"Galaxies in a Modestly Very Early Universe"

Hyper Suprime-Cam and WISH

1. HSC
2. HSC Strategic Survey
3. Hope on WISH

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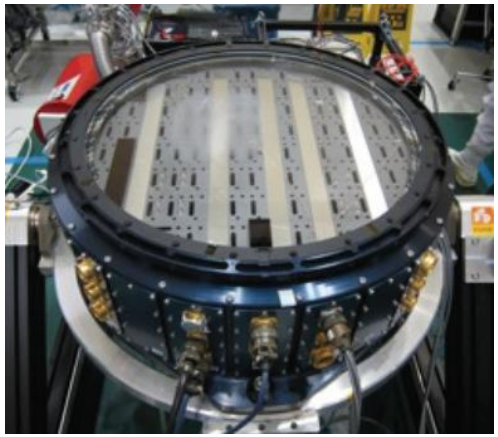
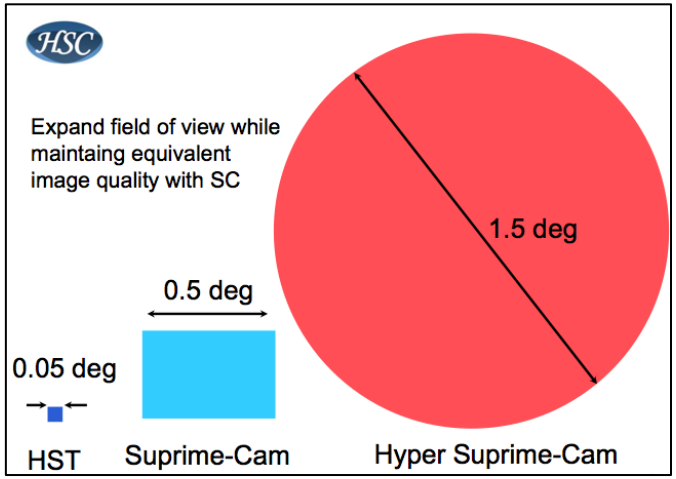
Hyper Suprime-Cam

Characteristics

Instrument weight	3.2 tons (estimate)
Field of View	1.5° diameter, 1.77 deg^2
Vignetting	0 at 0.15°; 26% at edge
Pixel scale	15μm = 0.16″
Delivered Image Quality	$D_{80} < 0.2''$ in all filters
CCDs	116 2K × 4K Hamamatsu Fully-Depleted
CCD QE	40% at 4000Å, 10,000Å; 95% at peak (at -100°C)
CTE	0.999999
Readnoise	4.5 e$^-$
Data Rate	2.31 GBytes/exposure (16-bit A-to-D)
Focal ratio at Focal Plane	2.25
Overhead between Exposures	29 sec
Wide-Field Corrector	7 optical elements, ADC
Shutter	Roll-Type
Filters	$grizy$ + 4 NB; Table ??
Filter Exchanger	6 filters installed at a time
Filter Exchange Time	10 minutes

Developed at NAOJ
(PI=S.Miyazaki)

