COSMIC DAWN

Radiation-Driven Superwinds and LyC Escape in Local Reionization-Era Analogs

UNIVERSITY OF MICHIGAN

Lena Komarova

University of Michigan

Sally Oey
Ricardo Amorín
Rui Marques Coelho Chaves
Svea Hernandez
Angela Adamo
Mattia Sirressi
Sophia Flury
Alberto Saldana-Lopez
Matthew Hayes
Anne Jaskot
et al.

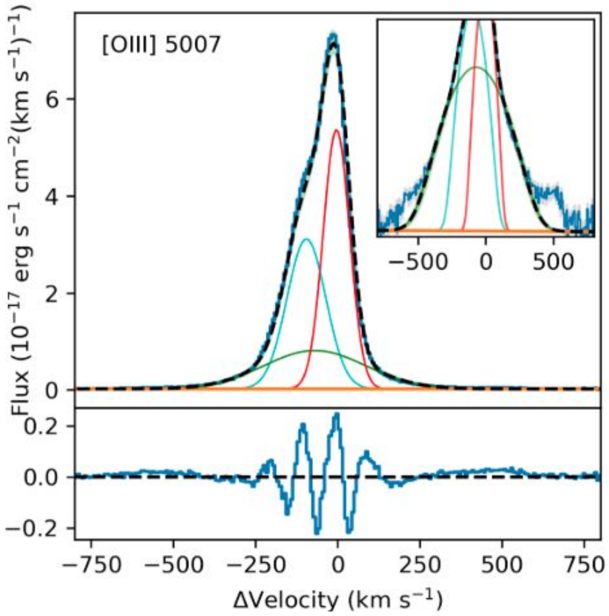
and LzLCS Team

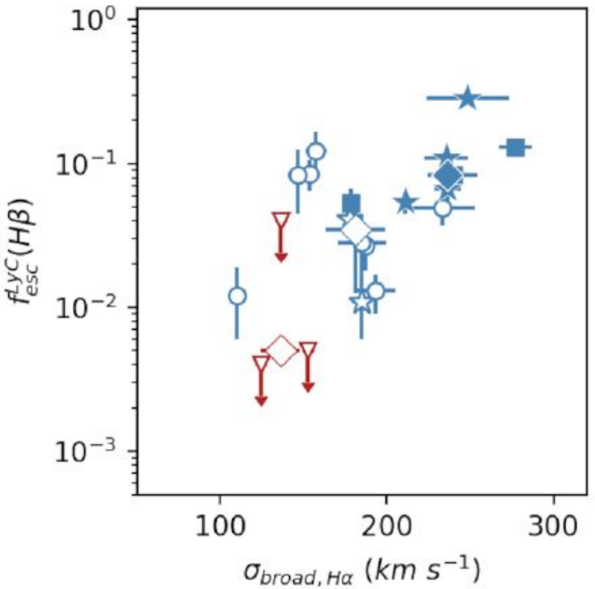
komarova@umich.edu

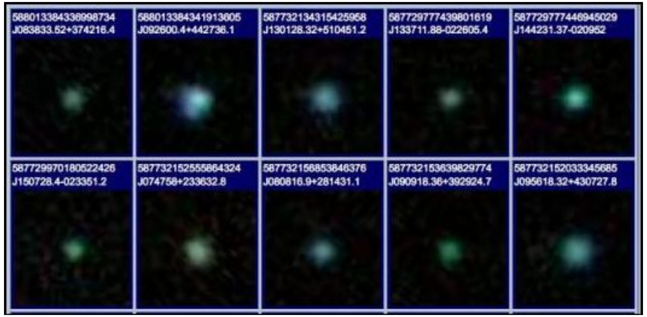
Outflows in Green Peas - largest class of local LCEs

200-1000 km/s broad emission in [O III], Balmer lines

→ **Amorín+2024: speed correlates with $f_{esc,LyC}$**







SDSS

Origin of the fast outflows and wing morphology?

