

Constraints on cosmological magnetic fields from gamma-rays

Jeffrey Blunier

PhD student in the APC theory group

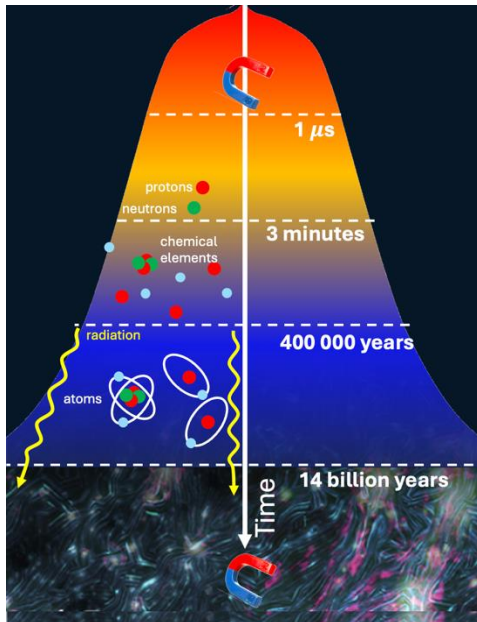
AADC Master students' visit to APC

14 October 2026

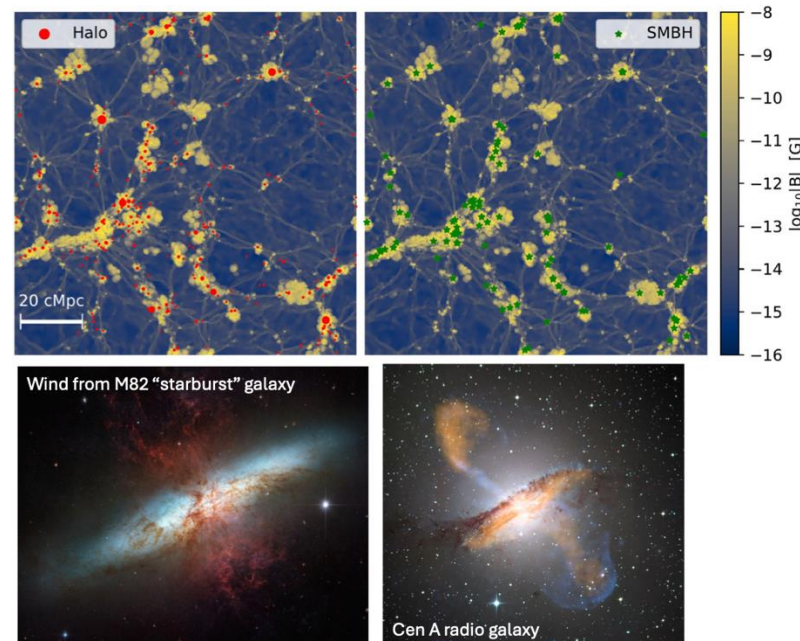
Cosmological Magnetic Field: What is it ?

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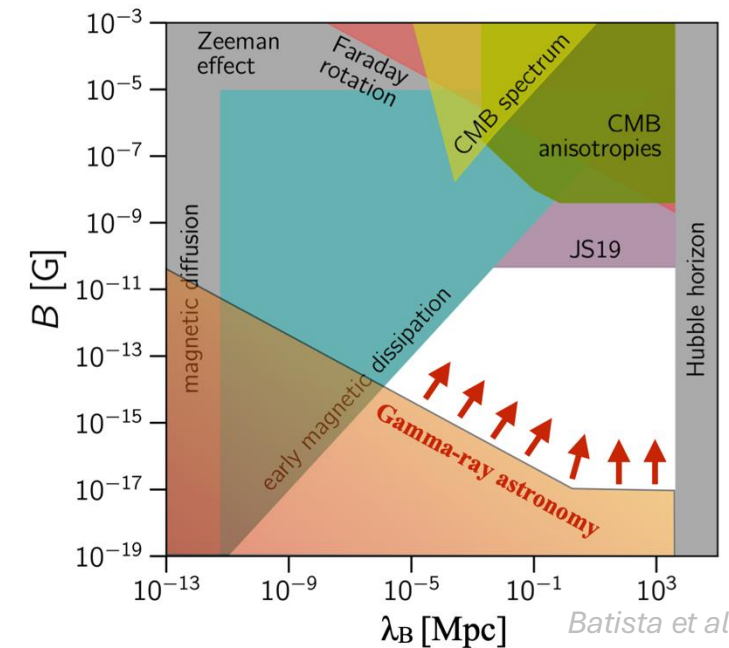
- At the origin of the magnetization of the Universe
- Could have been produced in the early Universe (inflation, phase transitions) or from pollution of the intergalactic medium from galaxies (winds, SMBH, SNe..)
- We are able to put upper and lower bound on the field strength from observational constraints



Credit: Nordita Winter School 2026



Garcia et al. 2021

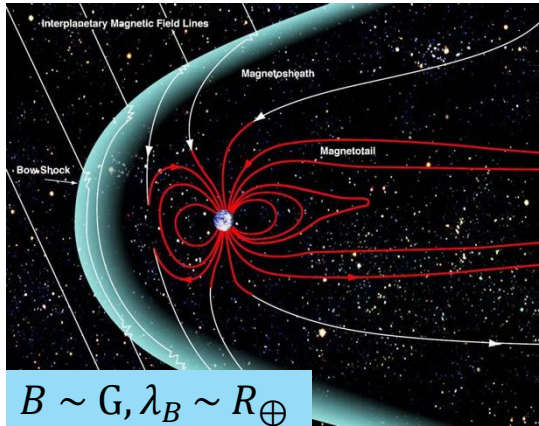


Batista et al. 2021,
ICRC 2025 Ténéma K.

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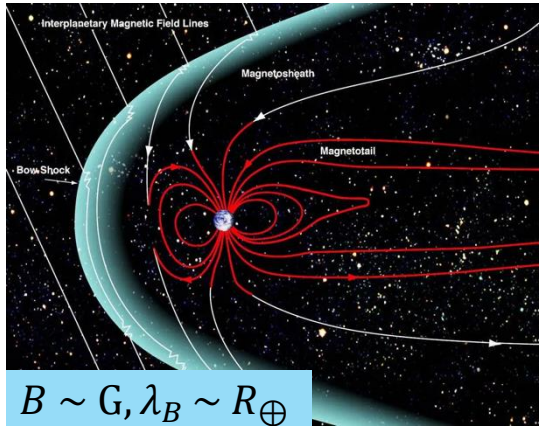
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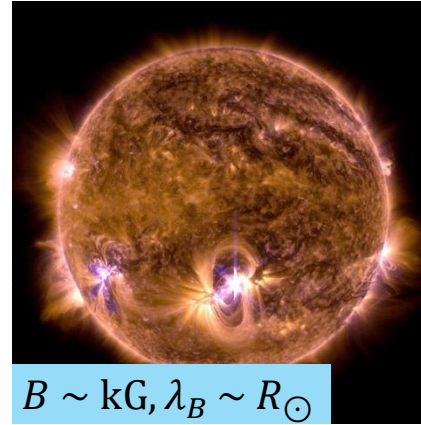