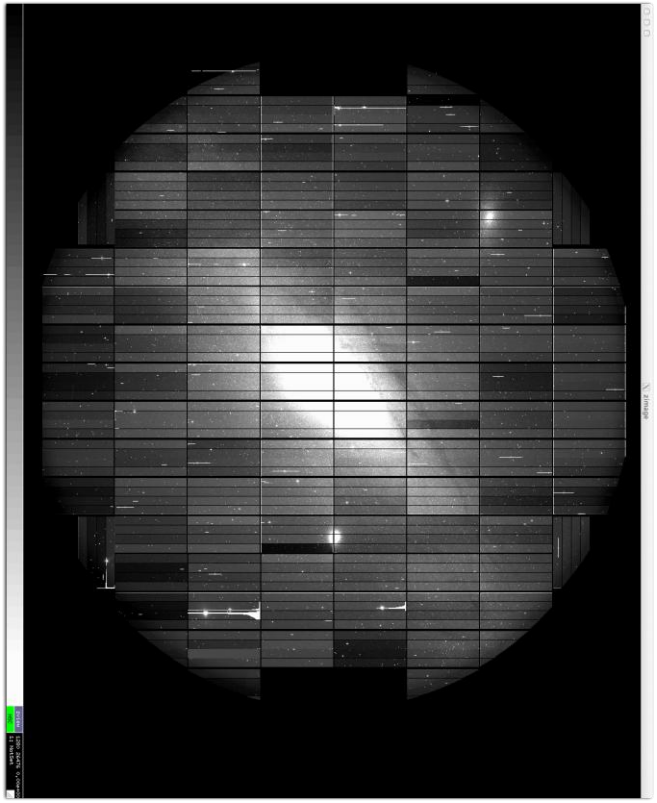




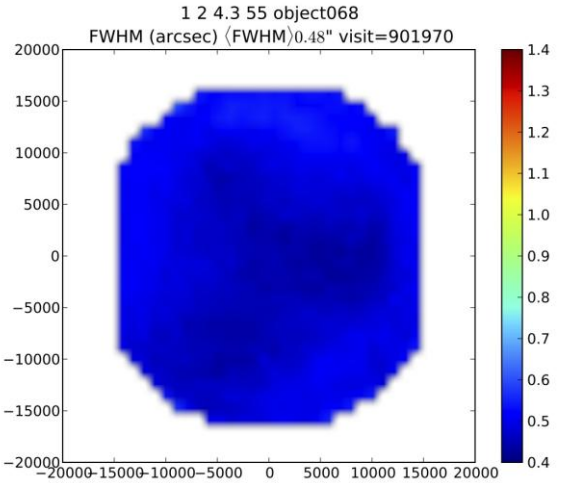
Status and Schedule

2012 Aug: Engineering First Light
2013 Jan: First Light for all 116 CCDs
2014: Open to common use

Last February's test observation



FWHM~0.5" over entire FoV



http://anela.mtk.nao.ac.jp/hscblog/builder/

HSC Strategic Survey

A Subaru Strategic Survey Proposal

Wide-field Imaging with Hyper Suprime-Cam: Cosmology and Galaxy Evolution

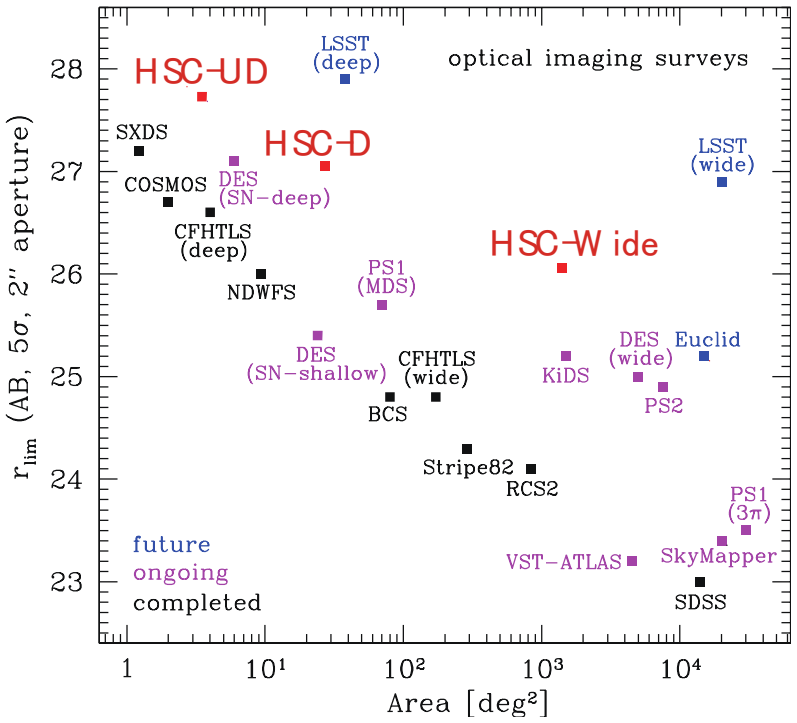
Satoshi Miyazaki et al.
(over 100 people incl. Princeton and Taiwan)

