Students experience collaborative work at international masterclass

This year more than 3000 high-school students from some 60 institutes across Europe and the US spent a day working at the frontier of physics in the second International Masterclasses for High-School Students. The Virtual Room Videoconferencing System (VRVS) teams from CERN and Caltech again coordinated the video link-up between the students during this event, which took place from 6 to 21 March.

A screen shot of part of the masterclass videoconference held with the Slovak Education Ministry (top right).

How did it start?

Particle physics masterclasses began in the UK in 1997, the centenary of J J Thomson's discovery of the electron. It was then that Ken Long of Imperial College and Roger Barlow of Manchester University came up with the idea for a series of one-day events for 16- to 19-year-old students and their teachers.

Run by particle physicists at various institutes all over the UK and coordinated through the High Energy Particle Physics group of the Institute of Physics, each year the programme offers a popular combination of exciting talks and hands-on experience of the interactive graphical display programs that particle physicists use at CERN. More recently the concept of the particle physics masterclasses has been adopted successfully by several institutes in Belgium, Germany and Poland.

The international idea

The World Year of Physics 2005, which commemorated Albert Einstein's *annus mirabilis*, was the inspiration for the particle physics masterclasses to spread even further. It was just enough to mention the idea of a Europe-wide version of this programme for all members of the European Particle Physics Outreach Group (EPPOG) to come on board and try to get institutes in their countries involved. Eventually, 58 institutes in 18 countries across Europe, from Athens to Bergen and from Lisbon to Helsinki, participated in the event, which was centrally coordinated by CERN and Bonn University. This year the event included two non-European participants – Brookhaven National Laboratory and Florida State University – organized by QuarkNet, the US network of universities and schools.

As with the original masterclasses, the basic idea of the pan-European event was to let the students work as much as possible like real scientists in an authentic environment at a particle physics institute – to feel the excitement of dealing with real data, and to experience the difficulties of validating the scientific results. After watching lectures by practising scientists the students performed measurements on real data from particle physics experiments, then at the end of each day, as in an international collaboration, they joined in a videoconference to discuss and combine their results.

The measurement of the branching ratios of Z boson decays at CERN's Large Electron Positron (LEP) collider was chosen as the main common task at all sites. For this the students had to identify the final states of quark-jets, electron pairs, muon pairs and the notoriously difficult tau pairs from the tracks and signals in various components of LEP detectors. Interactive computer material for this task was available using data from OPAL in the Identifying Particles package from Terry Wyatt at Manchester University, or alternatively using DELPHI data in A Keyhole to the Birth of Time by James Gillies and Richard Jacobsson at CERN, or in the well known Hands-on-CERN package developed by Erik Johansson of Stockholm.

To facilitate the students' access to the unfamiliar world of particle physics, EPPOG and the national institutes had translated the material into the local language of the students. By the start of the project, at least one of the packages was available in each of the 16 languages involved, with Hands-on-CERN now covering 15 languages, from Catalan to Slovak. This material, including real data for performing the measurements and several extra teaching and learning packages, lays the basis for regularly performing masterclasses at an international level. The EU acknowledged the success of the first European masterclasses by selecting the leader of the project, Michael Kobel, as a nominee for last year's Descartes prize for excellence in science communication.

The second international masterclasses retained most of last year's successful format. The skills for how to become a "particle detective" were communicated in the morning lectures at each institute. Since particle physics is not normally taught at high-school level in most countries, the talks had to give a comprehensive overview, starting with basic explanations and extending to the world of quarks and leptons. "I was surprised to be able to understand what is going on in current scientific research," was the reaction of one of the students at Dresden.

After some training by young researchers from the institute, the students discovered that they could even identify the

Masterclass students identify the final states of quark-jets, electron pairs, muon pairs and tau pairs using OPAL and DELPHI data samples.

elementary particles on the event displays themselves. The exercise was in fact usually performed quite quickly: "What next?" was a frequent demand once the Z-decays had been measured.

During the late-afternoon videoconference an extra component was added this year: a quiz about particle physics and CERN. This was particularly interesting since it triggered more discussion, not only about the exercise but also about CERN and its ongoing activities. The winners of the quiz at each session and at each site were awarded a prize.

