Snowmass 2021 CF7 LoI: *Cosmic Neutrino Probes of Fundamental Physics*

Mauricio Bustamante, on behalf of the authors

Niels Bohr Institute, University of Copenhagen

UNIVERSITY OF COPENHAGEN

VILLUM FONDEN

Snowmass 2021 CF7 Town Hall Meeting
July 30, 2020

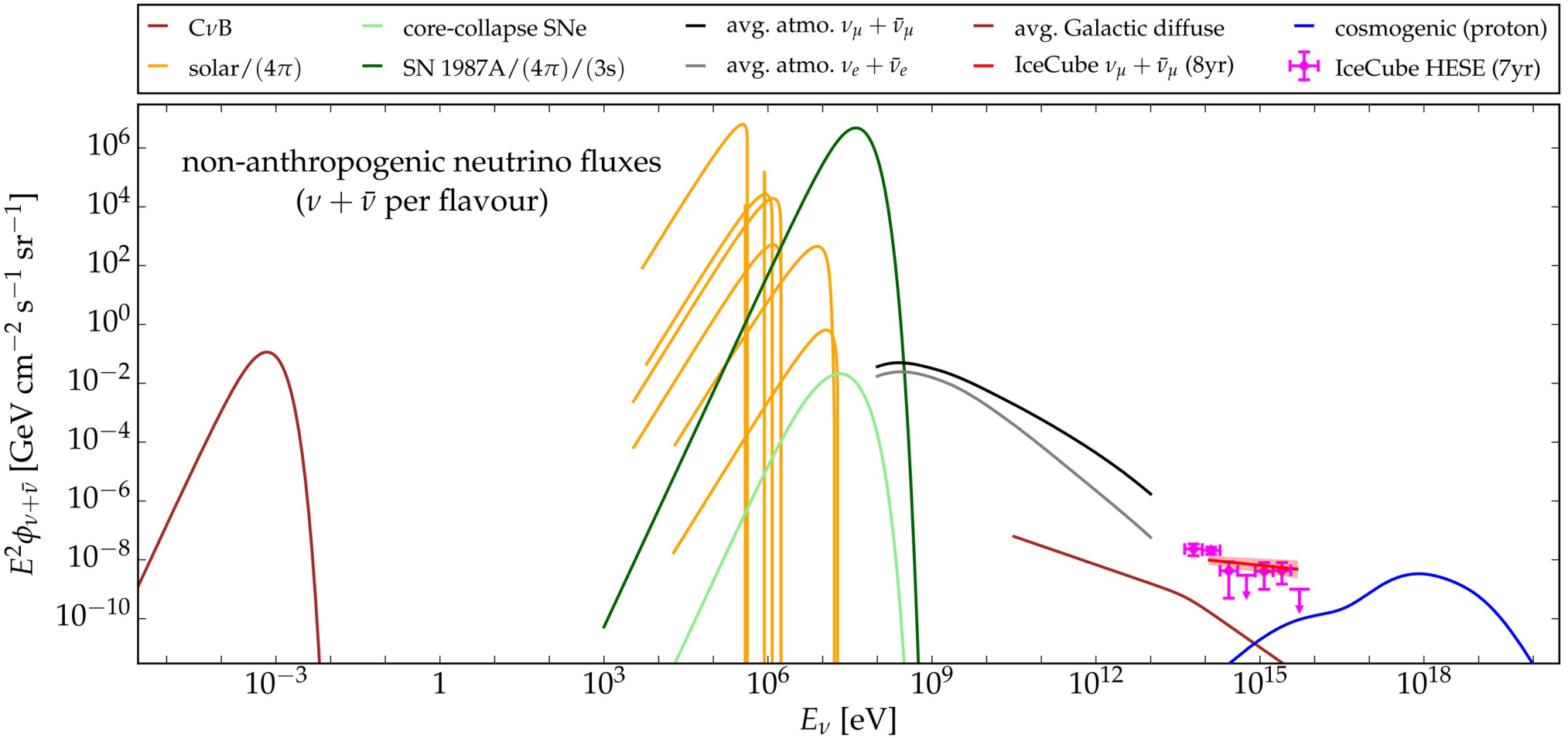
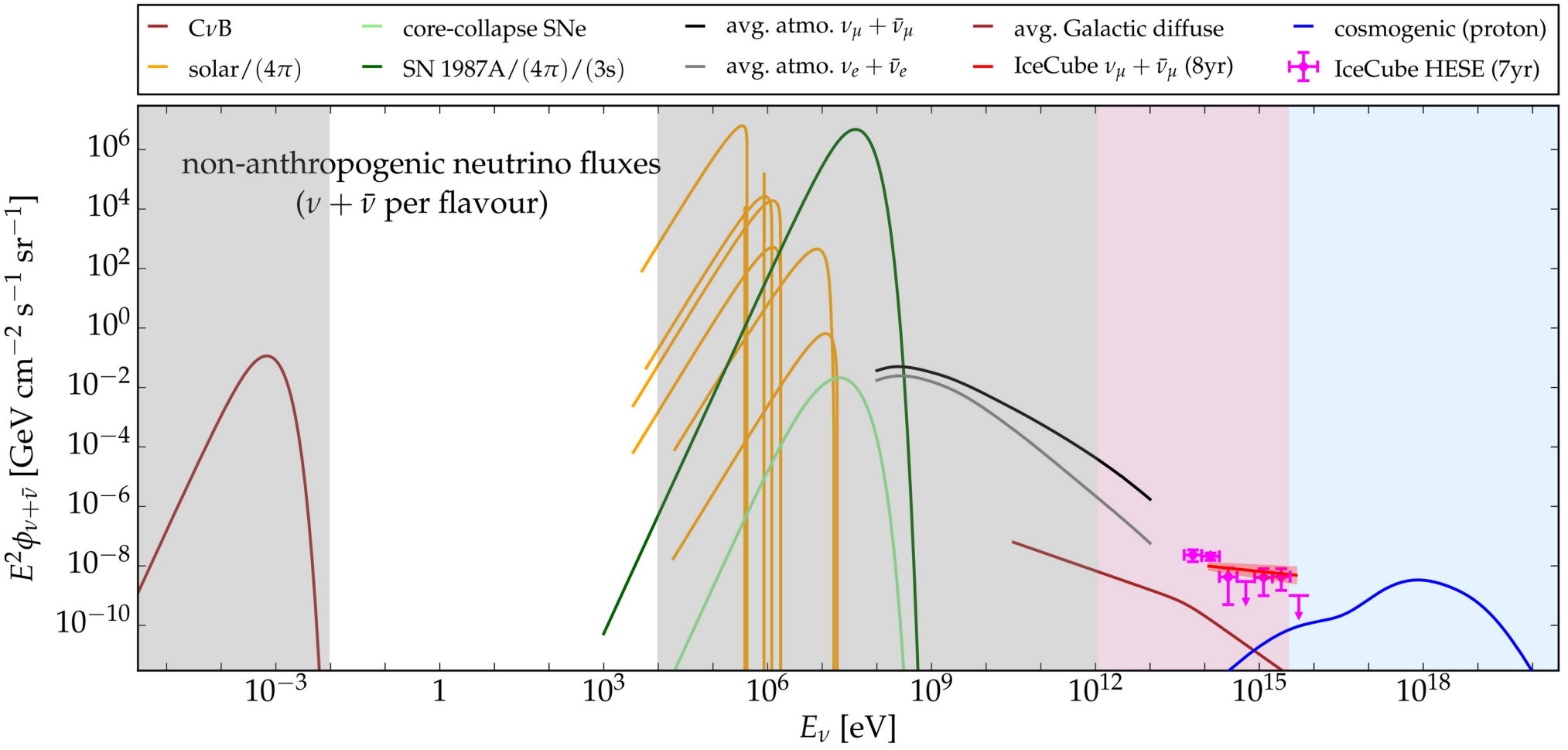


Figure courtesy of Markus Ahlers
Also in: Van Elewyck *et al.*, PoS(ICRC2019), 1023



