

# Experimental Particle Physics at HERA and LHC

Scientific Section

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# 1 Summary

We are submitting a request for continuing support for the participation of Universität Zürich in the H1 collaboration at HERA and for the installation and commissioning of a detector to study CP violation and B-meson physics at the LHC.

**HERA:** The HERA storage ring has been turned off in July 2007. After 15 years of successful operation, the H1 collaboration has acquired data from collisions of 27.4 GeV polarised and unpolarised electrons and positrons with mostly 920 GeV protons corresponding to a total integrated luminosity of  $\approx 500 \text{ pb}^{-1}$ .

With its very precise tests of the predictions of quantum chromodynamics (QCD), HERA has significantly contributed to the confidence in the validity of the Standard Model of strong and electroweak interactions. The large amount of very interesting data being available now represents a strong analysis challenge for the H1 collaboration for many years to come. Our group at Universität Zürich plans to contribute to this effort for at least four more years with some of its more senior group members and with two Ph.D. students. In recent years, our group has developed a new method for selecting and analysing events with photons in the final state.

The Swiss part of the H1 team also comprises groups at ETH Zürich (Prof. R. Eichler, Dr. C. Grab and group members) and at the PSI (Dr. S. Egli, Dr. R. Horisberger and group members). We cultivate a close collaboration with both these groups.

**LHCb:** LHCb is a second generation experiment on  $b$  quark physics, which will start data taking at the beginning of LHC operation by the end of 2008. The goal of the experiment is to perform systematic measurements of CP-violating processes and rare decays in the  $B$ -meson systems, with unprecedented precision and in many different decay channels of  $b$  quark mesons. Measuring CP violation in numerous decay modes of  $B_d^0$  and  $B_s^0$  mesons and comparing the results with predictions from the Standard Model, the experiment will search for “new physics”.

Our group at Universität Zürich concentrates on the development, construction, operation and data analysis of the LHCb Silicon Tracker, as well as on the preparation for physics analyses.

The silicon micro-strip detector station built at our institute has been installed at CERN. The installation and commissioning of the necessary infrastructure and electronics is ongoing. The installation and commissioning of detector modules will commence soon.

The coming year will mainly be devoted to commissioning the detector and to testing the system performance in the high track density environment of the LHC. This includes aligning the detector elements and optimising the running parameters of the electronic readout chains. The first data sets, which can be used to study the physics of the B meson system are expected to be available in late 2008.

In addition to our group, the *École Polytechnique Fédérale de Lausanne*, the University of Santiago de Compostela (Spain), the Max-Planck-Institut für Kernphysik, Heidelberg (Germany), the Budker Institute for Nuclear Physics, Novosibirsk (Russia) and the Ukrainian Institute of Science, Kiev (Ukraine) are members of the LHCb Silicon Tracker group. However, most activities are concentrated in Zürich and Lausanne.

The LHCb Silicon Tracker project, comprising the Trigger Tracker (TT) and the Inner Tracker (IT), is coordinated by us (O. Steinkamp and U. Straumann). It represents a significant Swiss contribution to the LHCb experiment, that is clearly visible and well recognised in the international particle physics community.

## 2 H1: analysis of isolated photons

Dr. Katharina Müller, Carsten Schmitz, Krzysztof Nowak  
in collaboration with Prof. Thomas Gehrmann, Dr. Aude Gehrmann, Eva Poulsen

On June 30, 2007, fifteen years of successful data taking came to an end at the  $e - p$  collider HERA at DESY. During this time, the H1 experiment has collected a total of  $478 \text{ pb}^{-1}$  of high quality data, about equally shared between  $e^-p$  and  $e^+p$  scattering. The detector is now being disassembled but the analysis of the data will continue for the coming years.

Isolated photons with high transverse momentum in the final state are a sensitive probe of the dynamics of the hard sub-process, since they are largely insensitive to hadronisation and fragmentation and carry unaltered information of the hard scatter. Furthermore, a good understanding of the Standard Model production mechanism of isolated photons is important for the understanding of backgrounds to a light Higgs decaying into two photons at LHC, as well as for searches for physics beyond the Standard Model.

