

Extreme Conditions in Compact Dwarf Starburst Galaxies

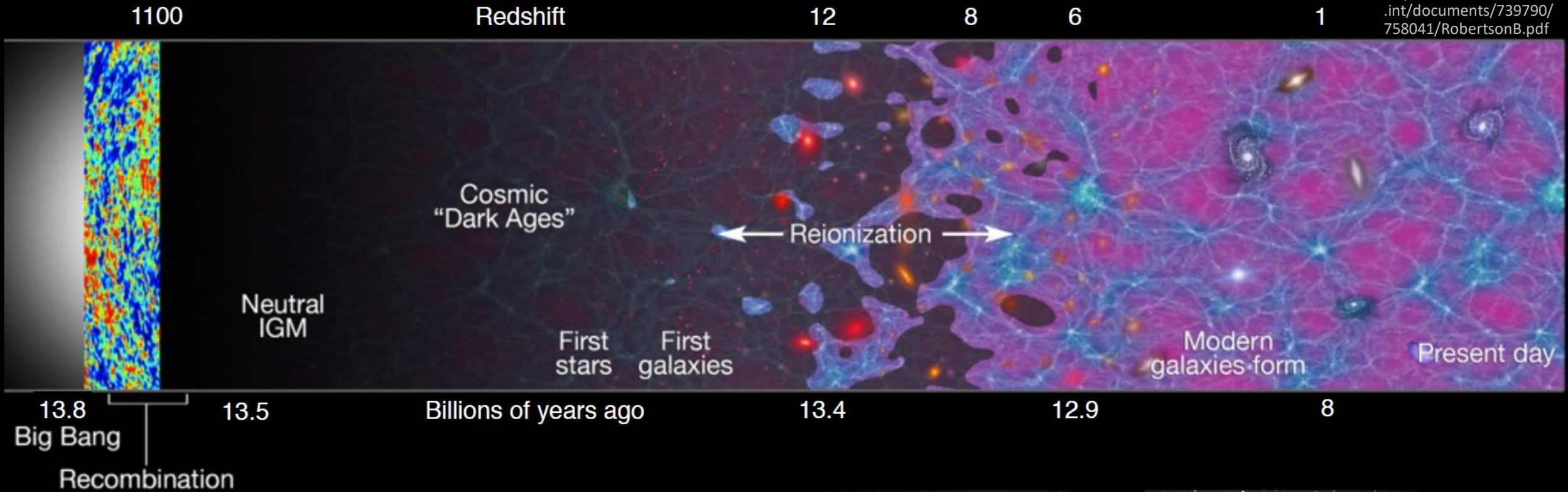
Adam Enders | AIRUB

F6 | Dark Matter and Gas Galaxies

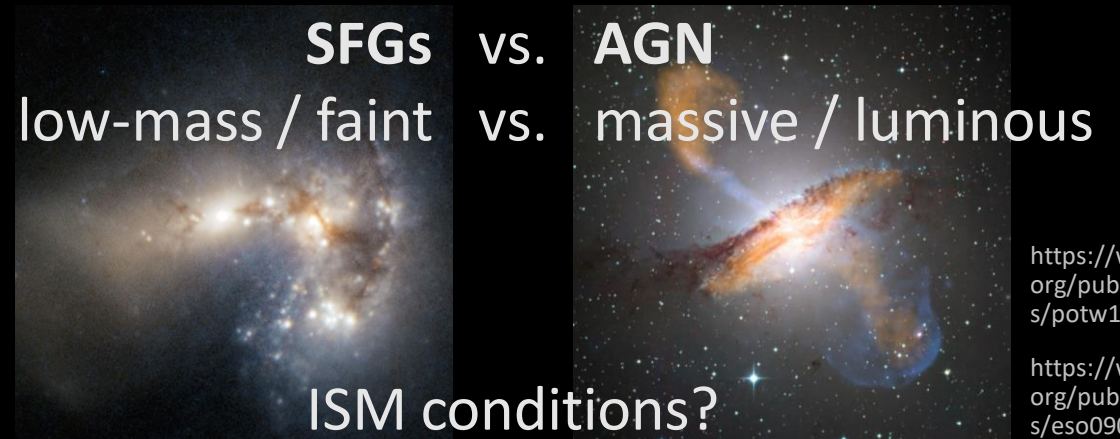
based on Enders et al., 2022, in prep.

Cosmic (Re)ionisation

<https://www.cosmos.esa.int/documents/739790/758041/RobertsonB.pdf>



direct LyC observation impossible at $z > 4$
 \Rightarrow study of **local analogues** required



<https://www.eso.org/public/images/potw1032a/>

<https://www.eso.org/public/images/eso0903a/>

Properties of high-z (analogue) SFGs

Local population of analogues: **LCGs** (Izotov et al., 2011) and **CSFGs** (Izotov et al., 2021)

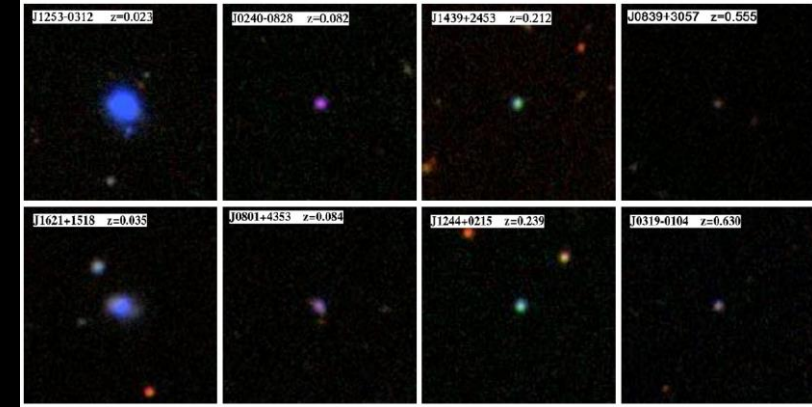
- **low stellar mass**
- **low metallicity**
- **young starburst**
- **compact morphology**

$$M \sim 10^9 M_{\odot}$$

$$\log(O/H) + 12 \sim 8.11 (8.0)$$

$$EW(H\beta) > 50 \text{ \AA} (100 \text{ \AA})$$

$$sSFR \sim 10^{-9} - 10^{-7} \text{ yr}^{-1}$$



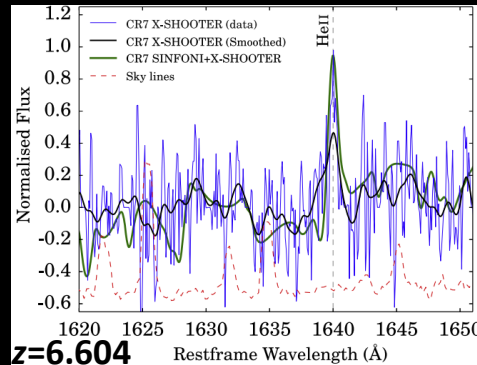
Izotov et al., 2011

Lensed high-z SFGs:

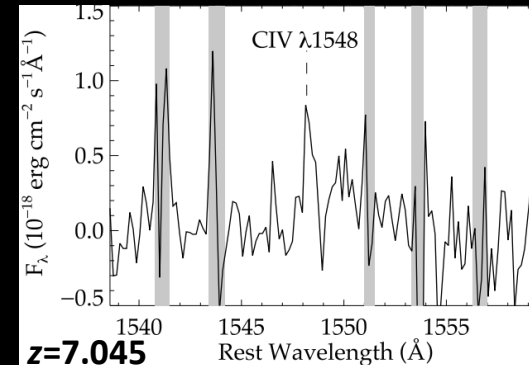
- **high ionisation nebular emission**

$$\Phi_{\text{He}^{2+}} = 54.4 \text{ eV}$$

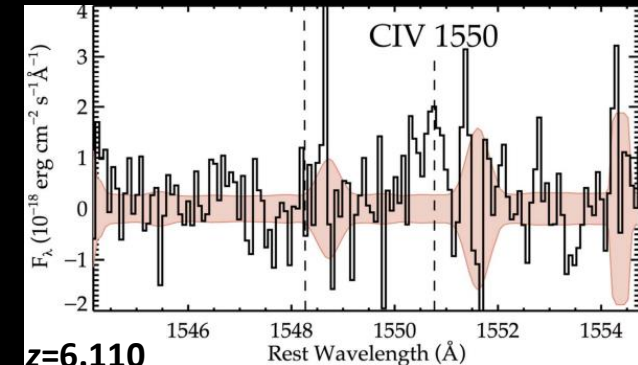
$$\Phi_{\text{C}^{2+}} = 47.9 \text{ eV}$$