LyC Escape Mechanisms

Supernovae

(Ma+2015, Zastrow+2013, Heckman+2011)

– Energy-driven, create cavities in ISM

→ But at low metallicity *Z*, SN onset is delayed

(Jecmen & Oey 2023, Sukhbold+2016)

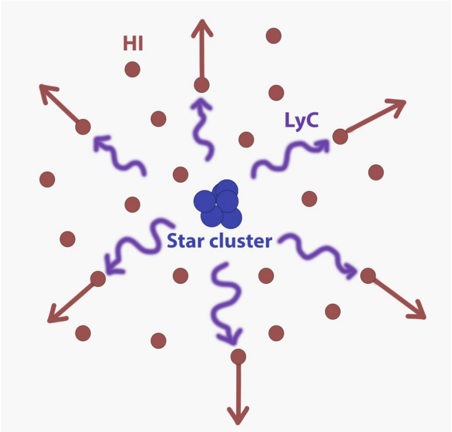
> 10 Myr

Radiation-driven superwinds

(Komarova+2021, Krumholz+2017, Thompson+2015)

– Tiny clumps with low filling factor driven by photon momentum: LyC escape

< 3 Myr, low Z, high log *U*

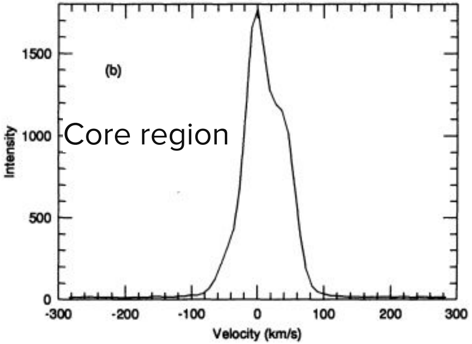


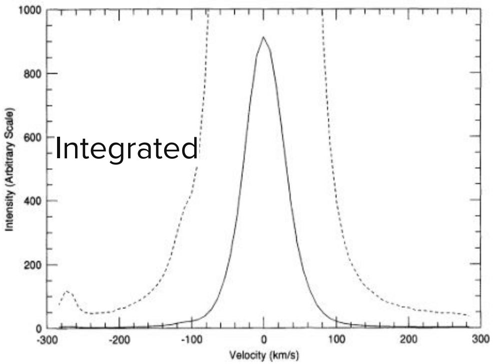
- Flury+2024, in prep; Carr+2024, in prep: combination of both results in highest f_{esc}

