Relativistic Jet Properties of GeV AGNs. I.
Jet Composition and Radiation Efficiency

Jin Zhang[1], En-Wei Liang[2], Xiao-Na Sun[2], Shuang-Nan Zhang[1,3]

1.National Astronomical Observatories, CAS, China, zhang.jin@hotmail.com
2. Department of Physics, Guangxi University, China, lew@gxu.edu.cn
3. Institute of High Energy Physics, CAS, China, zhangsn@ihep.ac.cn

zhang.jin@hotmail.com

◆ **Motivation:** Blazars are divided into BL Lacertae objects (BL Lacs) and flat spectrum radio quasars (FSRQs) according to their emission line features. Their broadband spectral energy distributions (SEDs), as well as that of GeV-selected narrow-line Seyfert 1 (NLS1) galaxies, are believed to be dominated by the jet emission. Is there any difference for the jet composition and radiation efficiency among the three classes of GeV AGNs? What is the intrinsic reason for their different jet properties ?

◆ **Sample:** The broadband SEDs for 24 GeV-TeV BL Lacs, 23 GeV FSRQs, and 5 confirmed GeV NLS1s are compiled from literature.

◆ **Model and Fitting Technique:** The single-zone leptonic models with the $\chi 2$-minimization technique are used to fit the SEDs from jet emission. The model parameters can be constrained at 1 σ confidence level, as shown in Fig 1.

- **BL Lacs:**
  Synchrotron+SSC
- **FSRQs & NLS1s:**
  Synchrotron+SSC+EC
  Sometimes the thermal emission from disk should be considered.

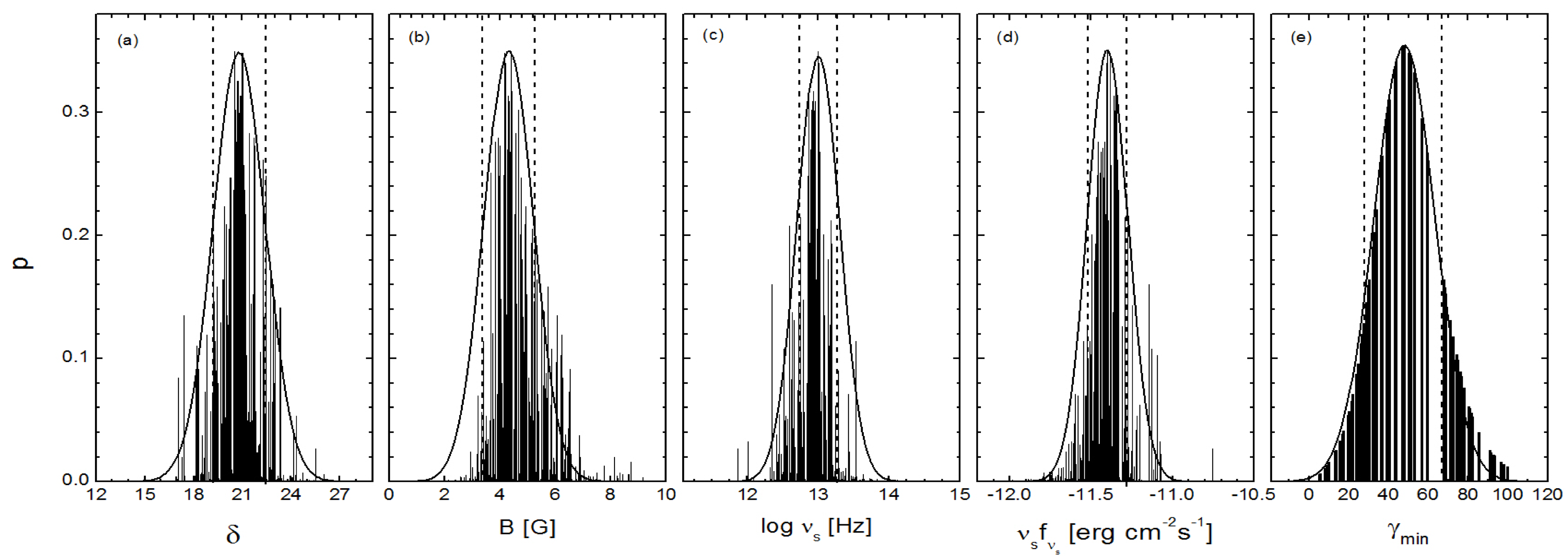

Fig. 1 Probability distributions of fitting parameters for B2 1520+31. Gaussian function fits to the profiles of distributions are shown with solid lines. The vertical dashed lines mark the 1σ ranges.

