WISH: Sensitivity and Survey Plan

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Summary of WISH science goals:

- Systematic search of objects at z>7
  - Exploring the 1st generation of galaxies
  - Galaxy formation and evolution
  - Cosmic re-ionization epoch
  - High-z QSOs and GRBs
- Supernova cosmology at high-z
  - Type Ia SNe at z>3
  - NIR light curves of SNe by multiple observations
  - History of cosmic expansion and the origin of dark energy
- Broad studies of Astronomy
  - Studies of galaxies at z<7
  - Galactic objects (bulge astrometry, open clusters, disk dynamics)
  - Ex-planets (transit objects, micro-lensing)
  - Objects in the solar system (H_2O ice on asteroids)
  - And many other auxiliary sciences

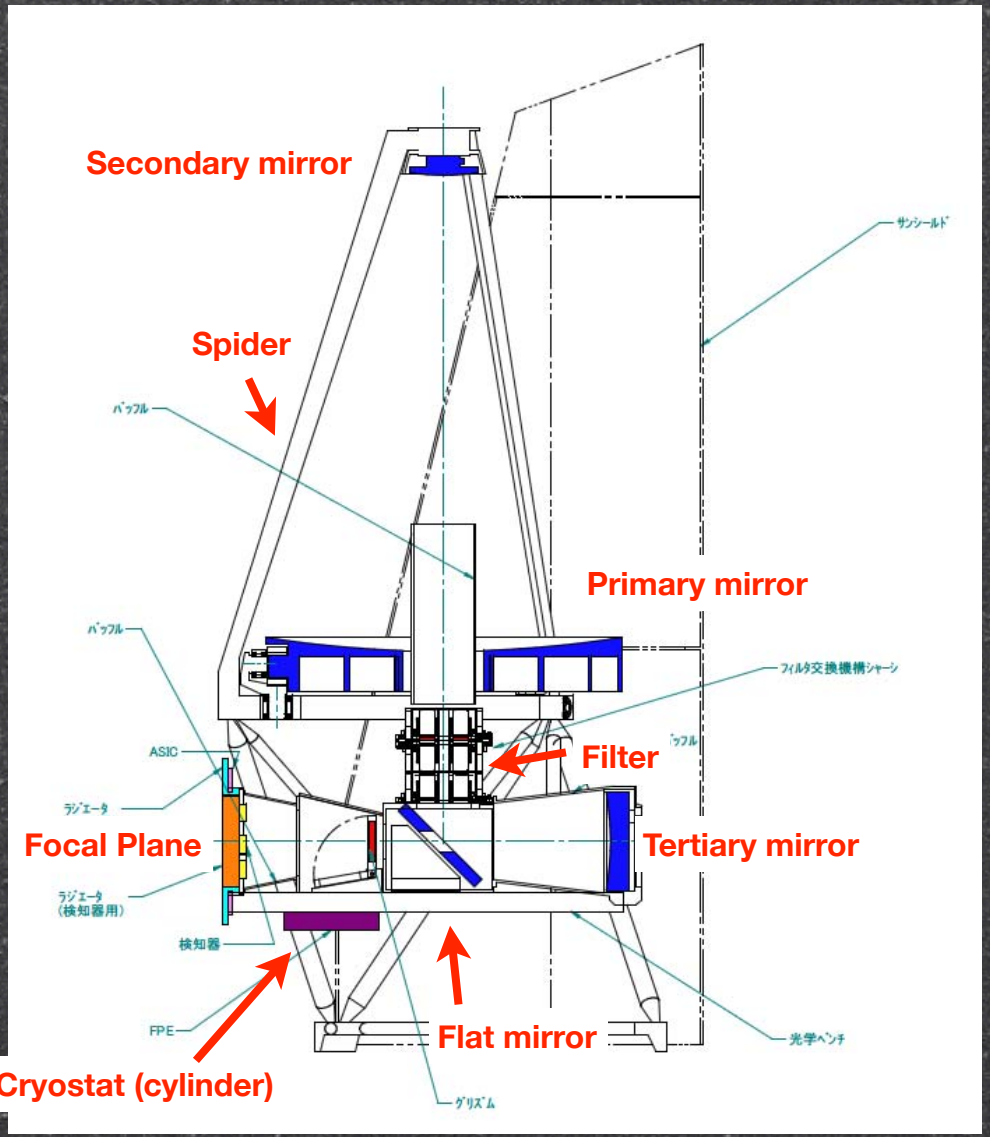
WISH: Deep and Wide NIR imaging survey

Summary of WISH science goals:

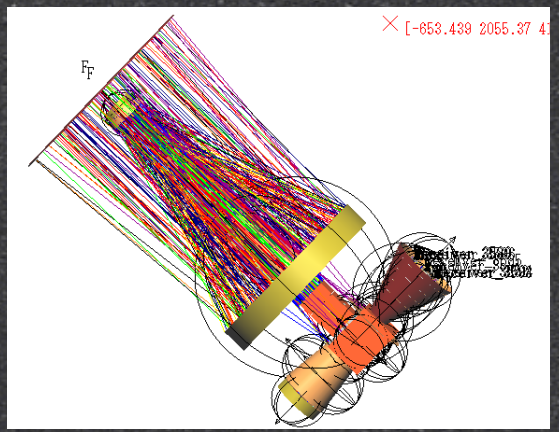
- Ultra Deep Survey (UDS): ~28 mag in 100 deg^2
- Ultra Wide Survey (UWS): ~25 mag in 1000 deg^2
- Extreme Deep Survey (EDE): ~30 mag in 1 FoV

Summary of WISH sensitivity:

- Thermal emission from telescope instruments
- We calculate photons / pix from each optical component



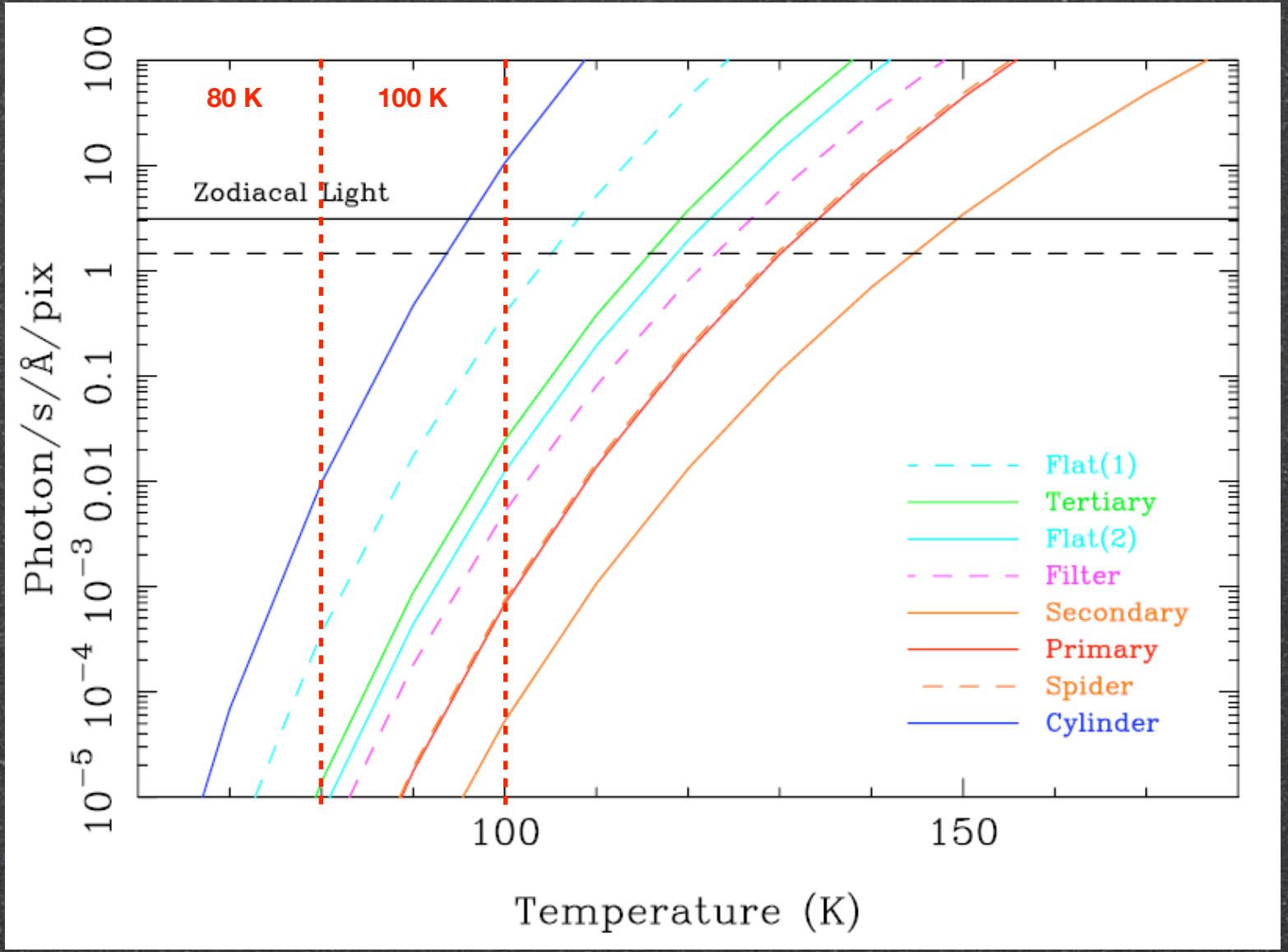
- The sensitivity is estimated by using the following instrument parameters
  - Emissivity of 5-10%
  - Detector: H2RG (cut off 5.0μm)
  - Pixel scale: 0.155”/pix
  - Dark current: 0.05 e^-/s/pix
  - Readout noise:15e^-
  - Aperture size = 2 x PSF FWHM



Note: Our background estimation is roughly consistent with detailed ray-tracing analysis

