

# Subaru/HSC Survey & DUNES<sup>2</sup>

*(Deep UKIRT NEar-IR Steward Survey)*

Eiichi Egami, Yun-Hsin Huang, Xiaohui Fan

# Goals

- Inform interested Steward researcher of the existing opportunity to use proprietary HSC-Deep/Ultradeep & DUNES<sup>2</sup> data for their science projects.
- To identify a group of potential users for the HSC and DUNES<sup>2</sup> data.
- Note: **The main goal today is to provide an overview**; For more detailed discussion needed for project planning, we could arrange follow-up group/individual meetings.

# Outline

## 1. Introduction (Egami)

- Project History
- What is Subaru/HSC? What is the HSC survey?
- What is DUNES<sup>2</sup>?

## 2. DUNES<sup>2</sup> (Huang)

- Data products
- Current science programs

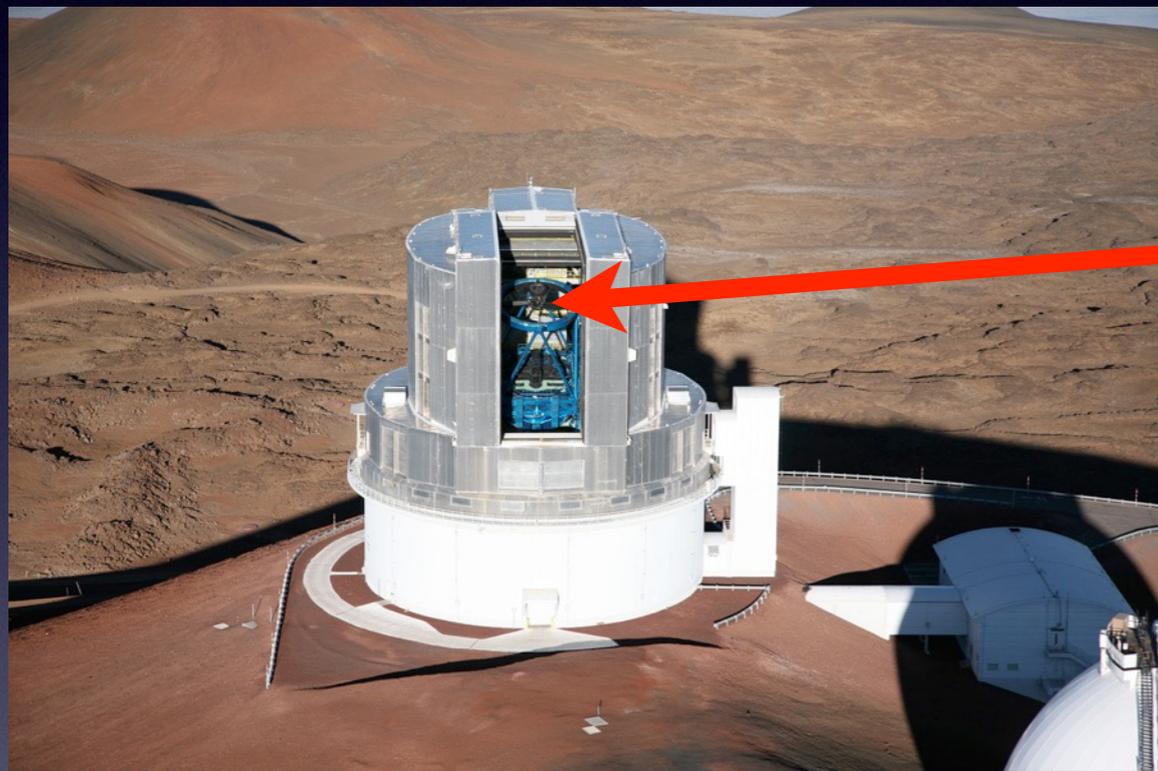
## 3. HSC-DUNES<sup>2</sup> data access (Egami)

# 1. Introduction

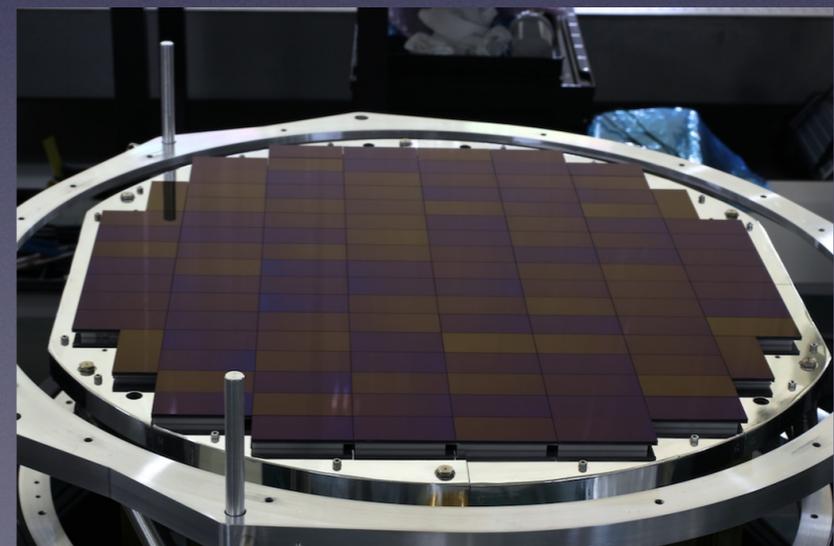
# Project History

- Early 2014: Lockheed Martin, Univ. of Arizona, & Univ. of Hawaii took over the operation of UKIRT.
- Summer-Fall 2014: Subaru/HSC - Steward/UKIRT collaboration MOU finalized
- 2014B - DUNES<sup>2</sup> observations started
- (semi-annual meetings to inform Steward researchers.)
- 2017 Feb - HSC 1st public data release (20%)
- 2017 Mar - Last Steward HSC-UKIRT meeting
- 2018A - DUNES<sup>2</sup> observations ended
- May 2019 - HSC 2nd public data release

# What is Subaru/HSC ? (HSC=Hyper-Suprime Cam)



D=8.2m telescope  
on Mauna Kea  
run by Japan  
(since 1999)



