Lyman radiation from Tol1214-277 and ionised halos

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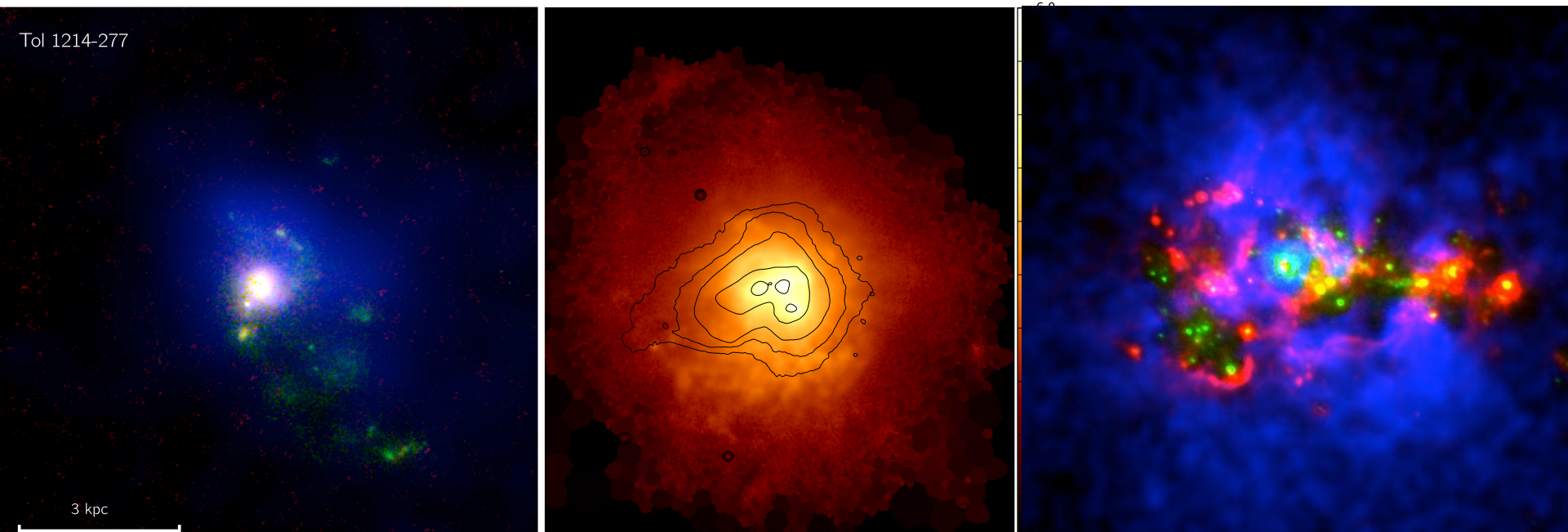
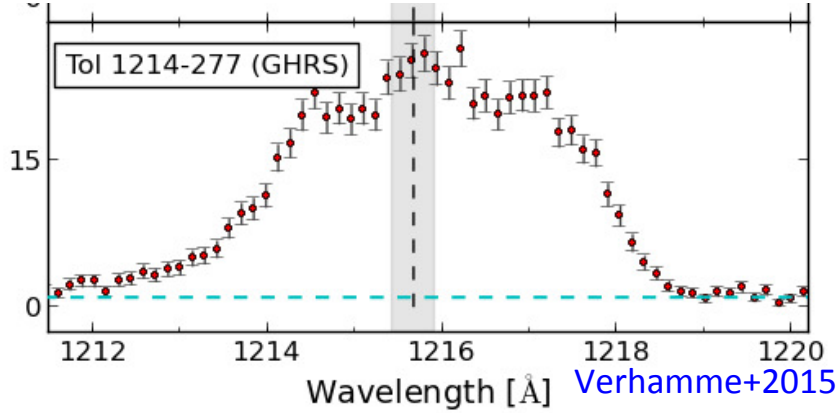
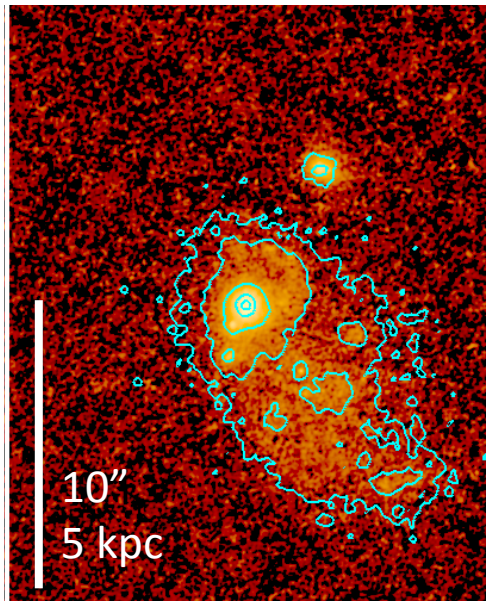


Tol 1214-217 (Tololo 21) – another odd ball?

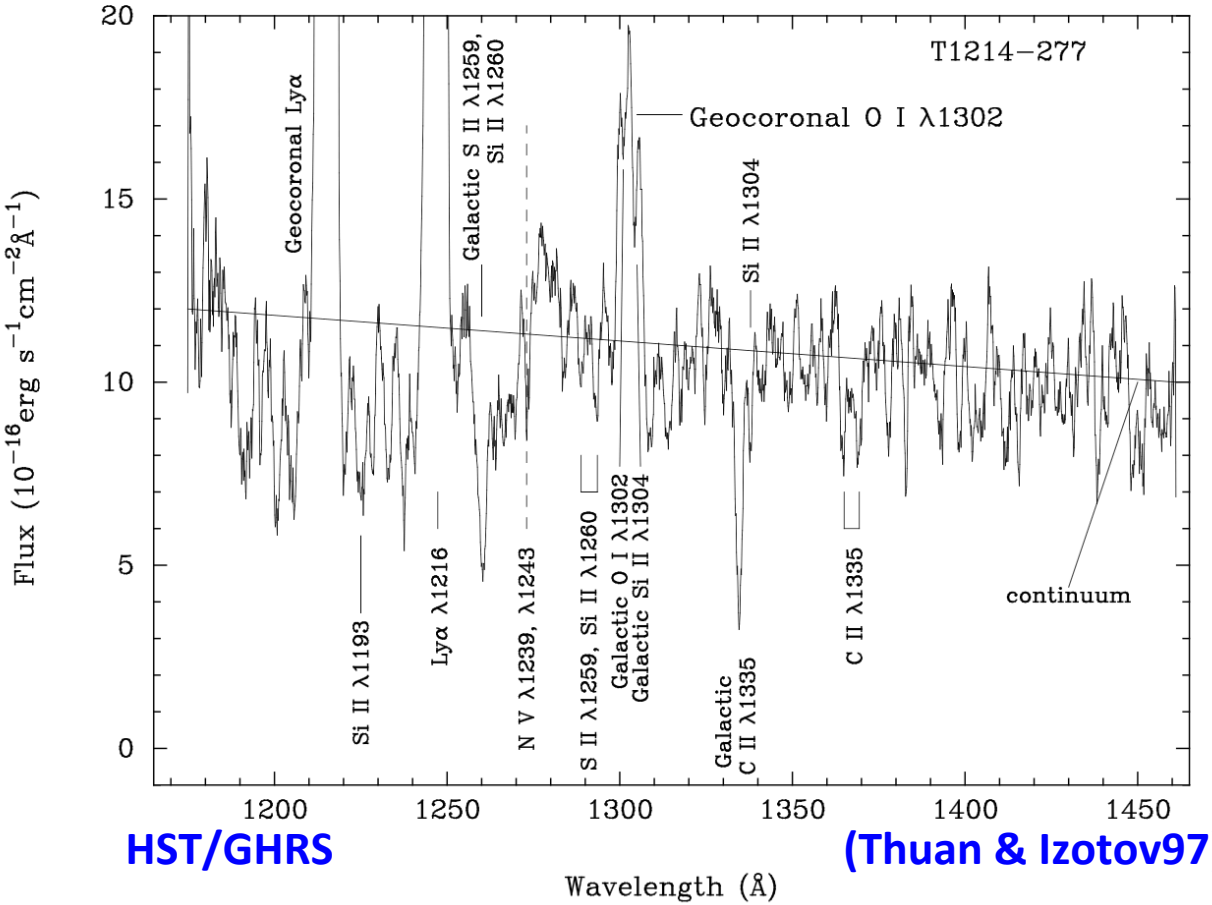
z=0.026, [O/H]=5% ⊙, M_{FUV}=-16
Lowest Z Lyα emitter
'symmetric Lyα profile'
Cometary BCG



