

Synergy between WISH and HSC for galaxy studies

- 1 – statistical nature of galaxy properties
- 2 – Hyper Suprime-Cam
- 3 – galaxy science with WISH only
- 4 – galaxy science with WISH + HSC

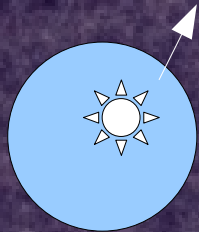
I assume that the previous speakers talked about galaxy science cases and I would like to focus on the following points:

- We need optical data to study galaxies up to $z \sim 4$ and beyond.
- What area/depths are needed?
- How can we collect such optical data? Can we use public data?

Statistical nature of galaxy properties

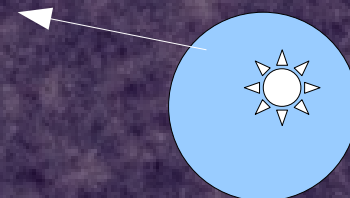
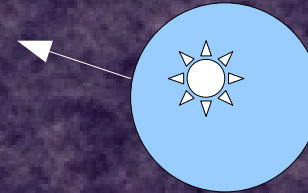
I know this is just like preaching the Buddha...

Galaxies form from density fluctuations

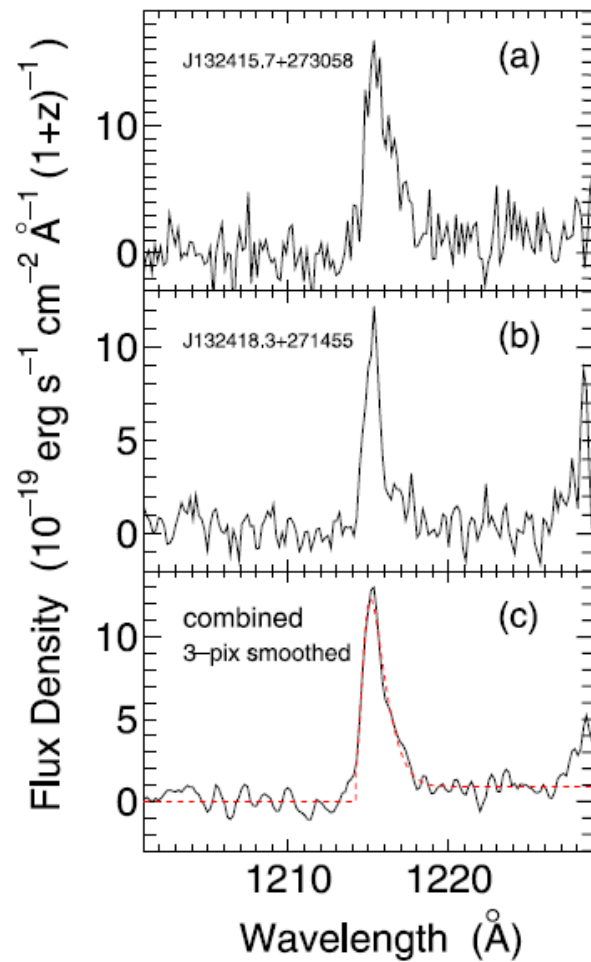


Galaxy formation takes place at peaks of density fluctuations – galaxy formation is a statistical event!

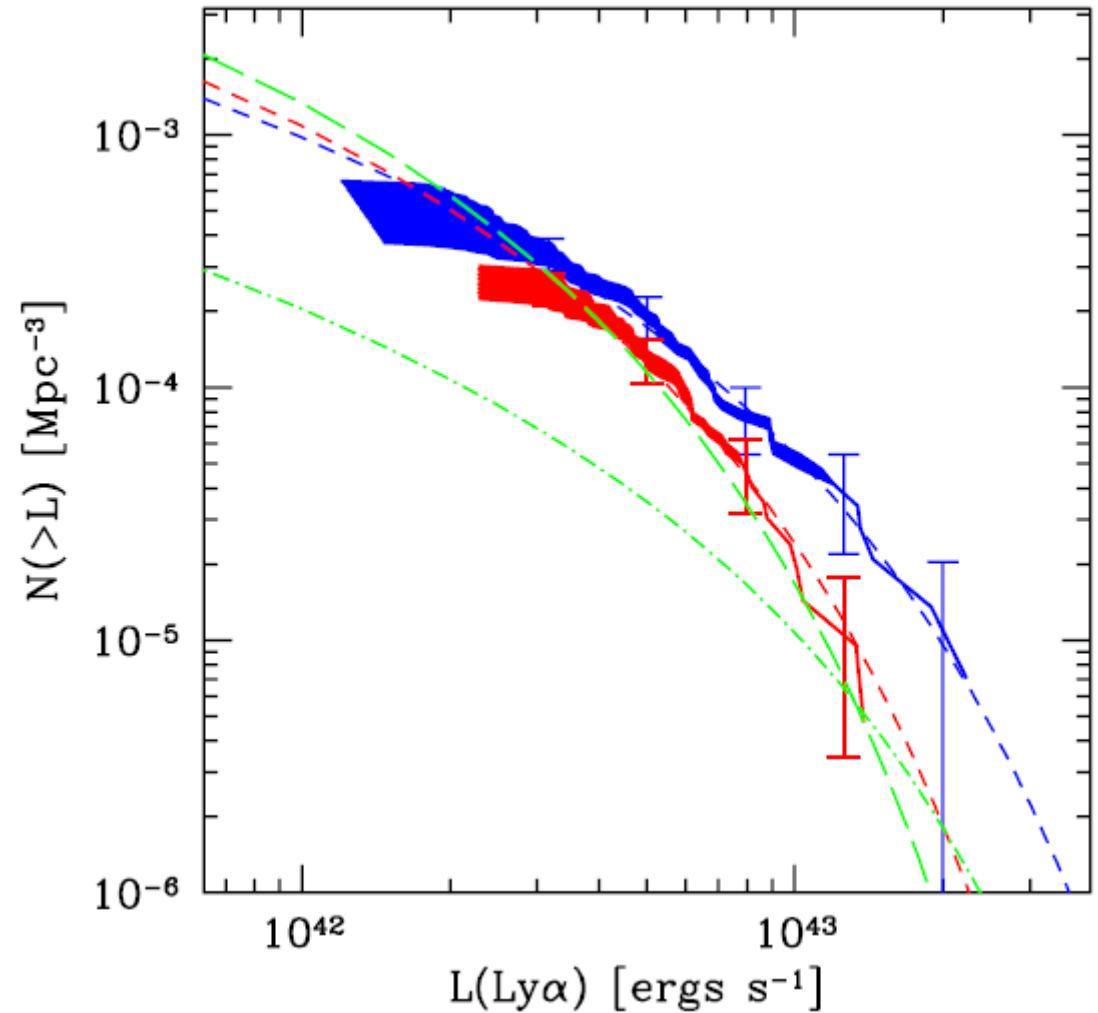
Not surprisingly, each galaxy form and evolve in different ways and the only way to address the galaxy evolution is to study galaxies in a statistical way.



...but, galaxy studies always start with poor statistics

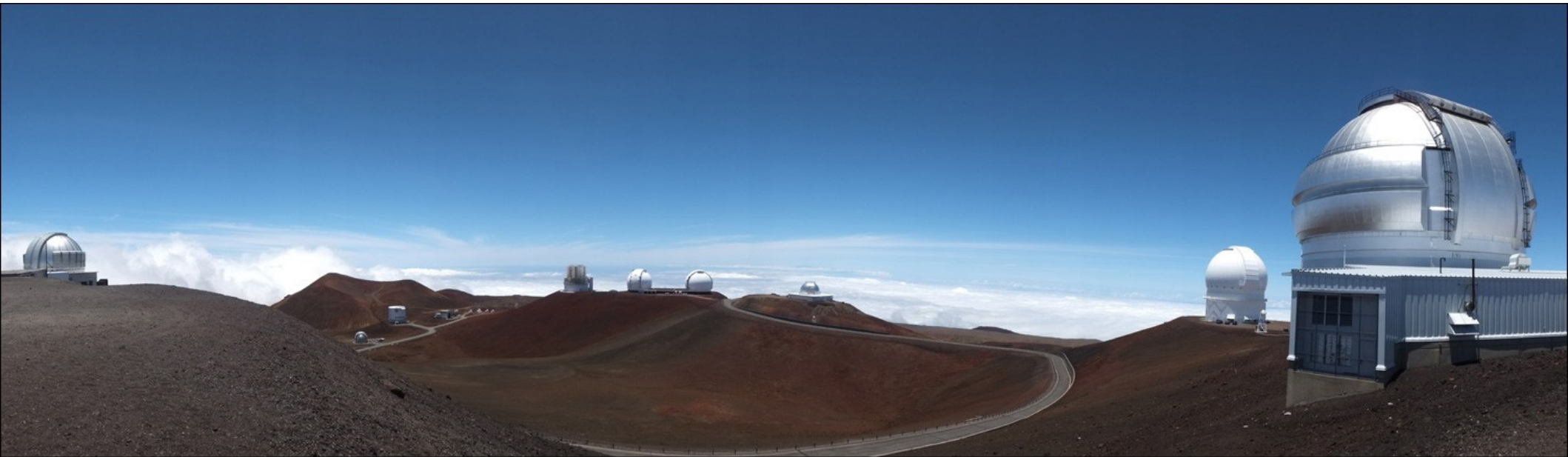


Kodaira et al. 2003



Kashikawa et al. 2011

It's been 10-15 years since the operation of 8-10m telescopes



Most of the up-coming programs are large surveys!

