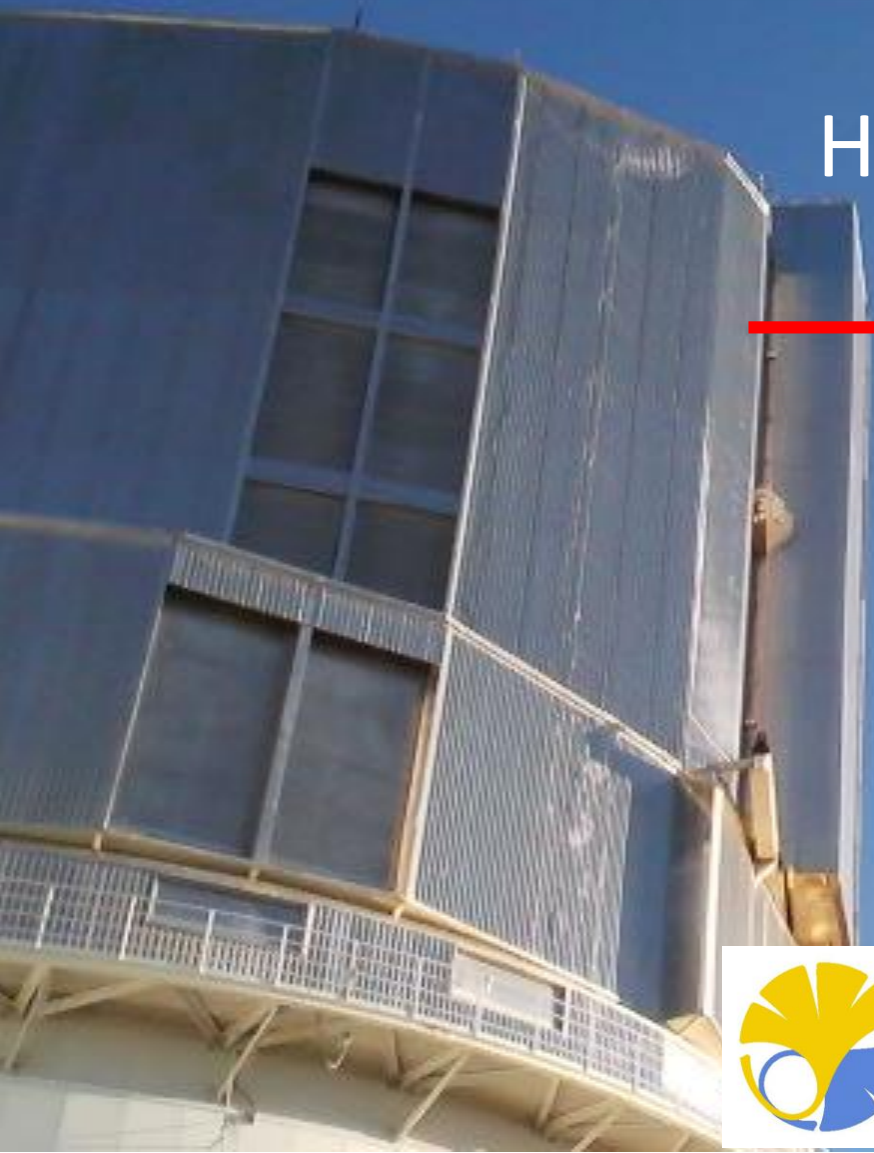


High-z protocluster survey by Subaru/HSC

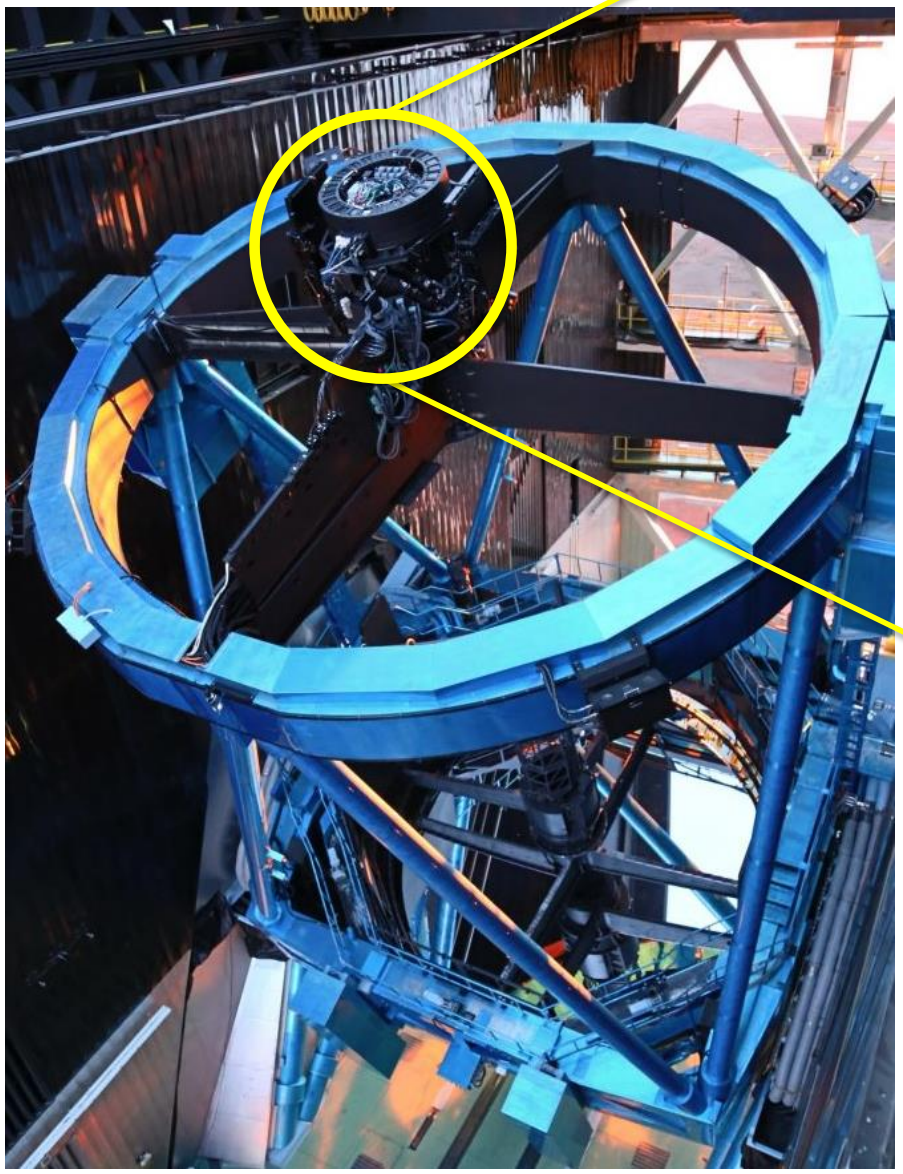
Nobunari Kashikawa
(U Tokyo)

