XXI International Workshop on Deep-Inelastic Scattering and Related Subjects

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Book of Abstracts
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WG6: Spin / 0

**Beam spin asymmetry of neutral pion in semi-inclusive electro-production**

**Author:** Zhun Lu

**Co-author:** Wenjuan Mao

We study the beam spin asymmetry $A_{LU}^{\sin \phi_h}$ in semi-inclusive $\pi^0$ electroproduction contributed by the T-odd twist-3 distribution function $g_\perp (x, k_T^2)$. We calculate this transverse momentum dependent distribution function for the $u$ and $d$ quarks inside the proton in a spectator model including the scalar and the axial-vector diquark components. Using the model results, we estimate the asymmetry $A_{LU}^{\sin \phi_h}$ in $ep \rightarrow e' \pi^0 X$ process in which the lepton beam is longitudinally polarized. The model prediction is compared with the data measured by the CLAS and the HERMES Collaborations and it is found that our numerical results agree with experimental data reasonably. Especially, our results can well describe the CLAS data at the region where the Bjorken $x$ and the pion transverse momentum is not large. We also make prediction on the asymmetry $A_{LU}^{\sin \phi_h}$ in $\pi^0$ electroproduction at CLAS12 using the same model calculation.

WG4: QCD and HFS / 2

**High precision measurement of the form factors of the semileptonic decays K+ -> pi0 l+- nu (KL3)**

**Author:** Dmitry Madigozhin

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Semileptonic kaon decays offer the most precise determination of the CKM matrix element $|V_{us}|$. The experimental precision is however limited by the knowledge of the form factors of this decay, since these enter both the phase space integral and the detector acceptances. The NA48/2 experiment presents new measurements of the form factors of the semileptonic decays of charged kaons, based on 4.3 million Ke3 and 3.5 million Kmu3 decays, both with negligible background. The result matches the precision of the current world average on the vector and scalar form factors and allows to significantly reduce the form factor uncertainty on $|V_{us}|$. In addition, the comparison of both channels sets tight constraints on lepton flavor violation and other possible new physics.

WG7: Future experiments / 4

**Prospects for K->p+nunu observation at CERN**

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The rare decays $K-\rightarrow pnn$ are excellent processes to make tests of new physics at the highest scale complementary to LHC thanks to their theoretically cleanness. The NA62 experiment at CERN SPS aims to collect of the order of 100 $K^{+}\rightarrow p+nunu$ events in two years of data taking, keeping the background at the level of 10%. Part of the experimental apparatus has been commissioned during a technical run in 2012. The physics prospects and the status of the experiment will be reviewed.

**WG5: Heavy Flavours / 8**

**Measurement of Beauty and Charm Photoproduction at HERA**

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The cross section for $e^p \rightarrow e b\bar{b} X$ in photoproduction is measured with the H1 detector at the ep-collider HERA. The decay channel $b\bar{b} \rightarrow ee X'$ is selected by identifying the semi-electronic decays of the $b$-quarks. The total production cross section is measured in the kinematic range given by the photon virtuality $Q^2 <= 1 \text{ GeV}^2$, the inelasticity $0.05 <= y <= 0.65$ and the pseudorapidity of the $b$-quarks $|\eta(b)|,|\eta(\bar{b})| <= 2$. The differential production cross section is measured as a function of the average transverse momentum of the beauty quarks $< P_T(b) >$ down to the threshold. The results are compared to next-to-leading-order QCD predictions.

Measurements of cross sections for beauty and charm events with dijets and a muon in the photoproduction regime at HERA are presented. The data were collected with the H1 detector and correspond to an integrated luminosity of 179 pb$^{-1}$. Events with dijets of transverse momentum $P_T\{(\text{jet1}) > 7 \text{ GeV and } P_T\{(\text{jet2}) > 6 \text{ GeV in the pseudorapidity range } -1.5 < |\eta(\text{jet})| < 2.5 \text{ in the laboratory frame are selected in the kinematic region of photon virtuality } Q^2 < 2.5 \text{ GeV}^2 \text{ and inelasticity } 0.2 < y < 0.8 \text{. One of the two selected jets must be associated to a muon with } P_T\{(\text{mu}) > 2.5 \text{ GeV in the pseudorapidity range } -1.5 < |\eta(\text{mu})| < 1.5 \text{. The fractions of beauty and charm events are determined using the impact parameters of the muon tracks with respect to the primary vertex and their transverse momentum relative to the axis of the associated jet. Both variables are reconstructed using the H1 vertex detector. The measurements are in agreement with QCD predictions at leading and next-to-leading order.**

**WG2: Low x and Diffraction / 9**

**Combined inclusive diffractive cross sections measured with forward proton spectrometers in deep inelastic ep scattering at HERA**

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A combination of the inclusive diffractive cross section measurements made by the H1 and ZEUS Collaborations at HERA is presented. The analysis uses samples of diffractive deep inelastic ep scattering data at a centre-of-mass energy $\sqrt{s} = 318 \text{ GeV where leading protons are detected by dedicated spectrometers. Correlations of systematic uncertainties are taken into account, resulting**
in an improved precision of the cross section measurement which reaches 6% for the most precise points. The combined data cover the range \(2.5 < Q^2 < 200 \text{ GeV}^2\) in photon virtuality, \(0.00035 < x_{IP} < 0.09\) in proton fractional momentum loss, \(0.09 < |t| < 0.55 \text{ GeV}^2\) in squared four-momentum transfer at the proton vertex and \(0.0018 < \beta < 0.816\) in \(\beta = x/x_{IP}\), where \(x\) is the Bjorken scaling variable.

WG1/5: Structure Functions and Heavy Flavours / 10

**Combination and QCD Analysis of Charm Production Cross Section Measurements in Deep-Inelastic ep Scattering at HERA**

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Measurements of open charm production cross sections in deep-inelastic ep scattering at HERA from the H1 and ZEUS Collaborations are combined. Reduced cross sections \(\sigma_{\text{red}}^{c\bar{c}}\) for charm production are obtained in the kinematic range of photon virtuality \(2.5 < Q^2 < 2000 \text{ GeV}^2\) and Bjorken scaling variable \(0.00003 < x < 0.05\). The combination method accounts for the correlations of the systematic uncertainties among the different data sets. The combined charm data together with the combined inclusive deep-inelastic scattering cross sections from HERA are used as input for a detailed NLO QCD analysis to study the influence of different heavy flavour schemes on the parton distribution functions. The optimal values of the charm mass as a parameter in these different schemes are obtained. The implications on the NLO predictions for \(W^+\) and \(Z\) production cross sections at the LHC are investigated. Using the fixed flavour number scheme, the running mass of the charm quark is determined.

WG2: Low x and Diffraction / 11

**Saturation, coherence and exclusive final states**

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Motivated by p-Pb experiments at Large Hadron Collider which require both knowledge of gluon densities accounting for saturation and for processes at a wide range of \(p_T\) we study basic momentum space evolution equations of high energy QCD factorization. Solutions of those equations might be used to form a set of gluon densities to calculate observables in generalized high energy factorization. Moreover in order to provide a framework for predictions for exclusive final states in p-Pb scattering with high \(p_T\) we rewrite the equation for the high energy factorizable gluon density in a resummed form. The resummed equation is then extended to account for colour coherence. This introduces an external scale to the evolution of the gluon density, and therefore makes it applicable in studies of final states.

We present solutions of obtained equations as well as discuss their properties.

WG4: QCD and HFS / 12
Study of Feynman Scaling in Very Forward Neutron and Photon Production in Deep-Inelastic Scattering at HERA

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Measurements of very forward neutron and photon production as a function of Feynman-x in deep-inelastic ep scattering at HERA are presented. The data are taken with the H1 detector in the years 2006 and 2007 and correspond to an integrated luminosity of 126 pb⁻¹. The analysis covers the range of negative four momentum transfer squared at the positron vertex 6<Q²<100 GeV², inelasticity 0.05<y<0.6 and the centre-of-mass energy of the virtual photon-proton system 70<W<245 GeV. The dependence of cross sections on W is investigated. The cross sections are compared to the predictions of DIS models and models of the hadronic interactions of high energy cosmic rays.

On a relation between production processes and total cross sections

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Perturbative QCD is the appropriate tool to describe many important properties of the inclusive observables measured at electron-proton (or ion) colliders, such as the energy dependence of the total cross sections in well-chosen kinematical regions. This is because the electron may effectively be replaced by its cloud of photons, whose virtualities provide a hard scale.

At hadron colliders instead, there is no hard scale in the initial state. Therefore, the observables one may compute perturbatively involve the production of jets, and thus belong to a quite different class of observables.

However, it turns out that there is a formal relation between production processes and total cross sections, enabling one to apply calculations of the latter to the former. We will review this relation, and present our recent proof that it holds at next-to-leading order.

Theoretical foundations of the quantum statistical approach to parton distributions and recent results

Author: Jacques SOFFER

Co-authors: Claude BOURRELY; Franco BUCELLA

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The theoretical foundations of the quantum statistical approach to parton distributions are reviewed together with the phenomenological motivations from a few specific features of Deep Inelastic Scattering data. The chiral properties of QCD lead to strong relations between quarks and antiquarks distributions and automatically account for the flavor and helicity symmetry breaking of the sea. We are able to describe both unpolarized and polarized structure functions in terms of a small number of parameters. The extension to include their transverse momentum dependence will be also considered.

WG4: QCD and HFS / 16

Scale Invariant Resonance Tagging in Multijet Events and New Physics Searches in Higgs pair production

Author: Juan Rojo Chacon

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We study resonant pair production of heavy particles in fully hadronic final states by means of jet substructure techniques. We propose a new resonance tagging strategy that smoothly interpolates between the highly boosted and fully unboosted regimes, leading to approximately constant signal efficiencies and background rejection factors for the whole allowed mass range. As a case study, we apply this technique to pair production of Standard Model Higgs bosons decaying into b quark pairs in generic New Physics theories, using Radion and Graviton production in warped extra dimensions models as benchmark scenario.

WG7: Future experiments / 18

ATLAS Upgrades Towards the High Luminosity LHC: extending the discovery potential

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After successful LHC operation at the center-of-mass energy of 7 and 8 TeV in 2011 and 2012, plans are actively advancing for a series of upgrades, culminating roughly 10 years from now in the high luminosity LHC (HL-LHC) project, delivering of order five times the LHC nominal instantaneous luminosity along with luminosity levelling. The final goal is to extend the data set from about few hundred fb-1 expected for LHC running to 3000 fb-1 by around 2030. Current planning in ATLAS also has significant upgrades to the detector during the consolidation of the LHC to reach full LHC energy and further upgrades to accommodate running already beyond nominal luminosity this decade. The challenge of coping with HL-LHC instantaneous and integrated luminosity, along with the associated radiation levels, requires further major changes to the ATLAS detector. The designs are developing rapidly for an all-new inner-tracker, significant upgrades
in the calorimeter and muon systems, as well as improved triggers and data acquisition. This presentation summarises the various improvements to the ATLAS detector required to cope with the anticipated evolution of the LHC instantaneous luminosity during this decade and the next.

WG1: Structure Functions / 19

The CJ12 parton distributions

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I present three new sets of next-to-leading order parton distribution functions (PDFs) determined by global fits to a wide variety of data for hard scattering processes. The analysis includes target mass and higher twist corrections needed for the description of deep inelastic scattering data at large x and low $Q^2$, and nuclear corrections for deuterium targets. The PDF sets correspond to three different models for the nuclear effects, and provide a more realistic uncertainty range for the d quark PDF compared with previous fits. Applications, in particular to weak boson production at colliders will also be discussed.

WG1/3: Structure Functions and Electroweak Physics / 20

Electroweak corrections to Parton distributions

Author: Stefano Carrazza

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Electroweak corrections to hadron collider processes become relevant at the level of precision reached by present-day LHC experiments. I will provide a brief discussion of the impact of electroweak corrections to parton distributions, concentrating on QED corrections to parton evolution equations, and a preliminary assessment of their impact.

WG1/5: Structure Functions and Heavy Flavours / 21

Impact of scheme dependence in PDFs on measurable quantities

Authors: Aleksander Kusina ; Fred Olness

1 Southern Methodist University
We analyze the impact of heavy flavors treatment in parton distribution functions (PDFs) on measurable quantities like DIS structure functions. We compare predictions obtained using ACOT scheme PDFs with different number of active flavors and results of fix-flavor-number scheme. We propose a correction factor that can be applied to calculations carried in the fix-flavor-number scheme but using 5-flavor PDFs.

Universality of TMD distribution functions

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Co-authors: Asmita Mukherjee; Piet Mulders

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We introduce transverse momentum dependent parton distribution functions (TMDs) for quarks and gluons with definite rank. The rank refers to the azimuthal dependence corresponding to the tensorial structure in transverse momenta multiplying universal functions only depending on $x$ and $p_T^2$. In this way only a finite number of functions of definite rank remains for a target with the number depending on its spin. Gauge links, required for color gauge invariance, enter in the explicit description of the matrix elements corresponding to these TMDs and account for their process dependence. In this way a general gauge link dependent function is expressed in the universal set, where all process (i.e. gauge link) dependence is isolated in gluonic pole prefactors multiplying the universal TMDs of definite rank.

Probing $\Delta g(x)$ at Low $x$ with the PHENIX detector

Author: Mickey Chiu

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Determining the contribution of gluon spin to the proton’s total spin is one of the crucial ingredients in resolving the proton spin puzzle. Hints from recent measurements of double longitudinal asymmetries ($A_{LL}$) from the Relativistic Heavy Ion Collider (RHIC) suggest $\Delta g$ is non-zero at moderate values of Bjorken $x \sim 10^{-2}$. In the PHENIX experiment at RHIC, we have a forward $PbWO_4$ electromagnetic calorimeter, the MPC, with acceptance in the region $3.1 < |\eta| < 3.9$, and sensitivity to $\Delta g$ down to Bjorken $x \sim 10^{-3}$. It is important to probe down to low-$x$ since much of the gluon spin contribution to the proton may come from lower $x$. We will present the status and challenges of the PHENIX measurement of the double longitudinal spin asymmetries, $A_{LL}$, from longitudinally polarized proton collisions at center of mass energies of 200, 500, and 510 GeV taken over the 2009-2012 period.
Recent HERMES Results on DVCS and Associated Processes

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Hard exclusive leptoproduction of real photons, Deeply Virtual Compton Scattering (DVCS), is one of the theoretically cleanest processes to access Generalized Parton Distributions (GPDs). The theoretical framework of GPDs includes information on the correlated transverse spatial and longitudinal momentum distributions of partons in the nucleon. In addition, GPDs may provide a way to investigate the contribution of quark orbital angular momentum to the spin of the nucleon. The HERMES experiment at DESY, Hamburg, collected unique data on DVCS utilizing the HERA polarized electron or positron beams with an energy of 27.6 GeV and longitudinally and transversely polarized or unpolarized gas targets (H, D or heavier nuclei). The azimuthal asymmetries measured in the DVCS process allow access to the imaginary and/or real part of certain combinations of GPDs. For the last two years of HERA running, the HERMES collaboration installed a recoil detector to improve the selection of DVCS events by direct measurement of the recoil protons. An overview of recent HERMES results on DVCS is presented including results on DVCS and associated processes ep -> e gamma p pi0 and ep -> e gamma n pi+ in the Delta-resonance region obtained with the recoil detector.

Double parton interactions in double J/Psi production at LHC

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The talk is based on the results of our publications [1]. First of all we show that the contribution from double parton scattering to the inclusive production of heavy meson pairs is comparable with the conventional single parton scattering mechanism at the LHC energy. Then we focus on the problem of disentangling the single (SPS) and double (DPS) parton scattering modes in the production of J/ pairs at the LHC conditions. Our analysis is based on comparing the shapes of the differential cross sections and on studying their behavior under imposing kinematical cuts. We come to the conclusion that disentangling the SPS and DFS modes is rather difficult on the basis of azimuthal correlations, while the rapidity difference looks more promising, provided the acceptance of the experimental detectors has enough rapidity coverage.

References

Single-spin asymmetry for forward neutron production

Author: Jacques SOFFER

Co-authors: Boris KOPELIOVICH; Irina POTASHNIKOVA; Ivan SCHMIDT
The transverse single-spin asymmetry of neutrons produced at forward rapidities in polarized pp collisions is calculated by means of an interesting interference mechanism and compared with a large effect observed from recent measurements by the PHENIX experiment at RHIC.

**WG3: Electroweak and Searches / 28**

**The resummation of the low-phistar domain of Z production**

**Authors:** Andrea Banfi¹; Lee Tomlinson²; Mrinal Dasgupta³; Simone Marzani⁴

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The presence of large logarithms in QCD corrections to observables spoils the validity of a calculation truncated at finite order and calls for an all-orders approach. The QT spectrum of massive lepton pairs, produced in hadron colliders by the Drell-Yan mechanism, has received a great deal of attention in electroweak phenomenology. We present and discuss a next-to-next-to-leading log (NNLL) resummed calculation of a related observable, namely phistar, that was recently introduced because of its distinct experimental advantages, but which is nonetheless sensitive to similar physics: soft-collinear gluon emission in the initial state. We also present various comparisons to collision data at Tevatron and the LHC.

**WG7: Future experiments / 29**

**Looking at the photoproduction of massive gauge bosons at the LHeC**

**Author:** Magno Machado¹

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In this contribution we investigate the photoproduction of massive gauge bosons, $W^\pm$ and $Z^0$, as part of relevant physics topics to be studied in the proposed electron-proton collider, the LHeC. The estimates for production cross sections and the number of events are presented. In addition, motivated by the intensive studies to test the deviations from the Standard Model at present and future colliders, we discuss the $W^\pm$ asymmetries and perform an analysis on the role played by anomalous $WW\gamma$ coupling.
Measurement of high-Q2 neutral current deep inelastic e+p scattering cross sections with a longitudinally polarised positron beam at HERA

Author: Olaf Behnke¹

¹ DESY

The cross sections for neutral current deep inelastic scattering in e+p collisions with a longitudinally polarised positron beam have been measured using the ZEUS detector at HERA. The single-differential cross-sections $d\sigma/dQ_2$, $d\sigma/dx$ and $d\sigma/dy$ and the double-differential cross sections in $Q_2$ and $x$ are measured in the kinematic region $Q_2 > 185$ GeV$^2$ for both positively and negatively polarised electron beams and for each polarisation state separately. The measurements are based on an integrated luminosity of 136 pb$^{-1}$ taken in 2006 and 2007 at a centre-of-mass energy of 318 GeV. The structure functions $xF_3$ and $xF_3^{\gamma Z}$ are determined by combining the e+p results presented in this analysis with previously measured e-p neutral current data. The measured cross sections are compared to the predictions.

Search for First-Generation Leptoquarks at HERA

Author: Olaf Behnke¹

¹ DESY

A search for first generation leptoquarks was performed in polarized electron-proton collider data recorded with the ZEUS detector at HERA in the years 2003-2007. They were analyzed for final states with an electron and jets or with missing transverse momentum and jets and a search for resonance structures or other deviations from the Standard Model predictions in the spectra of the invariant mass of lepton and jets was performed. No evidence for leptoquark signals was found. The data were combined with the previously taken data at HERA corresponding to an integrated luminosity of 0.5fb$^{-1}$ and limits were set on the Yukawa coupling lambda as a function of the leptoquark mass for different leptoquark types within the Buchmueller-Rueckl-Wyler model.
A search for events ep→ ep Z0 has been performed in ep collisions at HERA using the ZEUS detector. The search is based on the entire HERA-I and HERA-II data set, amounting to 0.49 fb⁻¹ of integrated luminosity. The Z0 was searched in the di-jet decay mode with elastic condition defined by etamax < 3, where etamax is defined as the pseudorapidity of the energy deposit in the calorimeter closest to the proton beam direction. A di-jet mass peak is observed at the Z0 mass and the number of signal events is extracted from a fit to the mass spectrum. The elastic Z0 production cross section is determined and compared to the SM prediction.

**Measurement of D+ production in Deep Inelastic ep Scattering with the ZEUS detector at HERA**

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Charm production in deep inelastic ep scattering was measured with the ZEUS detector using an integrated luminosity of 354 pb⁻¹. Charm quarks were identified by reconstructing D⁺ mesons in the D⁺ → K⁻ pi⁺ pi⁺ decay channel. Lifetime information was used to reduce combinatorial background substantially. Differential cross sections were measured in the kinematic region 5<Q²<1000 GeV², 0.02<y<0.7, 1.5<p_T(D⁺)<15 GeV and |η(D⁺)|<1.6, where Q² is the photon virtuality, y is the inelasticity, and p_T(D⁺) and η(D⁺) are the transverse momentum and the pseudorapidity of the D⁺ meson, respectively. Next-to-leading-order QCD predictions are compared to the data. The charm contribution, F2cc, to the proton structure-function F2 was extracted.

**Measurement of charm production in DIS with D⁺ mesons and extraction of F2cc**

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Charm production has been measured with the ZEUS detector in deep inelastic ep scattering at HERA. The measurement is based on the full reconstruction of the decay chain D⁺→D⁰pis, D⁰→Kpi and exploits the full HERA II statistics. Differential cross sections have been measured.

The kinematic range is 1.5 GeV < pT(D) < 10 GeV, |η(D)| < 1.5, 5 < Q² < 1000 GeV² and 0.02 < y < 0.7.

The observed cross sections is extrapolated to the full pt(D) and η(D⁺) range in order to determine the open-charm contribution, F2cc(x,Q²) to the proton structure function, F2.
Measurement of charm fragmentation fractions in photoproduction at HERA

Author: Ewald Paul

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The production of D*, D+, D0, Ds and Lambda_c charm hadrons and their antiparticles in ep scattering at HERA was studied with the ZEUS detector using the full HERA II data set. The measurement has been performed in the photoproduction regime. The fractions of c quarks hadronising as a particular charm hadron, f(c -> D, Lambda_c), were derived in the visible kinematic range.

Production of the excited charm mesons D_1 and D_2* at HERA

Author: Andrii Verbytskyi

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The production of the excited charm mesons D_1(2420) and D_2(2460) in ep collisions has been measured with the ZEUS detector at HERA using an integrated luminosity of 373 pb^-1. The masses of the neutral and charged states, the widths of the neutral states, and the helicity parameter of D_1(2420)^0 were determined and compared with other measurements and with theoretical expectations.

The measured helicity parameter of the D_1^0 allows for some mixing of S- and D-waves in its decay to D^+ pi^- . The result is also consistent with a pure D-wave decay.

Ratios of branching fractions of the two decay modes of the D_2(2460)^0 and D_2(2460)^+ states were measured and compared with previous measurements.

The fractions of charm quarks hadronising into D_1 and D^*_2 were measured and are consistent with those obtained in e^+e^- annihilations.

Measurement of Inelastic J/psi and psi' Photoproduction at HERA

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The double differential inelastic J/psi photoproduction cross section as function of the squared transverse momentum of the J/psi in bins of the inelasticity z has been measured in ep collisions with the ZEUS detector at HERA.

An integrated luminosity of 468 pb^-1 was used corresponding
to the full data sample collected by the ZEUS experiment. The events were required to have $0.1 < z < 0.9$, $p_t > 1$ GeV and $60 < W < 240$ GeV, where $p_t$ is the transverse momentum of the $J/\psi$ and $W$ is the photon-proton centre-of-mass energy. The $J/\psi$ mesons were identified through their decay into muon pairs. The double differential cross section measurements are compared to the most recent theoretical predictions.

WG4: QCD and HFS / 39

Using 1-Jettiness to Measure 2 Jets in DIS 3 ways

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We predict cross sections in deep inelastic scattering (DIS) for the production of two jets—one along the proton beam direction created by initial state radiation (ISR) and another created by final state radiation after the hard collision. Our results include fixed order corrections and a summation of large logarithms up to next-to-next-to-leading logarithmic (NNLL) accuracy in resummed perturbation theory. We make predictions for three versions of a DIS event shape 1-jettiness, each of which constrains hadronic final states to be well collimated into two jets along the beam and final-state jet directions, but which differ in their sensitivity to the transverse momentum of the ISR from the proton beam. We use the tools of soft collinear effective theory (SCET) to derive factorization theorems for these three versions of 1-jettiness. The sensitivity to the ISR gives rise to significantly different structures in the corresponding factorization theorems—for example, dependence on either the ordinary or the generalized $k_T$-dependent beam function. We give numerical results for $Q^2$ and $x$ values explored at the HERA collider, emphasizing that the target of factorization based analyses is to open the door for higher-precision jet phenomenology in DIS.

WG7: Future experiments / 40

Exploring Confinement at CERN

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It is obvious that the DIS experimental programme needs a new experimental facility to survive. For such a facility, to be seriously considered, several conditions must be fulfilled:

1. It must address new physics questions (beyond those addressed at HERA and TJNAF).
2. Its role must be widely recognized as essential for the model independent interpretation of the LHC experimental results and as imperative for the LHC precision measurement programme.
3. It must attract not only the HEP community but, equally, the nuclear physics community.
4. It must be challenging for the accelerator R&D.

5. It must be “CHEEP”.

None of the existing proposals: eRHIC, ELIC, and LHeC fulfills all the above criteria. The purpose of this talk is to argue that a new electron-proton and electron-nucleus collider using the existing SPS beams (optionally also the PS proton and ions beams), and the polarized electron beam in the range of 5 to 20 GeV from a newly built Energy Recovery Linac could fulfill all the above criteria.

WG6: Spin / 41

Gluon correlations in the transversely polarized nucleon at twist three

Author: Kazuhiro Tanaka

We discuss the gluonic correlations in the transversely polarized nucleon, which are relevant to single and double spin asymmetries in various hard processes. We explain that the single transverse-spin asymmetry (SSA) to be observed in the D-meson production with large transverse-momentum in semi-inclusive deep inelastic scattering, \( e p \rightarrow e D X \), is induced by the three-gluon correlation effects. We present the numerical calculations of the corresponding SSA at the kinematics relevant to a future Electron Ion Collider, based on the QCD factorization formula at twist three. We also clarify the independent degrees of freedom associated with three-gluon correlation effects, deriving the new exact twist-three relations between the multi-gluon correlators based on the operator product expansion and the QCD equations of motion. As a byproduct of our analysis, we mention the transverse-spin sum rule as the partonic decomposition of the transverse nucleon spin. The detail of this work is reported in our recent papers, Phys. Rev. D85, 114026 (2012) and JHEP1302, 003 (2013).

WG2: Low x and Diffraction / 42

Elastic and proton dissociative J/psi meson photoproduction at HERA

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Cross sections for elastic and proton dissociative photoproduction of J/ mesons are measured simultaneously in electron proton collisions at HERA using the H1 detector. Two data sets are analysed, one collected at the nominal ep centre-of-mass energy of sqrt(s)\(\approx\) 320 GeV and having an integrated luminosity of 130 pb\(^{-1}\) and one recorded with a reduced proton beam energy resulting in sqrt(s)\(\approx\) 225 GeV and corresponding to an integrated luminosity of L = 10.8 pb\(^{-1}\). Differential cross sections d/dt, where t is the squared four momentum transfer at the proton vertex, are measured in the range |t| < 1.2 GeV\(^2\) for the elastic process and |t| < 8 GeV\(^2\) for proton dissociation. The cross sections are measured as functions of the photon-proton center-of-mass energy W_{\gamma p} and the photon-proton center-of-mass energy W_{\gamma p} in the ranges 40 – 110 GeV and 25 – 80 GeV. The results are compared to previous measurements, and the energy and t-dependences are determined using fits to the data.

WG4: QCD and HFS / 43
Description of the ATLAS jet-veto measurement using the Banfi-Marchesini-Smye equation

Author: Cyrille Marquet

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I present a new QCD description of the ATLAS jet veto measurement, using the Banfi-Marchesini-Smye equation to constrain the inter-jet QCD radiation. This equation resums emissions of soft gluons at large angles, at leading-logarithmic accuracy, and accounts for both the so-called Sudakov and non-global logarithms. I show that this approach is able to reproduce the fraction of high-pT forward/backward di-jet events which do not contain additional hard emissions in the inter-jet rapidity range.

WG2: Low x and Diffraction / 44

Multi-particle production in the CGC framework

Author: Cyrille Marquet

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Within the Color Glass Condensate (CGC) framework, I will discuss particle production in the collision of a dilute projectile with a dense hadronic target. For years CGC studies focused on the dipole scattering amplitude, and its evolution towards high energies or small x. One has now reached an accuracy sufficient to quantitatively describe single inclusive particle production in p+A type collisions, at least in the forward rapidity region, sensitive to the smallest values of x. Recently the focus has turned to the quadrupole amplitude, necessary to compute the two-particle inclusive case. Actually in the large-Nc limit, only dipoles and quadrupoles contribute, and I will show that this is the case irrespectively of the numbers of particles measured in the final state.

WG6: Spin / 45

Spin-density matrix elements in hard exclusive electroproduction of omega mesons

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Spin density matrix elements (SDMEs) have been determined for exclusive \( \omega \) meson production on hydrogen and deuterium targets, in the HERMES kinematic region of \( 1.0 < Q^2 < 10.0 \text{ GeV}^2 \) and \( 3.0 < W < 6.3 \text{ GeV} \) and \( -t' < 0.2 \text{ GeV}^2 \). The data, from which SDMEs are determined, were accumulated with the HERMES forward spectrometer during the running period of 1996-2007 using the 27.6 GeV electron or positron beam of HERA. The resulting SDMEs are compared to those for \( \rho^0 \) production. A sizable contribution of unnatural parity exchange amplitudes is found for exclusive \( \omega \) meson production.
A model for high energy rho meson leptoproduction based on collinear factorization and dipole models

Author: Adrien Besse

Co-authors: Lech Szymanowski; Samuel Wallon

1 LPT Orsay
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We discuss the high-energy exclusive electroproduction of rho mesons, for both longitudinal and transversal polarizations. The theoretical description of the cross-section is based on the perturbative calculations of the transition $\gamma L \rightarrow \rho L$ and $\gamma T \rightarrow \rho T$, i.e. impact factors, within the collinear factorization of QCD. We show how these impact factors can be related to the dipole-nucleon scattering amplitude. This permits us to rely for phenomenological estimations on several existing models for the dipole/nucleon cross-section, already constrained by the fits performed on DIS inclusive and diffractive structure functions. We will then present the comparison of our predictions with HERA data.

Multijet Predictions for Higgs Studies

Authors: Jeppe Andersen; Matthias Neubert; Thomas Becher

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2 Johannes Gutenberg Universitat Mainz
3 University of Bern

Using methods from effective field theory, we have recently developed a novel, systematic framework for the calculation of the cross-sections for electroweak gauge-boson production at small and very small transverse momentum $q_T$, in which large logarithms of the scale ratio $M_V/q_T$ are resummed to all orders. This formalism is applied to the production of Higgs bosons in gluon fusion at the LHC. The collinear factorization anomaly leads to the dynamical generation of a non-perturbative scale $q_*$, which protects the process from receiving large long-distance hadronic contributions. We present a numerical predictions for the transverse-momentum spectrum of the Higgs boson, finding that it is quite insensitive to hadronic effects.

Nonperturbative and Parton Shower corrections in matched NLO-shower event generators

Author: Samantha Katherine Dooling

Co-authors: Francesco Hautmann; Hannes Jung; Paolo Gunnellini

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Comparisons of experimental data with theoretical predictions for collider processes containing hadronic jets rely on shower Monte Carlo event generators to include corrections to perturbative calculations from hadronization, parton showering, multiple parton collisions. We examine current treatments of these corrections and propose alternative methods to take into account nonperturbative effects and parton showering in the context of next-to-leading-order (NLO) event generators. We point out sizeable parton-showering corrections to jet transverse energy spectra at high rapidity, and discuss kinematic shifts in longitudinal momentum distributions from initial state showering in the case both of jet production and of heavy mass production at the Large Hadron Collider.

WG2/4: Diffraction and QCD / 49

Mueller Navelet jets at LHC: a clean test of QCD resummation effects at high energy?

Author: Bertrand Ducloue

1 LPT Orsay

Mueller Navelet jets were proposed 25 years ago as a decisive test of BFKL dynamics at hadron colliders. We here present a next-to-leading BFKL study of the cross section and azimuthal decorrelation of these jets. This includes both next-to-leading corrections to the Green’s function and next-to-leading corrections to the Mueller Navelet vertices. We compare our results with the same observables obtained within next-to-leading logarithm DGLAP type treatment.

WG4: QCD and HFS / 50

Resummation of clustering logarithms for non-global QCD observables

Author: Yazid Delenda

Co-author: Kamel Khelifa Kerfa

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2 Université des Sciences et de la Technologie HOUARI BOUMEDIENE

We address the problem of the resummation of Abelian clustering logarithms in QCD jet observables for jets defined using the kt, CA and SISCone algorithms. We specifically choose the jet mass distribution as an example and calculate up to O(\alpha_s^4) clustering-logarithm coefficients to single log accuracy. We hence show that these logarithms exhibit a pattern of exponentiation and provide a resummed result for this distribution including non-global logarithms in the large-N_c limit. We show that the resummed result we provide here, although does not fully account for all single logs, is a very good analytic approximation for the fully resummed result obtained using a numerical Monte Carlo program.
Prospects for the LHeC

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An overview is given on the LHeC and its prospects.

Hadron multiplicities at the HERMES experiment

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The HERMES collaboration has measured charge-separated pion and kaon multiplicities in semi-inclusive deep-inelastic scattering using a 27.6 GeV electron or positron beam scattering off a hydrogen or deuterium target. The results are presented as functions of the Bjorken variable x, the negative squared four-momentum transfer Q², a hadron fractional energy z and the hadron’s transverse momentum. These data will be very useful to understand the quark-fragmentation process in deep-inelastic hadron electro-production and will serve as crucial input in the understanding of charge/flavour separated fragmentation functions. Furthermore, it provides important information on the transverse-momentum dependence of hadron production.

Diffractive dijet photoproduction in ep collisions with a leading proton at HERA.

Author: Radek Zlebcík

The cross section of diffractive photoproduction processes e+p → eXp is measured, where the system X contains at least 2 jets and the proton is tagged in the Very Forward Proton Spectrometer (VFPS) of the H1 detector. The measurement is performed for untagged photoproduction with Q² <2 GeV² in photon virtuality. The results are compared to next-to-leading order QCD calculations based on diffractive parton distribution functions extracted from measurements of inclusive cross sections in diffractive deep-inelastic scattering.

Extraction of Transversity and Collins functions

Authors: Alexei Prokudin¹; Francesco Murgia²; Mariaelena Boglione¹; Mauro Anselmino¹; Stefano Melis³; Umberto D’Alesio⁴

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We present a global re-analysis of the experimental data on azimuthal asymmetries in semi-inclusive deep inelastic scattering (SIDIS), from the HERMES and COMPASS Collaborations, and in $e^+e^-$ to $h_1h_2X$ processes, from the Belle Collaboration. Transversity and Collins functions are extracted simultaneously, in the framework of a new and revised global analysis in which a new parameterization of the unknown functions will be tested.

**Neutrino-nucleus DIS data and their consistency with nuclear PDFs**

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In this talk, we discuss the compatibility of different deeply inelastic neutrino-nucleus data sets and the universal nuclear parton distribution functions (PDFs). This is an issue that has lately been investigated by different groups but the conclusions have been contradictory. While some studies have found a good overall agreement between the nuclear PDFs and the neutrino data, others have claimed for an incompatibility.

Here, we demonstrate that the independent neutrino data sets from NuTeV, CHORUS and CDHSW collaborations differ in the absolute overall normalization and that it is not possible to accurately reproduce all the data simultaneously with a single set of PDFs. Our strategy to overcome this difficulty and allow a consistent use of all neutrino data in global PDF analyses is to normalize the data by the integrated cross-sections thereby cancelling possible inaccuracies in the absolute normalization. Indeed, this brings all data to a surprisingly good mutual agreement underscoring the $x$-dependence of the nuclear modifications in a model-independent way. The consistency of these data with the present nuclear PDFs is verified by introducing a method to test the effect of a new data set in an existing global fit that performed a Hessian error analysis.

**Jet production and the inelastic pp cross section at the LHC**

**Authors:** Albert Knutsson; Anastasia Grebenyuk; Francesco Hautmann; Hannes Jung; Panagiotis Katsas
We suggest that, if current measurements of inclusive jet and leading track production for central rapidities at the LHC are extended to lower transverse momenta, one could define a visible cross section sensitive to the unitarity bound set by the recent determination of the inelastic proton-proton cross section.

MultiJet Predictions for Higgs Studies

**Authors:** Jennifer Smillie\(^1\), Jeppe Andersen\(^2\)

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The High Energy Jets (HEJ) framework provides an all-order, all-multiplicity description of jet production. It is built upon approximations to the hard-scattering matrix element which are derived from the High Energy limit, and as such contains the leading-logarithmic corrections in large invariant mass between partons. These corrections are especially important in regions where there is a large rapidity gap between partons, as is usually required in a Higgs plus jets analysis. In this talk, we will describe the HEJ framework, show and discuss results from multi-jet and W+jet data analyses, and discuss the latest comparisons of different Monte Carlo predictions for Higgs plus jets analyses.

Probing the intrinsic heavy quark content of the nucleon through direct photon plus heavy quark production

**Author:** Tzvetalina Stavreva\(^1\)

\(^1\) LPSC

The associated production of a direct photon with a heavy quark provides us with the opportunity to test for and constrain the presence of intrinsic charm and bottom in the nucleon. We present comparisons of the theoretical predictions for this process with the initial measurements from D0 and CDF, as well as with the recently updated D0 measurements. Future predictions and possibilities for measurement of the process at the LHC and the potential for constraining the heavy quark patron distributions there are presented.

On timelike and spacelike deeply virtual Compton scattering at next to leading order

**Authors:** Bernard Pire\(^1\); Franck Sabatié\(^2\); Hervé MOUTARDE\(^3\); Jakub Wańgan\(^4\); Lech Szymanowski\(^N\)
We study timelike and spacelike virtual Compton scattering in the generalized Bjorken scaling regime at next to leading order in the strong coupling constant, in the medium energy range which will be studied intensely at JLab12 and in the COMPASS-II experiment at CERN. We show that the Born amplitudes get sizeable O(\alpha_s) corrections and, even at moderate energies, the gluonic contributions are by no means negligible. We stress that the timelike and spacelike cases are complementary and that their difference deserves much special attention.

Re-evaluation of the Parton Distributions of Strange Quarks in the nucleon

Author: Harold E Jackson Jr

In 2008 HERMES published the results of an "isoscalar" extraction in leading logarithmic order (LO) in the strong coupling constant of quantum chromodynamics of the momentum and helicity density distributions of the strange sea in the nucleon from the charged-kaon production in deep-inelastic scattering (DIS) on the deuteron (Phys. Lett. B666, 446 (2008)). The shape of the momentum distribution was observed to be softer than that of the average of the uubar and dbar quarks. The helicity distribution was found to be compatible with zero within experimental uncertainties in the region of measurement 0.02 < x < 0.60. HERMES has since finalized the extraction of multiplicities for charged kaons in semi-inclusive deep-inelastic positron scattering. A re-evaluation of the extraction of the PDFs of strange quarks has been made using the results of the new final extraction of the multiplicities for charged kaons. In the measured range of x the strength of the polarization averaged PDF S(x)=s(x)+\bar{s}(x) is substantially less than reported earlier, but the shape is similar, i.e., the momentum densities are softer than previously assumed. The first moment of the helicity distribution Delta S(x) is consistent with zero and the partial moment of the octet axial combination is observed to be substantially less than the axial charge extracted from hyperon decays under the assumption of SU(3) symmetry.

Measurement of inclusive production of light charged hadrons at BaBar

Author: Isabella Garzia

Inclusive hadron production cross sections in e+e- collisions shed light on fundamental questions of hadronization and fragmentation processes. We present measurements of inclusive spectra of various light hadrons produced in e+e- collisions at a center-of-mass energy of about 10.5 GeV. These results help test the...
Observation of time reversal violation in B decays and Recent results on CP Violation in B- and D-meson decays at BaBar

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Although CP violation in the B-meson system has been well established by the B factories, there has been no direct observation of time-reversal violation in this system. Using 468 million B-Bbar pairs collected by the BABAR detector at SLAC, we measure T-violating parameters in the time evolution of neutral-B mesons by comparing the probabilities of B0 or anti-B0 transforming into definite CP final states and vice versa. The results lead to the first direct observation of Time Reversal noninvariance, independent of CP violation. In addition, we present a selection of recent results on CP violation effects in B- and D-meson decays using a data set of about 500 fb-1 collected at the peak of the Y(4S), with the BABAR detector at SLAC. They include the measurement of processes sensitive to the angles of the Unitarity Triangle; the study of direct CP violation effects in charmed and bottom meson decays, and a search for mixing-induced CP asymmetry in B0 mesons.

Searches for low-mass Higgs and dark bosons at BaBar

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Searches for low mass CP-odd Higgs boson (A0) predicted in non-minimal supersymmetric extensions of the Standard Model, and for dark-sector Higgs-like and gauge bosons motivated by recent astrophysical observations, have been performed at Babar studying the radiative decays of the Y(nS) resonances, with n=1,2,3, and multiparticle production in e+e- annihilations. Stringent limits on the production of a light Higgs boson and on the SM-dark sector mixing parameter have been set.

Hadron production in e+e- annihilation at BaBar, and implication for the muon anomalous magnetic moment.
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The BABAR Collaboration has an intensive program of studying hadronic cross sections at low-energy e+e- collisions, accessible at BaBar via initial-state radiation. Our measurements allow significant improvements in the precision of the predicted value of the muon anomalous magnetic moment. These improvements are necessary for shedding light on the current ~3.5 sigma difference between the predicted and the experimental values. We have published results on a number of processes with two to six hadrons in the final state. We report here the results of recent studies of the processes e+e- -> K+K-, and e+e- -> 4 hadrons, which constitute the main contribution to the hadronic cross section in the energy region between 1 and 3 GeV.

WG4: QCD and HFS / 71

Study of e+e- -> p anti-p process at BaBar

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Low-energy e+e- annihilation processes are accessible at BaBar via initial state radiation. The e+e- -> p anti-p cross section have been measured using a data set of about 500 fb-1, on a wide energy range from the production threshold up to 4 GeV. The proton magnetic form factor, and the ratio of the electric over the magnetic form factors have been extracted from the measured cross section with unprecedented accuracy. The steep rise of the form factor at an energy close to the production threshold, as well as unexplained structures at higher energies are confirmed.

WG3: Heavy Flavours / 72

Precision measurement of charmed meson properties with the BaBar detector

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We present the measurement of the mass of the D0 meson, the D(2010)+ natural line width, and the mass difference between the D(2010)+ and the D0 mesons using pure samples of D*(2010)+ -> D0 pi+ decays. The measurements are based on a data sample corresponding to an integrated luminosity of about 477 fb-1, collected with
the BaBar detector. Large improvements with respect to the existing measurements have been obtained for all the measured quantities.

WG5: Heavy Flavours / 73

Results on conventional and exotic charmonium at BaBar

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The B factories provide a unique playground for studying the properties of conventional and exotic charmonium states. We present recent results in initial state radiation and two-photon fusion, obtained using the full data set collected by the BaBar experiment.

WG6: Spin / 74

Measurement of Collins asymmetries in e+e- annihilation at BaBar

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We present a measurement of the azimuthal asymmetries induced by the Collins effect in inclusive production of charged pion pairs, in the e+e- \( \rightarrow \) pi pi X annihilation process, where the two pions are produced in opposite hemispheres. The data collected by the BABAR detector allows the determination of the Collins fragmentation function as a function of hadron fractional energies and transverse momenta, and can be combined with semi-inclusive deep-inelastic-scattering data to extract the transversity distribution function, which is the least known leading-twist component of the QCD description of the partonic structure of the nucleon.

WG1/7: Structure Functions and Future Experiments / 75

Nuclear PDFs from the LHeC perspective

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I will present the current status of the nuclear parton distribution functions highlighting the diverse possibilities that would be opened by the LHeC.

WG2: Low x and Diffraction / 76

Predictions of Diffractive, Elastic, Total, and Total-Inelastic pp Cross Sections vs LHC Measurements.

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Predictions of diffractive, elastic, total, and total-inelastic pp cross sections based on the renormalization model for diffraction are compared with recent measurements at the LHC.

WG6: Spin / 77

Valence transversities: the collinear extraction.

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We propose an extraction of the valence transversity parton distributions. Based on an analysis of pion-pair production in deep-inelastic scattering off transversely polarized targets, this extraction of transversity is performed in the framework of collinear factorization, where dihadron fragmentation functions are involved. The recently released data for proton and deuteron targets at HERMES and COMPASS allow for a flavor separation of the valence transversities, for which we give a complete statistical study.

WG7: Future experiments / 78

CHIC (Charm in Heavy Ion Collisions): An experiment to measure charm production at the CERN SPS

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Twenty five years ago, CERN pioneered the study of quarkonium production in heavy ion collisions at the SPS with the aim of characterizing the QGP phase transition and testing lattice QCD
predictions. In 1997, the NA50 experiment observed an anomalous suppression of J/ψ production in Pb+Pb collisions. Since then, these quarkonium studies have been extended to regimes of significantly higher energies as reached at BNL-RHIC and CERN-LHC. In addition with the results obtained at RHIC on J/ψ and more recently at LHC on quarkonium states, hints of the theoretically expected sequential suppression start to emerge.

Nevertheless, the experimental validations of such a scenario as well as the characterization of the phase transition require full control of the feed-down sequence. In particular, a precise measurement of quarkonium 1P states which significantly contribute to the yields of quarkonium 1S states is mandatory. For charmonium, the measurement of χ_c production together with J/ψ and ψ’ is needed to prove the sequential suppression scenario.

For this purpose, we propose a new experiment at the CERN SPS, which makes use of modern ultra-granular technologies to perform the measurement of χ_c → J/ψ + photon in Pb+Pb high multiplicity collisions.

In this talk, after a quick reminder of the physics case, we describe the proposed apparatus and present its expected performances.

WG2: Low x and Diffraction / 79

From Hard Exclusive Meson Electroproduction to Deeply Virtual Compton Scattering

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We systematically evaluate observables for hard exclusive electroproduction of real photons and compare them to experiment using a set of Generalized Parton Distributions (GPDs) whose parameters are constrained by Deeply Virtual Meson Production data, nucleon form factors and parton distributions. The Deeply Virtual Compton Scattering amplitudes are calculated to leading-twist accuracy and leading order in QCD perturbation theory while the leptonic tensor is treated exactly, without any approximation. This study constitutes a check of the universality of the GPDs. We summarize all relevant details on the parametrizations of the GPDs and describe its use in the handbag approach of the aforementioned hard scattering processes. We observe a good agreement between predictions and measurements of deeply virtual Compton scattering on a wide kinematic range, including most data from H1, ZEUS, HERMES, Hall A and CLAS collaborations for unpolarized and polarized targets when available. We also give predictions relevant for future experiments at COMPASS and JLab after the 12 GeV upgrade.

WG1/3: Structure Functions and Electroweak Physics / 80

Measurement of the Neutral Current DY process with the ATLAS detector

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Neutral current Drell Yan cross section is sensitive to the proton parton distribution functions, in particular to u-bar quark density. The measurements for two distinct kinematic regions, below the Z boson mass peak and above were performed by the ATLAS collaboration using 7 TeV pp collision data. The results are compared to NNLO QCD predictions corrected for NLO EW effects calculated using various PDF sets.

WG2: Low x and Diffraction / 81

Measurement of hard double-parton interactions with the ATLAS detector

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The production of W bosons in association with two jets in proton-proton collisions at a centre-of-mass energy of \( \sqrt{s} = 7 \) TeV has been investigated using data collected with the ATLAS detector. The fraction of events arising from double-parton scattering has been measured through the pT balance between the two jets. The measurement provides new information on the proton structure and is important to predict the rate of processes such as W+b and same sign WW production.