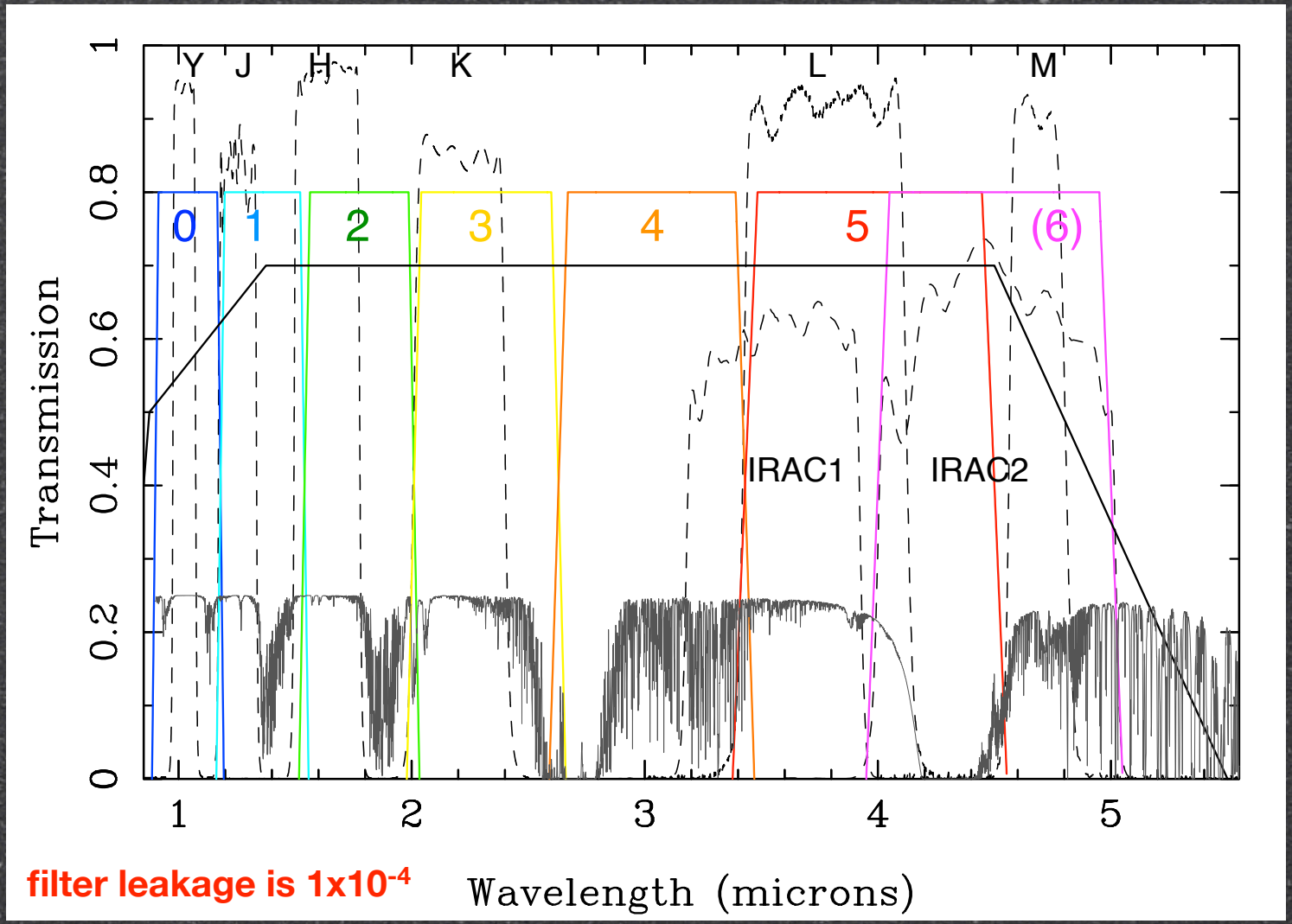
Summary of WISH sensitivity:

- Temperature: comp. near focal plane = 80K, others = 100K
- Thermal emission is lower than the zodiacal emission



Summary of WISH sensitivity: broad band filters

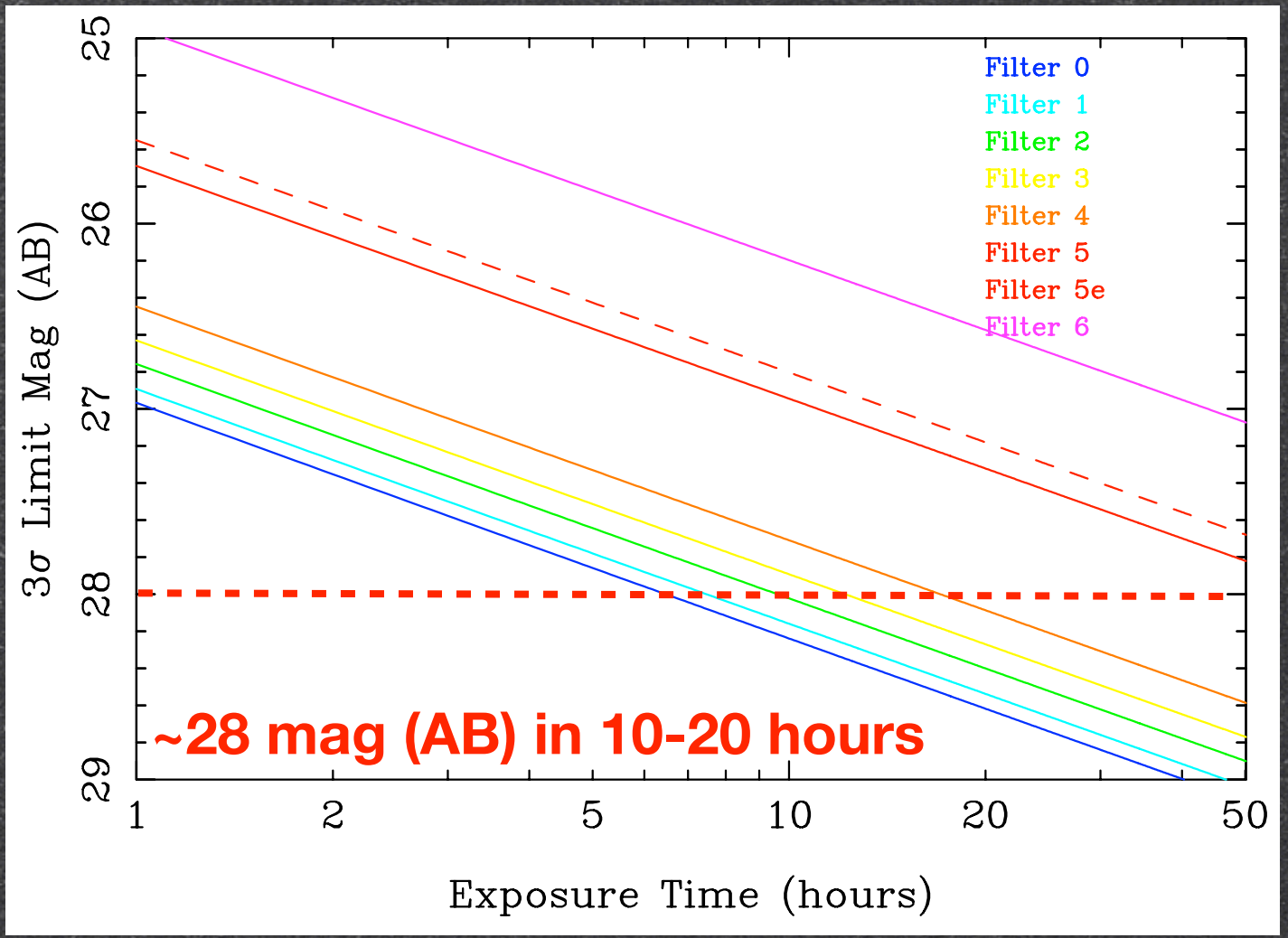
- Filters suitable for various scientific goals
- Filters cover wavelength range of 1 - 5 μm without any gaps
- Band widths are the same in logarithmic scale



filter leakage is 1×10^{-4}

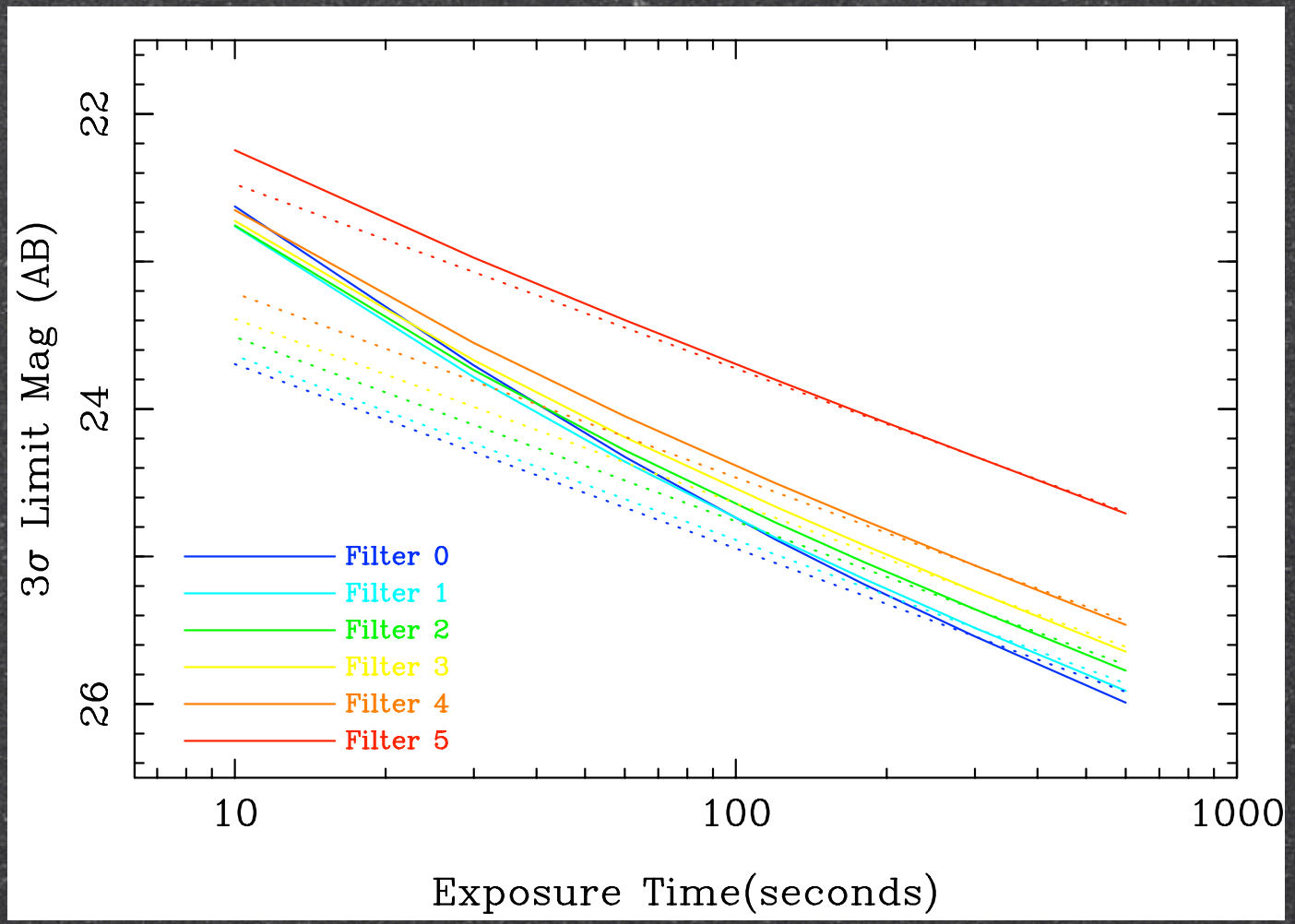
Summary of WISH sensitivity: broad band filters

