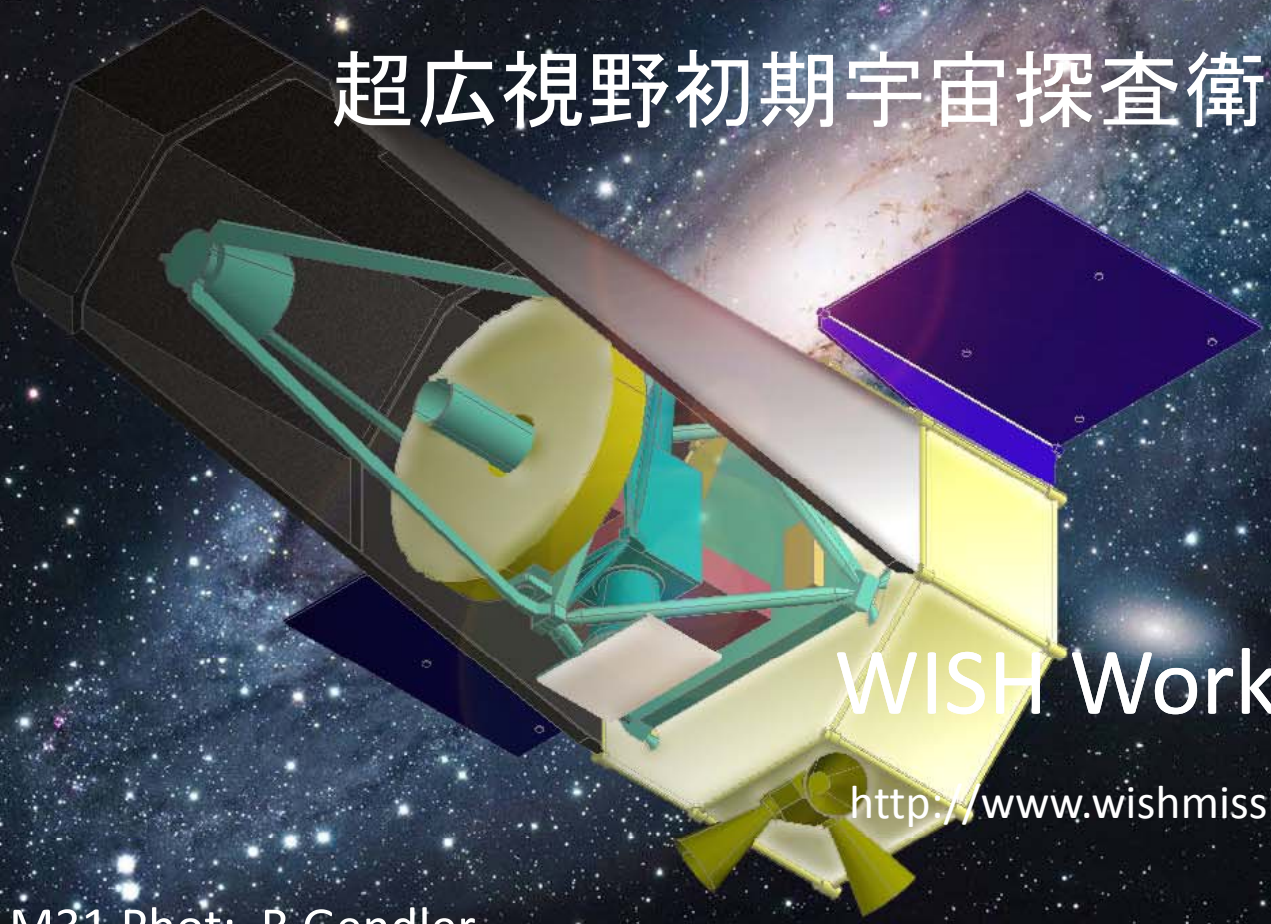
WISH

upon a first galaxy....

WISH

Wide-field Imaging Surveyor for High-Redshift

超広視野初期宇宙探査衛星



WISH Working Group

http://www.wishmission.org/en/index.html

M31 Phot: R.Gendler

WISH WG Members

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CG of a 1st –gen galaxy, by Toru Yamada

WISH Mission

- **Very Wide-field & Deep Imaging Surveyor at 1-5μm**
- **Exploring First-Generation Objects (Galaxies) in Early Universe**
- **1.5m Primary Mirror, Camera Field of View 1000 sq. arcmin**
  Simple Optics, Dedicated for Wide-field NIR Imaging
- **Complementary / Synergy**
  with JWST / Extremely-Large Telescope (TMT, EELT)
  ALMA / Subaru HSC

  compared with JDEM/Euclid
  unique capability at 2-5μm imaging
  optimized survey strategy for z=7-15 search

WISH Specifications Quick Summary

Primary Mirror Diameter 1.5m

Wavelength Coverage 1-5μm

Image Quality achieving diffraction limit to the FoV edge at 1-5 μm

Spatial Sampling 0.15”/18μm (optimized at 1.5μm)

Limiting Magnitude ~28 AB/10-20h ~20nJy (3sigma)

Camera Field of View ~1000acmin^2

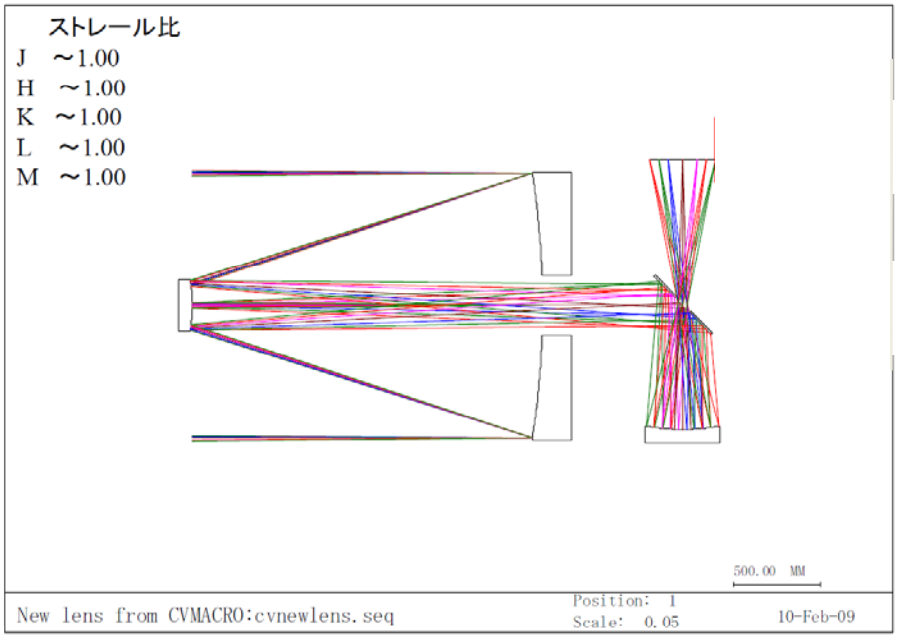
Orbit SE-L2

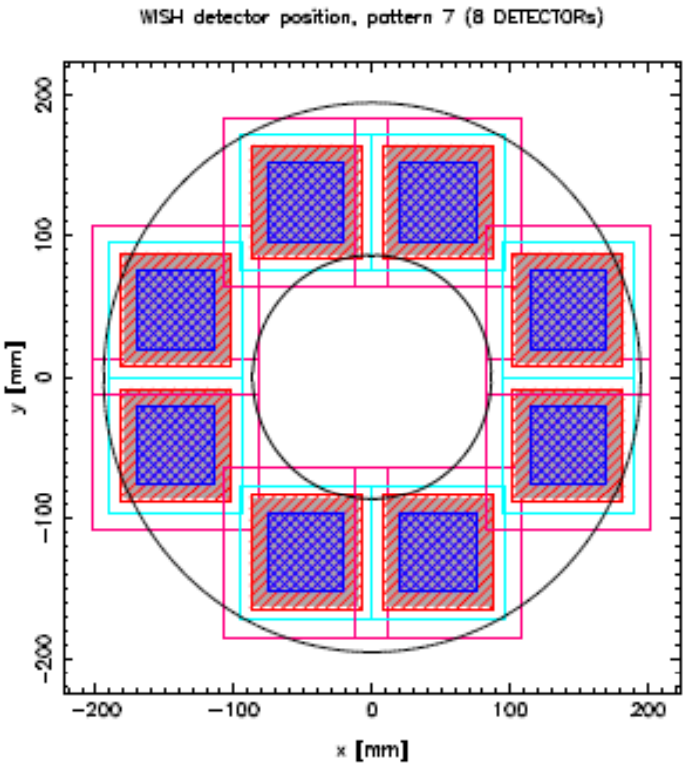
Launcher Japanese HIIA (fit to the Dual Launch)

