# WHIZARD $ab^{-1}$ Data Sets 2005

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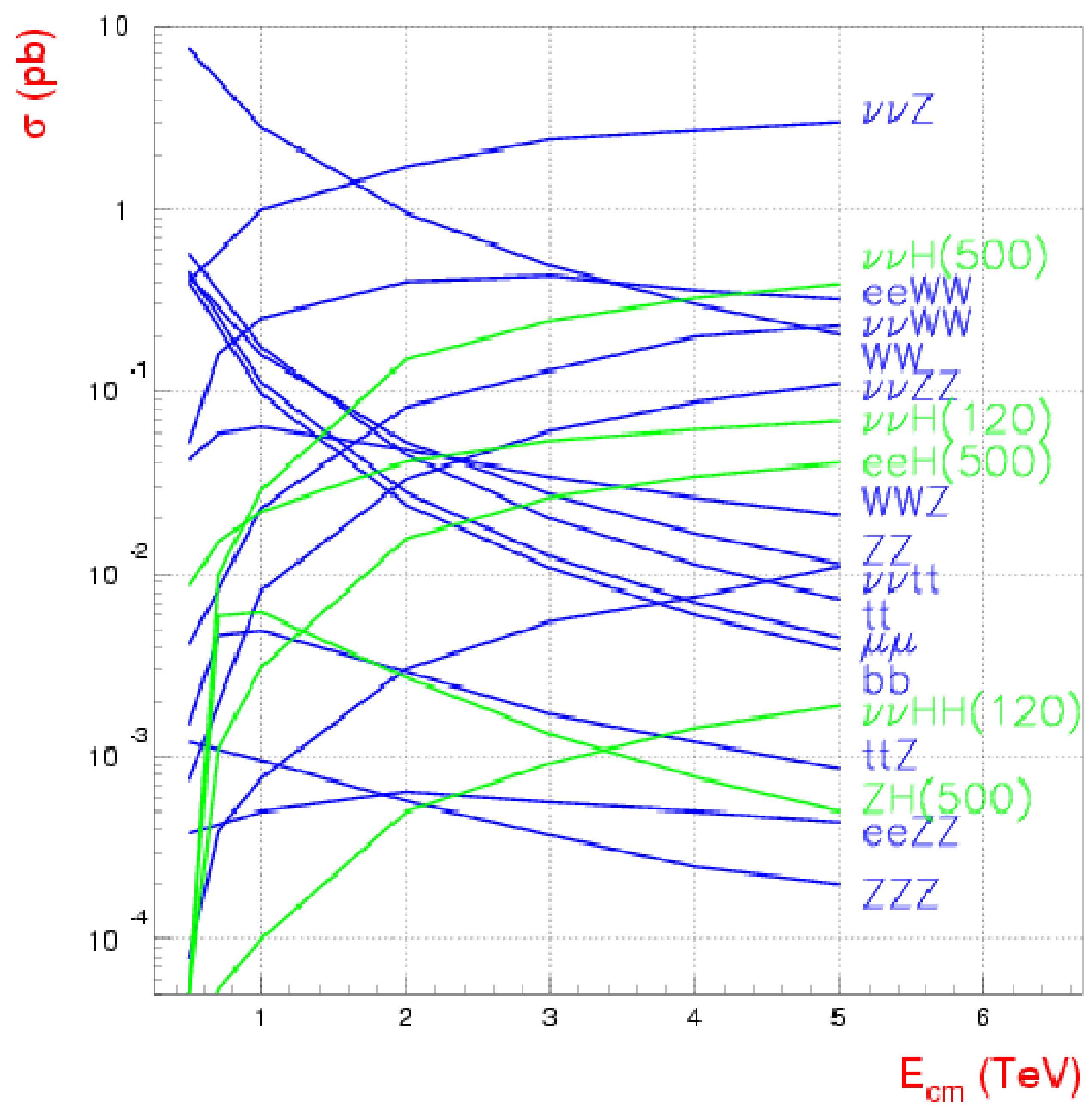

σ (pb)
10
1
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
1
2
3
4
5
6
$E_{cm}$ (TeV)
ννZ
ννH(500)
eeWW
ννWW
WW
ννZZ
ννH(120)
eeH(500)
WWZ
ZZ
ννtt
tt
μμ
bb
ννHH(120)
ttZ
ZH(500)
eeZZ
ZZZ

# Monte Carlo Production

- WHIZARD Monte Carlo is used to generate all 0,2,4,6-fermion and t quark dominated 8-fermion processes.
- 1 $ab^{-1}$ @ 0.5 TeV & 2 $ab^{-1}$ @ 1.0 TeV using NLC params have been generated so far.
- 100% electron and positron polarization is assumed in all event generation. Arbitrary electron, positron polarization is simulated by properly combining data sets.
- Fully fragmented MC data sets are produced. PYTHIA is used for final state QED & QCD parton showering, fragmentation, particle decay.

