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TOPICAL VOLUME 4 (S1), 2002

III International Symposium on LHC Physics and Detectors

Chia, Sardinia (Italy) – October 25-27, 2001

Editors: C. Bosio, R. Cashmore, D. Haidt, B. Saitta, J. Schukraft

This Symposium, attended by about 120 physicists from all over the world, was jointly organized by CERN and INFN.

Over three full days, its scientific programme not only covered all aspects of physics possible at LHC, but also overviews of deep inelastic scattering and neutrino experiments, as well as programmes at future accelerators. The status of all the LHC experiments was presented, compared and discussed along with results and the status of relevant experiments elsewhere. Discussions were lively and young people had the opportunity to present their work.

EPJdirectC publishes the results of the workshop as Topical Volume 4 (S1). All articles have been peer reviewed according to the standards of EPJC.

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Status of the ATLAS project

Peter Jenni

Abstract. The construction status of the ATLAS detector is presented. Within a tight schedule the project is on track to record the first physics events from the Large Hadron Collider in spring 2006 with an initial detector configuration that is capable of searching successfully for bench-mark processes like Higgs and SUSY particle productions.

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CMS overview

M. Della Negra

PACS: CMS, Assembly, Magnet, Tracker, Calorimeter, Muon, Cost, Schedule

Abstract. The CMS detector is described. The status of the construction is reviewed. The civil engineering work at point 5 is progressing well although some delays have been accumulated due to the bad geological conditions. The underground caverns will be ready in July 2004. The magnet construction is well advanced and on schedule with a test of the magnet on the surface in July 2004. Mass production has started for all sub-detector parts: silicon tracker, crystal calorimeter, hadron calorimeter and muon chambers. The TRIDAS architecture has recently evolved with a new design of the large 512×512 switch. The software and computing project is reviewed. Priority is given to High-Level Trigger studies. Finally the cost and schedule of CMS is discussed. A low luminosity detector can be ready in August 2006. The low luminosity detector is the complete CMS detector, except the 4th endcap muon station and the 3rd forward pixel layer.

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Status of the LHCb experiment

T. Nakada

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. LHCb is a dedicated experiment to study CP violation and other rare processes in the B meson system at LHC. It is designed to exploit the large sample of B_d and B_s mesons available at LHC by having a trigger system efficient for both leptonic and hadronic final states, particle identification capability over large momentum range and excellent decay time resolution. After the approval of Technical Design Reports of various subdetector systems, construction of detector components has started. The experiment is planned to be ready for data taking from the beginning of the LHC operation.

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Status of the ALICE experiment

P. Giubellino

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. ALICE (A Large Ion Collider Experiment), the dedicated detector designed to study nucleus–nucleus collisions at the LHC, is developing rapidly. While the experimental area is being cleared of the last elements of the L3 detector, who stopped data taking at the end of 2000, the ALICE collaboration is at work for the first steps of the installation of the detector, namely the refurbishing work on the L3 magnet and the adaptation of the infrastructure.

In the meantime, in the 77 laboratories of the Collaboration, the work of preparation of the detectors is changing gear: the R&D is completed on almost all elements, with some notable advances in innovative technologies, and the major detectors components have entered the production phase.

Moreover the TRD, a major new detector designed to expand the ALICE capability to identify electrons, has reached the Technical Design Report stage and is now being discussed by the LHCC.

The status of our understanding of the ALICE Physics potential is described in other papers in these proceedings, so I will concentrate here on a brief description of the ALICE detectors, with mention of the most recent results achieved.

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Design and expected performance of the ATLAS trigger and event selection

S. George

PACS: 07.05.Hd 07.05.Kf 29.90.+r

Abstract. The LHC and ATLAS present the T/DAQ system with a highly challenging environment: the unprecedented LHC rate of 10^9 interactions per second with large and complex detectors with $\mathcal{O}(10^8)$ channels to read out; the bunch crossing rate of 40 MHz requires a decision every 25 ns, while the event storage rate is limited to $\mathcal{O}(100)$ MB/s. Within these constraints, the ATLAS T/DAQ system must separate rare physics signatures from the overwhelming rate of background events. This paper gives an overview of the T/DAQ system and describes how the high level triggers are being designed to meet these challenges. Data bandwidth and processing times in the higher level triggers are reduced by region of interest guidance from the first level trigger and sequential steps in the reconstruction process. Flexibility is paramount in order to adapt to the changing luminosity, backgrounds and physics goals. This is achieved by simple, inclusive trigger menus and modular software design. Algorithms have been developed which provide the flexibility to control the trigger rates.

