Early days of e+ e- event generators – a personal account

Motivation:

Staszek Jadach got interested in electron-positron event generators Nov. 1980, after reading the first preprint and code on this topic.

His first paper on the subject was submitted early 1982 and his contributions did not stop since then.

Questions:

What existed before Staszek ? Or,

How arose the idea of event generators including radiative corrections?

Development in two steps:

1. Radiative Corrections (RC) beyond soft photons, i.e. with hard photons, with prescribed cuts on energy and collinearity of the two produced particles

2. RC with arbitrary cuts on the produced particles

General Context

We are now used to a sequence of events:

1. General physics motivation, leading to
2. Construction of colliders and experiments, leading to
3. New (practical) physics questions
4. Answered by working groups, yellow books, etc.

Situation around 1970

Less organized, smaller projects, various e+ e- colliders with max. beam energy ~3.5 GeV under construction:

CEA (Mass.)	BYPASS
Novosibirsk	VEPP III
DESY	DORIS
SLAC	SPEAR

Main physics motivation: higher energy

Example of a one-man study group:

Alan Litke, PhD student at CEA and Harvard

He studied the literature what could possibly be found with an e+ e- collider. Thesis title:

“Experiments with electron-positron colliding beams” , 1970

EXPERIMENTS WITH ELECTRON-POSITRON COLLIDING BEAMS

By

Alan Michael Litke

April 1970

Harvard University, Cambridge, Massachusetts

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Example of a practical physics question

If the intermediate vector boson W would have a mass of 3 GeV, it could be made at these colliders: e+ e- → W e ν ,since

a Russian paper predicts a cross section of

10 mb for beam energy 3.5 GeV, Mw = 3GeV
However calculation not gauge invariant, real value 0.1 nb (G. West +B., 1969)

For LEP2 this problem was rediscovered in 1995

Other practical question ~ 1970

What will be the QED RC for QED collision tests?

$d\sigma/d\Omega = d\sigma/d\Omega(\text{Born})[1+\delta(\text{virtual})+\delta(\text{soft})+\delta(\text{hard})]$

$\delta(\text{virtual})+\delta(\text{soft})$ known for Bhabha, 2 γ annihilation, but in 1970 not yet for mupairs: box diagrams not exact

$\delta(\text{hard})$,unknown,needed for few % accurate exp'ts

$\delta(\text{hard})$ photon integration over a phase space fixed by energy and colinearity cuts of final state particles
Project started at the CEA in 1970 by Gastmans, B.

Ingredients in the seventies

1. δ(virtual), QED
2. δ(soft)
3. Radiative cross section: Born cross section +γ
4. Integration over prescribed phase space

New physics motivation for RC in the seventies

Z changes Born cross section in mupair production: forward-backward asymmetry

QED RC do the same, so RC very relevant

New colliders will test this:

PETRA starts in 1978, PEP IN 1981

Experimental preference for RC with arbitrary cuts

Solution: QED event generators

1. Generate Born cross section with δ(virtual) +δ(soft) included
2. Generate hard photon radiative process
3. Take care of the correct ratio between cross sections 1 and 2