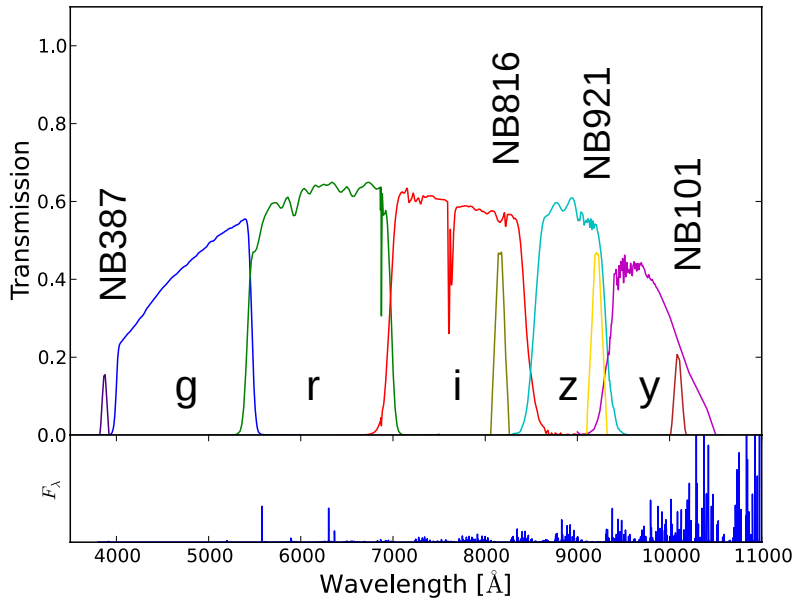
Requesting 300 nights over 5 years
Submitted last October
Currently under refereeing
Will start early next year

