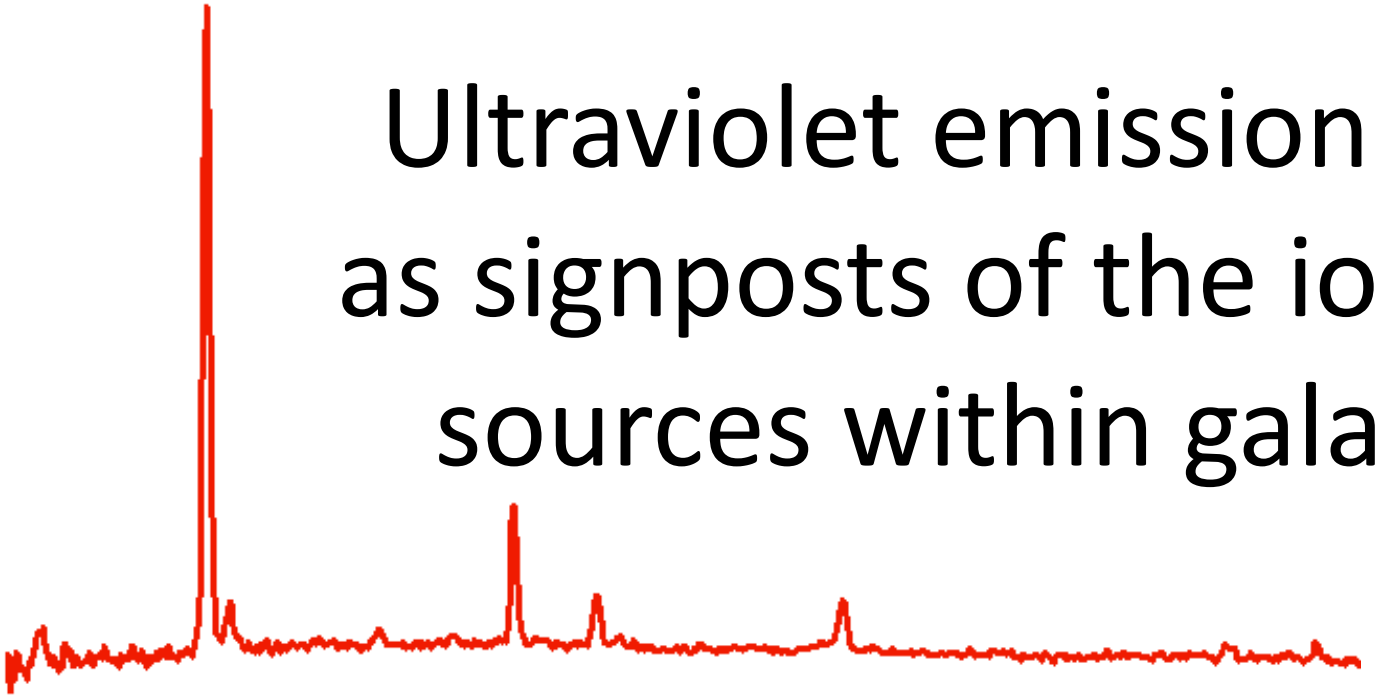


Ultraviolet emission lines as signposts of the ionizing sources within galaxies

A. Feltre

S. Charlot, E. Curtis-Lake, J. Gutkin, M. Hirschmann,
D. Stenning, A. Vidal-Garcia, A. Wofford (IAP),
J. Chevallard (ESA-ESTEC), C. Pacifici (STScI)
M. Mignoli, F. Calura, R. Gilli, G. Zamorani (INAF-BO)

UV tracers of ionizing sources

nature of the ionizing sources (and relative contributions)
at different cosmic epochs (out to cosmic reionization)

rest-frame ultraviolet spectroscopy of primeval galaxies
from current (e.g. VLT-KMOS/MUSE, Keck-MOSFIRE)
and future (e.g. JWST, E-ELT) facilities

accurate modelling to study the physical properties of active and inactive galaxies

UV emission-line ratios as diagnostics for the ionizing source

SF galaxy models

→ J. Gutkin's poster #32

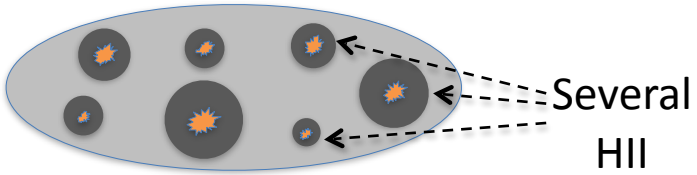
Gutkin+16 submitted

evolutionary population synthesis code GALAXEV

+

CLOUDY

Ferland+13



CB16

new stellar evolutionary tracks and atmospheres, also for massive stars (including WR stars)

→ G. Bruzual's talk

luminosity of the galaxy at age *t*

HII region

$$F_\lambda(t) = \int_0^t \Psi(t-t')\ f_\lambda[t', \tilde{Z}]\ T_\lambda(t,t')\ dt'$$

SFR at time *t-t'*

SSP of age *t'*

nebular (CLOUDY)

courtesy of J. Gutkin

AGN NLR models

AGN accretion disk luminosity

+

CLOUDY
Ferland+13

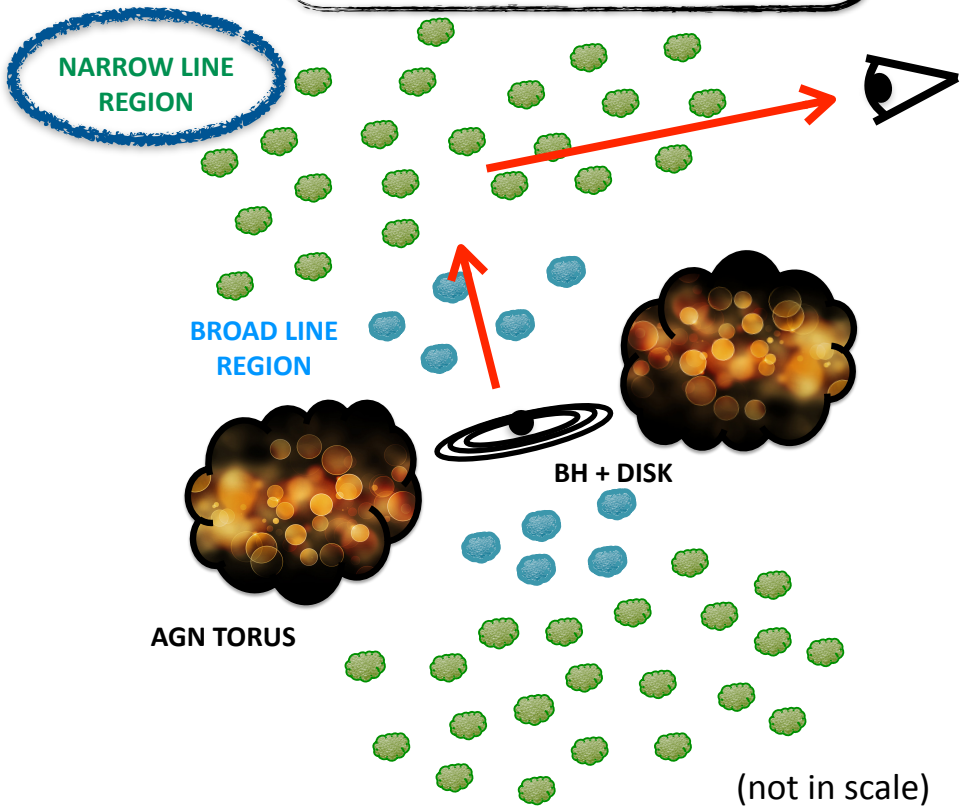
series of power laws

$$F_\nu \propto \nu^\alpha$$

UV spectral index
in the range 10-2500 Å

Feltre+16

for consistency, parametrization analogous to that of SF models



Main adjustable parameters

n_H = hydrogen gas density

U_S = ionization parameter = n_γ/n_H

Z = metallicity (gas+dust phase)

