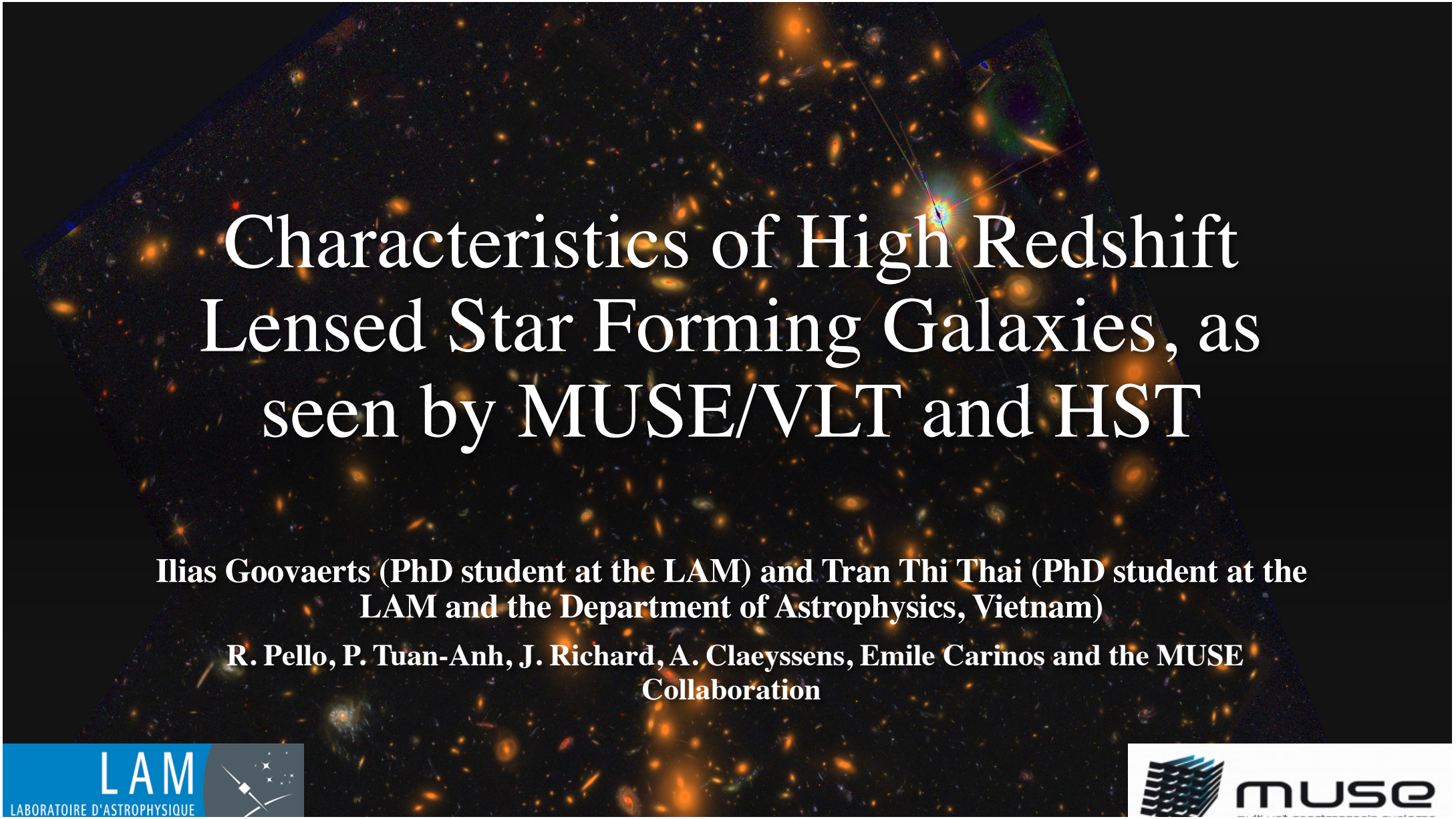


# Characteristics of High Redshift Lensed Star Forming Galaxies, as seen by MUSE/VLT and HST

**Ilias Goovaerts (PhD student at the LAM) and Tran Thi Thai (PhD student at the LAM and the Department of Astrophysics, Vietnam)**

