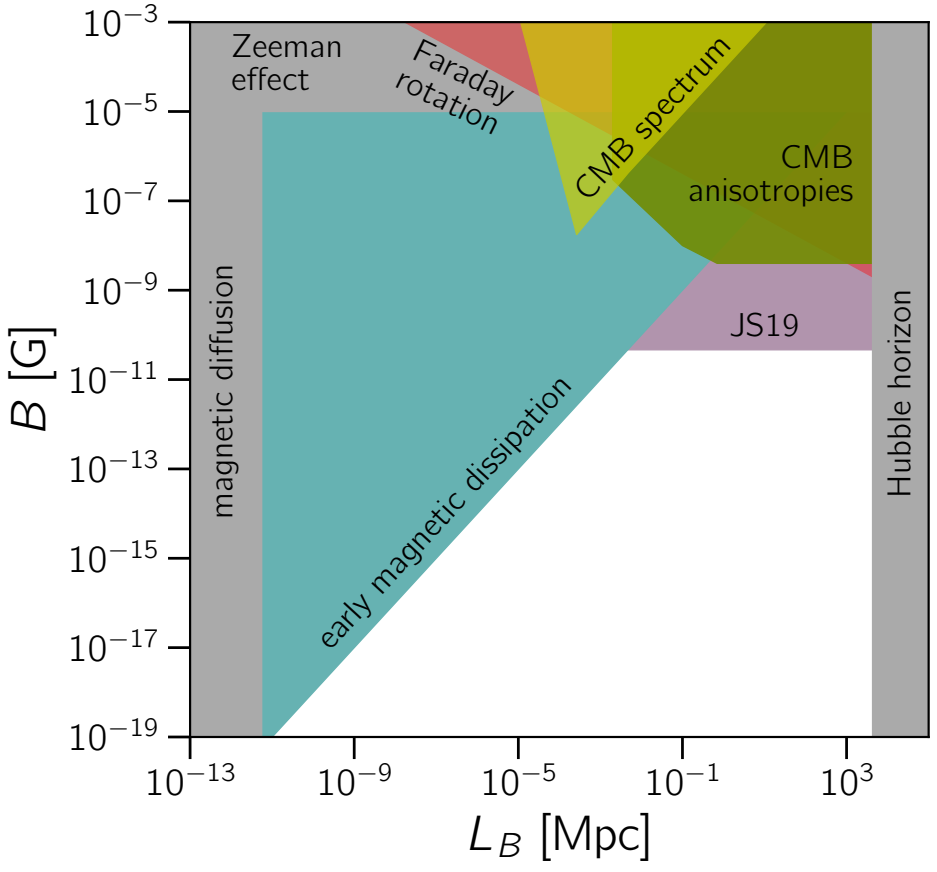
Using the TXS 0506+056 Flare to Constrain Integralactic Magnetic Fields

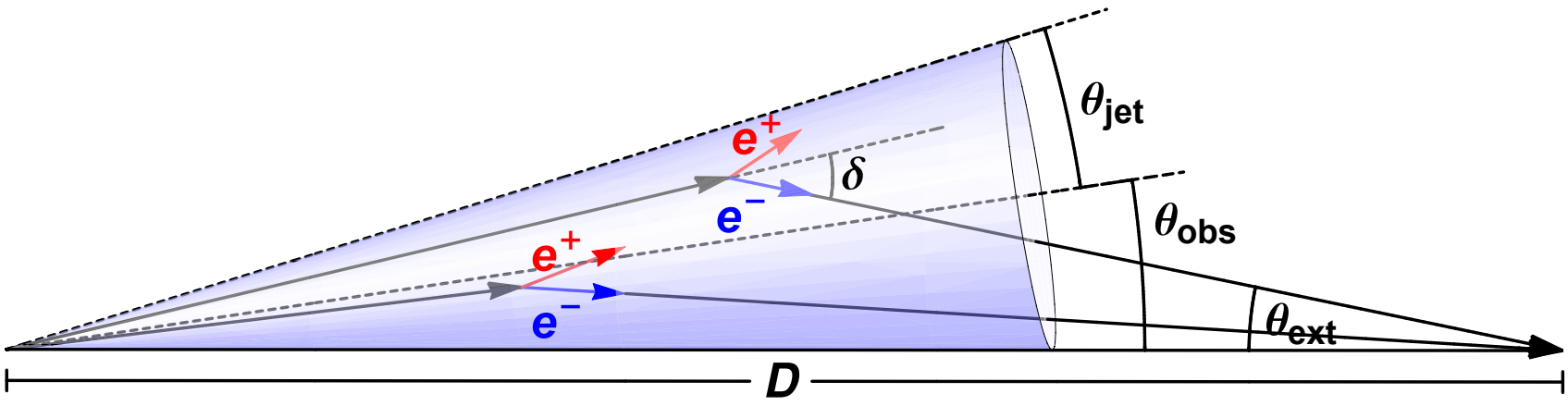
Andrey Saveliev

January 24th, 2023

IGMF - Standard Constraints [Alves Batista and Saveliev, 2021]