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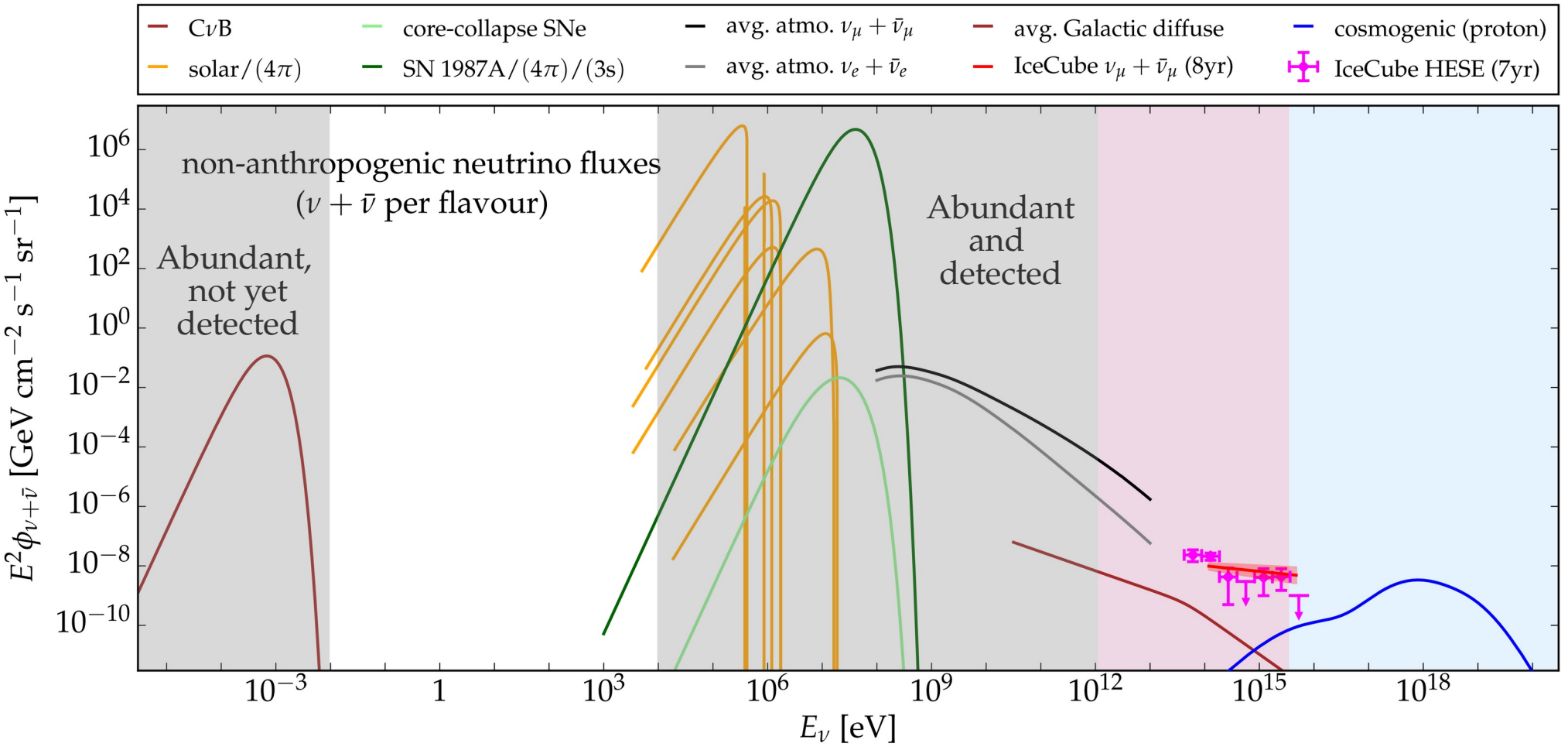

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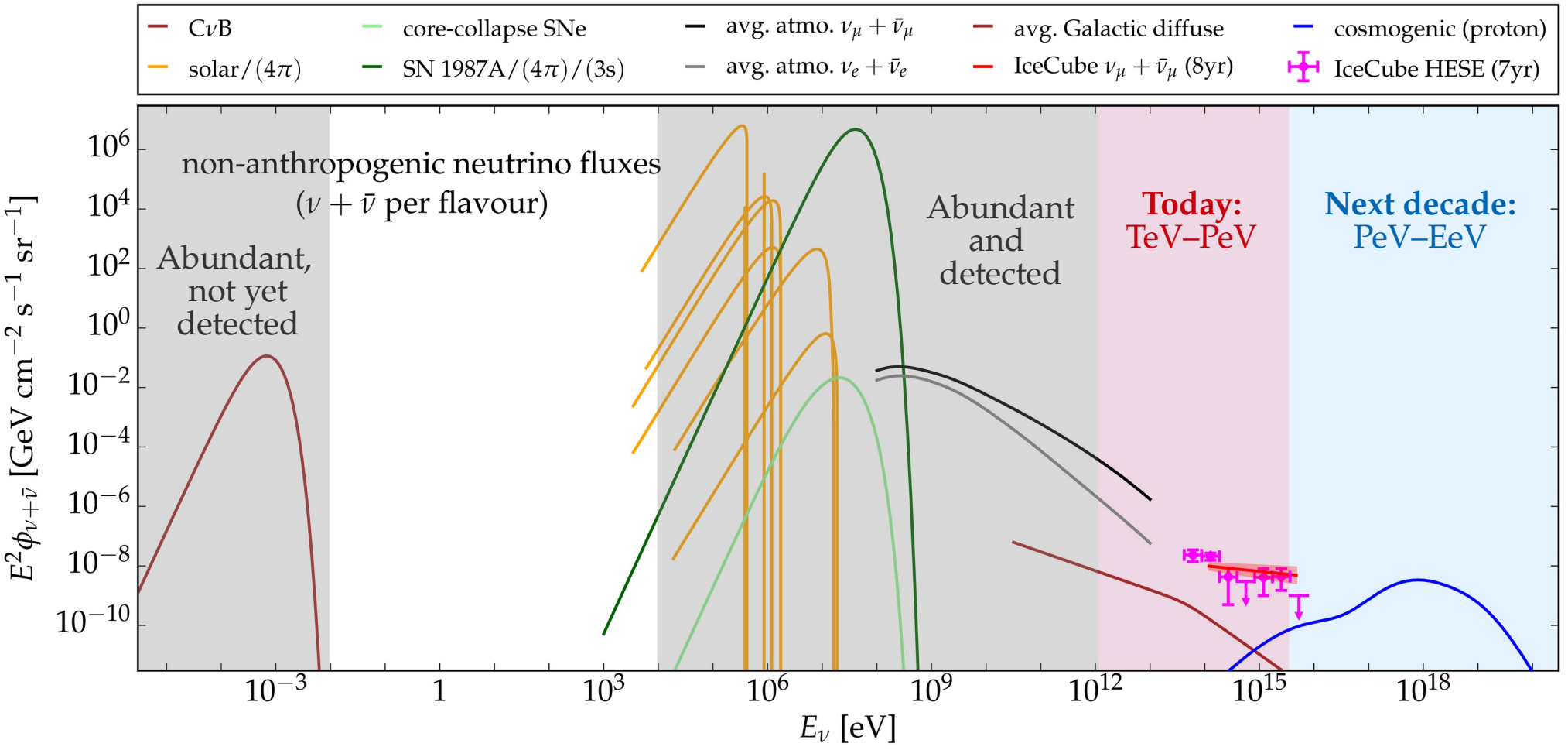

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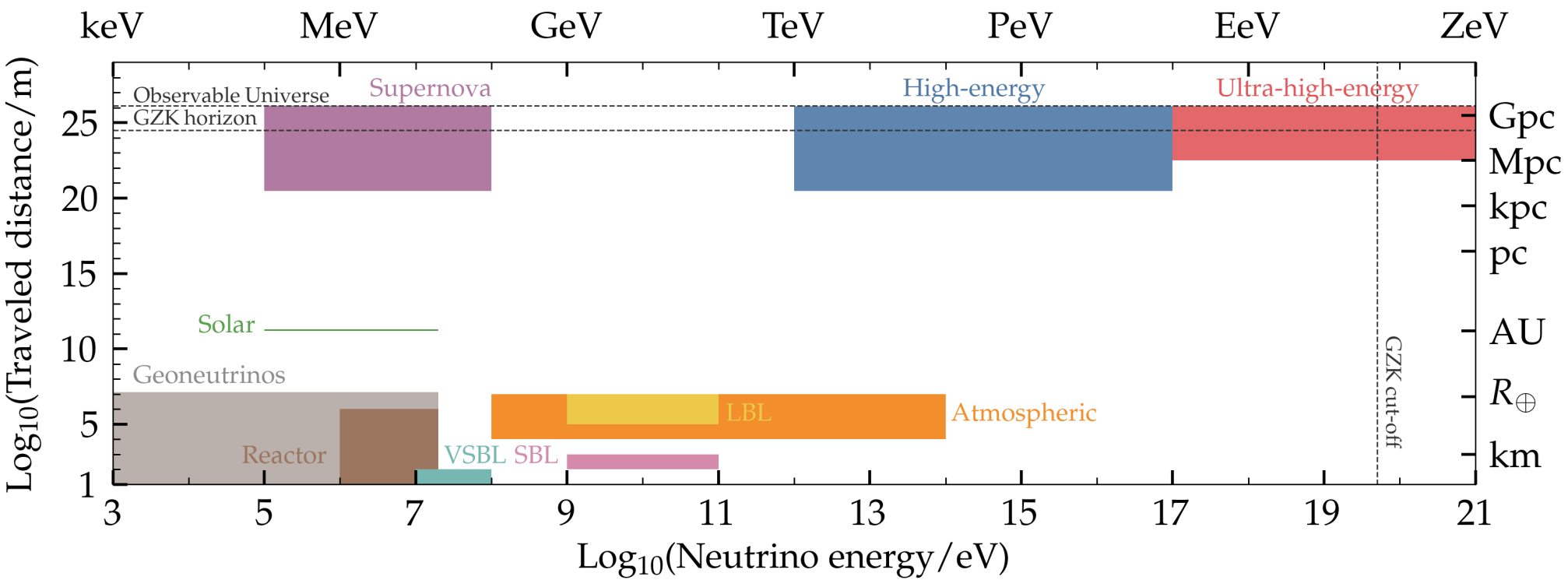
Why study fundamental physics with HE cosmic ν?

