SZG Tevatron: An Accelerator Attempt

Abstract

Objective:

My project will be a particle accelerator model based on a previously existing dynamical system RTICA written in c++. I mean for it to be a specific model of the Tevatron at Fermilab. Therefore it will collide proton antiproton pairs at energies on the order of 980 GeV each. The collisions will be slowed down so that they are discernible. The resultant particles will have a tail that will have a preset finite length and will be shown for several seconds, before the next collision begins. The collision area will be navigable and bounded as if it were in an actual collision chamber. They resultant particles will also be color coded and scaled to be visible.

Background:

The Tevatron is a superconducting synchrotron. It has one linear accelerator and three rings to accelerate particles at each other to a combined 1.96 TeV which for particles of this mass means velocities that are approximately 99% of the speed of light. These energies are necessary to discover electroweak unification and also for exploring the realm of quarks, muons and gluons. These particles are identified after a collision by the unique paths that they make in a magnetic field.

Method:

As mentioned, we will use an already working program as a base and add the new rules in. We will build in the forces in action and read initial conditions in from a file. Each particle will have their own properties which will determine their behavior post collision.

Narrative

History and Motivation

In the Dark Ages of physics (pre Einstein), little thought was given to what made up atoms. They were thought to be the smallest element of matter. Work such as the gold foil experiment proved that the atom had spaces and "stuff" in them. This led to the idea that the atom had constituent particles. Further researc confirmed that these particles were indeed the neutron, proton and electron. Again, there was a standstill, but physicists oncemore asked the question, what if there is still smaller stuff?

Indeed there were many particles that were smaller. In the early 30's, in the sunny vales of Berkeley, California, brave physicists began to engineer the next revolution in physics. They were attempting to build particle accelerators. GASP! But they could hurt themselves, with such dangerous equipment, you might say. Nay, they were men's men and feared not. The were strange times. There were jolly giants(such as Fermi and Lawrence) walking the earth, with accelerators.

The first proof of concept was completed in 1931 and was a mere 9 inches across, but it heralded what some call the golden age of physics. Through to the mid seventies, physicists were making particle discoveries left and right, sometimes scores in a single year. It was a heady time for them and out of the flurry of activity

arose the Standard Model of particle physics. It is a construct that seeks to describe all goings-on of the natural world with the exception of gravity, which is left (currently) to the field of relativity. There are several classes of particles including quarks, leptons, bosons and mesons.

The way the accelerator is much better described by its slang name, "atom smasher." Specifically, we utilize Einstein's famous equation E=mc^2. We also know that Kinetic E=.5 mv^2. By this equation, when there is a large amount energy embodied in a particle, it can convert into a pair of other particles. This is precisely the fact that makes the particle accelerators work.

But first we must get a large amount of energy into a small place. What the atom smashers do is use the properties of a charge carrying particle in a magnetic field to add kinetic energy

In the Tevatron at Fermilab, this occurs in several stages, starting with a pre-accelerator. This can add up to 750 KeV(a unit of energy) to the particle. Next a linear accelerator brings the energy of the proton to 400 MeV and then strips any remaining electrons, before heading to the booster. The booster is a "small" magnetic accelerator increasing energy to 8GeV. The next stage is the Main Injector, which can accelerate protons or use the protons to create antiprotons. Finally a particle is brought to the Main ring where it will have 980 GeV upon collision. The anti-particle traveling will have the same engergy so a total of 1.96

TeV is released upon collision.

Math & Physics

Considering only the magnetic force on a particle F=qV X B, where V=velocity and B=magnetic field are both vectors and q is a scalar specifying the charge. Without a rigorous walkthrough, it can be shown that if the velocity is perpendicular to the magnetic field, it will travel in a circle, with an initial radius approximately equal to mV/qB. This means, in general, that charged particles with any component of velocity perpendicular to the magnetic field will spiral, with positively charged particles moving in the opposite direction of negatively charged ones. The unique behavior of particles due to their mass and originating particles allow physicists to determine what a particle is.

Using The Program

The src files are in this directory, just add szgtevatron.zip to the current url. After unpacking, the readme has useful information concerning compiling. During runtime, (NOTE: this version must run in standalone mode...updates to come) you must choose one of the nine events depicting Higgs boson and W boson generation. Currently, the zapping function does not work. I recommend mode 5 and pressing the spacebar. Then pressing the middle and right buttons will toggle and reset the particle trials. Concerning the colors, white ones are gammas, blue is a pion, a type of meson and red is a kaon, another type of meson. Most particles resulting from the collision are of these types.

THANKS!!

I would like to thank Professor George Francis for guidance on the programming. I would also like to thank Professor Kevin Pitts of Fermilab for providing the data that makes this program possible.

There is no beginning or end...only the Force...

As this version does not yet run in the actual CAVE or CUBE, I would like to one day get it to work in there. Also I would like to incorporate pythia, a C++ collision modeller that would feed real time data in for basically infinitely many simulations.

Bibliography

www.fnal.gov, the Fermilab website.

"Physics for Scientists and Engineers, 6th ed." Serway & Jewett.