White Paper:
http://hscsurvey.pbworks.com/w/page/60427271/HSCWhitePaper

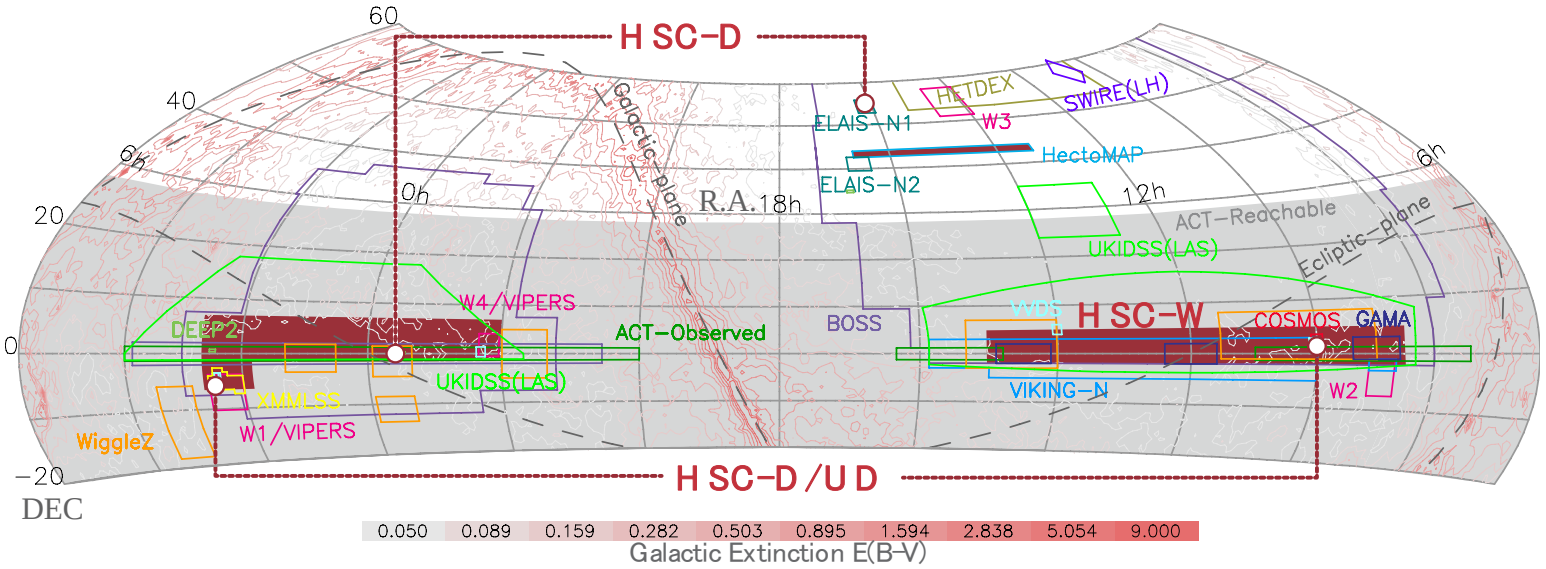
Three Layers

Layer	Area [deg^2]	# of HSC fields	Filters & Depth	Comoving volume [h^{-3}Gpc^3]	Key Science
Wide	1400	916	$grizy$ ($r \simeq 26$)	$\sim 4.4\,(z < 2)$	WL cosmology, $z \sim 1$ gals, cl
Deep	27	15	$grizy$+3NBs ($r \simeq 27$)	$\sim 0.5\,(1 < z < 5)$	$z < 2$ gals, reionization, WL
Ultradeep	3.5	2	$grizy$+3NBs ($r \simeq 28$)	$\sim 0.07\,(2 < z < 7)$	$z > 2$ gals, reionization, SNe