**R. Pello, P. Tuan-Anh, J. Richard, A. Claeyssens, Emile Carinos and the MUSE Collaboration**

LAM
LABORATOIRE D'ASTROPHYSIQUE

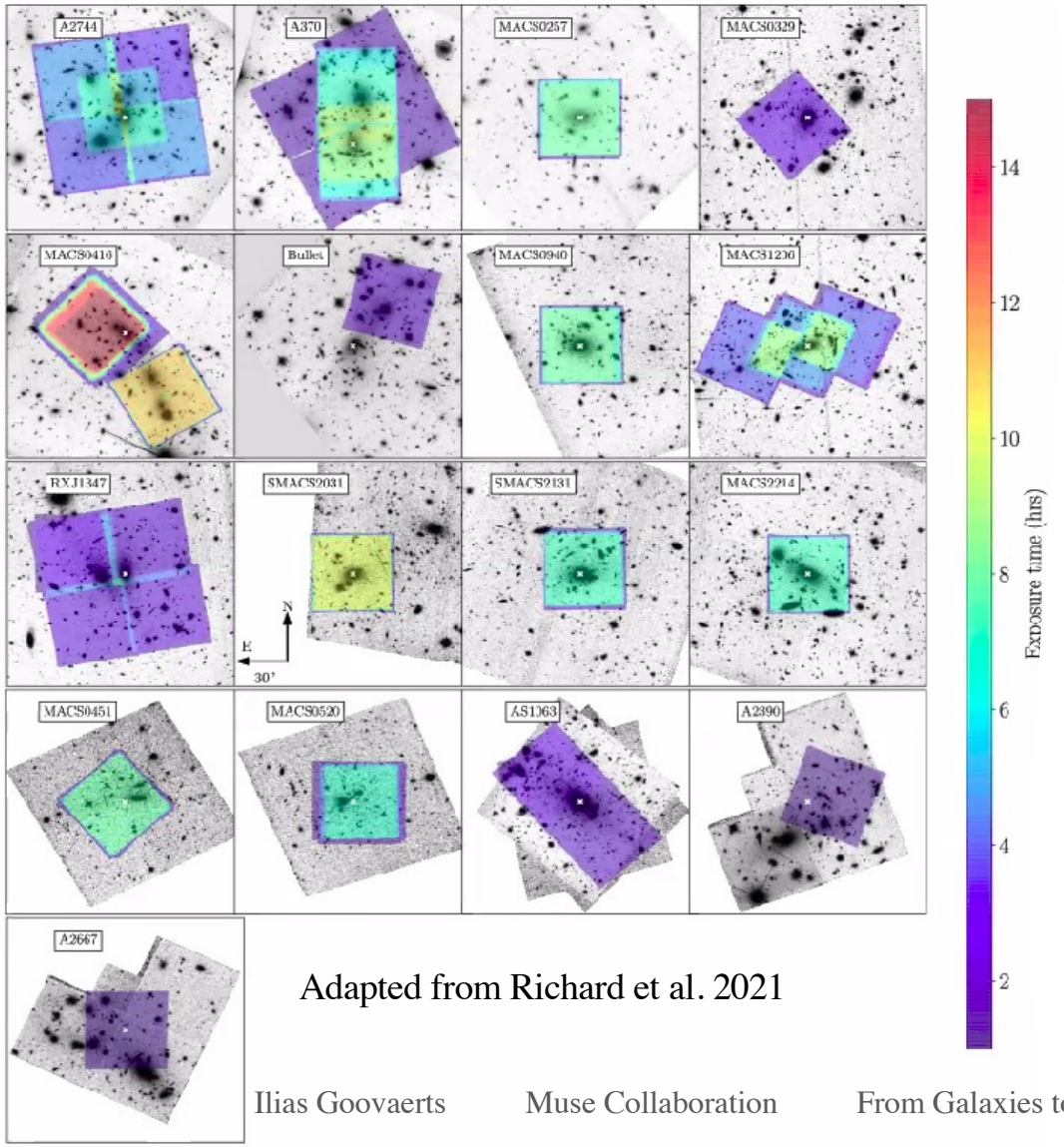
muse

# The Group

- Ilias Goovaerts (PhD at the LAM)
- Lyman-$\alpha$ Emitter (LAE) and Lyman Break Galaxy (LBG) Interrelation

Muse Lensing Group: (PI: J. Richard)
R. Pello, P. Tuan-Anh, A. Claeyssens, MUSE Collaboration

- Tran Thi Thai (Cotuition between the LAM and Department of Astrophysics, Vietnam)
- Lyman-$\alpha$ Emitter luminosity function (LAE LF)
- Poster: *Studying the Luminosity Function of Lyman Alpha emitters selected behind 17 lensing clusters from MUSE/VLT observations*



