

# wish

## Wide-field Imaging Surveyor for High-redshift

超広視野初期宇宙探査衛星計画



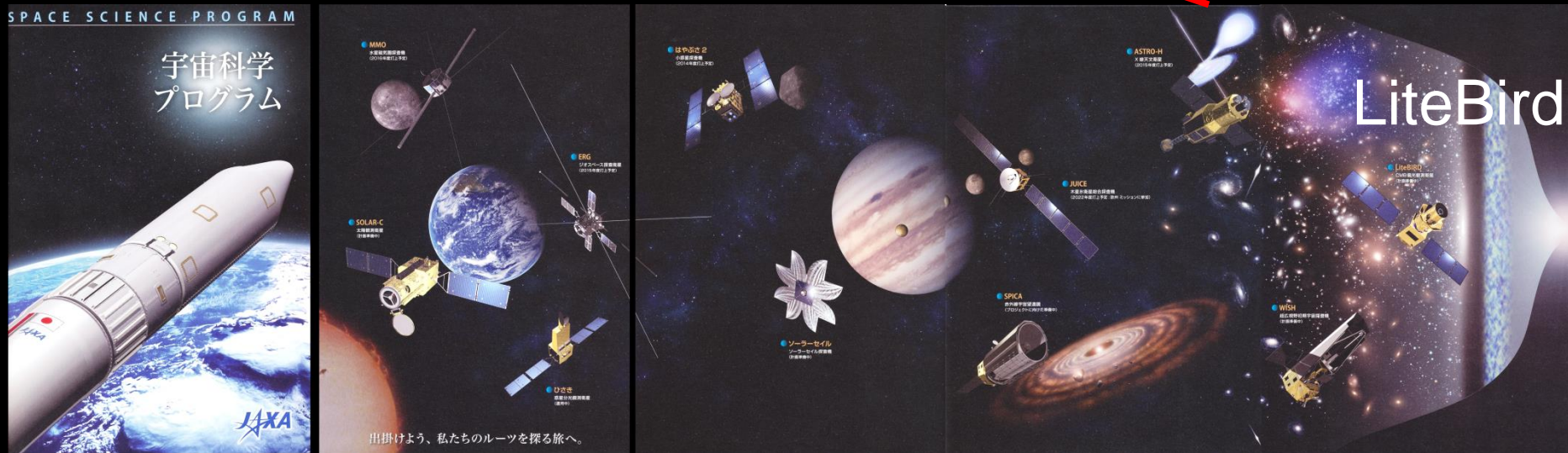
Akio Inoue

Toru Yamada

On behalf of

JAXA/ISAS WISH Working Group

WISH is a concept of future JAXA/ISAS space mission to be proposed and launched in early 2020's  
AO will be issued soon, ~~End of January~~  
proposal submission expected in February 2015 (TBC)



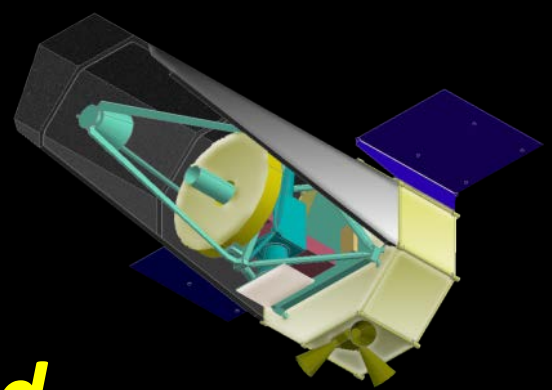
Solar-C

SPICA

WISH

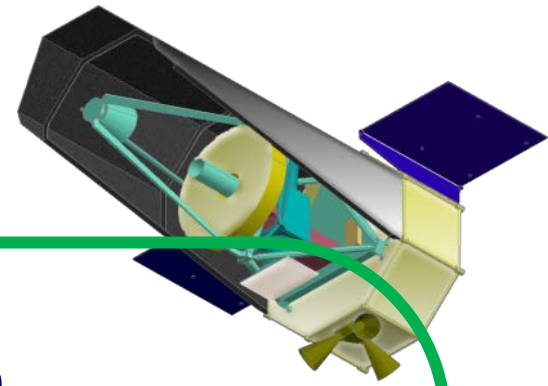
Status: WISH Working Group (pre-Phase A)  
under JAXA/ISAS 'Steering Committee for Space Science'

# WISH Science Goals



- 1. Exploring the Galaxies *beyond* the Epoch of Cosmic Reionization  $z=8-15$  (*Primary Science Case*)**
- 2. NIR search and light curves of type-Ia SNe  
History of cosmic expansion**
- 3. Deep and Wide NIR Survey @  $1-5\mu\text{m}$**

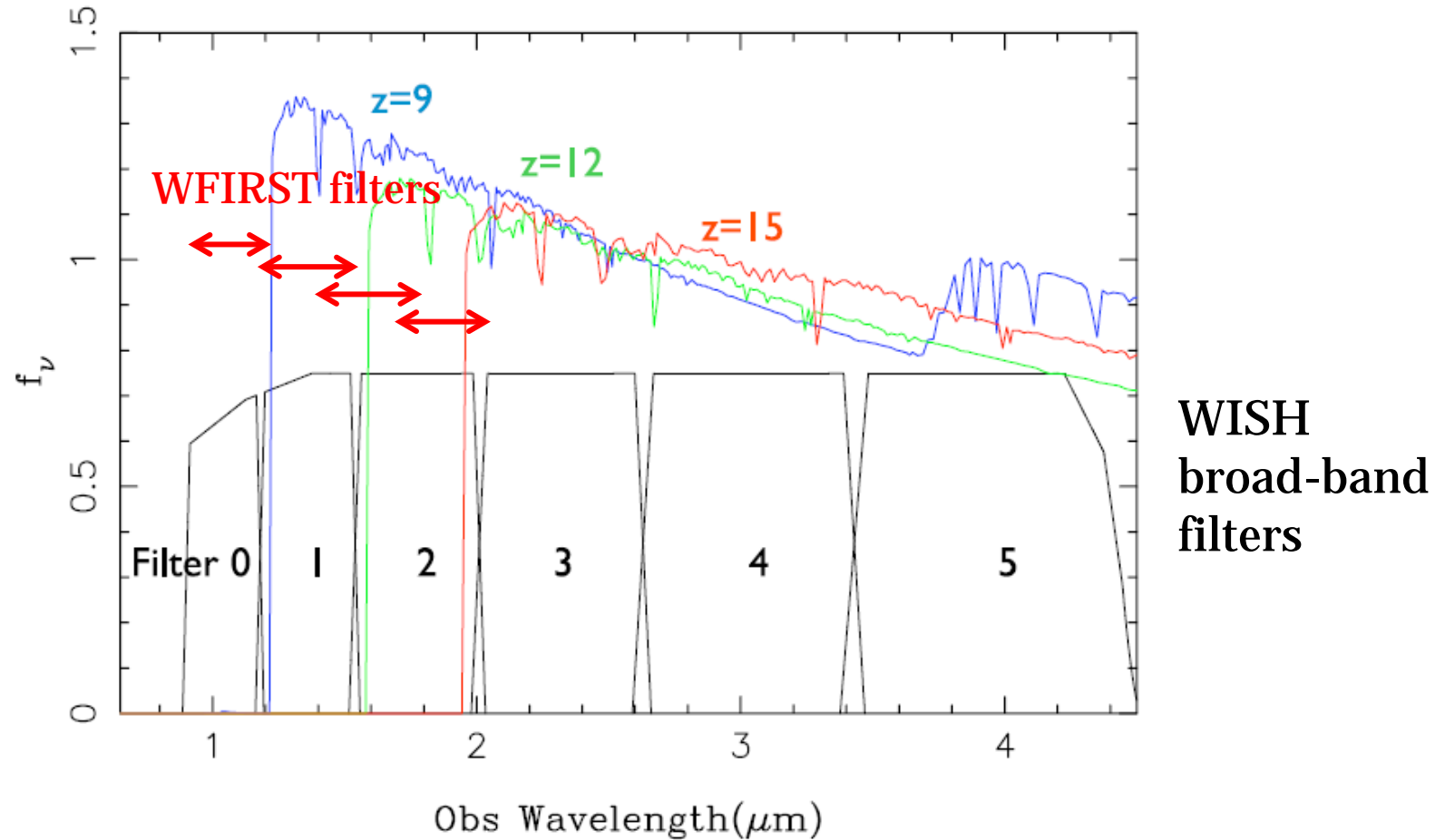
# WISH Reference Model



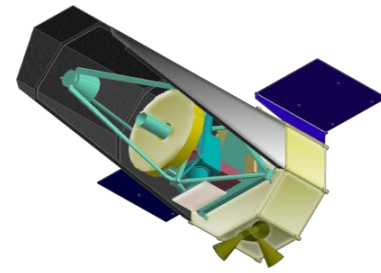
- **1-5  $\mu\text{m}$**  wavelength range
- 1.5m diameter telescope
- **Very Wide-Field Imager**
  - ~850 arcmin<sup>2</sup> FoV
- pixel scale: 0.155" / 18 $\mu\text{m}$  (f/16)
- Passively cooled to 90K (telescope)
- **SE-L2, JAXA HIJA**

