

# CHORUS Overview and LyC leaker search

---

Satoshi YAMANAKA (Waseda Univ.)

On behalf of CHORUS project (HSC project 147)

Akio K. INOUE (PI; Waseda Univ.),

CHORUS members, HSC collaborators

# CHORUS Overview and LyC leaker search

---

Satoshi YAMANAKA (Waseda Univ.)

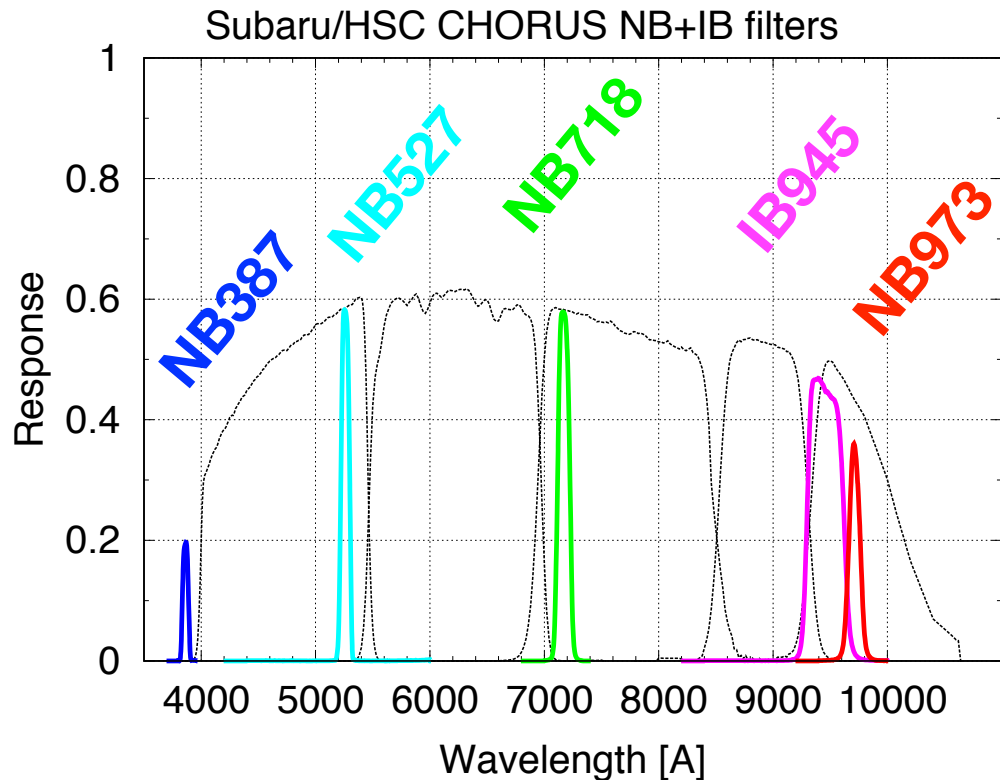
On behalf of CHORUS project (HSC project 147)

Akio K. INOUE (PI; Waseda Univ.),

CHORUS members, HSC collaborators

# CHORUS

Cosmic HydrOgen Reionization Unveiled with Subaru  
(PI: Akio K. Inoue)



- ✓ Ultimate goal of CHORUS project
  - understand the sources, topology, and history of cosmic reionization
- ✓ Imaging survey of 5 filters
  - 4 Narrow-band (NB) filters ( NB387, NB527, NB718, NB973 )
  - 1 Intermediate-band (IB) filter ( IB945 )

## Publication list

- [1] CHORUS. I. Cosmic HydrOgen Reionization Unveiled with Subaru: Overview, by [Akio, K. Inoue, S.Y., et al. submitted to PASJ](#)
- [2] CHORUS. II. Subaru/HSC Determination of the Ly $\alpha$  Luminosity Function at  $z = 7.0$ : Constraints on Cosmic Reionization Model Parameter, by [Itoh et al. 2018, ApJ, 867, 46](#)
- [3] CHORUS. III. Photometric and Spectroscopic Properties of Ly $\alpha$  Blobs at  $z = 4.9-7.0$ , by [Zhang et al. 2020, ApJ, 891, 177](#)

# CHORUS Public Data Release (PDR) 1

---

## Quick summary of CHORUS observations

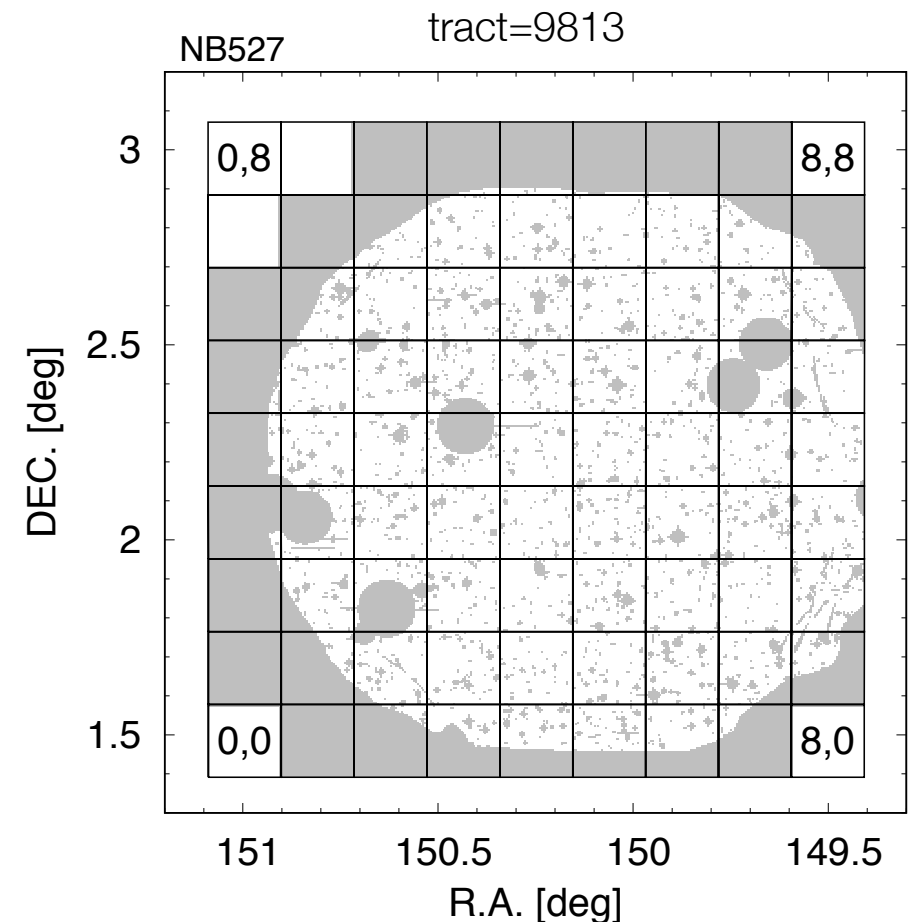
Filters	Exposure [h]	Dates	PSF FWHM	Lim. Mag. [ $5\sigma$ , $1.5''\phi$ ]
NB387	17.3	Jan. 17, 18, 19 (2018)	0.99"	26.07 <sup>*1</sup>
NB527	8.9	Dec. 16, 17, 18 (2017) Mar. 15, 16, 18 (2018)	0.82"	26.87
NB718	7.7	Feb. 25, Mar. 23, 25 (2017)	0.68"	26.47
IB945	10.2	Dec. 1, 2, 3, 12 (2018)	0.61"	25.92
NB973	14.7	Jan. 26, 28 (2017)	0.64"	25.37

