The 6th Subaru International Conference in Hiroshima (28/11/2016)

Lya Luminosity Functions at z=5.7 & 6.6 by Subaru/HSC 21deg^2 NB surveys

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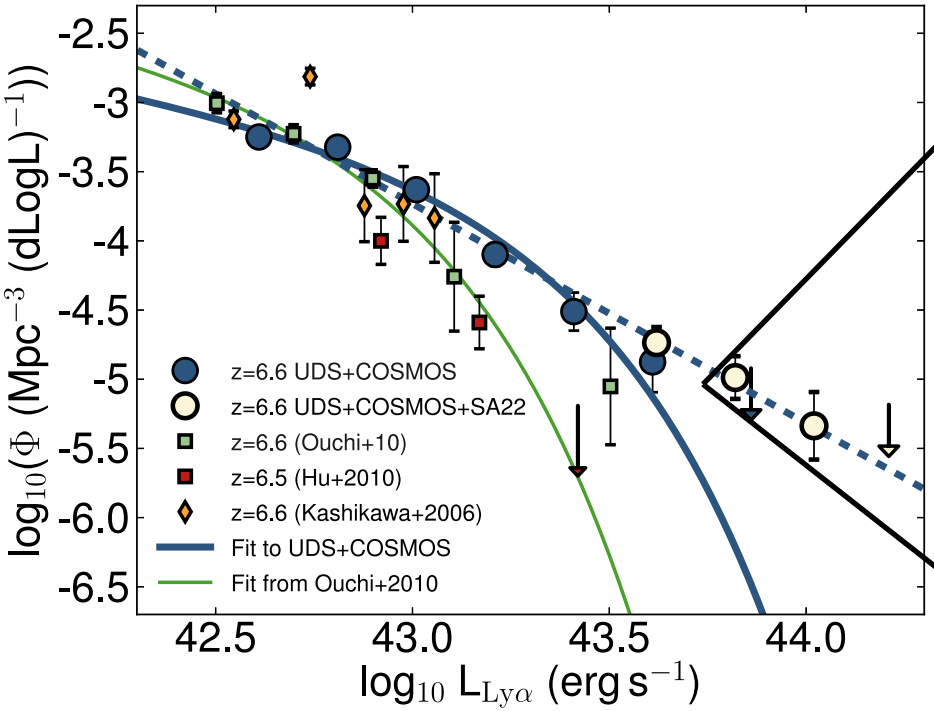
M. Ouchi, T. Shibuya, R. Higuchi (Univ. of Tokyo)

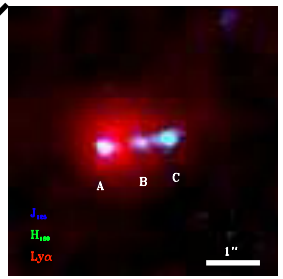
and HSC-SSP project 84 & 85 members

Introduction

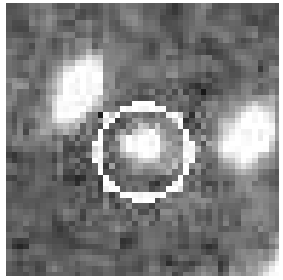
Matthee+15



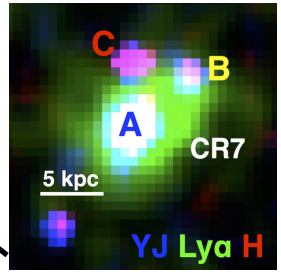
Himiko (Ouchi+09)

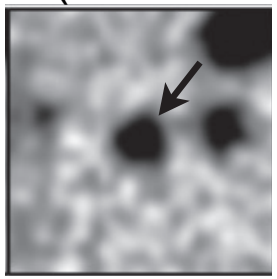


COLA1 (Hu+16)



CR7 & MASOSA(Sobral+15)





- Identification of interesting objects (see **T. Shibuya+'s talk**)

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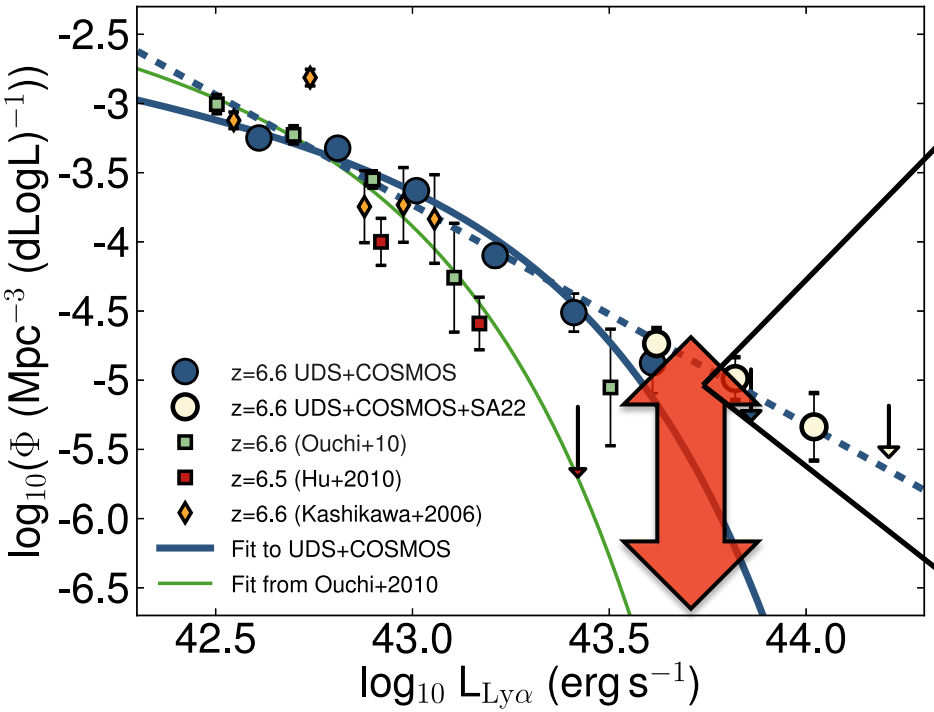
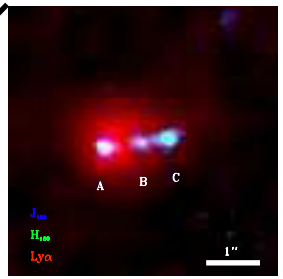


Himiko (Ouchi+09)



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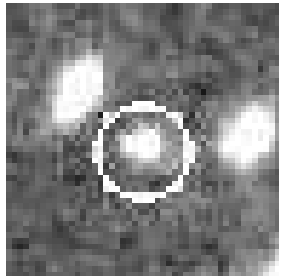

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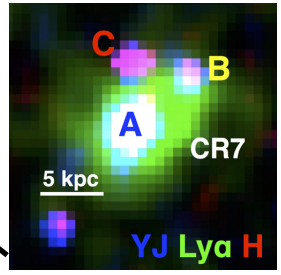

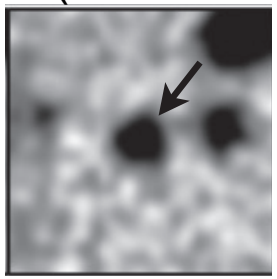

- Identification of interesting objects (see **T. Shibuya+'s talk**)
- Large uncertainties at bright ends of Lya LFs

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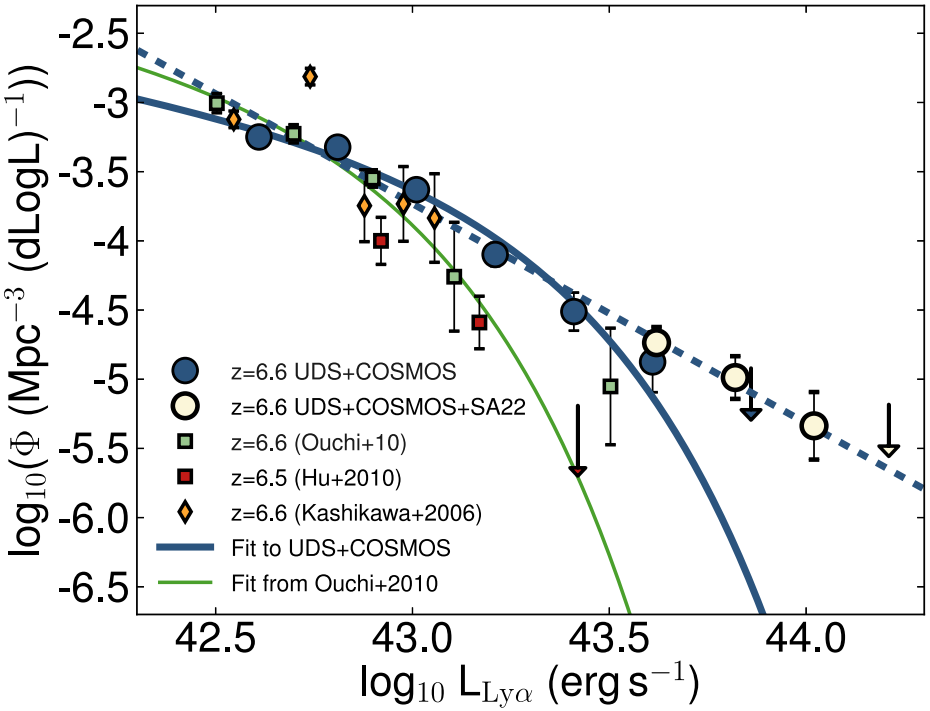
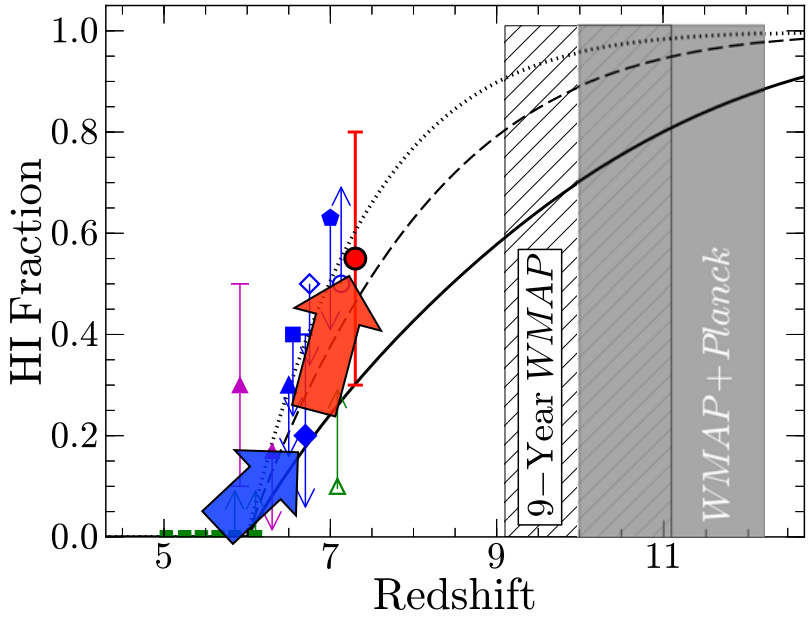
Matthee+15



Konno+14



- Identification of interesting objects (see **T. Shibuya+'s talk**)
- Large uncertainties at bright ends of Lya LFs
- Lya LF evolution at z>6 to constrain reionization history
  - Lya damping wing absorption by IGM HI gas

