Super-GZK Neutrinos

A. Ringwald

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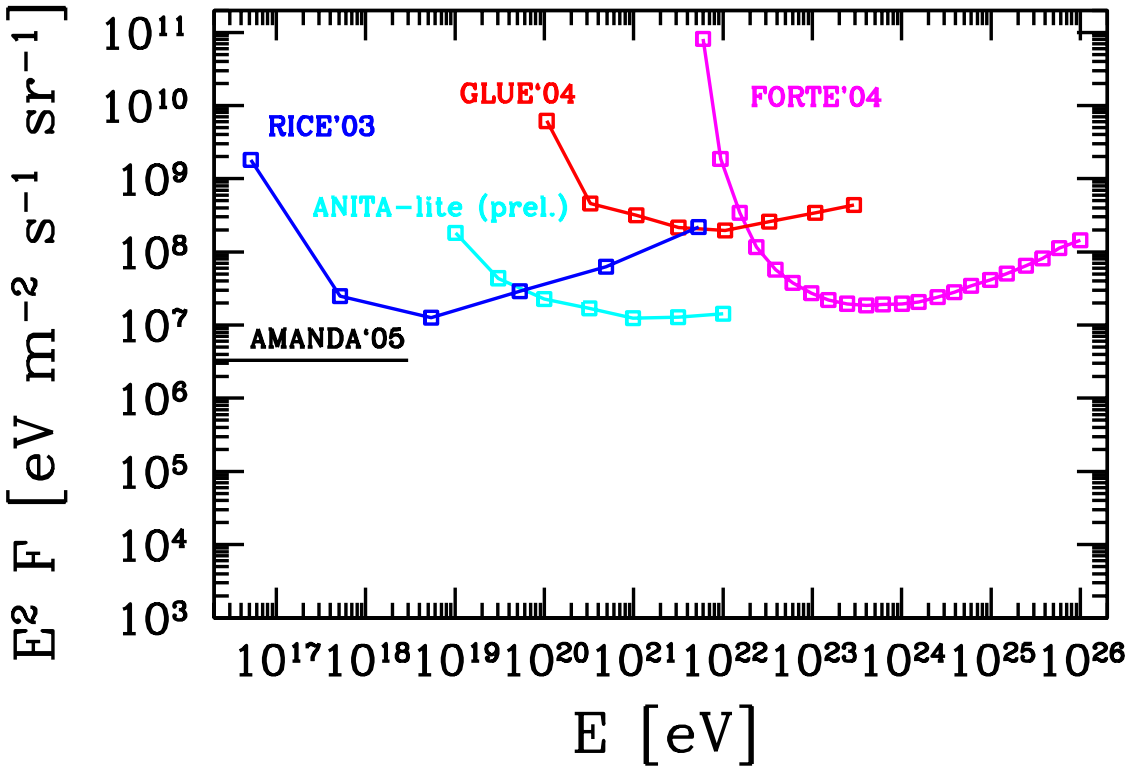
1. Introduction

- Existing observatories for **E**xtremely **H**igh **E**nergy **C**osmic neutrinos provide sensible upper bounds on flux



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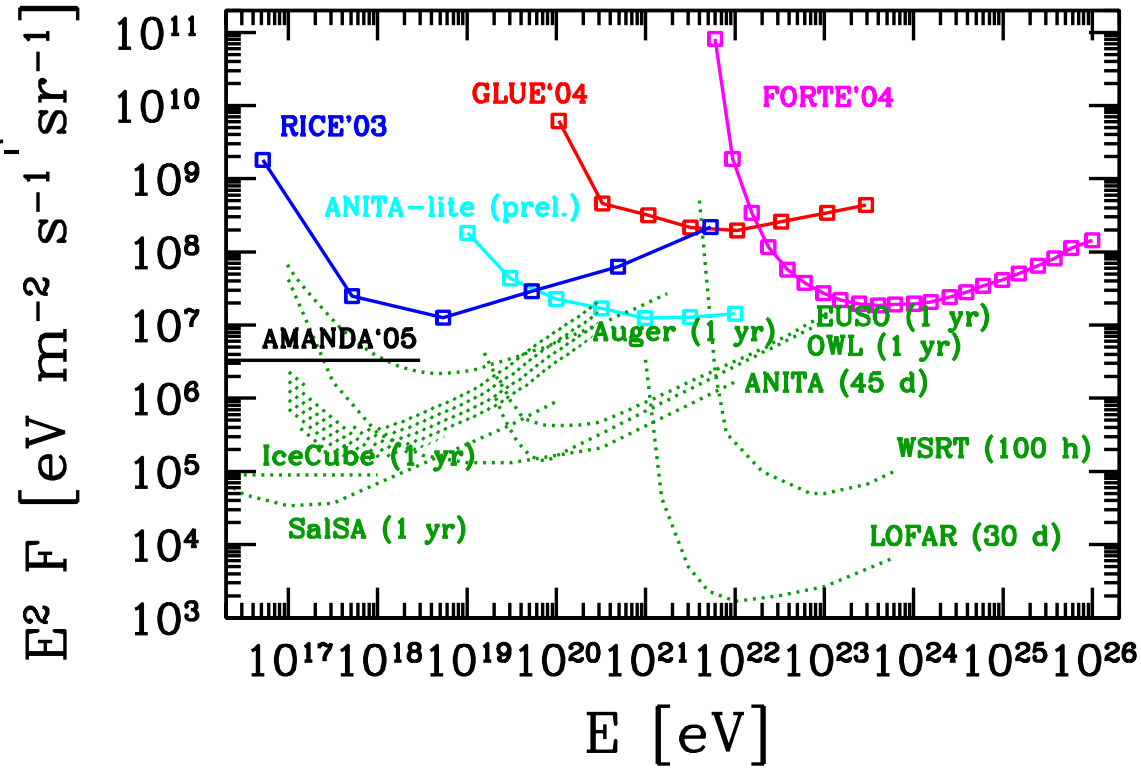

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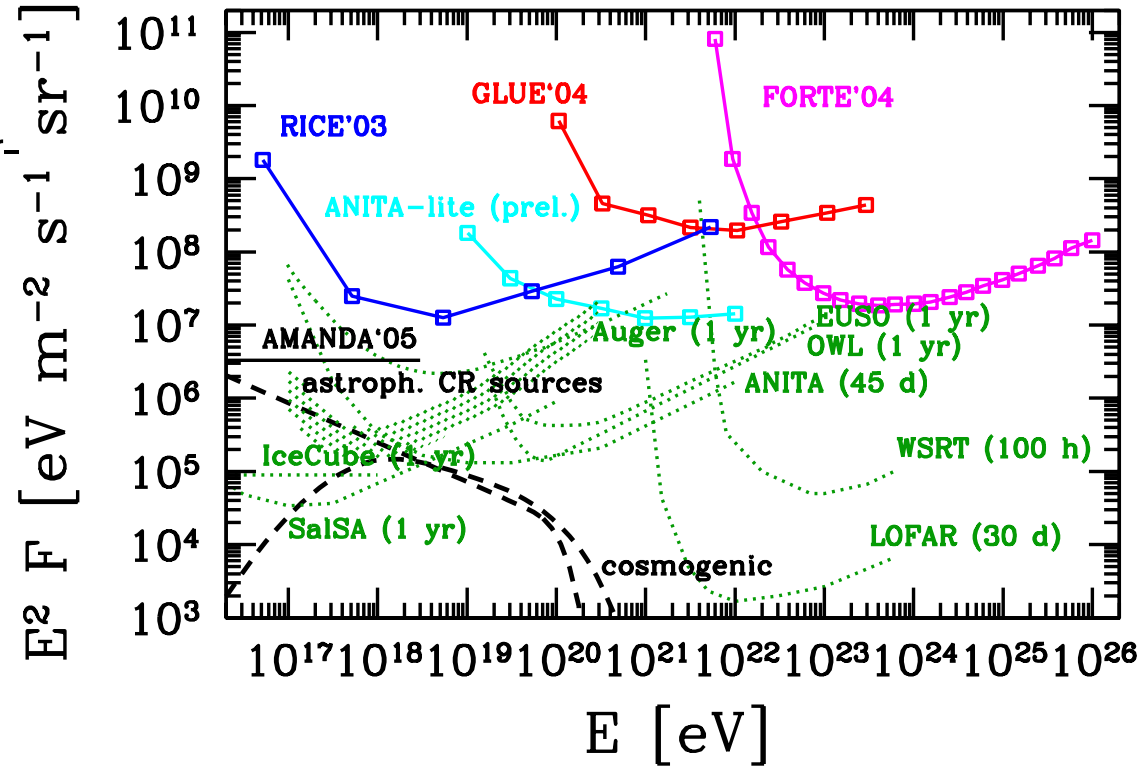

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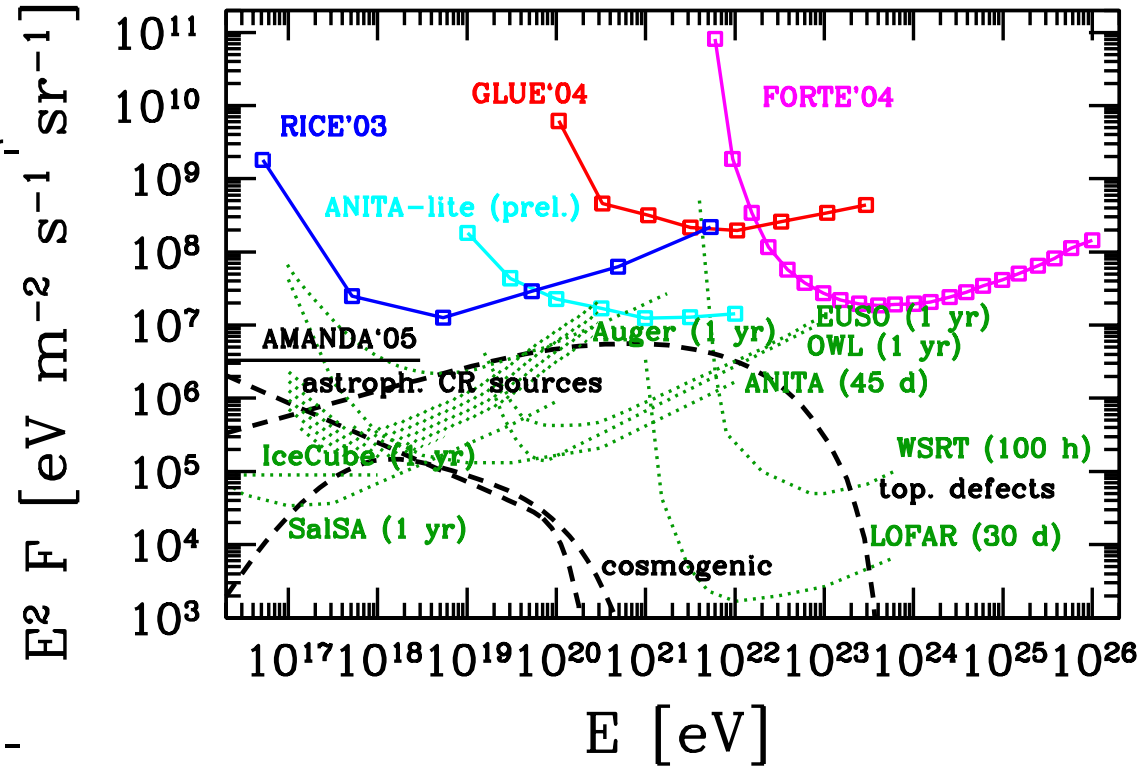
$\rightarrow$ **Cosmology:** relics of phase transitions; absorption on big bang relic neutrinos



- **Further content:**

  2. **Sources and fluxes of super-GZK neutrinos**
  3. **Fun with super-GZK neutrinos**
  4. **Conclusions**