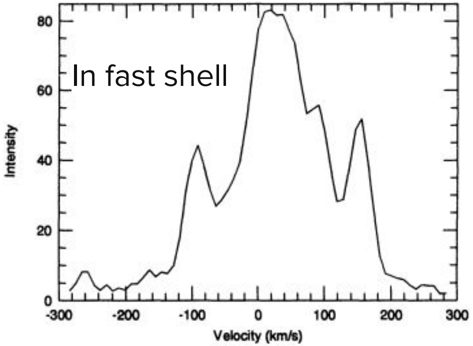
Broad Wing Morphology

SN-driven outflows - integral of complex structures is a gaussian profile

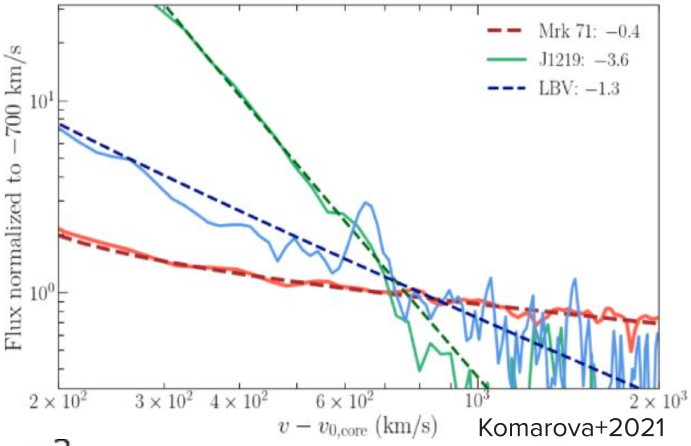
30 Doradus, Chu & Kennicutt 1994



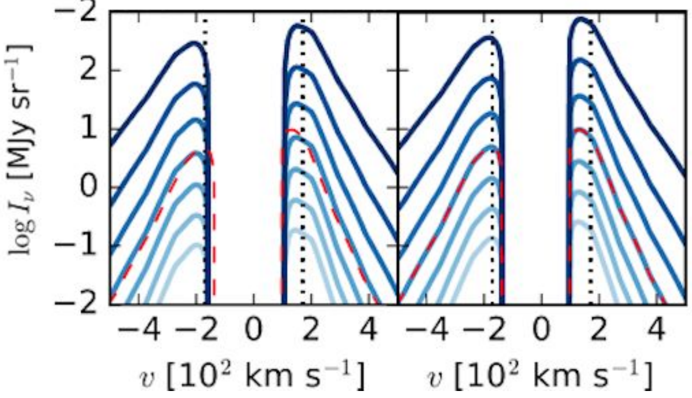




Radiation-driven outflows ➜ smooth, power-law or exponential wings



Komarova+2021



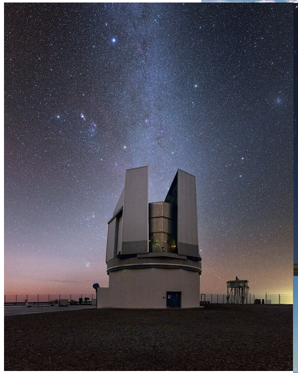
Krumholz+2017

Use broad wing morphology + galaxy properties to identify feedback mechanisms traced by broad wings

Sample

– 20 LCEs from Low-redshift Lyman Continuum Survey (LzLCS)

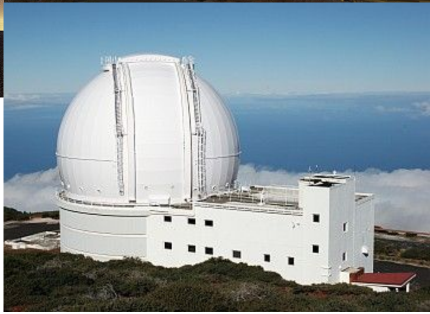
(Flury+2022a,b)



– 6 Izotov Green Pea LCEs (Izotov+2016a,b, 2018a,b)

Data

– MIKE/Magellan, Xshooter/VLT, ISIS/WHT optical spectra

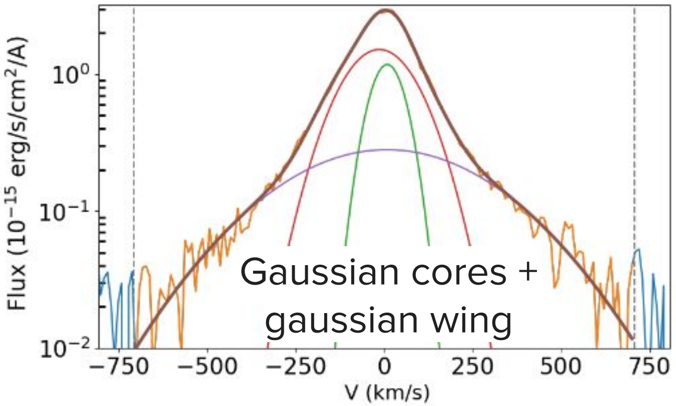


➔ [O III]5007, Hα broad wings: morphology, width, luminosity

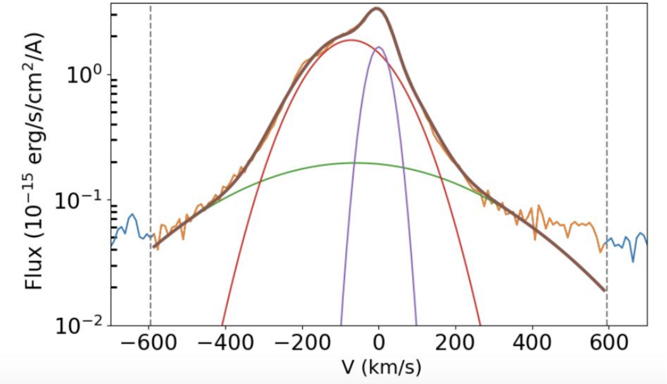
– LyC properties, stellar populations, line measurements from LzLCS (Flury+2022a,b)