\*1 : Value corrected for zero-point offset of NB387 (-0.45 mag)

# CHORUS Public Data Release (PDR) 1

---

- ✓ Target: COSMOS field
  - overlap with dud layer of HSC-SSP (tract=9813).
- ✓ Data reduction: hscPipe version 6.7
  - conducted by HSC-SSP team
  - "CHORUS PDR1" data set
- ✓ Data access: internal
  - CHORUS PDR1 catalog is available at HSC-SSP database.
- ✓ "CHORUS Official Mask":
  - masking stellar halos, stellar spikes, and bad pixels for each filter as possible by eyes



Ex.) NB527 Mask image

# Quality check of CHORUS PDR1

---

## 1. Full-width-at-half-maximum (FWHM) of PSF

- estimated from *FWHM\_IMAGE* parameter of SExtractor
- measurements for stellar-like objects in each patch

## 2. Limiting magnitude

- estimated from aperture photometry at random sky positions
- 1.5"- (and 2.0")-diameter aperture
- measurements with Astropy/photutils for each patch

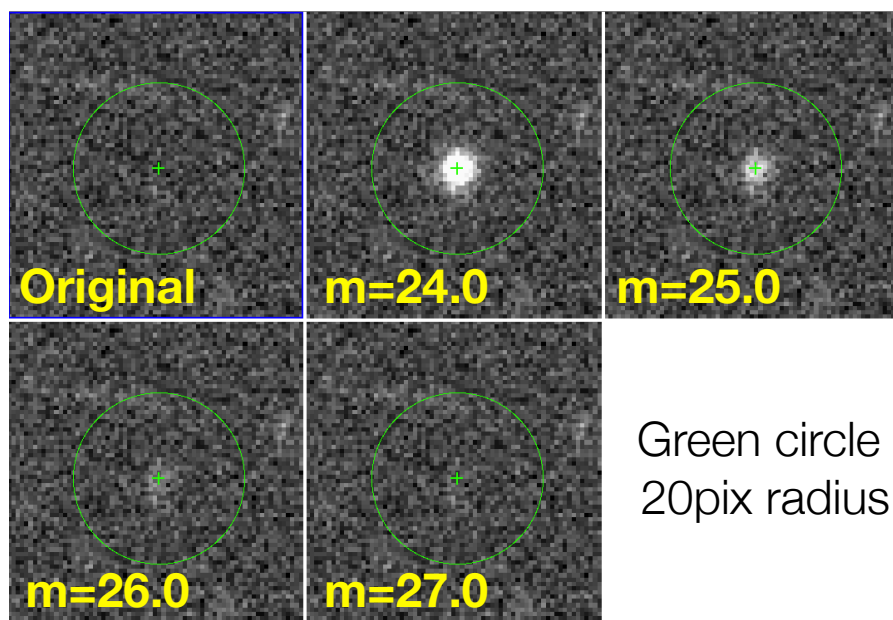
## 3. Detection completeness

- estimated from simulation of embedding and recovering mock galaxies
- detection completeness = (recovered objects) / (embedded objects)
- measurements with hscPipe, Astropy, and GALSIM for selected patches

