Big Blue Bump–Accretion disc connection and black hole masses of radio–loud narrow–line Seyfert 1 galaxies

Giorgio Calderone

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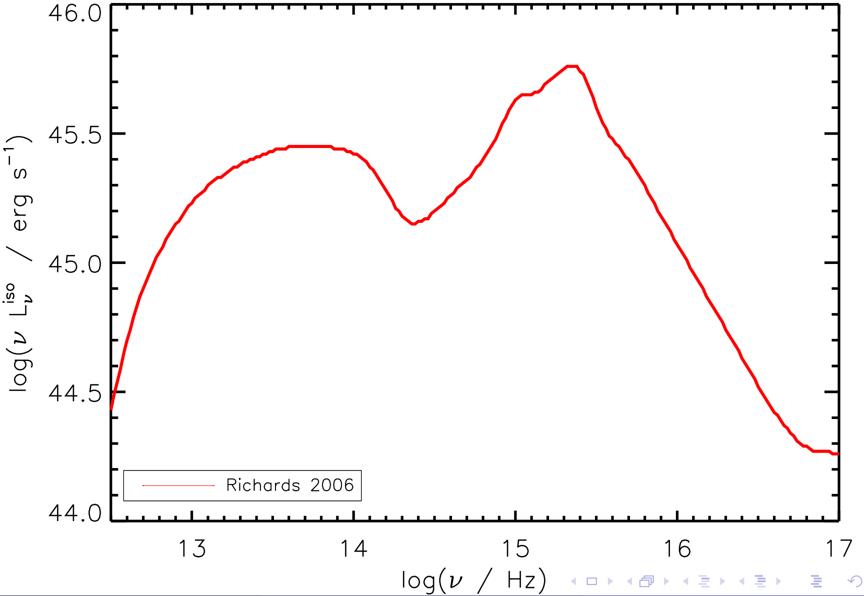
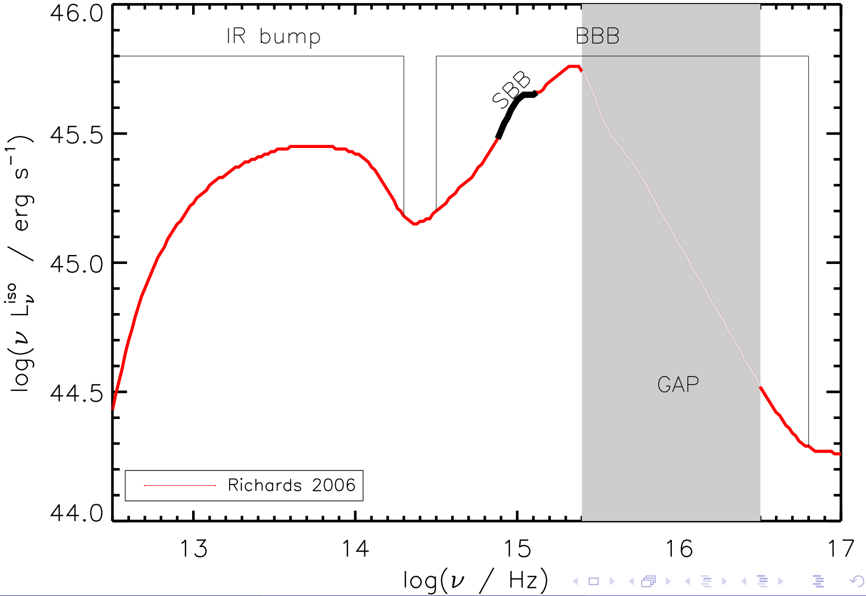
INAF – Osservatorio Astronomico di Brera (Merate)

11 Sep 2012

Outline of the talk

1. Connection between the Big Blue Bump (BBB) and the Shakura & Sunyaev (1973) accretion disc spectrum (SS–AD)
2. Black hole mass estimate through accretion disc spectral fitting
3. Application to a sample of radio–loud narrow–line Seyfert 1 (RL–NLS1) sources.


46.0
45.5
45.0
44.5
44.0
$\log(\nu\ L_\nu^{iso}\ /\ \mathrm{erg\ s^{-1}})$
Richards 2006
13
14
15
16
17
$\log(\nu\ /\ \mathrm{Hz})$


IR bump
BBB
SBB
GAP
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log(ν / Hz)
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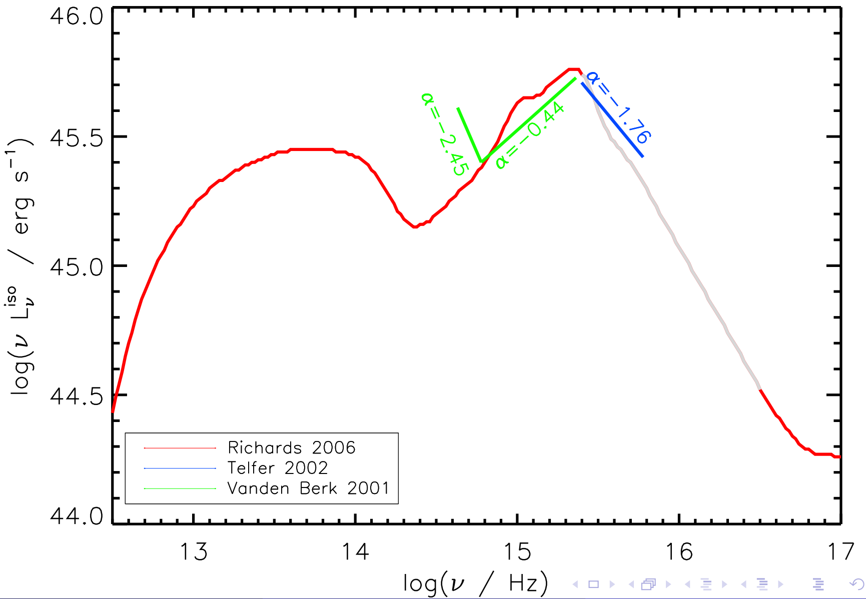
BBB ↔ SS–AD connection