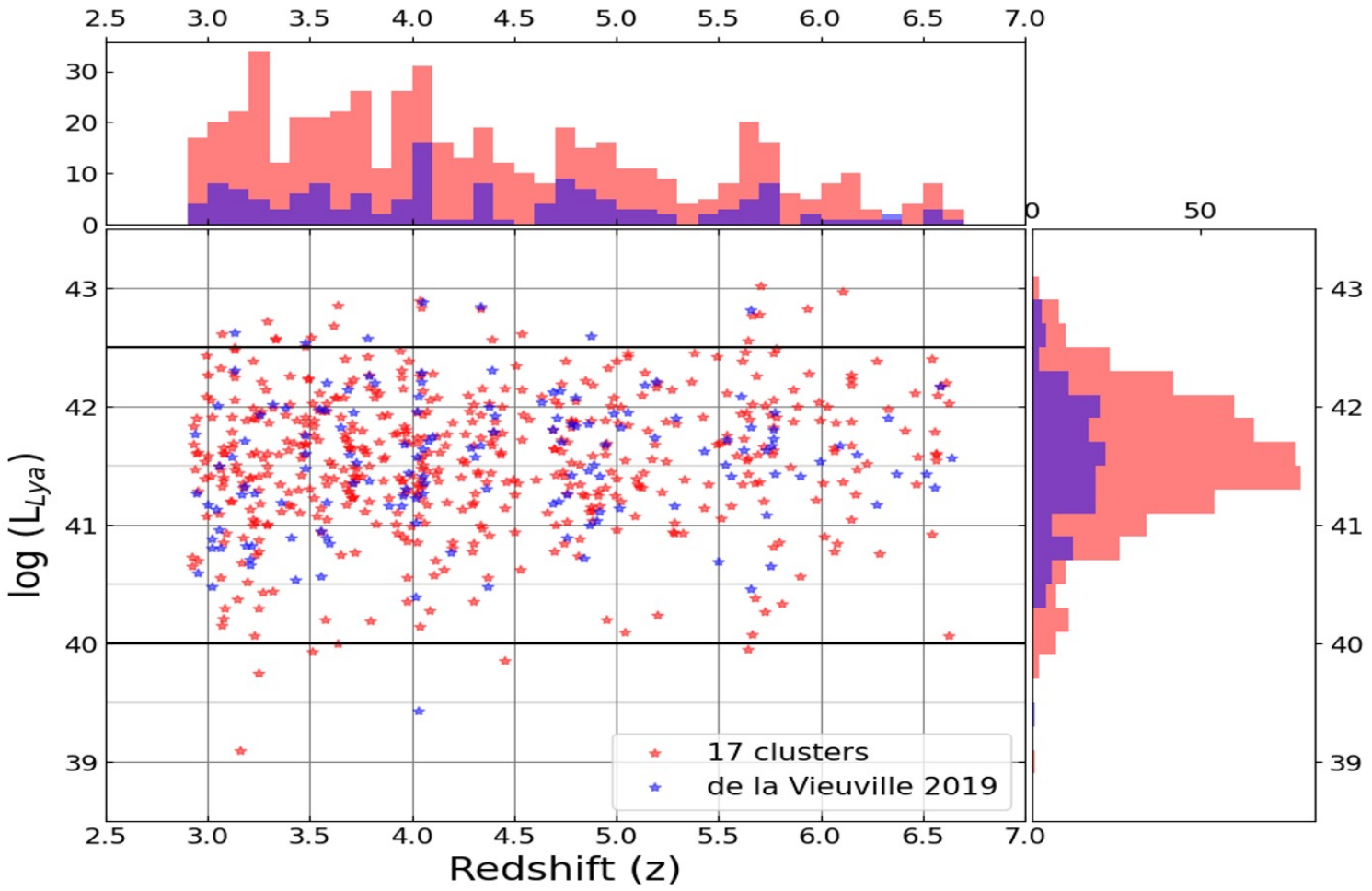

Adapted from Richard et al. 2021

# MUSE Lensing clusters – The LLAMAS sample

- 17 lensing clusters observed with MUSE/VLT – IFU spectroscopy. (Claeyssens et al. 2022)
- 603 LAEs with secure spectroscopic redshifts: $2.9 < z < 6.7$.
- MUSE Datacubes, Catalogs, Lensing Models publicly available for this sample - work ongoing to refine and add clusters.
- We can access faint populations that are out of reach for blank field surveys.

| Cluster | R.A. (J2000) | Dec. (J2000) | $z_{cl}$ | MUSE depth [hours] | N fields | N LAEs | Effective volume surveyed $Mpc^3$ |
|---|---|---|---|---|---|---|---|
| Abell 2744 | 00:14:20.702 | −30:24:00.63 | 0.308 | 3.5 - 7 | 4 | 142 (**121**) | 1969 |
| Abell 370 | 02:39:53.122 | −01:34:56.14 | 0.375 | 1.5 - 8.5 | 4 | 98 (**42**) | 2080 |
| MACS J0257.6−2209 | 02:57:41.070 | −22:09:17.70 | 0.322 | 8 | 1 | 48 (**25**) | 566 |
| MACS J0329.6−0211 | 03:29:41.568 | −02:11:46.41 | 0.450 | 2.5 | 1 | 8 (**17**) | 627 |
| MACS J0416.1−2403 N | 04:16:09.144 | −24:04:02.95 | 0.397 | 17 | 1 | 71 (**46**) | 597 |
| MACS J0416.1−2403 S | 04:16:09.144 | −24:04:02.95 | 0.397 | 11-15 | 1 | 56 (**34**) | 535 |
| MACS J0451.9+0006 | 04:51:54.647 | +00:06:18.21 | 0.430 | 8 | 1 | 45 (**21**) | 473 |
| MACS J0520.7−1328 | 05:20:42.046 | −13:28:47.58 | 0.336 | 8 | 1 | 33 (**19**) | 606 |
| 1E 0657−56 (Bullet) | 06:58:38.126 | −55:57:25.87 | 0.296 | 2 | 1 | 14 (**11**) | 743 |
| MACS J0940.9+0744 | 09:40:53.698 | +07:44:25.31 | 0.335 | 8 | 1 | 58 (**49**) | 1171 |
| MACS J1206.2−0847 | 12:06:12.149 | −08:48:03.37 | 0.438 | 4-9 | 3 | 82 (**50**) | 1777 |
| RX J1347.5−1145 | 13:47:30.617 | −11:45:09.51 | 0.451 | 2-3 | 4 | 124 (**72**) | 1247 |
| SMACS J2031.8−4036 | 20:31:53.256 | −40:37:30.79 | 0.331 | 10 | 1 | 44 (**21**) | 563 |
| SMACS J2131.1−4019 | 21:31:04.831 | −40:19:20.92 | 0.442 | 7 | 1 | 30 (**16**) | 512 |
| Abell 2390 | 21:53:36.823 | +17:41:43.59 | 0.228 | 2 | 1 | 14 (**8**) | 534 |
| MACS J2214.9−1359 | 22:14:57.292 | −14:00:12.91 | 0.502 | 7 | 1 | 33 (**17**) | 471 |
| Abell S1063 | 22:48:43.975 | −44:31:51.16 | 0.348 | 3.9 | 2 | 35 (**20**) | 1227 |
| Abell 2667 | 23:52:28.400 | −26:05:08.00 | 0.233 | 2 | 1 | 24 (**14**) | 423 |
| Total | | | | | 30 | 959 (**603**) | 16117 |