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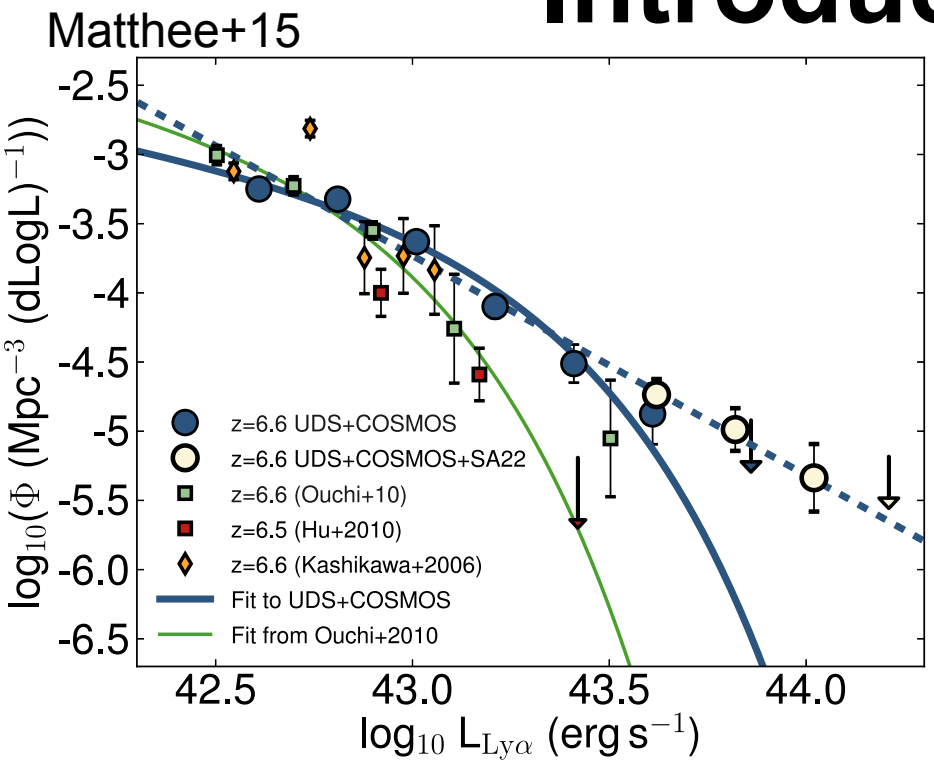
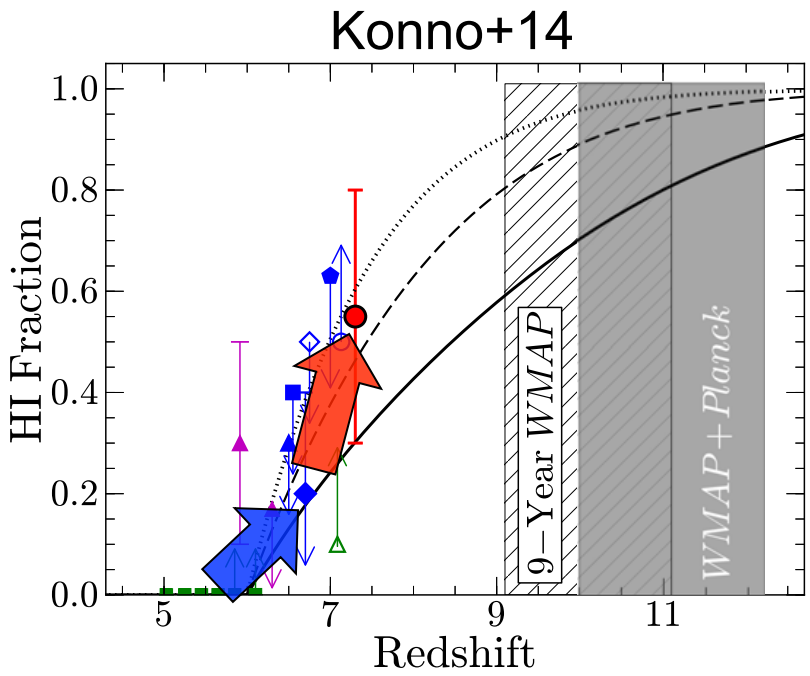
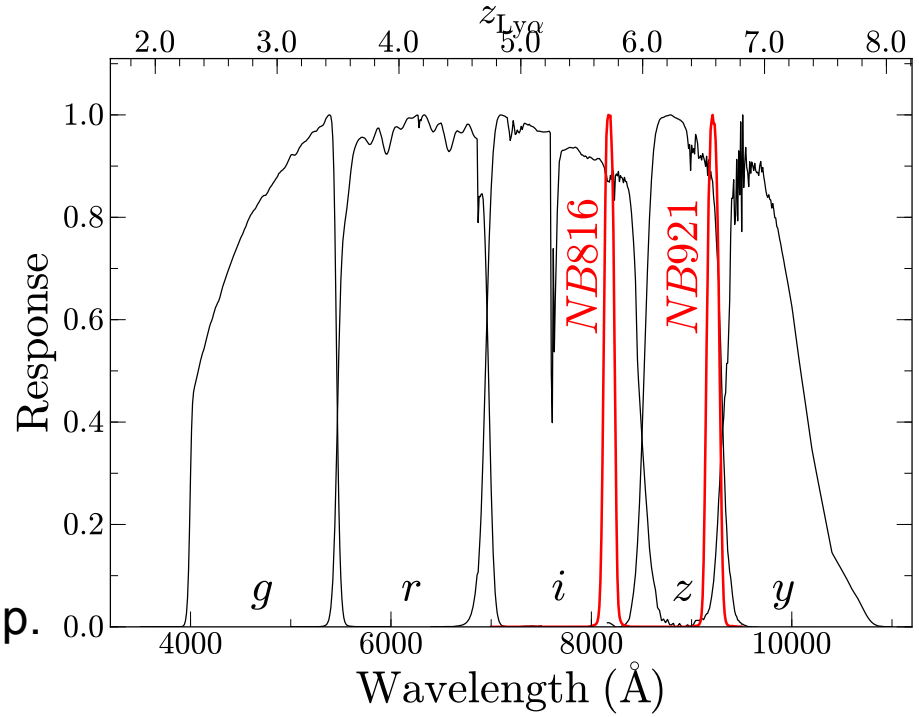




- Identification of interesting objects (see **T. Shibuya+'s talk**)
- Large uncertainties at bright ends of Lya LFs
- Lya LF evolution at z>6 to constrain reionization history
  - Lya damping wing absorption by IGM HI gas
- Wide area surveys to construct large z>6 LAE samples

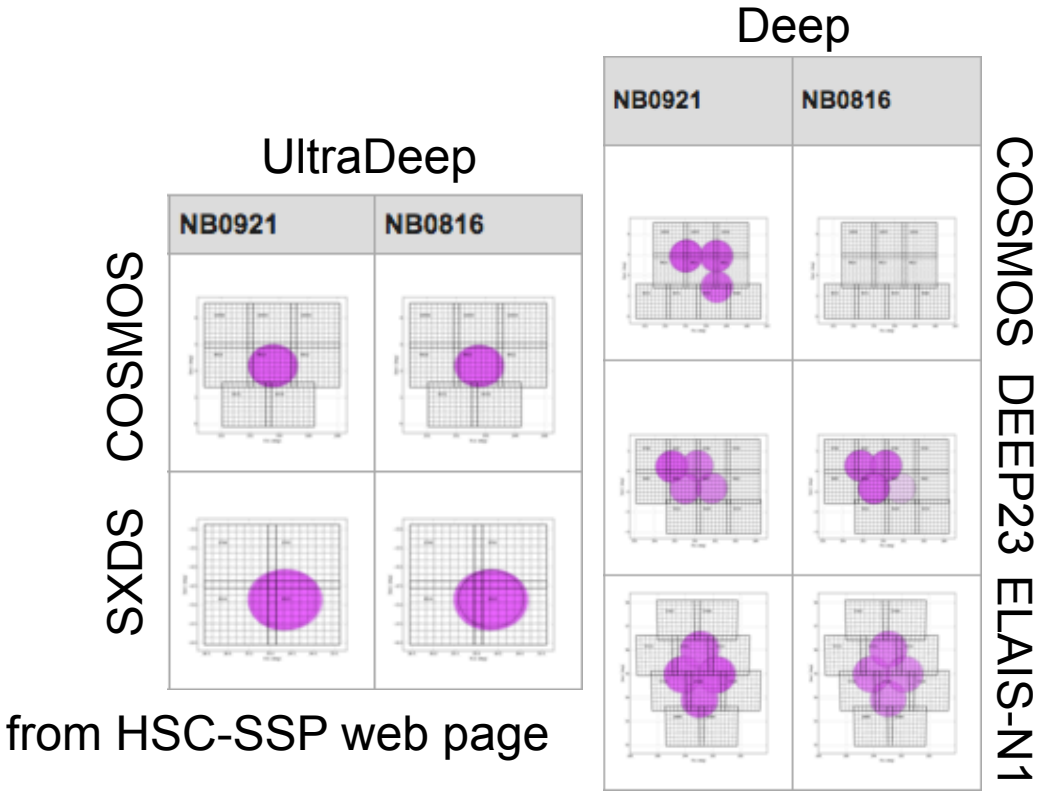
Subaru/HSC NB Surveys

Konno+ in prep.



- HSC-SSP 5-years survey (for z=5.7 & 6.6 LAEs)
  - Deep & Ultra-Deep NB816/921 imaging
  - Area … Deep: ~30 deg^2, UltraDeep: ~4 deg^2
  - Exp. Time … Deep: ~4 hrs, UltraDeep: ~12 hrs

Present Status of HSC-NB Data



from HSC-SSP web page

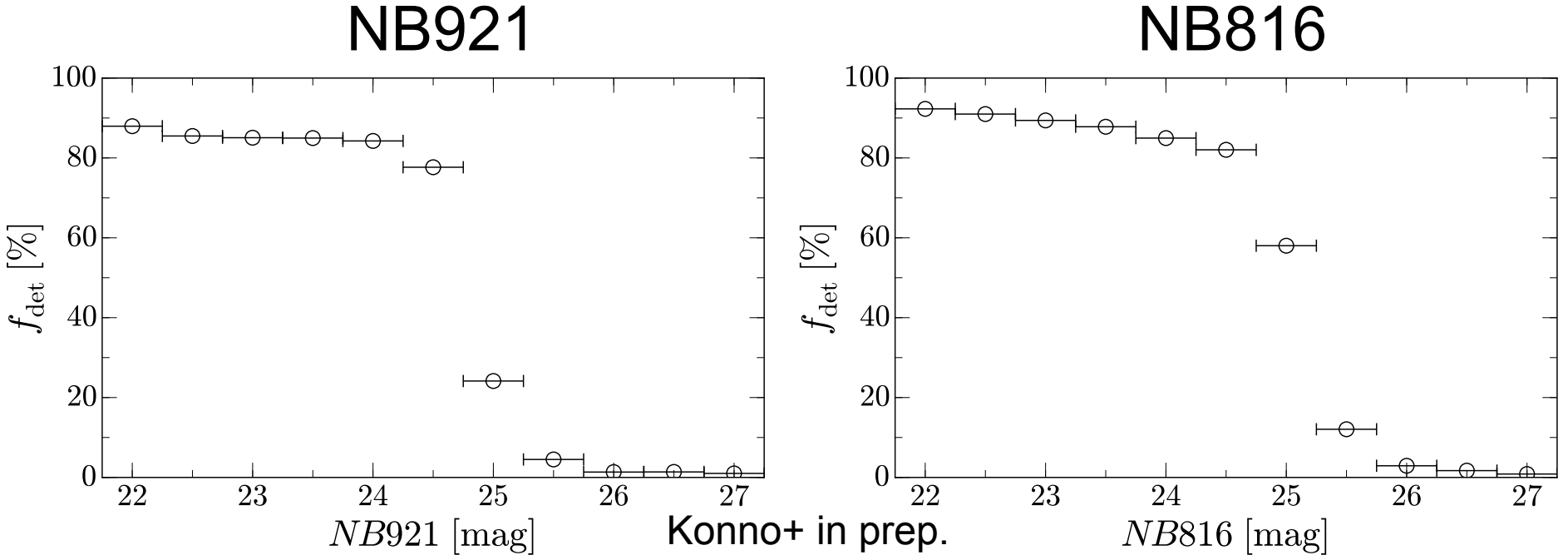
- Available data observed in Mar. 2014 – Apr. 2016
  - Area … 13.8 deg^2 (NB816) & 21.2 deg^2 (NB921)
  - Limit. mag … ~25.0 mag (Deep), ~25.5 mag (UltraDeep)
- **x2-10 (z=5.7), x4-20 (z=6.7) wider than Ouchi+, Santos+, Matthee+**

LAE Selection

	NB921	NB816
UD_COSMOS	435	202
UD_SXDS	60	224
D_COSMOS	249	---
D_DEEP23	178	423
D_ELAIS-N1	351	232
Total	**1273**	**1081**

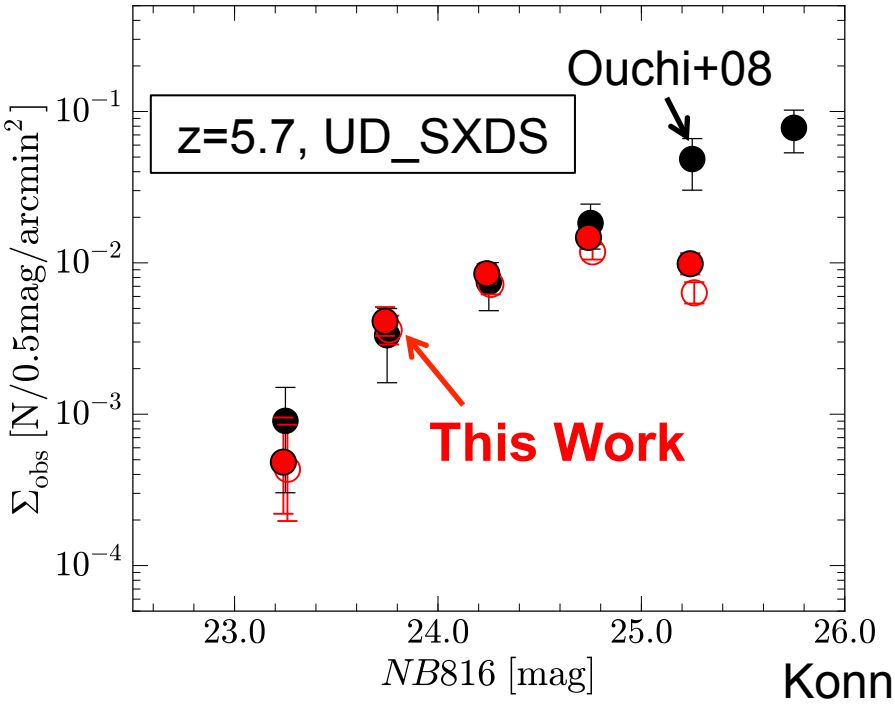
- NB color selection criterion to identify z=5.7/6.6 LAEs
- **~2400 LAEs** (total) have been found so far
  x2-6 larger than Ouchi+, Santos+, Matthee+'s samples
  (Shibuya+ in prep.; see also **T. Shibuya+'s talk**)

