

Massive Stars as Cosmic Abundance Probes with JWST

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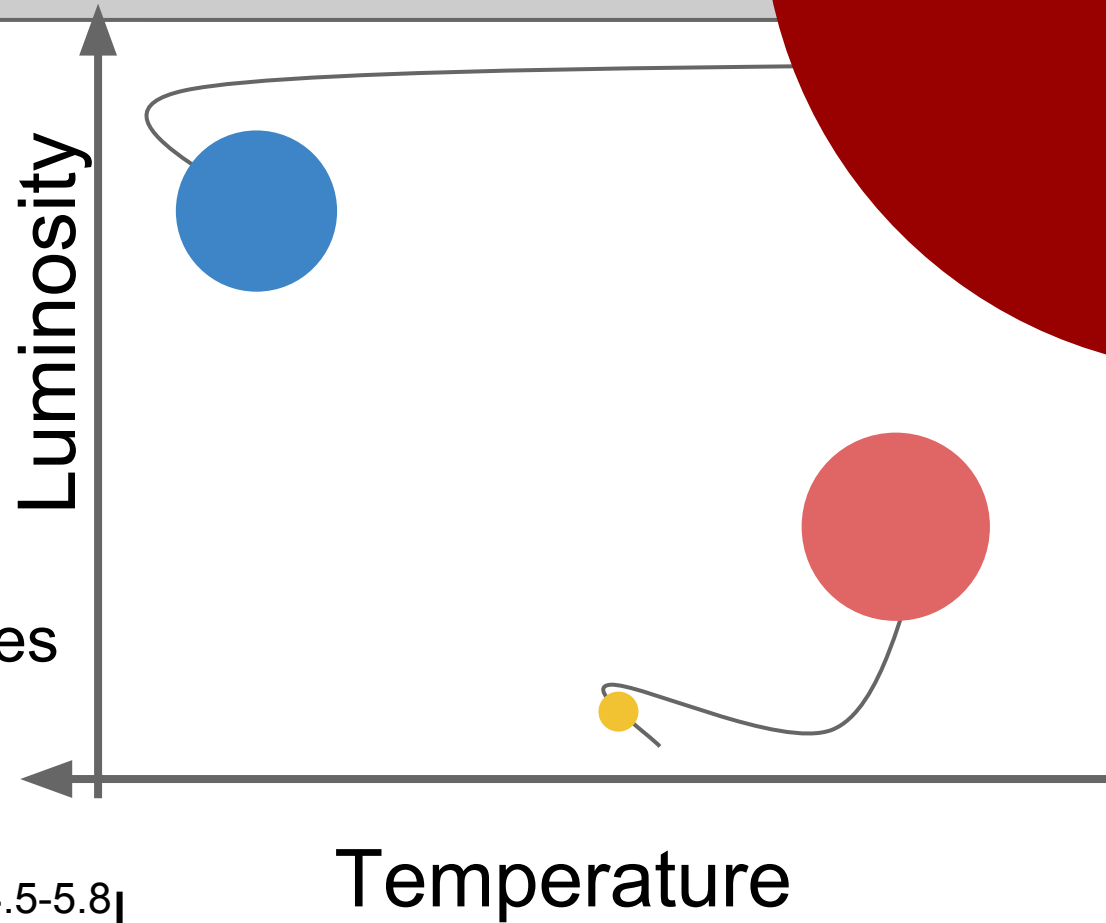
Collaborators: C. J. Evans, B. Davies,
R-P. Kudritzki, M. Bergemann, C. Lardo,
N. Bastian, B. Plez

Outline

- Motivation:
 - What are Red Supergiants (RSGs)?
 - Why do we care about galaxy metallicity?
- Estimating abundances from RSGs
- Metallicities from RSGs and Super Star Clusters (SSCs)
- RSG abundances with JWST

What are RSGs?

- Evolved massive stars
- SNe progenitors
- Extended atmospheres
= cool! $T_{\text{eff}} \sim 3900\text{K}$
- High luminosity $\sim 10^{4.5-5.8} L_{\odot}$
- Young $< 50\text{Myr}$



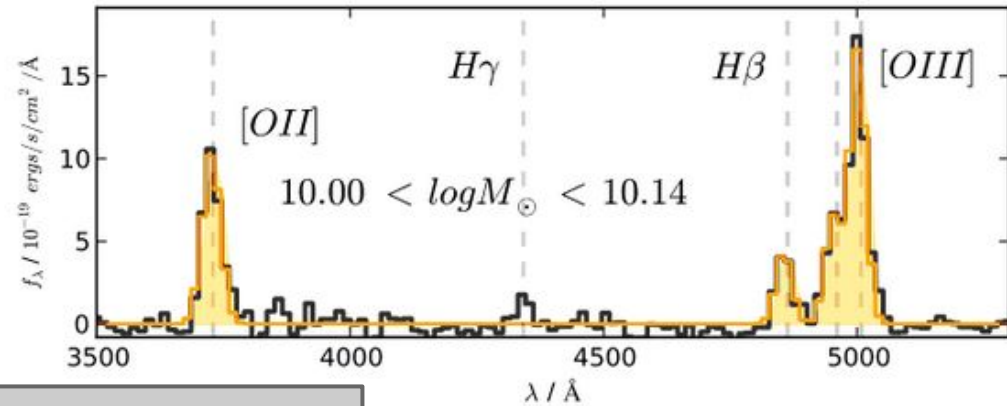
Galaxy Metallicity

- Metallicity determined by cycling of processed material
- Galaxy Mass-Metallicity (M-Z) Relation
- Metallicity gradient explains dynamics of galaxy evolution

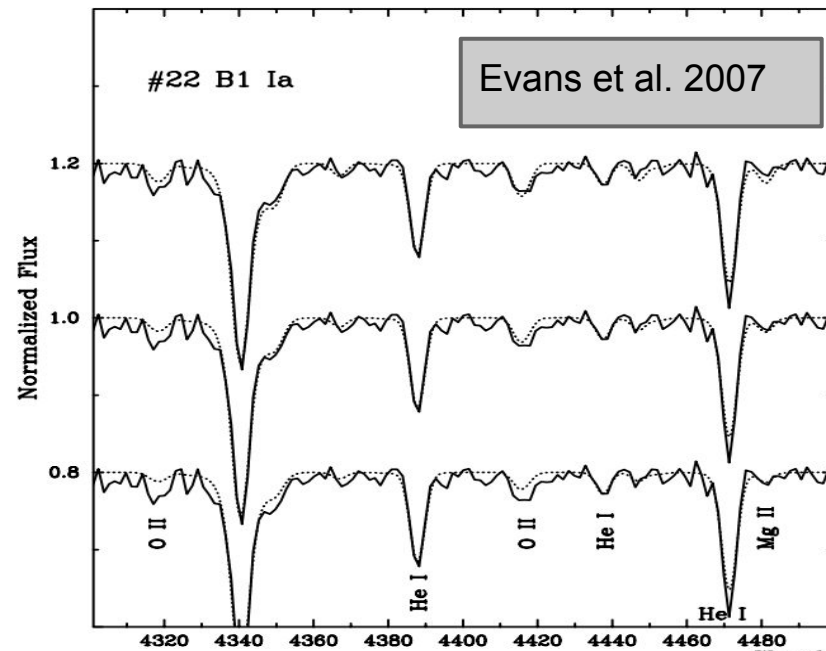


How to estimate Galaxy Metallicity

- Deriving metallicity:
 - HII regions
 - Young Stars



Cullen et al. 2014



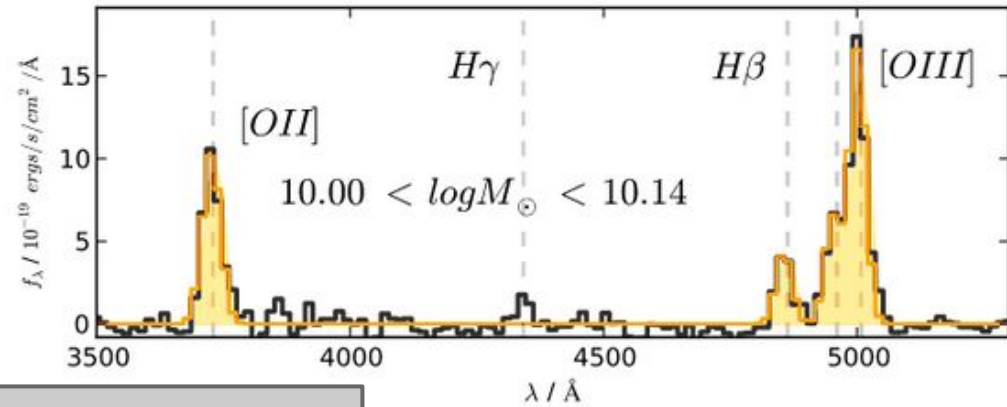
How to estimate Galaxy Metallicity

- Deriving metallicity:

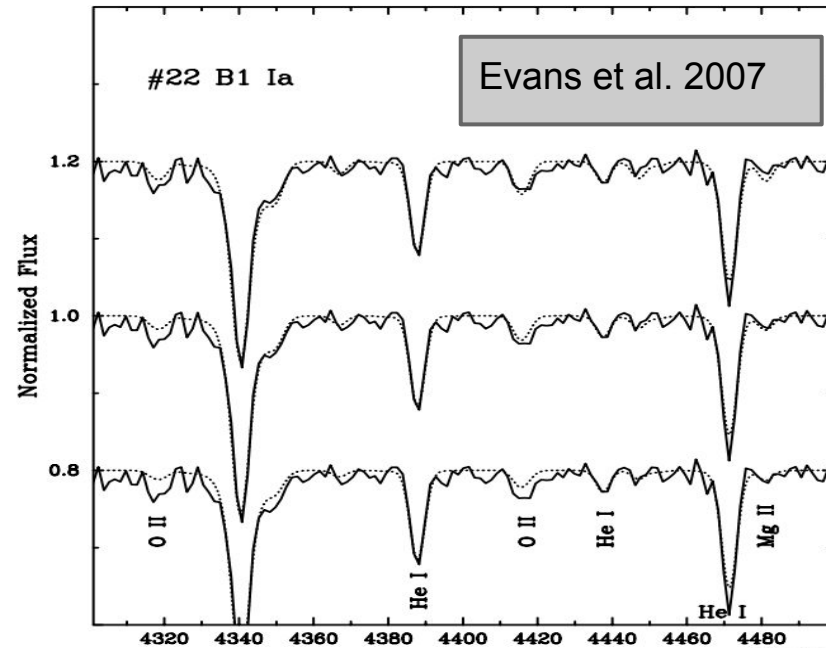
- HII regions

- Young Stars

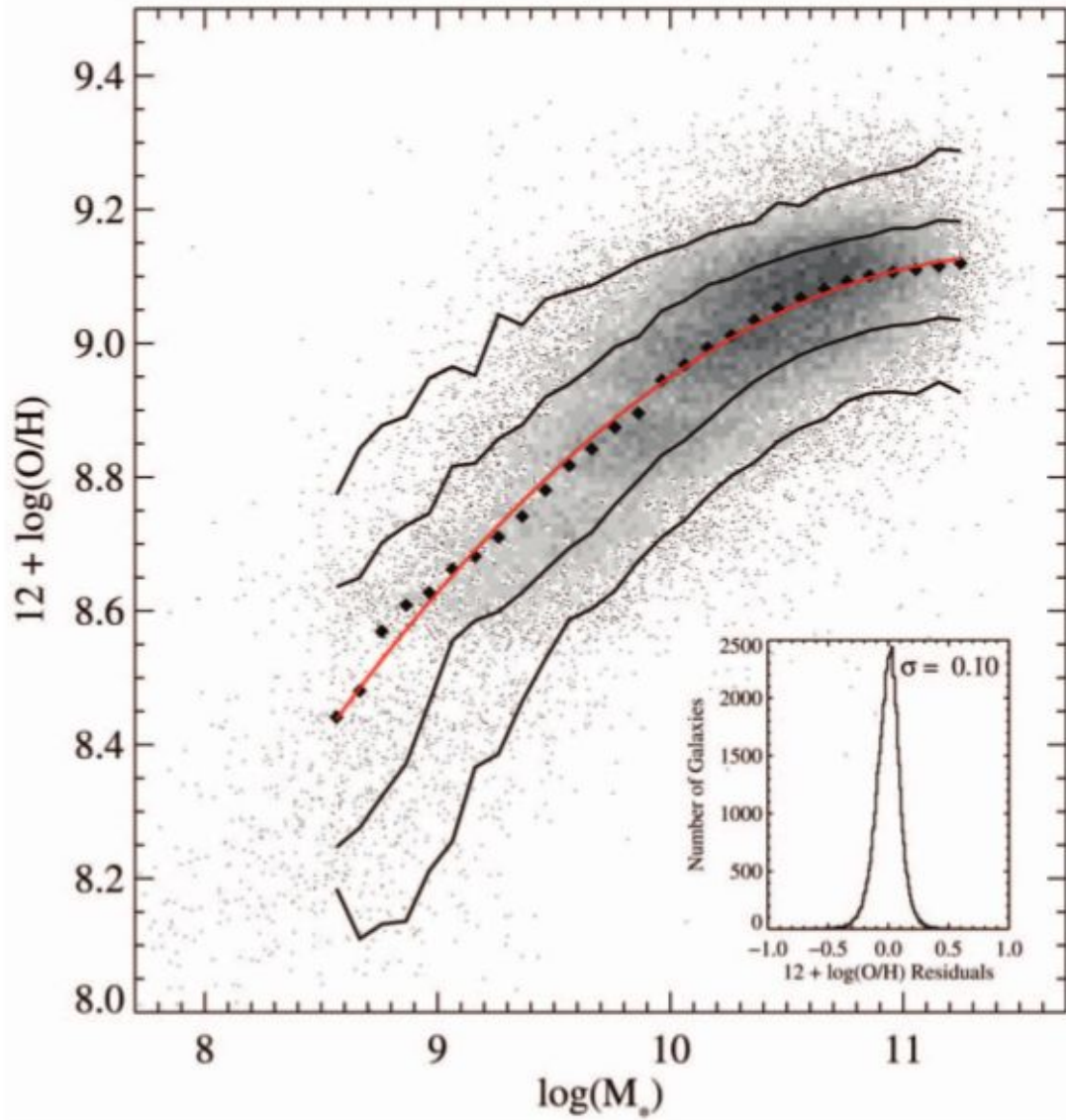
- and more ...



