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The seed factor: how a combination of four observables can unveil the location of the blazar GeV emission.

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Introduction.

The location in FSRQs in which GeV emission is produced is an open question. In leptonic scenarios, GeV radiation is most likely emitted via inverse Compton scattering of photons in the broad-line region (BLR) or in the molecular torus (MT), called external Compton (EC) scattering. We have developed a diagnostic criterion to deterine in which of these two locations GeV emission is produced for a given SED. We term this criterion the "seed factor" (SF). Multiwavelength emission from the BLR and the MT both produce characteristic values of the seed factor.

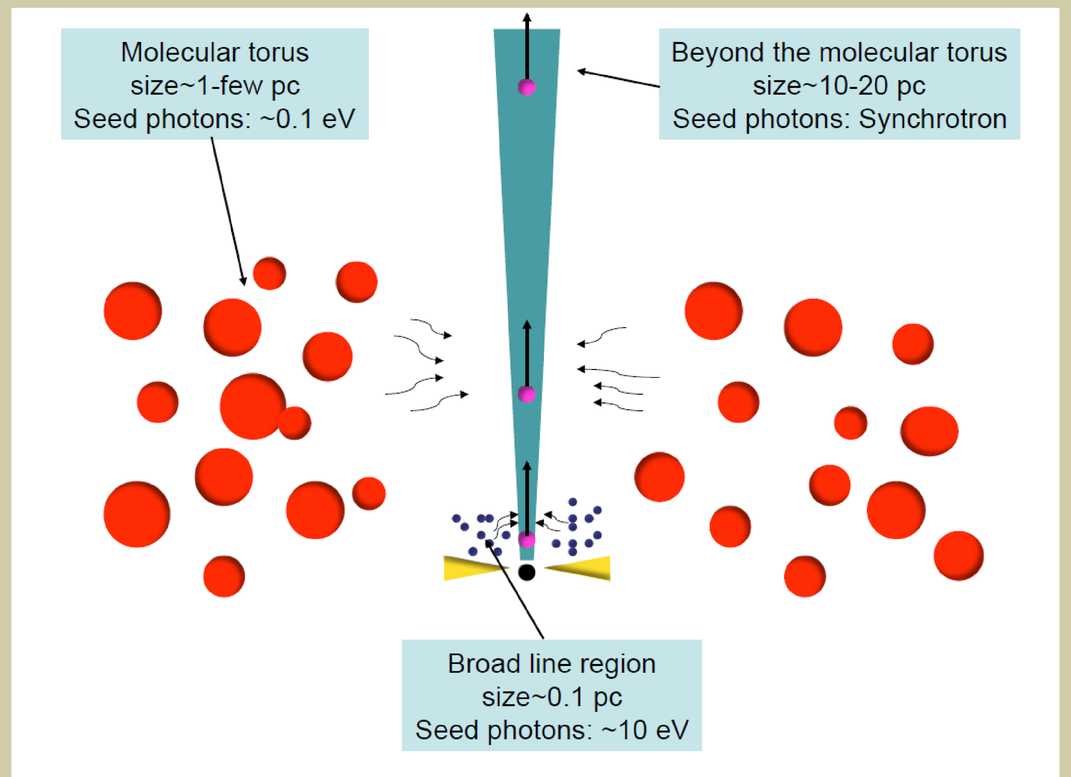

Figure 1: Blazar diagram showing distances of MT and BLR.

Derivation.

The peak energies (in units of electron rest mass energy) of synchrotron and external Compton scattering are, respectively,

$$\epsilon_s = \frac{B}{B_{cr}}\gamma^2\delta \quad (1)$$

$$\epsilon_c = \frac{4}{3}\epsilon_0\gamma_b^2\delta^2 \quad (2)$$

where ϵ_0 is the characeristic energy of the external seed photons.

Eqn. 2 is valid if the electron scattering takes place in the Thompson regime. Scattering is in the Thompson regime if $\sqrt{\epsilon_c\epsilon_0} \lesssim 1$. The highest energy possible for external seed photons are UV emission-line photons which have $\epsilon_0 \approx 10^{-4}$. Thus scattering is in Thompson regime if $\nu_c \lesssim 10^{24}$ Hz. Which is generally true, since for powerful blazars $\langle\nu_c\rangle \approx 10^{22}$ Hz.

Dividing Eqn. 2 by Eqn. 1 and solving for $\frac{B}{\delta}$,

$$\frac{B}{\delta} = \frac{4\epsilon_0\epsilon_s B_{cr}}{3\epsilon_c} \quad (3)$$

To create a diagnostic based solely on observables, we now consider the Compton dominance. This is,

$$k = \frac{L_c}{L_s} = \frac{32\pi\delta^2 U_0}{3B^2} \quad (4)$$

Solving for $\frac{B}{\delta}$ and equating to Eq. 3, we find,

$$\frac{U_0^{1/2}}{\epsilon_0} = 3.2\times10^4\ \mathrm{G}\frac{k_1^{1/2}\nu_{s,13}}{\nu_{c,22}} \quad (5)$$

where k_1 is the Compton dominance in units of 10, $\nu_{s,13}$ is the synchrotron peak in units of 10^{13} Hz, and $\nu_{c,22}$ is the EC peak in units of 10^{22} Hz. It is Eqn. 6 which we term the seed factor.

