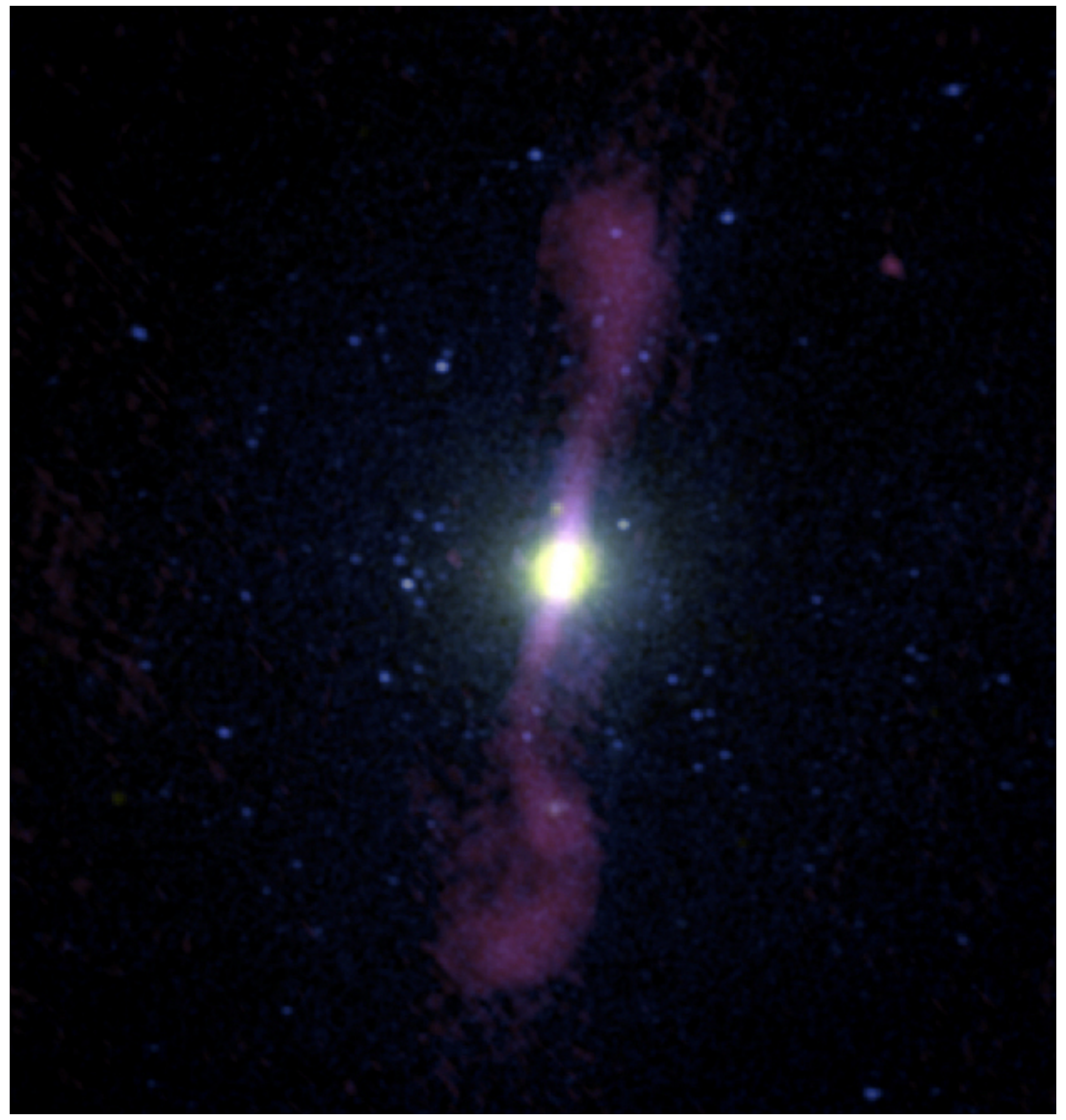
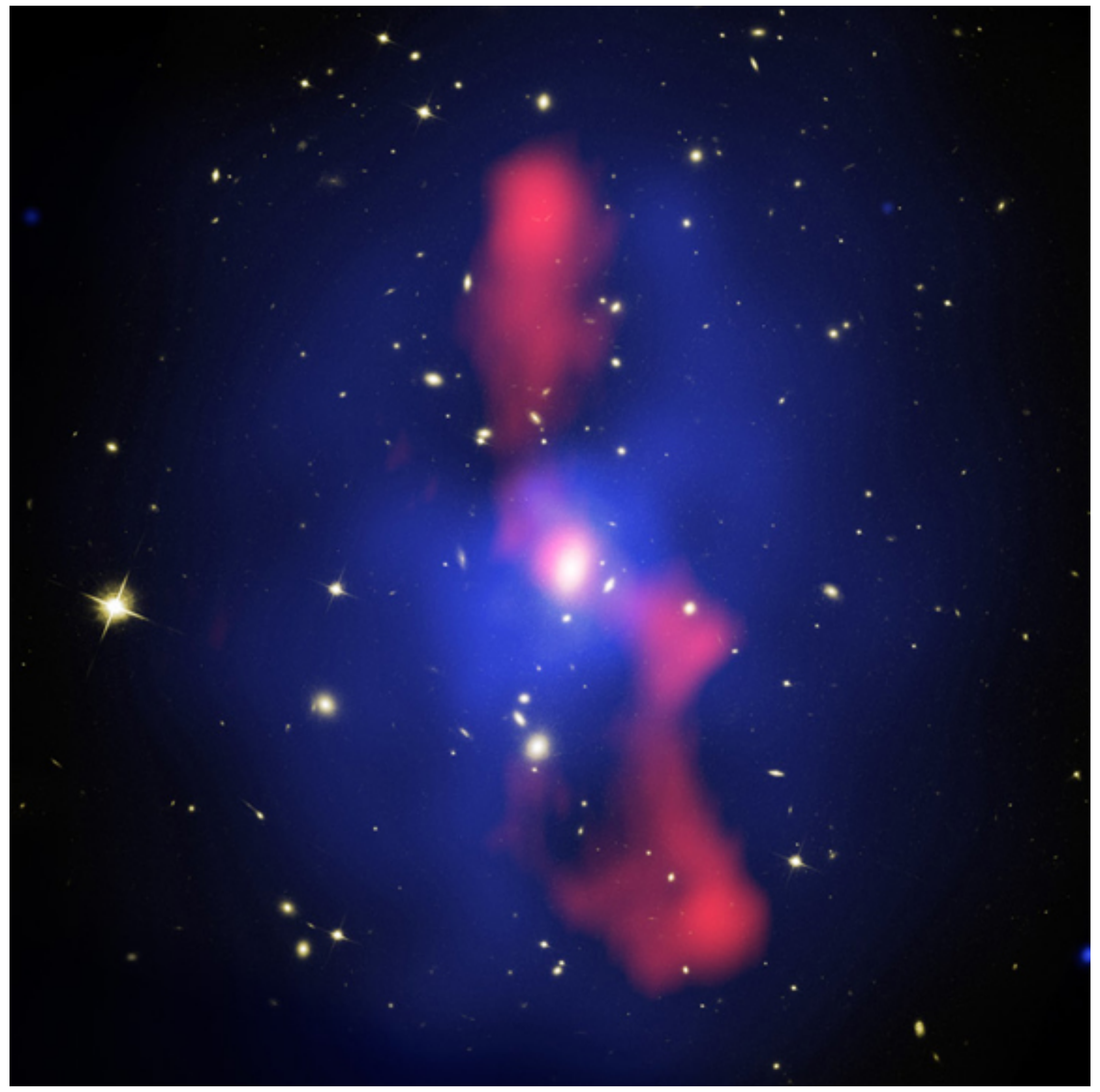
Cooling and AGN feedback in giant elliptical galaxies

In thermally unstable giant ellipticals, more massive black holes produce stronger jets

