Sascha Stahl

Personal

Birth **25. Februar 1985**, *Bad Kreuznach*.

Education

School

08/1995– 03/2004 **Secondary school**, *Lina-Hilger-Gymnasium*, Bad Kreuznach, Grade: 1.7 (good).

Social service

05/2004– 02/2005 **Social service**, *Wohnungslosenhilfe kreuznacher diakonie*, Bad Kreuznach, Social service in a house for homeless people.

Studies and PhD

04/2005– 06/2010 **Diploma in physics**, *Ruprecht-Karls Universität Heidelberg*, Heidelberg, Grade: sehr gut (very good).

08/2008– 01/2009 **Erasmus Programme**, *Uppsala University*, Uppsala, Exchange student in physics and internship with the Icecube experiment.
Topic: Finding Susy Dark Matter candidates with Icecube

05/2010 **Diploma thesis**, under the supervision of Prof. Dr. Stephanie Hansmann-Menzemer in the LHCb group of the Physikalisches Institut in Heidelberg.
Topic: Reconstruction of displaced tracks and measurement of K_s production rate in proton-proton collisions at $\sqrt{s} = 900$ GeV at the LHCb experiment

09/2010– today **PhD in physics**, *Ruprecht-Karls Universität Heidelberg*, Heidelberg.
Main activities are found below in section Research activities. Expected date of defense 11.06.2014.

09/2010– today **Member of Heidelberg Graduate School of Fundamental Physics**.

01/2012– 02/2013 **Research stay at CERN**, Geneva.

Scholarships

09/2010– 02/2013 **International Max Planck Research School for Precision Tests of Fundamental Symmetries in Particle Physics, Nuclear Physics, Atomic Physics and Astroparticle Physics at the University of Heidelberg**, *Max-Planck–Institut für Kernphysik*, Heidelberg.

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Teaching experience

2008-2011 **Tutor for undergraduate courses**, *Theoretical Mechanics, Theoretical Electrodynamics and Theoretical Quantum Dynamics*.

09/2013–02/2014 **Tutor for master course**, *Experimental Particle Physics*.

2010-2014 **Supervision of Bachelor and Summer Students**.

Research Schools

09/2010–today **Graduate School**, *Bi-annual Heidelberg Physics Graduate Days*, Heidelberg, Germany.

09/2010–today **Workshop**, *Annual German B Physics Workshop*, Neckarzimmern, Germany.

09/2011 **Summer School**, *The 2011 European School of High-Energy Physics*, Cheile Gradistei, Romania.

08/2012 **Summer School**, *2012 Joint Fermilab-CERN Hadron Collider Physics Summer School*, Fermilab, USA.

Talks

03/2010 **DPG Spring Meeting 2010 in Bonn**, *Talk in parallel session*, "Rekonstruktion der Spuren aus den K_s^0 Zerfällen und erste Signale auf Daten beim LHCb Experiment".

03/2010 **Rencontres des Moriond EW 2010**, *Talk in the Young Scientists Forum*, "Tracking performance in V0 reconstruction with first data at LHCb".

03/2012 **DPG Spring Meeting 2013 in Dresden**, *Talk in parallel session*, "Messung von CP-Asymmetrien im Charm-System mit semimyonischen B-Zerfällen bei LHCb".

03/2013 **Rencontres des Moriond QCD 2013**, "Properties of b and c hadrons at LHCb".

04/2013 **Institute Seminar**, *Physikalisches Institut Heidelberg*, "Measurement of CP violation in the Charm System".

Publications with significant personal contributions

09/2010 **Prompt K_S^0 production in pp collisions at $\sqrt{s}$ = 0.9 TeV**, *DOI: 10.1016/j.physletb.2010.08.055, [1]*.

12/2011 **Measurement of the $B_s^0 - \overline{B}_s^0$ oscillation frequency Δm_s in $B_s^0 \to D_s^-(3)\pi$ decays**, *DOI:10.1016/j.physletb.2012.02.031, [2]*.

12/2011 **Measurement of the CP-violating phase ϕ_s in the decay $B_s^0 \to J/\psi\phi$**, *DOI: 10.1103/PhysRevLett.108.101803, [3]*.

