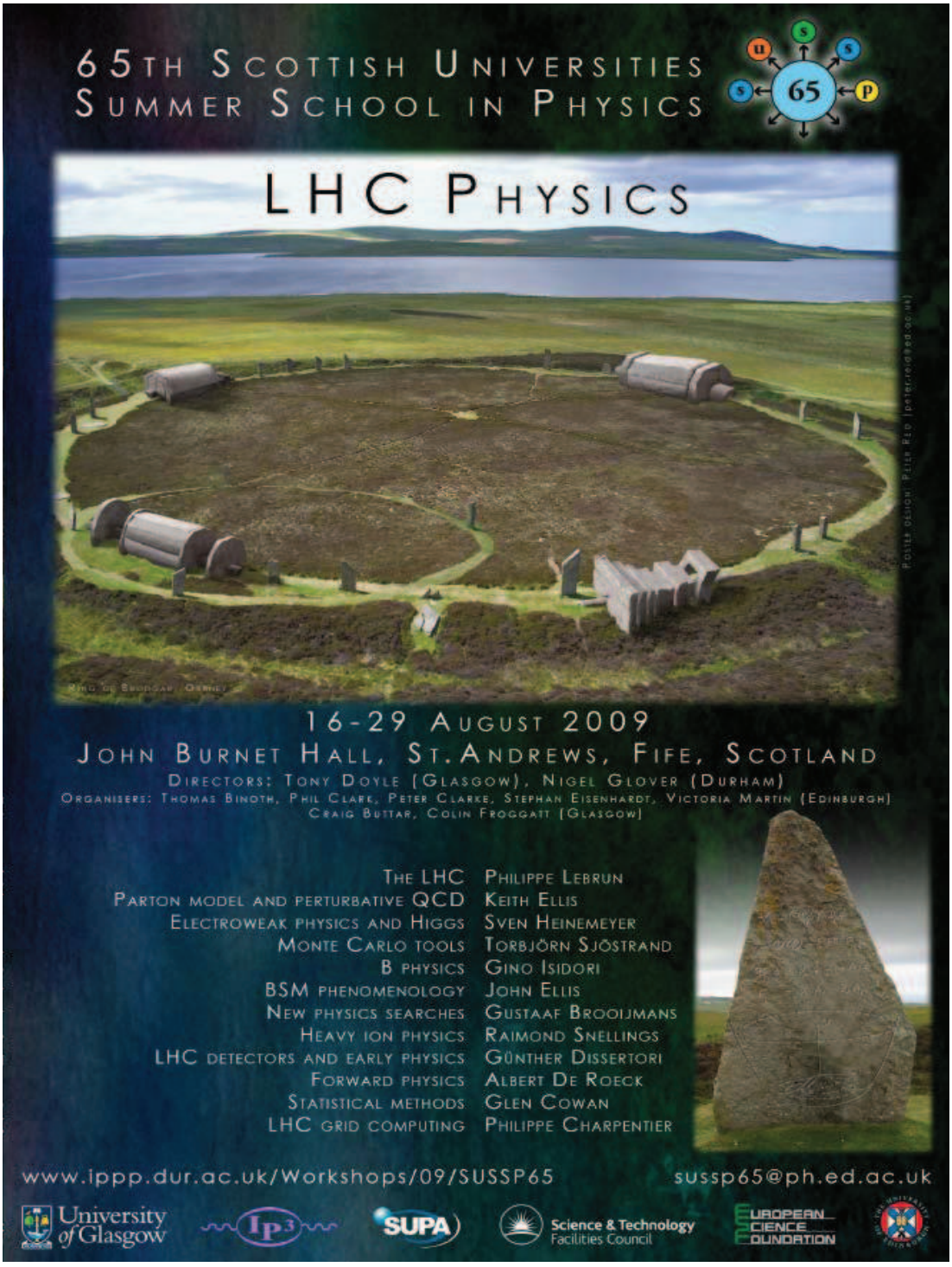

Report: Scottish Universities Summer School in Physics, SUSSP65

Professor Tony Doyle, Glasgow and Professor Nigel Glover, Durham

The 65th Scottish Universities Summer School on Physics on LHC Physics took place from 16 to 29 August 2009. This was a very successful school that met the objective of preparing young scientists for the exploitation of data from the LHC. The webpage of the school can be found at

www.ippp.dur.ac.uk/Workshops/09/SUSSP65

School Details

Title: **LHC physics**

Location: **John Burnet Hall, University of St Andrews**

Date: **16 – 29 August 2009**

No. of working days: 12 days

Objective: To provide understanding and knowledge of the underlying theory, latest tools and methods of analysis for investigating high energy particle physics phenomenology at the Large Hadron Collider.

