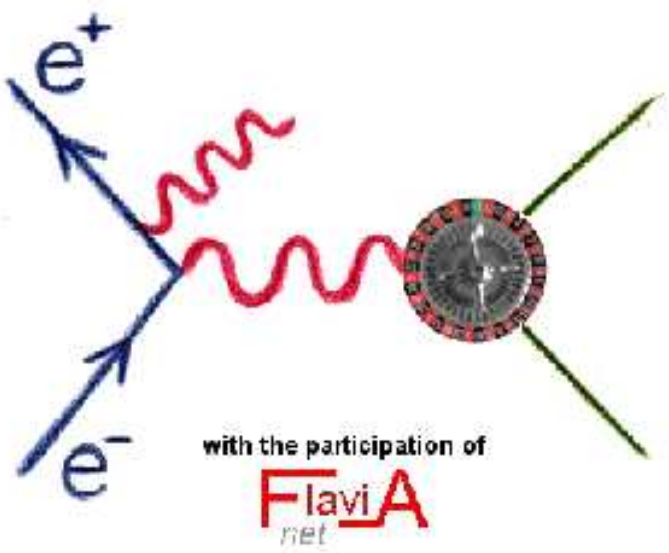
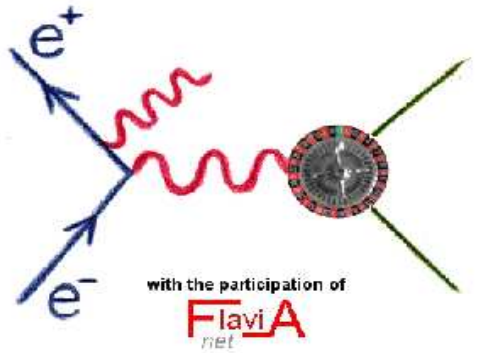


Working Group on Rad. Corrections and MC Generators for Low Energies
Report on activities

From Φ to Ψ 2009, BEIJING

H. CZYŻ, IF, UŚ, Katowice

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



Group coordinators: H. Czyż, G. Venanzoni (Frascati,KLOE)

Meetings:

* Frascati, 16-17 October 2006
* Frascati, 25-26 June 2007
* Frascati, 11 April 2008
* Beijing, 9-11 October 2008
* Frascati, April 6-7, 2009

The subjects covered:

- Monte Carlo generators for Luminosity

- Monte Carlo generators for e^+e^- annihilation into leptons and hadrons

- Monte Carlo generators for e^+e^- annihilation into hadrons plus an energetic photon from initial state radiation (ISR)

- Monte Carlo generators for τ production and decays

People involved

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

BaBar

BELLE

BES-III

CMD2

KLOE

SND

MC generators

BABAYAGA

KKMC

MCGPJ

PHOKHARA

PHOTOS

TAUOLA

Luminosity

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

Luminosity

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

Luminosity

Summary of theoretical errors

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

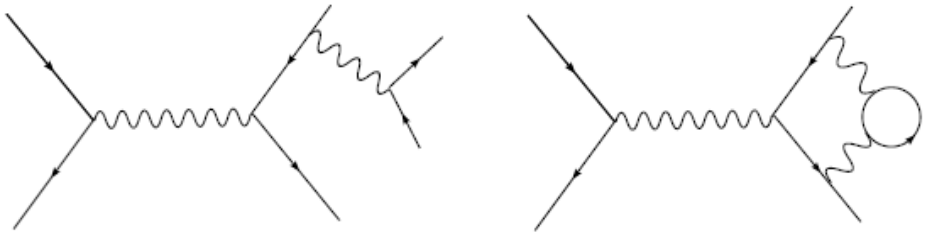
$\lvert\delta^{err}\rvert$ (%)	(a)	(b)	(c)	(d)
$\lvert\delta^{err}_{VP}\rvert$	0.01	0.00	0.02	0.04
$\lvert\delta^{err}_{pairs}\rvert$	0.02	0.03	0.03	0.04
$\lvert\delta^{err}_{H,H}\rvert$	0.00	0.00	0.00	0.00
$\lvert\delta^{err}_{phot+N_f=1}\rvert$	0.01	0.01	0.00	0.01
$\lvert\delta^{err}_{SV,H}\rvert$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

Luminosity

Light-pair corrections (real & virtual)

- They contribute at $\mathcal{O}(\alpha^2)$, VPC (part of 2-loop $N_F = 1$) and RPC largely cancel. Not included in `BabaYaga`.