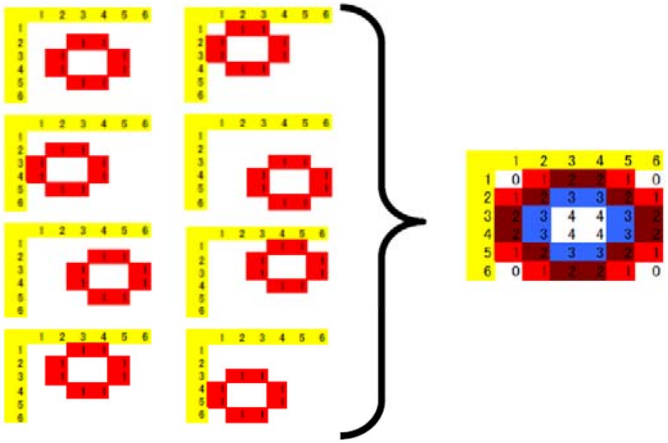
WISH Specification

Telescope	
Primary Mirror	1.5m
Wavelength Coverage	1μm – 5μm
Field of View	1000 arcmin^2
Temperature	<100K (40-80K near focal plane) , only passive cooling
Very Wide Field IR Imager	
Detector Arrays	HgCdTe (18μm/pixel)
Pixel scale	0.15”/pix(18μm)
operation temp.	40-80K
filters	5 broad-band filters which cover 1-5 μm TBD: Narrow-band/Grism
Launcher/Orbit	
Orbit	S-EL2
Launcher	HIIA (JAXA)
Weight	1.3t (TBD)
Others	
Mission Lifetime	5 years

WISH Optical Layout







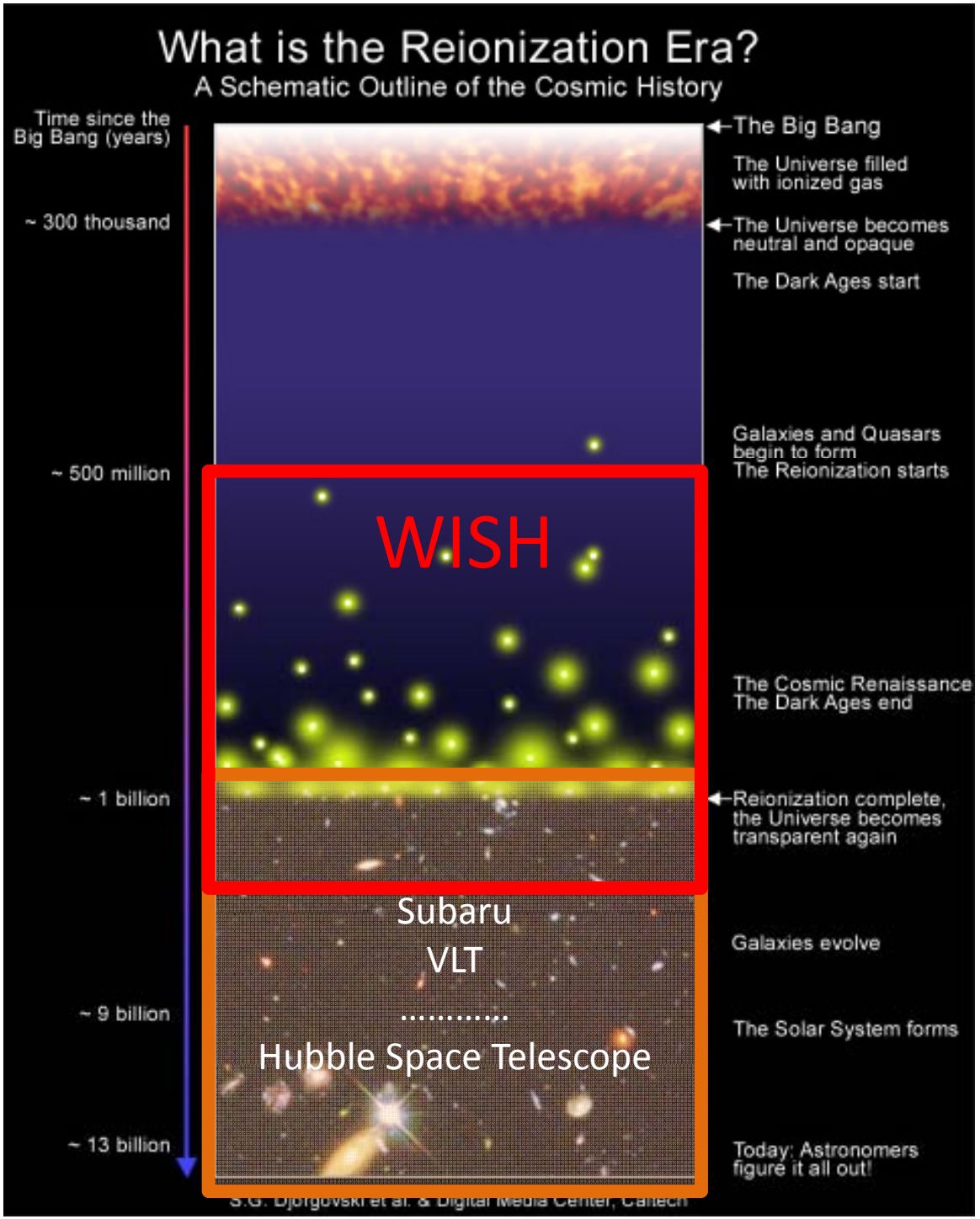
A design of
focal plane layout
and an example of
survey matrix

WISH Science Goals

[1] **Discovery of the First Generation Objects and Study Galaxy Formation at EoR.**

[2] **Study of the expansion history of the universe and properties of dark energy by using type-Ia supernovae luminosity at rest-frame NIR(i-band) wavelength**

[3] **Extensive study of galaxy formation and evolution utilizing the unique wide-area NIR observations**



