KKMC Status Report

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- New documentation.
- New tests.
- What next? Outlook.

Papers by S. Jadach, B.F.L. Ward and Z. Wąs:

Phys. Lett. B449 (1999) 97, (CERN-TH/98-253), CERN-TH/98-235, subm. to EPJ,

Comput. Phys. Commun. 130 (2000) 260, DESY-99-106, CERN-TH/99-235,

UTHEP-99-09-01, CERN-TH/2000-087, hep-ph/0006359, submitted to Phys.Rev.D.

Various slides on http://home.cern.ch/jadach

New documentation

Computer Physics Communications

Computer Physics Communications 130 (2000) 260–325

www.elsevier.nl/locate/cpc

The precision Monte Carlo event generator KK for two-fermion final states in e^+e^- collisions ☆

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Abstract

We present the Monte Carlo event generator KK version 4.13 for precision predictions of the Electroweak Standard Model for the process $e^+e^- \to f\bar{f} + n\gamma$, $f = \mu, \tau, d, u, s, c, b$, at centre-of-mass energies from τ lepton threshold to 1 TeV, that is for LEP, SLC, future Linear Colliders, b, c, τ-factories, etc. Effects due to photon emission from initial beams and outgoing fermions are calculated in QED up to second order, including all interference effects, within Coherent Exclusive Exponentiation (CEEX), which is based on Yennie–Frautschi–Suura exponentiation. Electroweak corrections are included in first order, with higher-order extensions, using the DIZET 6.21 library. Final-state quarks hadronize according to the parton shower model using JETSET. Beams can be polarized longitudinally and transversely. Decay of the τ leptons is simulated using the TAUOLA library, taking into account spin polarization effects as well. In particular the complete spin correlations density matrix of the initial-state beams and final state τ's is incorporated in an exact manner. Effects due to beamstrahlung are simulated in a realistic way. The main improvements with respect to KORALZ are: (a) inclusion of the initial–final state QED interference, (b) inclusion of the exact matrix element for two photons, and (c) inclusion of the transverse spin correlations in τ decays (as in KORALB). © 2000 Elsevier Science B.V. All rights reserved.

PROGRAM SUMMARY

Title of the program: KK, version 4.13

Catalogue identifier: ADMD

Program Summary URL: http://cpc.cs.qub.ac.uk/summaries/ADMD

Computer: Any computer with the FORTRAN 77 compiler and the UNIX operating system

Operating system: UNIX, program was tested under AIX 4.x, HP-UX 10.x and Linux

Programming language used: FORTRAN 77 with popular extensions such as long names, etc.

☆ Work supported in part by Polish Government grants KBN 2P03B08414, KBN 2P03B14715, the US DoE contracts DE-FG05-91ER40627 and DE-AC03-76SF00515, the Maria Skłodowska-Curie Joint Fund II PAA/DOE-97-316, and the Polish–French Collaboration within IN2P3 through LAPP Annecy.

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0010-4655/00/$ – see front matter
PII: S0010-4655(00)00048-5

First complete manual, long-write-up (DESY-99-106) appears now in Computer Phys. Communications. 88 pages.

New documentation

DRAFT September 28, 1999 DRAFT

Comoving Reference Frames For Multi-Bremsstrahlung

S. Jadach

Abstract

Special parametrization of the Lorentz invariant phase space for the multiple photon emission is defined and its validity is formally proven. The parametrization is helpful in the Monte Carlo (MC) simulation of the multiple photons emitted by an electric charge dipole, in the case when one charge or both are moving, that when four-momentum one or both of the charged particles in a dipole are integration variables of the phase space. The photon emission distribution is the simplest in the rest frame of the total momentum of the charged pair. This natural frame "comoving" with the charges is very useful for MC. It is show how to re-parametrise the phase space in order to take full advantage advantage of such a comoving frame. Reparametrization of the phase space is done using the method of the integration over the Lorentz group.

To be Submitted to Computer Physics Communications???

† Work supported in part by Polish Government grants KBN 2P03B08414, KBN 2P03B14715, the US DoE contracts DE-FC05-91ER40627 and DE-AC03-76SF00515, the Maria Sklodowska-Curie Joint Fund II PAA/DOE-97-316, and the Polish-French Collaboration within IN2P3 through LAPP Annecy.

First complete description of kinematics of MC!

To be submitted to Comp.Physs.Commun. 30 pages.

