EXPLORING HEII1640 EMISSION LINE PROPERTIES AT Z=2-4

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@themiyan

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What is so special about Hell???


Pop III
Stars
(Top heavy IMF)
E>54.4 eV

Cooling processes dominated by Ly-α and HeII

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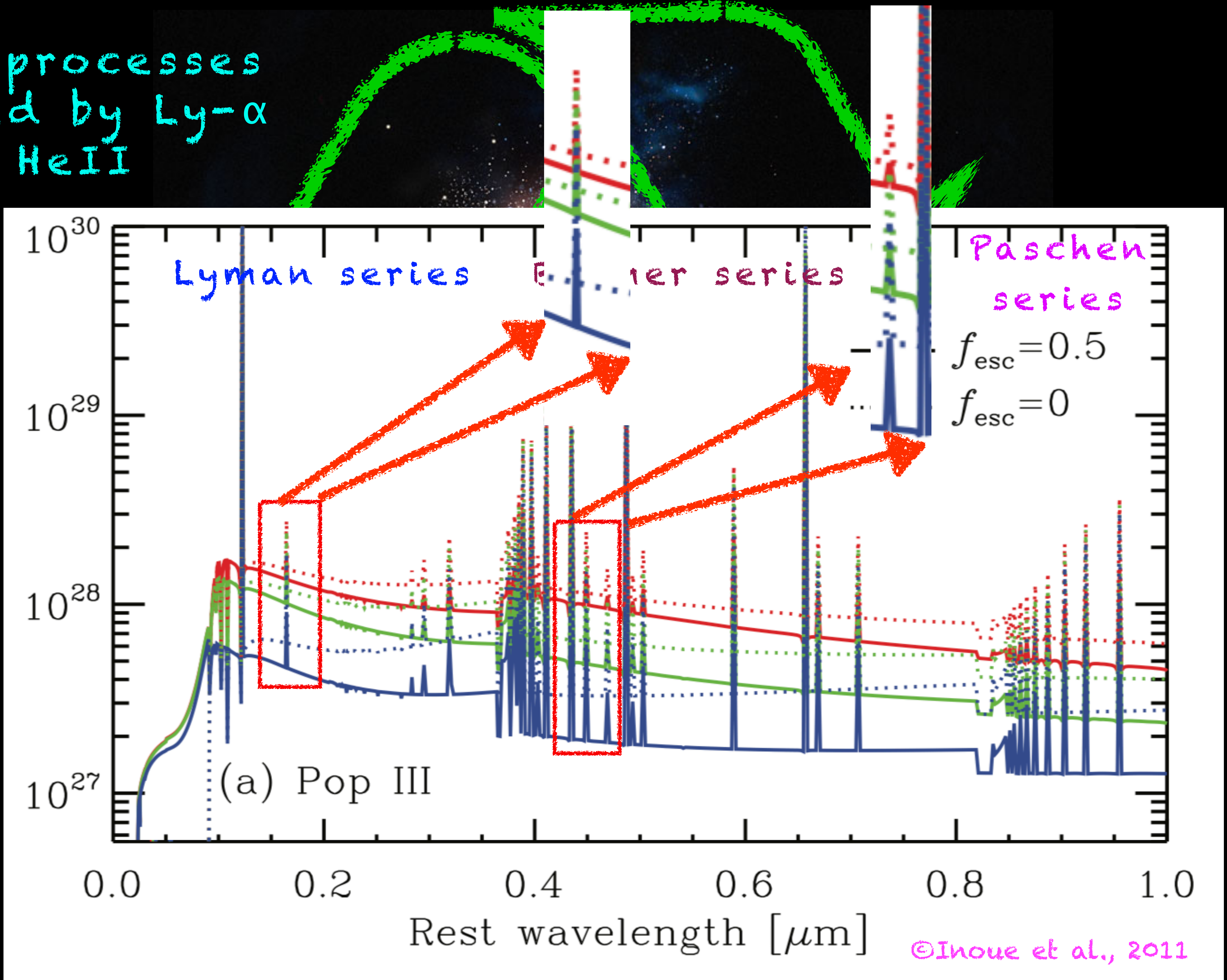
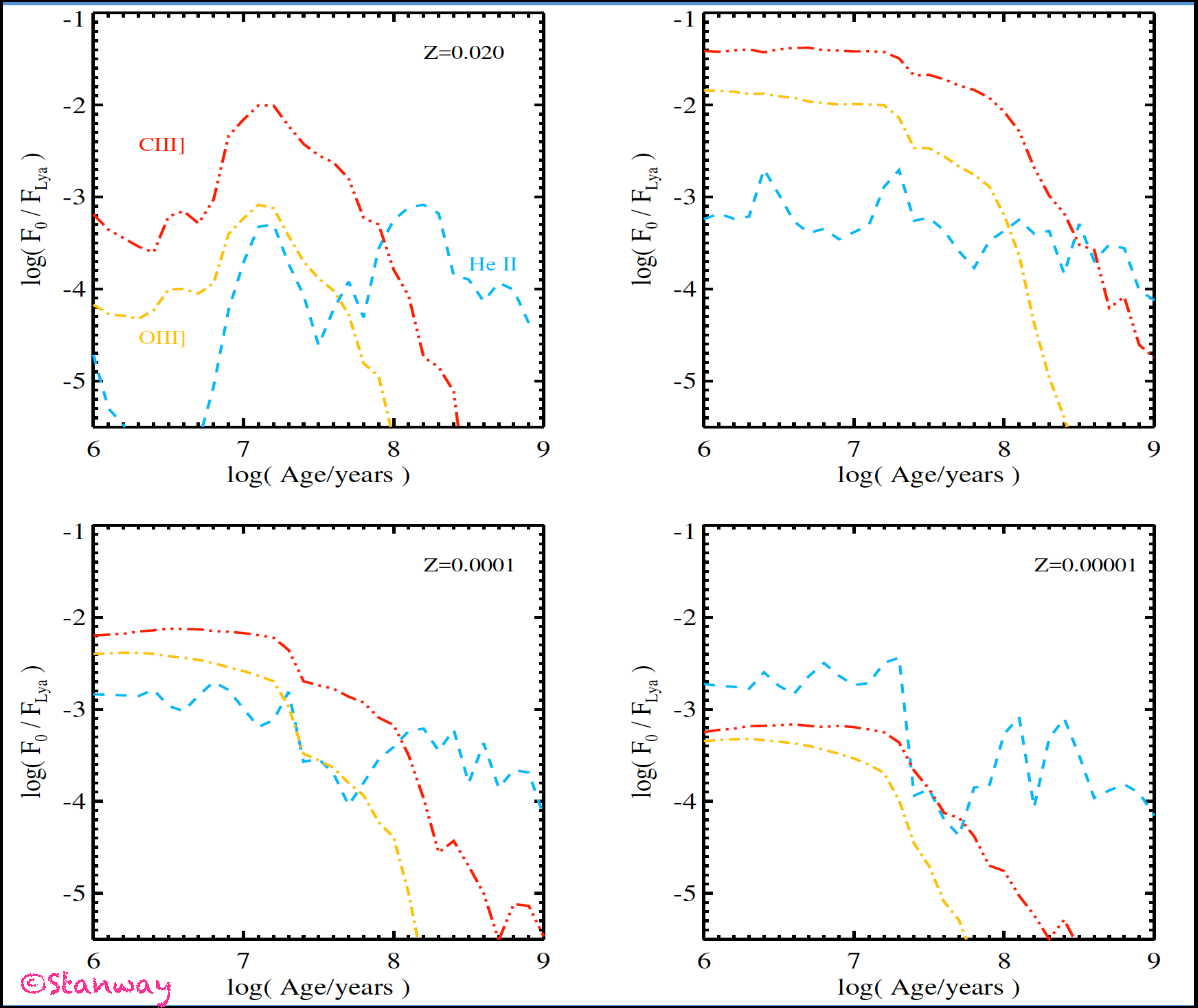
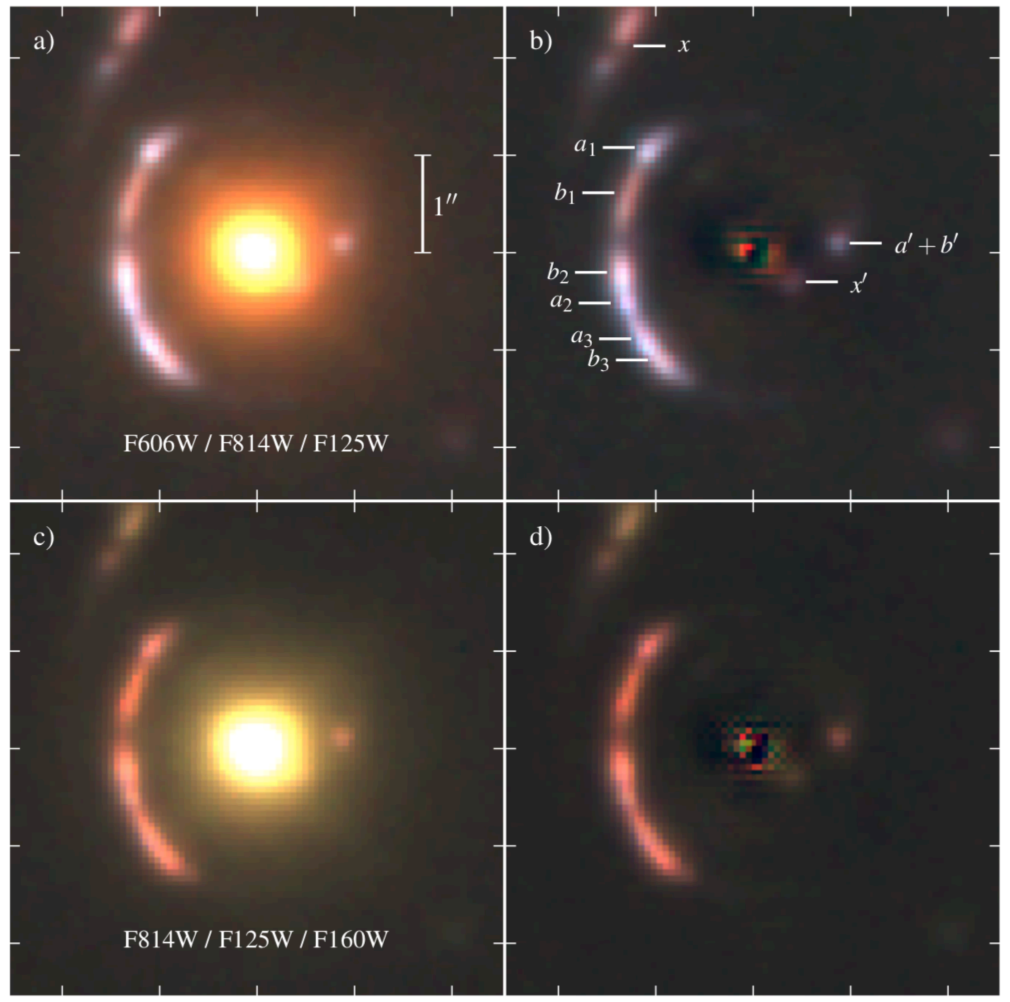


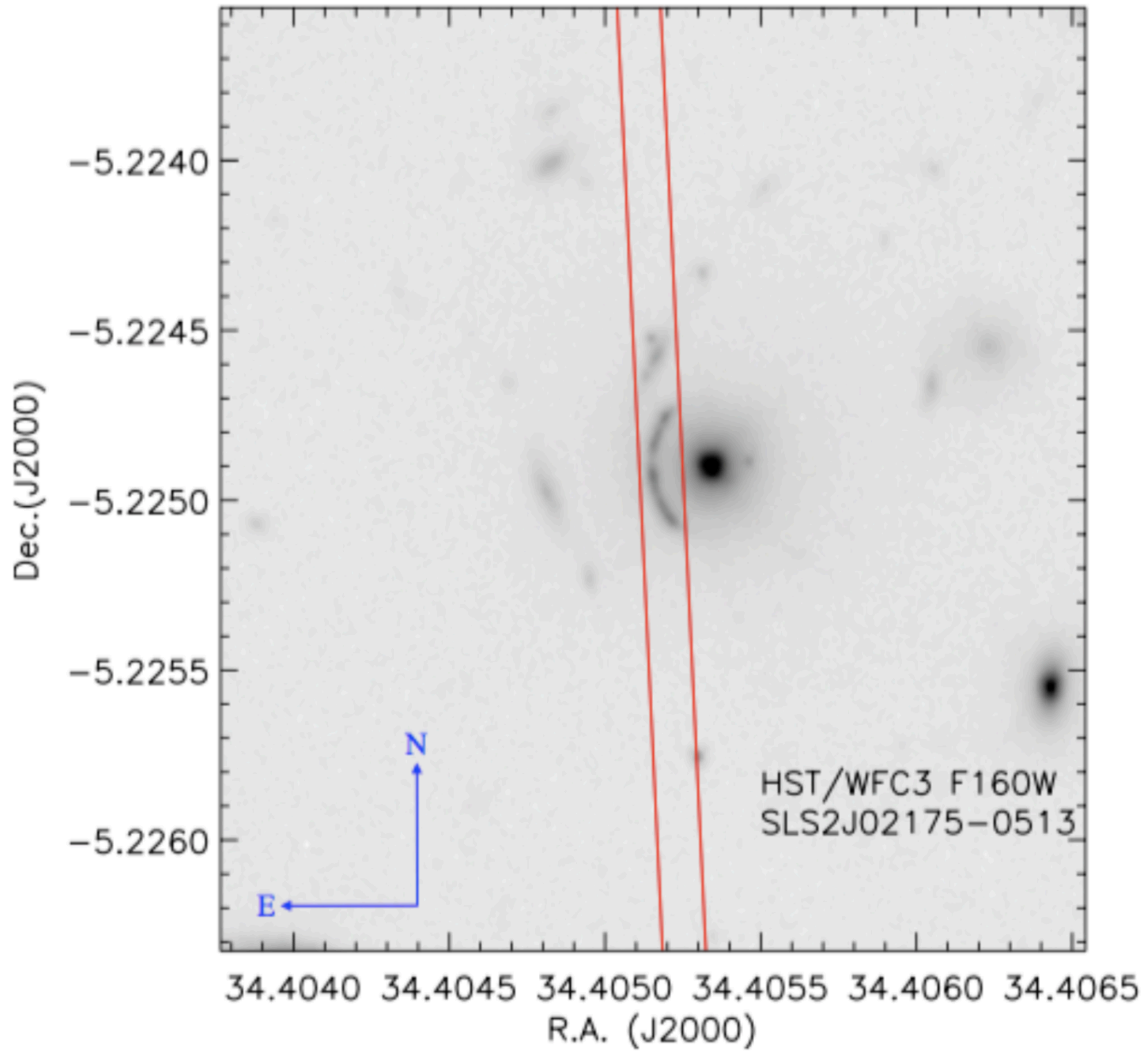
and in more moderate systems…

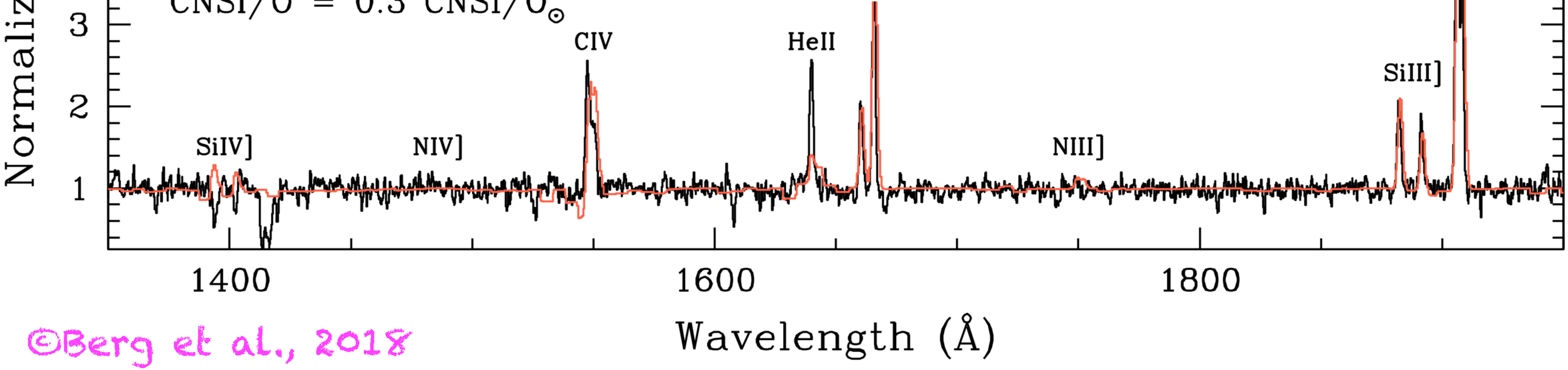
HeII may become the most dominant emission line at lower metallicities



Current stellar population / photoionisation models fail to predict the observed HeII features







©Berg et al., 2018

Current stellar population / photoionisation models fail to predict the observed HeII features

He+ ionising photons can be produced via multiple mechanisms, so some solutions include:

- Decrease Z/mass threshold to produce W-R stars → Binaries; VMS
- Include contribution from X-Ray Binaries → XRB population synthesis
- Increase N of Young massive stars → IMF variations
- Consider contributions from Shocks and AGN → Sub-dominant AGN