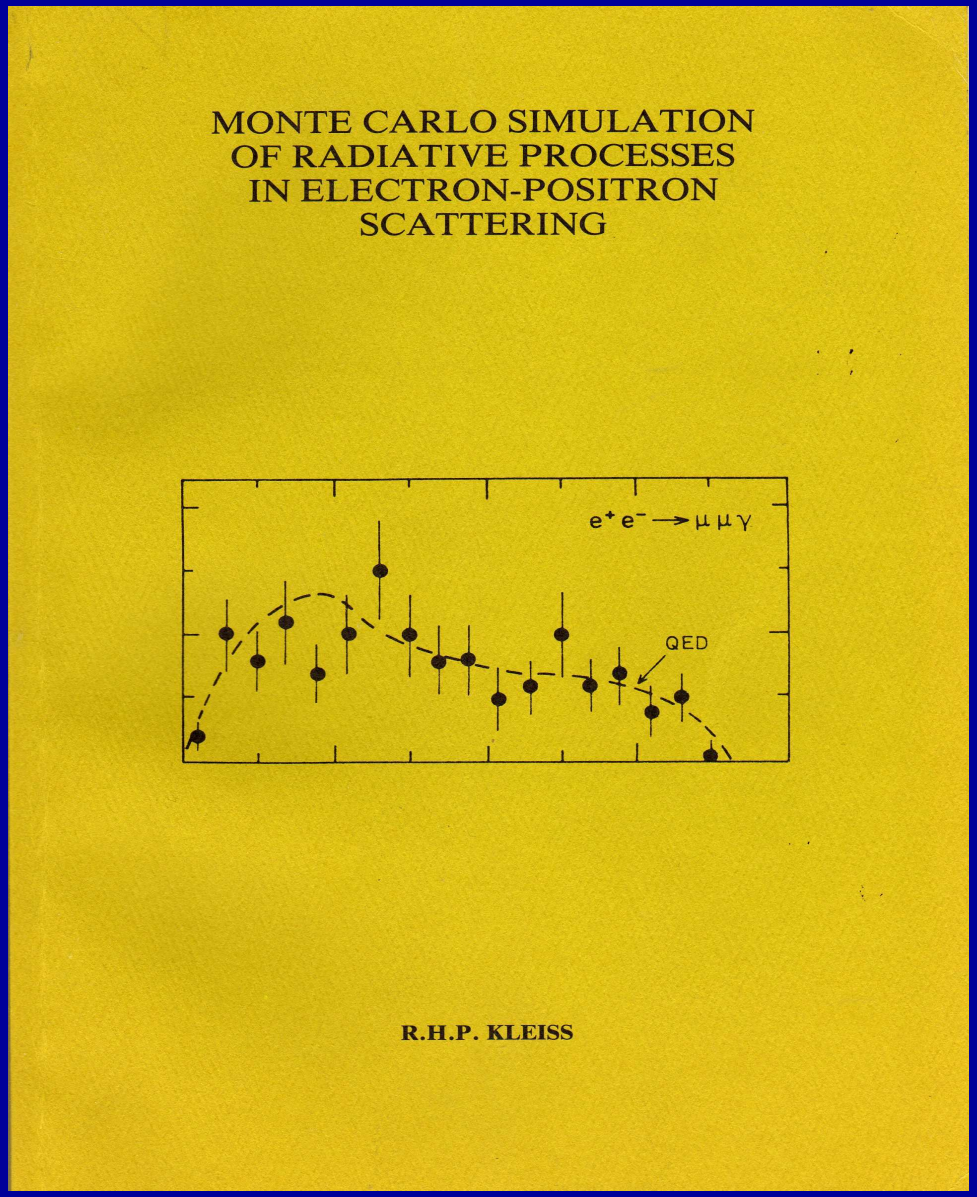
Ingredients end seventies

1. δ(virtual), QED
2. δ(soft)
3. Radiative cross section: Born cross section +γ
4. No specific integration, but generation of weight one events

Response to the generators

Since they were made at DESY (Kleiss+B.), DESY experimenters soon used them at PETRA

At PEP a bit later (~1981), in particular after the mysterious discovery of an excited muon, which decayed into a muon and a γ and which was not found at PETRA