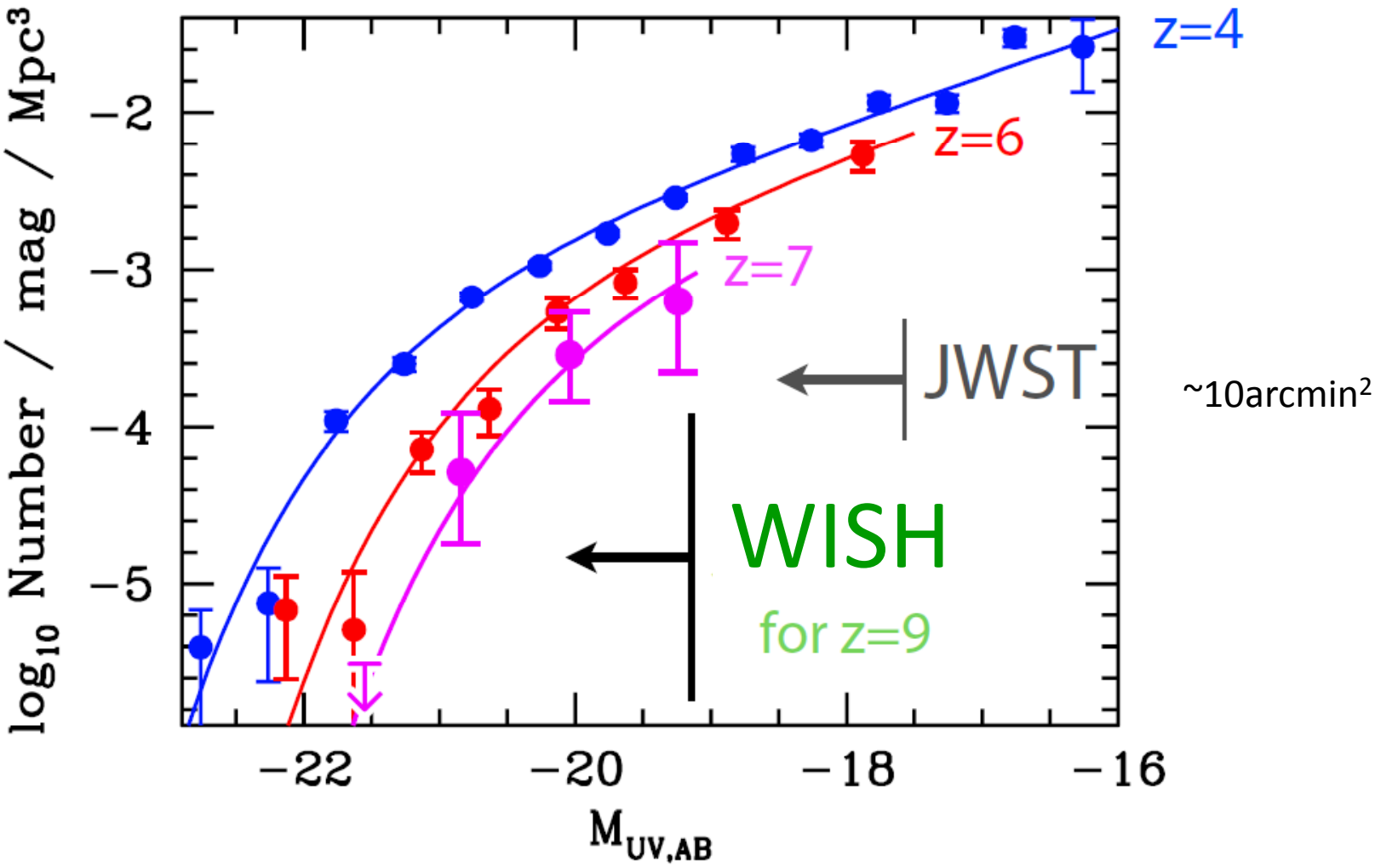
Cosmic Microwave Background (CMB)

Universe: Neutral

First-Generation Galaxies

Ultimate Frontier of Galaxies

Universe: Ionized



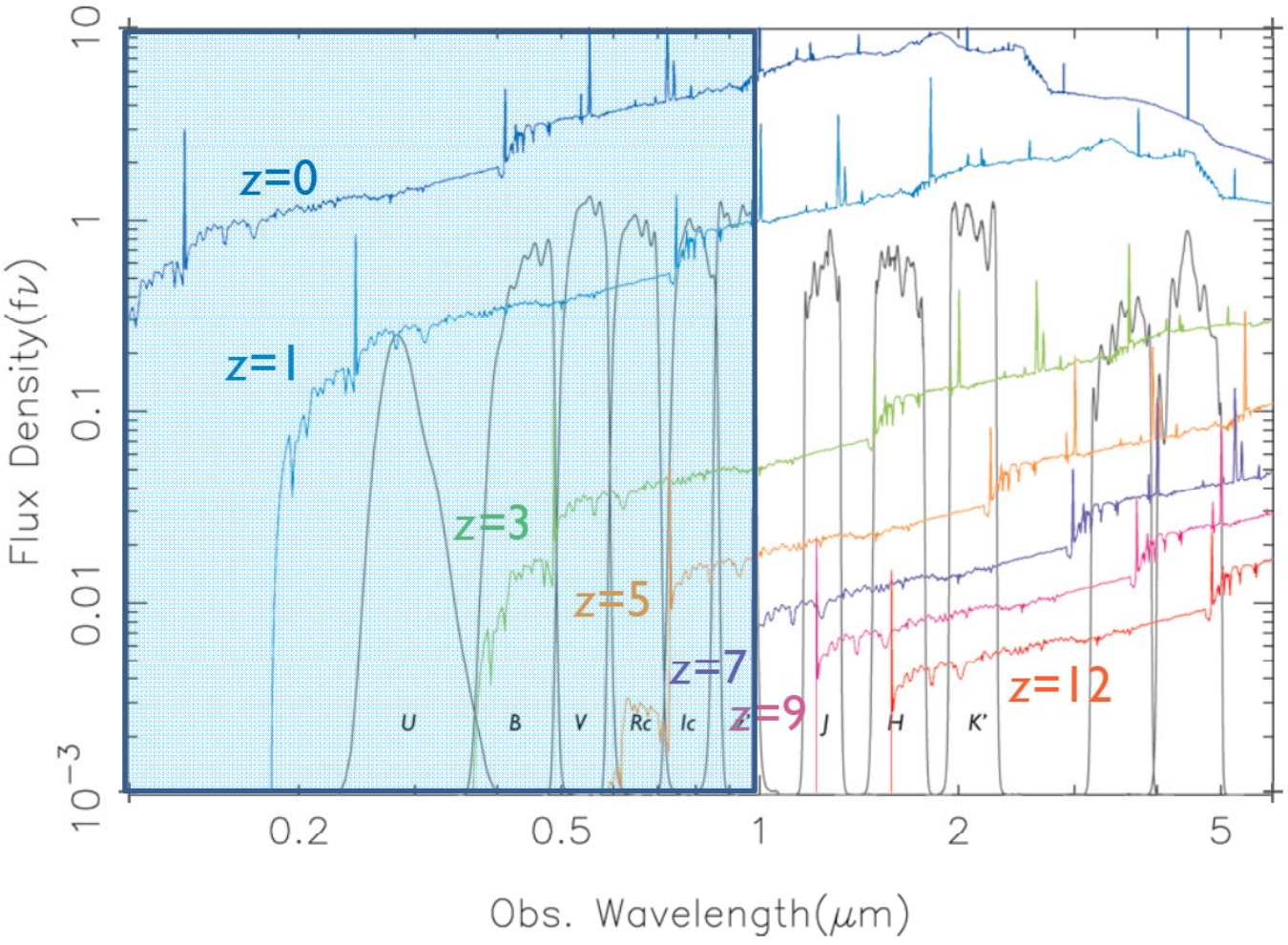
~10arcmin^2

based on Bouwens+2008

Why Space?

- Emission from galaxies at z>7 are redshifted above 1 μm
- Objects are fainter than the nominal detection limit of 8-10m class telescope with natural seeing (~26AB @ 2μm) due to the atmospheric background (OH lines)
- Ground-based AO (incl. GRAO, MCAO) cannot cover large area simultaneously

Expected Spectra of z=0-12 star-forming (Lyman Break) galaxies



Iwata et al.

Search for z=7-8 galaxies by HST NICMOS

Bouwens et al. (2007)

Field	Area (arcmin^2)	z_{850} Depth	J_{110} Depth	H_{160} Depth
UDF[10]	6.5	29.0	27.7	27.5
UDF NICPAR 1	1.3	28.6	28.7	28.5
UDF NICPAR 2	1.3	27.5	28.7	28.5
GOODS	4.9	27.5	27.2	27.0
HDF-North Thompson[14]	0.8	27.8	28.0	28.1
HDF-North Dickinson[15]	4.0	27.8	27.0	27.0

The deepest ground-based NIR imaging: MOIRCS Deep Survey

Ichikawa et al. 2006; Kajisawa et al. 2009; Yamada et al. 2009

		ch1		ch2		
Field	Band	FWHM	3σlimit	FWHM	3σlimit	Exposure
GT1	J	0.59	25.8	0.59	25.7	8.0
	H	0.58	25.2	0.59	25.0	2.5
	K	0.58	25.5	0.53	25.6	8.3
GT2	J	0.48	26.6	0.49	26.6	28.2
	H	0.46	25.7	0.46	25.6	5.7

F.o.V. ~ 28 sq. arcmin (~0.007 sq. deg)