IGMF – Lower Bound on B? [Alves Batista and Saveliev, 2021]



- Gamma rays emitted from a blazar develop an electromagnetic cascade due to interactions with photon background fields via Pair Production and Inverse Compton (IC) scattering. The interaction of this cascade with the IGMF results in several observational features.

Limits on IGMF using Multimessengers [Alves Batista and Saveliev, 2020]

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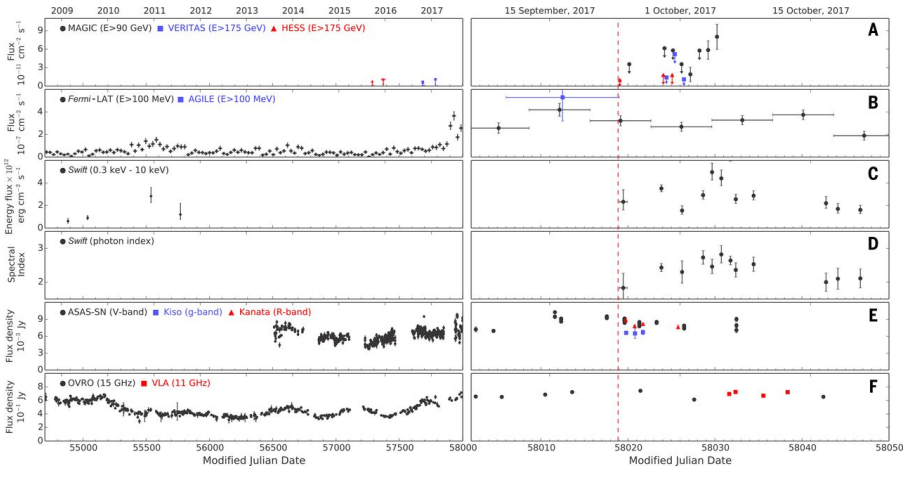
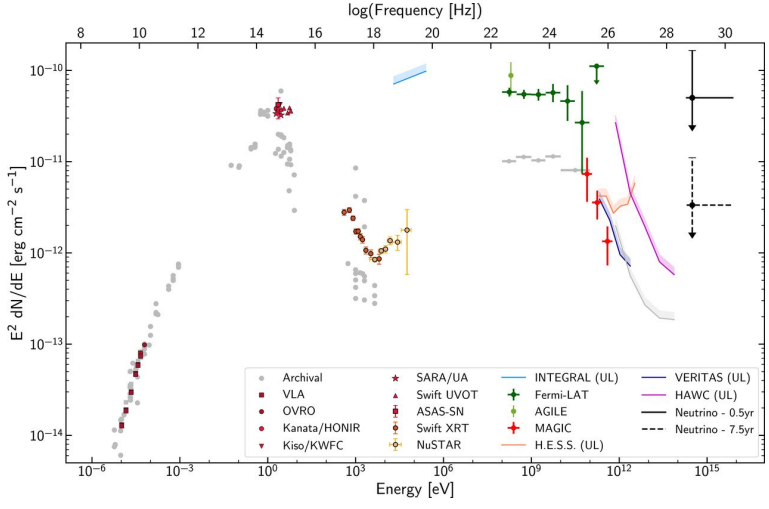
- Of particular interest is the IceCube neutrino event IC-170922A [IceCube Collaboration, 2018] which is associated with the 2017 flare of the blazar TXS 0506+056 in the electromagn. spectrum [IceCube Collaboration et al., 2018]