1. They have the highest energies (PeV–EeV–ZeV)
   ↦ Probe physics at new energy scales

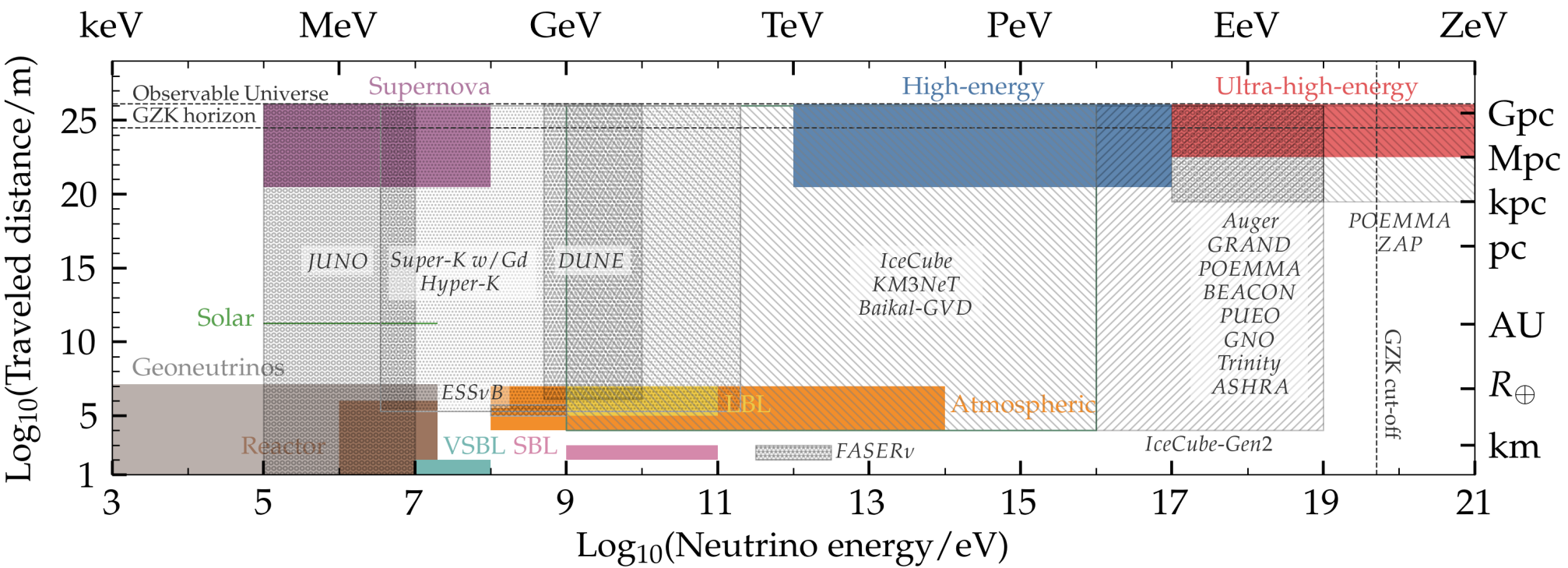
2. They have the longest baselines (~Gpc)
   ↦ Tiny effects can accumulate and become observable

3. Neutrinos are weakly interacting
   ↦ New effects may stand out more clearly

4. Neutrinos have a unique quantum number: flavor
   ↦ Powerful probe of neutrino physics (and astrophysics)



See more: Ackermann *et al.*, Astro2020 Decadal Survey (1903.04333)



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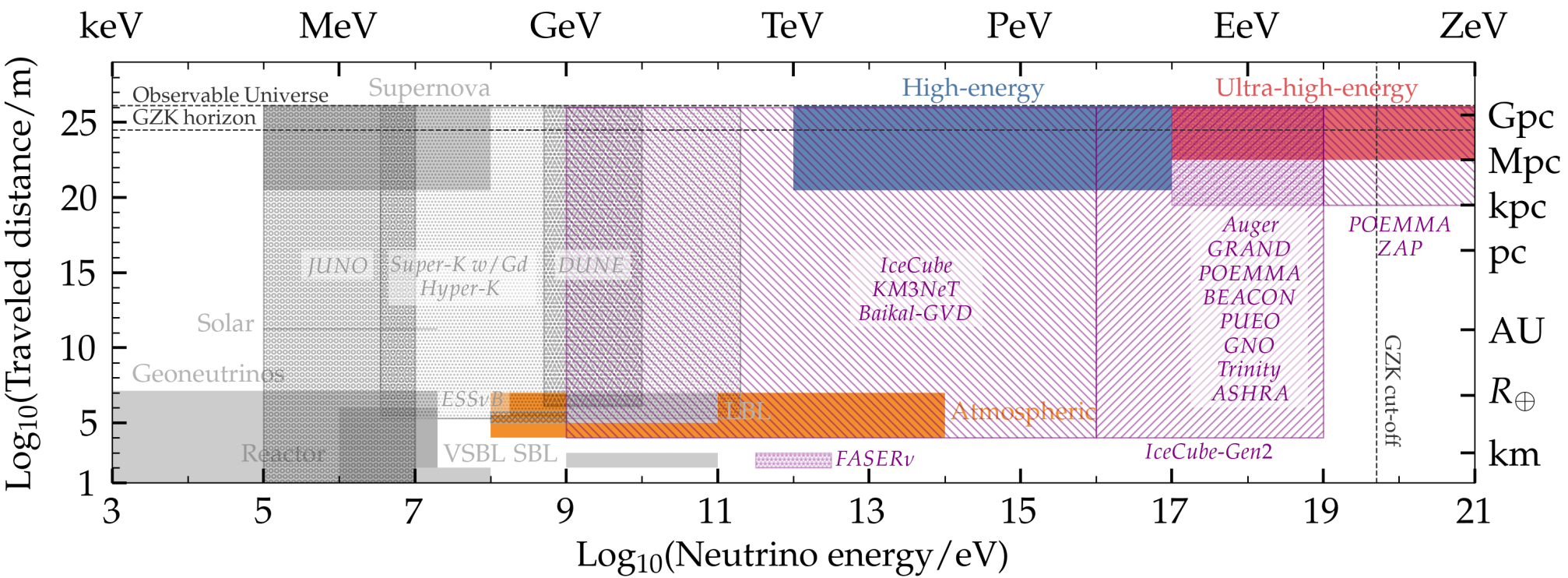

