

OPEN ACCESS

IOP Publishing

Journal of Physics G: Nuclear and Particle Physics

J. Phys. G: Nucl. Part. Phys. 43 (2016) 110201 (5pp)

doi:10.1088/0954-3899/43/11/110201

Major Report



CrossMark

LHC forward physics

K Akiba²¹, M Akbiyik¹, M Albrow², M Arneodo^{3,4}, V Avati^{5,6},
 J Baechler⁶, O Villalobos Baillie⁸⁷, P Bartalini⁷, J Bartels⁸,
 S Baur¹, C Baus¹, W Beaumont⁹, U Behrens¹⁰, D Berge¹¹,
 M Berretti^{6,12}, E Bossini¹², R Boussarie¹³, S Brodsky¹⁴,
 M Broz¹⁵, M Bruschi¹⁶, P Bussey¹⁷, W Byczynski⁸¹,
 J C Cabanillas Noris¹⁸, E Calvo Villar¹⁹, A Campbell¹⁰,
 F Caporale²², W Carvalho²¹, G Chachamis²², E Chapon²³,
 C Cheshkov²⁴, J Chwastowski²⁵, R Ciesielski²⁶,
 D Chinellato⁸³, A Cisek²⁵, V Coco⁶, P Collins⁶,
 J G Contreras¹⁵, B Cox²⁷, D de Jesus Damiao²¹, P Davis²⁸,
 M Deile⁶, D D'Enterria⁶, D Druzhkin^{29,6}, B Ducloue^{30,31},
 R Dumps⁶, R Dzhelyadin⁸², P Dziurdzia⁶, M Eliachevitch¹,
 P Fassnacht⁶, F Ferro³², S Fichet³³, D Figueiredo²¹, B Field³⁴,
 D Finogeev³⁵, R Fiore^{29,36}, J Forshaw²⁷, A Gago Medina¹⁹,
 M Gallinaro³⁷, A Granik⁸², G von Gersdorff³³, S Giani⁶,
 K Golec-Biernat^{25,38}, V P Goncalves³⁹, P Göttlicher¹⁰,
 K Goulianos²⁶, J-Y Grosslord²⁴, L A Harland-Lang⁴⁰,
 H Van Haeveermaet⁹, M Hentschinski⁴¹, R Engel¹,
 G Herrera Corral⁴², J Hollar³⁷, L Huertas²¹, D Johnson⁶,
 I Katkov¹, O Kepka⁴³, M Khakzad⁴⁴, L Kheyn⁴⁵,
 V Khachatryan⁴⁶, V A Khoze⁴⁷, S Klein⁴⁸, M van Klundert⁹,
 F Krauss⁴⁷, A Kurepin³⁵, N Kurepin³⁵, K Kutak⁴⁹,
 E Kuznetsova¹, G Latino¹², P Lebiedowicz²⁵, B Lenzi⁶,
 E Lewandowska²⁵, S Liu²⁸, A Luszczak^{25,38}, M Luszczak²⁵,
 J D Madrigal⁵⁰, M Mangano⁶, Z Marccone³⁴, C Marquet⁵¹,
 A D Martin⁴⁷, T Martin⁵², M I Martinez Hernandez⁵³,
 C Martins²¹, C Mayer²⁵, R Mc Nulty⁵⁴, P Van Mechelen⁷,
 R Macula²⁵, E Melo da Costa²¹, T Mertzimekis⁵⁵,
 C Mesropian²⁶, M Mieskolainen³¹, N Minafra^{6,56},
 I L Monzon¹⁸, L Mundim²¹, B Murdaca^{20,36}, M Murray⁵⁷,
 H Niewiadowski⁵⁸, J Nystrand⁵⁹, E G de Oliveira⁶⁰, R Orava³¹,
 S Ostapchenko⁶¹, K Osterberg³¹, A Panagiotou⁵⁵, A Papa²⁰,
 R Pasechnik⁶², T Peitzmann⁶³, L A Perez Moreno⁵³,
 T Pierog¹, J Pinfold²⁸, M Poghosyan⁶⁴, M E Pol⁶⁵, W Prado²¹,
 V Popov⁶⁶, M Rangel⁶⁷, A Reshetin³⁵, J-P Revol⁶⁸,
 M Rijssenbeek³⁴, M Rodriguez⁵³, B Roland¹⁰, C Royon^{25,43,57},
 M Ruspa^{3,4}, M Ryskin^{47,69}, A Sabio Vera²², G Safronov⁶⁶,
 T Sako⁷⁰, H Schindler⁶, D Salek¹¹, K Safarik⁶, M Saimpert⁷¹,