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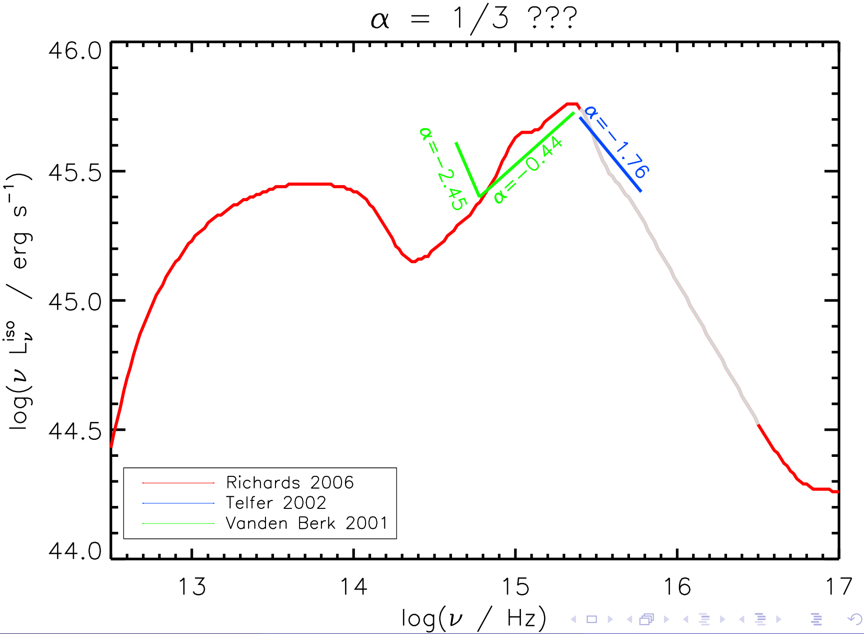

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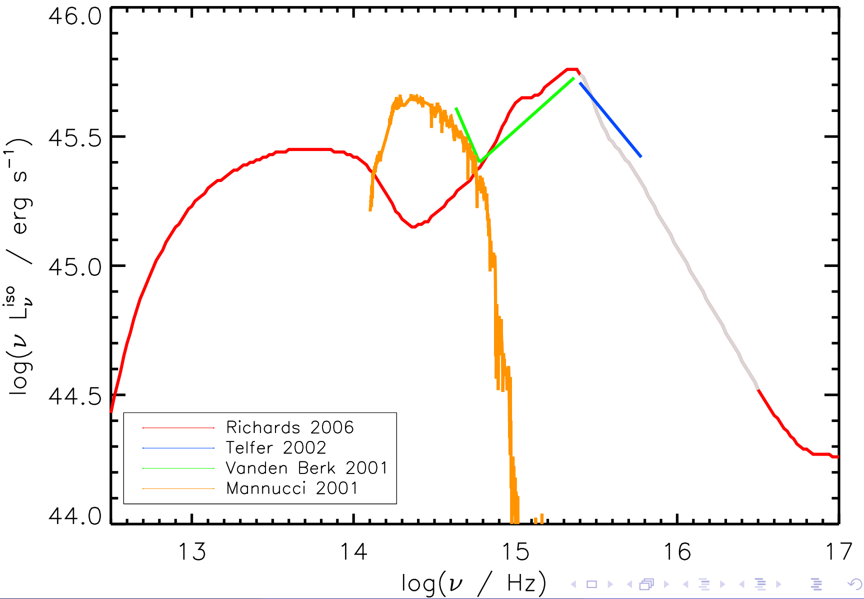

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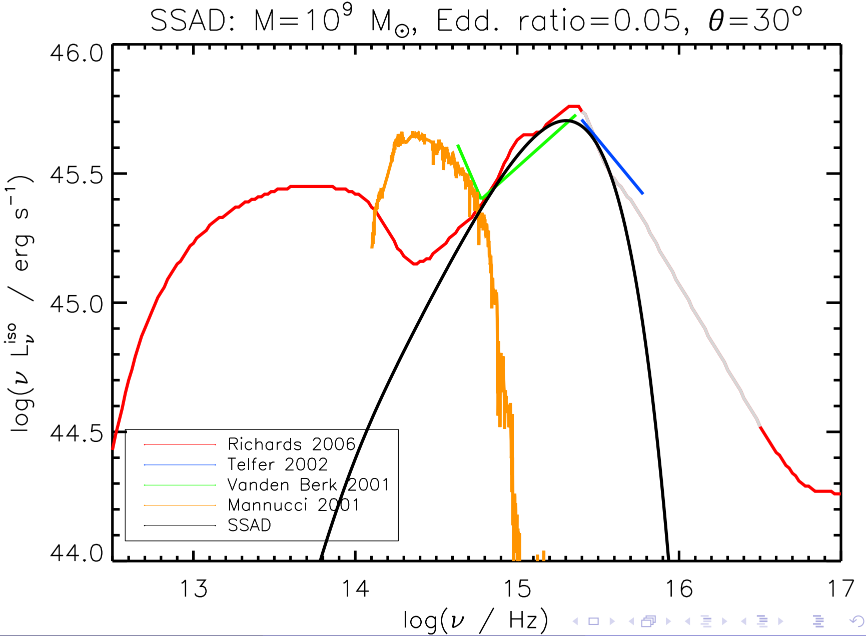

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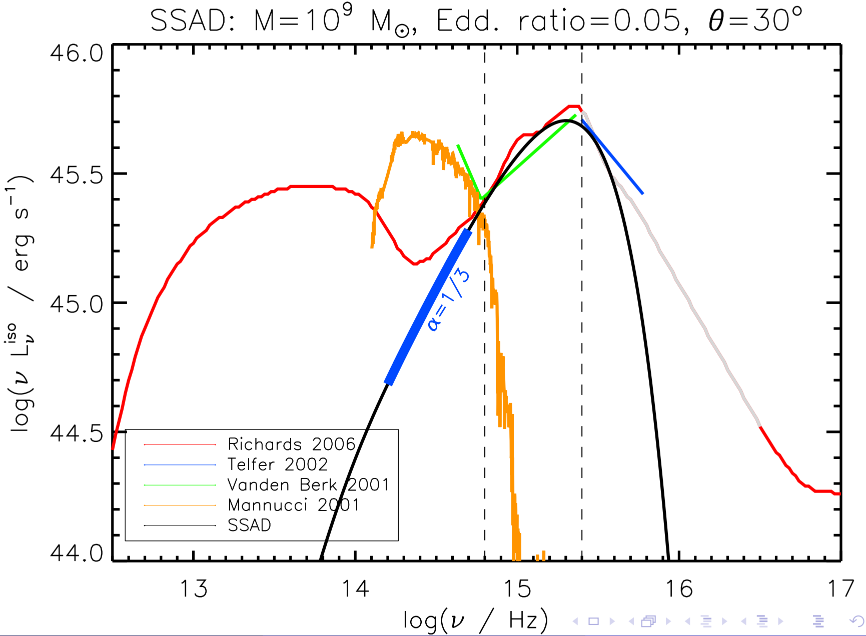

