

Little Red Dot analogues at low-redshift: A window into AGN ionisation at Cosmic Dawn

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Pérez Díaz, A. del Pino

Escape of Lyman radiation from galactic labyrinths
11th April 2025, OAC, Kolymbari, Crete



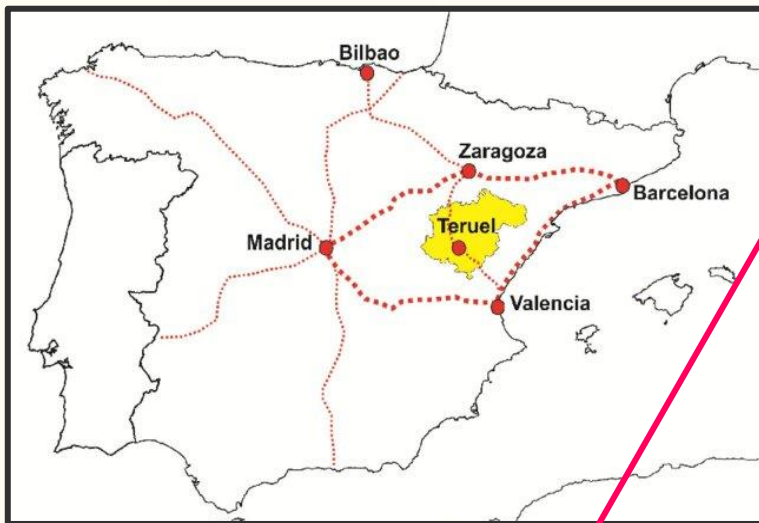


Got ya!!



29 March 2025

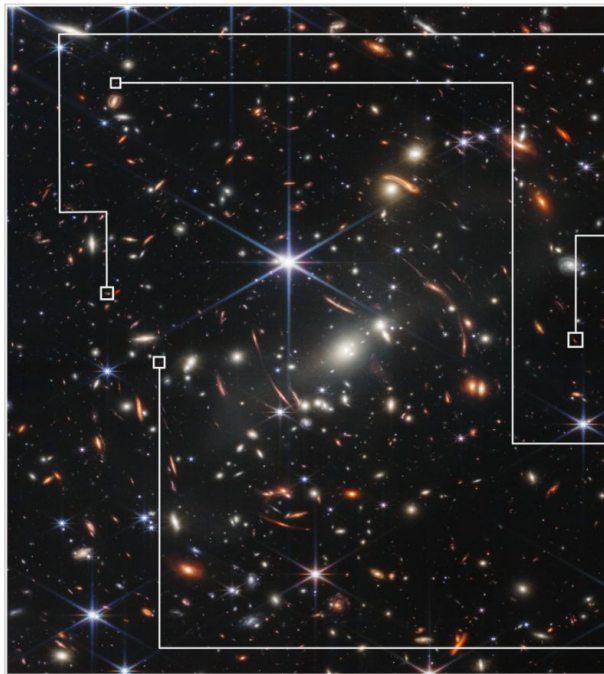
Teruel and the OAJ



A long time ago, in a Universe far, far away...

NIRCam Imaging

GALAXY CLUSTER SMACS 0723



11.3 billion years

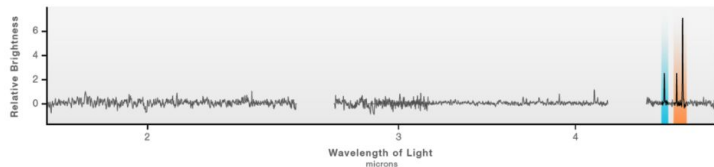
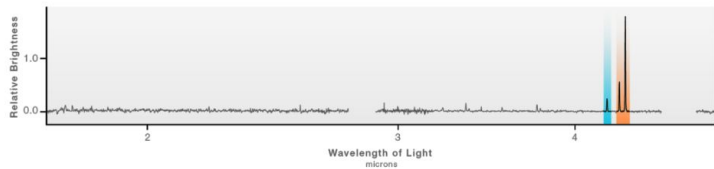
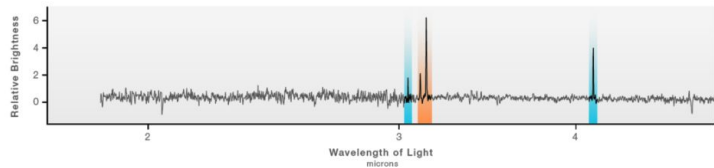
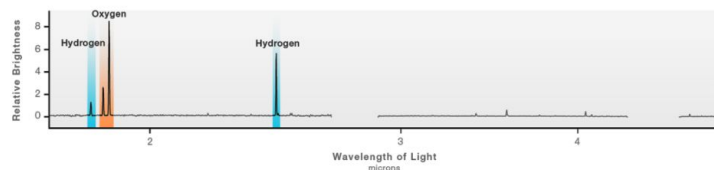
12.6 billion years

13.0 billion years

13.1 billion years

NIRSpect Microshutter Array Spectroscopy

Lowest redshift

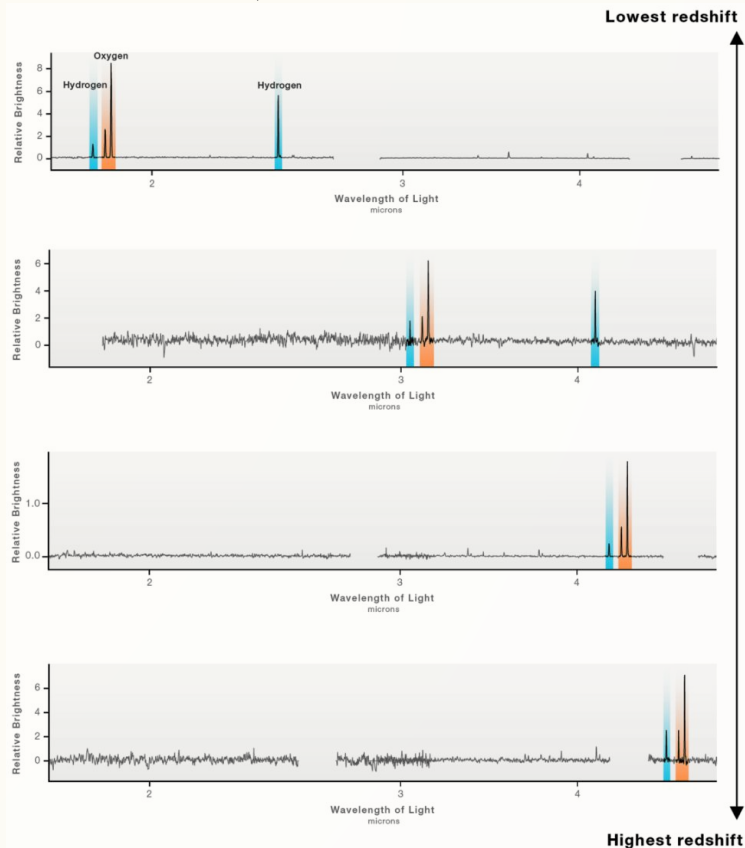


Highest redshift

A long time ago, in a Universe far, far away...

Star-forming galaxies at cosmic dawn are
not so different (e.g. Schaerer+22)

Local analogues (e.g. Tuesday's talks)



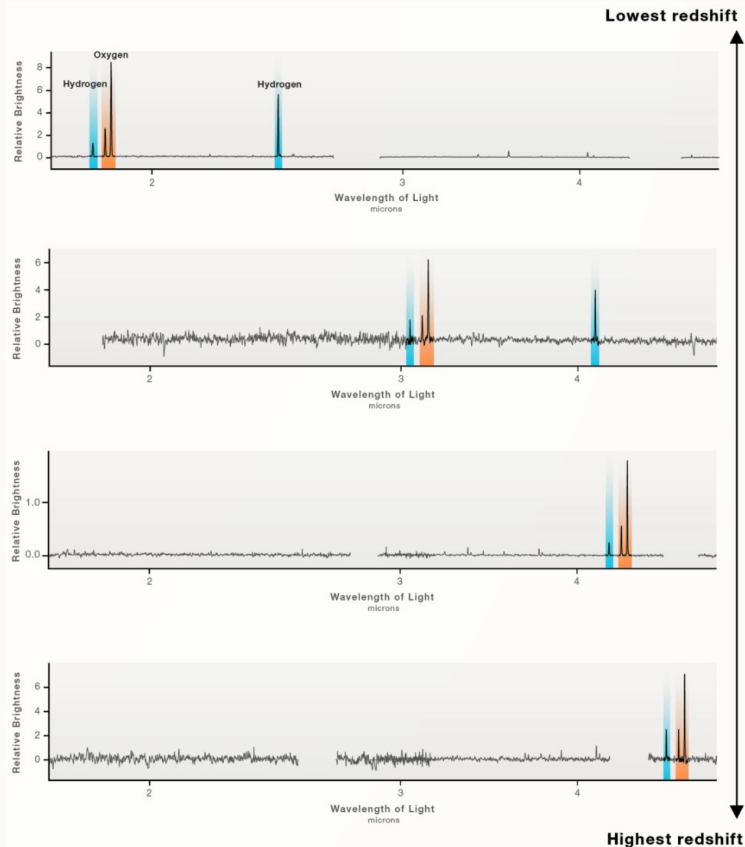
NASA, ESA, CSA, and STScI

A long time ago, in a Universe far, far away...

Star-forming galaxies at cosmic dawn are **not so different** (e.g. Schaerer+22)

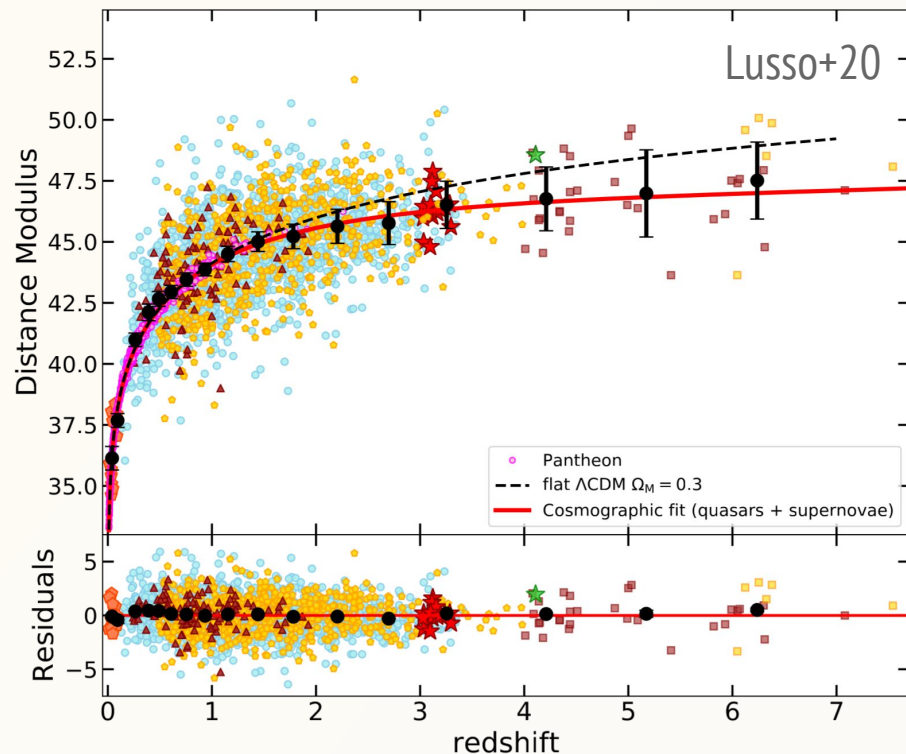
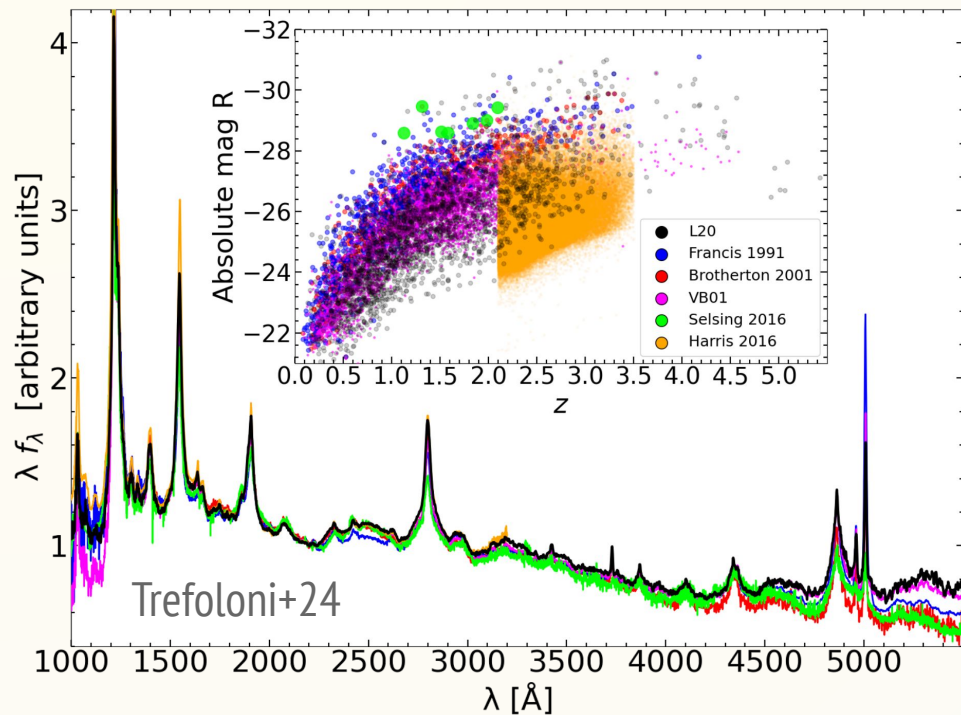
Local analogues (e.g. Tuesday's talks)

Similar **AGNs** to low-z counterparts were **expected**...