# Basic Plan: 6 Broad-band filters

$z=9,12,15$   $E(B-V)=0.1$



# WISH: Survey Dedicated Mission

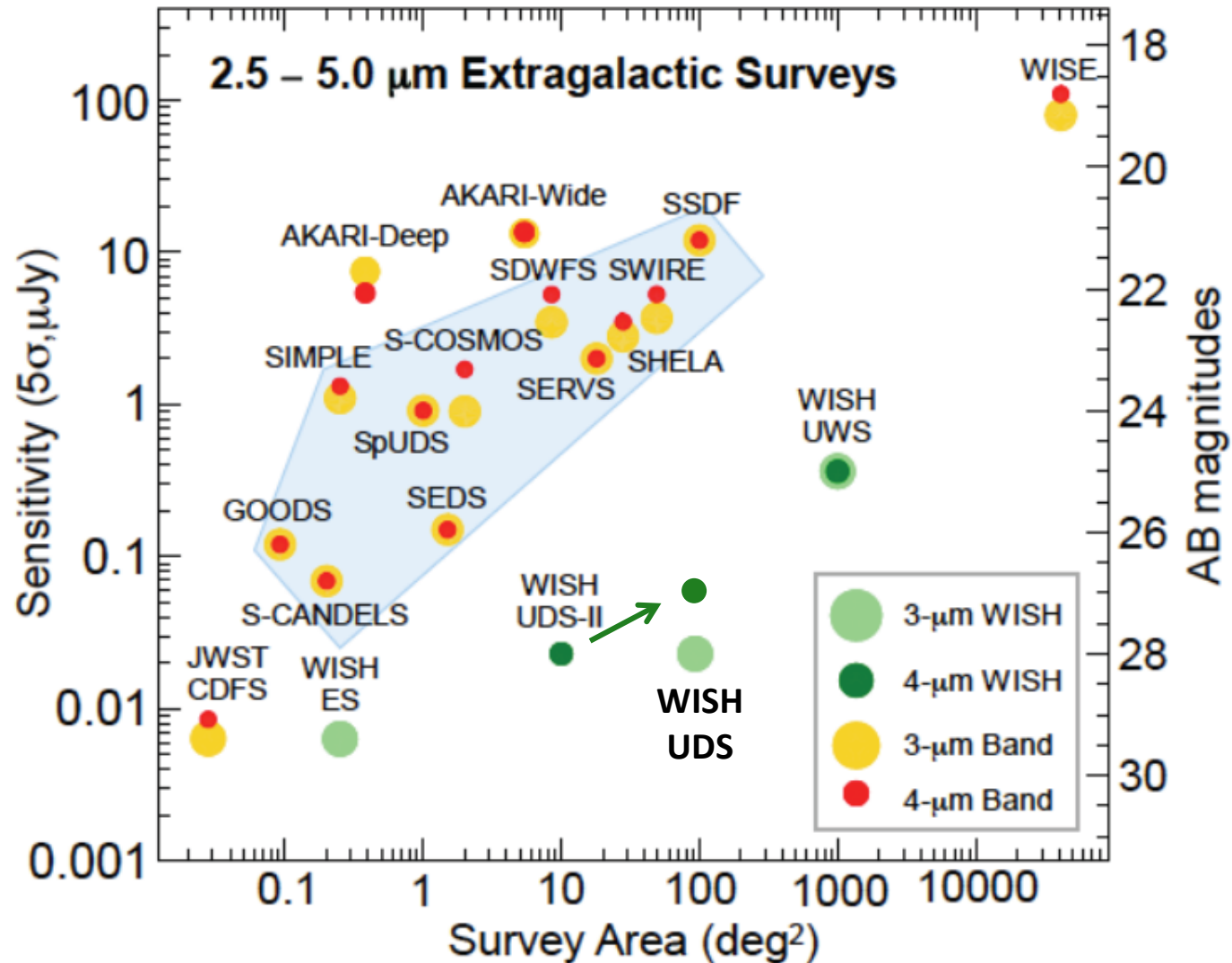


## WISH Base-Line Imaging Survey Plan

	Depth ( $5\sigma$ ) (AB mag)	Area	Example of the Filters $\lambda_0$ (a plan, to be determined)
<b>Ultra Deep Survey (WISH-UDS)</b>	<b>28</b>	<b>100 deg<sup>2</sup></b>	<b>1.0, 1.4, 1.8, 2.3, 3.0 <math>\mu\text{m}</math></b>
<b>+ Filter 5</b>	<b>~27</b>	<b>100 deg<sup>2</sup></b>	<b>4.0 <math>\mu\text{m}</math></b>
<b>Ultra Wide Survey (WISH-UWS)</b>	<b>24-25</b>	<b>1000 deg<sup>2</sup></b>	<b>1.4, 1.8, 2.3, 3.0, 4.0 <math>\mu\text{m}</math></b>
<b>Extreme Survey</b>	<b>29-30</b>	<b>0.25 deg<sup>2</sup></b>	<b>1.0, 1.4, 1.8, 2.3, 3.0 <math>\mu\text{m}</math></b>

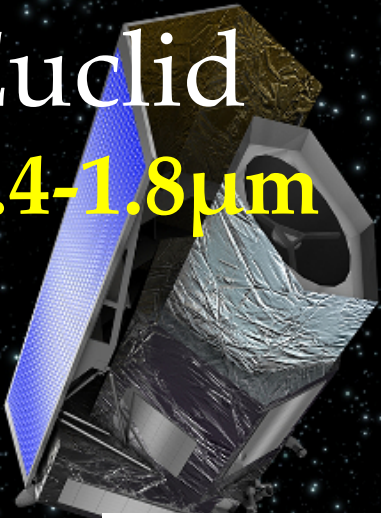
optional

# Uniqueness of WISH Surveys



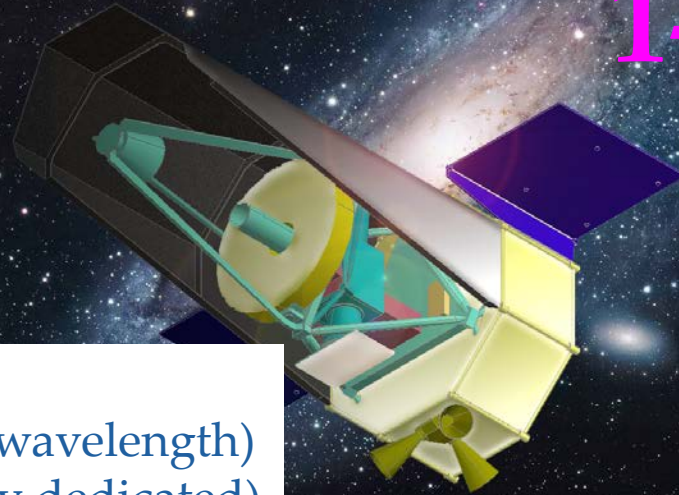
Euclid

0.4-1.8 $\mu\text{m}$



WISH

1-5 $\mu\text{m}$



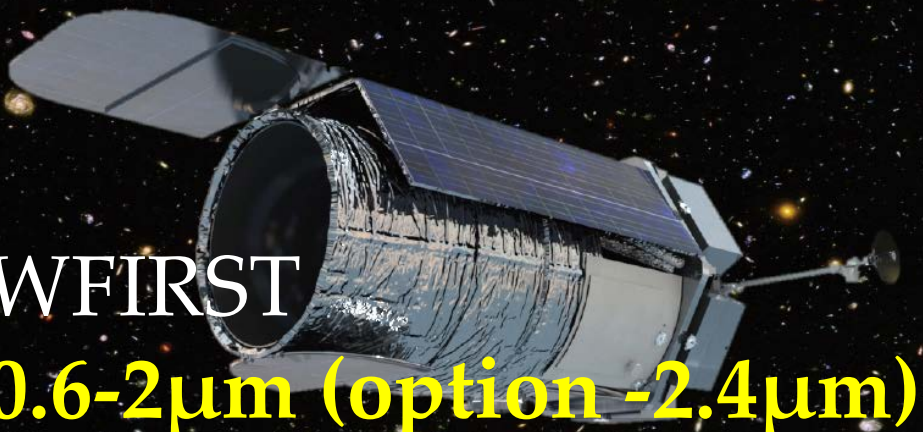
Complementary to  
Euclid and WFIRST (longer wavelength)  
And JWST (wide-field survey dedicated)



WFIRST-AFTA  
Wide-Field Infrared Survey Telescope

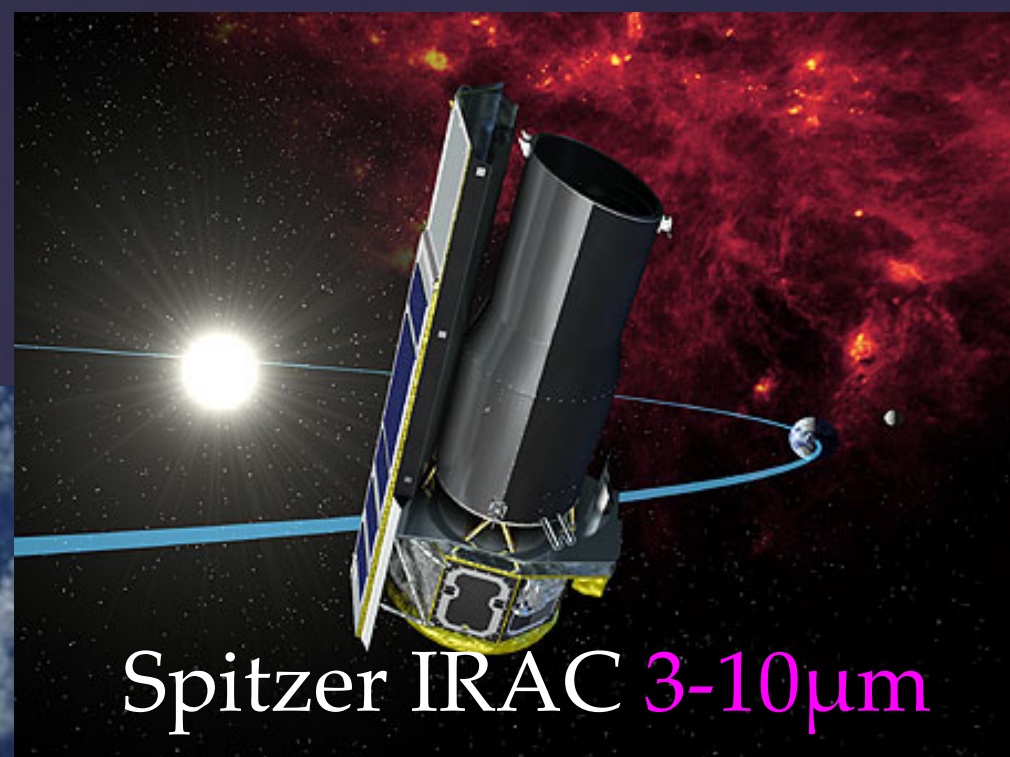
WFIRST

0.6-2 $\mu\text{m}$  (option -2.4 $\mu\text{m}$ )





