

Neutrinos, also known as...

HST2023

GHOST PARTICLES



Curriculum & Classroom Connections



Guzin



Micky



Ludivine



Arthur



Mark

Neutrinos can be included in the following units:

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• Conservation of Energy



• Conservation of Momentum



• Standard Model



• Particle Detectors



• Nuclear/Atomic Physics



• History of Science

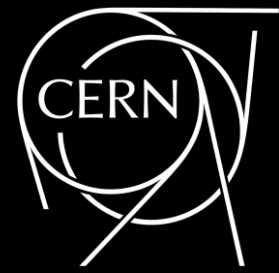


• Astronomy



• Coding

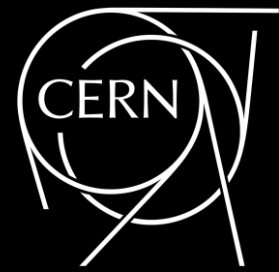




Key Ideas

- It is a neutral small particle (the only neutral fermion).
- They don't interact much with matter (ghost particle).
- Discovered in nuclear reactor: Cerenkov-effect in pool.
- They oscillate flavors (Nobel Prize 2015 for discovery of neutrinos oscillation)
- The reaction for beta-decay provides theoretical evidence for the existence of the neutrino.
- Much about the neutrino is unknown:
 - Neutrinos are their own anti-particle?
 - Neutrinos have mass but don't interact with Higgs?
 - Are there only three flavors of neutrinos?
 - Are they the reason why we have a universe made of matter and not antimatter?
 - How can we use the neutrino in our every day lives?

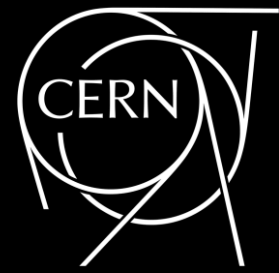




Experiments

- IceCube - <https://icecube.wisc.edu>
- Japan Super Kamiokande (hyper K in progress) - <https://www-sk.icrr.u-tokyo.ac.jp/sk/>
- MAJORANA Demonstrator - <https://www.npl.washington.edu/majorana/majorana-experiment>
- MINOS - <https://fnal.gov/pub/science/experiments/intensity/minos.html>
- DUNE - <https://lbnf-dune.fnal.gov>
- NOvA - <https://novaexperiment.fnal.gov>
- MINERvA - <https://minerva.fnal.gov>
- MicroBooNE - <https://microboone.fnal.gov>
- ICARUS - <https://icarus.fnal.gov>
- KATRIN - <https://www.katrin.kit.edu/deutsch/>
- GERDA - <https://www.mpi-hd.mpg.de/gerda/>
- NEXT - <https://next.ific.uv.es/next/>



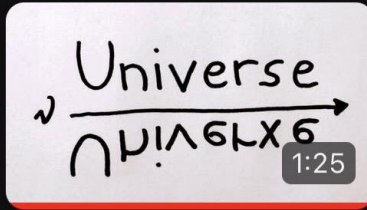


Potential Students' Conceptions & Challenges

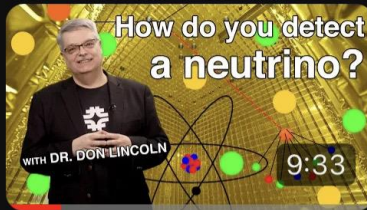
- Neutrino is a part of the nucleus
- There is only one type of neutrino
- Neutrinos are like photons
- Neutrinos don't have mass
- Neutrinos travel at speed of light or faster than light in vacuum
- Neutrinos can pass through anything
- Neutrino is radioactive or dangerous
- Neutrinos decay
- There are both right-handed and left-handed neutrinos
- Neutrinos interact with living material



