



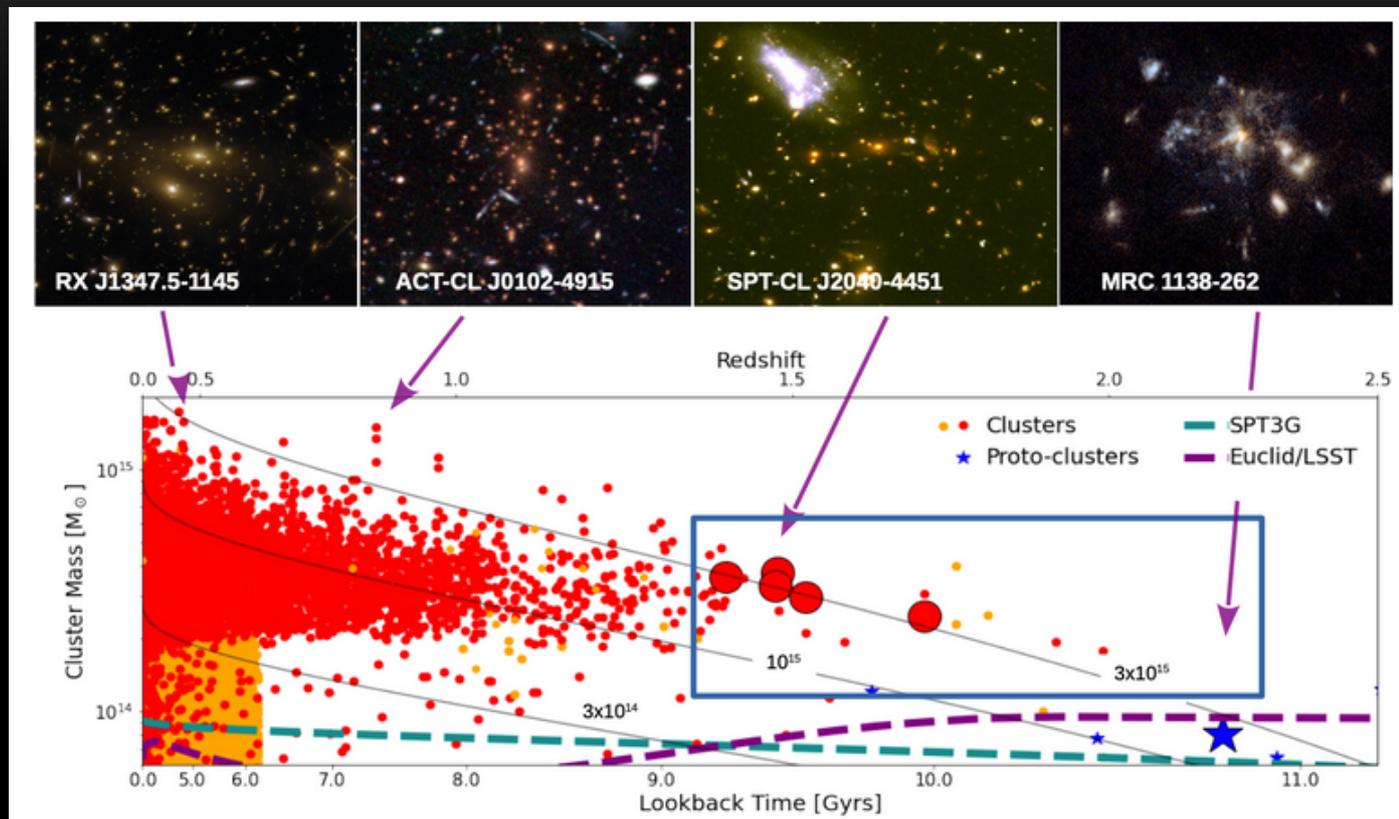
50% 15% 5%

THE SPIDERWEB PROTOCLUSTER REBOOTED

Maurilio Pannella

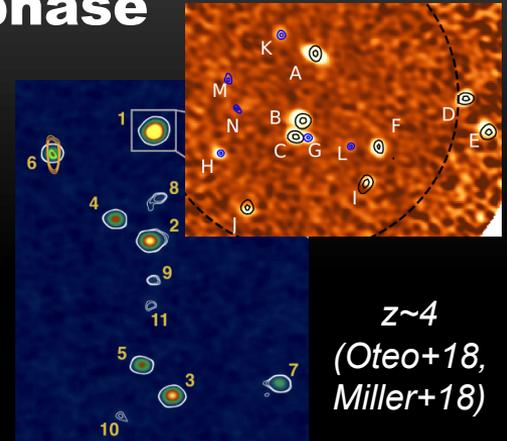
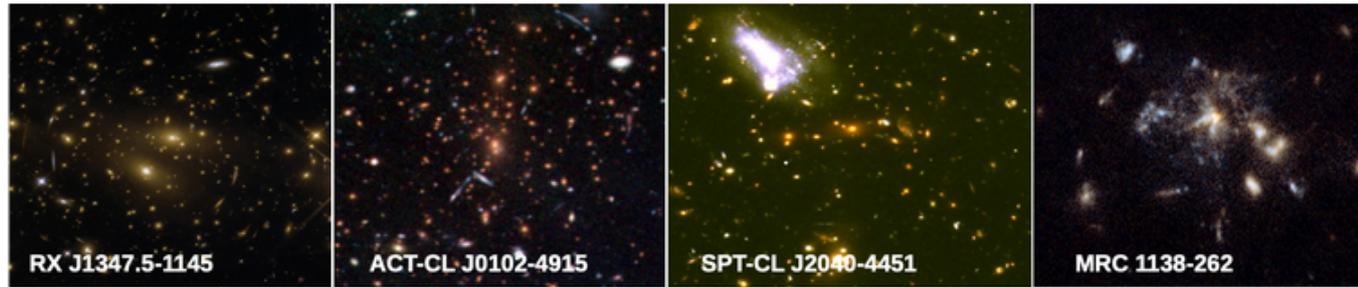
w Alex Saro, Veronica Strazzullo, Mario Nonino, Paolo Tozzi,
Peter Lustig, Michela Esposito, Luca Di Mascolo, Rosita Paladino
and the larger Spiderweb community

$z \sim 2$ protoclusters: a transitional phase

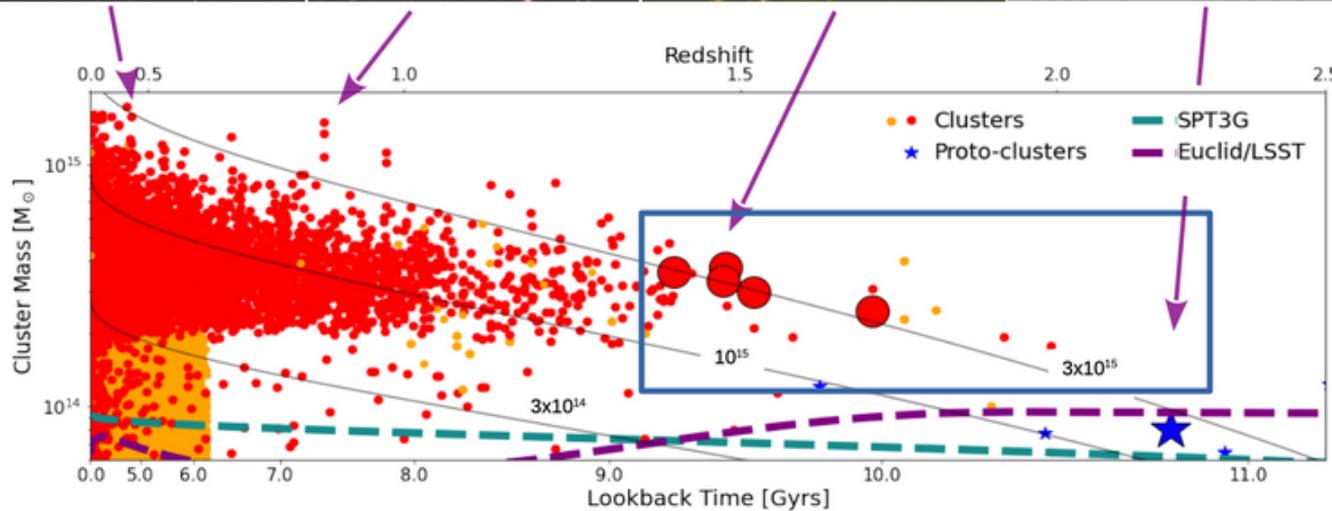


Credit: A. Saro

$z \sim 2$ protoclusters: a transitional phase

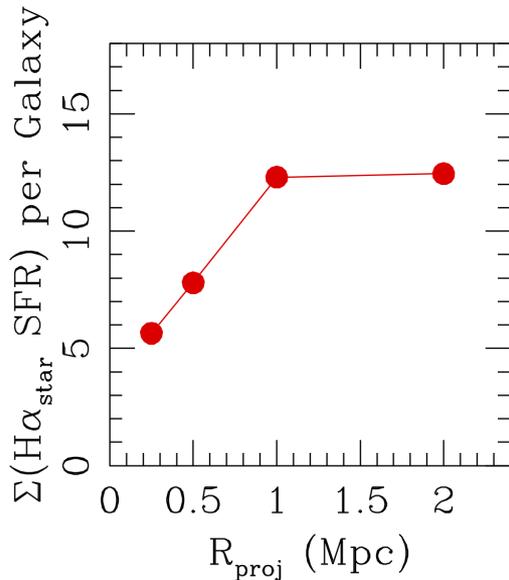
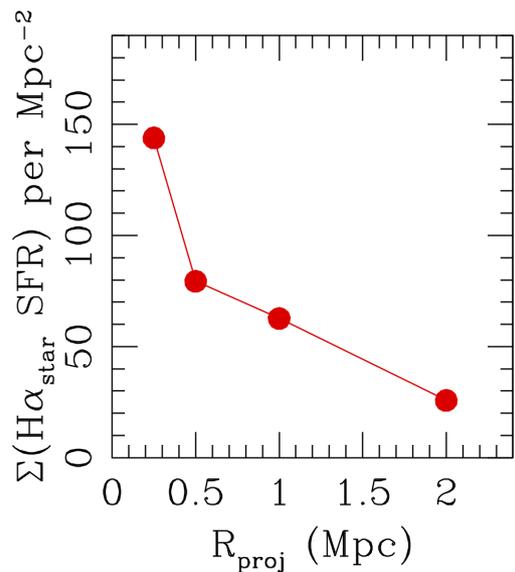


$z \sim 4$
(Oteo+18,
Miller+18)