Cullen et al. 2014

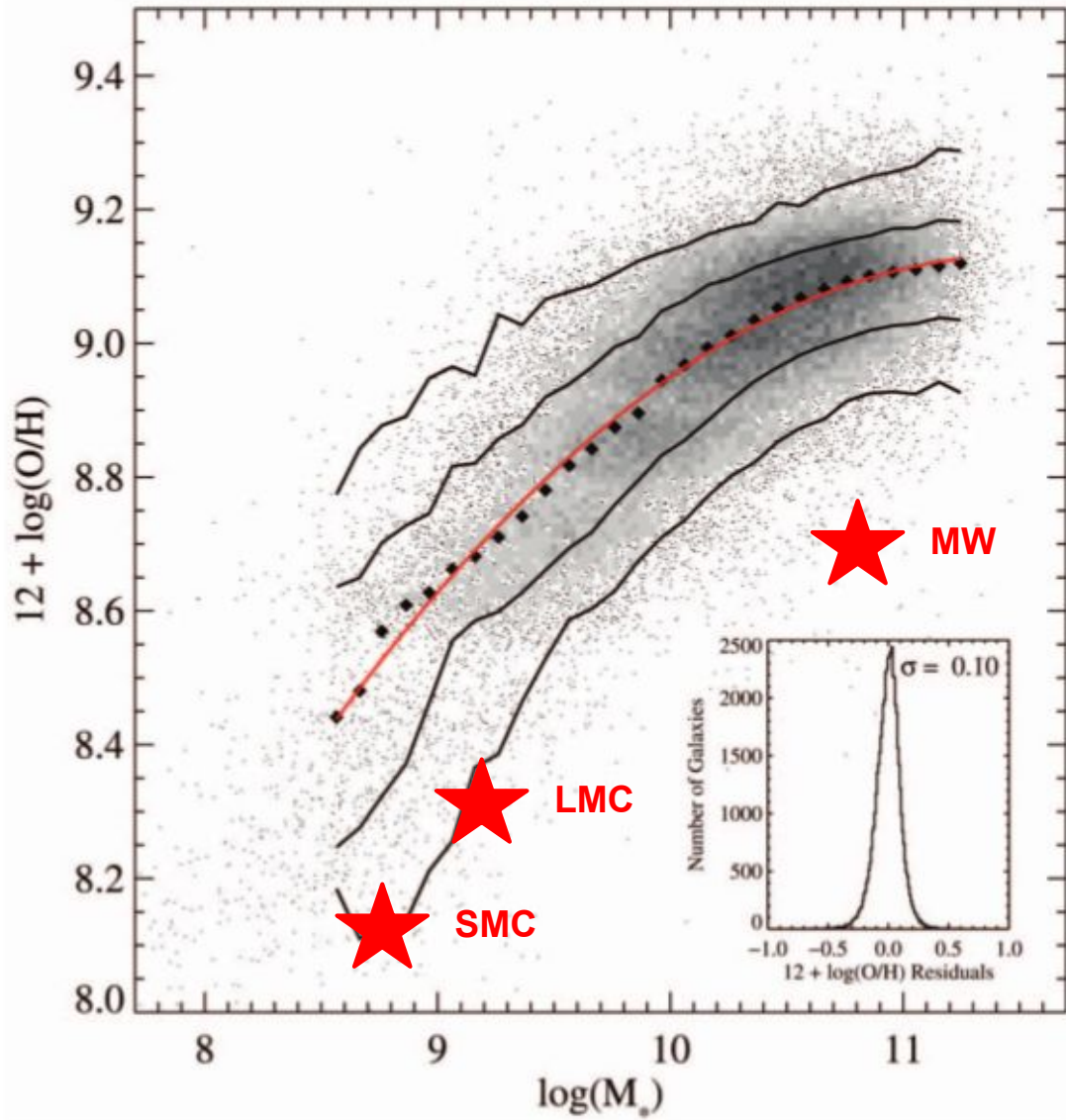


M-Z Relation



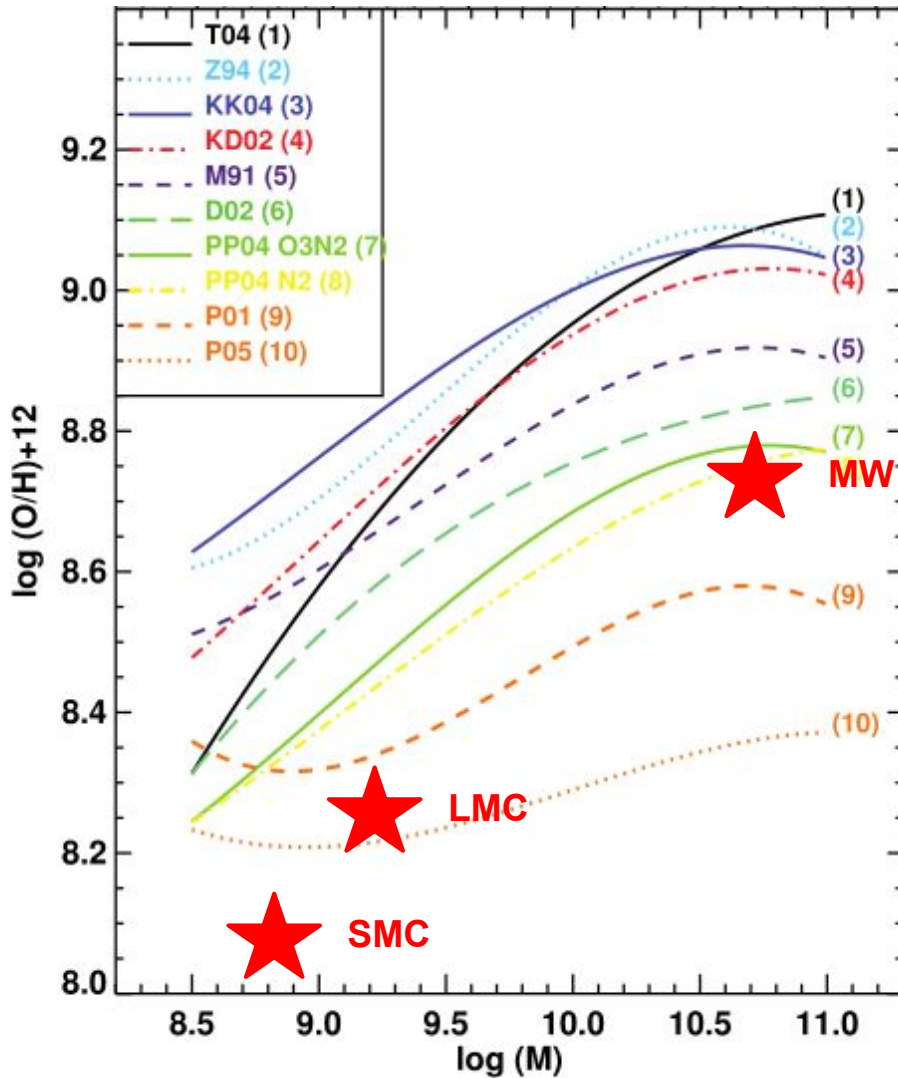
Tremonti et al. 2004

M-Z Relation



Tremonti et al. 2004

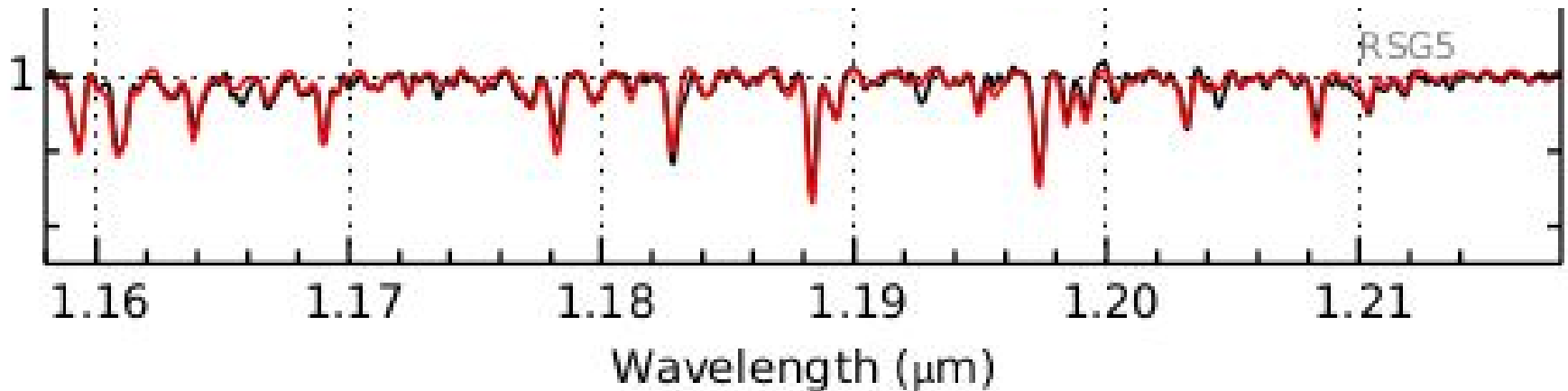
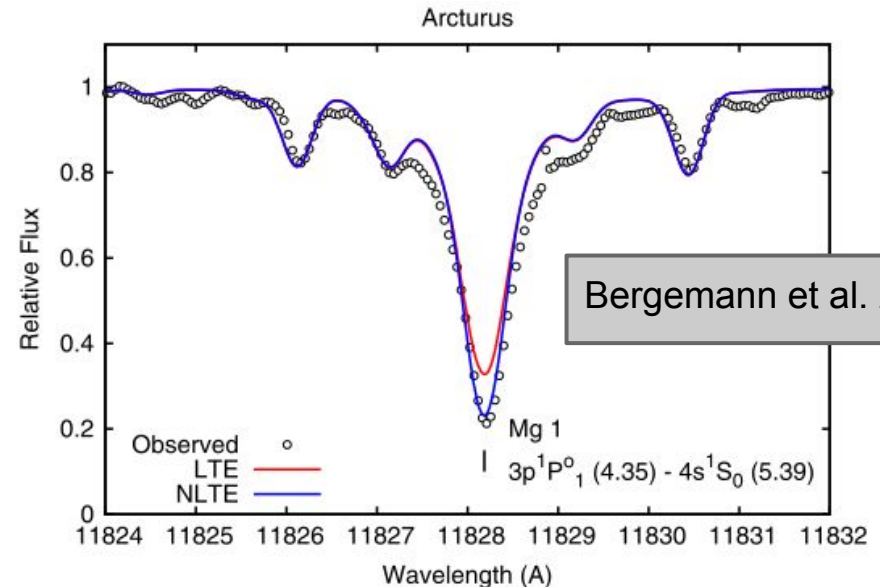
M-Z Relation

