

Training the next generation of Particle Physicists

The Third Linear Collider Physics School took place from 17 to 23 August 2009. The School is the third in a series of successful schools hosted on the Ambleside campus of the University of Cumbria addressing the physics of the next generation of particle colliders.

Third Linear Collider Physics School, Ambleside, 2009



The School has been organized by a Programme and Organizing committee and an International Advisory Committee. The 12 members of the Programme and Organizing committee have been Drs André Sopczak, chair, Chris Bowdery and Jonathan Gratus from Lancaster University, Phil Burrows from Oxford University, Chris Damerell from Rutherford Laboratory, Gudrid Moortgat-Pick and George Weiglein from IPPP Durham, Daniel Schulte from CERN, Thomas Teubner from Liverpool University, Mark Thomson from Cambridge University, Nigel Watson from Birmingham University and Volker Ziemann from Uppsala University. The 14 members of the International Advisory Committee have been Drs Sergio Bertolucci (CERN), Swapan Chattopadhyay (Cockcroft Institute), Brian Foster (Oxford University), Nigel Glover (IPPP Durham), Rohini Godbole (Bangalore University), Wolfgang Hollik (MPI Munich), Enzo Iarocci (INFN), Joachim Mnich (DESY), Tsunehiko Omori (KEK), Mark Oreglia (Chicago University), Per Osland (Bergen University), Francois Richard (LAL Orsay), Harry Weerts (Argonne National Laboratory), Sakue Yamada (KEK). The Linear Collider Physics School has now become a well-known international school. It is crucial to train the next generation of particle physicists and the Linear Collider Physics School makes an important contribution.

Our School is aimed at PhD students and postdoctoral researchers working on the proposed International Linear Collider. The circular Large Hadron Collider at CERN (Geneva) is expected to do a first survey of the TeV energy scale (a trillion times the energy provided to an electron by a 1 Volt battery) but a Linear Collider is best placed to make detailed measurements of any new particles plus the already known top quark and the Z weak force boson.

The proceedings of the 2009 Linear Collider Physics School will be published by Proceedings of Science (PoS) and cover Particle Theory, Accelerator Theory, Experimental Aspects, Cosmology and Topical Issues. After an introduction to the Standard Model (SM) of electroweak interactions and QCD, top quark physics, exotic particles, supersymmetry (SUSY), the Higgs mechanism and Higgs bosons in the SM and the Minimal Supersymmetric SM (MSSM) are discussed. The accelerator sessions introduce basic concepts such as synchrotrons, transverse focusing, phase stability and beam emittance. Then linacs and the designs of the International Linear Collider (ILC) and the Compact Linear Collider (CLIC) are discussed. Higgs searches at today's hadron colliders and the outlook for linear colliders are dealt with in Experimental Aspects section, along with a survey of detector technologies for the ILC and CLIC.

The School accommodated about 50 participants from 15 countries, mostly PhD students, a few students just about to start their PhD research and a few post-doctoral researchers. Twelve lecturers participated along with three local organizers and a few accompanying persons. In the organization of the School attention by the chair of the organizing committee has been given to cover the different regions in the world, Europe, North America and Asia, where particle physics research is strongly supported. The great variety of nationalities of the participants was particularly welcomed by the students who used this opportunity to establish new contacts around the world. Six students had a background in accelerator physics, 16 students in detector physics, 8 students noted their interest in phenomenology and theory, and 9 noted their interest in data analysis. The students have been a highly motivated group and their talent will surely contribute significantly to the field of particle physics in the future.