Reverberation mapping of radio quiet finds that $R_{BLR} \approx 10^{17}L_{d,45}^{1/2}$ [1]. Assuming this holds for powerful blazars and that $\xi_{BLR} \sim 0.1$ [2], $U_0 \approx 2.6\times10^{-2}$ erg cm^{-3}. The BLR SED can be approximated by a blackbody (BB) with peak at $\epsilon_0 \approx 3\times10^{-5}$ [3]. Thus $SF_{BLR} \sim 5.5\times10^3$ G.

In the MT, reverberation mapping [4,5] and NIR interferometric studies [6] of radio quiet sources find $R_{MT} \approx 10^{18}L_{d,45}^{1/2}$. Adopting $\epsilon_0 = 5.7\times10^{-7}$ (a BB of $T = 1200$ K) and $\xi_{MT} \sim 0.2$ [7] we obtain $SF_{MT} \sim 4\times10^4$ G.

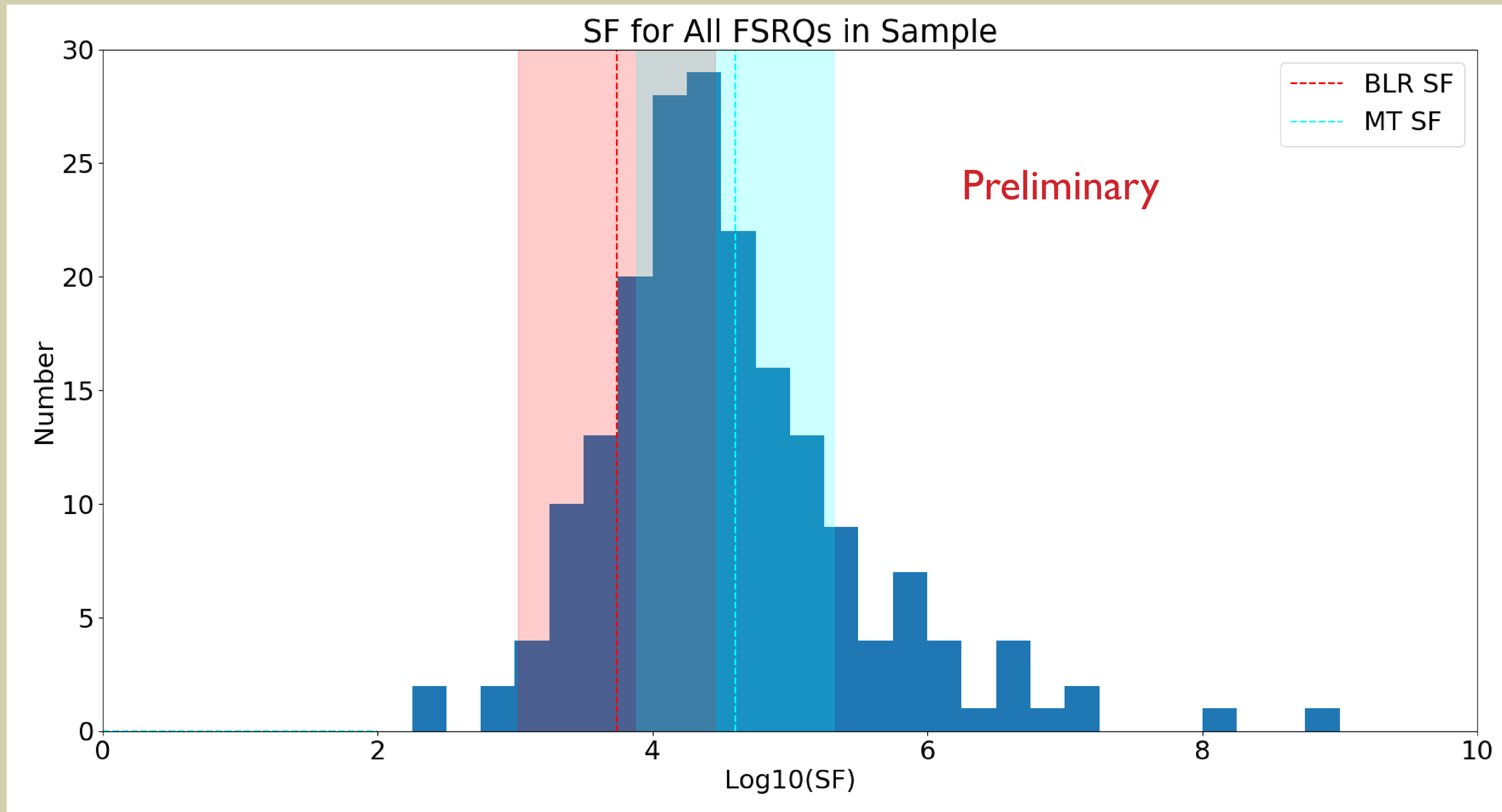

Figure 2: Histogram of seed factors for all FSRQs in sample.

