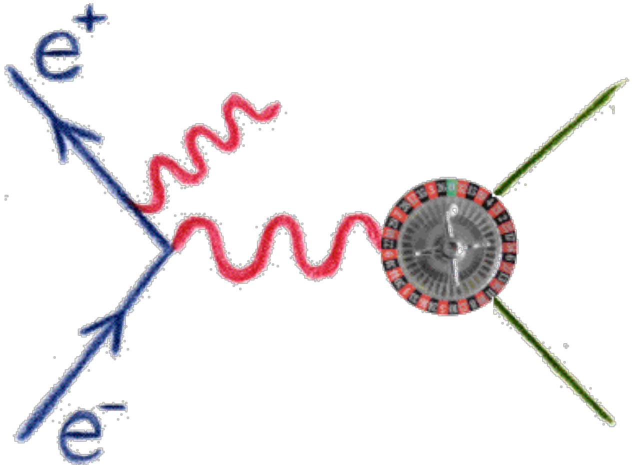
Working Group on Rad. Corrections and MC Generators for Low Energies (Radio MonteCarLow): a Status report



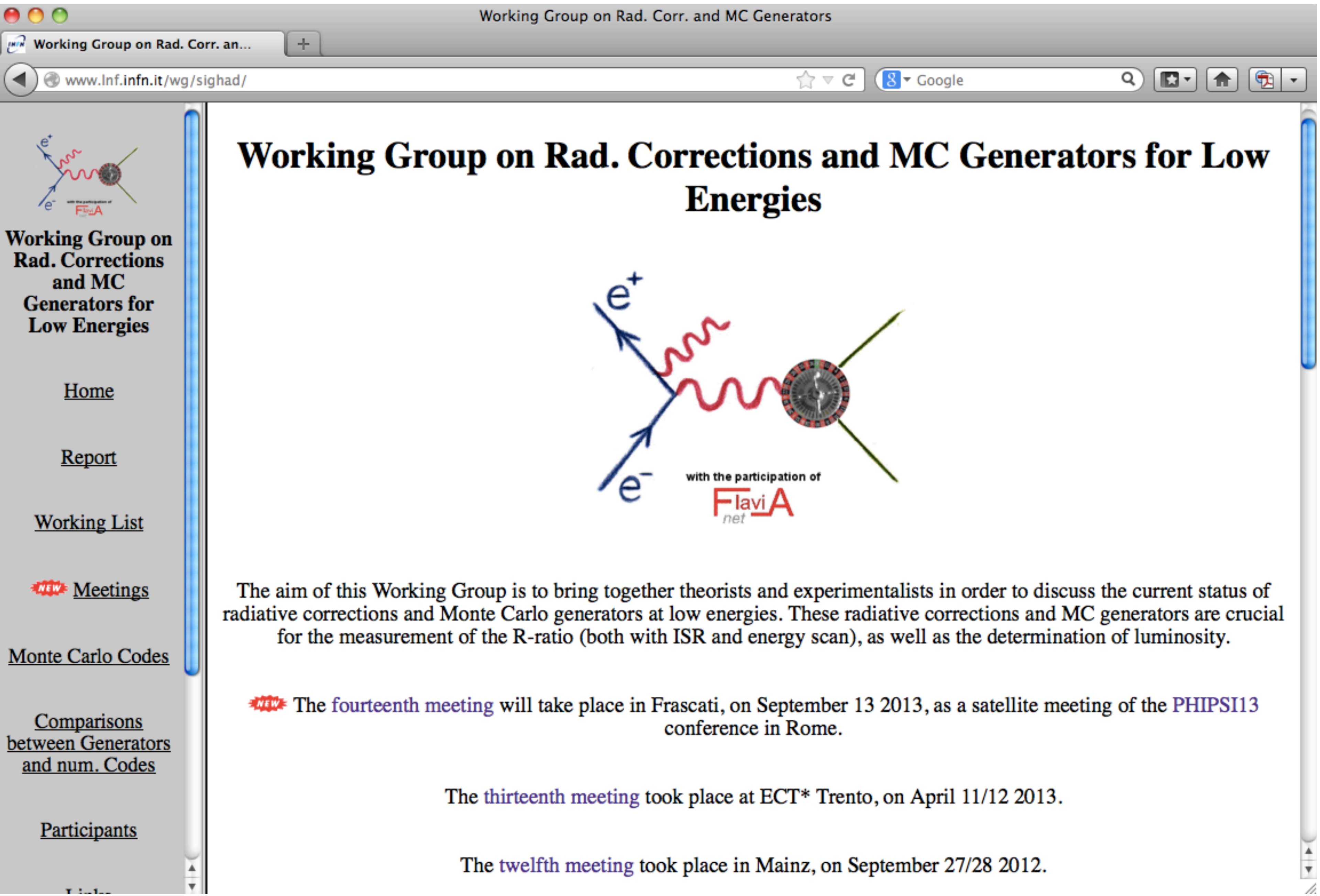
G. Venanzoni LNF/INFN

RC Workshop- IPN Orsay 8-10-2013

Working Group on Rad. Corrections and MC Generators for Low Energies

- First meeting in Oct 2006
- 14 meetings since then (2 meetings/year)
- 2 WG coordinators (H. Czyz, G. Venanzoni)
- 7 Subgroups
- One report in 2010:
  - >60 participants
  - 13 differenct countries
- Web page:

http://www.lnf.infn.it/wg/sighad/



Working Group on Rad. Corr. and MC Generators

www.lnf.infn.it/wg/sighad/

Working Group on Rad. Corrections and MC Generators for Low Energies

Home

Report

Working List

NEW Meetings

Monte Carlo Codes

Comparisons between Generators and num. Codes

Participants

Working Group on Rad. Corrections and MC Generators for Low Energies

The aim of this Working Group is to bring together theorists and experimentalists in order to discuss the current status of radiative corrections and Monte Carlo generators at low energies. These radiative corrections and MC generators are crucial for the measurement of the R-ratio (both with ISR and energy scan), as well as the determination of luminosity.