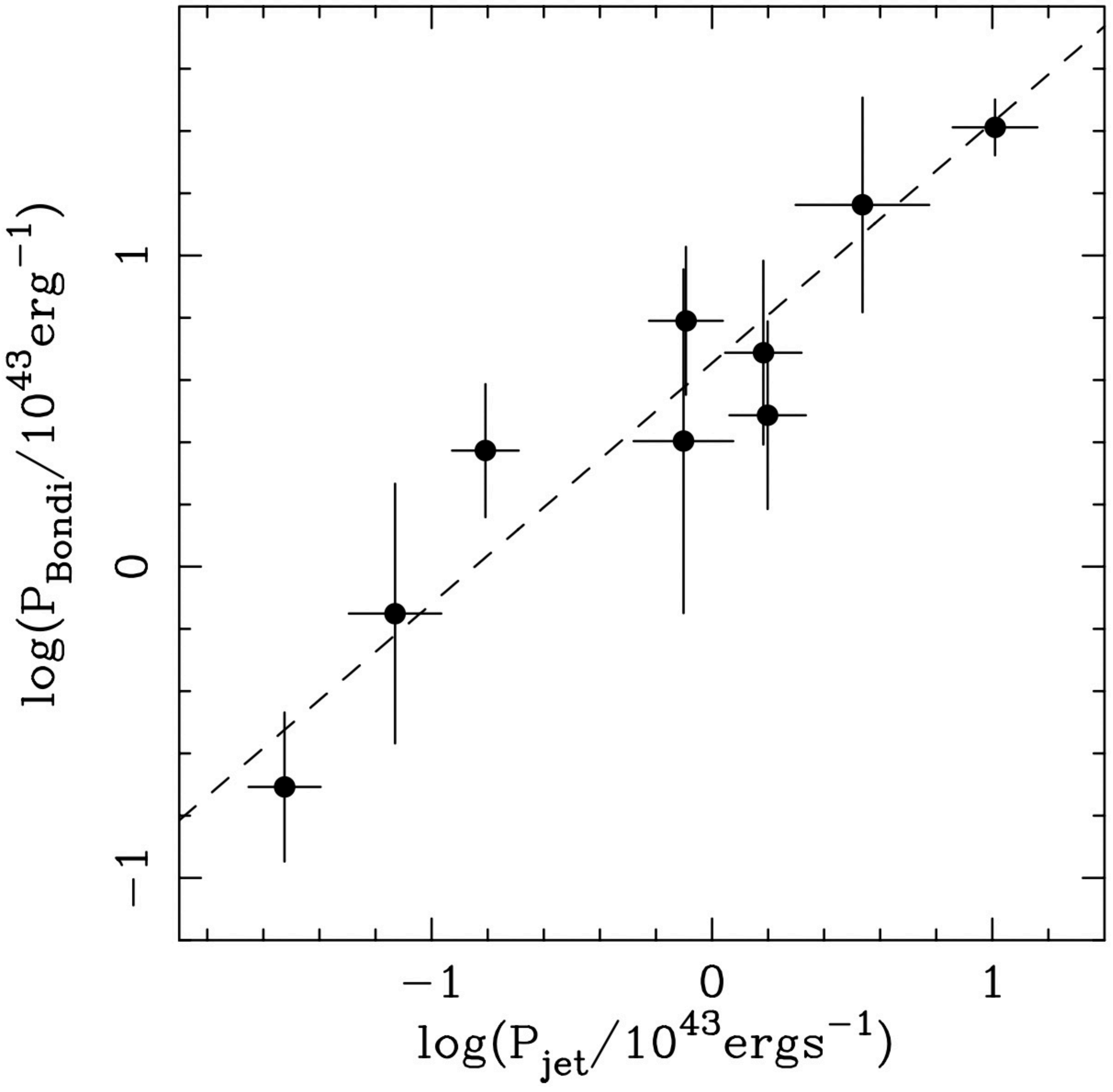




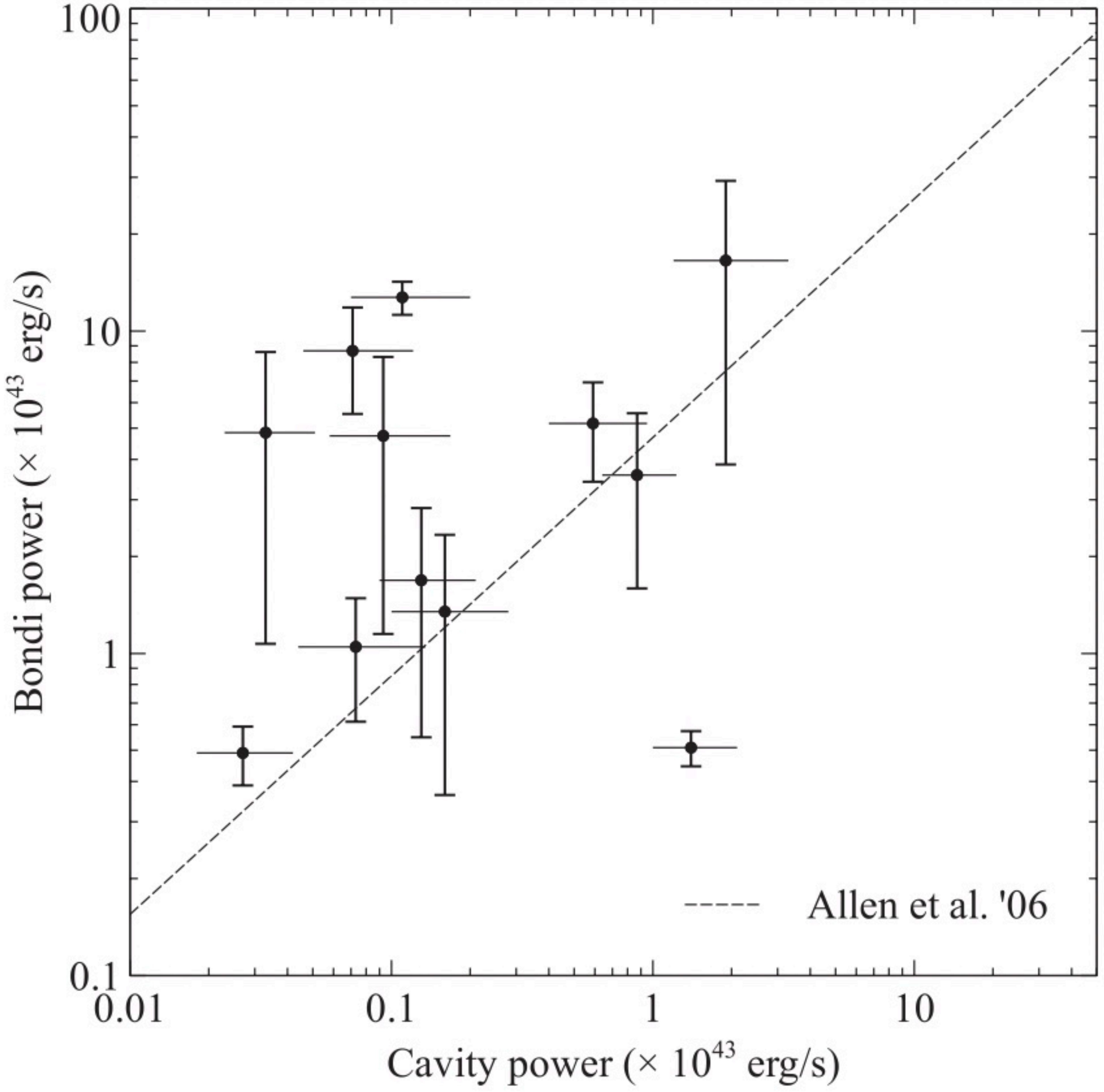
Norbert Werner (Masaryk University)

