Particle physics applications with Extragalactic background light

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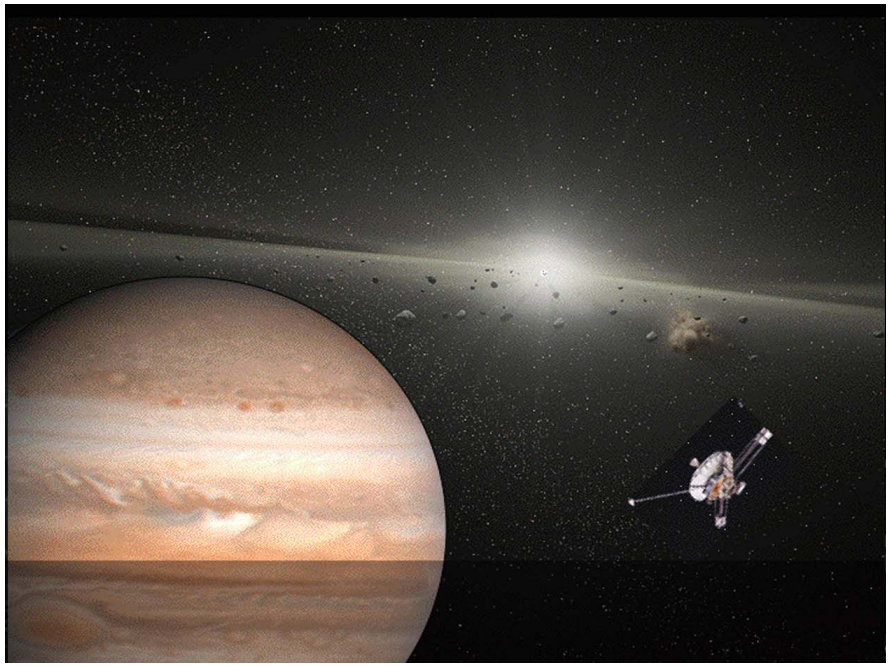
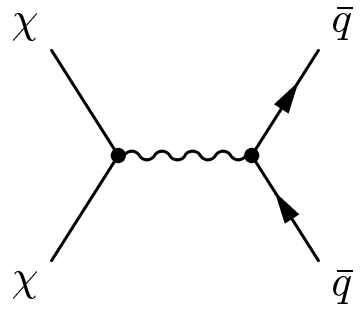


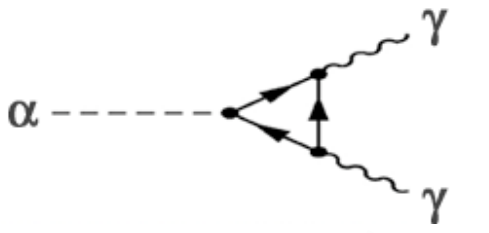
The View from 5 AU: Measuring the Diffuse Sky Brightness from the Outer Solar System
March 25, 2010
Irvine, CA

Particle dark matter

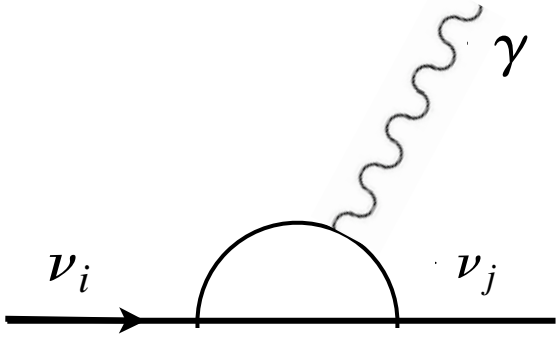
- WIMPs
  - Motivation: Supersymmetry, unification, dark matter
  - Indirect signals in gamma-rays [MeV-TeV]



