

Lyman continuum photon escape from FRI/FRII type radio sources in COSMOS

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Collaborators: P. Papaderos, J. M. Gomes, and the JVLA COSMOS team

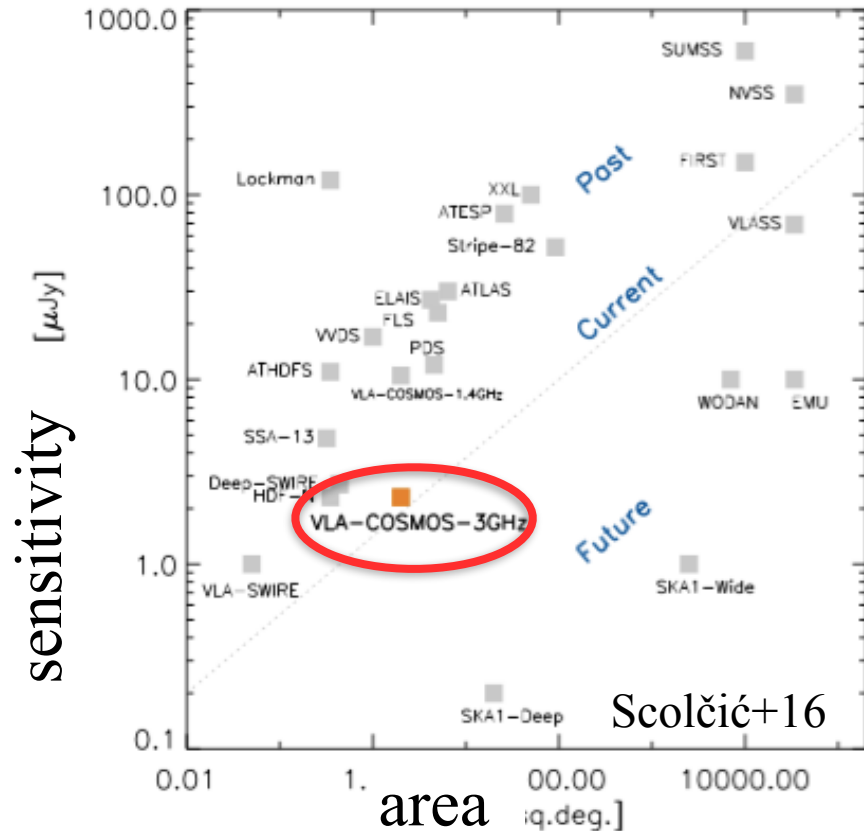
outline

- aims
- sample description - AGN from 3GHz JVLA COSMOS
- methods:
 - *STARLIGHT* + module (case b)
 - calculate τ ratio - Lyc leakage
- preliminary results:
 - 11/18 objects with τ ratios
 - 6/11 objects show Lyc leakage - gas missing
- conclusions

- use a sample of radio AGN (FR type) in the COSMOS field to investigate Lyman continuum (Lyc) radiation
- relate heating of intra-cluster medium (ICM) and Lyc escape from the centres of FRI/FRII type radio sources in the COSMOS field (*in prep.*)

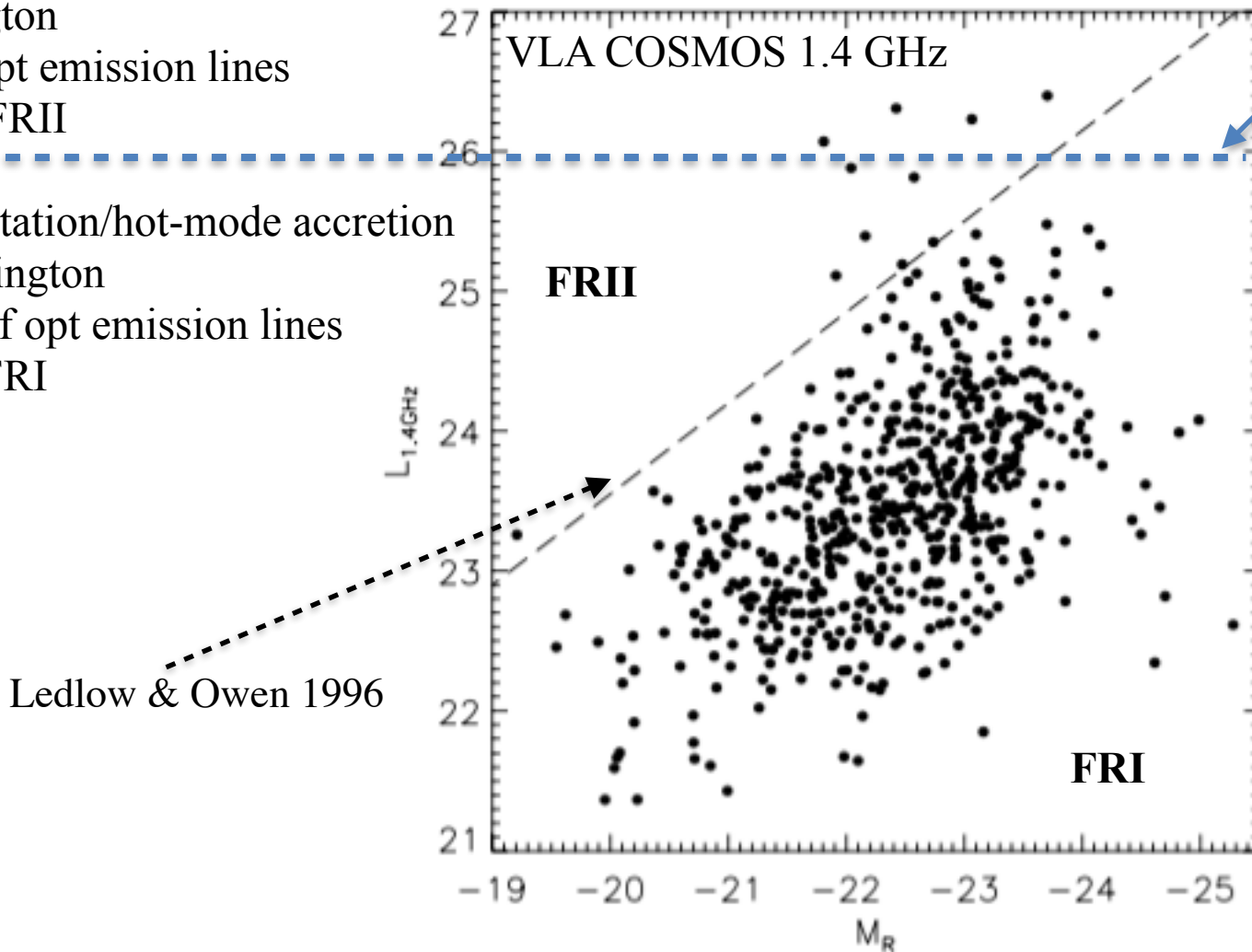
sample selection

- ~120 FRI/FRII radio sources from CC
 - JVLA 3 GHz (~0.75 arcsec resolution, 2.3 μJy)
 - >2 sq. deg.
 - multi-wavelength coverage
- match to SDSS DR7:
 - search radius 2 arcsec
- 18 FRI/FRII type radio sources from COSMOS
 - $0.1 < z < 2.1$
 - $10^{23} \text{ W/Hz} < L_{3\text{GHz}} < 10^{28} \text{ W/Hz}$



radio AGN

- high-excitation/cold-mode accretion
 - \sim Eddington
 - strong opt emission lines
 - mainly FR II
-
- low-excitation/hot-mode accretion
 - sub-Eddington
 - devoid of opt emission lines
 - mainly FR I

