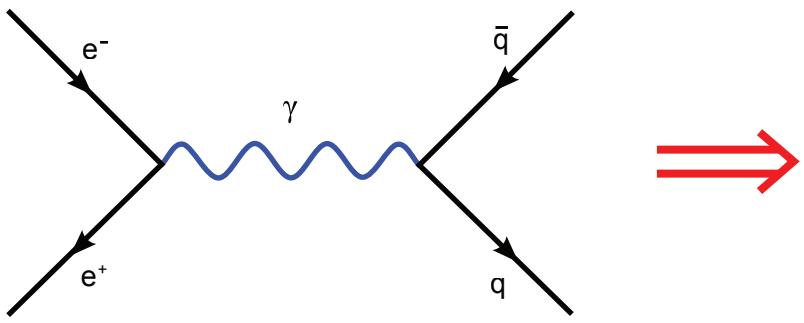
The Discovery of Gluons: The Mercedes Star

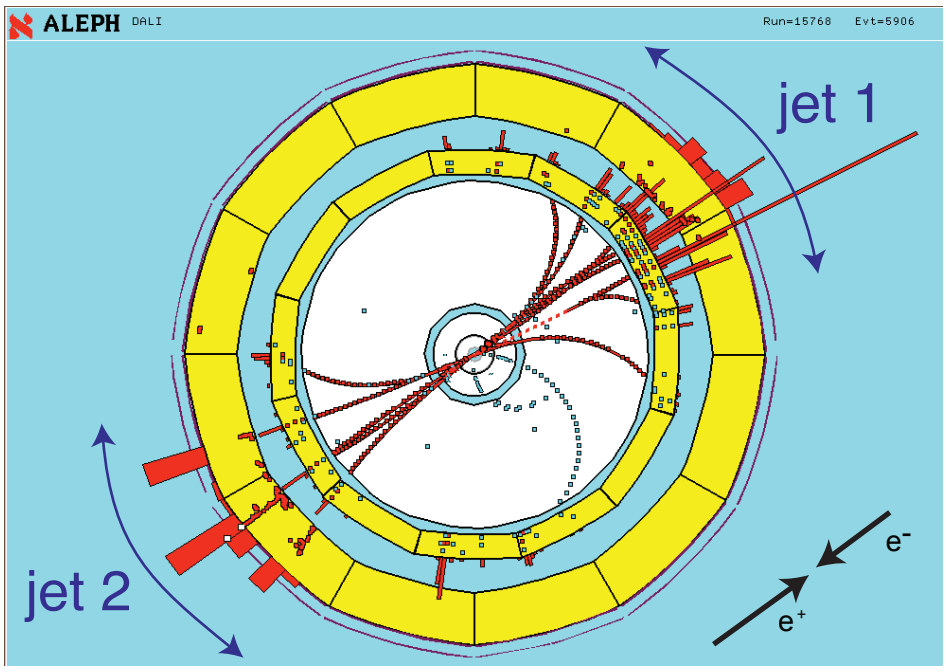
Energetic quarks and gluons produced in elementary particles at high energies fragment into narrowly collimated “jets” of sub-atomic particles consisting themselves of quarks, the so-called hadrons. (See QCD sidebar for a discussion of hadrons.) The angles and energies of these jets are measured with the sophisticated electronics of particle detectors of the size of small buildings.
In early collisions of electrons and their anti-matter counterparts, the positrons, the hadrons produced were bunched together in sprays of back-to-back jets. These were interpreted as the collision process is generating a quark and anti-quark, with both decaying in a separate jet or hadron shower. The process is depicted in the “Feynman diagram” below. The accompanying picture is an event display of such a 2-jet event in the ALEPH detector at the Large Electron-Positron Collider (LEP) at CERN, Switzerland.

Process producing 2-jets



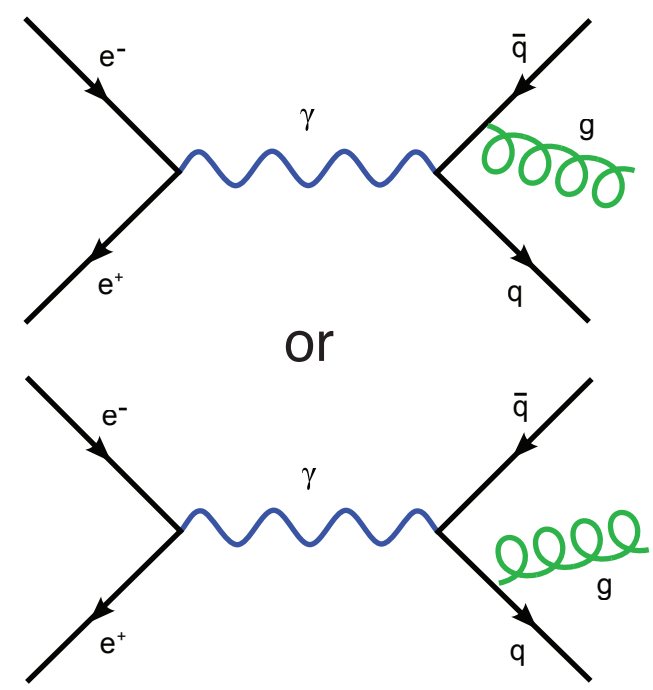
Feynman diagrams are pictorial representations of the mathematical expressions that describe the interaction of subatomic particles. The diagrams allow for a simple visualization of what would otherwise be a set of cryptic formulas. The scheme is named after its inventor Richard Feynman.

Event Display: 2-jets



The first direct evidence of gluons was obtained in 1979 at the electron-positron collider PETRA at DESY, Germany. The higher energies achieved allowed the generation of three jets, with the third jet generated from a gluon. This is clearly seen in the “Mercedes Star” pattern event display.
If we replace the gluon in the corresponding Feynman diagram by a photon, it too can decay—into electron-positron pairs, not hadrons. The decay pattern though would be similar.

Processes producing 3-jets



Event Display: 3-jets