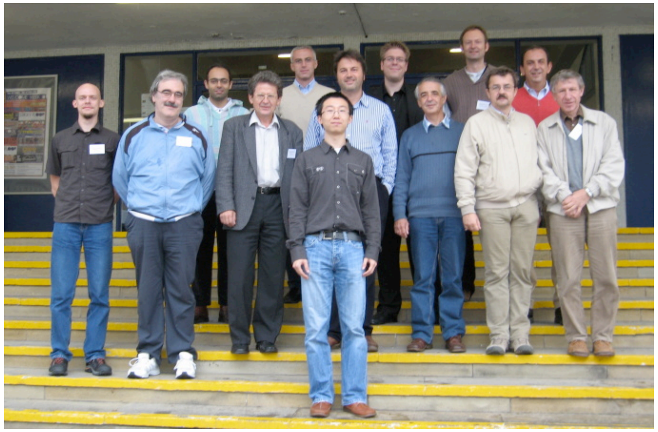
NEW The fourteenth meeting will take place in Frascati, on September 13 2013, as a satellite meeting of the PHIPSI13 conference in Rome.

The thirteenth meeting took place at ECT* Trento, on April 11/12 2013.

The twelfth meeting took place in Mainz, on September 27/28 2012.

Radio MonteCarlow WG page: www.lnf.infn.it/wg/sighad

14 meetings (2 per year in Spring/Fall, starting from Oct 06) :



Liverpool 2010

Novosibirsk 2011

Frascati 2008

Mainz 2012

Trento 2013

The Subjects covered:

RADIO MONTECARLOW

- Monte Carlo generators for Luminosity
- Monte Carlo generators for e+e- into hadrons and leptons
- Monte Carlo generators for e+e- into hadrons and leptons plus photon (ISR)
- Monte Carlo generators for τ production and decays
- Hadronic Vacuum Polarization, $\Delta\alpha_{em}(Z0)$ and $(g-2)_{\mu}$
- Gamma-gamma physics
- FSR models and Transition Form Factors

Each of them has 2 convenors

People involved

Not exaustive list

Aachen: Actis, Czakon
Beijing: Shen, Wang, Yuan, Zhang
Berlin: Jegerlehner
Bologna: Caffo, Remiddi
CERN: Beltrame, Mastrolia
Cracov: Grzelińska, Jadach, Przedzinski, Wąs
Dubna: Arbuzov, Kuraev
Edmonton: Penin
Frascati: Isidori, Pacetti, Pancheri, Shekhovtsova,Venanzoni
Freiburg: van der Bij
Karlsruhe: Kluge, Kühn,
Katowice: Czyż, Gluza, Kołodziej
Kharkov: Korchin
Mainz: Denig, Ferroglia, Hafner, Mueller
Moscow: Pakhlova
Novosibirsk: Cherepanov, Eidelman, Fedotovich, Sibidanov, Solodov
Palaiseau: Kalinowski
Padova: Passera
Parma: Trentadue
Pavia: Montagna, Nicrosini, Piccinini
Rome: Baldini, Bini, Greco, Nguyen
Southampton: Carloni-Calame
Valencia: Rodrigo, Roig
Wuppertal: Worek
Zeuthen: Riemann