104  
chips

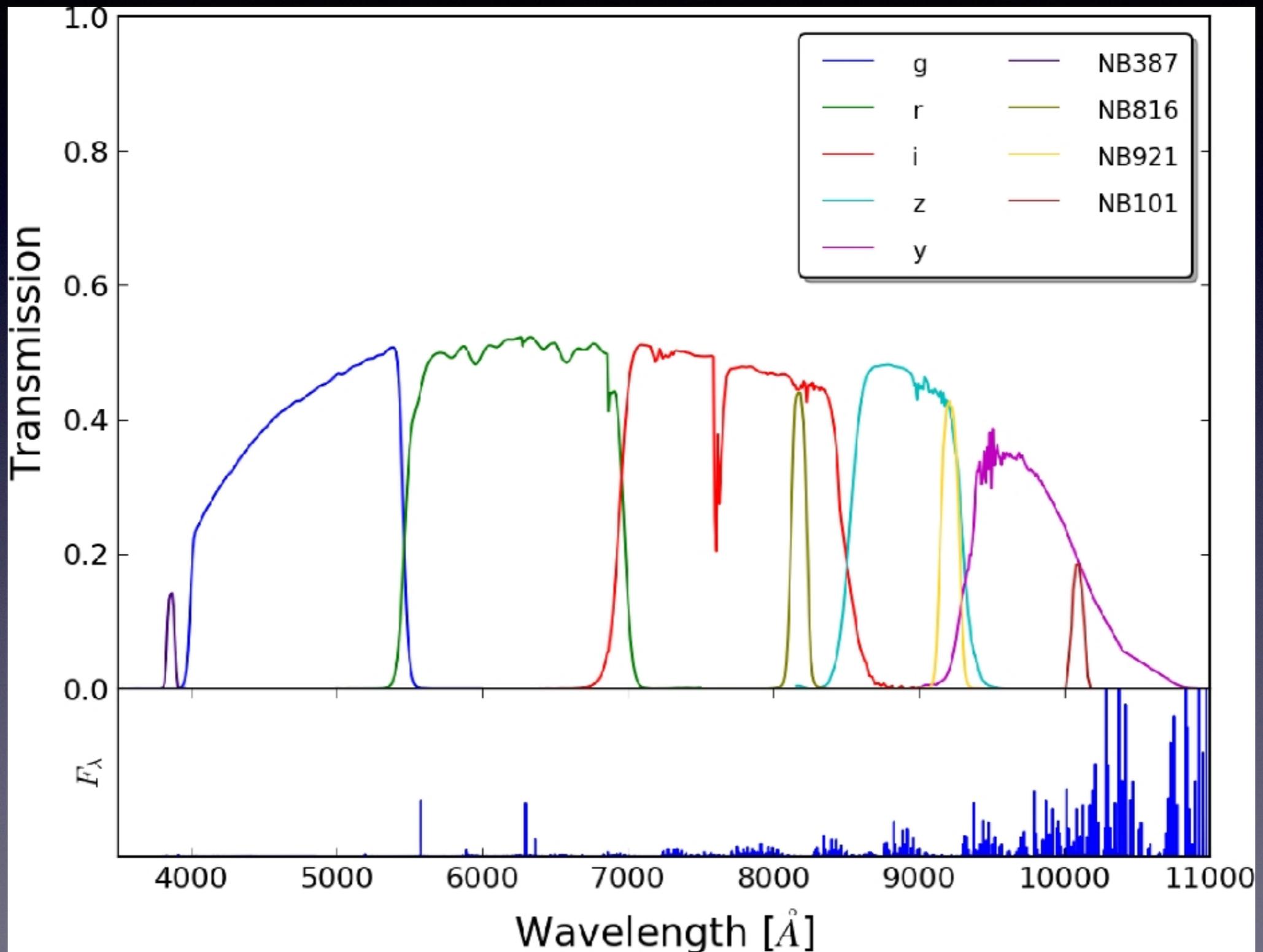
D=1.5 deg; FOV=1.77 deg<sup>2</sup>

# What is HSC Survey?

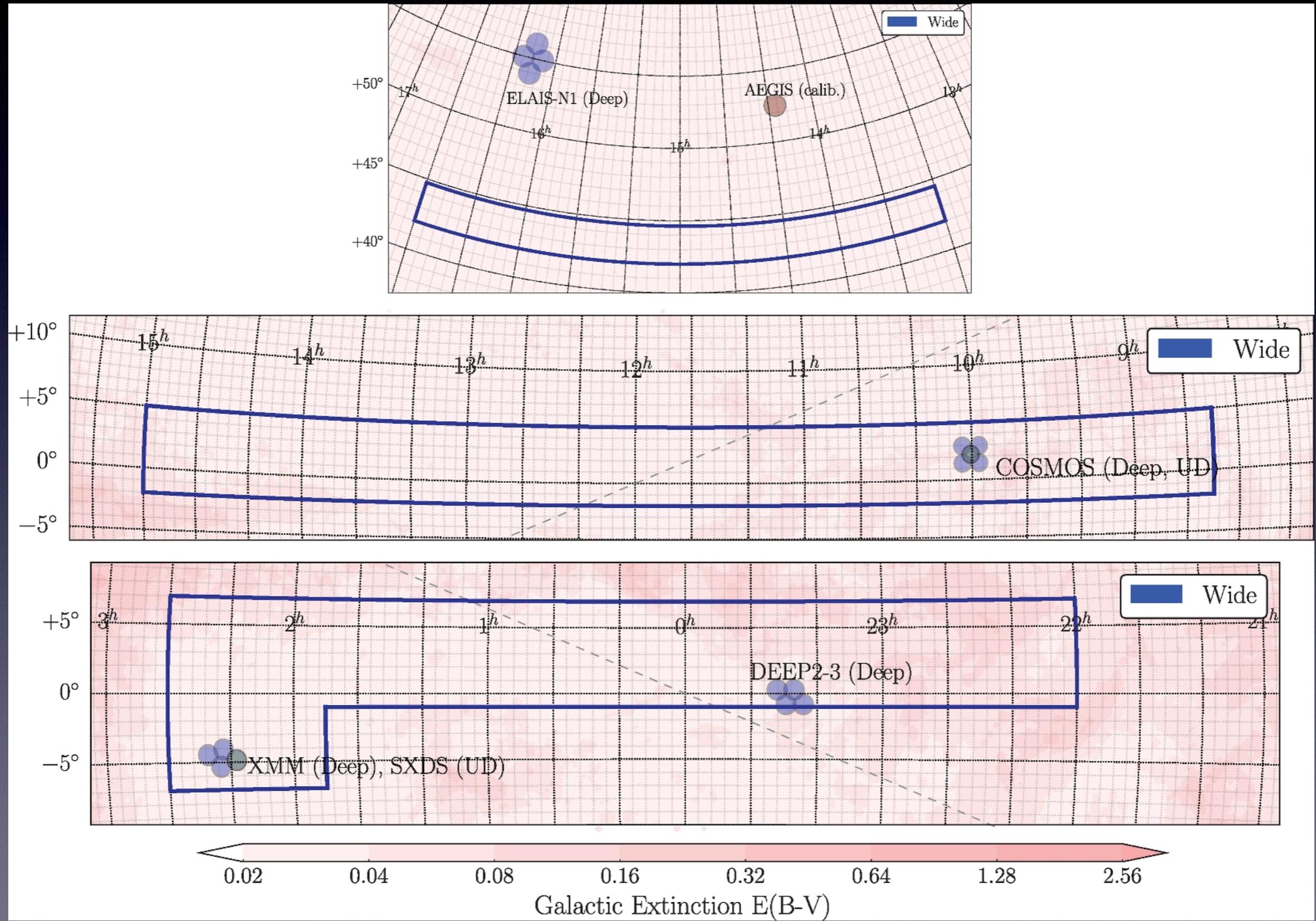
- **Wide** (VST/KiDS-VISTA/VIKING fields)  
(D=2.6m) (D=4.1m)
  - 1400 deg<sup>2</sup>, grizy,  $r_{AB} \sim 26$  mag, 214 nights
- **Deep** (4 fields)
  - 27 deg<sup>2</sup>, grizy+3NBs,  $r_{AB} \sim 27$  mag, 49 nights
- **Ultradeep** (SXDS/UKIDSS; COSMOS)
  - 3.5 deg<sup>2</sup>, grizy+3NBs,  $r_{AB} \sim 28$  mag, 37 nights

