TOUCHING THE SUN AT CERN

The Varvakios Pilot School students' experiment
awarded by CERN
in the "A Beam Line for Schools 2014" competition

Georgios Bantis, Elli Chroni, Christos Koutsoulas
Christodulos Liapis, Konstantinos Papathanassiou,
Nikolaos Plaskovitis, Artemis Potamianou,
Athanasia Sirrakou, Antonia Sotiropoulou,
Savina Tsichli, Konstantina Xipolia

Varvakios Pilot School, Athens, Greece

1 The Competition

In 2014, to coincide with its 60th anniversary, CERN made a fully equipped beam line available for a team of school students to run an experiment. Beam time was allocated by scientific competition, just as it is allocated for all CERN experiments. The competition was named "A Beam Line for Schools" and the proposals were evaluated according to the following criteria:

1. Motivation of the students
2. Creativity
3. Feasibility of the proposal
4. Demonstration of ability to follow the scientific method

Being a team of eleven students of the Varvakios Pilot School, supervised by our physics teacher Andreas Valadakis, we decided to take part in the competition. To comply with the rules of the competition we had to choose a name for our team and a brief statement about why we wanted to win the competition. We chose the name "Odysseus' Comrades" to show that even if we wouldn't win, we'd already have an amazing experience learning particle

Figure 1: The “Odysseus’ Comrades”

physics during the preparation of our proposal. We expressed these thoughts and feelings sending to the organizing committee the following statement:

“Riding on a particle beam, we’ve set out for a cosmic journey. Filled with mind adventures and understanding, we’d like to experience CERN.”

Then we started to look for an experiment to suggest and soon we realized that it would be worthwhile to study the evolution of ideas in particle physics by studying the history of CERN. So we found out that weak interaction, which is one of the four fundamental interactions of Nature, was the motive power for major discoveries at CERN: for the discovery of pion decay to electron, for the discovery of neutral currents, for the discovery of the particles W and Z and recently of Higgs boson. On a cosmological scale the weak interaction plays an absolutely fundamental role, since it controls the main burning reactions in the Sun and other stars. So in relation to 60th anniversary of CERN we decided to propose an experiment concerning this vital interaction and closely connected to the history of CERN.

2 Our Proposal and the Winners

We proposed to use the particle beam provided by CERN to create pions and study experimentally the preference of pions to decay through weak interaction more into muons than electrons. This is a peculiar property of weak interaction derived from the Standard Model and be known as helicity suppression. We sent our proposal and on 6th June 2014 CERN announced the winners: “Following almost 300 submissions from school groups around the world, two teams have been selected to come to CERN to carry out their own experiments at a CERN beam line. The winners are the Odysseus' Comrades team from Varvakios Pilot School in Athens, Greece and the Dominicuscollege team from Dominicus College in Nijmegen, the Netherlands." We also received this message: "The judges and Committee were particularly impressed with the understanding your team shows of the development of physics at CERN and in particular the weak interaction. The proposal has real scientific merit, although with the set-up available at the T9 beam, it will be challenging to achieve the result you are aiming for."

3 Running our Experiment

From 7th to 17th September 2014 we visited CERN and ran our experiment. We chose to work with a positive beam of pions than a negative one since the positive beam contains a larger multiplicity of particles per burst, allowing us to record more decays. Furthermore the positron component of the positive beam is very small and this would not spoil our measurements. A positive pion decay into an antimuon or into a positron and a neutrino proceeds as follows:

$$\pi^+ \to e^+ + \nu$$

or

$$\pi^+ \to \mu^+ + \nu.$$

In the entrance of the experimental area (Fig. 2) there were two Cherenkov counters to identify the pions and discriminate them against other particles contaminating the beam. Close to the second Cherenkov counter there was a scintillator to signal that a pion enters the experimental area and a delay wire chamber to record an initial position of the pion. Some meters away there was a second delay wire chamber to record a second position of the pion. Having recorded the two positions it was possible to reconstruct the track of the moving pion. Near this delay wire chamber there was a halo counter. Its purpose was to identify particles that are too far away from the beam axis. Then there was a free area where we knew theoretically a small fraction of the pions would spontaneously decay. After that with a third delay wire chamber we were recording the positions of the non decayed pions or of the antimuons and and the positrons produced by the pion decays (Fig.5). Two calorimeters (one of them was Dominicuscollege's calorimeter) followed to measure the energy of the coming particles and absorb the positrons. After the calorimeters there was a scintillator which was counting the number of particles left in the beam. Then there was a muon filter consisted of a big piece of iron which was absorbing every particle except muons. In the end of experimental setup there was a third scintillator which was counting the antimuons, the only particles left in the beam.

