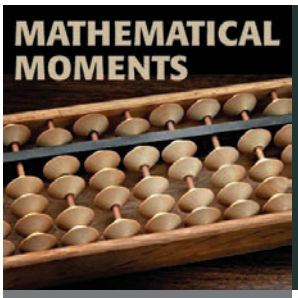
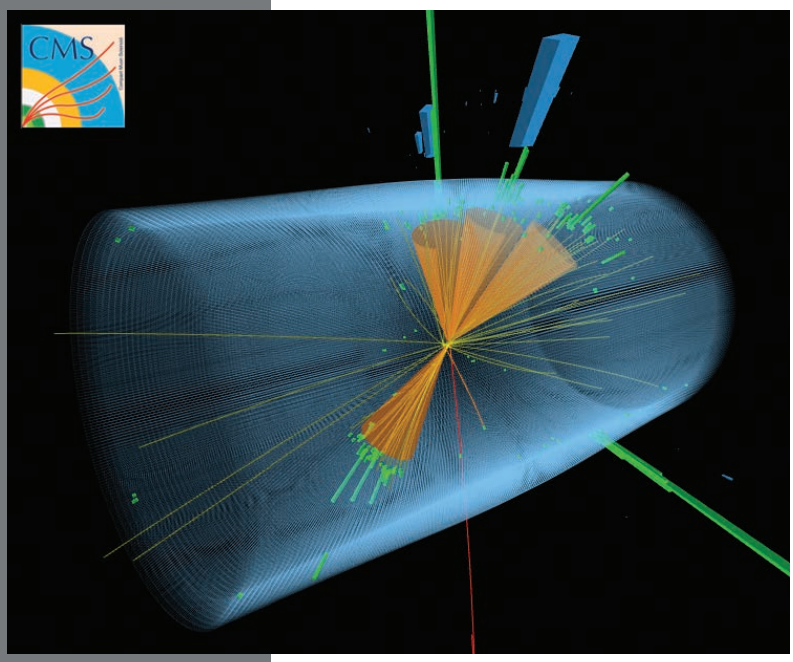


Smashing Particles up Against Mathematics



imagecredit: CERN

A diagram showing subatomic particles decaying in a particle detector at CERN.

At large particle colliders such as SLAC in California, and CERN in Geneva, Switzerland, physicists send subatomic particles careening toward each other at high speeds, hoping to generate collisions that result in new collections of particles. In a new paper, mathematicians joined with physicists to show that techniques from geometry can help analyze the results of these collisions.

Particle collisions take place within detectors, chambers whose walls can measure the energy and momentum of subatomic elements. After a collision, debris explodes towards the detectors. Physicists then use the detector data to reconstruct what happened during the collision itself.

To study this mathematically, three physicists proposed a new tool in 2019. Their tool, adapted from machine learning, represents collisions as energy patterns recorded by the detector. Called the Earth Mover's Distance, it allows researchers to compare the similarity of two different collisions. Specifically, it quantifies how much one pattern of energy would have to be modified before it would resemble another. The researchers found that the Earth Mover's Distance simplified many concepts from particle physics. For example, under the Earth Mover's Distance framework, a once-complex formula for how much a collision could be decomposed into subcollisions became a short and simple equation. In the new paper, the team of physicists and mathematicians demonstrated that not only was the Earth Mover's Distance useful, it was precisely the right perspective to take. According to the paper, no other distance could capture the nuances of particle collisions quite the same way.

References:

Joey Huston, *Explain it in 60 seconds: jets.* Symmetry Magazine.

Jesse Thaler, "The Hidden Geometry of Particle Collisions." UC Davis QMAP Particles Cosmology Seminar.

"Accelerators." CERN.

"How a detector works." CERN.

Patrick T. Komiske, Eric M. Metodiev, and Jesse Thaler, *The hidden geometry of particle collisions.* J. High Energ. Phys. 2020, 6 (2020).

Demba Ba, Akshunna S. Dogra, Rikab Gambhir, Abiy Tasissa, and Jesse Thaler, "SHAPER: can you hear the shape of a jet?" J. High Energ. Phys. 2023, 195 (2023).

Watch an interview with an expert!

MM/170

AMS American Mathematical Society

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments