



CERN/LHCC 2006-021

CMS TDR 8.2

26 June 2006

CMS Physics

Technical Design Report

Volume II:

Physics Performance

CMS Software and Physics, Reconstruction and Selection (PRS) Projects		
CMS Spokesperson	Michel Della Negra, CERN	Michel.Della.Negra@cern.ch
CMS Technical Coordinator	Austin Ball, CERN	Austin.Ball@cern.ch
CMS Collaboration Board Chair	Lorenzo Foa, Pisa	Lorenzo.Foa@cern.ch
CPT Project Manager	Paraskevas Sphicas, CERN and Athens	Paraskevas.Sphicas@cern.ch
CPT PRS Coordinator	Darin Acosta, Florida	Darin.Acosta@cern.ch
CPT PRS Coordinator	Albert De Roeck, CERN	Albert.De.Roeck@cern.ch

Editor

A. De Roeck

Chapter Editors

M. Grünwald, J. Mnich, A. Nikitenko, L. Pape, M. Spiropulu,

Cover Design

S. Cittolin

Acknowledgments

This report is the result of several years of work on the preparation for physics analysis at the LHC with CMS. Subprojects in all areas were involved (Detector, PRS, Software, and Computing) in order to produce the large Monte Carlo simulation samples needed, to develop the software to analyse those samples, to perform the studies reported in this Report, and to write and review our findings.

We wish to thank for the many useful discussions with our theory and phenomenology colleagues, in particular J. Campbell, D. Dominici, A. Djouadi, S. Heinemeyer, W. Hollik, V. Khoze, T. Plehn, M. Raidal, M. Spira, G. Weiglein for their contributions to this Report.

For their constructive comments and guidance, we would like to thank the CPT internal reviewers: J. Alexander, J. Branson, Y. Karyotakis, M. Kasemann and R. Turchini.

We would like to thank L. Malgeri and R. Turchini for their efficient organisation of the CMS notes.

For their patience in meeting sometimes impossible demands, we wish to thank the CMS Secretariat: K. Aspola, M. Azeglio, N. Bogolioubova, D. Denise, D. Hudson, G. Martin, and M.C. Pelloux.

We also would like to thank G. Alverson and L. Taylor for their invaluable technical assistance in the preparation of this manuscript.

Finally, we wish to thank the CMS management for their strong support and encouragement.

ISBN 92-9083-269-X

ISBN 978-92-9083-269-0

Trademark notice: all trademarks appearing in this report are acknowledged as such.

Also available at: <http://cmsdoc.cern.ch/cms/cpt/tdr/>

CMS Collaboration

Yerevan Physics Institute, Yerevan, ARMENIA

G.L. Bayatyan, S. Chatrchyan, G. Hmayakyan, A.M. Sirunyan

Institut für Hochenergiephysik der OeAW, Wien, AUSTRIA

W. Adam, T. Bergauer, M. Dragicevic, J. Erö, M. Friedl, R. Fruehwirth, V. Ghete, P. Glaser, J. Hrubec, M. Jeitler, M. Krammer, I. Magrans, I. Mikulec, W. Mitaroff, T. Noebauer, M. Pernicka, P. Porth, H. Rohringer, J. Strauss, A. Taurok, W. Waltenberger, G. Walzel, E. Widl, C.-E. Wulz

Research Institute for Nuclear Problems, Minsk, BELARUS

A. Fedorov, M. Korzhik, O. Missevitch, R. Zuyevski

National Centre for Particle and High Energy Physics, Minsk, BELARUS

V. Chekhovsky, O. Dvornikov, I. Emeliantchik, A. Litomin, V. Mossolov, N. Shumeiko, A. Solin, R. Stefanovitch, J. Suarez Gonzalez, A. Tikhonov

Byelorussian State University, Minsk, BELARUS

V. Petrov

Vrije Universiteit Brussel, Brussel, BELGIUM

J. D'Hondt, S. De Weirdt, R. Goorens, J. Heyninck, S. Lowette, S. Tavernier, W. Van Doninck^{**1}, L. Van Lancker

Université Libre de Bruxelles, Bruxelles, BELGIUM

O. Bouhali, B. Clerboux, G. De Lentdecker, J.P. Dewulf, T. Mahmoud, P.E. Marage, L. Neukermans, V. Sundararajan, C. Vander Velde, P. Vanlaer, J. Wickens

Université Catholique de Louvain, Louvain-la-Neuve, BELGIUM

S. Assouak, J.L. Bonnet, G. Bruno, J. Caudron, B. De Callatay, J. De Favereau De Jeneret, S. De Visscher, C. Delaere, P. Demin, D. Favart, E. Feltrin, E. Forton, G. Grégoire, S. Kalinin, D. Kcira, T. Keutgen, G. Leibenguth, V. Lemaitre, Y. Liu, D. Michotte, O. Militaru, A. Ninane, S. Ovin, T. Pierzchala, K. Piotrkowski, V. Roberfroid, X. Rouby, D. Teyssier, O. Van der Aa, M. Vander Donckt

Université de Mons-Hainaut, Mons, BELGIUM

E. Daubie, P. Herquet, A. Mollet, A. Romeyer

Universiteit Antwerpen, Wilrijk, BELGIUM

W. Beaumont, M. Cardaci, E. De Langhe, E.A. De Wolf, L. Rurua

Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, RJ, BRAZIL

M.H.G. Souza

Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ, BRAZIL

V. Oguri, A. Santoro, A. Sznajder

Instituto de Fisica - Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, BRAZIL

M. Vaz

Instituto de Fisica Teorica-Universidade Estadual Paulista, Sao Paulo, SP, BRAZIL

E.M. Gregores, S.F. Novaes

Institute for Nuclear Research and Nuclear Energy, Sofia, BULGARIA

T. Anguelov, G. Antchev, I. Atanasov, J. Damgov, N. Darmanov^{**1}, L. Dimitrov, V. Genchev^{**1}, P. Iaydjiev, B. Panev, S. Piperov, S. Stoykova, G. Sultanov, I. Vankov

University of Sofia, Sofia, BULGARIA

A. Dimitrov, V. Kozhuharov, L. Litov, M. Makariev, A. Marinov, E. Marinova, S. Markov, M. Mateev, B. Pavlov, P. Petkov, C. Sabev, S. Stoynev, Z. Toteva^{**1}, V. Verguilov

Institute of High Energy Physics, Beijing, CHINA

G.M. Chen, H.S. Chen, K.L. He, C.H. Jiang, W.G. Li, H.M. Liu, X. Meng, X.Y. Shen, H.S. Sun, M. Yang, W.R. Zhao, H.L. Zhuang

Peking University, Beijing, CHINA

Y. Ban, J. Cai, S. Liu, S.J. Qian, Z.C. Yang, Y.L. Ye, J. Ying

University for Science and Technology of China, Hefei, Anhui, CHINA

J. Wu, Z.P. Zhang

Technical University of Split, Split, CROATIA

N. Godinovic, I. Puljak, I. Soric

University of Split, Split, CROATIA

Z. Antunovic, M. Dzelalija, K. Marasovic

Institute Rudjer Boskovic, Zagreb, CROATIA

V. Brigljevic, D. Ferencek, K. Kadija, S. Morovic, M. Planinic**2

University of Cyprus, Nicosia, CYPRUS

C. Nicolaou, A. Papadakis, P.A. Razis, D. Tsiakkouri

National Institute of Chemical Physics and Biophysics, Tallinn, ESTONIA

A. Hektor, M. Kadastik, K. Kannike, E. Lippmaa, M. Müntel, M. Raidal

Laboratory of Advanced Energy Systems, Helsinki University of Technology, Espoo, FINLAND

