# EXPLORING STAR-FORMATION & INHOMOGENEITY IN PRISTINE ENVIRONMENTS: IFU STUDIES OF METAL-POOR DWARF GALAXIES

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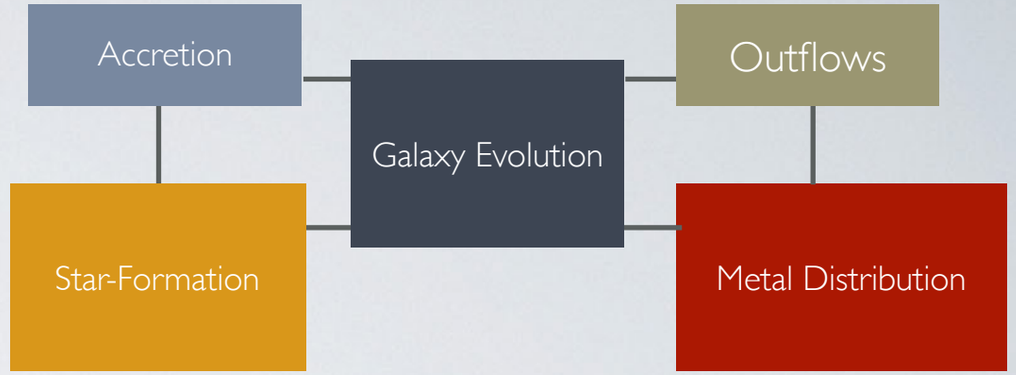
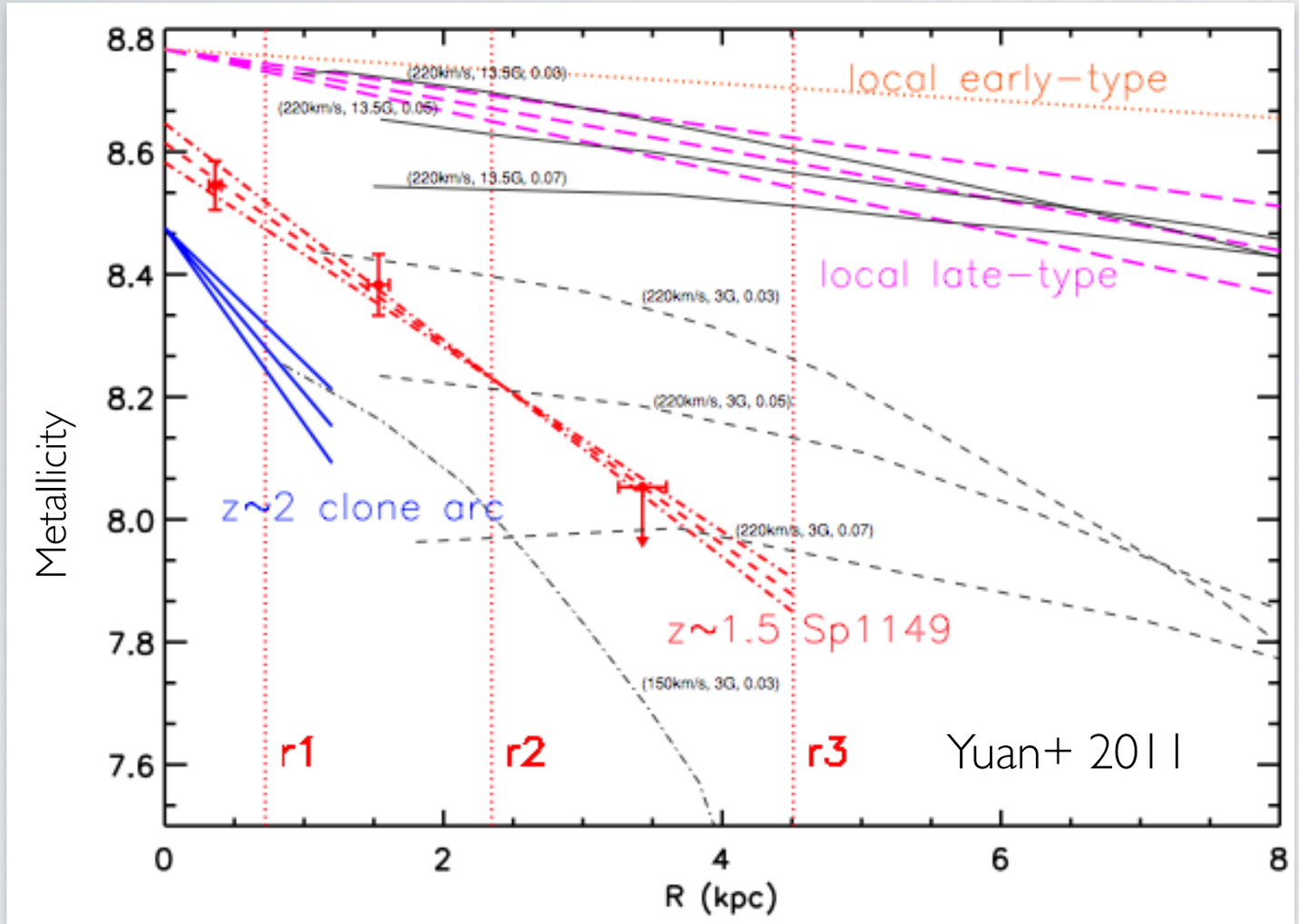
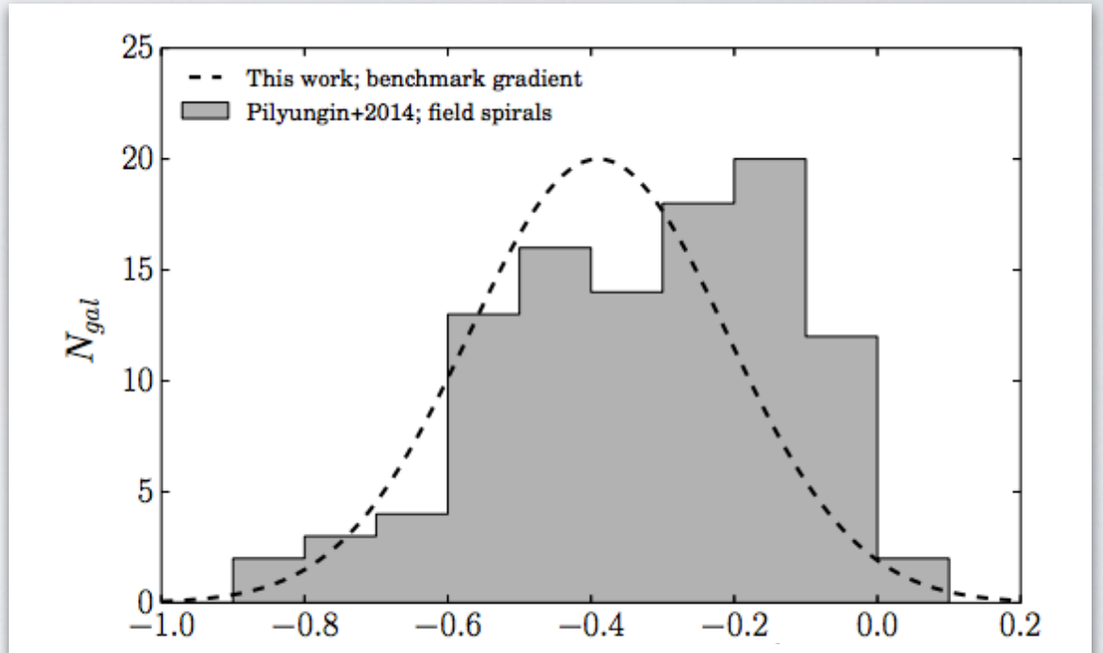
Small Galaxies, Cosmic Questions: Durham July 2019

# Are dwarf galaxies chemically homogeneous?




109 spirals, 49 SF galaxies (Ho+2014)



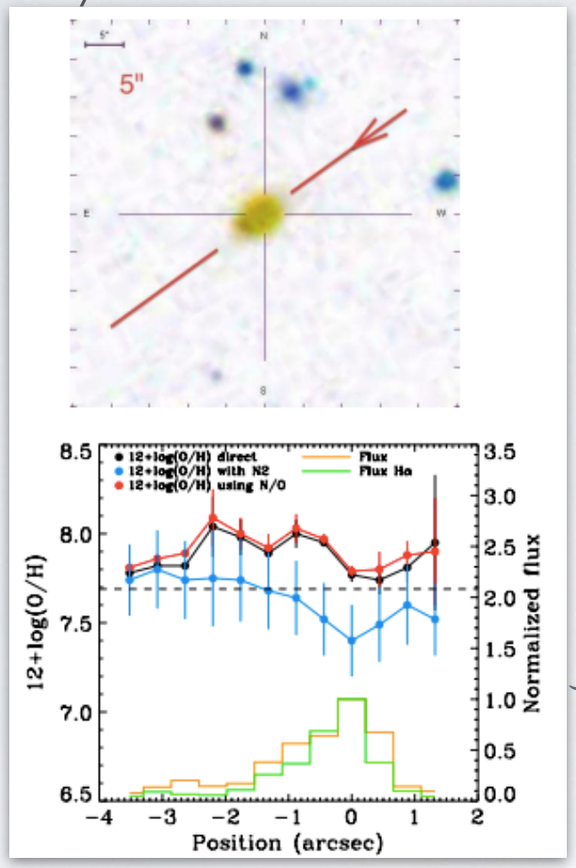

Metallicity gradient

**Negative gradients** → inside-out growth, flattening with time
**Positive gradients** → tidal mixing, interacting systems (low-z)
→ infall of pristine gas into center (high-z)
→ SNe blowout + fallback, metal mixings?, self pollution?

# LESSONS FROM CHEMICAL VARIATIONS IN DWARFS….

How is star-formation triggered?