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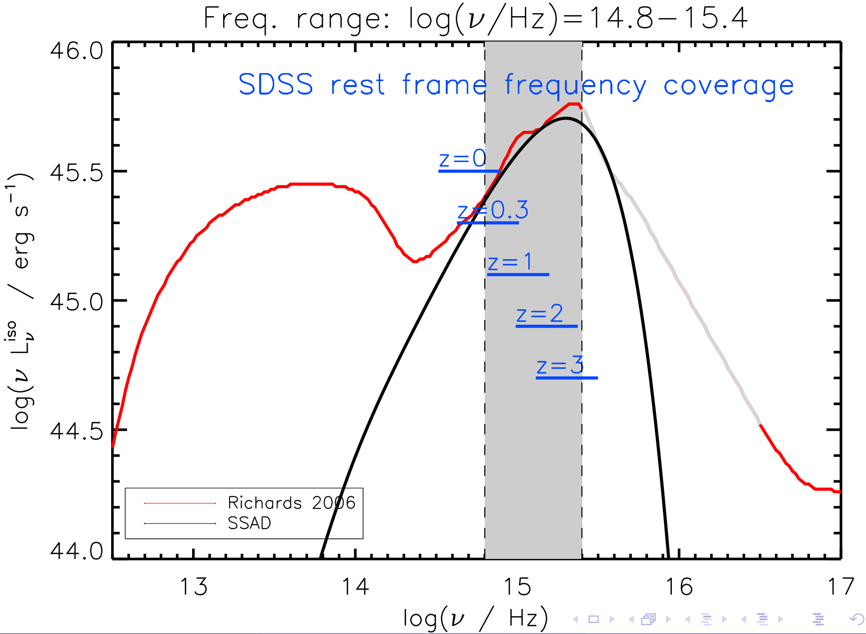

- SS–AD model fits well the composite SED in the range $\log(\nu/\mathrm{Hz}) = 14.8$–$15.4$;
- $\Rightarrow$ use SS–AD model fitting to infer black hole mass (M) and accretion rate ($\dot{M}$);
- $\Rightarrow$ use SDSS data for sources with z=0.3–2;

- historically this has been the first mass estimation method for Type 1 AGN (e.g. Shields 1978; Malkan & Sargent 1982; Malkan 1983; Zheng et al. 1995; Sun & Malkan 1989);
- later abandoned in favour of other methods:
  - reverberation mapping calibrated scaling relation ("virial method");
  - use width of narrow lines (e.g. [OIII], [SiII]) as proxy for stellar velocity dispersion, and M–σ_* relation;

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SS–AD model fitting

Assumptions:

- $R_{\rm in} = 3\ R_{\rm Schw}$
  $\Rightarrow \eta \sim 0.1$;
- $\cos\theta = 0.85$;

Scaling relations:

- $\dot{M} \propto L_{\rm d} \propto \nu_{\rm p} L_{\nu_{\rm p}}$;
- $M \propto \nu_{\rm p}^{-2}$
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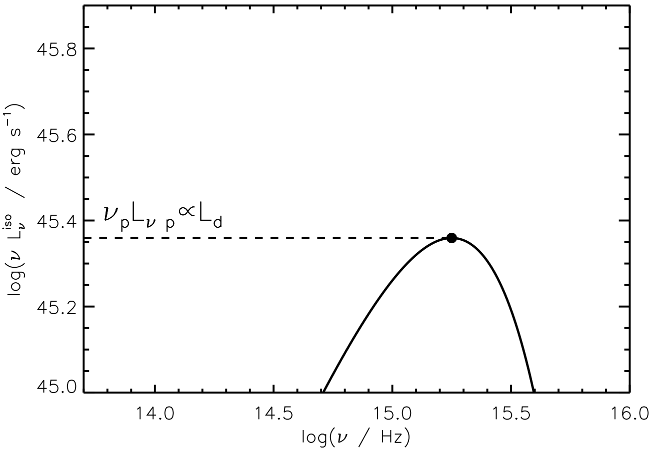

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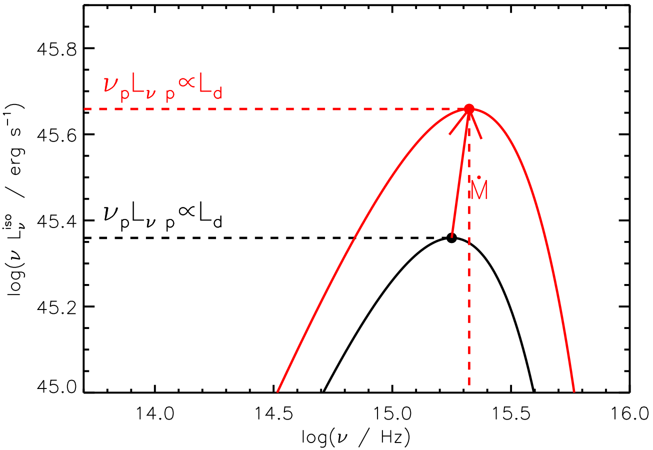

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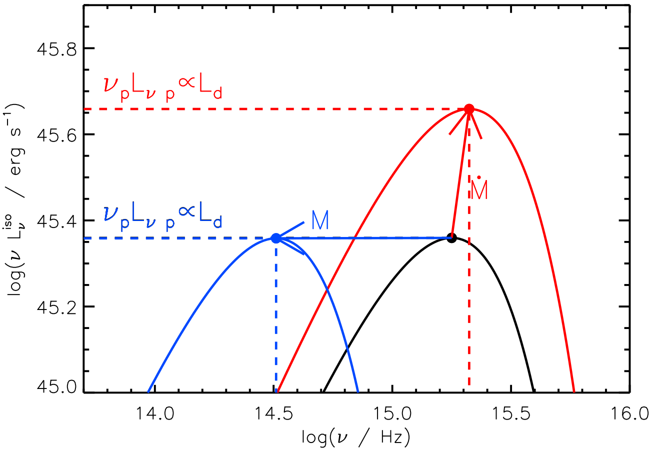