◆ **Constraint on γ_{min} :** The minimum energy of electron in jets is well constrained for FSRQs, NLS1s, and some of BL Lacs, which significantly affects the calculation of jet powers. The distributions of γ_{min} for our samples are given in Fig 2. The medians are 48 for FSRQs and 43 for NLS1s, respectively.

◆ **Calculations of jet powers and powers of each components:** Proton–electron pair assumption is widely adopted in the calculations of jet power in blazars (e.g., Ghisellini et al. 2009, 2010). We also assume that the jet power (P_{jet}) is carried by relativistic electrons (P_e), cold protons (P_p), magnetic fields (P_B), and radiation (P_r).

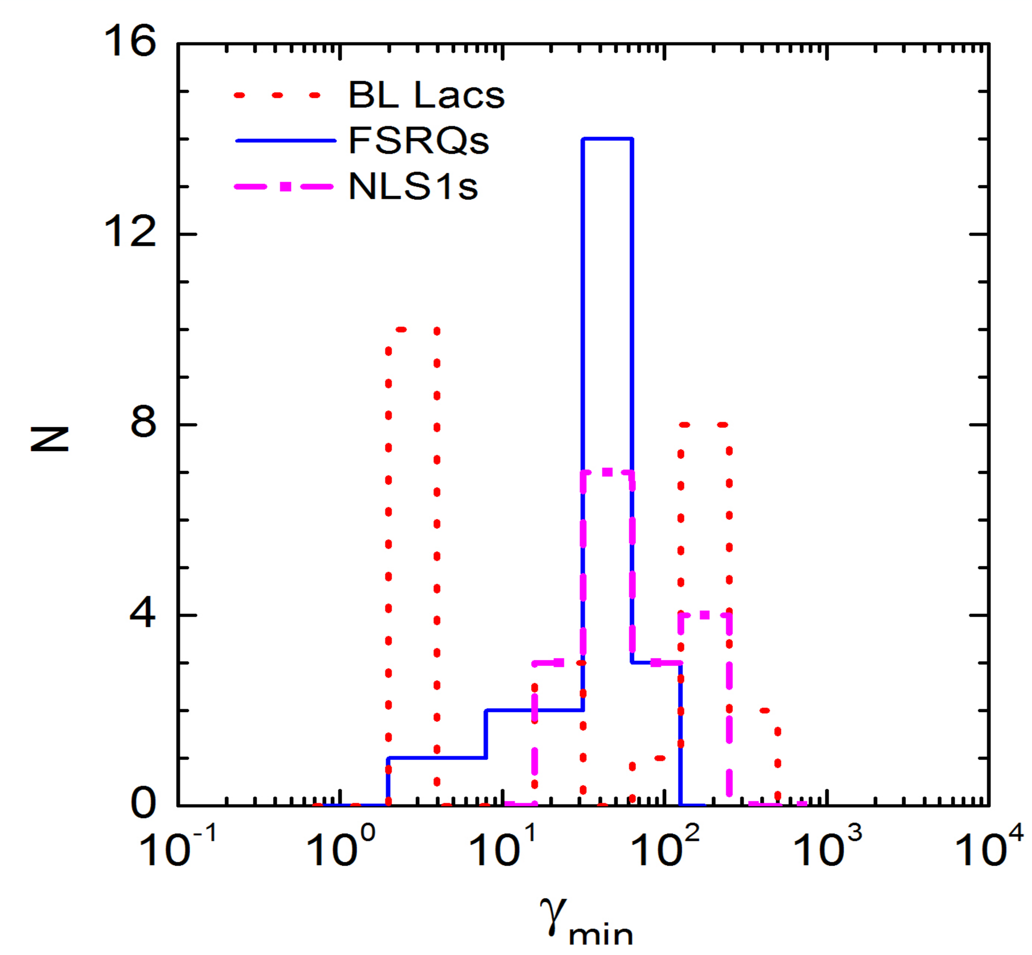

Fig. 2 Distributions of γ_{min} in jets.