Sobral et al., 2015



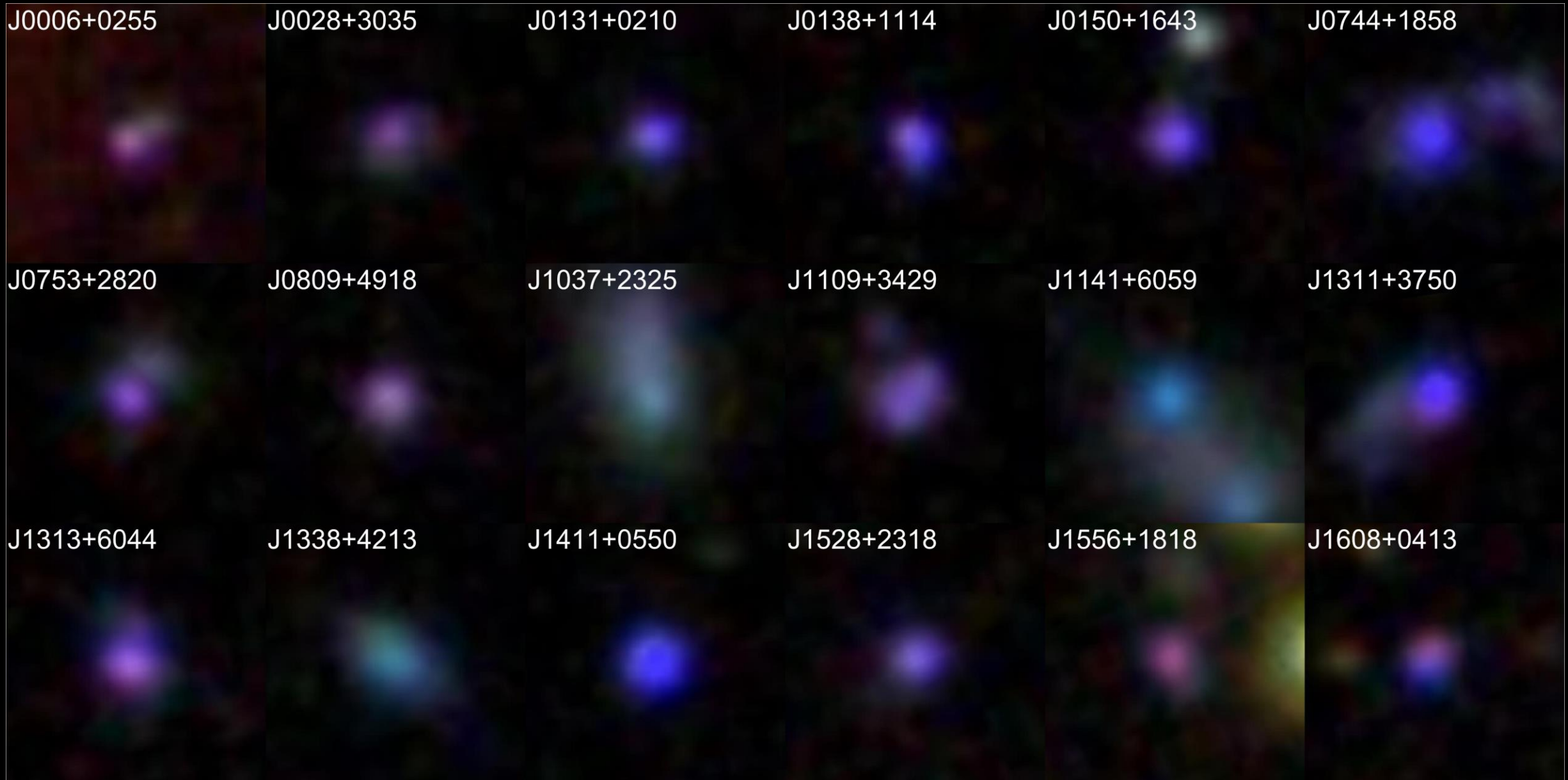
Stark et al., 2015



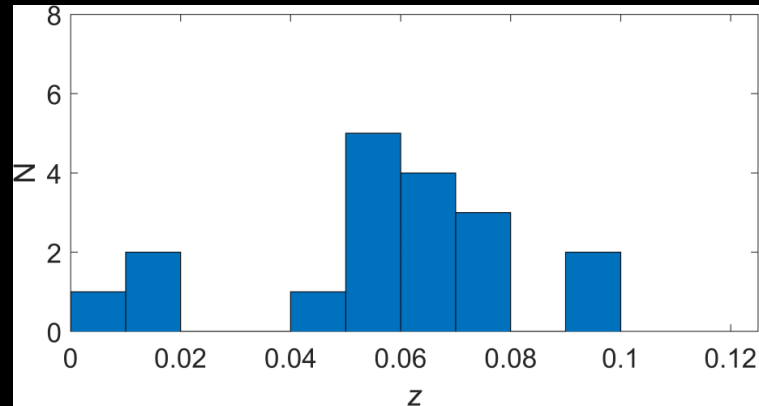
Mainali et al., 2017

⇒ strong motivator for using **He II 4686** as selection criterion

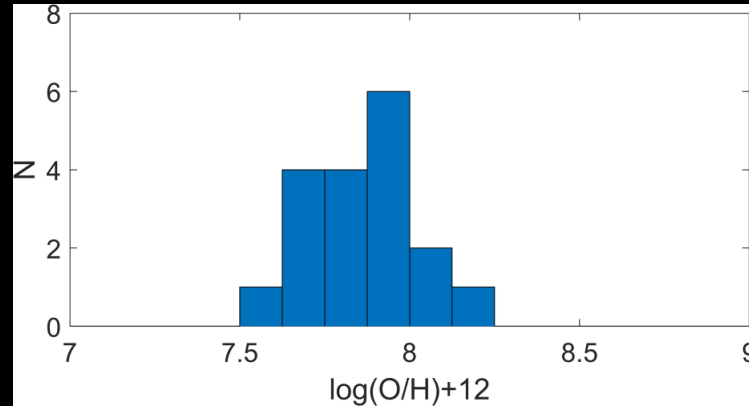
IMPs are compact, ...



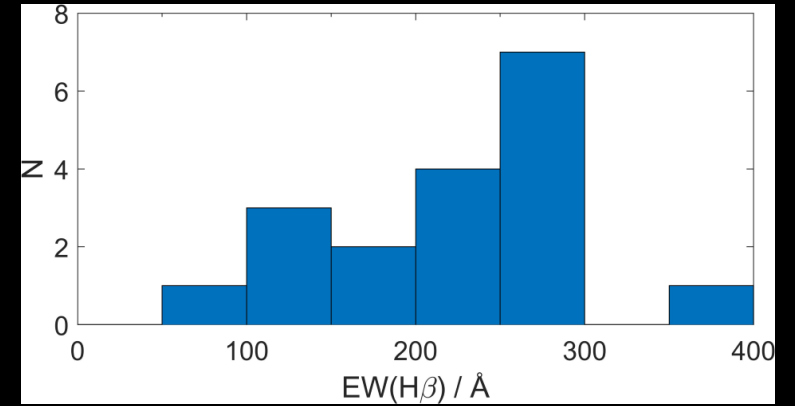
...low-mass, low-metallicity starbursts ...



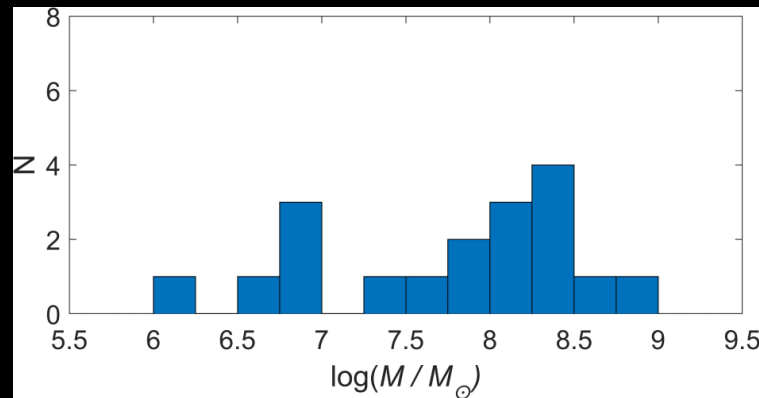
$$\langle z \rangle \sim 0.06$$



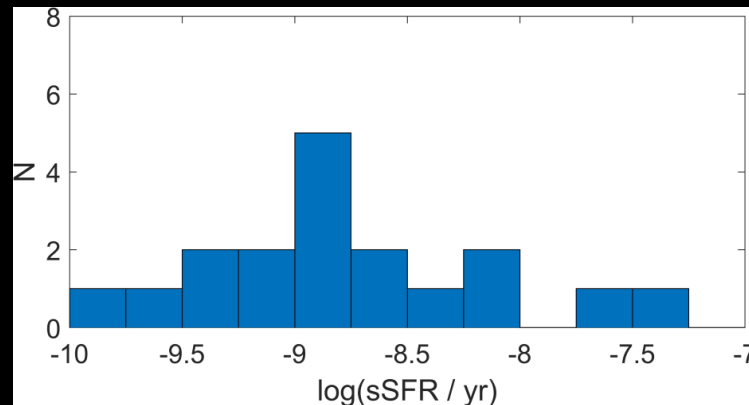
$$\log \langle \text{O}/\text{H} \rangle + 12 \sim 7.88$$



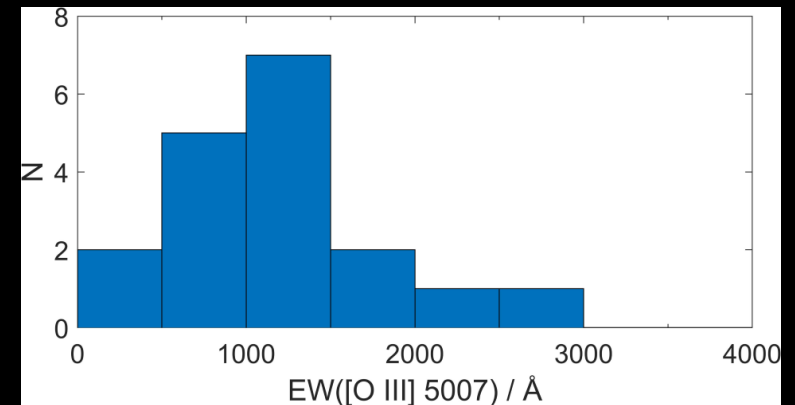
$$\langle \text{EW}(\text{H}\beta) \rangle \sim 230 \text{ \AA}$$



