Particle Physics with Neutrinos at Ultra High Energies

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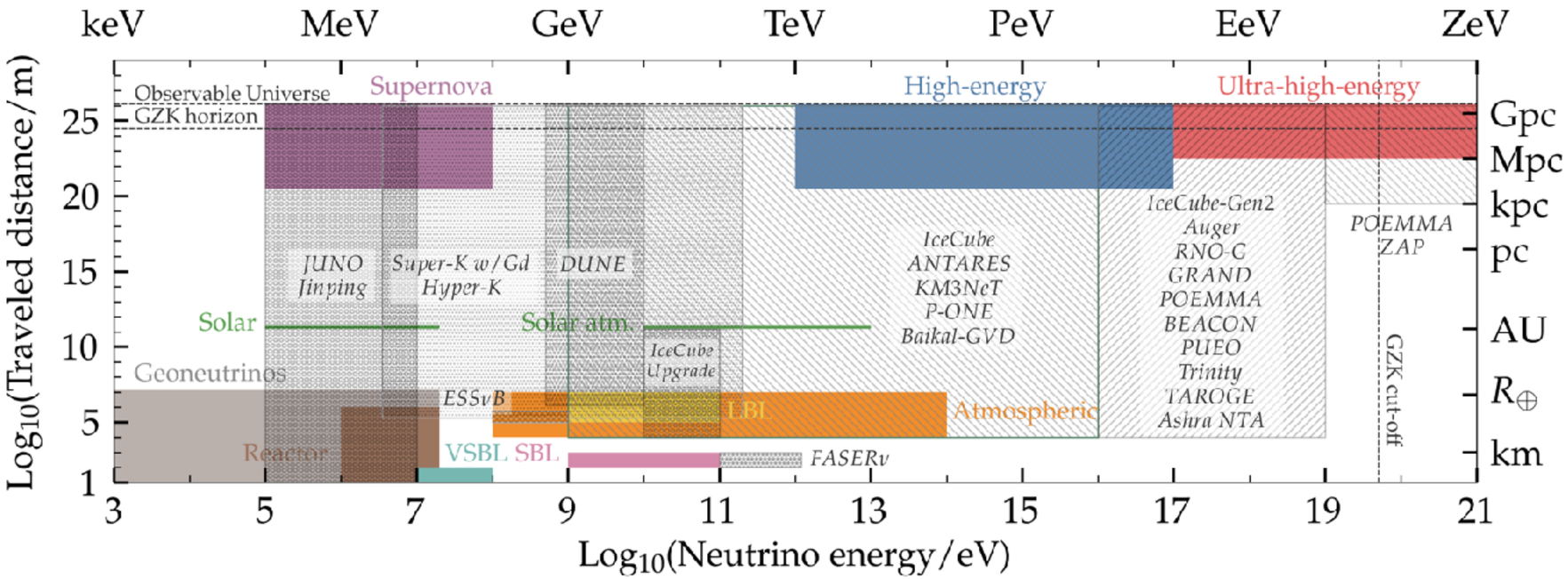
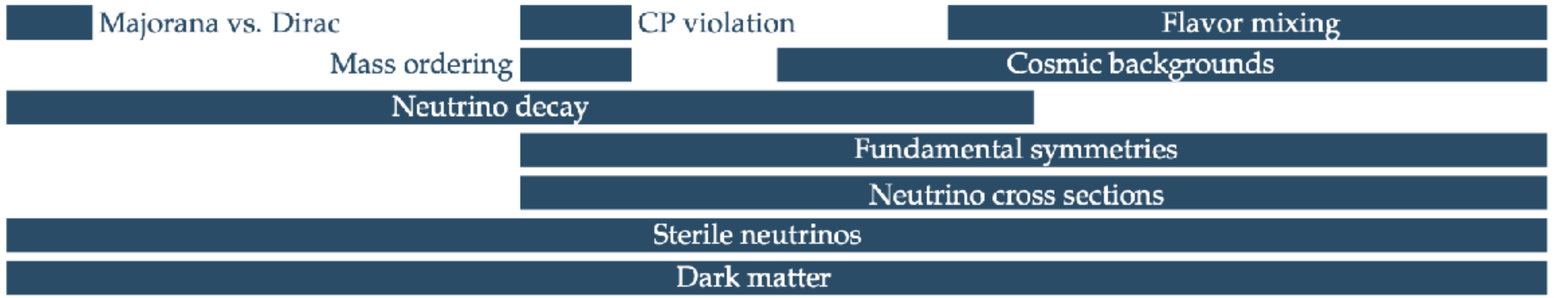
- Fundamental physics probe at the **highest energy scales (TeV to ZeV)**
- **Longest baselines** (~Gpc) allow even small effects to accumulate over **cosmological distances**