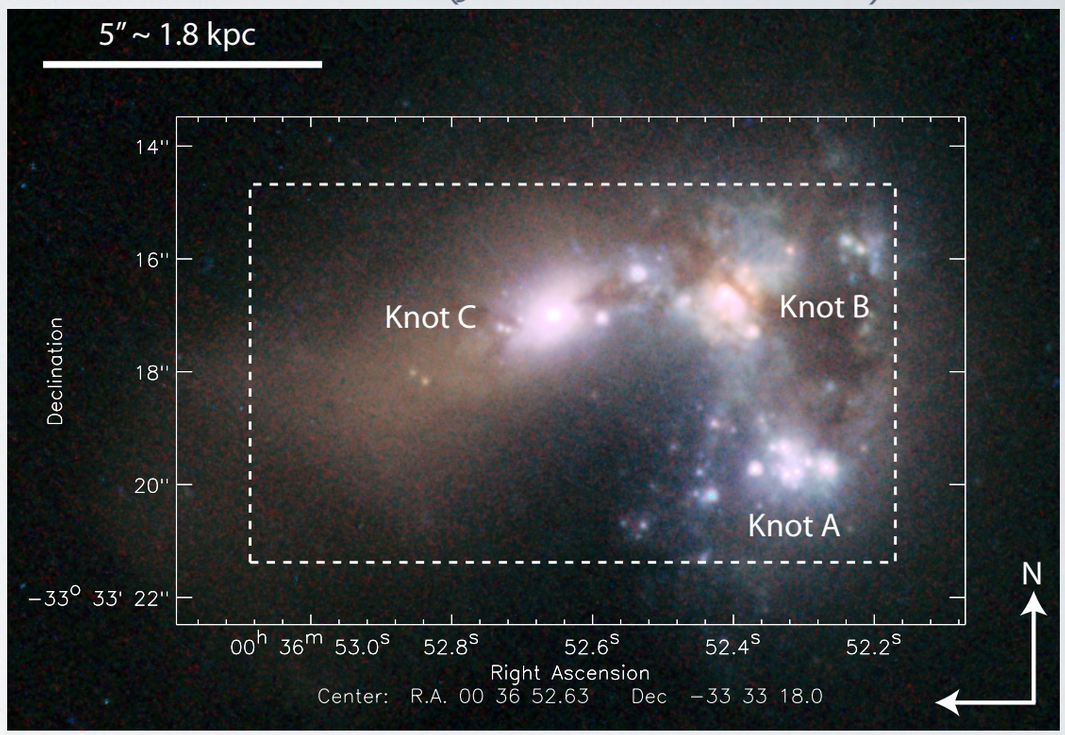
## Nearby Dwarf XMP Dwarfs

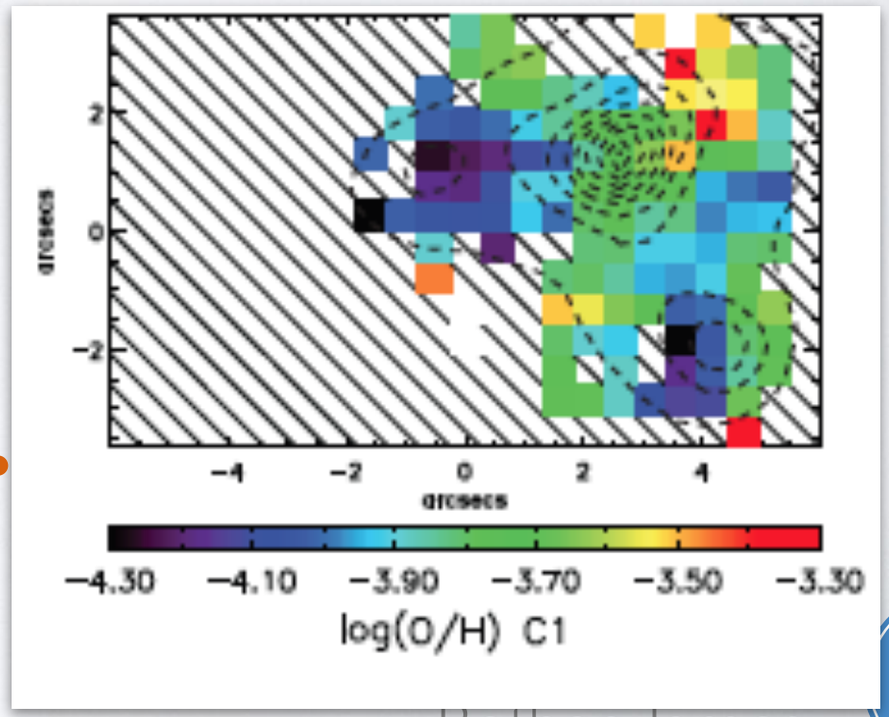



Sanchez-Almeida+, 2014

Accretion of pristine gas → star-formation

## Haro 11 (James+ 2013a)

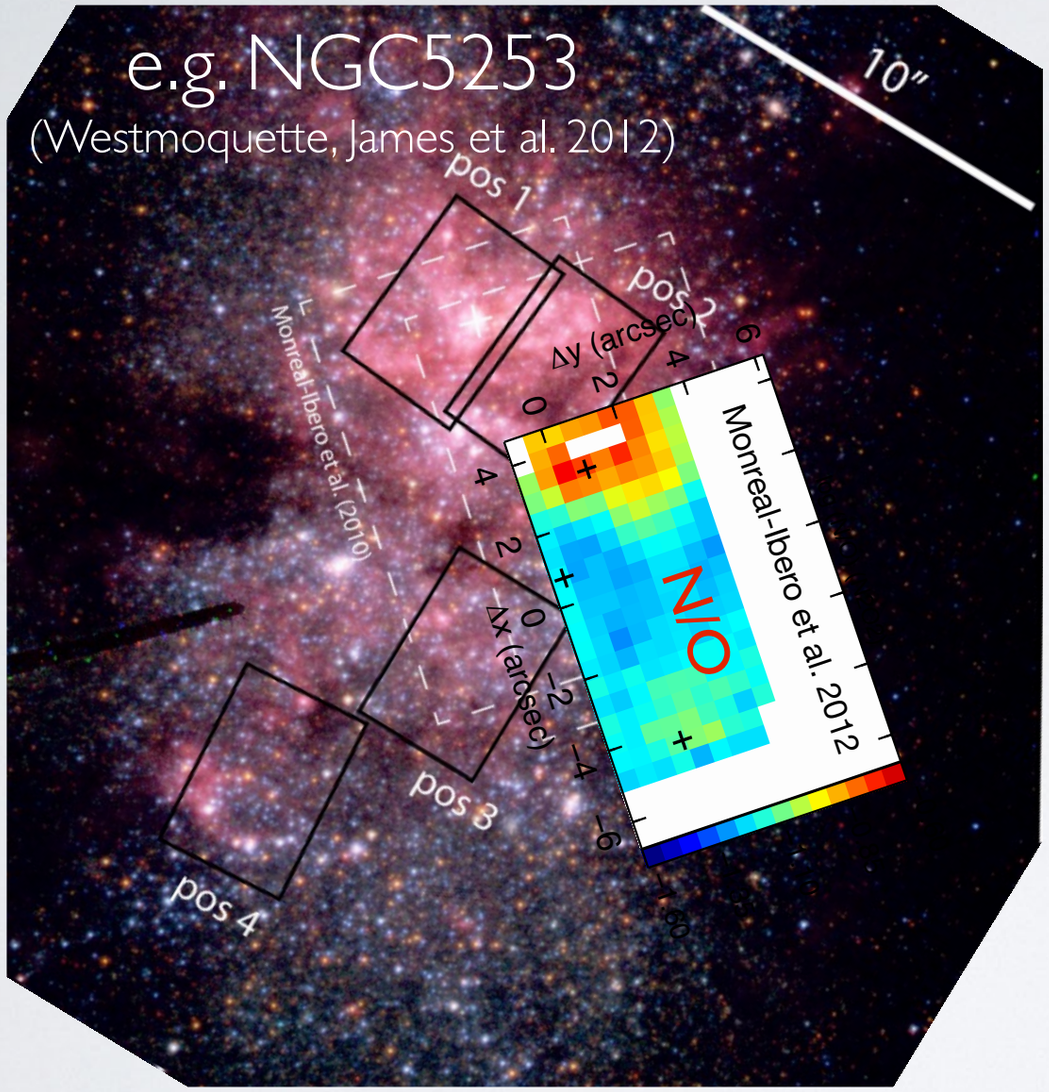


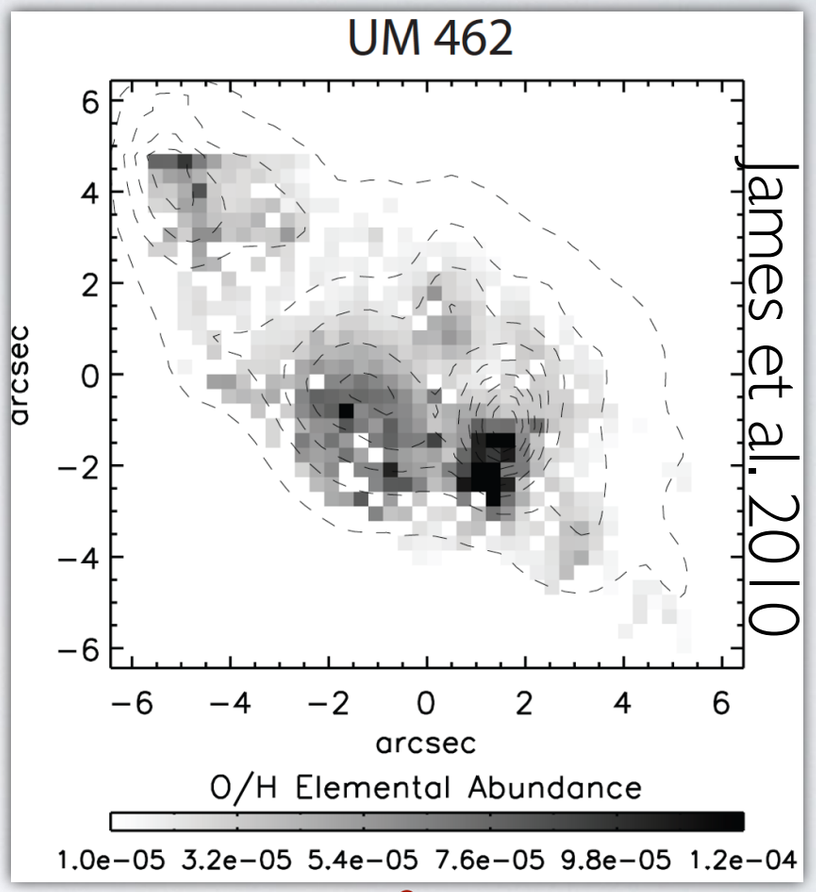
# LESSONS FROM CHEMICAL VARIATIONS IN DWARFS….

