Experimental summary and outlook

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For the first time at a 'Physics at the LHC' conference real collision data and results were presented from the LHC. Selected samples from the huge amount of commissioning studies have been described in this talk, all of which illustrate how impressively well the LHC experiments are ready for physics. Alongside, the Tevatron collider and its experiments continue to deliver efficiently a rich harvest of physics results, and only a few highlights could be emphasised. A roadmap of expected physics to come from the two hadron colliders has been sketched.

1 Introduction

The LHC began high-energy operation on 30th March 2010, with 7 TeV centre-of-mass pp collisions. This marks clearly the beginning of a new era in particle physics, the eagerly awaited journey into new territory at the energy frontier can start. The two most important messages of this conference can simply be summarized as: This is the first 'Physics at the LHC' conference with the LHC running, and the LHC experiments presenting real data from collisions, and the data presented demonstrate that the experiments are extremely well prepared for producing fast high quality physics results.

The progress of the LHC collider has been outstanding over the past months, and at the time of writing (end of July 2010) the data samples accumulated and analysed by the experiments have superseded the ones shown at the conference by more than an order of magnitude. Furthermore, as all the sophisticated analyses will be documented in these proceedings in detail, and 'first-hand' by those directly involved in the work, the experimental summary talk will not be reproduced here. It will be limited to a few general comments.

2 Commissioning the LHC experiments

It is impressive to note that the four large LHC detectors (ALICE, ATLAS, CMS and LHCb) are already operated, only a couple of months into the run, with very high efficiencies for data taking. For example the large, complex general purpose detectors ATLAS and CMS reported for all their subsystems typically more than 98% of the readout channels working, and overall data taking efficiencies above 90%. Even though they did not yet have to stress-test their trigger schemes with the luminosities reached so far at this stage by the LHC, very detailed studies with unbiased data allowed them to verify an accurate understanding of rates and threshold behaviours.

A huge variety of performance studies were reported by all experiments using the minimum bias data collected during the 900 GeV run end of last year and with the 7 TeV data from the current run over the last two months. These performance studies culminate in 'rediscovering' many classical resonance signals, charmed meson mass peaks, as well as the J/ψ decaying into lepton pairs. The resolutions are approaching already in many cases the design values, and detailed features like for example hit distributions, particle identification capabilities and energy distributions are almost perfectly well described by Monte Carlo simulations. It is not exaggerated to state that never in the past experiments have been ready to such a great extent when starting up operation with beams. This is certainly only possible thanks to a long history of test beam studies, which condition the detector simulations, combined with exploiting the huge amounts of cosmics data from the last couple of years. The collision data is now already used to 'fine-tune' the understanding of the detectors.

LHCf, one of the two small dedicated forward experiments, has been accumulating data of high quality since the start, whereas TOTEM has demonstrated its readiness to join running soon when conditions will permit.

A special comment is due to the smooth performance of the computing and software chains. The experiments have been able to efficiently handle large amounts of date, distributed worldwide in the collaborations, and to very quickly analyse them and produce results within days. The WLCG as backbone to all these operations has been crucial, and delivered reliably the expected performance.

3 Understanding the environment: minimum bias events at LHC

The first LHC physics publications cover basic features like differential and global charged particle multiplicity and transverse momentum distributions. All four experiments showed new results, allowing one to make detailed comparisons with Monte Carlo predictions. There is clearly a need for tuning the latter in order to get satisfactory descriptions of the pp event environment at the new energies of LHC. Further results addressed more detailed aspects, like the structure of the underlying events, distributions of identified particle types, and multiparticle correlations.

An important ingredient for the quantitative understanding of LHC physics will be the knowledge of parton distribution functions. The final HERA structure function results presented at this conference are of particular relevance in this respect.

4 Physics and outlook

Whereas the LHC is just entering the scene, the Tevatron Collider at Fermilab is continuing to perform in a superb way. The CDF and D0 collaborations operate with high efficiency their well understood detectors, and exploit them with highly developed analysis skills. No doubt that they have still a major potential for great physics in the near future. During that time the LHC experiments will continue to 'rediscover' the known particles from the Standard Model and make first basic measurements at 7 TeV. At this conference ATLAS and CMS have shown the first handful of W and Z events, again demonstrating that the detectors work well, and they are eagerly preparing for the Top as a next step.

Both CDF and D0 have shown a rich harvest of physics results which are discussed in many excellent summary talks, as well as the most topical ones in dedicated expert presentations. Combining their data they will remain certainly at the forefront for the Higgs search still for a couple of years, and in precision measurements, like the W mass measurement, it will take the LHC experiments still several years to match them. Owing to the high collision energy, the LHC is expected to take leadership in the coming year for searches of heavy mass objects like for example SUSY particles and W' or Z'. For the Higgs, combining ATLAS and CMS, a definite statement about its existence or not should be possible around 2015 when the LHC will have accumulated some $10\,\mathrm{fb}^{-1}$ or more at 14 TeV.

It is interesting to note that early hints for New Physics beyond the Standard Model could well come from the Heavy Flavour physics in the first years at LHC.

The turn-on of the LHC opens a great era for our community; exciting times are ahead of us!