02/2013 **Prompt charm production in pp collisions at $\sqrt{s}$ = 7 TeV**, *DOI: 10.1016/j.nuclphysb.2013.02.010, [4]*.

03/2013 **Search for direct CP violation in $D^0 \to h^- h^+$ modes using semileptonic B decays**, *DOI: 10.1016/j.physletb.2013.04.061, [5]*.

Heidelberg, February 19, 2014

~~Research~~ activities ~~with~~in LHCb

My first contact with the LHCb experiment was an internship in the summer of 2007 in the LHCb group of the Heidelberg University under the supervision of Prof. Dr. Stephanie Hansmann-Menzemer. My task was to optimize the selection of $\Phi \to K^+K^-$ decays with a multivariate ~~selection~~. ~~From May 2009 to June 2010 I wrote my diploma thesis studying tracking algorithms and measuring~~ the production cross-section of K^0_S mesons ~~in~~ the very first pp collision data. Since September 2010 I am doing a PhD in physics, the expected day of the defense is the 11th of June 2014. I was and ~~am~~ involved in several analyses, covering a broad spectrum of physics, including cross-section, mixing and CP asymmetry measurements. Most notable is my involvement in the measurement of CP violation in neutral charm mesons. I am the main ~~contributing~~ author of ~~the~~ analysis ~~and it is the basis~~ of my PhD thesis. ~~I am also part of the operation of the experiment due to many exciting shifts in the control room and my work on track reconstruction with focus on its application in the LHCb software trigger. I am one of the few experts of our reconstruction software.~~ Furthermore I ~~participate~~ in the ~~efforts to~~ upgrade the LHCb tracking detectors ~~in the long shutdown of the LHC in 2018~~.

Physics analyses ~~with~~in the LHCb experiment

During my diploma thesis and my PhD I worked on several analyses within the LHCb experiment.

Search for direct CP violation in $D^0 \to h^-h^+$ modes using semileptonic B decays

In November 2011 the LHCb experiment reported evidence of direct CP violation in the decay of ~~Charm~~ mesons in the modes $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$. This was a surprise as due to the hierarchy of the CKM matrix the predictions are generally close to zero. D^0 mesons are the only ~~neutral-meson system consisting of up-type quarks.~~ This makes them interesting for theories where new particles have different couplings to up-type quarks. The ~~findings of LHCb~~ sparked a big discussion among theorists and experimentalists. Theorists had to revisit their predictions. As the result was unexpected, it was important to cross-check it ~~within the experiment with a differently selected~~ sample of D^0 mesons. I am the main proponent of ~~the cross-check analysis and it~~ is the topic of my PhD thesis. The final sensitivity to CP violation in the decay of Charm mesons is $0.18\,\%$.

There are two ways to select high statistics samples of D^0 mesons in proton collisions. One uses ~~directly produced~~ charm quarks which have a high rate ~~but~~ also a large background as there are only hadrons in the final state. My analysis selects semimuonic B decays. ~~They have a lower rate but also an easier detection signature~~ due to the muon and the distinct signature of two displaced vertices. The challenge of all asymmetry measurements at this level of precision is to disentangle ~~the~~ CP asymmetry from production and detection asymmetries which are all ~~in~~ the order of per mille to a per cent. ~~Especially~~ detection asymmetries ~~have to be controlled and~~ a very good understanding of all detector ~~parts is needed.~~ The ~~more~~ robust number is the difference of the CP asymmetries in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ as nuissance asymmetries cancel in the difference. I performed the measurement with the

2011 data ~~set but~~ could not confirm the evidence ~~of~~ CP violation. ~~The result was published in early 2012 [5].~~ I showed my results at Rencontres des Moriond QCD 2013.
The next step of my work was to measure the ~~individual~~ asymmetries of $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ with the full data set ~~LHCb took until the Long Shutdown of the LHC.~~ This ~~means to directly measure~~ all production and detection asymmetries ~~which poses an extreme challenge~~. The main obstacle is the detection asymmetry of charged kaons in matter. The same method to measure the kaon asymmetry is also used in the measurements of the CP violating asymmetries in the mixing of B_d^0 and B_s^0 mesons. The measurement of CP violation in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays is currently in the collaboration wide review and is the main focus of my PhD thesis. My work and my thesis cover almost every part of the analysis. The approval by the collaboration to publish a paper is expected in March 2014. The final sensitivity to CP violation in $D^0 \to K^-K^+$ decays is $0.18\,\%$ which is the world's best single measurement.