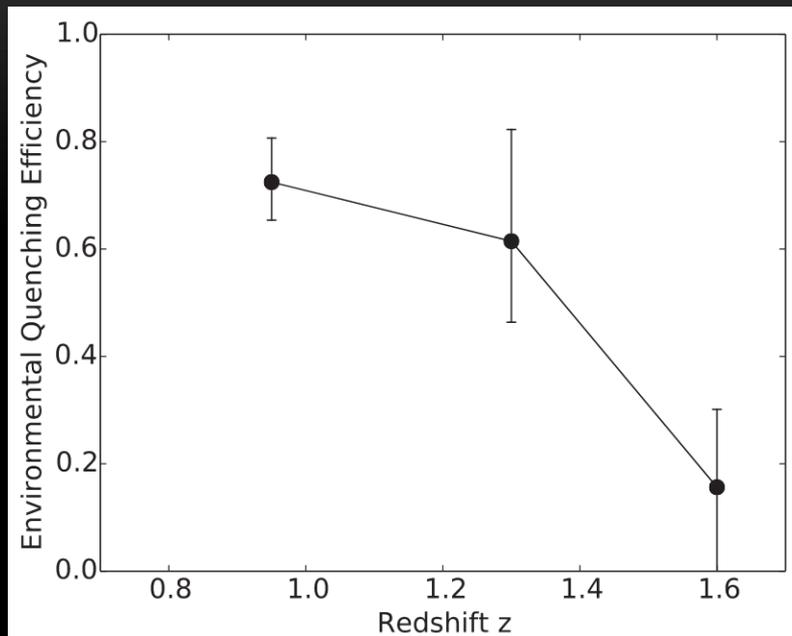


ENVIRONMENT AT WORK

IRC 0218 @ $z=1.623$ / MOSFIRE-H α

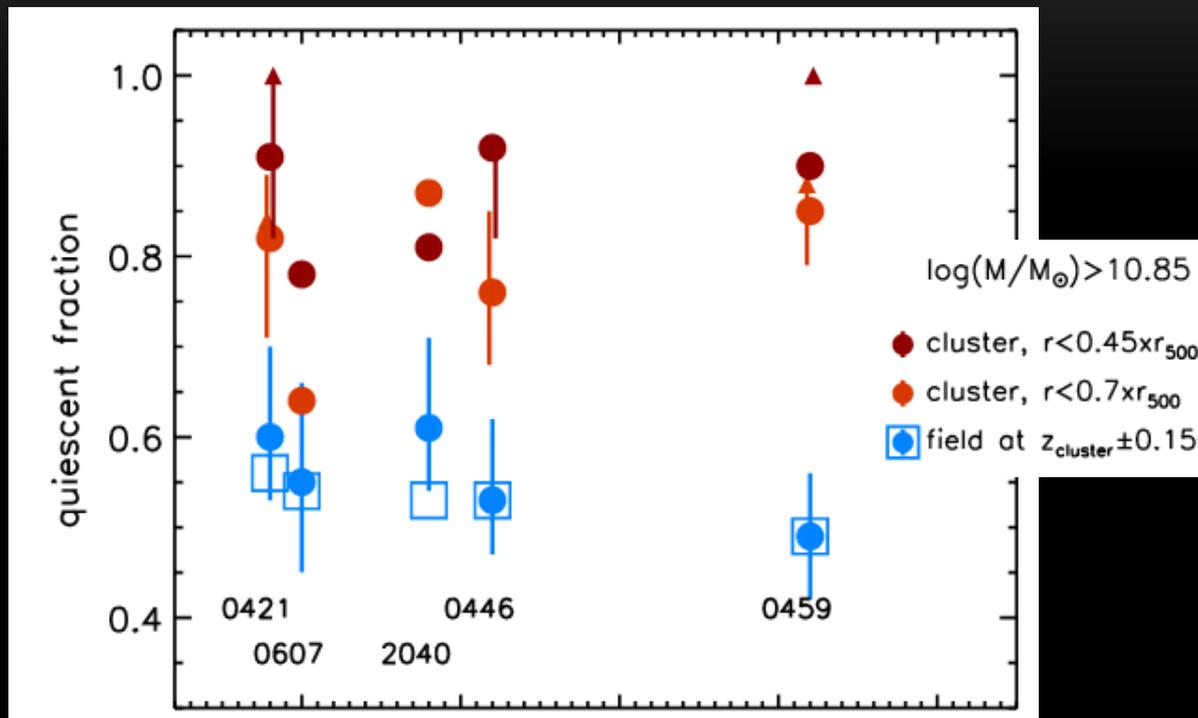


(Tran et al., 2015)



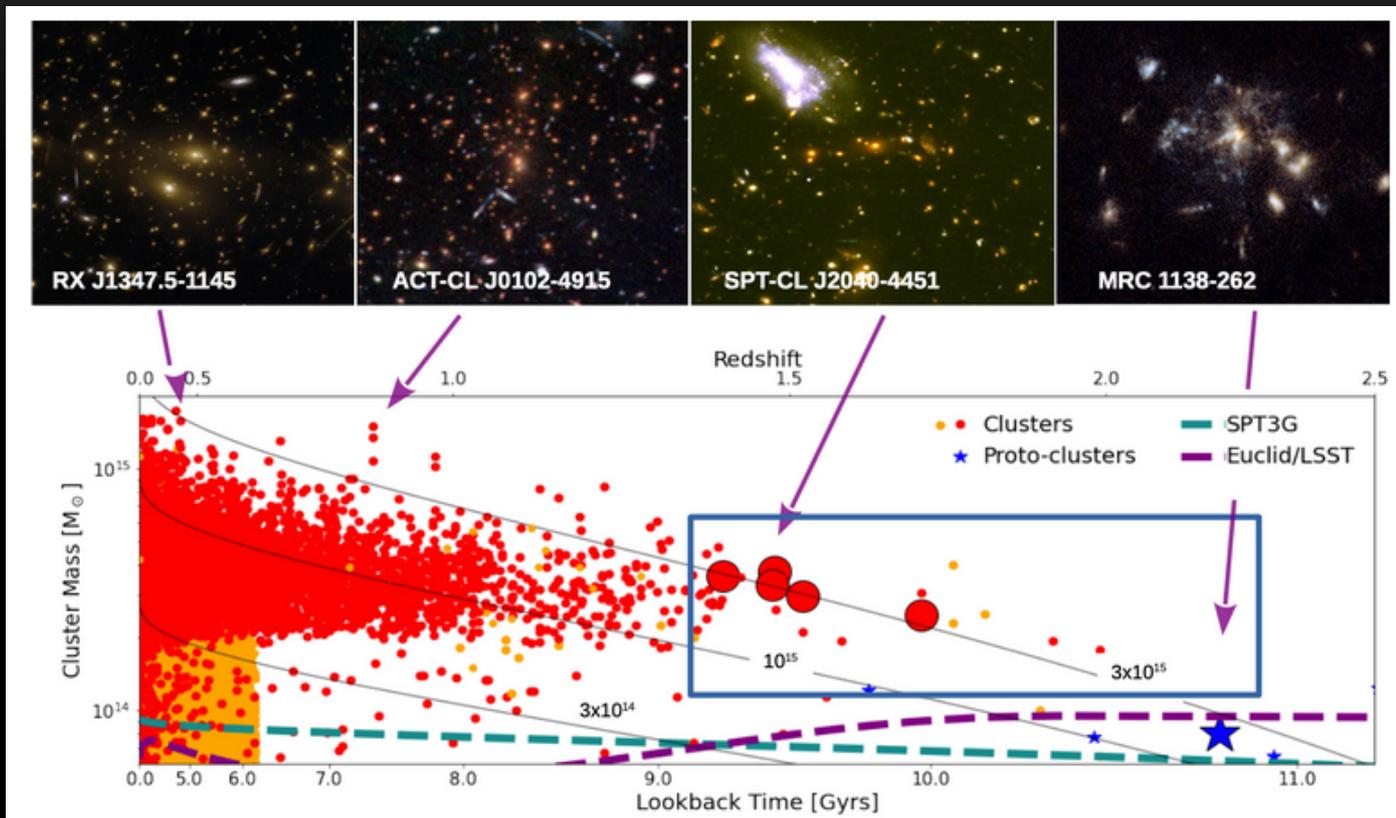
(Nantais et al., 2016)

ENVIRONMENT AT WORK

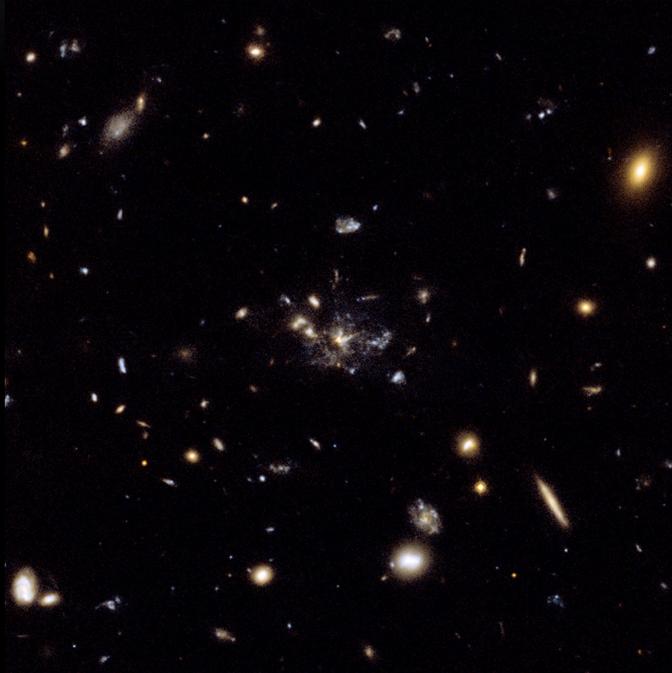


(Strazzullo, MP et al., 2019)

$z \sim 2$ protoclusters: a transitional phase



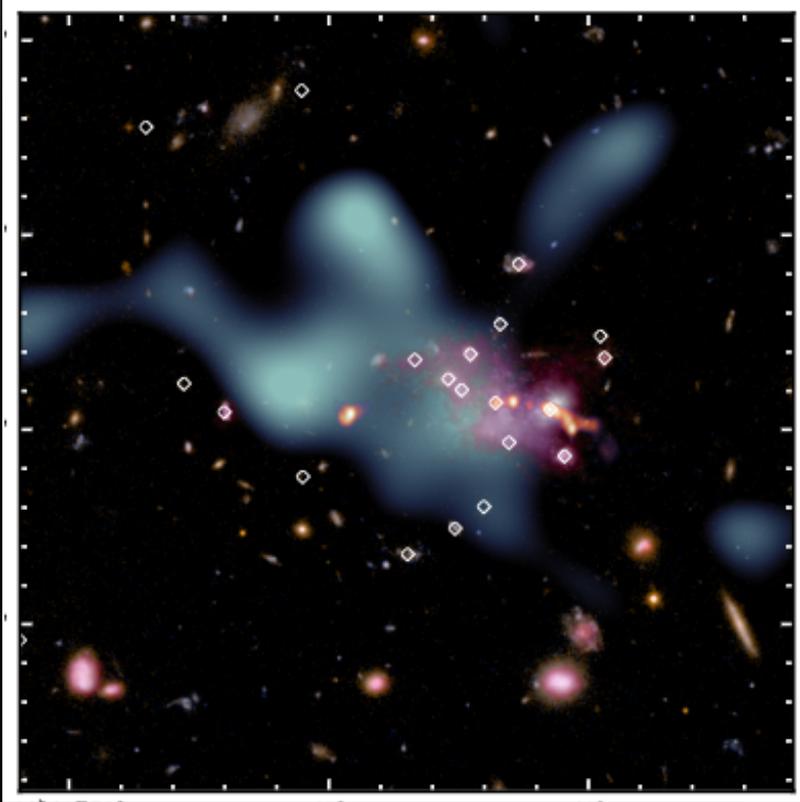
THE SPIDERWEB PROTOCLUSTER REBOOTED



(Miley et al. 2006)

- Heavily observed field in the last 25 years, with lots of data acquired and many papers published
- Observational pressure boosted in the last years:
 - Chandra LP (Tozzi) -JVLA data (Carilli) -ALMA-SZ (Saro)
 - MeerKAT/uGMRT and VISTA wide field observations (MP)
 - ATCA and JWST (Dannerbauer)
 - ALMA-dust continuum (Koyama)
 - WFC3 grism spectroscopy (Koyama)

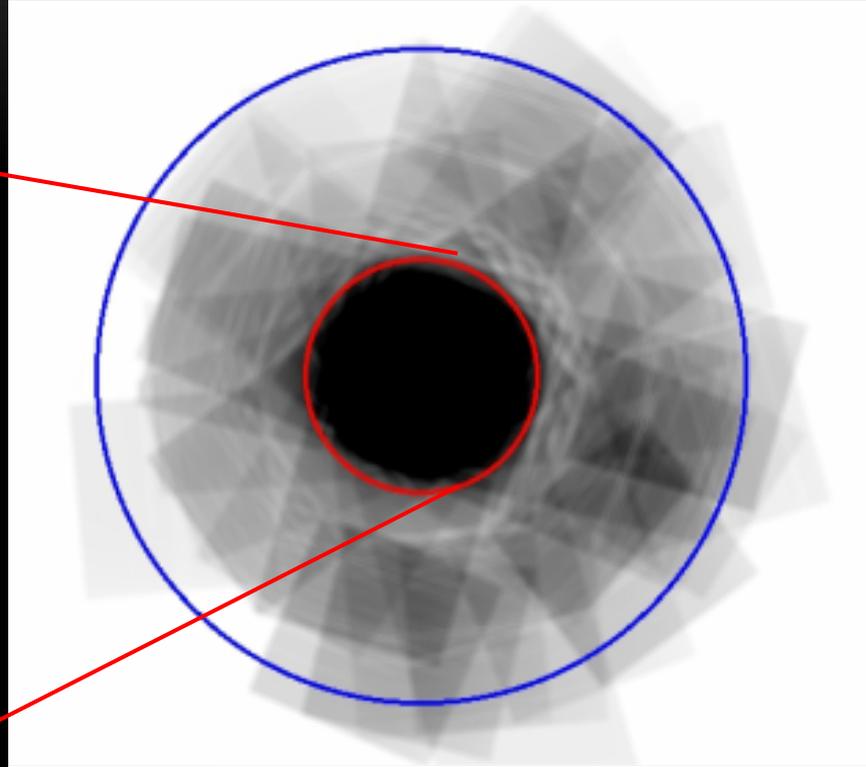
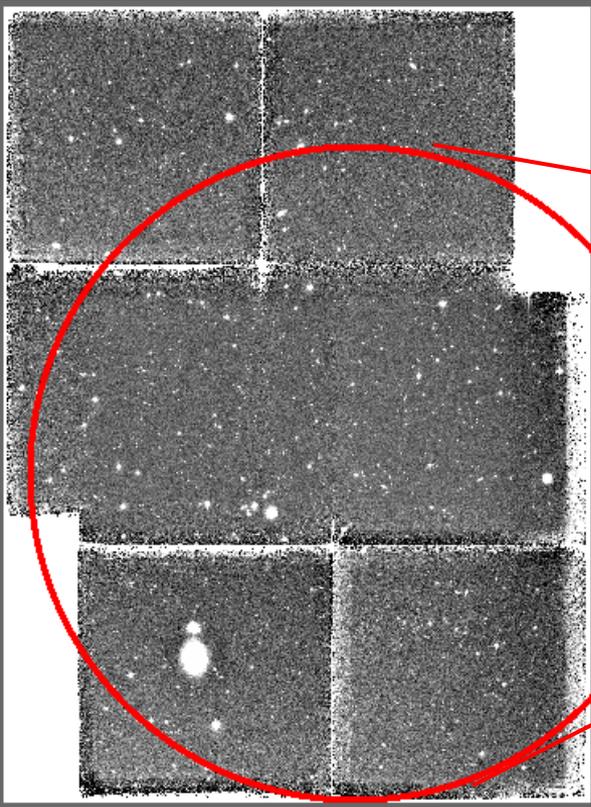
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THE SPIDERWEB PROTOCLUSTER REBOOTED