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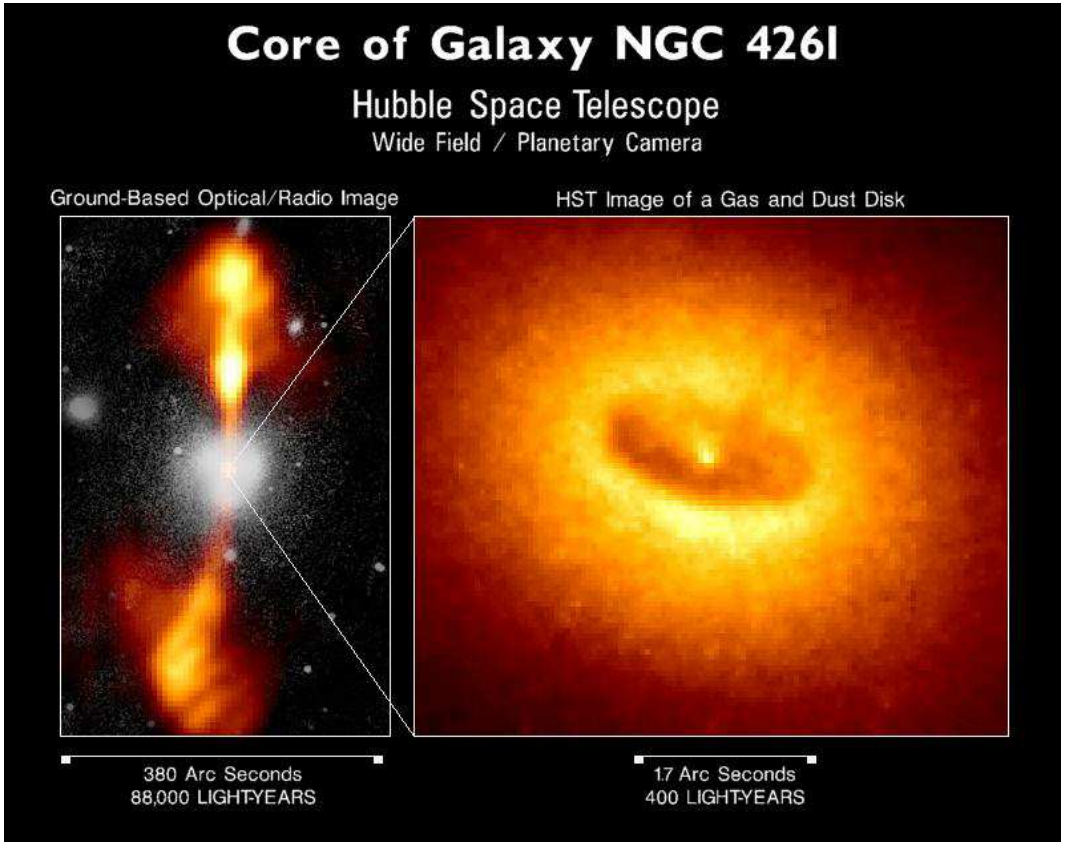

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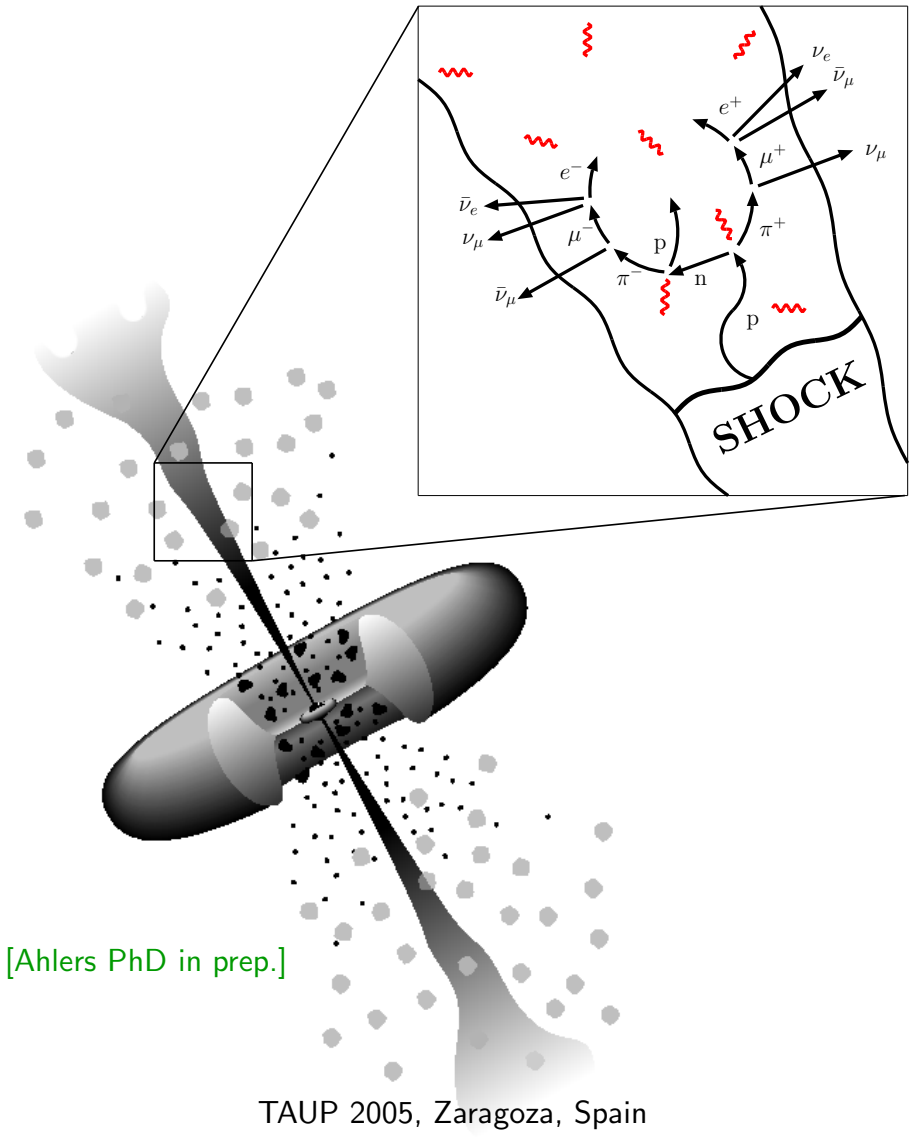

[Ahlers PhD in prep.]

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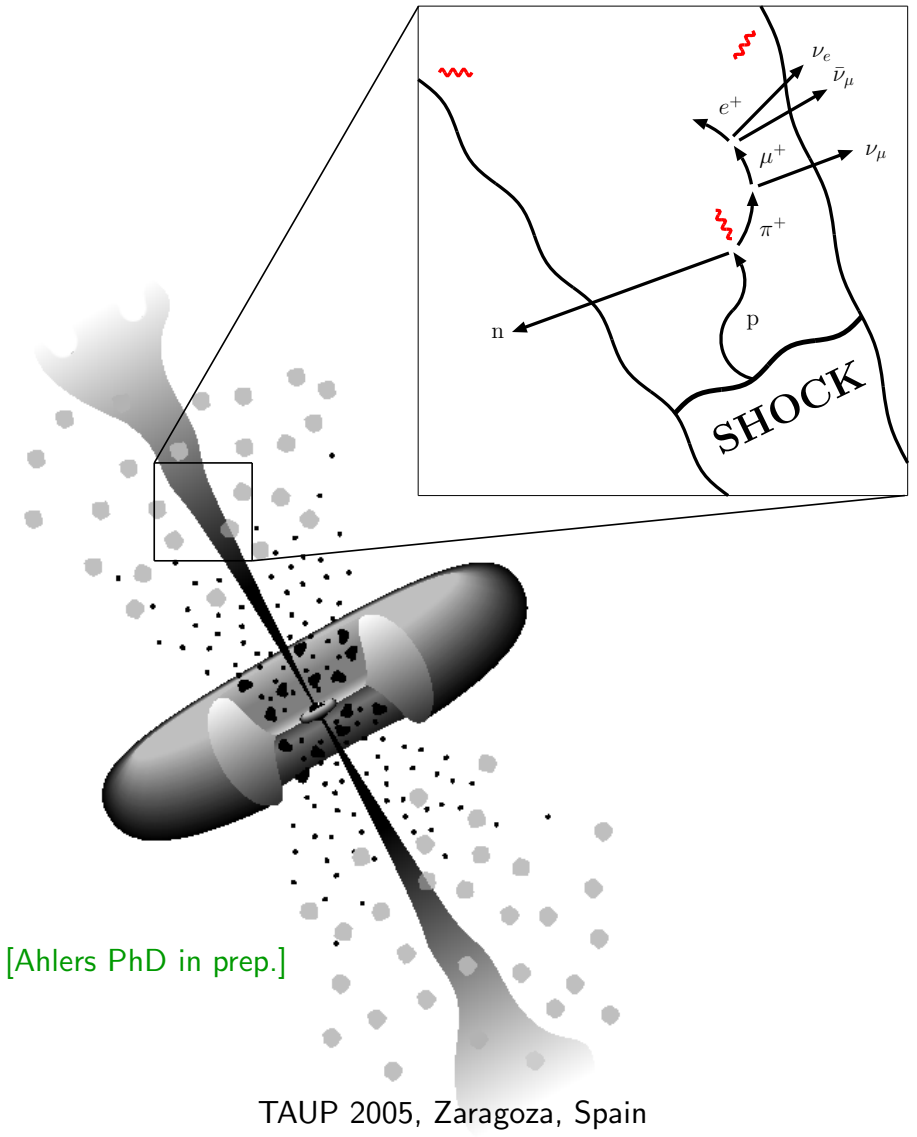

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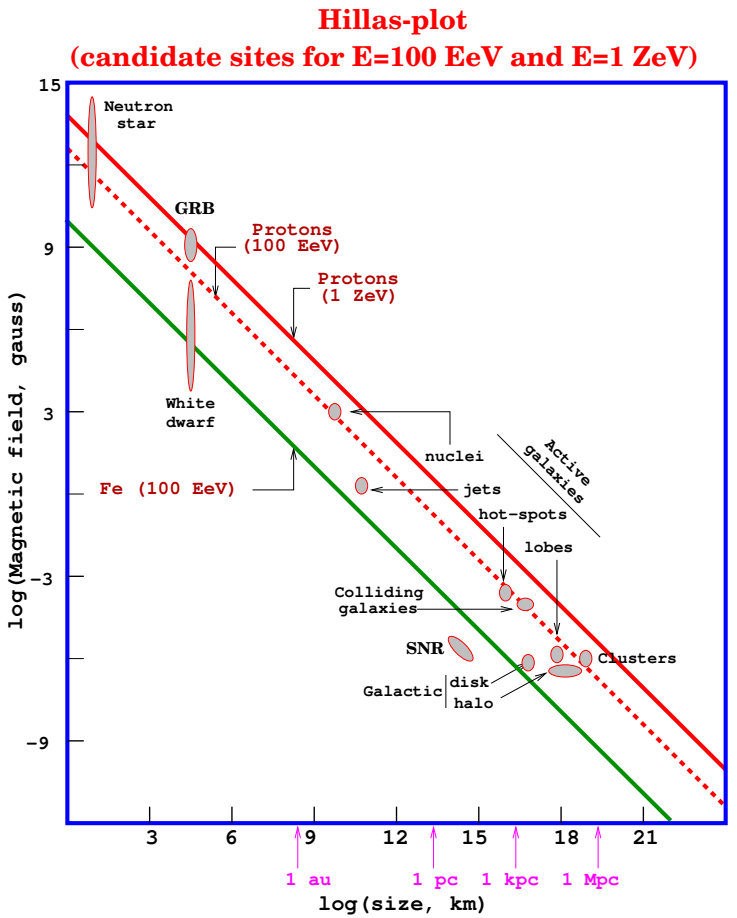

[Pierre Auger Observatory]