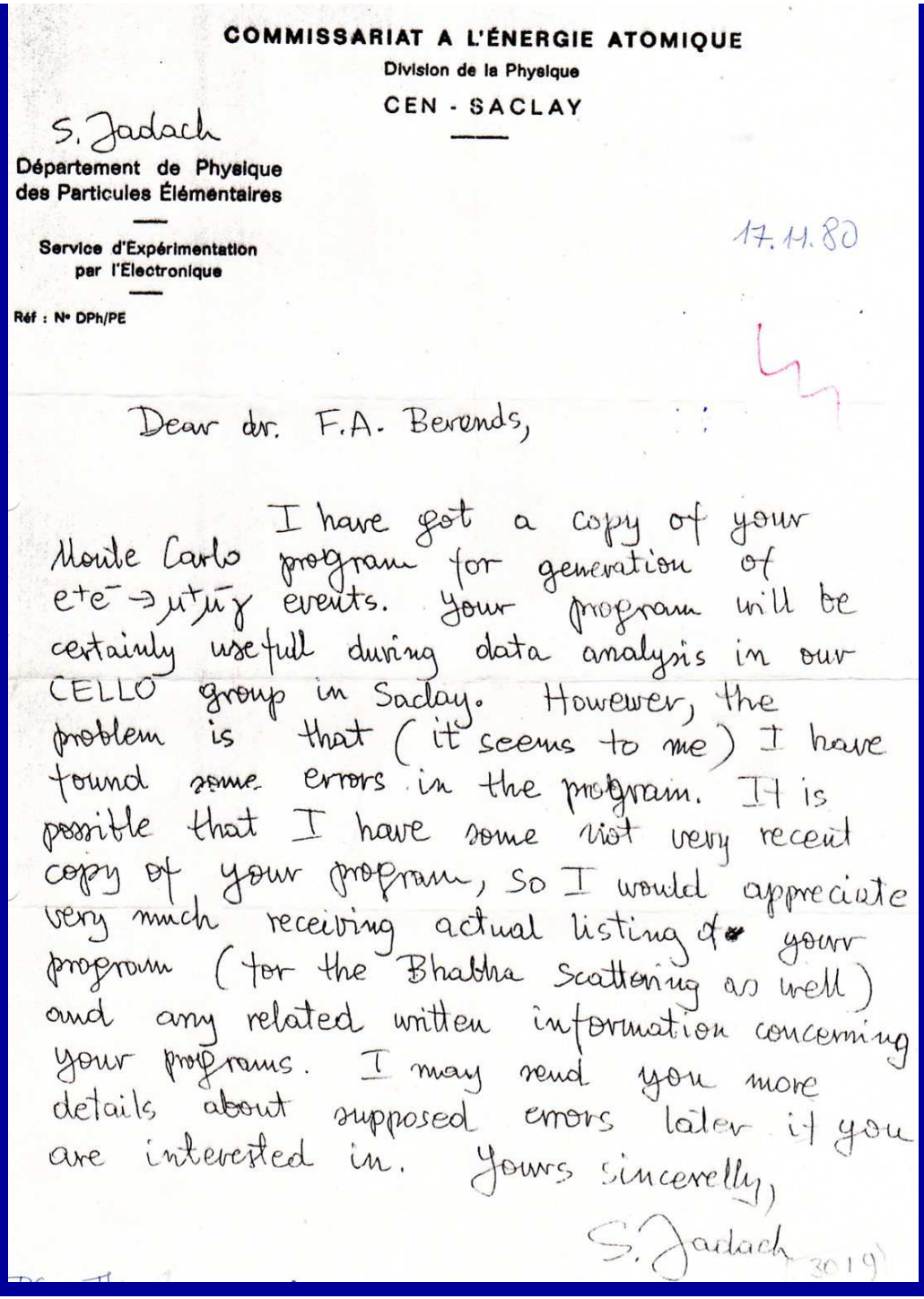


Thesis
June 1982

Invariant μγ mass plot PETRA

Quick response to the generators by Staszek Jadach

Staszek wrote a letter to the authors, half a year after the publication of the preprint on RC with a μ μ (γ) event generator



COMMISSARIAT A L'ÉNERGIE ATOMIQUE
Division de la Physique
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S. Jadach
Département de Physique
des Particules Élémentaires

Service d'Expérimentation
par l'Electronique

Réf : N° DPh/PE

17.11.80

Dear dr. F.A. Berends,

I have got a copy of your Monte Carlo program for generation of $e^+e^- \to \mu^+\mu^-\gamma$ events. Your program will be certainly useful during data analysis in our CELLO group in Saclay. However, the problem is that (it seems to me) I have found some errors in the program. It is possible that I have some not very recent copy of your program, so I would appreciate very much receiving actual listing of your program (for the Bhabha scattering as well) and any related written information concerning your programs. I may send you more details about supposed errors later if you are interested in. Yours sincerelly,

S. Jadach

(30 I 9)

His first letter
17 nov 1980,
soon followed
by others….

Dear dr. Berends

28.11.80

I would like to report on one error which I have found in your program for $\mu^+\mu^-$ process and next to make some remarks concerning also this program. But before I will come to details I would like to say that I find this program very interesting. I was for some years involved in constructing a serie of the Monte Carlo programs for multihadron production but for the first time I am dealing with M-C program for electromagnetic process and I find it quite amusing. I came to CELLO group in Saday for one year (starting from sept. 80) leaving on absence from Jagellonian University, Cracow, Poland. At the time I am helping to prepare first $\mu^+\mu^-$ data which are coming out, and hopefully I will be involved in the study "may CELLO go to LEP?" I have got your $\mu^+\mu^-$ program from Kapusta (Paris VI) at the begining of october. I have recalculated most of distributions used to generate events in this program and then I ~~ha~~ made some corrections which you may find in in the enclosed listing. I am also sending you separate summary of my calculations. Now, details.

