Suppression of the TeV pair-beam plasma instability by a tangled weak intergalactic magnetic field

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INTRODUCTION

- High energy photons from distance blazar annihilate with the EBL giving a pair beam, the pair beam is expected to produce secondary photons after inverse Compton scatter on the CMB.
- We ***don't see*** this Cascade emission, because of either pairs deflected by magnetic fields, or they lost their energy by pair-beam plasma instability.

THE KEY QUESTION

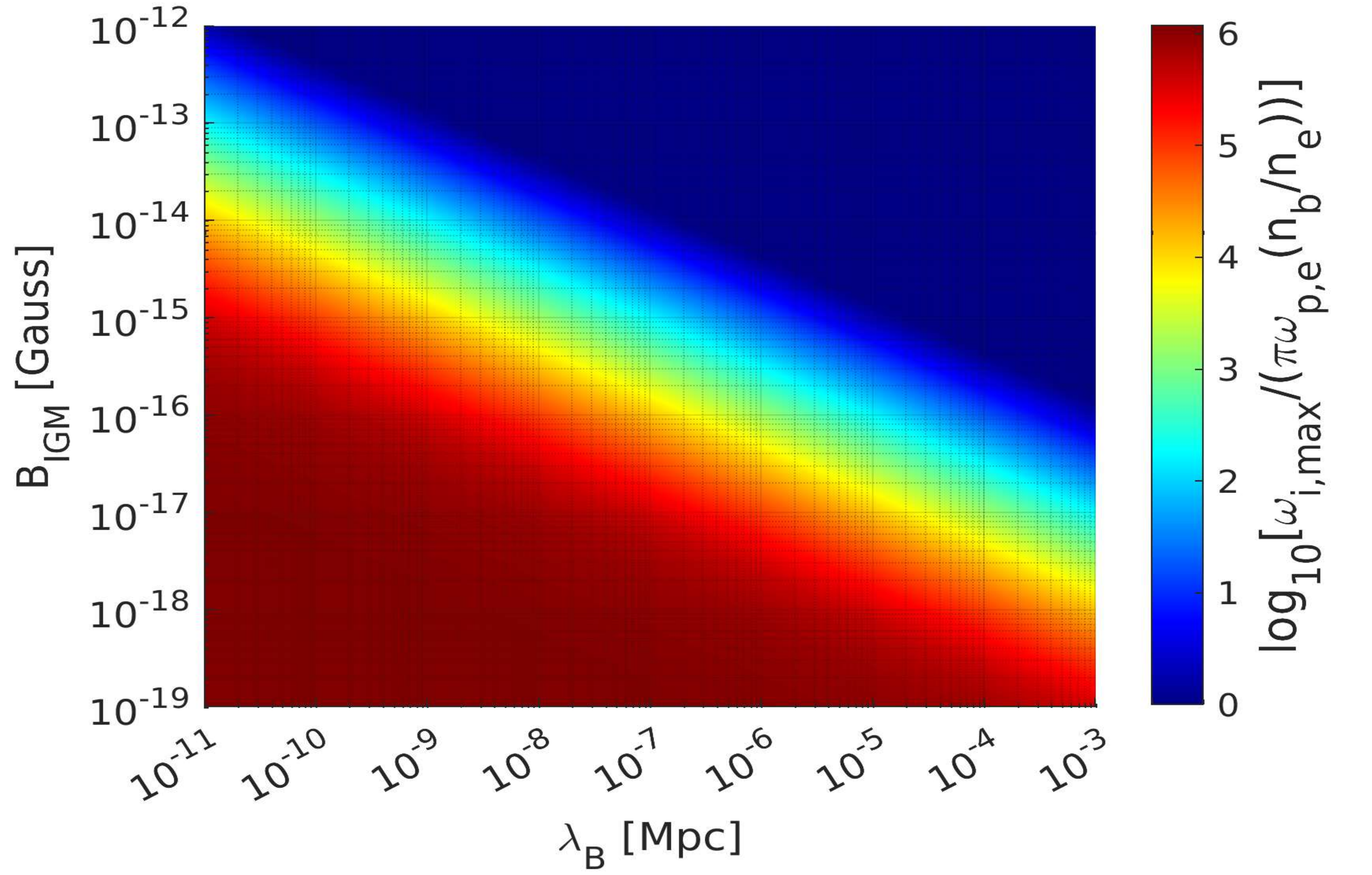
The plasma instability was calculated neglecting the IGM magnetic fields. How do the IGM magnetic fields impact the instability if it were there?

