Mid Term Report 2010 (01.04.2010-10.02.2011)

Type of the project	Helmholtz-(Hochschul-)Nachwuchsgruppen
Support Number	HGF-VH-NG-401
Topic	Physics of gluons and heavy quarks from HERA to the LHC: Precision measurement of the gluon density at HERA and its application for cross section measurements at the LHC
Scientist in charge	Katerina Lipka
Helmholtz Center:	DESY
University Partner	Hamburg, Mainz, Wuppertal
Reference period	05/2008 untill 04/2013

The topics addressed in the project are the precision measurement of the charm contribution to the proton structure function at HERA, phenomenology of charm quark production in deep inelastic electron-proton scattering, and the measurement of the top quark mass at the LHC. Correspondingly, the activities in the group are divided in 3 working packages. In the following, the progress in each of the working packages is summarised.

Progress on the working plan of the proposal

Role the heavy flavour and jet measurements in the determination of parton density functions at HERA and the impact on the cross section predictions for the LHC

Currently the most precise data on the charm contribution F_2^c to the proton structure function F_2 were provided by the group in 2009. This result triggered intensive discussions in the QCD analysis community about the proper treatment of heavy quarks in the PDF fits and about the interpretation and the value of the charm quark mass.

In 2010 the main focus of the group was the study of the impact of precise F_2^c data on the determination of parton distribution functions (PDF) in the proton and determination of the charm quark mass using DIS data. Impact on the W, Z and Higgs cross-sections at the LHC was studied. The group plays the major role on this subject in HERAPDF activities.

The simultaneous determination of PDFs and the strong coupling constant by using jet production cross-sections measured by H1 and ZEUS is addressed. The group plays the major role on this topic in HERAPDF activities.

The group is also involved in the finalization of the publication on charged current cross section measurements in DIS at H1 and the combination of this data with ZEUS measurements.

In this context the following progress was made.

- The work on the publication of combined F^c_2 data from H1 and ZEUS is ongoing, the publication is expected in the first half of 2011. The Fixed Flavour Number Scheme (FFNS) version of HERAPDF1.0 using different values of charm quark mass was

provided within the group to be used in the F^c_2 analysis. HERAPDF1.0 in FFNS will be published together with the combined F^c_2 data.

- For the first time the charm data are included into HERAPDF fit [1] together with the published combined H1 and ZEUS inclusive neutral and charged current cross sections. Strong sensitivity of this PDF fit to the value of charm quark mass was observed. Different values of charm quark mass m_c were tested. In contrast to the global fit groups, the best quality of the fit is obtained using the PDG value of m_c. The resulting parton densities are consistent with HERAPDF1.0 within the uncertainties, however steeper gluon distribution and a sizable effect on the sea distribution is observed. This study will be published together with the combined F^c_2 data.

- The role of inclusion of HERA F^c_2 data in the PDF fit using different heavy flavour schemes was studied [2]. A next-to-leading order QCD analysis is performed to the preliminary combination of HERA F^c_2 measurements together with the published HERA inclusive neutral and charged current cross sections. The fits are used to estimate the optimal value of the charm quark mass within a given heavy flavour scheme. The parton distribution functions determined using the different heavy quark schemes at their optimal values of m_c are further used to predict the $W^{\pm}$ and Z production cross sections at the LHC. Good agreement between these predictions for the $W^{\pm}$ and Z cross sections is observed which allows to reduce the PDF uncertainty on these predictions due to the heavy flavour treatment from 7% to below 1%. Reduction of the uncertainty on W and Z boson cross-section predictions is of particular importance for determination of the luminosity normalization at the LHC.

- Another problem of the PDF fits using inclusive data is addressed in the group. So far, in HERAPDF fits of neutral and charged current cross sections in DIS the strong coupling constant $!_S$ was fixed. The PDF fit of inclusive data is not able to disentangle the correlations between the gluon distribution and the strong coupling constant. The NLO QCD analysis using the jet measurements provided by both H1 and ZEUS collaborations are included into the PDF fit together with combined H1 and ZEUS inclusive neutral current and charged current cross sections. By using of the jet measurements the correlation between the gluon density function and the strong coupling is significantly reduced. Together with the parton density functions, the value of the strong coupling constant at the scale of Z-boson mass was extracted [3].