P.A. Aarnio

Helsinki Institute of Physics, Helsinki, FINLAND

S. Czellar, E. Haeggstroem, A. Heikkinen, J. Härkönen, V. Karimäki, R. Kinnunen, T. Lampén, K. Lassila-Perini, S. Lehti, T. Lindén, P.R. Luukka, S. Michal**1, T. Mäenpää, J. Nysten, M. Stettler**1, E. Tuominen, J. Tuominiemi, L. Wendland

Lappeenranta University of Technology, Lappeenranta, FINLAND

T. Tuuva

Laboratoire d'Annecy-le-Vieux de Physique des Particules, IN2P3-CNRS, Annecy-le-Vieux, FRANCE

J.P. Guillaud, P. Nedelec, D. Sillou

DSM/DAPNIA, CEA/Saclay, Gif-sur-Yvette, FRANCE

M. Anfreville, S. Beauceron, E. Bougamont, P. Bredy, R. Chipaux, M. Dejardin, D. Denegri, J. Descamps, B. Fabbro, J.L. Faure, S. Ganjour, F.X. Gentit, A. Givernaud, P. Gras, G. Hamel de Monchenault, P. Jarry, F. Kircher, M.C. Lemaire**3, B. Levesy**1, E. Locci, J.P. Lottin, I. Mandjavidze, M. Mur, E. Pasquetto, A. Payn, J. Rander, J.M. Reymond, F. Rondeaux, A. Rosowsky, Z.H. Sun, P. Verrecchia

Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, FRANCE

S. Baffioni, F. Beaudette, M. Bercher, U. Berthon, S. Bimbot, J. Bourotte, P. Busson, M. Cerutti, D. Chamont, C. Charlot, C. Collard, D. Decotigny, E. Delmeire, L. Dobrzynski, A.M. Gaillac, Y. Geerebaert, J. Gilly, M. Haguenaer, A. Karar, A. Mathieu, G. Milleret, P. Miné, P. Paganini, T. Romanteau, I. Semeniouk, Y. Sirois

Institut Pluridisciplinaire Hubert Curien, IN2P3-CNRS - ULP, UHA Mulhouse, Strasbourg, FRANCE

J.D. Berst, J.M. Brom, F. Didierjean, F. Drouhin**1, J.C. Fontaine**4, U. Goerlach**5, P. Graehling, L. Gross, L. Houchu, P. Juillot, A. Lounis**5, C. Maazouzi, D. Mangeol, C. Olivetto, T. Todorov**1, P. Van Hove, D. Vintache

Institut de Physique Nucléaire, IN2P3-CNRS, Université Claude Bernard Lyon 1, Villeurbanne, FRANCE

M. Ageron, J.L. Agram, G. Baulieu, M. Bedjidian, J. Blaha, A. Bonnevaux, G. Boudoul^{**1}, E. Chabanat, C. Combaret, D. Contardo^{**1}, R. Della Negra, P. Depasse, T. Dupasquier, H. El Mamouni, N. Estre, J. Fay, S. Gascon, N. Giraud, C. Girerd, R. Haroutunian, J.C. Ianigro, B. Ille, M. Lethuillier, N. Lumb^{**1}, H. Mathez, G. Maurelli, L. Mirabito^{**1}, S. Perries, O. Ravat

Institute of High Energy Physics and Informatization, Tbilisi State University, Tbilisi, GEORGIA
R. Kvatadze

Institute of Physics Academy of Science, Tbilisi, GEORGIA
V. Roinishvili

RWTH, I. Physikalisches Institut, Aachen, GERMANY

R. Adolphi, R. Brauer, W. Braunschweig, H. Esser, L. Feld, A. Heister, W. Karpinski, K. Klein, C. Kukulies, J. Olzem, A. Ostapchuk, D. Pandoulas, G. Pierschel, F. Raupach, S. Schael, G. Schwering, M. Thomas, M. Weber, B. Wittmer, M. Wlochal

RWTH, III. Physikalisches Institut A, Aachen, GERMANY

A. Adolf, P. Biallass, M. Bontenackels, M. Erdmann, H. Fesefeldt, T. Hebbeker, S. Hermann, G. Hilgers, K. Hoepfner^{**1}, C. Hof, S. Kappler, M. Kirsch, D. Lanske, B. Philipps, H. Reithler, T. Rommerskirchen, M. Sowa, H. Szczesny, M. Tonutti, O. Tsigenov

RWTH, III. Physikalisches Institut B, Aachen, GERMANY

F. Beissel, M. Davids, M. Duda, G. Flügge, T. Franke, M. Giffels, T. Hermanns, D. Heydhausen, S. Kasselmann, G. Kaussen, T. Kress, A. Linn, A. Nowack, M. Poettgens, O. Pooth, A. Stahl, D. Tornier, M. Weber

Deutsches Elektronen-Synchrotron, Hamburg, GERMANY

A. Flossdorf, B. Hegner, J. Mnich, C. Rosemann

University of Hamburg, Hamburg, GERMANY

G. Flucke, U. Holm, R. Klanner, U. Pein, N. Schirm, P. Schleper, G. Steinbrück, M. Stoye, R. Van Staa, K. Wick

Institut für Experimentelle Kernphysik, Karlsruhe, GERMANY

P. Blüm, V. Buege, W. De Boer, G. Dirkes^{**1}, M. Fahrner, M. Feindt, U. Felzmann, J. Fernandez Menendez^{**6}, M. Frey, A. Furgeri, F. Hartmann^{**1}, S. Heier, C. Jung, B. Ledermann, Th. Müller, M. Niegel, A. Oehler, T. Ortega Gomez, C. Piasecki, G. Quast, K. Rabbertz, C. Saout, A. Scheurer, D. Schieferdecker, A. Schmidt, H.J. Simonis, A. Theel, A. Vest, T. Weiler, C. Weiser, J. Weng^{**1}, V. Zhukov^{**7}

University of Athens, Athens, GREECE

G. Karapostoli^{**1}, P. Katsas, P. Kreuzer, A. Panagiotou, C. Papadimitropoulos

Institute of Nuclear Physics "Demokritos", Attiki, GREECE

G. Anagnostou, M. Barone, T. Geralis, C. Kalfas, A. Koimas, A. Kyriakis, S. Kyriazopoulou, D. Loukas, A. Markou, C. Markou, C. Mavrommatis, K. Theofilatos, G. Vermisoglou, A. Zachariadou

University of Ioánnina, Ioánnina, GREECE

X. Aslanoglou, I. Evangelou, P. Kokkas, N. Manthos, I. Papadopoulos, G. Sidiropoulos, F.A. Triantis

KFKI Research Institute for Particle and Nuclear Physics, Budapest, HUNGARY

G. Bencze^{**1}, L. Boldizsar, C. Hajdu^{**1}, D. Horvath^{**8}, A. Laszlo, G. Odor, F. Sikler, N. Toth, G. Vesztergombi, P. Zalan

Institute of Nuclear Research ATOMKI, Debrecen, HUNGARY

J. Molnar

University of Debrecen, Debrecen, HUNGARY

N. Beni, A. Kapusi, G. Marian, P. Raics, Z. Szabo, Z. Szillasi, G. Zilizi

Panjab University, Chandigarh, INDIA

H.S. Bawa, S.B. Beri, V. Bhandari, V. Bhatnagar, M. Kaur, R. Kaur, J.M. Kohli, A. Kumar, J.B. Singh