$$\log \langle M/M_{\odot} \rangle \sim 7.97$$



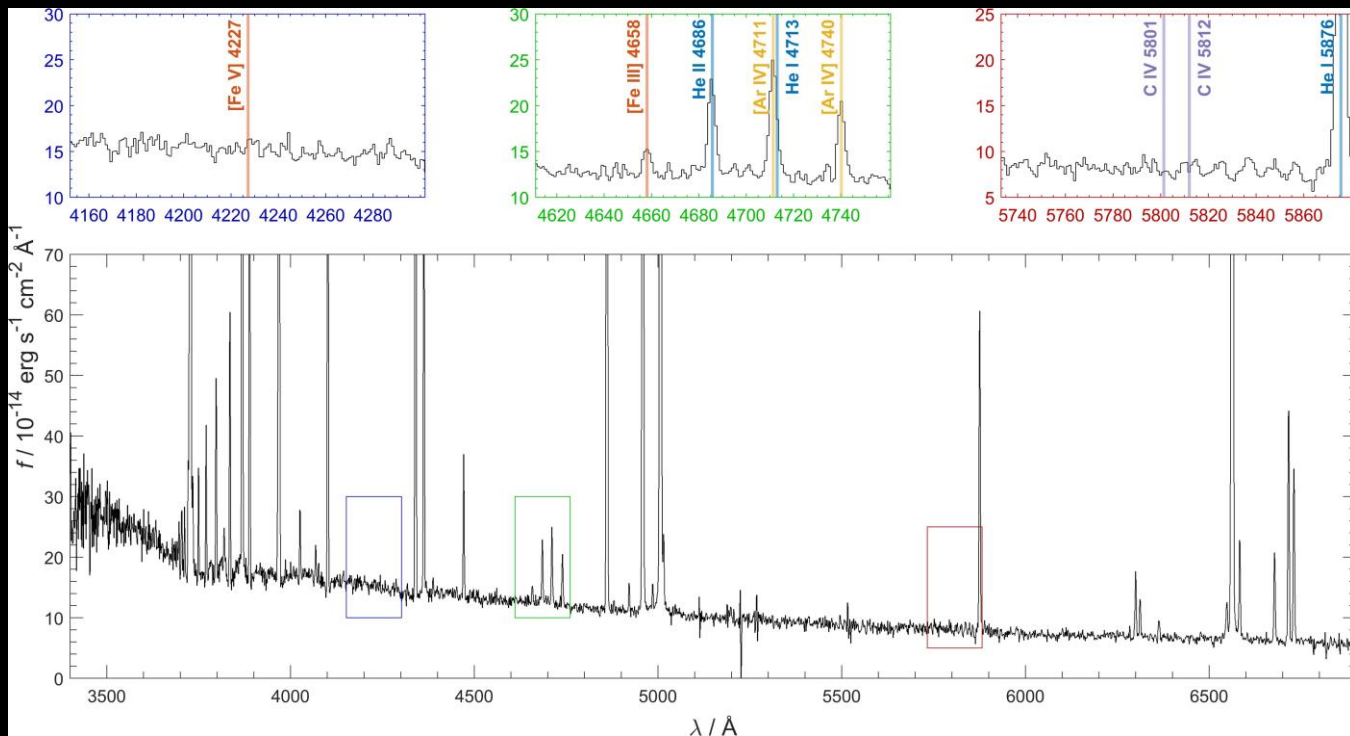
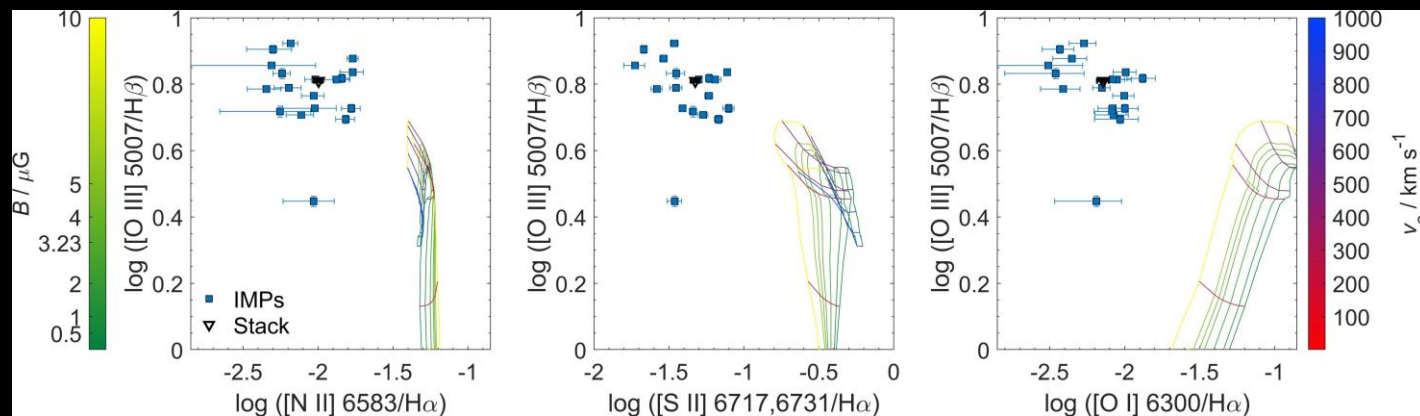
$$\log \langle \text{sSFR}/\text{yr} \rangle \sim -8.97$$



$$\langle \text{EW}([\text{O III}]) \rangle \sim 1200 \text{ \AA}$$

...photoionised by stellar sources...

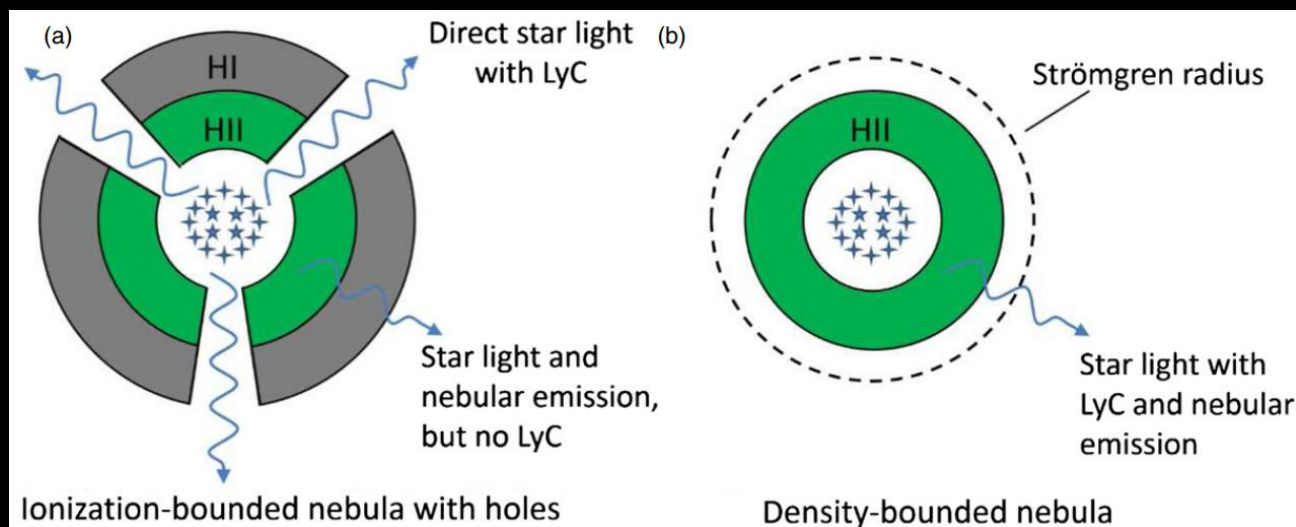
- **AGN** excluded by selection
- no dominant **shock** contribution
- no **Wolf-Rayet** features



⇒ **OB stars** dominate

- HMXBs?
- turbulent mixing layers?
- Superbubble X-Ray emission?