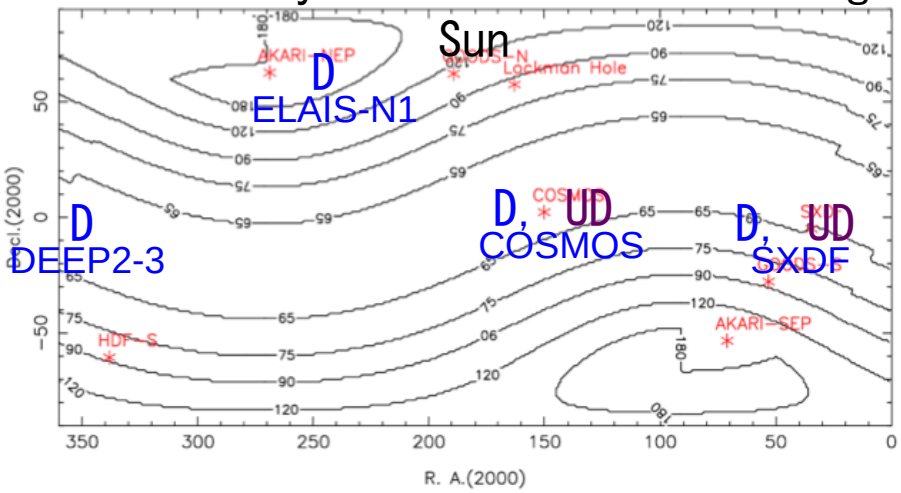




Survey Fields

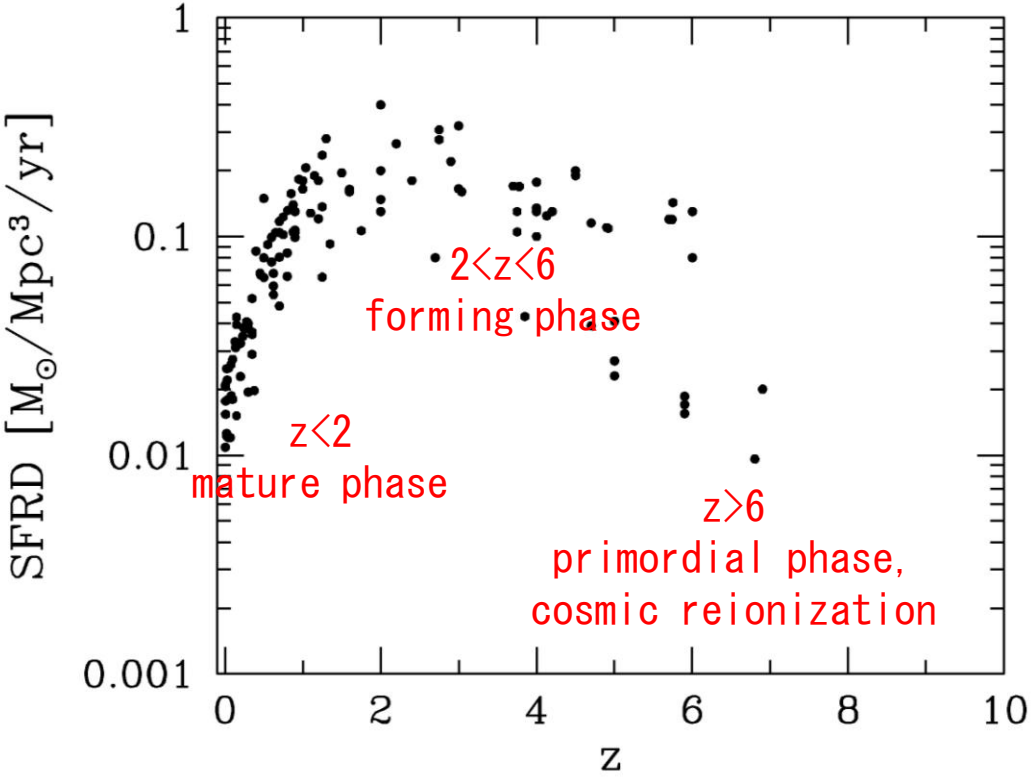


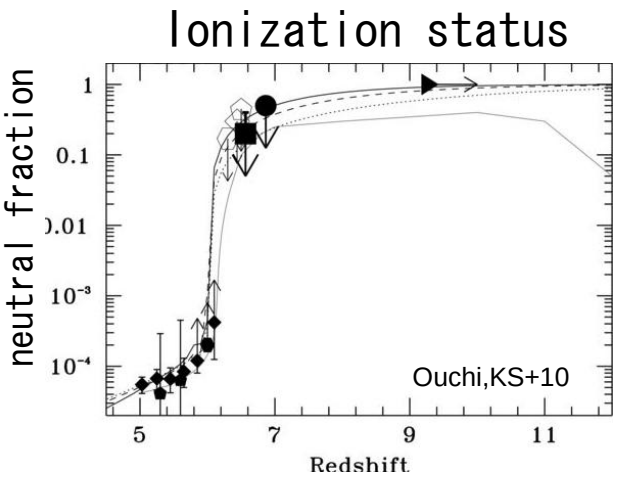
WISH visibility in the case of 30° against Sun



Yamada 2012

HSC Survey covers most of the history of galaxies





Wide

Deep

UltraDeep

Huge Samples of Lyα Emitters and Ly-break Galaxies

LAEs

narrow-band	NB387	NB816[a]	NB921[a]	NB101[a]
redshift	2.18 ± 0.02	5.71 ± 0.05	6.57 ± 0.05	7.30 ± 0.04
$N^b_{\rm UD}$	–	3.9k (60)	1.7k (30)	39 (0)
$N^b_{\rm D}$	9.0k (730)	14k (360)	5.5k (100)	–
$V^c_{\rm UD}$	–	1.2	1.2	0.79
$V^c_{\rm D}$	6.0	9.6	9.8	–
$L({\rm Ly}\alpha)^d_{\rm UD}$	–	1.5	2.5	6.8
$L({\rm Ly}\alpha)^d_{\rm D}$	2.7	2.9	4.1	–
science[e]	LA	LA, CR	LA, CR	LA, CR

