Annual Report

Funding Programme:	Helmholtz Young Investigators Groups
Project ID No.:	VH-NG-401
Project Title:	Physics of gluons and heavy quarks from HERA to the LHC
Group Leader:	Dr. Katerina Lipka
Helmholtz Centre:	DESY
Participating University:	Hamburg, Mainz, Wuppertal
Report Period (=Calendar Year):	05/2011-04/2012

1) Group Structure

Please report briefly on the structure and personnel development of your group.

Dr. Maria Aldaya
Dr. Sebastian Naumann-Emme
Dr. Krzystof Nowak
Dr. Kadeer Alimujiang
Dr. Ringaile Placakyte
Monica Dobre (Ph.D. student, University of Hamburg)
Jan Kieseler (Diploma student, University of Hamburg)

Personel changes in 2011:
- According to the planing of the YIG, Dr. Kadeer Alimujiang accomplished his work on the project and left in June 2011.
- Dr. Sebastian Naumann-Emme joined the group in July 2011 in order to work on top quark production at CMS experiment.
- Dr. Ringaile Placakyte joined the group in December 2011 (before associated member from Univ. Hamburg, BMBF Project 05H09GUF) to work on electroweak boson production at CMS experiment and PDF fitting tool development (in connection to the Sonderförderung Project S0-072)
- Jan Kieseler joined the group as a Diploma student in March 2011. He submitted his thesis to the University of Hamburg on 01.03.2012.

2) Network

Please describe how you / your research group are integrated within the Helmholtz Centre and the partner university (e.g. as member of committees).

The group is integrated in the High Energy Physics department of DESY in particular the H1 and CMS groups, and contributes significantly to the research program of the Centre. Also, the close collaboration with the DESY Zeuthen theory department is established. The collaboration with the University of Hamburg is well established via common analyses in the CMS experiment and activities within the BMBF project 05H09GUF. The collaboration with University of Mainz is supported by the Forschungszentrum des Landes Rheinland-Pfalz “Elementarkräfte und Mathematische Grundlagen”.

3) Satisfaction

How satisfied are you with the general working conditions provided by the Helmholtz Centre / partner university? Is there anything that meets your criticism?

DESY offers the perfect infrastructure for international research. The support of the Centre and the partner universities corresponds to the cooperation contract.

4) Scientific Progress / Milestones

How has your work plan progressed? Which important milestones could be achieved during the report period? Is the progress of your work in accordance with original planning or has the work plan been changed?

The activities of the group are divided in several working packages where major milestones were achieved. In general, the progress of the group work is in accordance with original planning, however the working plan was significantly extended to follow the important spin-off activity, i.e. tool development for determination of the proton structure and inclusion of the LHC data into the measurement of parton distribution functions (PDFs). This topic is extensively treated in the inter-experimental project "Determination of the proton structure using deep inelastic scattering and proton-proton collisions " (Sonderförderung through HGF IFV, SO-072). Unless not stated otherwise, the described activities are initiated and lead by the members of the group.

Progress on the working plan of the proposal.

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

- The analysis of the deep inelastic charged current scattering at HERA with longitudinal electron (positron) polarisation in HERA-II running period is accomplished. Results will be published in 2012 together with measurements of neutral current cross sections and NLO QCD analysis of the two data sets. This measurement is the prerequisite for the ultimate PDF set from HERA, the HERAPDF2.0.

- The work on the combination of the H1 and ZEUS measurement of charm quark cross-sections is accomplished and entered the publication procedure. In addition to the experimental data on charm production, the publication includes the QCD analysis of this measurements and determination of the value of the charm quark mass, used as parameter in different phenomenological schemes. Also the influence on the predictions for W and Z-boson production cross section at the LHC is discussed. The preliminary results were reported in detail in the annual report 2010, the publication is expected in 2012.

- The simultaneous extraction of the strong coupling constant $\alpha_s(M_Z)$ and of the parton density functions was performed at HERA, based on the inclusive measurements of deep inelastic scattering (DIS) and also including the jet measurements of H1 and ZEUS experiments. The extracted value of $\alpha_s(M_Z)$ is compatible with values obtained from different analyses of multi-jet production and the world average result.