Interlude: ISM Conditions in LCEs

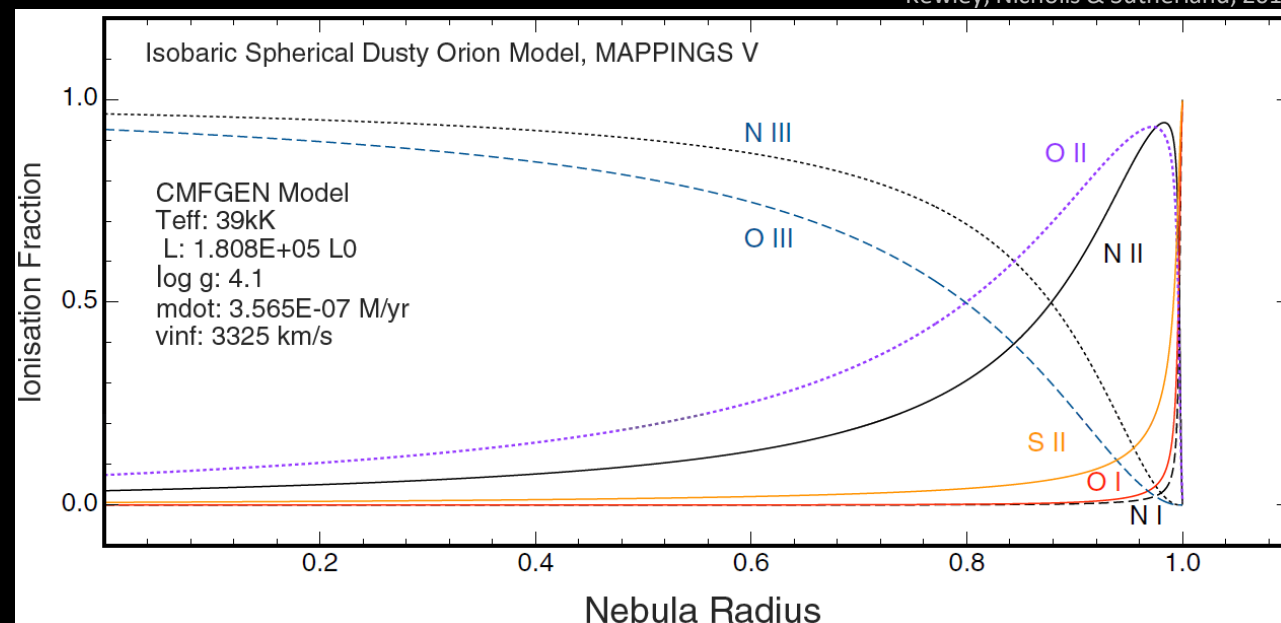


Zackrisson et al. 2013

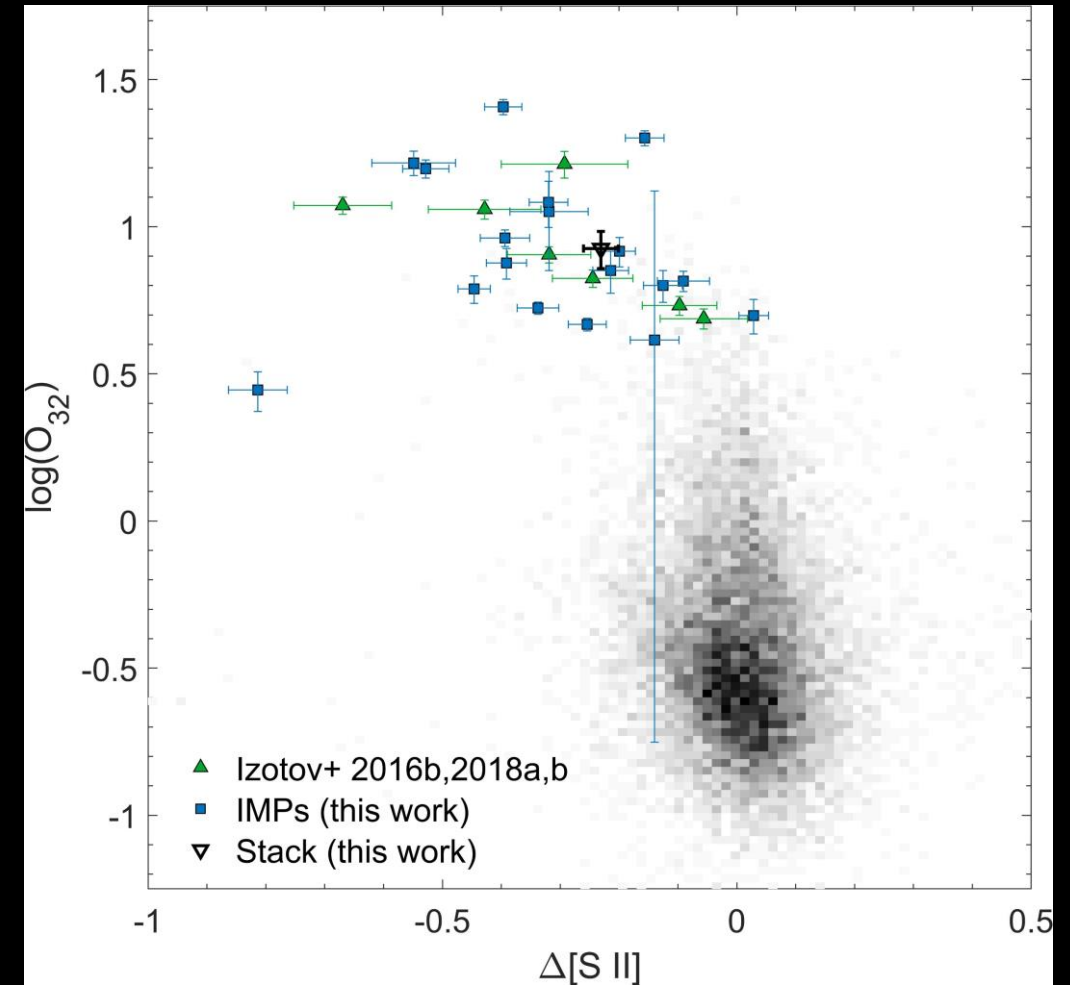
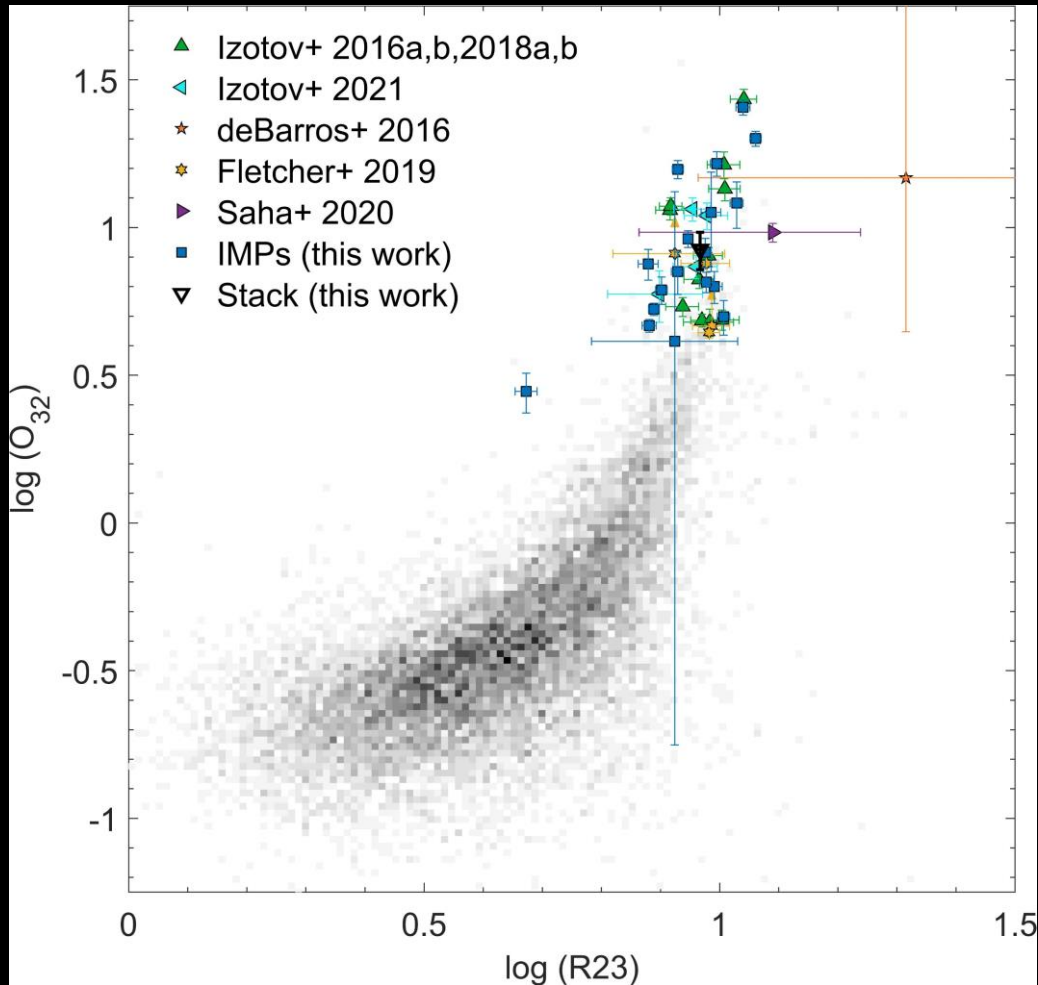
- two(+) scenarios in SF regions:
 - ionisation bounded nebula
 - density bounded nebula
- local variation in ISM structure

- different ions trace different zones of ionisation \Rightarrow **probe for ISM conditions**

Kewley, Nicholls & Sutherland, 2019

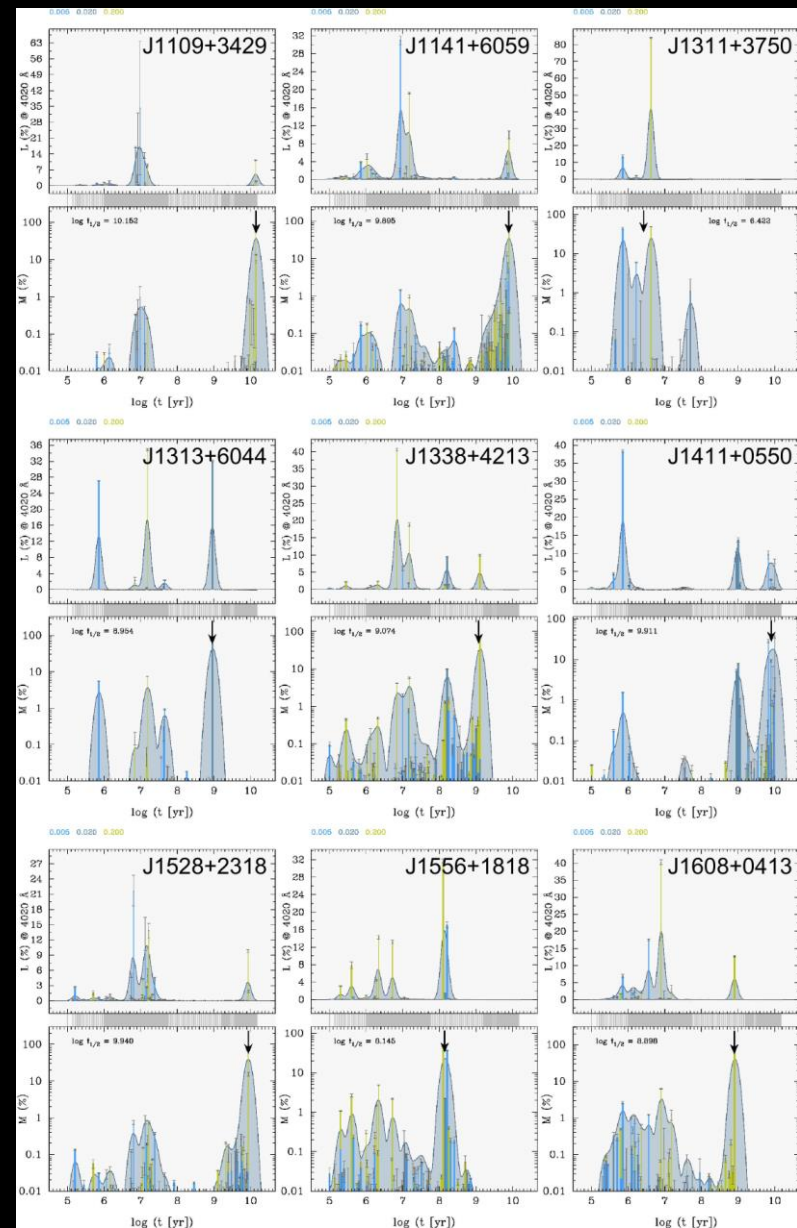
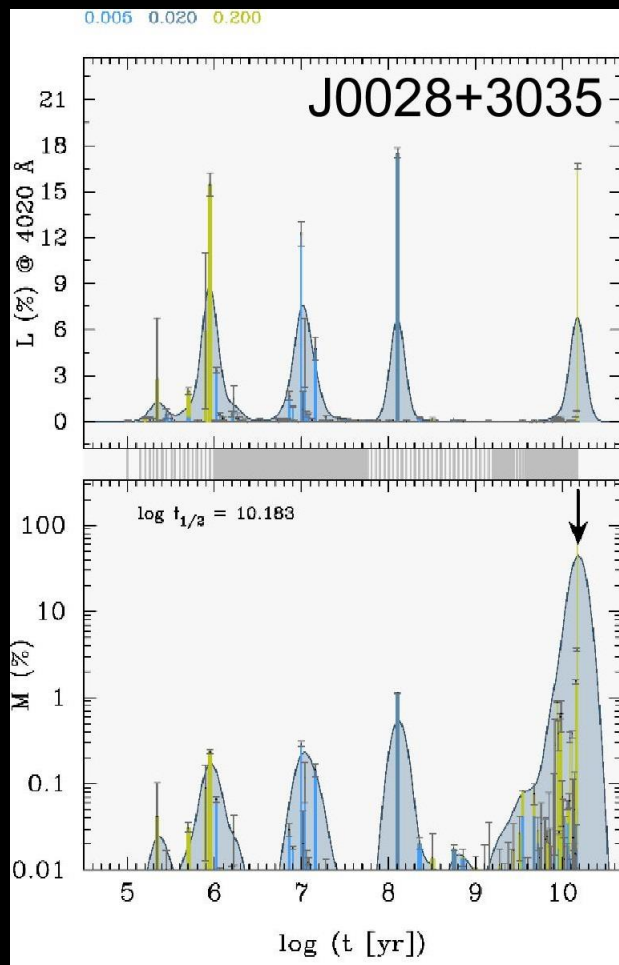
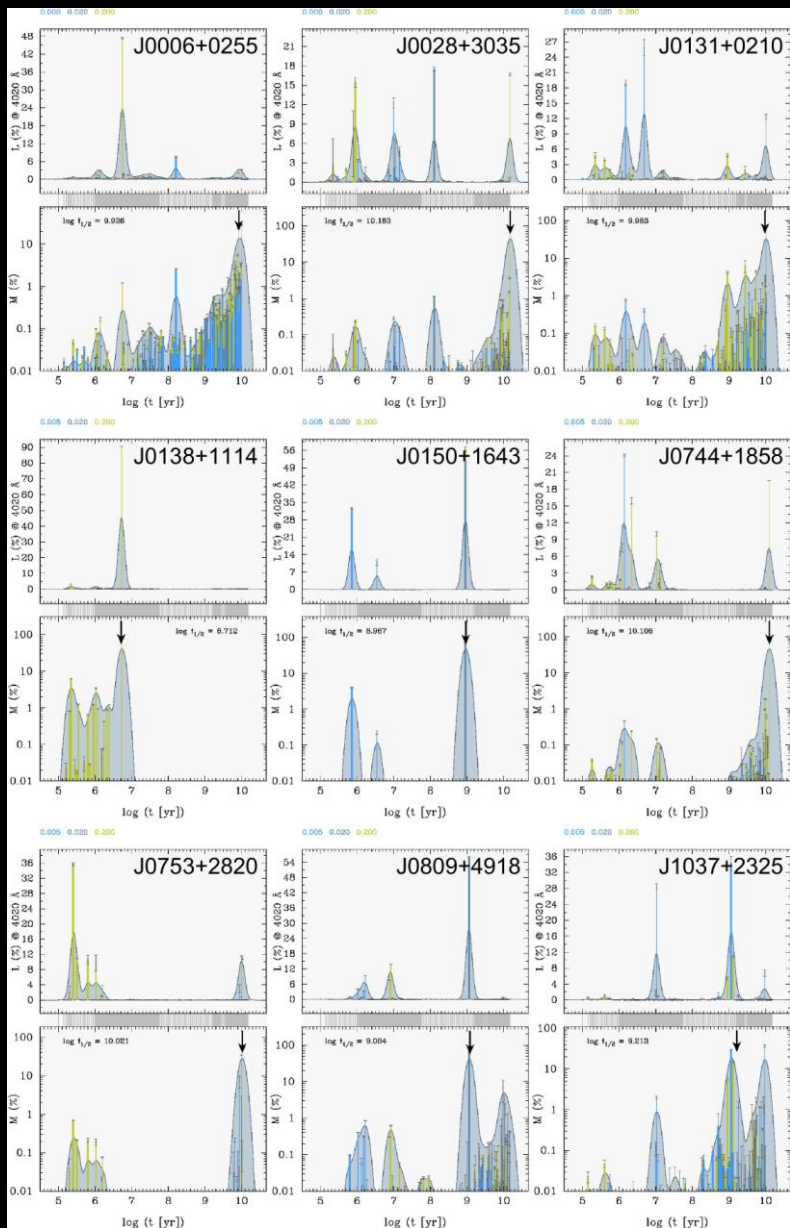


...leaking LyC photons?