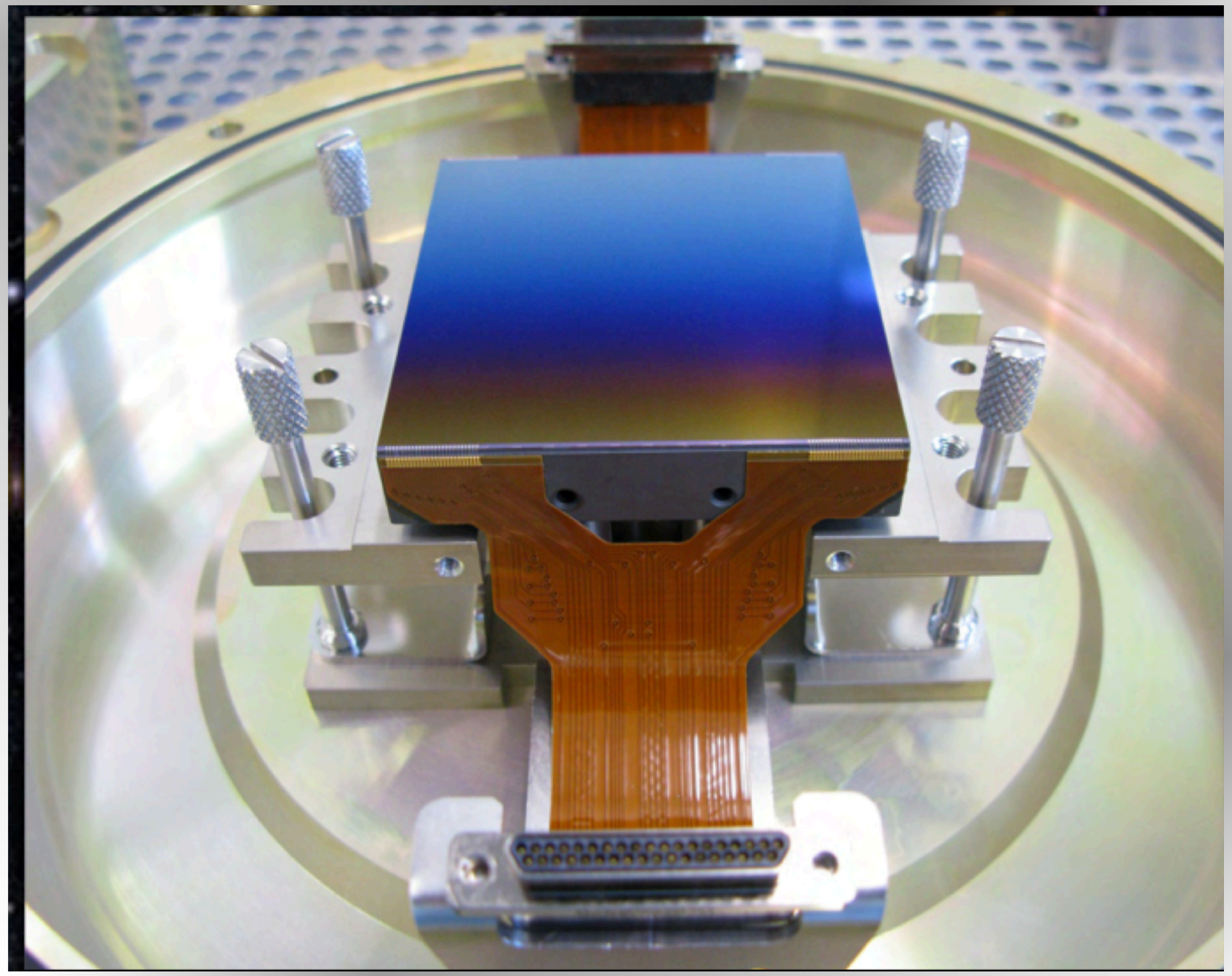
Testing these models and providing constraints requires HeII emitters in a variety of conditions

muse
multi unit spectroscopic explorer

ESO

NOVA

ETH



CRAL

AIP

Institut für Astrophysik Göttingen

irap
astrophysique & planétologie

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Part I: Sample Construction

We use multiple GTO pointings with deep exposures to identify any HeIIλ1640 emitters

Field name	FOV[a]	Exposure Time (h)	Nc[b]	Ns[c]
UDF10	$1' \times 1'$	31.00	122	0
UDF MOSAIC	$3' \times 3'$	10.00	431	6
HDFS	$1' \times 1'$	27.00	139	3
Groups COSMOS 30	$1' \times 1'$	9.75	35	1
Groups COSMOS 34	$1' \times 1'$	5.25	7	0
Groups COSMOS 84	$1' \times 1'$	5.25	13	0
Groups COSMOS 114	$1' \times 1'$	2.20	2	0
Groups VVDS 189	$1' \times 1'$	2.25	1	0
Quasar J2321	$1' \times 1'$	9.00	13	0
Quasar Q0422	$1' \times 1'$	20.00	25	3
Quasar UM287	$1' \times 1'$	9.00	11	0

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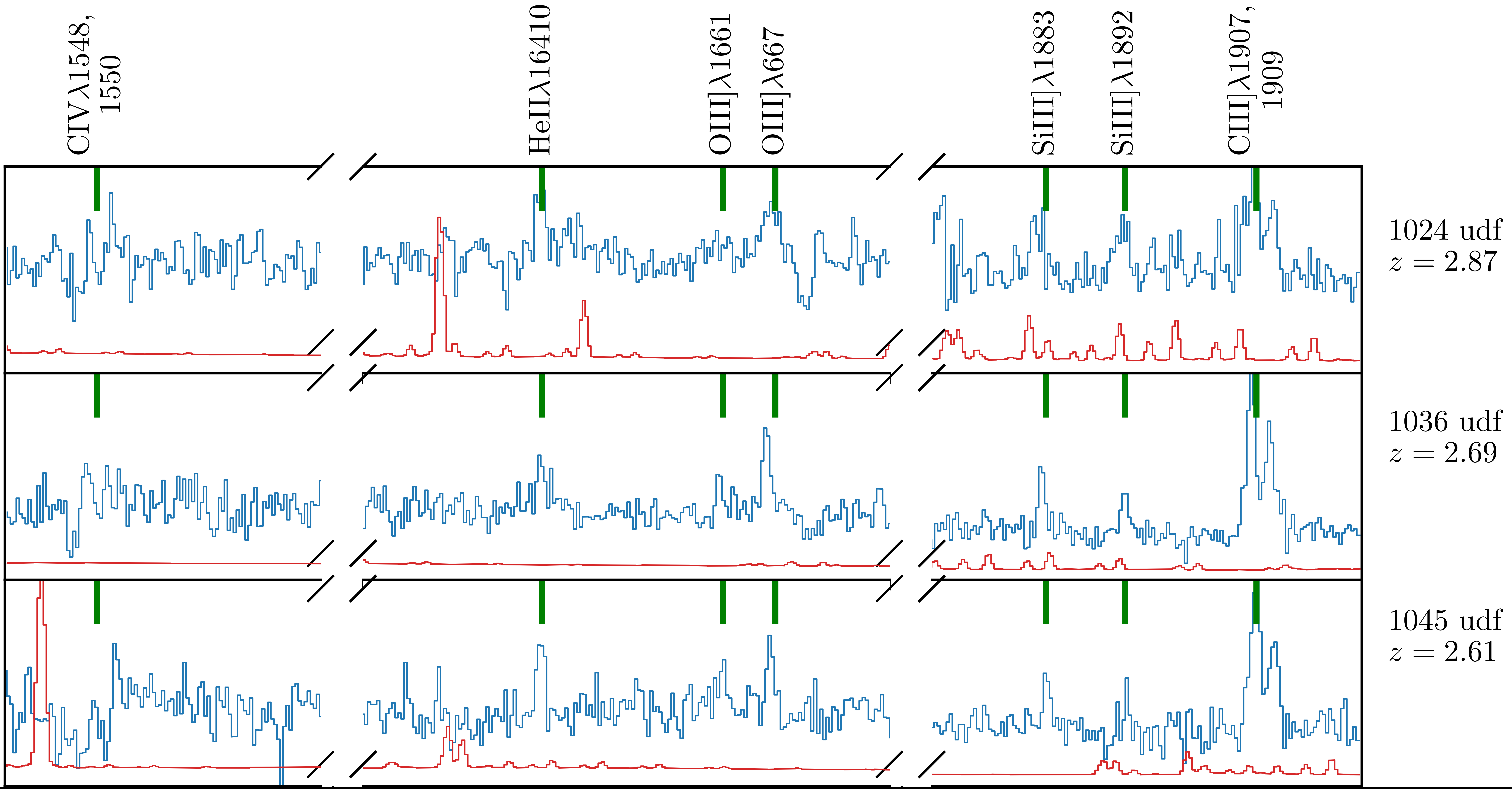
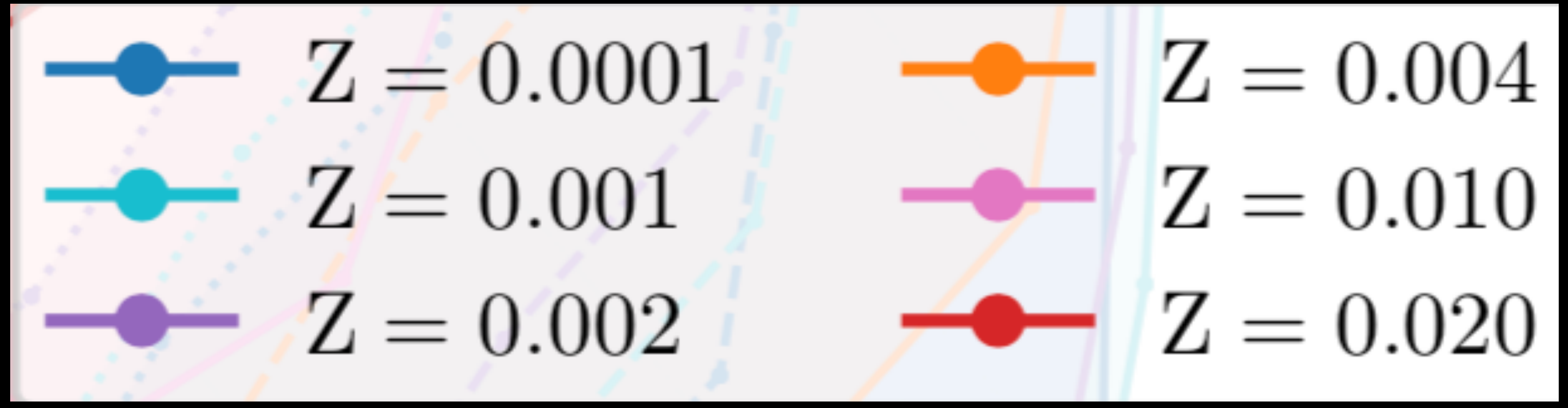
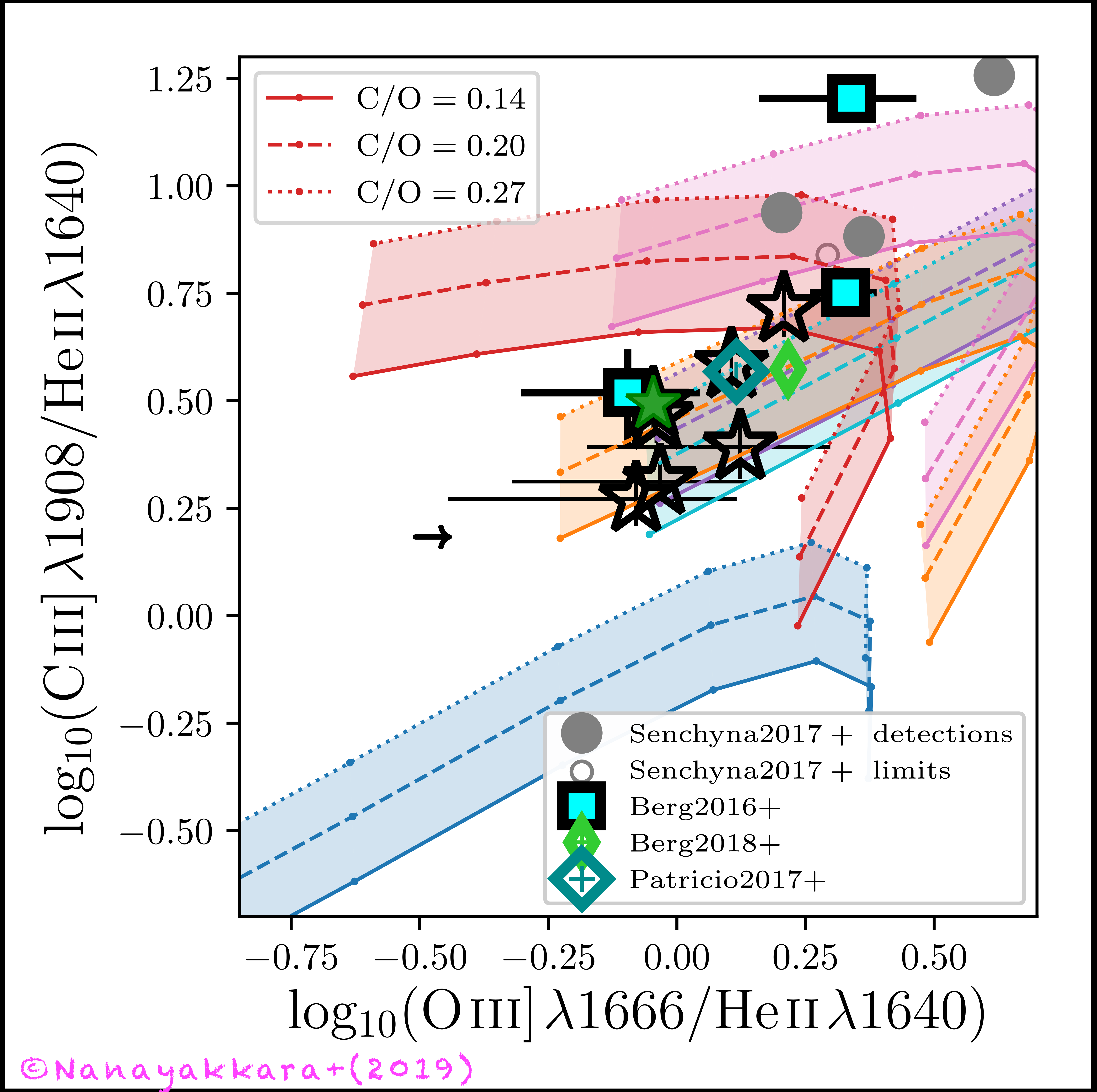
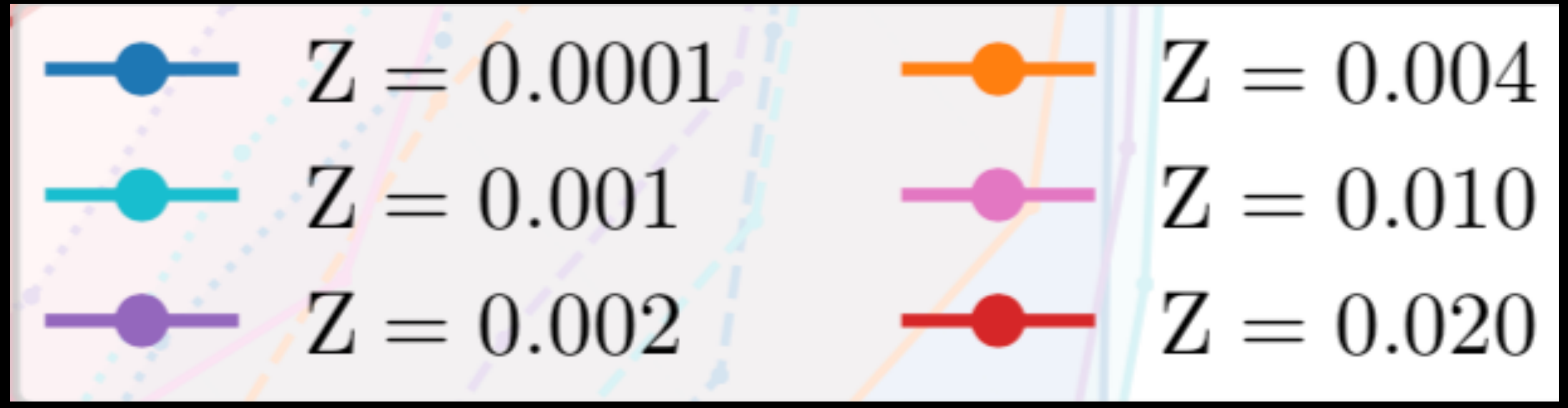

CIVλ1548, 1550
HeIIλ16410
OIII]λ1661
OIII]λ667
SiIII]λ1883
SiIII]λ1892
CIII]λ1907, 1909
1024 udf
$z = 2.87$
1036 udf
$z = 2.69$
1045 udf
$z = 2.61$

Part II: Analysis



When compared to Gutkin+2016 models, most galaxies in our sample fall within the line ratios occupied by the models.