Hubble  
0.1-1.8 $\mu\text{m}$



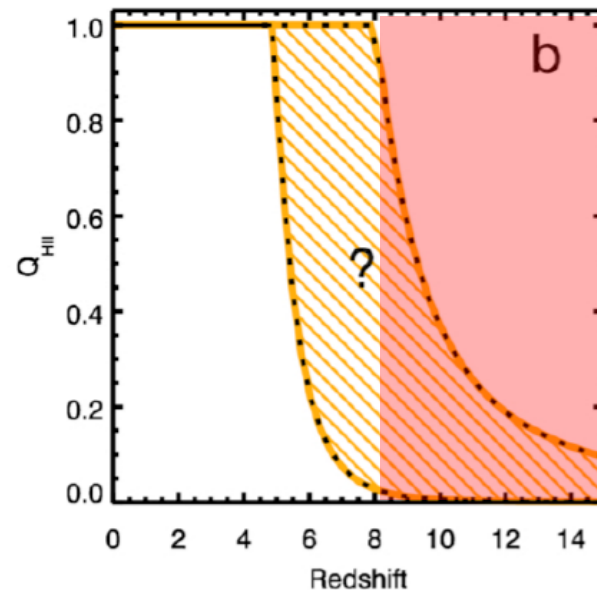
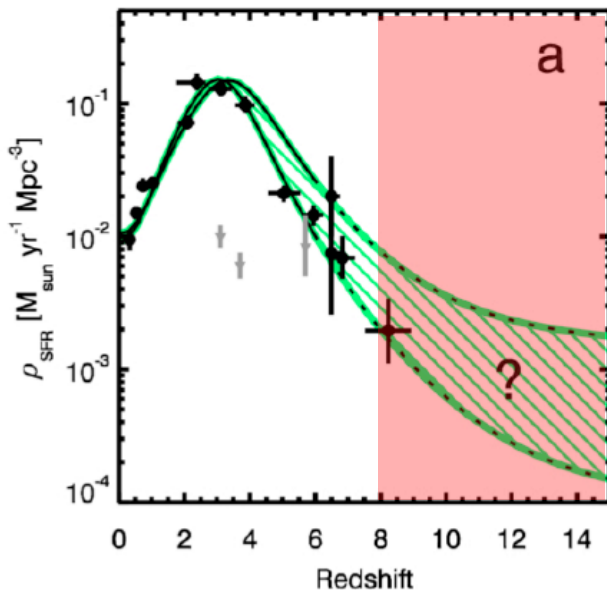
Spitzer IRAC 3-10 $\mu\text{m}$



Akari IRC NIR 2-5 $\mu\text{m}$

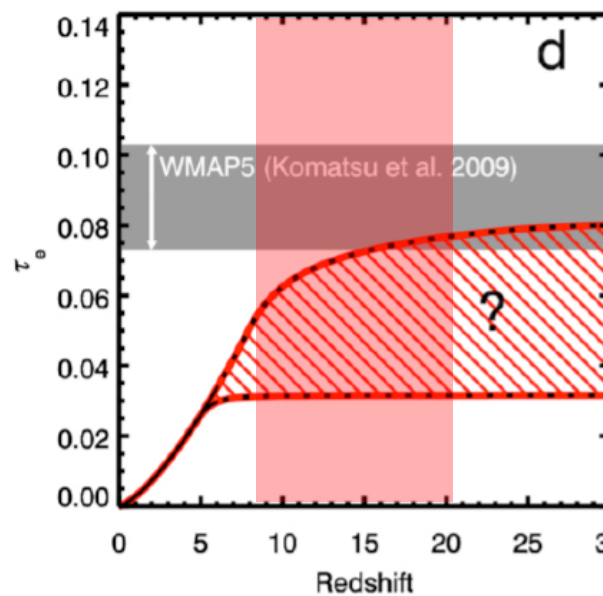
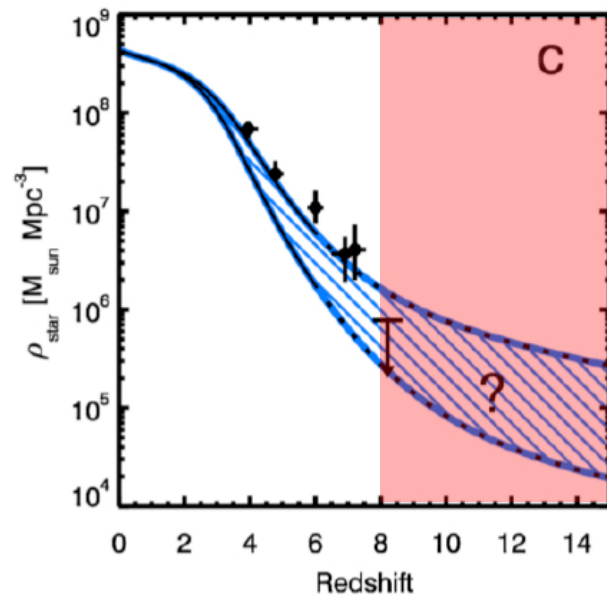
# A schematic picture Robertson et al. 2010

SFR density



Ionization degree

Stellar mass density



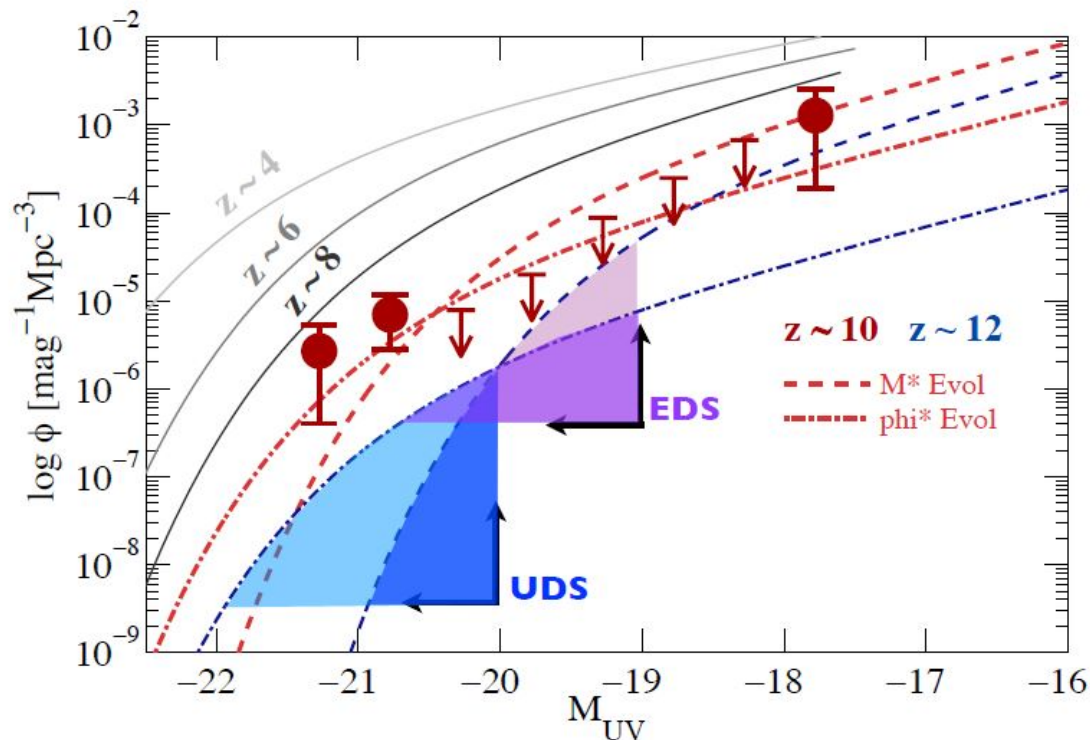
Electron scattering optical depth

# WISH for Galaxies *beyond* Epoch of Cosmic Reionization

- Exploration (detection, physical parameters)
- UV luminosity function  $z=8-15$   
(UDS.. Bright end / ExS.. Faint End + JWST .. Very faint end)
- Spatial distribution  
(marking structure at  $z>8$ , clustering, reionization topology)
- Rest-frame UV spectra  
(rest frame  $0.1-0.45\mu\text{m}$  for  $z\sim 9$  galaxies)
- Spectroscopic Targets for ELTs, JWST
- Correlation with HI21cm

