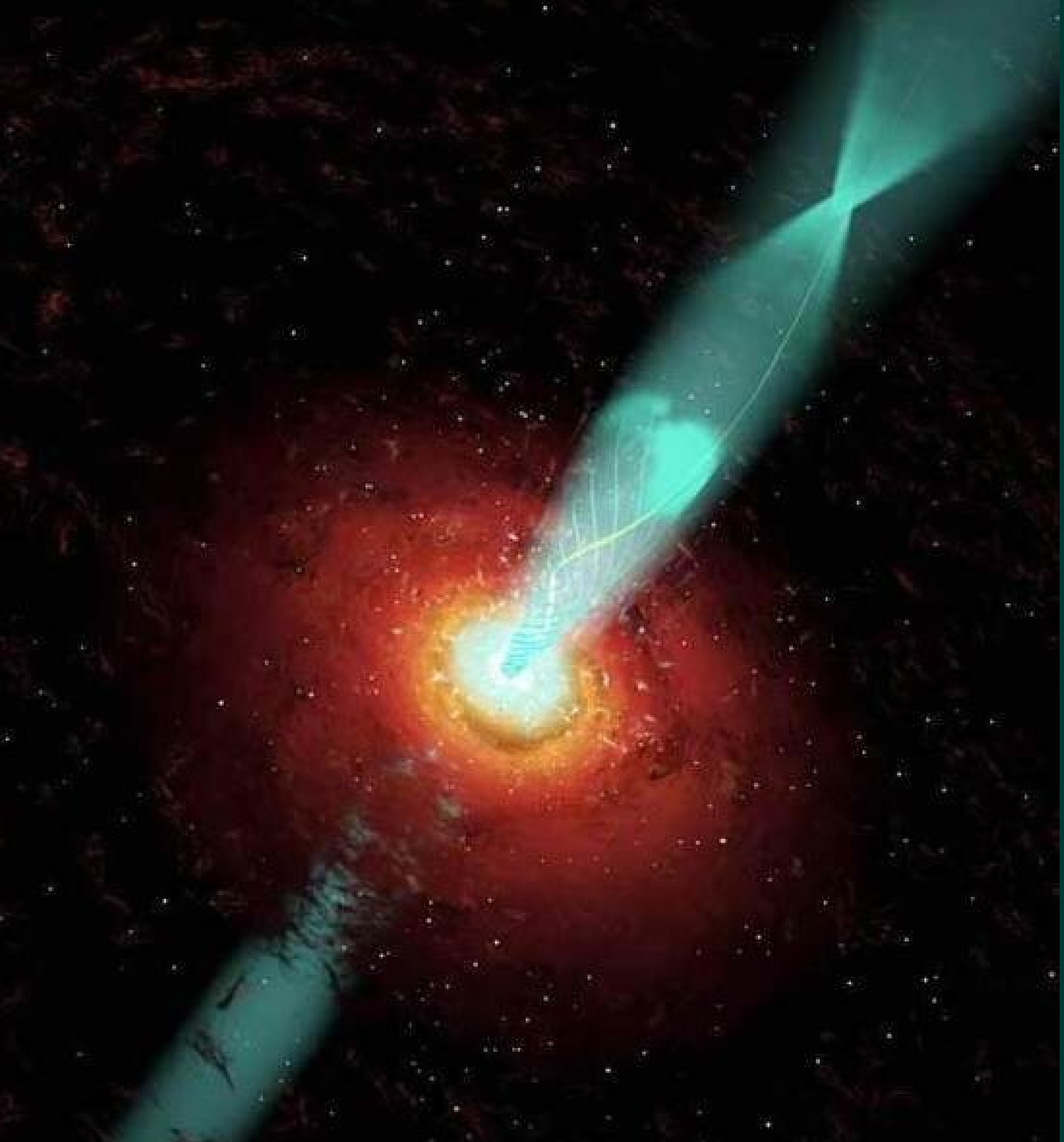


Jet Contribution to the γ-ray Luminosity in NGC1068

TevPa 2023 – Napoli, Italy

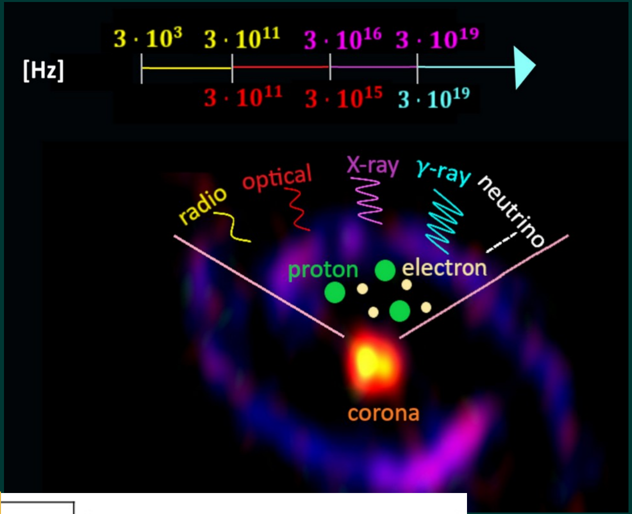
Silvia Salvatore

Ruhr Universität Bochum

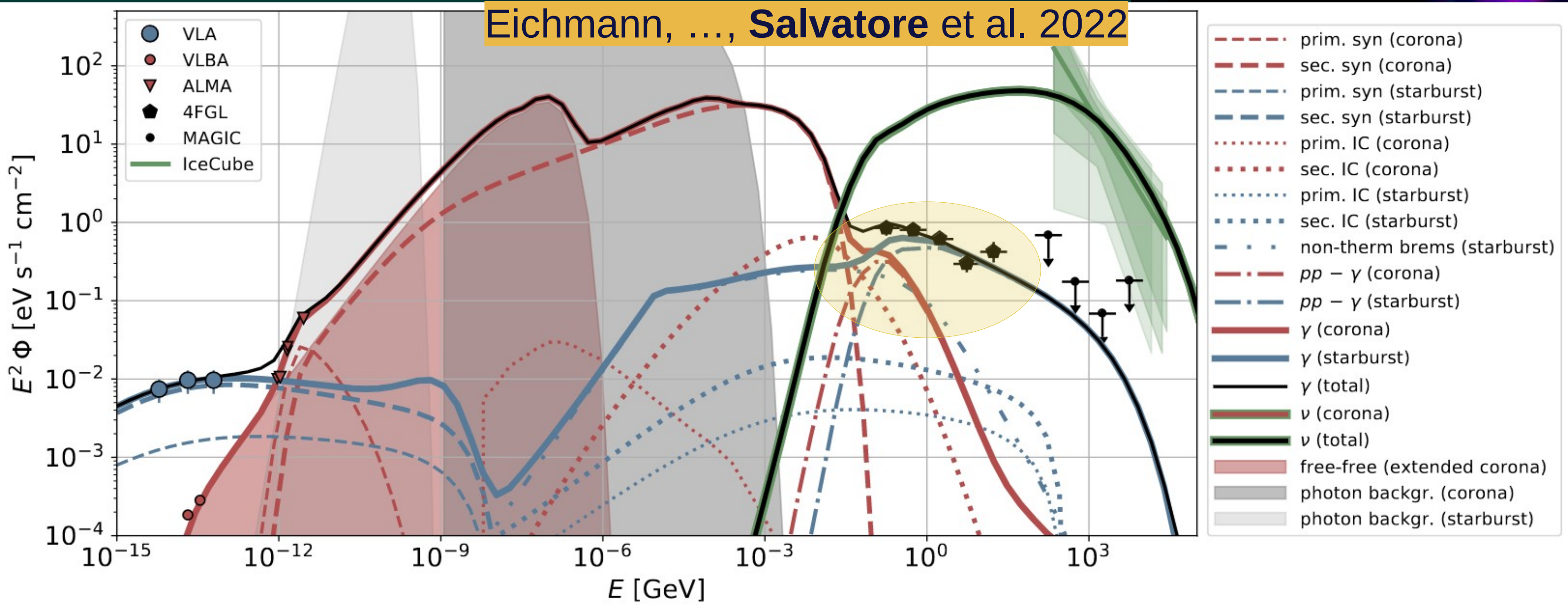
Two Zones Model

AGN corona+disk + starburst

- ALMA observations
- Significant difference in gamma-ray and neutrino flux for energies between 100 GeV and 10 TeV

