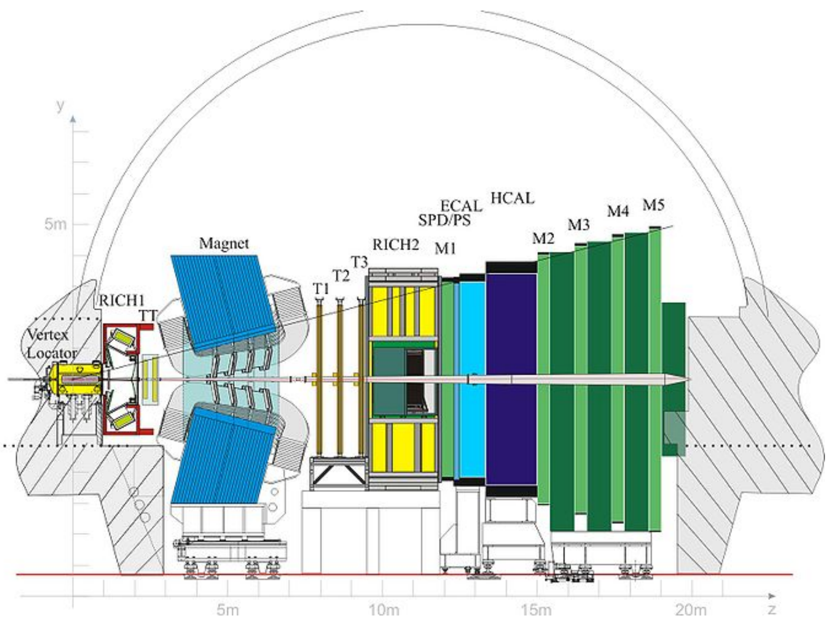
Work experience report – July 2012

After we arrived on Monday, we met in the staff common room and were welcomed by Dr. Helen Heath. We were then given a brief health and safety talk before we had a tour of the department. For the rest of the week we participated in a range of activities and talks:

David Voong Talk

Particle physics talk by PhD student David Voong who is currently doing research into the field of particle physics specifically the reason why our Universe is made of matter rather than antimatter. He explained that this is a rather disturbing question as the standard model predicts by symmetry that equal quantities of matter and antimatter were produced by the big bang. If this is true then all matter and antimatter should have annihilated soon after leaving the universe as a "sea" of photons. This clearly is not the case therefore we need a mechanism known as CP violation. CP symmetry states that the Universe behaves in the same fashion (hence the laws of physics are consistent) regardless of which type of matter we choose to build it with. CP violation therefore allows us for asymmetry between matter and antimatter. To find this David uses the LHCb 'beauty' detector at the large hadron collider to observe exotic particles known as b-mesons. These are believed to be responsible for CP violation. David explained to us how he tried to find these particles by observing their decay products, however to try and find these in the huge number of particles generated he needs to know roughly where to look. David explained that he tries to do this using a computer simulation that predicts where to find the decay products and allows him to eliminate unwanted background "noise". Another issue he faces is that a relatively low number of collisions result in the production of b-mesons. The LHC offers a way around this problem by producing a very high number of collisions. A rather unglamorous job he has to undertake is, in effect "counting" the particles produced from a given number of collisions.

Diagram of LHCb

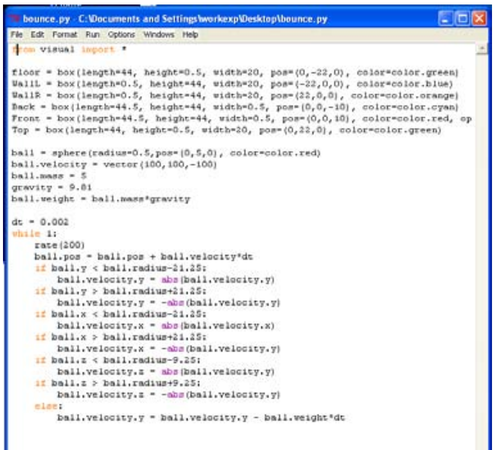


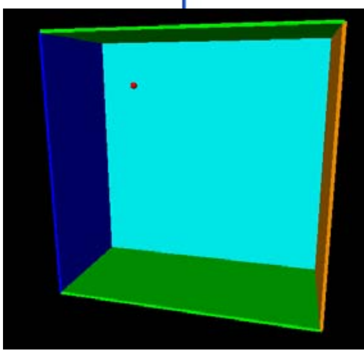
Cosmic Rays

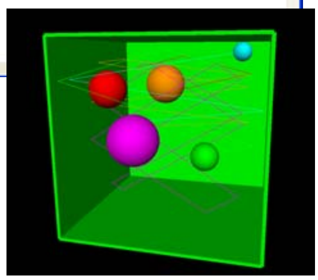
On Monday we spent the afternoon attempting to analyse cosmic rays. After filling out a risk assessment of the dangers involved with using dry ice and concentrated alcohols we were given instructions on how to build a simple cloud chamber. It was with high hopes of seeing particle tracks that we stuck alcohol soaked tissues to the bottom of beakers, which we then overturned onto metal plates which were cooled to -70°C by dry ice. These hopes quickly diminished, however, after all of our first and seconds attempts failed without exception. Luckily after transferring our cloud chambers into a dark room we were finally successful at spotting the trail of condensation caused by a particle travelling through the alcoholic cloud. Since we now had a working cloud chamber the particle tracks became much more frequent, with contrails appearing every few seconds. These differed in size and direction from which we could tell a bit about the type and origin of the particles which caused the tracks.