Measurement of K_s production rate in proton-proton collisions at $\sqrt{s} = 900$ GeV

~~My diploma thesis was the basis of the first analysis performed by the LHCb experiment on proton collision data taken at the end of 2009. The measuring~~ of the production cross-section of K_S^0 mesons in proton-proton collisions at a center-of-mass energy of 900 GeV. Due to the special conditions of the first data, the vertex detector was ~~not put into its nominal data taking mode~~. ~~I studied~~ a tracking algorithm to reconstruct charged particles ~~which have no signal~~ in the vertex detector. I ~~could~~ significantly ~~improve~~ the performance of the existing algorithm by $5\,\%$ for low momentum tracks and $1.5\,\%$ for high momentum tracks. ~~The largest part of the observed signal candidates in the first data has been reconstructed by this algorithm.~~ My ~~further~~ work included optimizing the event selection ~~to get a high signal over background ratio~~ and ~~studies on simulated events to extract~~ the reconstruction efficiencies. The work resulted in the first published paper of LHCb [1]. I was selected to ~~show parts of my work~~ at the Young Scientists Forum at Rencontres des Moriond EW 2010.

Measurement of the CP-violating phase ϕ_s in the decay $B_s^0 \to J/\psi\phi$

The Standard Model makes very precise predictions of the CP violating phase ϕ_s in the decay $B_s^0 \to J/\psi\phi$. Thus a measurement of this phase is a crucial probe of the Standard Model and extensions ~~of it.~~ I studied the decay time acceptance and the decay time resolution of these events ~~which is~~ a crucial input to a multi-dimensional fit in the decay time and angular observables to extract the phase ϕ_s. The analysis ~~was based on a part of the data taken in 2011 and~~ was published in [3].

Measurement of the $B_d^0 - \overline{B}_d^0$ and $B_s^0 - \overline{B}_s^0$ oscillation frequencies Δm_d and Δm_s

The first project during my PhD was to work on the measurement of the mixing frequencies of B_d^0 and B_s^0 mesons. One of the inputs to the flagship analysis, measurement of the CP-violating phase ϕ_s in the decay $B_s^0 \to J/\psi\phi$, is the mixing frequency Δm_s of B_s^0 mesons. The measurement demonstrates the great decay time resolution and flavour tagging capabilities of the LHCb experiment. I calibrated the flavour tagging algorithms by measuring the mixing frequency Δm_d of B_d^0 mesons. The analysis was ~~the back then~~ most precise measurement of the mixing frequency Δm_s of B_s^0 mesons [2].

Prompt charm production in pp collisions at $\sqrt{s} = 7$ TeV

The LHCb detector is fully instrumented in the forward region which makes it unique among the LHC experiments. The measurement of production cross-sections is important input to Monte Carlo generators. The LHCb experiment measured the prompt charm production in pp collisions at $\sqrt{s} = 7$ TeV in minimum bias events [4] taken in 2010. I worked on the measurement of the Λ_c baryon cross-section. ~~My task was the determination of~~ the reconstruction performance on simulated events and ~~systematic studies~~ due to ~~data and Monte Carlo differences~~.

Tracking and Trigger

Since my diploma thesis ~~I am one of the experts of the~~ reconstruction of charged particles ~~within the LHCb experiment.~~ I worked on tracking algorithms in the online reconstruction ~~in~~ the software trigger the offline reconstruction ~~of events~~ and I worked on the tracking for simulation studies of the upgrade ~~of the LHCb tracking detectors~~.

Upgrade of the LHCb tracking detectors

~~When the upgrade plans of the LHCb detector gained a lot of momentum at the end of 2012,~~ I setup the first fully functional tracking sequence for simulations of the ~~upgrade~~ detector. Furthermore I was responsible for the reconstruction software of the upgrade simulation~~s~~ until May 2013. My work was essential ~~such that the simulation was ready~~ to make the first fundamental design choices for the upgrade of the LHCb detector.