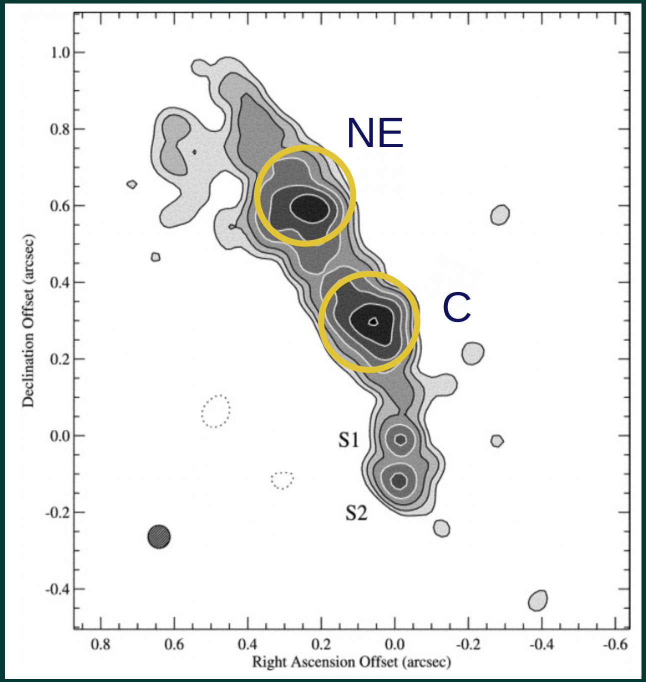


Eichmann, …, **Salvatore** et al. 2022

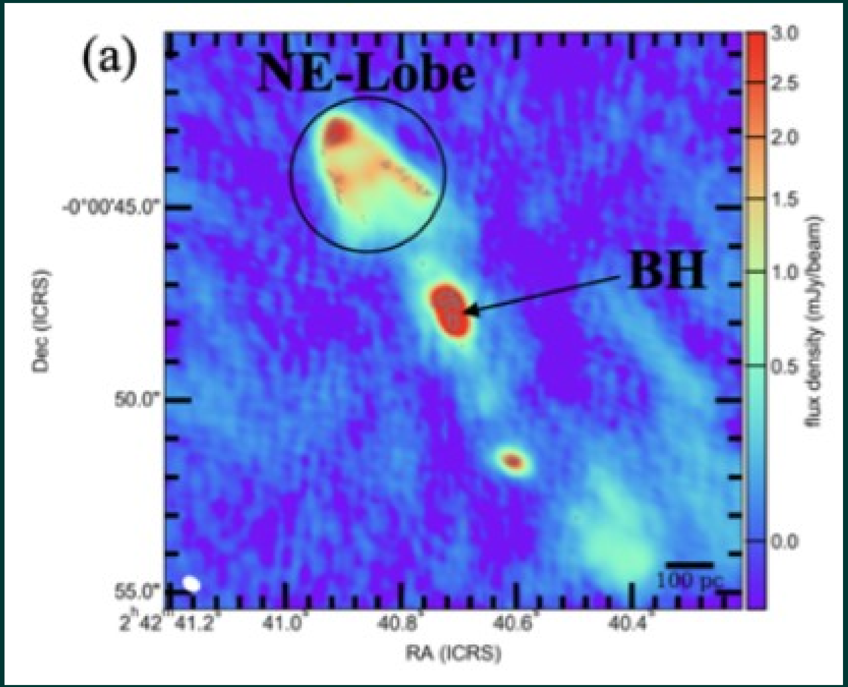


Introducing the Jet

Radio data



Gallimore et al., 2004



Michiyama et al., 2022

Introducing the Jet

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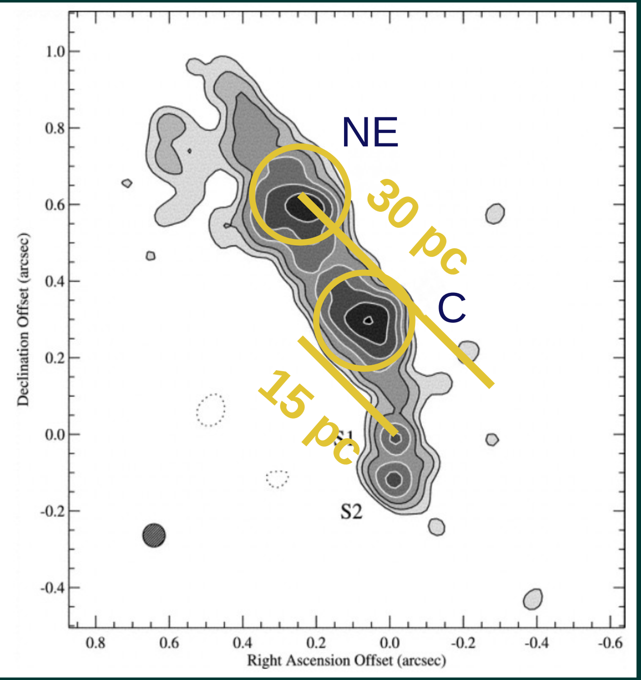