Experiments involved

Not exaustive list

BaBar

BELLE

BES-III

CMD2

KLOE

SND

MC generators

Not exaustive list

BABAYAGA

KKMC

MCGPJ

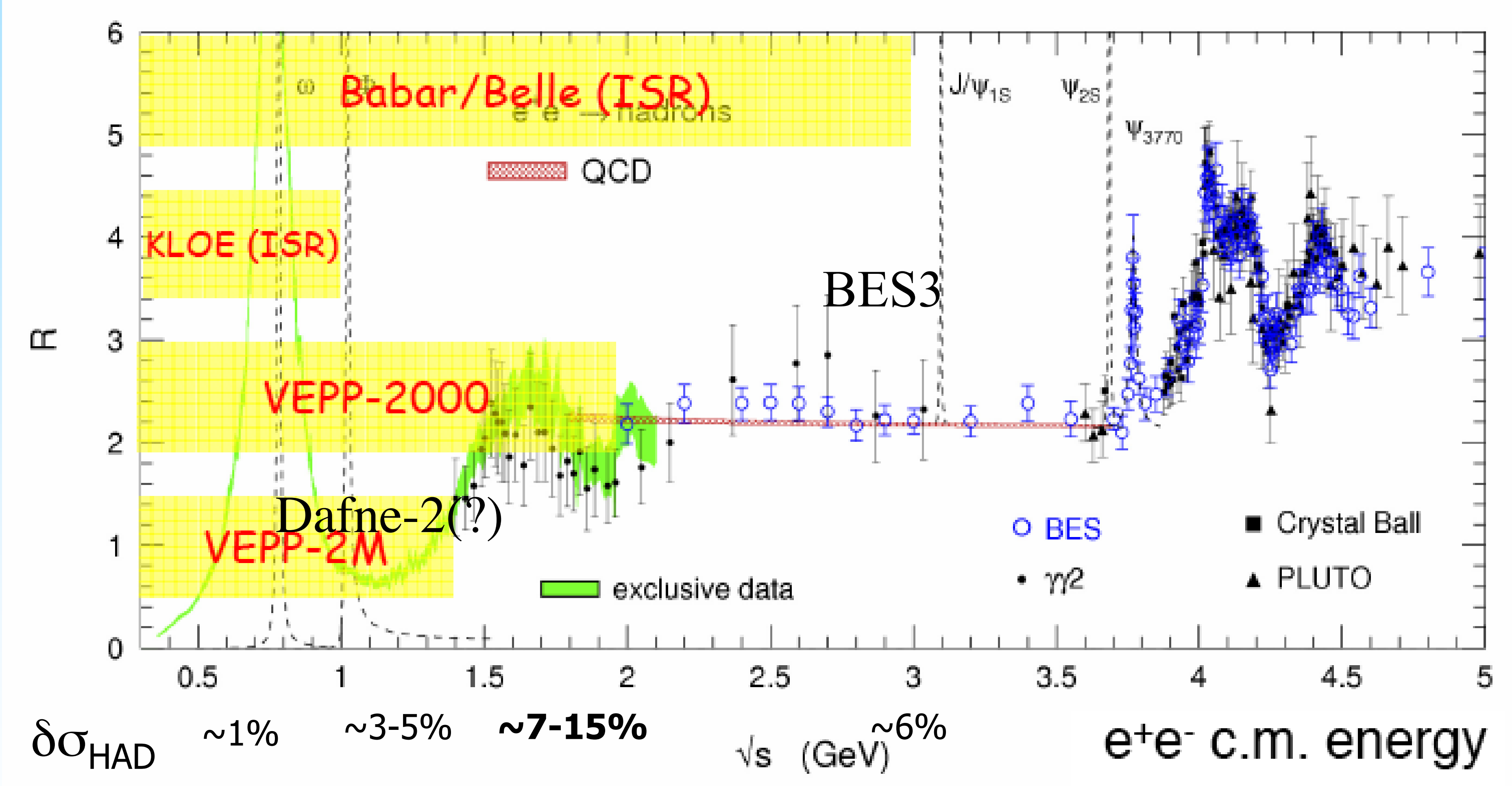
PHOKHARA

PHOTOS

TAUOLA

EKHARA

Ultimate goal of σ_{HAD}: 1% up to J/ψ (Ψ(4s)?)



How to reach 1% above 1 GeV?

How to reach <1% on σ_{HAD} ?

- Improve experimental accuracy
  - Systematic errors under control?
- Improve theory:
  - RC?
  - Modelling of hadron-photon interaction?
- Tuning comparison of MC generator very important:
  - For luminosity this was done within our group;
  - For ISR and scan still the situation is unsatisfactory, and we should try to improve it.

Radiative corrections are important!

- Unclear treatment of R.C. in old data.
- Reevaluation of RC leads to significant changes in recent data
- New data (CMD-2,SND, KLOE, Babar) paid more attention to :
  - ISR
  - Vacuum Polarization (VP)
  - FSR
- A lot of work for theorists to provide accurate MC generators (and for experimentalists to test it!)

$$\sigma_{bare} = \sigma_{dressed} \left|1 - \Pi(s)\right|^2 (1 + C_{FSR})$$

- $\sigma_{\text{dressed}} = \frac{N}{\int Ldt \ \varepsilon \ (1+\delta_{\text{ISR}})}$
- $\Pi(s) = \Pi_{\text{lep}}(s) + \Pi_{\text{had}}(s)$

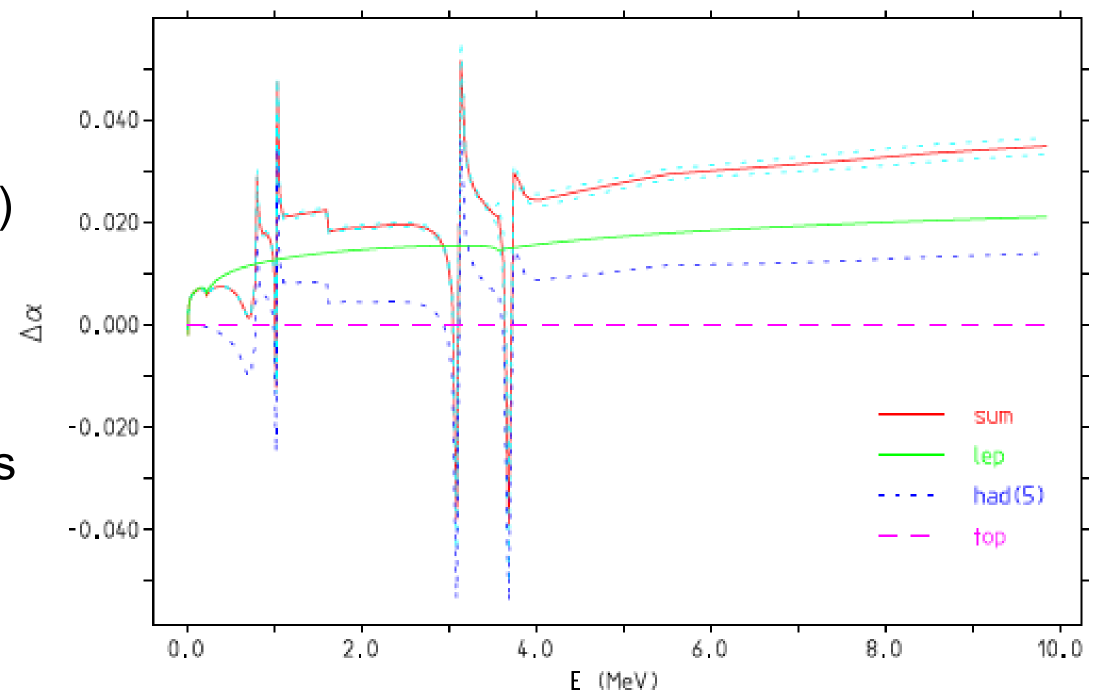


Figure from Fred Jegerlehner

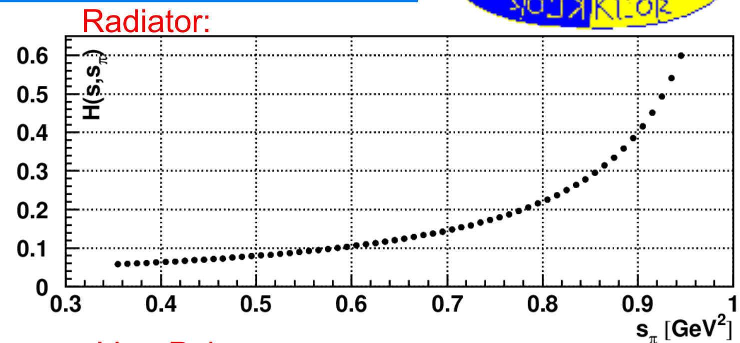
Radiative Corrections for ISR

Radiator-Function $H(s,s_p)$ (ISR):