The observation and analysis of such photons has become a major focus of the analysis efforts of our group in the past years. Under the supervision of Dr. K. Müller, two PhD students (C. Schmitz and K. Nowak) and one Bachelor student contribute to this effort. A very close and productive collaboration with the institute of theoretical physics at our university (Prof. T. Gehrmann, Dr. A. Gehrmann, E. Poulsen) for the measurement of isolated photons in deep inelastic scattering (DIS) demonstrates the strong interest in this subject and has made it possible to provide in parallel both a novel data analysis and a new theoretical calculation.

The analysis of isolated photons in DIS (PhD thesis of C. Schmitz) has been finalized. A paper is in the process of being published and preliminary results have been presented at the DIS2007 and EPS2007 conferences. Besides the inclusive production of isolated photons, also isolated photon production with jets was studied. Here, the sample of isolated photons with no additional hadronic jet is particularly interesting, because it is very sensitive to the quark-to-photon fragmentation function. Theoretical calculations underestimate the measured cross section in the inclusive measurement as well as for photons with no hadronic jet and for photons with hadronic jets by roughly a factor of two. The discrepancy is largest at low  $Q^2$ . A next-to-leading order calculation is available for the photon-plus-jets sample only. It describes the data well in shape but is also too low in absolute normalisation.

The analysis of isolated photons in photoproduction (PhD thesis of K. Nowak) has been extended to the full HERA II data set. Differential cross sections in pseudorapidity and transverse momentum of the photon have been determined. The sample of isolated photon plus at least one jet allows the extraction of the parton density functions of the photon and the proton, which are also studied as a function of the kinematics of the photon. The analysis is well advanced and we aim for preliminary results in spring.

In future, we aim to cross-check both analyses by using events with photons converted in the detector and to try to measure the quark-to-photon fragmentation function by a measurement of photons in the vicinity of jets. The latter analysis is very challenging and requires a detailed understanding of the influence of the overlap of signal clusters from different particles.

## 3 LHCb

Dr. Roland Bernet, Dr. Johannes Gassner, Stefan Steiner, Dr. Olaf Steinkamp, Dr. Jeroen van Tilburg, Dr. Achim Vollhardt, Angela Büchler, Christophe Salzmann, Dmytro Volyanskyy, Andreas Wenger

### 3.1 Status and plans for the Trigger Tracker

The production and testing of the detector modules for TT has been completed, including 15% fully operational spare modules. A total of 2 terabyte of data from quality assurance tests has been stored in the module production database. The overall quality of the modules is excellent. For example, the fraction of faulty readout channels is smaller than 0.1% and leakage currents are typically around  $0.1 \mu\text{A}$  per silicon sensor at the foreseen operating temperature of  $5^\circ\text{C}$ . The sensor misalignment is small compared to the expected spatial resolution of  $50 \mu\text{m}$ . Based on a detailed analysis of the test results, a module quality grading has been established. The best modules will be installed in the central region of the detector, where particle densities are highest, and the least good modules will be kept as spares.

The TT detector box was first assembled and its mechanical and thermal properties tested extensively in a lab in Zürich. These tests and the analysis of the accumulated data resulted in the master thesis of A. Büchler [1]. The detector box was then shipped to CERN and installed in the experiment. A survey of the box has been performed and has shown that the detector is at its nominal position within the precision of the measurement. The  $\text{C}_6\text{F}_{14}$  cooling system has been connected and the detector volume has been cooled down to the foreseen operating temperature. A detector module was installed during the cooling tests and no mechanical problems were observed. All cables, fibres and patch panels have been installed and connected. These tasks were performed by S. Steiner, J. v. Tilburg and A. Büchler.

The production of Digitiser Cards for TT and IT has been completed. All Service Boxes have been assembled and filled with Digitizer Cards and have passed an extensive burn-in test programme. Control Cards for the Service Boxes have been produced by our colleagues from Santiago de Compostela. The cards are currently being tested and will then be inserted in the Service Boxes. The Service Boxes will then undergo a final test in the lab, before they are installed in the experiment. The detector readout is a responsibility of A. Vollhardt.