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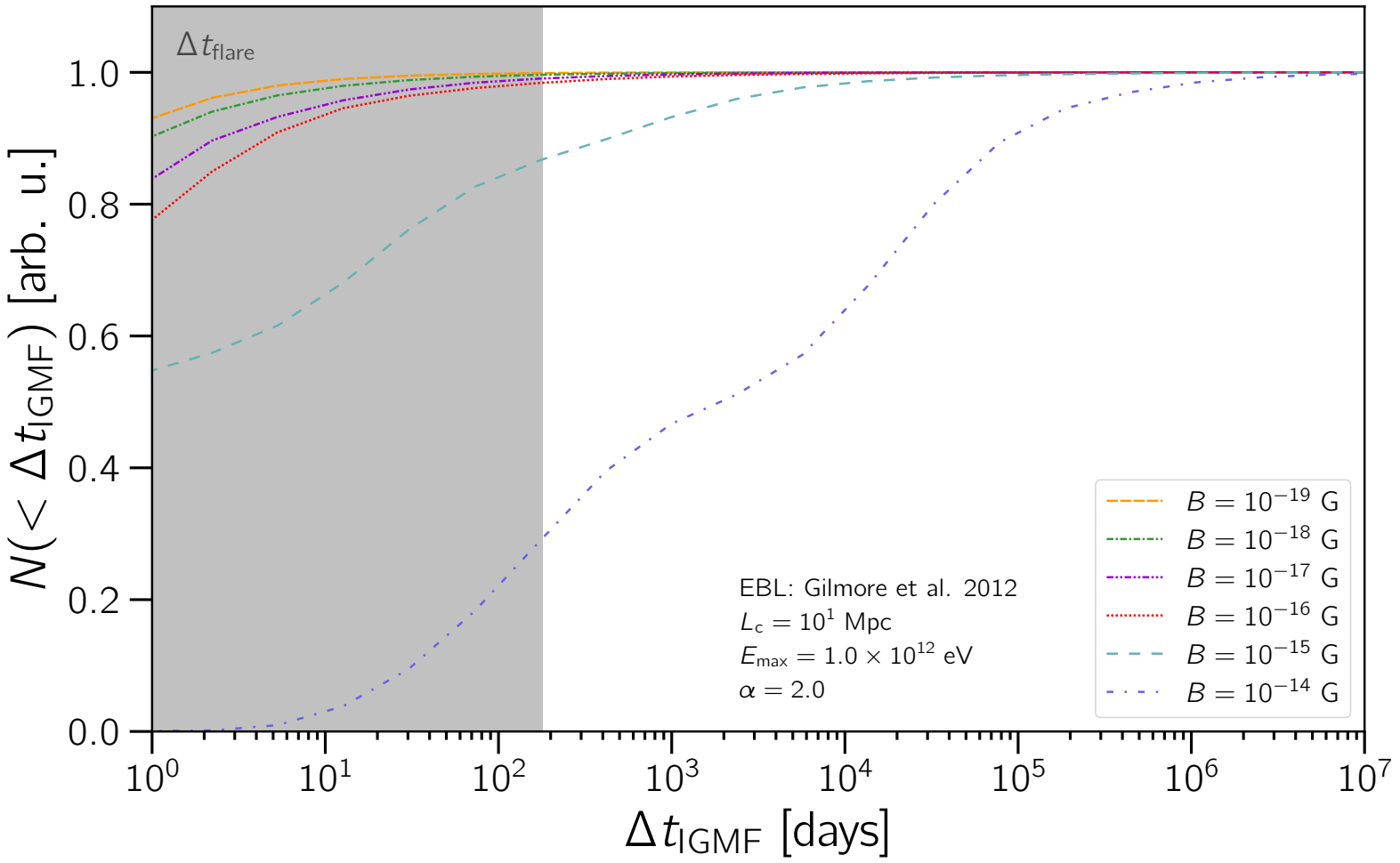

Cumulative distribution of time delays of gamma rays due to IGMF ($\Delta t_{\rm IGMF}$) for TXS 0506+056. The grey shaded region indicates the period of enhanced activity of the object ($\Delta t_{\rm flare}$)