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Electrons, photons, and muons in ATLAS

Alexandre Solodkov
for the ATLAS Collaboration

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. ATLAS is a general purpose experiment which will operate at the LHC. In this paper, the detector performance in terms of electrons, photons and muons identification and measurements are presented, combining full GEANT simulation and test beam results. Some of the prominent methods and event samples which will be used *in situ* to perform the calibration and evaluate the absolute energy scale are described as well. It is finally shown how these performances will allow ATLAS to accurately reconstruct signal mass peaks in several physics benchmark channels.

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Expected performance of ATLAS for measurements of jets, b-jets, τ-jets, and E_T^{miss}

Mariusz Sapinski
on behalf of the ATLAS Collaboration

PACS: 14.80.Bn; 29.40.Vj

Abstract. Jets and missing energy are among the most important objects for LHC physics. The accuracy of measurements of missing energy and direction and energy of jets puts strong requirements on the detector performance. These requirements and the ATLAS Calorimeter system which is projected to fulfill these requirements are presented. The jet reconstruction algorithms and jet energy scale calibration are briefly discussed. Forward jet tagging, b-tagging and τ-tagging are important issues for many physics analyses. Reconstruction of resonances is an example of complex use of calorimeter performance. Results presented here are based on simulation of the detector and the physics processes.

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CMS trigger and event selection

S. Dasu
representing the CMS Collaboration

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. CMS trigger and event selection system is described. The hardware level-1 trigger algorithms and simulated performance is presented. The results indicate that the billion interactions per second rate that will be seen by CMS can be reduced to 75 kHz by this system with high efficiency for the physics signals. The strategy for software high level triggers which are expected to reduce this 75 kHz rate down to 100 Hz of selected interesting physics events is also described.

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CMS: Electrons, photons, and muons

N. Neumeister
on behalf of the CMS Collaboration

PACS: CMS, Muon Trigger, High Level Trigger, Electrons, Photons, Muons

Abstract. The Large Hadron Collider (LHC) at CERN will provide proton-proton collisions at a centre-of-mass energy of 14 TeV and a bunch crossing interval of 25 ns. At design luminosity, $\mathcal{L} = 10^{34}$ cm^{-2}s^{-1}, an average of 17 collisions will occur at each bunch crossing, resulting in a billion inelastic pp interactions per second. The CMS (Compact Muon Solenoid) experiment is designed

to study these high energy proton-proton collisions to understand electroweak symmetry breaking and to search for new physics processes. In the search for new physics identification and precise reconstruction of electrons, photons and muons will be a key issue. This article describes the layout and the simulated performance of the Electromagnetic Calorimeter and the Muon System. The electron, photon and muon reconstruction algorithms, designed in the framework of the High Level Trigger software, are described.

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CMS: Jet/b, Jet/τ, Missing E_T

L. Silvestris
on behalf of the CMS Collaboration

PACS: CMS, Jet Identification, τ tagging, τ trigger, b tagging, Missing E_T

Abstract. The CMS detector has been designed to detect diverse signatures of new physics at Large Hadron Collider (LHC). It will do so by identifying and precisely measuring muons, electrons, photons and jets over a large energy range. In this article will be described the layout and the performances for the Inner Tracker and the Calorimeter System: electromagnetic and hadronic components. These CMS sub-systems play an essential role in jet identification and missing transverse energy studies. They are also important in studies on τ and b trigger and tag.

EPJ direct C 4 (S1), 12
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Operation and physics potential of Tevatron Run 2

John Womersley

PACS: 12.60, 13.85, 14.80, 29.20

Abstract. Run 2 at the Fermilab Tevatron collider is now starting up. This article reviews the current performance of the upgraded CDF and DØ detectors, and outlines the physics goals and prospects for this run.

