A New Probe of Relic Neutrino Clustering using Decaying Heavy Dark Matter

Writasree Maitra

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with Vedran Brdar, Bhupal Dev and Anna M. Suliga

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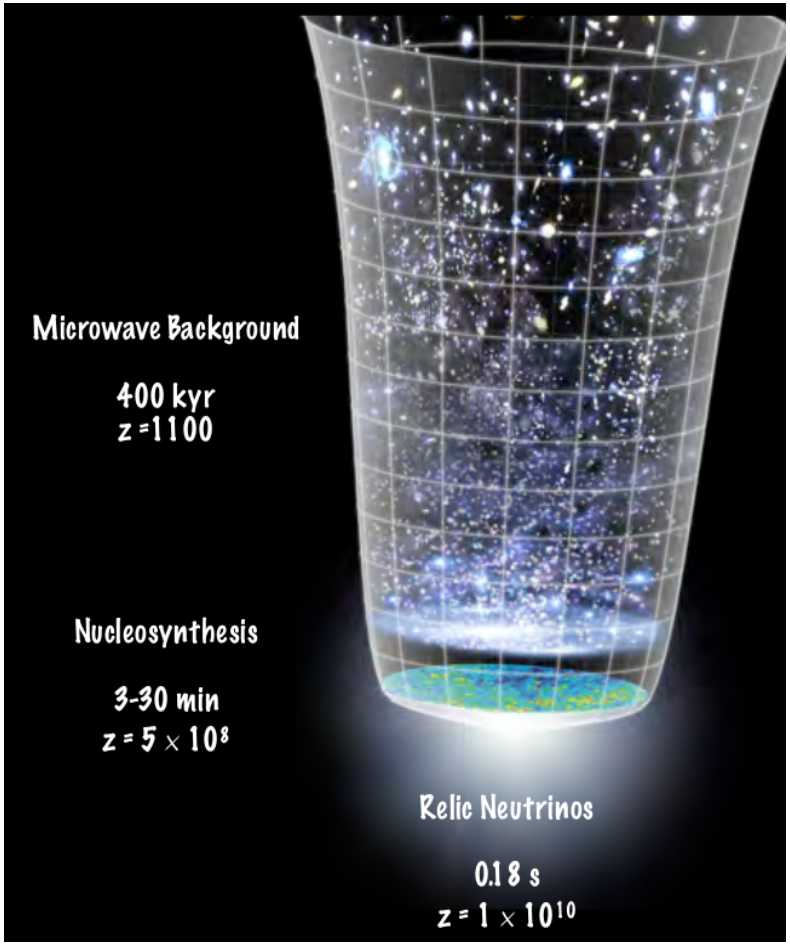
Relic Neutrinos



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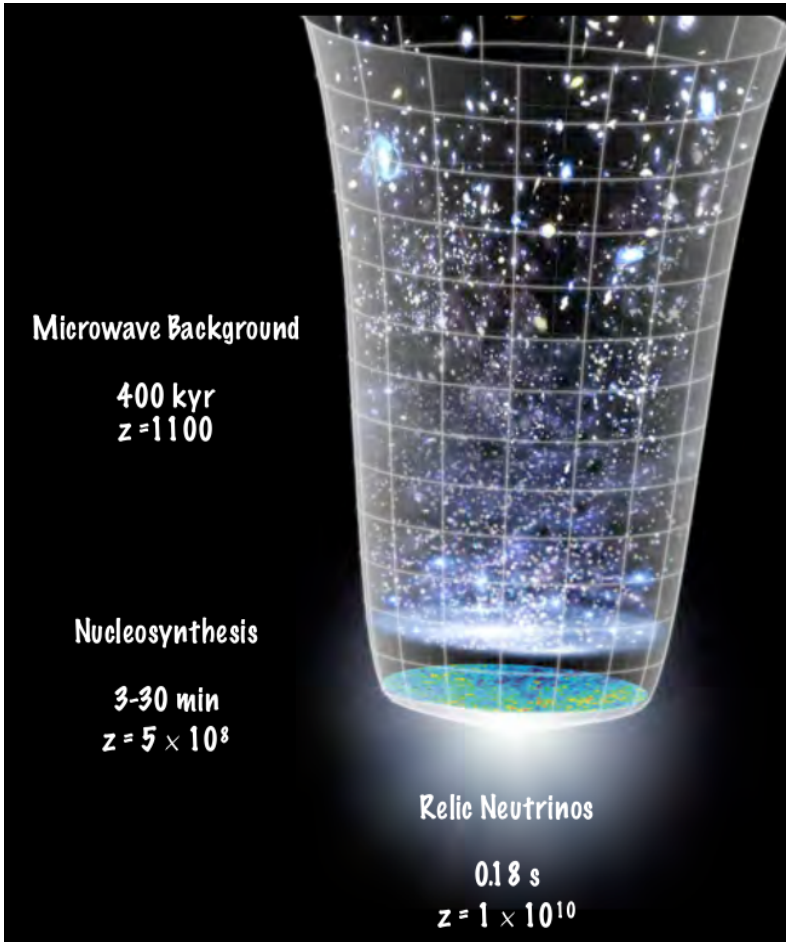

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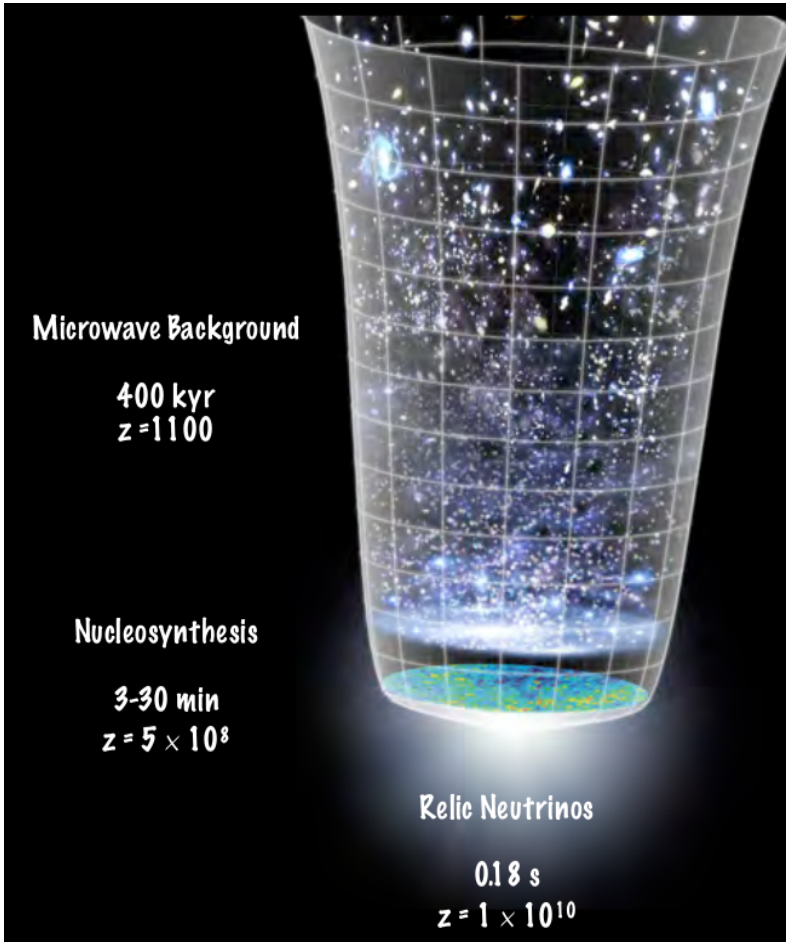

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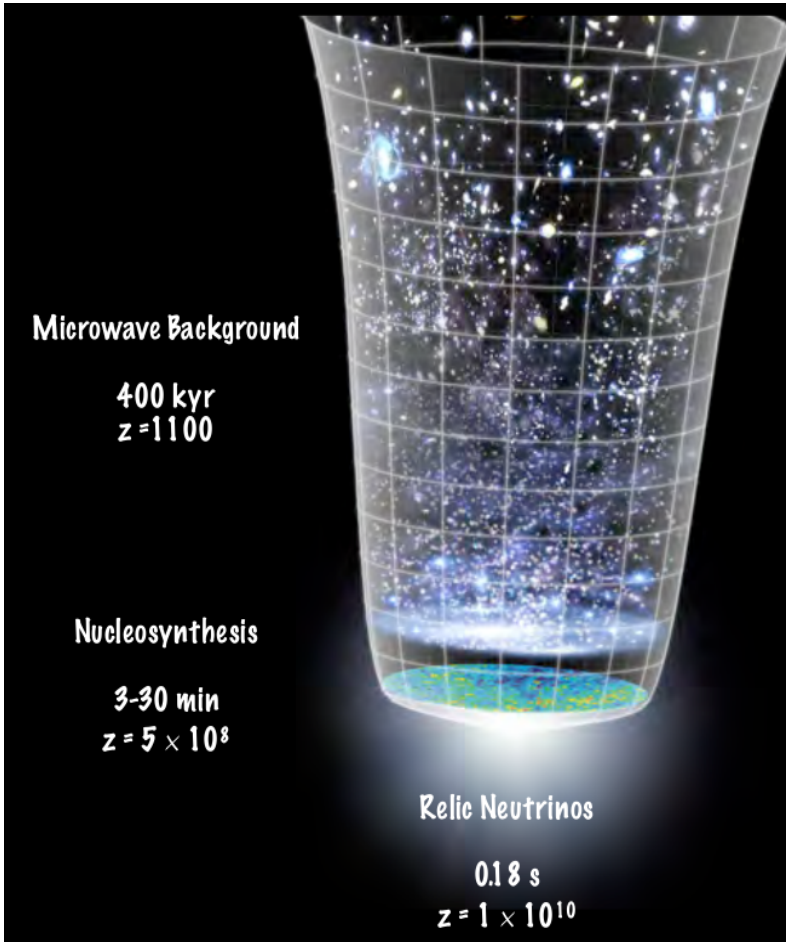

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- Detection of CνB will validate modern cosmological theory.
- It will provide a window to the first second of creation of the universe.

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- The current strongest experimental constraint on the local neutrino overdensity from the KATRIN experiment is $\xi < 1.1 \times 10^{11}$ (95% CL).