- Limiting magnitudes for 10 hours S/N=3 in broad band filters
- We assume 3 times more zodiacal background at the ecliptic pole
- 28 mag (AB) with 3σ in 10-20 hours in filter 0-4 (1-3 μm)
- >50 hours is required to reach 28 mag (AB) in filters with >4μm



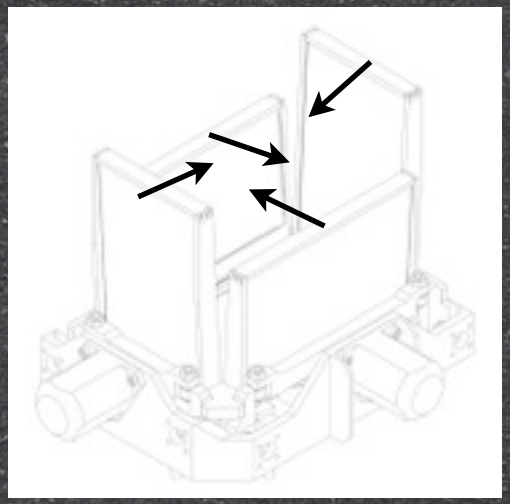
Summary of WISH sensitivity: broad band filters

- Sensitivity for bright objects
- Read-out noise is dominated below an exposure time of ~100 sec
- We recommend exposure of 300 sec taking into consideration CR
- Saturation becomes a problem for objects with <11 mag (AB)



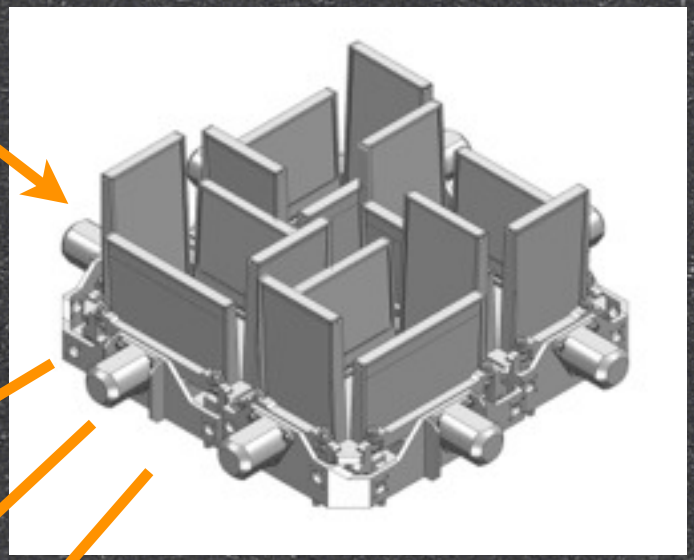
Dashed line: extrapolation if background limit is assumed

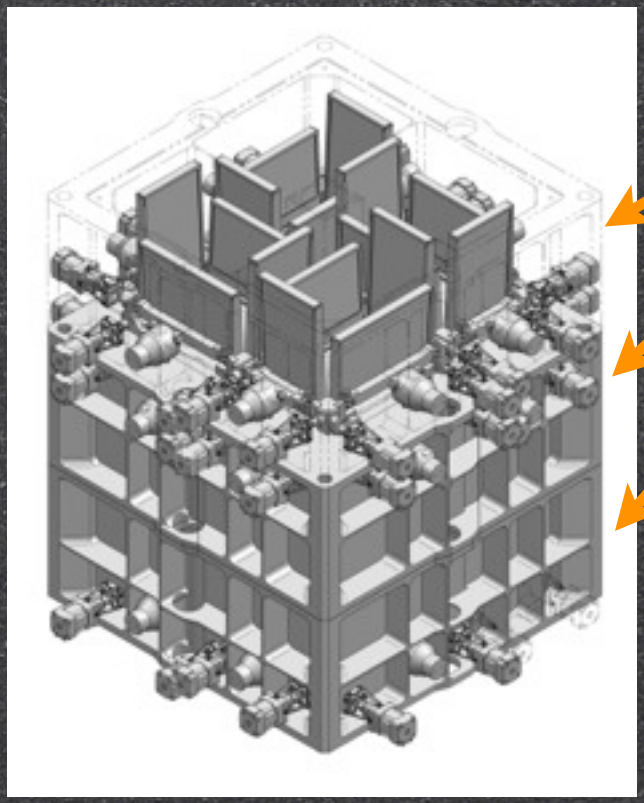
WISH filter exchanger unit:



← one exchanger unit

↓ one stage of the exchanger units





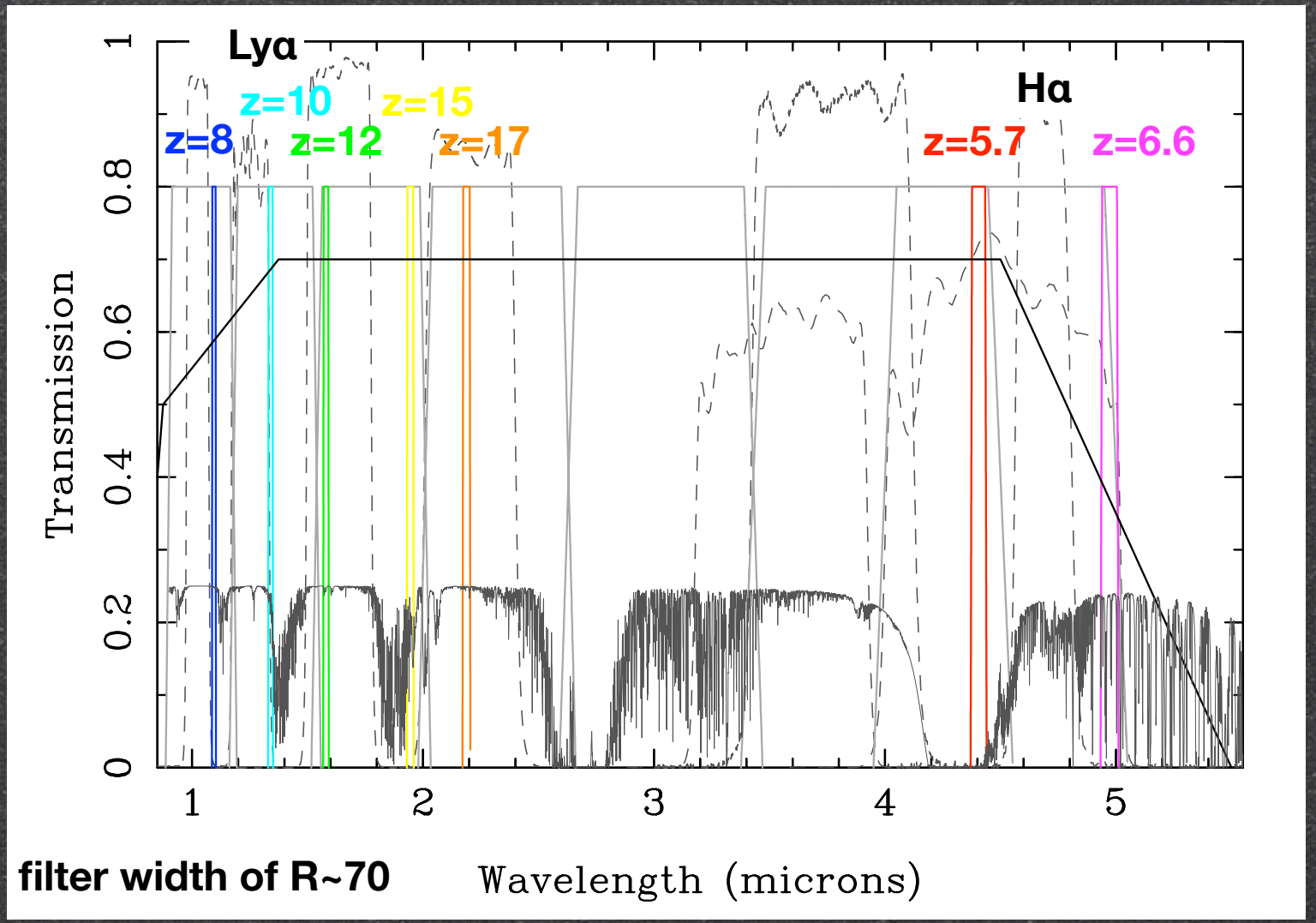
↑ three-stage structure

4 filters x 3 layers => 12 filters available

We use 6 slots for broad band filters and one slot for shutter: Remaining 5 slots will be used for other filters

