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Collisions: Rugby and Particle Physics

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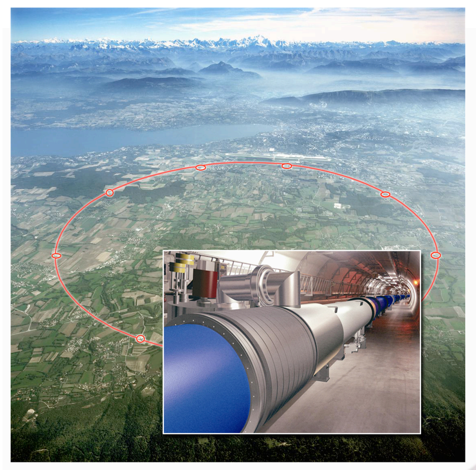
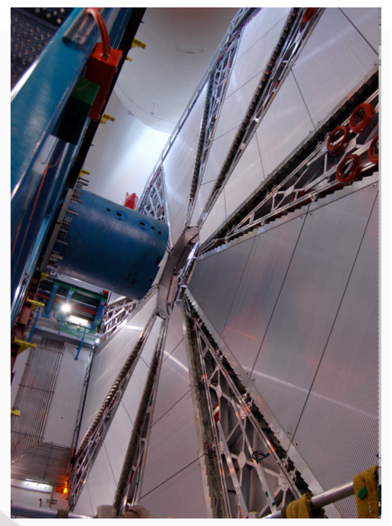


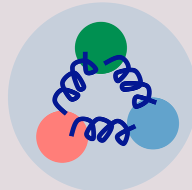
The Large Hadron Collider (LHC) is an accelerator underground in France and Switzerland. It is 27 km long and accelerates hundreds of millions of protons to 99.9999991% of the speed of light. The energy in each bunch of protons is equal to a 400 ton object moving at 150 km per hour. That would be a scary scrum!

The ATLAS detector looks at what happens after the teams of protons collide. This photo shows one part of ATLAS: hundreds of thousands of tubes that are specialized to look at muons. Muons are often produced when protons collide, and studying how fast they are moving and in what direction can tell physicists about what happened in the middle of the collision. Muon are heavy brothers of electrons.



A gluon is like a very strong spring or arm that holds protons together

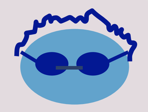
Hold strong! In a scrum, the players bind themselves by holding on to their neighbors' jerseys. If you look inside a proton, you'll find it is made up of three smaller particles called quarks. Who holds the quarks together? They are bound by particles with short arms and a powerful grip: gluons. The gluons are so powerful that their effect is called the strong force.



A proton is made of three quarks held together by gluons. As far as we know, quarks are not made of anything else.

A learning process. Physicists have been studying the game for a long time. Galileo figured out the motion of a single player: inertia. Newton understood one role of the teammate: gravity. Schrödinger, Planck and friends explained how the ball is passed: quantum mechanics. Physicists have figured out most of the game, but they're still not sure how the biggest, heaviest players interact.

Is that a Higgs?

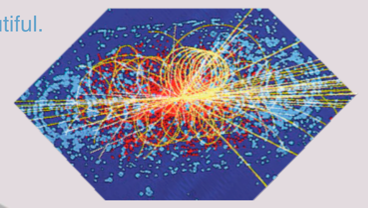


Physicists know how electrons and protons behave, but they're not sure that they have identified the whole team. Some theorists predict that there is a very heavy particle called the Higgs Boson that hasn't been seen before. Hopefully, studying the collisions at the LHC will confirm whether or not the Higgs is buried at the bottom of the scrum, changing the way other players behave.

What happens when a team of massive bodies pushing as hard as they can encounters another team of massive bodies pushing as hard as they can in the opposite direction? What if both groups are bound so tightly that the others can not go through?

Physicists call this a collision, but those fortunate enough to have watched this on a rugby pitch know that this type of collision is best called a scrum.

Particle collisions, like a scrum, are both gruesome and beautiful.



Collisions can provide endless entertainment, but what really counts—for physicists and rugby fans—is what comes out of them. Where did the ball end up? What's going to happen next? We can only understand what's happening if we know the rules of the game. In rugby, we learn about the rules of the game by asking our coaches, friends and family. Imagine if no one but the players knew the rules and you showed up to watch a game! It would be very confusing to try and figure out what was happening.

Studying particle physics is like studying a rugby game when no one has told us the rules. Physicists are trying to figure out the rules that determine the outcome of every interaction between the smallest players in the universe. Small particles might not sound that impressive, but everything else in the world is built of these fundamental pieces. Also, the smallest players tend to do the craziest things!

To understand rugby or particle physics, it's easiest to start with the basics. The first part is easy: a single player, alone on the pitch, runs in a straight line. Could more things happen if there were a teammate nearby? What if they're tossing a ball back and forth? What's allowed or not? What if there are two whole teams?

Particle physicists eventually hope to unfold the puzzle that will allow them to predict a whole game. Not only will this be incredibly satisfying, it will also be useful. Understanding how the rules work allows physicists to play the game. Playing the game could lead to more powerful computers, new sources of energy, better ways to study diseases, improved cancer treatments. Already, some of these advances have come from knowledge gained in studying particle physics. Who knows what the future holds!

What's colliding? As in rugby, there are many different types of collisions in particle physics. The LHC is focusing on a scrum-like collision, where lots of beefy protons take each other on. Other colliders, like the one at Stanford in California, focus on collisions between a skinny electron and its counterpart, a positron. That collision is more like one springy wing taking down another.

In particle physics, unlike in rugby, two players colliding can produce a new type of particle!

No two games are alike. The only way to learn rugby well enough to predict the outcome of each game is through careful watching of thousands of games, and even more scrums.

At CERN the collider will produce 40 million scrums per second! And everyone will be slightly different.

Motivating the players: the collider.
A particle collider (also called an accelerator) is a gigantic ring where teams of particles circulate both clockwise and counterclockwise at very large speed, colliding whenever they encounter an opposite moving bunch. The more energy the particles have, the more interesting things they can do when they collide. If the particles have enough energy, they might produce new types of particles that no one has ever seen before.

Watching the game: the detector.
The collisions of the LHC are too frequent and too small for the eye to see. Physicists use a crowd of electronic sensors to observe what happens. Each sensor is specialized to watch one type of player in one particular spot on the pitch. ATLAS, one of the LHC detectors, is made up of a crowd of millions of sensors, looking together at a 3D pitch of over 10,000 cubic meters. By studying what happens in the whole field, physicists can piece together what happened at the very center of the collision.