

## Editorial: Beauty in the South of France

---

### Robert Fleischer

*Nikhef and Department of Physics and Astronomy, Vrije Universiteit Amsterdam, Amsterdam, Netherlands*

*E-mail: [robert.fleischer@nikhef.nl](mailto:robert.fleischer@nikhef.nl)*

### Neville Harnew

*Department of Physics, University of Oxford, Oxford, United Kingdom*

*E-mail: [neville.harnew@physics.ox.ac.uk](mailto:neville.harnew@physics.ox.ac.uk)*

### Olivier Leroy

*CPPM, Aix Marseille Université, CNRS/IN2P3, Marseille, France*

*E-mail: [Olivier.Leroy@in2p3.fr](mailto:Olivier.Leroy@in2p3.fr)*

The International Conference on *B*-Physics at Frontier Machines, “Beauty 2016”, was held in the Hotel Mercure Vieux-Port, Marseille, France from 2nd to 6th May 2016. It was the 16th edition of the series “International Conference on *B*-Physics at Frontier Machines”, initiated in the Czech Republic in 1993. The aims of the conference are to review the latest theoretical and experimental results in heavy flavour physics and to discuss the future programmes. Beauty 2016 covered a wide range of topics including studies of CP violation and rare decay properties of beauty and charm hadrons. The conference attracted 91 scientists from all over the world, with a programme consisting of 66 invited talks split into 18 theoretical and 48 experimental presentations. In addition, nine early career researchers presented posters with short plenary talks in a dedicated session.

*16th International Conference on B-Physics at Frontier Machines  
2-6 May 2016  
Marseille, France*

These are exciting times for particle physics, with Run 2 of the LHC providing a wealth of new experimental data and theorists making great efforts to interpret them. Flavour physics is an essential part of this programme. In addition to the observation of the Higgs boson, highlights of the previous LHC Run 1 were the observation of the rare decay  $B_s^0 \rightarrow \mu^+ \mu^-$  and constraints imposed on CP violation in  $B_s^0$  decays with unprecedented precision.

The Beauty 2016 conference focussed on research at the high-precision frontier, putting it into context with the global picture of high-energy physics and also the quest for physics beyond the Standard Model. The meeting was opened by Hitoshi Murayama (University of California, Berkeley and Kavli Institute for the Physics and Mathematics of the Universe, Tokyo), who provided an overview and outlook of the theory landscape in the era of the LHC. Heavy flavour physics, in particular decays of  $b$ -hadrons, offers interesting probes of physics beyond the Standard Model in which new particles may manifest themselves in observables which can be calculated and measured with high precision. Run 1 of the LHC has resulted in new milestones in this research with the discovery of the rare decay  $B_s^0 \rightarrow \mu^+ \mu^-$  and constraints for CP violation in  $B_s^0 \rightarrow J/\psi \phi$  decays. Moreover, several puzzling patterns in data for rare  $b$ -hadron decays have emerged, which set the scene for a very inspiring atmosphere at the conference.

Varieties of interesting new results were presented at Beauty 2016. Highlights included the world's best measurement of the semileptonic CP asymmetry in  $B_s^0$ - $\bar{B}_s^0$  mixing by the LHCb experiment. The corresponding observable,  $a_{SL}^s = [0.39 \pm 0.26 \text{ (stat)} \pm 0.20 \text{ (syst)}]\%$ , probes a difference between  $B_s^0 \rightarrow \bar{B}_s^0$  and  $\bar{B}_s^0 \rightarrow B_s^0$  transitions. The new LHCb result is in agreement with the Standard Model expectation, hence not confirming a previous intriguing result by the DØ Collaboration. ATLAS presented the world's best measurement of the decay width difference  $\Delta\Gamma_d$  of the  $B_d^0$ -meson system, CMS reported the double Upsilon production result at  $\sqrt{s} = 8 \text{ TeV}$ , and the BaBar collaboration released the first study of the rare  $B^+ \rightarrow K^+ \tau^+ \tau^-$  decay, which is experimentally very challenging.