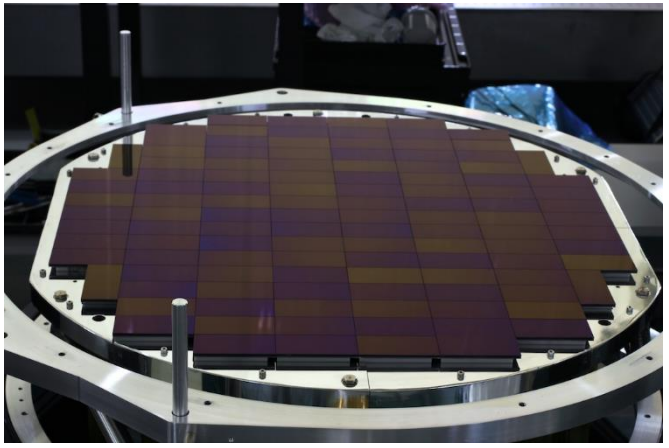
東京大学
THE UNIVERSITY OF TOKYO

SUBARU TELESCOPE
National Astronomical Observatory of Japan

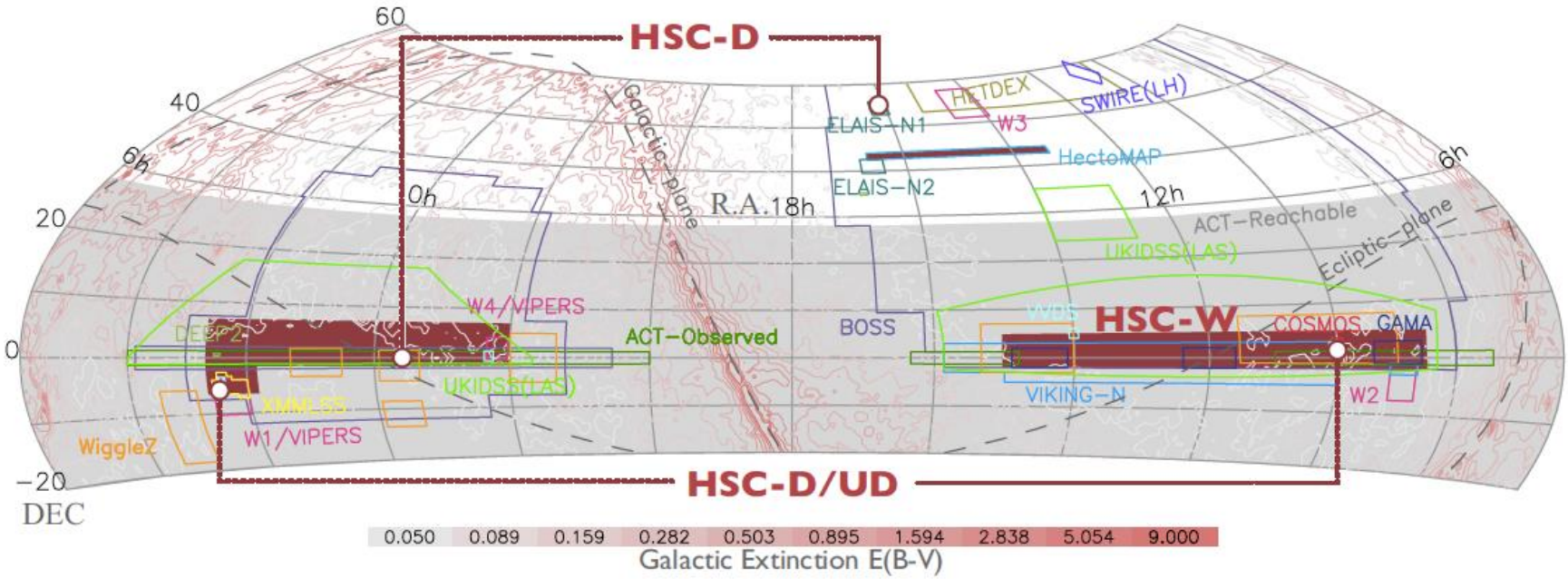
HSC

Hyper-Suprime-Cam (HSC)
1.77 deg^2 camera on Subaru





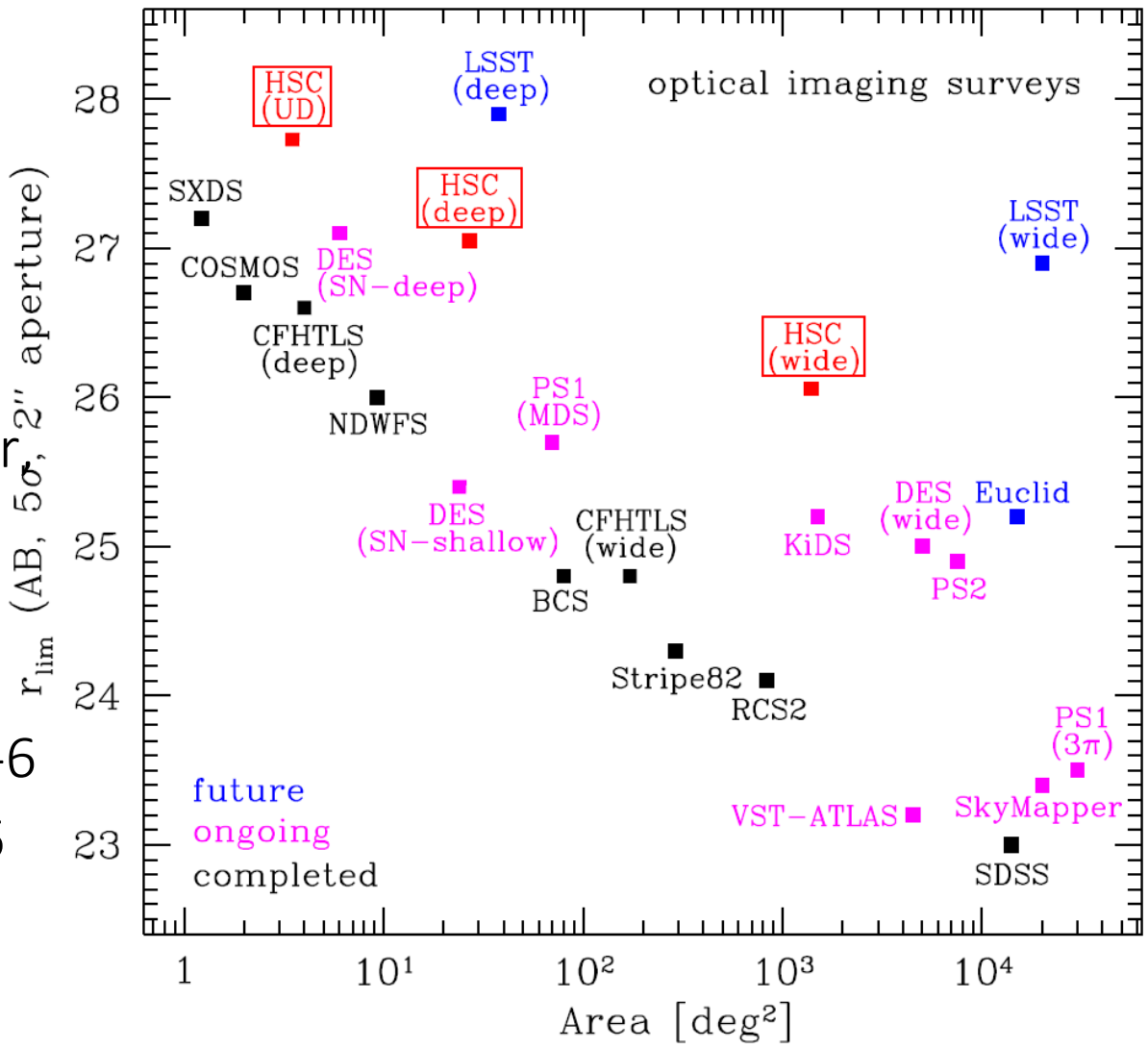
HSC strategic survey



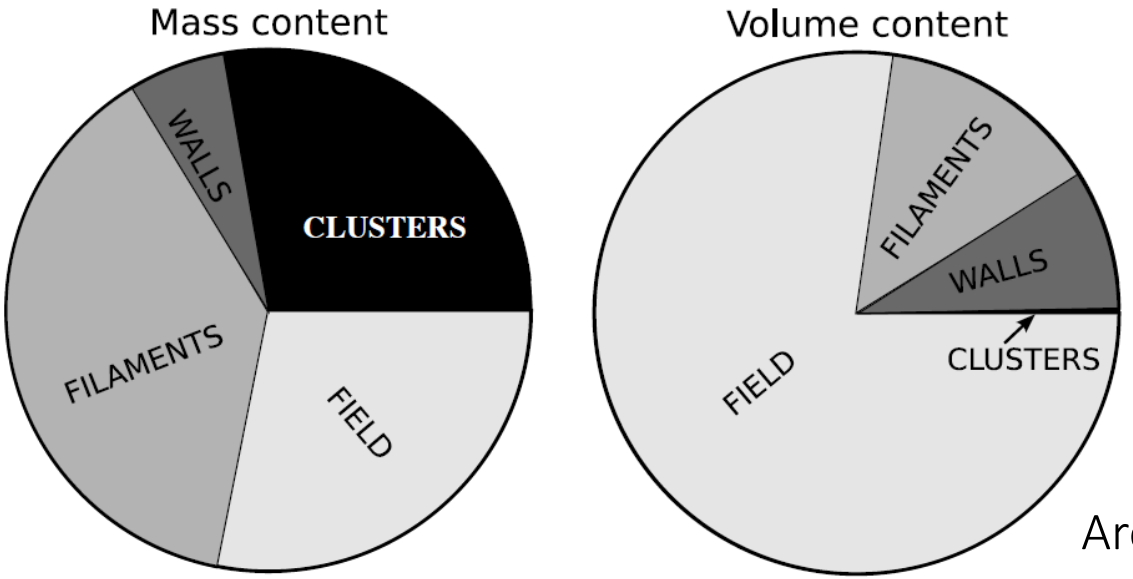
- HSC SSP (Subaru strategic program): 2014-2019, 300nights