The curriculum of the School consisted of 21 lectures delivered by 12 lecturers. The introductory lecture was delivered by Professor Phil Burrows from Oxford University and the John Adams Institute. Professor Thorsten Ohl (Würzburg

University) delivered the lectures on Electroweak Theory and Higgs Boson theory and on exotic particles. The lectures on accelerator physics have been delivered by Professor Ted Wilson from CERN and Oxford University and Dr Frank Zimmermann from CERN. Dr Bill Murray from Rutherford Laboratory and CERN gave the lectures on Higgs boson searches. Dr Jan Kalinowski from Warsaw University delivered the lectures on the Supersymmetric particles. Professor Chris Damerell from Rutherford Laboratory and Dr Michael Hausschild from CERN gave the lectures on detector physics. The relation of particle physics and cosmology has addressed in a lecture by Dr Geneviève Belanger from the Laboratoire d'Annecy-le-Vieux de Physique Théorique (LAPTH). The physics of QCD and top quarks has been addressed in a lecture by Dr Adrian Signer from IPPP Durham. The relation of the current hadron collider and the future electron-positron colliders ILC and CLIC explain the lecture by Dr Gudrid Moortgat-Pick from IPPP Durham. The inspiring outlook lecture was delivered by the director of the Cockcroft Institute Professor Swapan Chattopadhyay.



Some of the lecturers and organizers shown in the lecture hall.

In addition to the lectures Professor Chris Damerell gave a special seminar on vertex detectors reviewing the developments over a 30 year time period. The lectures were organized to allow for 15 minutes after each lecture which the student used for lively discussions. The changes in respect to the first two Linear Collider Physics Schools were well received by the students, in particular the introduction of three dedicated hours reserved for student discussions with the lectures on specific topics. These discussions were led by Professor David Miller on 'the big questions' in our field of research, by Ohl on electro-weak and Higgs physics, and jointly by Wilson and Zimmermann on accelerator physics, and Belanger, Ohl and Signer on QCD, exotics and cosmology. Students have appreciated very much the voluntary possibility to report briefly (10 min time allocation) on their research and obtain feedback from the expert lecturers. The slides of the lectures have been collected on the School's webpage under the programme page: www.hep.lancs.ac.uk/lc2009school

The lecturers have also kindly agreed to provide write-up of their lectures which will be published electronically by Proceedings of Science (PoS) "Third Linear Collider Physics School 2009 (LCPS2009)".

The students were encouraged to make new contacts by asking the lecturers questions in their free time, and making new contacts with fellow students or discuss career goals. Some of the contacts and friendships made would have a lifetime impact on the careers of the students.

Initial student feedback has been very positive. A few typical examples are given below:

"It was a very nice experience of being a part of the 3rd Linear Collider Physics School. We are very much satisfied with the organization of the school." Monica Jindal, Panjab University, Chandigarh, India

"This was a real good opportunity to see the efforts of the British people, on the Linear Collider which is, according to all kinds of particle and accelerator physicists, the next machine to be built. And Lancaster University, while proposing this school, is up-to-date with the future of particle physics. Keep it going." Philippe Doublet, Laboratoire de l'Accélérateur Linéaire Université Paris-Sud, France

"The school was very good and it gave your university a very good reputation. I was a good challenge to most of the participants including me myself as I personally gained a lot from the school." Anthony Shadrack, Jomo Kenyatta University, Kenya.

"Overall very good. Of course, I had to ask a lot of background information in the breaks, since I just began my PhD this month." Moritz Beckmann, DESY, Germany

"I was extremely satisfied with the overall organization and to put it more elaborately it surpassed my expectations. The quality of the teaching was of a very high standard and the lectures were well explained and the questions were answered to the satisfaction of the students." Supreet Pal Singh, Panjab University Chandigarh, India

"I enjoyed the school a lot. I learned a lot during the school. Most of the time you only concentrate on your own work, but the LC is a wide field and with the school this field was well covered." Katja Seidel, MPI Munich, Germany

"excellent organisation of the Linear Collider Physics School 2009. It provided me with a lot of new insight into the physics at the Terascale in general and physics of linear colliders in particular. The academic level of the lectures was high, but nevertheless very well presented, and thus suited equally for the experts and the non-experts of the specific field of the lectures." Peter Speckmayer, CERN, Switzerland

"I am really satisfied with the organization level of the school. I think that everything was organized very well. I had no problems with information support. Accommodation, meals, internet as well as entertainment programme, everything was wonderful.