# Quality check of CHORUS PDR1

## Detail of detection completeness

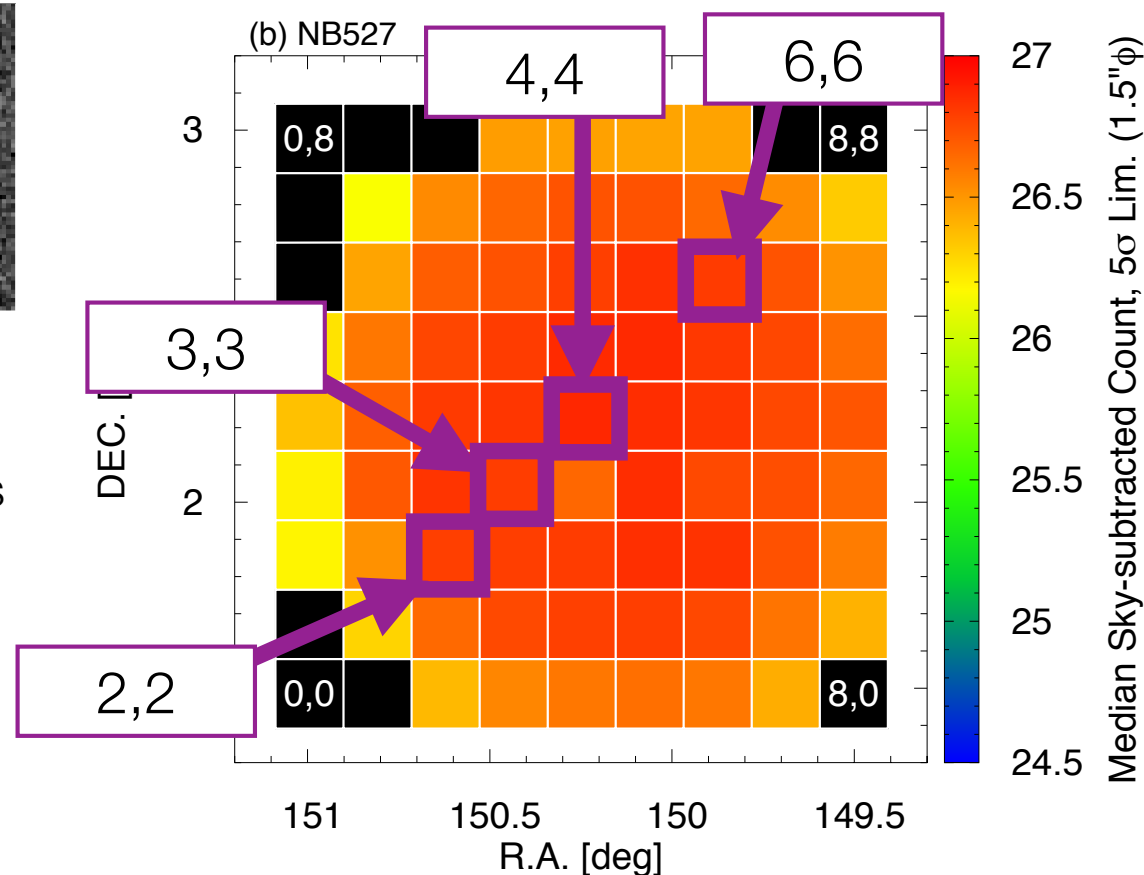
### Examples of fake galaxies



### Fake galaxies

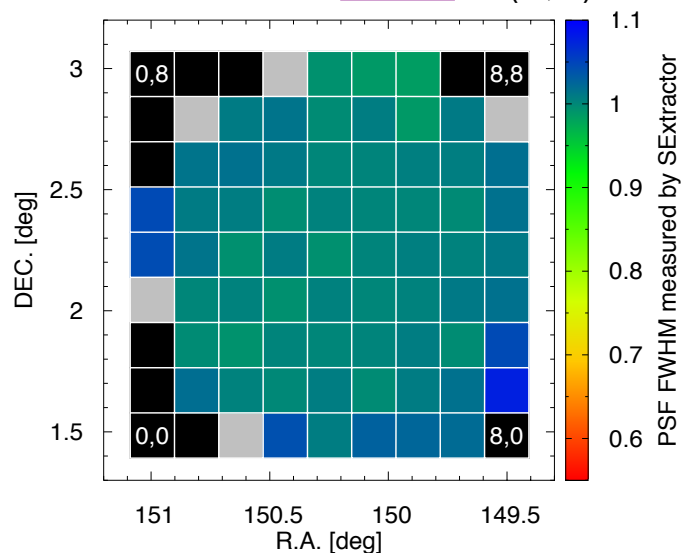
- sersic index  $n = 1.5$
- half-light radius  $\sim 1\text{kpc}$  ( $= 1\text{pix}$ )
- axis ratio  $= 1.0$
- position angle  $= 0.0$

### Patches used for simulation

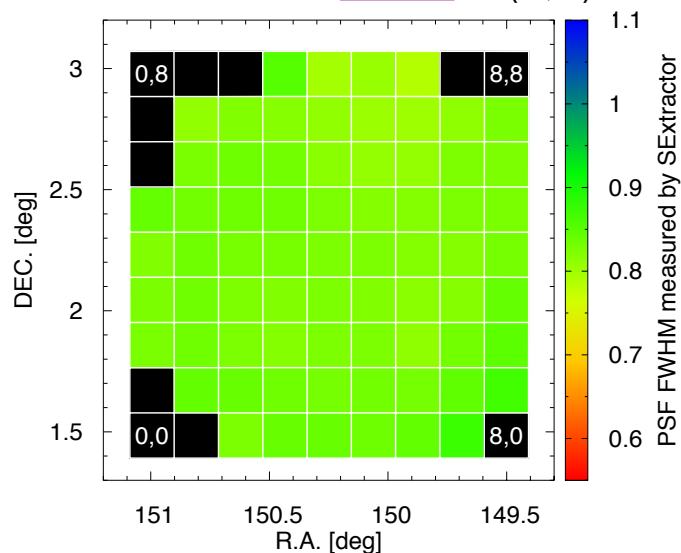


# Data quality - 1. PSF FWHM -

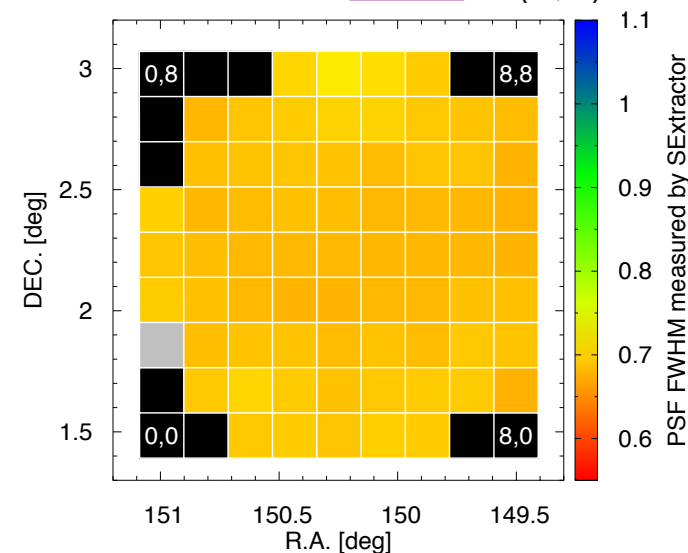
**NB387** : 0.99" @ (4,4)



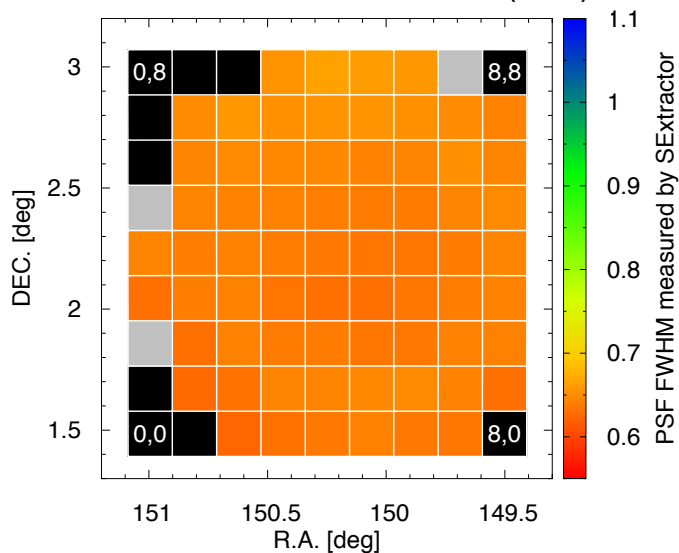
**NB527** : 0.82" @ (4,4)



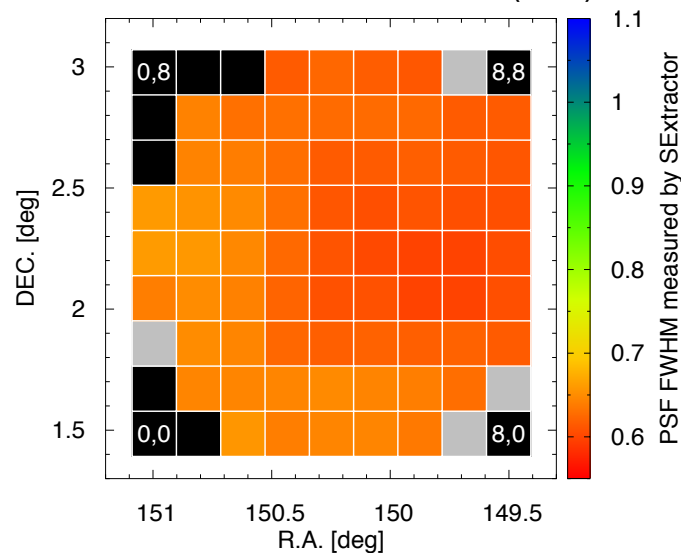
**NB718** : 0.68" @ (4,4)