From Claeyssens et al. 2021

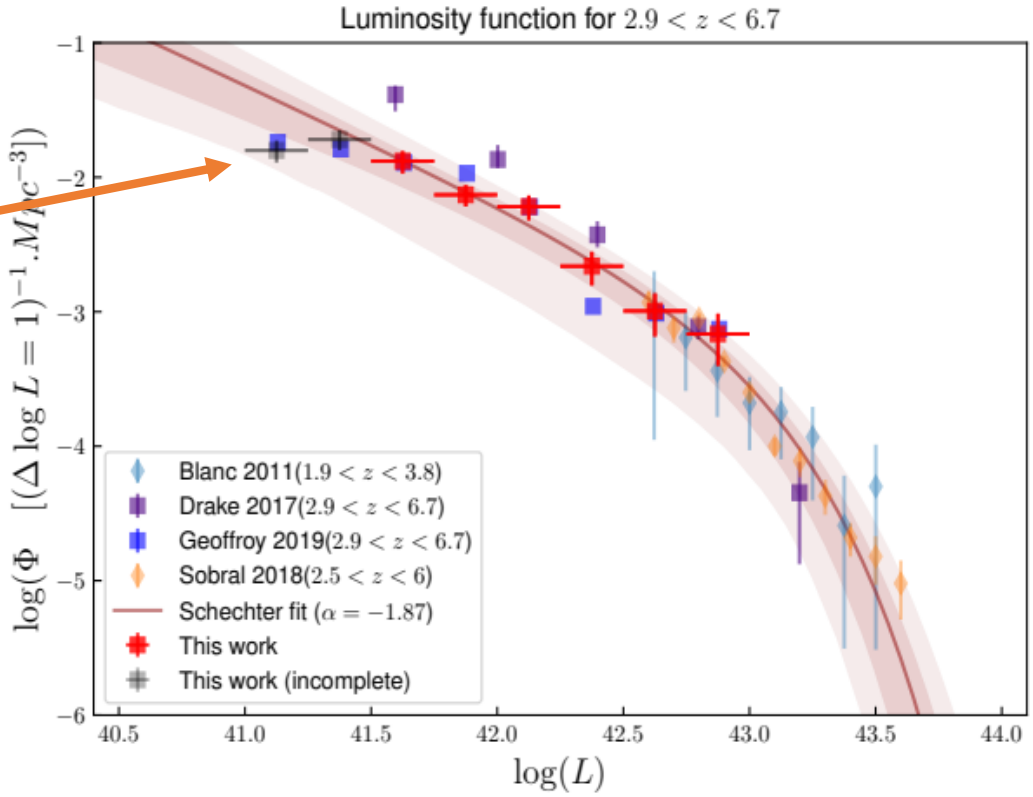

log ($L_{Lya}$)
Redshift (z)
17 clusters
de la Vieuville 2019

# LAE Luminosity Function

- LAE Luminosity Function (LF) ($2.9 < z < 6.7$) behind 17 lensing clusters
- 603 (high confidence) LAEs.
- We investigate the faint end of the LF: hunting the contributors to reionisation.
- Improved statistics at $\log(L_{Ly\alpha}) < 40.5$ with respect to initial study (de la Vieuville et al. 2019).

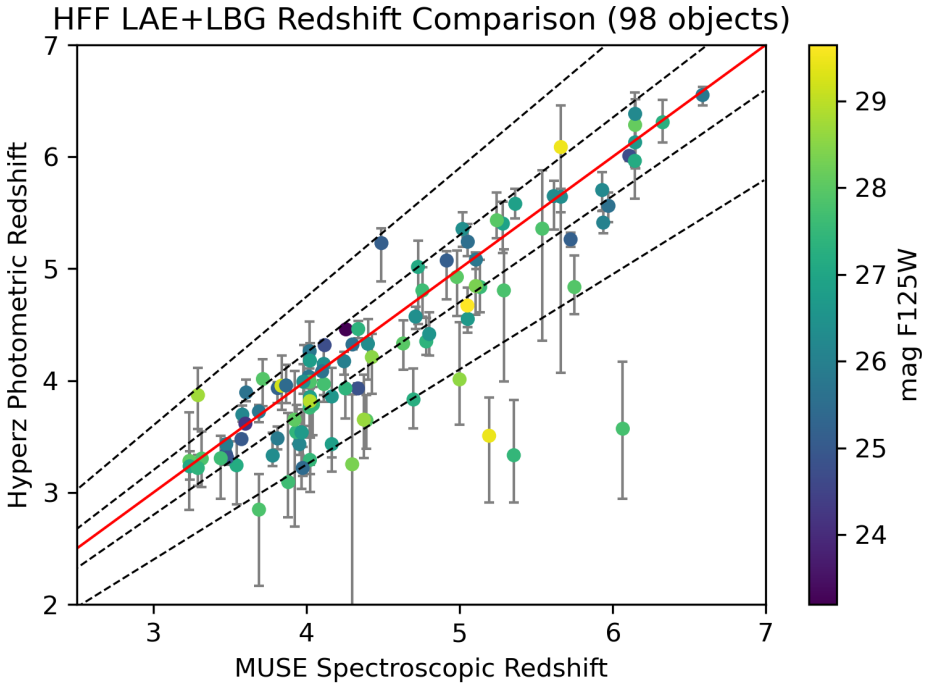
# Results – LAE Luminosity Function

- T. Tran et al. (in prep).
- Faint end slope: $\alpha = -1.87$
- ***Faint end turnover***



# LAE/LBG intersection

- Start this analysis with the HFF and CLASH clusters (7 in total).
- We complement MUSE spectroscopy with the deepest HST photometry we have available today on the HFF and CLASH fields.
- We use all available HST bands, $K_s$ from VLT and Spitzer/IRAC (3.6 and 4.5$\mu m$) – Shipley et al. 2018 for the HFF, Postman et al. 2012 for the CLASH.
- We select LBGs using pure photometric redshifts $2.9 < z < 6.7$ – Hyperz package and the integrated probability function.

