Introduction

A. Kupsc/G. Venanzoni 3rd Strong2020 Meeting – 26/5/2021



Agenda



3rd Meeting on database on hadronic cross sections Wednesday 26 May 2021, 10:00 → 12:35 Europe/Rome

10:00 \rightarrow 10:10 Introduction to the meeting

Speakers: Andrzej Kupsc (Uppsala University), Graziano Venanzoni (PI)

10:10 → 10:30 **DataBase web page status**

Speaker: Dr Alberto Lusiani (Scuola Normale Superiore and INFN, sezione di Pisa)

10:30 → 11:30 Report on pi+pi- channels in HEPDATA from various experiments

11:30 → 11:50 **Report at Theory Initiative meeting in June and future work**

11:50 → 12:00 **AoB**

STR SNG 2:20

Reminder: Strong2020

- European project (<u>http://www.strong-2020.eu</u>)
- WP21 JRA3 PrecisionSM: "Hadron Physics for Precision Tests of the Standard Model"
- Goal: combine theory and experiment for precision tests SM & BSM
- Task 2: Hadronic Effects in Precision Tests of the electromagnetic sector of the Standard Model: Muon g-2:
 - 2.1 Hadronic Vacuum Polarization from spacelike and timelike processes
 - 2.2 Hadronic Light-by-Light Scattering Contribution to $(g 2)\mu$
- Deliverable for Task 2.1:
 - database for low-energy hadronic cross sections in e+e- collisions.



- In June 2020 we discussed a first implementation of the DB (see https://agenda.infn.it/event/23209/)
- Data/experiments (maybe not all for updated calculation of g-2):
 - ACO, ADONE, ALEPH, AMY, ARGUS, BABAR, BBar, BCF, Belle, BES, BES3, BIG, CBALL, CELLO, CLEO, CMD, CMD2, CMD3, CUSB, DASP, DHHM, DM1, DM2, FENICE, GG2, JADE, KEDR, KLOE, LENA, M3N, MARK1, MARK3, MARKJ, MD1, MEA, MUPI, NA07, ND, OLYA, PLUTO, SND, SND2000, SPEAR, TASSO, TOF, TOPAZ, VENUS, VEPP2
 - +60 hadronic channels; +250 datasets
 - Statistical and systematic errors, covariance matrices, Radiative Corrections, etc..
 - Which data can be used (maybe some old set of data are superseded and/or can be discarded)?
 - Missing channels: parametrization, isospin relations,...?
- We need to identify one/two contact persons for each experiment



• Procedure:

- Precision SM web page (<u>https://precision-sm.github.io/</u>)
- Input data (from HEPData):
 - Published data
 - Additional data used in the measurements? (VP,RC,..)
- Check of «consistency» of input data
 - One person to upload the data; one person to check the correctness of these data. Both persons chosen by the collaboration?
- Responsive Plots
- Production of useful quantities (VP, alpha_EM, Adler Function...)
- Maintenance of the web page and polling to HEPData

• Discussion on Radiative Corrections:



- RC is certainly an important ingredient in our field.
- To understand the published measurement we need some knowledge/experts on methods and codes to deal with RC
- The discussion on RC is done in a more efficient way within the RadioMonteCarLow WG
- We could benefit from a discussion within the two groups (RMC vs Strong2020). The intersection is large.
- Common meetings/discussion?



