PrecisionSM: an annotated database for low-energy $e^+e^- \to$ hadrons

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on behalf of the Strong2020 group.

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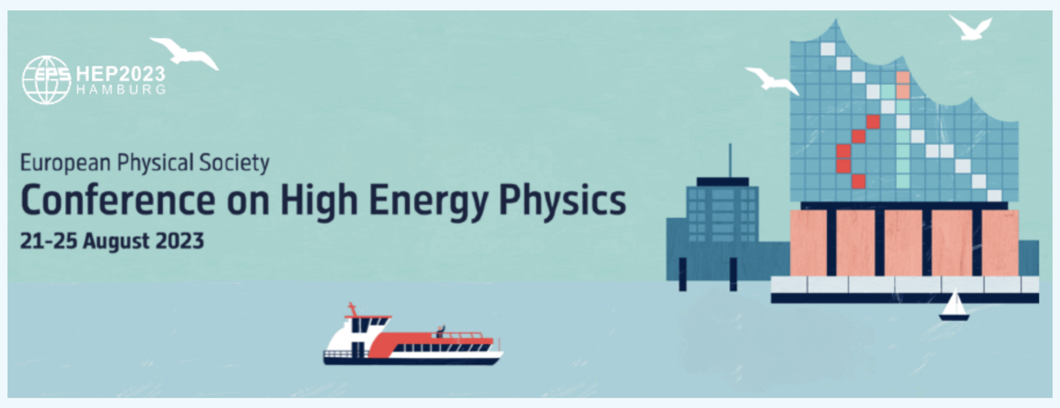


Abstract

PrecisionSM is an annotated database for low-energy e^+e^- into hadrons developed within the European Project STRONG2020 [1]. It relies on a custom web site (https://precision-sm.github.io) to list the measurements with links to their HEPData (https://www.hepdata.net/) location together with examples of tools to elaborate on them. The database contains information about the datasets, the systematic uncertainties and the treatment of Radiative Corrections. Such information is important for performing precision tests of the Standard Model, in the anomalous magnetic moment of the muon or in the electroweak sector where a limiting factor is the accuracy on the effective electromagnetic coupling at the Z boson mass.