NASA, ESA, CSA, and STScI

Quasars as high- z standard candles

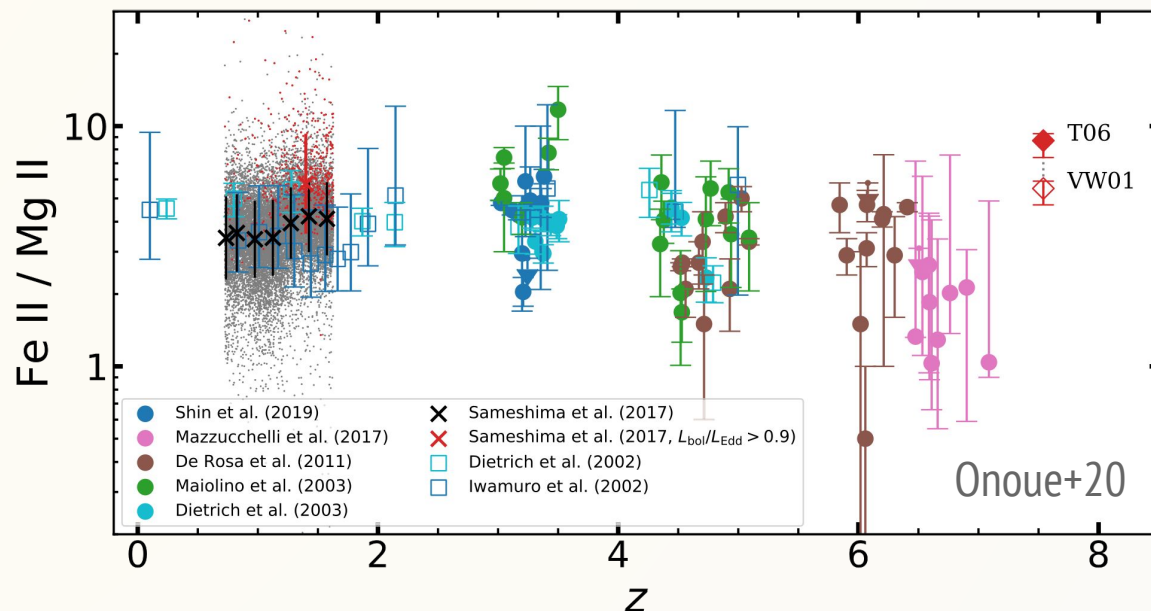




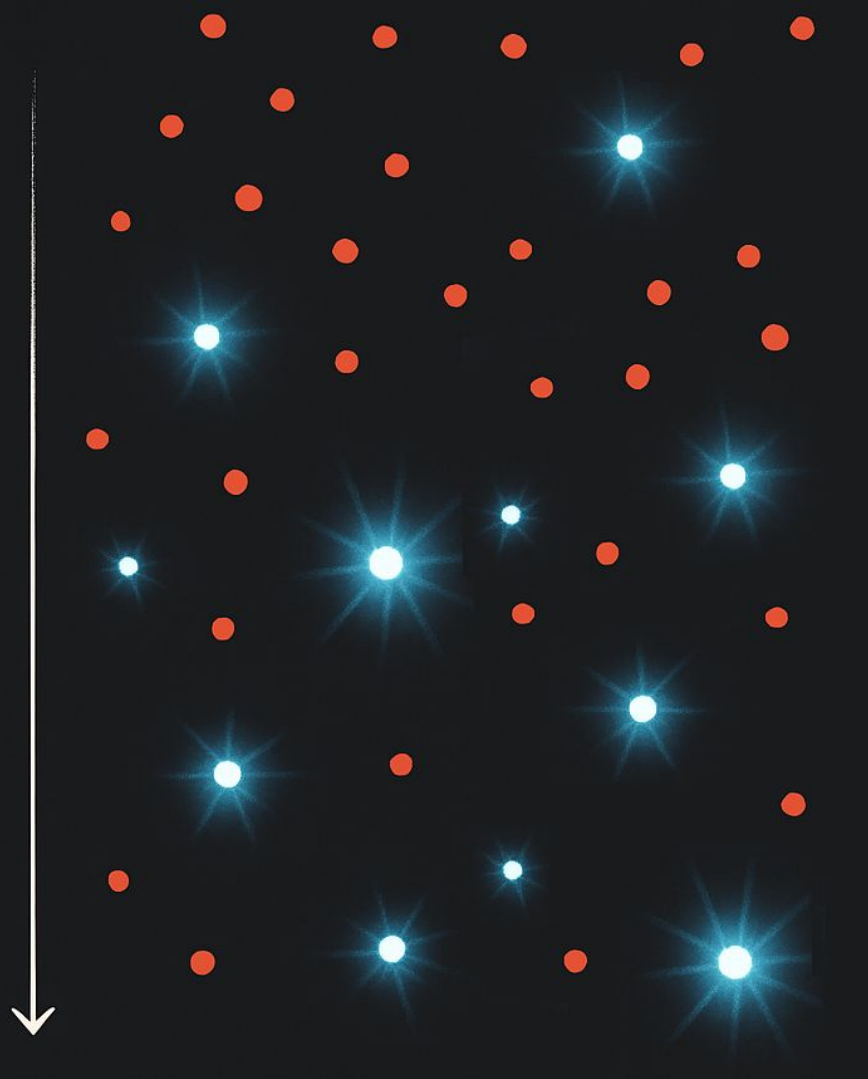
No Redshift Evolution in the Broad-line-region Metallicity up to $z = 7.54$: Deep Near-infrared Spectroscopy of ULAS J1342+0928

Masafusa Onoue¹ , Eduardo Bañados¹ , Chiara Mazzucchelli² , Bram P. Venemans¹ , Jan-Torge Schindler¹ , Fabian Walter¹ , Joseph F. Hennawi³ , Irham Taufik Andika¹ , Frederick B. Davies⁴ , Roberto Decarli⁵ , Emanuele P. Farina^{1,6} , Knud Jahnke¹ , Tohru Nagao⁷ , Nozomu Tominaga^{8,9} , and Feige Wang^{10,11,12}

No chemical evolution
in quasars?



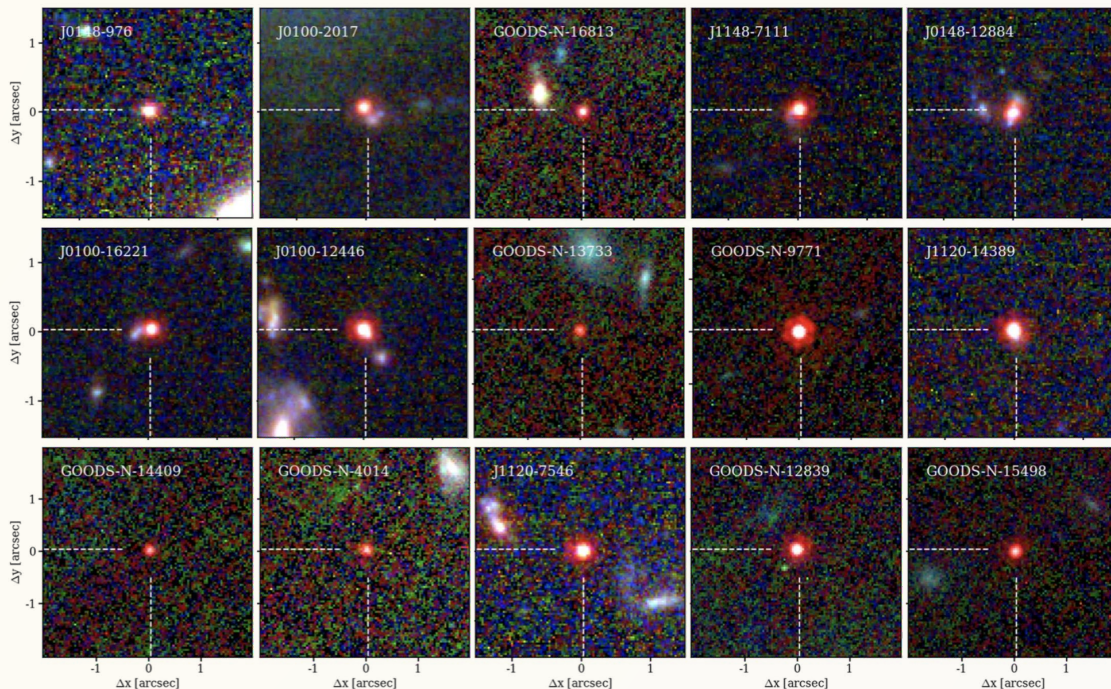
**AGNs of a
different kind?**



An overview of Little Red Dots

Discovered in photometric
JWST surveys

Continuum colour selection



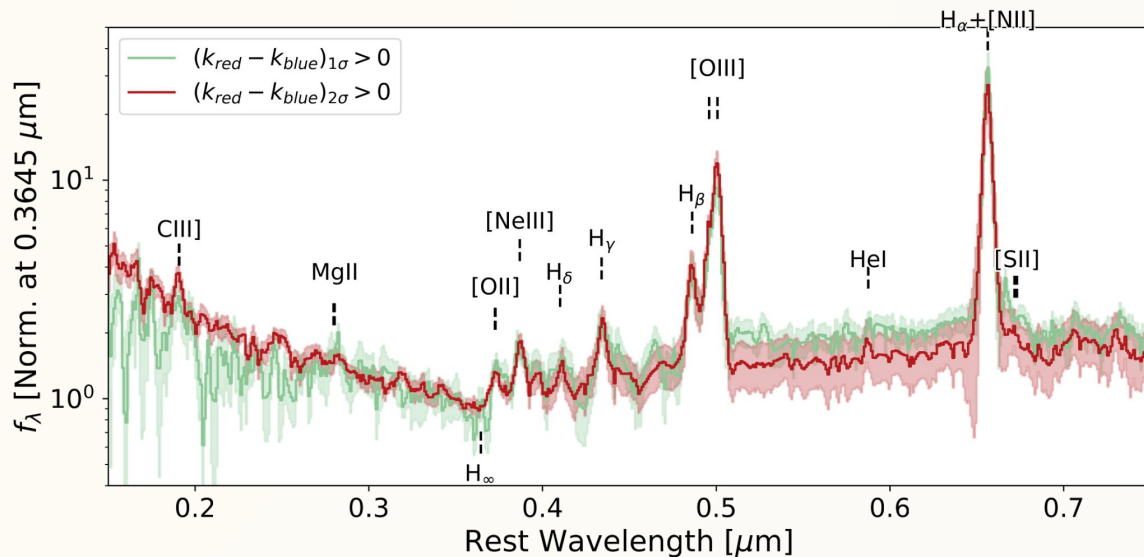
V-shaped continuum

Blue UV + red optical continuum

V-shape at **Balmer break**

$$\beta_{\text{UV}} < -0.37$$

$$\beta_{\text{opt}} > 0$$



Setton+24, Kokorev+24

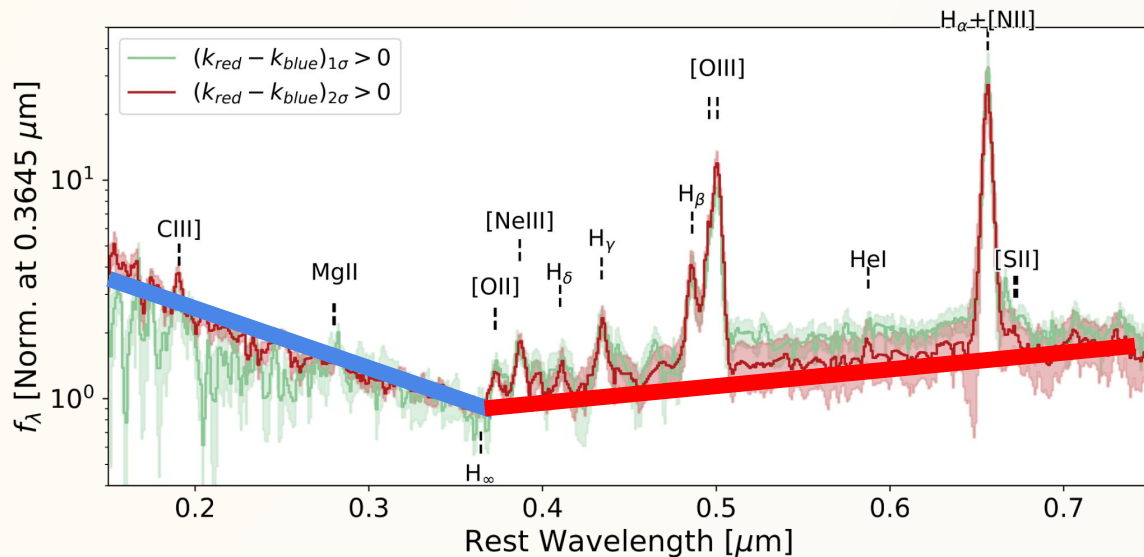
V-shaped continuum

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V-shape at **Balmer break**

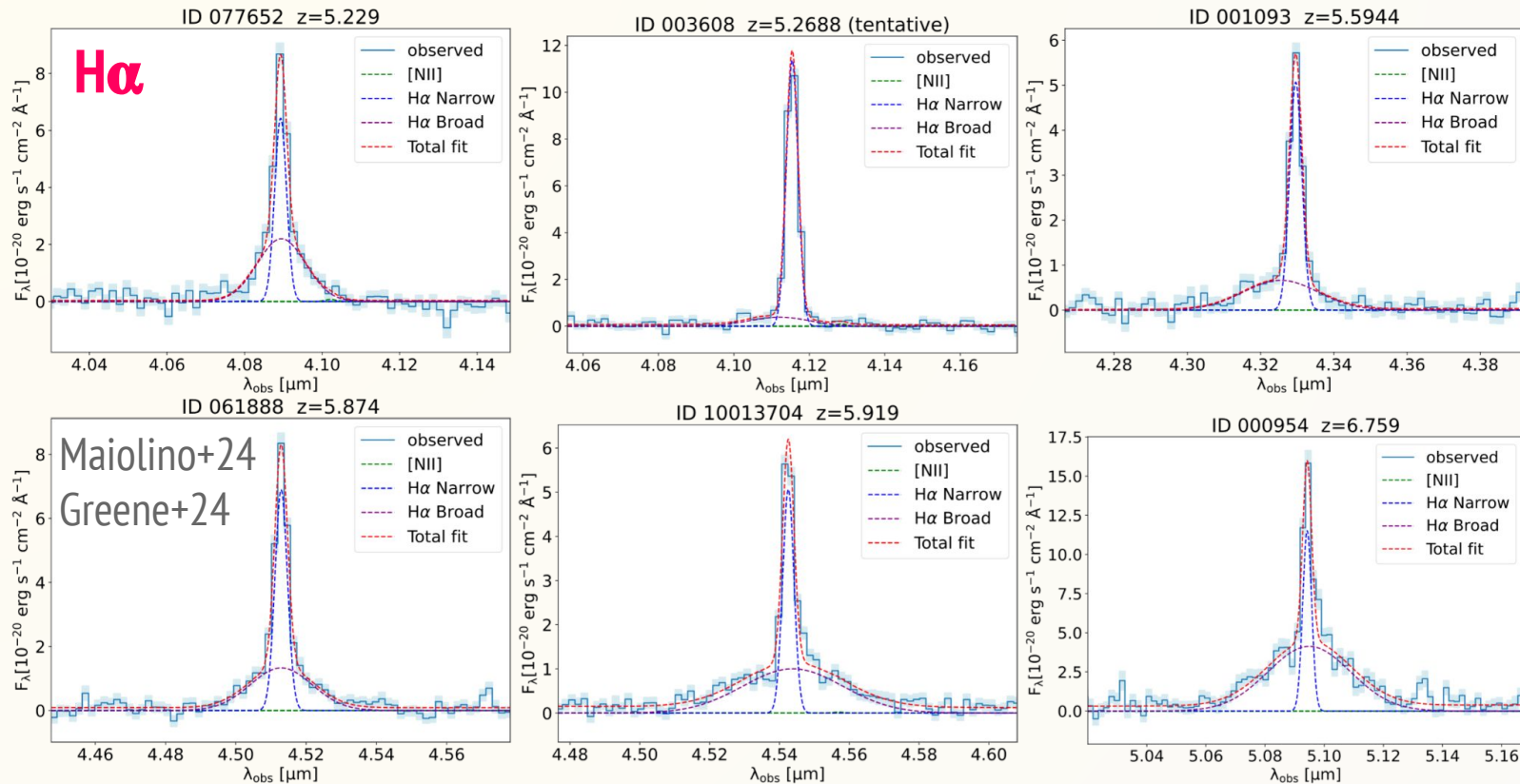
$$\beta_{\text{UV}} < -0.37$$

$$\beta_{\text{opt}} > 0$$



Setton+24, Kokorev+24

Broad emission lines ($\gtrsim 80\%$ of ●)