- O_{32} , He II: **highly ionised** ISM
- O_{32} , $\Delta[S II]$: **density-bounded** conditions

Star-Formation Histories



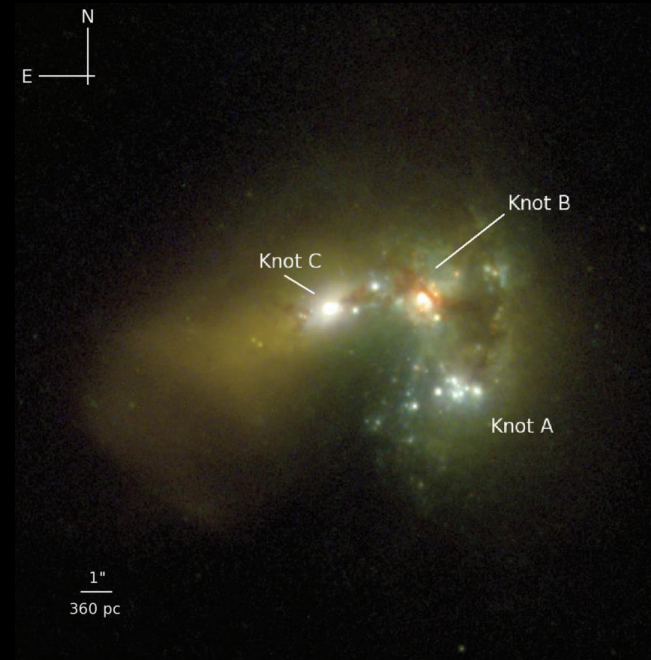
- young, multi-stage starburst
- similar to other candidate LCEs

IMPs in CIM: A2

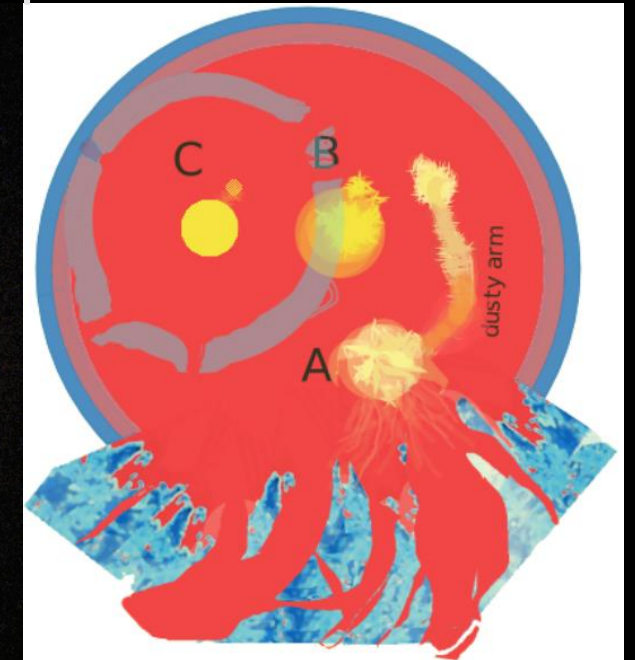
$$\frac{\partial n_i}{\partial t} = \nabla (D_i \nabla n_i) - \nabla \vec{u} n_i + \dots + Q_i$$

- SFH \Rightarrow cumulative SNe
 - temporal peaks in **source term**
- Outflow
 - strong **advective term**
- (relatively) low- $z \Rightarrow$ **LOFAR**
 - resolve magnetic field structure?
 - resolve galactic wind?

Haro 11 Superbubble:

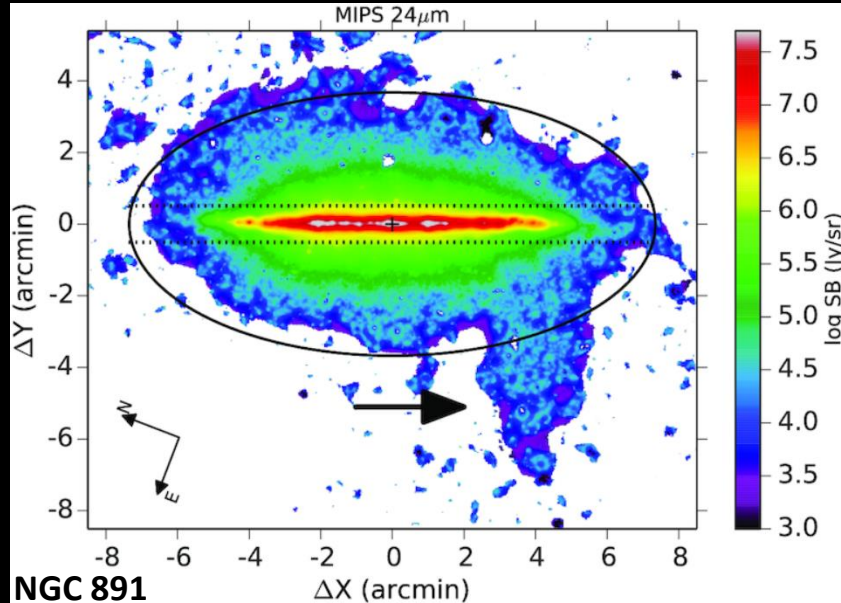


Adamo et al., 2010



Menacho et al., 2019

IMPs in CIM: F6

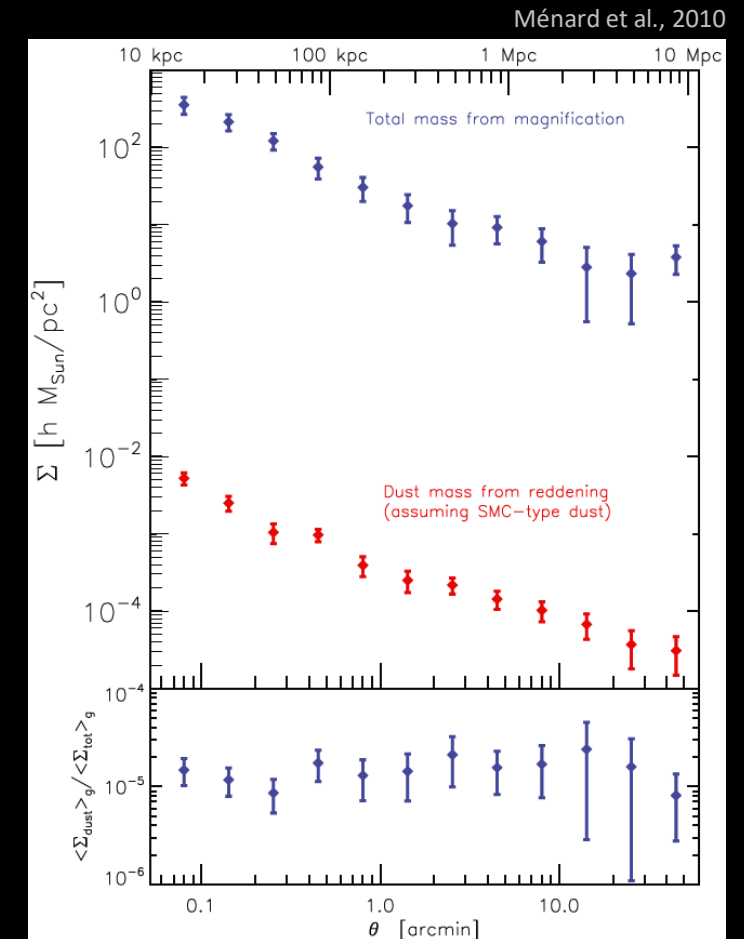


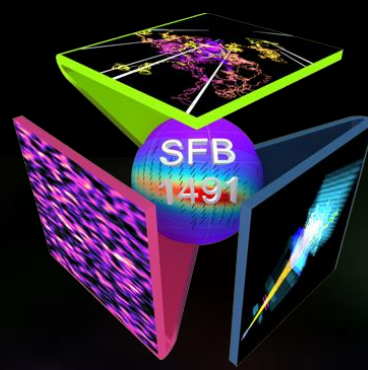
Yoon et al., 2020

- F6 (partial) goal: characterise **baryonic haloes**
 - down to low masses...
 - ...and large scale heights

- Feedback Processes

- halo morphology
- transport, creation and destruction of dust
- transport of metals





Thank you for your attention!