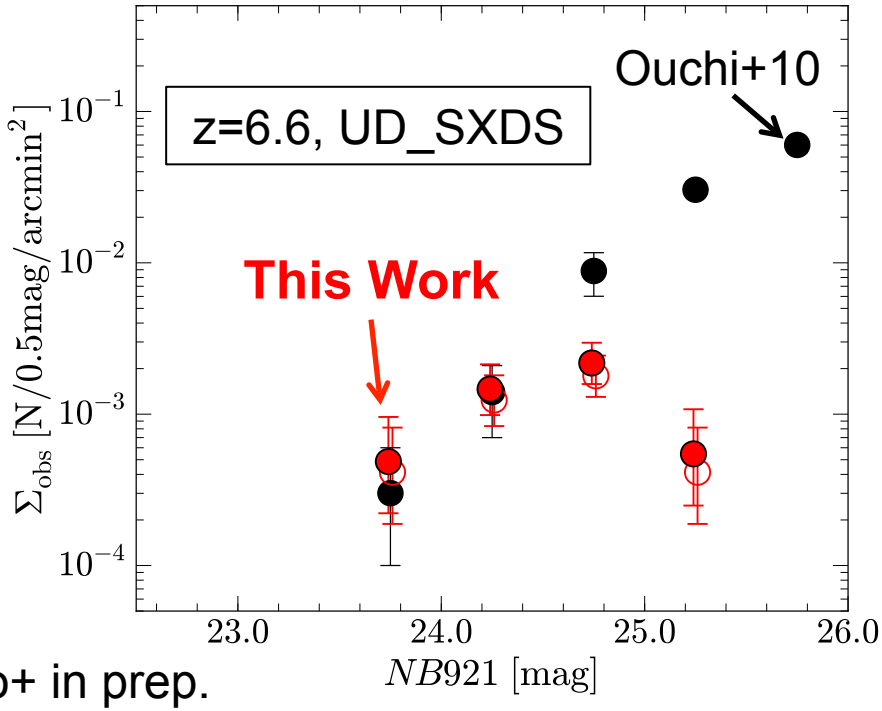
Completeness & Contamination



- Completeness estimates with Synpipe (Huang, Murata+)
  - Input & detect artificial objects in HSC images
  - ~80% at NB < 24 mag, ~50% at 5σ limit. mag.
- Contamination rate … 31% by spec. obs. (**Shibuya+'s talk**)

Number Counts of LAEs

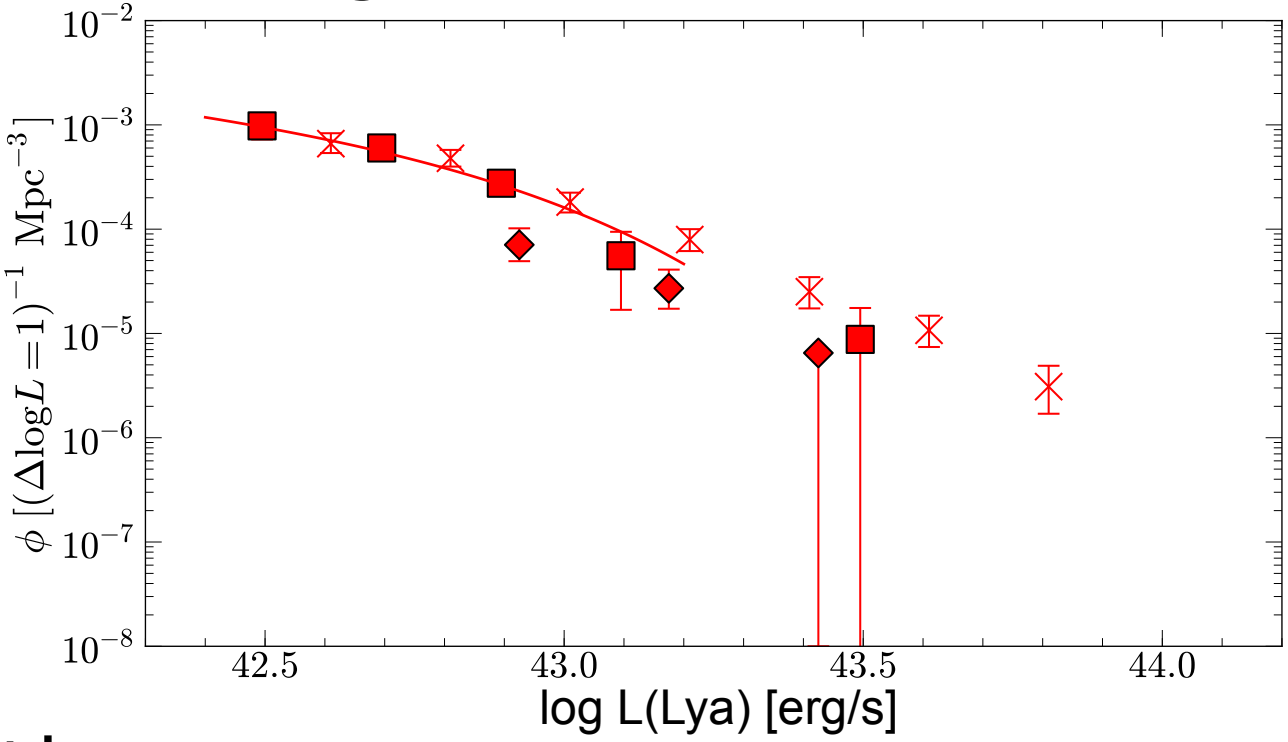




Konno+ in prep.

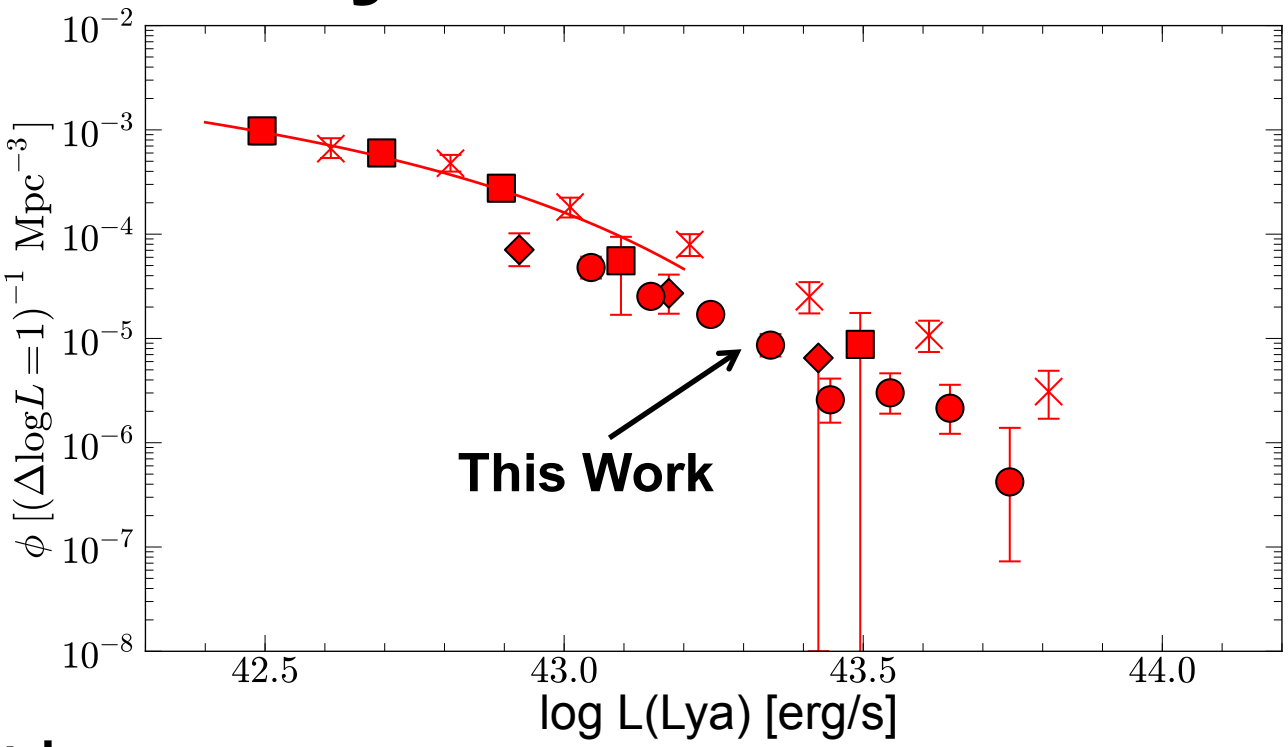
- Surface number densities of z=5.7, 6.6 LAEs
  - Ouchi+08/+10 … Obs. in SXDS w/ Suprime-Cam
- Consistent with previous Suprime-Cam results

