The importance of UVEX to explore UV diagnostics in local analogs: results from the CLASSY survey

Matilde Mingozzi

Space Telescope Science Institute

In collaboration with

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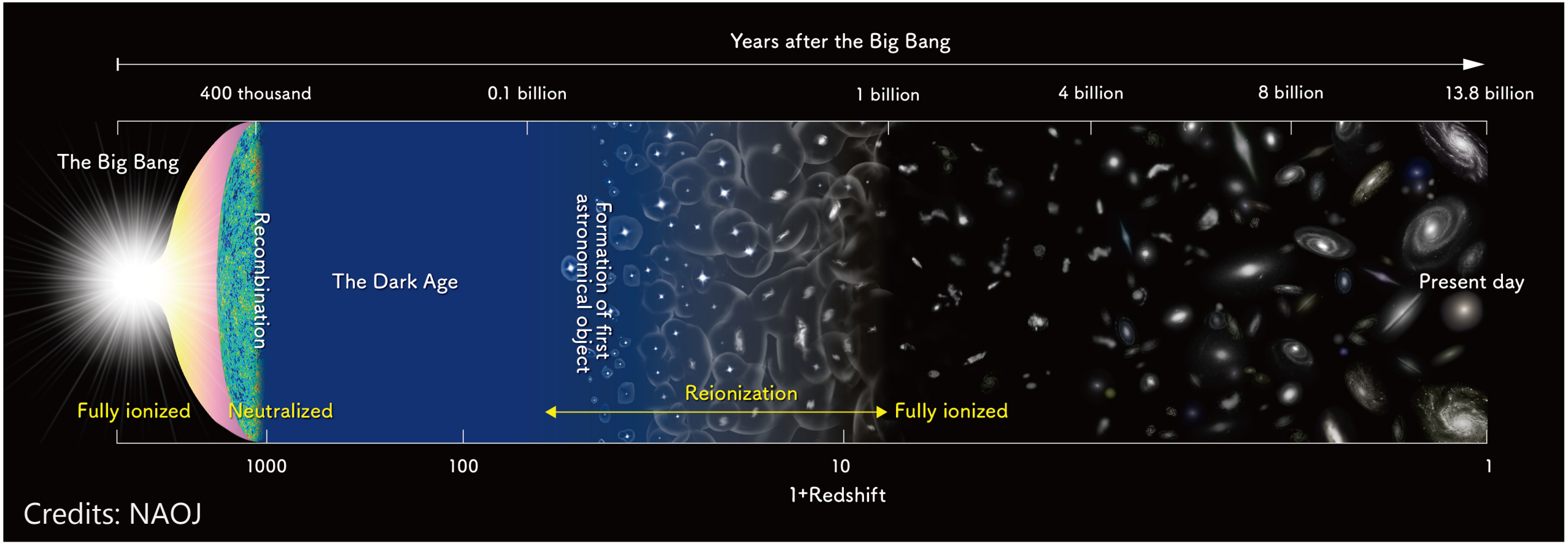
STScI | SPACE TELESCOPE SCIENCE INSTITUTE

CREDITS: NASA, ESA, CXC and the University of Potsdam, JPL-Caltech, and STScI

The Epoch of Reionization

What properties characterized the first galaxies? How did they reionize the universe?

Detailed insights on the physics of high-z galaxies will be only possible with JWST and ELT



Observations of low-redshift extreme emission-line dwarf galaxies to understand early phases of galaxy formation and evolution

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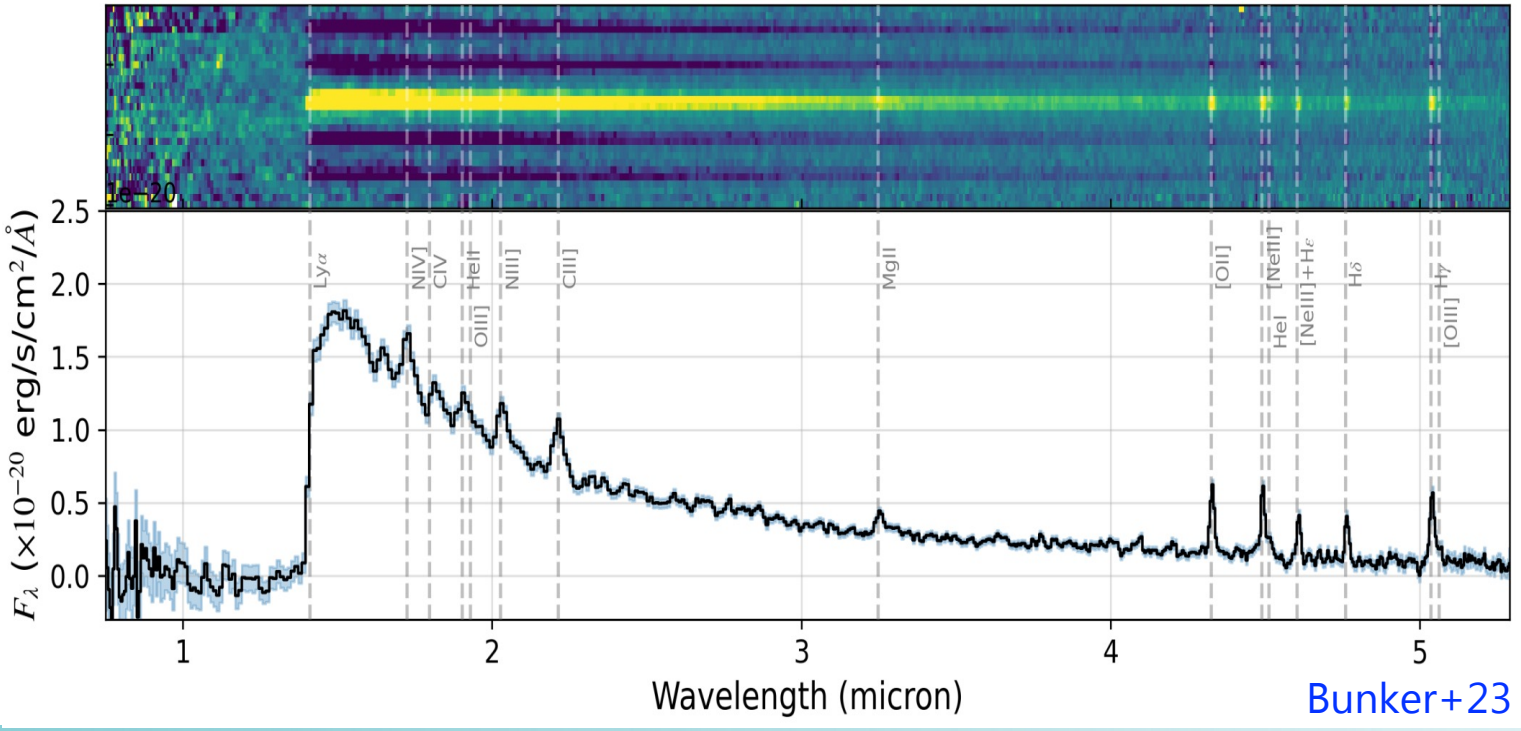
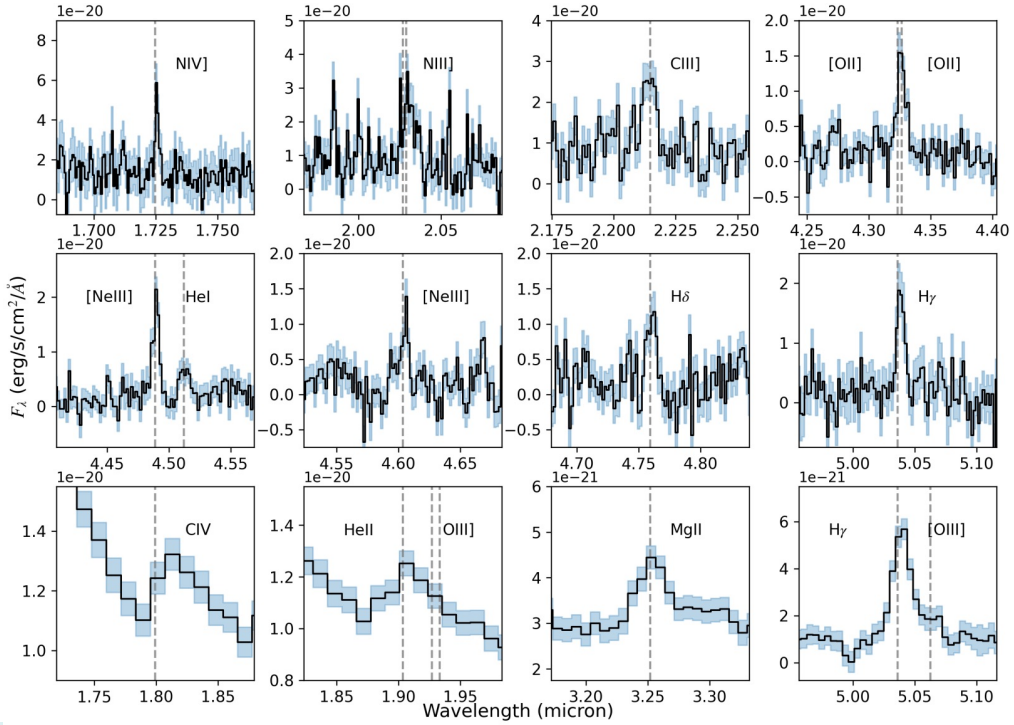
JWST/NIRSpec data of GN-z11 at z~10.6



Bunker+23



Currently furthest high-z galaxy for which emission lines are revealed

More high-z (z~6-13) spectra revealed with JWST
see e.g. Arellano-Córdova+22, Curti+22, Roberts-Borsani+23, Curtis-Lake+23

