A MIR Look at LyC Escape

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Lyman Labyrinths 2025
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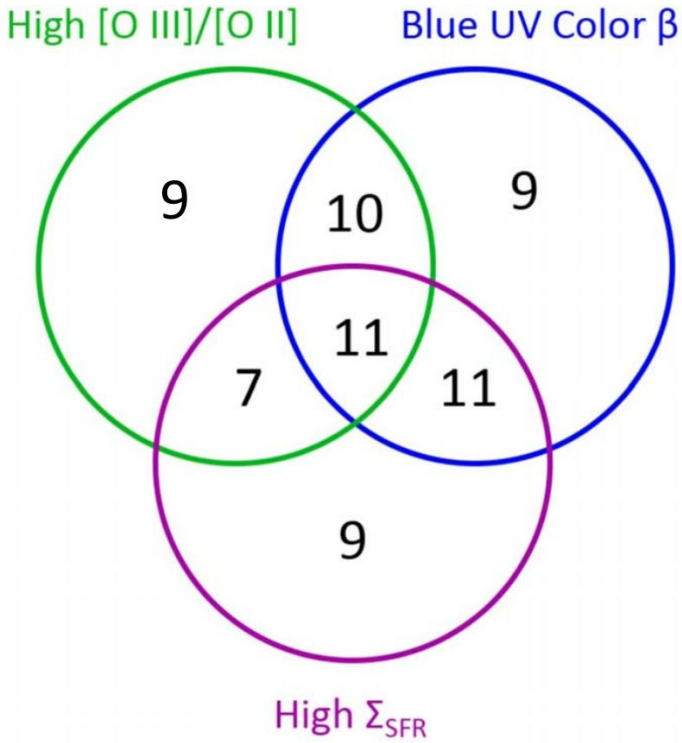
The LzLCS+

- HST survey of LyC in 66 z~0.3 galaxies
- wide parameter space
- test LyC diagnostics for use at higher redshift
- ~ triples number of LyC detections
- Jaskot+ 2024a,b predictors, Jaskot 2025 for review



Flury+ 2022a

Recurring Terms:

LzLCS - Low-redshift Lyman continuum survey

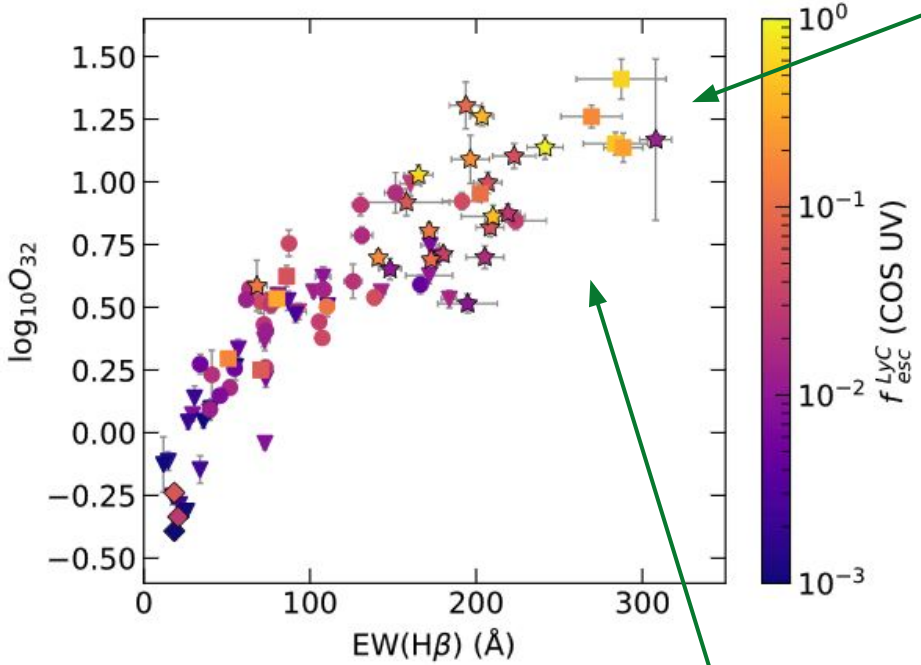
LyC - Lyman continuum (ionizing photons)

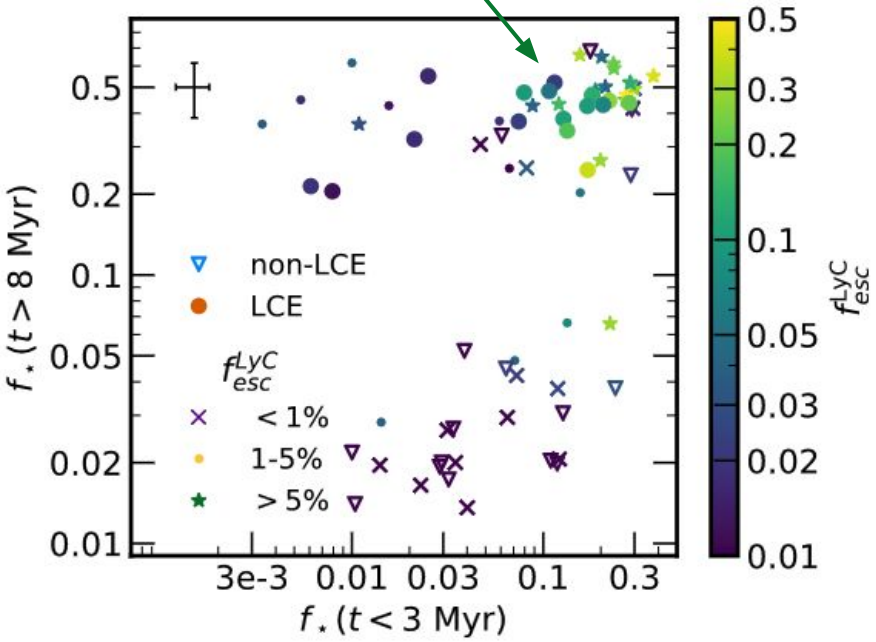
LCE - Lyman continuum emitter (“leaker”)

f_{esc} - fraction of ionizing photons which escape their host galaxy

Feedback and LyC Escape

Ionizing feedback primary driver!



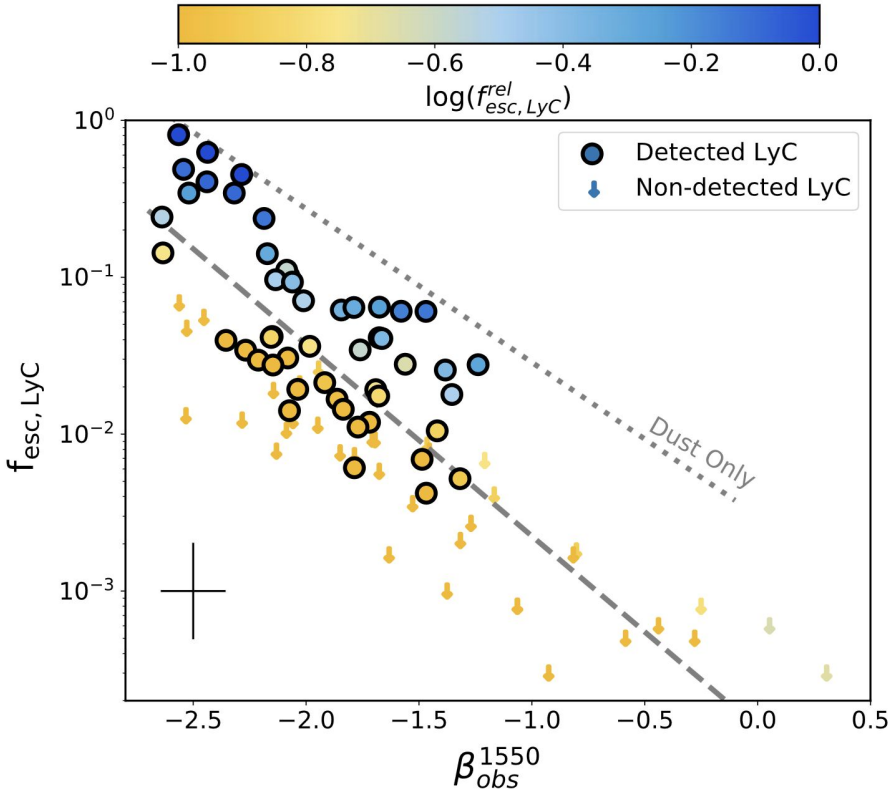


LyC escape is *not* isotropic!