Lya LFs at z=6.6



Konno+ in prep

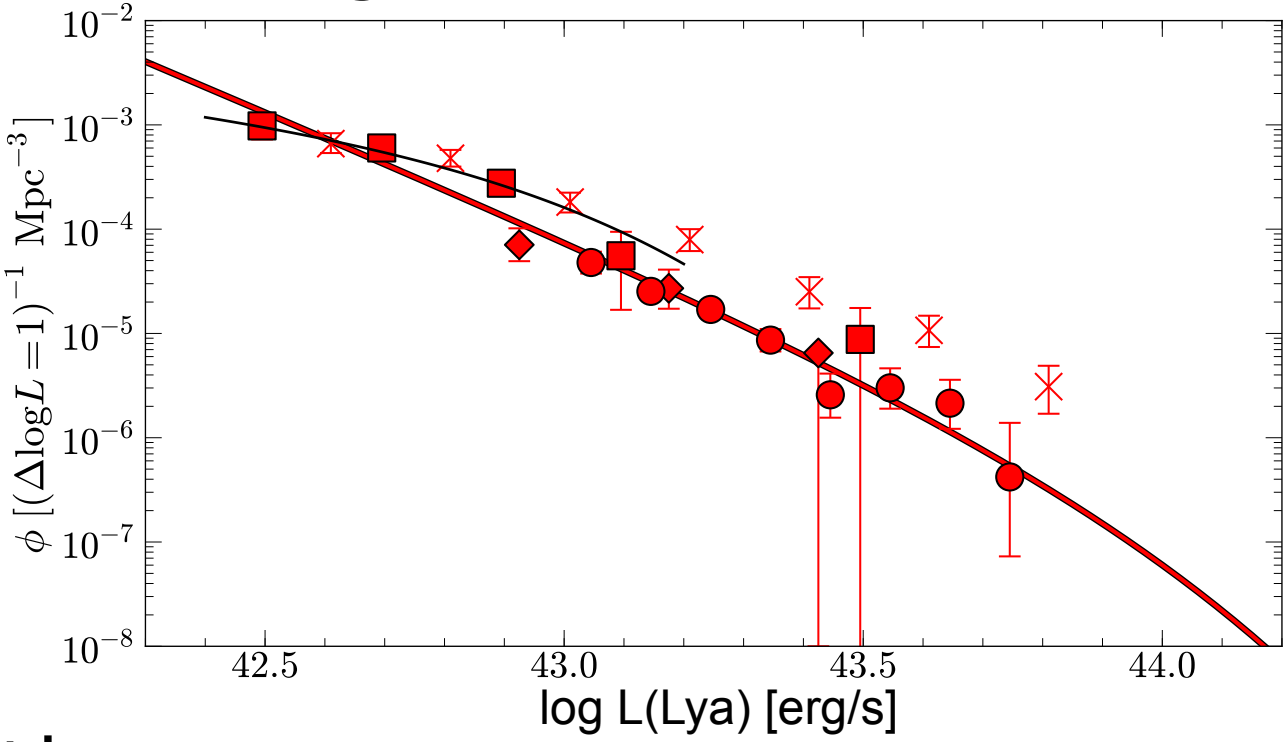
Lya LFs at z=6.6



Konno+ in prep

- Consistent with previous studies

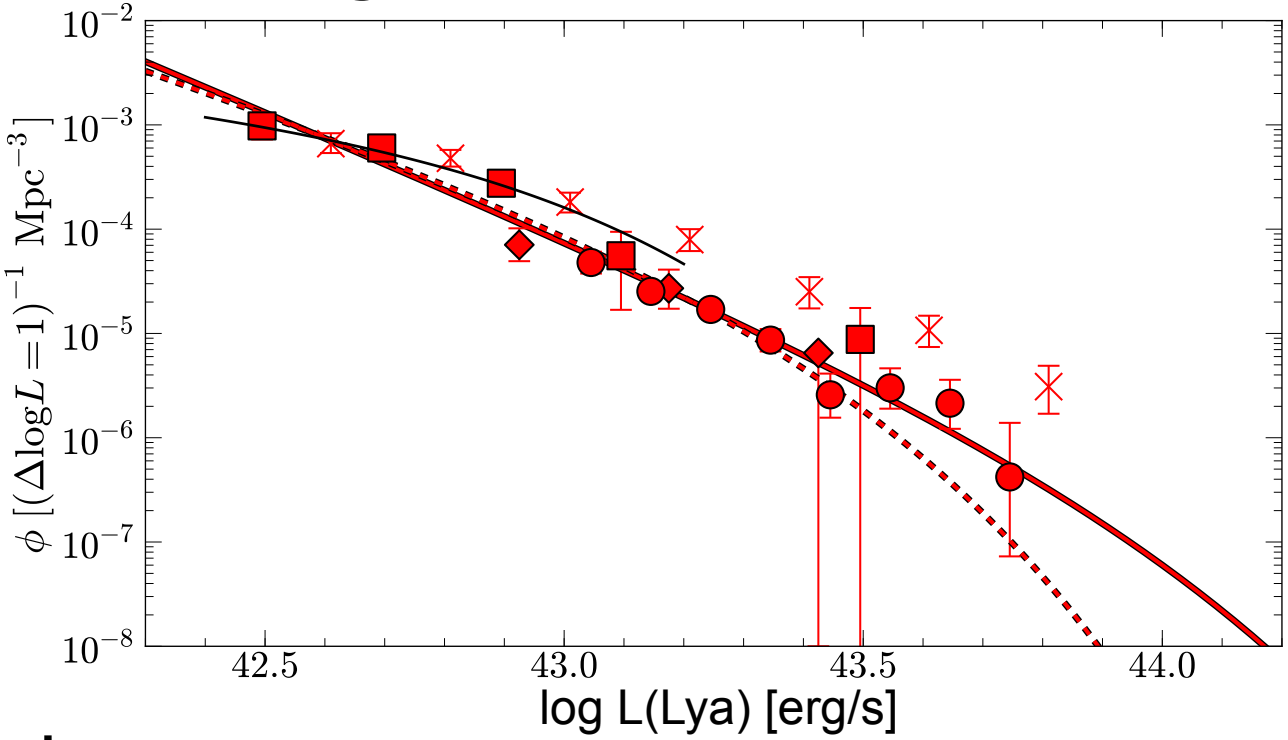
Lya LFs at z=6.6



Konno+ in prep

- Consistent with previous studies
  - Best-fit (whole L(Lya) range)

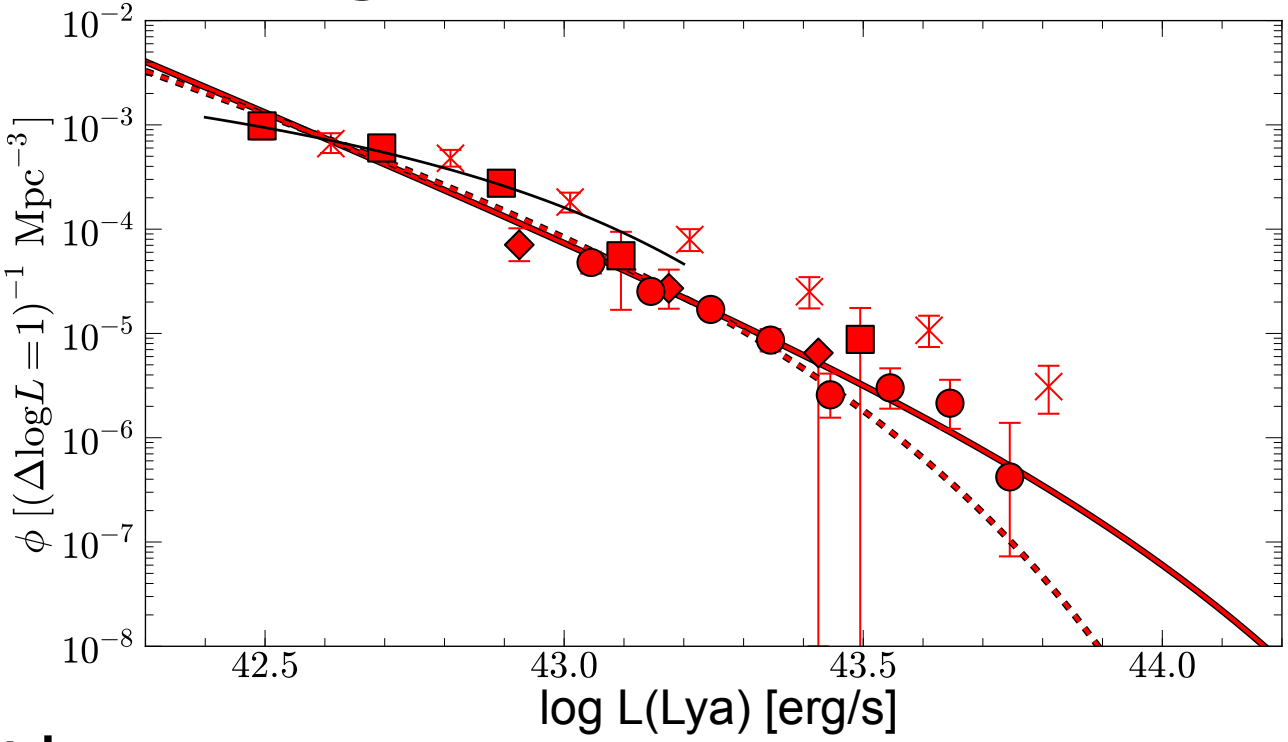
Lya LFs at z=6.6



Konno+ in prep

- Consistent with previous studies
  - Best-fit (whole L(Lya) range)
  - Best-fit (log L(Lya) < 43.5)

Lya LFs at z=6.6

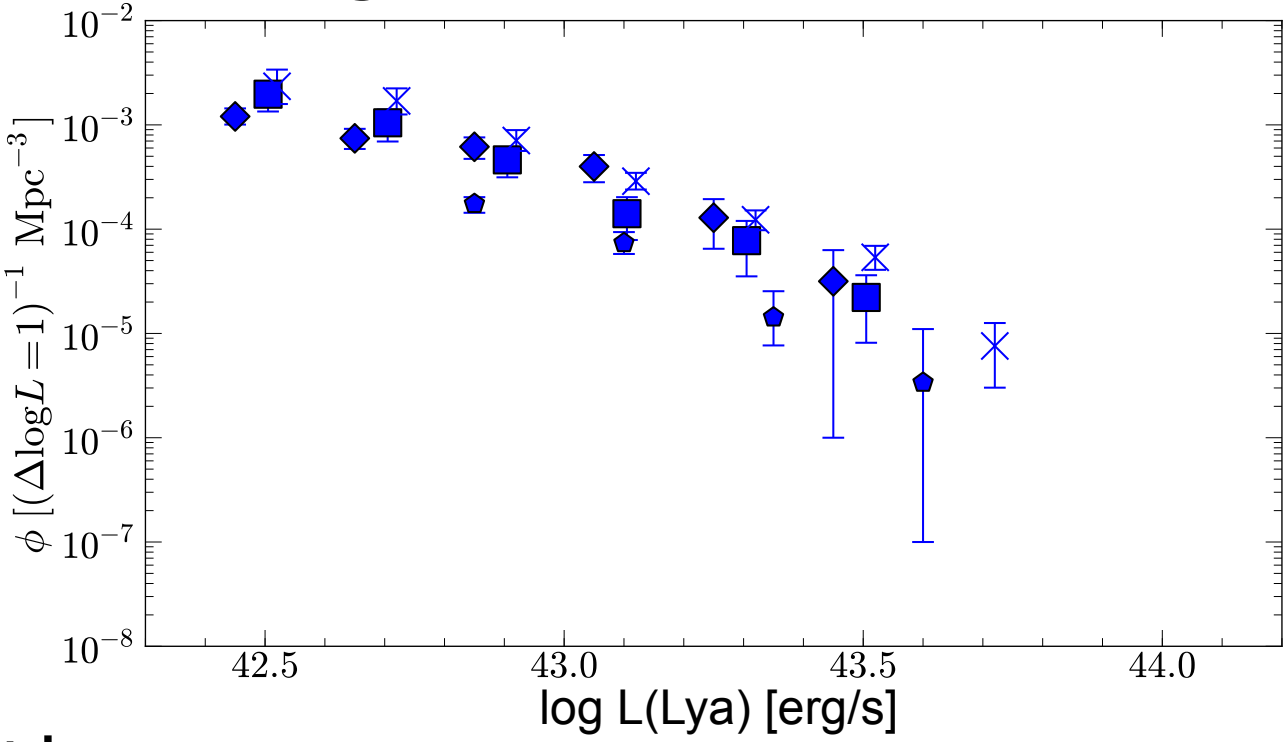


Konno+ in prep

- Consistent with previous studies
  - Best-fit (whole L(Lya) range)
  - Best-fit (log L(Lya) < 43.5)