Credit: NASA

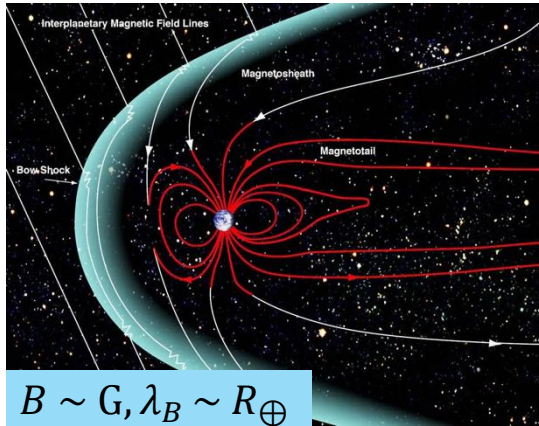
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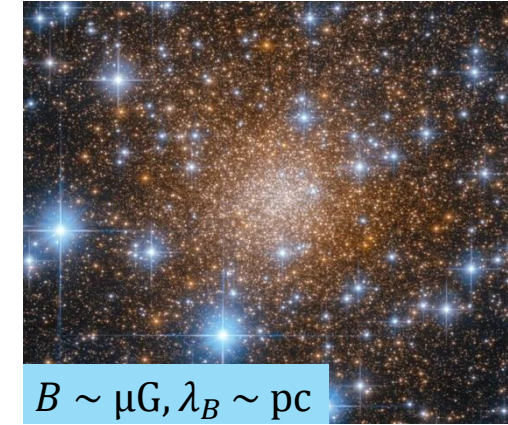
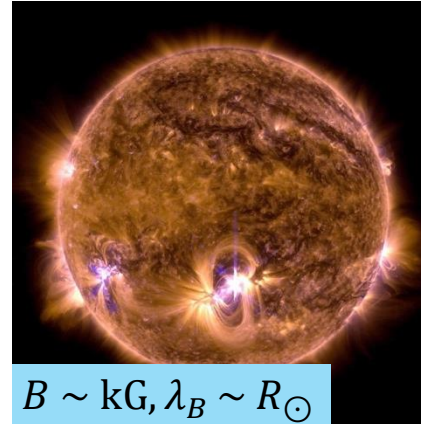
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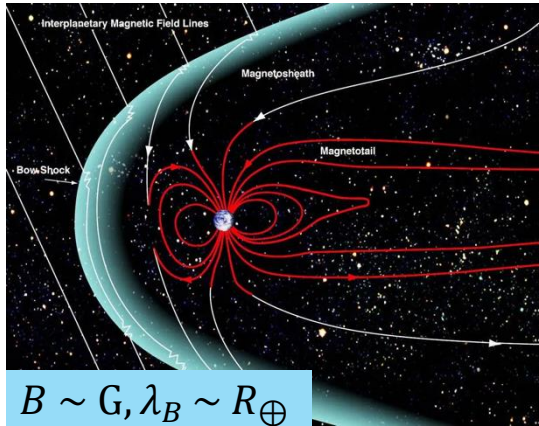
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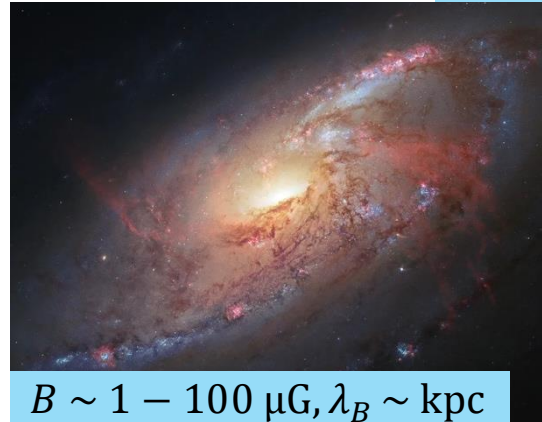
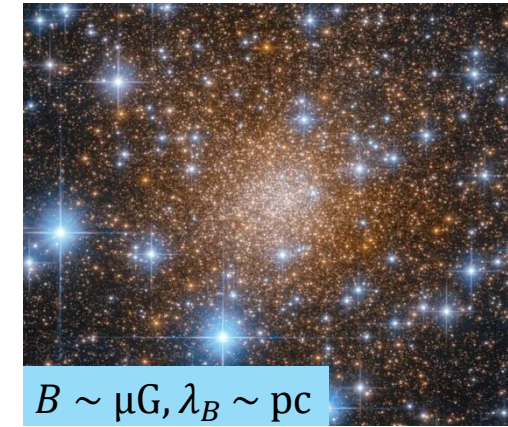
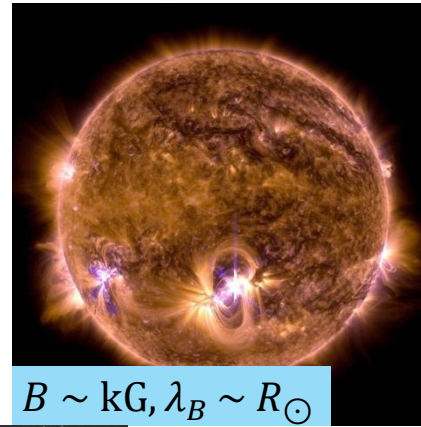
Credit: NASA



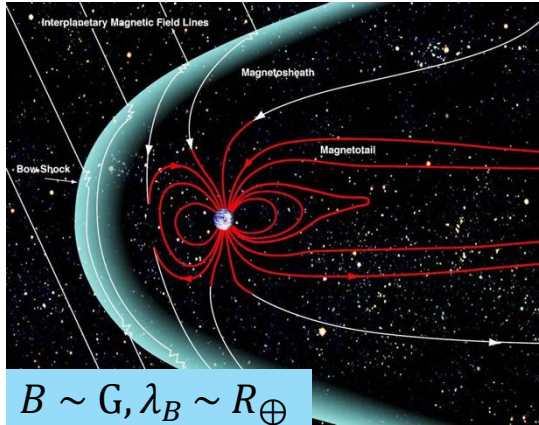
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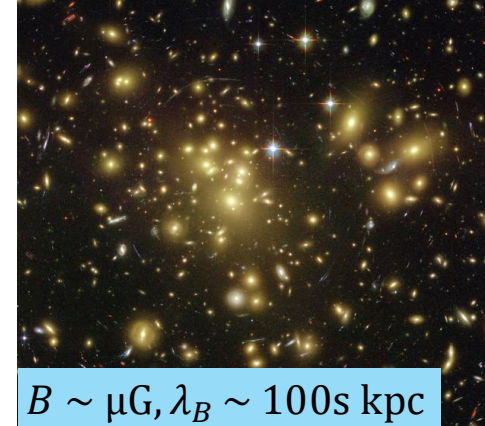
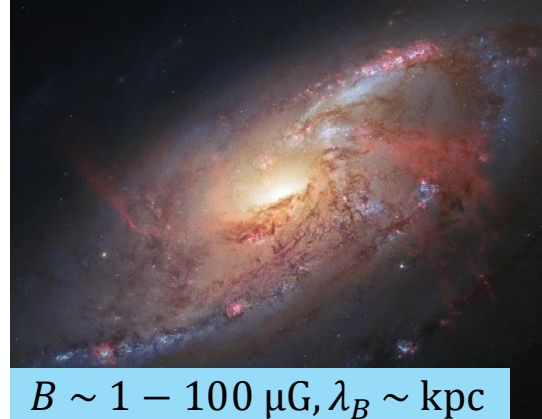
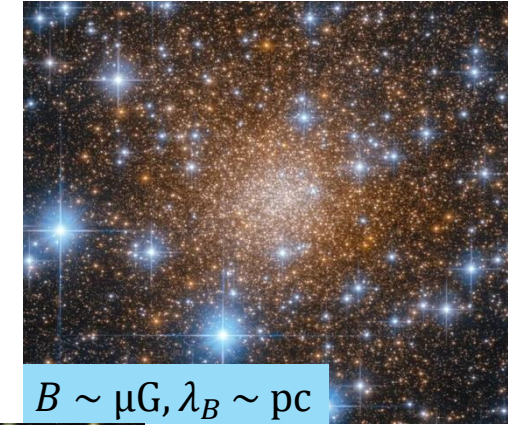
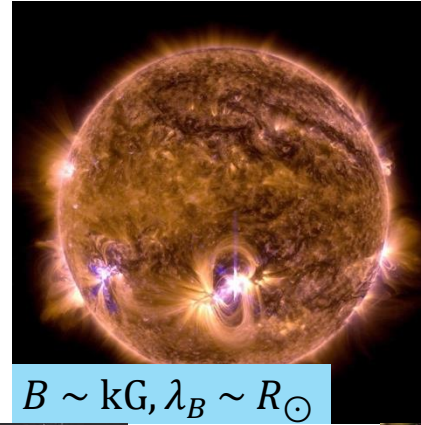
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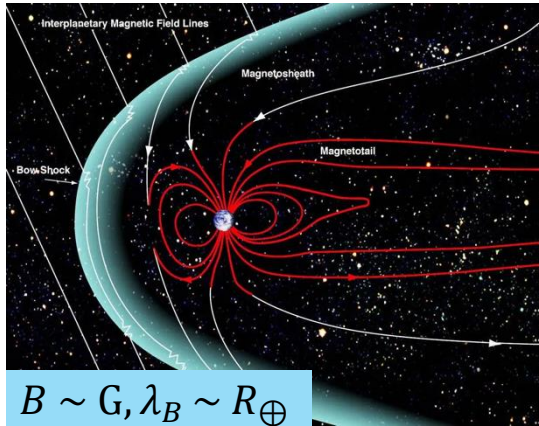
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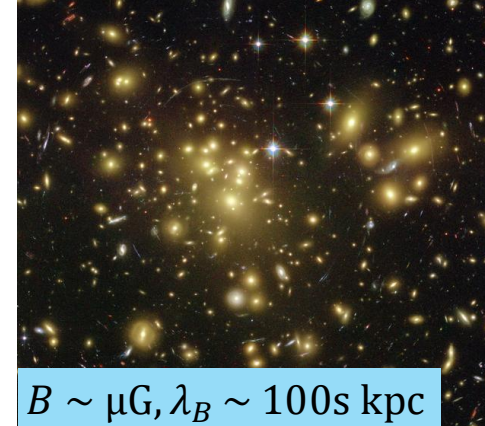
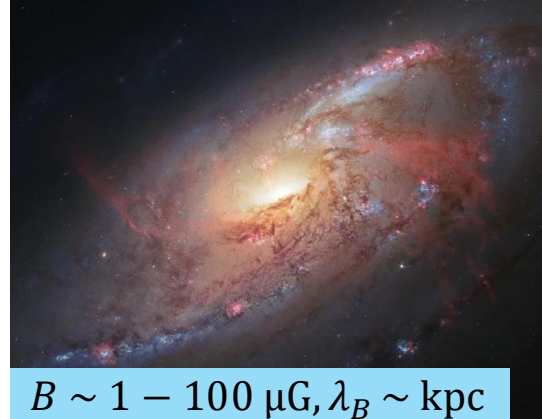
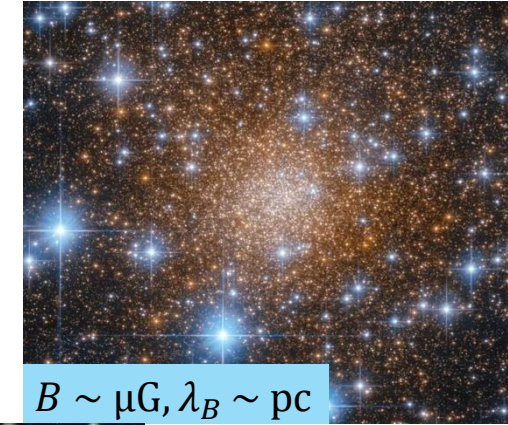
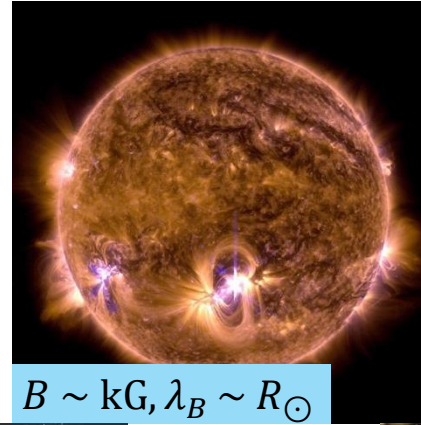
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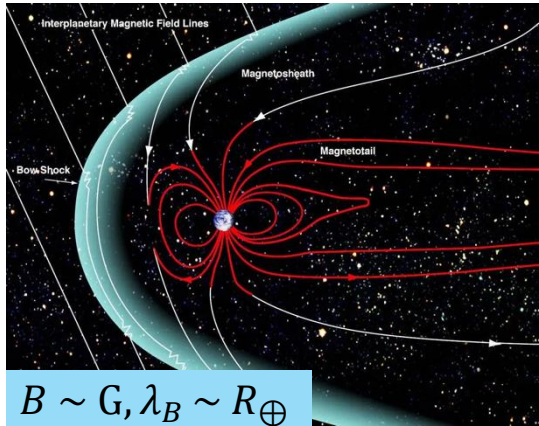


