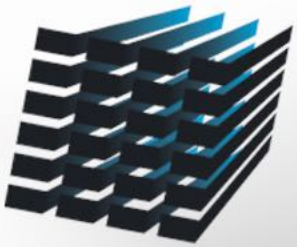
Beyond Hubble, MUSE offer a new view of the high redshift universe.

R. Bacon
CRAL

LPNHE
19 November 2015



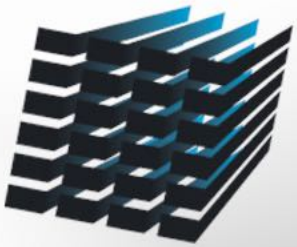
muse

multi unit spectroscopic explorer

Historical Context
The MUSE Instrument
Commissioning results
Hubble Deep Field South
Gravitational Lensing Clusters
What's next

LPNHE

19 November 2015



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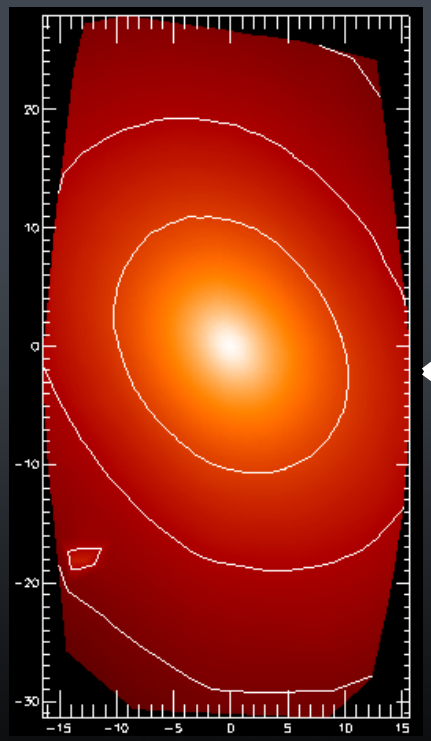
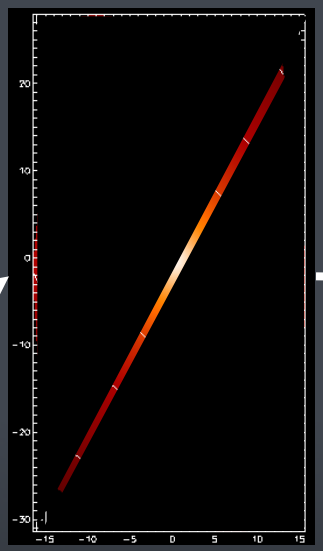
19 November 2015

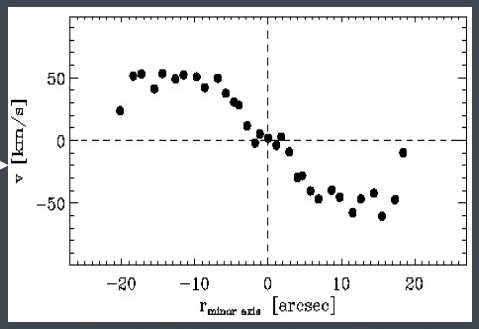
Integral Field Spectrography



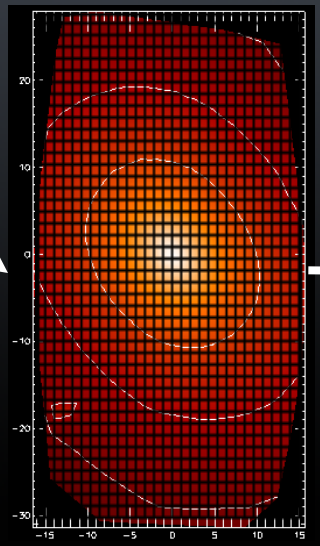
Imaging

Long Slit

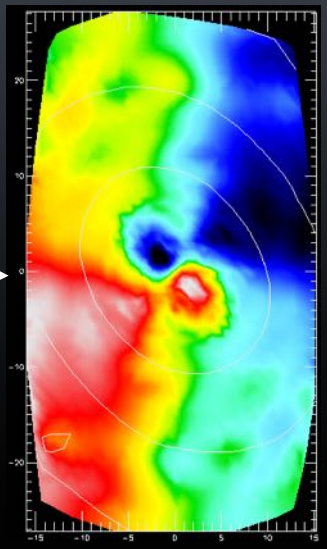




IFU



Velocity Field



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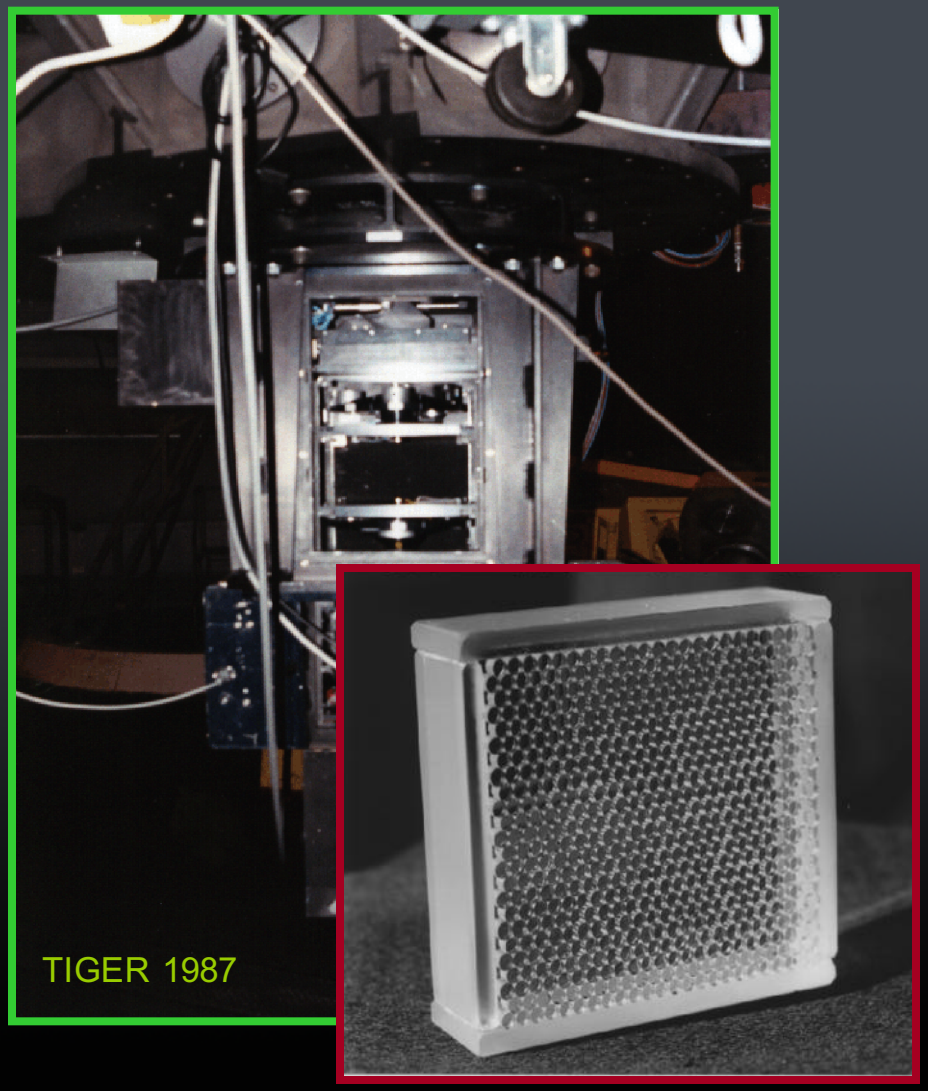
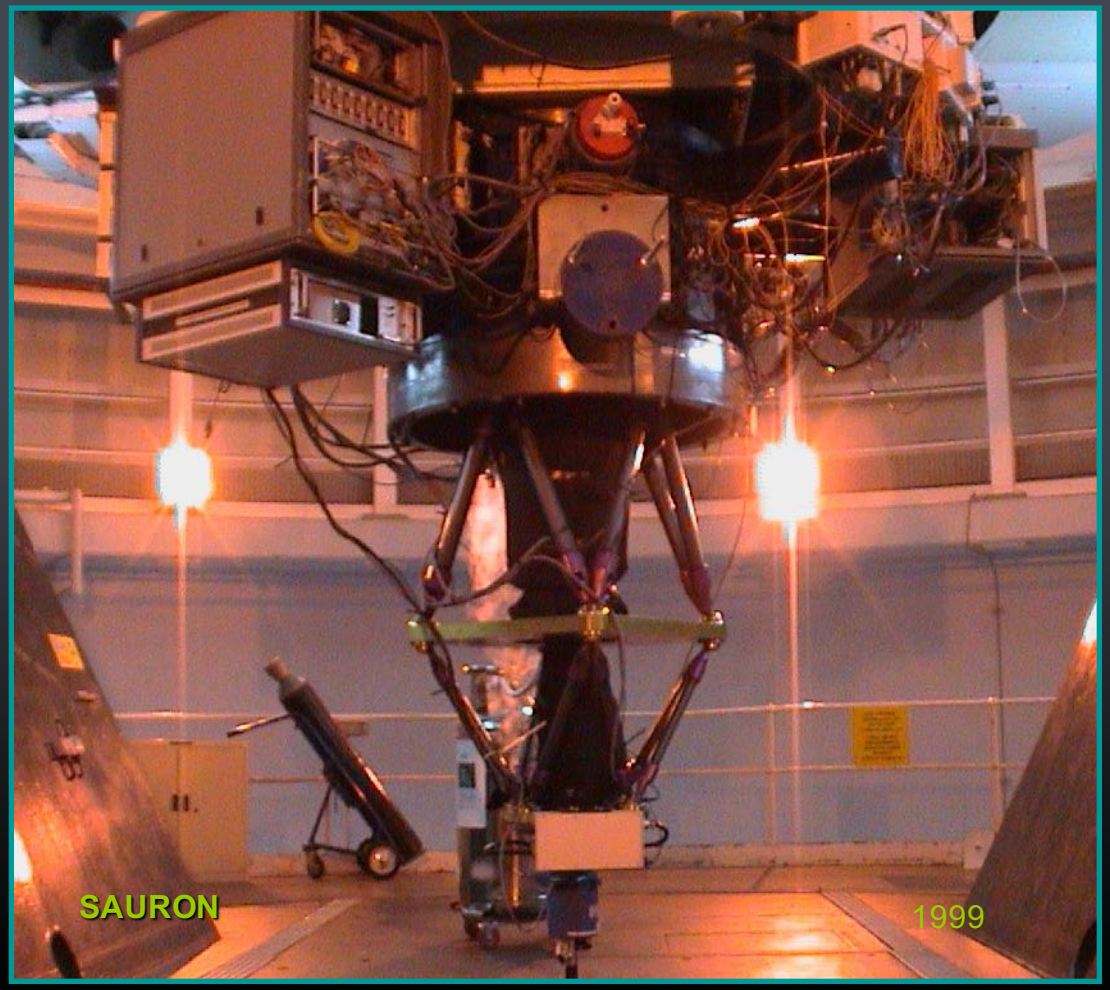
Historical Context

- 1987: first light of the first ever integral field spectrograph – TIGER
- 1990-2000: The first generation
  - Small field of view (~10 arcsec)
  - Visible wavelength range
  - Detailed study of individual objects



Historical Context

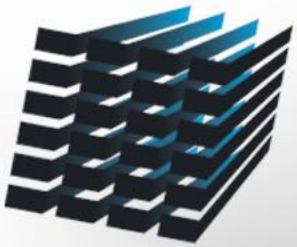
- 2000-2010: The second generation
  - Working in IR: SINFONI@VLT, OSIRIS@KECK
  - Coupled with AO: OASIS@CFH, SINFONI@VLT, OSIRIS@KECK
  - Larger field: SAURON@WHT, PMAS@CalarAlto
  - Dedicated: SNIFS@UH



Historical Context

- The third generation
  - IFU as a discovery machine
  - A true imager and an excellent spectrograph
  - High spatial resolution and large field of view
  - Good spectral resolution and wide simultaneous spectral range
  - Excellent throughput

MUSE … the Multi Unit Spectroscopic Explorer



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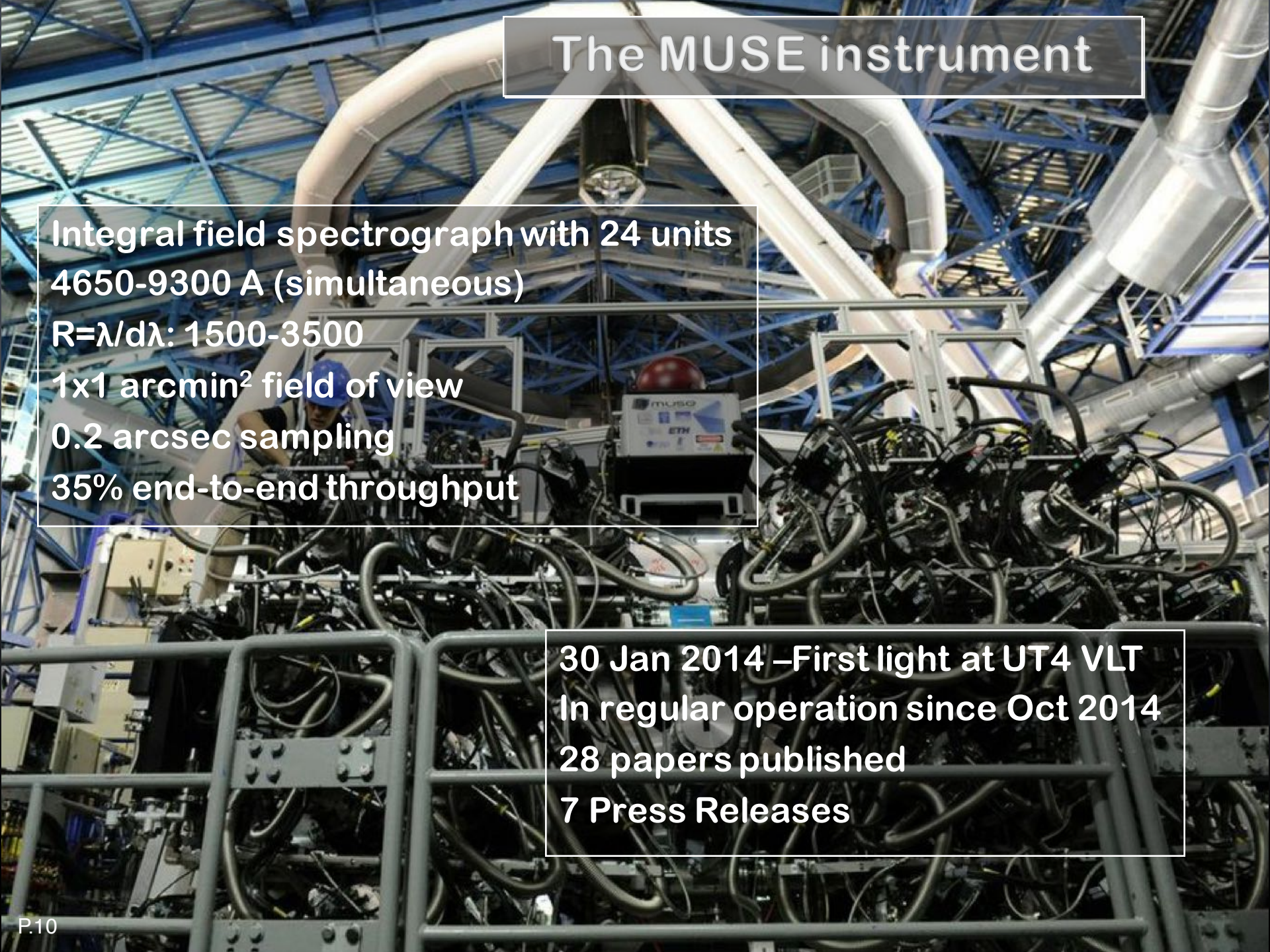
Consortium & Partners

The MUSE instrument

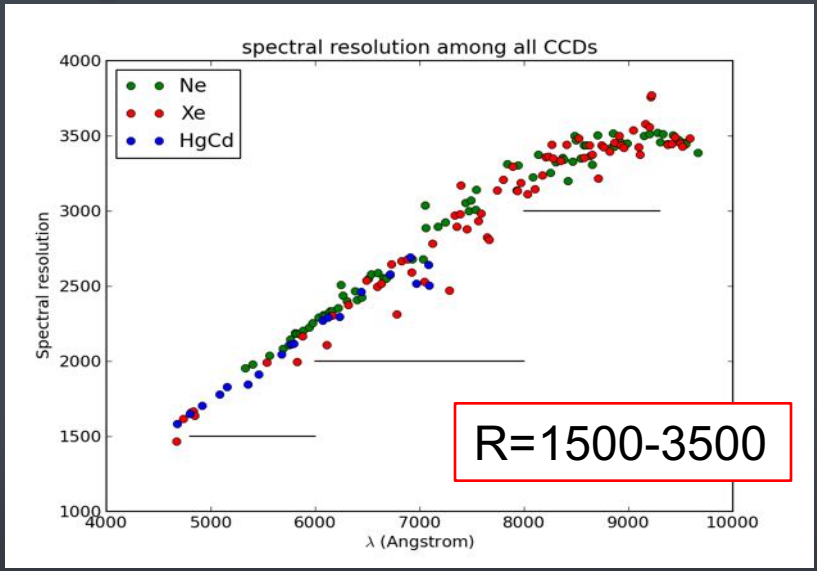


Integral field spectrograph with 24 units
4650-9300 A (simultaneous)
R=λ/dλ: 1500-3500
1x1 arcmin^2 field of view
0.2 arcsec sampling
35% end-to-end throughput

30 Jan 2014 –First light at UT4 VLT
In regular operation since Oct 2014
28 papers published
7 Press Releases

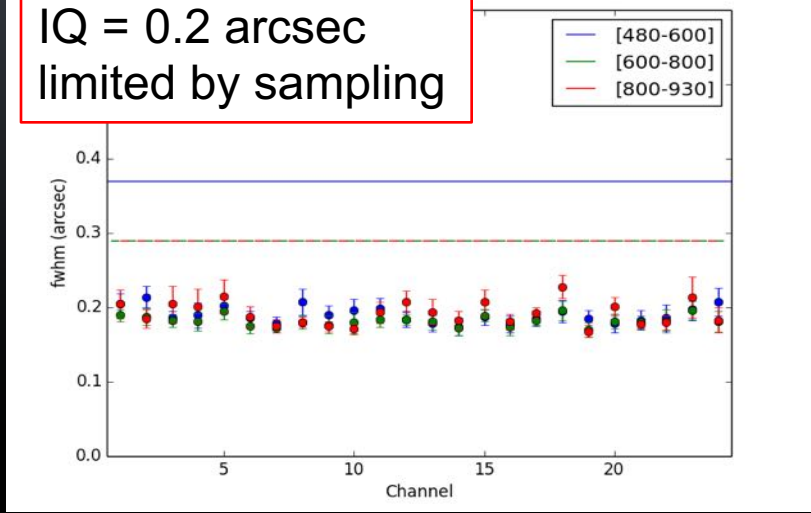

muse
ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich

Instrument Performances

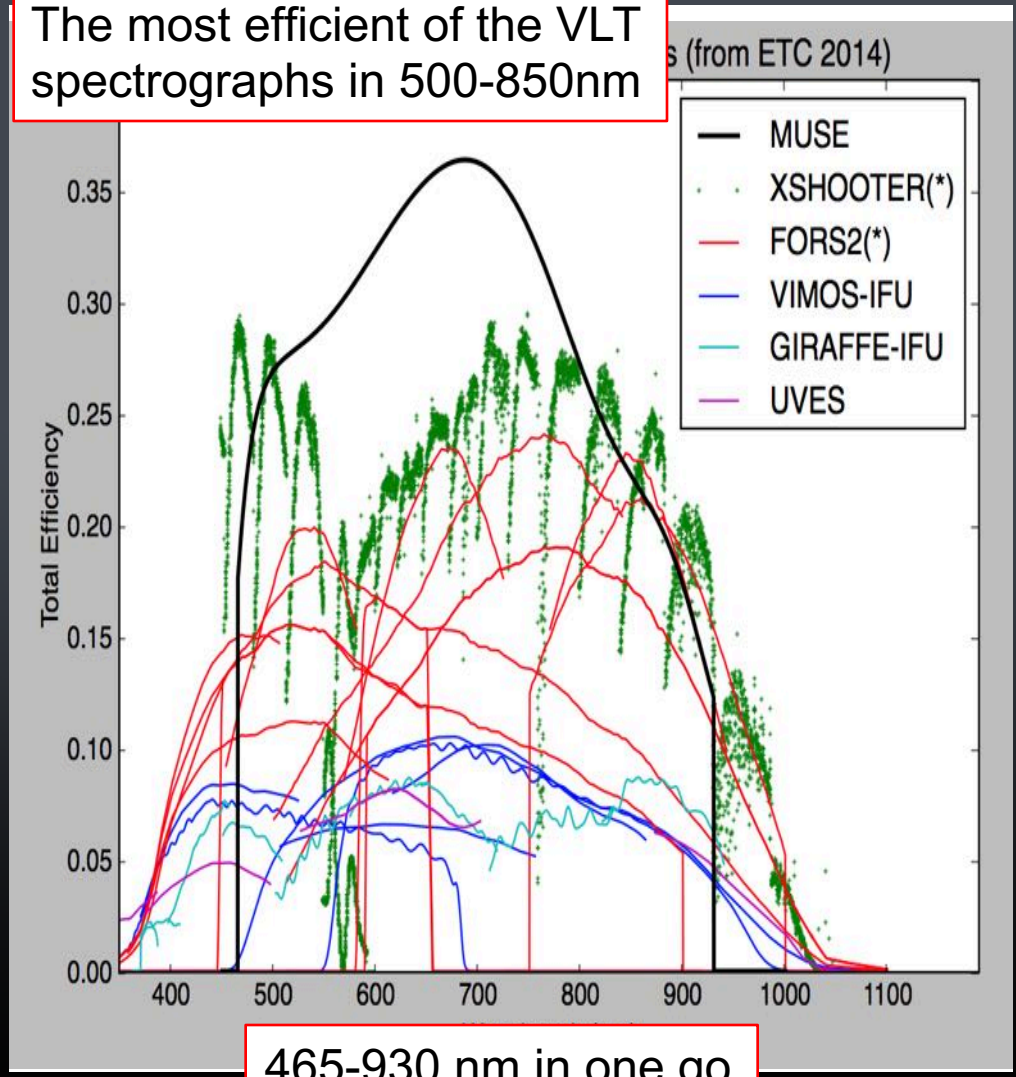


R=1500-3500

IQ = 0.2 arcsec
limited by sampling



The most efficient of the VLT spectrographs in 500-850nm



465-930 nm in one go

(*) 17% Slit loss included in FORS2 & XSHOOTER (e.g. 1 arcsec slit with 0.8 arcsec seeing)

2014, the MUSE year

- 19 Jan: MUSE land on UT4
- 31 Jan: First light
- 7-21 Feb: Comm1
- 11 Mar: ESO 3D Conf T
- 28 Apr – 6 Mai: Comm2
- 20-29 Jun: SV-1
- 25 Jun: SPIE Plenar
- 25 Jul – 3 Aug: Com
- 18 – 24 Aug: SV-2
- 13-26 Sep: 1st GTO
- 1 Oct: 1st GO run
- 10 Nov: 1st paper ou

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY
MNRAS 445, 4335–4344 (2014) doi:10.1093/mnras/stu2092

MUSE sneaks a peek at extreme ram-pressure stripping events – I. A kinematic study of the archetypal galaxy ESO137−001

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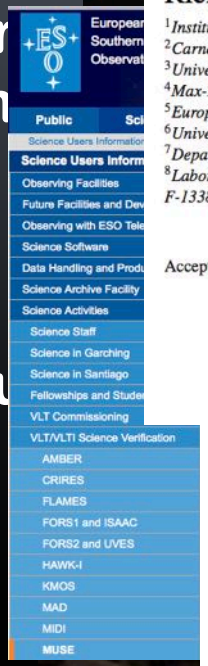
[7]*Department of Physics, University of Alabama in Huntsville, Huntsville, AL 35899, USA*
[8]*Laboratoire d'Astrophysique de Marseille – LAM, Université d'Aix-Marseille & CNRS, UMR7326, 38 rue F. Joliot-Curie, F-13388 Marseille Cedex 13, France*

Accepted 2014 October 6. Received 2014 September 29; in original form 2014 July 29

ABSTRACT

We present Multi Unit Spectroscopic Explorer (MUSE) observations of ESO137−001, a spiral galaxy infalling towards the centre of the massive Norma cluster at $z \sim 0.0162$. During the high-velocity encounter of ESO137−001 with the intracluster medium, a dramatic ram-pressure



data can be found here.