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Total cross section and luminosity

G. Matthiae

Abstract. The measurement of the total cross section and of the machine luminosity is the first objective of the experiment TOTEM. The total cross section will be measured with the luminosity independent method based on the simultaneous measurement of low momentum transfer elastic scattering and of the rate of inelastic interactions with fully inclusive trigger. Elastic scattering events will be detected with the Roman pot technique using a suitable machine optics obtained by properly tuning the quadrupoles in the intersection region. The measurement of the total cross section will be followed in due course by the study of elastic scattering at large momentum transfer and of diffractive processes.

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Low-P_T proton–proton physics at low luminosity at LHC

Jean-Pierre Revol

Abstract. This review of *Low-P_T proton–proton physics at low luminosity at LHC* should cover all LHC experiments, but in practice, is mainly related to ALICE, for reasons which will be explained. However, the relevance to other LHC experiments is clear, as low-P_T phenomena represent an important component of the background to their high-P_T phenomena which needs to be calibrated. The ALICE Collaboration will study proton-proton collisions as part of their heavy-ion program, where most signals are relative to the proton-proton system. In addition, the ALICE detector's unique acceptance at low-P_T as well as its unique particle identification capability will make it possible to carry out a program of genuine proton-proton physics complementary to those of other LHC experiments.

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Prospects for precision measurements at the Large Hadron Collider

O.M. Røhne

Abstract. The Large Hadron Collider with its two general-purpose proton-proton experiments Atlas and CMS provides ample opportunities for precision measurements of Standard Model parameters. Ultimate precisions of 15 MeV for the W boson mass and better than 1 GeV for the top mass are expected. Sensitivities to triple gauge couplings will improve by orders of magnitude. Novel areas like single top production and high-mass Drell–Yan lepton pairs will be open to exploration.

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Higgs physics at the LHC

K. Lassila-Perini

PACS: 12.60.Fr 12.60.Jv 14.80.Bn 14.80.Cp

Abstract. The physics of the Higgs sector in the Standard Model and the Minimal Supersymmetric Standard Model at the LHC is reviewed. The Higgs discovery reach of the two general-purpose experiments, ATLAS and CMS, is summarised.

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Supersymmetry at LHC

Shoji Asai
for the ATLAS and CMS Collaborations

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. This document describes prospects for discovering Supersymmetry and studying its properties at Large Hadron Collider (LHC). ATLAS and CMS collaborations have enormous potential to discover Supersymmetry, if it exists at mass scale less than about 2 TeV. Methods and potentials to determine the properties of SUSY particles using various kinematic distributions are also summarised.

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Digital Object Identifier (DOI):
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Exotica at LHC

P. Miné

Abstract. We review a variety of possible physics observable at the LHC energy, in extensions of the Standard Model and Supersymmetry. The discovery reach is discussed with examples from ATLAS and CMS.

Presented at *III International Symposium on LHC Physics and Detectors,* Chia, October 25–27, 2001

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First physics results from RHIC

T.S. Ullrich

PACS: 25.75.Dw

Abstract. The field of relativistic heavy ion physics is entering a new regime with the startup of the Relativistic Heavy Ion Collider (RHIC). RHIC commenced operation for physics in the Summer of 2000 in a short but successful run and continued in Fall 2001 delivering the highest center-of-mass energies for heavy ions ever reached in the laboratory. In this talk I give a brief overview of RHIC and its experiments, and discuss some of the many physics results obtained so far.

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Heavy ion physics at the LHC

Urs Achim Wiedemann

Abstract. I discuss the perspectives for new physics which become accessible with the heavy ion program of the Large Hadron Collider (LHC) at CERN.

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Hadronic measurements in ALICE

P. Foka
for the ALICE Collaboration

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. ALICE is the dedicated heavy-ion experiment at LHC. We discuss here the performance of the experiment for hadronic measurements and a few of the hadronic observables used to probe the system created in heavy-ion collisions. First results are shown from a test production of central Pb–Pb events using the full simulation and reconstruction offline software.

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Heavy quark measurements with ALICE

P. Crochet
for the ALICE Collaboration

PACS: 25.75.-q; 24.85.+p

Abstract. The capabilities of ALICE to measure hidden and open heavy flavours in nucleus-nucleus collisions at the LHC are reviewed.