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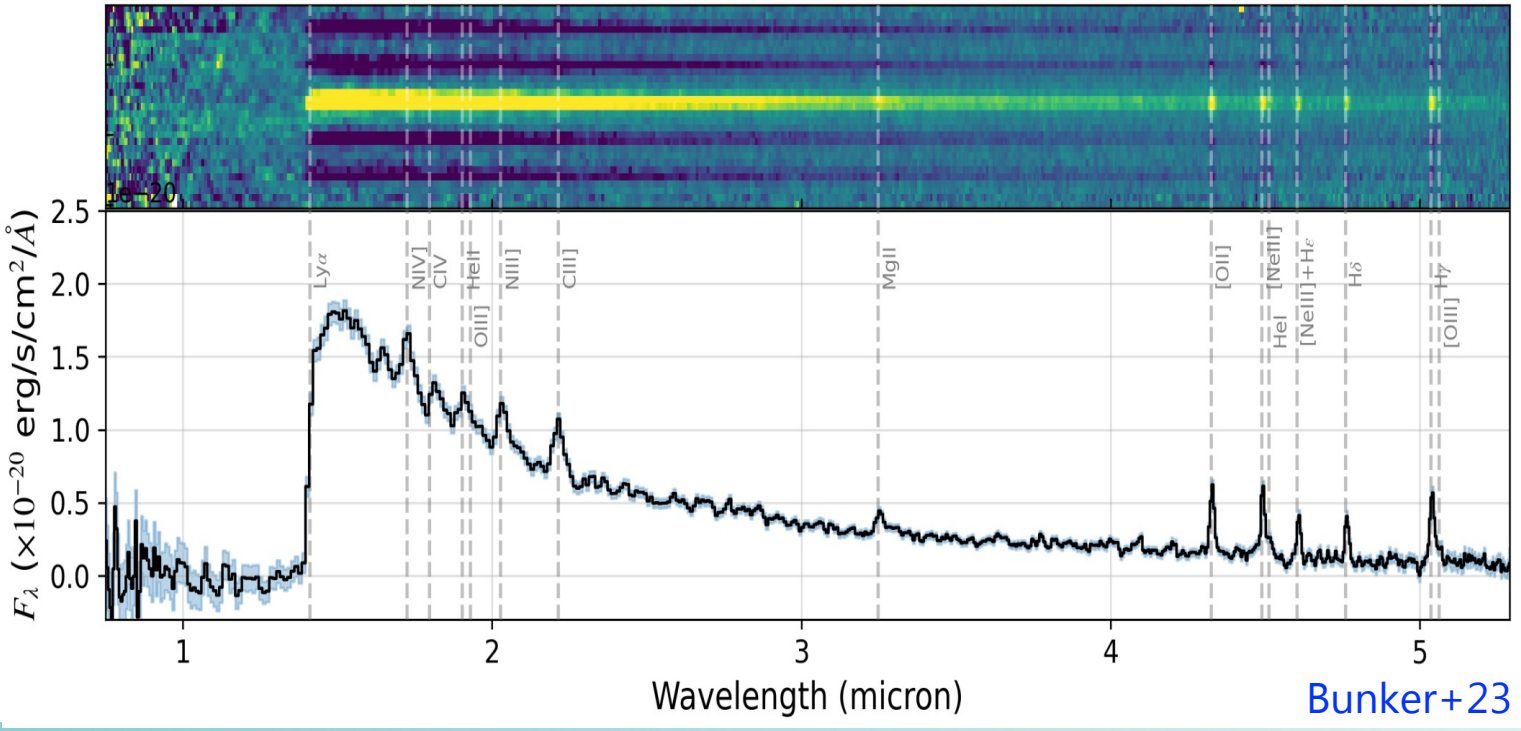

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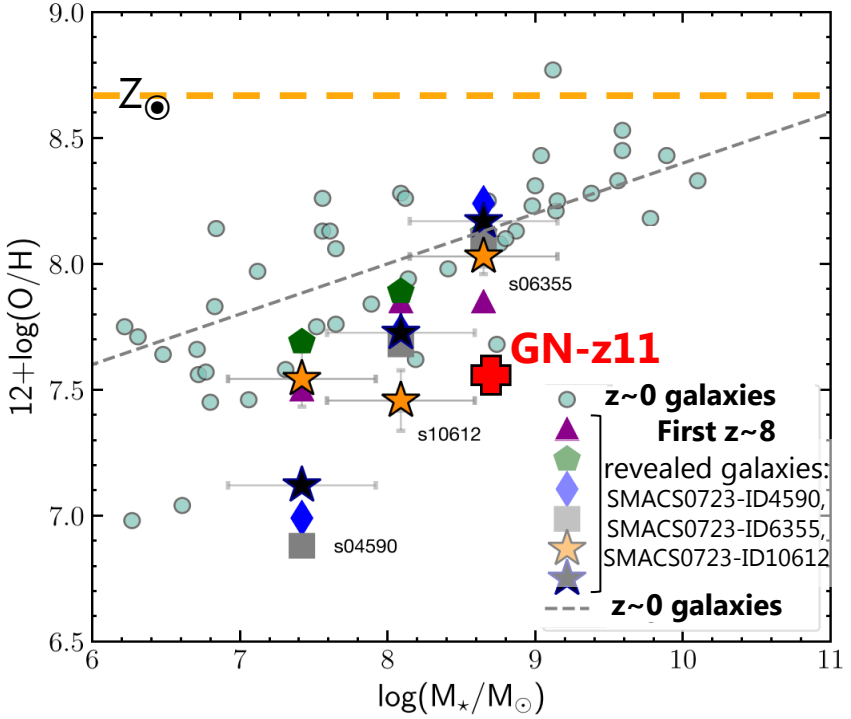

Adapted from Arellano-Córdova+22

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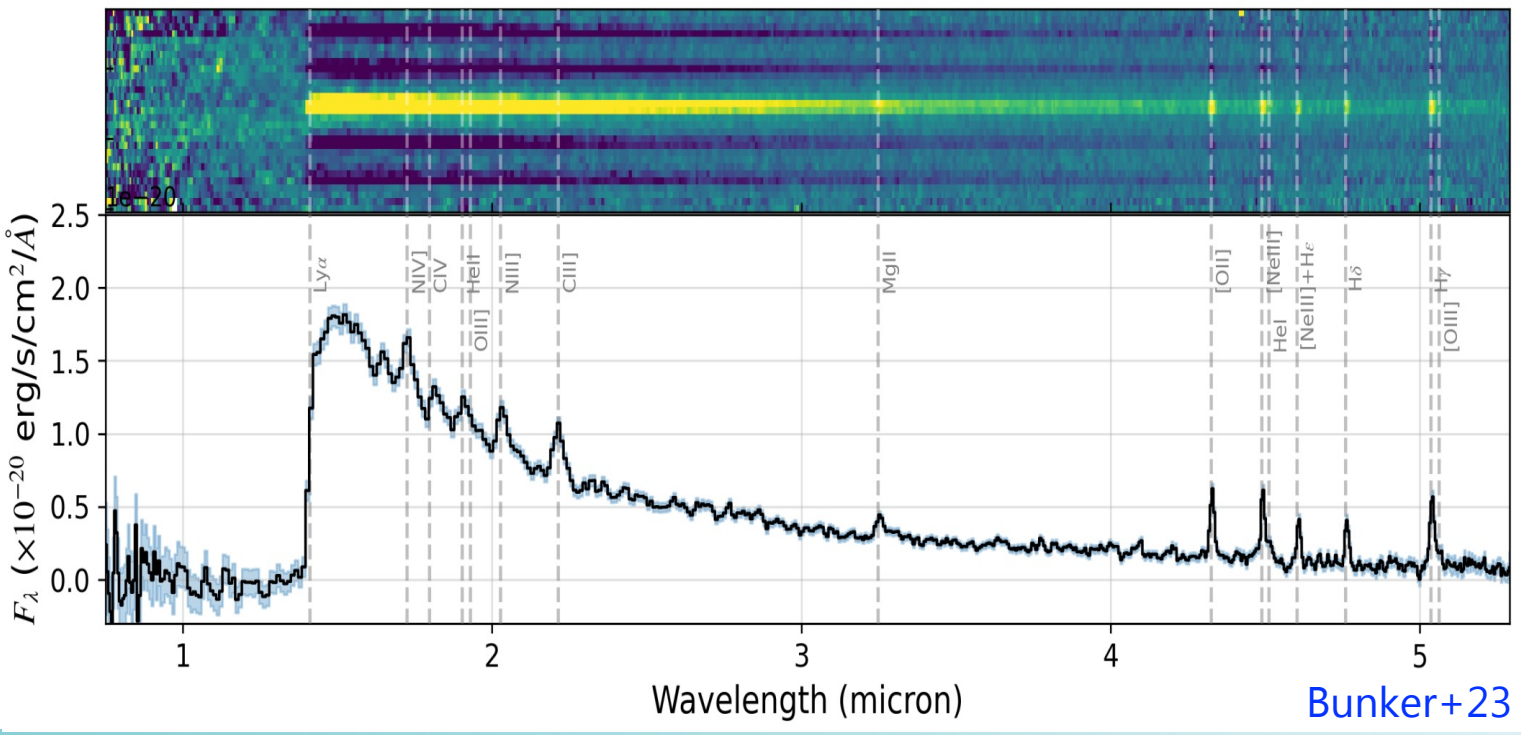

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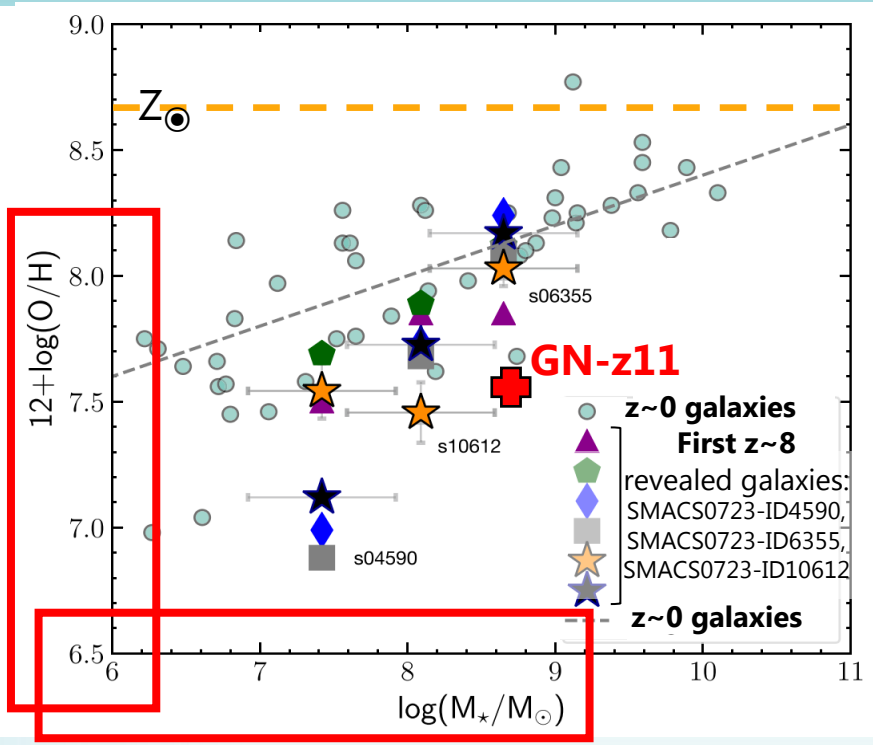

