

WHEN JETS ARE NOT ENOUGH

NEUTRINO EMISSION AND ACCRETION IN AGN

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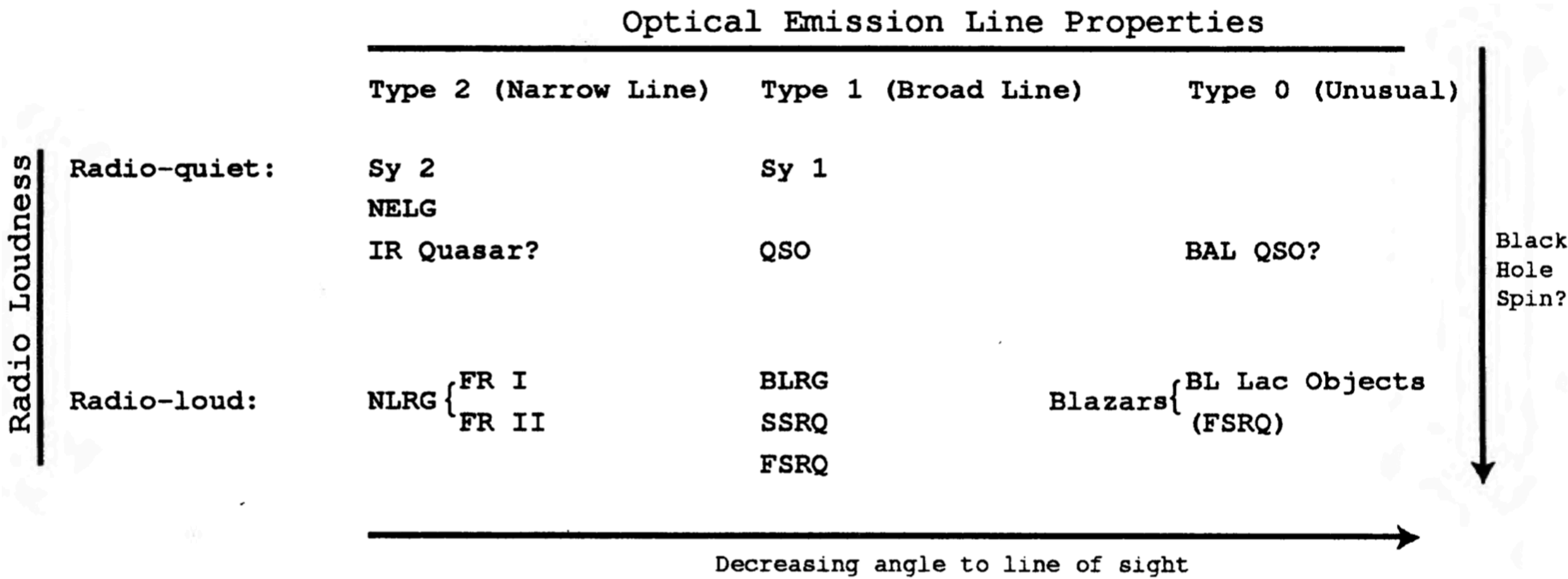
work in progress by:
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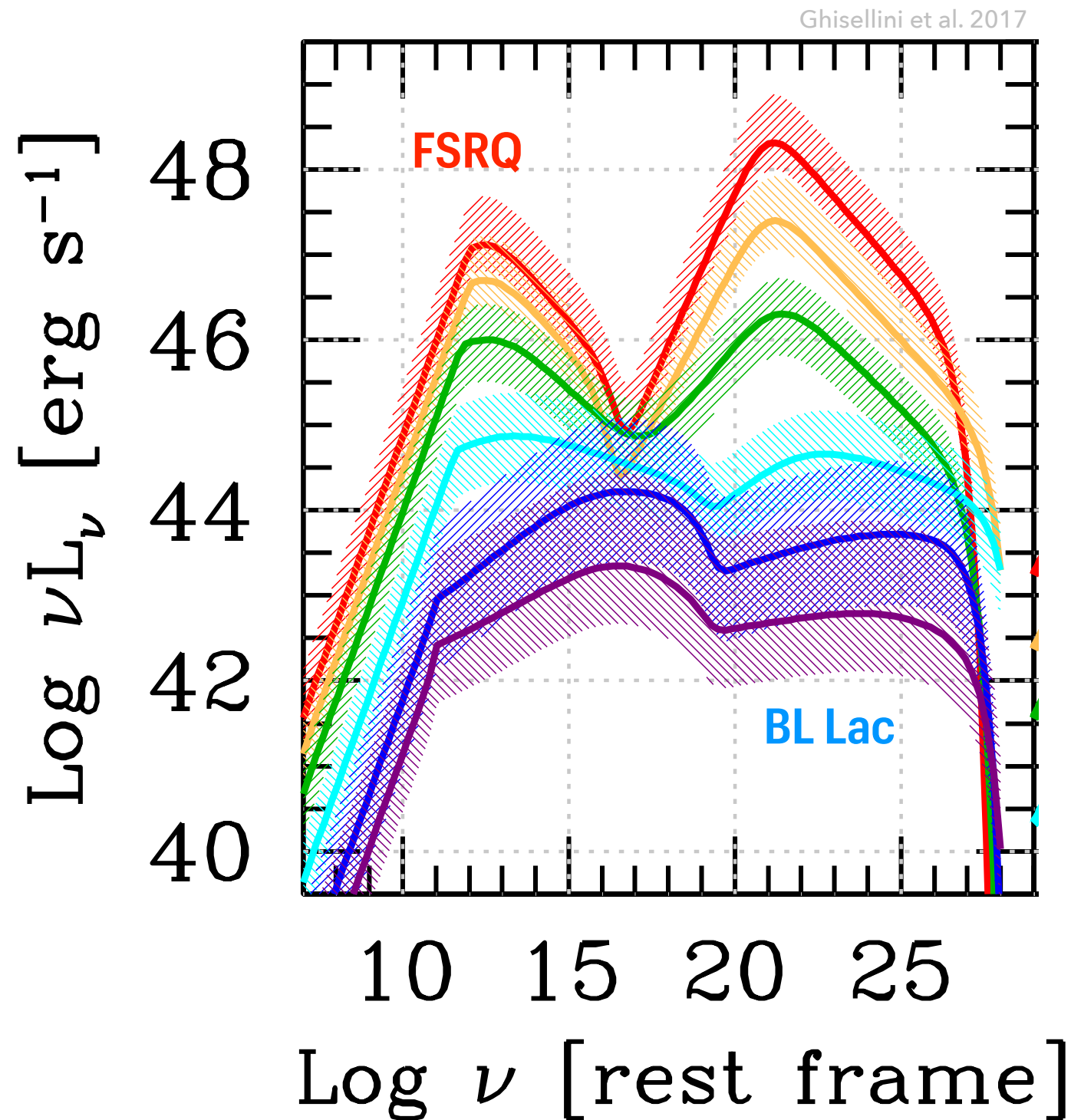


ACTIVE GALACTIC NUCLEI

Urry & Padovani 1995



BLAZARS: ALIGNED JETTED AGN



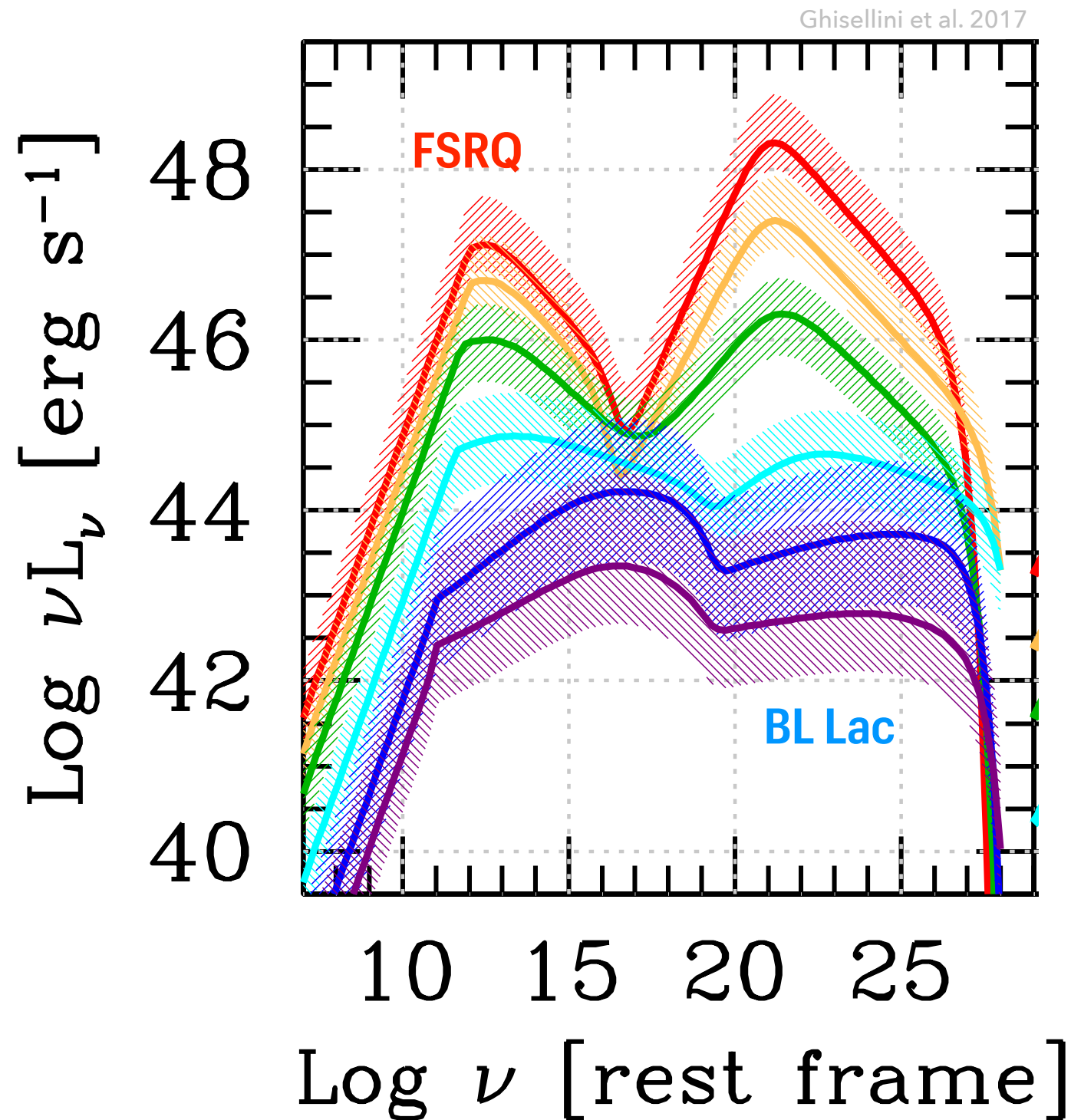
Flat Spectrum Radio Quasars:

luminous jets
fast accretion
broad emission lines

BL Lacertae Objects:

powerful but less luminous
slow accretion
no emission lines

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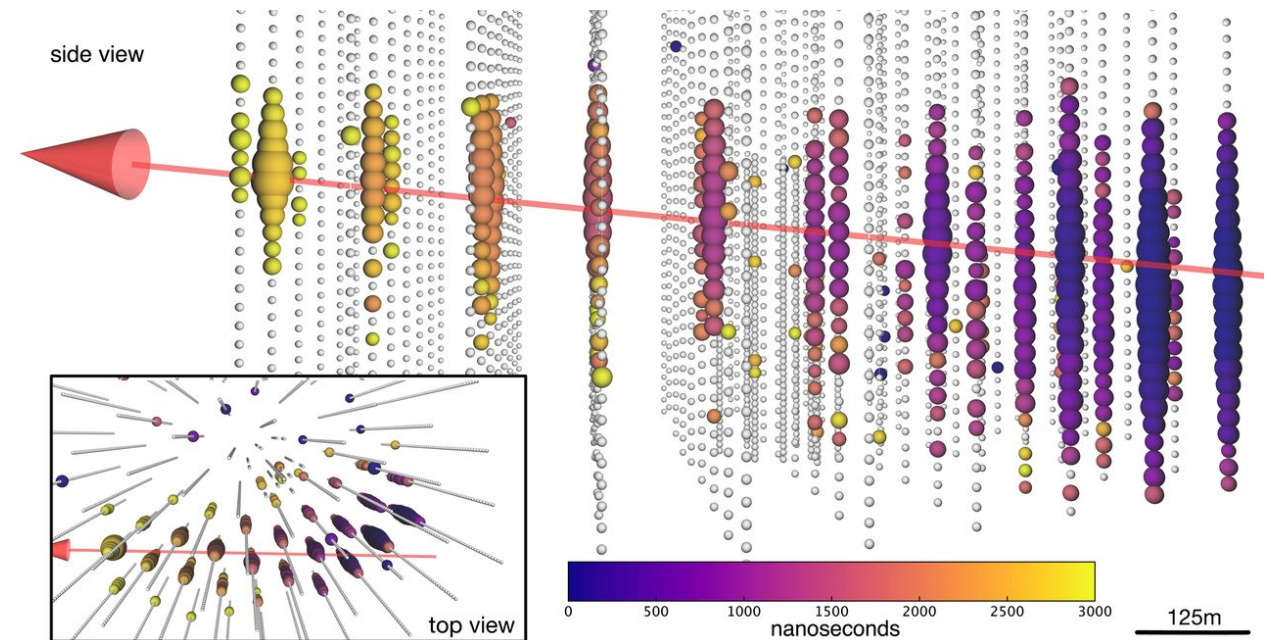
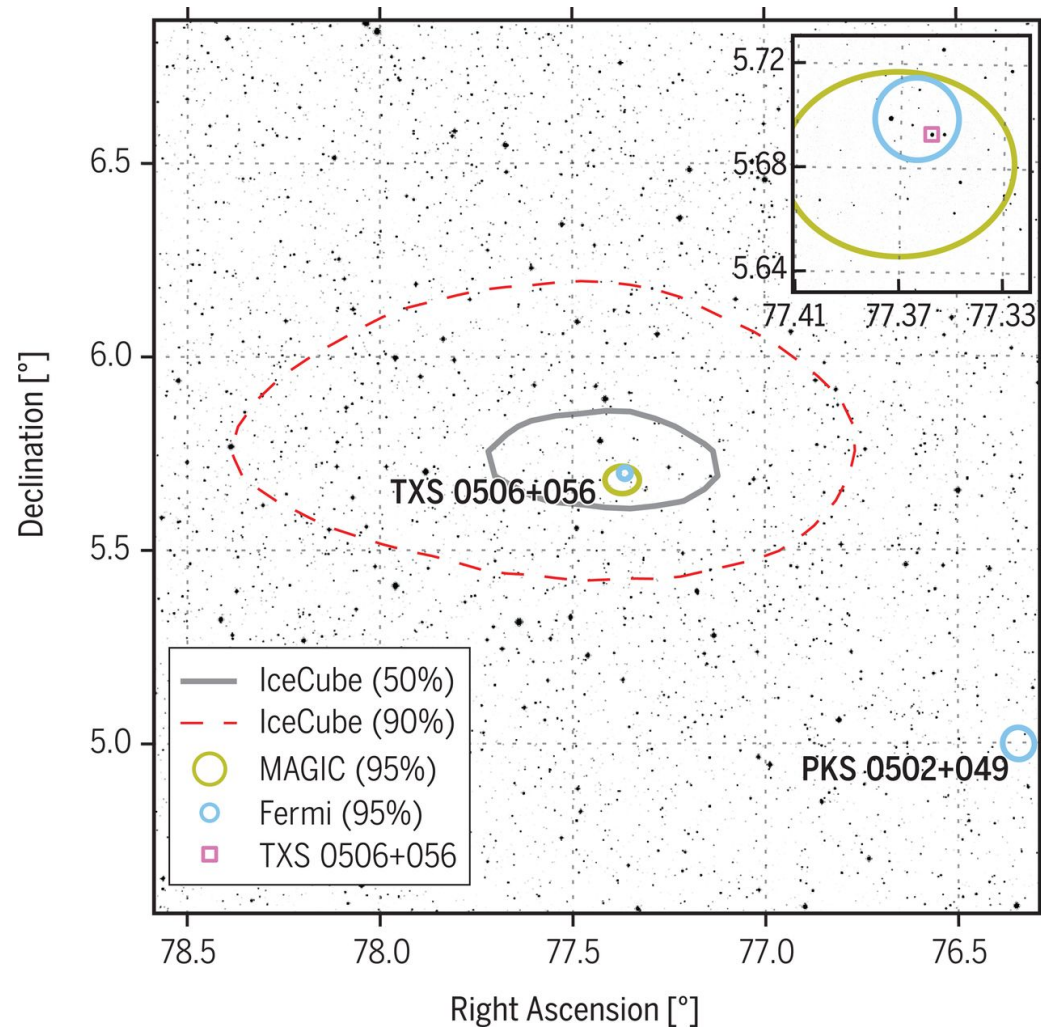
BL Lacertae Objects:

powerful but less luminous
slow accretion
no emission lines

expected to be the
most efficient in
emitting neutrinos

TXS 0506+056: THE FIRST NEUTRINO EMITTING BLAZAR

IceCube collab. et al. 2018



22 September 2017:

high-energy neutrino (290 TeV) leaving
a significant muon-track in IceCube
spatial correspondence with a blazar
follow-up: caught flaring in gamma rays

many are trying to give
uniformity to electromagnetic
and neutrino information

TXS 0506+056: THE FIRST NEUTRINO EMITTING BLAZAR

Monthly Notices

of the
ROYAL ASTRONOMICAL SOCIETY

MNRAS **484**, L104–L108 (2019)

Advance Access publication 2019 January 23



doi:10.1093/mnras/slz011

TXS 0506+056, the first cosmic neutrino source, is not a BL Lac

P. Padovani¹,^{1,2}★ F. Oikonomou,¹ M. Petropoulou,³ P. Giommi^{4,5,6} and E. Resconi⁷

¹European Southern Observatory, Karl-Schwarzschild-Str 2, D-85748 Garching bei München, Germany

²Associated to INAF - Osservatorio Astronomico di Roma, via Frascati 33, I-00040 Monteporzio Catone, Italy

³Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA

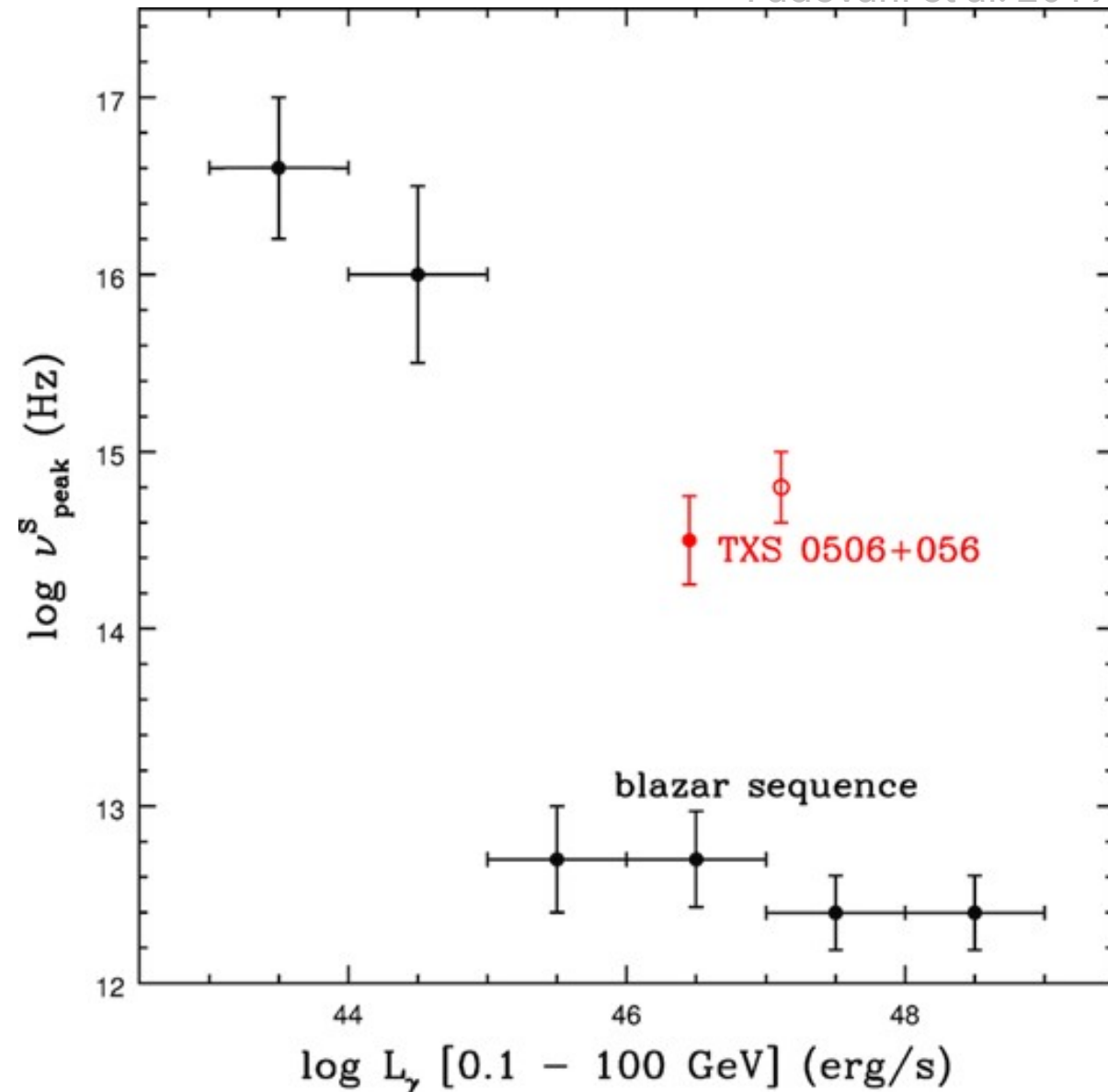
⁴Agenzia Spaziale Italiana, ASI, via del Politecnico s.n.c., I-00133 Roma, Italy

⁵Institute for Advanced Studies, Technische Universität München, Lichtenbergstr 2a, D-85748 Garching bei München, Germany

⁶ICRANet, Piazzale della Repubblica 10, I-65122 Pescara, Italy

⁷Physik-Department, Technische Universität München, James-Frank-Str 1, D-85748 Garching bei München, Germany

Padovani et al. 2019



TXS 0506+056: THE FIRST NEUTRINO EMITTING BLAZAR

first unexpected feature of
neutrino counterpart AGN!

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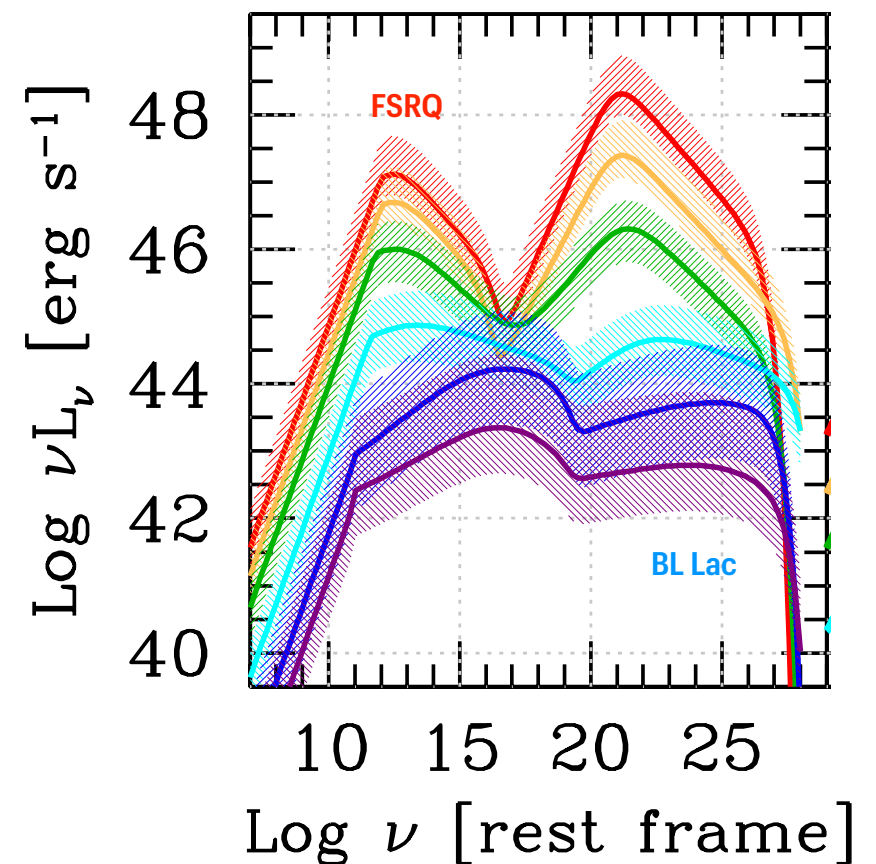
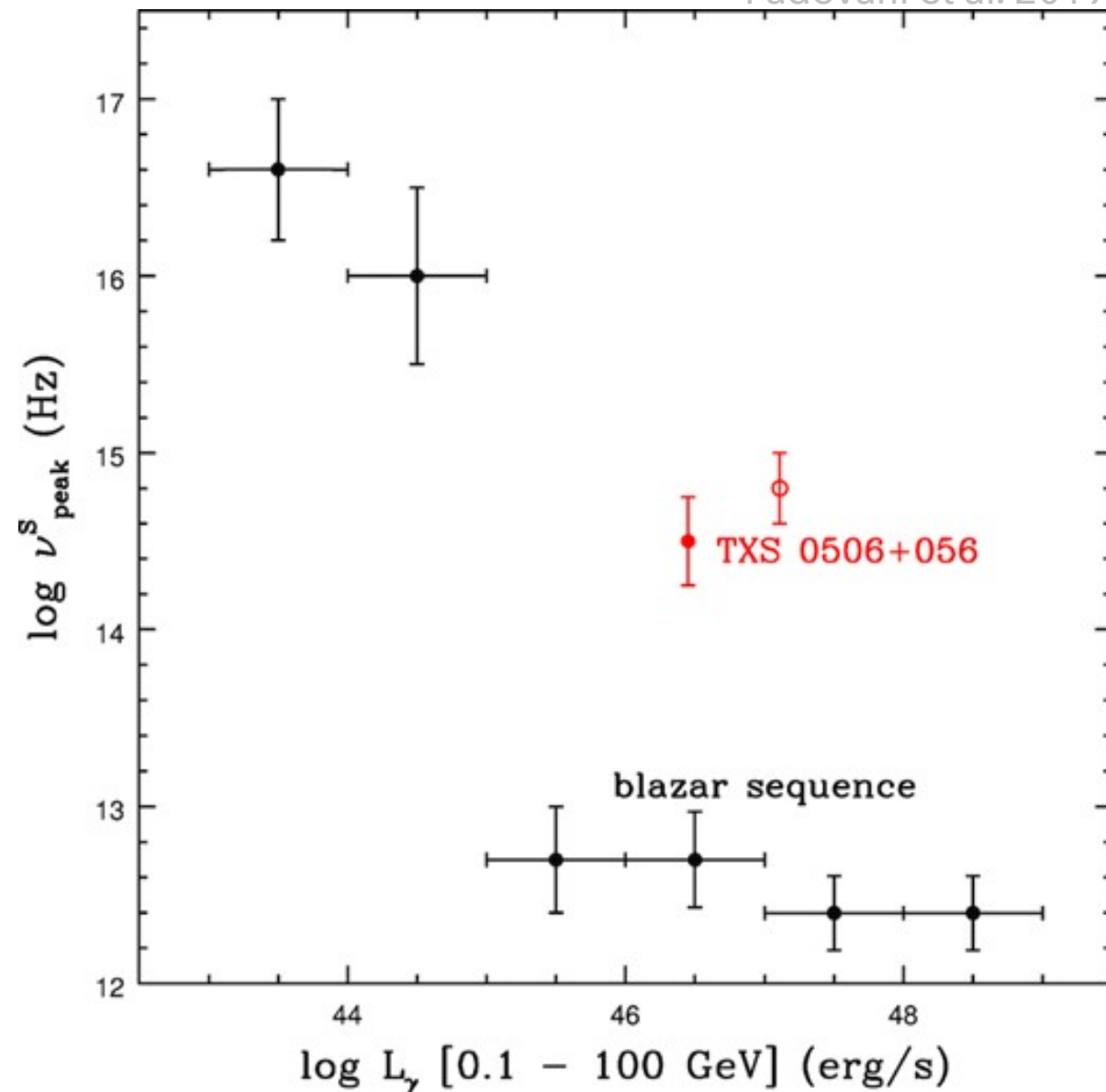
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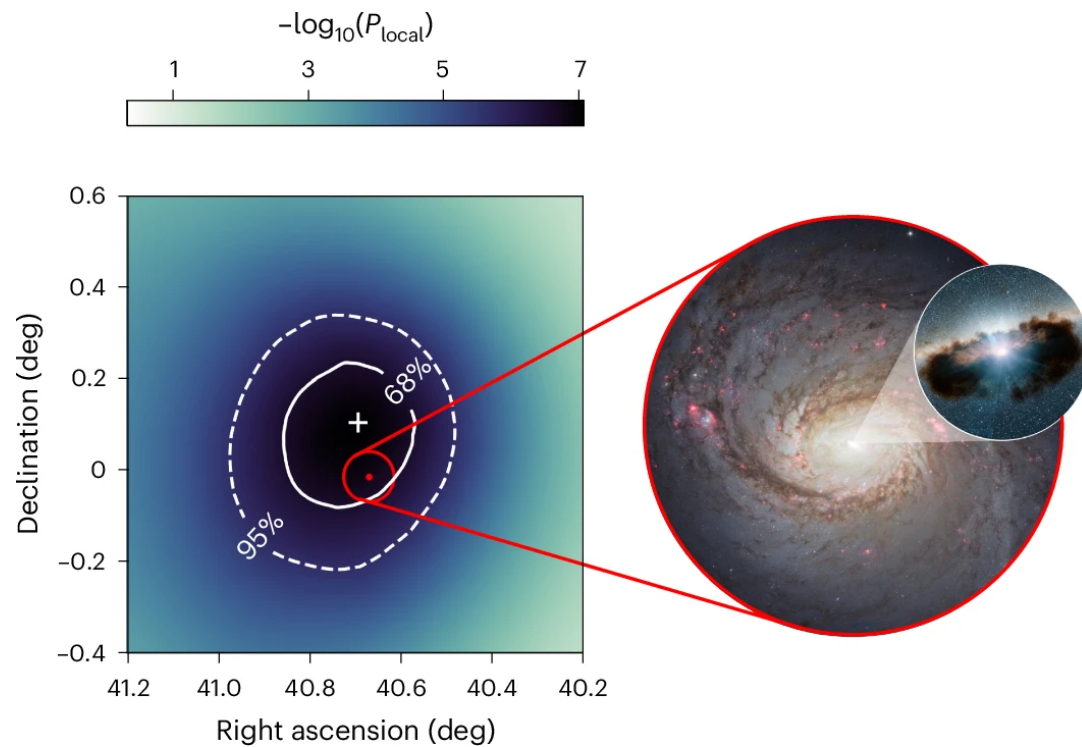
Padovani et al. 2019