Summary of WISH sensitivity: narrow band filters

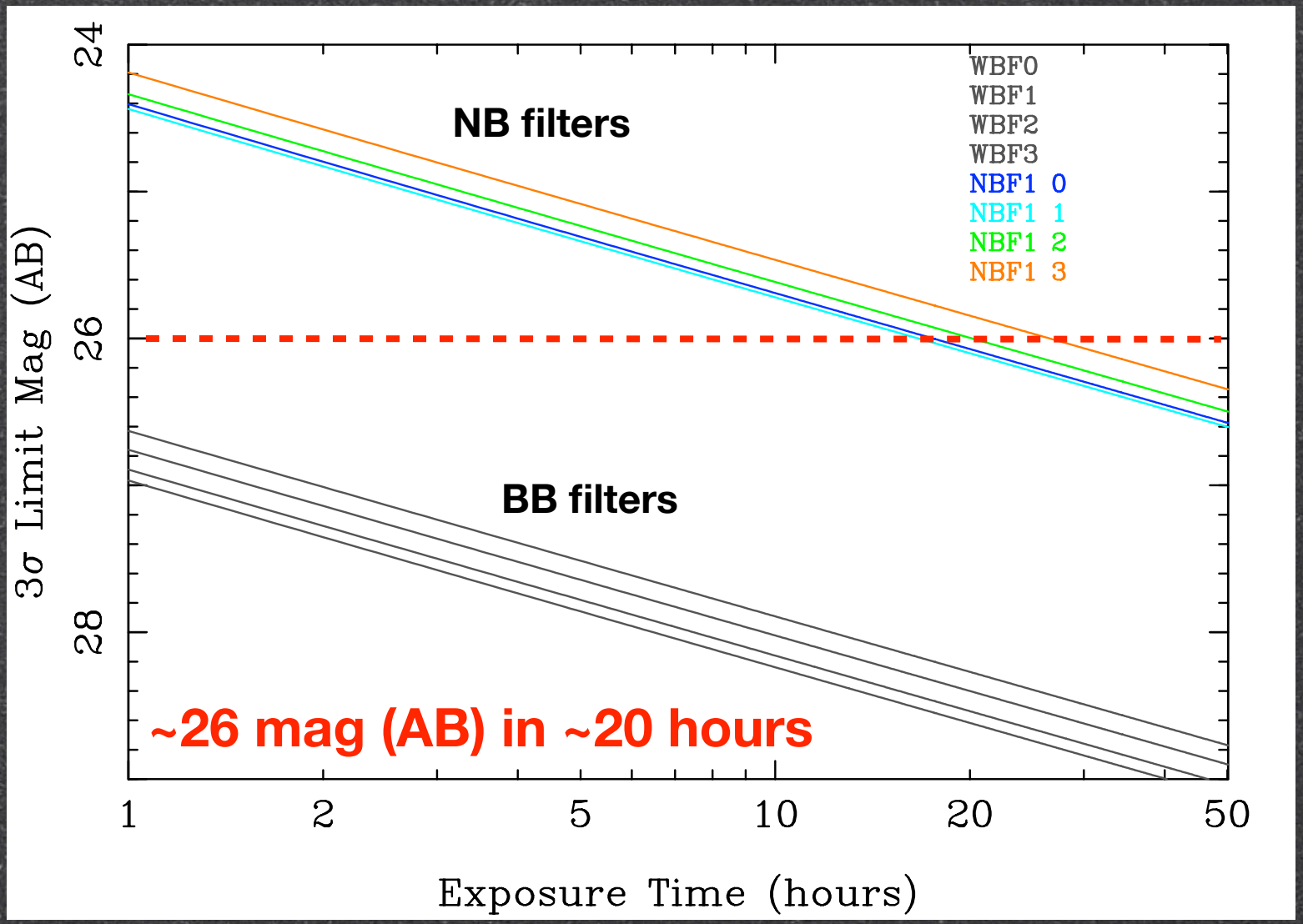
- WISH filter exchanger unit has 12 slots: 6 for BB filters 1 for a shutter
- 5 remaining slots for other filters
- Narrow band filters are options



filter width of R~70

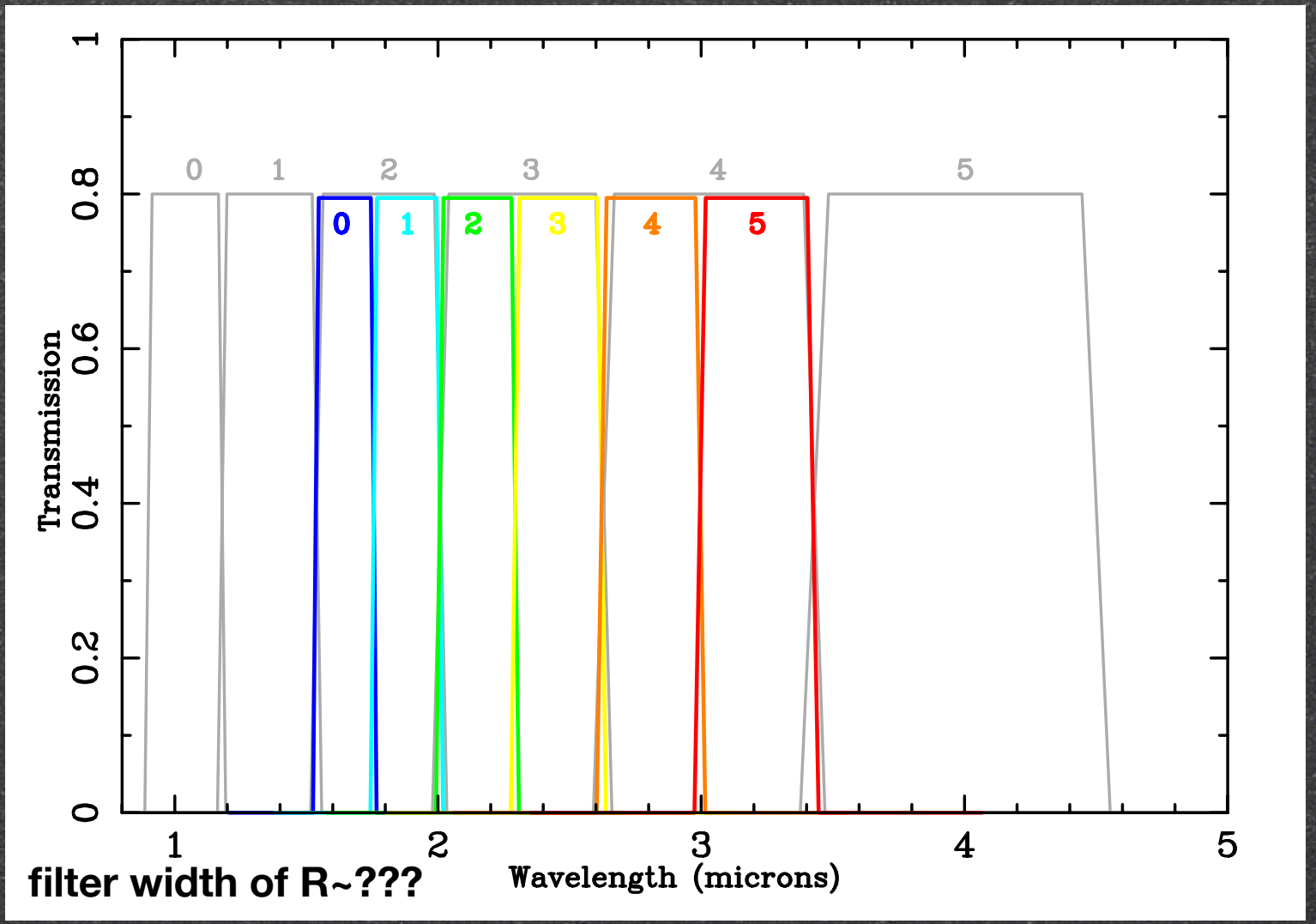
Summary of WISH sensitivity: narrow band filters

- Shallower limiting magnitude than that for broad band filters
- ~20 hour is required for 26 mag (AB) with 3σ in NB filters with 1-2 μm



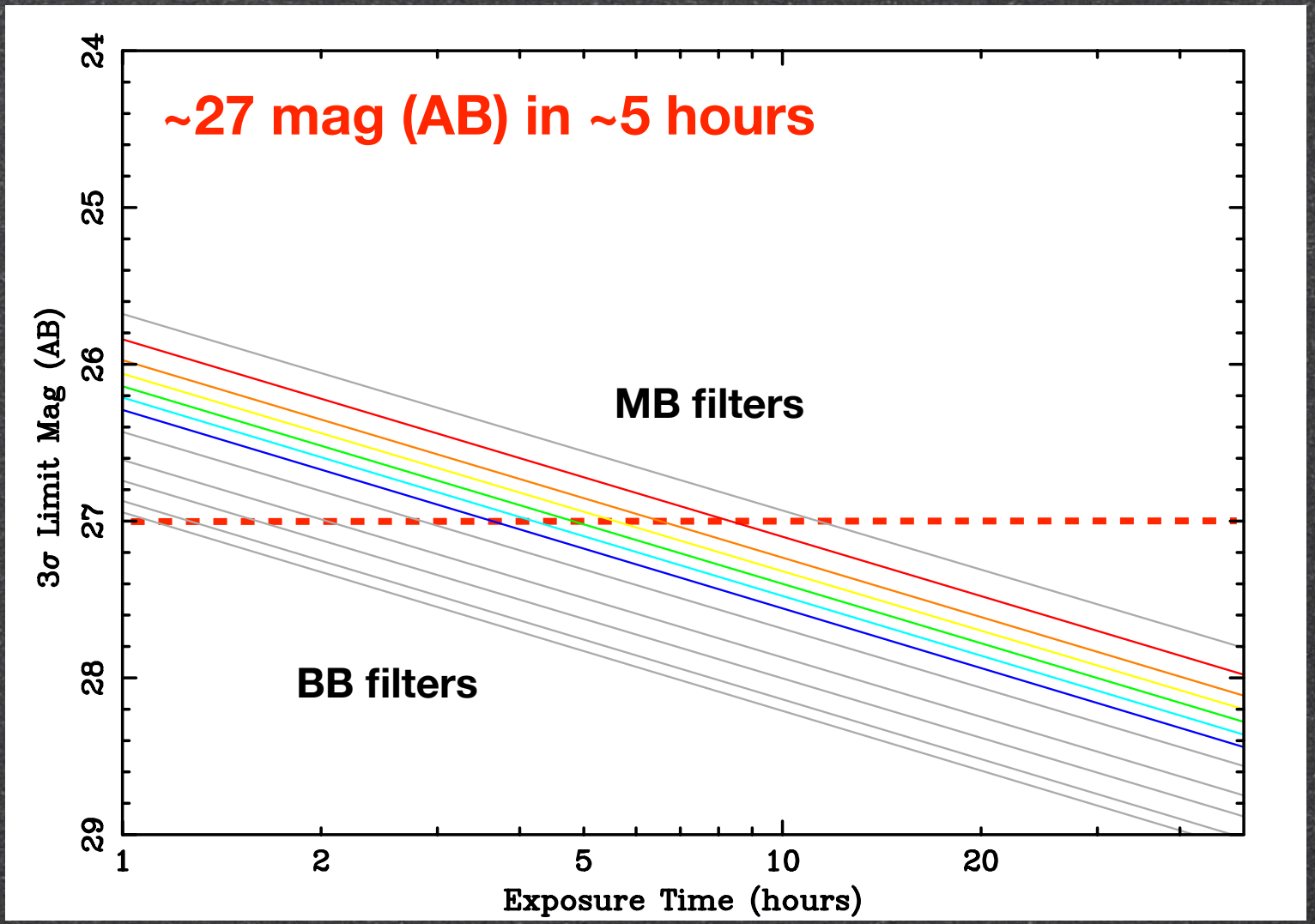
Summary of WISH sensitivity: medium band filters

