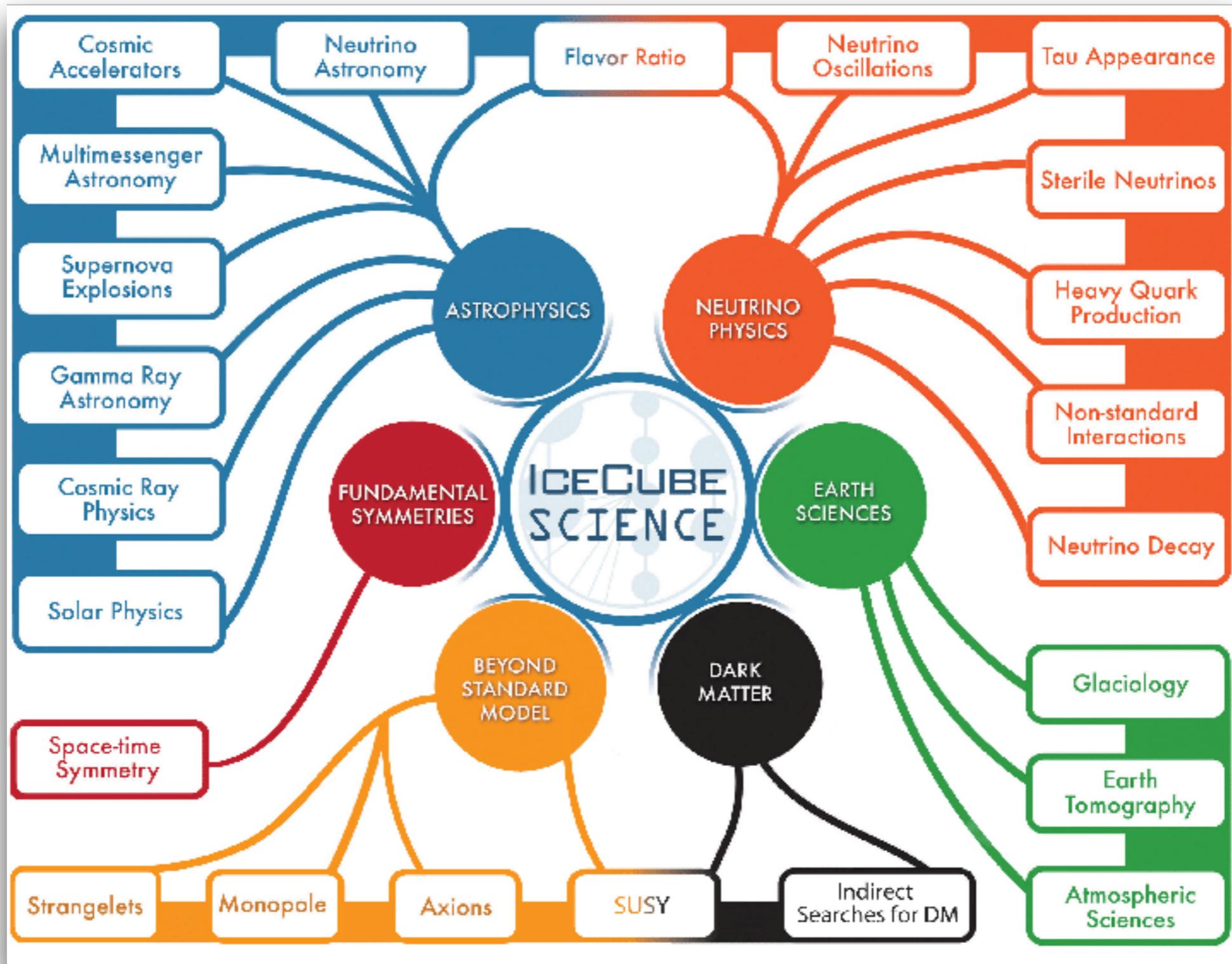


Working Group Overview: Beyond the Standard Model (BSM) Physics

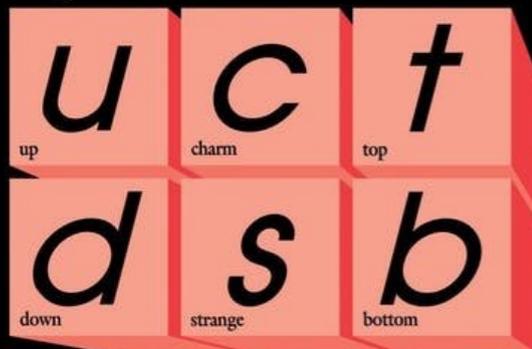
Mehr Un Nisa (MSU)
IceCube Summer School 2024



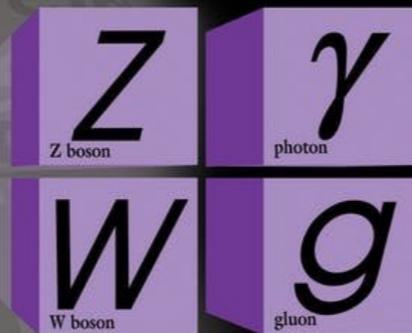
Working groups is where different collaborators with shared interests, **science goals** and **analysis methods** come together. The **boundaries** are somewhat **arbitrary** and mostly for organizational purposes.