300 nights of Subaru time over the next 5 years

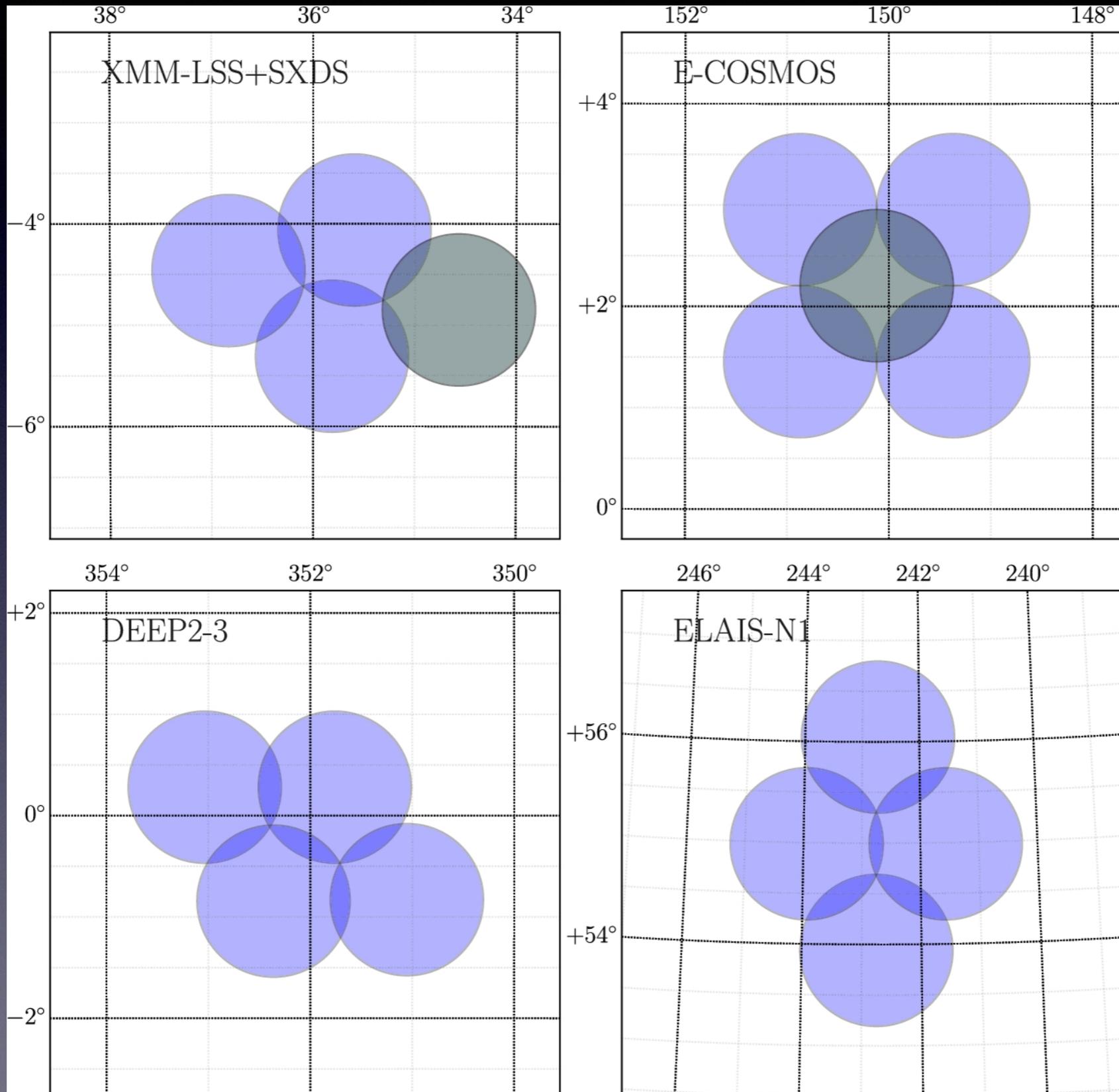
# HSC Filters



# HSC-Wide



# HSC-Deep & Ultradeep



# HSC-Deep Fields

VISTA/  
VIDEO

Field	RA & DEC (J2000)	Area (deg <sup>2</sup> )	HSC #Fields
XMM-LSS (=SXDS)	02:25:00 -04:30:00	5.3	3
E-COSMOS	10:00:20 +02:12:21	7.2	4
UKIRT/ UKIDSS	16:10:00 +54:00:00	7.2	4
DEEP2-3	23:30:00 +00:00:00	7.2	4

$g, r, i, z, y$  ( $5\sigma, 2''$ ) = 27.5, 27.1, 26.8, 26.3, 25.3 mag (AB)

# CLAUDS

## **CFHT Large Area U-Band Deep Survey**

18.6 deg<sup>2</sup> of  $U_{AB}=27.1$  CFHT imaging in HSC Deep/UD

Marcin Sawicki

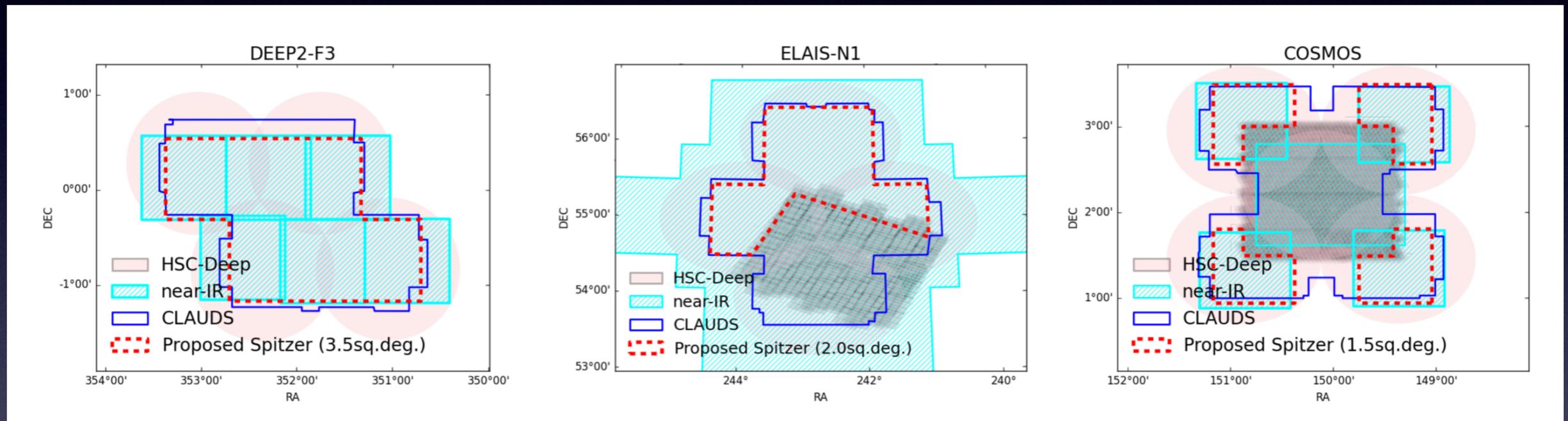
on behalf of the CLAUDS team

*and with contributions from:*

Lingjian Chen, Jean Coupon, Anneya Golob, Stephen Gwyn, Yuichi Harikane, Ikuru Iwata,  
Yipeng Jing, Chengze Liu, Thibaud Moutard, Yoshiaki Ono, Nathalie Thibert



# Spitzer/IRAC for HSC-Deep



PI: Anna Sajina (Tufts)