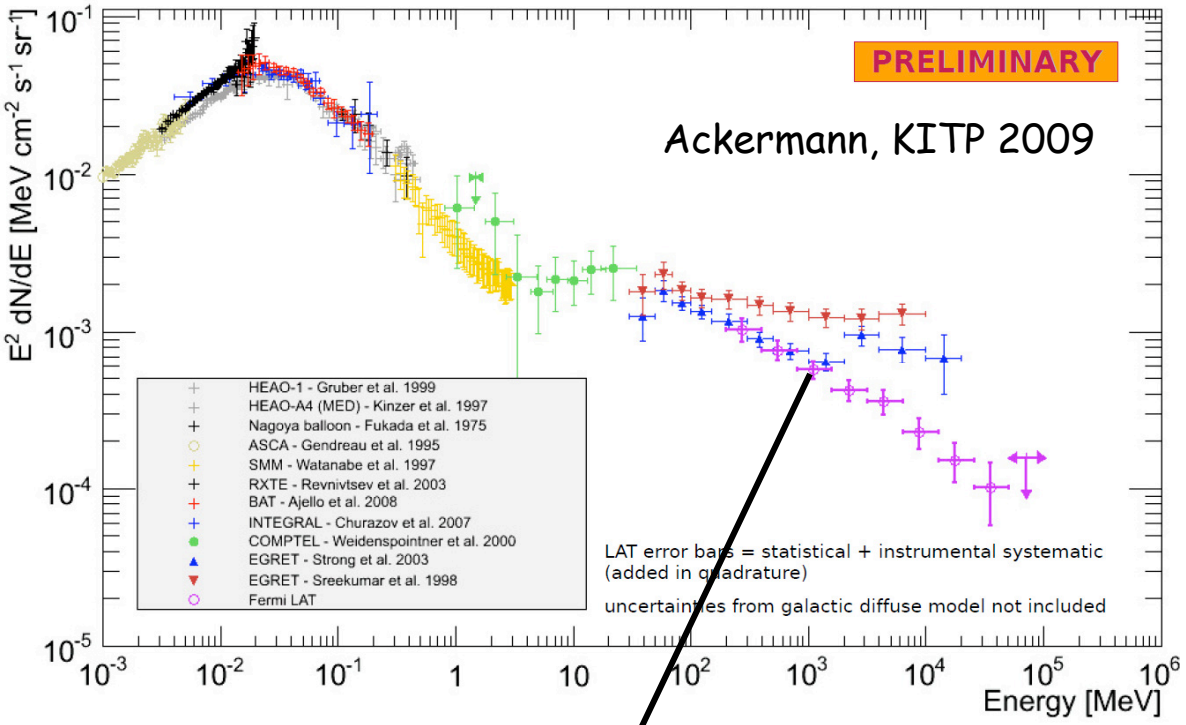
- Axions
  - Motivation: Strong CP problem
  - Indirect signals in optical/IR



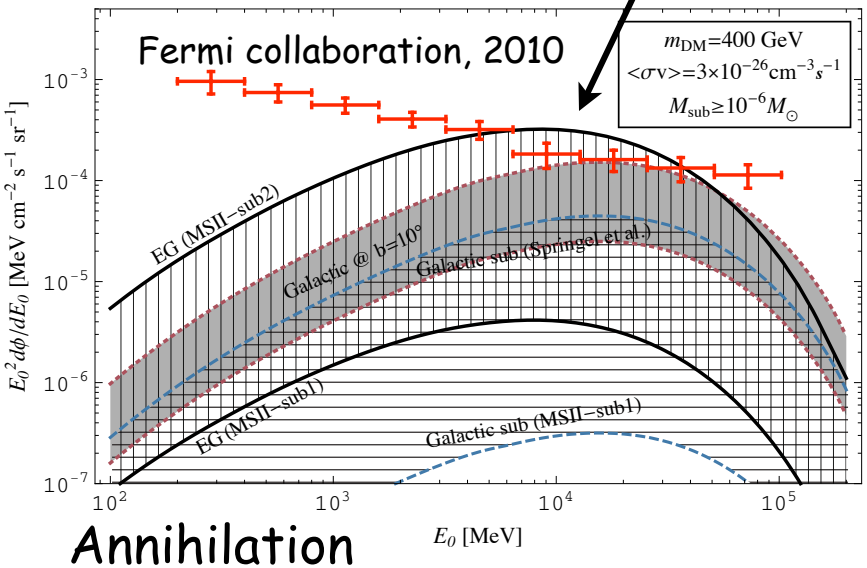
- Neutrinos
  - Indirect signals in IR/radio