- To estimate the impact, VPC evaluated as in Jadach et al. ('97); Kniehl ('90); Burgers ('85); Barbieri et al. ('72); RPC evaluated in soft approximation as in Arbuzov et al. ('97)
- the correction does not exceed 0.05% in LABS [1] and VLABS [2] at 1 and 10 GeV (see `hep-ph/0607181`)

[1] $20^\circ < \vartheta_\pm < 160^\circ$
[2] $55^\circ < \vartheta_\pm < 125^\circ$

Luminosity

T. Riemann, WG on RC and MC for Low Energies, Frascati, 2008 1

Hadronic corrections to Bhabha scattering

Tord Riemann, DESY, Zeuthen
based on work with:
S. Actis (RWTH Aachen), M. Czakon (U. Würzburg)
and J. Gluza (Sileasian U. Katowice)

Working Group on Radiative Corrections and Generators for Low Energy Hadronic Cross Section and Luminosity
11 April 2008, Frascati

- Introduction: Two-loop corrections to Bhabha Scattering
- Leptonic contributions with $m_e^2 << m_f^2 << s,t$
  ACGR: NPB 786 (2007) [arXiv:0704.2400]
- Leptonic contributions with $m_e^2 << m_f^2, s, t$
  ACGR: APP B38 (2007) [arXiv:0710.5111] → see also talk by Roberto Bonziani
- Hadronic contributions
  ACGR: PRL 100 (2008) [arXiv:0711.53847]
- Summary

Luminosity

Summary

- We determine the $N_f = 2$ contributions to 2-loop Bhabha scattering, including the hadronic corrections
- They are small, but non-negligible at the scale 10^{-3} ($\rightarrow$ No LEP influencing)
- Agreement for $m_e^2 << m_l^2 << s, t, u$ with:
  "Two-loop QED corrections to Bhabha scattering"
  Thomas Becher, Kirill Melnikov, arXiv:0704.3582 [hep-ph], JHEP
- Agreement for $m_e^2 << m_l^2, s, t, u$ with:
  "Two-Loop Heavy-Flavor Contribution to Bhabha Scattering",
  Roberto Bonciani, Andrea Ferroglia, Sacha Penin, arXiv:0710.4775v3 [hep-ph]
- To be evaluated yet:
  $\longrightarrow$ 1-loop diagrams with real photon emission, interfering with real (Born) radiation, including 5-point functions
- Also: $\longrightarrow$ Real pair production
- Both items were studied already by Andrei Arbuzov, Kuraev, Shaitchatdenov (1998, small photon mass)

PHOTOS

1

PHOTOS Monte Carlo – its phase-space and benchmarks

Z. Was

Institute of Nuclear Physics, Krakow *and* CERN-PH, Geneva

talk include contributions of:

P. Golonka

CERN IT/CO-BE , Geneva, Institute of Nuclear Physics, Krakow

G. Nanava

JINR, Dubna, Russia, Institute of Nuclear Physics, Krakow

PHOTOS

Purpose of the talk

Because QED corrections affect interpretation of measured quantities: cut off induced corrections to the rates, to parity sensitive asymmetries, CKM ...

PHOTOS was used for many years in low precision regime for that purpose by practically all experiments.

Precision requirements increased; responsability on the project grows.

We have completed re-amalysis of program content in some of its aspects:

-1- matrix elements for $Z \to l\bar{l}$; QED.

-2- matrix elements for $B \to K\bar{\pi}$; scalar QED.

-3- phase space *of no approximations*, **also for multiple photon radiation!** On mass-shell iterative relations are attracting attention, technique used in PHOTOS may become useful outside QED?

Z. Was

TAUOLA

1

Precision simulations with TAUOLA

Z. Wąs

Institute of Nuclear Physics, PAN, Kraków, Poland

Main messages:

- **What is new or important for the users of our package TAUOLA**
- **Different perspectives:**
- TAUOLA decays into 5 scalars with full ME now, not real progress yet.
- MC-TESTER for automated comparisons and benchmark database.
- universal interface of TAUOLA, bridge between medium and high energy
- Practical problems of encapsulation. C or not to C: coordination
- **Summary**

My web page is at http://home.cern.ch/wasm

Z. Was *Frascati, April 11, 2008*

TAUOLA

TAUOLA: basic structure these assumptions remain!

- Phase space.
- Matrix elements
- Leptonic decays: $\tau \to e(\mu)\nu_\tau\nu(\gamma)$.
- Electroweak vertex is clear and universal up to 0.1 $\%$ precision level..
- Semileptonic decays are different : Hadronic current need to remain experiments' property, in cases experiment wish so.
- The last point enforces constraint for program organization and requests good communication between experimentalists, model builders and TAUOLA authors.
- Also points to low energy e^+e^- data and models. Presence/absence of isospin symmetry need to be adressed.

Z. Was *Frascati, April 11, 2008*

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)

From EVA to PHOKHARA

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,2000]

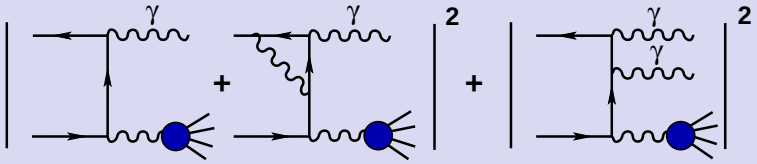
H.C., A. Grzelińska,

J. H. Kühn, E. Nowak-Kubat,

G. Rodrigo, A. Wapienik

PHOKHARA 6.0: $\pi^+\pi^-$, $\mu^+\mu^-$, 4π, $\bar{N}N$, 3π, KK, $\Lambda(\to\cdots)\bar{\Lambda}(\to\cdots)$

- **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://ific.uv.es/~rodrigo/phokhara/

From EVA to ...