New documentation

CERN-TH/2000-087
UTHEP-99-09-01

Coherent Exclusive Exponentiation For Precision Monte Carlo Calculations[†]

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Abstract

We present the new Coherent Exclusive Exponentiation (CEEX), the older Exclusive Exponentiation (EEX) and the semi-analytical Inclusive Exponentiation (IEX) for the process $e^+e^- \to ff + n\gamma$, $f = \mu, \tau, d, u, s, c, b$ with validity for centre of mass energies from τ lepton threshold to 1TeV, that is for LEP1, LEP2, SLC, future Linear Colliders, b, c, τ-factories etc. They are based on Yennie-Frautschi-Suura exponentiation. In CEEX effects due to photon emission from initial beams and outgoing fermions are calculated in QED up to second-order, including all interference effects. Electroweak corrections are included in first-order, at the amplitude level. Beams can be polarized longitudinally and transversely, and all spin correlations are incorporated in an exact manner. EEX is more primitive, lacks initial-final interferences, but it is valuable for testing the newer CEEX. IEX provides us set of a sophisticated semi-analytical formulas for the total cross section and selected inclusive distributions which are mainly used for cross-checks of the MC results. We analyse numerical results at the Z-peak 189 GeV and 500 GeV for simple kinematical cuts (comparisons with IEX) and for realistic experimental cuts. Physical precision and technical precision are determined for the total cross section and for the charge asymmetry.

To be Submitted to Phys. Rev. D

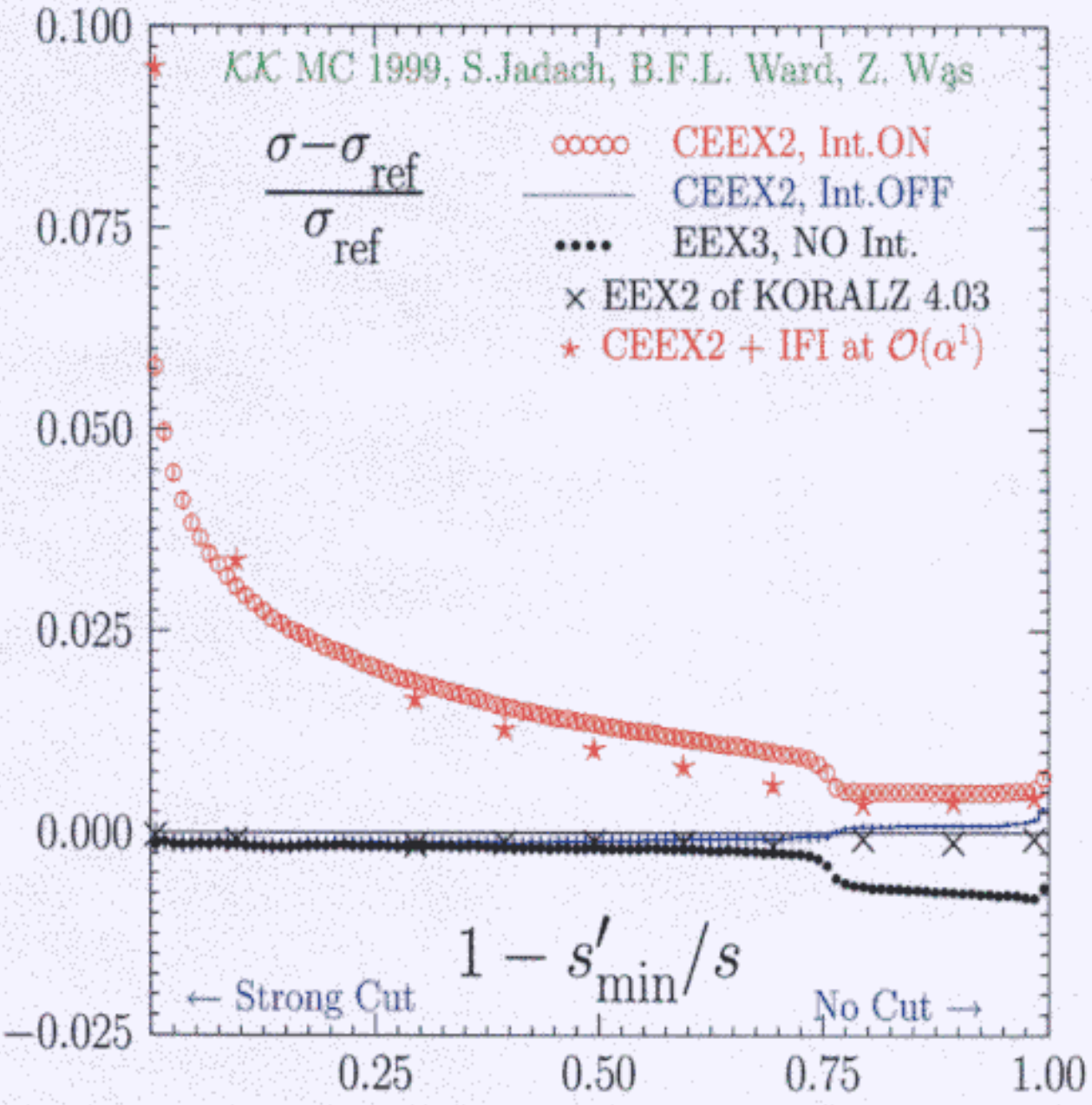
† Work supported in part by Polish Government grants KBN 2P03B08414, KBN 2P03B14715, the US DoE contracts DE-FG05-91ER40627 and DE-AC03-76SF00515, the Maria Skłodowska-Curie Joint Fund II PAA/DOE-97-316, and the Polish–French Collaboration within IN2P3 through LAPP Annecy.