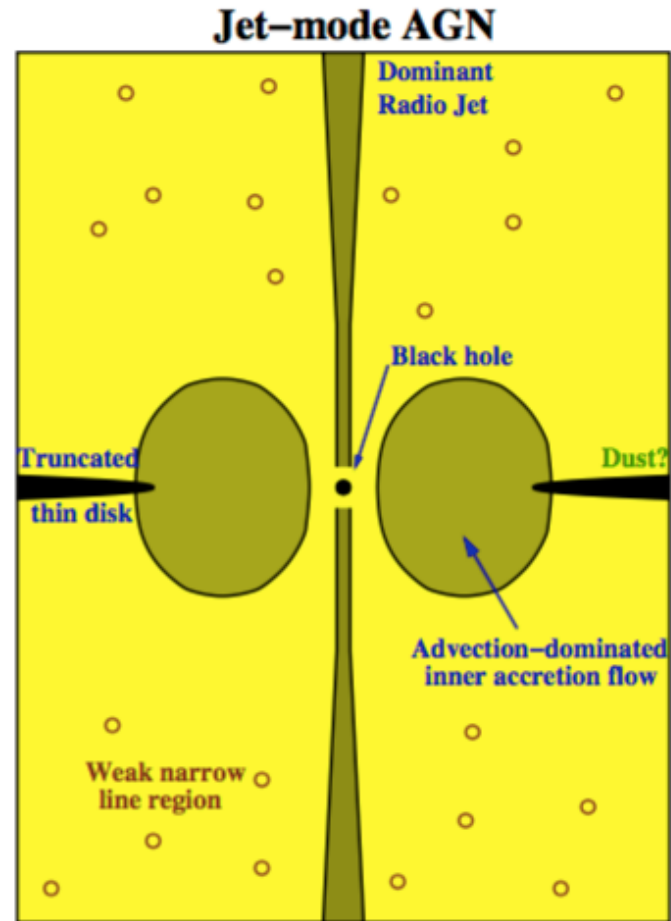
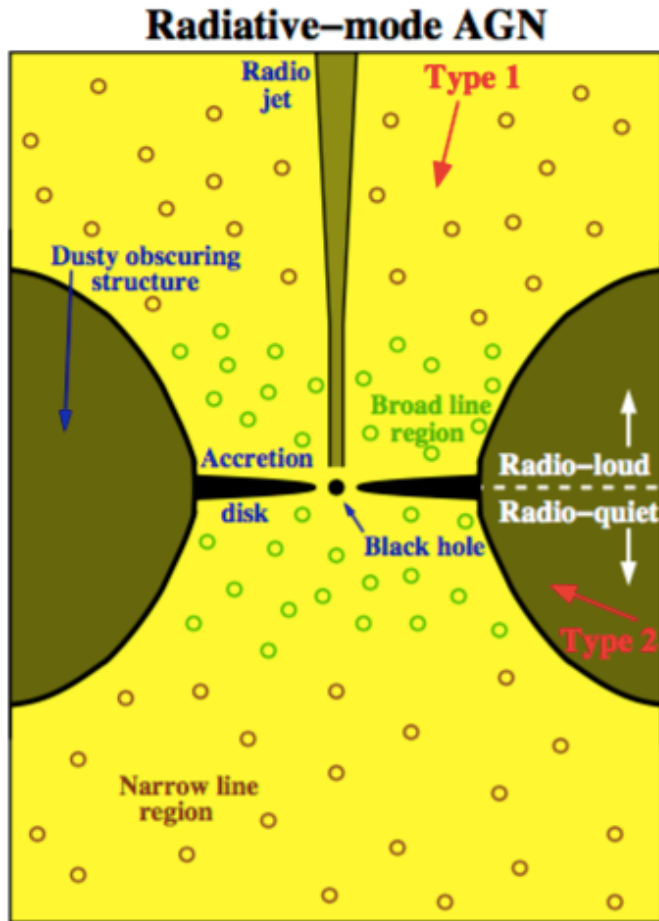


Scolčić+09

radio AGN

high-excitation / cold-mode

low-excitation / hot-mode



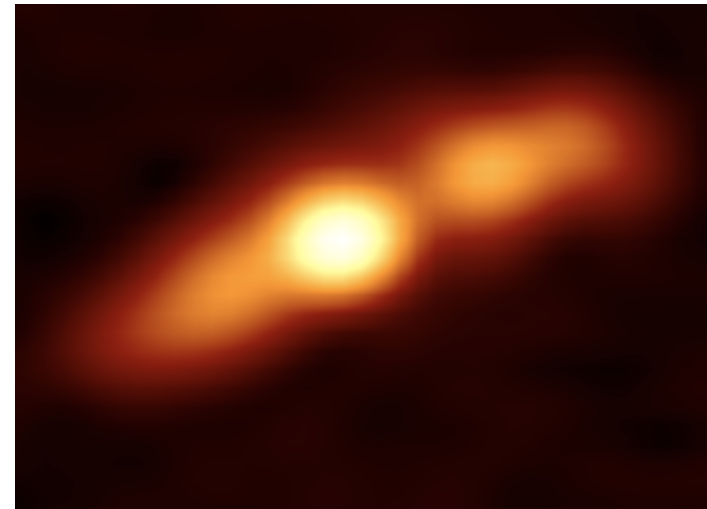
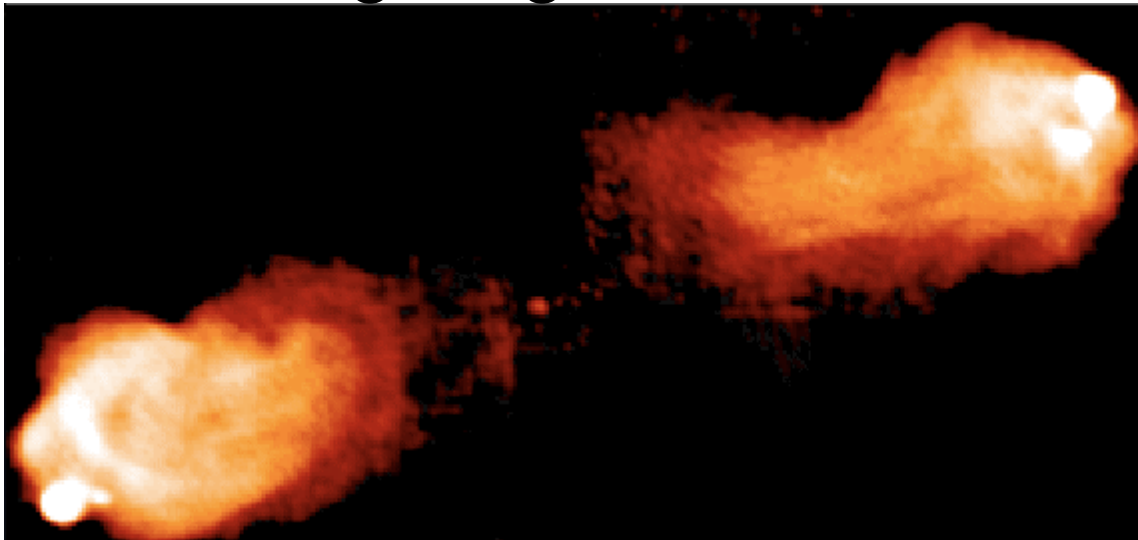
Heckman & Best 2014

FR-type radio sources

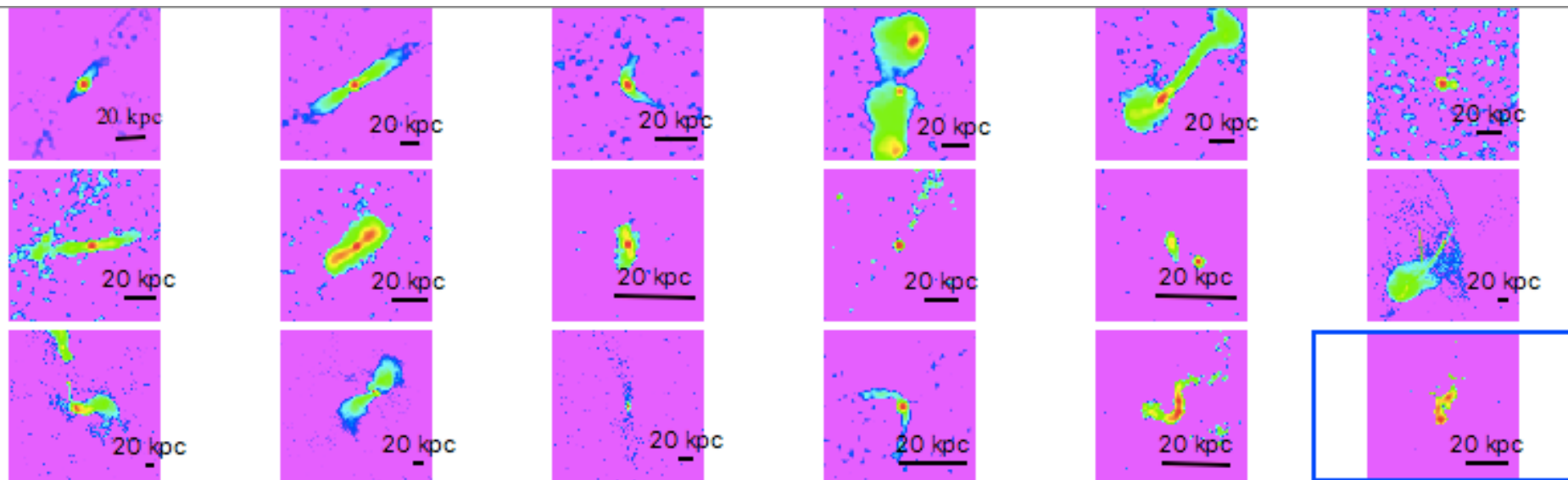
correlation between position of energy deposited and total luminosity (Fanaroff & Riley 1974)