- The determination of PDFs using all available inclusive and semi-inclusive data sets at HERA was performed [1]. This investigation includes the combined HERA data on inclusive DIS, the data collected with lower proton beam energies, the combined charm measurements and the published jet measurements of H1 and ZEUS. The different data sets, included in the QCD analysis simultaneously for the first time, are sensitive to different aspects of the proton structure and test different aspects of the related phenomenology. The determination of $\alpha_s(M_Z)$ and of charm quark mass parameter in different heavy flavour schemes was performed. The analysis supports the results based on separately tested charm and jet data and strengthens the conclusions from [2] and [3]. The resulting PDF, HERAPDF 1.7 [1], constitutes an important milestone for the ultimate PDF set from HERA, HERAPDF 2.0.

Tool development for determination of PDFs in hadron-induced interactions

The group contributed significantly to a joint H1-ZEUS project providing an open source tool, which can be used for determination of PDFs, HERAFitter. The HERAFitter program provides

the opportunity to experimentalists (in particular the LHC experiments) to study the effect of different measurements on the PDFs even on an early stage of the analysis, using different theoretical schemes. HERAFitter is successfully used in ATLAS and CMS collaborations. The development of HERAFitter has its origin in the HERAPDF group and is meanwhile supported by developers from the H1, ZEUS, ATLAS and CMS experiments and several QCD theory groups. Several major developers of the HERAFitter tool are members of the group (R. Placakyte, K. Nowak, S. Naumann-Emme) or are supported via the S0-72 project (V. Radescu, P. Starovoitov).

The first version of the HERAFitter has been made public in September 2011 [4]. The stable release is planned for 2012 along with the HERAPDF 2.0 publication. The group contributes to the stable release of the code through the implementation and validation of different heavy flavour schemes, providing the interface to PDF libraries and to the theory calculations of top-quark pair production, implementation of the new data sets and documentation.

Phenomenology of charm production in DIS at HERA

In close collaboration with the DESY Zeuthen theory group (ABM), the work on determination of the running charm quark mass using charm production measurement and the QCD calculation at NNLO calculation performed. This is the first measurement of running charm quark mass in DIS using the charm production data. The result is in good agreement with the world average and has competitive precision. The analysis is based on the measurement of D*-meson production cross-section, published by the H1 collaboration in 2011. The result is presented at the Deep Inelastic Scattering Workshop (DIS2012) [5]. The analysis at NLO QCD is being finalized.

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

The group is consolidating itself in a leading position in the Top Physics Analysis Group of the CMS experiment and works together with the DESY CMS top quark group and the University of Hamburg.

- Together with DESY CMS Top Group, we pioneered the LHC measurement of the top-quark pair differential cross sections at $\sqrt{s}$ = 7 TeV. The top-quark pair production is identified via top-quark decays with leptons in the final state. The cross sections are determined as a function of the kinematics of leptons, and top (antitop) quarks. The measurement has been performed in close collaboration with the group of Hamburg University and Korean groups and is published in the CMS publication [6]. Currently, the group is working towards the publication of the results with the full dataset, collected by the CMS experiment in 2011, corresponding to the integrated luminosity of 5 fb^{-1} [7].

- The inclusive cross section of top pair production with electrons and muons in the final state has been measured [8] and found to be consistent with the QCD predictions at approximate NNLO, providing an important cross-check for the earlier published CMS result [CMS-PAS-TOP-11-005].

- The cross section ratio of the top-quark pair to Z-boson production was performed, using the decay channels with muons and electrons in the final state. The complete data set, collected by the CMS experiment in 2011 is used. The ratio is insensitive to the luminosity uncertainties and is investigated as an alternative method to determine the top-pair cross section, making use of the NNLO prediction of the Z-boson production. The obtained top-quark pair cross section is in agreement with the SM predictions at approximate NNLO and with the earlier CMS result. This analysis has been the topic of a diploma thesis of J. Kieseler.

- The paper "Measurement of the top-pair production cross section and the top quark mass in the di-lepton channel in pp collisions at 7 TeV", to which the group contributed with the inclusive cross section measurement (cross-check analysis) and the cross section ratio top-pair to Z (main analysis) in the muon channel, has been published [9].

- The pole mass and running mass of the top quark was determined for the first time at the CMS experiment [10] by comparing the top-quark pair cross section measurement to different approximate NNLO predictions. This approach allows obtaining the top quark mass in an unambiguous definition, while the direct measurements so far always rely heavily on less-well defined top-quark masses from Monte Carlo simulations. The results are in very good agreement with similar measurements by the Tevatron experiments and ATLAS.

- Top-pair production at the LHC probes the range of high proton momentum fractions x of interacting partons. The PDFs in this x-range is poorly constrained so far using the data of HERA and Tevatron. Therefore, top-pair production at the LHC can help constraining the gluon density at high x. Studies on PDF constraints from measured top-quark pair cross sections are performed. The interface to the NNLO calculation through program Hathor into the HERAFitter is implemented, allowing for comparisons between data and predictions for the inclusive top-pair cross section at approximate NNLO. First study on the PDF-dependence of differential cross sections using NLO predictions.