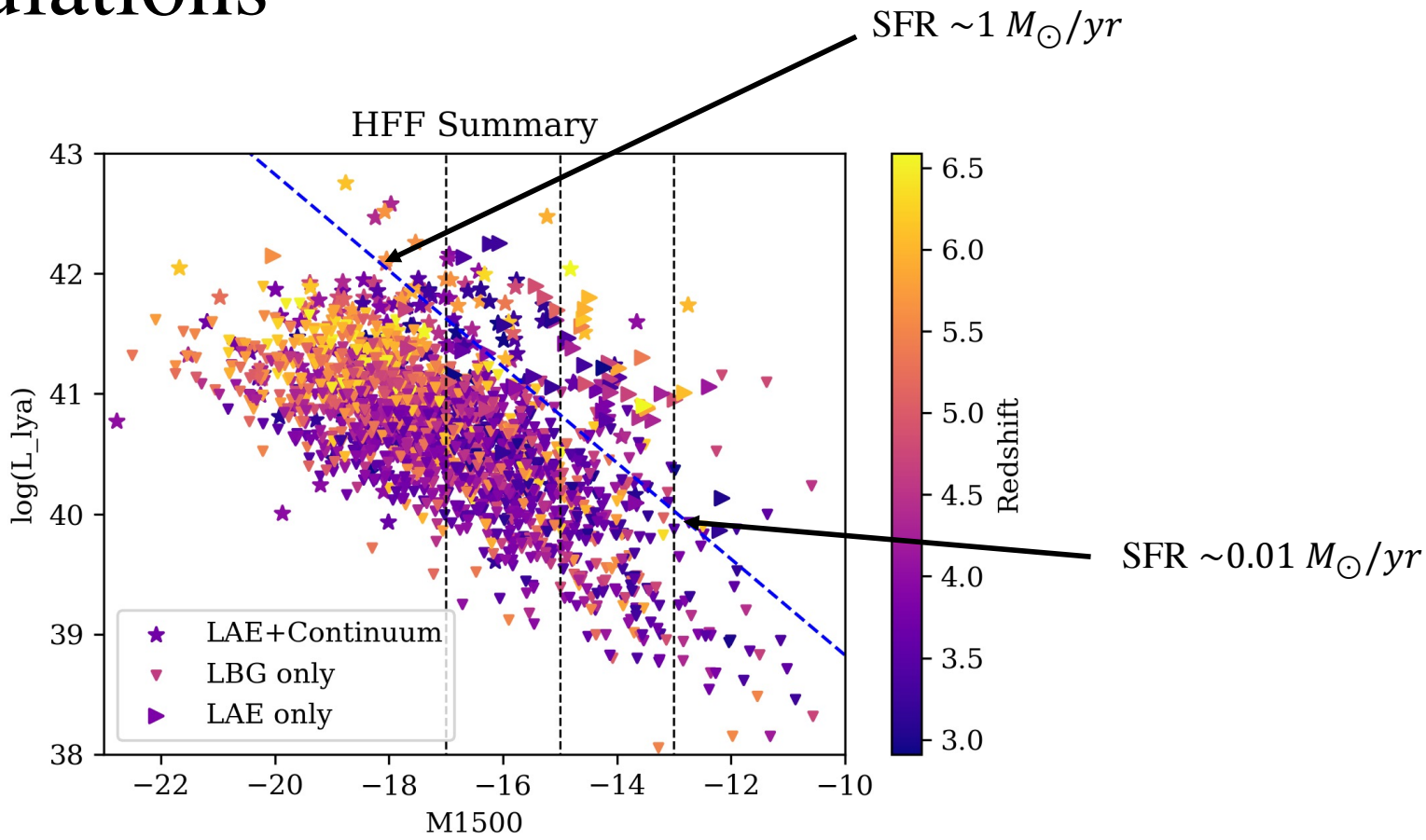


# LBG Selection - HFF

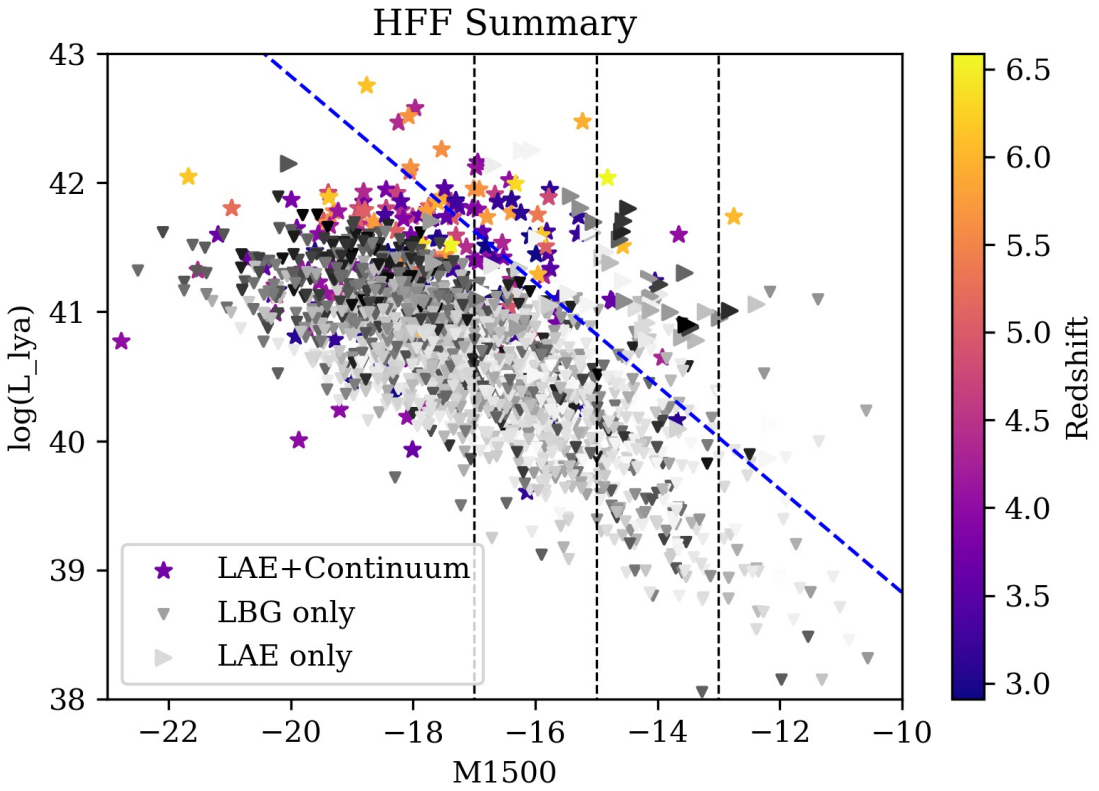
| Group | A2744 | A370 | AS1063 | M0416N | M0416S |
|---|---|---|---|---|---|
| **LAE only** | 24 | 8 | 6 | 14 | 5 |
| **LBG only** | <548 | <515 | <398 | <189 | <184 |
| **LAE+LBG** | 49 | 18 | 4 | 12 | 15 |
| **LAE+continuum** | 48 | 16 | 11 | 20 | 13 |

- LAE incompleteness have been calculated – used in the LF, will be used here also.
  - LBG multiple images
  - LBG incompleteness/intersection incompleteness