Existing probes and their difficulties

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- Direct detection experiments: KATRIN, PTOLEMY

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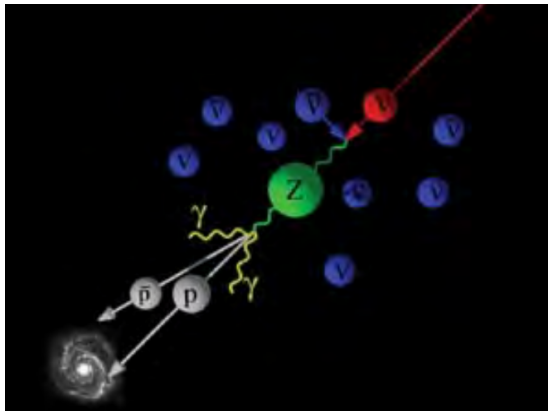

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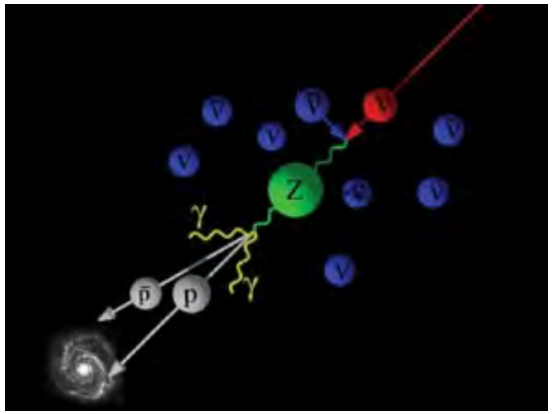

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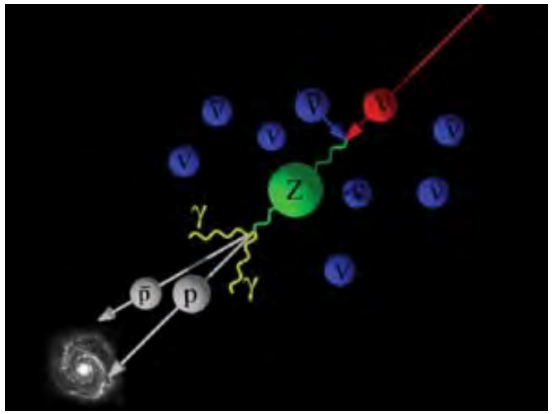

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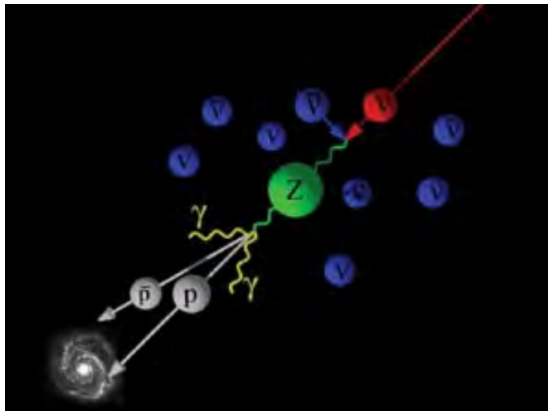

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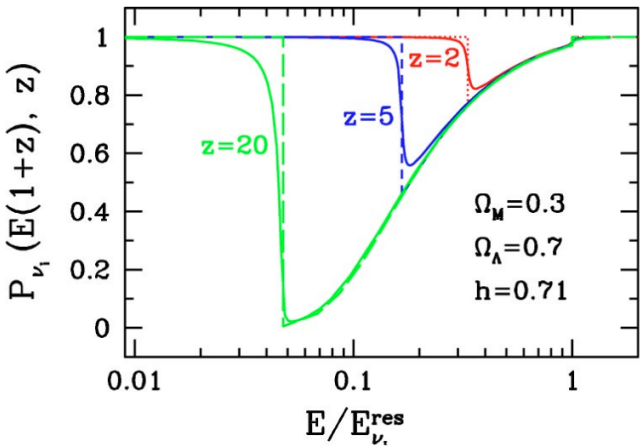

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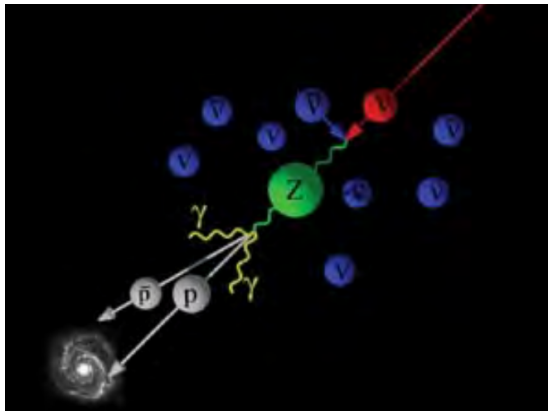

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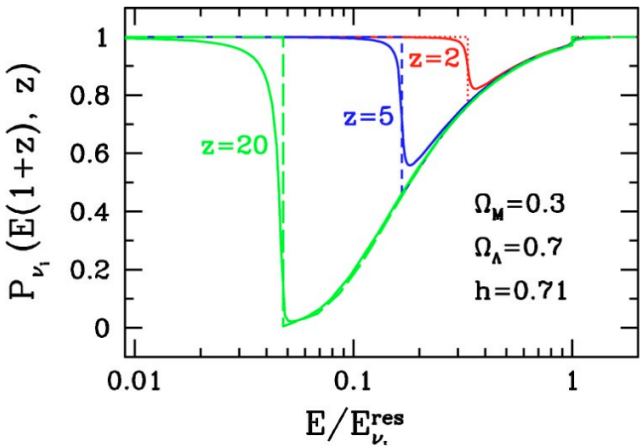

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Difficulty:- Dependent on redshift and source energy distribution of the unknown cosmic ray sources.

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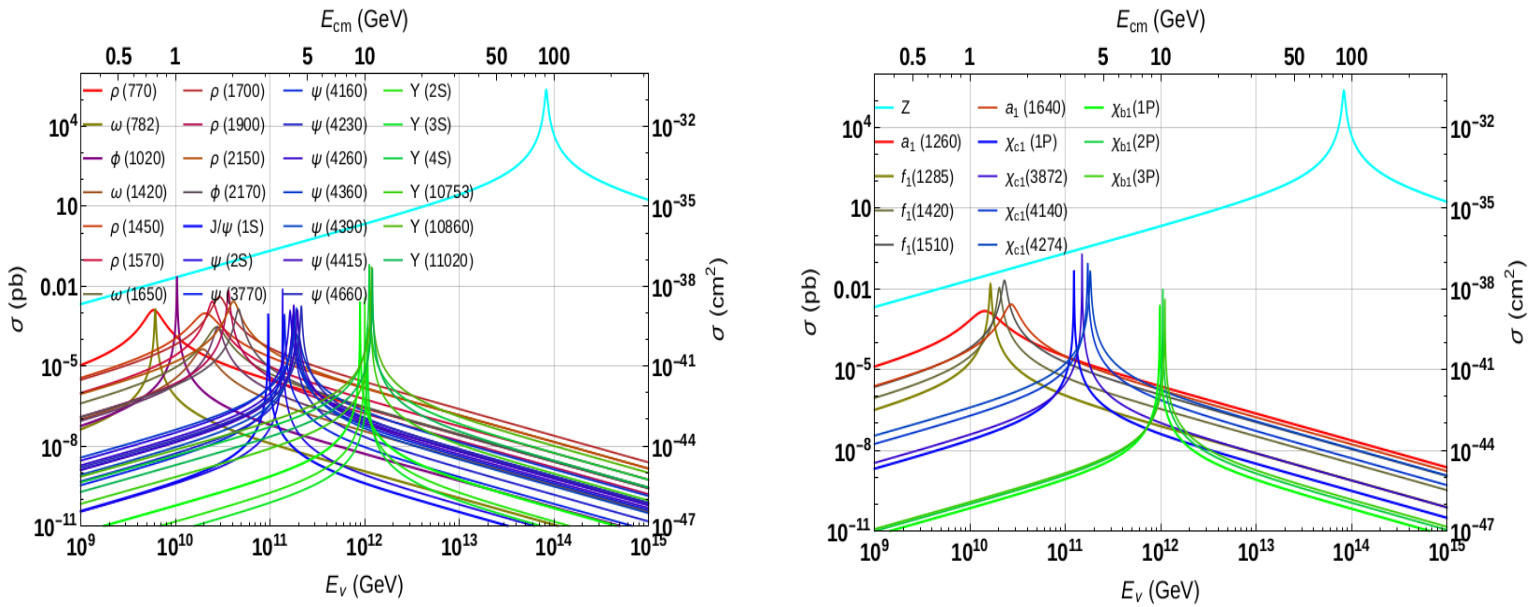

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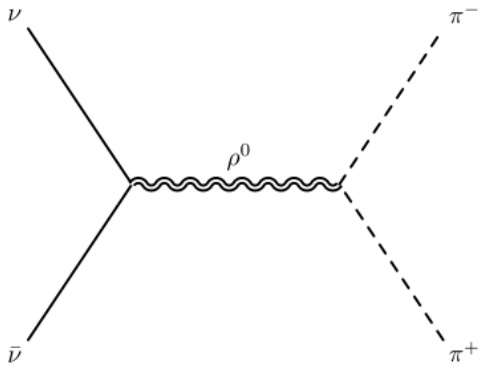

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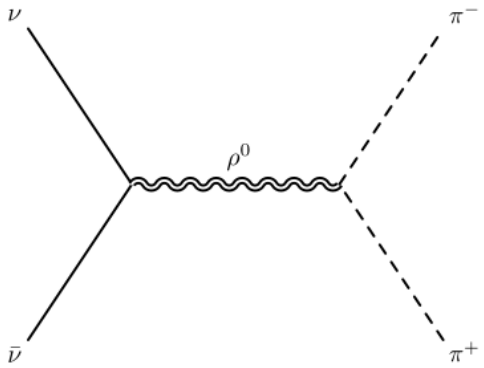

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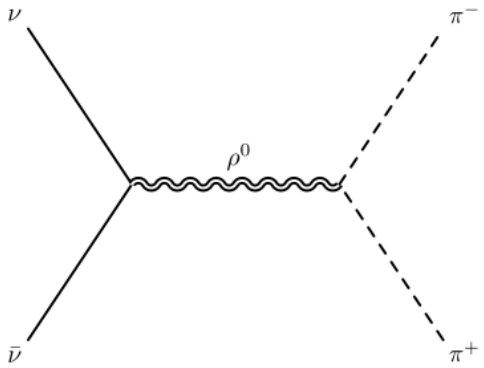

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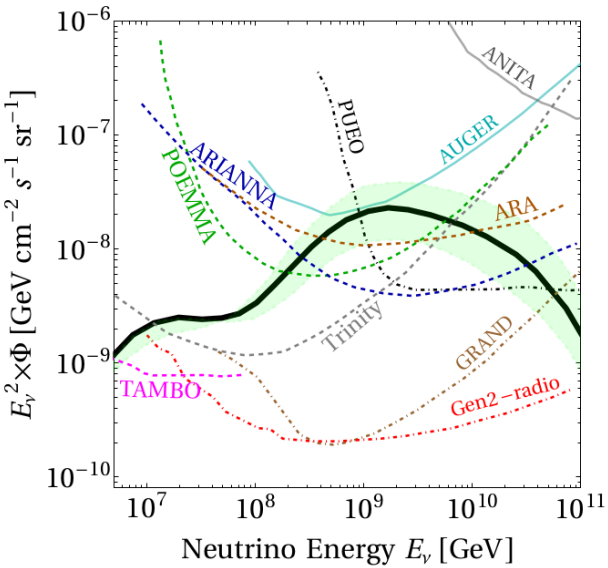

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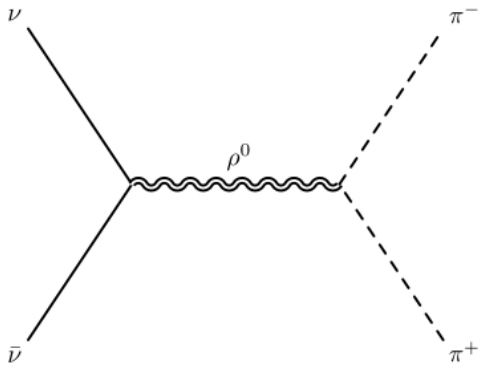

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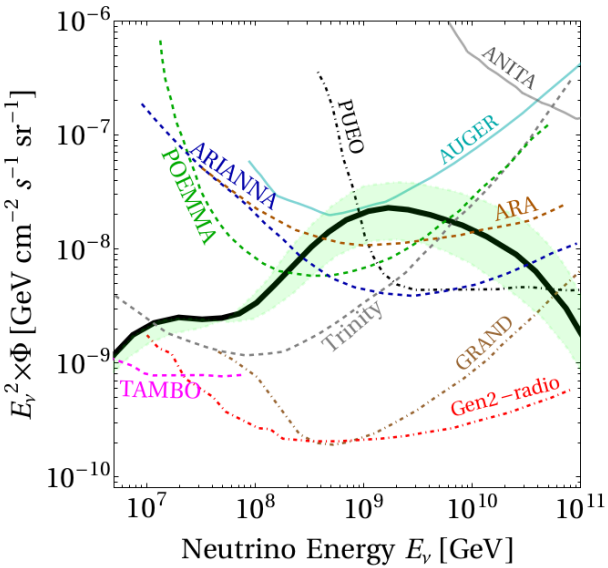

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The cosmogenic neutrino flux typically peaks around $10^{18}eV$