University of Delhi, Delhi, INDIA

A. Bhardwaj, S. Bhattacharya^{**9}, S. Chatterji, S. Chauhan, B.C. Choudhary, P. Gupta, M. Jha, K. Ranjan, R.K. Shivpuri, A.K. Srivastava

Bhabha Atomic Research Centre, Mumbai, INDIA

S. Borkar, M. Dixit, M. Ghodgaonkar, S.K. Kataria, S.K. Lalwani, V. Mishra, A.K. Mohanty, A. Topkar

Tata Institute of Fundamental Research - EHEP, Mumbai, INDIA

T. Aziz, S. Banerjee, S. Bose, N. Cheere, S. Chendvankar, P.V. Deshpande, M. Guchait^{**10}, A. Gurtu, M. Maity^{**11}, G. Majumder, K. Mazumdar, A. Nayak, M.R. Patil, S. Sharma, K. Sudhakar, S.C. Tonwar

Tata Institute of Fundamental Research - HECR, Mumbai, INDIA

B.S. Acharya, S. Banerjee, S. Bheesette, S. Dugad, S.D. Kalmani, V.R. Lakkireddi, N.K. Mondal, N. Panyam, P. Verma

Institute for Studies in Theoretical Physics & Mathematics (IPM), Tehran, IRAN

M. Arabgol, H. Arfaei, M. Hashemi, M. Mohammadi, M. Mohammadi Najafabadi, A. Moshaii, S. Paktinat Mehdiabadi

University College Dublin, Dublin, IRELAND

M. Grunewald

Università di Bari, Politecnico di Bari e Sezione dell' INFN, Bari, ITALY

M. Abbrescia, L. Barbone, A. Colaleo^{**1}, D. Creanza, N. De Filippis, M. De Palma, G. Donvito, L. Fiore, D. Giordano, G. Iaselli, F. Loddo, G. Maggi, M. Maggi, N. Manna, B. Marangelli, M.S. Mennea, S. My, S. Natali, S. Nuzzo, G. Pugliese, V. Radicci, A. Ranieri, F. Romano, G. Selvaggi, L. Silvestris, P. Tempesta, R. Trentadue, G. Zito

Università di Bologna e Sezione dell' INFN, Bologna, ITALY

G. Abbiendi, W. Bacchi, A. Benvenuti, D. Bonacorsi, S. Braibant-Giacomelli, P. Capiluppi, F.R. Cavallo, C. Ciocca, G. Codispoti, I. D'Antone, G.M. Dallavalle, F. Fabbri, A. Fanfani, P. Giacomelli^{**12}, C. Grandi, M. Guerzoni, L. Guiducci, S. Marcellini, G. Masetti, A. Montanari, F. Navarria, F. Odorici, A. Perrotta, A. Rossi, T. Rovelli, G. Siroli, R. Travaglini

Università di Catania e Sezione dell' INFN, Catania, ITALY

S. Albergo, M. Chiorboli, S. Costa, M. Galanti, G. Gatto Rotondo, F. Noto, R. Potenza, G. Russo, A. Tricoli, C. Tuve

Università di Firenze e Sezione dell' INFN, Firenze, ITALY

A. Bocci, G. Ciruolo, V. Ciulli, C. Civinini, R. D'Alessandro, E. Focardi, C. Genta, P. Lenzi, A. Macchiolo, N. Magini, F. Manolescu, C. Marchettini, L. Masetti, S. Mersi, M. Meschini, S. Paoletti, G. Parrini, R. Ranieri, M. Sani

Università di Genova e Sezione dell' INFN, Genova, ITALY

P. Fabbricatore, S. Farinon, M. Greco

Istituto Nazionale di Fisica Nucleare e Università Degli Studi Milano-Bicocca, Milano, ITALY

G. Cattaneo, A. De Min, M. Dominoni, F.M. Farina, F. Ferri, A. Ghezzi, P. Govoni, R. Leporini, S. Magni, M. Malberti, S. Malvezzi, S. Marelli, D. Menasce, L. Moroni, P. Negri, M. Paganoni, D. Pedrini, A. Pullia, S. Ragazzi, N. Redaelli, C. Rovelli, M. Rovere, L. Sala, S. Sala, R. Salerno, T. Tabarelli de Fatis, S. Viganò

Istituto Nazionale di Fisica Nucleare de Napoli (INFN), Napoli, ITALY

G. Comunale, F. Fabozzi, D. Lomidze, S. Mele, P. Paolucci, D. Piccolo, G. Polese, C. Sciacca

Università di Padova e Sezione dell' INFN, Padova, ITALY

P. Azzi, N. Bacchetta^{**1}, M. Bellato, M. Benettoni, D. Bisello, E. Borsato, A. Candelori, P. Checchia, E. Conti, M. De Mattia, T. Dorigo, V. Drollinger, F. Fanzago, F. Gasparini, U. Gasparini, M. Giarin, P. Giubilato, F. Gonella, A. Kaminskiy, S. Karaevskii, V. Khomenkov, S. Lacaprara, I. Lippi, M. Loretto,

O. Lytovchenko, M. Mazzucato, A.T. Meneguzzo, M. Michelotto, F. Montecassiano^{**1}, M. Nigro, M. Passaseo, M. Pegoraro, G. Rampazzo, P. Ronchese, E. Torassa, S. Ventura, M. Zanetti, P. Zotto, G. Zumerle

Università di Pavia e Sezione dell' INFN, Pavia, ITALY

G. Belli, U. Berzano, C. De Vecchi, R. Guida, M.M. Necchi, S.P. Ratti, C. Riccardi, G. Sani, P. Torre, P. Vitulo

Università di Perugia e Sezione dell' INFN, Perugia, ITALY

F. Ambroglini, E. Babucci, D. Benedetti, M. Biasini, G.M. Bilei^{**1}, B. Caponeri, B. Checcucci, L. Fanò, P. Lariccia, G. Mantovani, D. Passeri, M. Pioppi, P. Placidi, V. Postolache, D. Ricci^{**1}, A. Santocchia, L. Servoli, D. Spiga

Università di Pisa, Scuola Normale Superiore e Sezione dell' INFN, Pisa, ITALY

P. Azzurri, G. Bagliesi, A. Basti, L. Benucci, J. Bernardini, T. Boccali, L. Borrello, F. Bosi, F. Calzolari, R. Castaldi, C. Cerri, A.S. Cucoanes, M. D'Alfonso, R. Dell'Orso, S. Dutta, L. Foà, S. Gennai^{**13}, A. Giammanco, A. Giassi, D. Kartashov, F. Ligabue, S. Linari, T. Lomtadze, G.A. Lungu, B. Mangano, G. Martinelli, M. Massa, A. Messineo, A. Moggi, F. Palla, F. Palmonari, G. Petrucciani, F. Raffaelli, A. Rizzi, G. Sanguinetti, G. Segneri, D. Sentenac, A.T. Serban, G. Sguazzoni, A. Slav, P. Spagnolo, R. Tenchini, G. Tonelli, A. Venturi, P.G. Verdini, M. Vos

Università di Roma I e Sezione dell' INFN, Roma, ITALY

S. Baccaro^{**14}, L. Barone, A. Bartoloni, F. Cavallari, S. Costantini, I. Dafinei, D. Del Re^{**9}, M. Diemoz, C. Gargiulo, E. Longo, P. Meridiani, G. Organtini, S. Rahatlou

