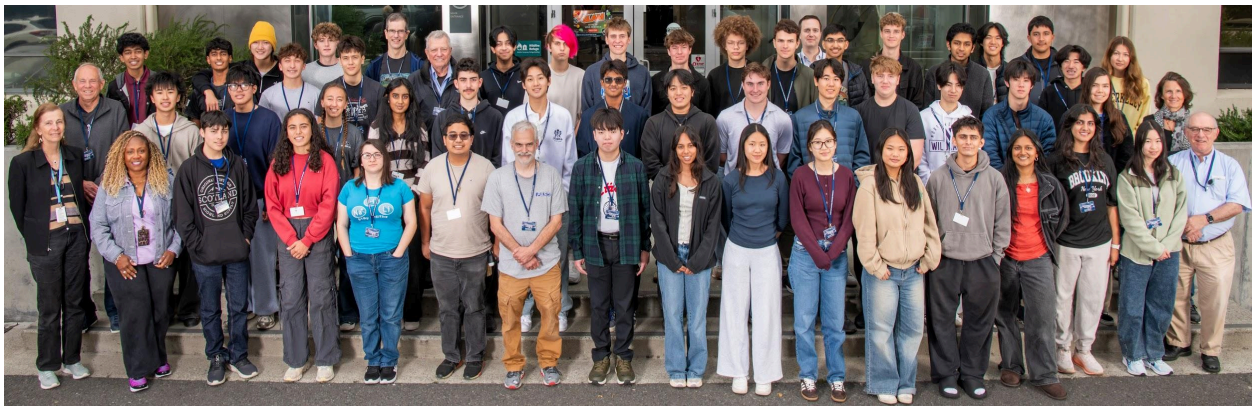
**Lawrence Berkeley National Laboratory**
**Annual Report 2026**
**July 16, 2026**
**Mentor: Tony Spadafora**
**Workshop Coordinator: Laurie Kerrigan**
**Co- Organizers: Ken Cecire (QuarkNet)**

The LBNL Physics Division hosted its twentieth "Physics in and Through Cosmology" workshop for QuarkNet Leadership teachers and high school students. This one-week in person workshop from June 22 to June 26, 2026 was held at the Lawrence Berkeley National lab. Seven physics teachers, including Workshop Coordinator Laurie Kerrigan, participated. Five of the teachers have been active members of QuarkNet, two are new to QuarkNet, one past active member of QuarkNet who is now retired, and 43 students participated. The teachers & students joined from public and private high schools in the greater San Francisco Bay Area.



***2026 Physics in and Through Cosmology Workshop***

We met from 8:30am-4pm daily with students & teachers participating together. On Wed afternoon, we had a teacher's only session. Most meetings started with a quick activity or question to get students thinking about that day's topic. Then there was a talk by an LBL scientist and either small group work, tours, or Quarknet activities. The small group work included a Scientist Interview Project and cosmic ray detectors.

We toured the ALS (Advanced Light Source). We also toured individual labs that were working on parts of the ATLAS upgrade. QuarkNet activities, led by Ken Cecire included Particle Cards and Quark Workbench, and "Express" ATLAS Masterclass. The teachers also completed a Review Data Activities Portfolio. Retired QuarkNet teacher, Glen Melnik, led the discussion on cosmic rays and how a cosmic ray detector worked and directed students in their small group work with the detectors.

The week ended with a Q & A session with the scientist presenters.

***Ken Cecire leading QuarkNet Activities***

Highlights of the program were a drop in visit by Nobel Prize winner, Saul Perlmutter, and a round table panel discussion with the Scientists on the last day. Each small group did a short report back to the group about the work the Scientist they interviewed was doing.

***Students asking questions of Saul Perlmutter***

***List of Teachers:***

Phil Becker Bob Bessin Matthew Casey Sean Fottrell Laurie Kerrigan
Armineh Koshkakaryan Carl Matabang Glen Melnik

***Scientists interviewed by students:***

Noah Weaverdyck  Yifei Luo  Tran Tsan  Botho Paschen  Kenneth Lin
Clara Verges  Anousha Greiveldinger  Kaja Rotermund  Abby Bault  Zach Marshall


***Cara Giovanetti presenting "The Merge Game at the Beginning of the Universe".***

## Formal presentations by LBNL scientists included:

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| **Nao Suzuki** | Tour of the Universe |
| **Shion Kubotu** | “How a Question About the Universe Took Me Around the World ~ from Japan to US, Europe, and 1 mile underground”. |
| **Maria Mironova** | Discovering the Invisible: Pixel Detectors In Particle Physics |
| **Beojan Stanislaus** | "Computing and Supercomputing in Particle Physics". |
| **Cara Giovanetti** | "The Merge Game at the Beginning of the Universe". |
| **Alina Sabyr** | "Cosmic microwave background: what can we learn from the Universe's oldest light" |
| **Rongpu Zhou** | Cosmic Cartographers: Mapping the Universe with DESI |
| **Natali de Santi** | Decoding the Universe: Cosmology in the Age of Artificial Intelligence |
| **Jannik Truong** | "What do exploding stars tell us about how the universe will end?" |

***From the evaluations comments by teachers and students:***

**Some responses for the question "what did you like about the workshop?"**

The opportunity to learn about the latest research in cosmology and particle physics by the current generation of researchers**.**

I think it was really great getting to hear from all the scientists and learning many sides of the story. It helped give me a lot of direction on where I want to go in life.

I really liked being able to connect with like-minded individuals and discuss topics I've never even heard about.

I liked the activities with Ken most.I also liked how many diverse speakers there were and how knowledgeable they were.