  - Wide layer: 1400deg^2 (i=25.9, grizy)
  - Deep layer: 27deg^2 (i=26.8, grizy+NB)
  - Ultra deep layer: 3.5deg^2 (i=27.4, grizy+NB)
  - Typical i-band seeing: 0.4-0.6 arcsec

HSC strategic survey

- So far 246deg^2, full color, full depth
- Expected numbers:
  - 10k-1M LBGs @z=2-6
  - 1k-10k LAEs @z=2-6
  - 10-100 LBGs/LAEs @z=7-8

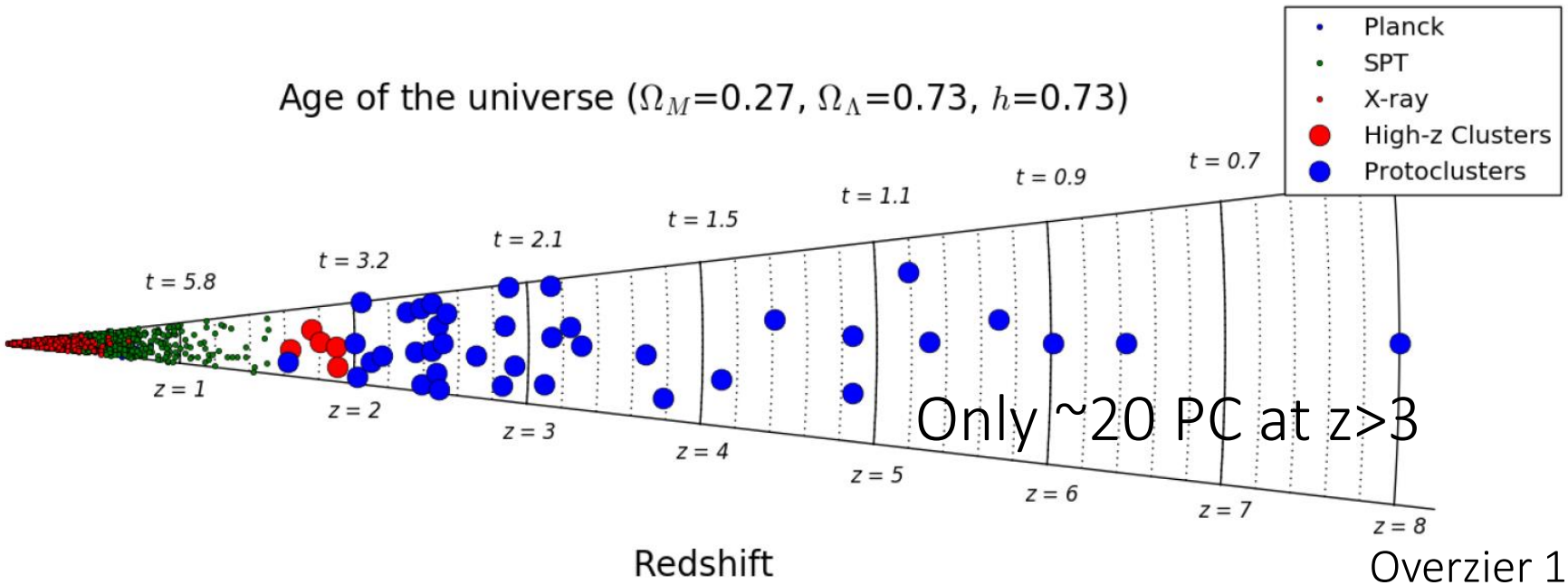


high-z protoclusters



0.38% !!!