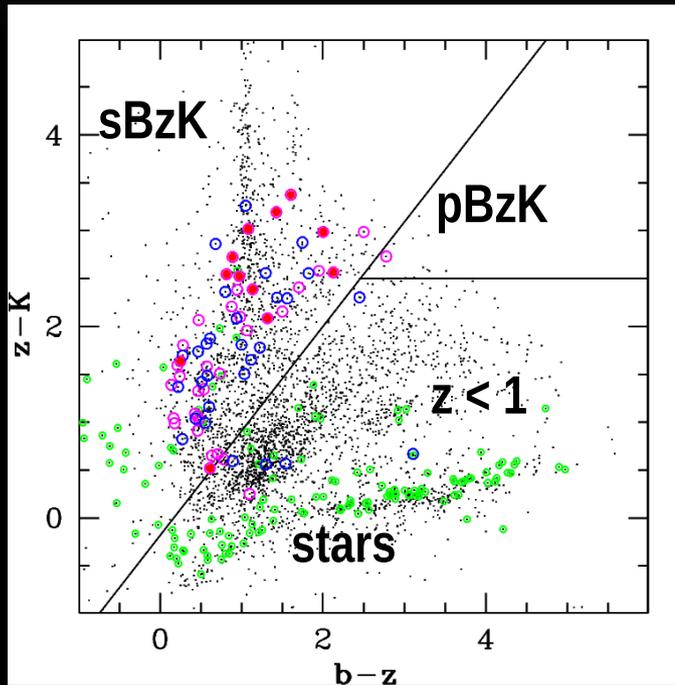


(Tozzi et al., 2022a)

- $K_{im} = 22.8$ (5 sigma)
- UbrzYHK SED fitting
- Photo-z accuracy $\sim 6\%$
- Complete to $M_* \sim 6 \cdot 10^{10} M_{\odot}$

THE SPIDERWEB PROTOCLUSTER REBOOTED

ONE MORE LOOK INTO THE GALAXY POPULATION...



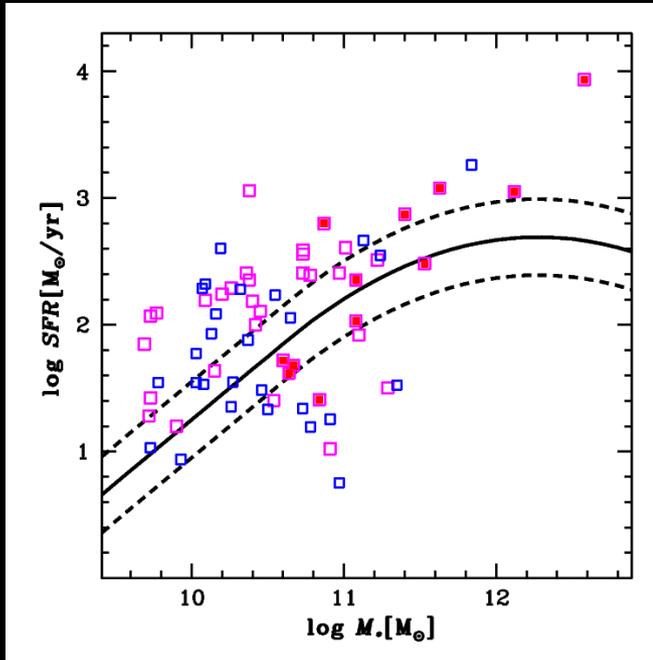
Quiescent vs star-forming galaxies: no UVJ no party ?

BzK selection instead...

- All spectroscopic members but one are star-forming (sBzK)
- Xray members also
- Only 1 spec member and 2 photo-z candidates in the passive area (pBzK) and they all are at more than 1 Mpc away from the radio galaxy

THE SPIDERWEB PROTOCLUSTER REBOOTED

THE STAR-FORMING POPULATION

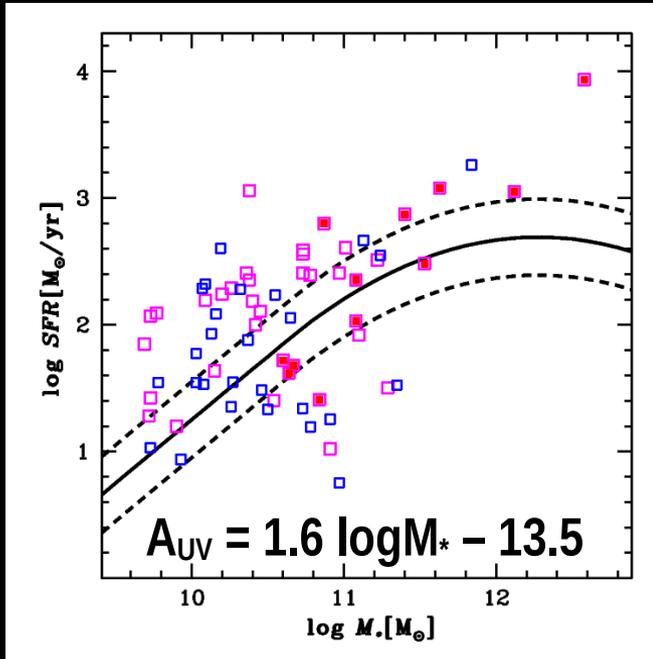


A new look at the MS in the spiderweb

- no IR or radio data... (in a few slides)
- Tentative enhancement (x2) vs. field value (More feeding available from the web?)

THE SPIDERWEB PROTOCLUSTER REBOOTED

THE STAR-FORMING POPULATION



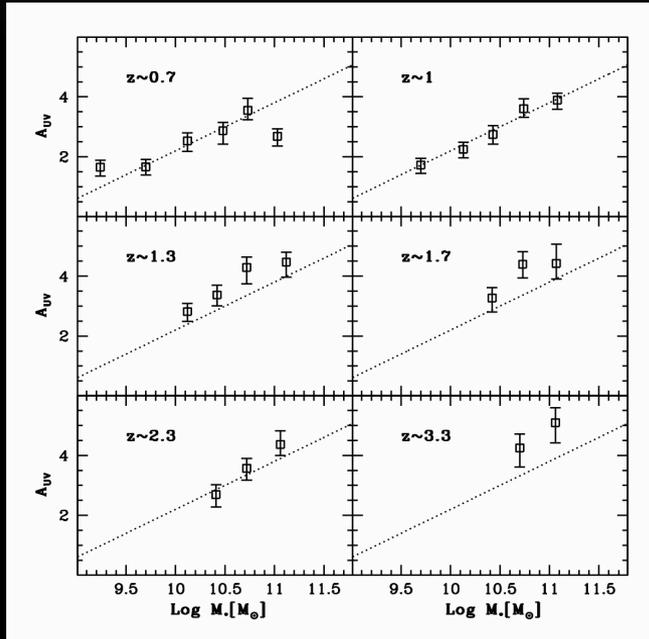
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DUST ATTENUATION UP TO $z \sim 4$

$$A_{UV} = 2.5 \text{ LOG} (\text{SFR}_{IR} / \text{SFR}_{UV} + 1)$$

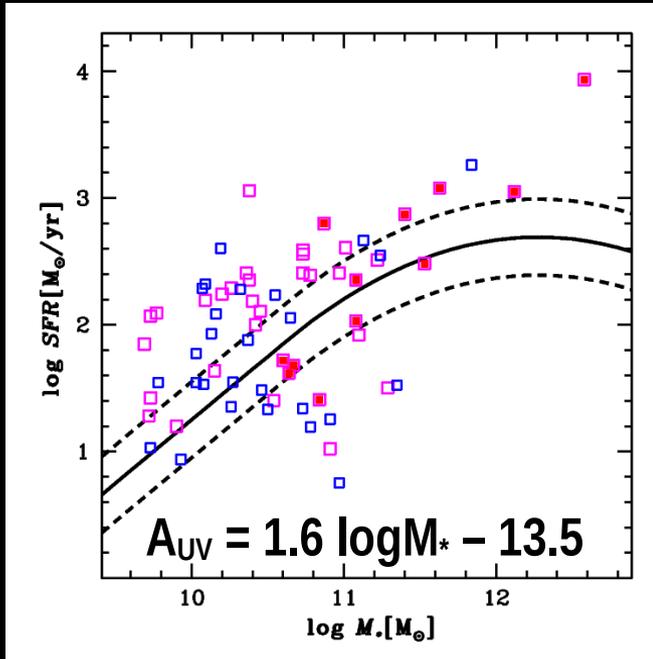


(MP et al., 2015)

- The correlation between M_* and A_{UV} does not evolve much up to $z \sim 4$
- The same amount of SFR is less attenuated at higher redshift

THE SPIDERWEB PROTOCLUSTER REBOOTED

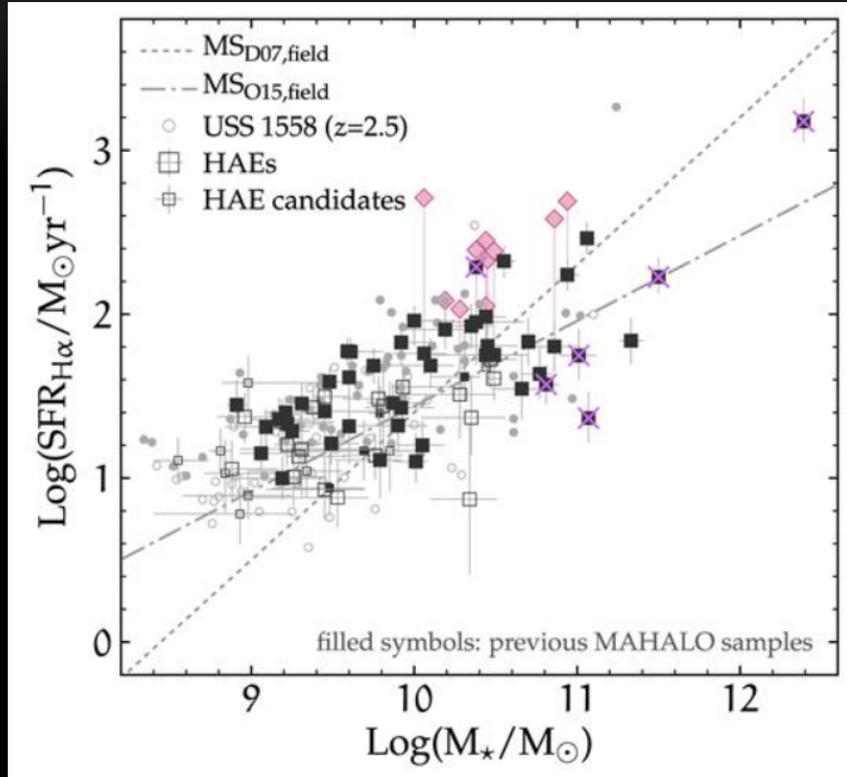
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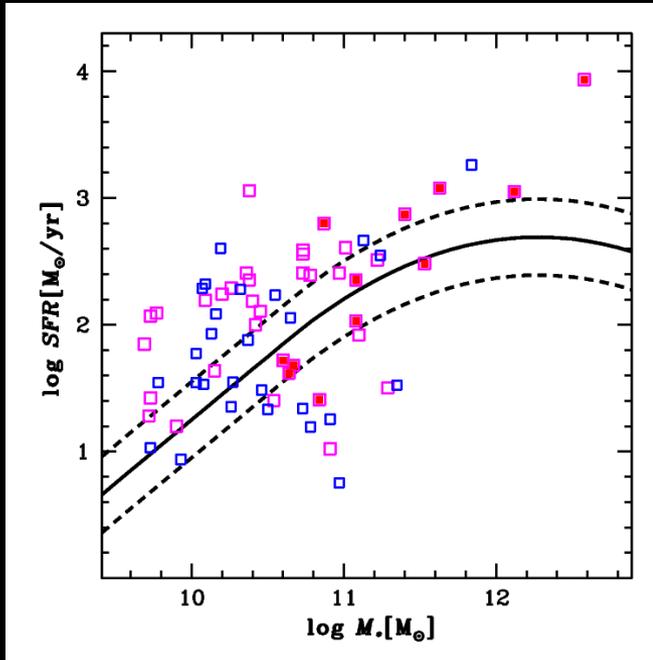
(Shimakawa et al., 2018)