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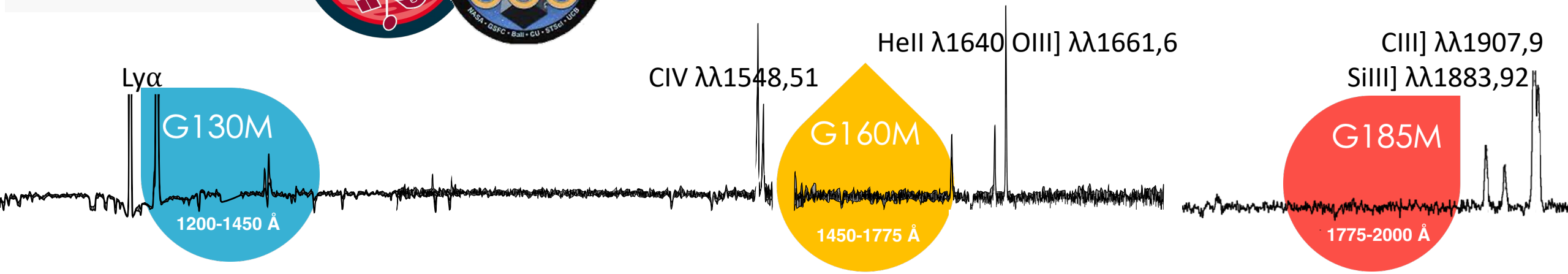
Rest-frame UV spectra will bridge the nearby and distant Universe

Current and future UV spectroscopic facilities

2.5″ aperture
G130M: 1200-1450 Å
G160M: 1450-1775 Å
G185M: 1775-2000 Å



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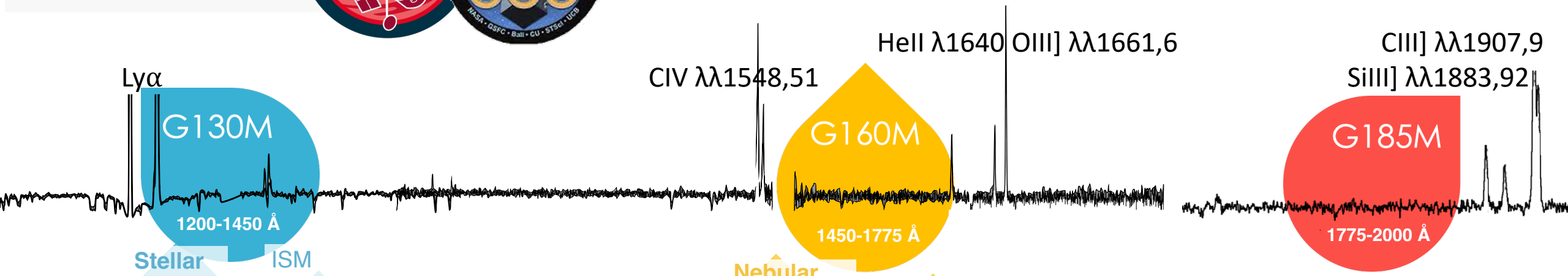

Stellar Winds
NV 1239, 1243
OV 1371
SiIV 1393, 1403

ISM Outflows
SiIII 1206
NV 1239, 1243
SII 1250,3
OI 1302
SiII 1260, 1304
CII 1334
SiIV 1393, 1403

Lyα
1216

Fine Structure
SiII* 1265, 1309
CII* 1335

Stellar Photospheric
CIII 1247
SiIII 1299
SiII 1417
CIII 1428
FeV 1430

Nebular Emission
NIV] 1483,87
CIV 1548,51
HeII 1640
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NIII] 1750

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AlII 1671

Fine Structure
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ISM Outflows
SiII 1808
Al III
1854,1863

Nebular Emission
SiIII] 1883,92
CIII] 1907,09

Typically previous studies have only used one of these HST/COS grating settings, accessing a limited range of diagnostics!

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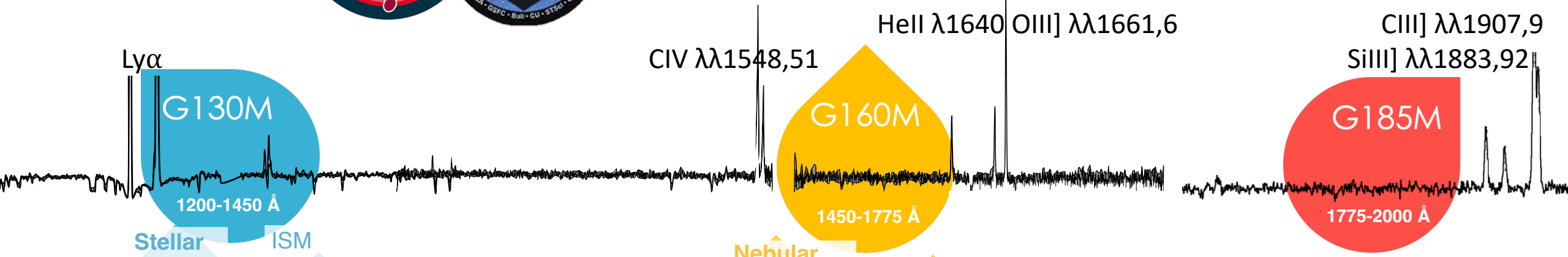
Multi-width slit (~60" length)
band 1150-2650 Å
Good resolution: R>1000



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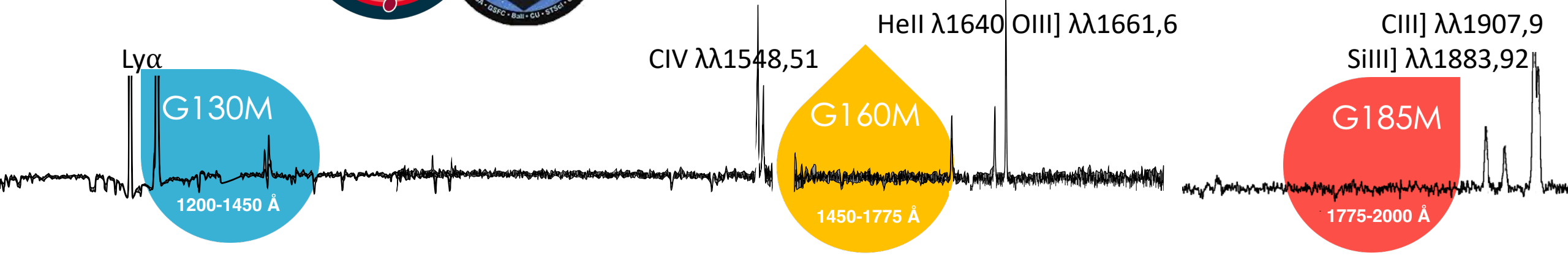
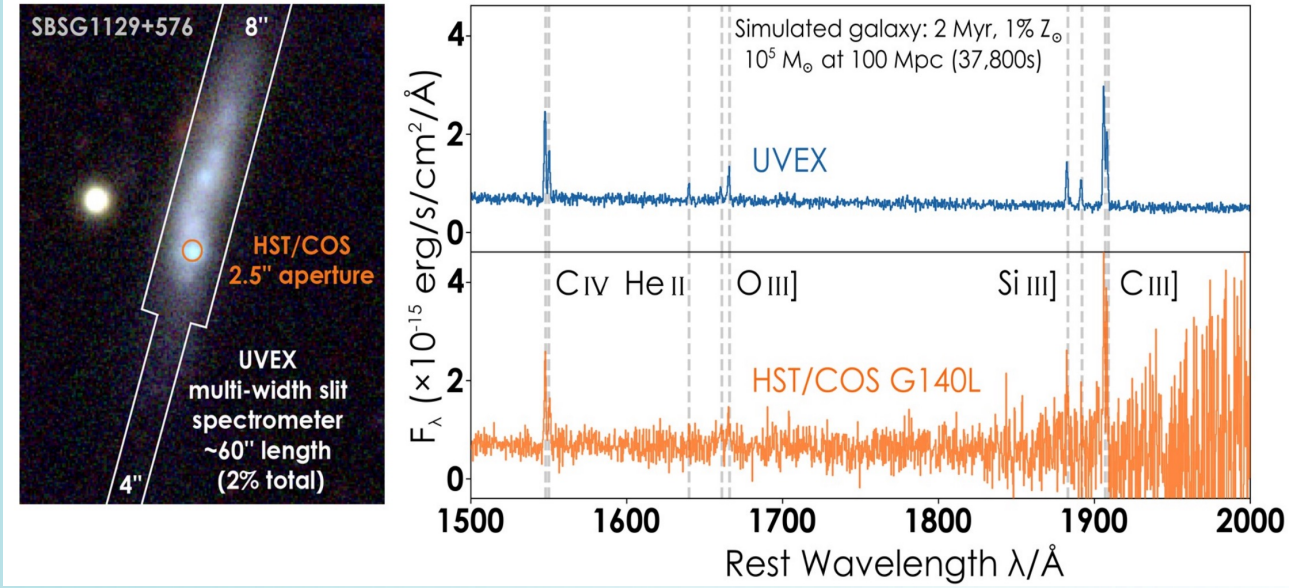


Kulkarni+23
(Science with the UVEX)



