New Generator Samples for the DBD

Tim Barklow (SLAC)

for the ILC Common Data Sample Subgroup – Akiya Miyamoto, Mikael Berggren and T.B.

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Outline

- ILC PEB Task Force Document on Benchmarks for the DBD
- Changes in Event Generation Since the LOI
- Status of Event Generation
  - WW and 4-fermion background
  - 6-fermion event generation
  - ttH and 8-fermion background

Detector Benchmarking for the 2012 DBD

ILC PEB Benchmarks Task Force

1. $e^+e^- \to \nu\bar{\nu}h^0$ at $E_{\rm CM} = 1$ TeV, where h^0 is a Standard Model Higgs boson of mass 120 GeV, in the final states $h^0 \to \mu^+\mu^-$, $b\bar{b}$, $c\bar{c}$, gg, WW^*. The goal is to measure the cross section times branching ratio for these reactions.

2. $e^+e^- \to W^+W^-$ at $E_{\rm CM} = 1$ TeV, considering both hadronic and leptonic (e, μ) decays of the W. The goal is to use the value of the forward W pair production cross section to measure in situ the effective left-handed polarization $(1 - P_{e^-})(1 + P_{e^+})/4$ for each of two polarization configurations.

3. $e^+e^- \to t\bar{t}h^0$ at $E_{\rm CM} = 1$ TeV, where h^0 is a Standard Model Higgs boson of mass 120 GeV, in the final state $h^0 \to b\bar{b}$. The reaction involves final states with 8 jets and final states with 6 jets, one lepton, and missing energy. The goal is to measure the Higgs boson Yukawa coupling to $t\bar{t}$.

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2. Generation of physics events.

Tim Barklow, Mikael Berggren, and Akiya Miyamoto have developed a semi-automated system for generating particle-level events using WHIZARD. This program allows generation of Higgs signal events, Standard Model e^+e^- background, and Standard Model two-photon background, including backgrounds from beamstrahlung photons. Barklow, Berggren, and Miyamoto have agree to take responsibility for generating a common sample of physics and background events to be used by both ILD and SiD in the exercise.

As a matter of principle, all relevant physics backgrounds should be included. For e^+e^- annihilation backgrounds, the process $e^+e^- \rightarrow t\bar{t}h^0$ requires simulating Standard Model background processes with up to 8 partons in the final state. It may be that Standard Model processes with higher numbers of final partners also leak into the sample to be analyzed. Barklow, Berggren, and Miyamoto will generate these additional, more complex, events as time and computing resources allow. In any event, ILD and SiD will use the same background event samples, as described below.

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Barklow, Berggren, and Miyamoto will also simulate a large sample of $\gamma\gamma$ events, including low-energy events with large cross sections. In the simulations, an appropriate number of these low-energy $\gamma\gamma$ events will be overlaid. See the next section for more details.

Events will be generated in four samples, corresponding to initial states with 100% electron and positron polarization (-/+, +/-, -/-, and +/+). The final physics events will be written to a file in stdhep format. Each event record should contain the specification of the initial state, including the momenta of all initial electrons, positrons, and photons. Each event record should contain a global event ID for easy identification. All events should have weight 1.

Changes Since the LOI

- Distribute Event Generation between KEK, DESY and SLAC
- Include initial state particles and final state polarization and color flow in event record
- Improved data base for event generation information
- Include amplitudes with CKM-suppressed vertices in event generation
- Use particle aliasing to reduce the number of distinct WHIZARD processes (let the WHIZARD program do the flavor sums)

