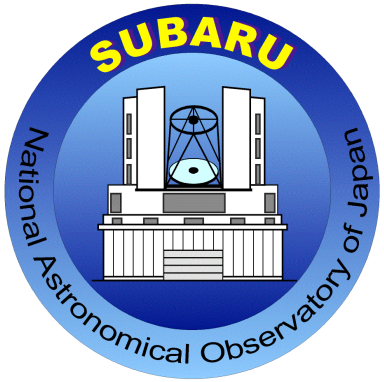
Metallicity of Narrow-Line Regions in High-z Narrow-Line Radio Galaxies



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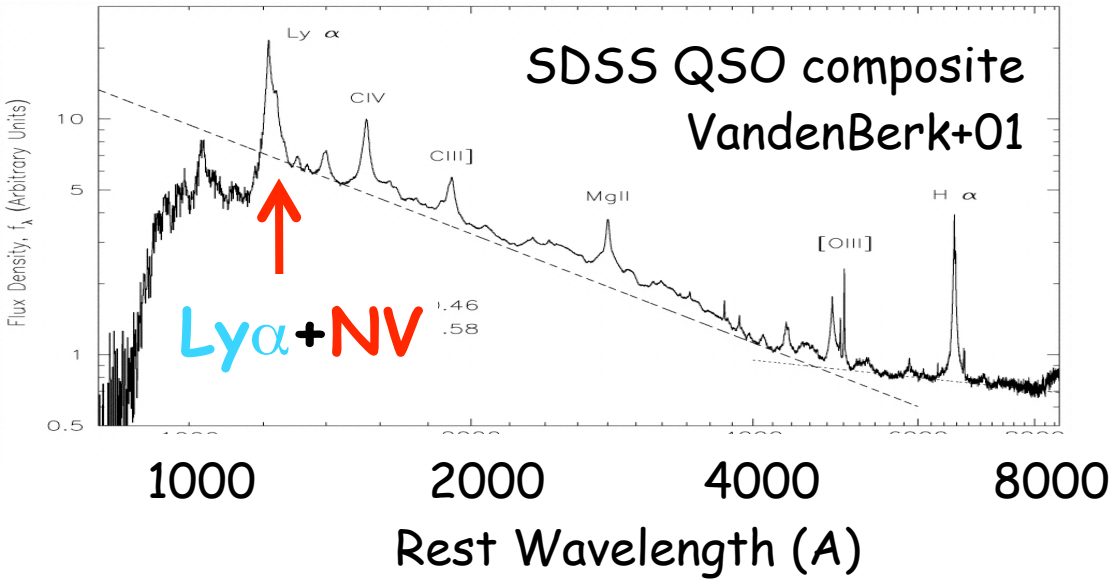
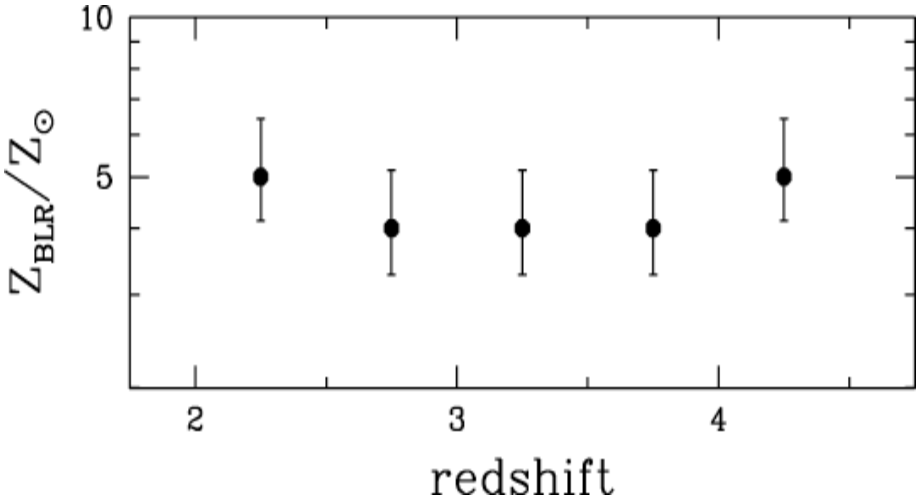
Università di Firenze

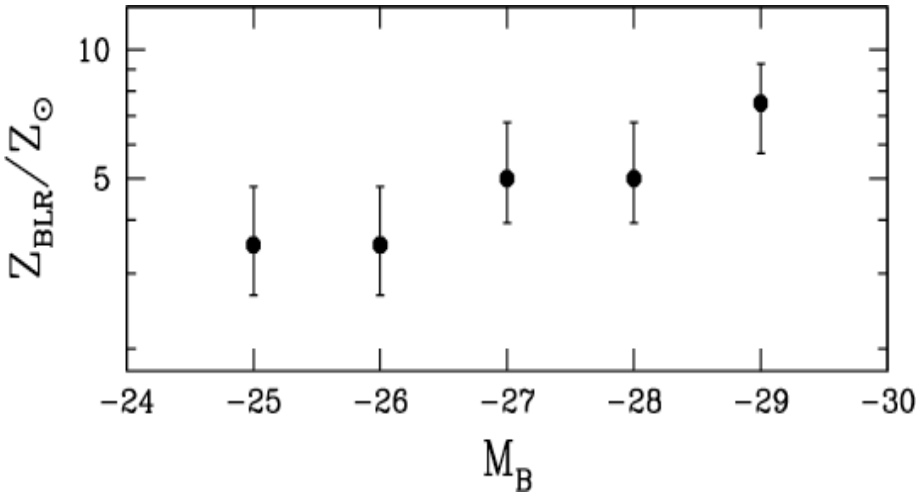
Introduction

- Why Metallicity ?
  - ~ Metallicity ⇔ Past Star-Formation History
  - ~ Constraints on Galaxy Evolutionary Scenarios
- Why High Redshift ?
  - ~ Interests on Major Era of Galaxy Evolution
  - ~ Constraints on the Early Star-Formation Epoch
- Why AGN ?
  - ~ Very Bright (⇔ normal galaxies are too faint…)
  - ~ Various Emission Lines in Rest-Frame Ultraviolet

Metallicity of BLRs in AGNs







TN, AM, RM (2006a)

