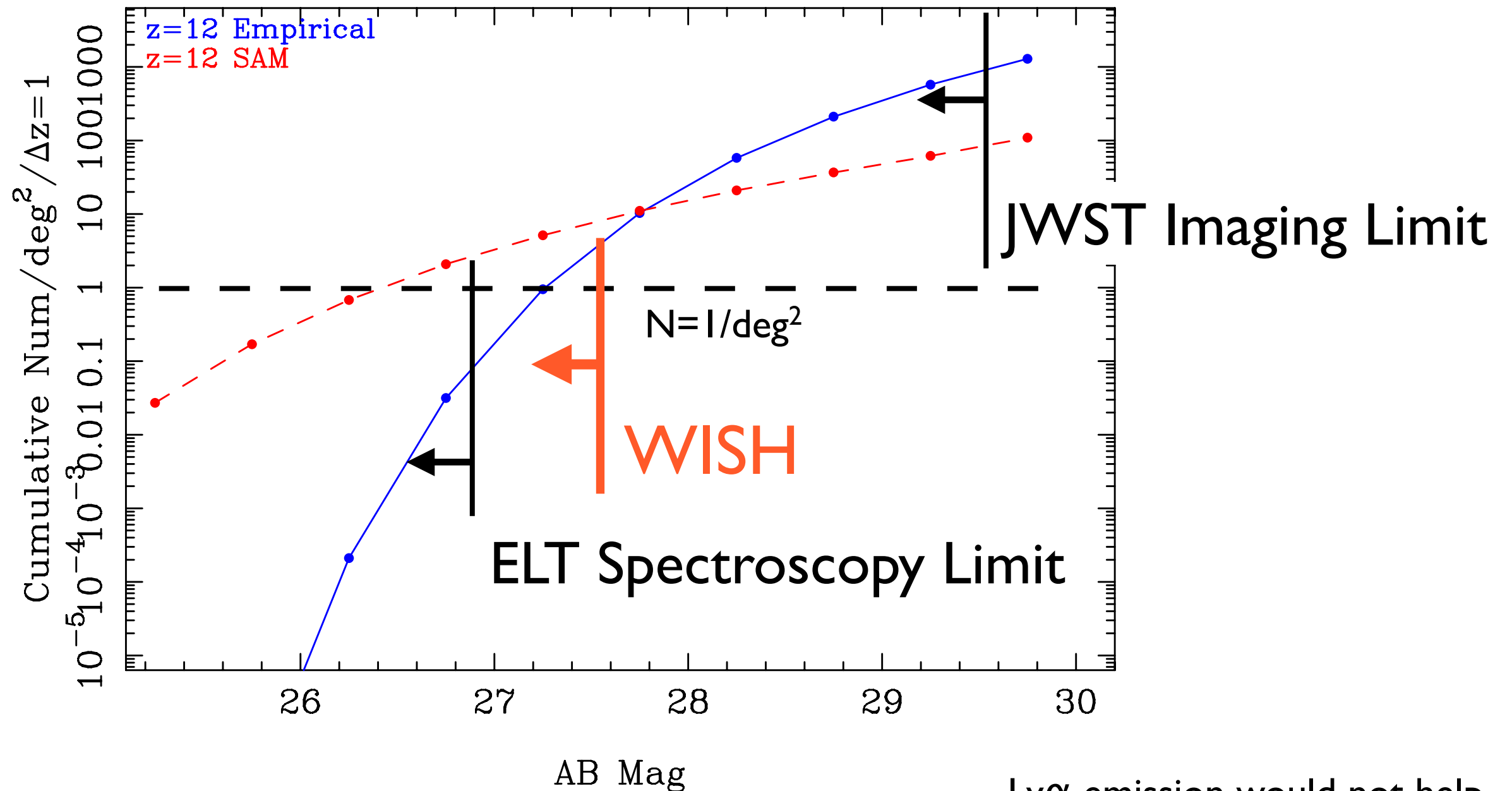


Bouwens+2010
Bunker+ 2010 etc.

Lehnert+2010
VLT/SINFONI



Number Density of $z=12$ Galaxies



Ly α emission would not help
improving the detection limit with
ELTs for extended sources

Field of View



↑
JWST/NIRCam
10min²



WISH
840min²

(32x 2k x 2k HgCdTe)

Survey Area

WISH Ultra-Deep Survey
100 deg²
450 Pointings

↑
JWST/NIRCam
10 min²

■
WISH
840 min²

Why is WISH So Important?