Methods

- The IGM magnetic fields with correlation lengths smaller than the pair's energy loss length cause stochastic deflections of the electrons and positrons **increasing the angular distribution function** of the pair beam as a Gaussian with the angular spread $\Delta\theta = \frac{m_e c}{p}\sqrt{1+\frac{2}{3}\lambda_B\lambda_{IC}\left(\frac{eB_{IGM}}{m_e c}\right)^2}$
- The linear growth rate for each unstable wave with a wave-vector **k** depends significantly on the pair beam distribution function

$$\omega_i(\boldsymbol{k}) = \omega_p \frac{2\pi^2 e^2}{k^2}\int d^3\boldsymbol{p}\left(\boldsymbol{k}\cdot\frac{\partial f}{\partial \boldsymbol{p}}\right)\delta(\omega_p - \boldsymbol{k}\cdot\boldsymbol{v})$$

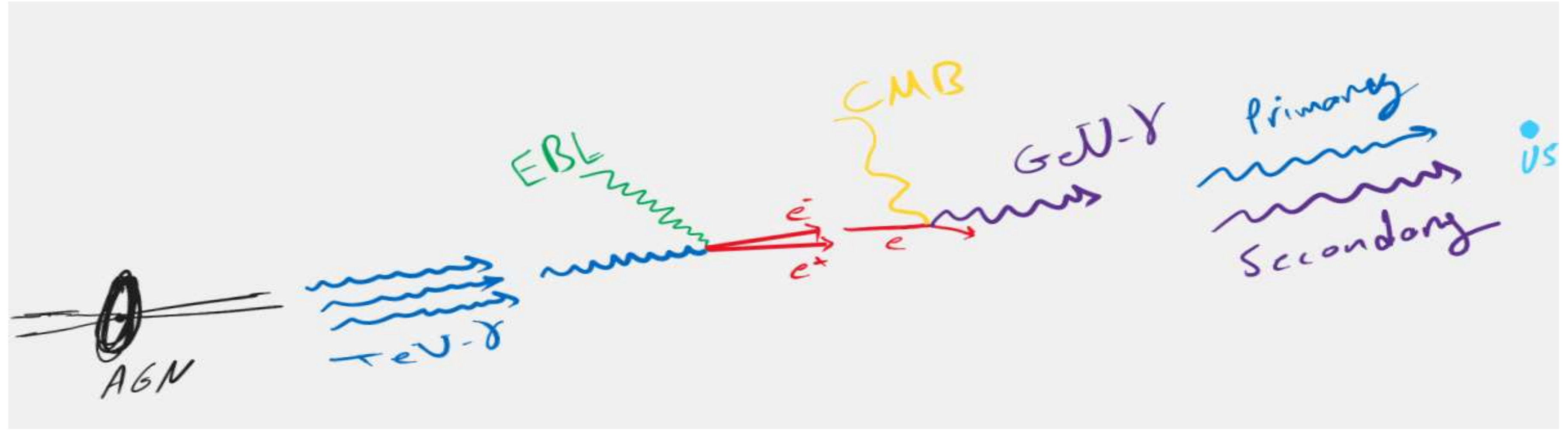
- **We found that the beam widening decreases the linear growth rate of the electrostatic instability significantly**



- **Growth rate reduction limits energy loss due to the beam-plasma instability.**