– On-going surveys

Kilo-Degree Survey + VISTA VIKING (1500deg^2 in ugrizZYJKs)

PanSTARRS (3π steradian + a number of surveys)

– (Hopefully) up-coming surveys

Hyper Suprime-Cam ($1000\text{deg}^2 + 30\text{deg}^2 + 4\text{deg}^2$)

Dark Energy Survey ($5000\text{deg}^2 + 6\text{deg}^2$)

– Future surveys

Euclid

LSST

WFIRST

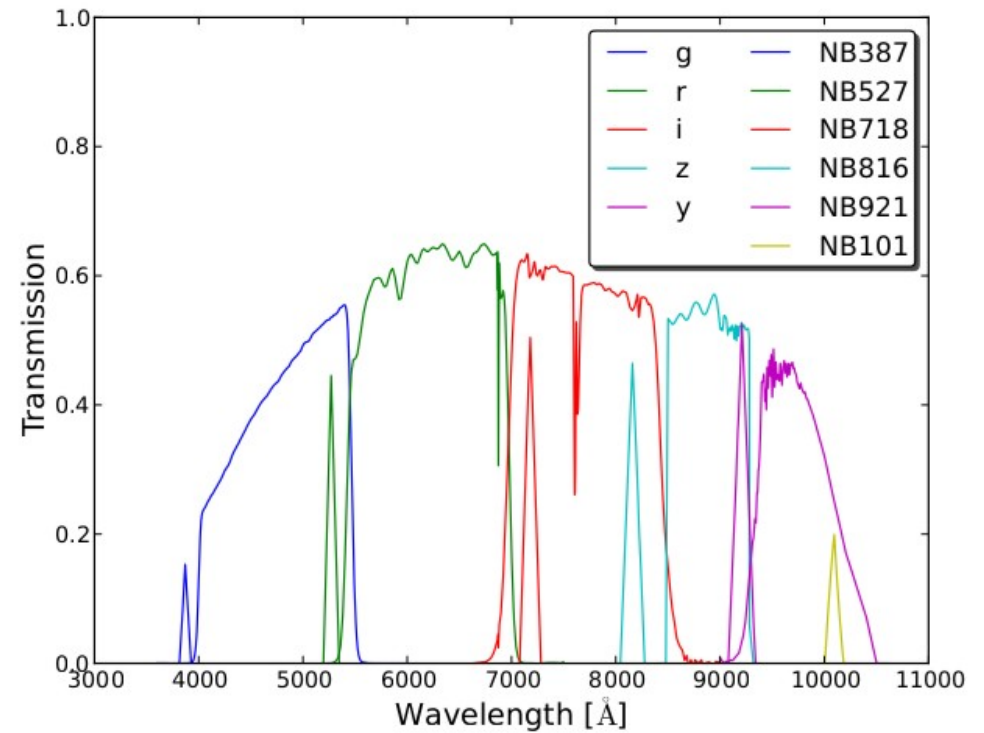
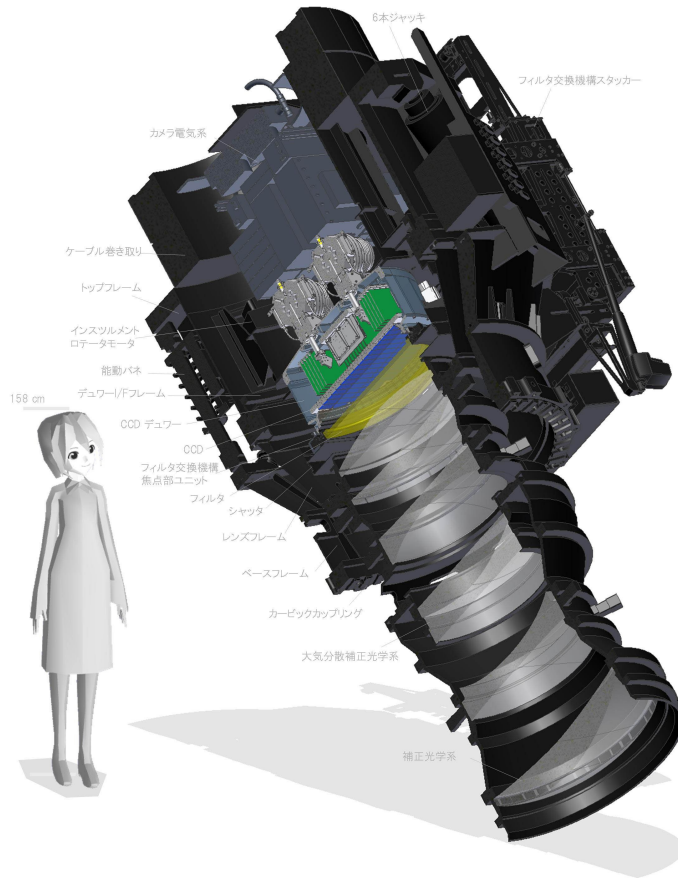
SPICA

WISH

These surveys are mostly driven by cosmology science.

Hyper Suprime-Cam (HSC) survey

Hyper Suprime-Cam



FoV = 1.5phi or 1.77 sq.deg

Strategic survey

Wide-field imaging with Hyper-SuprimeCam: Cosmology and Galaxy Evolution

A Strategic Survey Proposal for the Subaru Telescope

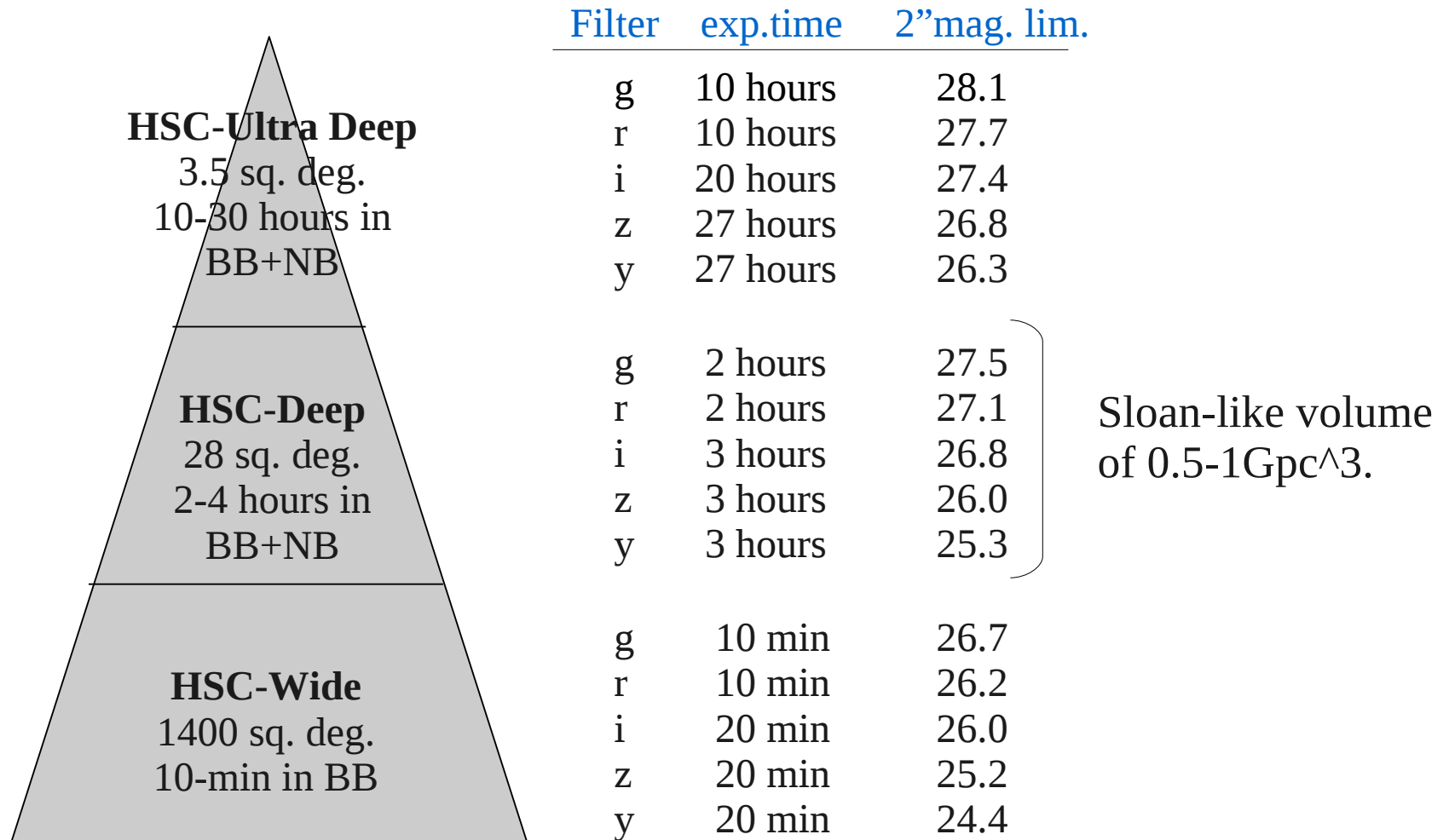
PI: Satoshi Miyazaki (NAOJ)