The Spiderweb MS in 2018

$\text{H}\alpha$ luminosities (narrow band and spectroscopy), dust-corrected with SED fit based A_v

THE SPIDERWEB PROTOCLUSTER REBOOTED

THE STAR-FORMING POPULATION

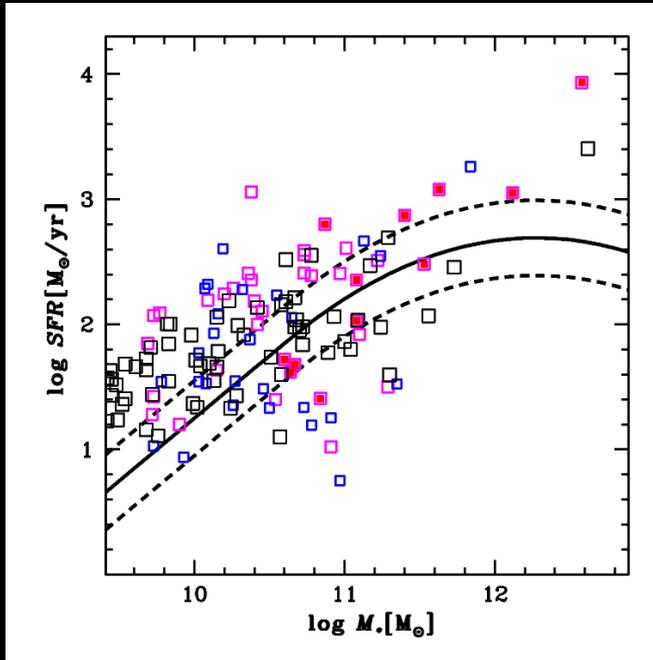


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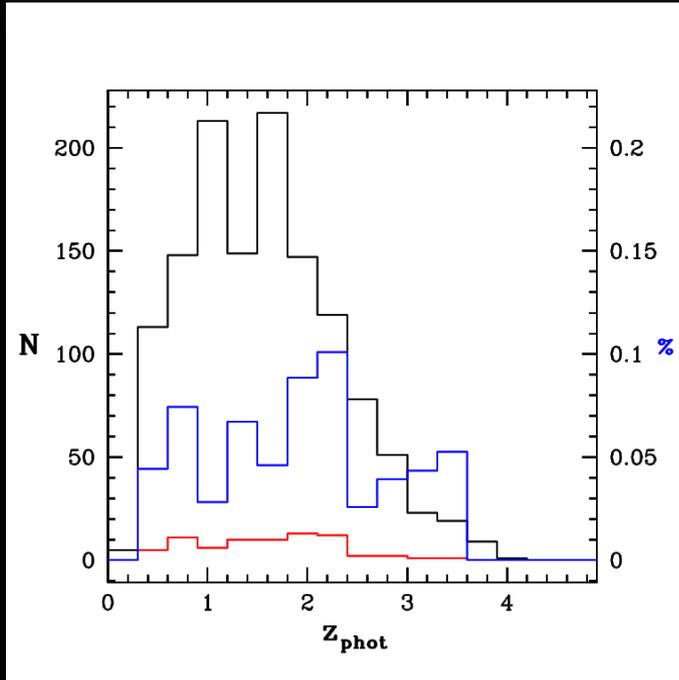


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THE SPIDERWEB PROTOCLUSTER REBOOTED

X-RAY AGN AND BLACK HOLE GROWTH

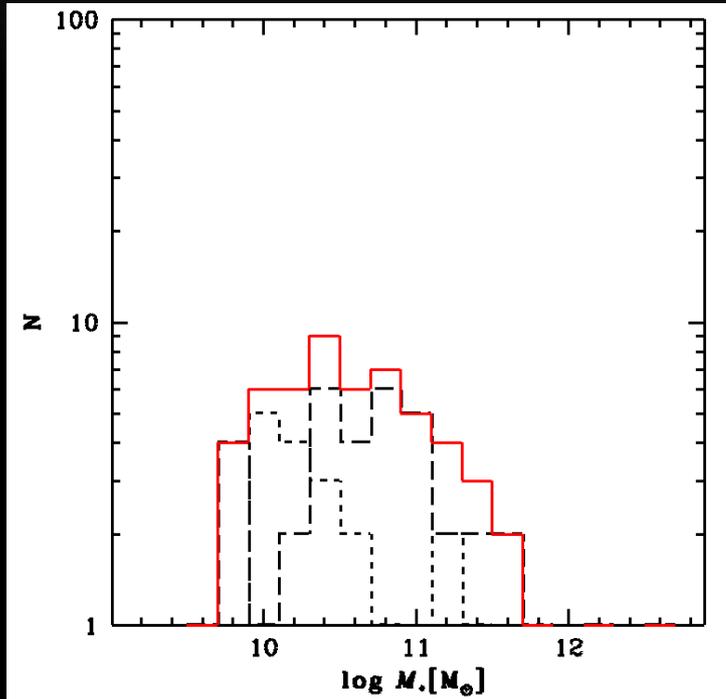


AGN activity in the protocluster

- photo-z selection and matching mass cut
- clear enhancement from field value
- same feeding of star formation?

THE SPIDERWEB PROTOCLUSTER REBOOTED

THE SPIDERWEB TOTAL MASS

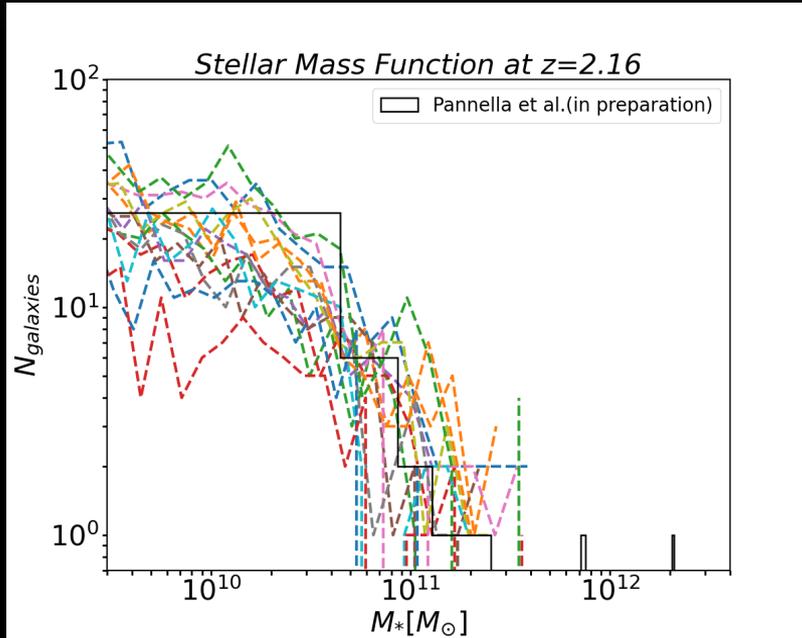


- lower limit on total stellar mass from spectroscopic members (40) and narrow band candidates (29) = $5.6 \cdot 10^{12} M_{\odot}$ within $r < 600$ kpc

(corresponding to a total mass of $\sim 3.8 \cdot 10^{14} M_{\odot}$ with lower- z cluster scaling relations but ...)

THE SPIDERWEB PROTOCLUSTER REBOOTED

THE SPIDERWEB IN SPH SIMULATIONS

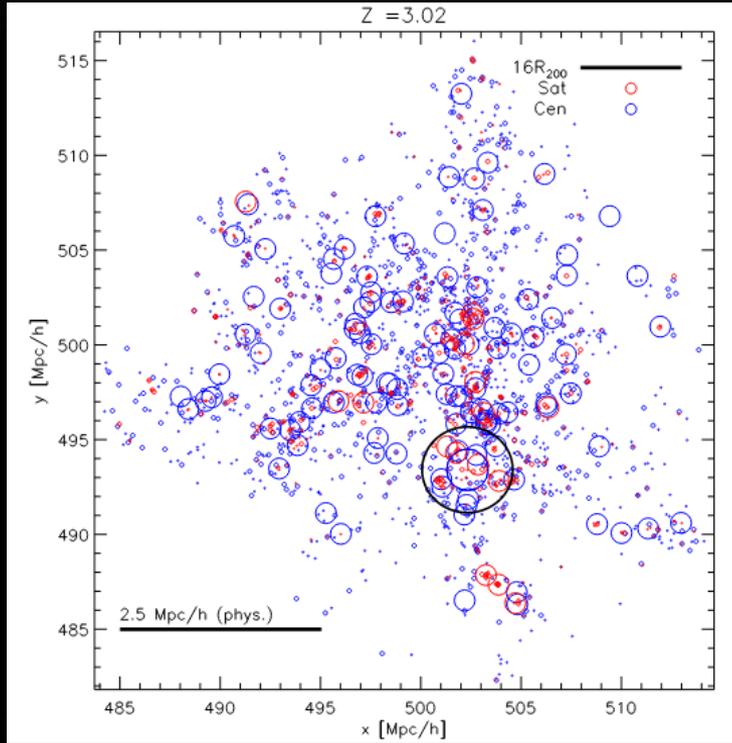


(Esposito et al. in prep)

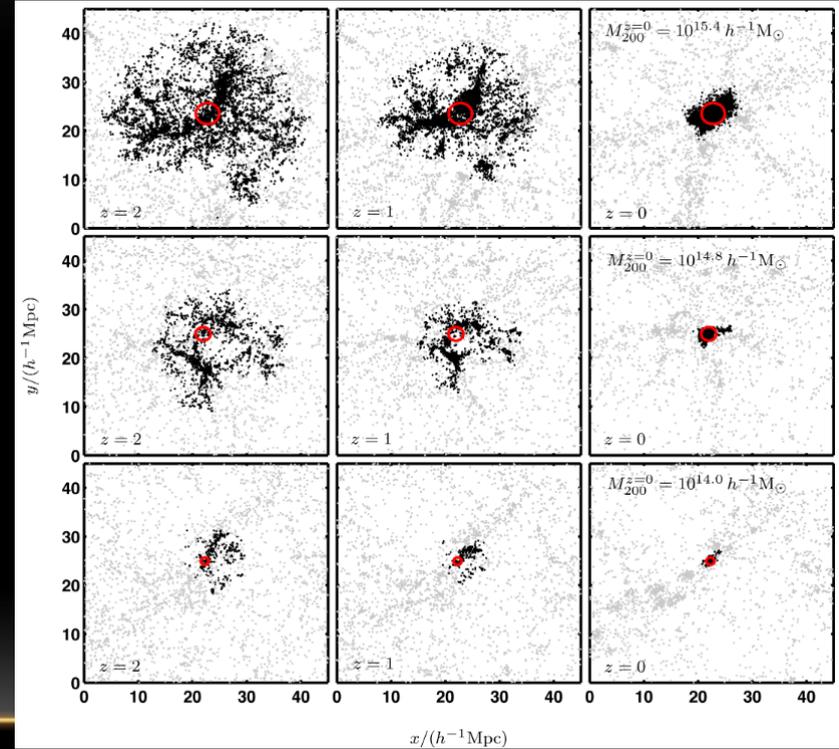
- Dianoga 25x zoom-in
- Hydrodynamical SPH - OpenGADGET
- 14 systems at z=2.16
- 3 Mpc radius

What's the physical scale to be investigated?