***Question and Answer session with the speakers.***

***Comments by students on what they learned according to NGSS major areas in Physics:***

**Structure and Properties of Matter**

We don't have the full picture! even though the standard model of elementary particles was "published" many questions remain

I learned everything I know about quarks, leptons, and bosons.

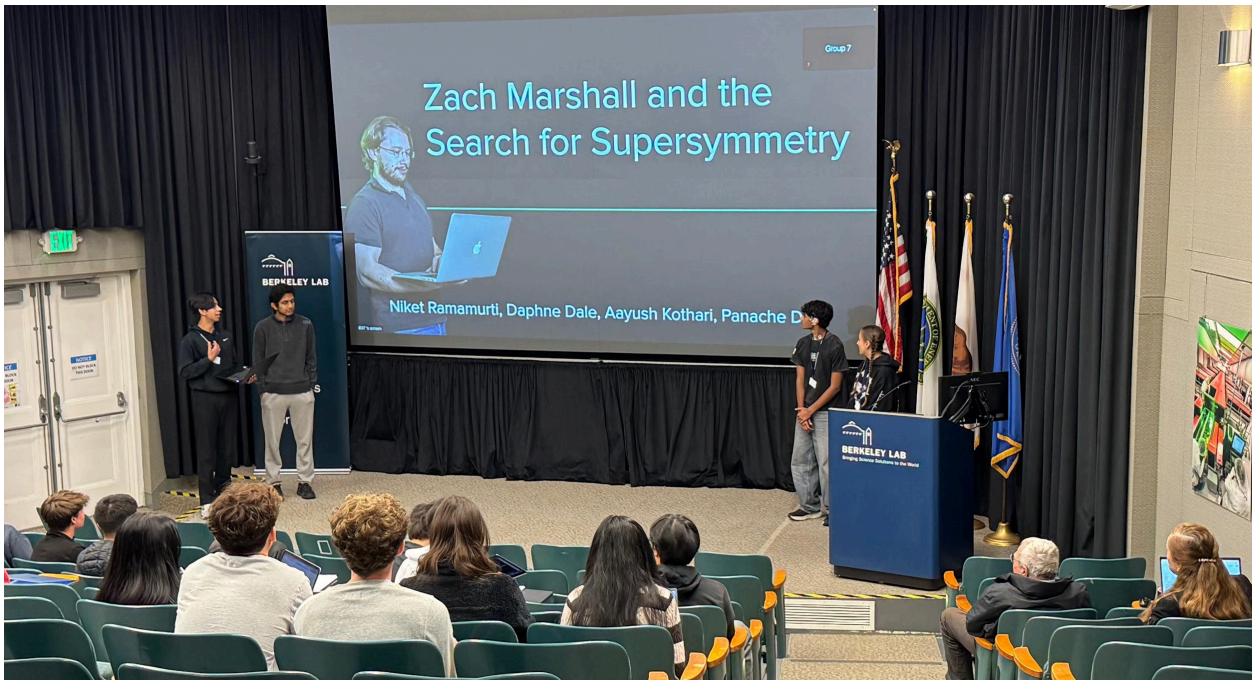
I learned about baryonic material, Baryonic acoustic oscillation, and before this, I didn't even know that muons, pions, quarks and lepton

**Forces and Interactions**

There are four main forces, the strong force, the weak force, the electromagnetic force and gravity. Additionally, most particles besides gluons and photons have mass due to their interaction with the Higgs Boson.

I learned a lot about different bosons, specifically the W and Z bosons, photons, gluons, and the Higgs boson.

I learned that the 4 fundamental forces are gravity, the weak/strong nuclear forces, and the electromagnetic force. I learned that the bosons are force carriers and help transmit forces.
I learned that when particles/matter have high enough energy, all of the forces become the same.




***Students presenting their share out about the scientist they interviewed.***

## Energy

Matter and energy are considered the same at the sub-atomic level.
I learned that energy is conserved and can be transferred between different forms in particle and physical systems. In high-energy physics, energy can be converted into mass and vice versa, which is important in particle collisions at places like the HL-LHC. When protons collide, huge amounts of energy can create new particles like quarks, Higgs bosons, and other short-lived particles.

## Waves and Electromagnetic Radiation

Radiation is how energy is transferred via e-m waves in sub-atomic interactions.
Electromagnetic waves stretch as the universe expands.
All of the subatomic particles act both as waves and particles. With most of the particles being excitations in their respective fields according to QFT. Photons are the source of electromagnetic radiation as they carry the electromagnetic force. The electromagnetic radiation can range from radio waves to gamma rays with gamma rays having the highest energy as they have the shortest wavelength. Light as we see it is in the visible section of the electromagnetic spectrum.

***Sean Fottrell and Students working on Cosmic Ray Detectors***

**Engineering Design**

I learned engineering and design comes up so much more in physics than I thought, such as DESI instrumentation and the building of particle accelerator detectors in the ASL labs

I learned more about how CERN detectors are made, such as ATLAS. For example, the Silicon detectors.

Parts get put together in different locations and built up to eventually be tested somewhere else.

A lot of things need to be fully vetted before installed because once installed, they probably can't be serviced

The big takeaway was really the scale of the collaboration between physicists and engineers when it comes to designing and building experiments and solving problems that could contaminate the data, like cosmic ray shielding for example. There were also a lot of specific design examples that I learned about like how the DESI experiment collects light, or how ATLAS is able to detect and track charged particles. I also learned how the massive amounts of data generated in particle physics experiments can be processed.

Experimental design is a bigger part of science than I initially realized. Seeing the labs helped me learn how creativity is definitely not lost in stem fields.