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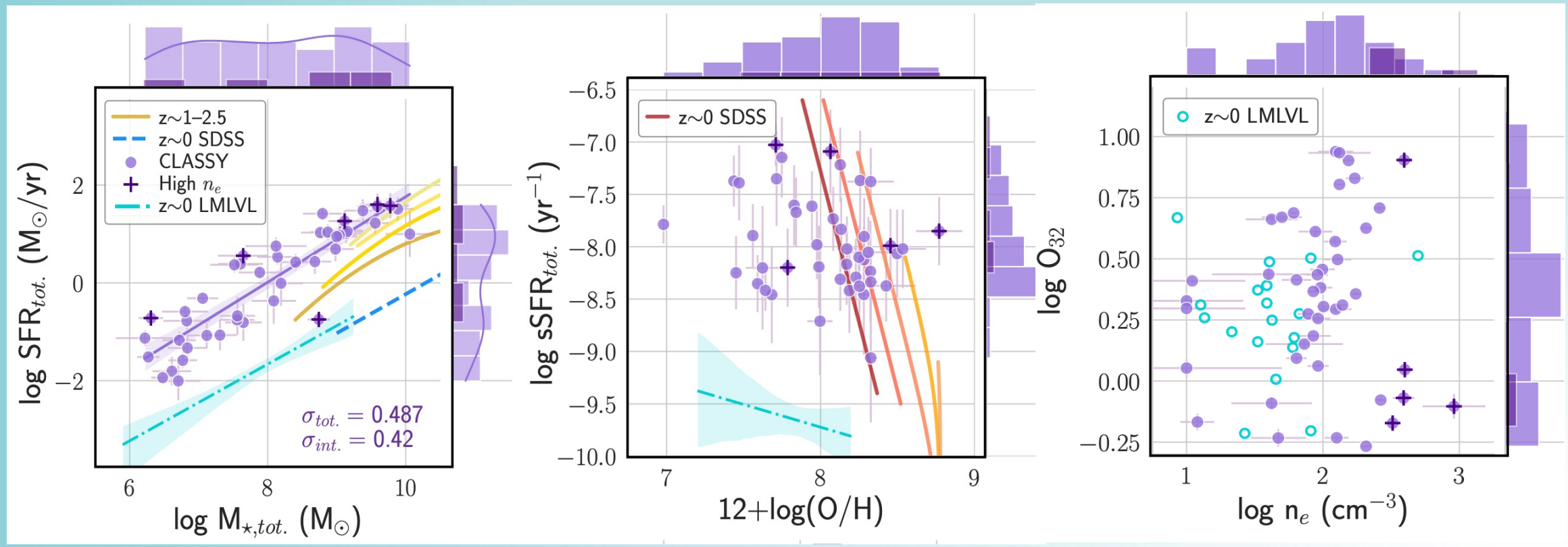
COS Legacy Archive Spectroscopic SurveY: A Treasury of Star-Forming Galaxies

PI: Berg Co-PIs: Chisholm, Heckman, James, Martin, Stark
& an international team of 38 co-Is

45 local star-forming galaxies with full rest-frame far-UV spectral coverage (1200-2000 Å)
spanning a broad dynamic range of M_*, SFR, sSFR, metallicity, ionization parameter and density
highly representative of the high-z Universe



Berg+22
(CLASSY presentation paper)

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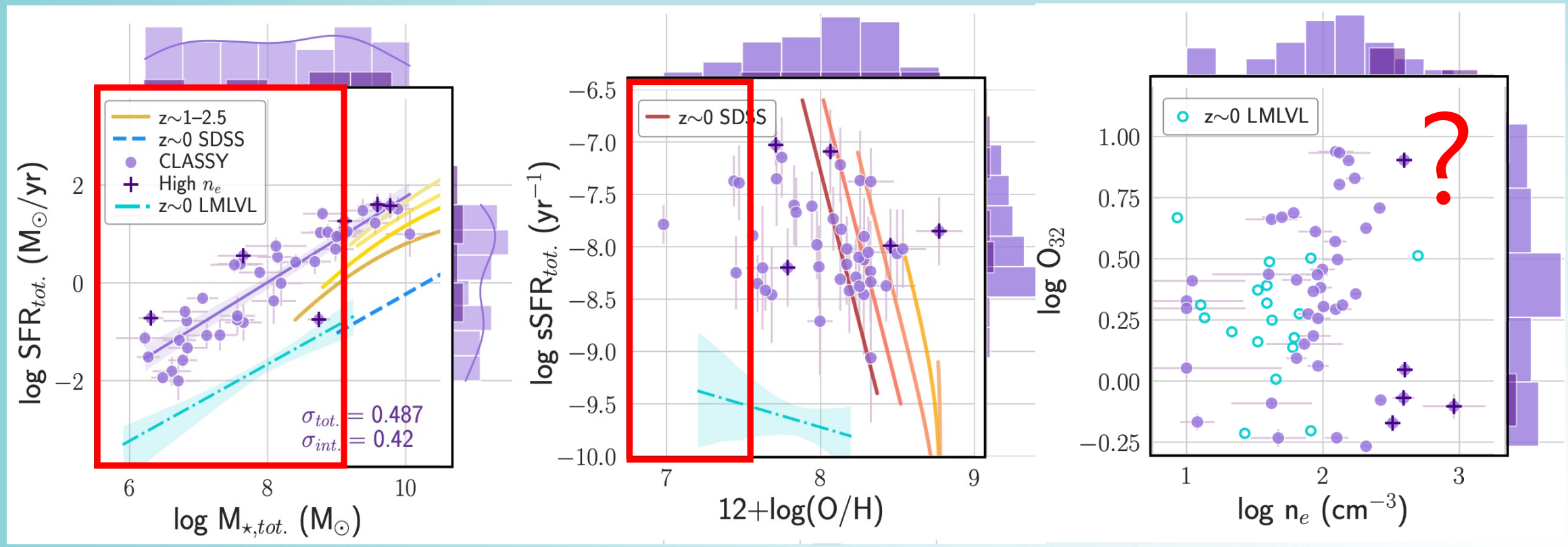

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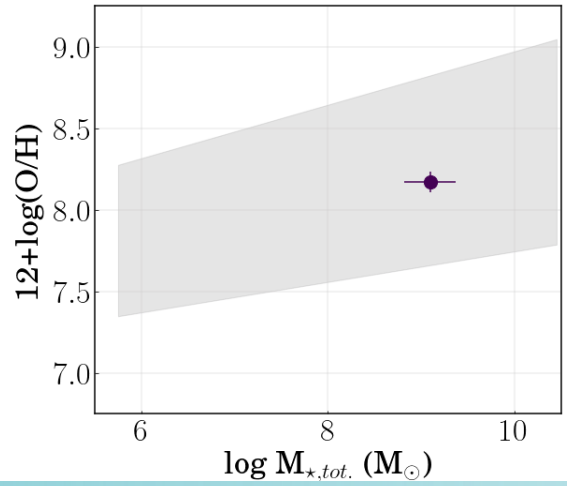

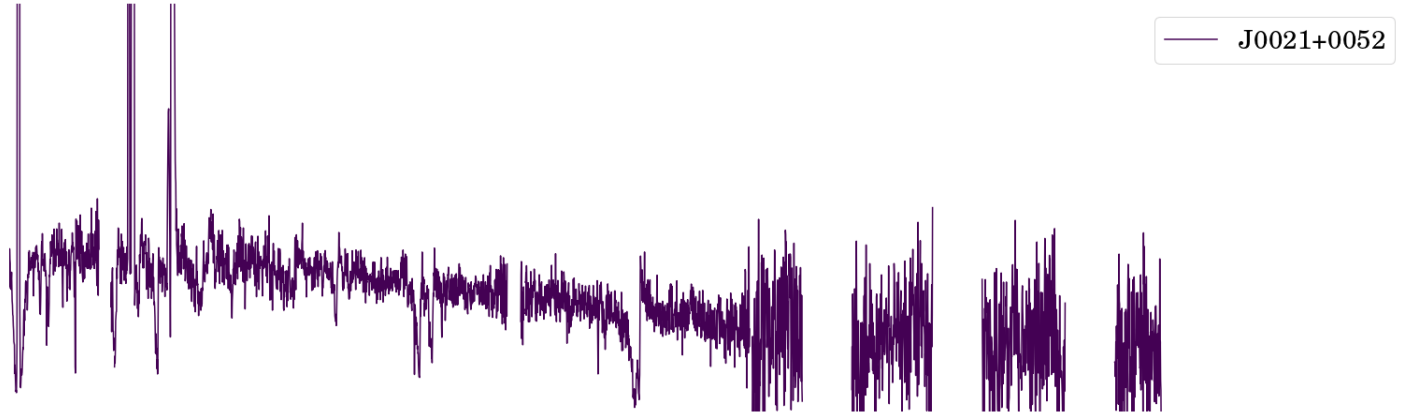

CREDIT: D. Berg

Berg+22 and James+22
(survey presentation and technical analysis papers)

webpage: https://stdatu.stsci.edu/hlsp/classy
MAST portal: https://mast.stsci.edu/search/ui/#/classy

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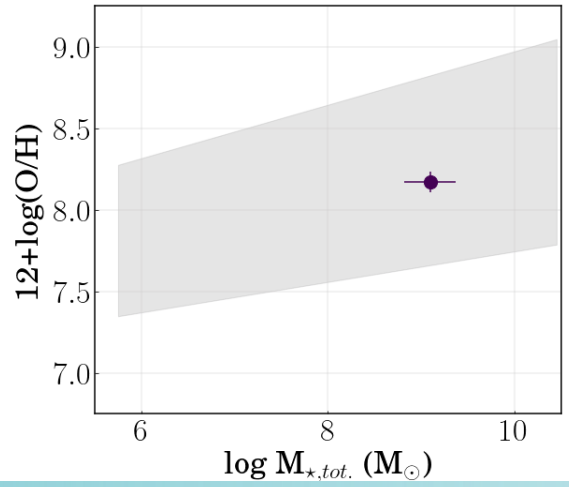

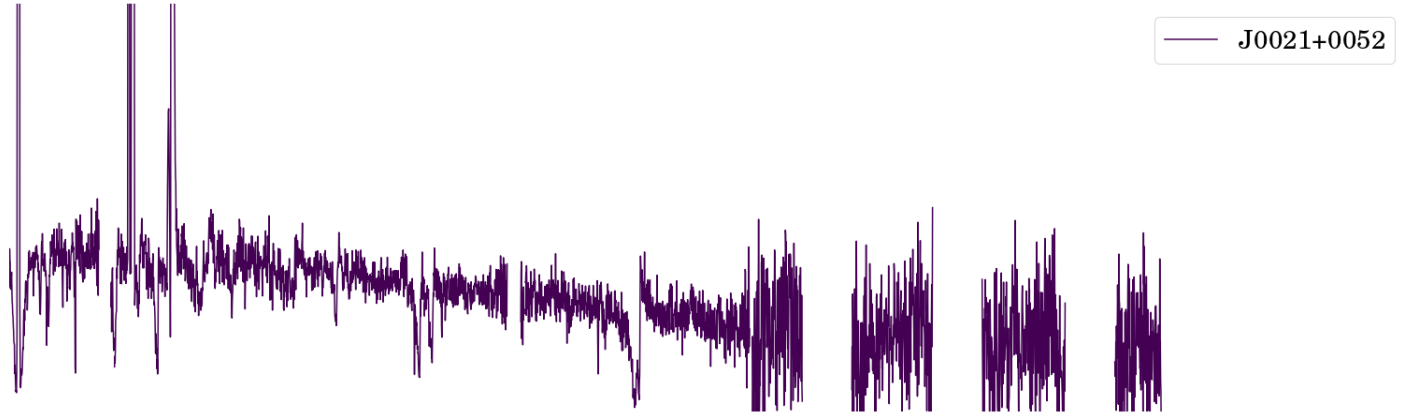

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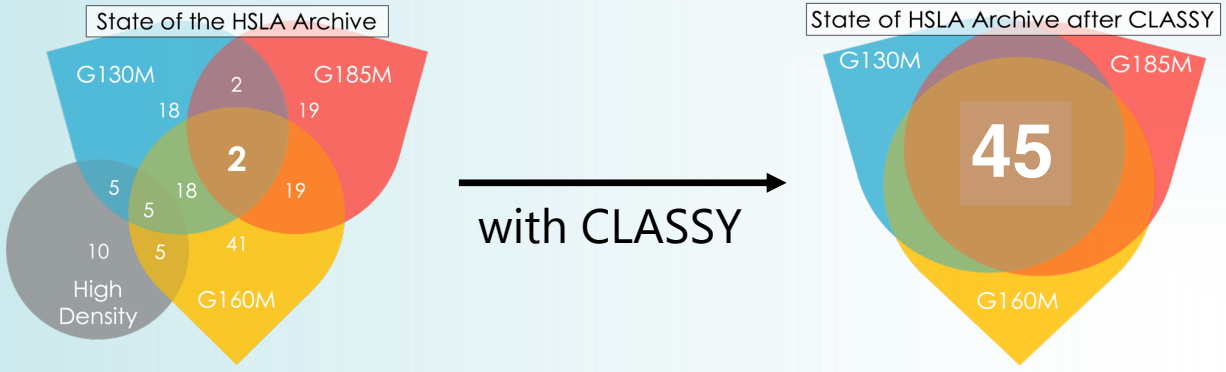