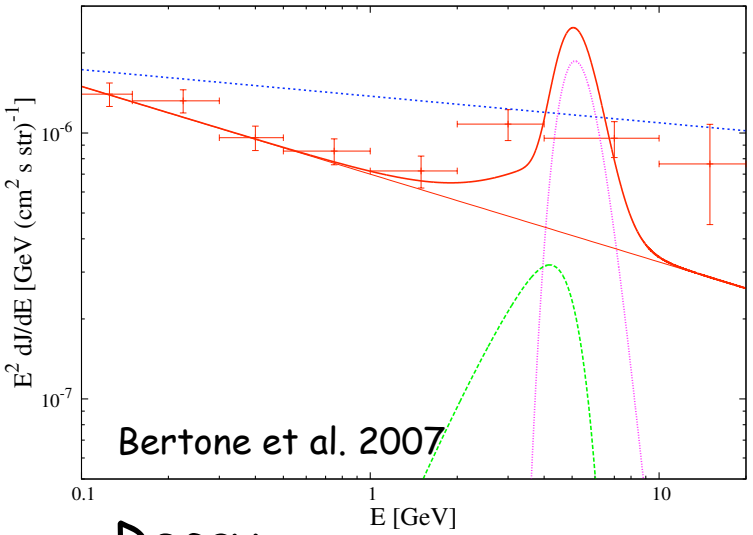
WIMPs and high energy photons: Modern applications



- Vast literature on WIMP annihilation prospects for Fermi, ACTs
- Lines from WIMP/sterlie neutrino decays in keV-GeV regime [e.g. Watson et al. 2006, Cembranos, Feng, Strigari, 2007, Yuksel & Kistler 2007, Yuksel et al. 2008, Bertone et al. 2007]



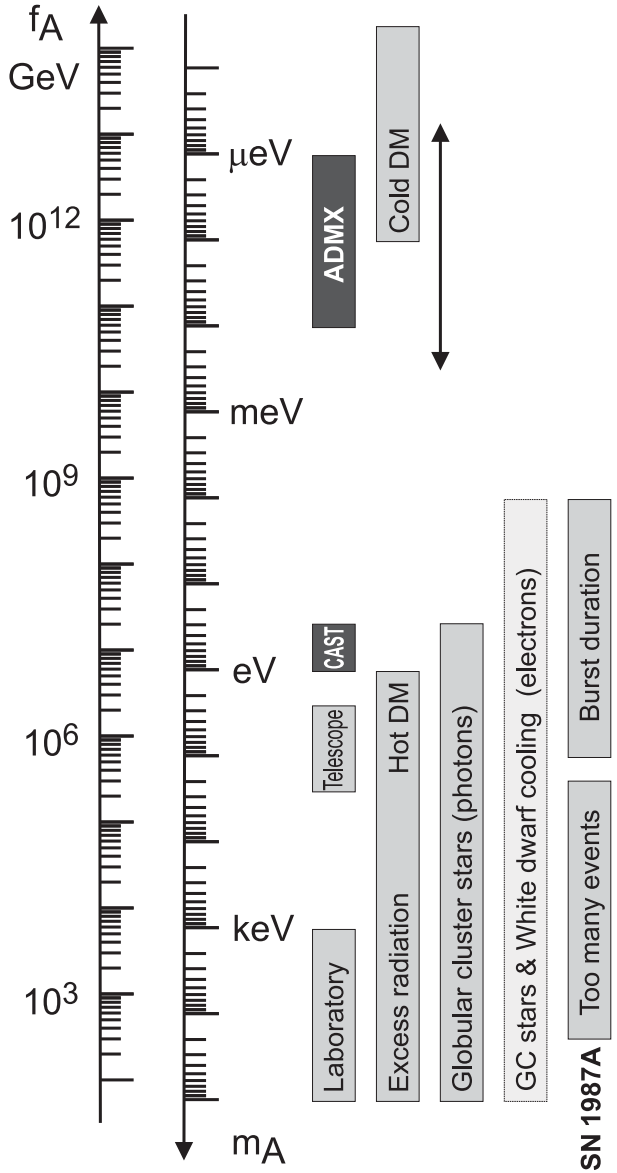
Annihilation



Decay

Axion mass constraints

- Thermal ($m_a > 0.01$ eV) or non-thermal ($m_a < 0.01$ eV)
- Astrophysical and Cosmological limits
  - Stellar energy-loss limits [Raffelt, 1996]
  - Diffuse background radiation [Turner 1987, Overduin & Wesson 1993]
  - Hot dark matter ($m_a < 1$ eV) [Hannestad et al. 2008, Melchiorri et al., 2007]
- Model dependence in constraints: Possible window in the eV regime if the coupling to photons is suppressed [e.g. Moroi & Muryama 1998]