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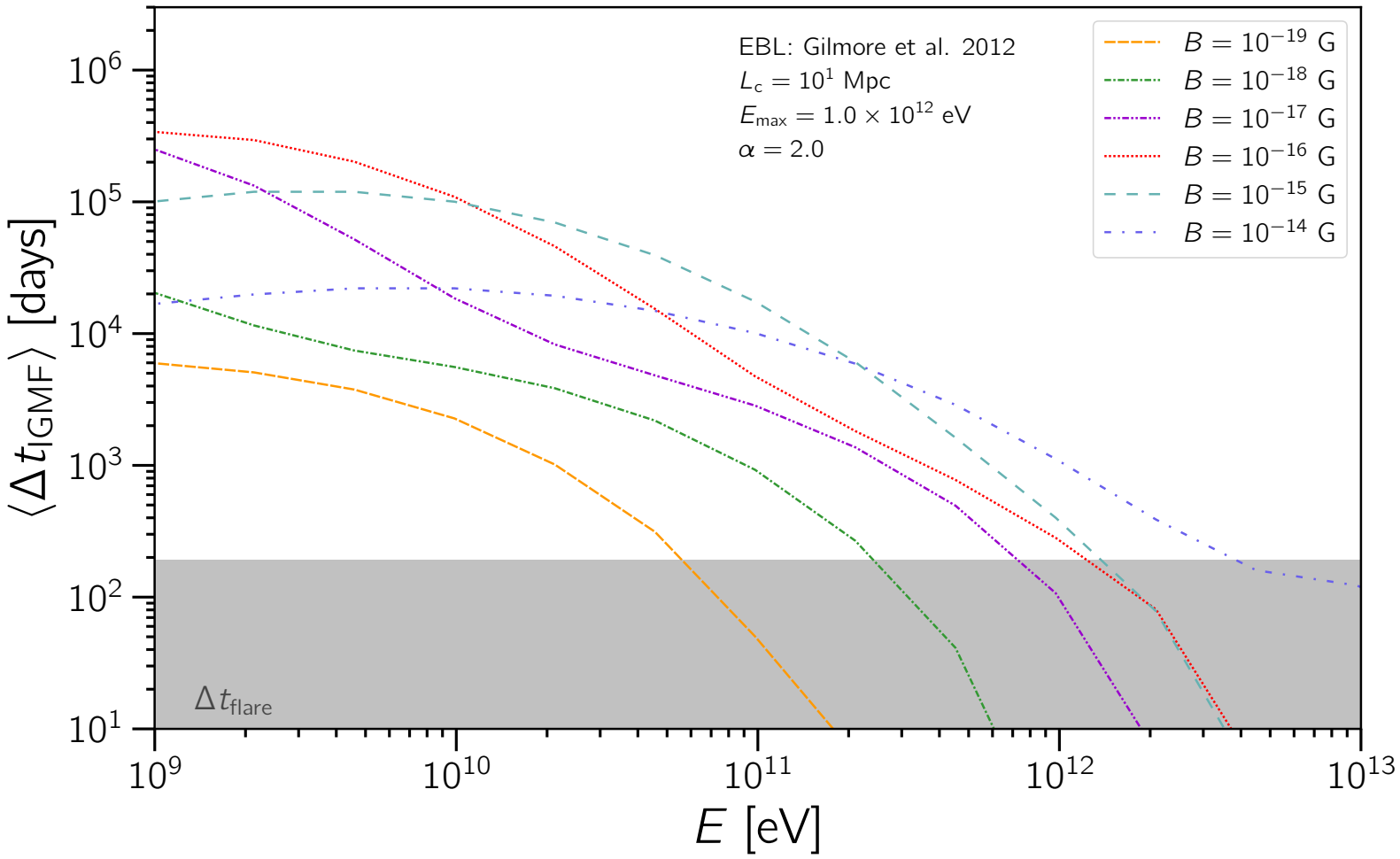

Average time delays Δt_{IGMF} as a function of the observed gamma-ray energy E

Limits on IGMF using Multimessengers [Alves Batista and Saveliev, 2020]

- We simulate the emitted flux as

$$\frac{dN}{dE} = J_0 \begin{cases} E^{-\alpha_\mathrm{l}} \exp\left(-\frac{E}{E_\mathrm{max,l}}\right) & \text{"low" (non-flaring) state}\,, \\ \eta E^{-\alpha_\mathrm{h}} \exp\left(-\frac{E}{E_\mathrm{max,h}}\right) & \text{"high" (flaring) state}\,, \end{cases}$$

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- We use four different EBL models for the simulation of the propagation of the electromagnetic cascade with the CRPropa code [Alves Batista et al., 2016] and consider large ranges of B, $L_{\rm c}$, $E_{\rm max}$ and α
- In order to analyze the data, we first determine the best-fit spectral parameters of the low state (i.e. $E_{\rm max,l}$ and $\alpha_{\rm l}$), and then scan over the remaining parameters (η, $E_{\rm max,h}$, $\alpha_{\rm h}$, B, $L_{\rm c}$)