NGC 1068: NEUTRINO FLUX & NO JET!

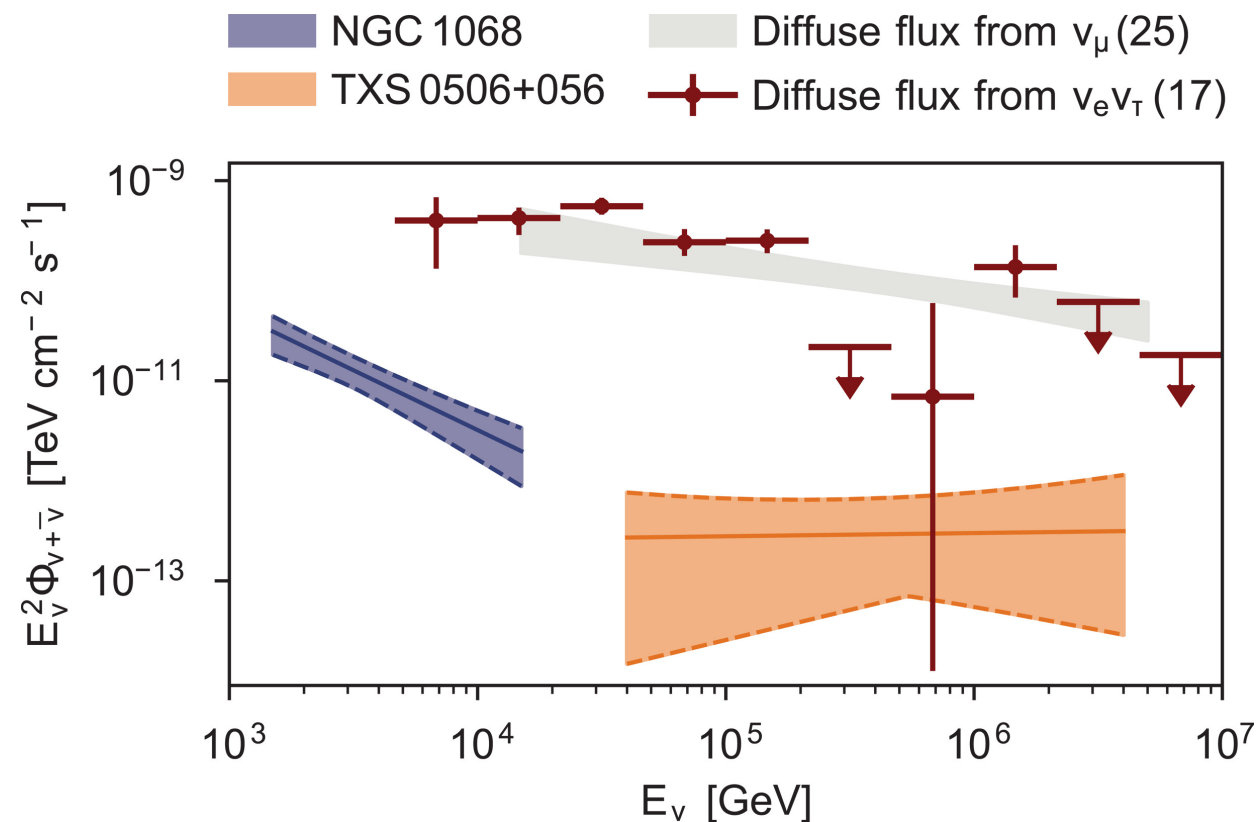
IceCube collab. 2022

Padovani et al. 2022



the most significant source of consistent high-energy neutrino flux is NGC 1068

the archetype of the “non-jetted” AGN!



NGC 1068: NEUTRINO FLUX & NO JET!

Padovani et al. 2022
Sbarrato et al. 2025

what region is responsible for those neutrinos?

X-ray Corona (in the obscured nuclear region)

has hadronic fraction sufficient to justify photo-pion processes

sufficiently photon-rich environment to absorb neutrino-associated gamma-rays

but Inoue et al. (2024) strongly suggest that the
Corona is not sufficient for this specific source!

Outer regions: starburst, outflows/winds

gamma-ray emitters

is it an energetic enough environment?

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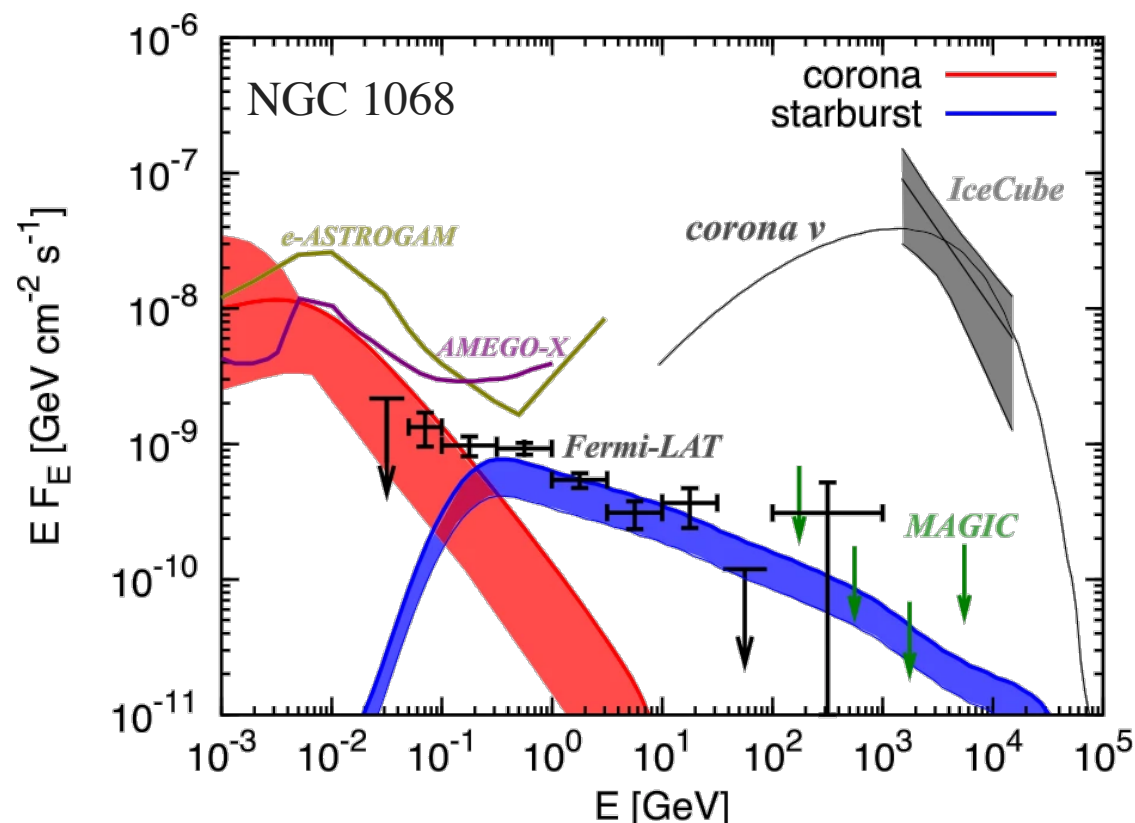
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is it an energetic enough environment?



**we need to explore
the MeV band:
poorly sampled
electromagnetic window**

WHO IS RESPONSIBLE FOR NEUTRINOS?

systematic study of all neutrino counterparts and candidates

currently many lower significance associations have been suggested

→ few tens of neutrino counterpart candidates are available

FOCUS ON THE NUCLEUS

WORK IN PROGRESS
BY GAIA DELUCCHI

systematic study of accretion regime and nuclear features
of neutrino counterpart candidates

how do ν -blazars accrete?

do their accretion regime reflects the non-BL Lac behaviour showed by their jets?

use emission lines to trace accretion regime:

are they emitted in an environment that includes a hot, Comptonized flow?

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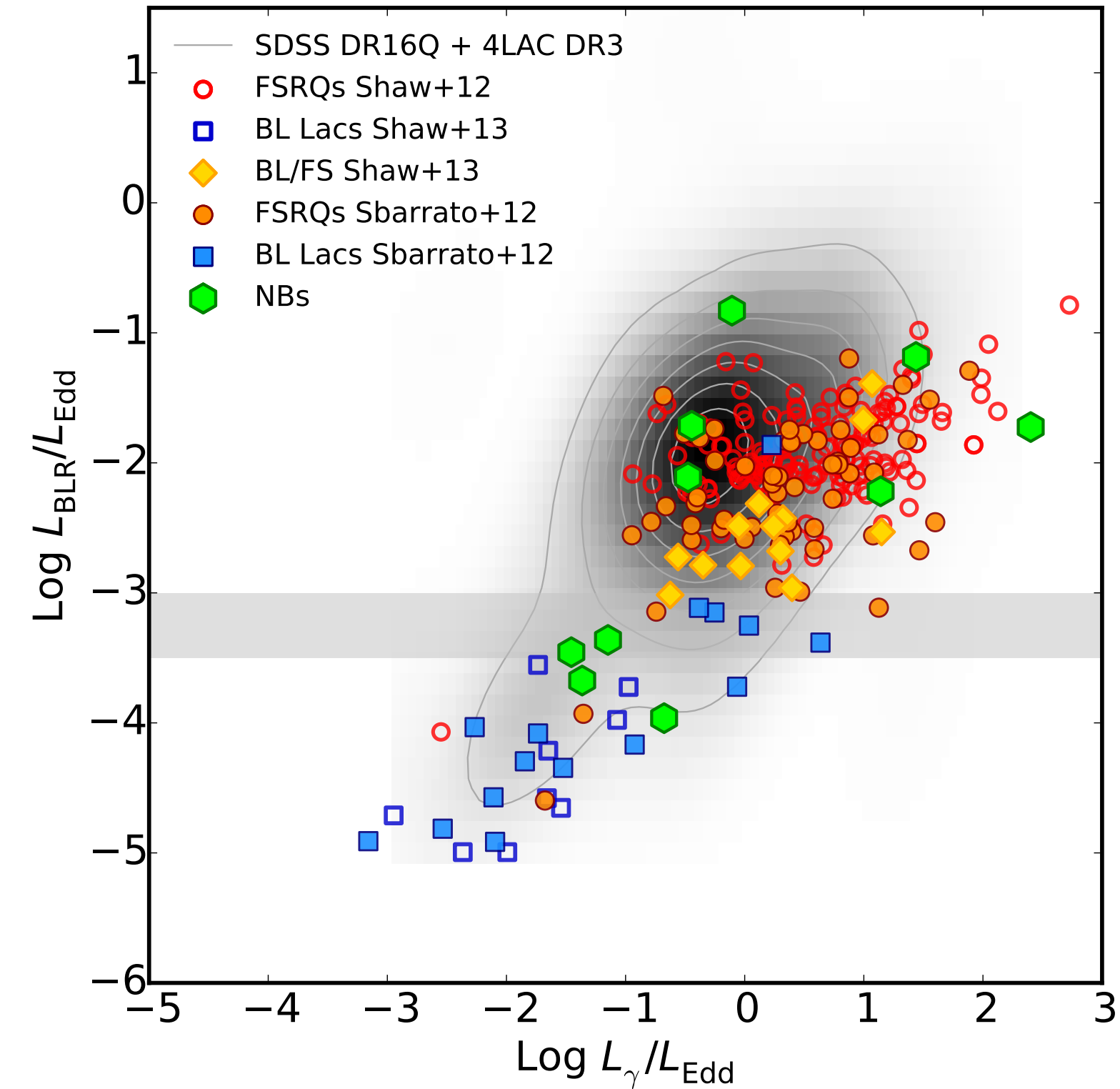
use emission lines to trace accretion regime:

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suitable
environment to
foster energetic
hadrons, similar to
X-ray Corona!