Broad Wing Morphology Classification

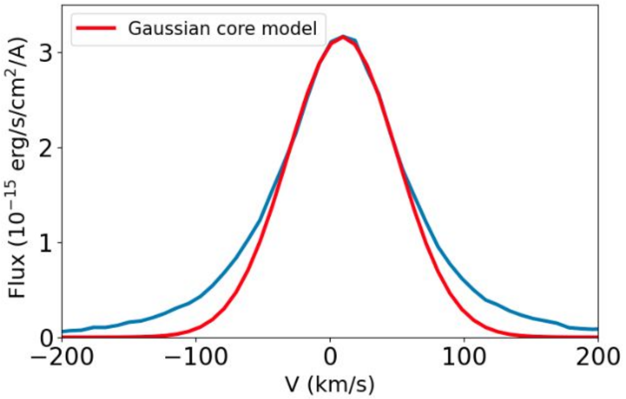
Gaussian



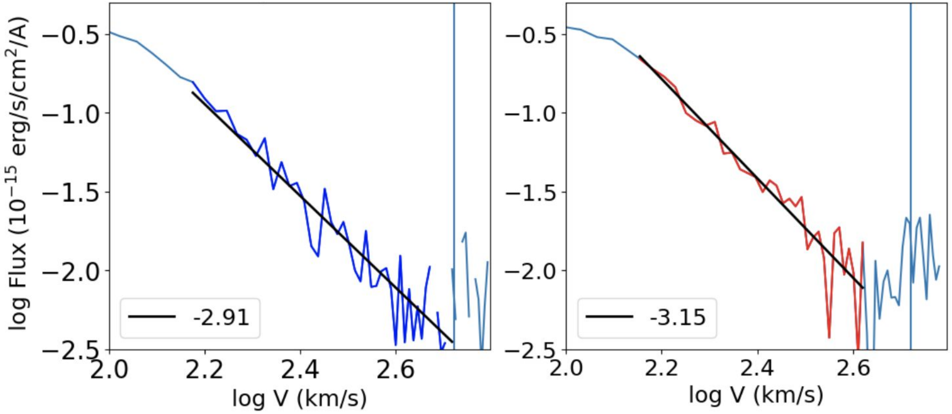
Ambiguous



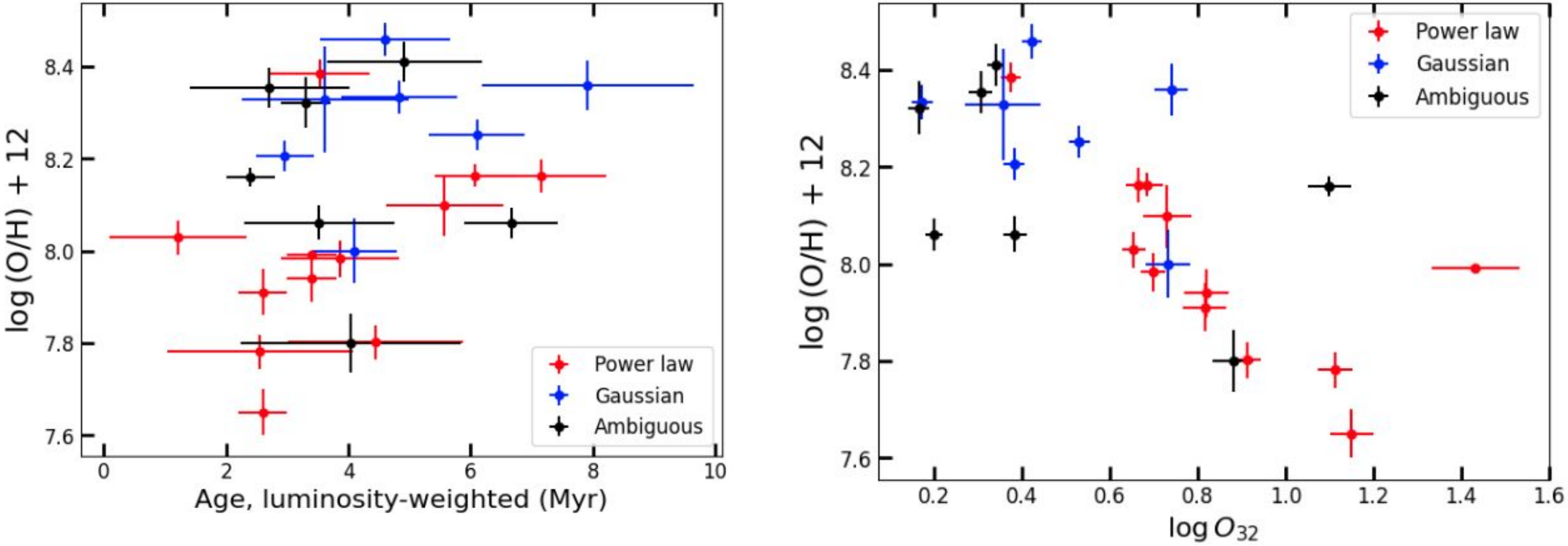
Power Law



Power law wing fit



Wing Morphology and Galaxy Properties: Preliminary



- Power-law wings in <u>young, low-metallicity, high-ionization</u> galaxies

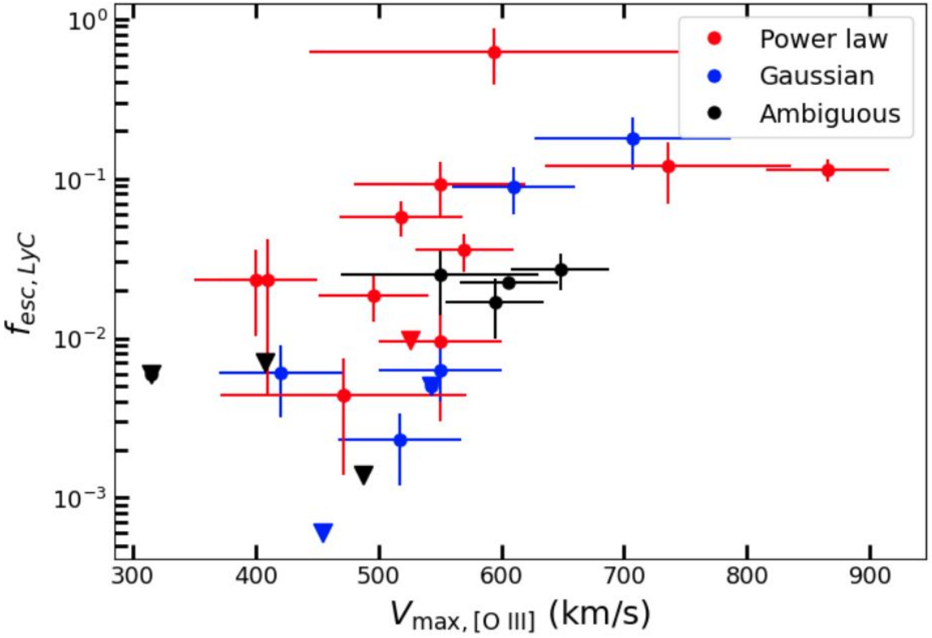
→ **Consistent with radiation-driven superwinds**