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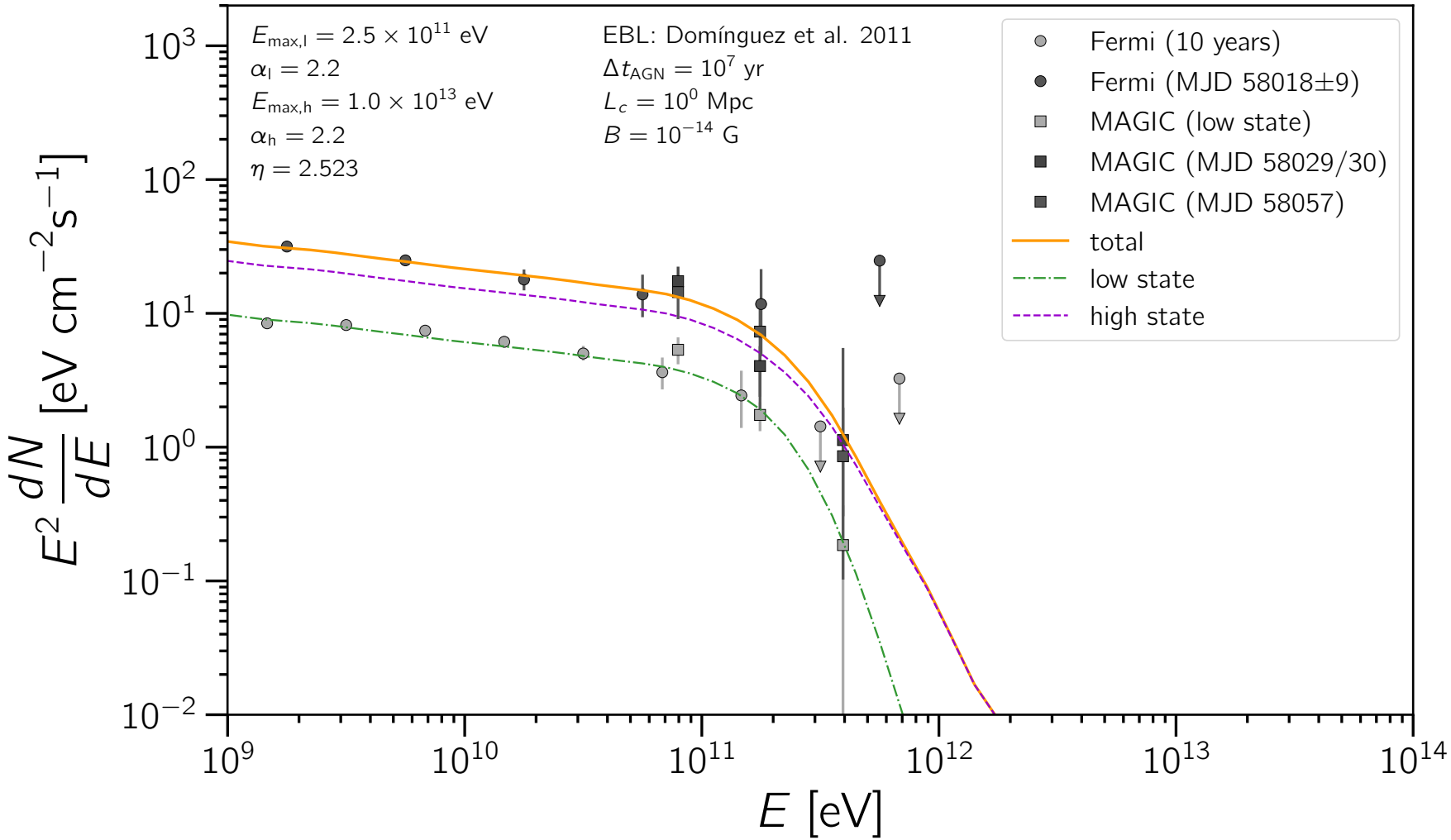

