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Evaluation of the Thesis submitted by Krzysztof Pawel Mekala

Dear Sirs and Ladies,

with this letter I would like to confirm that I am very impressed by the excellent and comprehensive thesis of Krzysztof Mekala. He covered in his work both the phenomenology and improved description of electroweak interactions at lepton colliders as well as the implementation of the formalism in WHIZARD.

Although the impressive results and precise measurement of the LHC new physics did not yet lead to a further discovery beyond the Higgs boson. Nevertheless the great success of the Standard Model (SM) several open questions, as, for instance the hierarchy problem, gauge unification and dark matter candidates, are open and ask for physics beyond the SM.

Since the scale have the new physics scale is still unclear there is a high demand for both high-precision theoretical predictions and for high precision measurements at future experiments. This includes the luminosity upgrade of the LHC but in particular the planned e^-e^+ and $\mu^-\mu^+$-colliders. The electroweak sector is one of the best motivated part for expecting deviations from the Standard Model predictions and in particular the clean Z-boson and its couplings is the place where to look at first motivated from the great successes of LEP and SLC already in the past. Exactly this area is one of Krzysztofs main foci in his thesis.

The first part treated the possibility how to improve measurements of Z-boson couplings to (light) quarks by about an order of magnitude. The method was worked out for operation at the Z-pole. Krzysztof worked out how to simultaneously exploit hadronic decays of the Z-boson in combination with the inclusion of radiative decay.

Fitting both results and exploiting a large statistics expected at future colliders and applying sophisticated quark flavour jet-tagging leads to an improvement of about one order of magnitude with respect to the former LEP results. He even was able to include s-quark tagging and it is impressive how accurate, careful and comprehensive Krzysztof describes the procedures, the method, the limitations and the dependences/correlations. It is a great pleasure to read.

The other focus topic in his thesis is the application of the equivalent vector boson approximation and his compelling discussion about this method in general, the comparison with the 'coloured' PDFs, again the limitations and its implementation in WHIZARD which uniquely allows to apply the worked out method for suitable cases.

That leads to a great simplification for coding and timing issues but only in the cases where this approximation is valid. Krzysztof compared it with the full matrix-element approach and discussed the results in detail for several Standard Model processes. Again his scientific view on all aspects is impressive, the limitations, the assumptions, the ranges and it clearly spells out the advantages of this method and under which circumstances to be used.

The PhD thesis is well written, all plots are well readable, the denotations are clear, important formulae are well labeled, the derivation of the calculations is clearly explained. All references are clearly labelled. The literature is absolutely impressive and shows the broad overview of the whole field that Krzysztof got during his PhD time. In the Appendices he provides in particular an excellent and compact overview about all currently discussed future lepton collider and detector design. Therefore Krzysztofs thesis fulfills as well all formal requirements of an excellent thesis.

Overall: the topic of the thesis is of high scientific importance and of high timely relevance. These newly worked out methods for determining the light Z-quark coupling could lead to an impressive improvement of the measurements. The thesis lays out the exact framework in a comprehensive manner for applying EVA appropriately. The implementation of the EVA method in WHIZARD allows to save computing time and power. In addition, this thesis provides an fantastic overview on the fundamentals of Monte-Carlo generators, on the concepts of possible future collider designs, on the calculation of electroweak PDFs, on the interplay with the coloured sector, on the basics of the used statistics, it is an impressive comprehensive study of state-of-the-art physics.

Therefore I strongly recommend the acceptance of the thesis and would strongly encourage the candidate to continue with his excellent contributions. Krzysztof thesis fulfills very well all criteria of a thesis and I congratulate to such an excellent and comprehensive work. His findings are of extremely high relevance for all future collider designs!

Sincerely Yours,

G. Moortgat-Pick