VLT HAWK-I 2x

ultra-VISTA ~1.5deg^2

AO(GLAO/MCAO) go deeper for unresolved object, but FoV smaller

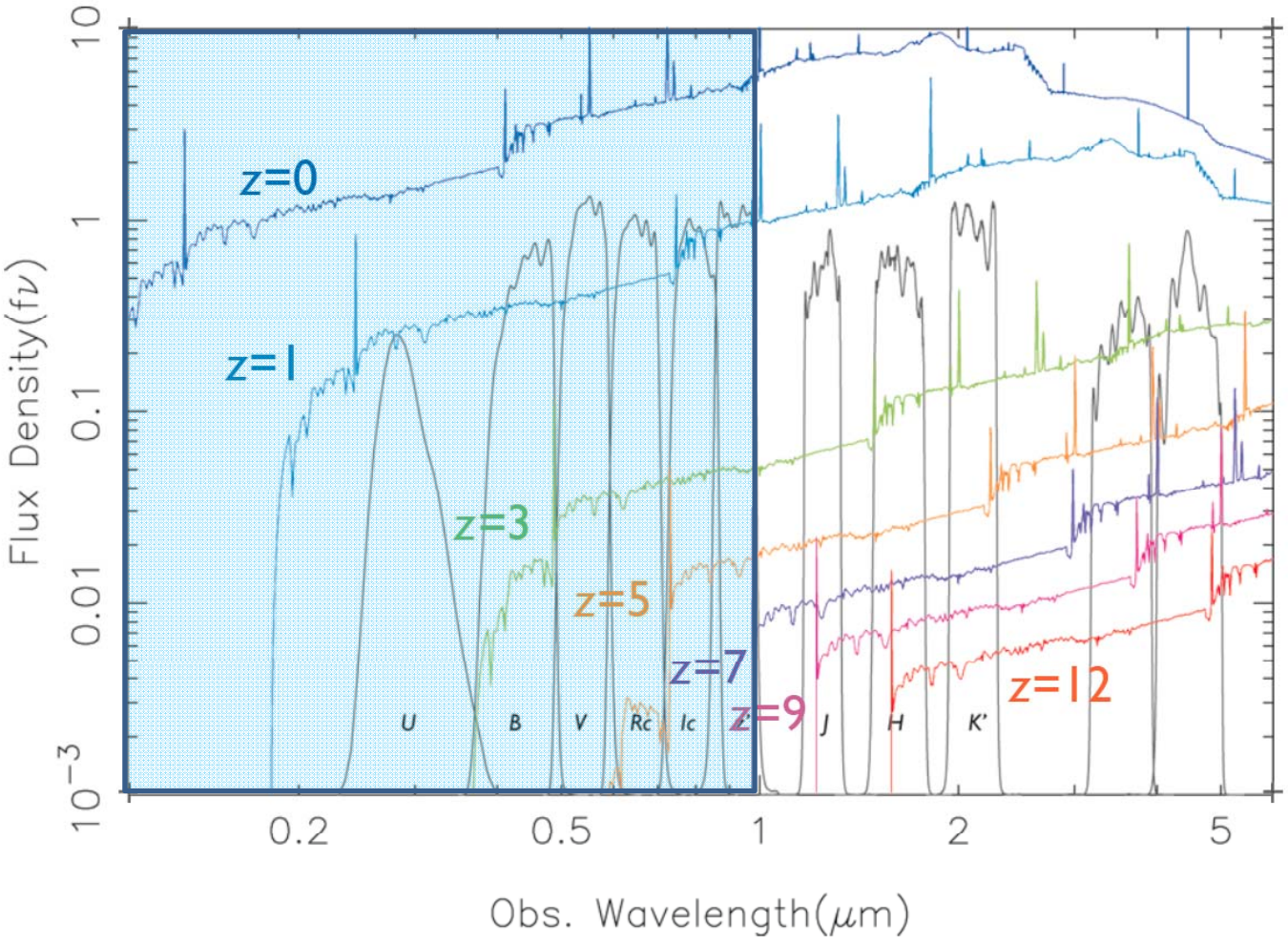
Why 1-5um?

- Searching for galaxies up to z ~ 15
  (at least 2 filter bands above the Lyα Break, ~2μm at z=15)

- Efficient removal of the interlopers
  (cool stars, dusty red galaxies)

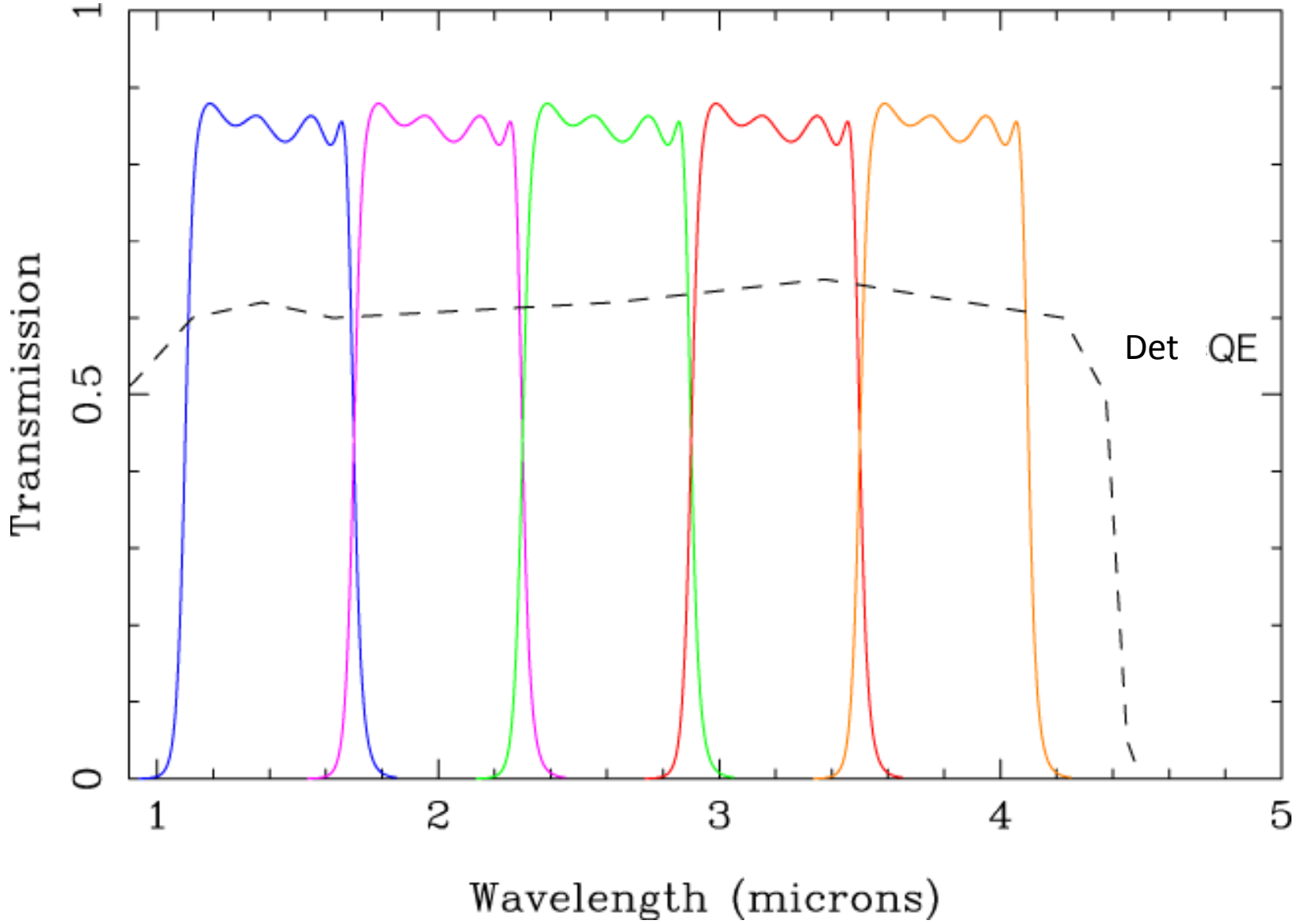
- Optical Observations (below 1μm) can be done
  with Subaru Hyper Suprime Cam (HSC)

Expected Spectra of z=0-12 star-forming (Lyman Break) galaxies



Iwata et al.