- FR II - edge brightened

- FR I - edge darkened

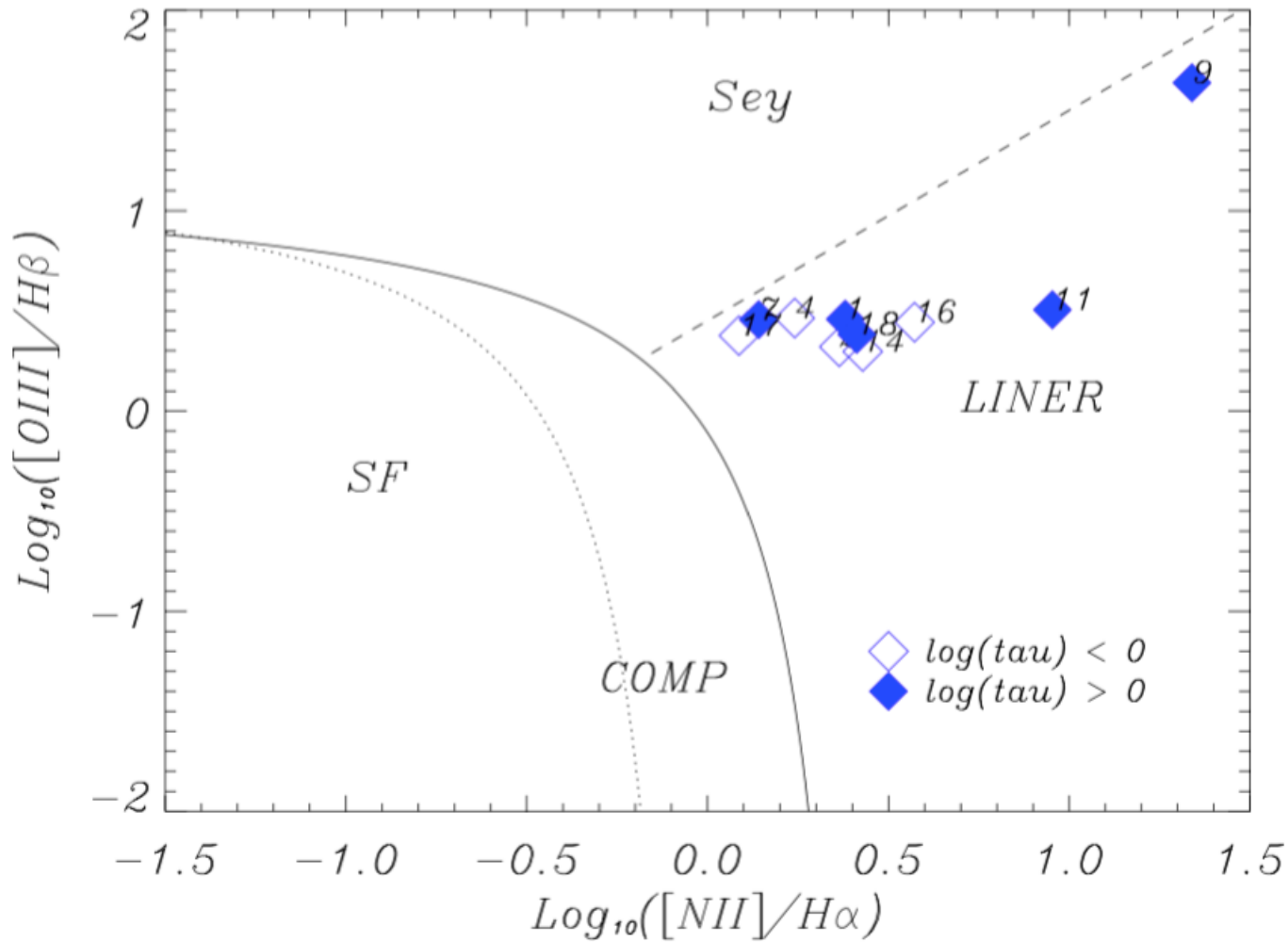


3GHz JVLA COSMOS FRI/FRIIs



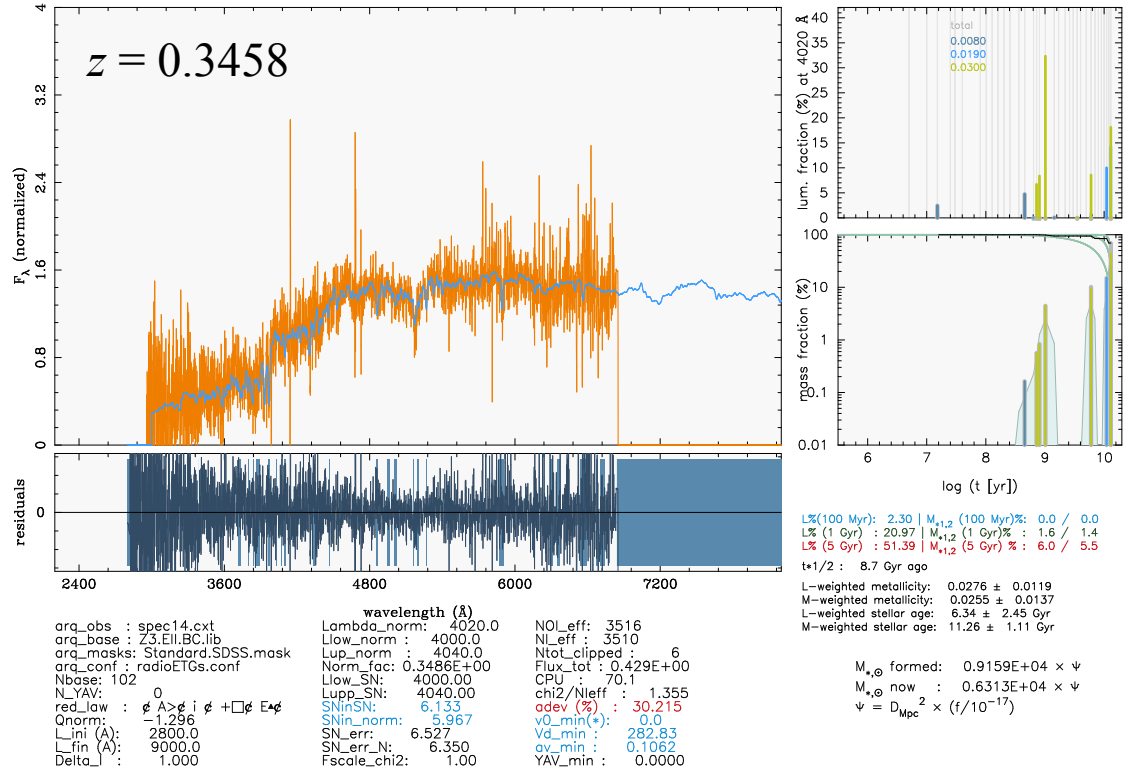
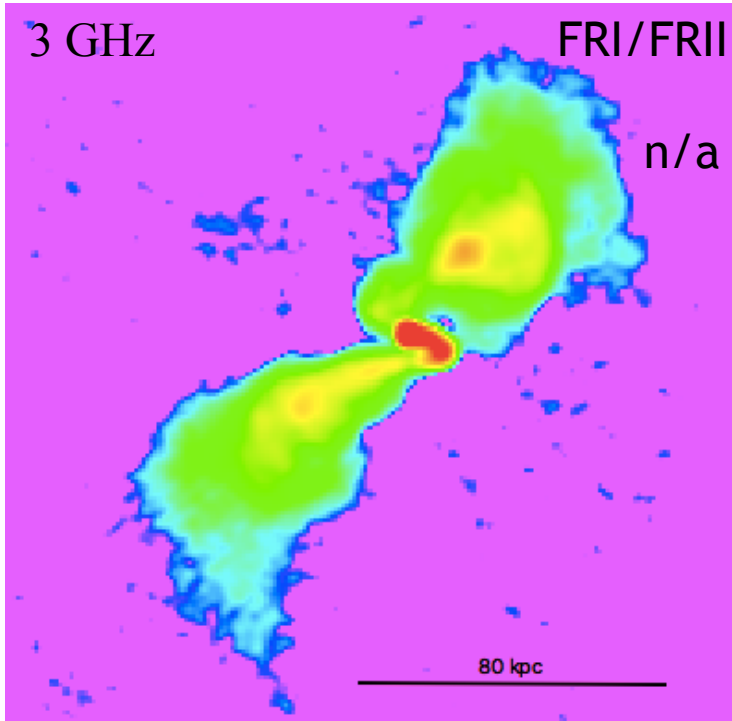
- match FRI/FRII JVLA COSMOS with SDSS DR7:
 - *18 radio sources (2 arcsec search radius)*
 - *AGN based on radio classification - LINERs based on BPT*

