8 July 2024

Group Work Problems

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Group Problems

- Spend ~1 hour/day for the next two weeks working on one problem with your colleagues here at the school.
- These are examples of problems that the experimenters at SNOLAB will be trying to solve.
- The experiments at the lab are all run by collaborations: groups of people who are generally geographically distributed, but have common scientific goals.
- The collaborations can have unique dynamics, but all are starting to incorporate the concepts of Equity, Diversity, and Inclusion.
- There is an EDI component to each physics problem.
  - Spend 10-15% on developing a solution to that question.

TRISEP-2024 Group Problem #1

Determine the number of neutrino interactions there would be in the CUTE water tank as a function of distance to the next galactic core-collapse supernova.

Helpful Links:

- https://www.sciencedirect.com/science/article/pii/S037026930300616 6?via%3Dihub
- https://www.frontiersin.org/articles/10.3389/fphy.2023.1319879/full

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a collaboration with about 50 people from 4 different counties and 8 different institutions. You have recently had interest from 2 new institutions to join the collaboration. Both institutions have international students and for some of them travel restrictions apply, such as long wait times for a VISA. What can/should your collaboration do to understand "how to best support these new collaborators. This includes how you would work to fully understand their needs and how to mitigate barriers. Provide a summary and possibly a policy. Ask for examples, if needed.

TRISEP-2024 Group Problem #2

Calculate the expected CEvNS events from a 10 kpc galactic supernova: in 100 kg of Si, Ge, Cs, Lu, and Pb. Compare the recoil spectrum of the different targets.

Helpful Link:

- https://www.sciencedirect.com/science/article/pii/S092765052300076 2?via%3Dihub

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a collaboration with about 55 people from 6 different counties and 10 different institutions. This collaboration has been recently formed and there is work on the governance documents ongoing, such as bylaws. Discuss in your group how the bylaws can ensure that younger members (Graduate students and Postdocs) have an appropriate voice in critical decisions that affect the scientific goals. Then draft that part of the by-laws. Ask for examples, if needed.

TRISEP-2024 Group Problem #3

What are the cosmic activation products in Si, Ge and NaI? Which isotopes that are produced a could be backgrounds in dark matter search experiments and why? For Ge what isotopes could be an issue for neutrino-less double beta decay?

Additionally, How much time under how much overburden is needed to overcome the activation? What are the systematics in the cosmogenic activation estimates and what are their deviations?

Helpful Links:

- http://www.lnhb.fr/home/nuclear-data/nuclear-data-table/
- http://nucleardata.nuclear.lu.se/toi/
- https://ieeexplore.ieee.org/document/5389314
- https://www.sciencedirect.com/science/article/abs/pii/S092765051630121 9
- https://arxiv.org/abs/1708.07449

TRISEP-2024 Group Problem #3

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a collaboration with about 50 people from 5 different counties and 10 different institutions. You have been asked to draft a Code of Conduct for this collaboration, which is no longer than 2 pages.

Think about where and when it applies, what are the goals, how do you best accomplish that – then go ahead and write it. Ask for examples, if needed.

TRISEP-2024 Group Problem #4

Current and near future double beta decay experiments are aiming to reach sensitivity in the inverted hierarchy. In order to reach the normal hierarchy mass ranges, detectors either will have to be very large or a new technology is needed.

What is the detailed mechanism for double beta decay? What is meant by mass hierarchy? What are the experimental conditions that need to be met for a double beta decay? Why is it so hard to reach the normal hierarchy ranges and what will be needed? Remember: think on a 25 to 40 year time scale and do not worry about cost.

Optional question: Would discovering neutrinoless double beta decay clearly tell us the mass of the neutrino?

TRISEP-2024 Group Problem #4

Helpful Links:

- https://www.annualreviews.org/content/journals/10.1146/annurev-nucl-101918-023407

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a collaboration with about 100 people from 6 different counties and 16 different institutions. Your collaboration has been together for 10 years already and recently performed a survey that showed a lack of gender diversity. You are part of the task force that was formed to come up with 2 or 3 initiatives to improve the situation over the next 5 years. Discuss and then describe the proposed initiatives. Ask for examples, if needed.

TRISEP-2024 Group Problem #5

- Calculate the radon implantation depth in material, with help of SRIM/TRIM simulation.
- What is the mean path for an alpha particle? Understand the dE/dx of alpha particle.
- Why can Radon222 can be problematic for low background experiments? What alpha energy? Which energy region of interest for rare event searches?
- What is the probability that radon sticks on the surface?
- Simulate implantation depth profile of radon on different materials - Ge, Cu, Si. (via TRIM)
- How can we estimate alpha surface activity on materials? What techniques are available and what would be needed for the next-generation low-background experiments? (energy resolution, surface area, PSD)

TRISEP-2024 Group Problem #5

Helpful Links:

- http://srim.org/
- https://link.springer.com/article/10.1140%2Fepjc%2Fs10052-011-1805-0
- https://www.sciencedirect.com/science/article/abs/pii/S016890021731136 1

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a collaboration with about 30 people from 4 different counties and 9 different institutions. The collaboration contains institutions in both Canada and the US. There is a new funding program available that is specifically meant to support Indigenous research, requiring at least two Indigenous researchers as partners. Discuss and summarize what the topic/goal for this application would be and how you would go about securing these partners. Ask for examples, if needed.