WG1: Structure Functions / 82

Inclusive jet production measured with ATLAS, and constraints on PDFs

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Inclusive jet and dijet double-differential cross sections have been measured in proton-proton collisions at a centre-of-mass energy of 2.76 and 7 TeV using the ATLAS detector. The cross sections were measured using jets clustered with the anti-\( k_T \) algorithm. The data are compared to expectations based on next-to-leading order QCD calculations corrected for non-perturbative effects, as well as to next-to-leading order Monte Carlo predictions. The ratio of cross section measurements at 2.76 and 7 TeV allows to reduce experimental and/or theoretical uncertainties substantially. An NLO QCD analysis of the data indicates some constraining power for the gluon density.

WG1/3: Structure Functions and Electroweak Physics / 83

Measurement of V+heavy flavour production at ATLAS

Author: Mark Oreglia

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Measurement of $W^+c$ production cross section has a unique sensitivity to the strange-quark density, which is poorly known at low $x$. $W^+b$ production, on the other hand, probes the $b$-quark production by higher order QCD processes. Cross sections are measured differentially as a function of jet multiplicity and transverse momentum of the leading $b$-jet, for the $W^+b$ measurement and as a function of lepton pseudorapidity for the $W^+c$ measurement. The results are compared to the QCD predictions at NLO.

**WG5: Heavy Flavours / 84**

**Top quark pair properties - spin correlations, charge asymmetry and complex final states**

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In proton-proton collisions at the LHC, pairs of top and anti-top quarks are expected to be mostly produced through gluon fusion, in contrast to production at the Tevatron, where quark annihilation dominates. Making use of the large number of top quark pairs, we present measurements of the spin correlation between top and anti-top quarks as well as of the top-quark charge asymmetry which constitute important tests of QCD and are sensitive to new physics. We also discuss top production in association of photons, $Z$ bosons and heavy quarks.

**WG1: Structure Functions / 85**

**Top quark production cross section in ATLAS**

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Measurements of the top quark production cross sections in proton-proton collisions with the ATLAS detector at the Large Hadron Collider are presented. The measurement require no, one or two electrons or muons in the final state (single lepton, dilepton, hadronic channel). In addition, the decay modes with tau leptons are tested (channels with tau leptons). The main focus are measurements of differential spectra of $t\bar{t}$ final states, in particular, measurements that are able to constrain the modelling of additional parton radiation. We also discuss the production of top quark pairs in association with heavy quarks (beauty and charm). Measurements of single top-quark production in the $t$- and $Wt$-channels are presented and determination of the CKM matrix element $|V_{tb}|$ is discussed. In addition, the $s$-channel production is explored and limits on exotic production in single top quark processes are discussed. This also includes the search for flavor changing neutral currents and the search for additional $W'$ bosons in the $s$-channel.
Search for heavy resonances with the ATLAS detector

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Resonances decaying into a pair of particles are an obvious place to look for phenomena beyond the Standard Model. This talk summarizes recent results on searches for resonances in pairs of jets, lepton pairs, leptons and missing transverse energy and pairs of photons. Various models models are considered such the Z' and W', the Randall-Sundrum gravitons as well as the ADD large extra dimension scenario, excited quarks, quantum black hole and contact interactions. Results from $\sqrt{s} = 8$ TeV are presented.

Search for resonant diboson production with the ATLAS detector

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The study of electroweak boson pair production is a powerful test of the spontaneously broken gauge symmetry of the Standard Model (SM) and can be used to search for phenomena beyond the SM. Heavy particles decaying to gauge boson pairs are predicted by many scenarios of new physics, including Extra Dimensions, and Technicolor models. We present generic searches for a heavy particle decaying to a pair of boson. The talk presents results from searches done in several gauge bosons decay channels collected by the ATLAS experiment at the LHC with $\sqrt{s} = 8$ TeV.

Searches for long-lived particles and lepton-jets with the ATLAS detector

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Several extensions of the Standard Model predict the existence of massive long-lived particles, some of these postulate the existence of a hidden sector of particles. We report on searches for weakly-interacting long-lived particles decaying to collimated lepton-jets far away from the interaction point, and for production of multicharged particles. The talk presents the final results of
analyses using data recorded in 2011 at $\sqrt{s}=7$ TeV centre-of-mass energy by the ATLAS experiment at the LHC.

WG3: Electroweak and Searches / 90

Searches for monojets and monophotons with the ATLAS detector

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The compactification of the extra spatial dimensions in the Arkani-Hamed, Dimopoulos, and Dvali model results in a Kaluza-Klein tower of massive graviton modes. These graviton modes are produced in association with a jet or a photon and do not interact with the detectors, resulting in a monojet or a monophoton signature. This channel is also sensitive to a large class of SUSY models. The talk presents results from searches for new physics in final states containing a single jet or a single photon and missing transverse energy studied by the ATLAS experiment at the LHC.

WG3: Electroweak and Searches / 91

Searches for new Physics in events with multiple leptons with the ATLAS detector

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Events containing several leptons are useful probes of new phenomena due to the low background from Standard Model processes. We look for anomalous production of prompt like-sign leptons or events with three or more leptons, as well as search for excited leptons, heavy leptons and heavy neutrinos. The searches use data recorded in 2012 at $\sqrt{s}=8$ TeV centre-of-mass energy by the ATLAS experiment at the LHC.

WG3: Electroweak and Searches / 92

Searches for vector-like quarks and ttbar resonances with the ATLAS detector

Author: Mark Oreglia

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Various extensions of the Standard Model predict the existence of new types of quarks. We report on several search channels such as vector-like quarks decaying to a Higgs boson and a top quark or to a W boson and a b quark. The talk presents results from searches for new resonances decaying to a top-antitop pair, including the use of boosted top quark reconstruction techniques. These searches use the data sample recorded in 2012 at $\sqrt{s}=8$ TeV centre-of-mass energy by the ATLAS experiment at the LHC.
A study of WW/WZ production in the semileptonic final state using proton-proton collisions at \( \sqrt{s} = 7 \) TeV recorded with the ATLAS detector is presented. The cross section is measured in the WW/WZ \( \rightarrow \) lepton \( \nu q\bar{q} \) decay channel where the lepton can be a muon or an electron. The measured cross section is consistent with the Standard Model expectation.

**WG3: Electroweak and Searches / 96**

**Measurement of the Z boson transverse momentum: direct and using \( \phi^* \) variable with ATLAS**

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A measurement of angular correlations in Drell–Yan lepton pairs via the \( \phi^* \) observable is presented. This variable probes the same physics as the Z/gamma boson transverse momentum (\( p_T \)) with a better experimental resolution, especially for low transverse momenta. The measurement using \( \phi^* \) and the direct measurement of \( p_T \) are compared to predictions based on QCD calculations and predictions from different Monte Carlo event generators.

**WG3: Electroweak and Searches / 97**

**Measurement of the forward-backward asymmetry in NC DY process with ATLAS**

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A measurement of the forward-backward asymmetry for the neutral current Drell Yan process is presented. The asymmetry is measured using dielectron and dimuon final states with \( \sqrt{s} = 7 \) TeV data. For the dielectron channel, the measurement includes electrons detected in the forward calorimeter which extends the covered phase space to the region less sensitive to the PDF uncertainties. The result is then used to extract a measurement of the effective weak mixing angle.

**WG3: Electroweak and Searches / 98**

**Inclusive searches for squarks and gluinos with the ATLAS detector**

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Despite the absence of experimental evidence, weak scale supersymmetry remains one of the best motivated and studied Standard Model extensions. This talk summarises recent ATLAS results on inclusive searches for supersymmetric squarks and gluinos in events containing jets, missing transverse momentum with and without light leptons, taus or photons.

Searches for gluino-mediated production of third generation squarks with the ATLAS detector

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Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the third generation quarks with masses not too far from those of their Standard Model counterparts. Real and virtual production of third generation squarks via decay of a gluino can be significant if the mass of the gluino does not exceed the TeV scale. The talk presents recent ATLAS results from searches for gluino mediated stop and sbottom pair production.

Searches for direct pair production of third generation squarks with the ATLAS detector

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Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the third generation quarks with masses not too far from those of their Standard Model counterparts. Top or bottom squarks with masses less than a few hundred GeV can also give rise to direct pair production rates at the LHC that can be observed in the data sample recorded by the ATLAS detector. The talk presents recent ATLAS results from searches for direct stop and sbottom pair production.

Searches for electroweak production of supersymmetric gauginos and sleptons with the ATLAS detector

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Many supersymmetry models feature gauginos and also sleptons with masses less than a few hundred GeV. These can give rise to direct pair production rates at the LHC that can be observed in the data sample recorded by the ATLAS detector. The talk presents results from searches for gaugino and slepton pair production in final states with leptons.

**WG3: Electroweak and Searches / 102**

**Searches for supersymmetry in resonance production, R-parity violating signatures and events with long-lived particles with the ATLAS detector**

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An extended QCD sector beyond the minimal supersymmetric standard model or the admission of R-parity violation introduces new signatures to the search for supersymmetry at the LHC. Strongly interacting resonances may decay to jets, sleptons may decay via lepton-flavour violating processes and lightest supersymmetric particles may decay into many leptons with or without missing transverse momentum. Several supersymmetric models also predict massive long-lived supersymmetric particles. Such particles may be detected through abnormal specific energy loss, appearing or disappearing tracks, displaced vertices, long time-of-flight or late calorimetric energy deposits. The talk presents recent results from searches supersymmetry in resonance production, R-parity violating signatures and events with long-lived particles with the ATLAS detector.

**WG1: Structure Functions / 103**

**The Effect of Recent Jet Results on MSTW PDFs**

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The effect of recent ATLAS inclusive- and di-jet results on the current standard PDF sets is investigated, and compared and contrasted to similar results from the Tevatron. We study the effect of the data using the parton reweighting technique. For ATLAS inclusive jets, there is good agreement across all values of x, and no significant pull is seen on the gluon. For dijets, both D0 and ATLAS data have a potential impact on the PDFs, and the optimum gluon is not necessarily in agreement with that required by the commensurate inclusive data, however the form of the theoretical prediction must be closely investigated, with significant sensitivity to scale choice observed.

**WG7: Future experiments / 104**

**Physics of the Higgs boson at the LHeC**

**Author:** Bruce Mellado Garcia¹

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The prospects for the measurement of properties of the Higgs boson at the LHeC are reviewed. This includes isolating the Higgs boson with the b\bar{b} decay with a 1:1 signal-to-background ratio. This allows for the model independent study of the CP structure of the HWW coupling separately from that of the HZZ coupling. The complementarity of Higgs physics at the LHeC and the LHC will be discussed.

**Kinematic dependences of Φ meson spin-density matrix elements extracted from all HERMES data**

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Spin-density matrix elements (SDMEs) for exclusive Φ meson leptoproduction were extracted using the 27.6 GeV HERA longitudinally polarized lepton beam and longitudinally or transversely polarized or unpolarized hydrogen and deuterium gas targets. The Q2 and t' dependences of SDMEs determined in the kinematic region 1<Q2<7GeV², t' >-0.4GeV², W²>4GeV², extracted from the whole HERMES data set, are presented for the first time. Based on the extracted values of SDMEs one can test the s-channel helicity conservation hypothesis. Presence of unnatural parity exchange mechanism of Φ meson production may also be checked.

**Scattering amplitudes for high-energy factorization**

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While several approaches and their implementations for the efficient calculation of scattering amplitudes within collinear factorization applied to hadron scattering exist, no automated tool exist to achieve the same within frameworks of factorization that allow for the initial-state partons, entering the hard partonic process, to have non-vanishing transversal momentum components. I will present a prescription to construct manifestly gauge invariant tree-level amplitudes with one or two off-shell initial-state gluons for processes with arbitrary particles in the final state, and will show that the prescription allows for calculations that are efficient and easy to automate.

**Contribution of the twist-3 fragmentation function to single transverse-spin asymmetry in SIDIS**
Authors: Koichi Kanazawa¹; Yuji Koike¹

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We study the contribution of the twist-3 fragmentation function to the single transverse-spin asymmetry in SIDIS within the framework of the collinear factorization. Using the Ward-Takahashi identities in QCD, we establish the collinear twist-3 formalism in the Feynman gauge to calculate this contribution with manifest color gauge invariance. Then we present a complete single-spin-dependent cross section formula for SIDIS in the leading-order QCD perturbation theory.

WG1: Structure Functions / 108

Determination of TMDs with HERA data

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We present a determination of the transverse momentum dependent (TMD) parton densities from HERA measurements. The gluon and sea quark TMDs are obtained in the one-loop approximation. The gluon density is also obtained in the all-loop, small x improved, mode. The determination of TMDs include also estimates on uncertainties.

WG6: Spin / 109

Inclusion of charm and $W$ production data in a polarized PDF determination via Bayesian reweighting

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We discuss how a Monte Carlo set of polarized parton distributions, based on inclusive DIS data only, can be supplemented with the experimental information coming from other processes via Bayesian reweighting. We briefly summarize the features of the reweighting technique and we use it to test the impact of open charm muoproduction and $W^\pm$ production data on a neural network, DIS-based, parton fit.
Top quark production at the LHC: differential cross section and phenomenological perspectives

Author: Marco Guzzi

Co-authors: Katerina Lipka; Sven-Olaf Moch

1 Desy Hamburg
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The rate of the t\bar{t} production at the LHC is large enough to make thorough measurements of the differential cross section in terms of the relevant kinematic final-state variables, i.e. transverse momentum $P_T$, rapidity $y$, invariant mass, etc..

The theoretical analysis of such differential distributions requires knowledge of QCD corrections beyond the NLO as well as higher-order soft-gluon contributions from threshold resummation. We illustrate a comparison of recent data to a NLO/NNLO-approx + NNLL calculation that benefits from recent improvements and explicit expressions from SCET and we also discuss differences between various approaches already present in the literature. Our main goal is to assemble all the elements into a computer code that can be used to compute t\bar{t} differential cross section for phenomenological applications and comparisons with the forthcoming data. Particularly relevant is the inclusion of this code in HERAFITTER, for the determination of PDFs and for a PDFs understanding of top quark production.

WG1/5: Structure Functions and Heavy Flavours / 111

Charm quark mass dependence in CTEQ NNLO global analysis

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Co-authors: Jun Gao; Pavel M. Nadolsky

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We determine the mass of the charm quark and study its effect in the next-to-next-to-leading order $\mathcal{O}(\alpha_s^4)$ CTEQ global analysis of parton distribution functions (PDFs) of the proton. Fits are based on the general-mass variable flavor number scheme S-ACOT-$\chi$ for the treatment of heavy-quark contributions and include the recently published measurements of open charm production cross sections in deep-inelastic $ep$ scattering at HERA.

The preferred charm quark $M_{\overline{MS}}$ mass and the experimental errors are determined. We examine the systematic uncertainty related to the theoretical inputs of the fits and investigate the correlations between charm quark mass and PDFs as well as the impact on $W/Z$ vector boson production cross sections at the LHC. We find that the value of the charm quark mass is in agreement with the world average value and with the estimates obtained by other groups.

WG1/3: Structure Functions and Electroweak Physics / 112

Charm production in association with an electroweak gauge boson at the LHC

Author: Eleni Vryonidou
The production of charm quark jets in association with electroweak gauge bosons at the LHC can be used as a tool to constrain quark parton distribution functions (PDFs). Motivated by measurements at the Tevatron and LHC, we calculate cross sections for $W/Z + c$, comparing these to $W/Z + \text{jet}$, for various PDF sets. The cross-section differences can be understood in terms of the different underlying PDFs, with the strange quark distribution being particularly important for $W + c$ production. We suggest measurements of appropriately defined ratios and comment on how these measurements at the LHC can be used to extract information on the strange and charm content of the proton at high $Q^2$ scales.

**BFKL Evolution as a Communicator Between Small and Large Energy Scales**

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We analyze, in leading and next to leading order of the BFKL equation, the effects of the quantization of the singularities of the $j$-plane, t-channel partial waves due to the imposition of appropriate infrared and ultraviolet boundary conditions. We show that the intercepts, $\omega_n$, of the Regge poles, which contribute significantly to the gluon density in the kinematic region measured at HERA and which can be calculated in QCD and in a supersymmetric extension of QCD, are substantially modified by Beyond the Standard Model (BSM) effects. We also develop a physically motivated heuristic model for the infrared boundary condition and apply it to the gluon density. We argue that, using this type of model, the analysis of present and future low-$x$ data could allow one to detect supersymmetry at a high energy scale.

**Vector boson + jets from kT-dependent parton showers**

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We investigate effects of small-$x$ gluon coherence on final states containing vector bosons and jets at the LHC. We use recent results on transverse momentum dependent parton branching and vector boson matrix elements, and present predictions for angular correlations and $p_T$ imbalance distributions in $W + 2$ jets production. We discuss implications of our results on studies of double parton scattering signatures.
Open heavy-flavour production with the ALICE experiment at the LHC

Author: Diego Stocco

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The ALICE experiment is designed to study the properties of the high energy density medium formed in ultra-relativistic heavy-ion collisions. The measurement of open charm and beauty production in heavy ion collisions has an important role in the investigation, since it gives access to the mechanisms of heavy-quark propagation and energy loss in the hot and dense QCD matter. Heavy-flavour measurements in pp collisions are fundamental in this analysis, since they provide a crucial reference for the study of the effects in heavy-ion collisions. Moreover, they have an interest on their own since they allow for a precise test of the perturbative quantum chromodynamics in the high energy domain.

With the ALICE detector, heavy-flavour production can be studied via reconstruction of D mesons through hadronic decay channels at mid-rapidity and inclusive reconstruction of heavy flavours in the semi-electronic and semi-muonic decay channel at central and forward rapidity, respectively. This presentation will be mainly focused on the results in pp collisions at a centre of mass energy of 2.76 and 7 TeV.

Developments Related to MSTW PDFs

Author: Robert Thorne

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I discuss the recent developments relating to the MSTW series of PDFs. I discuss the issues associated with heavy flavour and the influence of some recent data sets.

Transverse spin asymmetries at COMPASS: beyond Collins and Sivers effects

Author: Bakur Parsamyan

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One of the important objectives of the COMPASS experiment (CERN, Geneva) is the exploration of the transverse spin structure of the nucleon via spin dependent azimuthal asymmetries in single-hadron production in deep inelastic scattering of polarized leptons off transversely polarized target. For this purpose a series of measurements were made in COMPASS, using 160 GeV/c longitudinally polarized muon beam and transversely polarized 6LiD (in 2002, 2003 and 2004) and NH3 (in 2007 and 2010) targets.

In the past few years considerable theoretical interest and experimental efforts were focused on the study of Collins and Sivers transverse spin asymmetries. The experimental results obtained so far play an important role in the general understanding of the three-dimensional nature of the nucleon in terms of transverse momentum dependent parton distribution functions.

In addition to these two measured leading-twist effects, the SIDIS cross-section counts six more target transverse spin dependent azimuthal asymmetries, which have their own well defined leading or higher-twist interpretation in terms of QCD parton model. COMPASS preliminary results for these six “beyond Collins and Sivers” asymmetries, obtained from transversely polarized deuteron and proton data will be reviewed.

**ATLAS Jet production measurements and determination of \(\alpha_S\)**

**Author:** ATLAS Collaboration

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An inclusive jet multiplicity ratio is sensitive to the strong coupling constant \(\alpha_S\) and has reduced sensitivity to the uncertainties due to parton distribution functions. The ATLAS data are used to determine the strong coupling’s strength at the highest energy scales. The results probe the consistency of the running of the coupling as predicted by QCD.

**Studies of jet shapes and substructure with ATLAS**

**Author:** ATLAS Collaboration

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The internal structure of jets produced in proton-proton collisions at 7 TeV centre-of-mass energy provides a direct test of QCD calculations of gluon and quark radiation, as well as having sensitivity to hadronisation and underlying event. The transverse energy distribution around the jet core has been measured, as well as the fragmentation of a jet into charged particles. Jet shapes - including the jet mass - and jet substructure have the potential to identify jets coming from massive, boosted particles decaying hadronically. Techniques have also been developed for reducing the sensitivity of jet physics to soft QCD and to multiple proton-proton collisions. A selection of such variables is also measured and compared to a range QCD calculations and phenomenological models.

**Photon, diphoton and photon+jet production measured with the ATLAS detector**
Isolated prompt photons provide a direct probe of short-distance physics, complementary to that provided by measurements of jets or vector-bosons. The data are sensitive to the gluon density of the proton. The inclusive prompt photon cross sections have been measured over a wide range of transverse momenta; the diphoton cross section has also been measured as a function of diphoton mass, total transverse momentum and azimuthal separation; the cross section for photons produced in association with jets is also measured. The results are compared to the predictions of next-to-leading-order QCD.

SM background estimate for supersymmetry searches: challenges and methods

Supersymmetry features a broad range of possible signatures at the LHC. If R-parity is conserved the production of squarks and gluinos is accompanied by events with hard jets, possibly leptons or photons and missing transverse momentum. Some Standard Model processes also mimic such events, which, due to their large cross sections, represent backgrounds that can fake or hide supersymmetry. While the normalisation of these backgrounds can be obtained from data in dedicated control regions, Monte Carlo simulation is often used to extrapolate the measured event yields from control to signal regions. Next-to-leading order and multi-parton generators are employed to predict these extrapolations for the dominant processes contributing to the SM background: W/Z boson and top pair production in association with (many) jets. The proper estimate of the associated theoretical uncertainties and testing these with data represent challenges. Other important backgrounds are diboson and top pair plus boson events with additional jets that usually are estimated directly using Monte Carlo simulation. The talk presents the challenges and methods employed by ATLAS to determine backgrounds and uncertainties in supersymmetry searches.

Studies of vector boson+jet production with ATLAS

The production of jets in association with a W or Z boson in proton-proton collisions at 7 TeV study multileg QCD diagrams. The cross section, differential in several kinematics variables, has been measured up to high jet multiplicities and compared to new higher-order QCD calculations. The ratio of \((Z + \text{a single jet})/(W + \text{a single jet})\) can provide a very precise test of QCD and has also been measured. Overall, the cross sections demonstrate the need for the inclusion of higher-multiplicity matrix elements in the calculations, even in cases where a parton shower simulation is present.
A measurement of jet shapes in t−tbar final states using data recorded by the ATLAS detector is presented. Samples of events with top-quark pairs are selected in both the semileptonic and dileptonic decay modes and the differential and integrated shapes of the b-quark jets resulting from the top-quark decays are compared with those of the light-quark jets from the hadronic W-boson decays W -> q q' in the semileptonic channel. The main observation is that b-quark jets have a wider distribution of the momentum flow inside the jet cone than light-quark jets.

**WG4: QCD and HFS / 125**

**Measurement of kt splitting scales in W->lnu events at sqrt(s) = 7 TeV with the ATLAS detector**

**Author:** ATLAS Collaboration

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A measurement of splitting scales in the kt clustering algorithm for final states containing a W boson produced in proton-proton collisions is presented. The measurement focuses on the four hardest splitting scales in a kt cluster sequence of the hadronic activity accompanying the W boson, and suitably defined ratios. The data are compared to predictions from various Monte Carlo generators. Overall, reasonable agreement is found with all generators, but most of them show deviations in some aspects of the distributions.

**WG2/4: Diffraction and QCD / 126**

**Studies of the underlying event with ATLAS**

**Author:** ATLAS Collaboration

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Particle distributions sensitive to the underlying event in calorimeter jet events have been measured with the ATLAS detector at the LHC. Charged particle multiplicity, charged and inclusive sum transverse momentum (pT) densities and mean charged-particle pT in the regions of each event, azimuthally transverse to the hardest jet, are also presented. The underlying event properties are investigated for soft minimum bias events, events with hard jets and events associated with Z boson production. When compared to the predictions of different Monte Carlo models, the data show sensitivity to the modelling of the underlying event.