Based on work by Tomáš Plšek et al. 2022

Accretion and Jet Power in Giant Elliptical Galaxies

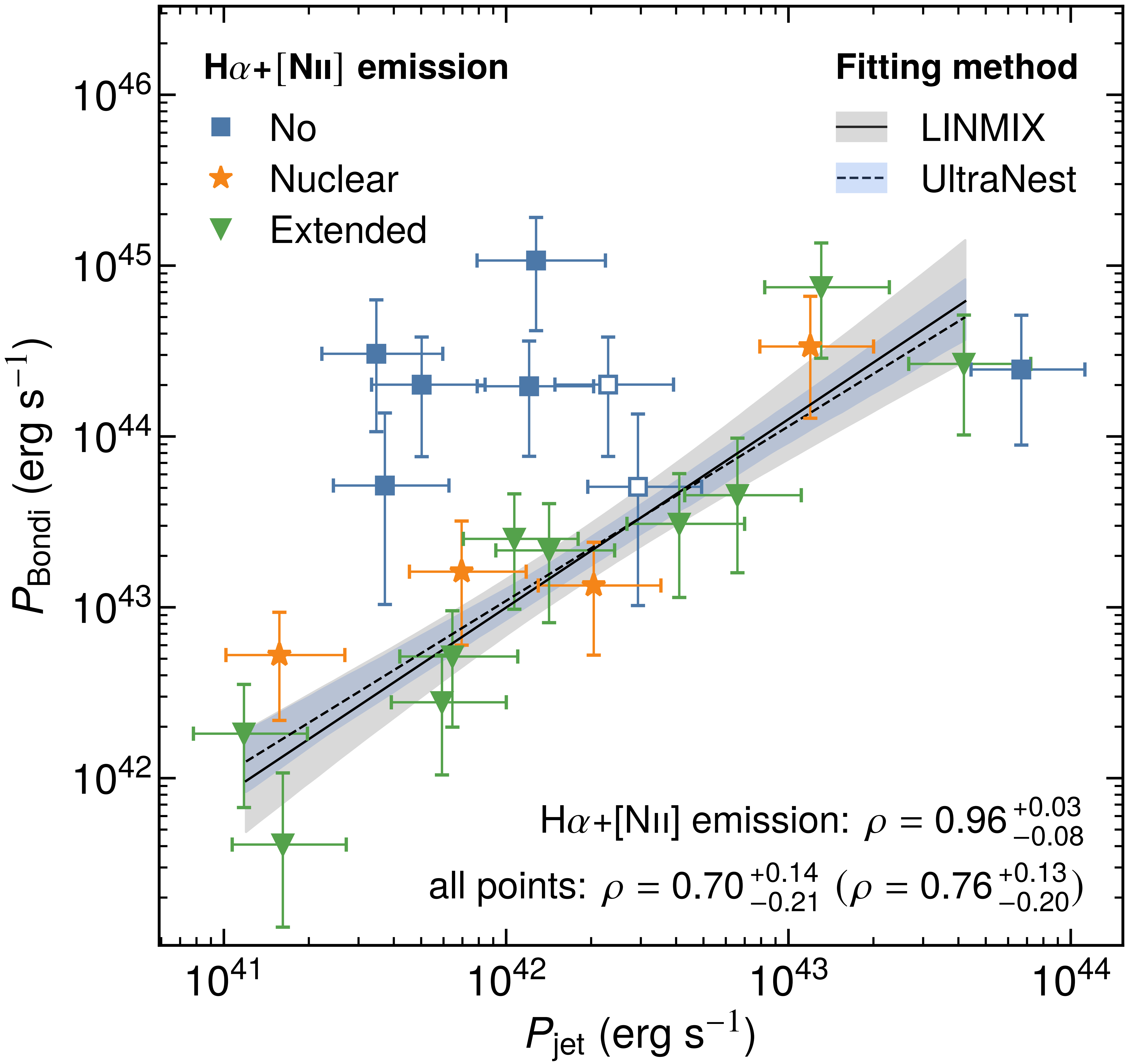


Allen et al. 2006



Russell et al. 2013

Accretion and Jet Power in Giant Elliptical Galaxies



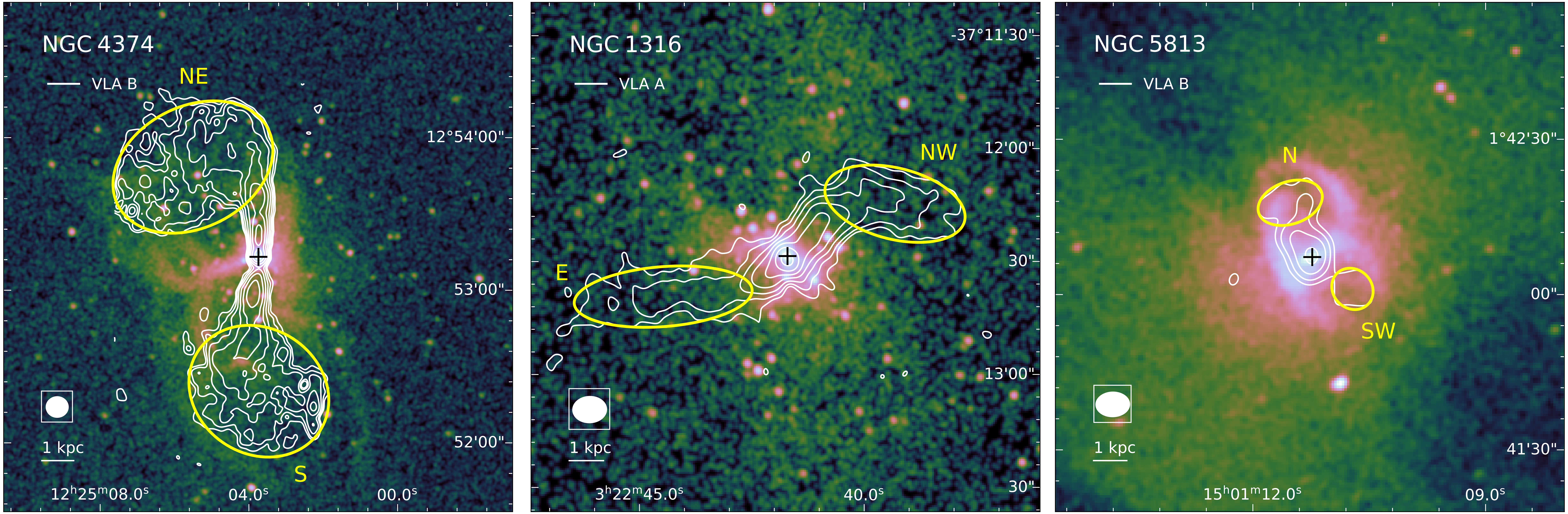
- Strong correlation between the Bondi accretion power and mechanical jet power for galaxies with thermally unstable atmospheres

$$\log \frac{P_{\rm Bondi}}{10^{43}\ {\rm erg\ s^{-1}}} = \alpha + \beta \log \frac{P_{\rm jet}}{10^{43}\ {\rm erg\ s^{-1}}},$$