- Program 60.A-9339(A), Hawthorn/Marconi/Salvato et al. **"Local AGN sample"**: program fully COMPLETED. The archive link to the data can be found here.
- Program 60.A-9340(A), Lanzoni et al., **"Metal-poor Globular Cluster"**: program fully COMPLETED. The archive link to the data can be found here
- Program 60.A-9341(A), Santoro/Hamer et al. **"CenA"**: program fully COMPLETED. The archive link to the data can be found here
- Program 60.A-9342(A), Valenti/Zoccali/Kuijken et al. **"MW Bulge"**: program fully COMPLETED. The archive link to the data can be found here
- Program 60.A-9343(A), Zoccali et al. **"Metal-rich Globular Cluster"**: program fully COMPLETED. The archive link to the data can be found here
- Program 60.A-9344(A), Kuncarayakti/Vink/Fernandez et al., **"Young Stellar populations"**: program fully COMPLETED. The archive link to the data can be found here.
- Program 60.A-9345(A), Clement/Caputi et al. **"Abell S1063"**: program fully COMPLETED. The archive link to the data can be found here.
- Program 60.A-9346(A), Laurikainen et al. **"Barlenses"**: Program not started, unfortunately no data were taken.
- Program 60.A-9347(A), Wesson/Ueta/Walsh et al. **"Planetary Nebula"**: program fully COMPLETED. The archive link to the data can be found here.
- Program 60.A-9348(A), Hainich/Mendel et al. **"Extragalactic stellar clusters"**: Program fully COMPLETED. The archive link to the data can be found here.
- Program 60.A-9349(A), Fumagalli/Hau/Slezak et al. **"Ram-pressure"**: program fully COMPLETED. The archive link to the data can be found here
- Program 60.A-9351(A), Melnick et al. **"30 Doradus"**: program only partially completed. The archive link to the data can be found here

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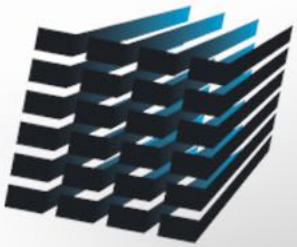

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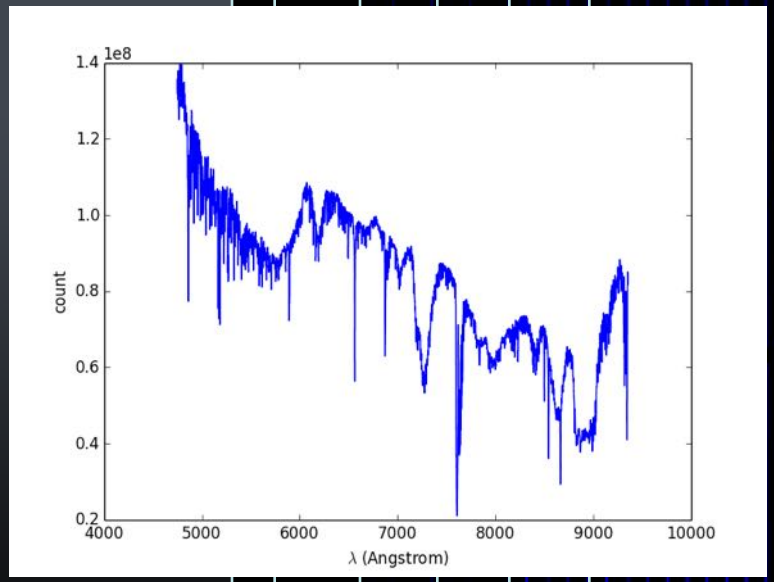
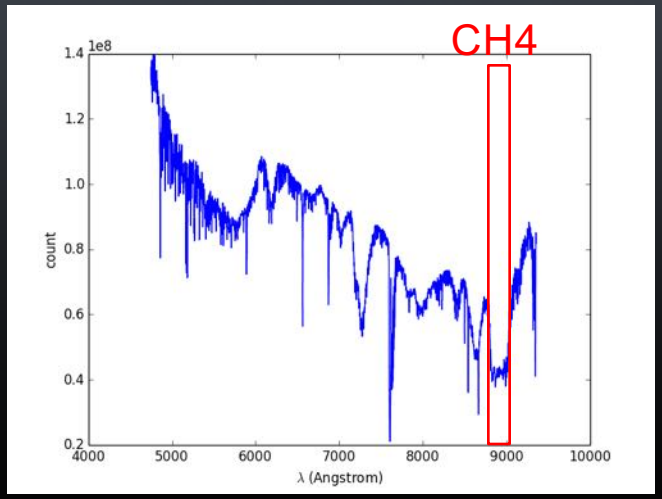
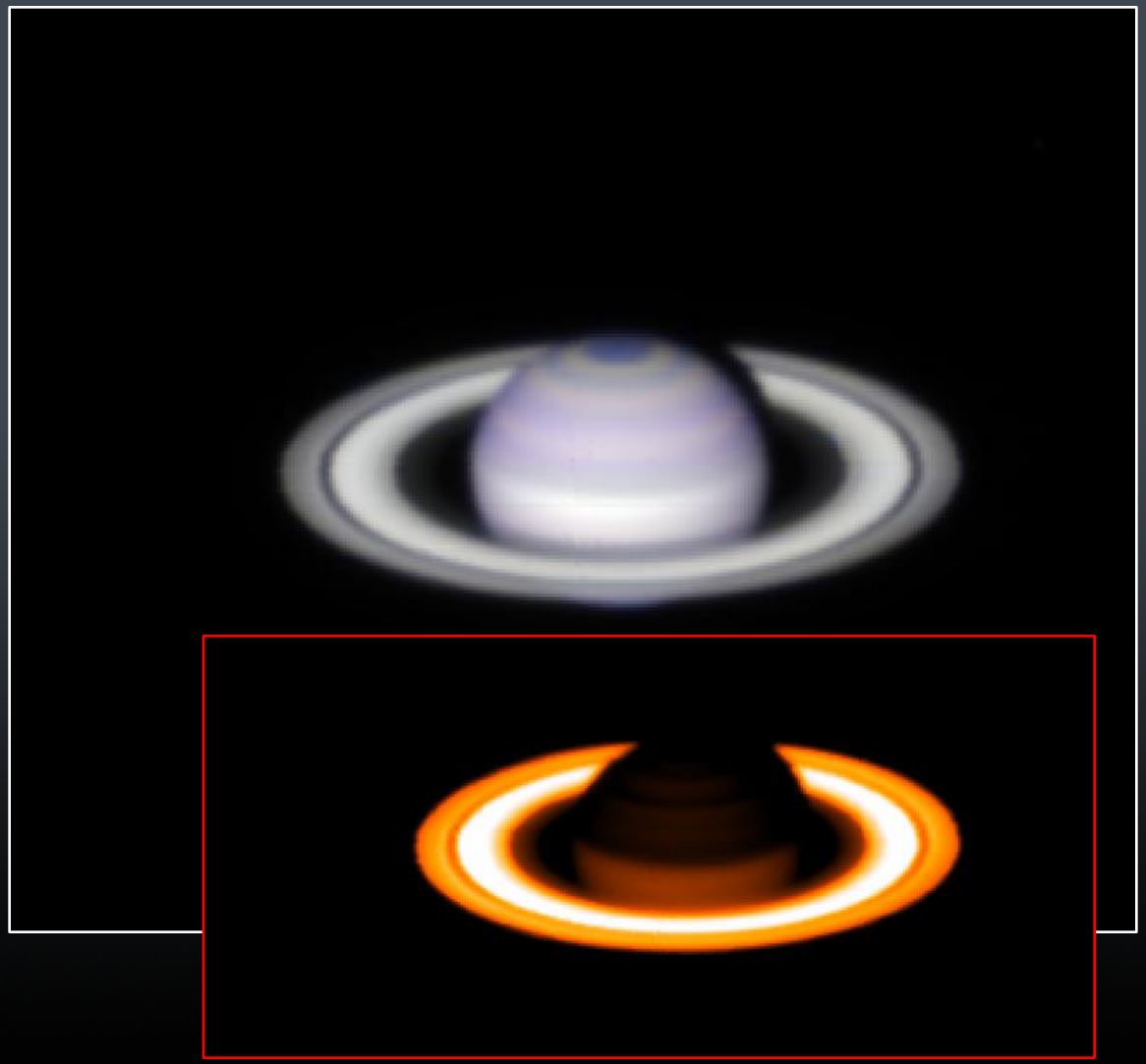
First reconstructed image: Saturn



1 arcmin^2
4x1 sec exposures
Seeing 0.85 arcsec

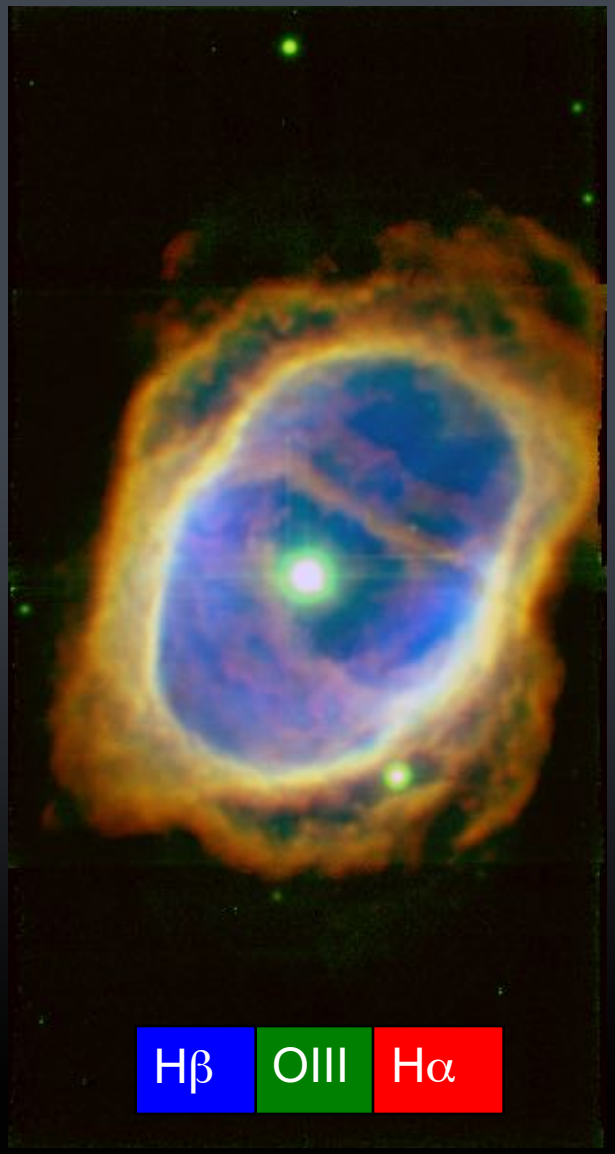
First reconstructed image: Saturn





Prepared by Johan Richard, CRAL

The Planetary Nebula NGC 3132



3x1 arcmin^2

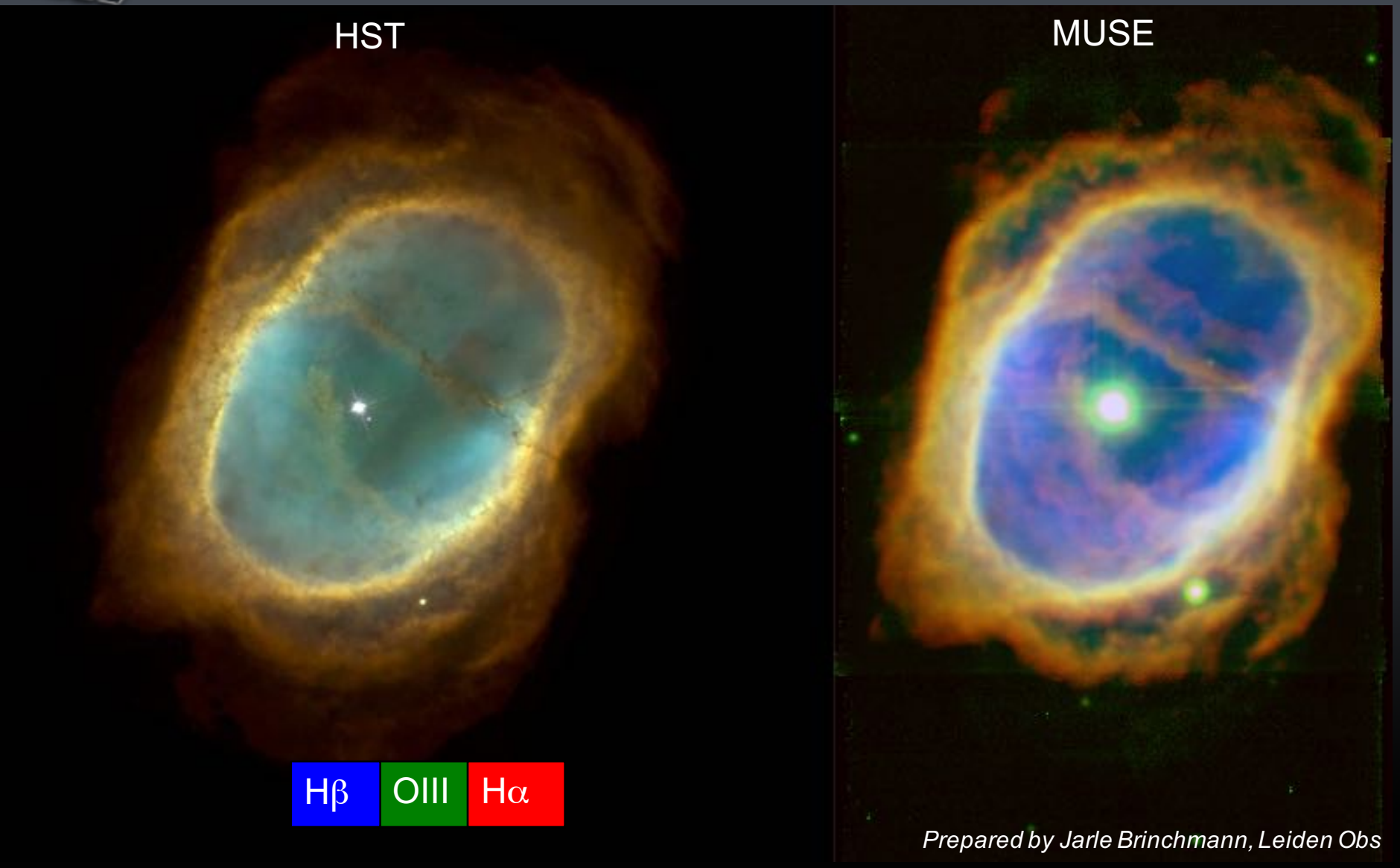
Mosaic of 3 fields

13 x 1 mn exposures

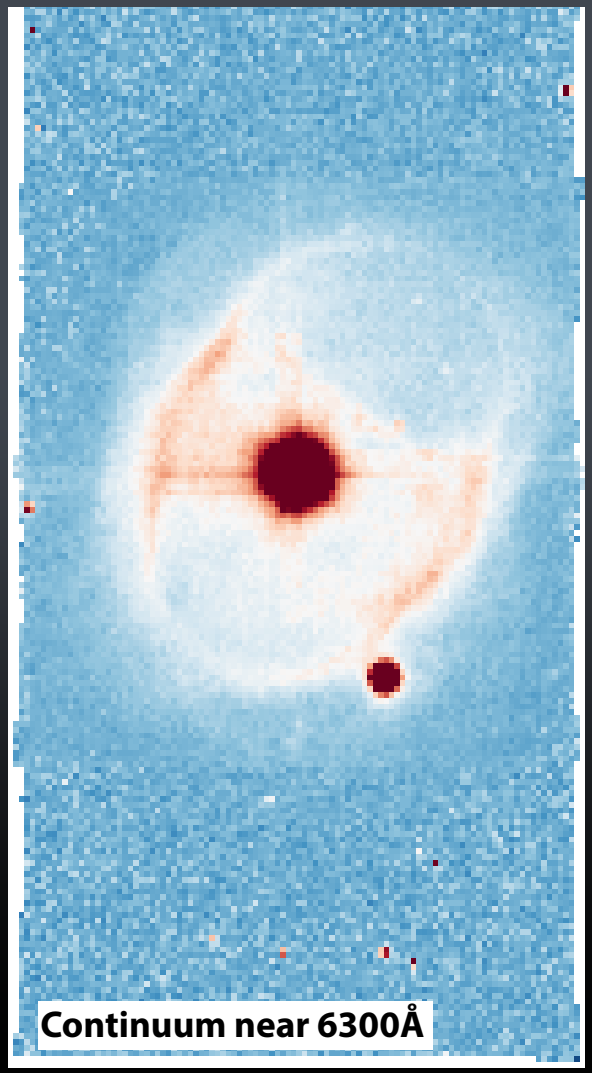
Seeing 0.7-0.8 arcsec

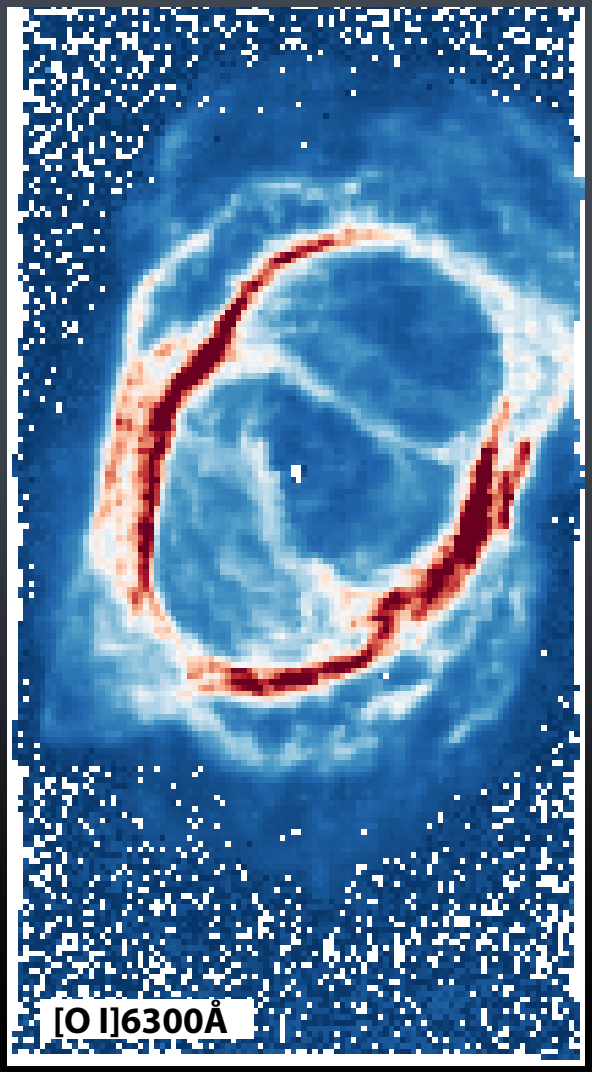
Prepared by Jarle Brinchmann, Leiden Obs

The Planetary Nebula NGC 3132



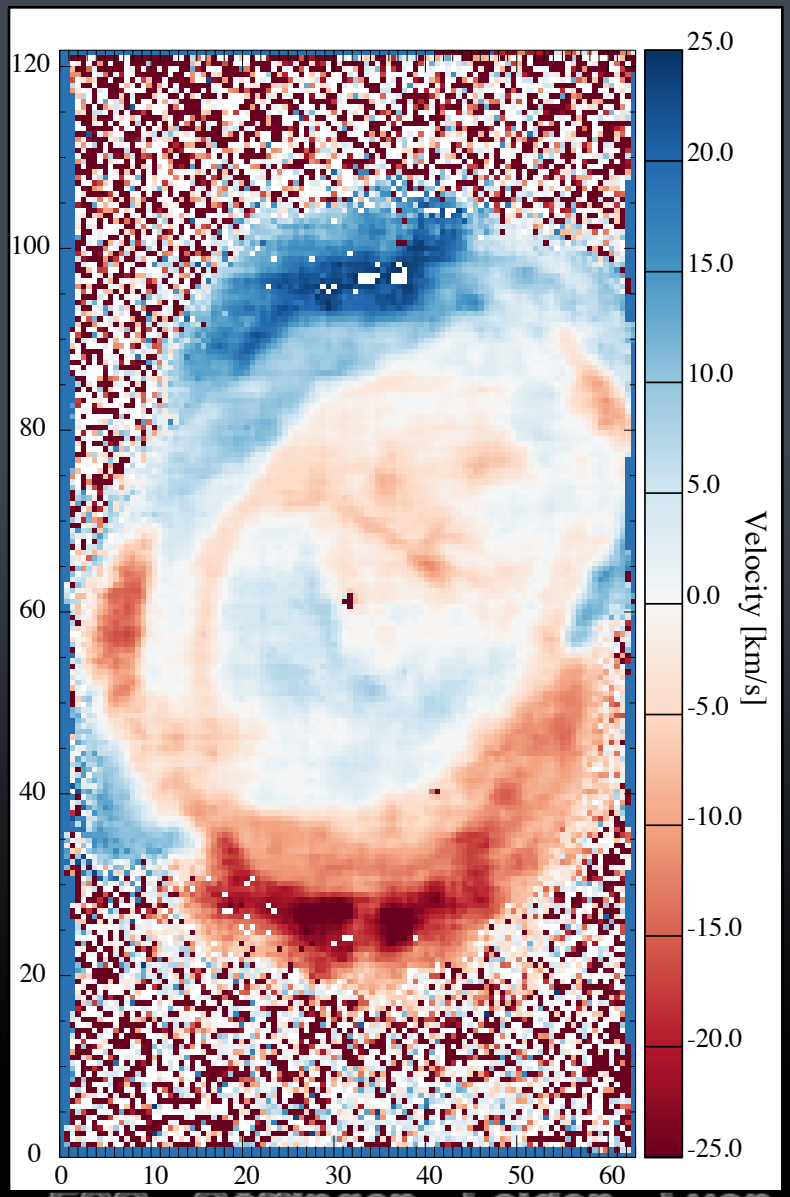
The Planetary Nebula NGC 3132





Prepared by Jarle Brinchmann, Leiden Obs

The Planetary Nebula NGC 3132



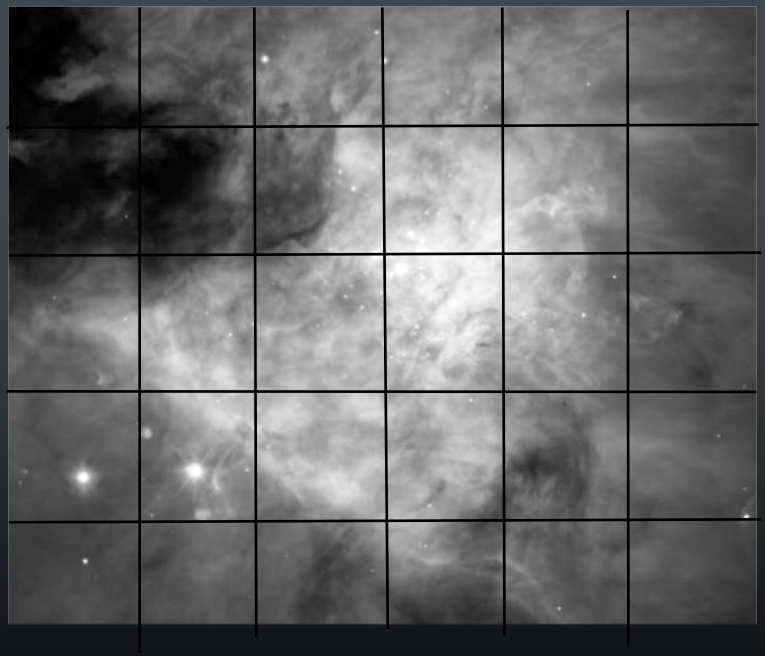
Gas Velocity field

V_{max} = 20 km/s

Accuracy ~1 km/s

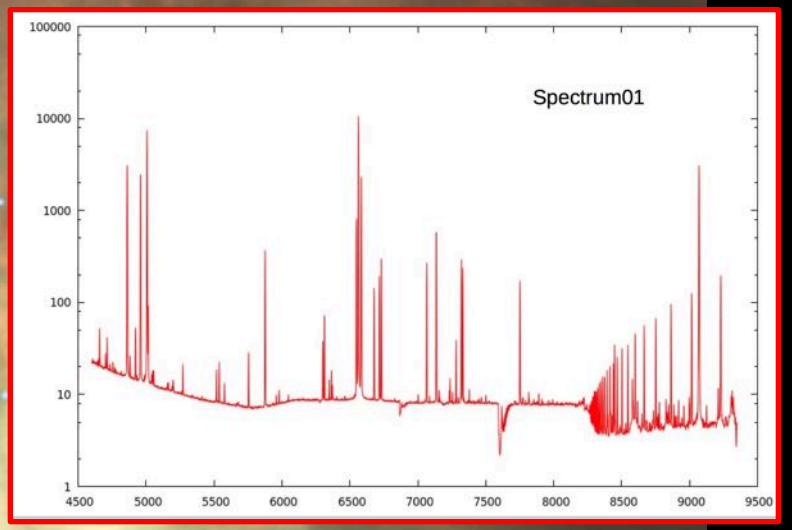
Prepared by Jarle Brinchmann, Leiden Obs

Mapping large area: the Orion Nebula



- 6x5 arcmin^2
- 30 fields, 60 exposures of 5 sec integration
- 2.5 hours total
- 5 millions of spectra
  - 300 spectra/sec (overhead included)
- Datacube of 1748x1460x4000