Star-formation ♻

metal mixing timescales



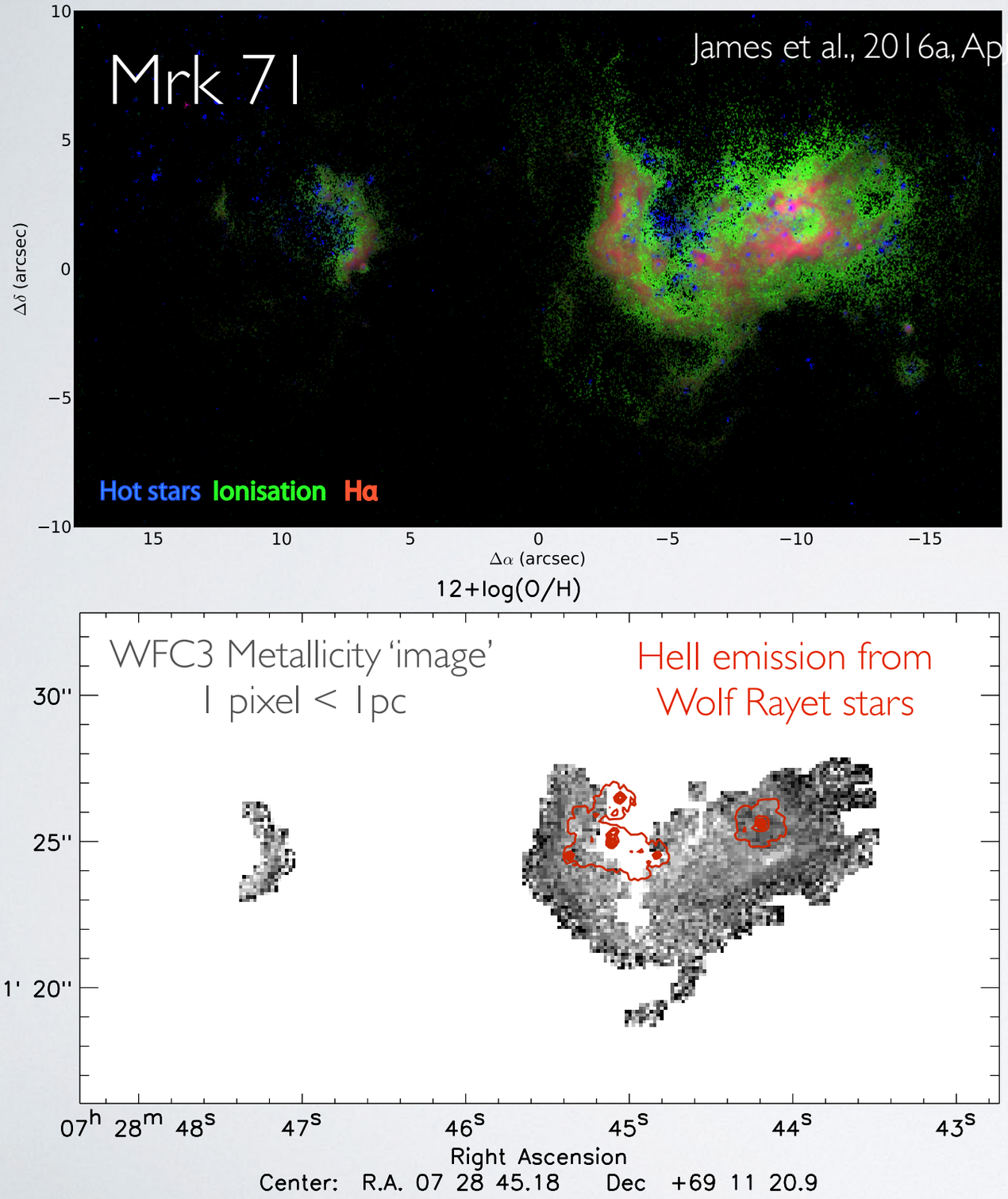

Self-pollution + young (WR) cluster

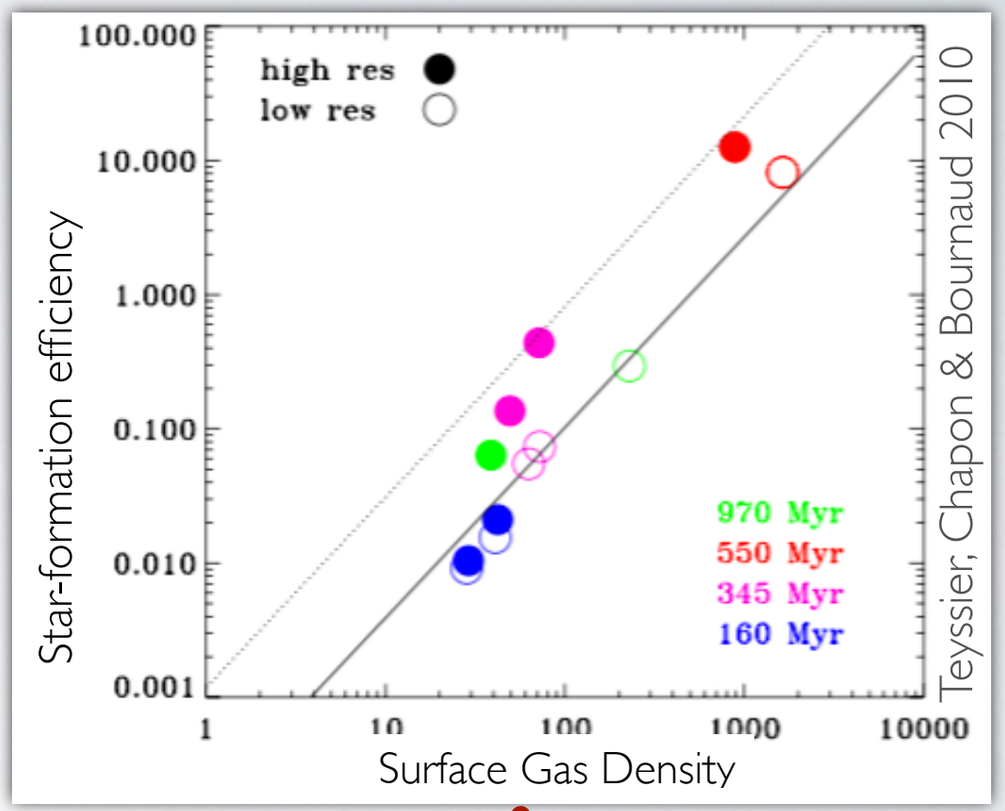



Metallicity gradient ≃ stellar age gradient

# LESSONS FROM SMALL SCALE CHEMICAL VARIATIONS IN DWARFS….

Star-formation efficiency

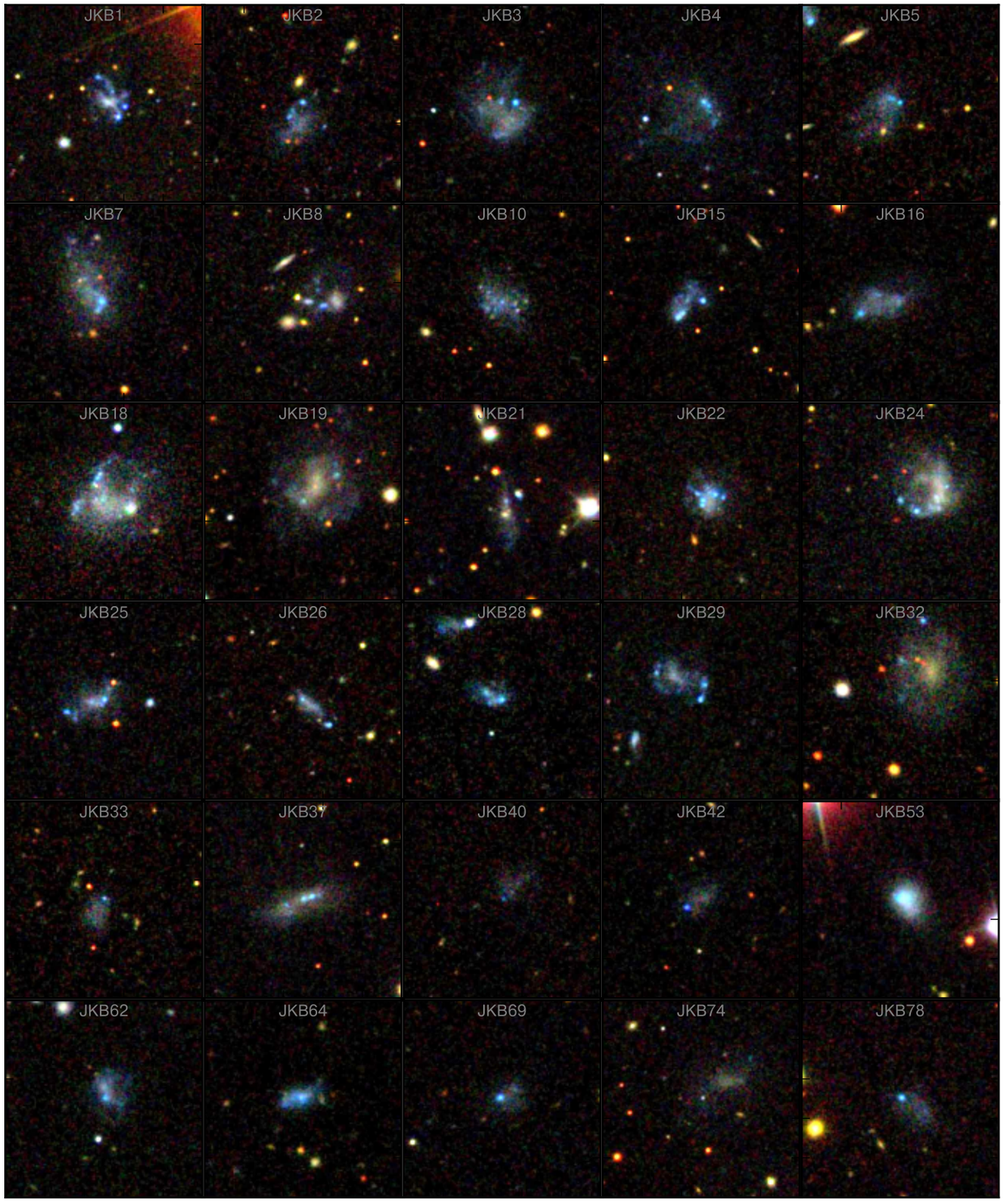



Chemical variations on <10pc scales
Thermal instabilities → gas fragmentation

# BLUE DIFFUSE DWARF GALAXIES

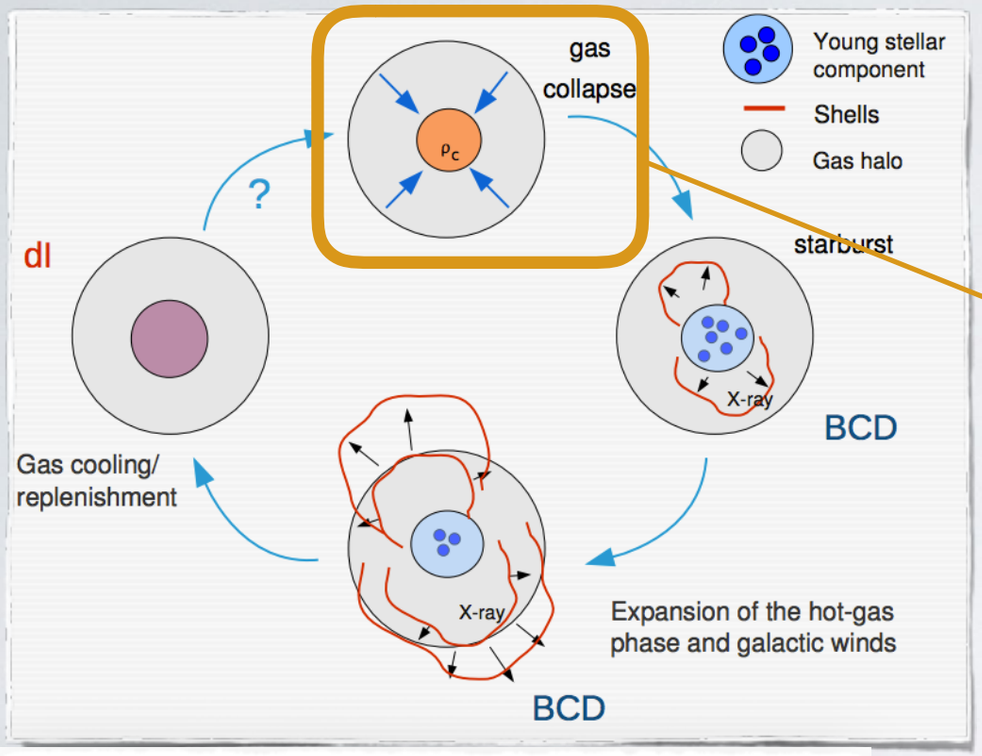
James, Koposov, Stark, Belokurov, McQuinn et al. 2015a, 2017



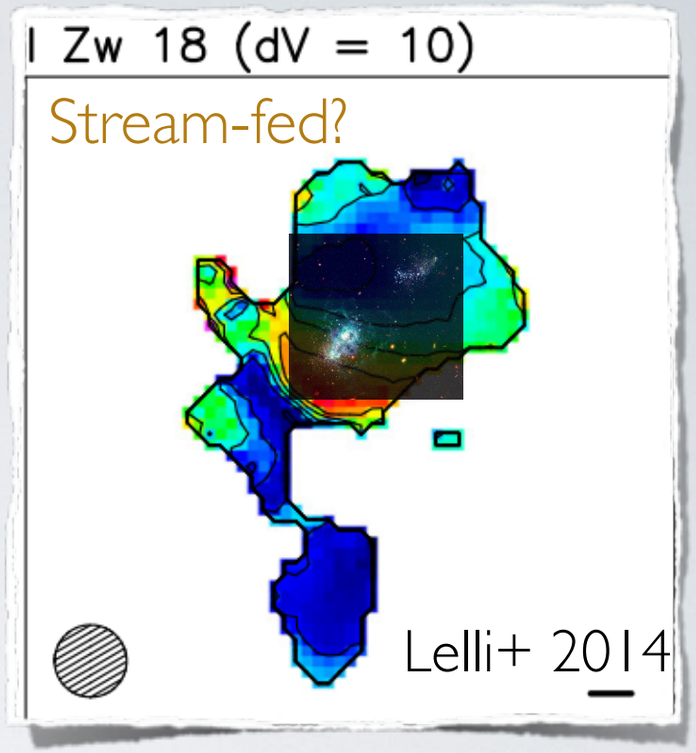

- SDSS-search based on Leo-P morphology
- ~120 previously unknown low surface brightness star-forming dwarf galaxies
- **25% are extremely metal poor (i.e. <0.1 Zsol)**