3.6/4.5  $\mu\text{m}$ ,  $\sim 23$  AB mag, 7 deg<sup>2</sup>, 488 hours

# What is DUNES<sup>2</sup> ?

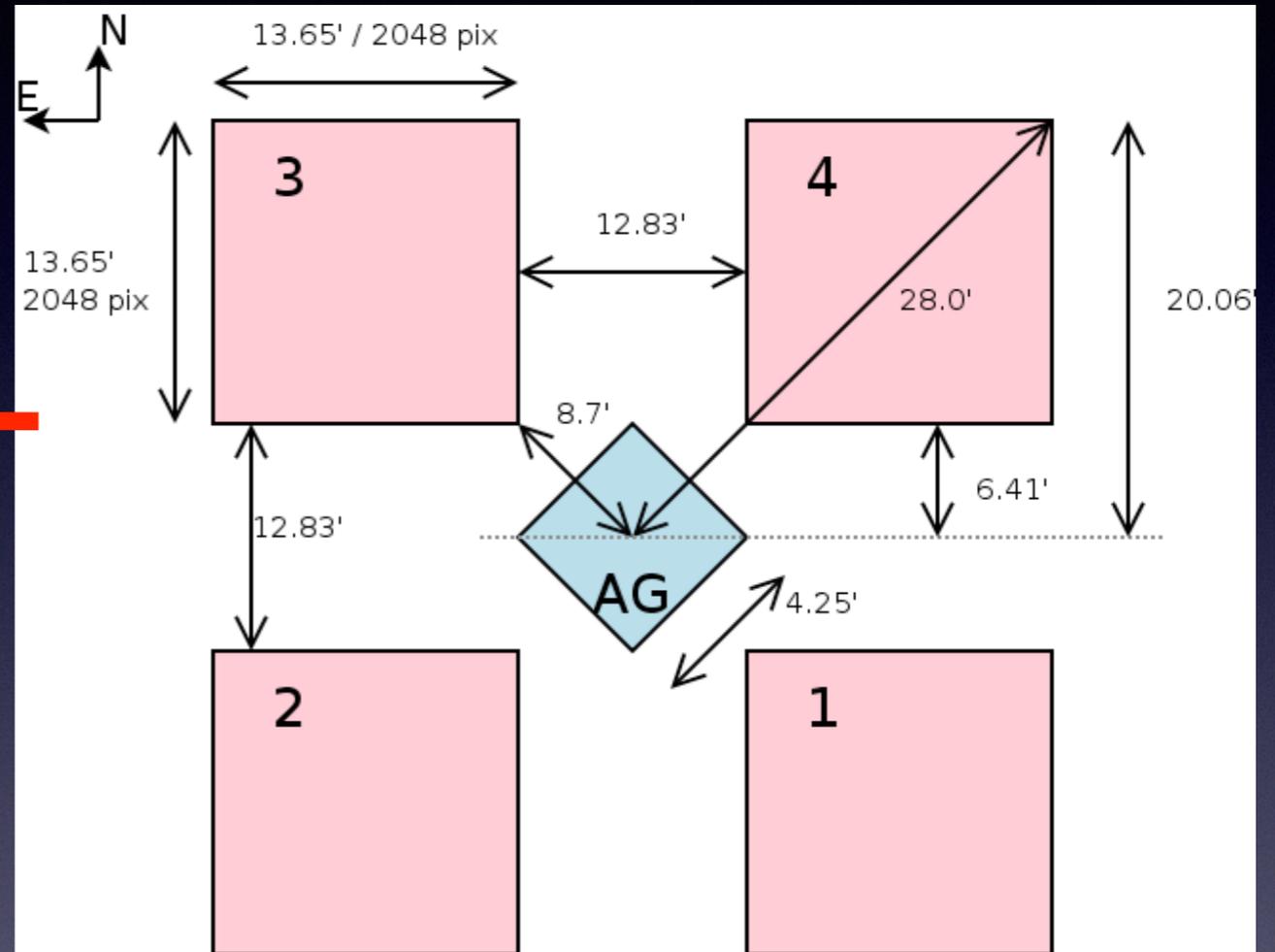
*(Deep **UK**IRT **NE**ar-IR **S**teward **S**urvey)*

Not to be confused with “**DU**st around **NE**arby **S**tars”

# UKIRT & WFCAM



D=3.8 m IR-optimized  
telescope  
on Mauna Kea  
(since 1979)



0.4"/pixel, tip/tilt secondary  
4 pointings to cover 0.75 deg<sup>2</sup>  
(since 2005)

# Goal

- Obtain UKIDSS/DXS-like J/H/K-band images (2hr/band) covering a total area of 7.5 deg<sup>2</sup> over two HSD-Deep fields:
  - E-COSMOS (4x0.75 deg<sup>2</sup>)
  - DEEP2-3 (6x0.75 deg<sup>2</sup>)
- Depth: 23.6 (J), 23.2 (H), 23.1 (K) AB mag (UKIRT/ETC: 5sigma, 0.9" seeing, D=2", airmass=1.2)
- 240 hours of open-shutter time (~30 nights if 8 hours/night)

# Final Status

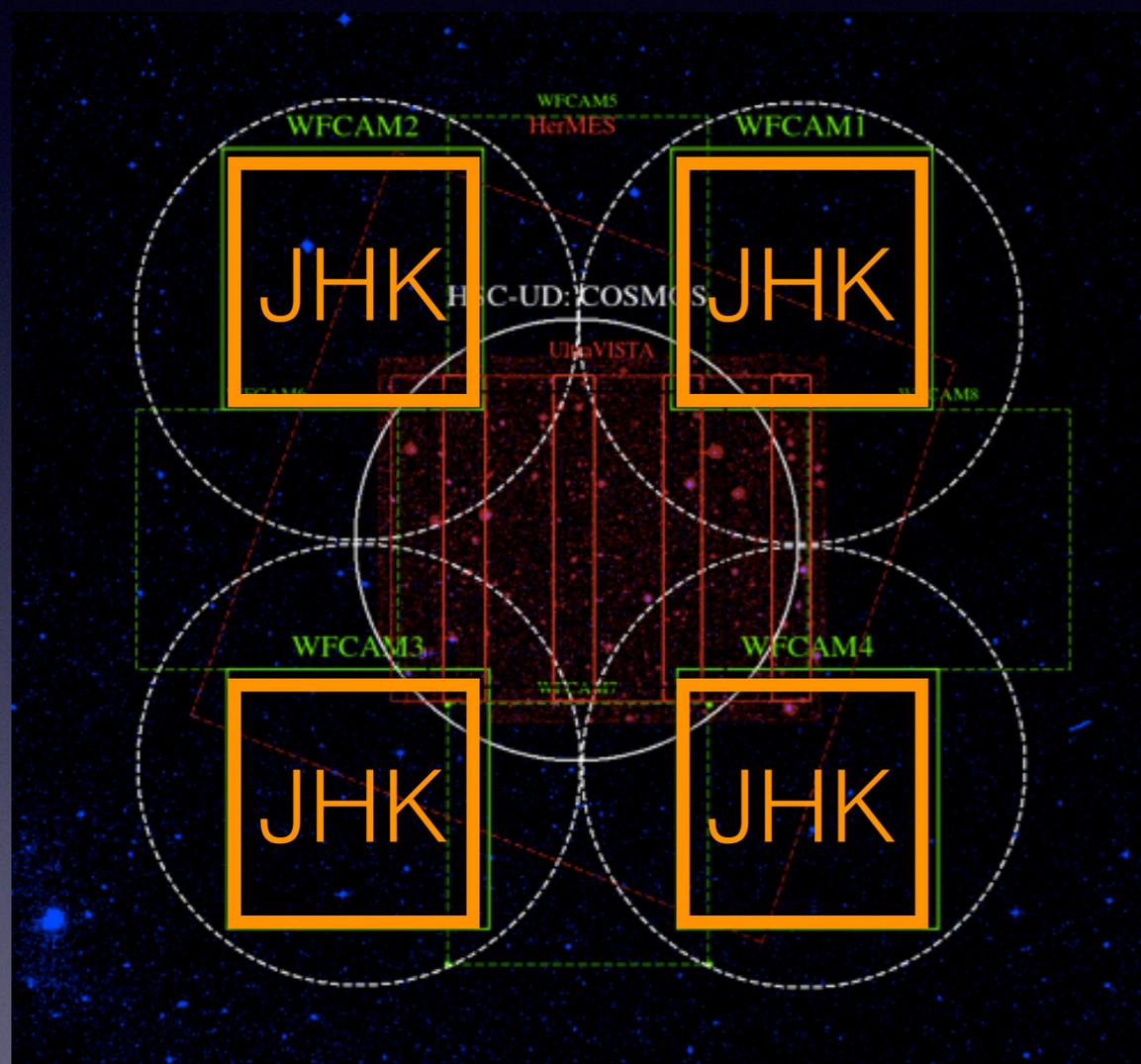
Period	Target	Allocated (hrs)	Executed (hrs)	Completion Rate (%)
2014B	DEEP2-3	140	33	23
2015A	E-COSMOS DEEP2-3	120	35 11	39
2015B	DEEP2-3	80 (Priority1) 90 (Priority 2)	33 16	29
2016A	E-COSMOS DEEP2-3 ELAIS-N1	80 (Priority 1) 80 (Priority 2)	55 22 (19)	60
2016B	DEEP2-3	50 (Priority 1) 50 (Priority 2)	27	27
2017B	DEEP2-3	15	4	27
2018A	DEEP2-3	15 in queue	8	53