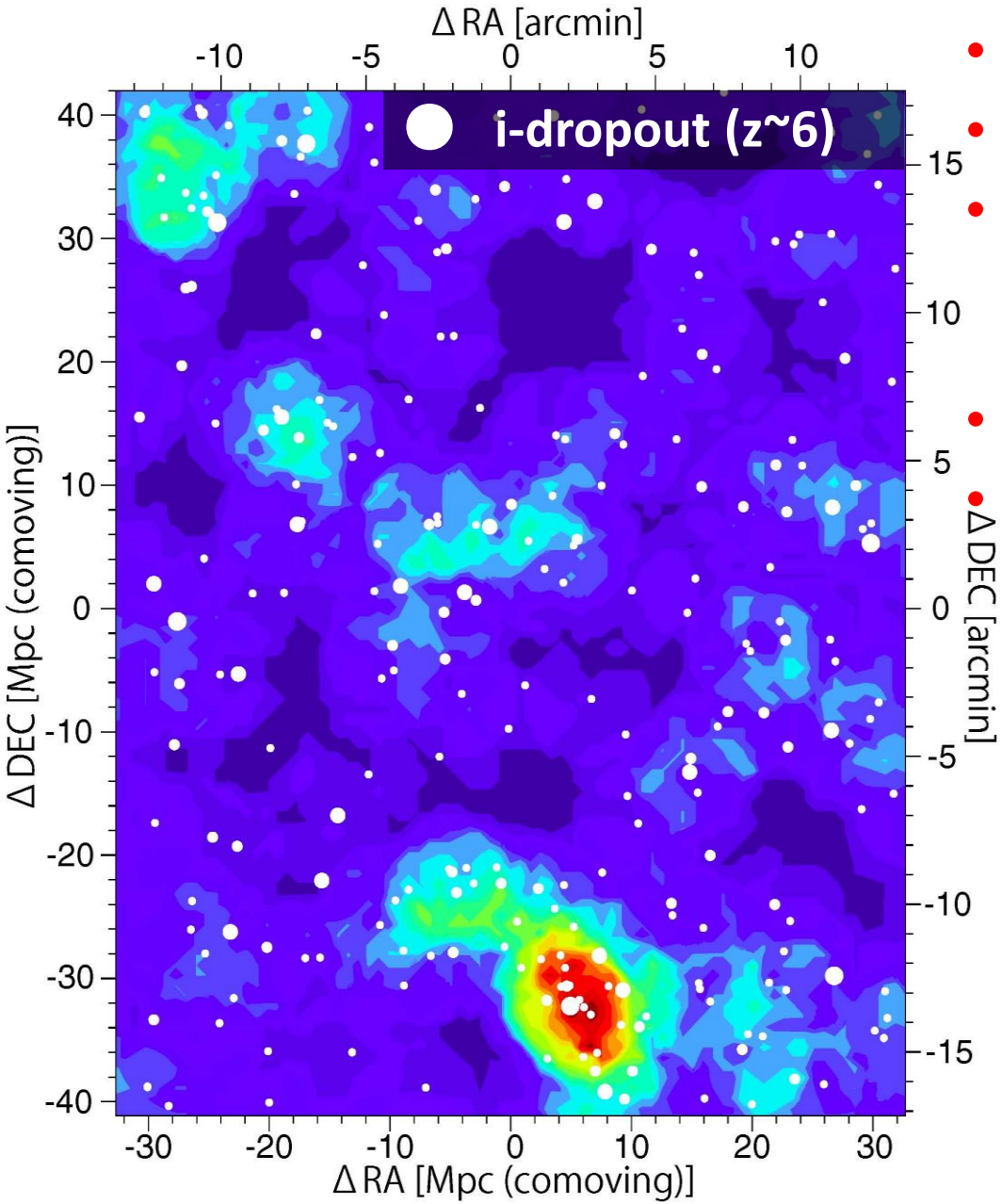
Arogon-Calvo+ 10



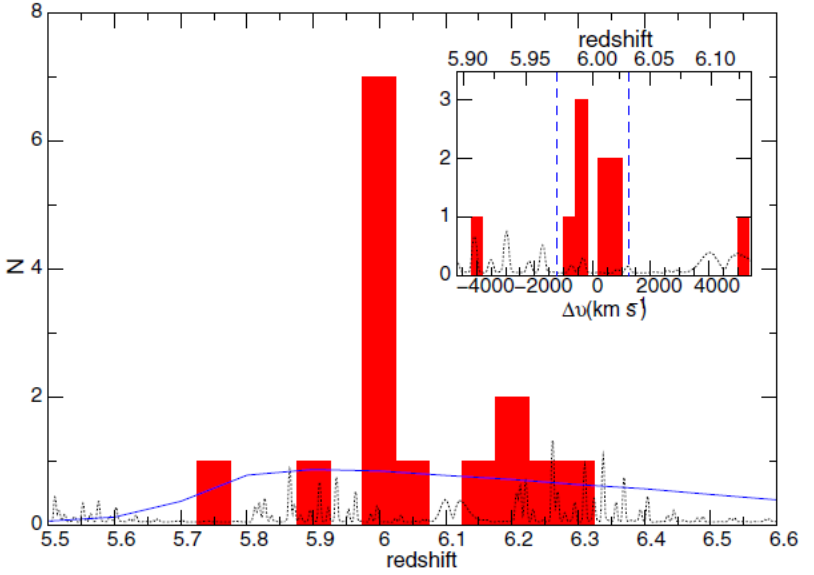
Only ~20 PC at z>3

Overzier 16

The most distant protocluster at z=6



- 6σ overdense significance
- ~6'x6' (14Mpc x 14Mpc)
- ~30 cluster member candidates have completely been spec. followed by DEIMOS
- 7σ overdensity in redshift space
- Further study w/CFHTLS data (Toshikawa+ 16)



Toshikawa, NK+ 12

HSC protocluster search

- **Systematic search of PCs at z=3-6 by using wide-field imaging**
- Science goals
  - Wide layer (~1400 deg^2)

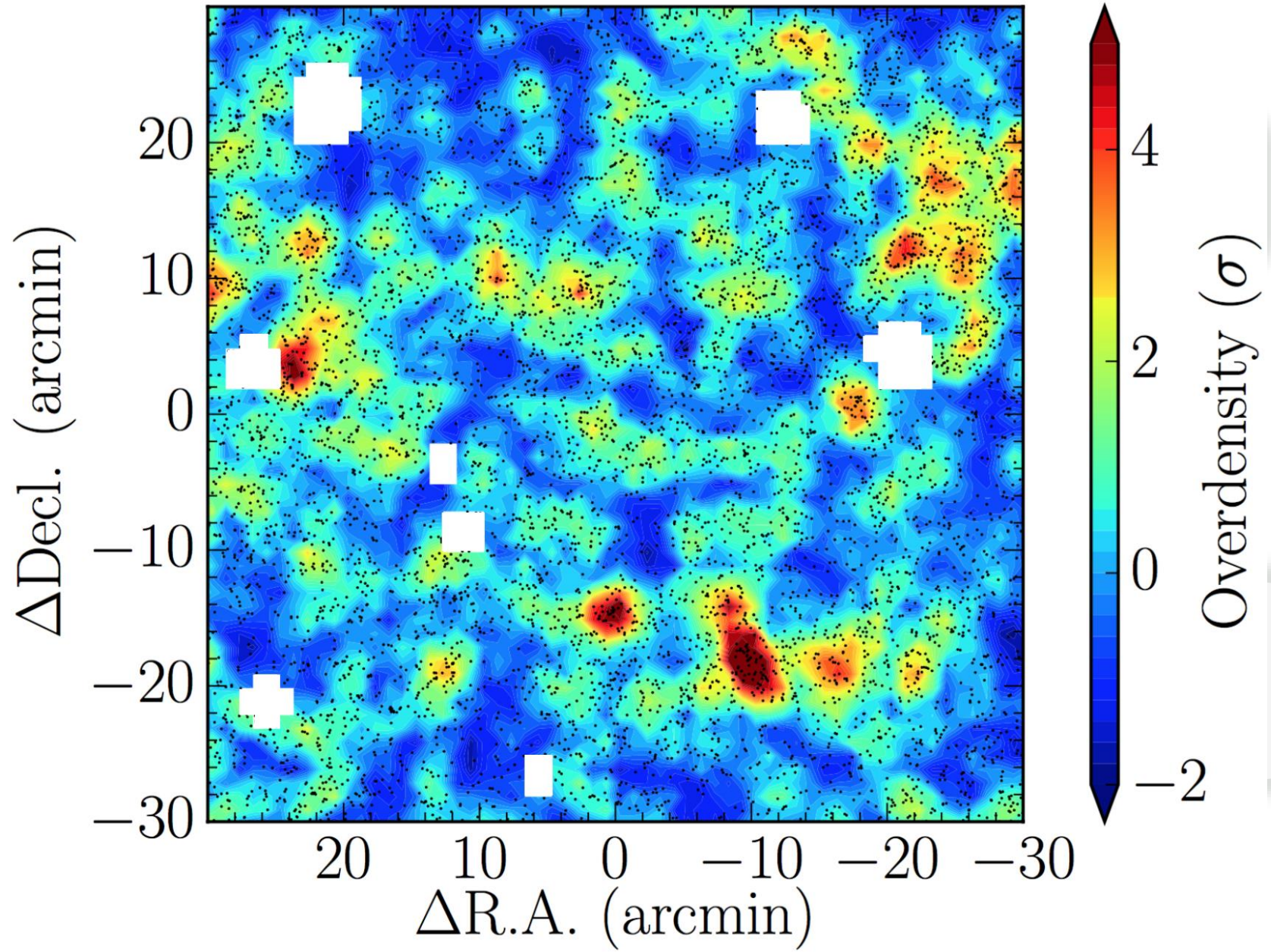
    ~1000 protoclusters will be found at z~4 (g-dropout)