Why Beyond the Standard Model

Quarks



Forces



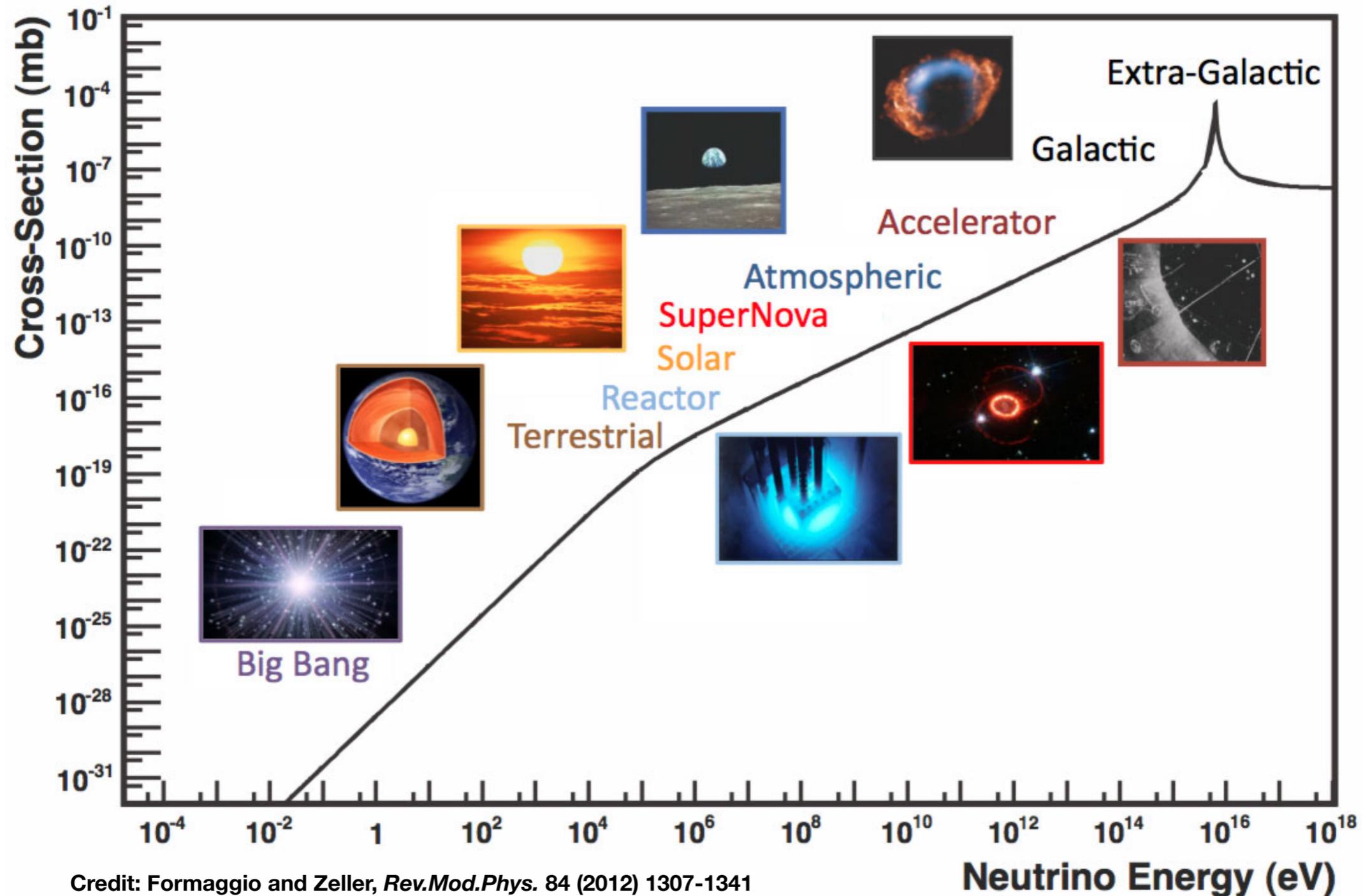
Leptons

“Normal” baryonic matter.
Stars, gas, planets, people...
Standard Model Physics

The Standard Model is incomplete.
We know that because:

- Neutrino oscillations
- Dark Matter
- And other observational anomalies...

Astrophysical Neutrinos and New Physics



- Probe a parameter space in particle physics (GeV—PeV) that is not accessible in other experiments (beam dump/accelerators) .

The Invisible Universe

- ◆ About 85% of the matter content of the universe is invisible.



The Invisible Universe

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The Invisible Universe

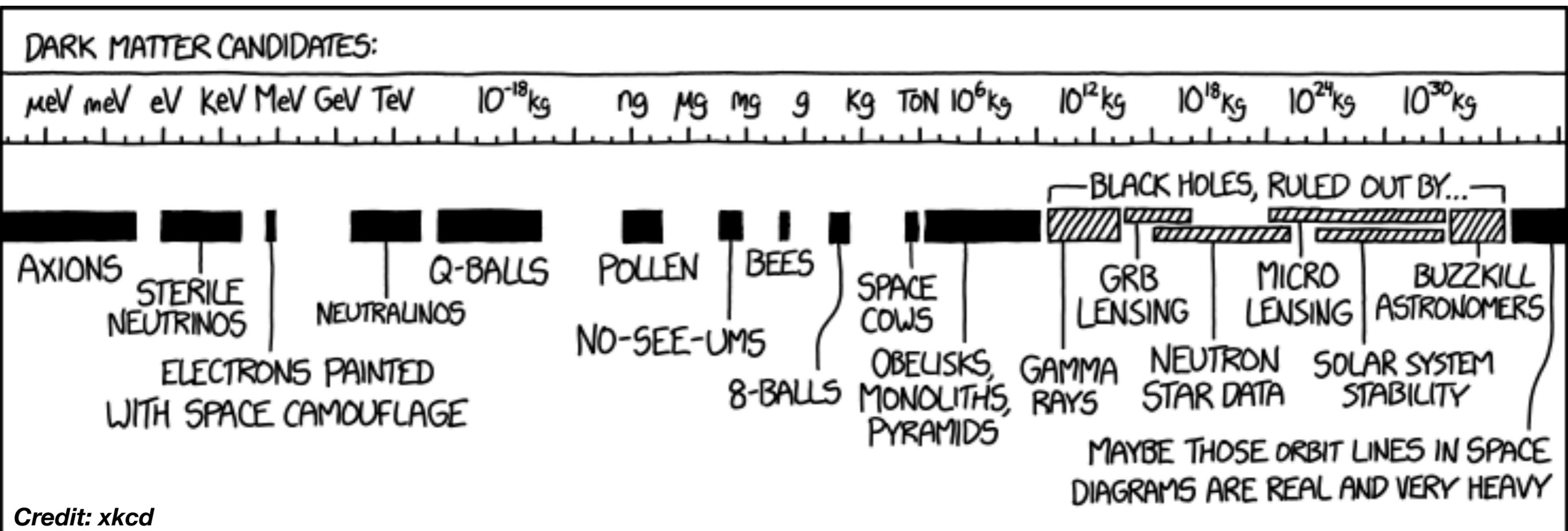
- ◆ About 85% of the matter content of the universe is invisible.