Verhamme+2015



HST/F775W + FUV contour



HST/GHRS **(Thuan & Izotov97)**

Tol 1214-217 (Tololo 21)

GHRS (Thuan & Izotov 1997, Verhamme 2015) R=1000

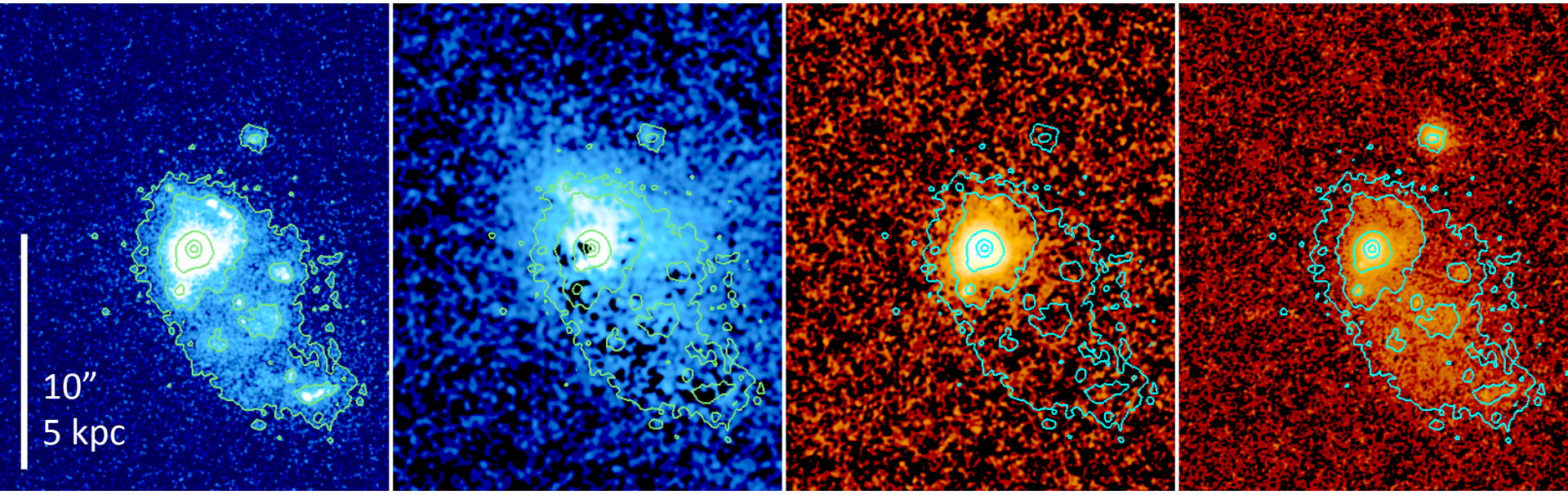
- Lyα 'symmetric' and centered at systemic velocity -> Lyman continuum escape?

- Forero-Romero+2017

Reobserve with HST !

HST/COS/G140M targetting Lyα and ISM absorption lines (e.g. SiII, SiIV)

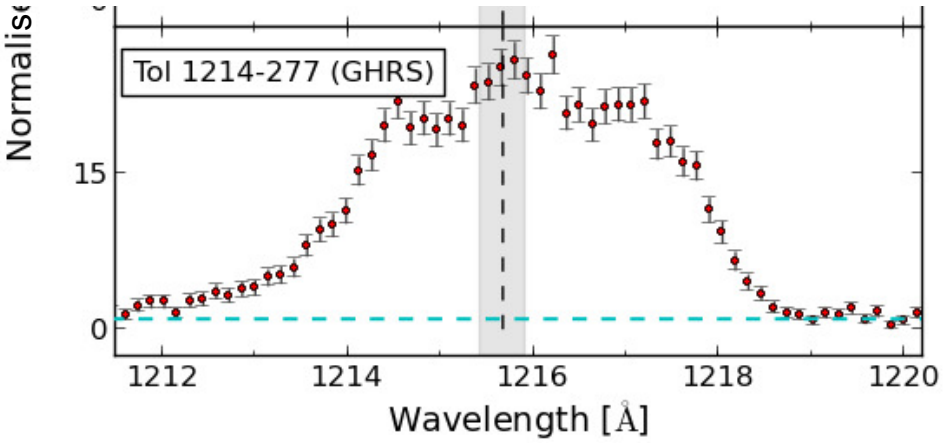
HST imaging in Lyα, Hα, Hβ, [OII], [OIII], FUV, u, b & i (ACS/SBC and WFC3/UVIS)



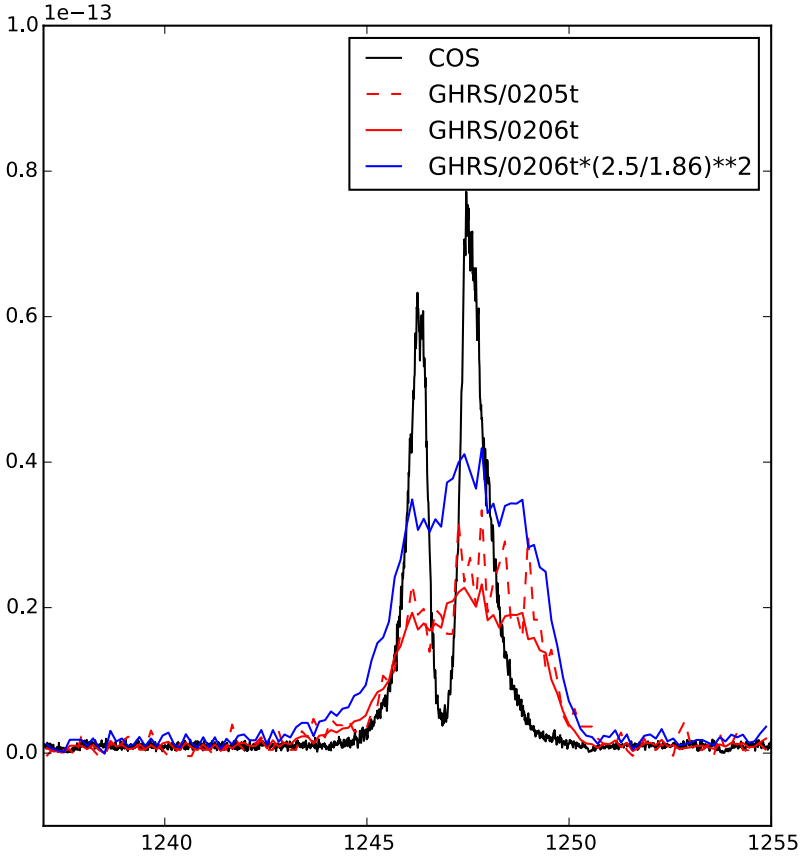
1500 Å Lyα [OIII]5007 *i* (F775W)

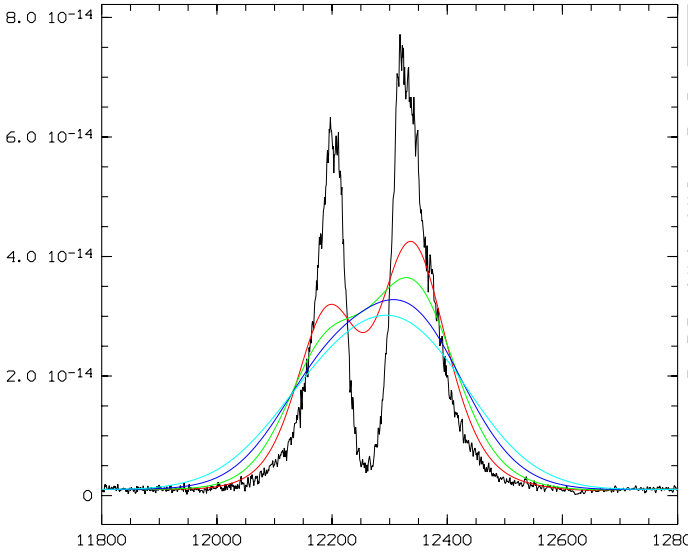
1500 Å contours in all images

Tol 21: only symmetric Lya in local universe…?