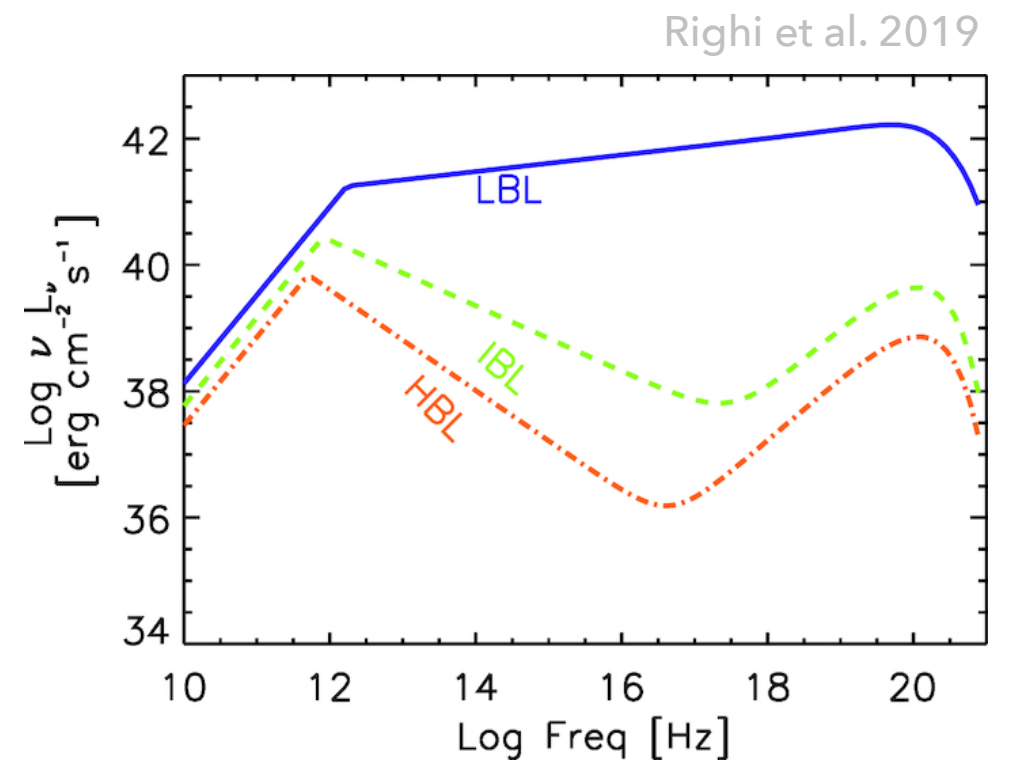
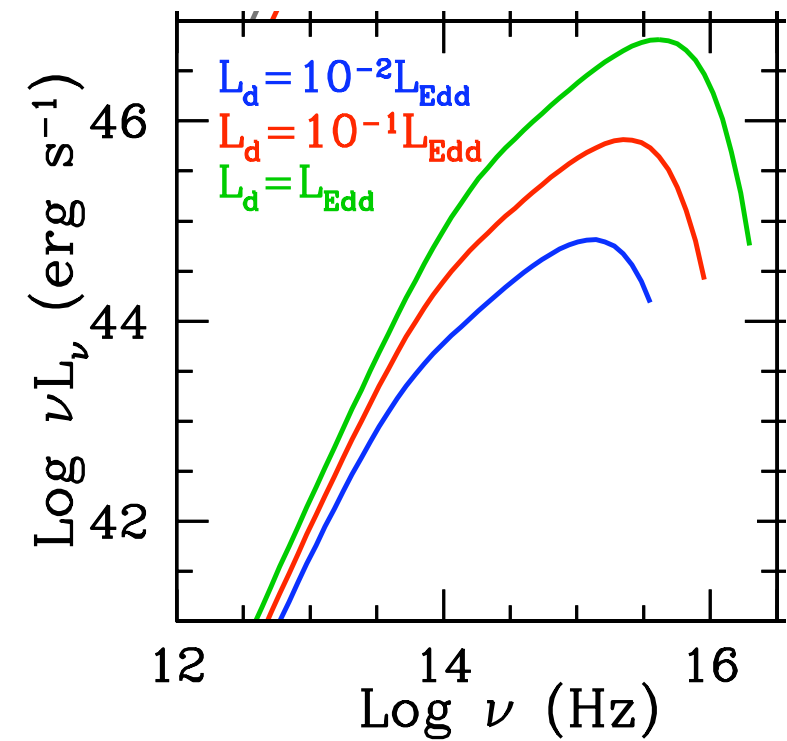
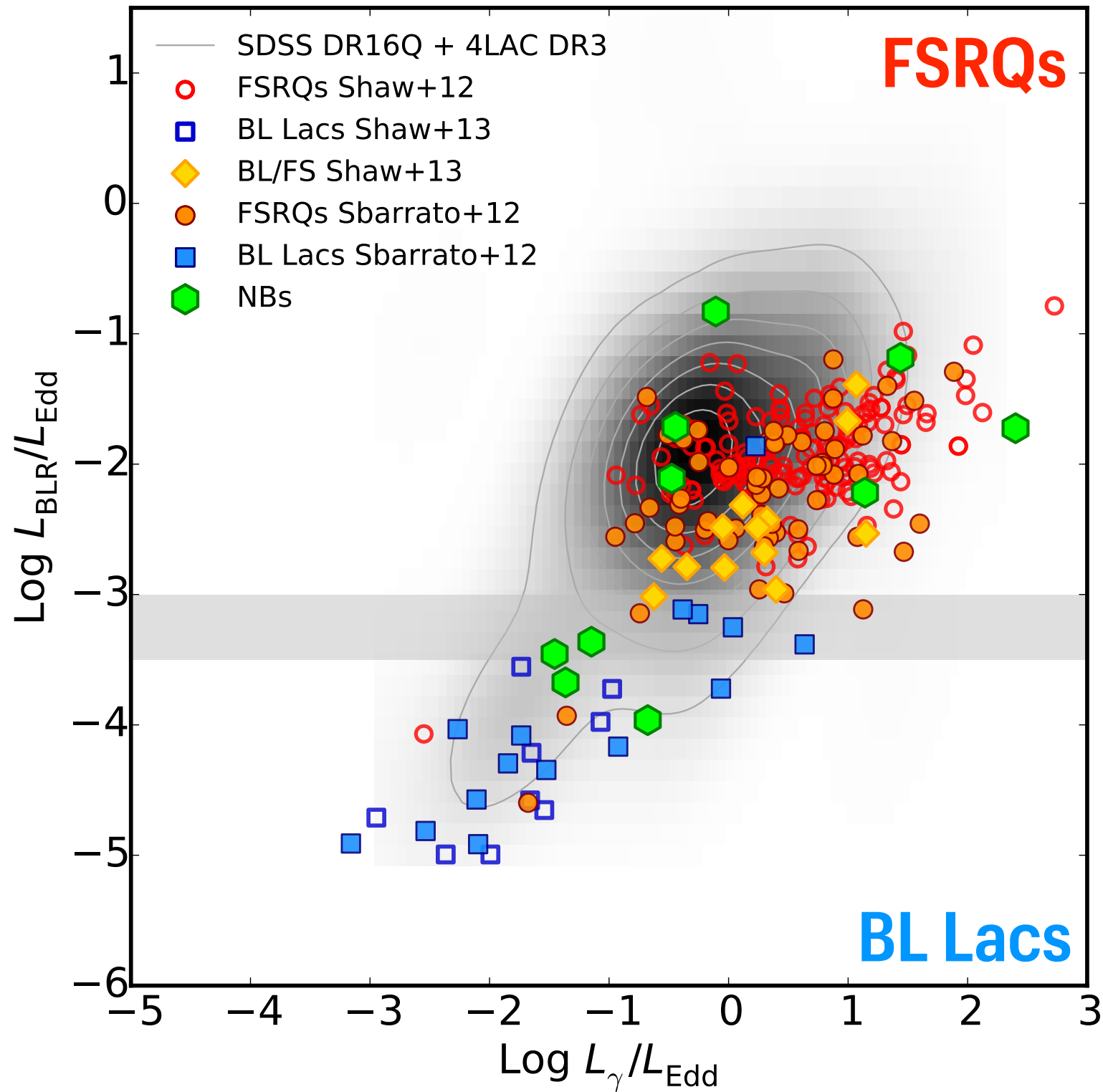
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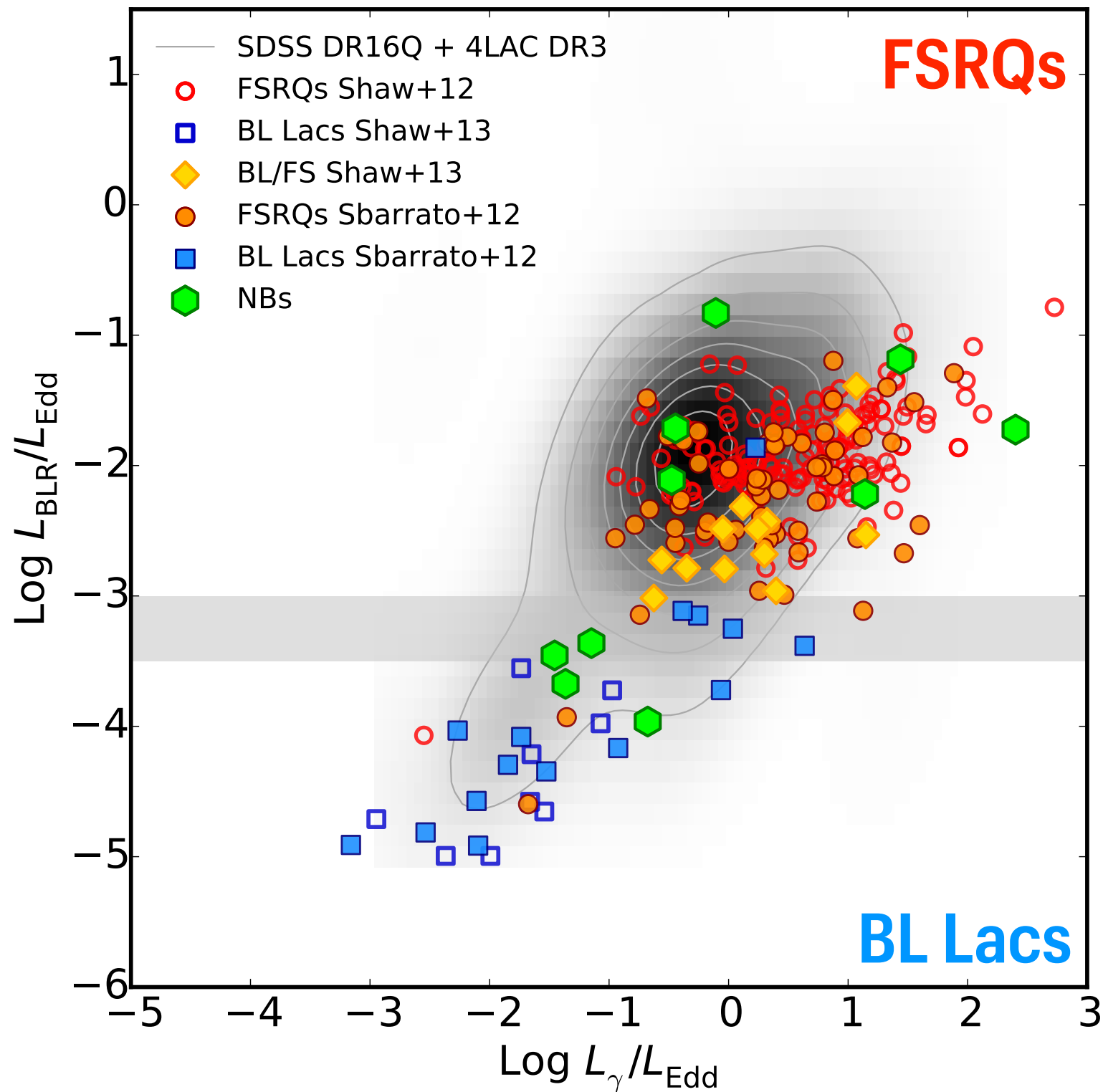
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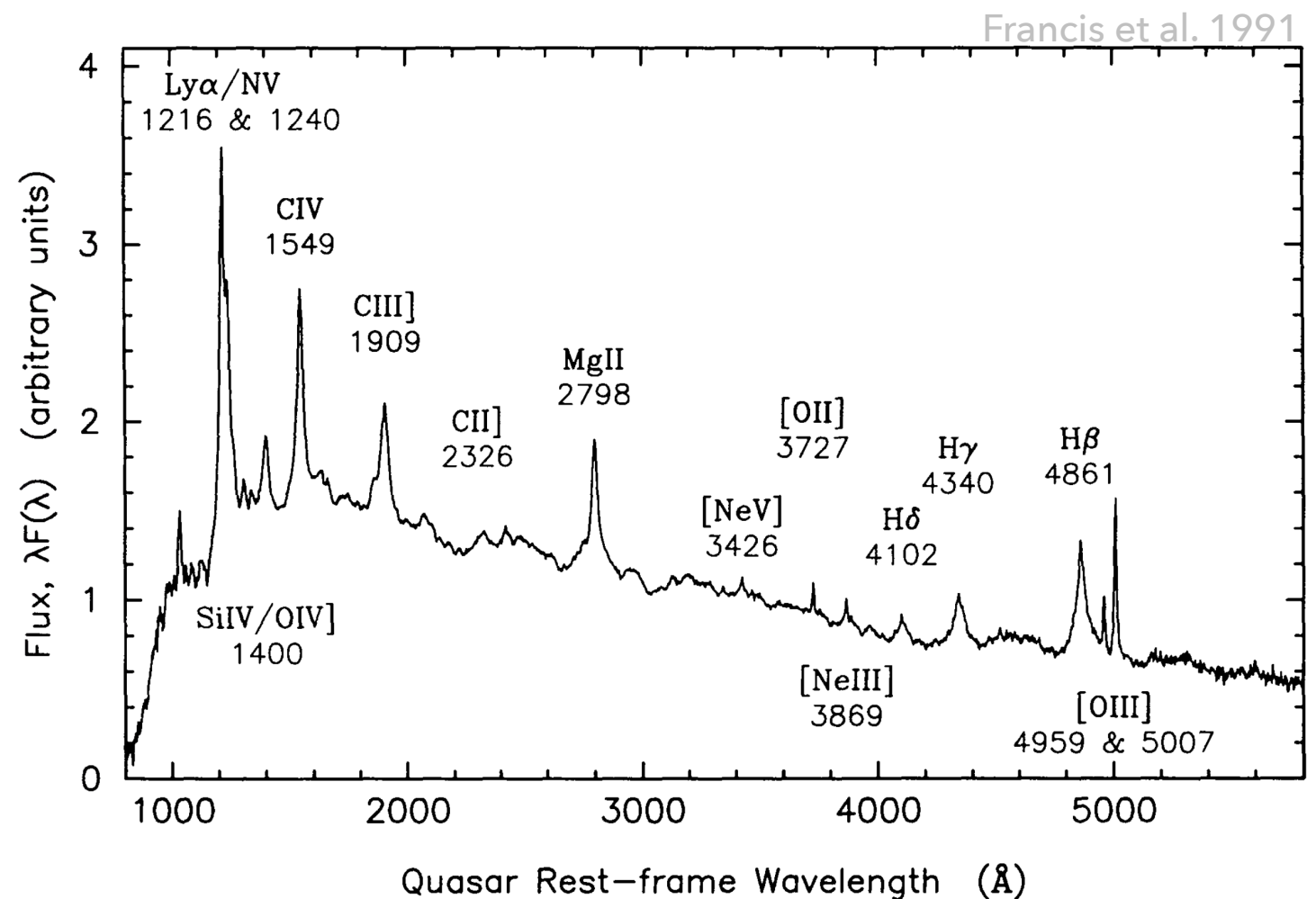
is this a reasonable
way of tracing
ionising radiation?