Preliminary Work.

We have derived the SF for four samples (Arsioli+ (2018) [8], MOJAVE [9], LBAS [10], DSSB [11]). A histogram of all the SFs from these samples can be seen in Fig. 2. A histogram for the MOJAVE sample can be seen in Fig. 4. The MOJAVE sample has been singled out due to the completeness of the MOJAVE sample.

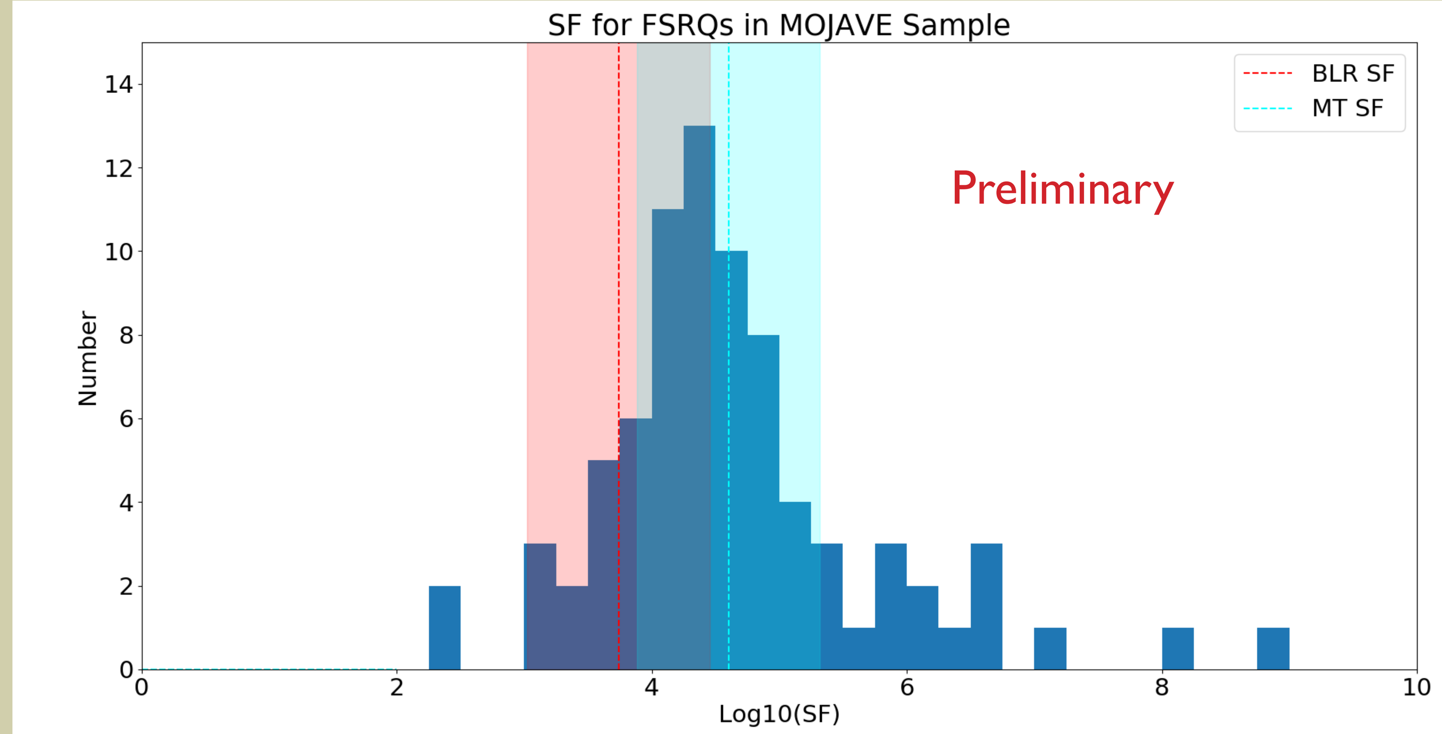

Figure 3: Histogram of seed factors of cumulative historical data from the ASDC SED Builder for MOJAVE sample FSRQs.

Combinig all four of these samples does not show a strong preference for either the BLR or the MT. The MT may be favored slightly in the MOJAVE sample. The MOJAVE sample is, however, in close agreement with the total distribution.

Our results show that emission is consistent with EC emission. There may be emission outside of the BLR or MT, as indicated by large values of the SF. More accurate measurements of the peak frequencies and luminosities can provide better discrimination between emission locations.

Future Work.

We will next focus on a comparison between the SF in FSRQs and in BL Lacs. If emission occurs due to EC scattering, then we would expect that the distribution of SFs for FSRQs and BL Lacs would be different. If they are found to be indistinguishable, then it may be the case that emission in FSRQs is due to the synchrotron self-Compton process.

References.

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