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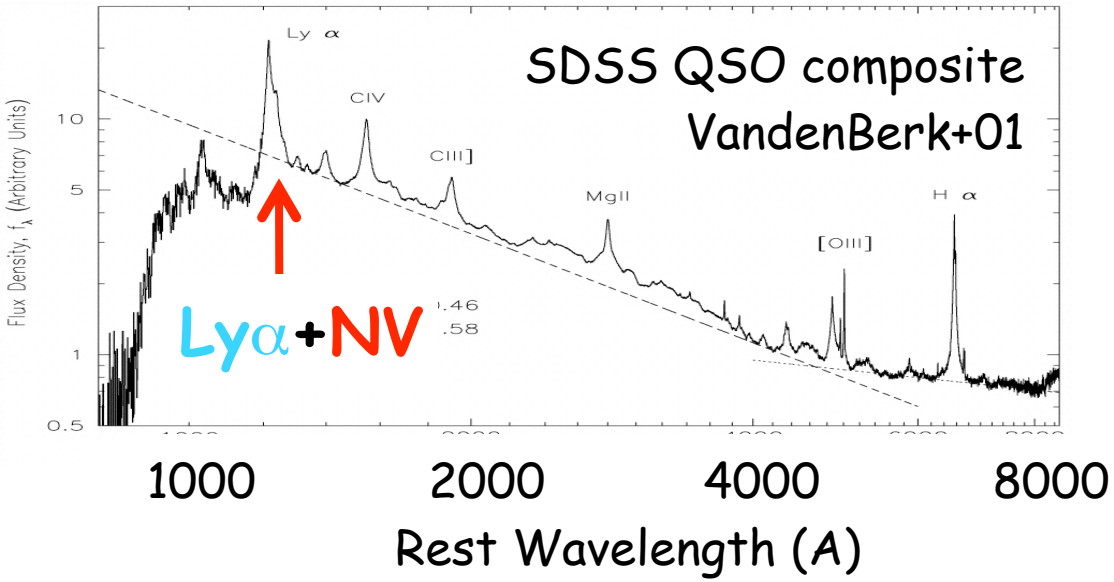
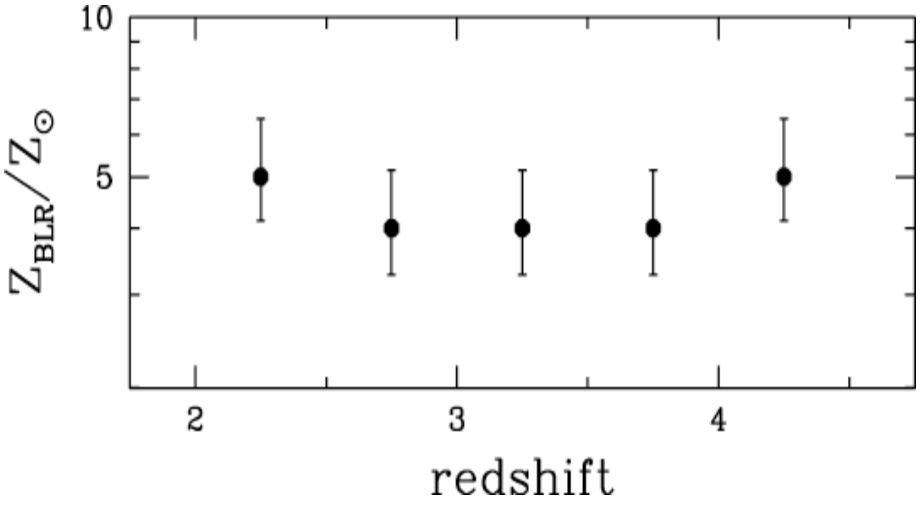
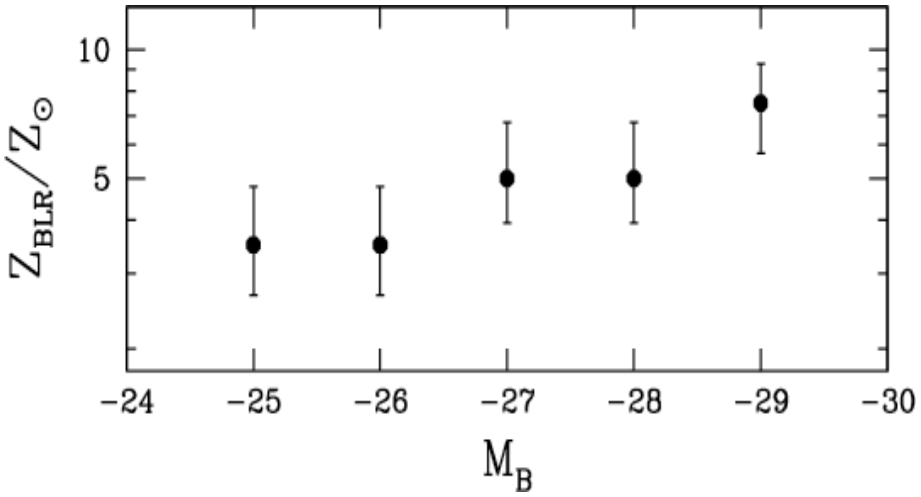


However, BLR traces only nuclear (r < 0.1pc) regions of galaxies...

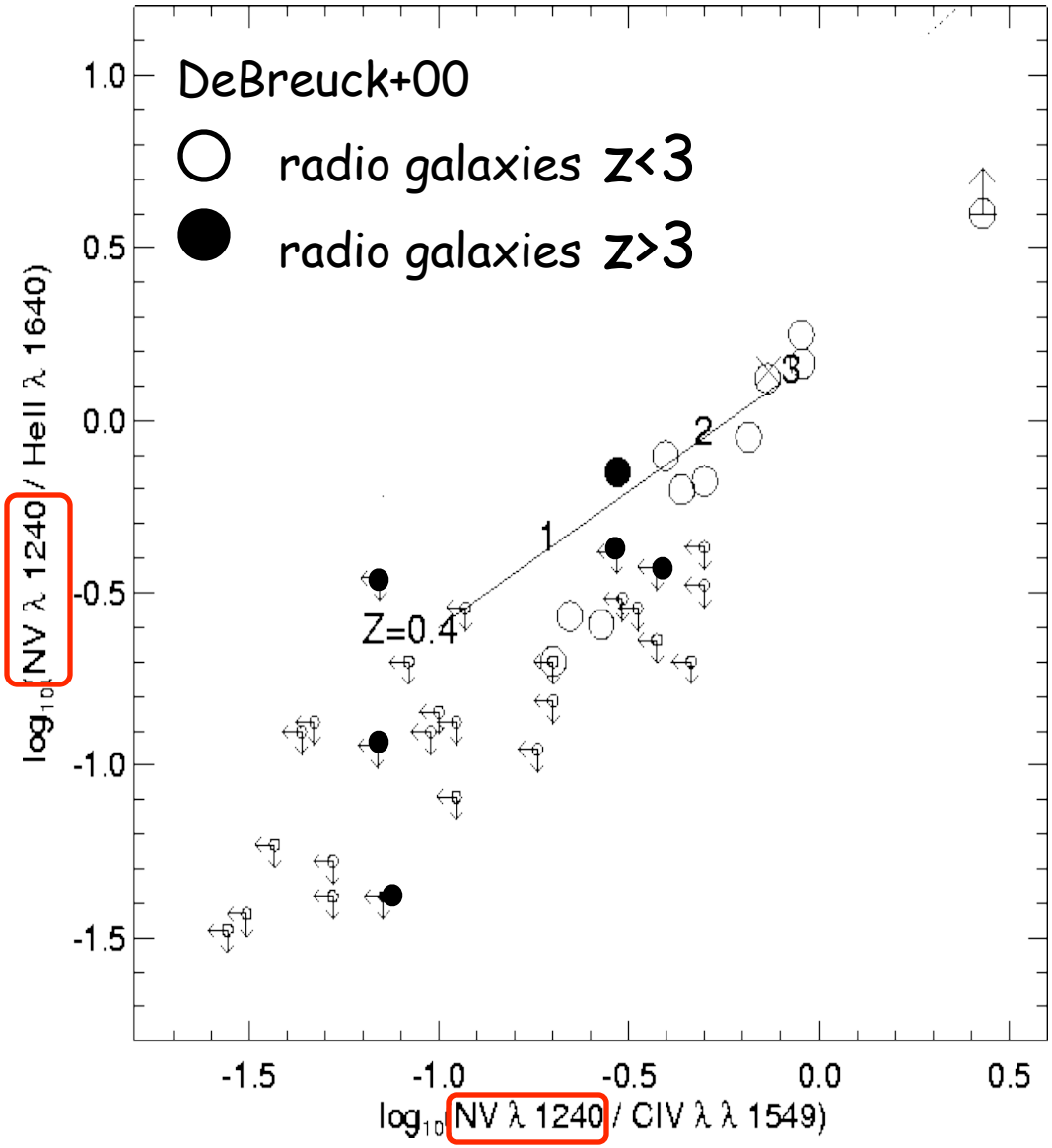
NLR of type-2 AGNs is an ideal target !!!





