The physical world: collisions
Collisions: the CERN particle accelerator

V/O: Just outside Geneva is CERN, the European Laboratory for Particle Physics. Here over 2,000 scientists drawn from all corners of the globe are using the laws of physics they know to discover the ones they don't.

PRESENTER: If you want to know what something's made of then break it. It's a lot harder to smash an atomic particle but the idea's the same. Collide two particles together and look at the bits that come flying off.

FRANK CLOSE: At CERN the aim is to do experiments using the smallest particles of matter, colliding them together in order to try to understand the nature of matter itself – what are we, what are we made of, what are the rules that govern the way that we and the Universe is built up?

PRESENTER: When you crash things together you can analyse the collision using the laws of conservation. The biggest challenge to these laws is to explore nature itself on the tiniest level, inside the atom.

V/O: At CERN they fire subatomic particles in opposite directions around an underground tunnel. These particles are then crashed together inside huge electronic detectors.

TEJINDER VIRDEE, CERN: Although the interaction takes place in a very, very small space the energies of the particles that come out, which are travelling at close to the speed of light, are very high, the momenta are very high, so to measure these with enough precision so we can reconstruct what happens in the collision requires very large detectors.

FRANK CLOSE: In doing experiments at CERN and interpreting them the conservation of energy and momentum are absolutely essential. You are speeding the particles up, giving them energy of motion, and when they collide you know that the energy that the particles had as they came together, at that moment of collision the total energy is the same, and then after this collision whole new forms of matter and anti-matter emerge, and the energy of all those bits in total must be the same as the energy of the original colliding particles, so you can then do a balance check. You can add up all the energies, all the momenta of the various particles that are spraying out and see if it does balance.

V/O: The particle tracks which stream out from a collision are like the skid marks in a car crash. By analysing these subatomic skid marks you can work out what new particles if any you've discovered as the matter breaks apart. So detectives investigating the subatomic world make sense of these patterns using the trusty rules for energy and momentum conservation.