Organising Committee

Co-directors: Tony Doyle (Glasgow) and Nigel Glover (Durham)

Secretary: Victoria Martin (Edinburgh) and Stephan Eisenhardt (Edinburgh) deputising

Treasurer: Colin Froggatt (Glasgow) and Stephan Eisenhardt (Edinburgh) deputising

Editors: Thomas Binoth (Edinburgh), Phil Clark (Edinburgh), Craig Buttar (Glasgow)

Stewards: Peter Clarke (Edinburgh) and Chris Parkes (Glasgow)

Description of the Summer School

With first collisions expected in late 2009, the summer of 2009 was an opportune moment to study LHC phenomenology with an emphasis both on the first years of data taking at the LHC, and on the experimental and theoretical tools needed to exploit that potential.

We therefore organised a summer school on LHC phenomenology, covering a very broad spectrum of experimental and theoretical activity in particle physics, from the searches for the Higgs boson and physics beyond the Standard Model, to detailed studies of Quantum Chromodynamics, the B-physics sectors and the properties of hadronic matter at high energy density as realised in heavy-ion collisions.

The lectures and informal discussions included an introduction to the theoretical and phenomenological framework of hadron collisions, and current theoretical models of frontier physics, as well as overviews of the main detector components, the initial calibration procedures and physics samples, and early LHC results. Explicit examples of physics analyses were drawn from the current Tevatron experience to help inform these exchanges.

The school covered all these at a pedagogical level, starting with a basic introduction to the Standard Model and its most likely extensions. Theoretical training was supplemented by courses on the detector capabilities and search strategies. In summary, the aim of the school was to equip young particle physicists with the basic tools to extract the maximum benefit from the various LHC experiments.

Following the pattern many recent successful schools, we held the School in St. Andrews in August 2009, using the facilities of the Chemistry Department and the John Burnet Hall of Residence. This location is ideal for a school of this size (72 students and 20 lecturers and other staff) and character (aimed at graduate students in their final years and young post-doctoral researchers).

The 72 participants came from UK and Europe (Belgium, Croatia, France, Germany, Greece, Italy, Netherlands, Poland, Spain, Sweden, Switzerland and Turkey), as well as the USA and India. There was a good gender balance with 32 of the 72 being female.
A full list of students can be found at
http://www.ippp.dur.ac.uk/Workshops/09/SUSSP65/Participants/

Poster competition

On Wednesday 19th August, there was a poster competition judged by the School Directors. These posters are available on the web site at
http://www.ippp.dur.ac.uk/Workshops/09/SUSSP65/Posters/
The posters overall were outstanding, and two of the winning posters are displayed below.

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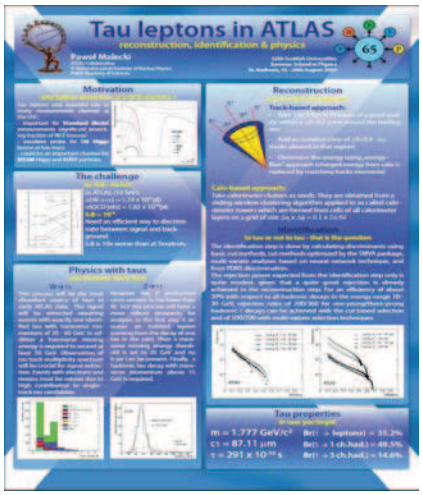
<td> 
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<td>Pawel Malecki
Institute of Nuclear Physics PAN</td>
<td>Liv Wiik
Albert-Ludwig-University Freiburg</td>
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There was ample opportunity for discussion and exposition, with participants (both students and lecturers) able to discuss the contents of the lectures and related issues throughout the school. The informal and relaxed atmosphere of St. Andrews and the John Burnet Hall contributed enormously to fostering this interaction.

Lecture programme and Lecturers

The lecturers were carefully chosen based on a balance of their:
1) acknowledged world-prominence and international impact in their research area;
2) their proven ability to deliver interesting and lively lectures; and
3) their commitment to contribute meaningfully to both formal and informal discussions with the students.
In keeping with the international nature of the school, we chose lecturers from as broad a spectrum of countries as possible whilst maintaining the integrity of having lecturers of international reputation and good teaching ability. The lecturers were uniformly of of high-international standing, each renowned for their ability to give inspiring and pedagogical lectures on the LHC.