TN, AM, RM (2006a)

NLR Metallicity (Previous Works)

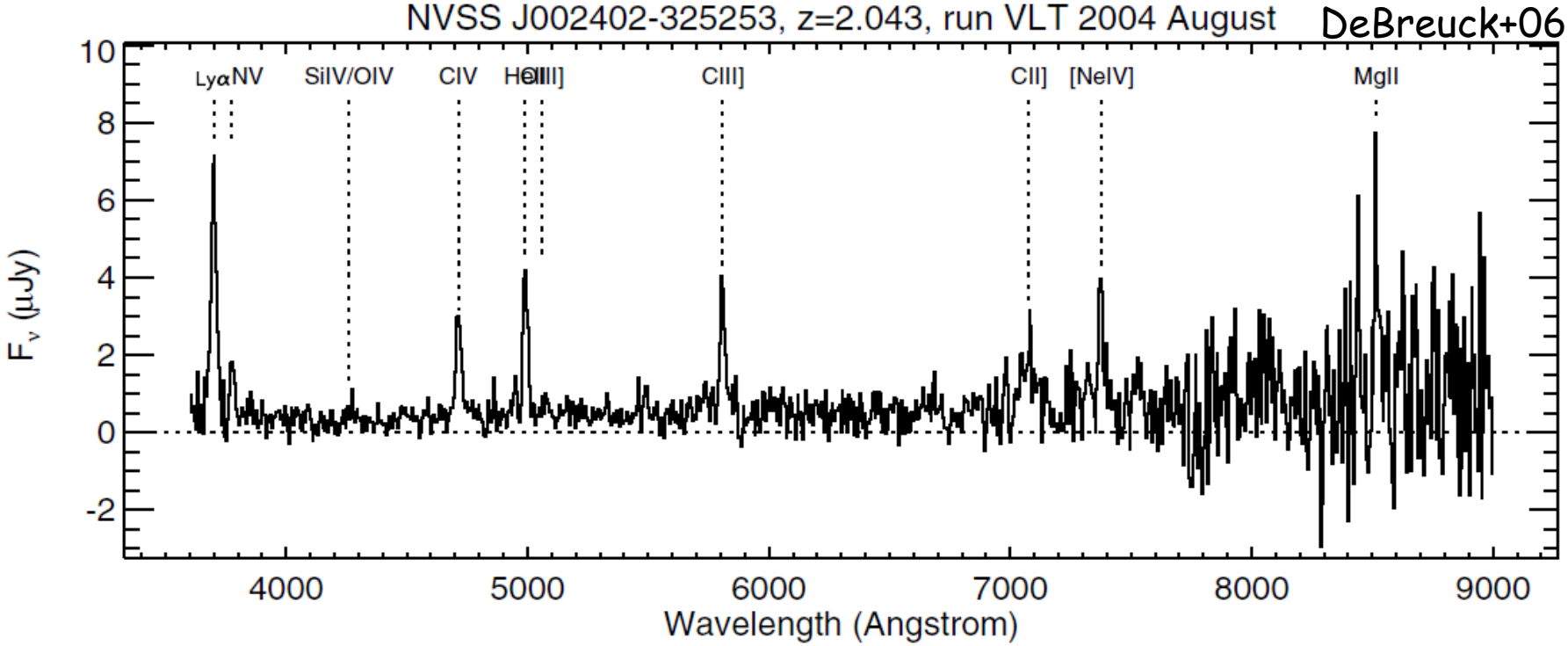


"Metallicity decreases at z>3" (DeBreuck+00)

NV of radio galaxies is generally very faint (only upper limit in most cases)

Metallicity diagnostics without NV emission seem highly crucial !!

