Merging Rates of the First Objects and Formation of the First Mini-Filaments in Models with Massive Neutrinos

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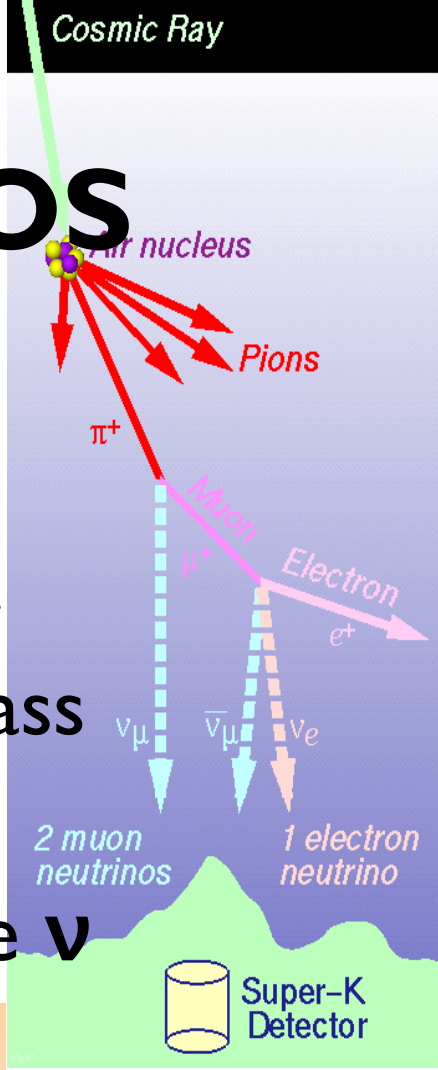
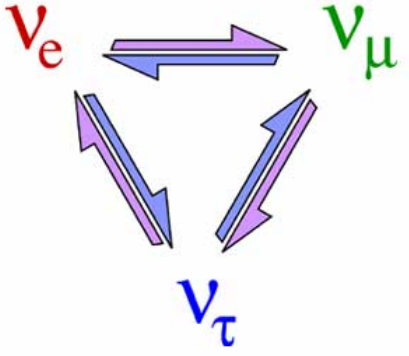
(Song & Lee 2011, ApJ, 736, 27)

MASSIVE NEUTRINOS

- Solar Neutrino Oscillation reveals neutrinos do have NON-ZERO mass.
- The strongest bounds on neutrino mass comes from Cosmology.
- Mixed Dark Matter = CDM + Massive ν (MDM)