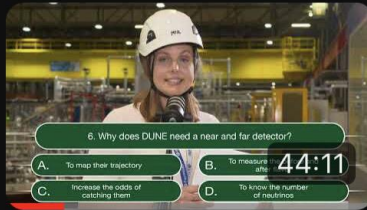
Helpful Materials and Resources



What is a Neutrino? :
minutephysics
2,1 Mn görüntüleme



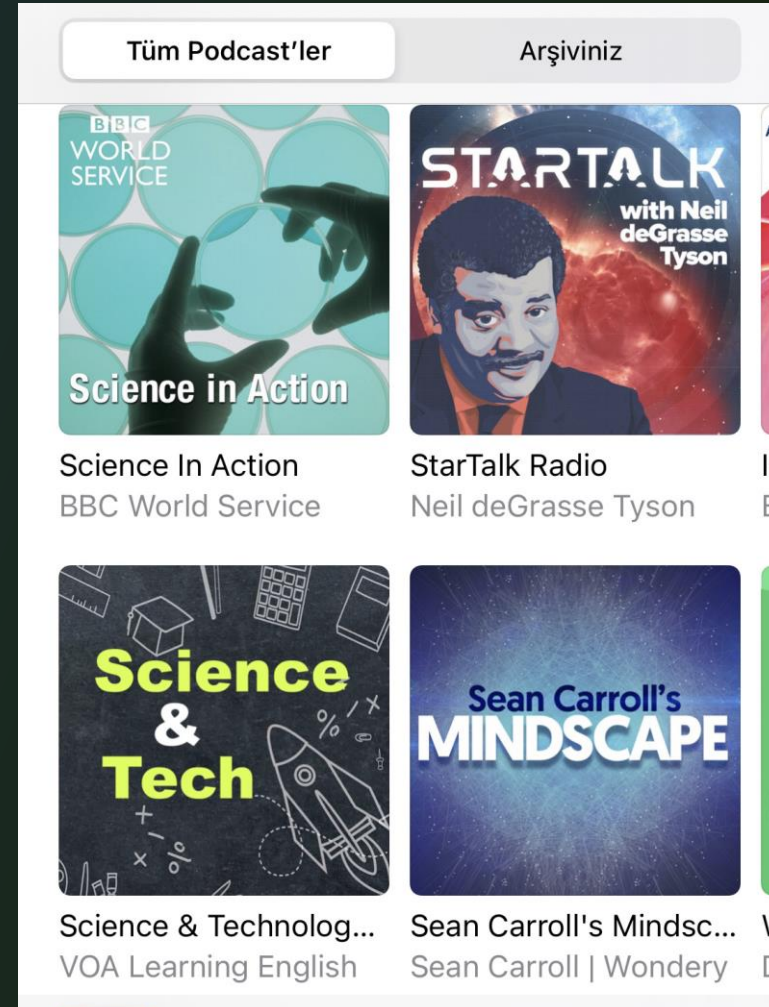
How do you detect a neutrino? :
Fermilab
175 B görüntüleme

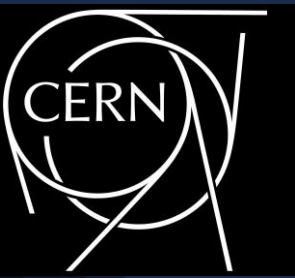


Particle Pursuit, a journey of the DUNE experiment :
CERN · 2,1 B görüntüleme



How do neutrino oscillations work? | Even Bananas 10 :
Fermilab
38 B görüntüleme





Helpful Materials and Resources

Webpages

- Fermilab: <https://www.fnal.gov/pub/science/particle-physics/experiments/neutrinos.html>

Videos

- CERN video about DUNE experiment: <https://www.youtube.com/watch?v=LaMjEINVhEg>
- TED Why Neutrinos Matter: <https://ed.ted.com/lessons/why-neutrinos-matter-silvia-bravo-gallart>

Virtual Reality

- Nuclear decay with formation of neutrinos: <https://disk.yandex.ru/i/PISQpGP84Dc45g>
 - VR File: <https://disk.yandex.ru/d/dDZruxePogBGFw>
 - Lesson Plan: <https://disk.yandex.ru/i/WLUgEel12pEiiA>
 - VR Software: https://academy.vrconcept.net/vrcget_en

Podcasts

- Science and Technology: <https://podcasts.apple.com/tr/podcast/a-new-way-to-look-at-the-milky-way-july-05-2023/id527234700?i=1000619404862&l=tr>
- Physics World Weekly Podcast: <https://podcasts.apple.com/tr/podcast/faser-searches-for-dark-photons-at-the-lhc-and-also/id1400686733?i=1000614499136&l=tr>

Simulations

- Beta Decay: https://www.labxchange.org/library/items/lb:LabXchange:d96d1be6:lx_simulation:1

** See our formal report for more links.



Best Practice Examples

Writing a Song Parody

Song must include:

- At least 3 scientific facts about neutrinos
- Reference at least 1 thing physicists are still trying to understand about the neutrino
- Mention 1 scientific experiment or 1 research center where neutrinos are being studied

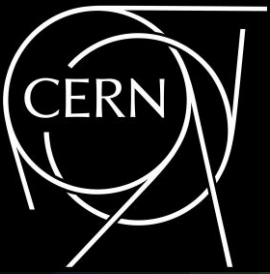
https://docs.google.com/document/d/1aPF8cTmB8rJXsXrrX_xM5349IytRlwMwPgXEPUTH8NY/edit?usp=sharing



Best Practice Examples

- Role Playing
- Assign one characteristic of neutrinos to groups of students and have them act it out.
 - They don't interact much with matter.
 - They have three flavors that oscillate.
 - They are only left-handed.



