

Argon Transfer Challenge

Deep Science

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Sanford Underground Research Facility (SURF), located in the former Homestake Gold Mine in Lead, South Dakota, hosts world leading research experiments in physics, biology, geology, and engineering.

DUNE is now one of the largest international science collaborations to exist. Over one-thousand scientists and hundreds of institutions are exploring the most abundant particle in our universe—the neutrino. Neutrinos will be produced using a particle accelerator in Chicago at Fermilab. The neutrinos will travel about 800 miles to South Dakota, where they will smash into argon atoms and produce signals of light. Scientists from all over the world will analyze the interactions of neutrinos and argon atoms. They hope to unlock answers to some of the most puzzling scientific questions in the universe.



**SANFORD
UNDERGROUND
RESEARCH
FACILITY**

Small Particles. Big Challenge.

The Deep Underground Neutrino Experiment (DUNE), housed in the Sanford Underground Research Facility, is a new international mega-science experiment. The DUNE experiment will detect neutrinos using enormous underground detectors which will contain 70,000 tons of liquid argon.

How can this argon be transported down the shaft to fill the detectors? How do engineers move a liquid that is -302.5°F (-186°C) almost a mile underground? How does everything pass through the narrow passage of the shaft to arrive safely below ground?



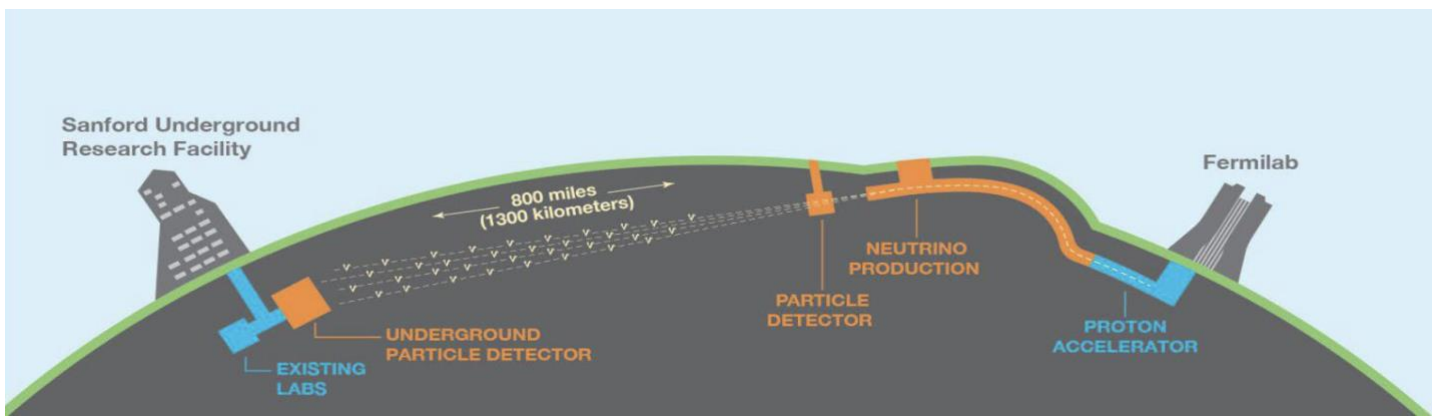
Teamwork

Each team member will have a different role.

Team Member #1: *Become an Argon expert!* Learn about argon to assist your team in solving the engineering challenge of transporting this vital element to the underground detectors.

Team Member #2: *Become a Phase Change expert!* Learn about energy transfer and phase changes to advise your team on safely moving argon to the underground detectors.

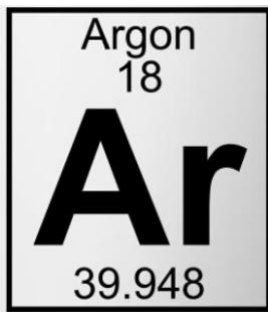
Team Member #3: *Become the Matter-Transfer expert!* Learn more about SURF and the physical challenges of moving materials to the underground.



Engineering Design Process

Identify/Imagine/Design

Each team member has learned important information about argon, phase changes, and energy transfer. Combine forces to design a plan to move 70,000 tons of argon into the underground detectors. You must convince the DUNE scientists and engineers that your plan will work. The goal is clear: safely and effectively transport the argon to the detector chambers.



Create

Create a multimedia presentation, a journal, or a digital model of your system. How will the argon be contained at each stage? How will heating and cooling be used to cause phase change(s) during transport? Make sure to clearly indicate which state the argon will be in at each stage of the journey.

Test/Improve (optional)

Water will be much easier than argon to find and use for testing your system design. Try to figure out a way to move 50.0 mL of water from one container to another by using only phase changes (adding or removing energy from the system). What materials might you use?

Share/Compare/Reflect

Which of your designs performed the best? What challenges did you have? How did you resolve them?

Now that you have some experience, what might you change?

Now that you have shared your findings with each other, what might it look like to select certain aspects from multiple designs and combine them?

Real-World Application

The work to create a plan to get the tons of argon to the underground detectors is underway. Many scientists and engineers are a part of this effort. Research and compare your plans to those proposed by other research teams.