Typical Spectra of High-z Radio Galaxies



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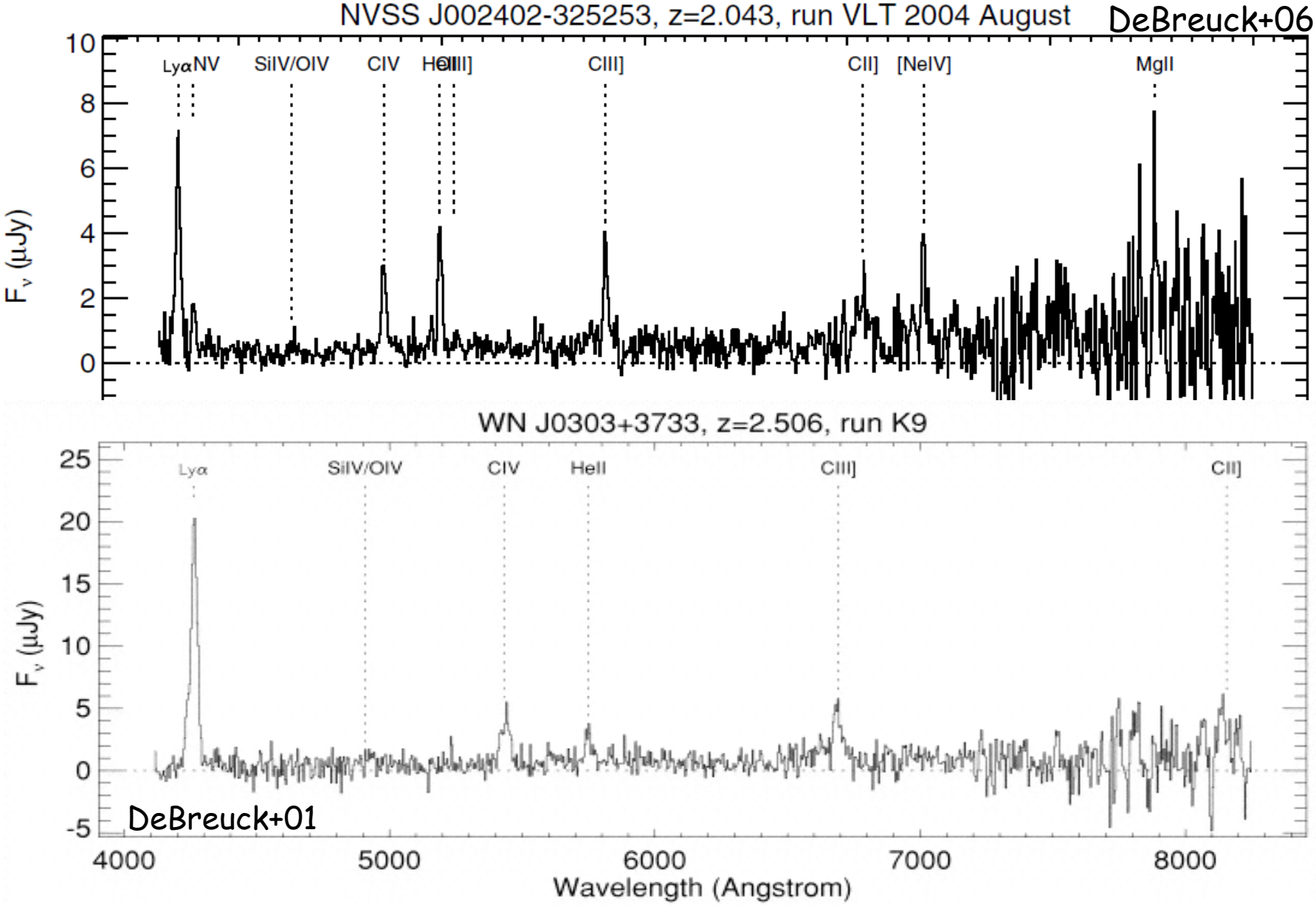

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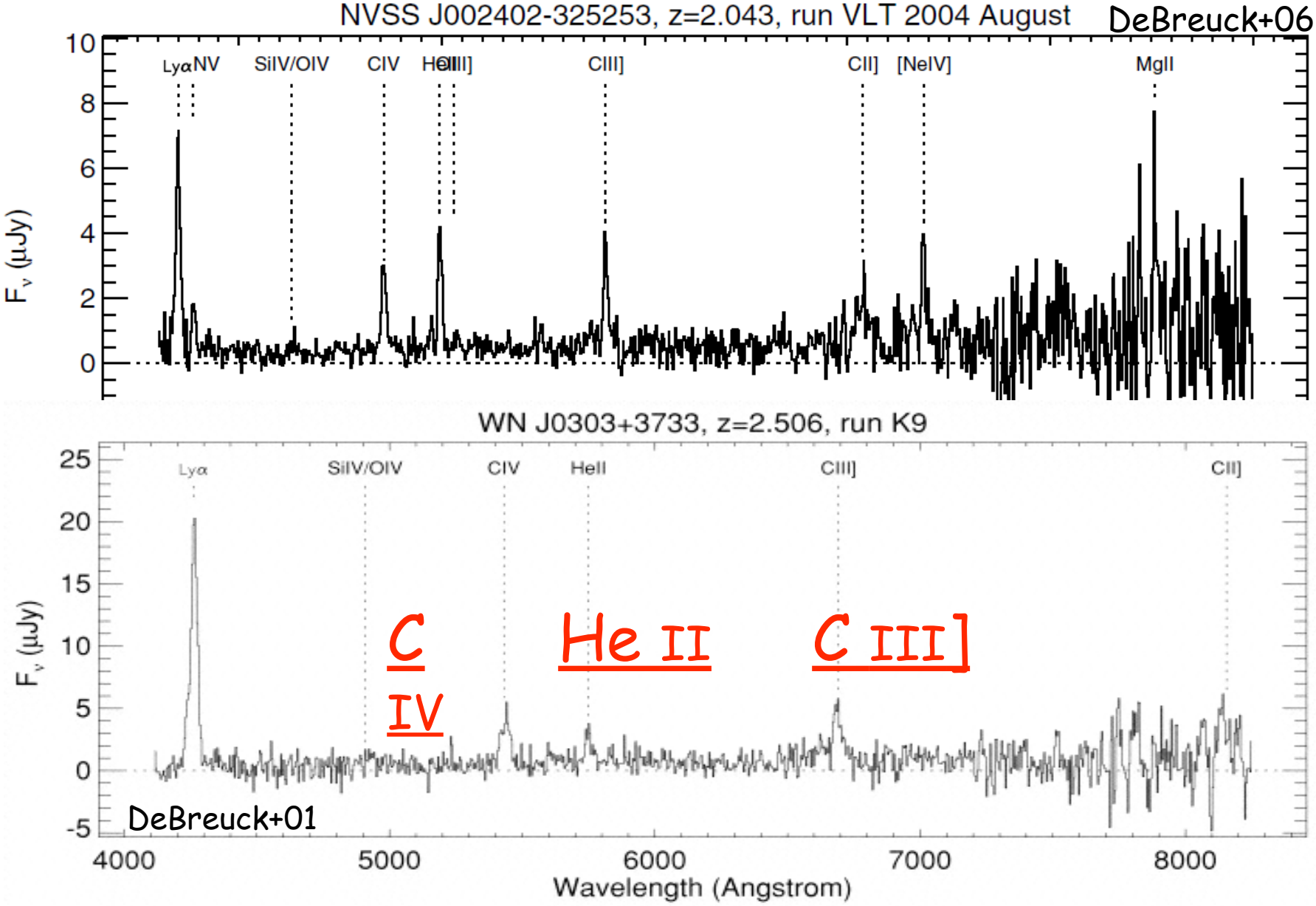