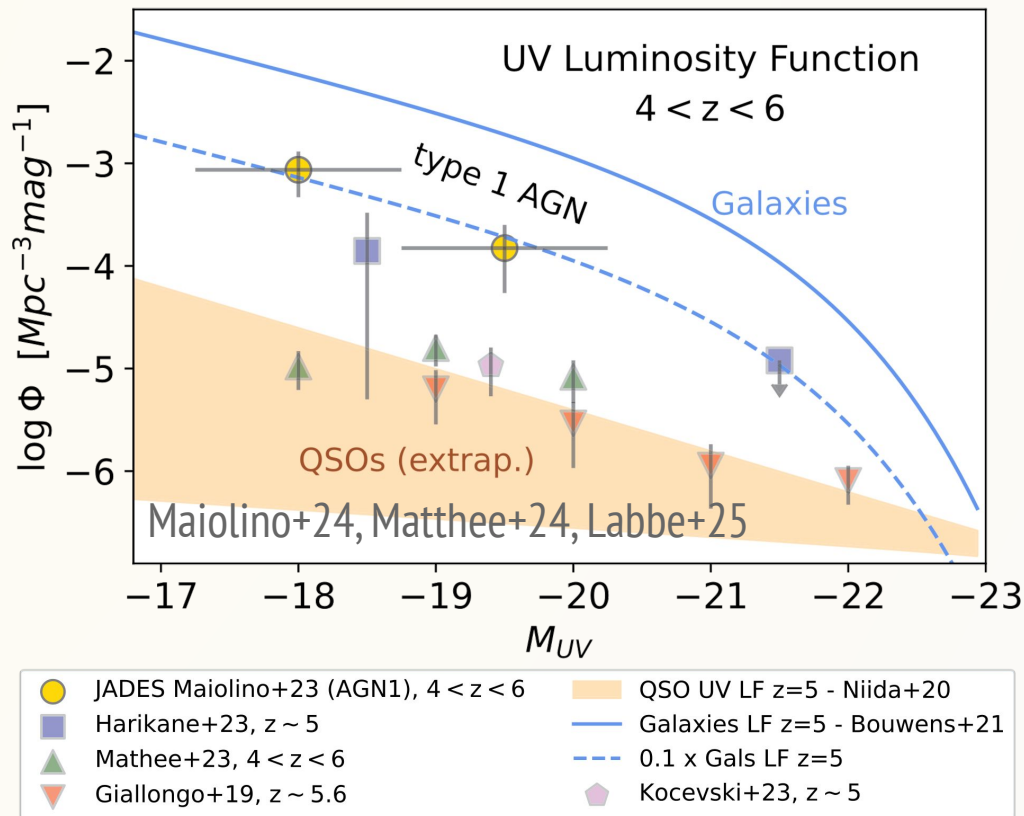


Most numerous AGN class at $4 < z < 8$

Moderate-luminosity AGN population
(few hundreds)

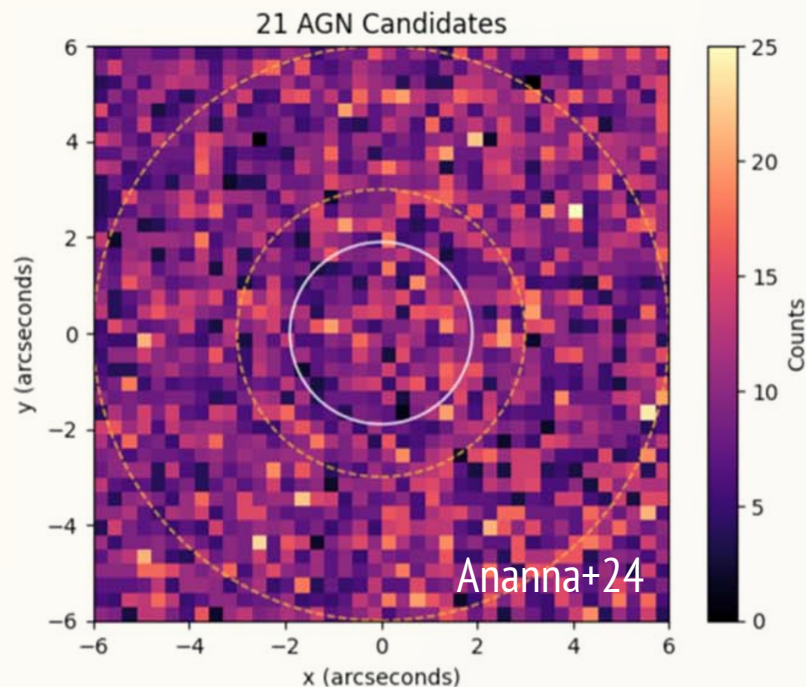
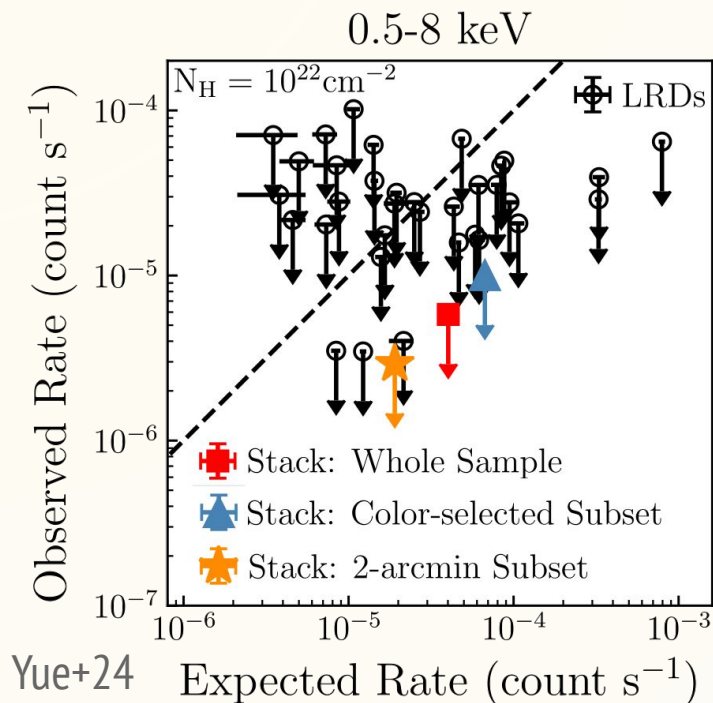
Dominate AGN number density $4 < z < 8$

~10% of galaxy population



Faint X-rays and radio continuum

Faint, mostly undetected in **X-rays**. Radio quiet (Perger+25)



Faint X-rays and radio continuum

Faint, mostly undetected in **X-rays**. Radio quiet (Perger+25)

A&A, 693, L2 (2025)

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**Astronomy
&
Astrophysics**

LETTER TO THE EDITOR

Deep silence: Radio properties of little red dots

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² CSFK, MTA Centre of Excellence, Konkoly-Thege Miklós út 15-17, 1121 Budapest, Hungary

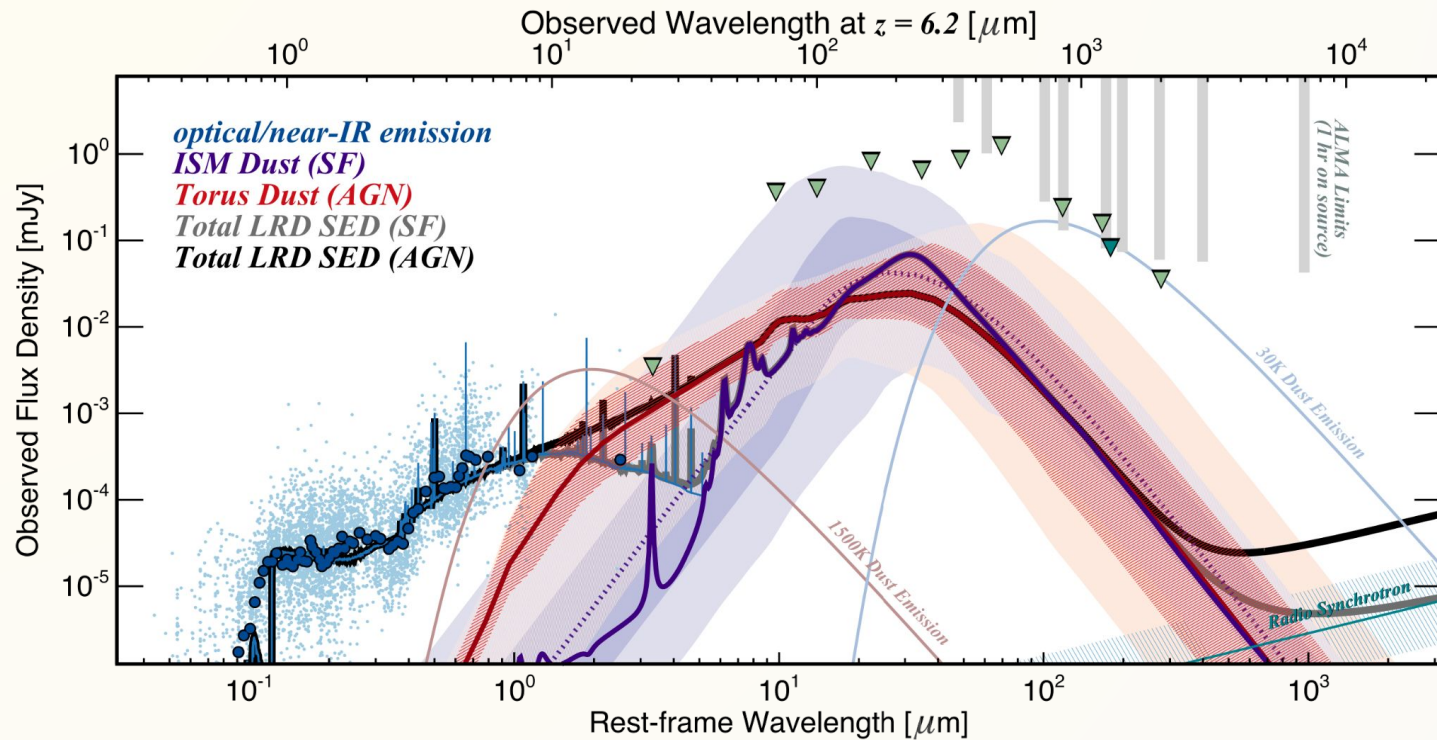
³ Institute of Physics and Astronomy, ELTE Eötvös Loránd University, Pázmány Péter sétány 1/A, 1117 Budapest, Hungary

⁴ Department of Astronomy, Institute of Physics and Astronomy, ELTE Eötvös Loránd University, Pázmány Péter sétány 1/A, 1117 Budapest, Hungary

⁵ HUN-REN–ELTE Extragalactic Astrophysics Research Group, ELTE Eötvös Loránd University, Pázmány Péter sétány 1/A, 1117 Budapest, Hungary

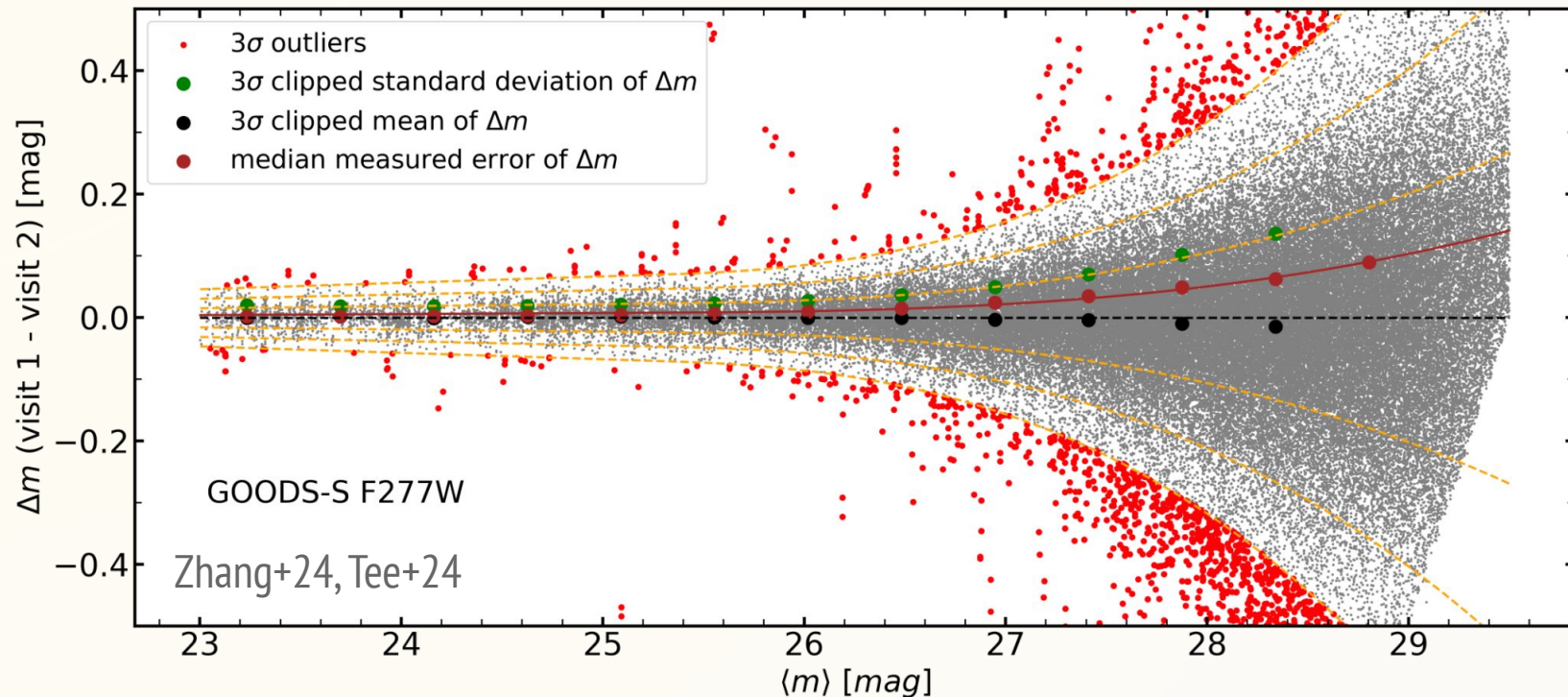
Not so red after all...