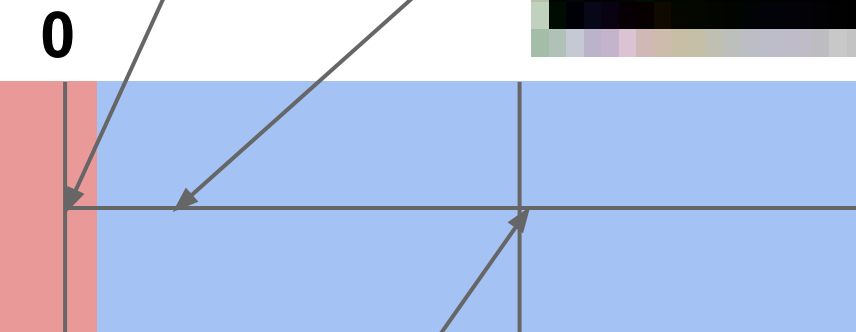


Kewley & Ellison 2008

Abundances with RSGs

- J-band clean spectral window
- Elemental features: Fe I, Si I, Ti I and Mg I





1

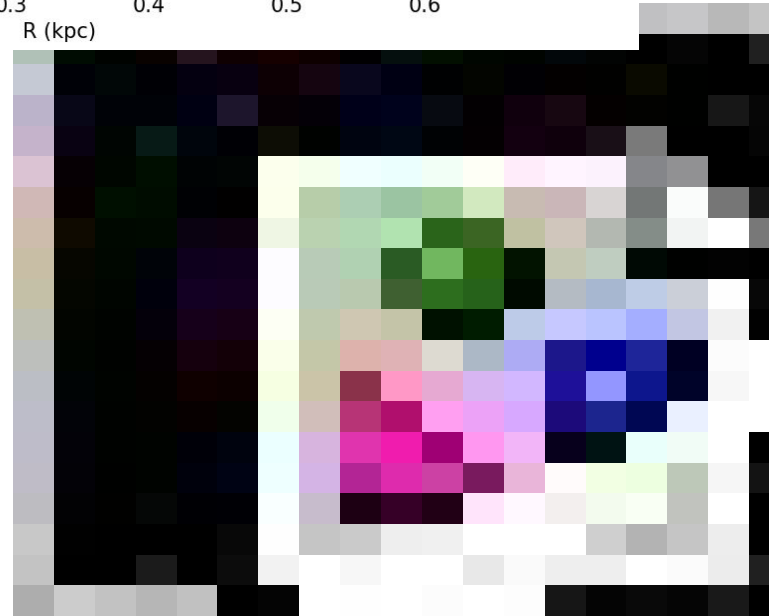
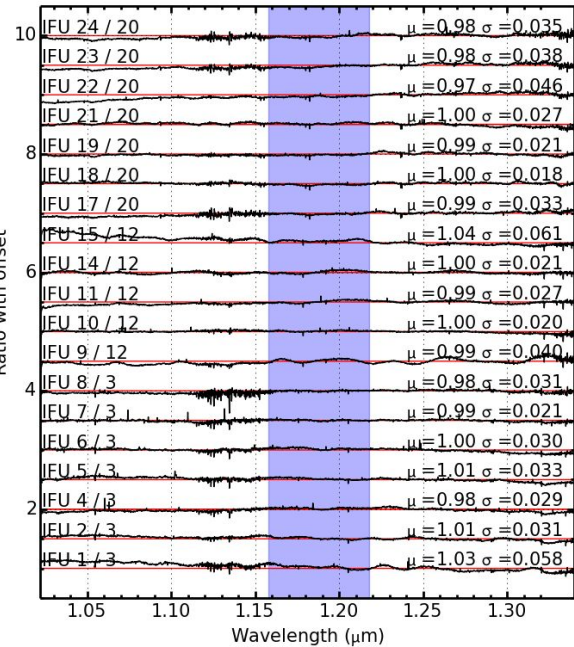
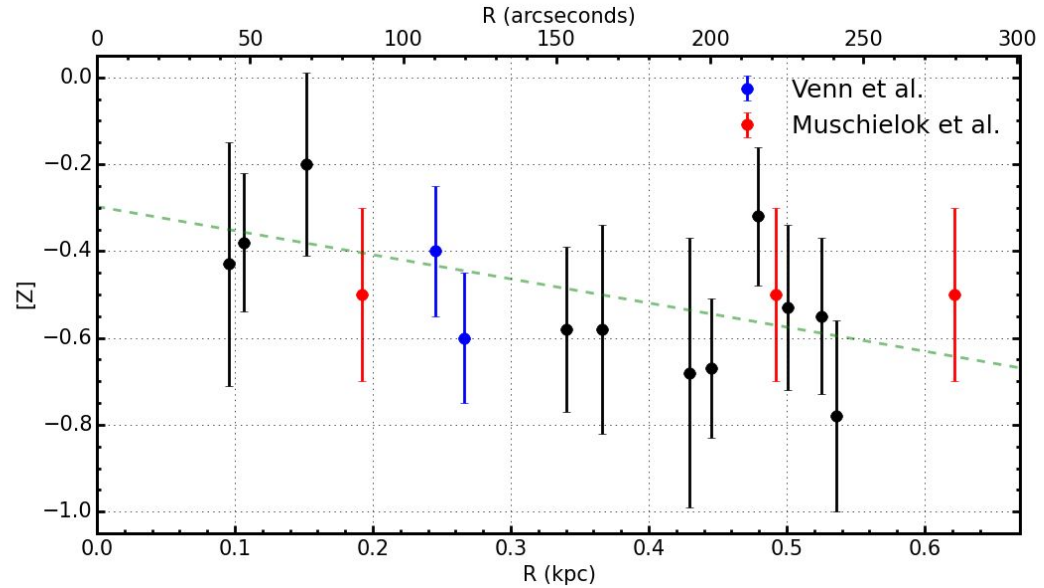
2 Mpc

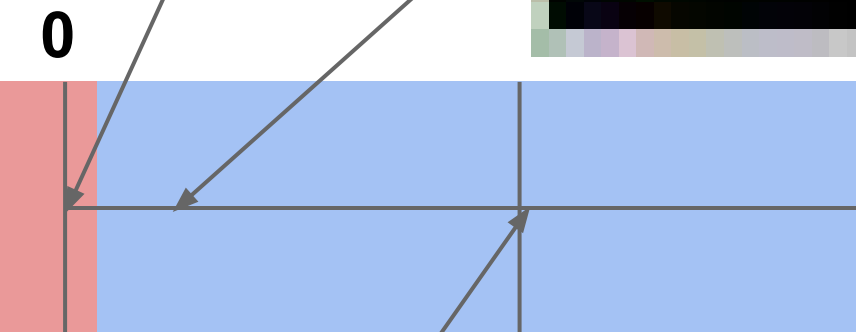




RSGs in NGC 6822 with KMOS

Patrick et al. 2015





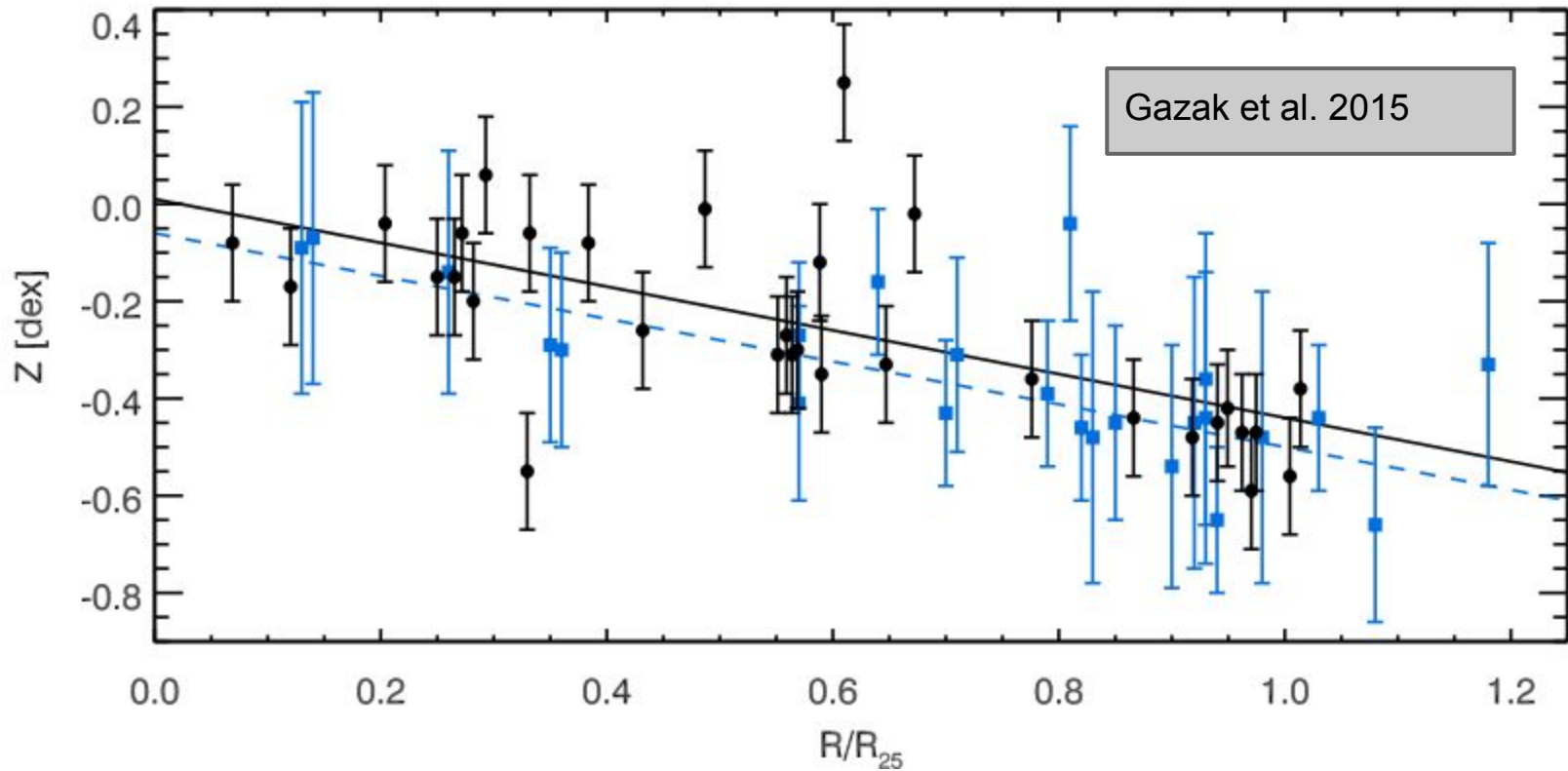
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2 Mpc