Talk (AIRUB / Science Seminar):

"IMPs from He II: Local Lyman Continuum Leaker Candidates from SDSS III/BOSS"

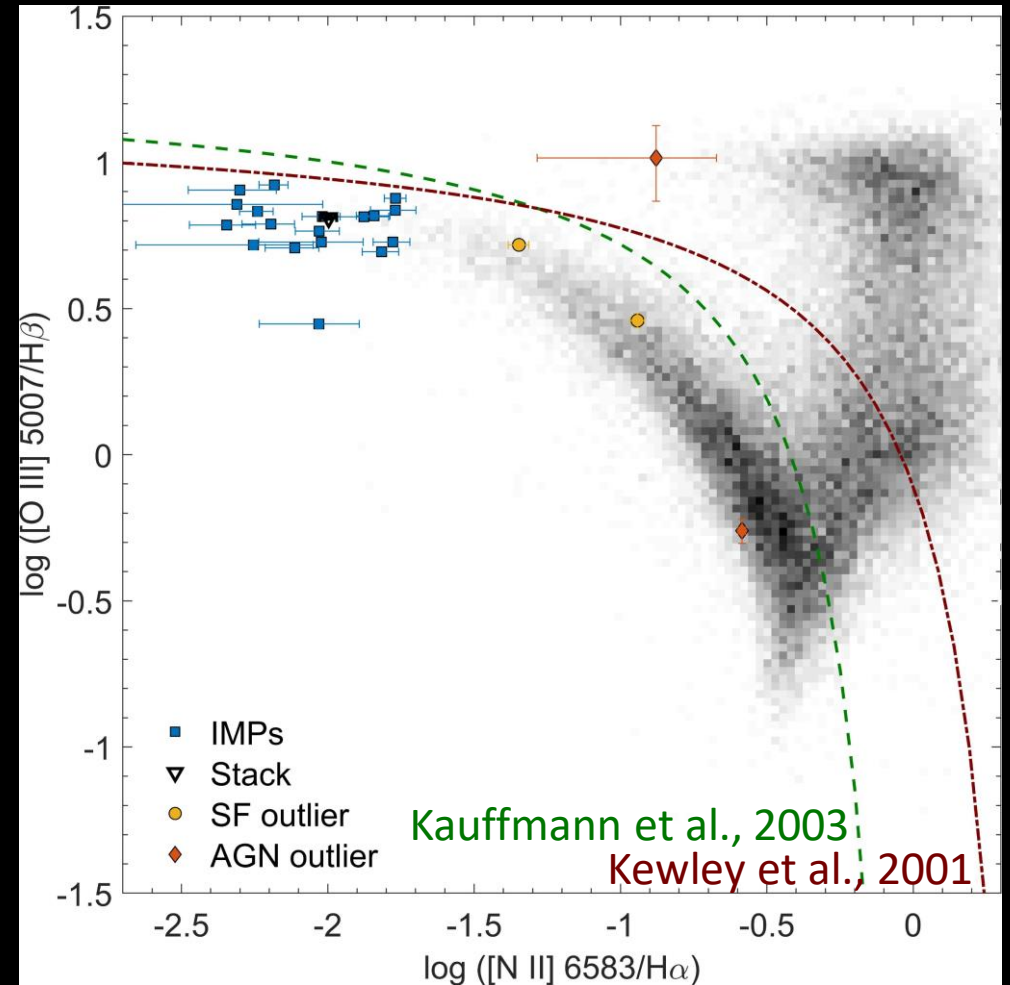
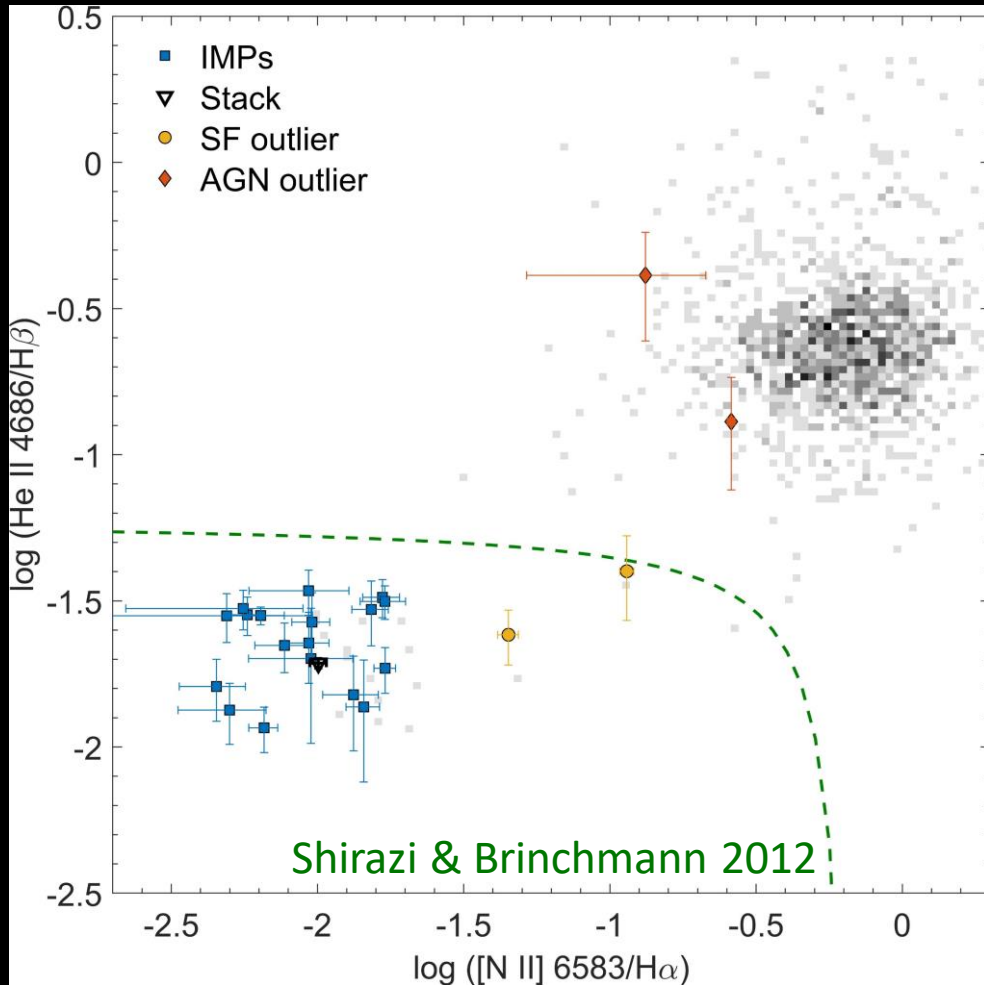
Wed June 15th, 10:15

GAFO 03 / 252

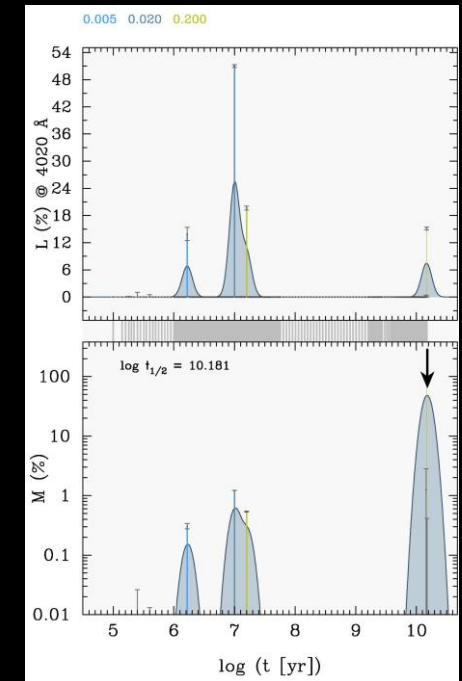
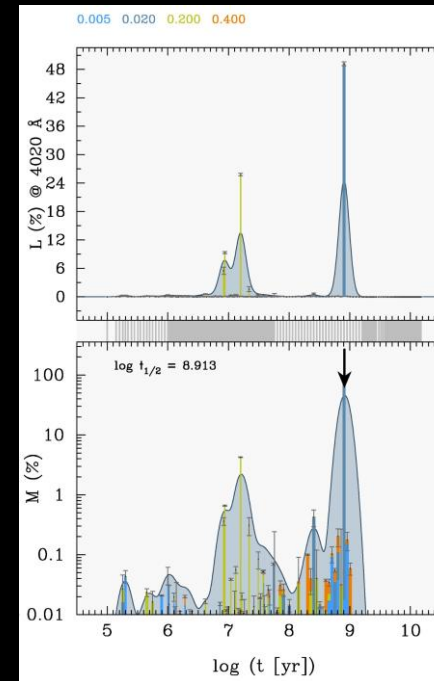
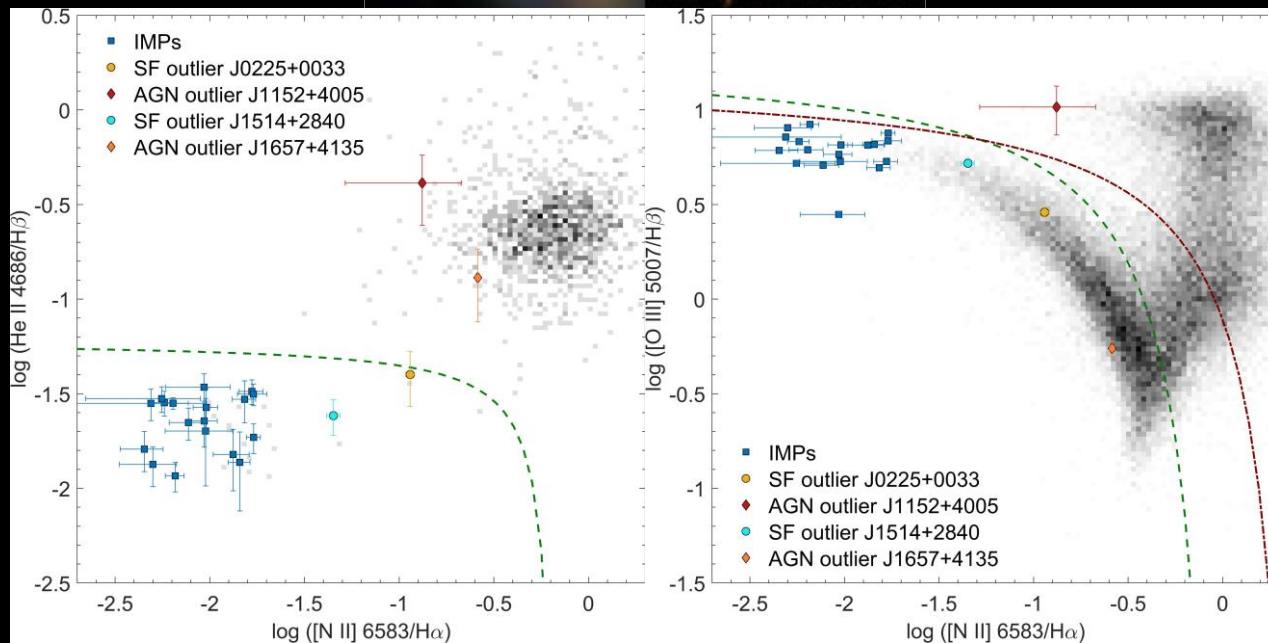
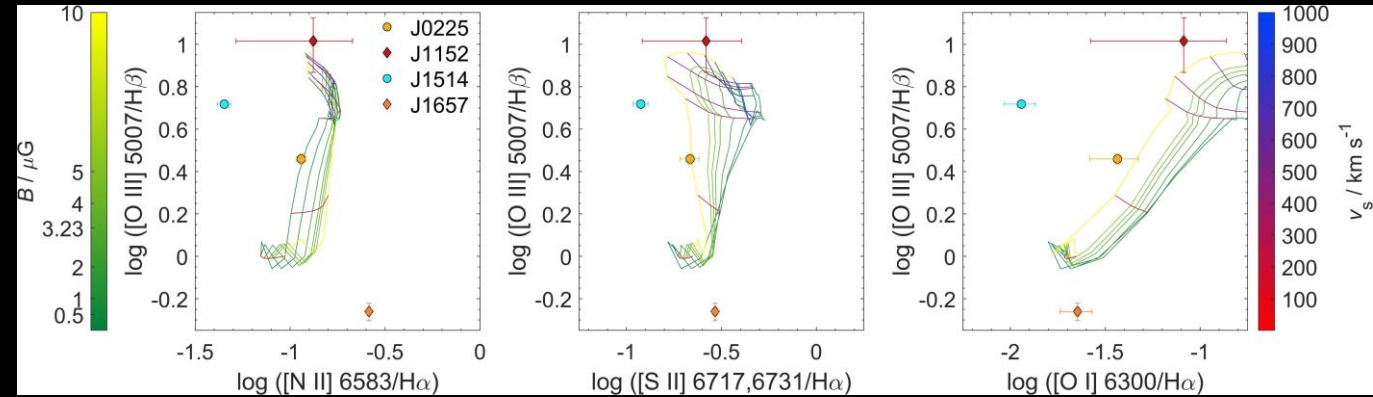
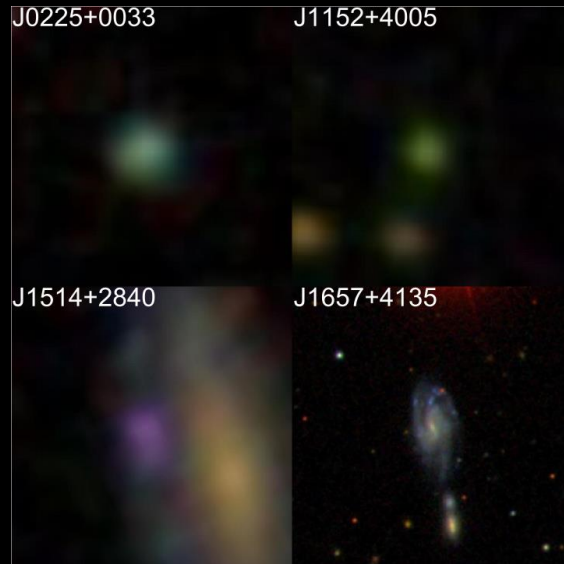
and via Zoom (mail to enders@astro.rub.de)