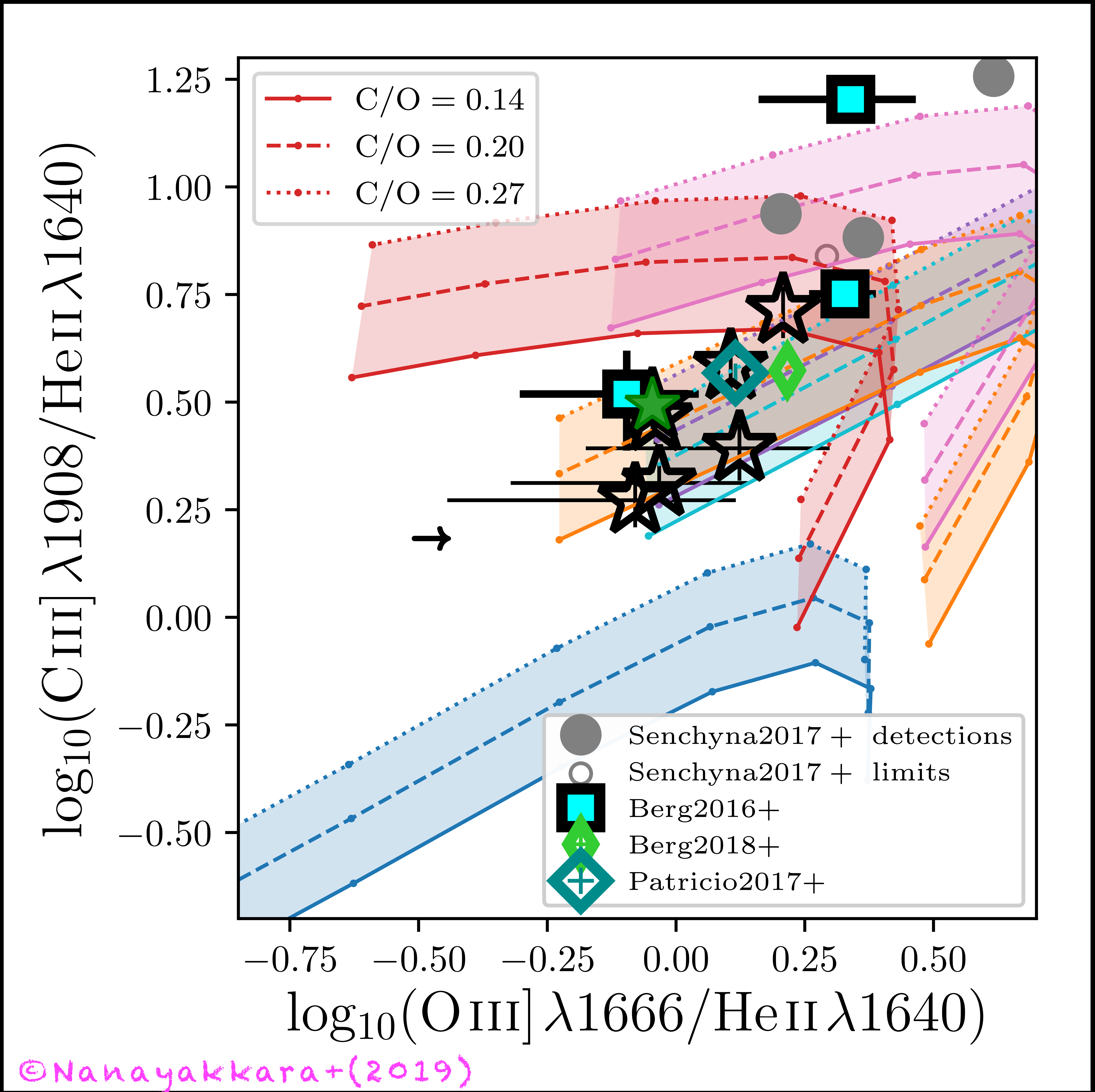
When compared to Gutkin+2016 models, most galaxies in our sample fall within the line ratios occupied by the models.

note:

- **a large variety in model parameters**
- **only single stars**

Parameter	Sampled values
$Z_{\rm ISM}$	0.0001, 0.0002, 0.0005, 0.001, 0.002, 0.004, 0.006, 0.008, 0.010, 0.014, 0.017, 0.020, 0.030, 0.040
$\log U_{\rm S}$	−1.0, −1.5, −2.0, −2.5, −3.0, −3.5, −4.0
$\xi_{\rm d}$	0.1, 0.3, 0.5
$\log(n_{\rm H}/{\rm cm}^{-3})$	1, 2, 3, 4
$({\rm C/O})/({\rm C/O})_{\odot}$	0.10, 0.14, 0.20, 0.27, 0.38, 0.52, 0.72, 1.00, 1.40
$m_{\rm up}/{\rm M}_{\odot}$	100, 300

©Gutkin+2016



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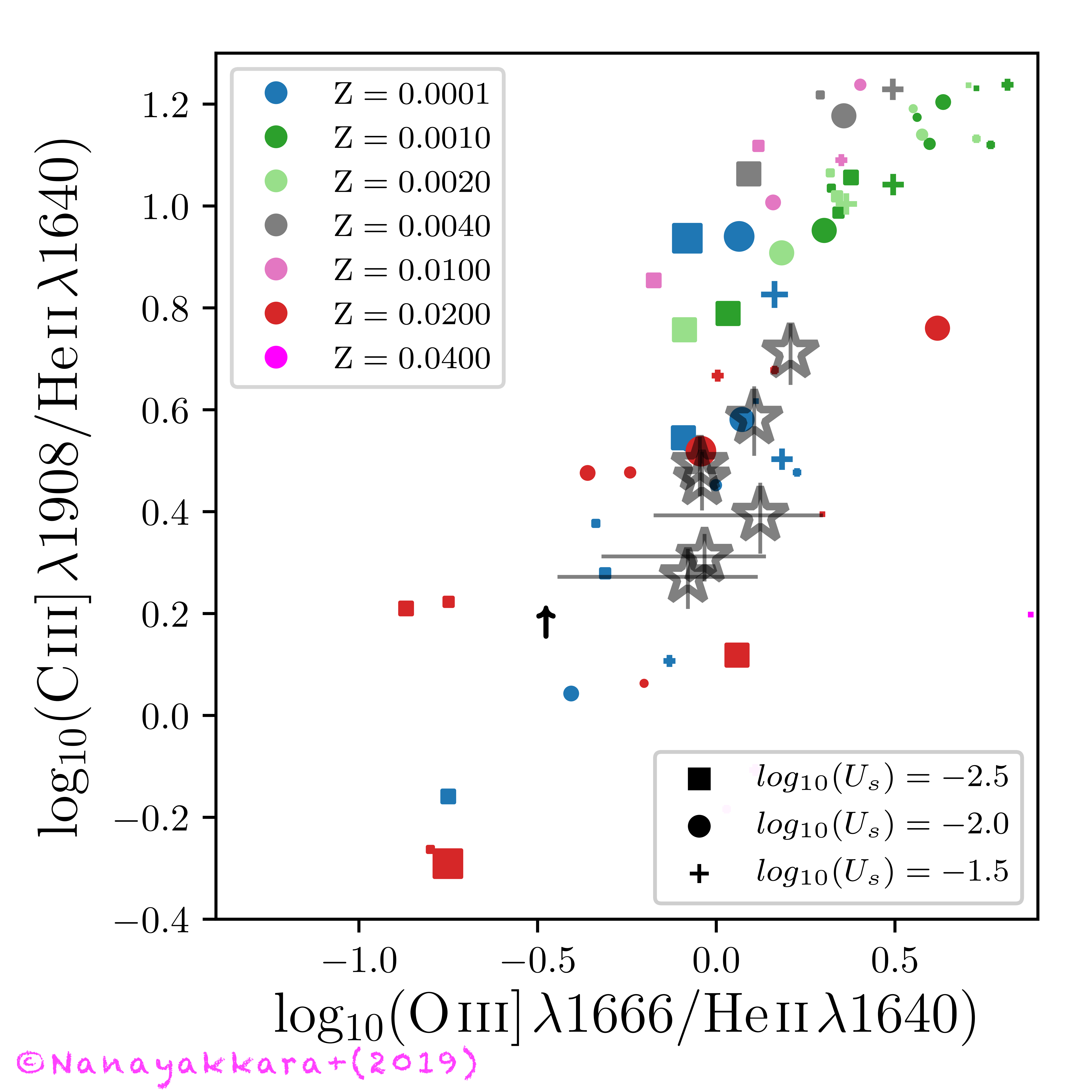
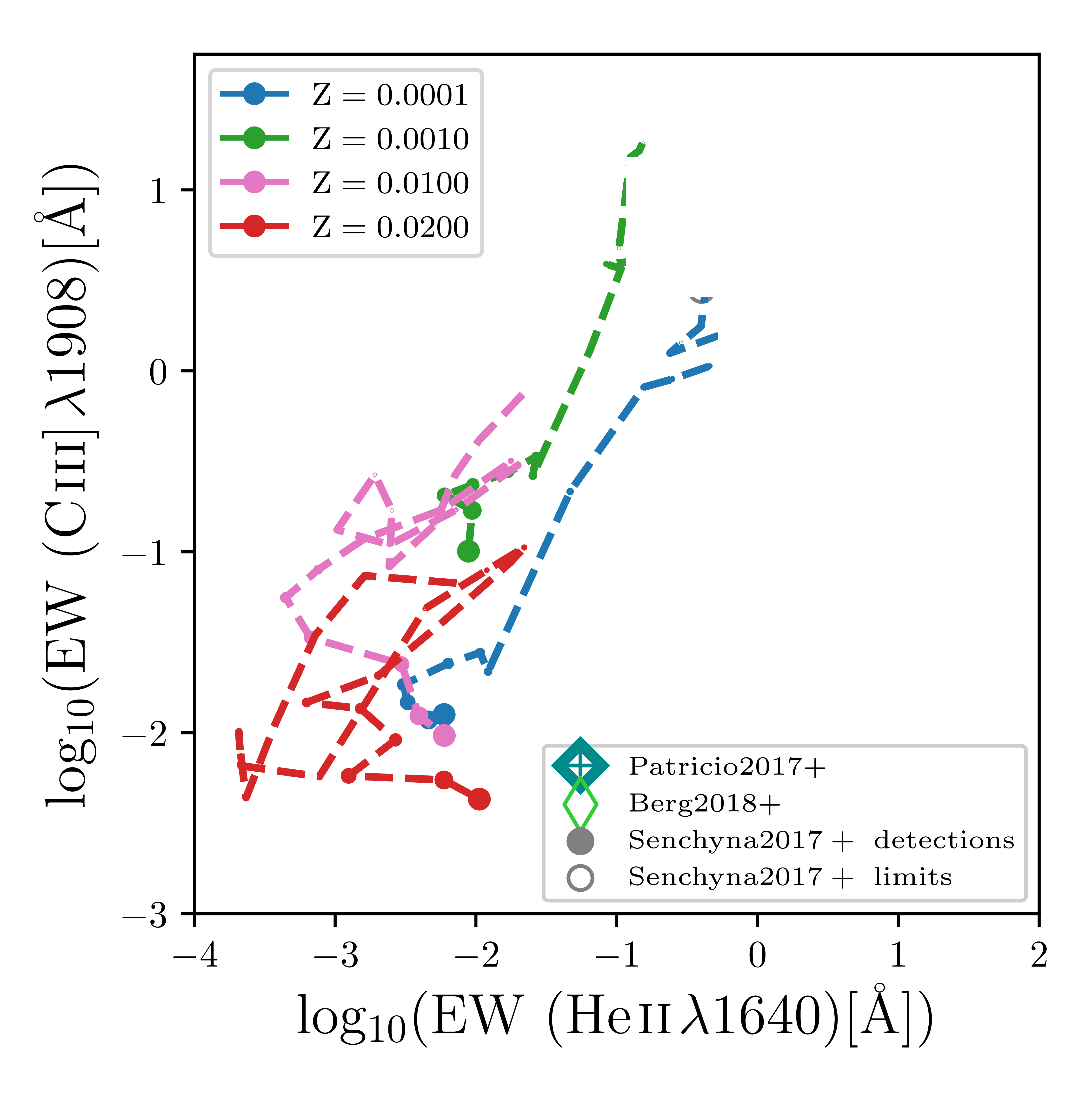
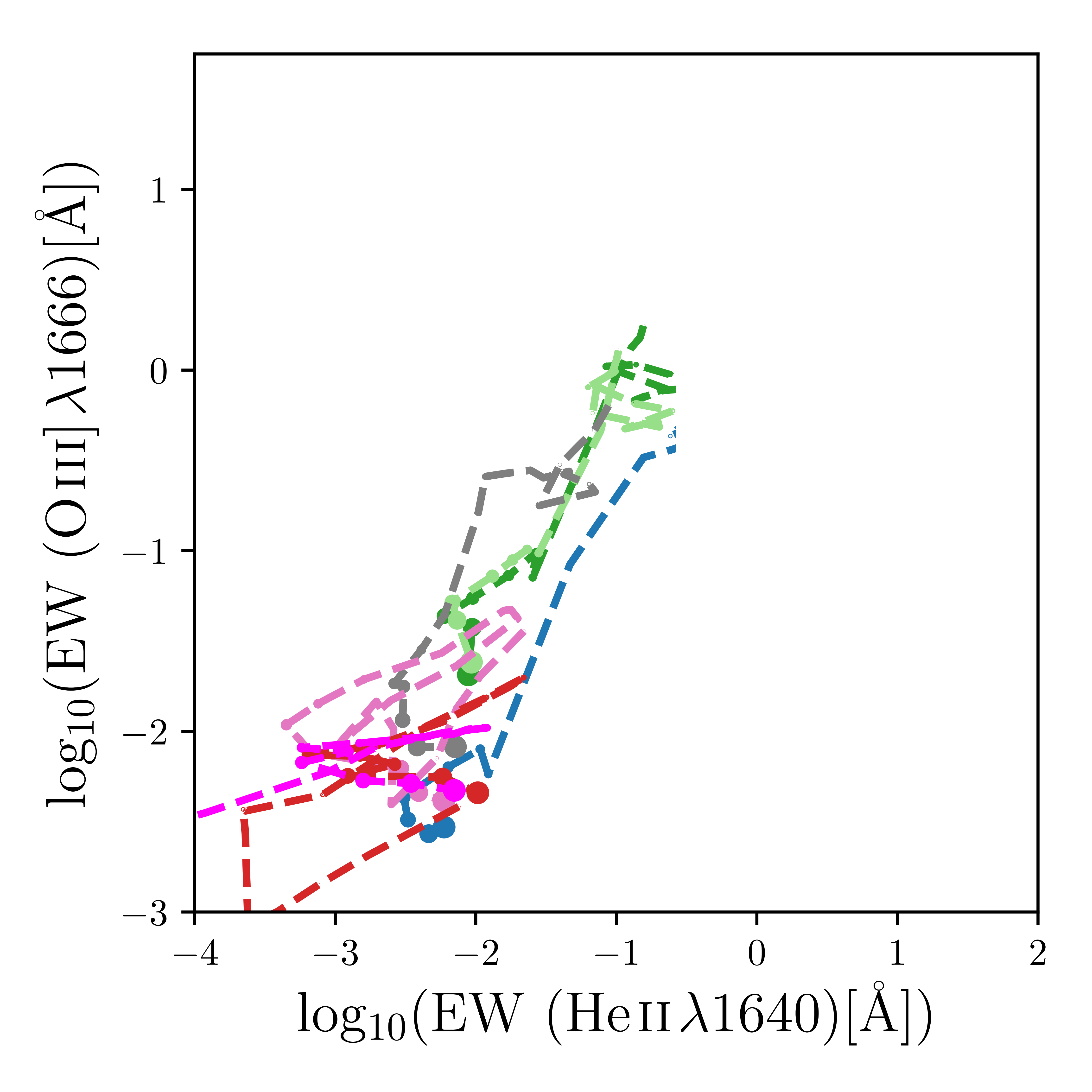
Considering effects of binary stars introduces added complexity to the line ratio diagnostics.



Models from BPASSv2.0
Xiao+2018
note:
- dust effects not considered

The Equivalent-widths are largely under predicted even with extremely low-Z high U models





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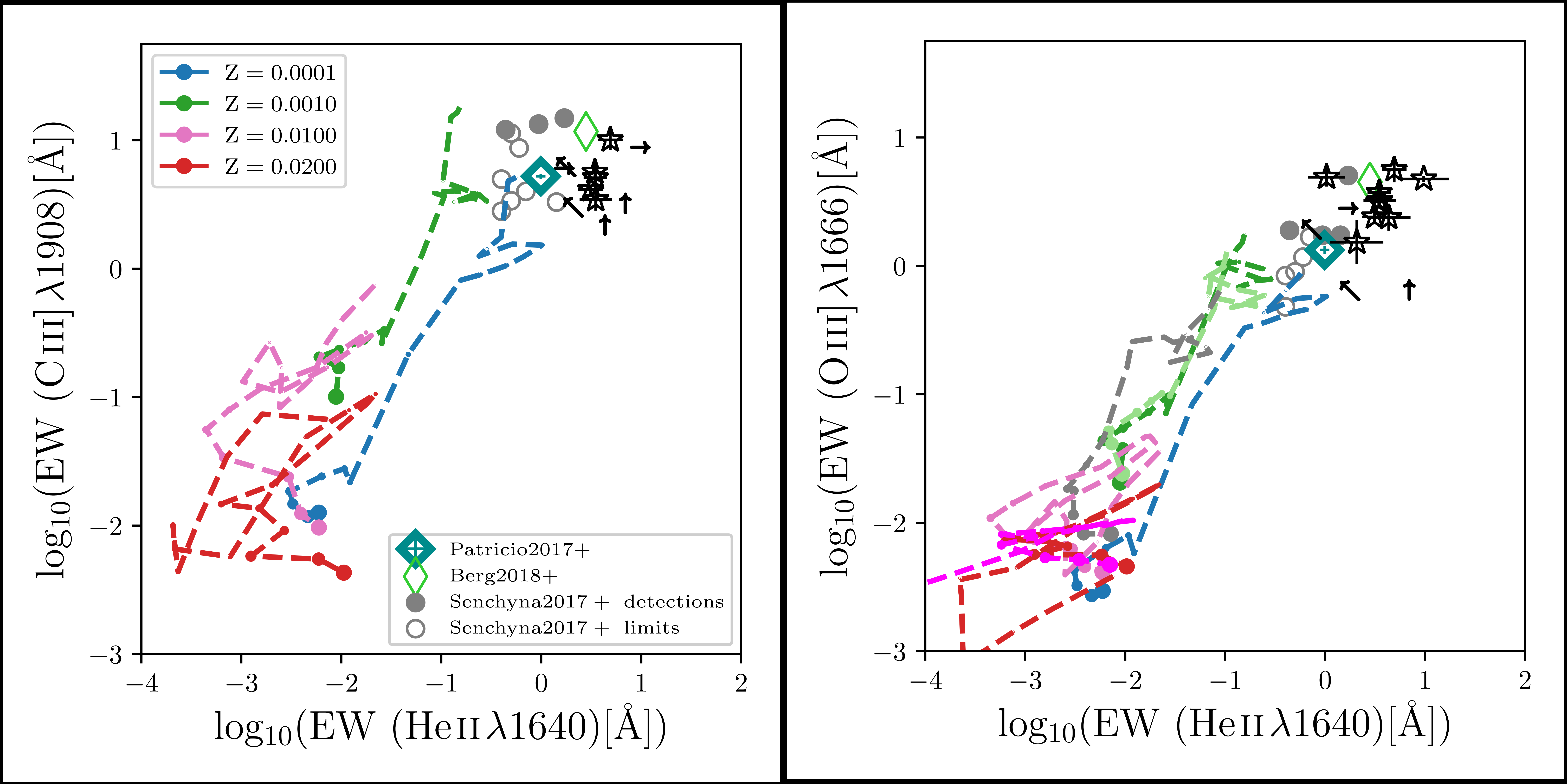