**Required: 300 hrs (240 hrs open-shutter + overheads)**

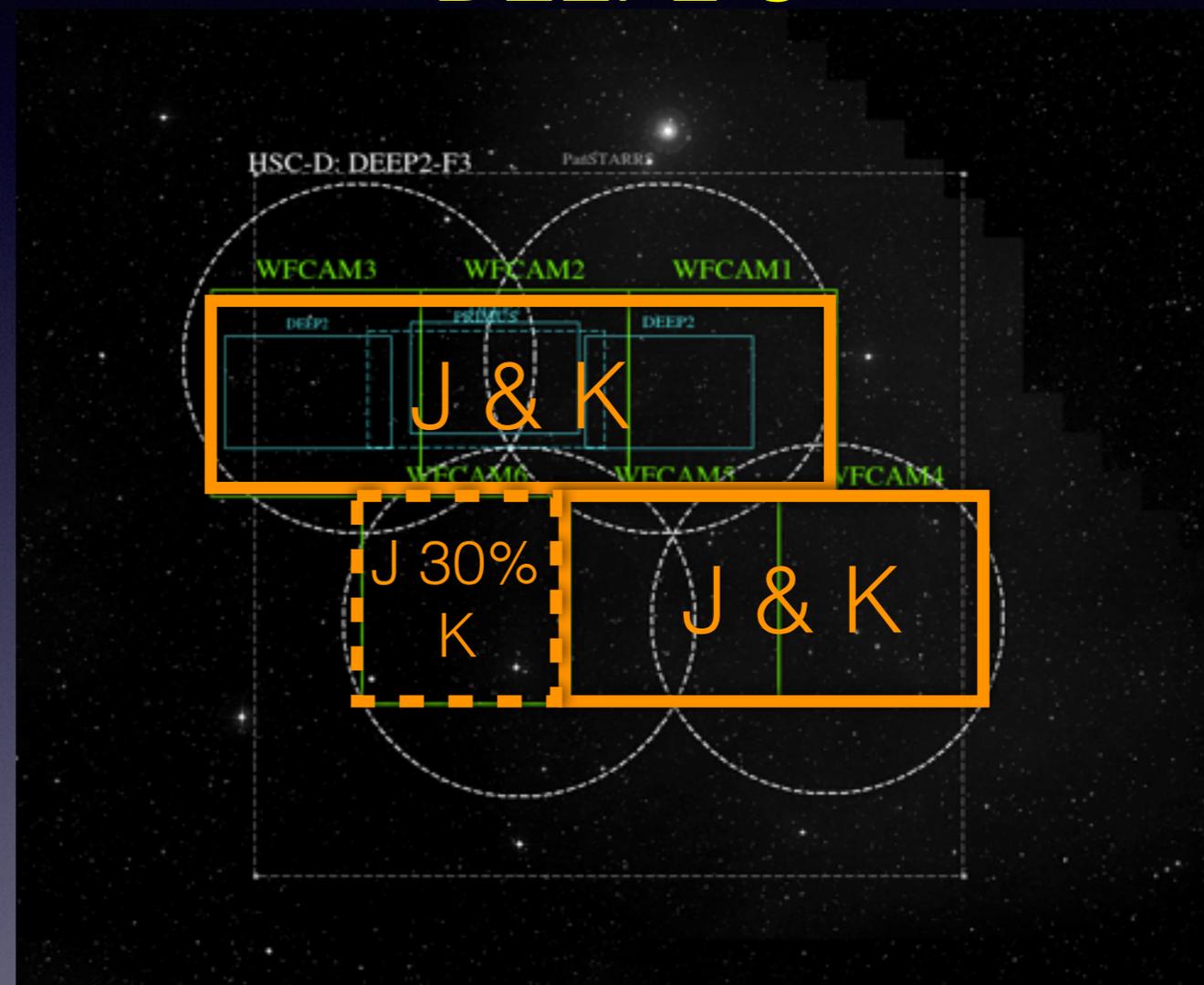
**Executed: 244 hrs (81%); 263 hrs (88%) including ELAIS-N1**