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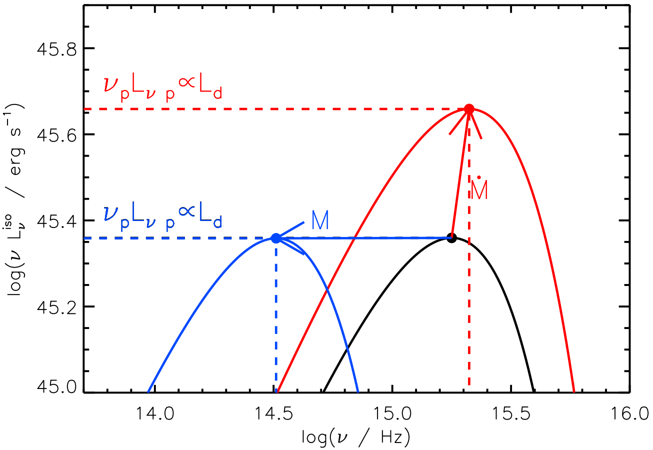

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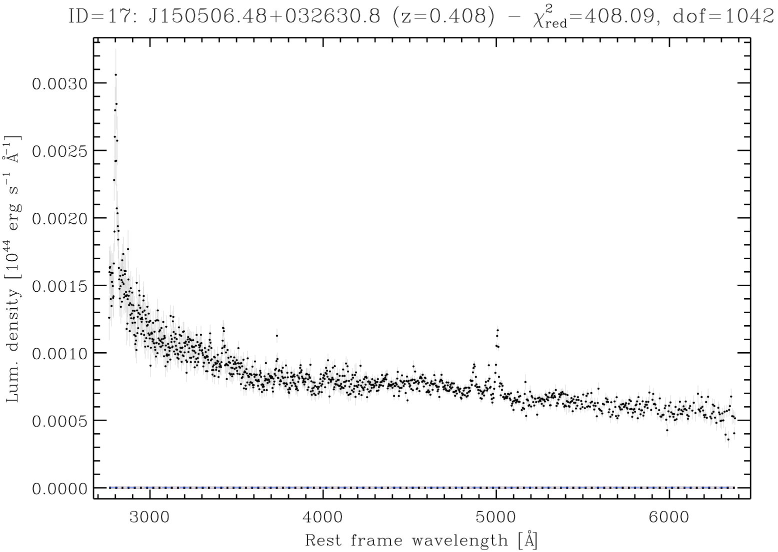
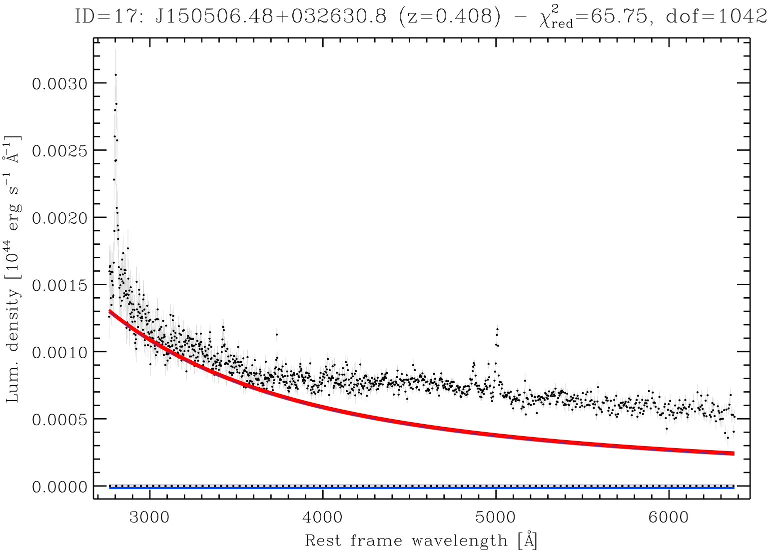
SDSS spectral decomposition



Data + errors

SDSS spectral decomposition



Data + errors + power-law

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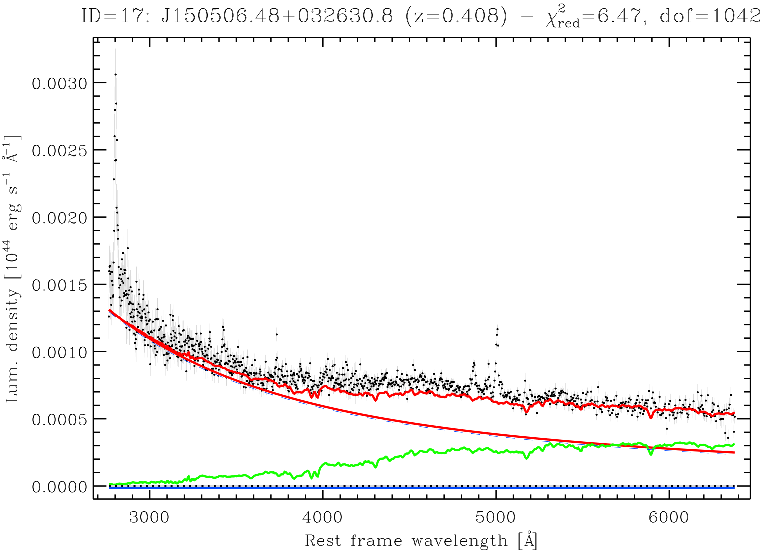

Data + errors + power-law + galaxy

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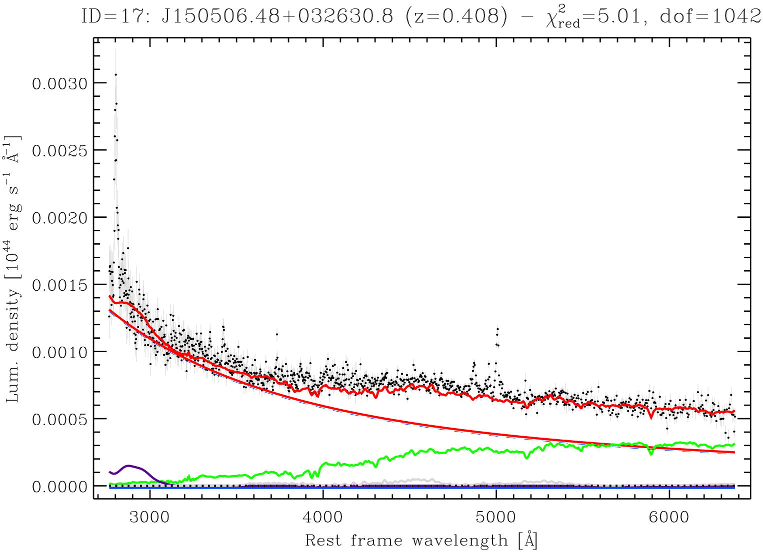