An working example of the broad-band filters for WISH



Contaminants: very cool stars

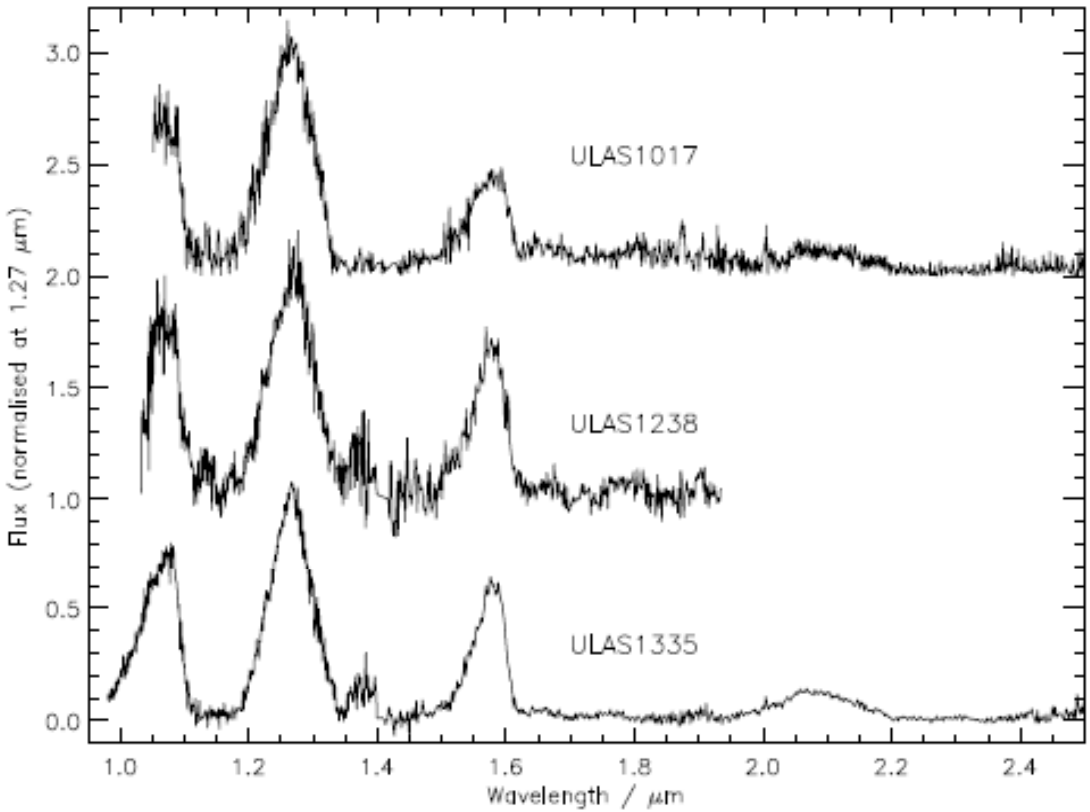
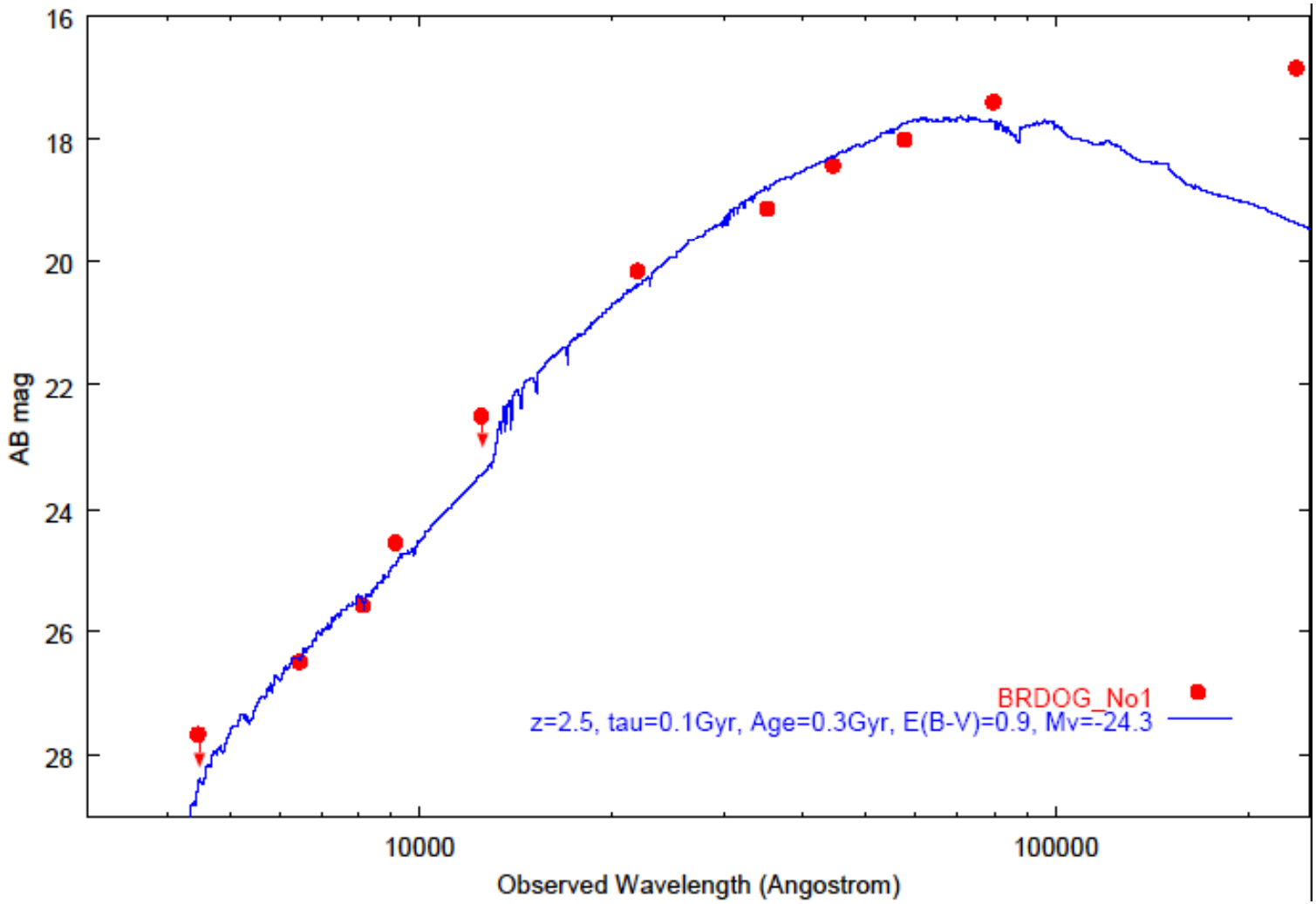


Figure 1. The NIRI *JHK* spectrum for ULAS1335 (bottom), the *JH* spectrum for ULAS1238 (middle). The IRCS *J* and NIRI *HK* spectrum of ULAS1017 is shown on the top row.