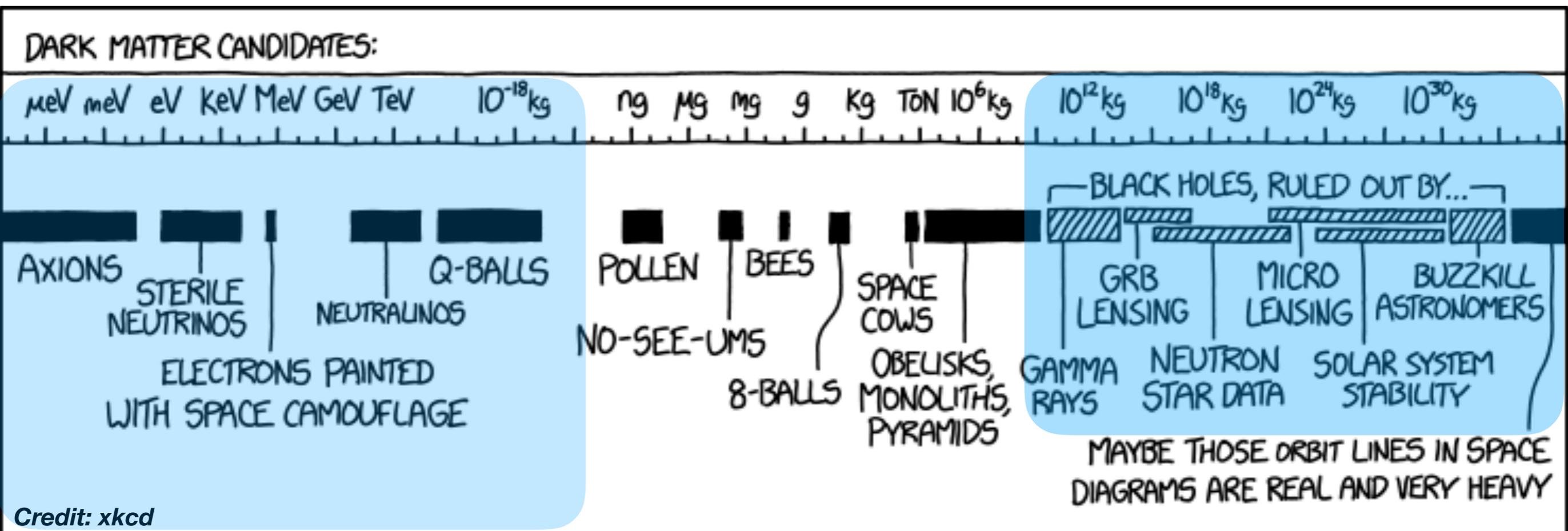
“Normal” baryonic matter.
Stars, gas, planets, people...
Standard Model Physics