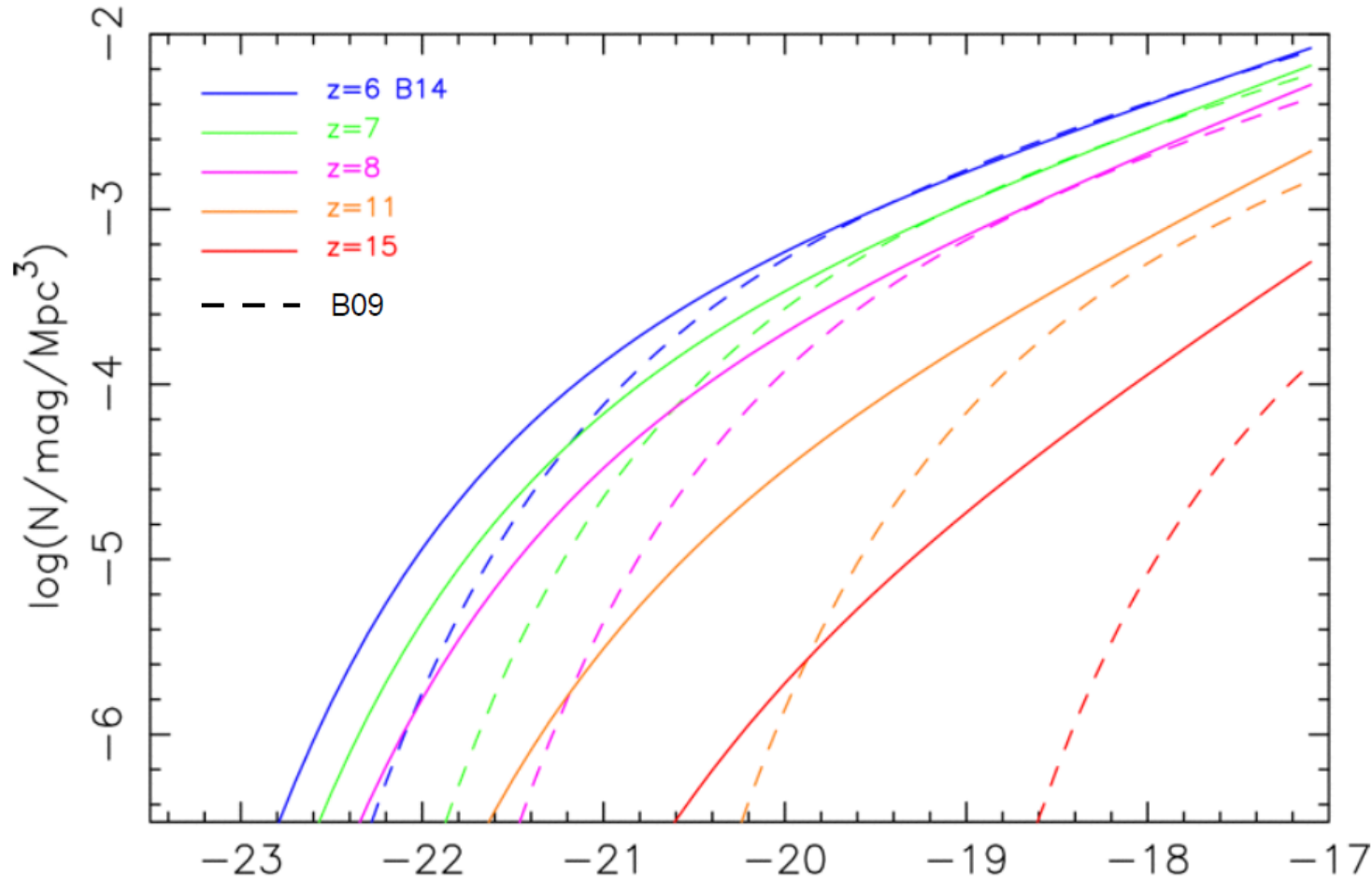
# WISH Constraints Bright End of UV LF @ $z \sim 12$

## Predictions for WISH



Phi\* Evolution would significantly boost  $z > 10$  galaxy counts for WISH!  
~7x for UDS, but: ~0.5x for EDS

# Empirical UVLF Evolution - Bouwens 2009/2011 vs. 2014



$M_{AB}(UV)$  Bouwens+2009 and 2011: only  $M^*$  evolution  
Bouwens+2014: ( $M^*$ ),  $\Phi^*$ ,  $\alpha$  evolution

# Expected Numbers with WISH Ultra-deep Survey

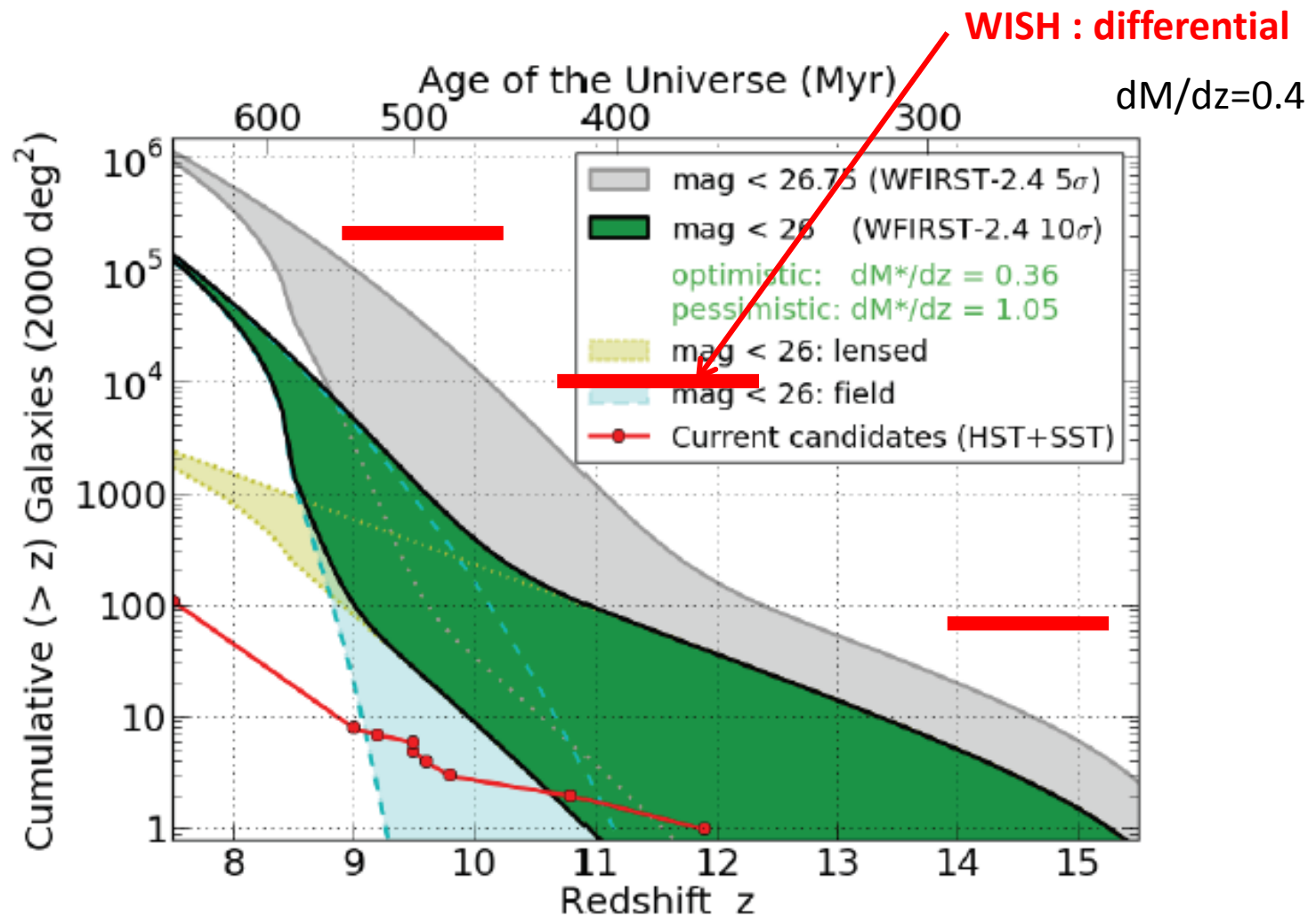
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- 100 sq. deg survey with 5 filters from 1.0 $\mu$ m to 3.0 $\mu$ m
  - Limiting magnitudes 28AB
  - Total 1,500 days

N/100deg	z=8-9	z=10-12	z=13-17
Empirical Ev. (prev)	169,000	10,400	72
Empirical Ev. (new)	208,400	31,500	2,080
SAM	63,100	4,970	107
DMH	85,200	412	0.3

WISH Can Determine  
How Bright-End of UVLF Evolves at  $z > 8$

# WISH UDS (100 deg<sup>2</sup>) can detect 10x-100x galaxies of WFIRST-2.4m 2000 deg<sup>2</sup> High Latitude Survey



Euclid  
26mag(5σ)  
40deg<sup>2</sup>  
(X1/50)

WFIRST SDT report

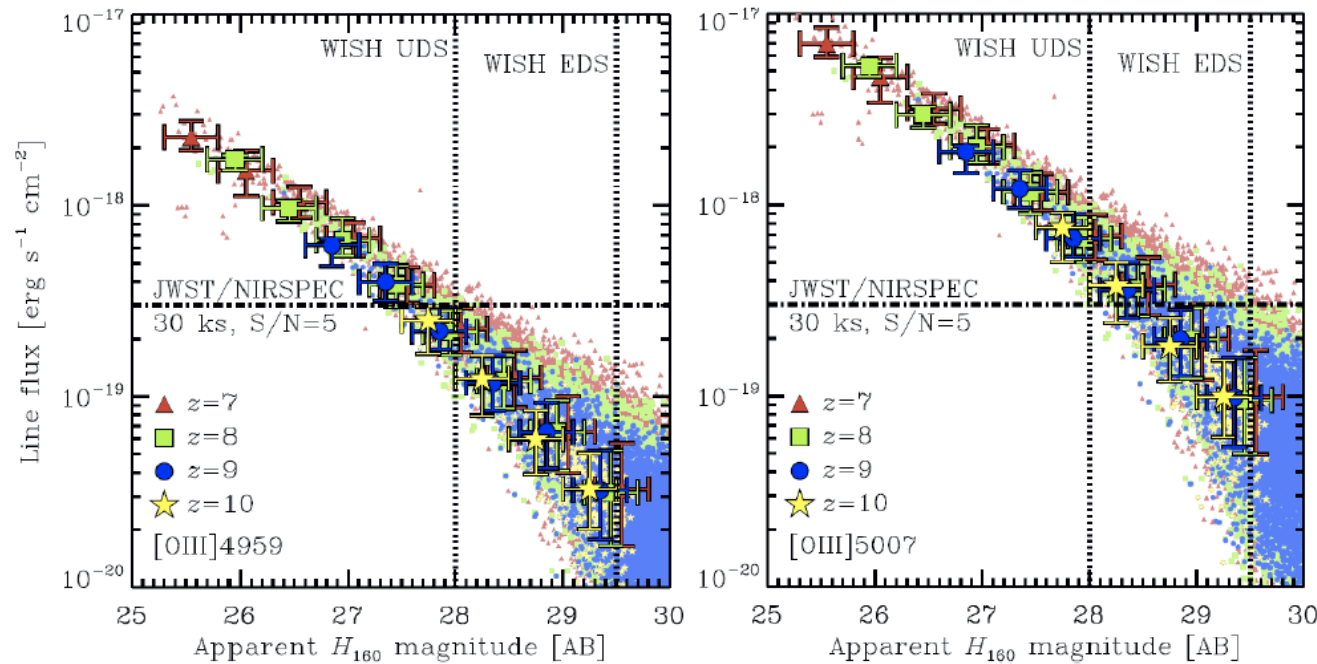
# WISH and JWST

See A. Inoue's poster

WISH UDS LBGs are nice targets for JWST spectroscopic follow-up.