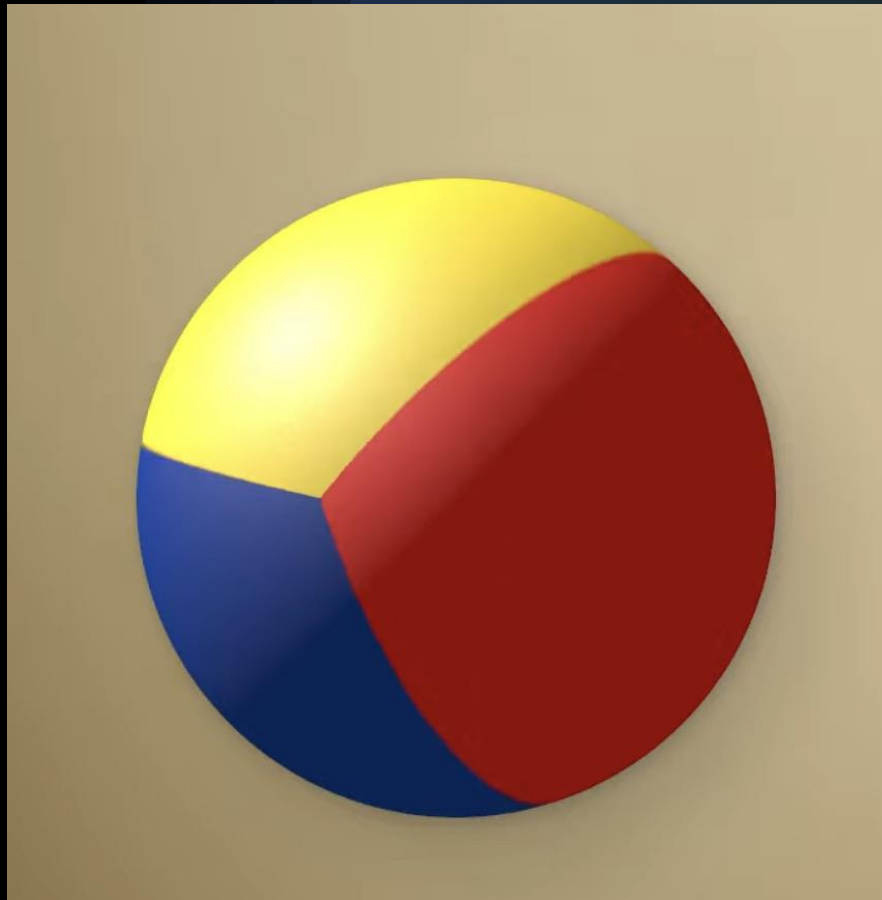


Best Practice Examples

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Beach Ball Demonstration

<https://youtu.be/eBT1-dV1BTM>





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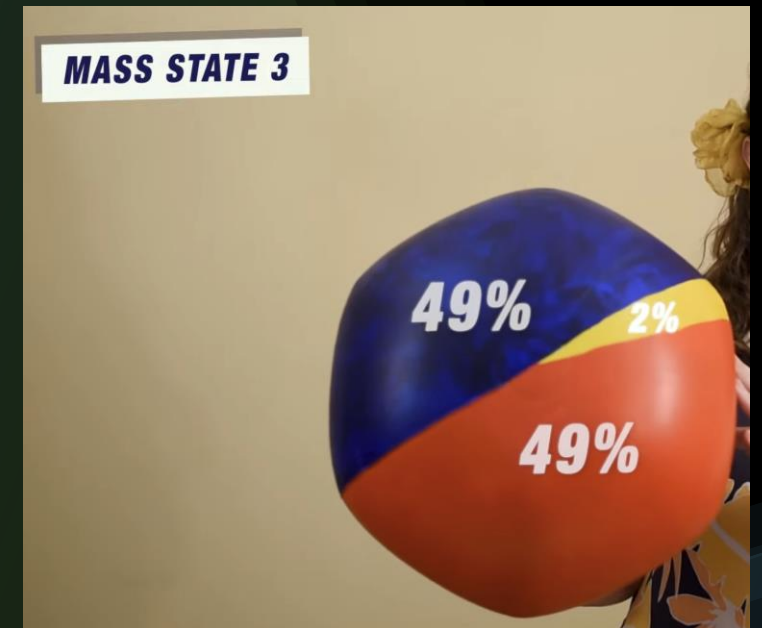
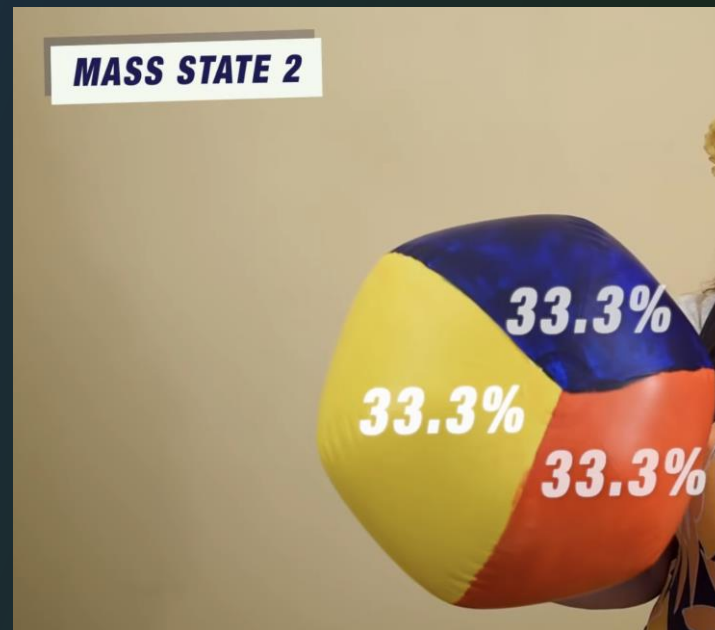
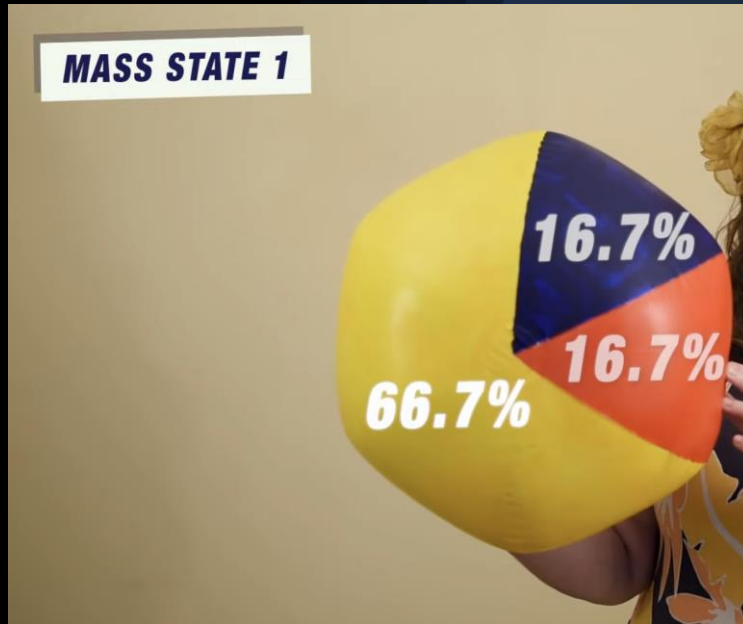


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Sources

Oliver, A. (2012). *Particle Quest Sprites* [Photograph]. CERN. <https://cds.cern.ch/record/1473657>.

Gross, M. (1984). *Ghostbusters Logo* [Drawing]. Logo Design Love. <https://www.logodesignlove.com/ghostbusters-logo>.

Parker Jr., R. (1984). Ghostbusters Theme Song (Instrumental) [Recorded by Ray Parker Jr.]. On *Ghostbusters: Original Soundtrack* [Album]. Arista.

ChatGPT. (2023, July 6). Please write me a song parody of the Ghostbusters Theme Song, but instead of ghosts, make it related to neutrinos. [Response to user question]. <https://openai.com/blog/chatgpt>.

ChatGPT. (2023, July 6). [Response to user question]. <https://openai.com/blog/chatgpt>.

Note: ChatGPT created the theme song *Neutrino Hunters* which we then adapted. ChatGPT was also used to help generate ideas but was not used to do our research or write our presentation.



Group 7

HST2023

GHOST HUNTERS

Thanks for listening.