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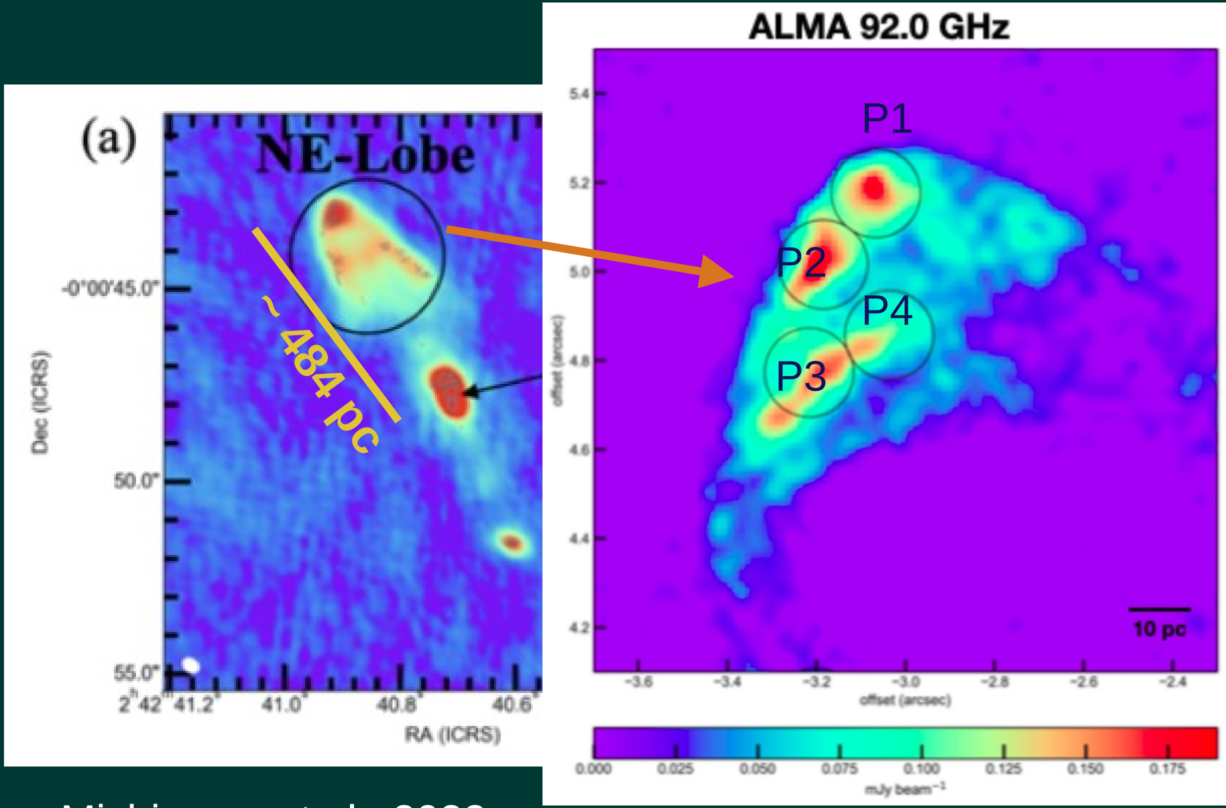

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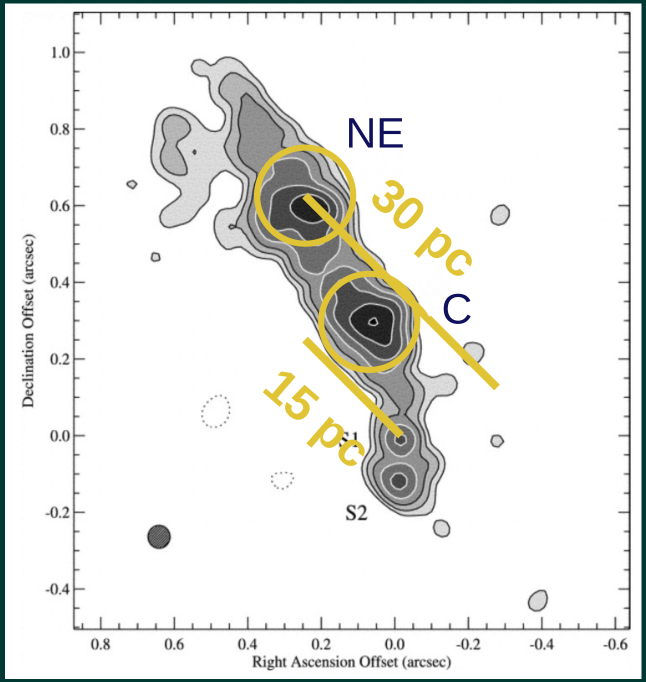
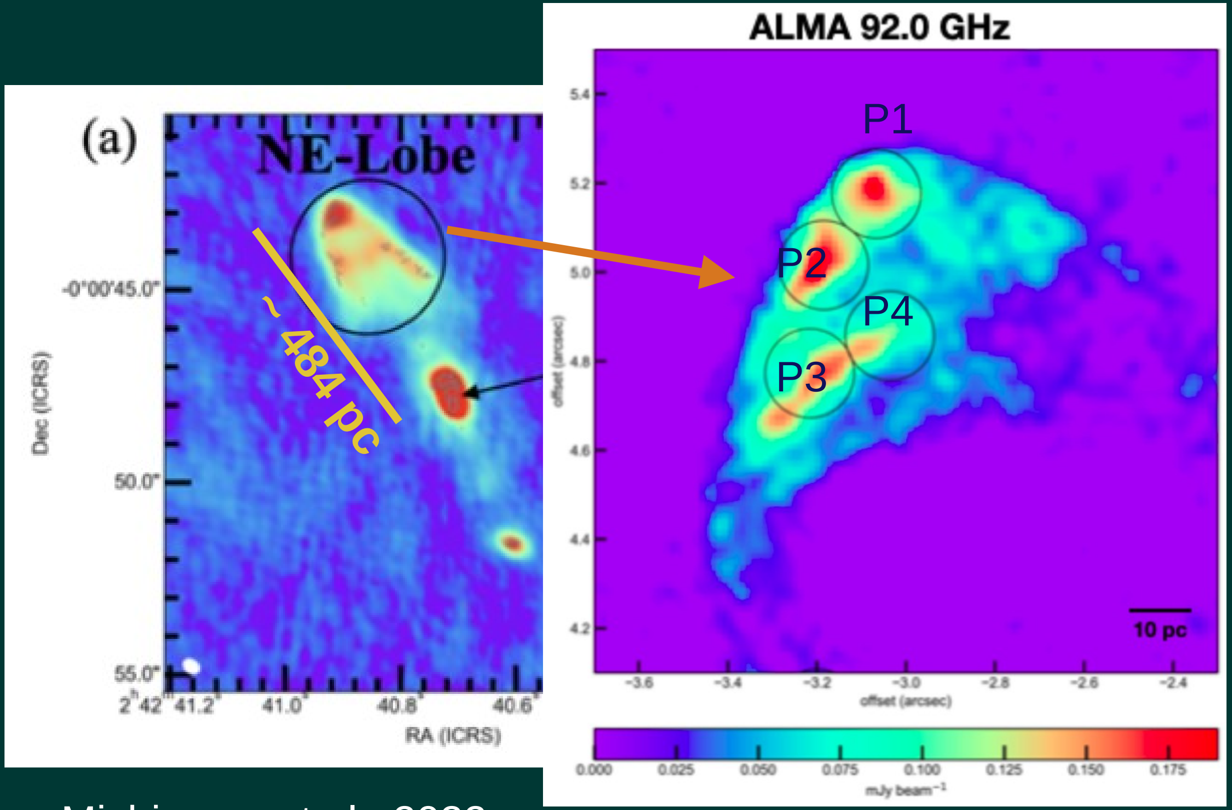