- JWST will discover numerous candidates of very high- z galaxies, but most of them are too faint to be followed-up with JWST itself and ELTs.
- Narrow FoV of NIRCam makes wide-field surveys very expensive.
- JWST + WISH: Complimentary to constrain UVLF Evolution
- Wide-field + Dedicated Surveyor Enables to Find 'Luminous' Galaxies

Euclid, WFIRST, and WISH

	Euclid	WFIRST	WISH
Mirror	1.2m	1.3m	1.5m
FoV	0.5 deg ²	0.3deg ²	0.23deg ²
Visual Imager	R1z	↓	--
NIR Imager	YJH	0.6-2.0μm	0.9-5.0μm
Lim. Mag.	24AB	25.9AB	28AB
Survey Area	20,000 deg ²	> 11,000 deg ²	100 deg ²
Primary Science	Dark Energy	DE, Exoplanet, QSO	First Galaxies

Euclid, WFIRST, and WISH

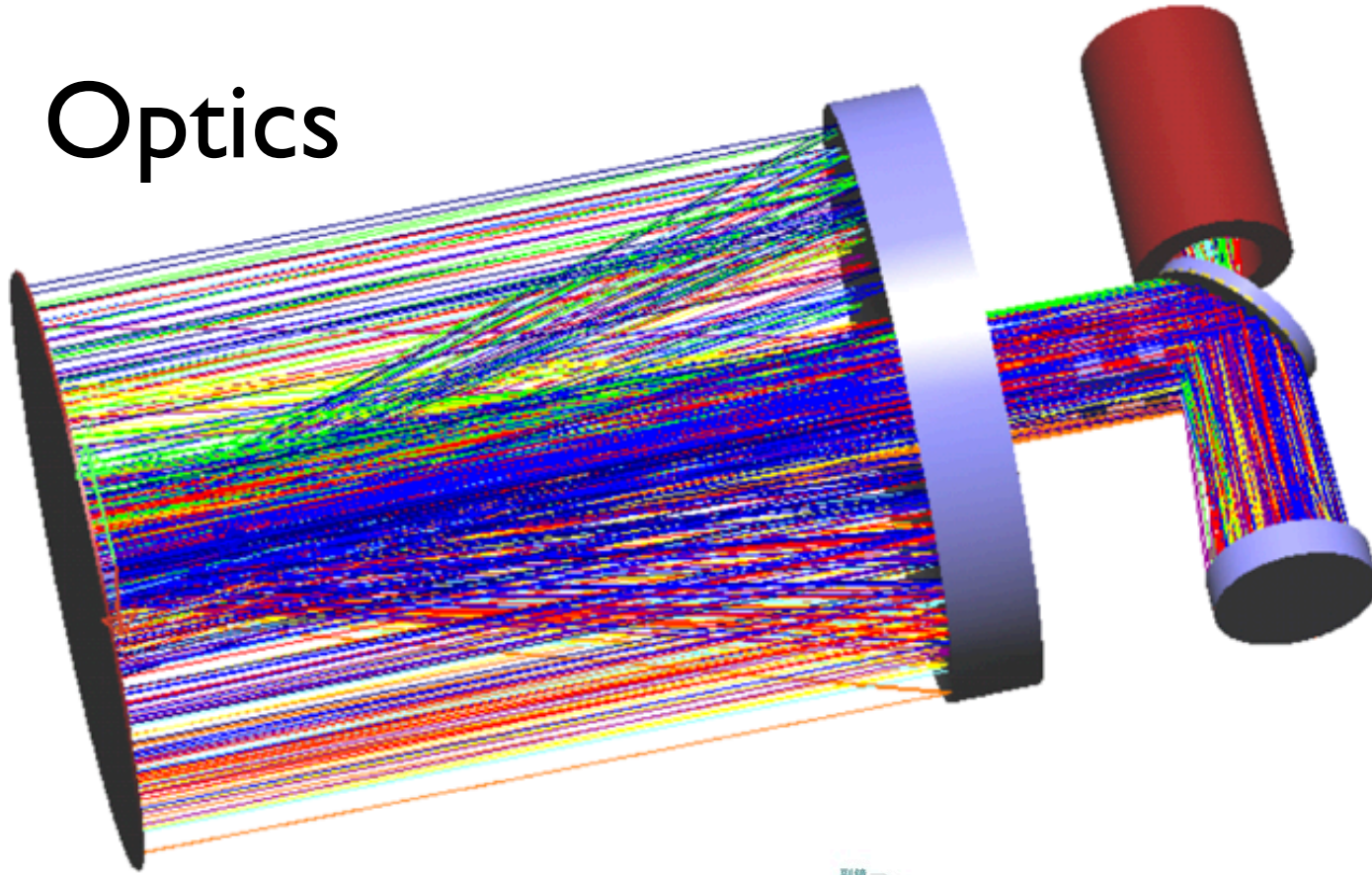
- Euclid, WFIRST:
 - Precise photometry and Image Quality
 - $>10,000 \text{ deg}^2$ Survey
- WISH:
 - Optimized for Detection of Luminous High-z Galaxies to Feed ELTs
 - 1.5m Diameter Mirror Size is Mandatory
 - Image Depth
 - Diffraction Limit ($0.15''$ at $\sim 1 \mu\text{m}$)
 - Cover $\lambda \sim 5 \mu\text{m}$