Peter Weilbacher, AIP

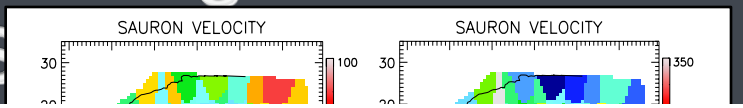


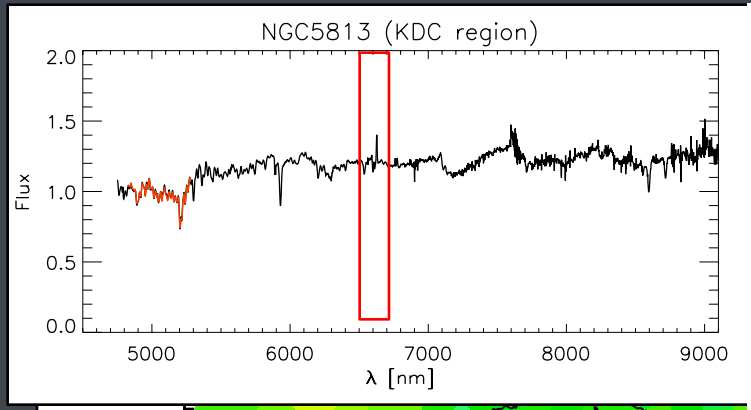
Just one over 2.5 millions spectra

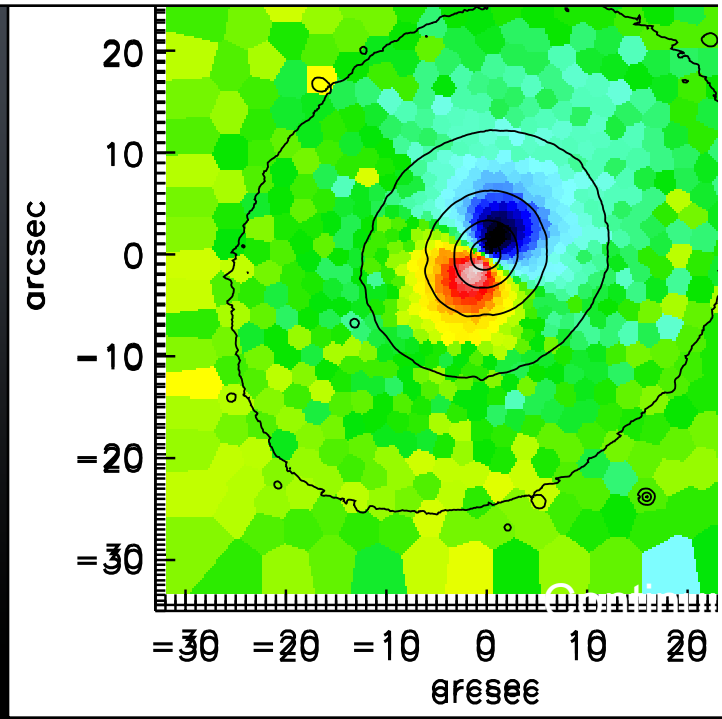
Peter Weilbacher, AIP

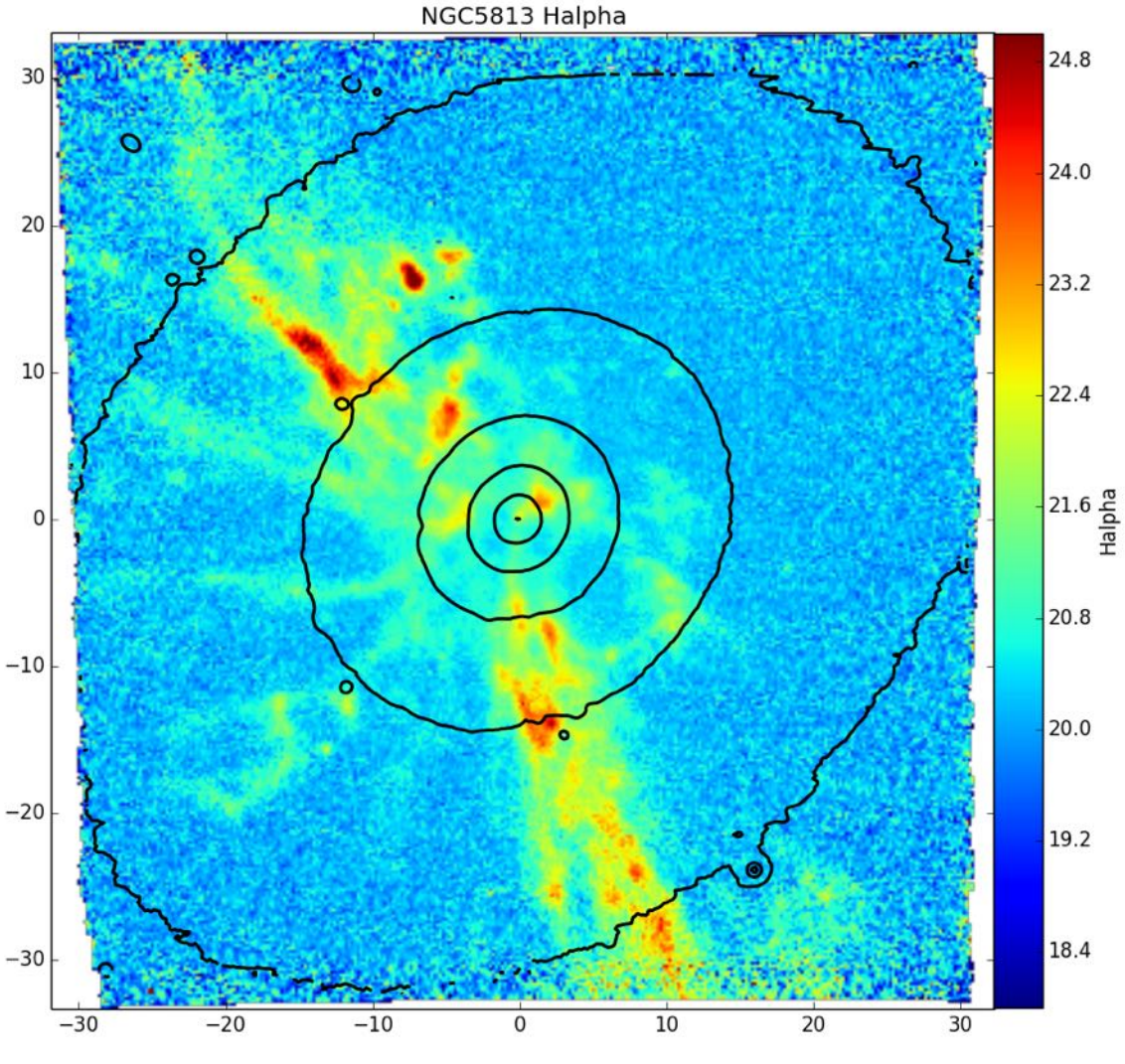
Hβ+OIII | Cont 5300 | Hα+NII

Why spectral range matters
NGC 5813 – S



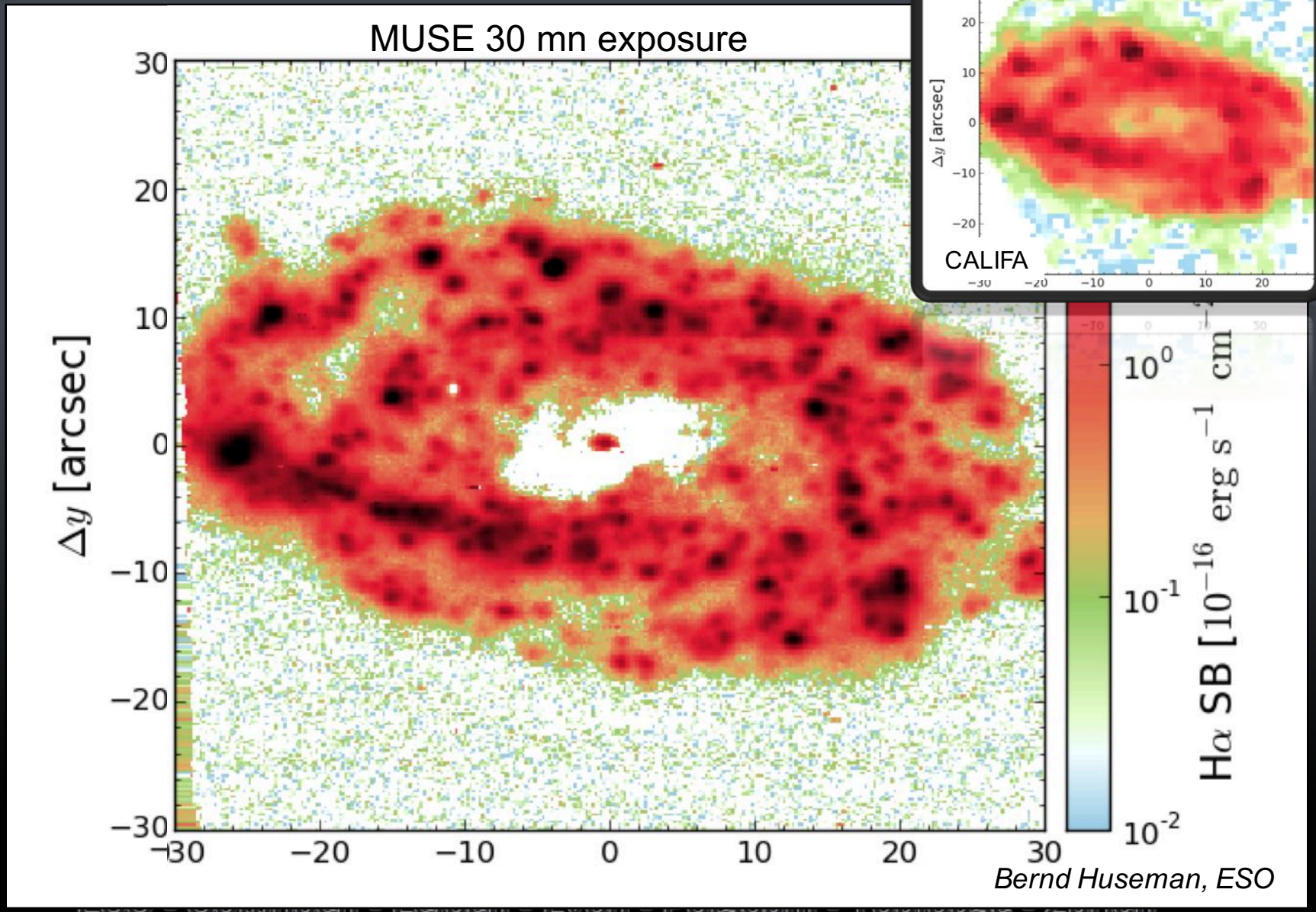


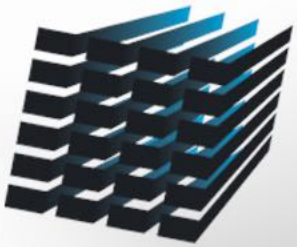




Davor Krajnovic, AIP

Why spatial resolution matters
NGC 2906 – CALIF





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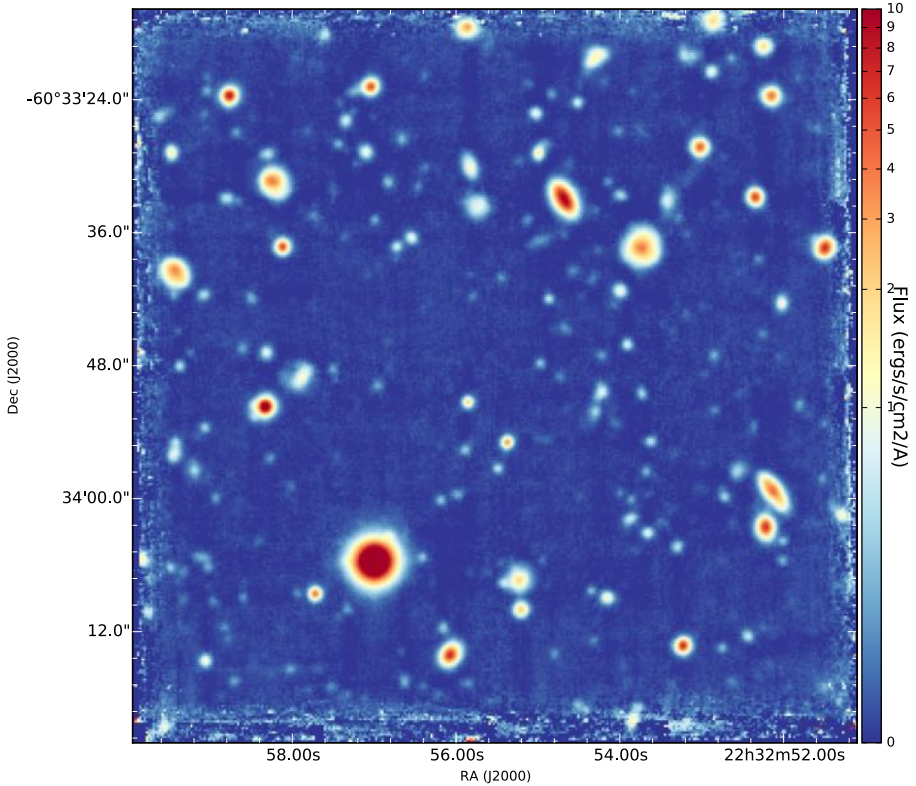
LPNHE

19 November 2015

The MUSE 3D view of the Hubble Deep Field South



R. Bacon[1], J. Brinchmann[2], J. Richard[1], T. Contini[3,4], A. Drake[1], M. Franx[2], S. Tacchella[5], J. Vernet[6], L. Wisotzki[7], J. Blaizot[1], N. Bouché[3,4], R. Bouwens[2], S. Cantalupo[5], C.M. Carollo[5], D. Carton[2], J. Caruana[7], B. Clément[1], S. Dreizler[8], E. Emsellem[1,6], B. Epinat[3,4,9], B. Guiderdoni[1], C. Herenz[7], T.-O. Husser[8], S. Kamann[8], J. Kerutt[7], W. Kollatschny[8], D. Krajnovic[7], S. Lilly[5], T. Martinsson[2], L. Michel-Dansac[1], V. Patricio[1], J. Schaye[2], M. Shirazi[5], K. Soto[5], G. Soucail[3,4], M. Steinmetz[7], T. Urrutia[7], P. Weilbacher[7], and T. de Zeeuw[6,2]

A&A, 575, 32 (2015)

Hubble Deep Field South

Williams et al (2000)
Casertano et al (2000)
mAB ~ 29

Before Aug 2014: A total of 18 redshifts from five previous papers

Hubble Deep Field South

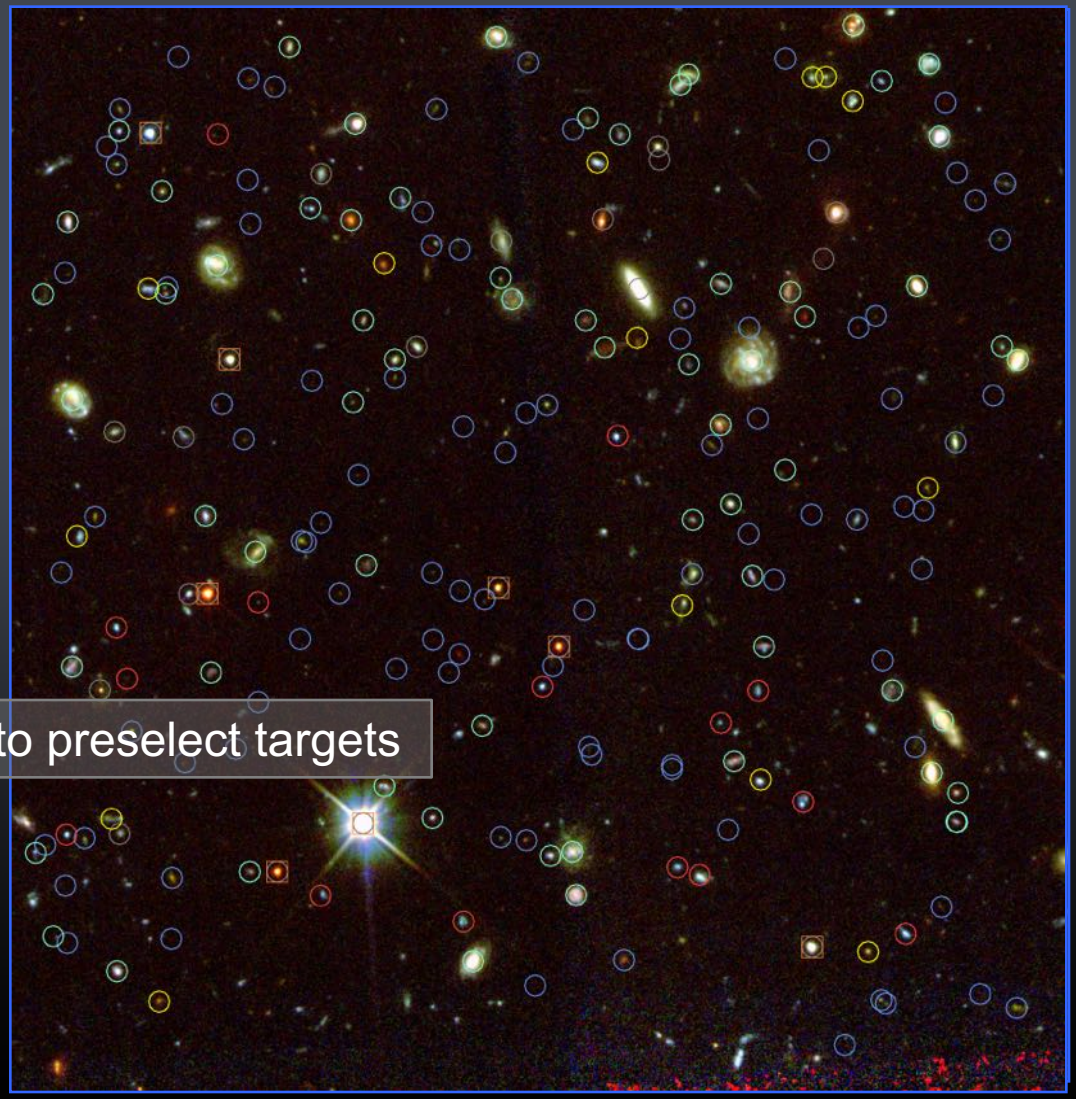
Williams et al (2000)
Casertano et al (2000)
mAB ~ 29

Before Aug 2014: A total of 18 redshifts from five previous papers

Enter MUSE

189 secured redshifts for now

Big advantage: no need to preselect targets



Hubble Deep Field South

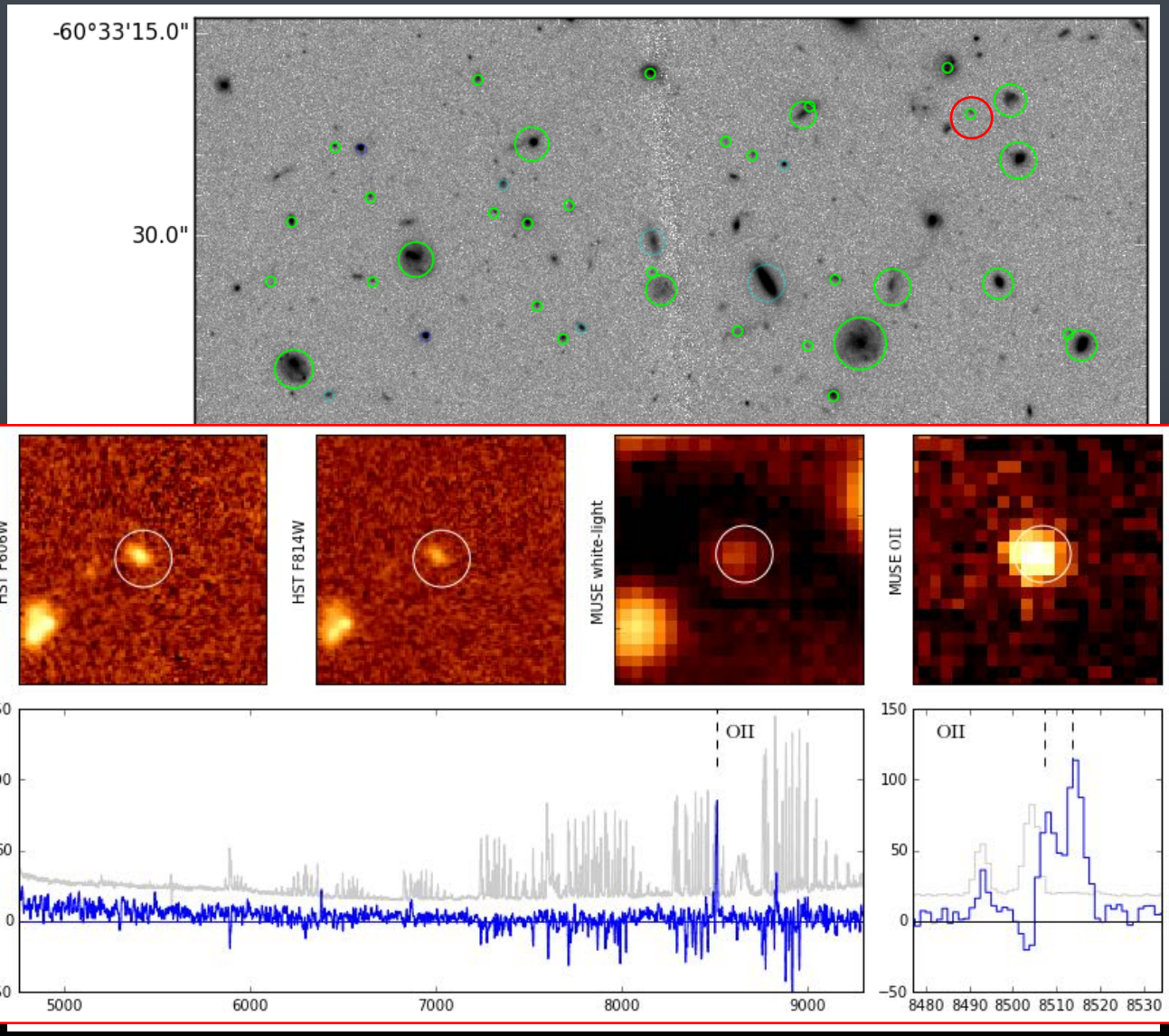
Enter MUSE
189 secured redshifts
for now

70 Lyα emitters seen in HST
26 Lyα w/o HST
65 [O II] emitters
15 C III]1909 emitters
8 Stars
14 Abs. line redshifts

out of 586 targets

Census of MUSE HDFS Field

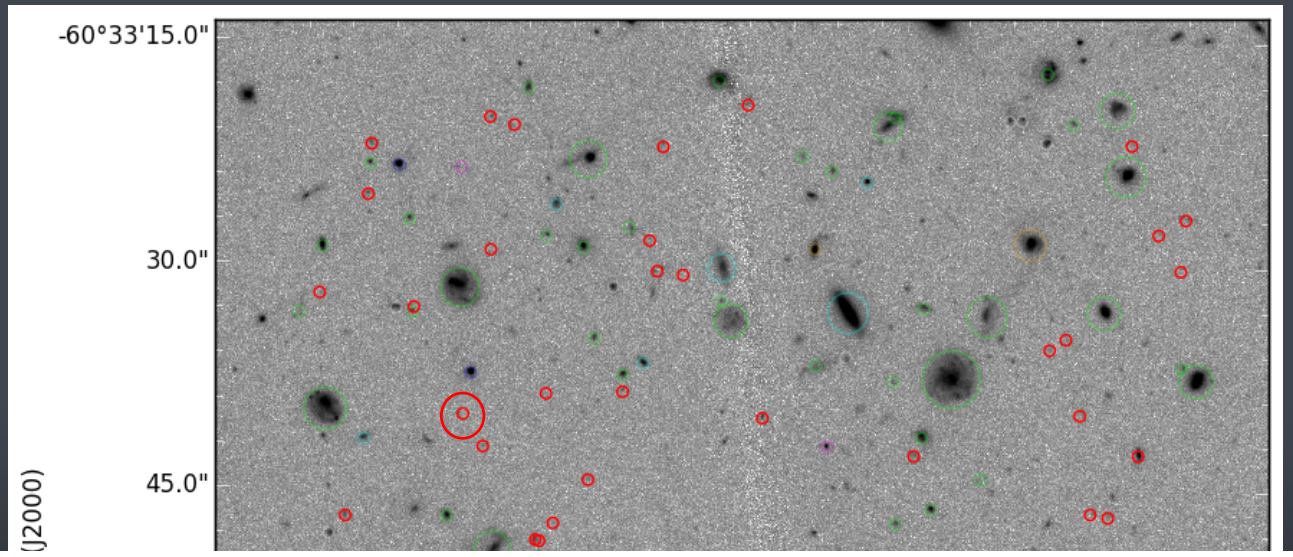
- ✓ HST WFPC2 F812W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
  - ✓ Z = [0.29 – 1.48]
  - ✓ I_{814} = [21.5 – 28.5]

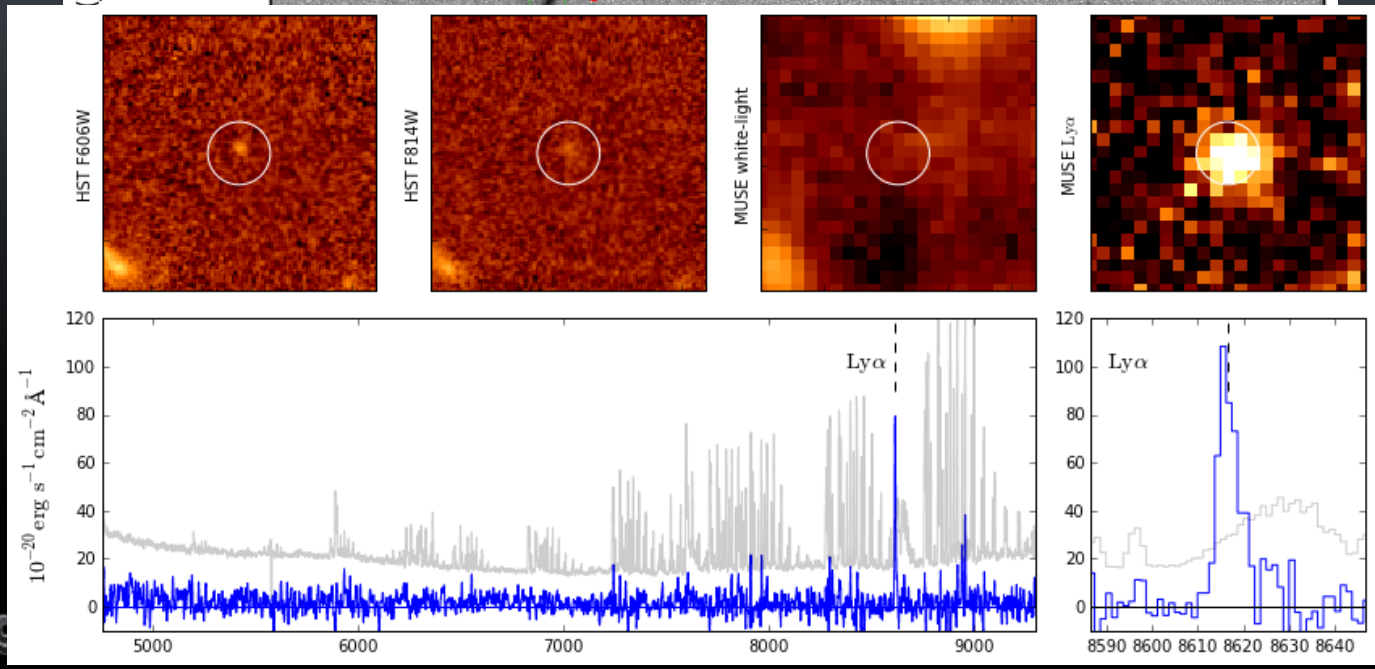


ID#160

Z = 1.28
I_{814} = 26.7
M ≈ 2 10^9 $M_\odot$

- ✓ HST WFPC2 F812W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ **63 Lyα emitters**
  - ✓ Z = [2.95 – 6.28]
  - ✓ I_{814} = [24.5 – 29.6]