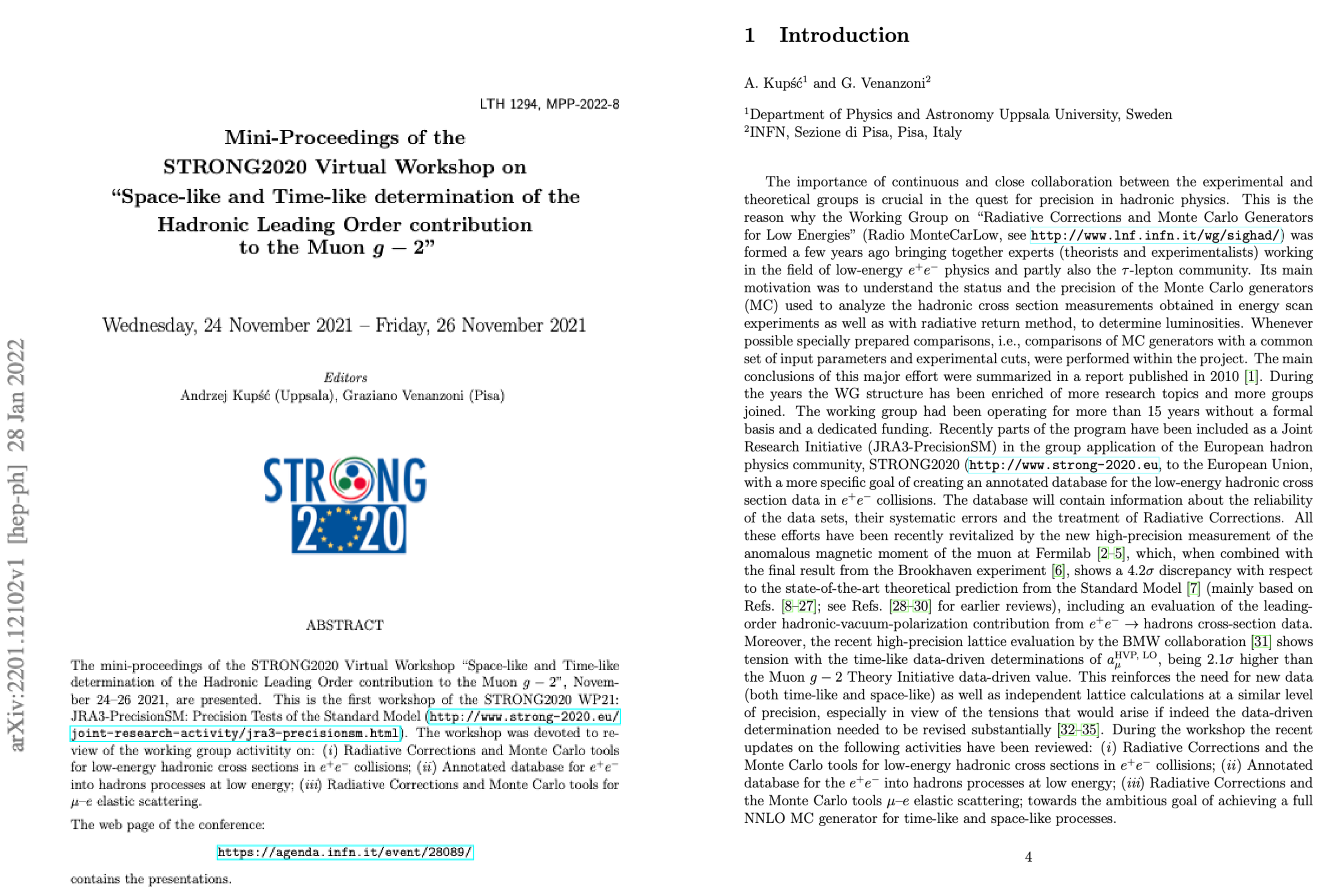
The Strong2020 Project

- EU project that aims to **study strong interactions** combining knowledge from many frontiers:

LOW ENERGY | HIGH ENERGY | INSTRUMENTATION | INFRASTRUCTURES

PrecisionSM: "Hadron Physics for Precision Tests of the Standard Model"

- Task within the Strong2020 project with the goal of:
  - combining theory and experiment for Standard Model and Beyond precision tests, **Recent Working Group Report** [2]



LTH 1294, MPP-2022-8

Mini-Proceedings of the STRONG2020 Virtual Workshop on "Space-like and Time-like determination of the Hadronic Leading Order contribution to the Muon $g-2$"

Wednesday, 24 November 2021 – Friday, 26 November 2021

Editors
Andrzej Kupść (Uppsala), Graziano Venanzoni (Pisa)

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ABSTRACT

The mini-proceedings of the STRONG2020 Virtual Workshop "Space-like and Time-like determination of the Hadronic Leading Order contribution to the Muon $g-2$", November 24–26 2021, are presented. This is the first workshop of the STRONG2020 WP21: JRA3-PrecisionSM: Precision Tests of the Standard Model (http://www.strong-2020.eu/joint-research-activity/jra3-precisionsm.html). The workshop was devoted to review of the working group activitity on: (*i*) Radiative Corrections and Monte Carlo tools for low-energy hadronic cross sections in e^+e^- collisions; (*ii*) Annotated database for e^+e^- into hadrons processes at low energy; (*iii*) Radiative Corrections and Monte Carlo tools for μ–e elastic scattering.

The web page of the conference:

https://agenda.infn.it/event/28089/

contains the presentations.