**NB973** : 0.64" @ (4,4)



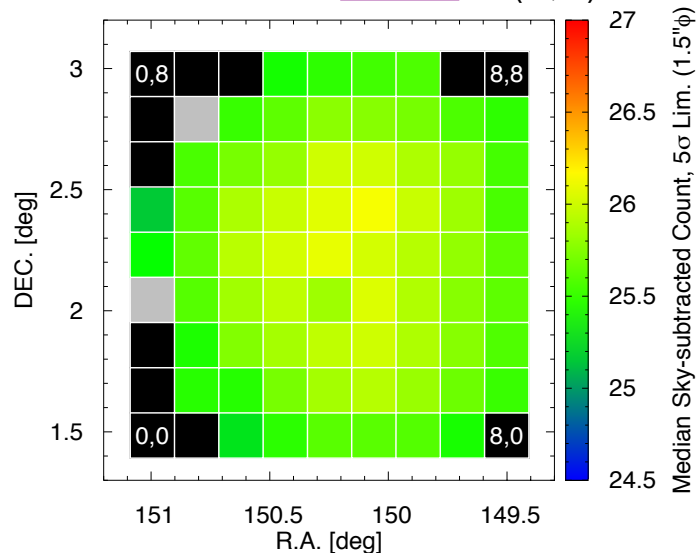
**IB945** : 0.61" @ (4,4)



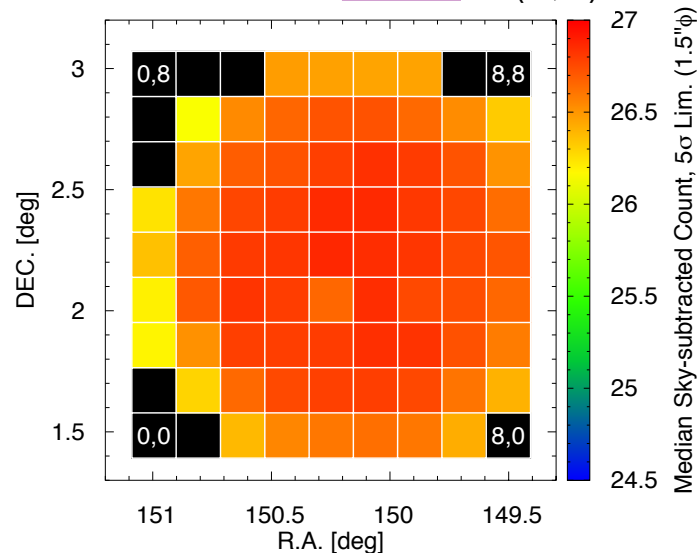


# Data quality - 2. Limiting mag. ( $5\sigma, 1.5''\phi$ ) -

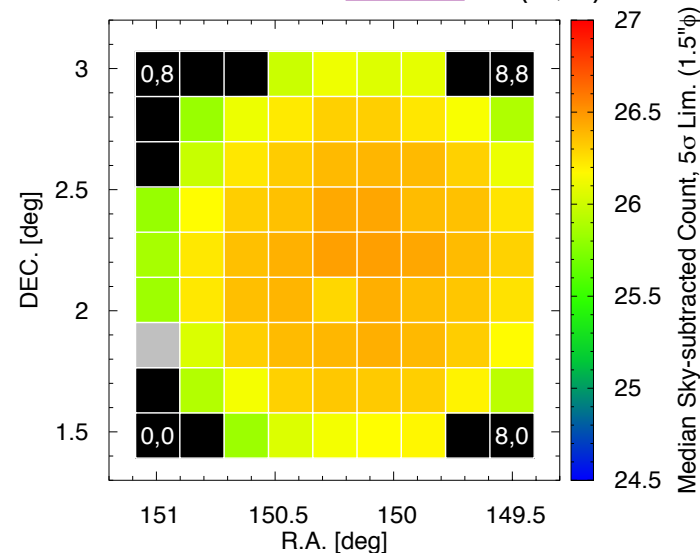
**NB387** : 26.07 @ (4,4)



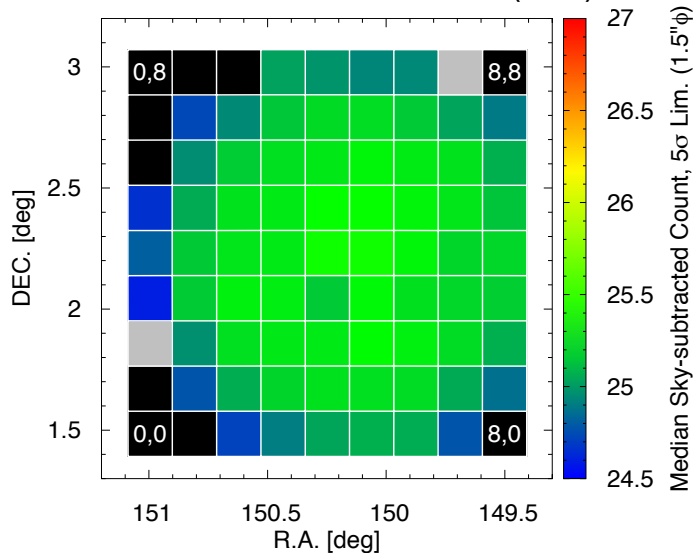
**NB527** : 26.87 @ (4,4)



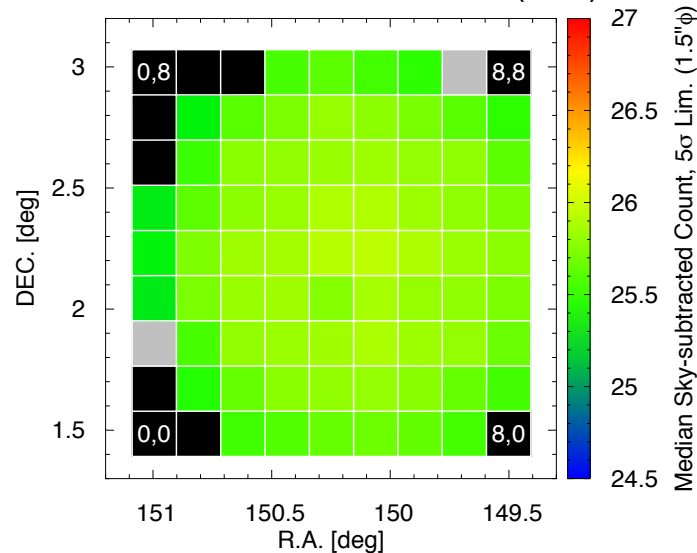
**NB718** : 26.47 @ (4,4)