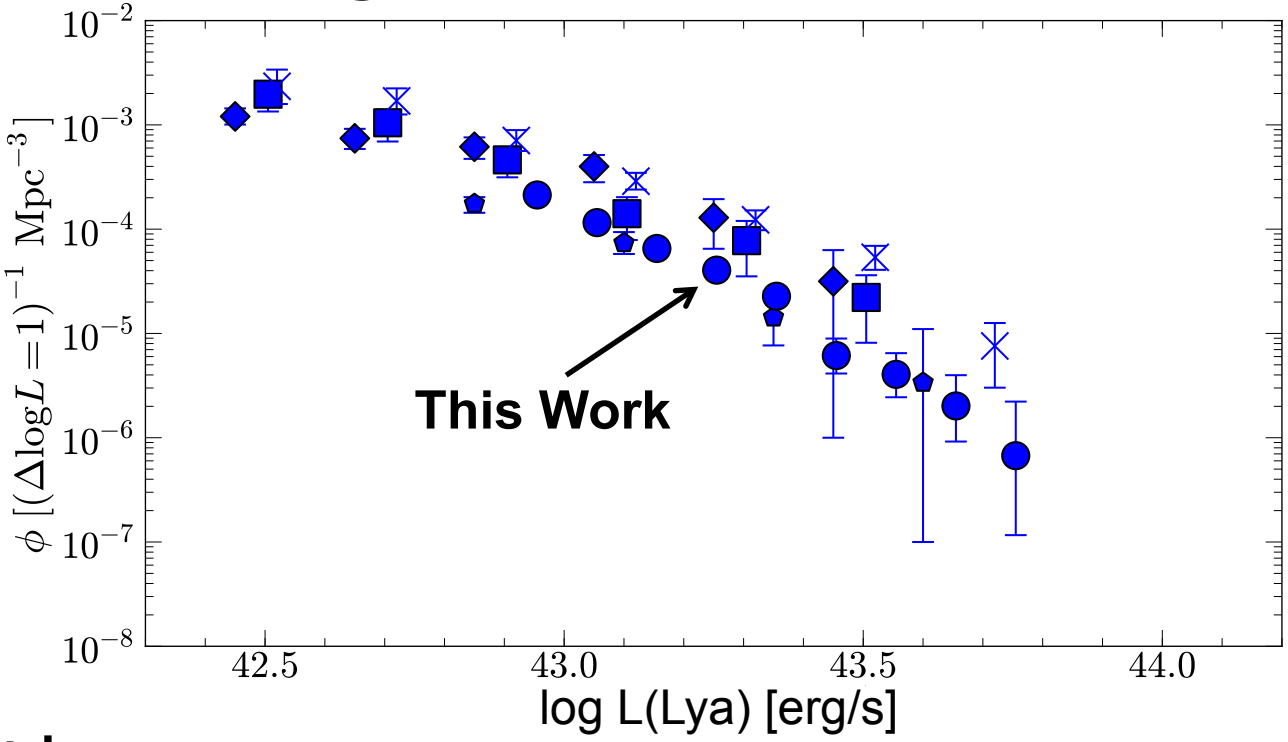
} **Emergence of bright-end hump**

Lya LFs at z=5.7



Konno+ in prep

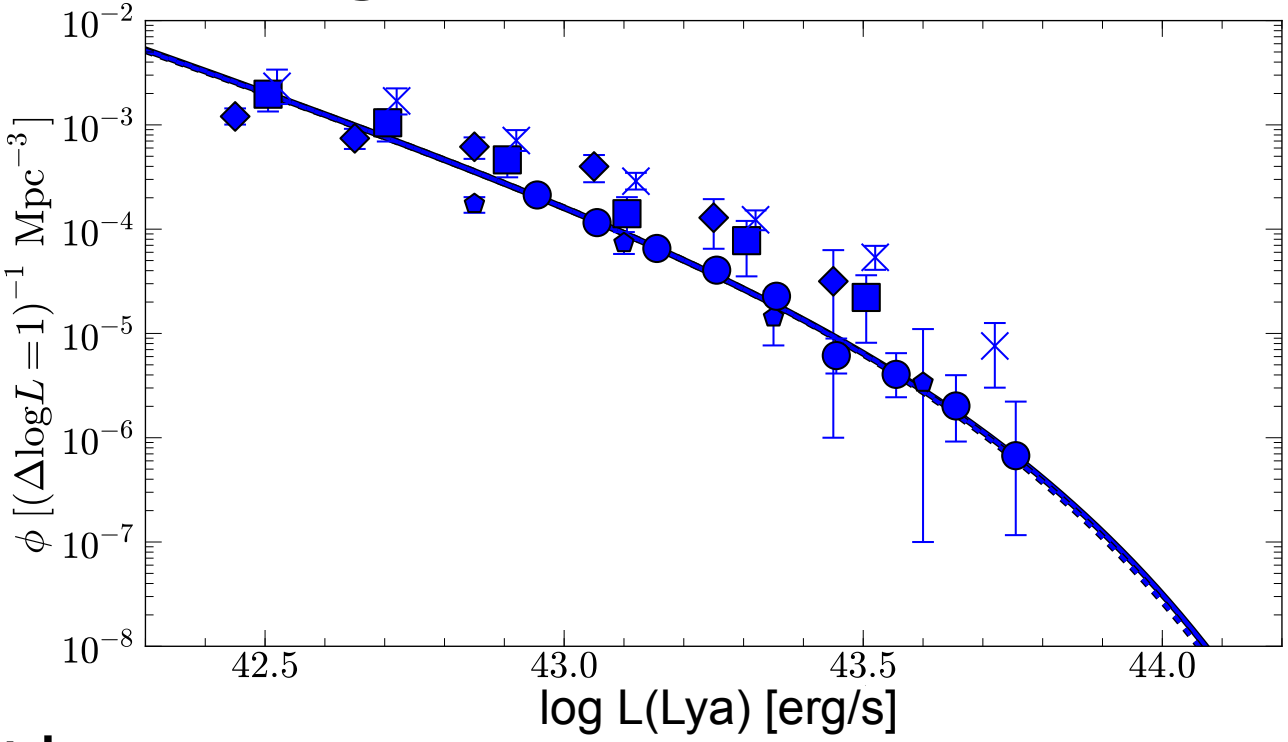
Lya LFs at z=5.7



Konno+ in prep

- Consistent with previous studies

Lya LFs at z=5.7

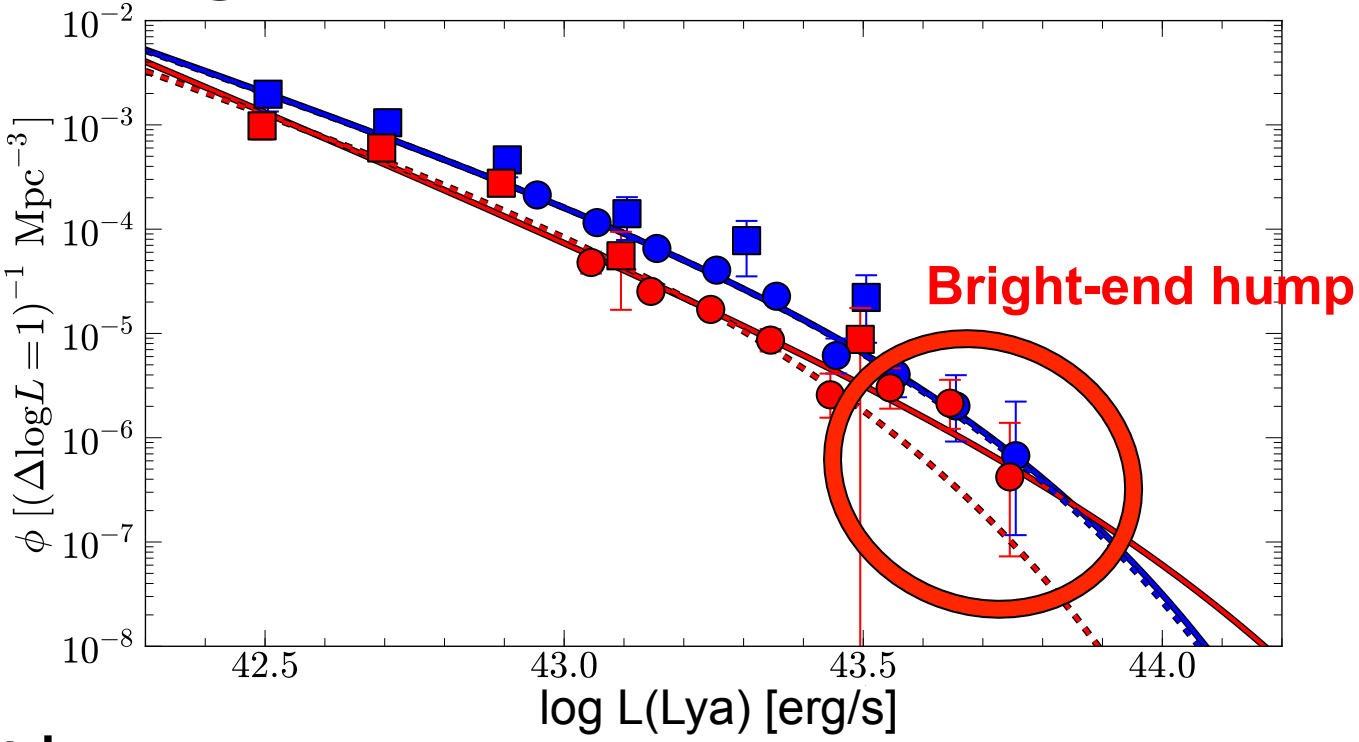


Konno+ in prep

- Consistent with previous studies
  - Best-fit (whole L(Lya) range)
  - Best-fit (log L(Lya) < 43.5)

No significant bright-end hump

Lya LFs at z=5.7 & 6.6



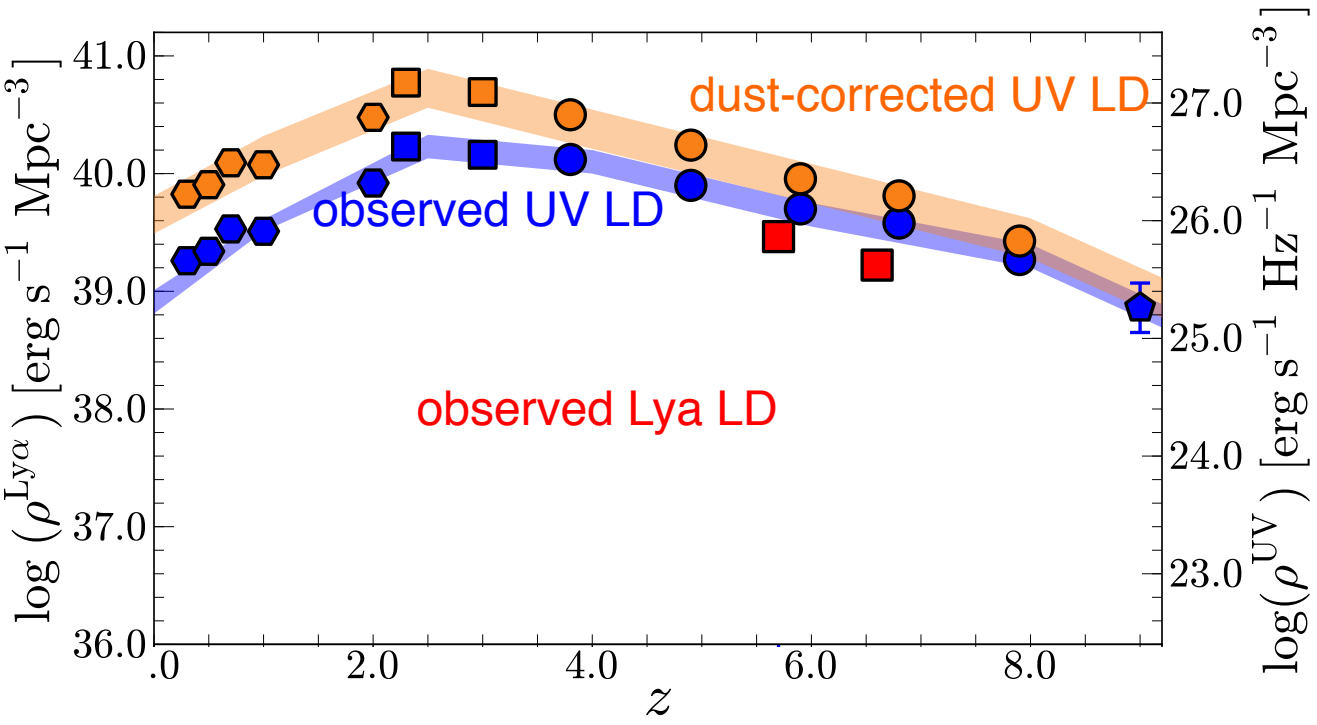
Konno+ in prep

- Significant bright-end hump can be seen at z=6.6

  ⇔ No hump in z=5.7 Lya LF

- Effects of large ionized bubbles around bright LAEs?
  or emergence of AGN at z=6.6?? (see **R. Higuchi+'s poster**)