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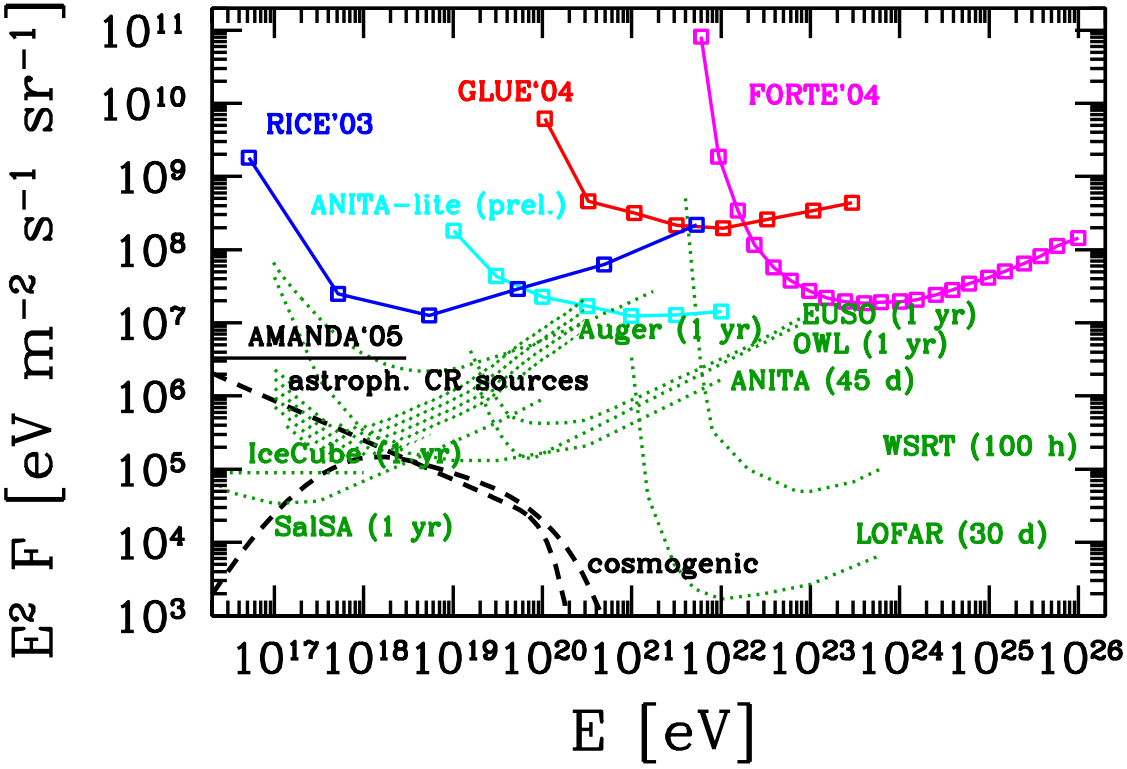

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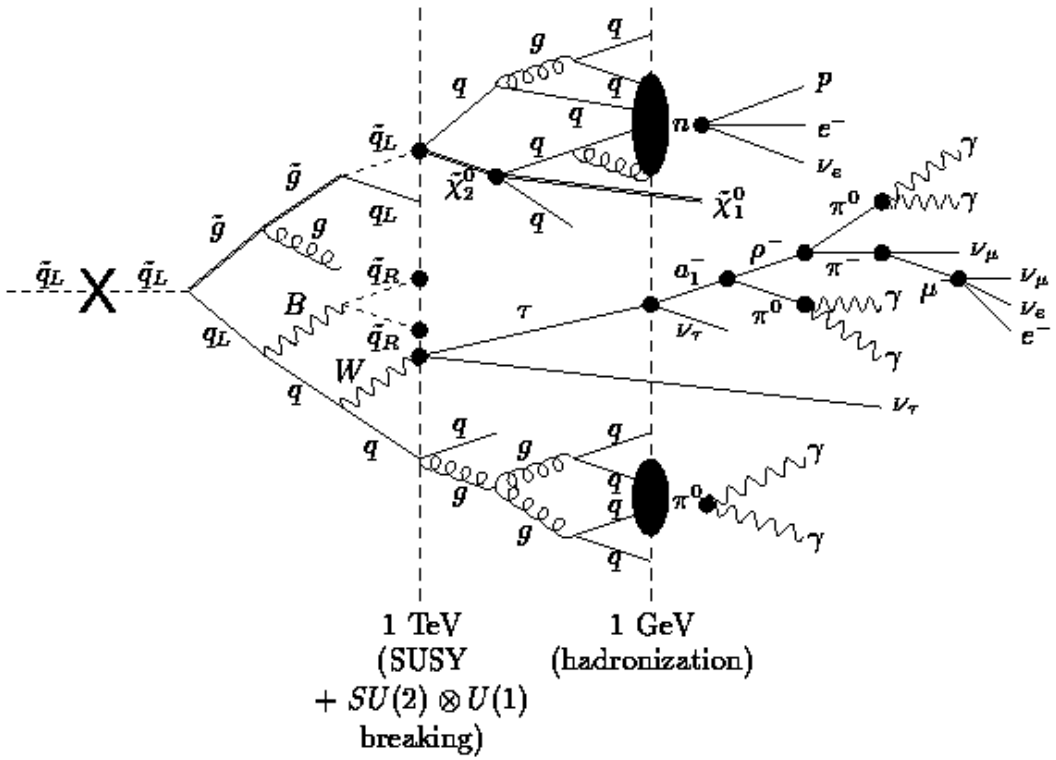

[Barbot,Drees '02]

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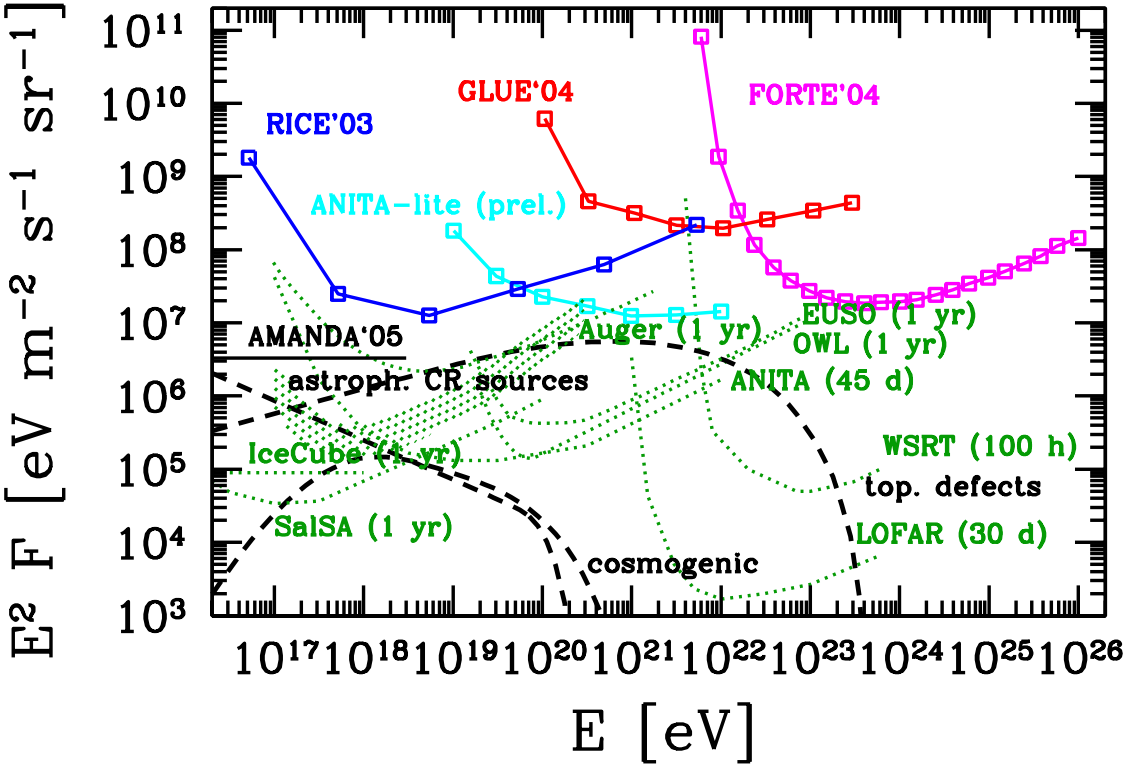

Top-down scenarios for super-GZK neutrinos

- Existence of superheavy particles with $10^{12}\ \mathrm{GeV} \lesssim m_X \lesssim 10^{16}\ \mathrm{GeV}$, produced during and after inflation through e.g.
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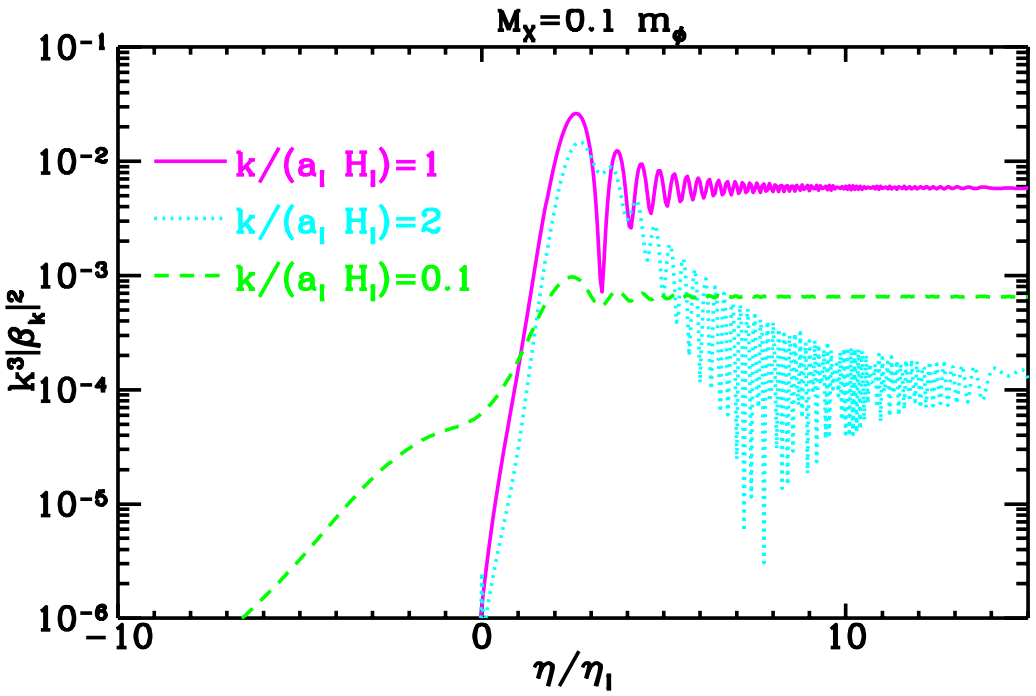

[Kolb,Chung,Riotto '98]

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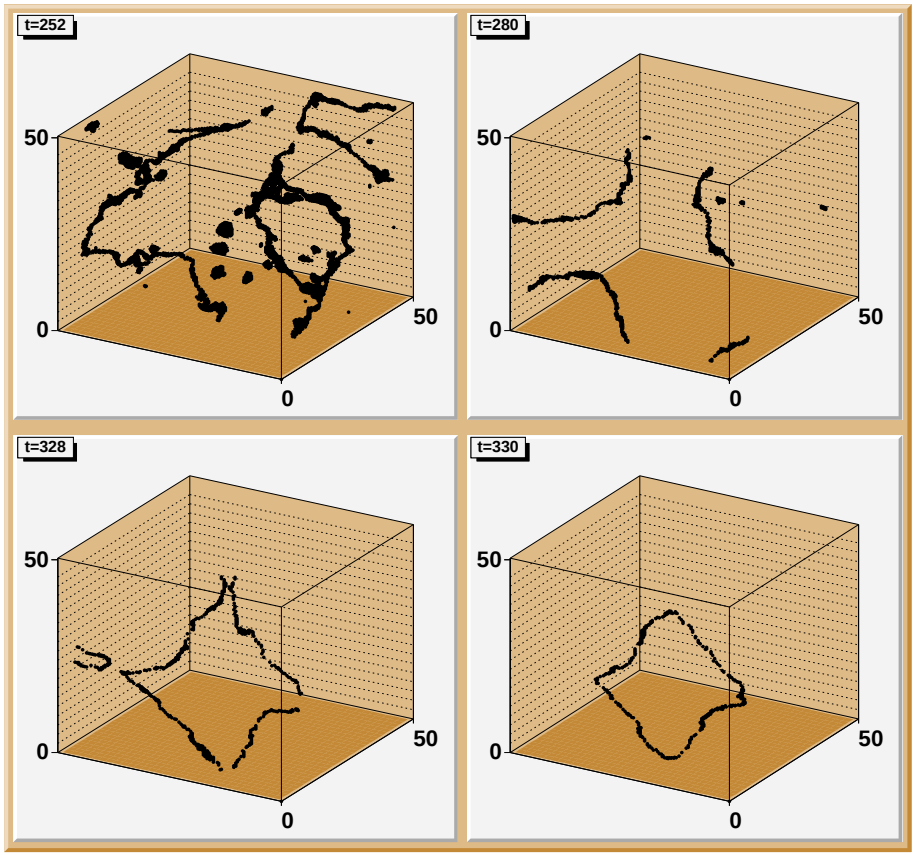