- In December 2020 (<u>https://agenda.infn.it/event/25088/</u>) we decided to start with 2π channel
- $\pi^+\pi^-$ ACO BABAR BCF BES CLEO CMD CMD2 CMD3 DM1 DM2 KLOE MEA NA07 OLYA SND SND2000 TOF VEPP2
- -BaBar (Bogdan M)
 - -Old Frascati and Orsay data (Graziano V and Stefan M)
 - -BESIII (Achim D, Christoph R)
 - -CLEO (Graziano will contact the authors)
 - -CMD2/CMD3 (Simon E, Fedor I)
 - -KLOE (Stefan M)
 - -SND/SMD2000 (Mikhail A)
 - -Old Novosibirsk data (Simon E, Fedor I)

$\pi^+ \pi^-$ "old" Frascati data

- FRASCATI-ADONE-BCF, Bollini et al. Nuovo Cim.Lett.14(1975)418 <u>https://inspirehep.net/literature/100180</u> The Pion Electromagnetic Form-Factor in the Timelike Range 1.44 GeV²-9.0 GeV²
 - Energy range 1.44-GeV**2-9.0-GeV**2 -R
 - Pion FF Data and diagonal error in HEPData;
 - Errors not divided between statistical and systematic ones
 - No mention to RC, VP
- FRASCATI-ADONE-MEA, Esposito et al. PL B67(1977)239
 <u>https://inspirehep.net/literature/124109</u> Momentum Analysis of Kaon and Pion Pairs Produced from Timelike Photons at 1.6-GeV Energy
 - Energy Range: 1.6 GeV (one single point)
 - σ and Pion FF Data and error in HEPData
 - Error not divided between statistical and systematic one
 - No mention to RC, VP
 - No formula given from sigma to PFF
- #FRASCATI-ADONE-MEA, Esposito et al. NCL 28(1980)337
 <u>https://inspirehep.net/literature/158283</u> MEASUREMENTS OF THE EM TIMELIKE FORM-FACTORS
 FOR KAON AND PION AT S**(1/2) = 1.5-GEV
 - Energy Range: 1.45-1.52 GeV (one single point)
 - σ and Pion FF Data and error in HEPData
 - Error not divided between statistical and systematic one
 - No mention to RC, VP
 - Formula given from sigma to PFF

π^+ π^- Cleo data

- CESR-CLEO,T.K. Pedlar et al. Phys.Rev.Lett.95:261803,2005. <u>https://inspirehep.net/literature/693873</u> Precision measurements of the timelike electromagnetic form-factors of pion, kaon, and proton
 - Energy range 3.671 GeV (one point)
 - Pion FF and cross section Data and error
 - NO entries in HEPData;
 - Errors divided between statistical and systematic ones
 - Mention to RC (ISR and FSR and VP). Unclear if the PFF is with or w/out VP, FSR
- CESR-CLEO, Kamal K. Seth et al., Phys.Rev.Lett. 110 (2013) 2, 022002, <u>https://inspirehep.net/literature/1189656</u> Electromagnetic Structure of the Proton, Pion, and Kaon by High-Precision Form Factor Measurements at Large Timelike Momentum Transfers
 - Energy range 3.772 GeV 4.170 GeV (two points)
 - Pion FF and cross section Data and error
 - NO entries in HEPData;
 - Errors divided between statistical and systematic ones
 - Mention to RC (ISR and FSR and VP). Unclear if the PFF is with or w/out VP, FSR
- CESR-CLEO,T. Xiao et al, Phys. Rev. D 97, 032012 (2018) https://inspirehep.net/literature/1643020

Precision Measurement of the Hadronic Contribution to the Muon Anomalous Magnetic Moment

- Energy range 0.3-1 GeV ISR
- Bare(?) cross section and diagonal error (no covariance matrix)
- Errors divided between statistical and systematic ones
- Mention to RC, VP (Phokhara)