Faint continuum in the mid- to far-IR restframe range



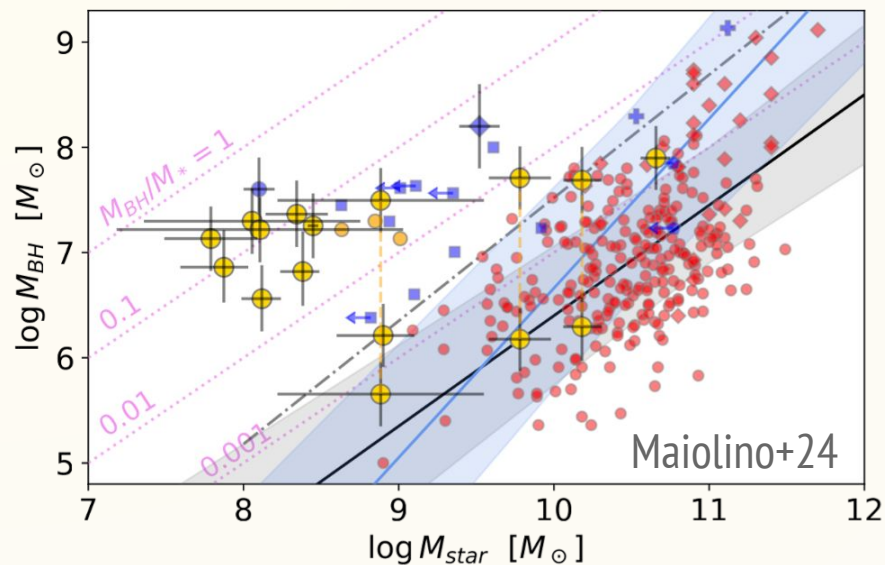
Casey+24
Setton+25

Minor variability



Overmassive black holes ($M_{\text{BH}} - M_{\star}$)

Tripodi+24, Maiolino+24, Durodola+24, Graham+25



High redshift

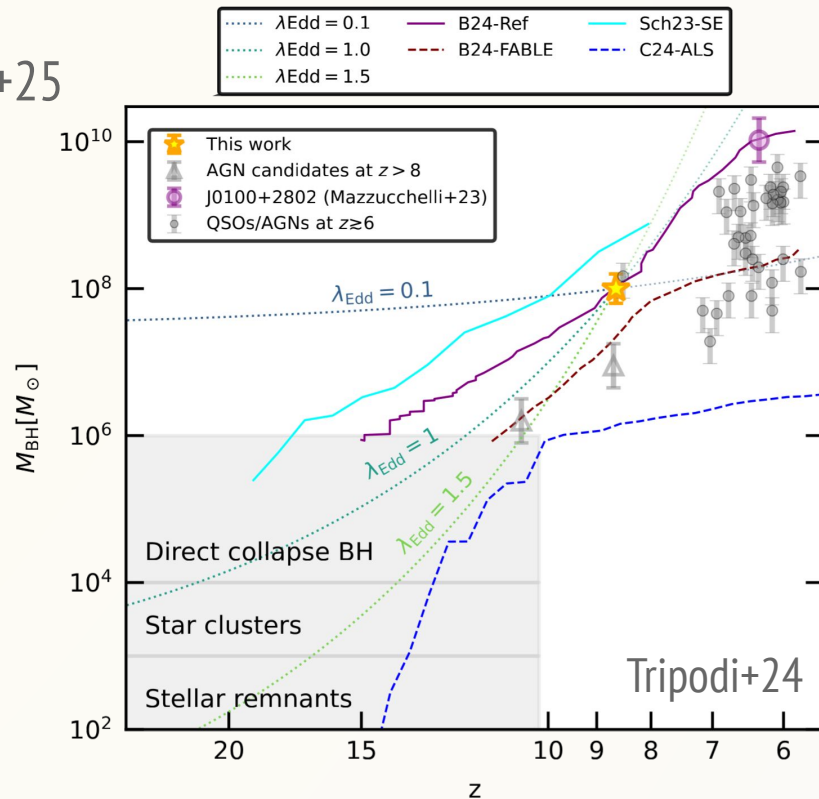
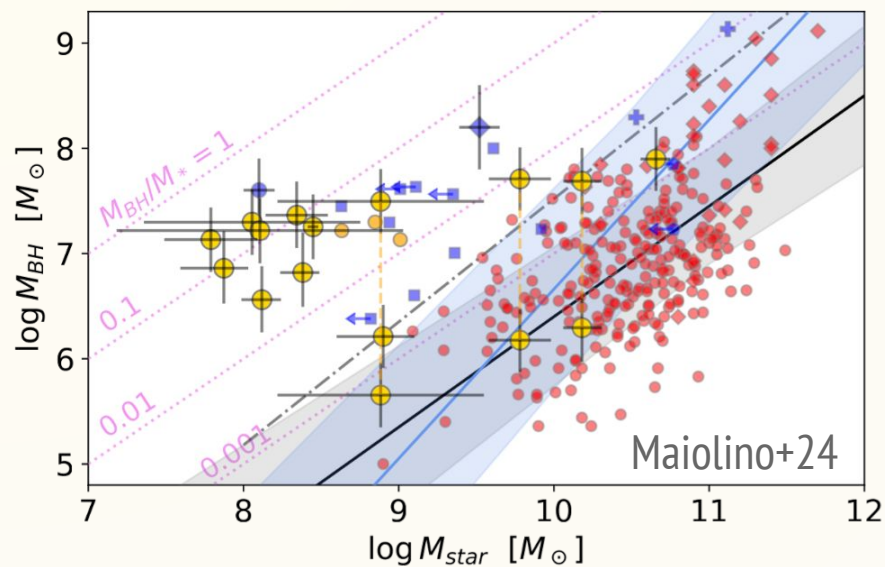
- JADES Maiolino+23, $4 < z < 11$
- JADES cand. merging BH
- JADES max M_{\star}
- JADES rot-corr
- Harikane+23, $4 < z < 7$
- ◆ Kocevski+23, $z \sim 5$
- ◆ Übler+23, $z = 5.5$
- ◆ Ding+22, $z \sim 6.4$
- Bogdan/Goulding+23, $z = 10.1$
- ▲ Izumi+19, $z \sim 6.5$

Local

- Reines+Volonteri 15
- ◆ Greene+20
- ▲ Bennert+21
- Kormendy+Ho 13
- Reines+Volonteri 15
- Greene+20
- const. M_{BH}/M_{\star} ratios
- Bennert+21
- .-.- Kormendy+Ho 13

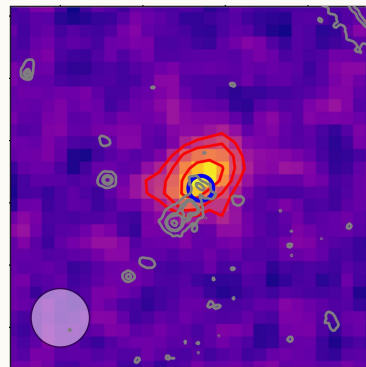
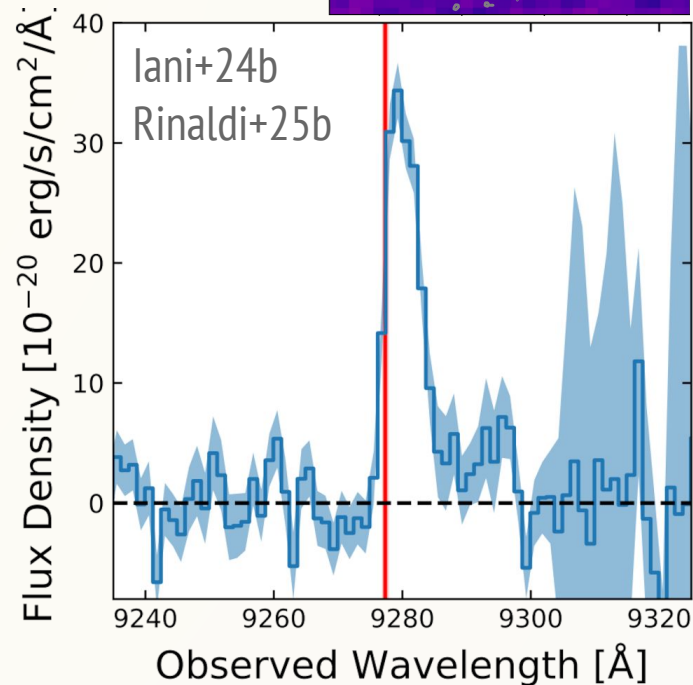
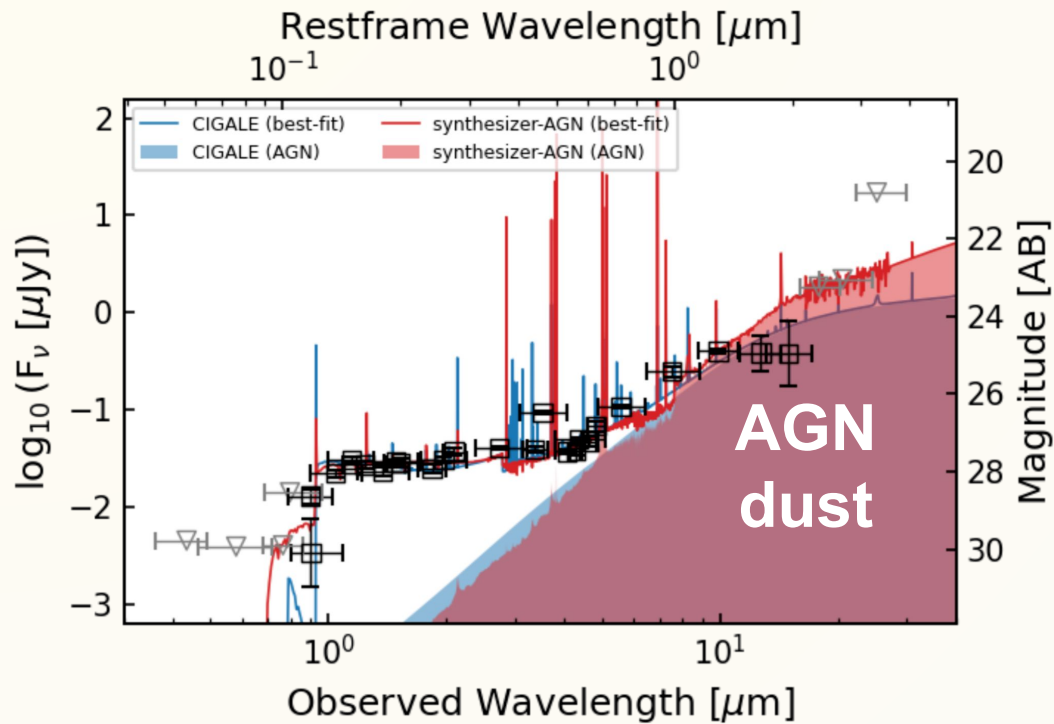
Overmassive black holes ($M_{\text{BH}} - M_{\star}$)

Tripodi+24, Maiolino+24, Durodola+24, Graham+25



Contribution to reionisation?

Virgil, a Red Dot LAE at $z = 6.6$



Red Dots in the neighbourhood?



Red Dots in the neighbourhood?

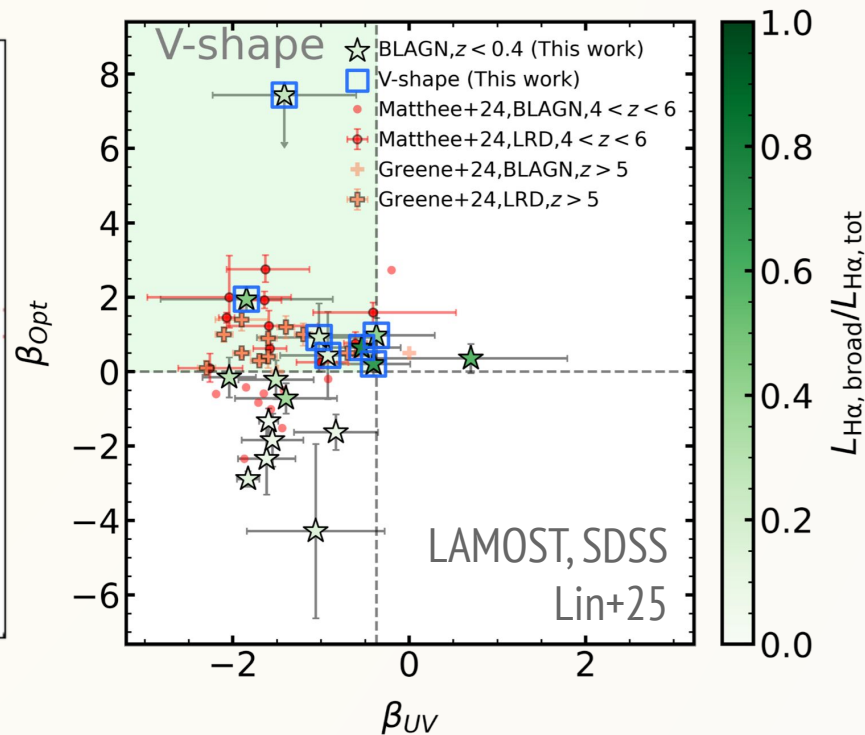
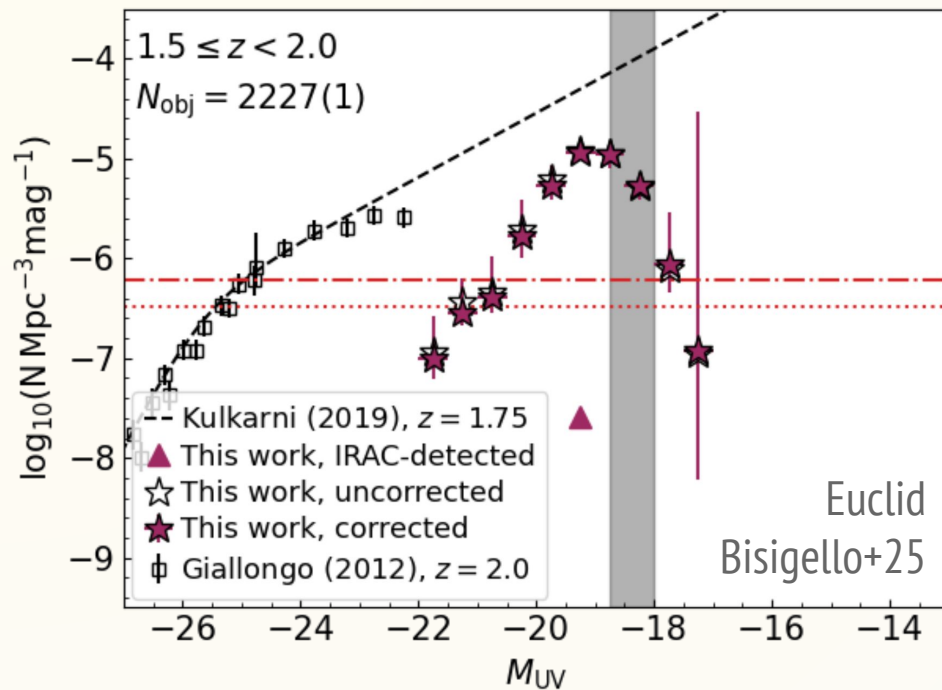
DESI Early Data Release

