

PLEASE PUT QUESTIONS FOR HEIDI AT THE END OF THIS DOC

Summer Virtual Meeting Agenda

<https://quarknet.org/content/virtual-quarknet-2020-summer-workshop-neutrinos-stepup-online-learning>

Attendance (Wednesday):

Mentors: Danielle, Antonio,

QN Staff: Ken Cecire, Shane Wood

Teachers: James Small, Darwin Smith, Kathy Kowski, Joel Klammar, David Trapp (lead),

Marteen Nolan,, Alison Bulson, Charlie Payne, Nicole Preiser, Debbie Gremmelsbacher, Megan Alvord,

Share-a-thon: what works well? Lab? Tool? Activity? Ideas for virtual learning - we'll do this Friday - put your thinking hat on.. Link to a spreadsheet that you can collect up the resources [spreadsheet\(link is external\)](#)

Implementation Plan? How will you bring these lessons to the classroom?

Notes and Questions

Please record any notes you think would help the group here. Also include any questions you would like to add an experimentalist. (See very bottom of Doc)

[Link to Heidi's slides](#) - you're welcome to peruse the slides early and use it to generate questions

Zoom Meeting Room

Kenneth Cecire is inviting you to a scheduled Zoom meeting.

Topic: Virtual QuarkNet Center August 2020 Workshop

Time: Aug 12, 2020 11:00 AM Eastern Time (US and Canada)

Join Zoom Meeting

<https://notredame.zoom.us/j/93212433847?pwd=OUFxVlpwbHU0M2FYb1VQTWVNbGZpUT09>

Meeting ID: 932 1243 3847

Passcode: minerva

One tap mobile

+16465588656,,93212433847#,,,,,0#,,6863225# US (New York)

+13017158592,,93212433847#,,,,,

.,0#.,6863225# US (Germantown)

Dial by your location

- +1 646 558 8656 US (New York)
- +1 301 715 8592 US (Germantown)
- +1 312 626 6799 US (Chicago)
- +1 669 900 6833 US (San Jose)
- +1 253 215 8782 US (Tacoma)
- +1 346 248 7799 US (Houston)

Meeting ID: 932 1243 3847

Passcode: 6863225

Find your local number: <https://notredame.zoom.us/j/93212433847>

Join by SIP

93212433847@zoomcrc.com

Join by H.323

162.255.37.11 (US West)

162.255.36.11 (US East)

Passcode: 6863225

For Antonio

Random Questions:

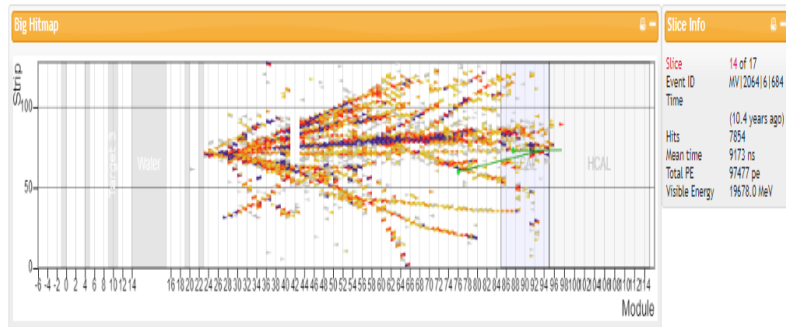
- 1) Please explain how symmetry breaking caused mixing of neutrino masses and flavors.
- 2) Is this symmetry breaking mentioned above the same symmetry breaking related to the Higgs?
- 3) Maybe also question one can be related to something currently being studied, 'do neutrinos obey normal hierarchy'? If no, what theories would be allowed? If yes, what theories would be allowed?
- 4) I think I read something about chirality and neutrinos and the Higgs. Left handed neutrinos would have to switch chirality to interact with the Higgs (or something like that). Please explain.
- 5) Is it correct that possibly neutrinos could be their own antiparticle? If yes, what experimental evidence do we need to determine if this is true?
- 6) How does the fourth neutrino (sterile neutrino) fit with the others (and that standard model)? I understand the possible experimental evidence (I think) but there are only 3 generations (for quarks and the other lepton - electron, muon and tau) so how does the fourth neutrino fit?
- 7) Not really a neutrino question but it is related to some of the other things mentioned above, can you explain how unitarity in QFT suggests that the Higgs mass should be close to the W and Z?

- 8) We've been discussing lifetime. As I understand it, it is NOT correct to say that the relationship between the width of a mass peak and lifetime (narrow peak, long lifetime or wide FWHM, short lifetime) is due to or can be explained by the uncertainty principle (even though you may read this in text books). What is a better conceptual way to explain this relationship that would be closer to correct?

For Heidi:

- 1) It would be great if you could take us through the Accelerator slides starting on slide 32. This is closely related to the data analysis we're working through for the Masterclass.
- 2) **Jim Small.** How many neutrinos actually fly through a detector system without ever hitting anything in the detector? Seems like it would be a really rare event for that to occur... (10^{15} ?). Also, how many neutrinos are actually produced originally? [context: slide 34]
- 3) What experiments are working on sterile neutrinos? Does Daya Bay have a different result than mini-Boone? (Ken)
- 4) It seems making up a particle, the sterile neutrinos, that does not interact with W/Z to explain an experimental result is maybe not the best solution. Sterile neutrinos might be a dark matter candidate but is there some other justification for explaining an experimental result in this way? Is there another explanation, other than sterile neutrinos? How will DUNE help with the search for sterile neutrinos?
- 5) Scale of detectors? We keep making bigger detectors for smaller particles, so how big does a neutrino detector need to be? (IceCube, SuperK big tank of water surrounded by scintillators)
- 6) So how is the problem of detecting neutrinos different from quarks? (sampling detector, background is going to kill you!)
- 7) Why did they know that the neutrino had to be predicted, rather than bad experiments?
- 8) Silly question maybe, does the 1, 2, and 3 in m_1 , m_2 , and m_3 , for neutrino masses refer to generations?
- 9) Connecting the question #8, then we say normal hierarchy if the order of masses is 1, 2 and 3 with 3 being the most massive and inverted if three is least massive? What does this mass ordering for neutrino masses tell us about the universe and how it works? Why is inverted order 3, 1, 2 (slide 29) and not 3, 2, 1? Is this because we know something about mass differences so we know if inverted, that would be the order?

10) If we find that for neutrinos and anti-neutrinos oscillate differently, does that also answer the question about neutrinos being their own antiparticle (Majorana particles)?



11) From Darwin and Ken: *What's this?* (Event in MINERvA - note the energy ~ 20 GeV.)

12) Is the sun's production rate of neutrinos (10^{11} neutrinos/sec/cm²) based upon calculations about the sun's rate of nuclear reactions or is it based on some direct measurement and a subsequent extrapolation? Same question about supernovae.