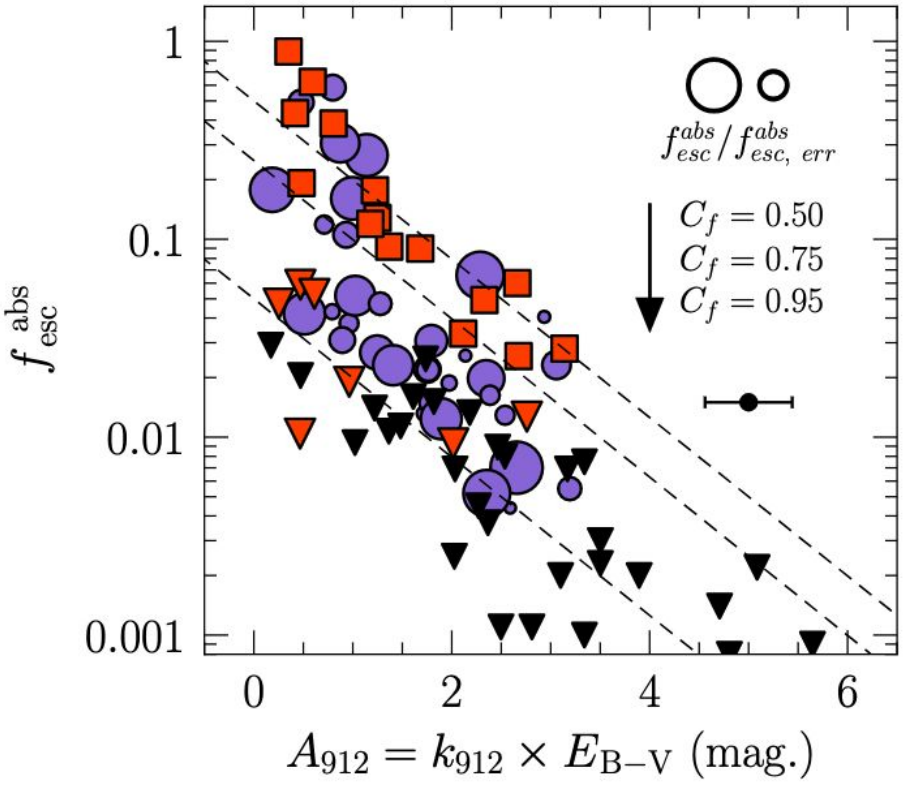
Flury+ 2022b

Flury+ 2024a

The Role of Dust



Chisholm+ 2022

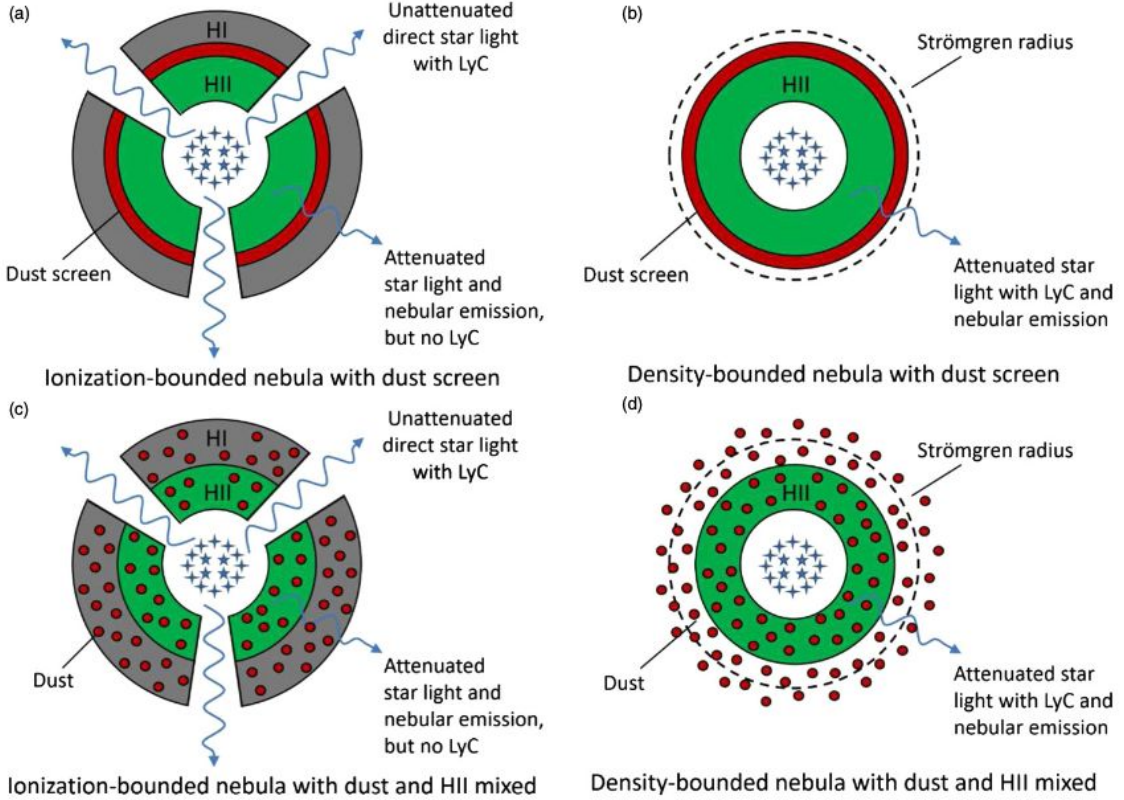


Saldana-Lopez+ 2022

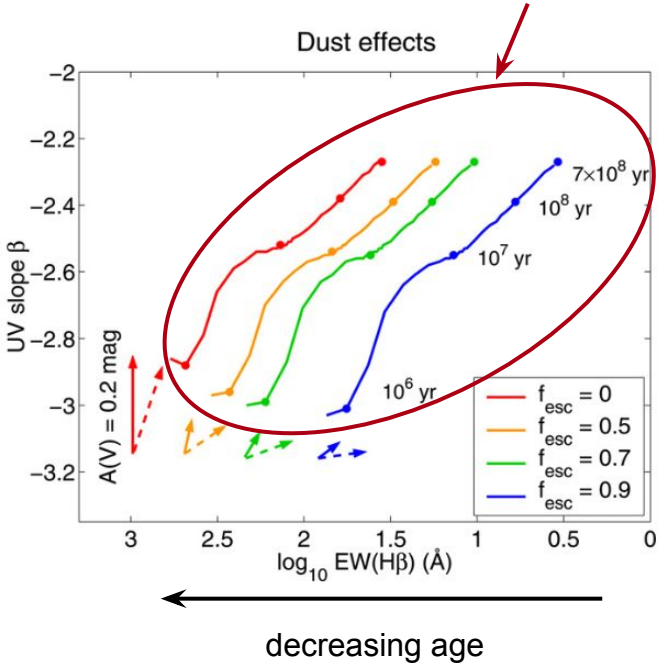
Effects of Dust

picket fence - anisotropic

density bounding — isotropic



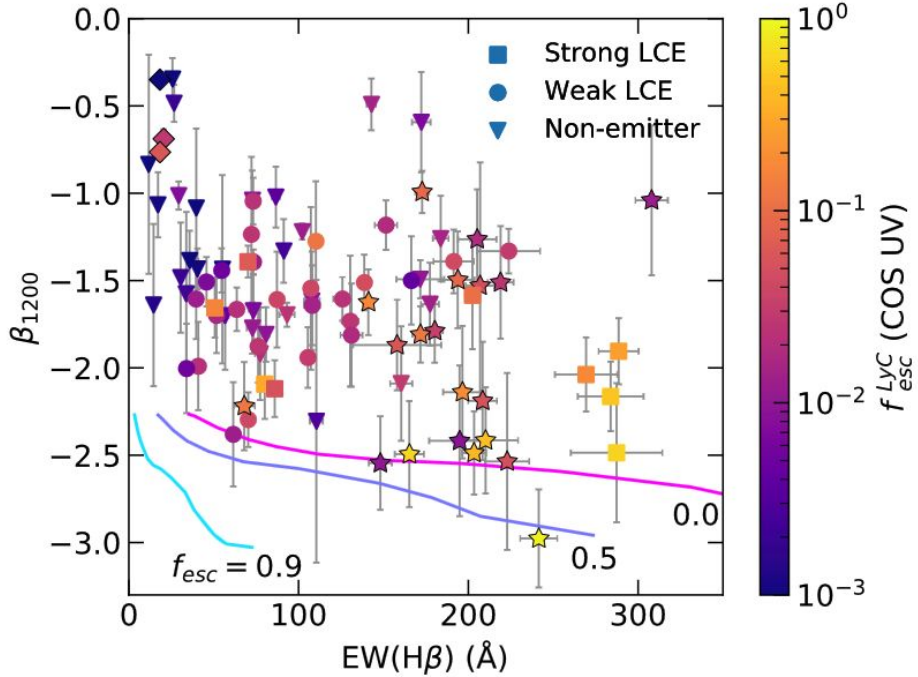
Dust-free



Zackrisson+ 2013

Expectations vs Reality

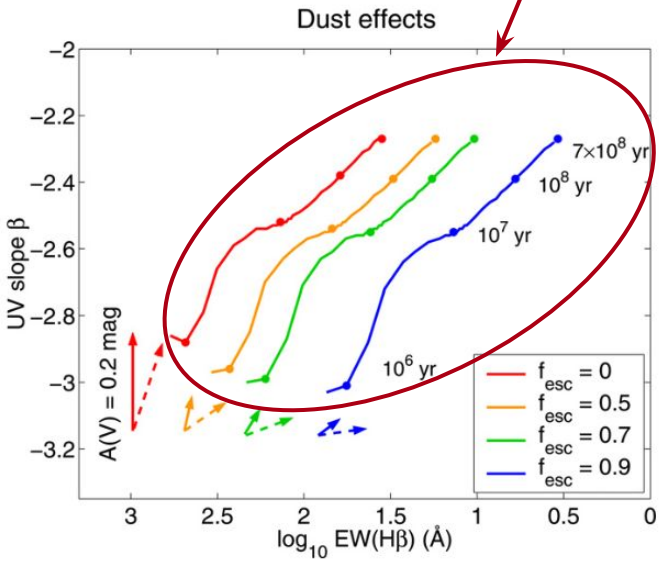
anisotropic escape



Flury+ 2022b

increasing age

Dust-free

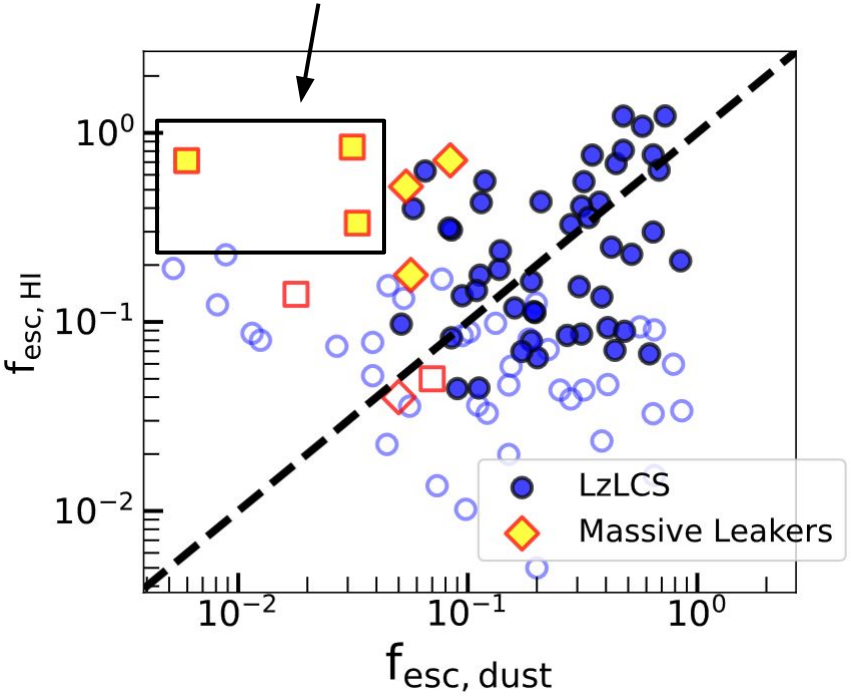


decreasing age

Zackrisson+ 2013