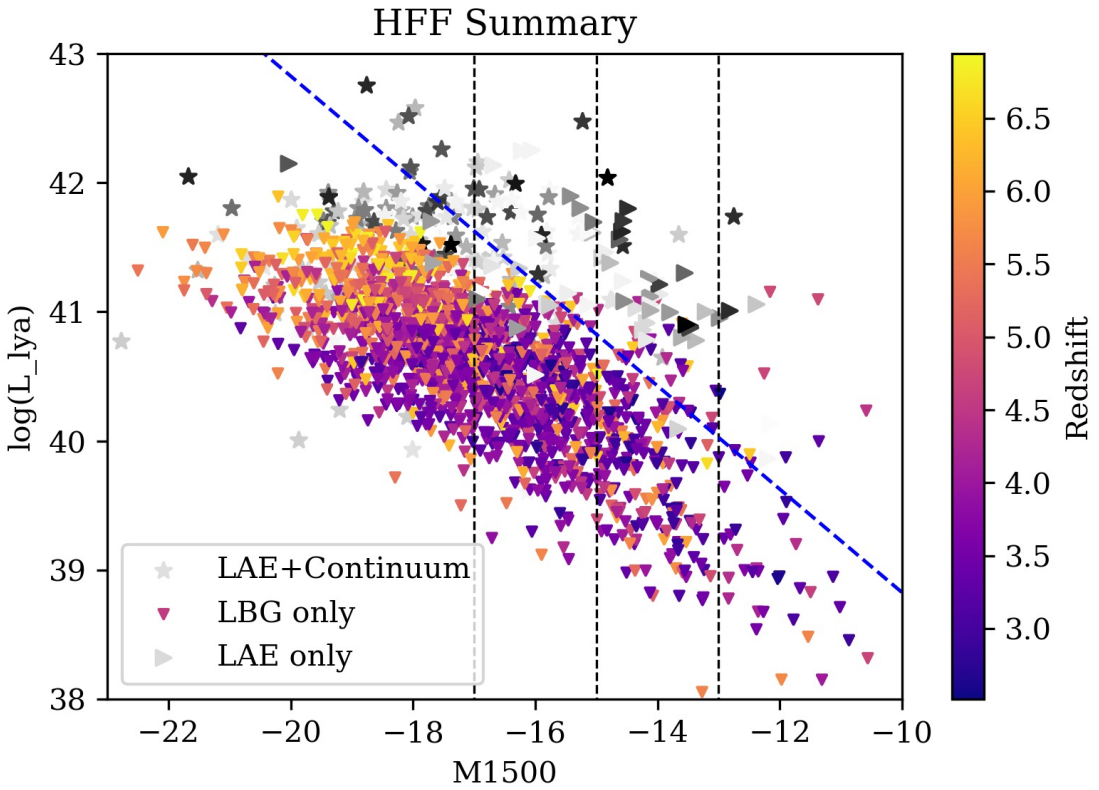
# All populations



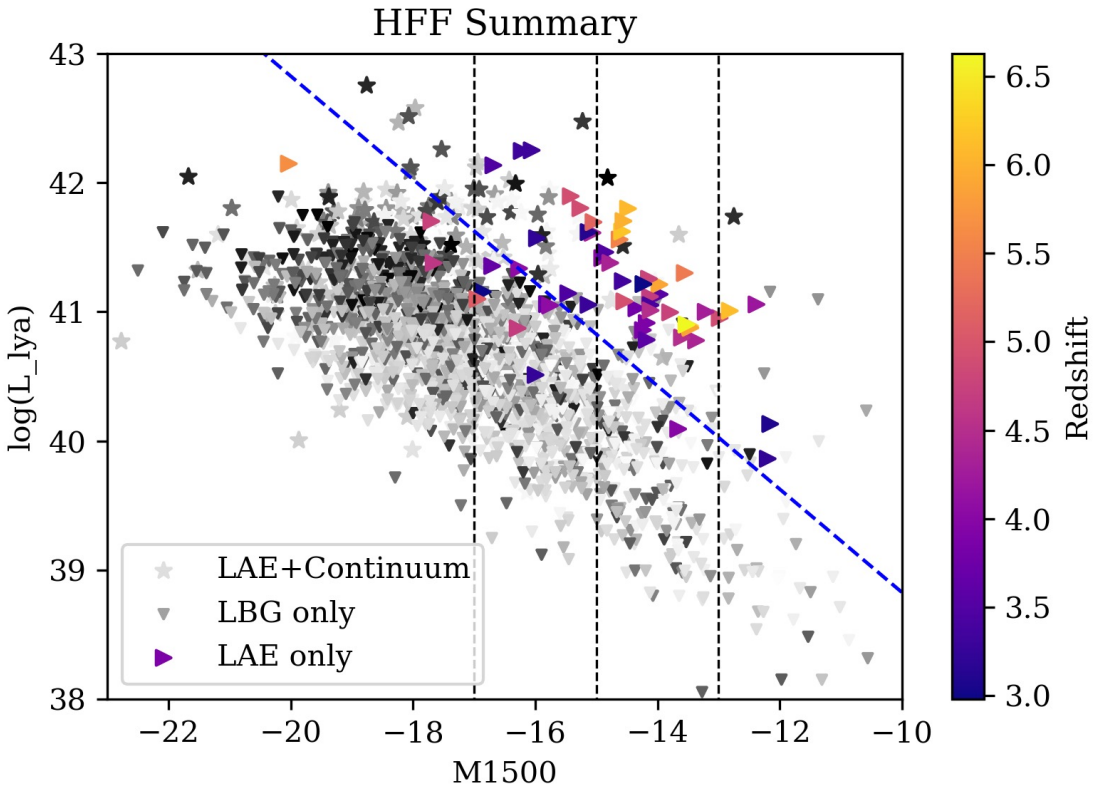
# LAE+continuum



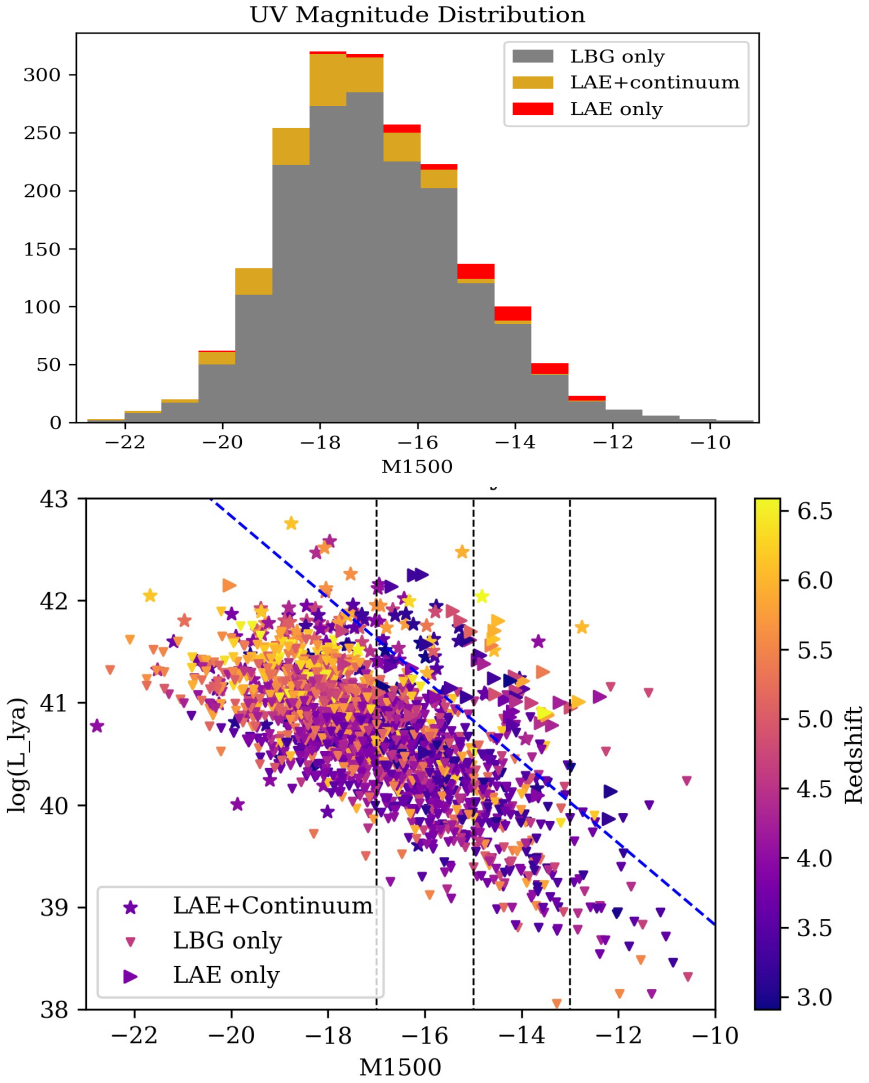
# LBG only


HFF Summary
log(L_lya)
M1500
Redshift
LAE+Continuum
LBG only
LAE only
43
42
41
40
39
38
−22
−20
−18
−16
−14
−12
−10
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0

# LAE only


HFF Summary
log(L_lya)
M1500
Redshift
LAE+Continuum
LBG only
LAE only
43
42
41
40
39
38
−22
−20
−18
−16
−14
−12
−10