The installation of detector modules will commence as soon as the Service Boxes are installed and operational. We foresee to install the modules detection layer by detection layer, with extensive functionality tests in between. This will permit to identify and correct possible faults and cabling errors while the modules under test are still easily accessible. All members of our group will participate in these activities and will therefore have to spend extended periods of time at CERN.

In parallel to debugging the hardware, these functionality tests will permit to commission the control, readout and reconstruction software (see below) and to integrate the detector into the LHCb environment. Starting by the end of 2007, we will gradually join the global LHCb commissioning effort to prepare the experiment for the first LHC interactions. The first charged particles traversing the detector will be used to adjust readout timings, try to reconstruct tracks and study the alignment of the detector.

### 3.2 Status and plans for LHCb software and analysis

The software activities in our group are focussed on experiment control software, on track reconstruction, and on physics analysis. The experiment control software is a crucial element in the commissioning and operation of the detector. It is organised in a hierarchical tree with different domains for data acquisition and trigger, for high voltage, and for low voltage and cooling. At the lowest level, device units steer and monitor the specific hardware components of the detector. For most components, device units are already existing and the integration of the control software for IT is already well advanced. A. Büchler has started to adapt the control hierarchy to the specific requirements of the TT, benefiting from the work already done for the IT. In the near future, she will work on the integration of the different components, the installation of the software on the computers in the control room, and its commissioning with the real detector hardware.

As a first step in the track reconstruction, the data from the TELL1 boards has to be converted into a format that is usable by the reconstruction software. In the last months, the offline representation of the data has been updated by C. Salzmann to comply with the actual online readout data. Furthermore, many improvements in the software for simulating and reconstructing Silicon Tracker data have been implemented. For the commissioning of both TT and IT, we will further develop this software and integrate it with the general LHCb software infrastructure. In addition, preparations have started to analyse the data from the detector surveys and to convert them into a format in which they can be implemented in the alignment conditions database. This information will then be used as an initial estimate of the location of the modules and as the starting point for the track-based alignment software. In the coming months, C. Salzmann will implement the survey parameters and, together with J. v. Tilburg, develop an alignment method for TT. With only four detection layers, TT does not provide enough constraints to align the detector modules without use of external information. Therefore, we will rely mostly on tracks from the already aligned VELO and T-stations. Some internal constraints might, however, be derived from tracks that pass through the overlap region of adjacent modules. All these software efforts are led by J. v. Tilburg, who is the Silicon Tracker software coordinator.

D. Volyanskyy has recently finalised his study on the decay channel  $B_s \rightarrow J/\psi\eta'$ , resulting in his PhD thesis [2]. After optimising the selection cuts, he found a signal yield of  $\sim 4200$  events for  $2\text{ fb}^{-1}$  of data, with a background-to-signal ratio of  $B/S < 0.42$  at 90% CL and a proper time resolution of  $(28.4 \pm 0.9)$  fs. Using these values, he determined the sensitivity on the mixing phase  $\phi_s$  of the  $B_s^0\text{--}\bar{B}_s^0$  system to be 0.08 rad. In the near future, more systematic studies on  $B_s \rightarrow J\psi X$ -like decay channels will be performed. For instance, we plan to study the sensitivity as a function of the proper time acceptance, as a function of the background, and as a function of detector misalignment. These studies are a key ingredient for the determination of trigger and selection strategies for these decay channels. They will be performed by C. Salzmann as part of his PhD thesis.

In the coming year, we will also turn our attention to the preparation for the analysis of the rare decay  $B_s \rightarrow \mu^+\mu^-$ . This decay is a very promising channel for LHCb. Its branching fraction is one of the most sensitive probes for “new physics” and with only  $0.5\text{ fb}^{-1}$  of data, there is the potential to exclude branching ratios up to the Standard Model prediction. This decay channel will be studied by A. Büchler as part of her PhD thesis.

### 3.3 Processor farm for the online data reduction for LHCb

The event filter farm is running the software trigger that processes events accepted by the L0 hardware trigger. The nominal accept-rate of L0 is 1 MHz. The total processing power that is required for this task has been estimated to be approximately 1600 CPUs of the 2007 type. This large installation has the typical size of a “Tier-1” centre on the Grid. It will output events to be recorded at a rate of 2 kHz.