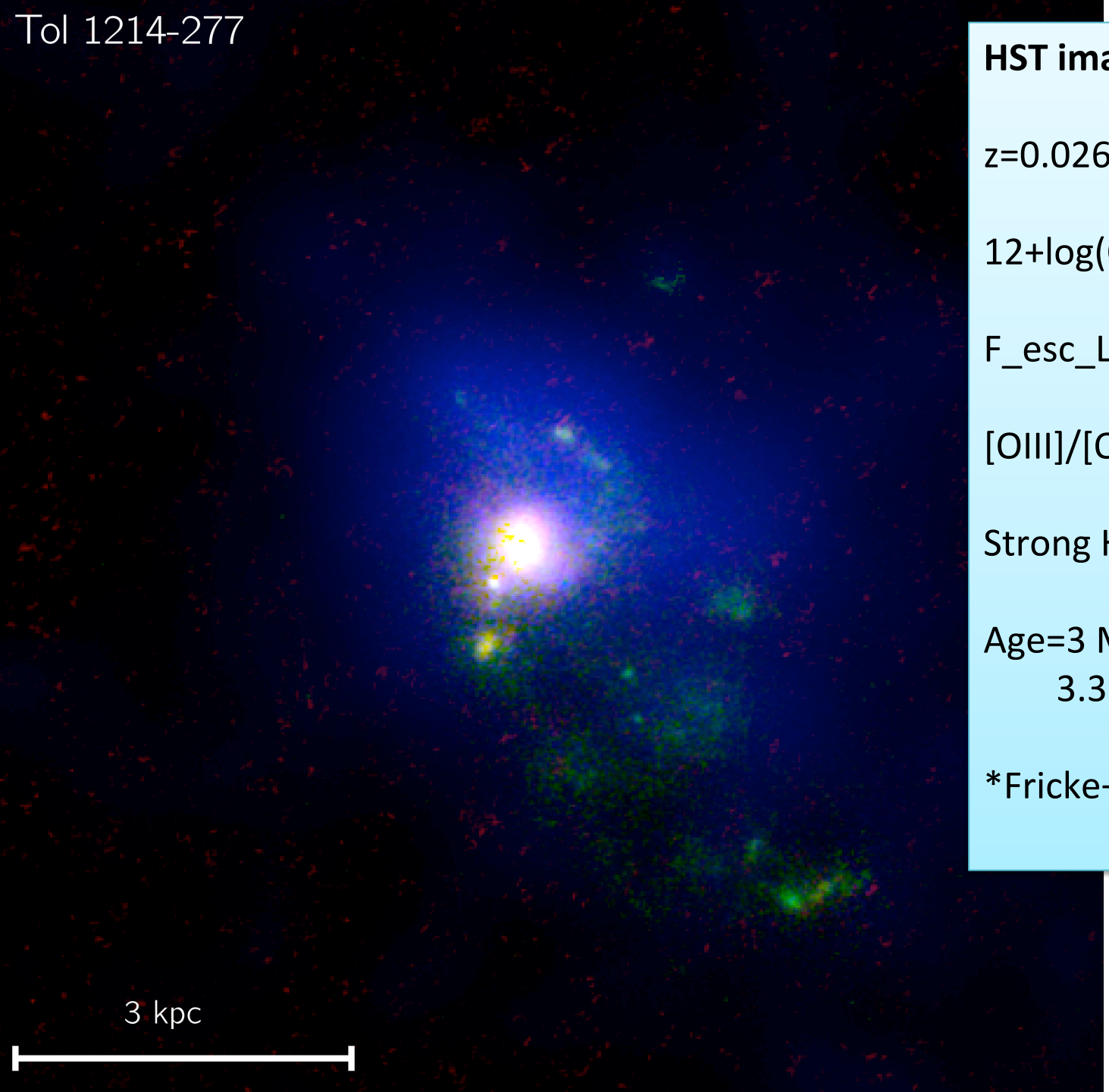
Comparison COS vs GHRS →





← **Smothing the COS spectrum to GHRS resolution**

- Odd spectrum caused by low R and poor S/N



HST imaging & COS spec

z=0.026

12+log(O/H)=7.52 (*)