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

- ISR at LO + Structure Function

[Czyż, Kühn]

→

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

- upgraded by BaBar - not public (?)
- PHOTOS [Barberio et al.] for FSR

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.]

→

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

- FSR studies, FEVA, FASTERD

[Pancheri,Shekhovtsova,Venanzoni]

FSR studies

Radiative return: a progress on FSR tests

Sergiy IVASHYN [1, 2]

H. Czyż[1], A.Korchin[2], A. Denig[3], S. Scherer[3], S. Müller[3]

[1] Instytut Fizyki, Uniwersytet Śląski, Katowice
[2] NSC KIPT, Kharkov
[3] Institut für Kernphysik, Universität Mainz

16 September 2009, Ustroń

FSR studies

"Non-Born"

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

- explicit form of $f^{NB}_{1,2,3}$ 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

FSR studies

KLOE model

Phenomenological parametrization/fit of $\pi^0\pi^0\gamma$ KLOE data

- worked out by KLOE
  with participation of N.N. Achasov
- transformed to $\gamma^* \to \pi^+\pi^-\gamma$ via isospin symmetry
- implemented in PHOKHARA 6.1 and FASTERD
  by O. Shekhovtsova

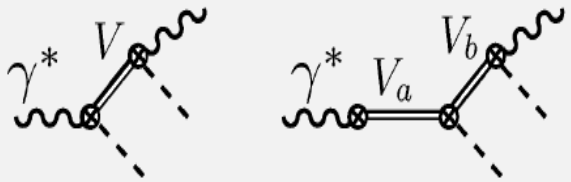
[Shekhovtsova, Venanzoni, Pancheri, arXiv:0901.4440 [hep-ph] (2009)]

FSR studies

KLOE model

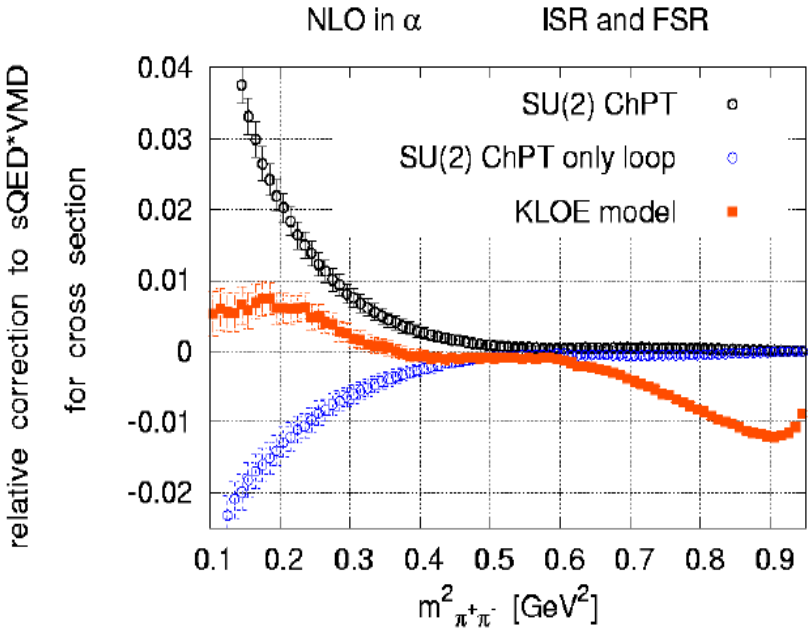
Phenomenological parametrization/fit of $\pi^0\pi^0\gamma$ KLOE data
Includes:

- ϕ radiative decay
- vector + double-vector contributions



FSR studies

Role of "non-Born" correction



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

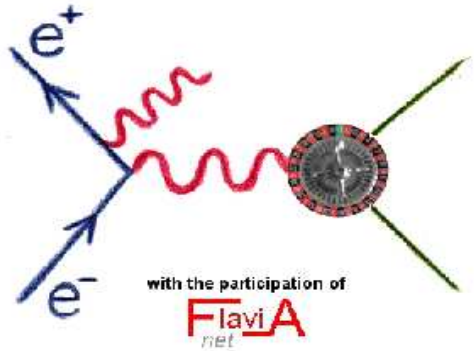
$\sqrt{s} = 1$ GeV

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

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

Summary

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



- is a valuable platform to exchange ideas
- and to bring together theorists and experimentalists

Saturday: 3 p.m. Room A415 - a short meeting

- status of the Report
- plans for the future