Dust And LyC Escape

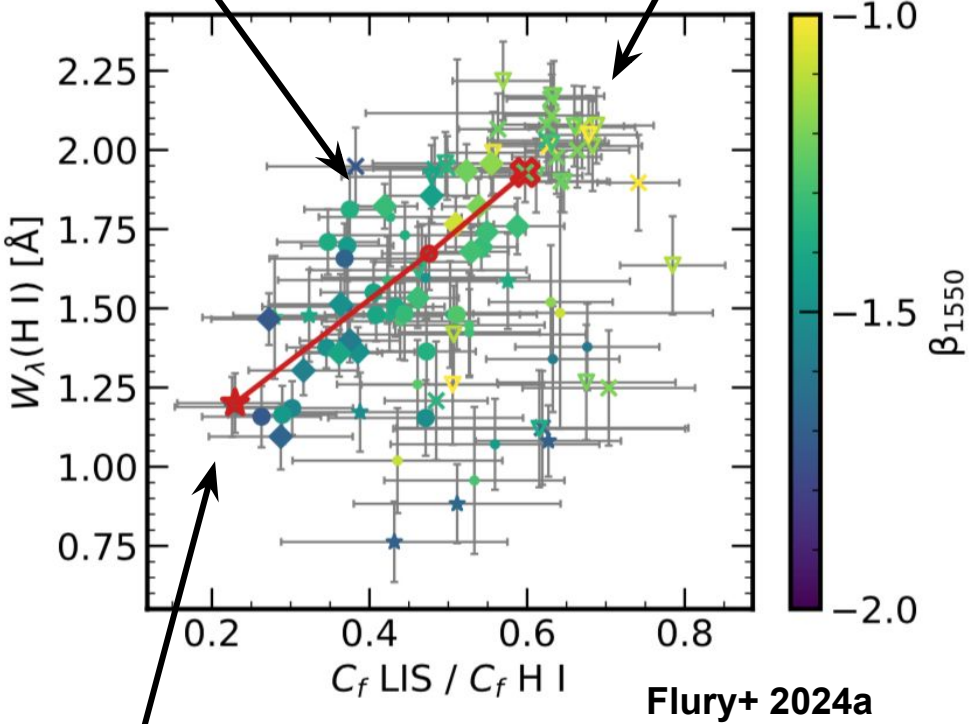
dust can dominate LyC absorption



Roy+ 2024

a) much dust, H I

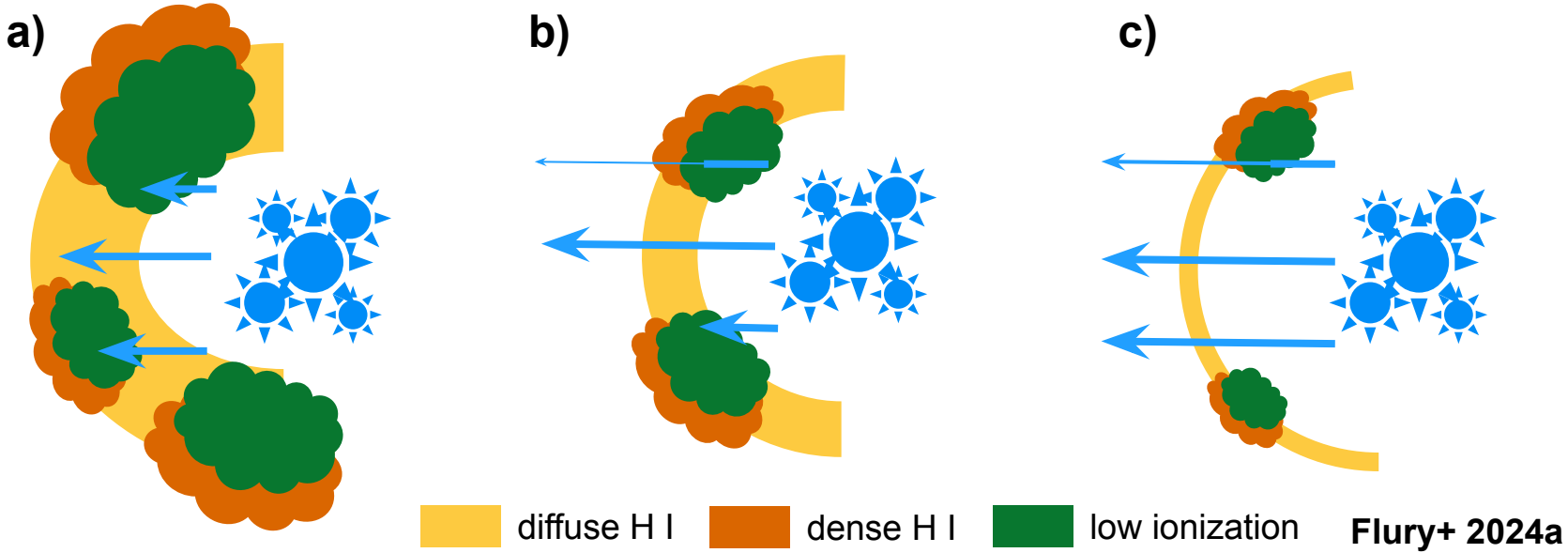
b) some dust, H I



Flury+ 2024a

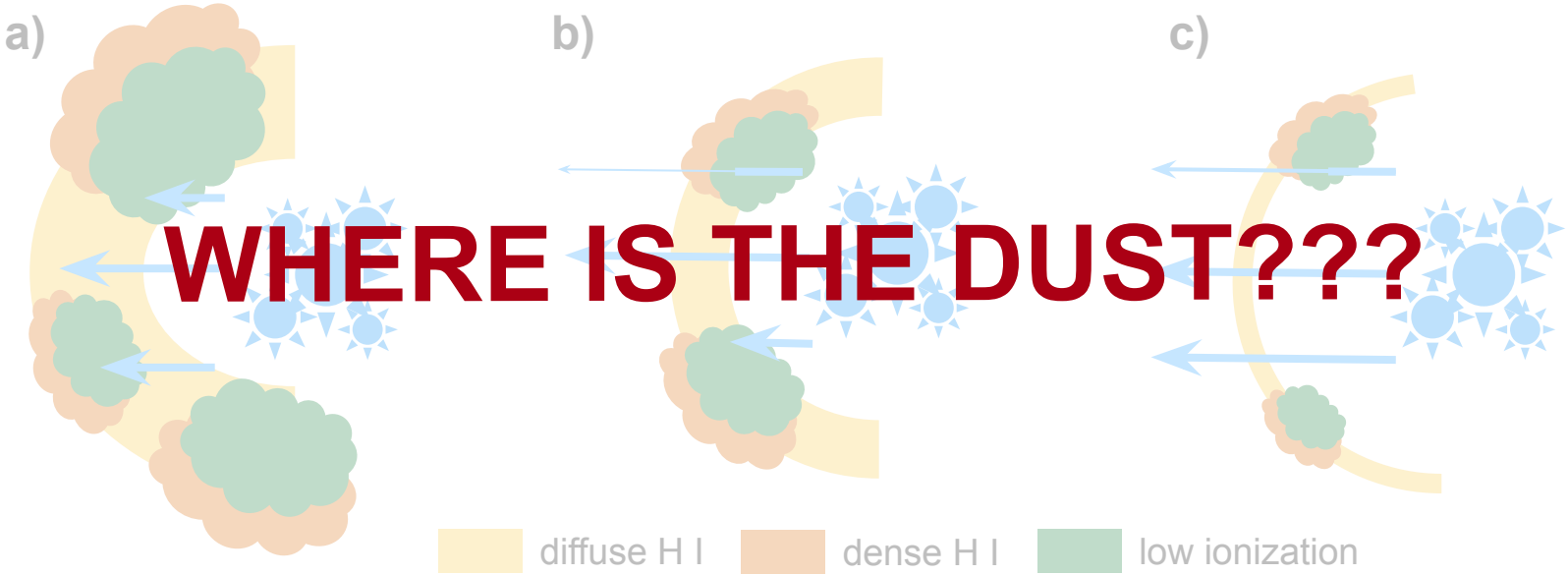
c) little dust, H I

LyC Escape Toy Geometric Model



stellar pop analysis suggests geometry shaped by bursty star formation

LyC Escape Toy Geometric Model



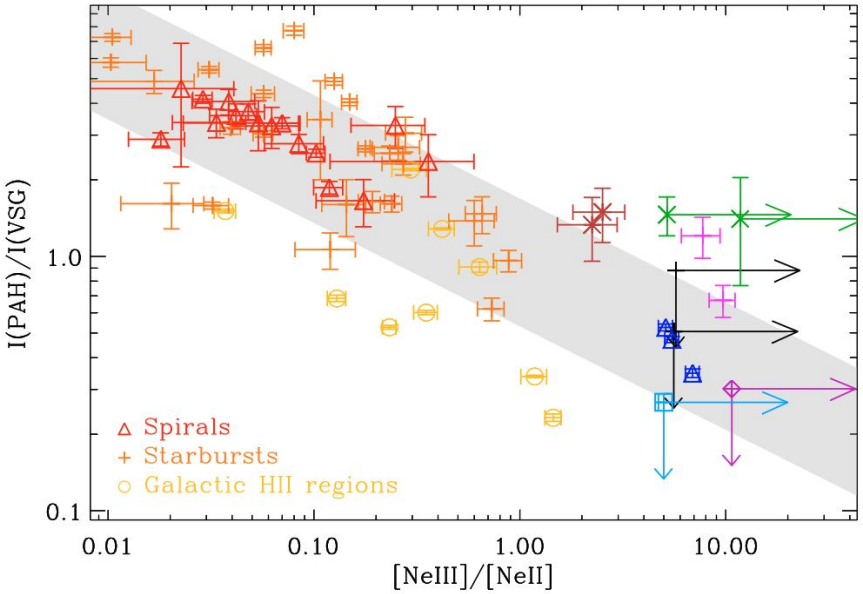
What Can We Learn from the MIR?

nebular lines

- uniquely sensitive to gas density → can trace clumping