Sculptor Group RSGs: NGC 300

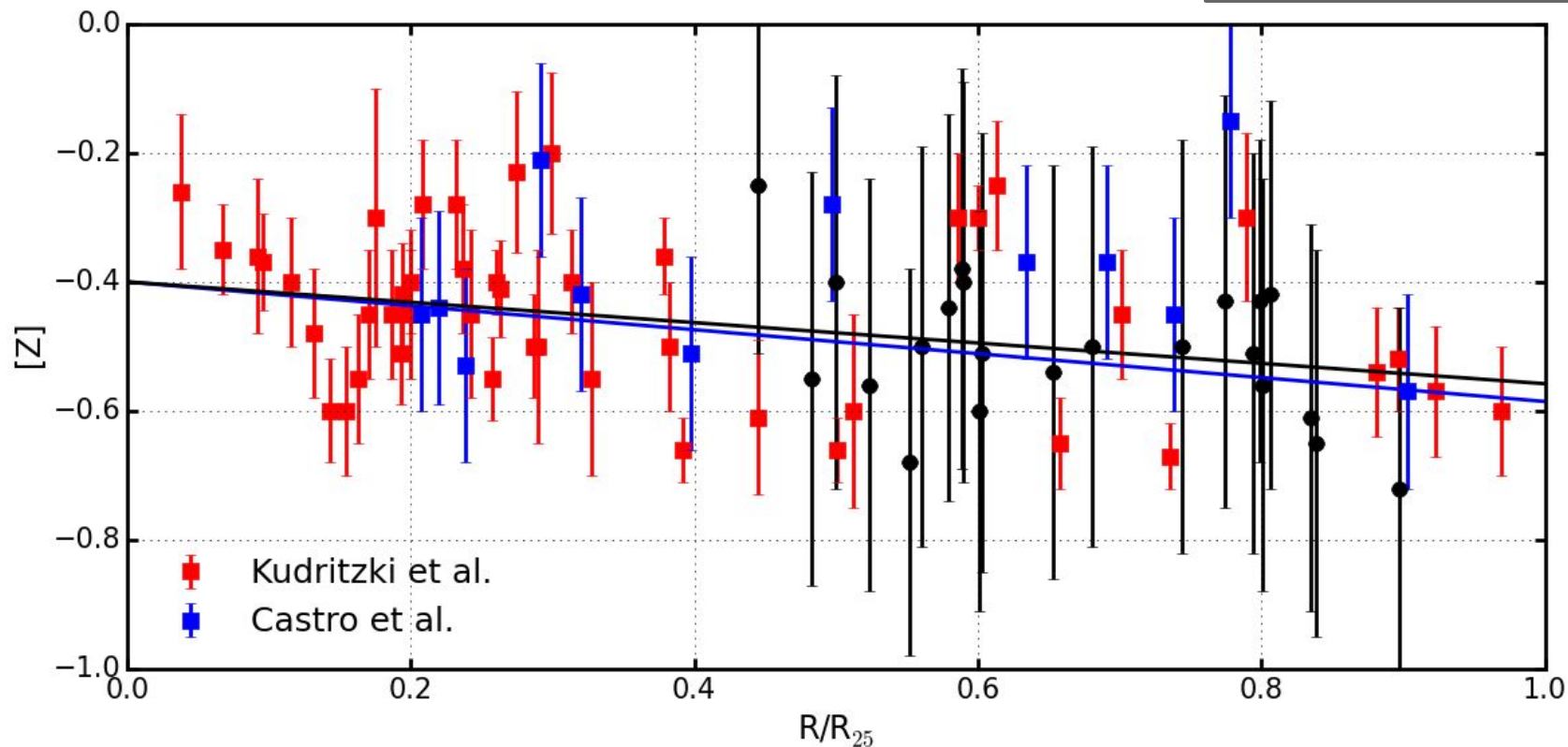
- gradient: $-0.081 \pm 0.011 \text{ dex kpc}^{-1}$