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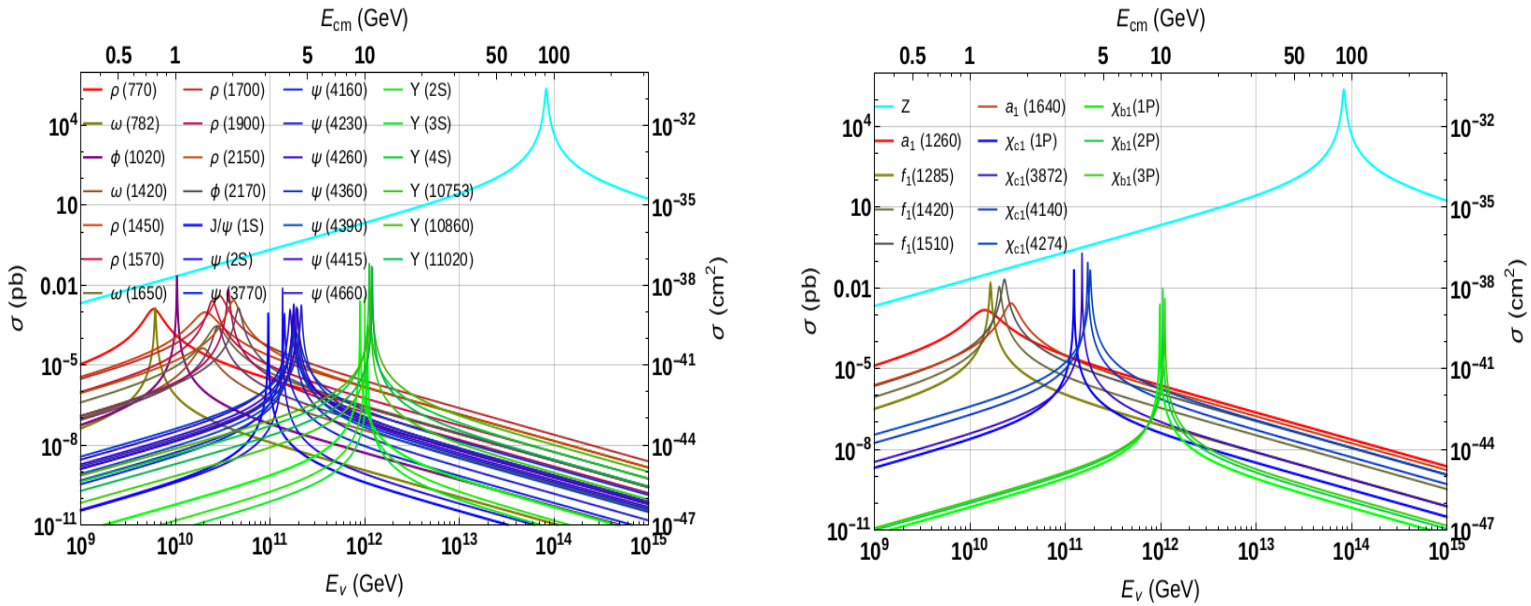

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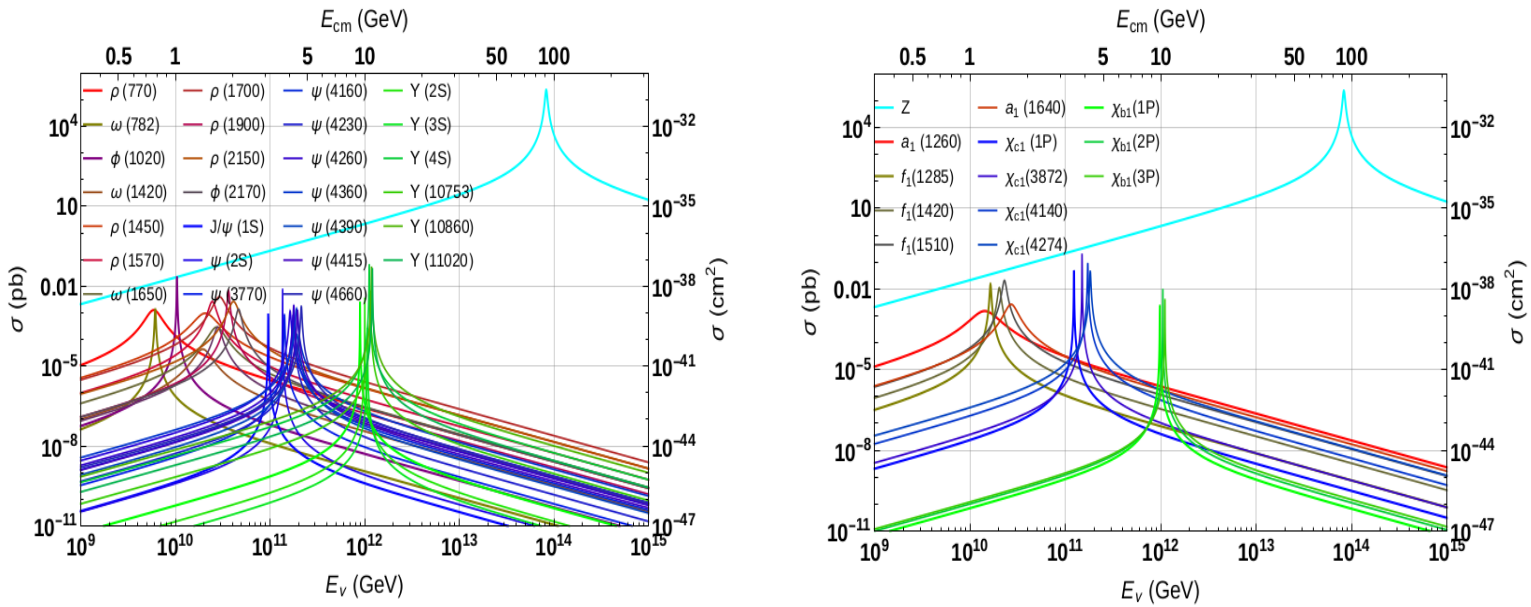

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- For the rest meson resonances, either resonance energy is beyond $10^{18} eV$ or the resonances have narrow width.

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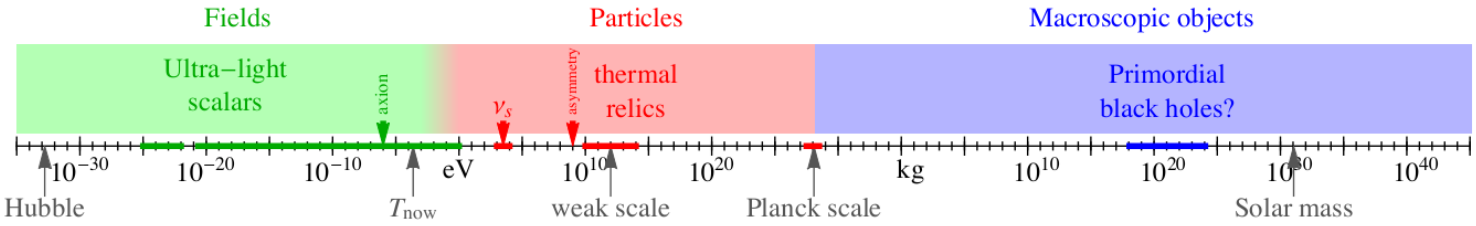

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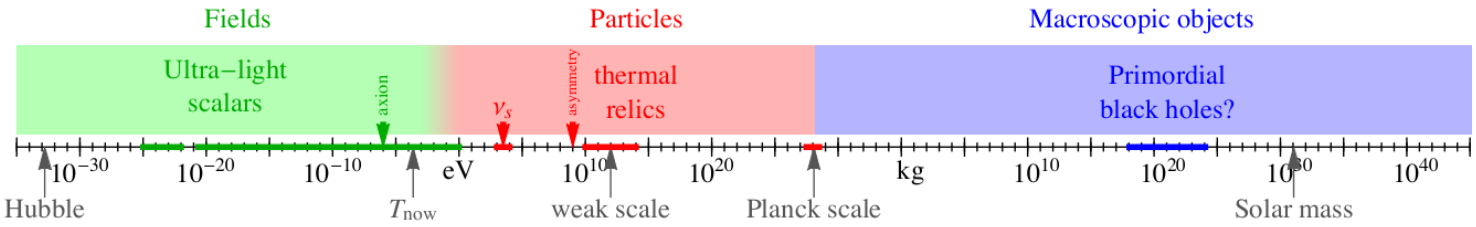

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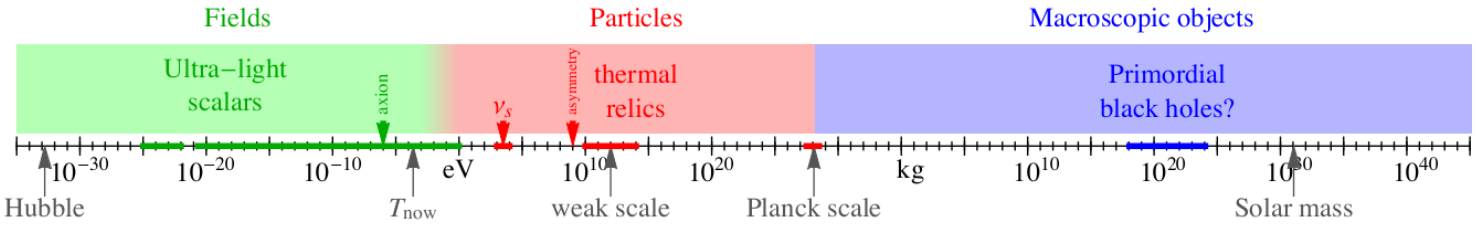

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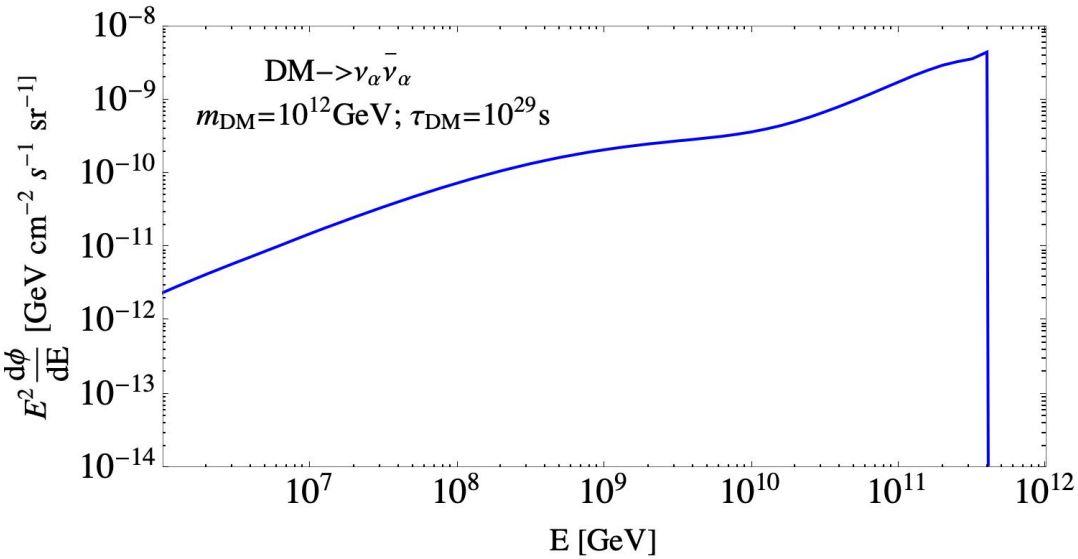
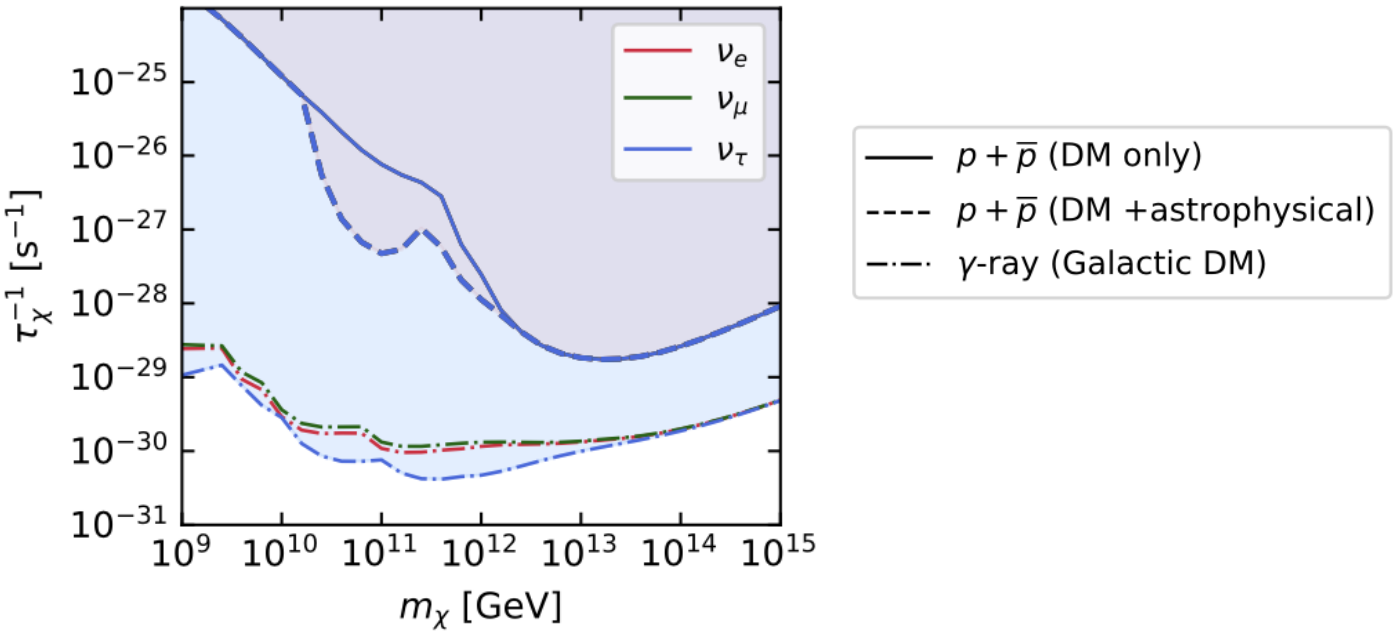