ξ_d = dust-to-metal mass ratio (depletion)

α = UV spectral index (only AGN models)

C/O ratio

M_{up} of the IMF (only SF models)

metal abundances from **Bressan+ 13**
(mix **Grevesse & Sauval 98** + **Caffau+11**)

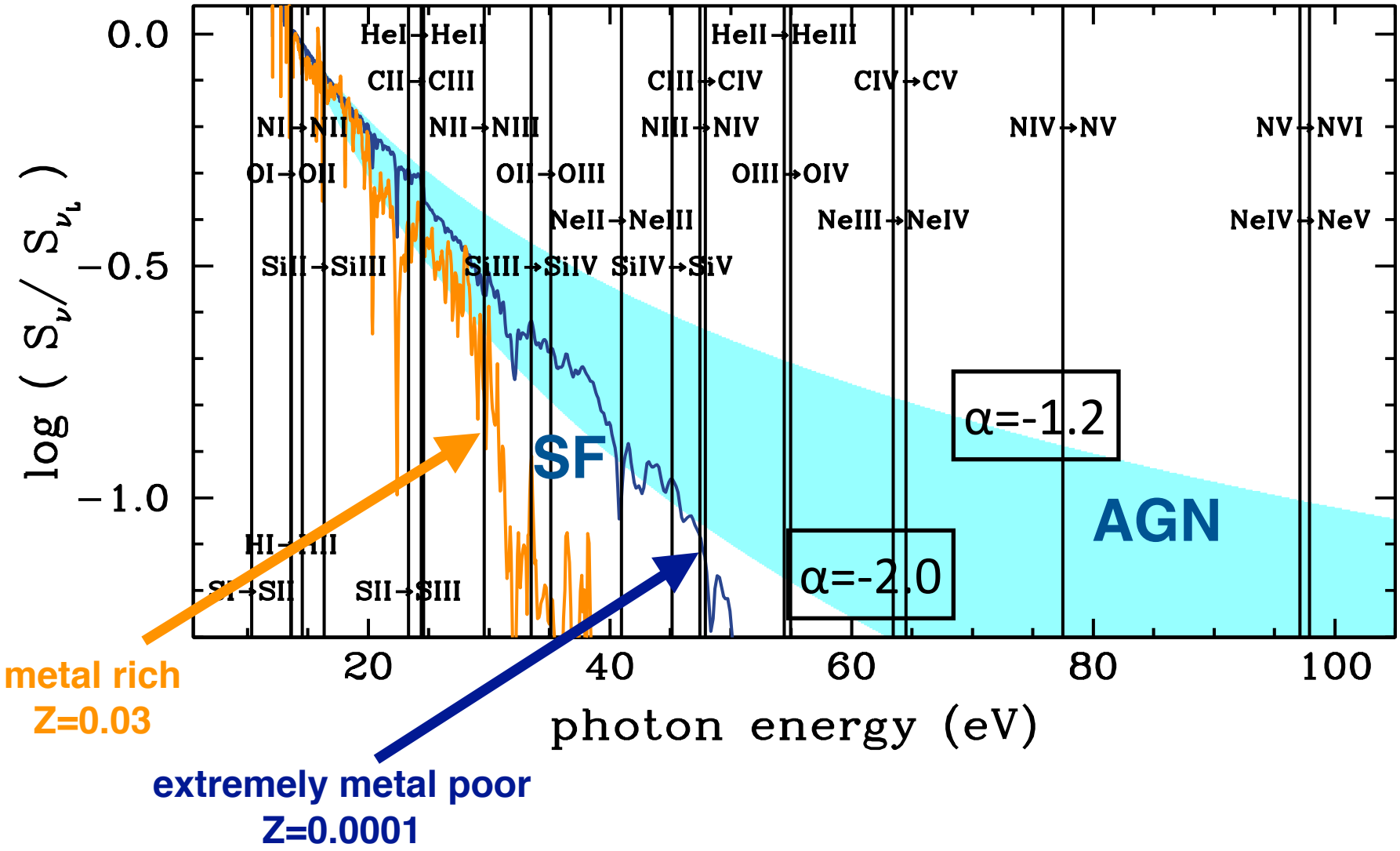
depletion values from **Gutkin+16**

→ J. Gutkin's poster

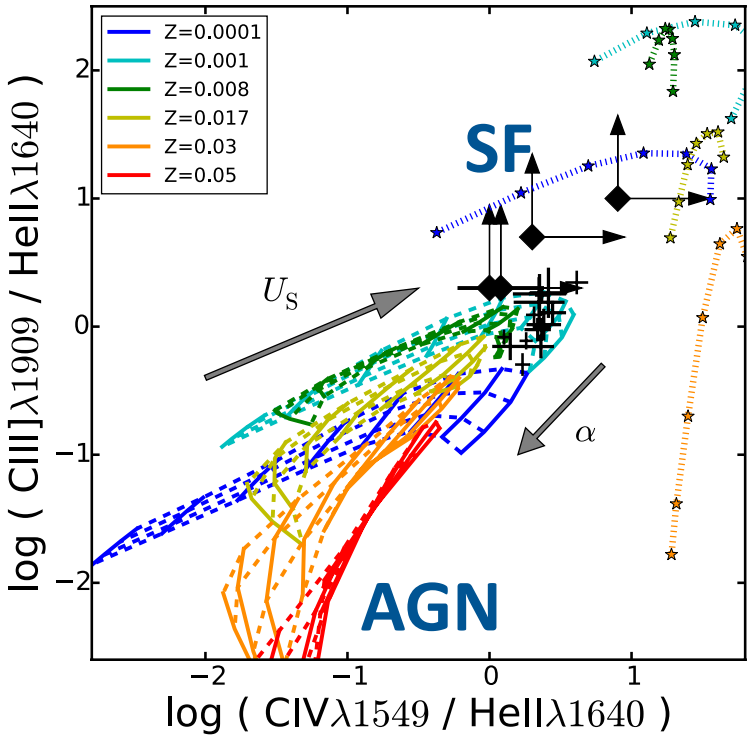
Parameter	AGN NLR	SF galaxies
Ionizing spectrum	α = -1.2, -1.4, -1.7, -2.0	constant SFR, age 10
log(Us)	-1.0, -.1,5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5	-1.0, -.1,5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5
log(n	2.0, 3.0, 4.0	2.0, 3.0, 4.0
Z	0.0001 ÷ 0.07	0.0001 ÷ 0.03
ξ_d	0.1, 0.3, 0.5	0.1, 0.3, 0.5