- Filter exchanging unit have 12 slots: 6 for BB filters 1 for a shutter
- 5 remaining slots for other filters
- Medium band filters are also options



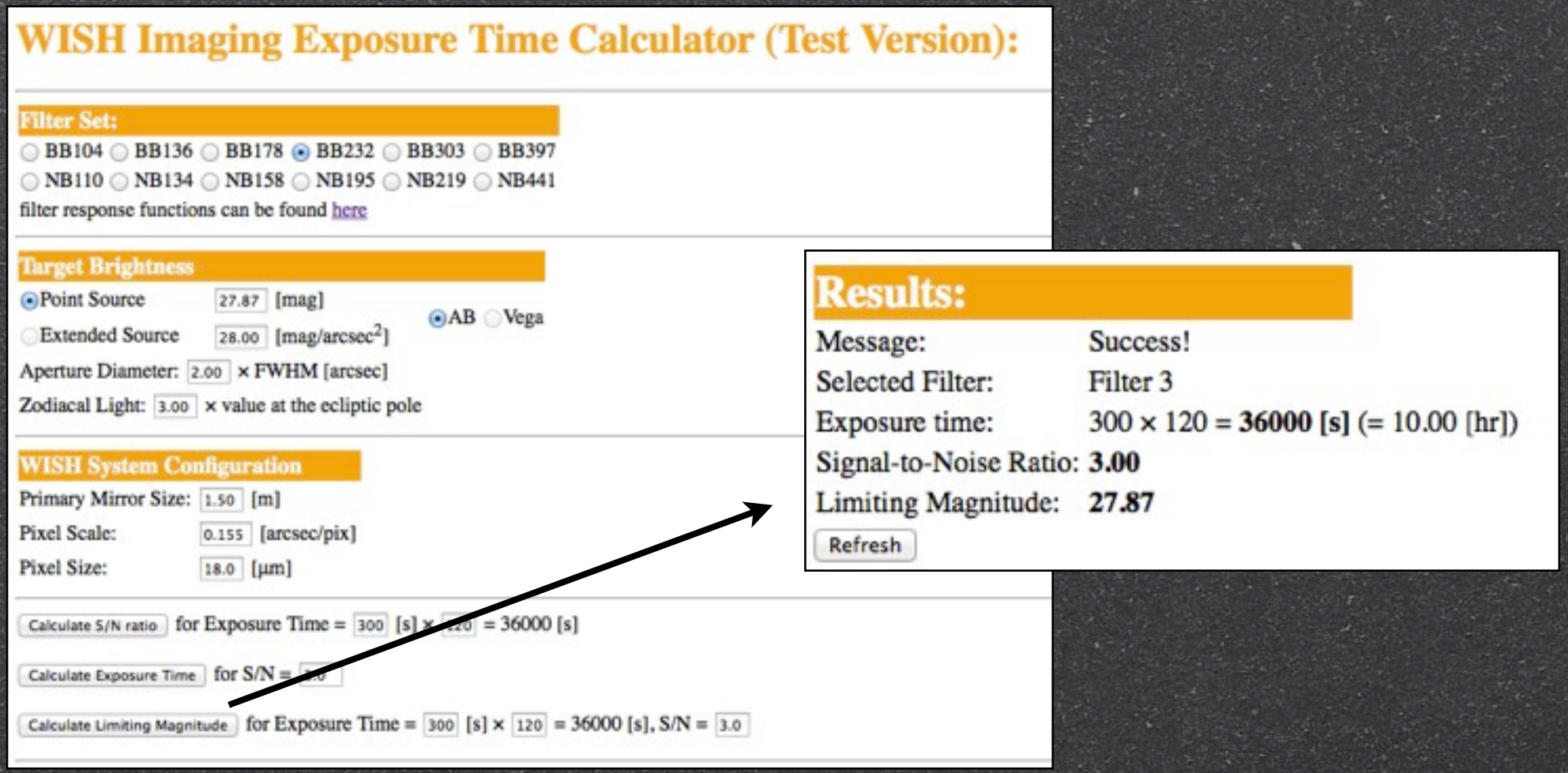
Summary of WISH sensitivity: medium band filters

- Filter exchanging unit have 12 slots: 6 for BB filters 1 for a shutter
- 5 remaining slots for other filters
- Medium band filters are also options



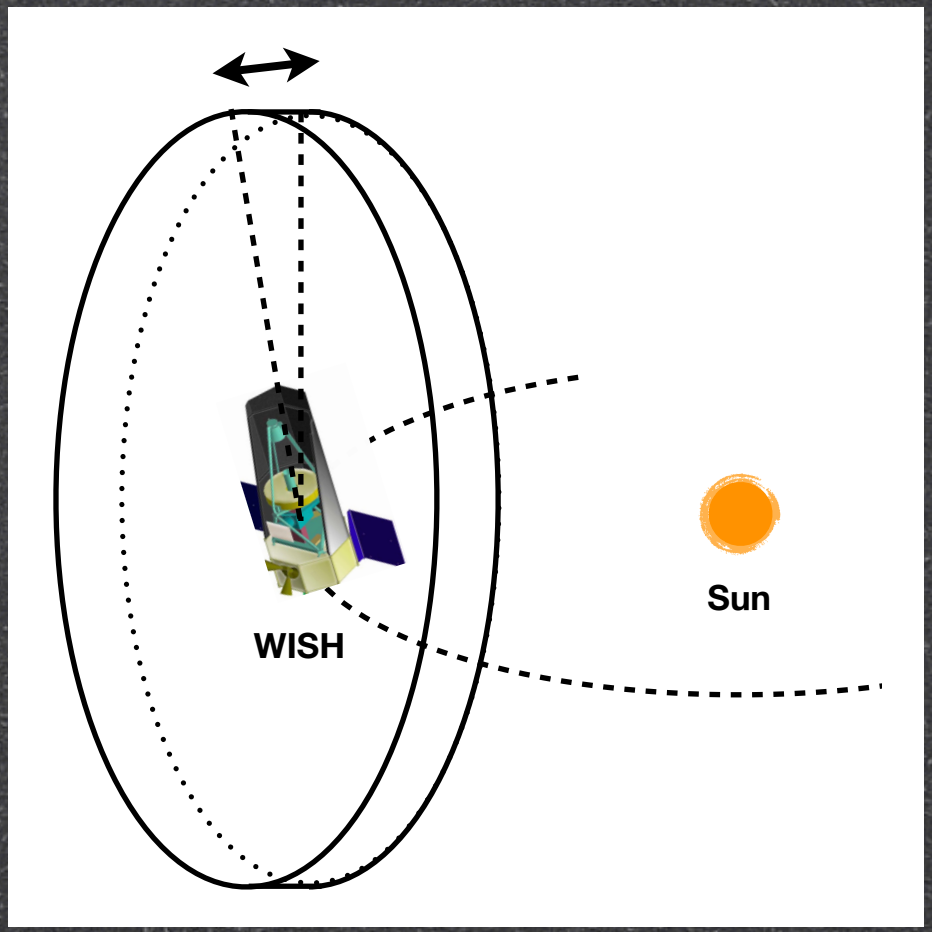
Summary of WISH sensitivity: Exposure Time Calculator

- WISH exposure time calculator (ETC) is now under development
- Beta version is available:
  http://optik2.mtk.nao.ac.jp/~kiyoyabe/WISH/ETC/ETC.py
- For broad/narrow/medium band filters
- ETC for spectroscopic mode?



Summary of WISH Survey Plan: Visibility

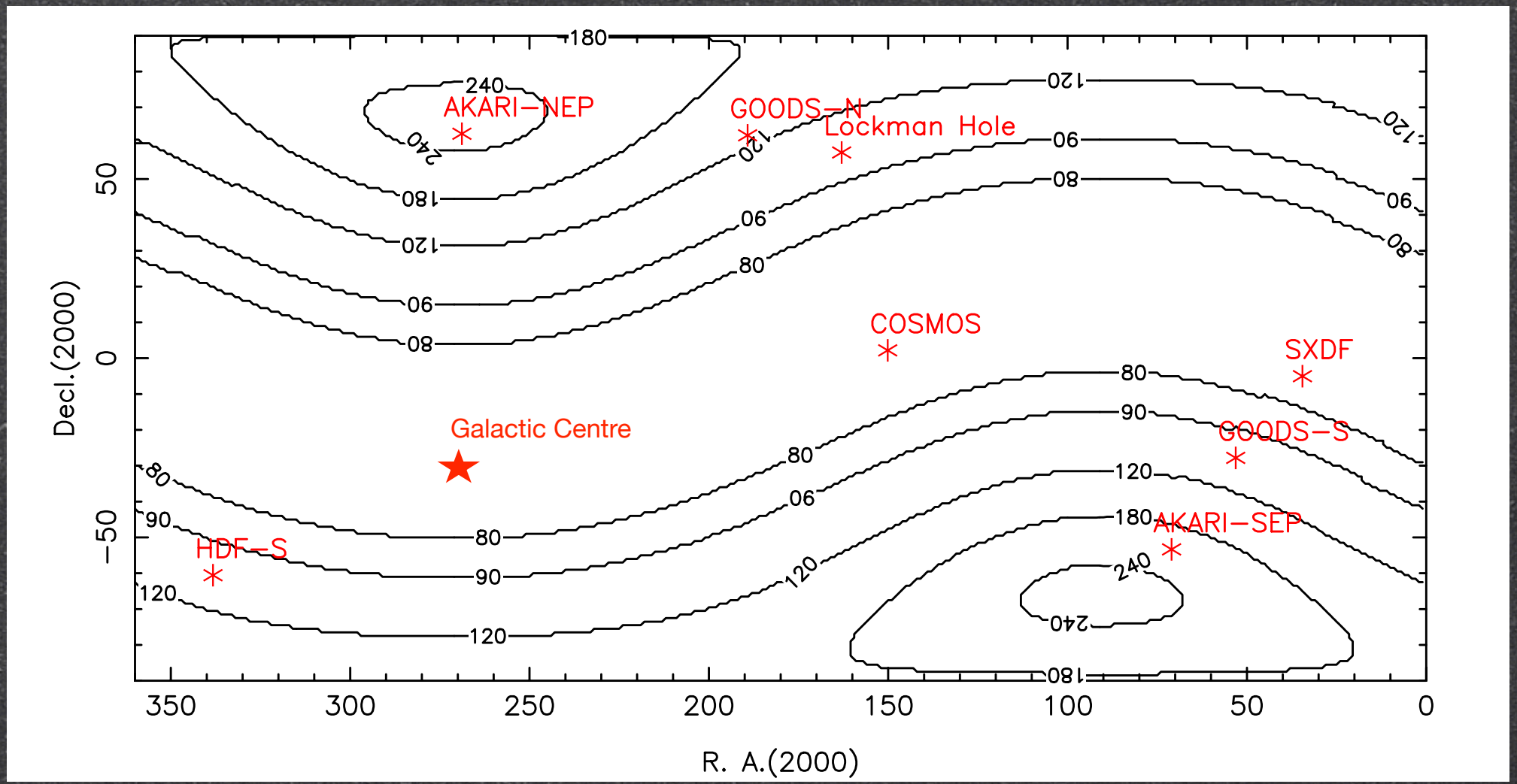
- Observable area of WISH telescope is limited by the satellite angle
  - Power supply from solar puddle
  - Thermal environment of satellite bus module
  - Size of the sun shield
- Typically, two chances of observing the same area in one year