**WG4: QCD and HFS / 127**

**Transverse energy flow and charged particle event shapes with ATLAS**

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The transverse energy flow and charged track properties provide inside on the structure of the hadronic events, for soft collisions as well as events with a presence of hard scale. The observables
studied include the transverse thrust, thrust minor and transverse sphericity, each defined using the momenta perpendicular to the beam direction of the final state charged particles. In addition to the differential distributions, the evolution of each event shape variable as a function of the leading charged particle transverse momentum, charged particle multiplicity and summed transverse momentum is presented. The analysis also includes the sum of the transverse energy of particles as a function of particle pseudorapidity, using calorimetry information. The distributions are compared to the predictions of various Monte Carlo event generators, which generally tend to underestimate the amount of transverse energy at high pseudorapidity.

**WG4: QCD and HFS / 128**

**Final state measurements in top pair events produced at LHC**

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The large centre-of-mass energy available at the proton-proton collider LHC allows for the copious production of top quark pairs in association with other final state particles at high transverse momentum. The ATLAS experiment has measured several final state observables that are sensitive to additional parton radiation in top anti-top quark final states. Examples are the multiplicity of jets for various transverse momentum thresholds or the probability to emit jets above a given threshold in a fixed rapidity region. These measurements are compared to modern Monte Carlo generators based on NLO QCD matrix element of LO multi-leg matrix elements and with systematic model parameter variations. The data are able to constrain the uncertainty on the modelling of the top pair production mechanism.

**WG3: Heavy Flavours / 129**

**Production cross section of Quarkonia states in ATLAS**

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The programme of measurement on quarkonia production performed by ATLAS in discussed. Particular emphasis is placed on the recent study of Y(1S), Y(2S) and Y(3S). The collected data extends to transverse momentum up to 70 GeV, much higher than in previous studies. The results are compared to theoretical models of Y production, which do not provide an accurate description of the data over the full range of transverse momentum.

**WG5: Heavy Flavours / 130**

**Production cross section of B-meson in ATLAS**

**Author:** Fabiola Gianotti

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A new measurement of production cross of B+ is presented. The double differential cross section is measured over the range |y| < 2.25 and 9 < pT < 120 GeV, much wider than in previous measurements. Comparisons with next-to-leading order theoretical predictions (POWHEG+PYTHIA, MC@NLO+HERWIG and FONLL) are discussed.

WG5: Heavy Flavours / 131

Mixing and CP violation in the decay of Bs to J/psi Phi in ATLAS

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Mixing and CP violation is studied by ATLAS in the decay of the Bs meson to J/psi Phi, observed in the final state mu+mu-K+K-. The different amplitudes contributing to the process are studied through the time dependence of the angular distribution. Measurements of the average lifetime and lifetime difference between the two eigenstate BH and BL, and of the CP violating phase phi_s are performed. New results obtained with the use of flavor-tagging will be discussed.

WG5: Heavy Flavours / 132

Study of the decay Bd to K* mu+mu- in ATLAS

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The decay of Bd mesons to the final state K*mu+mu- occurs via loop diagrams and is sensitive to physics beyond the Standard Model. The first study performed by ATLAS, based on data collected in 2011 and including measurements of q-square dependence and angular distribution, will be discussed.

WG4/5: Heavy Flavours, QCD and Hadronic Final States / 133

Measurement of the flavour composition of dijet events in pp collisions with ATLAS

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A measurement of the flavour composition of dijet events produced in pp collisions at 7 TeV using the ATLAS detector is presented. Six possible combinations of light, charm and bottom jets are identified in the dijet events, where the jet flavour is defined by the
presence of bottom, charm or solely light flavour hadrons in the jet. The results agree with the predictions of leading- and next-to-leading-order calculations, with the exception of the dijet fraction composed of bottom and light flavour jets, which is underestimated by all models at large transverse jet momenta. The ability to identify jets containing two b-hadrons, originating from e.g. gluon splitting, is demonstrated. The difference between bottom jet production rates in leading and subleading jets is consistent with the next-to-leading-order predictions.

WG3: Heavy Flavours / 134

**Intrinsic top quark properties - top mass, charge and polarisation**

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Properties of the top quark are measured with the ATLAS detector using LHC proton-proton collisions data. Measurements of the top-quark mass and charge, as well as of the polarization of W bosons in top quark decays to probe the Wtb-vertex are presented. A search for flavour changing neutral current processes in top quark decays is also presented. In addition, measurements of the spin correlation between top and anti-top quarks as well as of the top-quark charge asymmetry, which constitute important tests of QCD and are sensitive to new physics, are discussed. The search for flavour changing neutral current processes in top quark decays is reviewed.

WG7: Future experiments / 135

**A detailed study of the nucleus at an Electron-Ion Collider**

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Much information was gained in the past on the structure of the nucleon, there is little data on the structure of the nucleus, particularly at small-to-intermediate x. The construction of an Electron-Ion Collider (EIC) will allow the exploration of the nucleus across a wide region in x. Not only will nuclear PDFs be extracted, but the high statistics data generated will allow the study of the nucleus in fine detail. At high-x, the fragmentation of fast-moving partons in a nuclear environment will be investigated, something which has particular resonance to jet studies at RHIC and the LHC. At small-x, nucleon data have shown that gluons dominate at intermediate-to-small x. Indeed, it is believed that at some point, this growth is so large that it cannot grow any larger and it will saturate. The studies of saturation in e+p collisions require much high energies than those studied to date. However, the universality of this behaviour is expected to be exhibited in nuclear collisions at much higher values of x and at energies available at an EIC. Comparison to theoretical models have shown that diffractive collisions, in particular, will give clear signals of gluon saturation.

In this talk I will present the current status of the physics capabilities of e+A collisions at an EIC as outlined in the EIC White Paper [1].

Helium Compton Form Factor Measurements at CLAS

Author: Eric Voutier

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The partonic structure of hadrons as encoded via the so-called generalized parton distributions (GPD) can be accessed via deeply virtual Compton scattering (DVCS) experiments. Similarly to the scattering of light by a material, DVCS provides information about the dynamics and the spatial structure of hadrons. DVCS off nuclear targets allow to address the partonic structure of the nucleus (coherent channel) as well as the partonic structure of nucleons (incoherent channel) embedded in the nuclear medium. Identification of these reaction channels is however challenging, requiring a clear separation of the coherent and incoherent channels.

The high density of the He4 nucleus and its isoscalar nature have always been appealing features for nuclear structure studies. In the case of DVCS experiments, this translates into the ability to extract from the single measurement of the beam spin asymmetry (BSA), the real and imaginary parts of the Compton form factor that contains the He4 leading twist GPD.

The eg6 experiment at the Jefferson Laboratory explored nuclear DVCS off He4. The BSA was measured with the CLAS detector, complemented with a small angle electromagnetic calorimeter and a radial time projection chamber. This talk reviews the experimental methods and techniques of the eg6 run, and discusses the preliminary results of the measurements of the He4 Compton form factor.

Dihadron production in semi-inclusive DIS from transversely polarized protons

Author: Stephen Gliske

Transverse Momentum Dependent (TMD) dihadron production, including vector meson production, allows access to various TMD distribution and fragmentation functions. Dihadron production is complementary to single hadron semi-inclusive DIS measurements, pairing the same distribution functions with different fragmentation functions. While dihadrons present unique measurement opportunities, the TMD dihadron cross section is significantly more complex than that for single hadron production, due to the polarization in the final state. Various theoretical advances, which further clarify the complexity, will be highlighted. The HERMES analysis of the transverse target moments of the TMD dihadron cross section allows the first test of a particular prediction of the Lund/Artru string fragmentation model, specifically that the favored Collins fragmentation function has opposite sign in single hadron production versus vector meson production. The status and results of this analysis will be discussed and an extension of the Lund/Artru model for disfavored fragmentation will also be presented.

Forward Neutral Pion Cross Section and Spin Asymmetry Measurements at STAR
Author: Stephen Gliske

1 Argonne National lab, for the STAR Collaboration

The STAR endcap electromagnetic calorimeter (EEMC) was designed to allow measurement of cross sections and spin observables in the forward direction, $1 < \eta < 2$ and with the full azimuth. Using the EEMC to measure double longitudinal spin asymmetries in photonic channels—such as inclusive neutral pions, prompt photon, and prompt photon + jet—allows access to $\Delta G$ covering a lower $x$ region than current mid-rapidity measurements. Transverse spin asymmetries, shown to be zero at $\eta$ near zero and as large as 10% at $\eta$ near 4, measured with the EEMC occupy a previously unmeasured region in the 3D pseudorapidity, transverse momentum, and $x$-Feynman phase space. The neutral pion cross section measurement verifies that the signal of interest can be properly reconstructed and isolated from the background. Particle reconstruction with the STAR EEMC and the status of the spin asymmetries will be discussed, and the preliminary cross section measurement will be presented and compared to NLO pQCD theory.

WG6: Spin / 139

New COMPASS results on the proton spin-dependent structure function $g_{1}^{p}$

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New results on the double spin asymmetry $A_1$ and the spin-dependent structure function of the proton $g_{1}^{p}$ as a function of $x_{Bj}$ and $Q^2$ will be presented. They rely on the DIS data collected in 2011 by the COMPASS Collaboration with a polarised muon beam of 200 GeV and a polarised $NH_3$ target. The high energy of the beam allows $A_1$ measurements down to $x_{Bj} = 0.0025$ for the first time and extends the $Q^2$ range, which bring new inputs for QCD global fits of world data. The latest impact of the COMPASS data on the QCD fits will also be presented.

WG2: Low x and Diffraction / 140

Exclusive production of one and two heavy quarkonia in nuclear collisions

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Heavy nuclei at collider energies are a source of high-energy Weizsäcker-Williams photons. This photon flux may be utilized to study high-energy photon-nucleus interactions. We will first discuss the coherent diffractive production of heavy vector mesons on nuclear targets and show how it probes the unintegrated glue of the nucleus in the saturation domain. We present our calculations for rapidity distributions of exclusive coherent $J/\Psi$ and $\Upsilon$ mesons. Then we will turn to the gamma-gamma collisions and address the production of a pair of $J/\Psi$'s.

The presentation is based on:
On the role of the Sivers effect in AN for inclusive particle production in pp collisions

Author: Umberto D’Alesio¹
Co-authors: Alexei Prokudin ²; Francesco Murgia ³; Mariaelena Boglione ⁴; Mauro Anselmino ⁴; Stefano Melis ⁵

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Single spin asymmetries, AN, for inclusive particle production in pp collisions are considered within a generalized parton model with inclusion of spin and tranverse momentum effects.

We consider the potential role of the Sivers effect in AN, as extracted from a careful analysis of azimuthal asymmetries in SIDIS, and discuss its phenomenological consequences in connection with a recently updated study of the Collins effect.

Diffractive mechanisms in pp -> pp π0 reaction at high energies

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The amplitudes for pp → ppπ⁰ process at high energy discussed given.
Both diffractive bremsstrahlung and diffractive π⁰-rescattering (Drell-Hiida-Deck (DHD) type model) as well as photon-photon and photon-omega exchange mechanisms are included in the calculation and discussed in detail. Fairly large cross sections of the order of mb are predicted. The corresponding differential cross sections in rapidities and transverse momenta of outgoing protons and pions as well as relative azimuthal angle between outgoing protons are calculated for ISR, RHIC and LHC energies. The hadronic bremsstrahlung contributions dominate at large (forward, backward) pion rapidities.

The diffractive non-resonant background contributes at small π⁰p invariant mass and could be therefore misinterpreted as the Roper resonance. We predict strong dependence of the slope on the mass of the excited system.
At high energies and midrapidities the photon-photon contribution dominates over the diffractive components, however, the corresponding cross section is rather small. Our predictions are ready for verification at RHIC and LHC. The bremsstrahlung mechanisms discussed here contribute also to \( pp \to p(n\pi^+) \) reaction. Both channels give a sizeable contribution to the low-mass single diffractive cross section and must be included in extrapolating measured experimental single diffractive cross section.

**WG2: Low x and Diffraction / 146**

**Exclusive diffractive photon bremsstrahlung at high energies**

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We calculate differential distributions for the \( pp \to pp\gamma \) reaction at the LHC energy \( \sqrt{s} = 14\, \text{TeV} \). We consider diffractive classical bremsstrahlung mechanisms including effects of non point-like nature of protons. In addition, we take into account (vector meson)-pomeron, photon-pion as well as photon-pomeron exchange processes for the first time in the literature. Predictions for the total cross section and several observables related to these processes e.g. differential distributions in pseudorapidities and transverse momenta of photons or protons are shown and discussed.

The integrated diffractive bremsstrahlung cross section \( (E_\gamma > 100\, \text{GeV}) \) is only of the order of \( \mu \text{b} \).

We try to identify regions of the phase space where one of the mechanisms dominates.

The classical bremsstrahlung dominates at large forward/backward photon pseudorapidities, close to the pseudorapidities of scattered protons.

In contrast, the photon-pomeron (pomeron-photon) mechanism dominates at midrapidities but the related cross section is rather small.

In comparison the virtual-omega rescattering mechanism contributes at smaller angles of photons (larger photon rapidities).

Photons in the forward/backward region can be measured by the Zero Degree Calorimeters (ZDCs) installed in experiments at the LHC while the midrapidity photons are difficult to measure (small cross section, small photon transverse momenta).

Protons could be measured by ALFA detector (ATLAS) or TOTEM detector at CMS. The exclusivity could be checked with the help of main central detectors.

**WG2: Low x and Diffraction / 147**

**Revising the Impact-Parameter dependent Saturation model with combined HERA data**

**Author:** Amir Rezaeian\(^1\)

**Co-authors:** Marat Siddikov \(^1\); Raju Venugopalan \(^2\)
The Impact-Parameter dependent Saturation Model is a simple dipole model that incorporates key features of the physics of gluon saturation and matches smoothly to the perturbative QCD dipole expression at large $Q^2$ for a given $x$. It was previously shown that the model gives a good description of HERA data suggesting evidence for gluon saturation effects at small $x$. The model has also been applied to proton-proton and proton-nucleus collisions and provides the basis for the IP-Glasma model of initial conditions in heavy ion collisions. Here we present a reanalysis of available data in electron-proton collisions at small Bjorken-$x$, including the recently released combined data from the ZEUS and H1 collaborations. We first confront the model to the high precision combined data for the reduced cross-section and obtain its parameters. With these parameters fixed, we compare model results to data for the structure function $F_2$, the longitudinal structure function $F_L$, the charm structure function $F_2^{c\bar{c}}$, exclusive vector meson ($J/\psi$, $\phi$ and $\rho$) production and Deeply Virtual Compton Scattering (DVCS). Excellent agreement is obtained for the processes considered at small $x$ in a wide range of $Q^2$. Our results strongly hint at universality of the IP-Sat dipole amplitude and the extracted impact-parameter distribution of the proton. They also provide a benchmark for further refinements in studies of QCD saturation at colliders.

This work is based on:

WG4/5: Heavy Flavours, QCD and Hadronic Final States / 148

Production of two $c\bar{c}$ pairs in double-parton scattering within $k_t$-factorization approach

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We discuss production of two pairs of $c\bar{c}$ in proton-proton collisions at the LHC. Both double-parton scattering (DPS) and single-parton scattering (SPS) contributions are included in the analysis. Each step of DPS is calculated within $k_t$-factorization approach, i.e. effectively including next-to-leading order corrections. The conditions how to identify the DPS contribution are presented. The discussed mechanism unavoidably leads to the production of pairs of mesons: $D, \bar{D}$ (each containing $c$ quarks) or $\bar{D}, D$ (each containing $\bar{c}$ antiquarks). We calculate corresponding production rates for different combinations of charmed mesons as well as some differential distribution for $(D^0\bar{D}^0 + D^0\bar{D}^0)$ production. Within large theoretical uncertainties the predicted DPS cross section is fairly similar to the cross section measured recently by the LHCb collaboration. The best description is obtained with the Kimber-Martin-Ryskin (KMR) unintegrated gluon distribution, which very well simulates higher-order corrections. The contribution of SPS, calculated in the high-energy approximation, turned out to be rather small. Finally, we emphasize significant contribution of DPS mechanism to inclusive charmed meson spectra measured recently by ALICE, ATLAS and LHCb.

WG6: Spin / 150

Studies of TMDs with CLAS
Studies of single and double-spin asymmetries in pion electro-production in semi-inclusive deep-inelastic scattering of 5.8 GeV polarized electrons from unpolarized and longitudinally polarized targets at the Thomas Jefferson National Accelerator Facility using CLAS will be discussed. The dependence of these amplitudes on Bjorken $x$ and on the pion transverse momentum has been extracted and is compared to model calculations. Additionally, we employ a Bessel-weighting strategy to extract transverse momentum dependent parton distribution functions.

WG3: Electroweak and Searches / 151

Higgs boson and Top quark masses as tests of Electroweak Vacuum Stability

Author: Isabella Masina

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The measurements of the Higgs boson and top quark masses can be used to extrapolate the Standard Model Higgs potential at energies up to the Planck scale. Adopting a NNLO renormalization procedure, we: i) find that electroweak vacuum stability is at present allowed, discuss the associated theoretical and experimental errors and the prospects for its future tests; ii) determine the boundary conditions allowing for the existence of a shallow false minimum slightly below the Planck scale, which is a stable configuration that might have been relevant for primordial inflation; iii) derive a conservative upper bound on type I seesaw right-handed neutrino masses, following from the requirement of electroweak vacuum stability.

WG1/3: Structure Functions and Electroweak Physics / 152

Weak radiative corrections to dijet production at hadron colliders

Author: Alexander Huss

Co-authors: Christian Speckner; Stefan Dittmaier

We present the calculation of the most important electroweak corrections to dijet production at the LHC and the Tevatron, comprising tree-level effects of $O(\alpha_s \alpha, \alpha^2)$ and weak loop corrections of $O(\alpha_s^2 \alpha)$. Although suppressed by the small value of the coupling constant $\alpha$, these corrections can become large in the high-energy domain due to the appearance of Sudakov-type and other high-energy logarithms. A particular emphasis is put on the impact of the definition of observables, where the corrections become larger when the observable is dominated by the Sudakov regime at high energy scales.
WG2: Low x and Diffraction / 154

**Diffractive production of quark-antiquark pairs**

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We discuss the diffractive dissociation of gluons into heavy quark pairs. The particular mechanism is similar to the diffractive dissociation of virtual photons into quarks, which drives diffractive deep inelastic production of charm in the low-mass diffraction, or large $\beta$-region. The amplitude for the $gp \rightarrow Q\bar{Q}p$ is derived in the impact parameter and momentum space. The cross section for single diffractive $pp \rightarrow Q\bar{Q}pX$ is calculated as a convolution of the elementary cross section and gluon distribution in the proton. Both the integrated and the differential distributions in e.g. transverse momentum and rapidity of the charm and bottom quark and antiquark, quark-antiquark invariant mass are calculated for the nominal LHC energy for different unintegrated gluon distributions from the literature. The model leads to much smaller fractional longitudinal momentum losses than in the Ingelman-Schlein (IS) model. Quark and antiquark are produced exclusively either in the $y_1, y_2 > 0$ region or in the $y_1, y_2 < 0$ region. The gluon dissociation contributes into the region of very small $x_{FP}$, much smaller than in the Ingelman-Schlein model with absorption. These characteristics can be used to separate the present mechanism from the Ingelman-Schlein one. The ratio of the bottom-to-charm cross sections are shown and discussed.

WG3: Electroweak and Searches / 155

**EW precision measurements at the LHC: theory review**

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We present a theoretical overview of the present status and prospects for electroweak measurements at LHC, leading to precision tests of the standard model. The state of the art of Monte Carlo event generators is illustrated and special attention is paid to the interplay between QED and QCD, the measurement of the W mass and the effective weak mixing angle.
Polarised Drell-Yan measurements at COMPASS-II

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Much of the information that exists today about Transverse Momentum Dependent Parton Distribution Functions (TMDs) comes from SIDIS measurements with unpolarised and polarised beams and targets where they appear convoluted with fragmentation functions (FFs). Drell-Yan (DY) measurements are complementary to those by SIDIS experiments, as they allow to measure convolutions of only PDFs without involving FFs. Moreover, given the T-odd character of both Sivers and Boer-Mulders functions, the sign of these TMDs is expected to be reversed when observed from SIDIS or from DY. Measurements of SIDIS were performed by Compass in the period 2002 to 2007 and in 2010, using a naturally polarised m+ beam and a solid state target polarised either longitudinally or transversely with respect to the beam direction. Now the COMPASS-II Experiment has the unique opportunity to access TMDs also from single-polarised Drell-Yan processes, allowing to test the sign change prediction for the first time. We present here the future polarised DY measurements at COMPASS-II, which are foreseen to start in late 2014.

Heavy-quark production in deep-inelastic scattering

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We present a determination of the running charm-quark mass in the MSbar scheme in framework of global analyses of the proton structure using recent HERA data of charm production cross section measurements. A crucial prerequisite for this task are QCD precision predictions to higher orders which require the choice of a scheme for the description of heavy-quark production in deep-inelastic scattering. We present a comparative study of fixed flavor number and variable flavor number schemes.

The Electron Ion Collider: The Next QCD Frontier

Author: Abhay Deshpande

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How are the sea quarks, gluons, and their spins distributed in space and momentum inside the nucleon? Where does the saturation of gluon densities set in? How does the nuclear environment affect the distribution of quarks and gluons and their interactions in nuclei? These are profound and compelling questions in QCD that have (evolved and) remain unanswered despite decades of (success of, and) heroic effort by past experimental programs at BNL, CERN, DESY and SLAC. A
future (variable) high-energy and high-luminosity Electron Ion Collider (EIC) with possibility of col-
liding polarized electrons with polarized nucleons/light-nuclei, and a wide range in nuclear species
is being considered by the US nuclear science community which promises to quantitatively address
and resolve the above mentioned "profound and compelling questions" in QCD. I will present the
science highlights and the possible realization scenarios under consideration in the US.

WG4: QCD and HFS / 160

Tools for calculations in color space

Author: Malin Sjodahl

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Both the higher energy and the initial state colored partons contribute to making exact calculations
in QCD color space more important at the LHC than at its predecessors. This is applicable whether
the method of assessing QCD is fixed order calculation, resummation, or parton showers.

In this talk I will discuss tools for tackling the problem of performing exact color summed calcula-
tions. I will start with "theoretical tools" in the form of the (standard) trace bases
and the orthogonal multiplet bases (for which a general method of construction was recently pre-
sented). Following this, I will focus on two new packages for performing color structure calculations:
one easy to use Mathematica package, ColorMath, and one C++ package, ColorFull, which is suitable
for more demanding calculations, and for interfacing with event generators.

WG6: Spin / 161

Gluon polarisation results from the COMPASS experiment

Author: Luis Silva

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In the context of the nucleon spin structure, the contribution from the gluons plays an important
role. The so-called gluon polarisation can be determined in DIS through the Photon-Gluon Fusion
(PGF) process. In the COMPASS experiment, data were collected with a naturally polarised 160
GeV/c muon beam, impinging on a polarised nucleon. Two analyses aiming at the extraction of the
gluon polarisation were performed. One is based on the identification of open charm events and the
other on the selection of events with high-p_T hadrons.
The final results for the gluon polarisation from these analyses were obtained in LO approximation.
For the open charm data an analysis in NLO was performed. In the case of high-p_T events, for the
first time, the results are extracted in 3 x_g bins. Also A^2[2h] asymmetries were recently evaluated in
2-Dim bins of x and pT^2. In both analyses, a weighted method based on a neural network approach
is used.

WG5: Heavy Flavours / 162

New Heavy-flavor results from D0

Author: Iain Bertram

Co-authors: Marjorie Corcoran; Mark Williams
We present new and recent heavy-flavor results from the D0 Experiment, using the full \( \sim 10 \text{ fb}^{-1} \) sample of ppbar collisions collected at \( \sqrt{s} = 1.96 \text{ TeV} \), at the Tevatron collider. The semileptonic mixing asymmetries in \( B^0 (a^d_{sl}) \) and \( B^0_s (a^s_{sl}) \) decays are extracted independently, with data-driven methods used to correct for reconstruction asymmetries. Both \( a^d_{sl} \) and \( a^s_{sl} \) are found to be consistent with the standard model predictions. The measurement of \( a^d_{sl} \) is more precise than the previous world average, while the \( a^s_{sl} \) result is competitive with the world’s best measurement. Using a similar technique, we perform a measurement of the direct CP violation parameter in \( B^+ \rightarrow J/\psi K^+ \) decays, obtaining the most precise result to date. We also report the final update of the search for the rare decay \( B^0_s \rightarrow \mu^+ \mu^- \), using innovative methods to improve the separation of signal and background data candidates. We observe three events in the signal \( M(\mu^+ \mu^-) \) region, consistent with the expectations from background events, and set an observed (expected) limit at the 95% C.L. of \( 15 \times 10^{-9} (22 \times 10^{-9}) \).