10/15 Mpc ($\sim 20/30$ arcmin) according to simulations



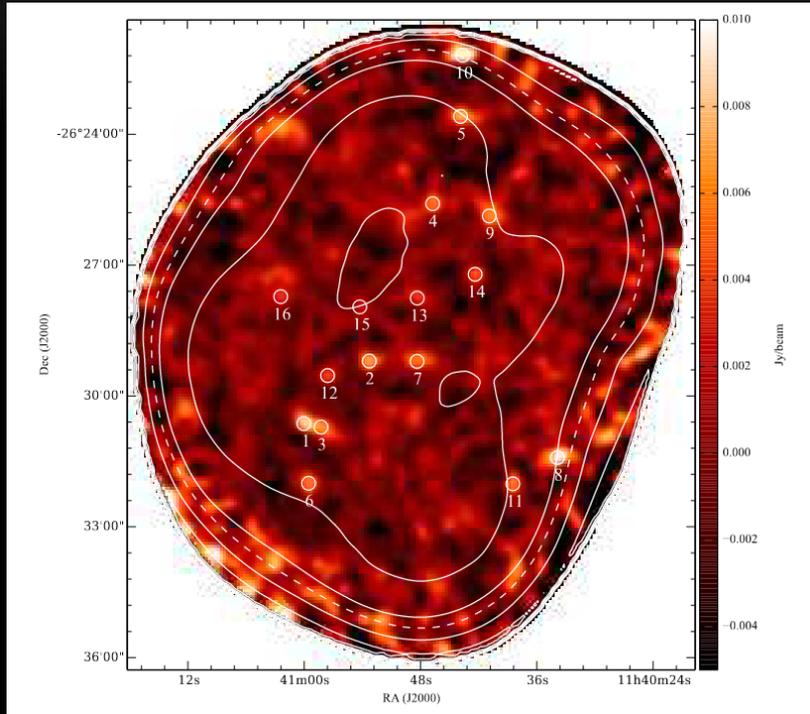
(Contini et al., 2016)



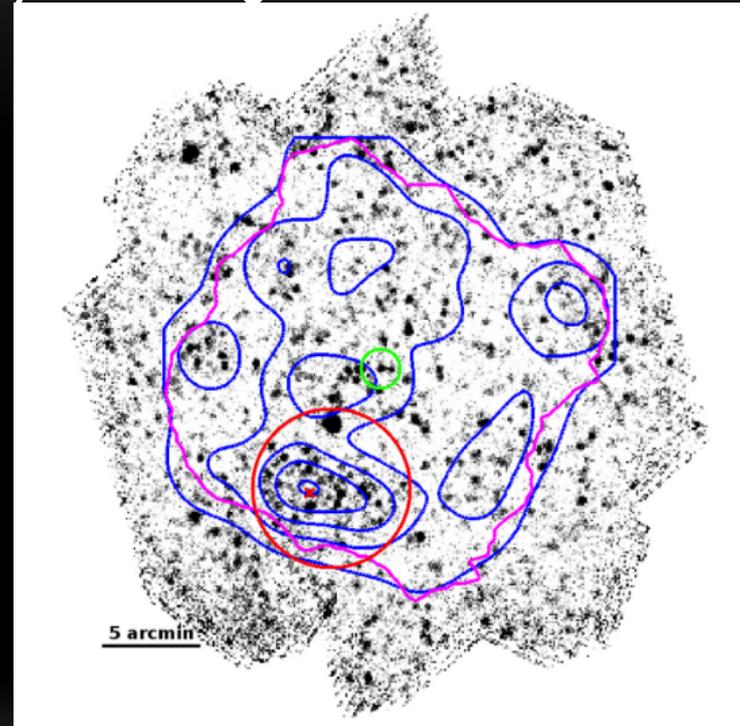
(Muldrew et al., 2015)

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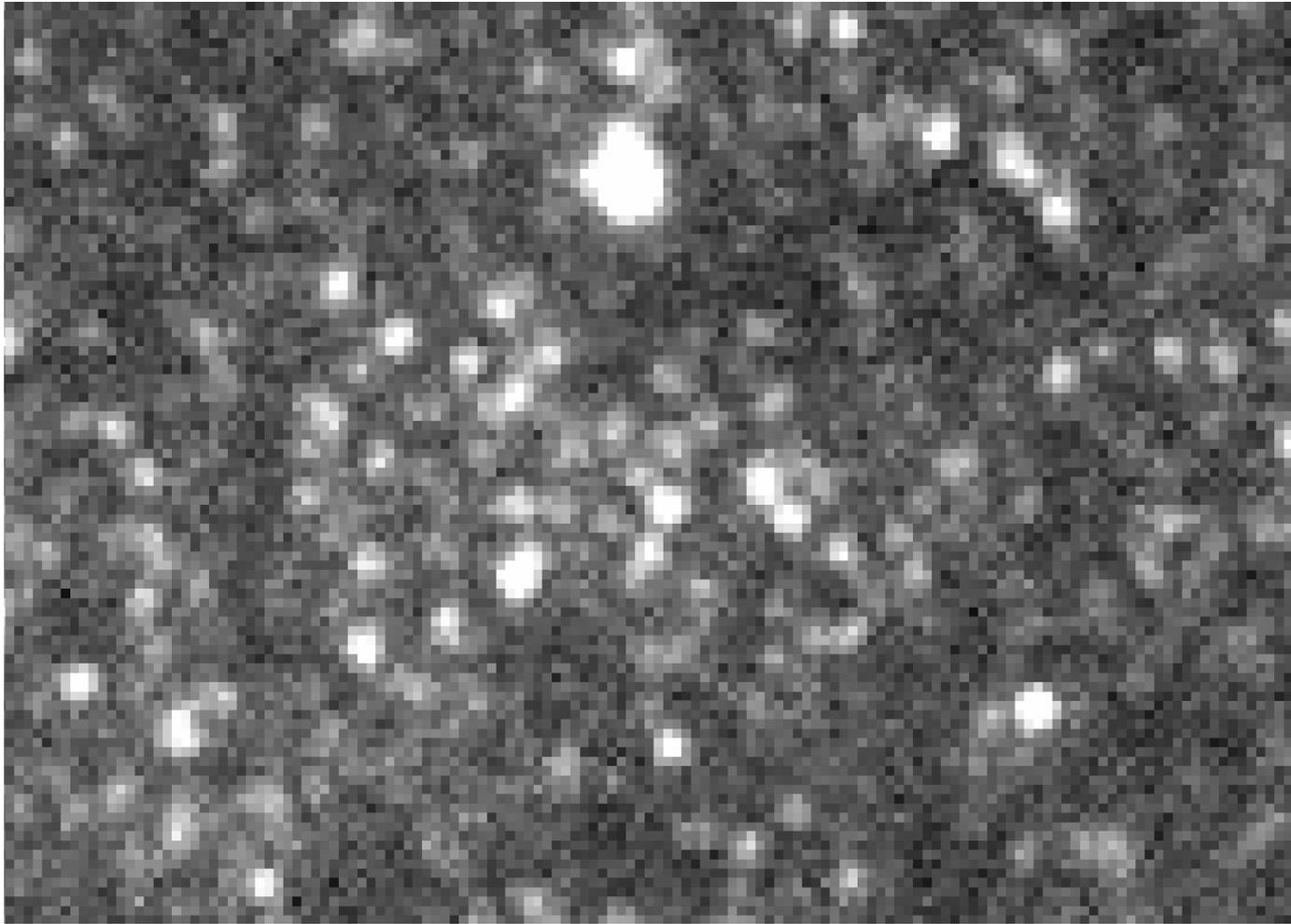
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(Dannerbauer et al., 2014, APEX)

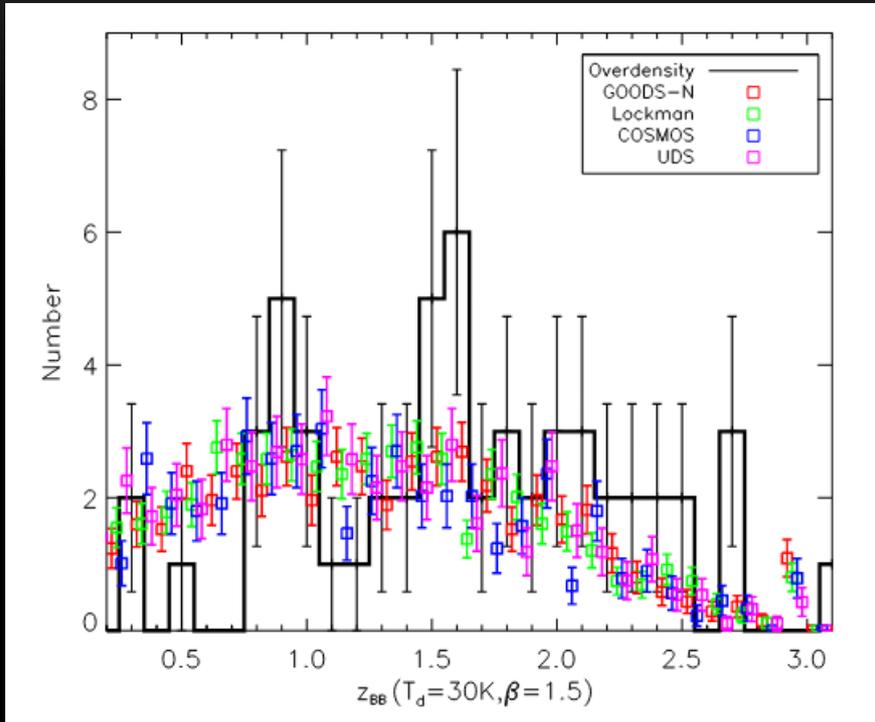


(Valtchanov et al., 2013, Herschel)



-0.02 -0.015 -0.01 -0.005 0.00016 0.0053 0.01 0.016 0.021 0.026 0.031

LSS AROUND THE SPIDERWEB?



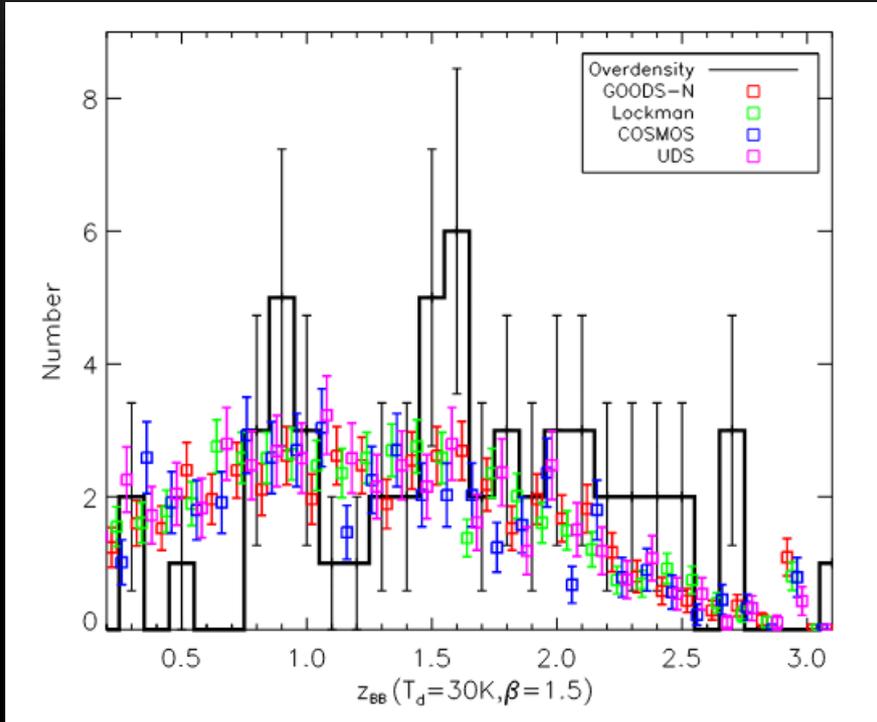
(Valtchanov et al., 2013)

MBB fitting to Herschel photometry with fixed temperature ($T = 30$ K) and dust emissivity index/RJ slope ($\beta=1.5$)

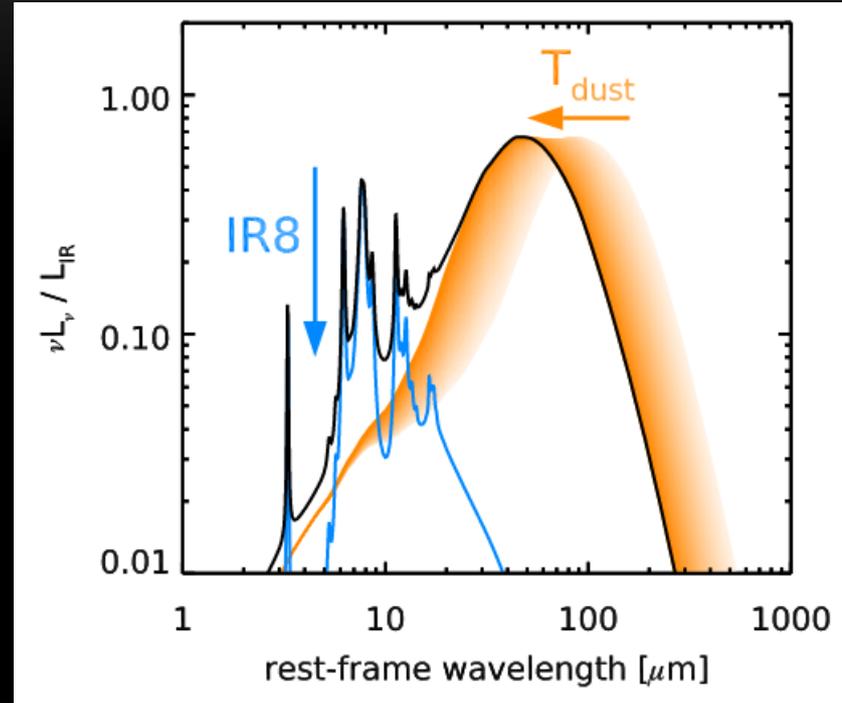
“...there is practically no correlation between the spectroscopic redshift and the derived z_{BB} at $z < 2$...”