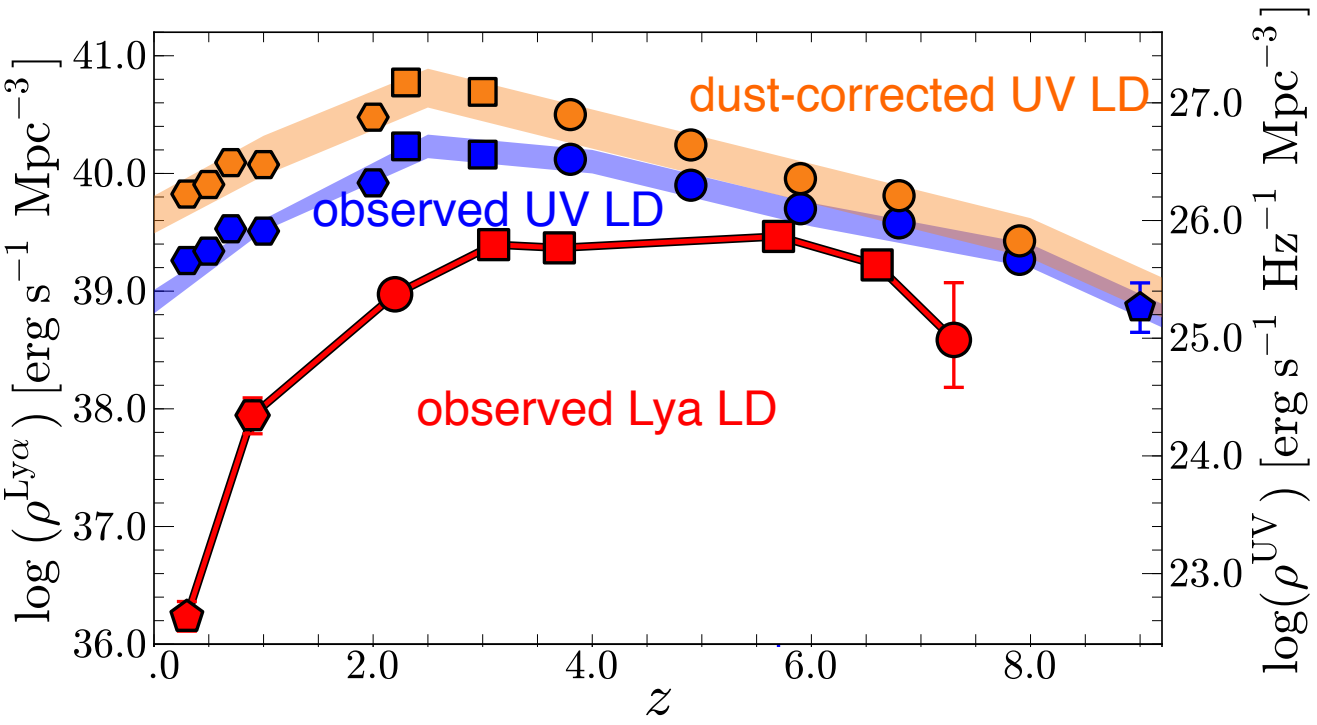
Lya/UD LD Evolution at z=0-7



Konno et al. 2016

- Lya LD obtained by HSC survey

Lya/UD LD Evolution at z=0-7



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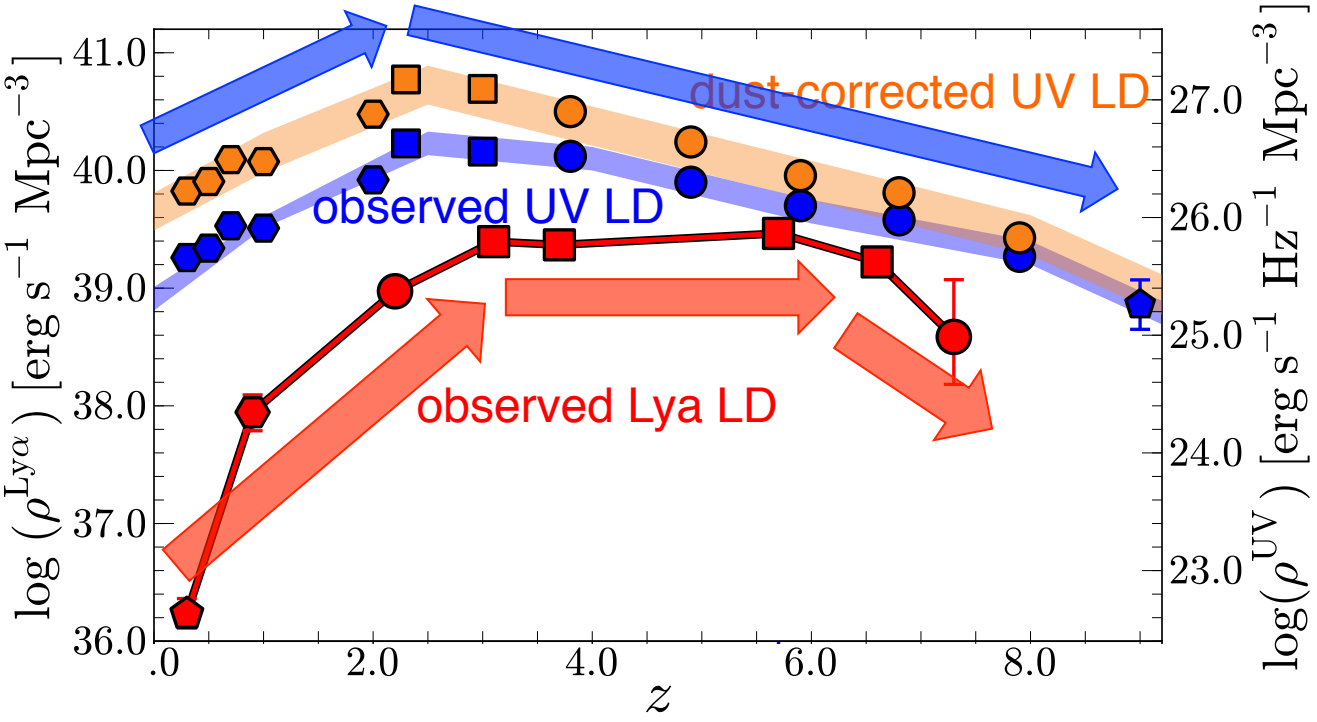
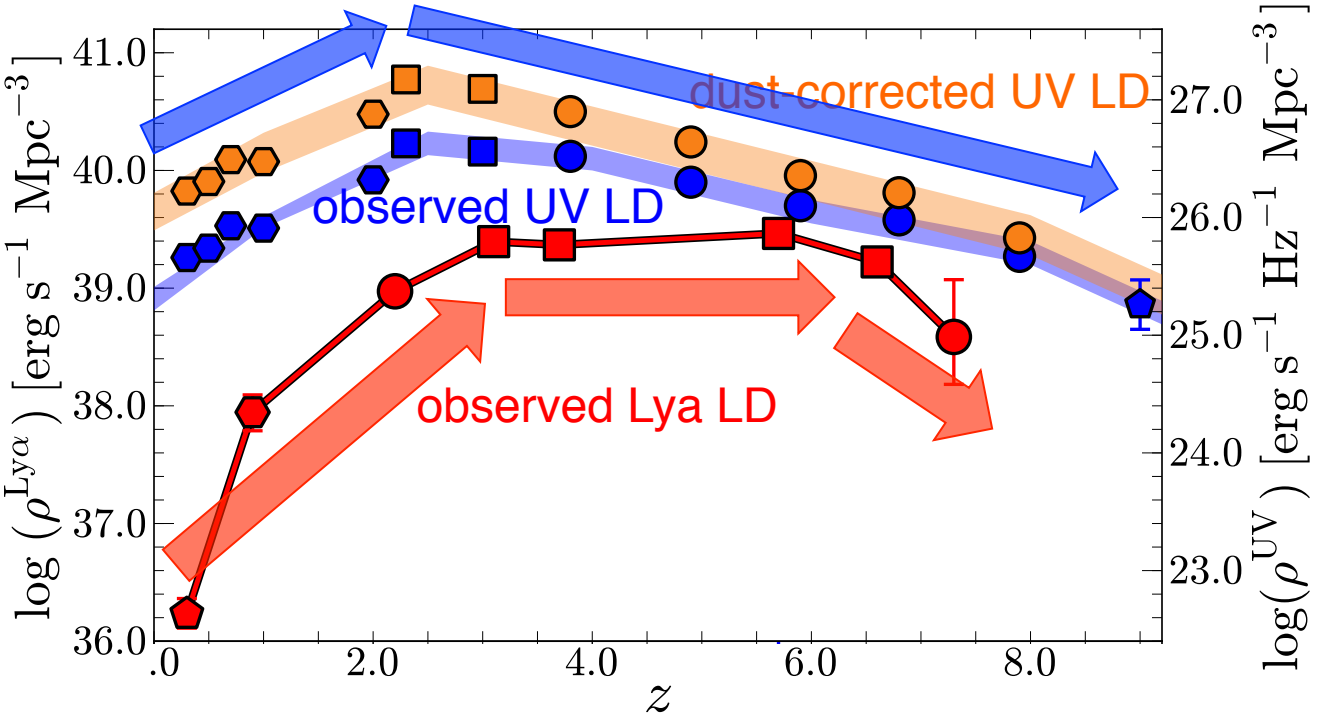


Konno et al. 2016

- Lya LD obtained by HSC survey
  - Large difference between Lya & UV LD evolution

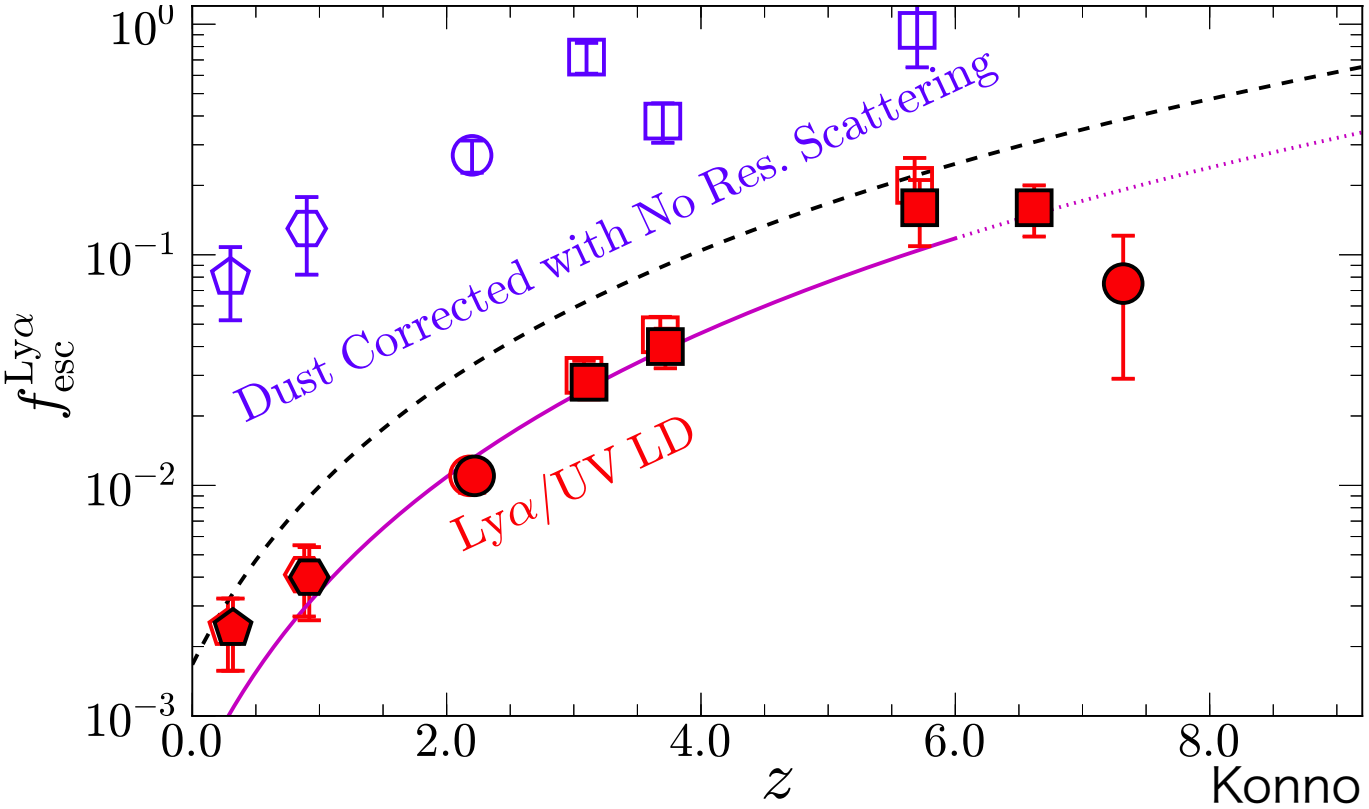
Lya/UD LD Evolution at z=0-7



Konno et al. 2016

- Lya LD obtained by HSC survey
  - Large difference between Lya & UV LD evolution
- Related to Lya escape fraction (f_{esc}(Lya)) evolution (e.g., Hayes+11)

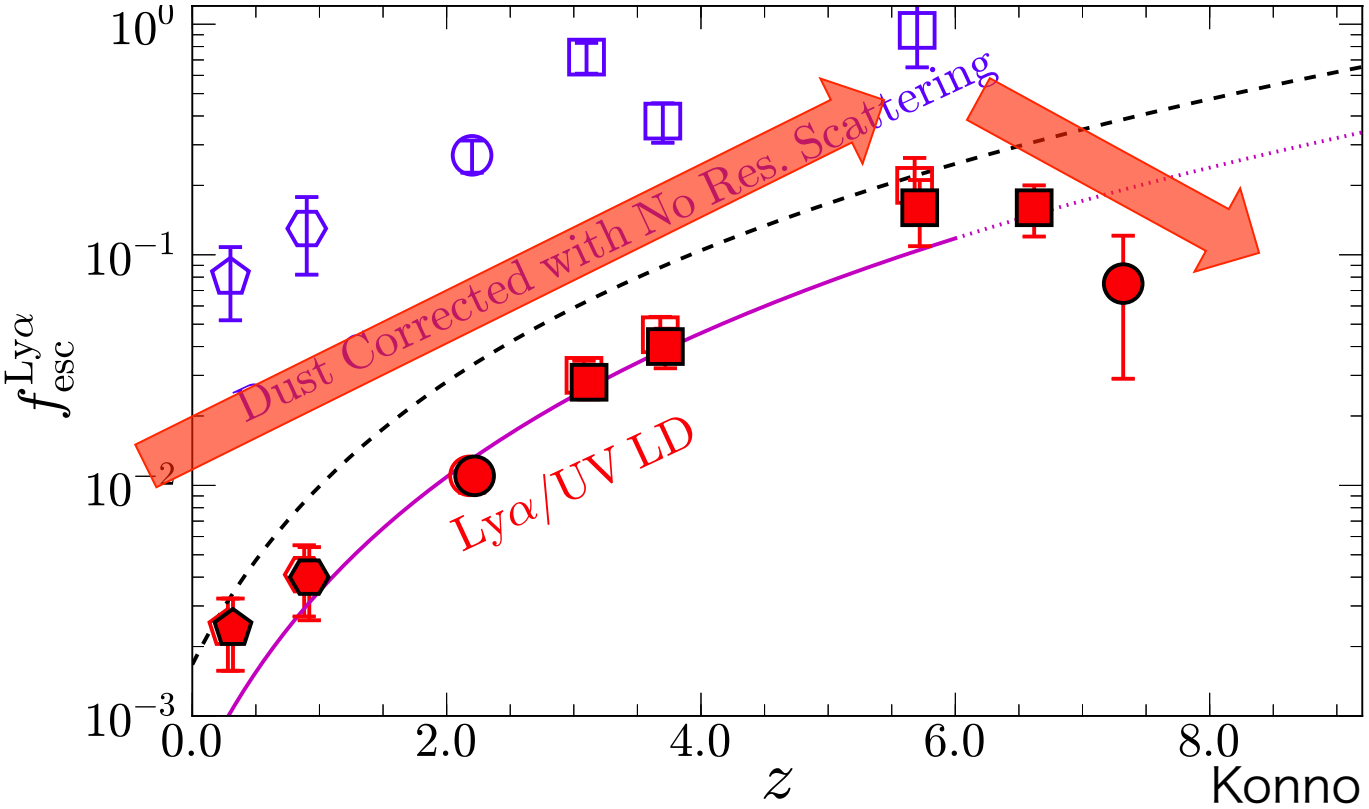
f_{esc}(Lya) Evolution z=0-8



Konno et al. 2016

- f_{esc}(Lya) = (observed Lya LD) / (dust-corrected UV LD)