# HSC-Deep Near-IR Coverage

E-COSMOS



DEEP2-3



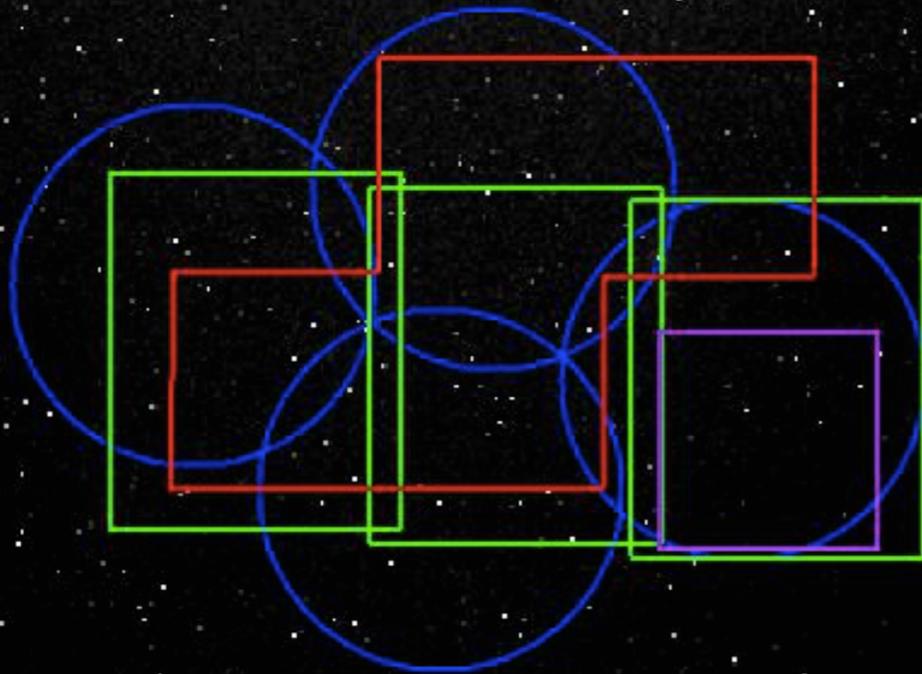
HSC-Deep

UltraVISTA  
Y/J/H/Ks

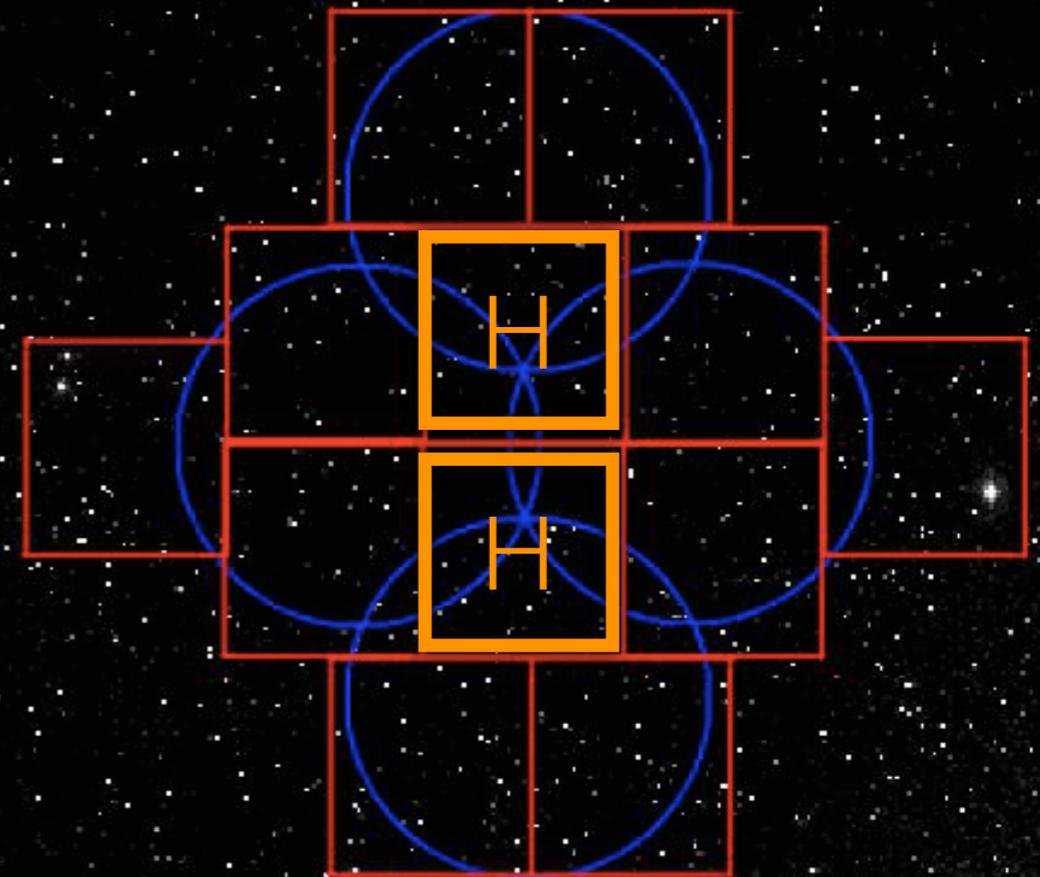
Steward/UKIRT  
J/H/K (Done)

# HSC-Deep Near-IR Coverage

XMM-LSS



ELAIS-N1



HSC-Deep

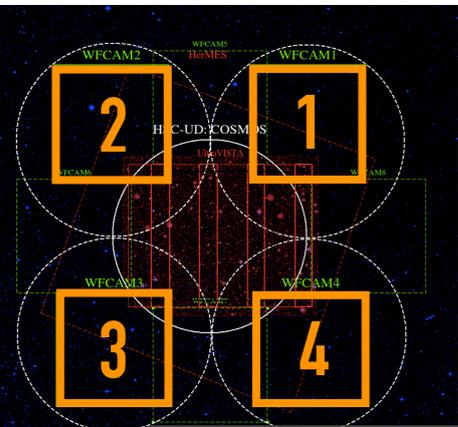
UKIDSS/DXS  
J/K

UKIDSS/UDS  
J/H/K

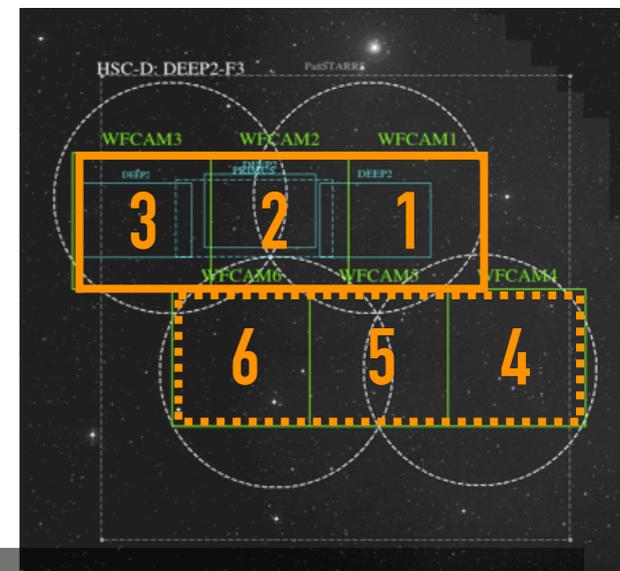
VISTA/VIDEO  
zYJHKs

# Survey Depths

## E-COSMOS



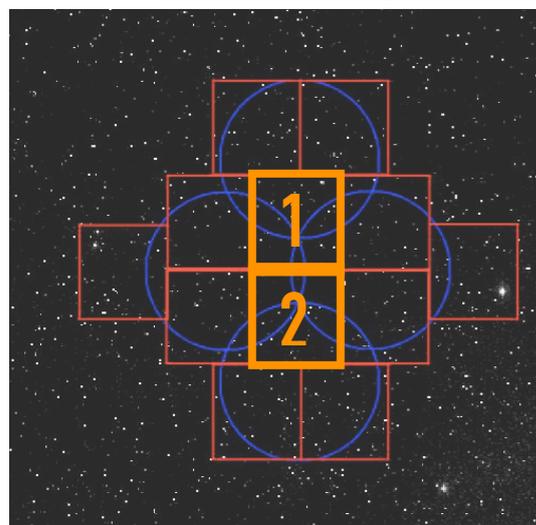
	WFCAM1	WFCAM2	WFCAM3	WFCAM4
J	23.2	23.3	23.3	23.2
H	23.2	23.2	23.2	22.9
K	23.0	22.8	23.0	22.8



## DEEP 2-3

	WFCAM1	WFCAM2	WFCAM3	WFCAM4	WFCAM5	WFCAM6
J	23.2	23.2	23.3	44%		
K	23.1	23.0	23.1	23.0	22.9	23.0
H	17%		35%			

## ELAIS-N1



	WFCAM1	WFCAM2
H	23.2	23.0

**Survey Depth: J ~ 23.2, K ~ 23**

# 2. DUNES<sup>2</sup>

(by Yun-Hsin)

# 3. HSC-DUNES<sup>2</sup> Data Access

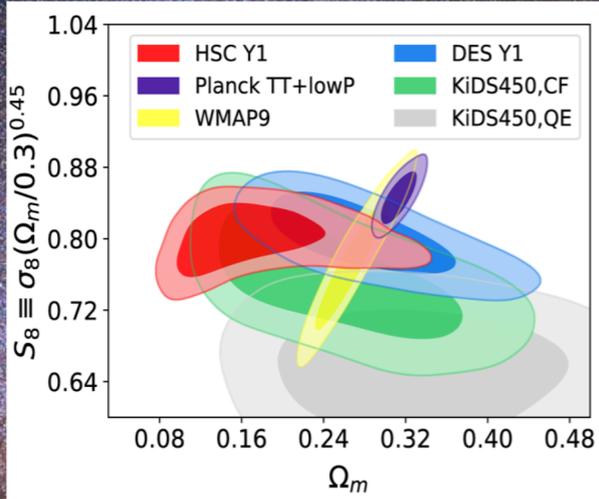
# HSC Survey Website

<https://hsc.mtk.nao.ac.jp/ssp/>

HSC Hyper Suprime-Cam Subaru Strategic Program

HOME SURVEY SCIENCE INSTRUMENT PIPELINE PUBLICATIONS GALLERY JOB OPPORTUNITIES DATA RELEASE

## News and Research Highlight



The plot shows constraints on  $S_8 \equiv \sigma_8(\Omega_m/0.3)^{0.45}$  versus  $\Omega_m$ . The x-axis ranges from 0.08 to 0.48, and the y-axis ranges from 0.64 to 1.04. The legend includes: HSC Y1 (red), DES Y1 (blue), Planck TT+lowP (purple), KiDS450,CF (green), WMAP9 (yellow), and KiDS450,QE (grey). The HSC Y1 constraint is notably tighter and deeper than the others.

The first cosmology results from HSC! The unrivaled depth and image quality from HSC allow us to place a strong constraint on the cosmological parameters (Hikage et al. arXiv:1809.09148).

Search ...

## Hyper Suprime-Cam Subaru Strategic Program

Data Release 1

Home Survey Processing Release Data Database Data Access FAQ

We peer deep into the Universe to unveil the nature of dark matter and dark energy.