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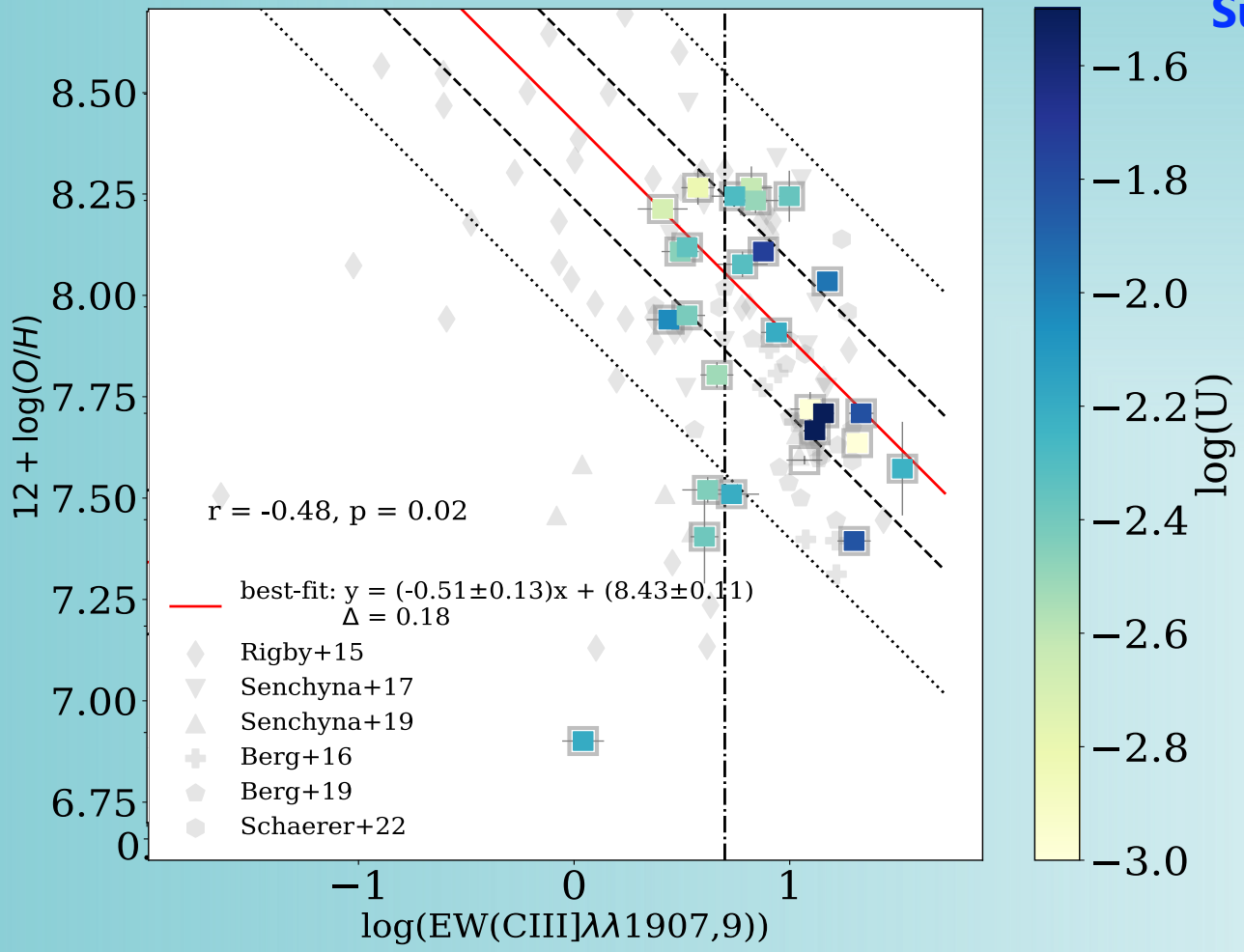
The UV toolkit to infer interstellar medium properties

Comparison of optical and UV emission line ratios to get prescriptions to infer ISM properties (density, temperature, metallicity, ionization parameter and source of ionization)



Mingozzi+22

Suite of UV-ISM diagnostics (Mingozzi+22; +23 in prep.)

UV-inferred **gas densities** ~2 dex higher than optical ones

Direct method to infer 12+log(O/H)
UV/optical temperatures agree with pure optical ones

$$\mathbf{12 + \log\left(\frac{O}{H}\right)} \sim 0.8\,\log(\mathrm{CIII]/OIII]}) + 7.34$$

$$\mathbf{12 + log\left(\frac{O}{H}\right)} \sim -0.51\,\log(\mathrm{EW(CIII])}) + 8.43$$

$$\mathbf{\log(U)} \sim 0.31\,\log(\mathrm{EW(CIV)}) - 2.20$$

$$\mathbf{\log(U)} \sim 0.41\,\log(CIV/CIII]) - 1.97$$

Revised **diagrams for ionization source**
based on CIV, CIII], HeII and OIII]1666

Caveat

In CLASSY no UV emission lines at 12+log(O/H) > 8.25

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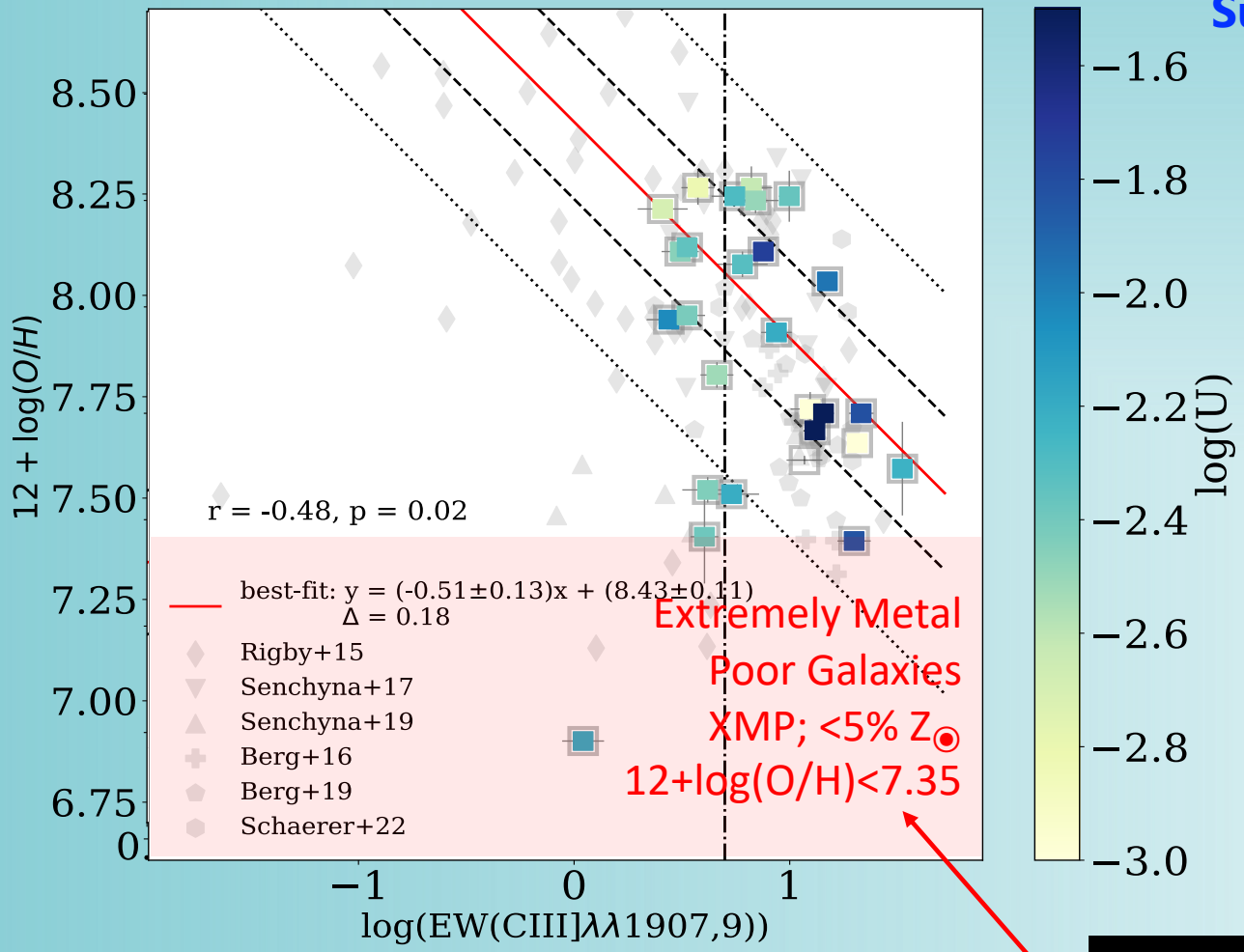

Mingozzi+22

Extremely Metal Poor Galaxies
XMP; <5% $Z_\odot$
12+log(O/H)<7.35

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Revised **diagrams for ionization source**
based on CIV, CIII], HeII and OIII]1666

Currently only few galaxies
(2 in CLASSY) with these diagnostics
in the XMP regime (<5% solar)