WG5: Heavy Flavours / 163

Studying hot QCD matter at the CERN-LHC with heavy quarks

Author: Andre Mischke

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Relativistic nucleus-nucleus collisions allow exploring the behaviour of strongly interacting matter at high temperatures and high energy densities, where a new phase of matter, the Quark-Gluon Plasma (QGP), is predicted to exist. In this phase colour confinement of quarks and gluons into hadrons should vanish. Heavy-flavour particles, containing charm and beauty, are sensitive probes to study the properties of the QGP. Due to their large mass, heavy quarks are produced predominantly in the (hottest) initial phase of the collision via gluon fusion processes and therefore allow to explore the complete space-time evolution of the QGP matter. Theoretical models based on perturbative QCD predict that heavy quarks should experience smaller energy loss than light quarks, when propagating through the QGP matter, due to the mass-dependent suppression of gluon radiation at small angles (the so-called dead-cone effect). Of particular interest is the quantitative understanding of fundamental quantities such as the transport coefficients.

In this talk selected highlights on open heavy-flavour production in lead-lead collisions at CERN’s Large Hadron Collider will be presented and discussed.

WG2: Low x and Diffraction / 165

Single and double diffractive prompt photon production at the LHC

Author: Cristiano Brenner Mariotto

Co-author: Victor Goncalves

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In this work we study the prompt photon production in single and double diffractive processes considering the resolved Pomeron model. We estimate the rapidity and transverse momentum dependence of the cross section for the production of two photons and of a photon and a jet. We show that these processes are sensitive to the pomeron structure. In contrast with the dijet and heavy quark production, which are dominated by gluon-gluon interactions, in prompt photon production, Compton like processes are dominant for single photon plus jet events, while in double photon production, quark-antiquark annihilation dominates. This gives a unique opportunity to constrain the quark distributions in the Pomeron. The results are obtained for the current and future LHC energies.

WG1: Structure Functions / 166

TMD quark distributions at small x

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Co-authors: Francesco Hautmann; Hannes Jung

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We discuss recent work on the transverse momentum dependent sea quark density at small x and its application to Drell-Yan production at both forward and central rapidities.

WG2: Low x and Diffraction / 167

Cross sections and forward multiplicities measurements with TOTEM

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The TOTEM experiment at the LHC has performed the first luminosity-independent measurements of the total proton-proton cross-section at sqrt(s) = 7 TeV and 8 TeV. These measurements are based on the optical theorem and require simultaneous measurements of the elastic rate by measuring the outgoing protons with Roman Pots and of the inelastic rate, accomplished with the forward charged-particle telescopes T1 and T2 in the range 3.1 < |eta| < 6.5.

TOTEM has also determined the total pp cross-section using the CMS luminosity measurement in various ways and the results were found in excellent agreement with the luminosity-independent measurement, despite having very different systematic dependencies. Moreover, since TOTEM is capable to detect inelastic events with diffractive masses down to 3.4 GeV, a limit on the cross section for low mass diffraction was set from the difference between the overall inelastic cross section (measured only using elastic scattering) and visible inelastic cross section (measured using T1 and T2).

The differential elastic cross section has been measured in the range 5*10^-3<|t|<2.5 GeV^2 for pp collisions at the center of mass energy of 7 TeV and down to |t|=0.01 GeV^2 for collisions at 8 TeV. The
measurement of the forward charged particle \( \eta \)-density has been performed at 7 TeV in the range \(5.3<|\eta|<6.4\). This measurement constitutes the most forward pseudorapidity density measurement ever obtained at LHC. This analysis is also repeated at 8 TeV by using a dedicated run taken with a common CMS/TOTEM trigger.

A summary of these measurements is here reported, as well as the preliminary results on single and double diffractive cross section.

**WG1: Structure Functions / 168**

**Proton structure functions and physical evolution kernels**

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Physical anomalous dimensions allow to describe the \( Q^2 \) dependence of proton structure functions in a factorization scheme independent manner. We perform the first numerical implementation of these physical evolution kernels at both leading and next-to-leading order. A comparison to conventional DGLAP evolution based on factorization into coefficient and parton distribution functions is provided.

**WG1/3: Structure Functions and Electroweak Physics / 169**

**Electroweak boson production at LHCb**

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We report measurements of Electroweak boson production in the forward region, using data collected at the LHCb experiment with a centre of mass energy of \( \sqrt{s}=7 \) TeV with an integrated luminosity of up to 1.0 fb\(^{-1}\). \( W \) and \( Z \) bosons are reconstructed in leptonic decay channels, and their cross-sections determined using data-driven techniques. All results are compared to NNLO predictions.

**WG3: Electroweak and Searches / 170**

**Limits on neutral Higgs production in the forward region in pp collisions at \( \sqrt{s}=7 \) TeV**

**Author:** Marta Calvi

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Limits on the cross-section times branching fraction for Higgs particles, produced in pp collisions at sqrt(s) = 7 TeV, and decaying to two taus with pseudorapidities between 2 and 4.5, are presented. The result is based on a dataset of 1.0 fb-1 collected by the LHCb detector. Model independent upper limits on neutral Higgs cross-section times branching fraction are set and are compared to the SM Higgs expectation. Model dependent MSSM upper limits on tan(beta) are also set.

WG2: Low x and Diffraction / 171

Exclusive J/psi and psi(2S) production in pp collisions at sqrt(s)=7 TeV

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Exclusive J/psi and psi(2S) vector meson production has been observed in the dimuon channel using the LHCb detector. The cross-section times branching fractions to two muons with pseudorapidities between 2.0 and 4.5 are measured and are found to be in good agreement with results from previous experiments and theoretical predictions. The J/psi photoproduction cross-section is reported as a function of the photon-proton centre-of-mass energy, and is shown to be consistent with measurements obtained at HERA with power law behaviour.

WG4: QCD and HFS / 172

Inclusive particle production at LHCb

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Due to its unique pseudorapidity coverage and the possibility of extending measurements to low transverse momenta, LHCb provides important input to the understanding of particle production and energy flow in a kinematical range where QCD models have large uncertainties. Measurements of charged & strange particle production and energy flow are performed in the approximate pseudorapidity range 2<eta<5, which corresponds to the acceptance of the LHCb spectrometer. The results are compared to predictions given by several Monte Carlo event generators, which model the underlying event activity in different ways.

WG2: Low x and Diffraction / 173

Studies of quarkonia production and polarisation at LHCb

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Studies of quarkonia production in the forward region provide important tests of NRQCD. The LHCb experiment has collected a dataset corresponding to an integrated luminosity of about 3 fb-1 in
proton-proton collisions at $\sqrt{s}$= 7 and 8 TeV. We present studies of the production and polarisation of the $J/\psi$, $\psi(2S)$ and $\chi_c$ charmonium states as well as those of $\Upsilon$ and $\chi_b$ bottomonia. Absolute and relative production cross-sections are presented and compared to the most recent theoretical predictions when available. We also discuss the future prospects for these measurements.

**WG5: Heavy Flavours / 174**

**Quarkonium measurements at STAR**

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The calculations of Quantum Chromodynamics on lattice showed that under conditions of high energy density or high temperature nuclear matter undergoes a phase transition from state of confined quarks and gluons to deconfined state, the Quark-Gluon Plasma (QGP). Such conditions were present in first moments after the Big Bang in the early universe and can be created in laboratory by colliding of heavy ions with sufficient energy. During the last decade, the STAR experiment at Relativistic Heavy Ion Collider has studied the properties of the Quark-gluon Plasma.

One of the most prominent signatures of QGP formation is the Debye screening of the quark-antiquark potential resulting in quarkonium suppression in central heavy ion collisions. However, cold nuclear effects, heavy quark recombination and hot wind dissociation could influence the measured quarkonium yields. Measurements of different quarkonium states in different collision systems and centralities are necessary to extract the color-screening effects.

Quarkonium measurements allow to extract the thermodynamic properties, since different quarkonium states have different binding energy and therefore disassociate at different temperature of QGP.

In this talk, we will report on the recent STAR measurements of $J/\psi$ and $\Upsilon$ production at mid-rapidity in $p+p$, $d+Au$ and $Au+Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV. We will also present the $J/\psi$ polarization measurement in $p+p$ collisions and the $J/\psi$ elliptic flow measurement in $Au+Au$ collisions.

**WG5: Heavy Flavours / 175**

**Charm and beauty production at LHCb**

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The LHCb experiment has accumulated more than 3 fb$^{-1}$ of data in proton-proton collisions data at different centre of mass energies, collecting a sample rich in charm and beauty hadrons. Studies of the production of these states provide a wealth of new measurements as well as probes of theory predictions. We will present studies of charm and beauty production including measurements of the properties of the produced hadrons.
WG5: Heavy Flavours / 176

Studies of excited charm and beauty mesons at LHCb

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We present the latest results concerning excited D(s) and B(s) mesons using data collected by the LHCb experiment in proton-proton collision at the LHC. High precision measurements of the masses and widths of the Ds1(2700), DsJ(2860), B, Bs1(5830) and Bs2(5840) states are reported. The observation of the new decay mode Bs2 -> B+K is also presented.

WG5: Heavy Flavours / 177

Properties and decays of the Bc meson and b baryons

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Using the large data sample collected by the CERN LHCb experiment, we present studies of Bc mesons and b baryons, including the first observation of new decay modes of the Bc meson as well as high precision mass measurements. The polarization amplitudes in Lambda_b -> J/psi Lambda_0 decay are measured together with measurements of the transverse polarisation of Lambda_b baryons produced in sqrt(s)=7 TeV pp collisions.

WG5: Heavy Flavours / 178

Quarkonia and quarkonia-like spectroscopy at LHCb

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The latest years have seen a resurrection of interest in searches for exotic states motivated by tantalising observations by Belle and CDF. Using the data collected at pp collisions at 7 and 8 TeV by the LHCb experiment we present limits on the X(4140) and studies of the X(3872) quantum numbers. Future prospects for other exotic states will be discussed.

WG7: Future experiments / 179

The LHCb upgrade

Author: Umberto Marconi
The LHCb experiment is designed to perform high-precision measurements of CP violation and search for New Physics using the enormous flux of beauty and charmed hadrons produced at the LHC. The operation and the results obtained from the data collected in 2010 and 2011 demonstrate that the detector is robust and functioning very well. However, the limit of 1 fb–1 of data per year cannot be overcome without improving the detector. We therefore plan for an upgraded spectrometer by 2018 with a 40 MHz readout and a much more flexible software-based triggering system that will increase the data rate as well as the efficiency specially in the hadronic channels. Here we present the LHCb detector upgrade plans, based on the Letter of Intent and Framework Technical Design Report.

Developments in CTEQ-TEA analysis

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I discuss recent developments in the CTEQ-TEA global analysis of parton distribution functions

Gluon Polarization and Jet Production in STAR

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One of the primary goals of the RHIC spin program is to determine the gluon polarization distribution within the proton. At leading order, pp collisions involve a mixture of quark-quark, quark-gluon, and gluon-gluon scattering. In RHIC kinematics, the quark-gluon and gluon-gluon contributions dominate, which makes RHIC an ideal tool to explore gluon polarization. The STAR experiment has measured the longitudinal double-spin asymmetry, A_LL, for inclusive and di-jet production at sqrt(s) = 200 GeV. The inclusive jet results provide the first experimental indication of non-zero gluon polarization in the x range sampled at RHIC. At leading order, the di-jet studies provide access to the incident parton kinematics, allowing a direct determination of the momentum dependence of the gluon polarization, Delta g(x,Q^2). During the 2012 and 2013 RHIC runs, STAR is investigating these same observables in pp collisions at sqrt(s) = 510 GeV, which will expand the kinematic reach to lower-x gluons. The STAR measurements at 200 GeV will be discussed, including recent analysis improvements that provide reduced systematic uncertainties. In addition, the anticipated sensitivity of the 510 GeV measurements will be discussed, and STAR plans for future gluon polarization studies will be described.

WG7: Future experiments

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PHENIX detector upgrades for enhanced physics programs

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The PHENIX collaboration has been developing detector upgrade plans for enhanced physics programs using full luminosity of recent upgraded RHIC facility. This upgrade, referred to as sPHENIX, provides a variety of programs with heavy-ion collisions and polarized proton collisions at RHIC. We’re proposing a major upgrade of the central-rapidity spectrometer consisting of a solenoidal magnet surrounded by electromagnetic and hadronic calorimeters with uniform coverage over |eta| < 1. The upgrade enables a crucial jet physics program to investigate the nature of the strongly-coupled quark-gluon plasma. Additional tracking layers and a preshower will expand the sPHENIX program to include heavy-flavor, neutral pion, low-mass dilepton, and direct photon measurements. Moreover we have been developing a forward-rapidity spectrometer upgrade plan with the open geometry. It has been designed for the study of cold nuclear matter effects in proton- and deuteron-nucleus collisions, precision measurements of single transverse-spin asymmetries for the Drell-Yan process, and measurements of novel observables in jet production in transversely polarized proton collisions.

WG7: Future experiments / 183

ePHENIX at eRHIC

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eRHIC is a proposed high luminosity, polarized Electron-Ion Collider (EIC), which would make use of the existing RHIC infrastructure. The eRHIC design is based on using one of the two RHIC hadron rings and a multi-pass Energy Recovery Linac (ERL). A polarized electron beam with an energy up to 30 GeV would collide with a number of ion species accelerated in the existing RHIC accelerator complex, from polarized protons with a top energy of 250 GeV to fully-stripped uranium ions with energies up to 100 GeV/u covering a center-of-mass energy range from 45 to 175 GeV for polarized e+p, and from 32 to 110 GeV for e+ A (for large A) collisions. eRHIC will be able to provide electron-hadron collisions in up to three interaction regions. In one of these regions will be the upgraded PHENIX detector, ePHENIX that evolves from the sPHENIX detector currently being designed. It is envisioned to fully use the sPHENIX detector at midrapidities (|eta|<1), followed by a sPHENIX-Forward upgrade with additional modifications specific to ePHENIX.

This presentation will describe the ePHENIX approach and goals and requirements for day-1 physics at eRHIC.

WG6: Spin / 184

Large p_T Forward Transverse Single Spin Asymmetries of π^0 Mesons at \sqrt{s}= 200 and 500 GeV from STAR.

Author: Steven Heppelmann

Penn State University for the STAR Collaboration
The STAR collaboration has collected two large data sets for measurement of forward π^0 transverse single spin asymmetries (SSA) in polarized pp collisions. Preliminary results and analysis progress will be presented for data from two RHIC runs, from RHIC Run 11 (2011) with energy √s=500 GeV and with luminosity of 22 pb^-1 and from RHIC Run 12 (2012) with √s=200 GeV and with luminosity of 18 pb^-1. Neutral pions are measured with the STAR forward electromagnetic calorimeter (called FMS) with nearly full azimuthal acceptance over the range of pseudo-rapidity from 2.65 to 4.0. Large transverse SSA is now seen over a much greater range of transverse momentum, up to 10 GeV/c, than reported in previous publications. The analysis of the underlying event structure raises important questions about the overall jet-like nature of events associated with the spin asymmetry of the π^0. These results may provide new insight into the 30 year old puzzle as to the nature of large SSAs in forward hadron production.

WG7: Future experiments / 185

AFTER@LHC: A Fixed-Target ExpeRiment at the LHC

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We outline the physics opportunities [1] which are offered by a next generation and multi-purpose fixed-target experiment exploiting the LHC beams extracted by a bent crystal. This mature extraction technique offers an ideal way to obtain a clean and very collimated high-energy beam, without altering at all the performance of the LHC [2,3,4]. The multi-TeV LHC beams grant the most energetic fixed-target experiment ever performed, to study pp, pd and pA collisions at sqrt(s_NN) ~ 115 GeV and PbA collisions at sqrt(s_NN) ~ 72 GeV. AFTER – for A Fixed-Target ExperRiment – gives access to new domains of particle and nuclear physics complementing that of collider experiments, in particular RHIC and the projects of electron-ion colliders. The typical instantaneous luminosity achievable with AFTER in pp and pA mode [1] surpasses that of RHIC by more than 3 orders of magnitude and is comparable to that of the LHC collider mode. This provides a quarkonium and heavy-flavour observatory [5] in pp and pA collisions where, by instrumenting the target-rapidity region, gluon and heavy-quark distributions of the proton, the neutron and the nuclei can be accessed at large x and even at x larger than unity in the nuclear case. The nuclear target-species versatility provides a unique opportunity to study nuclear matter versus the features of the hot and dense matter formed in heavy-ion collisions, including the formation of the quark-gluon plasma. During the one-month lead runs, PbA collisions can be studied at a luminosity comparable to that of RHIC and the LHC over the full range of target-rapidity domain with a large variety of nuclei.
Modern detection technology should allow for the study of quarkonium excited states, in particular the chi(c) and chi(b) resonances, even in the challenging high-multiplicity environment of pA and PbA collisions, thanks to the boost of the fixed-target mode. Precise data from pp, pA and PbA should help to understand better heavy-quark and quarkonium production, to clear the way to use them for gluon and heavy-quark PDF extraction in free and bound nucleons, to unravel cold from hot nuclear effects and to restore the status of heavy quarkonia as a golden test of lattice QCD in terms of dissociation temperature predictions at a sqrt(s_{NN}) where the recombination process is expected to have a small impact. The fixed-target mode also has the advantage to allow for spin measurements with polarized targets.


WG6: Spin / 186

W Physics Result of PHENIX

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Measuring the flavor-separated quark spins polarization is one of the primary goals in the PHENIX experiment at RHIC in order to understand the proton spin structure. The sea quark parton distribution function (PDF) is not well known while the valence quark PDF is well constrained. The asymmetry of W production from polarized protons is sensitive to the helicity distribution of quarks and anti-quarks, so that the asymmetry measurement enables to access the sea quark contribution to the proton spin.

RHIC provides us unique opportunity to perform this measurement using the longitudinally polarized proton collisions at center of mass energy up to $\sqrt{s} = 510$ GeV. PHENIX has measured W through their leptonic decays into electrons at central rapidity ($|\eta| < 0.35$) and muons at forward/backward rapidities ($1.2 < |\eta| < 2.2$). In succession to the first measurement performed in 2011, PHENIX collected twice in 2012 with fully upgraded detectors and triggering system. We will present recent results of W to electron and muon decay channels and the prospect of the further analysis.

WG6: Spin / 187

Fragmentation Functions measurement at COMPASS

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Fragmentation functions (FFs), which turn partons into non-perturbative hadronic bound states in hard-scattering reactions, represent a key ingredient to address proton spin structure in semi-inclusive deep inelastic scattering and proton-proton collisions. Fragmentation functions can not be determined from perturbative Quantum Chromodynamics and have to be extracted from experimental data in different processes. The COMPASS experiment at CERN provides a large data sample and
covers a wide kinematic range for precise measurement of hadron multiplicities, directly connected to FFs. Recent highly differential results on hadron multiplicity will be presented and discussed for single-hadron and hadron-pair production in SIDIS at COMPASS.

WG7: Future experiments / 190

The LHeC accelerator system

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The status of the LHeC accelerator proposal will be reviewed.

WG7: Future experiments / 192

The LHeC detector

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The plans for the LHeC detector will be presented.

WG1/3: Structure Functions and Electroweak Physics / 193

W and Z boson production at CMS

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We present selected measurements done with W and Z bosons performed with the CMS detector, based on samples of events collected during 2011 and 2012 physics runs. Measurements include W and Z inclusive cross sections, the lepton charge asymmetry in W events, and differential cross sections of Z and Drell-Yan production.

WG7: Future experiments / 194

Low-x Physics at the LHeC

Author: Nestor Armesto Perez
An overview of the possibilities for low-x physics at the LHeC will be reviewed. This will include inclusive, diffractive and final state observables.

**WG2: Low x and Diffraction / 195**

**MPI and DPS studies at CMS**

**Author:** Manfred Jeitler¹

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Measurements of the pseudorapidity distribution of charged hadrons in pp collisions at 8 TeV are presented, and compared to the predictions of Monte Carlo models.

**WG2: Low x and Diffraction / 196**

**Inclusive hadron production in p-p collisions in CMS**

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Characterization of the underlying event in p-p collisions in CMS

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Studies of the underlying event in p-p collisions at 0.9, 2.76, and 7 TeV are presented, using leading charged tracks at central rapidities, and the energy density measured at forward rapidities. The results are compared to model predictions, and provide constraints on the tuning of Monte Carlo parameters at the LHC.
Forward jets, forward+central dijets and dijets with large rapidity separations in p-p collisions in CMS

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We present results on forward and forward+central jet production, and on the properties of dijet events as a function of rapidity separation. The measurements are compared to model predictions to look for new effects in small-x interactions.

WG2: Low x and Diffraction / 199

Measurements of diffraction in p-p collisions in CMS

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We present measurements of soft and hard diffraction at the LHC, including measurements of diffractive dijets at 7 TeV. We also show the first candidates for central dijet production with both leading protons tagged at the LHC, using the combined CMS and TOTEM detectors.

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Exclusive processes in pp collisions in CMS

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We present results on exclusive production from CMS, including a first search for exclusive gammagamma->WW, and limits on anomalous quartic gauge couplings. We also present measurements of exclusive gammagamma->mumu and gammagamma->ee production, and the first limits on central exclusive production of photon pairs at 7 TeV.

WG3: Heavy Flavours / 201

Measurements of beauty quark production at CMS

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The large production cross-sections at LHC energies, combined with an adapted trigger strategy has enabled CMS to collect large data samples to perform detailed studies of Beauty hadron properties. In this talk we will report from our latest results, including Lambda_b production cross-section and
lifetime measurements, $b\bar{b}$, $c\bar{c}$ cross-section differential in the opening angles $\Delta\Phi$ and $\Delta R$ and on branching ratios of the rarely studied $B_c$ meson. The $\Lambda_b$ production cross-section versus $p_T$ is also compared to our previously measured $p_T$ spectra of $B_0$, $B^+$ and $B_c$ mesons. This talk might also include new results on $B$ hadron production, if approved in time.

WG5: Heavy Flavours / 202

Measurements of Quarkonium polarization at CMS

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In the present talk we will present results from a large data sample collected at 7 TeV, from which CMS could extensively study the polarization of the 3 Upsilon states, as a function of $p_T$ in two rapidity windows, conducting a complete analysis, including the polar and azimuthal anisotropy angles, and in 3 different polarization frames.

Thanks to the large data sample, CMS could also extensively study the polarization of the 3 Upsilon states, as a function of $p_T$ in two rapidity windows, conducting a complete analysis, including the polar and azimuthal anisotropy angles, and in 3 different polarization frames.

Given its powerful Silicon tracker, CMS has excellent photon conversion capabilities, allowing to separately study the $c^2$ and $c^1$ P-wave states, separated by a mass difference of 45 MeV only.

WG5: Heavy Flavours / 203

Studies of rare $B$ meson decays with the CMS detector

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Rare beauty decays are usually an excellent probe to the physics beyond the standard model. Especially those decays, that are proceed through flavor-changing neutral currents, can have the interference from new physics with the loop diagrams. Some of these decays are well predicted by the theory, such as $B_s,d$ to $\mu^+\mu^-$ branching fractions and the AFB of the $B\to K^*\mu^+\mu^-$, are the gold plate searches at the colliders. In this talk these searches in pp collisions at LHC using the data collected by the CMS detector are presented.

WG3: Electroweak and Searches / 204

Vector boson + jets measurements at CMS

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The associated production of jets and vector bosons allows for stringent tests of perturbative QCD calculations and is sensitive to the possible presence of new physics beyond the Standard Model. Measurements of jet production rates in association with W, Z or photons, in proton-proton collisions at 7 TeV or 8 TeV center-of-mass energy is presented, using data collected with the CMS detector. Measurements include inclusive jet multiplicity, differential jet cross sections, as well as associated charm- and bottom-quark jet production.