EELGs selected with **K-means** clustering (**Ricardo's talk**)

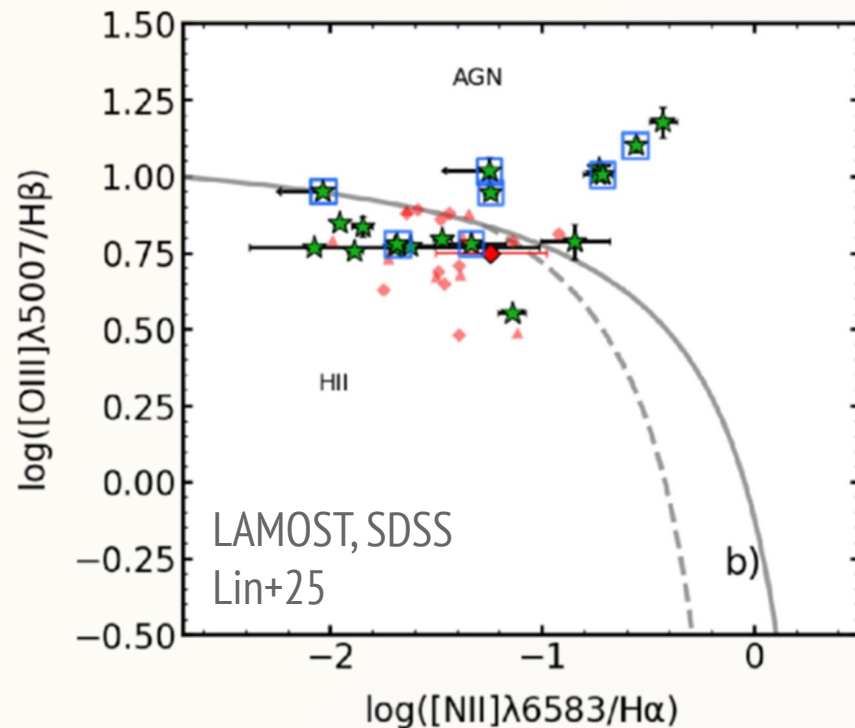
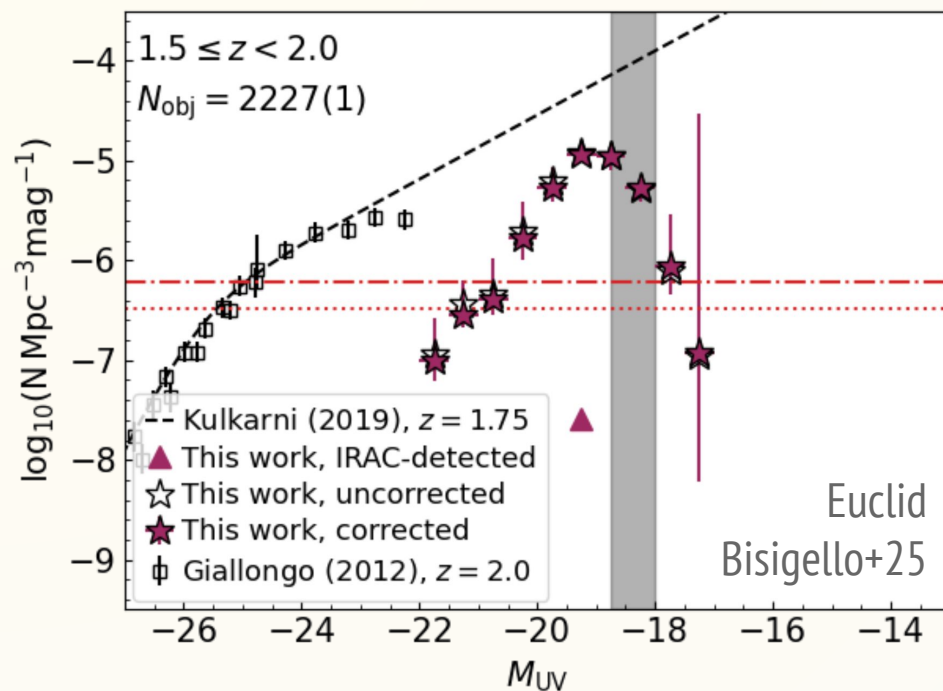
Spectroscopic selection

Line flux catalogue (Amorín, Bonato+ in prep.)

Red dots in the neighbourhood



Red dots in the neighbourhood

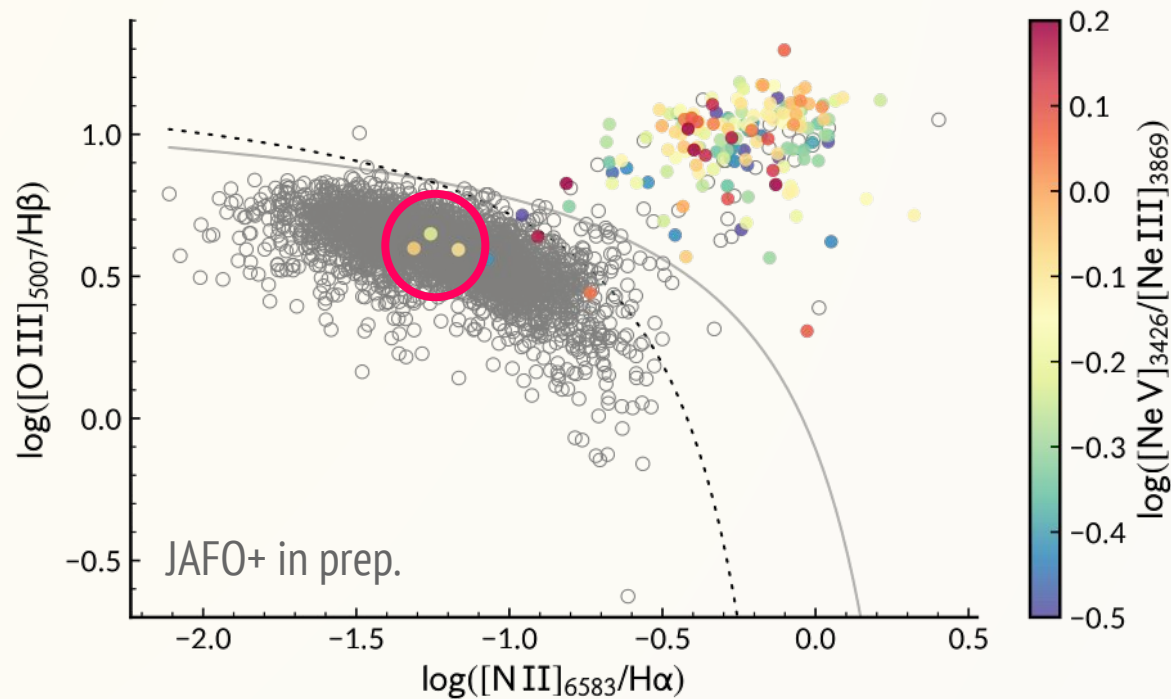


Selection based on line ratios

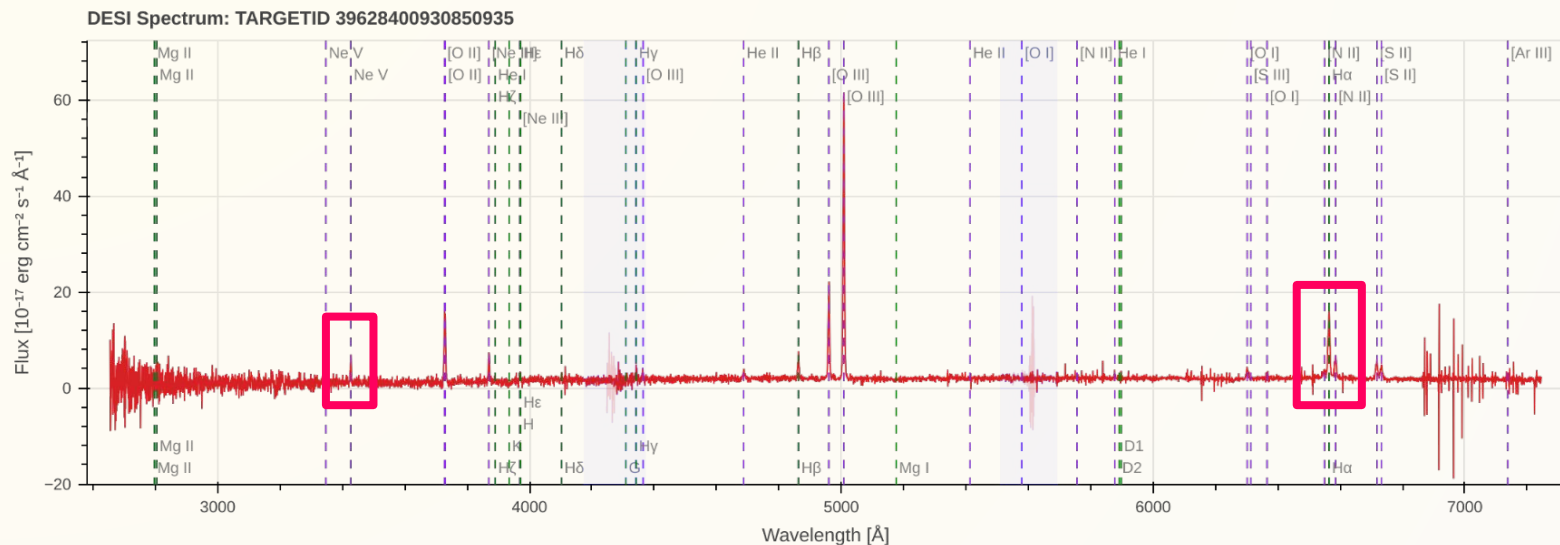
BPT up to $z < 0.45$

High-ionisation lines:

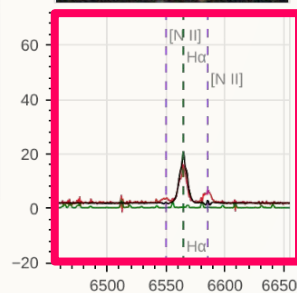
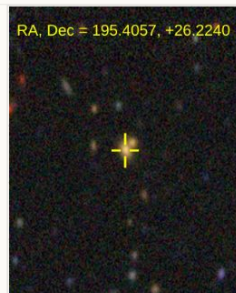
$$[\text{NeV}]_{3426}/[\text{NeIII}]_{3869} > 0.15$$



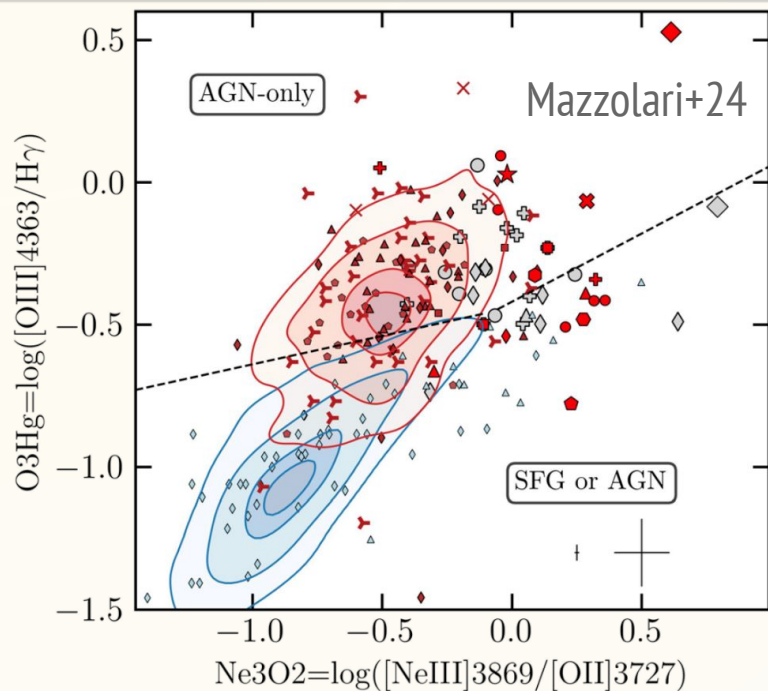
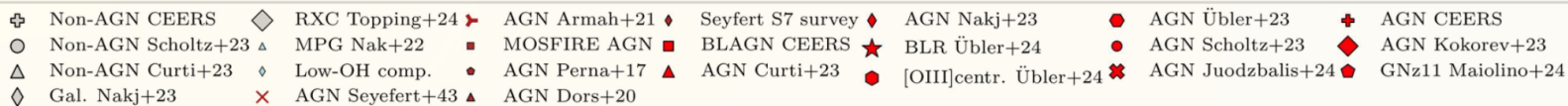
Selection based on line ratios