CF7 Topical Report
Snowmass

Astro2020
1903.04333



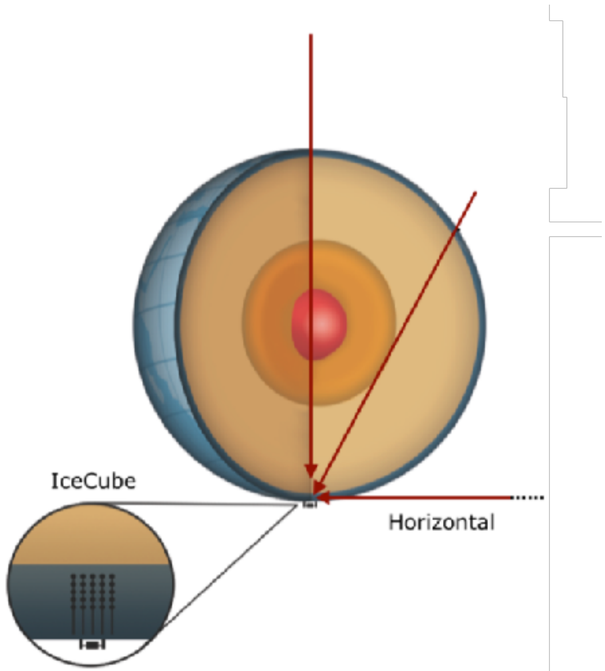
Cross Sections in a New Energy Regime

- Probe neutrino interactions previously unmeasured

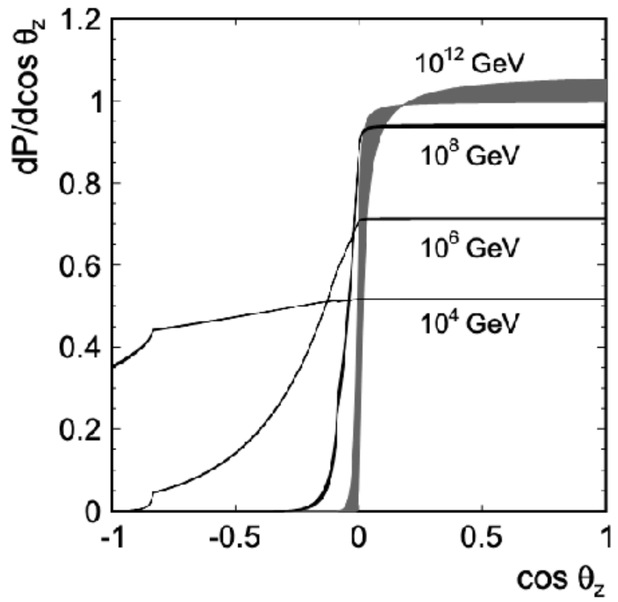
  DIS cross sections & inelasticity that probe parton distribution functions (low Bjorken-x, high Q^2)

- Ultra-high energies (>100 PeV) will probe new, otherwise unexplorable energy regime ($\sqrt{s} > 30$ TeV)