Ancillary Slide I: Sample Selection

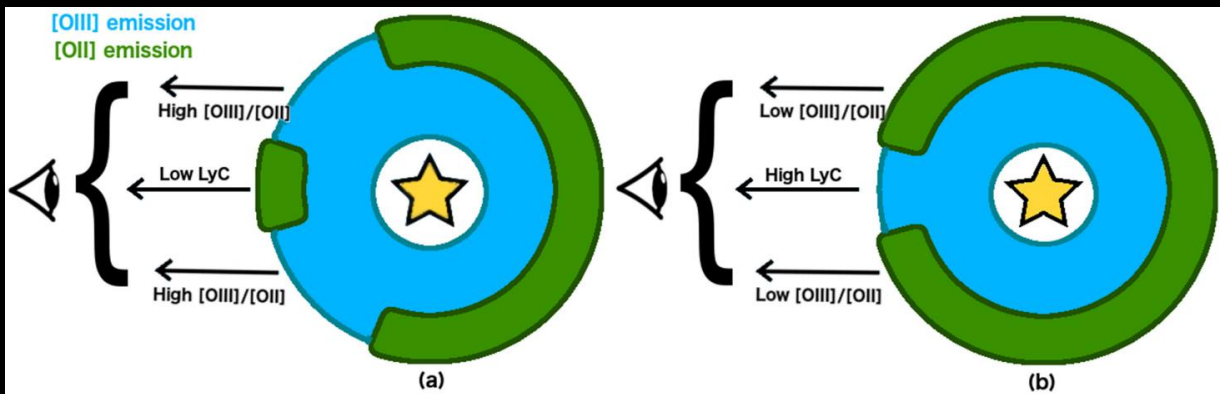
- 1508 He II 4686 emission line galaxies in SDSS DR12
- 18 "pure" SFGs: **IMPs** (Ionized, Metal-Poor Galaxies)