- **ISR-Process calculated at NLO-level**
  PHOKHARA generator
  (H.Czyż, A.Grzelińska, J.H.Kühn, G.Rodrigo, EPJC27,2003)

Precision: 0.5%

$$s \cdot \frac{d\sigma_{\pi\pi\gamma}}{ds_{\pi}} = \sigma_{\pi\pi}(s_{\pi}) \times H(s,s_{\pi})$$

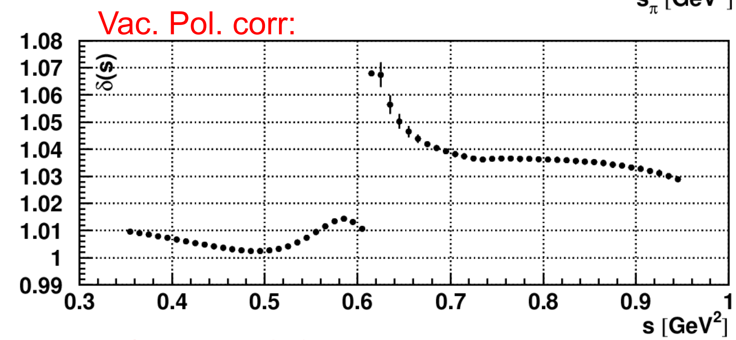


Radiative Corrections:

i) Bare Cross Section

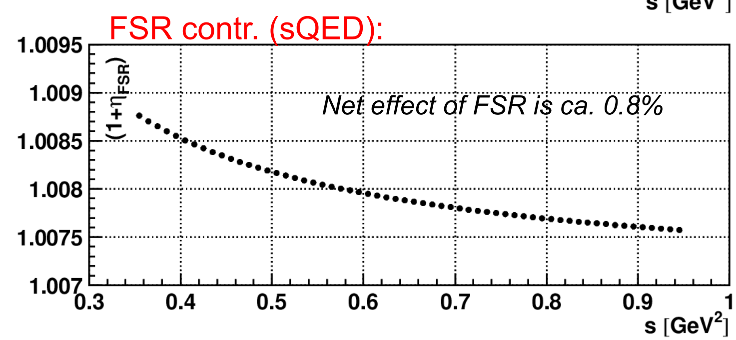
divide by Vacuum Polarisation $d(s)=(a(s)/a(0))^2$

➔ from F. Jegerlehner

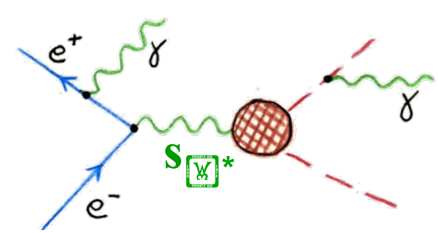


ii) FSR

Cross section s_{pp} must be incl. for FSR for use in the dispersion integral of a_m



FSR corrections have to be taken into account in the efficiency eval. (Acceptance, M_{Trk}) and in the mapping $s_{\pi} \rightarrow s_{\gamma*}$



$s_{\gamma*} > s_p$

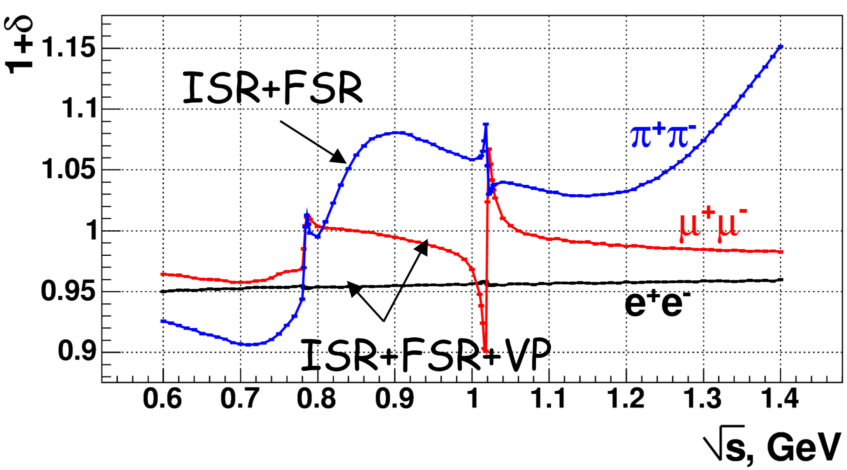
(H.Czyż, A.Grzelińska, J.H.Kühn, G.Rodrigo, EPJC33,2004)

Radiative corrections for **energy scan**:

All modes except 2π

$$\sigma\left(e^+e^- \to H\right) = \frac{N_H - N_{bg}}{L \cdot \varepsilon \cdot (1+\delta)}$$

- Luminosity L is measured using Bhabha scattering at large angles
- Efficiency ε is calculated via Monte Carlo + corrections for imperfect detector
- Radiative correction δ accounts for ISR effects only



2π

$$|F_\pi|^2 = \frac{N_{2\pi}}{N_{ee}} \cdot \frac{\sigma_{ee} \cdot (1+\delta_{ee})}{\sigma_{2\pi}(\text{point-like } \pi) \cdot (1+\delta_{2\pi})}$$

- Ratio N(2π)/N(ee) is measured directly ⇒ detector inefficiencies are cancelled out
- Virtually no background
- Analysis does not rely on simulation
- Radiative corrections account for ISR and FSR effects
- Formfactor is measured to better precision than L

Report from RMCWG: a common effort for RC and Monte Carlo tools

Eur. Phys. J. C (2010) 66: 585–686
DOI 10.1140/epjc/s10052-010-1251-4

THE EUROPEAN PHYSICAL JOURNAL C

Review

Quest for precision in hadronic cross sections at low energy: Monte Carlo tools vs. experimental data

Working Group on Radiative Corrections and Monte Carlo Generators for Low Energies