[Tkachev,Khlebnikov,Kofman,Linde '98]

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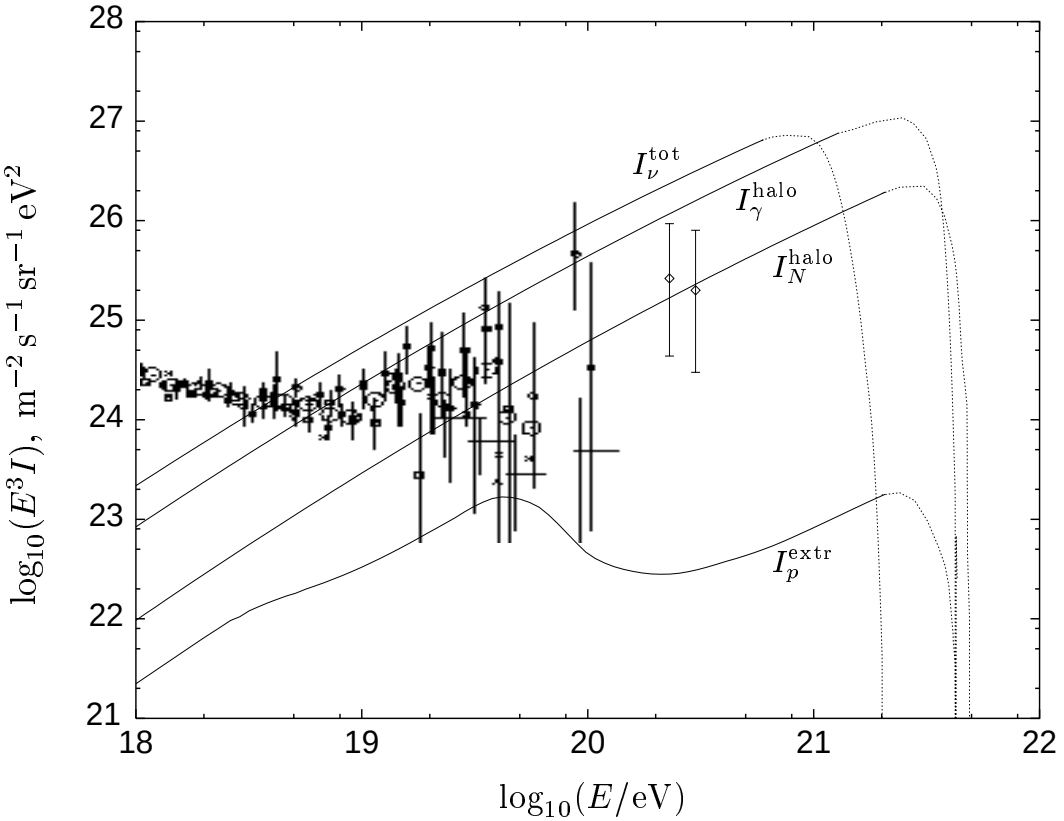

[Berezinsky,Kachelriess,Vilenkin '97]

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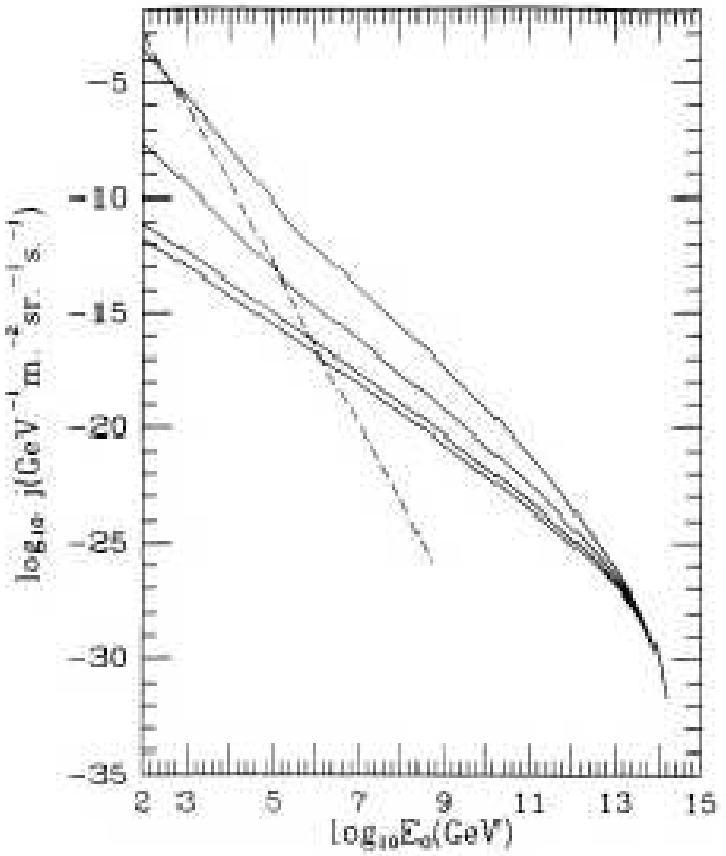

[Bhattacharjee,Hill,Schramm '92]

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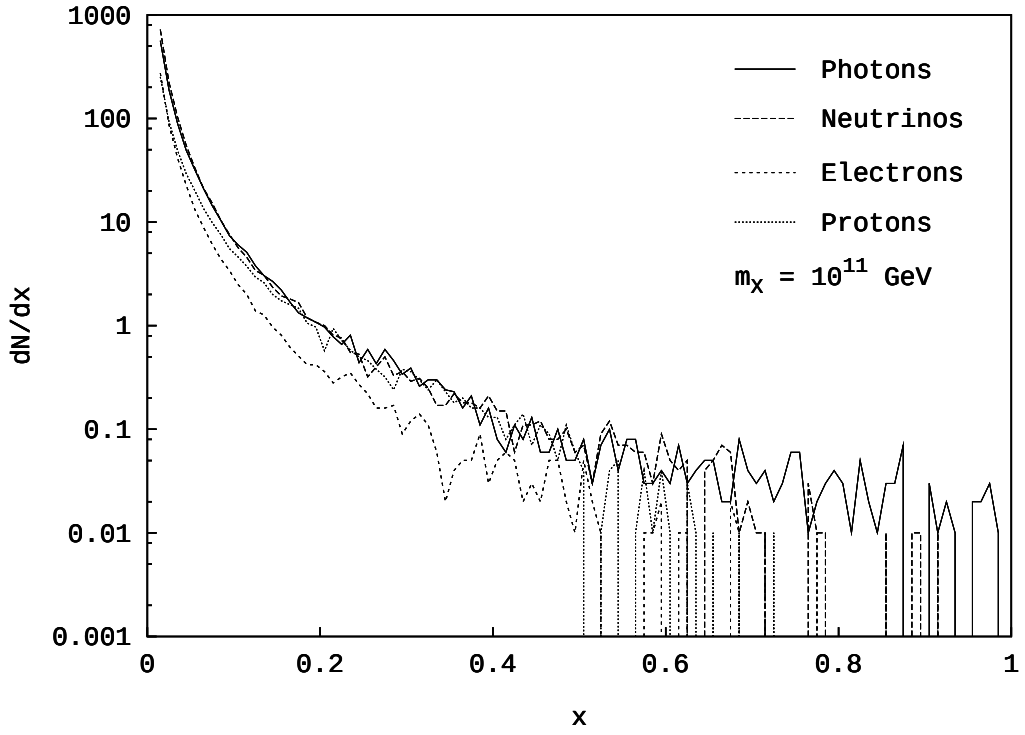

[Birkel,Sarkar '98]

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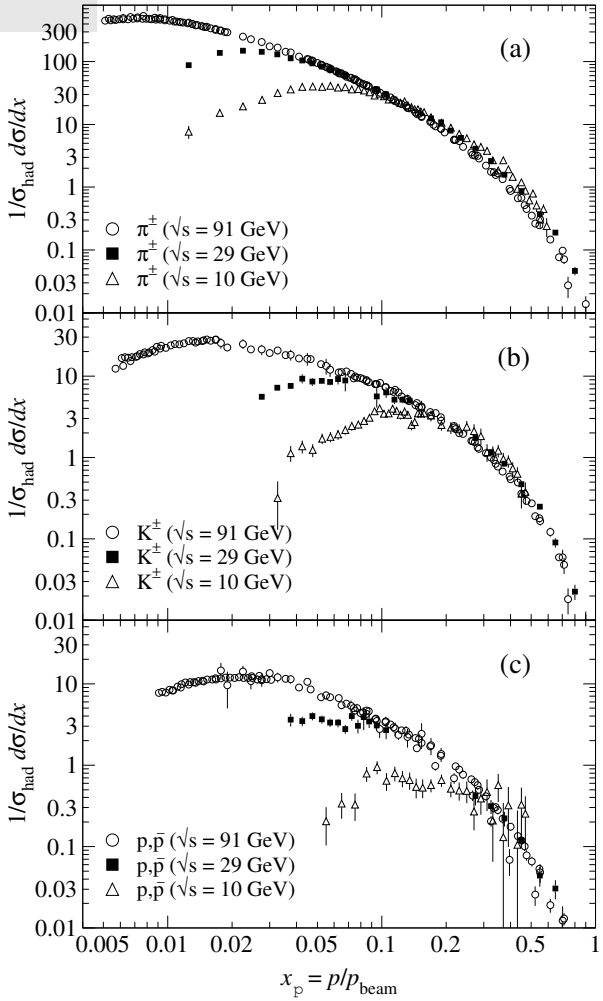

[Particle Data Group '04]

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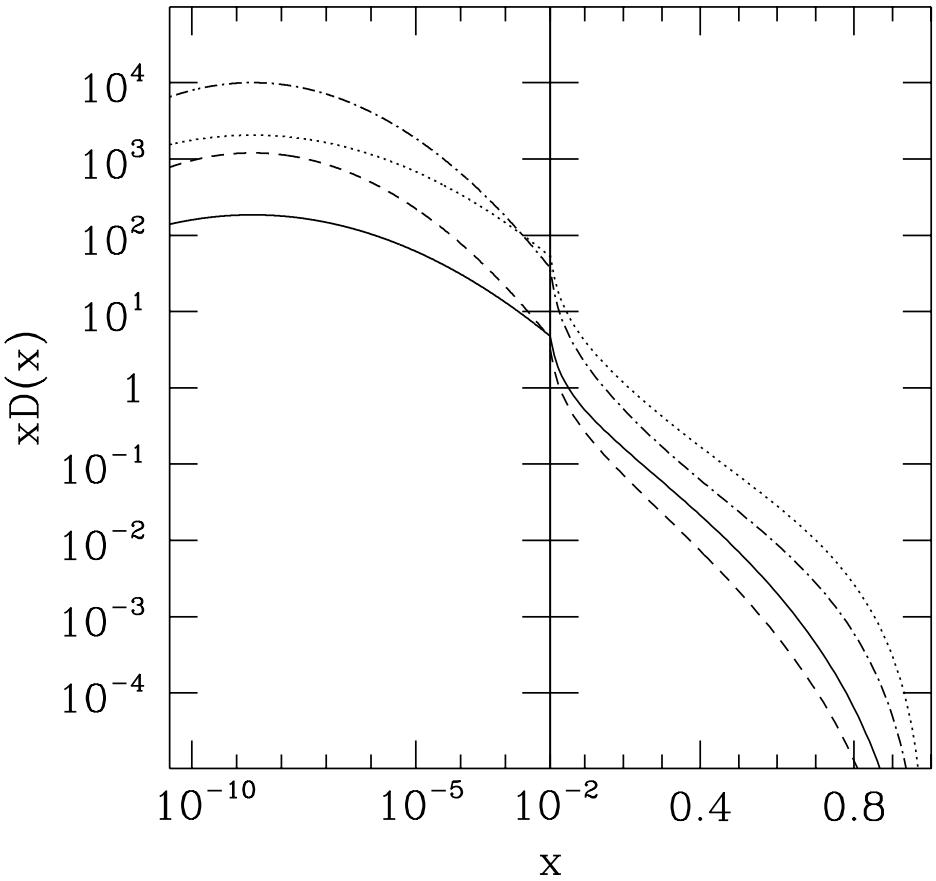