BPT diagram



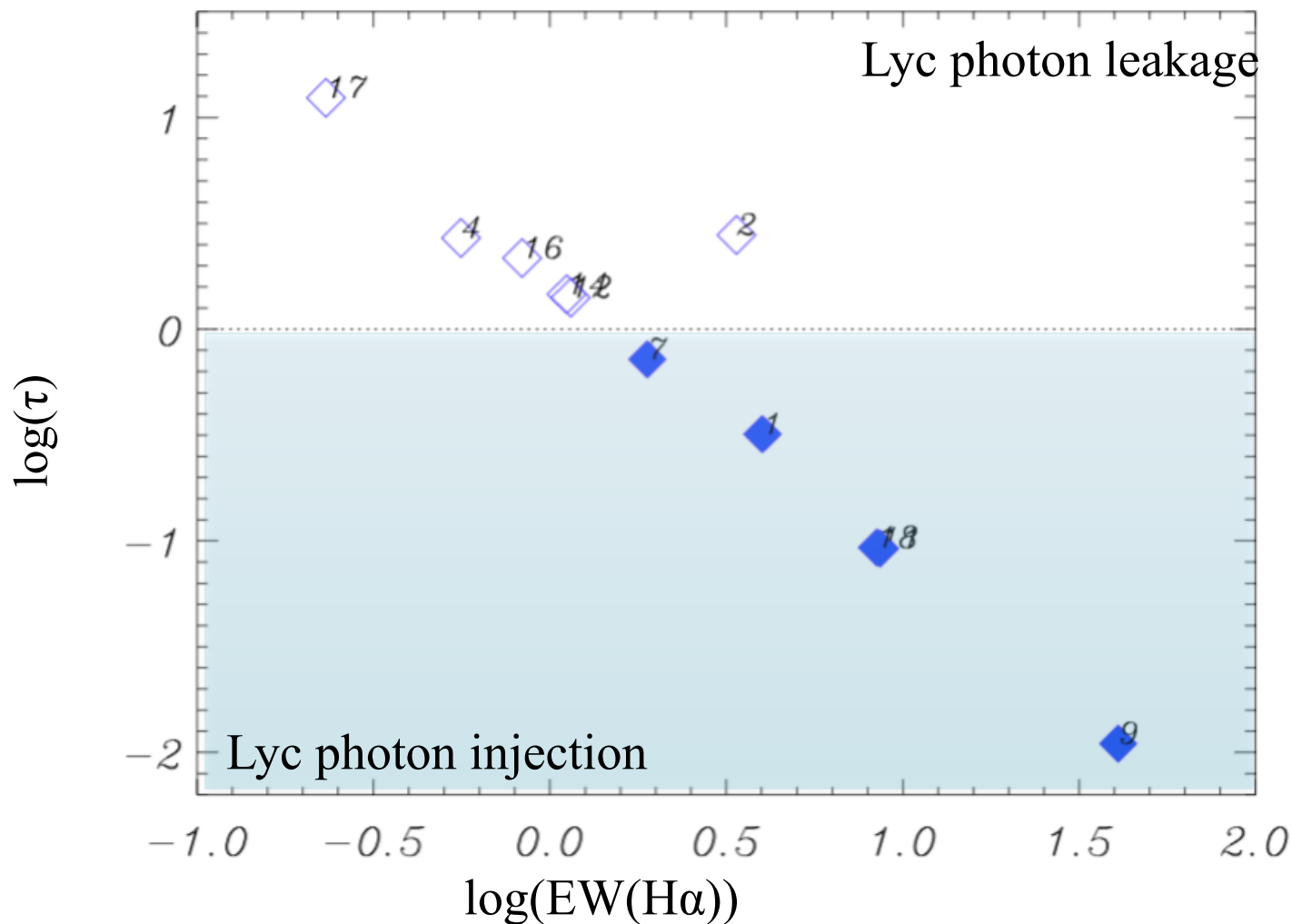
- *match FRI/FRII JVLA COSMOS with SDSS DR7:*
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 - *AGN based on radio classification - LINERs based on BPT*
- *STARLIGHT (Cid Fernandes+05) + standard case b recombination module to compute Ha line (e.g. 10^4 K, <100 particles/cm³)*

14 - JVLA 10933

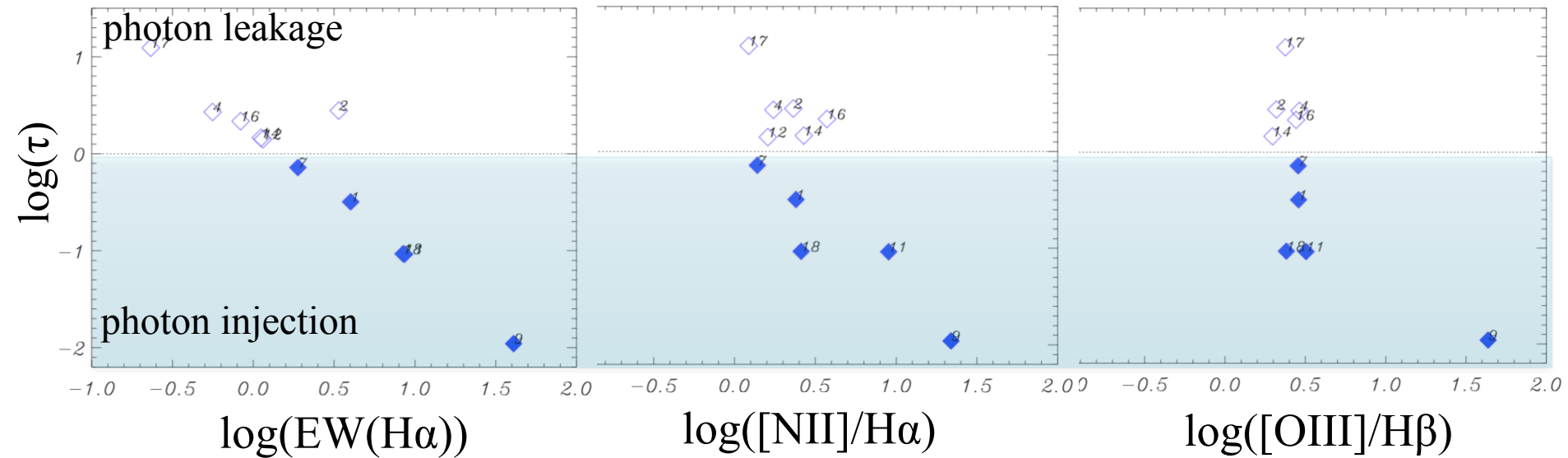


- *match FRI/FRII JVLA COSMOS with SDSS DR7:*
 - *18 radio sources (2 arcsec search radius)*
 - *AGN based on radio classification - LINERs based on BPT*
- *STARLIGHT (Cid Fernandes+05) + standard case b recombination module to compute H α line (e.g. 10^4 K, <100 particles/cm 3)*
- *estimate Ly α escape fraction*
 - *$\tau = \text{predicted H}\alpha \text{ for post-AGB} / \text{observed H}\alpha$*
 - *6/11 of sources show Ly α leakage*

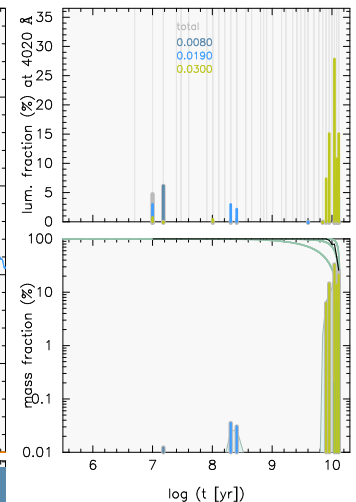
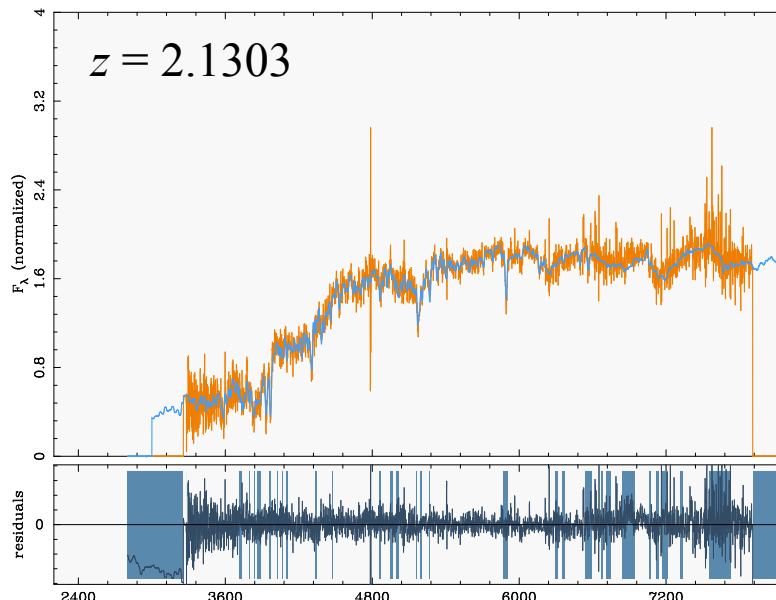
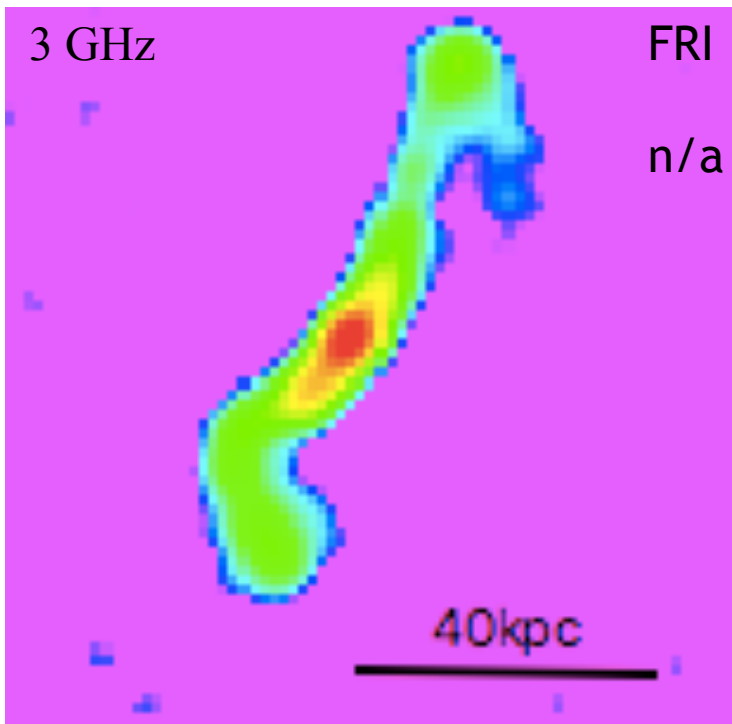
Ly α escape