where $\alpha = 1.10 \pm 0.24$ and $\beta = 1.10 \pm 0.23$

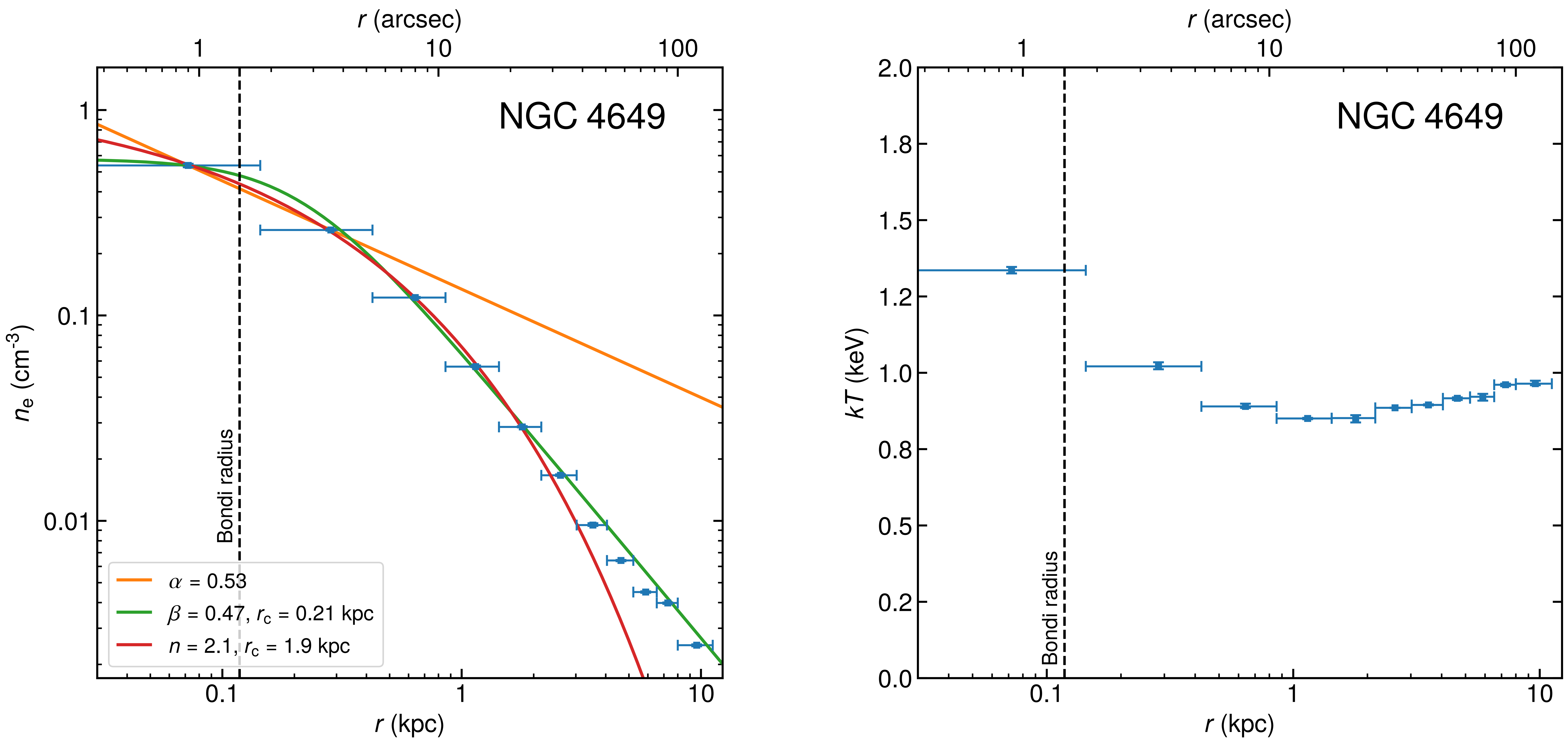
Plšek, Werner et al. 2022

Determining the Jet Power



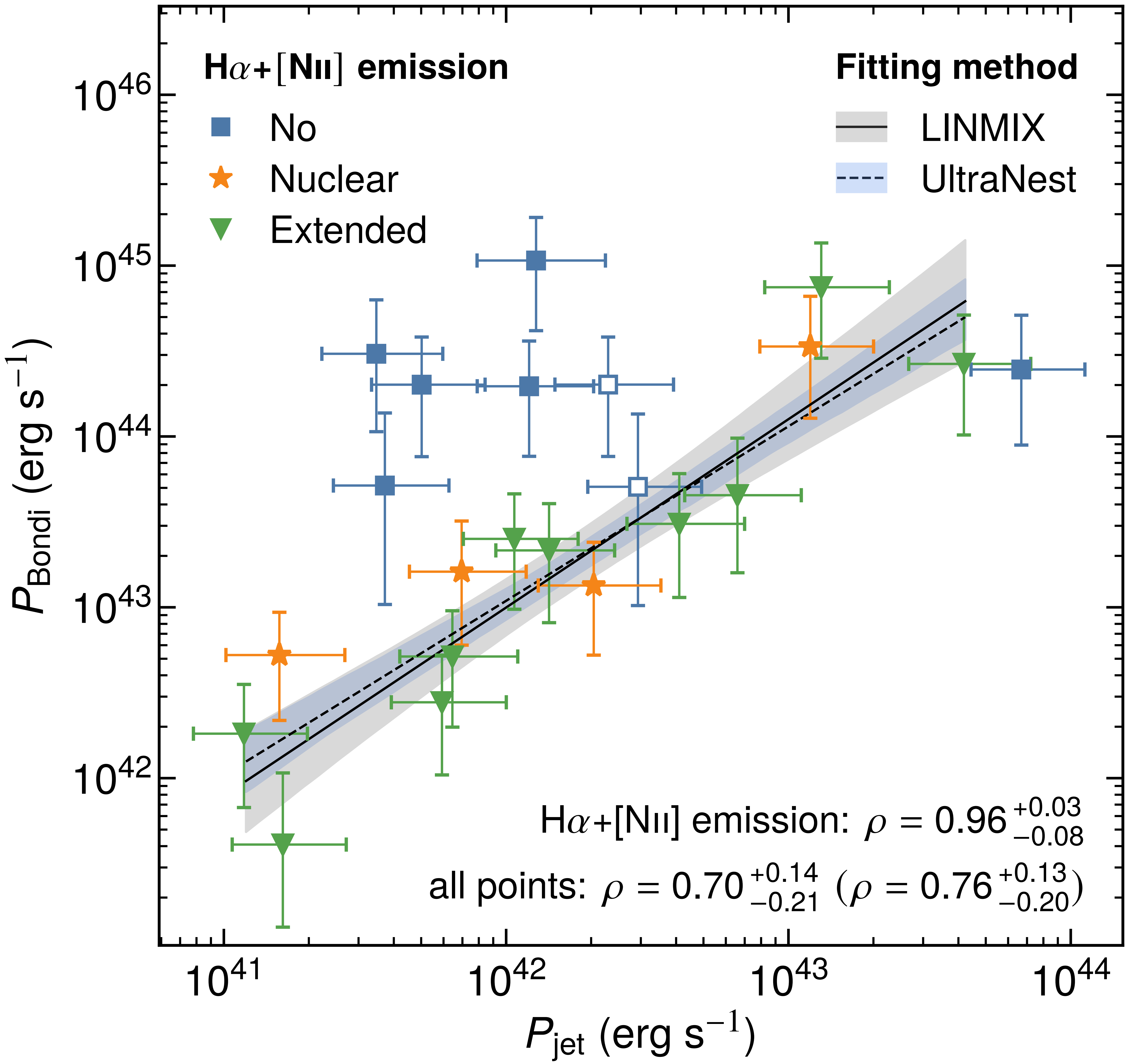
Plšek, Werner et al. 2022

Determining the Accretion Rate



Plšek, Werner et al. 2022

ACCRETION AND JET POWER IN GIANT ELLIPTICAL GALAXIES

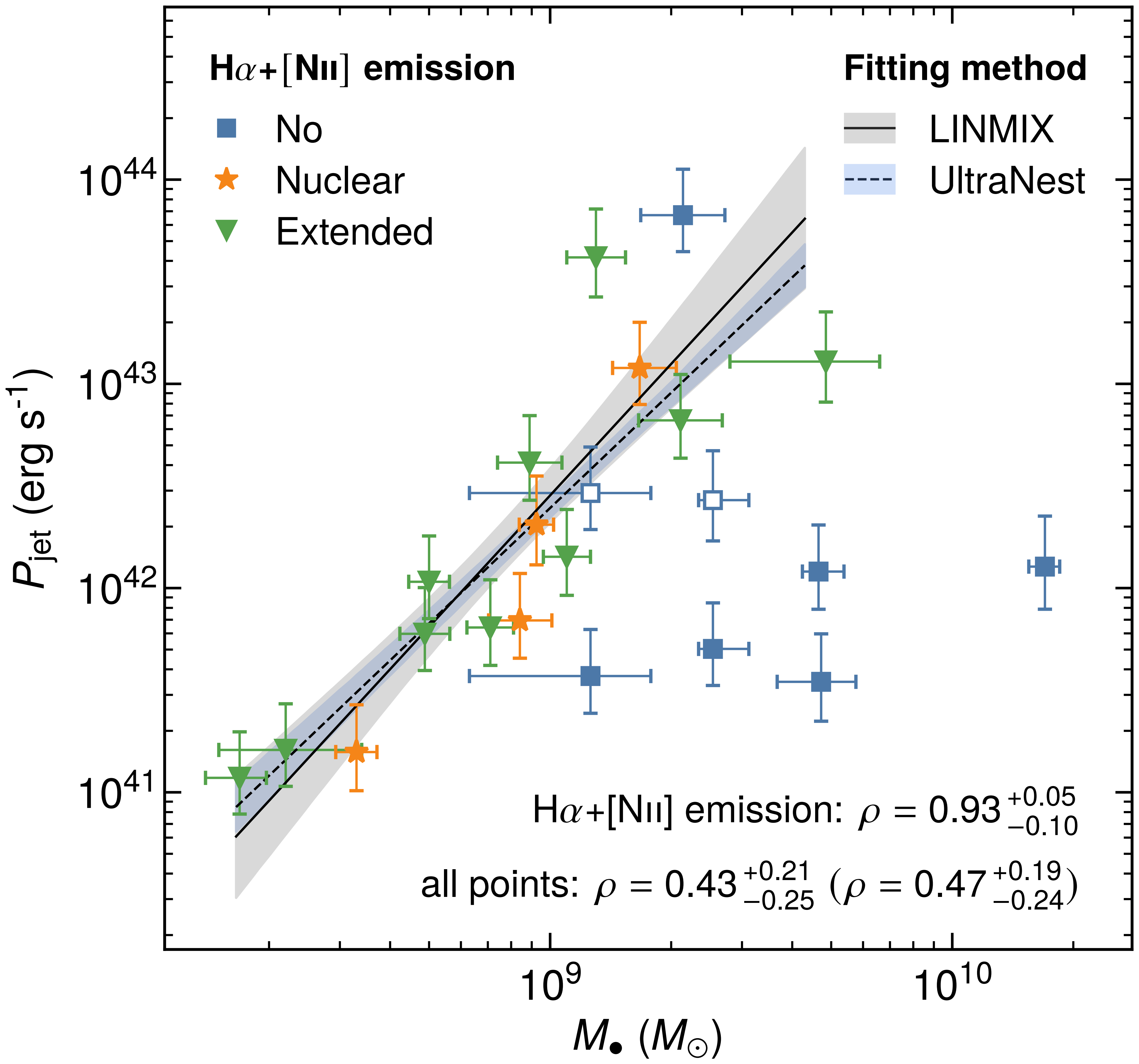