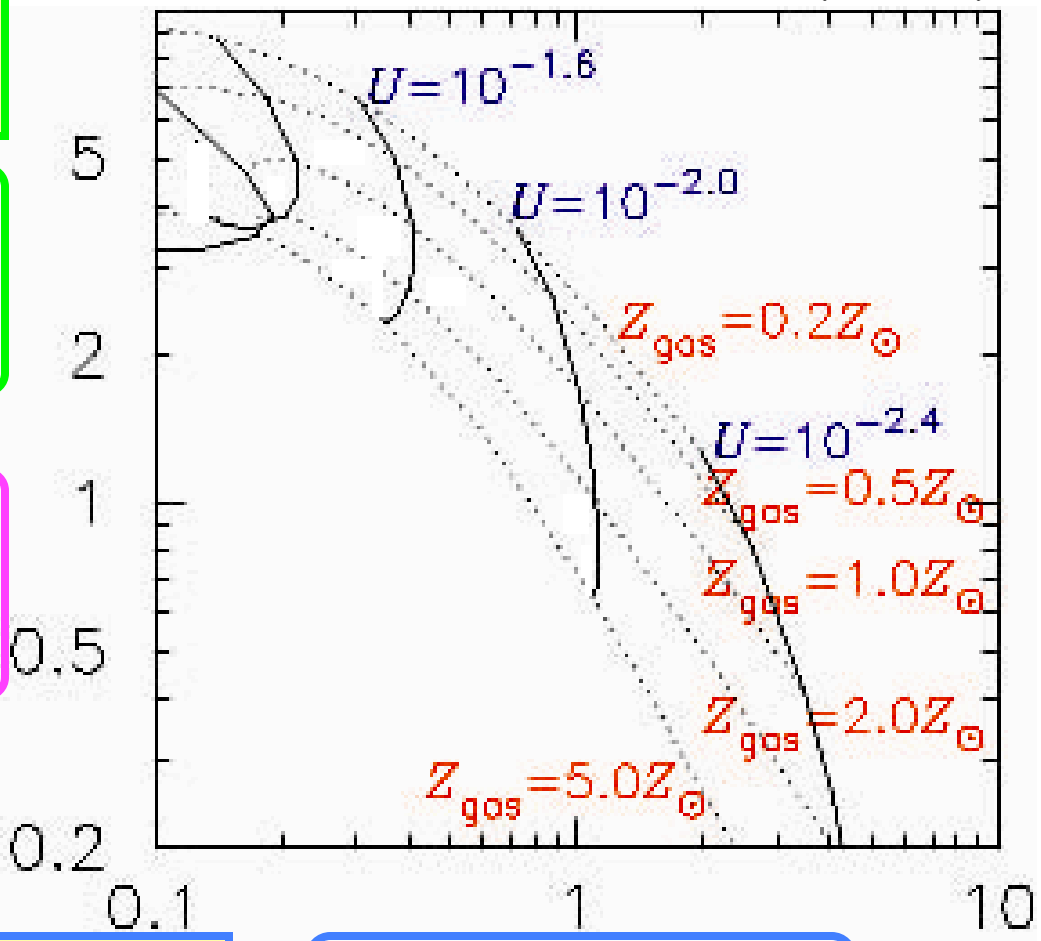
Powerful Diagnostics for NLR Metallicity

HeII Recombination Line
$L(HeII) \Leftrightarrow L_{ion}(He^{++}) \Leftrightarrow L_{AGN}$

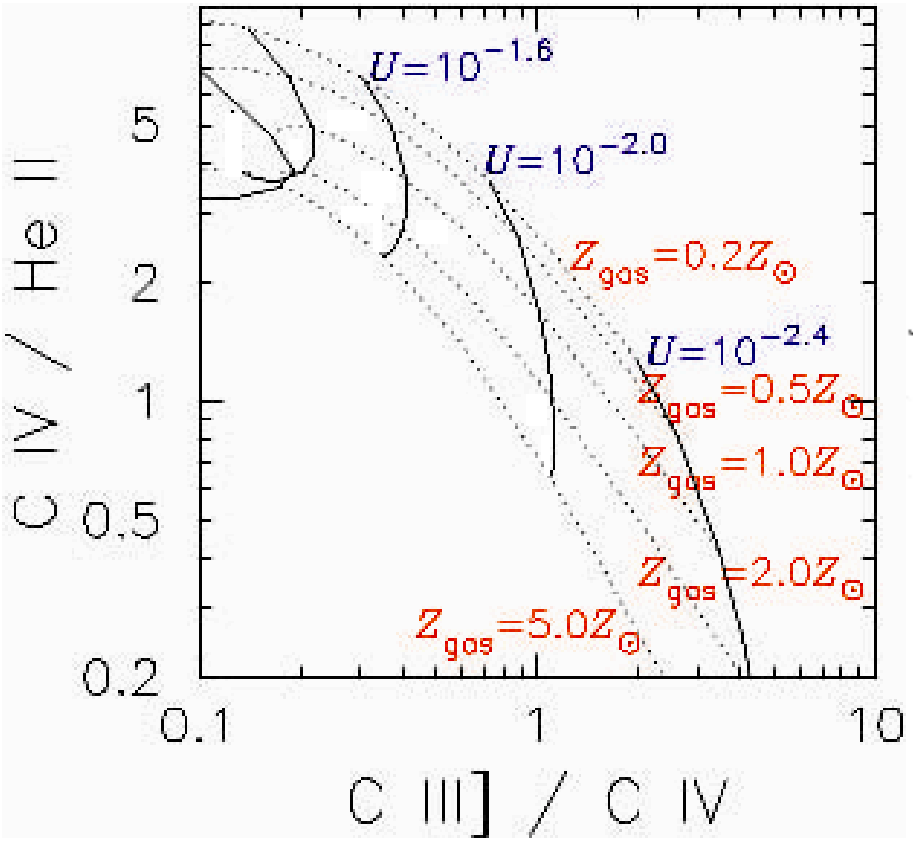
Collisional Excitation
Sensitive to T_{gas}
→ also to Metallicity

Correction for Ionization Effects

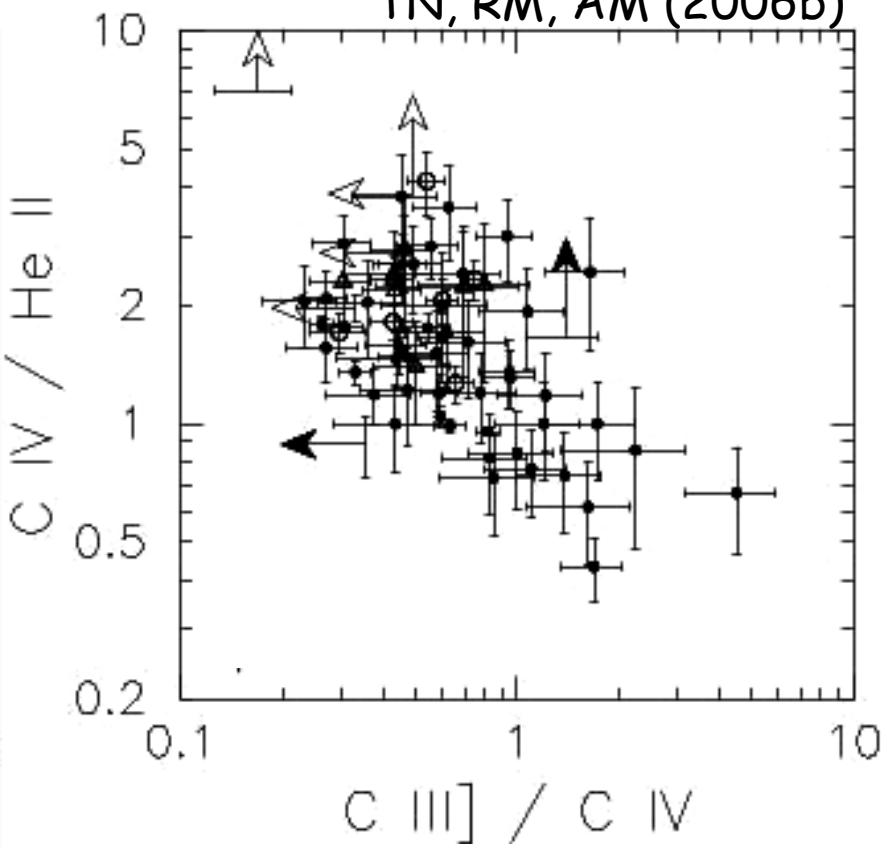
TN, RM, AM (2006b)



Our Study on the NLR Metallicity (Data)

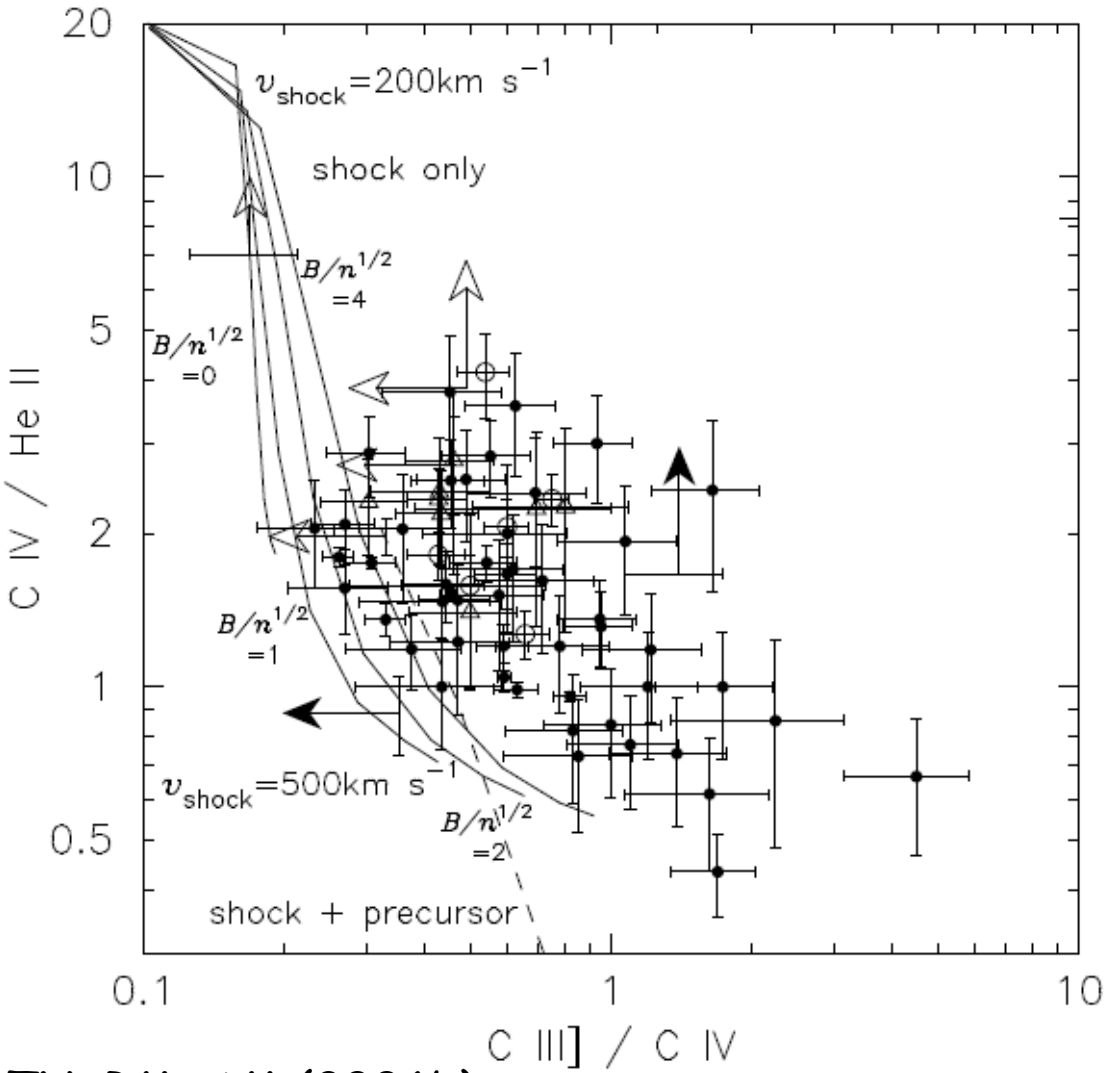


TN, RM, AM (2006b)



- 49 narrow-line radio galaxies at 1.2 < z < 3.8
- correlation: consistent to photoionization model

Shock Excitation in NLRs of Radio Galaxies ??