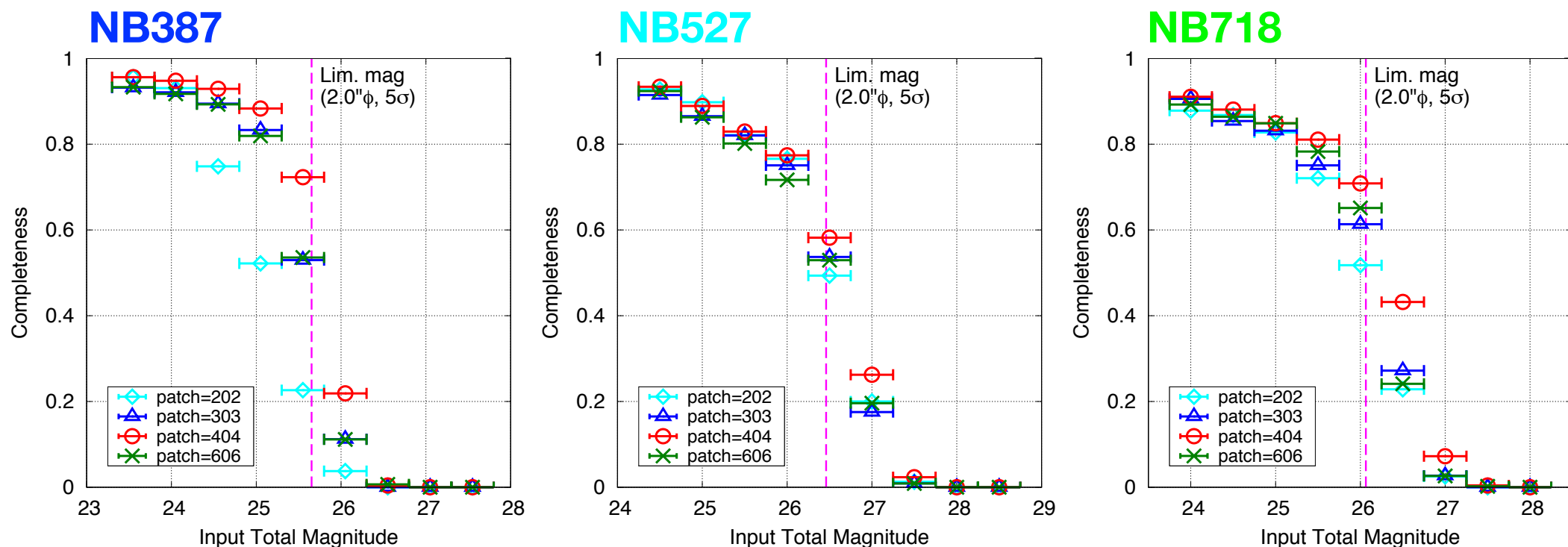
**NB973** : 25.37 @ (4,4)



**IB945** : 25.92 @ (4,4)

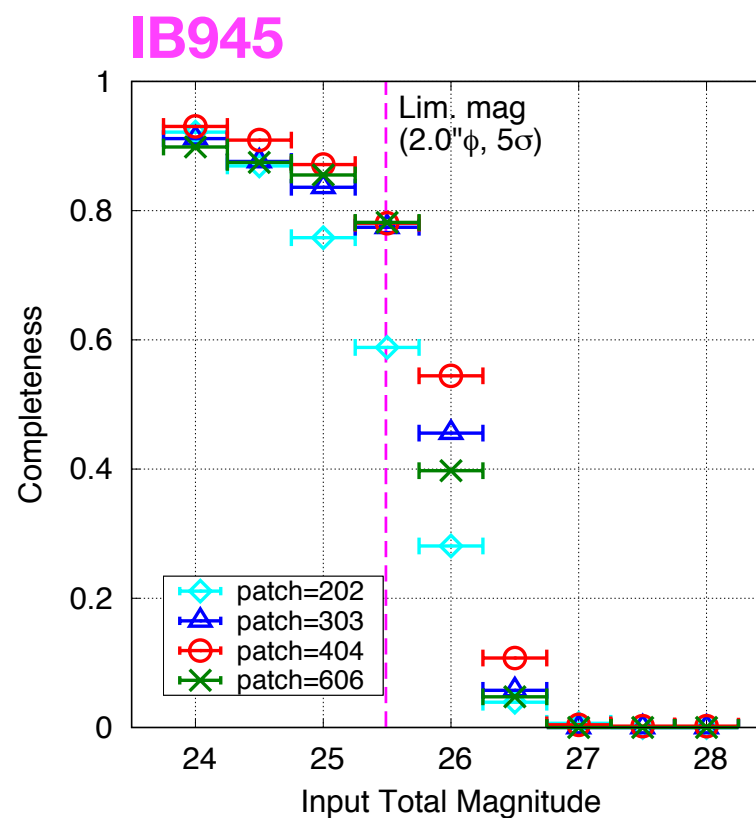
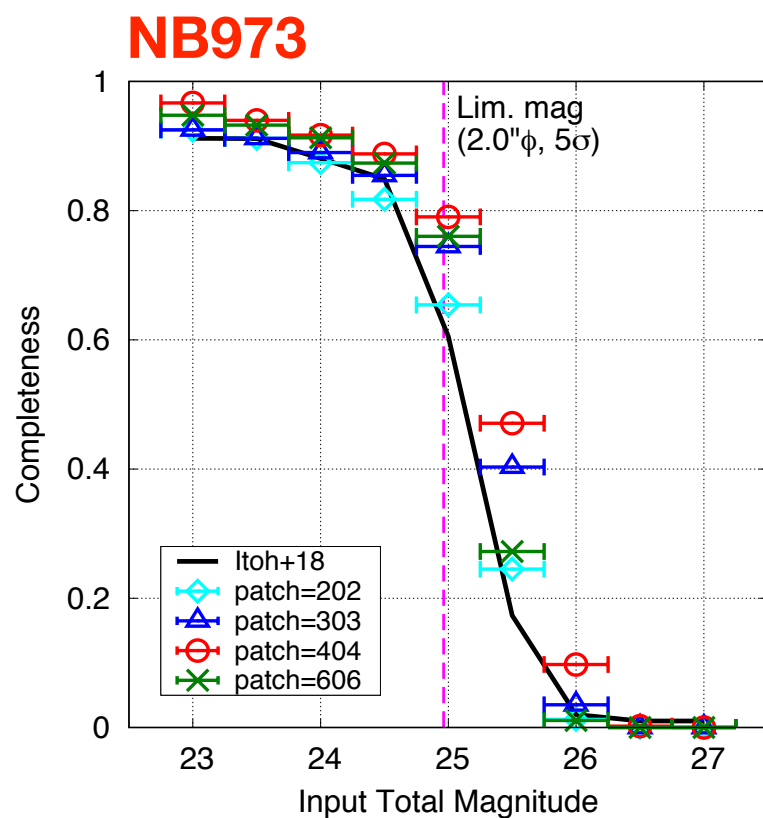


