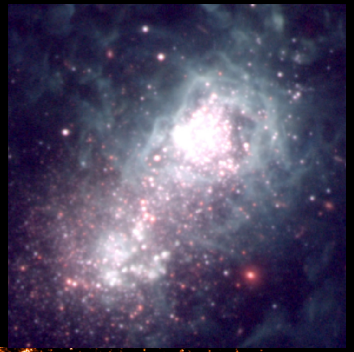
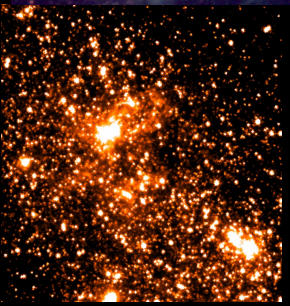
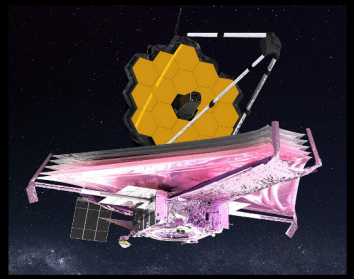




Dwarf galaxies, star clusters: *synergies between local and high-z Universe*



Francesca Annibali
(INAF-OAS Bologna)

Giornate RSN1
Feb 9-11, 2026
INAF – Osservatorio Astronomico di Capodimonte

Dwarf Galaxies and Reionization

- Dwarf galaxies at z>6 thought to be major contributors to Universe re-ionization

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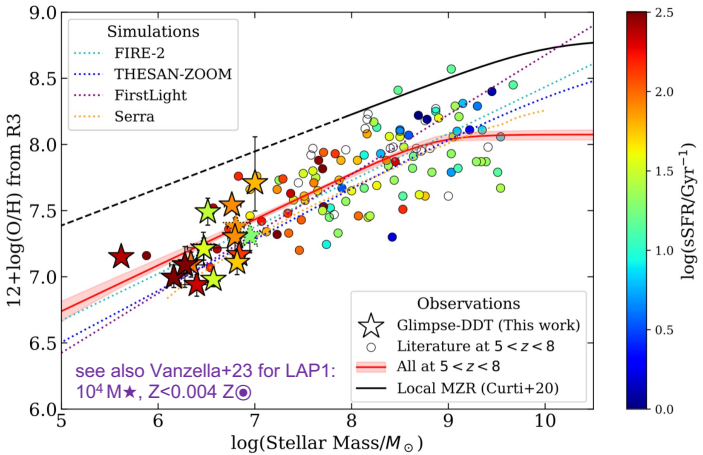
MZR at z>5 (Asada+26)



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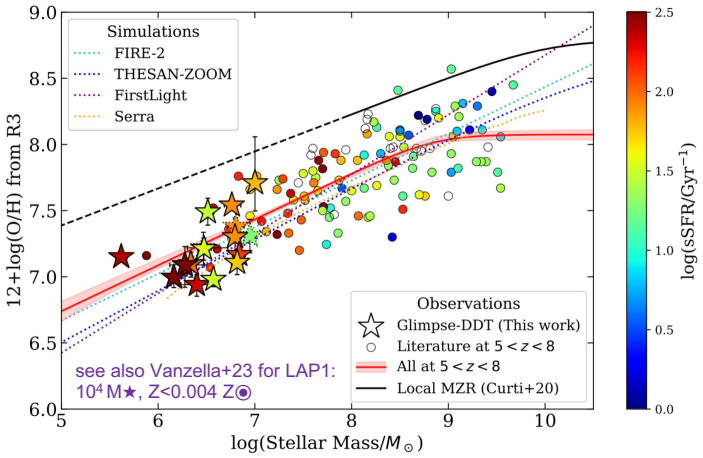
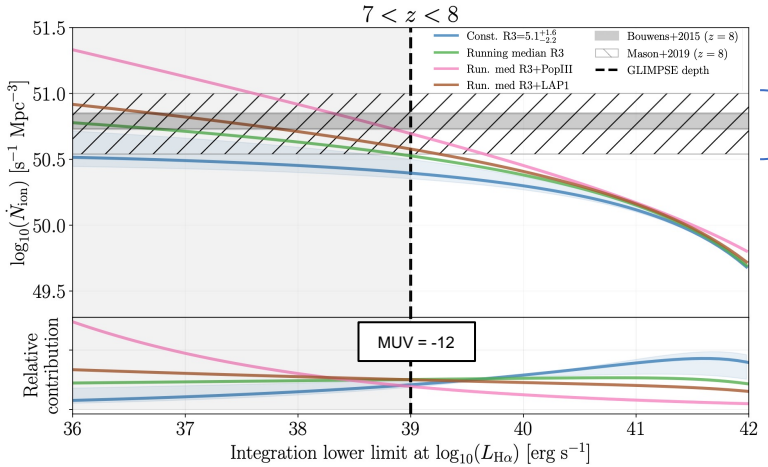


Cumulative ionizing photon rate from [OIII]+Hβ LF (Korber+26)



Required ioniz rate

Assumptions:

- f_{esc}=14%

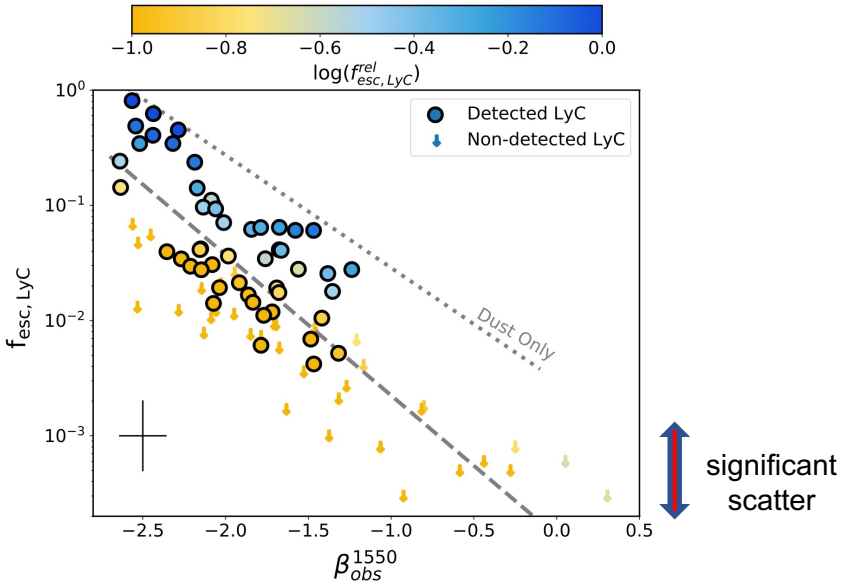
- Different colors are for different Z vs M_{UV} relations

- Not possible to directly detect LyC (<912 Å) at z>4 (IGM absorption)
- f_{esc} typically obtained from scaling relations calibrated in the local Universe

Dwarf Galaxies and Reionization

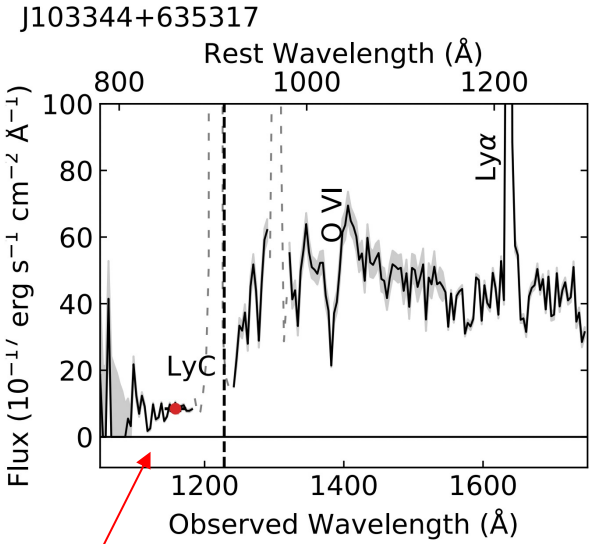
- Dwarf galaxies at z>6 thought to be major contributors to Universe re-ionization