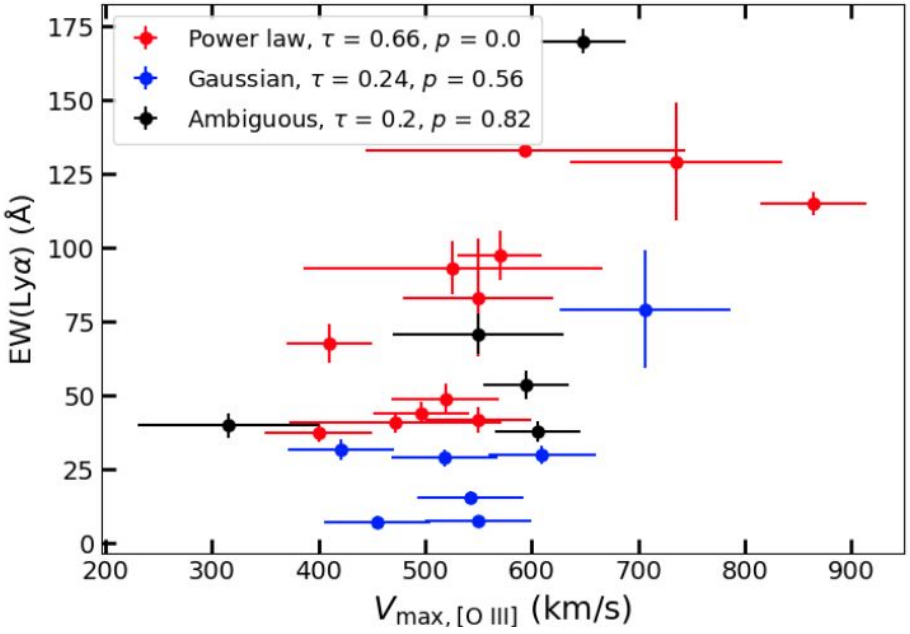
- Gaussian wings in older, higher-metallicity, lower-ionization galaxies