F_esc_Lya=30% global

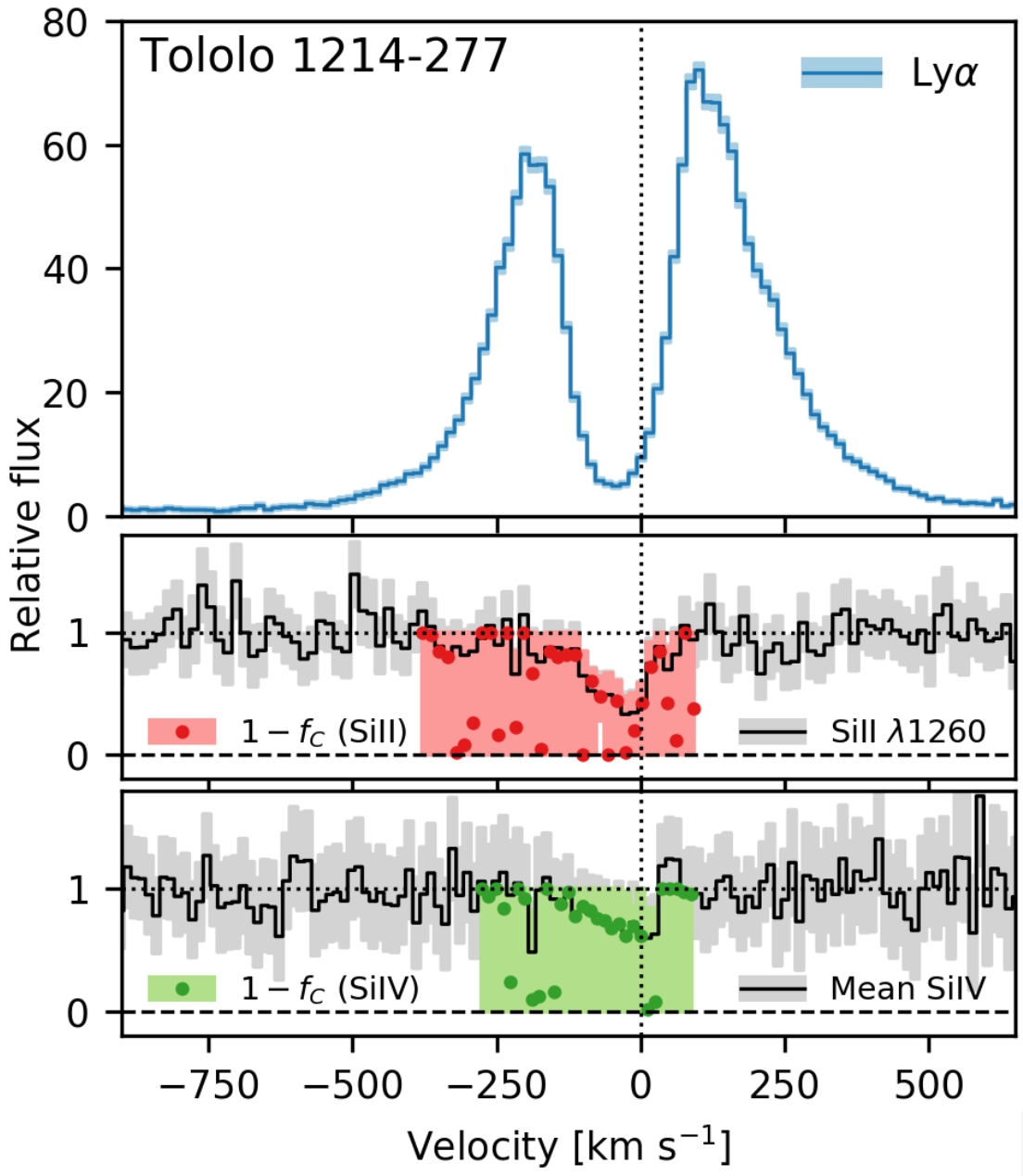
[OIII]/[OII]=19.3 COS

Strong HeII4686, 5% of Hβ*

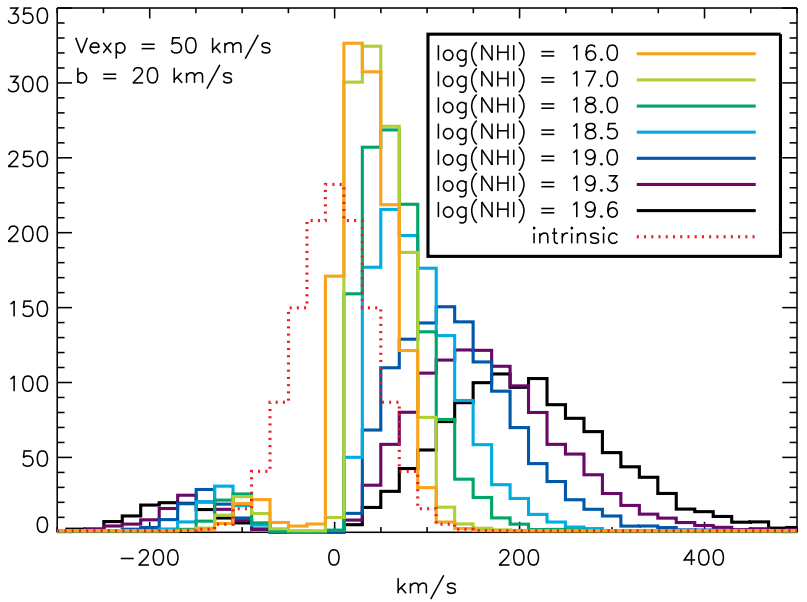
Age=3 Myr (SED)
3.3 Myr (WR-stars,*)

*Fricke+2001

Comparing Lyα and ISM absorption lines



Homogeneous shell models (Verhamme)

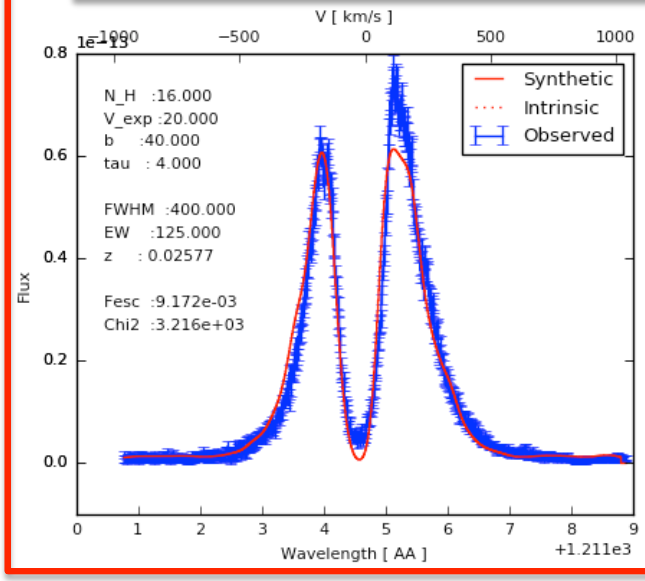


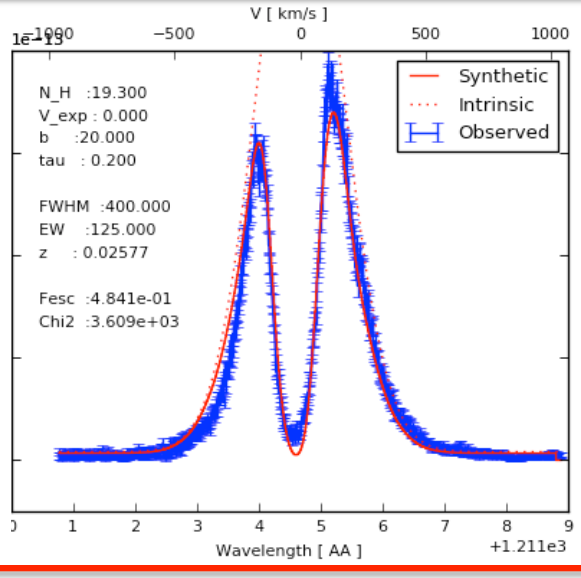
V_min_Lyα= -43 km/s
V_min_SiII ≈ -26 km/s
V_red = 99 km/s
V_blue = -199 km/s
FWHM_red= 160 km/s
FWHM_blue = 150 km/s
R(Lyα)≈3000
-> FWHM_intrinsic ≈ 120 km/s
(FWHM Hα = 59 km/s)

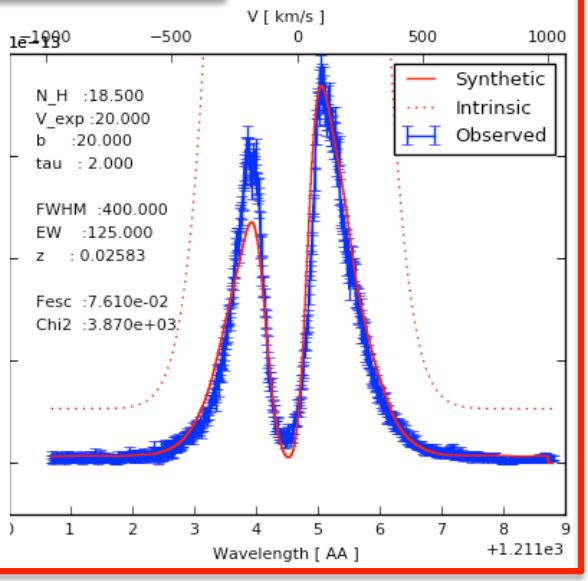
- Low covering. But is $\Sigma F_c < 1$?

Tol 21: radiative transfer modelling

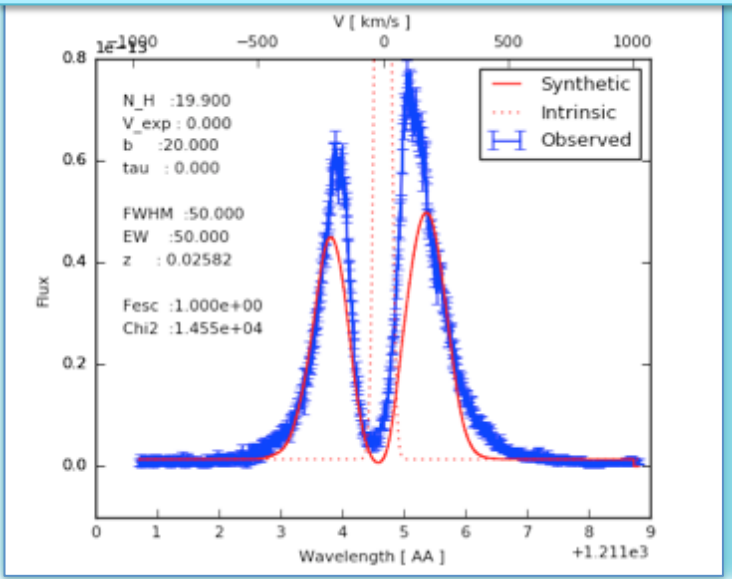
Best fit shell models, with only z fixed (Verhamme). NB FWHM=400 vs 50



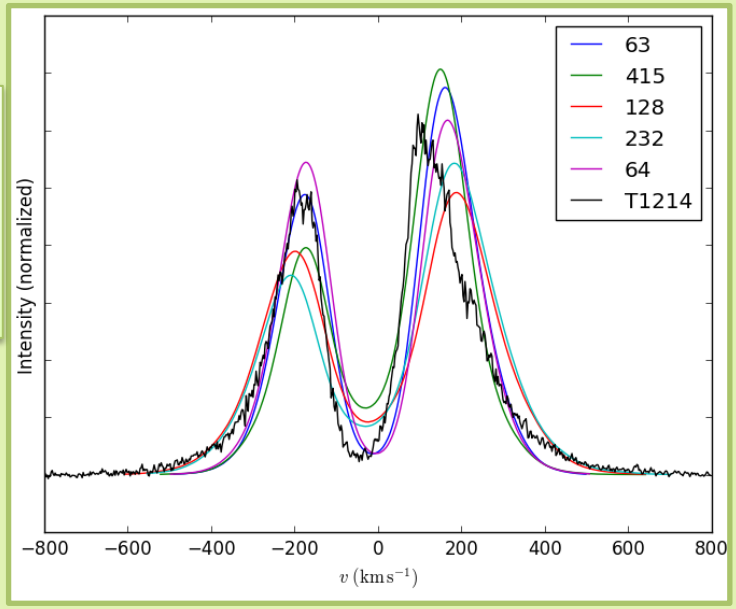




Best fit shell model, w correct FWHM



Clumpy shell model (Gronke) correct FWHM (in progress)