[Fodor,Katz '01]

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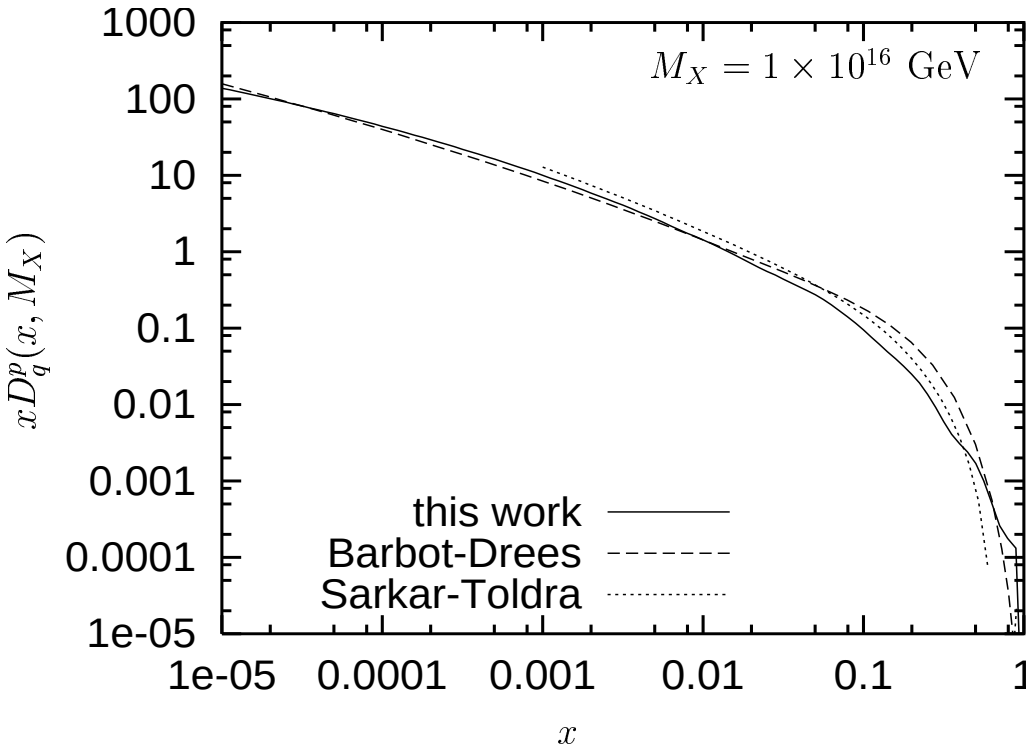

[Aloisio,Berezinsky,Kachelriess '04]

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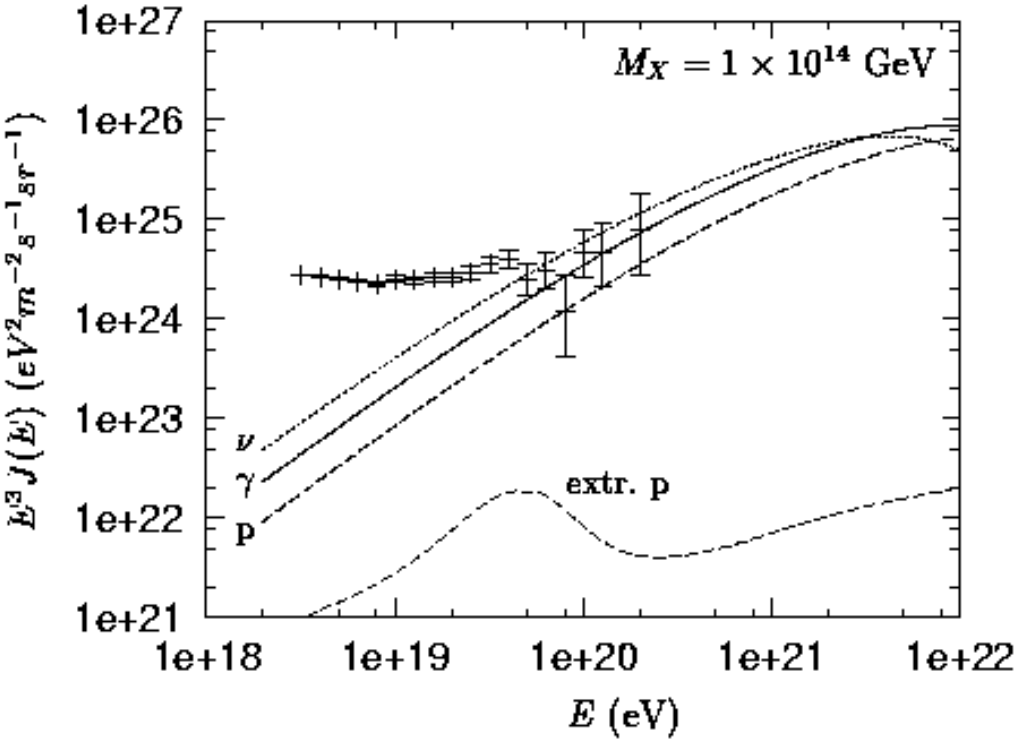

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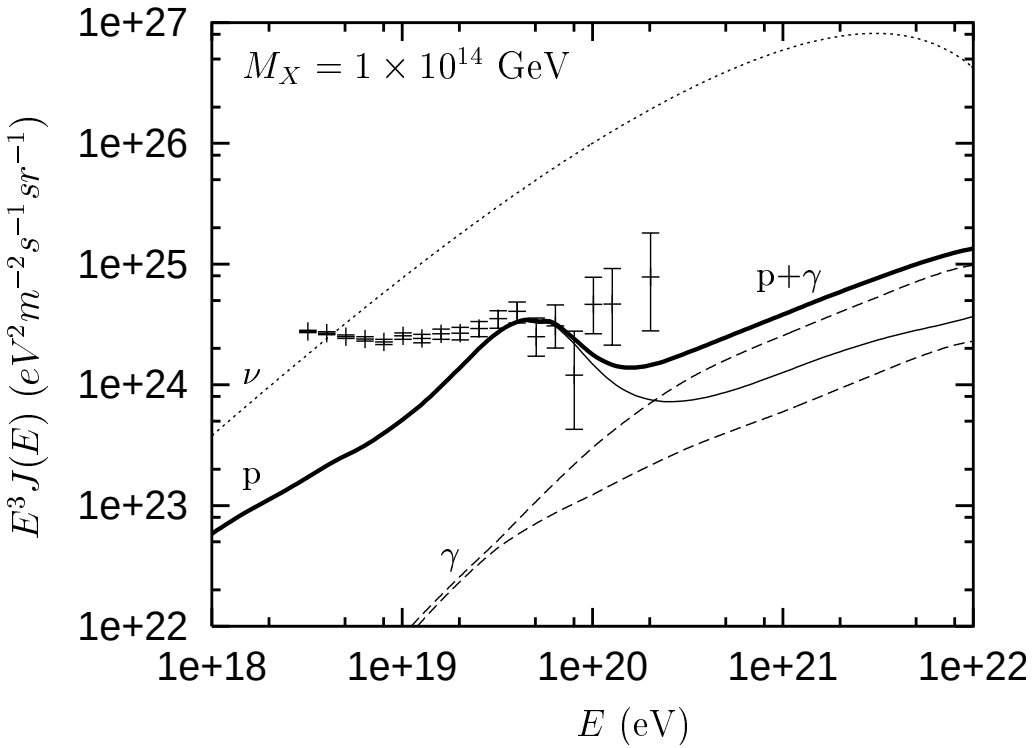
  - for topological defects, injection far away: $j_\nu \gg j_\gamma \sim j_p$



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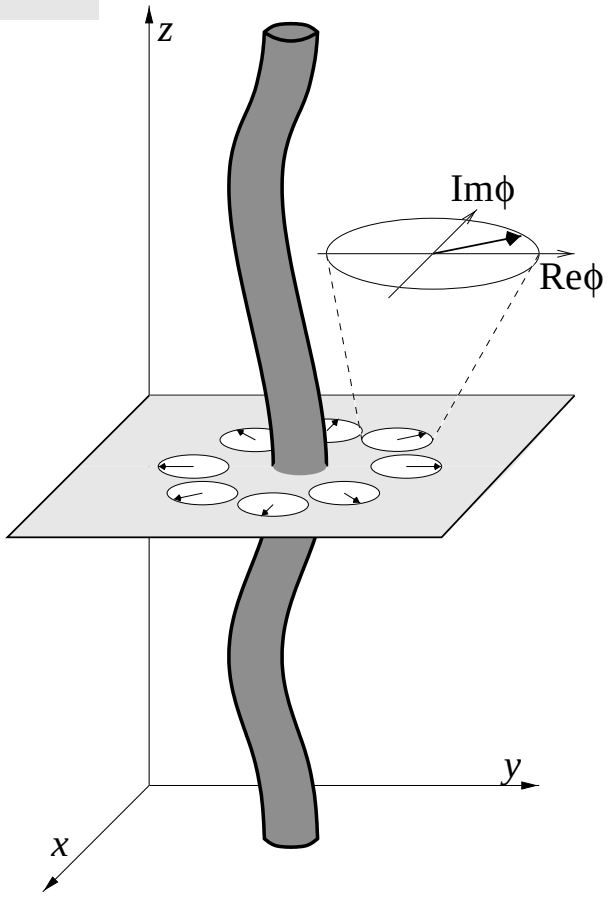

[Rajantie '03]

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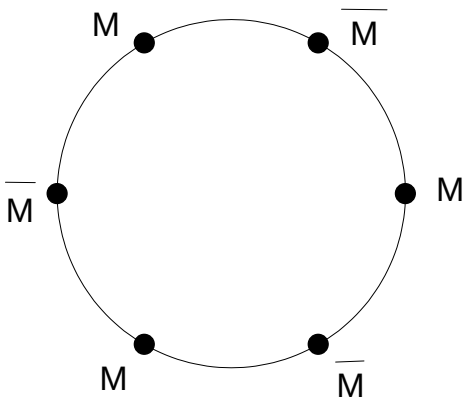
NECKLACE



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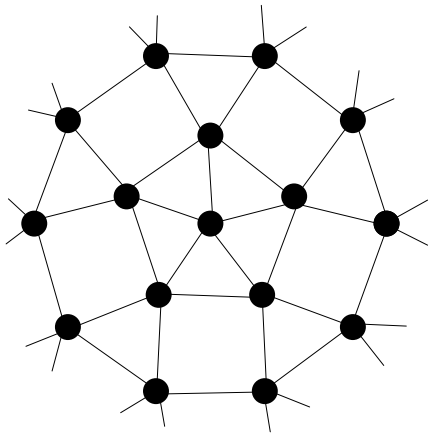

[Berezinsky '05]