Data + errors + power-law + galaxy + iron

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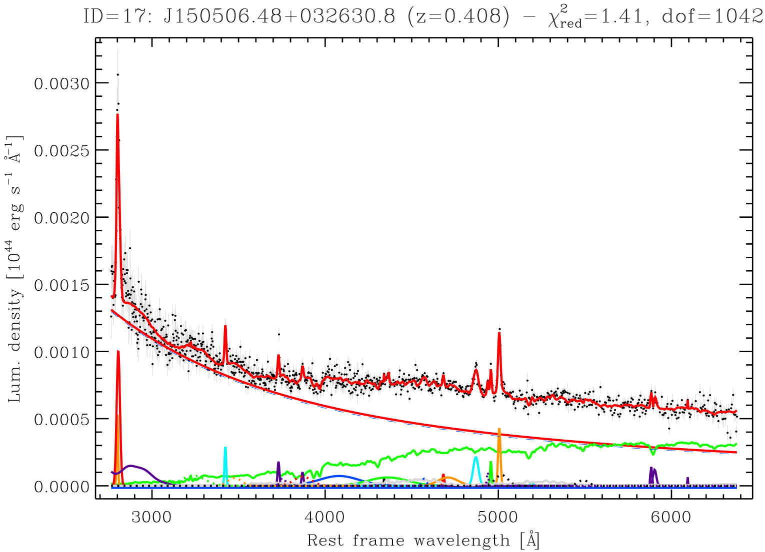

Data + errors + power-law + galaxy + iron + (broad & narrow) lines

SS–AD model fitting

Estimate L_d:

- Use a prescription similar to L_{bol}–λL_λ(cont.) relation;
- since continuum may be contaminated by either galaxy starlight or jet synchrotron radiation...
- ...we use line luminosities $\Rightarrow$ find L_d:

$$\begin{cases} L_d^{iso} = A \quad L(H\beta) \\ L_d^{iso} = B \quad L(MgII) \\ L_d^{iso} = C \quad L(CIV) \end{cases}$$

where the constant A, B and C are calibrated using a very big sample (Shen et al. 2011). Uncertainty are a factor $\sim$2;

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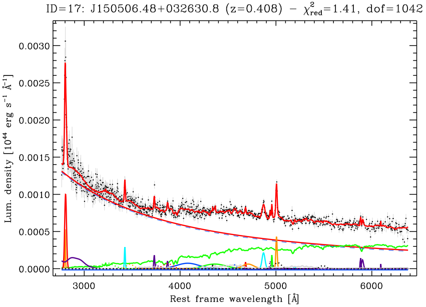

Calderone et al. in preparation

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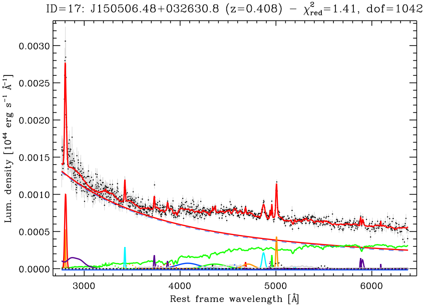

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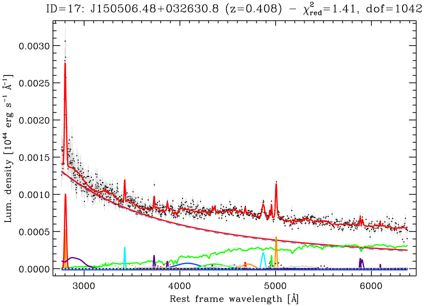

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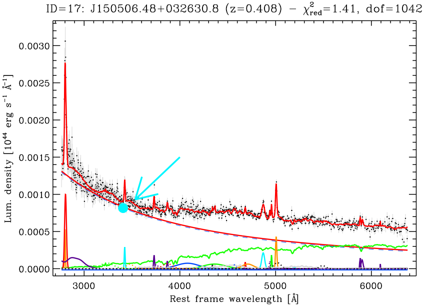

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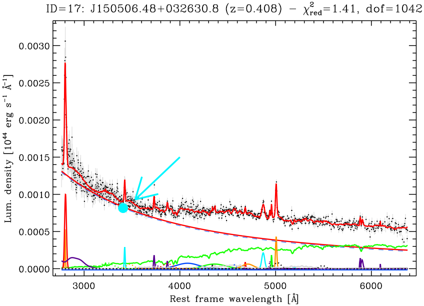

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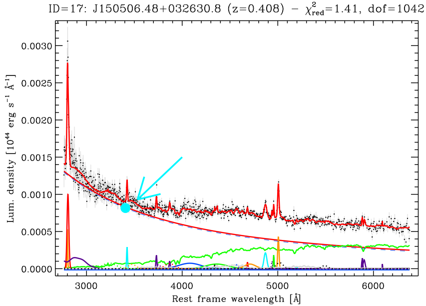