Co-PI: TBD

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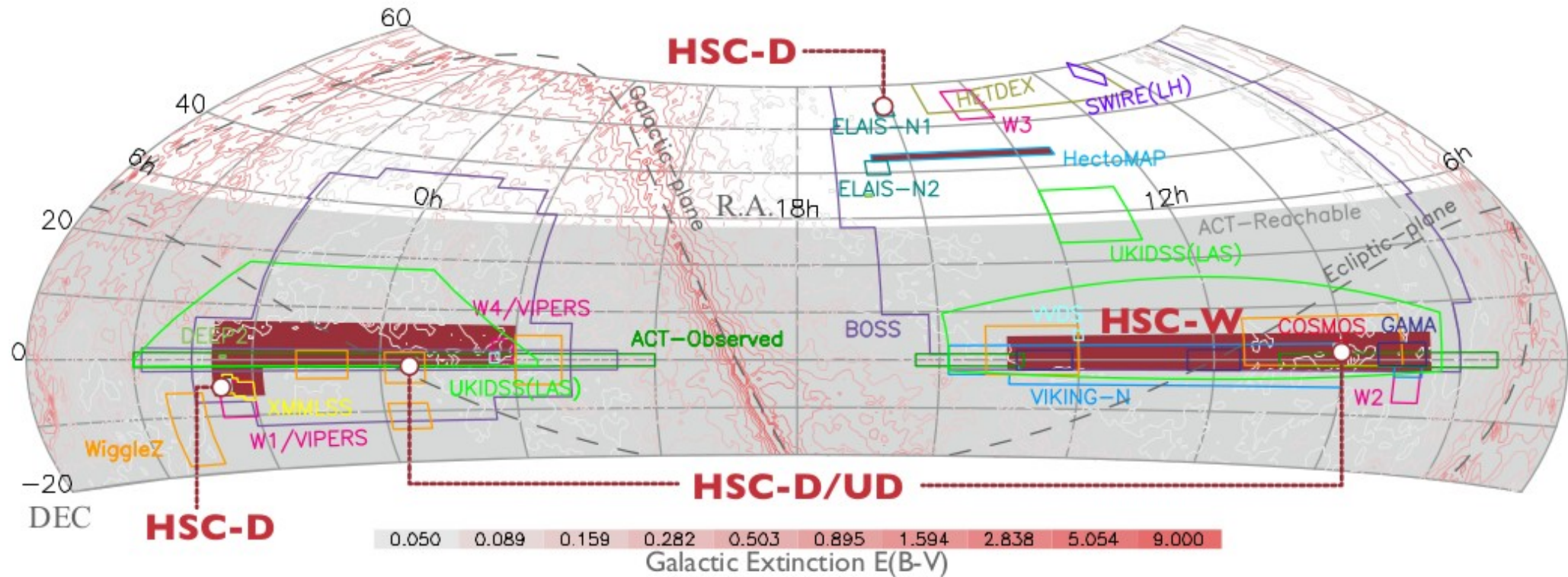
I'm going to say a few words about SSP, but I would suggest that WISH should use the best data available at the time of the launch. So, don't stick with HSC.

Survey strategy



A weather factor is included in the mag limits for D and UD.

Target fields



Wide : Spring/Autumn equatorial region + HectoMAP region

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

Udeep : SXDS (XMM-LSS), COSMOS

Galaxy science with WISH only

WISH?



テレビ番組の字幕ではカタカナで「ウィッシュ」と表記される事が多いが、本人曰く「ういっす」から派生させたので、正確にはひらがなでの表記が正しいとのこと。

出典 ウィキペディア

What do we need for galaxy science?

To study the galaxy evolution

(1) – we need their physical properties

To derive physical properties such as stellar mass

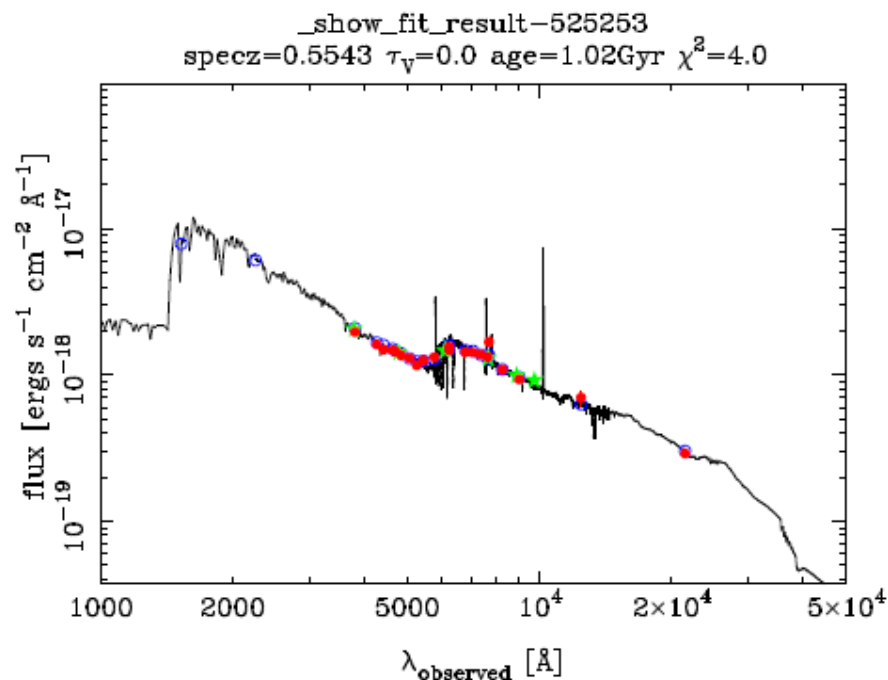
(2) – we need to constrain SEDs of galaxies AND their redshifts

How well can we constrain galaxy SEDs/redshifts with WISH?

I have done a set of photo-z simulations for WISH.

Of course, spec-z's, emission line objects, color-selected galaxies are useful and are complementary to photo-z selected galaxies.

WISH photo-z simulation

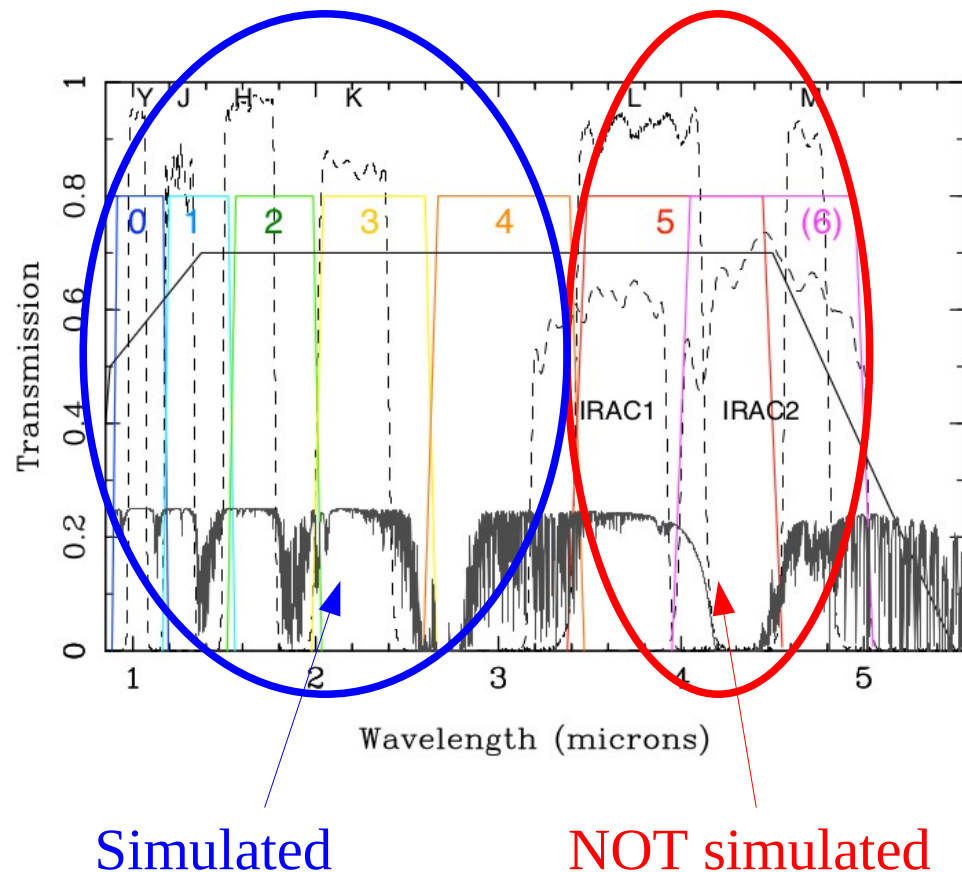


- Observed photometry
- Model photometry
- ★ HSC photometry

- 1 – collect public medium/broad- band photometry in COSMOS
- 2 – collect public/private spec-z's
- 3 – supplement the spec-z's with 30-band photo-z's
- 4 – fit SEDs of objects with $i < 25$
- 5 – convolve the best-fit SED with the WISH filters to derive synthetic mags
- 6 – perturb the photometry and assign mag_err to each object according to the mag limits.

So, the photo-z plots I'm going to show you are not deep enough for WISH, but they should give you an idea of what WISH photo-z's would look like.