Track reconstruction and its use in the trigger

During my stay at CERN from January 2012 to February 2013 I was heavily involved in the ~~running~~ of the software trigger project ~~of the experiment.~~ My main focus was the track reconstruction which takes most of the time. Before the restart in 2012 I optimized the momentum dependent search windows in the track reconstruction to increase the efficiency and decrease the processing time. ~~Due to this work I am one of the few experts on LHCb's most important tracking algorithms.~~ Furthermore I tuned the quality cuts of the reconstructed tracks such that the trigger stayed within its bandwith requirements. During data taking in 2012 I was involved in the operation of the software trigger. I took care of problems in the trigger and the tracking software and ~~did~~ many shifts. These included expert on call shifts, as well as shifts in the control room.

Tuning of the Downstream tracking algorithm

During my diploma thesis I studied the so called Downstream tracking algorithm. This algorithm is designed to find the tracks of decay products of long lived particles like K_S^0 mesons or Λ baryons. They often decay outside of LHCb's vertex detector. Thus they leave only signals in a tracking station very close to the dipole magnet and the main tracking stations behind the magnetic field. I could significantly improve the performance of the existing algorithm by $5\,\%$ for low momentum tracks and $1.5\,\%$ for high momentum tracks. Furthermore I tuned the algorithm for the taking of the first collision data in December 2009. The work is documented in an internal LHCb note and in my diploma thesis.

Statement of research interests

My focus in the last years has been the measurement of CP violation in the neutral ~~Charm system with a sample selected by~~ semileptonic B decays. ~~Also due to the~~ very precise measurements performed by ~~the~~ LHCb ~~experiment,~~ Charm physics ~~had~~ gained a lot of attention in the last years. I measured the difference between two CP asymmetries in the decay channels $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$, ΔA_{CP}, which is experimentally ~~more~~ robust [5] ~~but~~ also measured the individual asymmetries with the full data set with a precision of $0.18\,\%$. Asymmetry measurements ~~on~~ this level are very challenging as subtle effects in the event detection have to be controlled. The whole experiment gains through these analyses as ~~an extreme understanding of the detector is needed~~. The crucial point of ~~the latter~~ analysis was to measure the interaction asymmetry of kaons in matter which is about $1\,\%$ with $0.12\,\%$ precision to extract CP asymmetries close to ~~0~~. In the future other asymmetry measurements will profit from my work as many final states include kaons. The analysis is currently in the collaboration wide review and expected to be approved in March 2014. My work has shown that LHCb can perform precise CP asymmetry measurements with semileptonic B decays ~~on~~ the per mille level. The analysis also profited from ~~my~~ expertise in the event and track reconstruction I have gained in the last years ~~as~~ one of the tracking experts ~~within the LHCb experiment~~.
In the future I would like to ~~combine the knowledge I had gained in the mixing measurements with the measurement of very small asymmetries in the B system itself. I would like to~~ focus on the analysis of semileptonic B decays to extract the CP violating asymmetries in the mixing of B^0_d and B^0_s mesons. ~~Especially in the analysis of the asymmetry in B^0_d decays, a mixing analysis has to be performed to discriminate the small detection and production asymmetries from the small CP violating asymmetry in mixing.~~ Both are promising measurements ~~due to the precise predictions in the B system made by~~ the Standard Model. The theoretical predictions are $a^d_{sl} = -(4.1 \pm 0.6) \times 10^{-4}$ and $a^s_{sl} = (1.9 \pm 0.3) \times 10^{-5}$ [7]. The DØ collaboration ~~had previously~~ reported a 3σ deviation from the Standard Model [6] in these parameters. With more data, an improved event selection, online and offline, and refined analysis techniques the LHCb experiment might be able to reach the theoretical precision. This will make the measurements a good test of the Standard Model, not only for deviations ~~from it~~ but also to test theoretical ~~tools within the Standard Model,~~ like e.g. Heavy Quark Expansion [7]. A very interesting ~~side product~~ of ~~the~~ measurement will be the ~~measurement~~ of the production asymmetry of B mesons in proton-proton collisions ~~on~~ the per mille level and below. This will help to understand hadronization processes in proton-proton collisions ~~better~~ as predictions are not precise and theory needs more input from the ~~experimental side~~ [8]. All CP measurements in the B system will profit from a better ~~known~~ B production asymmetry ~~as the normalization of B and $\bar{B}$ mesons is needed.~~