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WORK IN PROGRESS
BY GAIA DELUCCHI

BLR luminosity is derived assuming fixed line ratios

derived for bright quasars, likely radiatively efficient accretors

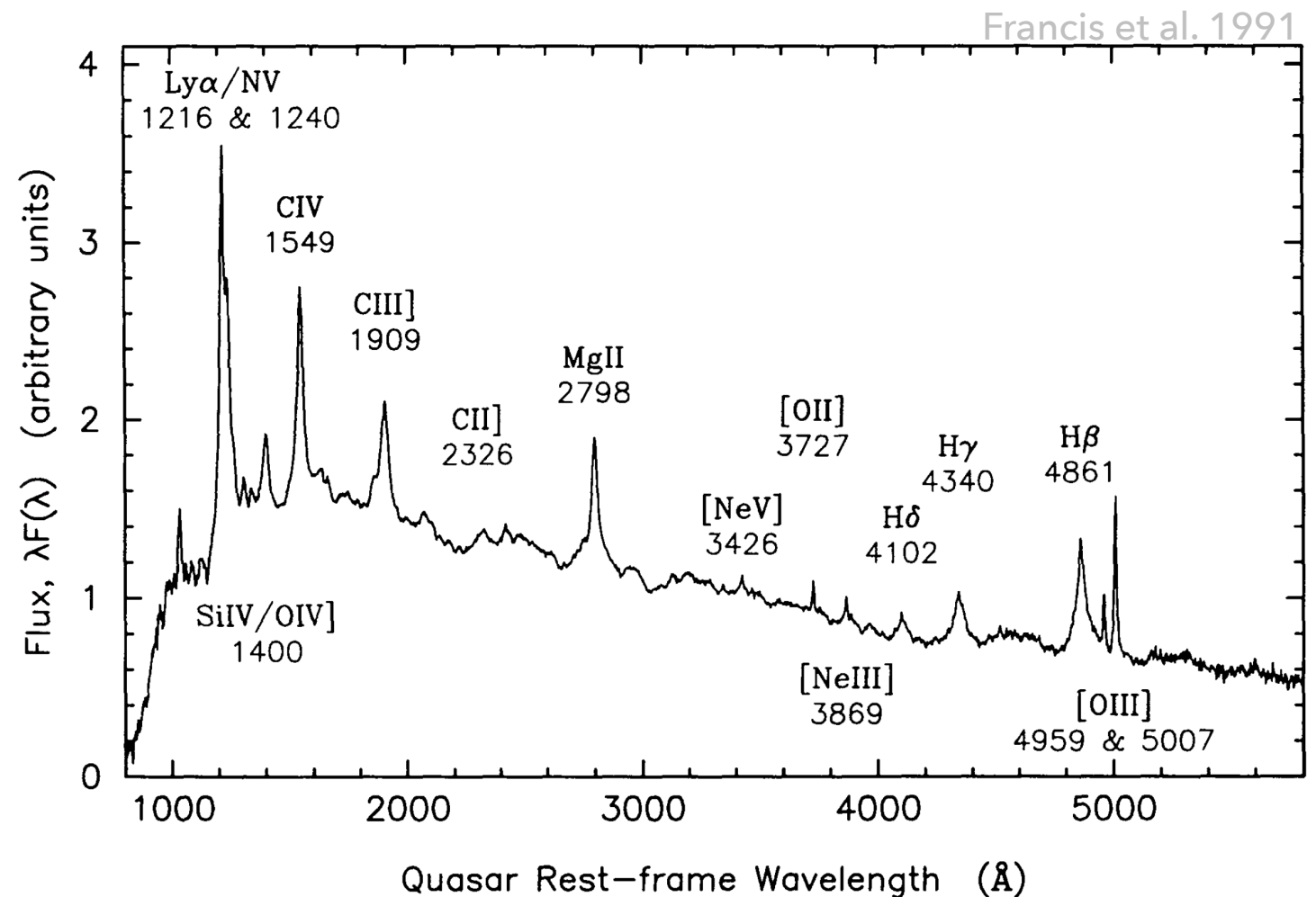
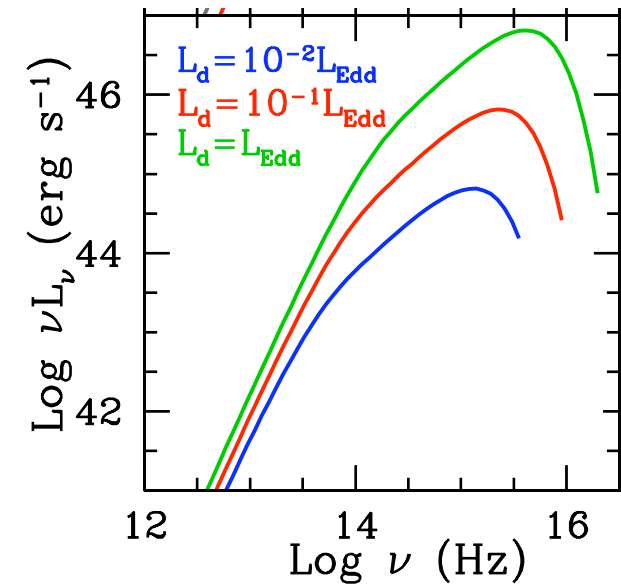


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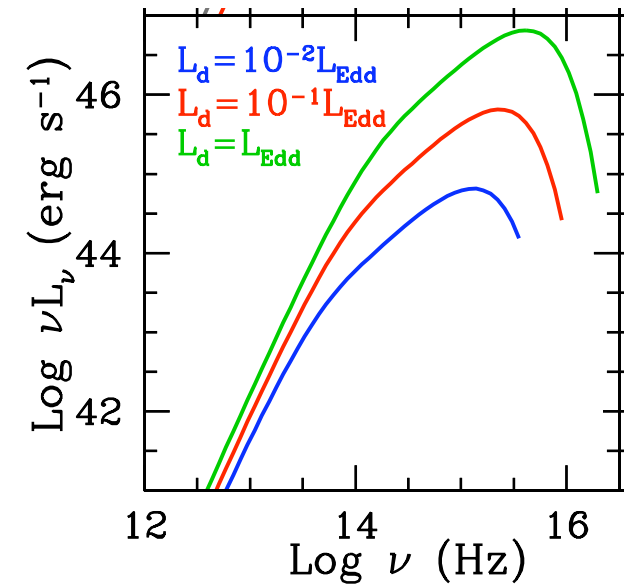


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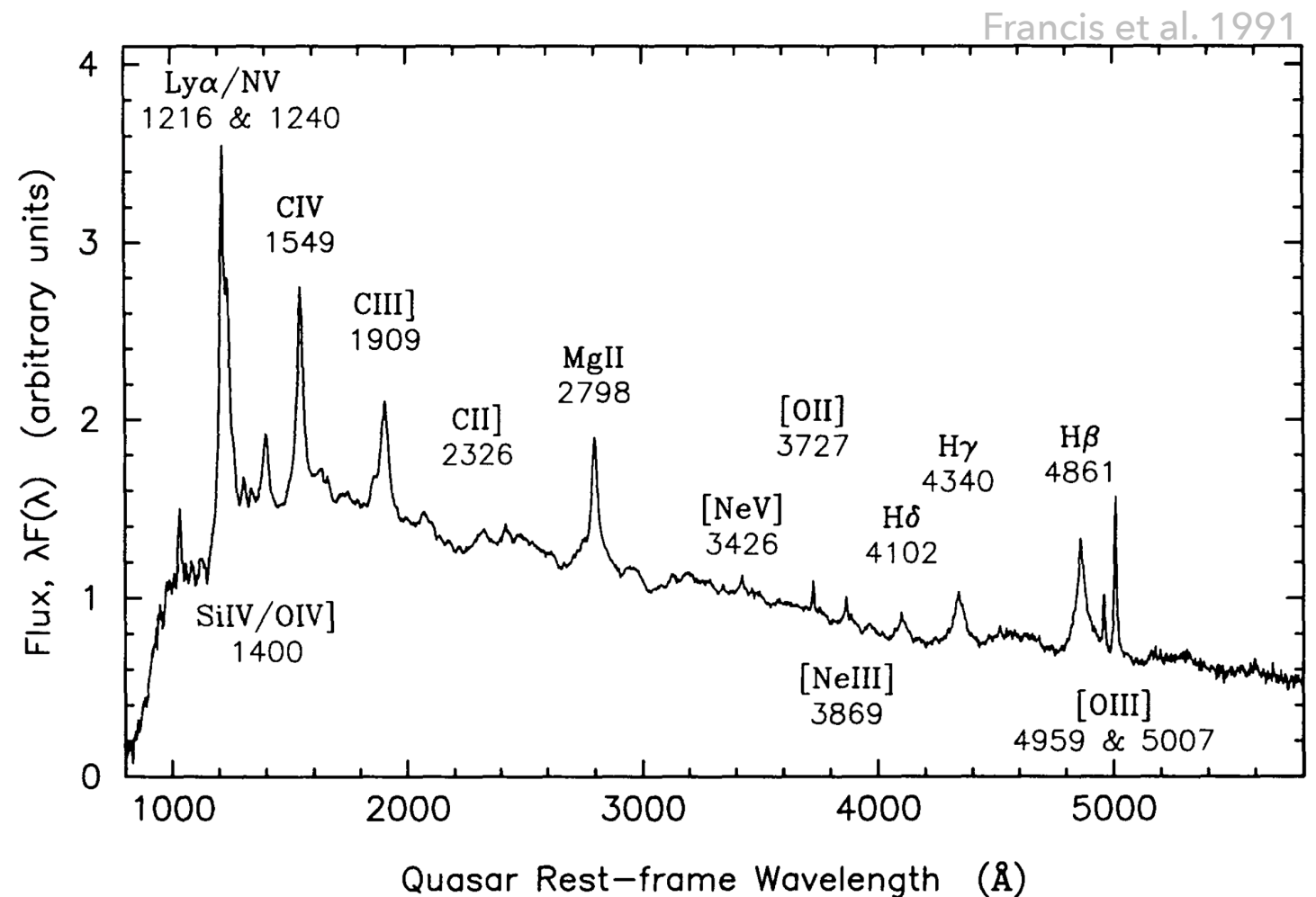
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a more detailed approach
is necessary