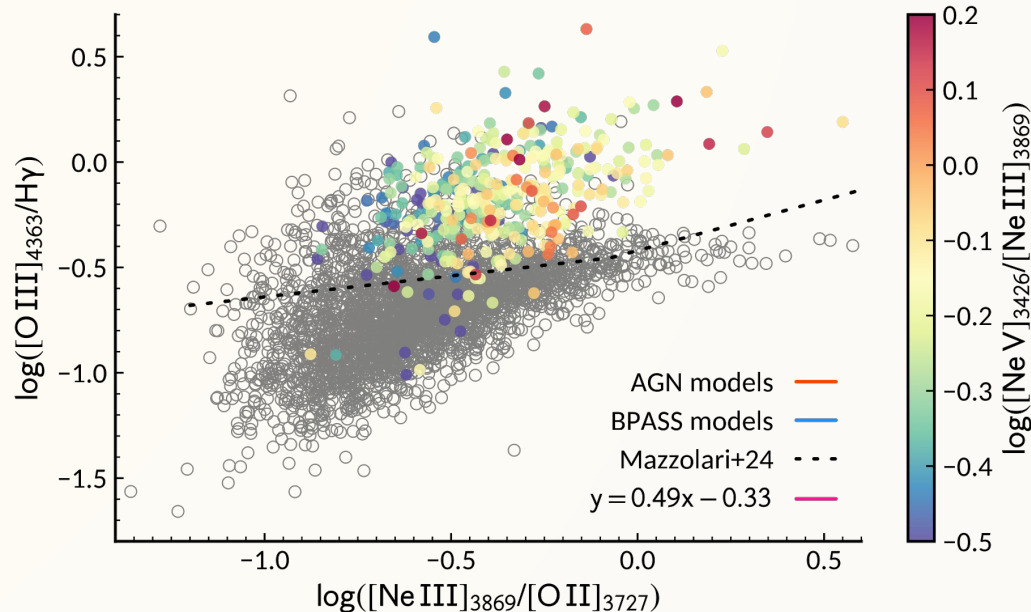
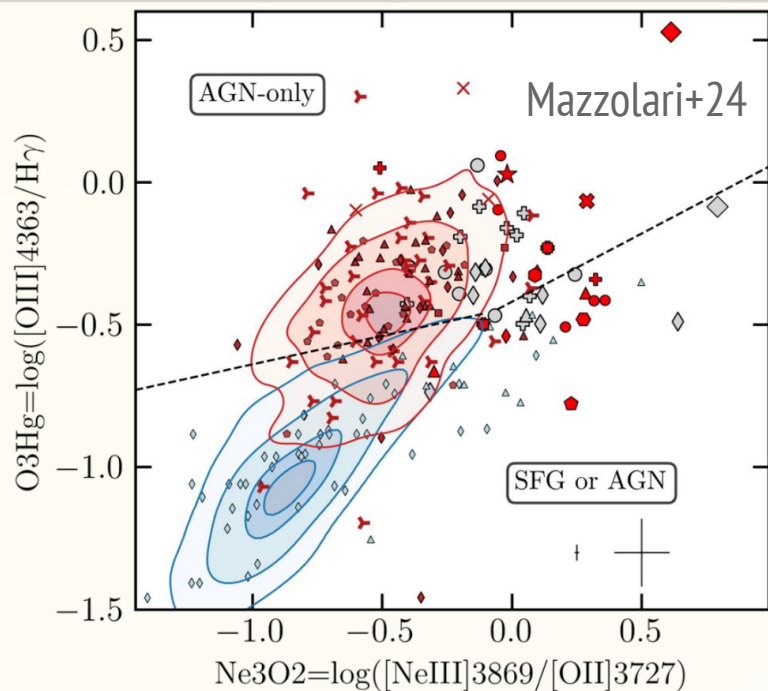
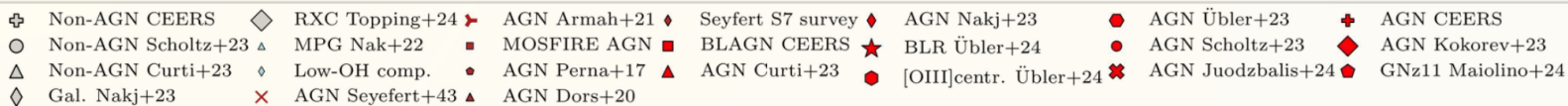
[NeV]3426

 $H\alpha + [NII]$ 

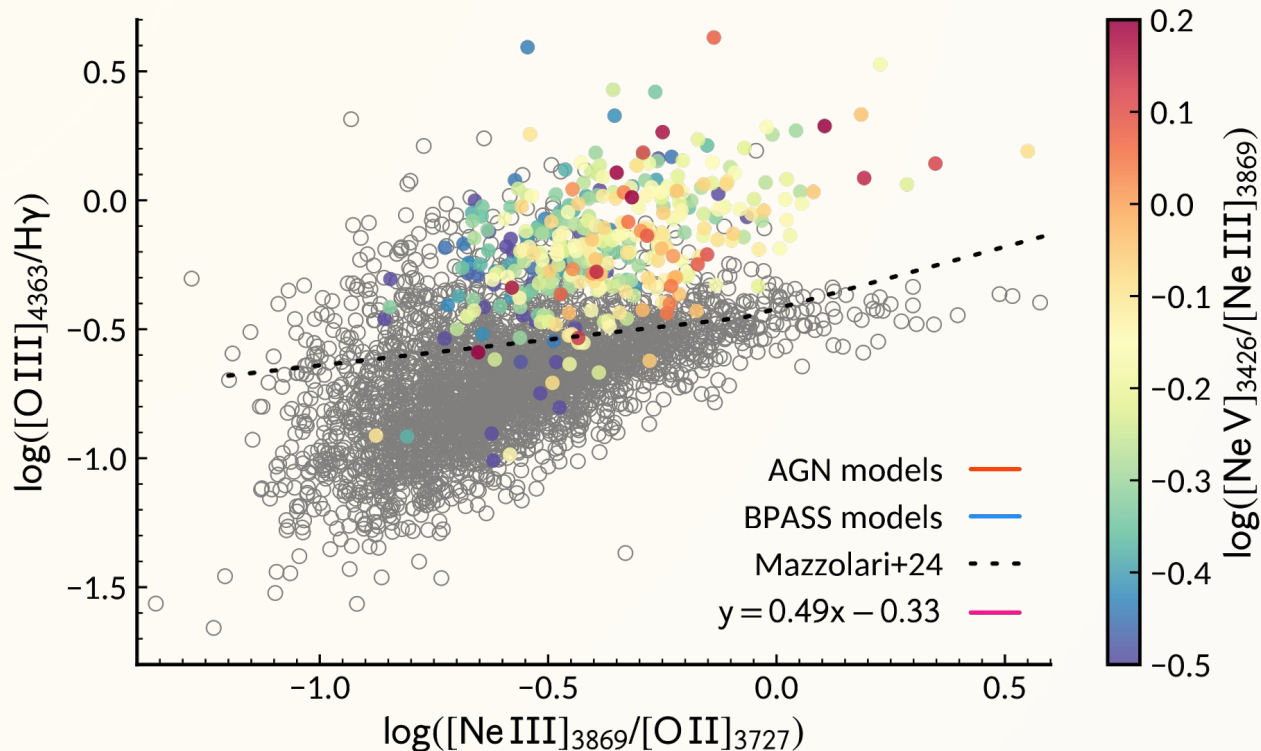
Selection based on line ratios



Selection based on line ratios

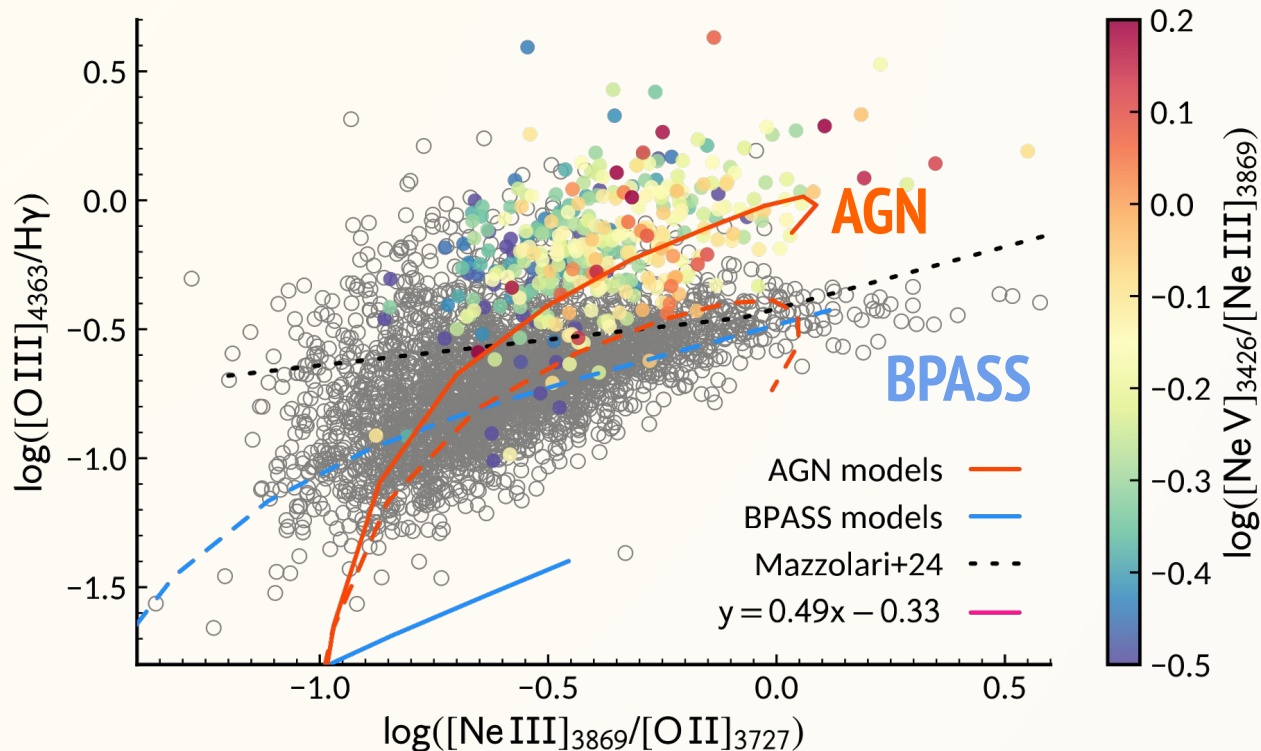


Selection based on line ratios



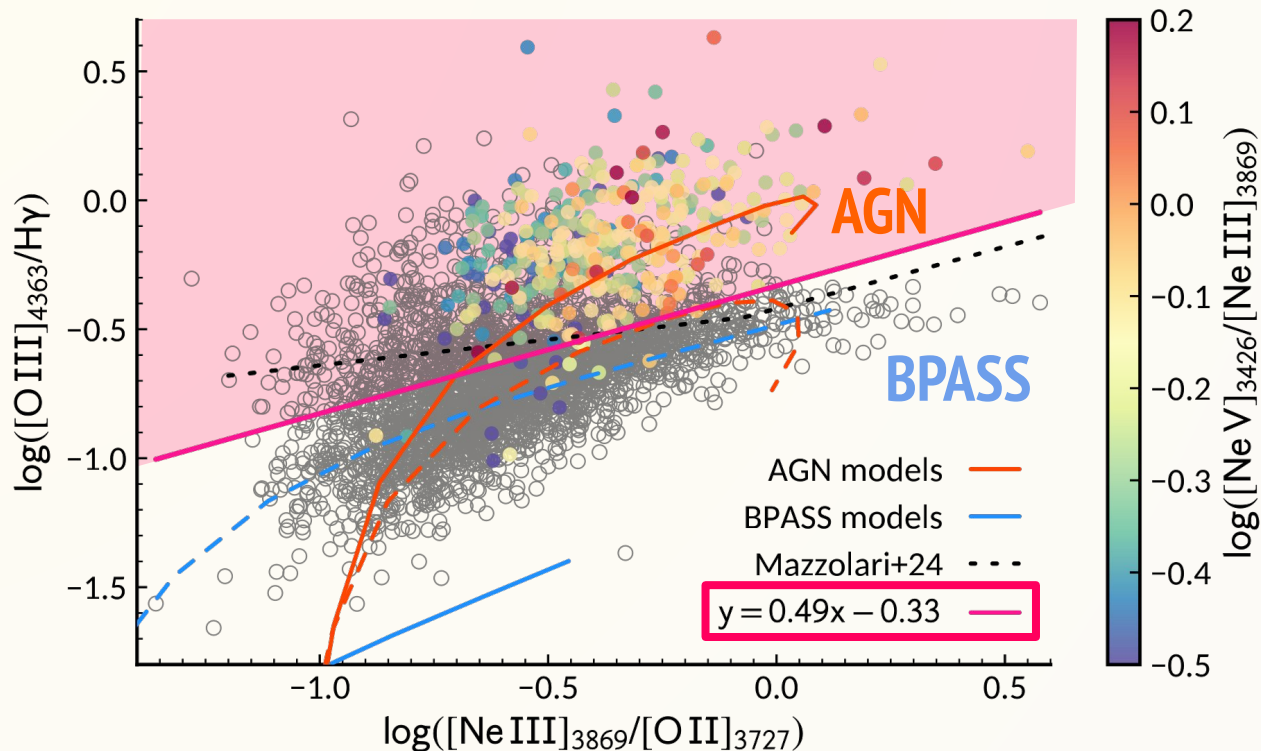
JAFO+ in prep.