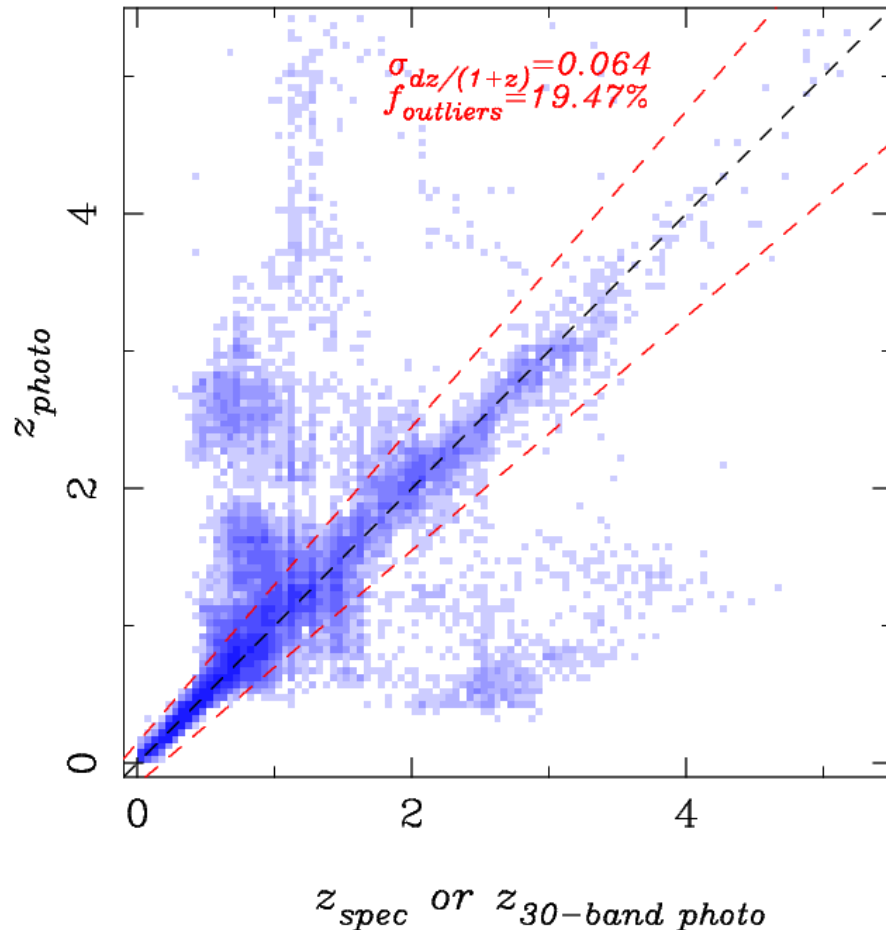
WISH photo-z simulation



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Photo-z's at $i < 25$ based on W0-4 filters.



Filter	$\lambda_{\text{center}} [\mu\text{m}]$	Lim. Mag.	Days
0	1.040	28.0	183.4
1	1.360	28.0	211.3
2	1.775	28.0	271.8
3	2.320	28.0	346.2
4	3.030	28.0	485.6
Total			1498.3

3sigma within 2xFWHM aperture

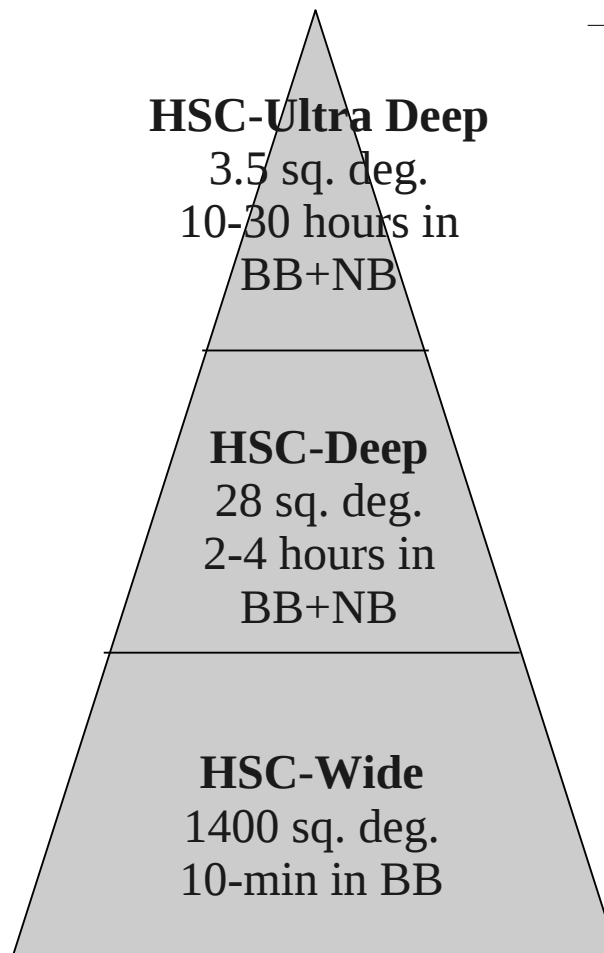
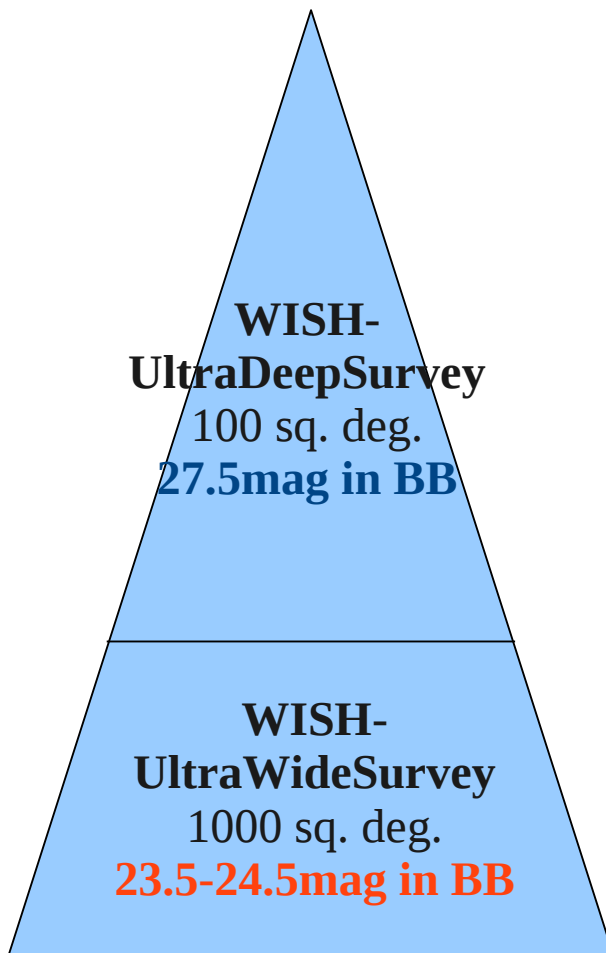
Assumed the UDS depths. The photo-z's are not good enough for galaxy studies...

Galaxy science with WISH

Galaxy science with WISH + HSC

Let's assume HSC for the optical data for now
because I have a code up and running for HSC...

How deep do we need to go with HSC?



Filter	exp.time	2"mag. lim.
g	10 hours	28.1
r	10 hours	27.7
i	20 hours	27.4
z	27 hours	26.8
y	27 hours	26.3
g	2 hours	27.5
r	2 hours	27.1
i	3 hours	26.8
z	3 hours	26.0
y	3 hours	25.3
g	10 min	26.7
r	10 min	26.2
i	20 min	26.0
z	20 min	25.2
y	20 min	24.4

Sloan-like volume
of $0.5-1 \text{ Gpc}^3$.

Let's take these numbers for now.

WISH-UDS + HSC-Deep photo-z

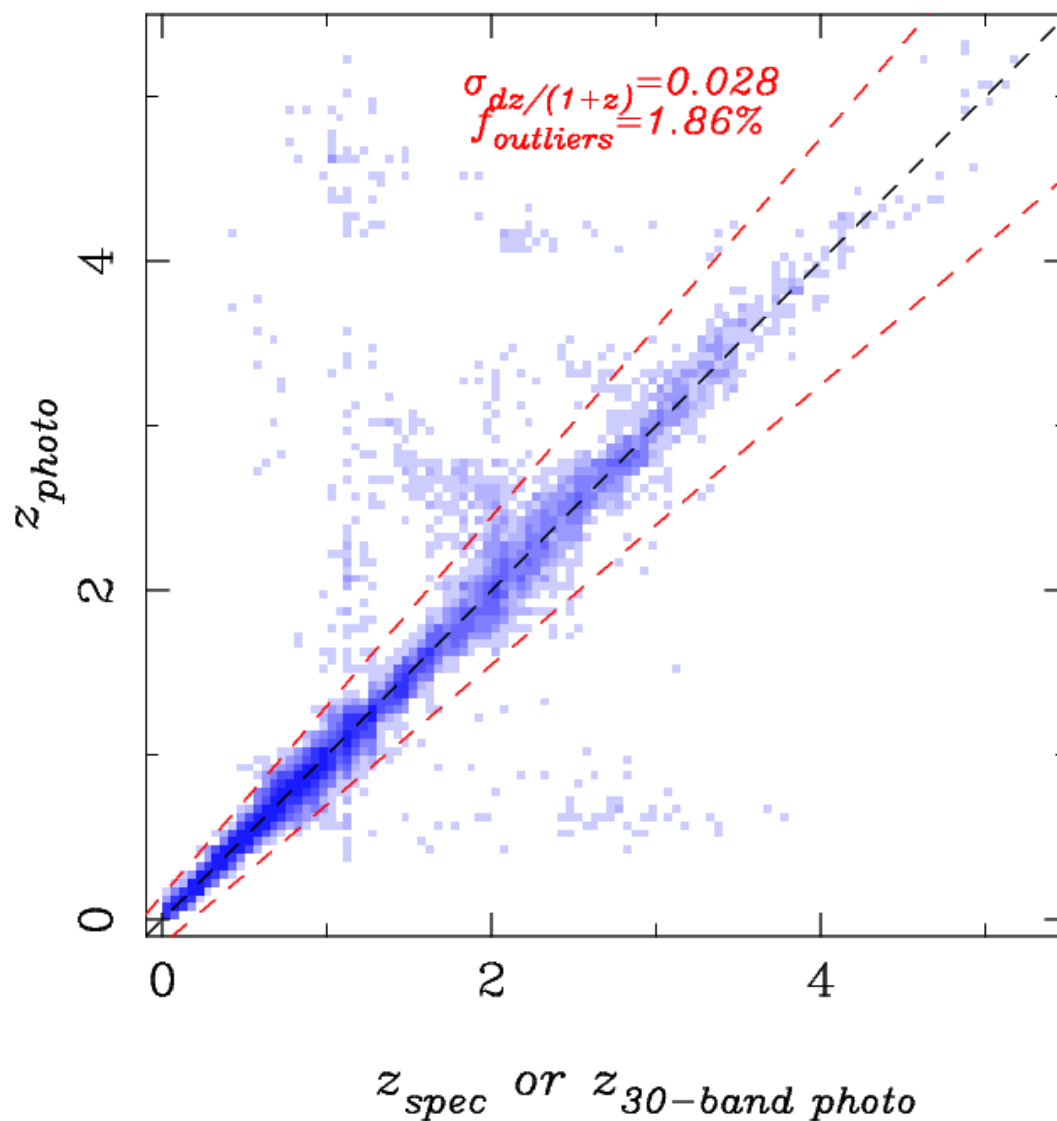
Filter	exp.time	mag. lim.
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g	2 hours	27.5
r	2 hours	27.1
i	3 hours	26.8
z	3 hours	26.0
y	3 hours	25.3