Contaminants: dusty red galaxies at lower-z

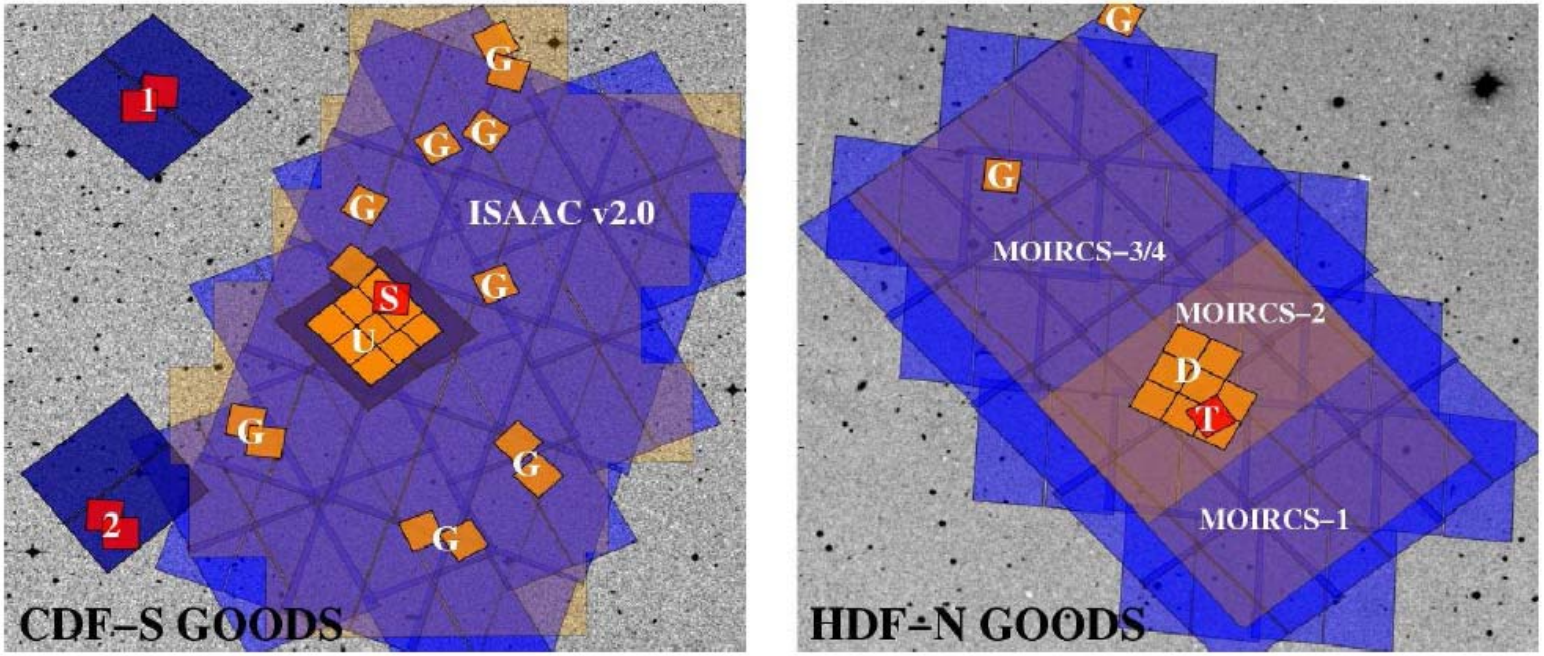


Why Wide-Field?

- High-z galaxies are rare, strongly biased
- Only ~10 (or less) galaxies at z=11-14 above AB27mag / 1 deg^2 are expected (SAM)

Why Wide-Field?

Current HST NICMOS – fov (50”x50” NIC3) is too small --



Bowuens et al. 2008

What’s Coming

HST WFC3 <1.7µm, 2’ x 2’ ➔ ~ 1 deg2

Spitzer WARM Mission 3.6, 4.5um shallow , source confusion

JWST NIRC

What is your *WISH* ?

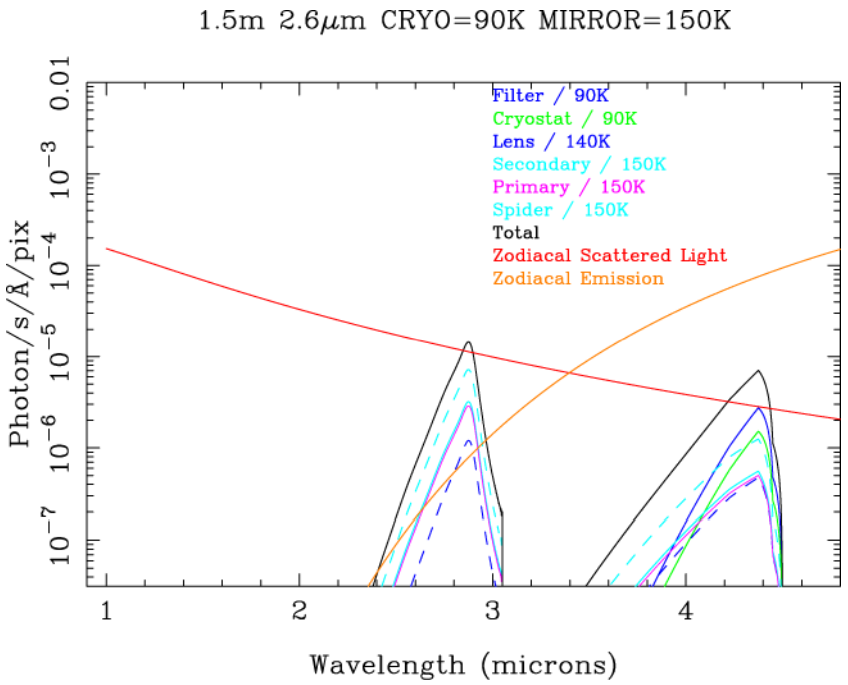
WISH Survey Goals

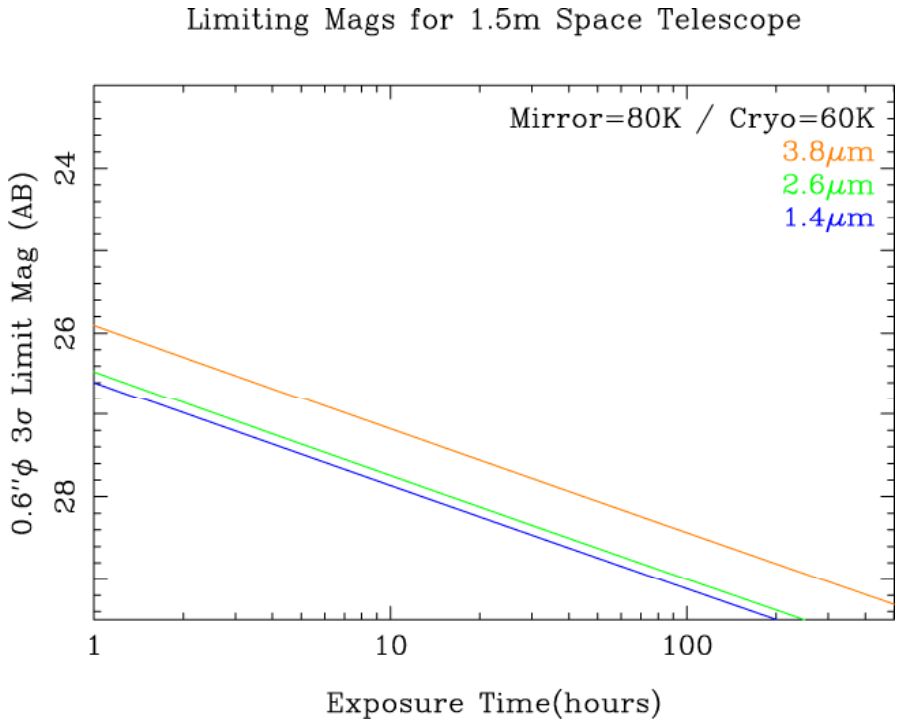
Within the Mission Lifetime of 5 Yrs

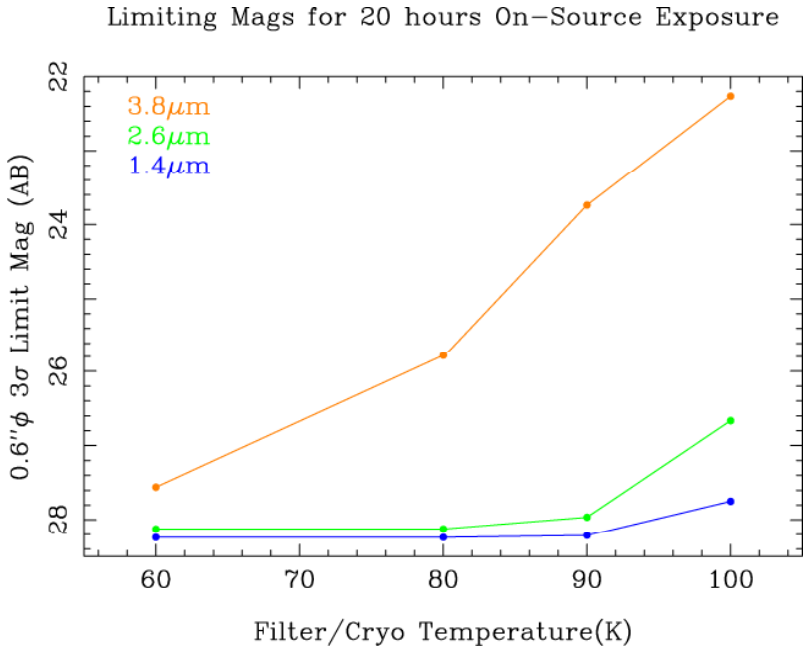
Survey	Limiting mag. (3sigma)	Number of Filters	Area
Ultra Deep Survey	28 AB	3-4 (TBD)	100 deg^2
Multi-Band Survey	27-28 AB	5 (TBD)	Sub WISH-UDS
Ultra Wide Survey	24-25 AB	2-3	1000 deg^2