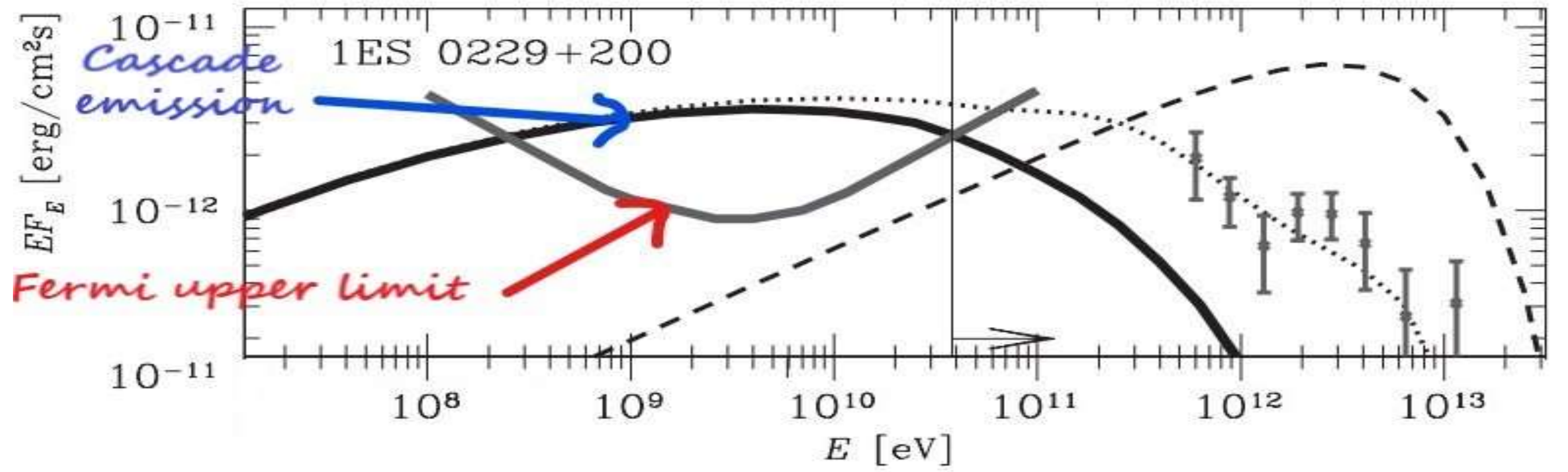
CONTEXT

- **High energy TeV gamma rays from distance blazars attenuate in the IGM medium giving a secondary GeV cascade**



- We ***don't see*** this **GeV cascade**

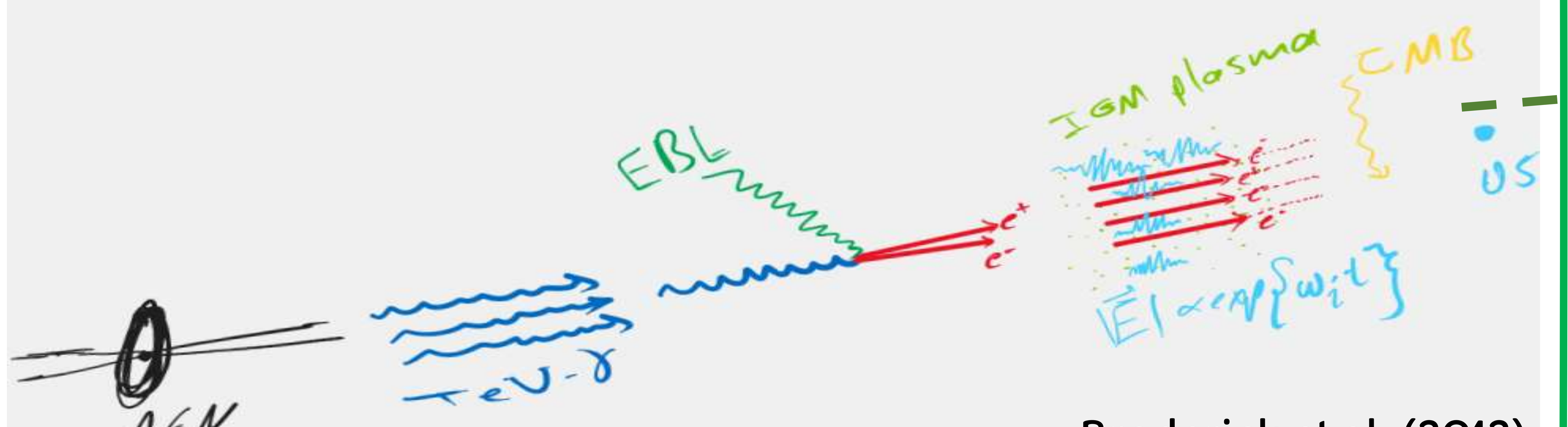
Neronov and Vovk (2010)



- The pair beam either: **1) Deflected by IGM magnetic fields.**

Neronov and Vovk (2010)