Ly α escape

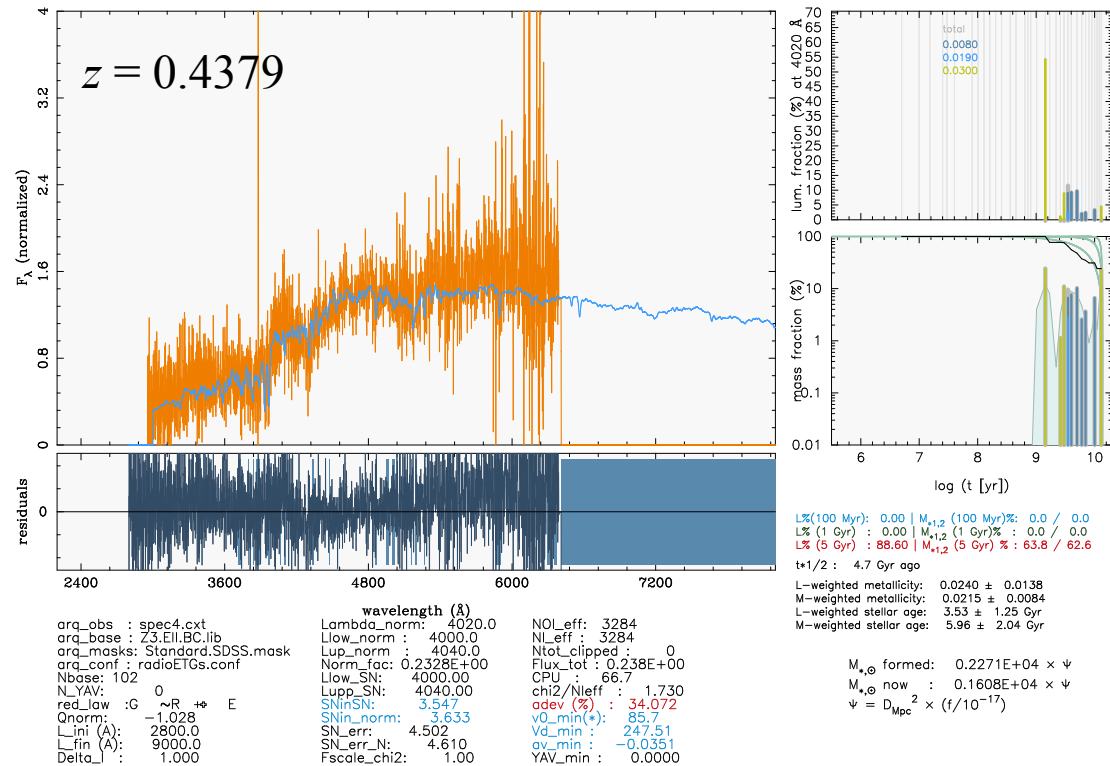
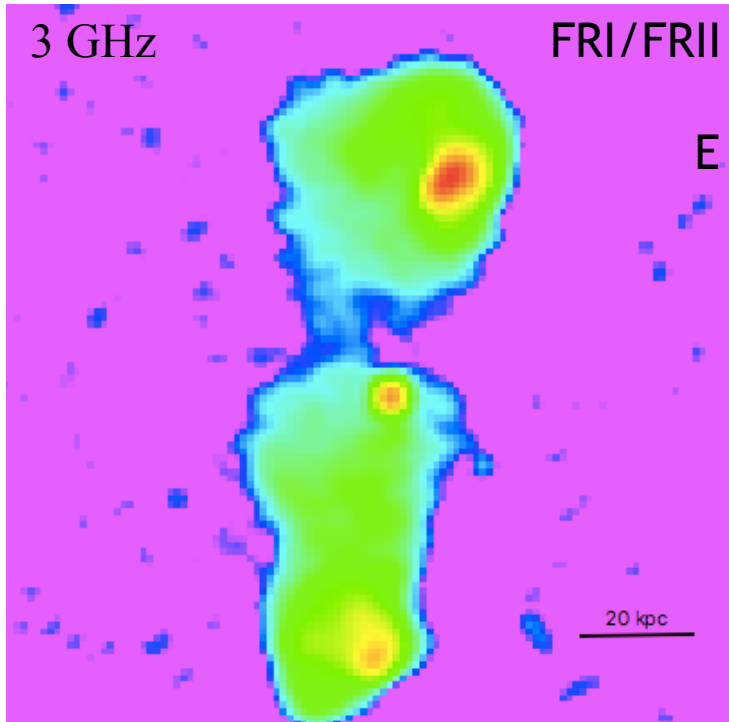


2 - JVLA 83

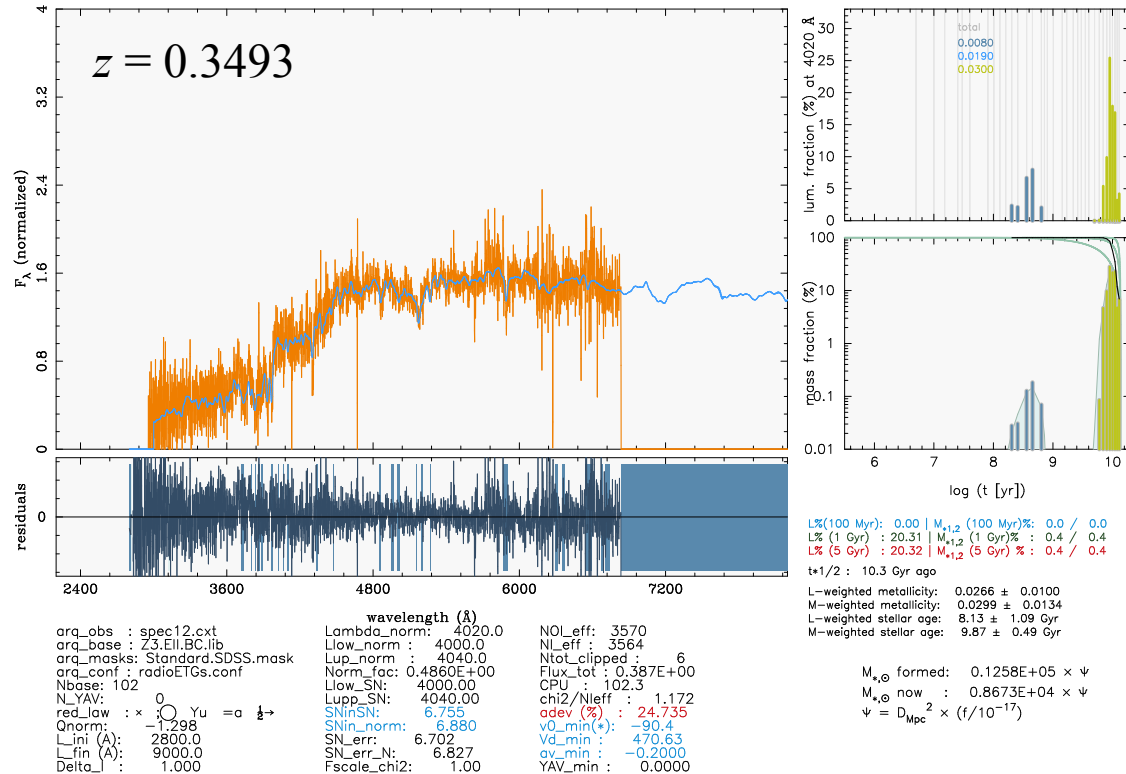
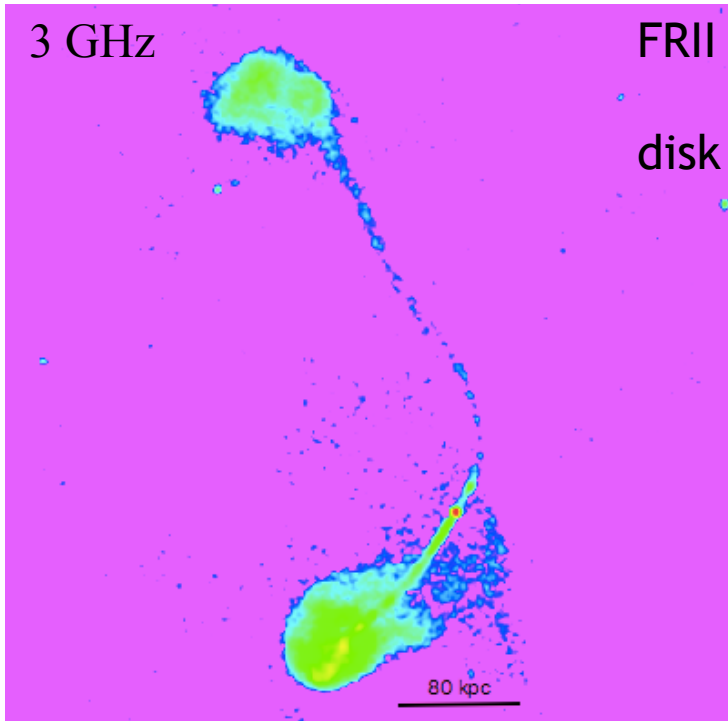