S. Actis[38], A. Arbuzov[9,e], G. Balossini[32,33], P. Beltrame[13], C. Bignamini[32,33], R. Bonciani[15], C.M. Carloni Calame[35], V. Cherepanov[25,26], M. Czakon[1], H. Czyż[19,a,f,i], A. Denig[22], S. Eidelman[25,26,g], G.V. Fedotovich[25,26,e], A. Ferroglia[23], J. Gluza[19], A. Grzelińska[8], M. Gunia[19], A. Hafner[22], F. Ignatov[25], S. Jadach[8], F. Jegerlehner[3,19,41], A. Kalinowski[29], W. Kluge[17], A. Korchin[20], J.H. Kühn[18], E.A. Kuraev[9], P. Lukin[25], P. Mastrolia[14], G. Montagna[32,33,b,d], S.E. Müller[22,f], F. Nguyen[34,d], O. Nicrosini[33], D. Nomura[36,h], G. Pakhlova[24], G. Pancheri[11], M. Passera[28], A. Penin[10], F. Piccinini[33], W. Płaczek[7], T. Przedzinski[6], E. Remiddi[4,5], T. Riemann[41], G. Rodrigo[37], P. Roig[27], O. Shekhovtsova[11], C.P. Shen[16], A.L. Sibidanov[25], T. Teubner[21,h], L. Trentadue[30,31], G. Venanzoni[11,c,i], J.J. van der Bij[12], P. Wang[2], B.F.L. Ward[39], Z. Was[8,g], M. Worek[40,19], C.Z. Yuan[2]

60 participants, 13 countries

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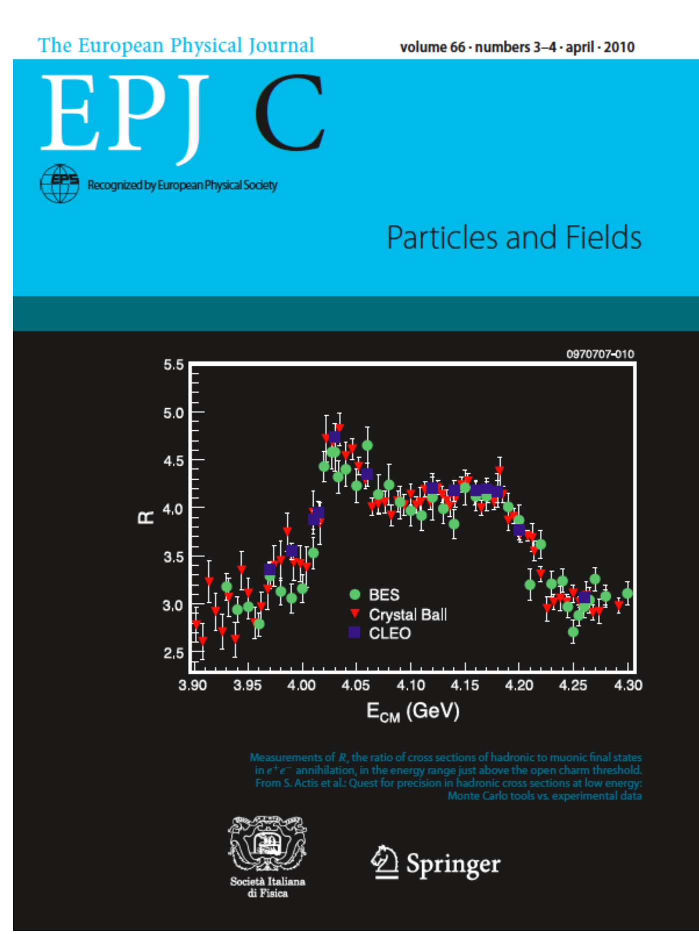

RMCWG Report

Received: 3 December 2009 / Published online: 23 February 2010

Abstract We present the achievements of the last years of the experimental and theoretical groups working on hadronic cross section measurements at the low-energy e^+e^- colliders in Beijing, Frascati, Ithaca, Novosibirsk, Stanford and Tsukuba and on τ decays. We sketch the prospects in these fields for the years to come. We emphasise the status and the precision of the Monte Carlo generators used to analyse the hadronic cross section measurements obtained as well with energy scans as with radiative return, to determine luminosities and τ decays. The radiative corrections fully or approximately implemented in the various codes and the contribution of the vacuum polarisation are discussed.

Contents

1 Introduction

The systematic comparison of Standard Model (SM) predictions with precise experimental data served in the last decades as an invaluable tool to test the theory at the quantum level. It has also provided stringent constraints on "new physics" scenarios. The (so far) remarkable agreement between the measurements of the electroweak observables and their SM predictions is a striking experimental confirmation of the theory, even if there are a few observables where the agreement is not so satisfactory. On the other hand, the Higgs boson has not yet been observed, and there are clear phenomenological facts (dark matter, matter-antimatter asymmetry in the universe) as well as strong theoretical arguments hinting at the presence of physics beyond

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[d]Section 2 conveners.
[e]Section 3 conveners.
[f]Section 4 conveners.
[g]Section 5 conveners.
[h]Section 6 conveners.
[i]Working group conveners.

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"Tuned" comparisons are essential!

Theoretical accuracies of these generators were estimated, whenever possible, by evaluating missing higher-order contributions. From this point of view, the great progress in the calculation of two-loop corrections to the Bhabha scattering cross section was essential to establish the high theoretical accuracy of the existing generators for the luminosity measurement. However, usually only analytical or semi-analytical estimates of missing terms exist which don't take into account realistic experimental cuts. In addition, MC event generators include different parameterisations for the VP which affect the prediction (and the precision) of the cross sections and also the RC are usually implemented differently.