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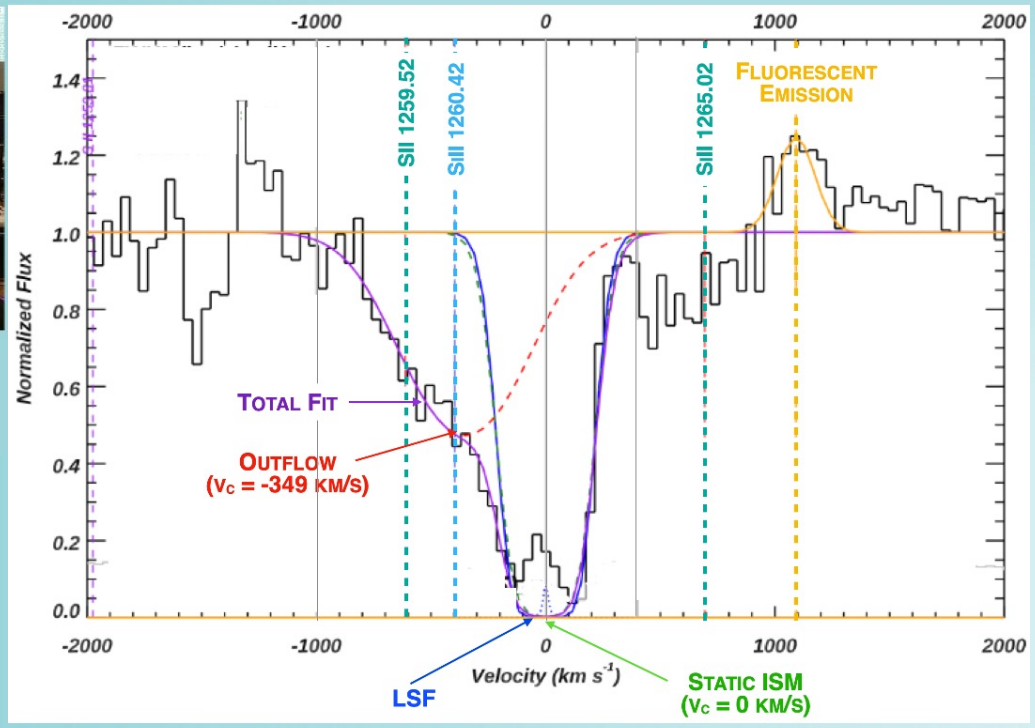
Study of ionized outflows through absorption UV lines

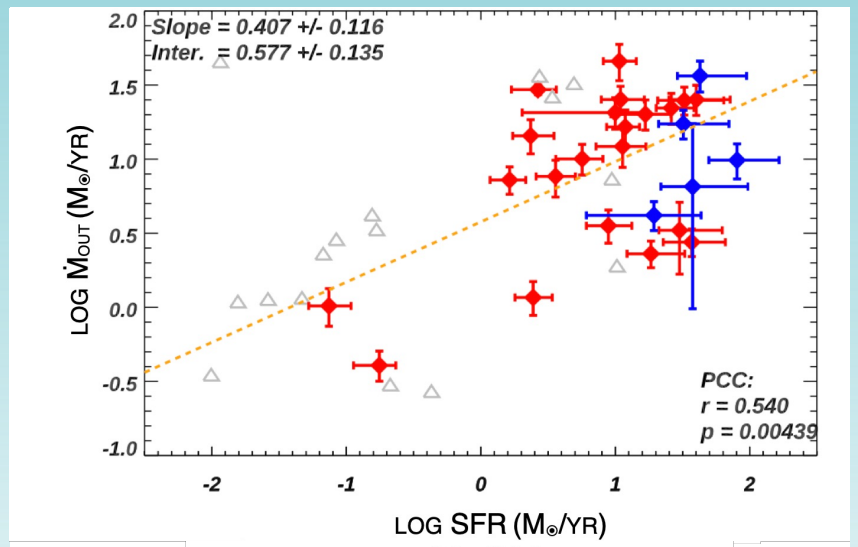
Galaxies with very shallow potential wells lose more than 10x of their gas through SF outflows than they form stars

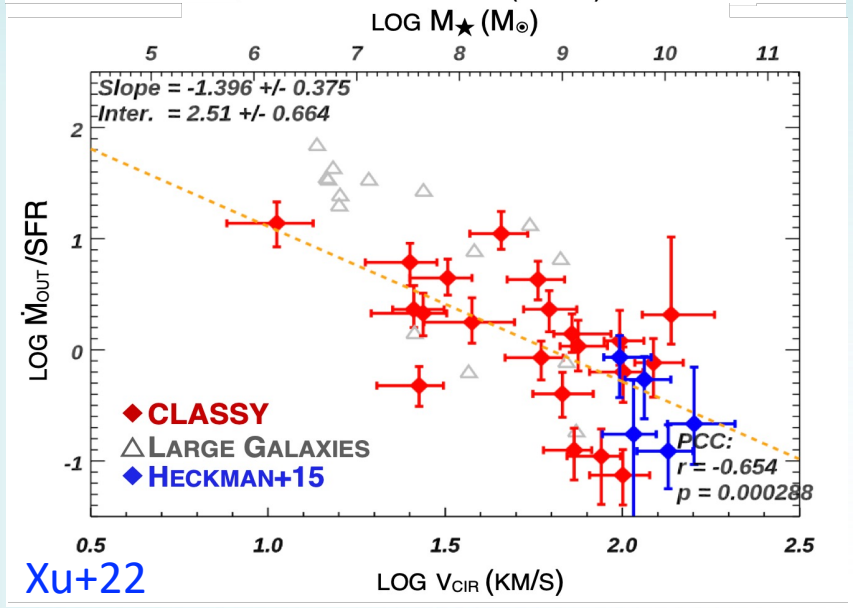
Identifying Galactic Outflows
with double gaussian fits and study of their properties

XINFENG XU,
POSTDOC AT JHU

Xu+22,23







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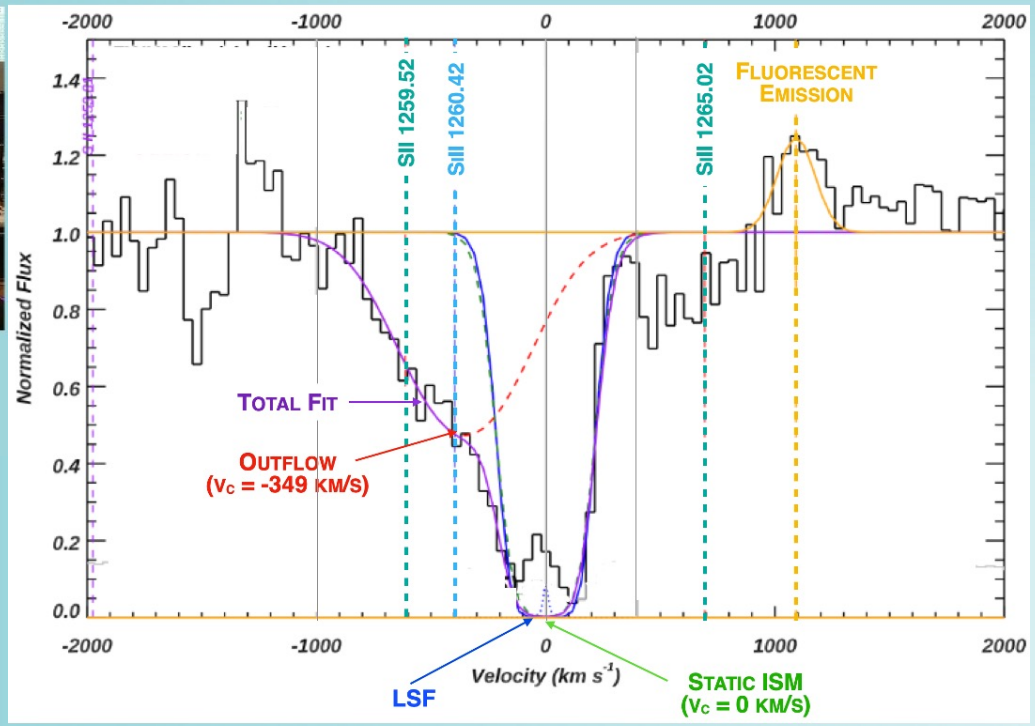