- The visibility of WISH telescope is roughly estimated with the following assumptions
  - 1 year = 360 days
  - Orbit at L2 point is neglected
  - Satellite angle: -5 deg. toward and 30 deg. against the sun

Summary of WISH Survey Plan: Visibility

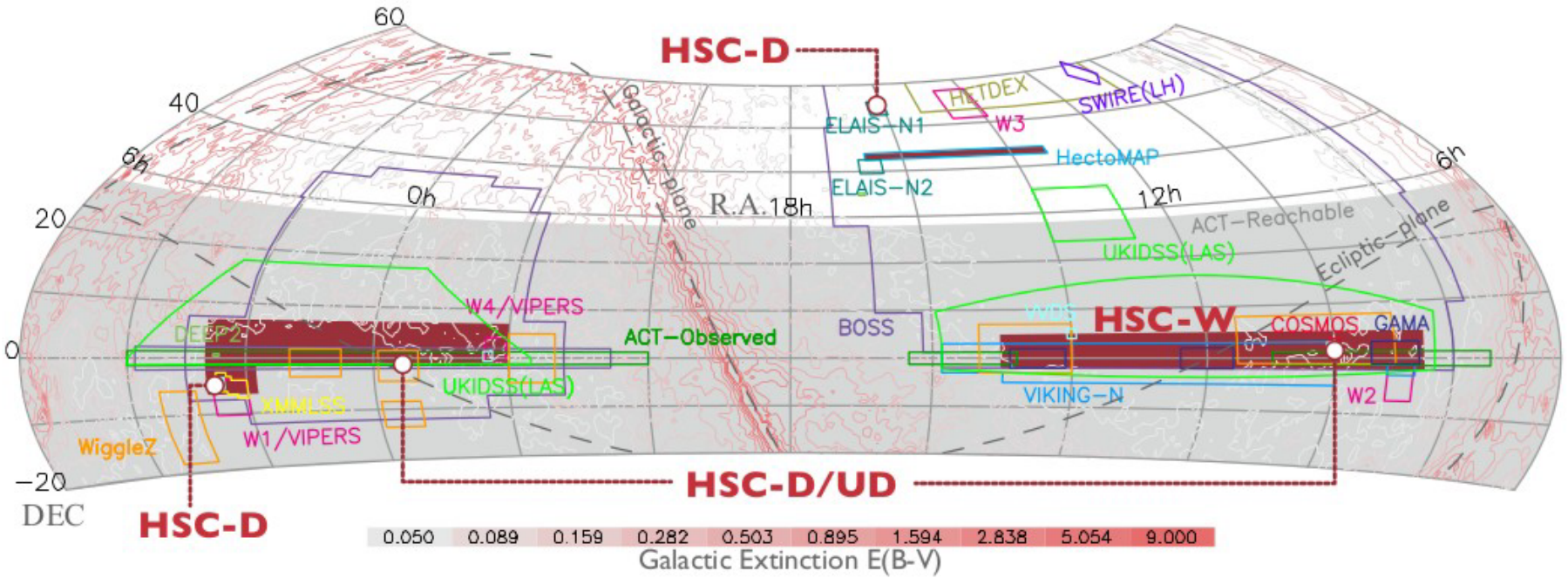
- Visibility map for a given coordinate
- The numbers indicate the visible days
- Higher visibility (~240 days) near ecliptic pole
- Lower visibility (~80 days) near ecliptic plane



Summary of WISH Survey Plan: Visibility

Subaru/Hyper Suprime-Cam Survey Fields

Target fields



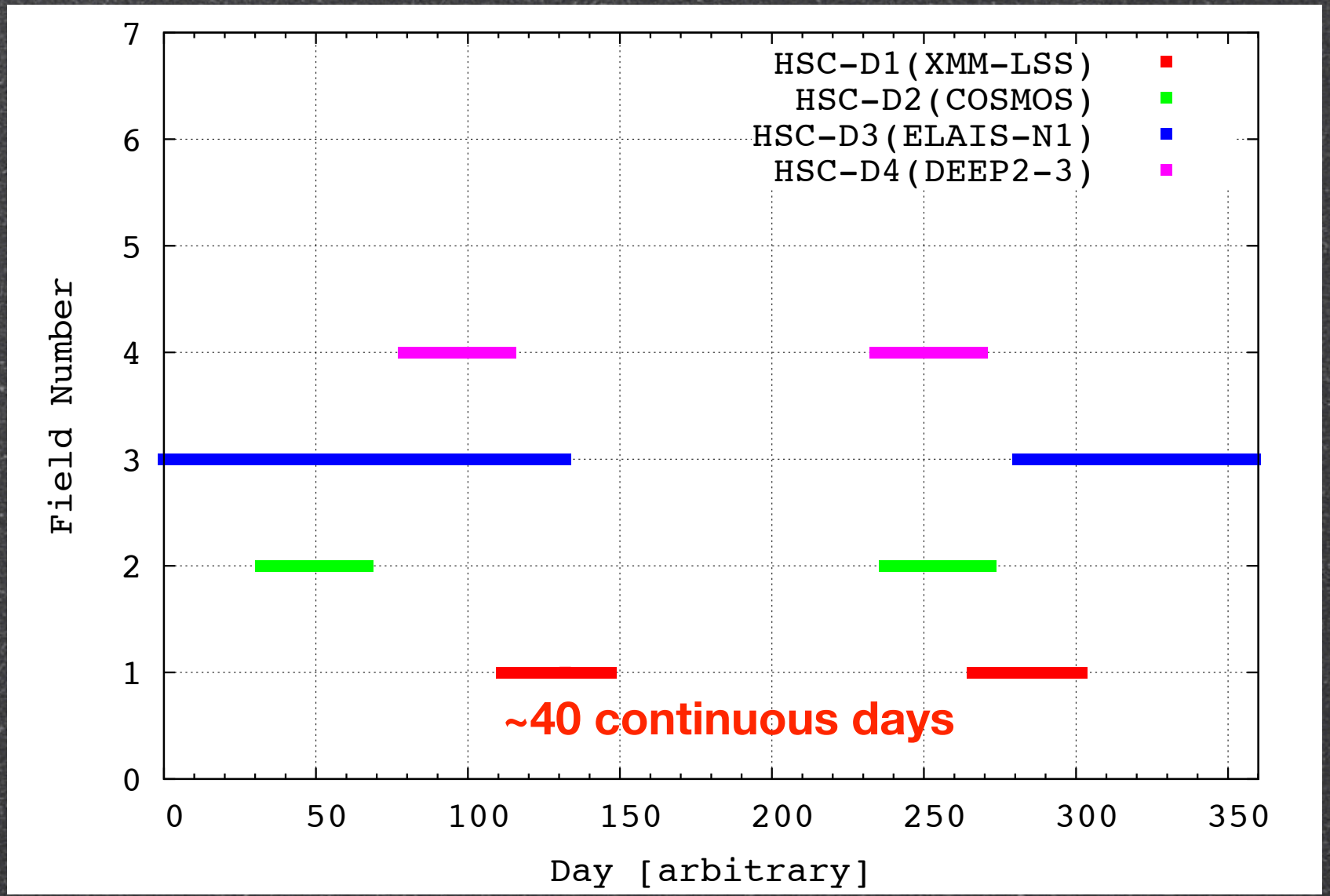
Wide : Spring/Autumn equatorial region + HectoMAP region

Deep : XMM-LSS, E-COSMOS, ELAIS-N1, DEEP2-3

Udeep : SXDS (XMM-LSS), COSMOS

Summary of WISH Survey Plan: Visibility

- Visibility at HSC Deep Survey fields (D1-D4)
- ~80 days (~40 continuous days) in one year are visible



Summary of WISH Survey Plan: Possible Survey Area

- Visibility near the equator
  - ~80 days (~40 continuous days) per year are visible
    - ✓ Not ideal for the SN surveys?
    - ✓ SN surveys require ≥5 different observations every 10 days
    - → ≥40 continuous days are necessary
- Visibility near Ecliptic pole (EP) is good
- Possible Ultra Deep Survey (UDS) Plan
  - HSC-Deep Fields
    - ✓ XMM-LSS, COSMOS, DEEP2
    - ✓ ~20 deg^2 (~7 deg^2 x 3 fields)
    - ✓ Deep optical data available
  - Other fields near EP
    - ✓ ~80 deg^2 (~20 deg^2 x 4 fields?)
    - ✓ Deep optical data unavailable
    - ✓ WISH-Deep Field with HSC?
- Possible UWS Survey Plan
  - HSC-Wide Fields? and other EP fields?

Summary of WISH Survey Plan:

- For 100 deg^2 area, 80 deg^2 in EP and 20 deg^2 in the HSC fields
- 3 times more zodiacal light is assumed in the HSC fields
- Other science targets including narrow band survey?

