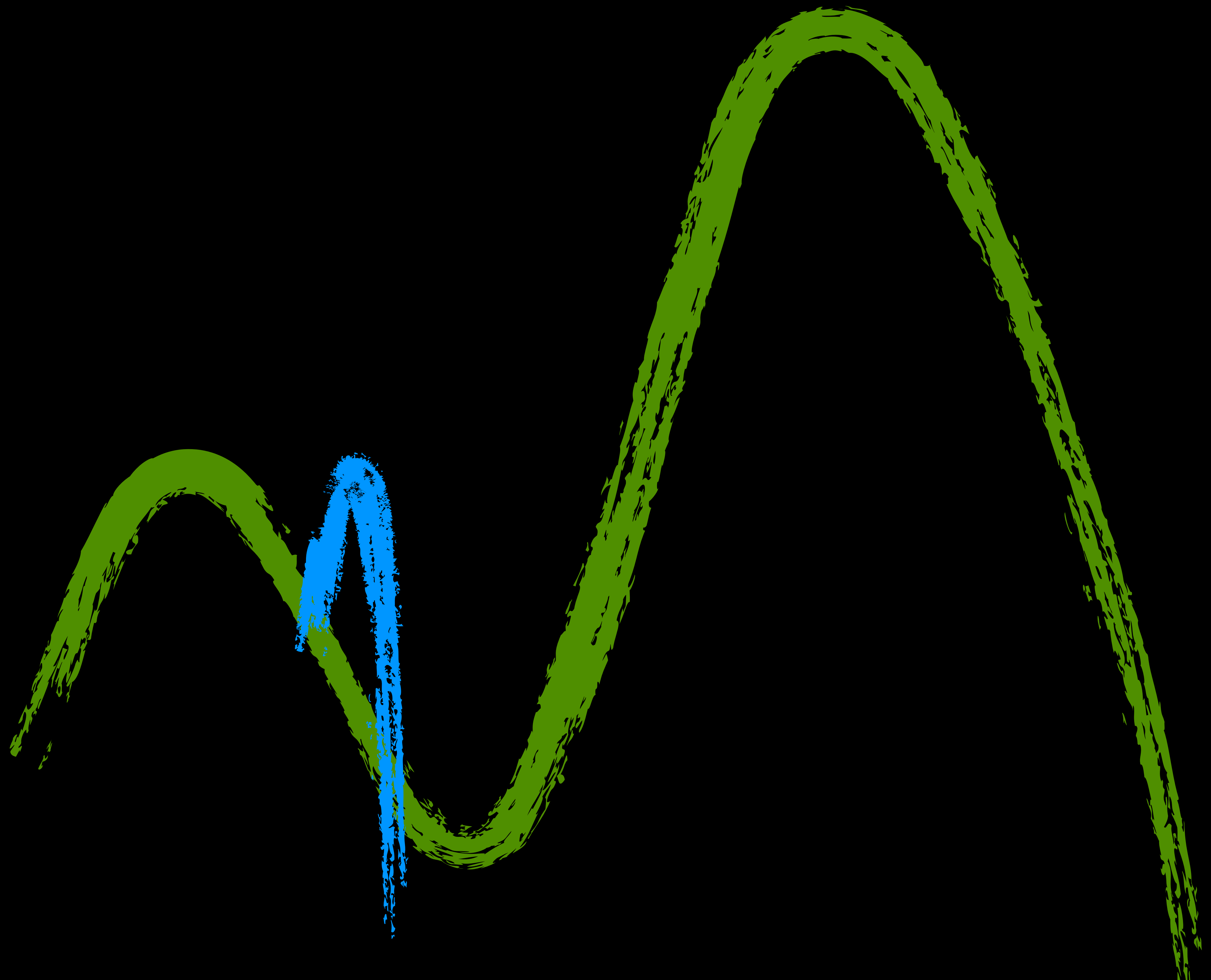
TOO MANY OR JUST RIGHT?

MASSIVE JETTED QUASARS IN THE EARLY UNIVERSE



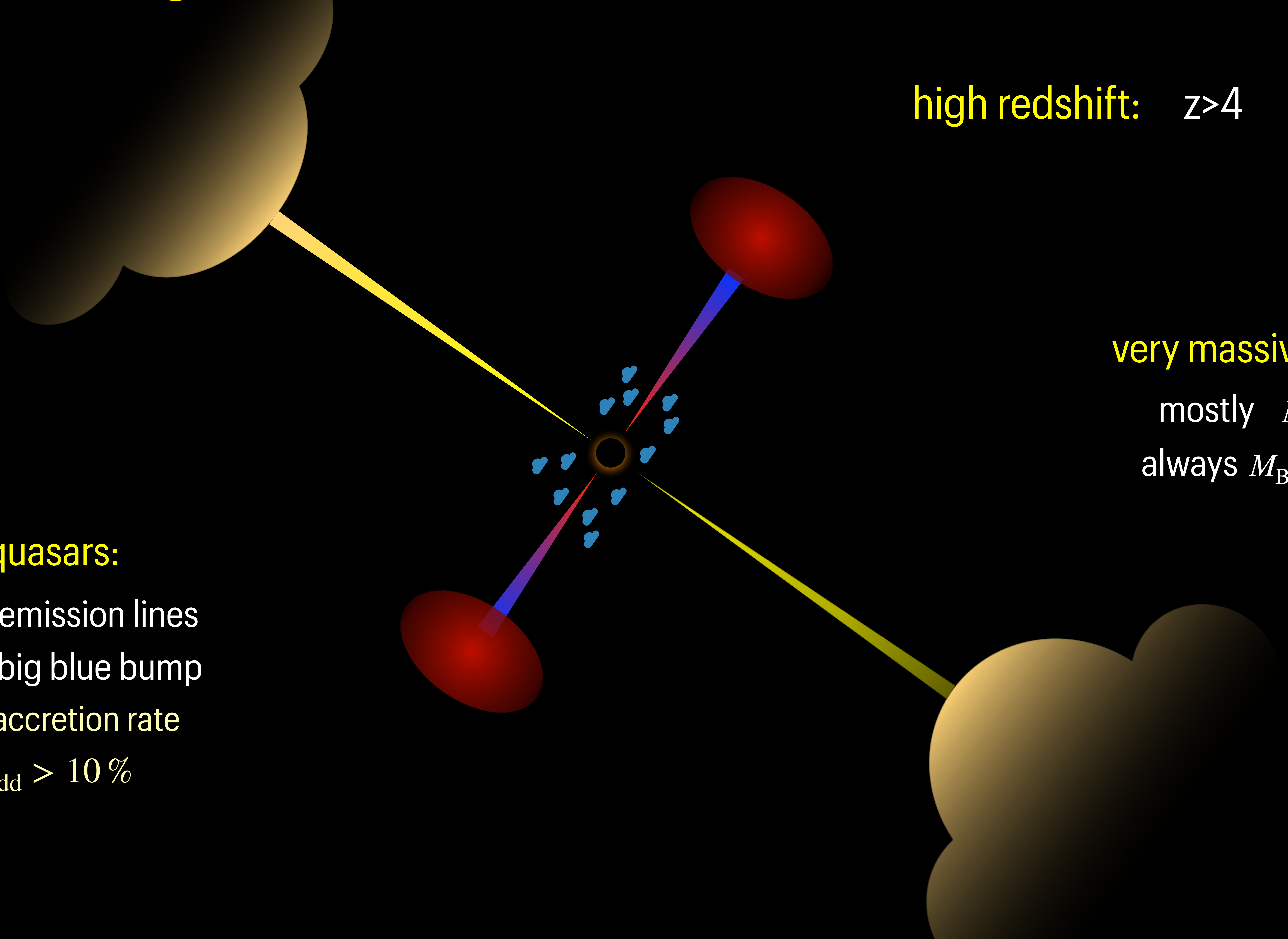
Tullia Sbarrato
INAF - Osservatorio Astronomico di Brera

mainly with S. Belladitta, J. Wolf, M. Salvato for the newest results

tullia.sbarrato@inaf.it

JETTED AGN @HIGH-Z: WHAT DO WE SEE?

high redshift: z>4



very massive black holes:

mostly $M_{\rm BH} > 10^9 M_\odot$

always $M_{\rm BH} > 5 \times 10^8 M_\odot$

quasars:

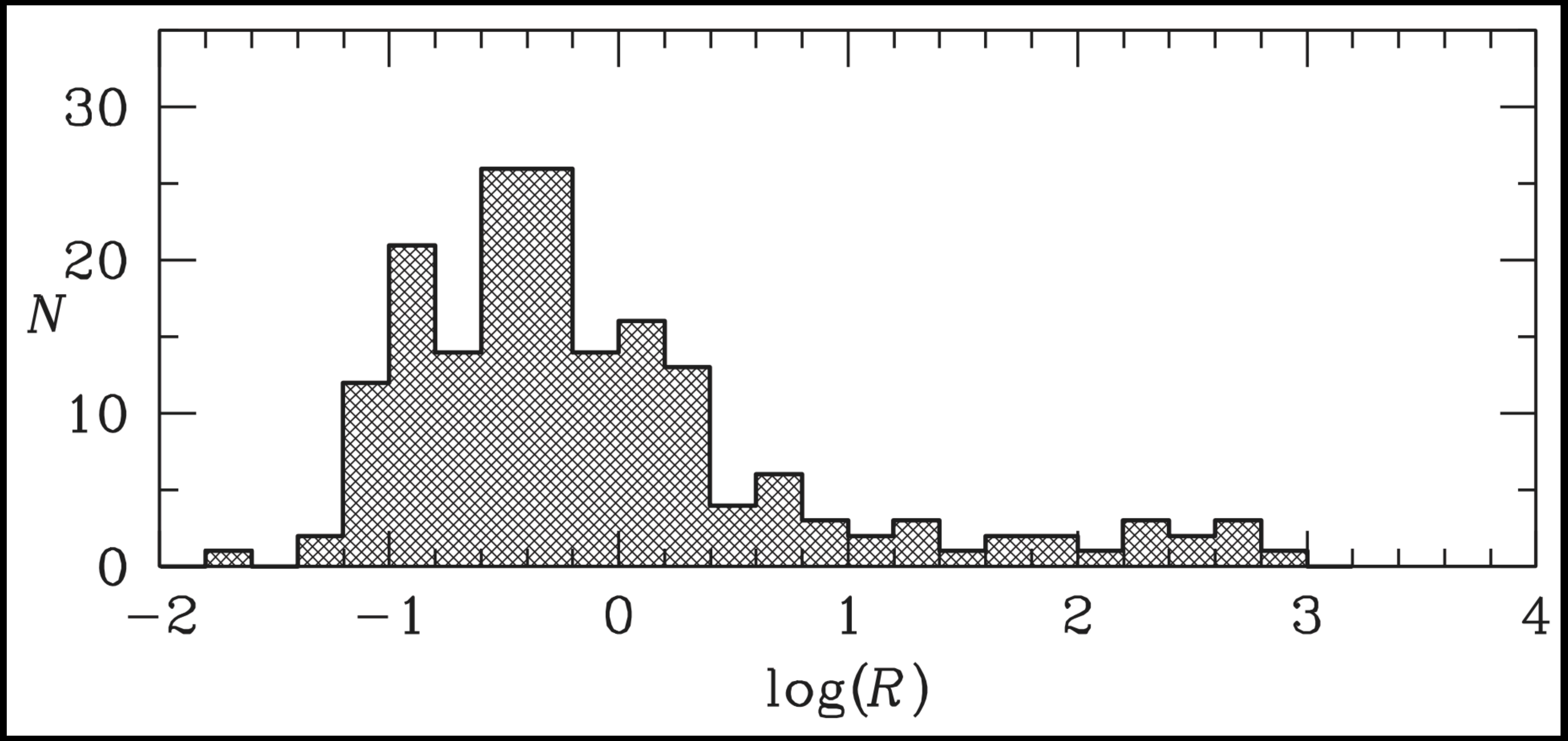
broad emission lines

bright big blue bump

high accretion rate

$\lambda_{\rm Edd} > 10\,\%$

THE MOST COMMON JET TRACER



Kellermann et al. 2016

radio-loudness: jet-to-nucleus ratio

$$R = \frac{F_{5\,\mathrm{GHz}}}{F_{4400\,\mathrm{Å}}}$$

tracer of jet presence

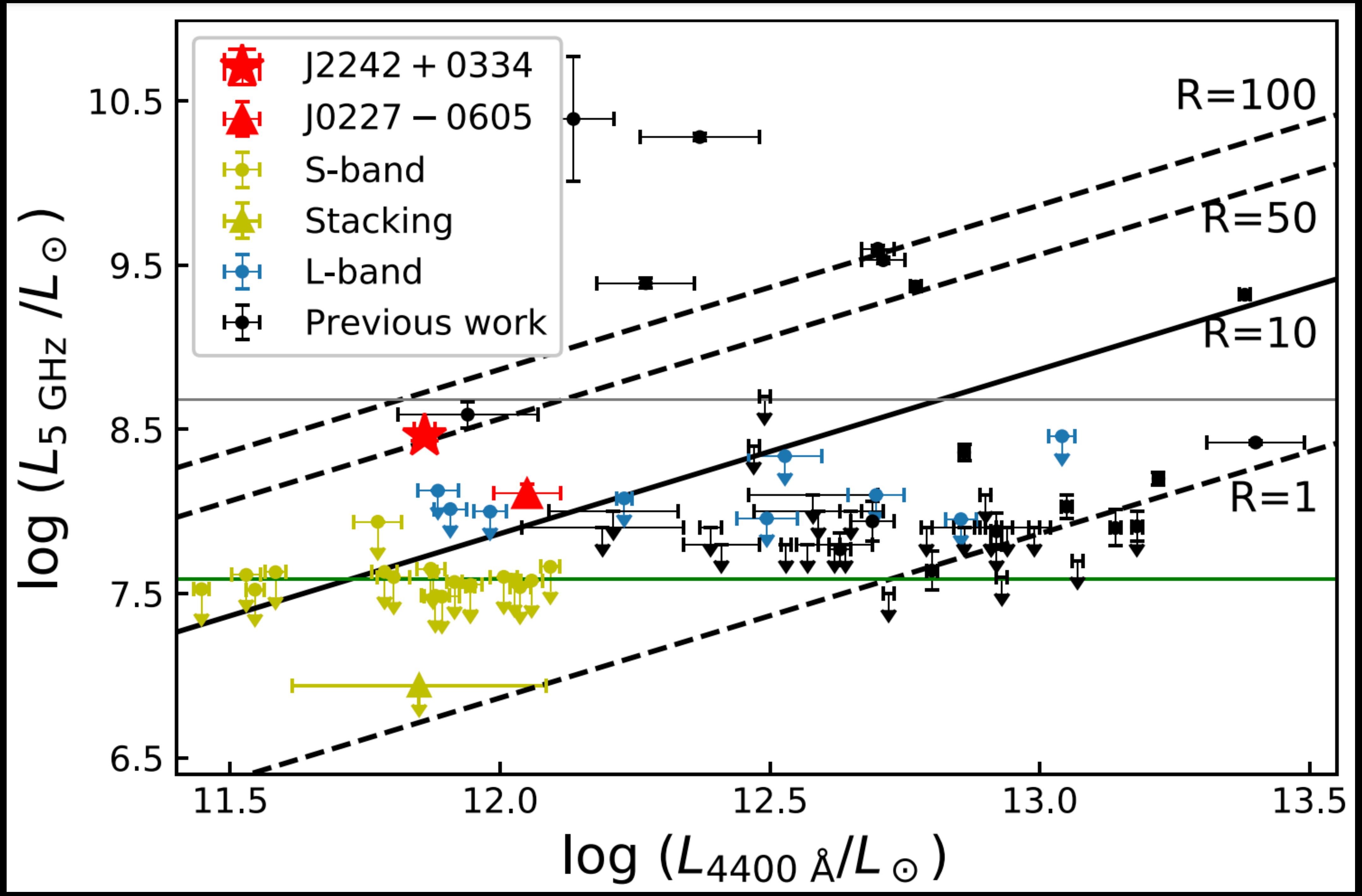
— when extreme, traces jet orientation —

155/236 z>5.7 quasars with radio detection:

radio-loudness fraction: 9.4 ± 5.7%

consistent with local Universe

Liu et al. 2021



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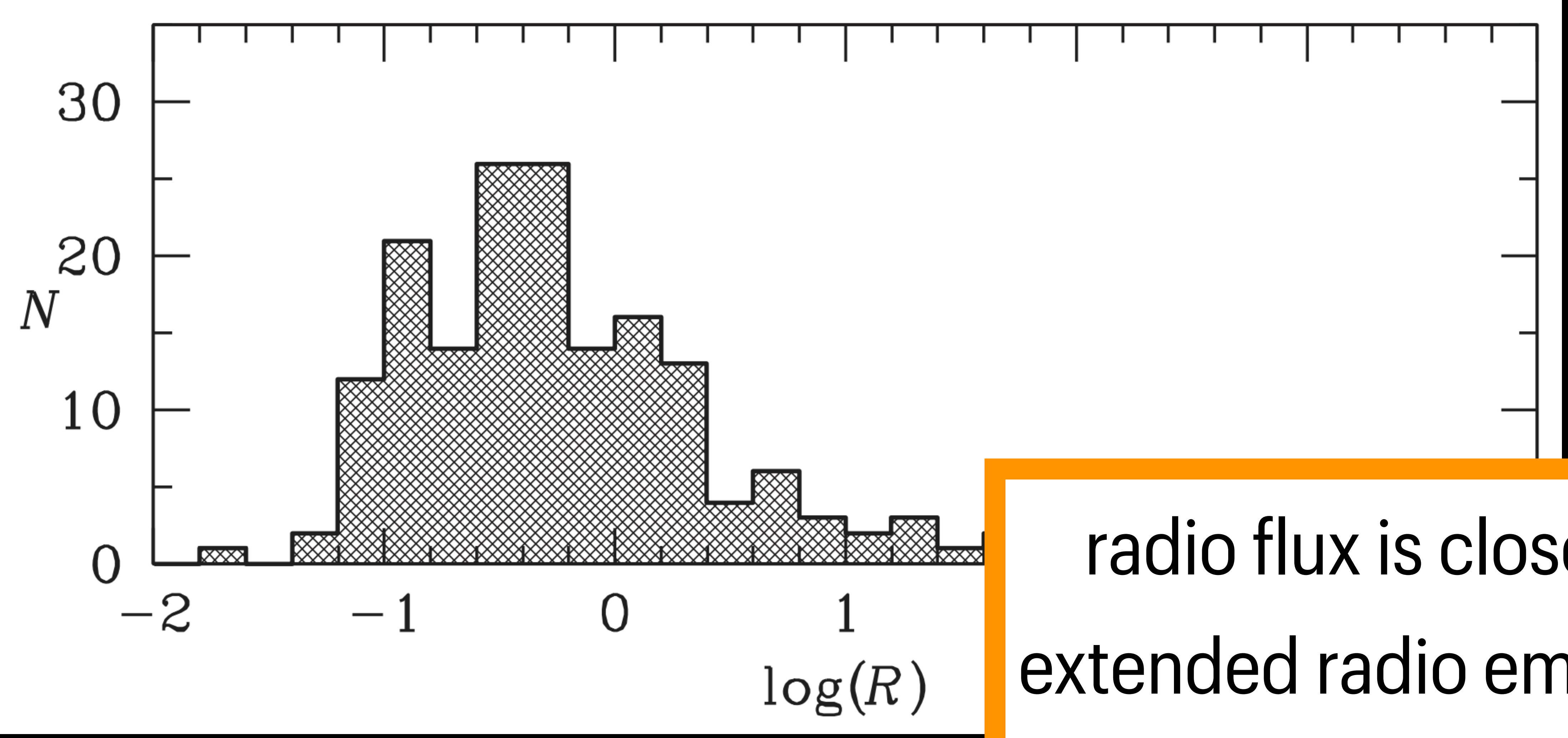

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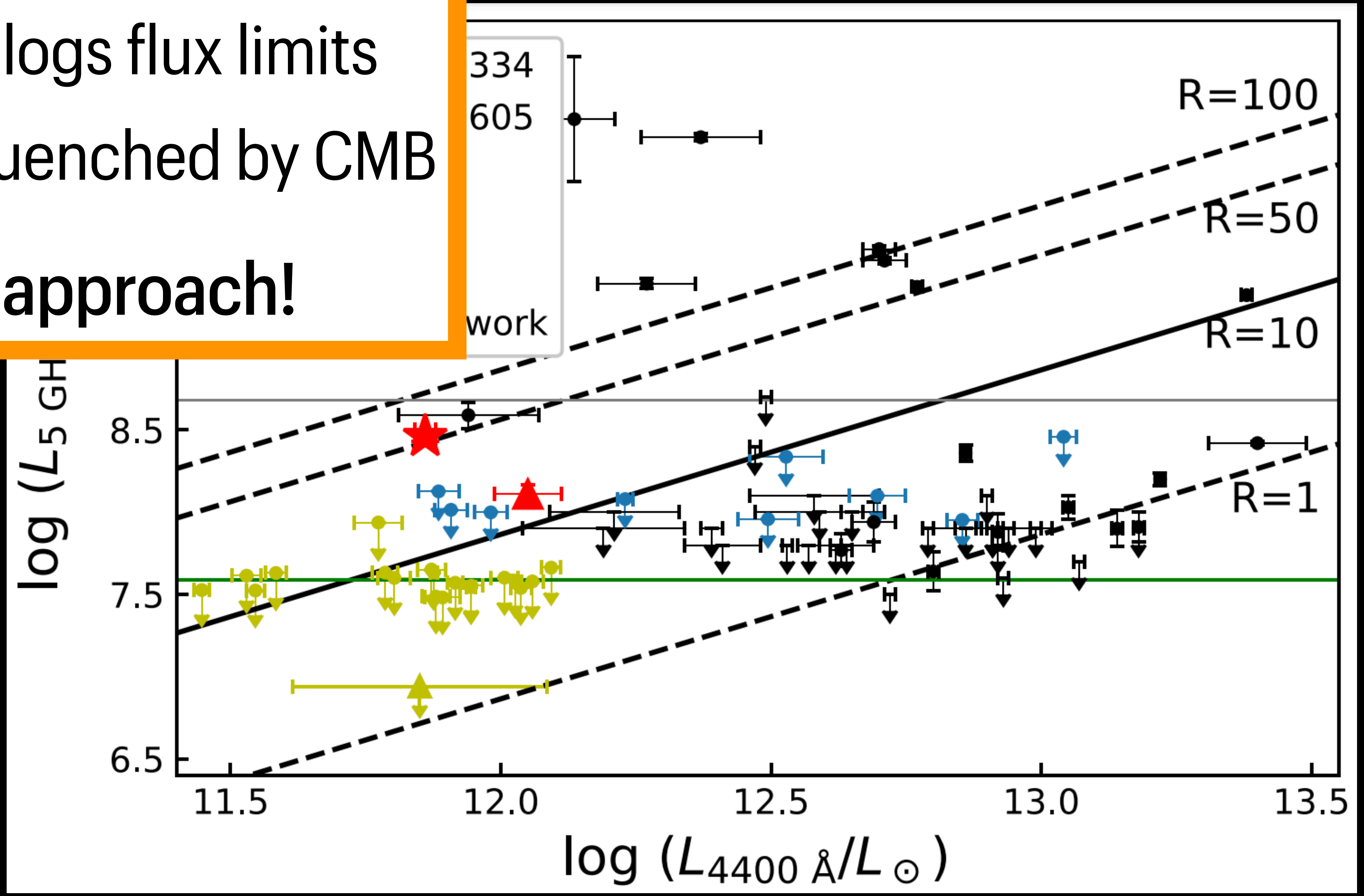

radio flux is close to catalogs flux limits

extended radio emission quenched by CMB

we need a different approach!