Università di Torino e Sezione dell' INFN, Torino, ITALY

E. Accomando, M. Arneodo^{**15}, A. Ballestrero, R. Bellan, C. Biino, S. Bolognesi, N. Cartiglia, G. Cerminara, M. Cordero, M. Costa, G. Dellacasa, N. Demaria, E. Maina, C. Mariotti, S. Maselli, P. Mereu, E. Migliore, V. Monaco, M. Nervo, M.M. Obertino, N. Pastrone, G. Petrillo, A. Romero, M. Ruspa^{**15}, R. Sacchi, A. Staiano, P.P. Trapani

Università di Trieste e Sezione dell' INFN, Trieste, ITALY

S. Belforte, F. Cossutti, G. Della Ricca, A. Penzo

Kyungpook National University, Daegu, KOREA

K. Cho, S.W. Ham, D. Han, D.H. Kim, G.N. Kim, J.C. Kim, W.Y. Kim, M.W. Lee, S.K. Oh, W.H. Park, S.R. Ro, D.C. Son, J.S. Suh

Chonnam National University, Kwangju, KOREA

J.Y. Kim

Konkuk University, Seoul, KOREA

S.Y. Jung, J.T. Rhee

Korea University, Seoul, KOREA

B.S. Hong, S.J. Hong, K.S. Lee, I. Park, S.K. Park, K.S. Sim, E. Won

Seoul National University, Seoul, KOREA

S.B. Kim

Universidad Iberoamericana, Mexico City, MEXICO

S. Carrillo Moreno

Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, MEXICO

H. Castilla Valdez, A. Sanchez Hernandez

Benemerita Universidad Autonoma de Puebla, Puebla, MEXICO

H.A. Salazar Ibarguen

Universidad Autonoma de San Luis Potosi, San Luis Potosi, MEXICO

A. Morelos Pineda

University of Auckland, Auckland, NEW ZEALAND

R.N.C. Gray, D. Krofcheck

University of Canterbury, Christchurch, NEW ZEALAND

N. Bernardino Rodrigues, P.H. Butler, J.C. Williams

National Centre for Physics, Quaid-I-Azam University, Islamabad, PAKISTAN

Z. Aftab, M. Ahmad, U. Ahmad, I. Ahmed, J. Alam Jan, M.I. Asghar, S. Asghar, M. Hafeez, H.R. Hoorani, M. Ibrahim, M. Iftikhar, M.S. Khan, N. Qaiser, I. Rehman, T. Solaija, S. Toor

Institute of Nuclear Physics, Polish Academy of Sciences, Cracow, POLAND

J. Blocki, A. Cyz, E. Gladysz-Dziadus, S. Mikocki, J. Turnau, Z. Wlodarczyk^{**16}, P. Zychowski

Institute of Experimental Physics, Warsaw, POLAND

K. Bunkowski, H. Czyrkowski, R. Dabrowski, W. Dominik, K. Doroba, A. Kalinowski, M. Konecki, J. Krolkowski, I.M. Kudla, M. Pietrusinski, K. Pozniak^{**17}, W. Zabolotny^{**17}, P. Zych

Soltan Institute for Nuclear Studies, Warsaw, POLAND

M. Bluj, R. Gokieli, L. Gosciolo, M. Górski, K. Nawrocki, P. Traczyk, G. Wrochna, P. Zalewski

Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, PORTUGAL

R. Alemany-Fernandez, C. Almeida, N. Almeida, A. Araujo Trindade, P. Bordalo, P. Da Silva Rodrigues, M. Husejko, A. Jain, M. Kazana, P. Musella, S. Ramos, J. Rasteiro Da Silva, P.Q. Ribeiro, M. Santos, J. Semiao, P. Silva, I. Teixeira, J.P. Teixeira, J. Varela^{**1}

Joint Institute for Nuclear Research, Dubna, RUSSIA

S. Afanasiev, K. Babich, I. Belotelov, V. Elsha, Y. Ershov, I. Filozova, A. Golunov, I. Golutvin, N. Gorbounov, I. Gramenitski, V. Kalagin, A. Kamenev, V. Karjavin, S. Khabarov, V. Khabarov, Y. Kiryushin, V. Konoplyanikov, V. Korenkov, G. Kozlov, A. Kurenkov, A. Lanev, V. Lysiakov, A. Malakhov, I. Melnitchenko, V.V. Mitsyn, K. Moisenz, P. Moisenz, S. Movchan, E. Nikonov, D. Oleynik, V. Palichik, V. Perelygin, A. Petrosyan, E. Rogalev, V. Samsonov, M. Savina, R. Semenov, S. Shmatov, S. Shulha, V. Smirnov, D. Smolin, A. Tcheremoukhine, O. Teryaev, E. Tikhonenko, S. Vassiliev, A. Vishnevskiy, A. Volodko, N. Zamiatin, A. Zarubin, P. Zarubin, E. Zubarev

Petersburg Nuclear Physics Institute, Gatchina (St Petersburg), RUSSIA

N. Bondar, V. Golovtsov, A. Golyash, Y. Ivanov, V. Kim, V. Kozlov, V. Lebedev, G. Makarenkov, E. Orishchin, A. Shevel, V. Sknar, I. Smirnov, V. Sulimov, V. Tarakanov, L. Uvarov, G. Velichko, S. Volkov, A. Vorobyev

Institute for Nuclear Research, Moscow, RUSSIA

Yu. Andreev, A. Anisimov, S. Gninenko, N. Golubev, D. Gorbunov, M. Kirsanov, A. Kovzelev, N. Krasnikov, V. Matveev, A. Pashenkov, V.E. Postoev, A. Sadovski, A. Solovey, A. Solovey, D. Soloviev, L. Stepanova, A. Toropin

Institute for Theoretical and Experimental Physics, Moscow, RUSSIA

V. Gavrilov, N. Ilina, V. Kaftanov^{**1}, I. Kiselevich, V. Kolosov, M. Kossov^{**1}, A. Krokhotin, S. Kuleshov, A. Oulianov, G. Safronov, S. Semenov, V. Stolin, E. Vlasov^{**1}, V. Zaytsev

P.N. Lebedev Physical Institute, Moscow, RUSSIA

A.M. Fomenko, N. Konovalova, V. Kozlov, A.I. Lebedev, N. Lvova, S.V. Rusakov, A. Terkulov

Moscow State University, Moscow, RUSSIA

E. Boos, M. Dubinin^{**3}, L. Dudko, A. Ershov, A. Gribushin, V. Ilyin, V. Klyukhin^{**1}, O. Kodolova, I. Lokhtin, S. Petrushanko, L. Sarycheva, V. Savrin, A. Sherstnev, A. Snigirev, K. Teplov, I. Vardanyan

State Research Center of Russian Federation - Institute for High Energy Physics, Protvino, RUSSIA

V. Abramov, I. Azhguirei, S. Bitioukov, K. Datsko, A. Filine, P. Goncharov, V. Grishin, A. Inyakin, V. Kachanov, A. Khmelnikov, D. Konstantinov, A. Korablev, V. Krychkine, A. Levine, I. Lobov, V. Petrov, V. Pikalov, R. Ryutin, S. Slabospitsky, A. Sourkov^{**1}, A. Sytine, L. Tourtchanovitch,