1/200th $Z_{\odot}$ binary stellar models are required to match observed vs predicted numbers of He^{+} ionising photons

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1/200th $Z_\odot$ binary stellar models are required to match observed vs predicted numbers of He^{+} ionising photons

This is in contrast to relatively higher metallicities inferred by line ratio diagnostics

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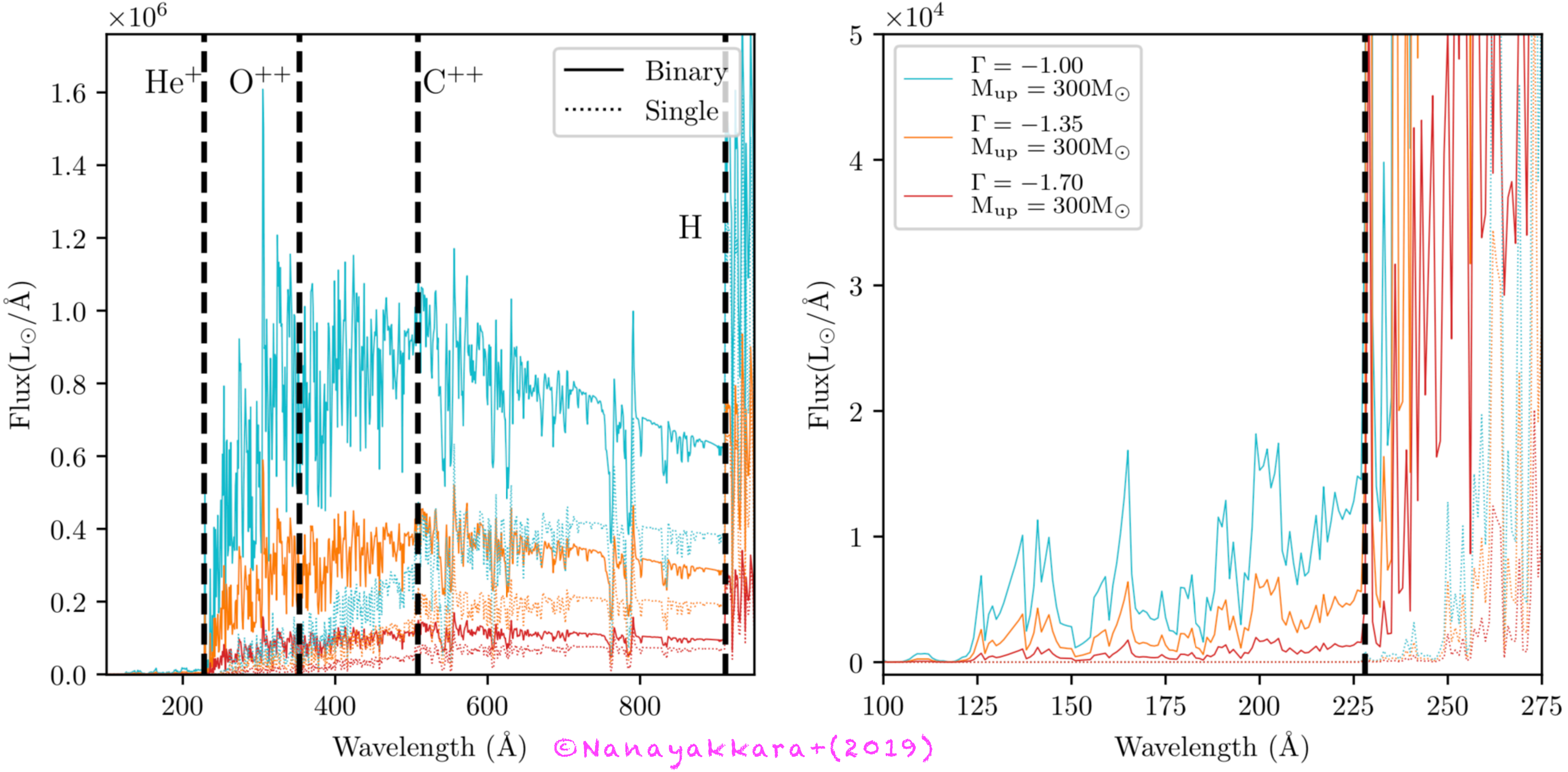
We lack a comprehensive understanding of stellar spectra in the FUV which may contribute to lack in mechanisms producing of $E_{photon} > 54eV$



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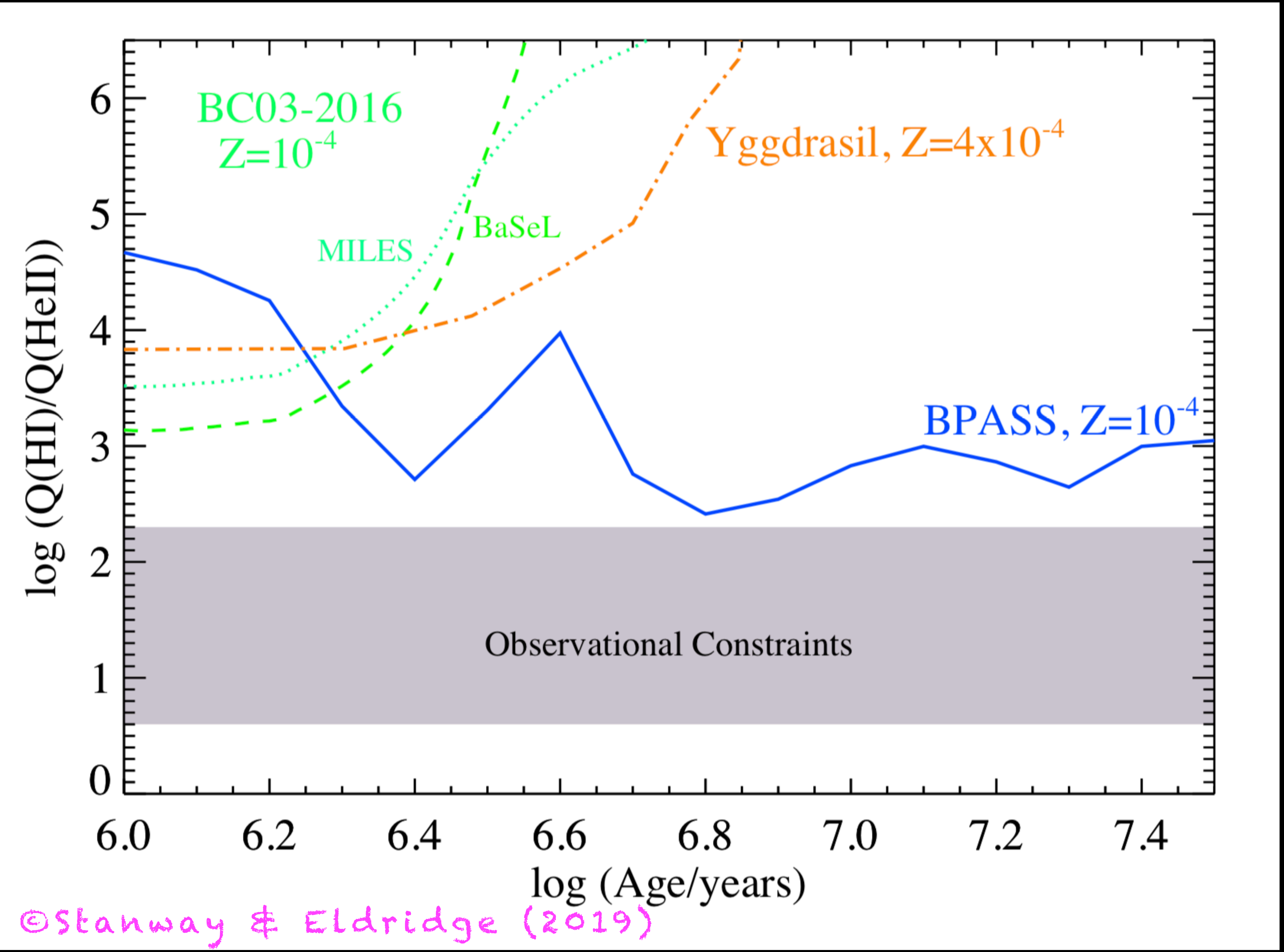
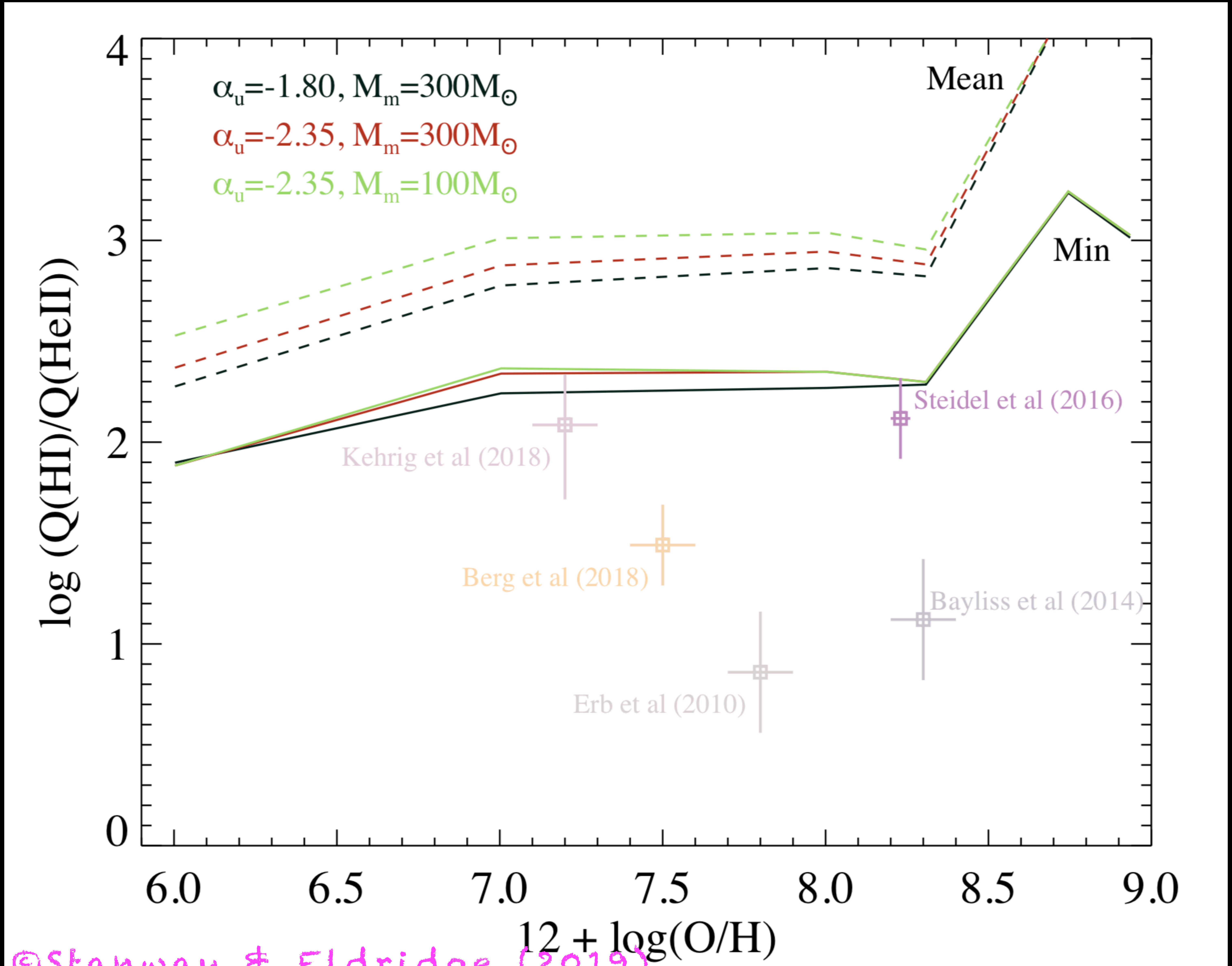
The lack of hard ionising photons is common for most stellar population models



Part III: Where are the missing photons?

Is it variations in the IMF?



©Stanway & Eldridge (2019)

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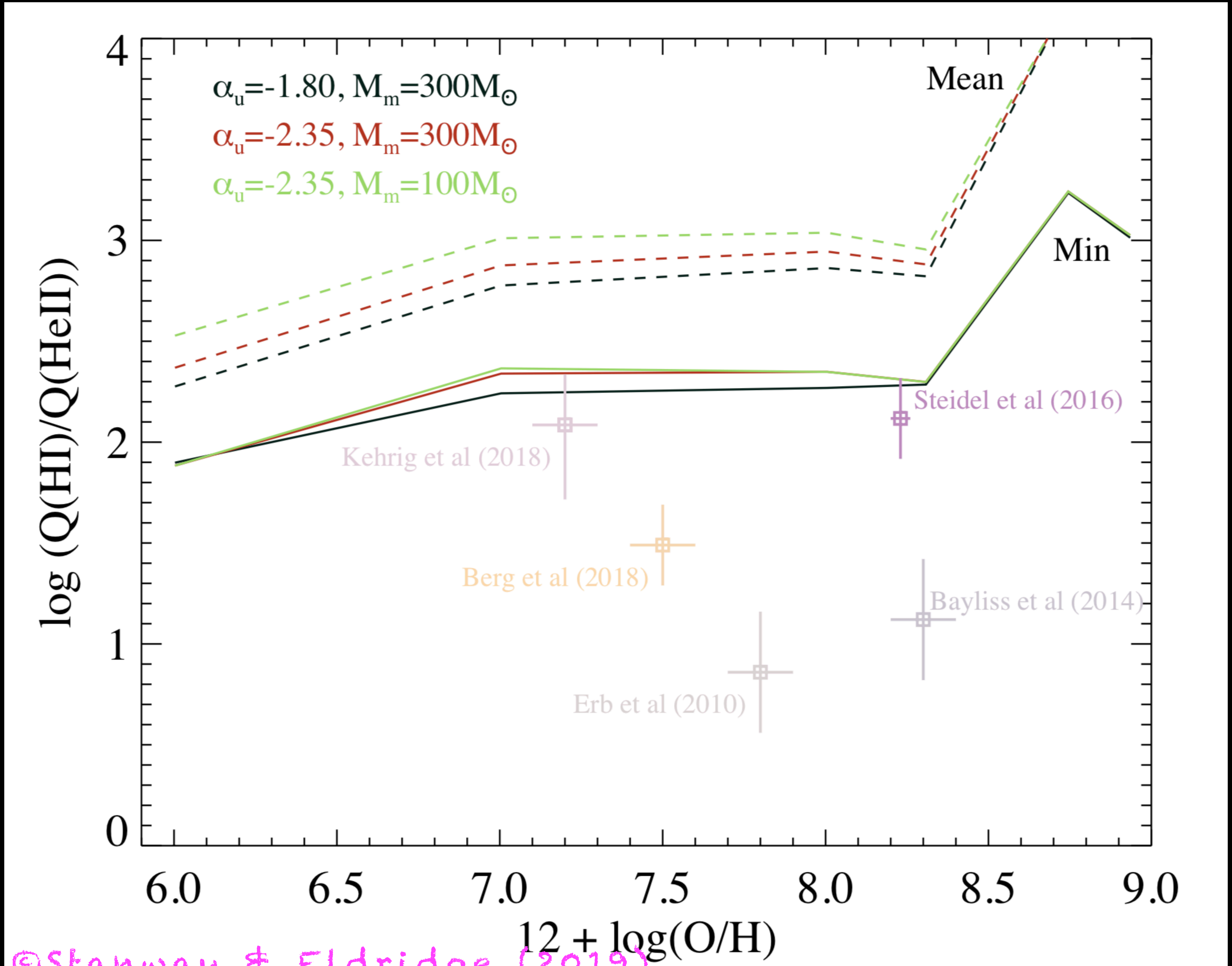
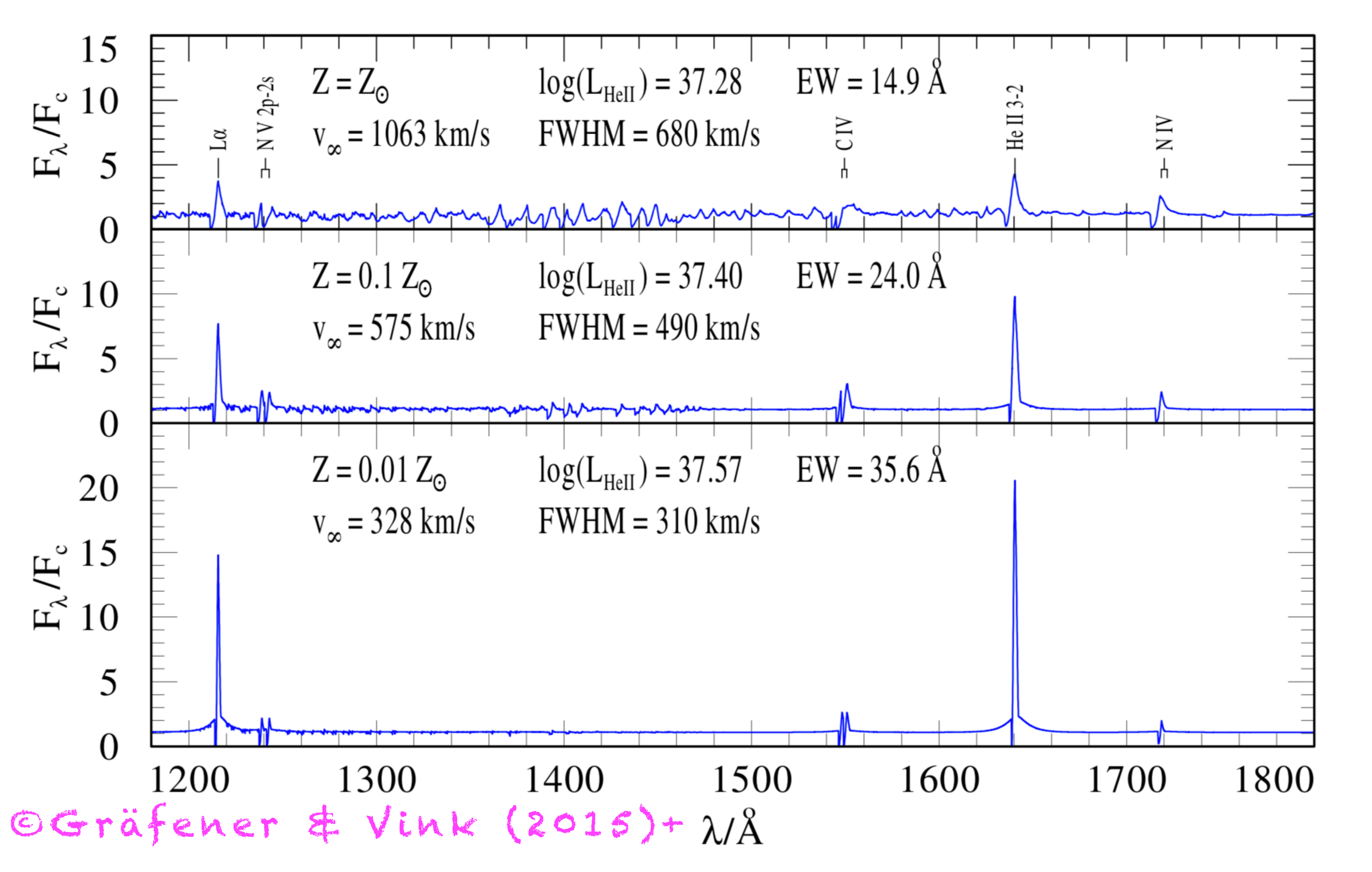


In the context of BPASS even variations in the IMF has shown to NOT be sufficient to compensate for the missing photons

Is it very massive stars at Eddington limit?