- Within the SLHC Tracker Simulation Group, and in collaboration with the DESY CMS group, the group has continued investigating the tracking, vertexing and b-tagging performance of the "Phase 1" upgraded pixel detector, both in the High-Level Trigger (HLT) and in the full CMS tracker [11]. Significantly improved simulations of the behaviour of the front-end electronics have been performed. As a result, options for further improvement of the Phase 1 tracking software and algorithms, developed by the group, have been identified and are being worked on.

5) Financial Plan / Time Schedule
Can you comply with the financial plan and time schedule or do you see a need for adjustment?

The expenses for personel and travel, including the CMS operation fees correspond to financial plan of the proposal. It is the great interest of the group to extend it's involvement in the physics case study of the CMS Phase-1 upgrade to active contribution in the assembling and testing the modules of the new pixel detector. Therefore the group is applying for the additional investment from the president's fond.

6) Status
Do you hold a joint Junior Professorship or a W2/W3 Professorship? Do you aim for such a position? What is the status of your negotiations in this respect?

The group leader position was tenured by DESY on 01.05.2011 after the evaluation in April 2011. There are no ongoing negotiations with the university of Hamburg and the group leader in connection to the HGF-NG-401. The group leader applies for professorships on a regular basis.

7) Teaching Activities of the Group Leader

Sommersemester 2011 Lecture/Seminars "Protons at highest energy: QCD and physics at the LHC", shared with Dr. Isabell Melzer-Pellmann

8) Publications of the Group

Public Presentations by the group members

- M. Aldaya, *"Recent Top Quark Physics Results from CMS"*, XXVI Rencontres de Physique

de la vallee d'Aoste, 26 Feb - 3 Mar 2012, La Tuile (Italy)

- M. Aldaya, *"Highlights of CMS Physics Results at 7 TeV*", DESY seminar, 13-14 Dec 2011, Hamburg-Zeuthen (Germany)
- M. Aldaya, *"Determination of the Top Quark Mass from the ttbar Cross Section at 7 TeV"* (poster), Hadron Collider Physics Symposium, 14-18 Nov 2011, Paris (France), CR-2012-014
- M. Aldaya, *"Determination of the Top Quark Mass from the ttbar Cross Section at 7 TeV",* (poster), 4th International Workshop on Top Quark Physics, 25-30 Sep 2011, Sant Feliu de Guixols (Spain), CR-2012-013
- M. Aldaya, *"Recent Results on Top Quark Physics at CMS"*, 23rd Rencontres de Blois on Particle Physics and Cosmology, 29 May - 3 Jun 2011, Blois (France)
- J. Kieseler, *"Measurement of the cross section ratio ttbar/Z in the ee and $\mu\mu$ final states at 7 TeV with the CMS experiment"*, 5th Annual Workshop of the Helmholtz Alliance "Physics at the Terascale", 7-9 Dec 2011, Bonn (Germany)
- J. Kieseler, *"Measurement of the cross section ratio ttbar/Z in the ee and $\mu\mu$ final states at 7 TeV with the CMS experiment"*, Spring Meeting of the German Physical Society (DPG 2012), 27 Feb - 2 Mar 2012, Göttingen (Germany)
- K. Lipka, *"From PDFs and Heavy Quarks at HERA to the LHC"*, DESY Seminar Feb. 2011
- K. Lipka, *"Proton structure measurements and PDFs at HERA"*, Ringberg workshop on new trends in HERA Physics, Lake Tegernsee, 25-28 Sept. 2011, proceedings to be published in Nuclear Physics B Proceedings Supplement
- K. Lipka, *"Recent results from HERA and their impact for LHC"*, Hadron Collider Physics Symposium 2011, Nov. 2011, Paris, proceedings http://arxiv.org/abs/1201.4486
- K. Lipka, *"Proton structure from DIS and the impact of the LHC data*", invited talk, 5th Annual Workshop of the Helmholtz Alliance "Physics at the Terascale", Dec. 2011, Bonn
- S. Naumann-Emme, *"Top-Quark Analyses in DCMS*", summary talk, FSP-CMS Annual Meeting, Karlsruhe, Sept. 2011
- S. Naumann-Emme, *"Top-Quark Measurements at the LHC"*, 3rd LC-Forum Meeting, DESY Hamburg, Feb. 2012
- K. Nowak, *"QCD analysis with determination of strong coupling based on HERA inclusive and jet data",* XIX International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS 2011), 11-15 April 2011
- K. Nowak, *"QCD measurements with jets and strong coupling determination at HERA"*, International Conference on the Structure and Interactions of the Photon and 19th International Workshop on Photon-Photon Collisions, 22-27 May 2011, Spa, Belgium
- K. Nowak, *"Summary of the Hadronic Final State working group"*, summary talk at XX International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS 2012), 26-30 March 2012
- R. Placakyte, *"Parton Distribution Functions, Uncertainties and Constraints",* DPG-Tagung, March 29 2011, Karlsruhe, invited talk
- R. Placakyte, *"QCD Analysis of the Combined H1 and ZEUS F2cc Data and the Impact on the Z, W Cross Section Predictions at the LHC"*, Workshops on Deep-Inelastic Scattering and Related Subjects (DIS), April 2011, proceedings
- R. Placakyte, *"Parton Distribution Functions",* XXXI Physics in Collision, Vancouver, Canada, Aug 28-1st Sep 2011; talk + proceedings (arXiv:1111.5452):
- R. Placakyte, *"HERAfitter project",* presentation on CMS General Weekly Meeting, 12.10.2011