The event filter farm is at the heart of the online event selection and is thus very important for all measurements that will be performed with LHCb. Our group is presently not directly involved in the development of this farm, but the basic physics and technical concepts of L0 and HLT triggering originate from ideas of U. Straumann, which he developed when he acted as trigger coordinator until 1998. We ask the FORCE pool for funding to support this farm, as it has been expected from Switzerland in the Memorandum of Understanding for the construction of LHCb.

It has recently been realised that a detailed monitoring of the trigger and detector performance, based on events reconstructed in offline quality in quasi real time, is crucial for keeping systematic effects under control. This is of course essential for high-precision measurements. For this reason, a monitoring farm in the pit is being added in parallel to the event filter farm mentioned above. About 25% of the 2 kHz output rate of the event filter farm should be processed immediately in the monitoring farm, which has to contain a few hundred CPUs. We increased our request to the FORCE pool accordingly, to be able to contribute to this monitoring farm.

### 3.4 Studies for a possible upgrade of the LHCb experiment

The LHCb collaboration has started to discuss options for improving the detector and the readout and trigger system to be able to take data at a ten-fold higher instantaneous luminosity of  $2 \times 10^{33} \text{cm}^{-2} \text{s}^{-1}$ . This would permit to extend the physics reach of the experiment for studies of decay rates and CP violation of very rare  $B$ -meson decays.

At the present time, we are not yet able to give a detailed physics justification for such an upgrade. In fact, to make a strong case for an upgrade, one would have to wait for the first results from the LHC to see if they reveal indications for “new physics”. However, since it will need several years of development and construction to upgrade the detector, it was felt that at least conceptual studies should be undertaken already now, such that the collaboration will be able to act quicker if this turns out to be desirable.

Our group intends to prepare for a new layout and a faster readout of the silicon detectors to be able to cope with the increased particle densities and trigger rates. For these studies, we will rely on technical manpower that is available at the institute. Therefore, no additional resources from SNF are needed at the present point in time. However, in order to be able to set up a prototype electronic readout chain, we ask for some investment money through the FORCE request.

## References

- [1] A. Büchler, *Thermal and Mechanical Characterization of the TT Detector for the LHCb Experiment*, Master thesis, Universität Zürich, February 2007.
- [2] D. Volyanskyy, *The Trigger Track and a Monte Carlo Study of the  $B_s \rightarrow J/\psi \eta'$  Decay in the LHCb Experiment*, Ph.D. thesis, Universität Zürich, September 2007.

## 4 Recent publications of the group members

*in the period from 1. January 2006 to 30. September 2007*

### 4.1 Habilitation and PhD Thesis

- *The Trigger Tracker and a Monte Carlo Study of the  $B_s \rightarrow J/\psi\eta'$  Decay in the LHCb Experiment*  
Dima Volyansky, Dissertation, Universität Zürich, September 2007
- *Search for Lepton Flavour Violation with the H1 Experiment at HERA*  
Linus Lindfeld, Dissertation, Universität Zürich, August 2006
- *Flavor-Changing Neutral Currents at Hadron Colliders*  
Frank Lehner, Habilitation, Universität Zürich, Mai 2006

### 4.2 Bachelor and Master Thesis

- *LHCb TT Module Properties*  
Viktor Hangartner, Bachelor Thesis, Universität Zürich, März 2007
- *The LHCb TT production database and an overview of quality characteristics of the detector modules*  
Nicola Chiapolini, Bachelor Thesis, Universität Zürich, März 2007
- *Thermal and Mechanical Characterization of the TT Detector for the LHCb Experiment*  
Angela Büchler, Master Thesis, Universität Zürich, März 2007
- *Contributions to noise in the data readout for the LHCb Trigger Tracker*  
Ueli Bieler, Diplomarbeit, ETH Zürich, März 2007
- *Experimentelle Charakterisierung des Einflusses der Blendenwärmung auf das Messresultat von PM06 Absolutradiometern*  
Markus Suter, Bachelorarbeit, Davos, Februar 2007
- *Observation for the  $B_s^0 \rightarrow \psi(2S)\phi$  decay with the D0 Experiment*  
Christophe Salzmann, Master Thesis, Universität Zürich, Dezember 2006