Phenomenology of charm production in DIS at HERA

In collaboration with the THEP group of the Johannes-Gutenberg University of Mainz, the group participates in the development of the theoretical models of charm production at HERA at next-to-leading order (NLO) of perturbative QCD. These activities are supported by the Forschungszentrum des Landes Rheinland-Pfalz “Elementarkräfte und Mathematische Grundlagen”. The development of the NLO program combing the calculation of the matrix element and the evolved fragmentation function is accomplished. The documentation of the code with description of the theory issues will be published by May 2011.

Compared to the pole mass definition of m_c in the coefficient functions currently used in the PDF fits, better convergence of the perturbative series and less dependence on variation of renormalization and factorization scales is shown by the ABKM group. In the framework provided by the ABKM group the determination of the running charm quark mass is possible for the first time using the DIS data, as reported by the ABKM group in 2010.

In close collaboration with the DESY Zeuthen theory group (ABKM), the work on determination of the charm quark mass in the MS-bar scheme has started. It is expected that the value of m_c (m_c) will become very precise after including the combined F^c_2 data into

this fit. First very encouraging result was obtained. The publication is expected for summer 2011.

Top quark physics at CMS and the Top-Quark related physics case investigation for the Phase1 upgrade of the CMS detector

- The group is well integrated in the Top Physics Analysis Group at CMS. The current focus of the group activities is the determination of the top quark-pair cross section within the DESY CMS group. Currently, the top di-leptonic decay channels are addressed, focusing on di-muon [4] and muon-electron [5] final states. The group participates also in the measurement of the cross section ratio of top quark-pair to Z-boson production in the di-muon channel [6]. The measured cross section in the di-muon channel and the cross-section ratio of top pair production to Z boson production are approved by the CMS collaboration and have been shown at the "Recontres de Moriond“ conference in March 2011. The group is also engaged in the development of the analysis tools for the top pair cross-section measurement in the di-electron decay channel.

- After discussion with the host institute, the group joined the PHASE-1 upgrade project for the silicon pixel detector in the CMS experiment, in which DESY plays the leading role. The PHASE-1 upgrade is foreseen for 2013. The upgrade of the pixel detector would include the insertion of an additional layer of silicon detectors in the barrel and one additional disk in each endcap. This would improve in particular track reconstruction at smaller particle transverse momenta and following increase of the b-tagging efficiency. Within the Super-LHC (SLHC) Tracker Simulation Group, and in collaboration with the DESY CMS group, the group has taken the responsibility of performing physics simulation studies of the pixel detector. The aim was to investigate the tracking and b-tagging performance of the detector after the upgrade, taking into account the improved geometry. The performance was studied both at the High-Level Trigger (HLT) level and in the full CMS track reconstruction.

- The group has performed significant changes of the existing tracking software to fully exploit the capabilities of the enhanced geometry. Such, the improvement in tracking efficiency from 80% to over 90% and decrease of the fake rate by a factor of 2, both in the HLT tracking using the tracks in the pixel detector only and in the full CMS tracker is shown. The developed software has been integrated in the CMS software and became the official tracking algorithm for the upgrade projects. The HLT triggers based on b-tagging have been commissioned using the new tracking, resulting in a significant improvement in the b-tagging performance. The publication of documentation of the new tracking is ongoing [7].

- The group has contributed to the Technical Proposal [8] and is involved in top-quark-related physics case analyses for the Technical Design Report (TDR) describing the PHASE-1 upgrade of the CMS detector.

- The paper “Measurement of the charge ratio of atmospheric muons with the CMS detector” is published [9].