[OIII]4959, 5007 → ~5 mic for z=9

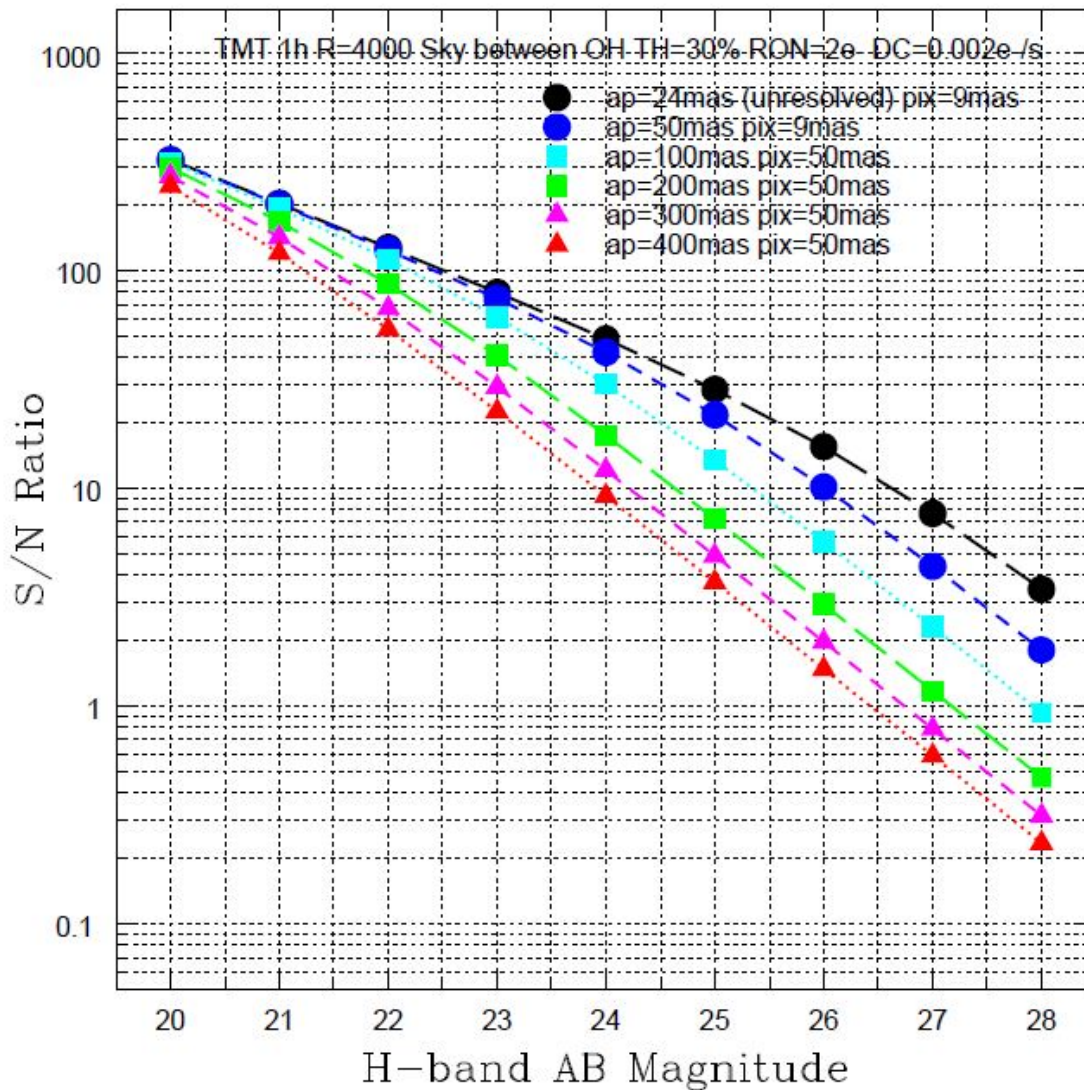


= WISH Filter2 magnitude





# WISH and ELTs



TMT 1h spectroscopy  
(between OH lines)

R~4000

200mas aperture  
10h, R~400  
AB~28 → S/N~3

# Proposed spectroscopic capabilities

- **WISHSpec (parallel IFU)** See D. Burgarella's poster
  - \* utilizing the beam 'not used' in wide-field imaging
  - \* parallel mode operation
  - \* IFU / no moving part
  - \* 30"x30"~1x1 arcmin<sup>2</sup>, R~1000
    - unique spectroscopic survey for bright galaxies at  $\lambda > 2\mu\text{m}$
    - limited number of targeted spectroscopy
- **Narrow-bands and medium-bands** See T. Kodama's poster
- **Wide-field grism slitless spectroscopy** (risky option)
  - \* using the beam for wide-field image, R=100

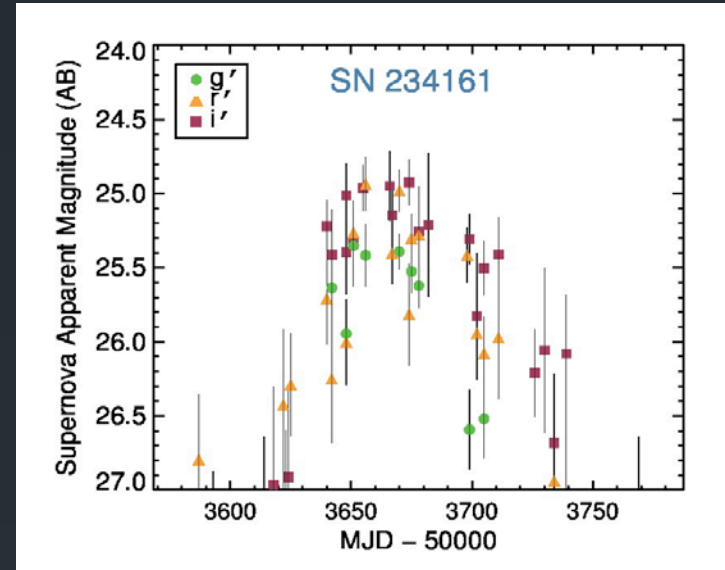
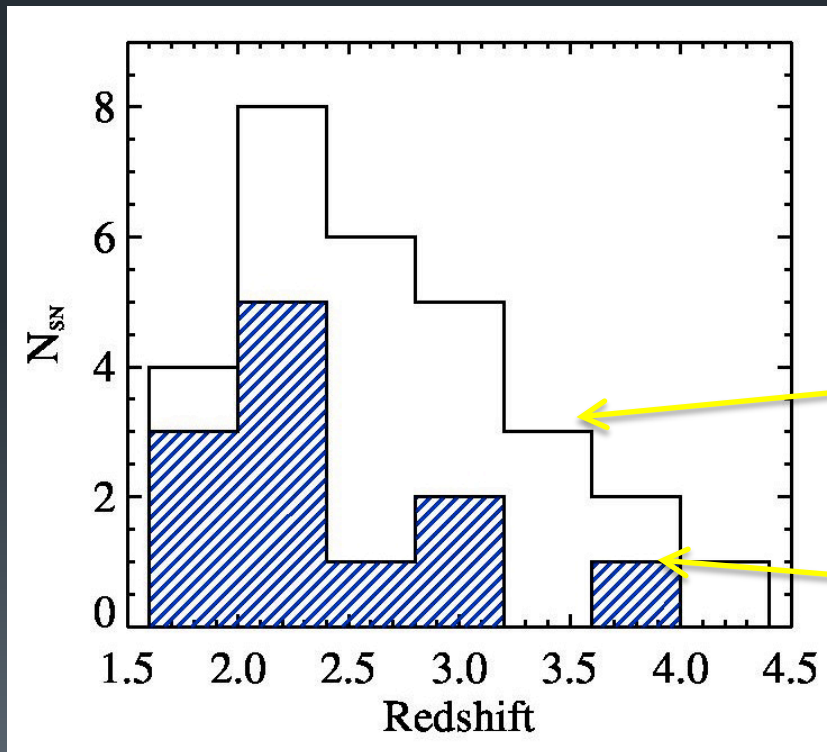
# WISH for distant SNe

## Ultra Deep Survey (100 deg<sup>2</sup>, ~28AB)

- *recurrent* observations
- *simultaneous* deep and wide search for *transients*
- **type-Ia** (reducing systematic errors in cosmology)
  - high photometric accuracy, homogeneity
  - high-redshift objects (rest-frame optical  $z \sim 2$ )
  - rest-frame NIR search and light curve ( $z = 0.5-1.5$ )
- **Superluminous SNe** e.g., type-II n