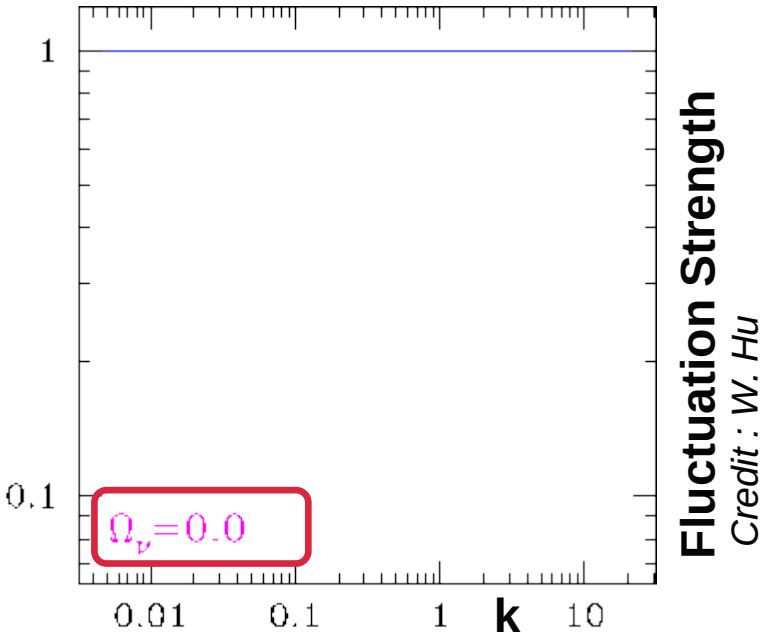




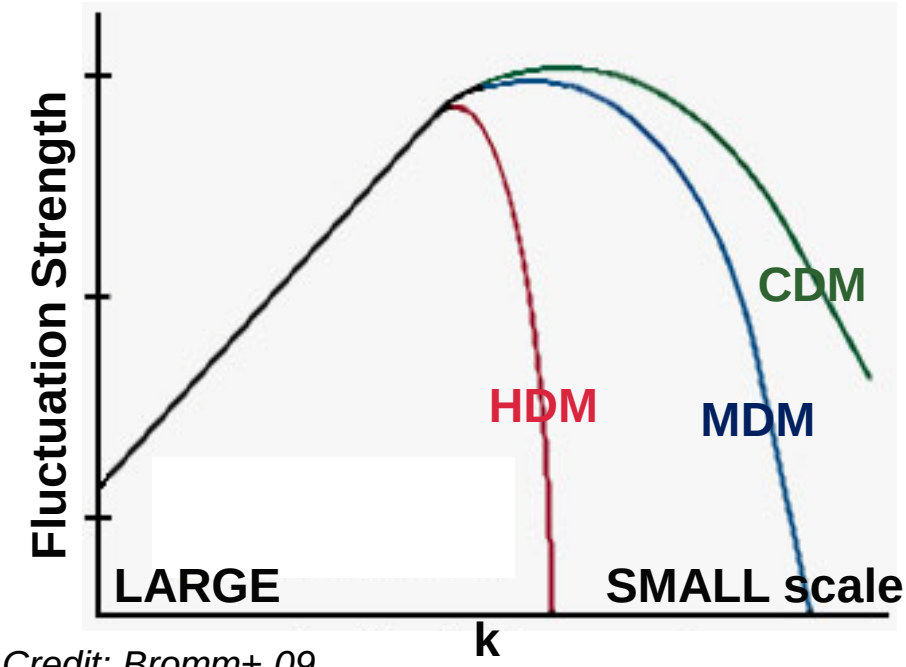
MASSIVE NEUTRINOS

- The growth of fluctuations is suppressed below the free-streaming scale.