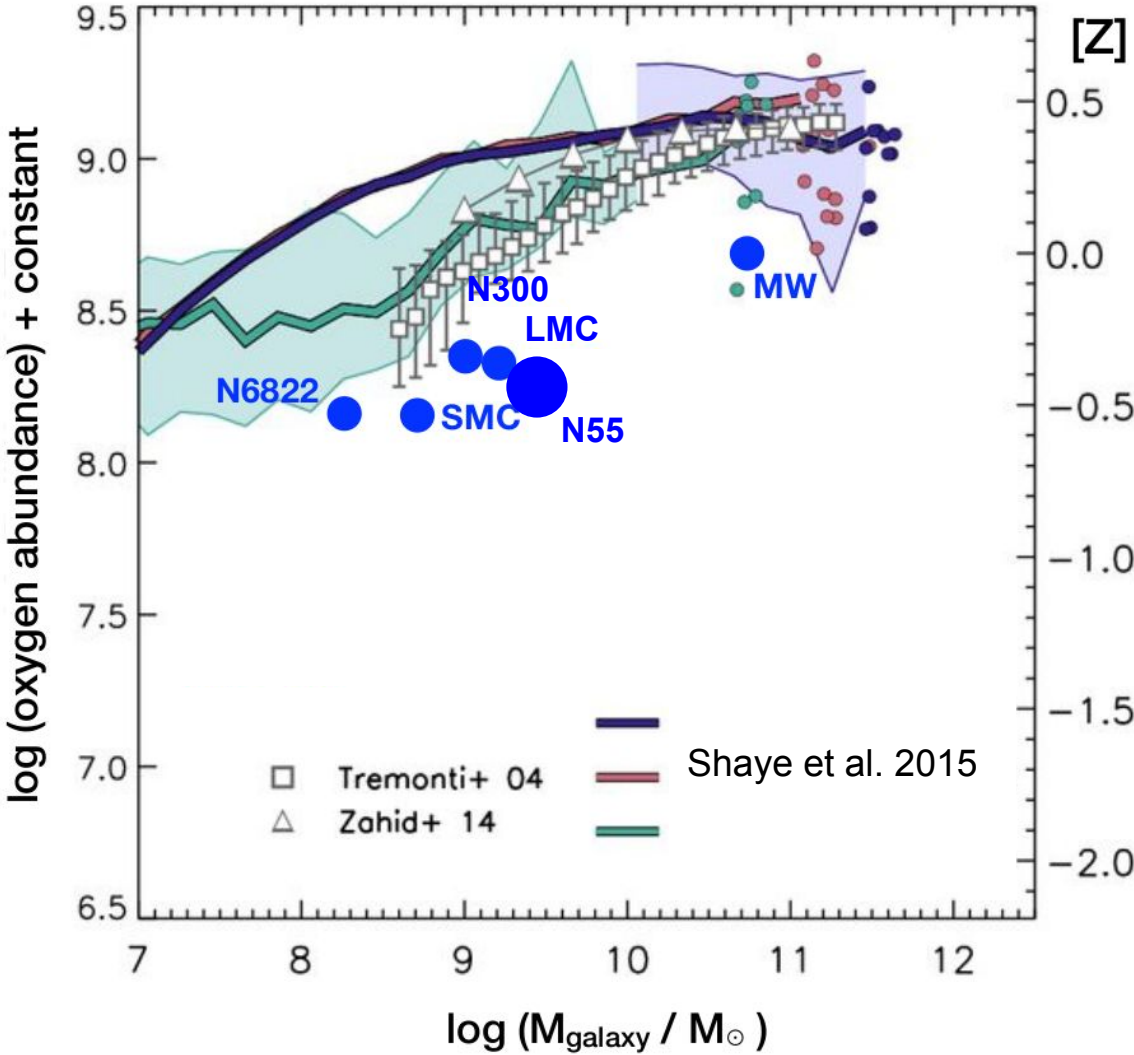
Sculptor Group RSGs: NGC 55

- gradient: $-0.026 \pm 0.006 \text{ dex kpc}^{-1}$

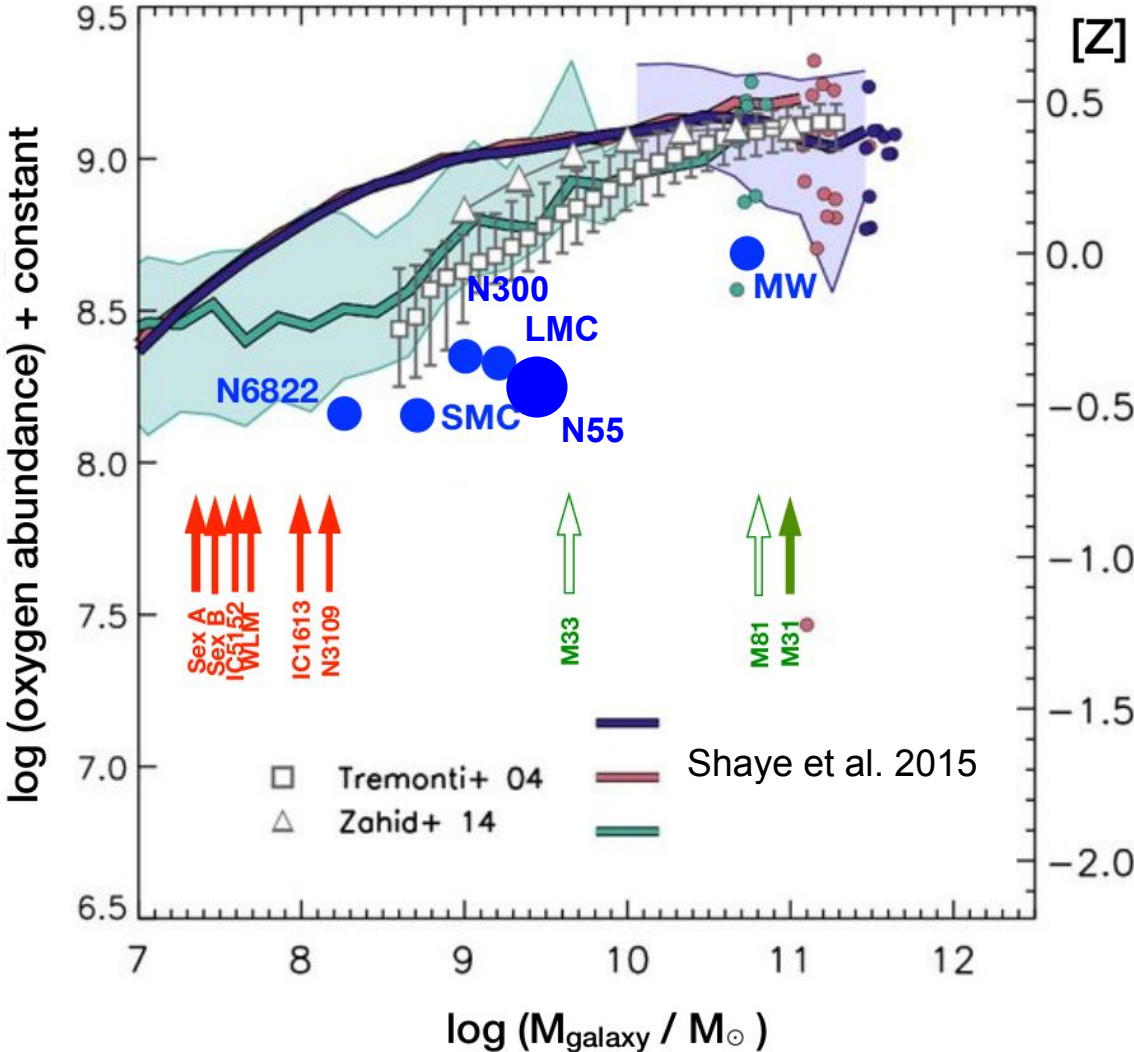
Patrick et al. in prep.,
Kudritzki et al. in prep.



M-Z Relation with RSGs

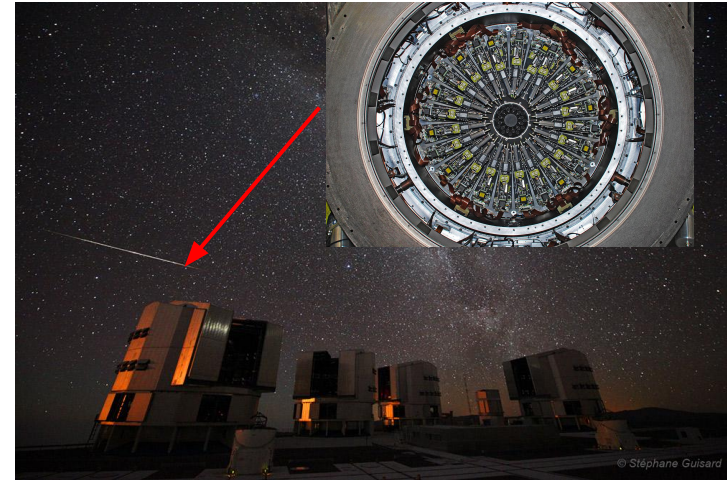
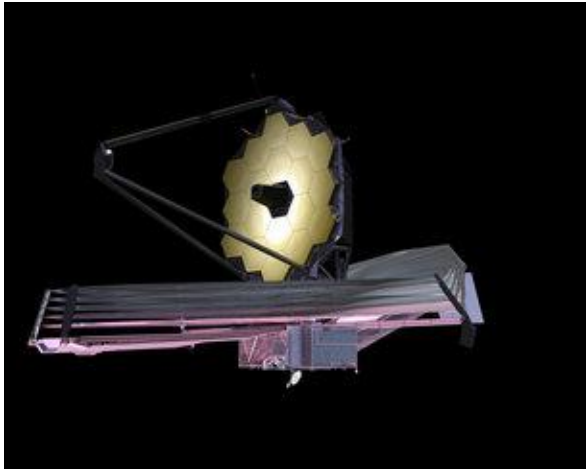


M-Z Relation with RSGs



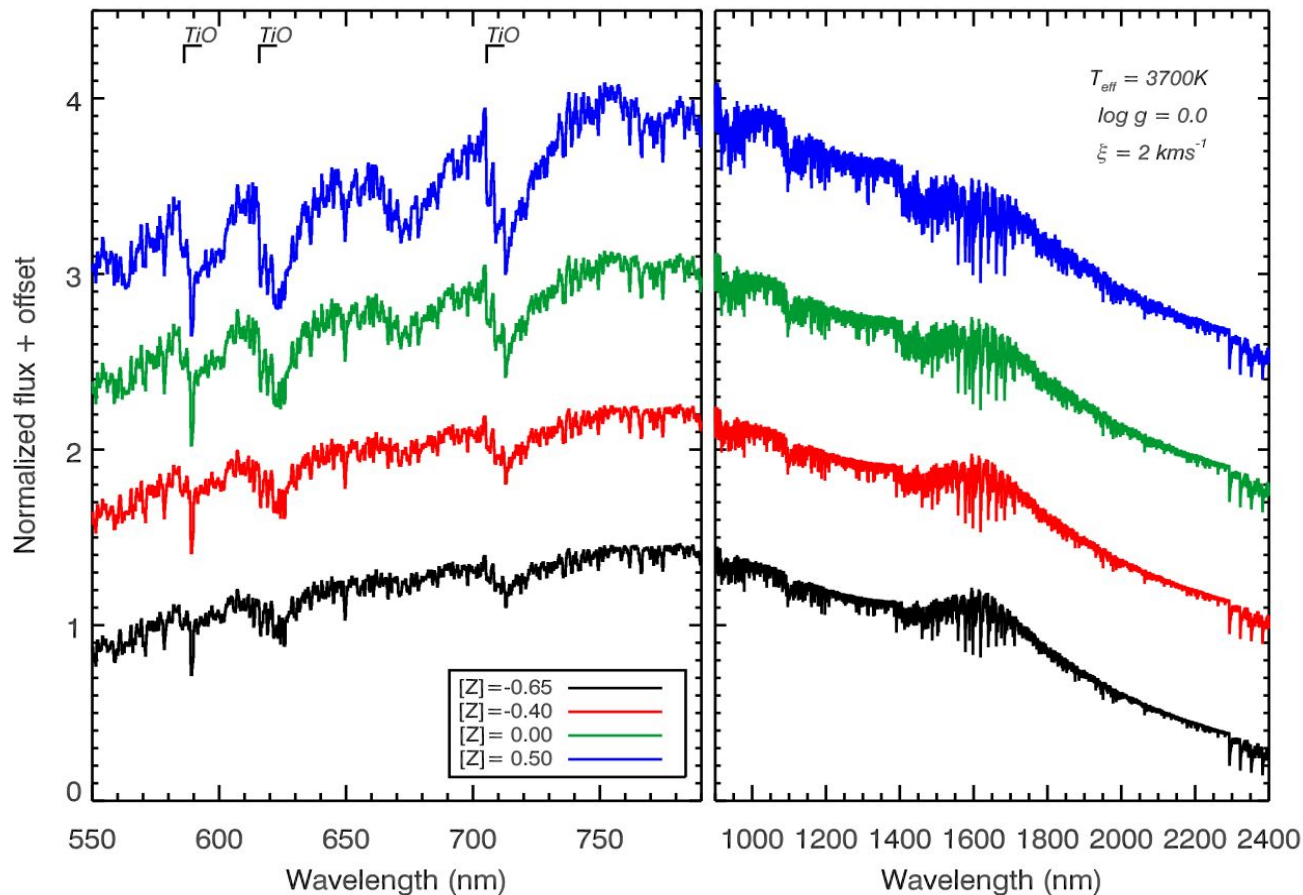
Potential of JWST-NIRSpec

- Metallicities of RSGs and SSCs to ± 0.20 dex
- Access to many different SF environments
- RSGs in Virgo Cluster $J \sim 21$: S/N ~ 75 in 100 ks

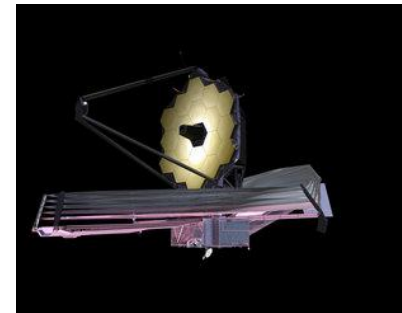


Potential of JWST-NIRSpec

- At $1.20 \mu\text{m}$, $R \sim 2300$ \longrightarrow at $1.75 \mu\text{m}$, $R \sim 3400$

