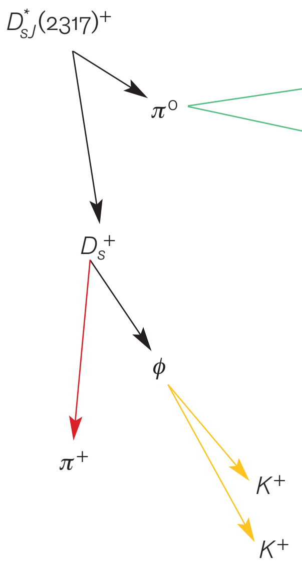
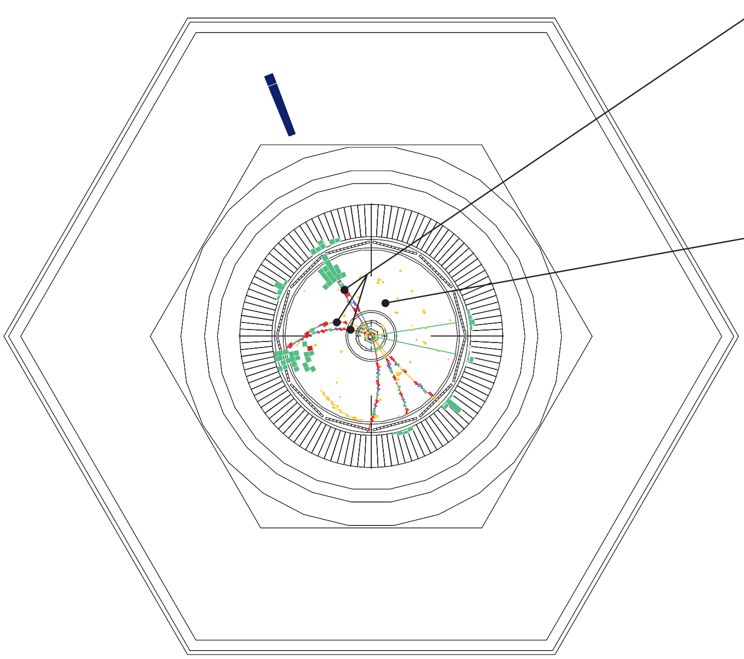
Finding new species of particles isn't as easy as simply watching them fly out of a collider experiment. Usually all physicists see are the remnants of a new particle decaying into other types of particles. From that, they infer the existence of the new species and can determine some of its characteristics. This event display shows what happened during one collision of an electron with a positron in the BaBar detector at the Stanford Linear Accelerator Center. The tree of arrows explains the stages of decay that must have led to the final products observed by BaBar. The $D^*_{sJ}(2317)^+$ particle discovered here is interesting because it doesn't fit into physicists' current understanding of charm quark-based matter.

Text: Steve Sekula, Massachusetts Institute of Technology
Data: Antimo Palano, BaBar collaboration