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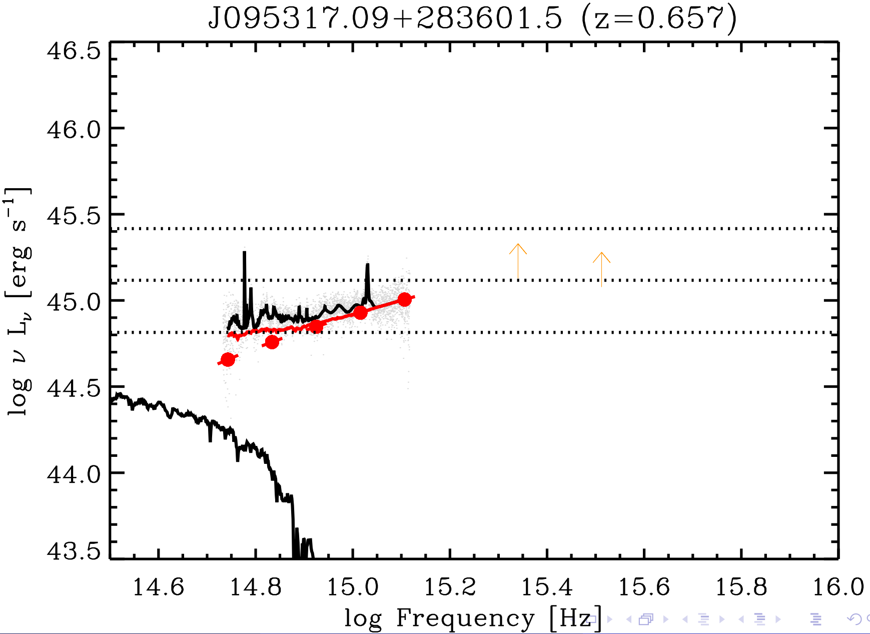
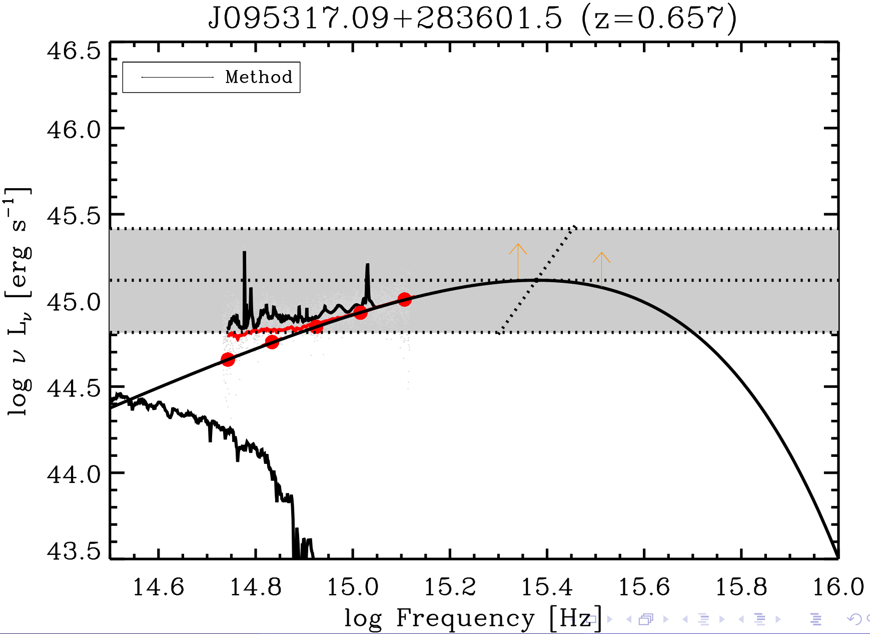
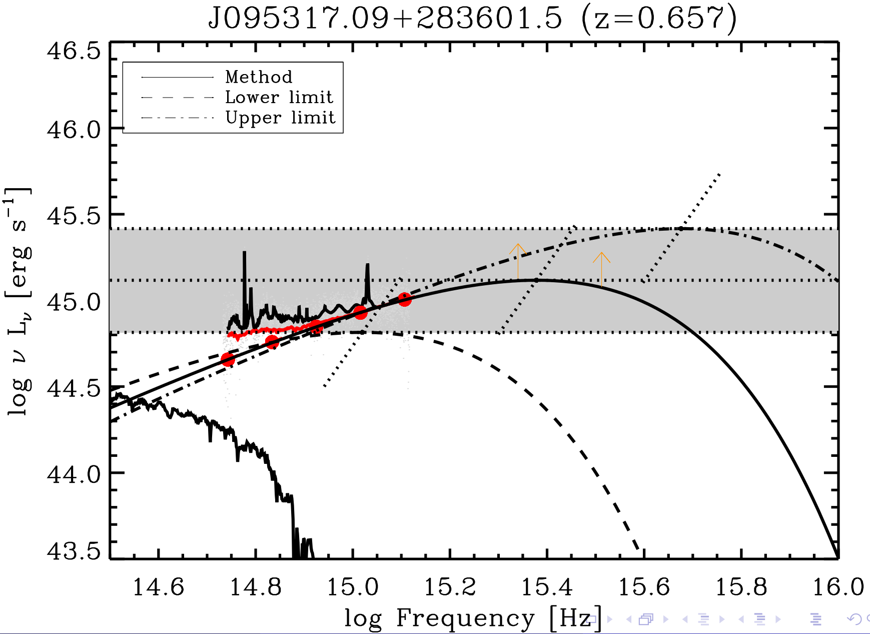
SS–AD model fitting (example)




J095317.09+283601.5 (z=0.657)
Method
46.5
46.0
45.5
45.0
44.5
44.0
43.5
log ν L_ν [erg s^-1]
14.6
14.8
15.0
15.2
15.4
15.6
15.8
16.0
log Frequency [Hz]


J095317.09+283601.5 (z=0.657)
Method
Lower limit
Upper limit
46.5
46.0
45.5
45.0
44.5
44.0
43.5
log ν L_ν [erg s^-1]
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Sample of Yuan et al. 2008

- sample of 23 radio–loud (R>100) narrow–line Seyfert 1 galaxies (RL–NLS1);
- small width of Hβ
  - $\Rightarrow$ small virial masses ($\log(M/M_{\odot})$ =6.5–8.5;
  - $\Rightarrow$ high Eddington ratio: 0.5–2.6;
- strong iron lines;
- observational properties similar to blazars, 4/23 sources have been detected at γ–rays by *Fermi*/LAT ($\Rightarrow$ jet);

Questions

1. do relativistic jet develops with such a small black hole mass ?
2. are RL–NLS1 intrinsically different sources wrt blazars ?

Analysis of a RL–NLS1 sample

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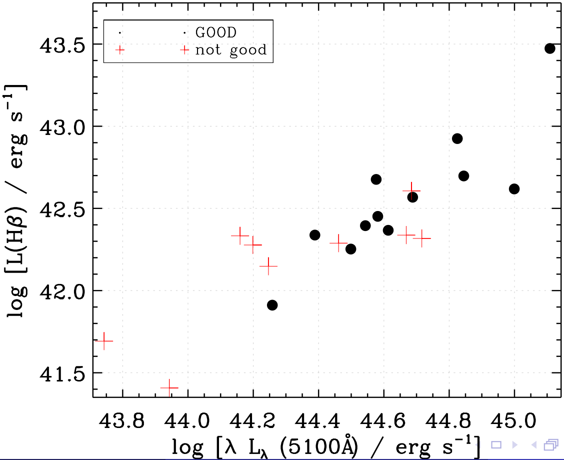