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Heavy ion physics with CMS detector

G. Wrochna

Abstract. The CMS detector is well suited to study heavy ion physics. Hermetic calorimetry, a precise inner tracking and a background free muon system make possible to study a wide range of phenomena, including quark-gluon plasma (QGP) formation. Trigger and data acquisition systems are flexible enough to cope with a large range of rates and particle densities.

In this paper we describe those features of the CMS detector which are important for heavy ion physics. We also discuss its physics potential with the emphasis on hard QGP probes, like jet quenching and resonance suppression.

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The Time Projection Chamber for the ALICE experiment

Luciano Musa
on behalf of the ALICE Collaboration

Abstract. The Time Projection Chamber is the main tracking detector in the central barrel of the ALICE experiment. The task of large acceptance tracking in a heavy ion experiment is similar to that encountered in the NA49 and STAR experiments at the SPS and RHIC, respectively. However, the extreme multiplicities of ion collisions at the LHC set qualitatively and quantitatively new demands making new designs indispensable. In this paper we present an overview of the main components, and some of the most crucial aspects addressed by the R&D activities that have preceded the design and construction of the ALICE TPC.

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R&D in ALICE: The CsI-based RICH high momentum particle identification detector

Y. Andres, J. Barbosa, A. Braem, E. Carrone, D. Cozza, M. Davenport, G. De Cataldo, D. Dell'Olio, D. Di Bari, A. Di Mauro, D. Fraissard, A. Franco, U. Fratino, F. Guber, S. Igolkin, A. Kourepin, L. Liberti, P. Martinengo, A. Morsch, E. Nappi, G. Paic, F. Piuz, F. Posa, V. Razin, A. Reshetin, J.C. Santiard, E. Schyns, J. Seixas, K. Shileev, V. Tiflov, J. Van Beelen, T.D. Williams

Abstract. We report on the R&D studies performed on a CsI-based RICH detector with a liquid perfluorohexane radiator running pure methane at atmospheric pressure. The development, initiated by the CERN RD26 project in 1993, has been pursued in the framework of the ALICE/HMPID collaboration. A prototype of the detector under construction for ALICE is taking data since two years in the STAR experiment at RHIC.

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Results from the current experiments: BaBar, Belle, CLEO

H. Aihara

PACS: 13.25.Hw,11.30.Er,12.15.Hh

Abstract. Year 2001 marks the first observation of CP violation in the neutral B meson system. The observations reported by BaBar and Belle are summarized. Also presented are results from CLEO, BaBar and Belle on search for direct CP violation, measurements of radiative/electroweak penguin decays, and search for $D^0 - \overline{D}^0$ mixing.

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B physics at the Tevatron collider Run II

N.S. Lockyer

PACS: 13.20.He; 14.40.Nd

Abstract. The status of the Tevatron collider, the CDF and D0 experiments, and the planned B physics program at the collider are described. A few specific topics are highlighted from CDF and D0 in the first year of running. To illustrate some of the issues in a B physics analysis in a hadron collider, such as the LHC, a new improved jet-charge tagging method is presented from CDF Run I along with an updated $\sin 2\beta$ result. CDF measures a preliminary value of $\sin 2\beta = 0.91 \pm 0.32 \pm 0.18$.

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CP violation and the search for new physics

Gustavo C. Branco

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. We present an overview of CP violation in the Standard Model and Beyond, describing various possible sources of CP violation and how to search for them.

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LHCb level-0 muon trigger

Olivier Leroy
on behalf of the LHCb Collaboration

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. The LHCb experiment will study CP violation and rare phenomena using the b-hadrons copiously produced by the LHC, at CERN. A powerful trigger system is required to select efficiently b-hadron decays of interest, while reducing the 40 MHz input rate to a level acceptable for tape storage systems. This document gives an overview of one part of the LHCb trigger system: the level-0 muon trigger.

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The LHCb level 0 calorimeter trigger

U. Marconi
on behalf of the LHCb Collaboration

PACS: CP-symmetry, beauty, trigger

Abstract. The L0 calorimeter trigger of the LHCb experiment is described. It performs the first step of the B events selection in the multi-level LHCb trigger selection system. The L0 calorimeter trigger selects high transverse energy clusters reducing the 40 MHz event input rate down to 1MHz.