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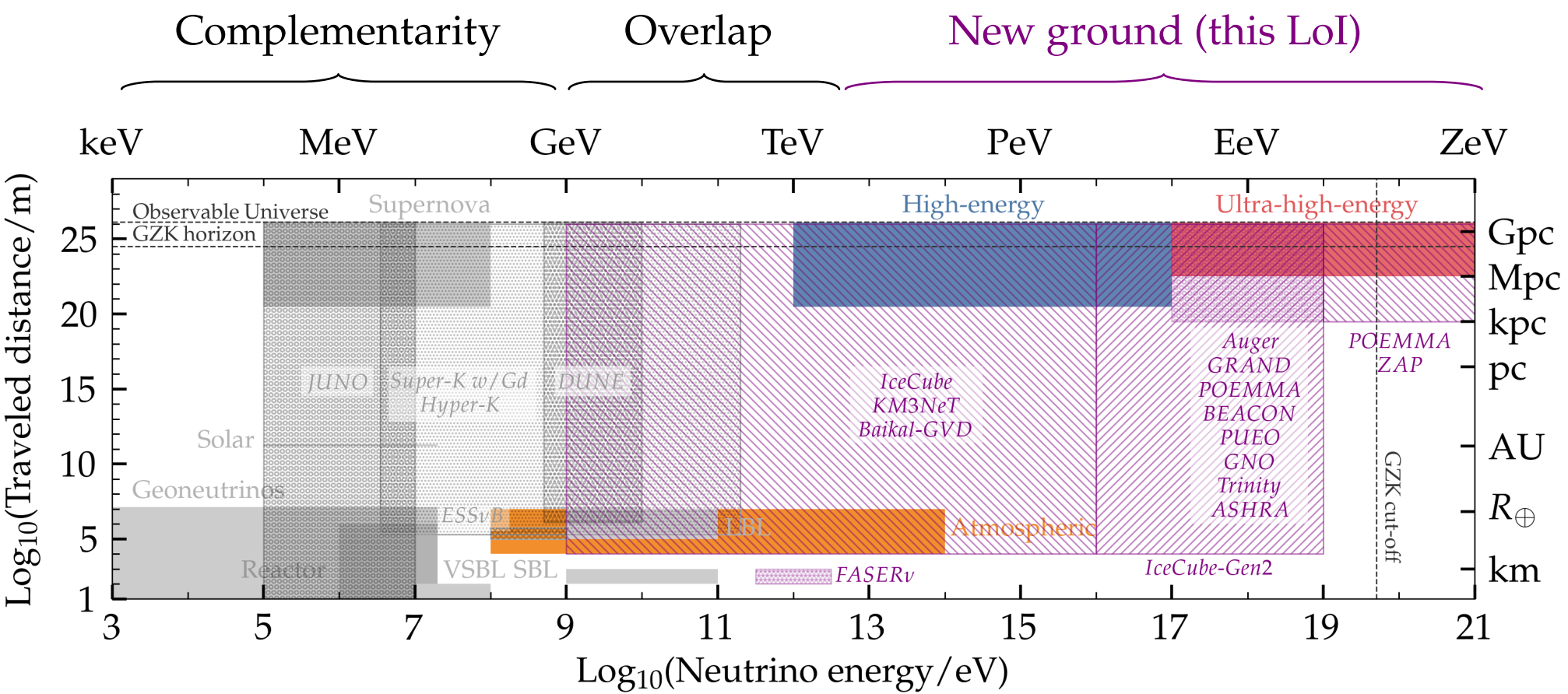

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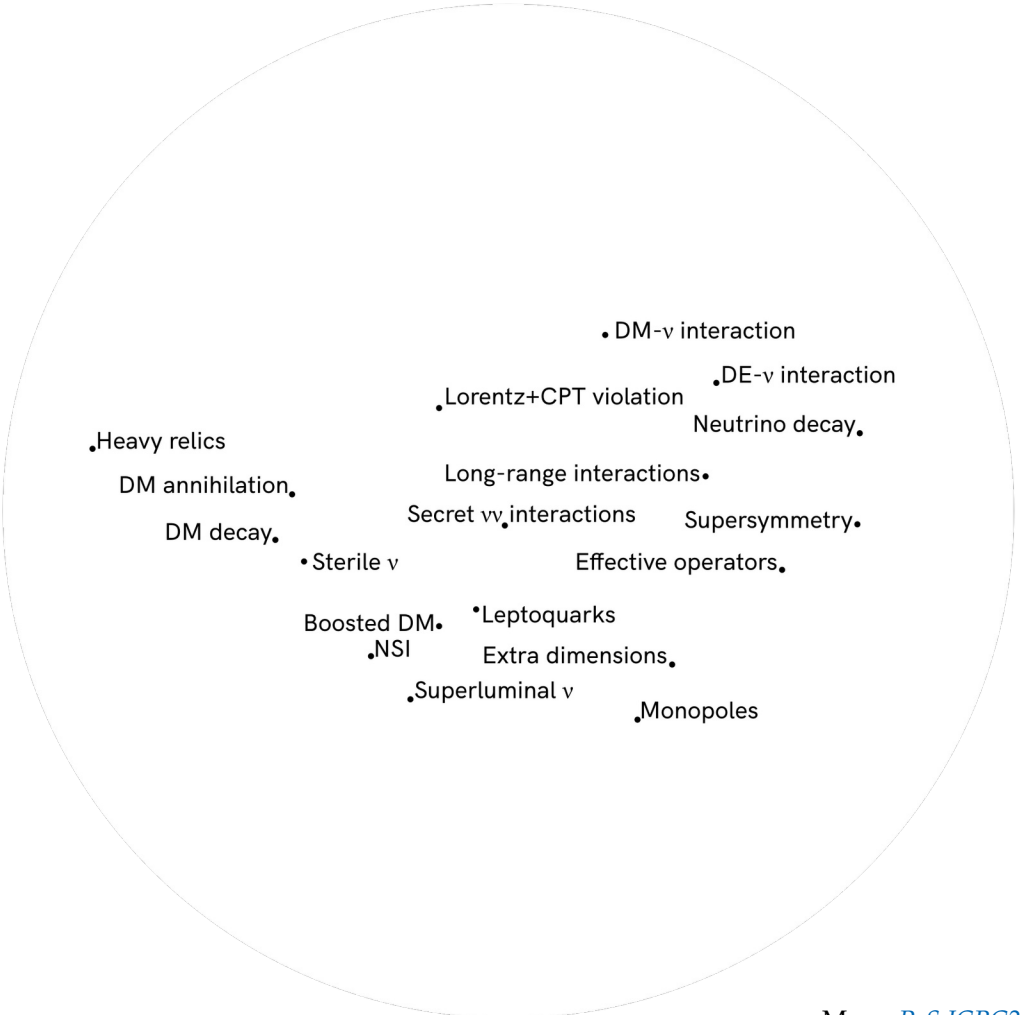
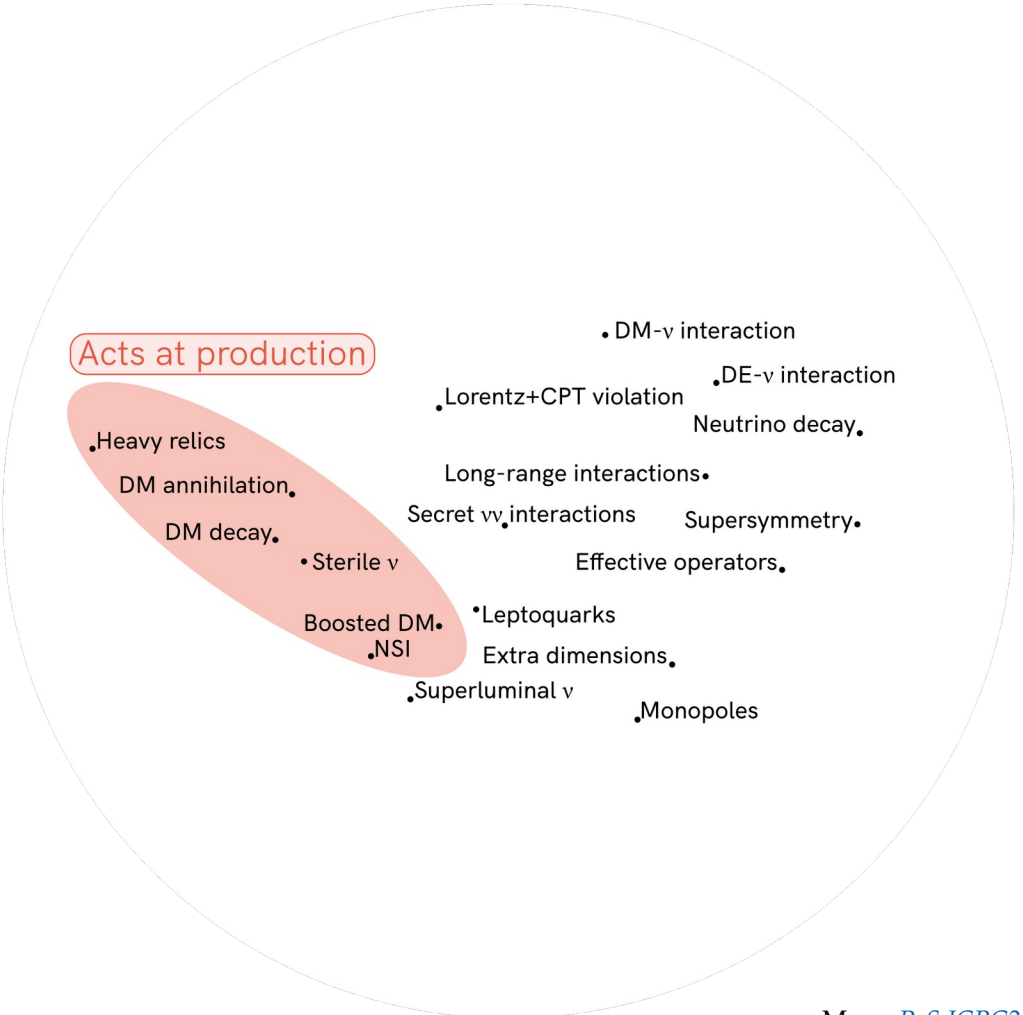