Achieved milestones

- PDF Fits using the combined HERA charm data
- Determination of the optimal charm quark mass for different heavy flavour treatment schemes in global QCD analyses
- Reduction of the uncertainty for the W and Z boson cross sections for the LHC by using PDFs with the optimal charm quark mass
- Simultaneus determination of PDFs and the strong coupling constatn by using the jet cros sections measurements by the H1 and ZEUS experiments into the PDF fit
- Development of the tracking algorithm for the tracker upgrade at CMS
- Finalizing the analysis on top quark pair production using CMS data

Responsibilities of the group

K. Lipka,H1:
- coordinator of HERA Combination Group
- convener of HERA Heavy Flavour Combination Subgroup
- convener of H1 Heavy Flavour Working Group

M. Aldaya,CMS
- DESY CMS offline coordinator
- convener of DESY CMS top-quark group

K. Nowak, H1:
- convener of H1 QCD and Final state working group
- convener of HERA Jet Combination Subgroup

R. Placakyte, H1:
- convener of HERA Proton Structure Combination Subgroup

University Teaching

K. Lipka “QCD and physics at the LHC”, lectures in the University of Hamburg, SS2010

R. Placakyte preparation of exercises for the lecture “Teilchenphysik fuer Fortgeschrittene”, WS2010/2011

Adherence to the time and financial plans.

Physics:

The physics plan of the group is in the excellent agreement with the project. The group is playing the leading role in H1 and H1+ZEUS combination activities and determination of PDFs using exclusive final states at DESY.

Personell: the group consists of the group leader and the following members

Post-Docs:
- Dr. Maria Aldaya Martin
- Dr. Kadeer Alimuijang
- Dr. Krzystof Nowak
- Dr. Martin Brinkmann (till 30.06.2010)
- Dr. Ringaile Placakyte (accosiate, funded by the BMBF Project „HERA–Analyse der Daten vom H1- und ZEUS-Detektor” 05H09GUF)

Ph.D. Students:

- Ms. Monica Dobre

Personel changes:

- Dr. Martin Brinkmann successfully accomplished his Ph.D. in 04.2010 and joined the group as a postDoc till 06.2010. From July 2010 he joined H1 and CMS experiments as a DESY Fellow.
- From 15.07.2010 Dr. Ringaile Placakyte is funded by the BMBF Project 05H09GUF from the University of Hamburg (Project leader Prof. R. Klanner), but is still working in close collaboration with the group on heavy quark treatment in PDFs and predictions for the LHC. She uses the travel and investment budget of the group provided by the University of Hamburg.

Investments

Investmets of the group is in accordance to the proposal, including the computing equipement of the group with 2 laptops for the group members.

Additional *(*travel*)* expenses

Additional expenses include the travel expenses of the group members and the invited collaborating scientists for seminars at HERA Physics Plenary Meeting. Also the CMS operation fee for Dr. Aldaya is included. These expenses correspond to the financial plan.

Relevant Publications and Public Results

[1] R. Placakyte, V.Radescu, A. Cooper-Sarkar “QCD analysis using charm data”, H1prelim-10-045, ZEUS-prel-10-009.

[2] A. Cooper-Sarkar, S. Glazov, K. Lipka, R. Placakyte, V. Radescu “The Role of the Charm Mass Parameter in the QCD Analysis of the Combined HERA Data and Implications for the LHC”, H1-prelim-10-143, ZEUS-prel-10-019.

[3] A. Cooper-Sarkar, K. Nowak “QCD analysis and determination of ! $_s$ using the combined H1 and ZEUS NC and CC cross sections and the jet production cross section measured by the H1 and the ZEUS experiments”, H1-prelim-11-034, ZEUS-prel-11-001.

[4] M.Aldaya, W.Behrenhoff, D.Dammann, A.Geiser, J.Hauk, B.Lutz, M.Marienfeld, A.B.Meyer, "Measurement of the Top-Quark Pair Production Cross Section in the Muon Electron Decay Channel at " s = 7 TeV", CMS AN-11-028, in preparation.