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The LHCb vertex trigger

F. Teubert
on behalf of the LHCb Collaboration

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. The second level trigger in LHCb (level 1) is based on the ability to reconstruct high impact parameter tracks in the vertex detector. The feasibility to reconstruct tracks using only the vertex detector in a time window of less than 1.7 ms is shown. Several algorithms under study to improve the performance of the vertex trigger are briefly described.

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Tracking in LHCb

M. Needham

Abstract. The LHCb tracking system is discussed in detail. The chosen technology for the inner and outer tracker and prototype development is described. The performance of the current system and ongoing optimization studies are described.

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Particle identification in the LHCb experiment

F.J.P. Soler
on behalf of the LHCb Collaboration

PACS: 13.20.Hw; 14.40.Nd; 29.40.Ka

Abstract. The present article describes the ring imaging Cherenkov (RICH) detectors of the LHCb experiment. The two RICH detectors of LHCb contain three radiators, carefully designed to provide particle identification of B meson decays in the relevant momentum range of the experiment. A status of the design of the RICH system will be presented with the expected overall performance.

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Prospects for B physics with the ATLAS and CMS detectors

G.F. Tartarelli

PACS: 12.15.Ff; 12.15.Hh; 13.20.He; 13.25.Hw; 14.20.Mr; 14.40.Nd; 14.65.Fy

Abstract. We describe the perspectives of the ATLAS and CMS experiments at the LHC in the B-physics field and review recent performance evaluations obtained by the two Collaborations. Despite having been designed for high-p_T physics, both experiments have a rich B-physics programme and can compete with dedicated detectors in many studies of B-hadron production, decay and CP violation. These results can significantly contribute to the knowledge of these phenomena in the LHC era.

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LHCb physics performance

P. Koppenburg
on behalf of the LHCb Collaboration

PACS: 25.70.Ef; 21.60.Gx; 27.30.+t

Abstract. The LHCb physics performance is presented with emphasis on the impact that LHCb can have on the determination of the CKM unitarity triangle.

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Visions of *ep* physics

B. Foster

Abstract. The subject of lepton-hadron scattering is discussed from its earliest beginnings, concentrating on what we have learnt from the HERA electron-proton storage ring. A brief selection of the HERA I results most relevant to LHC are discussed. The HERA and ZEUS upgrades are outlined, together with the HERA II physics programme. The impact of HERA results on LHC is discussed, in particular in the areas of luminosity measurement, background estimates and possible signatures of new physics. Finally, possible future developments in lepton-proton physics beyond HERA II are discussed.

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Present and future of neutrino oscillation experiments

A. Ereditato

Abstract. The possibility of a non-vanishing neutrino mass is an intriguing question in the present scenario of particle physics. On the one hand, there are no fundamental principles for the neutrino to be massless; on the other hand, a massive neutrino would indicate the existence of physics beyond the Standard Model of the elementary particles, hence representing a fundamental milestone in particle physics. In this paper a picture of the present experimental situation of massive neutrino physics is outlined

focusing on the strong experimental indications for neutrino oscillation. Emphasis is given to the future project aiming at the clarification of the scenario and to the assessment of the oscillation hypothesis. Future experiments will make use of neutrinos from astrophysics sources, from the Sun, from the atmosphere and from nuclear reactors and particle accelerators: it would be very hard to make an exhaustive review of these many experimental attempts. Therefore, I will only concentrate on (some!) solar, atmospheric and long baseline (LBL) accelerator neutrino projects and to their impact on the understanding of the neutrino mixing matrix.

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Visions: The coming revolutions in particle physics

Chris Quigg

PACS: 12.15.-y 13.85.-t 12.60.-i 14.80.Bn

Abstract. Wonderful opportunities await particle physics over the next decade, with the coming of the Large Hadron Collider to explore the 1-TeV scale (extending efforts at LEP and the Tevatron to unravel the nature of electroweak symmetry breaking) and many initiatives to develop our understanding of the problem of identity and the dimensionality of spacetime.

Contents Topical Volume 4 (S1), 2002