S. Troshin, N. Tyurin, A. Uzunian, A. Volkov, S. Zelepoukine**18

Vinca Institute of Nuclear Sciences, Belgrade, SERBIA

P. Adzic, D. Krpic**19, D. Maletic, P. Milenovic, J. Puzovic**19, N. Smiljkovic**1, M. Zupan

Centro de Investigaciones Energeticas Medioambientales y Tecnologicas, Madrid, SPAIN

M. Aguilar-Benitez, J. Alberdi, J. Alcaraz Maestre, M. Aldaya Martin, P. Arce**1, J.M. Barcala, C. Burgos Lazaro, J. Caballero Bejar, E. Calvo, M. Cardenas Montes, M. Cerrada, M. Chamizo Llatas, N. Colino, M. Daniel, B. De La Cruz, C. Fernandez Bedoya, A. Ferrando, M.C. Fouz, P. Garcia-Abia, J.M. Hernandez, M.I. Josa, J.M. Luque, J. Marin, G. Merino, A. Molinero, J.J. Navarrete, J.C. Oller, E. Perez Calle, L. Romero, J. Salicio, C. Villanueva Munoz, C. Willmott, C. Yuste

Universidad Autónoma de Madrid, Madrid, SPAIN

C. Albajar, J.F. de Trocóniz, M. Fernandez, I. Jimenez, R.F. Teixeira

Universidad de Oviedo, Oviedo, SPAIN

J. Cuevas, J.M. Lopez, H. Naves Sordo, J.M. Vizan Garcia

Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, SPAIN

A. Calderon, D. Cano Fernandez, I. Diaz Merino, L.A. Garcia Moral, G. Gomez, I. Gonzalez Caballero, J. Gonzalez Sanchez, A. Lopez Virto, J. Marco, R. Marco, C. Martinez Rivero, P. Martinez Ruiz del Arbol, F. Matorras, A. Patino Revuelta**1, T. Rodrigo, D. Rodriguez Gonzalez, A. Ruiz Jimeno, M. Sobron Sanudo, I. Vila, R. Vilar Cortabitarte

CERN, European Organization for Nuclear Research, Geneva, SWITZERLAND

D. Abbaneo, S.M. Abbas, L. Agostino, I. Ahmed, S. Akhtar, N. Amapane, B. Araujo Meleiro, S. Argiro**20, S. Ashby, P. Aspell, E. Auffray, M. Axer, A. Ball, N. Bangert, D. Barney, C. Bernet, W. Bialas, C. Bloch, P. Bloch, S. Bonacini, M. Bosteels, V. Boyer, A. Branson, A.M. Brett, H. Breuker, R. Bruneliere, O. Buchmuller, D. Campi, T. Camporesi, E. Cano, E. Carrone, A. Cattai, R. Chierici, T. Christiansen, S. Cittolin, E. Corrin, M. Corvo, S. Cucciarelli, B. Curé, A. De Roeck, D. Delikaris, M. Della Negra, D. D'Enterria**38, A. Dierlamm, A. Elliott-Peisert, M. Eppard, H. Foeth, R. Folch, S. Fratianni, W. Funk, A. Gaddi, M. Gastal, J.C. Gayde, H. Gerwig, K. Gill, A.S. Giolo-Nicollerat, F. Glege, R. Gomez-Reino Garrido, R. Goudard, J. Gutleber, M. Hansen, J. Hartert, A. Hervé, H.F. Hoffmann, A. Honma, M. Huhtinen, G. Iles, V. Innocente, W. Jank, P. Janot, K. Kloukinas, C. Lasseur, M. Lebeau, P. Lecoq, C. Leonidopoulos, M. Letheren, C. Ljuslin, R. Loos, G. Magazzu, L. Malgeri, M. Mannelli, A. Marchioro, F. Meijers, E. Meschi, R. Moser, M. Mulders, J. Nash, R.A. Ofierzynski, A. Oh, P. Olbrechts, A. Onnela, L. Orsini, I. Pal, G. Papotti, R. Paramatti, G. Passardi, B. Perea Solano, G. Perinic, P. Petagna, A. Petrilli, A. Pfeiffer, M. Pimiä, R. Pintus, H. Postema, R. Principe, J. Puerta Pelayo, A. Racz, J. Rehn, S. Reynaud, M. Risoldi, P. Rodrigues Simoes Moreira, G. Rolandi, P. Rosinsky, P. Rumerio, H. Sakulin, D. Samyn, F.P. Schilling, C. Schwick, C. Schäfer, I. Segoni, A. Sharma, P. Siegrist, N. Sinanis, P. Sphicas**21, M. Spiropulu, F. Szoncsó, O. Teller, D. Treille, J. Troska, E. Tsesmelis, D. Tsirigkas, A. Tsirou, D. Ungaro, F. Vasey, M. Vazquez Acosta, L. Veillet, P. Vichoudis, P. Wertelaers, A. Wijnant, M. Wilhelmsson, I.M. Willers

Paul Scherrer Institut, Villigen, SWITZERLAND

W. Bertl, K. Deiters, W. Erdmann, K. Gabathuler, S. Heising, R. Horisberger, Q. Ingram, H.C. Kaestli, D. Kotlinski, S. König, D. Renker, T. Rohe, M. Spira

Institute for Particle Physics, ETH Zurich, Zurich, SWITZERLAND

B. Betev, G. Davatz, G. Dissertori, M. Dittmar, L. Djambazov, J. Ehlers, R. Eichler, G. Faber, K. Freudenreich, J.F. Fuchs**1, C. Grab, A. Holzner, P. Ingenito, U. Langenegger, P. Lecomte, G. Leshev, A. Lister**22, P.D. Luckey, W. Lustermann, J.D. Maillefaud**1, F. Moortgat, A. Nardulli, F. Nessi-Tedaldi, L. Pape, F. Pauss, H. Rykaczewski**23, U. Röser, D. Schinzel, A. Starodumov**24, F. Stöckli, H. Suter, L. Tauscher, P. Trüb**25, H.P. von Gunten, M. Wensveen**1

Universität Zürich, Zürich, SWITZERLAND

E. Alagoz, C. AMSler, V. Chiochia, C. Hoermann, K. Prokofiev, C. Regenfus, P. Robmann, T. Speer, S. Steiner, L. Wilke

National Central University, Chung-Li, TAIWAN

S. Blyth, Y.H. Chang, E.A. Chen, A. Go, C.C. Hung, C.M. Kuo, W. Lin

National Taiwan University (NTU), Taipei, TAIWAN

P. Chang, Y. Chao, K.F. Chen, Z. Gao^{**1}, Y. Hsiung, Y.J. Lei, J. Schümann, J.G. Shiu, K. Ueno, Y. Velikzhanin, P. Yeh

Cukurova University, Adana, TURKEY

S. Aydin, M.N. Bakirci, S. Cerci, I. Dumanoglu, S. Erturk, S. Esen, E. Eskut, A. Kayis Topaksu, P. Kurt, H. Ozkurt, A. Polatöz, K. Sogut, H. Topakli, M. Vergili, T. Yetkin, G. Önengüt

Middle East Technical University, Physics Department, Ankara, TURKEY

H. Gamsizkan, C. Ozkan, S. Sekmen, M. Serin-Zeyrek, R. Sever, E. Yazgan, M. Zeyrek

Bogaziçi University, Department of Physics, Istanbul, TURKEY

A. Cakir^{**26}, K. Cankocak^{**27}, M. Deliomeroglu, D. Demir^{**26}, K. Dindar, E. Gülmez, E. Isiksal^{**28}, M. Kaya^{**29}, O. Kaya, S. Ozkorucuklu^{**30}, N. Sonmez^{**31}