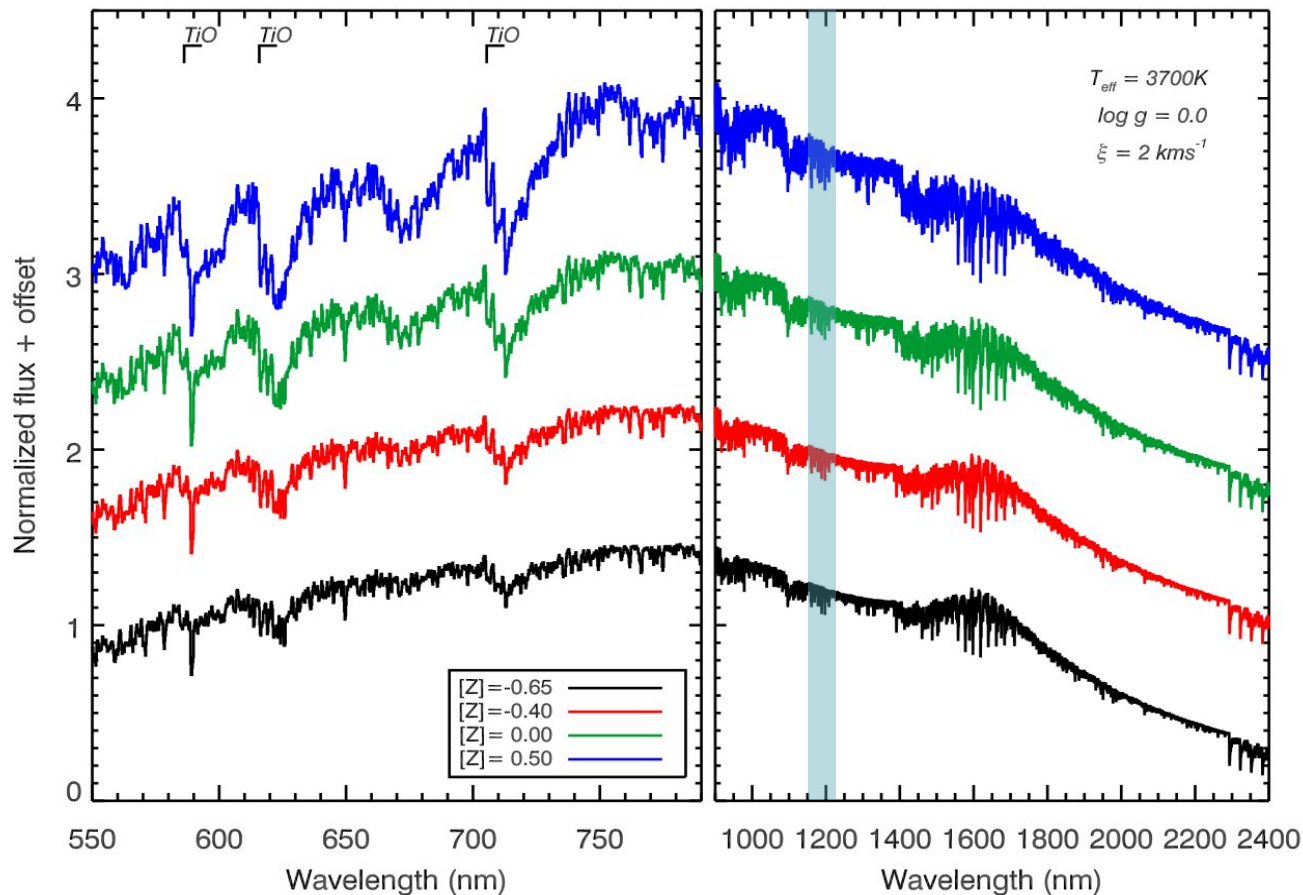


Davies et al. 2013

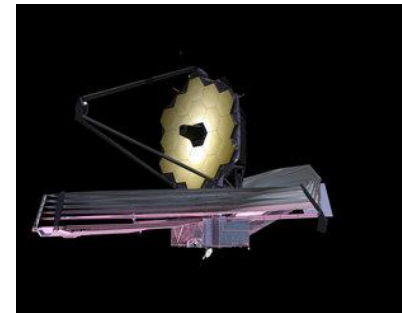


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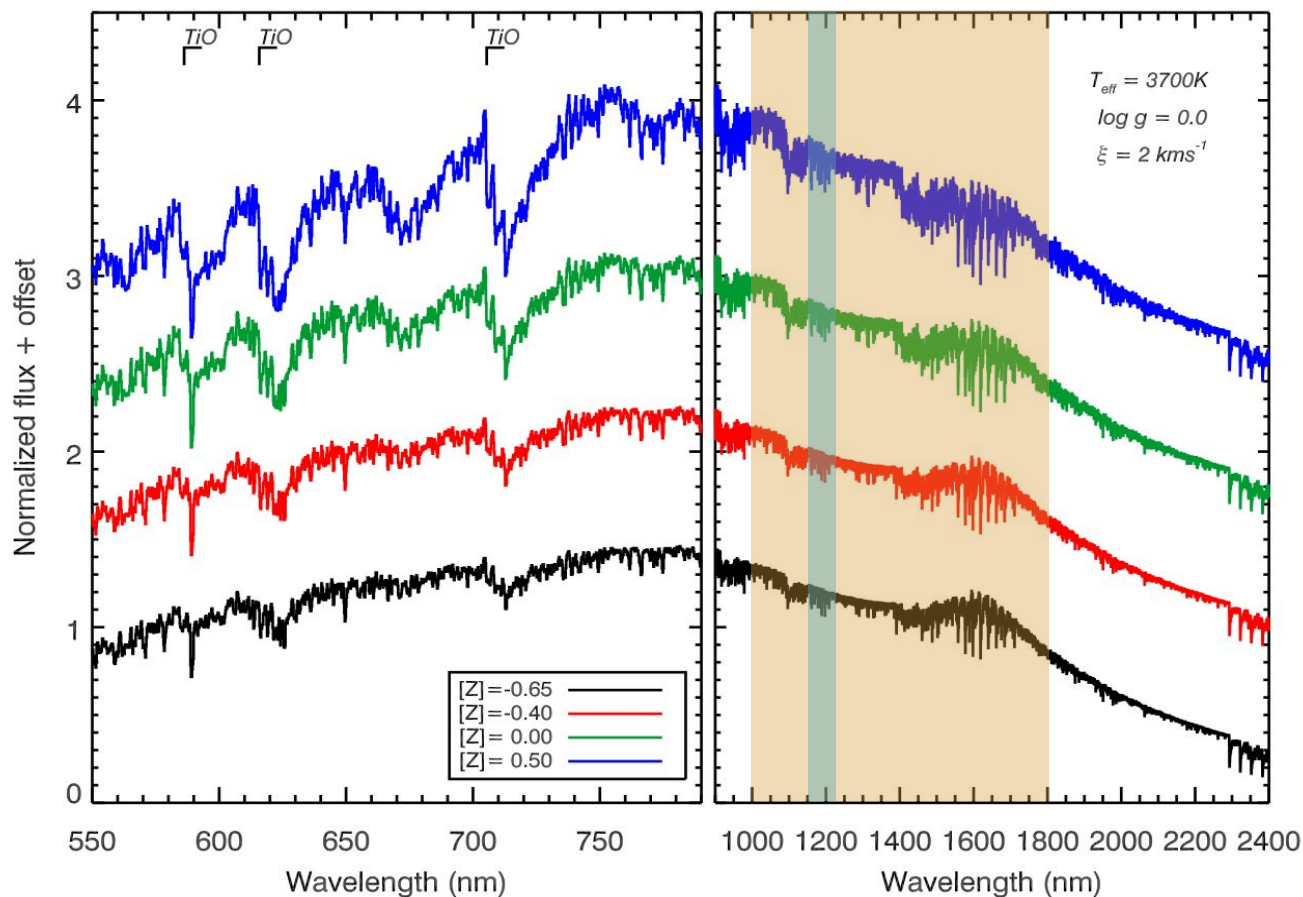


Davies et al. 2013

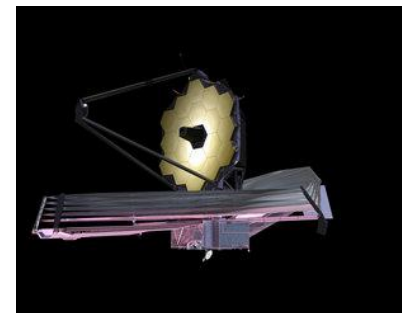


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Davies et al. 2013



Conclusions

- RSGs abundances in external galaxies
- First steps in the Local Universe:
NGC 6822, Sculptor Group (NGC 55/NGC 300) & Antennae
- RSGs with JWST-NIRSpec in many different environments