CERN-TH/2000-087
UTHEP-99-09-01
March 2000

First complete description of matr.elem. and basic tests!

Submitted to Phys.Rev. D. 110 pages.

Internal Test from hep-ph/0006359 (189GeV)



We concluded total precision 0.2%.

Based on several programs of our own.

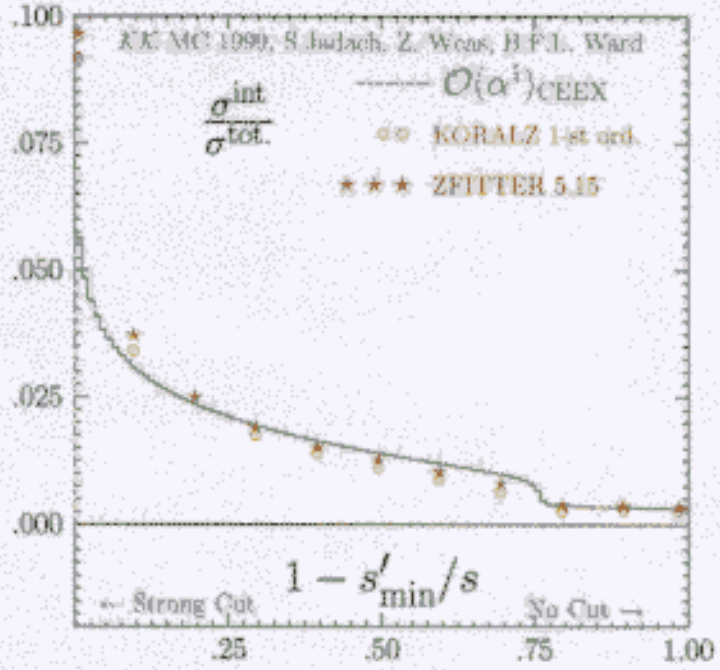
Blue line is complete $\mathcal{O}(\alpha^2)$ ISR, indedep. of BBvN 1988.

KKMC – ZFitter, March-June 2000

Even earlier comparison of May 1999 existed, with comparison of ISR*FSR interference contribution to the total cross section, see next slide, from http://home.cern.ch/jadach.
In the meantime ZFitter has got new improved exponentiation, and other new features and the agreement has evaporated.
New round of tests/comparisons was necessary.

