2.10 Nucleon form factors in PHOKHARA

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The electromagnetic nucleon form factors were studied from the conception of particle physics [1, 2, 3, 4]. and yet a lot has to be done to built a model which meets requirements in the era of precision hadronic physics. The not expected developments in this field show that we still have much to learn. The measurements of the ratio of the electric and magnetic form factors of the proton with two different methods were giving different results [5]. The two-photon exchange radiative corrections explaining to large extent this difference (see [6] for review) turned out to be unexpectedly large. Moreover their modelling goes beyond the nucleon form factor modelling adding to the complexity of the problem. In addition, usually the models are built separately in the space-like (see [7] for review) or time-like regions (see [8] for review). As one expects that each of the form factors is a unique analytic function valid in both space-like and time-like regions this attitude has to be changed and a model describing both regions has to be constructed. A step towards such a model was done in [9]. The model describes well data from both space-like and time-like regions. The form factors are normalised properly at zero invariant mass and, by construction, have correct behaviour [10] at large invariant masses. Yet the model is far from being satisfactory and further studies of photon-nucleon interactions are necessary. It is also clear that the progress can be achieved only through close collaboration of experimental and theory groups. Careful studies of charge and/or forward-backward asymmetries in $e^+e^- \to \bar{p}p$, $e^+e^- \to \bar{p}p\gamma$ processes together with angular distributions in $e^-p \to e^-p$ and $e^+p \to e^+p$ processes should allow for disentangling of the two-photon exchange contributions from the form factors.

Model testing is simplified if it is implemented into a Monte Carlo event generator. Such a generator serves also for other purposes like calculations of acceptance and/or efficiency corrections. For the radiative return (called also ISR) method such a tool was developed some time ago [11]. Nucleon final states were implemented in it already in [12] and the nucleon form factors were updated in [9], where also the modelling of the final state radiative corrections was addressed. Recently [13] also a possibility of generation of the process $e^+e^- \to$ hadrons, useful for scan experiments, was added.

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References

[1] I. Estermann, R. Frisch, and O. Stern Nature **132** (1933) 169.

[2] M. N. Rosenbluth, Phys. Rev. **79** (1950) 615.

[3] R. W. Mcallister and R. Hofstadter, Phys. Rev. **102** (1956) 851.

[4] R. Hofstadter, Rev. Mod. Phys. **28** (1956) 214.

[5] J. Arrington, Phys. Rev. C **68** (2003) 034325 [nucl-ex/0305009].

[6] C. E. Carlson and M. Vanderhaeghen, Ann. Rev. Nucl. Part. Sci. **57** (2007) 171 [hep-ph/0701272 [HEP-PH]].

[7] C. F. Perdrisat, V. Punjabi and M. Vanderhaeghen, Prog. Part. Nucl. Phys. **59** (2007) 694 [hep-ph/0612014].

[8] A. Denig and G. Salme, Prog. Part. Nucl. Phys. **68** (2013) 113 [arXiv:1210.4689 [hep-ex]].

[9] H. Czyz, J. H. Kuhn and S. Tracz, arXiv:1407.7995 [hep-ph].

[10] G. P. Lepage and S. J. Brodsky, Phys. Rev. D **22** (1980) 2157.

[11] G. Rodrigo, H. Czyz, J. H. Kuhn and M. Szopa, Eur. Phys. J. C **24** (2002) 71 [hep-ph/0112184].

[12] H. Czyz, J. H. Kuhn, E. Nowak and G. Rodrigo, Eur. Phys. J. C **35** (2004) 527 [hep-ph/0403062].

[13] H. Czyz, M. Gunia and J. H. Kuhn, JHEP **1308** (2013) 110 [arXiv:1306.1985, arXiv:1306.1985 [hep-ph]].