VRVS enables global research

The daily international videoconference used the same VRVS service (see www.vrvs.org) as that used by practising scientists. Here the students learnt to exchange their results and to discuss particle physics in English, the common language of modern science research.

The videoconferences made the students aware that masterclasses were also taking place in other countries, and created the feeling of belonging to an international collaboration of researchers. It was "interesting to learn how scientific information is exchanged around the globe" was a comment on one of the feedback questionnaires that were evaluated last year by the Leibniz Institute for Science Education (IPN) at Kiel University.

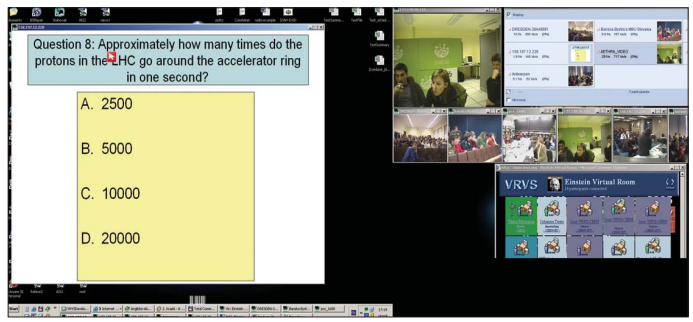
CERN's IT department and the Slovak group of the Caltech VRVS team provided valuable technical help for those institutes that had never used the system before. The link-up was moderated centrally by three inspiring young researchers at CERN: Silvia Schuh from ATLAS, LHC expert Mike Lamont, and Dave Barney from CMS. The technical set-up was coordinated centrally by Joao Fernandes from CERN (IT-UDS-AVC), and Viktor Michalcin and Marek Domaracky from the Slovak VRVS team (based at Pavol Jozef Safarik University in Kosice).

The VRVS service has been operating since 1997, serving the high-energy physics community and in particular the LHC experiments. There are some 4000 connected users in Europe, Asia and the Americas, and the service holds around 6000 hours of meetings each month.

VRVS is the only collaborative system that can scale up to the needs of large international physics experiments, especially the LHC experiments. VRVS is global in scope: it covers all existing and emerging protocols and all devices that clients use for collaboration, from desktop and handheld computers to installations in large auditoria. Therefore VRVS was the only system capable of supporting large international events such as the masterclasses, and it has contributed significantly to their success.

Moving on to EVO

After working with the VRVS system for 10 years, the VRVS team is preparing to release the new generation of collaborative systems – EVO (Enabling Virtual Organizations). The EVO system is based on a distributed intelligent software agent that creates a unique, efficient real-time infrastructure to support the community of research and academic users.



Students take part in a group quiz about particle physics and CERN.

EVO's advanced infrastructure will provide the core collaborative service for the LHC experiments and for other large international scientific experiments such as ITER. The service will operate over national and international networks in more than 100 countries. EVO promises to enhance all of the good points of VRVS and at the same time it includes new features such as instant messaging and presence, encryption, and automatic troubleshooting detection.

VRVS and EVO are essential for events such as the masterclasses. They enable the user to choose the type of client to use for the collaboration, independent of protocol, operating platform or budget. This is a key aspect because it is almost impossible to control each institution's set-up when more than 60 are involved. VRVS and EVO also provide full-scale multisite capabilities and enable users to see all of the remote participants at the same time, thus providing an immersive and collaborative experience for the young masterclass students.

How was it for you?

"I got the feeling that I did something which physicists do every day in their experiments, and I felt involved." This remark by a 17-year-old student shows that the authentic surroundings and the use of real data were indeed able to bring modern physics close to the hearts of young people. The masterclass teams from EPPOG, CERN and VRVS put students in contact all over the world, and enabled them to discuss the fascinating world of particle physics.

"I just wanted to say how much fun today was! I have not had as much fun at work for a long time! Lots of good questions, mainly from Poland (ranging from 'How old are you?' through 'Does the 8.3 tesla field of the dipoles have any effect on the environment' to 'Do you think quarks have substructure?')," said Dave Barney enthusiastically at the end of the last international masterclass day in 2006.

The CERN and Caltech VRVS teams