radio-loudness: jet-to-nucleus ratio

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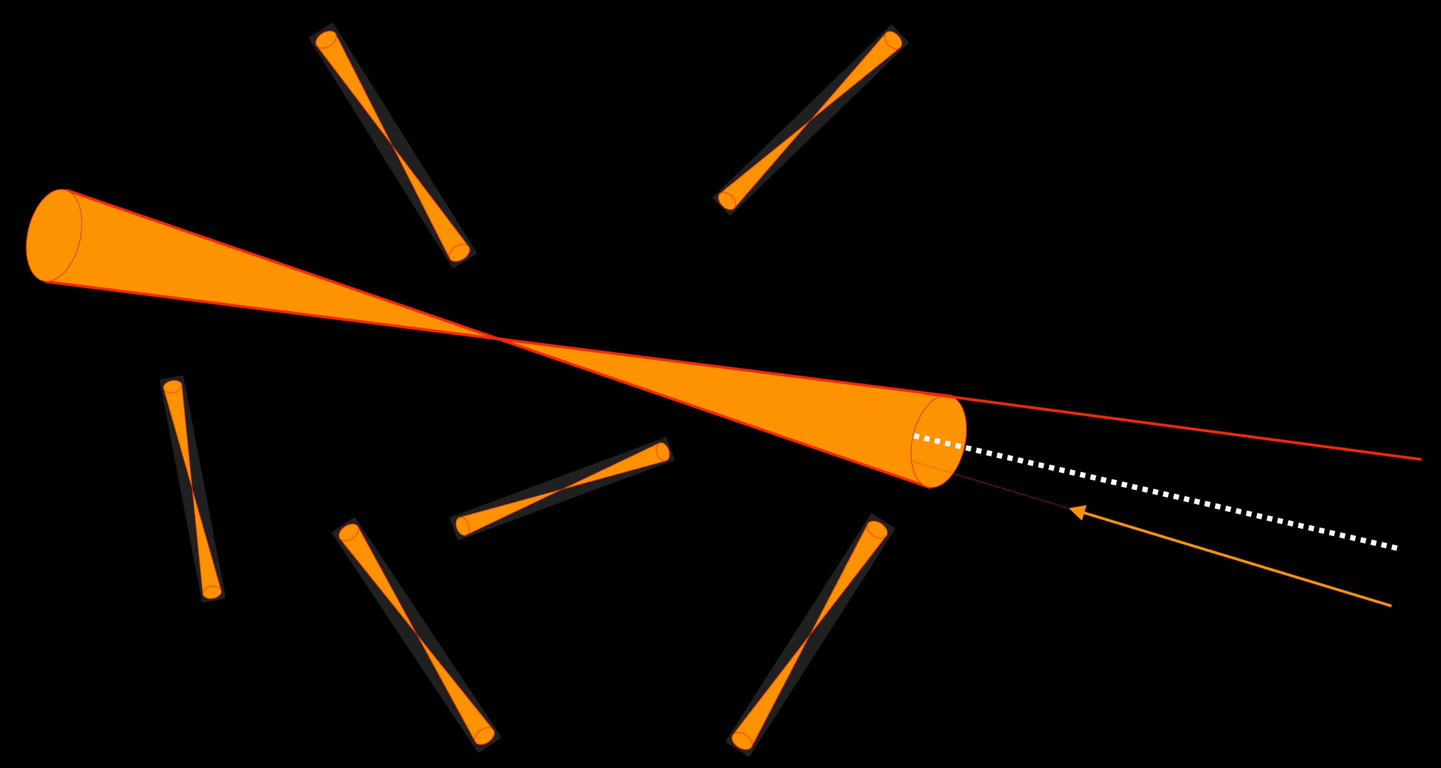
BLAZARS AS JET TRACERS



$\Gamma \sim 10 - 15$

bulk Lorentz factor of jet emitting region

viewing angle:

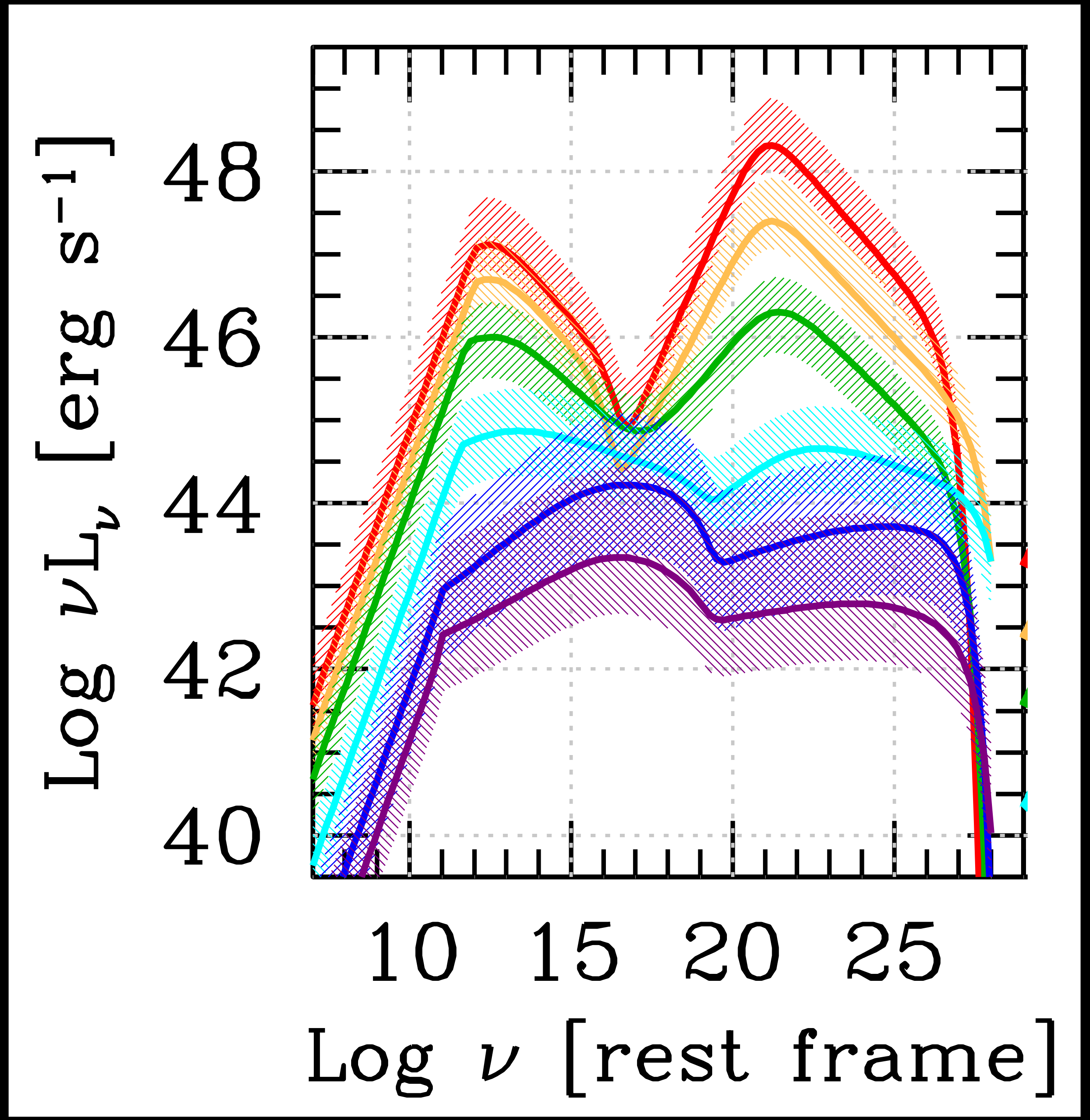
$\theta_v < 1/\Gamma$

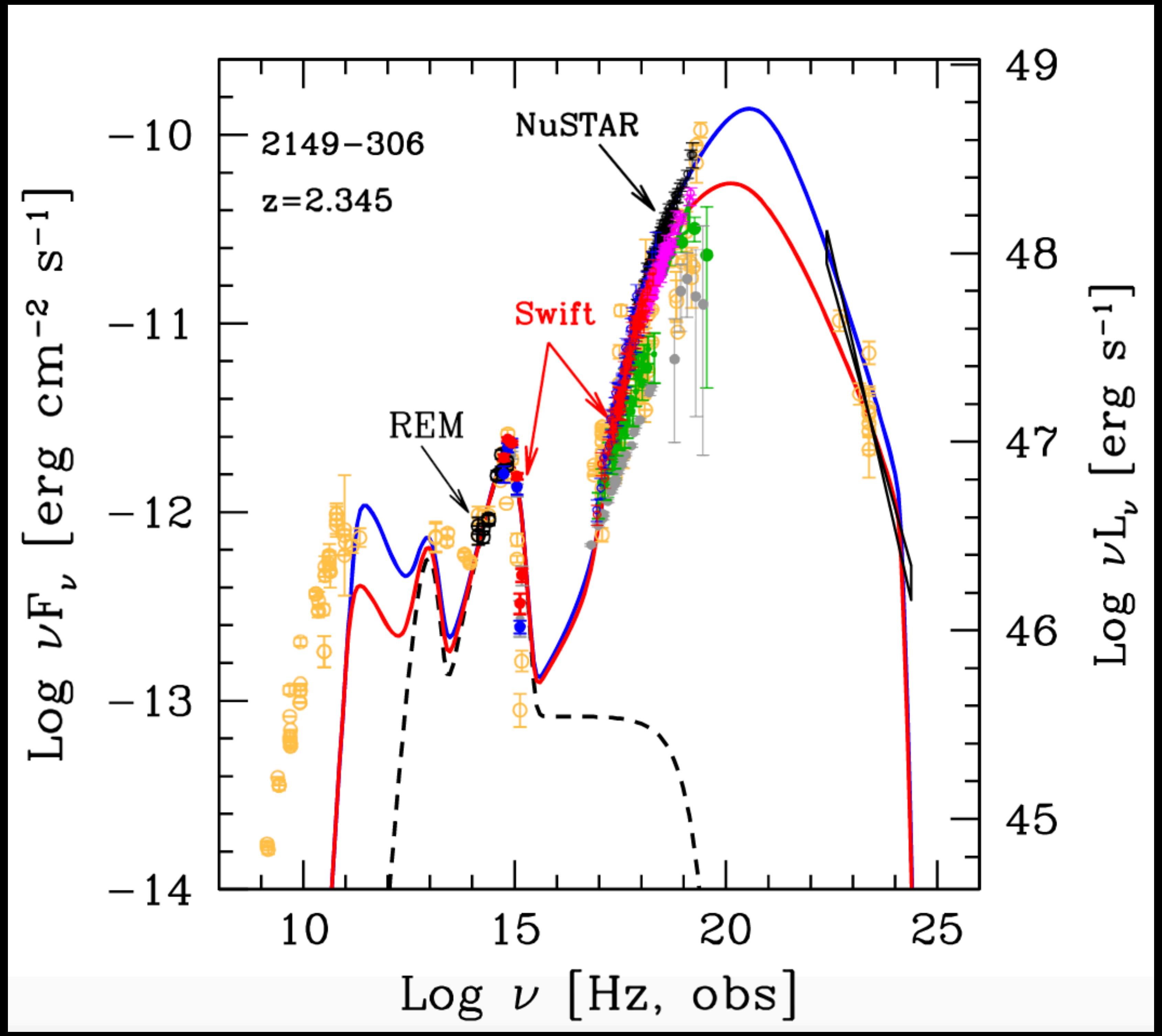
↓

analogous jetted AGN, randomly oriented:

$2\Gamma^2 \sim 200 - 450$

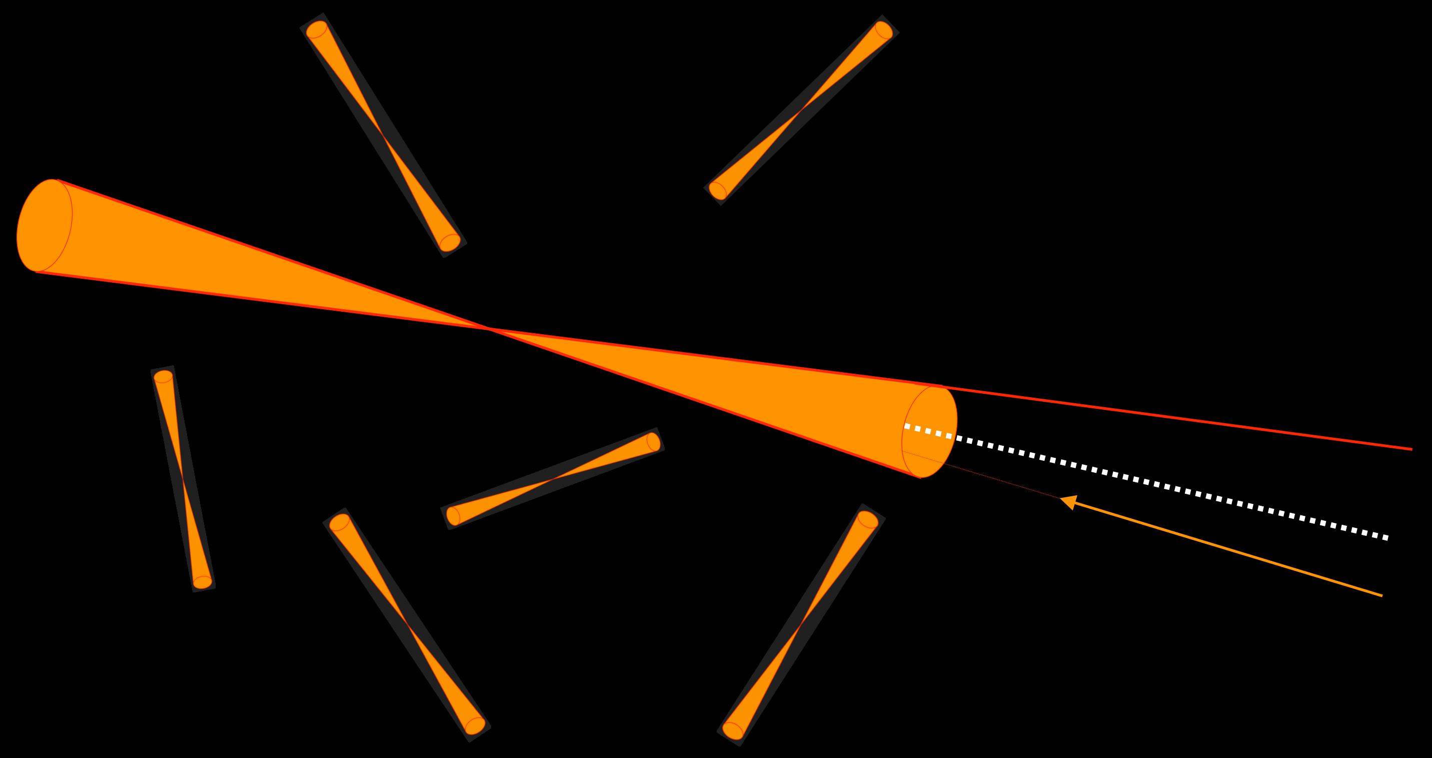
Ghisellini et al. 2017





Tagliaferri et al. 2015

BLAZARS AS JET TRACERS



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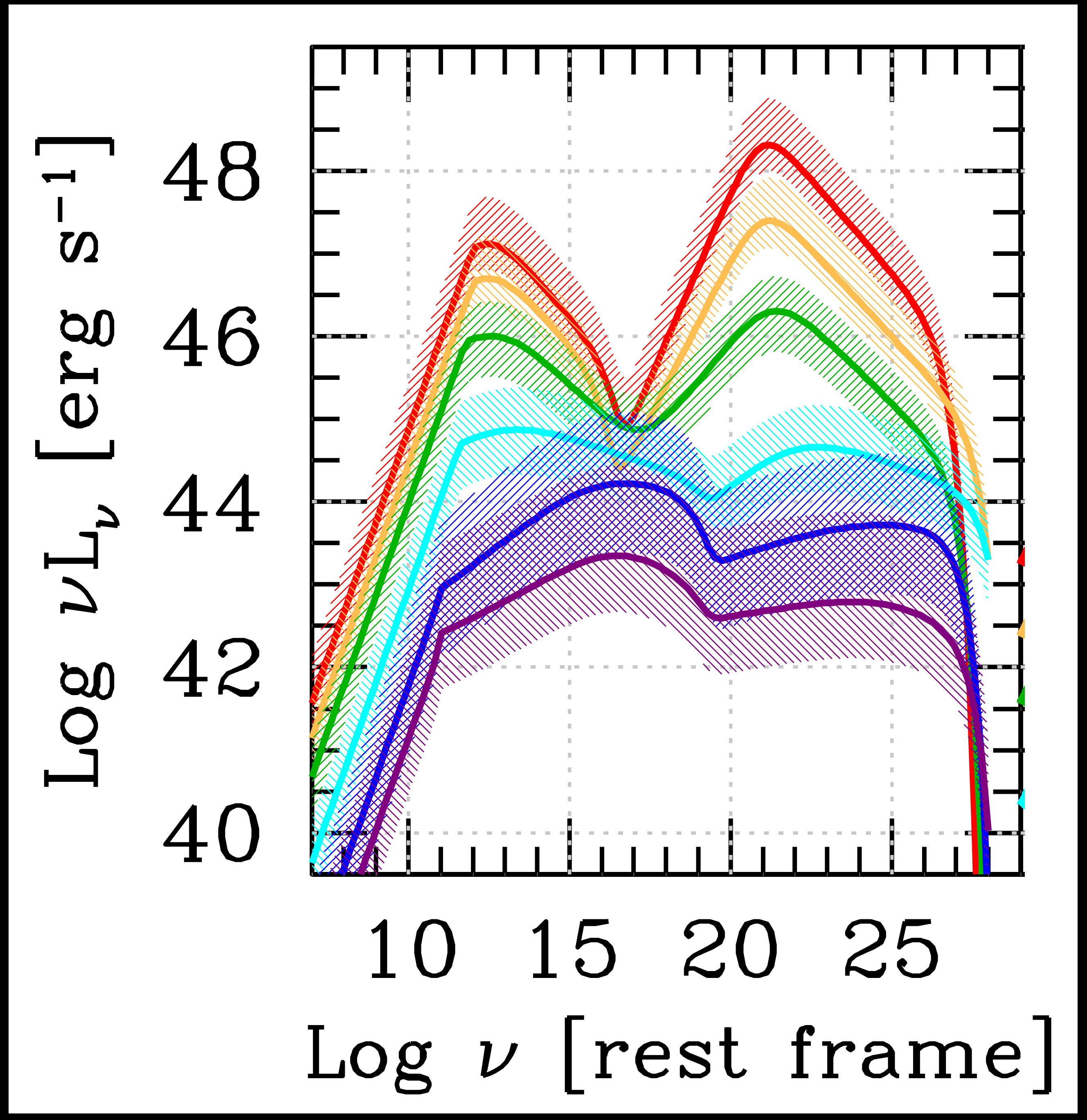
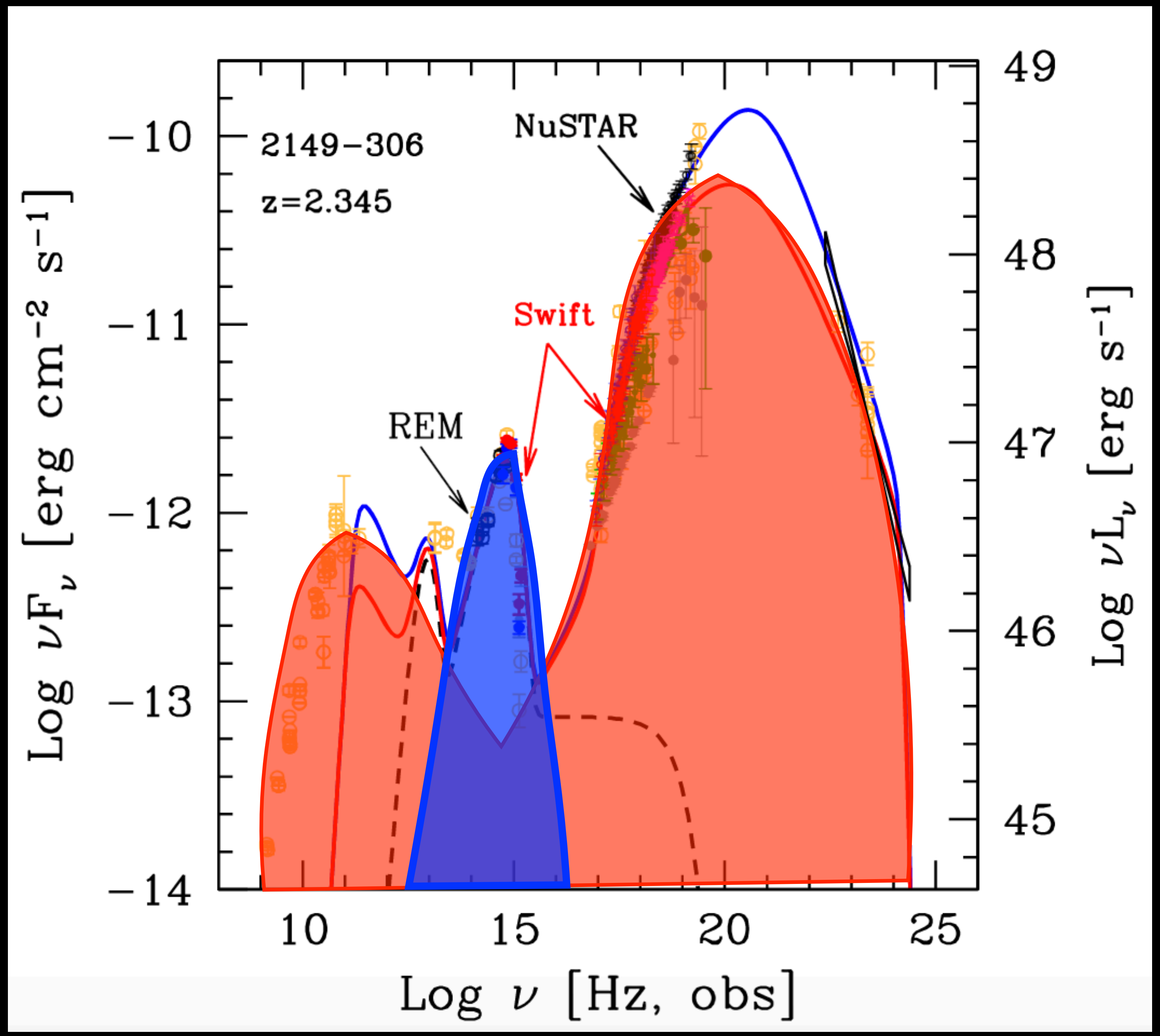




Tagliaferri et al. 2015

FIRST SYSTEMATIC SEARCH OF BLAZARS @Z>4

SDSS+FIRST quasar catalog

105 783

z > 4:

1248

radio-detected (>1mJy):

53

radio-loudness

$$R = \frac{F_{\rm radio}}{F_{\rm opt}} > 100$$

31

12 “newly” classified blazars thanks to dedicated Swift/XRT observations

... and we keep counting!