# High-z High-Luminosity SNe

From Jeff Cooke  
WISH Science WS 2013

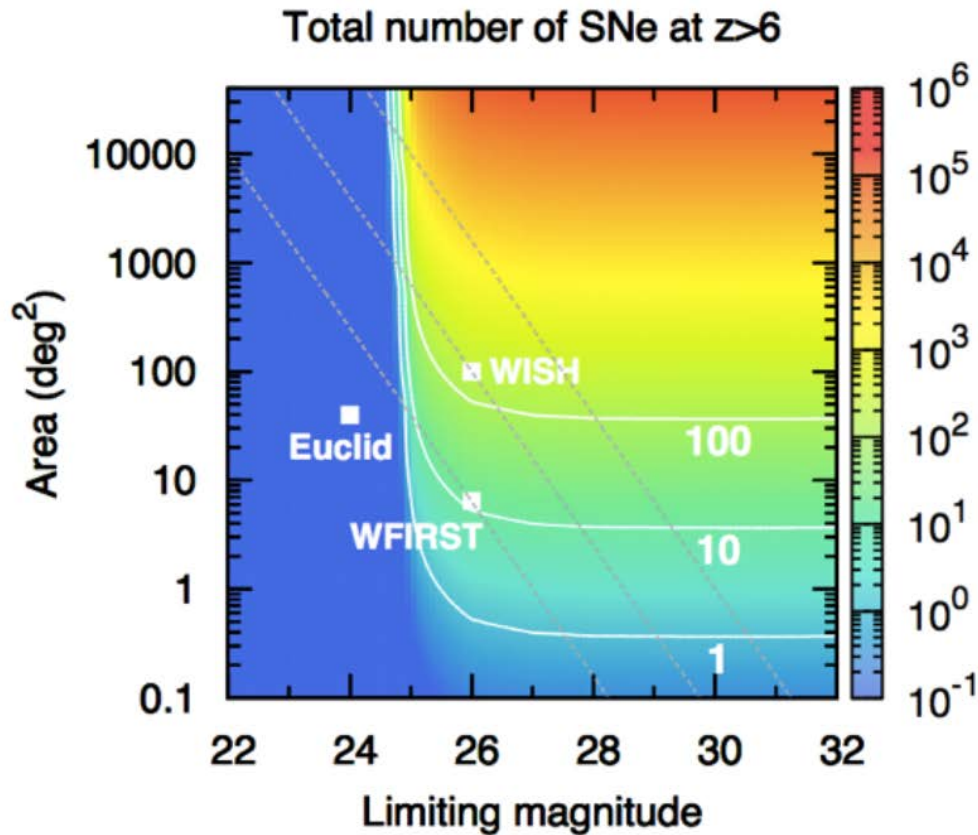


photometric candidates

spectroscopic sample;  
many events show late-time  
supernova emission

# WISH UDS $>100$ $z>6$ SLSNe

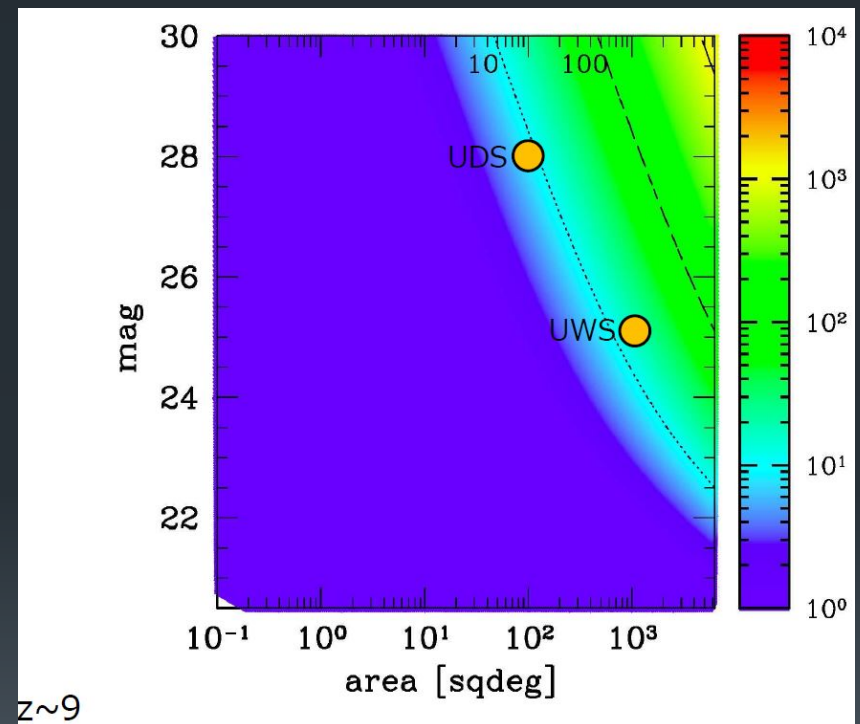
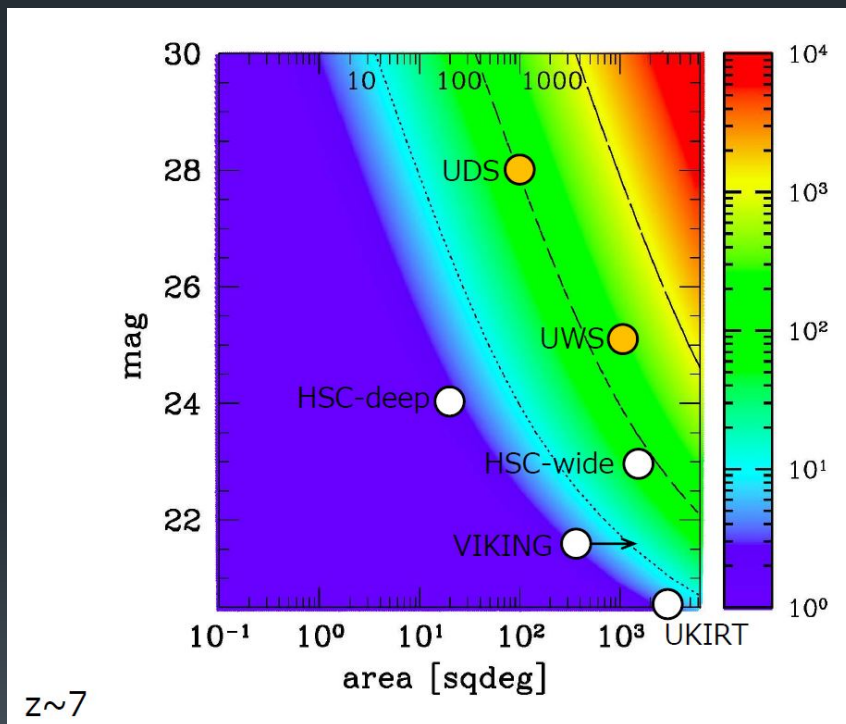
Beyond  $z=6$ : Monte Carlo LC simulation



Tanaka, Moriya, Yoshida et al. (2013)  
from Naoki Yoshida WISH Science Workshop 2013

# WISH and First Quasars

~100  $z \sim 7$  QSOs and ~10  $z \sim 9$  QSOs in UDS and UWS



Nobunari Kashikawa WISH Science Workshop 2013  
And update in 2014 August

# WISH Campaign Science Cases ( $<20\%$ of Mission Lifetime)

- Narrow Band / Grism Survey
- Targeted spectroscopy

## Variety of Science Cases

- **Bulge Campaign astrometry**
- Galactic Plane Campaign clusters / variables
- Transit Exoplanet Campaign
- Lensing Exoplanet Campaign
- Solar System Icy Minor Planets Campaign

Etc.....

# WISH International Collaboration

## US-collaboration (SAO, Giovanni Fazio)

- Proposal submitted for NASA SALMON2 MoO 2012  
(PI: G. Fazio, Smithsonian Astrophysical Observatory)
- Testing and Providing Focal Plane Arrays / ASIC electronics
- DSN antennas

## France-collaboration (LAM, Denis Burgarella)

- Proposal Submitted for CNES Missions of Opportunity Program
- IFU Spectrograph as an optional instrument
- possibly utilizing the LAM new chamber for testing
- CNEs could provide downlink antennas
- French internal WISH workshop at IAP (Oct 3)

## Canada (Marcin Sawicki)

- possibility: Filter Exchange Unit

**Focal Plane Arrays  
testing and procuring  
+ DSN antennas**

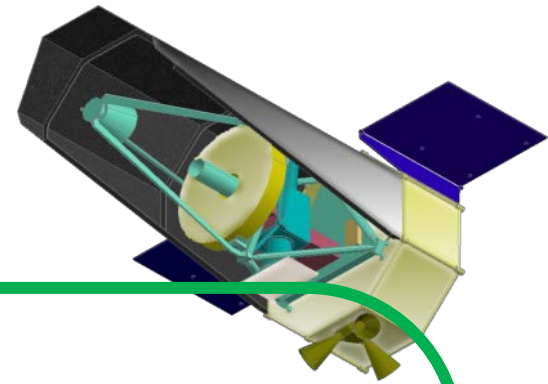
**“WISHSpec”  
adding spectroscopic capability  
- parallel operation  
during imaging survey  
+ CNES antenna**



## Current Status

- JAXA/ISAS WISH Working Group since 2008 (**pre Phase A**)
- More than 20 astronomers/engineers have been working for R&D
- JAXA/ISAS R&D budget (~1.2M\$, without including man power cost)
- **WISH Mission Proposal Draft distributed (500pages, in Japanese, 2012)**
- **Potential international Partners: SAO (USA), LAM (France), Canada**
- Proposed Schedule: 2015 Mission Definition Review,  
2016 System Definition Review, Launch by ~early 2020's
- Expected Cost : JAXA Cost Cap 300M\$ (incl. launch)  
+international collaboraiton

# Summary



- NIR **Deep** and **Wide-field** Imaging Surveyor
- Exploring the 1<sup>st</sup> generation galaxies
- Dedicated,  $\sim 100 \text{ deg}^2$ , 28AB ( $\sim 25 \text{ nJy}$ )
- $\sim 10^4$  galaxies at  $z=8-9$ ,  $\sim 3-6 \times 10^3$  at  $z=11-12$ ,  
and  $\sim 50-100$  galaxies at  $z=14-17$
- Concept developed under JAXA/ISAS WG  
to be launched by  $\sim 2020$

