PROCEEDINGS OF SCIENCE

The Strong2020 and Radio MonteCarLow activities

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In the past 15 years, the development of radiative corrections and Monte Carlo generators for low-energy positron-electron (e^+e^-) data and τ-lepton decays was the topic of the Radiative Corrections and Monte Carlo Generators for Low Energies Working Group (Radio MontCarLow WG). The group focused on facilitating the communication between theorists and experimentalists from the low-energy e^+e^- field and τ-community, which lead in 2010 to the publication of an highly cited report about the progress made towards precision hadronic physics at low energy. Recently, parts of the Radio MonteCarLow Working Group program were included as a Joint Research Initiative in the group application of the European hadron physics community Strong2020. A goal of this working group is the production of the PrecisionSM database which is an annotated database for low-energy hadronic cross-sections in e^+e^- collisions.
This proceeding reviews the results published by the Radio MonteCarLow Working Group and describes the status of the PrecisionSM database.

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1. Introduction

The recent confirmation of the long-standing discrepancy between the theoretical and the experimental values of the muon anomalous magnetic moment, a_μ, published by the Fermilab Muon $g-2$ Collaboration [1] revived the efforts of the Radio MonteCarLow working group [2] . The group focused on the development of the radiative corrections and the Monte Carlo generators which are necessary to calculate the hadronic component of a_μ using a data-driven approach based on the dispersion relation [3]. To compute the dispersion integral are needed, as input, cross-sections values from low-energy e^+e^- experiments. Therefore, recently the Strong2020 [4] project is producing an annotated database that collects the low-energy hadronic cross-sections available in literature.

2. The Radio MonteCarLow Activities

The Radio MonteCarLow WG was active between 2006 and 2019, during which the group organized 20 meetings in which theorists and experimentalists discussed the status of radiative corrections and Monte Carlo (MC) generators at low energies. During the meetings they focused on technical details and progress of radiative corrections and MC generators for:

- luminosity
- $e^+e^- \rightarrow$ leptons and hadrons,
- $e^+e^- \rightarrow$ hadrons + energetic γ from initial state radiation (ISR),
- τ production and decays.

Example of MC generators that were considered are BabaYaga@NLO (for luminosity measurements), PHOKHARA (for QED exclusive channels simulations) and MCGPJ (for simulations of $e^+e^- \rightarrow hadrons+\gamma$ processes with Initial State Radiation). Whenever possible tuned comparison and evaluation of missing higher-order were performed.

Result of this synergetic cooperation between the participants of the Radio MonteCarLow WG meetings produced a final report titled "Quest for precision in hadronic cross sections at low energy: Monte Carlo tools vs. experimental data" (published in 2010) [5]. This final report is divided in 5 sections:

1. high-precision luminosity measurements at low energies meson factories (up to B factories energy).
2. aspects of the direct R measurement performed at experiments with energy scans.
3. radiative return (another name for ISR), which refers at the presence of pronounced resonances with energy lower than the collider energy.
4. τ physics.
5. calculation of vacuum polarization with emphasis on the hadronic contributions.

Each section contains an overview of the experimental results and the status of Monte Carlo generators. Moreover, the report contains the achievements on hadronic cross section measurements and on τ-physics, as well as it outlines the prospects for future years.

3. The Strong2020 Project and the Precision Standard Model DataBase

Recently, parts of the Radio MonteCarLow Working Group program continued under the European project Strong2020. The Strong2020 project aims to study the strong interactions combining knowledge from many frontiers *i.e.*, high and low energy physics, instrumentation and research infrastructures. In particular, within the low energy frontier projects an activity called PrecisionSM focuses on the hadronic contribution to the anomalous magnetic moment of the muon. The group involved published in 2021 a report [6] that describes the status of the following topics:

1. R measurement,
2. Radiative Corrections and Monte Carlo generators for time-like processes,
3. Radiative Corrections and Monte Carlo generators for space-like processes.

One of the goals of the project is to build the annotated Strong2020 PrecisionSM DataBase for low-energy cross sections in $e^+e^- \to hadronic$. The database project includes:

1. uploading in the public repository HEPData [7] all measurements collected from experiments,
2. cataloguing the measurements in the PrecisionDB Website [8].

At present, we are in the process of cataloging $e^+e^- \to \pi^+\pi^-$ measurements, important for the calculation of the Hadronic Vacuum Polarization diagram to the Muon $g-2$. Figure 1 shows some of the pages of website.

4. Conclusions

The Radio MonteCarLow and the Strong2020 Working Groups are facilitating the collaboration between the experimental and theoretical groups with the goal of understanding the status of Monte Carlo generators for low energy e^+e^- into hadrons processes. All these efforts have been recently revitalized by the new high-precision measurement of the anomalous magnetic moment of the muon at Fermilab [1]. The work that is in progress comprises the creation of an annotated database and the implementation of radiative corrections into a full NNLO MC generator for low-energy hadronic cross sections in e^+e^- collisions [9].

5. Acknowledgements

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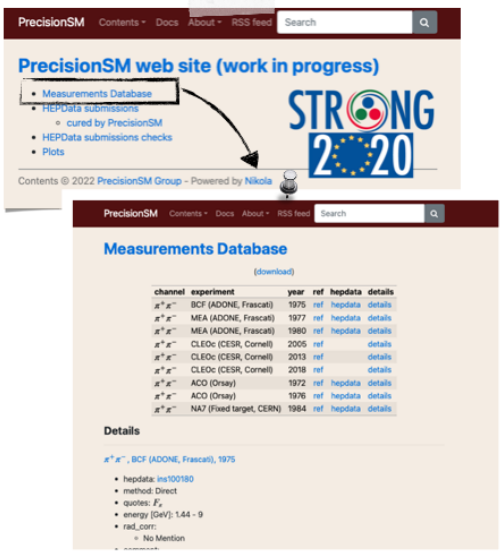

Figure 1: Pictures of the main page and the $\pi^+\pi^-$ channel measurement page from the Precision SM annotated database website that can be reached here [8].

References

[1] B. Abi *et. al* [Muon $g-2$ Collaboration], *Measurement of the Positive Muon Anomalous Magnetic Moment to 0.46 ppm*, Phys. Rev. Lett. **126**, 141801 (2021).

[2] Website of theWorking Group on Rad. Corrections and MC Generators for Low Energies: www.lnf.infn.it/wg/sighad/

[3] T. Aoyama *et. al*, *The anomalous magnetic moment of the muon in the Standard Model*, Phys. Rep. **887**, 1 (2020).

[4] STRONG2020 Webpage: http://www.strong-2020.eu.

[5] S. Actis *et al.* [Working Group on Radiative Corrections and Monte Carlo Generators for Low Energies], *"Quest for precision in hadronic cross sections at low energy: Monte Carlo tools vs. experimental data,"* Eur. Phys. J. C **66** (2010), 585-686

[6] G. Abbiendi, A. Arbuzov, S. Banerjee, D. Biswas, E. Budassi, G. Colangelo, H. Czyż, M. Davier, A. Denig and A. Driutti, *et al. "Mini-Proceedings of the STRONG2020 Virtual Workshop on "Space-like and Time-like determination of the Hadronic Leading Order contribution to the Muon $g-2$","* [arXiv:2201.12102].

[7] HepData Webpage: https://www.hepdata.net.

[8] Precision Standard Model Database Webpage: https://precision-sm.github.io.

[9] Talk by A. Signer "Status of Strong2020 Workstop in June 2023 at UZH", at the Muon Precision Physics Workshop in Liverpool.