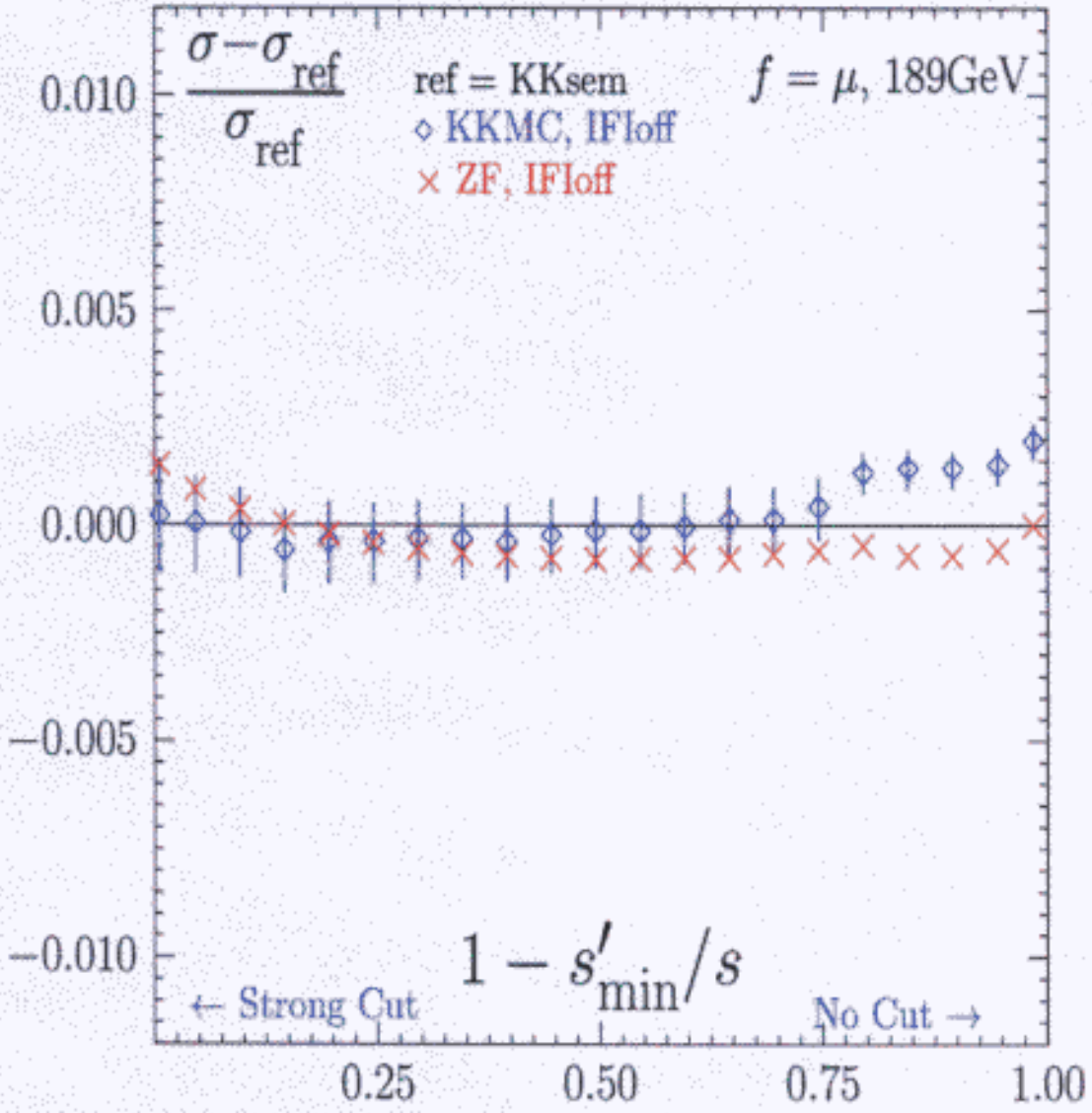
ISR*FSR in σ, cut-off dependence

The ISR*FSR interference correction to $\sigma(s'_{\min})$ at 189GeV. No cut in $\cos\theta^*$. From KK M.C. with $\mathcal{O}(\alpha^1)_{\rm CEEX}$ exponentiation at the amplitude level.