	5σ Depth (AB mag)	Area (deg^2)	Filter Central Wavelength (μm)	Survey Time[1] (days)
Ultra Deep Survey	28	100	1.0, 1.4, 1.8, 2.3	~1560
+ Filter 4 (3μm)	27	100	3.0	~130
+ Filter 5 (4μm)	26	100	4.0	~70
Ultra Wide Survey	25	1000	1.4, 1.8, 2.3	~45
Extreme Deep Survey[2]	29.5	0.25	1.0, 1.4, 1.8	~30
Total				~1800

Note: (1) 50% overhead included (2) the survey field is near EP

Additional slides:

Summary of WISH sensitivity: broad band filters

Magnitude limit (AB) in broad band filters

Filter	λcenter [μm]	10^h exp. 3σ mag.	hours to reach 28 AB mag.
0	1.040	28.24	6.50
1	1.360	28.16	7.50
2	1.775	28.02	9.67
3	2.320	27.89	12.25
4	3.030	27.71	17.08
5	3.965	26.95	69.67
5e	4.215	26.80	90.42
6	4.500	26.20	43.83(*)

Name	λcenter	Lyα z	FWHM	R	$10h^1$	$50h^2$
NB110	1.095	8.0	0.015	73.0	25.69	26.57
NB134	1.340	10.0	0.019	70.5	25.72	26.60
NB158	1.580	12.0	0.022	71.8	25.62	26.50
NB195	1.945	15.0	0.027	72.0	25.47	26.35
NB219	2.188	17.0	0.031	70.6	25.40	26.28
NB441	4.4052	5.71*	0.063	69.9	24.50	
NB497	4.9720	6.58*	0.071	70.0	23.53	

Hα

Magnitude limit (AB) in narrow band filters

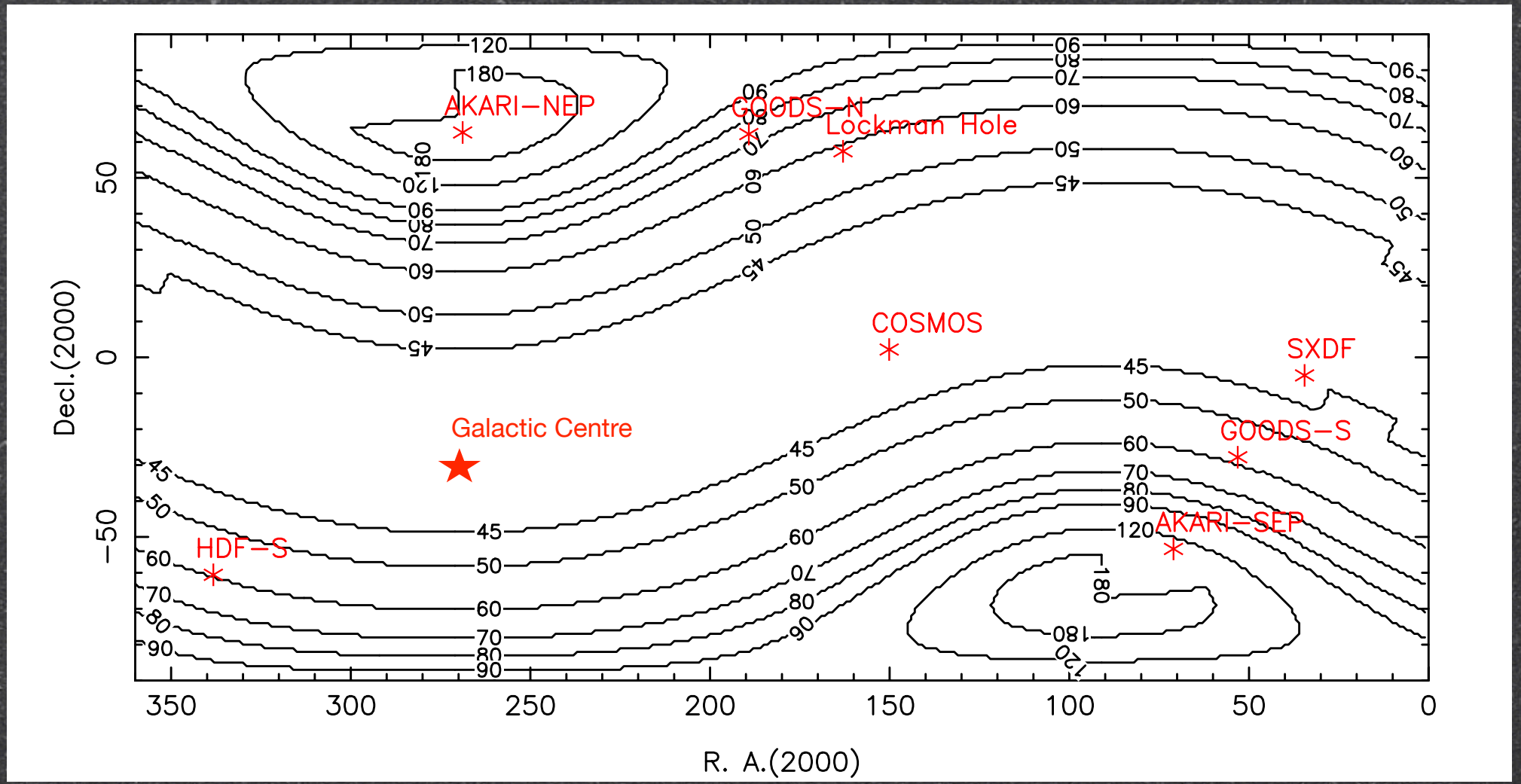
	Filter					
Exptime(sec)	0	1	2	3	4	5
1	12.28	12.25	12.06	11.81	11.53	11.27
5	14.03	14.00	13.80	13.56	13.27	13.02
10	14.78	14.75	14.56	14.31	14.03	13.77
100	17.28	17.26	17.06	16.81	16.53	16.27
300	18.48	18.45	18.25	18.01	17.72	17.47
500	19.04	19.01	18.81	18.56	18.28	18.03
1800	20.45	20.43	20.23	19.97	19.68	19.46

Magnitude limit (AB) in which saturation occurs

Summary of WISH Survey Plan: Visibility

- Visibility map for a given coordinate (R.A. and Dec.),
- The numbers indicate the visible days
- Higher (lower) visibility near ecliptic pole (plane)

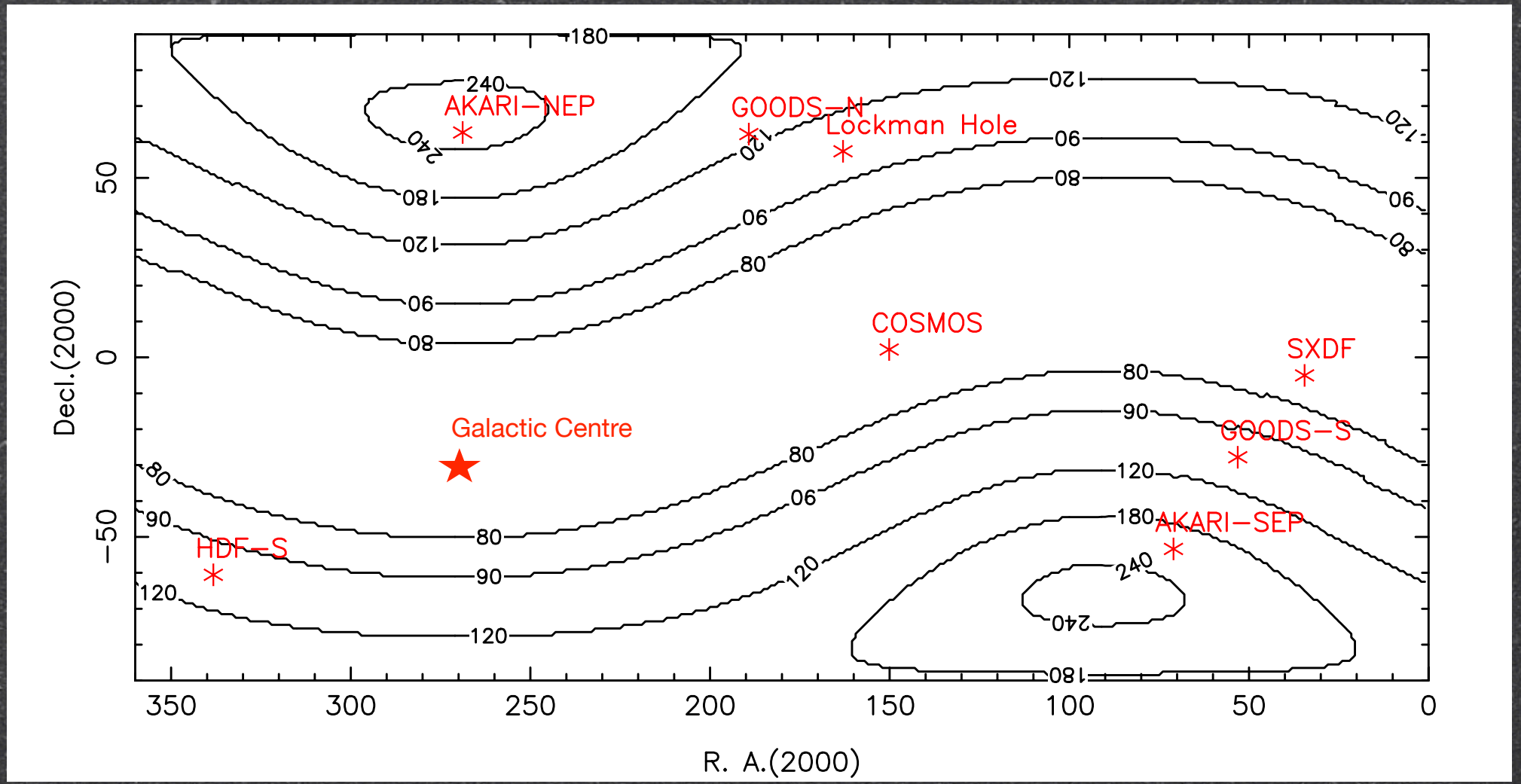
0 deg. toward **20** deg. against the sun



Summary of WISH Survey Plan: Visibility

- Visibility map for a given coordinate (R.A. and Dec.),
- The numbers indicate the visible days
- Higher (lower) visibility near ecliptic pole (plane)