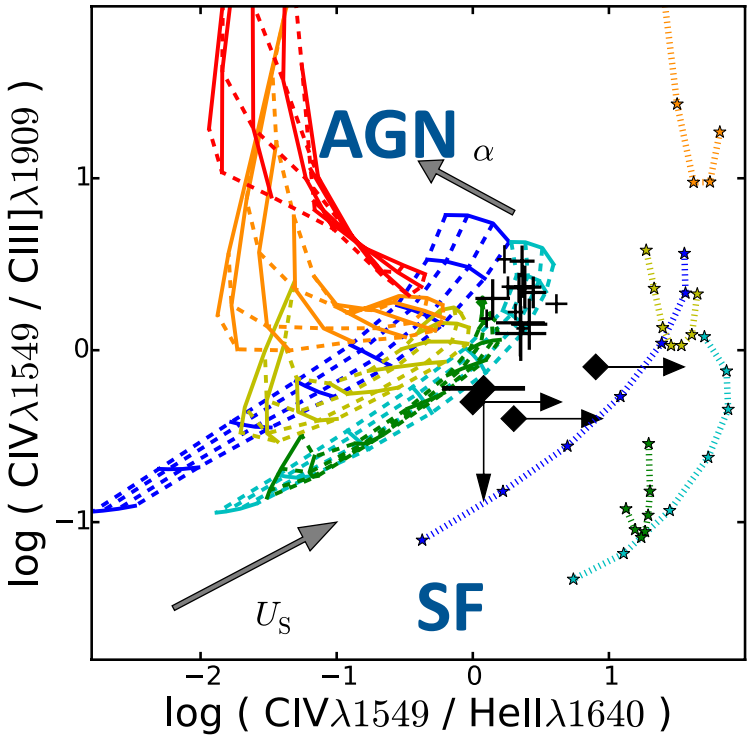
Feltre+16

AGN vs stellar ionizing spectra



UV spectral diagnostics





ξ_d =0.1
$n_H=10^2$ cm^{-3}

\+ **Dors+14**
Sy2 - low z
QSO2 - z~2

◆ **Stark+14**
dwarf galaxies
z~2

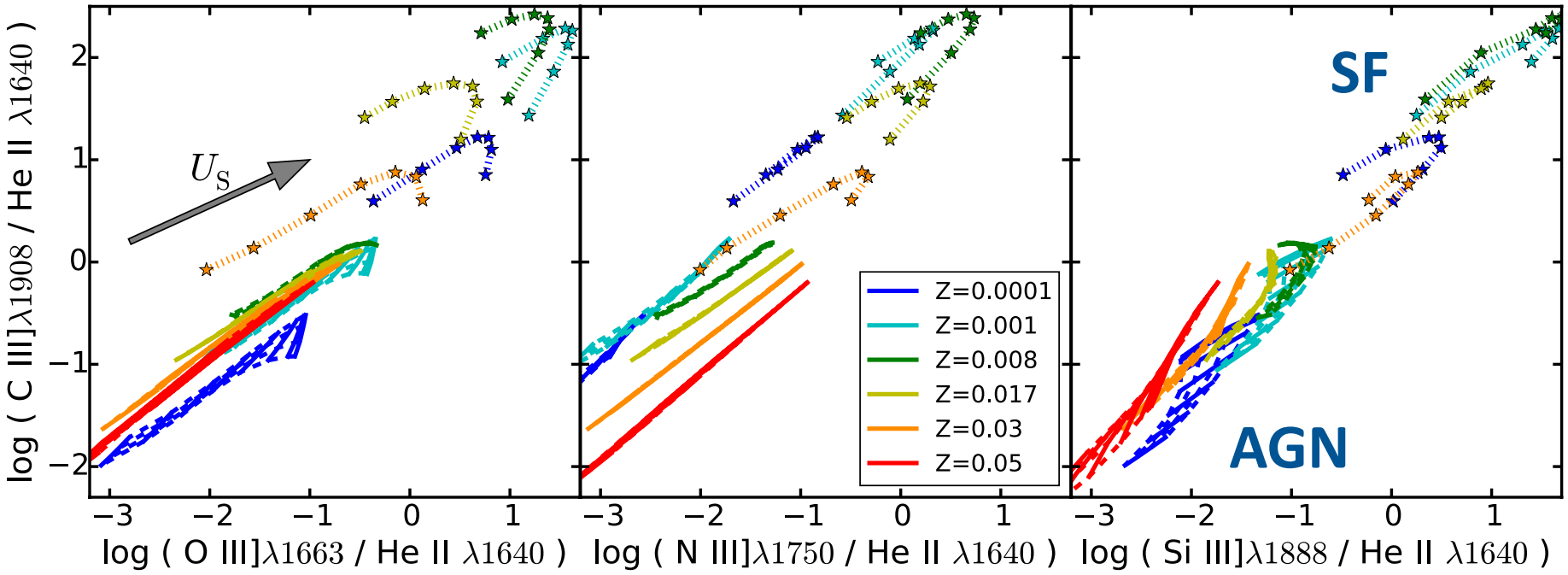
AGN and SF populate different regions of the diagrams

models predictions agree with data

Feltre+16

UV spectral diagnostics

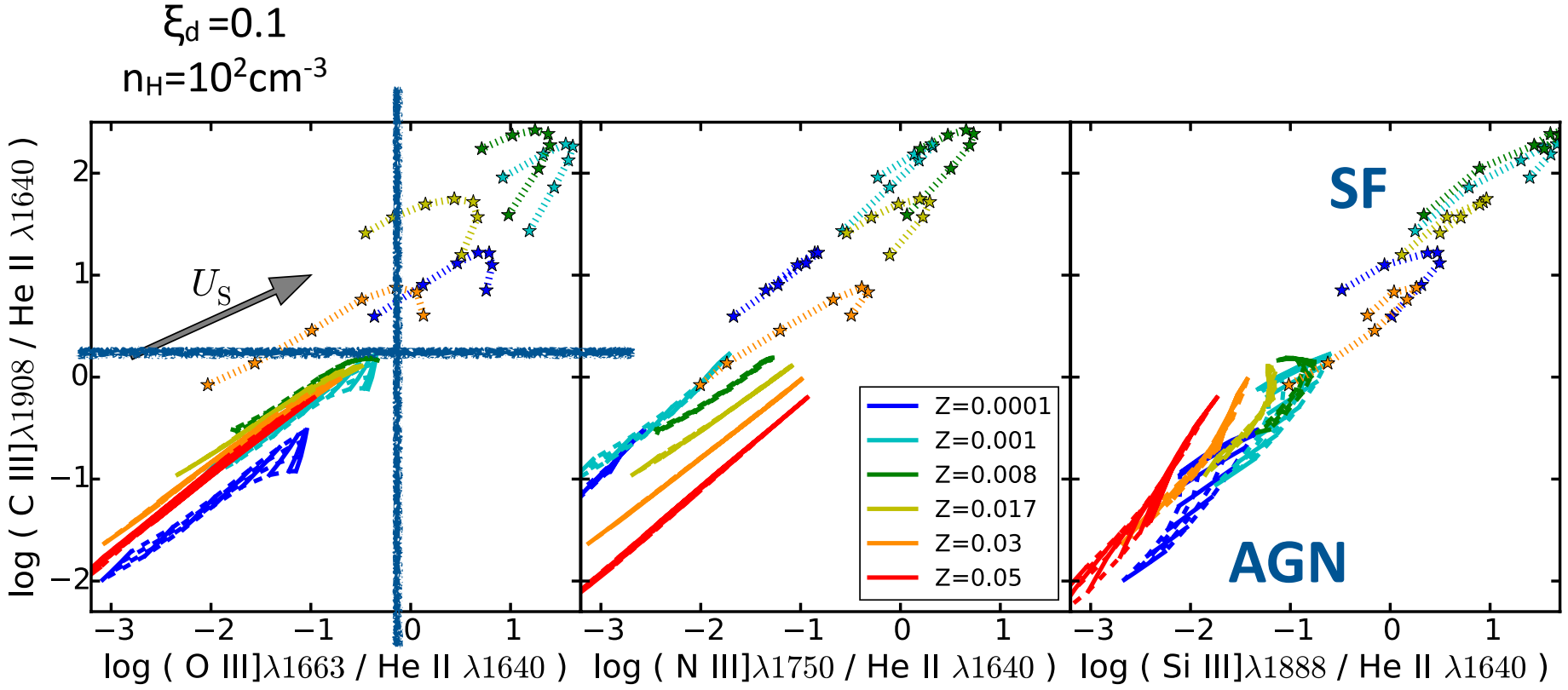
ξ_d =0.1
$n_H=10^2 cm^{-3}$



and many others such as CIII]1909/HeII1640 or CIV1240/HeII vs NV1240/HeII, NV1240/CIV1549, NV1240/NIII]1750, OIII]1661,1666/HeII, NIII]1750/HeII, [NeV]3426-[NeIV]2424 based