Institute of Single Crystals of National Academy of Science, Kharkov, UKRAINE

B. Grinev, V. Lyubynskiy, V. Senchyshyn

National Scientific Center, Kharkov Institute of Physics and Technology, Kharkov, UKRAINE

L. Levchuk, P. Sorokin

University of Bristol, Bristol, UNITED KINGDOM

D.S. Bailey, T. Barrass, J.J. Brooke, R. Croft, D. Cussans, D. Evans, R. Frazier, N. Grant, M. Hansen, G.P. Heath, H.F. Heath, B. Huckvale, C. Lynch, C.K. Mackay, S. Metson, D.M. Newbold^{**32}, V.J. Smith, R.J. Tapper

Rutherford Appleton Laboratory, Didcot, UNITED KINGDOM

S.A. Baird, K.W. Bell, R.M. Brown, D.J.A. Cockerill, J.A. Coughlan, P.S. Flower, V.B. Francis, M. French, J. Greenhalgh, R. Halsall, J. Hill, L. Jones, B.W. Kennedy, L. Lintern, A.B. Lodge, J. Maddox, Q. Morrissey, P. Murray, M. Pearson, S. Quinton, J. Salisbury, A. Shah, C. Shepherd-Themistocleous, B. Smith, M. Sproston, R. Stephenson, S. Taghavirad, I.R. Tomalin, J.H. Williams

Imperial College, University of London, London, UNITED KINGDOM

F. Arteche^{**1}, R. Bainbridge, G. Barber, P. Barrillon, R. Beuselinck, F. Blekman, D. Britton, D. Colling, G. Daskalakis, G. Dewhurst, S. Dris^{**1}, C. Foudas, J. Fulcher, S. Greder, G. Hall, J. Jones, J. Leaver, B.C. MacEvoy, O. Maroney, A. Nikitenko^{**24}, A. Papageorgiou, D.M. Raymond, M.J. Ryan, C. Seez, P. Sharp^{**1}, M. Takahashi, C. Timlin, T. Virdee^{**1}, S. Wakefield, M. Wingham, A. Zabi, Y. Zhang, O. Zorba

Brunel University, Uxbridge, UNITED KINGDOM

C. Da Via, I. Goitom, P.R. Hobson, P. Kyberd, C. Munro, J. Nebrensky, I. Reid, O. Sharif, R. Taylor, L. Teodorescu, S.J. Watts, I. Yaselli

Boston University, Boston, Massachusetts, USA

E. Hazen, A.H. Heering, D. Lazic, E. Machado, D. Osborne, J. Rohlf, L. Sulak, F. Varela Rodriguez, S. Wu

Brown University, Providence, Rhode Island, USA

D. Cutts, R. Hooper, G. Landsberg, R. Partridge, S. Vanini^{**33}

University of California, Davis, Davis, California, USA

R. Breedon, M. Case, M. Chertok, J. Conway, P.T. Cox, R. Erbacher, J. Gunion, B. Holbrook, W. Ko, R. Lander, D. Pellett, J. Smith, A. Soha, M. Tripathi, R. Vogt

University of California, Los Angeles, Los Angeles, California, USA

V. Andreev, K. Arisaka, D. Cline, R. Cousins, S. Erhan^{**1}, M. Felcini^{**1}, J. Hauser, M. Ignatenko, B. Lisowski, D. Matlock, C. Matthey, B. Mohr, J. Mumford, S. Otwinowski, G. Rakness, P. Schlein,

Y. Shi, J. Tucker, V. Valuev, R. Wallny, H.G. Wang, X. Yang, Y. Zheng

University of California, Riverside, Riverside, California, USA

R. Clare, D. Fortin, D. Futyan^{**1}, J.W. Gary, M. Giunta^{**1}, G. Hanson, G.Y. Jeng, S.C. Kao, H. Liu, G. Pasztor^{**34}, A. Satpathy, B.C. Shen, R. Stringer, V. Sytnik, R. Wilken, D. Zer-Zion

University of California, San Diego, La Jolla, California, USA

J.G. Branson, E. Dusinberre, J. Letts, T. Martin, M. Mojaver, H.P. Paar, H. Pi, M. Pieri, A. Rana, V. Sharma, A. White, F. Würthwein

University of California, Santa Barbara, Santa Barbara, California, USA

A. Affolder, C. Campagnari, C. Hill, J. Incandela, S. Kyre, J. Lamb, J. Richman, D. Stuart, D. White

California Institute of Technology, Pasadena, California, USA

J. Albert, A. Bornheim, J. Bunn, J. Chen, G. Denis, P. Galvez, M. Gataullin, I. Legrand, V. Litvine, Y. Ma, D. Nae, H.B. Newman, S. Ravot, S. Shevchenko, S. Singh, C. Steenberg, X. Su, M. Thomas, V. Timciuc, F. van Lingen, J. Veverka, B.R. Voicu^{**1}, A. Weinstein, R. Wilkinson, X. Yang, Y. Yang, L.Y. Zhang, K. Zhu, R.Y. Zhu

Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

T. Ferguson, M. Paulini, J. Russ, N. Terentyev, H. Vogel, I. Vorobiev

University of Colorado at Boulder, Boulder, Colorado, USA

J.P. Cumalat, W.T. Ford, D. Johnson, U. Nauenberg, K. Stenson, S.R. Wagner

Cornell University, Ithaca, NY, USA

J. Alexander, D. Cassel, K. Ecklund, B. Heltsley, C.D. Jones, V. Kuznetsov, J.R. Patterson, A. Ryd, J. Thom, P. Wittich

Fairfield University, Fairfield, Connecticut, USA

C.P. Beetz, G. Cirino, V. Podrasky, C. Sanzeni, D. Winn

Fermi National Accelerator Laboratory, Batavia, Illinois, USA

S. Abdullin^{**24}, M.A. Afaq^{**1}, M. Albrow, J. Amundson, G. Apollinari, M. Atac, W. Badgett, J.A. Bakken, B. Baldin, L.A.T. Bauerdick, A. Baumbaugh, U. Baur, P.C. Bhat, F. Borchering, K. Burkett, J.N. Butler, H. Cheung, I. Churin, S. Cihangir, M. Demarteau, D.P. Eartly, J.E. Elias, V.D. Elvira, D. Evans, I. Fisk, J. Freeman, P. Gartung, F.J.M. Geurts, D.A. Glenzinski, E. Gottschalk, G. Graham, D. Green, G.M. Guglielmo, Y. Guo, O. Gutsche, A. Hahn, J. Hanlon, S. Hansen, R.M. Harris, T. Hesselroth, S.L. Holm, B. Holzman, S. Iqbal, E. James, M. Johnson, U. Joshi, B. Klima, J. Kowalkowski, T. Kramer, S. Kwan, E. La Vallie, M. Larwill, S. Los, L. Lueking, G. Lukhanin, S. Lusin^{**1}, K. Maeshima, P. McBride, S.J. Murray, V. O'Dell, M. Paterno, J. Patrick, D. Petravick, R. Pordes, O. Prokofyev, V. Rasmislovich, N. Ratnikova, A. Ronzhin, V. Sekhri, E. Sexton-Kennedy, T. Shaw, D. Skow, R.P. Smith, W.J. Spalding, L. Spiegel, M. Stavrianakou, G. Stiehr, I. Suzuki, P. Tan, W. Tanenbaum, S. Tkaczyk, S. Veseli, R. Vidal, H. Wenzel, J. Whitmore, W.J. Womersley, W.M. Wu, Y. Wu, A. Yagil, J. Yarba, J.C. Yun