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- Strong impact of measurement for
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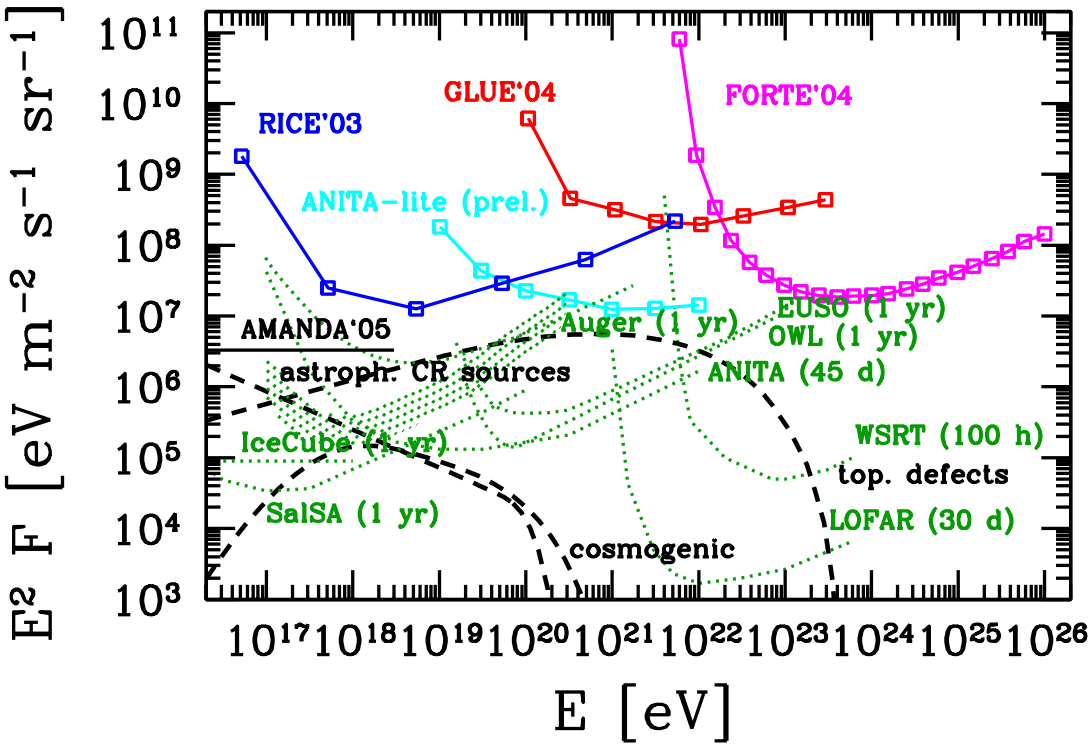

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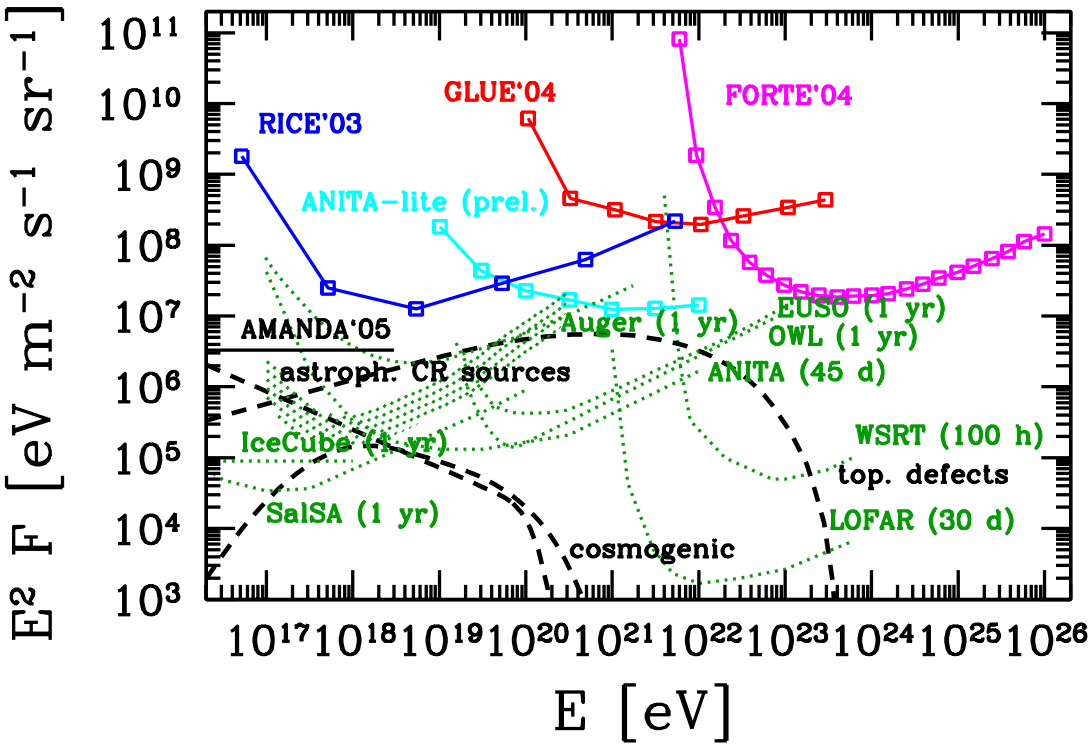

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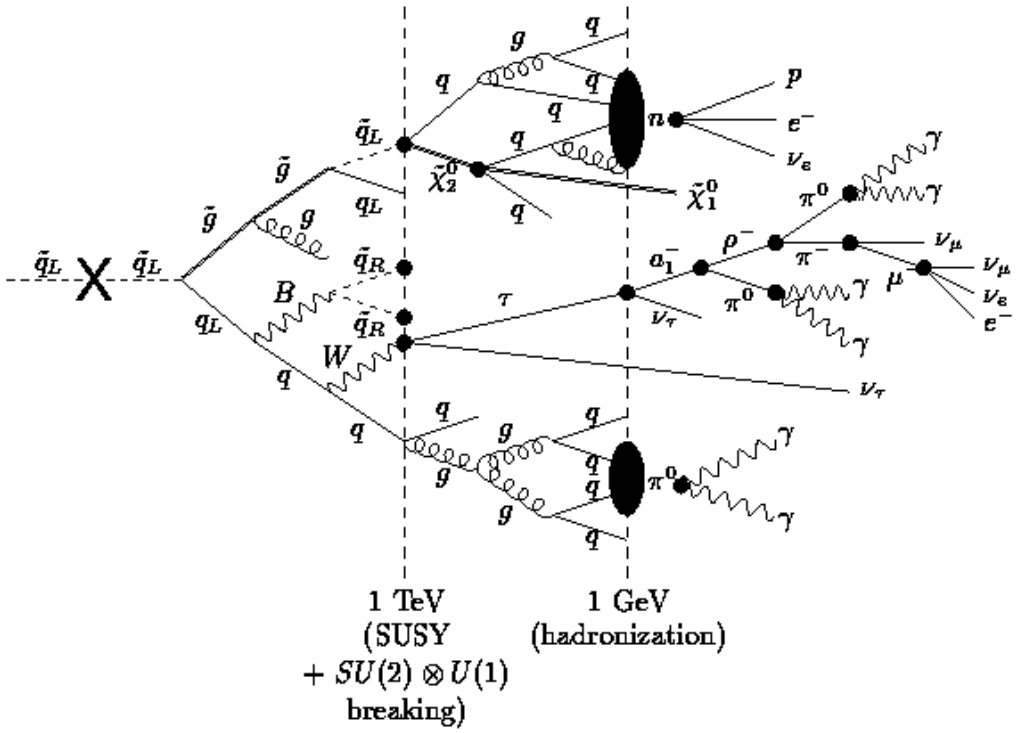

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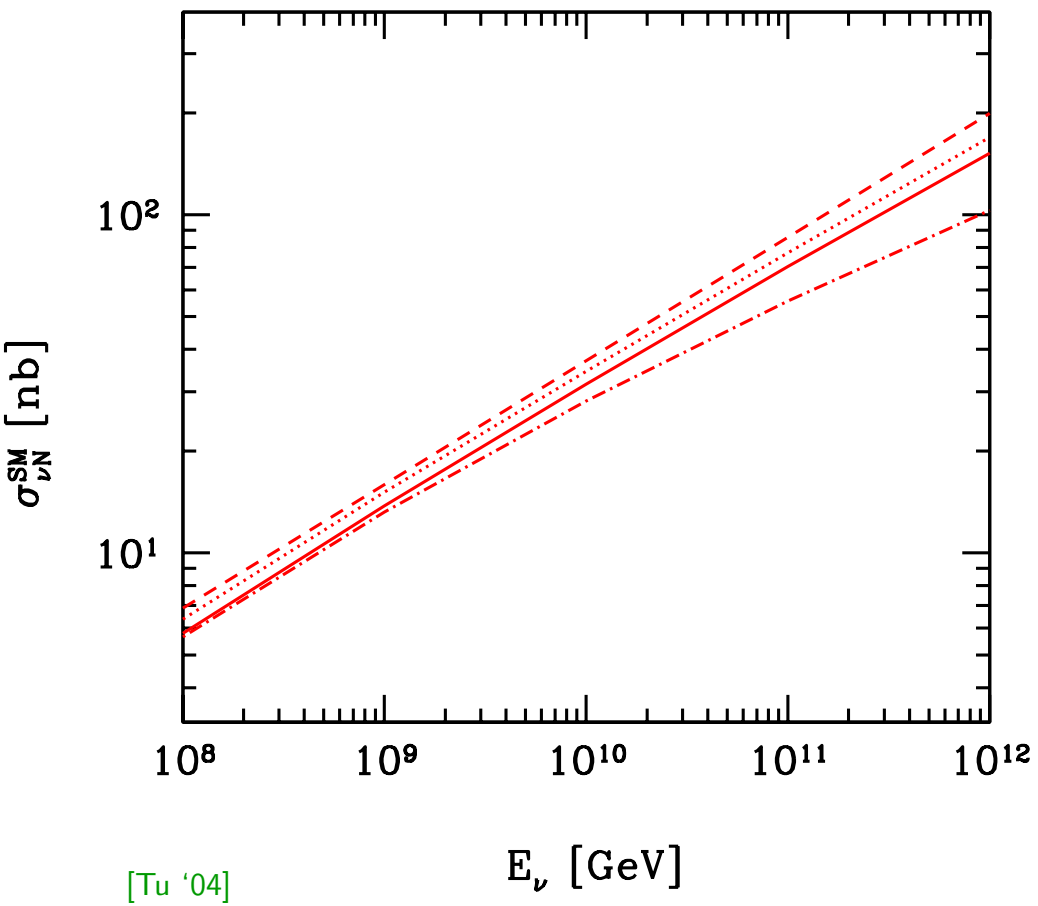

[Tu '04]

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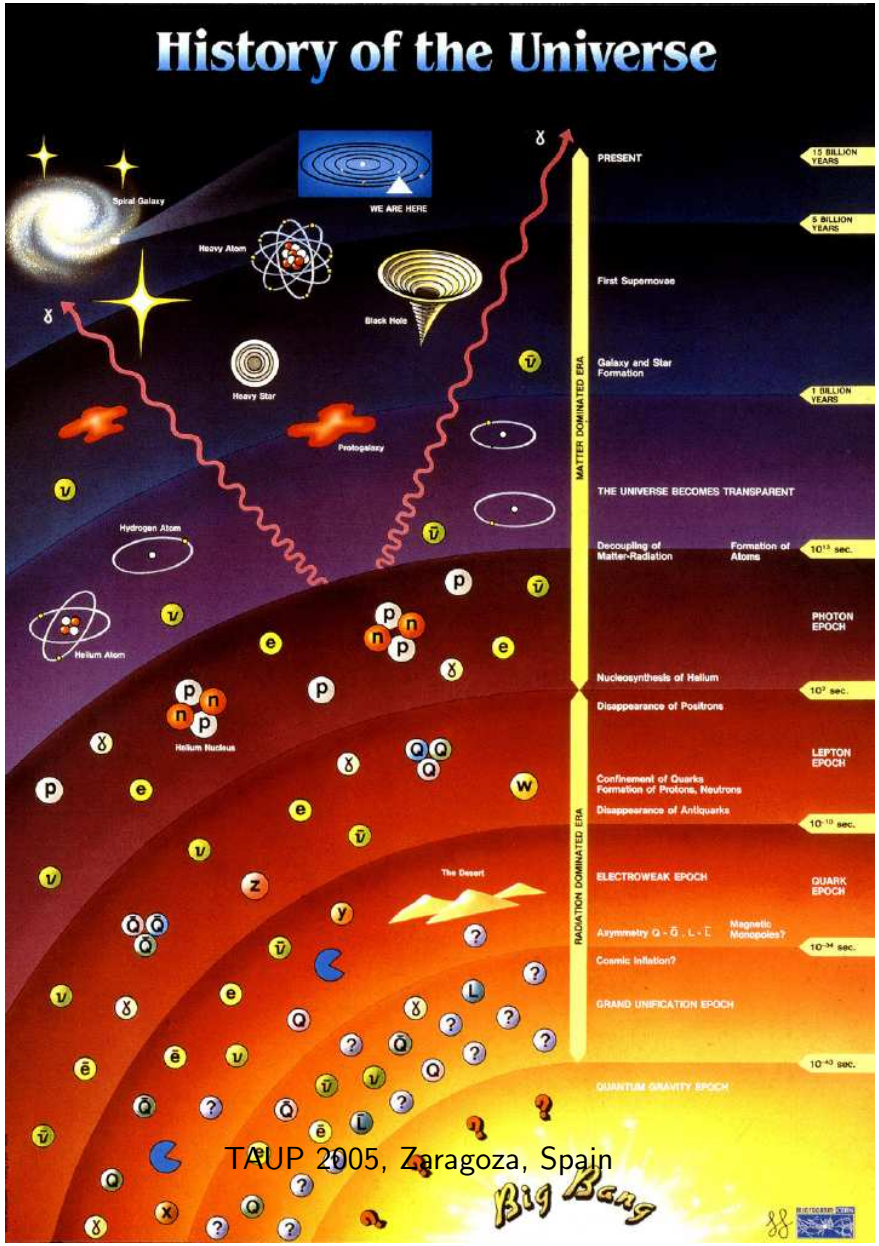
    - window on early phase transition
    - Hubble expansion rate $H(z)$
    - existence of the big bang relic neutrino background (CνB)

