Relic neutrino clustering in the Milky Way: reloaded

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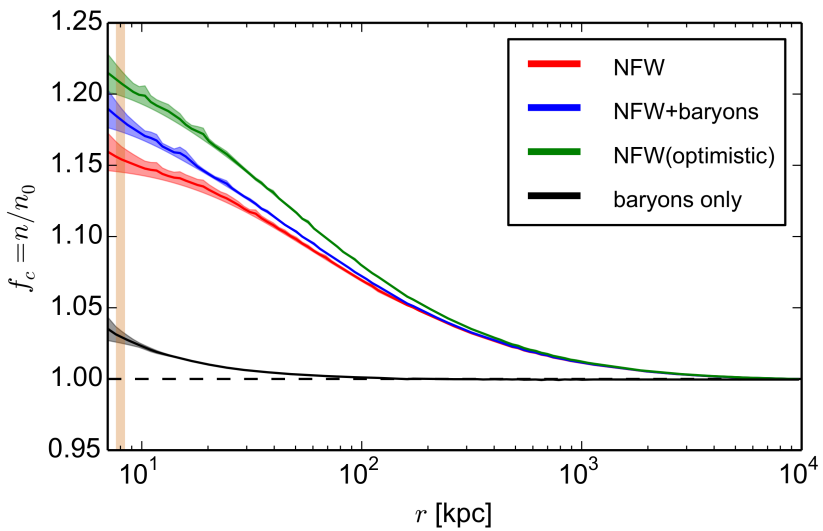
Clustering of cosmic neutrinos

- CνB key prediction of Big Bang model
- Massive neutrinos cluster in dark matter halos and galaxies
  1. How many cosmic neutrinos are there in the Solar vicinity?

$$f_c = \frac{n_i}{56/\mathrm{cm}^3/\mathrm{flavor}} \quad \text{clustering factor at Earth's position}$$

  2. Can we detect them with upcoming experiments?

- First work by Ringwald & Wong (2004): **N-one-body simulations**
- Improved modelling of Milky Way potential by De Salas *et al.* (2017): $f_c \approx 1.2$
- All assume spherical symmetry!



$M_\nu = 0.06$ eV, De Salas+17

A step further

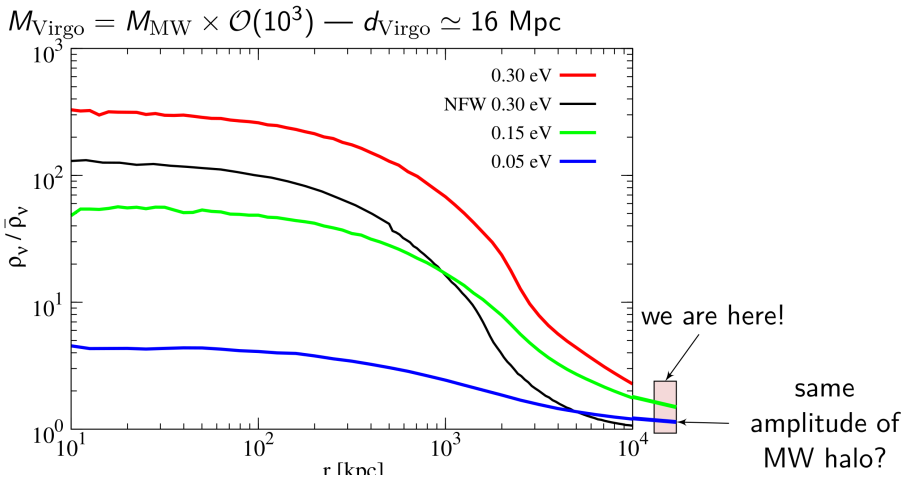
New procedure & improvements

1. Backtracking of particles
2. Introduce more structures
3. Increase number of dimensions (Milky Way 3D potential)

(1)

- Initial conditions at $z = 0$ in the Solar vicinity, assigning each particle a momentum
- Trace particles back, obtain positions and momenta at $z = 4$.
- Compute weights assuming that at high z the phase-space distribution is a Fermi-Dirac.
- Use those weights to compute density at Earth.