### 4.3 Conference contributions and invited seminars

#### 4.3.1 on HERA results

- *Isolated Photons at HERA*  
U. Straumann, Europhysics Conference on High Energy Physics, Manchester, England, 19-25 July 2007, proceedings to be published
- *Isolated Photons in DIS at HERA (H1)*  
K. Müller, XV International Workshop on Deep-Inelastic Scattering and related Subjects, 16.-10.4.07 Munich, 2007, proceedings to be published
- *H1 results*  
K. Müller, CHIPP workshop on the High-Energy Frontier of Particle Physics, 4.- 7.9.06 Zurich

- *Hadronic final states and spectroscopy in ep collisions at HERA*  
Carsten Schmitz, 42nd Rencontres de Moriond on QCD and High Energy Hadronic Interactions, March 17-24 2007, La Thuile, Aosta Valley, Italy  
preprint arXiv:0705.4625 [hep-ex]
- *Prompt Photons in Photoproduction*  
Krzysztof Nowak, Spring conference of the German Physical Society, 7. March 2007
- *Prompt Photons in Photoproduction*  
Krzysztof Nowak, Annual meeting of the Swiss Physical Society, 21. February 2007
- *Exotic (non-SUSY) Searches at HERA*  
Linus Lindfeld, SUSY06, 14th International Conference on Supersymmetry and the Unification of Fundamental Interactions, 12-17 June 2006, Irvine, California, USA
- *Prompt Photons in DIS*  
Carsten Schmitz, DIS 2006, XIV. International Workshop on Deep Inelastic Scattering, April 20-24 2006, Tsukuba Japan, arXiv:hep-ex/060793, to appear in the proceedings of 14th International Workshop on Deep Inelastic Scattering (DIS 2006)
- *Tau Production at HERA*  
Stefania Xella Hansen, DIS 2006, XIV International Workshop on Deep Inelastic Scattering, April 20-24 2006, Tsukuba Japan
- *Prompt Photons in DIS*  
Carsten Schmitz, Frühjahrstagung 2006 der Deutschen Physikalischen Gesellschaft e.V. - Fachverband Teilchenphysik, Dortmund, Deutschland, 28. - 31. März 2006
- *Single top production in ep collisions at HERA*  
Stefania Xella Hansen, TOP 2006, International workshop on Top Quark Physics, Jan 12-15, 2006, University of Coimbra, Portugal

#### 4.3.2 on B physics

- *$\gamma$  determination from tree decays ( $B \rightarrow DK$ ) with LHCb*  
Jeroen van Tilburg, Lake Louise Winter Institute 2007, 19-24 February 2007, Alberta, Canada.
- *Selection of the decay  $B_s^0 \rightarrow J/\psi \eta'$  at LHCb and its sensitivity to  $B_s^0$  mixing parameters*  
D. Volynskyy, Annual meeting of the Swiss Physical Society, 21. February 2007
- *Observation of the decay  $B_s^0 \rightarrow \psi(2S)\phi$*   
Christophe Salzmann, Annual meeting of the Swiss Physical Society, 21. February 2007.
- *Semileptonic B decays at Tevatron*  
Frank Lehner, 4th International Workshop on the CKM Unitarity Triangle, December 12 - 16, 2006, Nagoya, Japan.
- *Search for rare decays of the  $B_s$  meson at the Tevatron*  
R. P. Bernhard, 41st Rencontres de Moriond: QCD and Hadronic Interactions, La Thuile, Italy, 18-25 Mar 2006, arXiv:hep-ex/0605065, to appear in the proceedings
- *Flavor-changing neutral current charm and bottom decays at the Tevatron*  
Frank Lehner, International Workshop on Discoveries in Flavour Physics At  $e^+e^-$  Colliders, February 28 - March 03, 2006, Frascati, Italy.