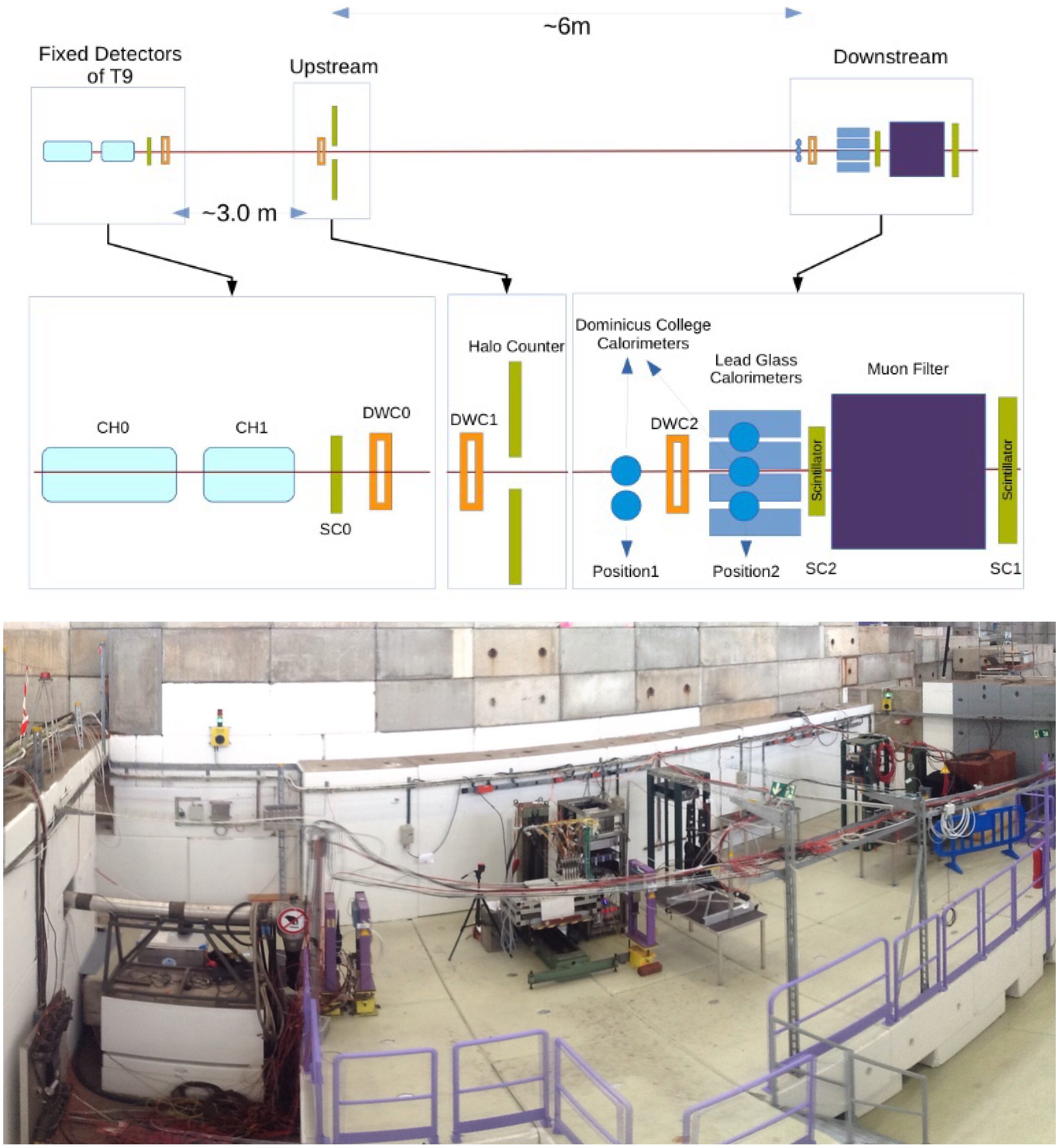

Figure 2: The experimental setup

Figure 3: Attaching the Cherenkov counters

Figure 4: Maybe one of our most precious moments: Every morning in the control room there was a meeting between our team, the Domenicus College team and the supervising CERN scientists. There we used to present and discus how the experiment had been gone the previous day and our planing for the present day.

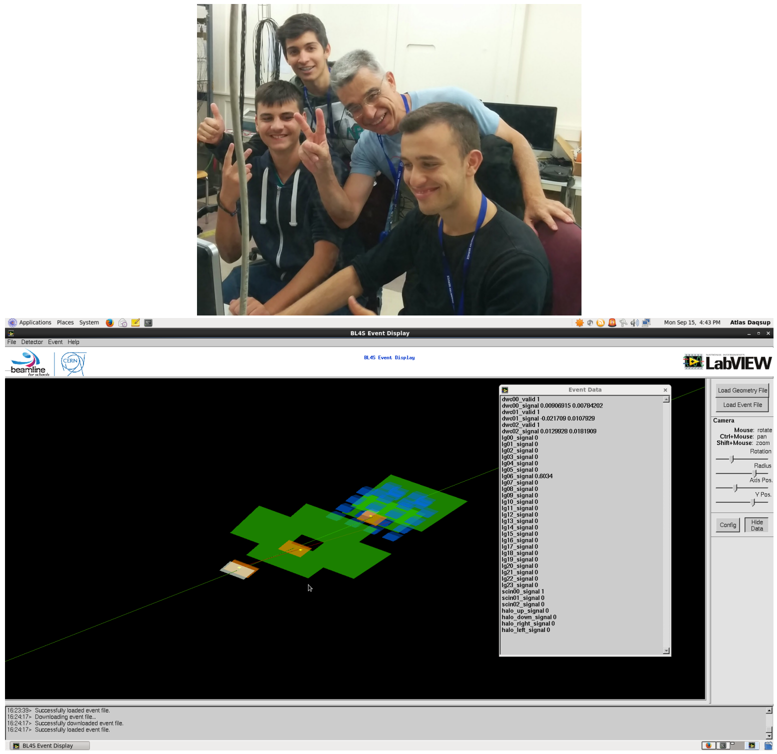

Figure 5: The moment we see our first pion decay. On each of the three delay wire chamber (depicting with orange colour) there is one yellow spot showing the position of a charged particle. The first two spots are the positions of a pion. Since the third one is not on the line expected to be the track of the pion, we conclude that the pion has been decayed and an antimuon or a positron has been produced, which left the last yellow spot on the third delay wire chamber.

Every day in the control room, in three shifts of 4 hours each, we were watching the collection of the data. We took data at 4, 7 and 10GeV.

4 Our Conclusions

It was and still is an incredible experience for us, not only for the knowledge we earned, but for having the opportunity to work in a very challenging environment, at the biggest laboratory of the world, collaborating with CERN scientists and students from an another country. Finally since the weak interaction has played an important role in the history of CERN and every moment it's being manifested in the Sun, studying experimentally this interaction we feel we lived the legend of CERN by almost touching the Sun.

5 Aknowledgments

Special thanks to Konstantinos Theofilatos for his precious help during the preparation of our proposal and the running of our experiment.

A lot of thanks to all the "A Beam Line of Schools" team for all they did for us. Especially we are thankful to CERN scientists supervising us: Christoph Rembser, who was the coordinator of this effort and whose brain child is this unique competition, Markus Joos, Cenk Yildiz, Saime Gurbuz, Lau Gatignon, Jorgen Petersen, Terry Pritchard and Stella Orfanelli.