WISH is the Best High-z Sample Feeder for ELTs and Right Strategy to Tackle the Enigmatic Early Stage of the Universe.

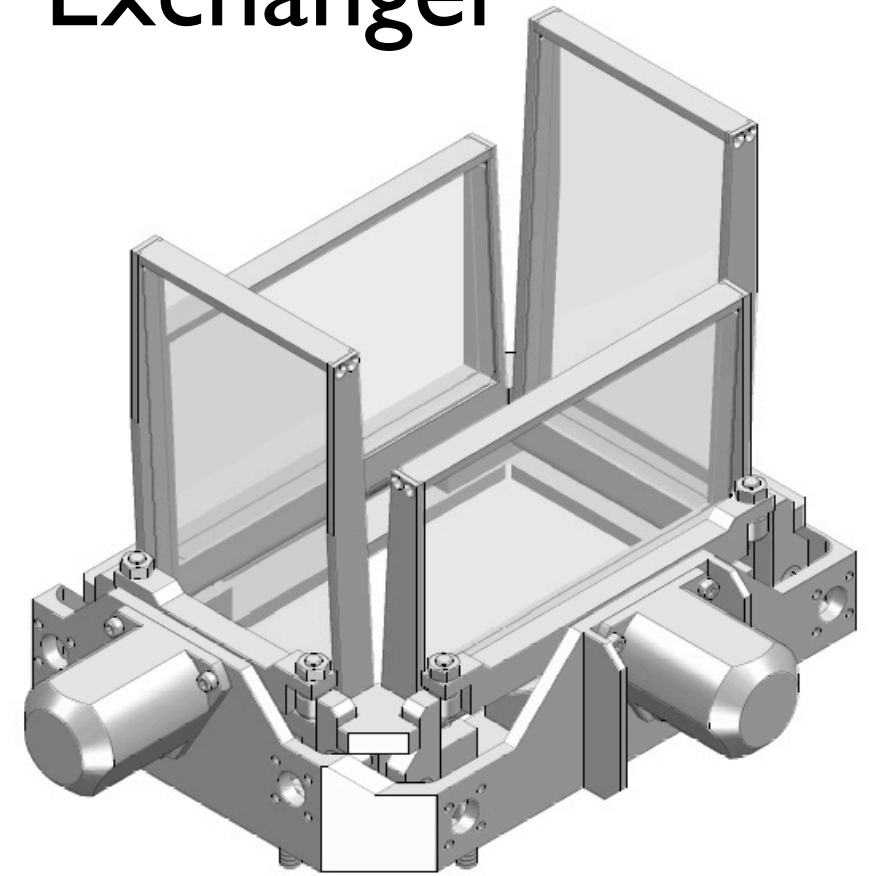


R&D

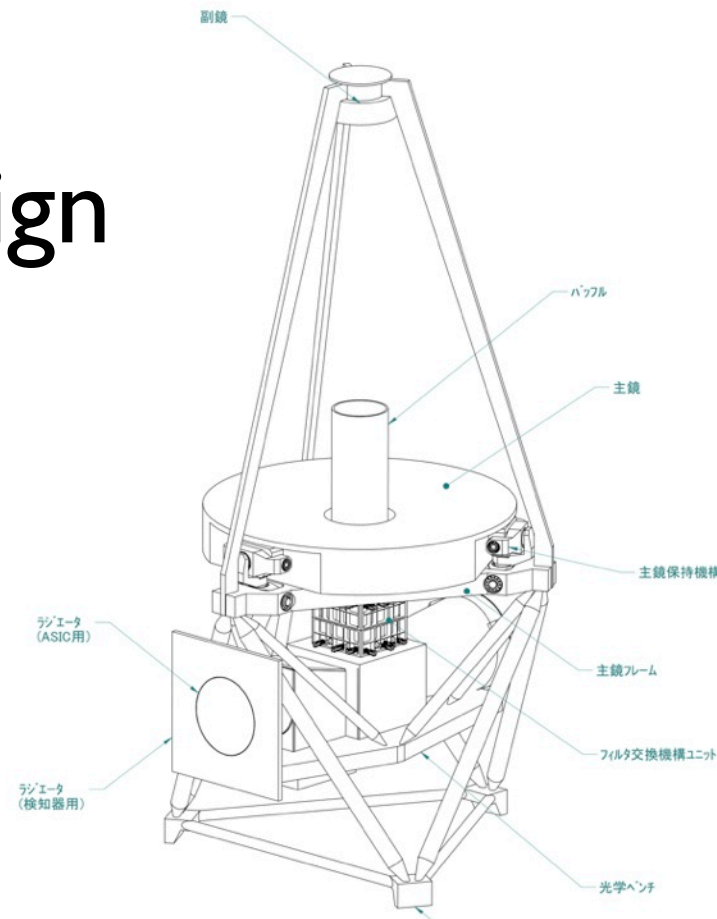
Optics



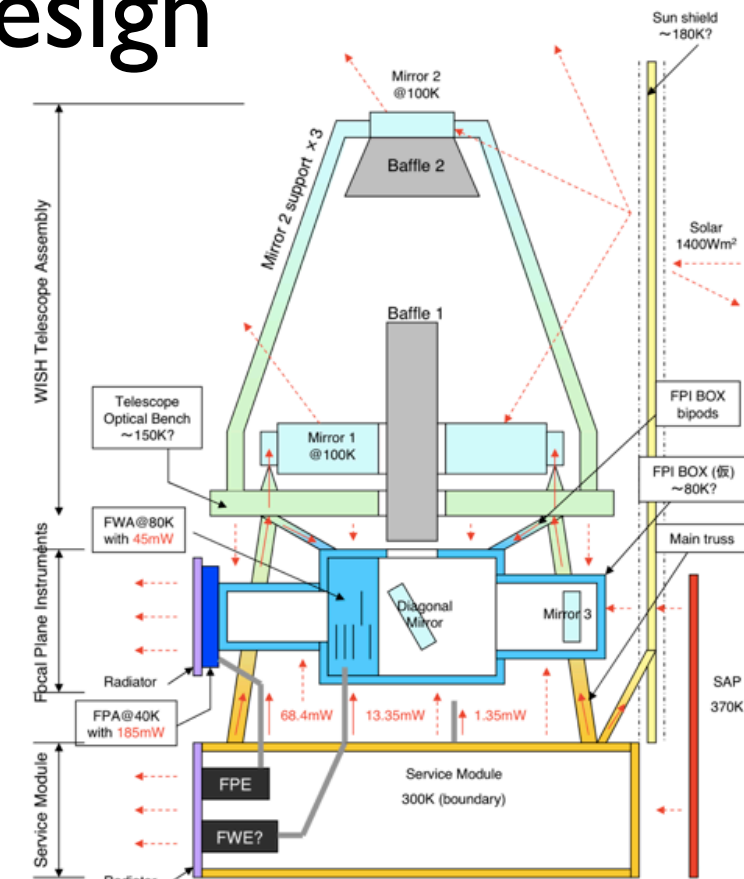
Filter Exchanger



Structure Design



Thermal Design



Make WISH Come True!

- 1.5m Space Telescope Optimized for Hunting Galaxies at $z > 10$
 - 28 AB mag., 100 deg²
 - λ up to 5 μm
- Provides Thousands of Galaxies at $z > 10$ and Hundreds of Galaxies at $z > 13$
- Now in Basic R&D and Preparing a Mission Proposal to JAXA
- Open for International Collaboration

<http://wishmission.org>