- access high ionization lines not in optical
- no stellar absorption effects, little dust effect

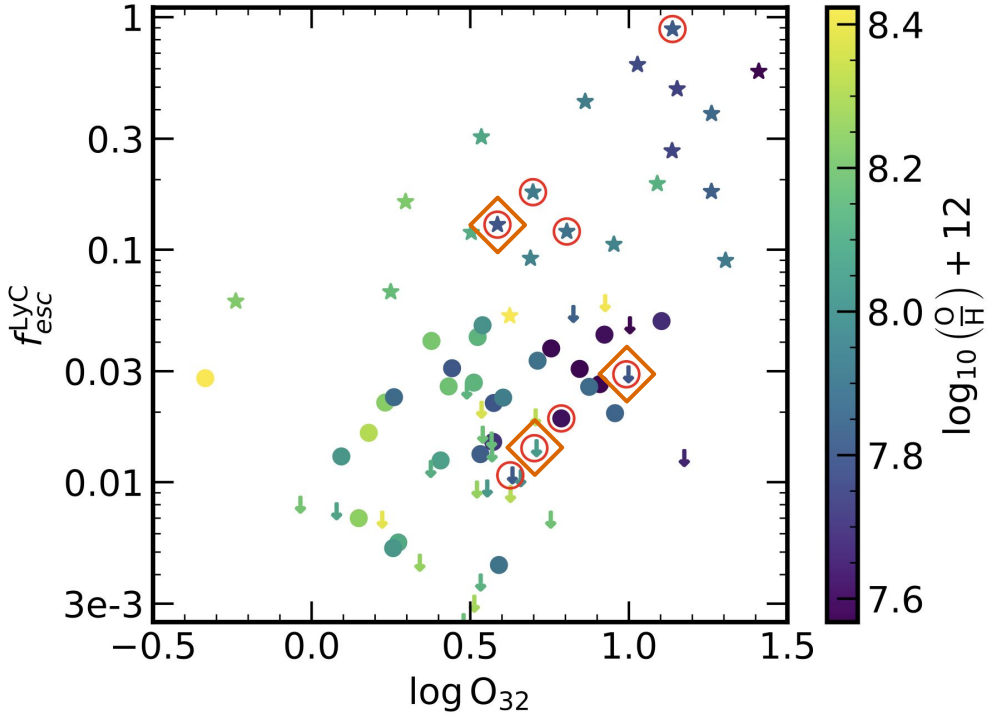
dust

- census of effects of ionization on PDRs and small dust grains
- assess isotropy of LyC escape with global dust emission



Madden+ 2006

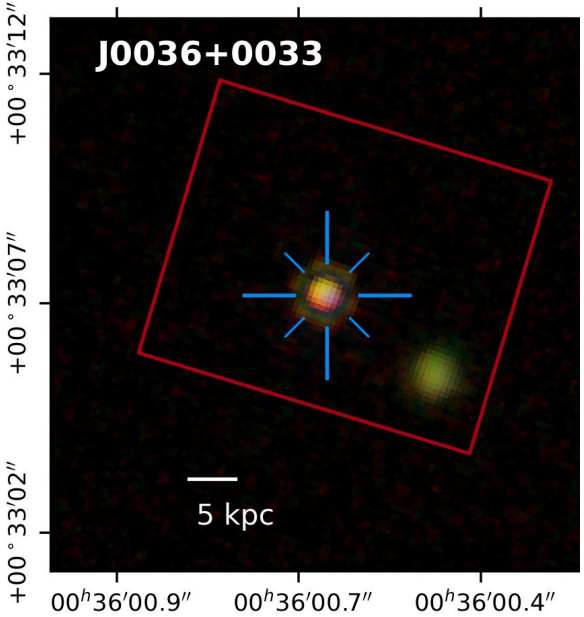
MIRI Observations



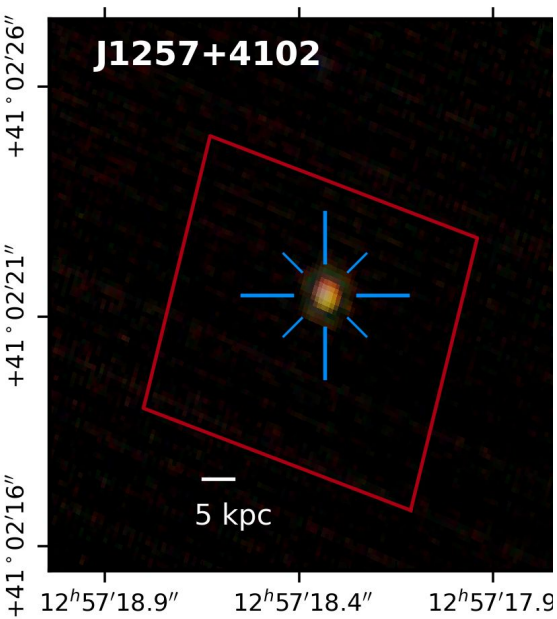
- 4 LCEs spanning wide range in metallicity, ionization, UV β
- 4 non-LCEs matched to control
- 2 non-LCEs, 1 LCE observed+processed so far
- will answer questions about dust and ionizing feedback