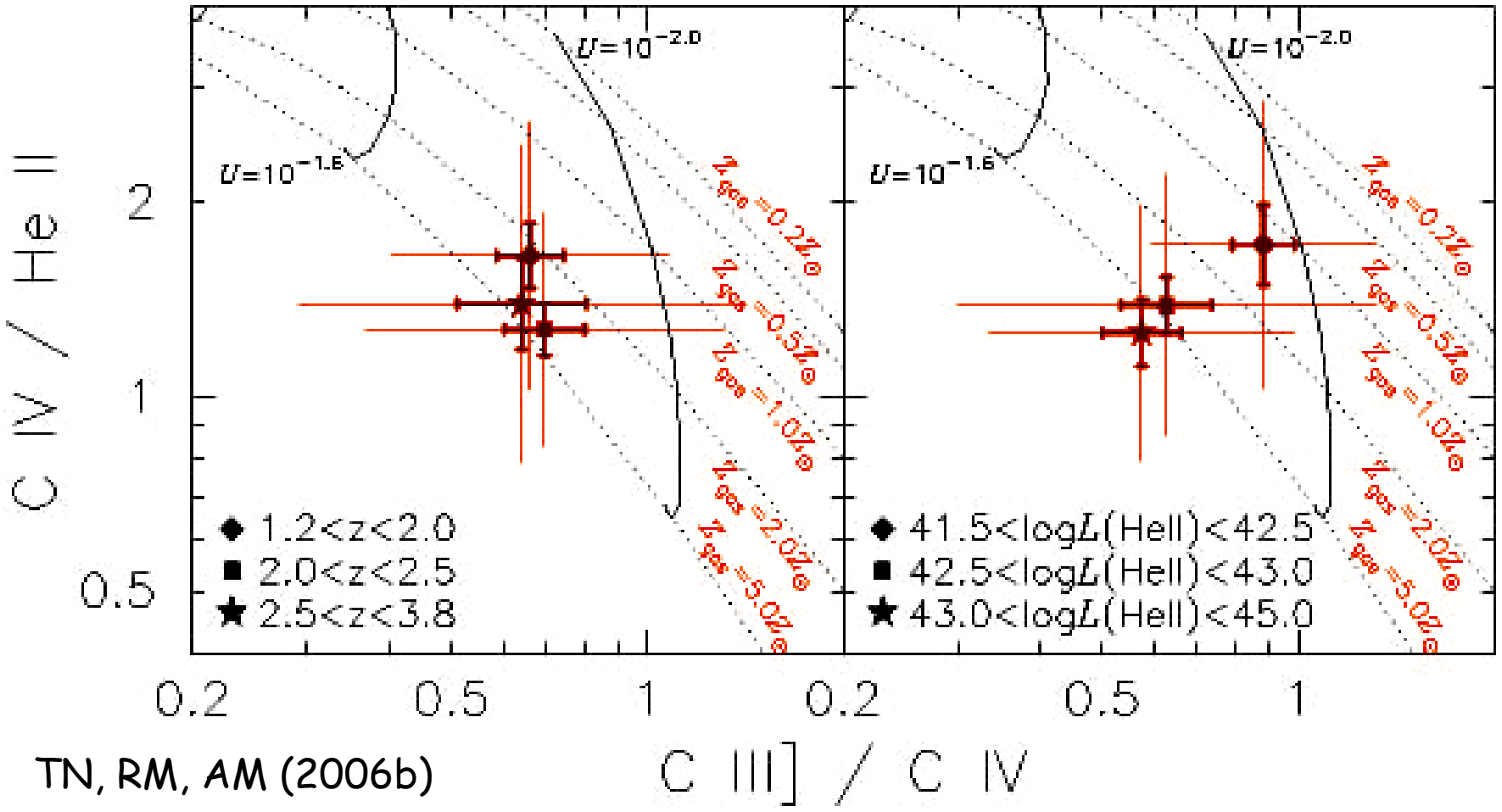


TN, RM, AM (2006b)

Shock models
(Dopita & Sutherland 96)
are inconsistent with
the flux-ratio data…

Suggesting that
the gas in NLRs are
mainly photoionized…

NLR Metallicity (Results)



TN, RM, AM (2006b)

Not only BLR, the NLR metallicity also depends on L_{AGN} but does not show any redshift evolution at 1.2<z<3.8 .

Discussion

- Luminosity-Metallicity Relation
- Seen in both BLRs and NLRs
- No Redshift Evolution

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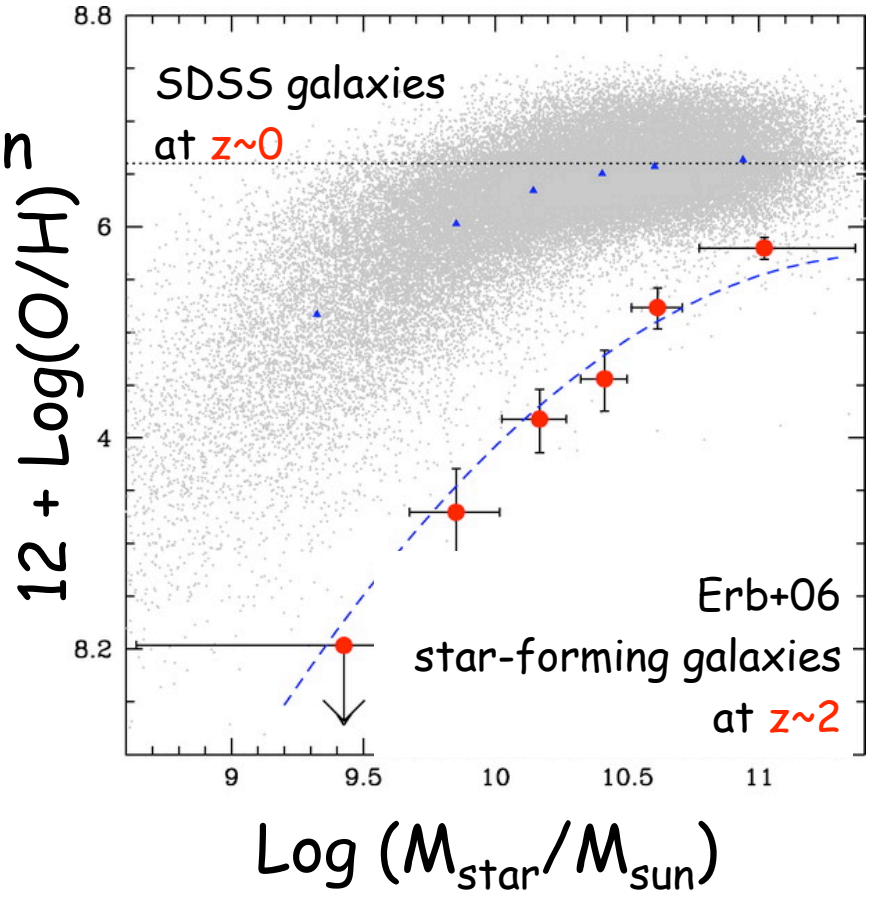