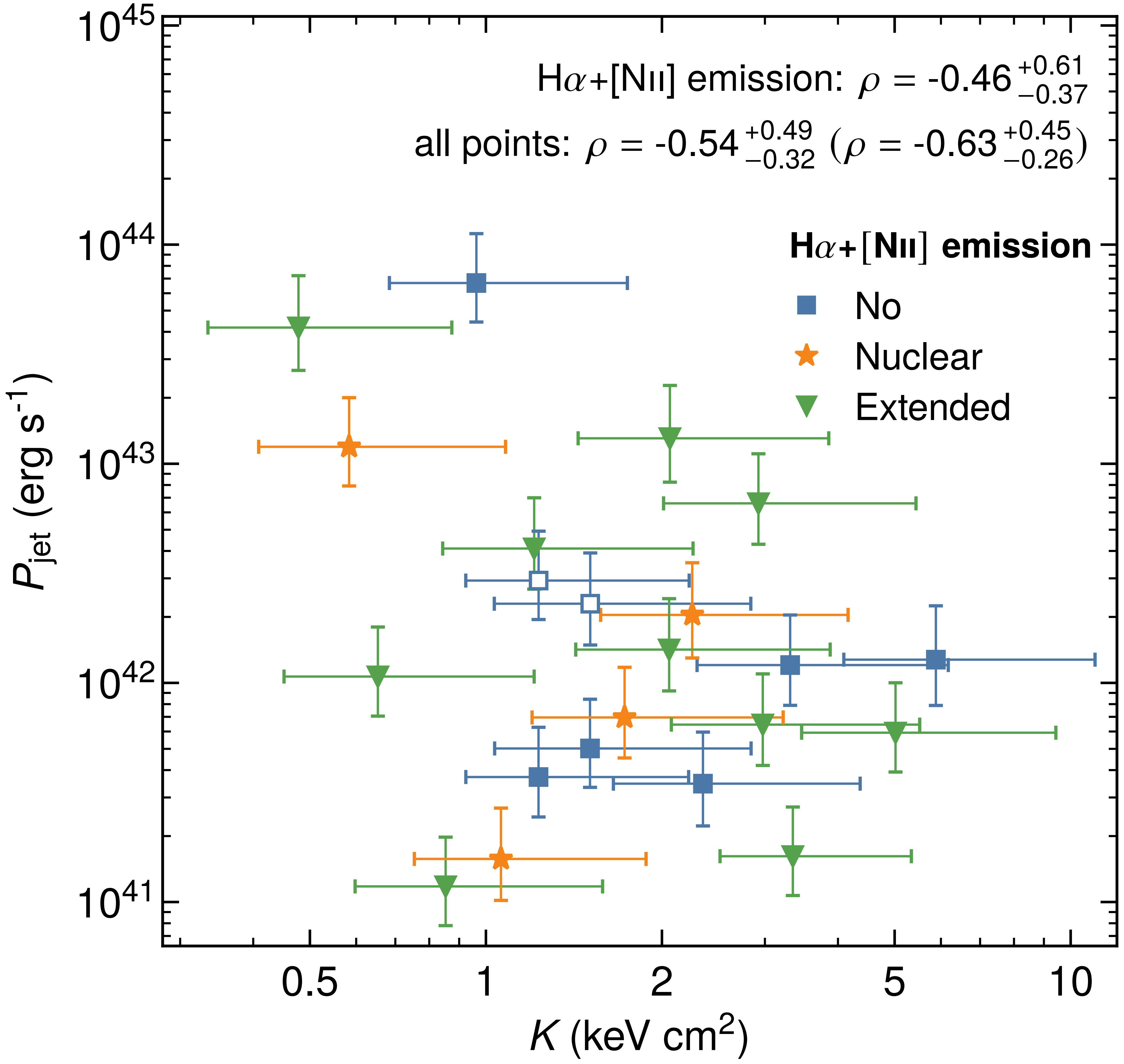
- Strong correlation between the Bondi accretion power and mechanical jet power for galaxies with thermally unstable atmospheres

Plšek, Werner et al. 2022

Accretion and Jet Power in Giant Elliptical Galaxies

$P_{\rm jet} \propto M^{2.14 \pm 0.44}$ $P_{\rm Bondi} \propto M^2 K^{-3/2}$ $P_{\rm jet}$? $f(K^{-3/2})$