# Comparison of **NIR IMAGING** Capability

	Euclid	WFIRST	WISH
Mirror	1.2m	2.4m	1.5m
Wavelength Coverage	0.9-2 $\mu$ m	0.8-2 $\mu$ m	1-5 $\mu$ m
FoV	0.5deg <sup>2</sup>	0.28deg <sup>2</sup>	0.23deg <sup>2</sup>
Pixel Scale	0.3arcsec	0.11arcsec	0.155arcsec
Num. Pixels	64Mpix	4RG,288Mpix	134Mpix
Filters	YJH	4BB	6BB+NB
Survey Area Deep	40deg <sup>2</sup>	TBD	100deg <sup>2</sup>
Survey Depth Deep	26AB	TBD	28AB
Survey Area Wide	20000deg <sup>2</sup>	HL >2000deg <sup>2</sup>	>1000deg <sup>2</sup>
Survey Depth Wide	24AB	26-27AB	24-25AB
Primary Science	Dark Energy	Dark Energy Exoplanets IR Survey	First Galaxies

Note: WISH is a dedicated imaging surveyor (with parallel IFU possibility) while Euclid / WFIRST has wide-field NIR spectroscopy (Euclid / WFIRST), optical imaging (Euclid), IFU spectroscopy (WFIRST), and coronagraph (WFIRST)

# JAXA/ISAS WISH Working Group (2008~)

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Toru Yamada (Tohoku)

Ikuru Iwata、Kiyoto Yabe、Masayuki Tanaka、Nobunari Kashikawa、

Taddy Kodama, Yutaka Komiyama, Hidehiko Nakaya (NAOJ)

Hideo Matsuhara, Takehiko Wada, Yoichi Sato, Atsushi Okamoto,

Makiko Ando (JAXA)

Akio Inoue (Osaka Sangyo), Nobuyuki Kawai (TiTeck), Kouji Ohta (Kyoto)

Tomoki Morokuma, Mariko Kubo, Naotaka Suzuki, Mamoru Doi,

Naoki Yasuda, Ryo Tsutsui (Tokyo)

Shinki Oyabu (Nagoya), Daisuke Yonetoku (Kanazawa), Tomo Goto (NTHU)

Jun Toshikawa (Soukendai/NAOJ), Chihiro Tokoku, Ken Mawatari (Tohoku)

Yuji Ikeda (Photocoding), Satoru Iwamura (MRJ)

+

WISH Science ML Members

# WISH

## in Japanese Astronomy Roadmap

Subaru



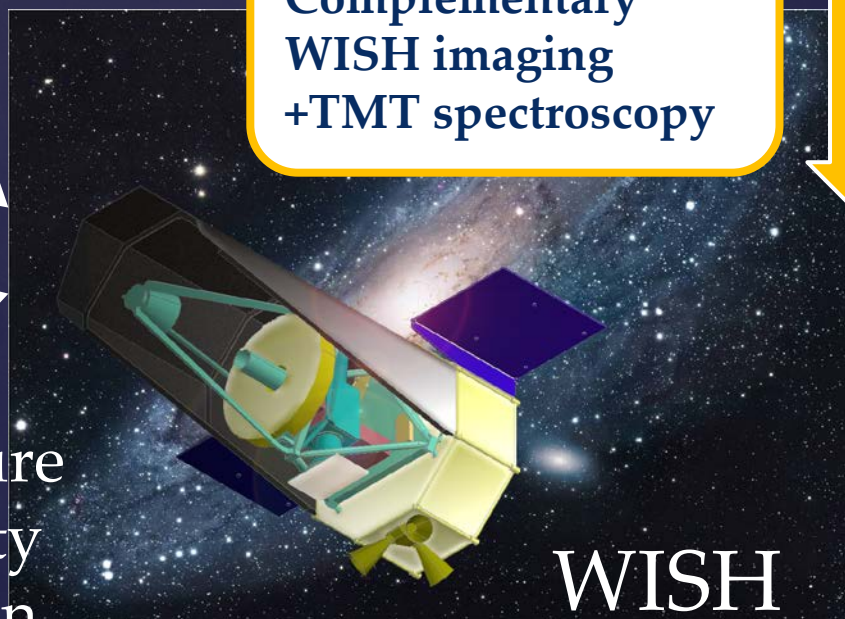
Wide-field deep imaging  
Opt  $\rightarrow$  NIR  
Higher redshift



Akari



Larger aperture  
NIR sensitivity  
NIR resolution



WISH

TMT

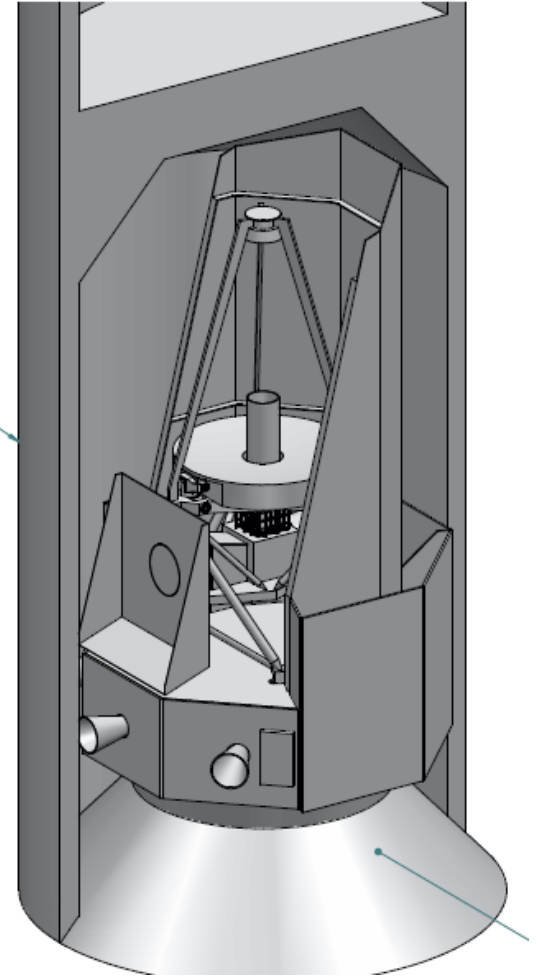
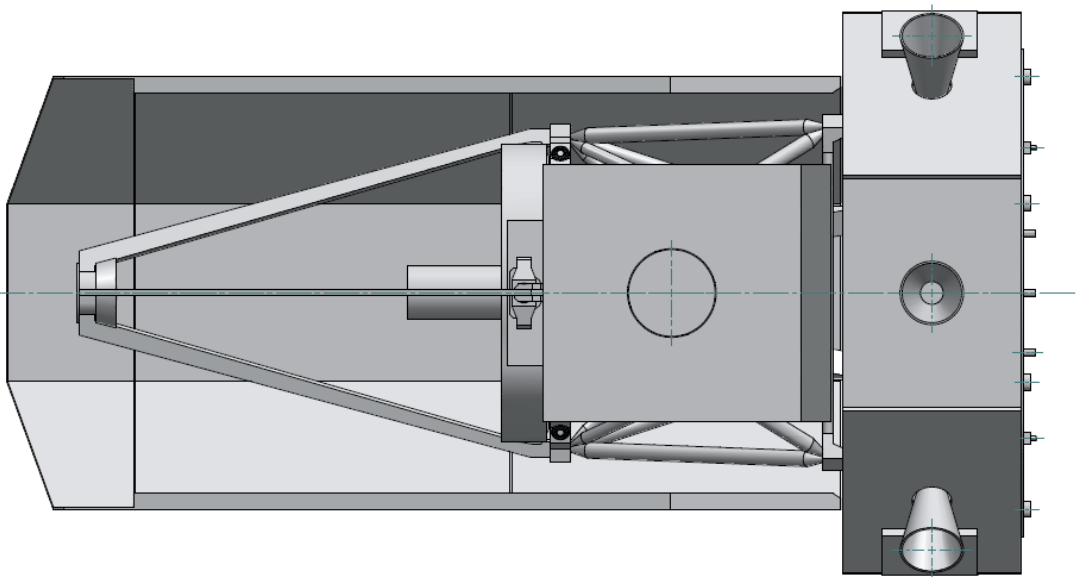
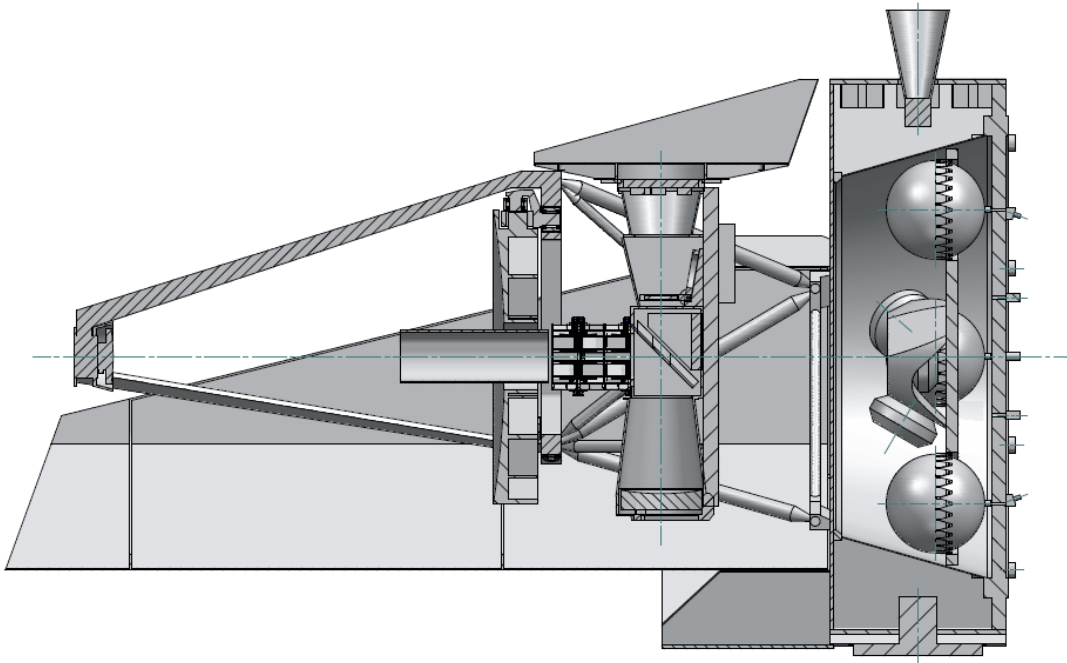