→ **Consistent with SN-driven superwinds**

Komarova+2024, in prep

Linking Kinematics to LyC and Lyα Properties



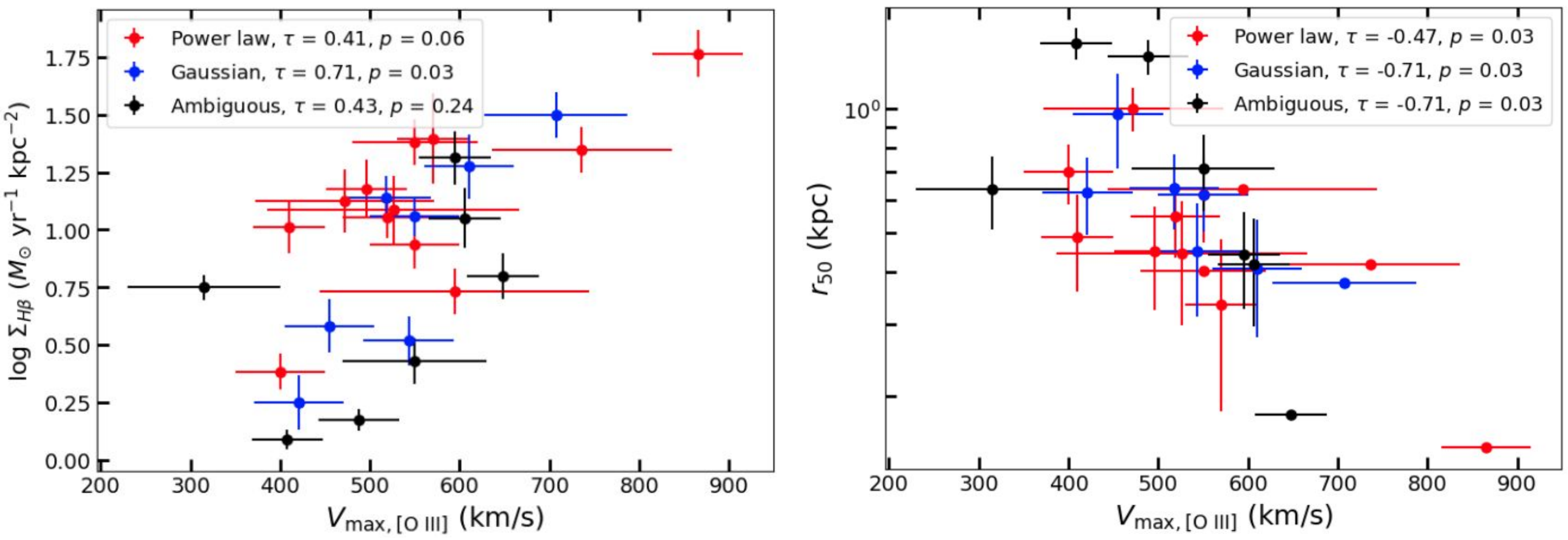


➔ Strongest LCEs show predominantly power-law wings

➔ Strongest Lyα emitters show broadest, power-law wings

Komarova+2024, in prep

Linking Kinematics to Galaxy Properties



➔ Faster winds in more compact, higher SFR density systems

- Regardless of feedback mechanism

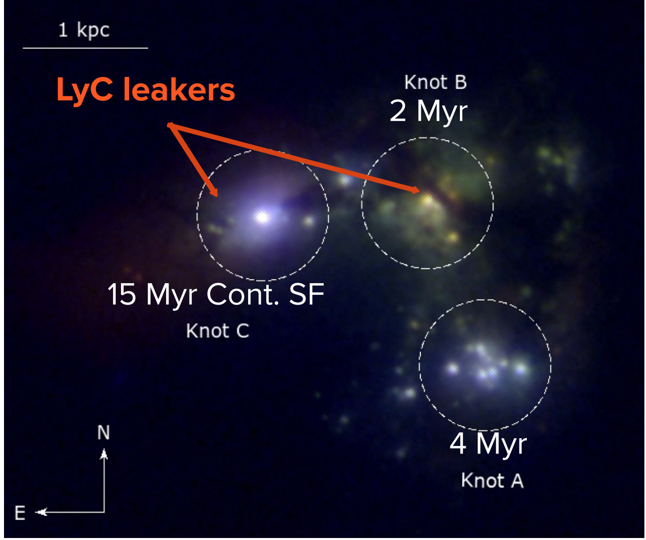
Haro 11: What's Hidden in Green Peas