~4000 analogous jetted sources!

TS+12,13b,22

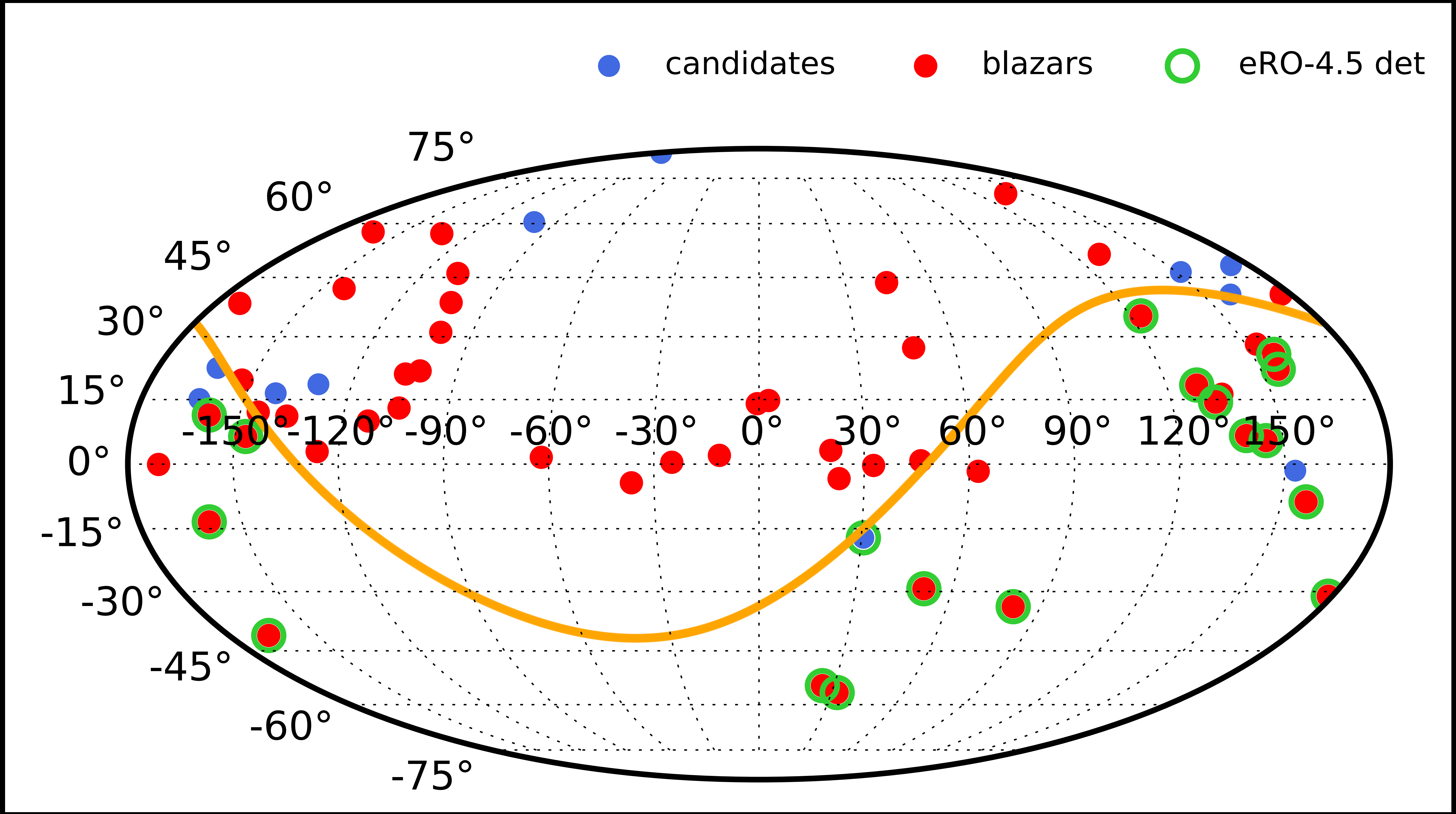
Z>4 BLAZARS AND E-ROSITA

51+1 confirmed blazars

via radio, X-ray or multi wavelength features

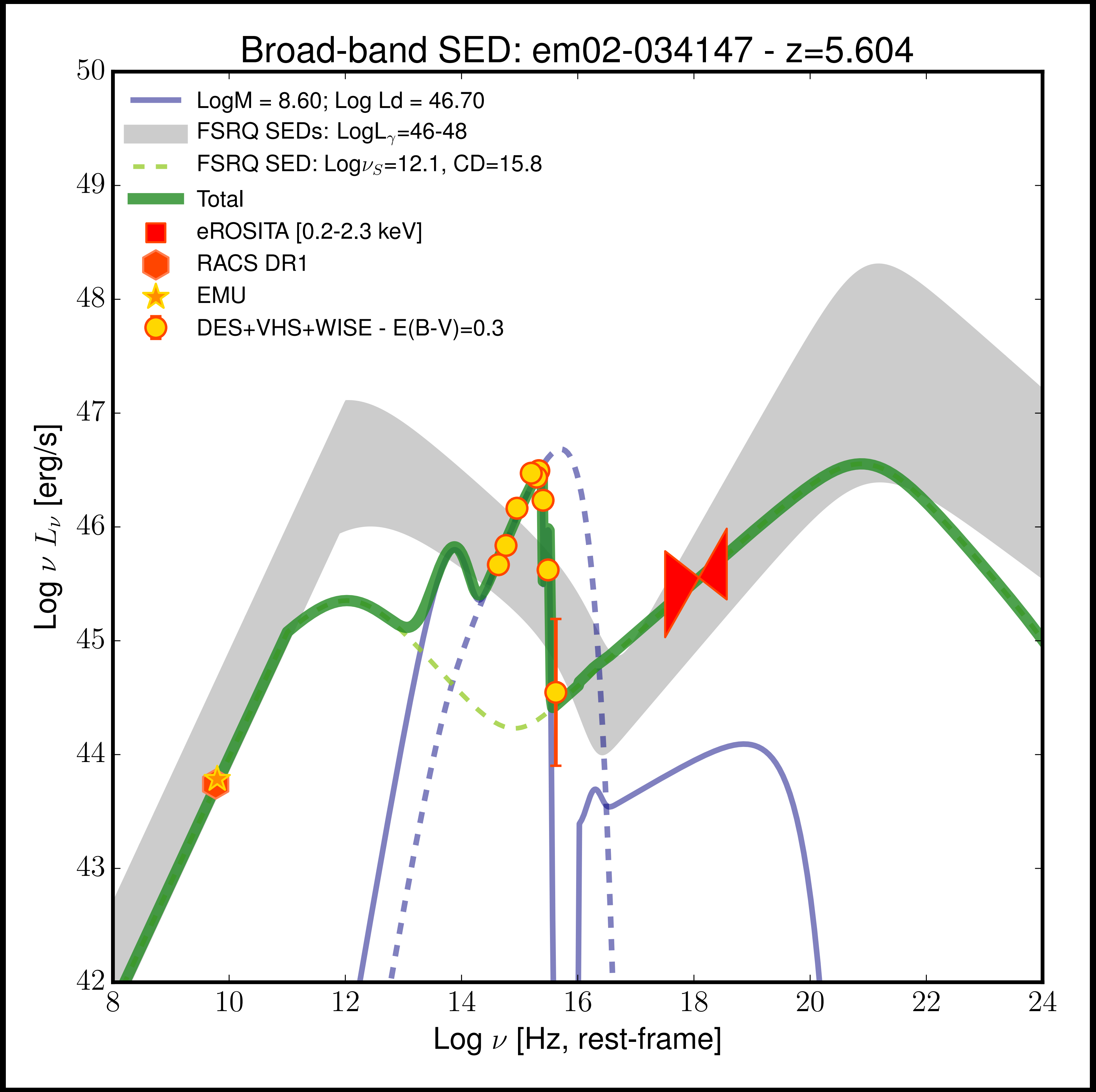
