The first results from the LHC, as well as recent results from the Tevatron, were among the highlights of Beauty 2011 – the latest conference in the series on physics involving the beauty quark.

The 13th International Conference on B-Physics at Hadron Machines (Beauty 2011) was held at the Felix Meritis building in the historic centre of Amsterdam on 4–8 April. Hosted by Nikhef, the National Institute for Subatomic Physics of the Netherlands, the meeting attracted about 100 participants, including experts from Europe, America and Asia. There were 60 invited talks.

The main topic was the physics of $B_q$ mesons, which consist of a $b$ (“beauty”) quark and an anti-$q$ quark, where $q$ can be an up, down, strange or charm quark. These particles offer interesting probes for precision tests of the Standard Model. In this context, asymmetries between decay rates of $B$ and $\bar{B}$ mesons, which violate the charge-parity (CP) invariance of weak interactions, play a key role. Such observables and various strongly suppressed rare decays of $B$ mesons show a sensitivity to “new physics”, thanks to the possible impact of the contributions of new particles to virtual quantum loops.

The search for these indirect footprints of physics beyond the Standard Model through high-precision measurements is complemented by the search for direct signals of new particles at high-energy colliders. Here, physicists aim to produce new particles (such as supersymmetric squarks or new gauge bosons) and to study their decays in general-purpose detectors – ATLAS and CMS, in the case of the LHC at CERN. The exploration of heavy flavours, and the $B$-meson system in particular, is the target of the LHCb experiment, which is exploiting the many $B$ mesons that are produced in the proton–proton collisions at the LHC.

Studies of CP violation
The Beauty conferences traditionally have a strong focus on studies of $B$ mesons at hadron machines. In the previous decade, this field was the domain of the CDF and DØ experiments at the Tevatron, the proton–antiproton collider at Fermilab. The electron–positron $B$ factories at SLAC and KEK, with the BaBar and Belle detectors respectively, were the first to establish CP violation in the $B$-meson system, while the Tevatron experiments have extended the measurements into the $B_s$-meson sector, which is still poorly explored. These studies have shown that the Cabibbo-Kobayashi-Maskawa matrix is the dominant source of flavour and CP violation, in accordance with the Standard Model.

However, there is evidence that this model is not complete and recent studies of $B_s$-decays by the CDF and DØ collaborations give a hint of new sources of CP violation in a quantum-mechanical phenomenon, $B_s$-$\bar{B}_s$ mixing – although the uncertainties are still too large to draw definite conclusions. In specific scenarios for physics beyond the Standard Model (such as supersymmetry and models with extra $Z'$ bosons), it is actually possible to accommodate the effect of new physics of this kind.

The first physics results from the LHC experiments were the main highlight of Beauty 2011. It was impressive to see the
Conference

wealth and high quality of the data presented. The LHCb collaboration’s presentation of the first analysis of the CP-violating observables of the $B_s \rightarrow J/\Psi \phi$ decay was particularly exciting. Although the experimental errors are still large, it is intriguing that the data seem to favour a picture similar to the results from CDF and DØ, mentioned above. Fortunately, the LHCb experiment should be able to reduce the uncertainties significantly within a year, with the prospects of revealing new phenomena in $B_s - B_s$ mixing.

Quantum loops
Another exciting decay in which to search for new physics is the rare decay $B_s \rightarrow \mu^+\mu^-$, which originates from quantum-loop effects in the Standard Model. New particles running in the loops or even contributing at the tree level may significantly enhance the decay rate. So far, this decay has been the domain of the CDF and DØ experiments; they have put upper bounds on the branching ratio that are still about one order of magnitude above the Standard Model prediction. Now LHCb has entered the arena, presenting a first upper bound that is similar to the results from the Tevatron. The constraints from LHCb, and soon those from ATLAS and CMS, will quickly become stronger and it will be interesting to see whether eventually a signal for $B_s \rightarrow \mu^+\mu^-$ will emerge that is significantly different from the predictions of the Standard Model.

In addition to these key channels that are facilitating the search for new physics in $B$ decays in the early phase of the LHC, the conference covered a range of other topics. Results on heavy-flavour production were presented with the first LHC data collected in the ATLAS, CMS, LHCb and ALICE experiments. Another interesting topic was charm physics, with results from the BES III experiment, CDF and the first analyses from LHCb. A summary was given of $B$-factory results on the measurement of CP violation and the unitarity triangle parameters and the status of lepton-flavour violation and models of physics beyond the Standard Model was also presented. Moreover, the potential of upcoming $B$-physics experiments – SuperB, SuperKEKB and the LHCb upgrade – was discussed.

The many experimental presentations were complemented by theoretical review talks. Theory also figured in the conference summaries, in which Andrzej Buras of the Technische Universität München developed a vision for theory for 2011 and beyond, while the outgoing LHCb spokesperson, Andrei Golutvin, highlighted the experimental results. The discussions about physics also continued in an informal way during a tour on historic boats through the canals of Amsterdam, with people enjoying the spectacular weather and a visit to the Hermitage museum where the conference dinner was held.

Beauty 2011 showed that these are exciting times for $B$ physics, with plenty still happening at the Tevatron and the first physics results from the LHC. It will be interesting to see whether the data collected by LHCb and the general-purpose detectors in 2011 will already reveal new physics in the $B$-meson sector. Flavour physics is moving towards new frontiers and is a fascinating part of the LHC adventure. Correlations between various flavour-physics observables and the interplay with the direct searches for new particles will play a key role in obtaining insights into the physics lying beyond the Standard Model.

For further information and the slides of the presentations, visit the conference webpage www.beauty2011.nikhef.nl.

Résumé
La beauté à Amsterdam

Les premiers résultats du LHC, ainsi que les résultats récents du Tevatron, ont été à l’honneur lors de la conférence Beauty 2011, qui s’inscrit dans une série de conférences sur la physique du quark beauté. Accueillie par le NIKHEF (Institut national de physique subatomiques des Pays-Bas), elle a rassemblé une centaine de participants, dont des spécialistes éminents venus d’Europe, d’Amérique et d’Asie. L’accent a été mis particulièrement sur la physique des mésons $B_s$, domaine où les mesures précises de confirmation du Modèle standard pourraient conduire à une nouvelle physique. Jusqu’à présent, ce domaine a été exploré surtout par les expériences du Tevatron, qui ont trouvé quelques effets surprenants qui font maintenant l’objet de recherches au LHC.

Robert Fleischer, Nikhef.
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