Gallimore et al., 2004 Michiyama et al., 2022

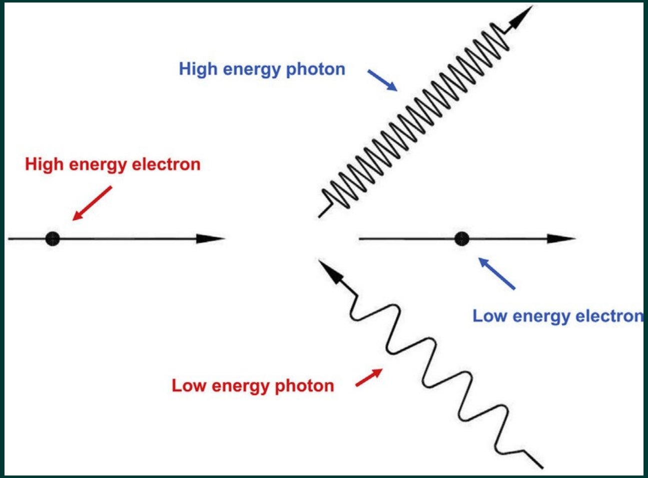
very slowly moving blobs → negligible Doppler factor

How to Produce High Energy Photons from These Blobs?

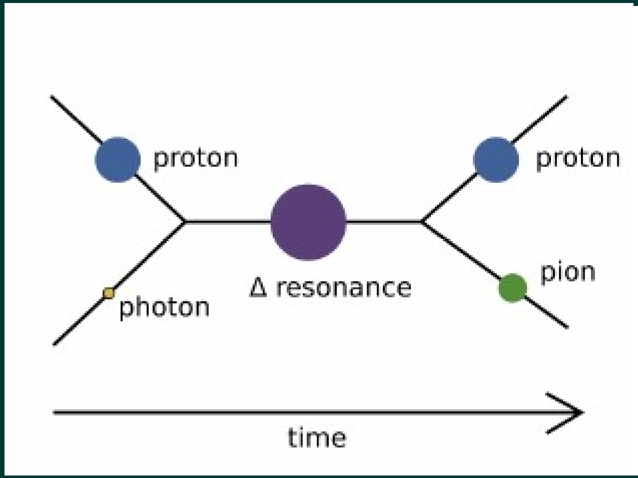
Possible γ-ray production scenarios:

- Leptonic scenario → Inverse Compton (constrained by the jet radio data)
- Hadronic scenario → pγ interaction (constrained by the jet power)