Note: Not an exhaustive list

More: *PoS ICRC2019* (1907.08690)
Argüelles, **MB**, Kheirandish, Palomares-Ruiz, Salvadó, Vincent



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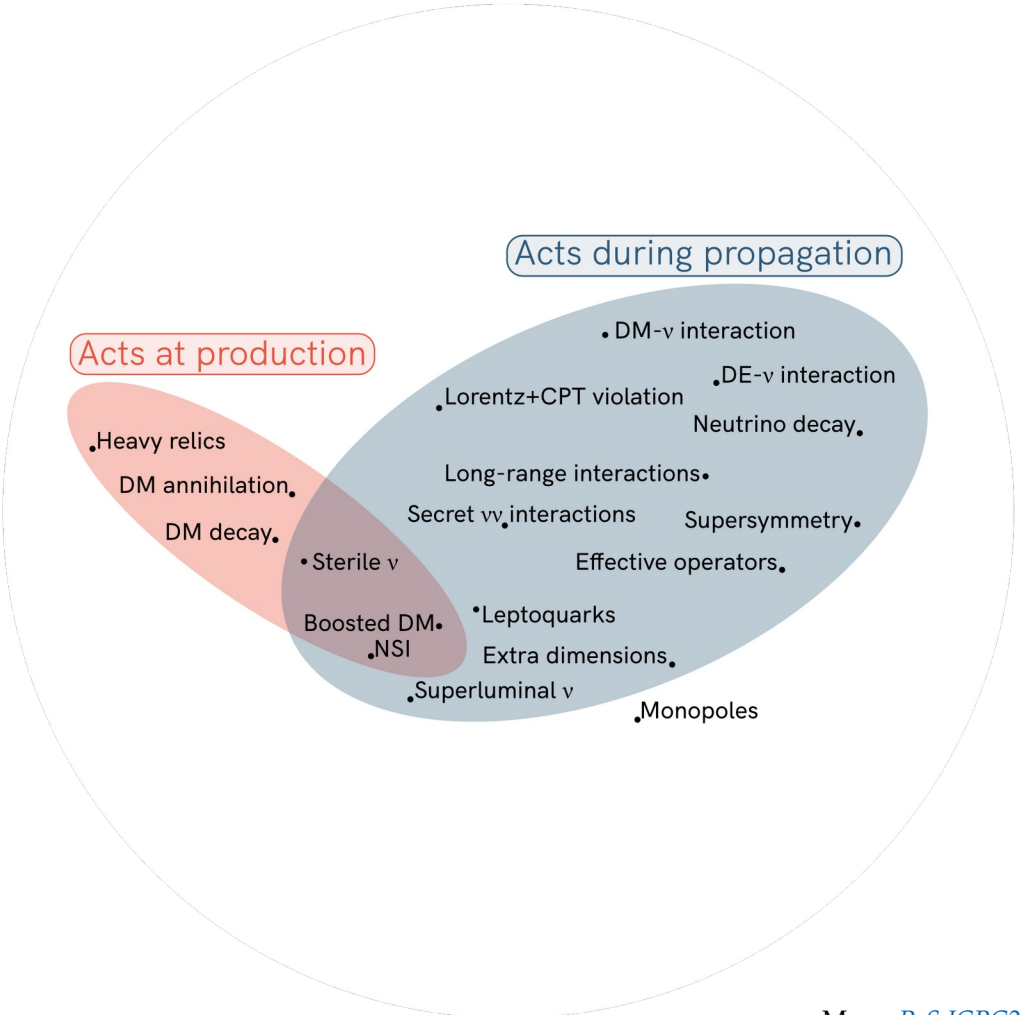

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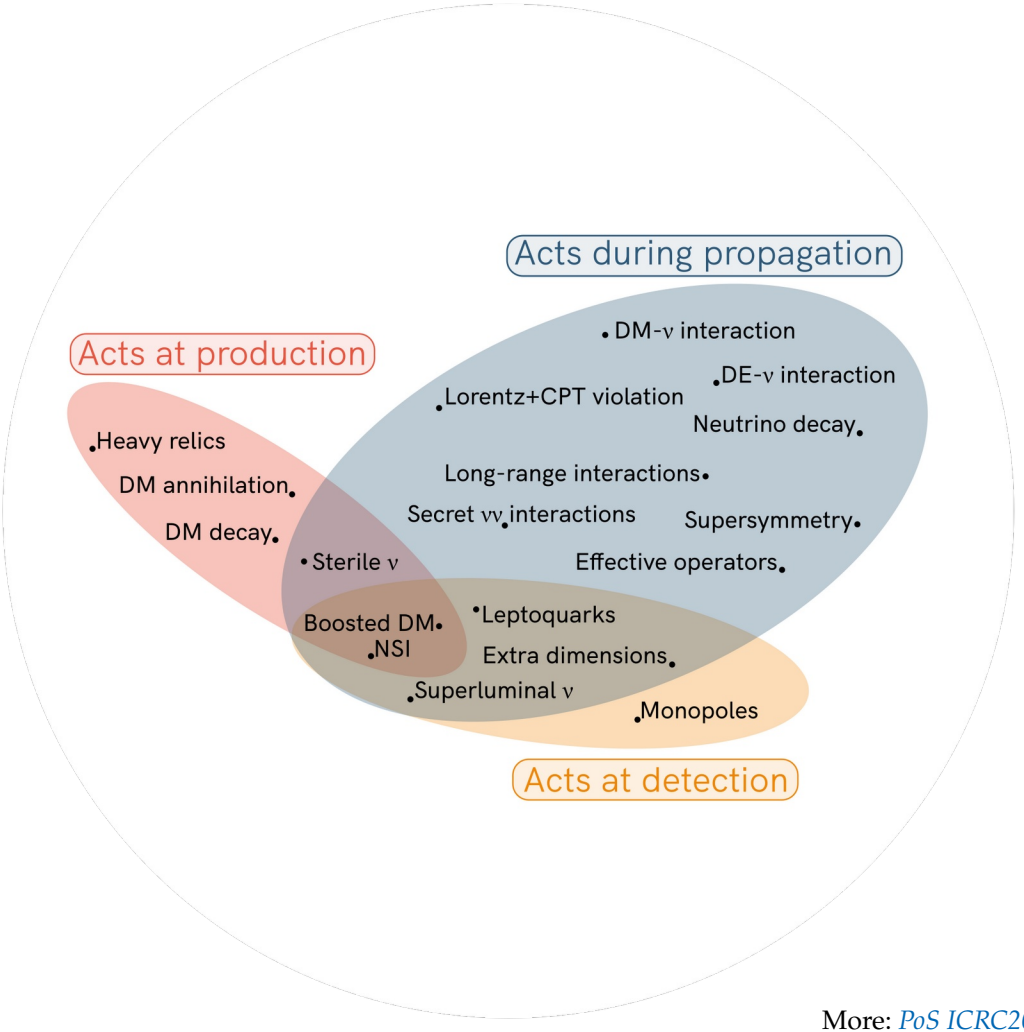

