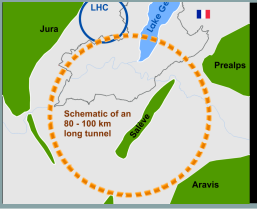
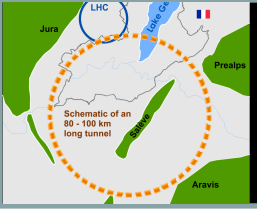


KKMCee for FCCee (BES)

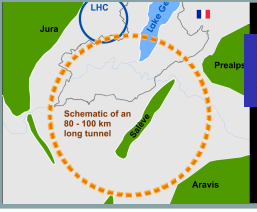
Stanisław Jadach, Marcin Chrząszcz

Physics Performance meeting, CERN **October 18th, 2021**



OUTLINE

- KKMC status Oct. 2019 (FCC software meeting)
  https://nz42.ifj.edu.pl/_media/user/jadach/main/talks/2019-10-04-cern-fccsoftware.pdf
- KKMCee where we are now in 2021
- More on BES = beam energy spread



More KKMC versions available since 2000

https://twiki.cern.ch/twiki/bin/view/FCC/FccGenerators

http://192.245.169.66:8000/FCCeeMC/wiki/kkmc

KKMC for fermion pair production at electron-positron colliders

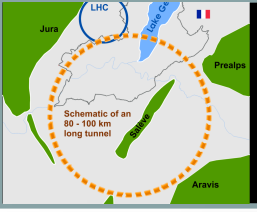
- Production Version 4.16, Oct. 2001, (KKMC-v.4.16d-export.tar.gz). Improved $\nu\bar{\nu}$ matrix elm. RRes module for $\gamma^* \rightarrow$ *narrow resonances* at LEP.
- Developement Version 4.19, Sept. 2002, (KKMC-v.4.19.b-export.tar.gz). With C++ wrappers. Improved $\nu\bar{\nu}$ matrix element and RRes for low energy colliders. ISR with complete NLO corrs, as in Phys.Rev. D65(2002) 073030 by S.J., M.Melles, B.F.L.Ward and S.A. Yost. Collinear beamstrahlung for NLC/ILC.
- Developement Version 4.22, June 2013, (KKMC_v4_22.tgz). Tested with $\mu^-\mu+$ and $q\bar{q}$ beams (instead of e^-e^+) at fixed energy. Optionally, collinear PDFs for $q\bar{q}$ beams instead of beamstrahlung, as a patch in the source code (temp. solution).
- First version [4.24] of the **KKMCee development branch**.

Beamstrahlung implementation for FCCee/ILC/CLIC is now improved, simplified and better debugged. Temporary insertions in the source code for quark beams are removed (kept and developed further in KKMChh branch, to be published).

More on KKMC version 4.22 (2013)
Technical points

- Old benchmarks, Table III in Pys.Rev. D 63 (2001) and more, are reproduced under SLC5 and SLC6, after adjustments of flags in makefile's and minor corrections in f77 code.
- Unpublished (public) v.4.16,4.19 include varying subset of extra subdirectories, not included in v4.13. Also not in v.4.22.
- System of original interrelated custom *Makefile*'s is renamed *Makefile* $\rightarrow$ *KKMakefile* and preserved.
- *Atomake*/*Autotools* are introduced (*makefile.am* etc.). Hence KKMC is more platform independent and can be easily put under *kdevelop*3 or *eclipse*.
- Interface to C++ is provided. Main program (histogramming, etc) can be in C++, using optionally ROOT. (On request, or in v4.19)
- Scripts for running on PC-farms slightly upgraded and working.
- Old versions of PHOTOS and TAUOLA.

Version 4.24 (2017) tested/run under Centos7 and Ubuntu16



TAUOLA is an important part of KKMC

https://twiki.cern.ch/twiki/bin/view/FCC/FccGenerators

FCC hh ee he

arch
FCC All webs

StaszekJadach
Log Out
FCC

CommonTools
FccGenerators
Bhabha
Higgsline
Kkmc
Tauola

FCC web page
FCC-ee (TLEP) web page
FCC-hh (FHC) old twiki
FCC-eh (LHeC) web page

Web Left Bar

TWiki > FCC Web > CommonTools > FccGenerators (2017-05-03, MarcinChrzaszcz)