Publications

[1] A. Cooper-Sarkar, K. Nowak, The NLO QCD analysis of inclusive, charm and jet data from HERA (HERAPDF1.7), H1prelim-11-143, ZEUS-prel-11-010

[2] A. Cooper-Sarkar, K. Nowak "QCD analysis and determination of α_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.

[3] 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.

[4] [H1 and ZEUS Collaborations] HERAFITTER, http://herafitter.hepforge.org/

[5] S. Moch et al, presentation at XX International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS 2012), 26-30 March 2012, proceedings to be published

[6] The CMS Collaboration, "Measurement of top quark pair differential cross sections at 7 TeV", CMS-PAS-TOP-11-013

[7] M.Aldaya et al, "Measurement of Top Quark Pair Differential Cross Sections in the Dilepton Final State", CMS-AN-2012-065, in preparation

[8] M. Aldaya et al, "Measurement of Top Quark Pair Differential Cross Sections in the Di-Lepton Final State at sqrt(s) = 7 TeV ", CMS-AN-2011-186

[9] The CMS Collaboration, "Measurement of the ttbar production cross section and the top quark mass in the dilepton channel in pp collisions at sqrt(s) = 7 TeV", CMS-PAS-TOP-11-002, JHEP 07 (2011) 049

[10] M. Aldaya, K. Lipka, S. Naumann-Emme, "Extraction of the Top Quark Mass from ttbar Cross Sections Measured by CMS at 7 TeV", AN-2011-359;
The CMS Collaboration, "Determination of the Top Quark Mass from the ttbar Cross Section at 7 TeV", CMS-PAS-TOP-11-008

[11] M. Aldaya et al, "Simulation Studies of an Upgraded CMS Pixel Detector", IN-2011-017

Theses

J. Kieseler, “Measurement of the Top-Antitop and Z^0-Boson production cross sections and their ratio in the dileptonic decay channels at $\sqrt{s}$=7 TeV with the CMS Experiment”. Diplomarbeit, submitted to the University of Hamburg on 01.03.2012.

Responsibilities of the group members, **organization of public events:**

- M. Aldaya: convenor of DESY CMS top-quark group, advising DESY Ph.D. students working in the DESY top-quark working group
- K. Lipka: coordinator of HERA combination activity, convenor of HERA heavy flavour group, member of Program Advising Committee for the XX Workshop on Deep Inelastic Scattering and Related Subjects (DIS2012, Bonn), organisation of the CMS PDF Forum.
- S. Naumann-Emme: software coordinator of the CMS Top Group, organizer of the workshop on Constrained Kinematic Fits in Events with Top Quarks at CMS, CERN, December 2011
- K. Nowak: convenor of HERA jet combination group, convenor of H1 QCD/HFS group, convenor of the Working Group “Hadronic Final State” during the XX Workshop on Deep Inelastic Scattering and Related Subjects (DIS2012, Bonn)
- R. Placakyte: convenor of the HERA Proton Structure group, convenor of the Working Group “Structure Functions”, during the XX Workshop on Deep Inelastic Scattering and Related Subjects (DIS2012, Bonn), organisation of the CMS PDF Forum.

9) External Funding

10) Patent Applications
11) Awards received by Group Members / Professorship Appointments offered to Group Leader