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The STRONG2020 and Radio MonteCarLow activities

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Abstract: For over 15 years, the "Radiative Corrections and Monte Carlo Generators for Low Energies" Working Group (Radio MonteCarLow WG) has been providing valuable support to the development of radiative corrections and Monte Carlo generators for low energy positron-electron data and tau-lepton decays. The Radio MonteCarLow WG held 20 meetings in which theorists and experimentalists, experts working in the field of positron-electron physics and partly also from the tau community, produced the higlhy-cited report "Quest for precision in hadronic cross sections at low energy: Monte Carlo tools vs. experimental data". Recently, parts of the program have been included as a Joint Research Initiative in the group application of the European hadron physics community, STRONG2020, to the European Union. A specific goal of the working group is to create the annotated "PrecisionSM database" for low-energy hadronic cross sections in positron-electron collisions. The database will contain information about the reliability of the data sets, their systematic errors, and the treatment of Radiative Corrections. This proceeding reviews the results published by the Radio MonteCarLow WG and describes the status of the PrecisionSM database.

Keywords: Analysis and statistical methods; Performance of High Energy Physics Detectors

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Contents

1 Introduction

The efforts of the Radio MonteCarLow Working Group (see http://www.lnf.infn.it/wg/sighad/) have recently been revived. In 2021, the first results of the Muon $g-2$ experiment at Fermilab confirmed the long-standing discrepancy between the experimental value of the muon anomalous magnetic moment (a_μ) and the Standard Model prediction based on the dispersive data-driven approach, bringing its significance to $4.2\,\sigma$ [1, 2]. In 2021, using the lattice QCD approach, the BMW collaboration presented a prediction of a_μ^{HVP} which was in tension with the prediction from the dispersive approach, and which stands $1.5\,\sigma$ away from the experimental value [3]. The recent measurement of the $e^+e^- \rightarrow \pi^+\pi^-$ cross section with the CMD-3 detector evaluated the hadronic contribution to the muon anomalous magnetic moment that was significantly larger than the value obtained from previous measurements [4], and hence it was less in tension with the experimental measurement of a_μ.

2 The Radio MonteCarLow WG activities

During 20 meetings from 2006 to 2019, the synergetic cooperation between experimentalists and theorists of the Radio MonteCarLow WG focused on technical details and on the progress of radiative corrections and Monte Carlo generators, and produced a final report divided in 5 sections [5]: high-precision luminosity measurements at low energies meson factories; aspects of the direct R measurement performed at $e^+e^- \rightarrow\ hadrons$ experiments with energy scans; Initial State Radiation; τ-lepton physics; calculation of vacuum polarization with emphasis on the hadronic contributions. The report contained overviews of experimental results and the status of Monte Carlo generators for each section, as well as the achievements in hadronic cross section measurements and in τ-lepton physics, and finally it outlined the future prospects for the following years.

3 The annotated PrecisionSM database in the Strong2020 Project

The European Union Strong2020 Project (see http://www.strong-2020.eu/) recently incorporated parts of the Radio MonteCarLow WG, with the aim of studying strong interactions by combining

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knowledge from many frontiers: high and low energy physics, instrumentation and research infrastructures. Within this project, the PrecisionSM activity focuses on the hadronic contribution to the anomalous magnetic moment of the muon: R measurements, Radiative Corrections and Monte Carlo generators for time-like and space-like processes (see the report in ref. [6]). One of the goals is to compile an annotated database for low-energy hadronic cross sections in e^+e^- collisions, which involves several steps: we collect inputs from experiments published on InspireHEP; the Point-of-Contact of a published experiment submits data (tables of cross sections and/or form factors as a function of the energy) to the public repository HepData; a reviewer is appointed for cross checks, to make sure there are no mistakes and that the data follows the HepData prescriptions; when the data is validated, it is catalogued in the PrecisionSM database https://precision-sm.github.io/. As shown in figure 1, we have catalogued $e^+e^- \to \pi^+\pi^-$ measurements, a particularly important channel for the calculation of the Hadronic Vacuum Polarization diagram to the Muon $g-2$, and we are in the process of reviewing other channels.