17+1 detected in the eRO-4.5 survey

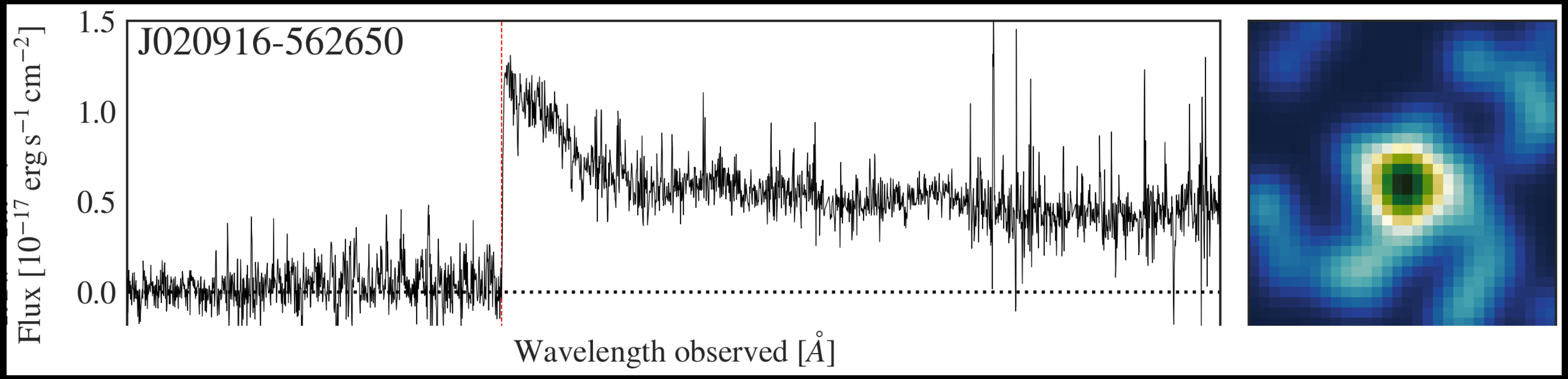
TS et al in prep



ERO-DETECTED BLAZARS

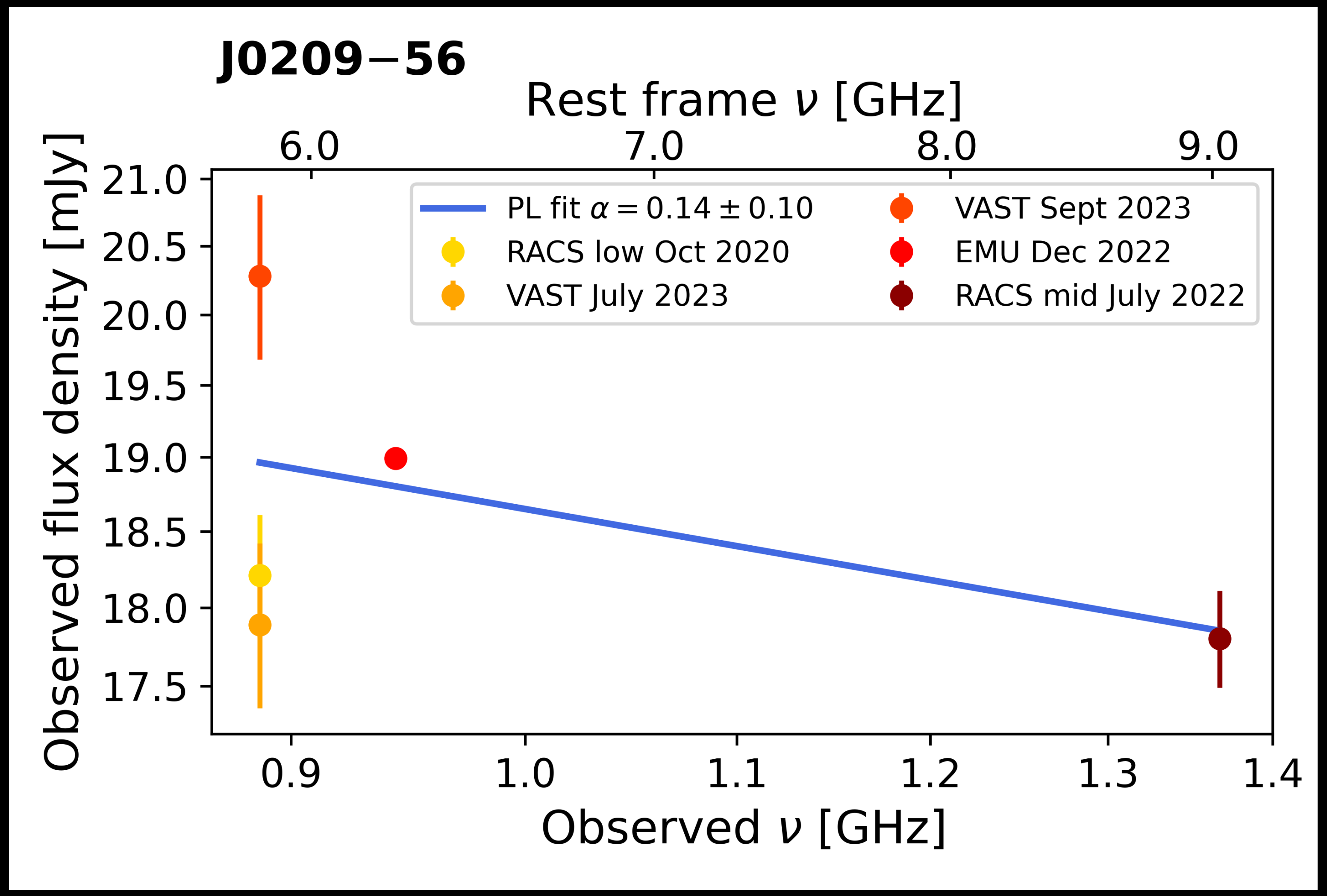
Wolf et al. 2024
eRASS:4





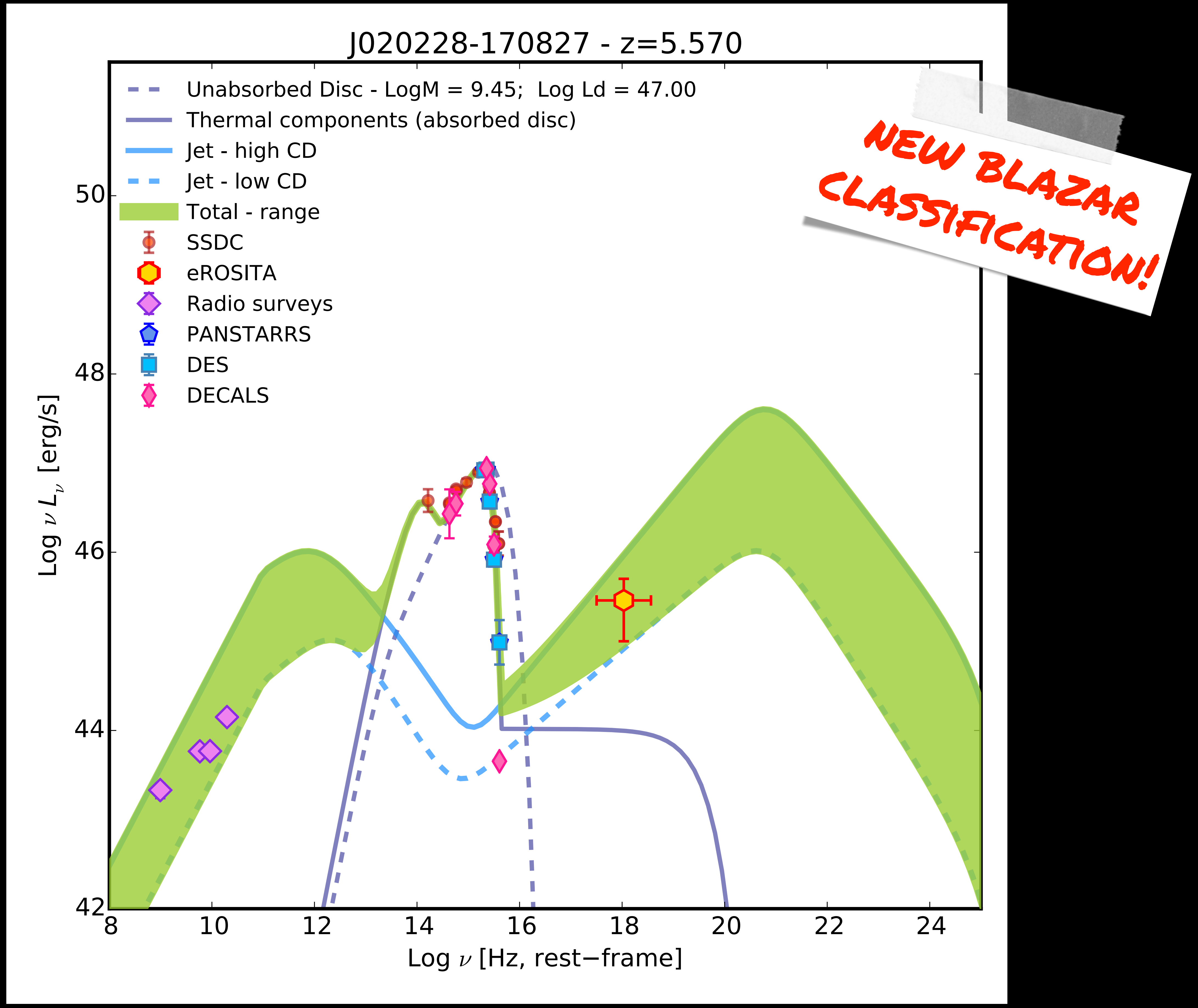
NEW BLAZAR DISCOVERY!