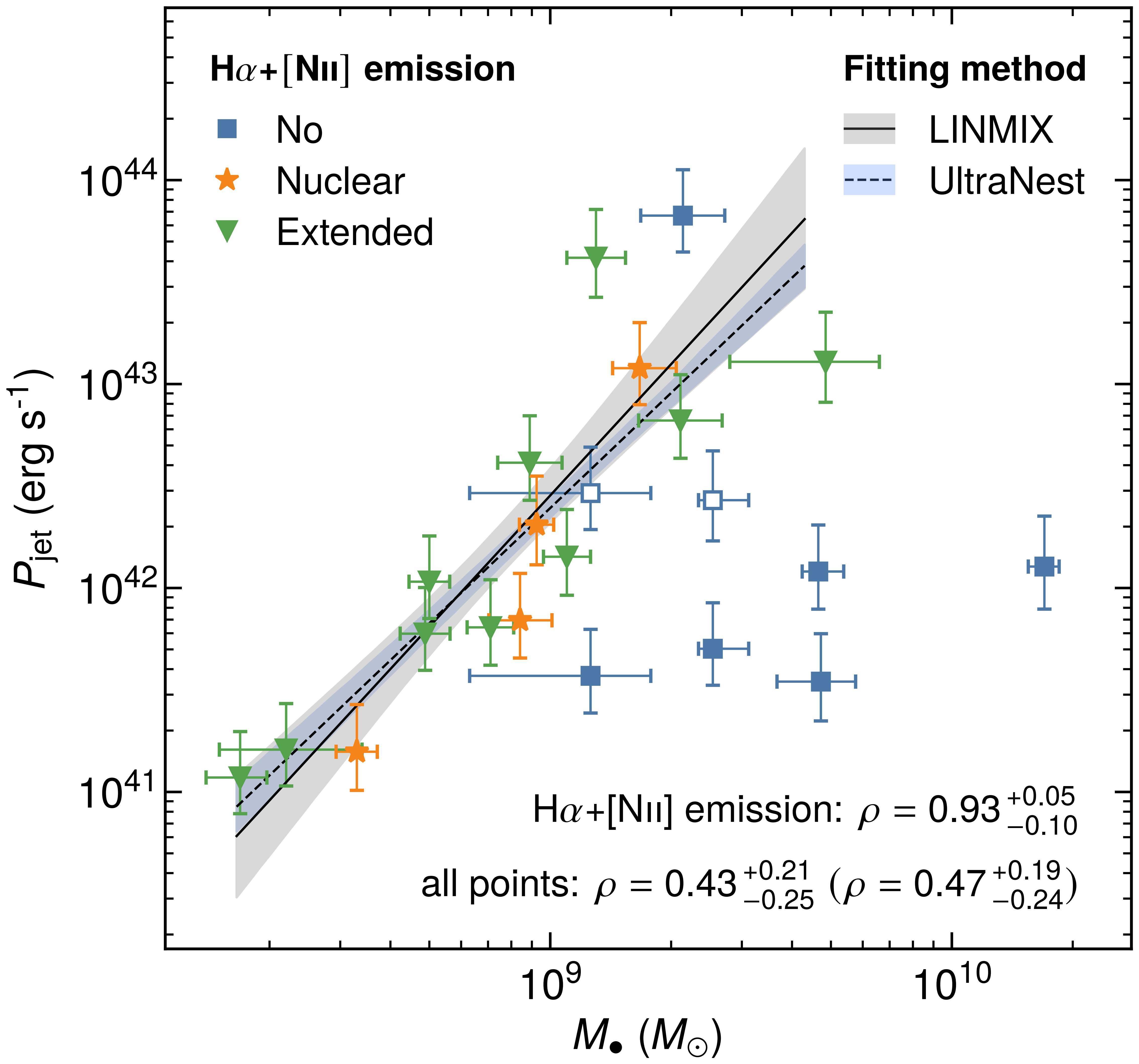




Plšek, Werner et al. 2022

Accretion and Jet Power in Giant Elliptical Galaxies

$P_{\rm jet} \propto M^{2.14 \pm 0.44}$



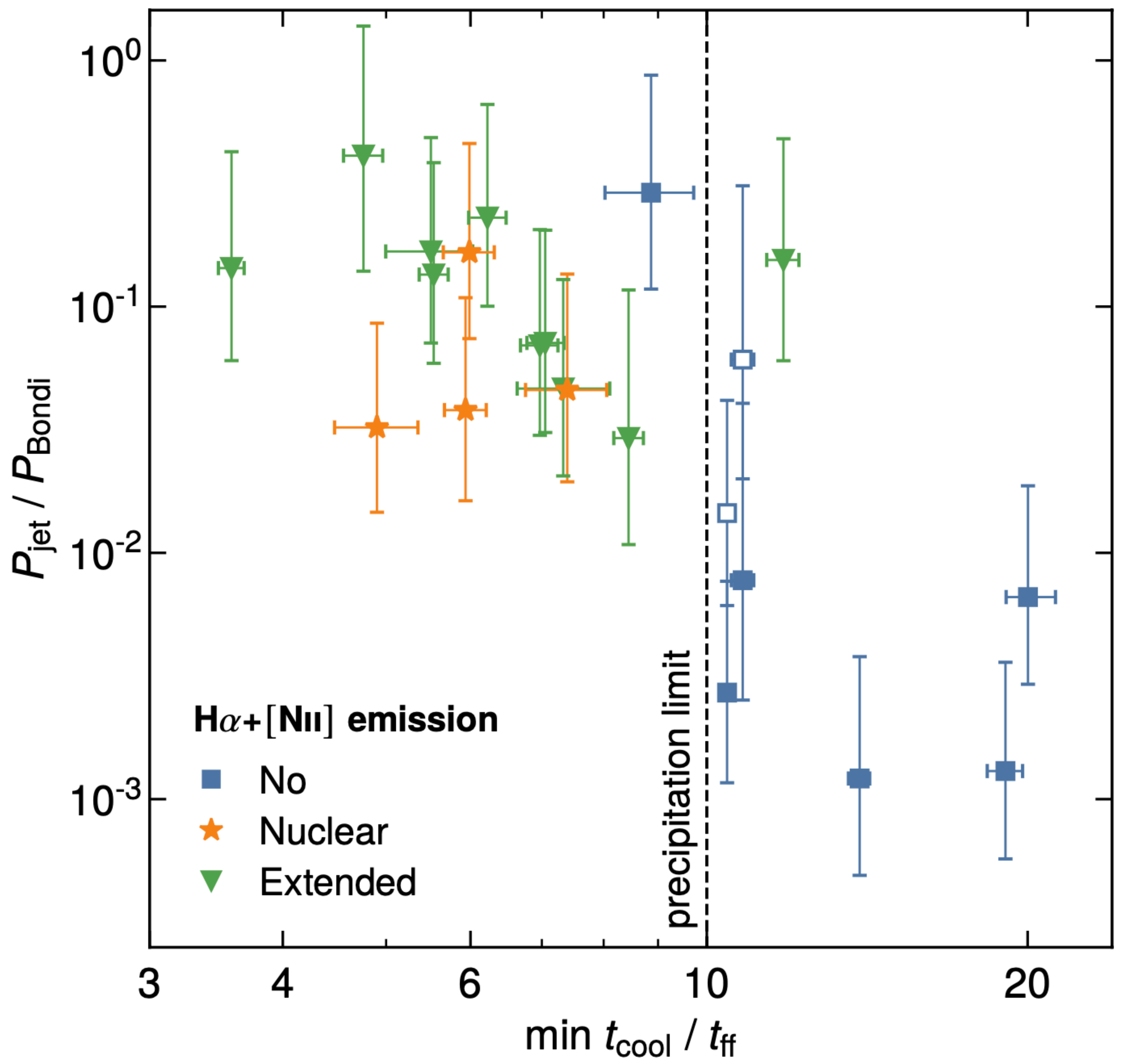
- Strong correlation between the central black hole mass and mechanical jet power for galaxies with thermally unstable atmospheres

$$\log \frac{P_{\rm jet}}{10^{43}\ {\rm erg\ s^{-1}}} = \alpha + \beta \log \frac{M_\bullet}{10^9\ M_\odot},$$