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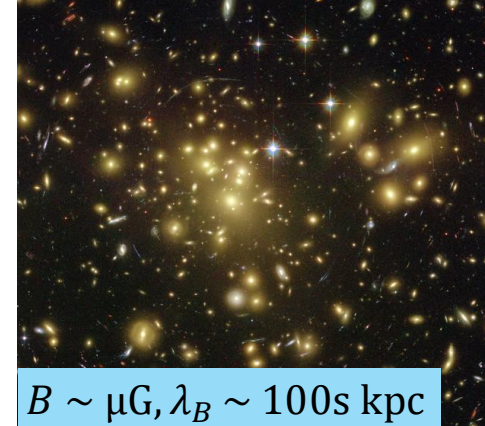
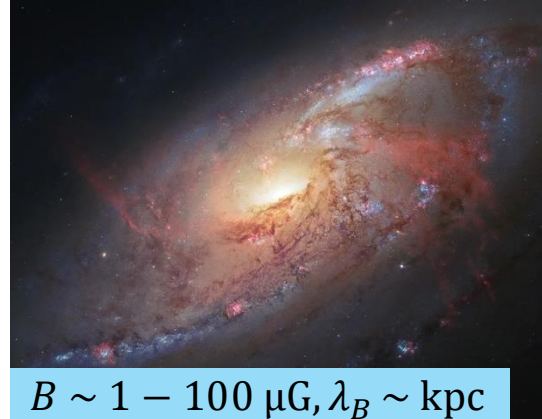
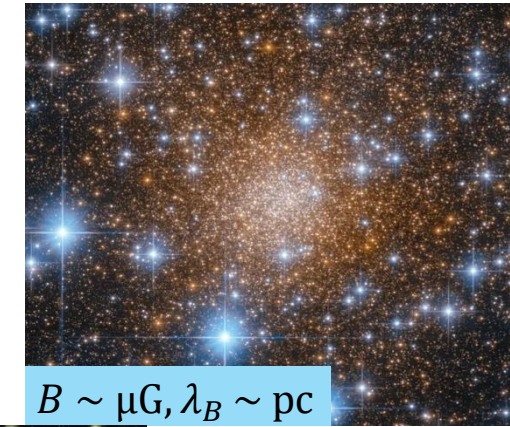
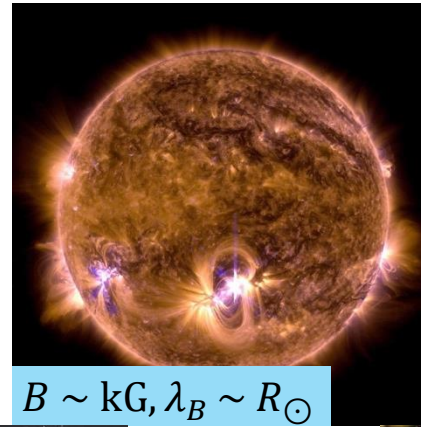


- Dynamos enhance magnetic fields in structure formation with loss of memory of the original strength (*Garaldi et al. 2021*)

Intergalactic magnetic field (IGMF) : Where is it ?