**WG3: Electroweak and Searches / 205**

**Searches for new physics with leptons and/or jets at CMS**

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This talk will cover a wide range of new physics searches including many from the full dataset of 8 TeV pp collision from 2012. Included in the talk will be new physics searches in decays to multi-jet final states, leptons plus jets, and also searches for heavy long-lived charged particles.

**WG3/4: QCD, Hadronic Final States and Electroweak Physics / 206**

**Search for exotic resonances with top quarks**

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In many models of physics beyond the Standard Model the coupling of new physics to third generation quarks is enhanced. We present a review of searches for heavy particles beyond the standard model decaying to final states with top and bottom quarks. This includes searches for heavy gauge bosons and excited states. Several final states originating from the top are considered and the event reconstruction is optimized accordingly. We use data collected with the CMS experiment during the year 2012, in proton-proton collisions at the LHC at a centre-of-mass energy of 8 TeV.

**WG3/4: QCD, Hadronic Final States and Electroweak Physics / 207**

**Search for exotic heavy quark partners**

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We present searches for massive top and bottom quark partners at CMS using data collected at sqrt(s)=7 and 8 TeV. Such partners can be seen in 4th generation models, or can be found in models predicting vector-like quarks to solve the Hierarchy problem and stabilize the Higgs mass. The searches span a range of final states, from multi-leptonic to entirely hadronic, and limits are set on mass and production cross sections as a function of branching ratios.
NWG: QCD and HFS / 208

NLO predictions for multileg processes using BlackHat and Sherpa

Author: Daniel Maitre

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I will present the BlackHat one-loop library, which implements on-shell methods to compute one-loop amplitudes and show its use in conjunction with Sherpa to produce NLO accurate predictions for high multiplicity processes at the LHC and Tevatron. I will also discuss the use of ROOT n-tuple files to store the information needed to compute different results and to transmit them to experimenters.

WG3: Electroweak and Searches / 209

Searches for new heavy resonances and large extra dimensions at CMS

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Additional heavy leptonic resonances (e.g. Z', W') are predicted by a number of new physics models. Models with extra dimensions include not only the possibility for resonant signatures like predicted in RS scenarios, but might also result in a non-resonant enhancement of high mass lepton pairs as suggested by the ADD model of large extra dimensions.

CMS has performed searches for both resonant and non-resonant signatures of new physics in the lepton mass spectra. Most of the presented results are based on the full 2012 dataset of proton-proton collisions at a center of mass energy of 8 TeV. No evidence for event contributions beyond the standard model is observed, and the results are interpreted in terms of limits on model parameters in the considered new physics scenarios.

WG3: Electroweak and Searches / 210

Measurements of properties of the Higgs-like Particle at 125 GeV by the CMS collaboration

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CMS results are presented on the measurement of properties of the Higgs-like particle discovered last summer with a mass in the range of 125-126 GeV, based on the full statistics of about 25 fb-1, collected in 2011 and 2012 at 7 and 8 TeV respectively. A discussion will be given on the mass measurement, couplings and the spin-parity properties of this new particle. The most recent results will be presented.
Exotic quarkonium spectroscopy and production

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In this talk we will report from the two structures found in the J/psi phi decay channel, accessed through the exclusive B+ → J/psi phi K+ decay. One of the structures confirms a previous observation by the CDF experiment, while the second structure has been observed by CMS for the first time. These contribute to the “systematic” studies of new structures in the search for new exotic quarkonium states.

Using large data samples of di-muon events, CMS has performed detailed measurements in the field of exotic quarkonium production. We will present very recent result on the X(3872) exotic state, in the J/psi pi pi decay channel, based on ˜6500 events, collected at sqrt(s) = 7 TeV, and covering unprecedentedly high values of pT. The cross-section ratio w.r.t. the psi(2S) will be given differentially in pT, as well as pT integrated. For the first time at the LHC the fraction of X(3872) coming from B hadron decays has been established. We also give a measurement of the di-pion mass spectrum to establish details of the nature of the decay.

Jet physics measurements at CMS

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We present CMS results related to jet production cross sections, which pose a central test to perturbative QCD predictions and which place an important constraint on parton distribution functions and the strong coupling constant. Results include recent measurements performed with 2011 data taken at center-of-mass energy of 7 TeV and 2012 data taken at 8 TeV.

Production of multiple electroweak bosons at CMS

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We present studies of diboson production in pp collisions at 7 TeV and 8 TeV center-of-mass energy based on data recorded by the CMS detector at the LHC in 2011 and 2012. These include precise measurements of W and Z production in association with a photon, as well as WW, WZ, and ZZ production at the LHC. The results are interpreted in terms of constraints on anomalous triple gauge couplings.
Search for Quarks and Gluinos in events with missing transverse momentum

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In this talk, the latest results from CMS on inclusive searches for squark and gluino production at the LHC are reviewed, including third generation signatures. A variety of complementary final state signatures and methods are presented using up to 20/\( \text{fb} \) of data from the 8 TeV LHC run of 2012.

Searches with multilepton final states

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In this talk, the latest results from CMS on searches for new physics with multiple leptons in the final state are presented using up to 20/\( \text{fb} \) of data from the 8 TeV LHC run of 2012. Interpretations of results in terms of RP conserving as well as violating models of supersymmetry are presented for weak and strong production mechanisms. For RP conserving models, both neutralinos and gravitinos as lightest supersymmetric particles are considered.

Search for stop and sbottom pair production at the LHC using the CMS detector

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In this talk, the latest results from CMS on direct stop or sbottom pair production are reviewed. We present searches performed for different stop and sbottom decay modes using up to 20/\( \text{fb} \) of data from the 8 TeV LHC run of 2012.

Top Quark Pair Cross Section Measurements at CMS

Author: Manfred Jeitler\(^1\)
Measurements of inclusive and differential top quark pair production cross section at 8 TeV are presented, performed using CMS data collected in 2012. The total cross section is measured in the lepton+jets and dilepton channels, including the tau-dilepton mode. Differential cross sections are measured as a function of various kinematic observables, including the transverse momentum and rapidity of the (anti)top quark as well as the top-antitop system, as well as multiplicity and transverse momenta of jets produced in addition to the top pair. The results are combined and confronted with precise theory calculations. The data allow for tests and determinations of MC-parameters, such as those related to the scales for renormalization and factorization and for the matching between the matrix-element and parton-shower level.

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Top quark mass measurements with CMS

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Measurements of the top quark mass are presented, obtained from CMS data collected in 2011 and 2012 at a centre-of-mass energy of 7 TeV and 8 TeV. The mass of the top quark is measured using several methods. The results of the various channels are combined and compared to the world average. The dependence of the top-quark mass measurement on event kinematics is studied. The top mass and also alphas are extracted from the top pair cross section measured at CMS, including a determination of m_{top} in the MSbar scheme.

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Measurements of the top-quark properties at CMS

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Measurements of several top-quark properties are presented, obtained from the CMS data collected in 2011 and 2012 at centre-of-mass energies of 7 and 8 TeV. The results include measurements of the top pair charge asymmetry, the W helicity in top decays, the top quark charge, and of the t\(\bar{\text{t}}\) spin correlation and the search for anomalous couplings. The fraction of top quarks decaying into a W-boson and a b-quark relative to all top quark decays, \(R=\frac{\text{BR}(t\rightarrow Wb)}{\text{Sum} (\text{BR}(t\rightarrow Wq))}\), is determined. Furthermore, the cross sections of t\(\bar{\text{t}}\) events produced in association with a photon or a W or a Z boson are measured.

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Measurements of single top quark processes with CMS
Measurements of single top quark production are presented, performed using CMS data collected in 2012 at centre-of-mass energies of 8 TeV. The cross sections for the electroweak production of single top quarks in the t-channel and in association with W-bosons is measured and the results are used to place constraints on the CKM matrix element V_{tb}. Measurements of top quark properties in single top quark production are also presented. The results include the W-helicity in top quark decay and the search for anomalous couplings.

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Study of Higgs Production in Bosonic Decay Channels at CMS

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Results are presented on the study and search for Higgs-like particles decaying into a ZZ, WW and 2 photon final states, based on the full statistics of about 25 fb-1, collected in 2011 and 2012 at 7 and 8 TeV respectively with the CMS experiment. Different production channels namely inclusive, VBF and associated production are studied for the 2-photon final state. The following ZZ decay channels are studied: 4 charged leptons, 2l 2nu, 2l 2tau and 2l 2q. Special attention will be to the low mass region where evidence for a new particle was reported earlier in 2012. The WW channel includes the study of full leptonic and semi-leptonic final states. The most recent results will be presented.

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Study of Higgs Production in Fermionic Decay Channels at CMS

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Results are presented on the study of the Higgs-like particle at 125 GeV decaying into final states consisting of either two taus, or a b anti-b quark pair, based on the full statistics of about 25 fb-1, collected in 2011 and 2012 at 7 and 8 TeV respectively with the CMS experiment. Leptonic and hadronic decay channels for the tau lepton are included in the search. Different production channels namely inclusive, VBF and associated production have been studied. The b bbar decay channel is studied in associated production with W/Z and top quarks. SM and MSSM interpretations of the data will be given for both decay channels. The most recent results will be presented.
Double spin asymmetry measurement from SANE-HMS data at Jefferson Lab

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In Hall C at the Thomas Jefferson National Laboratory, the Spin Asymmetries of the Nucleon Experiment (SANE, E07-003) measured the spin asymmetries of the proton, using a polarized electron beam and a polarized ammonia target. By rotation of superconducting magnet about the target, parallel and near-perpendicular double spin asymmetries were measured at beam energies of 4.7 and 5.9 GeV. The spin structure functions $g_1$ and $g_2$ can be extracted from these asymmetries. The primary experiment used the Big Electron Telescope Array (BETA) which covered a large solid angle (≈300 msr) to detect electrons scattered to the beam left at 40 degrees. Simultaneously, the High Momentum Spectrometer (HMS) detected electrons scattered to beam right. Although BETA covers larger kinematic region, the HMS, by varying the central angle and momentum, collected complementary data at four-momentum transfer $Q^2$ of 0.8, 1.3, and 1.9 GeV$^2$, from the resonance region to the region of invariant mass $W = 2.3$ GeV. These regions are the extended range of previous RSS experiment, allowing better determination of the integral of $g_2$ and the $Q^2$ dependency of $A_1$ and $A_2$ at resonance region. In this talk, the current progress of the analysis and preliminary spin asymmetries from HMS data will be presented.

Unpolarized azimuthal asymmetries in SIDIS at COMPASS

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The study of the spin structure of the nucleon and of the effects due to the quarks transverse momentum are part of the scientific program of COMPASS, a fixed target experiment at the CERN SPS. The azimuthal modulations which appear in the cross-section of SIDIS off unpolarised targets give insight on the intrinsic momentum structure of the nucleon and on the possible correlation between transverse spin and transverse momentum of the quarks. We present the results for the amplitudes of the $\cos(\phi)$, $\cos(2\phi)$, and $\sin(\phi)$ modulations (where $\phi$ is the azimuthal hadron angle in the gamma-nucleon system) obtained from the COMPASS data collected with a 160 GeV/c positive muon beam impinging on a deuteron target. The amplitudes are measured separately for positive and negative hadrons, and the results on the dependence of the relevant kinematical variables obtained after a multi dimensional analysis are also presented.

COMPASS results on the Collins and Sivers asymmetries

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COMPASS, a fixed target experiment at the CERN SPS, is measuring the partonic structure of the nucleon since 2002. An important part of this program are the measurements of transverse spin effects in semi-inclusive deep inelastic scattering of high energy muons off transversely polarized deuteron and proton solid state targets. This talk is dedicated to the measurements of the Collins and Sivers asymmetries, which give access to the transversity and the Sivers parton distribution functions. The proton and deuteron COMPASS results are reviewed. Particular focus is put on the very recent results from the data collected in 2010 using the transversely polarized proton target, which show asymmetries clearly different from zero and confirm the results from the 2007 data but with considerably improved accuracy. The comparison of these COMPASS data with the results from experiments using lower energy incoming leptons gives important constrains for the Q2 evolution of the transverse momentum dependent distribution and fragmentation functions.

Transverse target single-spin asymmetry in inclusive electroproduction of charged pions and kaons

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Single-spin asymmetries were investigated in inclusive and semi-inclusive electroproduction of charged pions and kaons from a transversely polarized hydrogen target at the HERMES experiment. The asymmetries were studied as a function of the azimuthal angle $\psi$ about the beam direction between the 'upwards' target spin direction and the hadron production plane, the transverse hadron momentum $P_T$ relative to the direction of the incident beam and the Feynman variable $x_F$ in the lepton-nucleon center-of-momentum frame. The sin{$\psi$} amplitudes are positive for $\pi^+$ and $K^+$, slightly negative for $\pi^-$ and consistent with zero for $K^-$, with particular $P_T$ but weak $x_F$ dependences. Especially large asymmetries are observed for two small subsamples of events, where also the scattered electron was recorded by the spectrometer.

Charmonium and e+e- pair photoproduction in ultra peripheral Pb-Pb collisions at sqrt(s_NN)=2.76 TeV

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Ultra-relativistic heavy ions generate strong electromagnetic fields which offer the possibility to study gamma-gamma and gamma-nucleus interactions at the LHC in the so called ultra-peripheral collisions (UPC). The J/psi photoproduction in UPC events is sensitive to the gluon distribution of the interacting nuclei, providing information on the nuclear gluon shadowing at Bjorken-x ranging from $10^{-5}$ to $10^{-3}$.

Here we report on ALICE results of J/psi photoproduction measured in Pb-Pb collisions at sqrt(s_NN) = 2.76 where the J/psi has been measured in the muon decay channel with the Alice Muon Spectrometer in the rapidity range -3.6<y<-2.6; at midrapidity ($|y|<0.9$) both the leptonic
decay channels (ee, mu+mu-) were used. The cross sections are compared with the predictions provided by several event generators. In addition, the cross section for the gamma-gamma \(\rightarrow ee\) process was studied and compared with the theoretical model expectations.

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**COMPASS results on transverse spin dependent azimuthal asymmetries in two-hadron production in SIDIS**

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The parton distribution function \(h_1\) of a transversely polarized quark inside a transversely polarized nucleon, is chiral-odd and therefore not accessible in deep inelastic scattering. It can only be observed in semi-inclusive deep inelastic scattering (SIDIS) in combination with another chiral-odd function like e.g. the two-hadron interference fragmentation function (IFF) \(H_1\). The 160 GeV/c polarized muon beam of CERN’s M2 beamline allows COMPASS to investigate the production of hadrons in deep inelastic scattering using polarized solid state targets. In this contribution an overview of COMPASS results for the azimuthal asymmetries in two-hadron production on transversely polarized nucleon targets is given. This includes the results of all hadron pairs \(h+h^-\) on a polarized deuteron target from the data taken in the years 2002-04, as well as the first data set on a transversely polarized proton target taken in the year 2007 and a data set taken on the same target during the year 2010 to increase precision. The COMPASS spectrometer allows a very precise particle identification, which can be used to determine the composition of the \(h+h^-\) pairs in terms of pions and kaons. The results for the possible combinations, obtained very recently from the 2007 and the 2010 data, will be discussed in detail. Further the asymmetries for pion pairs will be compared to the available model predictions and the corresponding results from HERMES. These results are an important input for the extraction of \(h_1\).

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**Higgs boson properties from hadron colliders experiments**

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The recently discovered resonance at 125 GeV has properties remarkably close to those of the Standard Model Higgs boson. Therefore, it is fundamental to investigate them thoroughly. I will review the status of our understandings of this particle’s properties and I will show the results of our fits of all presently available data.

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**The Dijet Cross-section Measurement of Polarized Proton-Proton Collisions at \(\sqrt{s} = 500\) GeV**
The STAR Spin program aims to measure the gluon helicity distribution $\Delta g(x)$ in the proton, which remains highly unconstrained at small momentum fractions $x < 0.05$. Dijet reconstruction in polarized proton collisions at $\sqrt{s} = 500$ GeV will extend these constraints by sampling lower $x$ gluons while also providing more precise information about the partonic kinematics. This contribution will present studies of the anti-$k_T$ jet algorithm, the dijet selection procedure, and progress towards the first measurement of the dijet cross-section at $\sqrt{s} = 500$ GeV from $\sim 10 \text{pb}^{-1}$ of data collected in 2009.

Highlights of Transverse Spin Physics in PHENIX

Understanding the spin structure of the proton is deeply entangled with the properties and dynamics of quarks and gluons as described by the theory of quantum chromodynamics (QCD). Transversity is one of three leading twist parton distribution functions in collinear perturbative QCD and so far the least well known due to its chiral odd nature. Experimentally, it can only be observed in combination with additional spin dependent final state effects. These can include interference fragmentation functions in the collinear picture or the so-called Collins fragmentation in a transverse momentum dependent (TMD) framework. Similarly, initial state TMD distribution functions (Sivers effect) can cause transverse asymmetries. The PHENIX experiment at RHIC has measured transverse observables of various probes in polarized proton-proton collisions in the past. New data at $\sqrt{s} = 200$ GeV has been recorded in 2012 with an integrated luminosity of 9.2 pb$^{-1}$ and average beam polarizations of $\approx 58\%$ (more than twice the figure of merit of previously accumulated data). In this talk we will present recent results and discuss the status of on-going efforts and their possible implications for a global analysis.

Transverse target spin asymmetries in exclusive $\rho^0$ muoproduction

Generalized parton distributions (GPDs) provide a dynamical picture of the nucleon. The exclusive production of $\rho^0$ mesons off a transversely polarised target is sensitive to the nucleon helicity-flip GPDs $E$ which are related to the total angular momentum of quarks and gluons. In 2007 and 2010 the COMPASS experiment at CERN collected data by scattering a 160 GeV/c muon beam on a transversely polarised NH$_3$ target. The final state particles were detected with the two-stage spectrometer with high resolution tracking and calorimetry. In this talk new results for the azimuthal asymmetries $A_{UT}$ and $A_{LT}$ are presented.
Open heavy flavor production at STAR

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Relativistic heavy ion collisions provide a unique opportunity for studying Quark-Gluon Plasma (QGP), a new state of nuclear matter whose properties are determined by quark and gluon degrees of freedom. Such a nuclear matter existed in the Early Universe, a few millionths of a second after the Big Bang. Heavy quarks are unique probes of the QGP properties because they are produced very early in the heavy-ion collisions and they are expected to interact differently from light quarks with the QGP. Moreover, their production is sensitive to the dynamics of the medium; such measurements could be used to determine the fundamental properties of the QGP, for instance transport coefficients.

In this talk we present recent STAR results on open heavy flavor production at mid-rapidity in $p+p$ and Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. We report on measurements of open charm mesons (reconstructed directly via hadronic decay channels) and electrons from semileptonic decays of heavy flavor hadrons ($e^{HF}$). Production of $D^0$ and $e^{HF}$ as a function of transverse momentum and collision centrality is presented. We also report on measurements of azimuthal momentum anisotropy of $e^{HF}$ at 39, 62 and 200 GeV. STAR data are compared to theoretical model calculations and physics implications are discussed.

Future GPD measurements using COMPASS at CERN

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A major part of the future COMPASS program will be dedicated to the investigation of the nucleon structure through Deeply Virtual Compton Scattering (DVCS) and Deeply Virtual Meson Production (DVMP). COMPASS will measure DVCS and DVMP reactions with a high intensity muon beam of 160 GeV of opposite charge and polarization which will allow to access the Compton form factor related to the dominant GPD $H$ and to study the $x_B$-dependence of the $t$-slope of the pure DVCS cross section.

For this program, the Compass spectrometer is upgraded with a 4 m-long recoil proton detector, a 2.5 m-long liquid hydrogen and a large angle calorimeter. Projections on the achievable accuracies and preliminary results of pilot measurements will be presented.
We solve the modified non-linear extension of the CCFM equation – KGBJS equation – numerically for certain initial conditions and compare the resulting gluon Green functions with those obtained from solving the original CCFM equation and the BFKL and BK equations for the same initial conditions. We improve the low transversal momentum behaviour of the KGBJS equation by a small modification.

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**Determining the Higgs spin and parity in the di-photon decay channel using gluon polarization**

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We present the di-photon distribution in the decay of an arbitrary spin-0 and spin-2 boson produced from gluon fusion, taking into account the fact that the gluons inside an unpolarized proton are linearly polarized to some extent. The gluon polarization brings about a difference in the transverse momentum distribution of positive and negative parity states. At the same time, it causes the Collins-Soper phi distribution of the photon pair to be non-isotropic for several spin-2 coupling hypotheses, allowing one to distinguish these from the isotropic scalar and pseudoscalar distribution.

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**Heavy quark impact factor and the single bottom production at the LHC**

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We use the heavy quark impact factor at NLO order and multi-regge kinematic regime to calculate of single bottom production cross section at large rapidity at LHC energies.

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**Generalized parton distributions from neutrino experiments**
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The analysis of deeply virtual meson production is extended to neutrino-production of the pseudo-Goldstone mesons (pions, kaons, eta-mesons) on nucleons, with the flavor content of the recoil baryon either remaining intact, or changing to a hyperon from the SU(3) octet. We rely on the SU(3) relations and express all the cross-sections in terms of the proton generalized parton distributions (GPDs). The corresponding amplitudes are calculated at the leading twist level and in the leading order in $\alpha_s$, using a phenomenological parametrization of GPDs. In the analysis, we take into account the electromagnetic Bethe-Heitler type contribution to neutrino-induced deeply virtual meson production ($\nu$DVMP). Such $O(\alpha_s)$-corrections decrease with $Q^2$ in the Bjorken regime less steeply than the standard $\nu$DVMP handbag contribution. Therefore, they are relatively enhanced at high $Q^2$. The Bethe-Heitler terms give rise to an angular correlation between the lepton and hadron scattering planes with harmonics sensitive to the real and imaginary parts of the DVMP amplitude. These corrections constitute a few percent effect in the kinematics of the forthcoming Minerva experiment at Fermilab and should be taken into account in precision tests of GPD parametrizations. For virtualities $Q^2 \sim 100 \text{ GeV}^2$ these corrections become on a par with DVMP handbag contributions.


WG1: Structure Functions / 239

Parton Distributions with LHC data

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An accurate and reliable determination of parton distribution functions is vital to fully exploit the potential of the LHC. However the LHC itself also has the ability to provide substantial constraints upon existing PDF determinations. We shall discuss the tools available to study the impact of LHC measurements upon PDFs and discuss the NNPDF2.3 PDF set, which includes constraints from LHC electroweak vector boson production and inclusive jet data.

WG2: Low x and Diffraction / 240

Initial conditions for evolution of double parton distributions

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Double parton distributions (DPDs) are used in the QCD description of double parton scattering. The DPDs evolve with hard scales through relatively new QCD evolution equations and obey nontrivial sum rules: momentum and valence quark number sum rules. Based on a constructed numerical program, we present recent results on the QCD evolution of the DPDs. In particular, we discuss the problem how to specify initial conditions which exactly fulfill the above mentioned sum rules. In the current proposals these rules are obeyed only approximately.

**WG4: QCD and HFS / 241**

**Recent results on quarkonium spectroscopy and exotic quarkonium-like resonances at Belle**

**Author:** Daniel Santel\textsuperscript{none}

Quarkonium resonances and quarkonium-like states provide great information and insights on strong interactions of quarks and gluons. The Belle experiment has collected world’s largest event sample of Y(1S), Y(2S), Y(4S) and Y(5S) decays using energy-asymmetric e$^+$ e$^-$ collision at KEKB collider. In this talk we present recent results on b $b$-bar and c $c$-bar quarkonium spectroscopy and exotic quarkonium-like states from Belle.

**WG5: Heavy Flavours / 242**

**Open Heavy Flavor Results from PHENIX**

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Due to their large mass, heavy quarks are produced in the earliest stages of the collision and will, therefore, experience the full evolution of the system. Leptons resulting from heavy flavor decay are an important tool to probe the hot and dense matter created in nucleus-nucleus collisions at the Relativistic Heavy Ion Collider (RHIC). PHENIX is capable of measuring electrons in the central rapidity region ($|\eta| < 0.35$) and muons in the forward rapidity region ($1.2 < |\eta| < 2.2$).