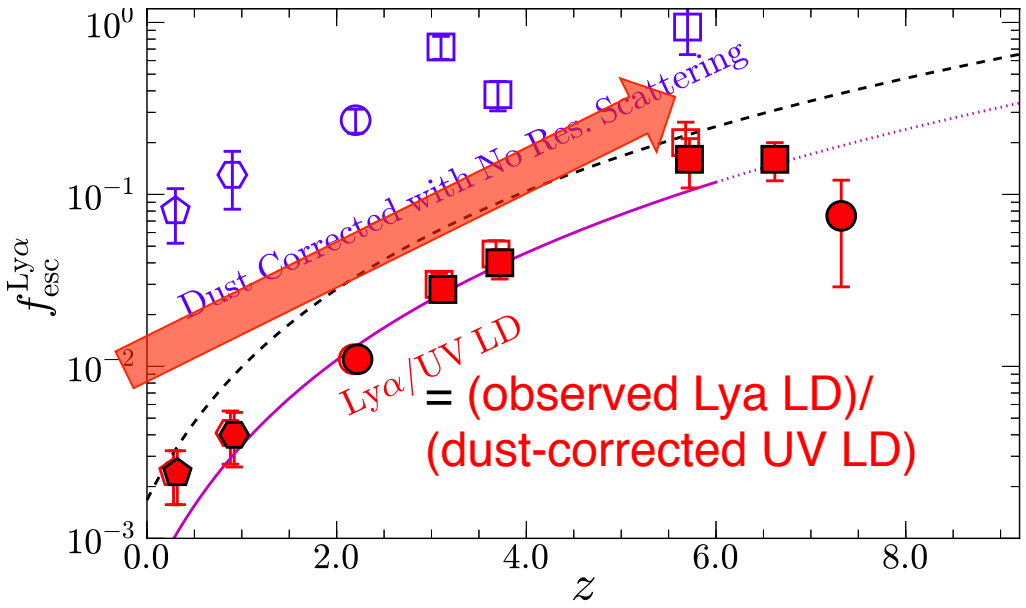
f_{esc}(Lya) Evolution z=0-8

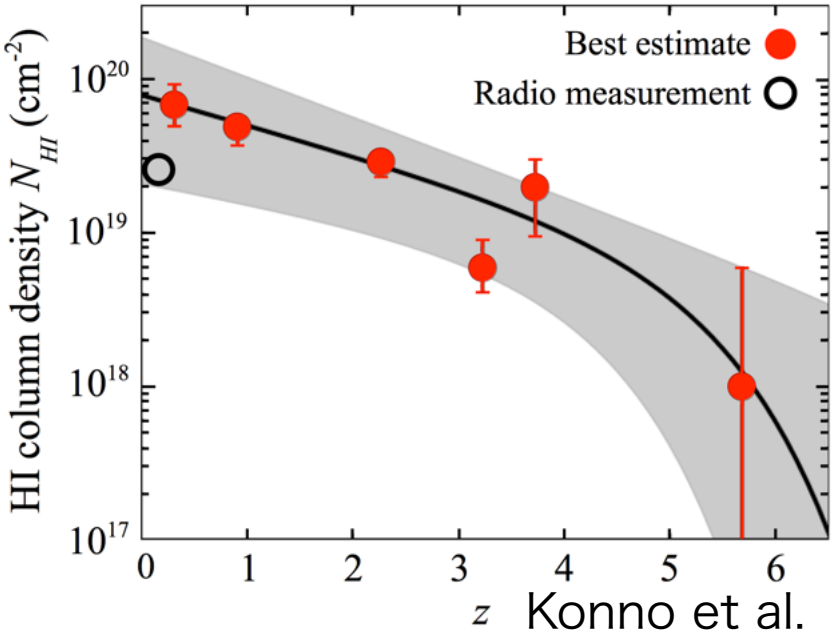


Konno et al. 2016

- f_{esc}(Lya) = (observed Lya LD) / (dust-corrected UV LD)
- Different f_{esc}(Lya) evolution between at z=0-6 & at z>6
  - Increase of f_{esc} (Lya) at z=0-6 by 2 orders of mag.

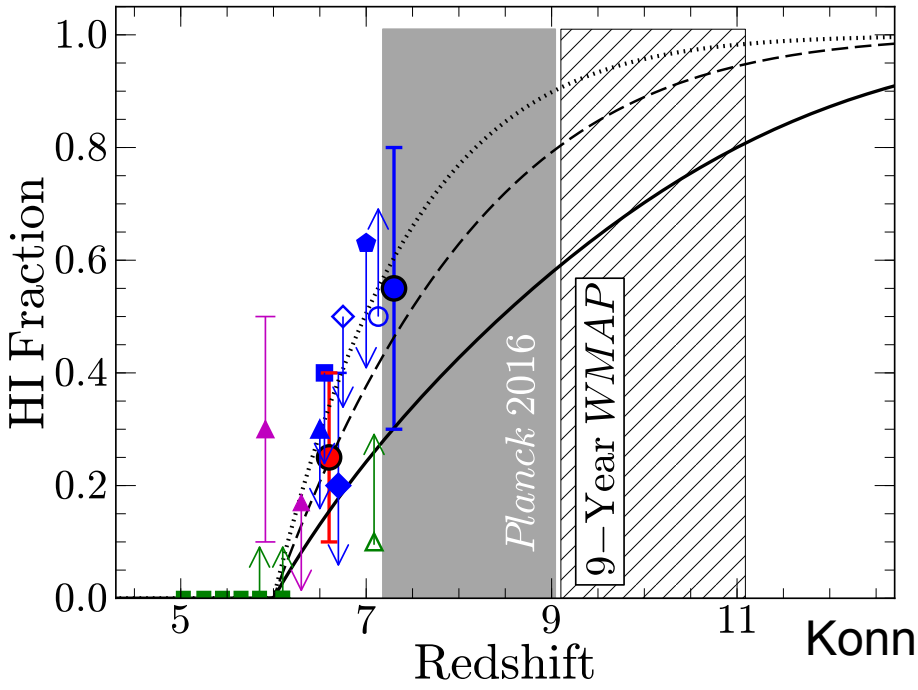
f_{esc}(Lya) Evolution z=0-6

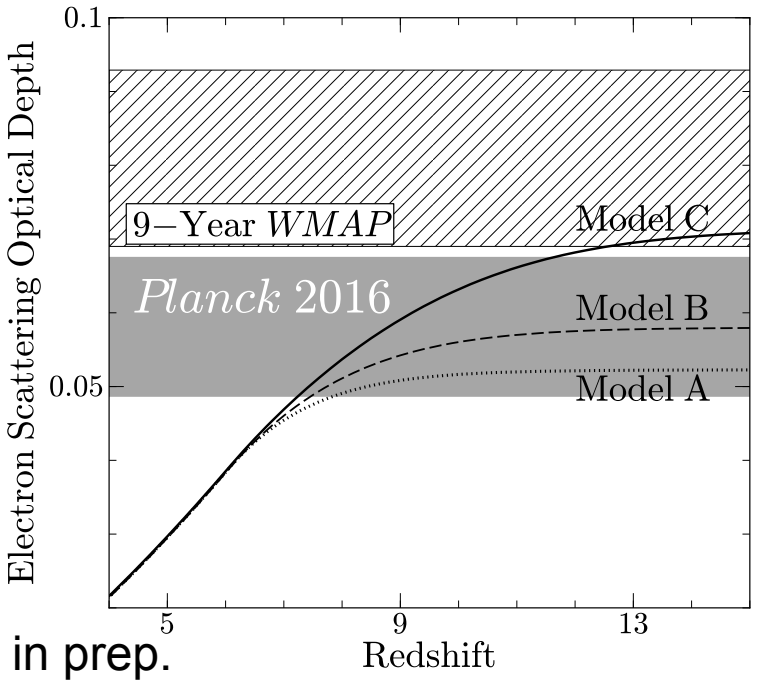




- 4 possibilities to explain the f_{esc} evolution;
  - (1) Age, (2) outflow … Not so large evolution at z=0-6
  - **(3) Dust Extinction** … Cannot explain at z=0-4
  - **(4) Resonance Scattering of ISM HI gas** (w/ dust extinction)
    - Expanding shell model (MCLya; e.g., Verhamme+06)
    - Suggests **~1/100 decrease of N_{HI} from z=0 to 6**
    - HI deficit & high ionization state (e.g., D. Stark's talk)

Cosmic Reionization History





Konno+ in prep.

- x(HI) = 0.1-0.4 at z=6.6 w/ simple theoretical model
  - Consistent with previous studies
- Comparing x(HI) evolution w/ the latest *Planck* 2016 results
  - x(HI) & τ_{el} are consistent (e.g., Robertson+15, Bouwens+15)

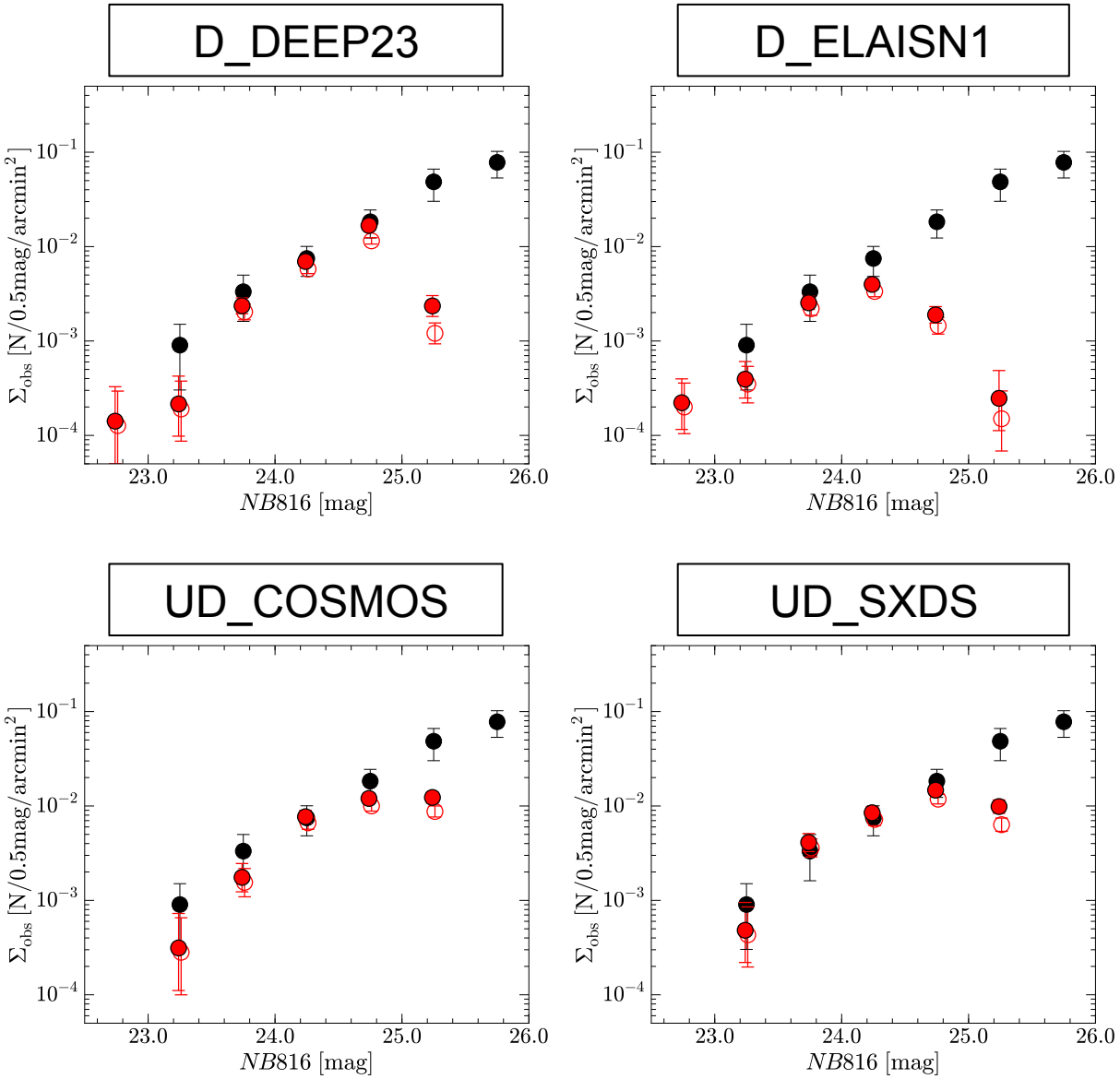
Summary

- We conduct Subaru/HSC SSP survey, and obtain ~21deg^2 NB imaging data, so far.
  → ~2400 LAEs at z=5.7 & 6.6 (the largest sample to date)

- We determine the Lya LFs at z=5.7 & 6.6, and find a bright-end hump in z=6.6 Lya LF, but no hump at z=5.7
  → Large ionized bubble around bright LAEs?