“...the location of the z_{BB} peak depends strongly on the assumed dust temperature and could range from 2.33 ($T = 40$ K) to 0.7 ($T = 20$ K)...”

LSS AROUND THE SPIDERWEB?

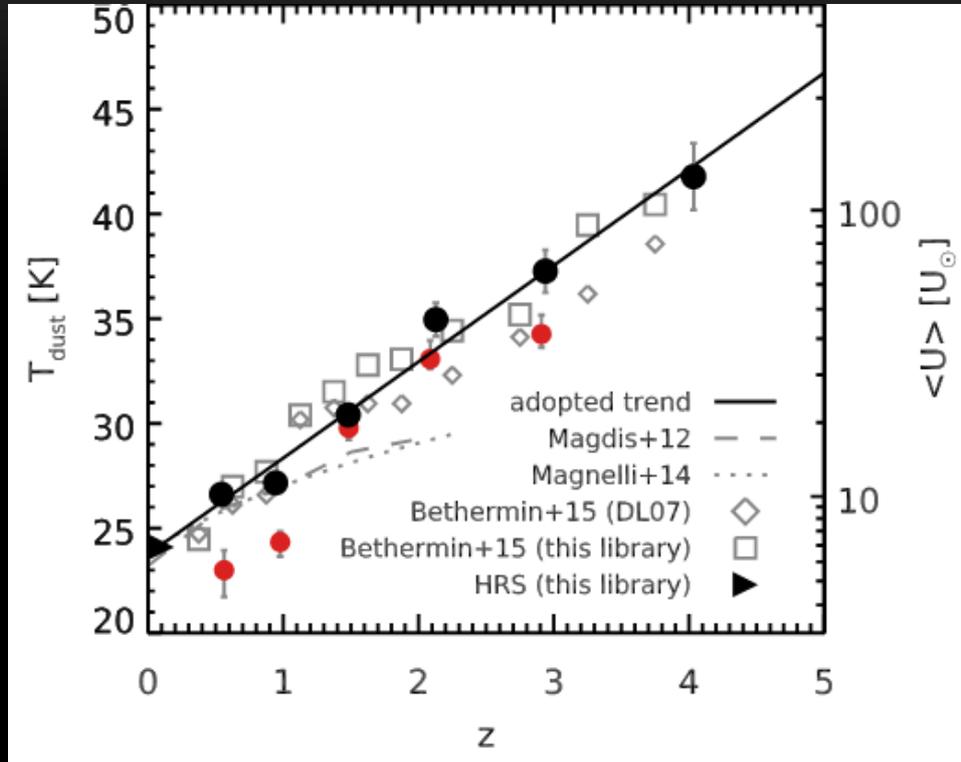


(Valtchanov et al., 2013)



(Schreiber et al., 2018)

LSS AROUND THE SPIDERWEB?



(Schreiber et al., 2018)

LSS AROUND THE SPIDERWEB?

MeerKAT Open Time observations

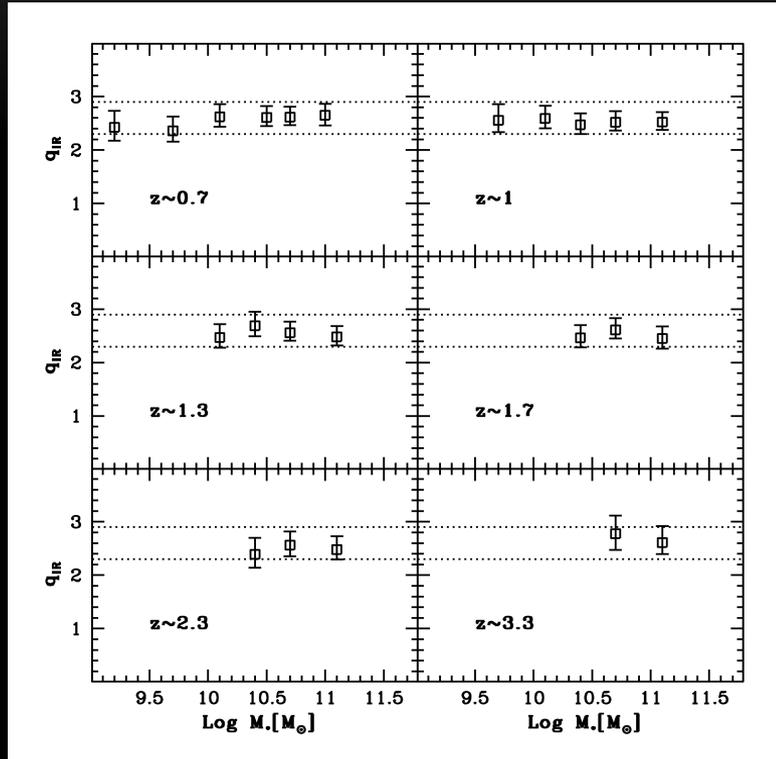


L band 1.28 GHz
FWHP ~ 55 arcmin
8" angular resolution

rms ~ 4 μ Jy/beam

$M_* \sim 8 \cdot 10^{10} M_{\odot} (5\sigma)$

RADIO-FIR CORRELATION

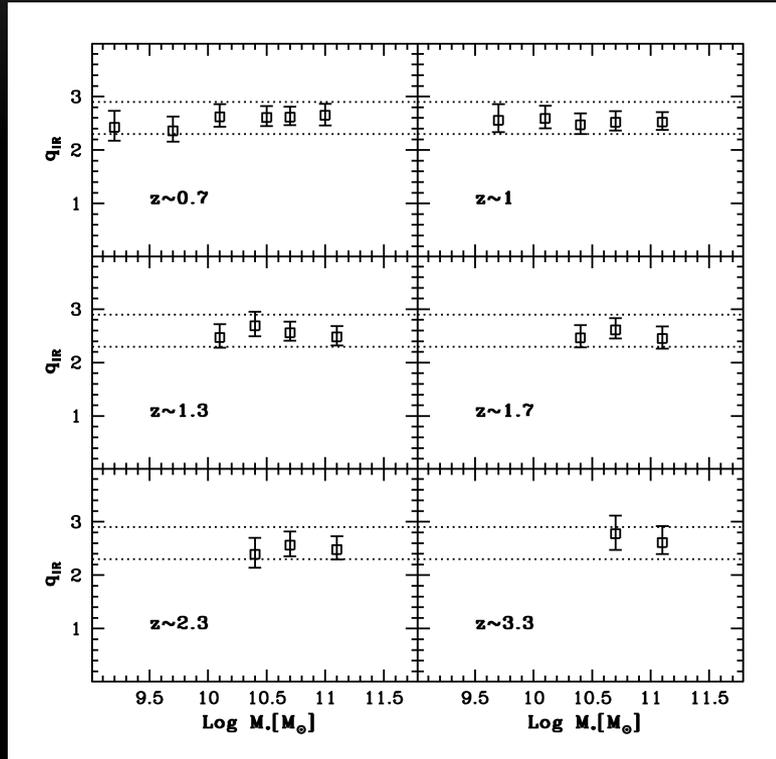


The radio-FIR correlation
Long story short ...

- the correlation holds up to high z
- stays (fairly) constant with redshift...

(MP et al. 2015)

RADIO-FIR CORRELATION

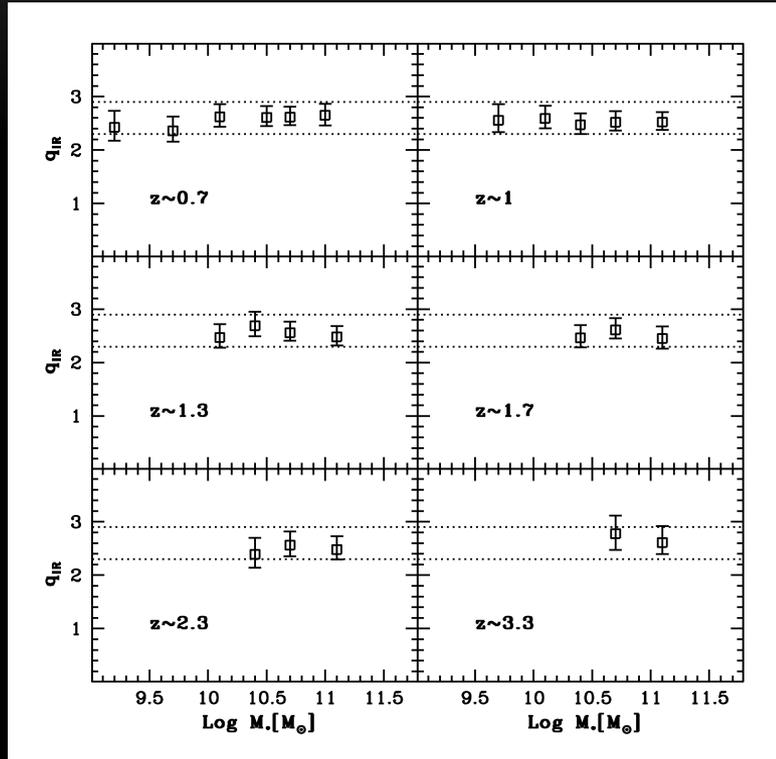


The radio-FIR correlation

- Dust unbiased star formation rates
- Radio AGN – galaxy population

(MP et al. 2015)

RADIO-FIR CORRELATION



(MP et al. 2015)

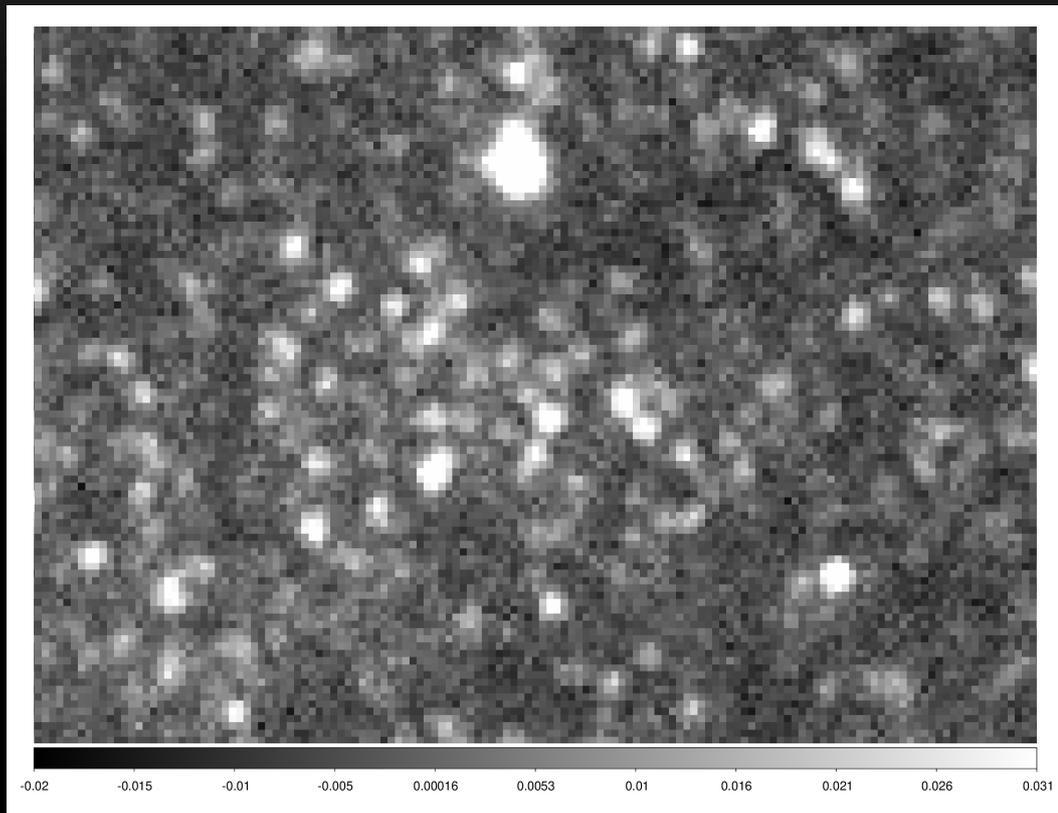
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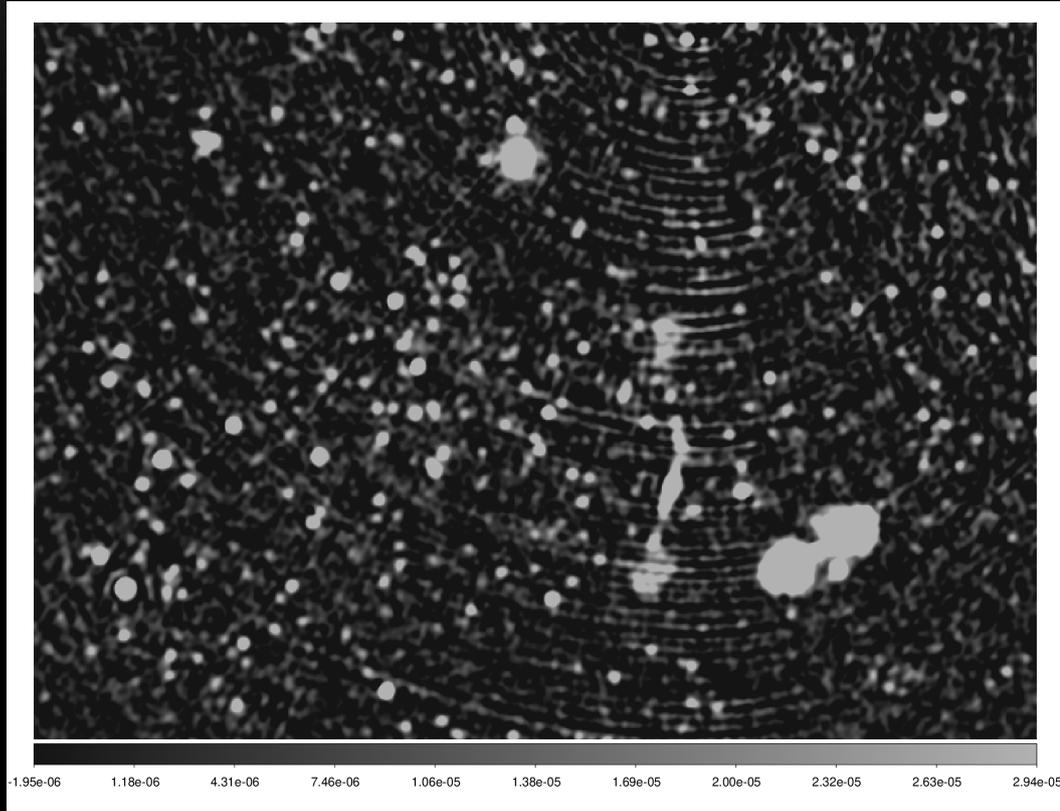
LSS around the Spiderweb