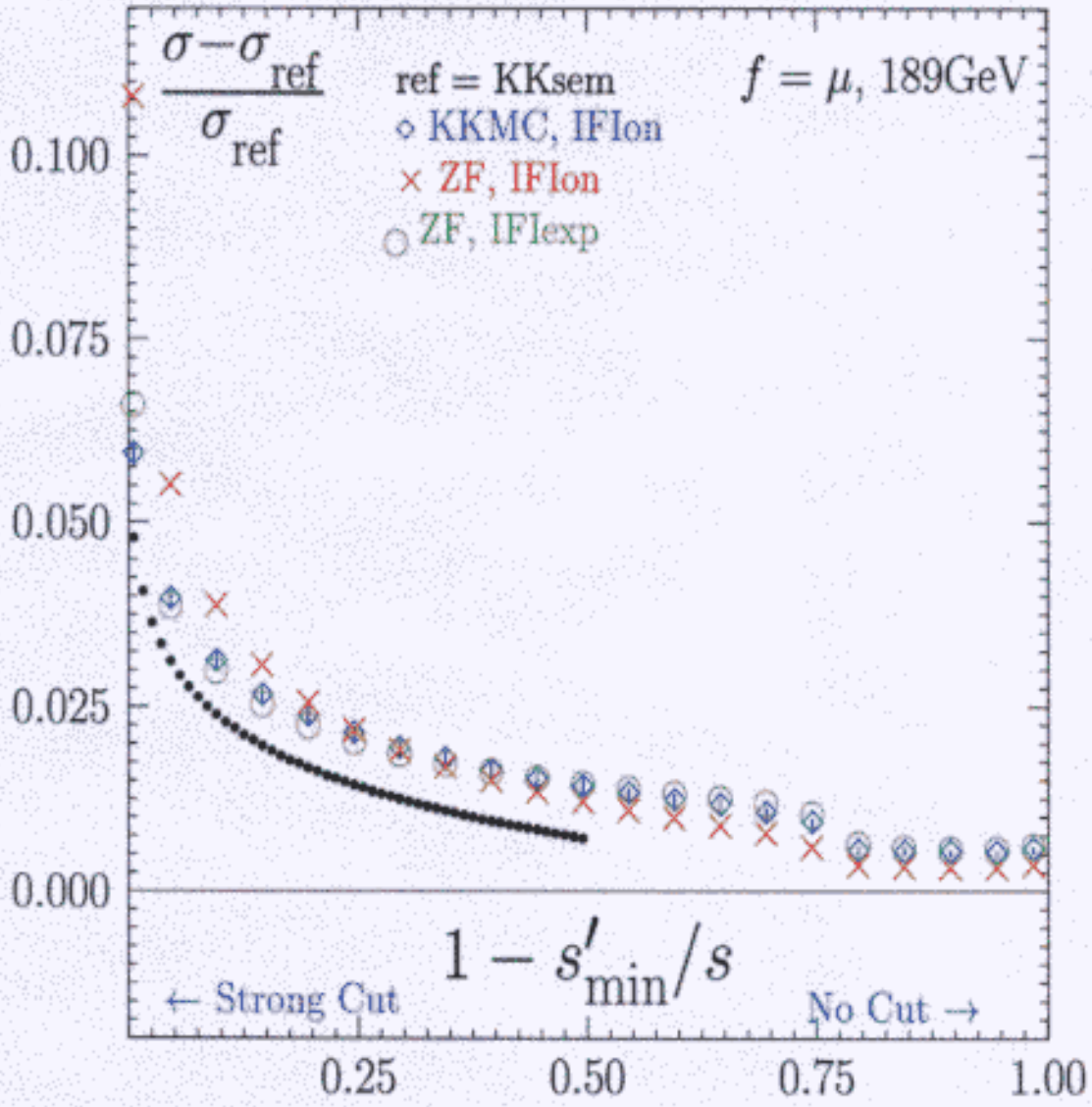
DESY

KKMC – ZFitter, March-June 2000



The comparison at 189GeV. The IFI is OFF for KKMC, ZFitter and the reference KKsem. The agreement is 0.2%