where $\alpha = -0.55 \pm 0.14$ and $\beta = 2.14 \pm 0.44$

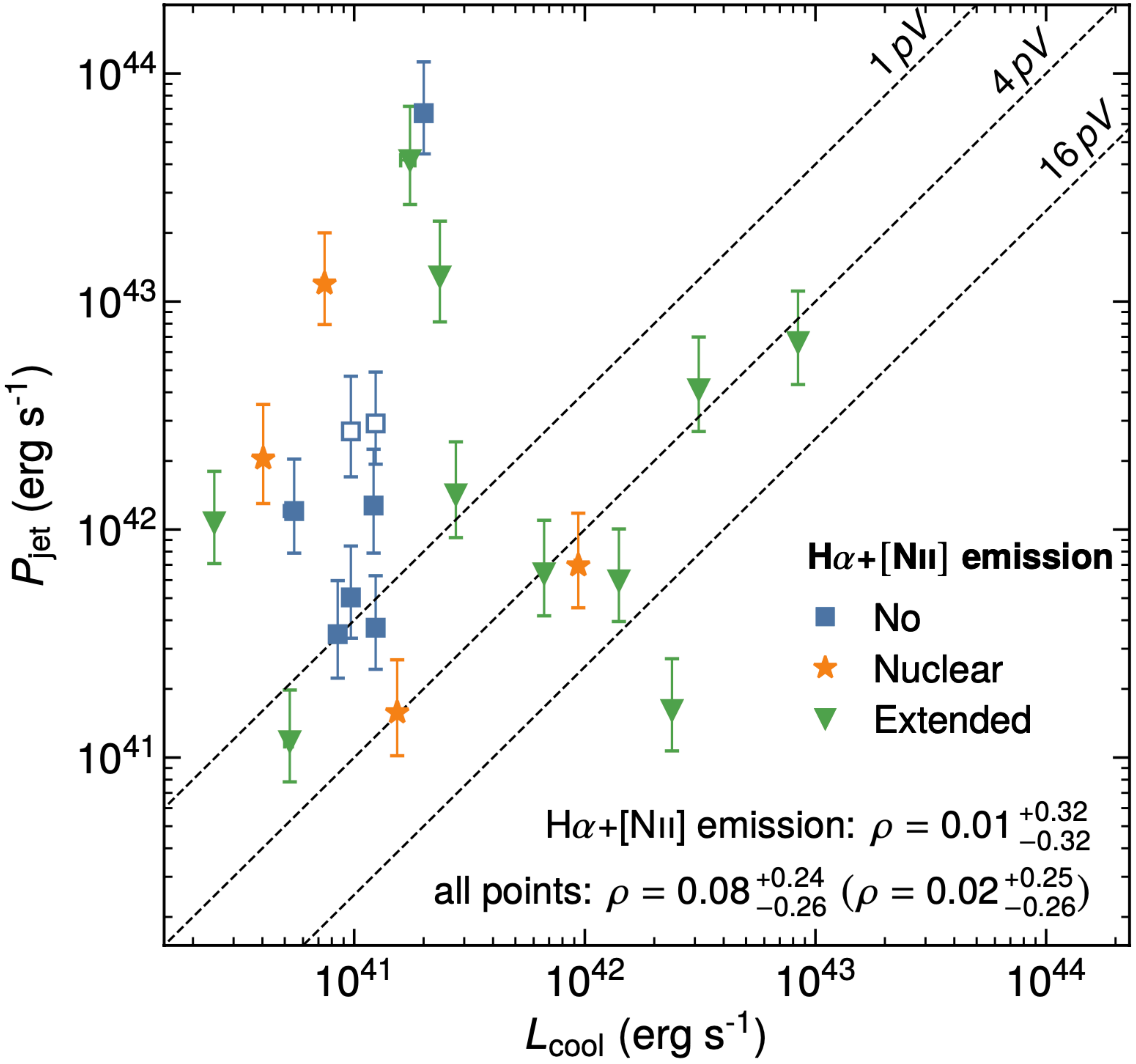
Plšek, Werner et al. 2022

Accretion and Jet Power in Giant Elliptical Galaxies



Plšek, Werner et al. 2022

Jet Power and Cooling in Giant Elliptical Galaxies



Plšek, Werner et al. 2022

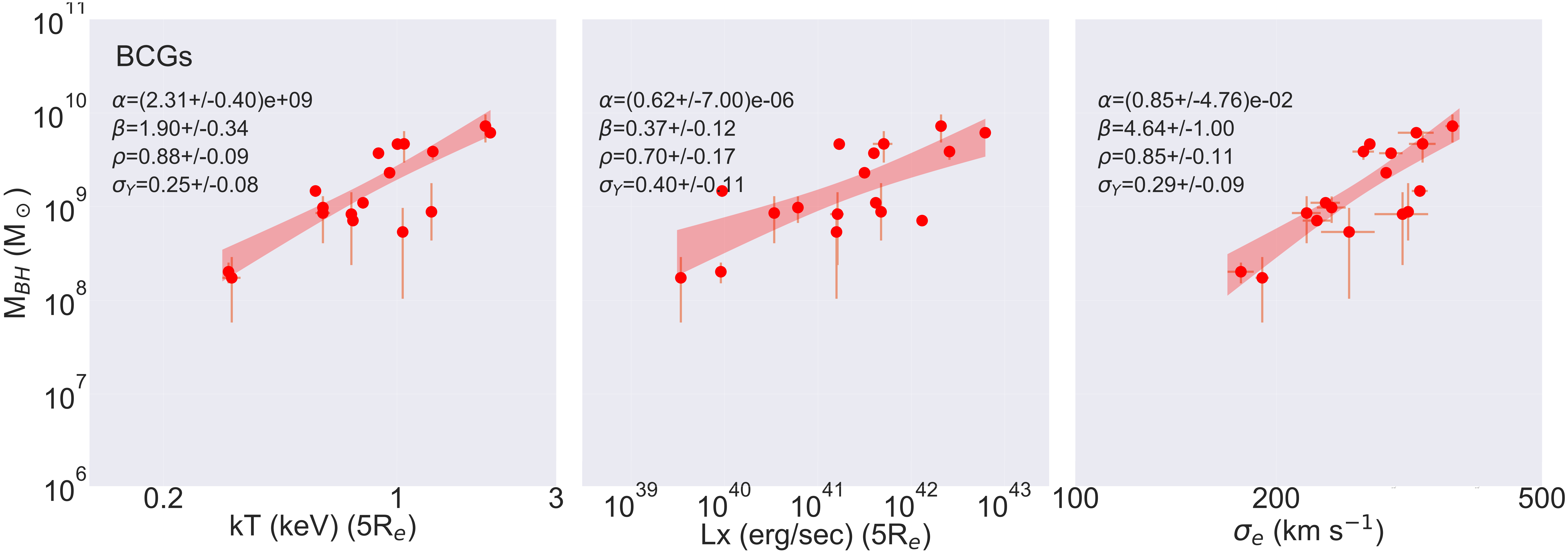
Some Conclusions

- In thermally unstable galactic atmospheres, the jet power correlates with the mass of the central supermassive black hole.

- The thermodynamic properties of the hot atmospheres provide an ‘on/off switch’ which determines whether the atmosphere will be thermally stable or not - and for the thermally unstable systems, the jet power is set by the supermassive black hole mass.

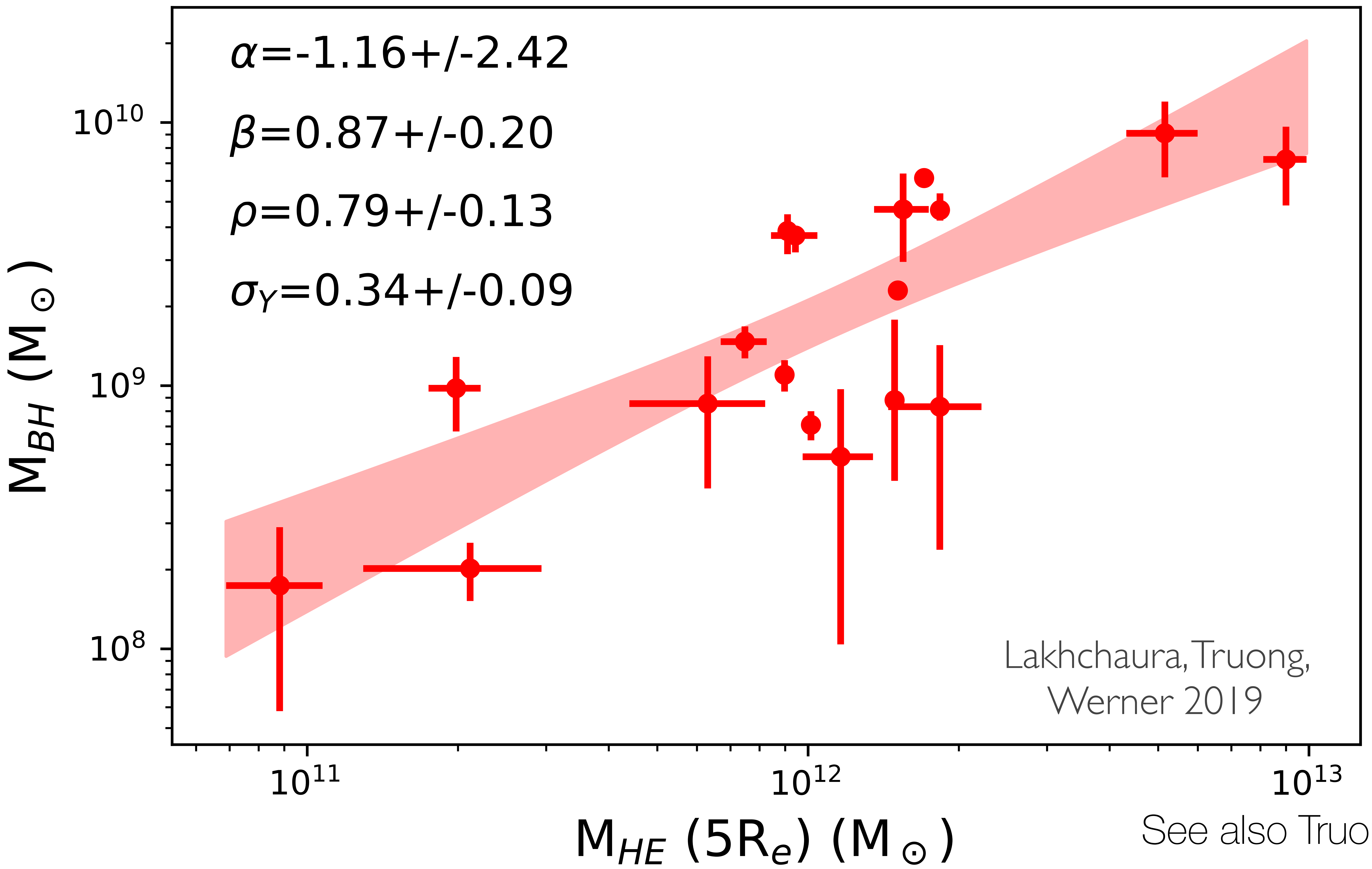
- The accretion must be relatively stable and continuous to produce the observed correlation