Lectures were very useful for me. I really learnt a lot. I think they were interesting both for experimentalists and theorists. They covered a lot of different topics on collider physics and, I think, everybody has found something helpful for his (her) research. This school also provided us with the possibility to communicate with Ph.D. students, postdocs and professors from different universities, to make friends. My opinion is that, of course, organization of such events as this School is very good for the reputation of the University of Lancaster. It increases the 'scientific weight' of the university, because if the university has a possibility to organize such an important scientific event and do it very well, it indicates the high scientific and organizational level of all the people who work there, the presence of many connections between this university and other world scientific centres, which is very important." Vasili Andreyeu, Belarussian State University, Belarus

"A lot of the participants representing different universities around the world will surely talk to their research groups about the school which is good for Lancaster's reputation." Rhorry Gauld, Oxford University

"This was my pleasure to take part at the Third Linear Collider Physics School 2009 and to have had the possibility to present shortly my work.

In my opinion the quality of the school was high. The lectures were very interesting and covered all the Linear Collider aspects, from the detectors to the accelerators and spanning all kind of theories concerning the Linear Collider Physics potential.

In my work I'm involved mostly in the detectors, so I had the possibility to learn also the accelerator issues and the theory that in some way can be confirmed or not at the Linear Collider.

Also the lecturers were very kind, they spent a lot of time with us to answer questions and share their opinions." Vito Di Benedetto, University of Salento, Italy

"The level of the lectures was good. In contrast to other physics schools where the all high energy physics are covered, the lecturers always related their topic (accelerator, detectors, but also QCD and SUSY) to the linear collider, and thus made it more interesting to me (since I'm working on the linear collider). To me the lively discussions of what could be measured with which kind of accelerator technology (ILC, CLIC, LHC) were very interesting." Nanda Wattimena, DESY, Germany

"It is one of the best organization I have ever attend." Ali Övgün, Izmir Institute of Technology, Turkey

"I have got different kind of experience and knowledge about many things about collider physics both experimental and theory. Honestly I would like to say beginning of the school I had no much idea about ILC, CLIC, SiD and ILD. This school was useful to me to gain big knowledge about those things. That was a very valuable and great chance for me to participate such kind of school." Nadeesha Wickramage, University of Ruhuna, Sri Lanka.

"Participating at the linear collider school was really fruitful and pleasant for me. The lectures covered a wide variety of subjects and helped me understand what's going on also outside detectors, which is my field.

The lecturers were high qualified and willing to answer questions and discuss.

Seminars were also a nice idea. Since there were a lot of people from different projects and background this led to an interesting scientific interaction.

I think is always positive for the reputation of a university to organize a successful school. The level and the organization were high and satisfactory.

Lecturers and students from a lot of different institutes and fields learned about Lancaster university and I think most of them left with a positive opinion for it and the people who who worked for the linear collider school. It was an opportunity for the university to become more widely known and may cooperate in the future with some people, professors or students who attended this school.

Finally I believe this school gave a boost to the student who attended it and I hope you will keep organizing it in the future." Georgios Gerasimos Voutsinas, IPHC Strasbourg, France

"It was very well organized, it gave a lot of information that would help in my research." Khadije Younes Bazzi, Wayne State University, USA

"To me, it has been a very interesting School from which I learnt a lot about the future facilities, the new ideas to be developed and to be discussed and the path our field will follow in the near future.

It has been a good place where to exchange opinions and discuss about such ideas and to be updated regarding the concrete projects by my experimental colleagues are working on.

I also appreciated especially the time devoted to discussion, in which also students like me could express his own opinion, as well the possibility for students to give a small talk. A feedback from professors is usually welcome, even just a piece of paper with the goods and bads.

LC are nowadays thought as a downstream of particle physics giving the imminent turn on of the LHC, that gathers most of the attention. But since we need to plan also our future, I think such a School should be established on a regular basis

for the reasons I gave earlier on. It could be good to enlarge the audience, although too many people will break the "informal" atmosphere I appreciated, that allows everyone to join the discussion.