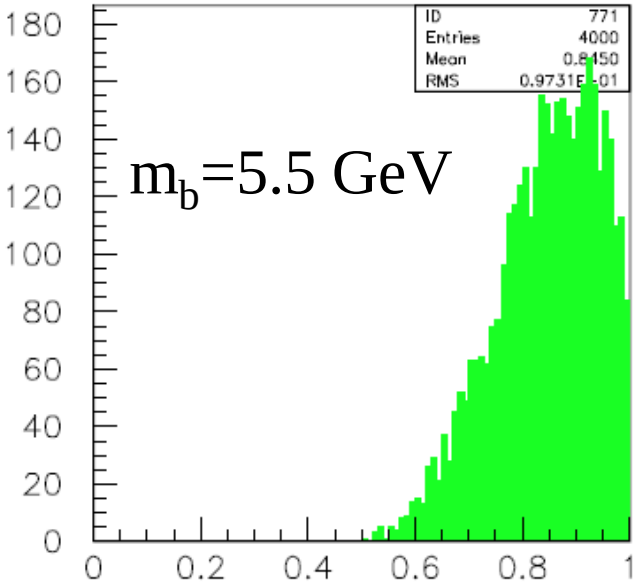
Aliasing

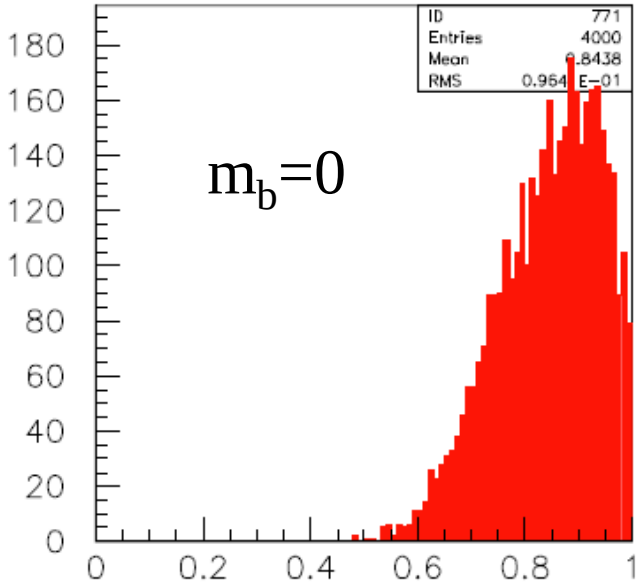
```
alias q u:d:s:c:b:U:D:S:C:B
alias r u:d:s:c:U:D:S:C
alias e e1:E1
alias l e2:e3:E2:E3
alias v n1:n2:n3:N1:N2:N3
alias x u:c:U:C
alias y d:s:D:S
alias k b:B
```

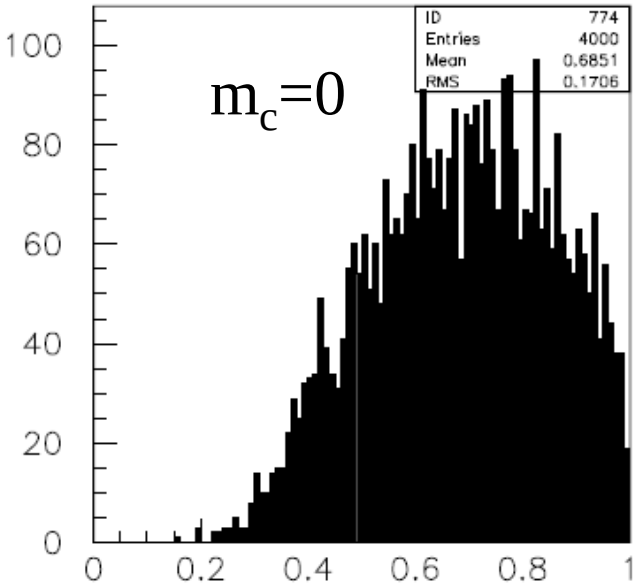
Aliased particles must have the same charge, color rep, and mass

processes dominated by $e^+e^- \to t\bar{t} \to b\bar{b}qqqq$:

```
bbxxyy_o    e1,E1   k,k,x,x,y,y    omega    w:c,c
bbxxby_o    e1,E1   k,k,x,x,k,y    omega    w:c,c
bbxxbb_o    e1,E1   k,k,x,x,k,k    omega    w:c,c
```







$e^+e^- \to b\bar{b}$

$e^+e^- \to c\bar{c}$

$\sqrt{s} = 1\ \text{TeV}$

no ISR, no FSR

4-Fermion Production

- With aliasing, number of processes changed from 45 without CKM-suppressed final states to about 18 including CKM-suppressed final states
- Mikael Beggren has created a script that can generate all 4-fermion events with a specified lumi, fill a status file, copy stdhep files to grid and output other info (.log, .in, .out, .prc.,… files) to a web directory.
- Mikael recently tested the script by generating all 4-fermion processes excluding those with final state electrons and produced 1 ab-1 equiv overnight.