89 SF galaxies **at 0.2<z<0.4** *(Chisholm+22)*



significant scatter

COS@HST spectra *(Flury+22)*

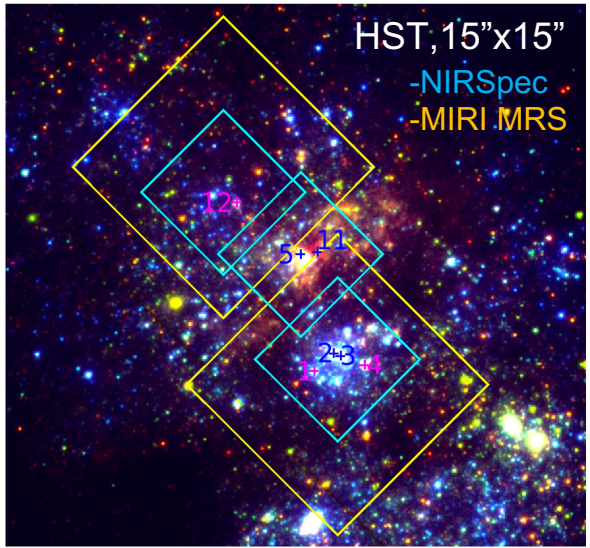


Relation of f_{esc} vs. UV slope, derived from direct detection of LyC + SED modeling

A complementary approach: constraining f_{esc} from nearby galaxies

- Selecting local galaxies with properties (Z, SFR) similar to high-z dwarfs

- Low metallicity starburst NGC 5253 (D=3.8 Mpc) as a *pilot project:*
  - $M_{\star}$=4 x 10^8 M_{sun}, 1/3 Z_{sun} , SFR~0.5 M_{sun}/yr
  - Young radio super-nebula embedded in dust
  - Several young massive clusters



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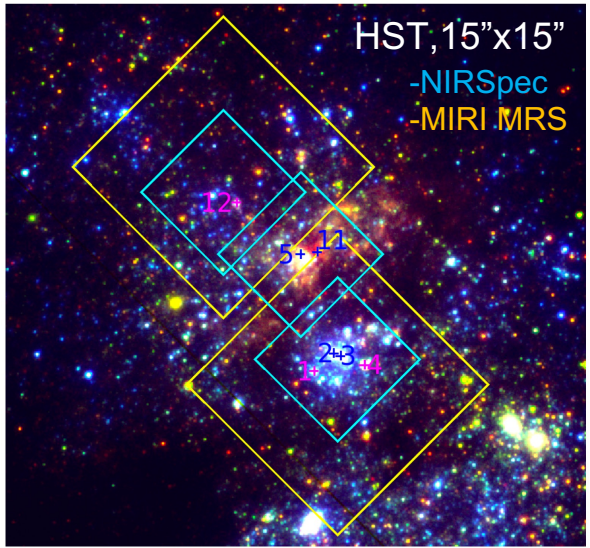
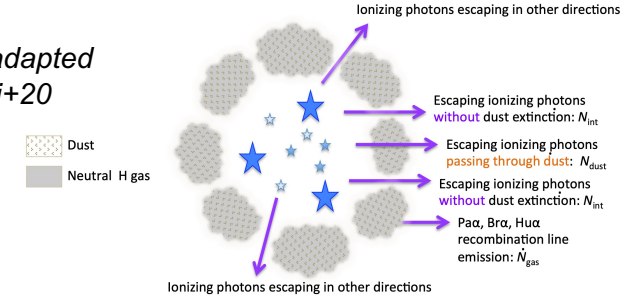


- NIRCam img., NIRSpec/IFU, MIRI img., MRS/IFU (JWST Cy3, PI Hunt) to study @3-7pc resolution:
  - Star clusters, feedback, and the ISM
  - Stellar dust production and mass assembly
  - ISM porosity and leakage of LyC photons

NB: this kind of analysis, with *Spitzer* and *Herschel*, only possible within the Local Group (D<1 Mpc). <u>However, no strong starburst dwarf exists in the LG!</u>

A complementary approach: constraining f_{esc} from nearby galaxies

Cartoon adapted from Choi+20



Not possible to directly detect LyC in very nearby systems!

$$f_{esc} = \frac{N_{int} - N_{gas} - N_{dust}}{N_{int}}$$

A complementary approach: constraining f_{esc} from nearby galaxies

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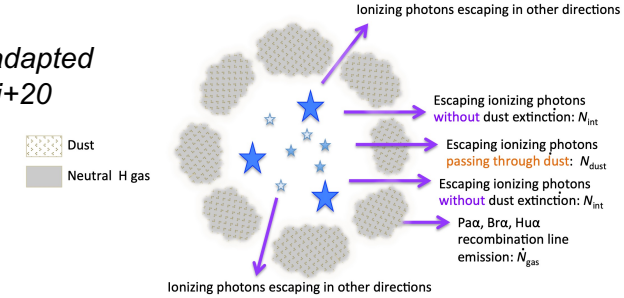

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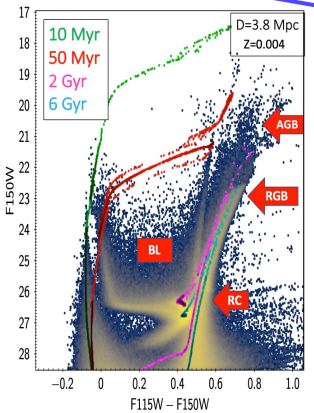
NIRCam+ UV/optical HST



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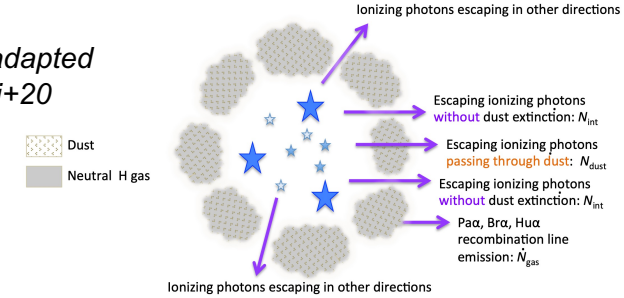

Not possible to directly detect LyC in very nearby systems!

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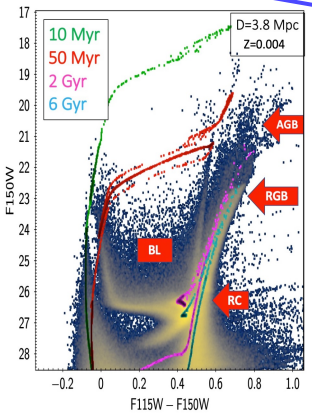
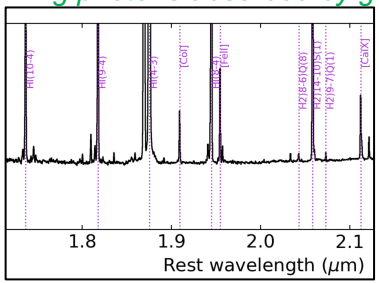
$$f_{esc} = \frac{N_{int} - N_{gas} - N_{dust}}{N_{int}}$$

ionizing photons absorbed by gas

NIRCam+ UV/optical HST

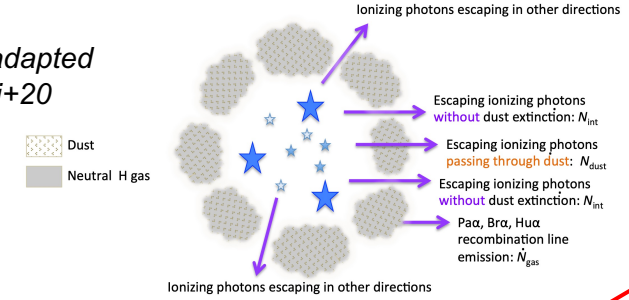




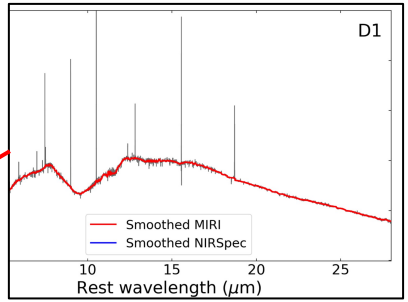
NIRSpec

A complementary approach: constraining f_{esc} from nearby galaxies

Cartoon adapted from Choi+20



ionizing photons absorbed by dust

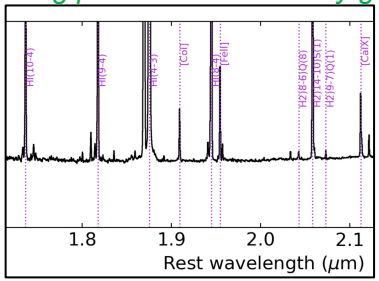


MIRI

intrinsic ionizing photons

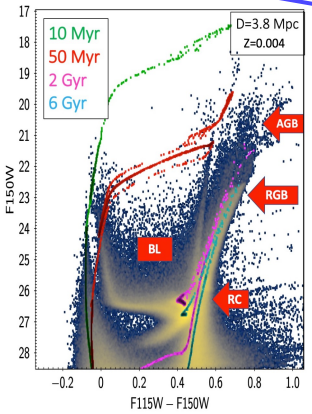
$$f_{esc} = \frac{N_{int} - N_{gas} - N_{dust}}{N_{int}}$$