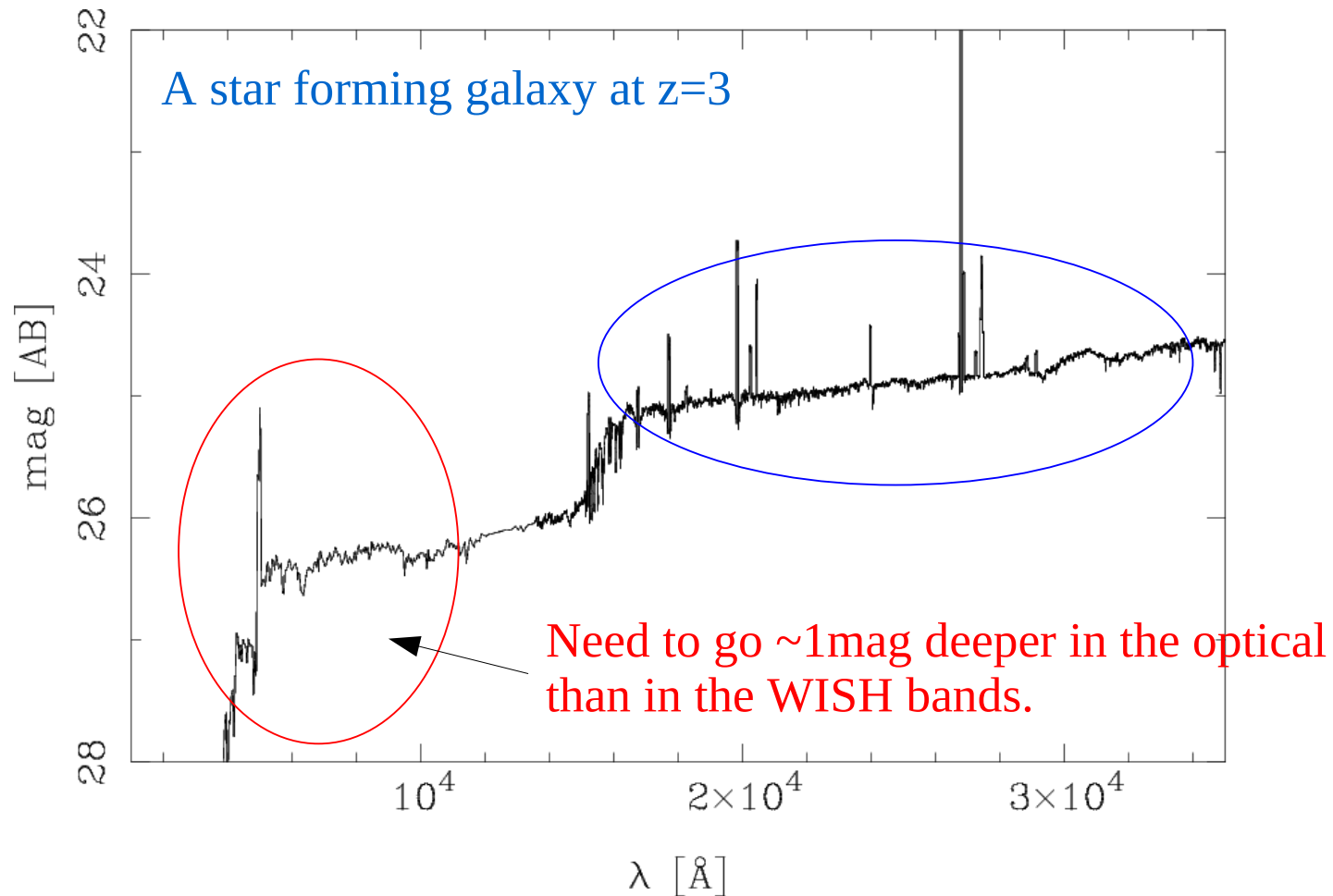
W0	51 days	27.5
W1	59 days	27.5
W2	76 days	27.5
W3	97 days	27.5
W4	136 days	27.5

Total ~420 nights to cover 28 sq.deg.

We clearly need to simulate fainter galaxies (i~26.5)!

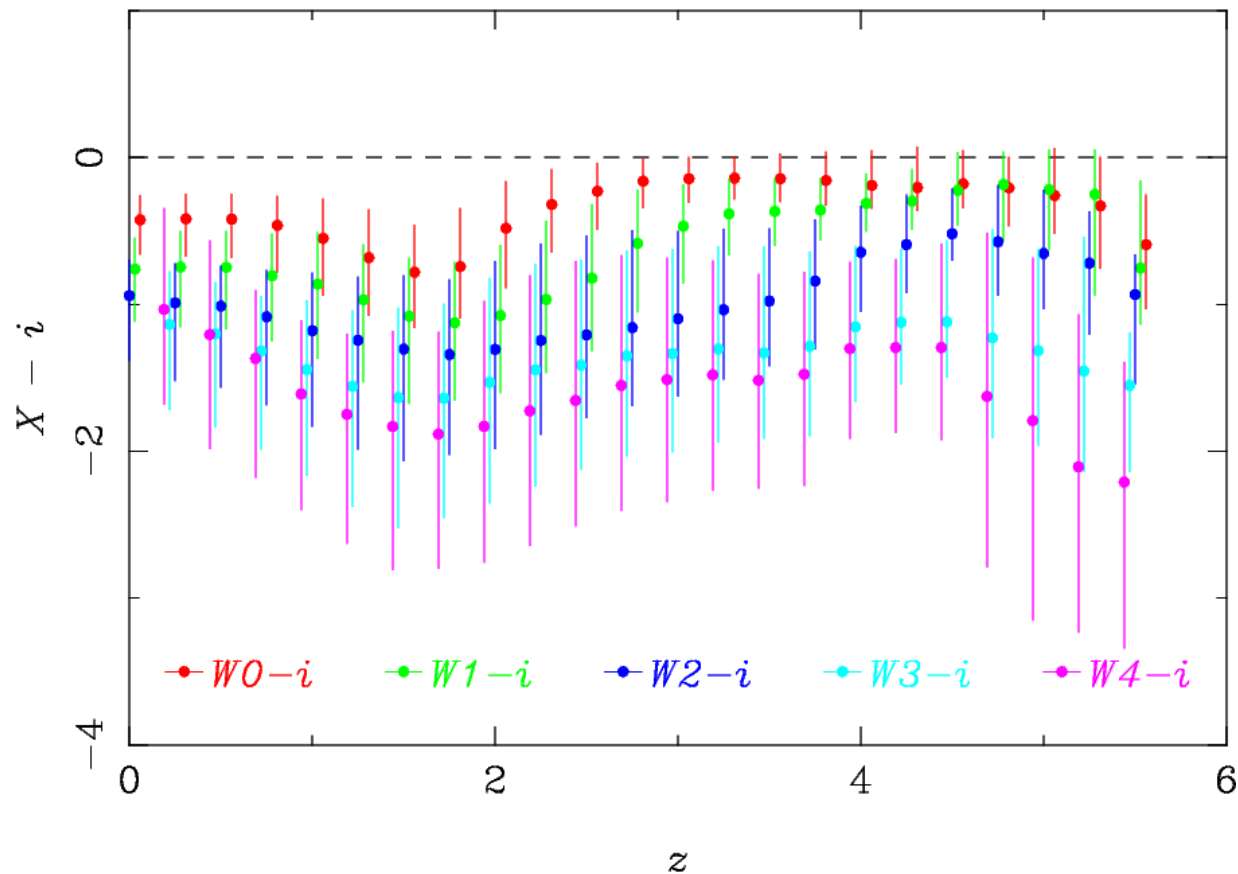


How deep do we need to go with HSC?