ID#290

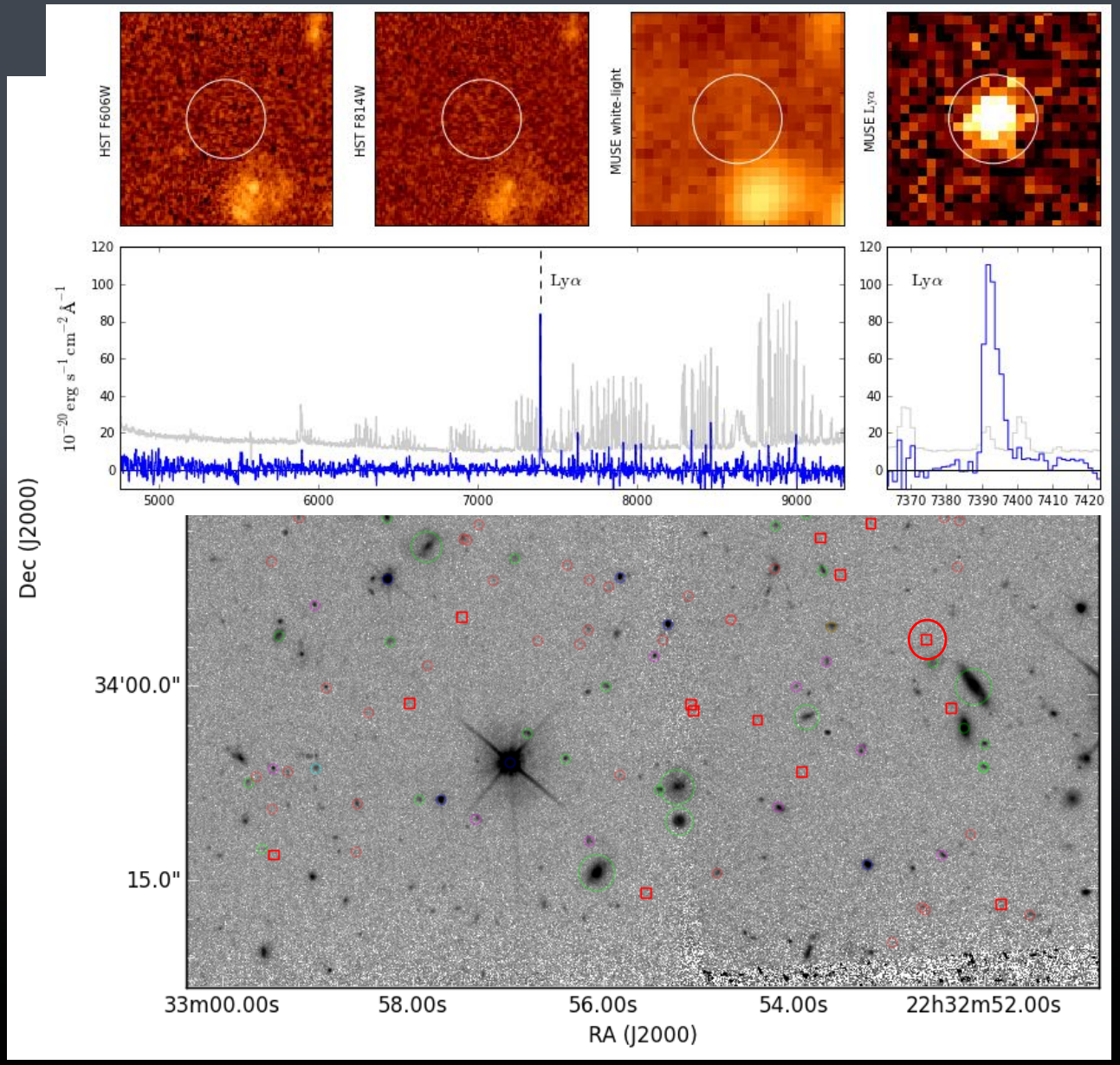
Z = 6.08
I_{814} = 27.8

Census of MUSE HDFS Field

ID#553

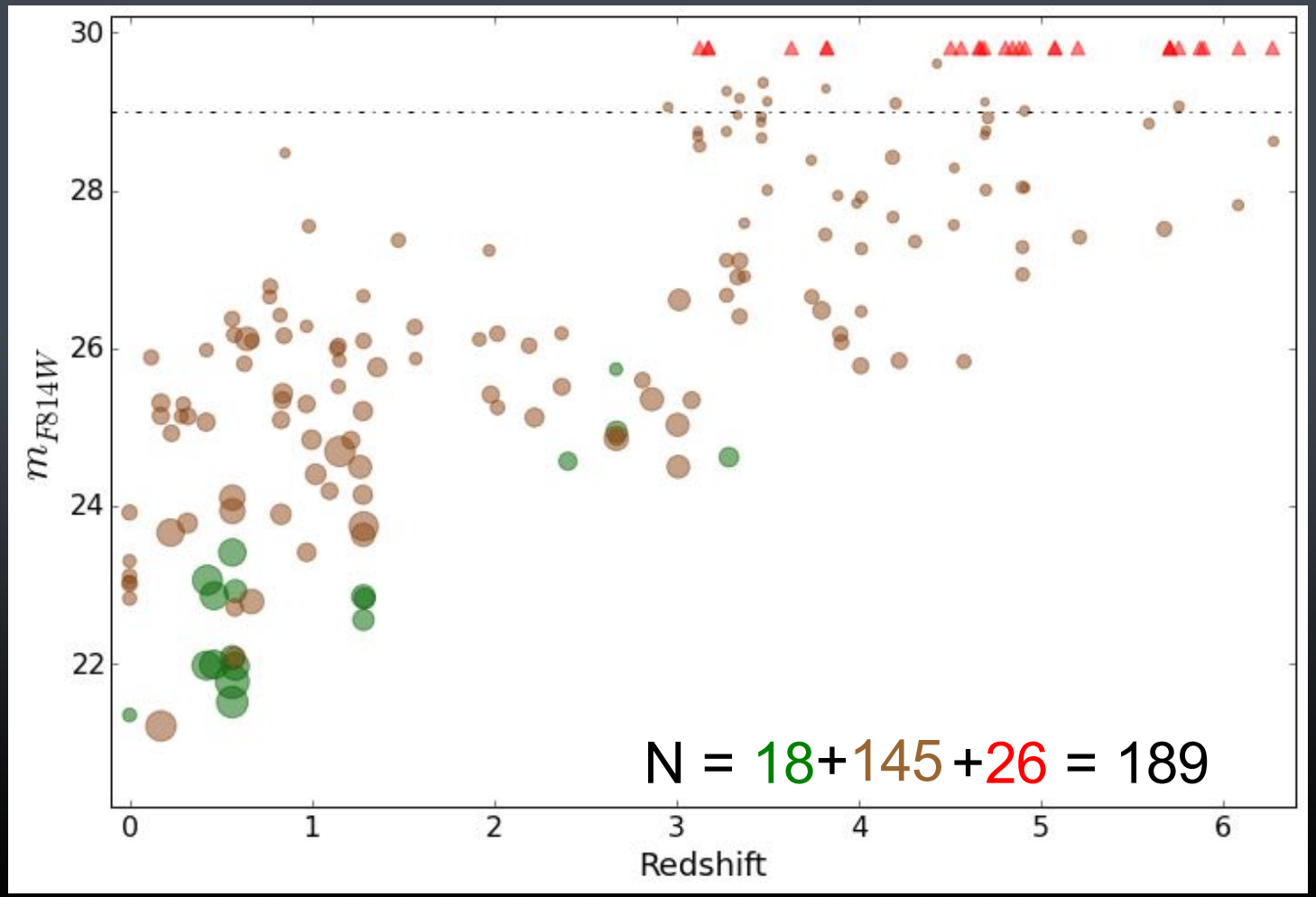
Z = 5.08
I_{814} > 29.8

- ✓ H
- ✓ 1 …bic F…
- ✓ 1 …in M…
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ 63 Lyα emitters
- ✓ **26 Lyα emitters without HST counterpart**
  - ✓ Z = [3.12 – 6.27]
  - ✓ I_{814} > 29.8

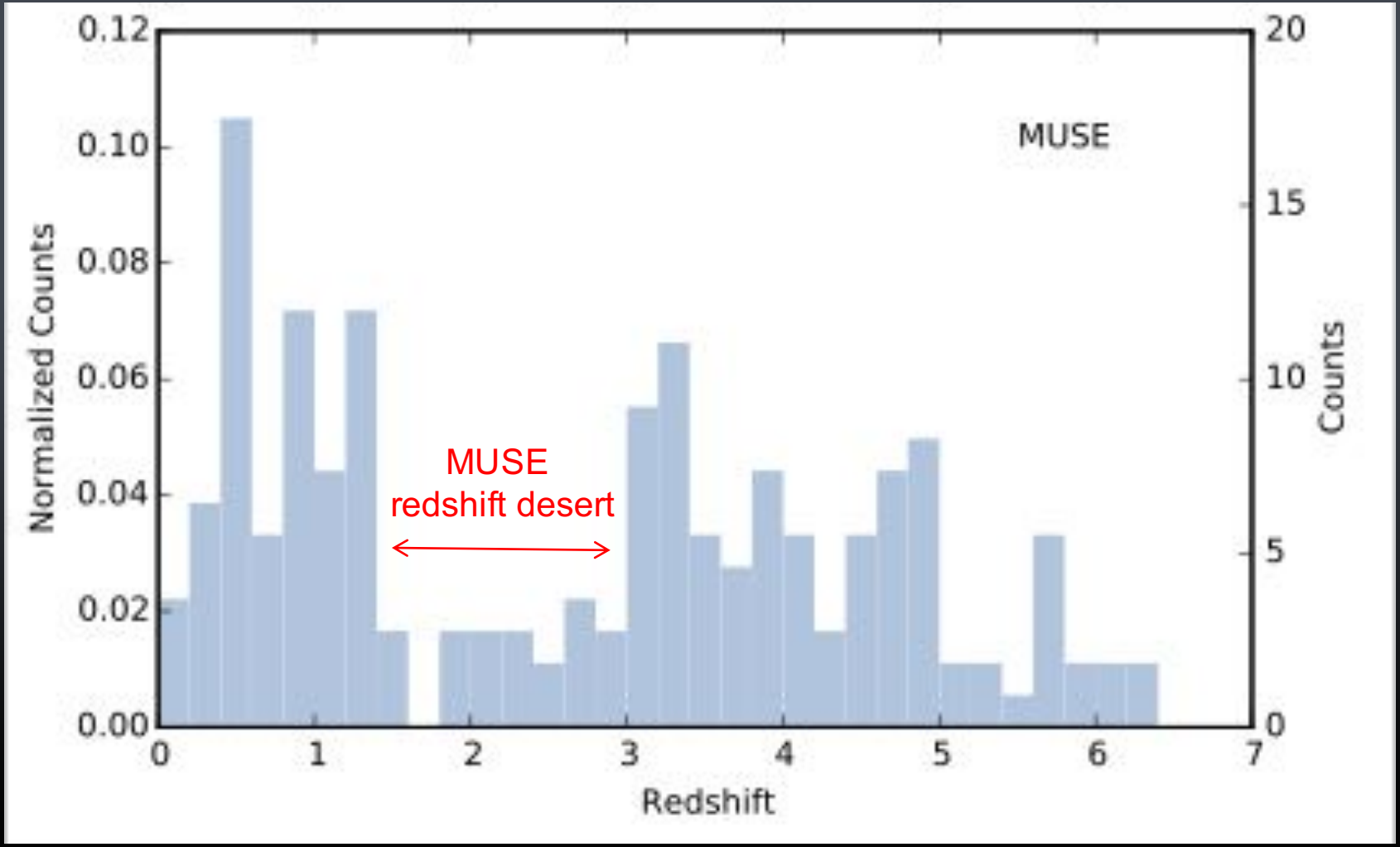


ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich

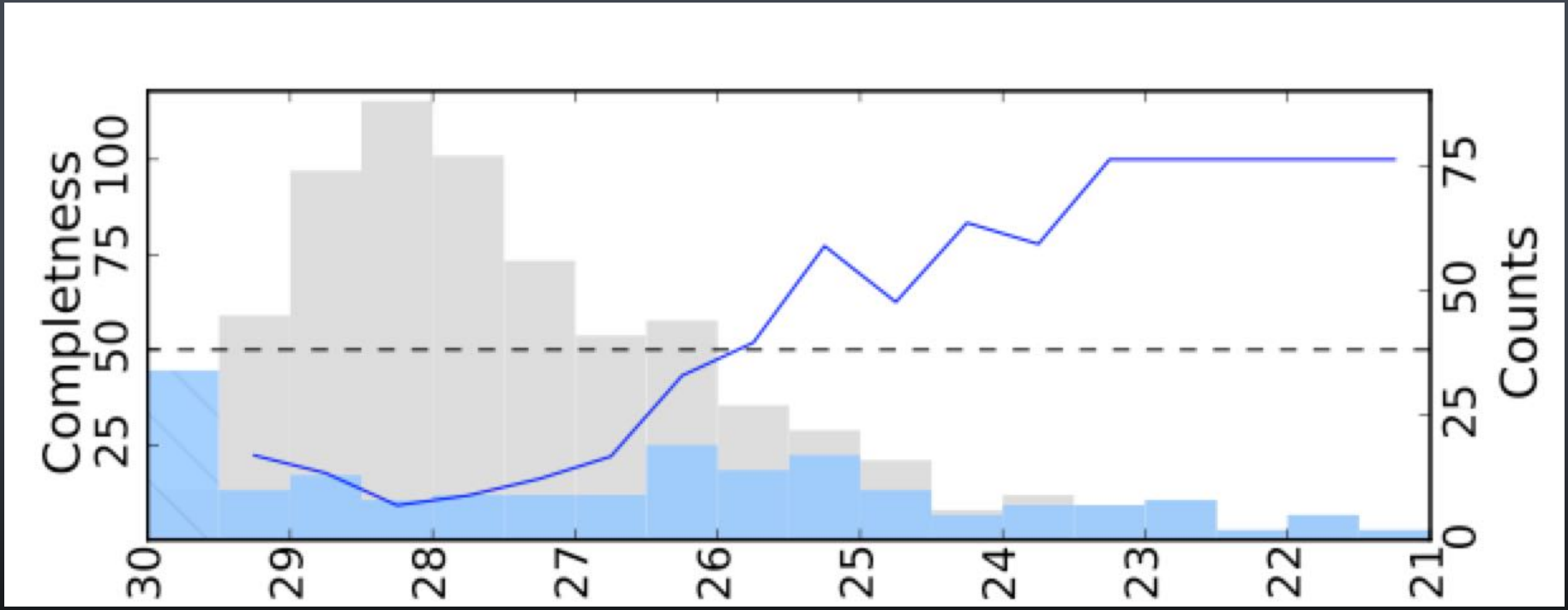
Redshift distribution



Redshift distribution

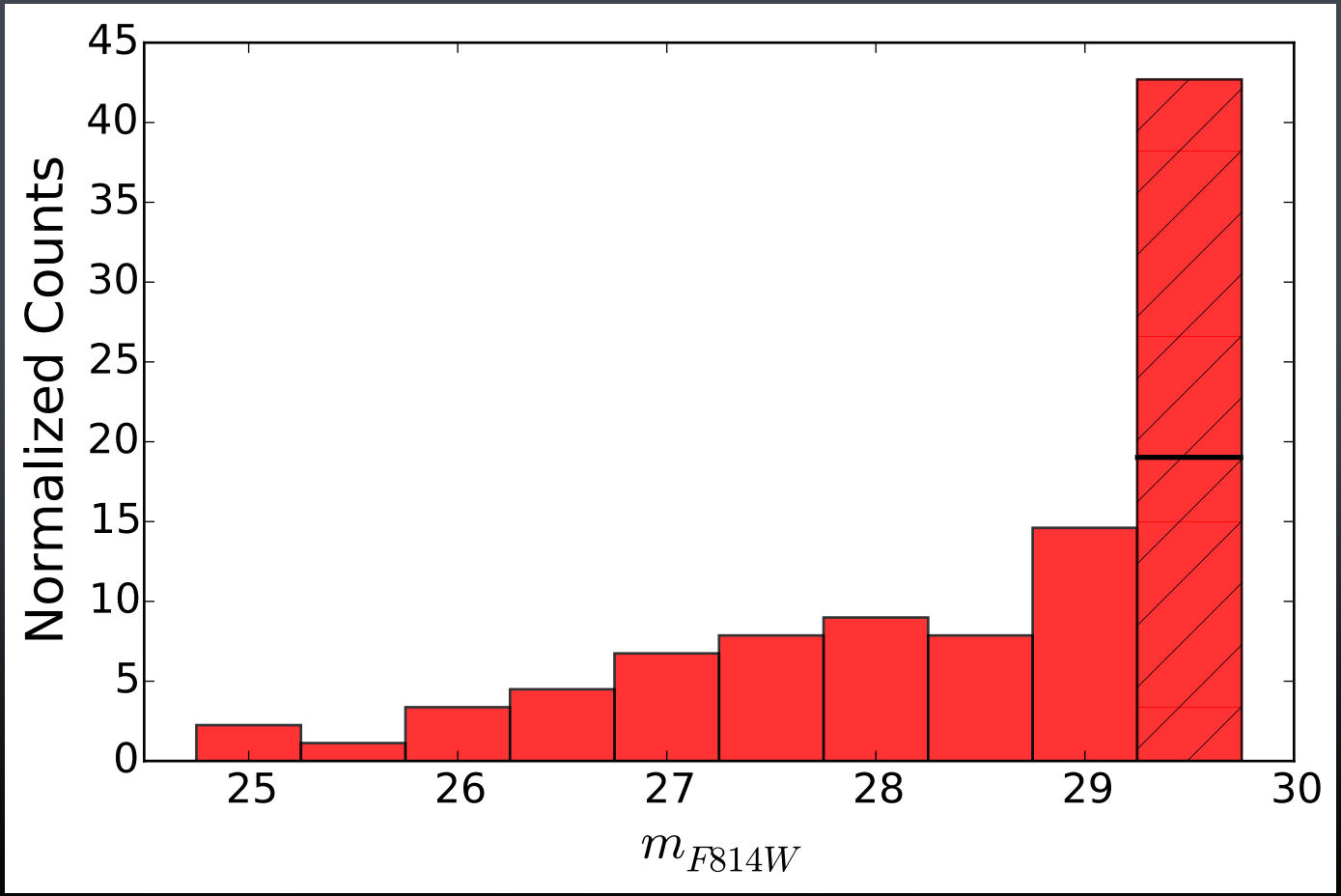


Redshift distribution



With decent completion down to 26th magnitude but still significant numbers at m_{F814} ~ 29.

Lyα distribution with magnitude

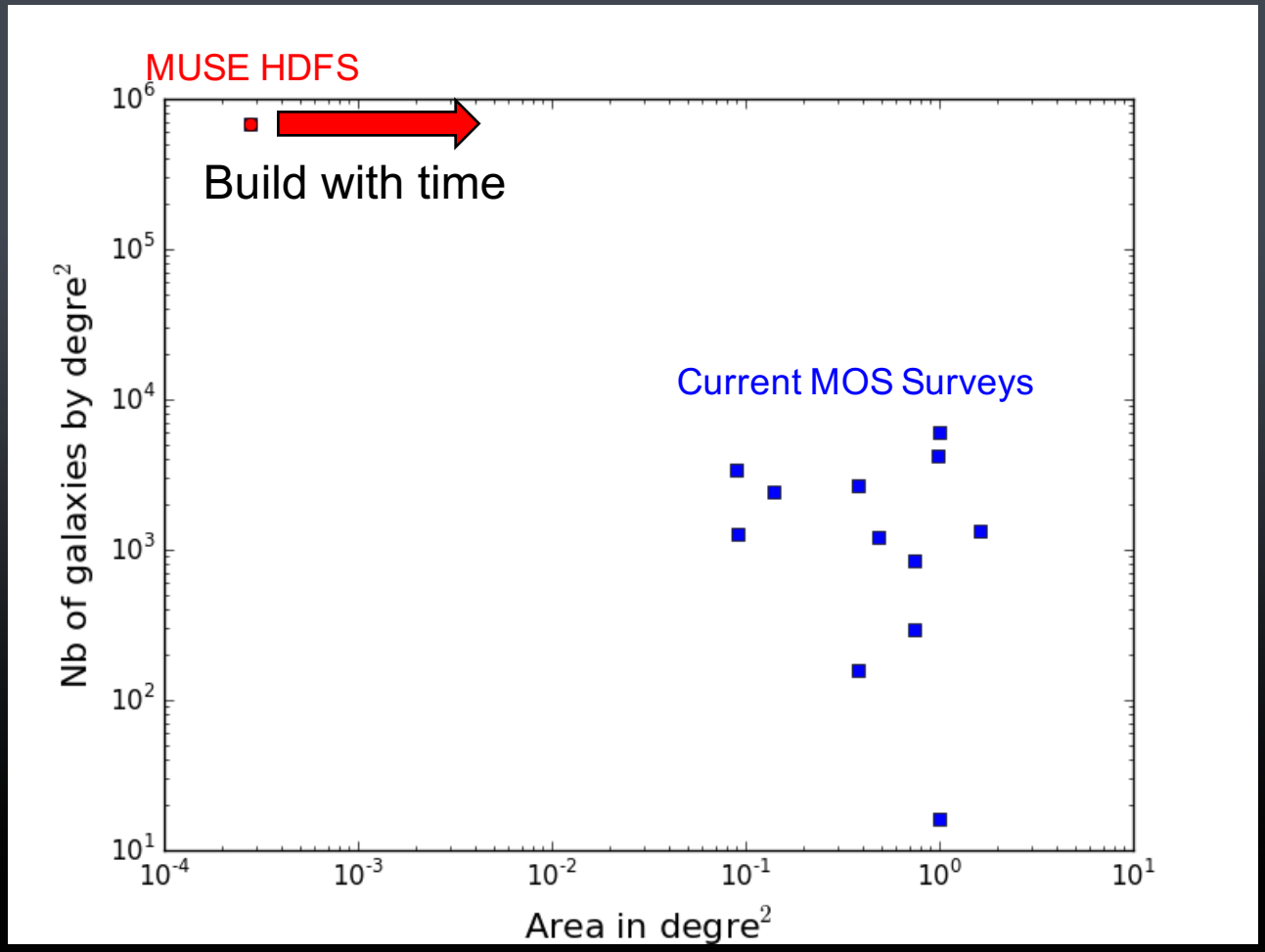


Groups

Table 2. Galaxy groups detected in the HDFS ordered by redshift.

z	v_{rms} km s^{-1}	r_{rms} kpc	N_m	Member IDs
0.172	65	43	3	1, 63, 70
0.421	262	54	4	6, 57, 101, 569
0.564	52	142	7	3, 4, 9, 23, 32, 135
0.578	424	150	5	5, 8, 11, 17, 122
0.972	56	201	3	24, 68, 129
1.284	354	92	9	10, 13, 15, 25, 27, 35, 64, 114, 160
2.672	101	87	4	50, 51, 55, 87
3.013	350	115	3	40, 56, 155
3.124	329	92	4	422, 437, 452, 558
3.278	36	144	4	162, 202, 449, 513
3.349	35	90	3	139, 200, 503
3.471	324	139	4	433, 469, 478, 520
3.823	161	93	4	238, 514, 563, 581
4.017	113	181	4	89, 144, 216, 308
4.699	430	109	6	325, 441, 453, 474, 499, 548
4.909	370	164	6	186, 218, 334, 338, 484, 583
5.710	26	101	3	546, 547, 574

MUSE and MOS surveys



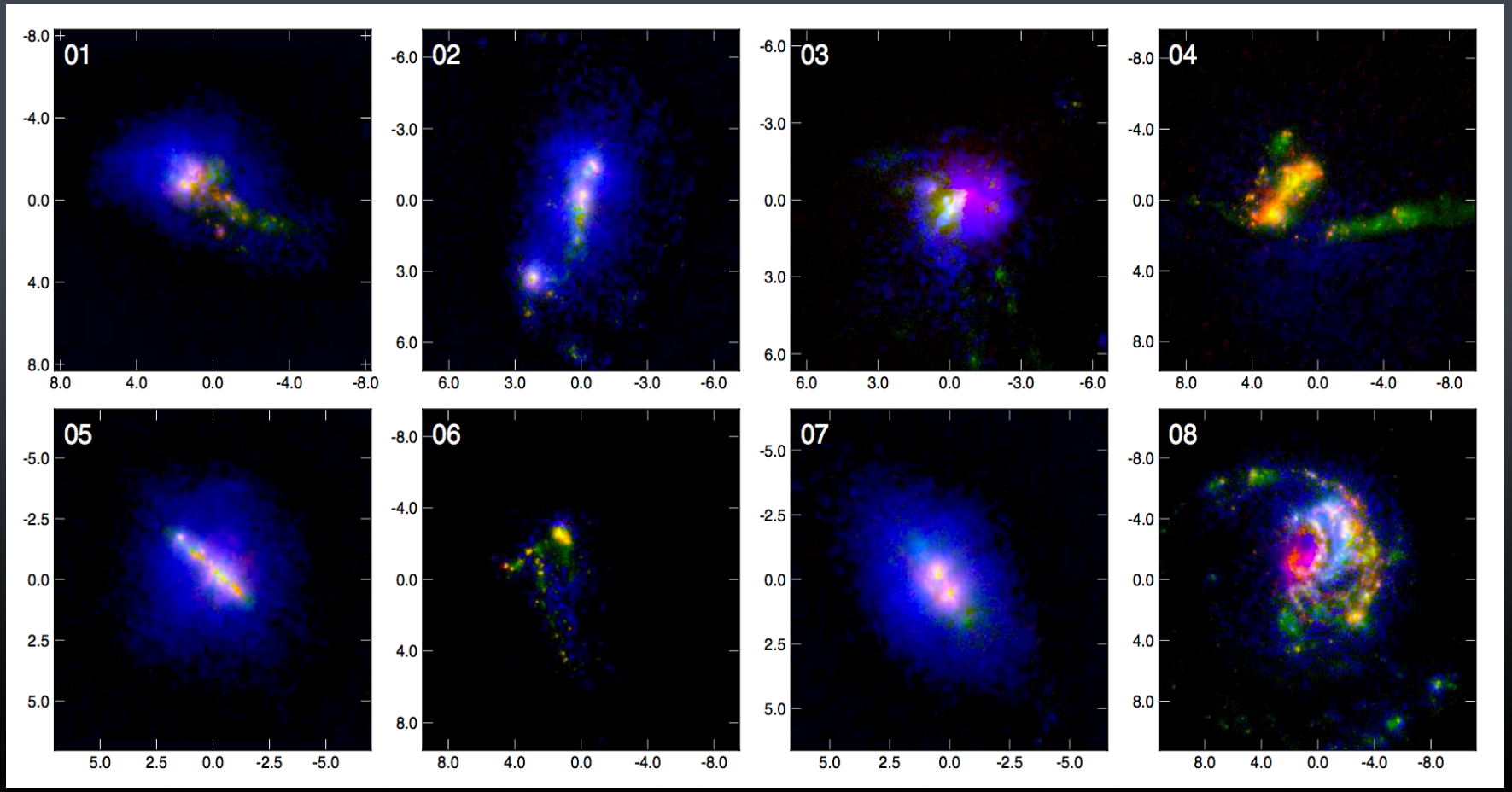
Astronomy & Astrophysics manuscript no. LAE-ext
September 18, 2015

Extended Lyman α haloes around individual high-redshift galaxies revealed by MUSE