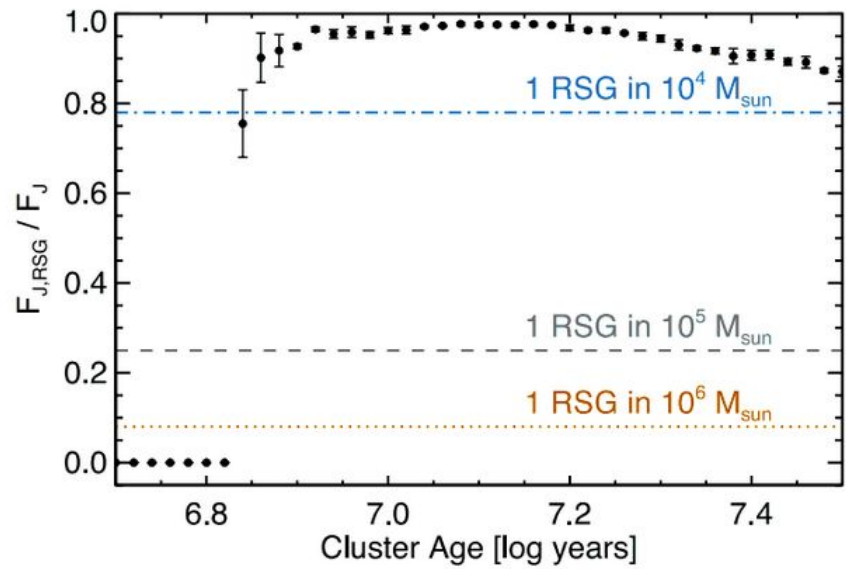
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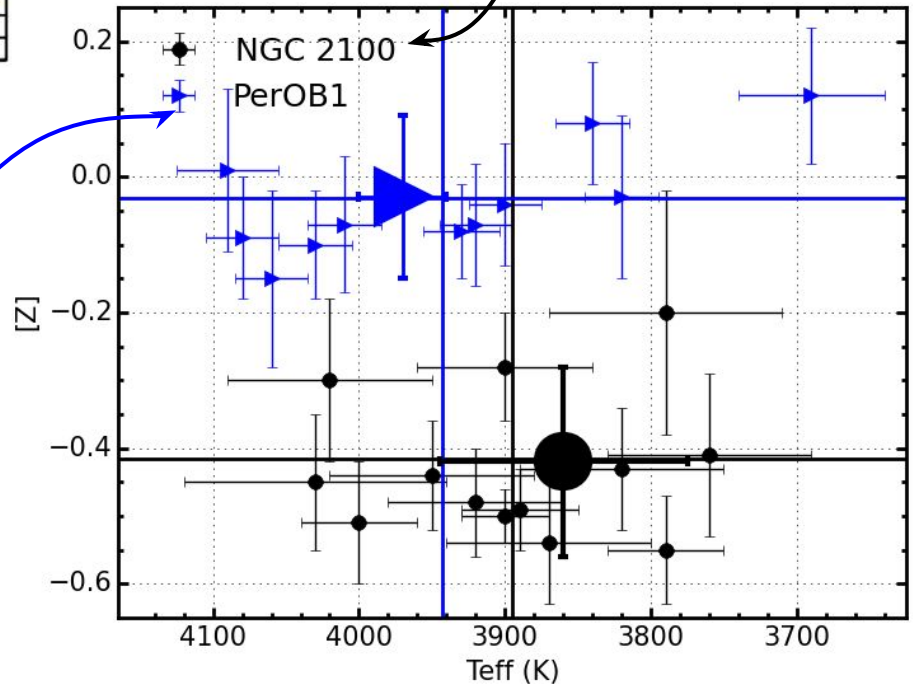
Young Massive Clusters



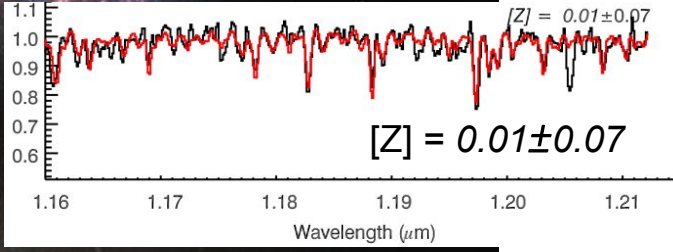
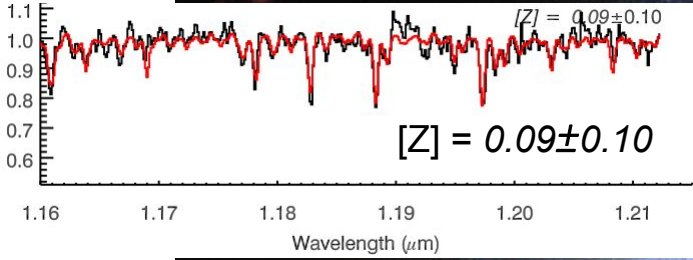
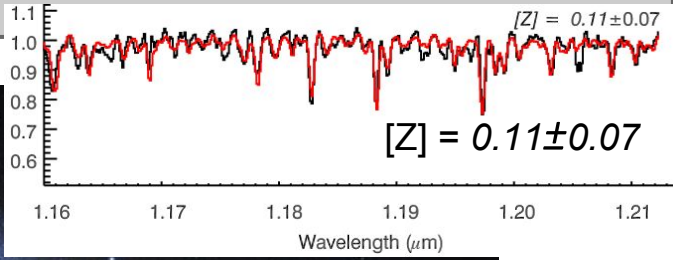
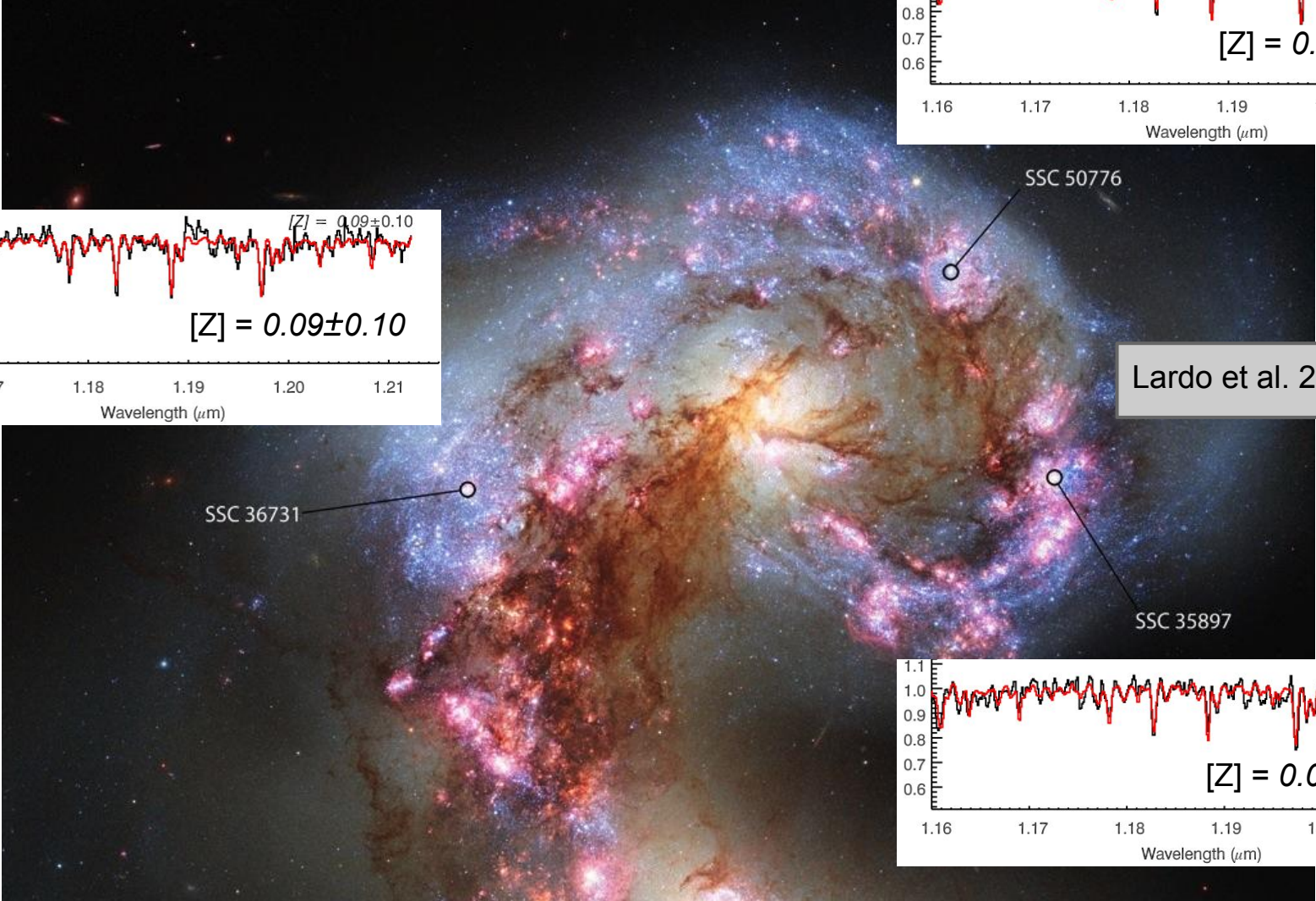
Gazak et al. 2013

Gazak et al. 2015

Patrick et al. 2016



Antennae Galaxy



Lardo et al. 2015