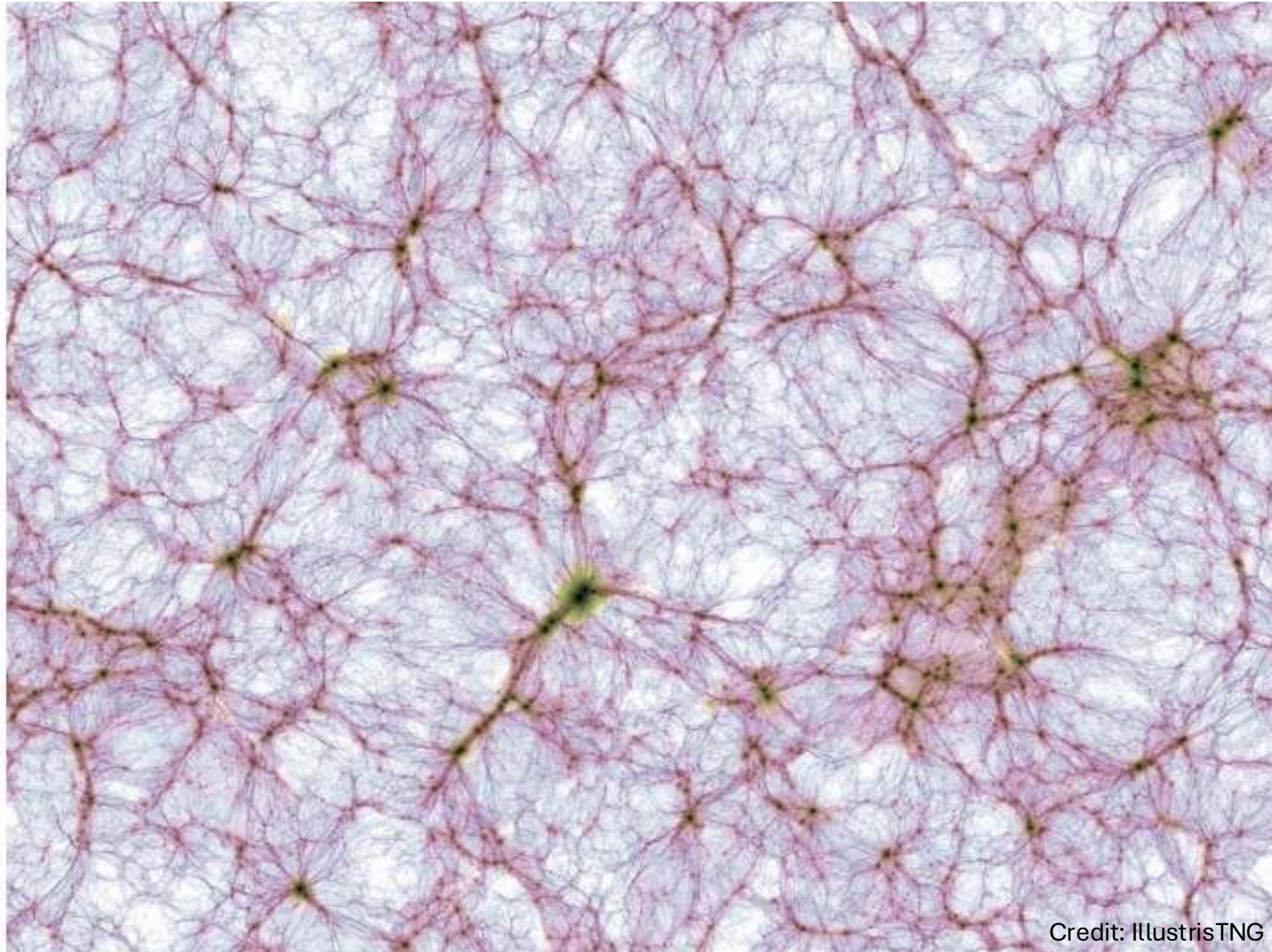


Credit: NASA



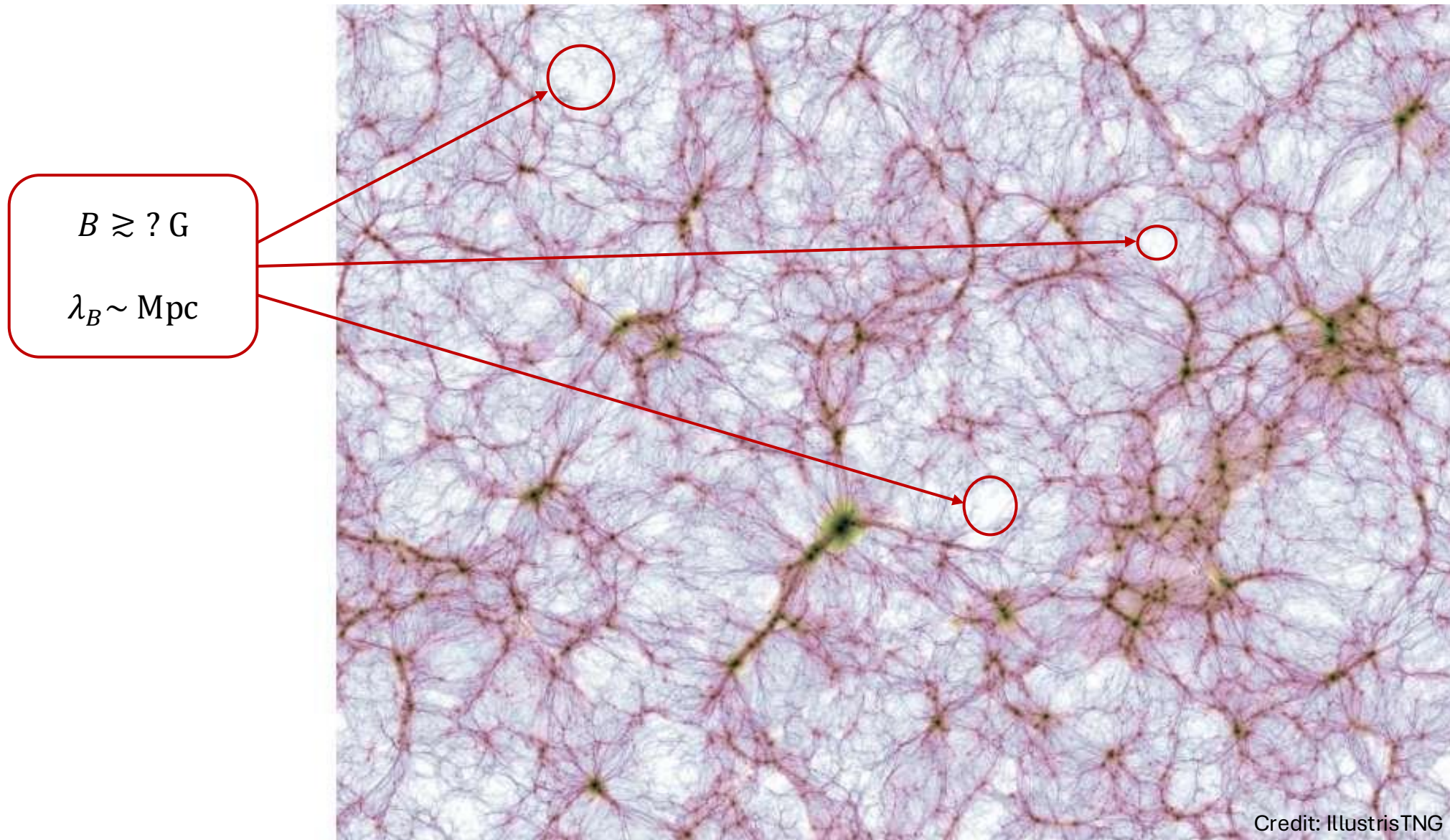
- Dynamos enhance magnetic fields in structure formation with loss of memory of the original strength (*Garaldi et al. 2021*)
- Where does the original field comes from ? → Lowest density regions of the Universe = Cosmic voids

IGMF : Where is it ?



Credit: IllustrisTNG

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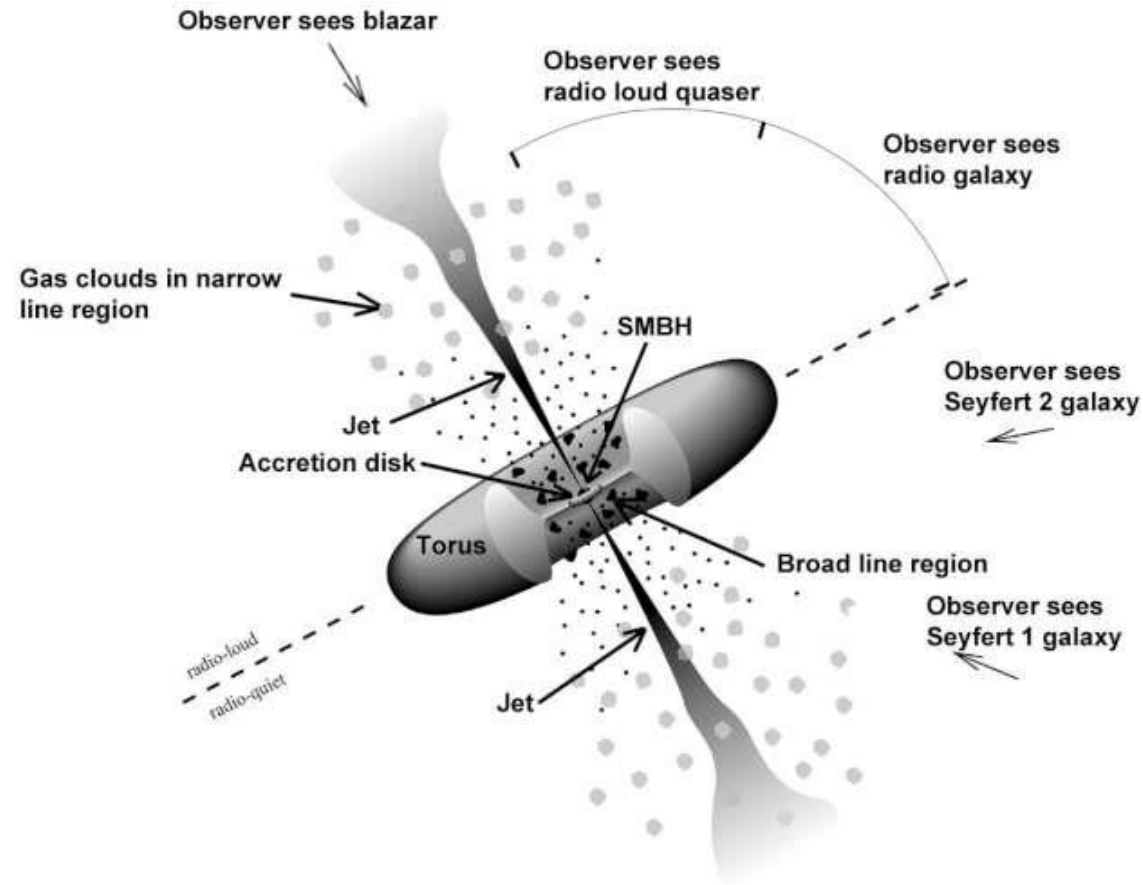


Intergalactic Magnetic Field (IGMF) :

How to constrain it ?