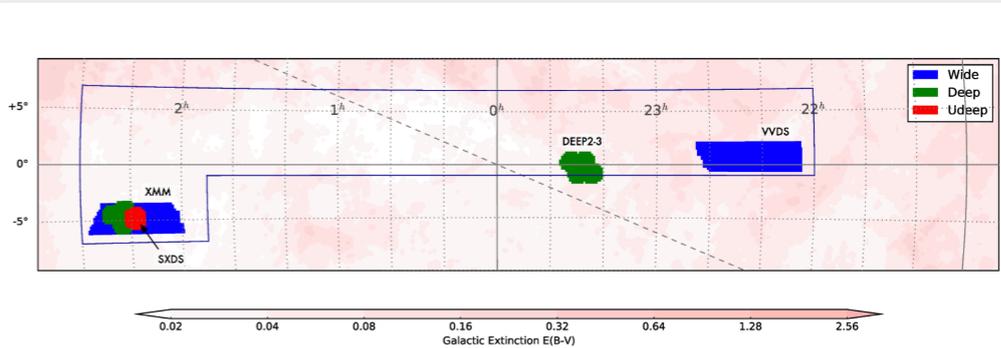
### Public Data Release 1

#### News: the second incremental data release!

We are pleased to announce the 2nd incremental data release from HSC-SSP. This release includes (1) [emission-line object catalog from Hayashi et al. \(2017\)](#), (2) [weak-lensing simulation data from Mandelbaum et al. \(2017\)](#), and (3) [deep, multi-band photometric catalog from Mehta et al. \(2017\)](#). In addition, two new data retrieval tools are available: [PSF picker](#) and [postage-stamp retriever](#). The former is an online tool, where a user can upload a coordinate list and retrieve PSF models at the input positions. This will be useful for detailed analysis of object shapes. The latter is a client tool, with which a user can download postage stamps of multiple objects in color. For details, follow the links from the [Data Access page](#).

### Public Data Release 1

Welcome to the [Hyper Suprime-Cam Subaru Strategic Program Data Release Site!](#)  
The first public release of HSC-SSP occurred on 28 February 2017. The release includes over 100 square degrees of deep multi-color data served through dedicated databases and user interfaces. The figures below shows the area covered in this release and the table gives an overview of the data in the three survey layers. Refer to [our survey website](#) for details of the survey design.



The map shows the survey footprint in Galactic coordinates (l, b). The x-axis is Galactic longitude (l) from 0h to 23h, and the y-axis is Galactic latitude (b) from -5 to +5. The legend indicates Wide (blue), Deep (green), and Udeep (red) layers. Key regions labeled include XMM, SXDS, DEEP2/3, and VVDS. A color bar at the bottom indicates Galactic Extinction E(B-V) from 0.02 to 2.56.

# HSC Survey DR1

(61.5 nights = 20%)

<b>UltraDeep</b>	<i>g</i>	<i>r</i>	<i>i</i>	<i>z</i>	<i>y</i>	<i>NB387</i>	<i>NB816</i>	<i>NB921</i>	<i>NB101</i>
exposure (min)	70	70	130	130	210	—	200	270	—
seeing (arcsec)	0.74	0.62	0.64	0.59	0.74	—	0.60	0.76	—
depth (mag)	27.5	27.3	27.2	26.5	25.7	—	26.3	25.9	—
target exposure (min)	420	420	840	1134	1134	—	630	840	1050
target depth (mag)	28.4	28.0	27.7	27.1	26.6	—	26.8	26.5	25.1
<b>Deep</b>	<i>g</i>	<i>r</i>	<i>i</i>	<i>z</i>	<i>y</i>	<i>NB387</i>	<i>NB816</i>	<i>NB921</i>	<i>NB101</i>
exposure (min)	20	15	30	35	20	—	45	60	—
seeing (arcsec)	0.83	0.68	0.55	0.69	0.59	—	0.53	0.65	—
depth (mag)	26.8	26.6	26.5	25.6	24.8	—	25.9	25.6	—
target exposure (min)	84	84	126	210	126	84	168	252	—
target depth (mag)	27.8	27.4	27.1	26.6	25.6	24.8	26.1	25.9	—
<b>Wide</b>	<i>g</i>	<i>r</i>	<i>i</i>	<i>z</i>	<i>y</i>	<i>NB387</i>	<i>NB816</i>	<i>NB921</i>	<i>NB101</i>
exposure (min)	10	10	20	20	20	—	—	—	—
seeing (arcsec)	0.72	0.67	0.56	0.63	0.64	—	—	—	—
depth (mag)	26.8	26.4	26.4	25.5	24.7	—	—	—	—
target exposure (min)	10	10	20	20	20	—	—	—	—
target depth (mag)	26.8	26.4	26.2	25.4	24.7	—	—	—	—

<i>g</i>	<i>r</i>	<i>i</i>	<i>z</i>	<i>y</i>	<i>NB387</i>	<i>NB816</i>	<i>NB921</i>
24%	18%	24%	17%	16%	0%	27%	24%

# DR1 Data Access Page

## Online Registration

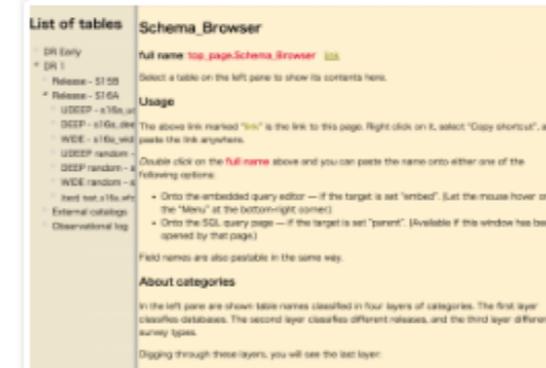


## CAS Search



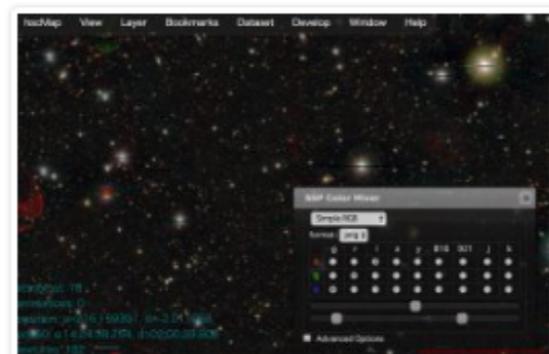
ReadMe

## Schema Browser



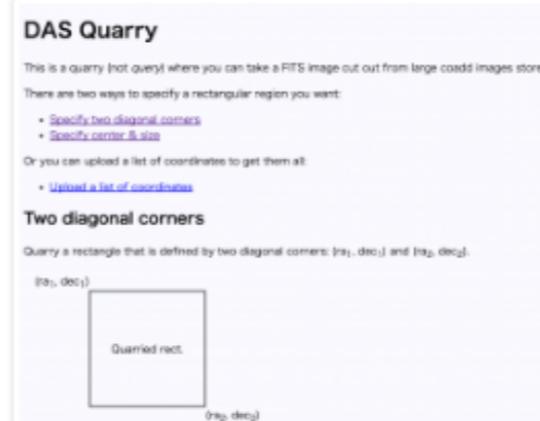
ReadMe (top page of the schema browser)

## hscMap



ReadMe

## DAS Quarry



ReadMe

## DAS Search



ReadMe

## Direct access to the directory tree

UltraDeep

Deep

Wide

# DUNES<sup>2</sup> Website

<http://gxn.as.arizona.edu/DUNES>



Image/catalog access

“dunes2” & “wfcam\*ukirt”

Policy document

## Welcome to DUNES<sup>2</sup> !

### What is DUNES<sup>2</sup> ?

The Deep UKIRT NEar-Infrared Steward Survey (DUNES<sup>2</sup>; pronounced as “Dunes” for simplicity) is an effort to increase near-infrared coverage for the Subaru/Hyper Suprime-Cam (HSC) Deep fields, using the wide-field WFCAM near-infrared camera on UKIRT. With a total observing time of ~260 hours allocated between 2014 and 2018, the DUNES survey has observed the parts of the HSC-Deep fields without any existing near-infrared data, the four flanking fields of E-COSMOS (3 deg<sup>2</sup>; J/H/K) and DEEP2-3 field (4.5 deg<sup>2</sup>; J/K), down to J/H-23.2 & K-23 AB mag. In terms of observing strategy and data characteristics, DUNES<sup>2</sup> is similar to the UKIDSS Deep Extragalactic Survey (DXS). It also added H-band coverage to the central part of ELAIS-N1 (1.5 deg<sup>2</sup>), which already has the UKIDSS/DXS J/K-band data.