6-Fermion Production

- Aliasing has allowed us to consolidate the processes
- Compilation and MC integration take much longer than before because of the CKM-suppressed vertices. However, compilation and integration only has to be done once, so this ultimately should not hold us up.

```
! WHIZARD version 1.95 (Feb 25 2010)
! Process qqqqvv_o:
! WHIZARD run for process qqqqvv_o:
!=============================================
! Input checksum = 3B68C2EF06B73739B27D58725EAA
!-------------------------------------------------------------
! It    Calls  Integral[fb]  Error[fb]   Err[%]   Acc  Eff[%]
!-------------------------------------------------------------
  1   100000  1.8876599E+02  4.82E+01   25.52  80.70*
!-------------------------------------------------------------
  2   100000  2.7958961E+02  8.46E+01   30.27  95.73
  3   100000  1.9658823E+02  2.40E+01   12.23  38.66*
  4   100000  2.8185948E+02  5.33E+01   18.90  59.75
  5   100000  2.4860713E+02  2.14E+01    8.63  27.28*
  6   100000  3.4910129E+02  6.17E+01   17.66  55.86
  7   100000  3.0980266E+02  7.07E+01   22.81  72.13
  8   100000  2.8654682E+02  1.66E+01    5.80  18.35*
  9   100000  3.0247930E+02  3.10E+01   10.24  32.38
 10   100000  2.4706612E+02  1.31E+01    5.30  16.77*
 11   100000  2.5830282E+02  1.44E+01    5.58  17.63
!-------------------------------------------------------------
 12   300000  4.8821383E+02  2.00E+02   40.95 224.30
```

```
! WHIZARD version 1.95 (Feb 25 2010)
! Process yyyyvv_o:
!   e a-e ->   d   d a-d a-d nu_e a-nu_e
!   e a-e ->   s   s a-d a-d nu_e a-nu_e
!   e a-e ->   b   b a-d a-d nu_e a-nu_e
!                  .
!                  .
!                  .
!  128  64 ->   1   2   4   8    16     32
!
! WHIZARD run for process yyyyvv_o:
!=============================================
! Input checksum = 2614242A99DAD29364C961343F1B
!-------------------------------------------------------------
! It    Calls  Integral[fb]  Error[fb]   Err[%]   Acc  Eff[%]
!-------------------------------------------------------------
  1   100000  2.0310620E+02  1.33E+02   65.57 207.37*
!-------------------------------------------------------------
  2   100000  1.0657116E+02  3.55E+01   33.29 105.26*
  3   100000  1.2243194E+02  7.28E+01   59.50 188.14
  4   100000  8.0454756E+01  2.10E+01   26.09  82.49*
  5   100000  7.2777974E+01  6.07E+00    8.34  26.37*
  6   100000  6.6693845E+01  8.77E+00   13.15  41.59
  7   100000  5.7516211E+01  3.10E+00    5.39  17.06*
  8   100000  6.3220731E+01  3.29E+00    5.20  16.43*
  9   100000  6.0997089E+01  2.46E+00    4.04  12.78*
 10   100000  7.5510690E+01  6.70E+00    8.87  28.06
 11   100000  6.4766940E+01  3.63E+00    5.60  17.71
!-------------------------------------------------------------
 12   300000  8.1706588E+01  9.21E+00   11.27  61.71
```

8-Fermion production

- Production of tth suspended for the moment at KEK
- Problems with ordering of final state fermions in the interface between WHIZARD and PYTHIA (not an uncommon problem)
- Still looking for a solution to the problem of generating 8-fermion and 10-fermion backgrounds to ttH