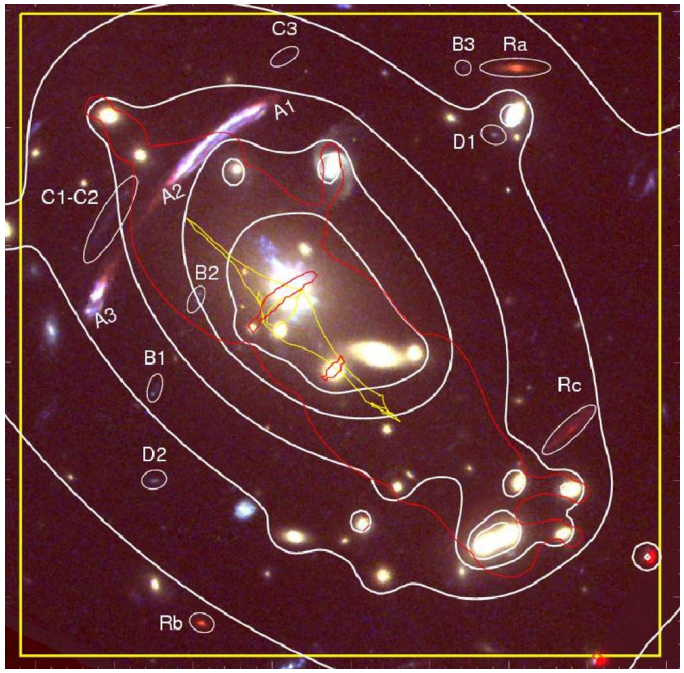
Particle data group

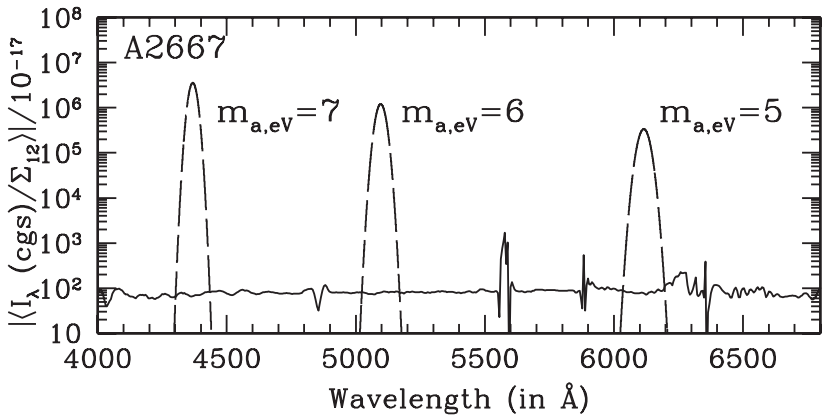
Axion lines from clusters

Bershady et al 1991, Ressell 1991

$$\tau = 6.8 \times 10^{24} \xi^{-2} m_{\mathrm{a.eV}}^{-5} \ \mathrm{s}$$

- Rest frame axion decay line of 24,800 Angstrom/$m_{a,eV}$ (1+z)
- Axions accrete onto clusters even if they are not the dominant DM component.
- Phase-space considerations likely make clusters a better target than the MW (Ressell 1991)
- Modern constraints on mass profiles from gravitational lensing