Database for $e^+e^- \to \pi^+\pi^-$ channels

Experiment	Year	Reference (link to INSPIRE-HEP)	Link to Hepdata	Details	Status
BESIII (BEPC, Beijing)	2016	Phys.Lett.B 753(2016) 629-638 [errata: Phys.Lett.B 812 (2021) 135982]	ins1385603	details	Finalized
BaBar (SLAC, Stanford U.)	2016	Phys.Rev.D 86 (2012) 032013		details	In Preparation
CLEO (CESR, Cornell U.)	2018	Phys.Rev.D 97 (2018) 3, 032012	ins1643020	details	Finalized
CLEO (CESR, Cornell U.)	2013	Phys.Rev.Lett. 110 (2013) 2, 022002	ins1189656	details	Finalized
CLEOc (CESR, Cornell U.)	2005	Phys.Rev.Lett. 95 (2005) 261803	ins693873	details	Finalized
KLOE (DAPHNE, Frascati)	2017	JHEP 03 (2018) 173		details	In Preparation
KLOE (DAPHNE, Frascati)	2012	Phys.Lett.B 720 (2013) 336-343		details	In Preparation
KLOE (DAPHNE, Frascati)	2010	Phys.Lett.B 700 (2011) 102-110		details	In Preparation
KLOE (DAPHNE, Frascati)	2008	Phys.Lett.B 670 (2009) 285-291	ins797438	details	In Review
KLOE (DAPHNE, Frascati)	2004	Phys.Lett.B 606 (2005) 12-24, 2005	ins655225	details	In Review
MEA (ADONE, Lab. Naz. Frascati)	1980	Lett.Nuovo Cim. 28 (1980) 337-342	ins158283	details	Finalized
MEA (ADONE, Lab. Naz. Frascati)	1977	Phys.Lett.B 67 (1977) 239-242	ins124109	details	Finalized
BCF (ADONE, Lab. Naz. Frascati)	1975	Lett.Nuovo Cim. 14 (1975) 418	ins100180	details	Finalized
NA007 (CERN)	1984	Phys.Lett.B 138 (1984) 454-458	ins195944	details	Finalized
ACO (Orsay)	1976	LAL-1287	ins109771	details	Finalized
ACO (Orsay)	1972	Phys.Lett.B 39 (1972) 289-293	ins73648	details	Finalized
DM2 (DCI, Orsay)	1989	Phys.Lett.B 220 (1989) 321-327	ins267118	details	Finalized
DM1 (DCI, Orsay)	1978	Phys.Lett.B 76 (1978) 512-516	ins134061	details	Finalized
SND (VEPP-2000, Novosibirsk)	2021	JHEP 01 (2021) 113	ins1789269	details	Finalized
SND (VEPP-2M, Novosibirsk)	2005	J.Exp.Theor.Phys. 101 (2005) 6, 1053-1070, Zh.Eksp.Teor.Fiz. 128 (2005) 6, 1201-1219 [errata: HEP-EX/0605013]	ins686349	details	Finalized
CMD2 (VEPP-2M, Novosibirsk)	2007	Phys.Lett.B 648 (2007) 28-38	ins728302	details	Finalized
CMD2 (VEPP-2M, Novosibirsk)	2006	JETP Lett. 84 (2006) 413-417, Pisma Zh.Eksp.Teor.Fiz. 84 (2006) 491-495	ins728191	details	Finalized
CMD2 (VEPP-2M, Novosibirsk)	2005	JETP Lett. 82 (2005) 743-747, Pisma Zh.Eksp.Teor.Fiz. 82 (2005) 841-845	ins712216	details	Finalized
CMD2 (VEPP-2M, Novosibirsk)	2002	Phys.Lett.B 527 (2002) 161-172 [errata: HEP-EX/0308008]	ins568807	details	Finalized
OLYA (VEPP-2M, Novosibirsk)	1984	Nucl.Phys.B 256 (1985) 365-384	ins221309 Table 1	details	Finalized
CMD (VEPP-2M, Novosibirsk)	1983	Nucl.Phys.B 256 (1985) 365-384	ins221309 Table 2	details	Finalized
TOF (VEPP-2M, Novosibirsk)	1981	Yad.Fiz. 33 (1981) 709-714, Sov.J.Nucl.Phys. 33 (1981) 368-370	ins167191	details	Finalized
VEPP-2 (Novosibirsk)	1972	Phys.Lett.B 41 (1972) 205-208	ins75634	details	Finalized
VEPP-2 (Novosibirsk)	1971	Phys.Lett.B 34 (1971) 328-332	ins69313	details	Finalized
VEPP-2 (Novosibirsk)	1969	Yad.Fiz. 9 (1969) 114-119, Phys.Lett.B 25 (1967) 6, 433-435	ins57008	details	Finalized

(download)

Figure 1. Screenshot of the table from the PrecisionSM website that lists all published measurements in the $e^+e^- \to \pi^+\pi^-$ channel. The up-to-date version of the table is accessible from the following link: https://precision-sm.github.io/2pi-db/.

Ultimately, users will be able to access responsive plots of hadronic cross sections and form factors, like the ones that are currently present for a selection of channels. Some examples are shown in figure 2: these tools allow users to toggle on/off different experiments or channels when displaying the physics plots.

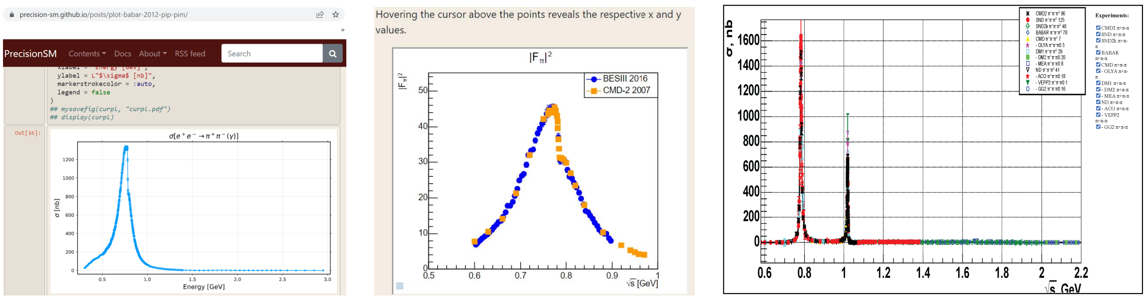

Figure 2. Example of responsive plots of hadronic measurements stored in HepData.

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4 Conclusions

The Radio MonteCarLow and the Strong2020 Working Groups have been facilitating the collaboration between the experimental and theoretical groups with the goal of understanding the status of Monte Carlo generators for low energy hadronic e^+e^- processes. The PrecisionSM activity is contributing with a database for low-energy hadronic cross sections with relevant information (e.g. Radiative Corrections treatment and systematic errors). All these efforts have been recently revived by the new high-precision measurement of the anomalous magnetic moment of the muon at Fermilab [7], and by the measurement of the $e^+e^- \to \pi^+\pi^-$ cross section with the CMD-3 detector.

Acknowledgments

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