Feltre+16

UV spectral diagnostics



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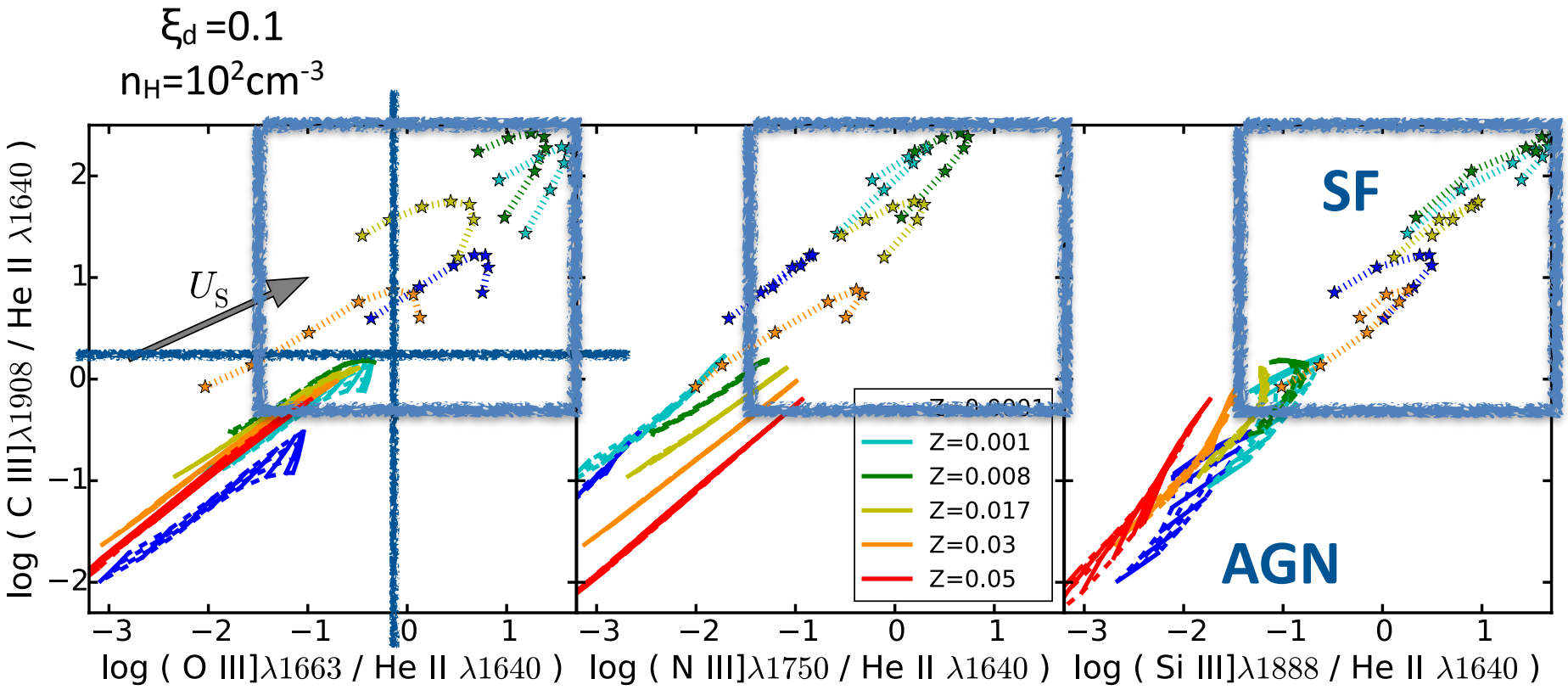

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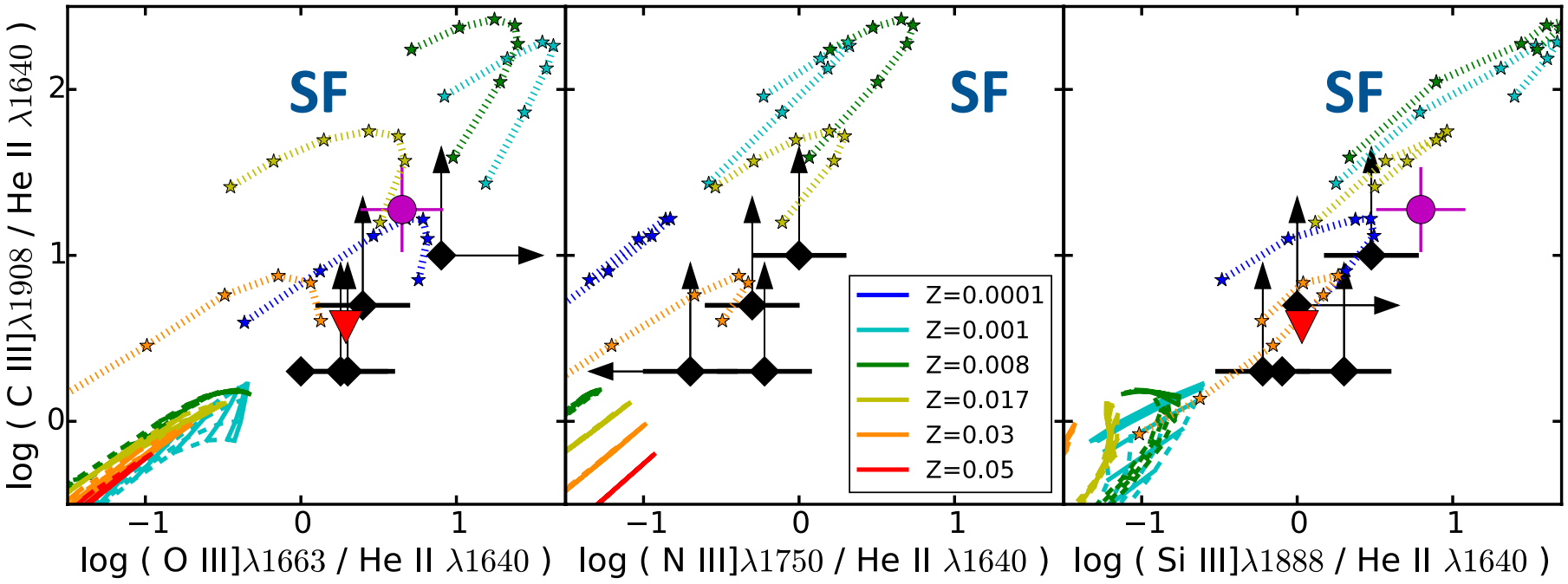