Computing

On the Tuesday 10th we started the day by receiving a talk on the basics of computer programming, specifically in the computer language VPython. This language is used for 3D modelling and easy to pick up even for those with little or no knowledge of coding. We were then given a simple document modelling a bouncing ball on a plate and given sometime to understand how the code worked and experiment with it. From there we were then set several tasks in improving the code, modelling a spring or designing a logic experiment. As we were of all different levels with this skill it really helped us bond with the more advanced helping the less experienced. We all gained a valuable skill that is vital to the modern physicist's success.







Janina Moereke Talk

Talk led by Janina Moereke, another PhD student in her third year of study. She told us how the PhD course is structured with the first six months being lecture intensive and how research begins to take precedence in the second and third year of study. Janina's research is into improving the efficiency and reliability of semiconductors which are in common use in transistors. The most common method she used to test transistors was to subject them to a range of voltages to find particular bands where there was high impedance to the flow of electrons through the material. This impedance is often caused by flaws in the material which cannot always be detected by optical techniques. Another problem limiting the reliability of semiconductors is flaws in the material, electrons can sometimes become trapped in gaps in the atomic lattice. Janina also explained to us in quantum terms the behaviour of conductors and insulators. In any material you have two distinct bands in which the electrons exist. When in the ground state the electrons of the material occupy what's known as the valence band, the valence band confines the electrons to a particular atom thus preventing them from travelling through the material and carry and electric current. In order to carry electricity some of the electrons in the material are promoted to the conduction band which requires the electrons to have energy greater than the Fermi level. Promotion to the conduction band can happen when an electron gains energy either by collision with another electron or by absorption of a photon. In a conductor such as a metal the valence and conduction bands overlap allowing electrons to transfer to the conduction band at will whereas in an insulator the energy required for an electron to move into the conduction band is significantly greater than the Fermi level. With no energy levels bridging this gap it makes it very difficult for an electron to be promoted to the conduction band. In a superconductor there is a small gap between the valence band and the conduction band small enough that with constant electrical potential electrons can be promoted to the conduction band therefore allowing the material to conduct.

Kate Husband Talk

We were given a talk by Kate Husband describing her PhD research on galaxies in red-shift 5 (the part of the universe at which light has been shifted by a wavelength of about 5 Angstroms, or 500 picometres, by the time it reaches Earth). As the distance from these galaxies to Earth is so large, measurements are extremely difficult to take accurately and she described ways that they overcame the problem of distinguishing the useful galaxies. She also went into detail about her life as a PhD student which was very useful to those of us considering physics research as a future career. The talk gave us an insight into the world of Astrophysics and what physics is like once we move past the easily observable parts of our universe.

Low temperature Lab Talk

After completing our preparation for the Sutton trust summer school for the next day, we attended a tour of the low temperature labs of Bristol University. The tour was given by Phil Walmsley whose research involves superconductors and liquid helium and nitrogen. The talk was very interesting especially for those who have a special interest in the field of thermodynamics. Following a quick safety briefing on the rules of the low temperature labs, he then gave us a short insight into the field of work that he is currently doing. His work involves the use of super cool liquids to create superconductors, these are materials that create no resistance against the electric current. Phil then showed us an interesting experiment involving liquid nitrogen and a magnetic train track. Liquid nitrogen which is at -169°C, was poured into a train which was placed on the magnetic train track, then with a little push the train was able to move along the train track without actually touching it. This is caused by the extreme coolness of the liquid nitrogen giving the train super conductor properties. I think that everyone thoroughly enjoyed the visit and we wish Phil the best with his research.

Richard Webster Talk

We were given a talk by PhD student Richard Webster about the research he was doing into the properties of ImGaN Nanorods as a replacement for traditional silicon solar cells. Richard explained to us that the current commercial solar cells only have an efficiency of 15% and in simulations the ImGaN Nanorods were more efficient- around 30%. Richard showed us that the primary focus of his research was to focus on how the InGaN Nanorods were 'grown' and their physical structure. He showed us a couple of ways they studied these ImGaN Nanorods at the nanoscopic level, by using Scanning Electon Microscopes (which take a surface down/ 'bird's eye view' of the material, by firing electrons at the surface of the material and detecting how they are reflected back) and Tunneling Electron Microscopes (these scan through the target surface by firing electrons at a higher energy level and are detected by a phosphorus plate, which then emits photons). He explained that the main reason for his research in this field was the increase of surface area that the cylindrical Nanorods provided and the properties of the Nanorod material- InGaN.