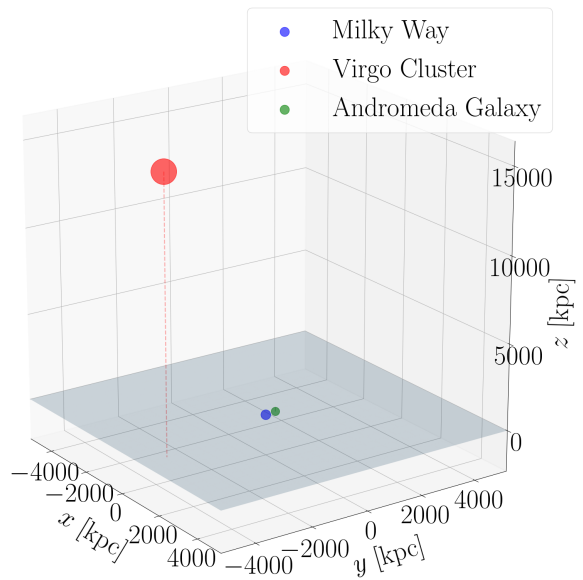
(2)



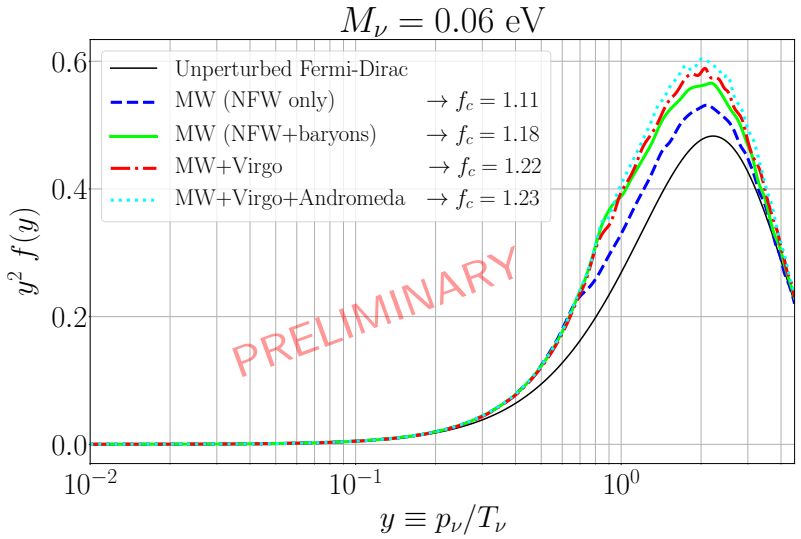
Villaescusa-Navarro *et al.*, 2011

(adapted by S. Gariazzo)

(3)