spectroscopic follow-up,
radio variability,
broad-band study



ERO-DETECTED BLAZARS

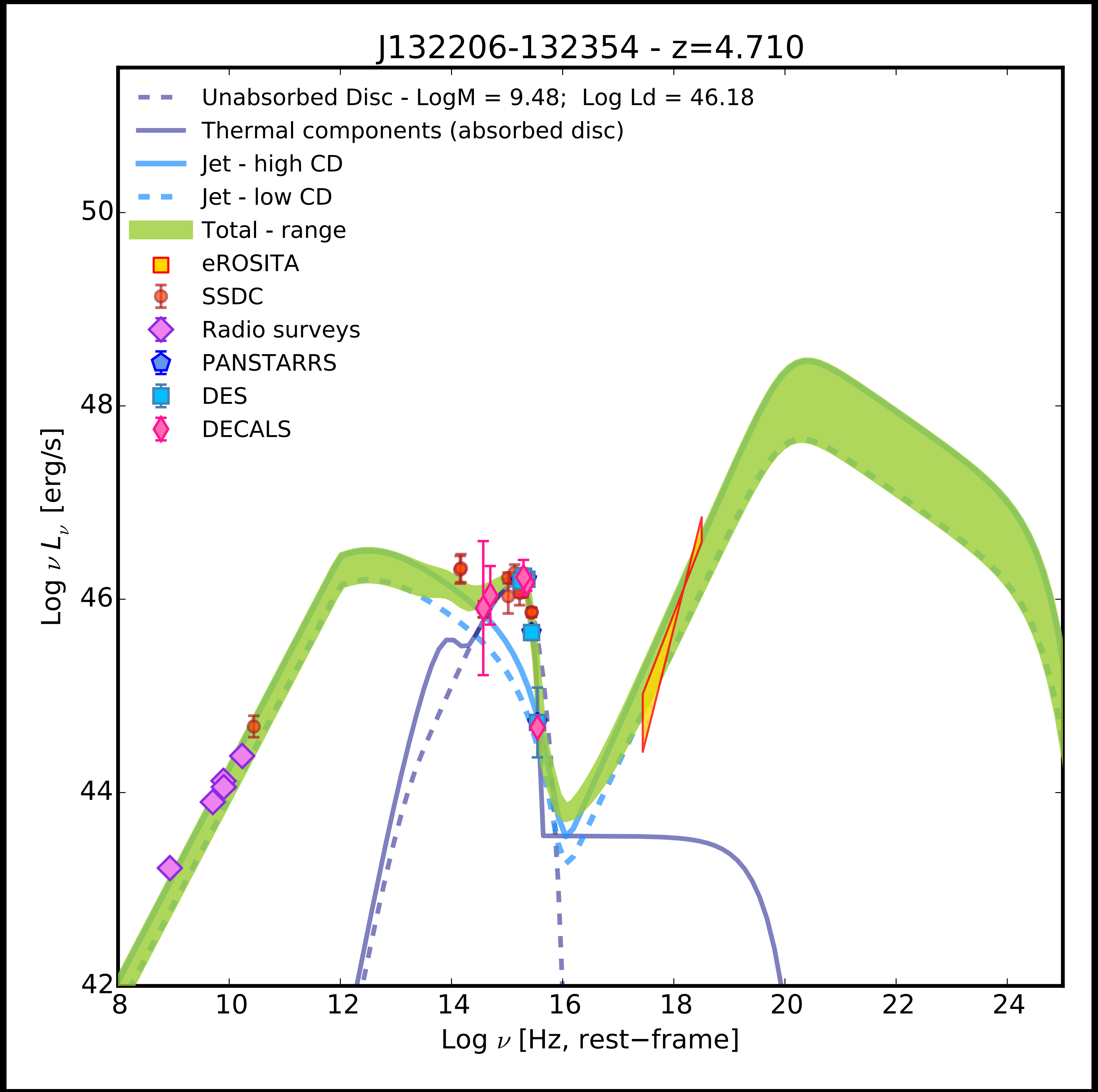
TS et al. in prep
eRO-4.5



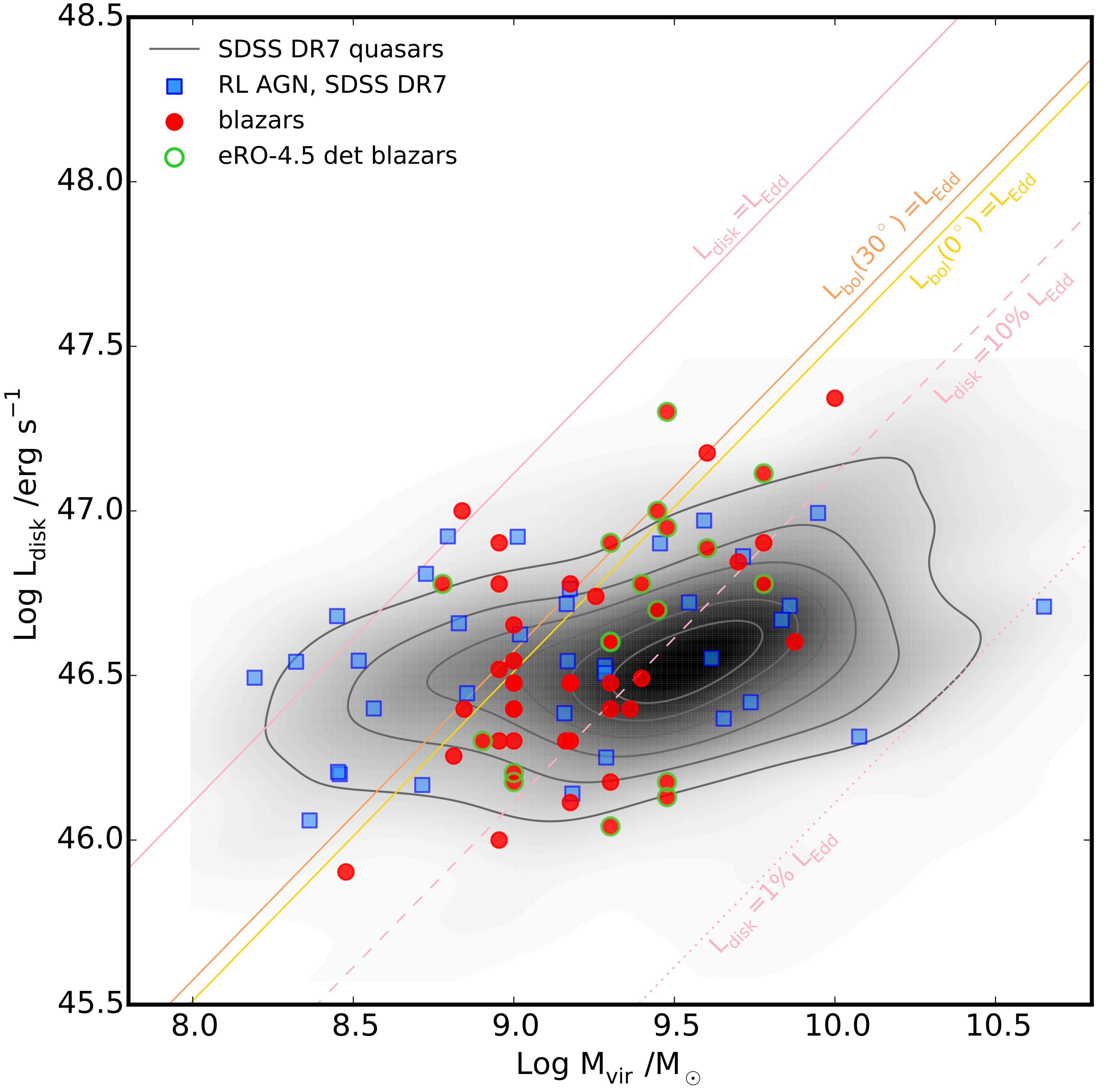
significant X-ray excess wrt Coronal emission

well constrained X-ray spectrum

enough flux to test variability

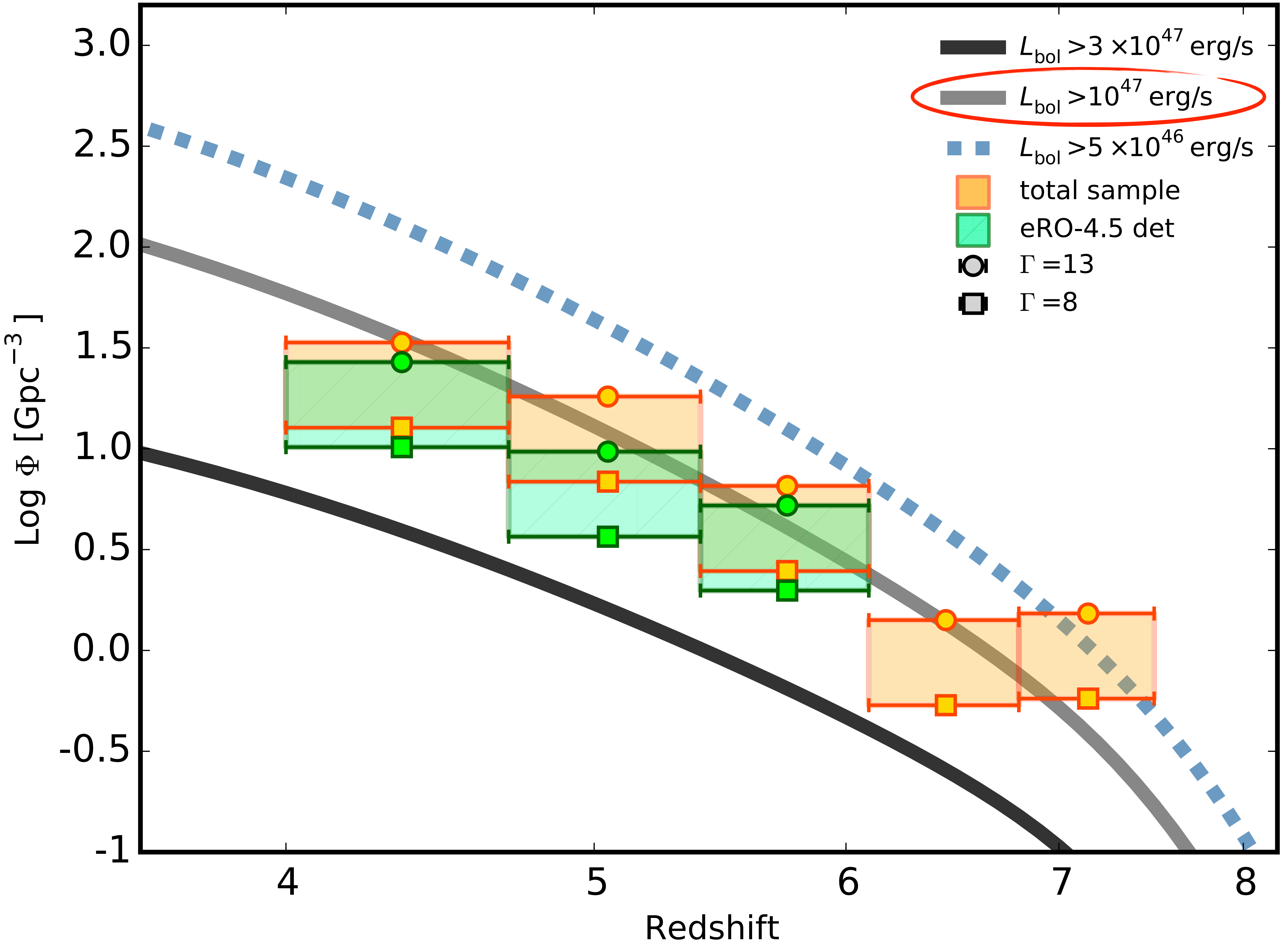


TS et al in prep
eRO-4.5



THE MAJORITY OF Z>4 (JETTED) QUASARS ACCRETES BELOW THE EDDINGTON LIMIT

TS et al in prep
eRO-4.5



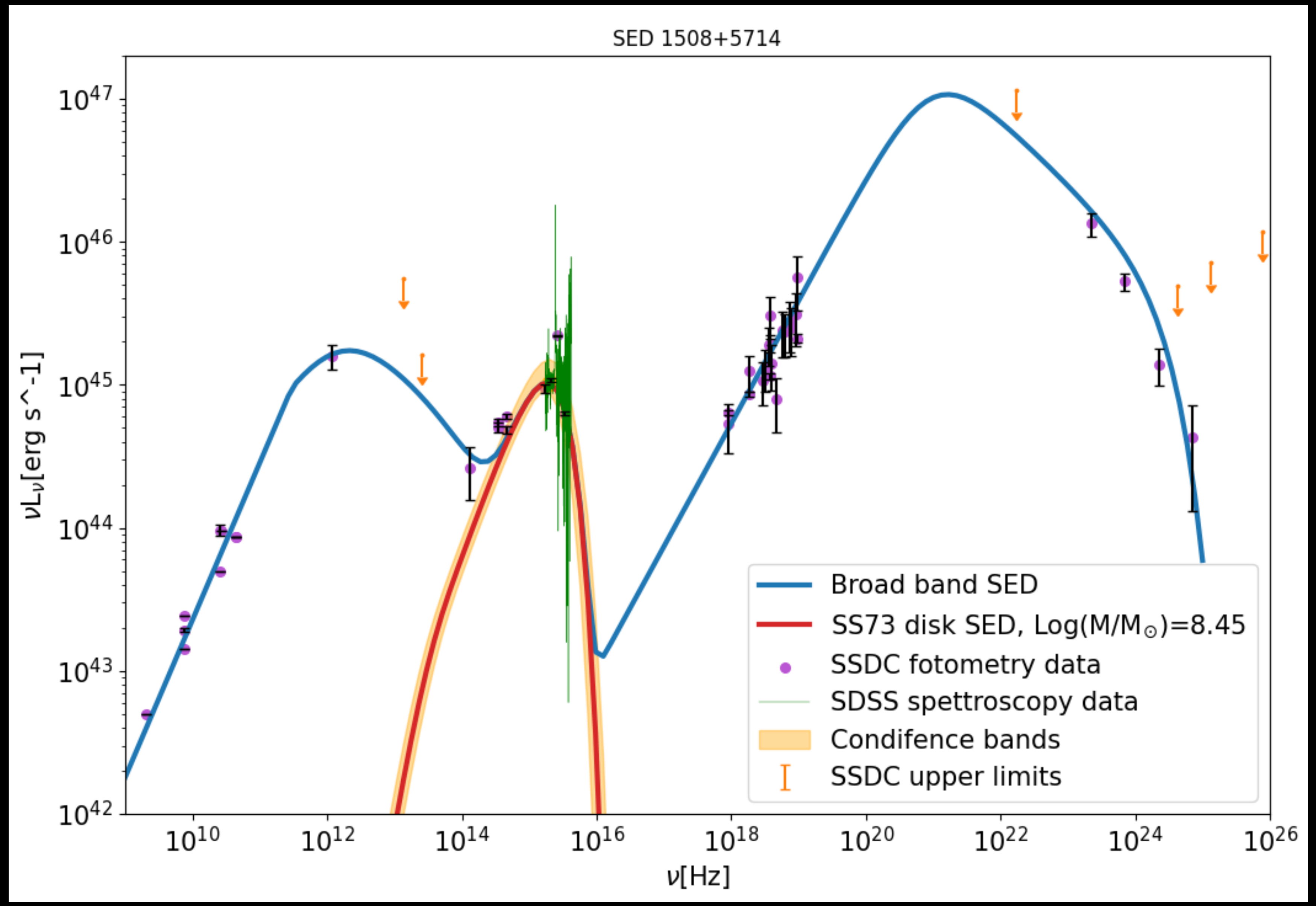
MASSIVE SMBHS SEEM TO PREFER FORMING/LIVING IN JETTED AGN AT VERY HIGH REDSHIFT

most z>4 blazars accrete sub-Eddington:

there is not enough time to grow them
from 100 M_{sun} black hole seeds
at their observed rate

WHY DO THEY SEEM TO ACCRETE SLOWLY?

Alzati et al. subm.