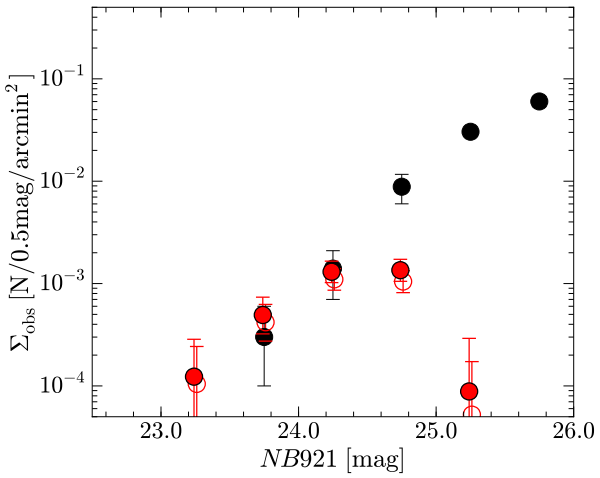
- We derive Lya LDs at z=0-8, and find the f_{esc}(Lya) increase at z=0-6, and f_{esc}(Lya) decrease at z>6.
  → Suggests N_{HI} evolution at z=0-6 by 2 orders of mag.
  → x(HI) = 0.1-0.4 at z=6.6, and confirm that x(HI) evolution are consistent with the latest *Planck* 2016 results.

Number Count (z=5.7, individual fields)

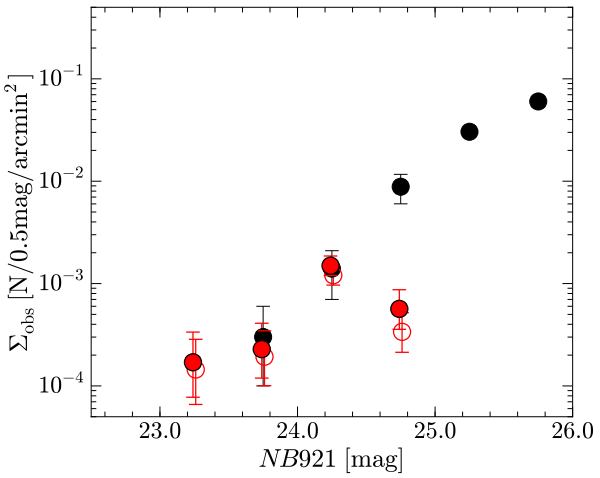


Number Count (z=6.6, individual fields)

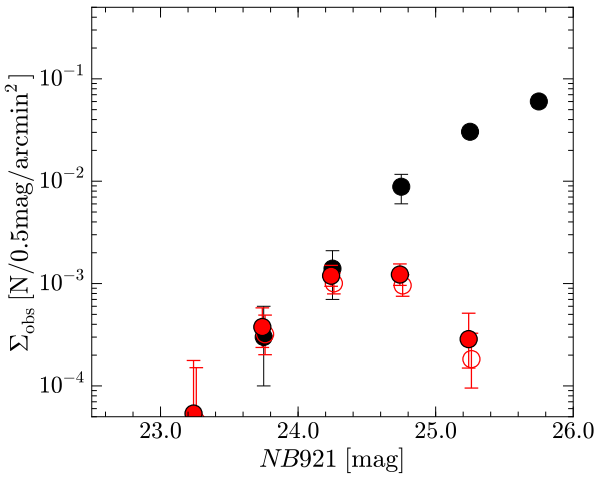
D_COSMOS



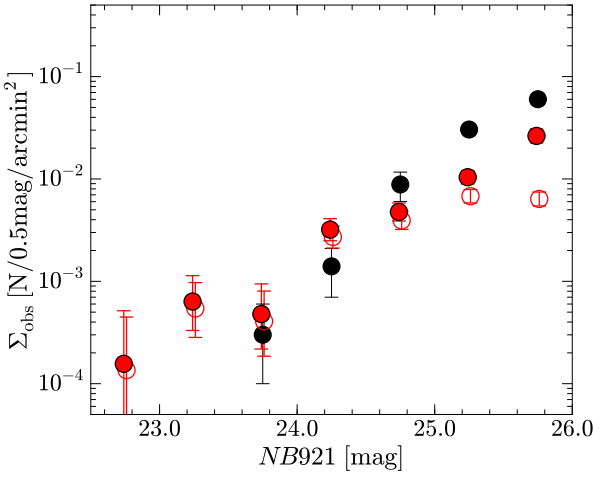
D_DEEP23



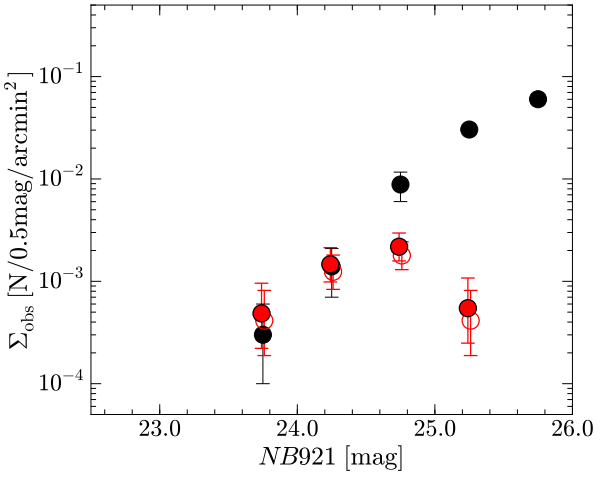
D_ELAISN1



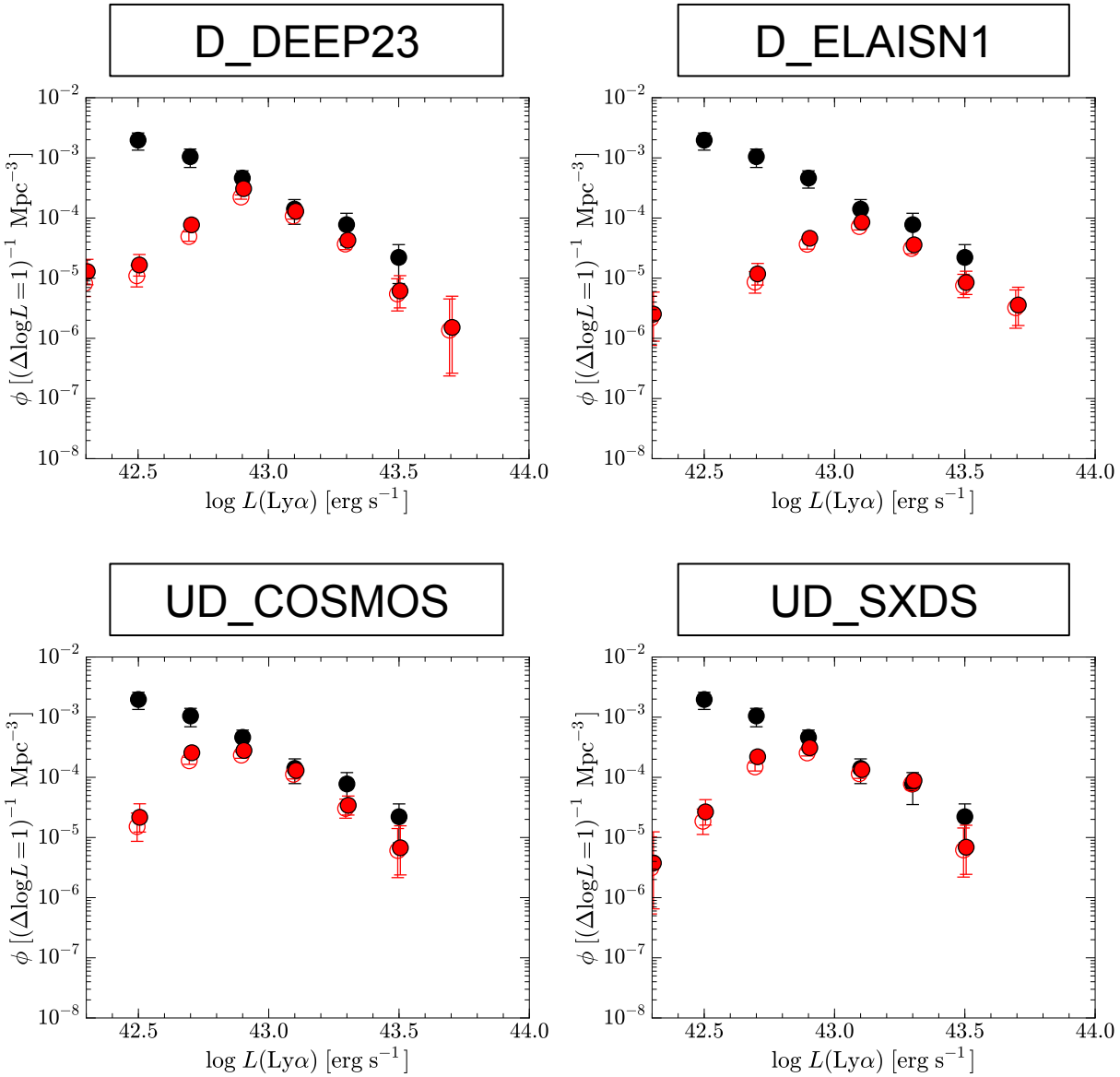
UD_COSMOS



UD_SXDS

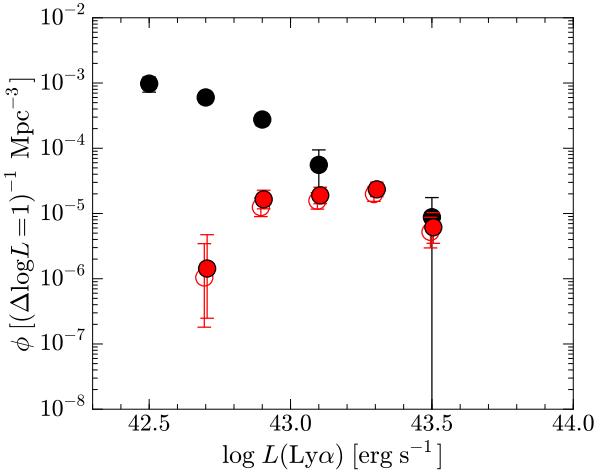


Lya LF (z=5.7, individual fields)

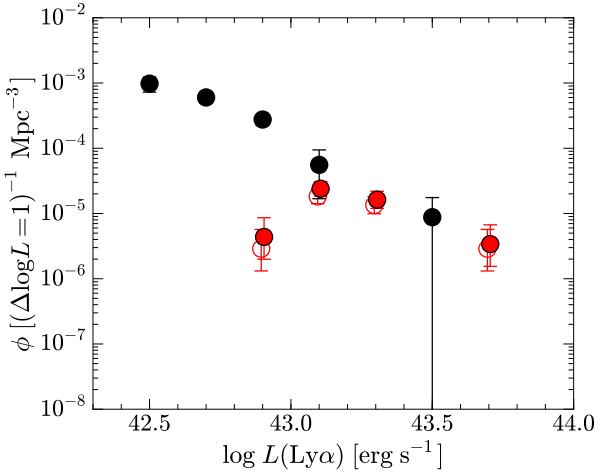


Lya LF (z=6.6, individual fields)

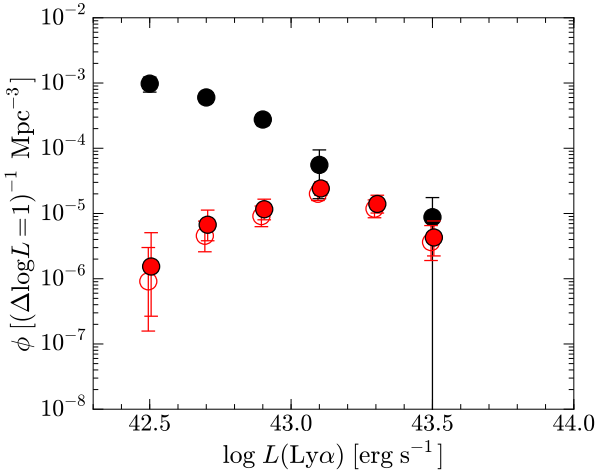
D_COSMOS



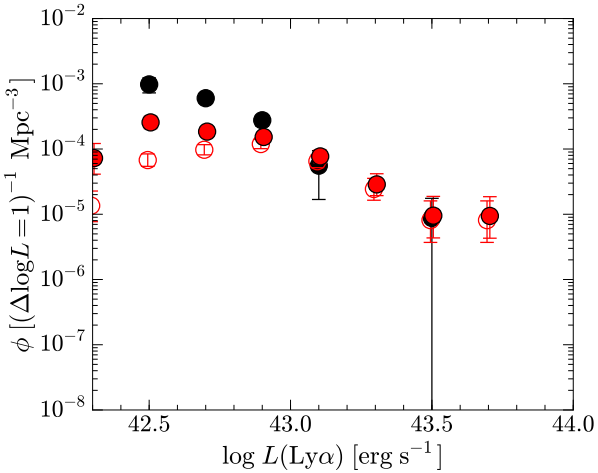
D_DEEP23



D_ELAISN1



UD_COSMOS



UD_SXDS