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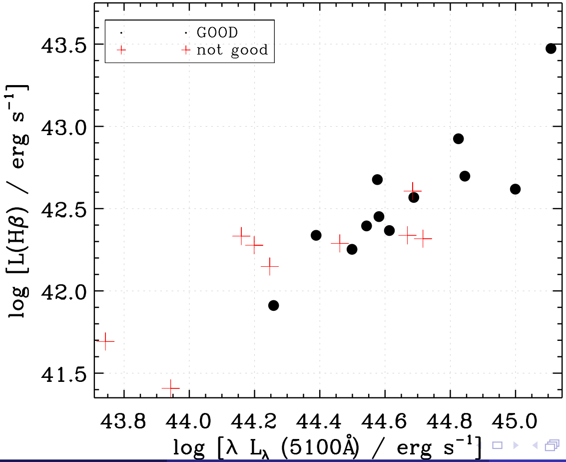
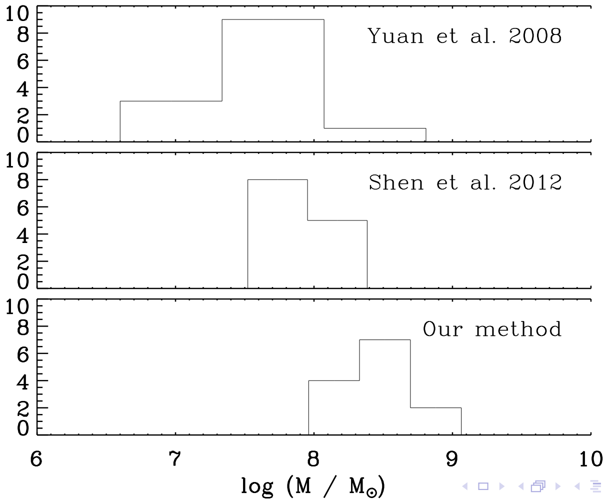


Results (2)

- Our masses are a factor $\gtrsim$3 than virial estimates;



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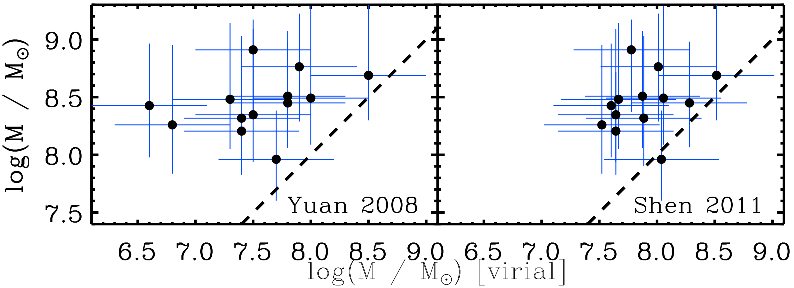
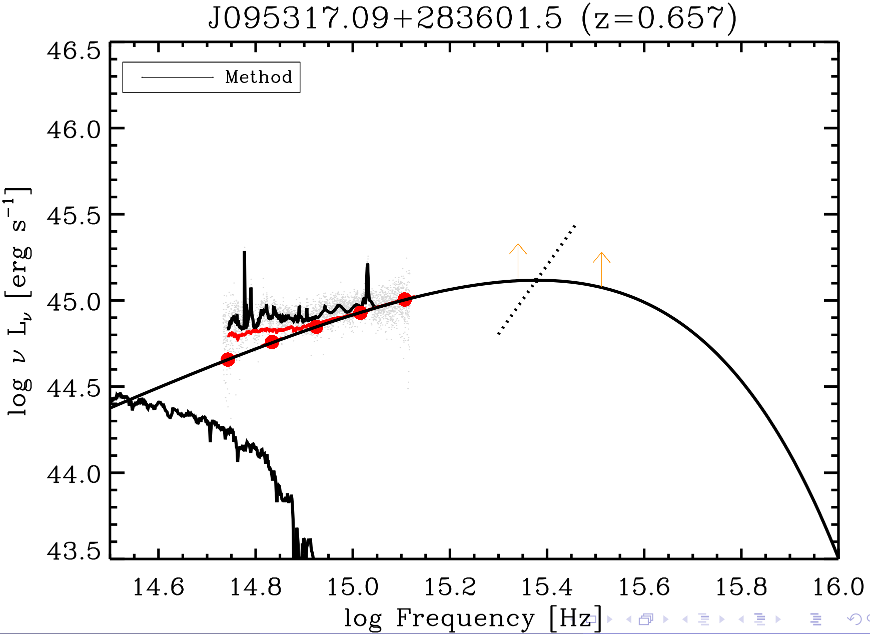
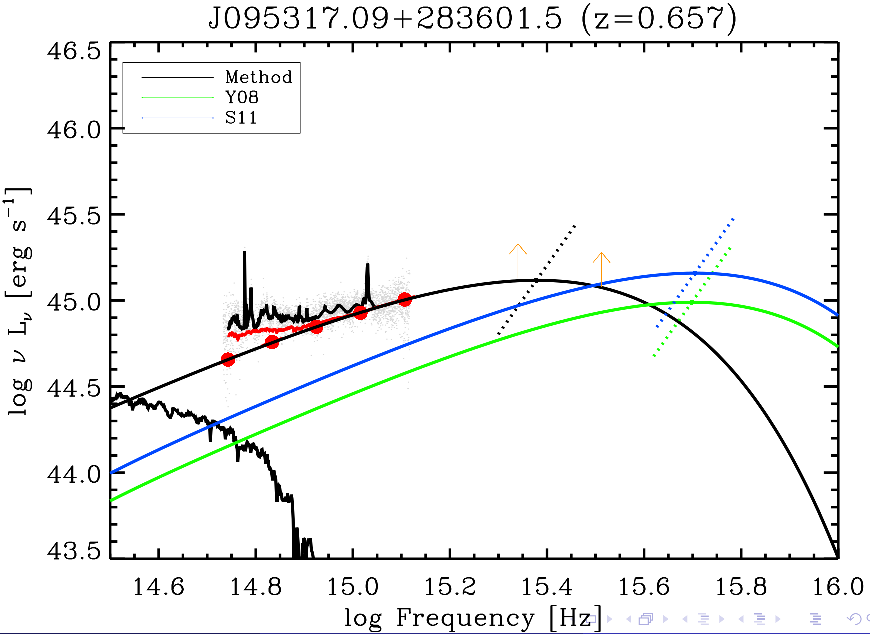



J095317.09+283601.5 (z=0.657)
Method
46.5
46.0
45.5
45.0
44.5
44.0
43.5
log ν L_ν [erg s^-1]
14.6
14.8
15.0
15.2
15.4
15.6
15.8
16.0
log Frequency [Hz]

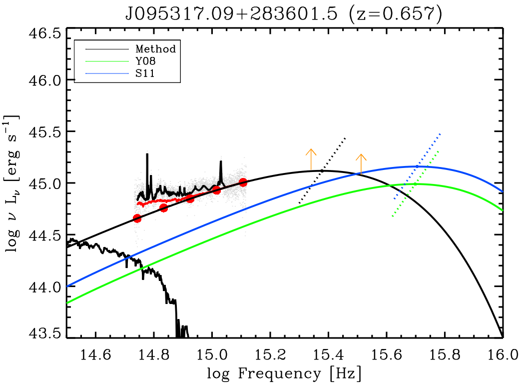

J095317.09+283601.5 (z=0.657)
Method
Y08
S11
log ν L$_\nu$ [erg s^{-1}]
46.5
46.0
45.5
45.0
44.5
44.0
43.5
14.6
14.8
15.0
15.2
15.4
15.6
15.8
16.0
log Frequency [Hz]

SS–AD versus virial estimate

- SS–AD is a super–position of black body spectra;
- Lower frequencies (temperatures) require greater emitting surfaces for a given luminosity;
- ⇒ greater masses;

Wrong assumptions ?