6000 LAEs in UD
30000 LAEs in D

LBGs

sample	BX/BM[a]	u-drop[a]	g-drop	r-drop	i-drop	z-drop	y-drop[b]
redshift	2.3 ± 0.5	3.0 ± 0.5	3.8 ± 0.5	5.0 ± 0.5	5.9 ± 0.5	6.8 ± 0.5	7.8 ± 0.3
$N^c_{\rm UD}$	0.9M	0.22M	0.24M	50k	11k	700	2
$N^c_{\rm D}$	0.8M	98k	1.1M	0.2M	34k	99	0
$N^c_{\rm W}$	–	–	17M	1.9M	38k	4	–
$V^d_{\rm UD}$	16	16	15	14	12	11	2.6
$V^d_{\rm D}$	129	129	122	108	98	89	24
$V^d_{\rm W}$	–	–	6100	5400	4900	4450	–
$M^e_{\rm UD}$	$-18.0/-17.0$	-18.3	-18.2	-19.0	-19.9	-20.6	-21.6
$M^e_{\rm D}$	-19.5	-20.8	-18.8	-19.6	-20.4	-21.6	-24.1
$M^e_{\rm W}$	–	–	-19.8	-20.6	-21.6	-22.5	–
science[f]	GE	GE	GE	GE	GE	GE, CR	CR

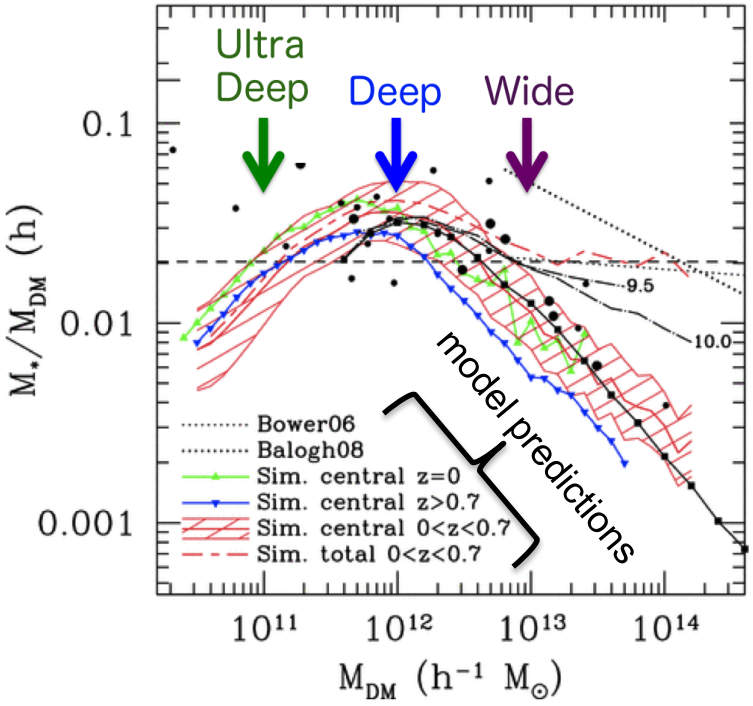
1.4M LBGs in UD
2.2M LBGs in D
19M LBGs in W

High-z Science: Galaxies in Dark Haloes

Tie galaxy properties to their hosting halo masses to physically understand galaxy evolution