◆ **P_{jet} is strongly correlated with the cavity kinetic power (L_{kin})** of the jets as shown in Fig 3, indicating that the calculation of jet power is reasonable. L_{kin} is estimated with the relation between L_{kin} and radio luminosity (Meyer et al. 2011).

◆ **Jet radiation efficiency and magnetization parameter:** $\varepsilon = P_r / P_{jet}$ $\quad \sigma = P_B / (P_p + P_e + P_r)$

The jet radiation efficiencies of FSRQs are much higher than that of BL Lacs and the jets of FSRQs may be dominated by the Poynting flux, whereas the jets of BL Lacs may be dominated by particles. The NLS1s are intermediate between FSRQs and BL Lacs, but are more analogous to FSRQs.

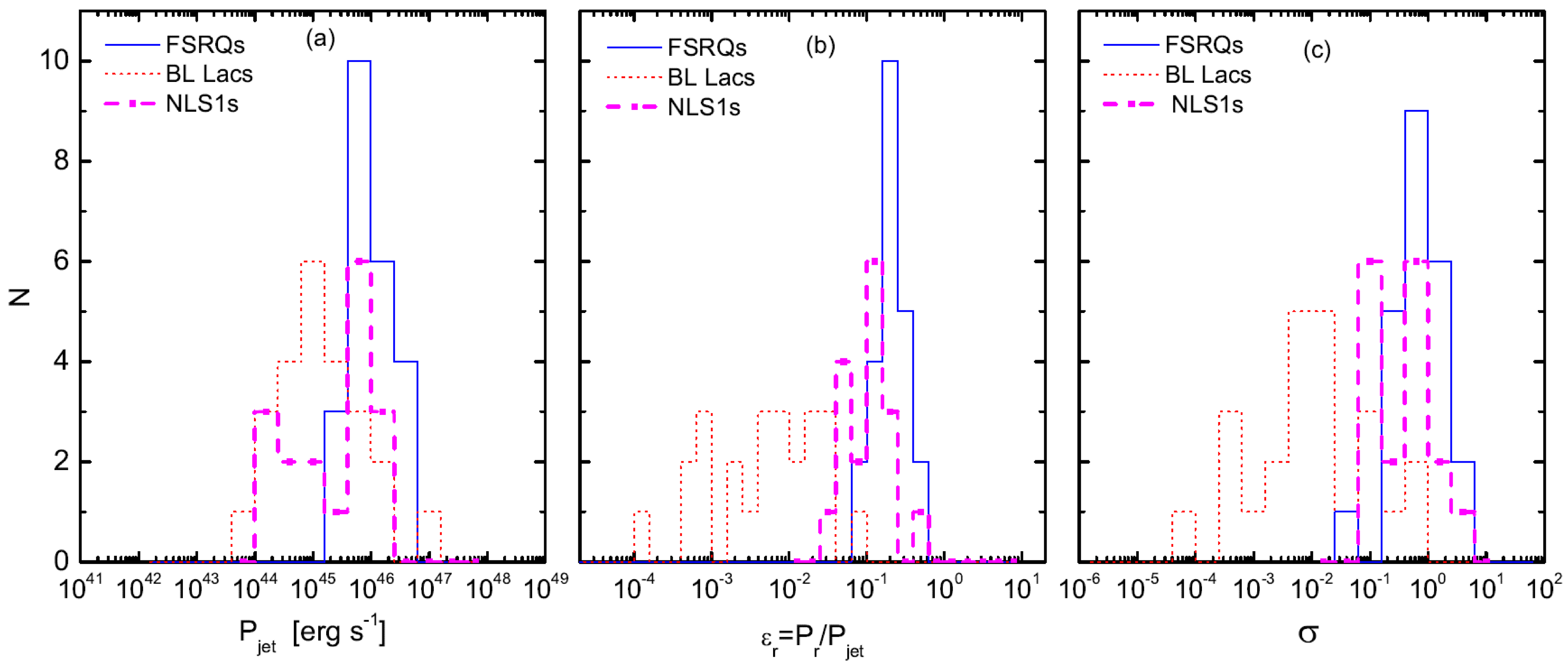

Fig 4 Distributions of the jet powers (a), the jet radiation efficiencies (b), and the magnetization parameters (c) of the three classes of GeV AGNs.

