Big and young SMBHs in the early Universe: specific cases

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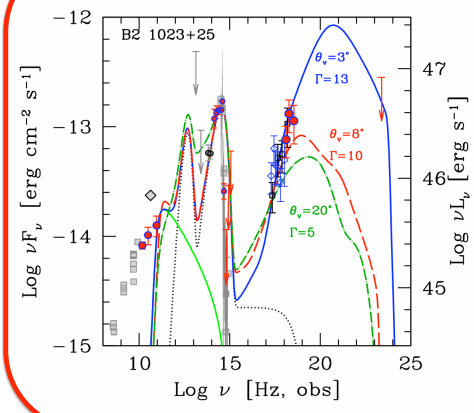
The formation of supermassive black holes (SMBHs) in the early Universe is still an obscure and intriguing mechanism. The presence of extremely massive black holes (M_{BH}>$10^9 M_{sun}$) at redshift z>4, specifically in jetted systems, deeply challenges the SMBH formation models. In this perspective, the search of blazars at extremely high redshift is then crucial, since they are reliable tracers of the whole family of jetted AGN. We are presenting the successful classifications of our best blazar candidates and their consequences on the overall picture of SMBHs at extremely high redshift. The identification of even few blazars at z>4, in fact, clearly shows differences in the formation of SMBHs hosted in jetted and non-jetted systems, suggesting two different formation periods. Blazar search and identification then proof to be key tools for studying the formation and growth of SMBHs in the early Universe.

Fitting the SED: consistency check in the case of B2 1023+25



hard and strong X-ray flux:

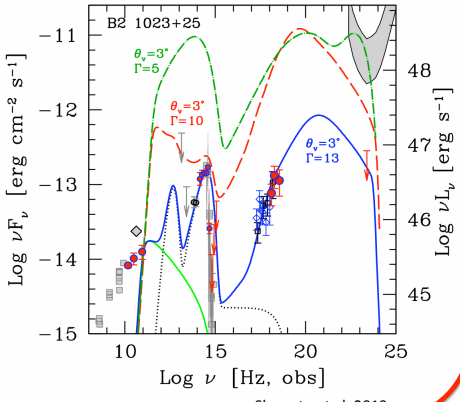
$F_X[5-10\mathrm{keV}] = 5.5\times10^{-14}\mathrm{erg\,cm^{-2}s^{-1}}$

$\Gamma_X = 1.60^{+0.27}_{-0.26}$

$\Gamma = 13$ → best fit: blazar!
$\theta_v = 3°$ $\theta_v < 1/\Gamma$

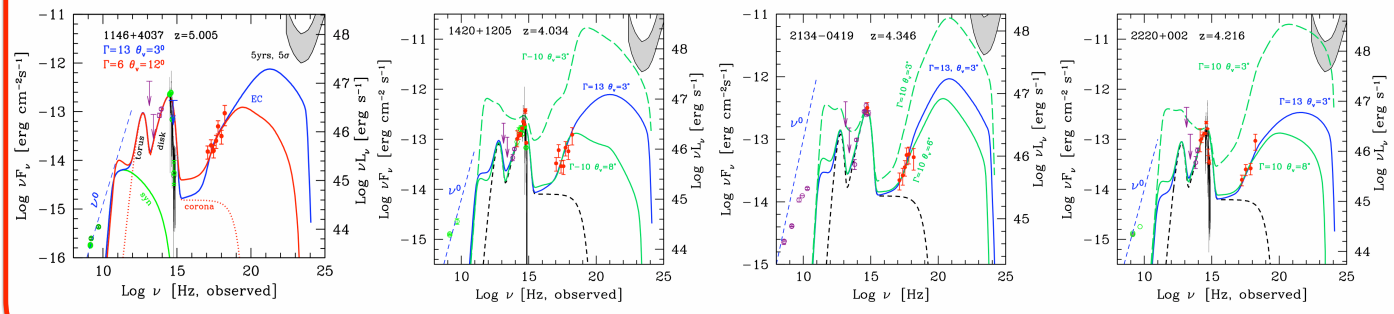
$\Gamma = 10$ → re-oriented at 3° as a **consistency check**: synchrotron hump unprecedently luminous. θ_v=8° is the largest viewing angle possible.
$\theta_v = 8°$

$\Gamma = 5$ → poor fit to X-ray data: Γ and θ_v values are rejected
$\theta_v = 20°$
(Frey et al. 2013)



Sbarrato et al. 2013

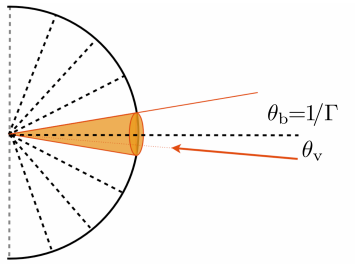
Classified blazars at z>4

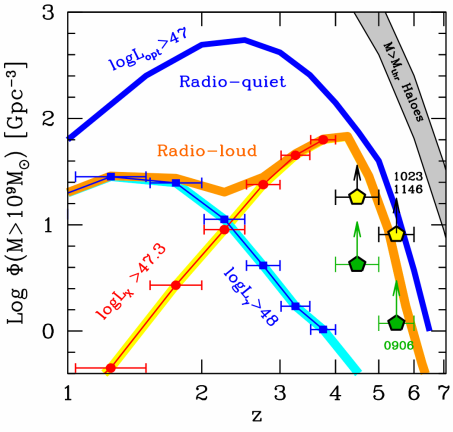


Ghisellini et al. 2014; Sbarrato et al. 2014

Two epochs for black hole formation?

Blazars trace the whole family of misaligned jetted AGN:
Blazars are seen under viewing angles smaller than their jet beaming angles (θ_v<1/Γ, where Γ is the bulk Lorentz factor).
For each blazar observed, we can infer the presence of $2\Gamma^2$=338(Γ/13)^2 analogous objects, with their jets randomly oriented.





Comoving number density of heavy black holes (M>10^9M$_{sun}$), hosted in radio-quiet (blue line) and radio-loud quasars (orange line). The radio-loud density is obtained from blazar luminosity functions: blue data and light blue line are from the *Fermi*/LAT γ-ray blazar catalog, while red data and yellow line are obtained from the [15-55keV] *Swift*/BAT luminosity function. Green pentagons are the z>4 data available before the beginning of our work. Yellow pentagons are the results obtained by Sbarrato et al. (2012, 2014) and Ghisellini et al. (2014). Note that **black holes hosted in jetted systems seem to form earlier than those hosted in non-jetted AGN** (z~4 vs. z~2.5).

Sbarrato et al. 2014