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0

# UV Magnitude Distribution



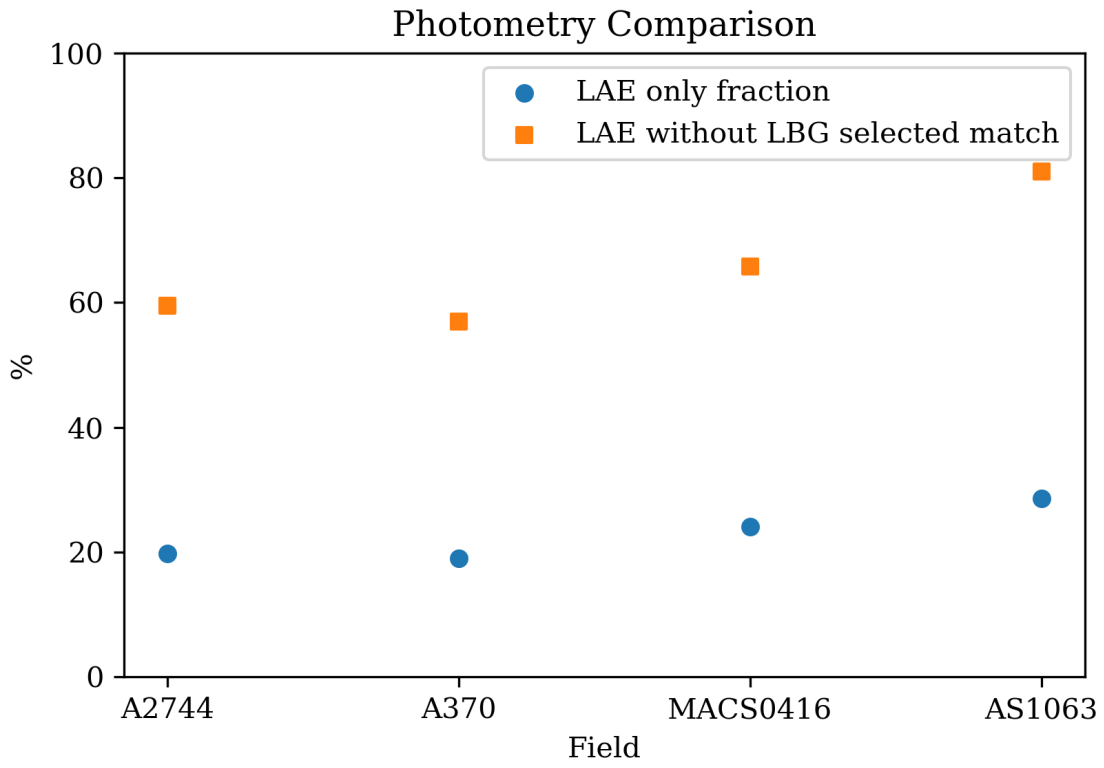
# Upcoming challenges

1. LBG multiple images
   - ✓ Done for the LAEs
   - ❑ To do for the LBGs
2. Incompleteness treatment
   - ✓ Done for the LAEs
   - ❑ Needs to be done for the LBGs
   - ❑ Needs to be done for the intersection…
3. Extend to the CLASH (short-term) and the full LLAMAS sample (longer-term).
   - ❑ Photometry is significantly worse in some of these fields.