Stark+14

dwarf galaxies z~2

Steidel+16

composite SF galaxies
<z>~2.4

Patricio+16

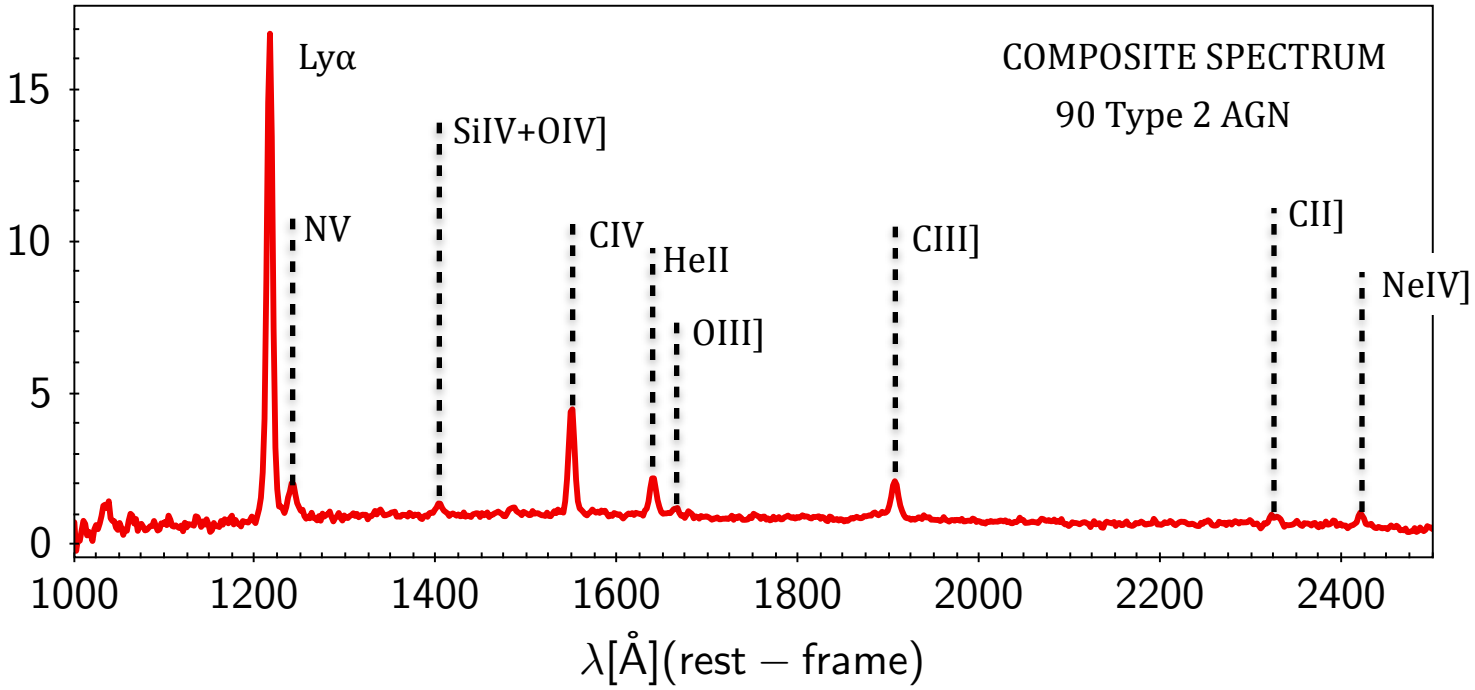
SF galaxy z~3.5

z-COSMOS DeepType 2 AGN

zCOSMOS Deep (PI: S. Lilly)
BzK selection + U dropout colour selected galaxies with z>1.4
8k sample (K<23.5 & B<25.5)
192 CIV-selected AGN with 1.5 < z < 3.0
VIMOS/VLT

Mignoli+ in prep

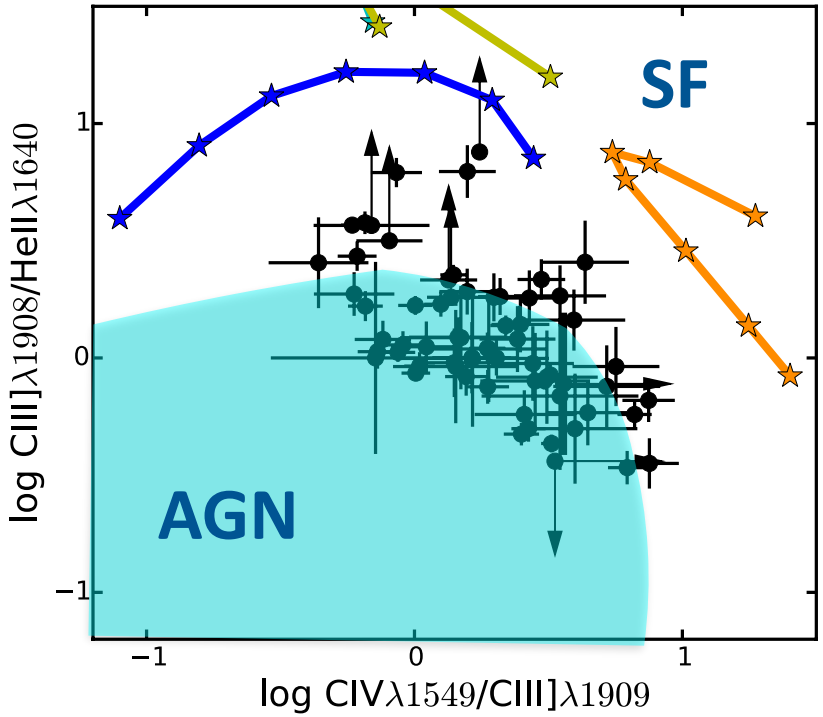
- search for Type 2 (obscured AGN) at high z
- study the excitation properties of the AGN NLR ionised gas

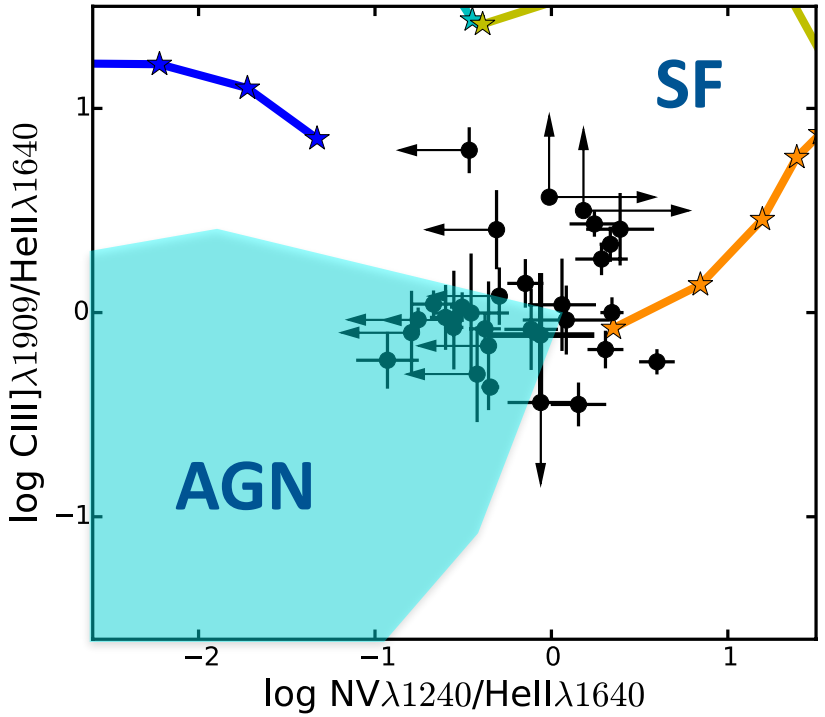


Diagnostics - CIV selected AGN2

NV "problem": NV/HeII often stronger than model predictions

—> 'selectively 'enhanced elemental abundances and super-solar metallicities (e.g. **Hamann&Ferland 92,93**)