**A Santoro²¹, R Schicker⁷³, J Seger⁶⁴, S Sen⁷³, A Shabanov³⁵,
W Schafer²⁵, G Gil Da Silveira³⁹, P Skands⁷⁴, R Soluk²⁸,
A van Spilbeek⁹, R Staszewski²⁵, S Stevenson⁷⁵,
W J Stirling⁸⁶, M Strikman⁷⁶, A Szczurek^{25,38},
L Szymanowski⁷⁷, J D Tapia Takaki⁵⁷, M Tasevsky⁴³,
K Taesoo⁷⁸, C Thomas⁷⁵, S R Torres¹⁸, A Tricomi⁷⁹,
M Trzebinski²⁵, D Tsybychev³⁴, N Turini¹², R Ulrich¹,
E Usenko³⁵, J Varela³⁷, M Lo Vetere⁸⁰, A Villatoro Tello⁵³,
A Vilela Pereira²¹, D Volynskyy⁸⁴, S Wallon^{13,85},
G Wilkinson⁷⁵, H Wöhrmann¹, K C Zapp⁶ and Y Zoccarato²⁴**

¹ Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

² Fermilab, Batavia, USA

³ INFN Torino, Italy

⁴ Università del Piemonte Orientale, Novara, Italy

⁵ AGH University of Science and Technology, Krakow, Poland

⁶ CERN, Geneva, Switzerland

⁷ Central China Normal University (CCNU), Wuhan, Hubei, People's Republic of China

⁸ University of Hamburg, Germany

⁹ University of Antwerpen, Belgium

¹⁰ DESY, Hamburg, Germany

¹¹ NIKHEF and GRAPPA, Amsterdam, The Netherlands

¹² INFN Pisa, Pisa, Italy and Università degli Studi di Siena, Siena, Italy

¹³ LPT, Université Paris-Sud, CNRS, F-91405, Orsay, France

¹⁴ SLAC National Accelerator Laboratory, Stanford University, Stanford, CA, USA

¹⁵ Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Prague, Czech Republic

¹⁶ Università and INFN, Bologna, Italy

¹⁷ University of Glasgow, UK

¹⁸ Universidad Autónoma de Sialoa, Culiacan, Mexico

¹⁹ Pontificia Universidad Católica del Perú (PUCP), Lima, Peru

²⁰ Università della Calabria, Cosenza, Italy

²¹ Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Brazil

²² Instituto de Física Teórica UAM/CSIC and Universidad Autónoma de Madrid, Cantoblanco, Madrid, Spain

²³ LLR, Ecole Polytechnique, Palaiseau, France

²⁴ IPN, Institut de Physique Nucléaire, Université Claude Bernard Lyon-I, CNRS/IN2P3, Lyon, France

²⁵ Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland

²⁶ The Rockefeller University, New York, USA

²⁷ School of Physics and Astronomy, University of Manchester, UK

²⁸ University of Alberta, Canada

²⁹ Research and Development Institute of Power Engineering (NIKIET), Moscow, Russia