Galaxies Observed So Far

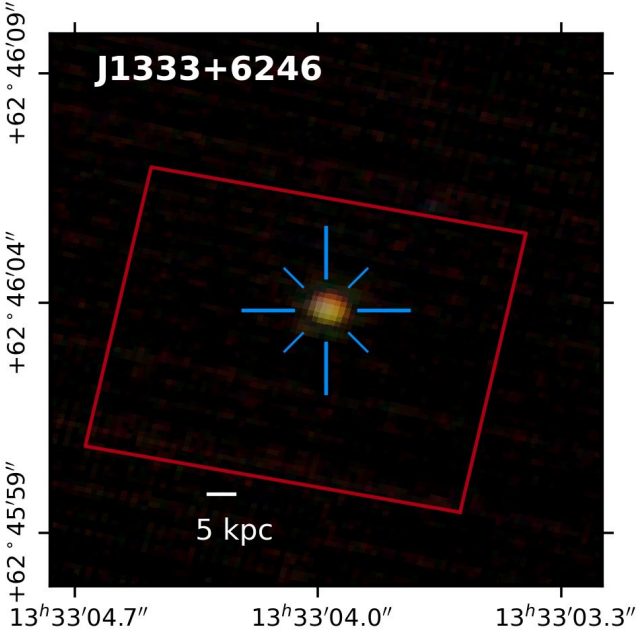
$f_{esc} < 1.5\%$



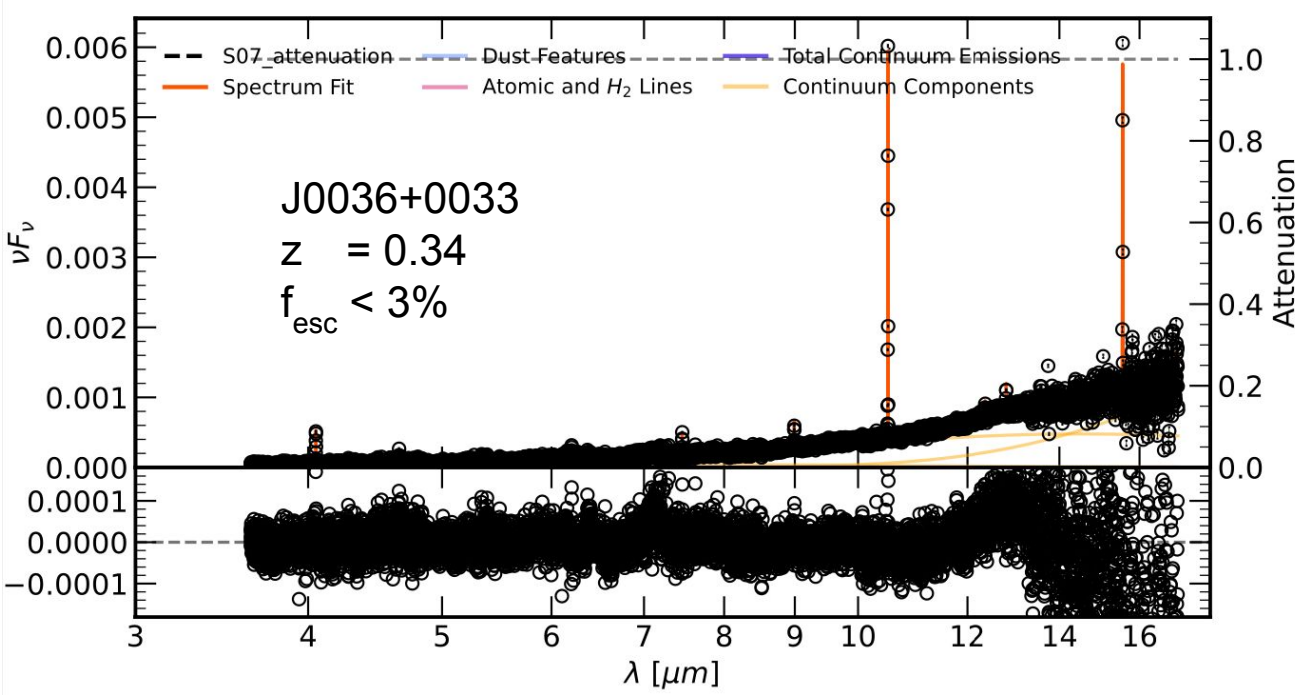
$f_{esc} < 3\%$



$f_{esc} = 13\%$

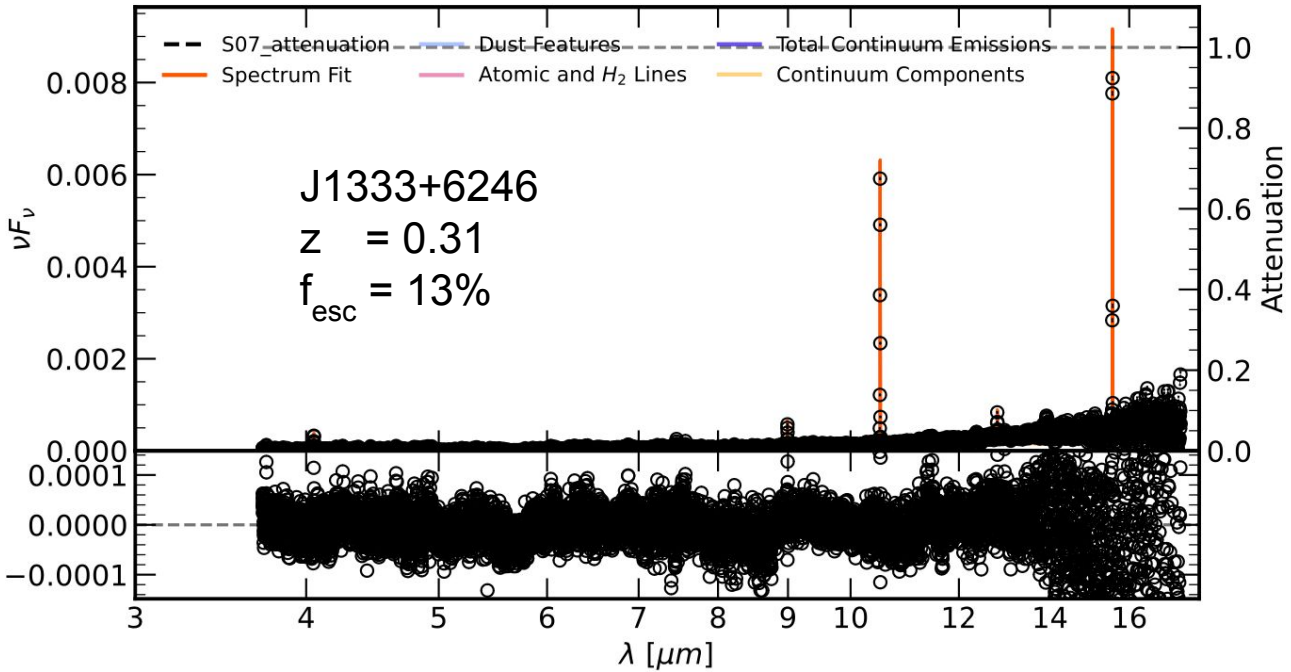


Example PAHFit — non-LCE



- no PAH features
- bright forbidden high ionization lines
- many H I lines
- prevalent hot small dust grains in emission
- little to no extinction