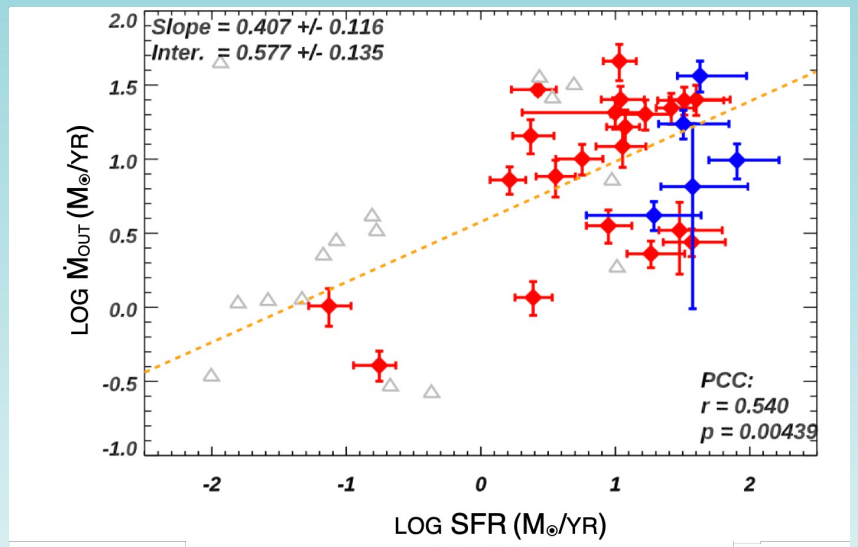

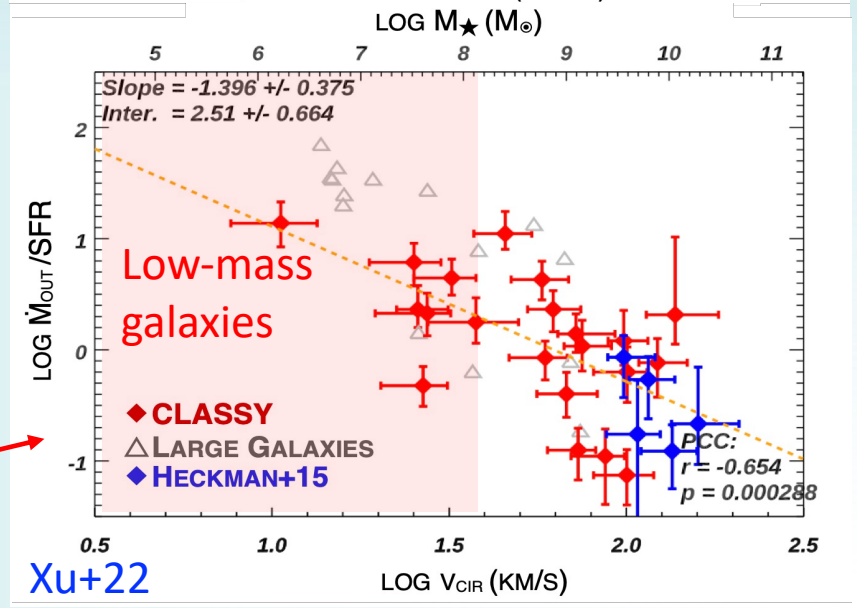

Xu+22

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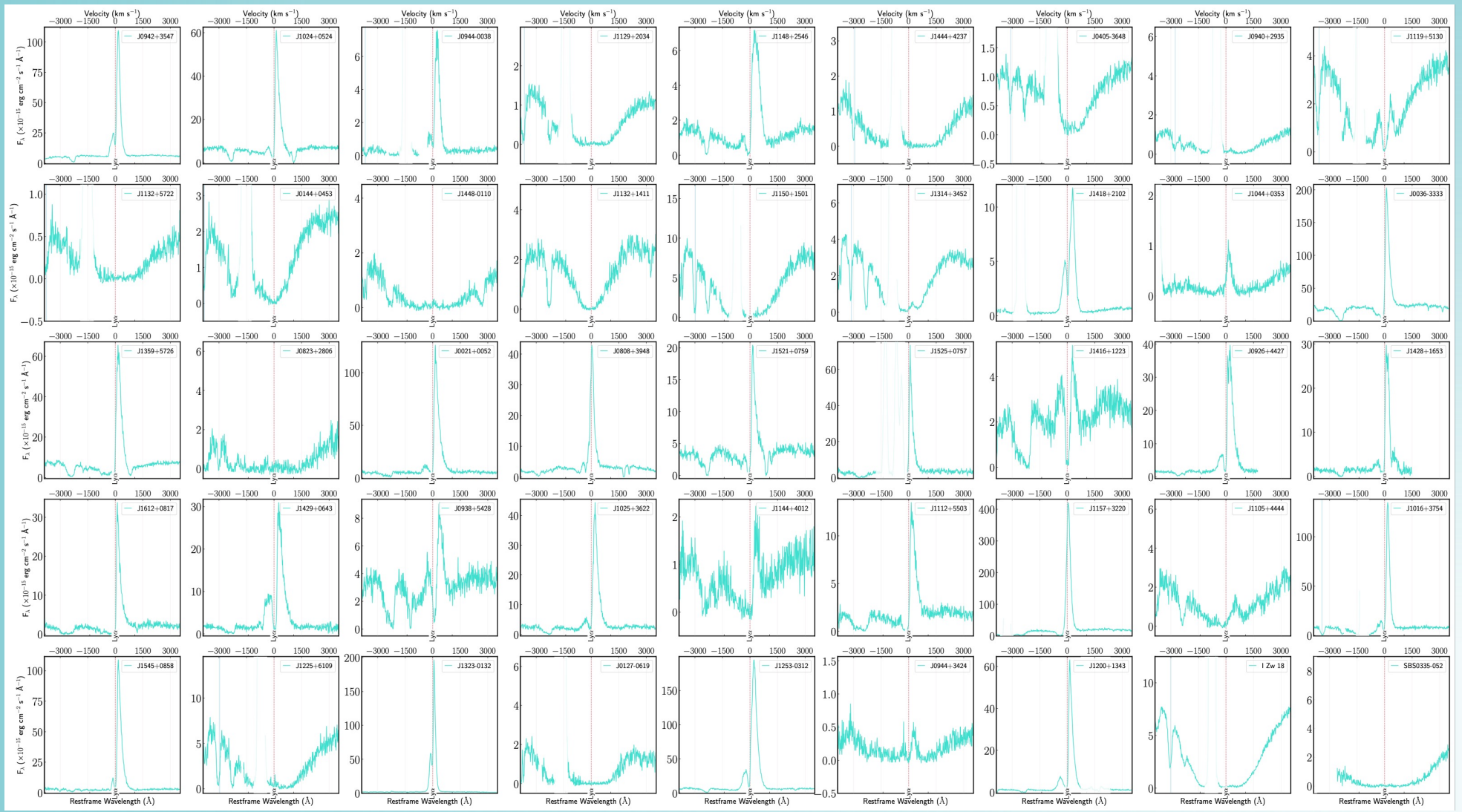
The study of Lyα profiles and low-ionization lines

Wide variety of Lyα profile shapes



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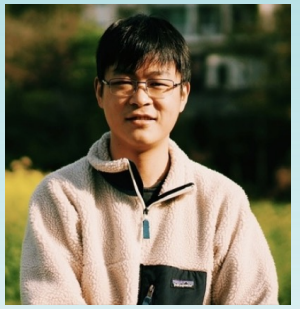
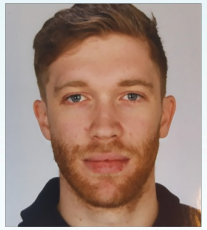
Powerful probe to investigate neutral ISM and Lyman Continuum leakage

Hu+23 submitted



WEIDA HU,
POSTDOC AT UC SB

LYA PROFILES



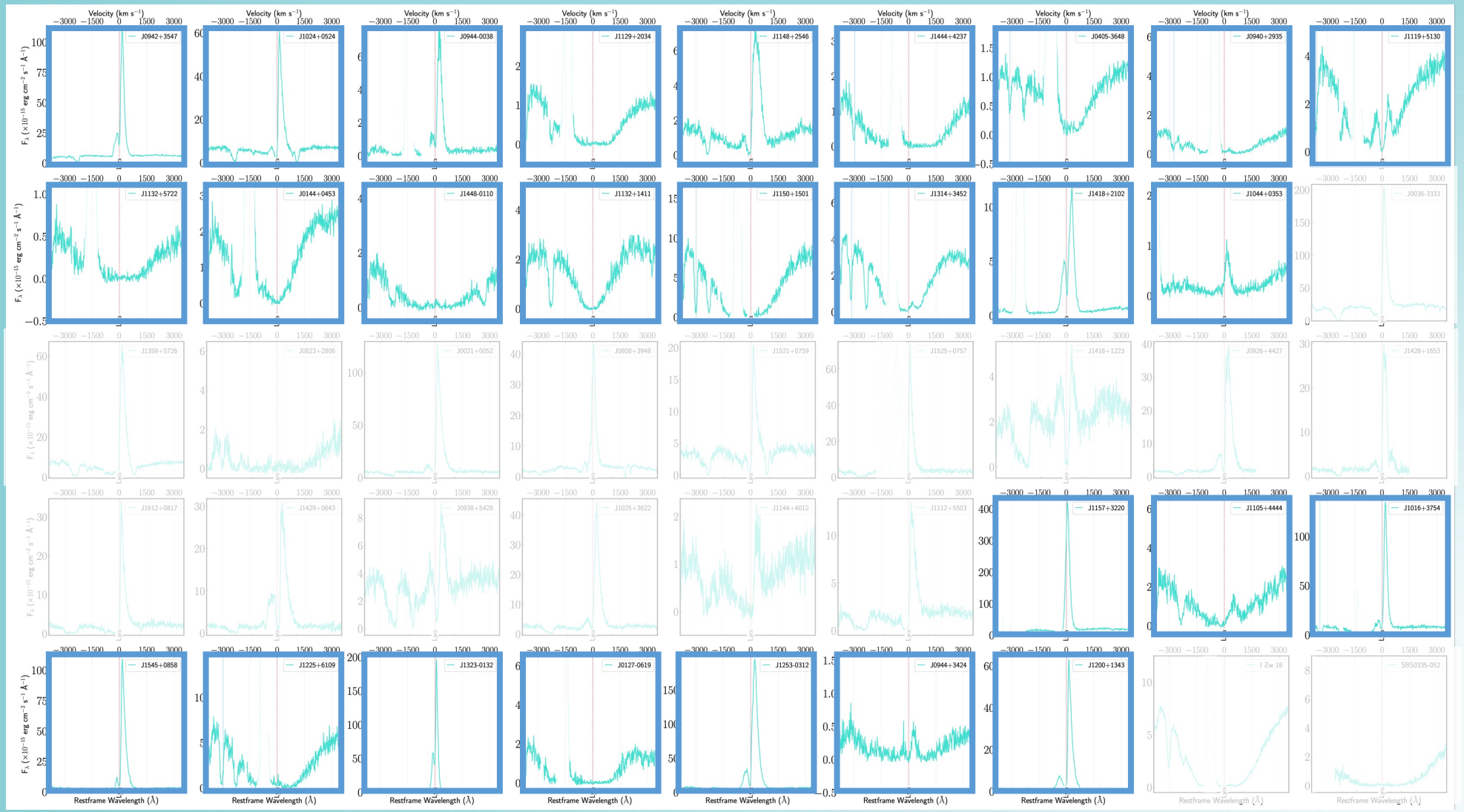
SIMON GAZAGNES,
POSTDOC AT UT

Gazagnes+23 submitted

Study of low-ionization emission lines CII 1334 and SiII 1260

The study of Lyα profiles and low-ionization lines

27 CLASSY galaxies did not have Lyα coverage



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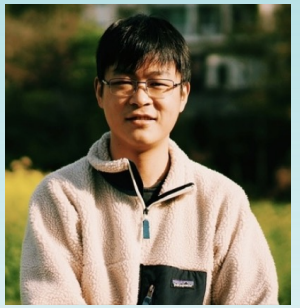

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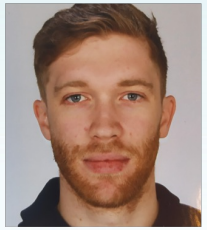