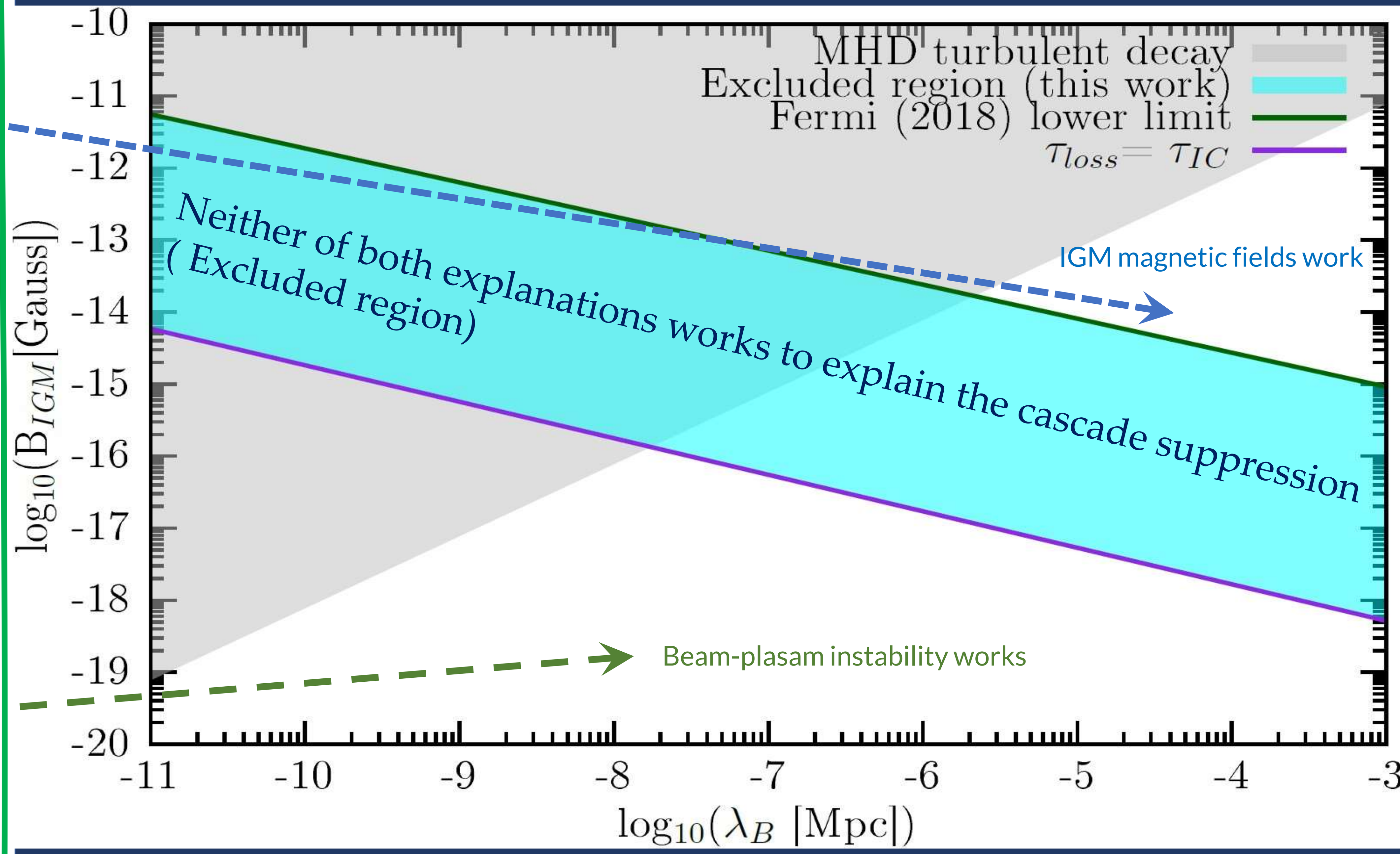
- **2) Lost their energy by the pair-beam plasma instability.**



Broderick et al. (2012)

RESULTS

- We found that **IGM magnetic fields slow down the linear growth rate** of the blazar-induced pair beam insatiability.
- The reduction of the linear growth rate limits the energy loss of the instability.
- We found that this suppression becomes effective at magnetic fields strength **three order of magnitude** less than the magnetic fields strength needed to suppress the cascade emission by magnetic deflection.
- In the intermediate strength magnetic fields region (Cyan region below) the instability is suppressed compared to the inverse Compton scattering and the IGM magnetic fields are not strong enough to deflect the cascade emission, **and hance this region is excluded**.



For more details, please refer to : Alawashra and Pohl 2022, *ApJ*, 929, 67.

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