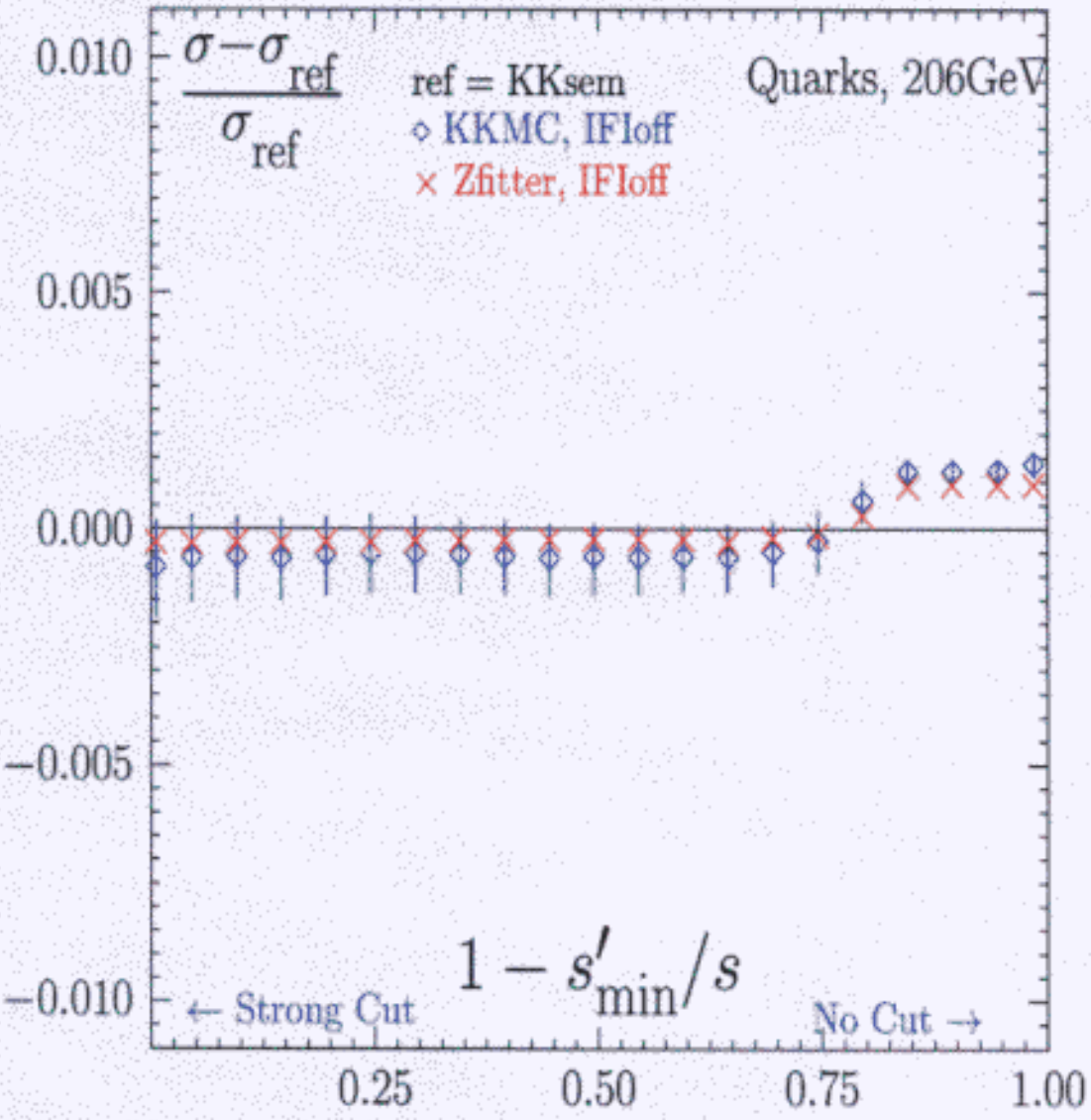
KKMC – ZFitter, March-June 2000



The comparison at 189GeV. The IFI is ON for KKMC and ZFitter and OFF for the reference KKsem. Black dots represent:

$$\delta_{IFI}(v_{\max}) = 1 - 2A_{FB}\kappa \ln v_{\max} + \kappa^2 \ln^2 v_{\max}\left(\tfrac{1}{2} + \tfrac{\pi^2}{6}\right) + const,$$

KKMC – ZFitter, March-June 2000



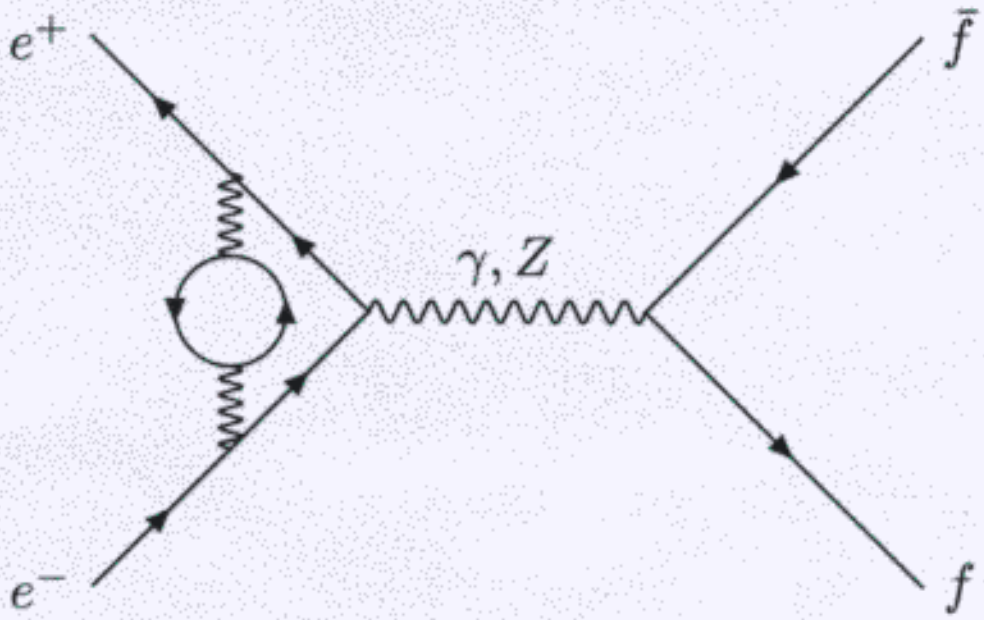
First systematic comparison for quarks (at 206GeV). The IFI is OFF. The agreement for x-section is 0.2% !