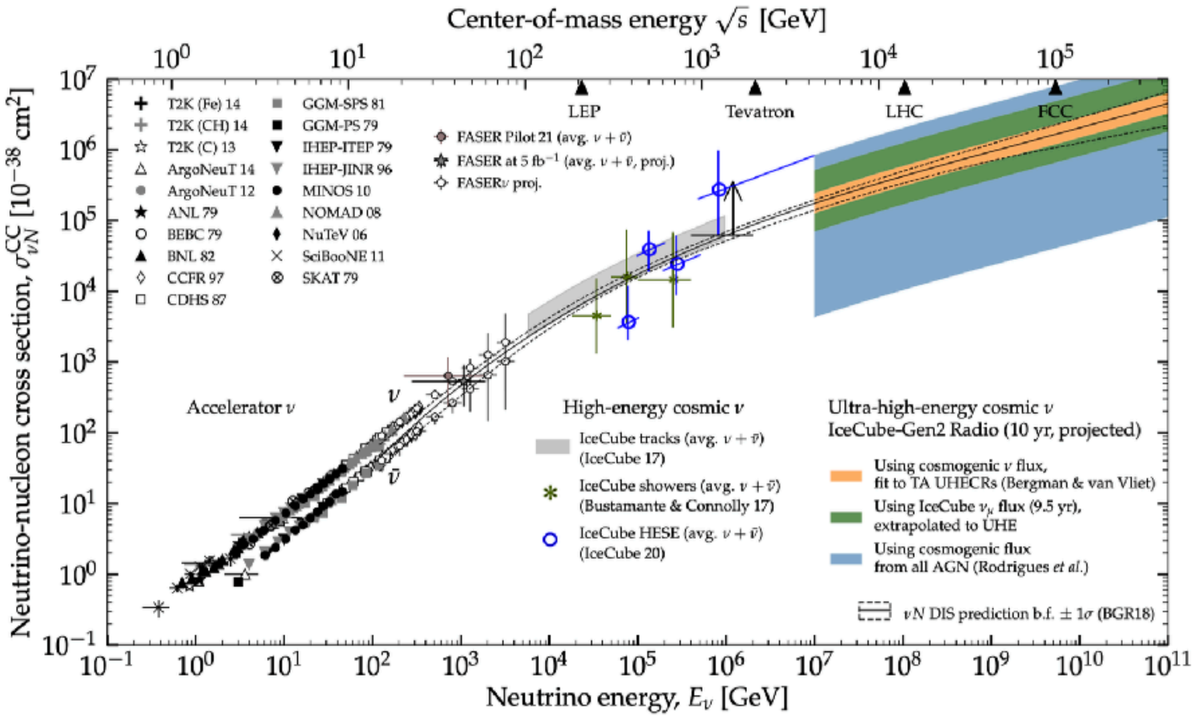
  Good (zenith) angular resolution over broad energy range (large neutrino target) needed