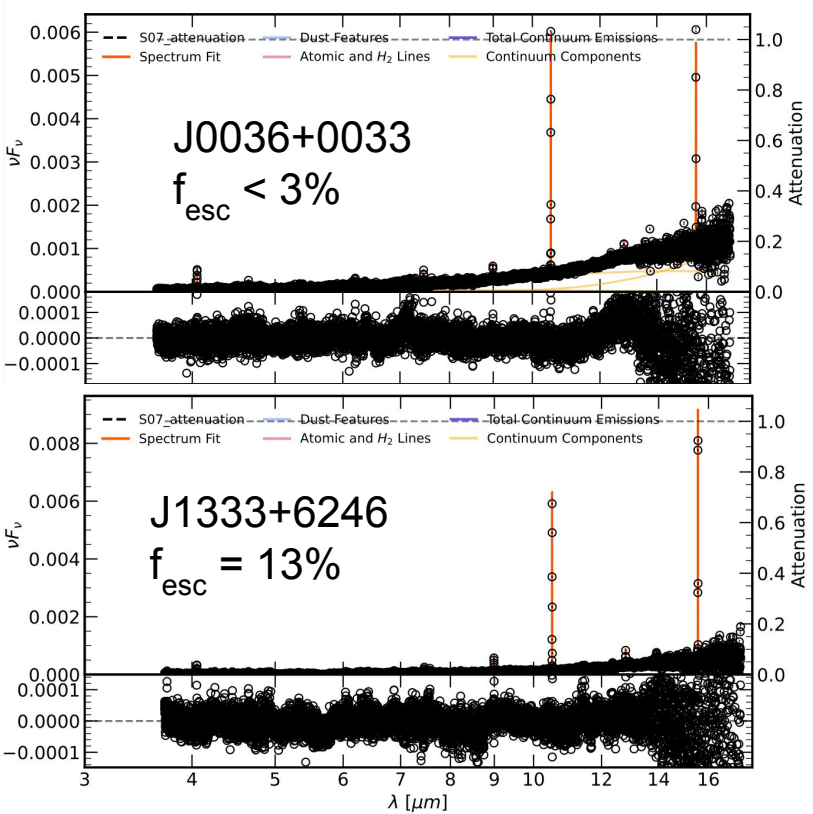
Example PAHFit — LCE



- no PAH features
- bright forbidden high ionization lines
- many H I lines
- *absent* hot small dust grains in emission!!
- little to no extinction
- decrease in H I flux
- brighter [Ne III]

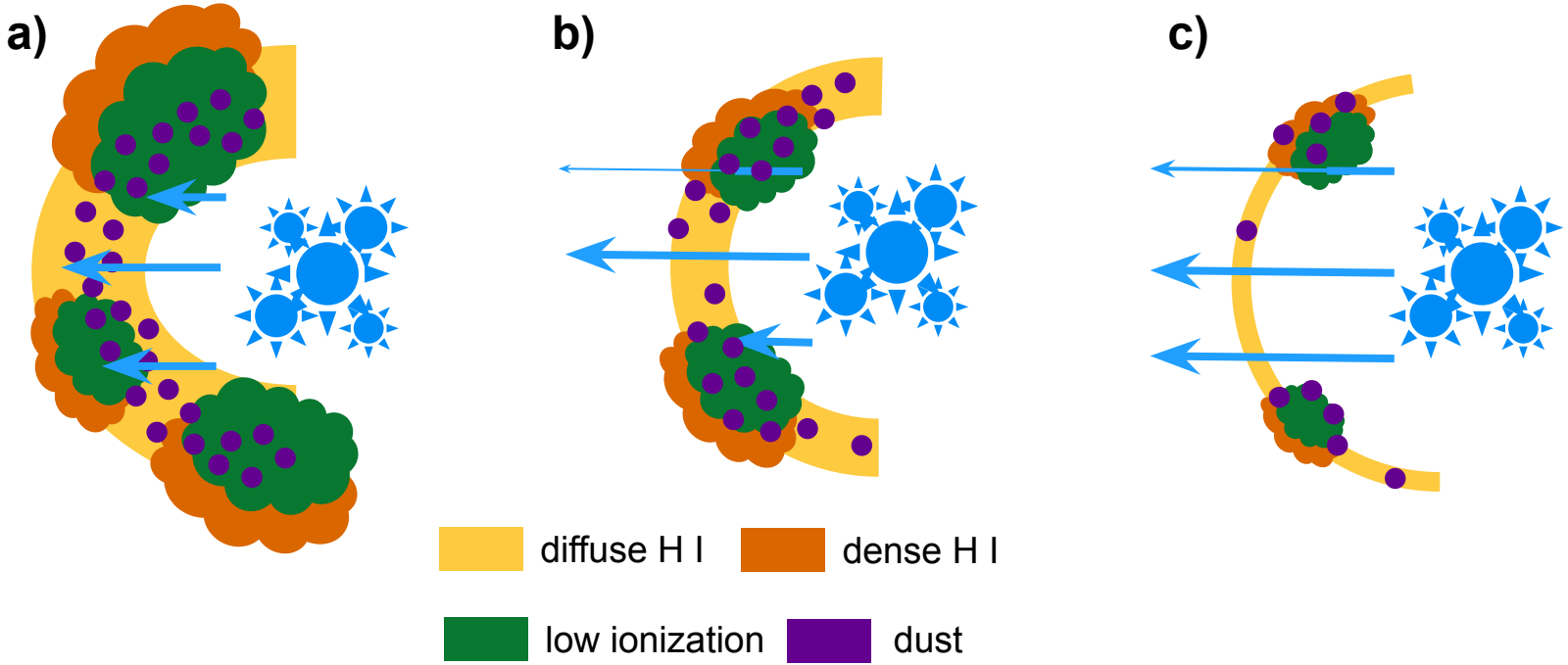
Preliminary Fit Interpretation

- less H I emission LCE
  — less Q or less global H I?
- less dust emission in LCE
  — fewer small grains, but why?
  photodissociation?
  outflows? (Andrea Ferrera's talk)
- brighter [Ne III]
  — harder stellar SED or
  SNe-driven shocks?

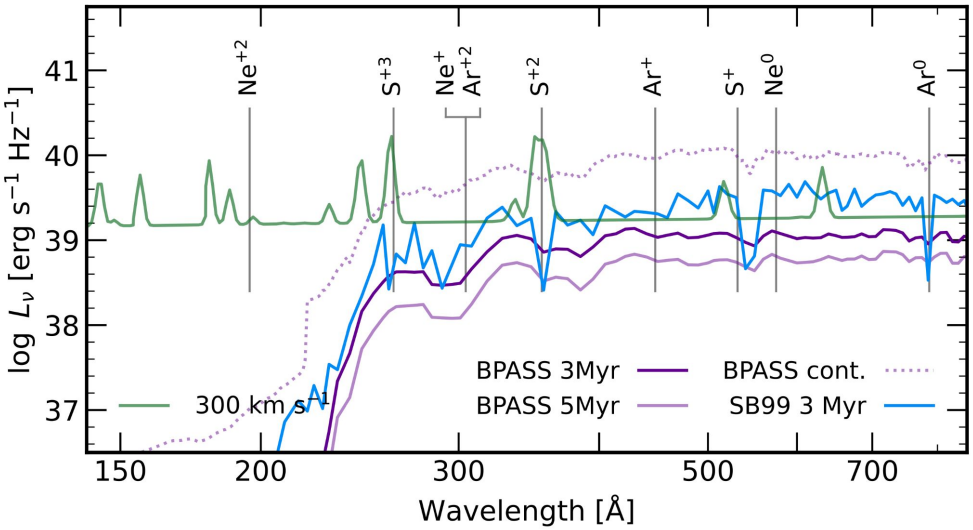


Flury+ 2025 in prep

Revisiting the LyC Escape Model



Constraints from MIR Nebular Lines

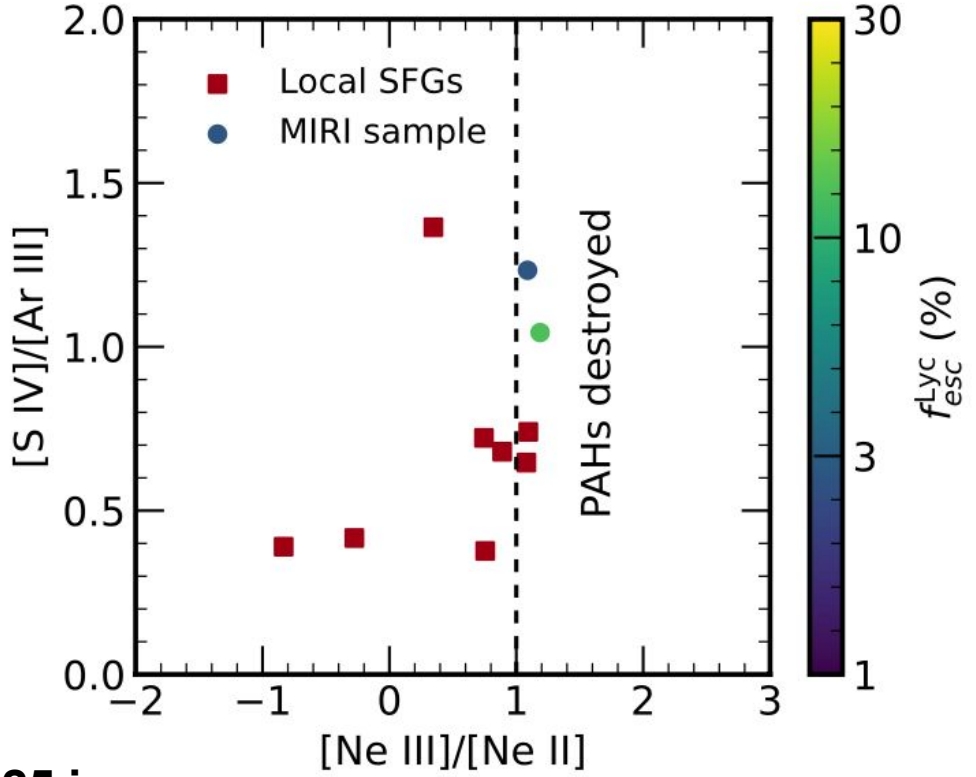


Flury+ 2025
in prep

- Ne, S, and Ar evolve similarly with metallicity
  — rule out effects of abundances
- dust extinction is invariant with wavelength
- shape of the ionizing SED in LCEs
  — stellar populations
  — nature of ionizing feedback
- evidence for dense gas? (see talk by Karla Arellano)