#### 4.3.3 on experiments with ultracold neutrons

- *A direct experimental limit on neutron  $\rightarrow$  mirror neutron oscillations*  
A. Knecht, International Workshop on Search for Baryon and Lepton Number Violations, 20-22 September 2007, Berkeley, USA
- *Amorphous carbon coating for ultracold neutron experiments*  
Stefan Heule, E-MRS Spring meeting, Symposium P, 1. June 2007, Strasbourg, France
- *Storage and guide materials for PSI ultracold neutron source*  
S. Heule, Annual meeting of the Swiss Physical Society, 21. February 2007.
- *Systematic Effects in the Neutron EDM Experiment*  
Andreas Knecht, nEDM collaboration, Annual meeting of the Swiss Physical Society, 21. February 2007.
- *Diamond-like carbon coatings for ultracold neutron guides*  
S. Heule et al., Annual meeting of the Swiss Physical Society, 14. February 2006.

#### 4.3.4 on experimental techniques

- *The LHCb Silicon Tracker*  
O. Steinkamp, Workshop on Silicon Detector Systems for the CBM Experiment, GSI, Darmstadt, April 18-24, 2007
- *Construction of the LHCb Trigger Tracker station*  
Angela Büchler, Annual meeting of the Swiss Physical Society, 21. February 2007.
- *Status and prospects of the LHCb Experiment*  
U. Straumann, Kolloquium, PSI, Villigen AG, 4. Januar 2007
- *Design and Production of the LHCb Silicon Tracker*  
O. Steinkamp, 11th Vienna Conference in Instrumentation (VCI 2007) Vienna, Austria, February 19-24, 2007, proceedings to appear in Nucl Instr and Meth A
- *Design and Production of the LHCb Silicon Tracker*  
O. Steinkamp, 6th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors (STD6), Carmel, California, USA, September 11-15, 2006, proceedings to appear in Nucl Instr and Meth A
- *Tracking In High Multiplicity Environments*  
O. Steinkamp, Colloquium at NIKHEF, Amsterdam, The Netherlands, April 5, 2006
- *The LHCb Silicon Tracker*  
D. Volyanskyy, Annual Swiss Physical Society meeting 2006, Feb. 14, 2006, Lausanne, Switzerland

#### 4.3.5 for the general public

- *Forces: Fundamental Interactions in Particle Physics*  
U. Straumann, Vortrag fuer die Swiss Physics Olympiad Teilnehmer, Aarau, 25. März 2006

## 4.4 Articles in refereed journals

### 4.4.1 Articles on experimental techniques

- *Design and Production of detector modules for the LHCb Silicon Tracker*  
O. Steinkamp (on behalf of the LHCb Silicon Tracker group), Nucl. Instr. and Meth. A579 (2007) 736.
- *The outer tracker detector of the HERA-B experiment. III: Operation and performance*  
H. Albrecht et al. [HERA-B Outer Tracker Group], Nucl. Instrum. Meth. A576 (2007) 312
- *The Beam and detector for the NA48 neutral kaon CP violations experiment at CERN*  
V. Fanti et al. [NA48 Collaboration], Nucl. Instrum. Meth. A574 (2007) 433.
- *A vertex trigger based on cylindrical multiwire proportional chambers*  
J. Becker et al., arXiv:physics/0701002 (Submitted to Nucl.Instrum.Meth.A)
- *Performance of long ladders for the LHCb silicon tracker*  
O.Steinkamp, Nucl.Instr.Meth.A569 (2006) 84-87
- *Silicon sensor probing and radiation studies for the LHCb silicon tracker*  
C.Loicq, Nucl.Instr.Meth.A568 (2006) 277-283
- *Long term performance studies of the silicon strip detectors of the LHCb Silicon Tracker*  
S.Köstner and H.Voss, Nucl.Instr.Meth.A563 (2006) 259-262
- *Tracking in high multiplicity environments*  
Proceedings of the 1st Workshop TIME 2005, Zuerich, Switzerland, October 3-7, 2005  
Editors: R. Bernhard, J. Gassner, F. Lehner, M. Needham, O. Steinkamp, U. Straumann and A. Vollhardt, Nucl.Instr.Meth. **A566** (2006)
- *The LHCb silicon tracker project*  
M. Agari et al., Nucl. Phys. Proc. Suppl. **150**, 114 (2006)
- *LHCb silicon tracker performance studies*  
S. Köstner et al., IEEE Trans. Nucl. Sci. **53**, 2440 (2006)
- *Design and performance of the LHCb silicon tracker*  
K. Vervink et al., Nucl. Instrum. Meth. A **566**, 170 (2006), CERN-LHCB-2005-102