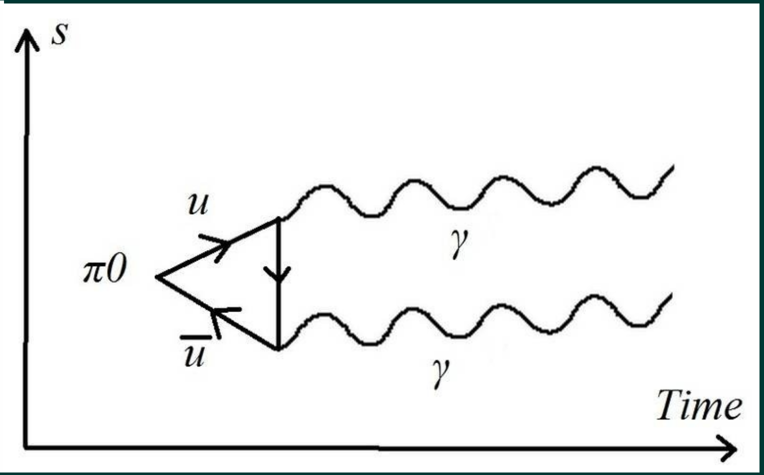
IC



pγ interaction

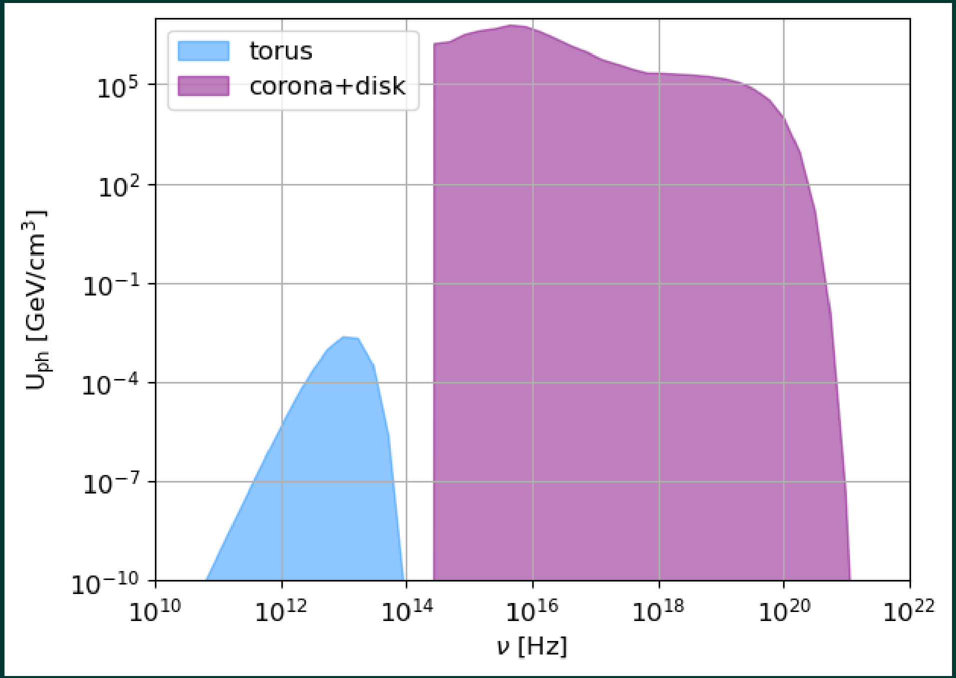


…. → pion decay



Photon Fields

Spectral distribution of the energy densities



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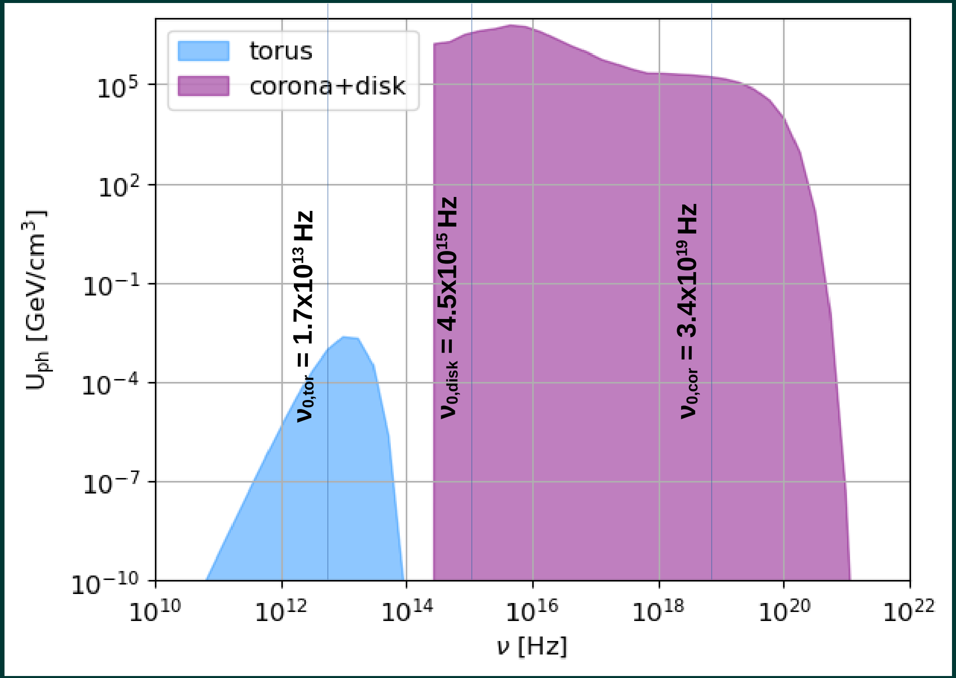

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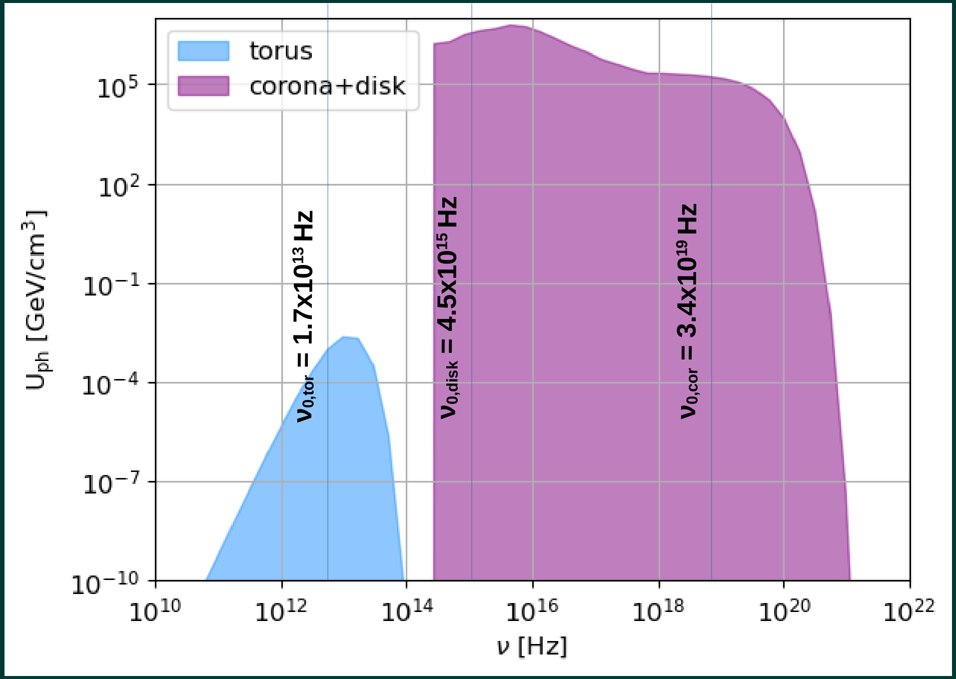
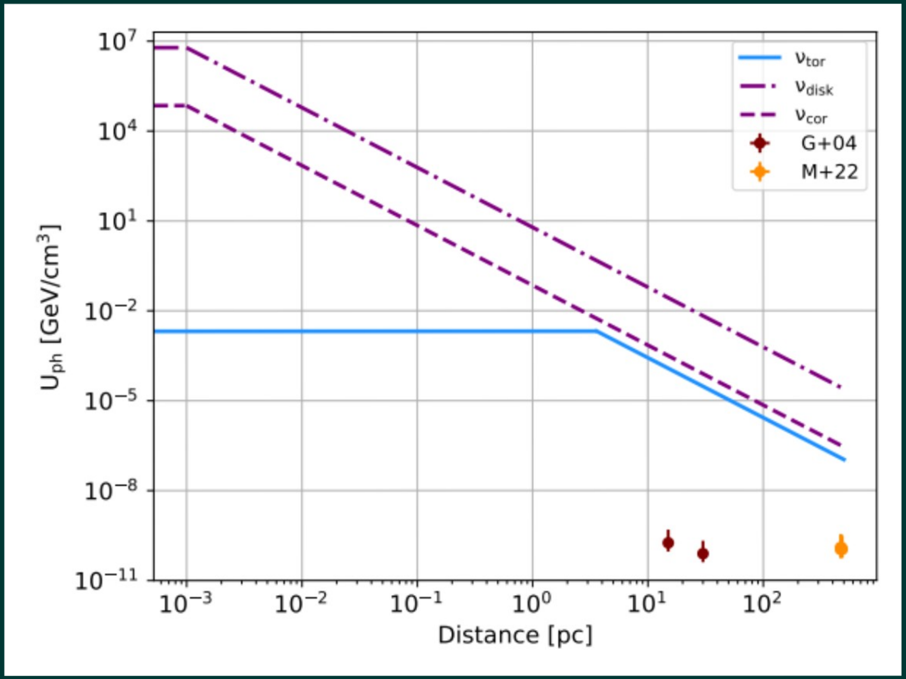