Edit Attach PDF

Welcome to LEP/TLEP/FCCee repository of the MC generators

Low Angle Bhabha BHLUMI (by S.Jadach, W.Placzek, E.Richter-Was, B.F.L.Ward and Z.Was)

source code, documentation, talks

Fermion pair production: KKMC (by S.Jadach, et. al)

source code, documentation, talks

Tau lepton decays: TAUOLA (by M.Chrzaszcz, T. Przedzinski, Z. Was, J. Zaremba)

source code, documentation, talks

TAUOLA source code:

* Source code of TAUOLA for FCCee TAUOLA-FORTRAN-03-05-2017.tar.gz

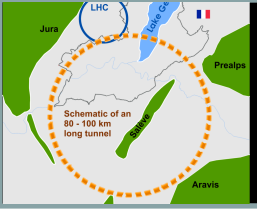
Documentation (papers):

- https://arxiv.org/abs/1609.04617

PHOTOS is inside

Attachments

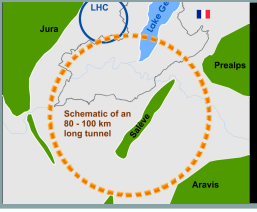
I	Attachment	History	Action	Size	Date	Who
	TAUOLA-FORTRAN-03-05-2017.tar.gz	r1	manage	9914.1 K	2017-05-03 - 23:09	MarcinChrzaszcz



Recent developments in KKMC

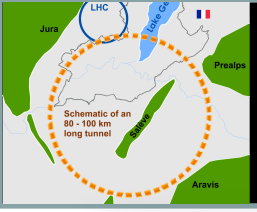
- Upgrade of DIZET electroweak library, hadronic VP routine, more steering parameters for manipulating EW corrections.
- Upgrade of TAUOLA library.
- Output LHE event record.
- Upgraded F77 code including BES is now available on GitHub.
- Complete and well tested version of KKMCee entirely in C++ (except DIZET and TAUOLA) is there on GitHub but not published yet.

More on GitHub repository:
https://github.com/KrakowHEPSoft/KKMCee
The current version:
https://github.com/KrakowHEPSoft/KKMCee/releases/tag/v4.32.01



More on BES

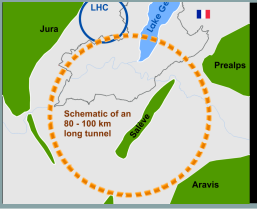
- Generally one may include BES ***inside*** the MC event generator or ***outside***.
- Second method in principle is easy, just generate beam energies E_1 and E_2, run MC at the reduced CM energy $s'^{1/2} = 2(E_1 E_2)^{1/2}$ and boost events to LAB.
- (Patrick has provided compact algorithm for generating E_1 and E_2 according to correlated double-gaussian distribution of FCCee.)
- In practice it does not work like above, because most of MCs memorise $s^{1/2}$ and internal variables dependent on $s^{1/2}$. Cannot change $s^{1/2}$ event per event:(
- One may apply workaround proposed by Patrick Janot:
  Using an additional MC create look-up tables of correction due to (small) change of $s^{1/2}$ for the total cross section and/or for other important observables.
  Next proceed as before, correcting MC events with the weight from tables.
- There will be always some other distributions which will be not corrected:(
- The only perfect solution is to include generation of E_1 and E_2 as any other variables in the MC algorithm of the event generator.
- This is presently implemented in ***KKMCee***.



BES distribution in KKMCee

- In KKMC there is since long an option of the variable beam energies due to beamstrahlung (BST) distributions of ILC.
- BST distributions reside in the 3-dimensional integrand of **FOAM**, along with the total energy loss due to initial state radiation ISR.
- Recently **BES** spectrum from Patrick Janot has been added as another new option in KKMCee in the same FOAM integrand.
- Example of the input data activating **BES** *ffbench/Mu/Mu_input_1k_KeFix=4*, looks like below…

```
 5 BeginX
 6 ********************************************************************************
 7 *               ACTUAL DATA FOR THIS PARTICULAR RUN
 8 ********************************************************************************
 9 *indx____data_____ccccccccc0ccccccccc0ccccccccc0ccccccccc0ccccccccc0ccccccccc0
10 *     Center-of-mass energy [GeV]
11     1         91.0e0      CMSene =xpar( 1) Average Center of mass energy [GeV]
12    25              4    KeyFix=0 normal, =2 beamsstrahlung =3,4 for gaussian BES
13 *indx____data_____ccccccccc0ccccccccc0ccccccccc0ccccccccc0ccccccccc0ccccccccc0
14    80          0.0e0      ParBES(0) E1=0 will be replaced by CMSene/2
15    81          0.0e0      ParBES(1) E2=0 will be replaced by CMSene/2
16    82        0.132e-2     ParBES(2) sigma1/E1
17    83        0.132e-2     ParBES(3) sigma2/E2
18    84         0.300e0     ParBES(3) rho correlation parameter, dimensionles
19 ********************************************************************************
20 *     Define process
21   413              1      KFfin, muon
22   100              1      store lhe file to (LHE_OUT.LHE)
23 ************************* one can change the lhf file name between brackets
24 ********************************************************************************
25 EndX
```