Surely, it has been a very good experience, and this School should be reproposed next year, maybe becoming the reference for other activities on LCs, for sure in UK but also in Europe." Lorenzo Basso, NExT Institute, University of Southampton and RAL

"As the organizer of the event, University of Lancaster will gain a greater recognition within the field of particle physics around the world." Nils-Erik Bomark, University of Bergen, Norway

"Under my point of view, the organization was perfect. Everything run in a smooth way and every detail was prepared very well. Concerning the academic quality: I had very difficulties to follow some of the talks (specially the ones of Thorsten and Jan). Probably, the reason for that is that I am working 100% in detectors hardware, so I am not involved in this kind of physics studies. On the other hand, the rest of the talks (specially Ch. Damerell, Ph. Burrows and Bill Murray) were brilliant!

I have to say that I have learned a lot, and that the School fulfilled my expectations. On the next school, you must reserve some more time for student's presentations. It is a very nice opportunity to lose the fear to speak in front of experts and defend your work.

Under my point of view, this School gives good reputation to the University of Lancaster. Taking in account the high level of the speakers and the Committees (organising and international advisory), this school is a reference for students working in future e^+e^- colliders, both in theoretical and experimental aspects. I think that, in a future, you should promote this event in the different ILC/CLIC meetings and universities all over the world." Carlos Marinas, IFIC, Valencia, Spain

"I was very satisfied with the LCPhysics school! I thought the courses were well planned and delivered.

Being a theorist, I definitely came away feeling that I had learnt a lot from the week of lectures - especially the accelerator and detector lectures.

I felt that the overall organisation of the School (both in the academic sense and the excursion/free time sense!) was excellent, I really can't think of anything I could say that would improve this!

So far as how good the school is for Lancaster University to organise...I think it definitely shows that Lancaster university is involved not only in the biggest ever experiment done by man (the LHC) but also indicates links with the next big physics experiment (the Linear Collider) which will undoubtedly have a huge impact on our understanding of nature. And I think this can only be a good thing for Lancaster to be involved in." Andrew Papanastasiou, IPPP Durham

"it gives me great pleasure in expressing my appreciation to the team of organizers in the way they have successfully handled the recent Linear Collider School in Ambleside.

Your whole-hearted effort, sincerity and dedication have ensured the success of it." Giovanni Marco Pruna, NExT Institute, University of Southampton

"The Linear Collider Physics School 2009 has motivated me to prioritize the physics of my own research." "Also as a result of this school, I become more aware of the collaborative efforts of competing experiments." "There was a healthy mix of faculty and subject matter spanning the diversity of high energy physics experiments." "The parts I really enjoyed were the student/faculty discussions." "In my future physics career I look forward to continuing work with many of this school's faculty, post-docs and students for current and future experiments. After attending this school I have found a new source of energy and perspective to progress in my own research and now have the tools to do so." Jacob Smith, University of Texas at Arlington and Argonne National Laboratory, USA

"The lectures and seminars had a high academic standard and were extremely powerful due to the complete coverage of the Linear Collider topic: Accelerators, detectors, analysis and phenomenology as well as theory.

The University of Lancaster demonstrates a very welcoming hospitality, shows its powerful links to its colleagues who contributed happily, and proves its own engagement in the Linear Collider field. Last but not least, the Lancaster members of staff show and add their expertise to the school." Fabian Gross, Heidelberg University

The School has been made possible through the generous support of the following institutions and agencies: Lancaster University, DESY, CERN, STFC, John Adams Institute, Cockcroft Institute, IPPP Durham, and the UK Institute of Physics. In addition the national support for some students is acknowledged.

The training of a new generation of particle physicists is very important and this School has contributed towards this goal. After the success of the previous Schools and the growing international attention to the School, we have decided to continue the series of Schools which takes place every three years in the Ambleside. The previous Schools took place in 2003, 2006, 2009, and we have reserved the much-in-demand Ambleside centre for 18 to 25 August 2012. This timing fits in well with the preparation of TDRs for the Linear Collider and as well as being the time when decisions will have to be made globally about the next big machine in our field.

André Sopczak