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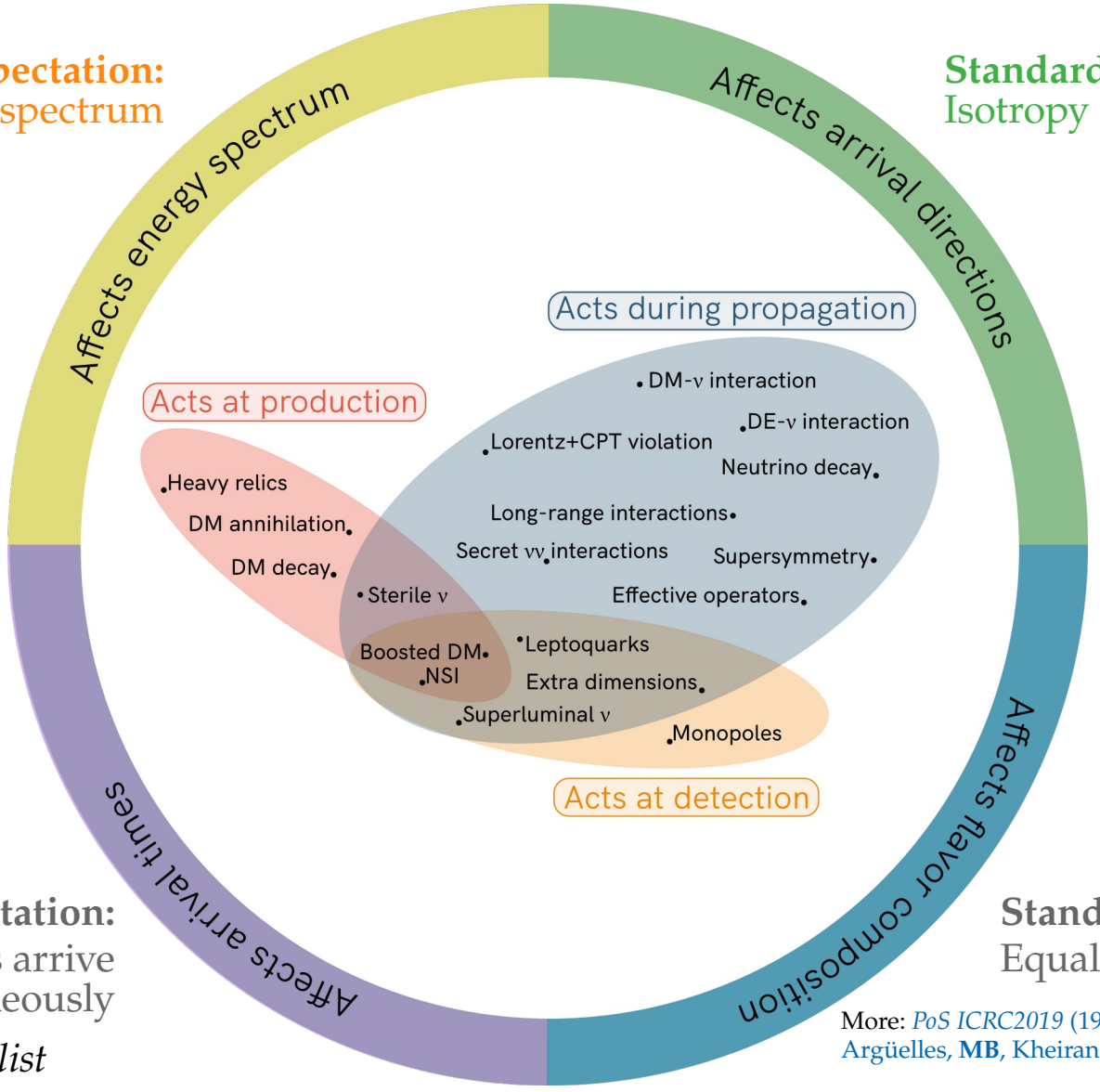
Power-law energy spectrum

Standard expectation:
Isotropy (for diffuse flux)



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ν and γ from transients arrive simultaneously

Standard expectation:
Equal number of ν_e, ν_μ, ν_τ

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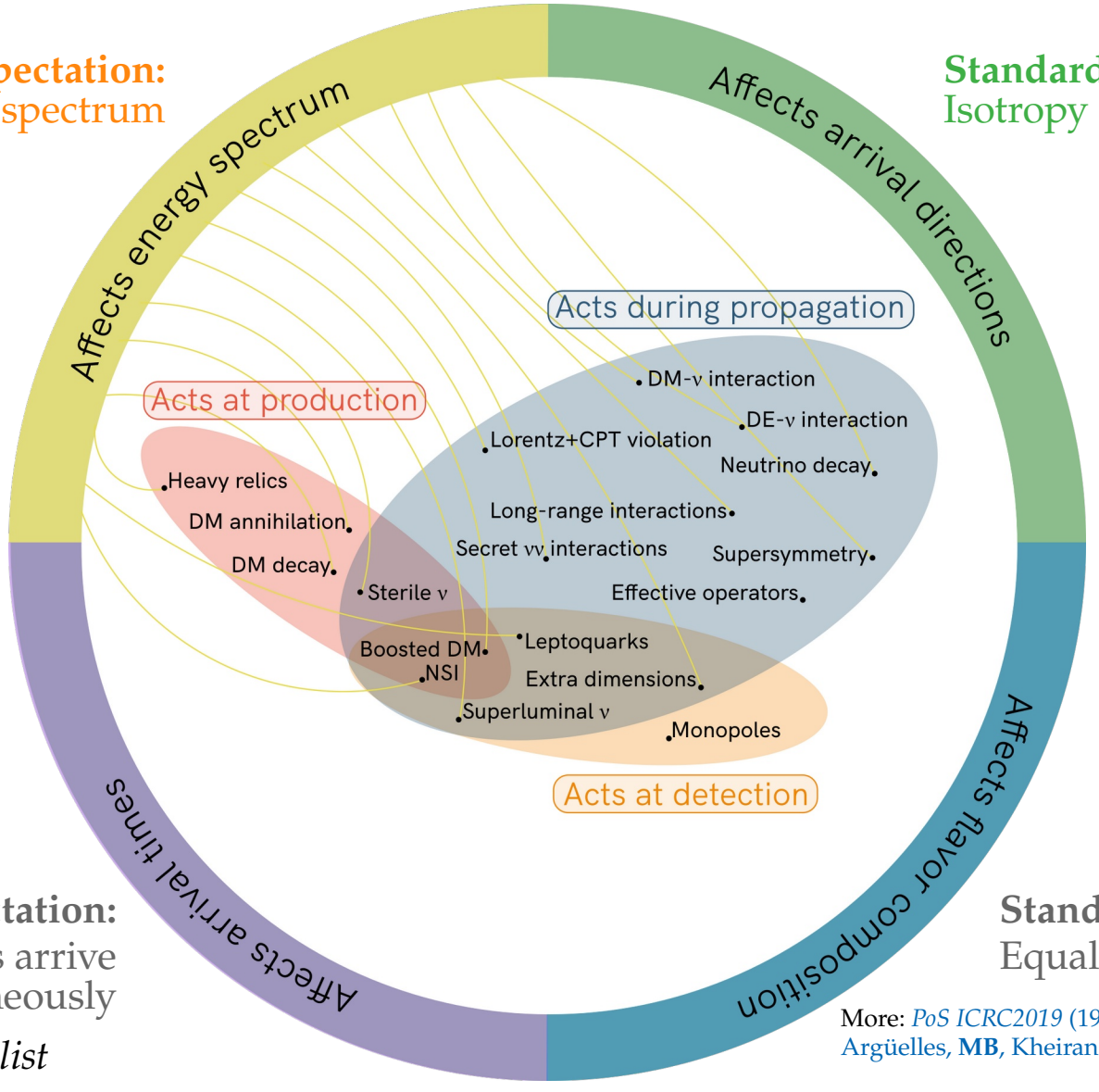

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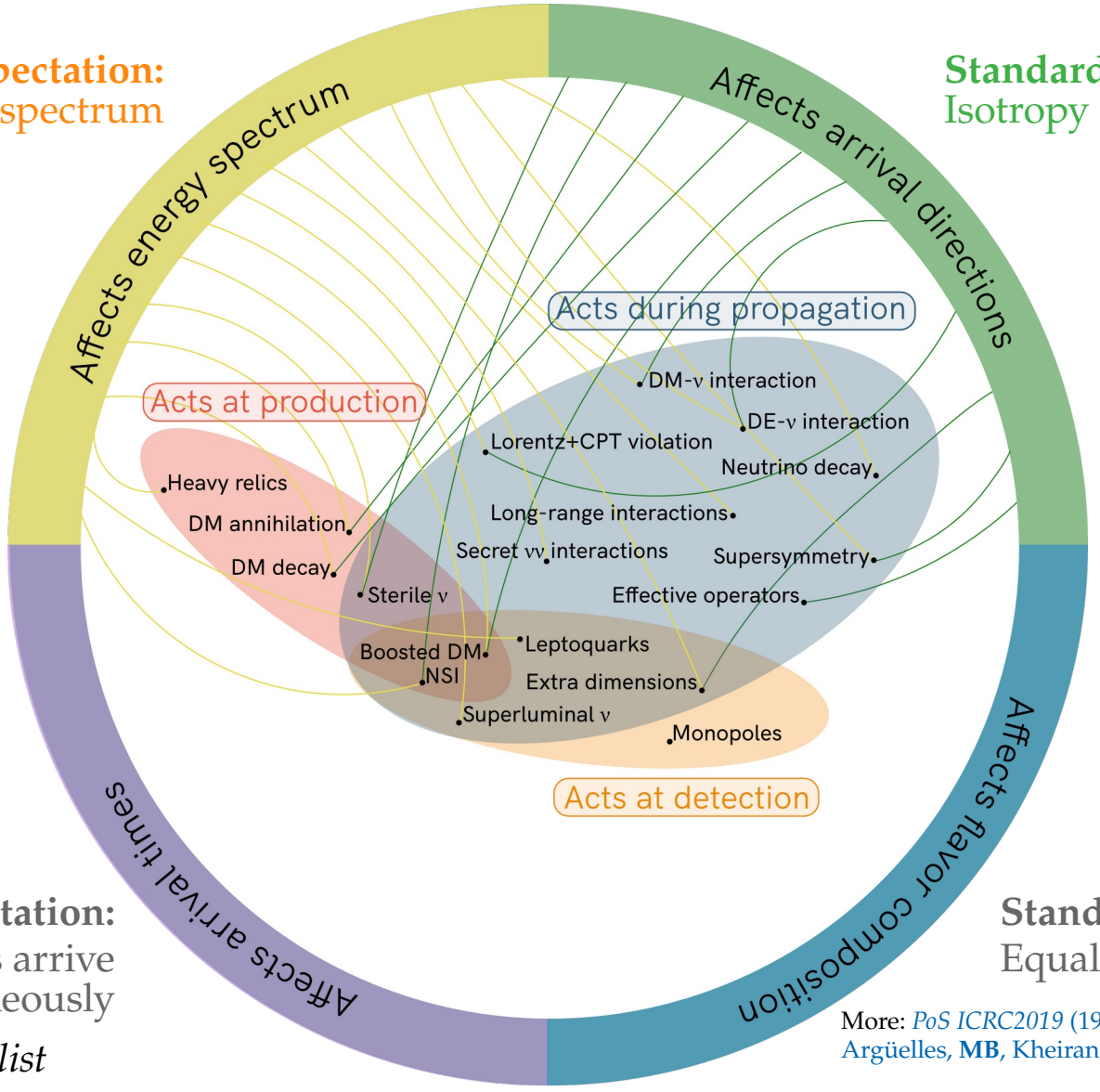