# Data quality - 3. Detection completeness -



- ✓ Completeness of ~60-80% roughly corresponds to 5 $\sigma$  lim. mag.
- ✓ decreasing toward edge of FoV
- ✓ NB973 is consistent with a previous work (Itoh et al. 2018)

# Data quality - 3. Detection completeness -



- ✓ Completeness of ~60-80% roughly corresponds to 5σ lim. mag.
- ✓ decreasing toward edge of FoV
- ✓ NB973 is consistent with a previous work (Itoh et al. 2018)

# Number density of detected objects

---

## 1. CHORUS PDR1 NB/IB-detected catalog

- downloaded from Catalog Archive Server (CAS) of HSC-SSP
- criteria of SQL query

*nchild = 0*

*detect\_ispatchinner IS True*

*merge\_peak\_{n387|n527|n718|n973|i945} IS True*

*{n387|n527|n718|n973|i945}\_pixelflags\_saturatedcenter IS False*

*{n387|n527|n718|n973|i945}\_pixelflags\_bright\_object IS False*

## 2. Checking CHORUS Official Mask

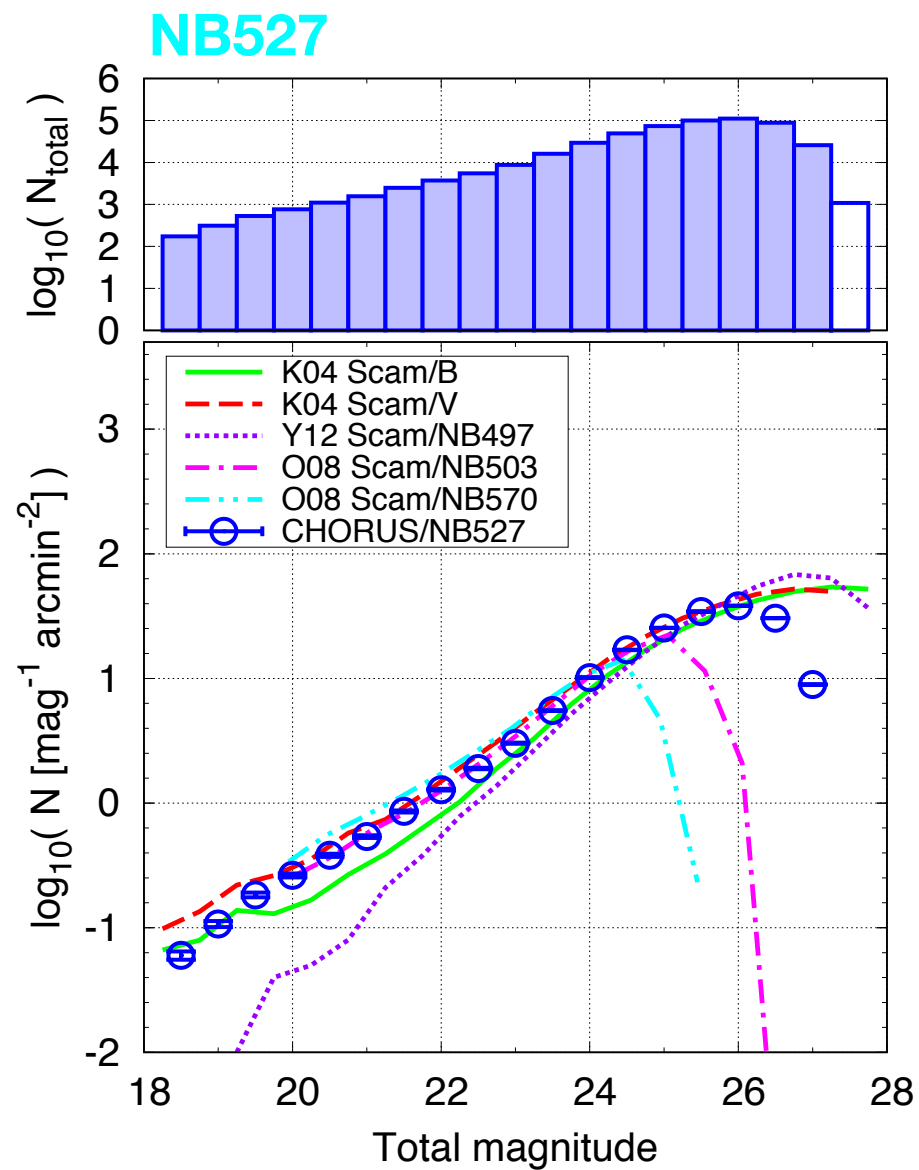
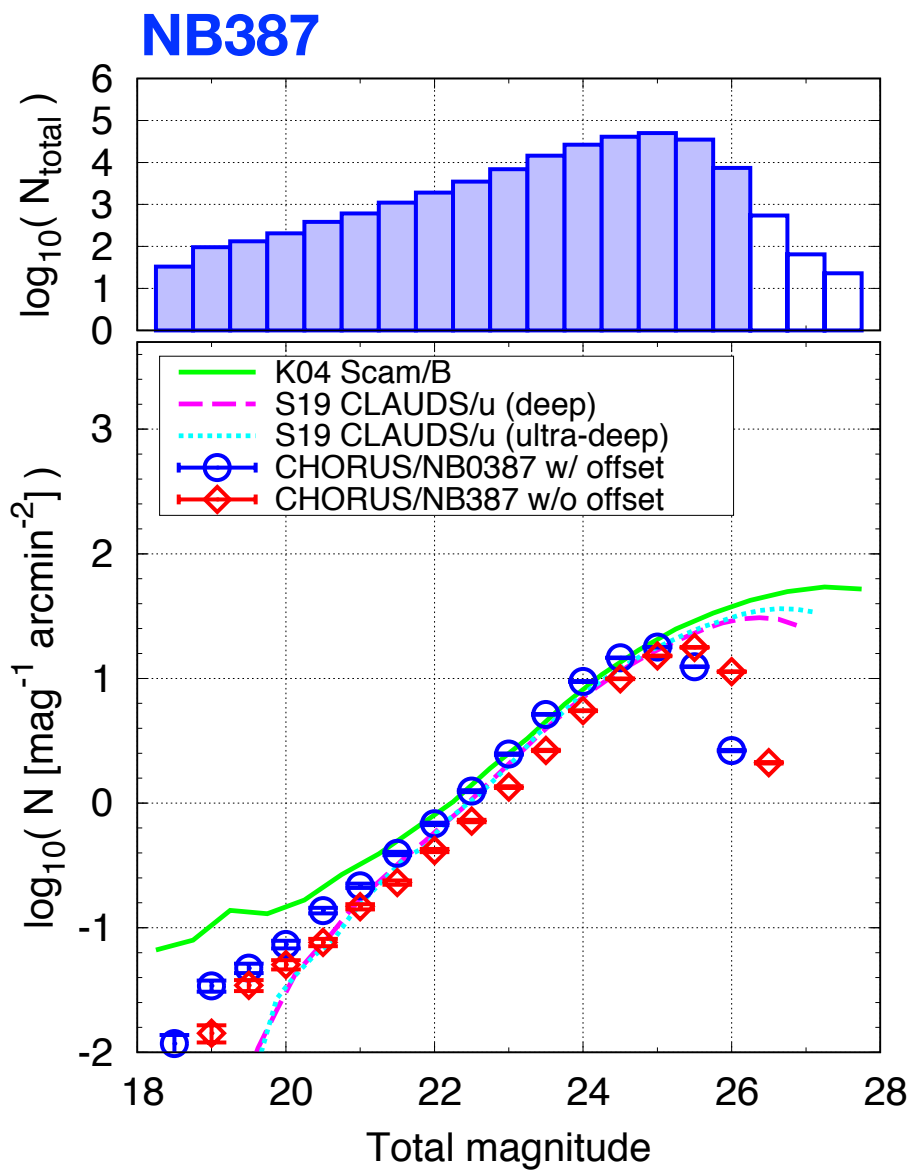
- rejecting objects in masked area
- calculating effective survey area (CHORUS mask + hscPipe flags)