[5] M.Aldaya, W.Behrenhoff, D.Dammann, A.Geiser, J.Hauk, B.Lutz, M.Marienfeld, A.B.Meyer, E.Gallo, "Measurement of the Top-Quark Pair Production Cross Section in the Dimuon Decay Channel at " s = 7 TeV", CMS AN-10-428, contribution to the CMS paper TOP-11-002.

[6] M.Aldaya, W.Behrenhoff, D.Dammann, A.Geiser, J.Hauk, B.Lutz, M.Marienfeld, A.B.Meyer, "Measurement of the Cross-Section Ratio of Top-Pair Production and Z Production in pp Collisions at " s = 7 TeV using the CMS Detector", CMS AN-10-429, contribution to the CMS paper TOP-11-002.

[7] M.Aldaya, J.Olzem, "Quadruplet seeding and tracking with the upgraded CMS pixel detector in Phase1", CMS note in preparation.

[8] The CMS Collaboration: "Technical Proposal for the upgrade of the CMS detector through 2010", under review by the LHCC committee.

[9] The CMS Collaboration: "Measurement of the charge ratio of atmospheric muons with the CMS detector", Phys. Lett.B 692 (2010) 83-104

Theses

M. Brinkmann, “Measurement of the D* Meson Production Cross Section and F^c_2 at High Q^2 in ep Scattering at HERA” Univ. of Hamburg, Dissertation 2010/03 DESY-THESIS-2010-016

Organisation

- K. Lipka, convener of the Heavy Flavour Working Group at XVIII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2010), April 2010
- K. Lipka, organisation of PDF4LHC Workshop at DESY, November 2010
- R. Placakyte, convener of the Parton Density Working Group at XVIII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2010), April 2010

Public Presentations

- M.Aldaya, "Status of CMS at DESY", talk at 70th PRC, Oct. 2010

- M.Aldaya, "The upgrade of the CMS pixel detector for LHC Phase 1", CMS CR-10-245, The International symposium XXX Physics in Collision (PIC2010), September 2010, proceedings to be published

- M. Brinkmann, “D* and F^c_2 at high Q^2 ”, XVIII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2010), April 2010, proceedings PoS(DIS 2010)149

- K. Lipka, summary talk “Heavy flavours in DIS and hadron colliders: WG summary” XVIII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2010), April 2010, proceedings PoS(DIS 2010)016

- K. Lipka, "Recent Combined Results of H1 and ZEUS", open session of the 69 DESY Physics Research Committee, April 2010

- K. Lipka, "Proton Structure Function Measurement at HERA", The International symposium XXX Physics in Collision (PIC2010), September 2010, proceedings to be published

- K. Lipka "Proton Structure Measurements at HERA", Particle Physics Seminar, University of Bonn, November 2010

- R. Placakyte, summary talk "Parton densities from DIS and hadron colliders to LHC: WG summary", XVIII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2010), April 2010, proceedings PoS(DIS 2010)013

- R. Placakyte, "Measurements of the proton structure in the electroweak regime at HERA" Low-x workshop, Kavala, Greece, June 2010
- R. Placakyte, "QCD analysis of combined H1 and ZEUS F^c_2 data", QCD at the LHC workshop, Trento, Italy, September 2010

- R. Placakyte, "H1 Status Report", open session of the 70 DESY Physics Research Committee, October 2010

- R. Placakyte, "QCD Analysis of Combined HERA F^c_2 Data and Impact fro the LHC", Standard Model Benchmarks at the Tevatron and LHC, CTEQ Workshop, Fermilab, November 2010

- R. Placakyte, "HERA PDFs and the Impact for the LHC", invited talk at Enrico Fermi Institute lunch seminar (Chicago University) November 2010

- R. Placakyte, "QCD Analysis of Combined HERA F^c_2 Data and Impact for the LHC" PDF4LHC meeting, DESY, November 2010

- K. Nowak, “Precise QCD measurements at HERA“, Lake Louise Winter Institute, Canada, February 2011