Channel	Experiment	Reference	Energy Range	Meth od	Quotes	RC	HEPData	Comment
π+π-	BCF (ADONE, Frascati)	https://inspi rehep.net/lit erature/100 180	1.44-9 GeV ²	Direct	F_{π} errors	No Mention	YES	Errors not divided
$\pi^+\pi^-$	MEA (ADONE, Frascati)	https://inspi rehep.net/lit erature/124 109	1.6 GeV	Direct	F_{π}, σ errors	No Mention	YES	Errors not divided; no mention to fomula from ${\sf F}_{\pi}$, σ
$\pi^+\pi^-$	MEA (ADONE, Frascati)	https://inspi rehep.net/lit erature/158 283	1.45-1.52 GeV	Direct	F_{π}, σ errors	No Mention	YES	Errors not divided; fomula from ${\sf F}_{\pi}$, σ
π+π-	CLEOc (CESR, Cornell)	https://inspi rehep.net/lit erature/693 873	3.671 GeV	Direct	F_{π}, σ errors	Yes	NO	Unclear if the PFF is with or w/out VP, FSR
π+π-	CLEOc (CESR, Cornell)	https://inspi rehep.net/lit erature/693 873	3.772 GeV 4.170 GeV	Direct	F_{π}, σ errors	Yes	NO	Unclear if the PFF is with or w/out VP, FSR
π+π-	CLEOc (CESR, Cornell)	https://inspi rehep.net/lit erature/693 873	0.3-1 GeV	ISR	F_{π} , σ errors	Yes	NO	RC according to PHOKHARA No cov matrix



- How to Continue:
 - $\pi^+\pi^-\pi^0$ channel?
 - Other suggestions?
 - How to organize/improve the web page?

 $\pi^+\pi^-$ ACO BABAR BCF BES CLEO CMD CMD2 CMD3 DM1 DM2 KLOE MEA NA07 OLYA SND SND2000 TOF VEPP2 $\pi^+\pi^-\pi^0$ ACO BABAR BCF CMD CMD2 CMD3 DM1 DM2 GG2 M3N MEA MUPI ND OLYA SND SPEAR **K⁺K⁻J/** ψ BELLE

R ALEPH AMY BBar BCF BES CBALL CELLO CLEO CUSB DASP DHHM GG2 JADE KEDR LENA M3N MARK1 MARK2 MARKJ MD1 MEA MUPI PLUTO TASSO TOPAZ VENUS



- Report at the next TI meeting (June 2021)
 - I got an invitation to present MUonE and RMCLow activity. I could include few slides on Strong2020 activity.



- Example notebook
- Fedor Ignatov responsive plots

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From the proposal



Task 2: Hadronic effects in precision tests of the electromagnetic sector of the Standard Model

We will coordinate efforts of EU researchers working on hadronic contributions to $(g-2)_{\mu}$ by organizing meetings and by contributing to DOE Muon g-2 Theory Initiative white books which are scheduled in parallel with anticipated Fermilab results with increased precision. In particular we will provide a data base for low energy hadronic processes relevant to $(g-2)_{\mu}$. T2.1 - HVP: Compilation of an annotated database for low-energy hadronic cross sections in e^+e^- collisions. The database will contain information about the reliability of the data sets, their systematic errors, and the treatment of RC. This project is supported by the Particle Data Group at the IPPP Durham (UU, INFN-Pisa, UL, USlaski, BINP, Mainz, LAL UPS). Feasibility studies for the spacelike HVP determination by developing methods for RC and multiple scattering effects with new level of precision. T2.2 -**HLbL:** On the experimental side this subtask includes preparation of knowledge data base on the differential cross sections for the production and decay processes of mesons and production of meson pairs relevant to HLbL. On the theory side various contributions to $(g-2)_{\mu}$ will be studied to see how they depend on the experimental constraints. This will be done using a variety of methods concentrating on Euclidean methods (Lund, Giessen) and dispersive constraints (Mainz, Bern). The groundwork for a new comprehensive analysis of the HLbL including the study of all theoretical asymptotic constraints and double counting issues at boundaries and between different types of contributions (Lund, Giessen, Barcelona, Marseille, Bucarest, LPHNE) will be laid. This will include comparison with lattice QCD, meson form factors, and other processes with off-shell photons. Meson transition form factors and hadronic decays will be studied theoretically (UBO, UU, Lund, Prague, Orsay, Bern, Mainz, UAB, FZJ).