University of Florida, Gainesville, Florida, USA

D. Acosta, P. Avery, V. Barashko, P. Bartalini, D. Bourilkov, R. Cavanaugh, A. Drozdetskiy, R.D. Field, Y. Fu, L. Gray, D. Holmes, B.J. Kim, S. Klimenko, J. Konigsberg, A. Korytov, K. Kotov, P. Levchenko, A. Madorsky, K. Matchev, G. Mitselmakher, Y. Pakhotin, C. Prescott, P. Ramond, J.L. Rodriguez, M. Schmitt, B. Scurlock, H. Stoeck, J. Yelton

Florida International University, Miami, Florida, USA

W. Boeglin, V. Gaultney, L. Kramer, S. Linn, P. Markowitz, G. Martinez, B. Raue, J. Reinhold

Florida State University, Tallahassee, Florida, USA

A. Askew, M. Bertoldi, W.G.D. Dharmaratna, Y. Gershtein, S. Hagopian, V. Hagopian, M. Jenkins, K.F. Johnson, H. Prosper, H. Wahl

Florida Institute of Technology, Melbourne, Florida, USA

M. Baarmand, L. Baksay**35, S. Guragain, M. Hohlmann, H. Mermerkaya, R. Ralich, I. Vodopyanov

University of Illinois at Chicago (UIC), Chicago, Illinois, USA

M.R. Adams, R.R. Betts, C.E. Gerber, E. Shabalina, C. Smith, T. Ten

The University of Iowa, Iowa City, Iowa, USA

U. Akgun, A.S. Ayan, A. Cooper, P. Debbins, F. Duru, M. Fountain, N. George, E. McCliment, J.P. Merlo, A. Mestvirishvili, M.J. Miller, C.R. Newsom, E. Norbeck, Y. Onel, I. Schmidt, S. Wang

Iowa State University, Ames, Iowa, USA

E.W. Anderson, O. Atramentov, J.M. Hauptman, J. Lamsa

Johns Hopkins University, Baltimore, Maryland, USA

B.A. Barnett, B. Blumenfeld, C.Y. Chien, D.W. Kim, P. Maksimovic, S. Spangler, M. Swartz

The University of Kansas, Lawrence, Kansas, USA

P. Baringer, A. Bean, D. Coppage, O. Grachov, E.J. Kim, M. Murray

Kansas State University, Manhattan, Kansas, USA

D. Bandurin, T. Bolton, A. Khanov**24, Y. Maravin, D. Onoprienko, F. Rizatdinova, R. Sidwell, N. Stanton, E. Von Toerne

University of Maryland, College Park, Maryland, USA

D. Baden, R. Bard, S.C. Eno, T. Grassi, N.J. Hadley, R.G. Kellogg, S. Kunori, F. Ratnikov, A. Skuja

Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

R. Arcidiacono, M. Ballintijn, G. Bauer, P. Harris, I. Kravchenko, C. Loizides, S. Nahn, C. Paus, S. Pavlon, C. Roland, G. Roland, K. Sumorok, S. Vaurynovich, G. Veres, B. Wyslouch

University of Minnesota, Minneapolis, Minnesota, USA

D. Bailleux, S. Corum, P. Cushman, A. De Benedetti, A. Dolgoplov, R. Egeland, G. Franzoni, W.J. Gilbert, J. Grahl, J. Haupt, Y. Kubota, J. Mans, N. Pearson, R. Rusack, A. Singovsky

University of Mississippi, University, Mississippi, USA

L.M. Cremaldi, R. Godang, R. Kroeger, D.A. Sanders, D. Summers

University of Nebraska-Lincoln, Lincoln, Nebraska, USA

K. Bloom, D.R. Claes, A. Dominguez, M. Eads, C. Lundstedt, S. Malik, G.R. Snow, A. Sobol

State University of New York at Buffalo, Buffalo, New York, USA

I. Iashvili, A. Kharchilava

Northeastern University, Boston, Massachusetts, USA

G. Alverson, E. Barberis, O. Boeriu, G. Eulisse, Y. Musienko**36, S. Muzaffar, I. Osborne, S. Reucroft, J. Swain, L. Taylor, L. Tuura, D. Wood

Northwestern University, Evanston, Illinois, USA

B. Gobbi, M. Kubantsev, H. Schellman, M. Schmitt, E. Spencer, M. Velasco

University of Notre Dame, Notre Dame, Indiana, USA

B. Baumbaugh, N.M. Cason, M. Hildreth, D.J. Karmgard, N. Marinelli**21, R. Ruchti, J. Warchol, M. Wayne

The Ohio State University, Columbus, Ohio, USA

B. Bylsma, L.S. Durkin, J. Gilmore, J. Gu, D. Herman, P. Killewald, K. Knobbe, T.Y. Ling

Princeton University, Princeton, New Jersey, USA

P. Elmer, D. Marlow, P. Piroué, D. Stickland, C. Tully, T. Wildish, S. Wynhoff, Z. Xie

Purdue University, West Lafayette, Indiana, USA

A. Apresyan, K. Arndt, K. Banicz, V.E. Barnes, G. Bolla, D. Bortoletto, A. Bujak, A.F. Garfinkel, O. Gonzalez Lopez, L. Gutay, N. Ippolito, Y. Kozhevnikov**1, A.T. Laasanen, C. Liu, V. Maroussov, P. Merkel, D.H. Miller, J. Miyamoto, N. Neumeister, C. Rott, A. Roy, A. Sedov, I. Shipsey

Purdue University Calumet, Hammond, Indiana, USA

N. Parashar

Rice University, Houston, Texas, USA

G. Eppley, S.J. Lee, J. Liu, M. Matveev, T. Nussbaum, B.P. Padley, J. Roberts, A. Tumanov, P. Yepes

University of Rochester, Rochester, New York, USA

A. Bodek, H. Budd, Y.S. Chung, P. De Barbaro**1, R. Demina, R. Eusebi, G. Ginther, Y. Gotra, A. Hocker, U. Husemann, S. Korjenevski, W. Sakumoto, P. Slattery, P. Tipton, M. Zielinski

Rutgers, the State University of New Jersey, Piscataway, New Jersey, USA

E. Bartz, J. Doroshenko, E. Halkiadakis, P.F. Jacques, M.S. Kalelkar, D. Khits, A. Lath, A. Macpherson**1, L. Perera, R. Plano, K. Rose, S. Schnetzer, S. Somalwar, R. Stone, G. Thomson, T.L. Watts

Texas Tech University, Lubbock, Texas, USA

N. Akchurin, K.W. Carrell, K. Gumus, C. Jeong, H. Kim, V. Papadimitriou, A. Sill, M. Spezziga, E. Washington, R. Wigmans, L. Zhang

Vanderbilt University, Nashville, Tennessee, USA

T. Bapty, D. Engh, W. Johns, T. Keskinpala, E. Luiggi Lopez, S. Neema, S. Nordstrom, S. Pathak, P. Sheldon, E.W. Vaandering, M. Webster

University of Virginia, Charlottesville, Virginia, USA

M.W. Arenton, S. Conetti, B. Cox, R. Hirosky, R. Imlay, A. Ledovskoy, D. Phillips II, H. Powell, M. Ronquest, D. Smith