- Random regions of active SF in diffuse continuum → akin to high-z systems

- 50/120 observed with MMT
- 7/120 observed with McDonald
- 1/120 observed with VLT/MUSE…

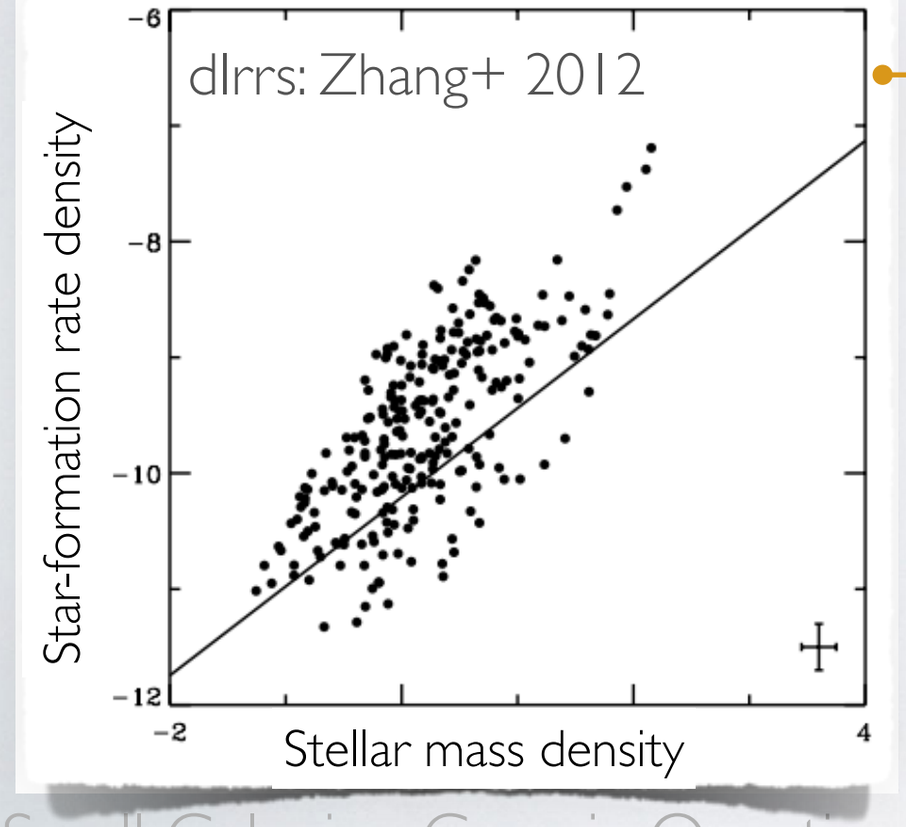
# HOW IS STAR FORMATION TRIGGERED IN BLUE DIFFUSE DWARFS?




Gas density too low for gravitational instability (dIrrs, Hunter+ 1998).




Triggered by external processes?



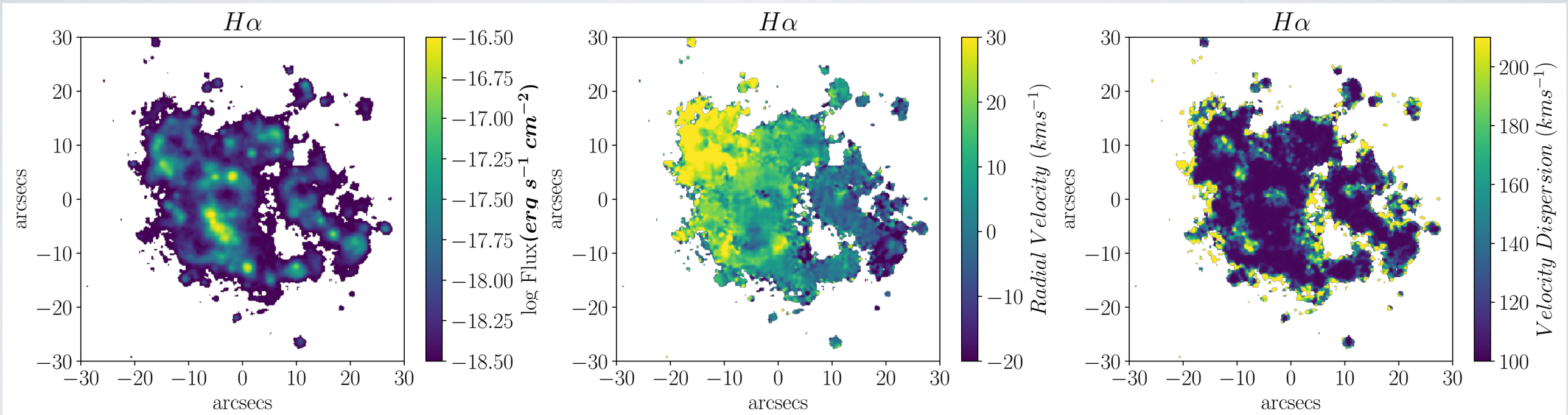

Internal factors?
e.g. turbulence, stellar feedback
(Elmegreen & Hunter 2006)

How stable is the gas? Is it turbulent?
Are there signs of accretion?
Is there an older stellar population?

# JKB18: MUSE OBSERVATIONS

James, Kumari + 2019a, in-prep

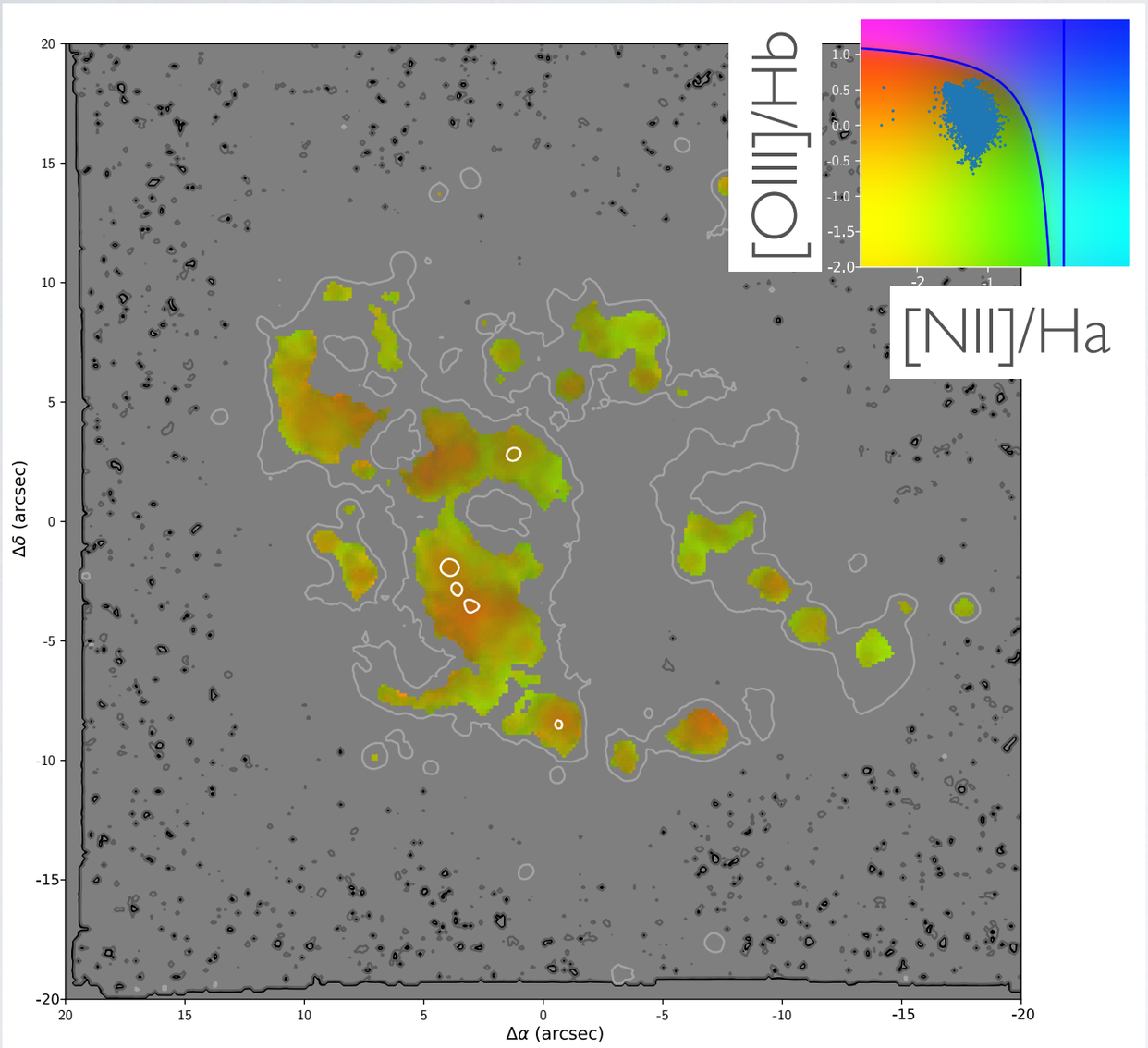
λ=4650-9300Å
300x300 spaxels
900,000 spectra
0.2" spaxels
~0.9" seeing