### HSC-Deep Fields

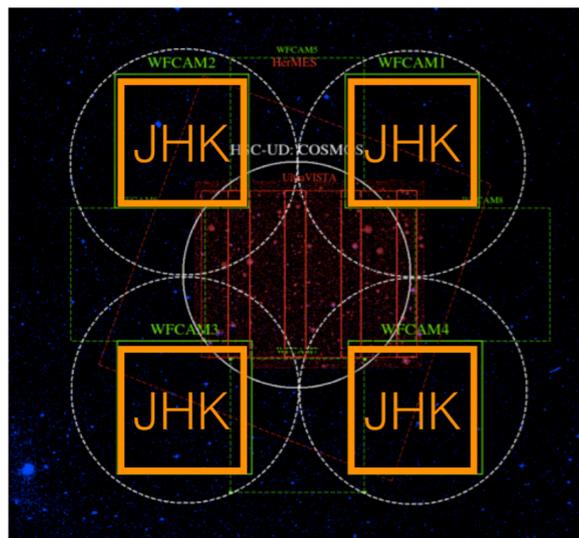
Hyper Suprime-Cam (HSC) is Subaru Telescope's newly commissioned prime-focus CCD mosaic camera with a wide field of view (D=1.5 deg). The Subaru Observatory will allocate ~300 nights of Subaru time over a ~5-year period to conduct a large extragalactic survey with three components: Wide (1400 deg<sup>2</sup>; r~26 AB mag), Deep (27 deg<sup>2</sup>; r~27 AB mag), and Ultradeep (3.5 deg<sup>2</sup>; r~28 AB mag). The HSC-Deep survey targets four fields, XMM-LSS, E-COSMOS, ELAIS-N1, and DEEP2-3, and the DUNES<sup>2</sup> survey is designed to provide deep near-infrared coverage for those HSC-Deep fields that are lacking such data, complementing the existing near-infrared surveys such as UKIDSS/DXS & UDS, UltraVISTA, and VIDEO.

### More Information

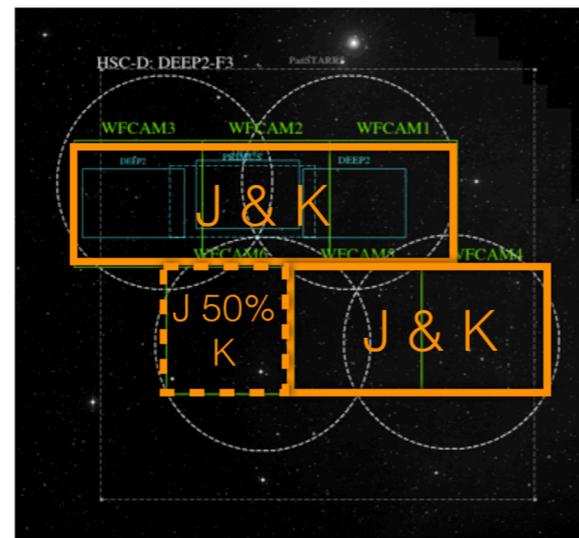
- DUNES<sup>2</sup> Survey**
  - HSC-DUNES<sup>2</sup> collaboration policy (password required)
- Subaru/HSC Survey**
  - HSC Survey website
  - Data Release website
  - Overview and survey design paper
  - First data release paper
- Near-infrared Surveys (for HSC-Deep)**
  - UKIDSS/DXS
  - UltraVISTA
  - VIDEO
- CLAUDS (CFHT u-band survey for HSC-Deep)**
  - CLAUDS (coming soon)

## HSC-Deep Fields & DUNES<sup>2</sup> Coverage

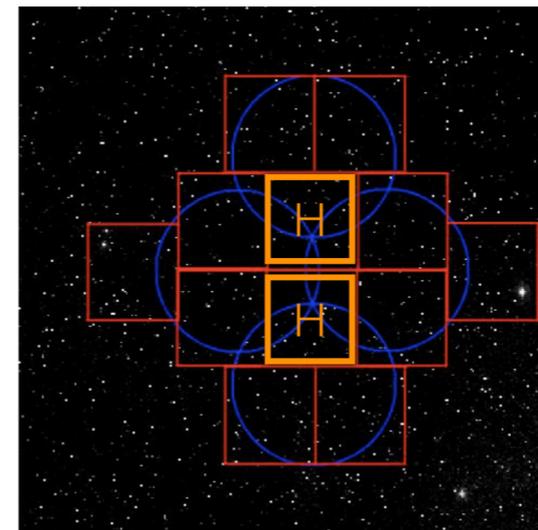
The DUNES coverage is shown as orange squares/rectangles below.



**E-COSMOS**  
White circles - HSC, Red - UltraVISTA

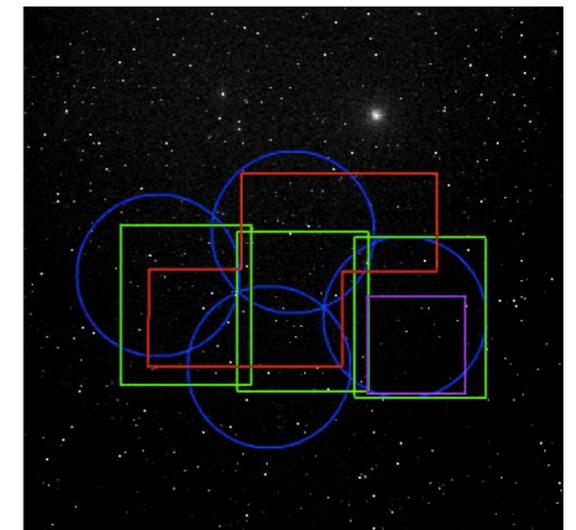


**DEEP2-3**  
White circles - HSC



**ELAIS-N1**

Blue - HSC, Red - UKIDSS/DXS



**XMM-LSS**

Blue circles - HSC, Green - VIDEO, Red - UKIDSS/DXS, Purple - UKIDSS/UDS

### The Team

Steward Observatory, University of Arizona  
Eiichi Egami (PI)  
Yun-Hsin Huang  
Xiaohui Fan  
and 18 Co-Is on the original proposal.

### Contact

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eegami@as.arizona.edu  
Steward Observatory, University of Arizona

### Mailing List

Name	<input type="text"/>	Subscribe
Email	<input type="text"/>	
Affiliation	<input type="text"/>	

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Please sign up for the mailing list!

# Policy

- **DUNES2**

- All the data products (images and catalogs) are available to Steward researchers as of today, but please consult with us for their use.

- **HSC-Deep/Ultradeep**

- To access the proprietary data, **a project proposal needs to be submitted to the HSC Board for approval** (please consult with Egami). When approved, **you will become an HSC external collaborator**.
- **We do not have free access to the HSC proprietary data**. The data access will be provided only **on a project-by-project basis**.
- The use of narrow-band data is more restricted (must have some connection to the use of DUNES<sup>2</sup> or other near-IR data).

- **HSC-Wide** (no special access although you may join specific projects)

*In some cases, it may be more beneficial to wait for the public data release.*