Mignoli+ in prep

Feltre+ in prep

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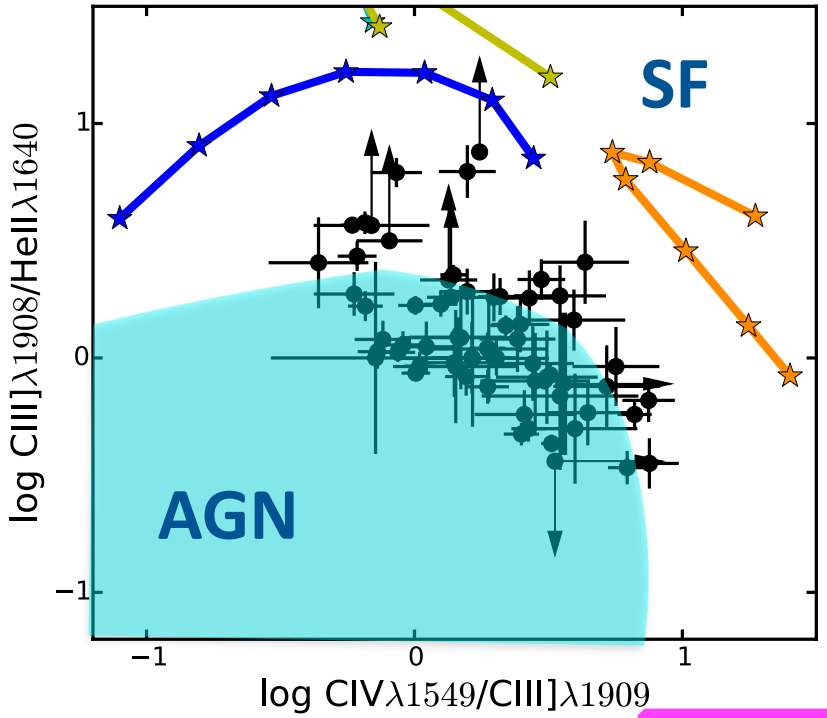

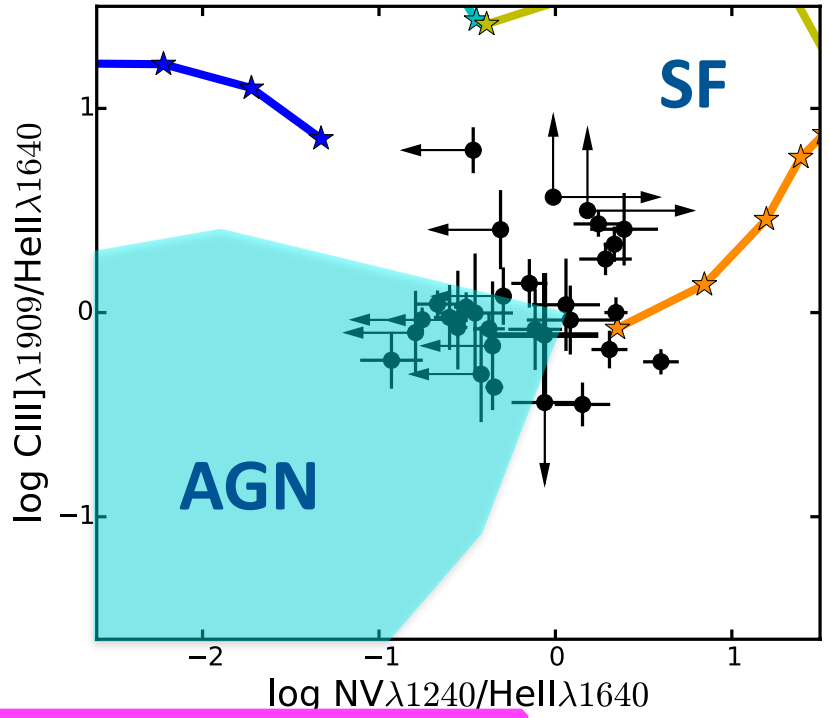

Mignoli+ in prep

Feltre+ in prep

3-10 x smaller inner radius (30 - 90 pc)

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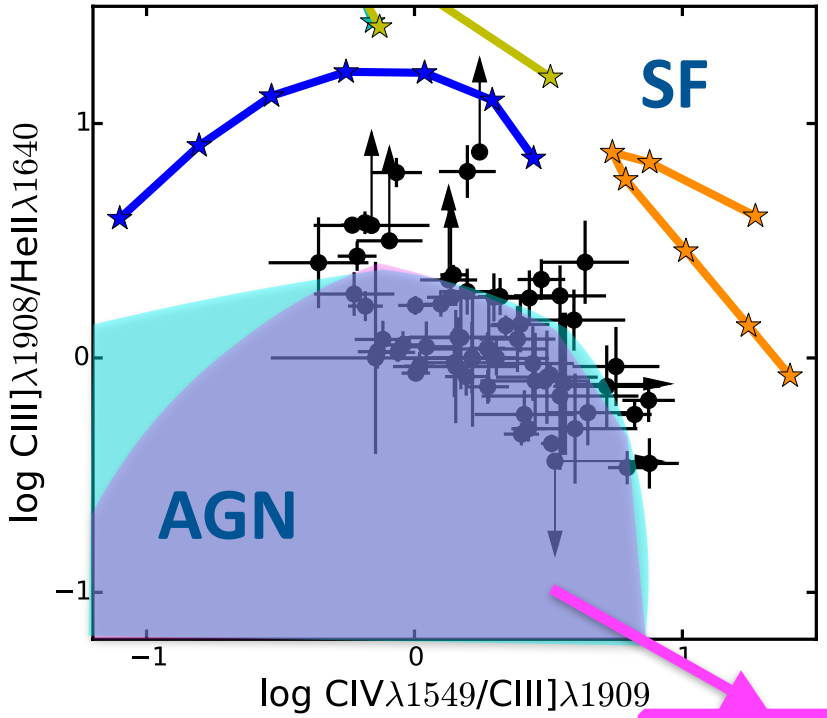

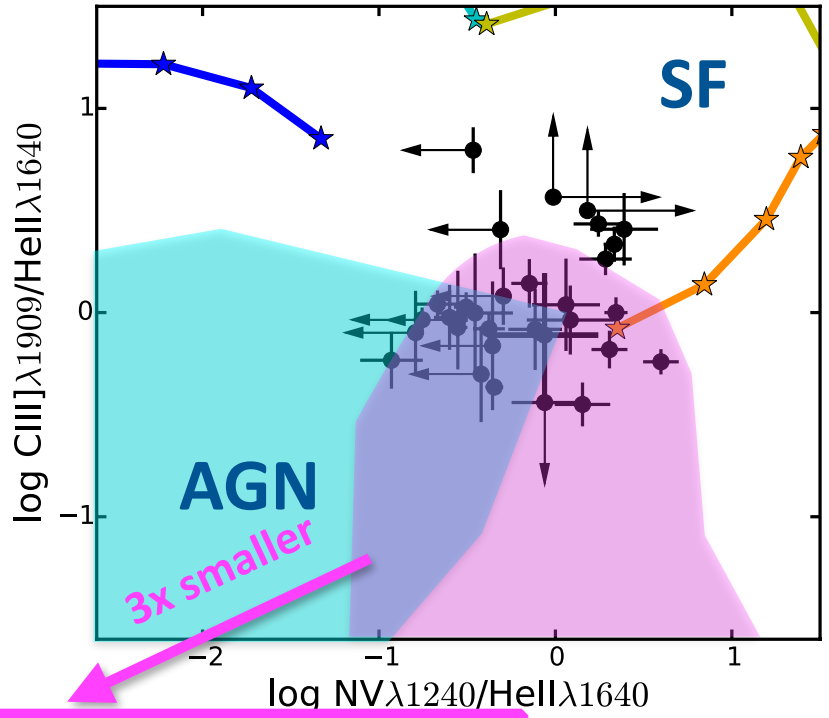

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+ internal microturbulence
Bortoff & Ferland 2000
(v=100-200 km/s)