Example:

BabaYaga and its theoretical accuracy

Carlo M. Carloni Calame

INFN, Sezione di Pavia

Working Group on Radiative corrections and generators for low energy hadronic cross section and luminosity

based on hep-ph/0607181 (accepted by **NPB**)

in collaboration with G. Balossini, G. Montagna, O. Nicrosini, F. Piccinini

Estimate of the theoretical accuracy

- switching off VP, tuned comparisons with independent calculations/approaches (Labspv, Bhwide)
  - ⋆ $\Delta\sigma/\sigma < 0.03\%$ on cross sections
  - ⋆ up-to-0.5% differences between BabaYaga and Bhwide in distribution tails
- comparison with existing perturbative 2-loop calculations
  - ⋆ currently available
    1. Penin: complete virtual 2-loop photonic corrections (for $Q^2 \gg m_e^2$) plus real radiation in the soft limit
    2. Bonciani et al.: virtual $N_F = 1$ [only electron in the loops] fermionic contributions plus real radiation in the soft limit
  - ⋆ the photonic and $N_F = 1$ $\mathcal{O}(\alpha^2)$ content of the S+V part in the BabaYaga matched formula can be easily extracted. The terms to be directely compared to 1. and 2. can be read out!
  - ⋆ the impact of the missing $\mathcal{O}(\alpha^2)$ S+V corrections can be quantified within realistic setup

Summary of theoretical errors

- for Bhabha cross section, within realistic setup for luminometry, the theoretical errors of the new BabaYaga are summarized

$\lvert\delta^{err}\rvert$ (%)	(a)	(b)	(c)	(d)
$\lvert\delta^{err}_{VP}\rvert$	0.01	0.00	0.02	0.04
$\lvert\delta^{err}_{pairs}\rvert$	0.02	0.03	0.03	0.04
$\lvert\delta^{err}_{H,H}\rvert$	0.00	0.00	0.00	0.00
$\lvert\delta^{err}_{phot+N_f=1}\rvert$	0.01	0.01	0.00	0.01
$\lvert\delta^{err}_{SV,H}\rvert$	0.05	0.05	0.05	0.05
$\lvert\delta^{err}_{total}\rvert$	0.09	0.09	0.10	0.14

Table: LABS (a) (c), VLABS (b) (d), 1.02 GeV (a) (b), 10 GeV (c) (d)

Higher order QED radiative corrections to Bhabha scattering

Andrej Arbuzov

Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, Russia

Talk at the Radio MontecarLow workshop, Frascati, 6–7th April 2009

Outline

- Bhabha: hierarchy of contributions
- Higher order corrections: how much?
- NLO factorization for exclusive Bhabha
- MC integrator
- 2-loop Soft + Virtual
- 2 Hard photons
- 1 Hard photon $\otimes$ 1-loop Soft + Virtual
- e^+e^- soft $+$ virtual pair corrections
- Outlook

Event selection conditions

Numerical illustrations are given for the simple set of conditions:

- $E_{\mathrm{beam}} = 1$ **GeV**
- $\pi/3 < \theta_{+,-} < 2\pi/3$
- $E_{+,-} > 50$ **MeV**
- $\theta_{\mathrm{acoll}} > 30$ **mrad**
- **no $e\gamma$ recombination: BARE event selection**

Studies on accuracy of the contributions from pair production in Babayaga generator - a status report

Michal Gunia

Working Group 'Radio Monte CarLow', Frascati

28 March 2011

Table of contents

Cuts dependence study for different experiments

1.Φ factories KLOE/DAΦNE (Frascati)

(a) $\sqrt{s} = 1.02$ GeV
(b) $E_{min} = 0.4$ GeV
(c) For $\theta\pm$ two selections have to be checked
i. tighter selection $55^\circ < \theta\pm < 125\ ^\circ$
ii. wider selection $20^\circ < \theta\pm < 160\ ^\circ$
(d) ζ_{max}=4,5,6,7,8,...,14°, with reference value ζ_{max}=9°

2. B-factories BABAR/PEP-II (SLAC) & BELLE/KEKB (KEK)

(a) $\sqrt{s} = 10.56$ GeV
(b) $|\vec{p}_+|/E_{beam} > 0.75$ and $|\vec{p}_-|/E_{beam} > 0.50$
or $|\vec{p}_-|/E_{beam} > 0.75$ and $|\vec{p}_+|/E_{beam} > 0.50$
(c) For $|cos(\theta\pm)|$ the following selections have to be checked
i. $|cos(\theta\pm)| < 0.65$ and $|cos(\theta+)| < 0.60$ or $|cos(\theta-)| < 0.60$
ii. $|cos(\theta\pm)| < 0.70$ and $|cos(\theta+)| < 0.65$ or $|cos(\theta-)| < 0.65$
iii. $|cos(\theta\pm)| < 0.60$ and $|cos(\theta+)| < 0.55$ or $|cos(\theta-)| < 0.55$
(d) ζ^{3d}_{max}= 20,22,24,...,40°, with reference value ζ^{3d}_{max}=30 °

Issues to be discussed here

Comparison of results with vacuum polarization obtained using :VPHLMNT (T.Teubner et all.) and hadr5n09 (F. Jegerlehner) (all results from BabaYaga) - all results in nb

KLOE: $55^\circ < \theta\pm < 125\ ^\circ$, $\zeta_{max}=4^\circ$
σ_{BY} **=436.85(5)**

vacpol	σ_h	σ_{v+s}	sum:
VPHLMNT(2009)	1.4346(5)	-1.126(2)	0.309(2)
hadr5n09	1.6264(6)	-1.405(2)	0.221(2)
relative difference: $\left\lvert\frac{\sigma^{NNLO}_{VPHLMNT}-\sigma^{NNLO}_{hadr5n09}}{\sigma_{BY}}\right\rvert$			0.201(6)‰

BES: $\sqrt{s} = 3.650$ GeV, $|\cos\theta| < 0.8$
σ_{BY} **= 116.41(2) nb**

vacpol	σ_h	σ_{v+s}	sum:
VPHLMNT2.0(2010)	1.6613(3)	-1.7860(2)	-0.1247(4)
hadr5n09	1.6471(7)	-1.7686(2)	-0.1215(7)
relative difference: $\left\lvert\frac{\sigma^{NNLO}_{VPHLMNT}-\sigma^{NNLO}_{hadr5n09}}{\sigma_{BY}}\right\rvert$			0.0275‰