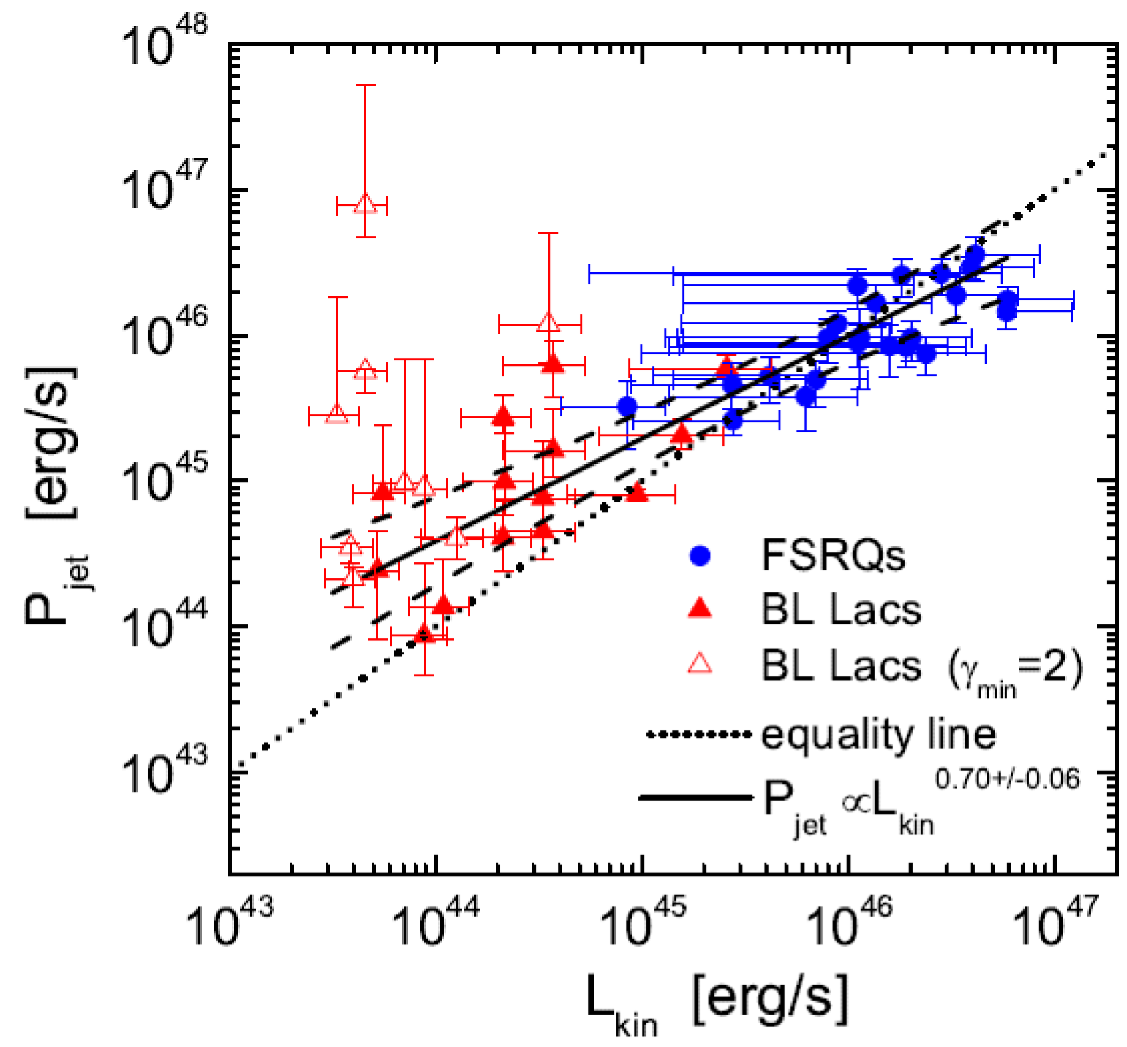

Fig. 3 Comparison of P_{jet} and L_{kin} for blazars. The solid line is the best fits (without considering the opened triangles points), dashed lines indicate the 3σ confidence bands.