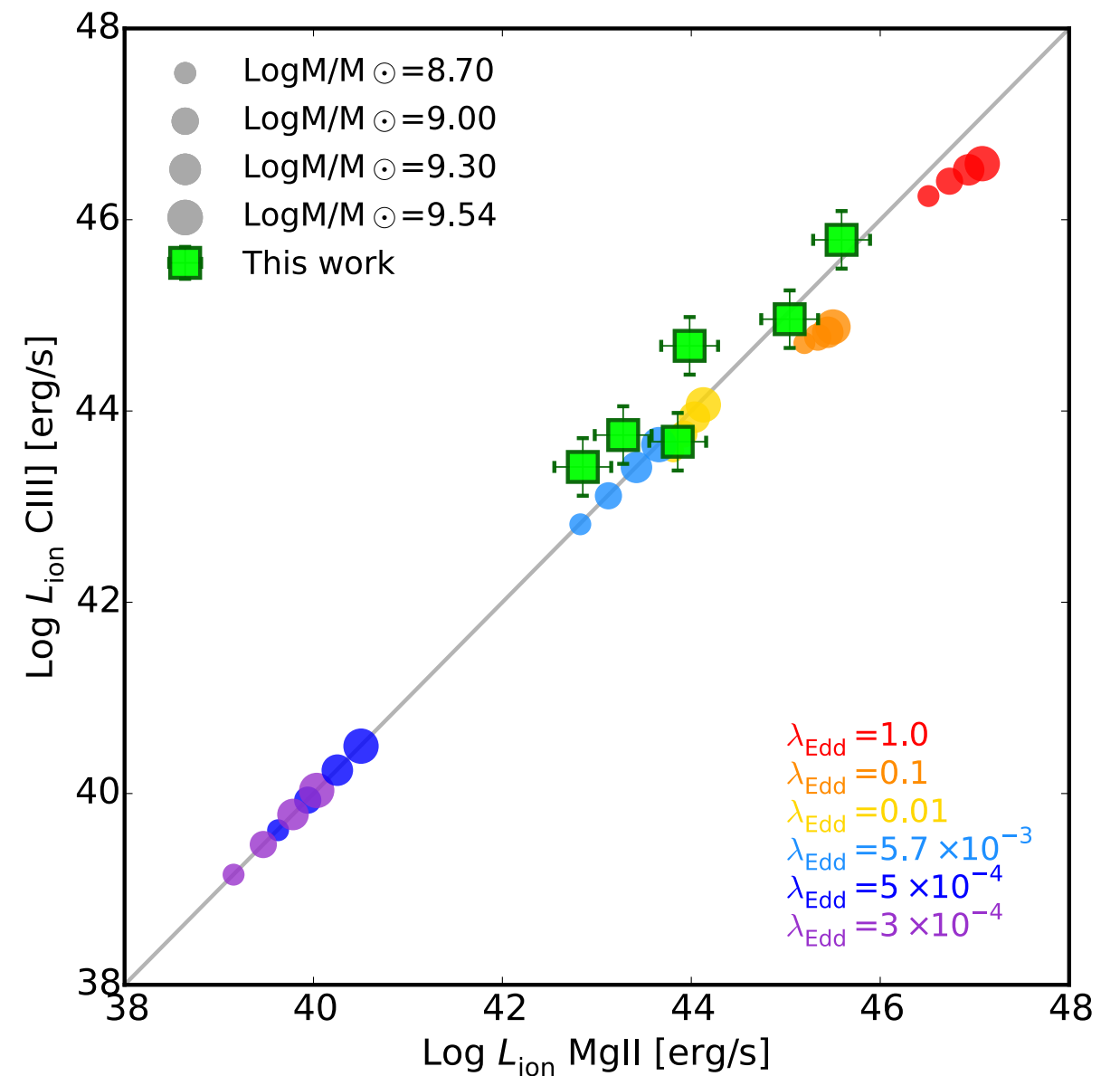
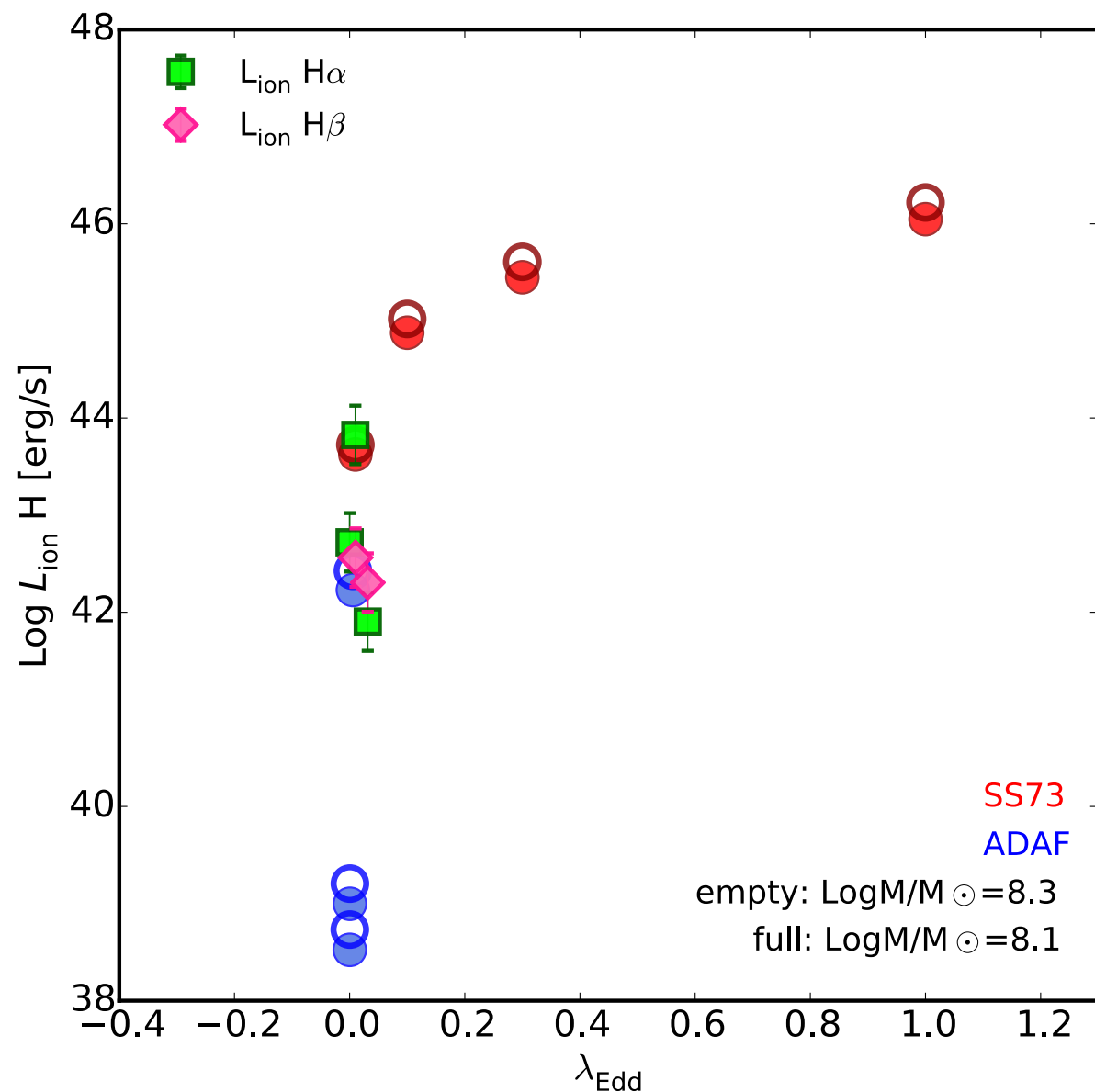
specific lines trace
specific ionising radiation



FOCUS ON THE NUCLEUS

WORK IN PROGRESS
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simple comparison of line luminosities with their respective ionising luminosities,
derived for a grid of mass and accretion rate values,
both for alpha-disk and ADAF models



FOCUS ON THE NUCLEUS

WORK IN PROGRESS
BY GAIA DELUCCHI
WITH MADDALENA BARILE

MCMC approach:

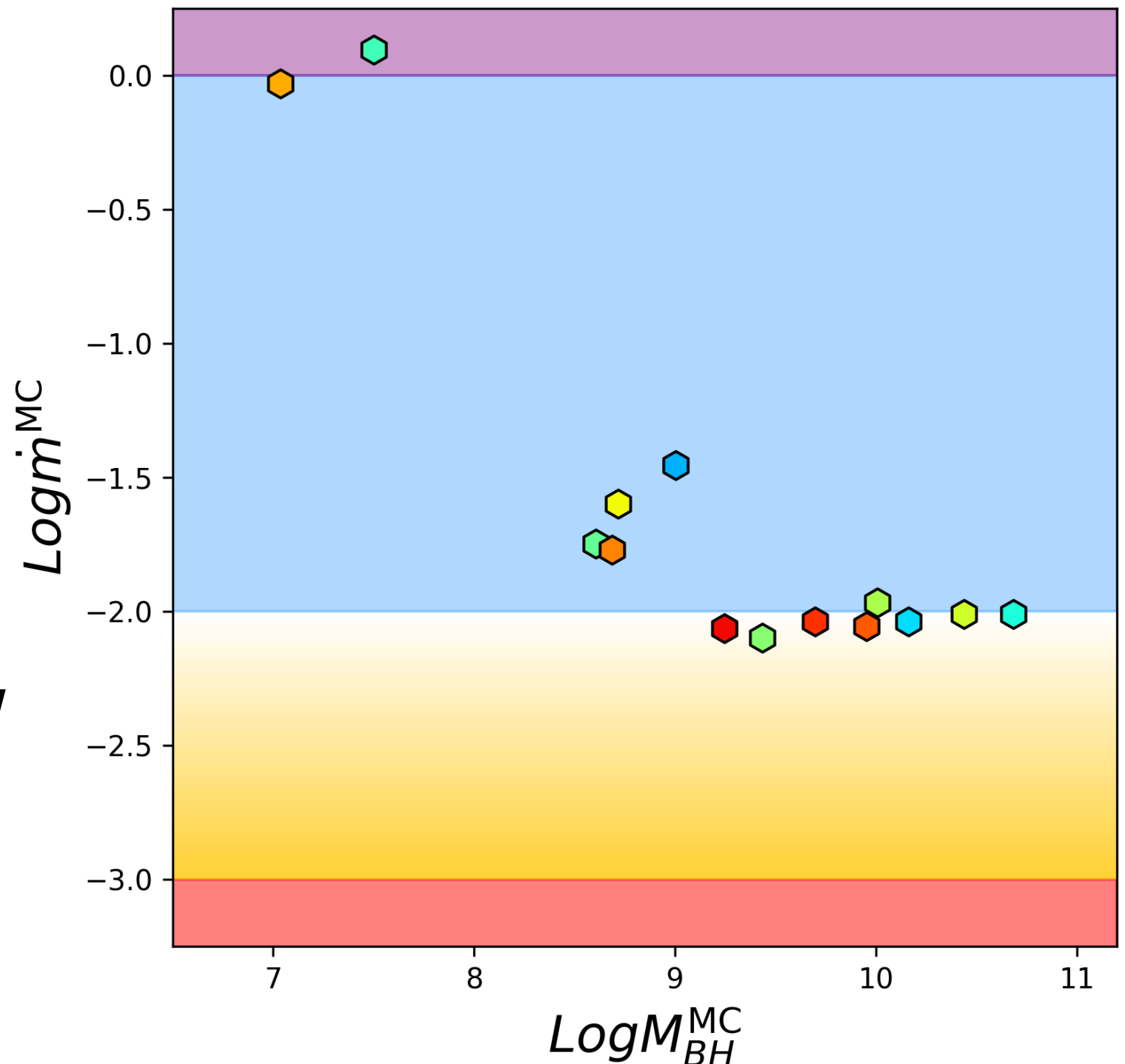
find mass and accretion rate
that provide an ionising luminosity
10x the measured line luminosities

models:

SS73, ADAF

plain switch at 1% Eddington limit

**about 60% of ν -blazar candidates
accrete close to the transition btw
efficient and inefficient regimes**



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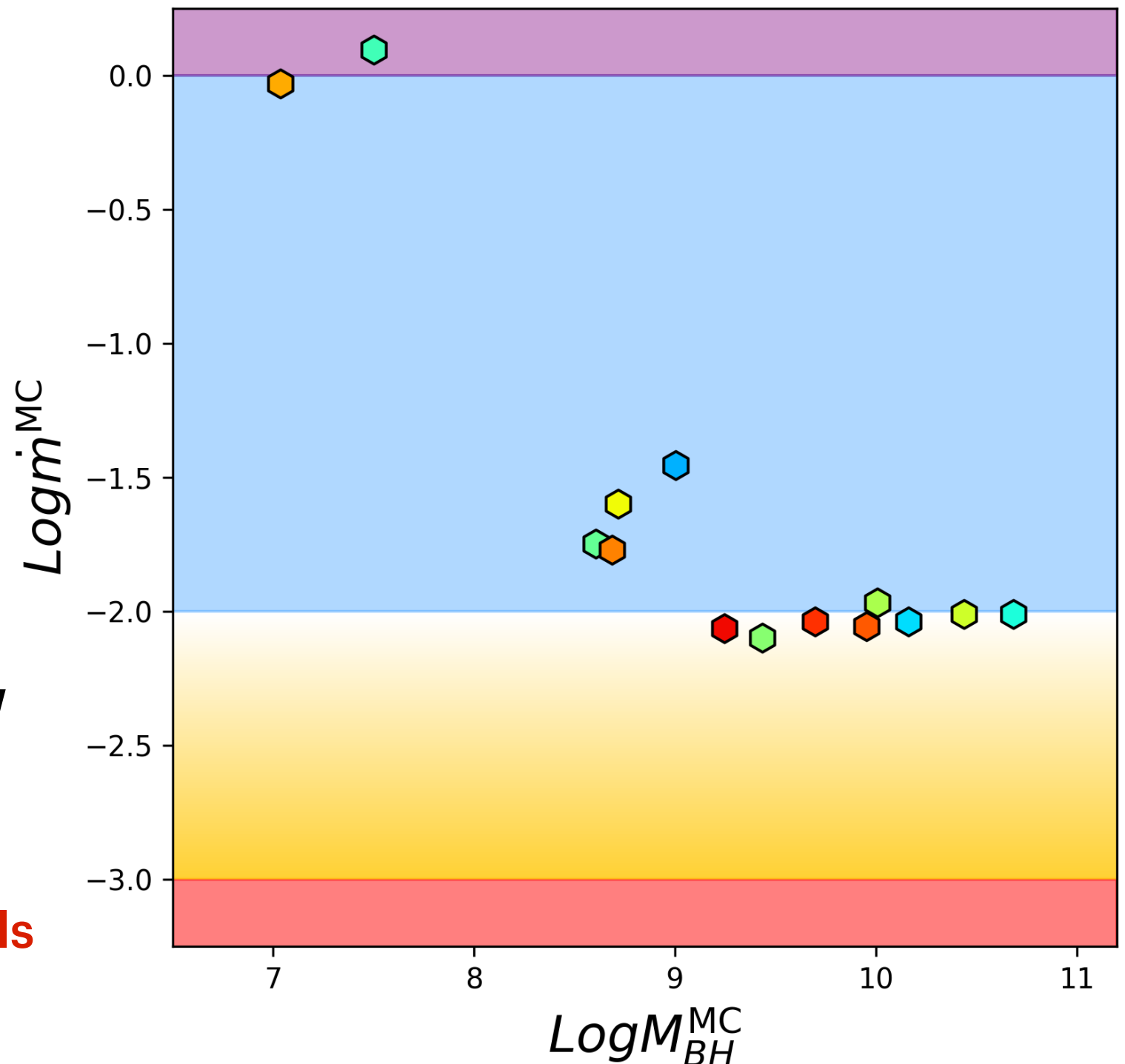
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**we need to include more details
in the transition process!**