Issues to be discussed here

BES:$\sqrt{s} = 3.686$ GeV,$|\cos\theta| < 0.8$
σ_{BY} = **114.27(2) nb**

vacpol	σ_h	σ_{v+s}	sum:
VPHLMNT2.0(2010)	10.006(4)	-16.80(1)	-6.79(1)
hadr5n09	9.60(1)	-16.28(2)	-6.68(3)
relative difference: $\left|\frac{\sigma^{NNLO}_{VPHLMNT} - \sigma^{NNLO}_{hadr5n09}}{\sigma_{BY}}\right|$			0.96‰

BES:$\sqrt{s} = 3.097$ GeV,$|\cos\theta| < 0.9$
σ_{BY} = **378.48(5) nb**

vacpol	σ_h	σ_{v+s}	sum:
VPHLMNT2.0(2010)	-116.50(6)	287.7(3)	171.2(3)
hadr5n09	-119.1(2)	291.9(3)	172.8(4)
relative difference: $\left|\frac{\sigma^{NNLO}_{VPHLMNT} - \sigma^{NNLO}_{hadr5n09}}{\sigma_{BY}}\right|$			4.227‰

MCGPJ

Systematic treatment of second order NLO QED radiative corrections to exclusive observables

Andrej Arbuzov

Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, Russia

Talk at the Radio MontecarLow workshop, Frascati, 11th April 2008

MCGPJ: A. Arbuzov

Outlook

- The ansatz for the treatment of $\mathcal{O}\left(\alpha^2 L^1\right)$ QED radiative corrections to exclusive observables is described
- The ansatz is suited for MC simulations
- Many processes can be treated in this way
- $\mathcal{O}\left(\alpha^2 L^0\right)$ contributions can be put into the same structure
- MCGPJ can be upgraded
- MC integrator and generator for Bhabha scattering is under development (upgrade of SAMBHA MC)

Status of MC generators for radiative return

H. CZYŻ, IF, UŚ, Katowice FRASCATI 2006

Motivation - what is the radiative return

What do we have on the market

Tests - comparisons, which were performed

My wish list

From EVA to PHOKHARA and ...

EVA: $e^+e^- \to \pi^+\pi^-\gamma$

- tagged photon ($\theta_\gamma > \theta_{cut}$)
- ISR at LO + Structure Function
- FSR: point-like pions

[Binner et al.]

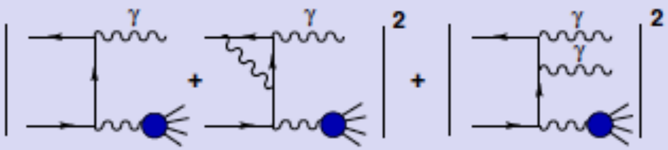
$e^+e^- \to 4\pi + \gamma$

- ISR at LO + Structure Function

[Czyż, Kühn]

PHOKHARA 5.1: $\pi^+\pi^-$, $\mu^+\mu^-$, 4π, $\bar{N}N$, 3π, KK

- **ISR at NLO:** virtual corrections to one photon events and two photon emission at tree level



- FSR at NLO: $\pi^+\pi^-$, $\mu^+\mu^-$, K^+K^-
- tagged or untagged photons
- Modular structure