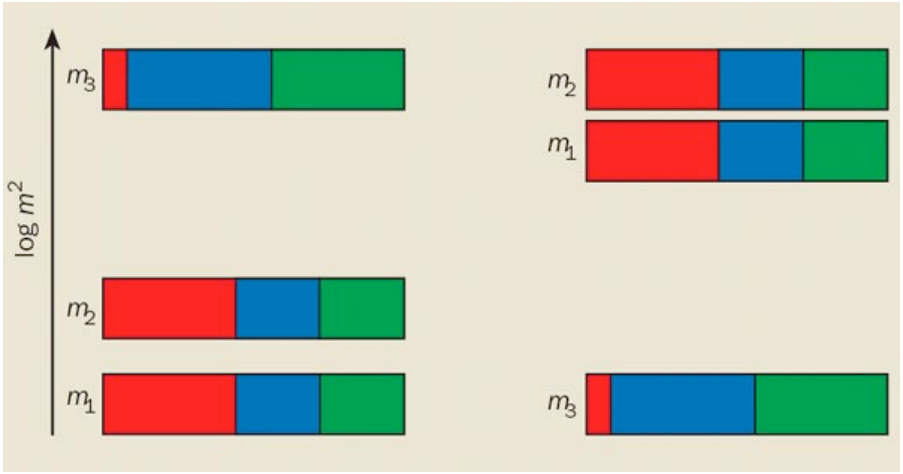
D. Grin et al. 2007

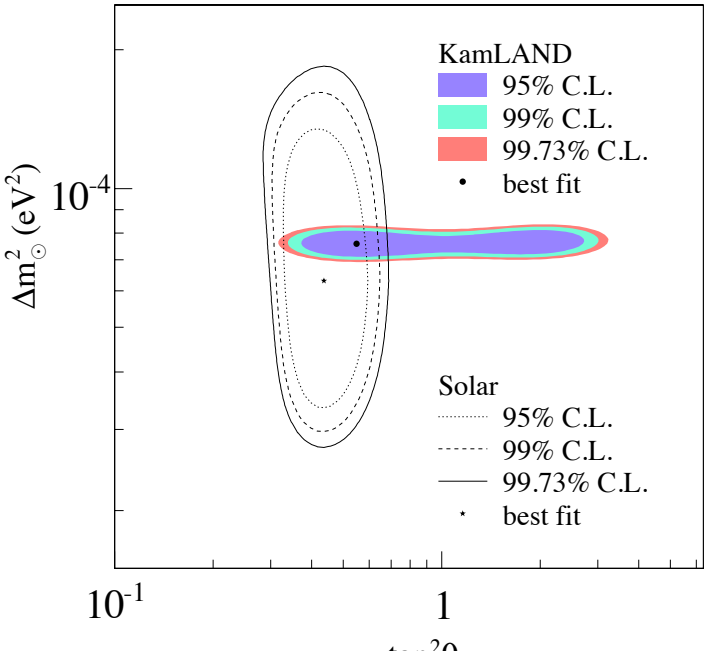
Standard model neutrinos

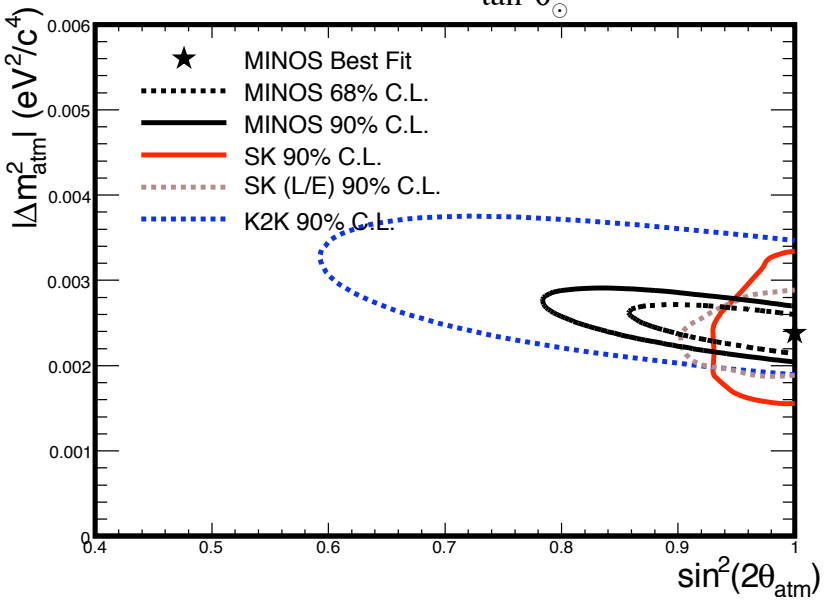
- Mass matrix characterized by 3 mass splittings and one phase
- Mass limits from laboratory and from cosmology,

  [Seljak et al. 2006, Lesgourgues & Pastor 2006]