<pre> arg_obs : spec2.cxt arg_base : Z3.Ell.BC.lib arg_masks : Standard_SDSS.mask arg_conf : radioETGs.conf Nbase: 102 N_YAV: 0 red_low : 0 Qnorm: -1.657 L_ini (Å): 2800.0 L_fin (Å): 9000.0 Delta_l : 1.000 </pre>	<pre> wavelength (Å) Lambda_norm: 4020.0 Low_norm : 4000.0 Lup_norm : 4040.0 Norm_fac: 0.1134E+01 Low_SN: 4000.00 Lupp_SN: 4040.00 SNinSN: 12.219 SNin_norm: 12.154 SN_err: 9.701 SN_err_N: 9.649 Fscale_chi2: 1.00 </pre>	<pre> NOL_eff: 3891 NL_eff : 3890 Ntot_clipped : 1 Flux_tot : 0.118E+01 CPU : 68.3 chi2/Nleff : 0.534 adev (%) : 6.540 vD_min(*): 62.2 vD_min : 259.38 ov_min : 0.0024 YAV_min : 0.0000 </pre>
<pre> L*(100 Myr): 10.44 M_{1,2} (100 Myr)%: 0.0 / 0.0 L*(1 Gyr) : 15.82 M_{1,2} (1 Gyr)% : 0.1 / 0.1 L*(5 Gyr) : 15.82 M_{1,2} (5 Gyr) % : 0.1 / 0.1 t*1/2 : 11.9 Gyr ago L-weighted metallicity: 0.0275 ± 0.0106 M-weighted metallicity: 0.0288 ± 0.0130 L-weighted stellar age: 9.68 ± 1.05 Gyr M-weighted stellar age: 11.25 ± 0.56 Gyr </pre>		
<pre> M_{*} formed: 0.4464E+05 x psi M_{*} now : 0.3065E+05 x psi psi = D_{Mpc}^2 x (f/10^{-17}) </pre>		

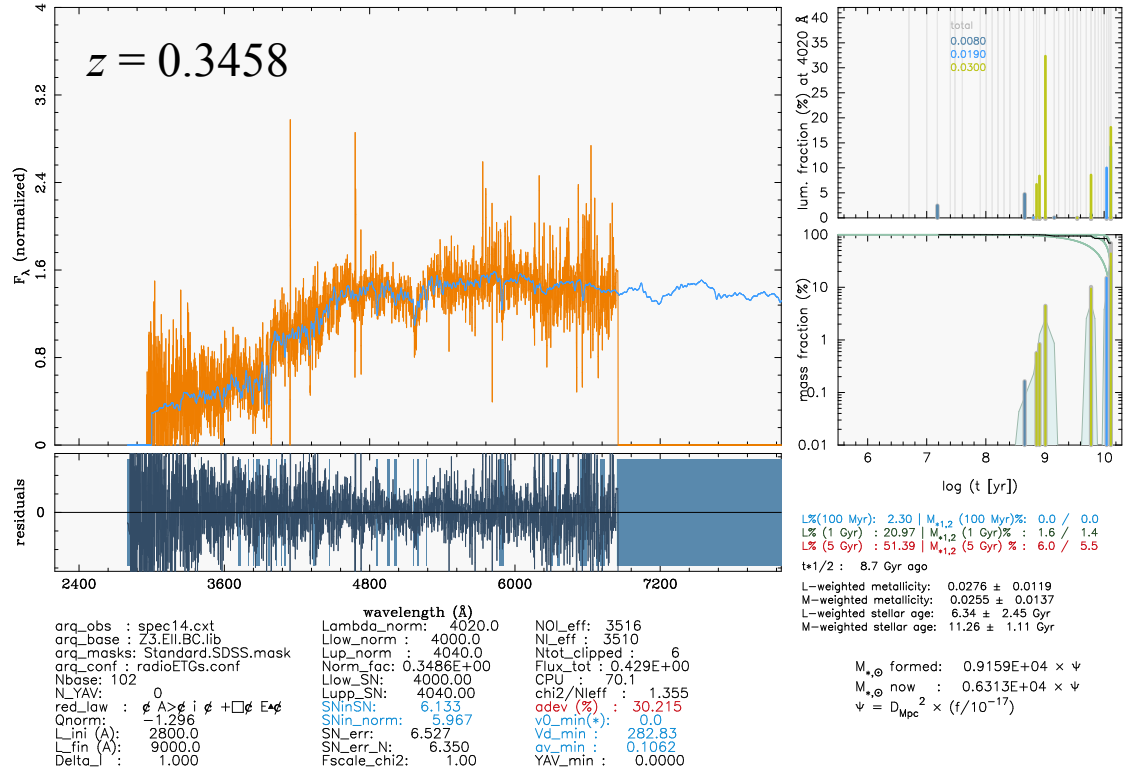
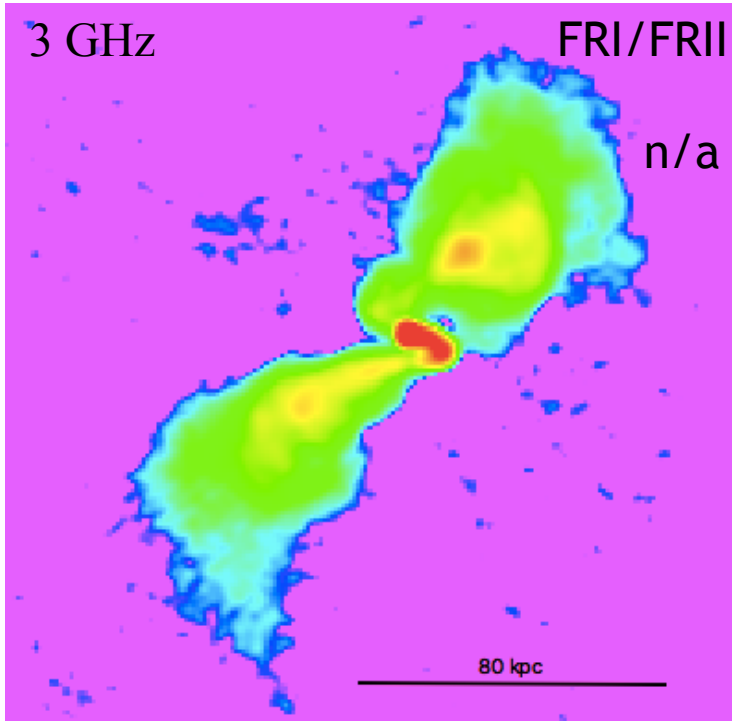
4 - JVLA 145