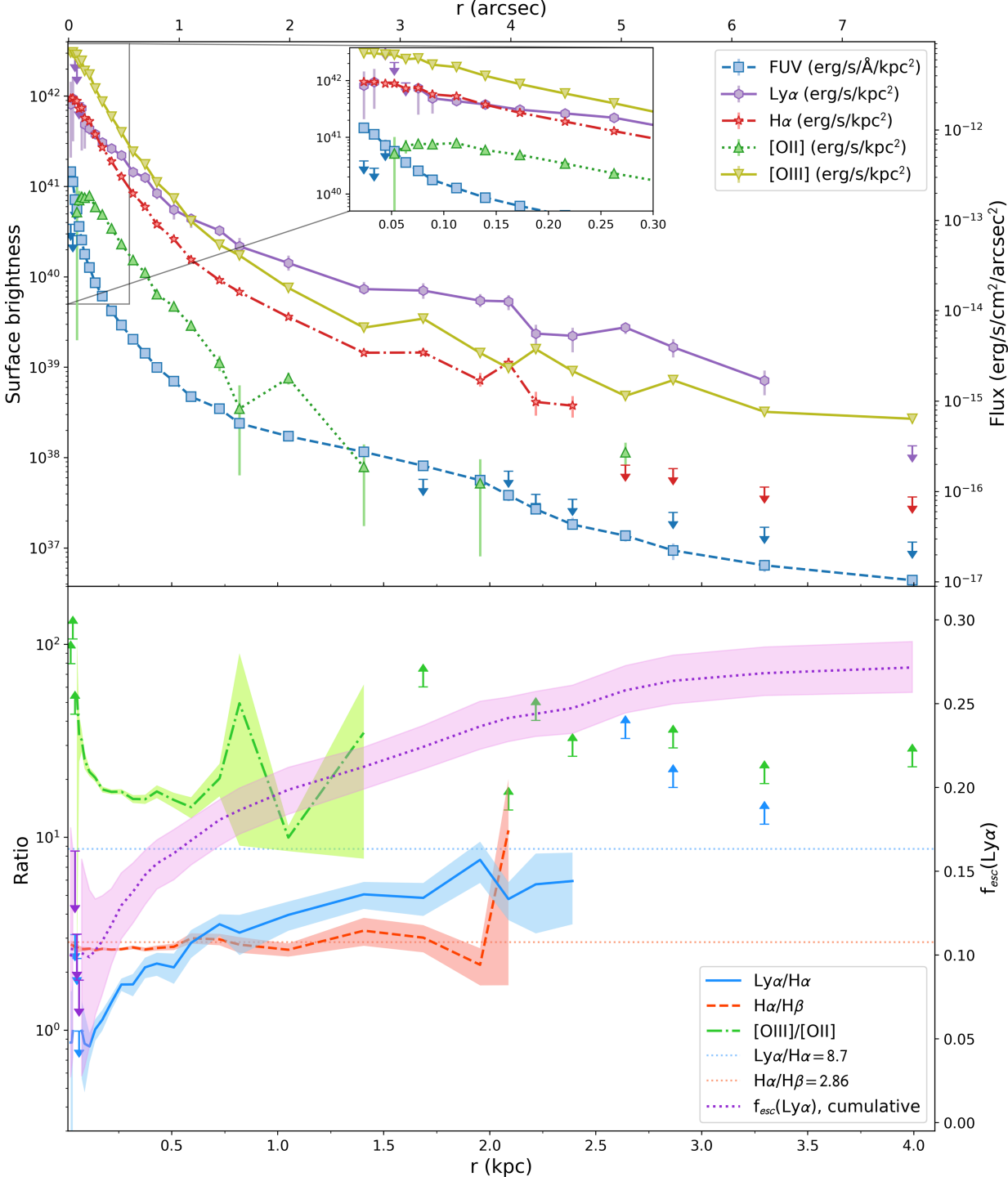
Tol1214-277
Radial luminosity profiles

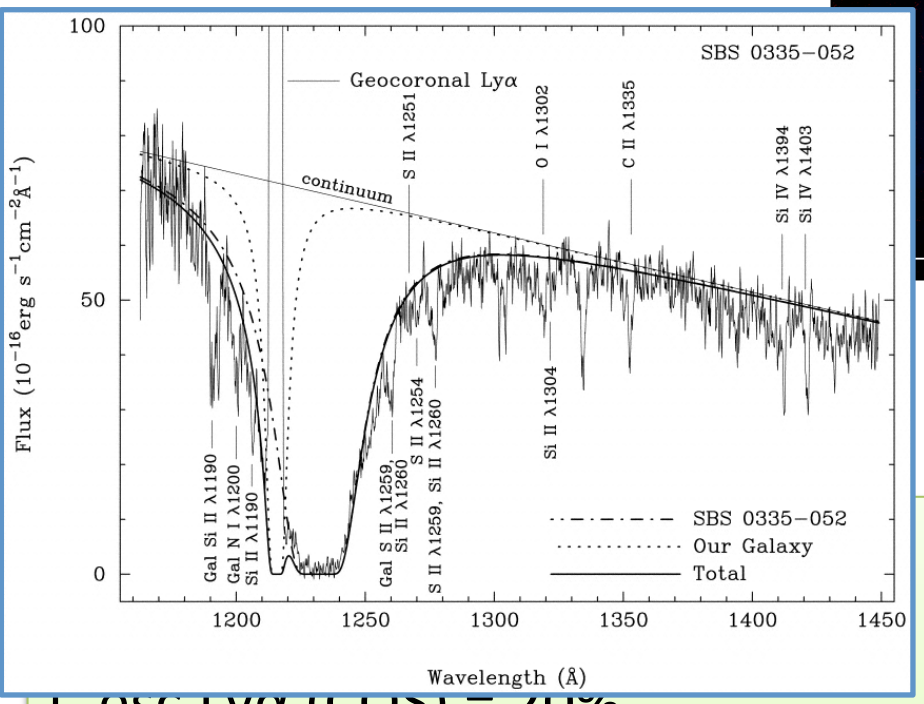
No dust, still moderate Lyα

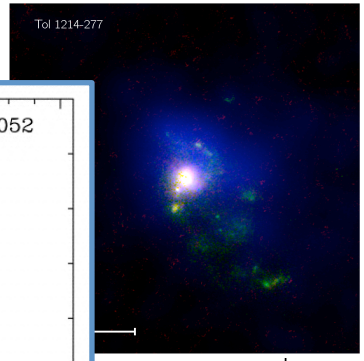
Extreme O_{32}

+ small Lyα peak separation
+high EW blue/red

-> probable LyC leaker



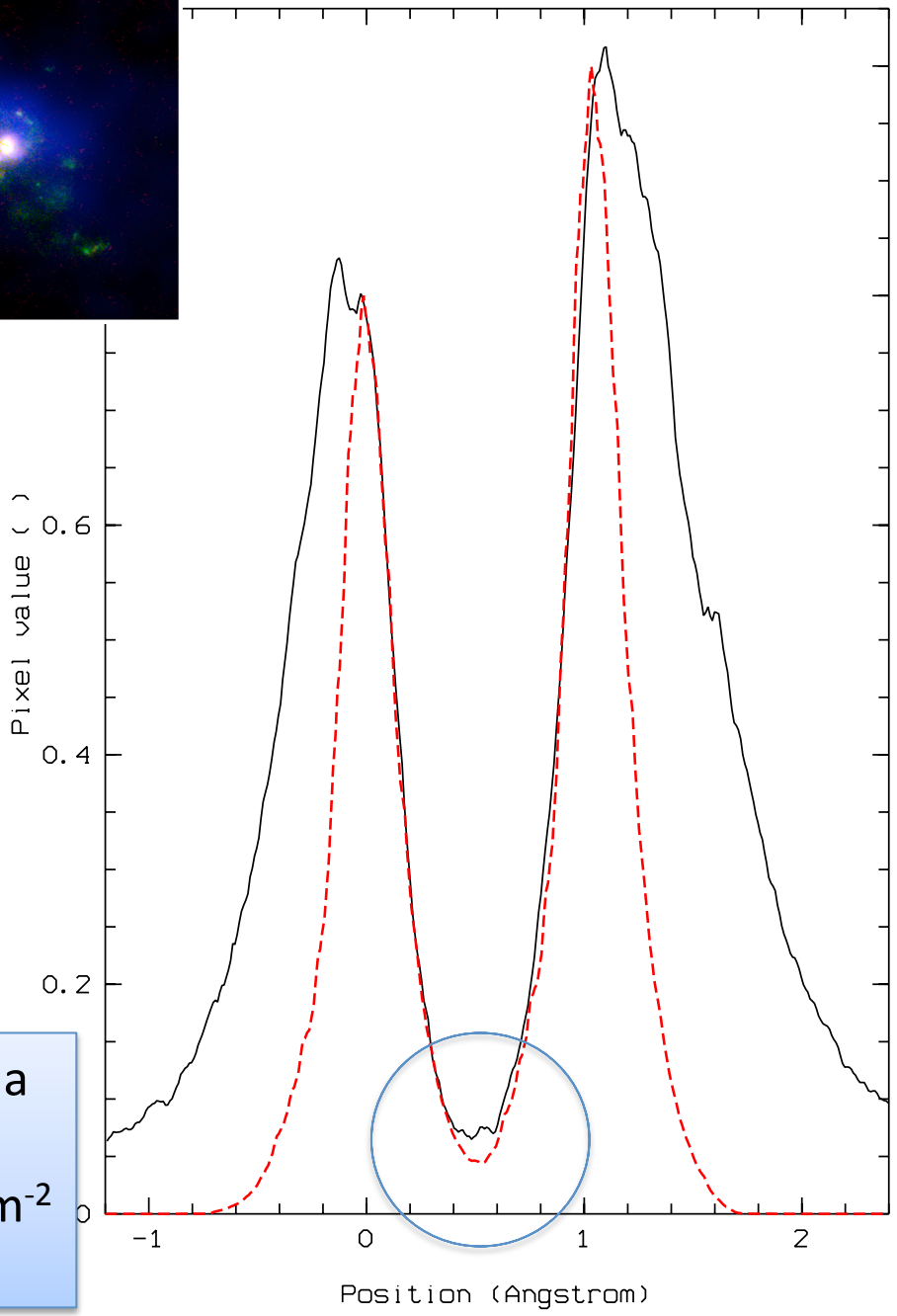




f_esc,Lyα (COS) = 20%

⇒ 0.2% of Lyα escape unscattered

⇒ Lyman continuum escape?