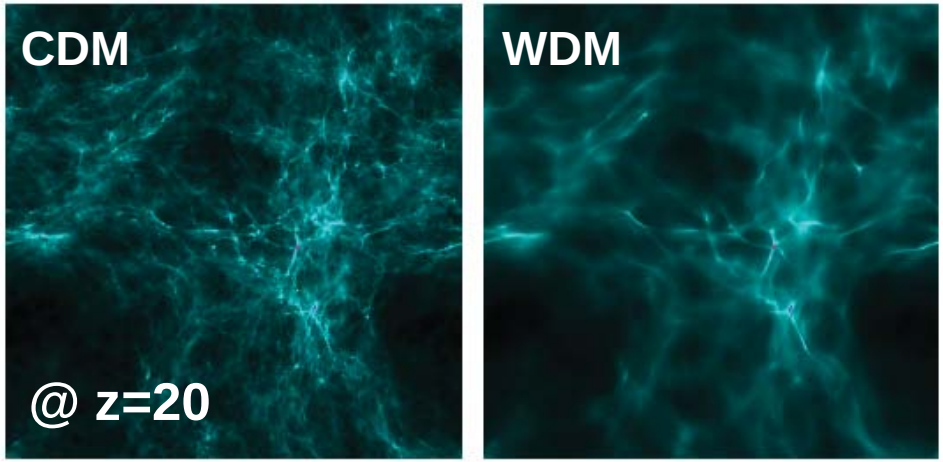
EFFECT OF MASSIVE NEUTRINOS



Credit : W. Hu



Credit: Bromm+ 09



MERGING RATES in MDM

Halo-to-Halo

first halos
$10^6 M_{sun}$ @z=20

a larger halo

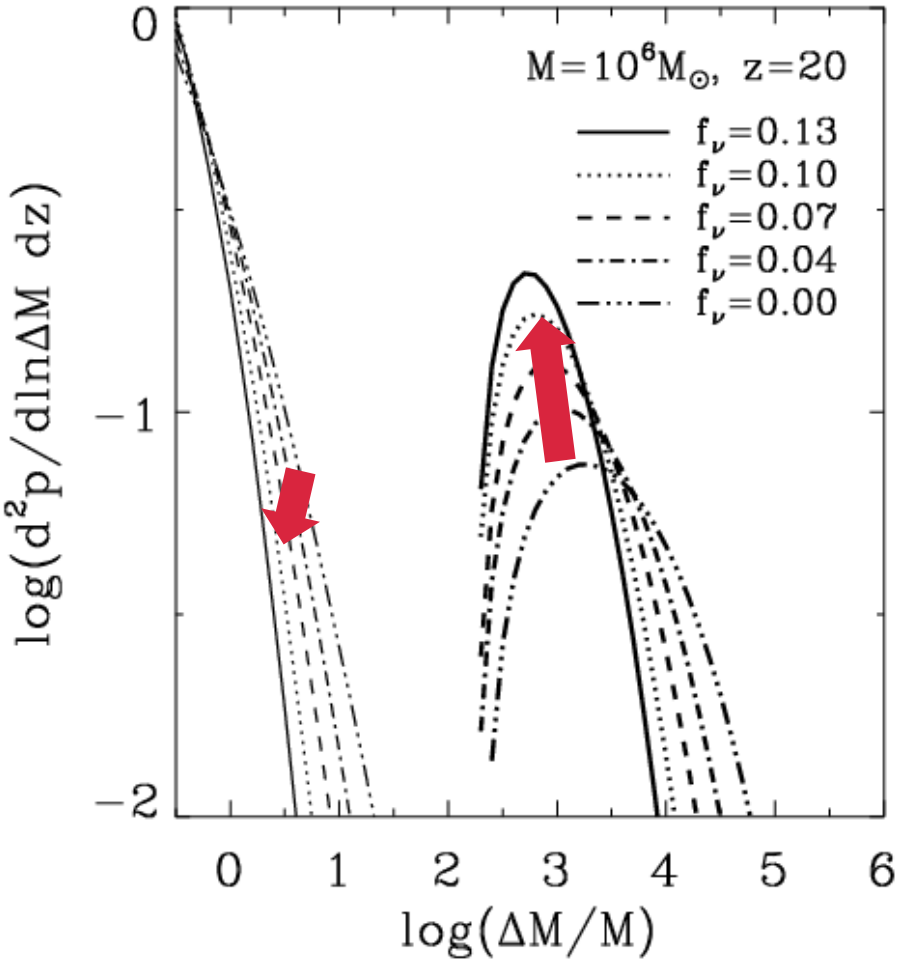
$$\frac{d^2P(\text{bigger halo/filament @z+dz} \mid \text{halo @z})}{d\ln\Delta M\, dz}$$