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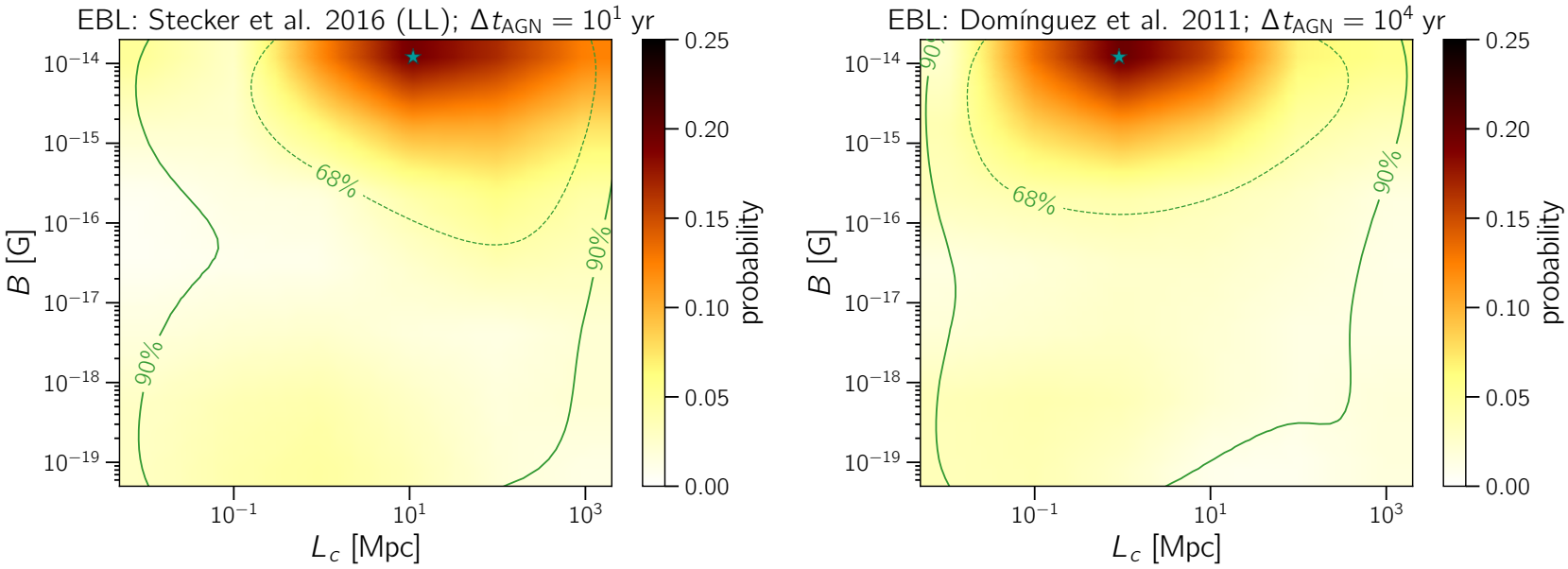

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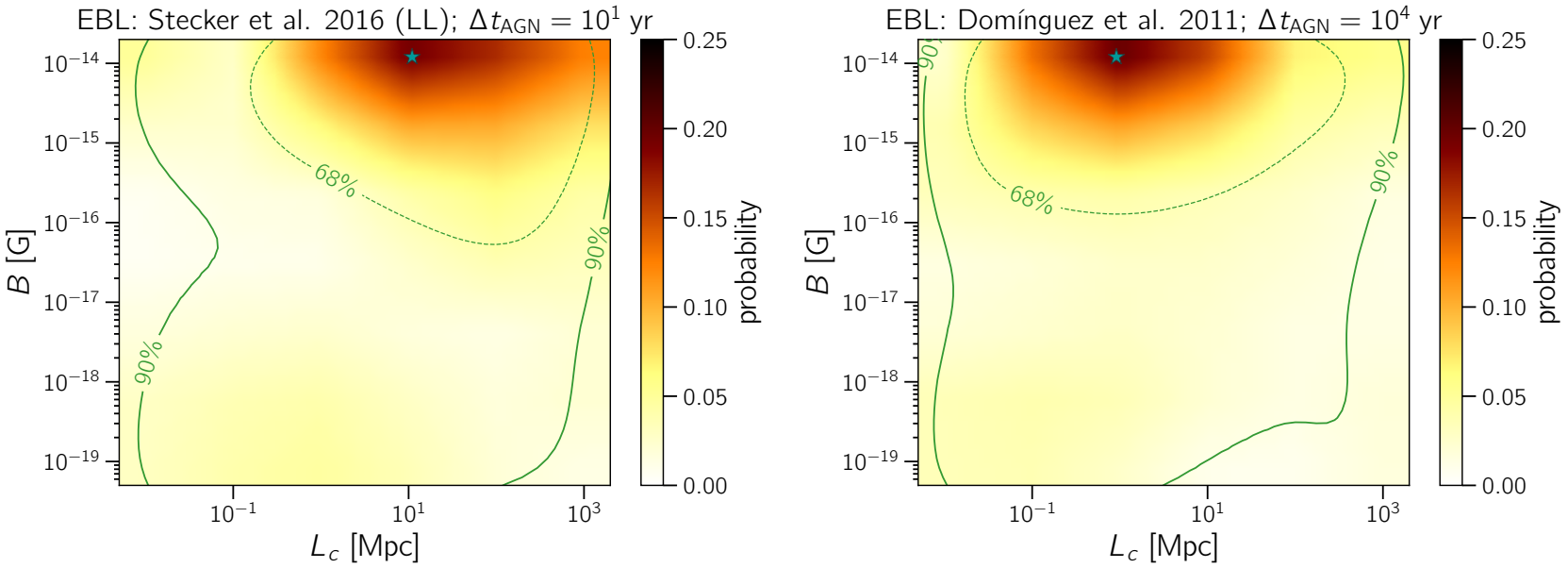