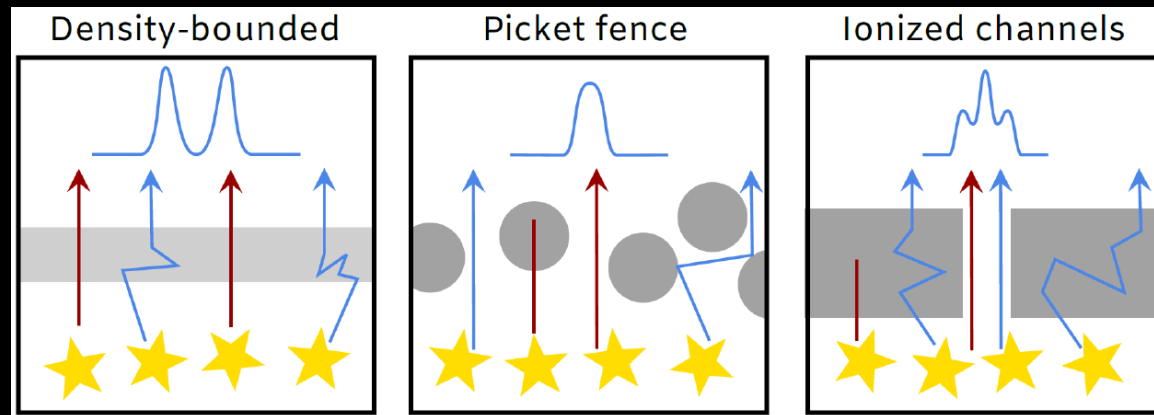
Ancillary Slide II: Outlier Galaxies



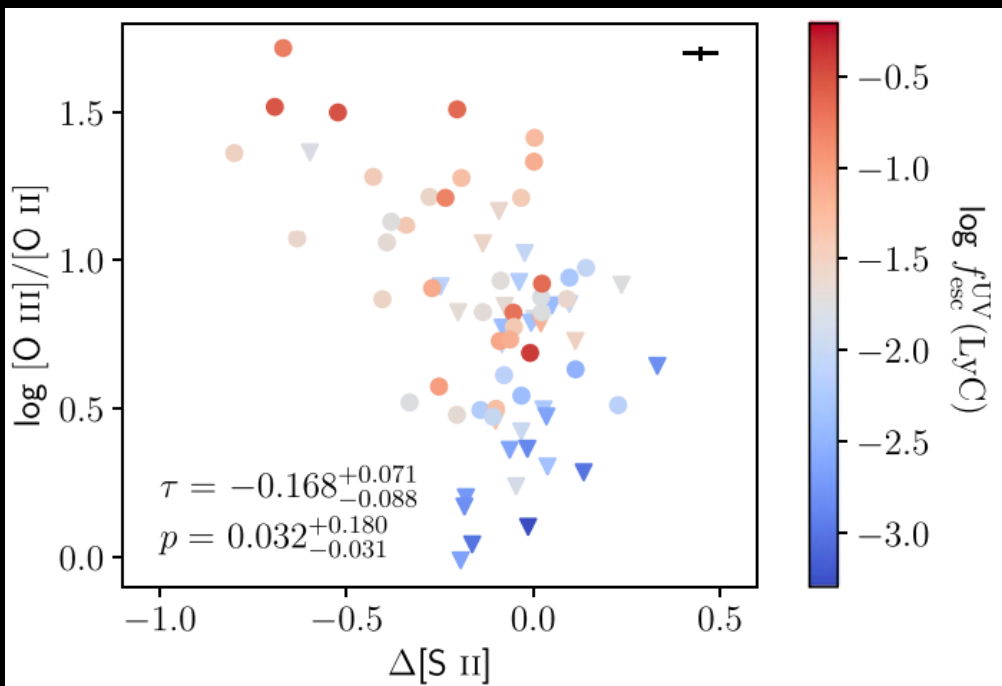
Ancillary Slide III: ISM Conditions I



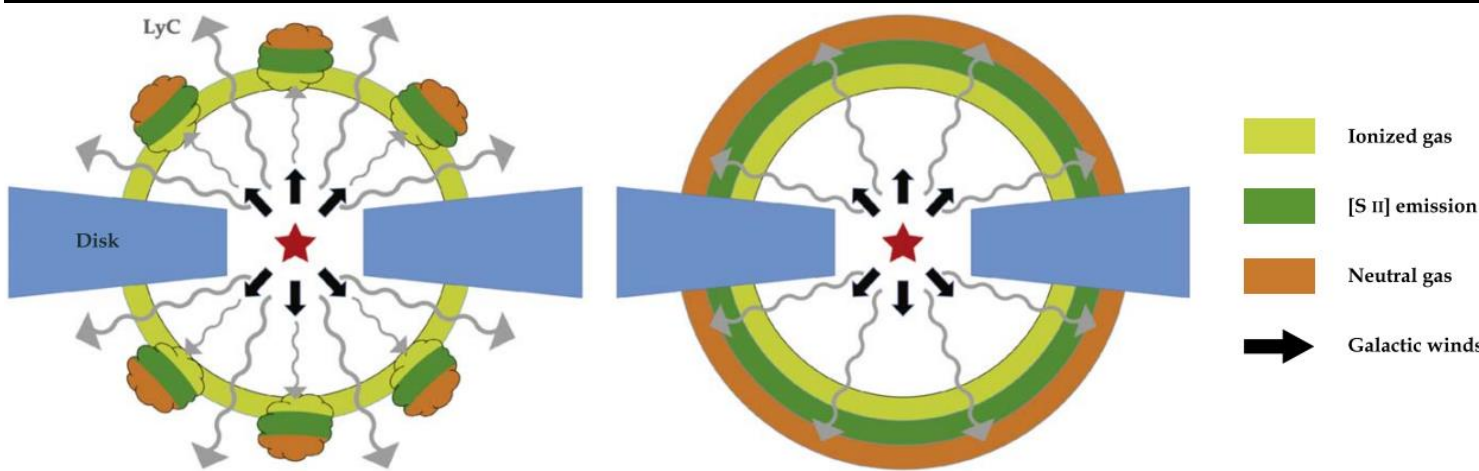
Bassett et al., 2019



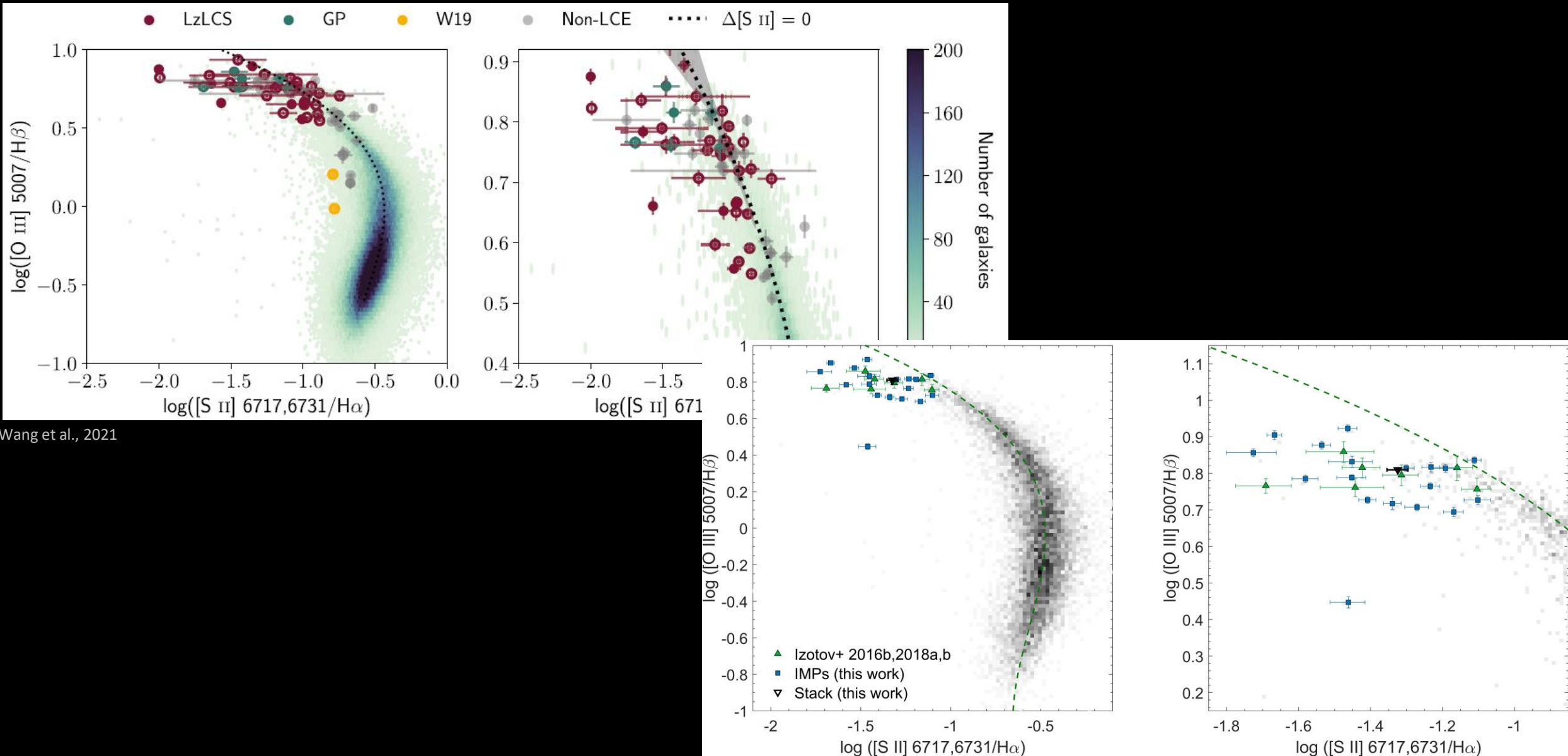
Rivera-Thorsen et al., 2017



Wang et al., 2021

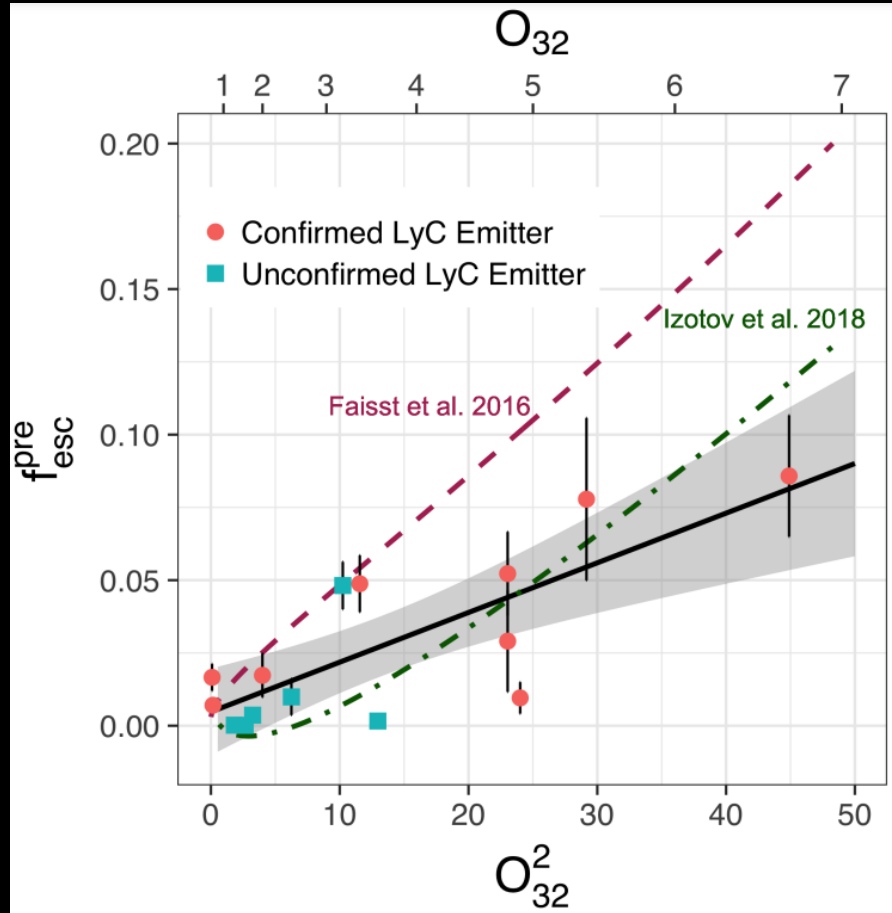


Ancillary Slide IV: ISM Conditions II

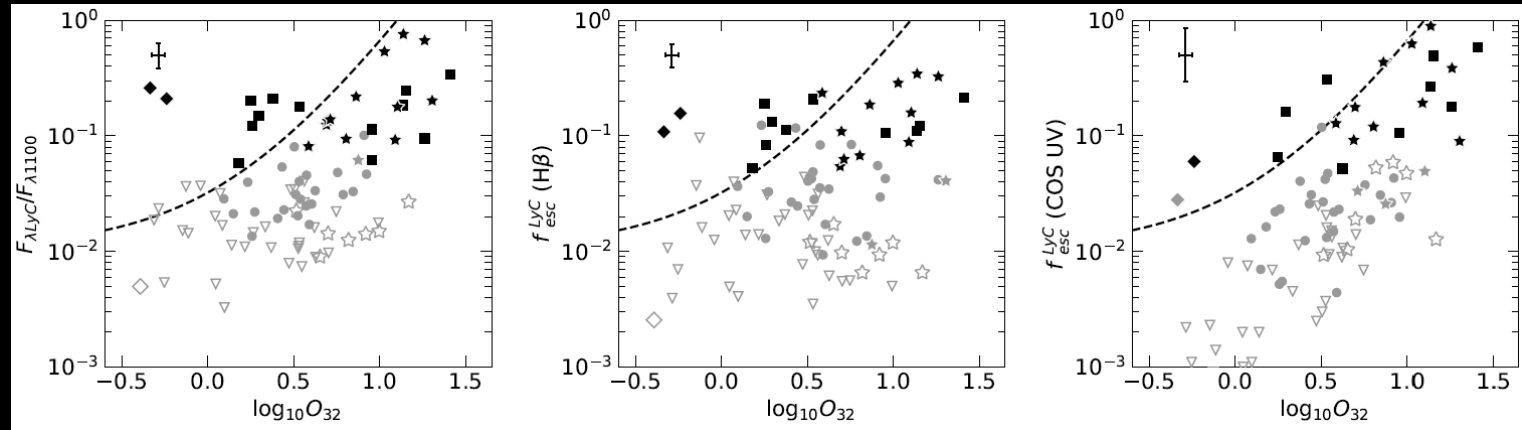


Wang et al., 2021

Ancillary Slide V: f_{esc}

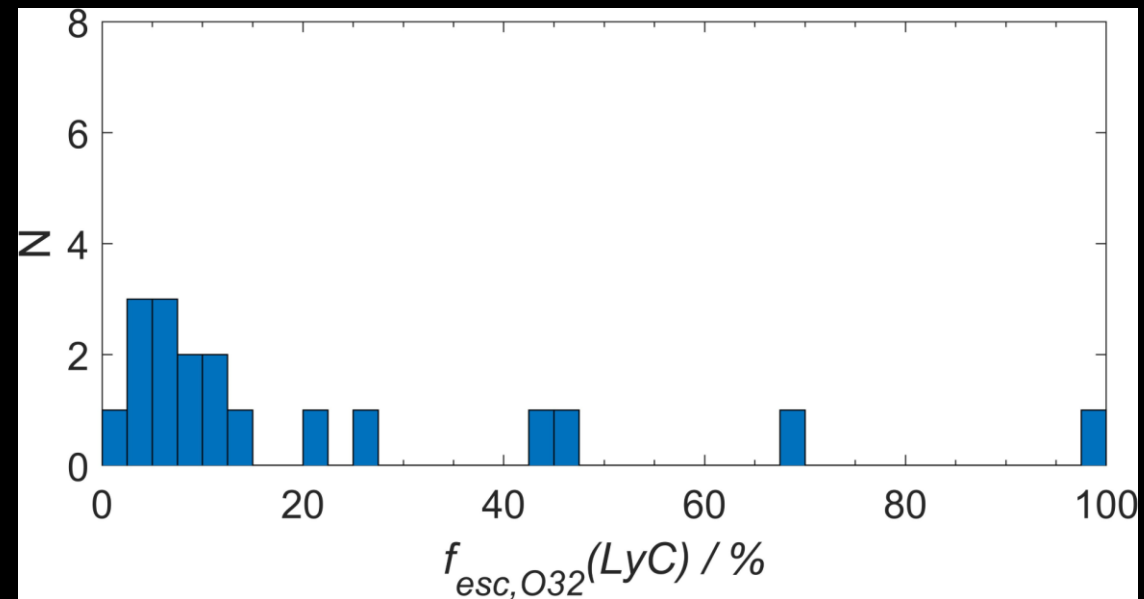


Chisholm et al., 2018



Flury et al., 2022

$f_{\text{esc}}(\text{LyC})$ of the IMPs:



Ancillary Slide VI: Future Prospects

- deeper optical spectra
 - other high ionization lines
 - chemical enrichment history
- UV spectra

- Mg II $\lambda\lambda 2796, 2803$ (Chisholm et al., 2020)
- Residual flux in absorption lines (Heckman et al., 2001)
- UV slope β / $EW(H\beta)$ (Zackrisson et al., 2013)
- Ly α (Verhamme et al., 2015)

https://www.esa.int/ESA_Multi-media/Images/2012/12/Hubble



- direct LyC observation



<https://www.nasa.gov/topics/universe/features/lbti20101206-i.html>