ionizing photons absorbed by gas



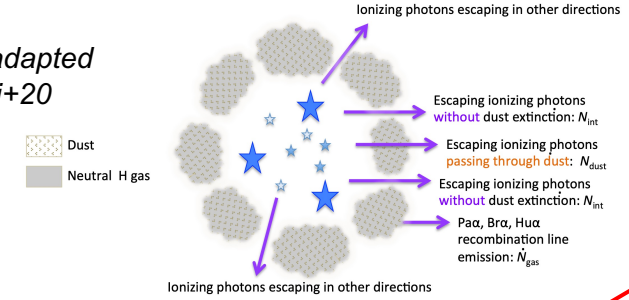
NIRSpec

NIRCam+ UV/optical HST

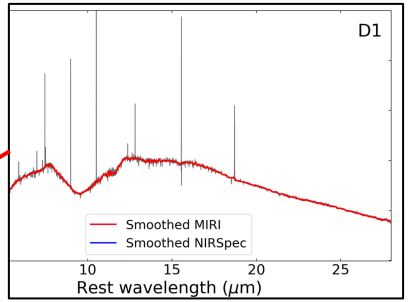


A complementary approach: constraining f_{esc} from nearby galaxies

Cartoon adapted from Choi+20



ionizing photons absorbed by dust

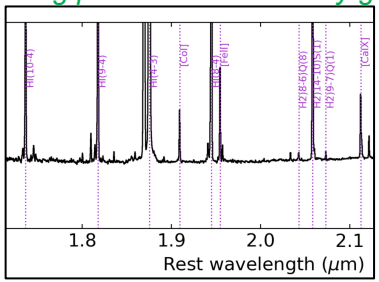


MIRI

intrinsic ionizing photons

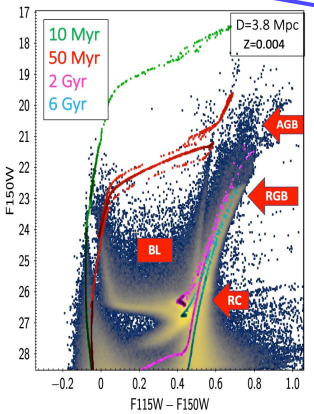
$$f_{esc} = \frac{N_{int} - N_{gas} - N_{dust}}{N_{int}}$$

ionizing photons absorbed by gas



NIRSpec

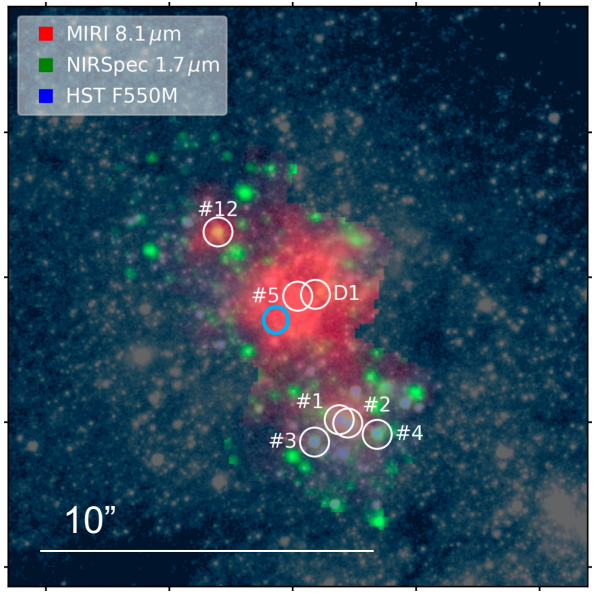
NIRCam+ UV/optical HST



We will produce maps of f_{esc} and characterize the ISM porosity

NGC 5253 – JWST preliminary results

Hunt et al. in prep



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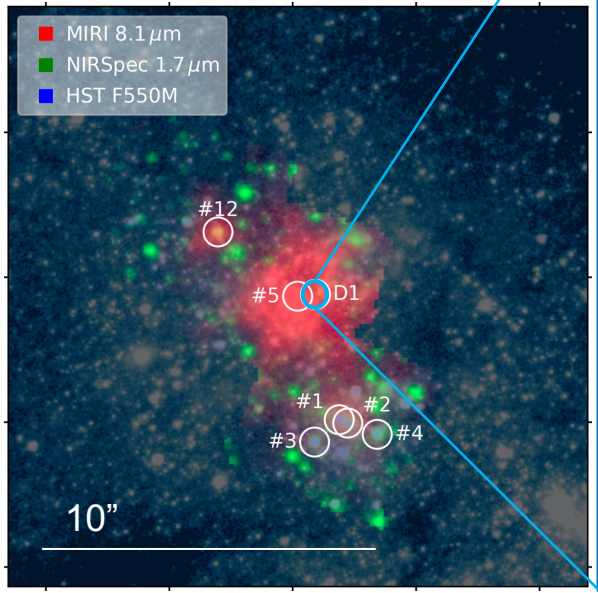
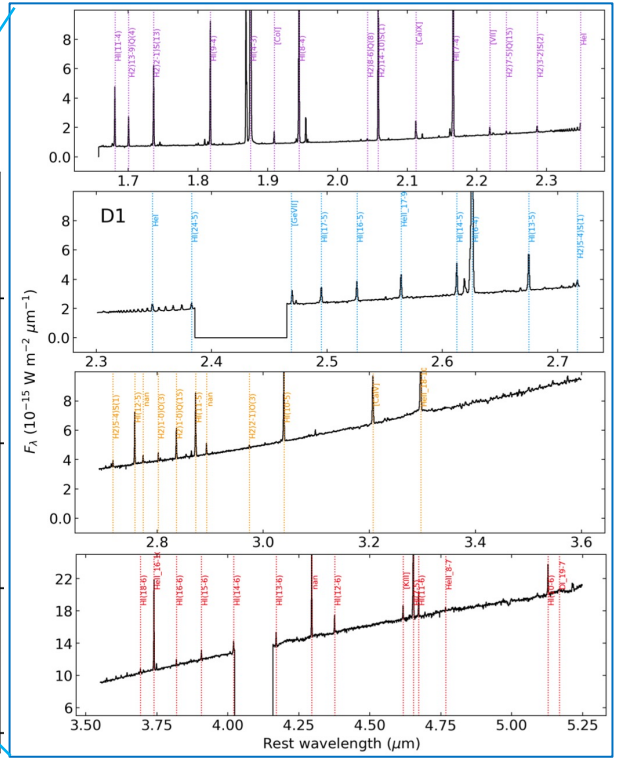
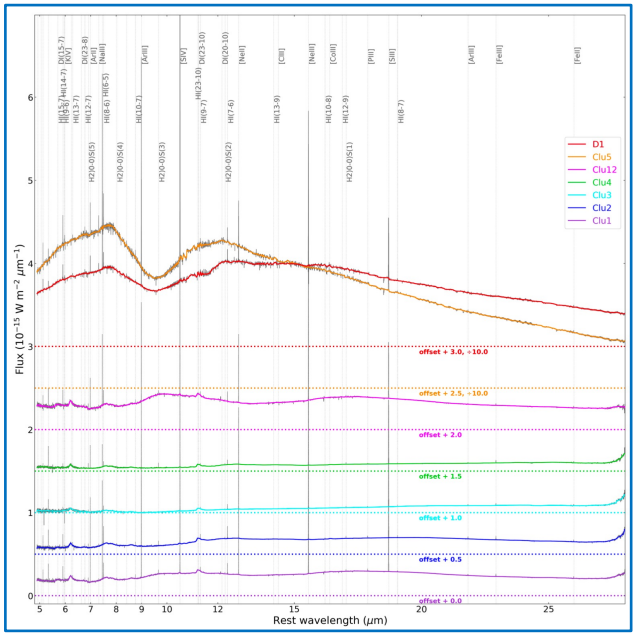