◆ Jet radiation rates (P_r/L_{Edd}) and production rates (P_{jet}/L_{Edd}) per BH mass:

Narrow distributions of the jet production and radiation rates per central BH mass for FSRQs (as shown in Fig 5) likely indicate that a dominating jet formation mechanism may work at these sources, but it is not for BL Lacs.

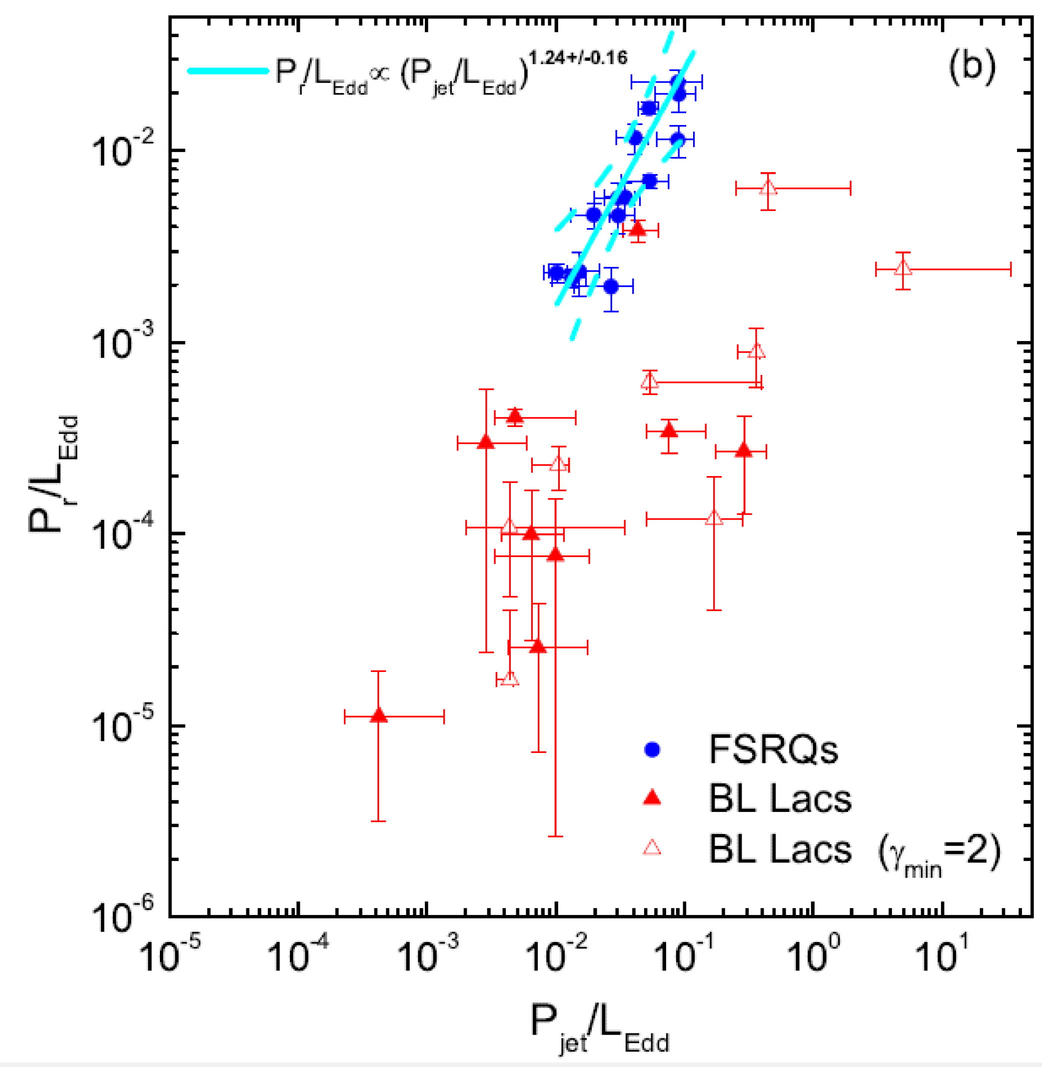

Fig 5 Jet radiation rates as a function of jet production rates for FSRQs and BL Lacs. The solid line is the best fit to the data of FSRQs and dashed lines mark the 3σ confidence bands.

