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Editorial

Focus Point on Taking stock: measurements, searches and discoveries at the LHC

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The experiments at CERN's Large Hadron Collider (LHC) have gained considerable attention during these recent years, both inside and outside the scientific community. Key to this was the remarkable success of the first LHC running period in the years 2010–2012, that culminated in the announcement, by the ATLAS and CMS Collaborations, of the discovery of the long-sought Higgs boson in July 2012. Besides this obvious highlight, all collaborations, including also the ALICE and LHCb experiments, have achieved outstanding performance of their detectors and carried out numerous analyses that altogether have resulted in an amazing number of more than 1300 publications to date. A considerable fraction of these papers focused on the search and the later studies of the Higgs boson, on direct searches for physics beyond the standard model and on precision measurements of known standard model processes. Not surprisingly, many review articles have already been published on these topics. However, somewhat less attention, in terms of overviews and summary publications, has been paid to other two areas of LHC physics, where major achievements have been made during this first LHC run. These are the physics topics focusing on the collision, production and/or decays of *heavy* objects, namely *heavy ion physics* and *heavy flavour physics*. In fact, two of the four experiments have been designed with particular attention to the optimal study of the related phenomena, namely ALICE and LHCb, respectively. However, it should be said that also ATLAS and CMS have made important contributions to the overall physics output in these sectors.

Both heavy ion and heavy flavour physics are characterized by many important open fundamental questions. In the first case, it is both an experimental and a theoretical challenge to understand and describe, in detail and at great precision, the state of coloured matter at the highest achievable energy densities and particle multiplicities. Among the many highlights of these recent years, it should be mentioned that at the LHC it has become possible, for the first time, to study many different types of (really) hard probes (jets, electroweak bosons, heavy quarks etc.) that emerge from the initial hot and dense system. This and many other important aspects and results are reviewed in the summary article by N. Armesto and E. Scomparin.

On the side of heavy flavour physics, I think it is fair to say that the flavour sector of the standard model is the least understood part of this theory. While the phenomenology is very successful, we lack a deeper understanding of the family structure, of the mass hierarchy and of the mixing patterns, both concerning quarks and leptons. Here it is important to increase the precision with which production, decay and mixing behaviour of heavy-flavoured particles are studied, and to search for very rare decays of such states. In all these cases new physics phenomena could manifest themselves, via quantum-loop effects and thus at new mass scales not necessarily accessible by direct detection, in the form of deviations from the standard model predictions. A much discussed highlight at the LHC, in terms of such rare decays, has been the first observation of the very rare $B_s \to \mu^+\mu^-$ decay by the LHCb and CMS experiments. An extensive review of this and similar indirect searches for new physics with heavy flavour decays can be found in the article by G. Isidori and F. Teubert.

I am convinced that these two excellent review articles, forming a Focus Point on two particular sectors of the rich LHC physics programme, will be interesting for experts, for newcomers and for generally interested readers alike. They also represent a timely snapshot of the overall situation, after the first LHC years and now in the early phases of its second running period, with many further interesting and possibly unexpected new insights to arrive in the coming years.

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Guest Editor