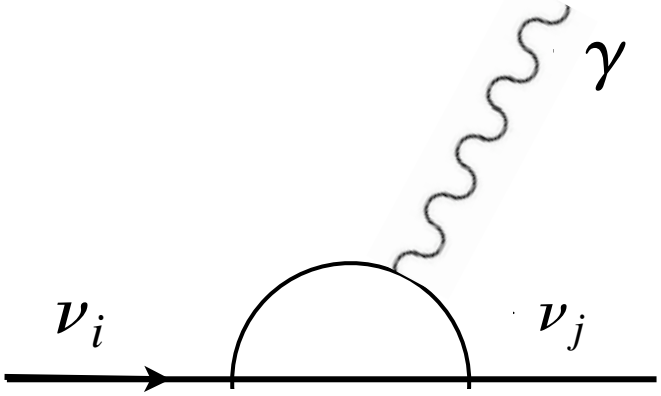
$$\sum_i m_i < (0.17 - 2.0)\ \mathrm{eV}$$







Neutrino lifetime

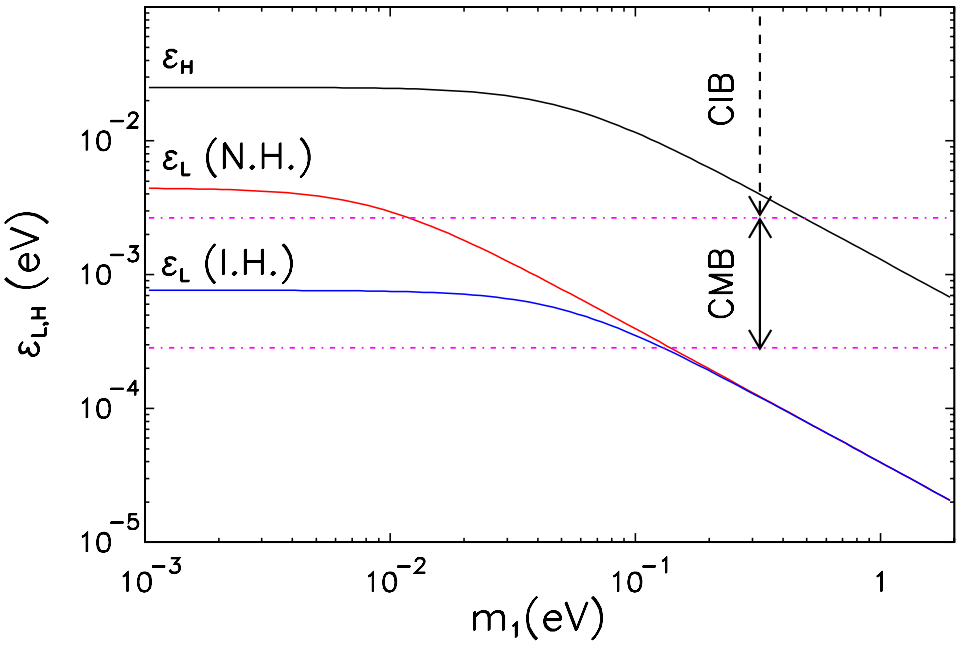


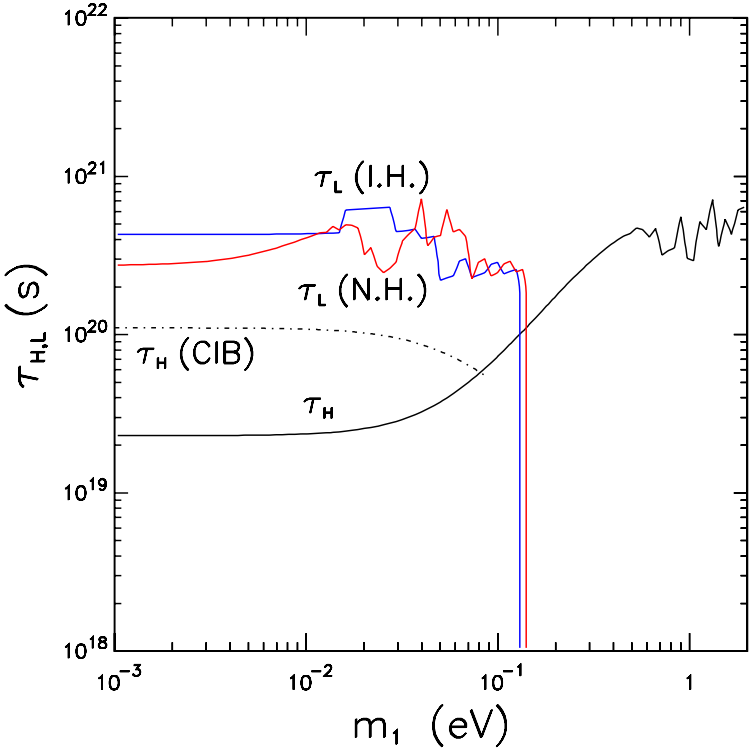
Neutrino source	L/E	τ/m (s/eV)
Accelerator	30 m / 10 MeV	10^{-14}
Atmosphere	10^4 km / 300 MeV	10^{-10}
Sun	500 s / 5 MeV	10^{-4}
Supernova	10 kpc / 10 MeV	10^5
AGN	100 Mpc / 1 TeV	10^4