- galaxy properties from multiwavelength data
- halo masses from clustering

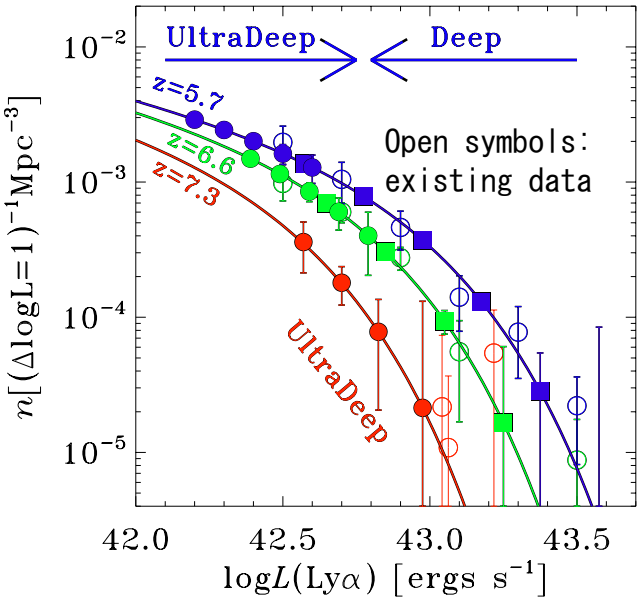
Star formation efficiency against halo mass



High-z Science: Cosmic Reionization

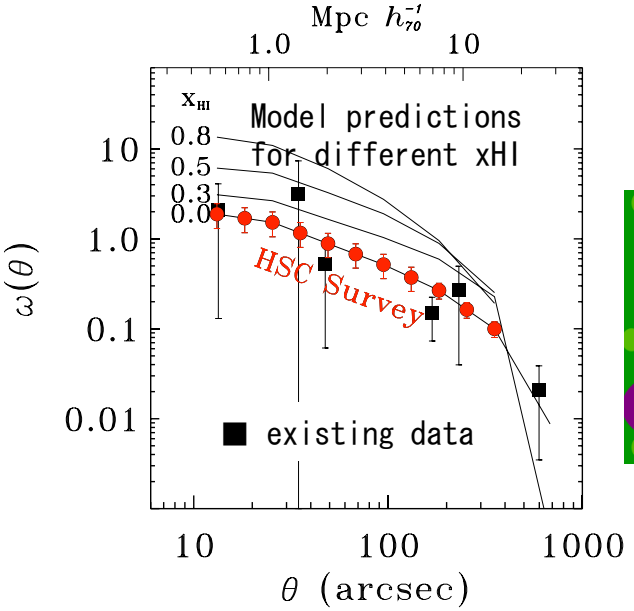
Cosmic reionization occurred somewhere from z~10 to z~6
Constrain hydrogen neutral fraction xHI at z~7 using LAEs
z=6.6: Estimate xHI independently from LF(Lya) and clustering
Map out ionizing topology using Deep-layer 27deg^2 sample
z=7.3: First meaningful constraint for z>7
Constrain ionizing photon number density with LBG samples

LF(Lyα)



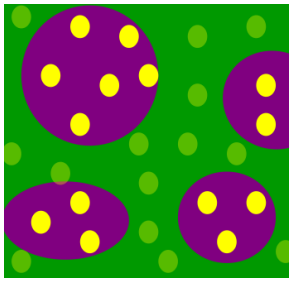
LF(Lyα) will decrease with increasing xHI

Angular Corr Fn



A distinct pattern will appear in ACF
due to inhomogeneous reionization

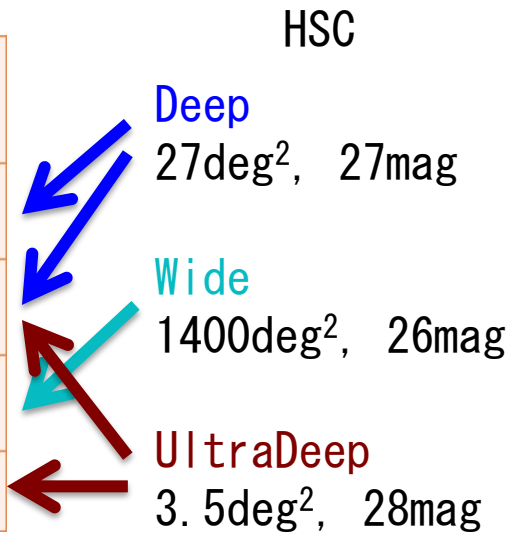
Illustration of Inhomogeneous reionization