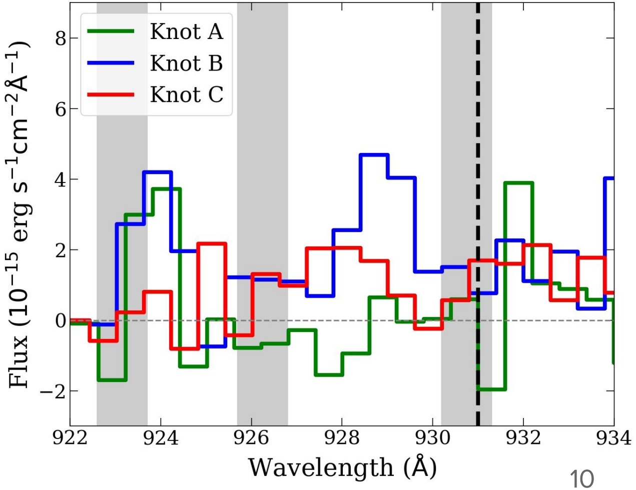
- **Closest (88 Mpc), first confirmed LCE**

(Bergvall+2006, Leitet+2011)

- Our new HST/COS spectra <u>show Knots B and C are LCEs</u>

  - **Knot B** dominates observed LyC **luminosity**, f_{esc} ~ 3%
  - **Knot C** has higher f_{esc} ~ 5%





Komarova et al. 2024 *ApJ* 967 117

Insights from Resolving Haro 11

→ **Leaked LyC luminosity is as important to EoR as f_{esc}**

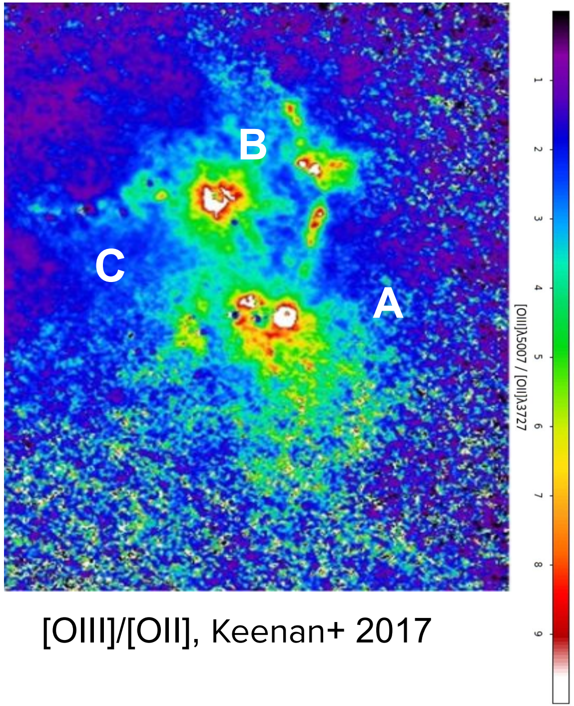
- Hinges on <u>ionizing photon production</u>