HDMSpectra

[Bauer, Rodd, Webber (JHEP '21)]

Constraint on DM lifetime



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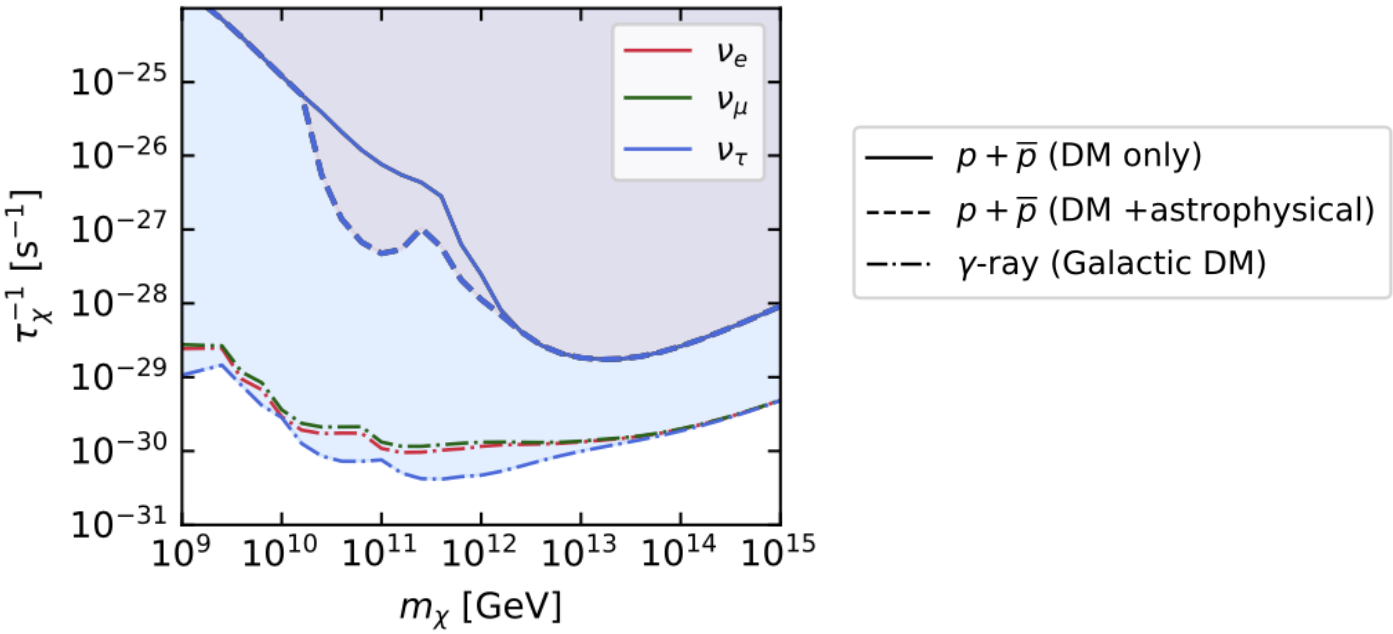

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We have considered-

- $p - \bar{p}$ (DM + astrophysical) constraint $\rightarrow$ weaker constarint on τ_{DM}
- γ ray (Galactic DM) constraint $\rightarrow$ stronger constarint on τ_{DM}

Result

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Number of unattenuated events,

$$N_{wo} = \int_{E_{min}}^{E_{max}} dE_\nu \;\; T \;\; \Omega \;\; A_{eff}(E_\nu) \;\; \frac{d\Phi}{dE_\nu}(E_\nu, m_{DM}, \tau_{DM})$$

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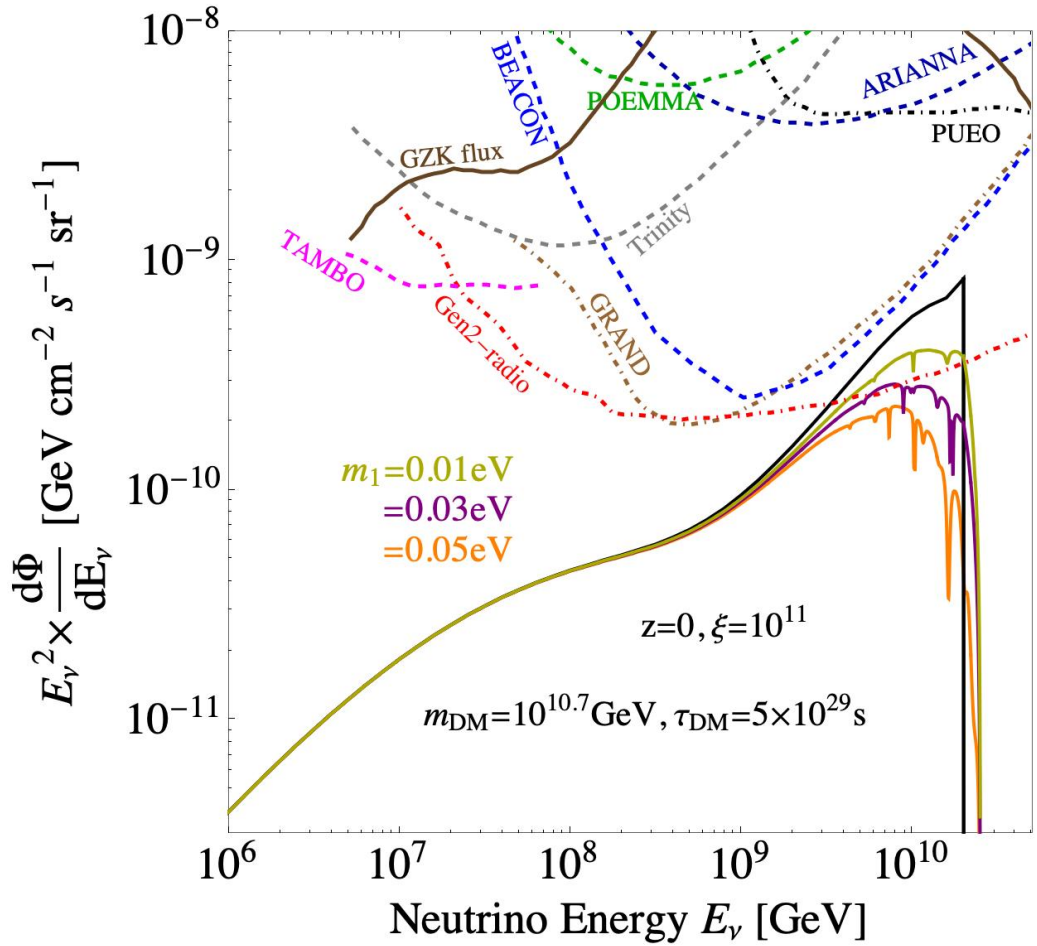

Stronger constraint on DM lifetime

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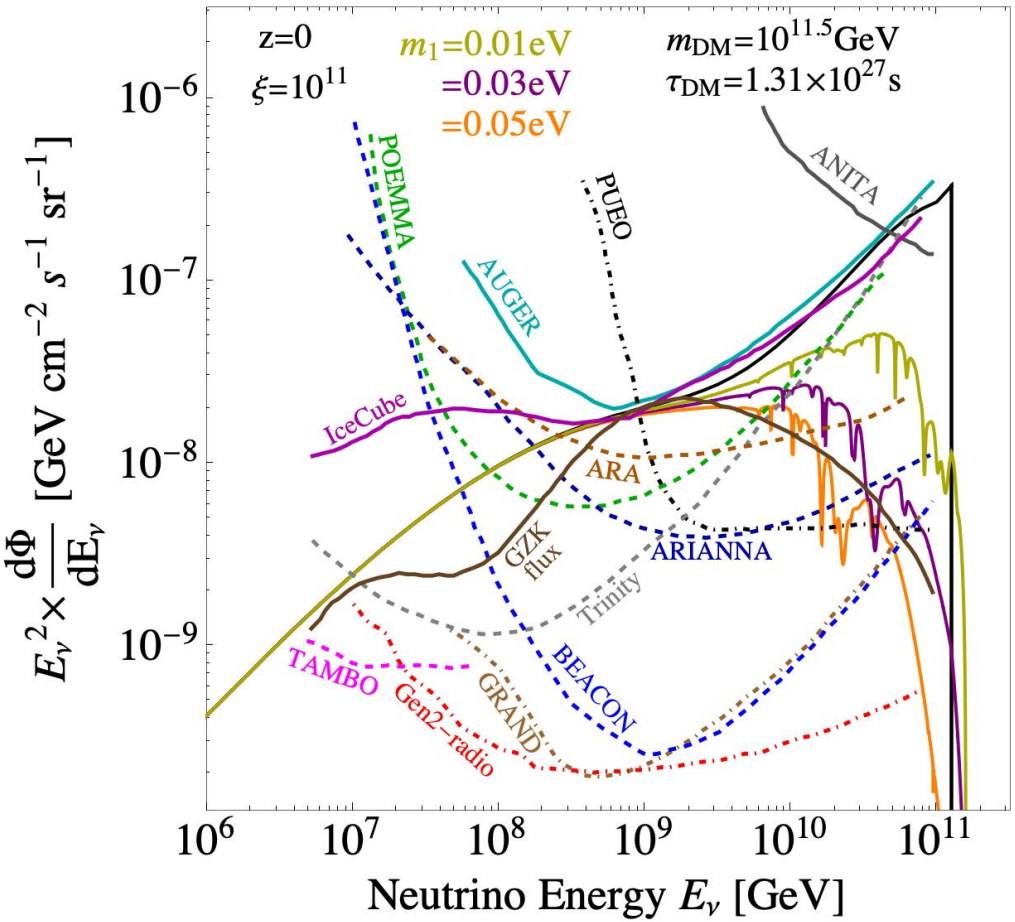