### 4.4.2 Articles on experiments with ultracold neutrons

- *Measurement of the Fermi potential of diamond-like carbon and other materials*  
F. Atchison et al., NIM B **260** (2007) 647-656.
- *Diamond-like carbon coatings for Ultracold neutron guides*  
F. Atchison, M. Daum, A. Foelske, R. Henneck, S. Heule, M. Kasprzak et al., Contribution to the Symposium H of the E-MRS 2006 conference, Applied Surface Science 253 (2007) 8245.
- *Structural characterization of diamond-like carbon coatings for ultracold neutron applications*  
F. Atchison, T. Bry, M. Daum, P. Fierlinger, A. Foelske, M. Gupta, R. Henneck, S. Heule, M. Kasprzak, K. Kirch et al., Diamond and Related Materials 16 (2007) 334.
- *Storage of ultracold neutrons in a volume coated with diamondlike carbon*  
F. Atchison, B. Blau, M. Daum, P. Fierlinger, A. Foelske, P. Geltenbort, R. Henneck, S. Heule, M. Kasprzak et al., Phys.Rev. **C74** (2006), 055501

### 4.4.3 Articles with the D0 Collaboration

- *Search for single production of scalar leptoquarks in  $p$  anti- $p$  collisions decaying into muons and quarks with the D0 detector*  
V. M. Abazov *et al.* [D0 Collaboration], arXiv:hep-ex/0612012 (Submitted to Phys.Lett.B)
- *Measurement of the  $p\bar{p}$  to  $t\bar{t}$  production cross section at  $\sqrt{s}=1.96$  TeV in the fully hadronic decay channel*  
V. M. Abazov *et al.* [D0 Collaboration], arXiv:hep-ex/0612040 (Submitted to Phys.Rev.D)
- *Evidence for production of single top quarks and first direct measurement of  $-V(tb)-$*   
V. M. Abazov *et al.* [D0 Collaboration], arXiv:hep-ex/0612052 (Submitted to Phys.Rev.Lett.)
- *Measurement of the  $t$  anti- $t$  production cross section in  $p$  anti- $p$  collisions at  $s^{**}(1/2) = 1.96$ -TeV using secondary vertex  $b$  tagging*  
V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **74**, 112004 (2006)
- *Measurement of the CP-violation parameter of  $B0$  mixing and decay with  $p\bar{p} \rightarrow \mu\mu X$  data*  
V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **74**, 092001 (2006), [arXiv:hep-ex/0609014]
- *Measurement of  $B/d$  mixing using opposite-side flavor tagging*  
V. M. Abazov *et al.* [D0 Collaboration], arXiv:hep-ex/0609034, (Submitted to Phys.Rev.D)
- *Measurement of the  $W$  boson helicity in top quark decay at D0*  
V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **75**, 031102 (2007) [arXiv:hep-ex/0609045]
- *Measurement of the top quark mass in the lepton + jets final state with the matrix element method*  
V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **74**, 092005 (2006), [arXiv:hep-ex/0609053]
- *Measurement of the top quark mass in the dilepton channel*  
V. M. Abazov *et al.* [D0 Collaboration], arXiv:hep-ex/0609056, (Submitted to Phys.Rev.Lett.)
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## 4.5 Collaboration notes for LHCb

LHCb notes can be accessed through the CERN document server on <http://cdsweb.cern.ch/>

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- *Selection of the  $B_s^0 \rightarrow J/\psi(\mu^+\mu^-)\eta'(\rho^0\gamma)$  decay at LHCb and its sensitivity to the  $B_s^0$  mixing phase  $\phi_s$*   
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## 4.6 Publications in other fields

- *A measurement of Newton's gravitational constant*  
S. Schlamminger, E. Holzschuh, W. Kundig, F. Nolting, R. E. Pixley, J. Schurr and U. Straumann, Phys. Rev. D **74**, 082001 (2006) [arXiv:gr-qc/0609027]
- *Measurement of  $K0(\mu3)$  form factors*  
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## 4.7 Non-scientific publication

- *Der Bachelor- und Masterstudiengang in Physik an der Universität Zürich*  
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