Preliminary Results — Nebular Lines

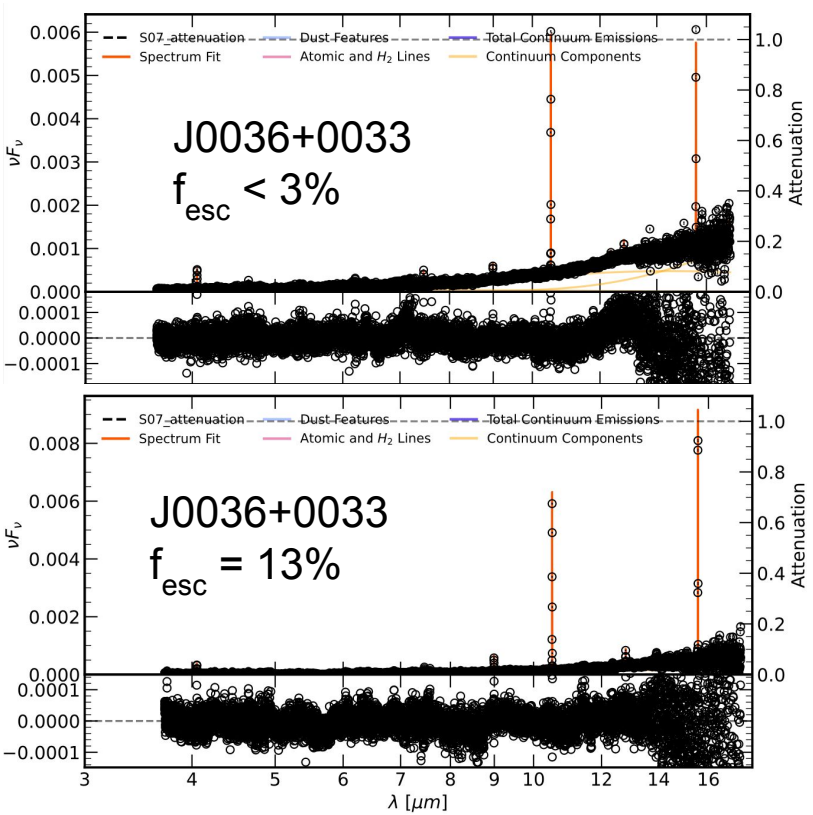
- similar to local low-metallicity galaxies
- all sources live in the regime for PAH destruction by the LyC
- major difference between LCE and two control targets: global dust emission