Halo-to-Filament

first halos

neutrino free streaming

first filament

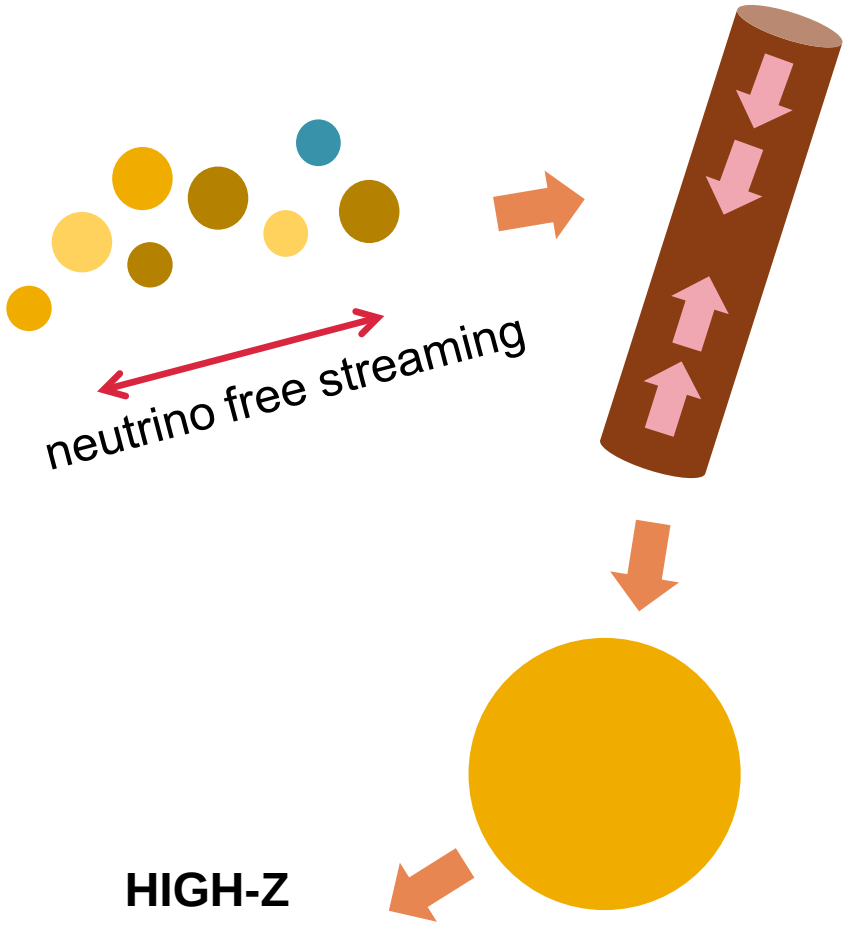


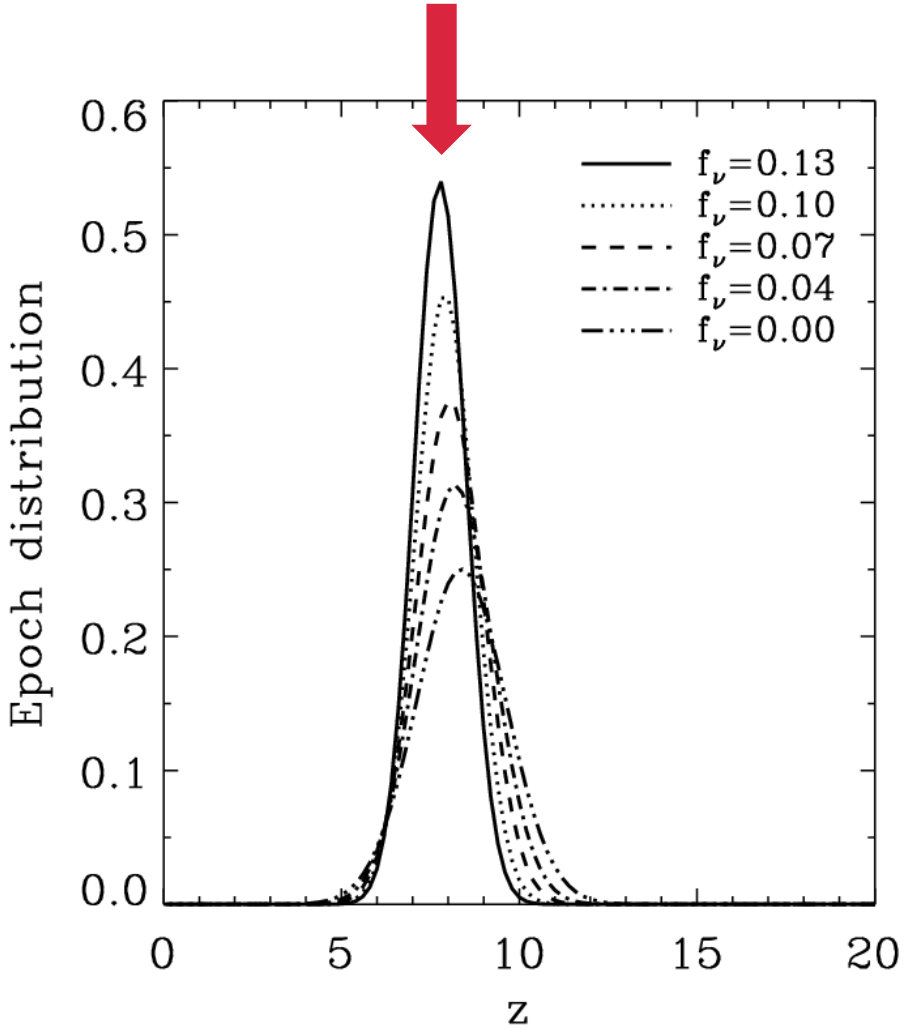
$f_v=\Omega_v/\Omega_m$ $m_v=(f_v\Omega_m h^2/N_v)93.2\text{eV}$