PHENIX has multiple cross section measurements in p+p collisions at 200 and 500 GeV. These measurements provide a test of pQCD theory in additional to a crucial baseline to study the hot and cold nuclear matter effects present in heavy ion collisions. Similar measurements in d+Au allow access to initial state cold nuclear matter effects. Modification of heavy flavor production in heavy ion collisions (Au+Au and Cu+Cu) is beyond that expected from cold nuclear matter effects alone. In this talk, PHENIX open heavy flavor results from p+p, d+Au, and heavy ion measurements will be presented.

**WG5: Heavy Flavours / 243**

**Study of mixing, CP violation and polarization of the Bs $\rightarrow$ Ds(\textsuperscript{*})+ Ds(\textsuperscript{*})- and a new measurement of Bs $\rightarrow$ Ds(\textsuperscript{*}) h at Belle**
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The Belle experiment has recorded 121 fb⁻¹ of data at the Y(5S) resonance, making this the world’s largest data sample at this energy. As the Y(5S) decays to Bs(Bs) pairs, this large sample provides a unique opportunity for detailed studies of Bs decays at an e⁺e⁻ machine. Here we report a recent measurement of Bs→Ds(Ds) decays and a new measurement of Bs→D(s*)h decays.

WG6: Spin / 244

Linearly polarized gluon distributions at small-x

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We show explicitly how the linearly polarized gluon distributions appear naturally in high-energy dense-dilute collisions, where the small-x effects are important, and that under the proper kinematic conditions our results agree with the TMD-factorization formalism. In particular, the processes of dijet production in DIS and Drell-Yan in p-A collisions are studied and it is shown that they involve two different gluon distributions, the Weizsacker-Williams distribution and the dipole distribution.

WG1/7: Structure Functions and Future Experiments / 245

Investigating the Nucleon Structure at COMPASS

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A description of a nucleon structure in terms of partons demands knowledge of parton momentum-, helicity- and transversity distribution functions. COMPASS facility at CERN, with its high energy, polarised muon beam, large polarised proton- and deuteron targets and particle identification detectors, permits investigating the (longitudinal and transverse) spin-dependent structure function and unfolding relevant parton distribution functions.

An overview of the following COMPASS results will be given: all the inclusive data for the proton and deuteron spin dependent structure function g₁ and their NLO QCD analysis (for a part of them), the LO analysis of flavour helicity distributions based on the semi-inclusive data with identified hadrons and with a particular attention drawn to the problem of a strange sea polarisation determination and to different methods of extracting the (LO and NLO) polarisation of gluons. Ongoing analysis of single and double hadron multiplicities produced on the deuteron target which may lead to a determination
of fragmentation functions, critical for the extraction of the strange sea polarisation will also be mentioned.

WG6: Spin / 246

Charge-integrated pion and kaon multiplicities from Belle e+e−-annihilation data

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Multiplicities and azimuthal asymmetries were extracted from e+e−-annihilation data collected with the Belle detector. These data were taken at the KEKB e+e− collider at a center-of-mass energy of sqrt(s) = 10.52 GeV. The multiplicities provide the cleanest access to spin-independent fragmentation functions, which describe the hadronization of quarks into final-state hadrons. The low center-of-mass energy and the multiplicity extraction beyond z = 0.7 extend the kinematic region covered by earlier measurements. This in combination with the high-precision of the extraction, will in particular allow an improved determination of the gluon fragmentation function. Spin-independent fragmentation functions provide invaluable input for the analysis of the nucleon structure, studied in semi-inclusive deep-inelastic scattering and proton-proton collisions, since they are needed for the spin-dependent and spin-independent flavor decomposition of quark and gluon distribution functions in the nucleon. The recent status of the Belle measurement of charge-integrated pion and kaon multiplicities as well as of azimuthal asymmetries will be presented.

WG4: QCD and HFS / 247

The Vincia parton shower

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I present recent developments in Vincia.

Vincia is a parton shower program, implemented as a plugin to Pythia 8, which emphasises efficient matching to fixed-order matrix elements and comprehensive estimates of uncertainties.

I discuss the extension of Vincia to hadronic initial states, a first step to LHC applications.

I also present the implementation of a shower evolving partons with identified helicities, which greatly speeds up matching to tree-level matrix elements.
Inclusive Cross Sections in ME+PS Merging

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We discuss an extension of matrix element plus parton shower merging at leading and next-to-leading order. The algorithm does preserve inclusive cross sections at the respective input order. This constraint avoids potentially large logarithmic contributions, which would require approximate (N)NLO contributions to cancel against. We will report on the status of implementing the new procedure in the framework of the Herwig++ event generator.

Combined search for the SM Higgs Boson at D0

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We present the combination of searches for the Standard Model Higgs boson at a center-of-mass energy of $\sqrt{s}=1.96$ TeV, using the full Run 2 dataset collected with the D0 detector at the Fermilab Tevatron collider. The major contributing processes include associated production ($WH\rightarrow lvbb$, $ZH\rightarrow vvbb$, $ZH\rightarrow llbb$, and $WH\rightarrow WWW$) and gluon fusion ($gg\rightarrow H\rightarrow WW$). The significant improvements across the full mass range resulting from the larger data sets, improved analyses and inclusion of additional channels are discussed. The combination of all channels results in significantly improved sensitivity across the 90-200 GeV mass range.

Precision Multiboson Phenomenology

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We present recent results in precision multiboson (+jet) phenomenology at the LHC. Results for diboson (+ jet) and triboson (+jet) will be discussed focusing on the impact of the perturbative corrections on the expected phenomenology.
Detailed studies of neutrino-nucleus scattering with nuSTORM

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The nuSTORM facility will provide $\nu_e$ and $\nu_\mu$ beams from the decay of 3.8GeV muons confined within a storage ring. A detector placed approximately 1500m from the end of the decay straight, combined with a near detector, can be used to make exquisitely sensitive searches for sterile neutrinos. The instrumentation of the ring, combined with the excellent knowledge of muon decay, will make it possible to determine the neutrino flux at the %-level or better.

The neutrino and anti-neutrino event rates are such that the nuSTORM facility serving a suite of near detectors will be able to measure $\nu_eN$ and $\nu_\muN$ cross sections with the %-level precision required to allow the next generation of long-baseline neutrino-oscillation experiments to fulfil their potential. The status of the nuSTORM project will be presented along with the performance of the facility in terms of sterile-neutrino sensitivity and precision on measurements of neutrino-nucleus scattering.

Modeling the elastic differential cross-section at LHC

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We present an update of a simple parametrization of the elastic differential cross-section, originally based on two exponential terms and a relative phase. Previous analyses of TOTEM data at LHC7 had shown the model to be able to reproduce well the region before, through and after the dip, however missing by 10-20% the optical point. We show that inclusion of a multiplicative factor, corresponding to the proton form factor, can describe well the entire t-region measured by TOTEM. Application of two asymptotic Sum Rules, allows for predictions at higher LHC energies. Predictions from a QCD based model for inelastic and total cross-section will also be presented, with comparison with data from different LHC experiments.

Recent results within Lipatov’s high energy effective action

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We review Lipatov’s high energy effective action and show that it is a useful computational tool to calculate QCD scattering amplitudes in the high energy limit. We explain in some detail our recent work where a novel regularization and subtraction procedure has been proposed that allows to extend the use of this effective action beyond tree level. As explicit results we discuss the derivation of forward jet vertices, for jet events with and without rapidity gaps.

Neutron Structure at Large x

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While an impressive amount of high quality nucleon structure function data exists from hydrogen, deuterium, and other targets, the lack of a neutron target has made direct comparisons between proton and neutron structure nearly impossible at large x where nuclear effects become large. The behavior of the d quark as x approaches 1 is particularly sensitive to deuterium nuclear corrections. The impact on the parton distribution functions (PDFs) from uncertainties in the deuteron wave function at short distances, nucleon off-shell effects, the use of relativistic kinematics, as well as the use of less a restrictive parametrization of the d/u ratio have been evaluated within a global PDF analysis. These results will be discussed, as well as compared to results from the Barely Off-Shell Nucleon Structure (BONUS) Experiment. The BONUS experiment employed a novel radial time projection chamber to detect spectator protons resulting from electron-deuteron interactions in coincidence with electrons in the CEBAF Large Acceptance Spectrometer in Hall B at Jefferson Lab - thereby ensuring an inclusive electron-neutron scattering event. Lastly, an overview of additional, planned neutron structure measurements at large x will be presented.

Physics Opportunities with the 12 GeV Upgrade at Jefferson Lab

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Construction of the 12 GeV upgrade to the Continuous Electron Beam Accelerator Facility at the Thomas Jefferson National Accelerator Facility (Jefferson Lab) is presently underway. This upgrade includes doubling the energy of the electron beam to 12 GeV, the addition of a new fourth experimental hall, and the construction of upgraded detector hardware. The result will be an exciting physics program, providing new insights into the structure of the nucleon, the transition between the hadronic and quark-gluon descriptions of matter, and the nature of quark confinement. It also allows for specific symmetry tests in hadronic physics. An overview of this upgrade project will be presented, along with highlights of the anticipated experimental program.
The nCTEQ PDFs

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A global analysis of the proton PDF requires a combination of DIS, DY, and jet data. The flavor differentiation depends heavily on the DIS data, much of which is measured on nuclear targets; hence the nuclear PDFs (nPDFs) come into play. A global nPDF analysis finds tensions between the nuclear correction factors in various data sets. We explore possible sources of this tension, and compute ratios of experimental observables which (largely) minimize any theoretical bias. We also quantify the nPDF uncertainty using a set of error PDF functions and show comparisons with recent nPDF determinations.

Searches for Exotic Higgs decays in CMS

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Results are presented from CMS on searches for Higgs-like particles in models beyond the Standard Model and searches for rare or exotic decays of the 125 GeV particle. Light Higgses as predicted in the NMSSM models are searched for. Decays of the 125 GeV Higgs-like particle into muons are explored. The most recent results will be presented.

Search for new physics in lepton + MET final states

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A search for new physics in final states with an electron or a muon and a low mass neutrino is presented based on the full 2012 data set at $\sqrt{s}=8$ TeV. The analysis searches for an excess of events above the SM expectation in the $l+\text{MET}$ transverse mass spectrum. The results are interpreted in several different models, such as a new, heavy SM-like boson $W'$ with and without interference with the SM $W$-boson, split UED and a four-fermion contact interaction as a sign of fermion compositeness. We also present a model independent cross section limit.

Measurement of Quarkonium Production with CMS

This talk presents quarkonium results, collected in pp collisions at $\sqrt{s} = 7$ TeV by the CMS collaboration, including the $p_T$ and rapidity differential prompt production cross-section of $S$-wave state quarkonia ($J/\psi$, $\psi'$, $Y(nS)$), extending over a range of up to 100 GeV. We also present the $B$-hadron fraction in the charmonium system, differentially in $p_T$.

Given its powerful Silicon tracker, CMS has excellent photon conversion capabilities, allowing to separately study the $\text{chic}_2$ and $\text{chic}_1$ $P$-wave states, separated by a mass difference of 45 MeV only.

Finally, we present results on the production of two $J/\psi$. This final state is expected to provide constraints on contributions from single-parton (SPS) versus double-parton (DPS) scattering. From proton collisions at $\sqrt{s}=7$ TeV corresponding to an integrated luminosity of about 5 fb$^{-1}$ taken in 2011 the total production cross section in an acceptance regime defined by the individual $J/\psi$ transverse momentum and rapidity has been measured. In addition, the difference in rapidity $\Delta y$ between the two $J/\psi$ in the event has been measured and the ratio between SPS and DPS production applying several production models has been estimated.

Measurements of $WW$ and $ZZ$ production and anomalous trilinear gauge couplings with the D0 detector

We present results of diboson production studies with the D0 detector at $\sqrt{s}=1.96$ TeV, including measurements of the $WW$ cross section in the $l\ell'\nu\nu$ channels and the $ZZ$ cross section in the $l\ell l\ell'$ ($l=e,\mu$) channels using data corresponding to integrated luminosity of 9.7 fb$^{-1}$. We also present measurements of anomalous $WW\gamma$ and $WWZ$ trilinear gauge boson couplings from $WW$ and $WZ$ production with lepton plus dijet final states, and a combination of these results with $W\gamma$, $WW$, and $WZ$ production with leptonic final states, yielding the most stringent limits from a hadron collider, as well as the most precise measurements of the $W$ boson magnetic dipole and electric quadrupole moments.
Double Longitudinal Spin Asymmetry Measurements of Inclusive pi0 and eta Production at PHENIX in 200 GeV Polarized p+p Collisions

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A major emphasis of the RHIC spin program at BNL is to understand the gluon spin contribution, Delta G, to the spin of the proton. The PHENIX experiment at RHIC probes Delta G, utilizing its highly segmented calorimeter, by measuring the double longitudinal spin asymmetry, A_LL, in the production of inclusive channels like pi0 and eta. pi0 data from runs 2005 and 2006 were included in a recent NLO global analysis [1], DSSV, and set substantial new constraints on the polarized gluon distribution in the proton over the kinematic range 0.05 < x < 0.2. With improved luminosity and polarization, the figure of merit for the 2009 data set was a factor of 1.5 better that the previous runs combined. We present the 2009 results for pi0 and eta A_LL, along with a discussion of the results from inclusion of these data in a recent update of the DSSV global analysis.


WG3: Electroweak and Searches / 266

Measurements of the W boson mass and muon charge asymmetry with the D0 detector

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We present a measurement of the W boson mass using data corresponding to an integrated luminosity of 4.3 fb⁻¹ collected with the D0 detector during Run 2 at the Fermilab Tevatron ppbar collider. With a sample of 1,677,394 W --> e nu candidate events, we measure M_W = 80.367 +/- 0.026 GeV. This result is combined with an earlier D0 result determined using an independent Run 2 data sample, corresponding to 1 fb⁻¹ of integrated luminosity, to yield M_W=80.375 +/- 0.023 GeV. We also present a measurement of the muon charge asymmetry from W --> mu nu decay using data corresponding to 7.3 fb⁻¹ of integrated luminosity. The measured asymmetry is compared with theory predictions and with the electron charge asymmetry measurement from the D0 Collaboration.

WG6: Spin / 268

Resummation of soft-collinear contributions in deeply virtual Compton scattering

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We derive an all order resummation formula for the deeply virtual Compton scattering amplitude, which takes into account soft-collinear gluon exchanges in the partonic (quark gluon) amplitude.
We identify at each order of the perturbative series the diagrams responsible in a specific gauge to the leading contributions. An exponentiated expression results in a simple closed expression valid in the vicinity of the boundary regions between characteristic domains of the kinematical inner variables.

**WG5: Heavy Flavours / 269**

**Quarkonia results from PHENIX**

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The measurement of quarkonia production in relativistic heavy ion collisions provides a powerful tool for studying the properties of hot and dense matter created in these collisions. To have a complete understanding, however, such measurements must cover a wide range of quarkonia states, collision energies and colliding species. The PHENIX detector recently collected high statistics data using a variety of heavy ion species and beam energies in a broad rapidity range. This talk will present the most recent measurements of $J/\psi$, $\psi'$, $\chi_c$ and $\Upsilon$ production in $d+Au$, $Au+Au$, $Cu+Cu$ and $Cu+Au$ collisions at $\sqrt{s_{NN}}=200$ GeV, 62 GeV and 39 GeV in mid ($|y|<0.35$) and forward rapidities ($1.2<|y|<2.2$).

**WG6: Spin / 270**

**Recent STAR results and future prospects for the W boson program at RHIC at BNL**

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The STAR experiment at the Relativistic Heavy-Ion Collider at Brookhaven National Laboratory is carrying out a spin physics program in high-energy polarized proton collisions at $\sqrt{s}=200$ GeV and $\sqrt{s}=500$ GeV to gain a deeper insight into the spin structure and dynamics of the proton.

The collision of polarized protons at $\sqrt{s}=500$ GeV opens a new era of spin-flavor structure measurements from $W^{-}(+)\rightarrow (\bar{u}+d)$ boson production. $W^{-}(+)\rightarrow (\bar{u}+d)$ bosons are produced in $\bar{u}+d$ collisions and can be detected through their leptonic decays, $e^-+\bar{\nu}_e(e^++\nu_e)$, where only the respective charged lepton is measured. The discrimination of $\bar{u}+d$ quark combinations requires distinguishing between high $p_T$ through their opposite charge sign, which in turn requires precise tracking information.

Recent STAR results on the measurement of $W^-/W^+$ and $Z$ boson production at mid-rapidity will be shown.

The STAR experiment has recently completed the installation of the Forward GEM Tracker to enhance the charge separation of high $p_T$ $e^-(+)$ at forward pseudorapidities. The status of the Forward GEM Tracker along with a discussion of future prospects will be presented.
Status of MEIC Design Studies

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A polarized medium energy electron-ion collider (MEIC) is envisioned at Jefferson Lab as its future nuclear science program beyond the 12 GeV CEBAF fixed target program. Over the last three years, a conceptual design of MEIC has been successfully developed, and a comprehensive report summarizing the baseline and accelerator R&D progress has been released recently. The MEIC design studies have now entered a new phase, focusing primarily on design optimization, and critical accelerator R&D to prove the design concept. In this talk, I will provide an overview for the MEIC design and also report the recent progress of the accelerator design studies.

Diffractive vector meson production at HERA using holographic AdS/QCD wavefunctions

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**Co-author:** Jeff Forshaw

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We show that AdS/QCD generates predictions for the rate of diffractive $\rho$-meson electroproduction that are in agreement with data collected at the HERA electron-proton collider. We also predict the exclusive two pion spectra recently measured at HERA using AdS/QCD holographic light-front wave functions for the $\rho$-meson and its radial excitations.

Predicting radiative B decays to vector mesons in holographic QCD

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We use new AdS/QCD Distribution Amplitudes (DAbs), derived from the meson AdS/QCD light-front wave function, in order to investigate radiative B decays to light vector mesons. When computing the annihilation diagrams in $B \to \rho + \gamma$ and the isospin asymmetry in $B \to K^* + \gamma$, we find that the AdS/QCD DAs do not lead to the end-point divergences encountered with standard QCD Sum Rules DAs. Our predictions for the branching ratios and isospin asymmetry are in good agreement with experiment. We also predict the branching ratio for the rare $B_s \to \rho + \gamma$ decay which proceeds mainly via annihilation and may be investigated at LHCb.
WG4: QCD and HFS / 275

Monte Carlo techniques in small-x physics: Formal studies and phenomenology

Author: Grigorios Chachamis¹
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We will discuss briefly our recent studies on the non-forward BFKL equation in the adjoint representation for the N = 4 SYM theory at both LO and NLO accuracy using Monte Carlo techniques. We will then demonstrate the potential of these techniques for phenomenological studies at the LHC.

WG2: Low x and Diffraction / 276

Computing the full two-loop gluon Regge trajectory within Lipatov’s high energy effective action

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Lipatov’s high energy effective action is proving to be a useful computational tool for studying QCD scattering amplitudes in the high energy limit. We explain how we calculate within this framework the full gluon Regge trajectory at two loops using a novel regularization and subtraction procedure.

WG7: Future experiments / 277

Physics capabilities at the MEIC at JLab

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The Electron-Ion Collider (EIC) is envisioned as the next-generation US facility for exploring the strong interaction. The Medium-energy EIC (MEIC) is the first stage of the EIC at Jefferson Lab (JLab), designed for mapping the spin- and spatial structure of the quark and gluon sea in the nucleon, understanding the emergence of hadronic matter from color charge, and probing the gluon fields in nuclei. Kinematically, it will on one end connect to the JLab 12 GeV, and on the other with HERA. Achieving these goals requires an accelerator providing high performance over a wide range of energies for polarized protons, deuterons, and other light ions, as well as different species of heavy ions. To fully utilize this capability one needs a full-acceptance detector able to detect all fragments, nuclear or partonic, including spectators, with high resolution, and to provide a wide
coverage in $t$ for recoil baryons from exclusive (diffractive) reactions at all beam energies. The combination of a high luminosity, polarized lepton and ion beams, and detectors fully integrated with the accelerator will make the EIC a quantum leap in our understanding of the fundamental structure of matter.

**WG4: QCD and HFS / 278**

### New photon results from CDF

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We present measurements of the cross sections of prompt photon pair production and direct photon production in association with a heavy quark (b or c) jet in ppbar collisions at $\sqrt{s}=1.96$ TeV. The data samples for both results correspond to the full data set collected with the CDF II detector. Measurements are compared with the current state-of-the-art theoretical predictions.

**WG7: Future experiments / 279**

### Upgrade and physics prospects of ALICE

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ALICE at LHC, collecting data in Pb-Pb, p-Pb and pp collisions, aims for the characterization of the QCD matter at high temperature and energy density. While the first running period until 2017 can provide detailed description of the global and bulk phenomena and a first set of results on rare probes of heavy-ion collisions, many important questions involving rare processes cannot be addressed in details with the current experimental setup. In this talk we give an overview of the ALICE Upgrade program focusing on the physics prospects related to heavy-quarks, quarkonia, low-mass dileptons, jets and exotica searches achievable in high luminosity Pb-Pb collisions at LHC. We also discuss the technological challenges and choices of the detector upgrades to be installed during the LHC Long Shutdown 2.

**WG1/3: Structure Functions and Electroweak Physics / 280**

### The Impact of PDF uncertainties on the measurement of the W boson mass at the Tevatron and the LHC

**Author:** Juan Rojo Chacon¹

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We study at a quantitative level the impact of the uncertainties on the value of the W boson mass measured at hadron colliders due to the proton parton distribution functions (PDFs). The value of the W boson mass is extracted, by means of a template fit technique, from the lepton-pair transverse mass distribution measured in the charged current Drell-Yan process. We conclude that PDF uncertainties do not challenge a measurement of the W boson mass at the level of 20 MeV accuracy. We discuss the prospects to improve on this accuracy with available and future data from the LHC.

Constraints on the gluon PDF from top quark pair production at hadron colliders

Author: Juan Rojo Chacon

We derive NNLO+NNLL theoretical predictions for top quark pair production based on all the available NNLO PDF sets, and compare them with the most precise LHC and Tevatron data. In this comparison we study in detail the PDF uncertainty and the scale, \( m_t \) and \( \alpha_s \) dependence of the theoretical predictions for each PDF set. Next, we exploit the observation that top quark pair production provides a powerful direct constraint on the gluon PDF at large \( x \) to include top pair data consistently into a global NNLO PDF fit. We then explore the phenomenological consequences of the reduced gluon PDF uncertainties by showing how it can improve searches for Beyond the Standard Model physics at the LHC. Finally, we update to full NNLO+NNLL theoretical predictions for the ratio of top quark cross sections between different LHC center of mass energies as well as the cross sections for heavy top-like fermion production at the LHC.

Correlation effects in multiple hard scattering

Author: Markus Diehl

I discuss the possible size and the observable consequences of interparton correlations in multiple hard scattering processes.

From form factors to generalized parton distributions

Author: Markus Diehl
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I report on a recent fit of generalized parton distributions to the world data of electromagnetic nucleon form factors.

WG5: Heavy Flavours / 285

Charmed mesons and leptons from semileptonic decays at the LHC

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Part 1:

We discuss production of charmed mesons in proton-proton collisions at the LHC. The cross section for inclusive production of \(c\bar{c}\) pairs is calculated in the framework of the \(k_t\)-factorization approach. Taking wide range of \(x\) values necessary for the calculation we use and test several unintegrated gluon distributions from the literature. Some of them include effect of small-\(x\) saturation and fullfil Balitsky-Kovchegov evolution equation. Theoretical uncertainties of the model related to the choice of renormalization and factorization scales as well as due to the quark mass are also discussed. Results of the \(k_t\)-factorization approach are compared to NLO parton model and FONLL predictions.