Selection based on line ratios



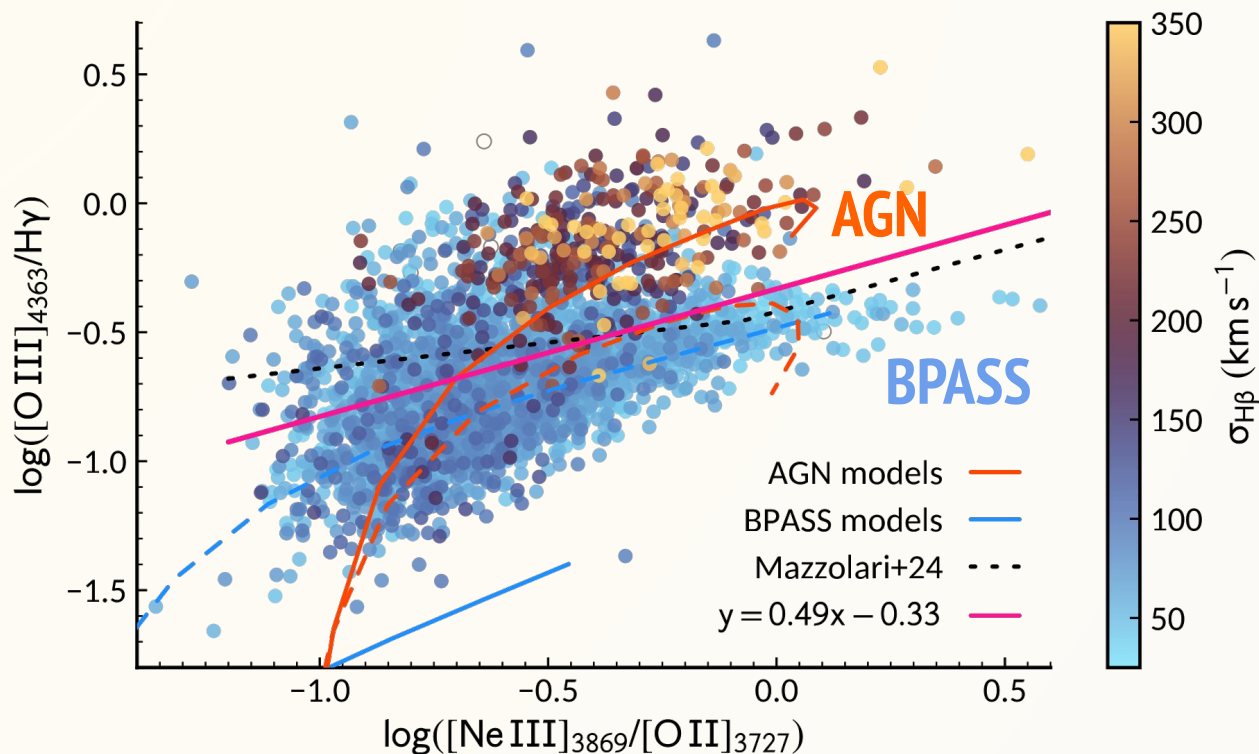
JAFO+ in prep.
Pérez-Montero
14,+19

Selection based on line ratios



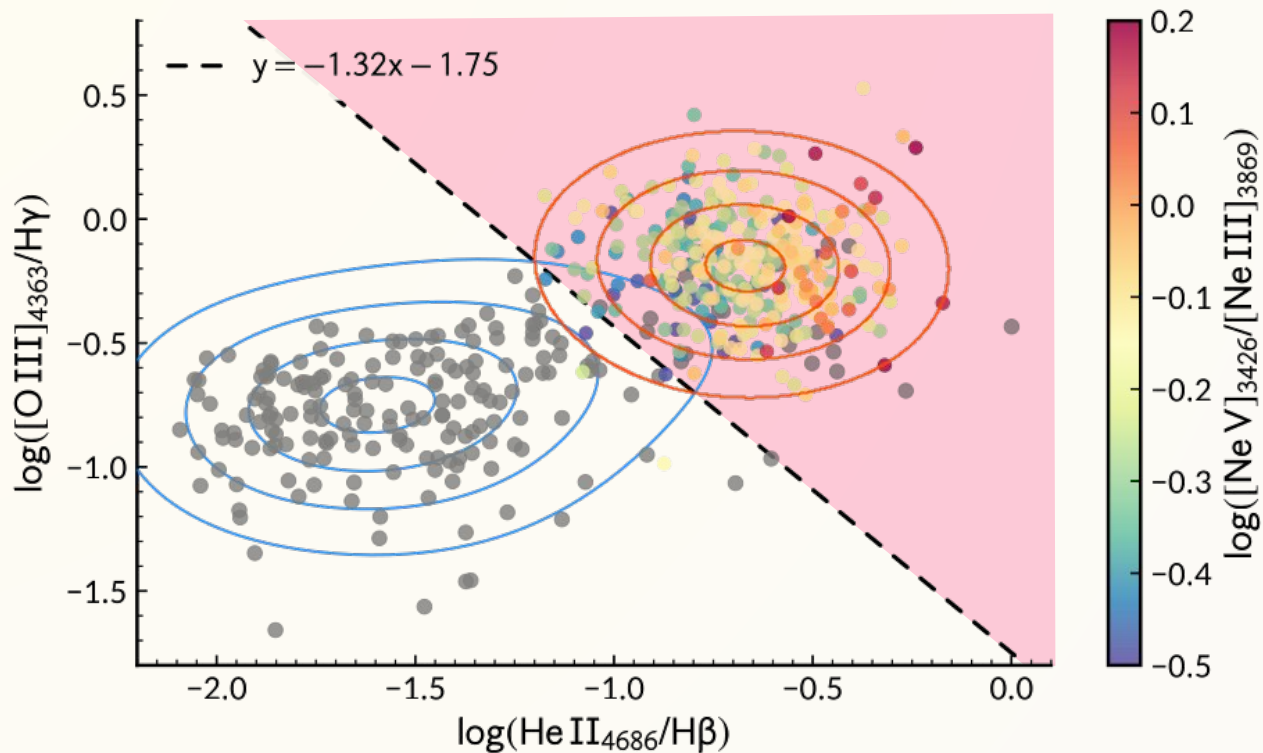
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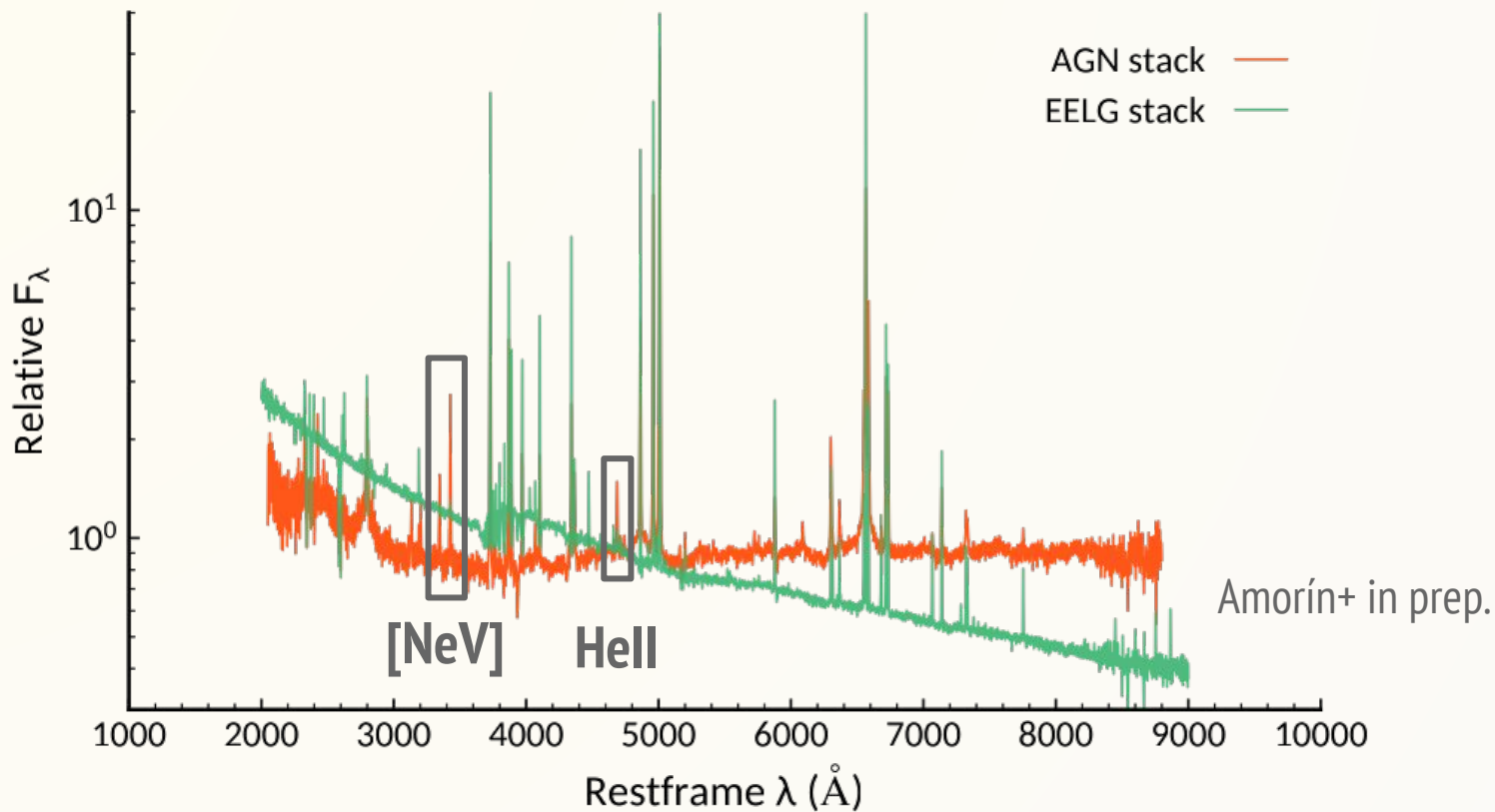
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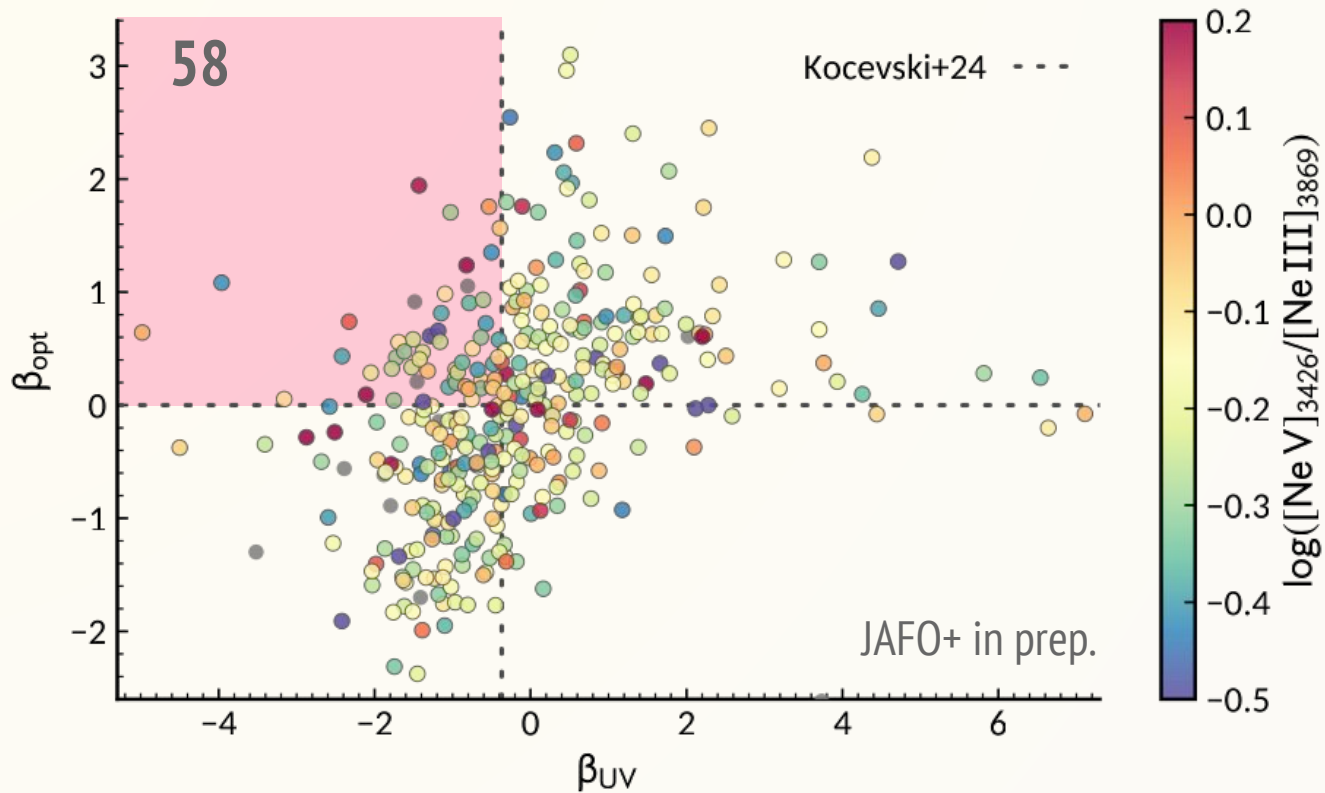


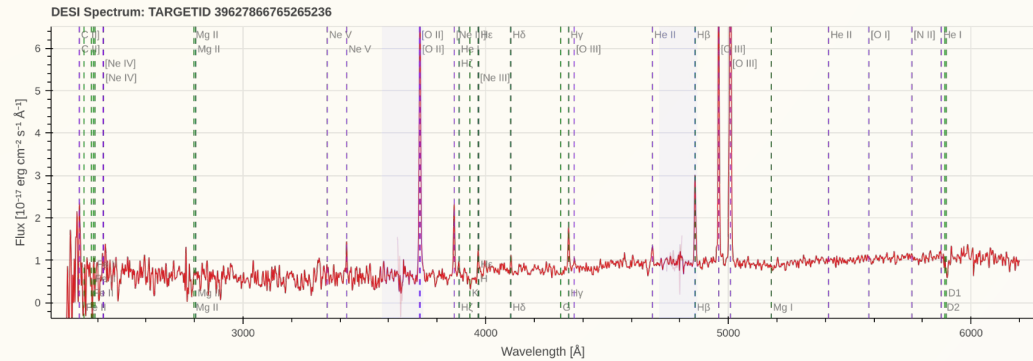
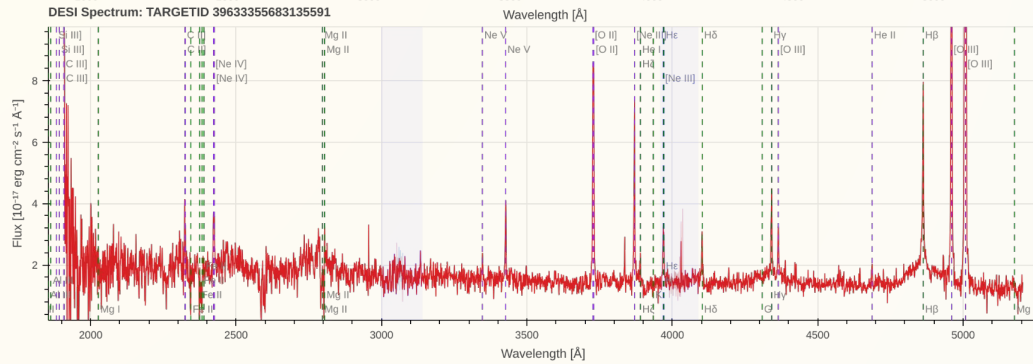
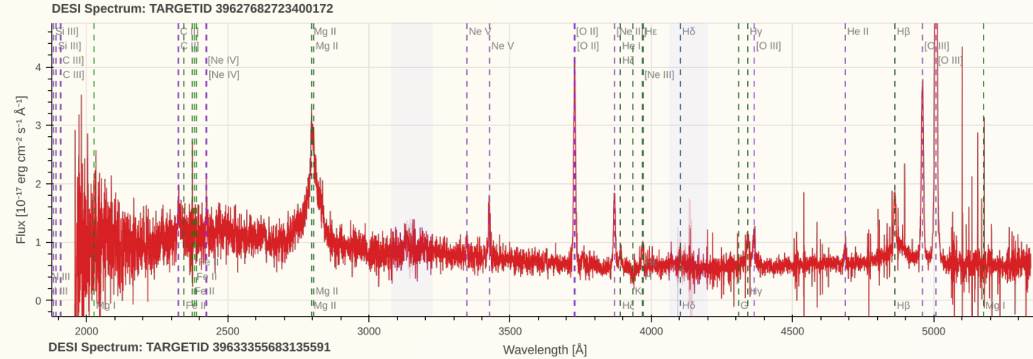
JAFO+ in prep.