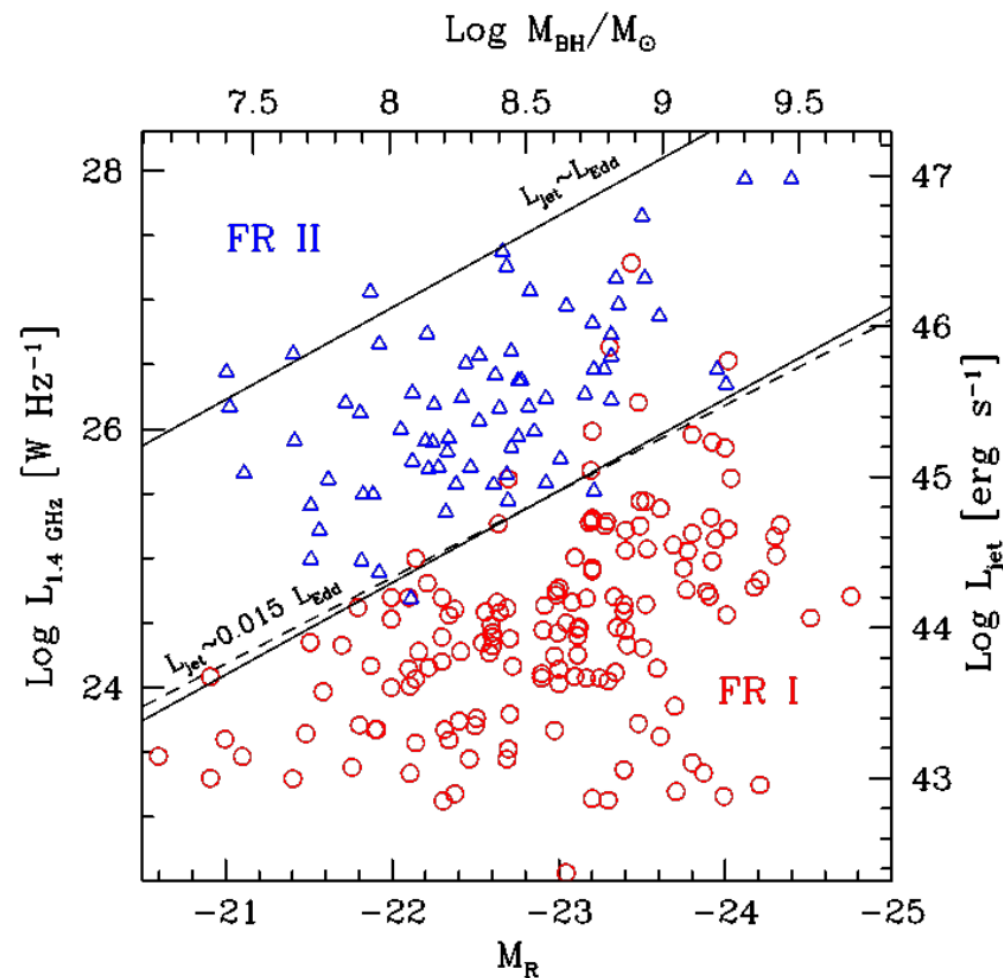


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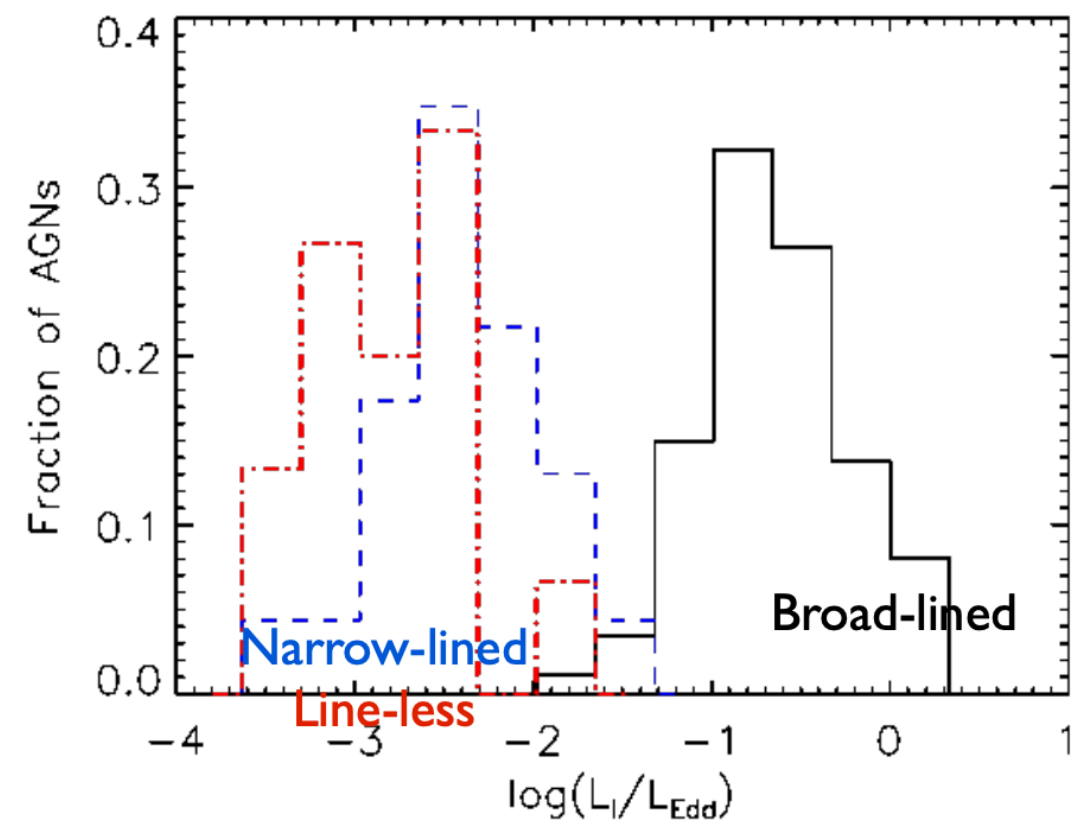
Something is happening at $L \sim 0.01 L_{\text{Edd}}$

ADAF - Shakura/Sunyaev ?



Ledlow & Owen 1996
Ghisellini & Celotti 2002

Sample 82 unobscured AGNs



Trump et al. 2011

Changing-look AGN are close to that L !

slide from L. Costamante's talk on Monday

Changing-look ~~AGN~~ are close to that L? blazars

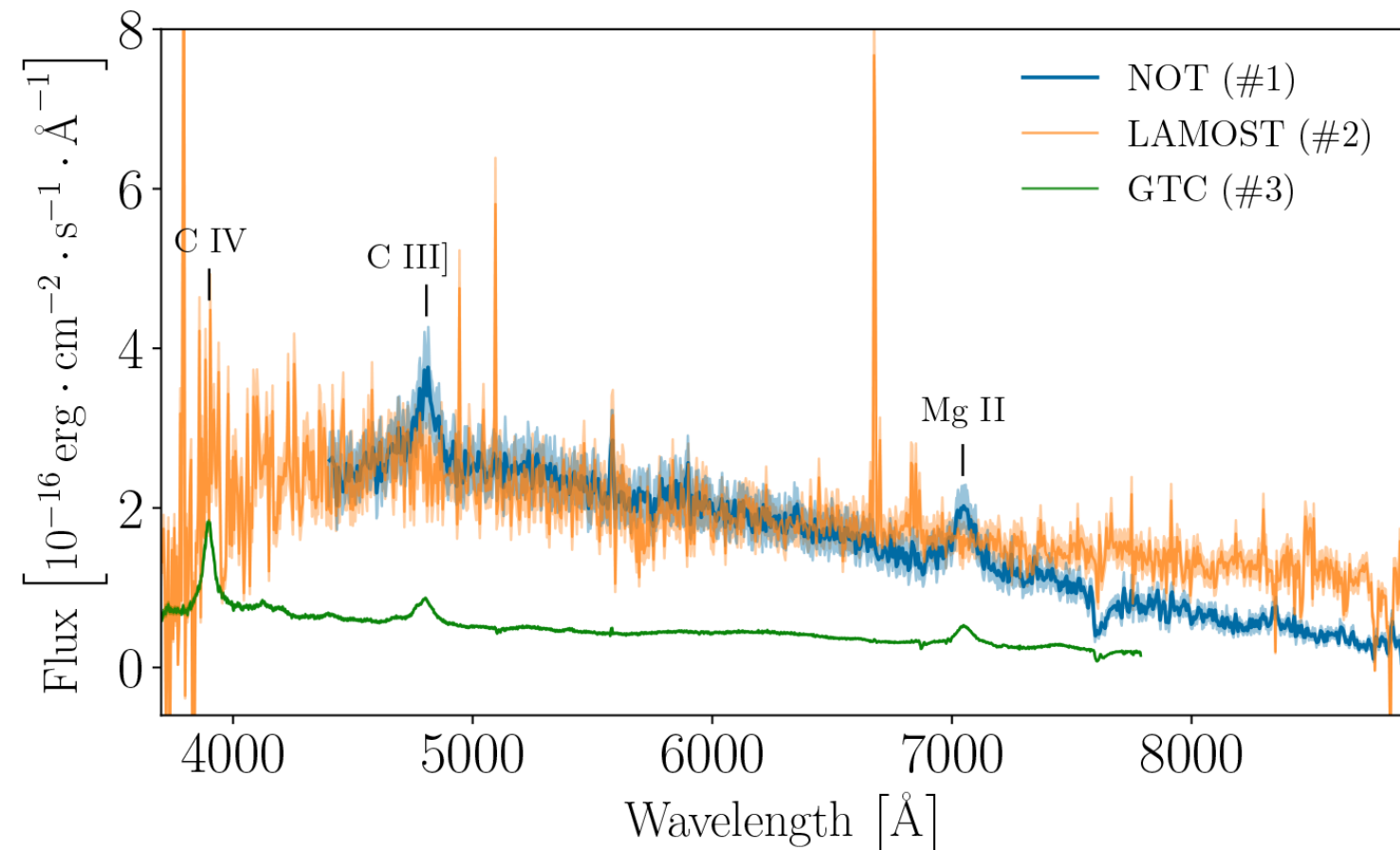
Azzollini et al. 2025

5BZQ J1243+4043 $z=1.518$

3 epochs:

#2 is lineless (and noisy)

the other 2 show clear broad emission lines



Changing-look ~~AGN~~ are close to that L? blazars

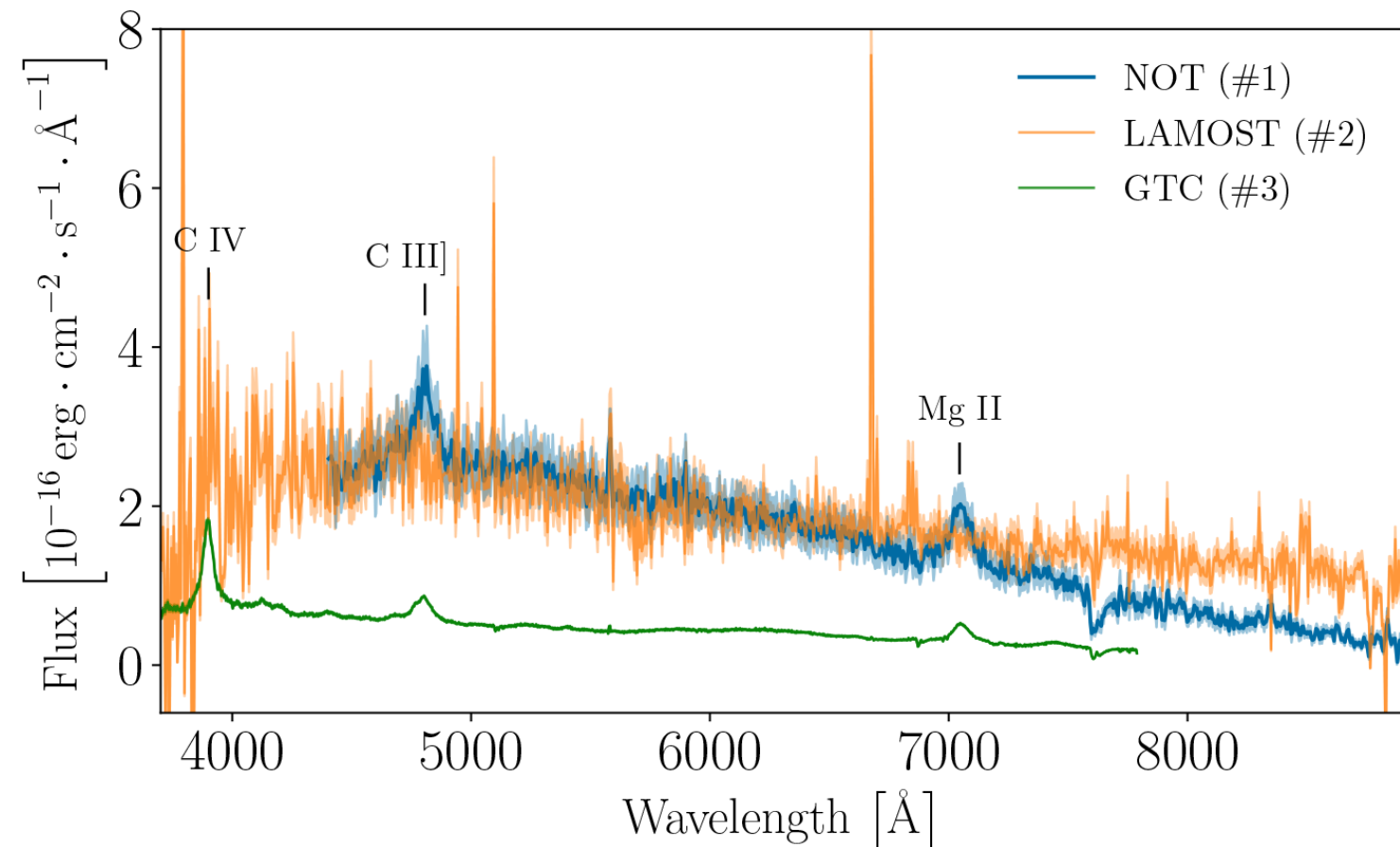
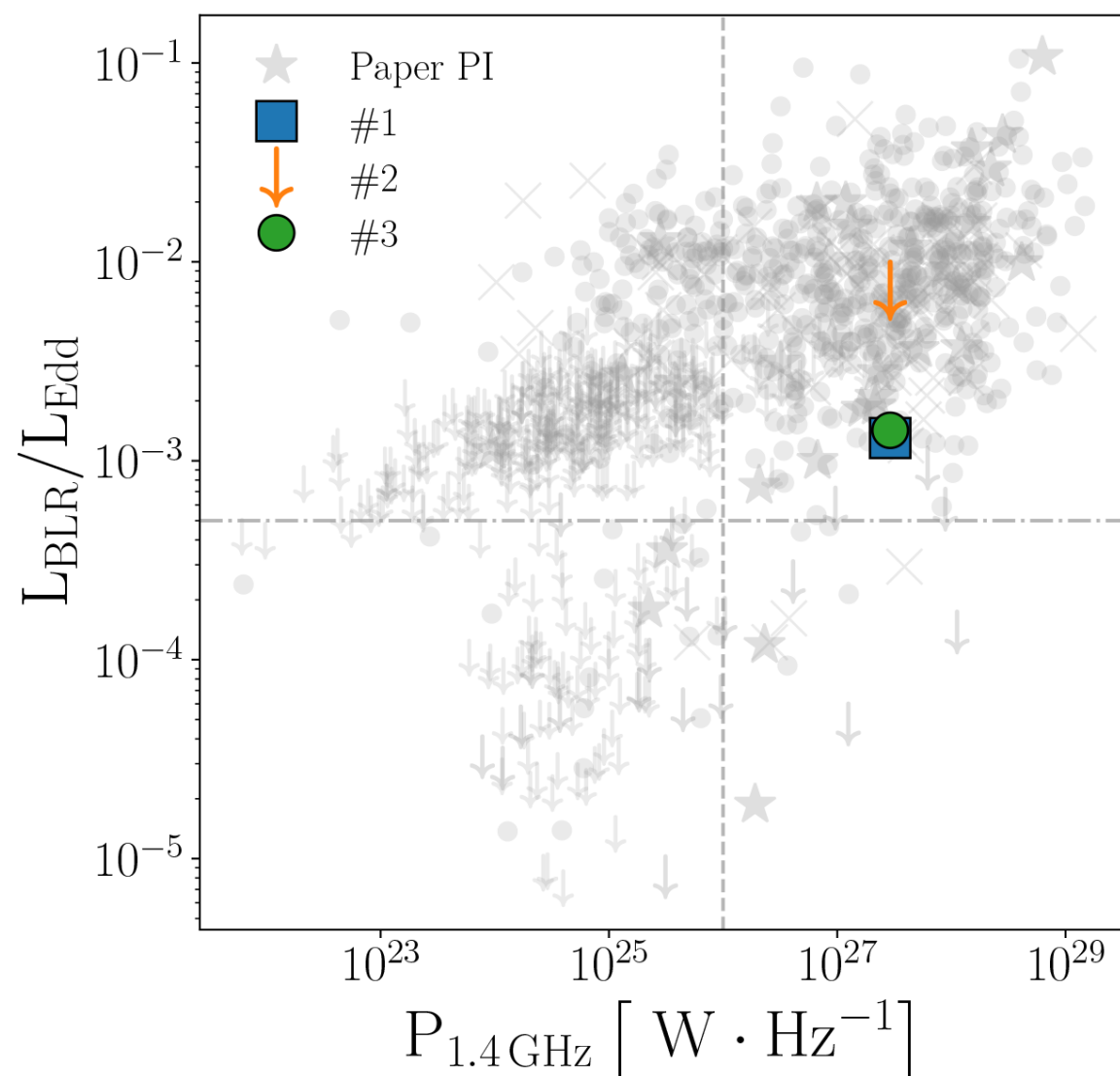
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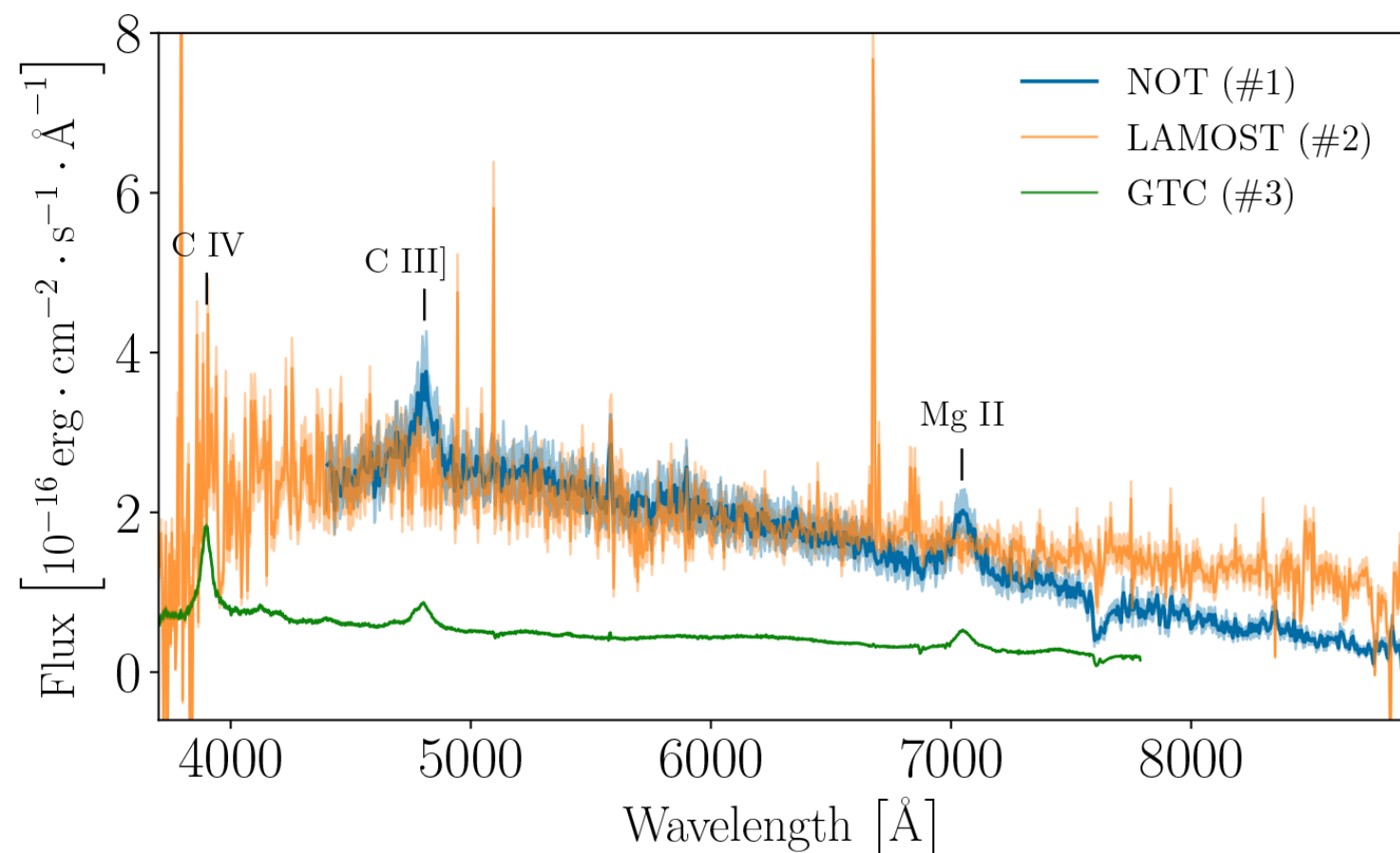
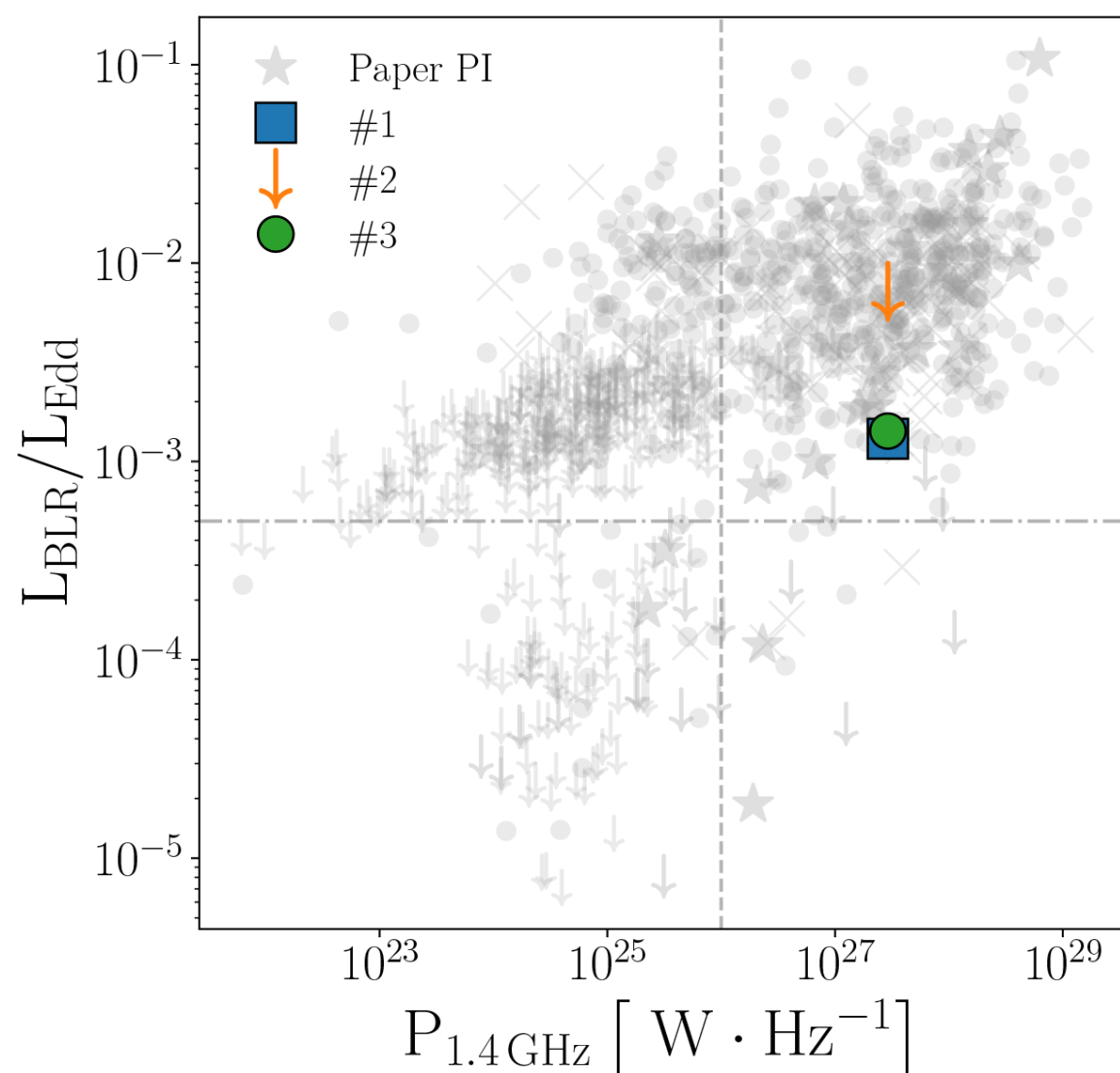
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broad emission lines and their UL
are consistent among the 3 epochs

specific check on jet state

SUMMARY

credits to Paolo for putting photons and neutrinos together!

- neutrino production process:
 - * jets, the Usual Suspects
 - * accretion might be the unexpected player
- ν -blazars show **unexpected jet features** — blue FSRQs / masquerading BL Lacs
- MCMC simulation → 60% of ν -blazars lie on the **boundary between α -disk and ADAF**

**might high-energy neutrinos be the
smoking gun of transitional accretion regimes?**

**are neutrino energetics different
for different accretion regimes?**

**could different accretion regimes suggest
different neutrino production regions?**