    → diversity of protoclusters
  - Ultradeep/Deep layer (~27 deg^2)

    ~10-20 protoclusters will be found at each redshift

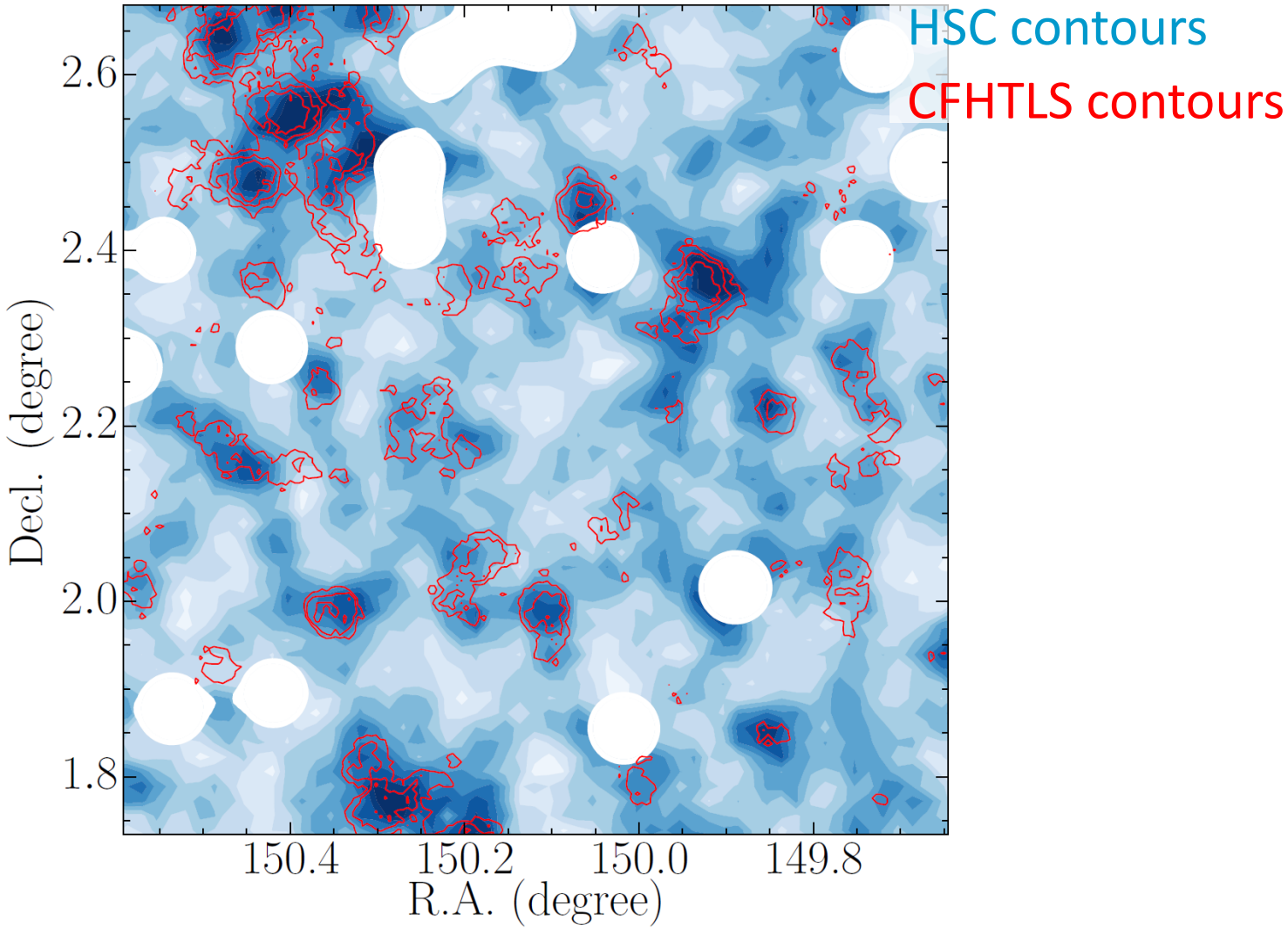
    → redshift evolution of ~30 cluster members
  - various follow-up observations to reveal cluster formation and galaxy evolution. (spec., IR, radio, etc.)
- Initial results (internal data release: S16A DR ver.)
  - Toshikawa et al. 2018 --- **z~4 PC sample over 120 deg^2**
  - Uchiyama et al. 2018 --- relation with luminous quasars
  - Onoue et al. 2018 --- relation with multiple quasars