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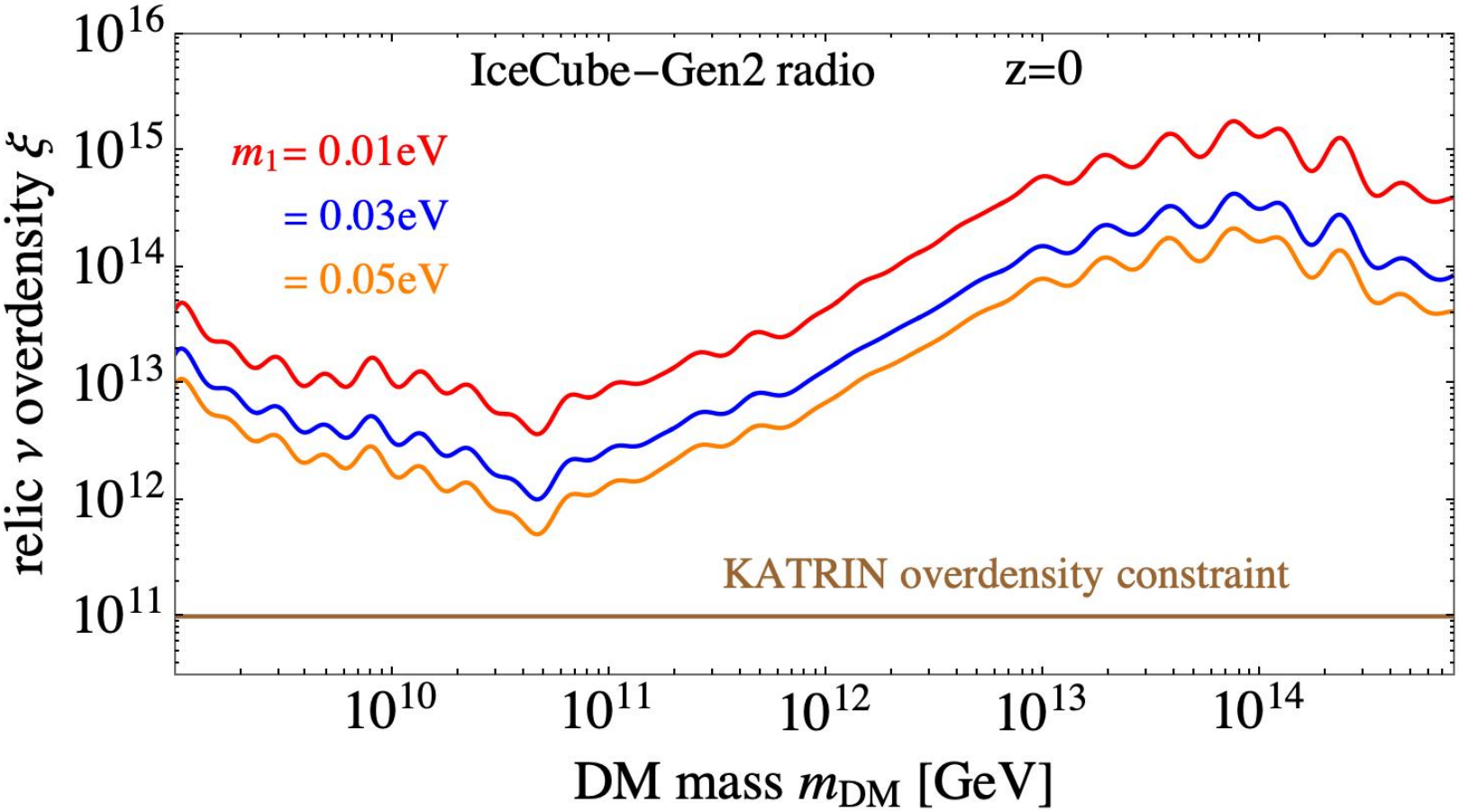

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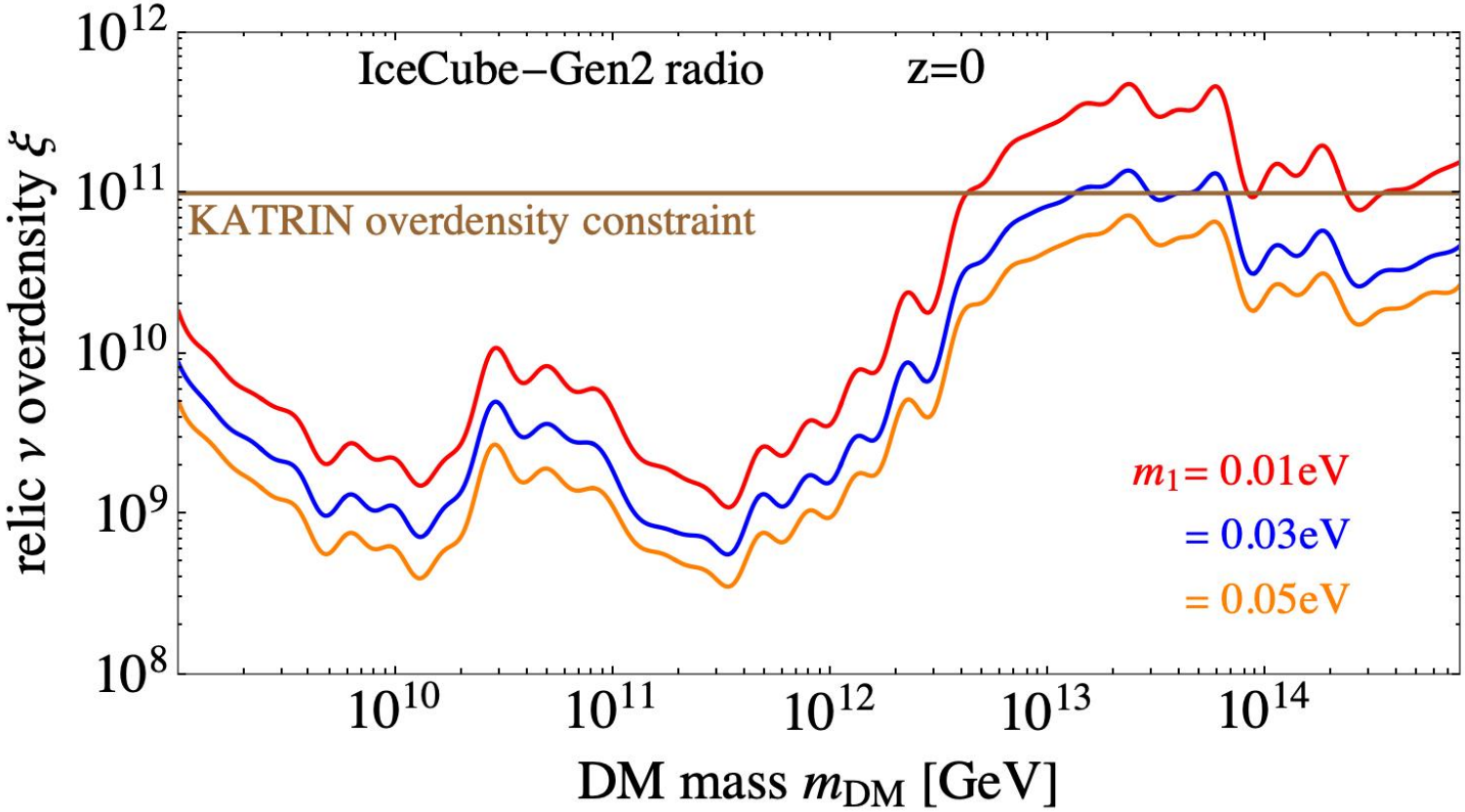

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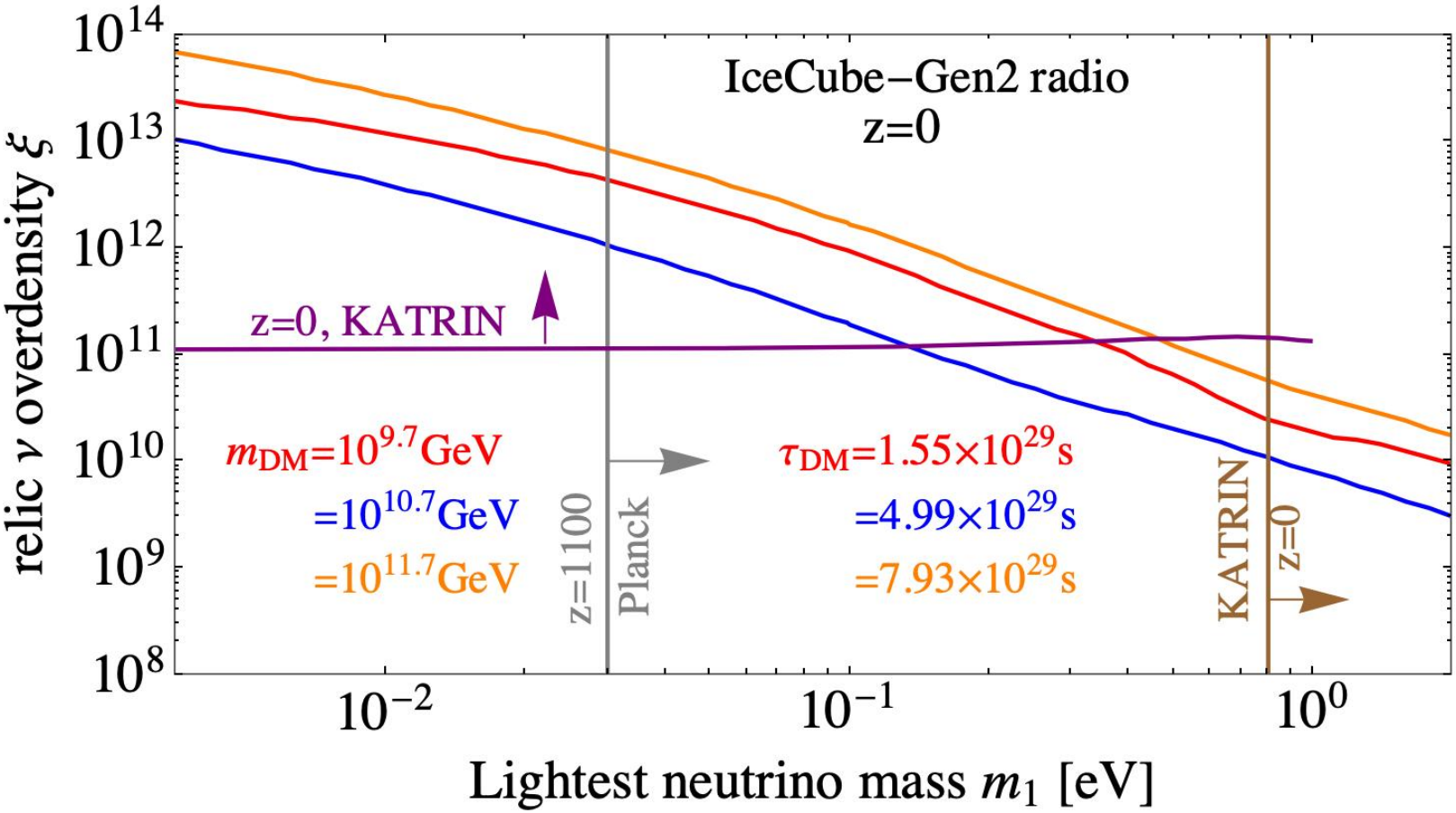