Dark halo

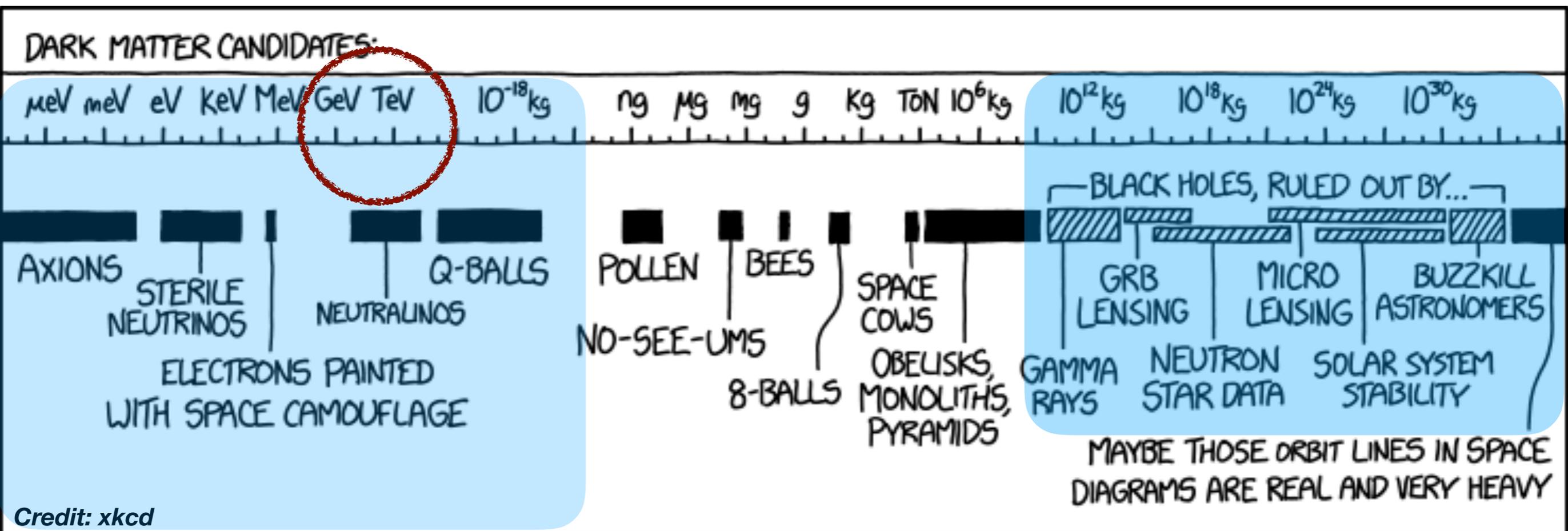
Particle DM Candidates



Particle DM Candidates



Particle DM Candidates



Searching for New Physics

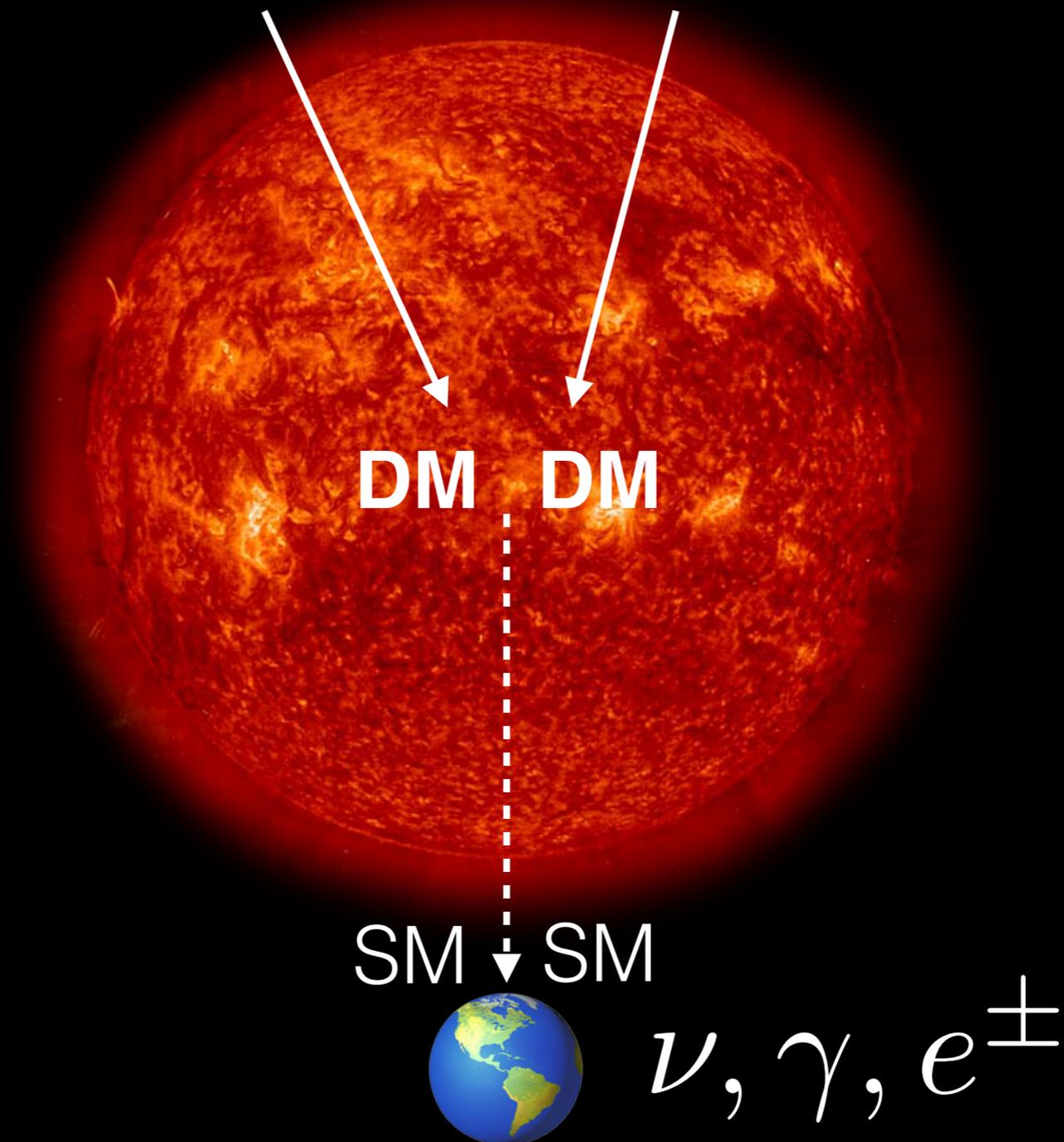
Look for interactions between the “dark sector”
and the Standard Model world.

Signatures of new physics could show up in
neutrino directions, spectrum and flavor.