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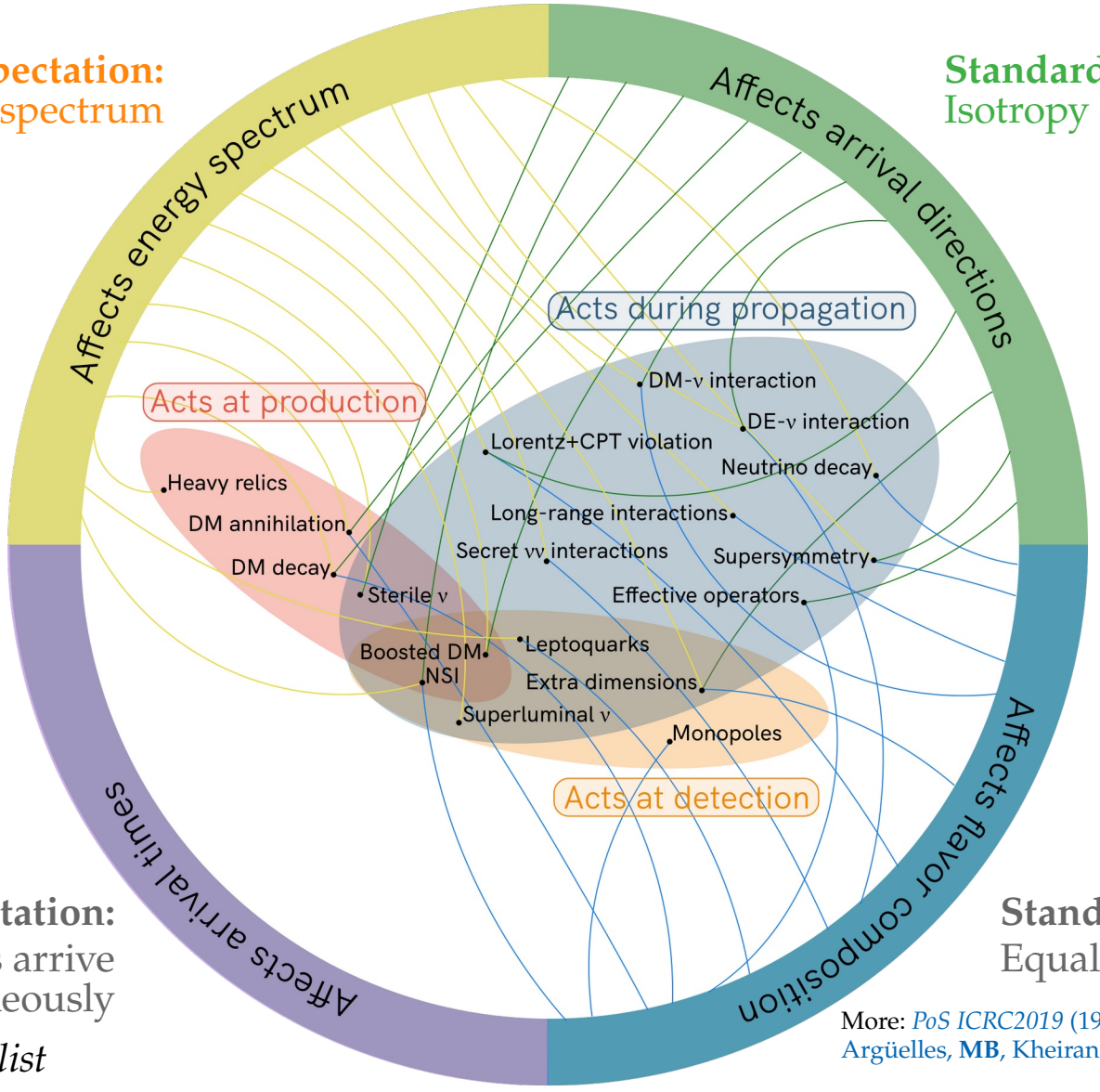

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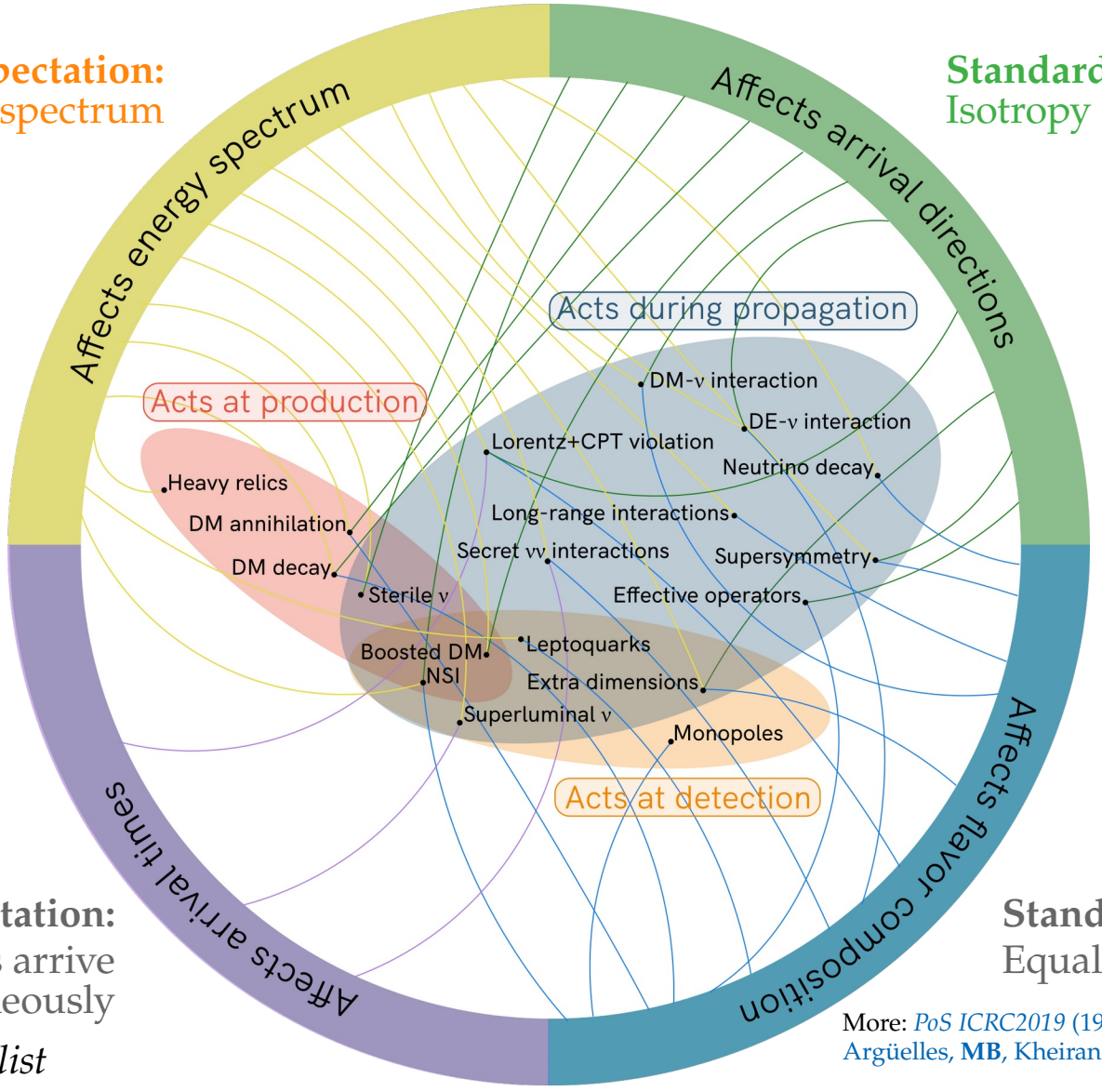