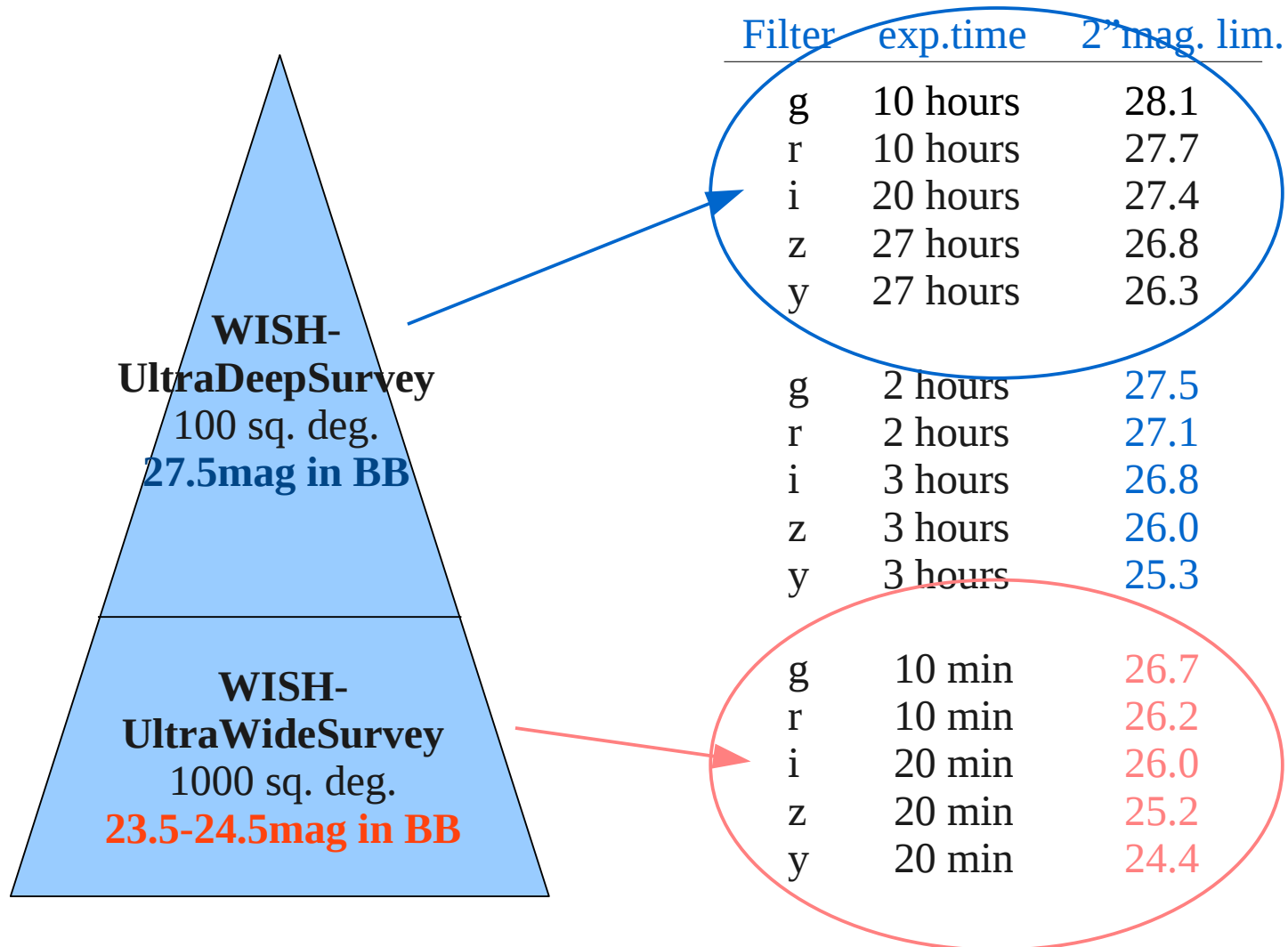
WISH can be shallower by ~ 1 mag than the optical.
That is about the right balance between WISH and optical.

How deep do we need to go with HSC?



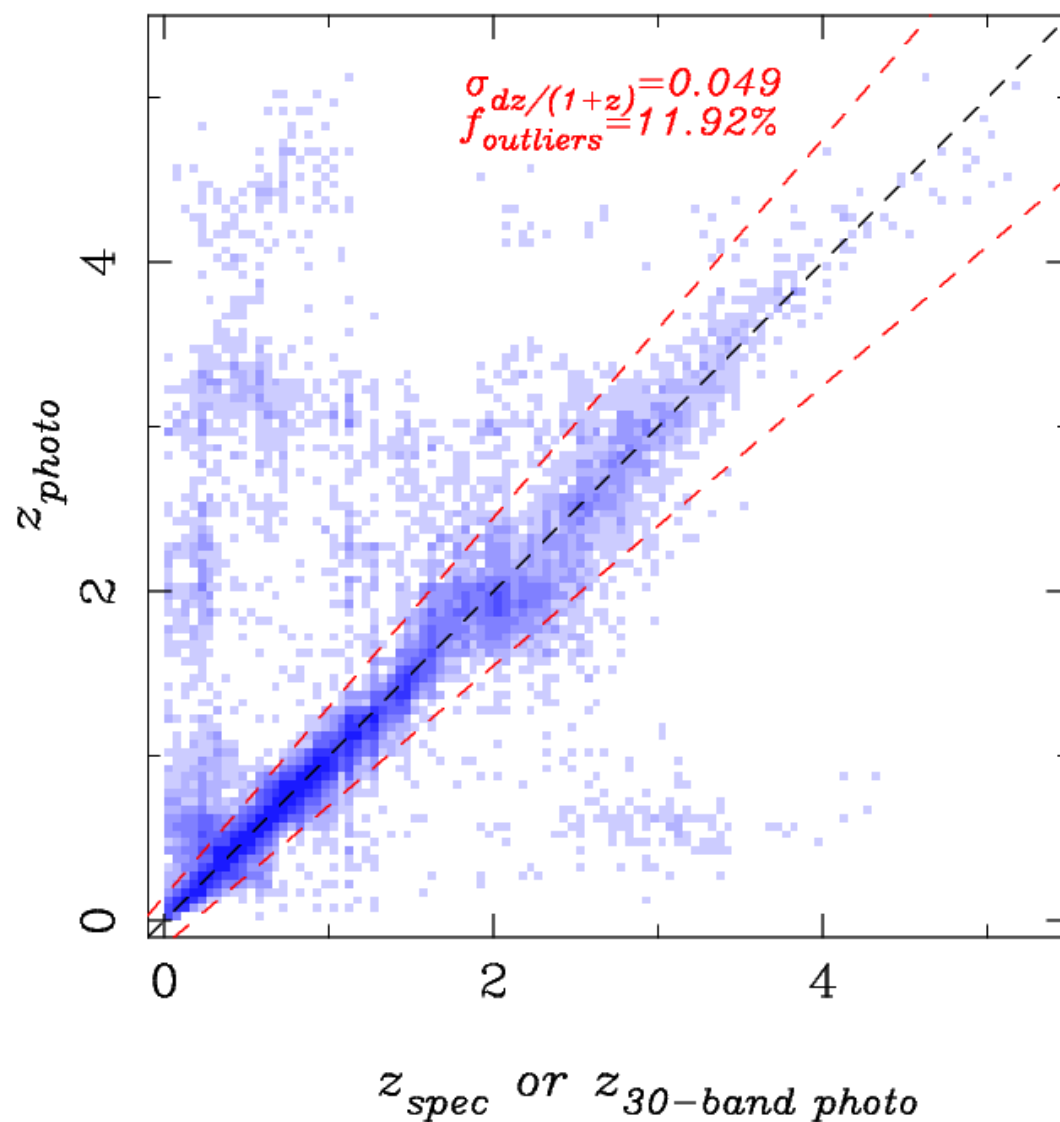
Optimal depths would be roughly:
“**W0/W1/W2 ~ optical**” and “**W3/W4 ~ optical - 1 mag**”

Good match between optical and WISH



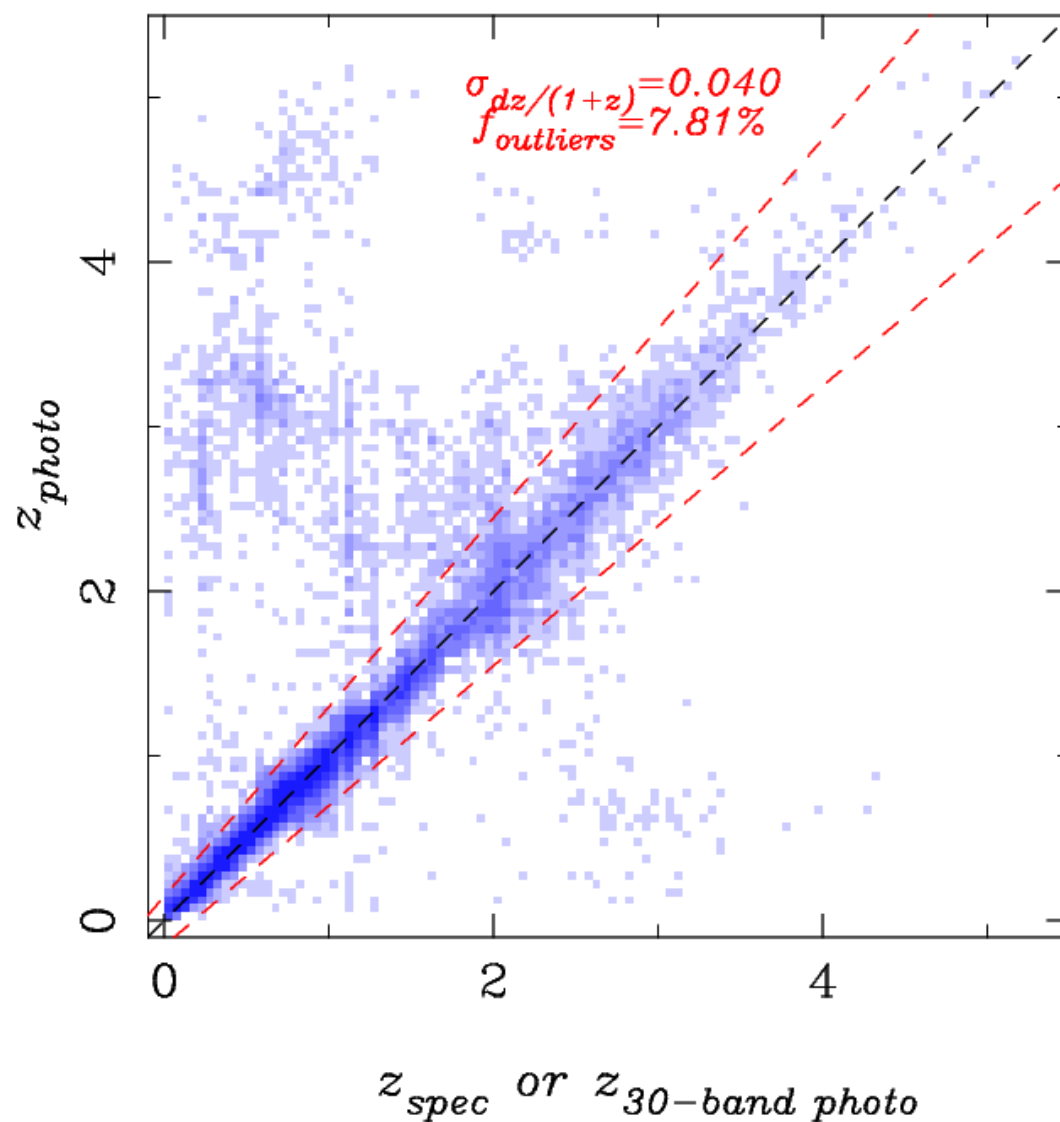
WISH-UWS + HSC-Wide photo-z

Filter	exp.time	mag. lim.
g	10 min	26.7
r	10 min	26.2
i	20 min	26.0
z	20 min	25.2
y	20 min	24.4
W0		—
W1		24.5
W2		24.5
W3		24.5
W4		—