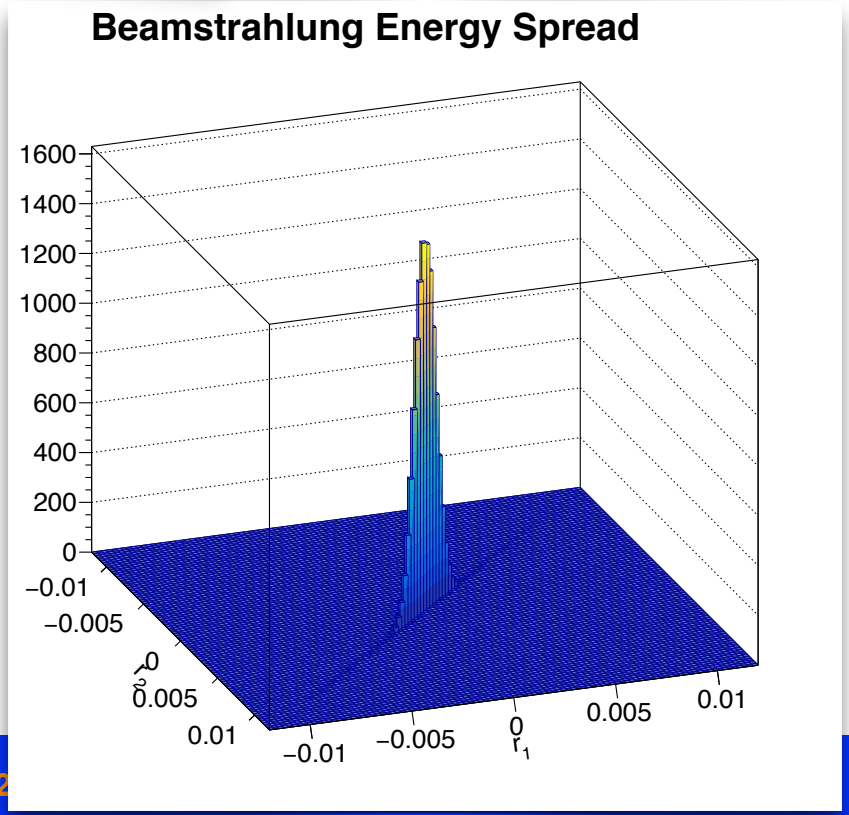


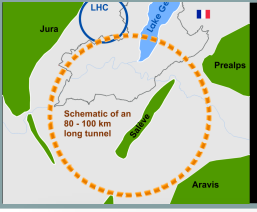
BES in KKMCee

- Correlated double-Gaussian BES from Patrick Janot implemented in KKMCee:

$$P(x,y)=\frac{1}{2\pi\sigma_x\sigma_y\sqrt{1-\rho^2}}\exp\left(-\frac{1}{2(1-\rho^2)}\left[\left(\frac{x-x_0}{\sigma_x}\right)^2+\left(\frac{y-y_0}{\sigma_y}\right)^2-2\rho\left(\frac{x-x_0}{\sigma_x}\right)\left(\frac{y-y_0}{\sigma_y}\right)\right]\right)$$

Histogram of two beam energies (relative deviations from central values) from KKMCee, 1M events.