◆ Variability of jet emission: Peak luminosities of the EC bumps (Lc) are tightly correlated with beaming factor (δ). The variations of jet radiation luminosity (L_{jet}) and δ are accompanied with the variations of corona emission for GeV NLS1 1H 0323+342. Compared to radio quiet Seyferts, 1H 0323+342 has the higher ratio of L_{corona}/L_{disk}.

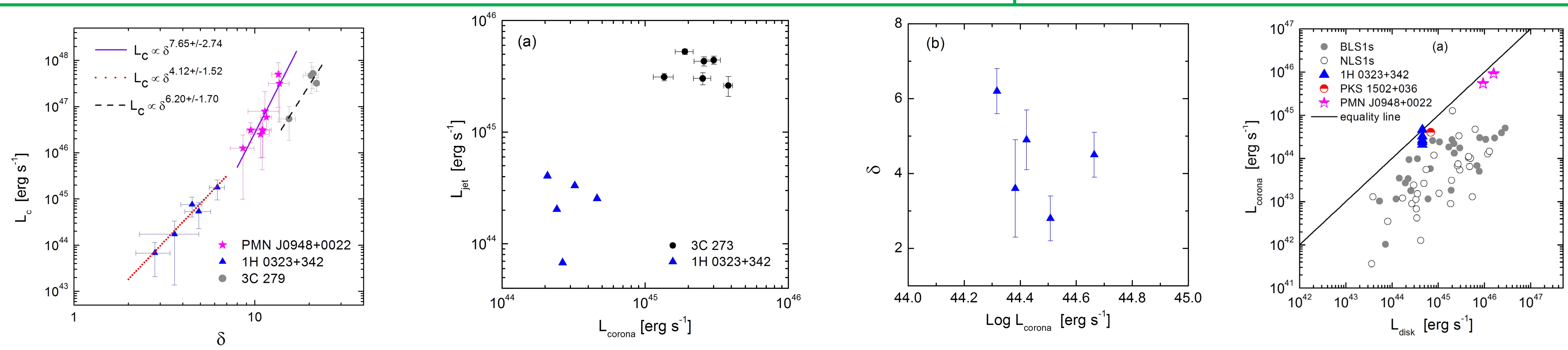

Fig 6 L_c as a function of δ. L_{jet} and δ of GeV NLS1 1H 0323+342 as a function of its corona luminosity (L_{corona}), where the data of 3C 273 are from Grandi & Palumbo (2004). L_{corona} as a function of L_{disk}, where the data of radio quiet Seyferts are from Wang et al. (2004).

◆ Conclusions:

- FSRQ jets are highly magnetized with high radiation efficiency, but BL Lac jets may be dominated by particles with low radiation efficiency. The NLS1s are intermediate between FSRQs and BL Lacs, but are more analogous to FSRQs. Essentially, the different mechanisms dominate their jet launching.
- The instability of the corona may result in the variation of the physical condition of jets and lead to the variation of the jet emission.

◆ References:

1. Ghisellini, G., Tavecchio, F., & Ghirlanda, G. 2009, MNRAS, 399, 2041
2. Ghisellini, G., Tavecchio, F., Foschini, L., et al. 2010, MNRAS, 402, 497
3. Meyer, E. T., Fossati, G., Georganopoulos, M., & Lister, M. L. 2011, ApJ, 740, 98
4. Grandi, P., & Palumbo, G. G. C. 2004, Sci, 306, 998
5. Wang, J.-M., Watarai, K.-Y., & Mineshige, S. 2004, ApJL, 607, L107

Further details and references, please refer to our full papers:

(1) J. Zhang, E. W. Liang, S. N. Zhang, J. M. Bai, 2012, ApJ, 572, 157

(2) J. Zhang, S. N. Zhang, E. W. Liang, 2013, ApJ, 767, 8

(3) J. Zhang, X. N. Sun, E. W. Liang, R. J. Lu, Y. Lu, S. N. Zhang, 2014, ApJ, 788, 104

(4) X. N. Sun, J. Zhang, D. B. Lin, Z. W. Xue, E. W. Liang, S. N. Zhang, 2015, ApJ, 798, 43