NIRSpec



- Lines of Ca, Co, V, Ge, K, Ni, Fe, Si, typically associated with SNe II
- No high ionization potential lines (e.g. [OIV])
- Many PAHs detected

MIRI/MRS

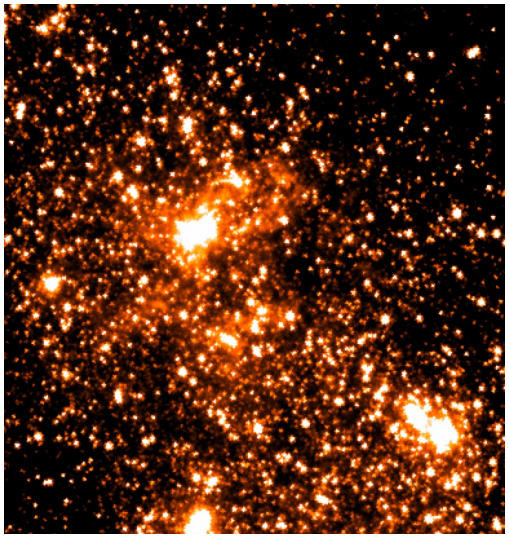


Spectra by F. Loiacono and G. Navarro Ovando

NGC 5253 – JWST preliminary results

- Age-dating stars through color-magnitude diagrams

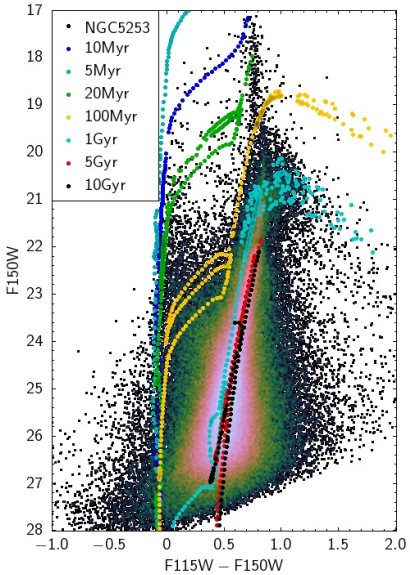
NIRCam portion of the central starburst



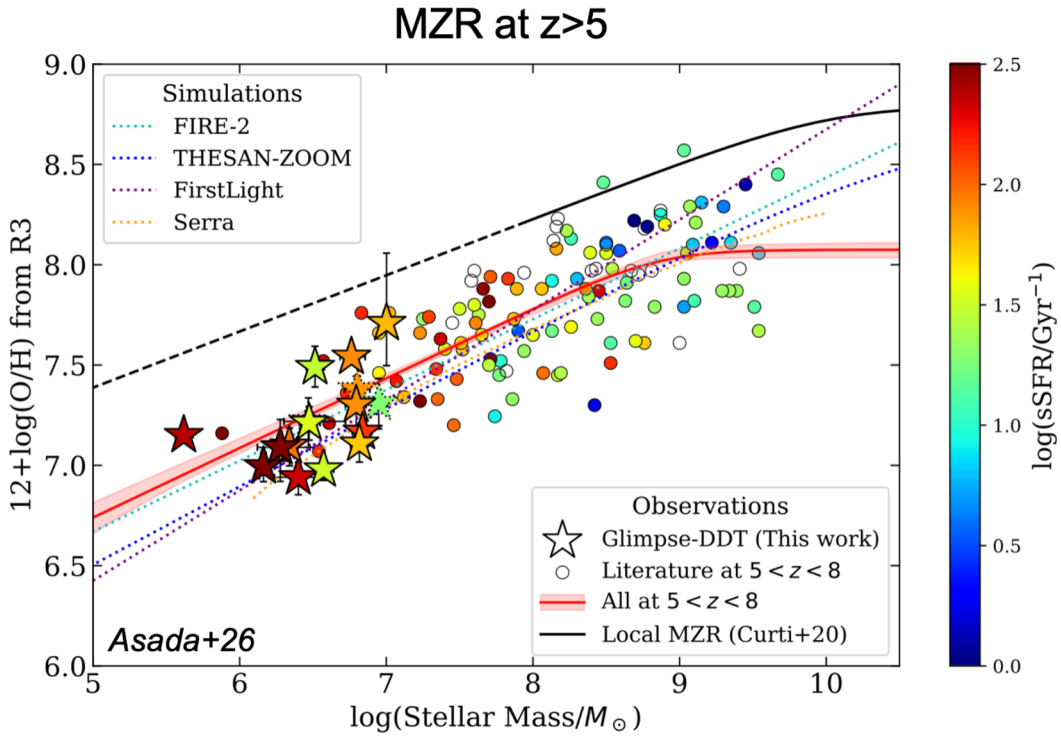
inary results

NIRCam mosaic,
Correnti et al. in prep.

We will infer the **SFH** by modeling the observed CMDs with synthetic ones



Nearby Starburst Dwarfs in the high-z context



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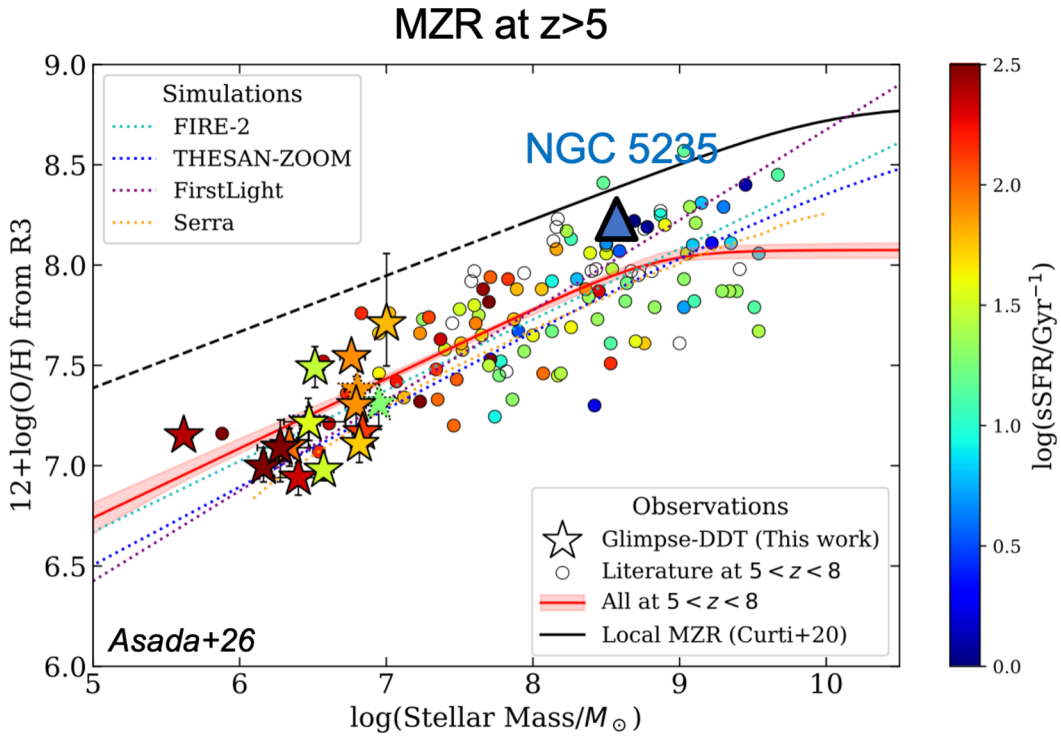