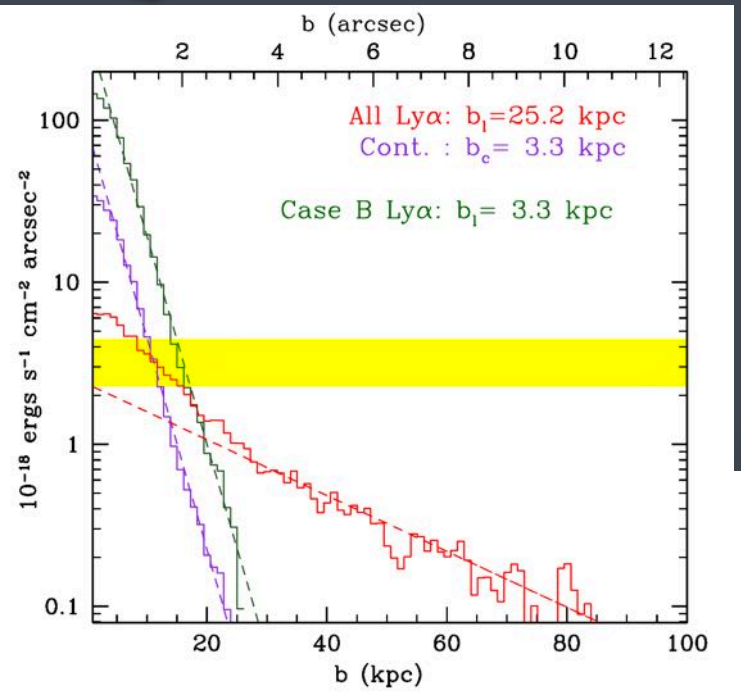
L. Wisotzki[1], R. Bacon[2], J. Blaizot[2], J. Brinchmann[3,4], E. C. Herenz[1], J. Schaye[3], N. Bouché[5], S. Cantalupo[6], T. Contini[7,8], C. M. Carollo[6], J. Caruana[1], J.-B. Courbot[9,2], E. Emsellem[10,2], S. Kamann[11], J. Kerutt[1], F. Leclercq[2], S. J. Lilly[6], V. Patrício[2], C. Sandin[1], M. Steinmetz[1], L. A. Straka[3], T. Urrutia[1], A. Verhamme[2,12], P. M. Weilbacher[1], and M. Wendt[13,1]

Extended Lyα halos

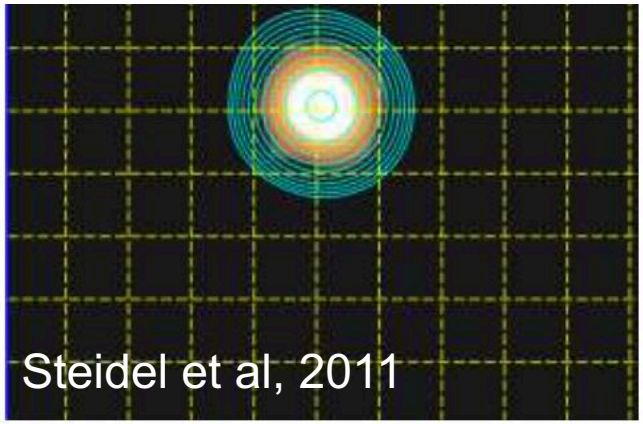
Ostlin et al 2009, LARS sample, Hayes et al, 2013



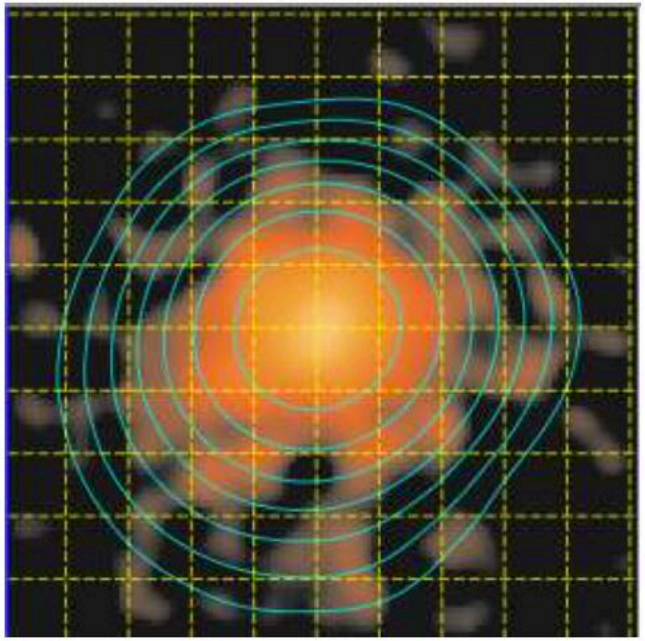
Extended Lyα halos



Matsuda et al, 2012: 2128 LAEs @ z=3
Feldmeier et al, 2013: 607 LBGs @ z=3
Momose et al, 2014: 3600 LAEs @ z=2.2-6.7



Steidel et al, 2011



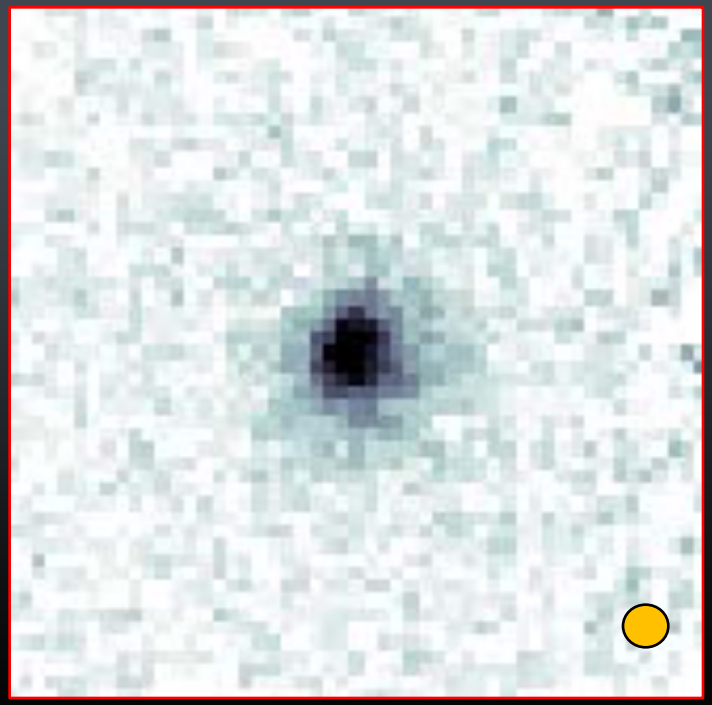
Extended Lyα halos at z = 3-6

HST WFPC2 F814W

ID#43, m814 = 24.7

MUSE Lyα NB

z = 3.29

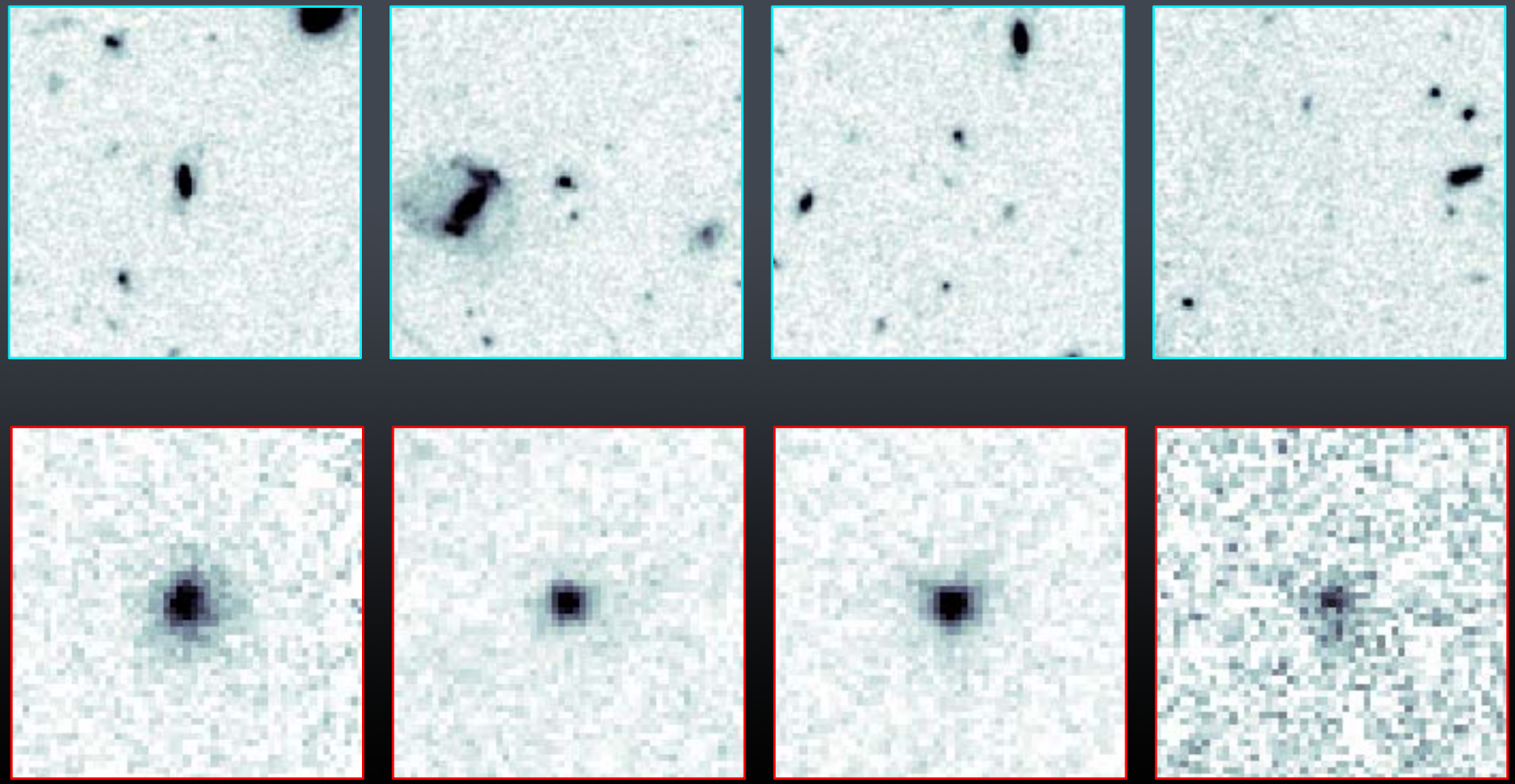


Extended Lyα halo revealed around an individual galaxy at z>3

The sample

- 89 Lyα emitters
  - Exclude field edges
  - Isolated (no pairs at same redshift)
  - Blended with other emission line objects [OII]
  - Exclude AGN
  - Cut in Lyα Flux to have S/N>3 on 3” aperture

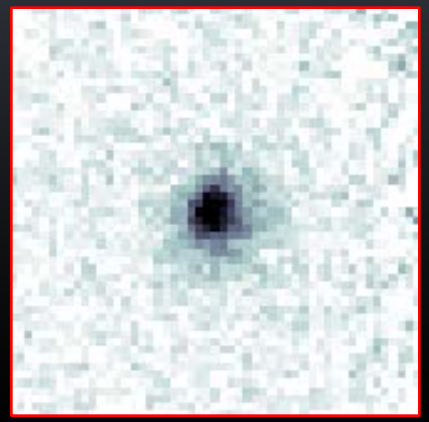
  - Result in a sample of 26 Lyα emitters


ID#43, m814 = 24.7
ID#112, m814 = 26.1
ID#325, m814 = 27.9
ID#558, m814 > 29
HST WFPC2 F814W
MUSE Lyα NB
z = 3.29
z = 3.91
z = 4.7
z = 3.13