³⁰ Department of Physics, University of Jyväskylä, Jyväskylä, Finland

³¹ Department of Physics, University of Helsinki, Helsinki, Finland

³² INFN Genova, Italy

³³ ICTP South American Institute for Fundamental Research, Instituto de Física Teórica, Sao Paulo State University, Brazil

³⁴ Stony Brook University, Stony Brook, New York, USA

- ³⁵ Russian Academy of Sciences, Institute for Nuclear Research (INR), Moscow
- ³⁶ Gruppo Collegato INFN of Cosenza, Italy
- ³⁷ LIP, Lisbon, Portugal
- ³⁸ University of Rzeszow, Rzeszow, Poland
- ³⁹ High and Medium Energy Group, Instituto de Fisica e Matematica, Universidade Federal de Pelotas, Pelotas, Brazil
- ⁴⁰ Department of Physics and Astronomy, University College London, UK
- ⁴¹ Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico, Mexico
- ⁴² Centro de Investigacion y de Estudios Avanzados del IPN CINVESTAV , Dep. de Fisica and Dep. de Fisica Aplicada, Mexico
- ⁴³ Institute of Physics, Academy of Sciences, Prague, Czech Republic
- ⁴⁴ IPM, Institute for Research in Fundamental Sciences, Tehran, Iran
- ⁴⁵ Moscow State University, Moscow, Russia
- ⁴⁶ Alikhanyan National Scientific Laboratory (ANSL), Armenia
- ⁴⁷ Institute for Particle Physics Phenomenology, Physics Department, University of Durham, UK
- ⁴⁸ Lawrence Berkeley National Laboratory, Berkeley, CA, USA
- ⁴⁹ Instytut Fizyki Jadrowej Polskiej Akademii, Krakow, Poland
- ⁵⁰ Institut de Physique Théorique, CEA Saclay, Gif-sur-Yvette, France
- ⁵¹ Centre de Physique Théorique, Ecole Polytechnique, CNRS, Palaiseau, France
- ⁵² University of Warwick, UK
- ⁵³ Benemerita Autonomous University of Puebla, Mexico
- ⁵⁴ University College Dublin, Dublin, Ireland
- ⁵⁵ University of Athens, Greece
- ⁵⁶ Dipartimento Inter-ateneo di Fisica di Bari, Italy; INFN Sezione di Bari, Bari, Italy
- ⁵⁷ University of Kansas, Lawrence, USA
- ⁵⁸ Case Western Reserve University, Department of Physics, Cleveland, USA
- ⁵⁹ Department of Physics and Technology, University of Bergen, Bergen, Norway
- ⁶⁰ Departamento de Fisica, Universidade Federal de Santa Catarina, Florianopolis, Brazil
- ⁶¹ Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany
- ⁶² Theoretical High Energy Physics, Department of Astronomy and Theoretical Physics, Lund University, Sweden
- ⁶³ Utrecht University and Nikhef, Utrecht, The Netherlands
- ⁶⁴ Creighton University, Omaha, USA
- ⁶⁵ Centro Brasileiro de Pesquisas Fisicas (CBPF), Rio de Janeiro, Brazil
- ⁶⁶ ITEP, Moscow, Russia
- ⁶⁷ Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil
- ⁶⁸ Centro Studi e Ricerche ‘Enrico Fermi’, Roma, Italy
- ⁶⁹ Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg, Russia
- ⁷⁰ STEL/KMI, Nagoya University, Nagoya, Japan
- ⁷¹ IRFU-SPP, CEA Saclay, Gif-sur-Yvette, France
- ⁷² Ruprecht-Karls-Universitaet Heidelberg, Germany
- ⁷³ Hacettepe University, Ankara, Turkey
- ⁷⁴ School of Physics and Astronomy, Monash University, Clayton, Australia
- ⁷⁵ Department of Physics, University of Oxford, Oxford, UK
- ⁷⁶ Penn State University, University Park, USA
- ⁷⁷ National Center for Nuclear Research, Warsaw, Poland
- ⁷⁸ Yonsei University, Seoul, Korea
- ⁷⁹ University of Catania and INFN Sezione di Catania, Italy
- ⁸⁰ Università degli Studi di Genova, Dipartimento di Fisica and INFN, Genova, Italy
- ⁸¹ Cracow University of Technology, Poland