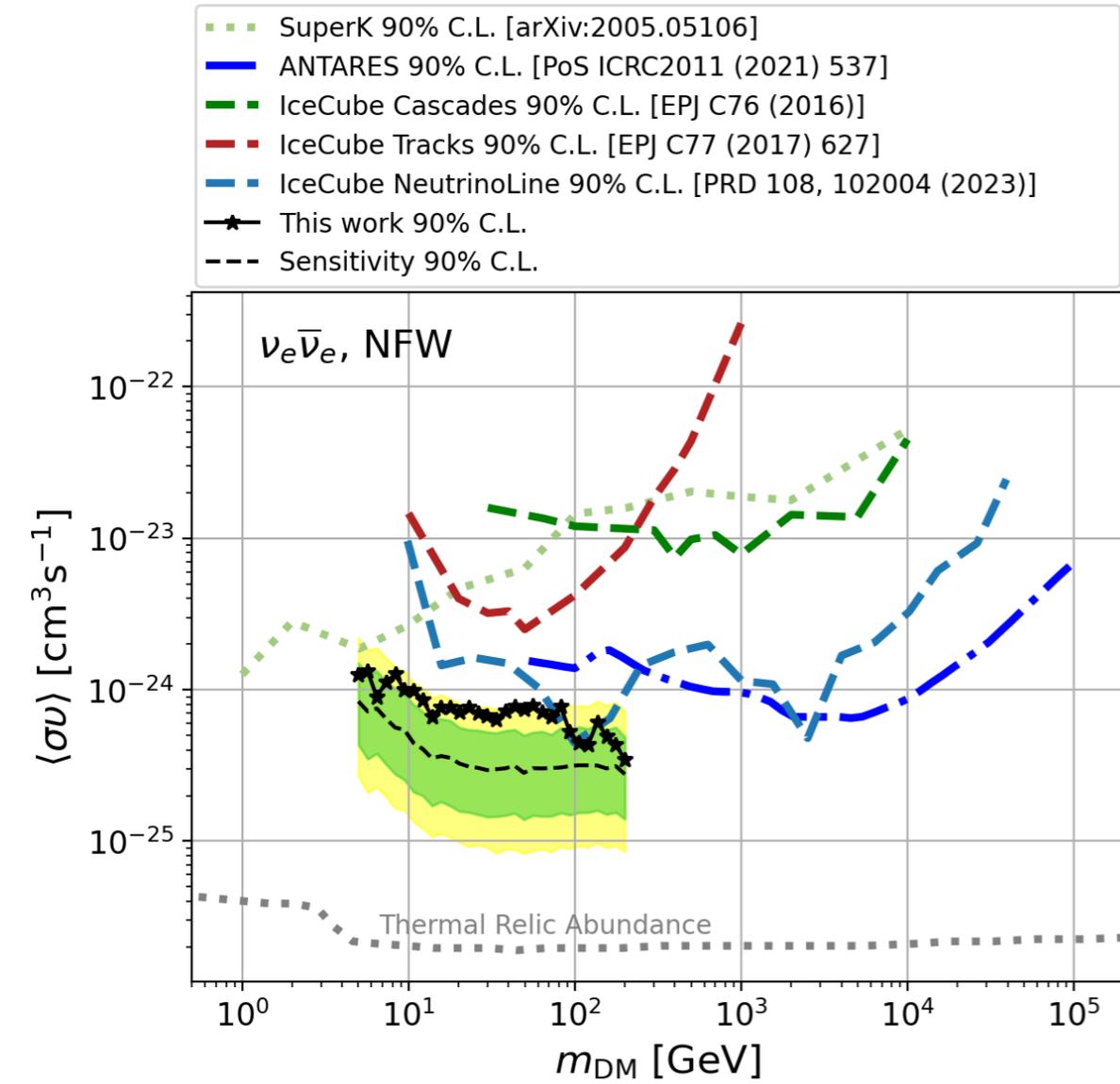
**DARK
MATTER**

Search for Dark Matter Annihilation to Neutrinos

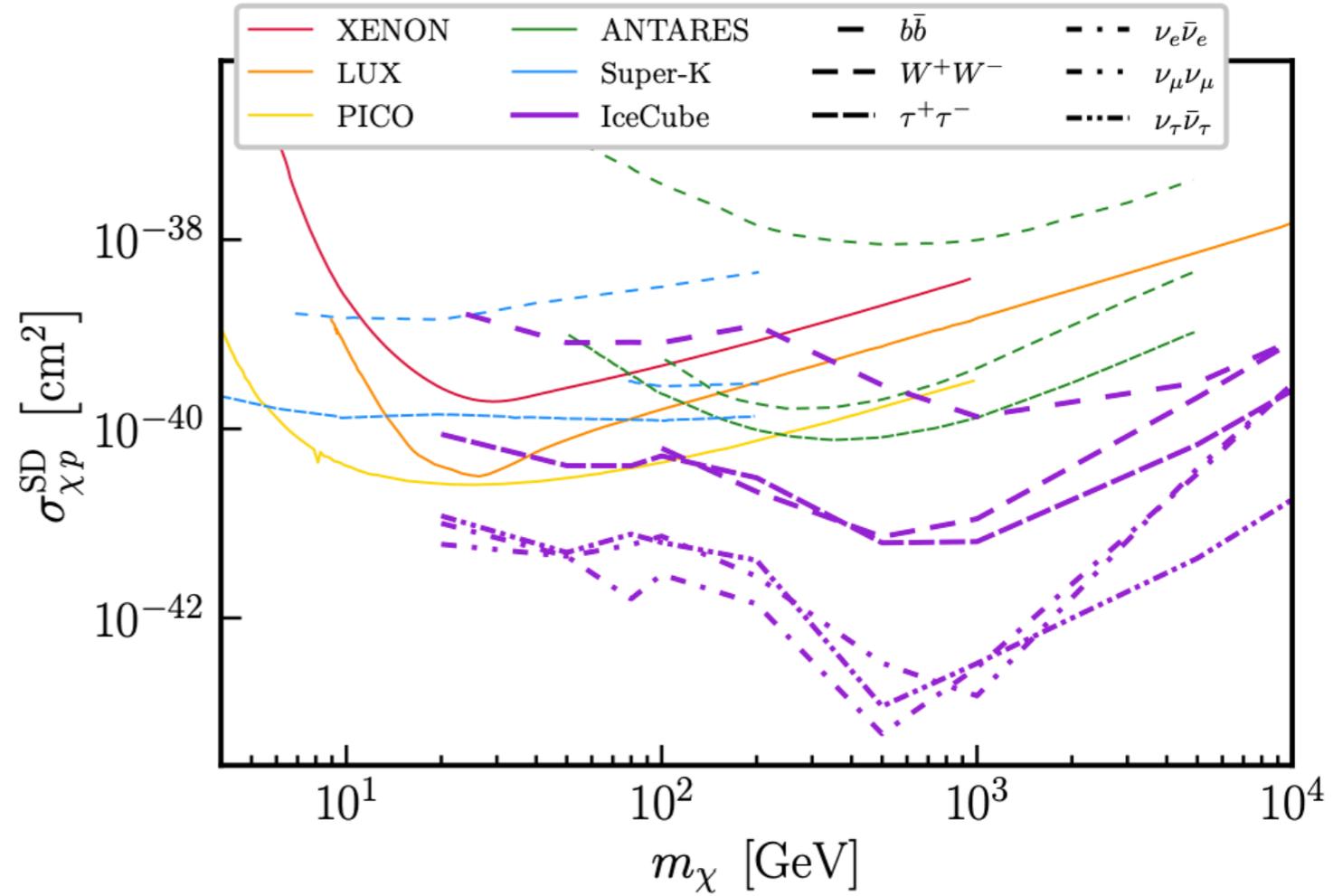
Several analyses in progress searching for DM annihilation in the Sun, Earth and nearby galaxies.



