Neutral current

In the late 1970's, the high energy community has been looking forward to the completion of the new high energy accelerator being built near Chicago with energy of 200 Gev. That was the highest energy machine in the world at that time and will cost lots of money to build. As usual many states are interested getting the machine built in their states. At the end the site near Chicago was chosen. The story is that Senator Everett Dirksen who was from Illinois ans was a powerful Republican leader in the senate made a deal with Lydon Johnson to get this high energy machine in exchange for a support of Vietnam war.

Before the machine in Chicago was built, the highest energy accelerator was the AGS (Alternating Gradient Synchrotron) in Brookhaven with energy around 33 Gev or so. With such a big leap in energy to 200 Gev, physicists were wondering what are the new things might lie in these new territory which has not been explored before. Many high energy people are busy studying what are possible phenomena out there. The physics we know up to 35 Gev or so does not seen to give any clue to what might happen at much higher energies.

In 1969, I was in my 4th year in graduate study in physics and signed up for a course on special topics in high energy physics. The teacher, Professor A. Mann did not have a clear idea as to what will be interesting topics to focus on. At that time one of the models on the market was a Fireball model which is a very crude model based on the idea that at very high energy all kind of particles can be produced. This model does not go much beyond this simple naive discussion. The students in the class did not know what to do with this model except trying to understand what had been said before. In the second semester Prof. Mann decided to concentrate on the study of the production of W-boson which is the hypothetical bosons which mediate the weak interaction. So he asked me to compute the cross section using the simplest production mechnism. But this was 1970 and computer was not very advanced. The punched cards were used to read the programs into the machine. I wrote down the matrix element for the production by the neutrnio beam but was unable to do the phase space integration without using the computer. But Prof. Mann did not give up and went to many places to talk to people who are willing to listen. Luckly at Bookhaven he ran into Robert Brown of Case Wetern Reserve and Jack Smith of Stony Brook.These two are experts on using computer for physical applications. They also realized that using the latest inclusive deep inelastic cross sections measured in SLAC which are unexpectedly large the production of W-boson is very much enchanced. Al Mann saw this is a really good opportunity and formed a team with Rubbia of Harvad and Cline of Wiscosinn to make a proposal to search for W-bosn in the new accerlerator near Chicago. This is the well-known HPW collaboration. The Laboratory near Chicago was originally named National Accerator Laboratory, NAL for short and it was later renamed Fermi National Laboratory after the great Physicist Enrico Fermi.

The accelerator was completed in early 1970's and the physics research programs started right away. The HPW collorboration's search for W-boson is one of the first experiments to be run and the other one is the measurement of total

crossection of neutrino scattering off proton. Clearly the emphasis is on the studies of weak interactions.The reason is that weak interaction is somewhat simpler and can be treated perturbatively while the strong interaction is quite complicate to analyzed.

Soon after the accelerator was turned on HPW did not find the W-boson and turn their attention to the study of the neutral current phenomena. The discovery of this class of events have played an important role in the development of the theoretical framework for the high energy physics. Historically, the very first neutral current reaction being studied is the neutrino proton elastic scattering performed in Brookhaven laboratory. This is a very difficult reaction to study because the neutrinos in the initial and final states are not really directly observable and can only be inferred indirectly. Neverthelss it has been performed and came up with a null result. Many people did not take this result seriously because it had been very difficult to produce a good quality neutrino beam. In the early 1970, Gargamelle detector(a bubble chamber) at CERN seems to observe events without muon or electron in the final states and can be interpreted as neutral current events. This caused a big excitement becuase around the same time a new theory of weak interaction seems to call for such events. HPW experiment working with the neutrino beam line turne their attention to look for neutral current events. First HPW said that they had not seen the events.Later, they said that they have seen the neutral current events and confirm the new theory of weak interaction. As a satire some people dubbs this flip flop as "alternating neutral current events". In the new theory of weak interaction this neutral current reactions are supposed to be mediated by a neutral weak boson called Z boson. So in addition to W-bosons which carry electric charge we have neutral Z-boson. These 3 weak bosons were not found in the early experiments in Fermi Laboratory. But all the indirect information convince people that their existence are for sure. We just need to reach high enough energies to produce. Sure enough W and Z bosons are found in the early 80's at CERN. These results put the new model of weak interaction on a very firm foundation and is later called the **Standard Model**. This model has endured all the experimental tests being performed.