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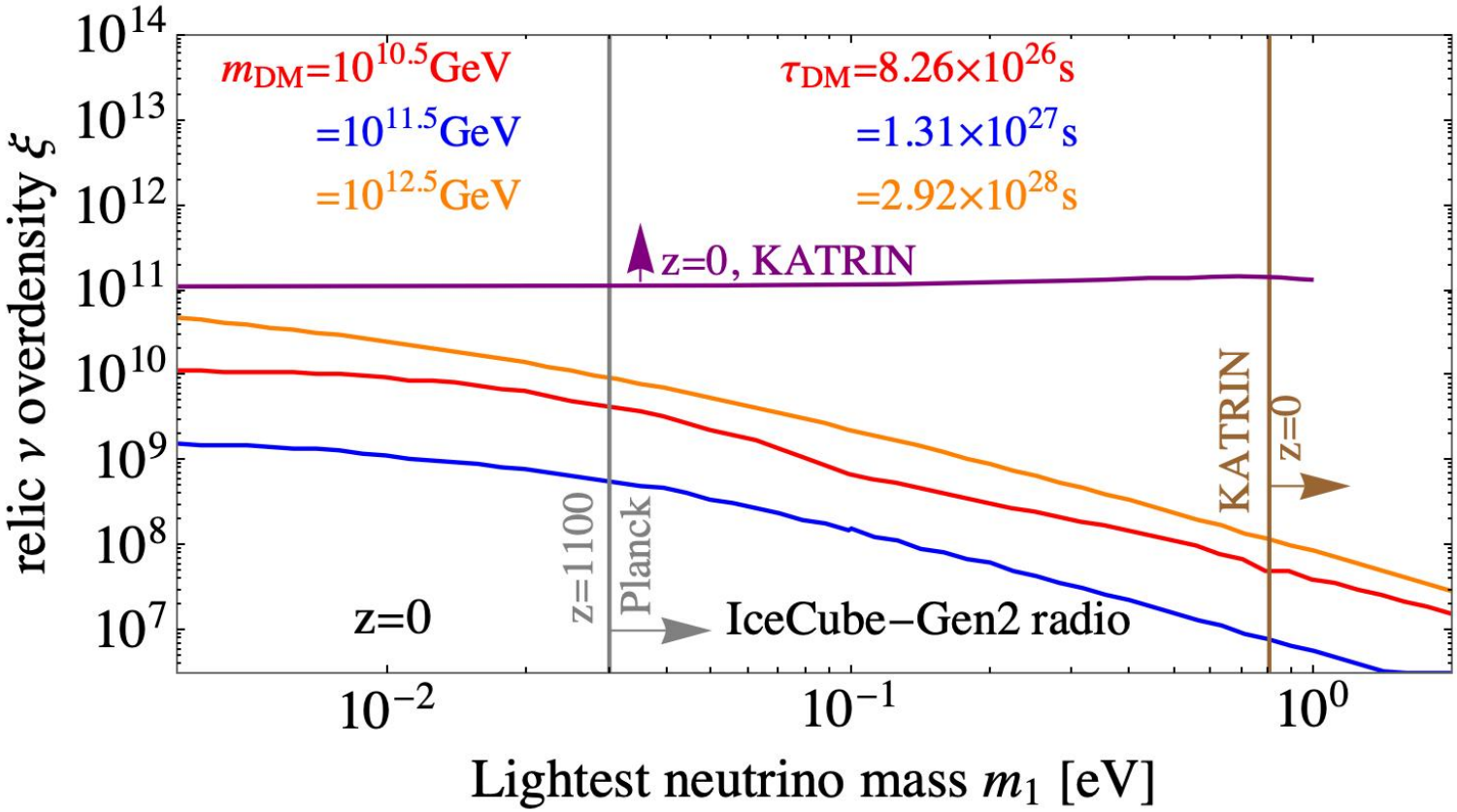
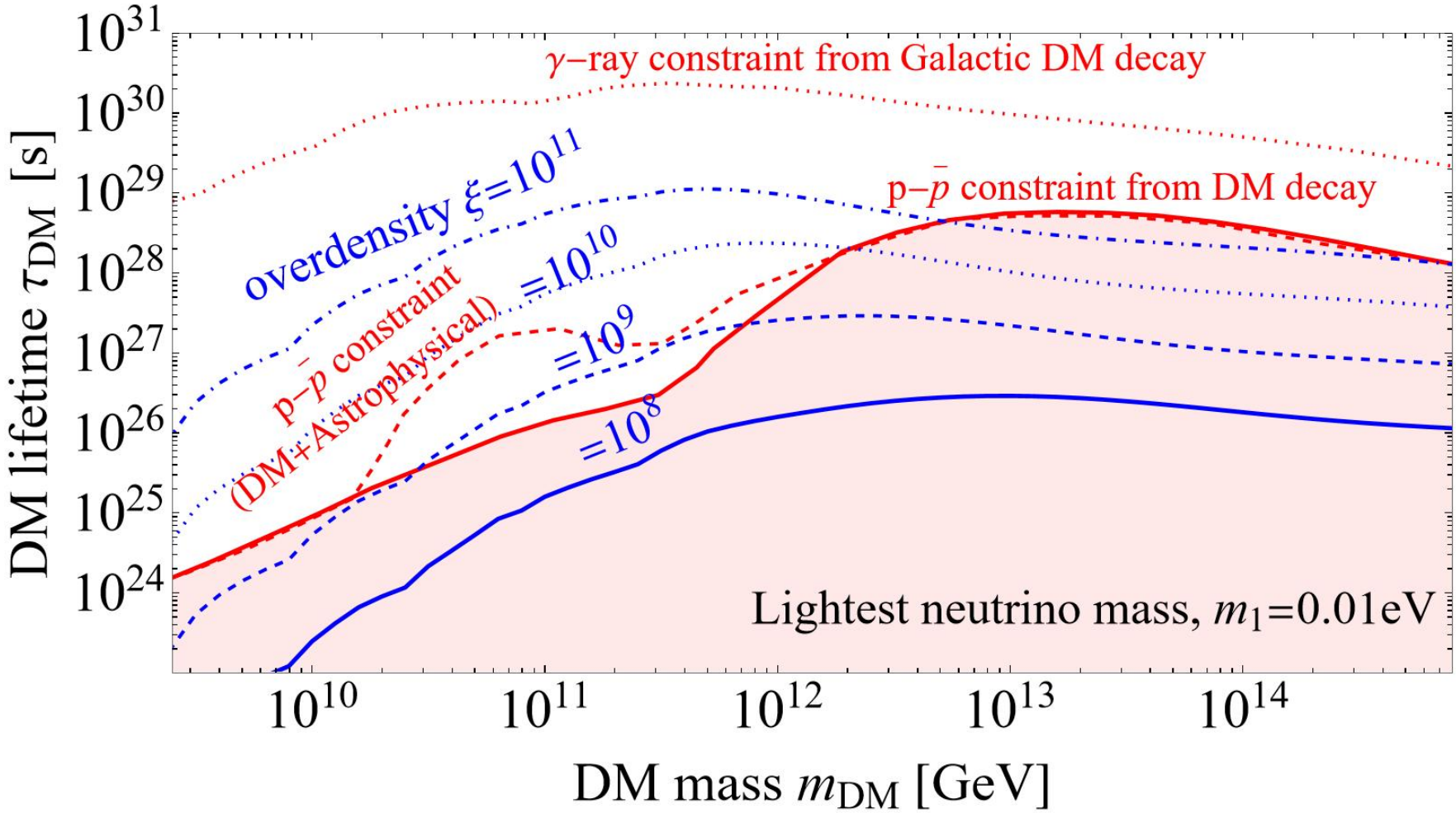
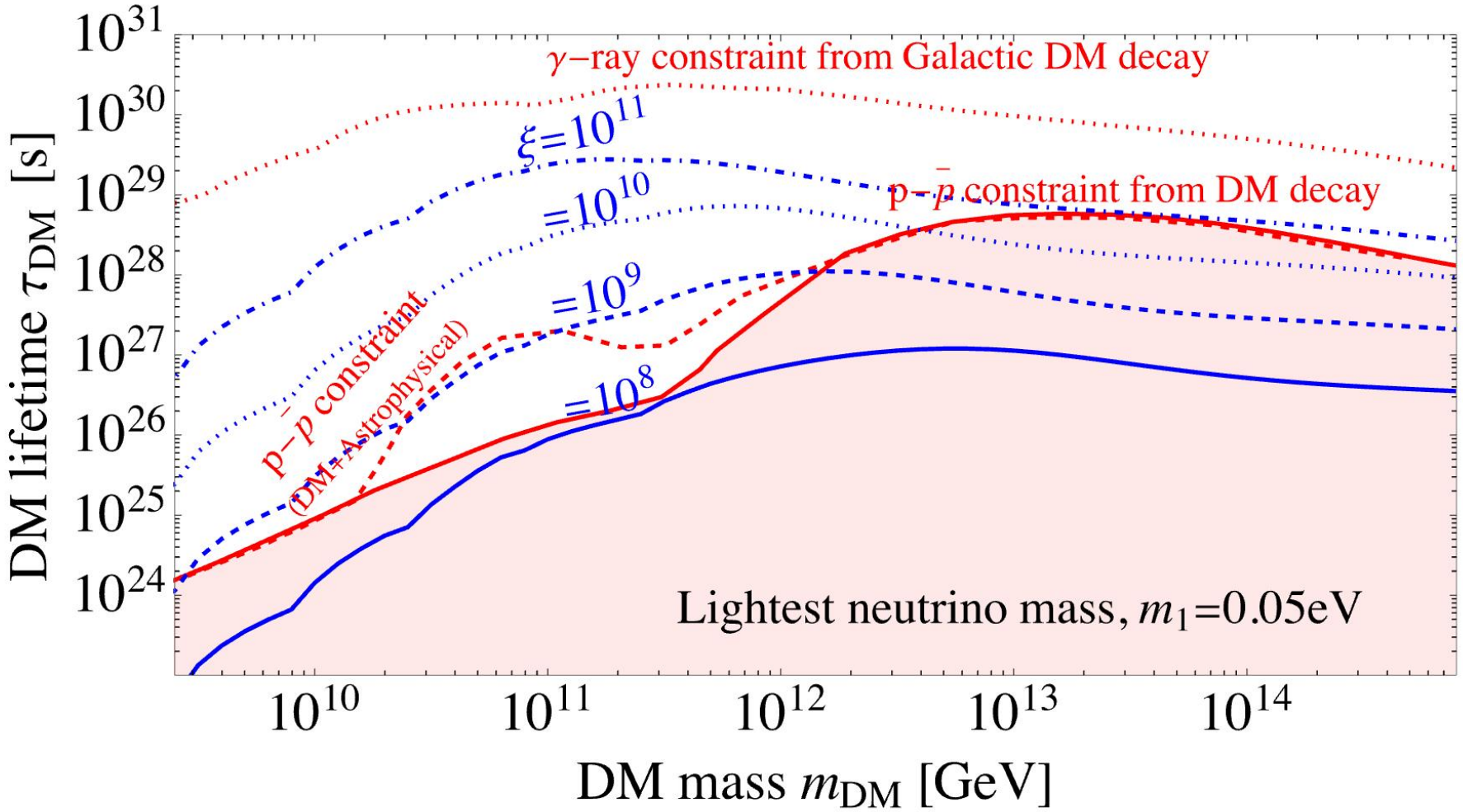


Weaker constraint on DM lifetime

Result


γ−ray constraint from Galactic DM decay
p−p̄ constraint from DM decay
overdensity ξ=10^11
=10^10
=10^9
=10^8
p−p̄ constraint (DM+Astrophysical)
Lightest neutrino mass, m1=0.01eV
DM lifetime τDM [s]
DM mass mDM [GeV]
10^31
10^30
10^29
10^28
10^27
10^26
10^25
10^24
10^10
10^11
10^12
10^13
10^14

Result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Lightest neutrino mass, m_1=0.05eV
DM lifetime τ_{DM} [s]
DM mass m_{DM} [GeV]
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10^30
10^29
10^28
10^27
10^26
10^25
10^24
10^10
10^11
10^12
10^13
10^14