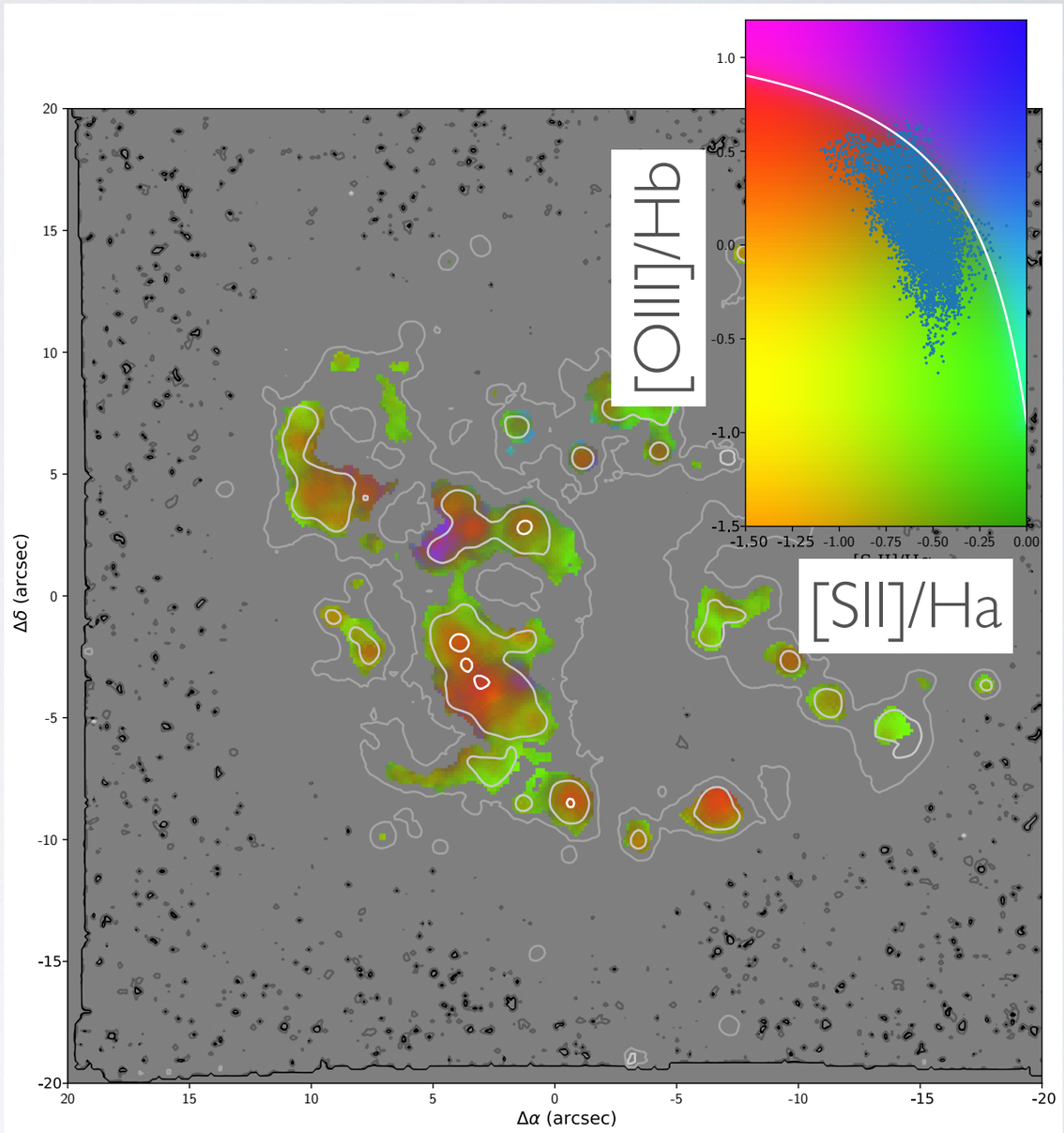



**1 spaxel~20pc**

Regions of star-formation in arm-like structures
Disturbed velocity field → past merger?
Uniform velocity dispersion → no evidence of outflowing gas

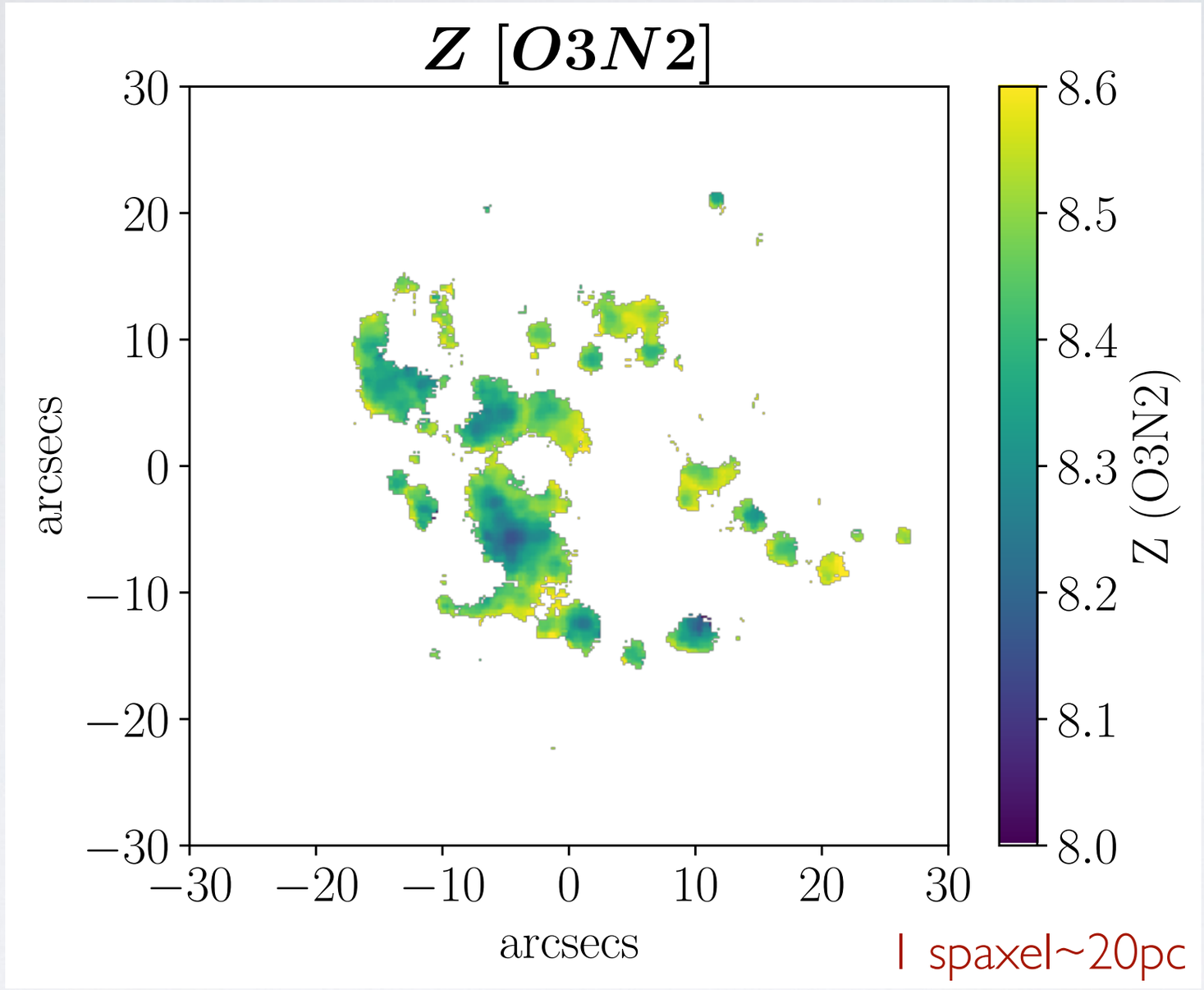
# JKB18: IONIZATION MAPPING




- Mostly photoionization
- Gradients of high ionization mis-aligned with star-formation
- Evidence of shocks/gas-interactions
- No diffuse ionized gas