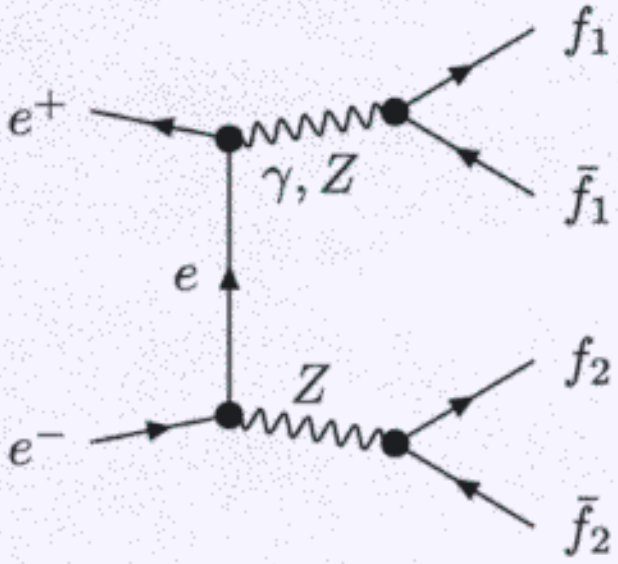
KKMC – ZFitter, March-June 2000

f	(a) KKsem	(b) $\mathcal{O}(\alpha^2)^{\rm mOFF}_{\rm CEEX}$	(c) Zfitter 6.x	(b-a)/a	(c-a)/a
	$A_{FB}(v_{\rm max})$[pb], $v_{\rm max}=0.01$, 200GeV				
d	0.5969 ± 0.0000	0.5962 ± 0.0017	0.5794 ± 0.0000	-0.0007 ± 0.0017	-0.0176 ± 0.0000
u	0.6698 ± 0.0000	0.6692 ± 0.0014	0.6485 ± 0.0000	-0.0005 ± 0.0014	-0.0213 ± 0.0000
s	0.5969 ± 0.0000	0.5966 ± 0.0017	0.5794 ± 0.0000	-0.0003 ± 0.0017	-0.0176 ± 0.0000
c	0.6697 ± 0.0000	0.6701 ± 0.0014	0.6489 ± 0.0000	0.0004 ± 0.0014	-0.0208 ± 0.0000
b	0.6022 ± 0.0000	0.6019 ± 0.0017	0.5867 ± 0.0000	-0.0004 ± 0.0017	-0.0155 ± 0.0000
all	0.6355 ± 0.0000	0.6353 ± 0.0015	0.6165 ± 0.0000	-0.0003 ± 0.0015	-0.0191 ± 0.0000
μ	0.5550 ± 0.0000	0.5553 ± 0.0013	0.5541 ± 0.0000	0.0003 ± 0.0013	-0.0009 ± 0.0000
	$A_{FB}(v_{\rm max})$[pb], $v_{\rm max}=0.10$, 200GeV				
d	0.5962 ± 0.0000	0.5952 ± 0.0014	0.5788 ± 0.0000	-0.0009 ± 0.0014	-0.0174 ± 0.0000
u	0.6706 ± 0.0000	0.6696 ± 0.0012	0.6495 ± 0.0000	-0.0010 ± 0.0012	-0.0211 ± 0.0000
s	0.5962 ± 0.0000	0.5954 ± 0.0014	0.5788 ± 0.0000	-0.0008 ± 0.0014	-0.0174 ± 0.0000
c	0.6705 ± 0.0000	0.6705 ± 0.0012	0.6498 ± 0.0000	0.0000 ± 0.0012	-0.0207 ± 0.0000
b	0.6016 ± 0.0000	0.6014 ± 0.0014	0.5863 ± 0.0000	-0.0003 ± 0.0014	-0.0153 ± 0.0000
all	0.6356 ± 0.0000	0.6350 ± 0.0013	0.6167 ± 0.0000	-0.0006 ± 0.0013	-0.0189 ± 0.0000
μ	0.5559 ± 0.0000	0.5557 ± 0.0011	0.5552 ± 0.0000	-0.0002 ± 0.0011	-0.0007 ± 0.0000
	$A_{FB}(v_{\rm max})$[pb], $v_{\rm max}=0.20$, 200GeV				
d	0.5952 ± 0.0000	0.5942 ± 0.0013	0.5774 ± 0.0000	-0.0009 ± 0.0013	-0.0177 ± 0.0000
u	0.6716 ± 0.0000	0.6704 ± 0.0011	0.6501 ± 0.0000	-0.0012 ± 0.0011	-0.0214 ± 0.0000
s	0.5952 ± 0.0000	0.5943 ± 0.0013	0.5774 ± 0.0000	-0.0009 ± 0.0013	-0.0177 ± 0.0000
c	0.6715 ± 0.0000	0.6713 ± 0.0011	0.6505 ± 0.0000	-0.0003 ± 0.0011	-0.0210 ± 0.0000
b	0.6008 ± 0.0000	0.6004 ± 0.0013	0.5852 ± 0.0000	-0.0004 ± 0.0013	-0.0156 ± 0.0000
all	0.6356 ± 0.0000	0.6348 ± 0.0012	0.6164 ± 0.0000	-0.0008 ± 0.0012	-0.0192 ± 0.0000
μ	0.5570 ± 0.0000	0.5568 ± 0.0011	0.5560 ± 0.0000	-0.0003 ± 0.0011	-0.0010 ± 0.0000
	$A_{FB}(v_{\rm max})$[pb], $v_{\rm max}=0.30$, 200GeV				
d	0.5939 ± 0.0000	0.5924 ± 0.0013	0.5754 ± 0.0000	-0.0015 ± 0.0013	-0.0185 ± 0.0000
u	0.6727 ± 0.0000	0.6711 ± 0.0011	0.6506 ± 0.0000	-0.0017 ± 0.0011	-0.0222 ± 0.0000
s	0.5939 ± 0.0000	0.5923 ± 0.0013	0.5754 ± 0.0000	-0.0016 ± 0.0013	-0.0185 ± 0.0000
c	0.6727 ± 0.0000	0.6718 ± 0.0011	0.6509 ± 0.0000	-0.0009 ± 0.0011	-0.0217 ± 0.0000
b	0.5999 ± 0.0000	0.5990 ± 0.0013	0.5836 ± 0.0000	-0.0009 ± 0.0013	-0.0163 ± 0.0000
all	0.6356 ± 0.0000	0.6343 ± 0.0012	0.6156 ± 0.0000	-0.0013 ± 0.0012	-0.0199 ± 0.0000
μ	0.5584 ± 0.0000	0.5576 ± 0.0010	0.5568 ± 0.0000	-0.0008 ± 0.0010	-0.0016 ± 0.0000