Strong Synergy  
Complementary  
WISH imaging  
+TMT spectroscopy

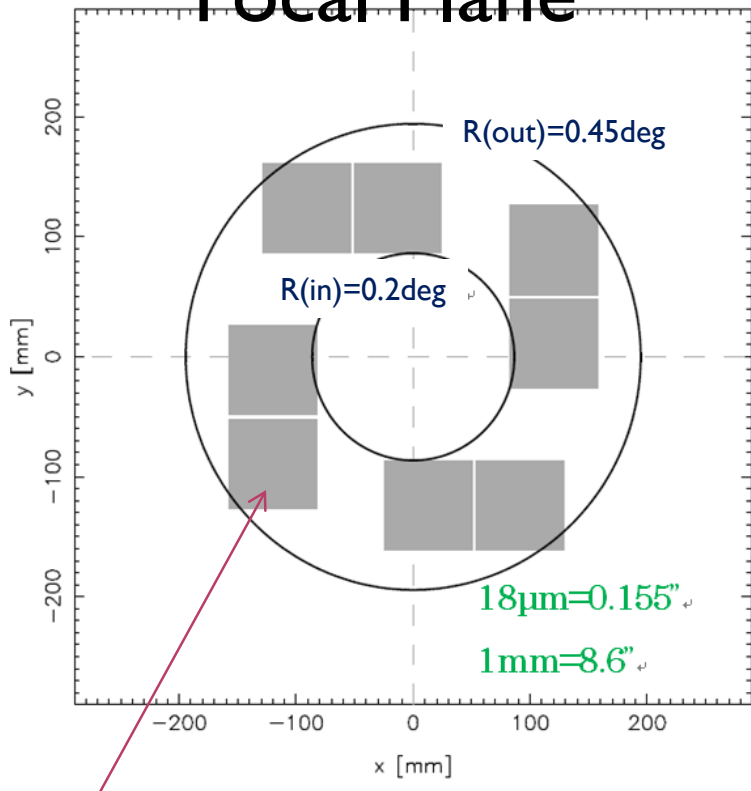


backup

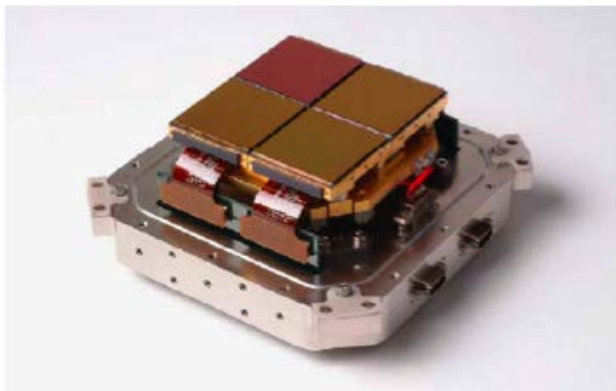
Size: (HII-A) 4/4D-LC  
Mass: ~ 1.4t  
Power: 1.2kW



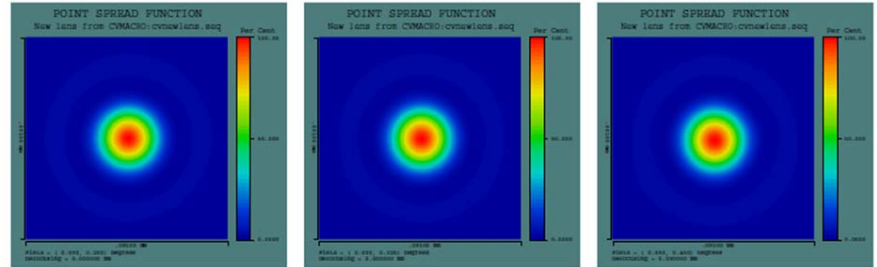
# Focal Plane



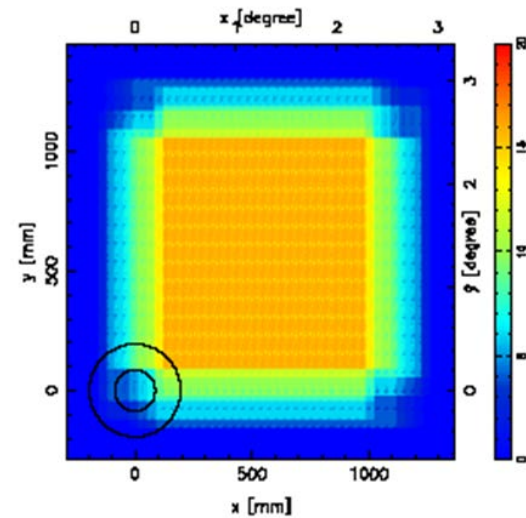
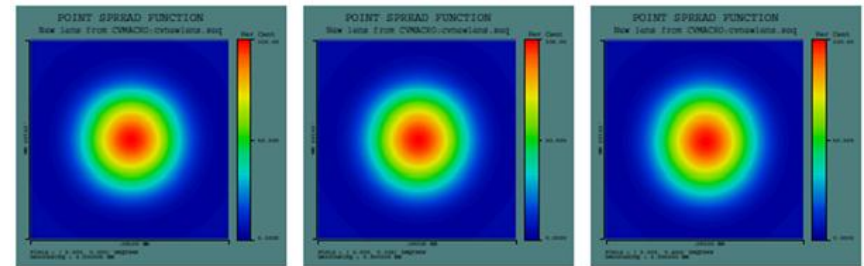
4 x 2kx2k FPA



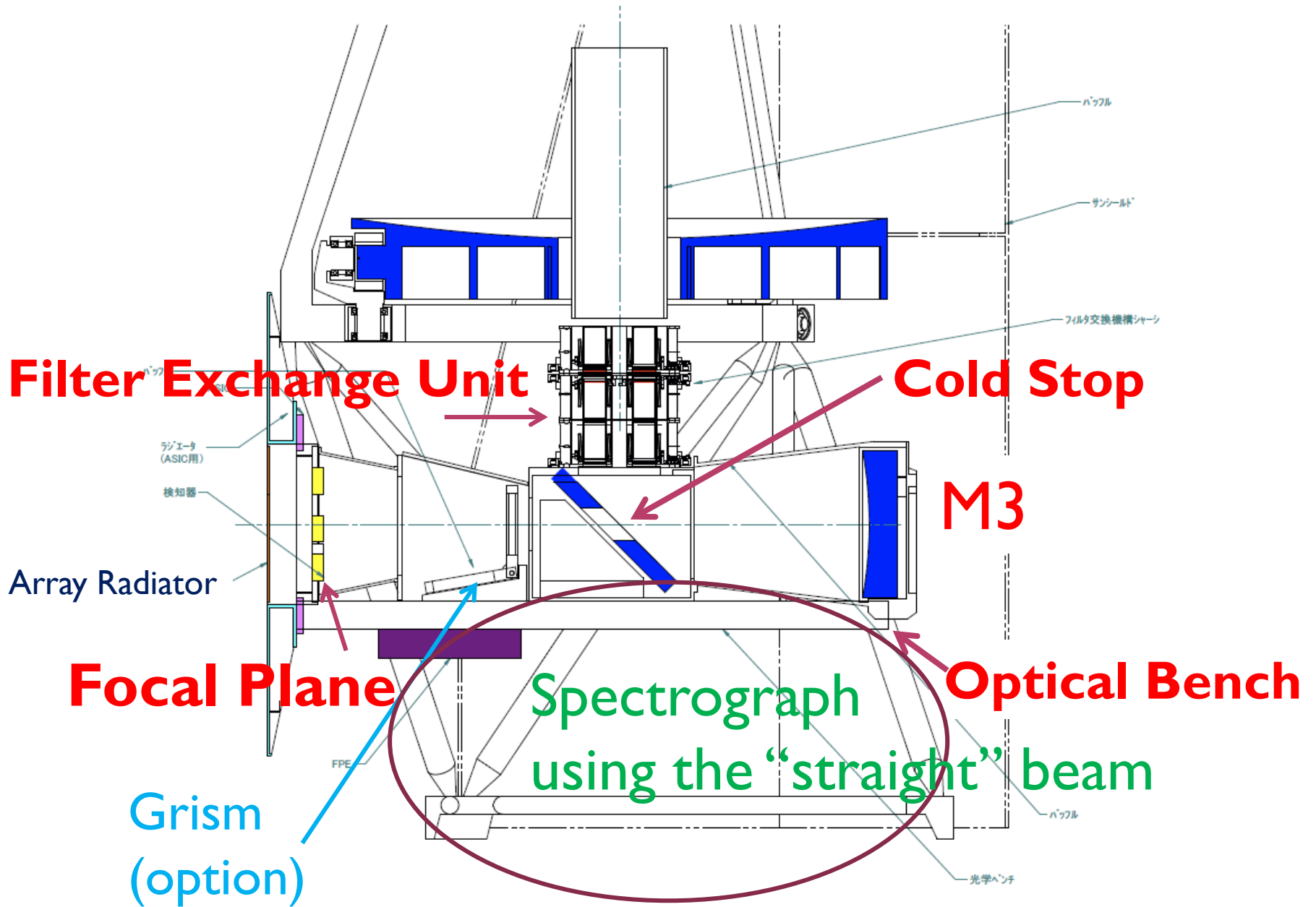
$R=0.2, 0.325, 0.4 \text{ deg @ } 1.25 \mu\text{m}$



$R=0.2, 0.325, 0.4 \text{ @ } 2.2 \mu\text{m}$







望遠鏡 断面図