Planning and design studies for the upgrade ~~are~~ very important for the LHCb experiment and the future of heavy flavour physics. I believe that with my expertise ~~on~~ track reconstruction I can contribute significantly to this common endeavour. However, at the same time we should not lose sight of urgent problems that will arise when starting up the detector in 2015.
It will be important to have experienced people ~~in 2015 which~~ can react quickly to the new

challenges. One specific example is ~~that the LHC would like to go from a 50 ns to 25 ns spacing between the proton bunches. This means a higher activity in the tracking detectors. New tunings of the pattern recognition algorithm will be required as they have been tuned for 50 ns~~.

Due to the very flexible software trigger running at 1 MHz, the LHCb experiment ~~can constantly~~ extend its physics programme. Track reconstruction is a vital part of the trigger as most of time is spent there. In its second stage the trigger performs a full event reconstruction. One exciting task will be to optimize the track reconstruction to give the rest of the system, e.g. the particle identification system, more time to select the events which are needed for physics analyses. ~~Already in my diploma thesis I had studied ways to make a better use of the computing time. Then during my stay at CERN in 2012, I was involved in the operation of the software trigger. My task was to tune the track reconstruction to keep a high efficiency while sustaining the bandwidth requirements.~~

Everything we learn in the operation of the trigger system ~~in the second run of the LHC~~, will also impact the upgrade plans of the experiment. The activity in the detector will be much higher after the upgrade. This will create much more stress on the track reconstruction and the trigger system. However, many ideas which are currently ~~in~~ development, like an earlier detector calibration or algorithms which are better optimized for parallelized computing, can ~~be already~~ tested in the next years.

I am looking forward to ~~contribute~~ to ~~the~~ ~~challenges ahead,~~ ~~to make~~ the restart in 2015 and the upgrade of the detector a success. ~~Due to my experience~~ I feel well prepared for these tasks.

References

[1] R. Aaij et al. Prompt K_S^0 production in pp collisions at $\sqrt{s} = 0.9$ TeV. *Phys. Lett. B*, 693(arXiv:1008.3105. CERN-PH-EP-2010-027. LHCb-PAPER-2010-001):69–80. 24 p, Sep 2010.

[2] R. Aaij et al. Measurement of the $B_s^0 - \overline{B}_s^0$ oscillation frequency Δm_s in $B_s^0 \to D_s^-(3)\pi$ decays. *Phys. Lett. B*, 709(arXiv:1112.4311. LHCB-PAPER-2011-010. CERN-PH-EP-2011-194):177–184. 19 p, Dec 2011. Comments: 12 pages, 4 figures.

[3] R. Aaij et al. Measurement of the CP-violating phase ϕ_s in the decay $B_s^0 \to J/\psi\phi$. *Phys. Rev. Lett.*, 108(arXiv:1112.3183. CERN-PH-EP-2011-214. LHCB-PAPER-2011-021):101803. 9 p, Dec 2011.

[4] R. Aaij et al. Prompt charm production in pp collisions at $\sqrt{s} = 7$ TeV. *Nucl. Phys. B*, 871(arXiv:1302.2864. LHCB-PAPER-2012-041. CERN-PH-EP-2013-009):1–20. 27 p, Feb 2013.

[5] R. Aaij et al. Search for direct CP violation in $D^0 \to h^- h^+$ modes using semileptonic B decays. *Phys. Lett. B*, 723(arXiv:1303.2614. LHCB-PAPER-2013-003. CERN-PH-EP-2013-039):33–43. 21 p, Mar 2013.

[6] Victor Mukhamedovich Abazov et al. Study of CP-violating charge asymmetries of single muons and like-sign dimuons in p pbar collisions. *Phys.Rev.*, D89:012002, 2014.

[7] Alexander Lenz. Theoretical update of B-Mixing and Lifetimes. *arXiv*, 2012.

[8] E. Norrbin and T. Sjostrand. Production and hadronization of heavy quarks. *Eur.Phys.J.*, C17:137–161, 2000.