University of Wisconsin, Madison, Wisconsin, USA

Y.W. Baek, J.N. Bellinger, D. Bradley, D. Carlsmith, I. Crotty**1, S. Dasu, F. Feyzi, T. Gorski, M. Grothe**37, W. Hogg, M. Jaworski, P. Klabbers, A. Lanaro, R. Loveless, M. Magrans de Abril, D. Reeder, W.H. Smith, D. Wenman

Yale University, New Haven, Connecticut, USA

G.S. Atoyan**36, S. Dhawan, V. Issakov, H. Neal, A. Poblaguev, M.E. Zeller

Institute of Nuclear Physics of the Uzbekistan Academy of Sciences, Ulugbek, Tashkent, UZBEKISTAN

B.S. Yuldashev

**1: Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland

**2: Also at University of Zagreb, Zagreb, Croatia

**3: Also at California Institute of Technology, Pasadena, USA

**4: Also at Université de Haute-Alsace, Mulhouse, France

**5: Also at Université Louis Pasteur, Strasbourg, France

**6: Now at Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain

**7: Also at Moscow State University, Moscow, Russia

**8: Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary

**9: Also at University of California, San Diego, La Jolla, USA

**10: Also at Tata Institute of Fundamental Research - HECR, Mumbai, India

**11: Also at University of Visva-Bharati, Santiniketan, India

**12: Also at University of California, Riverside, Riverside, USA

**13: Also at Centro Studi Enrico Fermi, Roma, Italy

**14: Also at ENEA - Casaccia Research Center, S. Maria di Galeria, Italy

- **15: Now at Università del Piemonte Orientale, Novara, Italy
- **16: Also at Institute of Physics, Swietokrzyska Academy, Kielce, Poland
- **17: Also at Warsaw University of Technology, Institute of Electronic Systems, Warsaw, Poland
- **18: Also at Institute for Particle Physics, ETH Zurich, Zurich, Switzerland
- **19: Also at Faculty of Physics of University of Belgrade, Belgrade, Serbia
- **20: Also at INFN-CNAF, Bologna, Italy
- **21: Also at University of Athens, Athens, Greece
- **22: Now at University of California, Davis, Davis, USA
- **23: Now at ESO, Munich-Garching, Germany
- **24: Also at Institute for Theoretical and Experimental Physics, Moscow, Russia
- **25: Also at Paul Scherrer Institut, Villigen, Switzerland
- **26: Also at Izmir Institute of Technology (IYTE), Izmir, Turkey
- **27: Also at Mugla University, Mugla, Turkey
- **28: Also at Marmara University, Istanbul, Turkey
- **29: Also at Kafkas University, Kars, Turkey
- **30: Also at Suleyman Demirel University, Isparta, Turkey
- **31: Also at Ege University, Izmir, Turkey
- **32: Also at Rutherford Appleton Laboratory, Didcot, United Kingdom
- **33: Also at Università di Padova e Sezione dell' INFN, Padova, Italy
- **34: Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary
- **35: Also at University of Debrecen, Debrecen, Hungary
- **36: Also at Institute for Nuclear Research, Moscow, Russia
- **37: Also at Università di Torino e Sezione dell' INFN, Torino, Italy
- **38: Also a Marie-Curie Fellow.

Executive Summary

The Large Hadron Collider will provide extraordinary opportunities in particle physics based on its unprecedented collision energy and luminosity when it begins operation in 2007. The principal aim of this Technical Design Report is to present the strategy of CMS to explore the rich physics programme offered by the LHC: Volume 1 covering the operational procedures and reconstruction tools necessary to perform physics at the LHC, and Volume 2 demonstrating the physics capability of the CMS experiment based on this foundation. A description of the procedures and reconstruction tools specifically for LHC start-up, including the performance of the High-Level Trigger algorithms and the early physics opportunities, will be published in an addendum to this Report.

In the first volume we highlight the final detector configuration as it will appear shortly after LHC start-up, including new detectors in the forward regions and for determining the beam luminosity. Results on the performance of the CMS detectors as obtained from detailed simulations are presented for realistic operating conditions, and validated where possible against test-beam or cosmic-ray data. Schemes to synchronise, calibrate, align, and monitor the detectors before, during and after LHC start-up are also given. Reconstruction algorithms developed to perform measurements of muons, electrons, photons, jets, taus, heavy-flavour quarks and the missing transverse energy using these detector subsystems are described. The performance of the reconstruction algorithms is determined from detailed simulations for realistic operating conditions, but techniques to measure the performance from LHC data are described as well. Parameterisations of the performance have been derived to facilitate faster simulations for some of the physics studies described in Volume 2. Included in this first volume are descriptions of the software components needed to implement all of the above, covering simulation, reconstruction, calibration and alignment, monitoring, and visualisation.

The second volume covers the capability of the CMS experiment to address physics at the LHC. The prime goals of CMS are to explore physics at the TeV scale and to study the mechanism of electroweak symmetry breaking—through the discovery of the Higgs particle or otherwise. To carry out this task, CMS must be prepared to search for new particles, such as the Higgs boson or supersymmetric partners of the Standard Model particles, from the start-up of the LHC since new physics at the TeV scale may manifest itself with modest data samples of the order of a few fb^{-1} or less. The experience of the Magnet Test and Cosmic Challenge, scheduled for second quarter 2006, plays a crucial role in the preparation of CMS experiment, whereby calibration, alignment and reconstruction procedures are tested and made ready in advance of the LHC pilot and first physics runs. Lessons drawn from this test, as well as the plans for the first physics runs, will be described in an addendum to this Report.

The tools that have been prepared in Volume 1 are applied in Volume 2 to study in great detail and with all the methodology of performing an analysis on CMS data specific benchmark processes upon which to gauge the performance of CMS. These processes cover several

Higgs boson decay channels, the production and decay of new particles such as Z' and supersymmetric particles, B_s production and processes in heavy ion collisions. The simulation of these benchmark processes includes subtle effects such as possible detector miscalibration and misalignment. Besides these benchmark processes, the physics reach of CMS is studied for a large number of signatures arising in the Standard Model and also in theories beyond the Standard Model for integrated luminosities ranging from 1 fb^{-1} to 30 fb^{-1} . The Standard Model processes include QCD, B -physics, diffraction, detailed studies of the top quark properties, and electroweak physics topics such as the W and Z^0 boson properties. The production and decay of the Higgs particle is studied for many observable decays, and the precision with which the Higgs boson properties can be derived is determined. About ten different supersymmetry benchmark points are analysed using full simulation. The CMS discovery reach is evaluated in the SUSY parameter space covering a large variety of decay signatures. Furthermore, the discovery reach for a plethora of alternative models for new physics is explored, notably extra dimensions, new vector boson high mass states, little Higgs models, technicolour and others. Methods to discriminate between models have been investigated.

In summary, the content of these two volumes is meant to serve as a comprehensive reference for new CMS collaborators. It provides an entry point to the documentation of the standard simulation, reconstruction, and analysis tools and provides a measure of the expected detector performance and physics reach as we head into the LHC era.

Structure of Volume 2

Chapter 1, the Introduction, describes the context of this document.

Chapters 2-6 describe examples of full analyses, with photons, electrons, muons, jets, missing E_T , B -mesons and τ 's, and for quarkonia in heavy ion collisions.

Chapters 7-15 describe the physics reach for Standard Model processes, Higgs discovery and searches for new physics beyond the Standard Model.