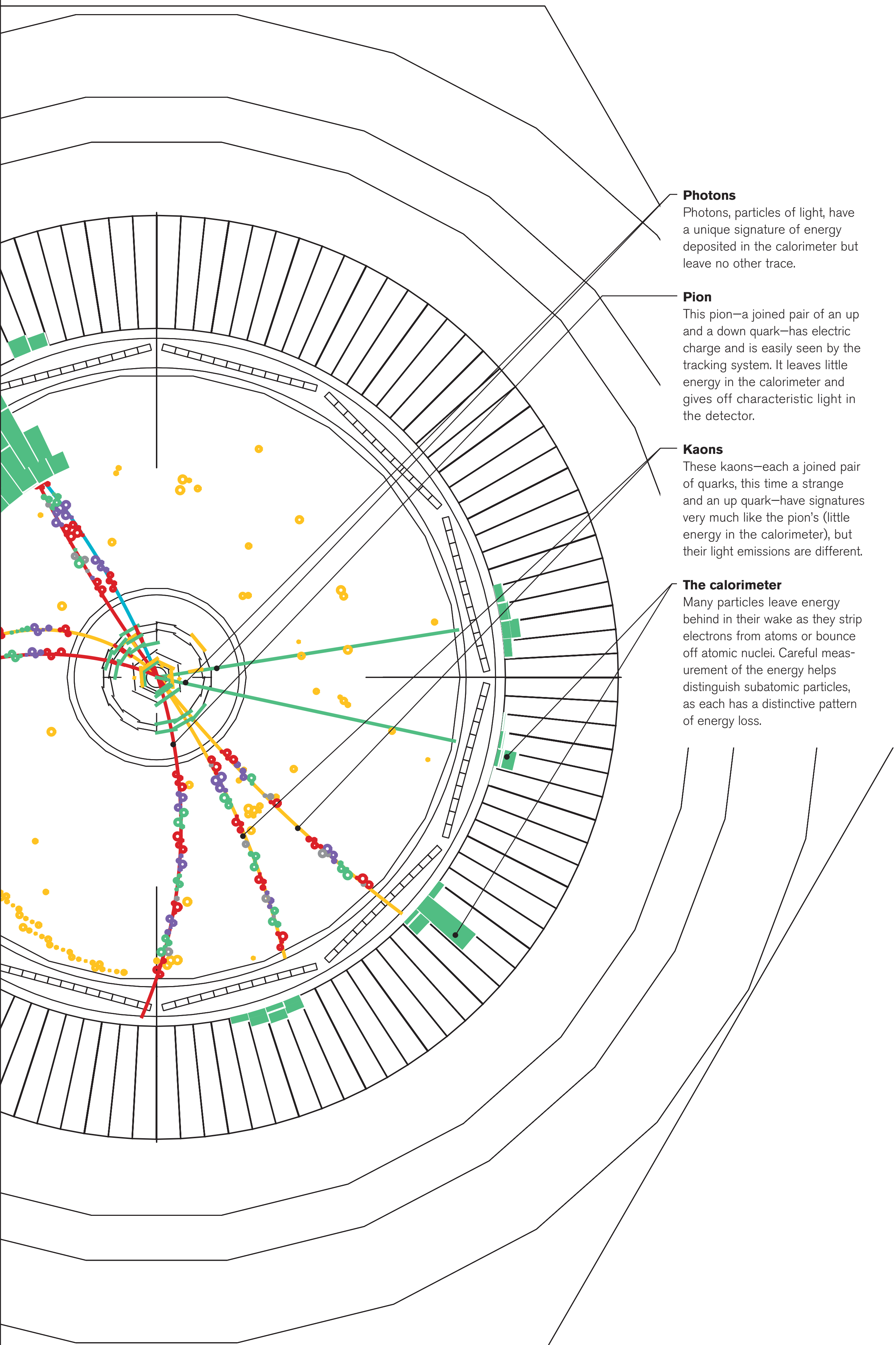


The decay chain
From the energy of collision, two charm quarks materialize, one of which pairs with a strange quark to form the exotic $D^*_{sJ}(2317)^+$, the number indicating its mass, measured in MeV (millions of electron volts). Because it is so heavy, it almost immediately decays into a lighter D_s^+ particle, which further decays. After a sequence of decays, all that is left are a charged pion, two kaons and two photons. The particles are like footprints in sand, and measuring their energy and position precisely is like measuring the depth of the footprints: it tells us about the mass of the object that made them. Tracing these detectable particles back, we catch a glimpse of the progenitor $D^*_{sJ}(2317)^+$ that birthed them.



Other particles
Nature conserves momentum, and particle collisions provide a good example. Two photons, two kaons, and a pion are balanced out by other particles recoiling in the opposite direction. These extra particles are a result of energy conservation, produced by a second heavy particle moving in the direction opposite to the $D^*_{sJ}(2317)^+$.

The "rubbish"
The extra blips and bumps in the picture are electronic noise, unavoidable in any real instrument made of real electronics.



Photons
Photons, particles of light, have a unique signature of energy deposited in the calorimeter but leave no other trace.

Pion
This pion—a joined pair of an up and a down quark—has electric charge and is easily seen by the tracking system. It leaves little energy in the calorimeter and gives off characteristic light in the detector.

Kaons
These kaons—each a joined pair of quarks, this time a strange and an up quark—have signatures very much like the pion's (little energy in the calorimeter), but their light emissions are different.

The calorimeter
Many particles leave energy behind in their wake as they strip electrons from atoms or bounce off atomic nuclei. Careful measurement of the energy helps distinguish subatomic particles, as each has a distinctive pattern of energy loss.