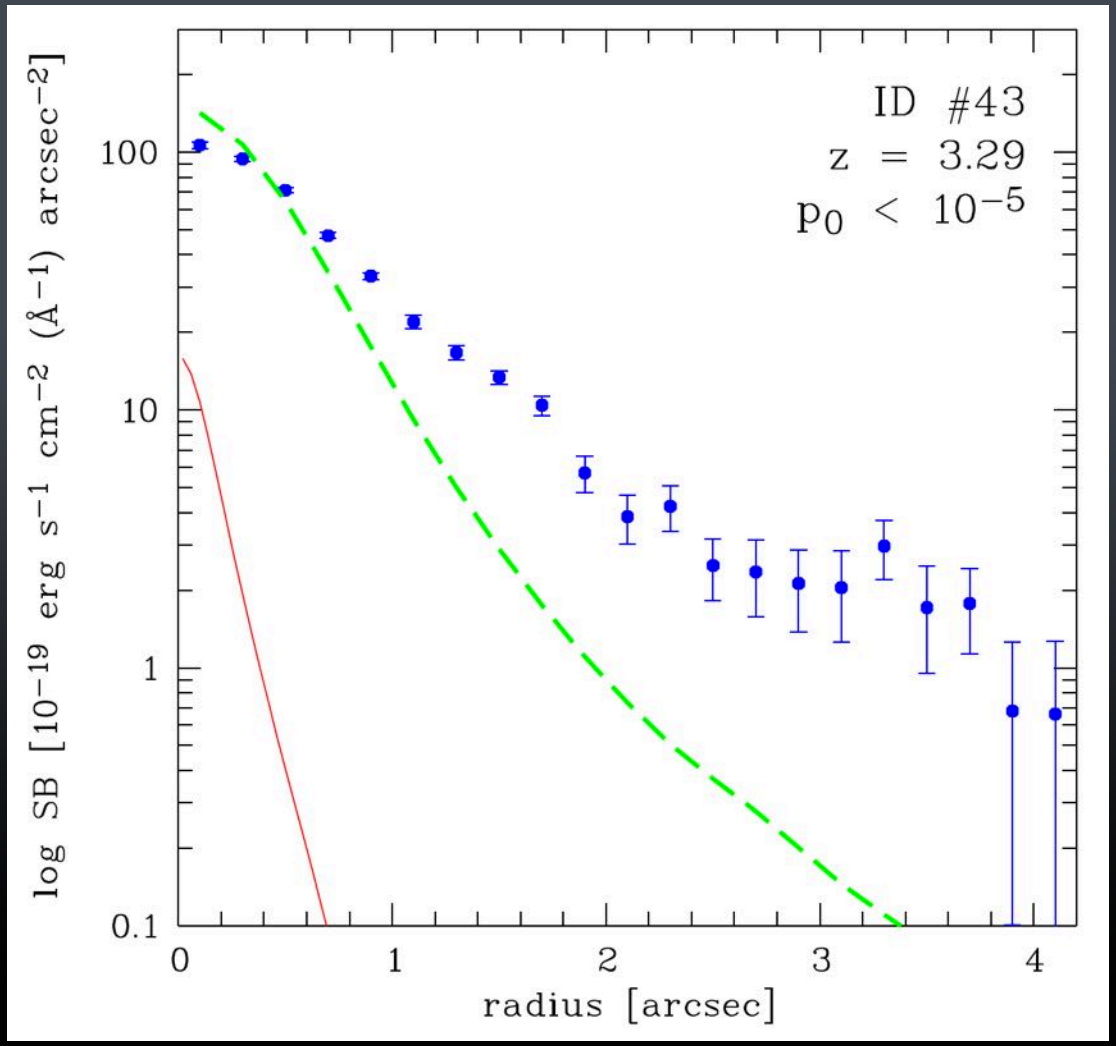
ID#43, m814 = 24.7

HST WFPC2 F814W

MUSE Lyα NB



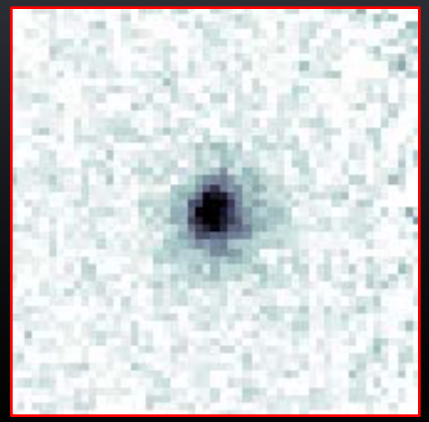
z = 3.29



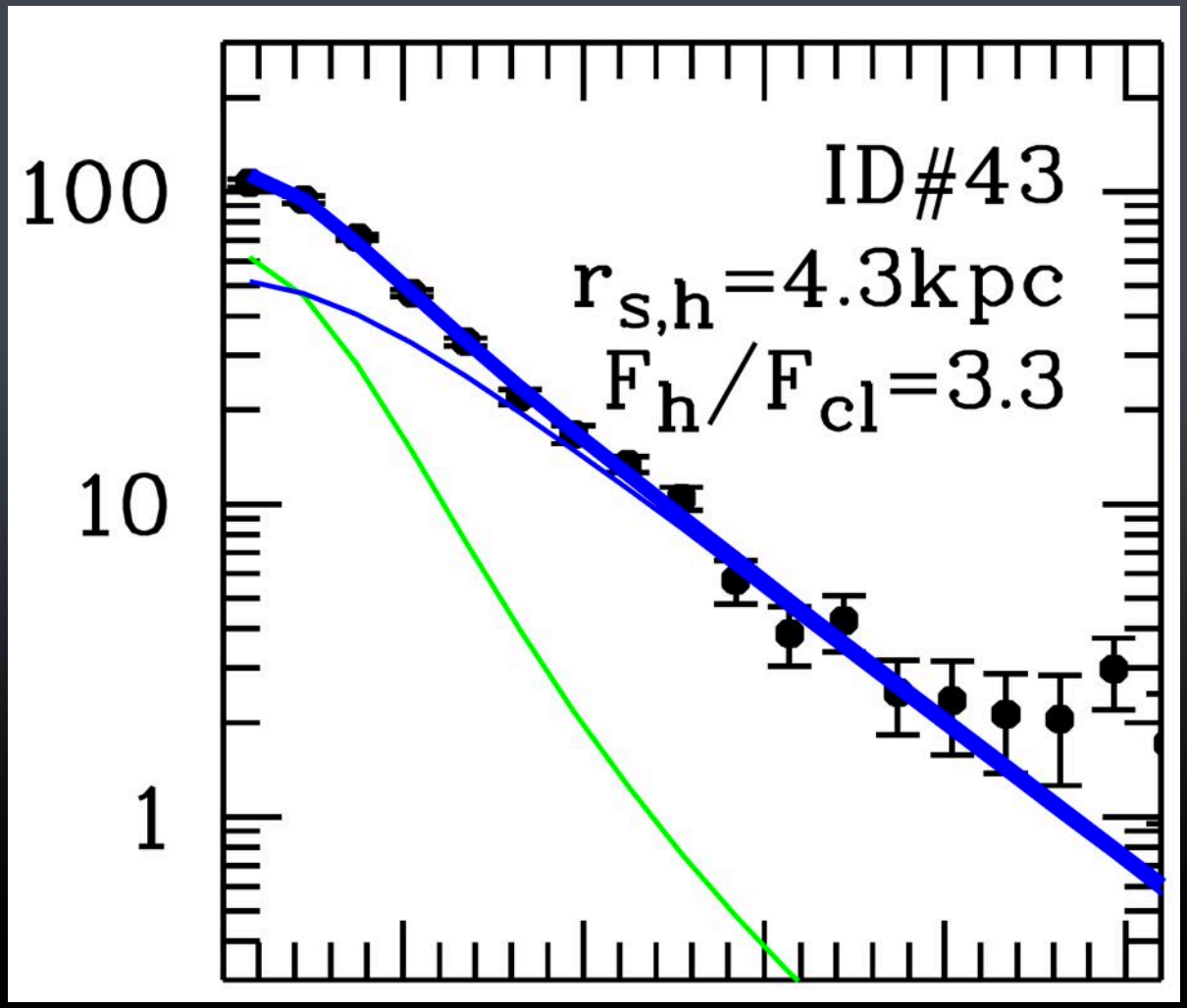
ID#43, m814 = 24.7

HST WFPC2 F814W

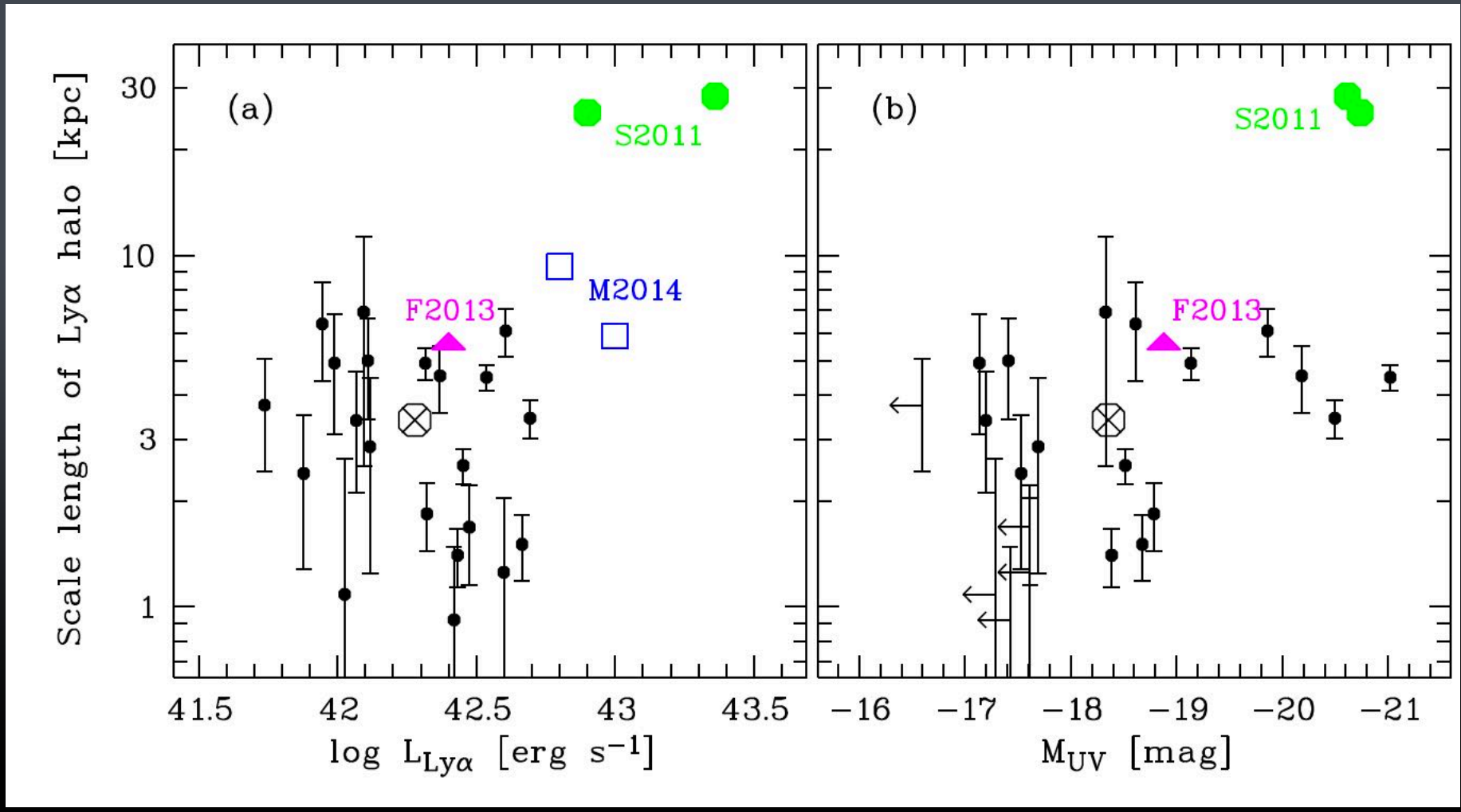
MUSE Lyα NB

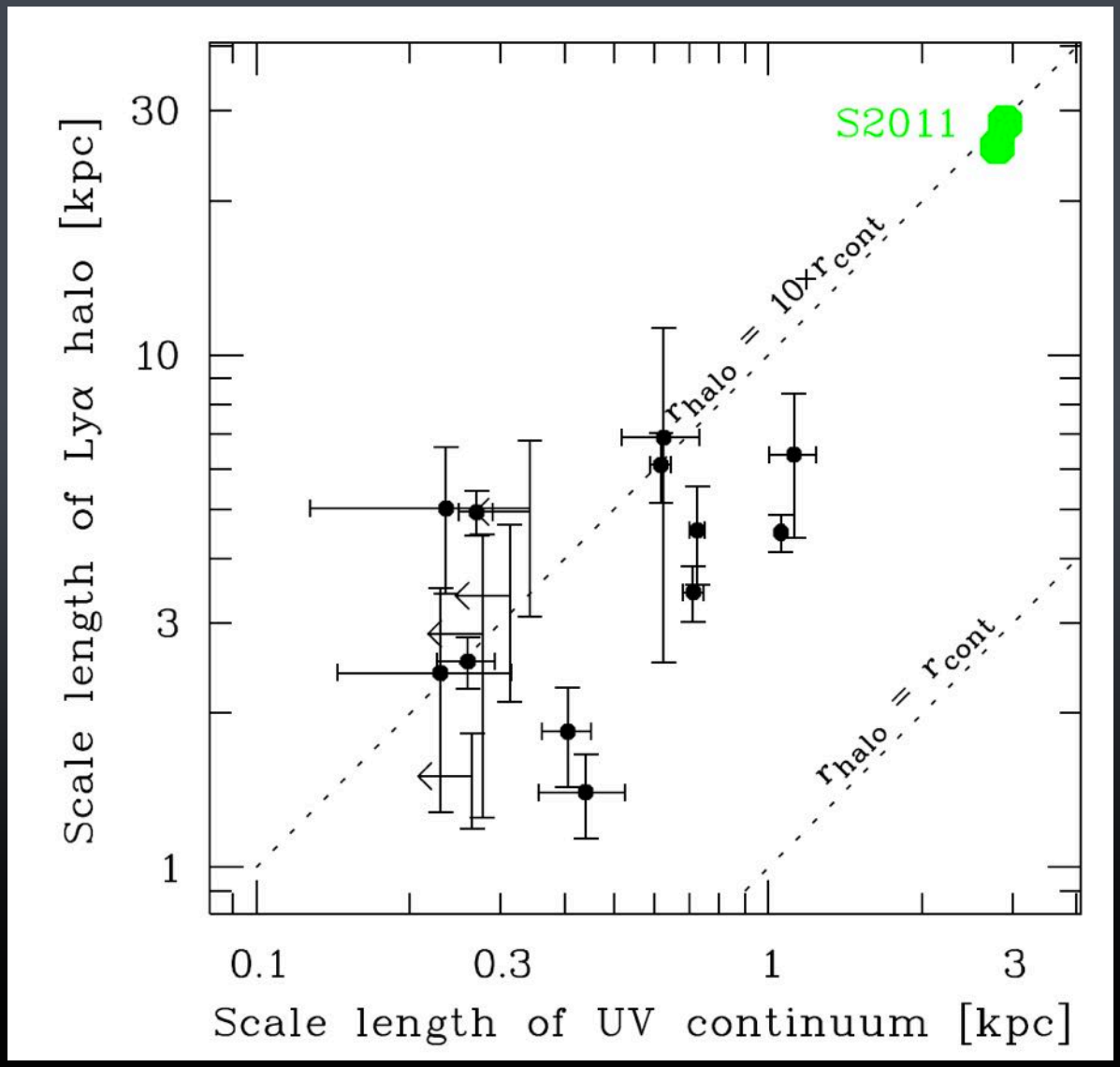


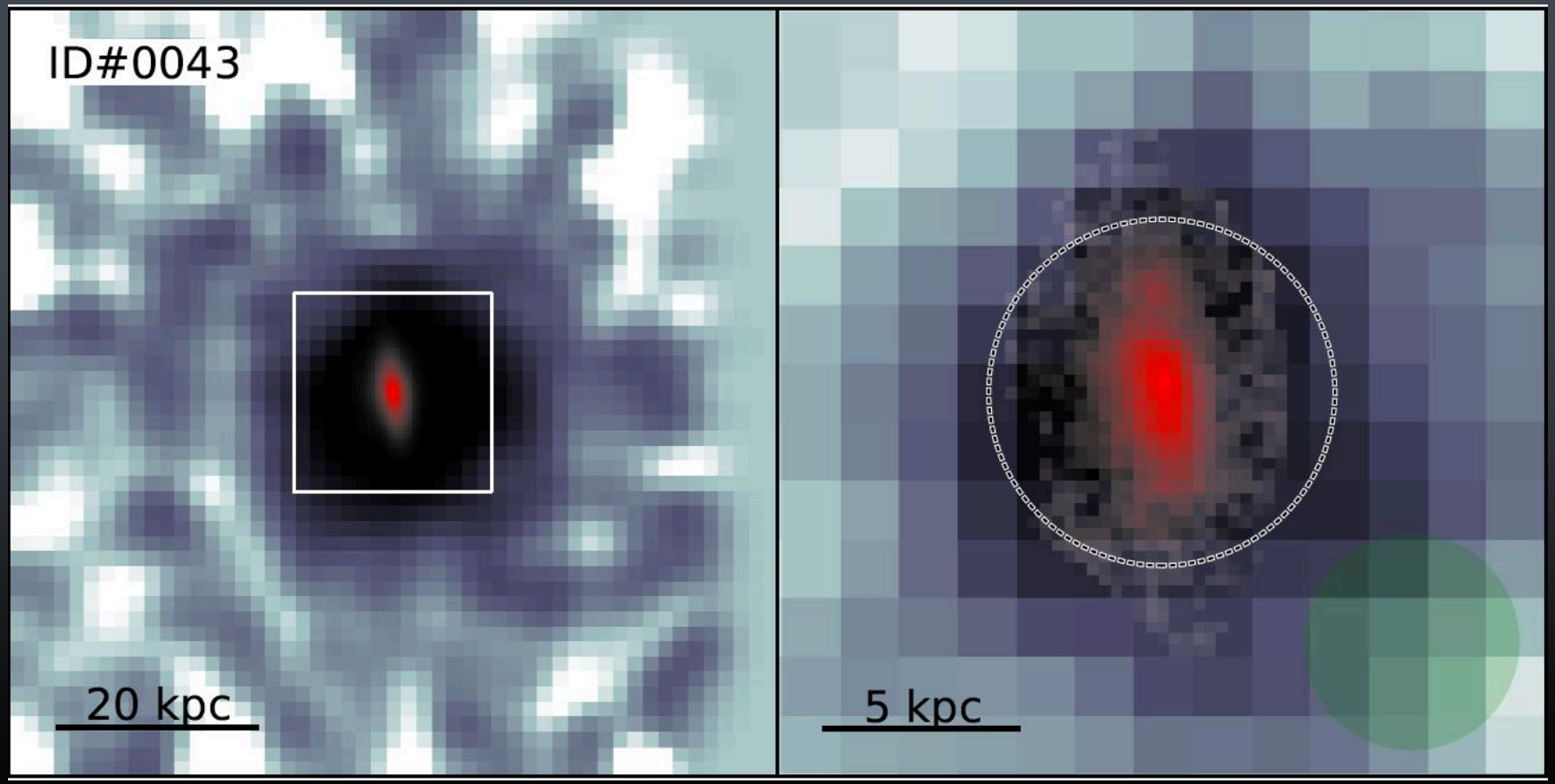
z = 3.29

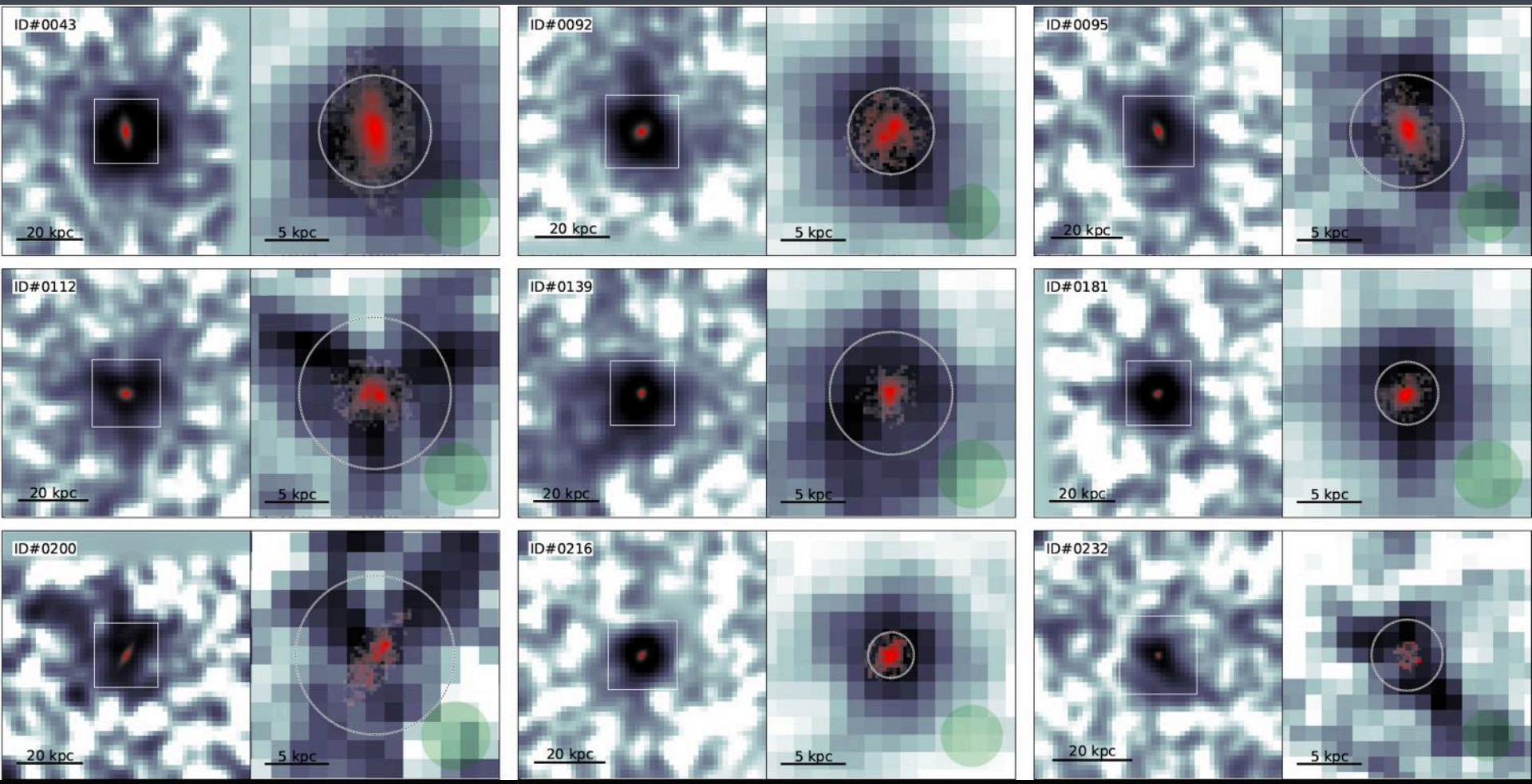


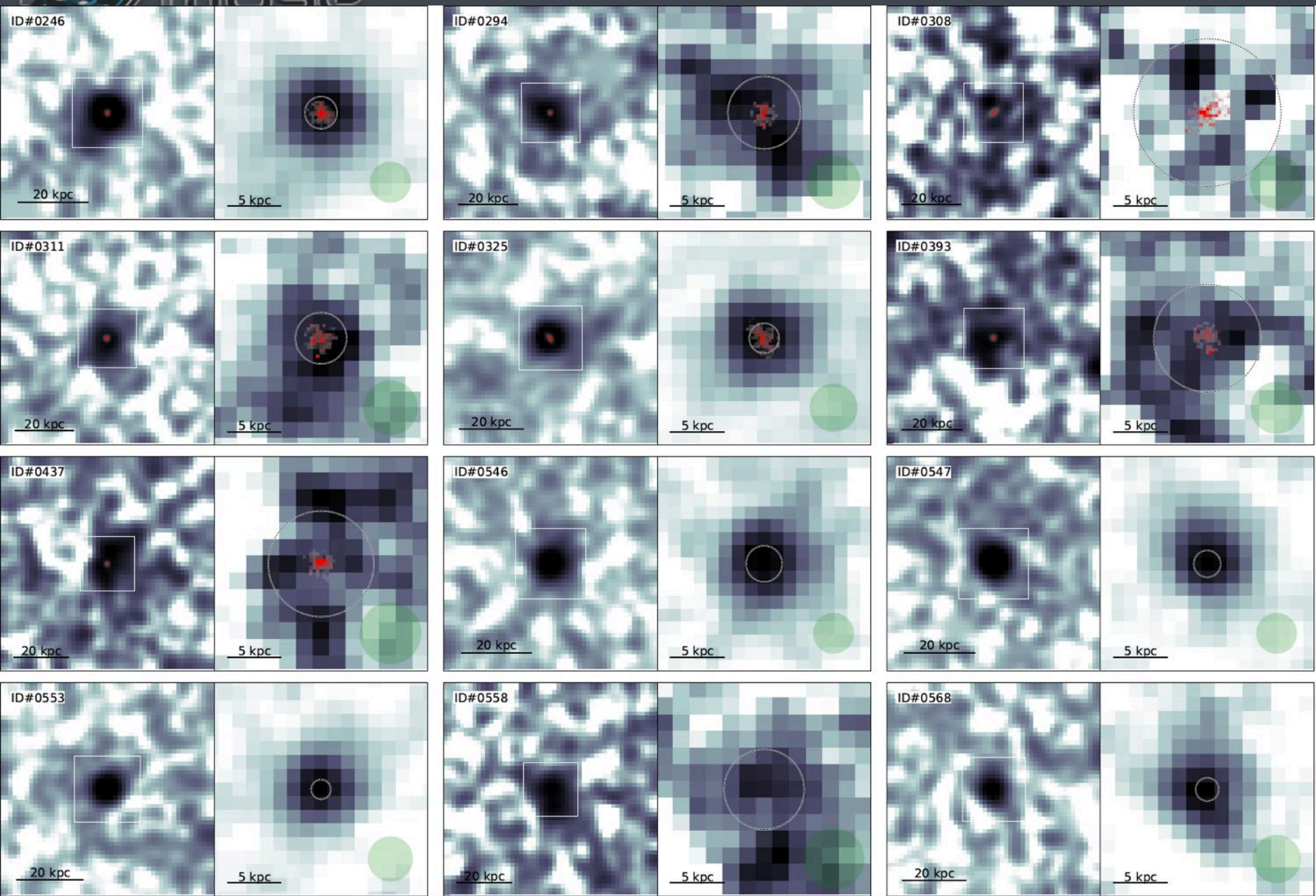
Steidel 2011, Feldmeier 2013, Matusma 2014




S2011
$r_{halo} = 10 \times r_{cont}$
$r_{halo} = r_{cont}$
Scale length of Lyα halo [kpc]
30
10
3
1
0.1
0.3
1
3
Scale length of UV continuum [kpc]


ID#0043
20 kpc
5 kpc


ID#0043
20 kpc
5 kpc
ID#0092
20 kpc
5 kpc
ID#0095
20 kpc
5 kpc
ID#0112
20 kpc
5 kpc
ID#0139
20 kpc
5 kpc
ID#0181
20 kpc
5 kpc
ID#0200
20 kpc
5 kpc
ID#0216
20 kpc
5 kpc
ID#0232
20 kpc
5 kpc


ID#0246
20 kpc
5 kpc
ID#0294
20 kpc
5 kpc
ID#0308
20 kpc
5 kpc
ID#0311
20 kpc
5 kpc
ID#0325
20 kpc
5 kpc
ID#0393
20 kpc
5 kpc
ID#0437
20 kpc
5 kpc
ID#0546
20 kpc
5 kpc
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5 kpc
ID#0553
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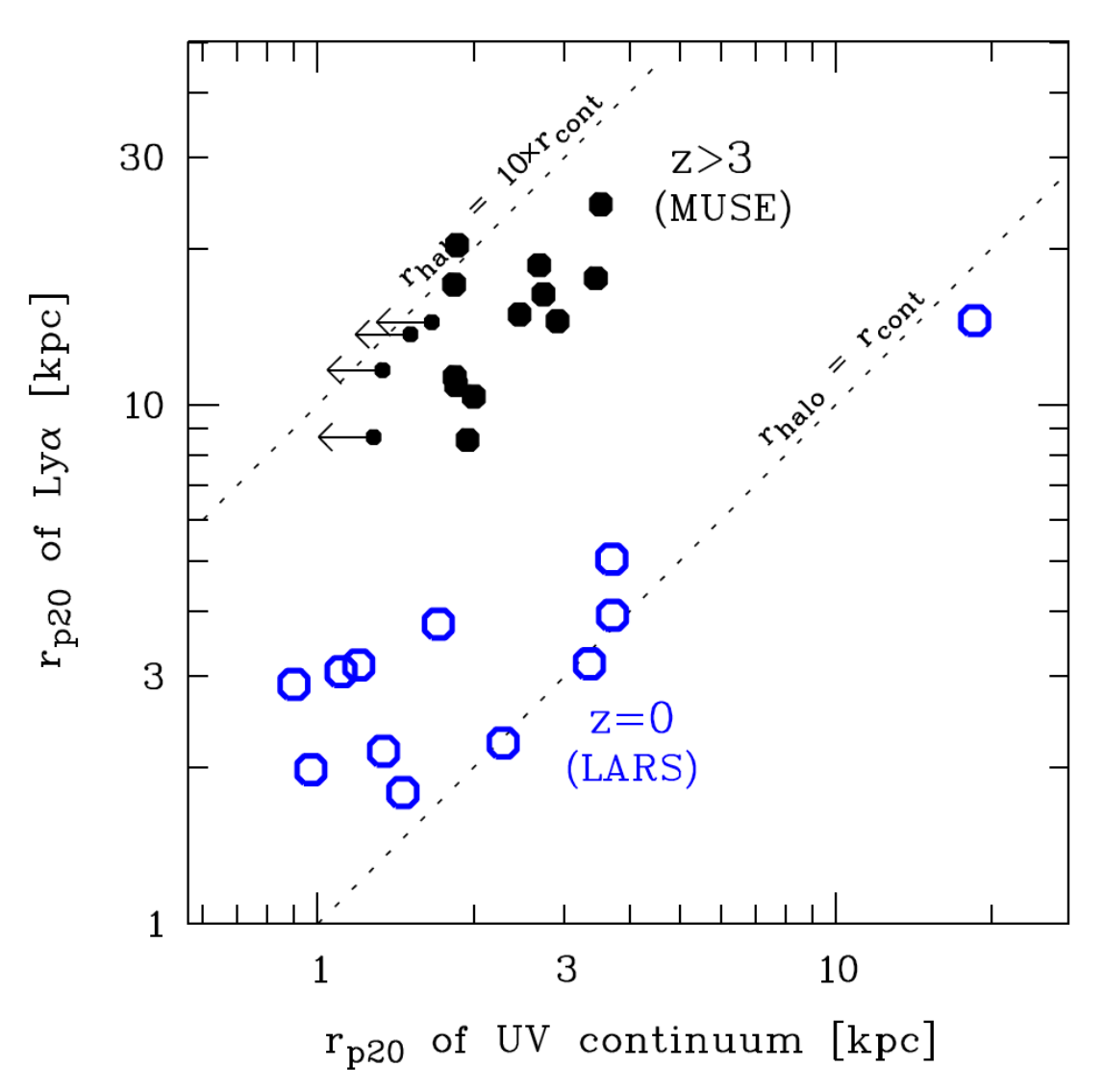
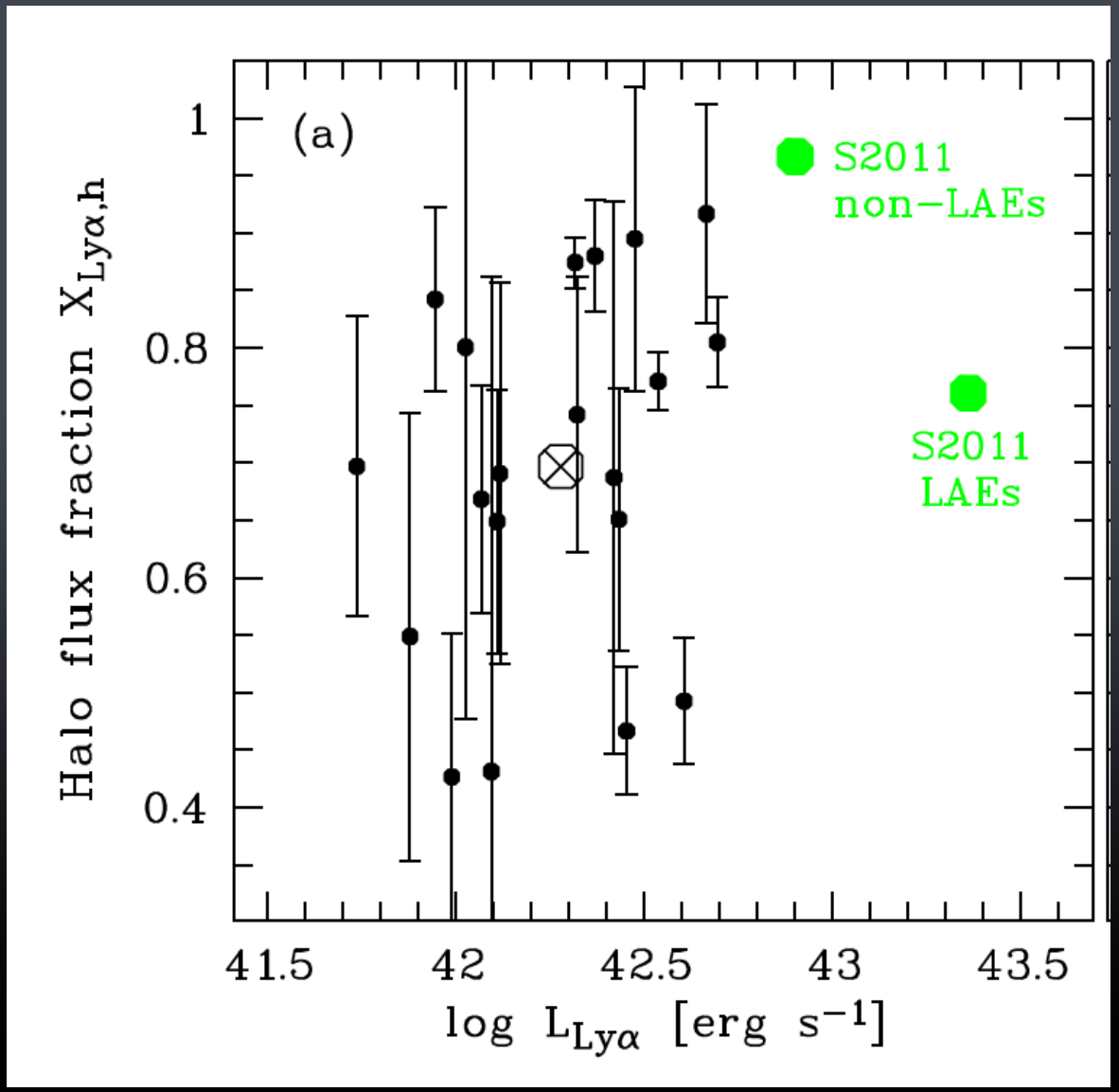
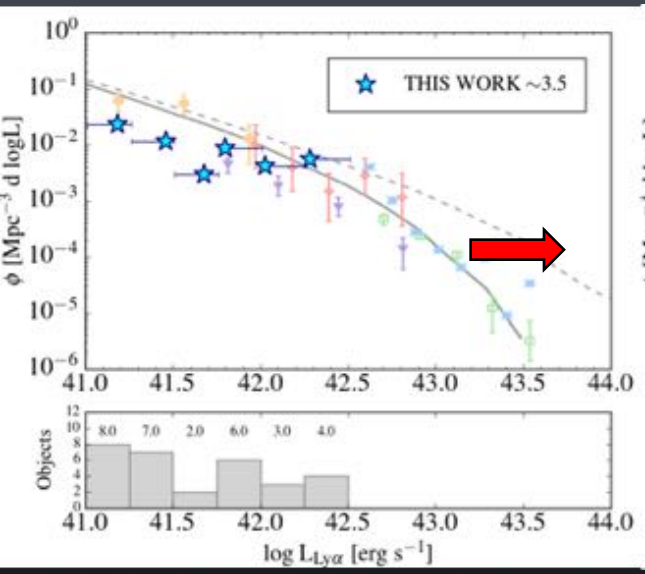
5 kpc
ID#0558
20 kpc
5 kpc
ID#0568
20 kpc
5 kpc

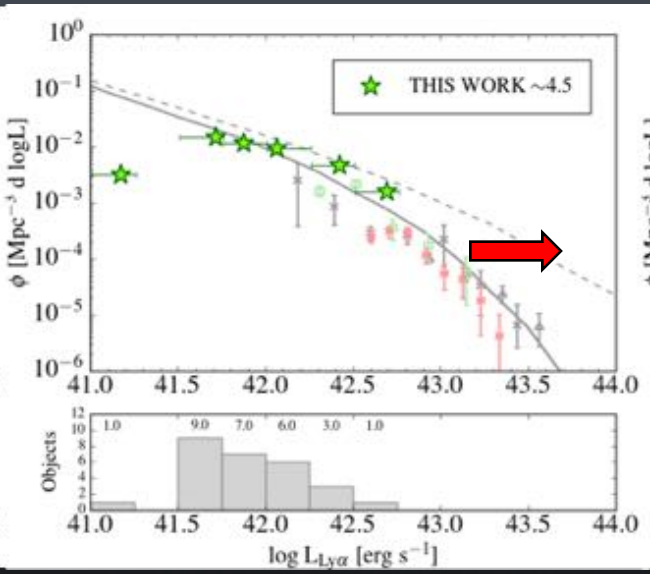

30
10
3
1
1
3
10
r_{p20} of Lyα [kpc]
r_{p20} of UV continuum [kpc]
$r_{halo} = 10 \times r_{cont}$
$r_{halo} = r_{cont}$
z>3
(MUSE)
z=0
(LARS)

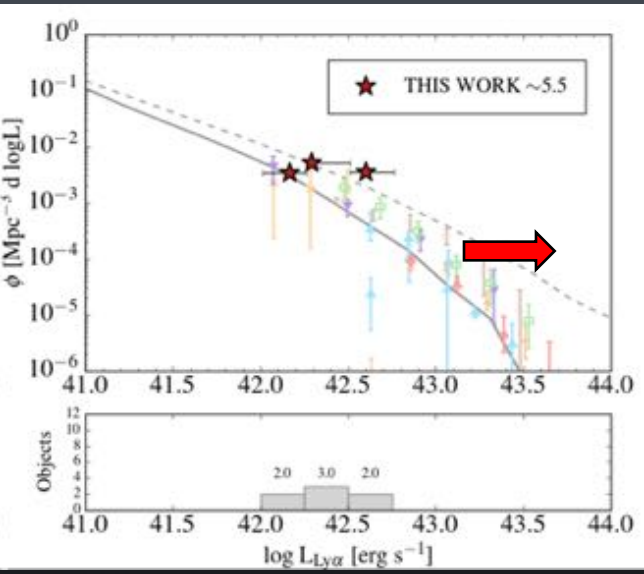

(a)
S2011
non−LAEs
S2011
LAEs
Halo flux fraction $X_{Ly\alpha,h}$
1
0.8
0.6
0.4
41.5
42
42.5
43
43.5
log $L_{Ly\alpha}$ [erg s^{-1}]

Impact: The Faint End of the Lyα LF

Drake et al, in preparation







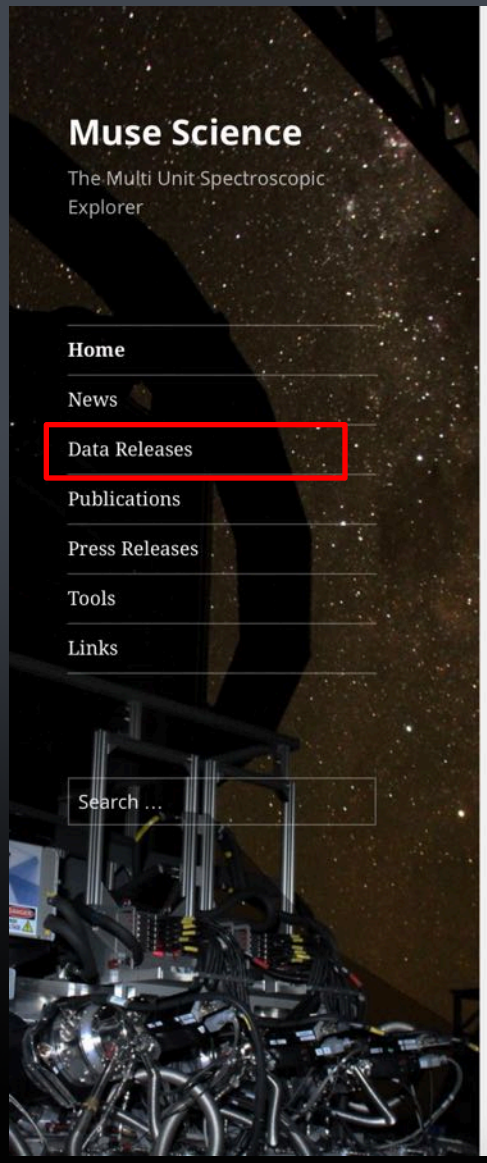
30 objects

27 objects

7 object

ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich

http://muse-vlt.eu/science

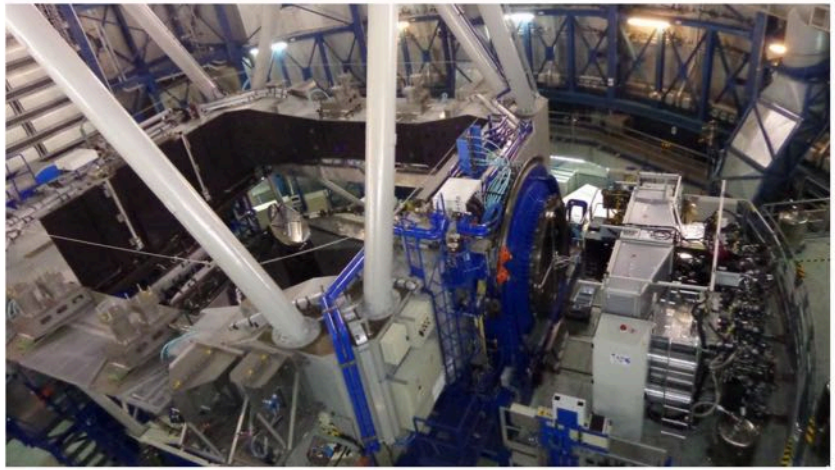


Welcome to the MUSE Science Web Service

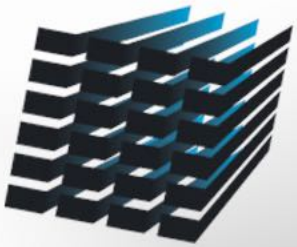
muse
multi unit spectroscopic explorer

Latest News 2015-02-26: Grand new opening of the Muse science web service.