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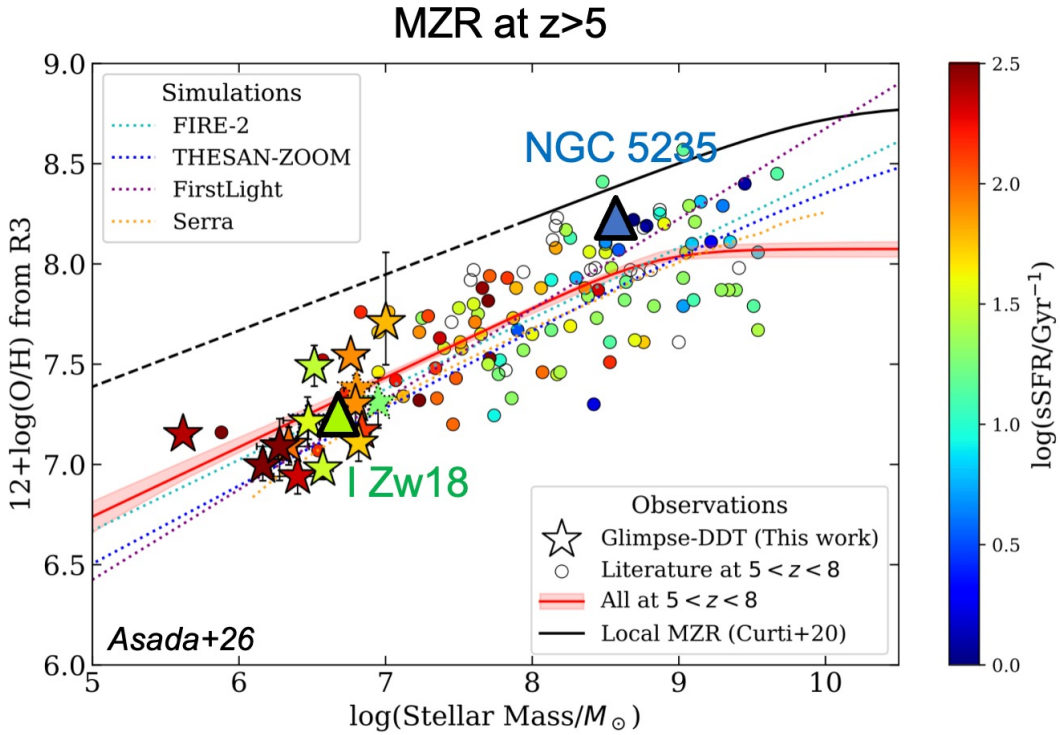
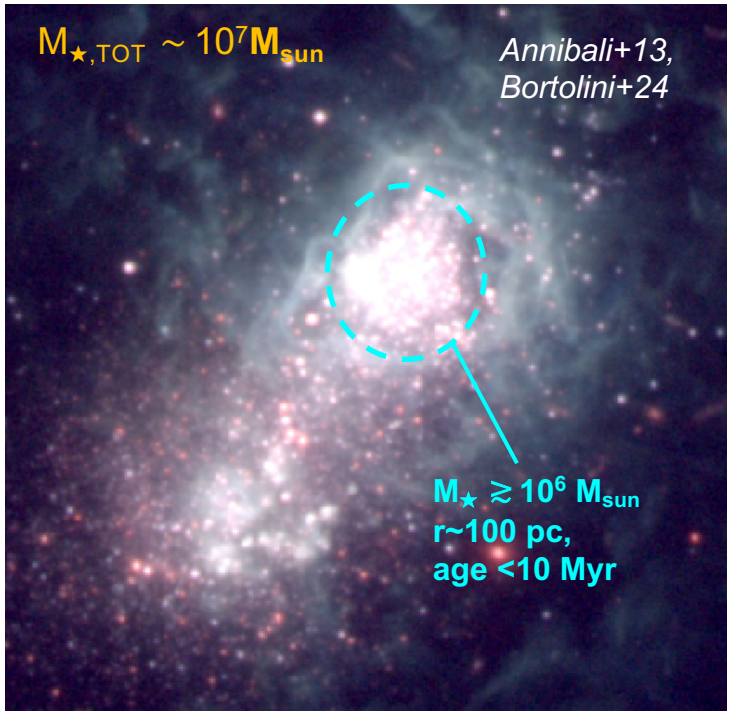


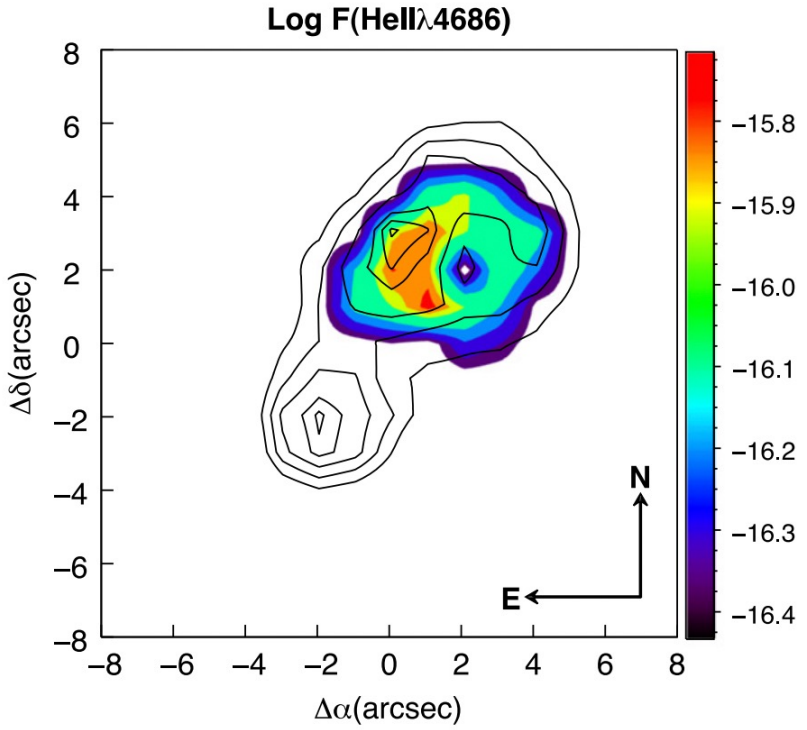
Extremely metal poor local dwarfs

BCD IZw18, Z~2-3 % solar, $M_\star \lesssim 10^7$ M_{sun} , D=18 Mpc

IZw18, HST ACS
F555W, F606W, F814W



Hard radiation field (Kehrig+15)

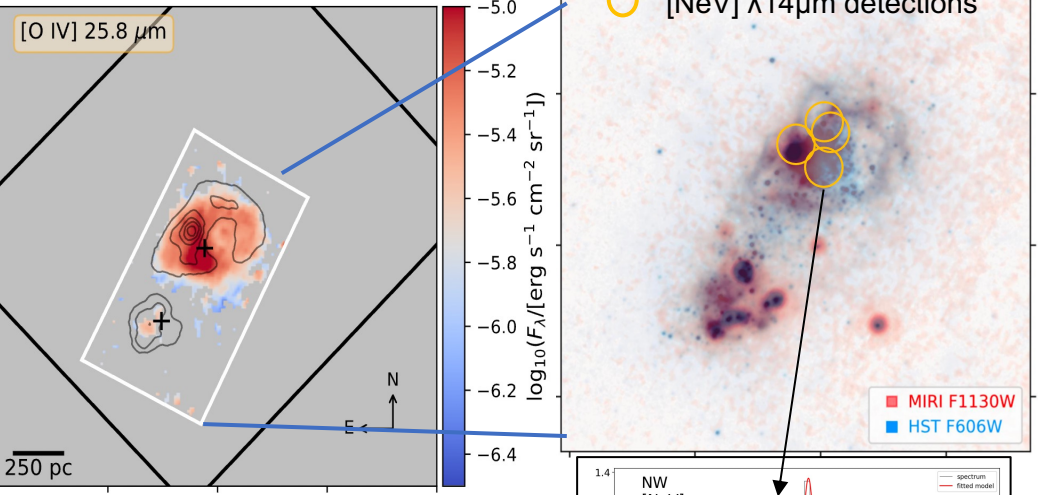


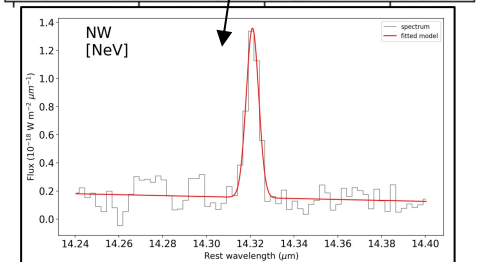
First JWST [NeV] detection in IZw18

IZw18, JWST MIRI/MRS
(Cy2, Pis Aloisi/Hunt)

HeII IP = 54 eV
[OIV] IP = 55 eV
[NeV] IP = 97 eV

[OIV] map





Hunt+25a; Vaught+25a; Arroyo-Polonio+25.
See also Mingozzi+25 for [NeV] in SBS0335-052