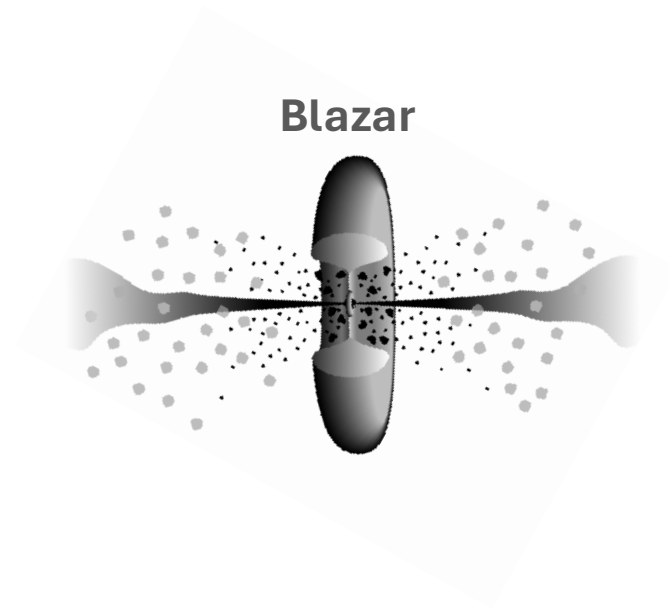
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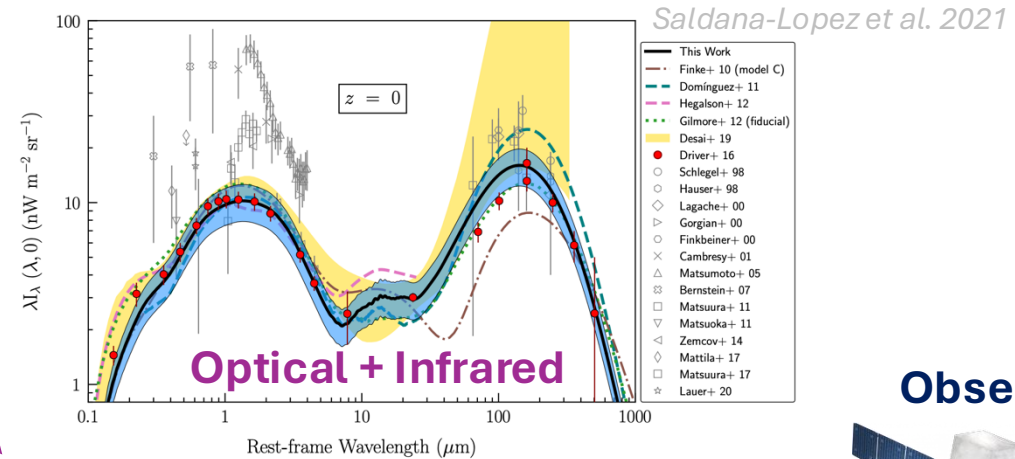
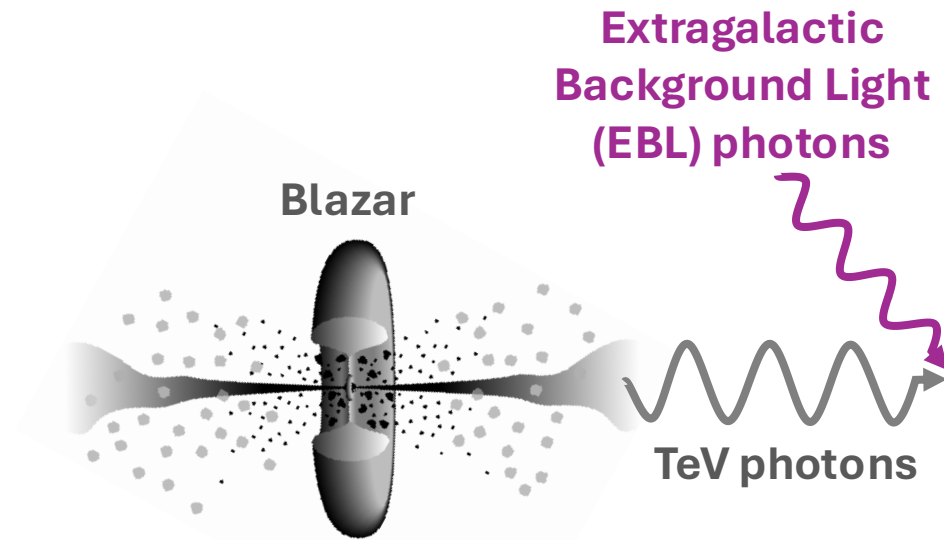
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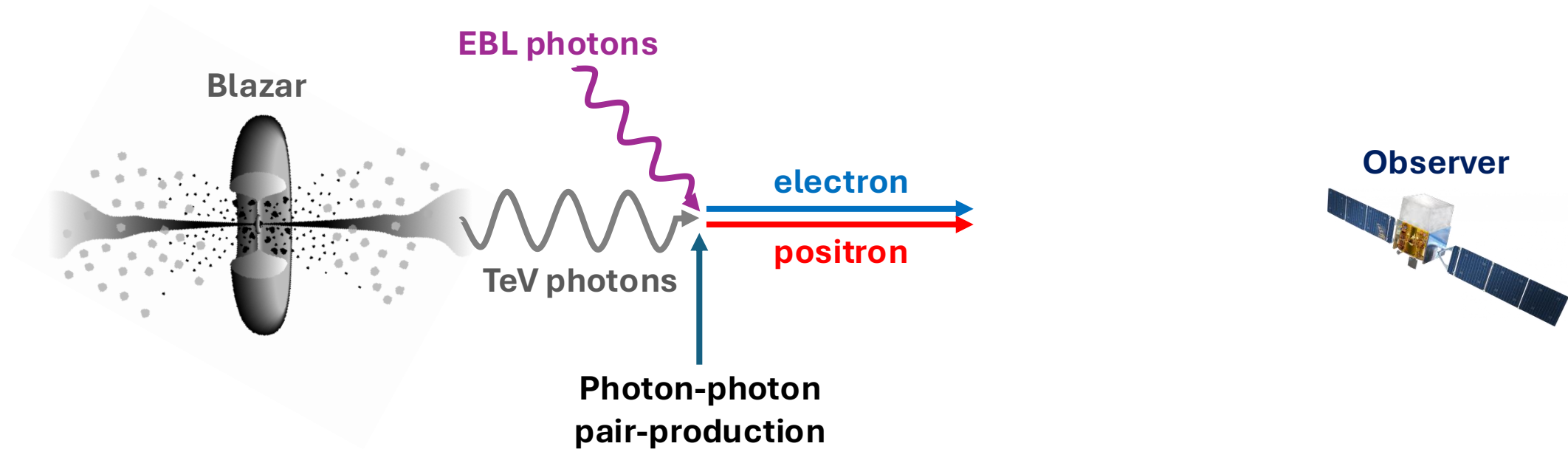