GB 1508+5714 (z=4.31): highest-z Fermi blazar

$$\mathrm{Log}M_{\mathrm{vir}}/M_{\odot} = 8.52 \qquad \lambda_{\mathrm{Edd}} \sim 10\,\%$$

KERBB and SLIMBH:

$$\mathrm{Log}M/M_{\odot} \sim 8.2 - 8.8 \quad \lambda_{\mathrm{Edd}} \sim 6 - 4\,\%$$

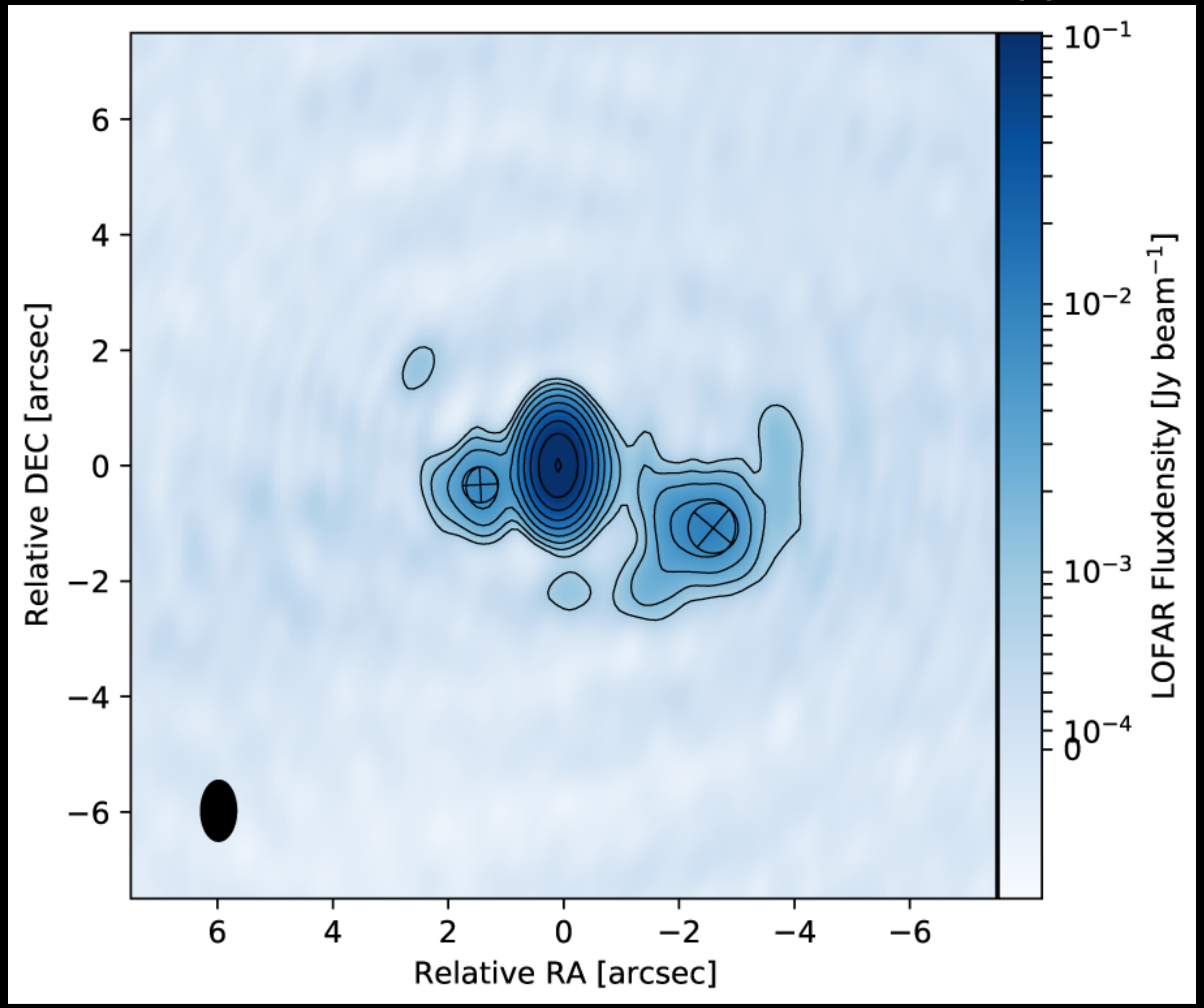
what if:

these sources had evolved with the observed rate only since the jet was launched?

extended jet observed in LOFAR: **135kpc**
estimated hotspot speed: 0.06c

jet age: **7.3 Myr**

Kappes+22



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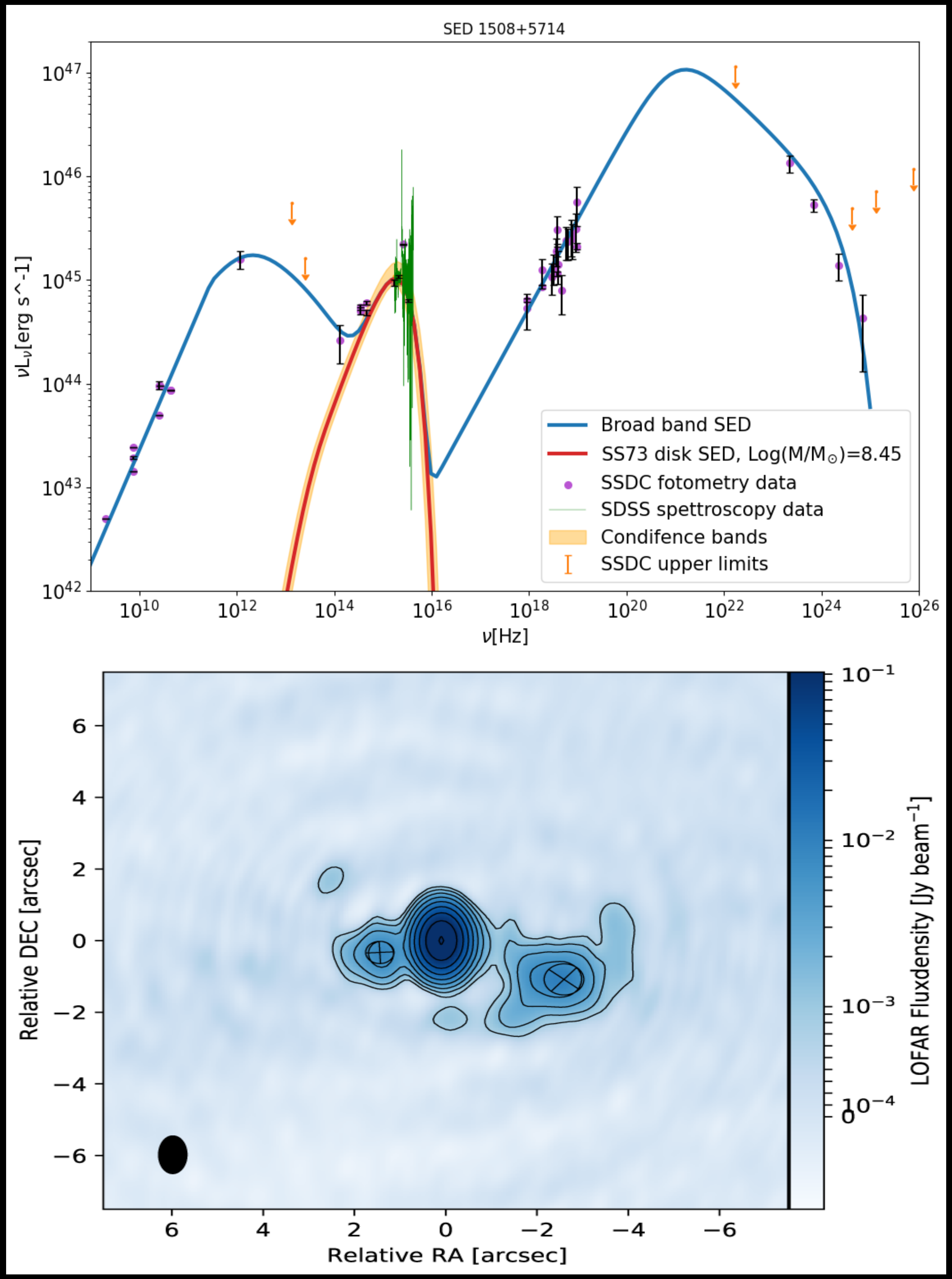
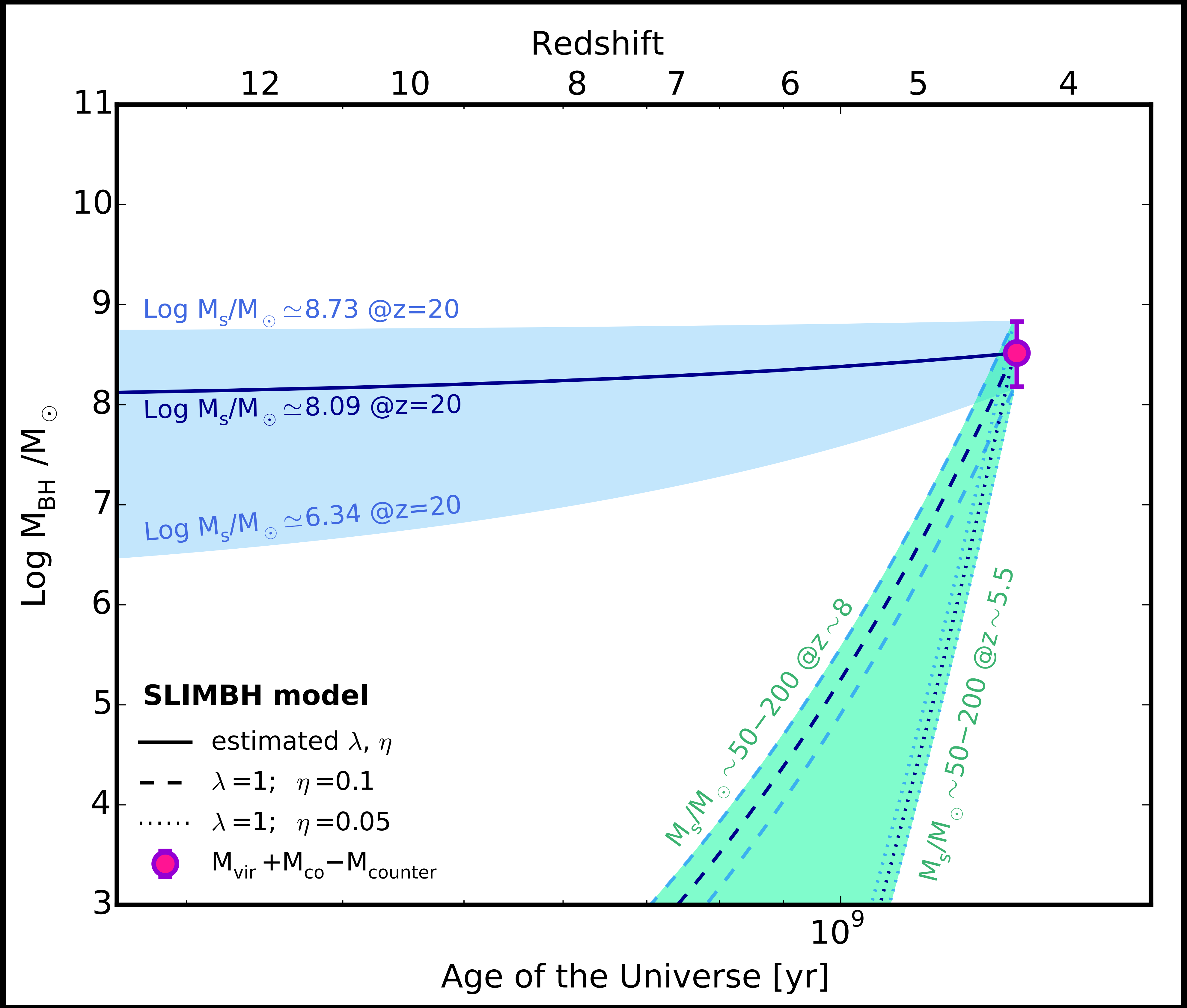


super-Eddington epoch → spin up → jet launch → "moderate" evolution

reasonable (50-100 M_{sun}) BH seeds at redshift 5 to 8



SO MANY JETTED QUASARS!

at high z, jets are **more numerous** than expected

jetted AGN do not seem to be fast accretors at high-z:
previous super-Eddington accretion triggering jets?

massive SMBHs seem to prefer forming/living in jetted AGN at very high redshift

eROSITA: very efficient in observing jets at z>4!