~100Mpc

WISH Survey Plan

	Depth (3 σ) (AB mag)	Area	Example of the Filters (a plan, to be determined)
Ultra Deep Survey (UDS)	28	100 deg^2	1.0,1.4,1.8, 2.3, 3.0 μm
Multi-Band Survey (MDS)	28	10 deg^2	4.0
Ultra Wide Survey (UWS)	24-25	1000 deg^2	1.4, 1.8, 2.3, (3.0, 4.0)
Extreme Survey	29-30	0.25 deg^2	1.0, 1.4, 1.8, (3.0, 4.0)



Hope on WISH

- Launched successfully
- Observe HSC Survey fields
  - stellar populations
  - go beyond z ~ 8
- Add narrow-band filters

Filters and Depths

Layer	Filter	Exp.[a] (# of epochs)	Total[b] nights	Lim. mag.[c] (5σ, $2''$)	Moon[d] phase	Requirement(s)[e]	Main scientific driver(s)[f]
Wide	g, r	10 min (3)	53	26.5, 26.1	d	photo	photo-z, $z \lesssim 2$ gals, QSO
Wide	i	20 min (6)	53	25.9	d	FWHM $\lesssim 0.7''$	WL, $z \lesssim 2$ gals, QSO
Wide	z, y	20 min (6)	108	25.1, 24.4	g	photo	photo-z, clusters, $z \sim 1$ gals, $z \sim 6$–7 QSO
Deep	g, r	1.4 hrs (10)	7.3	27.5, 27.1	d	cadence	SNeIa
Deep	i	2.1 hrs (10)	5.4	26.8	d	FWHM $\lesssim 0.7''$, cadence	WL calibration, SNeIa
Deep	z	3.5 hrs (10)	9.1	26.3	g	cadence	$z \lesssim 2$ gals, ionization topology, SNeIa, QSO
Deep	y	2.1 hrs (10)	5.4	25.3	g	cadence	$z \lesssim 2$ gals, SNeIa, QSO
Deep	$N387$	1.4 hrs ($\simeq$10)	3.6	24.5	d	photo	$z \simeq 2.2$ LAEs & LABs
Deep	$N816$	2.8 hrs ($\simeq$ 10)	7.2	25.8	g/d	photo	ionization topology, $z \simeq 5.7$ LAEs & LABs
Deep	$N921$	4.2 hrs ($\simeq$ 10)	11	25.6	g/d	photo	ionization topology, $z \simeq 6.6$ LAEs & LABs
UD	g, r	7 hrs (20)	4.8	28.1, 27.7	d	cadence	$z \gtrsim 2$ gals, SNeIa
UD	i	14 hrs (20)	4.8	27.4	d	cadence	$z \gtrsim 2$ gals, SNeIa, QSO
UD	z, y	18.9 hrs (20)	13	26.8, 26.3	g	cadence	$z \gtrsim 2$ gals, SNeIa, QSO
UD	$N816$	10.5 hrs ($\simeq$ 10)	3.6	26.5	g/d	photo	$x_{\rm HI}(5.7)$, $z \simeq 5.7$ LAEs & LABs
UD	$N921$	14 hrs ($\simeq$ 10)	4.8	26.2	g/d	photo	$x_{\rm HI}(6.6)$, $z \simeq 6.6$ LAEs & LABs
UD	$N101$	17.5 hrs ($\simeq$ 10)	6.1	24.8	g/d	photo	$x_{\rm HI}(7.3)$, $z \simeq 7.3$ LAEs