→ <u>Lyα escape fractions trace LyC escape</u> in individ. regions

→ **But not leaked Lyman luminosities**

- **Knot A** shows high ionization, low optical depth
  - Density-bounded conditions yet <u>no detection</u>

    → Highly anisotropic LyC escape



[OIII]/[OII], Keenan+ 2017

Komarova *et al* 2024 *ApJ* 967 117

Summary

- Use broad wing morphology + galaxy properties of local LCEs to constrain LyC escape mechanisms

- Power law profiles seen in young, low Z, high O_{32} galaxies

  ➜ **Link to radiation-driven superwinds**

- Gaussian profiles seen in older, higher-Z, lower-O_{32} galaxies

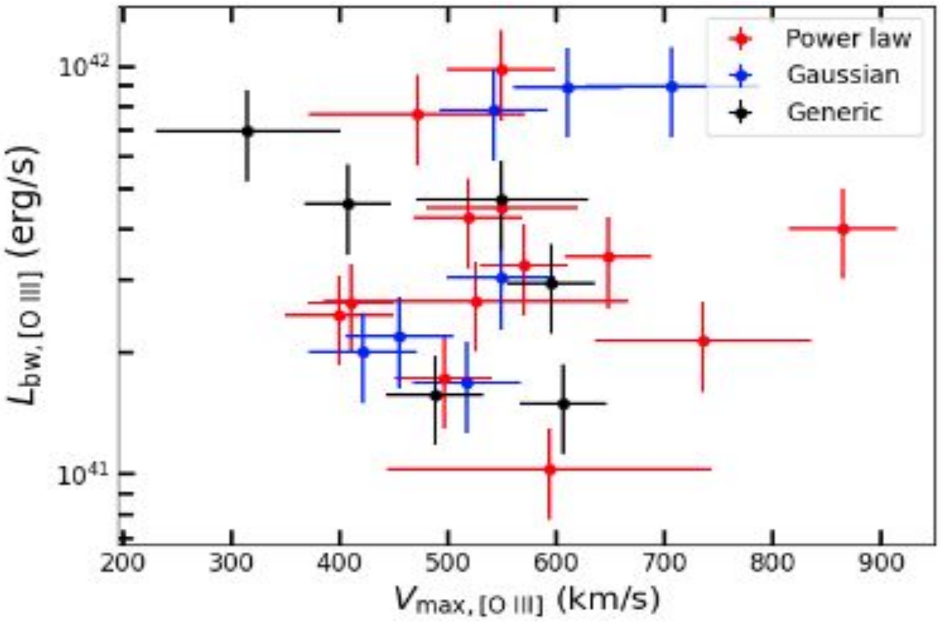
  ➜ **Link to SNe-driven superwinds**

- Haro 11 shows complexity and multiplicity of LyC escape mechanisms

  ➜ **Importance of intrinsic LyC luminosity, age and SFR, to leaked LyC**

Extra

Sample



- All morphologies show a range of wind speeds and luminosities
- No bias from wing SNR

J1154+2443
J0901+2119
J1442-0209
J0925+1403
J1011+1947
J1152+3400

J004743+015440
J003601+003307
J091113+183108
J011309+000223
J012217+052044
J081409+211459
J095838+202508
J091703+315221
J105331+523753
J144010+461937
J113304+651341
J115855+312559
J124835+123403
J131037+214817
J131419+104739
J134559+112848
J164607+313054
J123519+063556
J124423+021540
J012910+145935

Two Modes of LyC Escape

Flury+2024 in prep; Carr+2024 in prep

Flury+2022b