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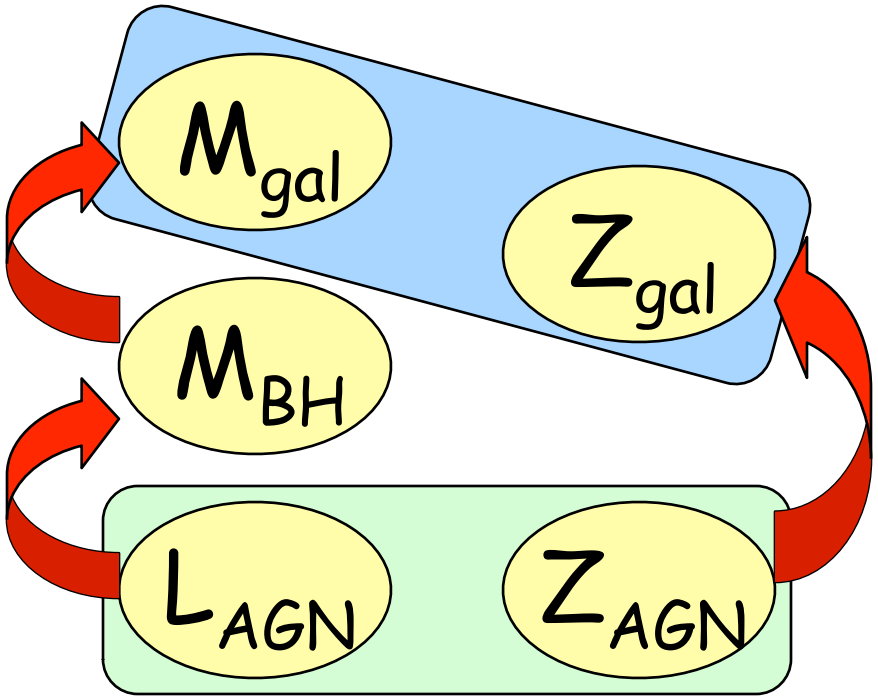
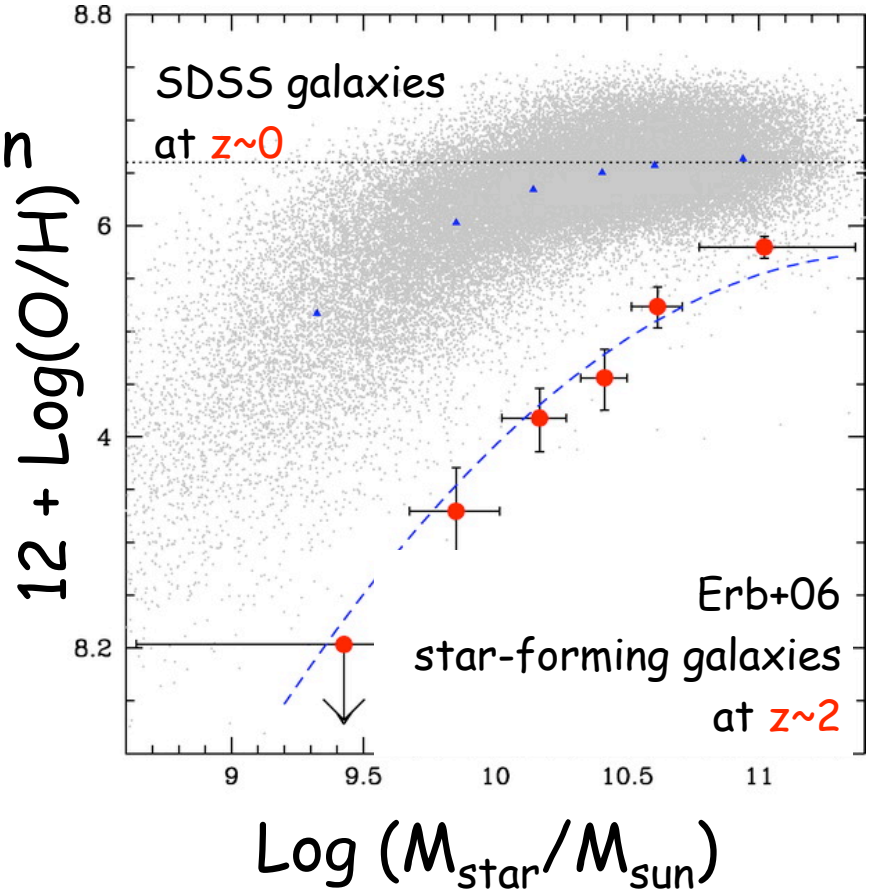
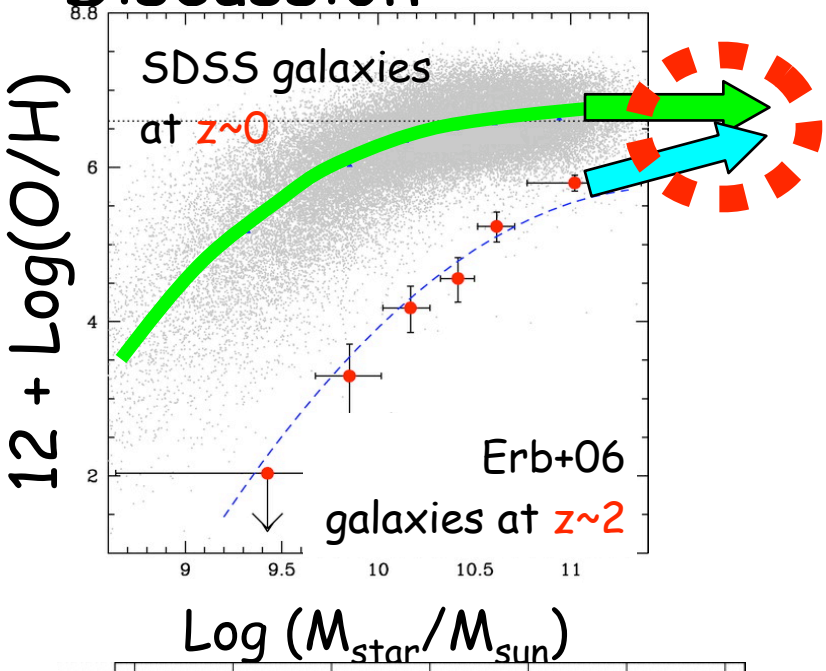
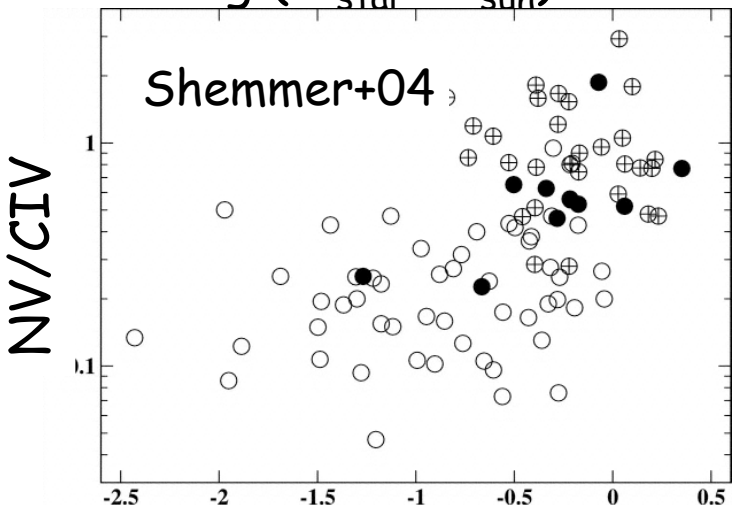




…inconsistent situation?

Discussion





Interpretation (1)

- Downsizing chemical evolution.
- Massive galaxies completed their evolution in higher redshift.
- High-z AGNs are associated in most massive galaxies.
- AGNs completed their evolution at z>4 (no evolution at z<4)…
- [cf. K-z relation of radio galaxies]

Interpretation (2)

- AGN luminosity is determined by M_{BH} and accretion rate (L/L_{Edd}).
- L/L_{Edd} may be essential for Z.
- M_{BH} may be not important for Z.
- AGN L-Z relation and galaxy M-Z relation may be independent…

Summary

- NLR Metallicity Diagnostic Method
  - ~ Without NV ⇔ Applicable to Metal-Poor Objects
  - ~ Using Strong Lines ⇔ Applicable to Faint Objects
- Application to High-z Radio Galaxies
  - ~ NLR Metallicity: Depends on L, Independent of z
  - ~ Consistent to Previous Results on BLRs
- Interpretations: Not Simple…
  - ~ Downsizing Chemical Evolution ?
  - ~ Effects of Mass Accretion Rate ?
- Further Observations (Future Study)
  - ~ 10 More Objects at $z > 3$