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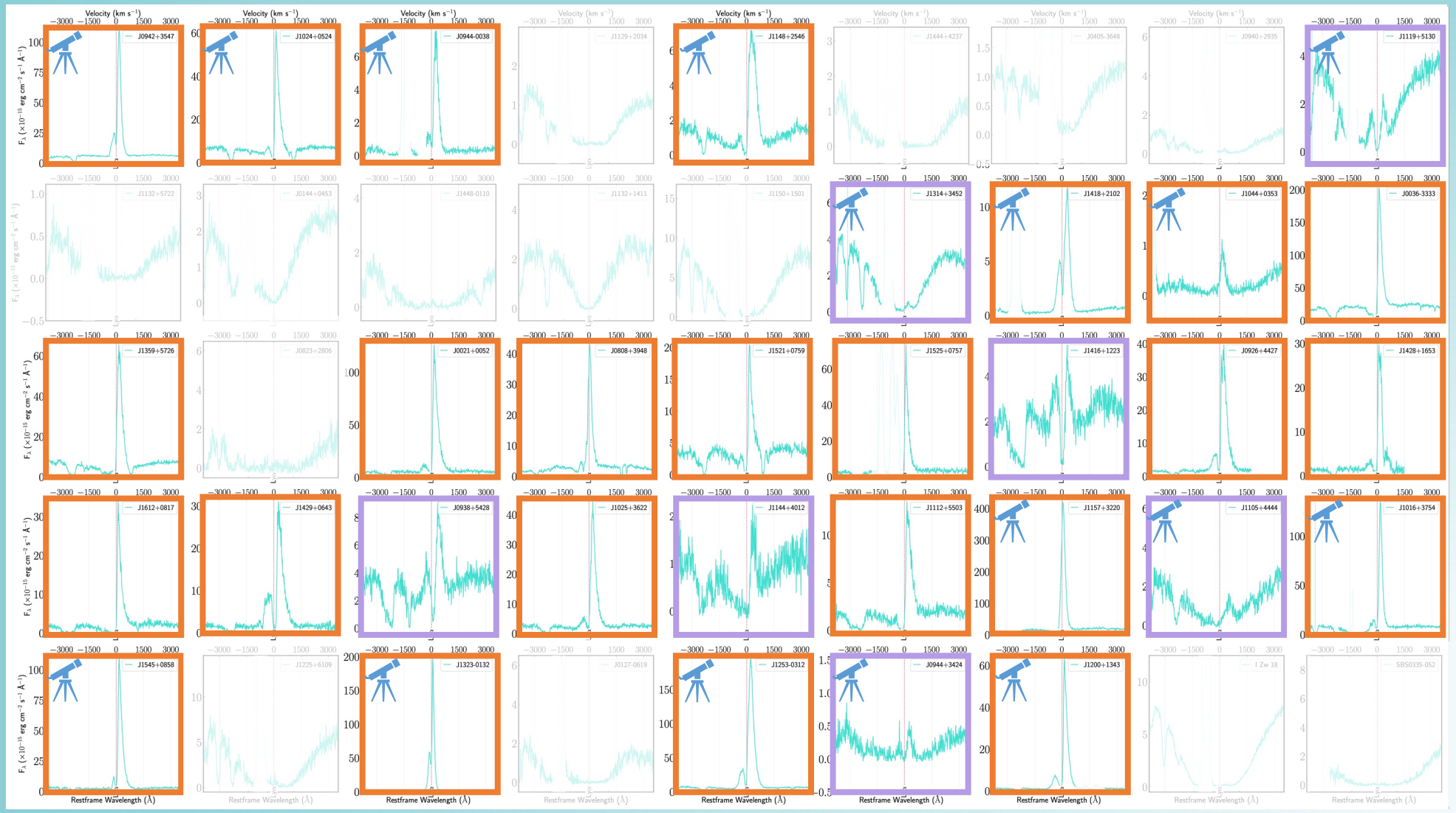
The study of Lyα profiles and low-ionization lines

24 strong LAEs **7 weak or combo LAEs** **16 new CLASSY LAEs**



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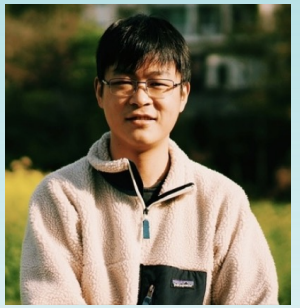

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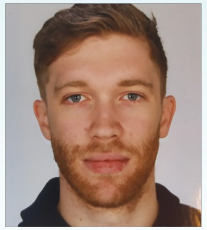
POSTDOC AT UC SB

LYA PROFILES



SIMON GAZAGNES,
POSTDOC AT UT

Gazagnes+23 submitted

Study of low-ionization emission lines CII 1334 and SiII 1260

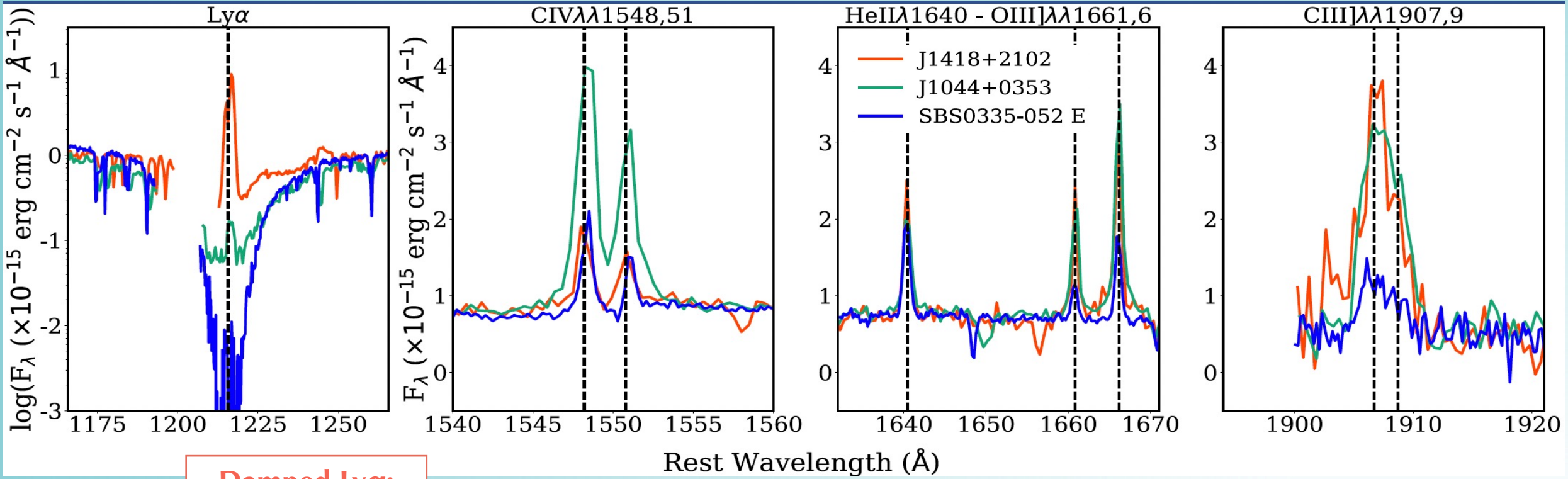
An example of the synergistic science UV spectra can provide

Lyα emission:
Holes in the HI gas?

Strong, resonant CIV emission:
High-energy photons escaping

See Berg+19!

Strong, high-ionization emission:
Copious amounts of high-energy photons produced



Damped Lyα:
High column densities of HI

See e.g. **Berg+19,22, Mingozzi+22** for more details about these spectra and UV emission lines

Ongoing (+archival) HST observations (PI Mingozzi)

Matilde Mingozzi to perform **Lyα, CIV, CIII] imaging** and investigate their distribution and ratios in these 3 CLASSY targets

COS LEGACY ARCHIVE SPECTROSCOPIC SURVEY: A TREASURY OF STAR-FORMING GALAXIES

CLASSY represents the largest sample of rest-frame high-resolution FUV spectra for 45 galaxies, including analogs to high-z systems

webpage: https://stdatu.stsci.edu/hlsp/classy
MAST portal: https://mast.stsci.edu/search/ui/#/classy

Fundamental insights to interpret z>6 galaxies in the JWST era

- CLASSY I and II (**Berg+22; James+22**): Sample and data reduction presentation
- CLASSY III and VI (**Xu+22,23**): Analysis of ionized outflows through UV absorption lines
- CLASSY IV and IX (**Mingozzi+22; Mingozzi+23 in prep.**): Suite of UV-based diagnostics to infer the ISM properties
- CLASSY V (**Arellano-Córdova+22**): Effect of aperture of optical spectra on ISM properties used in comparison to UV spectra
- CLASSY VII (**Hu+23 submitted**): Study of Lyα profiles
- CLASSY VIII (**Gazagnes+23 submitted**): Study of low-ionization emission lines CII 1334 and SiII 1260
- CLASSY X (**Arellano-Córdova+23 in prep.**): N and alpha-elements abundances in local high-z analogs
- CLASSY XI (**Berg+23 in prep.**): C/O abundance
- And counting ☺

Matilde Mingozzi

mmingozzi@stsci.edu

COS Legacy Archive Spectroscopic SurveY: A Treasury of Star-Forming Galaxies

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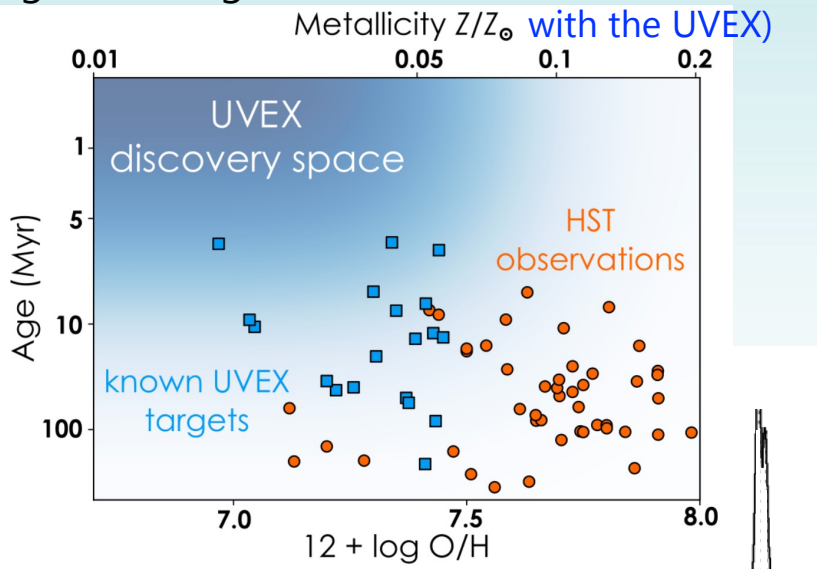
Extend our studies on many more nearby (**z<0.03**), metal-poor and low-mass ($M_* > 10^6\ M_\odot$) representative samples and up to up to **z~0.38** (still covering CIII]1907,9)

Kulkarni+23 (Science with the UVEX)



Thank you for your attention!

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