thin lines : halo-to-halo

thick lines : halo-to-filament

COLLAPSE EPOCH in MDM

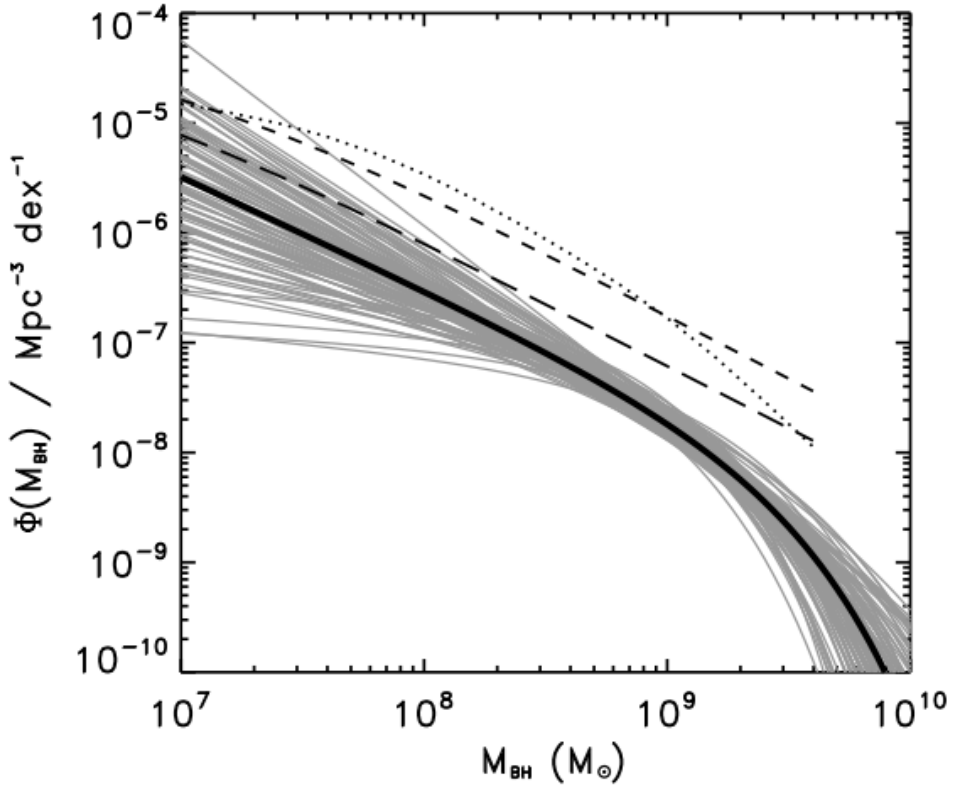




CONNECTION TO HIGH Z QUASARS

- Park & Lee 09
  - Matter and gas accreting more efficiently through filamentary structure. (bridge effect)
- Gao & Theuns 07, Willott + 10
  - Filaments' longest axis collapse would result in forming the first massive galaxies and seeding SMBHs in it.
  - Later these SMBHs would power high-z quasars.
- First Filament MF ⇔ High-z Quasar MF