① I took the squared amplitude in collinear approximation X^{coll} as it stands in TEST routine (under the name COLL) and first I integrat it over φ_γ finding result in agreement with that in YFIG routine This was not the case for c_γ integral.

$$\int^{c_\gamma} \frac{dz}{x+k-1+\Delta} \to \int_x \frac{dx}{(x+k-1+\Delta)x^2} \to \frac{1}{(1-k+\Delta)^2} \ln \frac{x}{x+k-1+\Delta} - \frac{1}{(1-k+\Delta)} \frac{1}{x}$$

where as usually $x = 2(1-k)/(2-k+kz)$

Dear dr. Berends,

Saday 19.12.80

My boss being back from DESY was rather frightened by the perspective that I will spend six months on preparing M.C. program for Zo, cutting all my activities in the group. I tried to explain to him that I can easily do this things parallely (what I believe is true) but I do not think I convinced him.
Leaving those political consideration I would like to stress that I am fascinated by the problem and strongly decided to make some good job in this subject. At the moment I am preparing simplified version of your $\mu^+\mu^-$ program in order to learn some tricks. This program will serve also as an input subprogram

Etc, at the end of the letter a very practical travel problem:

I did not make any progres with my french visa problem but we can talk on telephone and communicate by letters. This is not the same and I would greatly appreciate the possibility of ~~some~~ meeting you. Please indicate me where and when are you ~~are~~, telephone numbers and extensions. Best wishes for Christmas and New Year,

yours sincerelly

S. Jadach

Nuclear Physics B202 (1982) 63–88

RADIATIVE CORRECTIONS TO MUON PAIR AND QUARK PAIR PRODUCTION IN ELECTRON–POSITRON COLLISIONS IN THE Z_0 REGION

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Received 25 January 1982

A calculation of first-order radiative corrections to the process $e^+e^- \to \mu^+\mu^-$ is presented, which is in particular applicable to the Z_0 region. The emphasis is on a detailed treatment of hard photon effects, which affect the size of the corrections in the Z_0 region considerably. The technique used is that of a Monte Carlo simulation of $\mu^+\mu^-$ and $\mu^+\mu^-\gamma$ events. In an appendix the generalization to quark pair production is presented.

Computer Physics Communications 29 (1983) 185–200
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MONTE CARLO SIMULATION OF RADIATIVE CORRECTIONS TO THE PROCESSES $e^+e^- \to \mu^+\mu^-$ AND $e^+e^- \to \bar{q}q$ IN THE Z_0 REGION

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and

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Received 13 September 1982

PROGRAM SUMMARY

Joint effort for the 1st LEP 1 generator

Deformation of resonance: Peak suppression and tail
Fast generator

Papers inspite of martial law

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QED RADIATIVE CORRECTIONS TO ELECTRON-POSITRON ANNIHILATION INTO HEAVY FERMIONS*

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S. JADACH AND Z. WĄS

Institute of Physics, Jagellonian University, Cracow**

(Received November 23, 1982)

We reexamine the $O(\alpha^3)$ corrections to the process $e^+e^- \to \tau^+\tau^-$ (or any other heavy fermion pair) taking into account the effects of the masses of the final-state particles. The relevant analytic formulae are presented as well as some Monte Carlo results.

PACS numbers: 12.20.Ds

Paper marks the start of a Jadach group of scientists, another talk

80's: making better ingredients for LEP

1. δ(virtual), QED → δ(virtual, but electroweak)
   δ(virtual), QED → virtual QED one order in α higher
   relevant for line shape and tail Z
2. δ(soft)
3. Radiative cross section: Born cross section + γ →
   Doubly radiative cross section: Born + 2 γ
4. No specific integration, but generation of weight one events
5. Generators for ee → 4 leptons, spinorial calculation
6. YFS method for event generators: Jadach and Ward

Time to celebrate Staszek's 60th birthday (Jan Steen, Leiden, 1665)