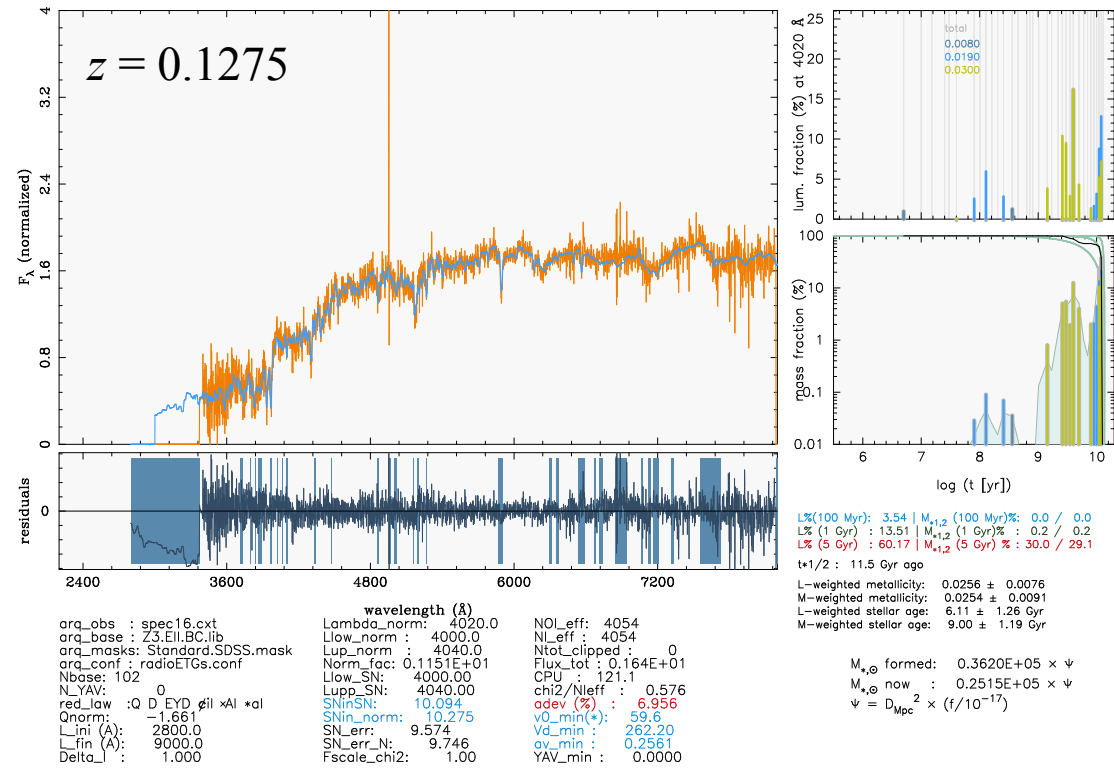
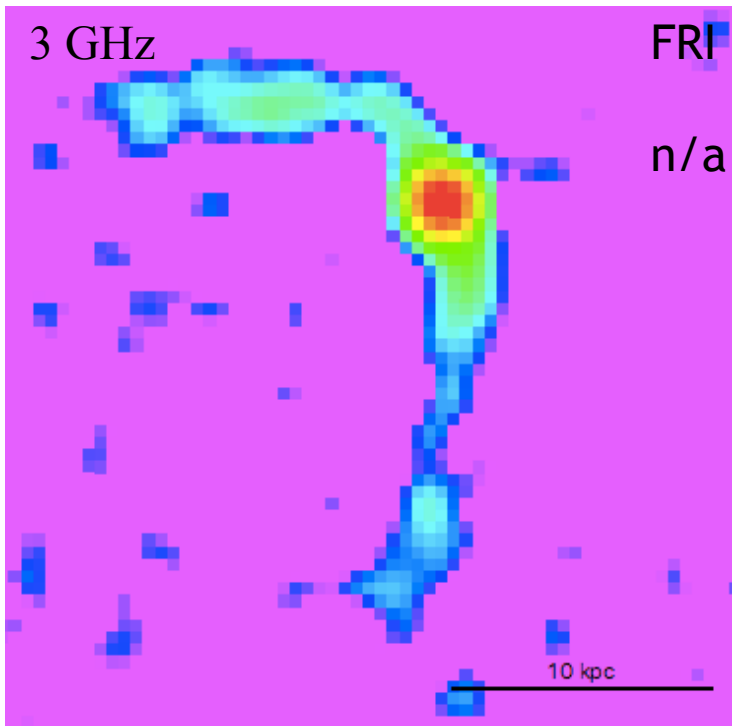
12 - JVLA 10913



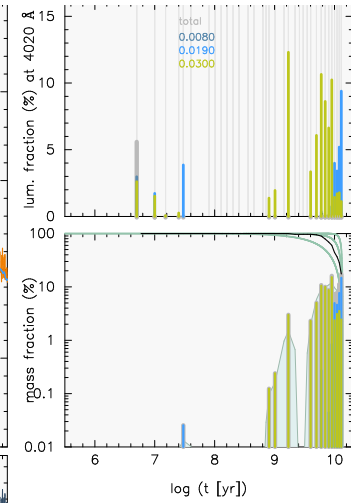
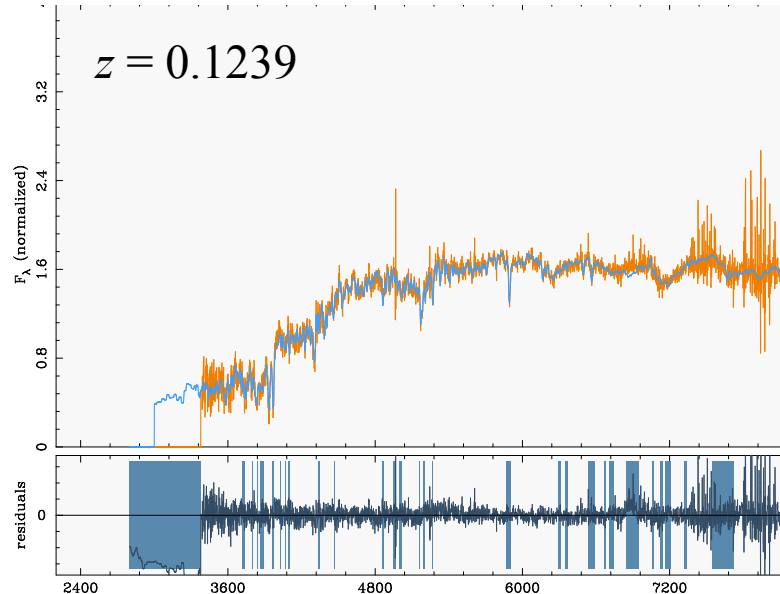
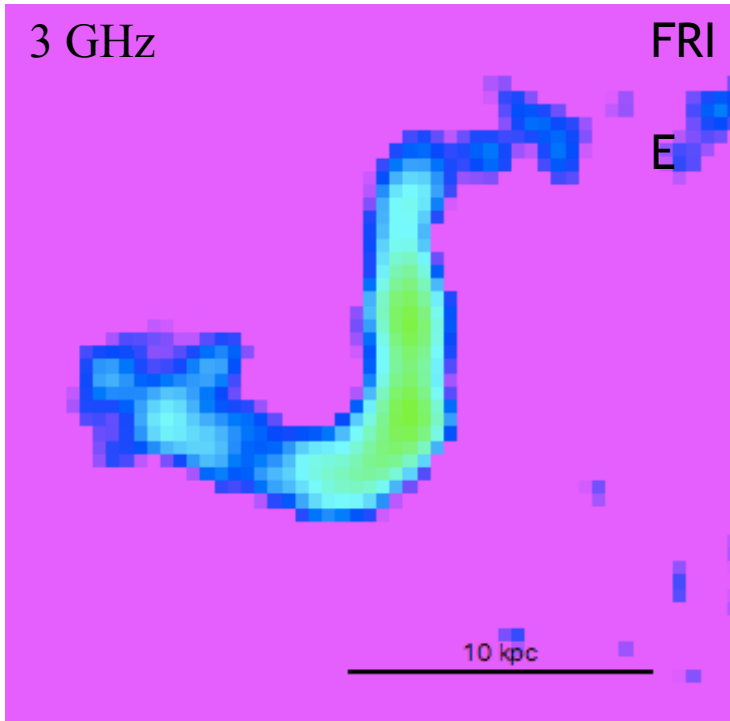
14 - JVLA 10933



16 - JVLA 10950



17 - JVLA 10958



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arq_obs : spec17.cxt          Lambda_norm: 4020.0      NOL_eff: 4067
arq_base : Z3.Ell.BC.lib     L_low_norm : 4000.0      NL_eff : 4067
arq_masks : Standard.SDSS.mask L_up_norm : 4040.0      Ntot_clipped : 0
arq_conf : radioETGs.conf    Norm_fac: 0.1514E+01    Flux_tot : 0.179E+01
Nbase: 102                   L_low_SN: 4000.00      CPU : 93.7
N_YAV: 0                     Lupp_SN: 4040.00      chi2/Nleff : 0.392
red_low : 2U11a V my uE     SNinSN: 13.643         adev (%) : 4.340
Qnorm: -1.503                SNin_norm: 13.759      v0_min(*): 75.3
L_ini (A): 2800.0            SN_err: 11.103         v0_min : 217.10
L_fin (A): 9000.0           SN_err_N: 11.198      ov_min : 0.0981
Delta_l : 1.000              Fscale_chi2: 1.00     YAV_min : 0.0000
    