Recent Work



Galactic Center

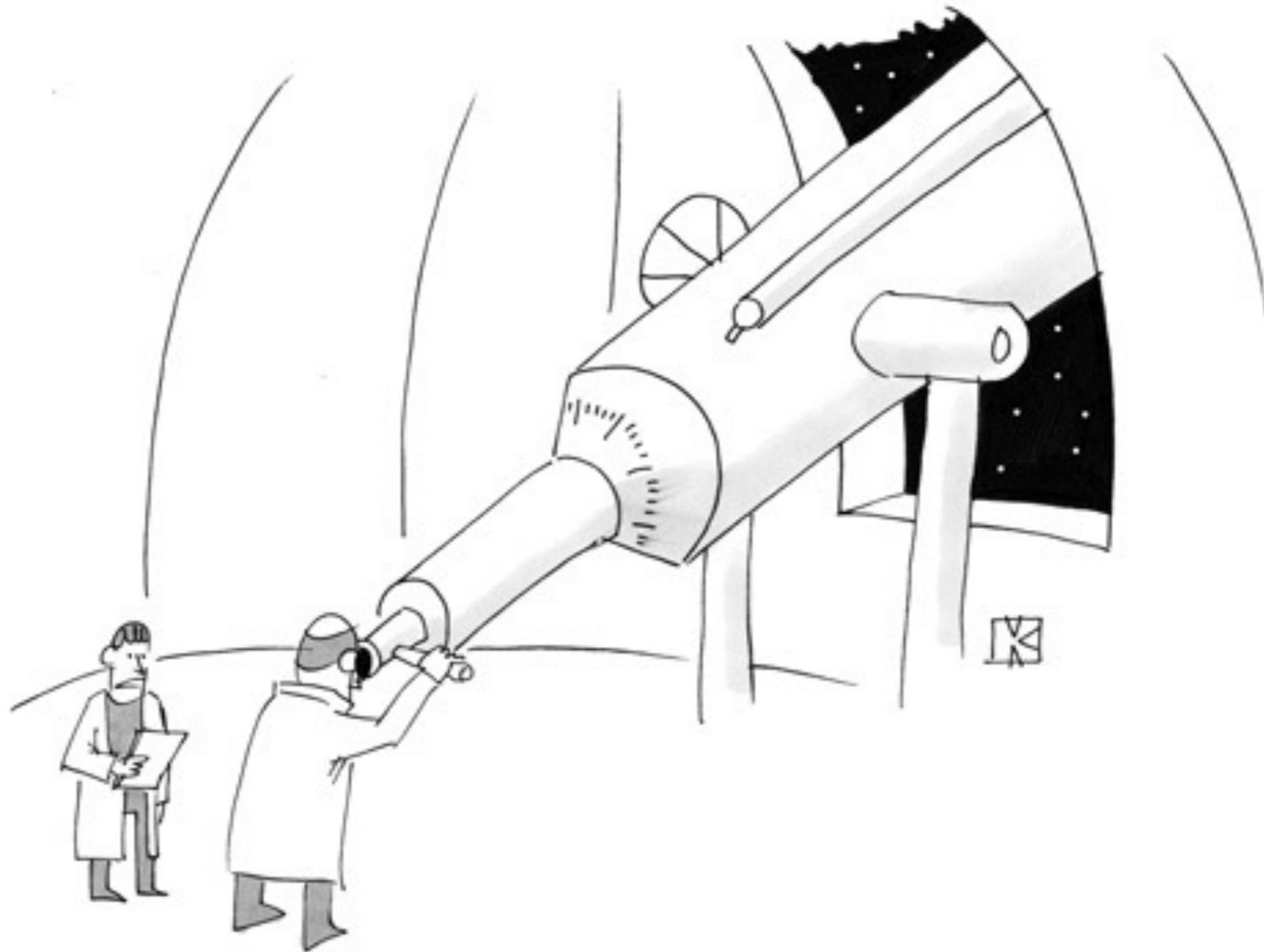


Solar DM

The burden of proof is really high in this area

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GagCartoons.com

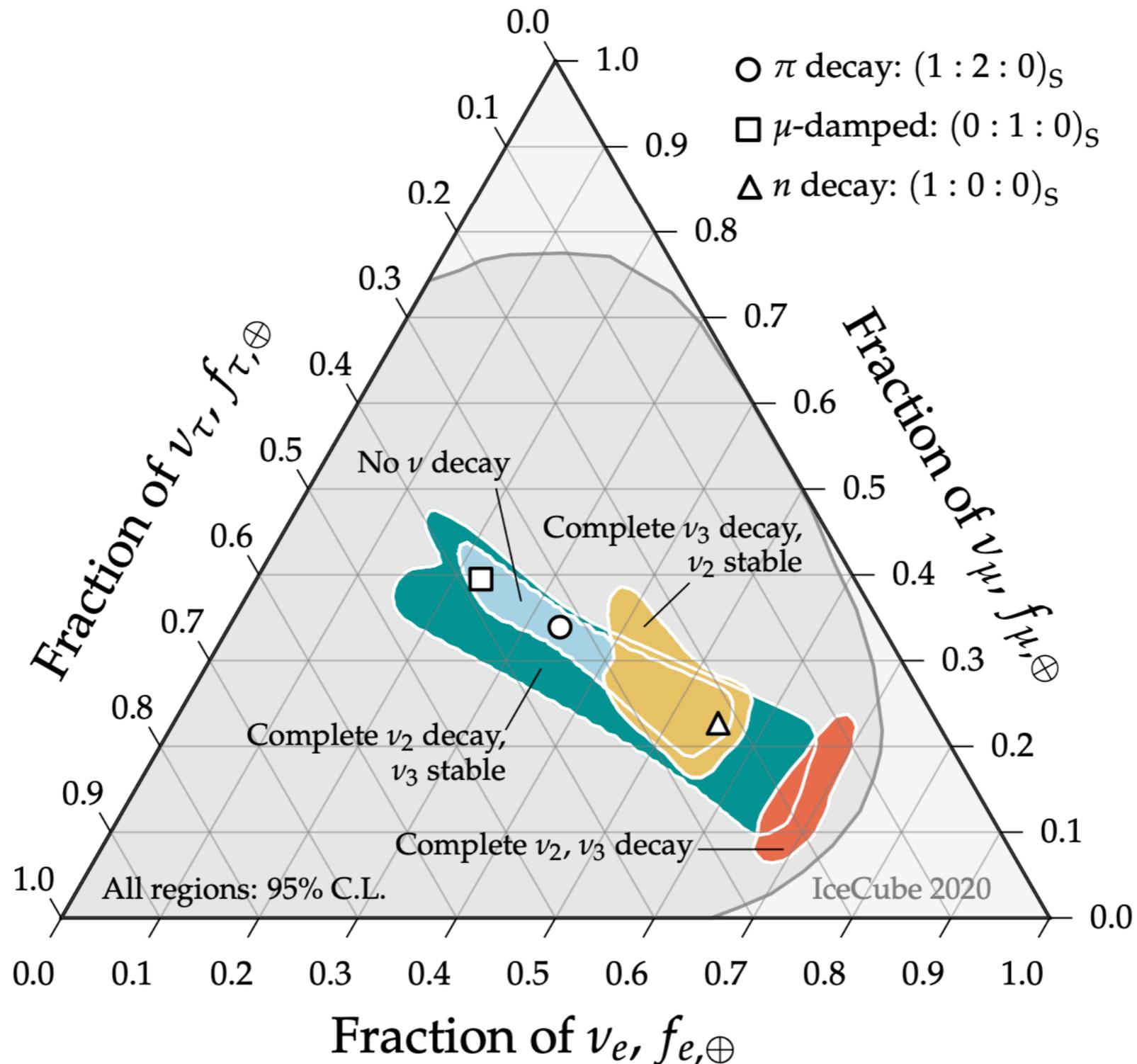


“That isn’t dark matter, sir—you just forgot to take off the lens cap.”