Summary

- The existence of relic neutrino background is a strong prediction of big bang cosmology.
- Its direct detection is difficult because of its low kinetic energy.
- Its indirect detection via cosmic ray-CνB scattering is limited to inclusion of only ρ meson resonance.
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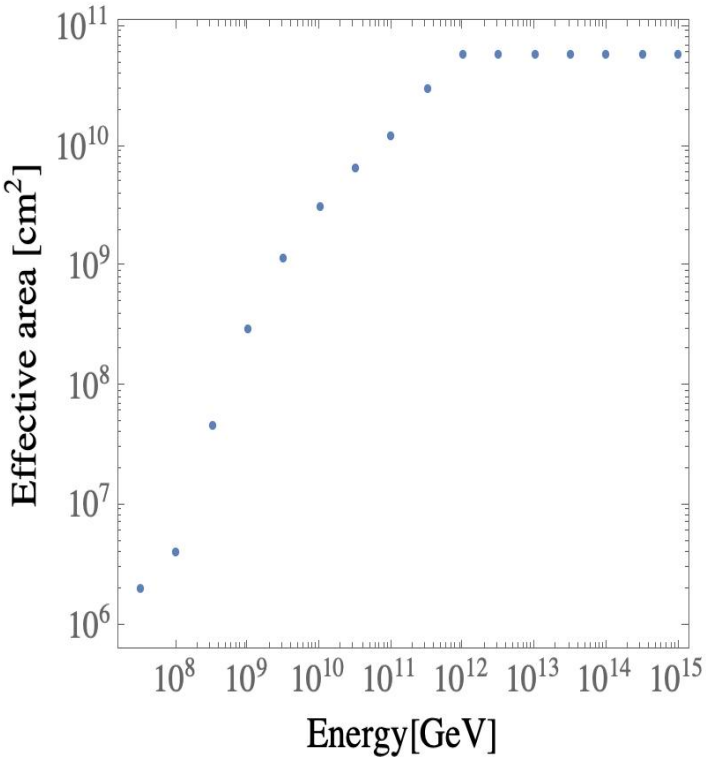
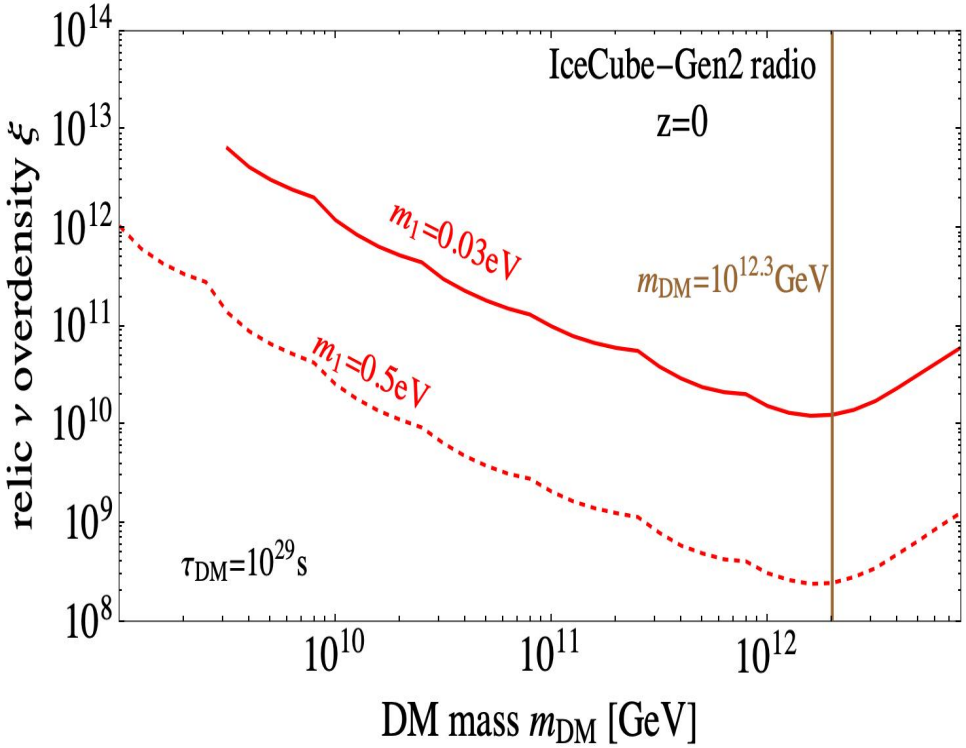
Thank you :)

Backup Slides





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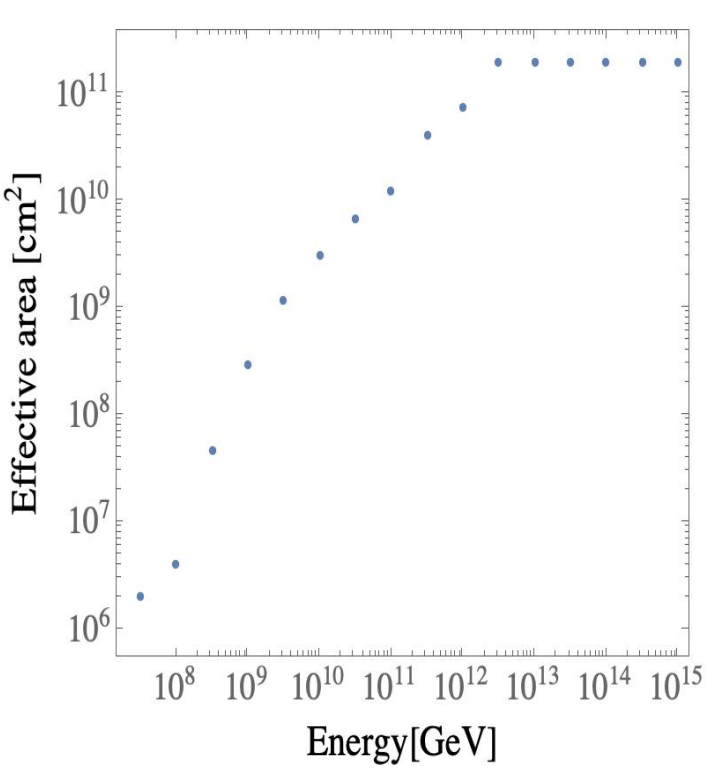

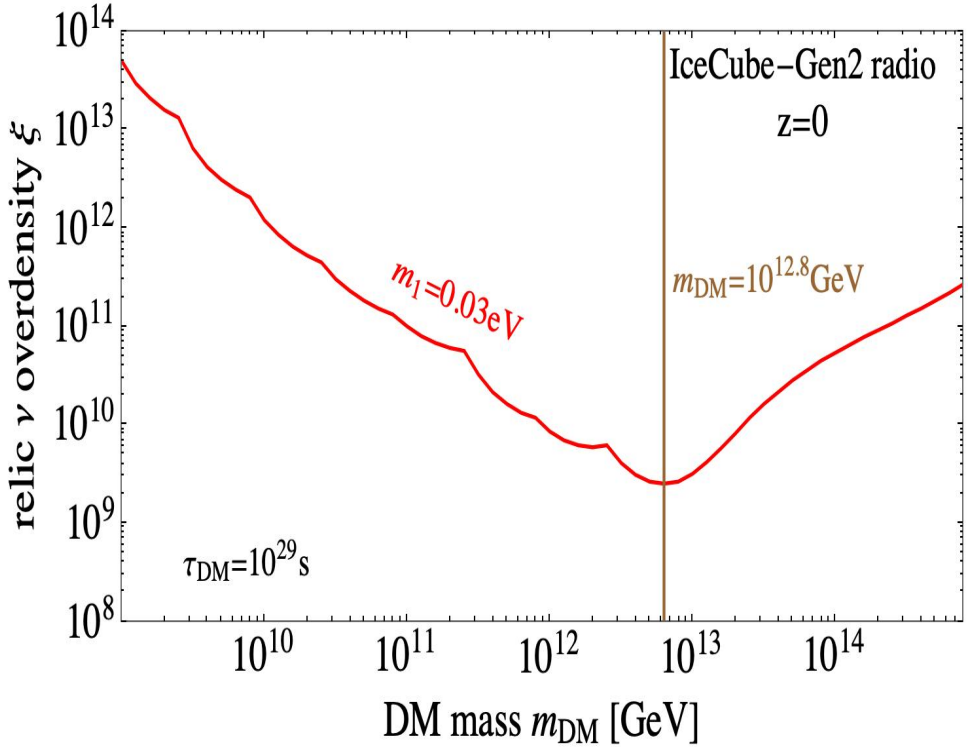

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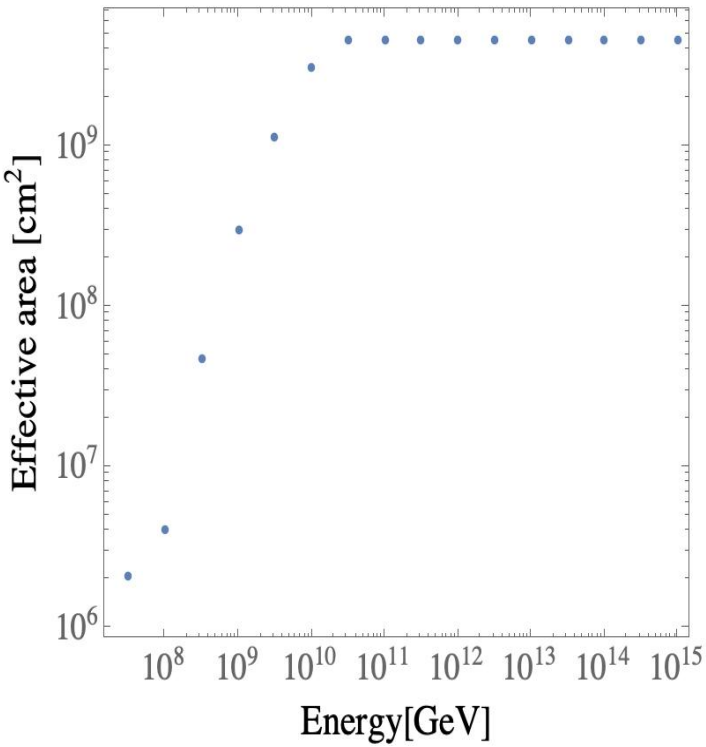