Fixed aperture method



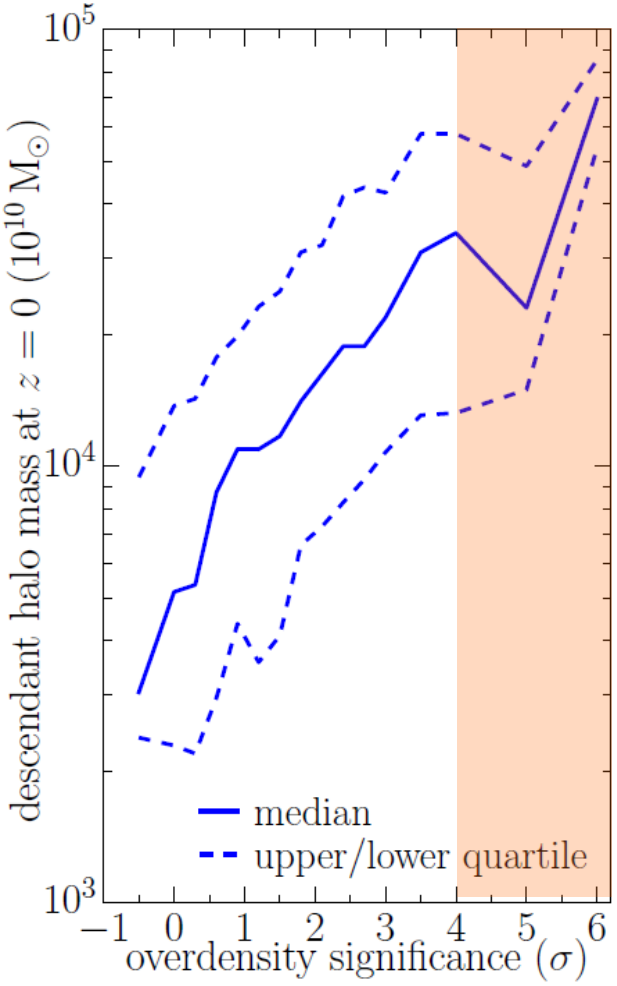
Consistency with our previous work

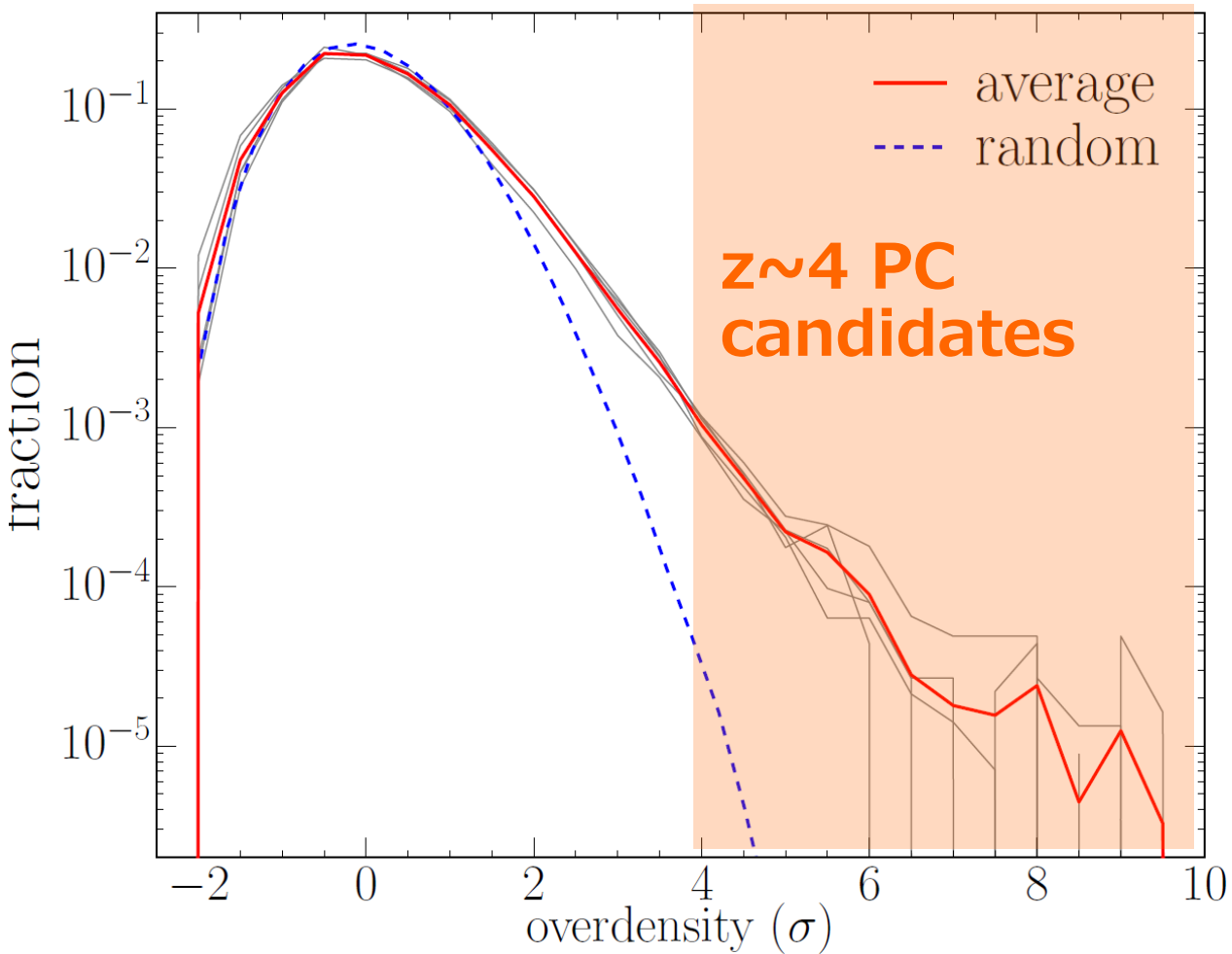
- COSMOS field
- Same dropout selection and overdensity estimate



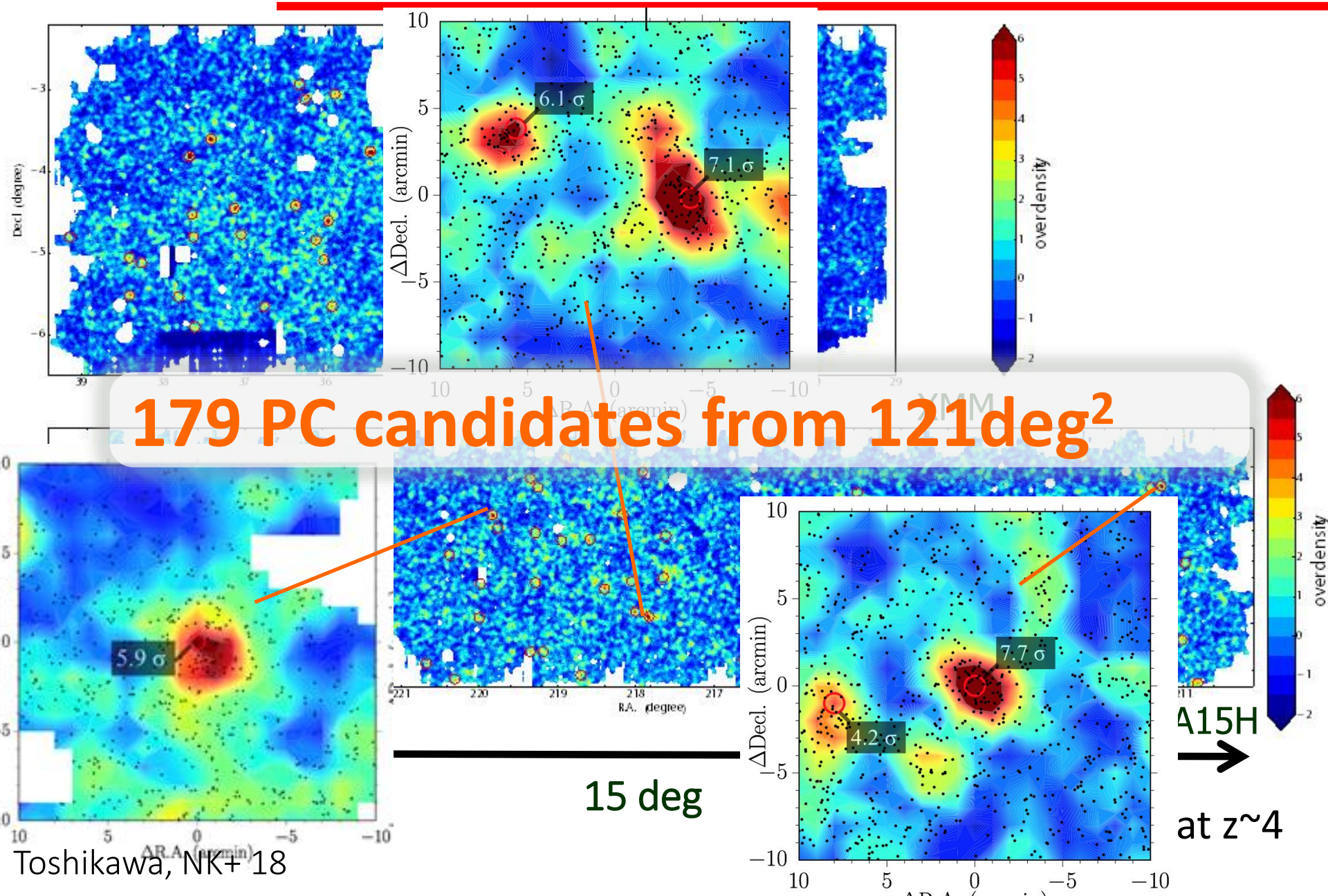
Overdensity significance

- PC are defined as regions w/ **> 4σ** at the peak.
- 76% of these candidates are expected to evolve into galaxy clusters w/halo mass>10^{14}Msun at z=0 (Chiang+13, Toshikawa, NK+ 16)