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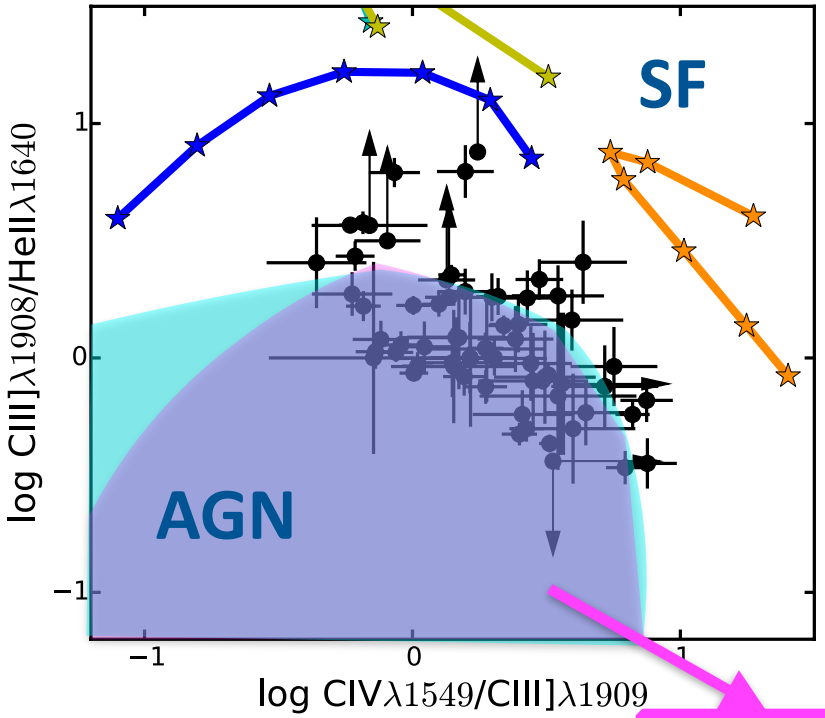

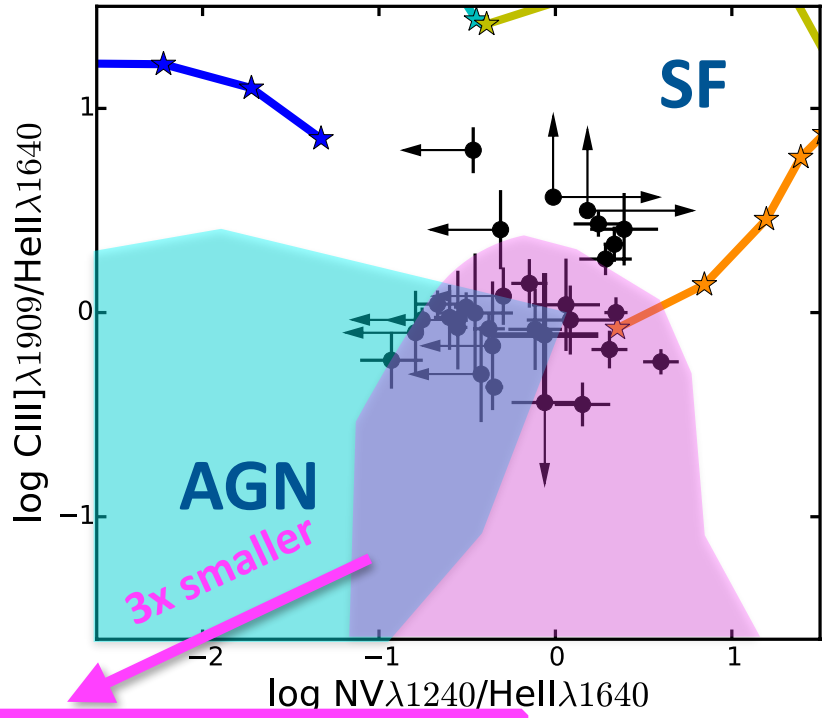

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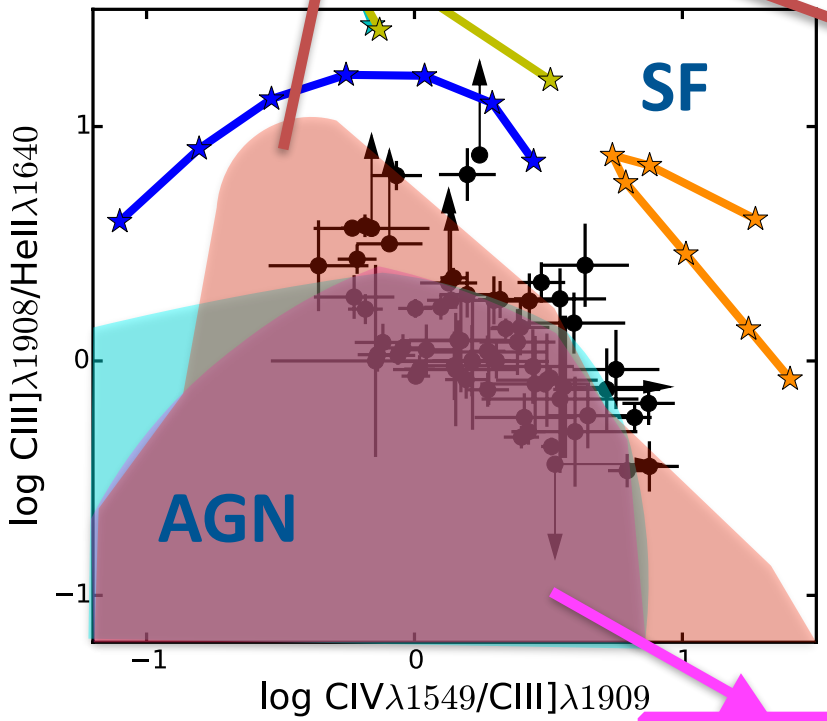
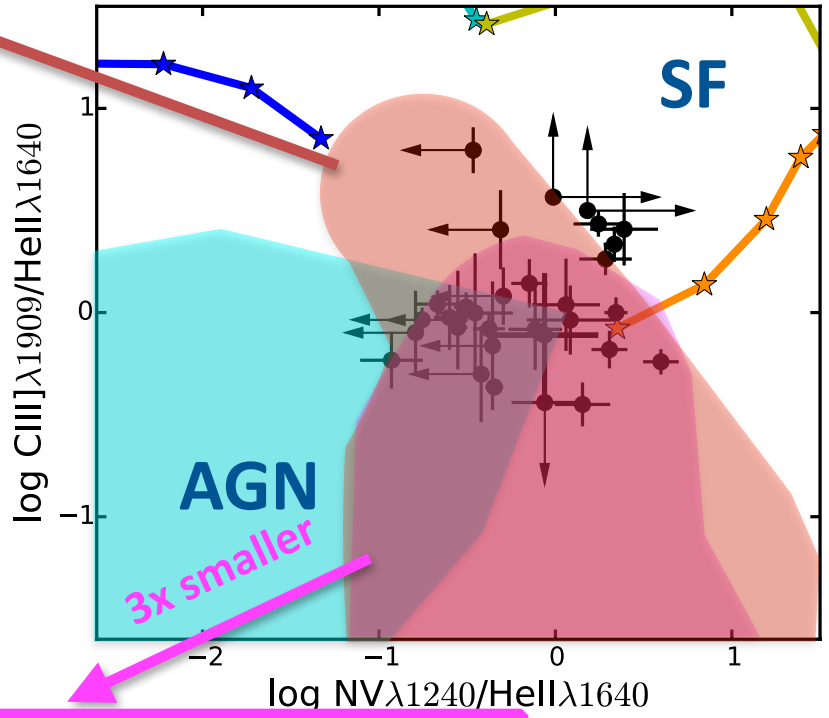
100 km/s





