The ATLAS Experiment at the pp-Collider LHC ◊

S. Chouridou, M. Deile, N. P. Hessey, D. Schaile, A. Staude, R. Ströhmer, and T. Trefzger

The pp-collider LHC at the international research center CERN, Geneva, is the only approved accelerator project in particle physics which will extend the energy available for hard constituent collisions by an order of magnitude.

A central motivation of this accelerator arises from the question of the origin of particle masses: The Standard Model (SM) of particle physics is based on the principle that forces are a natural consequence of symmetry requirements to the basic equations of the theory. The very precise experiments at the e^+e^--colliders LEP and SLC test this theory at an accuracy where quantum corrections to several observables become significant. The calculation of higher order corrections makes extensive use of the validity of the symmetry requirements of the SM. The fact that the precisely measured observables are all consistent with a single set of very few SM parameters, and even more, that the mass of the top quark which was recently discovered at the $p\bar{p}$-collider Tevatron coincides with the value needed to describe these measurements, are an impressive experimental validation of the symmetry requirements of the SM. Up to now, however, there is absolutely no experimental hint of a mechanism called spontaneous symmetry breaking which explains how these symmetry requirements can be fulfilled in a world with massive particles. The quest to understand this mechanism is not only restricted to the SM but may become a key feature in explaining the evolution of the universe. If this mechanism resembles the SM explanation we are bound to find at least one elementary particle with spin 0, the Higgs boson, which must not be heavier than the discovery reach of LHC.

There is a general agreement, however, that the SM is only a low energy approximation to nature with several open problems. The discovery potential of the LHC covers an energy scale which will probe promising theoretical concepts that offer solutions.

An interesting aspect of LHC is also the high production rate of heavy quarks. In the SM, all CP conserving and CP violating weak decays of quarks are characterized by only 4 parameters. There are doubts, however, whether these are sufficient to explain the dominance of matter over antimatter in the universe and in this context the bottom quark sector is regarded as the Achilles heel of the SM. Also of particular interest is the investigation of the abundantly produced top quark because any mixing effects from new physics at very high energy scales are expected to be largest in the most massive fermions we can study.

First pp-collisions at LHC are expected in 2005. The construction of two complementary general purpose detectors, ATLAS and CMS, which will pioneer the exploration of the physics potential of LHC is already well on its way. The LMU Munich group is participating in the ATLAS experiment [1] together with about 150 institutes from 35 countries. The design of the ATLAS detector, shown in Fig. 1, has been optimized to attack the physics challenges above. The central detector, a combination of high resolution pixel and strip detectors in the inner part and straw tubes with transition radiation capability in the outer part, is contained within a solenoidal magnetic field of 2 T. Electromagnetic energy is measured in a Liquid Argon sampling calorimeter with excellent performance in terms of energy and position resolution. The bulk of hadronic calorimetry is provided by a novel technique based on scintillating tiles. The LMU Munich contributes in close collaboration with the MPI für Physik in Munich to the construction of the muon spectrometer [2], which is the outmost layer of the ATLAS detector with a total diameter of about 23 m and a length of 45 m.

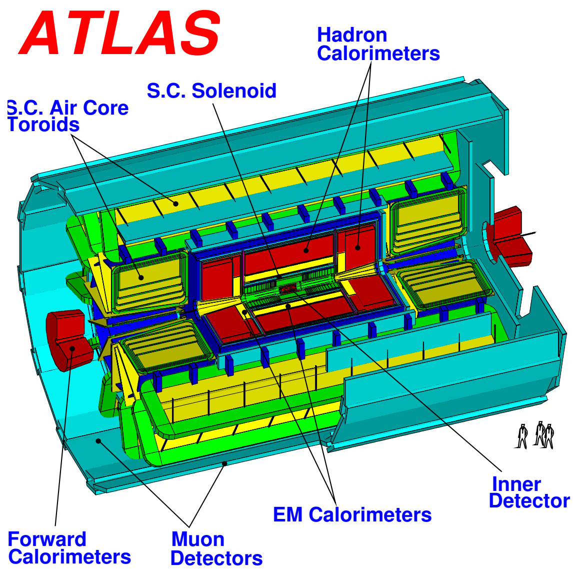

Fig. 1: The ATLAS detector.

The quality of the muon measurement has been one of the guiding design criteria of the ATLAS detector. A system of three large superconducting air-core toroid magnets, precision tracking detectors and a powerful dedicated trigger system ensure a reliable, high resolution ($\Delta p_T/p_T^2 \approx 10^{-4}$ GeV^{-1} above the multiscattering limit of $\Delta p_T/p_T \approx 2\%$) and stand-alone performance over a p_T range from 5 GeV into the TeV region.

The precise measurement of the muon trajectories is achieved by several layers of pressurized drift tubes which are arranged into chambers of manageable geometry. The challenge of this detector system is to develop stable operating and calibration procedures which guarantee a single hit accuracy of 80 μ and a demanding relative alignment of tubes with reference points controlled to the level of 30 μ. This requires substantial R&D work in the laboratory as well as in test beams with high energy muons at CERN and special quality control and calibration efforts during the production with ongoing activities described in this report.

References

[1] ATLAS Technical Proposal, CERN/LHCC/P2, 1994.
[2] ATLAS Muon Spectrometer, Technical Design Report, CERN/LHCC/97-22, 1997.

◊ supported in part by the BMBF