The **Multi Unit Spectroscopic Explorer (MUSE)** is a second generation instrument installed on the Nasmyth focus of UT4 at the Very Large Telescope (VLT) of the European Southern Observatory (ESO).



It is a panoramic integral-field spectrograph operating in the visible



muse

multi unit spectroscopic explorer

Historical Context

The MUSE Instrument

Commissioning results

Hubble Deep Field South

Gravitational Lensing Clusters

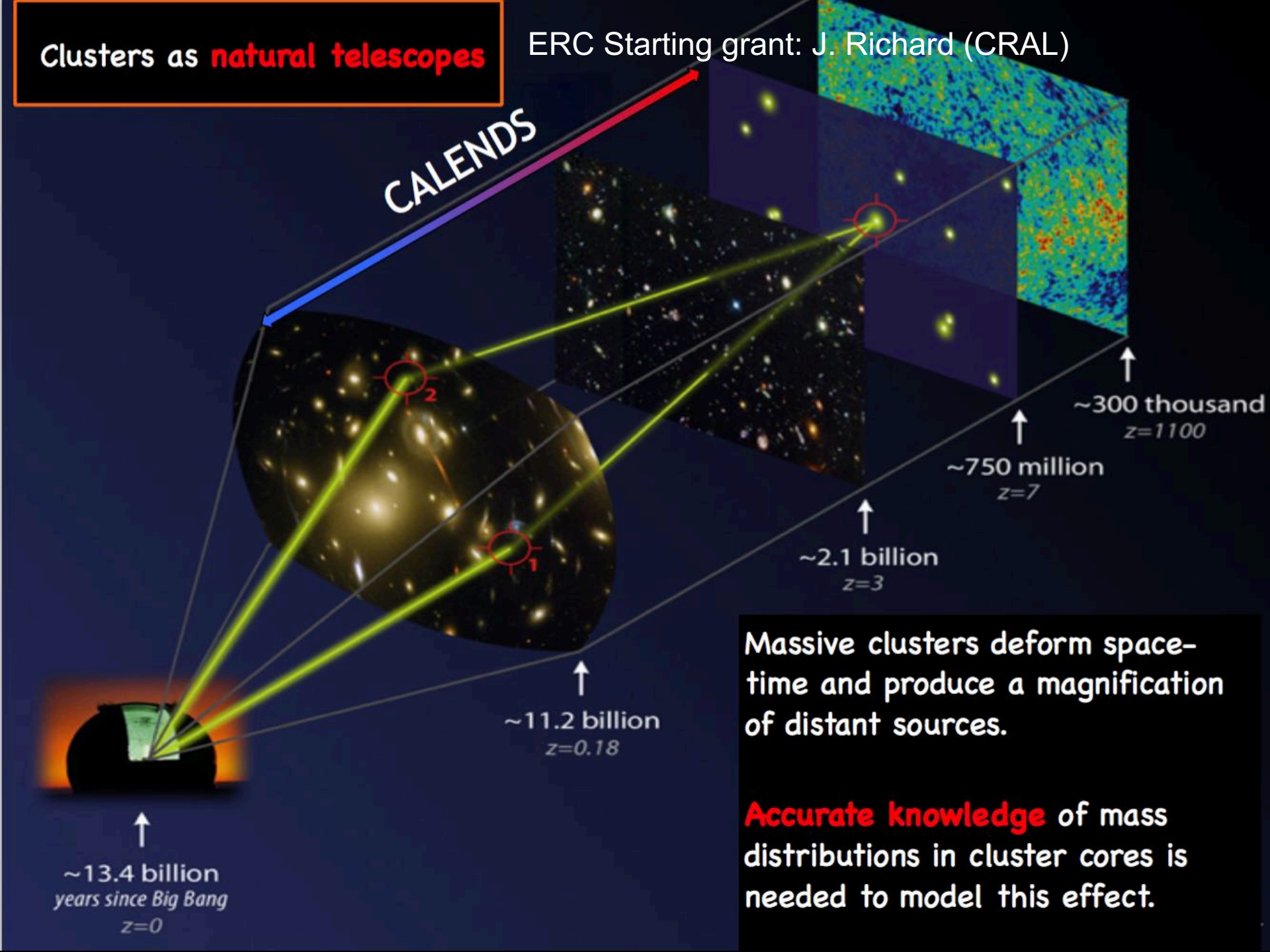
Conclusions & what's next

LPNHE

19 November 2015

Clusters as natural telescopes

ERC Starting grant: J. Richard (CRAL)

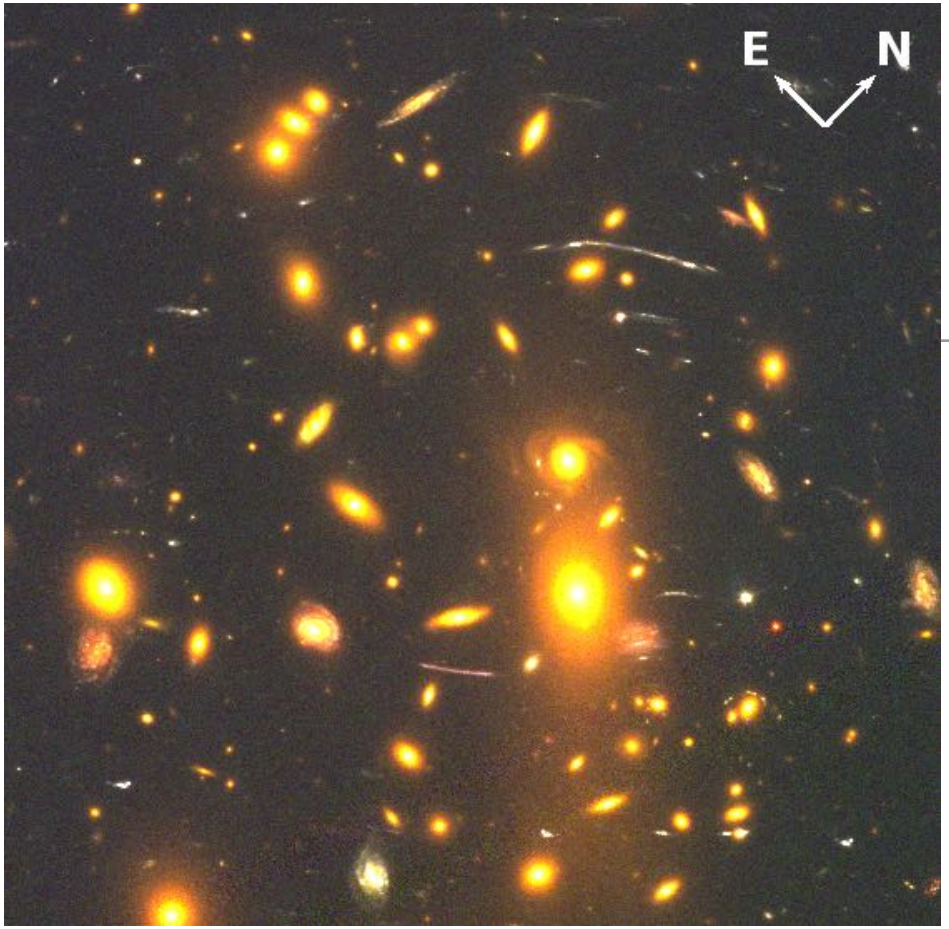


Massive clusters deform space-time and produce a magnification of distant sources.

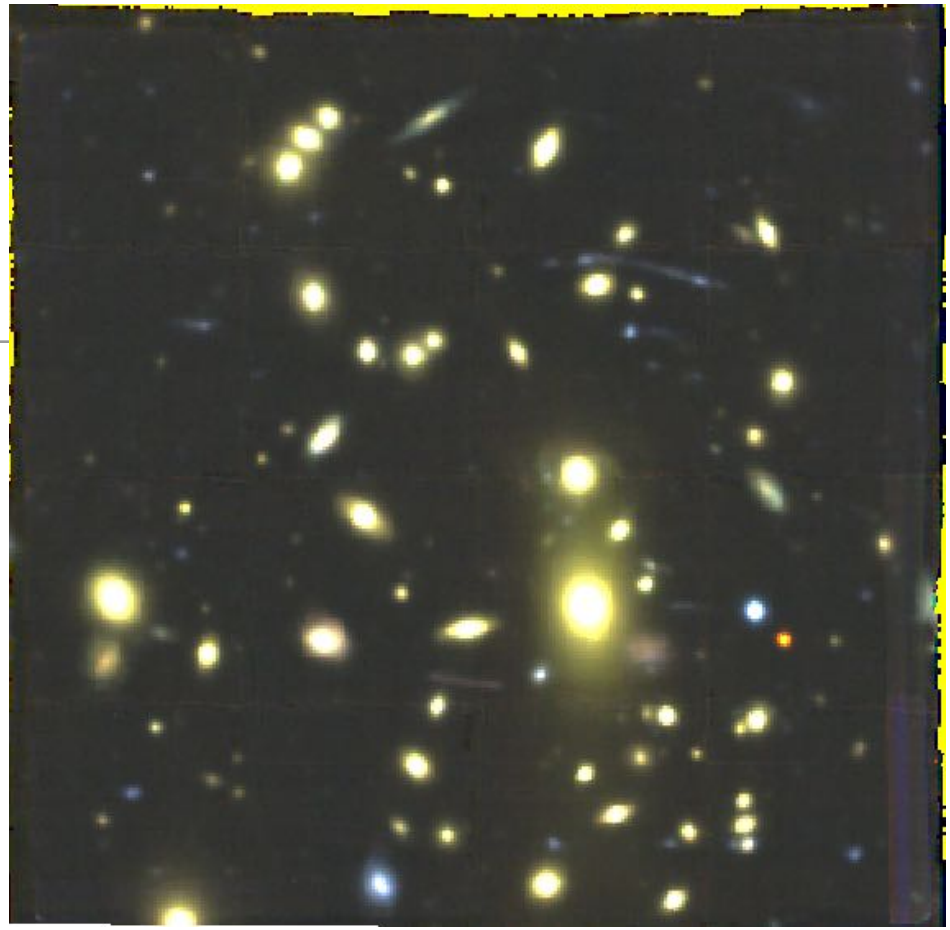
Accurate knowledge of mass distributions in cluster cores is needed to model this effect.

MUSE GTO program : MACS0416

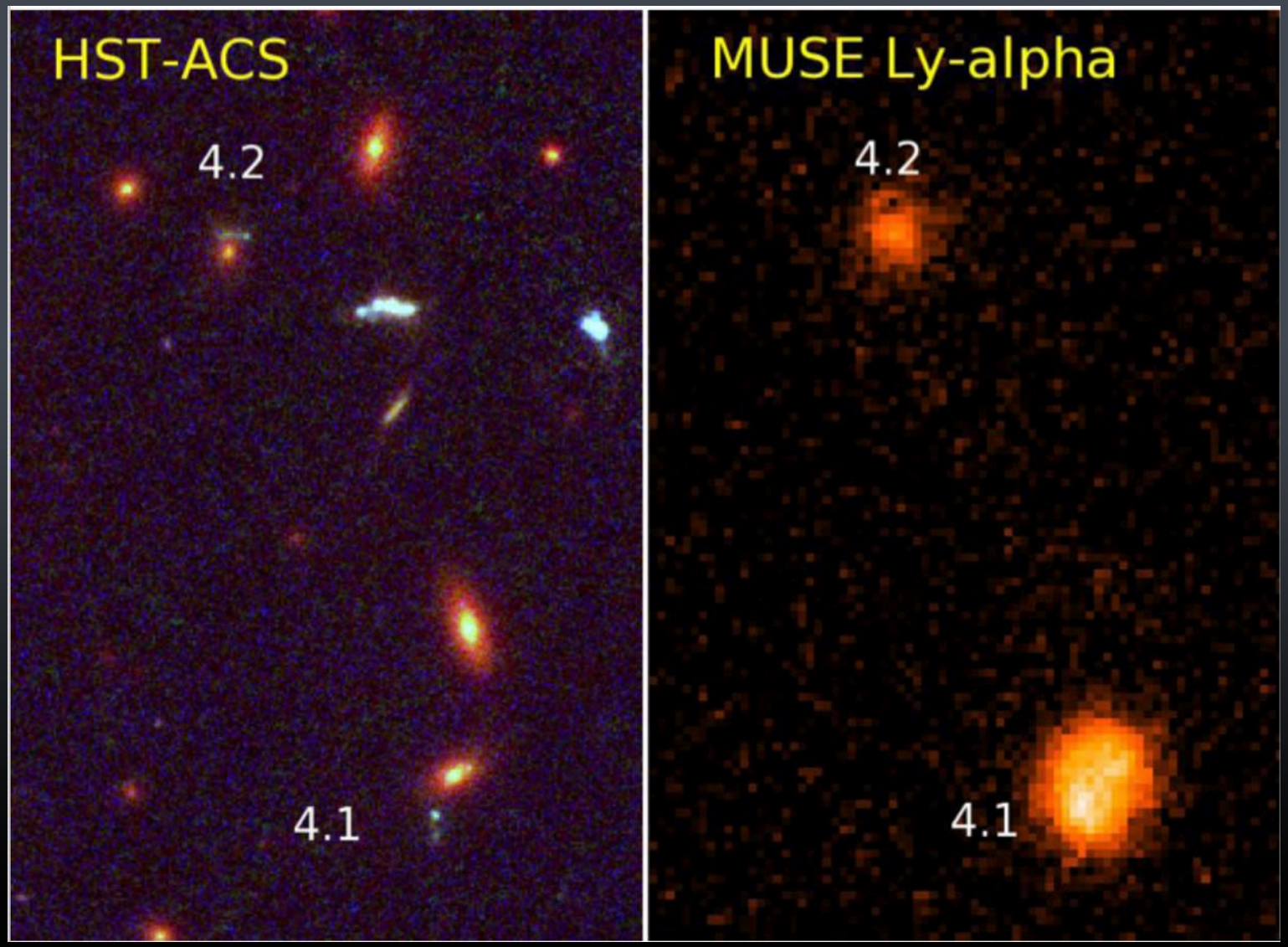
HST/ACS



VLT/MUSE

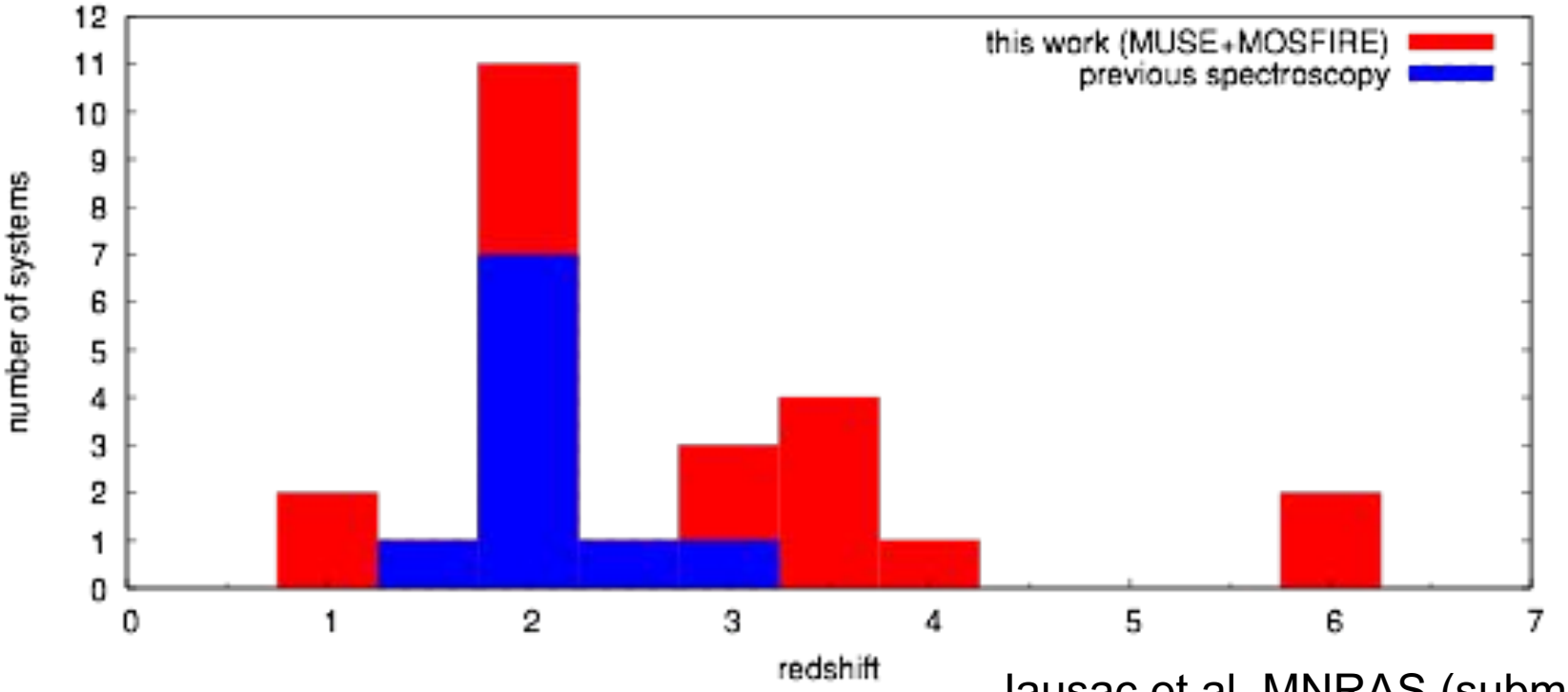


Exemple: z=2.95 multiple image



MACS0416 spec-z distribution

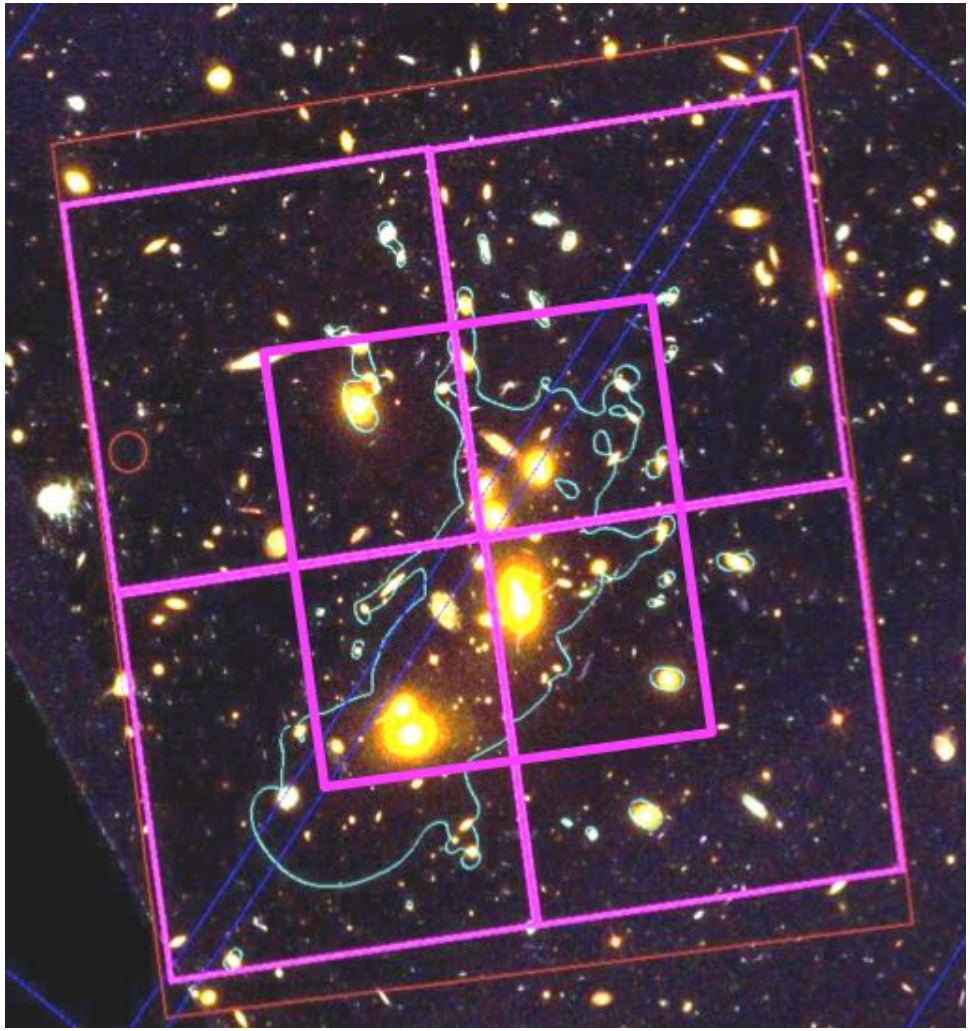
- 56 cluster members with spec-z
- 31 / 71 multiple systems (from HST) covered with MUSE
- additional follow-up with Keck/MOSFIRE
- before MUSE : 10 systems with spec-z
- now : 14 systems have new redshifts measured with MUSE
  1 system has redshift from MOSFIRE
- total : 25 systems (75 images) with spec-z (in 2 hrs!)



Jausac et al, MNRAS (submitted)

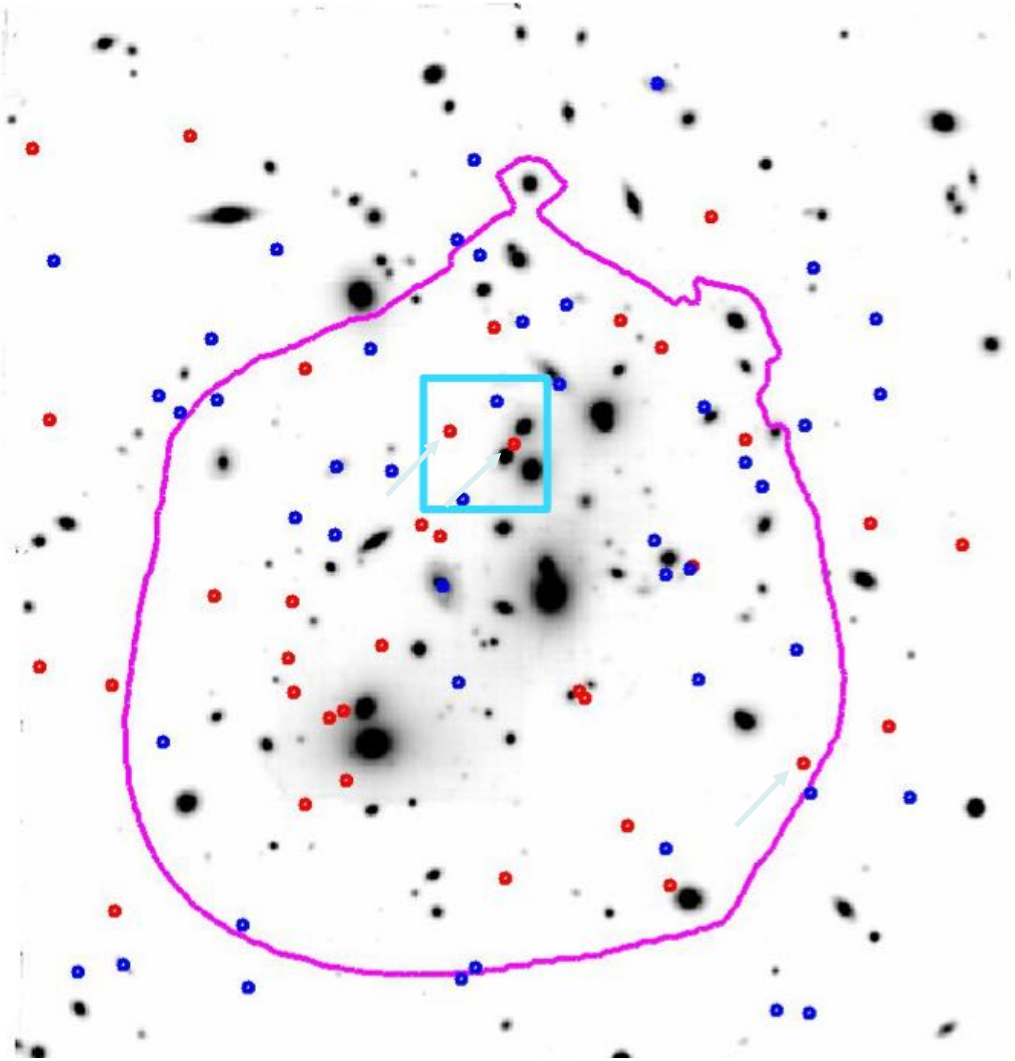
Slide prepared by Benjamin Clément (CRAL)