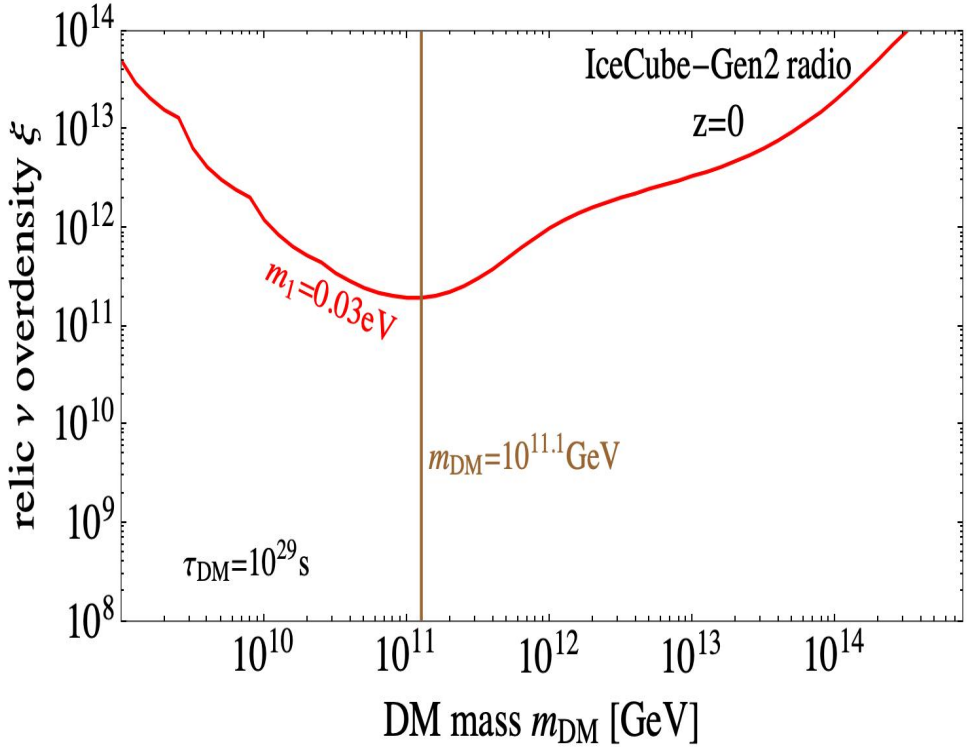

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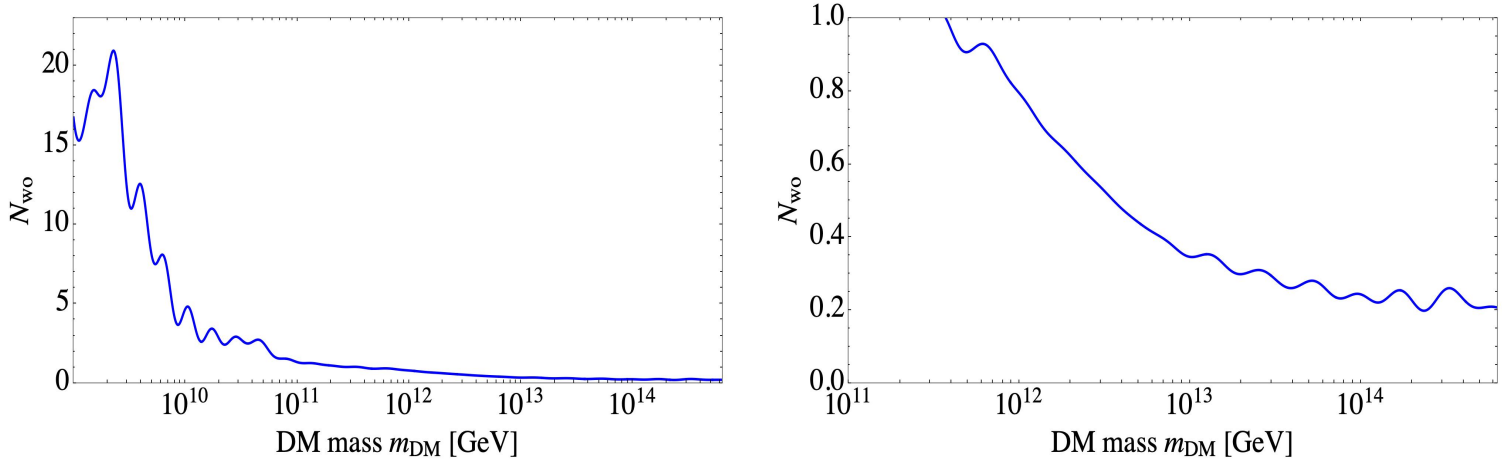


Figure: When the stronger DM lifetime-constraint is considered.

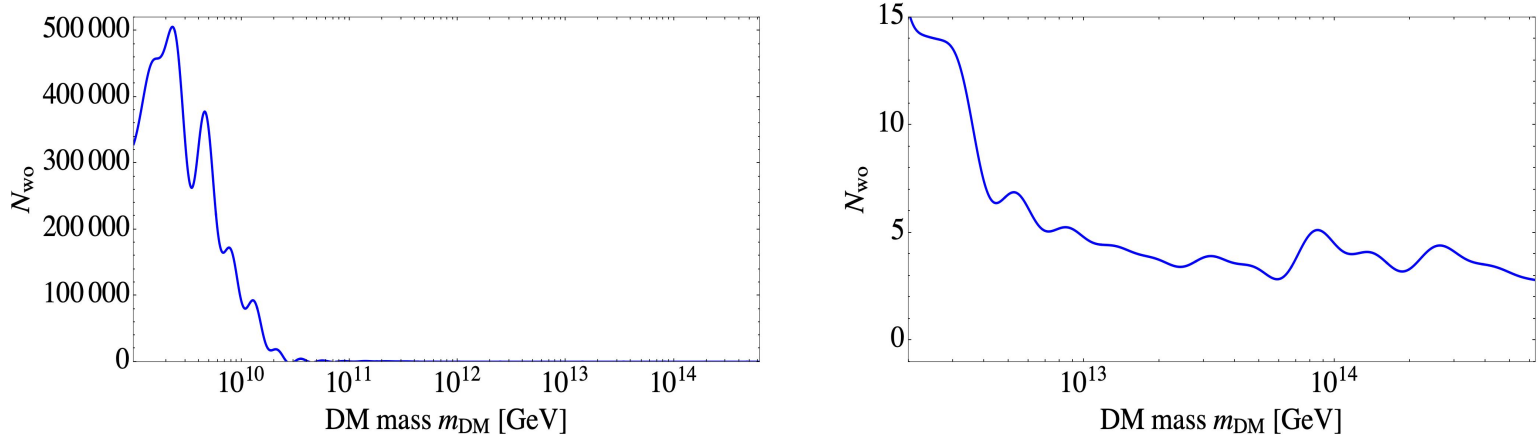
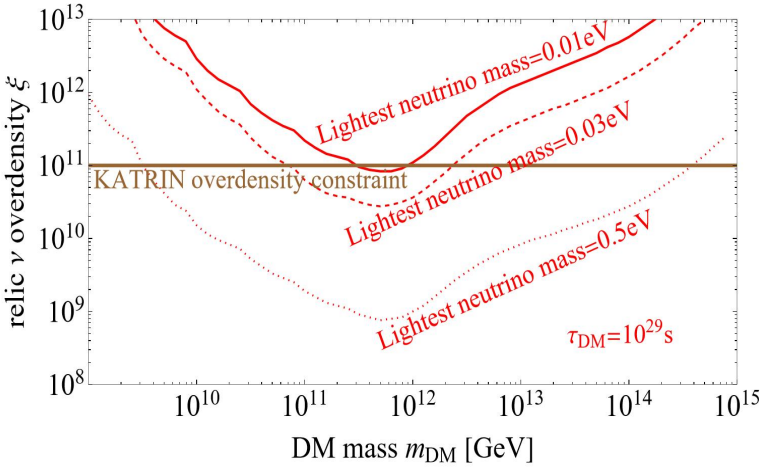
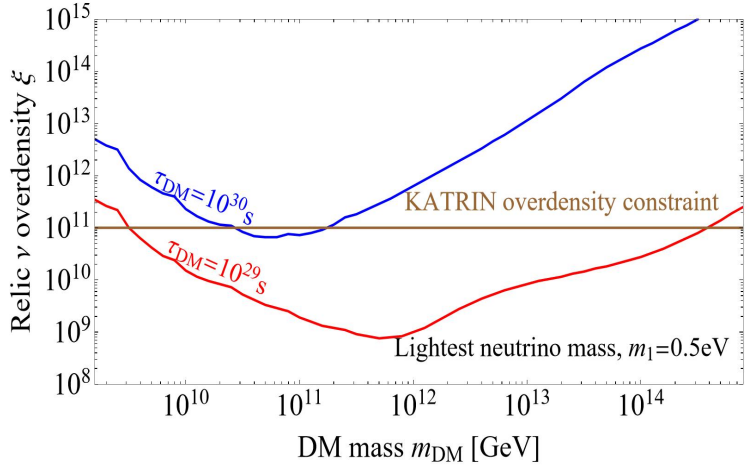
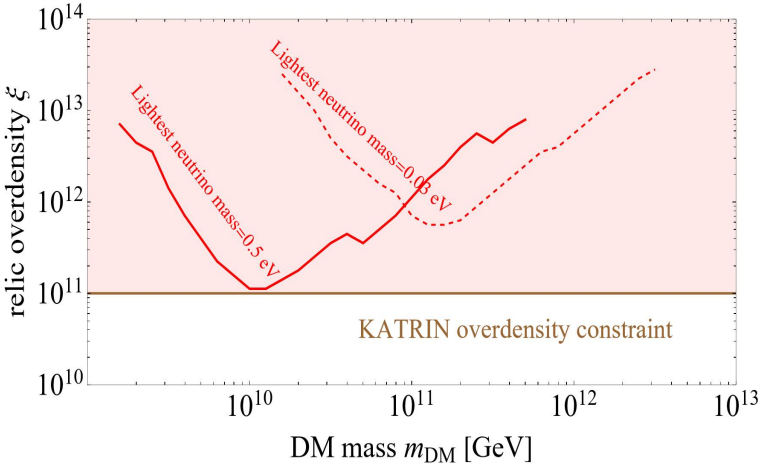


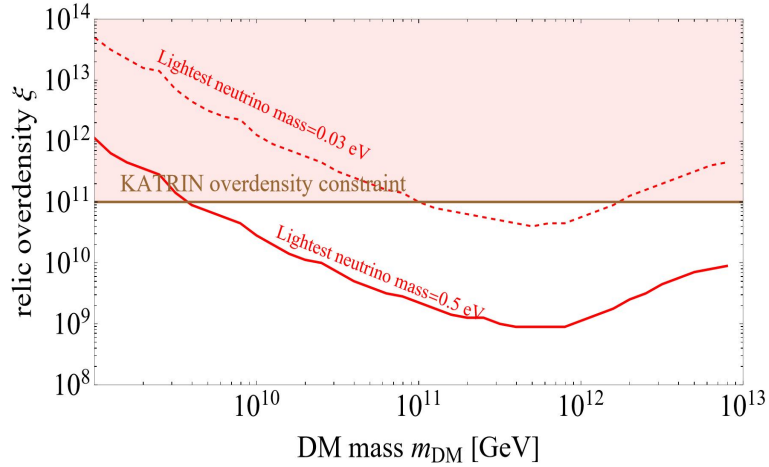
Figure: When the weaker DM lifetime-constraint is considered.

Backup slides









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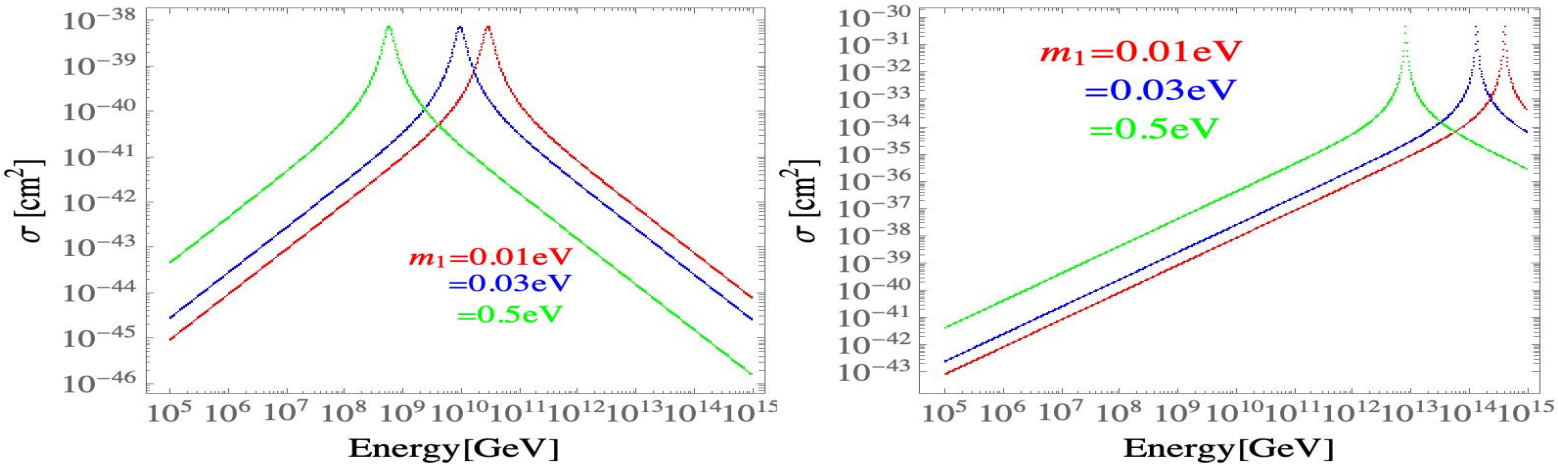

(left) ρ meson & (right) Z meson.