Stacked templates

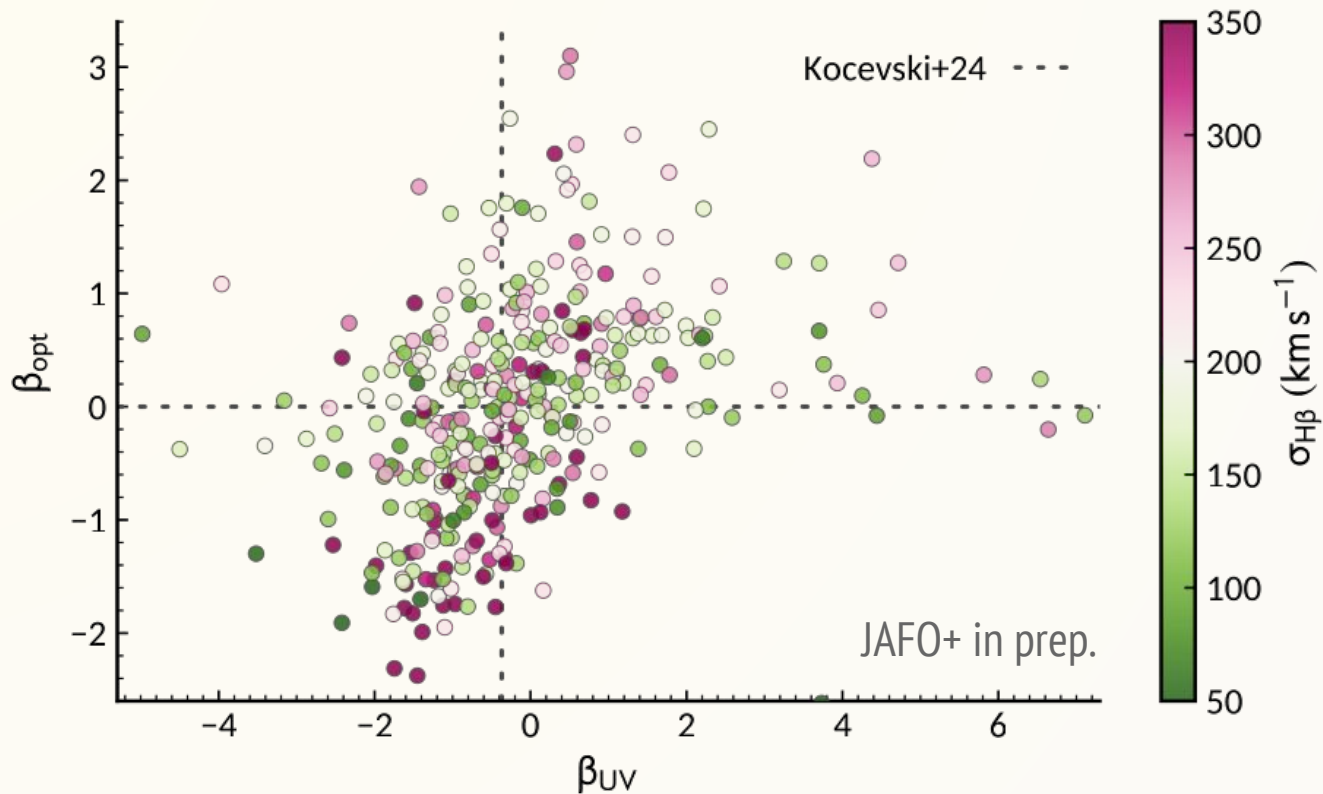


A local sample of Red Dots

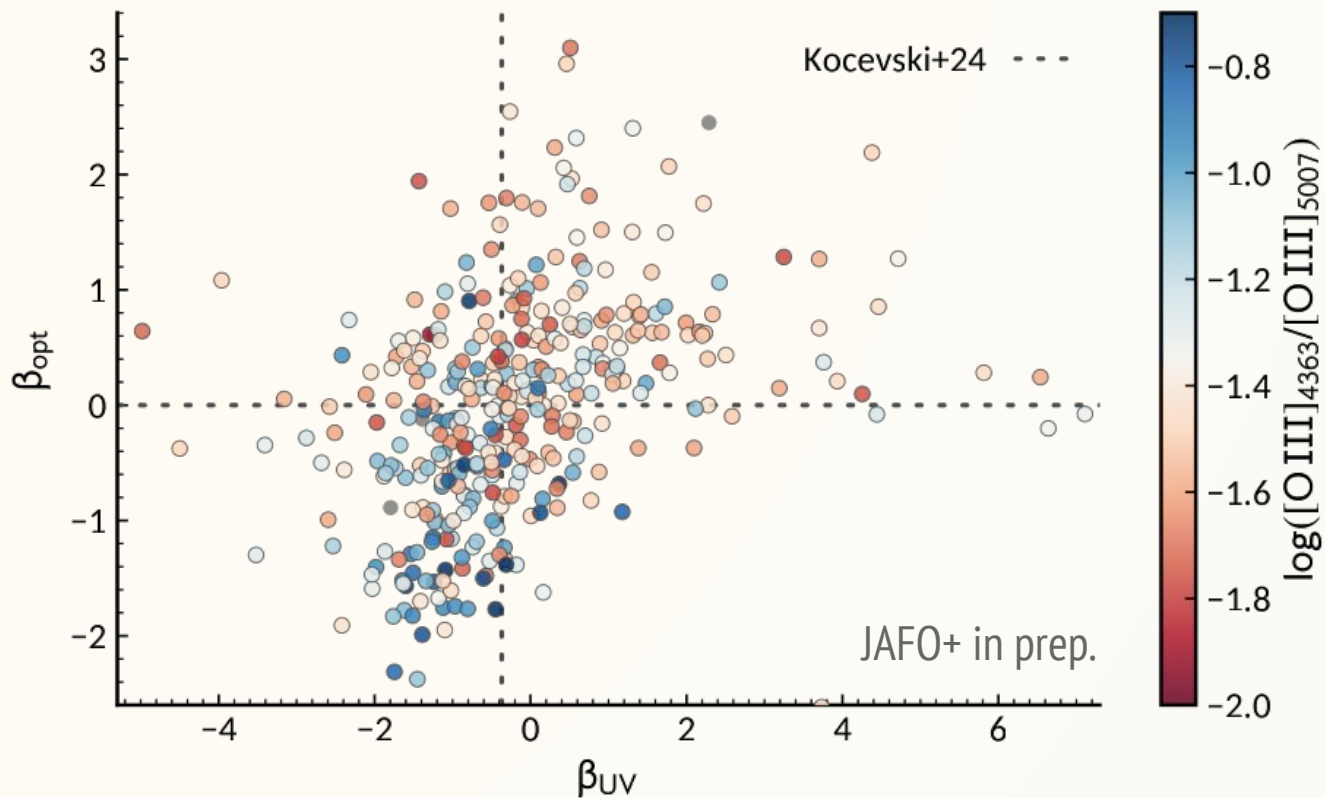




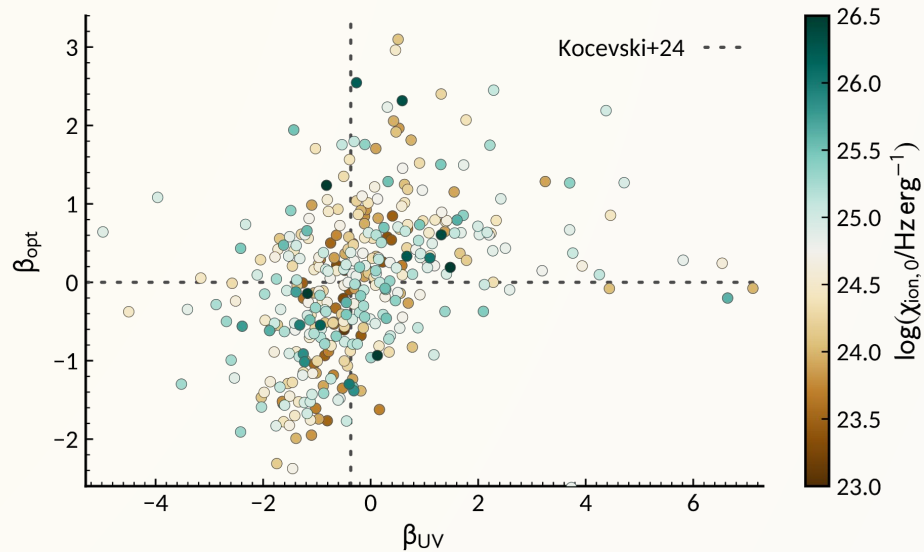
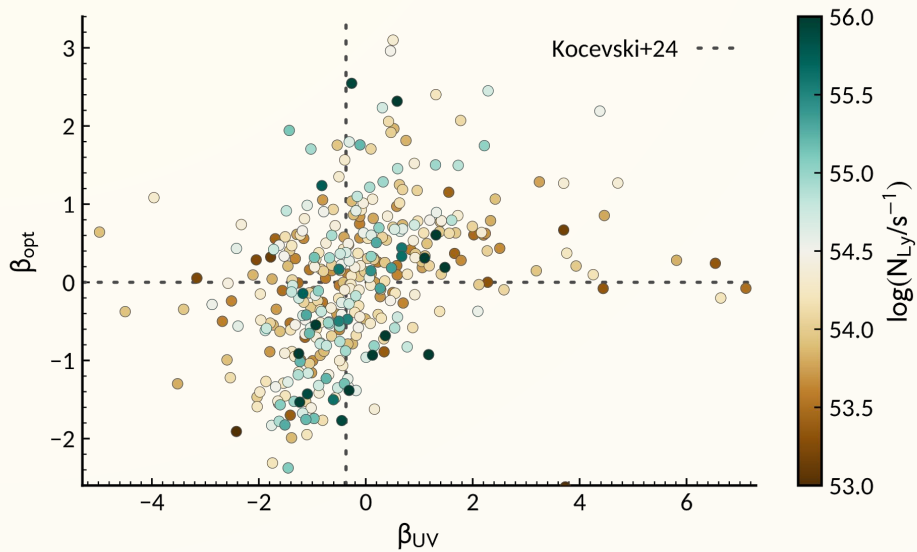
A local sample of Red Dots



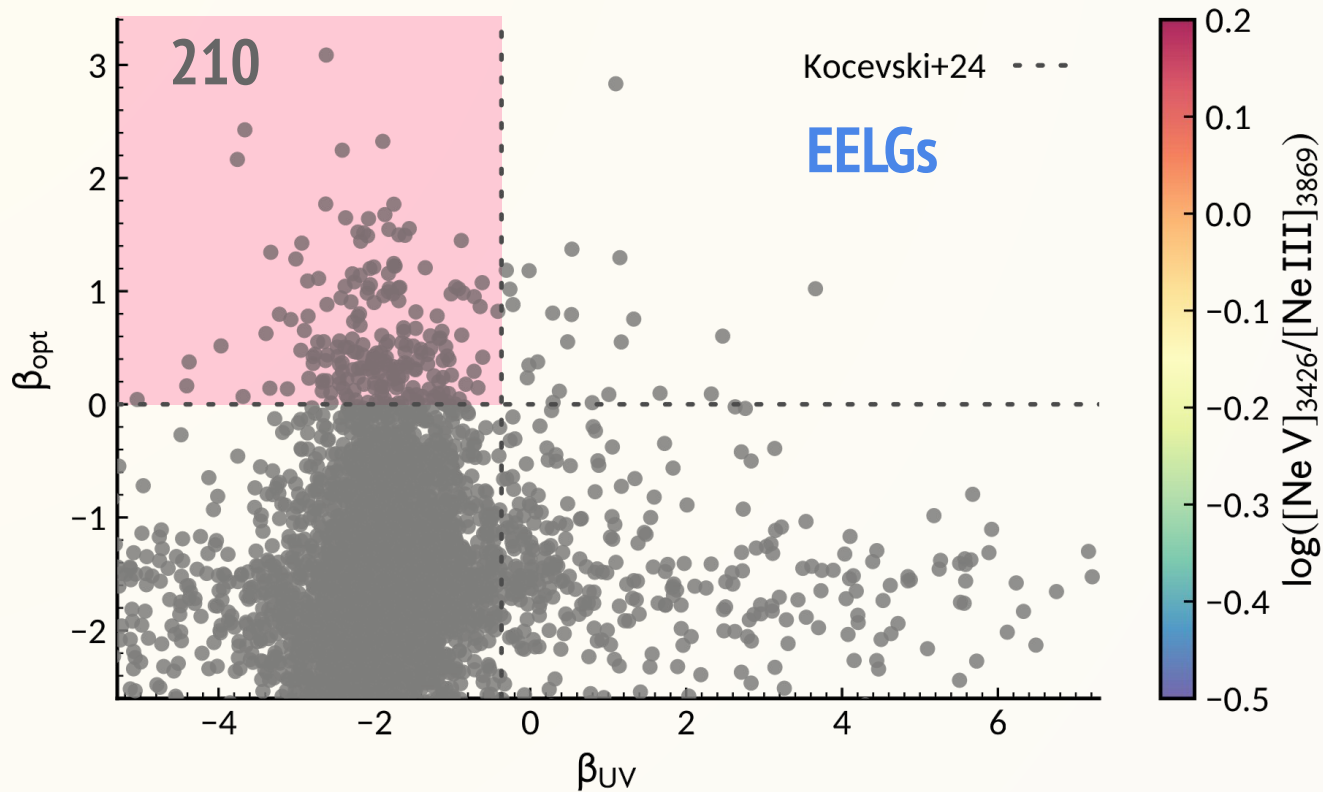
A local sample of Red Dots



A local sample of Red Dots



A local sample of Red Dots



Summary

Continuum selection → heterogeneous sample

High-excitation lines, [NeV]3426, He II, for a 'physics-driven' selection

~ 60 AGN Red Dots at low-z in DESI EDR, ~270 in total

A benchmark for AGN in early Universe (Amorín+, JAF0+ in prep.)

Moderate-luminosity AGN may be an important source of hard-photons during reionization

thanks!

ευχαριστώ!