Parton model and perturbative QCD	Keith Ellis (Fermilab, FNAL)
Electroweak Physics and Higgs	Sven Heinemeyer (Instituto de Fisica de Cantabria (CSIC-UC))
Monte Carlo tools	Torbjorn Sjostrand (Lund University)
B physics	Gino Isidori (Laboratori Nazionali, Frascati)
BSM phenomenology	John Ellis (CERN)
New physics searches	Gustaaf Brooijmans (Columbia University)
Heavy ion physics	Raimond Snellings (NIKHEF)
LHC: detectors and early physics	Gunther Dissertori (ETH, Zurich)
Forward physics	Albert De Roeck (CERN and Antwerp U.)
The LHC	Philippe Lebrun (CERN)
Statistical methods	Glen Cowan (Royal Holloway, London)
LHC grid computing	Philippe Charpentier (CERN)

Altogether 32 lectures were given according to the timetable below:

	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
	16	17	18	19	20	21	22	23	24	25	26	27	28	29
08:00-09:00		Breakfast												
09:00-10:15		K. Ellis 1	Sjostrand 2	Sjostrand 3	Dissertori 1	J. Ellis 2	J. Ellis 3		J. Ellis 4	De Roeck 2	Heinemeyer 3	Cowan 1	Snellings 2	Cowan 3
10:15-10:45		coffee							coffee					
10:45-12:00		Sjostrand 1	K. Ellis 2	K. Ellis 3	Charpentier 1	Dissertori 2	Dissertori 3		De Roeck 1	Heinemeyer 2	Isidori 2	Isidori 3	Cowan 2	Brooijmans 2
12:30-13:15		lunch						Dunnotar/Glamis	lunch					
13:15-16:00		Private Study		Falkland Palace	Private Study		Edinburgh		Private Study					Departure
16:00-16:30	Arrival	tea			tea				tea			tea		
16:30-17:45		Lebrun 1	Lebrun 2		J. Ellis 1	Charpentier 2			Heinemeyer 1	Isidori 1		Snellings 1	Brooijmans 1	
18:30-19:00	Welcome	dinner						dinner						
19:30-21:00		Discussion	Whisky tasting	Poster Session	Discussion	Discussion			Discussion	Ceilidh	Public Lecture	Discussion	Banquet	

The format of the school followed the tried-and-tested pattern of no more than three one-hour lectures per day, with 15 minutes for questions after each lecture, a period of private study in the afternoon rounded off with an open-ended evening discussion session lasting approximately 90 minutes.

Copies of the transparencies from the lectures, as well as audio recordings of the lectures are available at http://conference.ippp.dur.ac.uk/conferenceDisplay.py?confId=277

Proceedings

The proceedings are now being collected and will be published by Taylor and Francis as a text book

1. Theoretical Foundations
    1. Parton model and perturbative QCD – K. Ellis (3 hours, 30 pages)
    2. Electroweak Physics and Higgs – S. Heinemeyer (3 hours, 30 pages)
    3. B physics – G. Isidori (3 hours, 30 pages)
    4. BSM phenomenology – J. Ellis (4 hours, 40 pages)

2. The Large Hadron Collider
    1. LHC: machine and detectors – L. Evans (2 hours, 20 pages)
    2. LHC: first results – G. Dissertori (3 hours, 30 pages)
    3. Forward physics - B. Cox (2 hours, 20 pages)
    4. Heavy ion physics – R. Snellings (2 hours, 20 pages)
    5. New physics searches – G. Brooijmans (2 hours, 20 pages)

3. Tools
    1. Monte Carlo tools – T. Sjostrand (3 hours, 30 pages)
    2. Statistical methods – G. Cowan (3 hours, 30 pages)
    3. LHC grid computing – P. Charpentier (2 hours, 20 pages)

The textbook will thus comprise approximately 350 pages and encompass the theoretical foundations, anticipated first experimental results and associated physics tools. All participants and lecturers will be given a free copy of the textbook.

Outreach

It is becoming increasingly important that we take our message to the public. Consequently, on Wednesday 26 August, we held a schools outreach event in the afternoon, with a lecture for the general public in the evening. Buses were provided for local schools from Fife and the surrounding area. Altogether over 150 students attended the afternoon. Hands-on displays and experiments were provided by the Particle Physics for Scottish Schools project (PP4SS) which is supported by the School of Physics and Astronomy, the University of Edinburgh and by STFC. The exhibition was staffed by experienced demonstrators familiar with the PP4SS setups, mostly research students themselves as well as about 10 volunteer students from the school. The audience was encouraged to try out the displays and experiments and was naturally drawn into discussions about the topics on display and often also further afield.