Distance dependance of the energy densities at ν_0



Leptonic Scenario

- $\varepsilon_{syn}(\nu_{syn})d\nu_{syn} \simeq P_{syn}(\gamma_e)n_e(\gamma_e)d\gamma_e/4\pi$
- $\varepsilon_{IC}(\nu_{IC})d\nu_{IC} \simeq P_{IC}(\gamma_e)n_e(\gamma_e)d\gamma_e/4\pi$

γ_e **ν_{syn}**

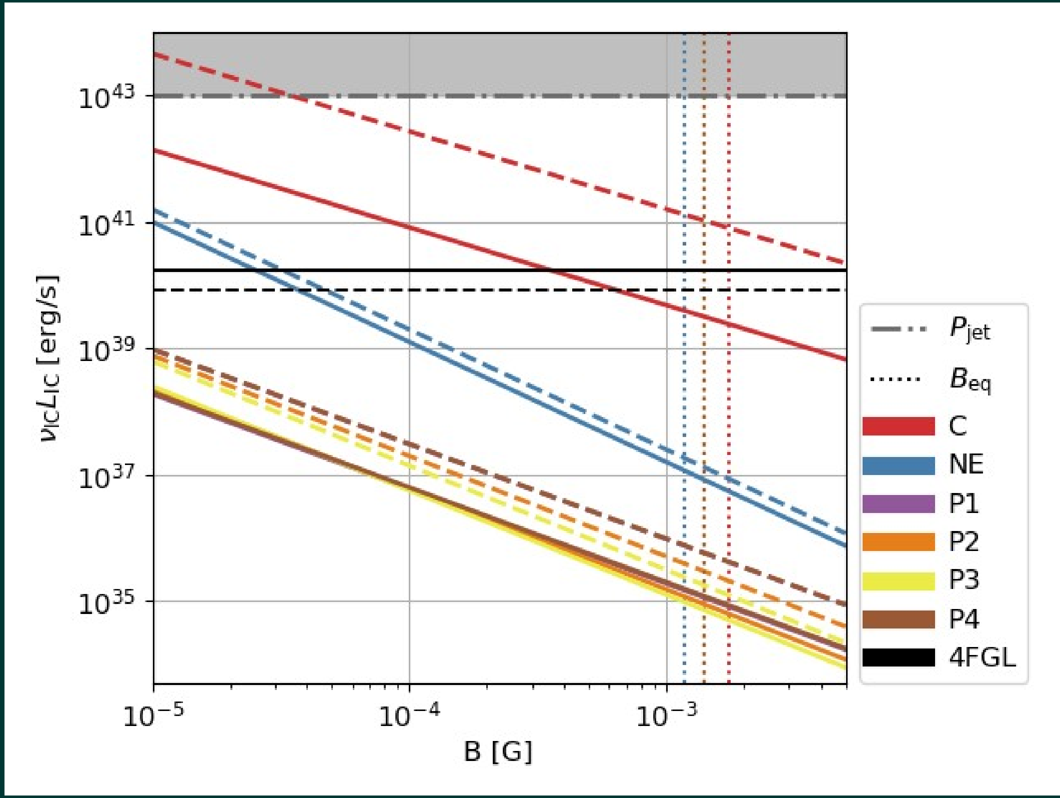
$n_e(\gamma_e)$ **ν_{IC}**

$$\nu_{IC}L_{\nu_{IC}} \simeq 2[3\nu_{IC}e/(8\pi\,\nu_{syn}\nu_0\,m_ec)]^{(3-q_e)/2}\,\nu_0L_{\nu0}B^{-(1+q_e)/2}\nu_{syn}L_{\nu_{syn}}/d^2c$$

Leptonic Scenario

	d [pc]	r_b [pc]	ν_{obs} [GHz]	$\nu_{obs} L_{\nu_{obs}}$ [10^{36} erg/s]	α
C	21	2.5	5	6.4	0.23
NE	43	4.6	5	9.5	0.90
P1	484	3.5	92	7.6	0.50
P2	477	3.5	92	8.6	0.59
P3	468	3.5	92	8.8	0.65
P4	468	3.5	92	7.5	0.50

- ν_{IC} → Fermi-LAT band between $\nu_{IC,low}$ = 0.18 GeV/h (_____) and $\nu_{IC,high}$ = 17.20 GeV/h (------)



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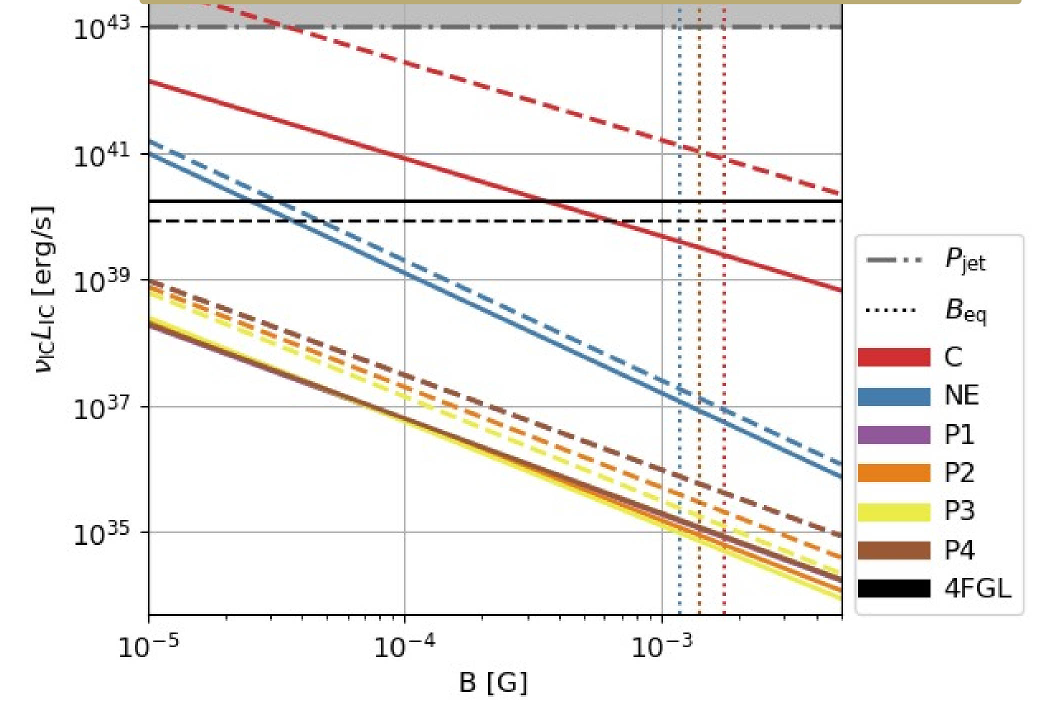
$$B_{eq} = (4.5)^{2/7}(1+k)^{2/7} c_{syn}^{2/7} r_b^{-6/7} \left(\nu_{syn} L_{\nu_{syn}}\right)^{2/7}$$