WISH Sensitivity

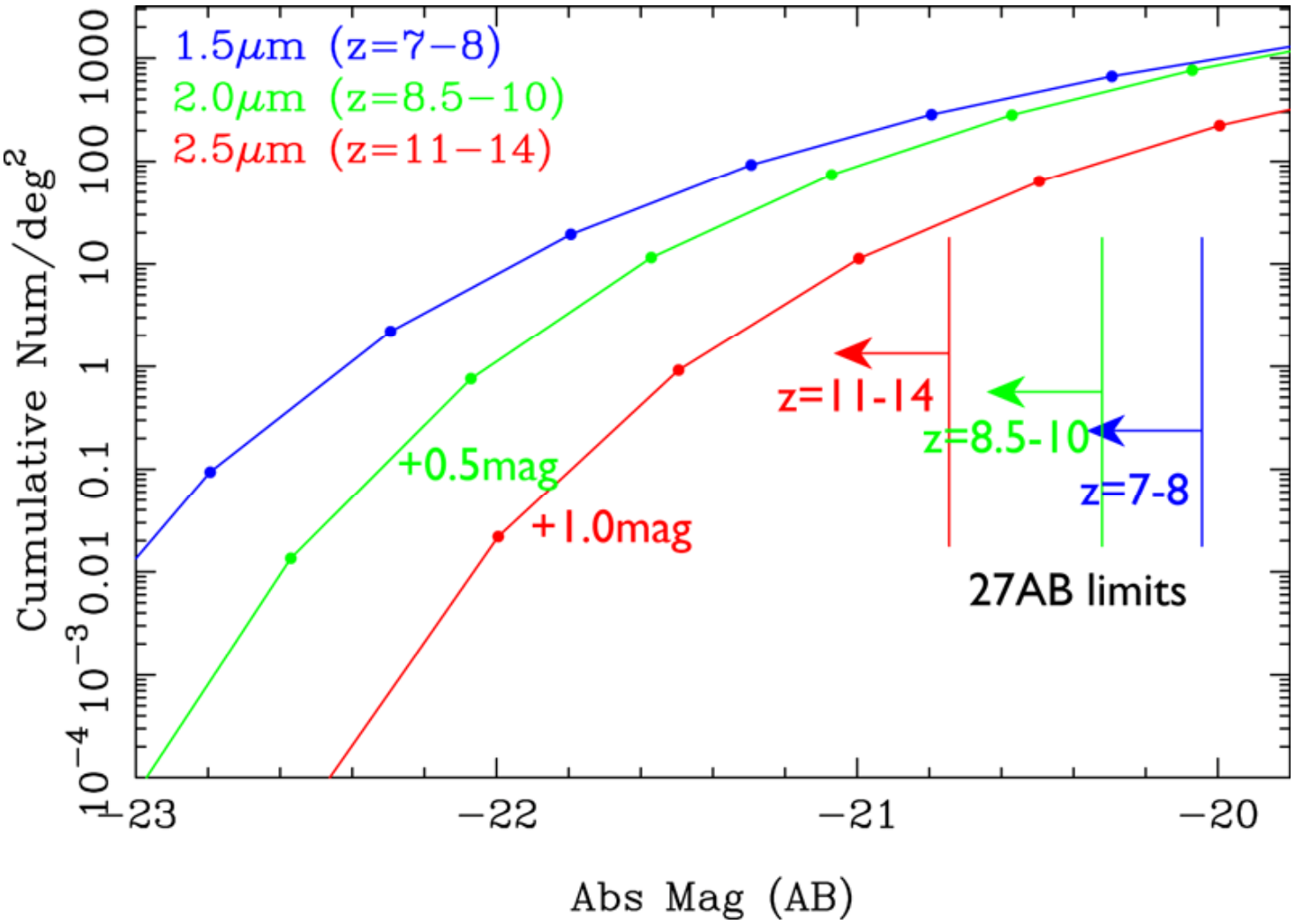
- 1.5m
- 0.15” /pix
- Zodiacal Light, Thermal Background







WISH Survey Goals



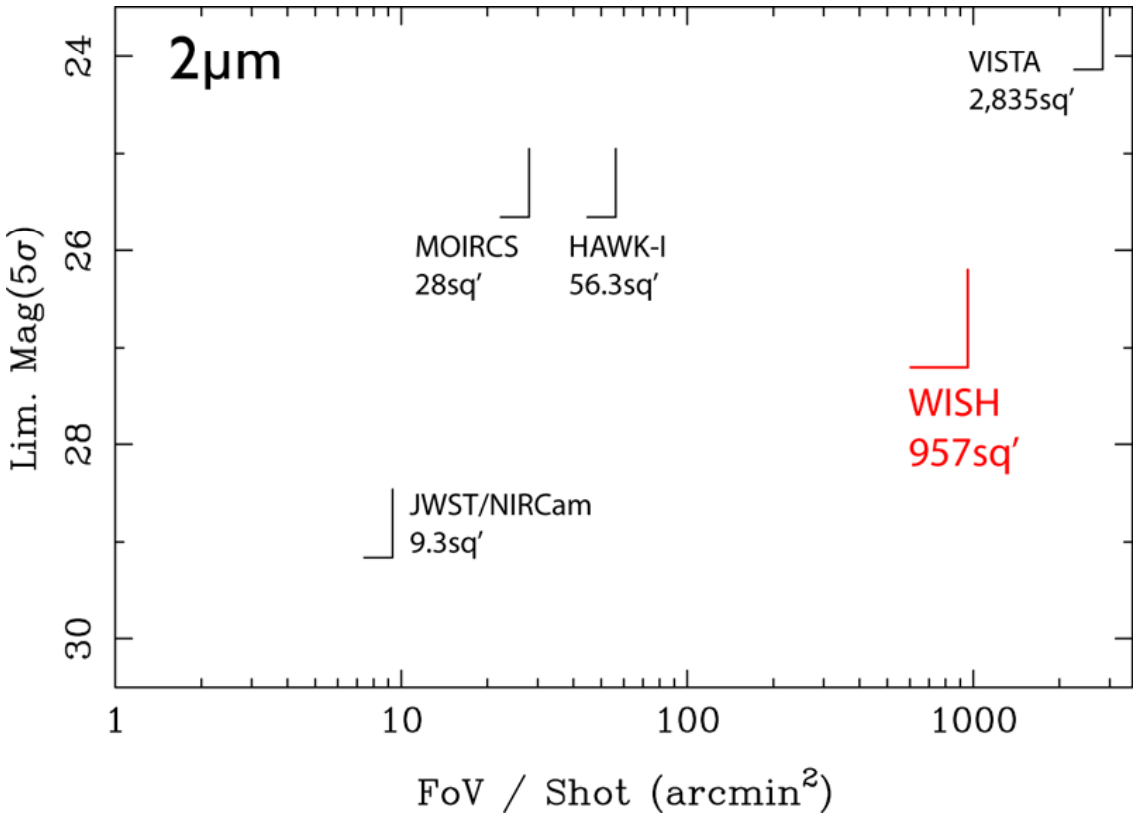
WISH Survey Goals

Redshift	(A) No	(B) 1mag	(C) DMH	(D) SAM
z=7-8	220,000	←	54,000	160,000
z=8-11 (J-drop)	180,000	26,000	1,100	60,000
z=11-14 (H-drop)	68,000	6,300	0	1,000