The hadronization of charm quarks is included with the help of different fragmentation functions found for the production of charm in \(e^+e^-\) collisions. Sensitivity of our predictions to the choice of the model of fragmentation is also shown. Inclusive differential distributions in transverse momentum and (pseudo)rapidity of several charmed mesons (\(D^0, D^\pm, D^{*\pm}, D^{\ast 0}_S\)) will be presented and compared to recent results of the ALICE, ATLAS and LHCb collaborations. Furthermore, we also consider production of different pairs of charmed mesons (\(D^0\bar{D}^0, D^0D^-\), \(D^+D^-\) etc.) in unique kinematics of forward rapidities of the LHCb experiment. Kinematical correlations in azimuthal angle \(\varphi_{DD}\) and invariant mass \(M_{DD}\) distributions are presented and compared to LHCb data.

Part 2:

We discuss production of electrons/muons from semileptonic decays of charm and bottom mesons in proton-proton collisions at the LHC. The cross section for inclusive production of \(c\bar{c}\) and \(b\bar{b}\) pairs is calculated in the framework of the \(k_t\)-factorization approach. Here, the KMR and Jung unintegrated gluon distribution functions, used recently for description of charm and bottom cross sections at the LHC, are applied. Theoretical uncertainties of the model related to the choice of renormalization and factorization scales as well as due to the quark mass are also discussed. Results from the \(k_t\)-factorization approach are compared to FONLL predictions. The hadronization of charm and bottom quarks is included with the help of the Peterson fragmentation functions. The semileptonic decay functions found by fitting recent semileptonic data obtained by the CLEO and BABAR collaborations are used. In this context some effects of non-zero motion of D and B mesons in the laboratory frame and related modifications of the decay functions are also discussed. Inclusive differential distributions in transverse momentum and (pseudo)rapidity of leptons for several kinematical regions will be presented and compared to recent results of the ALICE, ATLAS and CMS collaborations. Furthermore, kinematical correlations between two leptons are also studied, including invariant mass spectra.
WG1: Structure Functions / 286

ABM PDFs updated

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We report on an update of the ABM NNLO PDF fit, which includes recent LHC data on the W- and Z-boson production along with their experimental uncertainties. We illustrate the constraints on PDFs coming from those LHC data and we also perform a determination of the strong coupling constant \(\alpha_s\). Cross section predictions for important benchmark processes at the LHC will be presented.

WG6: Spin / 287

First JAM results on the determination of polarized parton distributions

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The Jefferson Lab Angular Momentum (JAM) collaboration is a new initiative aimed at the study of the angular-momentum-dependent structure of the nucleon. First results on the determination of spin-dependent parton distribution functions from world data on polarized deep-inelastic scattering will be presented and compared with previous determinations from other groups. Different aspects of global QCD analysis will be discussed, including effects due to the nuclear structure of deuteron and Helium targets, target-mass corrections and higher twist contributions to the \(g_1\) structure function as well as the \(g_2\) structure function.

WG1: Structure Functions / 288

HERAFitter - an open source QCD fit framework

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The proton parton distribution functions (PDFs) are essential for precision physics at the LHC and other hadron colliders. Their current level of accuracy dominates the theory uncertainties.
in Higgs production and it affects substantially theory predictions for Beyond Standard Model high mass production.

The determination of the PDFs is a complex endeavor involving several physics process. The main process is the lepton proton deep-inelastic scattering (DIS), with data collected by the HERA ep collider covering a large kinematic phase space needed to extract PDFs. Further processes (fixed target DIS, ppbar collisions etc.) provide additional constraining powers for flavour separation. In particular, the precise measurements obtained or to come from LHC will continue to improve the knowledge of the PDF.

HERAFitter project is an open source QCD fit framework ready to extract PDFs and assess the impact of new data which we would like to present here. The framework includes modules allowing for a various theoretical and methodological options, capable to fit a large number of relevant data sets from HERA, Tevatron and LHC. This framework is already used in many analyses at the LHC.

A new release is available publicly with added features for different parametrisation methods, alternative options to assess the impact of new data based on bayesian reweighting technique, different representation of the chisquare, as well as the option to accomodate for asymmetric systematic uncertainties.

WG2: Low x and Diffraction / 289

New results on diffractive and exclusive production from CDF

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We would like to present results on diffractive and exclusive production from CDF experiment including new study of ppbar collisions at the Tevatron that have 2 or 4 charged hadrons in the central region with |eta|<1.3 with large rapidity gaps on either side. We use data taken at sqrt(s)=1960 and 900 GeV. This data provides a useful window on hadron spectroscopy, as well as providing benchmarks for testing pomeron models.

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Inclusive Deep Inelastic Scattering at High Q2 with Longitudinally Polarised Lepton Beams at HERA and Determination of the Integrated Luminosity at HERA using Elastic QED Compton Events
A measurement of the integrated luminosity at the ep collider HERA is presented, exploiting the elastic QED Compton process ep → ep. The electron and the photon are detected in the backward calorimeter of the H1 experiment. The integrated luminosity of the data recorded in 2003 to 2007 is determined with a precision of 2.3%. The measurement is found to be compatible with the corresponding result obtained using the Bethe-Heitler process.

Inclusive e^p+mp single and double differential cross sections for neutral and charged current deep inelastic scattering processes are measured with the H1 detector at HERA. The data were taken at a centre-of-mass energy of √s = 319 GeV with a total integrated luminosity of 333.7 pb⁻¹ shared between two lepton beam charges and two longitudinal lepton polarisation modes. The differential cross sections are measured in the range of negative fourmomentum transfer squared, Q², between 60 and 50 000 GeV², and Bjorken x between 0.0008 and 0.65. The measurements are combined with earlier published unpolarised H1 data to improve statistical precision and used to determine the structure function xF_3^γZ. A measurement of the neutral current parity violating structure function F_2^γZ is presented for the first time. The polarisation dependence of the charged current total cross section is also measured. The new measurements are well described by a next-to-leading order QCD fit based on all published H1 inclusive cross section data which are used to extract the parton distribution functions of the proton.
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A precision measurement of the ratio $R_K$ of the rates of kaon leptonic decays $K^+ \rightarrow e^+ \nu$ and $K^+ \rightarrow \mu^+ \nu$ with the full minimum bias data sample collected with low intensity 75 GeV/c beam by the NA62 experiment at CERN in 2007-2008 is reported. The result, obtained by analyzing ~150,000 reconstructed $K^+ \rightarrow e^+ \nu$ candidates with 11% background contamination, has a record precision of 0.4% and is in agreement with the Standard Model expectation.

The sensitivity of the NA62 experiment at CERN to charged kaon decays violating lepton number conservation, neutral pion decays forbidden in the Standard Model and heavy sterile neutrinos is discussed. An upper limit on the lepton number violating $K^+ \rightarrow \pi^- \mu^+ \mu^+$ decay rate from the NA48/2 experiment is presented.

A precision lepton universality test by measurement of the helicity suppressed ratio of leptonic decay rates of the charged kaon with ~10^5 $K^+ \rightarrow e^+ \nu$ decays collected by the NA62 experiment in 2007-08 is presented. The record accuracy of 0.4% constrains the parameter space of new physics models with extended Higgs sector, a fourth generation of quarks and leptons or sterile neutrinos. An improved upper limit on the rate of the lepton number violating decay $K^+ \rightarrow \pi^- \mu^+ \mu^+$ from the NA48/2 experiment, which probes the resonant enhancement of the rate in the presence of heavy Majorana neutrinos in the ~100 MeV range, is presented. The prospects for the searches of lepton number and flavour violating decays of the charged kaon with an improved sensitivity down to ~10^{-12} during the forthcoming main phase of the NA62 experiment are discussed: these would probe new physics scenarios involving heavy Majorana neutrinos or R-parity violating SUSY.

**WG1/5: Structure Functions and Heavy Flavours / 293**

**3-Loop Heavy Flavor Corrections to Deep-Inelastic Scattering**

**Author:** Johannes Bluemlein

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New results on the 3-loop heavy flavor corrections to DIS are reported. They concern the case of graphs with 2 massive lines, both of equal and unequal masses ($m_c$ and $m_b$), and an extension in the renormalization. Furthermore, we present results for massive ladder, V-graph and Benz-topologies, as well as new classes of mathematical functions needed in the analytic description of these results.

**Plenary / 294**

**Welcome talks**

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**WG3: Electroweak and Searches / 296**
W’ and Z’ searches at the LHC

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Searches for extra heavy W’ and Z’-bosons in the leptonic Drell-Yan channel at the LHC are favoured by present data. We focus on the common approximations used in theoretical and experimental analyses: neglecting interference and finite width effects. And present the implications of adopting such approximations on the data interpretation and the extraction of exclusion limits on W’ and Z’-boson masses. First results from experimental analyses are quoted.

DPHEP: From Study Group to Collaboration

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The international study group on data preservation in high energy physics, DPHEP, achieved a milestone in 2012 with the publication of its eagerly anticipated large scale report, which contains a description of data preservation activities from all major high-energy physics collider-based experiments and laboratories. A central message of the report is that data preservation in HEP is not possible without long term investment in not only hardware but also human resources, and with this in mind DPHEP will evolve to a new collaboration structure in 2013. The DPHEP study group and the major conclusions from the report will be presented as well as an outline of the future working directions of the new collaboration.

Introduction of the EIC program in China

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There is a plan that the Institute of Modern Physics (IMP) of CAS (Lanzhou) in China will build a EIC under the High Intensity heavy ion Accelerator Facility (HIAF). The EIC@HIAF includes two stages: in the first stage we will build 3 GeV (electron energy) x 12 GeV (proton energy) EIC with luminosity up to $10^{33}$ in 2019; In the second stage we will build about 10˜15 GeV (electron energy) x 100 GeV (proton energy) EIC with luminosity $10^{35}$ in 2030. In this talk we will discuss our plan and possible physics goals for the EIC@HIAF.
Direct-photon hadron correlations at $\sqrt{s} = 200$ GeV with PHENIX

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Direct photon tagged jets, in the form of photon-hadron correlations, are well suited to provide unique insight into how jets interact with the quark gluon plasma. Since high momentum photons are unmodified by the strongly coupled medium produced at RHIC, the measured photon momentum approximately balances that of the away-side parton. Therefore, the effective modification to the fragmentation function can be measured by comparing integrated away-side yields in direct photon-hadron correlations in Au+Au collisions to those in p+p. By varying the away-side integration range, the angular dependence of modification to the effective fragmentation function can also be studied. Direct photon-hadron correlations have been measured with PHENIX in p+p and Au+Au using a statistical subtraction technique to remove the decay photon contribution from the inclusive photon-hadron correlations, with an additional isolation cut applied in p+p. These recently published results will be discussed in light of complementary results from STAR and the LHC, as well as qualitative comparisons with theoretical predictions.

Recent STAR results on the W boson program at RHIC at BNL

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The STAR experiment at the Relativistic Heavy-Ion Collider at Brookhaven National Laboratory is carrying out a spin physics program in high-energy polarized proton collisions at $\sqrt{s} = 200$ GeV and $\sqrt{s} = 500$ GeV to gain a deeper insight into the spin structure and dynamics of the proton.

The collision of polarized protons at $\sqrt{s} = 500$ GeV opens a new era of spin-flavor structure measurements from $W^{-(+)}$ boson production. $W^{-(+)}$ bosons are produced in $\bar{u} + d (d + u)$ collisions and can be detected through their leptonic decays, $e^{-} + \nu_{e} (e^{+} + \nu_{e})$, where only the respective charged lepton is measured. The discrimination of $\bar{u} + d (d + u)$ quark combinations requires distinguishing between high $p_{T}$ $e^{-(+)}$ through their opposite charge sign, which in turn requires precise tracking information. Recent STAR results on the measurement of $W^{-}/W^{+}$ and Z boson production at mid-rapidity will be shown.

Re-evaluation of the Parton Distributions of Strangeness in the nucleon

Author: Harold E Jackson Jr
In 2008 HERMES published the results of an "isoscalar" extraction in leading logarithmic order (LO) in the strong coupling constant of quantum chromodynamics of the momentum and helicity density distributions of the strange sea in the nucleon from the charged-kaon production in deep-inelastic scattering (DIS) on the deuteron (Phys. Lett. B666, 446 (2008). The shape of the momentum distribution was observed to be softer than that of the average of the uubar and ddbar quarks. The helicity distribution was found to be compatible with zero within experimental uncertainties in the region of measurement $0.02 < x < 0.60$. HERMES has since finalized the extraction of multiplicites for charged Kaons in semi-inclusive deep-inelastic positron scattering. A re-evaluation of the extraction of the PDFs of strange quarks has been made using the results of the new final extraction of the multiplicities for charged kaons. In the measured range of $x$ the strength of the polarization averaged PDF $S(x)=s(x)+sbar(x)$ is substantially less than reported earlier, but the shape is similar, i.e., the momentum densities are softer than previously assumed. The first moment of the helicity distribution Delta $S(x)$ is consistent with zero and the partial moment of the octet axial combination is observed to be substantially less than the axial charge extracted from hyperon decays under the assumption of SU(3) symmetry.

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**Parton Distributions in the Higgs Boson era**

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**Plenary / 303**

**Constraints on Proton Structure**

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**Plenary / 304**

**Polarised proton structure**

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  including future of intensity
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**Precision QCD measurements in DIS**

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**Multiparton interactions: Theory and experimental findings**

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**Precision QCD and hadron machines (LHC)**

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**Hot strong matter**

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ALICE

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**New Results from Tevatron**
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Higgs and EW at LHC

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Energy Frontier at LHC

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WG1 Highlights - Structure Functions

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WG2 Highlights - Small x, Diffraction and Vector Mesons

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WG3 Highlights - Electroweak and searches

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WG4 Highlights - HFS and Precision QCD

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WG5 Highlights - Heavy Flavours

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WG6 Highlights - Spin Physics

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**WG7 Highlights - Future DIS Experiments**

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**Outreach talk:**

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Public Lecture

**Summary:**

The search of a deeper understanding of our universe at the Large Hadron Collider: the World’s Largest Particle Accelerator

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**WG4: QCD and HFS / 321**

**Probing non perturbative QCD with Ke4 and K+- → pi+- gamma gamma decays from the NA48/2 and NA62 experiments**

**Author:** Dmitry Madigozhin

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A sample of about 300 K+- → pi+- gamma gamma rare decays with a background contamination below 10% has been collected by the NA48/2 and NA62 experiments at CERN during low intensity runs with minimum bias trigger configuration. The presented measurements of the decay spectrum and rate provide a crucial test of the Chiral Perturbation Theory (ChPT) describing weak low energy processes. Study of K+ to pi+ pi- e+- nu and to pi0 pi0 e+- nu at the NA48/2 experiment at CERN

Content

The NA48/2 collaboration has analyzed 1.13 million charged kaon decays Ke4(++) to pi+ pi- e nu leading to an improved determination of the Branching Fraction at percent level precision and detailed form factor studies.
The hadronic form factors in the S- and P-wave and their variation with energy are obtained concurrently with the phase difference between the S- and P-wave states of the pi pi system. The latter measurement allows a precise determination of $a_{00}$ and $a_{02}$, the $I=0$ and $I=2$ S-wave pi pi scattering lengths. A combination of this result with another NA48/2 measurement, obtained in the study of $K^+ \rightarrow \pi^0 \pi^0 \pi^+$ decays, brings a further improved determination of $a_{00}$ and the first precise experimental measurement of $a_{02}$. These measurements bring new inputs to low energy QCD calculations and are crucial tests of existing predictions from Chiral Perturbation Theory and lattice QCD calculations.

The NA48/2 collaboration has accumulated $\sim 66000$ semi-leptonic charged kaon decays $K^+e_4(00)$ to $\pi^0 \pi^0 e^+\nu$, increasing the world available statistics by several orders of magnitude. Background contamination at the one percent level and very good $\pi^0$ reconstruction allow the first accurate measurement of the Branching Fraction and decay Form Factor. The achieved precision makes possible the observation of small effects such as a deficit of events at low $\pi^0 \pi^0$ invariant mass which can be explained by charge exchange rescattering in the $\pi\pi$ system below the $2m(\pi^+)$ threshold. Future prospects include the observation of several $\sim 1000$ decays in similar muonic modes $K_{\mu4}(00)$ (never observed) and $K_{\mu4}(+-)$ (7 events observed). Such poorly known modes could be studied also in the forthcoming NA62 experiment currently under construction.

**WG6: Spin / 322**

**Evolution of the helicity and transversity Transverse-Momentum-Dependent parton distributions**

**Authors:** Alessandro Bacchetta$^1$; Alexei Prokudin$^2$

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We examine the QCD evolution of the helicity and transversity parton distribution functions when including also their dependence on transverse momentum. Using an appropriate definition of these polarized transverse momentum distributions (TMDs), we describe their dependence on the factorization scale and rapidity cutoff, which is essential for phenomenological applications.

**WG4: QCD and HFS / 324**

**Strangeness Production in Deep-Inelastic ep Scattering at HERA**

**Authors:** H1 Collaboration$^1$; Khurelbaatar Begzsuren$^2$ 

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The production of neutral strange hadrons is investigated using deep-inelastic scattering events measured with the H1 detector at HERA. The measurements are made in the phase space defined by the negative four-momentum transfer squared of the photon $7 < Q^2 < 100$ GeV$^2$ and the inelasticity $0.1 < y < 0.6$. The $K_s$ and Lambda production cross sections and their ratios are determined. $K_s$ production is compared to the production of charged particles in the same region of phase space. Predictions of leading order Monte Carlo programs are compared to the data. The production of Lambda baryons is studied at high $Q^2$, using DIS events recorded with the H1 Detector. Using the full HERA-II statistics, differential Lambda production cross sections, the lambda production rate per event and the lambda-antilambda asymmetry is presented as a function of several...
kinematic variables. The H1 data are compared to theoretical predictions, based on leading order Monte Carlo programs with matched parton showers.

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Measurement of Charged Particle Spectra in Deep-Inelastic ep Scattering at HERA

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Charged particle production in deep-inelastic ep scattering is measured with the H1 detector at HERA. The kinematic range of the analysis covers low photon virtualities, $5 < Q^2 < 100 \text{ GeV}^2$, and small values of Bjorken-$x$, $10^{-4} < x < 10^{-2}$. The analysis is performed in the hadronic centre-of-mass system. The charged particle densities are measured as a function of pseudorapidity ($\eta$) and transverse momentum ($p_T$) in the range $0 < \eta < 5$ and $0 < p_T < 10 \text{ GeV}$ differentially in $x$ and $Q^2$.

The data are compared to predictions from different Monte Carlo generators implementing various options for hadronisation and parton evolutions.

Charged particle production is also measured in deep inelastic ep scattering at $\sqrt{s} = 225 \text{ GeV}$ with the H1 detector at HERA. The kinematic range of the analysis covers low photon virtualities, $5 < Q^2 < 10 \text{ GeV}^2$, and medium to high values of inelasticity $y$, $0.35 < y < 0.8$. The analysis is performed in the virtual photon-proton centre-of-mass system. The charged particle production cross sections is investigated double-differentially as a function of pseudorapidity $\eta$ and transverse momentum $p_T$ in the range $0 < \eta < 3$ and $p_T < 10 \text{ GeV}$. The data are compared to different phenomenological models.

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Strategy for Particle Physics in Europe and the World

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Closing overview talk

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Summary of IAC meeting

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Closing remarks

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WG4: QCD and HFS / 330

Measurement of isolated photons with and without accompanying jets at HERA

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Isolated-photon+jet production in ep collisions at a centre-of-mass energy of 318 GeV has been measured with the ZEUS detector at HERA using an integrated luminosity of up to 300 pb⁻¹. Measurements of prompt-photon+jet cross sections are presented as functions of the photon transverse energy and pseudorapidity in a wide range of exchanged-photon virtuality. In addition, differential gamma+jet cross sections are presented as functions of the jet transverse energy and pseudorapidity. Leading-logarithm parton-shower Monte Carlo predictions and perturbative QCD calculations were compared to the data.

Isolated-photon production in photoproduction, both inclusive and together with a jet, has been measured with the ZEUS detector at HERA using an integrated luminosity of 370 pb⁻¹. Measurements were made in the isolated-photon transverse-energy and pseudorapidity ranges 6 < E_Tγ < 15 GeV and −0.7 < ηγ < 0.9, and for jet transverse-energy and pseudorapidity ranges 4 < E_Tjet < 35 GeV and −1.5 < ηjet < 1.8, for exchanged photon virtualities Q² < 1 GeV². Differential cross sections are presented for inclusive isolated photon production as functions of the transverse momentum and pseudorapidity of the photon and the jet. Higher-order theoretical calculations are compared to the results.

WG7: Future experiments / 331

eRHIC: New Technology Frontiers in machine, IR and detector design

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eRHIC is a proposed high luminosity, polarized Electron Ion Collider (EIC), which would make use of the existing RHIC infrastructure.
eRHIC is a triple-IP collider, with a dedicated eRHIC detector and the possibility of using the two existing, but upgraded IP detectors PHENIX and STAR. This presentation will describe the novel eRHIC machine, interaction region and dedicated detector designs as well as give a short overview about the presently ongoing R&D activities for making technology choices towards such a new detector.

WG6: Spin / 332

Measurement of inclusive production of light charged hadrons at BaBar

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Towards the phenomenology of TMD’s at NNLL

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As a product of the factorization theorem of DY processes one can derive the evolution of TMDPDF at NNLL. An implementation of the evolutor is found which overcomes some difficulties due to the presence of the Landau pole. Final results are compared with phenomenology. Future developments are also discussed.

WG2: Low x and Diffraction / 339

Standard and quasi-conformal BFKL kernels

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In the BFKL approach scattering amplitudes are given by convolutions of impact factors of colliding particles and Green functions of two reggeized gluons. A possibility to rearrange radiative corrections to scattering amplitudes between the impact factors and the Green functions leads to an ambiguity of NLO BFKL kernels for equations of evolution of the Green functions with energy. The ambiguity permits to write the BFKL kernels in quasi-conformal shapes, i.e. in the forms where conformal invariance is violated only by running coupling. For the singlet representation of the gauge group the conformal invariance means invariance of the kernel in the Möbius representation with respect to the conformal transformations in the impact parameter space, whereas for the adjoint representation it means invariance of the kernel with subtracted gluon trajectory depending on the total transverse momentum with respect to the conformal transformation in the transverse momentum space. The differences between standard and quasi-conformal shapes of the BFKL kernels are found in the momentum space and are proved to be rather simple.
**WG1: Structure Functions / 340**

**The EMC Effect and Short-Range Correlations**

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The deep inelastic scattering cross section for scattering from bound nucleons differs from that of free nucleons. This phenomenon, first discovered 30 years ago, is known as the EMC effect and is still not fully understood. Recent analysis of world data showed that the strength of the EMC effect is linearly correlated with the relative amount of Two-Nucleon Short Range Correlated pairs (2N-SRC) in nuclei. The latter are pairs of nucleons whose wave functions overlap, giving them large relative momentum and low center of mass momentum, where high and low is relative to the Fermi momentum of the nucleus. The observed correlation indicates that the EMC effect, like 2N-SRC pairs, is related to high momentum nucleons in the nucleus. I will review studies of the EMC-SRC correlation studies, in particular the contribution of protons versus neutrons in asymmetric nuclei. Also I will present a planned experiment aimed at studying the origin of this EMC-SRC correlation.

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**WG7: Future experiments / 343**

**Process dependence and Sivers effect-SIDIS and inclusive jet production**

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We consider the role process dependence in the Sivers effect from analyzing the single transverse spin asymmetry for inclusive jet production in proton-proton collisions recently collected by AnDY experiment at RHIC, and the asymmetry data from semi-inclusive deep inelastic scattering experiments are presented. After carefully taking into account the initial-state and final-state interactions between the active parton and the remnant of the polarized hadron, the calculated jet spin asymmetry based on the Sivers functions extracted from HERMES and COMPASS experiments is consistent with the AnDY experimental data. This provides a first indication for the process-dependence of the Sivers effect in different processes. We make predictions for both direct photon and Drell-Yan spin asymmetry, to further test the process-dependence of the Sivers effect in future experiments.

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**Flash Info from the organizers**
Announcements