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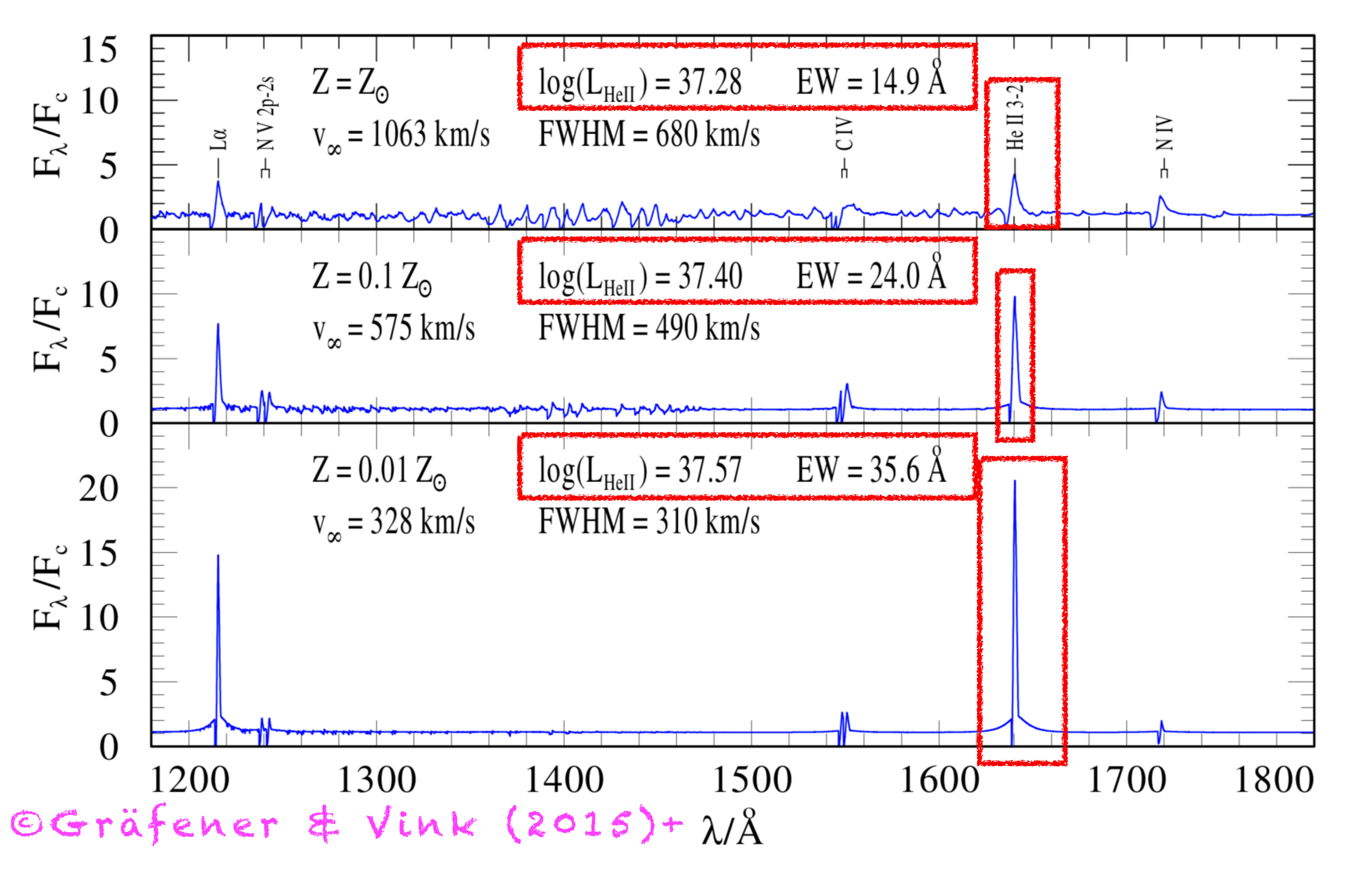

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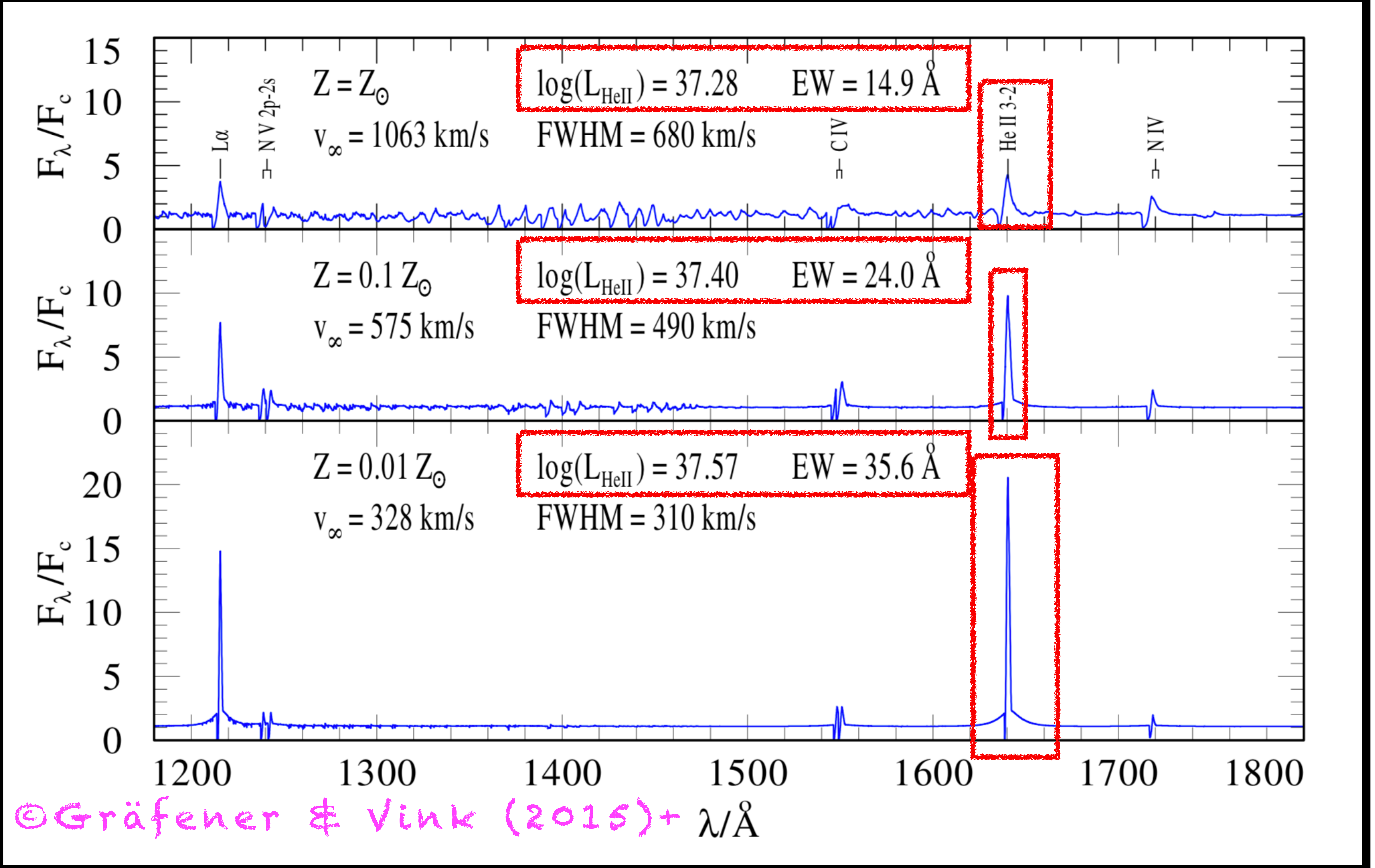

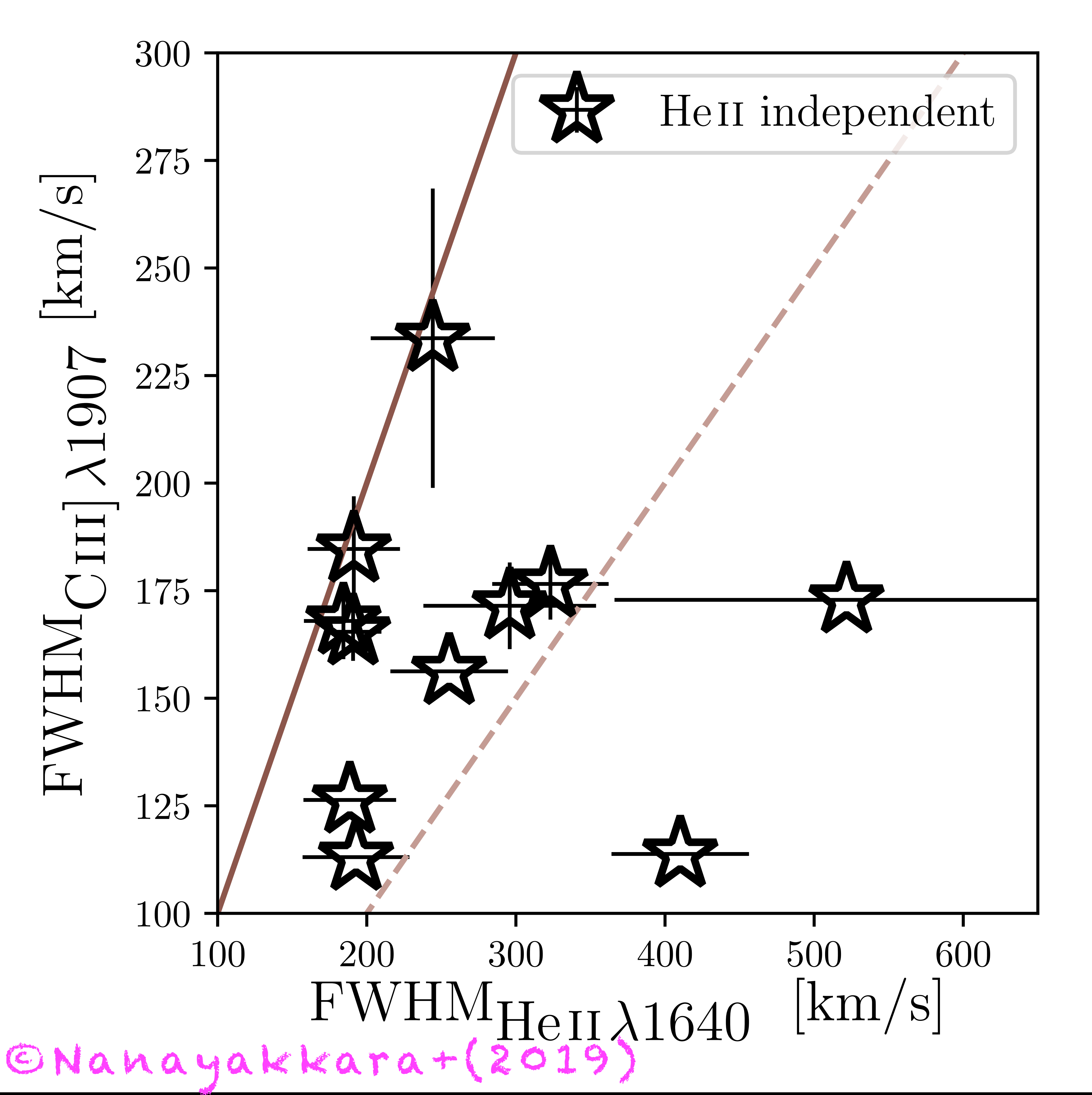

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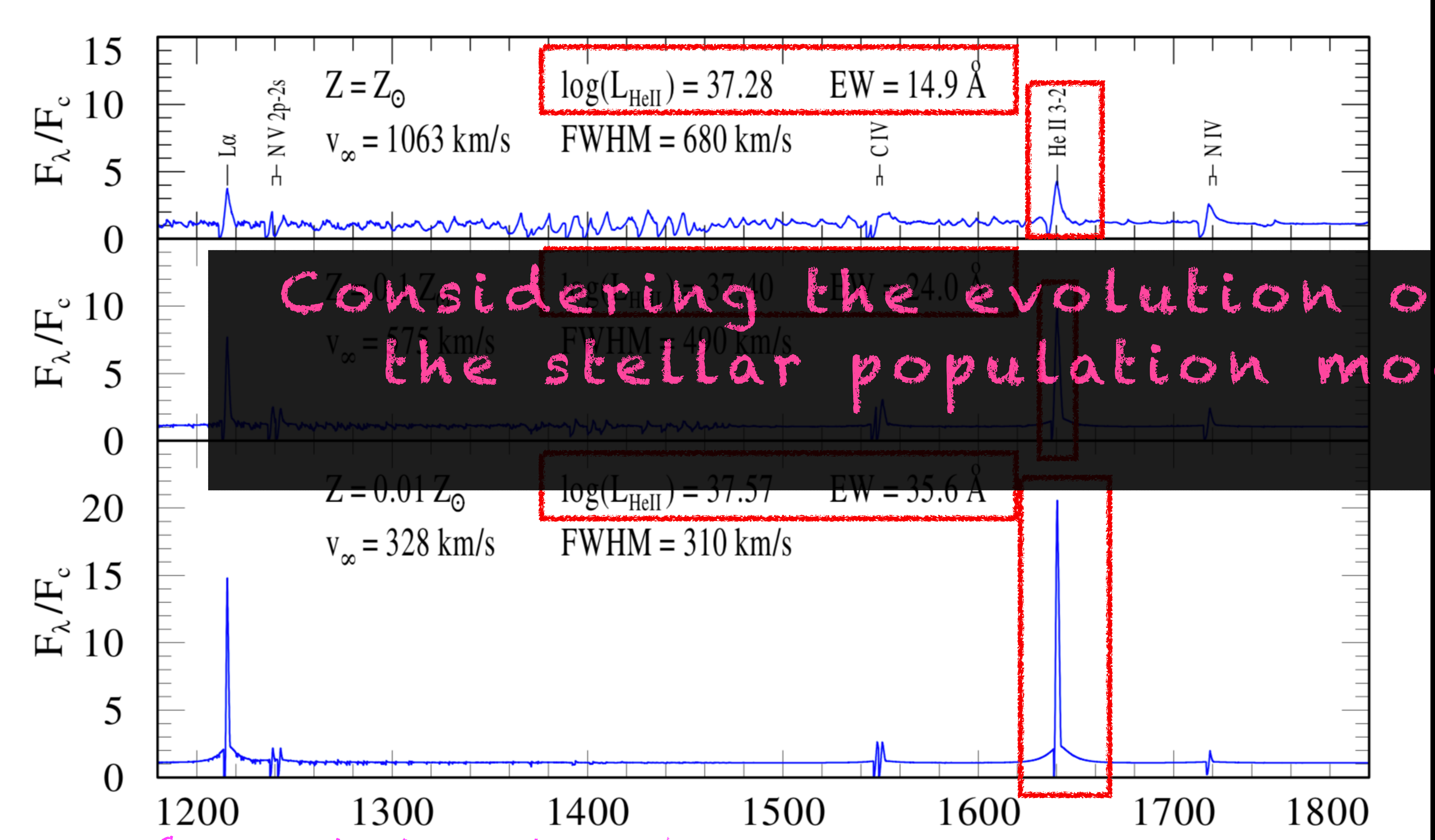