- FIR-radio photo-z (SED dependent)

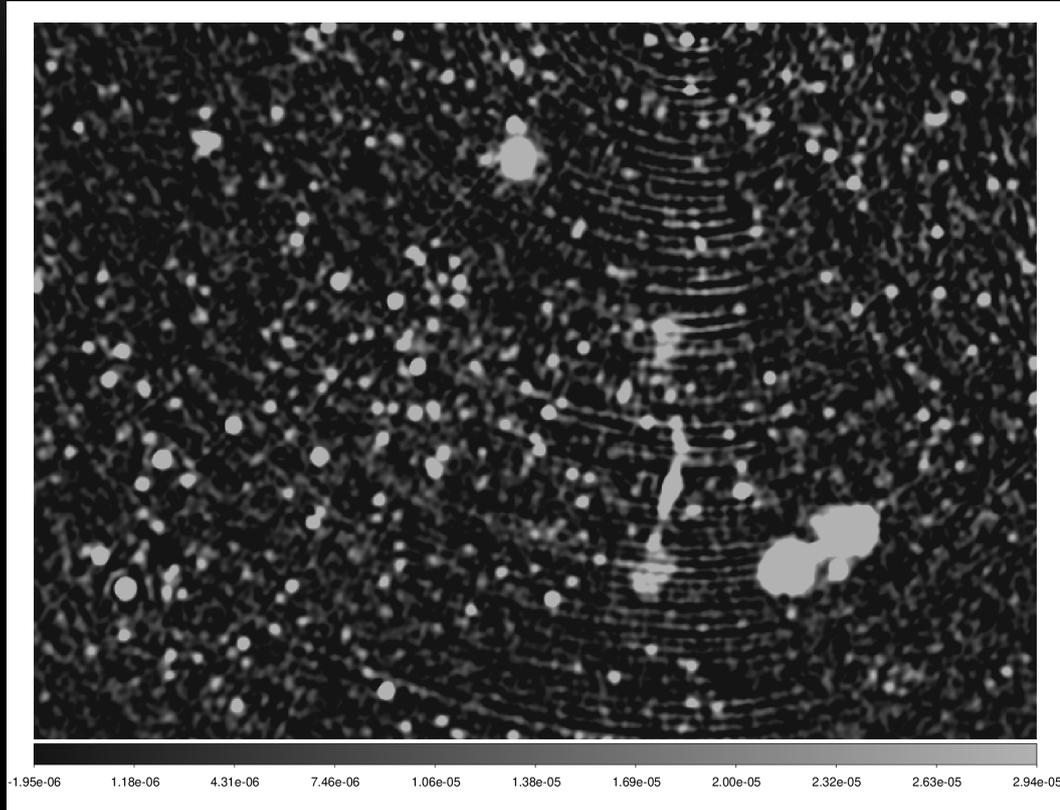
LSS AROUND THE SPIDERWEB?



LSS AROUND THE SPIDERWEB?



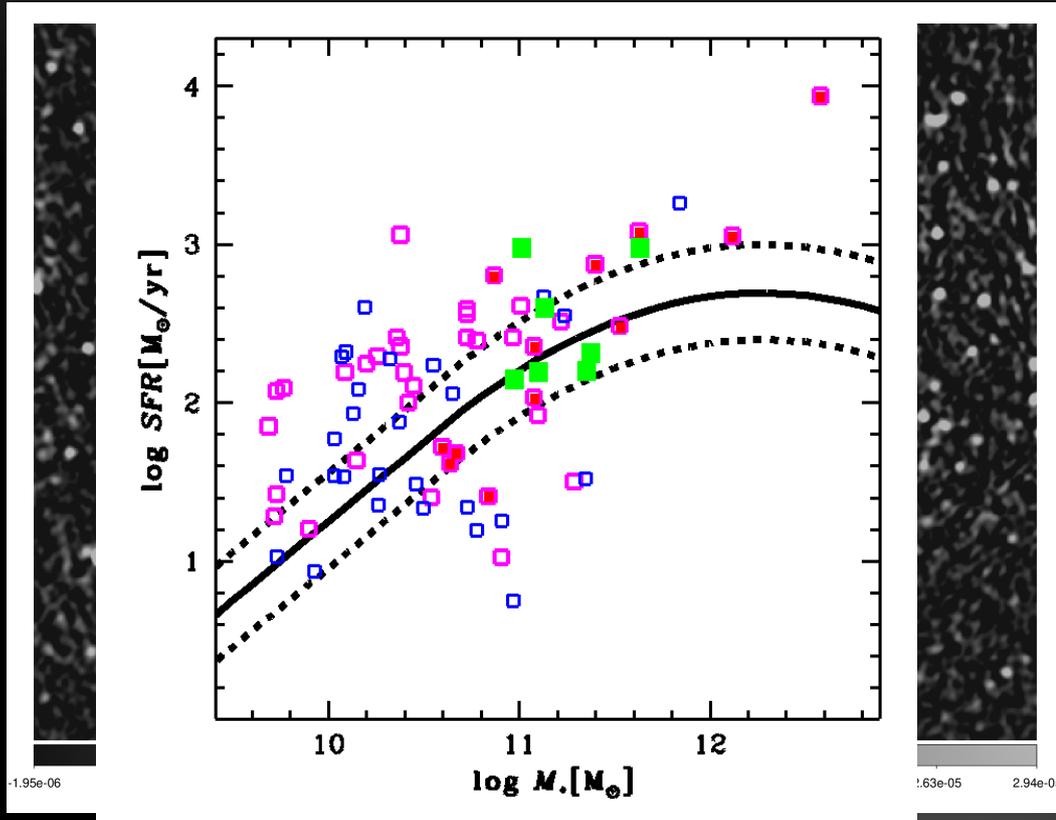
LSS AROUND THE SPIDERWEB?



First results from the FIR-radio analysis show that some of the sources in the Valtchanov+13 overdensity have photo-z consistent with 2.2...

- extending the analysis to the square degree field, including all available multiwavelength data

LSS AROUND THE SPIDERWEB?



First results from the FIR-radio analysis show that some of the sources in the Valtchanov+13 overdensity have photo-z consistent with 2.2...

- extending the analysis to the square degree field, including all available multiwavelength data

THE SPIDERWEB PROTOCLUSTER REBOOTED

On going work to investigate the large scale structure around the Spiderweb:

- Building a multiwavelength catalog to complement FIR-radio photoz
 - + Proprietary NIR (Ks, J) VISTA covering the square degree field
 - + Public DECAM u, Subaru-HSC Y, unWISE 3.6 and 4.5 um dataset
 - + Missing wide optical coverage (Brz Suprime-Cam ~27'x34')

THE SPIDERWEB PROTOCLUSTER REBOOTED

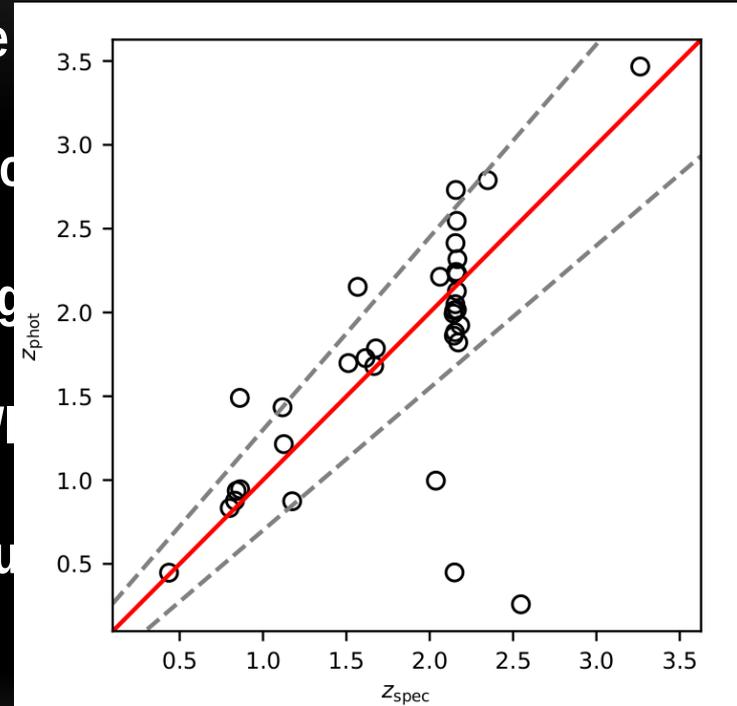
On going work to investigate the large scale