IceCube 2011



Connolly et al 2011



CF7 Topical Report
Snowmass 21 white paper: 2203.08096

$L_{int} \sim 300$ km: Use Earth-shielding as cross-section analyzer

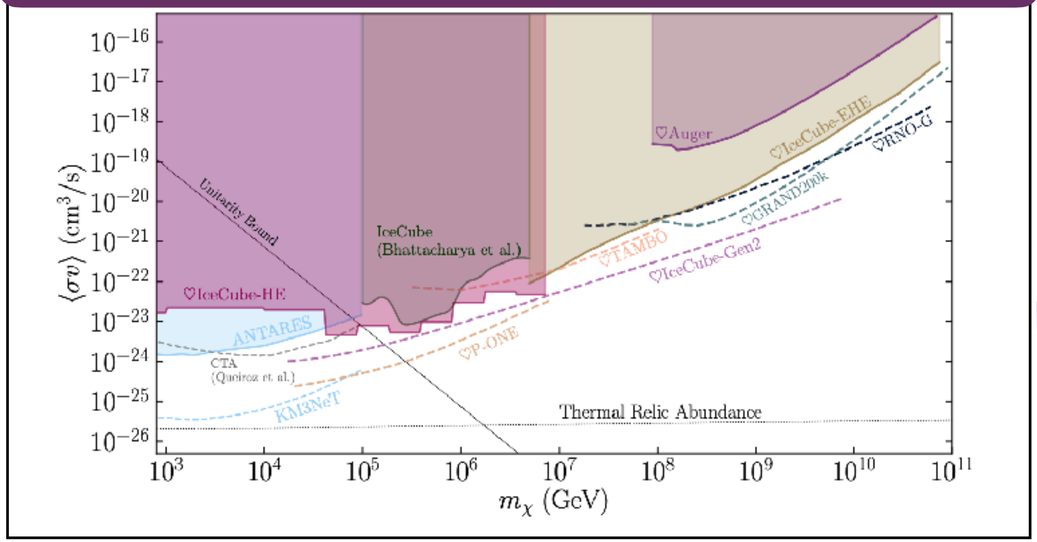
New Physics Impact on Neutrinos

Palomares-Ruiz, Salvadó arXiv:1907.08690

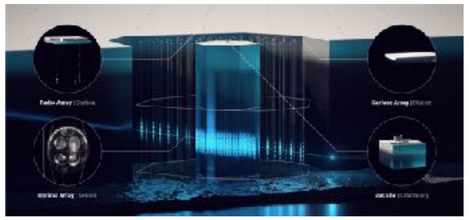
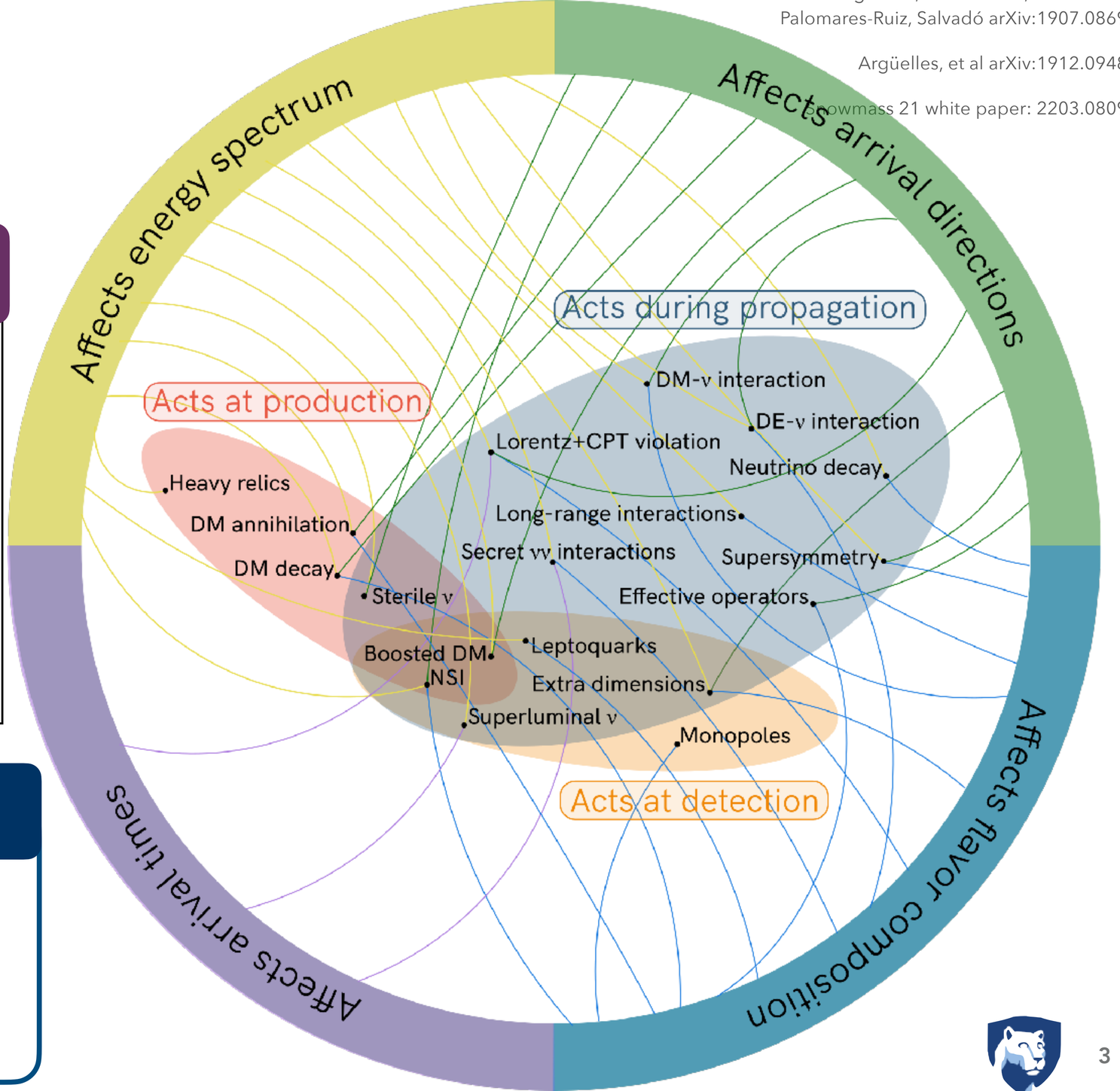
Argüelles, et al arXiv:1912.09486

Snowmass 21 white paper: 2203.08096

Example: Super Heavy Dark Matter



Comprehensive Approach

Broad energy range, multiple techniques, flavor sensitivity

IceCube-Gen2