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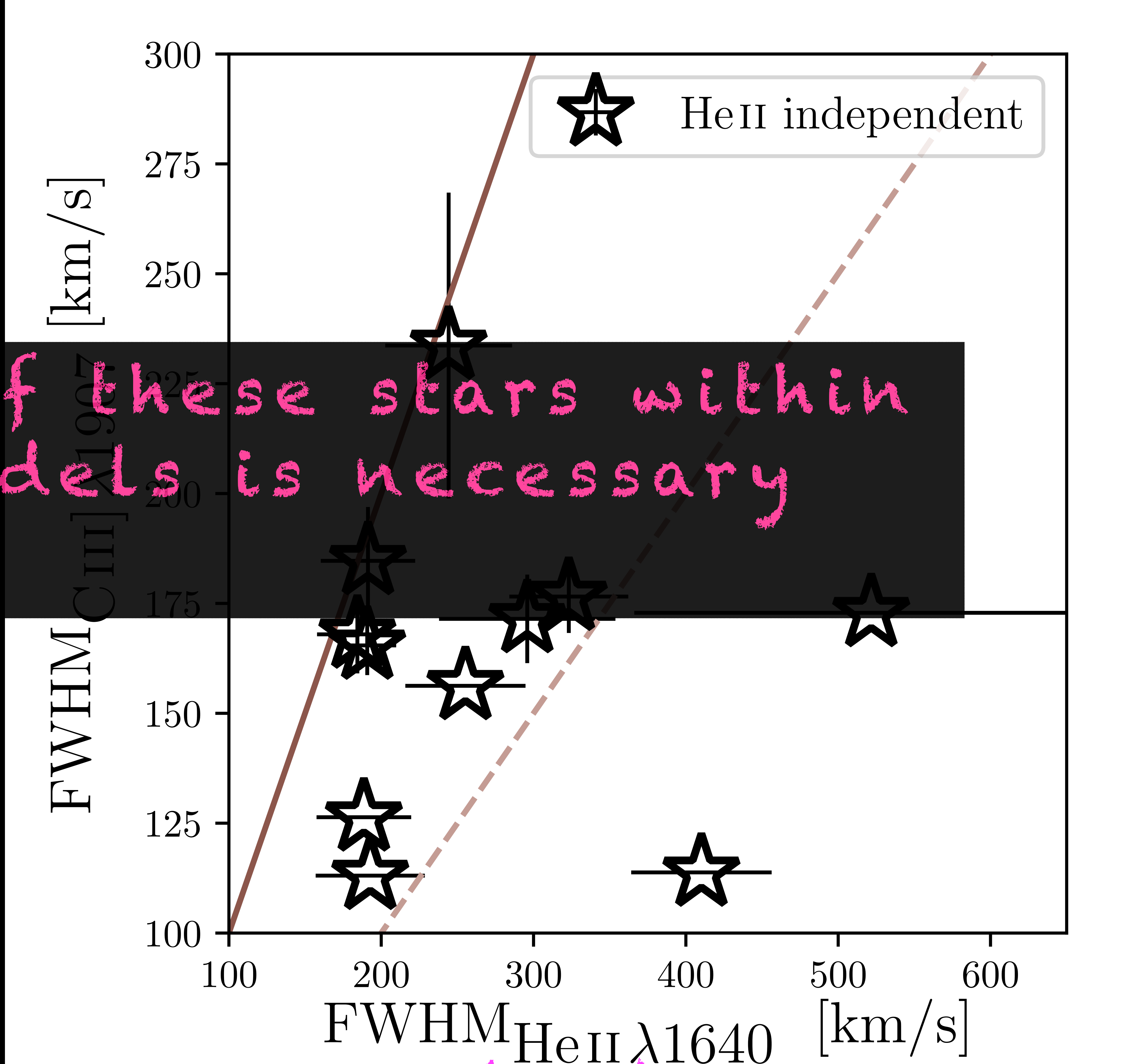

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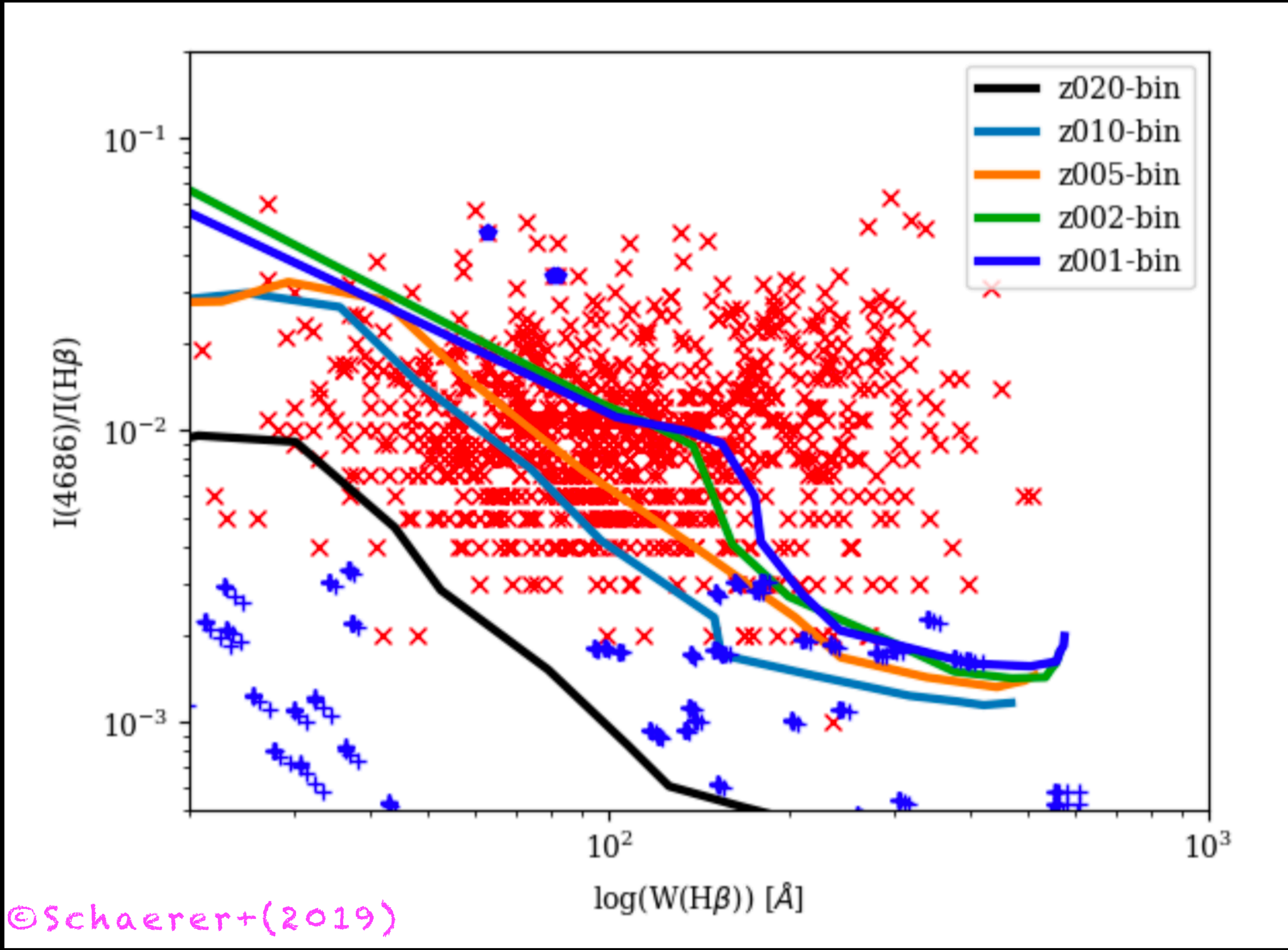
Considering the evolution of these stars within the stellar population models is necessary

Is it contributions from X-ray Binaries?



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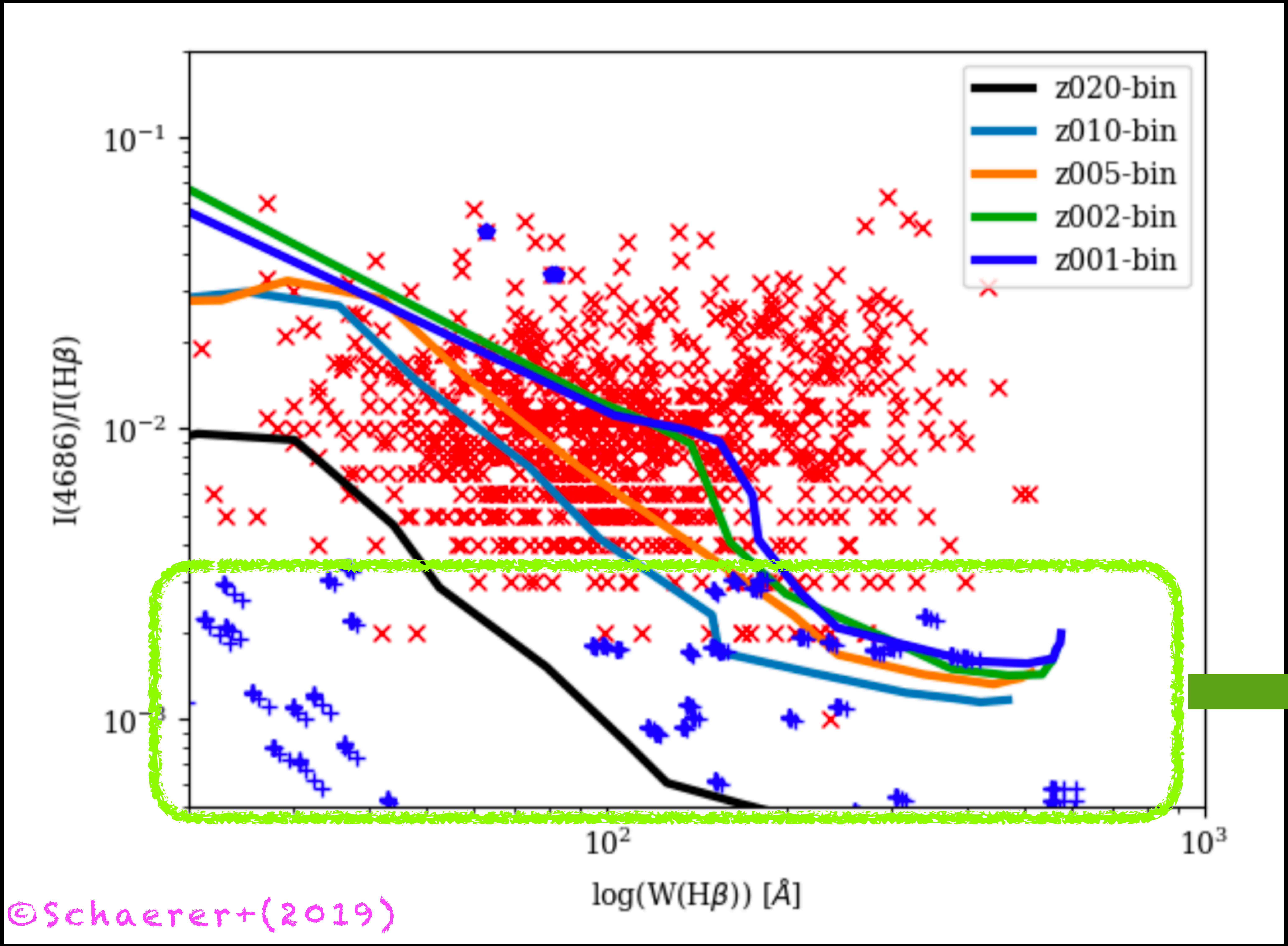

BPASS only

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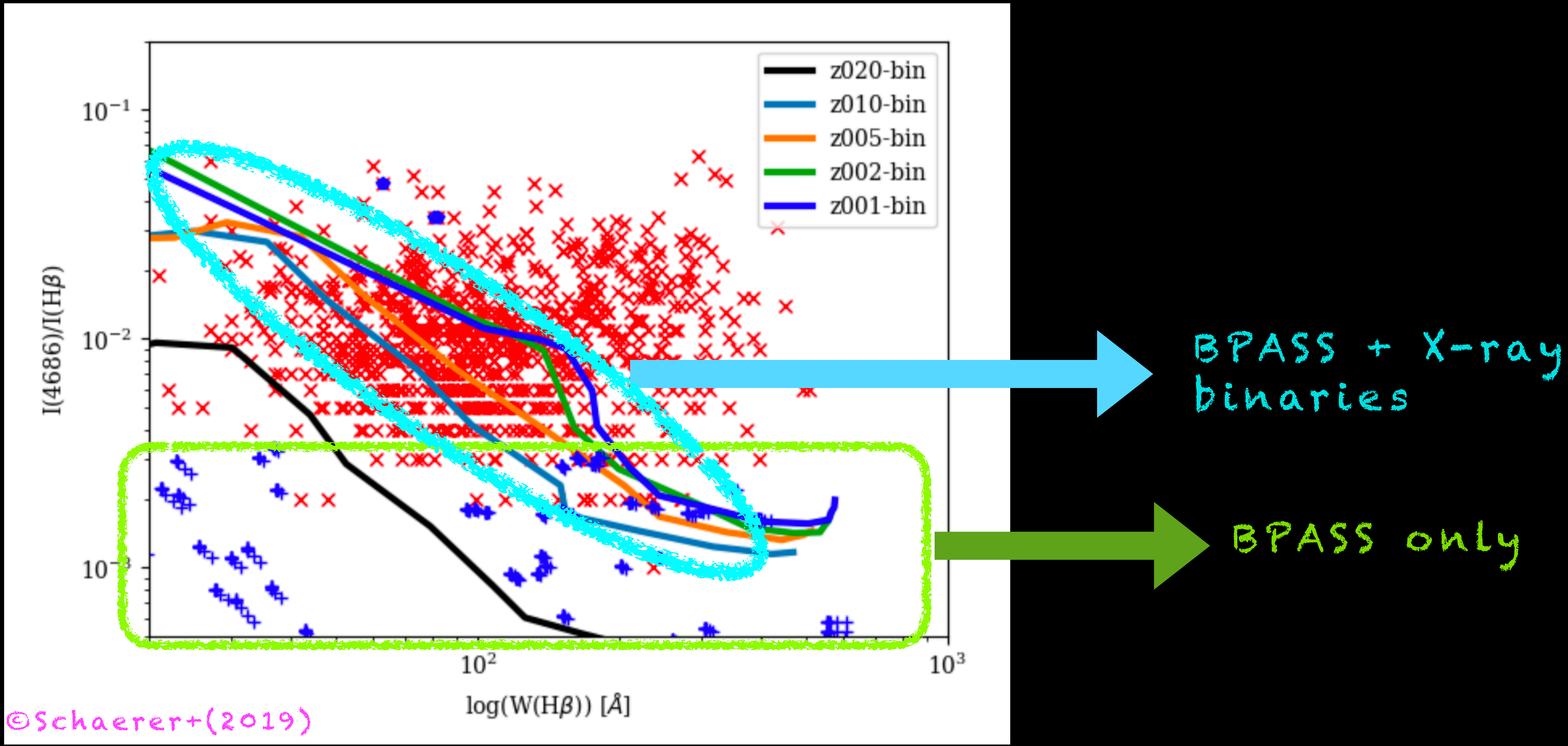

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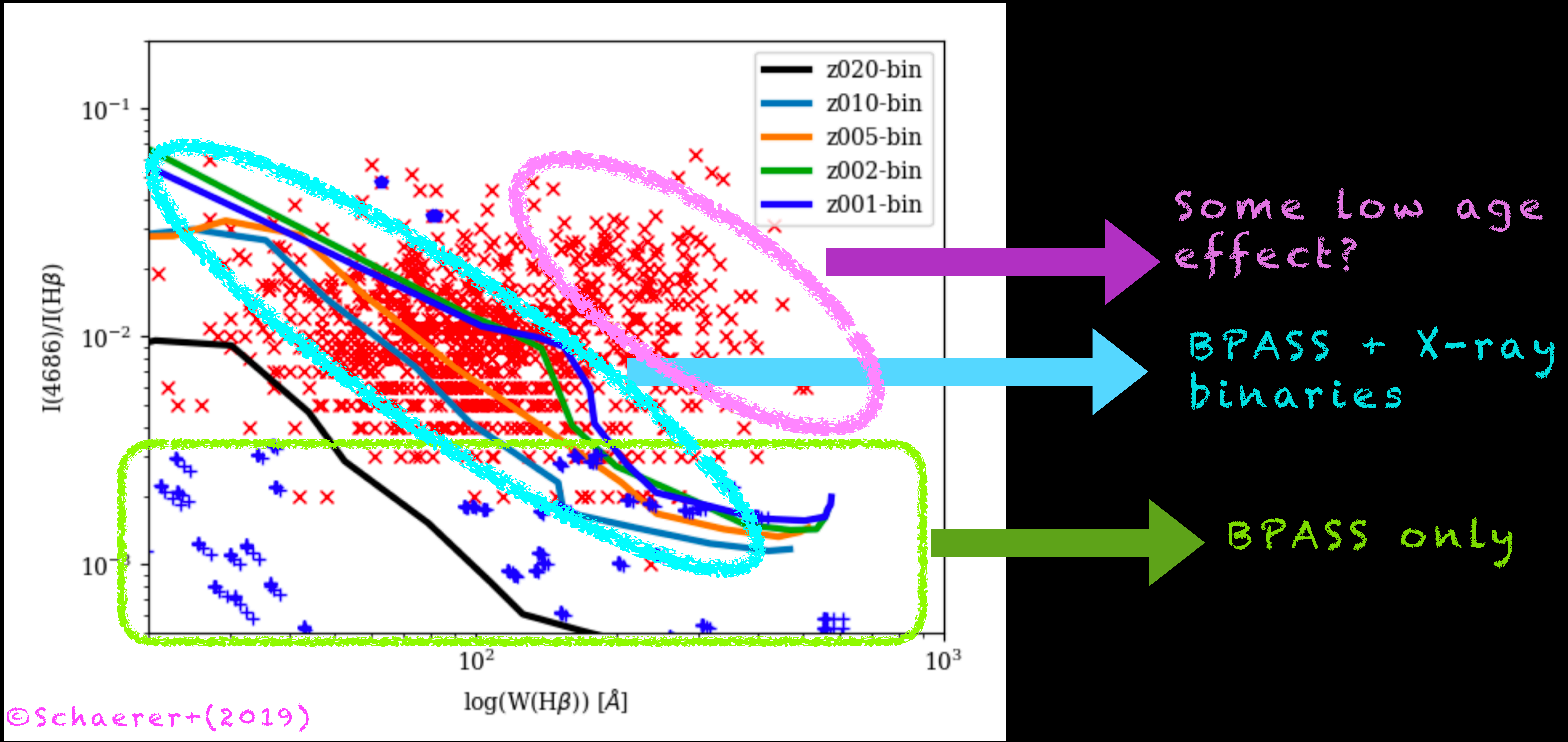
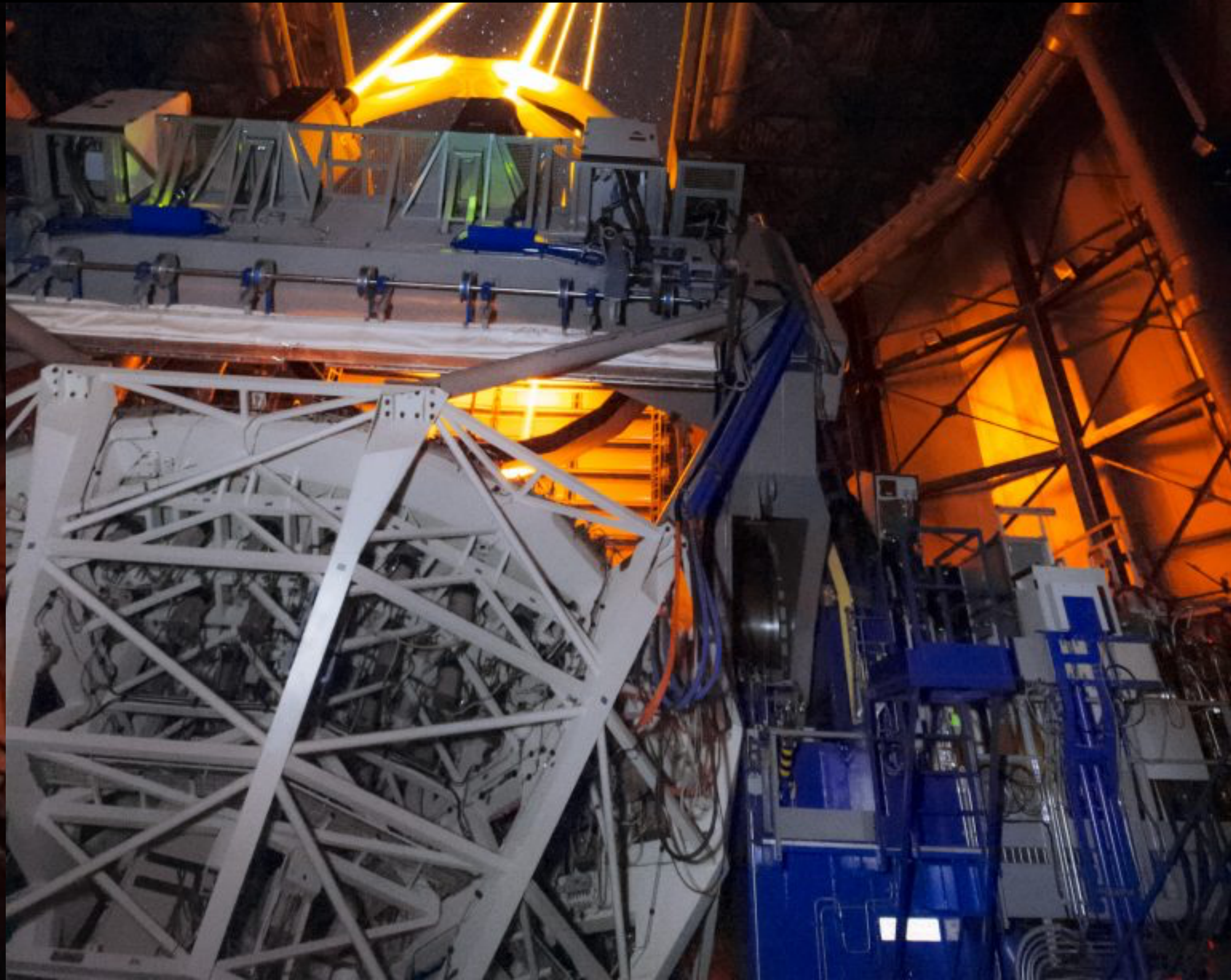