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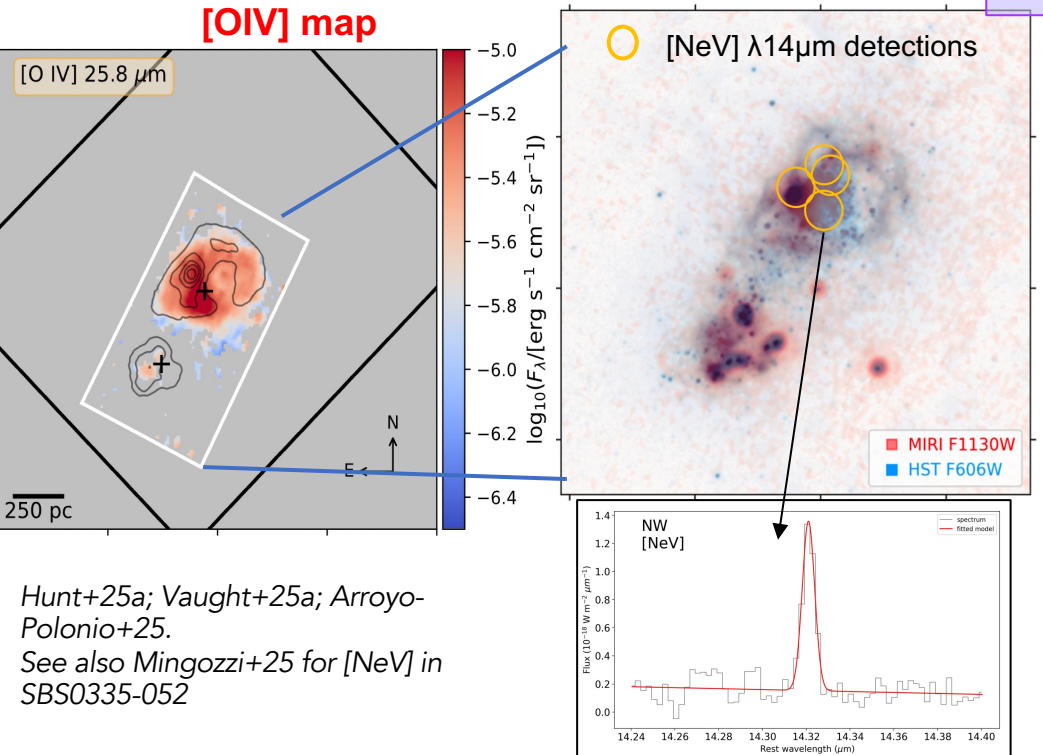
Very hard Radiation Field, also seen in LyC leakers

[OIV] map



Hunt+25a; Vaught+25a; Arroyo-Polonio+25.
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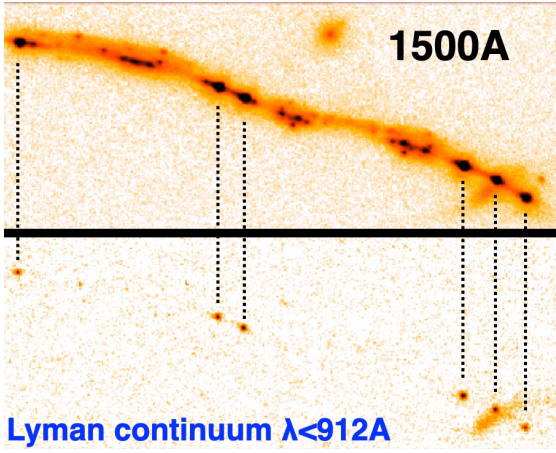
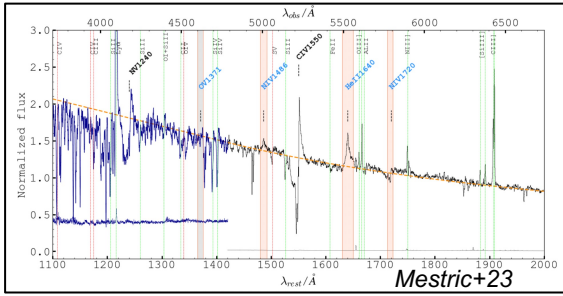
The Sunburst arc at z=2.37
(Vanzella+20,22; Rivera-Thorsen+19,25)



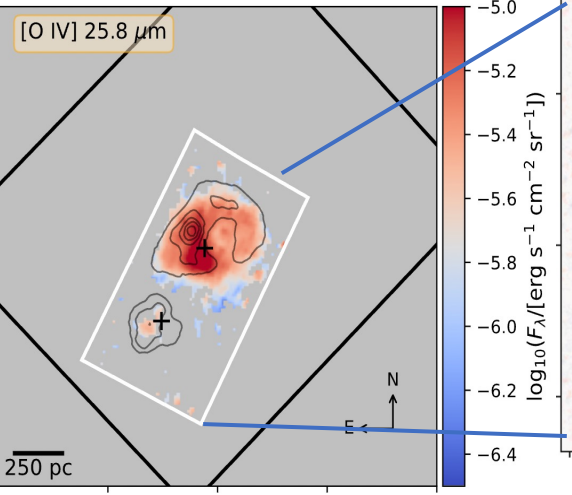


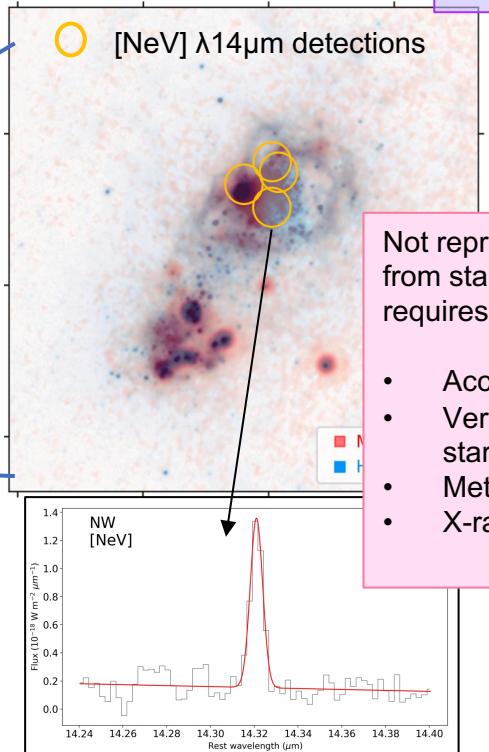
Courtesy: E. Vanzella

First JWST [NeV] detection in IZw18

IZw18, JWST MIRI/MRS
(Cy2, Pis Aloisi/Hunt)

[OIV] map





HeII IP = 54 eV
[OIV] IP = 55 eV
[NeV] IP = 97 eV

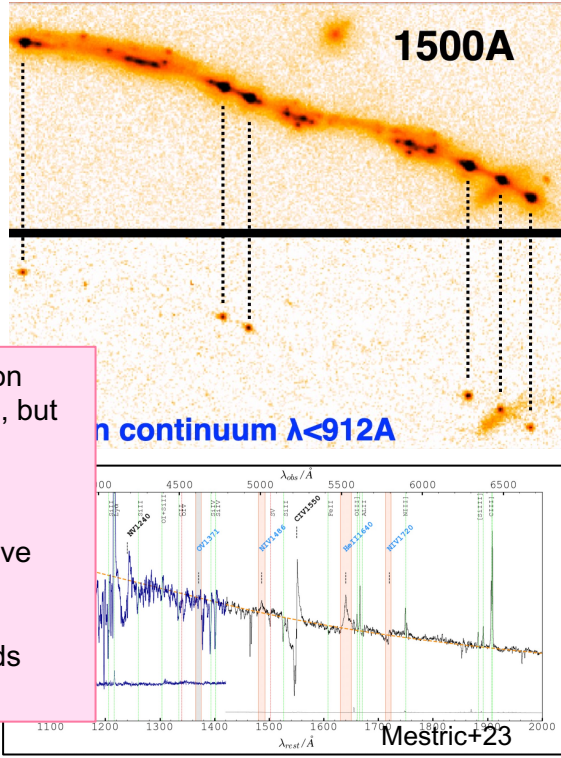
Very hard Radiation Field, also seen in LyC leakers

Not reproduced by photoionization from standard stellar populations, but requires:

- Accreting IMBH
- Very metal poor supermassive stars
- Metal poor stars + ULX
- X-rays from star cluster winds