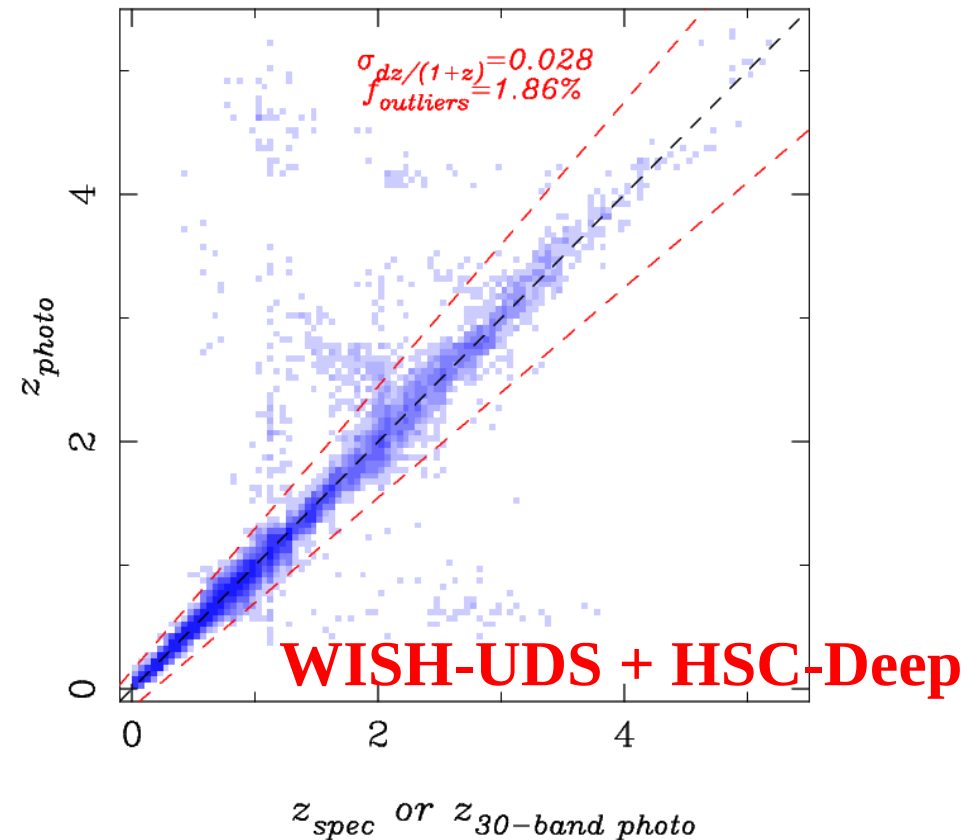
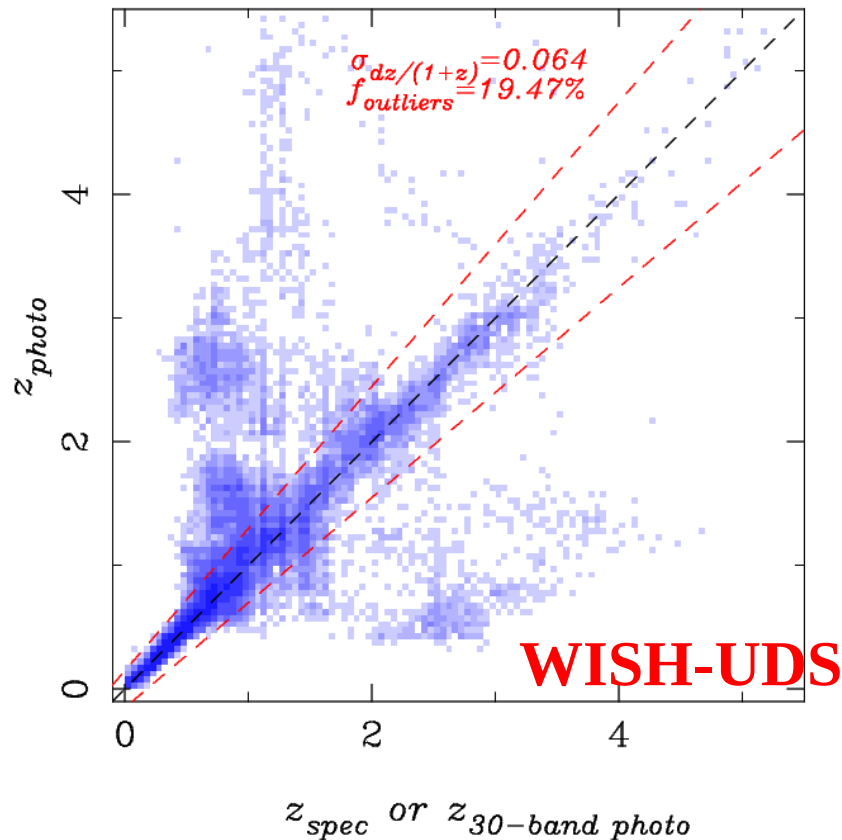


WISH-UWS + HSC-Wide photo-z

Filter	exp.time	mag. lim.
g	10 min	26.7
r	10 min	26.2
i	20 min	26.0
z	20 min	25.2
y	20 min	24.4
W0		24.5
W1		24.5
W2		24.5
W3		24.5
W4		24.5



Short summary of the photo-z simulation



Optimal depths would be very roughly:

10-20 hours of the optical data for WISH-UDS
10-20 min of the optical data for WISH-UWS.

Getting the optical data

OK, I hope I have convinced you that you need deep optical data even if you are interested in low/medium-redshift galaxies.

Now the question is how can we get such deep optical data?

Boundary conditions

- ◆ Need to cover at least ~ 30 sqdeg.
- ◆ Need to go ~ 1 mag deeper in the optical than WISH
- ◆ WISH depths should be unreachable from the ground
- ◆ Stay within realistic observing time.
- ◆ Observe fields where a large number of spec-z's are available.

Option #1 : dedicated HSC obs of WISH-UDS/UWS

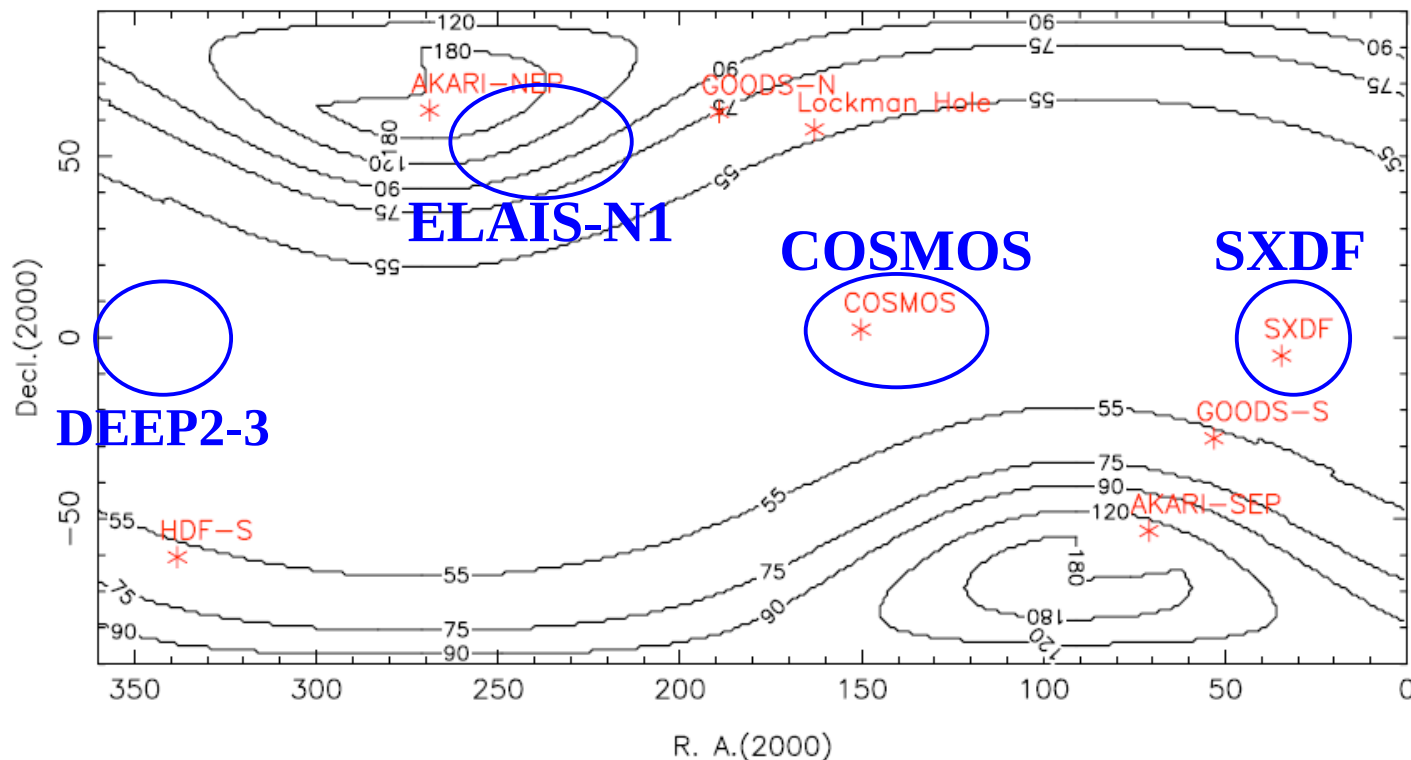
Need to go deep AND wide. HSC is probably the only instrument to achieve this. If you do a completely new HSC survey to WISH-UDS/WDS, you need

~400 nights to cover 100 sqdeg with 10-20 hours exposure time.
~70 nights to cover 1000 sqdeg with 10-20 min exposure time.
(assumed griz imaging, 8 hours per night, no weather loss)

The first one is not realistic. Some compromise between the area and depth has to be made. Perhaps 10-20 hours exposure over 30 sqdeg would be reasonable (~110 nights) ??