How can we provide observational constraints?

Deep high S/N data for simultaneous rest-UV emission and absorption analysis.



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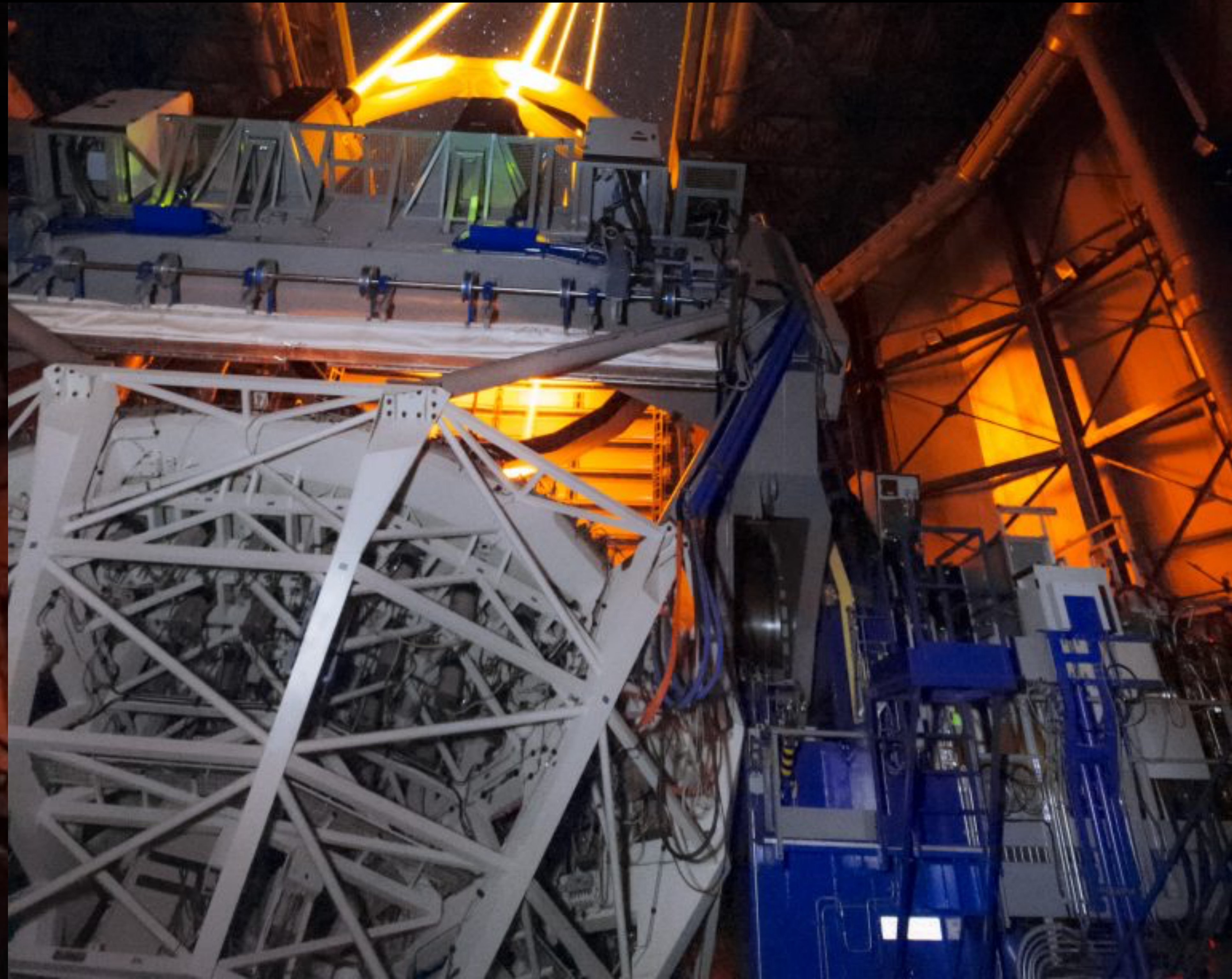
Deep high S/N data for simultaneous rest-UV emission and absorption analysis.

Deep MUSE pointings:

- MXDF ~160h single UDF pointing
- HFF parallels



MUSE XDF program

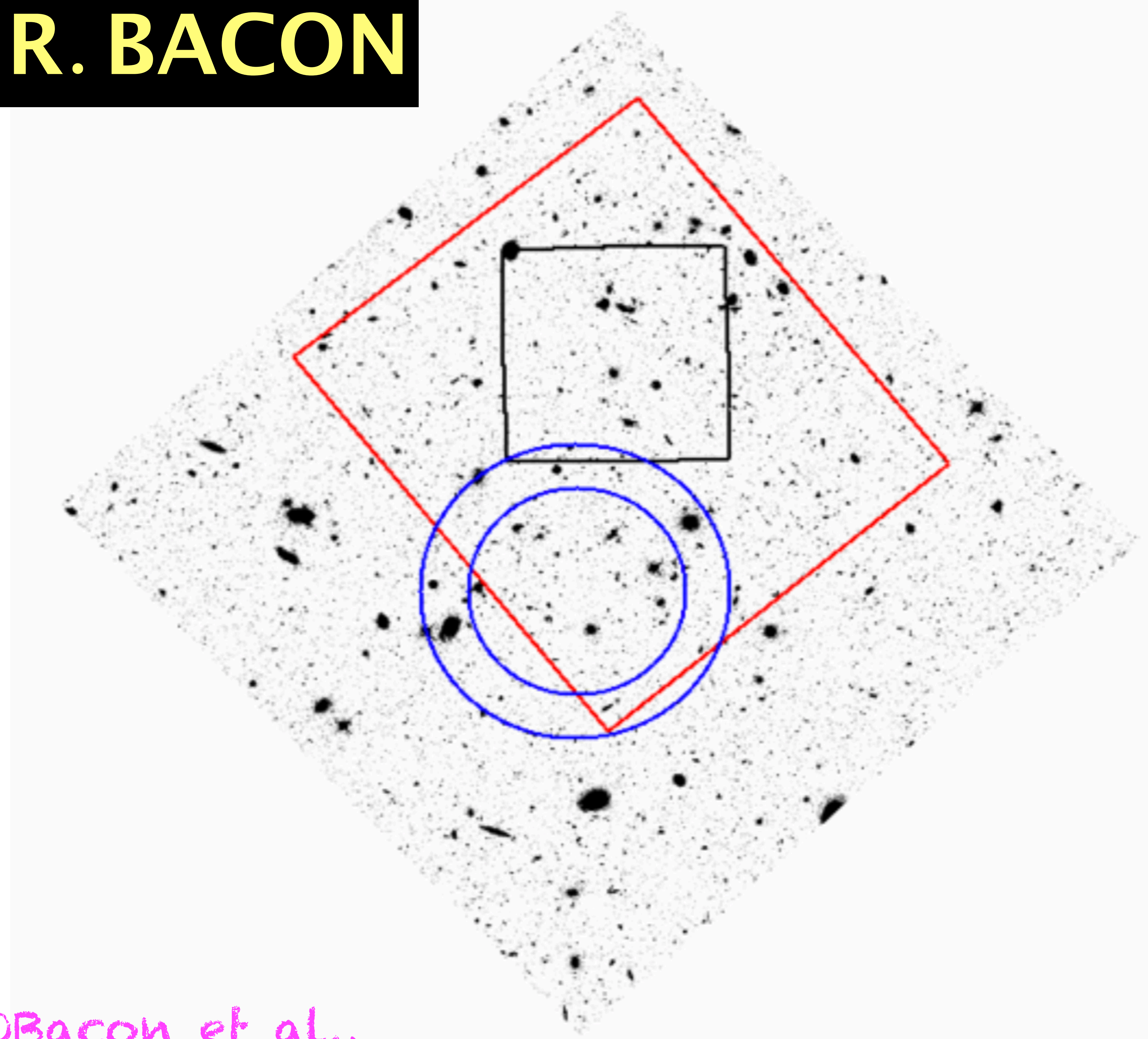
MUSE XDF program

160h 1′x1′ single pointing in UDF

Complemented by MUSE UDF program:

- Deep: 1′x1′ 30h pointing
- Shallow: 9′x9′ 10h pointings

PI R. BACON



©Bacon et al.,

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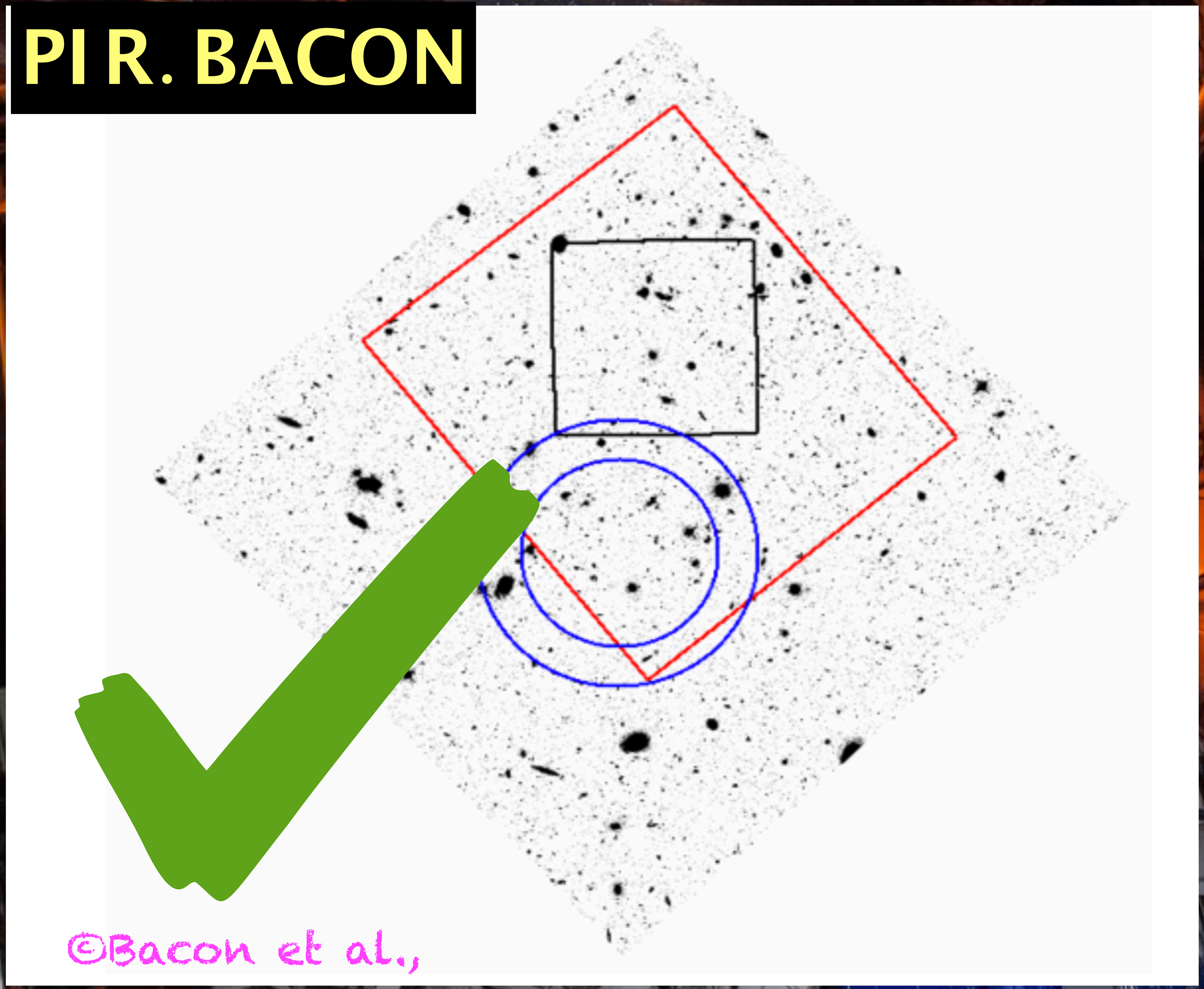
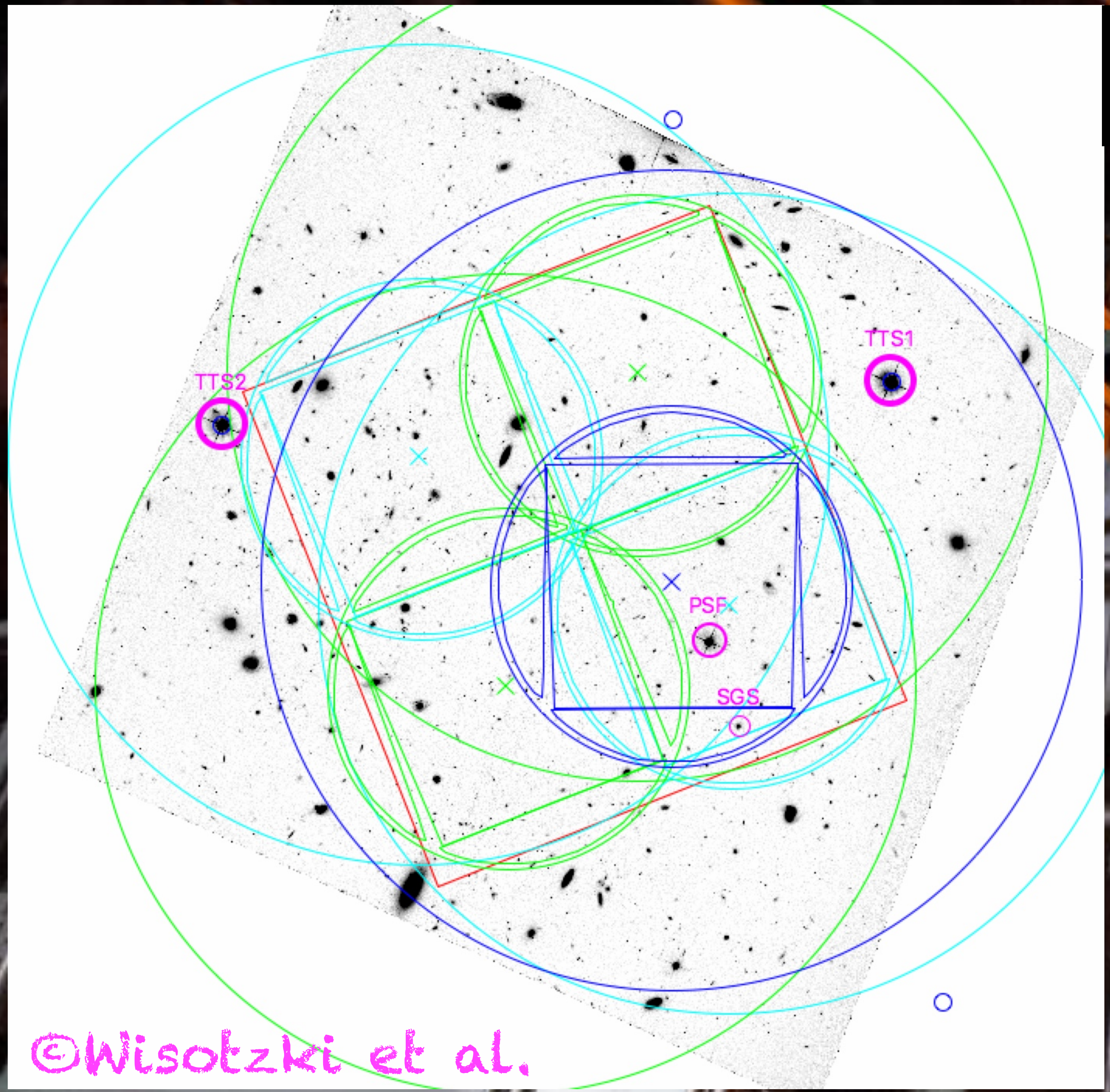
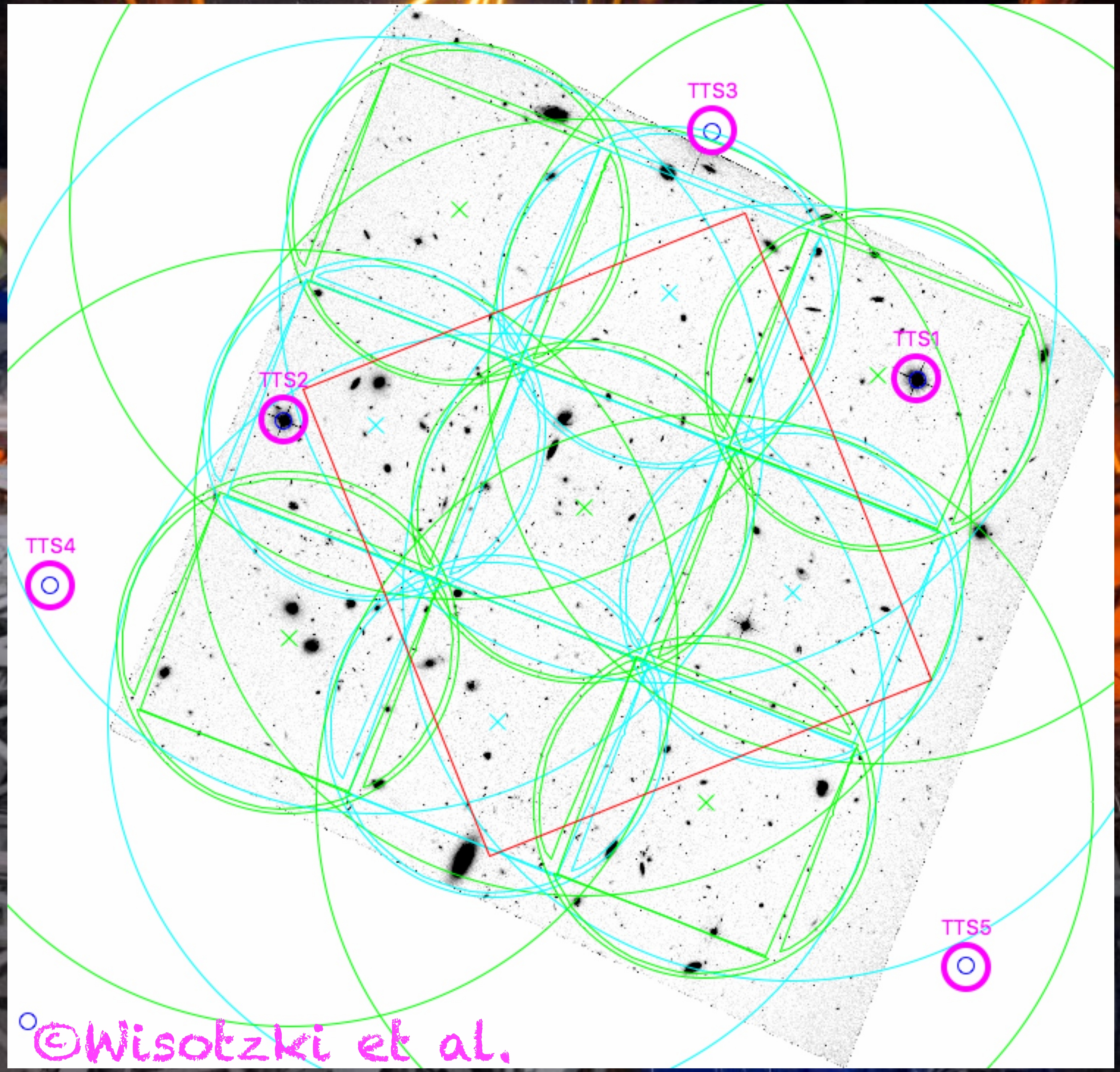