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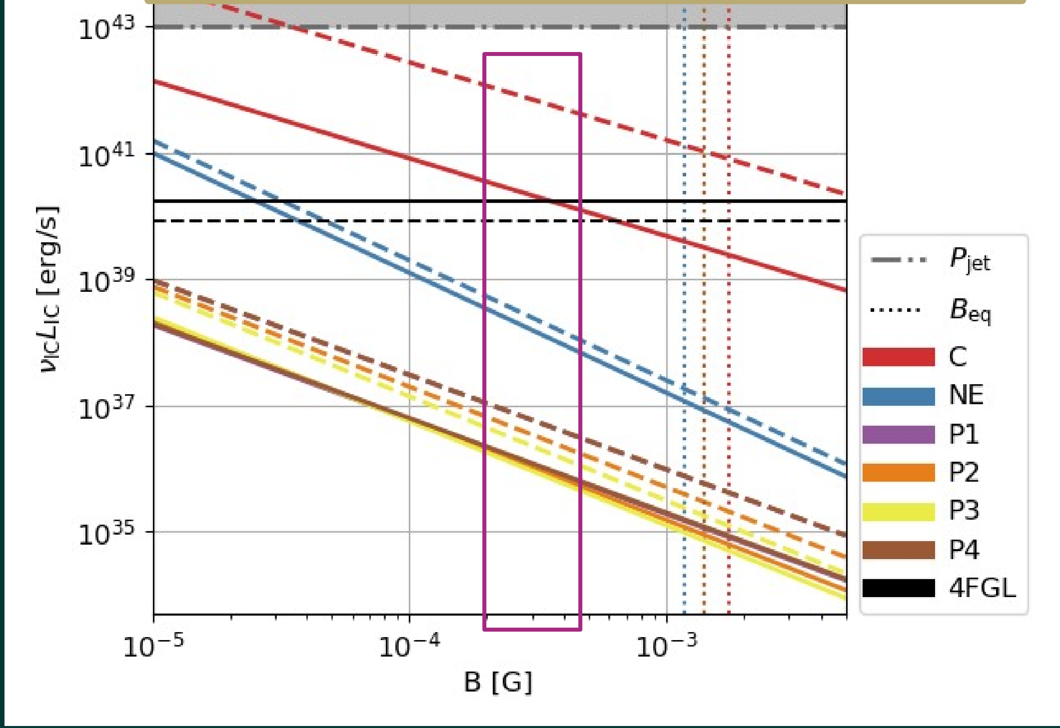

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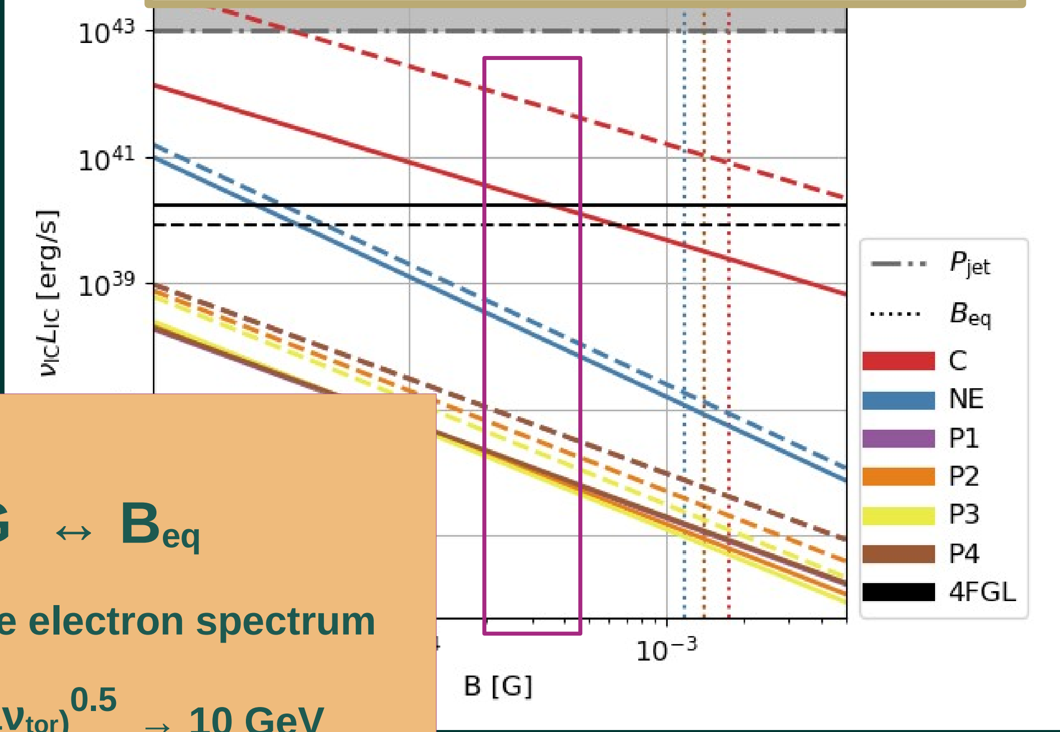

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B ~ 0.3 mG ↔ B_{eq}

softening of the electron spectrum

at $\gamma_e = (3\nu_{IC,low} / 4\nu_{tor})^{0.5}$ → 10 GeV

Hadronic Scenario

$$\nu_{\pi\gamma}L_{\nu\pi\gamma}= r_b(h\nu_{\pi\gamma})^2A_\gamma f_{jet}P_{jet}(2-q_p)\gamma_p^{-q_p-2}/(3m_pc^3(\gamma_{p,max}^{2-q_p}-\gamma_{p,min}^{2-q_p}))\int_{\epsilon_l'/2\gamma_p}^{\infty}d\epsilon\, n_{ph}(\epsilon)f(\gamma_p,\epsilon)/\epsilon^2$$