Mignoli+ in prep
Feltre+ in prep

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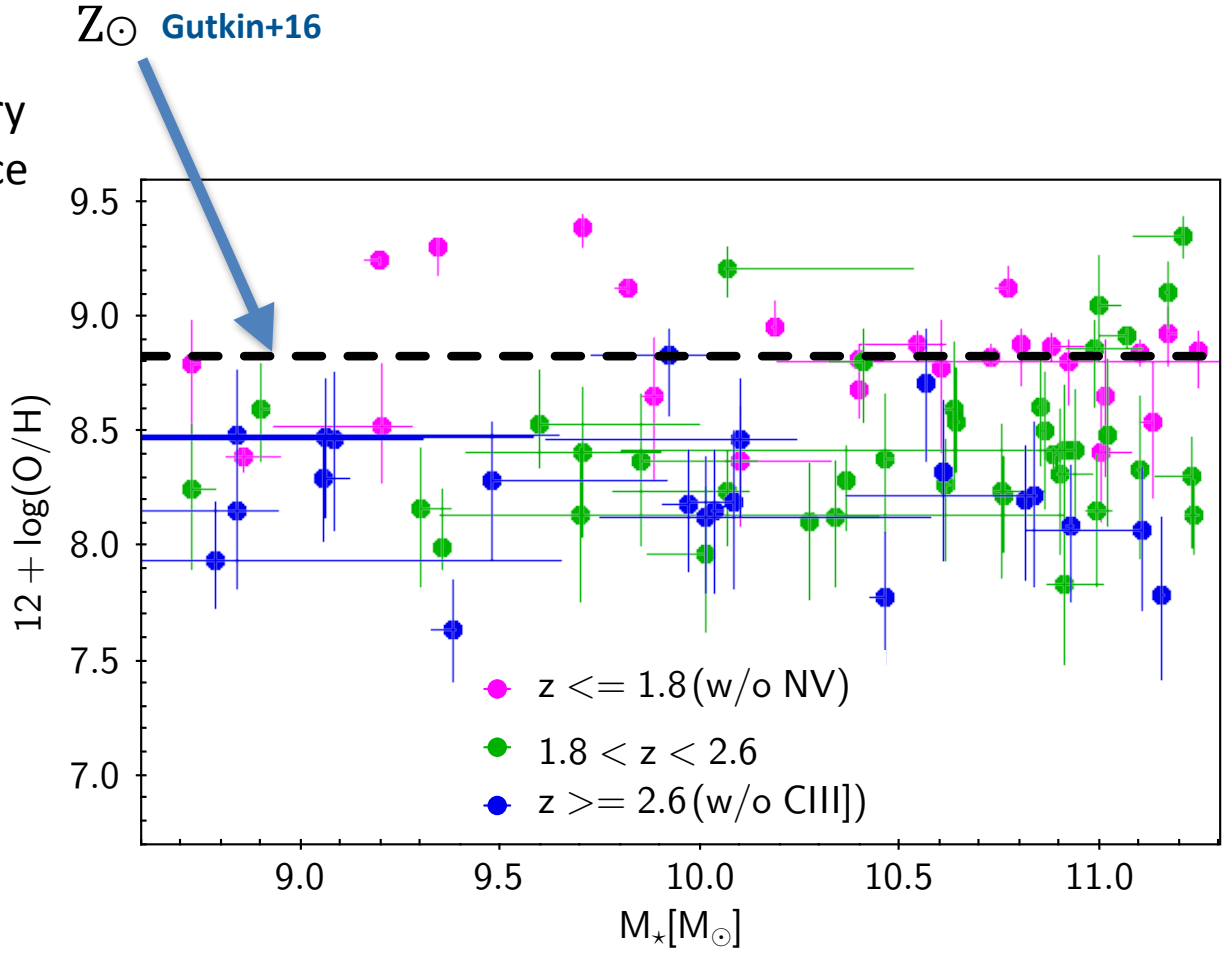
CIV selected AGN2 - M* vs O/H

PRELIMINARY

Mignoli+ in prep

- no need of models with very high metallicity to reproduce the observed ratios
- flat relation O/H vs stellar mass
- metallicity evolution with redshift?

future plan:
simultaneous fit of photometry + spectral lines with a Bayesian fitting code (e.g. BEAGLE, Chevallard+16)



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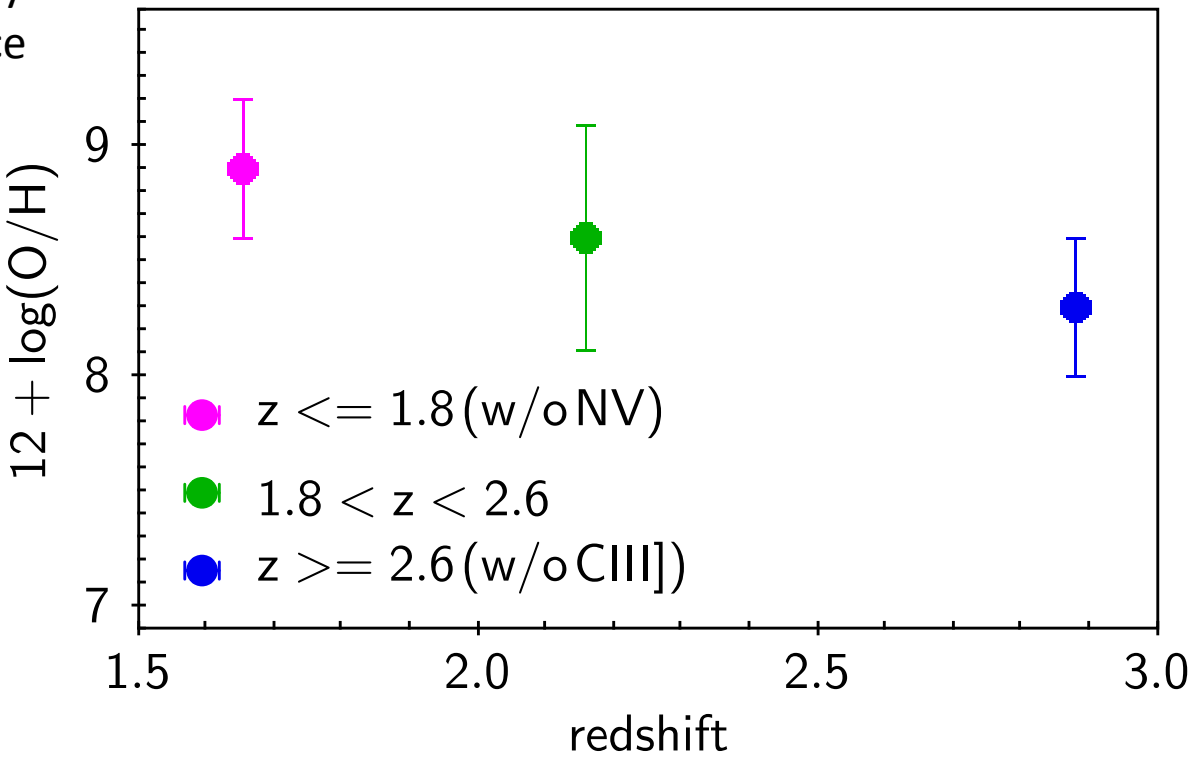

Summary

- ✦ UV emission-line ratios are good **diagnostics of the ionizing source** (nuclear vs stellar activity)
- ✦ interpretation of spectroscopic observations to study **physical properties of the ionized gas** (e.g. metallicity, density) of both active **(Mignoli+in prep)** and inactive galaxies **(Stark+14,15a,15b,16)**
- ✦ can be easily implemented in **SED fitting tools**, e.g. **BEAGLE (Chevallard+16)**
- ✦ **combined with cosmological simulations** to better understand feedback processes and black hole growth **(Hirschmann +in prep)**
- ✦ **interpret current spectroscopic observations** (VLT-KMOS/MUSE and Keck-MOSFIRE) of high redshift sources
- ✦ **groundwork** for **future facilities**, such as NIRspec on-board JWST and the ELT which will push studies up to the **epoch of reionization** (z>7)