Flury+ 2025 in prep

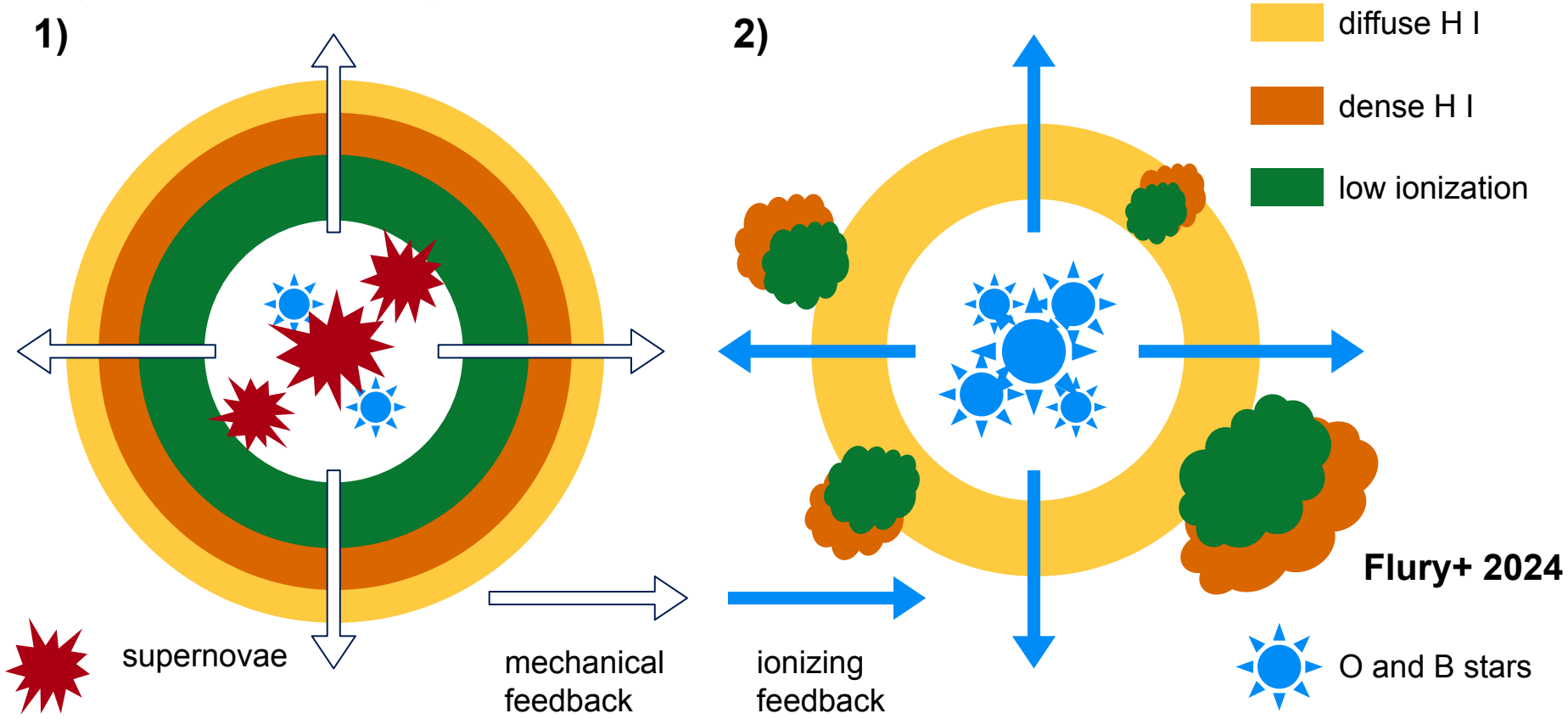
Summary

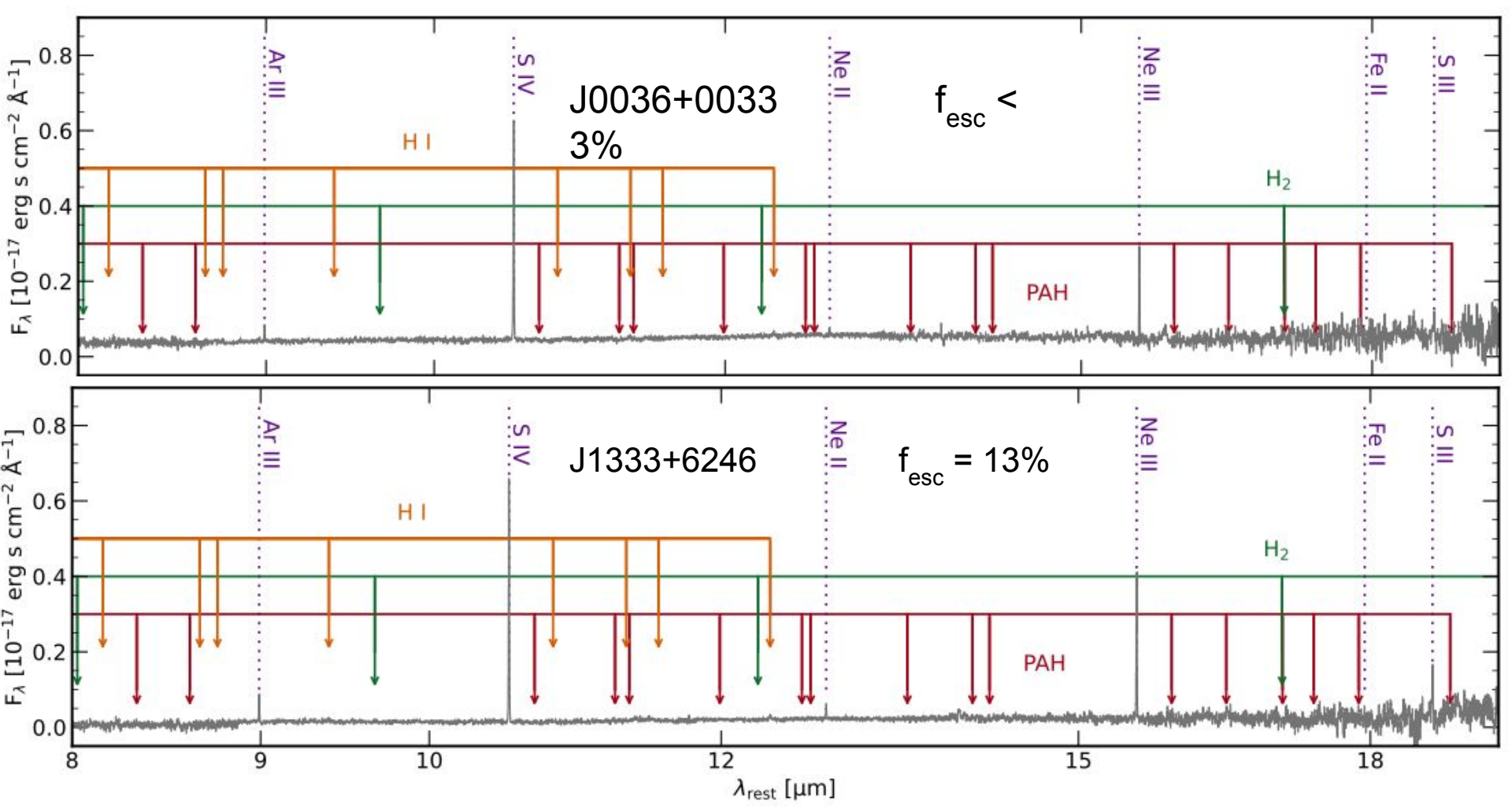
- dust content and ionizing feedback appear key to LyC escape — see upcoming review **Jaskot 2025 ARA&A**
- MIRI will probe both using nebular lines, PAH limits, and emission from hot dust
- (preliminary) — primary difference in LCEs is isotropic destruction of dust grains by ionizing photons



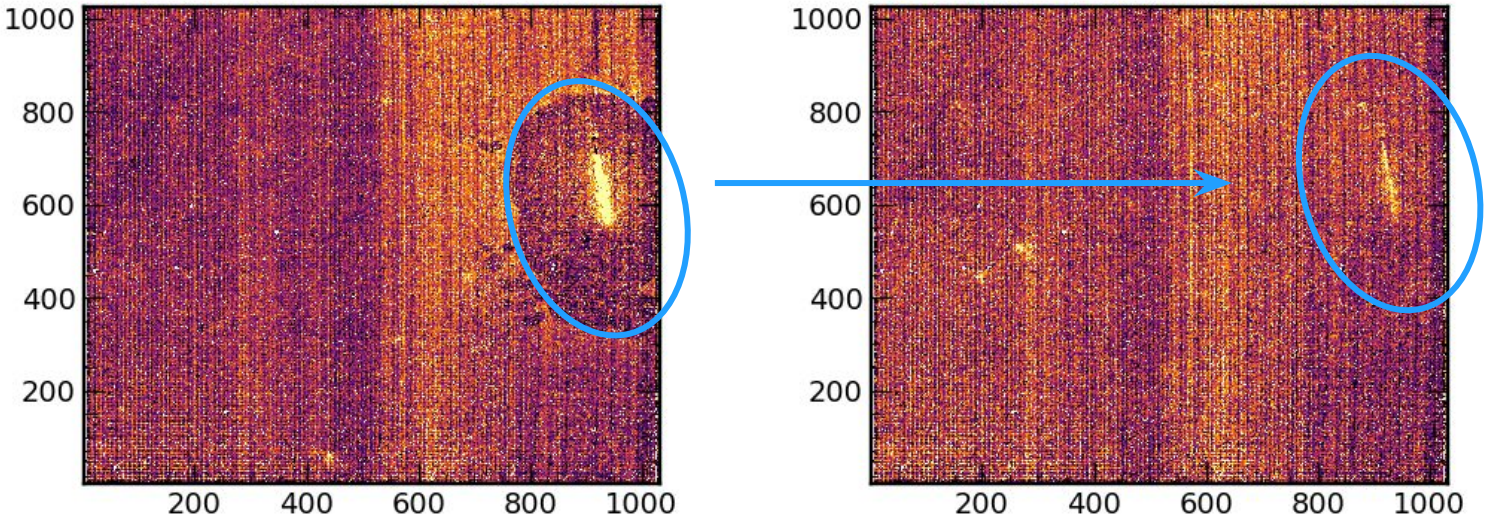
Flury+ 2025 in prep

LyC Escape Toy Model



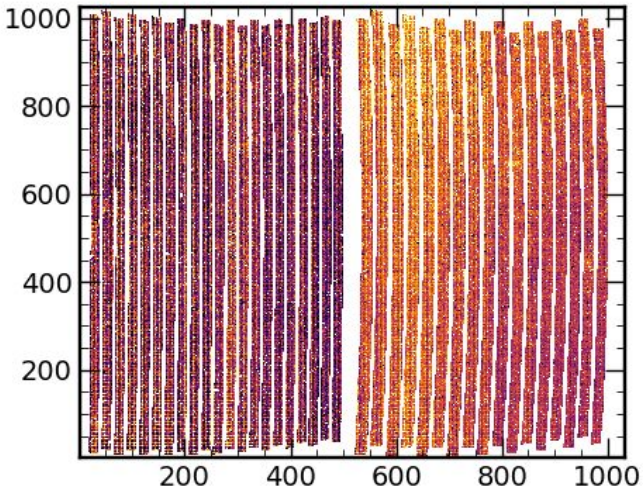

J0036+0033
f_{esc} < 3%
J1333+6246
f_{esc} = 13%
Ar III
S IV
Ne II
Ne III
Fe II
S III
H I
H_2
PAH
F_λ [10^{-17} erg s cm^{-2} Å^{-1}]
λ_{rest} [μm]

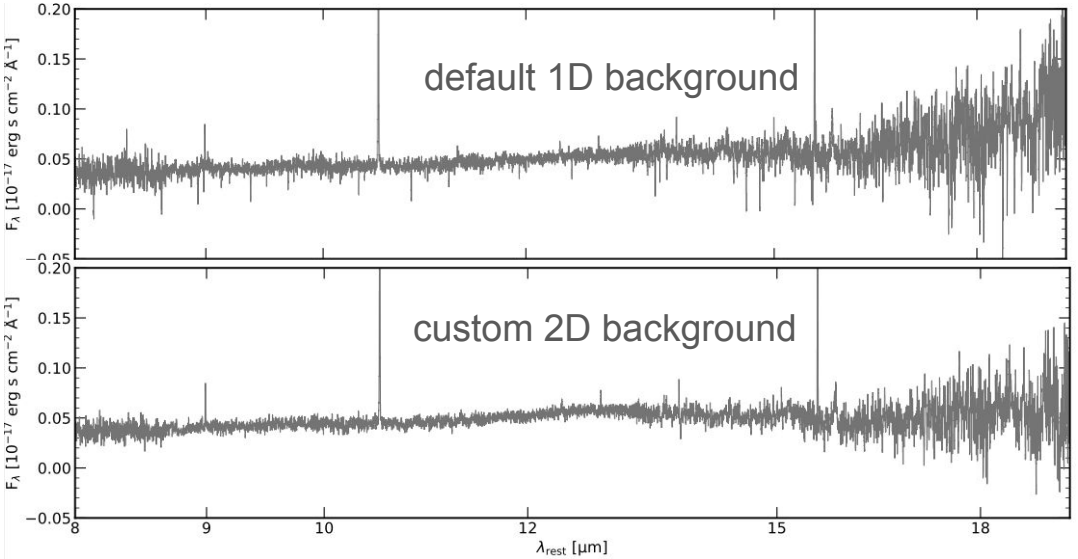
Cosmic Ray Flagging



cosmic rays can persist over multiple exposures (here, ghosting two exposures after the initial event) — missed by pipeline!!

Custom Backgrounds





pipeline uses collapsed 1D background, losing key spatial background information