- ~~$\cos\theta = 0.85$~~: mass changes by $\sim$20%;
- ~~$\eta \sim 0.1$~~: greater value for η imply even greater masses!
- Continuum is not due to AD ? (then AD radiation would be 100% re–processed;



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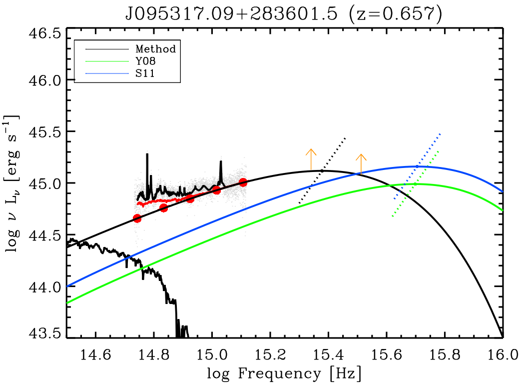

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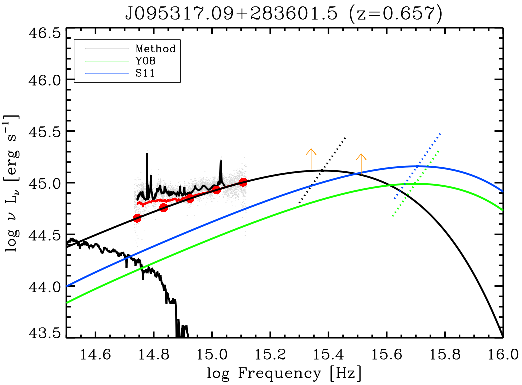

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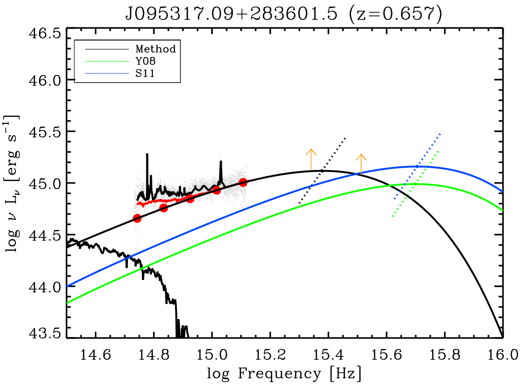

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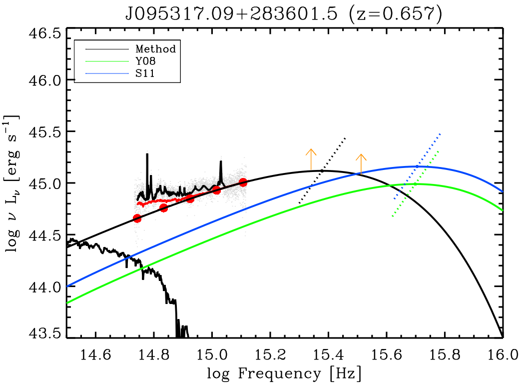

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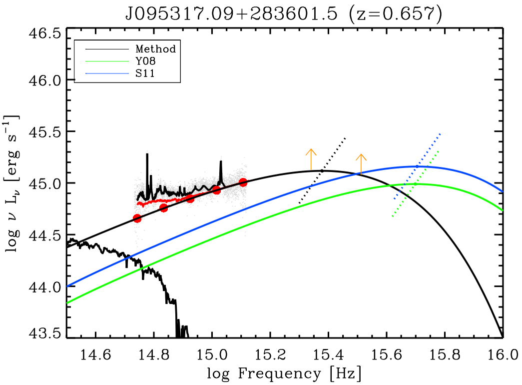
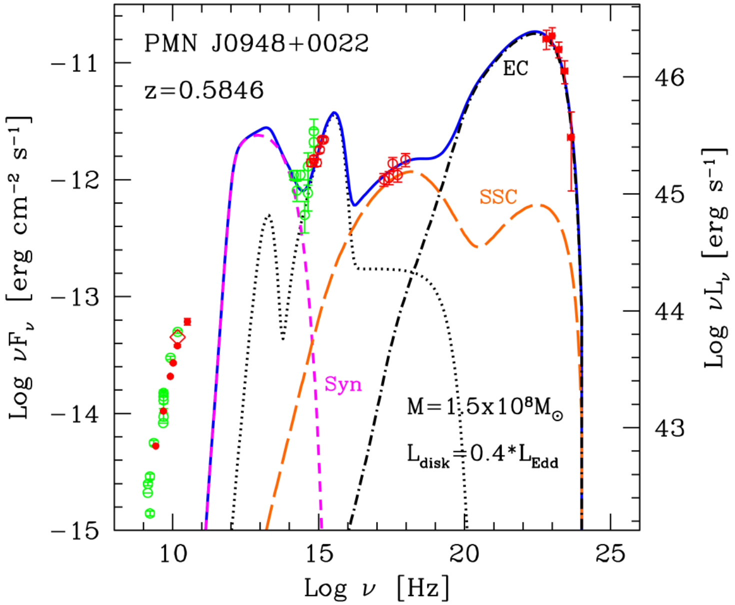


Conclusions

- The disc is there! SS–AD model provides a good fit to Type 1 AGN SED in the range $\log(\nu/\mathrm{Hz}) =$14.8–15.4;
- SS–AD fitting procedure is an alternative way to estimate black hole mass;
- through spectral decomposition we estimated black hole mass for 23 RL–NLS1 sources in the sample of Yuan et al. 2008;
  - masses are a factor $\gtrsim$3 greater than virial estimates (Eddington ratios are lower of the same factor);
  - Minimum mass is 10^8 $M_\odot$, no source seems to develop a jet with smaller masses;
  - black hole masses and Eddington ratios lies in the same range as blazars.


PMN J0948+0022
z=0.5846
EC
SSC
Syn
M=1.5x10⁸M⊙
Ldisk=0.4*LEdd
Log νFν [erg cm⁻² s⁻¹]
Log νLν [erg s⁻¹]
Log ν [Hz]
−11
−12
−13
−14
−15
46
45
44
43
10
15
20
25