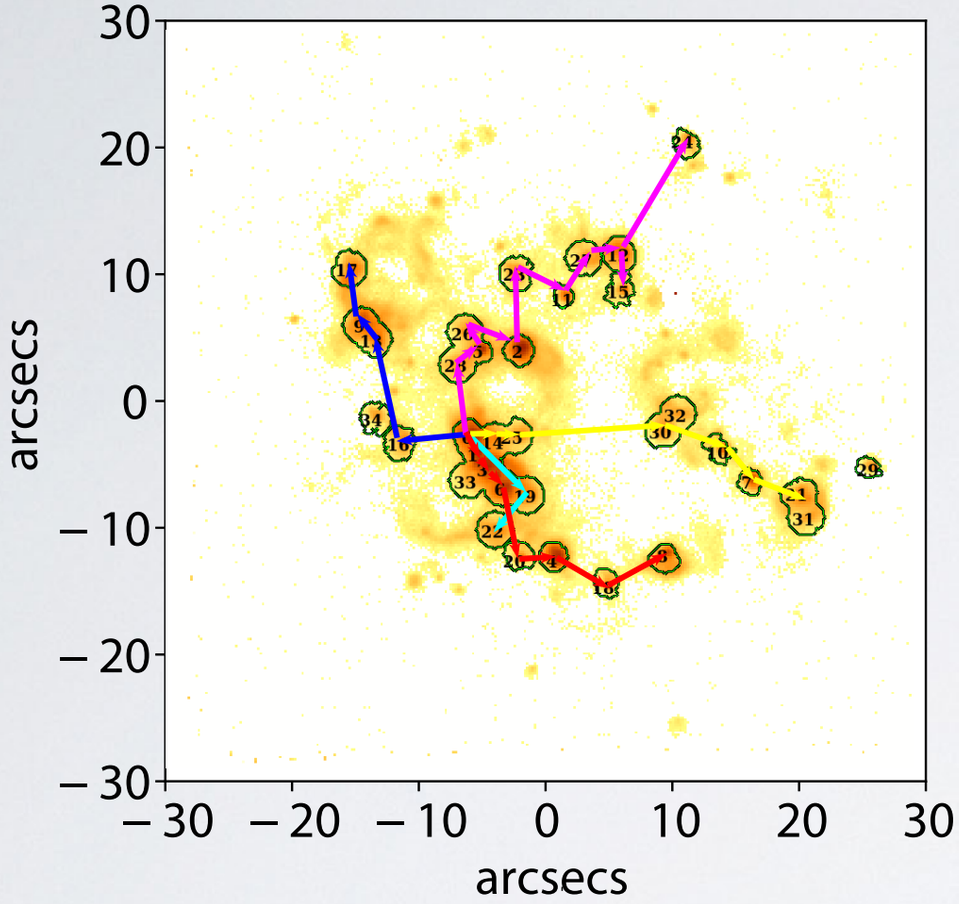
# JKB18: METALLICITY MAP



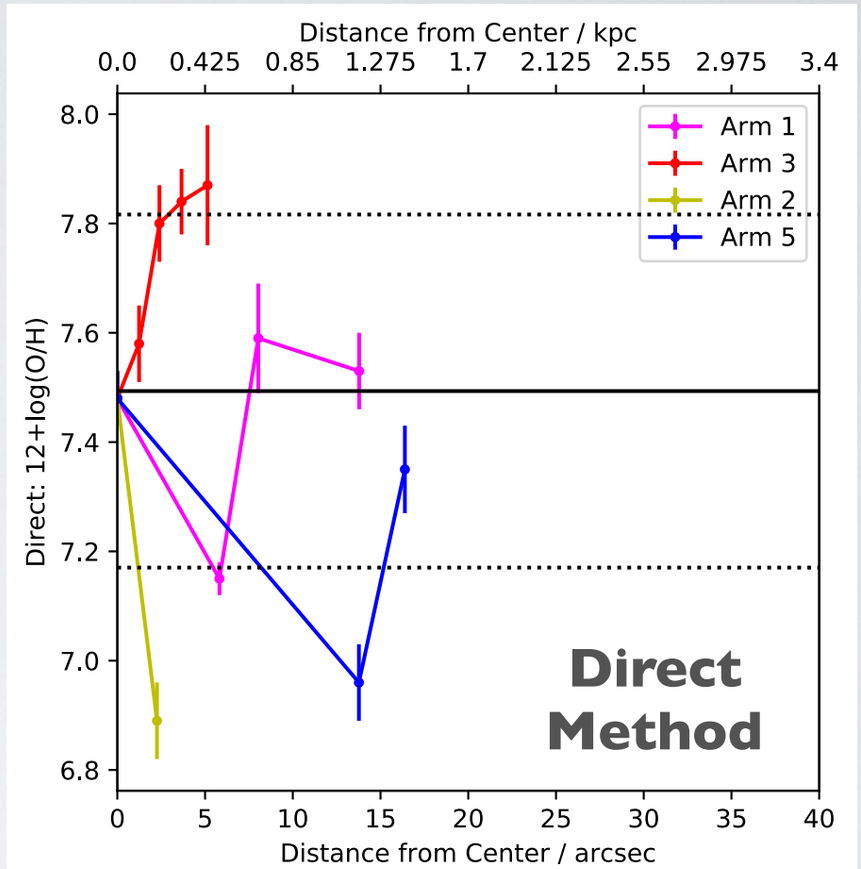

- Evidence of ~0.5 dex chemical variations
- Variations depend on the metallicity diagnostic, but larger than diagnostic uncertainties

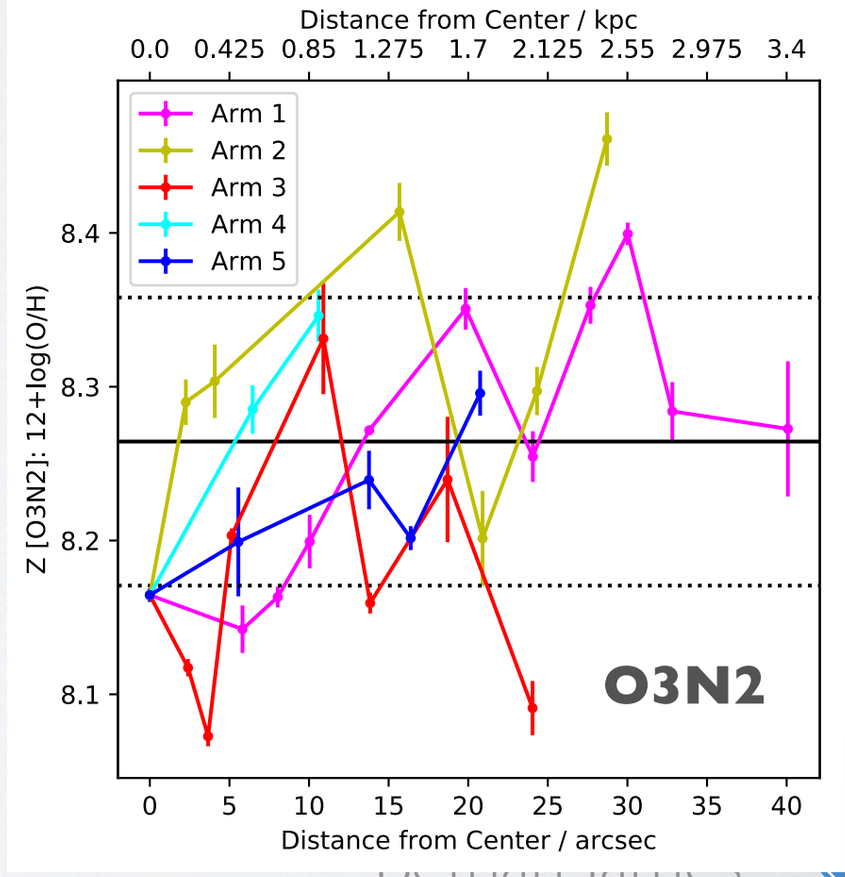
# JKB18: INHOMOGENEITY?

**1 HII region ~100pc**

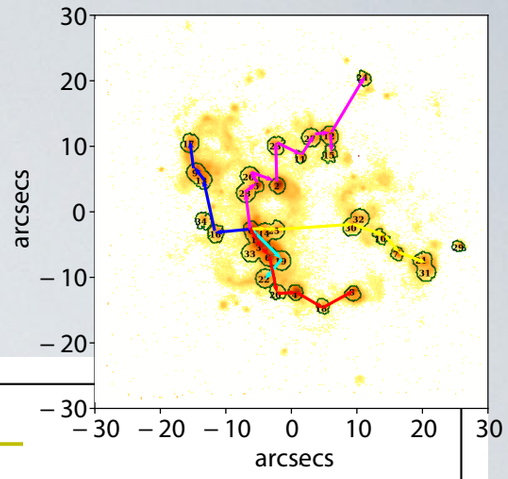


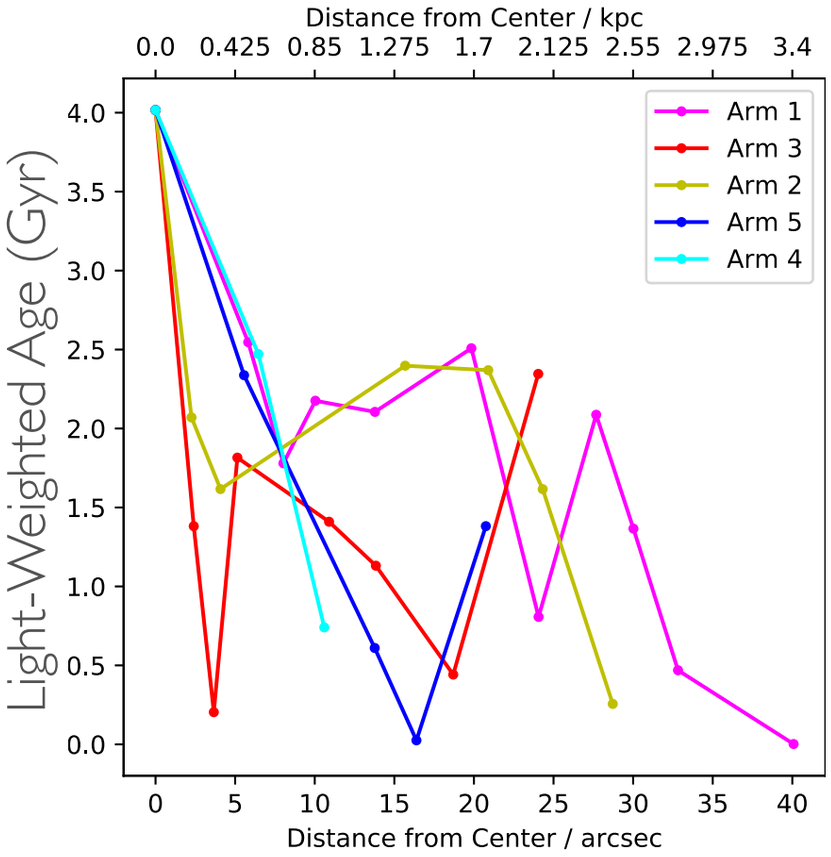

- Variations do exist outside the mean
- Only <u>small scale variations</u>, considering random distribution of SF regions, stellar ages, gas velocity