Option #2 : WISH + HSC-W/D/UD + dedicated HSC obs

A major problem is the visibility...



Based on the current design of the telescope pointing, the equatorial fields are observable for 40-45 days per year. If we allow 30 / 45 deg against the sun, these fields are observable for 60 / 100 days.

Option #2 : WISH + HSC-W/D/UD + dedicated HSC obs.

A few examples out of many combinatinos:

- (a) Full overlap with HSC-W and partial overlap with HSC-D. HSC-W and WISH-UWS is a good match. Place 4 separate patches of WISH-UDS on HSC-D fields. Build further depth upon these fields with dedicated observation with HSC (10-20 hours with ~100 nights). In this case, the visibility is probably not an issue. Remaining 70sqdeg of WISH-UDS???
- (b) Forget dedicated obs. Go shallower with WISH. E.g., WISH Medium Depth Survey down to ~26.5mag on HSC-Deep fields. This depth is still unreachable from the ground, so this is unique.

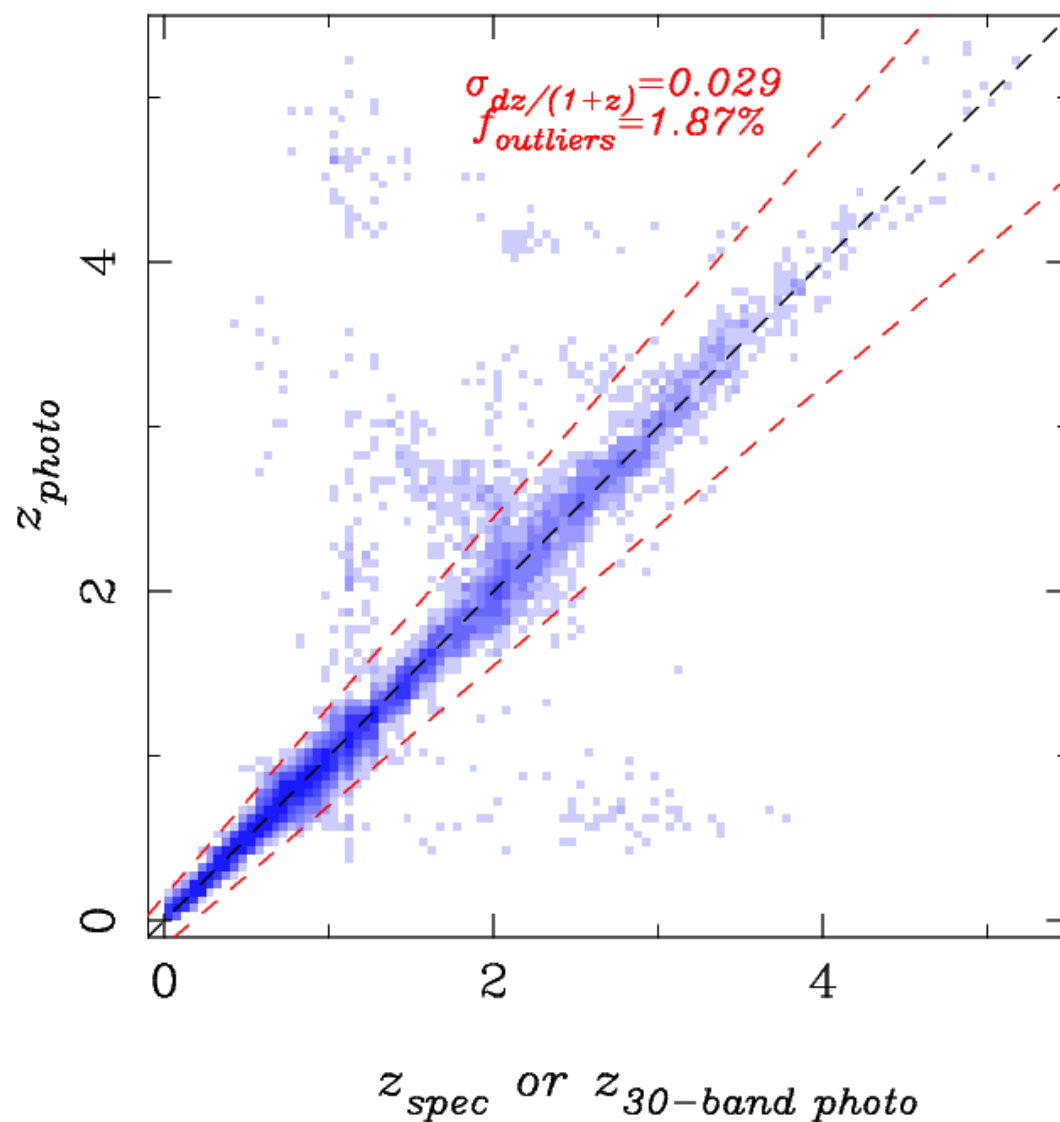
WISH-MDS + HSC-Deep photo-z

Filter	exp.time	mag. lim.
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g	2 hours	27.5
r	2 hours	27.1
i	3 hours	26.8
z	3 hours	26.0
y	3 hours	25.3

W0	8 days	26.5
W1	10 days	26.5
W2	13 days	26.5
W3	16 days	26.5
W4	23 days	26.5

~70days in total.



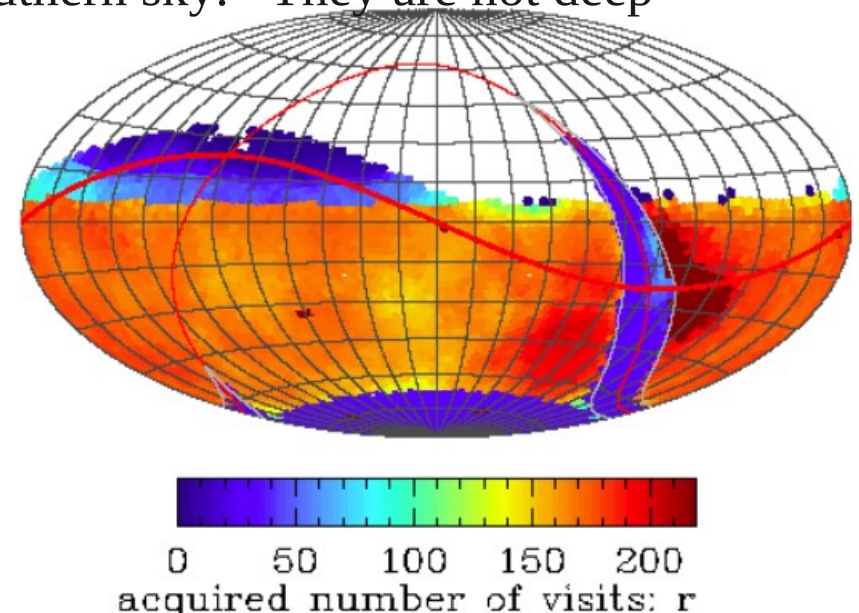
Option #3 : WISH + other surveys

1 – **LSST** goes deeper and wider than HSC, but a problem is that they observe the southern sky. A major difference from the HSC-W/D/UD data is that LSST is rather uncertain at this point – **we don't know when it starts and when they release the data**. Note that they build-up the data over the years and so their initial data are probably very shallow.

2 – **KIDS** is also observing the equator and southern sky. They are not deep enough to be interesting to WISH.

3 – **DES** is yet another survey in the south.

4 – **PanSTARRS** is in the north, but I could not get detailed info about this survey...



LSST survey footprint

Summary

Summary

- (1) You will need deep optical data to study $z < 4-5$ galaxies.
- (2) WISH-UDS is very wide and very deep. Need to make some compromise for optical follow-up obs. Boundary conditions include
 - (a) you need a $> \sim 30$ sqdeg area to probe a large enough volume.
 - (b) you need to go ~ 1 mag deeper in the optical than WISH.
 - (c) WISH depths should be unreachable from the ground
 - (d) Stay within realistic observing time.
 - (e) **Meet science requirements.**
- (3) These will naturally lead to use HSC or public data from LSST. Other public surveys are not going to be deep enough to be interesting to WISH.
- (4) A few options that I talked about include:
 - (i) WISH-UWS + HSC-Wide is a nice combination.
 - (ii) WISH-UDS + HSC-Deep + dedicated HSC obs to get to 10-20 hours.
 - (iii) WISH-Medium deep survey of HSC-UD/D down to 26.5 (5sigma)
 - (iv) Use LSST data (but when they start the survey and release the data is unknown)

ういっしゅ！