- For two of the EBL models we could reject the $B = 0$ hypothesis
- For these two models it is possible to constrain the magnetic field strength B *and* the correlation length L_c
  [Alves Batista and Saveliev, 2020]

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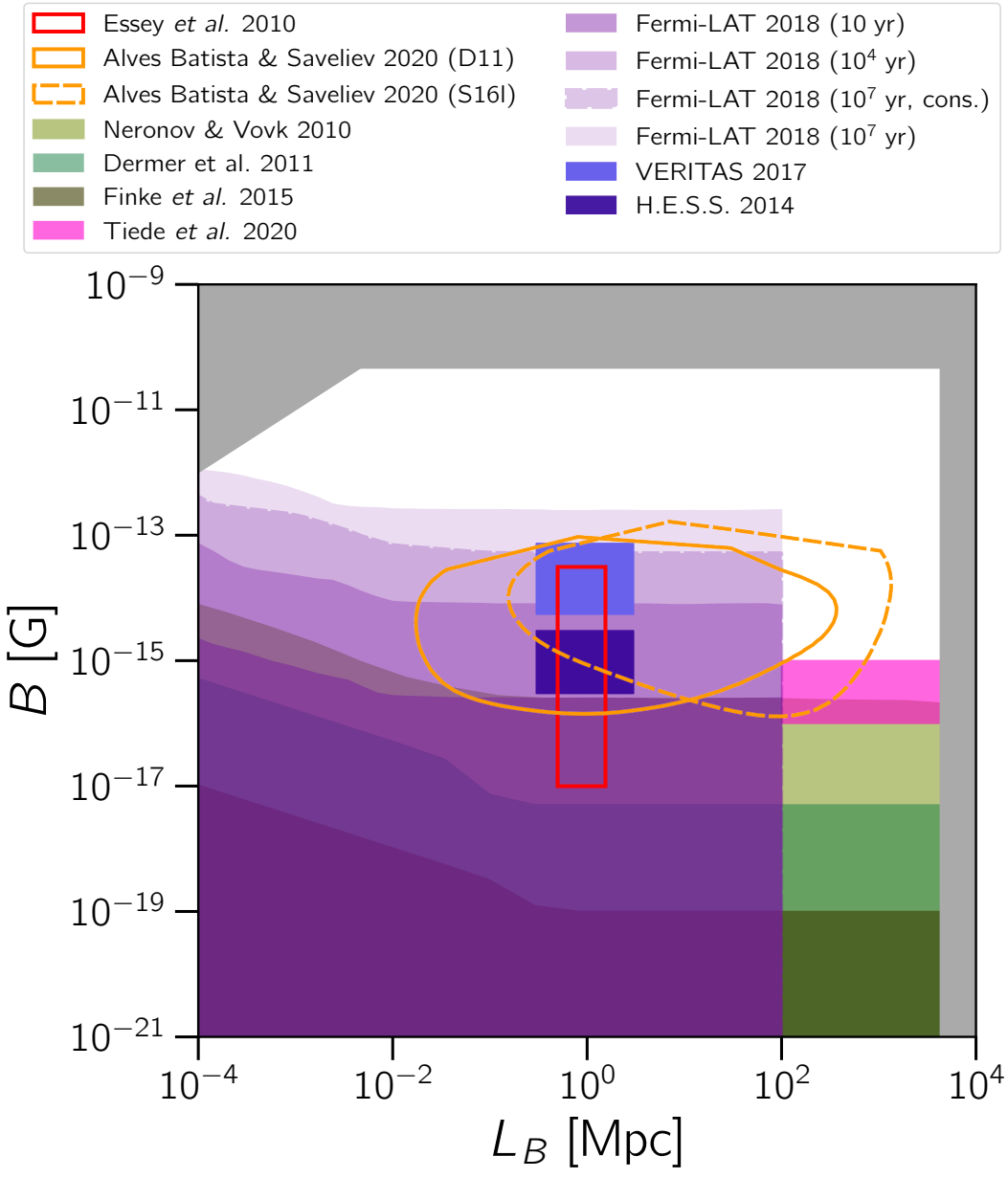
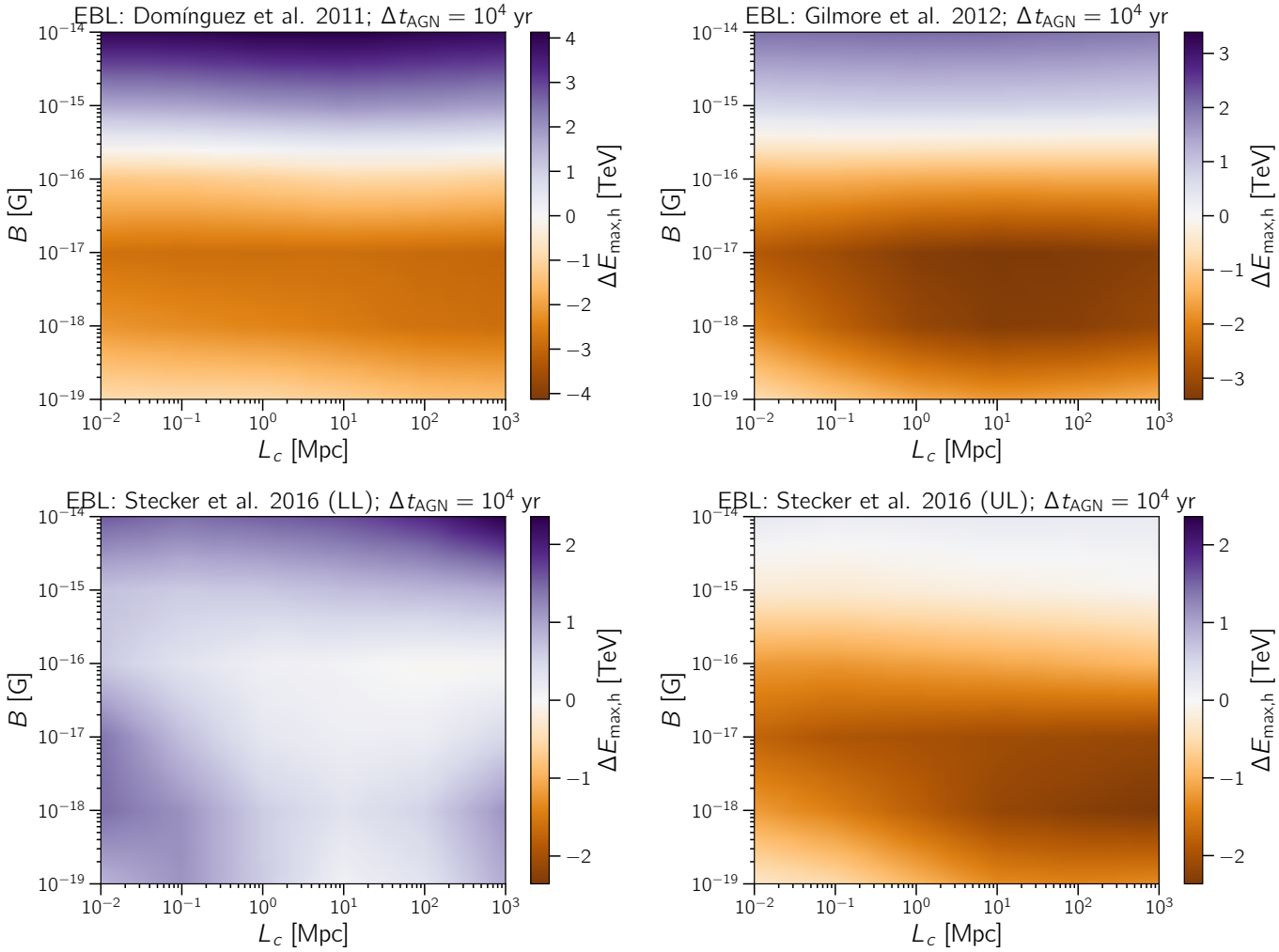


Limits on IGMF using Multimessengers [Saveliev and Alves Batista, 2021]



- IGMF have a significant impact on the determination of the intrinsic spectral properties of the source
- While α is rather unaffected, $E_{\rm max}$ might shift significantly

Conclusions and Outlook

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- We have also shown that IGMF have to be taken into account when determining the intrinsic spectral properties of a source
- In the future we will extend our analysis to other flaring objects to obtain more robust magnetic field limits and extend the parameter space, in particular considering higher magnetic field strengths


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