Physics of Neutrinos

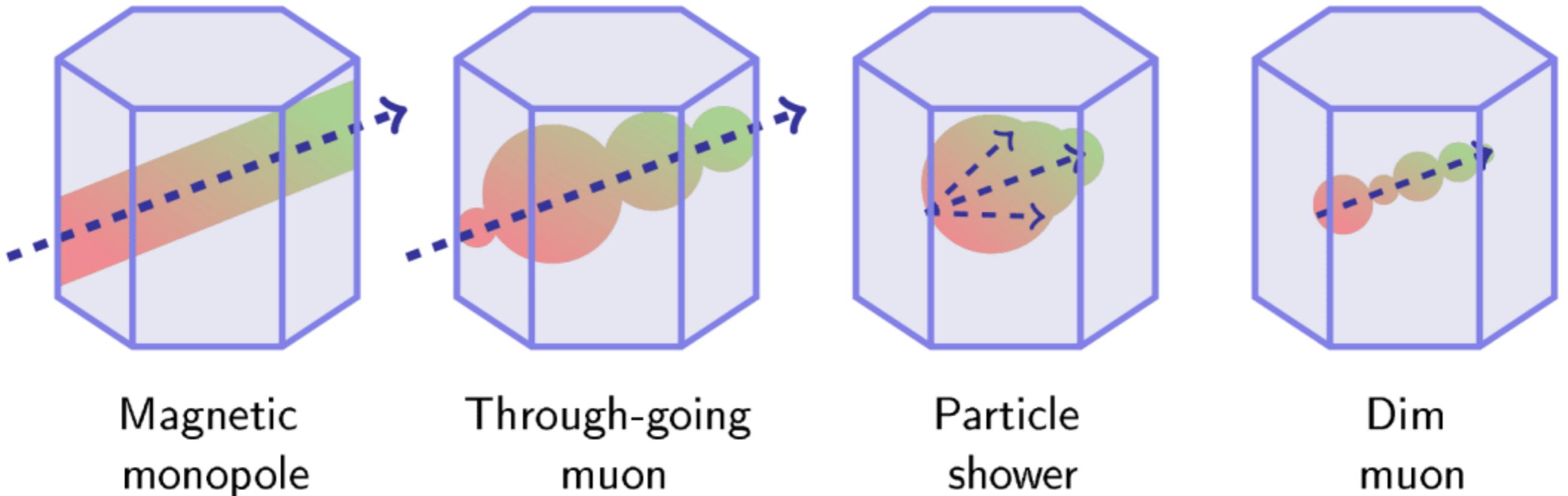


BSM
analyses
look for
flavor ratios
that may be
compatible
with new
physics



Exotics

- We can also use IceCube's large volume to look for signatures of new particles predicted by extensions of the standard model
- Monopoles, long-lived particles, heavy neutral leptons...