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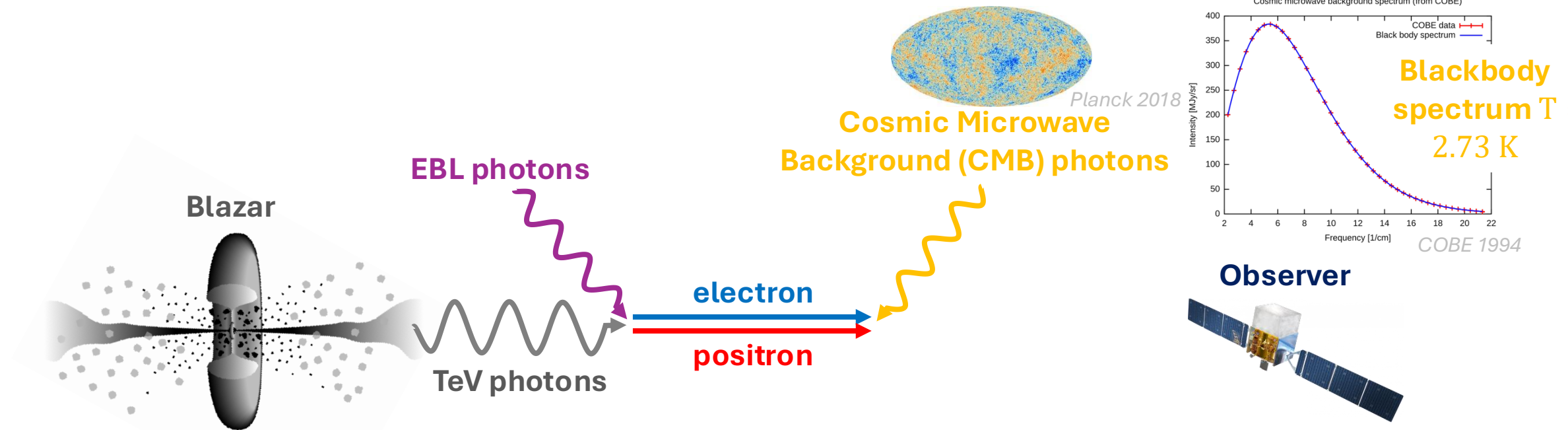
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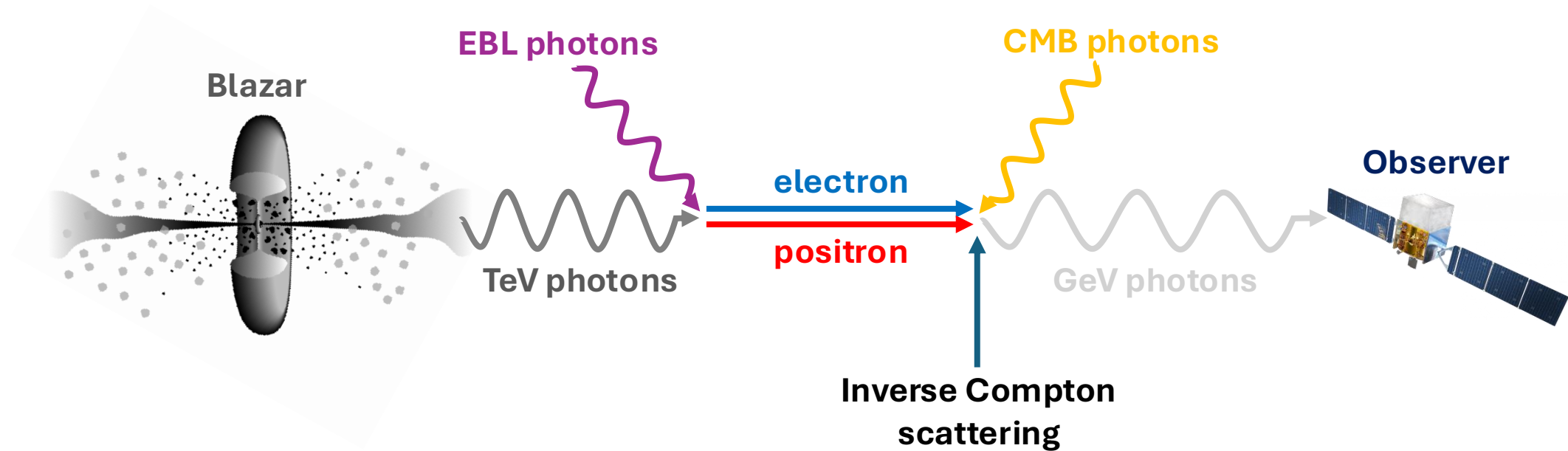
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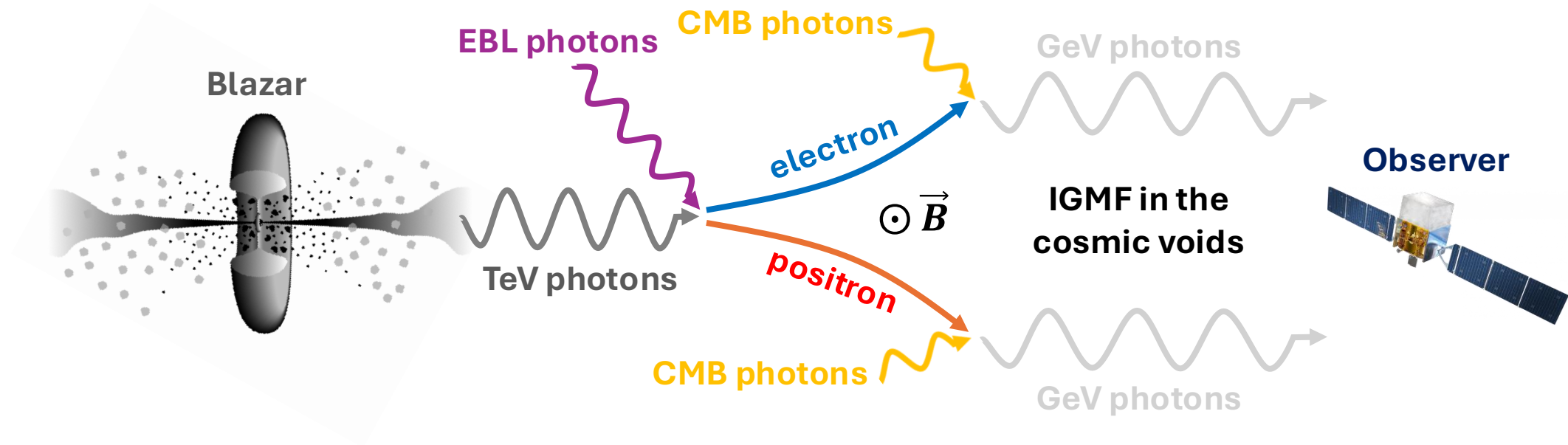