Interesting presentations and lively discussions were devoted to the “flavour anomalies” in the current data. In particular the  $R(D^{(*)}) = \text{BR}(B \rightarrow D^{(*)} \tau \nu) / \text{BR}(B \rightarrow D^{(*)} \ell \nu)$  ratio measurements ( $\ell = \mu, e$ ), which provide a test of (non)-lepton universality, give current experimental values which are about  $4\sigma$  away from Standard Model expectations. The rare  $B^0 \rightarrow K^{*0} \mu^+ \mu^-$  decay was also a hot topic of discussion, where one observable of the angular distribution of its decay products,  $P_5'$  looks particularly intriguing.

The experimental talks were complemented by theory overview talks of rare  $B$  decays, possible implications for violation of lepton flavour and universality, and for physics beyond the Standard Model in general. A crucial element for the interpretation of the data is the point of reference given by the Standard Model. In the case of  $P_5'$ , the situation is complicated in view of effects from strong interactions, and this has to be clarified in the future. There has also recently been impressive progress on lattice QCD to calculate quantities which are crucial as inputs for theoretical predictions. A key example is the decay constant of the  $B_s^0$  mesons, which enters the prediction of the  $B_s^0 \rightarrow \mu^+ \mu^-$  branching ratio. Also there has been significant progress in calculations of hadronic form factors, which again play key roles. It will be very interesting to see how the data for the corresponding observables will evolve at Run 2 of the LHC, and an interplay between theory and experiment will be essential.

Concerning CP violation, LHCb reported new world-best measurements of the determination

of the angle  $\gamma$  of the unitarity triangle from pure tree decays. The measured value,  $(70.9_{-8.5}^{+7.1})^\circ$ , still has a significant uncertainty and leaves much space for future improvement. Concerning the exploration of CP violation in the  $B_s^0 \rightarrow J/\psi\phi$  decay, which is predicted to be very small in the Standard Model, the experimental precision has reached a level where effects from penguin topologies have to be included. The recent experimental results were presented with the state-of-the-art strategies to interpret these data.

There was also a session dedicated to charm physics with experimental and theoretical presentations, focusing on mixing and CP violation as well as rare  $D$ -meson decays. Whilst CP violation in the charm sector has not yet been observed, LHCb is close to approaching Standard Model expectations.

Presentations were also devoted to hadron spectroscopy and exotic states, where in particular the pentaquark state observed by LHCb has received much attention. A  $(udsb)$  state recently reported by DØ has not been confirmed in LHCb data. The rich wealth of data from BES-III was also discussed.

Another topic on the Beauty 2016 agenda was kaon physics. Recent theoretical progress in direct CP violation in the neutral kaon system has provided results which are not in good agreement with experiment, thereby adding yet another “flavour anomaly” which has to be understood. Furthermore, an exciting prospect will be a search for beyond the Standard Model physics through the measurement of the rare decay  $K^+ \rightarrow \pi^+ \nu\bar{\nu}$  at the NA62 experiment in the near future.

The future programme of experimental heavy-flavour physics was another important topic. The super- $B$  factory at KEK will start data taking in 2018 and where the Belle-II experiment is under construction, and further exciting new options will emerge in the upgrade era of the LHC. Also extreme flavour studies beyond the LHCb Upgrade were discussed, as well as possibilities for flavour studies at the Future Circular Collider (FCC). The conference was concluded by two excellent and very stimulating summary talks: Estia Eichten (Fermilab) discussed the theoretical aspects of flavour physics while Marie-Hélène Schune (LAL, Université Paris-Sud, CNRS/IN2P3) gave a summary of the experimental results.

The scientific part was complemented by an enjoyable social programme, including a reception by the mayor of Marseille for a cocktail in the City Hall, a boat trip to the Calanques National Park with its impressive white limestone cliffs, and a guided tour of the old city of Marseille. There was an outreach event in the famous library “Alcazar” with three fun programmes: a scientific speed dating, an outreach talk on antimatter by François Le Diberder including a live video transmission with the LHCb pit at CERN, where Patrick Robbe presented the LHCb detector to the audience. The conference dinner was held in “La Nautique”, a floating restaurant on the old harbour offering a spectacular venue.

In summary, the 16<sup>th</sup> Beauty conference was a great success, and we look forward to the next Beauty conference in 2018!



**Figure 1:** Group photograph of the Beauty 2016 participants in front of the conference venue.