NB even i holes Lyα will be optically thick for a static medium (like in Tol 1214)

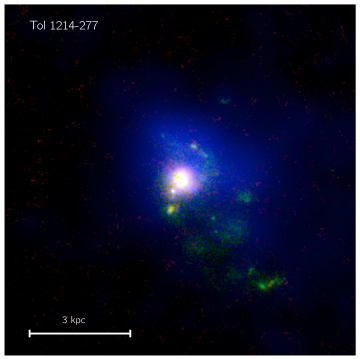
n_e = 10 cm^{-3}, r=1kpc, $\chi_{HI}=10^{-5}$ -> N_{HI}= 3 10^{17} cm^{-2}

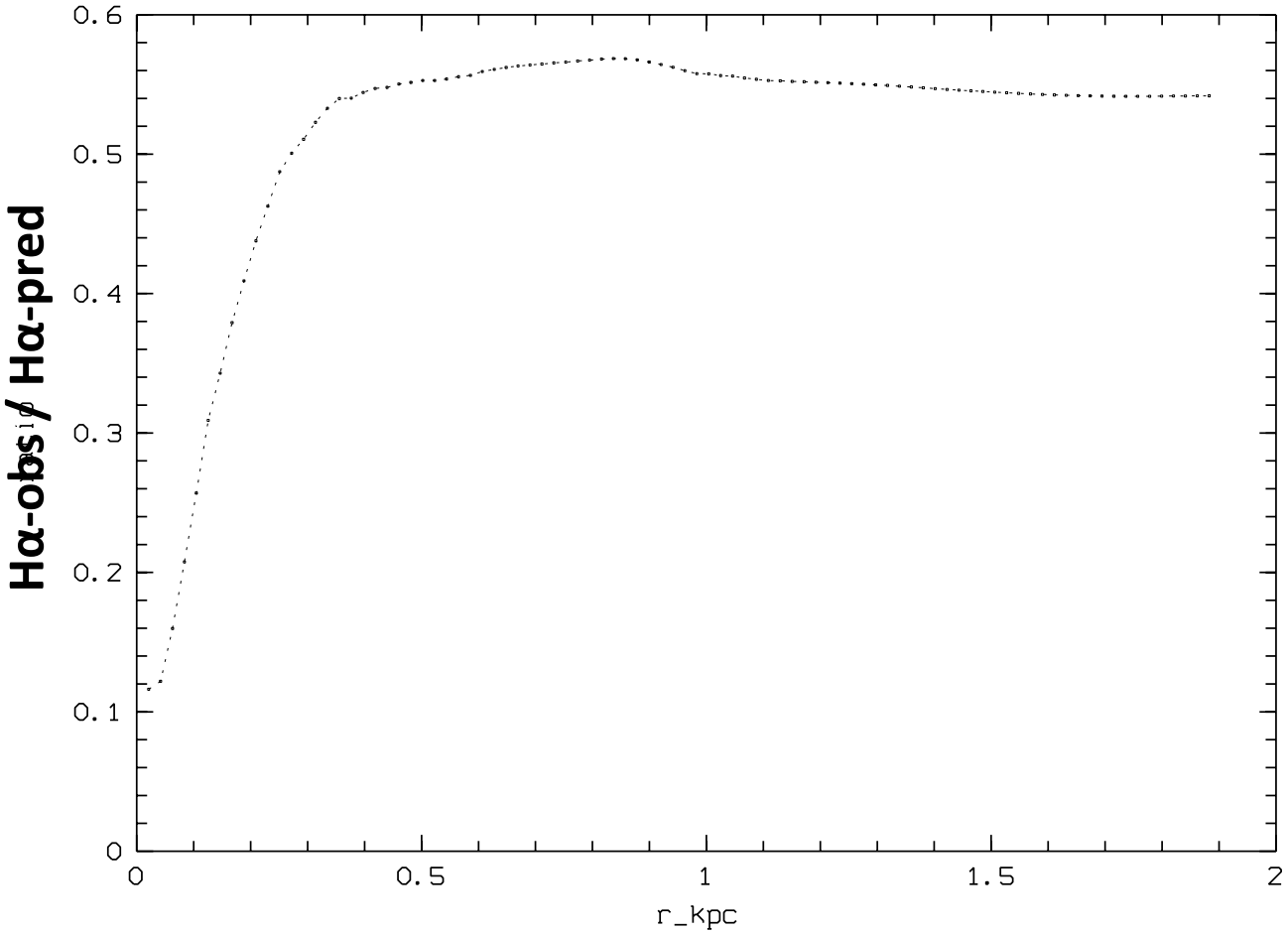
$\tau_{LyC} \approx 1$, $\tau_{Ly\alpha} >> 1$, Need v>100 km/s for $\tau_{Ly\alpha} \approx 1$

Ionising energy budget (cf talks by Relano Pastor, Weilbacher)