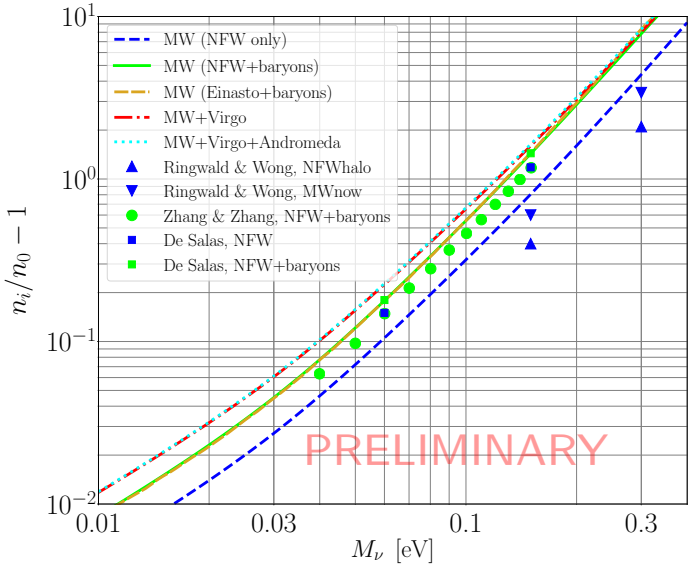


Results I

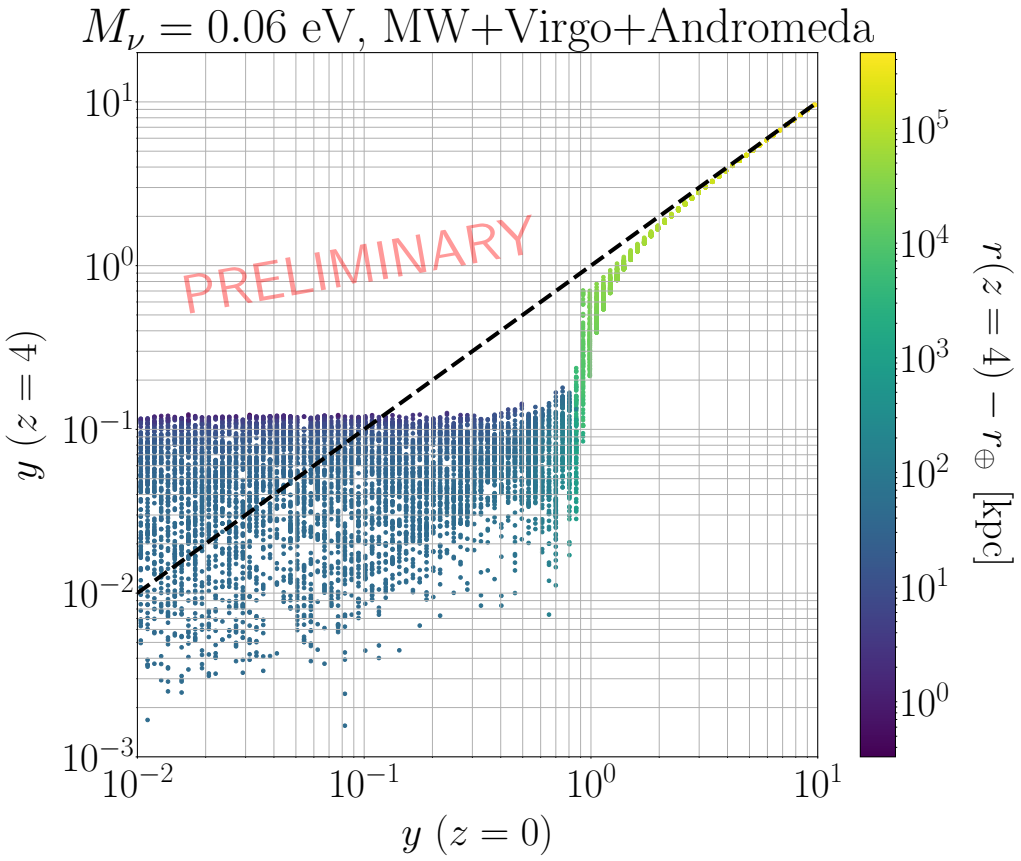


- Baryons increase f_c by $\sim 7\%$
- Virgo enhances clustering factor by $\sim 4\%$; Andromeda almost negligible
- $f_c \sim 1.23$, i.e. $n_i = 69/\mathrm{cm}^3/\mathrm{flavor}$

- Dark matter counts less than in De Salas *et al.* (2017) while baryons play a greater role
- Einasto and NFW profiles are equivalent
- Virgo and Andromeda impact only for low masses



Results II



- High speed neutrinos pass undisturbed through large-scale structure
- Turnaround point at $y \sim 1$: escape velocity from MW
- Low energy neutrinos are trapped in the MW

Are these neutrinos observable?

PTOLEMY

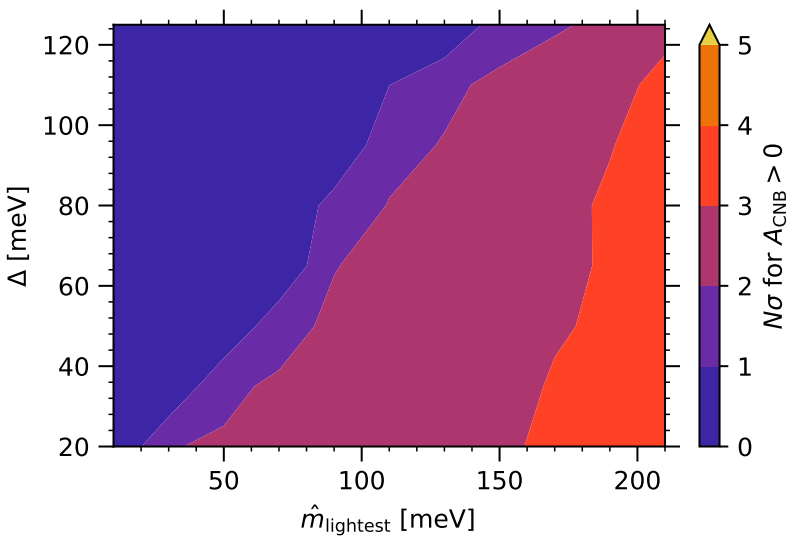
- Direct detection of cosmic neutrinos
- Neutrino capture in β-decaying nuclei (100 g tritium)
- Recoil of electron on graphene sheet

Detection rate

$$\Gamma_{C\nu B} = \sum_{i=1}^{N_\nu} |U_{ei}|^2 f_c(m_i) \left[n_{i,0}(\nu_{h_R}) + n_{i,0}(\nu_{h_L}) \right] N_T \bar{\sigma}$$

$$\sim 10\ yr^{-1}$$

2-σ detection only for $\Delta < 0.86\ \frac{M_\nu}{\text{meV}} - 14$ meV



Betti *et al.*, 2019

Thanks for the attention!