Beacom & Bell 2002

- Decays probe the parameter space of lifetime/mass

$$\Gamma_{ij}^{\gamma} = \frac{|\mu_{ij}|^2 + |\epsilon_{ij}|^2}{8\pi}\left(\frac{m_i^2 - m_j^2}{m_i}\right)^3$$

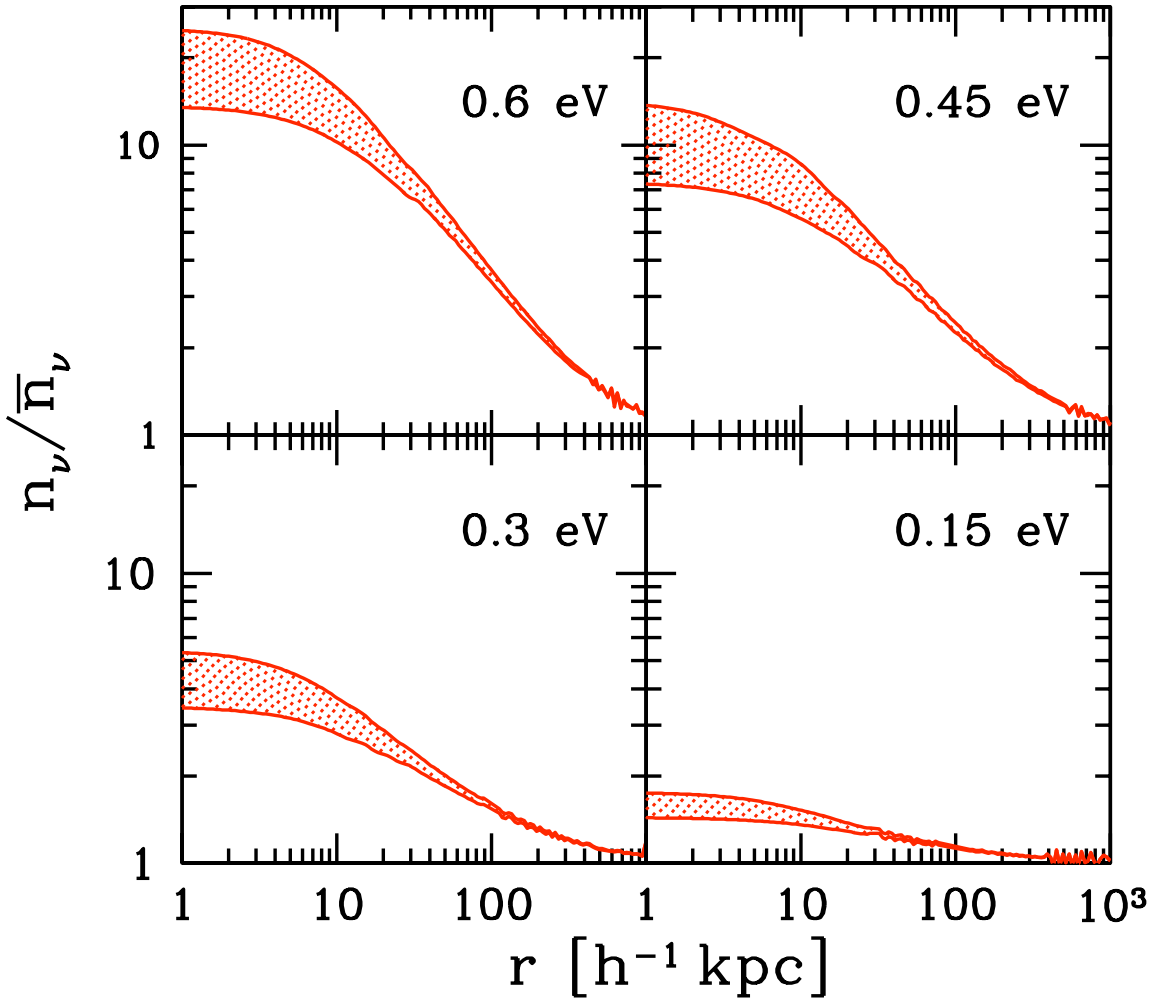




Mirizzi et al. 2007

Relic neutrino clustering

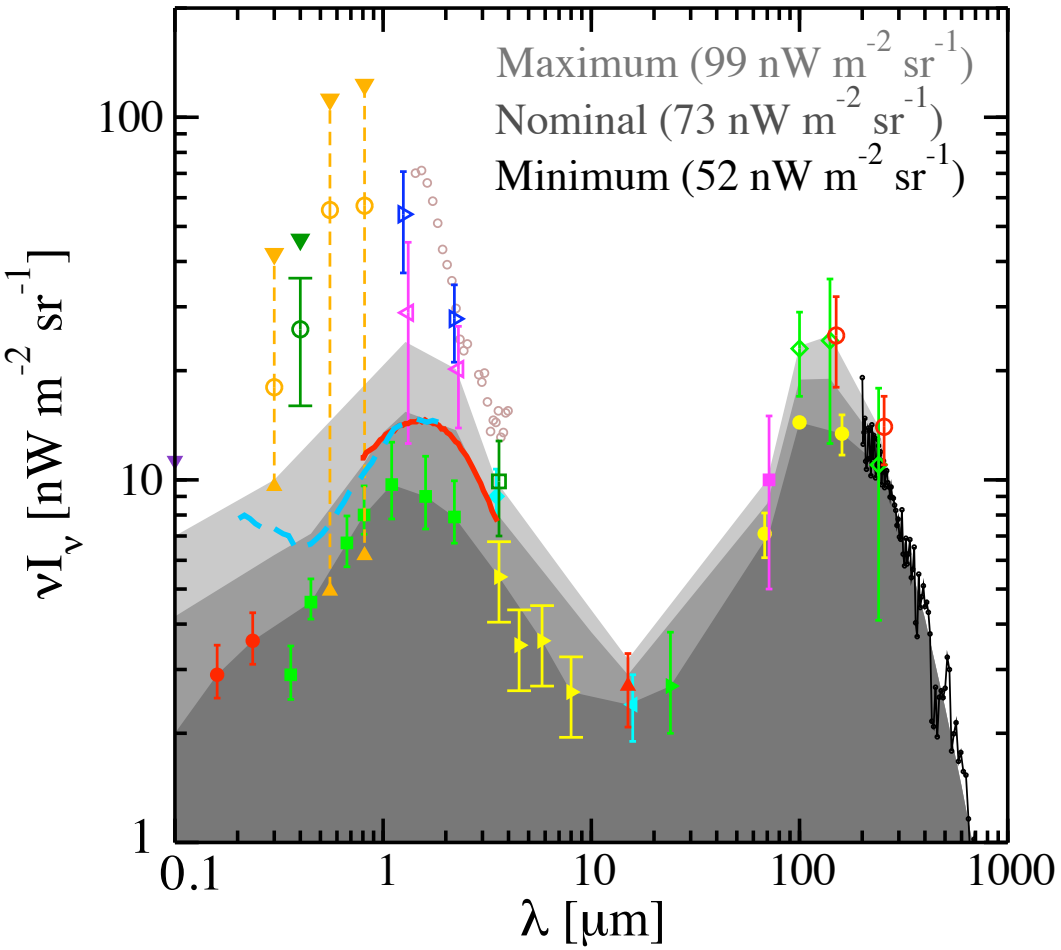
- Depending on mass, neutrinos would cluster around seed galaxy and clusters
- Clusters may then be ideal targets for radiative decay lines



Ringwald & Wong 2003

Conclusions/Prospects

- Prospects for constraining new physics with EBL
- Spectroscopy would be sensitive to lines from neutrino or axion decays
- Improve on Spitzer IRS results: more sensitivity and more targets



Horiuchi, Beacom, Dwek, 2009