BES: technical point

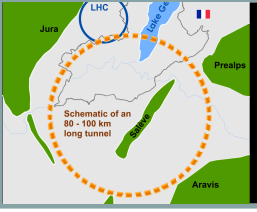
- Correlated double-Gaussian BES from Patrick Janot is implemented twice in KKMCee, using two different methods — once using mapping invented by Patrick (KeyFix=3):

```
429 C mapping of Patrick Janot for 2-dim Gaussian BES with optional correlation
430 C in this case Jacobian*distribution=1 is omitted.
431       E1    = m_BES_ene1
432       E2    = m_BES_ene2
433       corho = m_BES_rho
434       x1 = sqrt(-2.*log(r1)) * cos(2.*m_PI*r2)
435       x2 = sqrt(-2.*log(r1)) * sin(2.*m_PI*r2)
436       y1 = x1
437       y2 = corho * x1 + sqrt(1.-corho*corho) * x2
438       rr1= y1 * m_BES_sig1
439       rr2= y2 * m_BES_sig2
440       Ebeam1 = E1 * (1.0 + y1 * rr1)
441       Ebeam2 = E2 * (1.0 + y2 * rr2)
```

- and alternatively by providing FOAM with the distribution — mapping is done by FOAM (KeyFix=4).

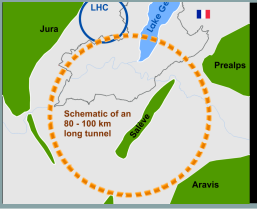
```
449 ! the same BES distribution from Patrick Janot
450       E1    = m_BES_ene1
451       E2    = m_BES_ene2
452       sigma1= m_BES_sig1*E1
453       sigma2= m_BES_sig2*E2
454       corho = m_BES_rho
455 ! standard distribution for FOAM
456       sigma = SQRT(sigma1*sigma2)
457       delE1 = 10*sigma*(2*r1-1.0)  ! range is +-10sigma
458       delE2 = 10*sigma*(2*r2-1.0)  ! range is +-10sigma
459       Rho = Rho* (20*sigma)**2  ! Jacobian
460       m_x1 = delE1/E1 ! can be negative
461       m_x2 = delE2/E2 ! can be negative
462       dGauss = (delE1/sigma1)**2+ (delE2/sigma2)**2 -2*corho*(delE1/sigma1)*(delE2/sigma2)
463       dGauss = EXP(-0.5/(1-corho**2)*dGauss)
464       dGauss = dGauss* 1/(2.0*m_PI)/(sigma1*sigma2)/SQRT(1-(corho)**2) ! Normalization fac
465       Rho = Rho* dGauss;
```

- The resulting generated distribution is the same (providing proof/cross-check of the Patrick's mapping :).



C++ version of KKMCee

- Complete code in C++ of KKMCee is already there in the non-public repository on GitHub since a few months, waiting for publication…
- It is interfaced with electroweak library DIZET 6.24 and TAUOLA, both in F77.
- It reproduces exactly all classic benchmarks of KKMC from the 1999 LEP workshop and from PRD63 (2000) article.
- From the physics point of view it is identical with F77 version, but is planned as a starting point for the future development.
- It is armed with LHE interface and includes BES of FCCee.
- Complete documentation (CPC article) is urgently needed.
- Repository to be be cleaned up of unused F77 source code.



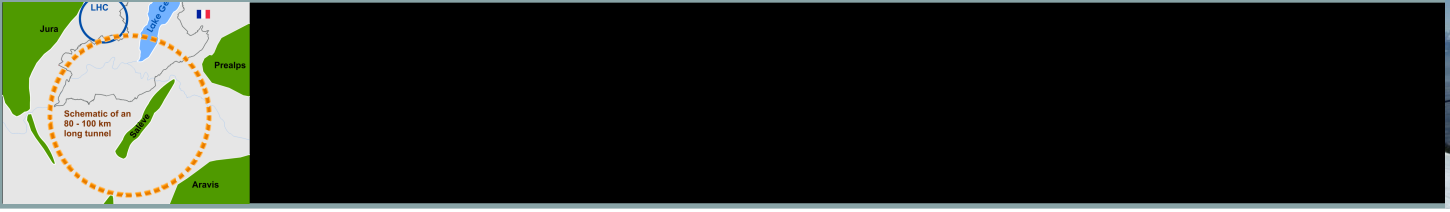
Summary

- KKMC legacy code written F77 is alive and is available for FCCee related studies since long.

- KKMCee in C++ is already there,
  to be documented and published.

- Two web pages and public GitHub repository with the F77 source codes and extensive documentation are available.

- The ultimate future KKMCee version for the precision physics at FCCee is to be developed, starting from the C++ version.


LHC
Jura
Lake Ge
Prealps
Schematic of an
80 - 100 km
long tunnel
Salève
Aravis


Reserve