Expected number of the detected 1st Gen galaxies (in WISH-UDS)
galaxies brighter than 27AB in their rest-frame UV light
(A)No Evolution from z=7 (LF at z=6-7)
(B) Evolution: 1.0-mag luminosity evolution from z>7
(C) Evolution: Proportional to the DM halo evolution
(D) Prediction by a Semi-Analytic Model (Kobayashi, M. WISH SW)

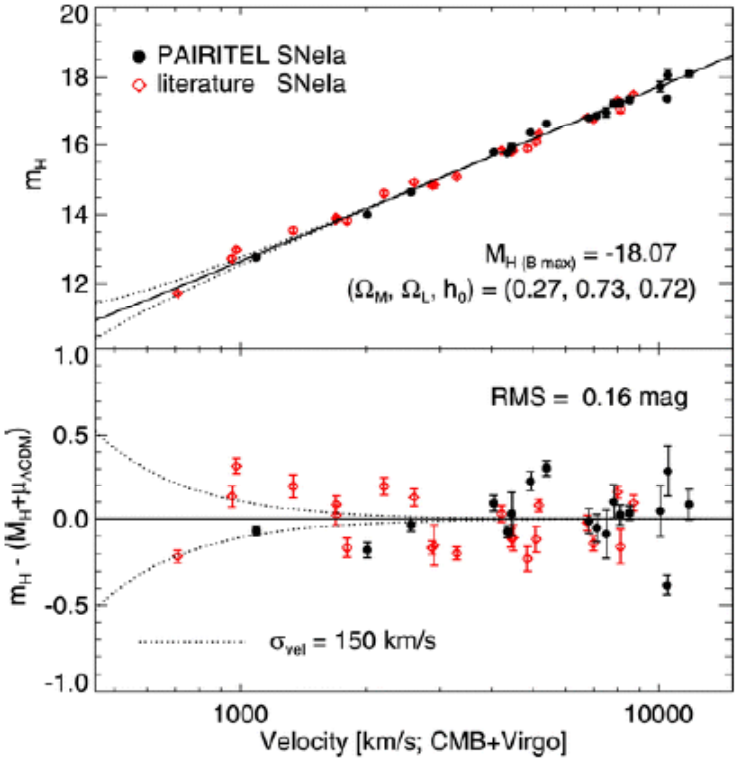
WISH Survey Goals

Unique Survey Capability



- Wide-Field
- High Spatial Resolution over wide area
- High Sensitivity from space

Probing Type Ia SNe with WISH



Wood-Vasey et al. 2008

Rest-frame Band	Redshift range	# of SNeIa / f.o.v.
B-band	z > 1.9	31
I-band	0.6 < z < 1.6	33
H-band	0.0 < z < 0.9	9

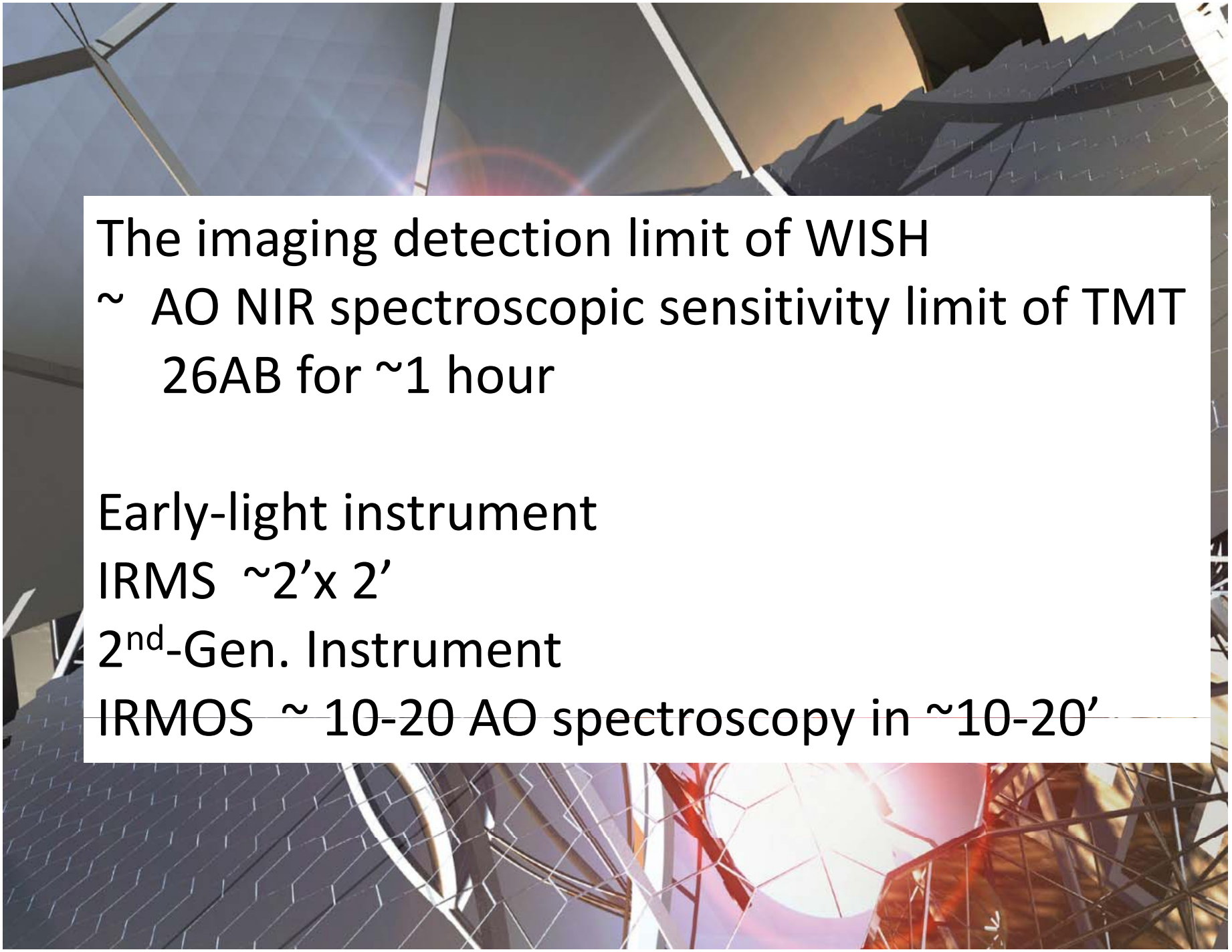
WISH UDS – x 400 (fov)

N.Yasuda WISH SW 2009

For Multi-wavelength Study of Re-ionization Era

- 2D cross correlation with HI;
  at z>10, WISH sources will be very sparse, and
  HI bubble overlap will be small
  ➔ though the Δz of the WISH sources is large,
  2D clustering may still be seen significantly.

- Redshift-space cross correlation with HI;
  Spectroscopic follow-up for WISH sources
  - grism spectroscopy by WISH (for bright sources)
  - JWST (if still there)
  - ELT



The imaging detection limit of WISH

~ AO NIR spectroscopic sensitivity limit of TMT 26AB for ~1 hour

Early-light instrument

IRMS ~2'x 2'

2nd-Gen. Instrument

IRMOS ~ 10-20 AO spectroscopy in ~10-20'

WISH Proposed Schedule

FYr	Items
FYr0 (2008)	**Project launched** **JAXA/ISAS Working Group** **Conceptual Study for Specification**
FYr1-2	Conceptual Study, R&D Mission Definition Review Mission Proposal
FYr3	Phase A / Proto Models
FYr4-5	Proto Models / Test Preliminary Design Review Primary Mirror / Detector fabrication start
FYr6-7	Proto Models Test Critical Design Review Flight Model
FYr8	Flight Model / Test
FYr8-9 (NET 2017)	Flight Model / Test Launch

Summary

- **WISH mission, which realize**
  very Wide-field & Deep survey at 1-5μm
  optimized for detecting galaxies at z=7-15

- **1.5m Primary Mirror,**
  Camera Field of View ~1000 sq. arcmin
  Simple Optics, Dedicated for Wide-field Imaging

- Development of the mission concept including the Preliminary Design of the Optical Layout, Optical Elements, Telescope Structure, Filter-exchanging System, Filters, and FPA Assembly is being proceeded under the JAXA/ISAS WISH Working Group (PI:Toru Yamada).

wishmission

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Stay Tuned !