The main lecture (repeated to an audience of

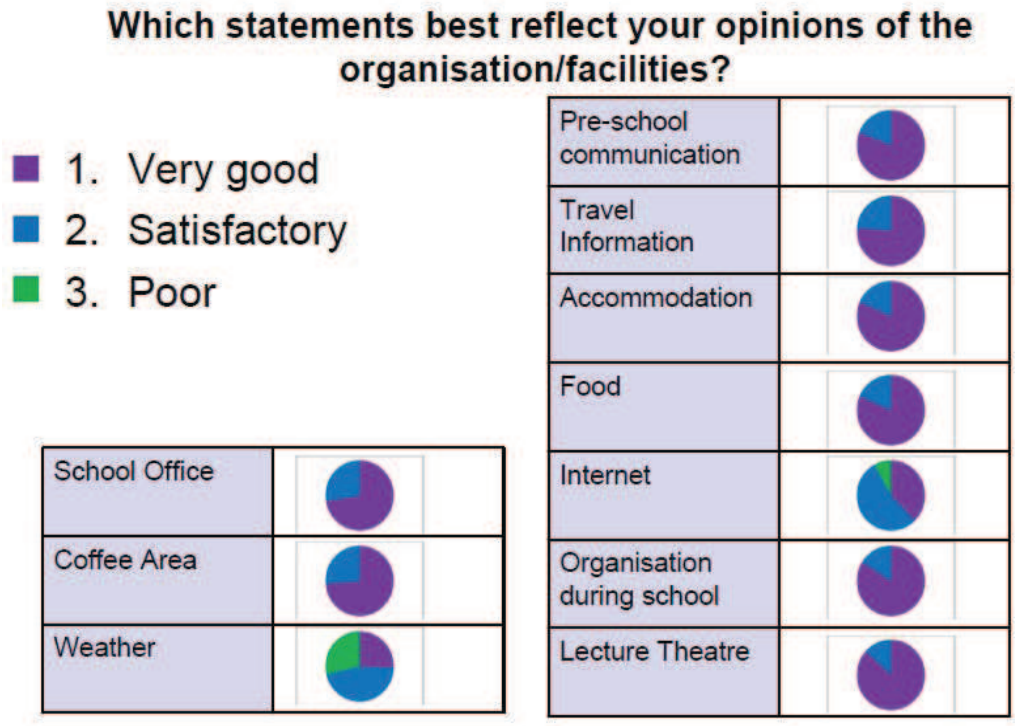
over 100 in the evening) was given by Professor Brian Cox (Manchester University) and titled “CERN's Big Bang Machine: The Large Hadron Collider”. As one might expect, it was an outstanding event and thoroughly enjoyed by all who attended.

Feedback on the School

The feedback on the school was enormously positive. 100% of students found the school either “extremely useful” or “very useful”. 100% of the students either “strongly agreed” or “agreed” with the statement that the school had better equipped them with the tools to extract the maximum benefit from the LHC.

The overall rating for the lectures was very very good, with almost all lectures being rated “extremely useful”, “very useful” or simply “useful”.

The organisation of the school was also praised. With the only glitches being the Scottish summer weather and teething problems with the internet at St Andrews.



When asked “Any things you really liked about SUSSP65?”. The responses included

- ✓ Nice combination of lectures and breaks long enough for discussion.
- ✓ Great mix of experiment and theory.
- ✓ The school was absolutely wonderful.
- ✓ This is a great programme and should be used as a model for other summer schools.
- ✓ Meeting people from different fields of research.
- ✓ Long question times after lectures.
- ✓ Lecturers and students sharing accommodation.
- ✓ Outreach day was the highlight of the school.
- ✓ Atmosphere, high quality, availability and pedagogy of the lecturers.
- ✓ Good combination of social activities and lectures.

Social Programme

Summer Schools are not just about science - they are about dialogue, discussion, meeting people, and forming lifelong friendships. The School succeeded in this secondary aim, aided by a full social programme. The SUSSP has a tradition of hard work accompanied by the opportunity to sample Scottish culture – through trips to local castles (Dunottar and Glamis, or to Falkland Palace), a whisky tasting, a traditional ceilidh, a visit to Edinburgh, Haggis, pipers and of course, putting on the “Himalayas” mini golf course. The highlight for many was Peter Higgs attending to the School Banquet, and giving many the opportunity of talking and being photographed with him. The highlight at the banquet was the after dinner speech by Alan Walker, who gave a very humorous and interesting account of the history and traditions of the SUSSP.

The Organising Committee gratefully acknowledges the support of the UK Science and Technology Facilities Council (STFC), the European Science Foundation (ESF), the Scottish Universities Physics Alliance (SUPA), the Institute for Particle Physics Phenomenology in Durham, the Scottish Universities Summer Schools in Physics (particularly Ken Bowler and Alan Walker), the Institute of Physics, the Physics and Astronomy Departments of the Universities of Edinburgh and Glasgow and Chemistry Department of St. Andrews without which the school would not have been possible.

The training of a new generation of particle physicists is very important and this School has contributed towards this goal. We were encouraged to develop future schools in particle physics based upon the overall success of this School.