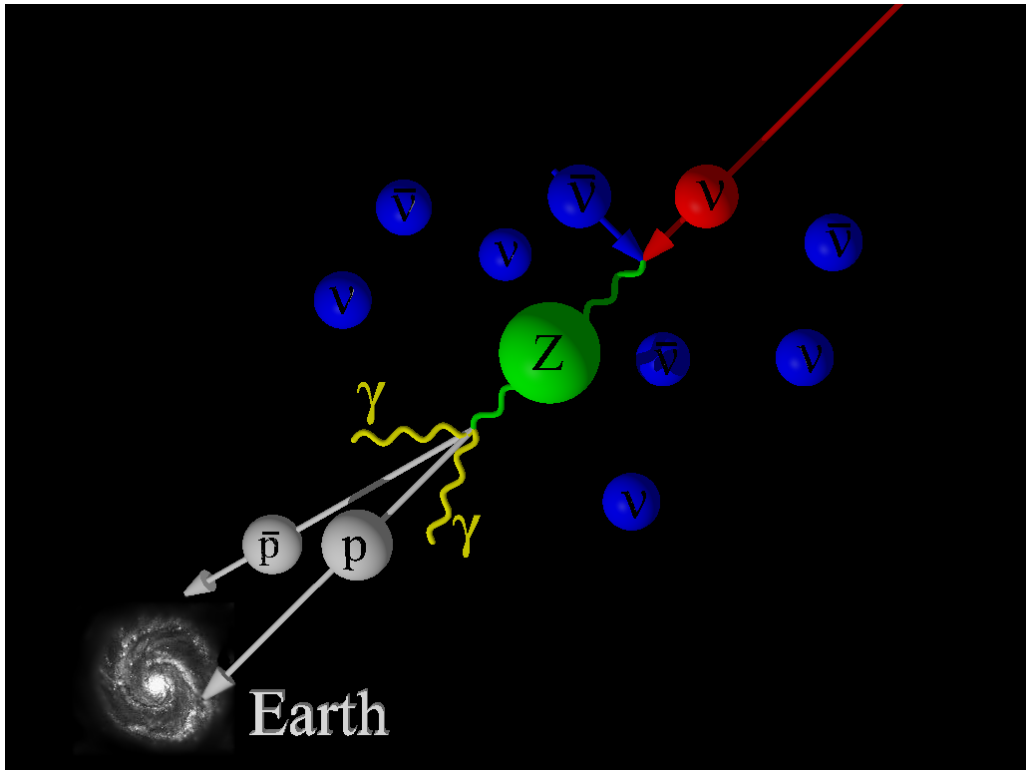


Absorption of super-GZK neutrinos by the CνB

- At the resonance energies

$$E_\nu^{\rm res} = \frac{m_Z^2}{2m_\nu} \simeq 4 \times 10^{21}\ {\rm eV} \left(\frac{\rm eV}{m_\nu}\right)$$

super-GZK neutrinos annihilate with relic neutrinos into Z bosons



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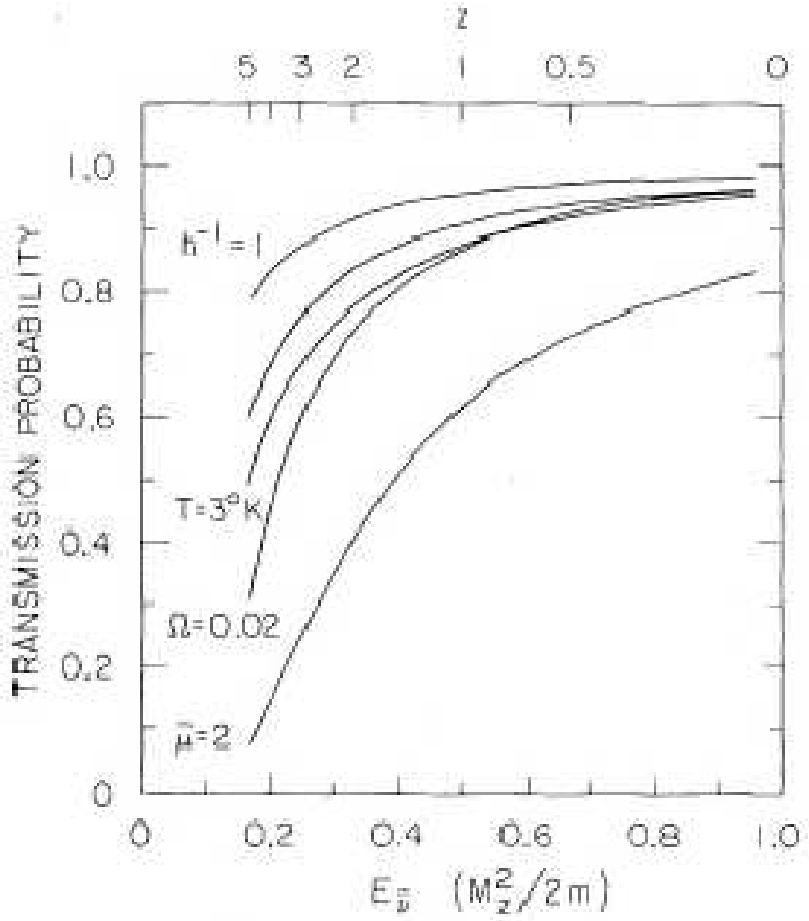

[Weiler '82]

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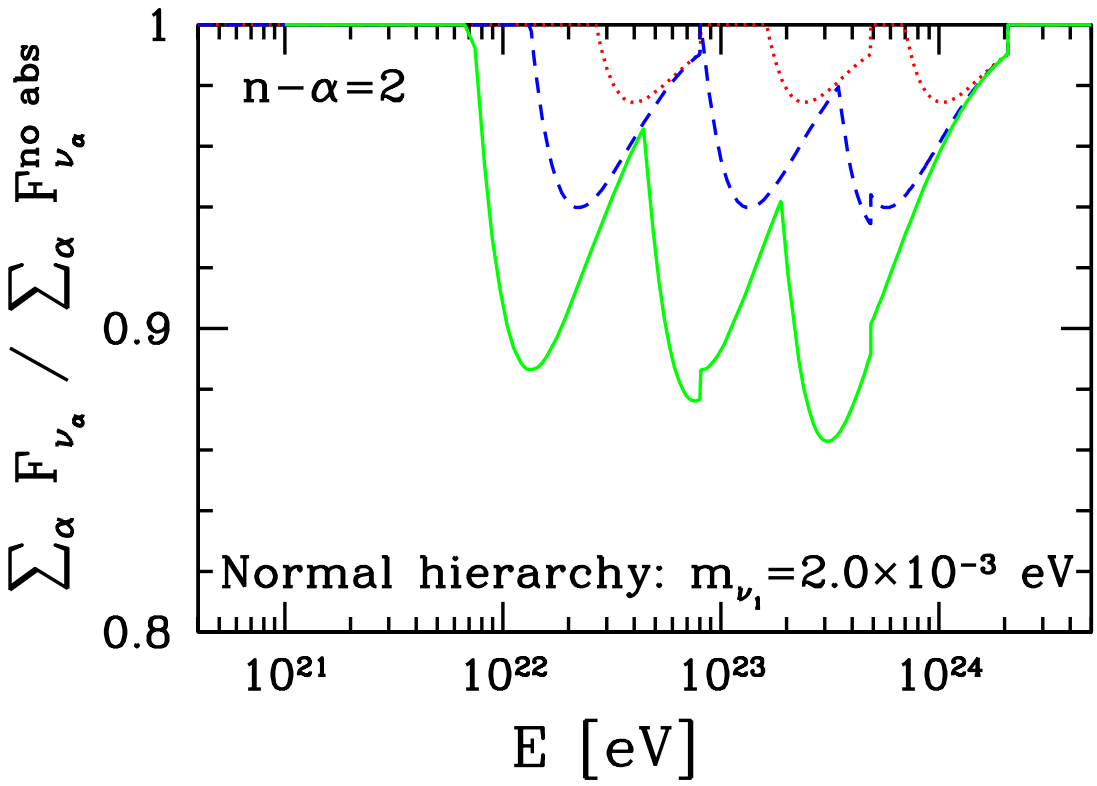

[Eberle,AR,Song,Weiler '04]

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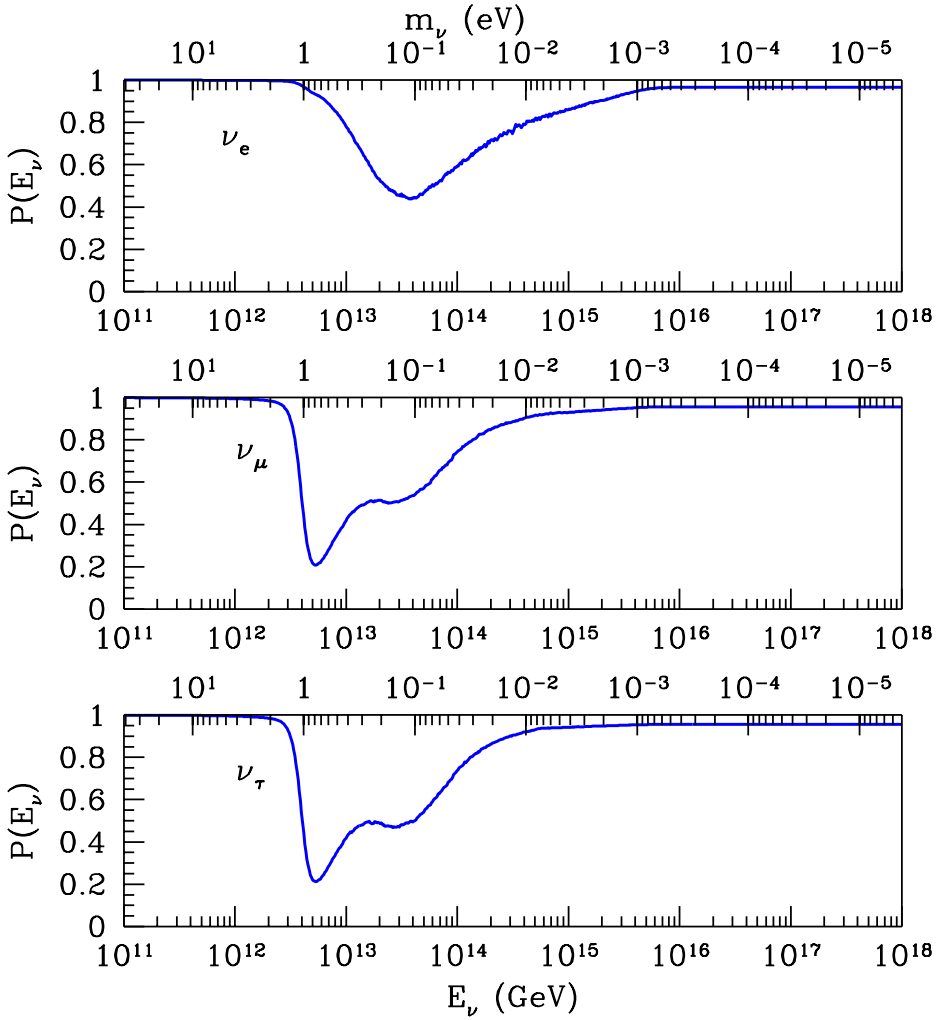