Ice cream Talk

On the fourth day of our work experience, we had a lecture on making ice cream with liquid nitrogen cunningly disguised as a lecture on phase changes and latent heat. After a brief introduction on the chemical contents and manufacturing methods of ice cream, we then proceeded to have a little play with liquid nitrogen, doing things from liquefying the air within a balloon to flash freezing a cabbage. Finally, we began to make ice cream by adding the liquid nitrogen to the mixture and churning it, making a rather tasty blend that certainly was popular with the audience.

Sutton Trust Summer School Activities:

During the same week of our work experience placement, there was also a summer school for A-level students happening at Bristol University, for part of their summer school they got to look around the Physics laboratories. As work experience students we got to set up and demonstrate the experiments to a small group of summer school pupils take measurements, so we really did have to understand the experiment we were talking about. The sorts of experiments were mainly based around waves and are outlined below:

Speed of Light experiment

For this experiment we were trying to measure the speed of light, to do this we used different lengths of fibre optic cables. For the experiment we used an oscilloscope to measure the wave produced by signal generator and the wave produced when the signal (laser) was received by the detector. The time delay which was clear on the oscilloscope, meant we could then count the boxes on the scale and multiply this by the amount of nanoseconds each box represented (this changed depending on how magnified the waves were on the oscilloscope). We changed the length of the fibre optic wire to then plot a graph with all the different results. We then used the gradient on the graph (distance/time) to work out the speed. To change this into seconds from nanoseconds we multiplied this by 10^9. To find the speed of light in a vacuum, rather than in the fibre optical scale we needed to multiply this by the refractive index of the fibre optical cable. We got an average result of 2.33×10^8, which was much closer than we were expecting.

Electron diffraction experiment

On the fourth day one of the experiments we had to demonstrate was the electron diffraction experiment. This is where we accelerate electrons through a thin sheet of graphite. The graphite would act as a diffraction grating, diffracting the electrons (as if they were waves) creating rings on the edge of a bulb.

The point in the experiment was to get a value for Planck's constant, using de Broglie's equation of wavelength according to momentum ($\lambda = h/mv$). As two of these values are unknown to us, the wavelength of the electron and the velocity in which the electron was moving, this experiment was also a test of our problem solving and mathematical skills.

Our basic method for this experiment was to measure the radius of the first ring created by the electrons, on the bulb. This ring is the first order wave (relating to the wave diffraction equation, $n\lambda = d\sin\theta$, using the length of the electron emitter – the edge of the bulb where the rings are created, we can find θ and therefore find our wavelength.

We can find the velocity by relating the electrons energy, E, to their energy in electron volts (eV), equating their eV to their kinetic energy ($1/2mv^2$), some simple equation rearranging, then voila! We have the velocity. We can then find Planck's constant by using $h = \lambda mv$.

The experiment was very interesting as is required lots of problem solving skills. Teaching it to the Sutton trust students was challenging as few had done As level physics or maths, but when every group came close to the actual value of Planck's constant, it felt very rewarding.

Optical diffraction experiment

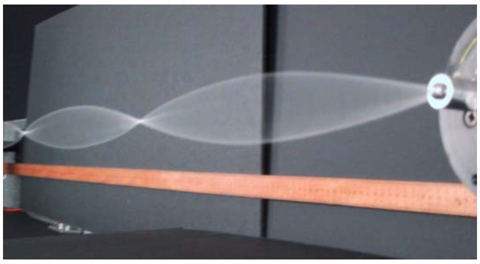
The optical experiment revolved around a laser being diffracted at a diffraction grating. This produced points of maximum and minimum intensity as a result of constructive interference of the electromagnetic light waves of the laser. From simple trigonometric calculations we were able to find the angle θ at which the 1st order maximum was present relative to the pre-diffracted laser beam.

We used the equation: $n\lambda = d\sin\theta$

This allowed us both to derive the wavelength from a given slit spacing, and the slit spacing from a given wavelength. We were then able to check our results against the true values.

Standing waves experiment

We were investigating how the tension of a string affects the speed of standing waves on the string by measuring the frequency and the wavelength of the waves when the string had different weights on the end and plotting the frequency against 1/wavelength on a graph. The gradient of the graph was the speed. Standing waves are created when a wave going one way and its reflection going the other way interfere with each other, creating nodes and antinodes



which stay in the same position.

Mechanical wave experiments

On the Thursday morning of our work experience we were given the almighty task. We had to perform a twenty minute practical to a summer school each practical had to have a method of which students could take a measurement or reading and record it. The group that I was in, took charge of a set of demonstrations of which the students would watch and then have ago at. The main goal of these experiments was to show standing waves. We had a couple of practice runs to get our act together until we were ready to demonstrate are experiments. When we started it was very rough and the group didn't take a lot of interest, but soon it became a lot smoother and we had managed to attract more attention from our viewers. Once we had managed to complete our section we sent them on to the other groups, at the end after all the groups had passed, we took our prestigious bow and continued with our thrill ridden day.