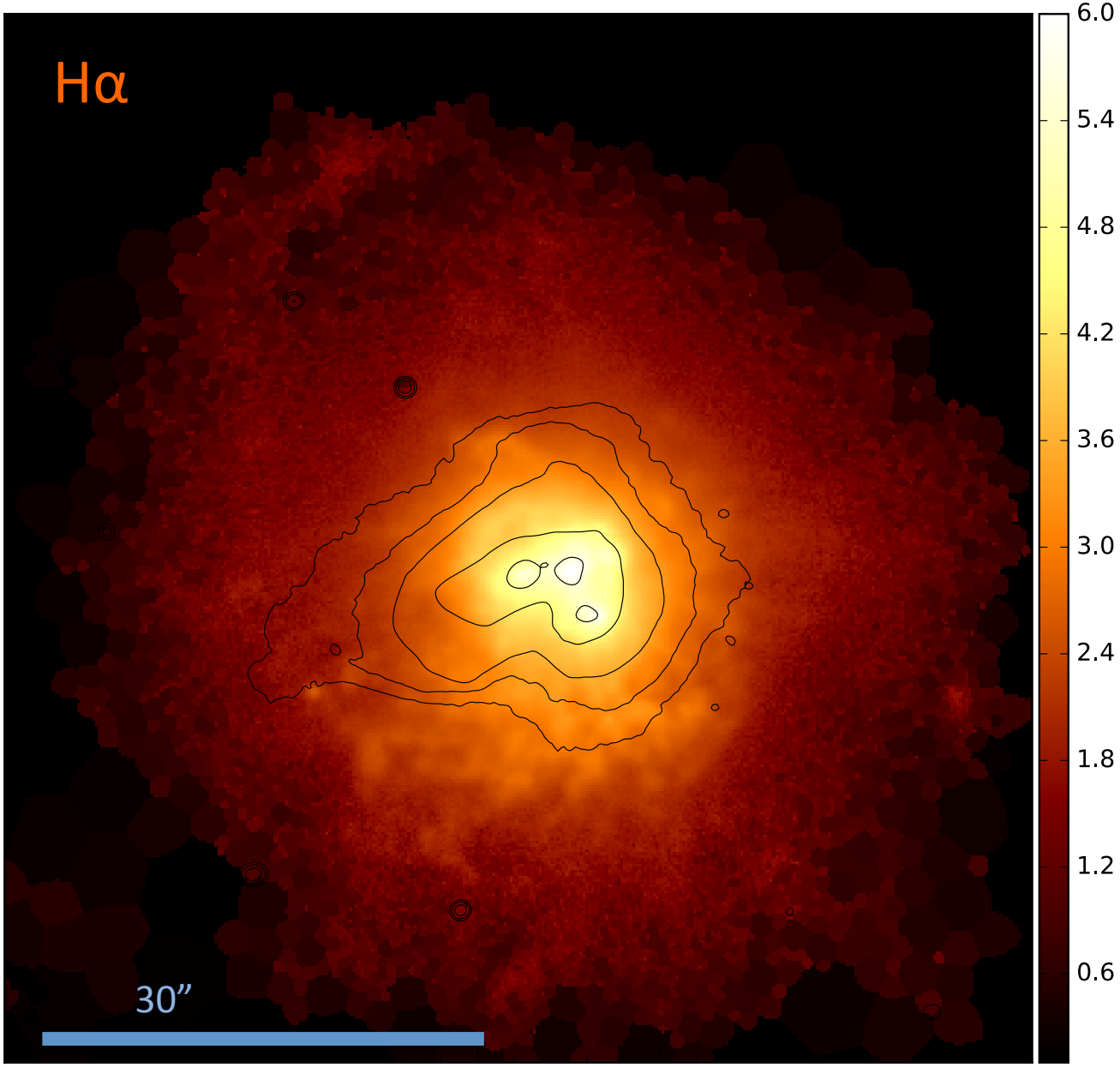
- Spatially resolved SED modelling with 2 pop + gas
- Q-map -> predicted Hα
- No appreciable dust, based on Hα/Hβ
- radial integration -> 45% of Hα missing

Stellar rotation, binaries, IMF can affect ratio (cf talk by Stanway)

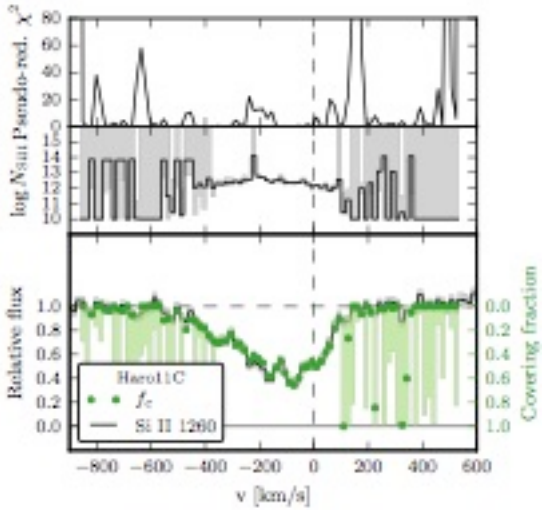




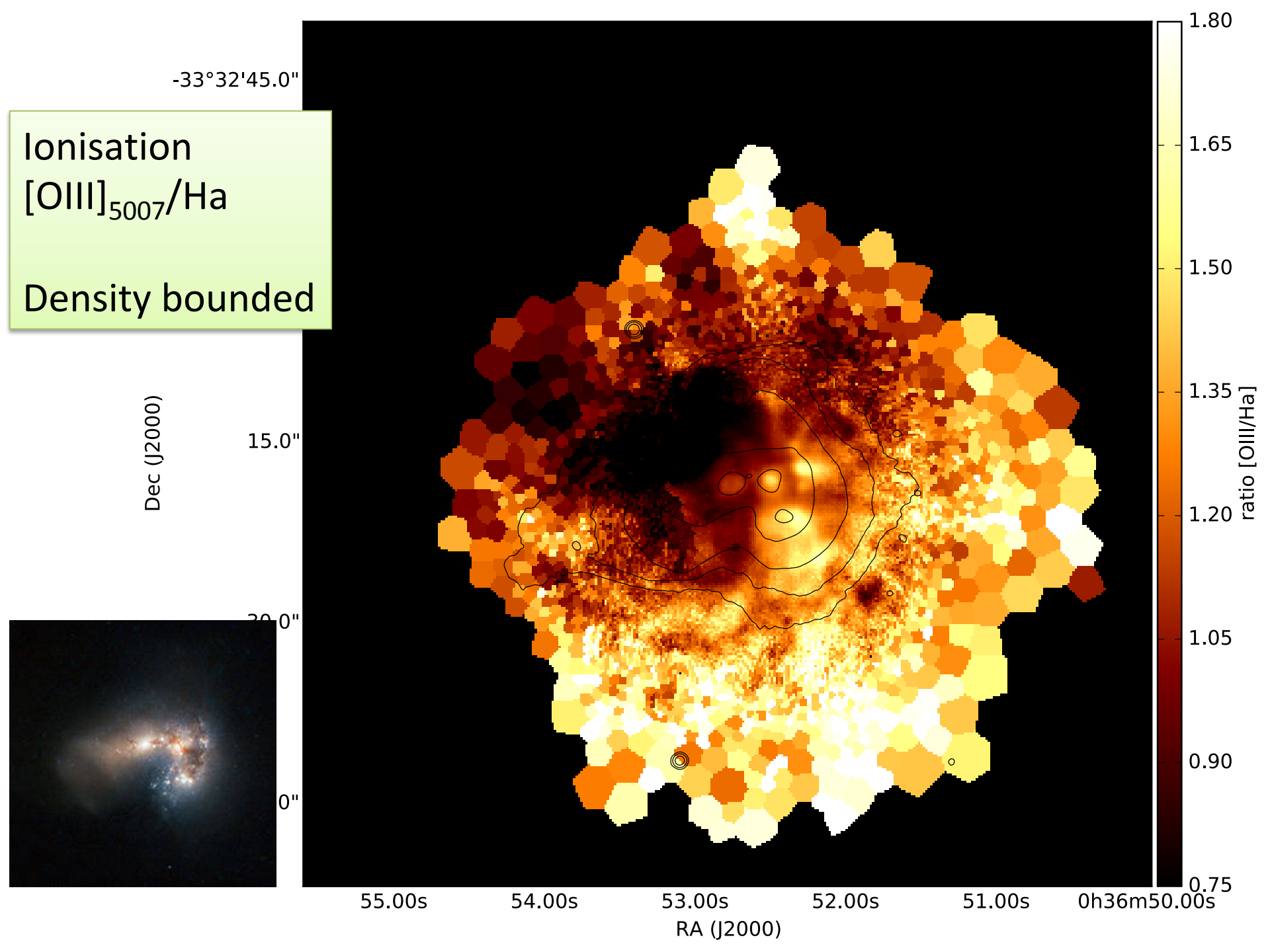
Haro11 with MUSE (cf Menacho's talk)