TRISEP-2024 Group Problem #6

- The cosmic microwave background has been studied very well and greatly increased our knowledge about the early Universe. There is also cosmic neutrino background at an even lower temperature, which still holds lots of secrets. Measuring cosmic neutrino background is very challenging and ideas of how to approach this measurement are necessary. How would you do that?
- What is cosmic microwave background?
- What is cosmic *neutrino* background and what can it tell us about the early Universe?
- What are the experimental challenges for this measurement?
- What kind of approach/detector technology has the best chance of being able to measure cosmic neutrino background?
- Remember: think on a 25 to 40 year time scale and do not worry about cost.

Optional question: Why is knowledge about the early Universe so interesting?

TRISEP-2024 Group Problem #6

Helpful Links:

- Frontiers | Looking for cosmic neutrino background | Physics (frontiersin.org)
- [1602.03347] Can one measure the Cosmic Neutrino Background? (arxiv.org)

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a collaboration with about 120 people from 7 different counties and 17 different institutions. Your collaboration has a Code of Conduct and an EDI/DEI action plan that has been in place for a few years. In 3 of the countries it has become mandatory to describe an EDI/DEI plan in your collaboration funding application, which is part of the evaluation process. Provide 1-2 pages summarizing the achievements in the last 2 years and plans for the next 2. Ask for examples, if needed.

TRISEP-2024 Group Problem #7

- Long lived neutral particles are an intriguing Beyond Standard Model (BSM) possibility. One could imagine models in which neutral particles are created that escape the detector before decaying to SM particles. The MATHUSLA collaboration has a letter of intent to study such particles.

- Describe some BSM models that create LLPs (Long Lived Particles). What sort of models could you probe with a detector far from the interaction point at the proposed International Linear Collider? How do the different designs do this?

- How could you build a next-generation LLP detector at the LHC or ILC? Could you benefit by putting the detector underneath the ground? i.e. How do muons create backgrounds and can muons create backgrounds that look like they are coming up from the interaction point? (For this part of the question do not worry about cost. The LHC is 100 meters underground. If you like, assume the ILC is deeper than that but keep it reasonable.)

- Start with the Mathusla and SHiP, but what LLP detector at a collider would you like to see in 25 to 40 years?

TRISEP-2024 Group Problem #7

Helpful Links:

- arXiv:1811.00927
- https://arxiv.org/abs/1807.11737
- https://arxiv.org/abs/1811.12522

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a relatively new collaboration with about 60 people from 5 different counties and 9 different institutions. Your experiment is currently under construction at a remote site with a very small local group. There is a lack of willingness for other collaborators to spend significant amounts of time on site to support the construction efforts. Funding is limited, which means it is up to the collaboration to ensure the people needed go to site. Discuss and summarize possible rules and policies that can be put in place to ensure that approximately 5 additional collaborators are on site at any given time. Ask for examples, if needed.

TRISEP-2024 Group Problem #8

- Investigate the possibility of generating light dark matter candidates directly underground at the SNOLAB facility, using the rock surroundings the lab and a “small-scale” electron linear accelerator (e-linac).

- If we were to consider a e-linac similar to what is being use for the ARIEL facility at TRIUMF (https://fiveyearplan.triumf.ca/teams-tools/e-linac-electron-linear-accelerator/), how big would the rock layer have to be in order to produce dark matter particles but shield from any possible secondary particles that could be a source of background for all other experiments in the lab?

- Conceptually design what would be an ideal detector (or detectors) to place downstream from the e-linac, optimized for light dark matter detection. Carefully explain the full process in your design idea and highlight/motivate any specific technology or technique that you would adopt. You can also consider modifying current experiments.

TRISEP-2024 Group Problem #8

Helpful Links:

- https://arxiv.org/pdf/1712.01518.pdf
- https://arxiv.org/pdf/1812.03829.pdf
- https://pdg.lbl.gov/2021/web/viewer.html?file=%2F2021/reviews/rpp2020-rev-passage-particles-matter.pdf

Spend 10-15% of your time thinking about this and coming up with a solution:

You are in a collaboration with about 80 people from 8 different counties and 17 different institutions. Your collaboration has decided to run 3 collaboration meetings per year in different locations. You are trying to decide where, how long and in what format they should be held. You have a fair number of collaborators with small children who have travel constraints. What principles can you apply in your decision making to ensure maximum access to attend in person, and also to accommodate those who can't? Discuss and then summarize, potentially providing guidelines or policies. Ask for examples, if needed.

Group Project

Rank your Group Project Question