Hunt+25a; Vaught+25a; Arroyo-Polonio+25.
See also Mingozzi+25 for [NeV] in SBS0335-052

The Sunburst arc at z=2.37
(Vanzella+20,22; Rivera-Thorsen+19,25)

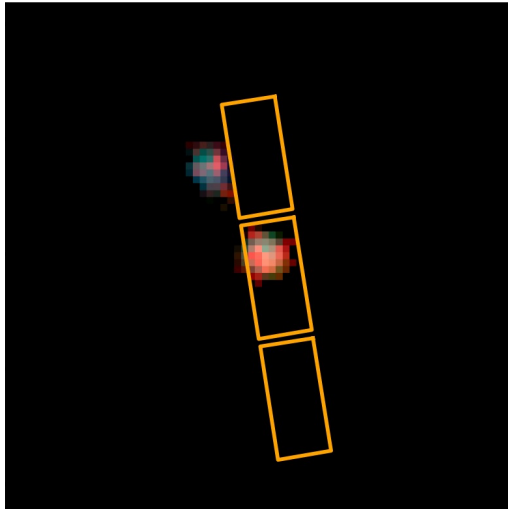


Courtesy: E. Vanzella

IMBH in high-z dwarfs

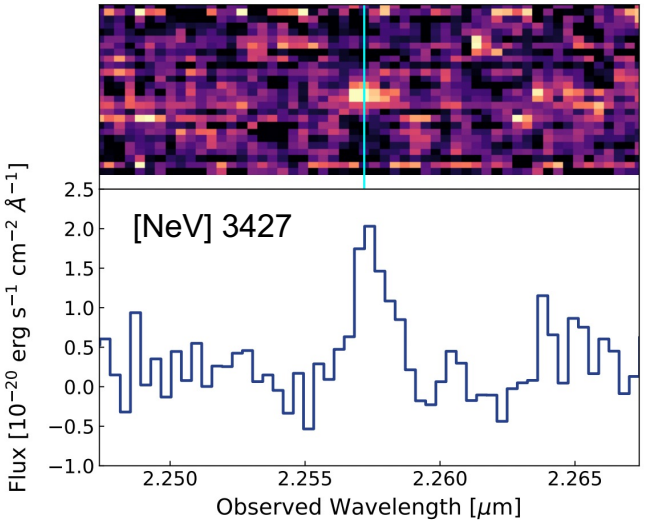
- High IP lines in JWST data used to identify AGN at very high z (e.g. Chisholm+24, Scholtz+25)
- .. but local Universe results show that SF in low metallicity environments can <u>also</u> mimic hard radiation field associated with IMBH

Chisholm+24



GN 42437:

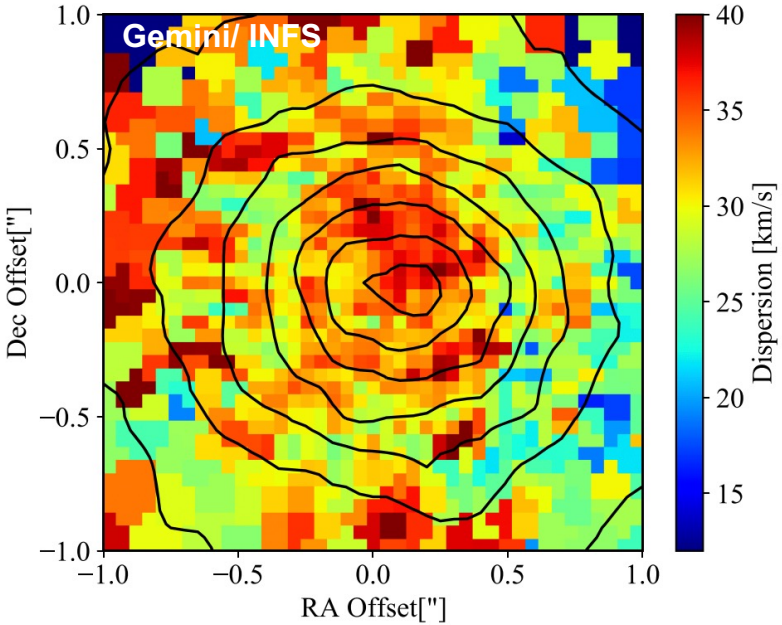
- z=5.6
- $M_\star \sim 10^8\ M_\odot$
- R_e<500 pc
- $\mathrm{Log}(M_{BH}/M_\odot)$=5-7

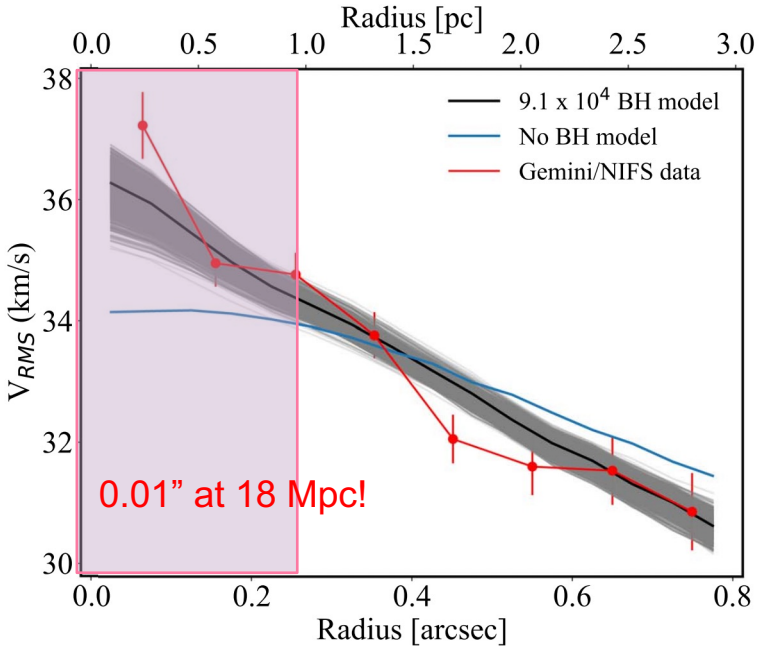


kinematic detection of IMBH?

- Even in local dwarf galaxies, detection of IMBHs through **kinematics of star and gas is challening because of the small sphere of influence**

GC B023-G078 in M31 (D~1 Mpc), $M_\star \sim 6 \times 10^6\ M_\odot$, $M_{BH} \sim 9 \times 10^4\ M_\odot$,
(Pechetti+2022)