Problem to be solved: 2% discrepancy in A_{FB} for quarks.

Problem of secondary pairs





Problems: (a) definition of the signal,

(b) reliability of the calculations.

Current solution: ZFITTER + GENTLE

Our MC solution: KKMC + KORALW.

Evolution of KK MC and comparison with predecessors

Feature	KORALB	KORALZ	KK 4.14	KK 2000+?
QED type	$\mathcal{O}(\alpha)$	EEX	CEEX, EEX	CEEX, EEX
CEEX(ISR+FSR)	none	none	$\{\alpha, \alpha L; \alpha^2 L^2, \alpha^2 L^1\}$	$\{...\alpha^2 L^1; \alpha^3 L^3\}$
EEX(ISR*FSR)	none	$\{\alpha, \alpha L, \alpha^2 L^2\}$	$\{\alpha, \alpha L, \alpha^2 L^2, \alpha^3 L^3\}$	$\{...\alpha^2 L^2, \alpha^3 L^3\}$
ISR-FSR int.	$\mathcal{O}(\alpha)$	$\mathcal{O}(\alpha)$	$\{\alpha, \alpha L\}_{\rm CEEX}$	$\{\alpha, \alpha L\}_{\rm CEEX}$
Exact bremss.	1 γ	1, 2coll. γ	1, 2, 3coll. γ	up to 3 γ
Electroweak	No Z-res.	DIZET 6.x	DIZET 6.x	2-nd EW libr.
Virt. pairs	None	None	Simple	Improved
Beam polar.	long+trans.	longit.	long+trans.	long+trans.
τ polar.	long+trans.	longit.	long+trans.	long+trans.
Hadronization	—	JETSET	JETSET	PYTHIA
τ decay	TAUOLA	TAUOLA	TAUOLA	TAUOLA
Inclusive mode	—	No	Yes	Yes
Beamstrahlung	—	No	Yes	Yes
Beam spread	—	No	Yes	Yes
$\nu\nu$ channel	—	Yes	No	Yes!!
ee channel	—	No	No	Yes!
tt channel	—	No	No	yes?
WW channel	—	No	No	yes?

What next?

- Neutrino channel
- Bhabha, low+wide angle
- Virtual pairs (better hadronic contr.)
- Second EW library
- Improvements in phase space integration

First official version 4.13 of KK MC available. Next version 4.13 in a few weeks.

Check **http://home.cern.ch/jadach** for slides, programs.