[Barenboim,Mena,Quigg '05]

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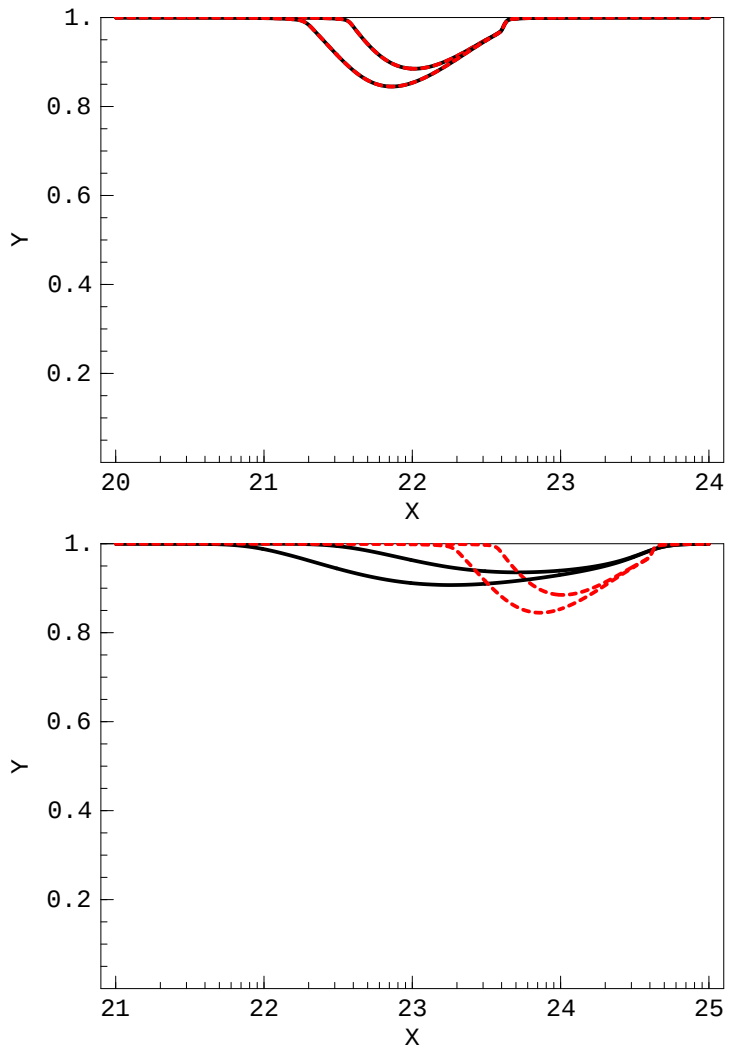

[D'Olivo,Nellen,Sahu,Van Elewyck '05]

Absorption of super-GZK neutrinos by the CνB

- At the resonance energies

$$E_\nu^{\rm res} = \frac{m_Z^2}{2m_\nu} \simeq 4 \times 10^{21}\ {\rm eV} \left(\frac{\rm eV}{m_\nu}\right)$$

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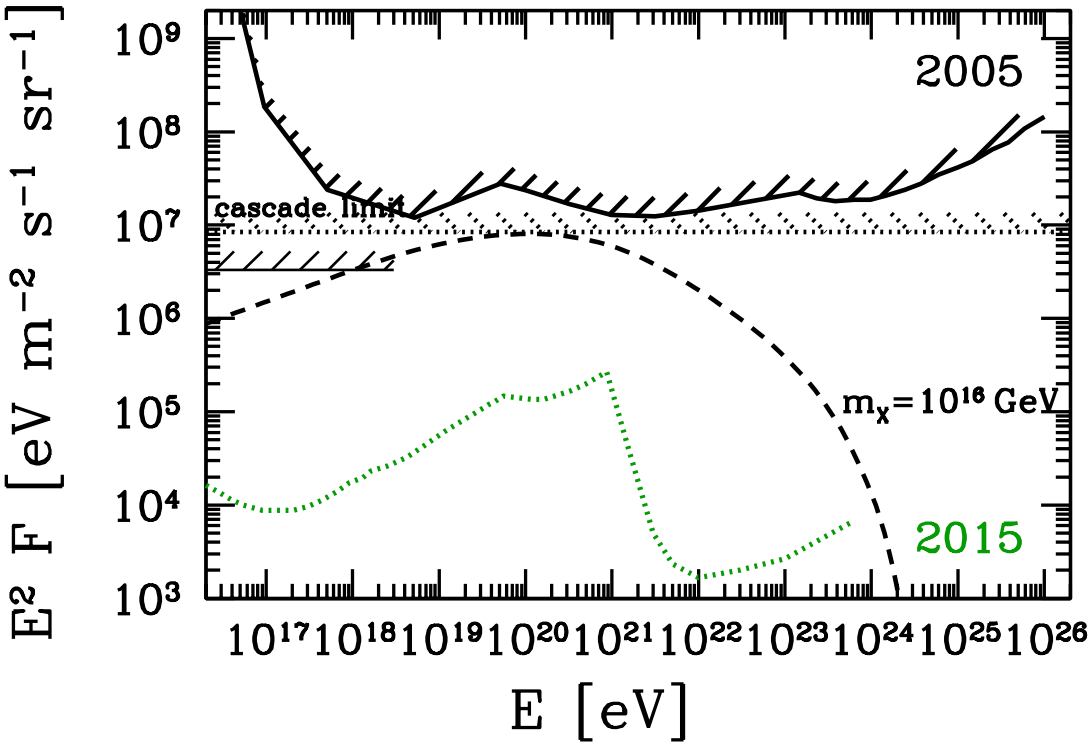
- Detectable within next decade if
  - $m_X \gtrsim 10^{15}$ GeV
  - super-GZK neutrino flux close to current observational bounds



[Eberle,AR,Weiler,Wong,in prep.]

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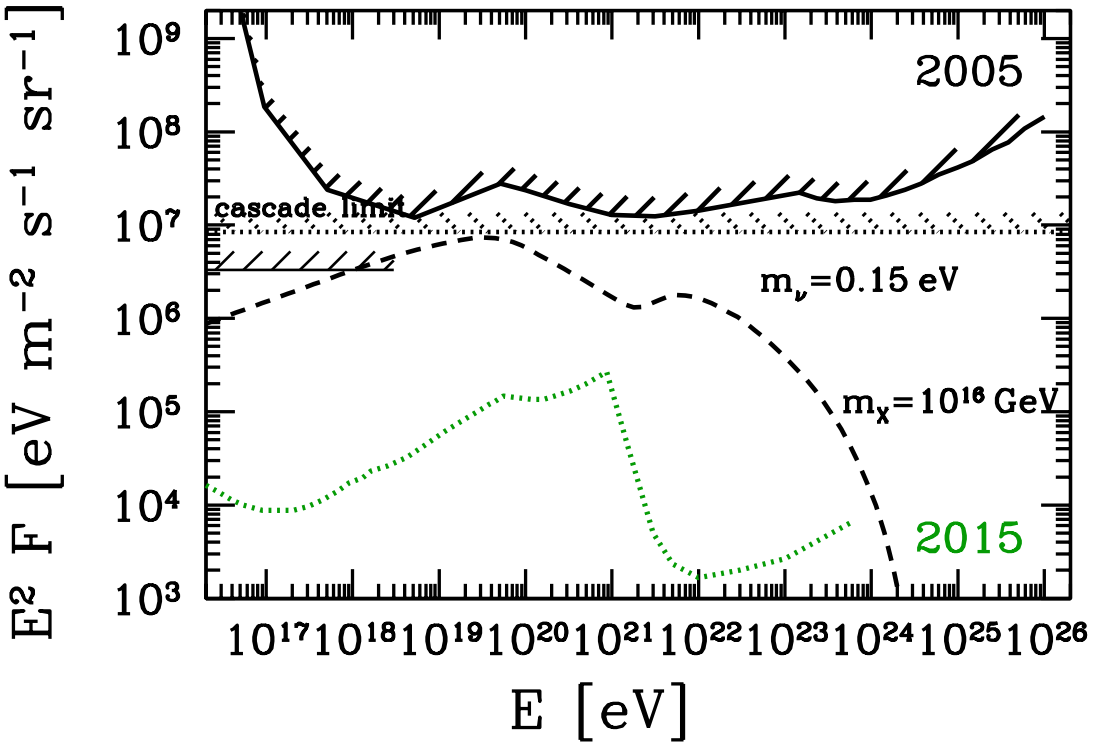

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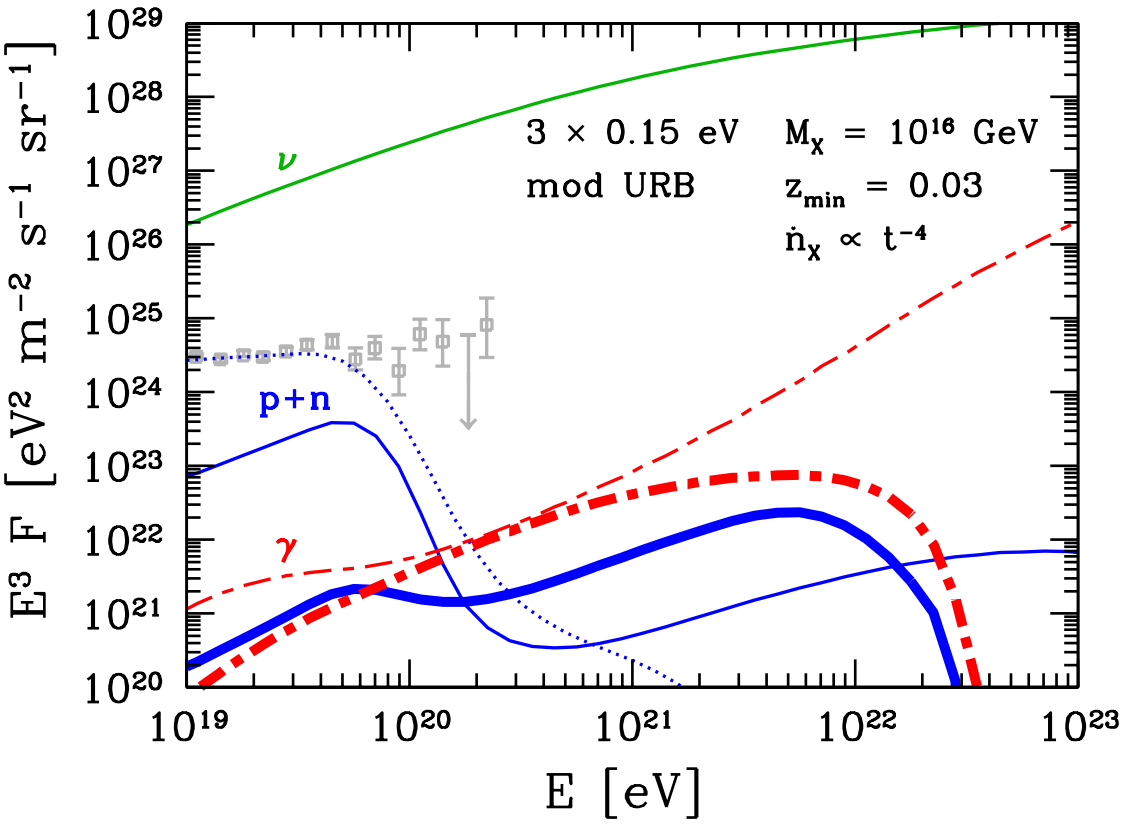
- Z-bursts as super-GZK recovery



[Eberle,AR,Weiler,Wong,in prep.]

4. Conclusions

- Exciting times for super-GZK neutrinos:
  - many observatories under construction

  $\Rightarrow$ appreciable event samples

- Expect strong impact on
  - astrophysics
  - particle physics
  - cosmology