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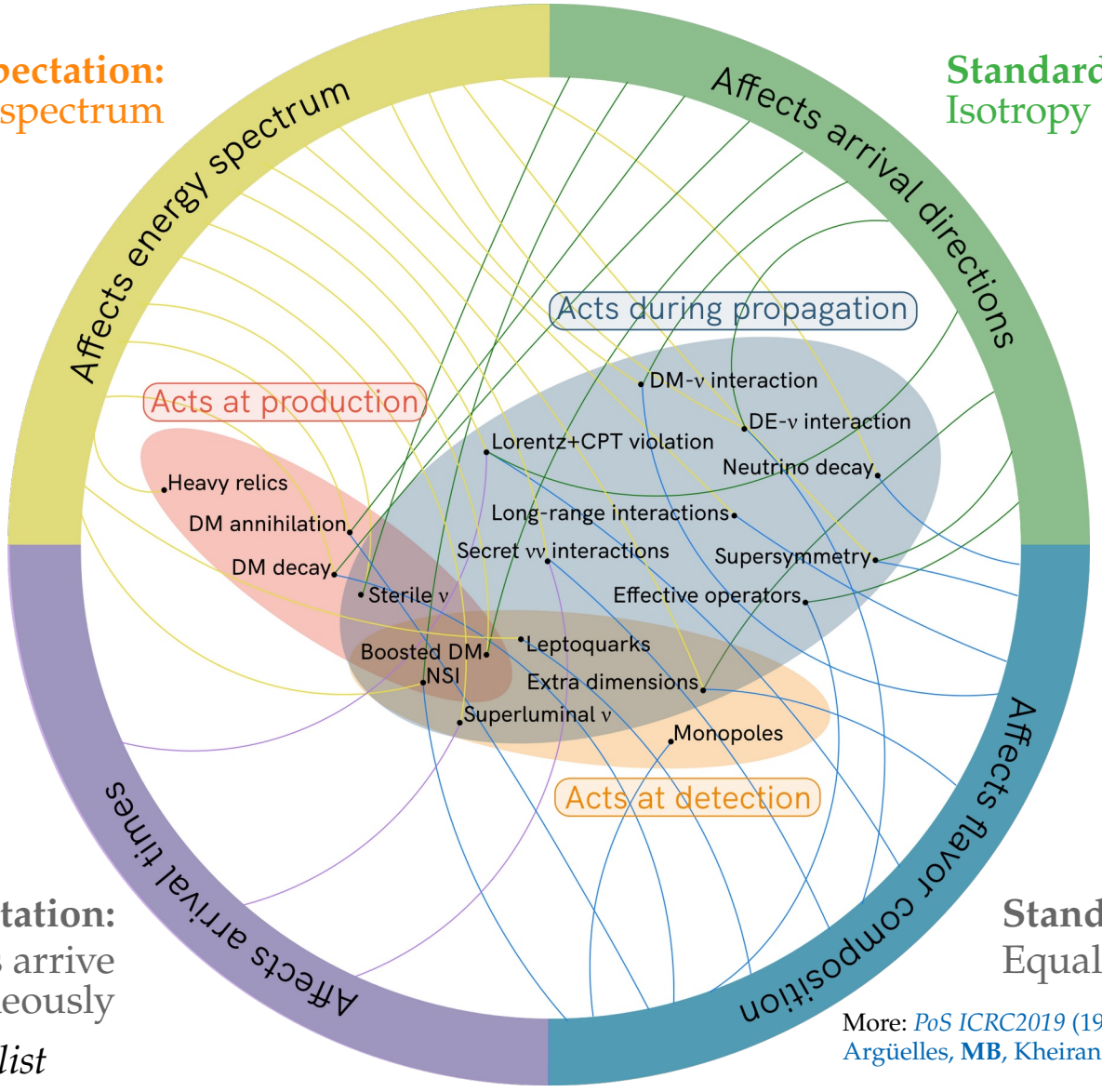

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Sample questions with high reward yield

- How do neutrino cross sections behave at high energies?
- How do neutrino flavors mix at high energies?
- Are there new fundamental symmetries of Nature?
- Are neutrinos stable?
- What can neutrino telescopes say about dark matter?
- Are there hidden neutrino interactions with cosmic backgrounds?
- What is the origin of the anomalous ANITA EeV events?
- ...

Main goal of the LoI

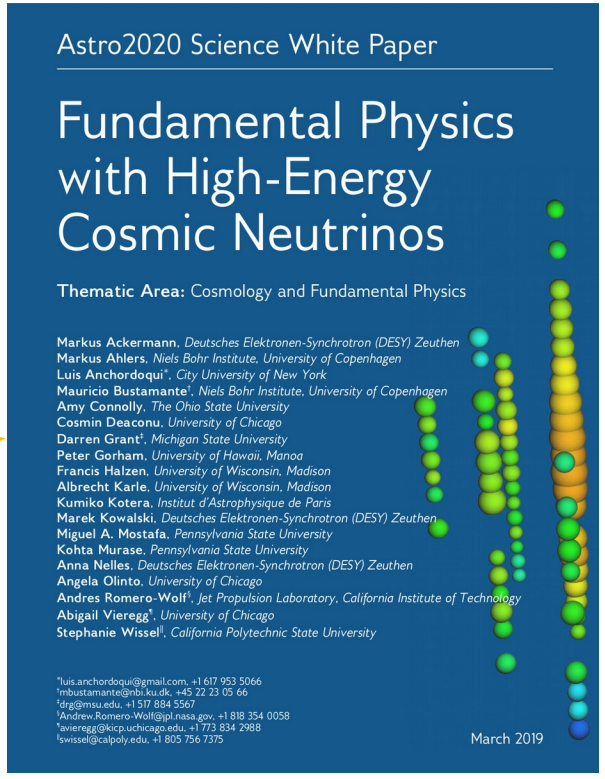
Provide a work plan for high-energy cosmic neutrino physics for the next decade that maximizes chances of discovery and progress

Complementary goals

- Define target sensitivities: energy, direction, *etc.*
- Exploit multi-messenger connections
- Identify synergies with lower energies

Status and plan

- LoI in progress
- Will submit a contributed paper later
- Overlaps with:
  - Energy Frontier (EF09)
  - Neutrino Physics Frontier (NF03, NF04, NF05, NF06, NF10)
  - Theory Frontier (TF09, TF11)
- Working group:
  - ~30 theorists and experimentalists
  - Junior + senior scientists
  - Some co-authors of Astro2020 counterpart on this topic



M. Ackermann *et al.*, Astro2020 Decadal Survey (1903.04333)

Working group for this LoI

Markus Ahlers (NBI)
Luis Anchordoqui (CUNY)
Ignatios Antoniadis (Sorbonne, Bern)
Carlos Argüelles (Harvard)
Vernon Barger (UW Madison)
Mauricio Bustamante (NBI)
Peter Denton (BNL)
Glennys Farrar (NYU)
Jonathan Feng (UC Irvine)
Carlos García Canal (La Plata)
Francis Halzen (UW Madison)
Tao Han (Pittsburgh)
Dan Hooper (Chicago, Fermilab)
Marc Kamionkowski (Johns Hopkins)
Teppei Katori (King's College)
Ali Kheirandish (UW Madison)
Spencer Klein (LBL)
Alexander Kusenko (UCLA, IPMU)
John Learned (Hawaii)
Danny Marfatia (Hawaii)
Kohta Murase (Penn State)
Angela Olinto (Chicago)
Sergio Palomares (IFIC)
Andrés Romero-Wolf (JPL)
Jordi Salvadó (Barcelona)
Ian Shoemaker (Virginia Tech)
Floyd Stecker (NASA Goddard)
Xerxes Tata (Hawaii)
Abigail Vieregg (Chicago)
Aaron Vincent (Queens)
Eli Waxman (Weizmann)
Stephanie Wissel (Penn State)

Contact: Mauricio Bustamante (mbustamante@nbi.ku.dk)