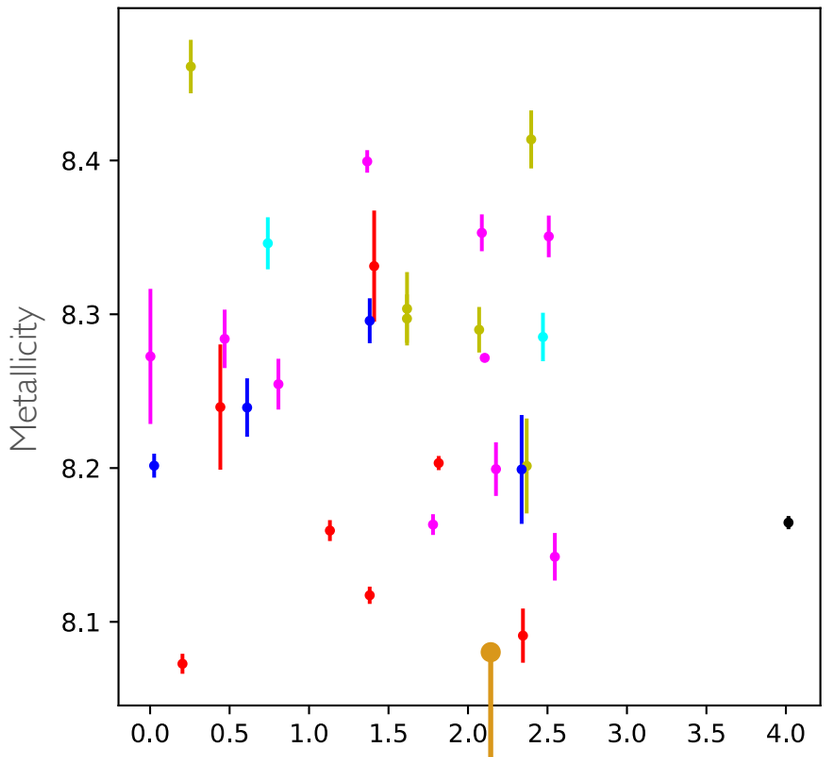


# JKB18: CAUSE/EFFECTS OF CHEMICAL INHOMOGENEITY

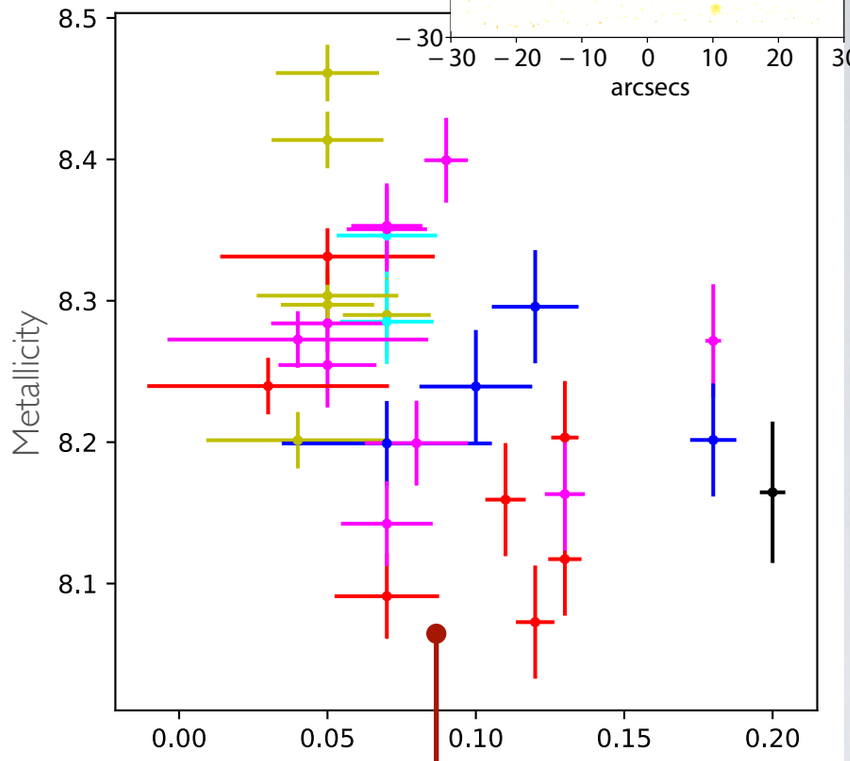



Age (Gyr)

Gas is well mixed
no self-pollution




SFR (Msol/yr)

No sign of pristine gas
accretion
or outflows

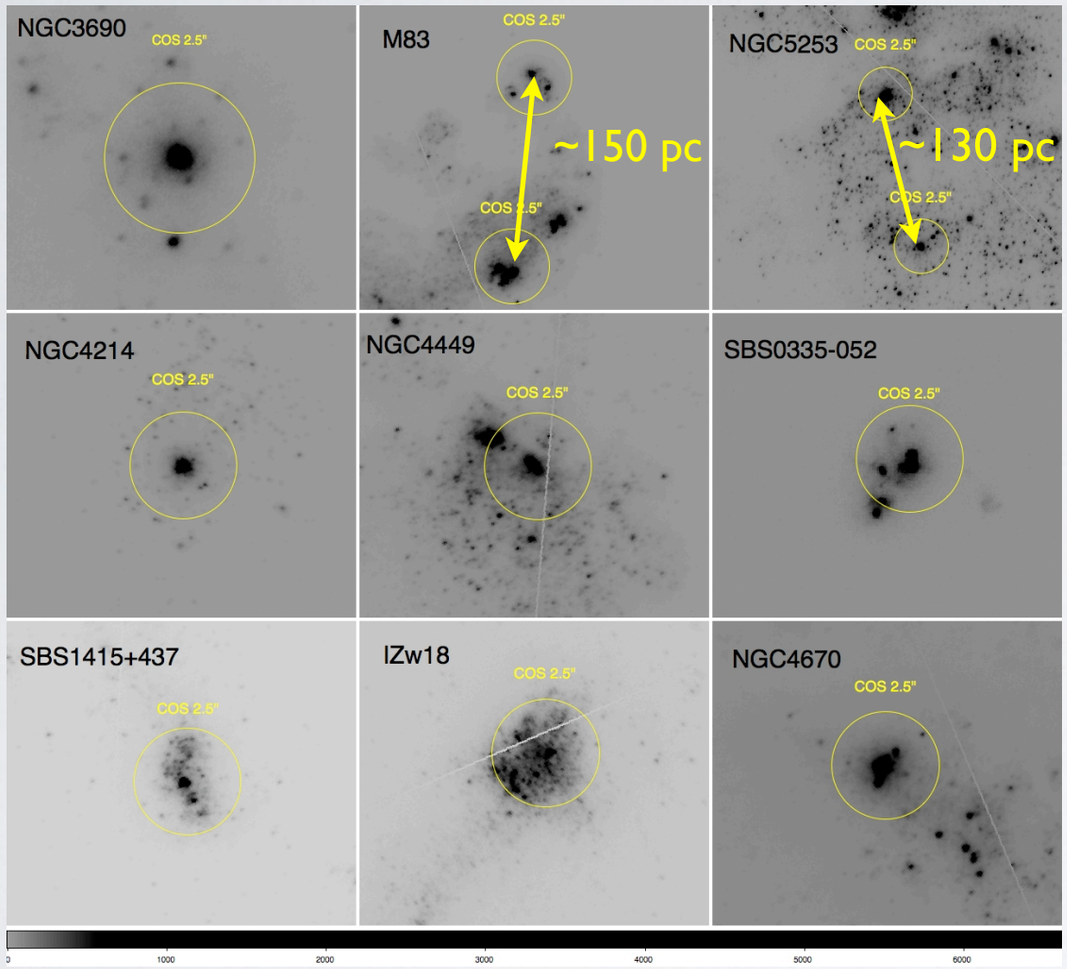
**What do simulations of low-mass galaxies show us at these scales?**
**Can simulations see such small-scale metal variations?**