1 Introduction

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The importance of continuous and close collaboration between the experimental and theoretical groups is crucial in the quest for precision in hadronic physics. This is the reason why the Working Group on "Radiative Corrections and Monte Carlo Generators for Low Energies" (Radio MonteCarLow, see http://www.lnf.infn.it/wg/sighad/) was formed a few years ago bringing together experts (theorists and experimentalists) working in the field of low-energy e^+e^- physics and partly also the τ-lepton community. Its main motivation was to understand the status and the precision of the Monte Carlo generators (MC) used to analyze the hadronic cross section measurements obtained in energy scan experiments as well as with radiative return method, to determine luminosities. Whenever possible specially prepared comparisons, i.e., comparisons of MC generators with a common set of input parameters and experimental cuts, were performed within the project. The main conclusions of this major effort were summarized in a report published in 2010 [1]. During the years the WG structure has been enriched of more research topics and more groups joined. The working group had been operating for more than 15 years without a formal basis and a dedicated funding. Recently parts of the program have been included as a Joint Research Initiative (JRA3-PrecisionSM) in the group application of the European hadron physics community, STRONG2020 (http://www.strong-2020.eu, to the European Union, with a more specific goal of creating an annotated database for the low-energy hadronic cross section data in e^+e^- collisions. The database will contain information about the reliability of the data sets, their systematic errors and the treatment of Radiative Corrections. All these efforts have been recently revitalized by the new high-precision measurement of the anomalous magnetic moment of the muon at Fermilab [2–5], which, when combined with the final result from the Brookhaven experiment [6], shows a 4.2σ discrepancy with respect to the state-of-the-art theoretical prediction from the Standard Model [7] (mainly based on Refs. [8–27]; see Refs. [28–30] for earlier reviews), including an evaluation of the leading-order hadronic-vacuum-polarization contribution from $e^+e^- \to$ hadrons cross-section data. Moreover, the recent high-precision lattice evaluation by the BMW collaboration [31] shows tension with the time-like data-driven determinations of $a_\mu^{\mathrm{HVP,\,LO}}$, being 2.1$\sigma$ higher than the Muon $g-2$ Theory Initiative data-driven value. This reinforces the need for new data (both time-like and space-like) as well as independent lattice calculations at a similar level of precision, especially in view of the tensions that would arise if indeed the data-driven determination needed to be revised substantially [32–35]. During the workshop the recent updates on the following activities have been reviewed: (*i*) Radiative Corrections and the Monte Carlo tools for low-energy hadronic cross sections in e^+e^- collisions; (*ii*) Annotated database for the e^+e^- into hadrons processes at low energy; (*iii*) Radiative Corrections and the Monte Carlo tools μ–e elastic scattering; towards the ambitious goal of achieving a full NNLO MC generator for time-like and space-like processes.