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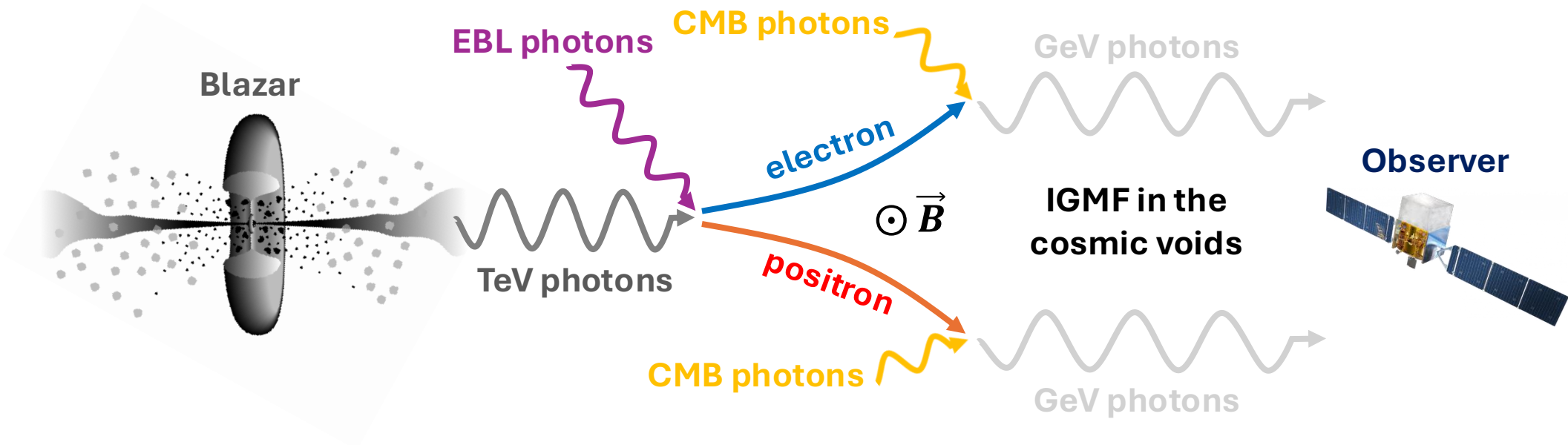
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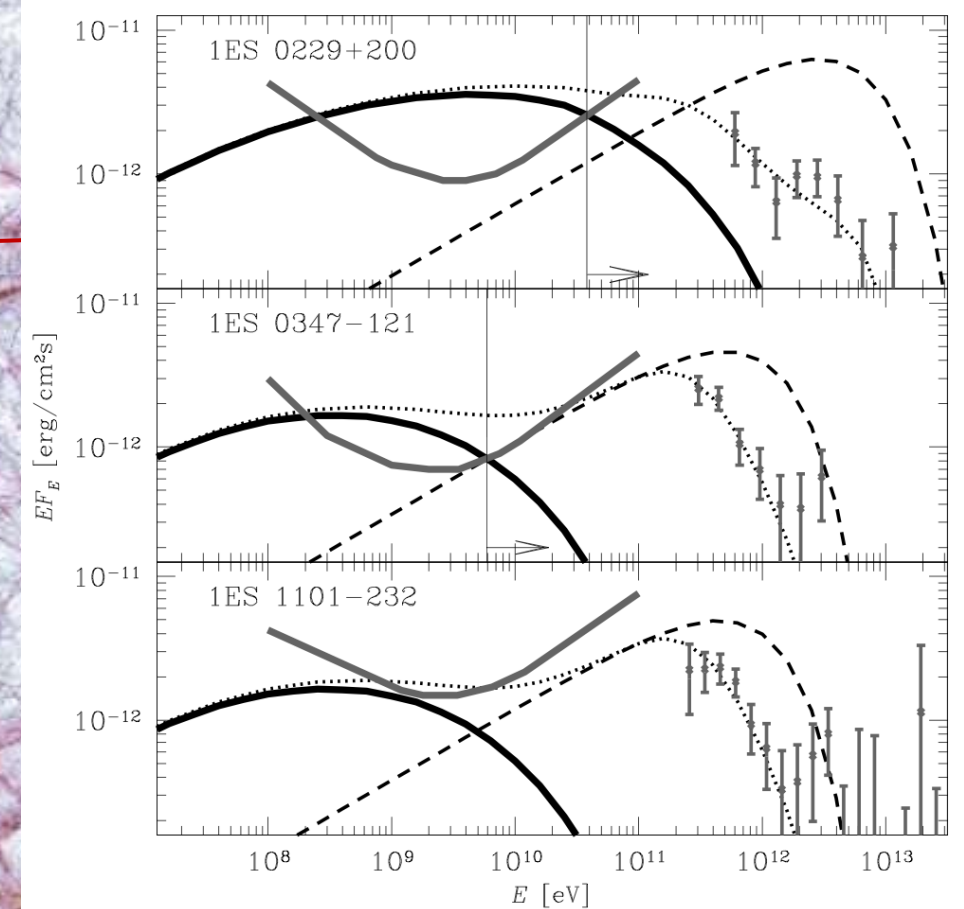
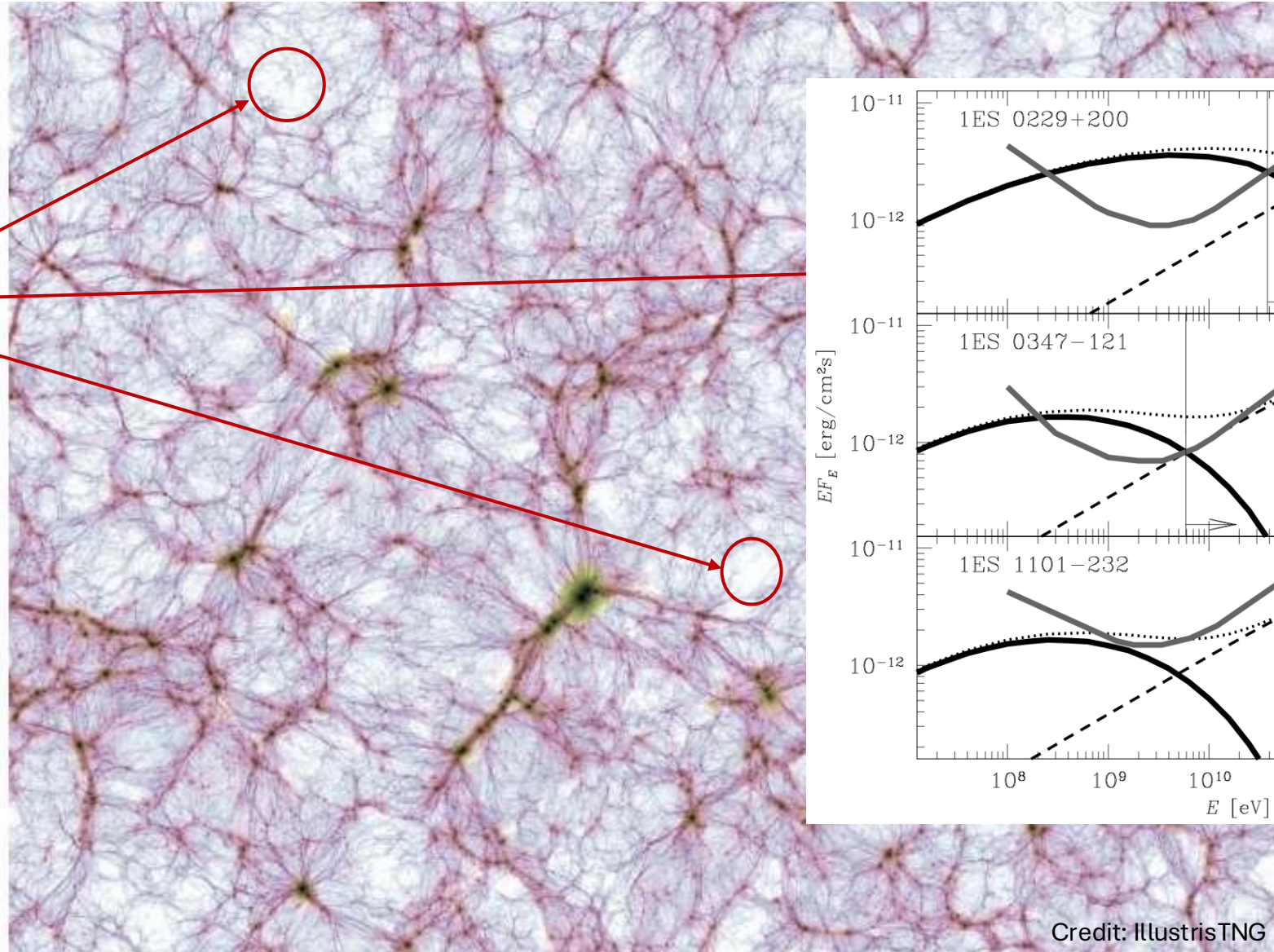
- Possibility to infer lower bound on IGMFs from modeling + observations