MUSE HFF program



PI L. WISOTZKI

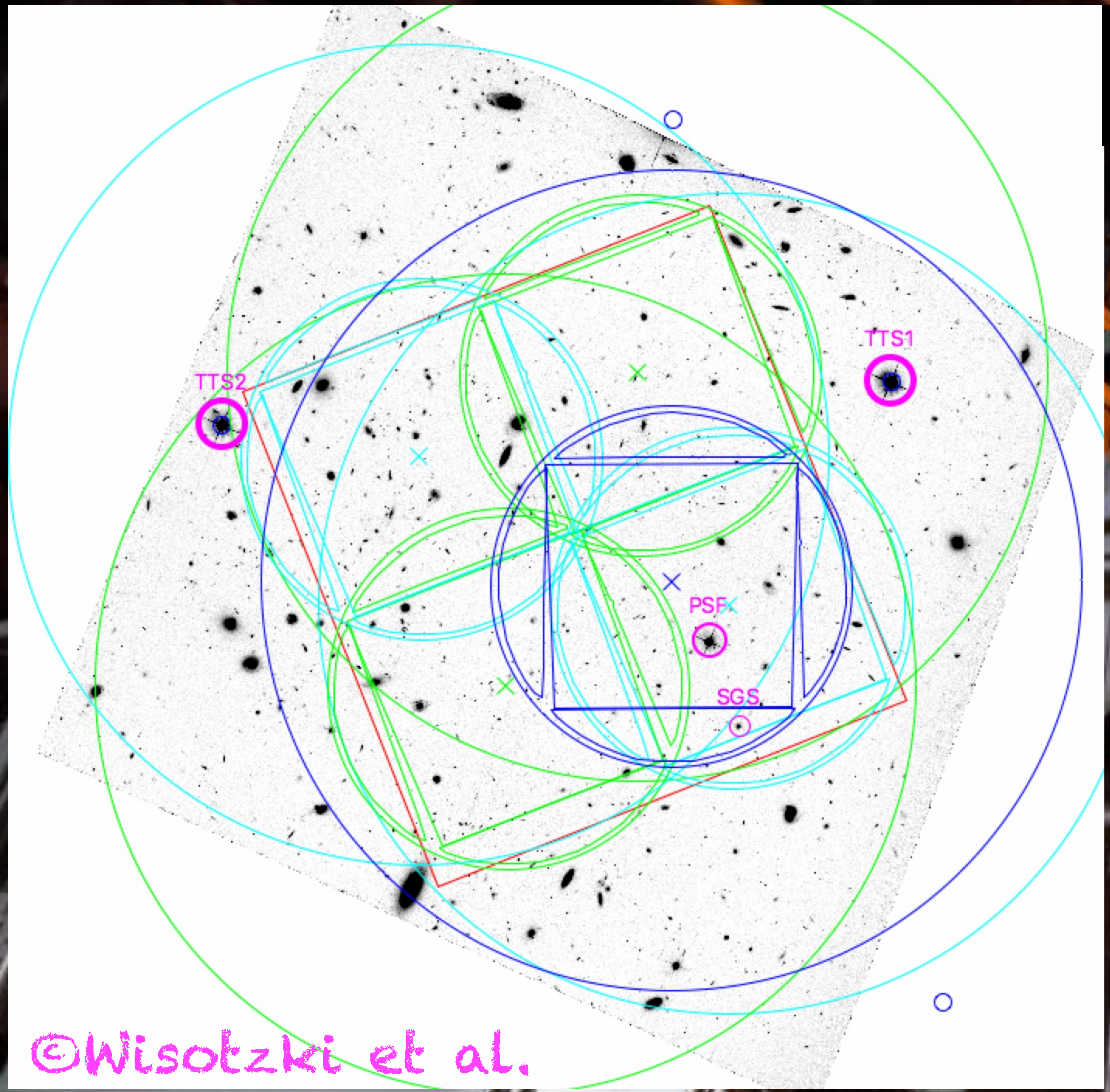


MUSE HFF program

200h program with 4 HFF parallel fields.

Each field:

- Deep: 1`x1` 25h pointing
- Medium: 2`x2` 5h pointings
- shallow: 3`x3` 1.7h pointings



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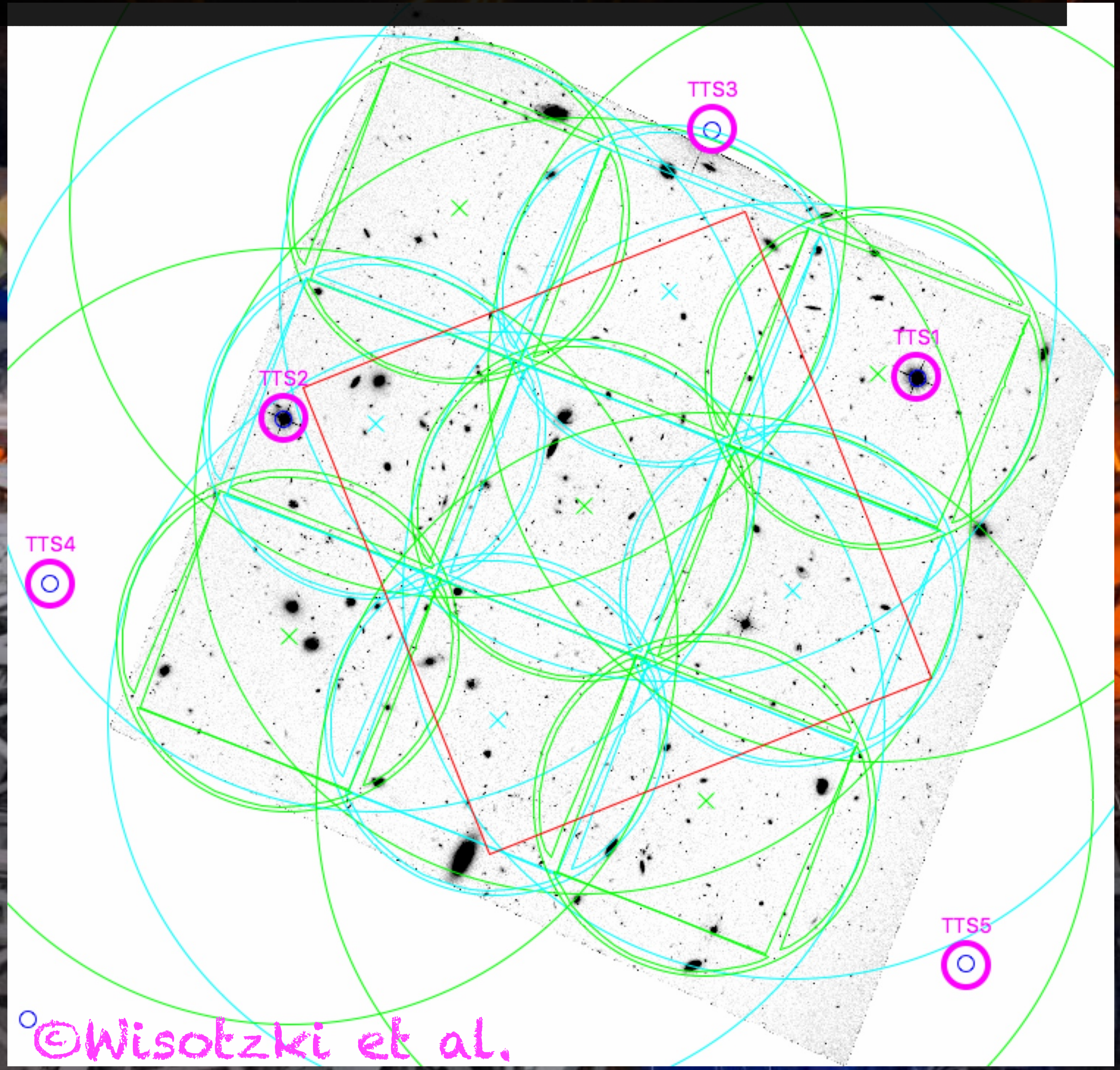

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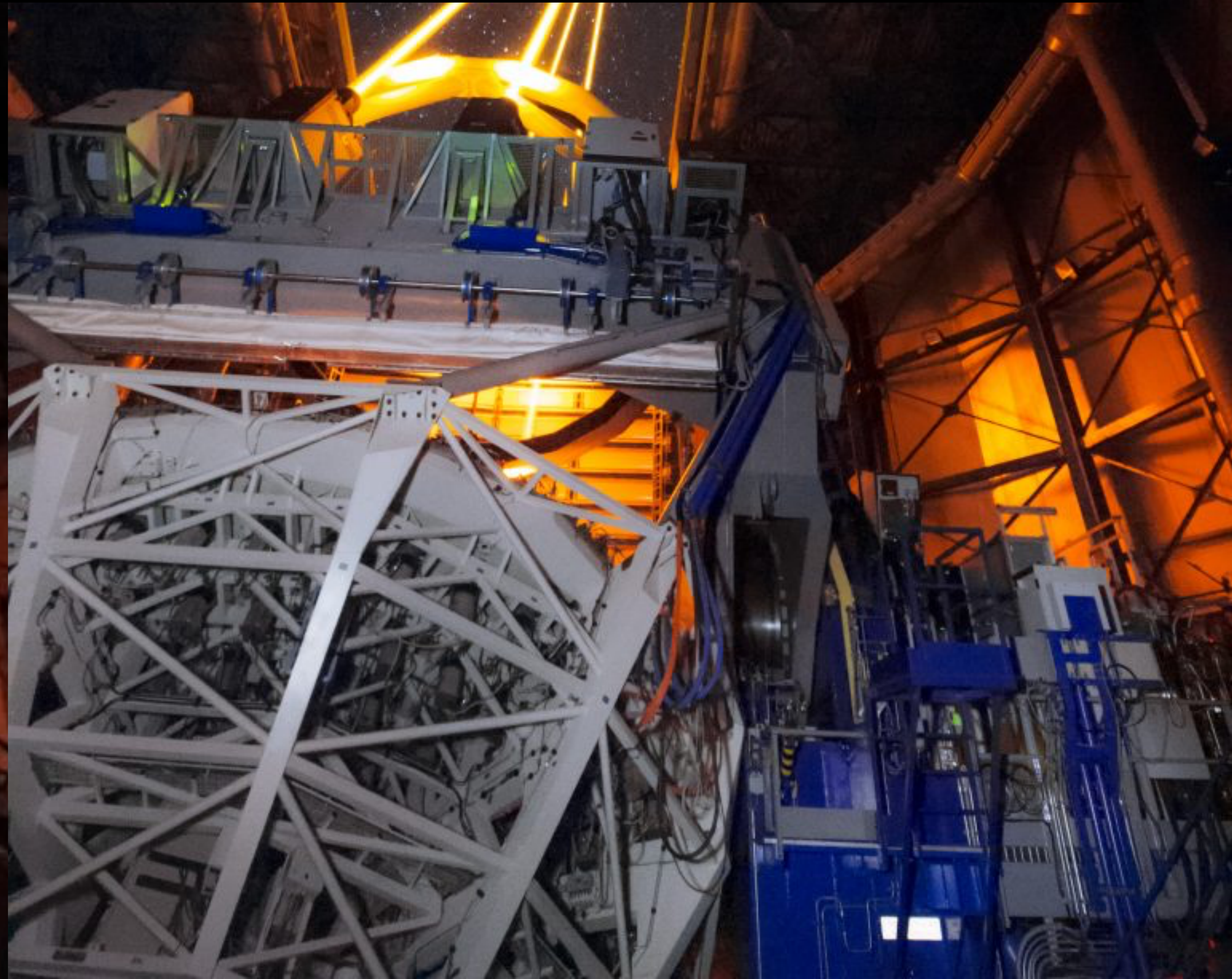

How can we provide observational constraints?

Deep high S/N data for simultaneous rest-UV emission and absorption analysis

Deep MUSE pointings:

- **MXDF ~160h single UDF pointing**
- **HFF parallels**

Stacking MUSE UDF (30h) + MUSE WIDE (10h*9) + several ~10 other GTO pointings

Testing stellar population models

Include X-ray binary spectra, VMS evolution models in SSPs and investigate observed correlations with galaxy properties

Investigate the variations in the IMF along with other changes

Include realistic dust models and investigate how extra ionising photons effects observed emission line ratios

CONCLUSIONS

arXiv:1902.05960

- We compose a catalogue with ≈13 HeII$_{1640}$ detections from MUSE (and ≈20 tentative detections from other public surveys).
- Using Gutkin et al., (2016) models we show our observed emission line ratios can be reproduced via high-U sub-solar Z models.
- Including effects of binaries from Xiao et al., (2018) models makes the model parameters degenerate.
- We show even BPASS models are unable to reproduce the observed HeIIλ_{1640} and OIII]λ_{1666} equivalent widths.
- We show that matching HeIIλ_{1640} luminosities with BPASS models require ~1/200 $Z_{\odot}$ models which are in tension with gas phase metallicities inferred via line-ratio diagnostics.
- IMFs with larger fractions of high mass stars (top heavy) or exotic stellar population mechanisms such as XRBs or very massive WNh stars that can produce photons at wavelength > 275 Å with relatively low wind effects are required to match our observed data with models.