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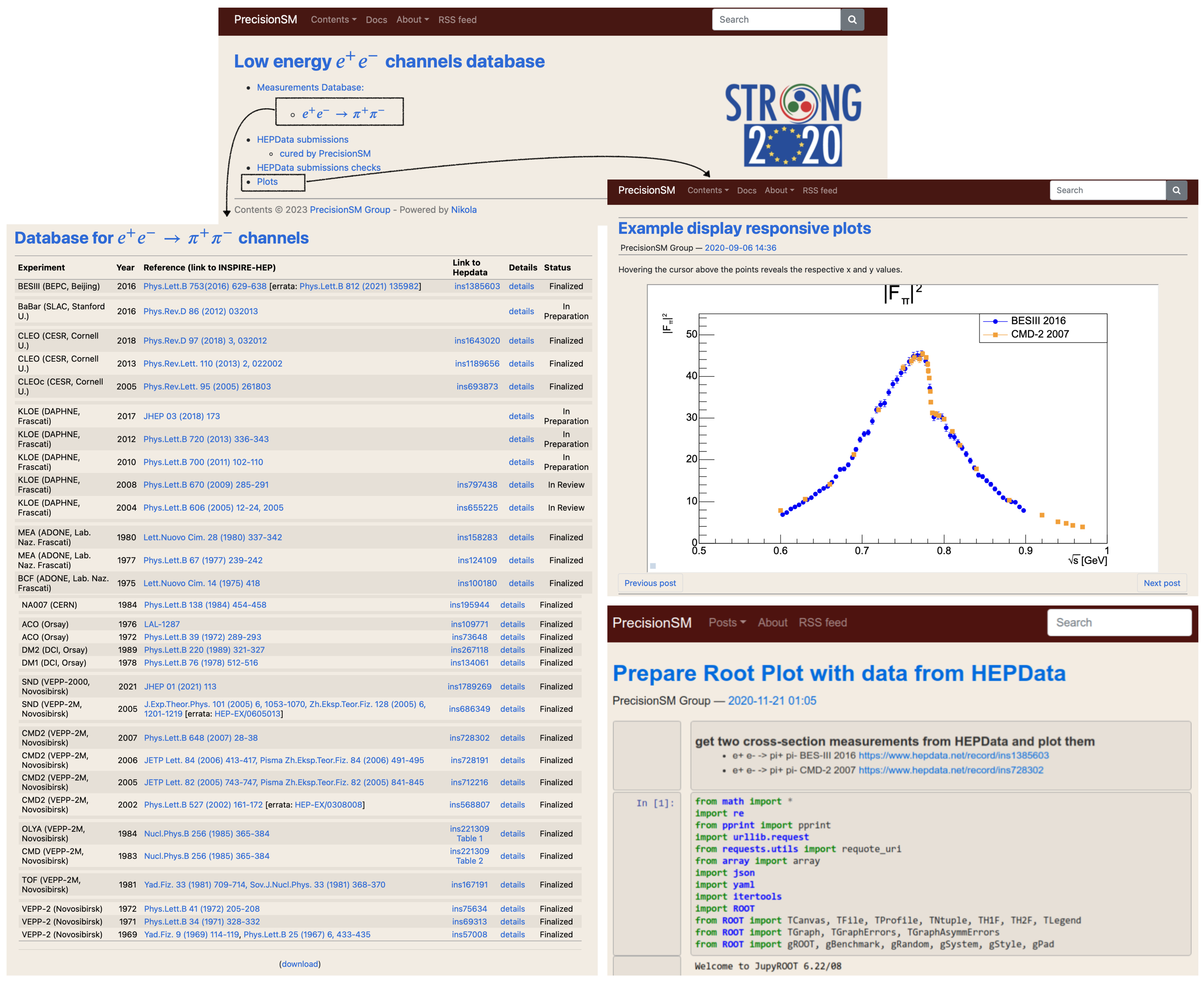
→ Topics:

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

- constructing the annotated **Strong2020 Precision SM DataBase** for low-energy cross sections in $e^+e^- \to hadronic$, which includes:
  1. uploading in the public repository HEPData [3] all measurements from all experiments
  2. cataloguing the measurements in the **PrecisionDB Website** [https://precision-sm.github.io]
     - it contains also examples on how to read HEPData measurements and prepare responsive plots

→ At present $e^+e^- \to \pi^+\pi^-$ measurements, important for the calculation of the Muon $g-2$ theoretical value, are catalogued.



Conclusions

The Strong2020 Working Group has the goal of facilitating the collaboration between the experimental and theoretical groups with the goal of understanding the status of the Monte Carlo generators and the measurements in hadronic physics. All these efforts have been recently revitalized by the new high-precision measurement of the anomalous magnetic moment of the muon at Fermilab [4][5]. PrecisionSM provides an annotated database for low-energy $e^+e^- \to hadrons$ cross-section data, which is relevant for the updated comparison of the muon g-2 measurement with the Standard Model prediction based on the evaluation of the leading-order hadronic-vacuum-polarization contribution that uses the dispersive approach [6].

References

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[5] Muon g-2 Collaboration http://arxiv.org/abs/2308.06230 (2023)
[6] T. Aoyama, *et al.* Phys. Rept. **887**, 1-166 (2020) [https://muon-gm2-theory.illinois.edu]

Acknowledgements

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