## 3. Counting the objects and dividing by effective survey area

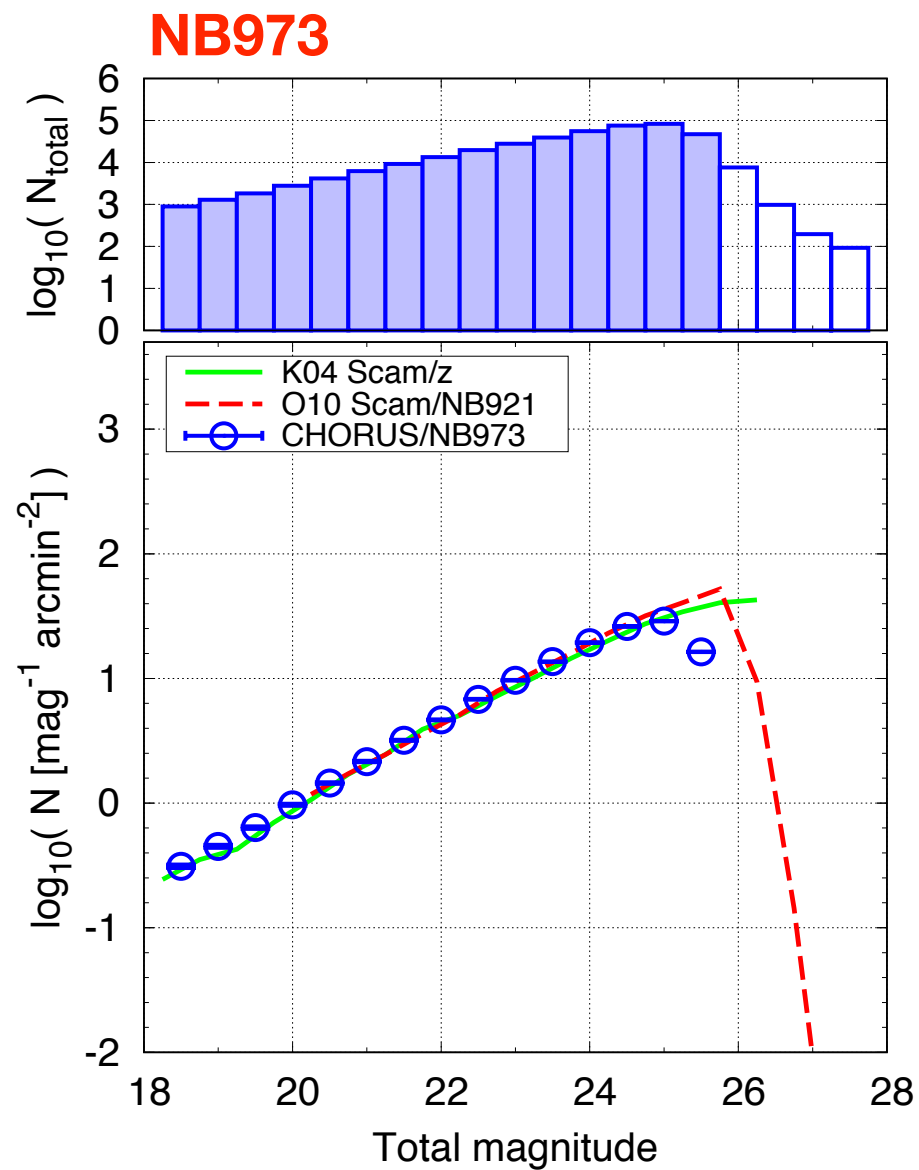
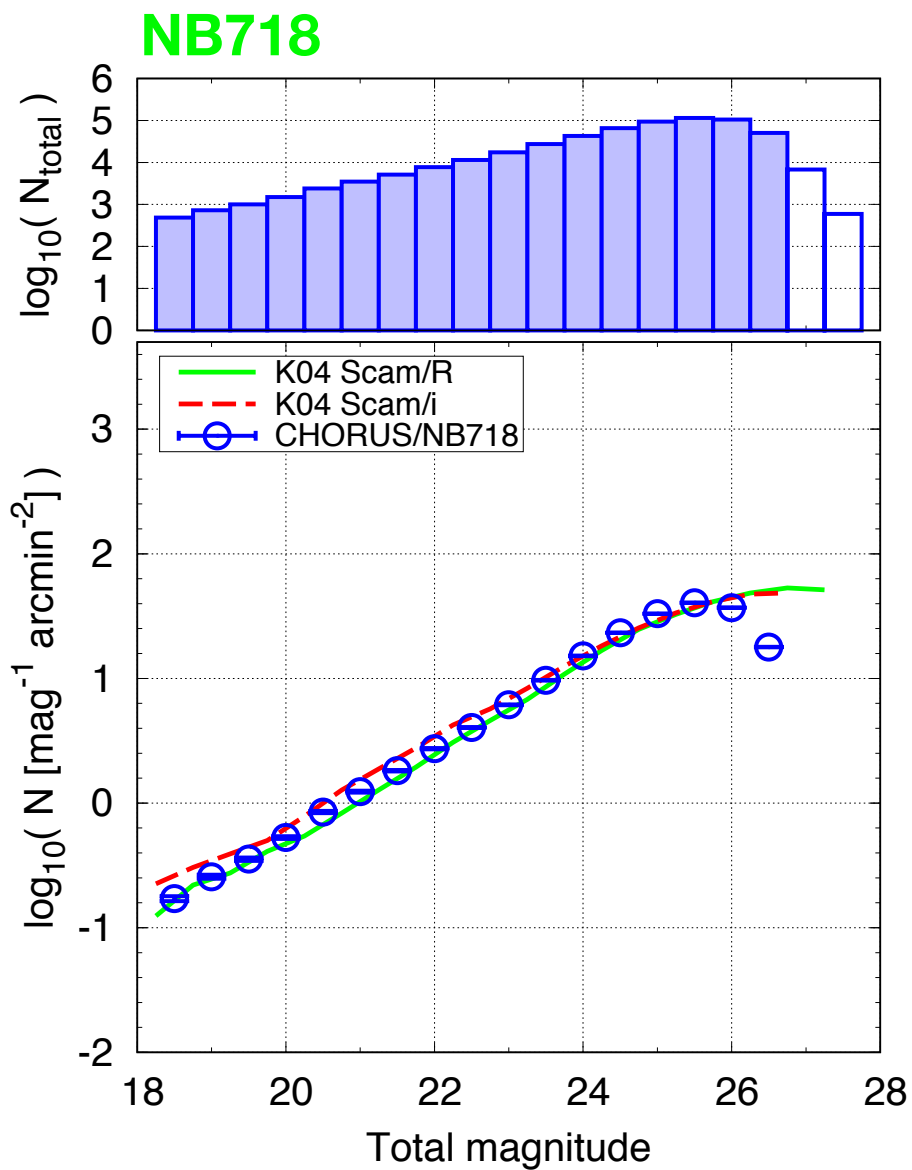
## 4. Compared with previous works