$f_{esc,LyC}$ =3.3% (Leitet+2011)
$f_{esc,,Ly\alpha}$ =3.7% (Östlin+2009)
M_B= -20 , M_{FUV} = -19.7
12+log(O/H)=8.1 (Guseva+201
M_{HI}=5 10^8 $M_\odot$ (Pardy+2017)
SFR=29 $M_\odot$/yr (Madden+2014



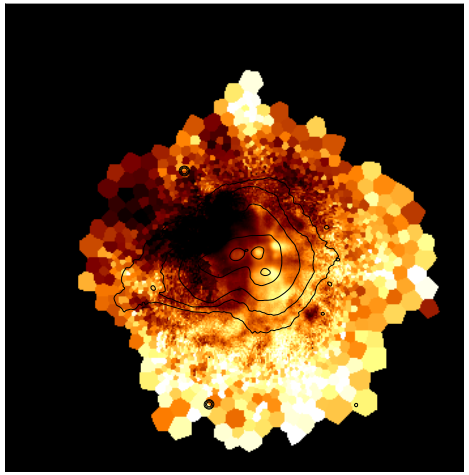
(Rivera-Thorsen+2017)


Ionisation
[OIII]5007/Ha
Density bounded
-33°32'45.0"
15.0"
0"
Dec (J2000)
55.00s
54.00s
53.00s
52.00s
51.00s
0h36m50.00s
RA (J2000)
1.80
1.65
1.50
1.35
1.20
1.05
0.90
0.75
ratio [OIII/Ha]

South-western half of halo has very high ionisation level, suggesting density bounded conditions

- Is it optically thin to Lyman continuum?
  - yes
- Is the halo a source of Lyman cotinnum?
  - yes, 40% of recombinations are to ground state …

...(cf Lyman bump, Inoue)



Make a simple model of the H-alpha halo

Input parameters: n_e follows a Sersic profile + central enhancement ***Observed***

f, volume filling factor

η, dust to gas ratio

r is the radial coordinate, s the impact parameter (projected radius)

$$I_{H\alpha}(s) = \Sigma n_e^2 \, f \, \alpha_{H\alpha} \, h\nu_{H\alpha} \, dr^3$$

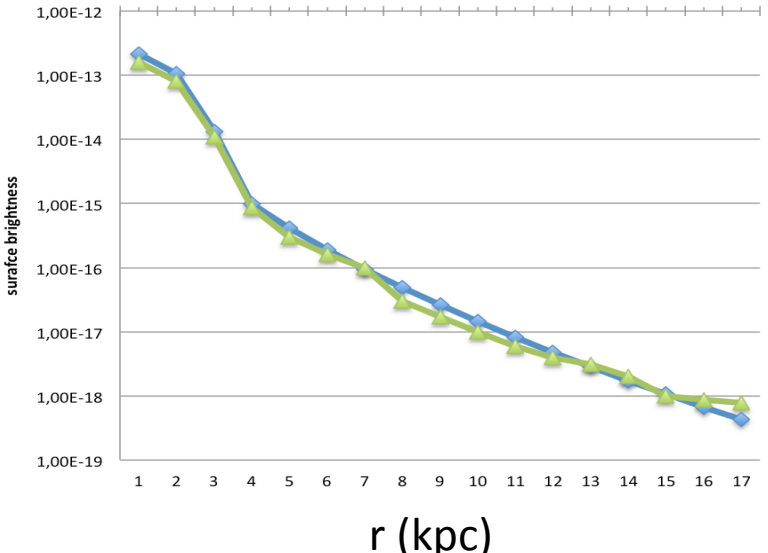
$$C(s) = \Sigma (n_e^2 \, e^{-\tau}) \, f \, \alpha_{H\alpha} \, h\nu_{H\alpha} \, dr^3$$

Where $\tau = \tau_{LyC}$ from HI (evaluate χ_{HI}) and dust (Hα/Hβ))

$$f_{esc,LyC}(s) = I_{H\alpha}(s)/C(s)$$

Check that Hα profile is reproduced

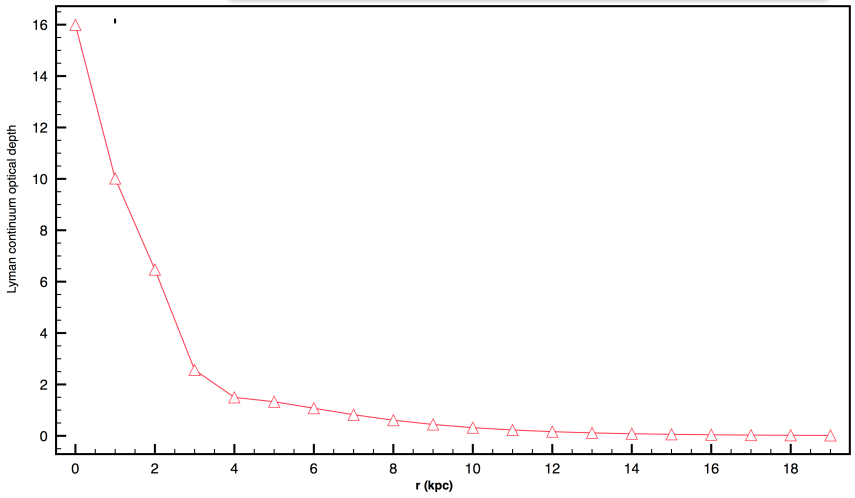
n_e constrained by observed [SII]6716/6731 ratio



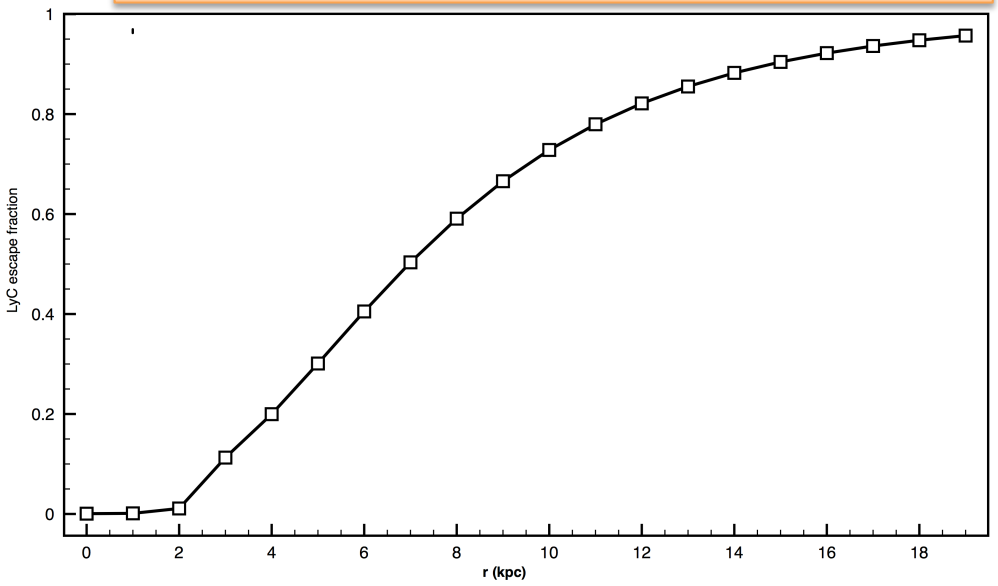
Results:

- The neutral fraction in the halo is $\leq 10^{-5}$
- The halo is optically thin to Ly cont.
- Can account for half LyC seen by FUSE
- Ionised halos at high-z will be sources of Lyc

Integrated LyC optical depth



Fraction of Lyman continuum produced by ground state recombinations escaping



Summary

- Tol1214-277 turns out to be an ordinary LAE but is probably leaking LyC
- Very high O32, and other diagnostics suggest Lyc leakage
- Ionising energy budget -> leakage
- Halo of Haro11 is not only transparent in LyC, but will also be a LyC source of its own

Thank you