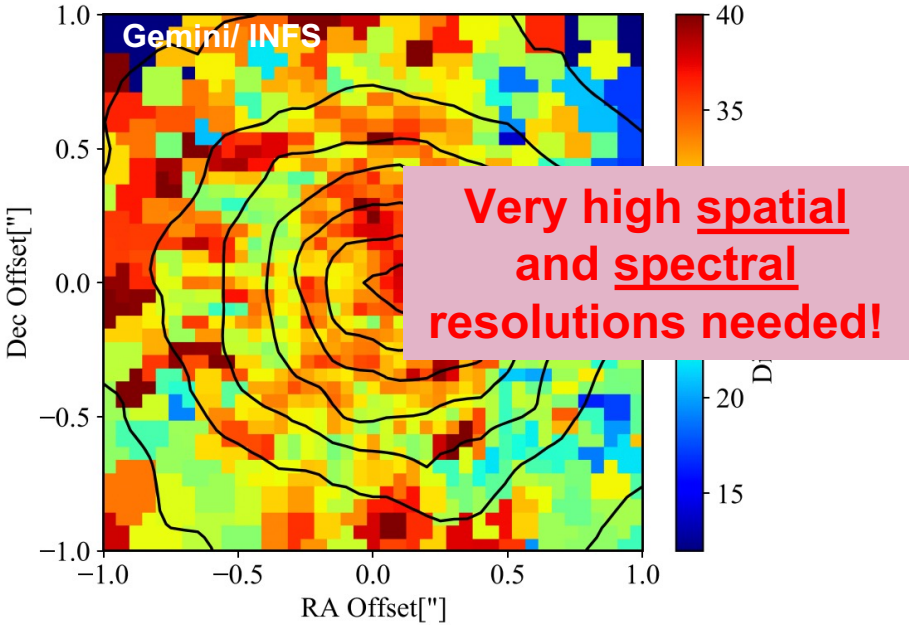




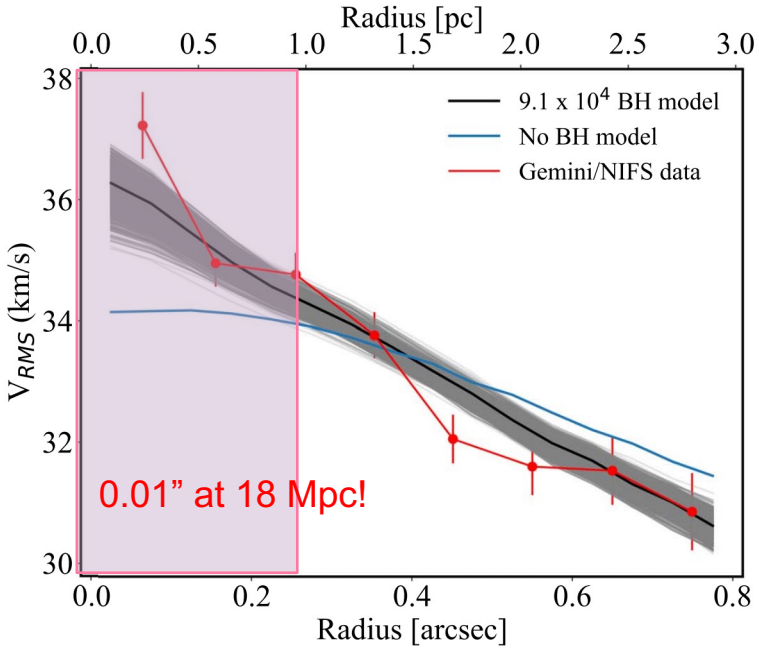
kinematic detection of IMBH?

- Even in local dwarf galaxies, detection of IMBHs through **kinematics of star and gas is challening because of the small sphere of influence**

GC B023-G078 in M31 (D~1 Mpc), $M_\star \sim 6 \times 10^6\ M_\odot$, $M_{BH} \sim 9 \times 10^4\ M_\odot$,
(Pechetti+2022)



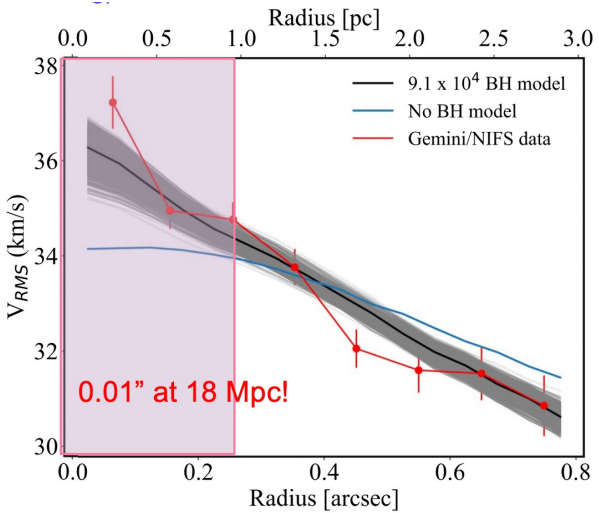
Very high <u>spatial</u> and <u>spectral</u> resolutions needed!

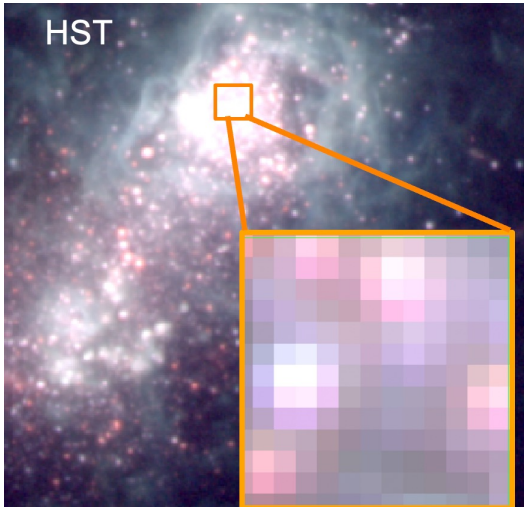


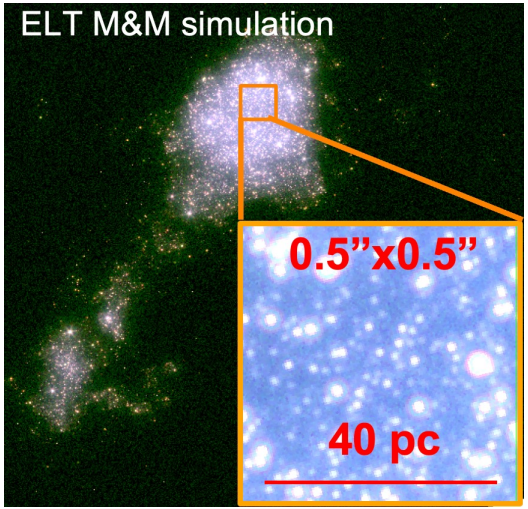
Dwarf galaxies and the ELT perspective

MORFEO+MICADO
resolution in physical scale

10 mas at:		
Galactic Center	8 kpc	0.4 mpc
Cen A	4 Mpc	0.2 pc
Virgo Cluster	18 Mpc	1 pc
Cosmic Noon	z~ 2	80 pc





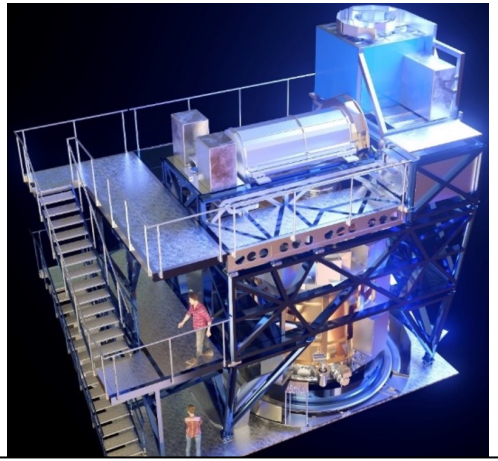


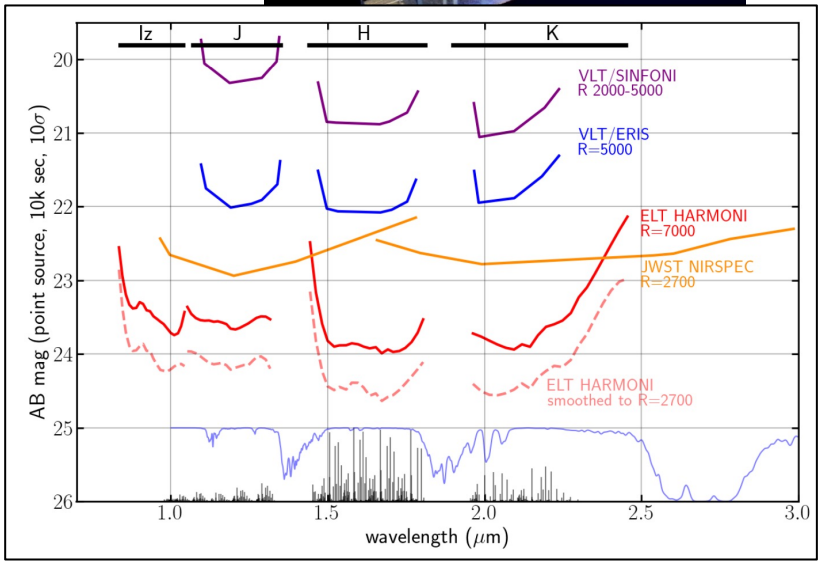
MICADO long slit: 16 mas width, R~20,000
~1.3 pc at Virgo distance

HARMONI IFU:
6mas x 6 mas pix scale,
1.2"x 0.9" FoV, R=7000
25mas x 25 mas pix scale,
3.8" x 5.1" FoV, R=3000

- HARMONI recently rescoped (MORFEO will provide AO correction)

Simplified HARMONI		
Spatial pixel scale	6x6 mas	25x25 mas
FoV	1.2”x 0.9”	3.8” x 5.1”
Wavelength range	0.8 – 2.4 μm	
Spectral resolution	R=7000 (Iz, J, H, K) R=3000 (Iz+J, H+K)	
SCAO	4x4 mas sampling	
MCAO		





- Courtesy Mark Swinbank (HARMONI PS)