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$$B \gtrsim 10^{-16} \text{ G}$$

$$\lambda_B \sim \text{Mpc}$$

Non-observation
of secondary
emission from
blazars

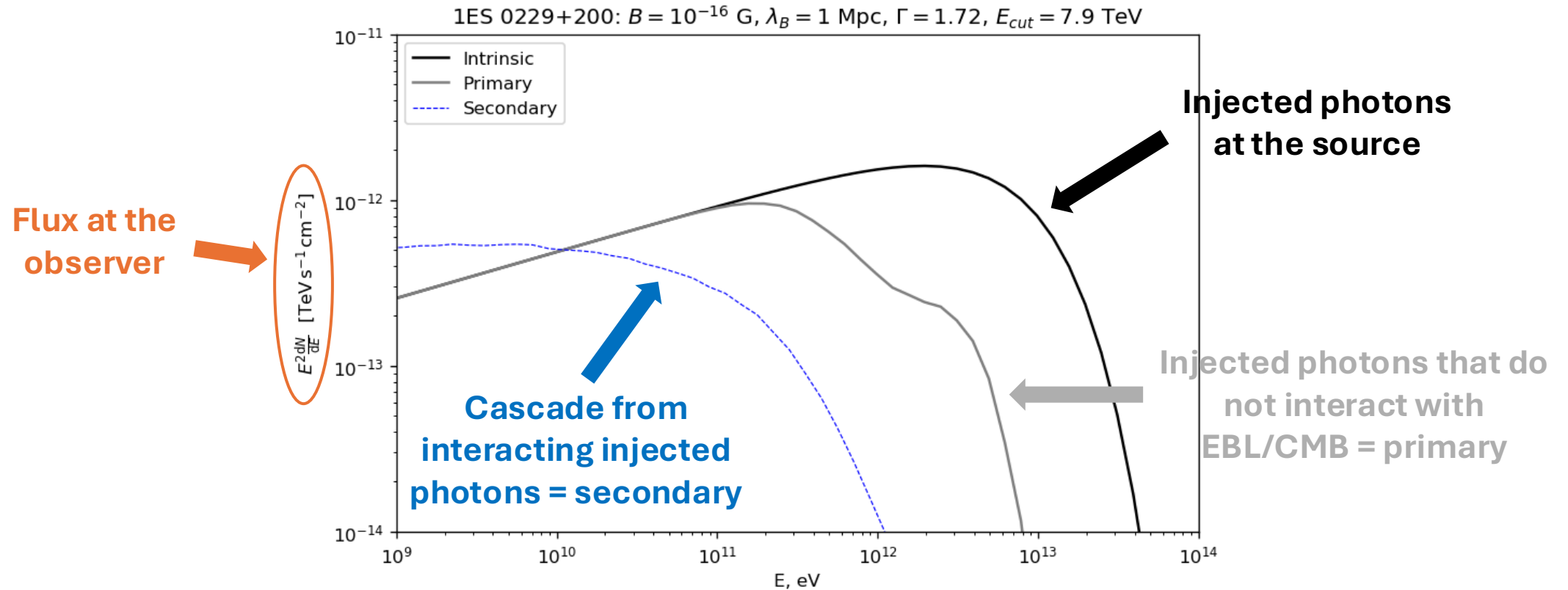


Neronov & Vovk 2010

Credit: IllustrisTNG

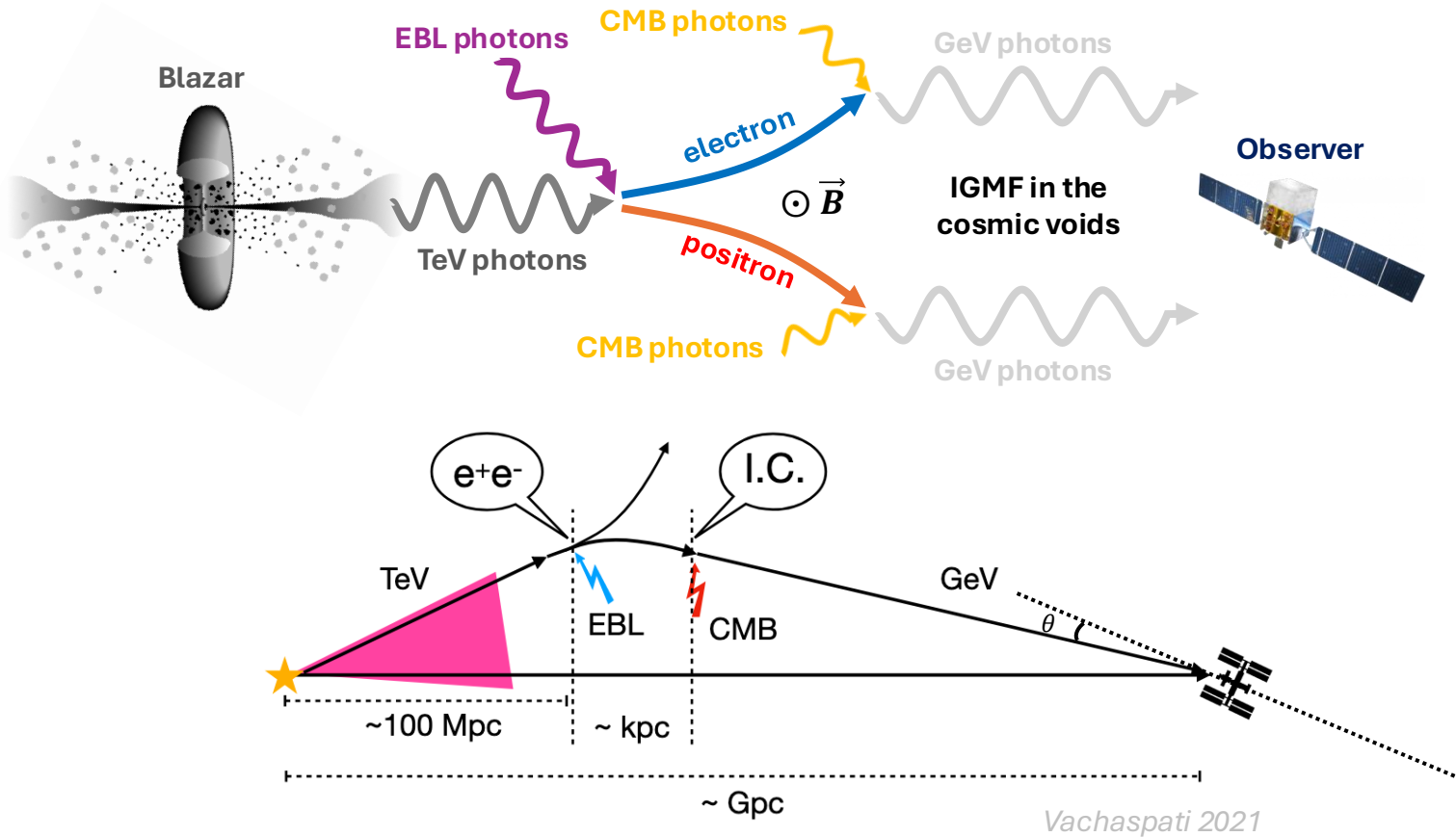
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- **The CRbeam code:** Monte Carlo code for simulating electromagnetic cascades (Pair production, Inverse Compton) through the intergalactic medium (IGM) (*Berezinsky & Kalashev 2016, Kalashev et al. 2023*)



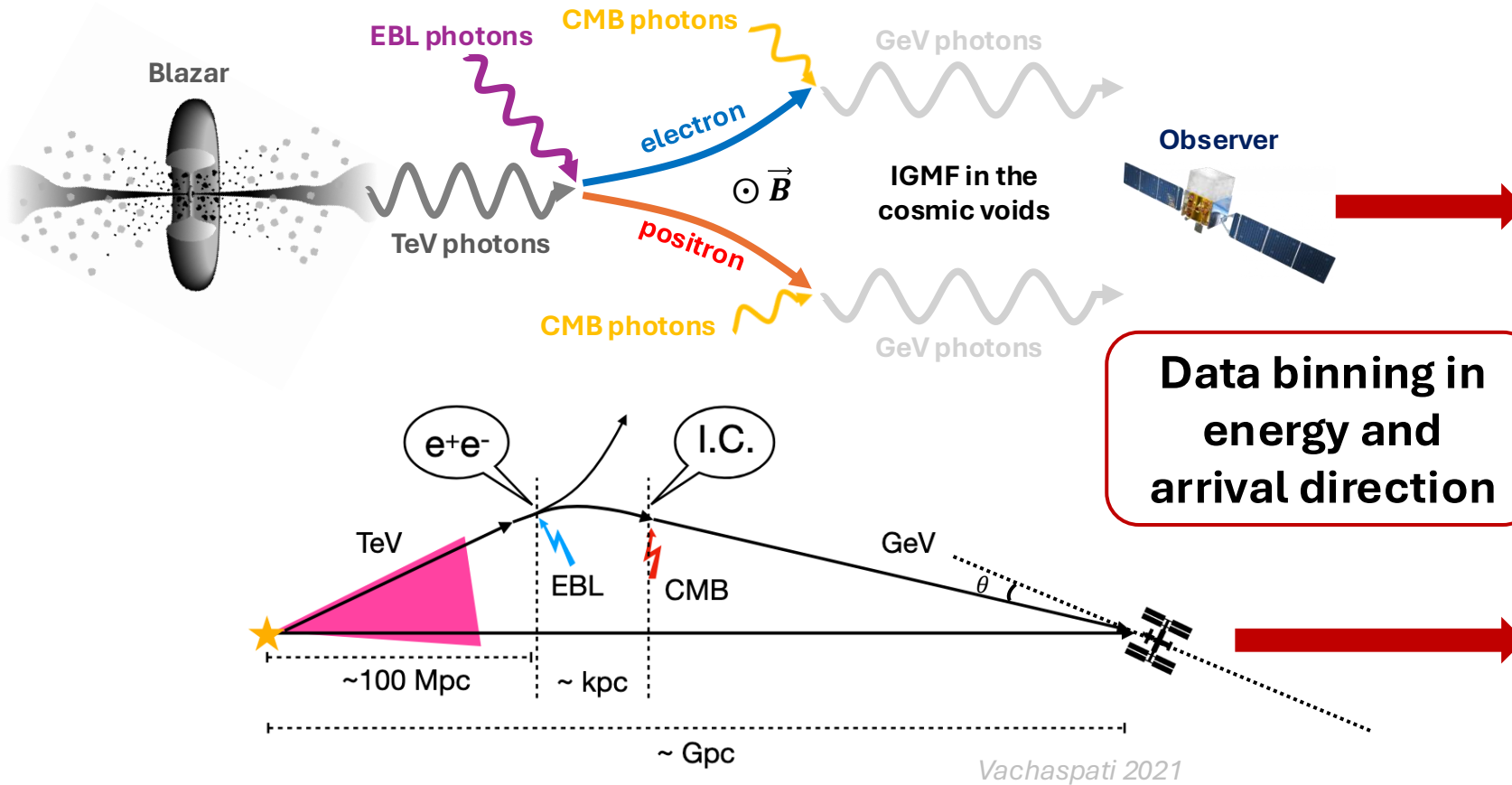
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- Secondary emission from blazars can create a halo around the source due to different arrival angles



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Thank you !