```

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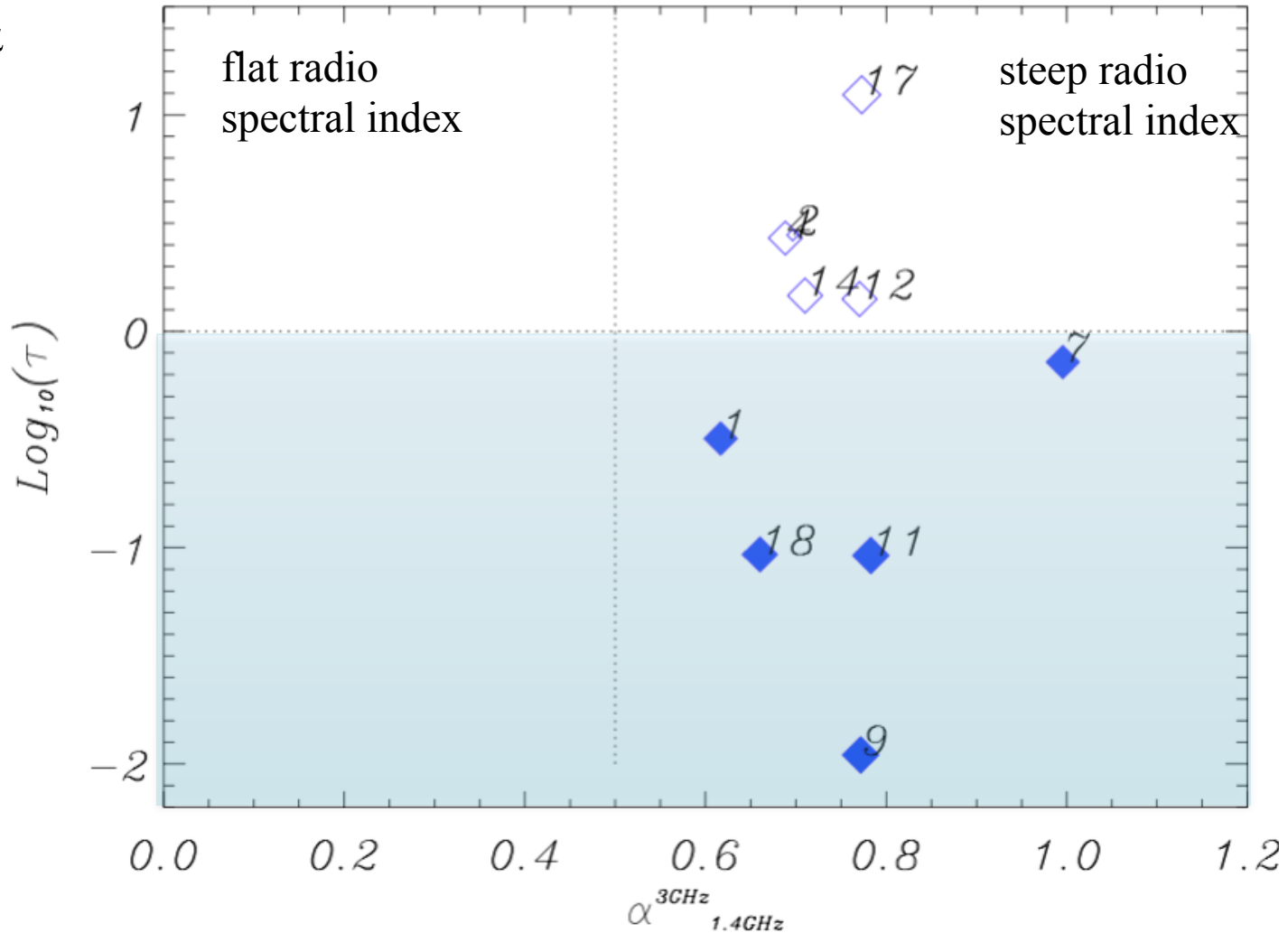
L%(100 Myr): 12.59 | M_1,2 (100 Myr)%: 0.0 / 0.0
L%(1 Gyr) : 13.92 | M_1,2 (1 Gyr)% : 0.2 / 0.1
L%(5 Gyr) : 36.83 | M_1,2 (5 Gyr)% : 10.8 / 10.4
t1/2 : 9.6 Gyr ago
L-weighted metallicity: 0.0272 ± 0.0073
M-weighted metallicity: 0.0263 ± 0.0080
L-weighted stellar age: 6.78 ± 1.06 Gyr
M-weighted stellar age: 9.07 ± 0.83 Gyr
    
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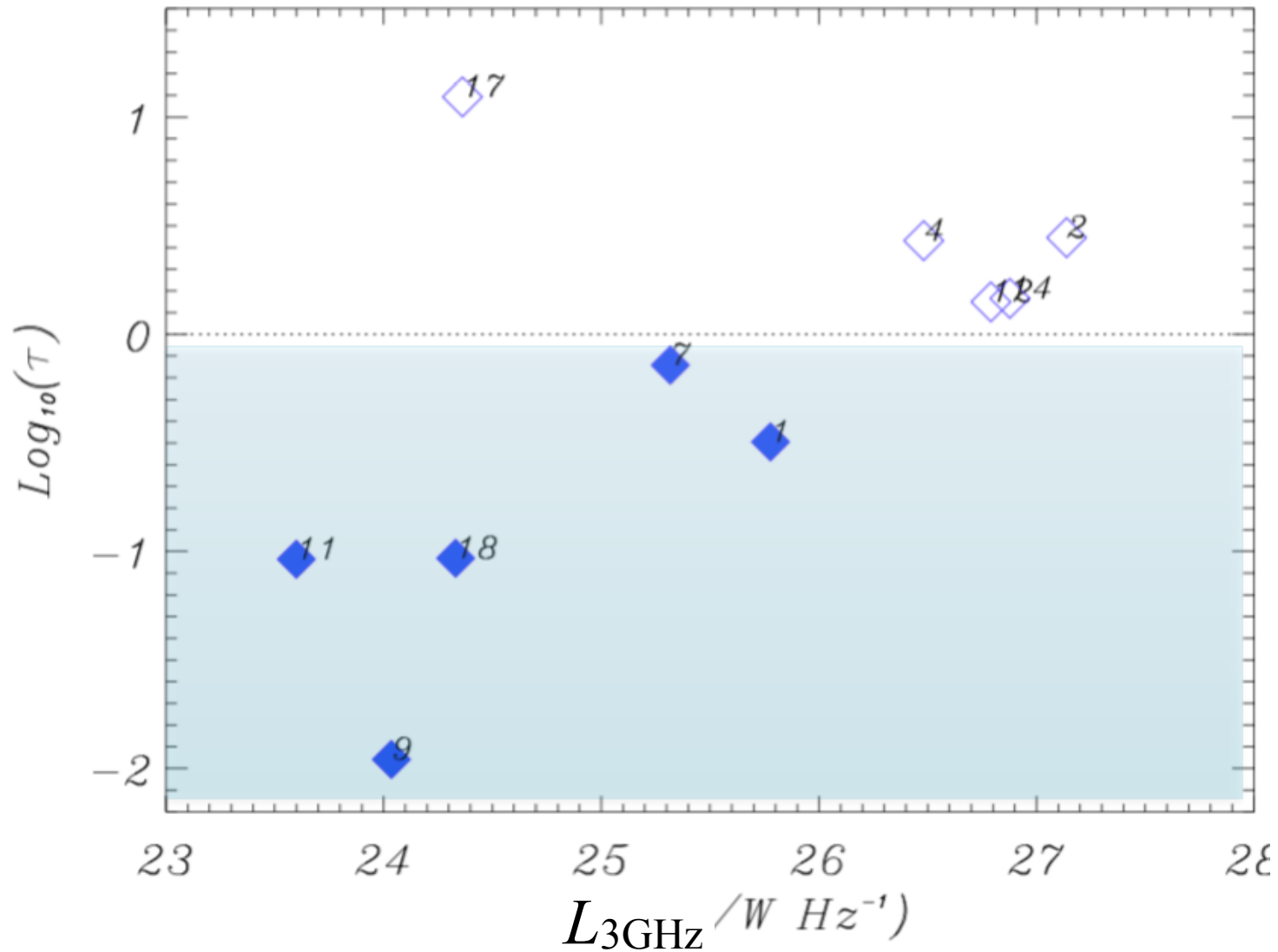
M_*,* formed: 0.4340E+05 x psi
M_*,* now : 0.3007E+05 x psi
psi = D_Mpc^2 x (t/10^-17)
    
```

radio properties

$$S_\nu \sim \nu^{-\alpha}$$



radio properties



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conclusions

- studied 18 FRI/FRII radio AGN from COSMOS JVLA 3 GHz
- used *STARLIGHT* to estimate Balmer lines and calculate the τ ratio (predicted to observed for post-AGN stars)
- all objects **LINERs** on the BPT
- 11/18 objects have τ ratios
- 6/11 show Lyc leakage: *not enough gas* to reprocess emission from AGB
- **FUTURE:** perform analysis on ~ 120 FRI/FRIIs JVLA COSMOS

thank you