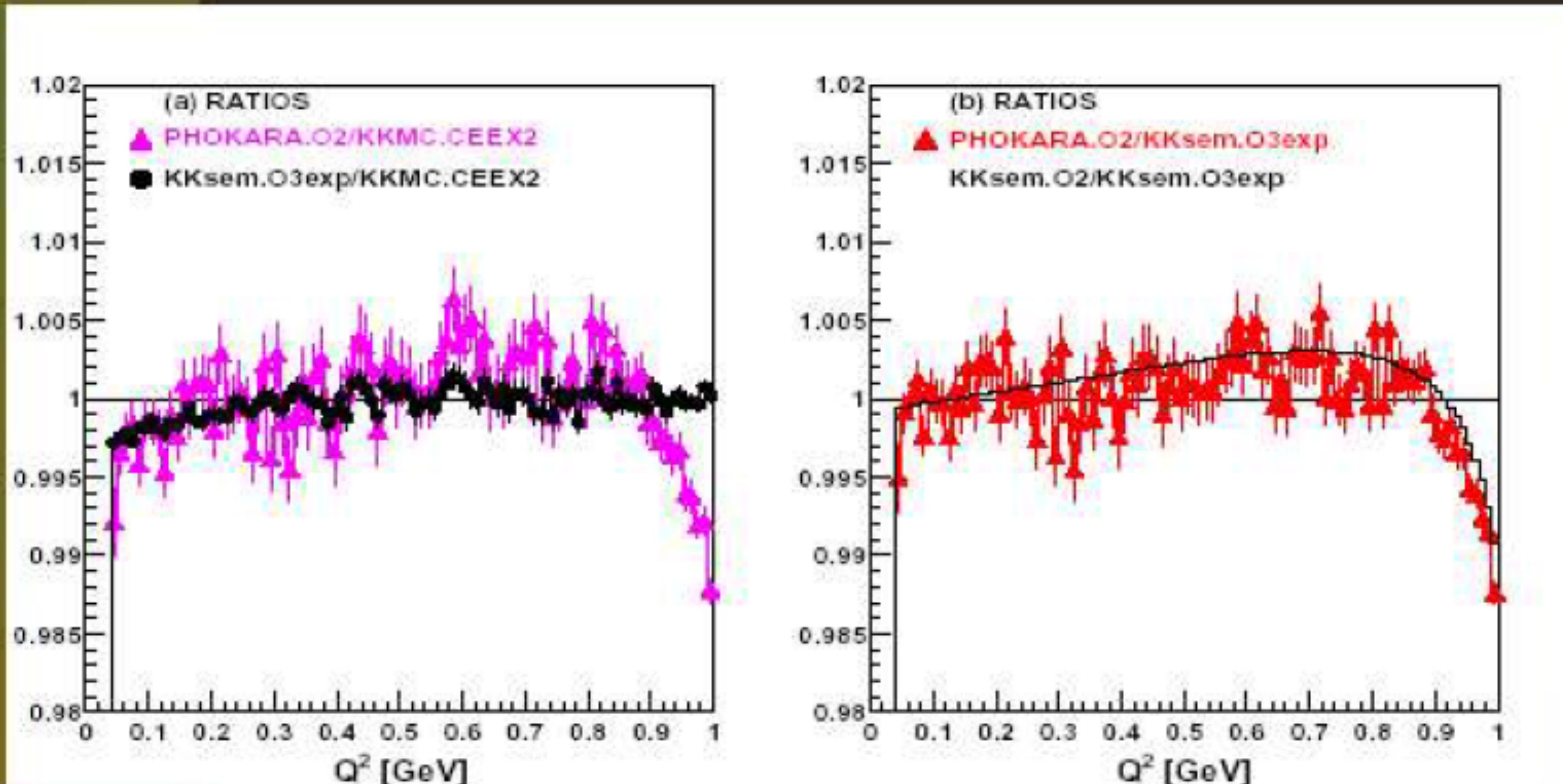
http://cern.ch/german.rodrigo/phokhara

KKMC

S. Jadach, B. F. L. Ward and Z. Wąs

- YFS exponentation
- high accuracy only for muon pairs
- can we hope for: upgrades ???
  broader collaboration ???

PHOKHARA included in the game, μ-pairs again



PHOKHARA agrees to within 0.3% with KKMC and KKsem.

Discrepancy at high Q^2 reflects lack of exponentiation in PHOKHARA

From H. Czyz:

My wish list

- benchmark for ISR NLO
  separately (?) for virtual and real corrections

- benchmark for ISR NNLO ???
  What accuracy do we need ?

- beyond ISR for muon and pion pairs:
  testing the codes and FSR models

- collect the results of separate code tests
  and comparisons

FSR studies

"Non-Born"

$$M_{NB}^{\mu\nu}(Q,k,r) = -ie^2(\tau_1^{\mu\nu} f_1^{NB} + \tau_2^{\mu\nu} f_2^{NB} + \tau_3^{\mu\nu} f_3^{NB}),$$

- explicit form of $f_{1,2,3}^{NB}$ is model-dependent

We now work with

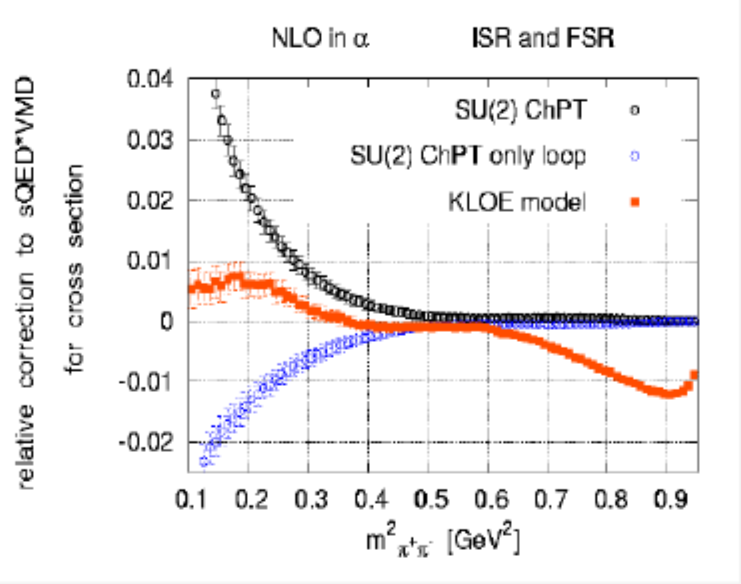
- SU(2) and SU(3) Chiral Perturbation Theory
- KLOE model as implemented in PHOKHARA 6.1 and FASTERD by Olga Shekhovtsova [Shekhovtsova, Venanzoni, Pancheri, arXiv:0901.4440 [hep-ph] (2009)]

These models give "predictions" for FSR:
parameters are fixed independently

Using realistic cuts:

FSR studies

Role of “non-Born” correction



$e^+e^- \to \pi^+\pi^-\gamma$

$\sqrt{s} = 1$ GeV

$50^o < \theta_\gamma < 130^o$

- model dependence is small
- at KLOE statistics the ChPT-corrections are not visible
- effect is enhanced at low $m_{\pi\pi}$

International Workshop on e+e- collisions from Phi to Psi 2013

PHI PSI 13

Rome, 9th -12th September 2013

"Sapienza" University - Physics Department

Status of Monte Carlo generators for gamma-gamma physics

Sergiy Ivashyn

NSC “KIPT” and V.N.Karazin Kharkiv National University
(Kharkiv, Ukraine)

September 9, 2013

MC used in experiments

The collaborations typically use their pivate MC

- KLOE (a MC by Nguyen, Piccinini and Polosa)
- CLEO (TwoGam by D.Coffman / V.Savinov)
- Belle (TREPS by S.Uehara)
- BES-III (UDOD by V.Bytev and A. Zhemchugov and TwoGam from DELPHI)

Lately: publicly available MC generators (via CPC)

- KLOE-2, BES-III (EKHARA)
- BaBar (GGRESRC)

A safe approach to rad.corrs

- use exact QED formulae
- no analytic integration of hard photon spectrum
- implement in MC
- make it numerically efficient

Under development in EKHARA MC generator

EKHARA rad.cors. Work in progress

- Check independence of result from
  - ✓ IR regulator λ
  - ✓ Soft-Hard matching scale M_0

- Developing efficient mappings
- To compare with GGRESRC

Conclusion: RMCWG

- It's an informal room and a valuable platform to exchange ideas
- It has been enriched of new subjects (and people) during the years
- Meetings with theorists and experimentalists sitting together. A first report in 2010. Maybe a new Report will be done next year.
- A good example to follow:
  - Use tuned comparison
  - Whenever possible avoid patched MC
  - **A common effort also from your group?→ Report?**
- Participation and contribution from other peoples/experimental groups/subjects are welcome

http://www.lnf.infn.it/wg/sighad/

If you are interested, please contact me (Graziano.Venanzoni@lnf.infn.it) or Henryk Czyz (czyz@us.edu.pl)

Next meeting most likely next March in Mainz