- Kashikawa et al.2004 (K04); Ouchi et al. 2008 (O08), 2010 (O10); Yamada et al. 2012 (Y12); Sawicki et al.2019 (S19)

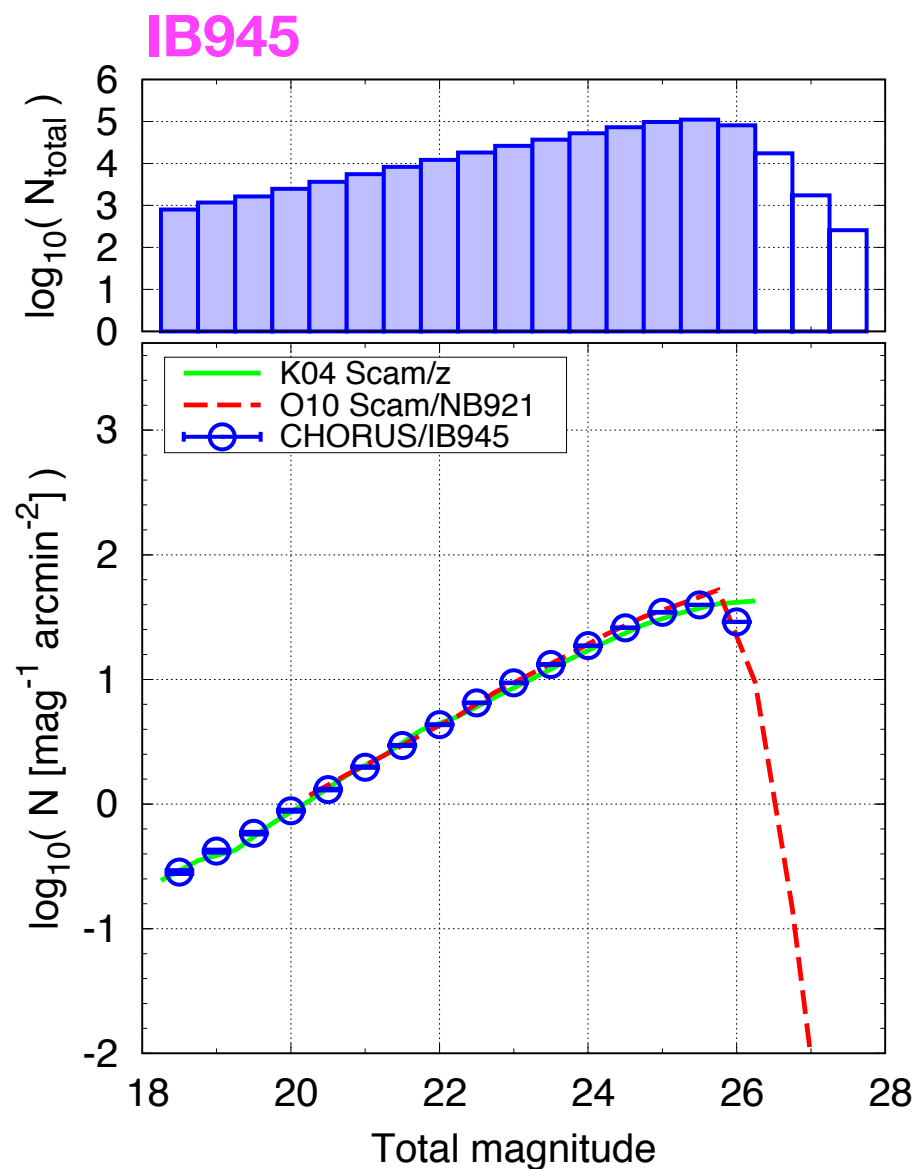
# Number density of detected objects



# Number density of detected objects



# Number density of detected objects



Excellent consistency with  
previous works

(Kashikawa et al. 2004; Ouchi et al. 2008,  
2010; Yamada et al. 2012; Sawicki et al.  
2019)

Zero-point offset of NB387  
is reasonable.

Source detection and  
measurement of photometry  
are adequately conducted.

# Summary

---

- CHORUS is a HSC project for understanding ionization sources, topology, and history of cosmic reionization.
- CHORUS PDR1 data (images and catalog) is available via HSC-SSP database.
- Target field is  $\sim 1.6 \text{ deg}^2$  area of COSMOS field, which overlaps with ultra-deep layer of HSC-SSP.
- We investigate PSF FWHM, limiting magnitude, and detection completeness for each NB/IB filter.
- We verify number density of detected objects in CHORUS PDR1 catalog

**CHORUS PDR1 is ready for scientific studies !!**