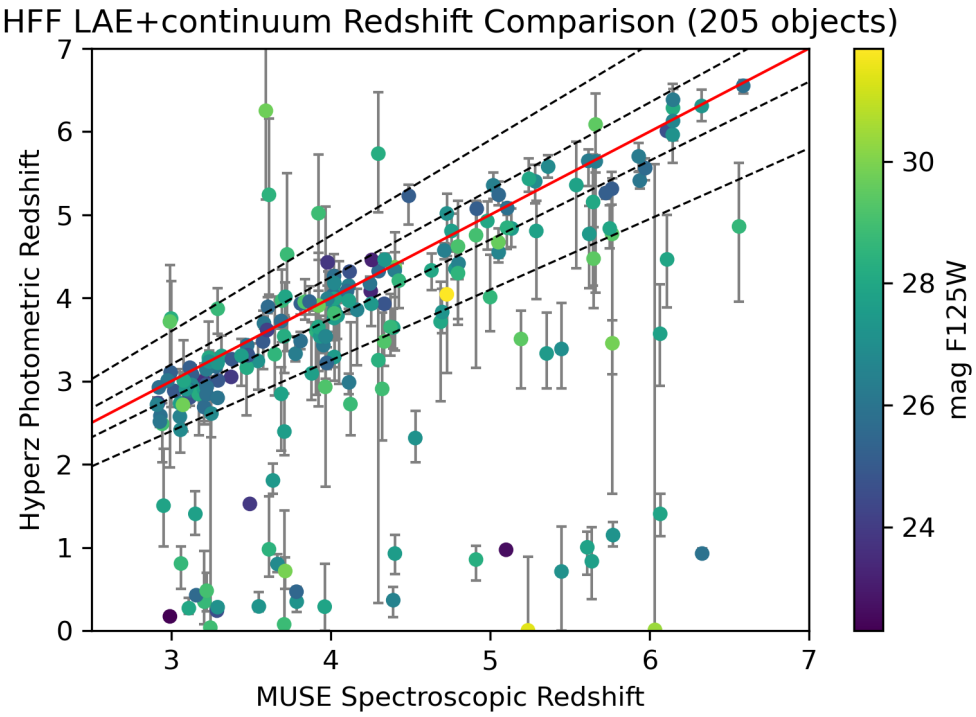
# Summary

- MUSE IFU observations
- LLAMAS sample: 600+ LAEs at redshifts between 2.9 and 6.7.
- We probe luminosities down to $\log(L_{Ly\alpha}) \approx 39.5$, much deeper than in blank field studies.
- Faint end of the LF slope $\alpha = -1.87$, faint end turnover.
- Preliminary results on the LAE/LBG intersection.
- ~2000 LBGs in the HFF fields $(2.9 < z < 6.7)$ using photometric redshifts.
- Photometry quality and selection effects are very important in LBG selection.

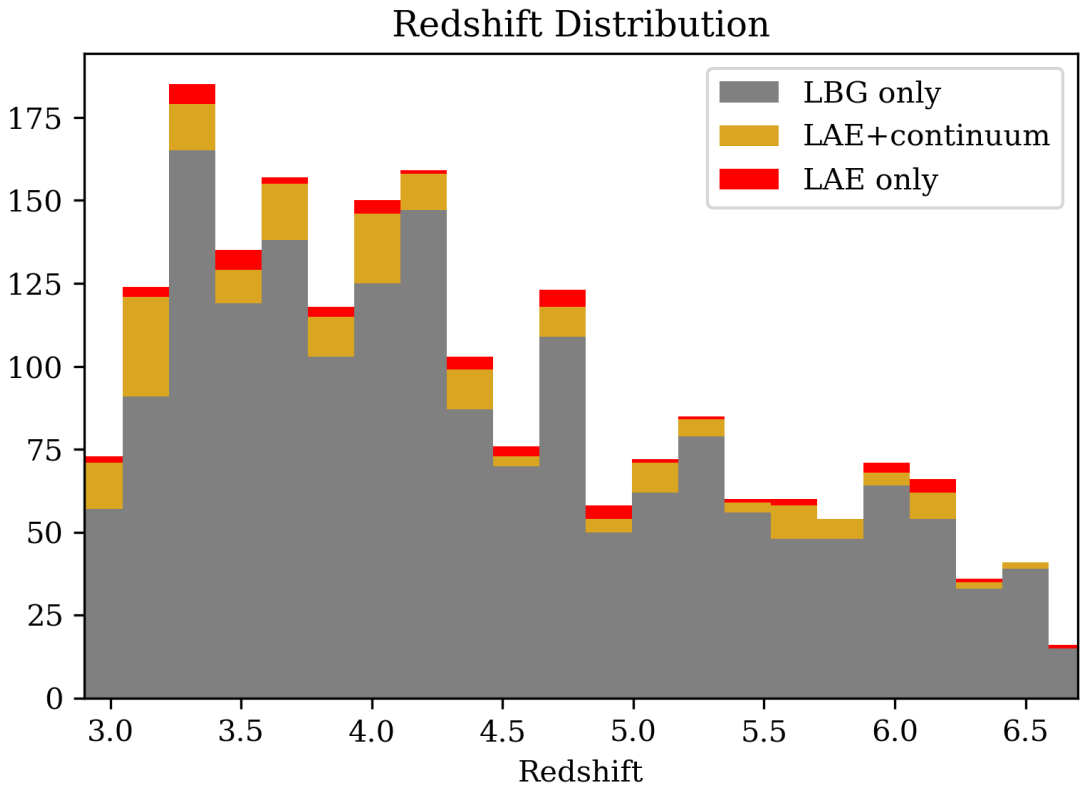
# Photometry Comparison



# LAE and Continuum Sample



# Redshift Distribution



# Results – LAE Luminosity Function