– Building a multiwavelength catalog to co

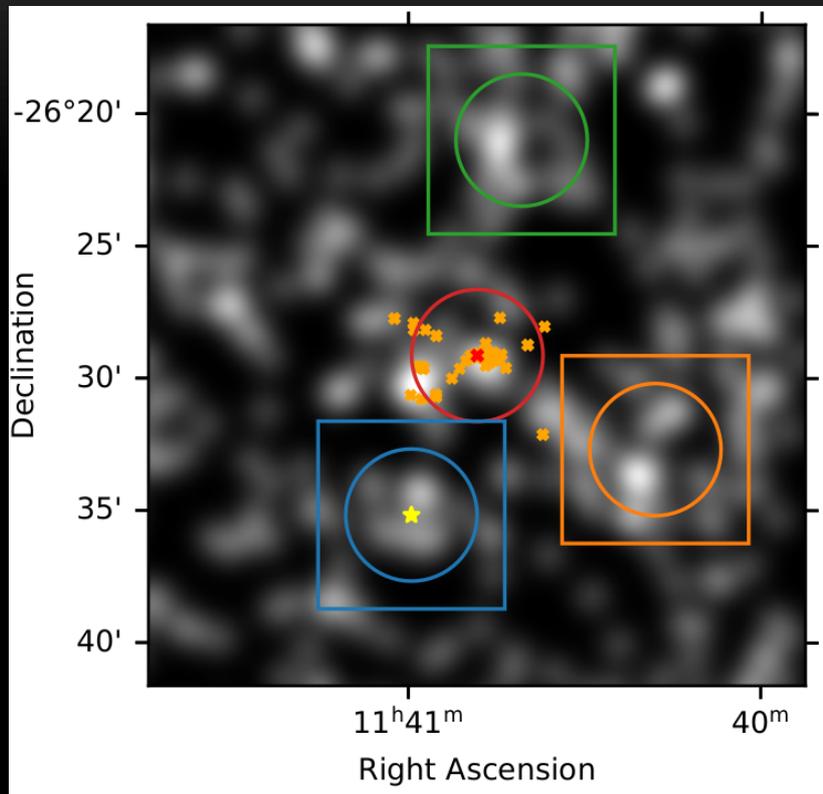
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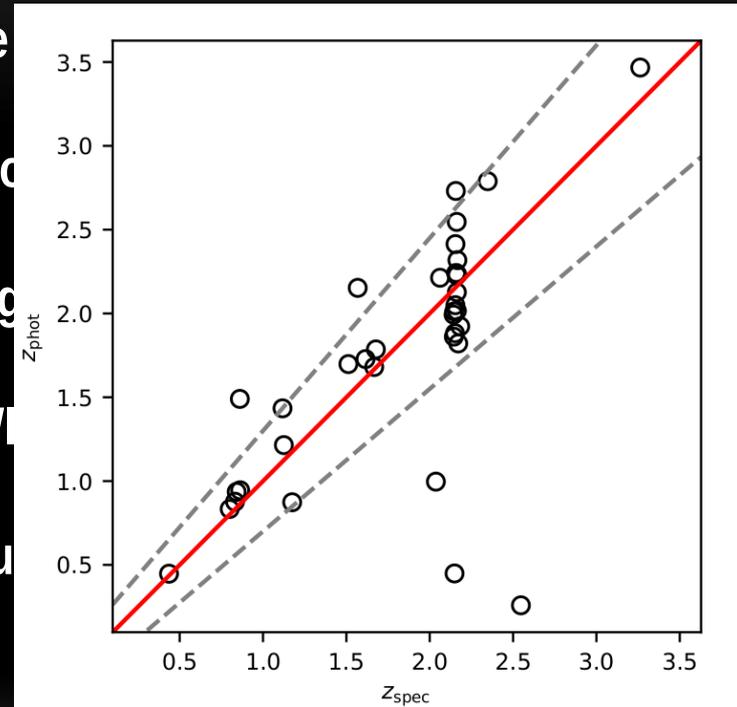
+ Missing wide optical coverage (Brz Su



THE SPIDERWEB PROTOCLUSTER REBOOTED



Large scale
analog to co
covering
C Y, unW
e (grz Su



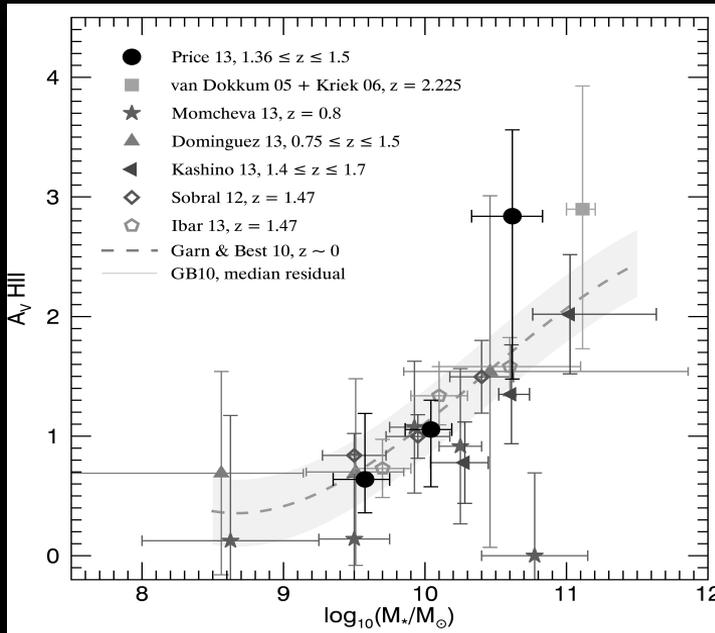
(Lustig et al., in prep)

THE SPIDERWEB PROTOCLUSTER REBOOTED

- Enhanced star formation and black hole growth**
 - Likely due to an excess of available gas in the assembling environment**
 - Deep and wide radio continuum imaging to beat dust attenuation but also to produce a first look tomography of the large scale structure**
 - First results seem to confirm the presence of an extended structure connected to the inner protocluster but more work is needed**
-

DUST ATTENUATION UP TO Z~4

$$A_{UV} = 2.5 \text{ LOG} (\text{SFR}_{IR} / \text{SFR}_{UV} + 1)$$

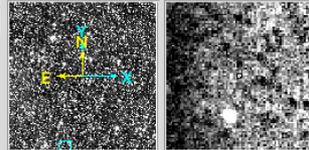


(Price et al., 2013)

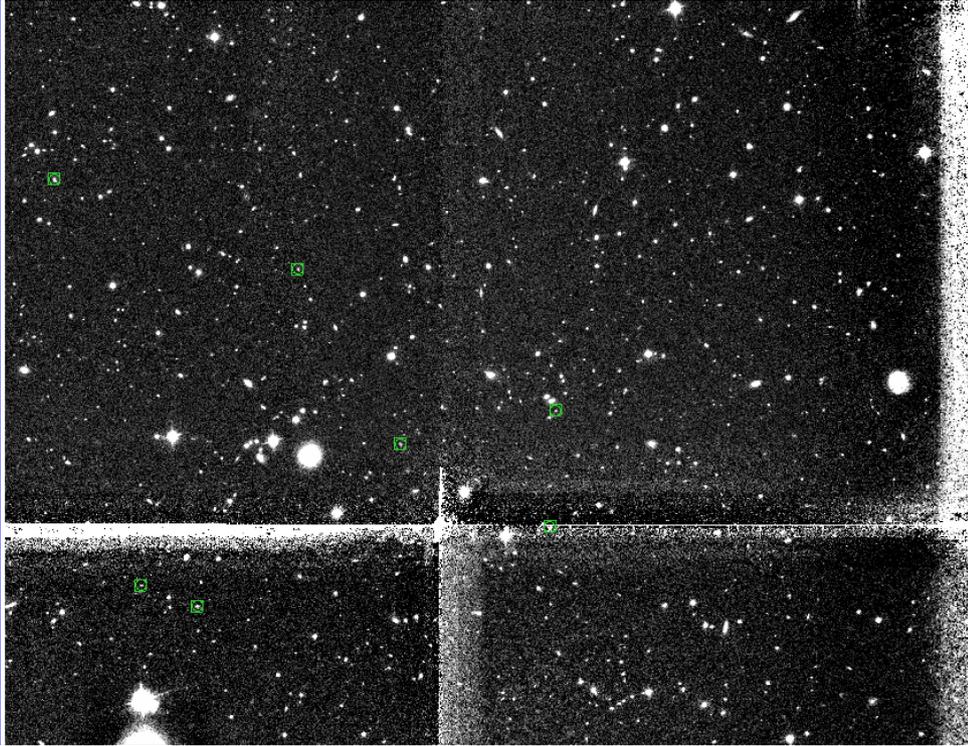
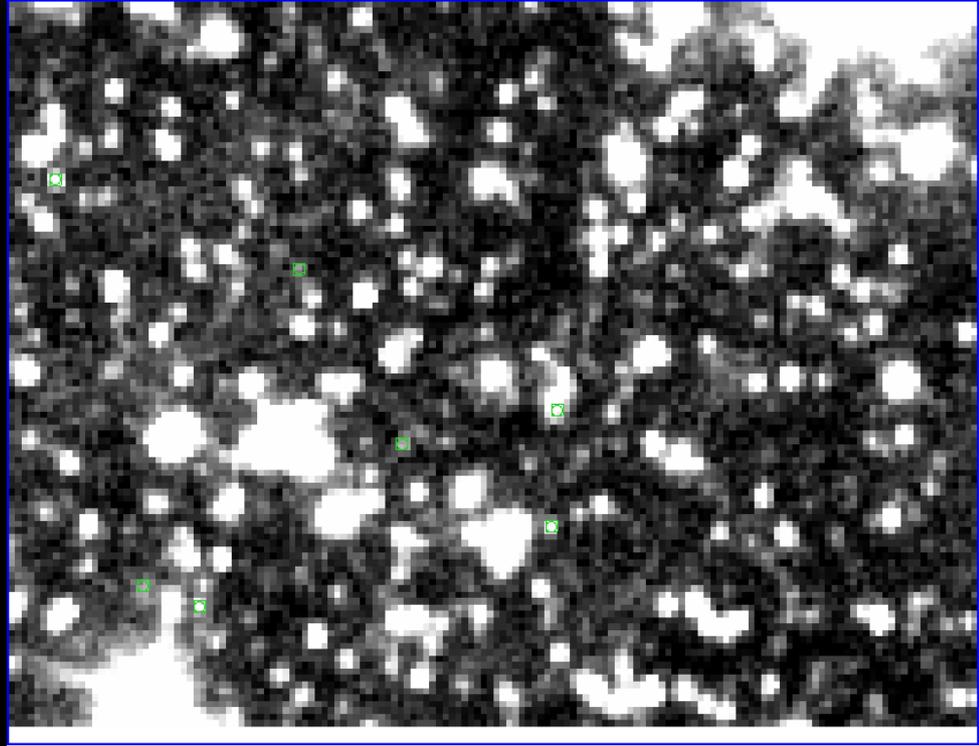
- Garn & Best (2010) on SDSS data
- The correlation between M_* and A_{HII} does not evolve up to $z \sim 1.5$
- The dust attenuation of HII regions do not seem to change with redshift



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Physical	x	2734.76	y 886.928
Image	x	2734.76	y 886.928
Frame 2	x	0.40198	0 °



file	edit	view	frame	bin	zoom	scale	color	region	wcs	analysis	help
linear	log	power	sqrt	squared	asinh	sinh	histogram	min max	zscale		



The Young and the Wild: What happens to Protoclusters forming at $z \approx 4$?

RHEA-SILVIA REMUS,¹ KLAUS DOLAG,^{1,2} and HELMUT DANNERBAUER^{3,4}

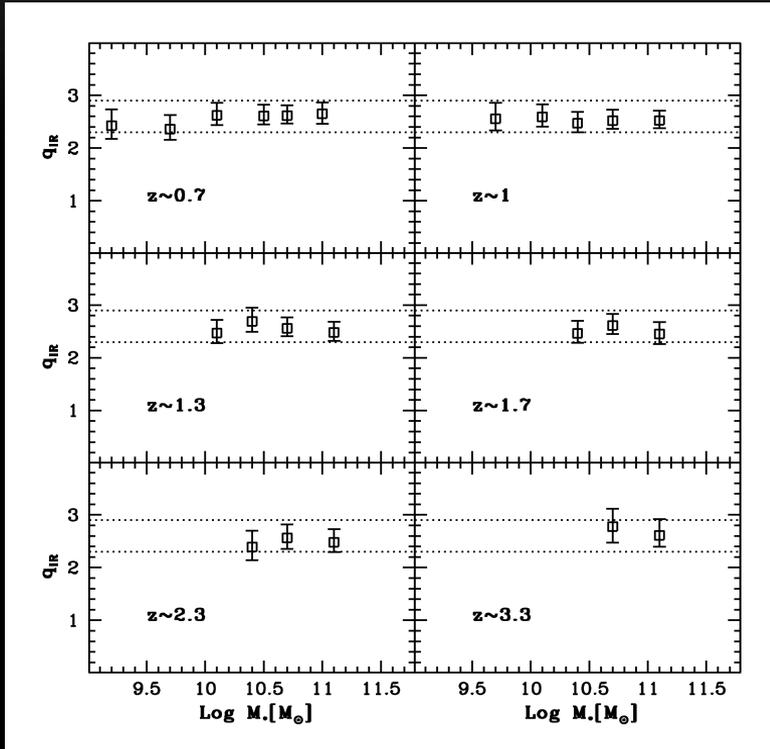
¹*Universitäts-Sternwarte München, Fakultät für Physik, Ludwig-Maximilians-Universität, Scheinerstr. 1, D-81679 München, Germany*

²*Max-Planck-Institute for Astrophysics, Karl-Schwarzschild-Str. 1, D-85748 Garching, Germany*

³*Instituto de Astrofísica de Canarias, E-38205 La Laguna, Tenerife, Spain*

⁴*Universidad de La Laguna Dpto. Astrofísica, E-38206 La Laguna, Tenerife, Spain*

AN UNBIASED VIEW OF THE RADIO-IR CORRELATION UP TO Z~4



(MP et al., 2015 and in prep.)

- The correlation holds up to high redshift
- B field likely increases with redshift
- Main Sequence galaxies keep their “similarity” but they are becoming more bursty with increasing redshift