HSC Protocluster search @z~4



179 PC candidates from 121deg²

A15H

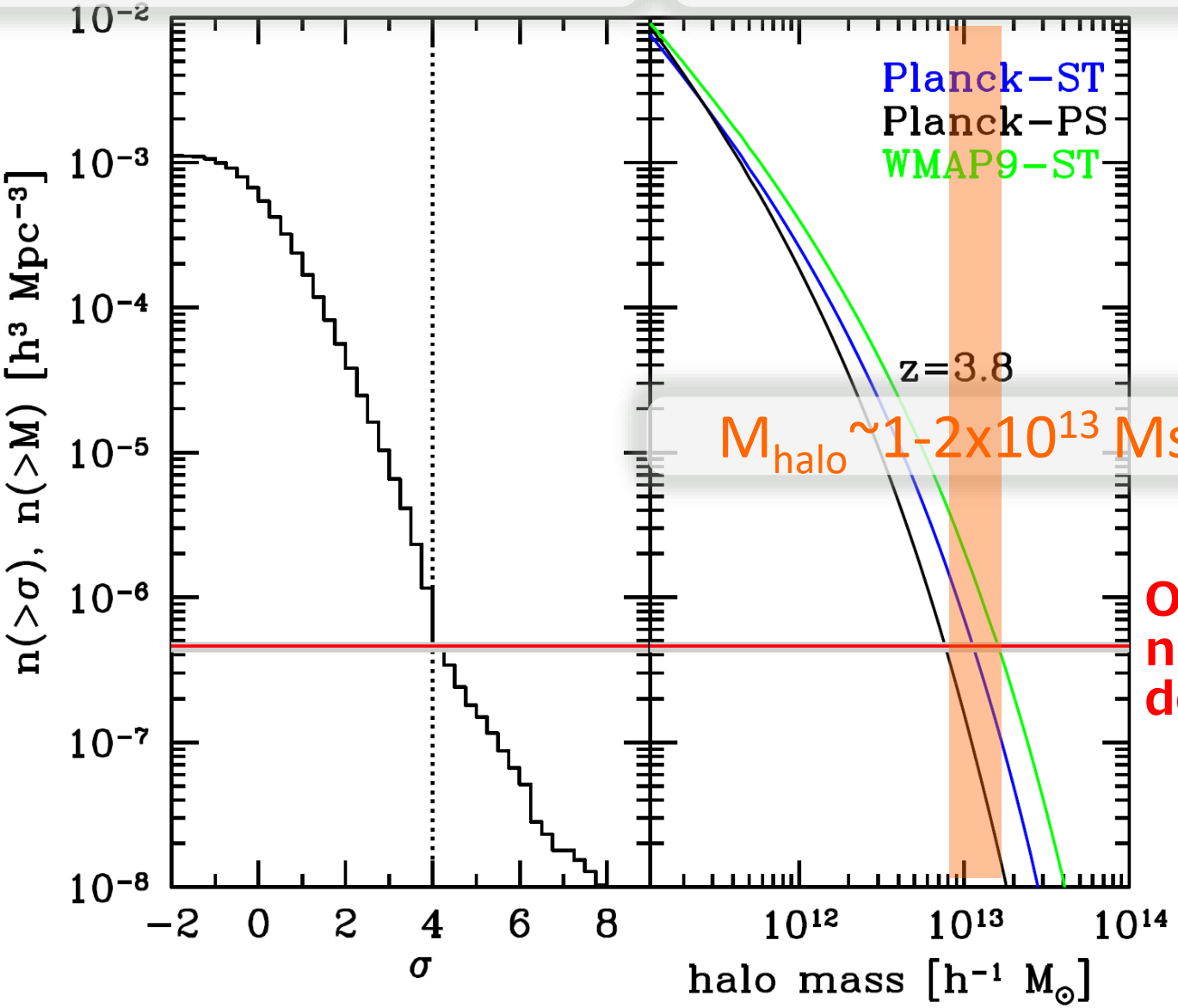
at z~4

Toshikawa, NK+ 18

“Abundance matching”of z~4 PCs

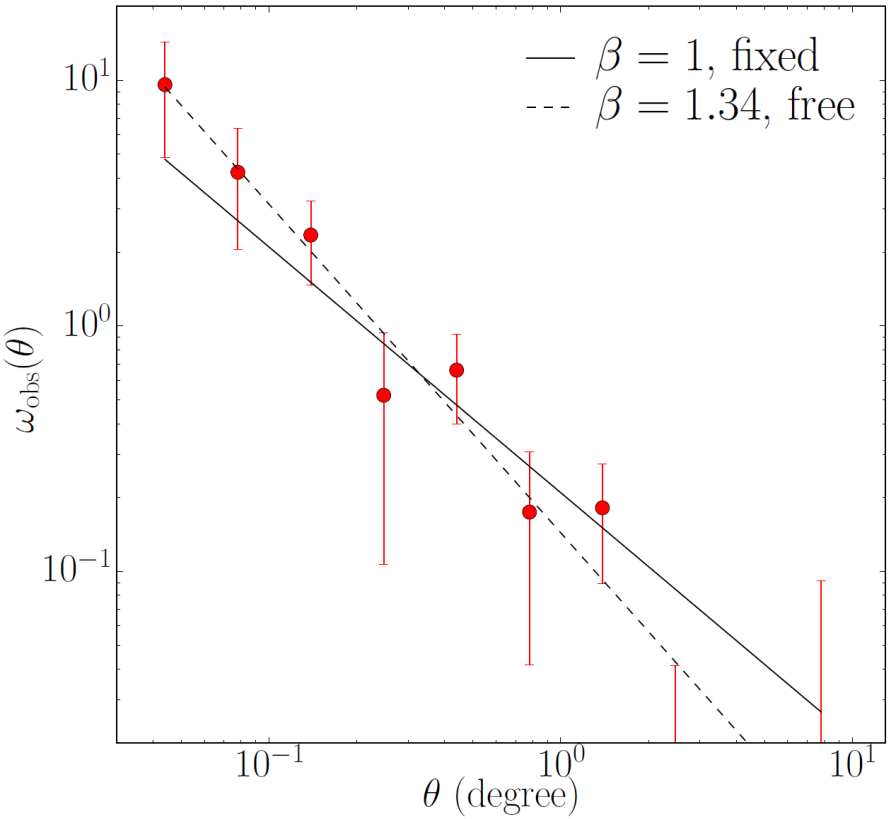
Observed overdensity distribution

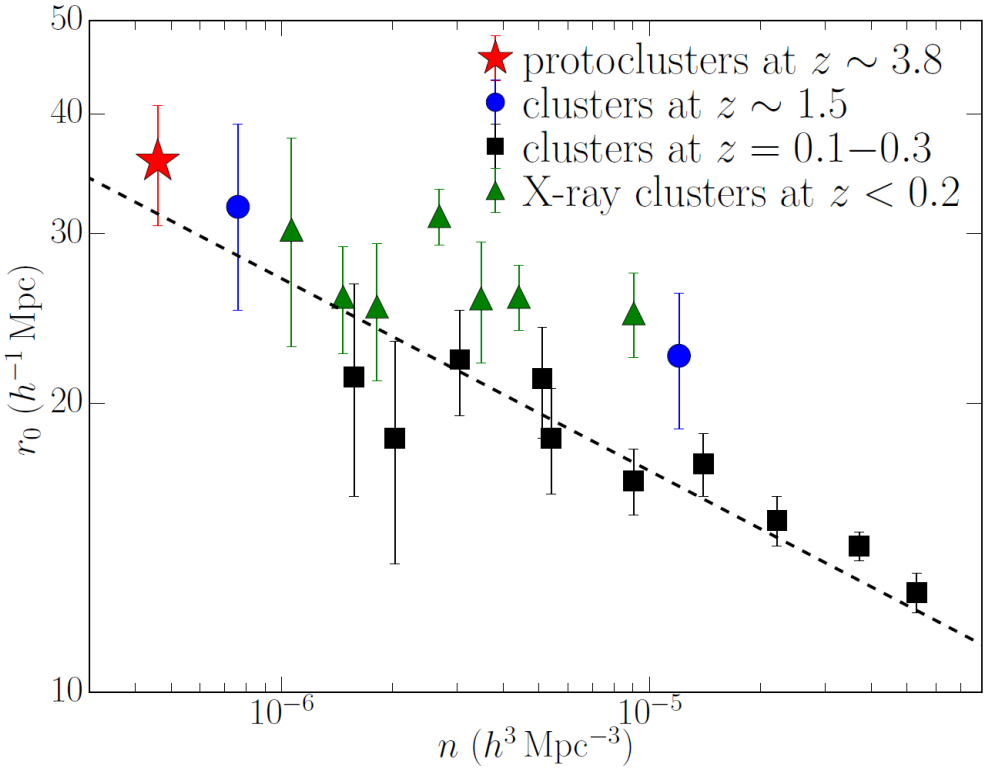
Predicted Mass function



ACF of z~4 PCs

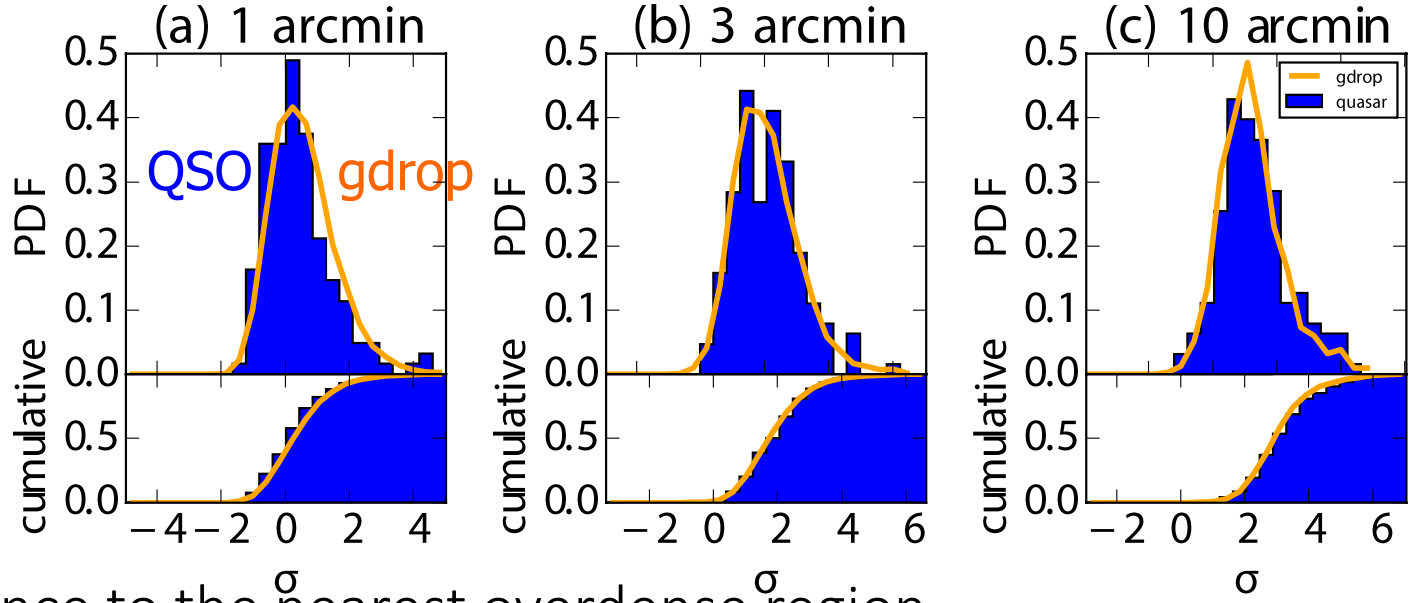
- $r_0 = 35.0^{+3.0}_{-3.3}\,h^{-1}\,\mathrm{Mpc}$ → $\langle M_h \rangle = 2.3^{+0.5}_{-0.5} \times 10^{13}\,h^{-1}\mathrm{M}_\odot$
- Consistent with the AM estimate.
- Descendant halo mass at z=0: $\langle M_h \rangle = 4.1^{+0.7}_{-0.7} \times 10^{14}\,h^{-1}\mathrm{M}_\odot$
- These overdense regions at high-z almost exactly marks the region of the most massive dark matter halos.



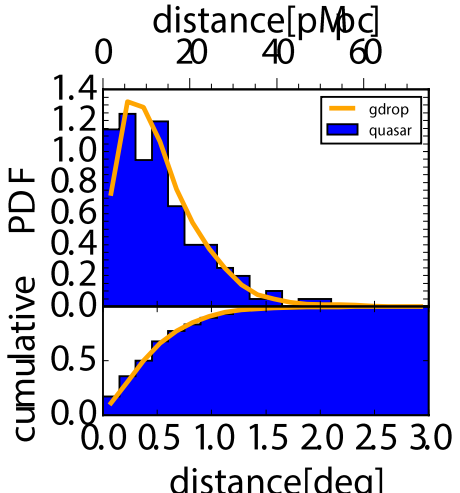


quasars and protocluster

- Only two Sloan quasars out of ~200 exist in the PC region
- Overdensity significance at the quasar position



- Distance to the nearest overdense region



- **Luminous quasars do not live in overdense regions of LBGs at z~4**
- quasar and galaxy overdense region are not significantly correlated at z~4 based on the statistically robust sample. (cf. consistent w/Orshi+16)

Uchiyama, NK+ 18

Summary

- HSC: wide-field imager to explore early universe.
- High-z protoclusters: will provide the initial conditions of clusters at their birth, and closely related to the patchy reionization. HSC survey will collect a significant number of PCs.
- Based on S16A DR, **179 z~4 PC candidates from 121deg^2**
- Dark halo mass: $\langle M_h \rangle = 2.3^{+0.5}_{-0.5} \times 10^{13}\, h^{-1}\mathrm{M}_\odot$
- Luminous quasars do not live in overdense regions of LBGs at z~4
- Next scope: SF properties of PC regions, comparison w/field
- First HSC public data release (PDR1) is now available (~100 deg^2 of imaging in 5 bands)
- Lots of exciting science coming soon!