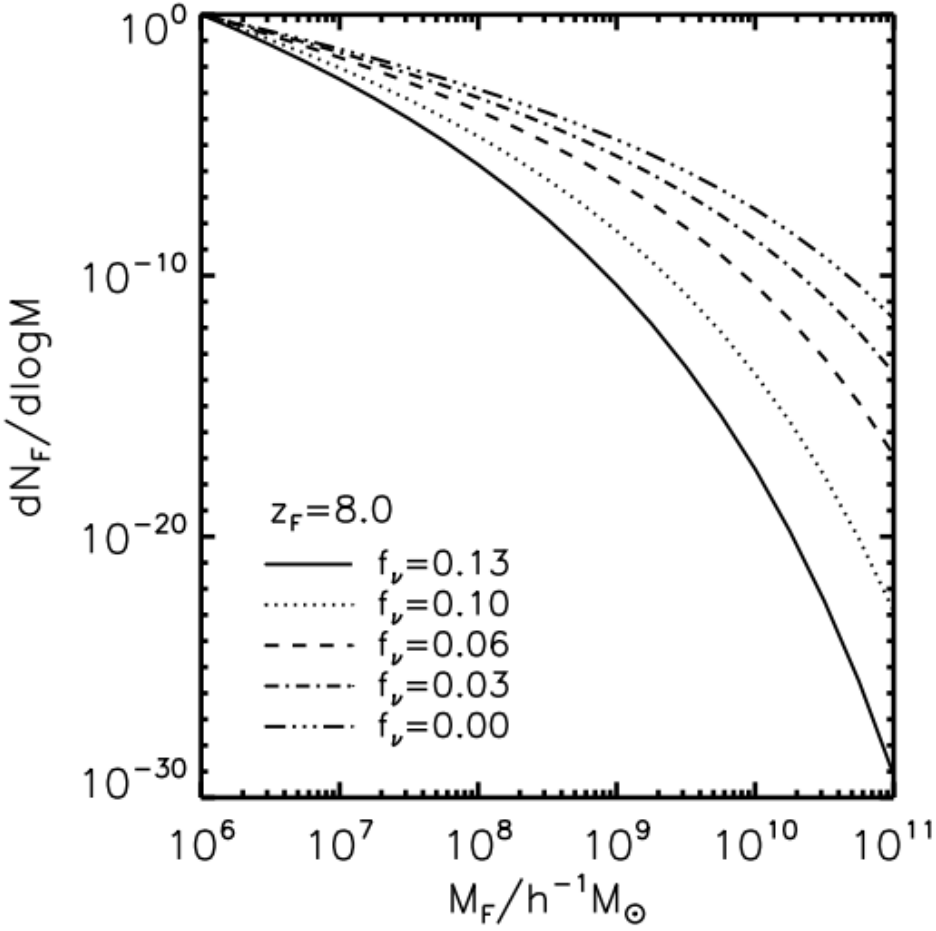
CONSTRAIN NEUTRINO MASS



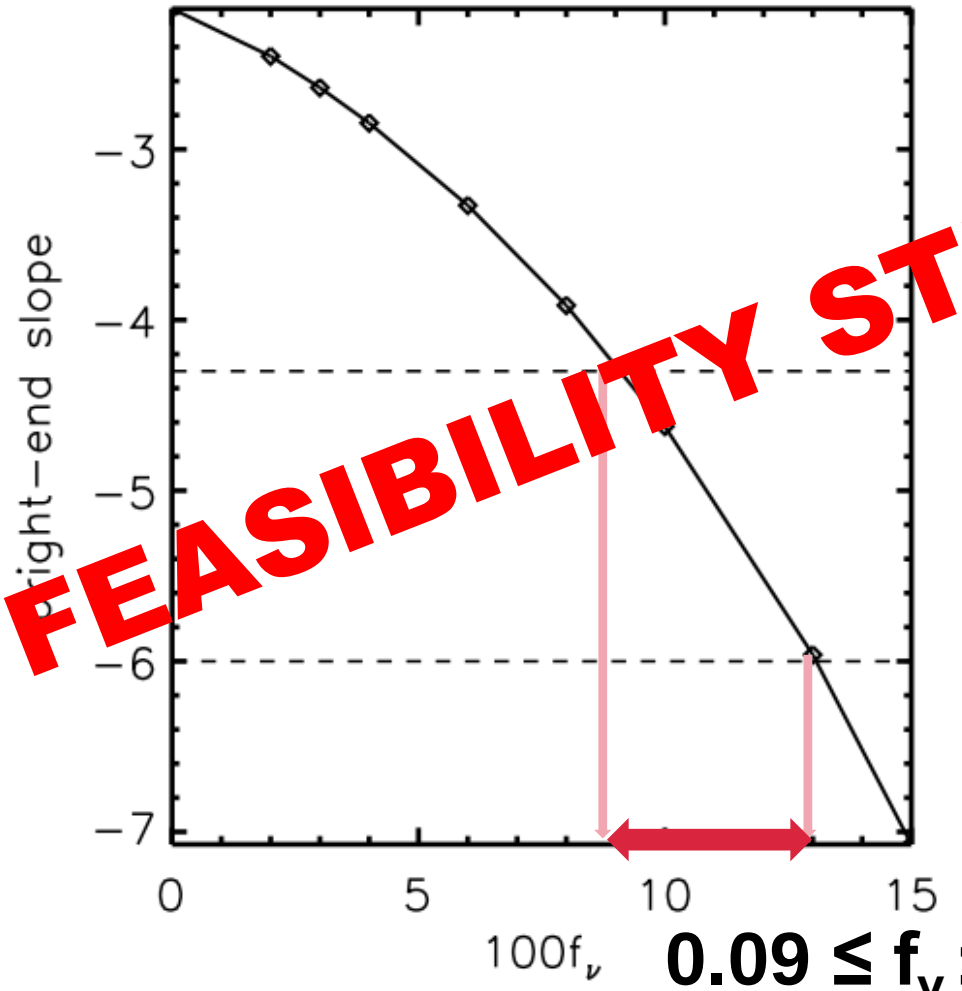
High-z Quasar MF

Willott + 10

Filament MF



CONSTRAIN NEUTRINO MASS



FEASIBILITY STUDY!

$0.09 \leq f_\nu \leq 0.13$

$0.375 \leq m_\nu/\mathrm{eV} \leq 0.542$

SUMMARY

- We explore the effect of massive neutrinos on the formation and evolution of the first filaments.
- We suggest that the first filaments may open a new channel to form high-z quasars and we also test the possibility of constraining the neutrino mass from the high-z quasar mass function.
- Recently, for another approach to constrain neutrino mass, we examine the alignment of cluster galaxies. (arXiv:1106.5104)

Thank You ☺