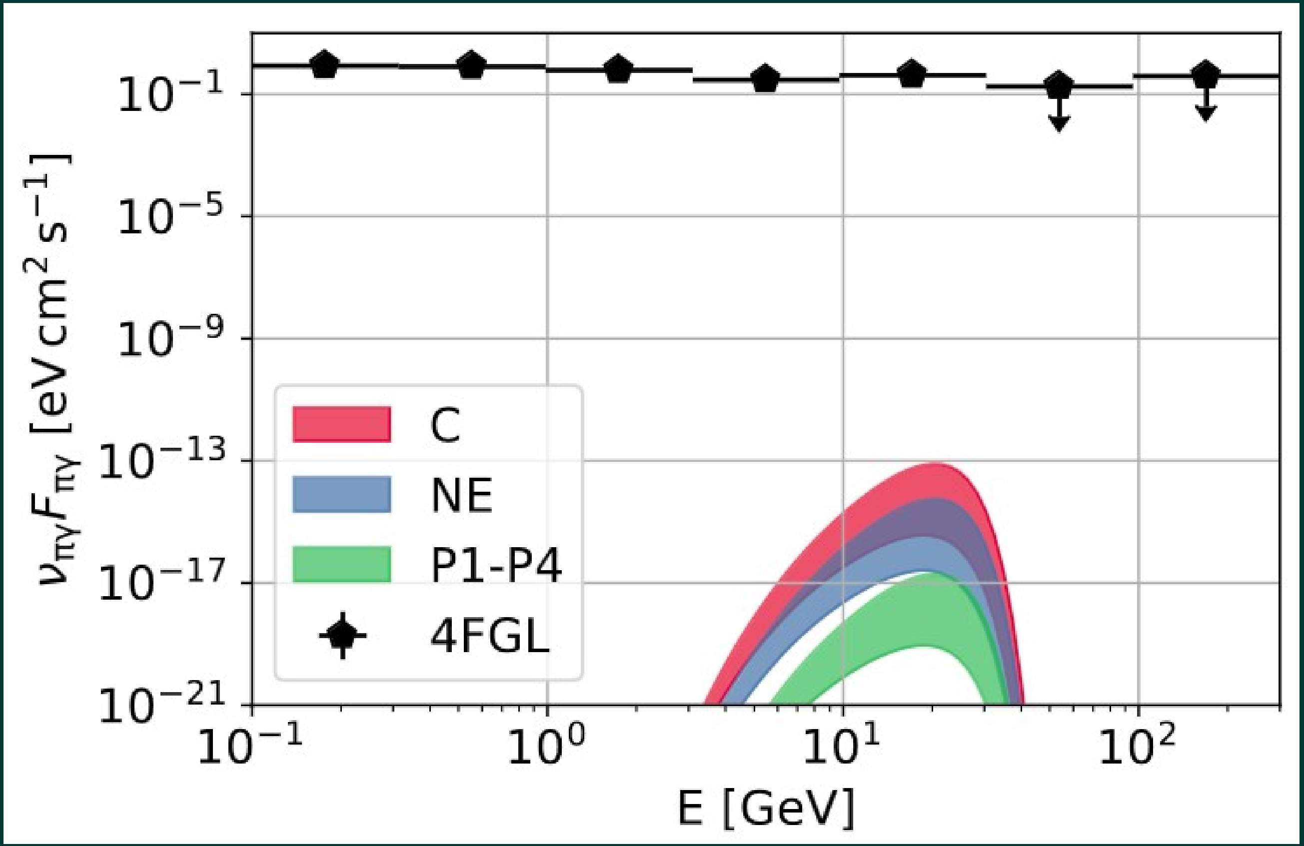
P_{jet} **f_{jet}** **q_p**

$\gamma_{p,min}$ **$\gamma_{p,max}$**

n_{ph}

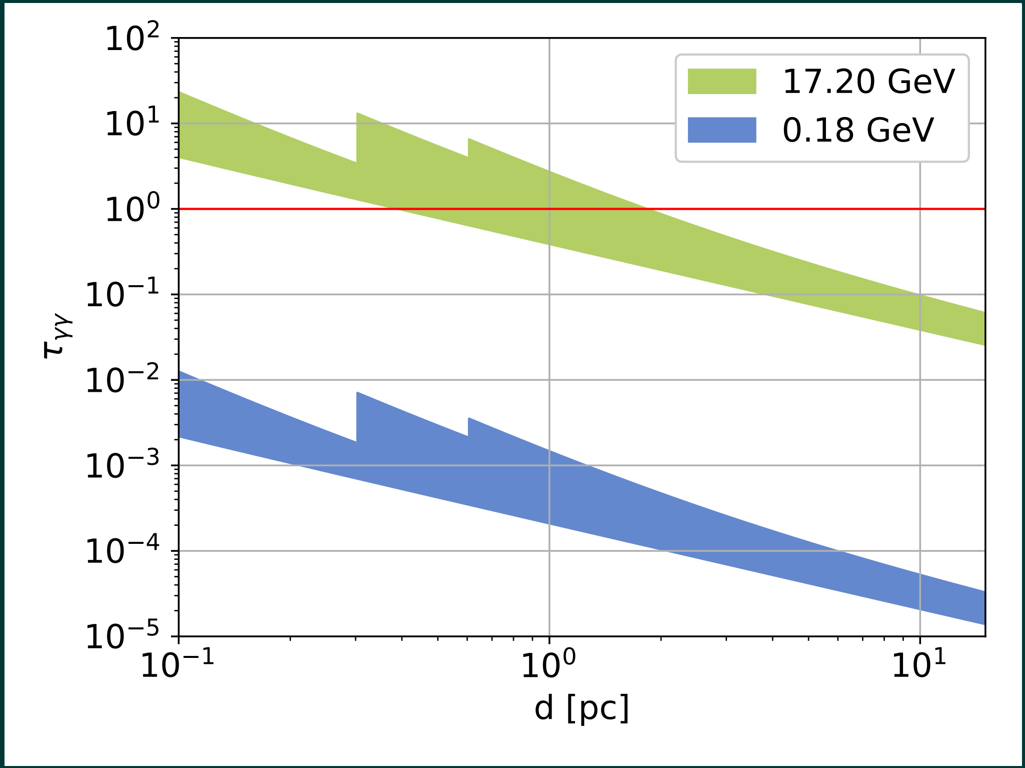
Hadronic Scenario

- $f_{jet} = 0.5$
- $P_{jet} = 10^{43}$ erg/s
- $\gamma_{p,min} = 1, \quad \gamma_{p,max} = 200$
- $q_p \rightarrow (1,3)$



Sub-pc Scales Emission Sites?

Optical thickness evolution for different r_b evolution scenarios



Conclusions

- The leptonic scenario → unlikely

  most likely candidate → Blob C (~ 15 pc from BH) :
  - ⩾ B ~ 0.3 mG
  - ⩾ softening of electron spectrum at ~ 10 GeV

  agreement with Lenain et al. (2010) : $d_{b\text{-}tor}$ = 65 pc → our approach: radio features are accounted for
  r_b = 7 pc
  B = 0.1 mG

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