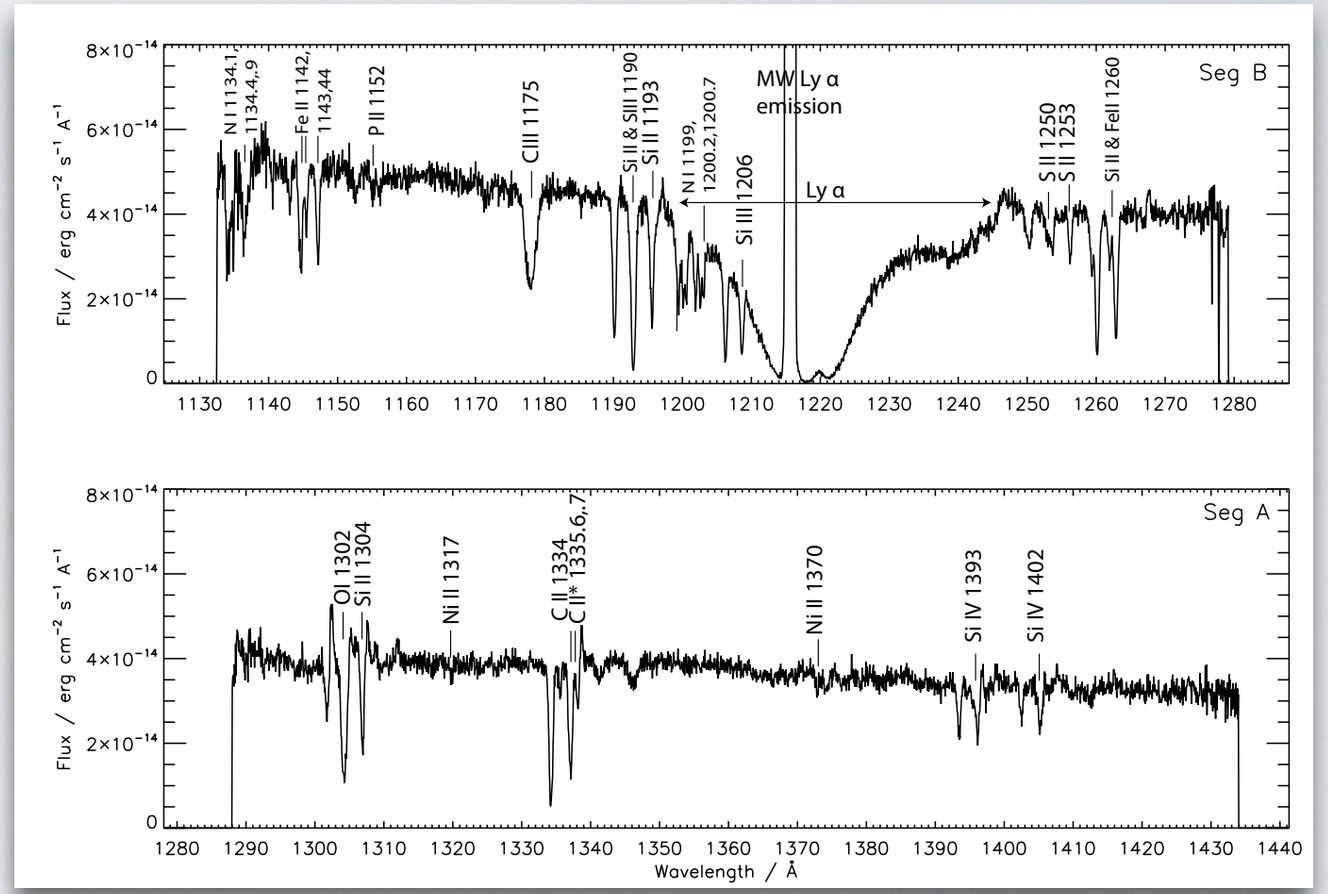
# CHEMICAL VARIATION BETWEEN GAS PHASES

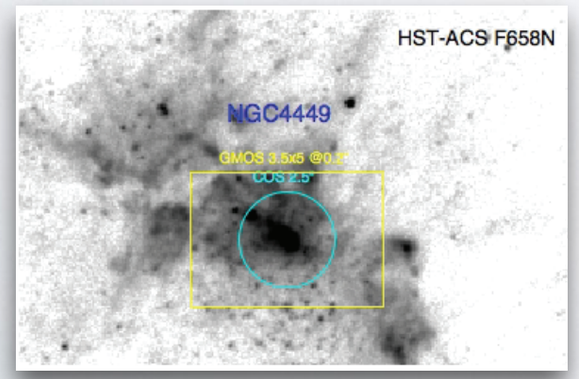
## HST-COS Survey of Local Star-Forming Galaxies (mostly BCDs)

(34 Orbits in Cycle17, 33 Orbits Cycle 25, PI: Aloisi)

James et al., 2014b, ApJ




Accurate line-of-sight abundances

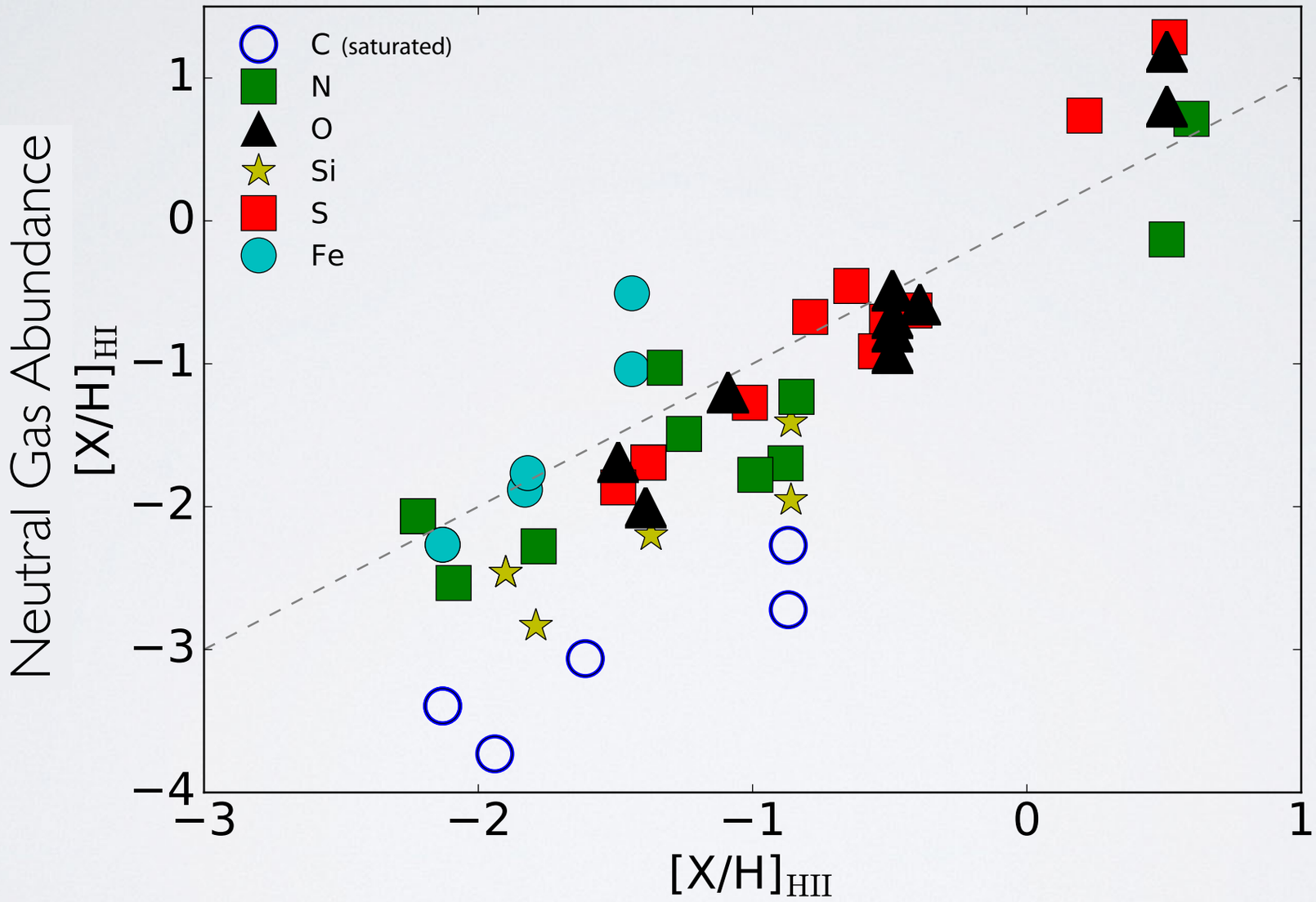
→Gemini-GMOS data (PI: James, **Kumari** et al. 2017, 2018, 2019)

→Keck/CWI data (PI: Hernandez, due 2020)

# CHEMICAL VARIATION BETWEEN GAS PHASES

**New COS data allows for tailor made ICF models for each galaxy (Hernandez et al. 2019 in-prep)**

All elements



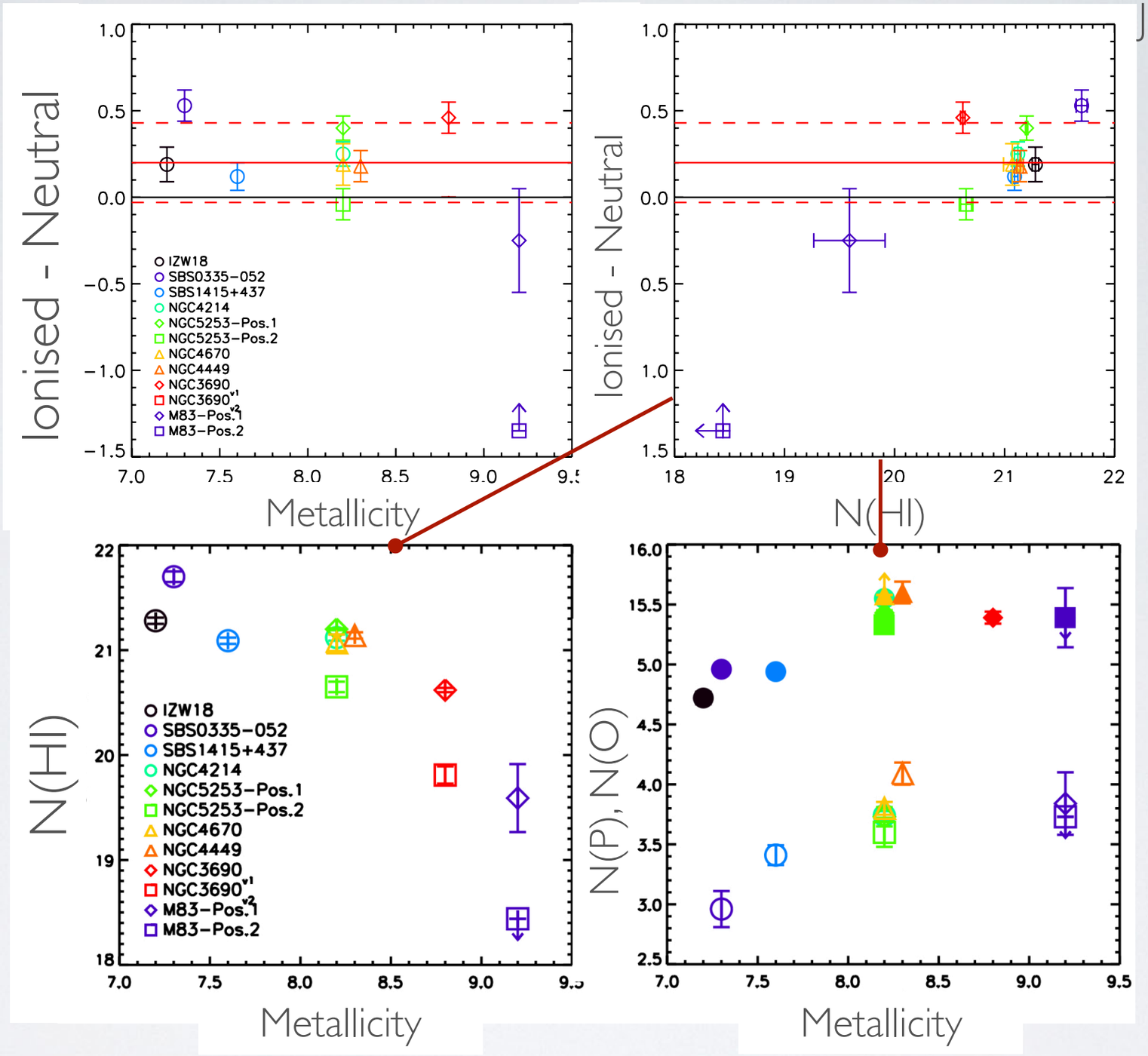

To be continued with +45 galaxies in CLASSY (PIs Berg, James & Stark +, Cycle 27)

# CHEMICAL VARIATION BETWEEN GAS PHASES

James & Aloisi 2018

## Just Oxygen

Gas is well mixed, despite metallicity




O/H in neutral phase increases in high mass galaxies

Amount of HI is strong function of metallicity

Decrease in metals only seen at very low metallicities

Galactic outflows and/or SF inefficiency in most metal poor systems

# SUMMARY

Dwarf galaxies are not always chemically homogeneous

Chemical variations in dwarfs tell us about:

- chemical mixing timescales
- past interactions
- accretion of metal-poor gas
- star-formation mechanisms
- galactic outflows
- Self pollution...or complete lack of.

Incorporating these variations into models is essential for accurate representation of galaxy evolution
...especially for dwarf galaxies