- ⁸² B.P. Konstantinov Petersburg Nuclear Physics Institute PNPI, Russia
⁸³ Universidade Estadual de Campinas (UNICAMP), Campinas Brazil
⁸⁴ Heidelberg, Max Planck Inst., Heidelberg, Germany
⁸⁵ UPMC Univ. Paris 06, faculté de physique, 4 place Jussieu, F-75252 Paris Cedex 05, France
⁸⁶ Imperial College, London UK
⁸⁷ University of Birmingham, Birmingham, UK

We give here an introduction to the complete report that may be found at: stacks.iop.org/jpg/43/110201/mmedia

In early 2013 the LHC forward physics and diffraction working group (WG) was formed, as part of the activities of common interest to the LHC experiments organized by the LHC Physics Centre at CERN (LPCC, <http://cern.ch/lpcc>). The primary goal of the WG was to coordinate, across the experiments and with the theoretical community, the discussion of the physics opportunities, experimental challenges and accelerator requirements arising from the study of forward phenomena and diffraction at the LHC. The mandate of the group included the preparation of a report, to outline a coherent picture of the forward physics programme at the LHC, taking into account the potential of the existing experiments—including possible detector upgrades—the possible beam configurations and performance of the accelerator, and the optimization of the LHC availability for these measurements, in view of the priority need to maximize the LHC total integrated luminosity.

The WG was set up by the LPCC in coordination with the management of the ALICE, ATLAS, CMS, LHCb, LHCf and TOTEM experiments, which nominated their representatives in the WG steering group and the WG co-chairs. The steering group identified theory conveners, to oversee the relevant sections of the report, and created three subgroups to focus the WG activity, reflecting the physics goals appropriate to different LHC running conditions:

- low pileup and luminosity (few 10 pb^{-1}),
- medium luminosity (few 100 pb^{-1}),
- high luminosity (100 fb^{-1}).

All interested physicists were then invited to attend the 16 WG meetings held so far, and to contribute to the writing of this report, which hopefully represents the unanimous views of the broad forward-physics community. The detailed information about the WG, including the composition of the steering committee and of the subgroups' conveners, the list of meetings, the link to the WG material and to its mailing list subscription, can be found in the WG web page at: http://cern.ch/LPCC/index.php?page=fwd_wg.

As requested by the LHC experiments committee (LHCC), and following the several presentations delivered to the committee in the course of the WG activity, this final report has been submitted to the LHCC, and forms the basis for its internal discussions and recommendations on the requests by the experiments for beam time and detector upgrades, related to forward physics, during Run 2 of the LHC and beyond. More in general, we trust that this report will promote the deeper understanding and appreciation of the value of this component of the LHC physics programme, and will encourage further progress and the development of new ideas, both on the theoretical and experimental fronts.



Original content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

We give a comprehensive overview of the rich field of forward physics, with special attention to the topics that can be studied at the LHC. The report starts by presenting a selection of the Monte Carlo simulation tools currently available, chapter 2, then enters the rich phenomenology of QCD at low, chapter 3, and high, chapter 4, momentum transfer, while the unique scattering conditions of central exclusive production are analyzed in chapter 5. The last two experimental topics, cosmic ray and heavy ion physics are presented in chapters 6 and 7 respectively. Chapter 8 is dedicated to the BFKL dynamics, multiparton interactions, and saturation. The report ends with an overview of the forward detectors at LHC. Each chapter is correlated with a comprehensive bibliography, attempting to provide to the interested reader with a wide opportunity for further studies.

The chairs of the LHC Forward Physics working group.