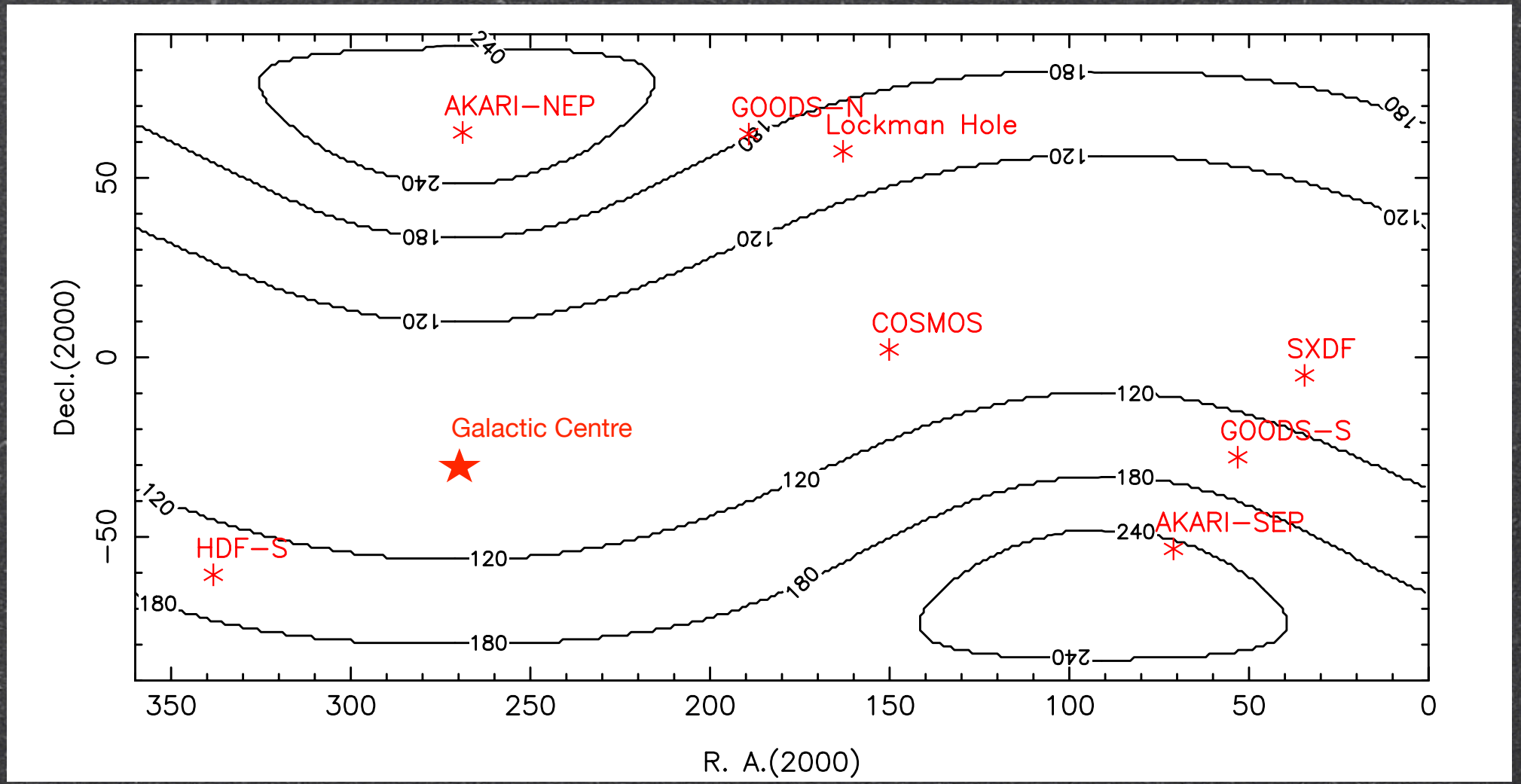
5 deg. toward 30 deg. against the sun



Summary of WISH Survey Plan: Visibility

- Visibility map for a given coordinate (R.A. and Dec.),
- The numbers indicate the visible days
- Higher (lower) visibility near ecliptic pole (plane)

10 deg. toward **40** deg. against the sun



Summary of WISH Science Goals:

- Expected number of galaxies in each case of UVLF evolution
- From the SAM prediction, ~600, ~50, and ~1 galaxies per 1 deg^2 at z=8-9, z=11-12, and z=14-17, respectively, are expected
- See details in Iwata-san's talk

Limiting Magnitude = 28.0 AB mag (3σ)

	z	No LF evolution	LF evolution (empirical)	LF evolution (DMH)	LF evolution (SAM)
0-drop	8-9	~4000	~1700	~850	~630
1-drop	11-12	~2400	~100	~4	~50
2-drop	14-17	~1200	~1	~0.003	~1

Limiting Magnitude = 27.45 AB mag (5σ)

* The expected detection numbers per 1deg^2

	z	No LF evolution	LF evolution (empirical)	LF evolution (DMH)	LF evolution (SAM)
0-drop	8-9	~3000	~1200	~300	~500
1-drop	11-12	~1600	~40	~0.7	~40
2-drop	14-17	~800	~0.02	~0.0001	~0.6

Summary of WISH Survey Plan: Visibility

- SE L2 orbit is ideal for cooling efficiency, thermal stability, and prevention of scattering light
- Geostationary earth orbit (GEO) and Tundra orbit is the second best
- GEO
  - Prevention of light from the earth
  - Variation of the thermal condition
  - Visibility / Seasonal variation
- Tundra orbit
  - Variation of the thermal condition
  - Visibility

TABLE F1. WISH FPA Requirements and Margins

FPA Parameter	Requirement	Expected	% Margin
Median read noise	≤15 e-/sec	≤12 e-/sec	25
Median pixel-pixel crosstalk	≤4 %	≤2%	100
Median quantum efficiency	≥70%	≥80%	14
Median dark current	≤0.05 e-/sec	≤0.01 e-/sec	400
Median well capacity	≥65000	≥85000 e-	30
Inoperable pixels	≤5%	≤1%	400

Giovanni’s talk yesterday

Summary of WISH Survey Plan:

	3σ Depth[1] (AB mag)	Area[2] (deg^2)	Filter Central Wavelength (μm)	Survey Time[3] (days)
Ultra Deep Survey	28	100	1.0, 1.4, 1.8, 2.3, 3.0	~1300
+ Filter 5 (4μm)	27	100	4.0	~280
Ultra Wide Survey	25	1000	1.4, 1.8, 2.3	~45
Extreme Deep Survey	30	0.25	1.0, 1.4, 1.8	~60
Total				~1700

Note: (1) 3 times more zodiacal light at pole assumed. (2) 1 WISH FoV=0.25.
(3) 50% overhead included

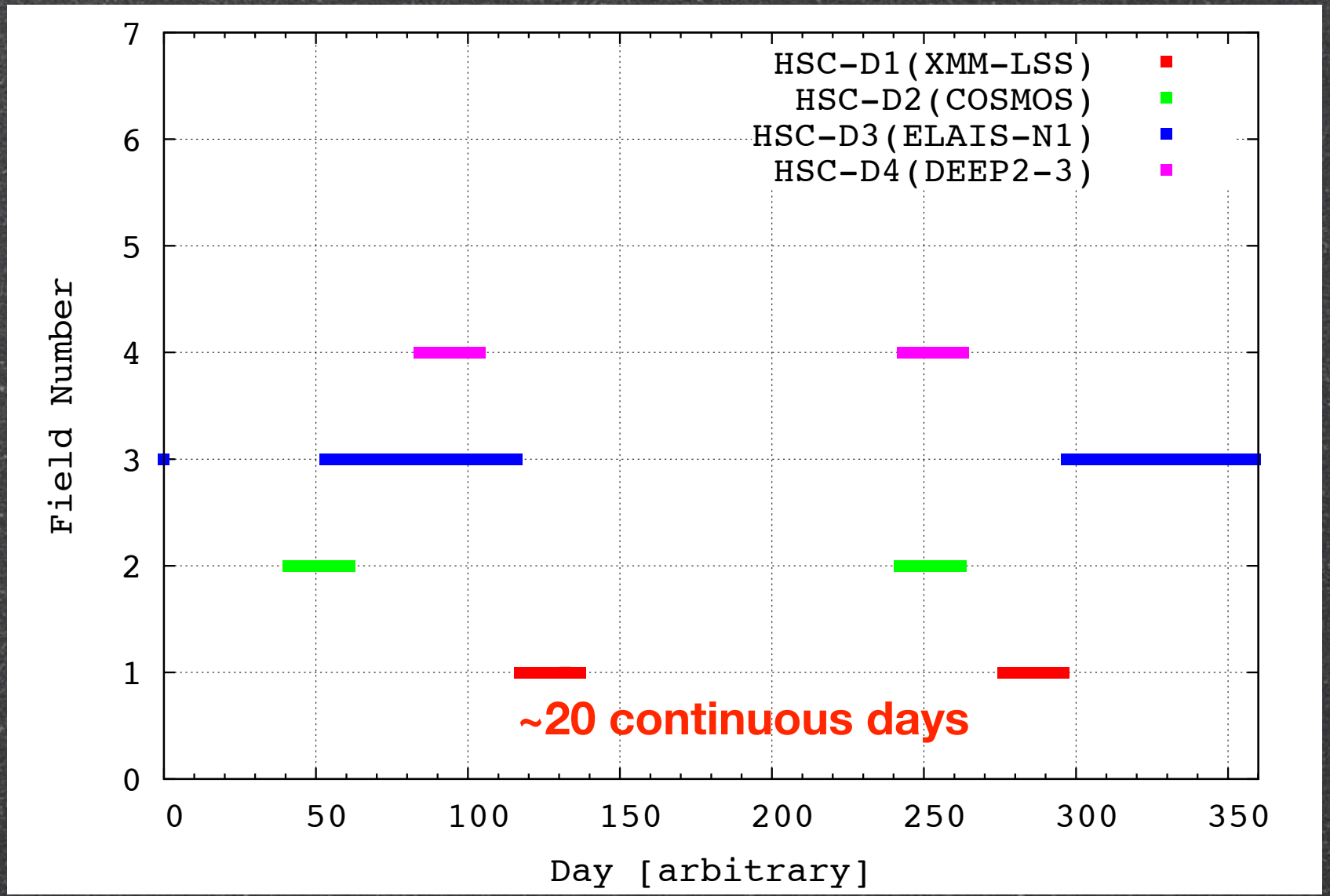
Summary of WISH Survey Plan:

	5σ Depth[1] (AB mag)	Area[2] (deg^2)	Filter Central Wavelength (μm)	Survey Time[3] (days)
Ultra Deep Survey	28	100	1.0, 1.4, 1.8, 2.3	~1300
+ Filter 4 (3μm)	27.5	100	3.0	~270
+ Filter 5 (4μm)	26.5	100	4.0	~45
Ultra Wide Survey	25	1000	1.4, 1.8, 2.3	~45
Extreme Deep Survey	29.5	0.25	1.0, 1.4, 1.8	~30
Total				~1700

Note: (1) zodiacal light at pole assumed. (2) 1 WISH FoV=0.25.
(3) 50% overhead included

Summary of WISH Survey Plan: Visibility

- Visibility at HSC Deep Survey fields (near the equator)
- Visible for ~45 days per year (except for ELAIS-N1)
- The number of days continuously visible is ~20 days



Summary of WISH Survey Plan: Visibility

- Visibility at the ecliptic poles (EPs)
- Visible for ~180 days per year
- The number of days continuously visible is ~180 days