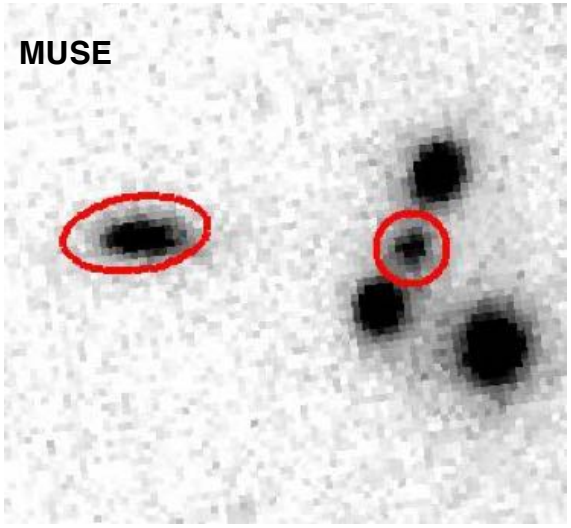
MUSE GTO program : A2744

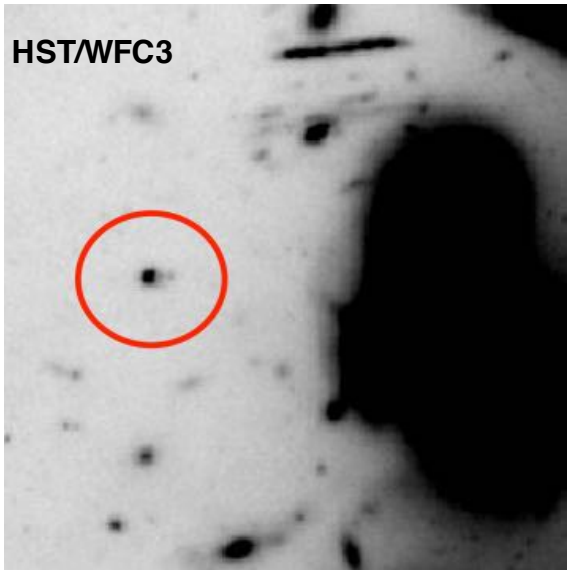


- PI: Richard CALENDS Team
- 5 x 2 hrs mosaic to cover central region + almost full WFC3 fov. (+ 8 hrs)
- Seeing ~0.6”-0.7”

Extended Lyα emission at z=5.661

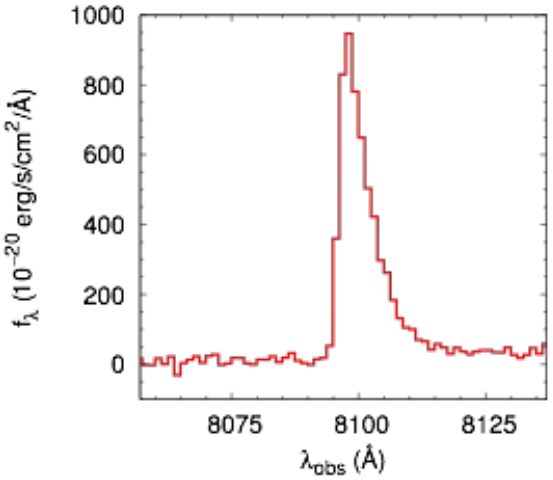


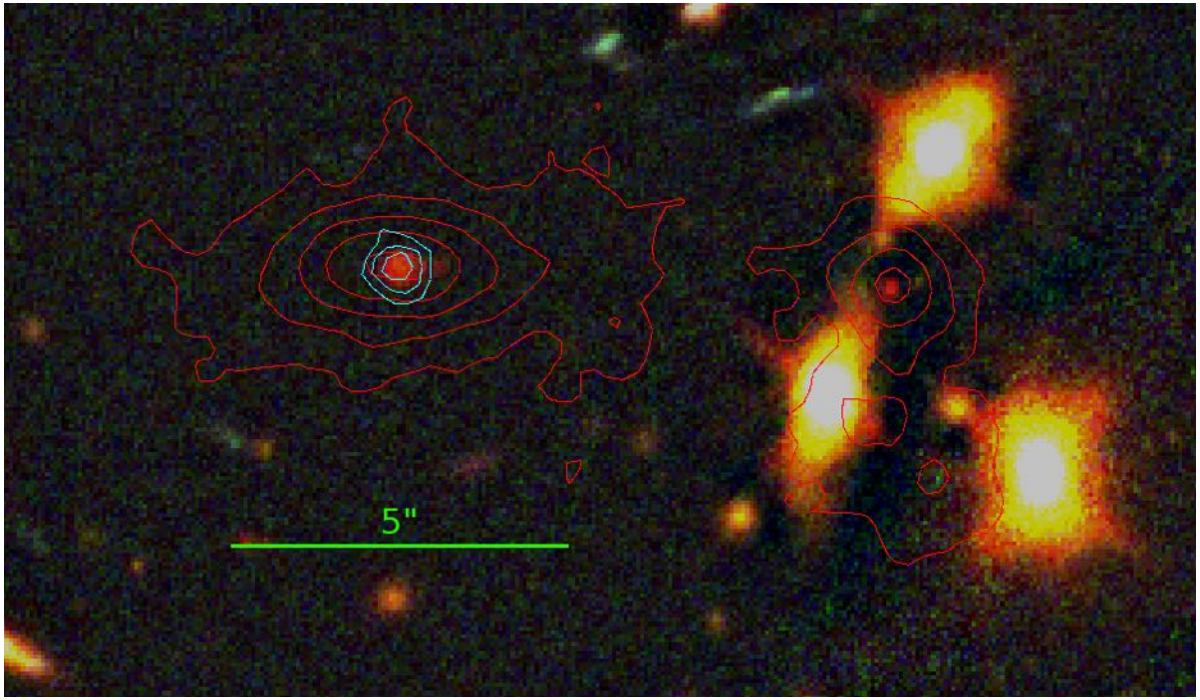




Slide prepared by Benjamin Clément (CRAL)

Extended Lyα emission at z=5.661





- $F_{Lya,obs}$ = 7 10^{-17}
- μ = x18.7 (3.2 mag)

→ 3.7 10^{-18}

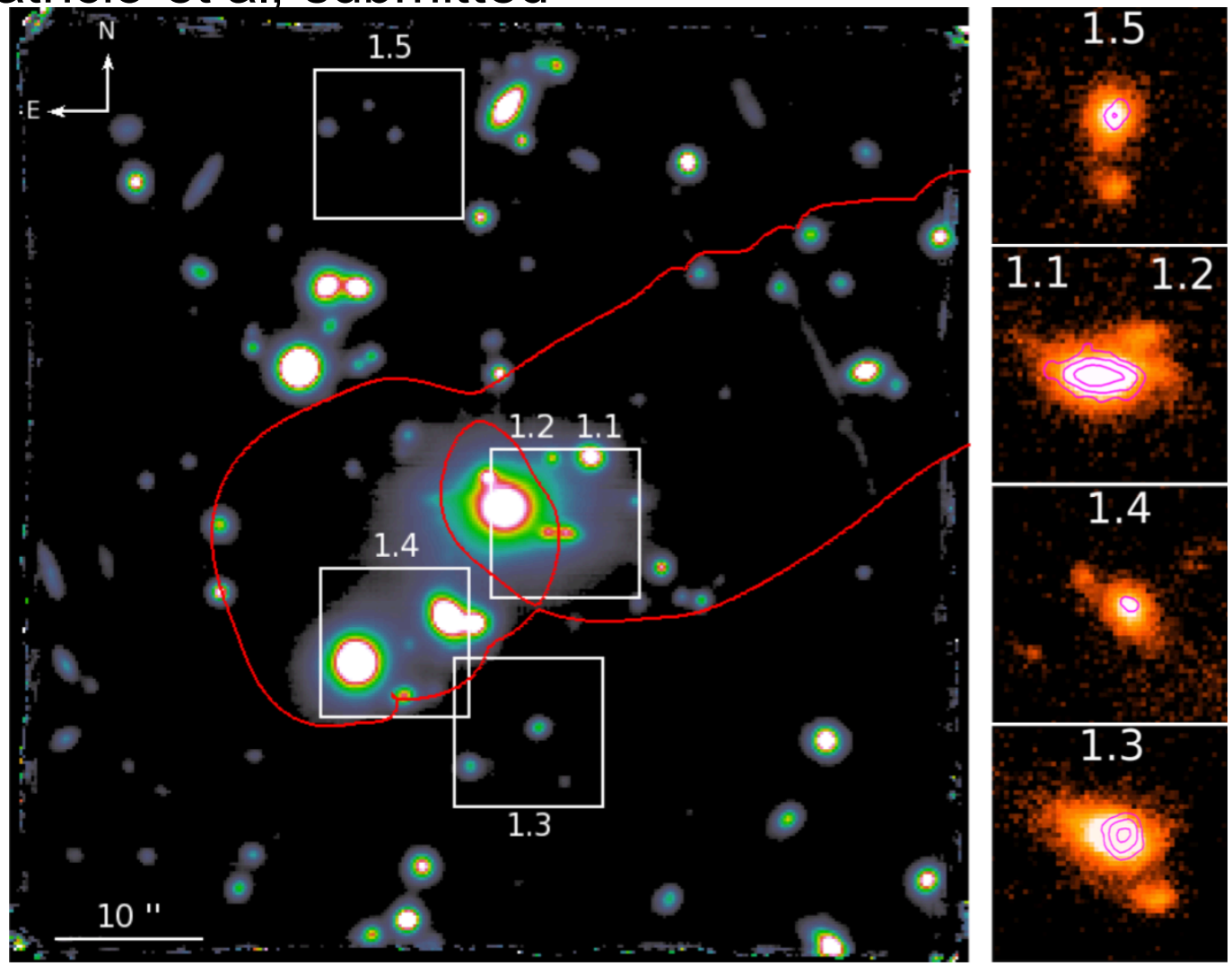
4 hrs → 300 hrs !

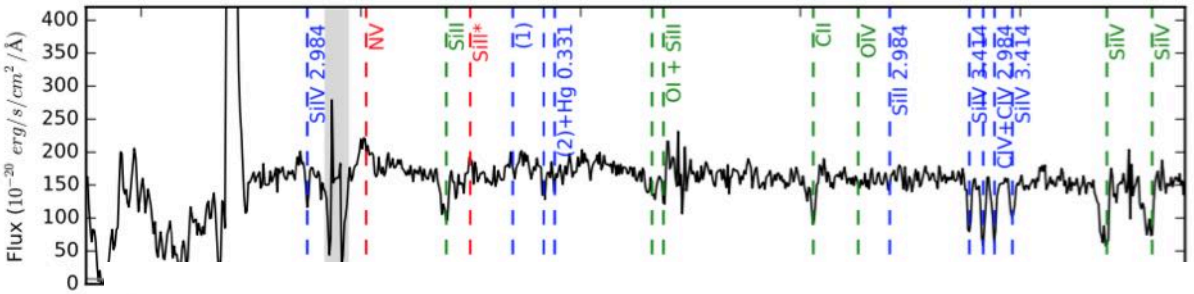
Slide prepared by Benjamin Clément (CRAL)

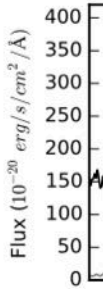
MUSE observation of SMACS 2031

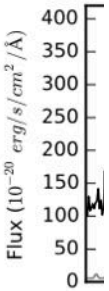
Resolved property of $M_\star = 6 \times 10^9\ M_\odot$ galaxy at $z = 3.5$

Patricio et al, submitted

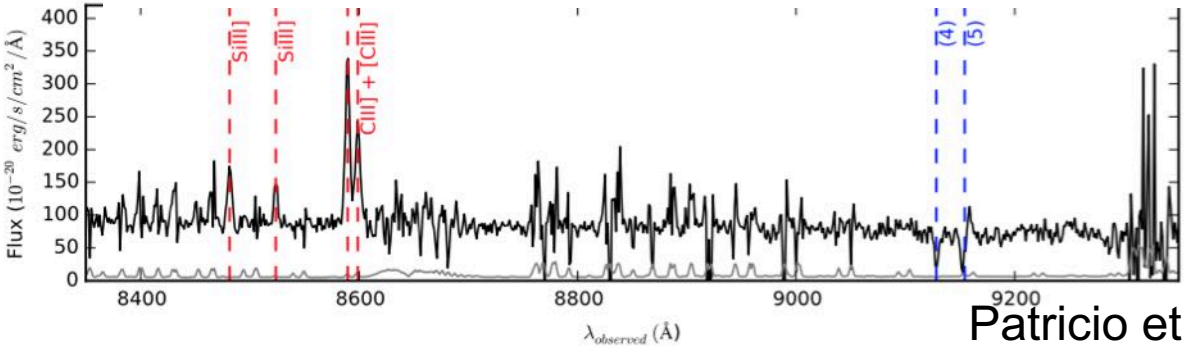




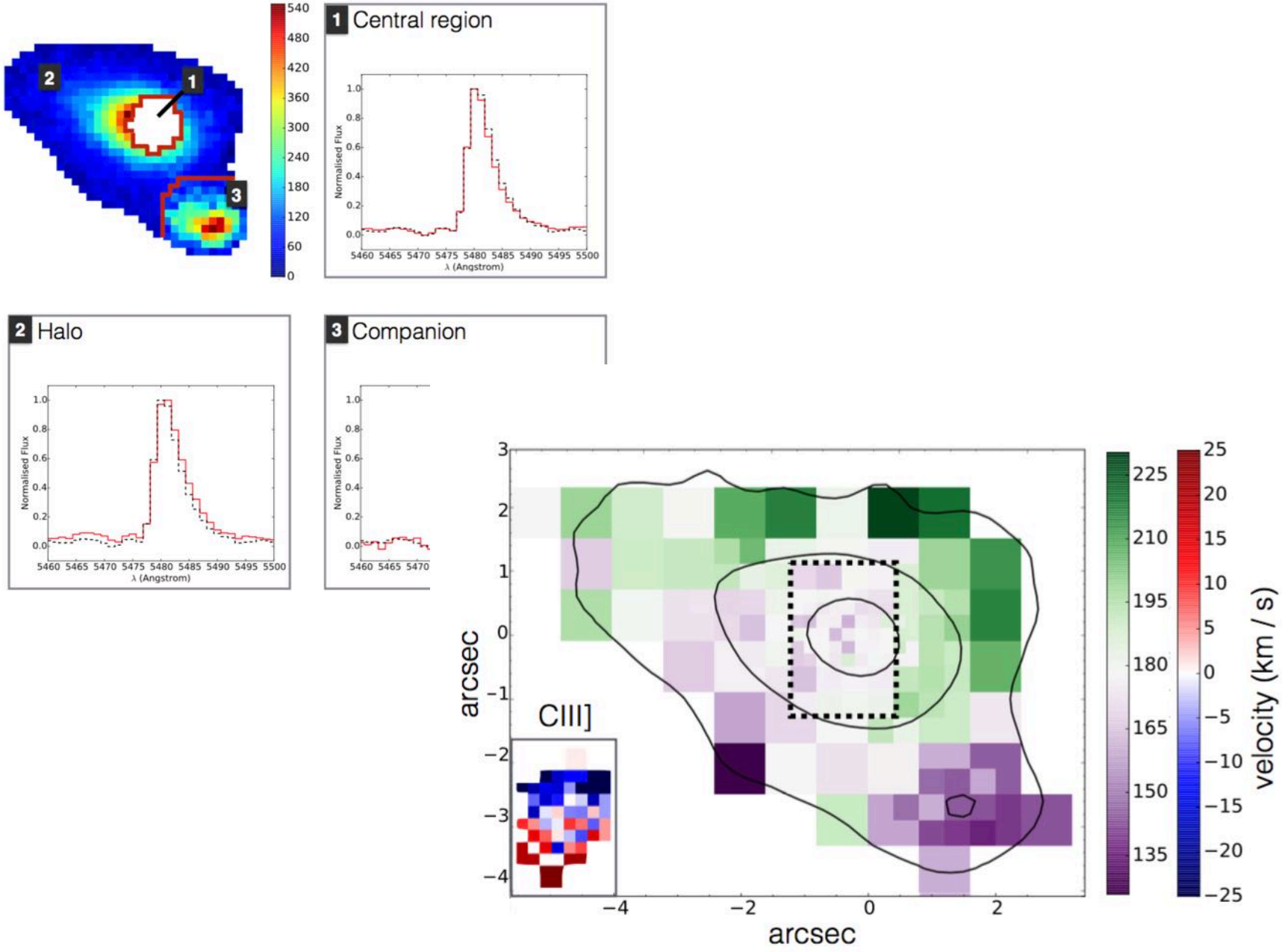




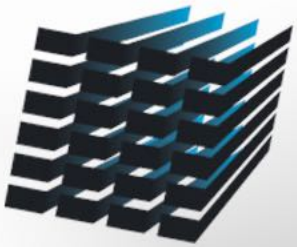
Line	λ_{rest} [Å]	λ_{obs} [Å]	Flux $\times 10^{-20}$ [erg/s/cm^2]	σ [km/s]	EW [Å]
Ly α	1215.67	5479.02 ± 0.01	51100 ± 165	110.5 ± 0.8	17.22 ± 2.44
N v	1242.80	5604.83 ± 0.33	2560 ± 138	257.9 ± 14.0	0.67 ± 0.04
Si II*	1264.74	5699.55 ± 0.93	417 ± 103	24.8 ± 20.2	0.11 ± 0.01
[N IV]	1483.32	6683.47 ± 0.07	613 ± 58	104.0 ± 4.2	0.21 ± 0.02
N IV]	1486.50	6697.77 ± 0.07	2996 ± 80	103.7 ± 4.2	1.04 ± 0.05
He II	1640.42	7390.39 ± 0.13	2301 ± 114	76.9 ± 6.7	0.99 ± 0.10
O III]	1660.81	7481.77 ± 0.11	1479 ± 92	58.6 ± 6.2	0.65 ± 0.05
O III]	1666.15	7505.92 ± 0.04	3002 ± 56	54.1 ± 1.4	1.33 ± 0.09
[Si III]	1881.96	8481.49 ± 0.09	1363 ± 52	55.3 ± 2.7	0.81 ± 0.06
Si III]	1892.03	8523.66 ± 0.13	41110 ± 66	62.2 ± 4.2	0.67 ± 0.05
[C III]	1906.68	8589.61 ± 0.03	5090 ± 72	60.0 ± 1.0	3.14 ± 0.19
C III]	1908.73	8598.84 ± 0.03	3417 ± 77	59.9 ± 1.0	2.11 ± 0.13



Patricio et al, submitted



Patricio et al, submitted



muse

multi unit spectroscopic explorer

Historical Context
The MUSE Instrument
Commissioning results
Hubble Deep Field South
Gravitational Lensing Clusters
Conclusions & what's next

LPNHE

19 November 2015

Conclusions

- First high-z results from the MUSE observation of the HDFS has resulted in
  - An order of magnitude more spectroscopic redshifts - the main difference from before is the spatial density of spectra.
  - A nearly flat redshift distribution for 3<z<6
  - Most galaxies are in groups or pairs
  - The discovery of large population of Lyα emitters fainter than the HST detection limit (I814>30)
  - The detection of 21 extended Lyα halos in a sample of 26 Lyα emitters selected sample. Halos size are 1-5 Kpc, 10x larger than the UV component, 5x larger than halos at low z. They contain 70% of the total Lyα flux.

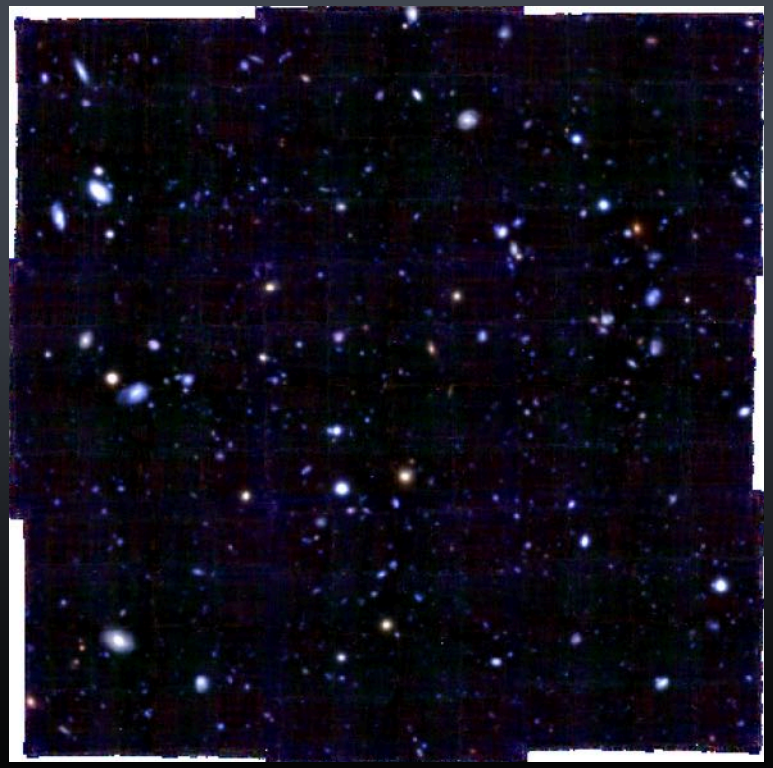
Conclusions

- First high-z results from the MUSE observation of HST Frontier fields and other lensing clusters has resulted in
  - An order of magnitude more spectroscopic redshifts of lensed galaxies.
  - An improved modelling of the dark matter distribution in the cluster
  - Spatially resolved properties of high z galaxies

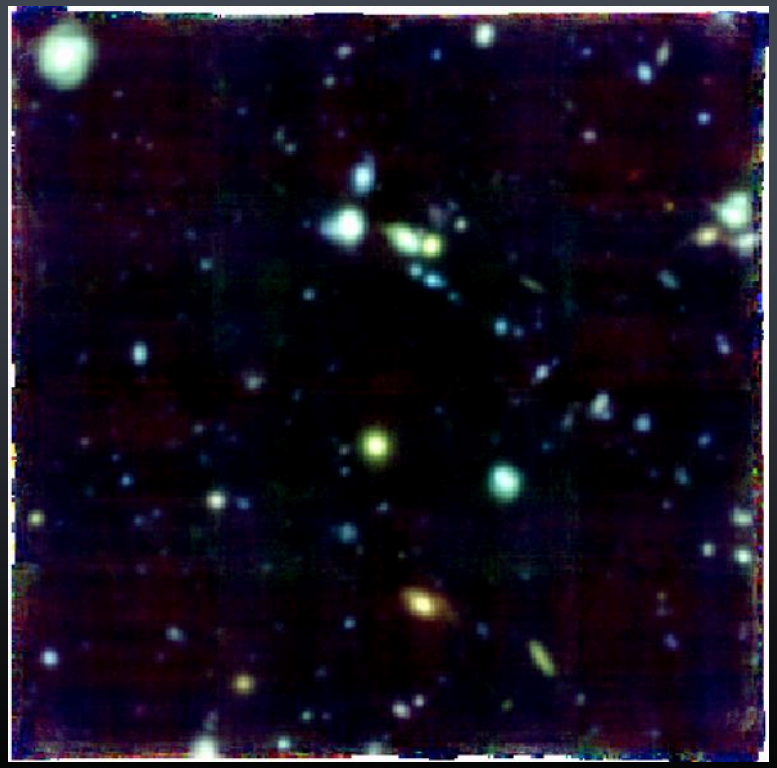
  - The exploration of the faint end of Lyα Luminosity function (in progress)

What's next

- **MUSE GTO observing (250 nights over 5 years)**
  - **One Deep fields up to ~100 hours and many fields to ~10 hours depth.**



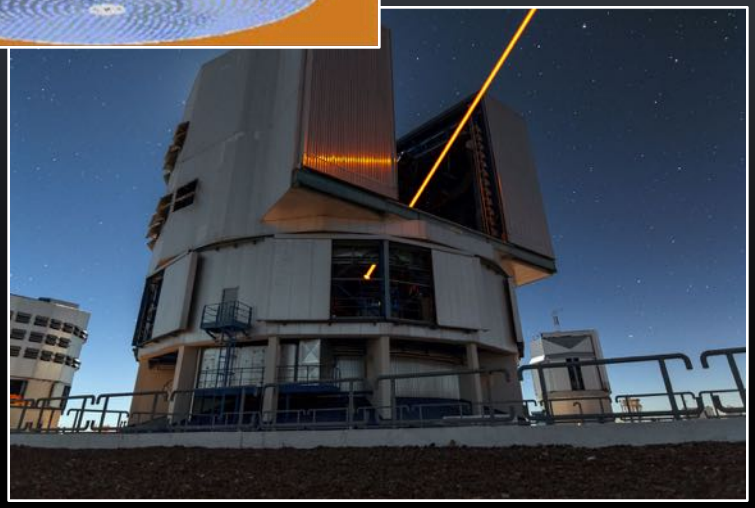
UDF Mosaic 3'x3'
(currently 5.8 h depth)



UDF Ultra Deep 1'x1'
(currently 20.5 h depth)

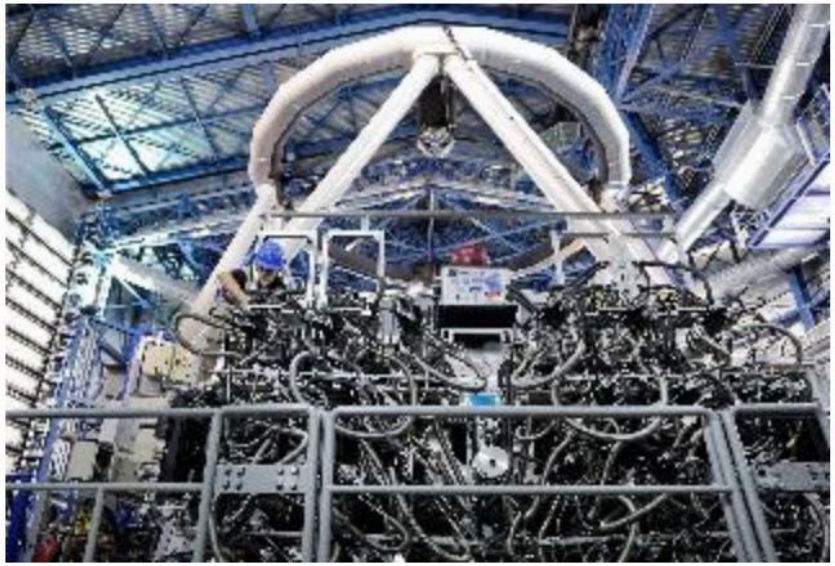
What's next for MUSE ?

- AOF/GALACSI in 2017
  - improve spatial resolution (~ 0.6 arcsec median)
  - 0 impact on throughput
  - minimal impact in overhead
  - Narrow Field Mode 7x7 arcsec2, 20% Strehl at 8500



Call for Ideas: Public Deep Field with MUSE

Published: 16 Nov 2015



The ESO Director General proposes to dedicate up to 60 nights of Directors Discretionary Time in four forthcoming observing periods to a Public Deep Field using MUSE. This project will be carried out towards the end of 2017 with enhanced seeing capabilities provided by GALACSI – the wide-field Ground Layer Adaptive Optics (GLAO) unit of the quad-laser Adaptive Optics Facility (AOF) on VLT UT4.

The goal of this Call is to collect ideas from the astronomical community, ensuring the selection of a target field with the greatest potential to advance our understanding of the Universe. Ideas should be sent to musepublicsurvey@eso.org no later than **29 February 2016**. Full details for the submission of the Call for Ideas can be found here.


muse
ETH
irap
DANGER

A few examples from the MUSE gallery