The Black Hole - X-Ray Atmosphere Correlation in BCGs



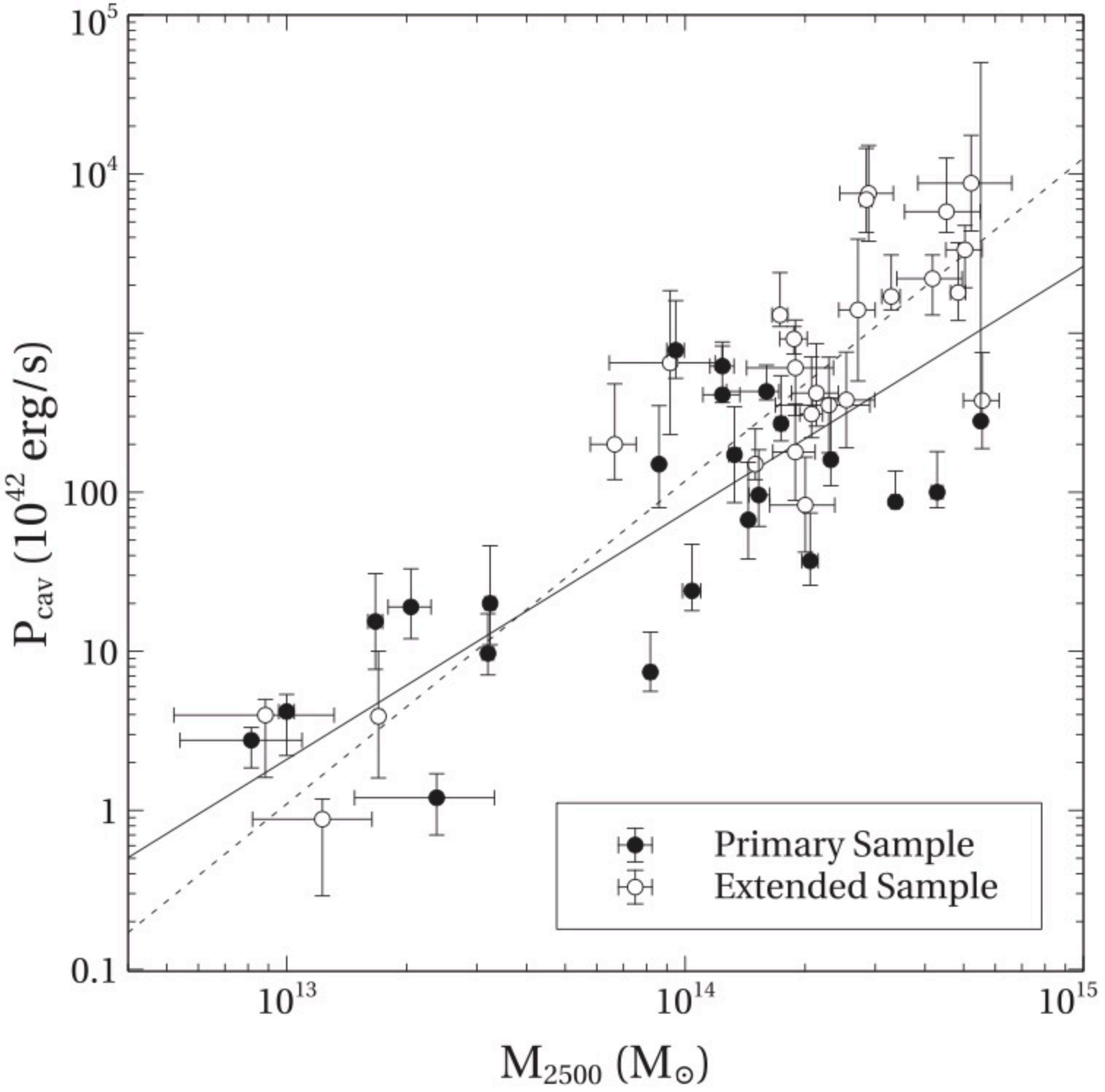
Lakhchaura, Truong, Werner 2019

The Black Hole - Dark Matter Halo Correlation



See also Truong et al. 2021

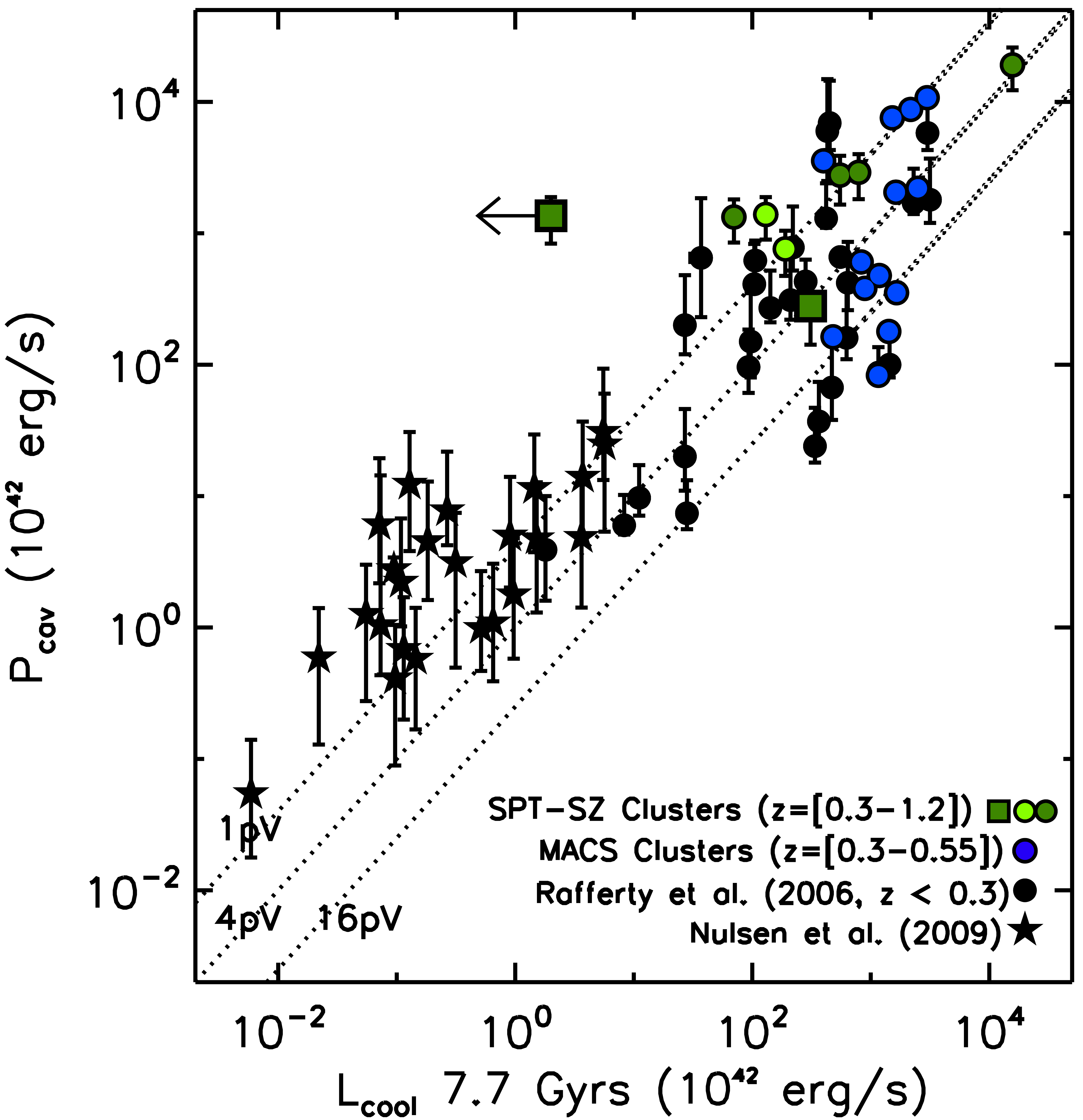
Jet Power - Halo Mass Correlation



Feedback power scales with halo mass when the central cooling time < 1 Gyr

Main et al. 2017

Jet Power and Cooling Across Masses



Hlavacek-Larrondo et al. 2015

SUMMARY

- We have confirmed the presence of a correlation between the Bondi accretion power and the mechanical jet power in early-type galaxies reported by Allen et al. (2006)

- A particularly strong correlation holds for galaxies with thermally unstable atmospheres, as indicated by the presence of cool gas traced by Hα+[NII] emission and with min($t_{\rm cool}/t_{\rm ff}$) < 10, while for the whole sample of galaxies the correlation is weaker.

- We find a strong correlation between the mechanical jet power ($P_{\rm jet}$) and the mass of the central supermassive black hole ($M_\bullet$) and, although poorly constrained, a hint of an anti-correlation with the specific entropy (K) of the ambient gas inside the Bondi radius.

- The results indicate that at least for thermally unstable systems, the jet power is set primarily by the supermassive black hole mass. Since the central black hole mass of X-ray luminous early-type galaxies correlates with the total mass of the host halo, more massive systems undergoing thermally unstable cooling will naturally have larger jet powers.