Credit: Alexander Burgman

Lorentz Invariance Violation

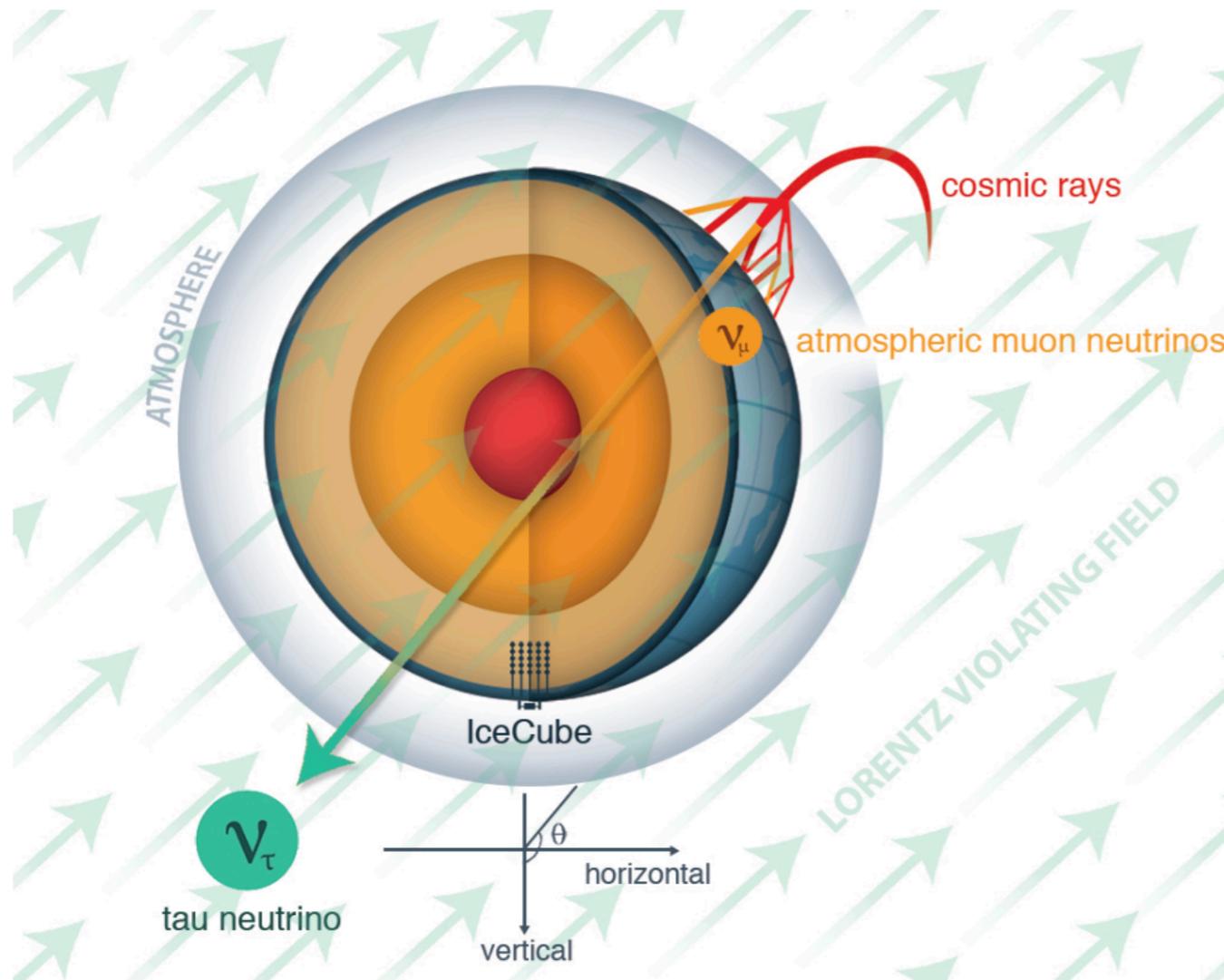
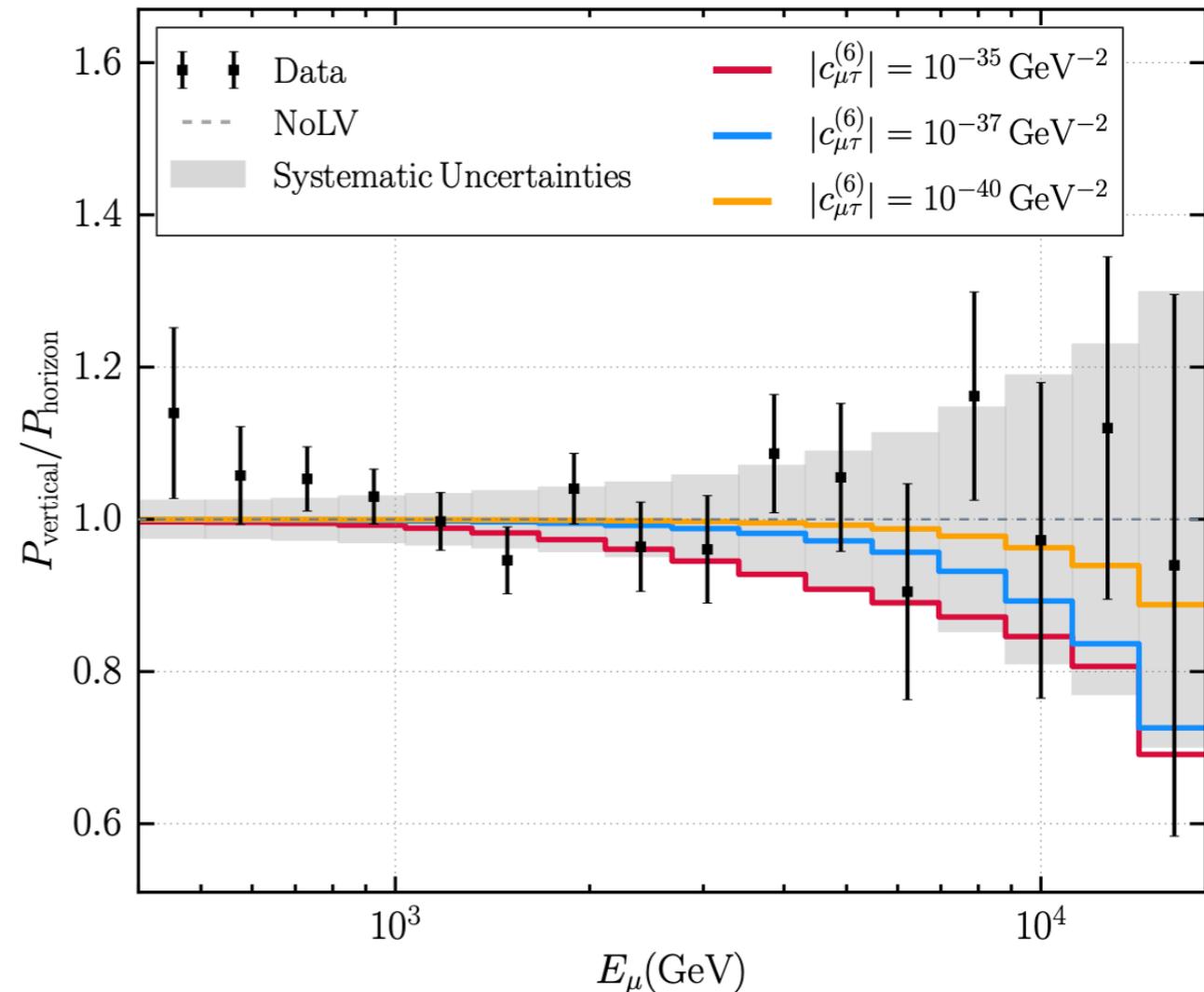


FIG. 1: Schematic figure of the test of LV with atmospheric neutrinos in IceCube. Muon neutrinos produced in the upper atmosphere are detected by IceCube in Antarctica. The potential signal is the anomalous disappearance of muon neutrinos, which might be caused by the presence of a hypothetical LV field that permeates space. The effect can be directional (arrows), but in this analysis we test the isotropic component.



Fundamental symmetry of nature that guarantees different inertial observers see the same physics. Can be violated in extensions of SM producing effects in neutrino measurements by IceCube.

WG Intro

- Wiki page
- Biweekly phone calls. Alternate Tuesdays at 9 am Eastern/3 pm CET/10 pm Japan time.
- Mailing list beyond_sm-wg@icecube.wisc.edu
- Slack #bsm



Carlos Argüelles



Mehr Un Nisa

Working Group Leads



Jeff Lazar

Technical lead



Philip Weigel

Data curators



Minjin Jeong

List of on-going analyses

How to Get Started

- **Attend WG phone calls, If you would like to present at an upcoming call, please request a slot using this [form](#).**
- **Present your analysis idea and receive feedback**
- **Things to consider:**
 - **What physics question you're addressing**
 - **What kind of data sample would you need**
 - **Analysis and reconstruction software to use**
 - **What has already been done in this area, both in and outside IceCube.**
- **Blind analysis: Evaluate sensitivity on scrambled data or burn sample**
- **WG reviewer**
- **Collaboration reviewer**
- **Technical/code review**
- **Unblinding plan and request**
- **Approval -> unblind -> discovery of a lifetime 🎉 or something more sobering 😓 -> publication**
- **Analysis steps**