## SM Final States

### 0-fermion

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

### 2-fermion

| | | |
|---|---|---|
| $e^+e^- \to$ | $ff$ | $f \neq \nu$ |
| | $\nu\nu\gamma$ | |
| | $\nu\nu\gamma\gamma$ | |
| | $\nu\nu\gamma\gamma\gamma$ | |
| $e^-\gamma \to$ | $e^-\gamma$ | |
| $\gamma e^+ \to$ | $e^+\gamma$ | |

### 4-fermion

| | | |
|---|---|---|
| $e^+e^- \to$ | $\nu\nu\nu\nu\gamma$ | 6 total |
| | $u_j\overline{d}_jd_k\overline{u}_k$ | 25 total |
| | | $\nu_e e^+ e^- \overline{\nu}_e$ |
| | | $\nu_e e^+ \mu^- \overline{\nu}_\mu$ |
| | | $\nu_e e^+ \tau^- \overline{\nu}_\tau$ |
| | | $\nu_e e^+ d\overline{u}$ |
| | | . |
| | | . |
| | | $c\overline{s}s\overline{c}$ |
| | $u_j\overline{u}_ju_k\overline{u}_k$ | 9 total |
| | $u_j\overline{u}_jd_k\overline{d}_k$ | 25 total |
| | $d_j\overline{d}_jd_k\overline{d}_k$ | 21 total |
| $\gamma\gamma \to$ | $f\overline{f}$ | 8 total |
| $e_L^-\gamma \to$ | $\nu_e d_k\overline{u}_k$ | 5 total |
| $e^-\gamma \to$ | $e^- f\overline{f}$ | 10 total |
| $\gamma e_R^+ \to$ | $\overline{\nu}_e u_k\overline{d}_k$ | 5 total |
| $\gamma e^+ \to$ | $e^+ f\overline{f}$ | 10 total |

### 6-fermion

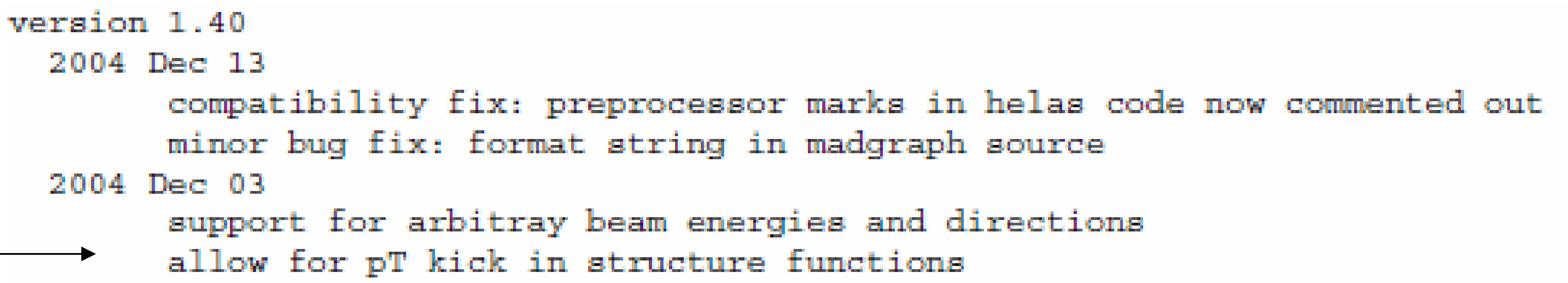
| | | |
|---|---|---|
| $e^+e^- \to$ | $u_i\overline{u}_iu_j\overline{d}_jd_k\overline{u}_k$ | 125 total |
| | $d_i\overline{d}_iu_j\overline{d}_jd_k\overline{u}_k$ | 150 total |
| | $u_i\overline{u}_iu_j\overline{u}_ju_k\overline{u}_k$ | 25 total |
| | $u_i\overline{u}_iu_j\overline{u}_jd_k\overline{d}_k$ | 65 total |
| | $u_i\overline{u}_id_j\overline{d}_jd_k\overline{d}_k$ | 75 total |
| | $d_i\overline{d}_id_j\overline{d}_jd_k\overline{d}_k$ | 56 total |
| $\gamma\gamma \to$ | $u_j\overline{d}_jd_k\overline{u}_k$ | 25 total |
| | $u_j\overline{u}_ju_k\overline{u}_k$ | 9 total |
| | $u_j\overline{u}_jd_k\overline{d}_k$ | 25 total |
| | $d_j\overline{d}_jd_k\overline{d}_k$ | 21 total |
| $e_L^-\gamma \to$ | $\nu_e u_j\overline{u}_jd_k\overline{u}_k$ | 25 total |
| | $\nu_e d_j\overline{d}_jd_k\overline{u}_k$ | 30 total |
| $e^-\gamma \to$ | $e^- u_j\overline{d}_jd_k\overline{u}_k$ | 20 total |
| | $e^- u_j\overline{u}_ju_k\overline{u}_k$ | 10 total |
| | $e^- u_j\overline{u}_jd_k\overline{d}_k$ | 20 total |
| | $e^- d_j\overline{d}_jd_k\overline{d}_k$ | 21 total |
| $\gamma e_R^+ \to$ | $\overline{\nu}_e u_j\overline{d}_ju_k\overline{u}_k$ | 25 total |
| | $\overline{\nu}_e u_j\overline{d}_jd_k\overline{d}_k$ | 30 total |
| $\gamma e^+ \to$ | $e^+ u_j\overline{d}_jd_k\overline{u}_k$ | 20 total |
| | $e^+ u_j\overline{u}_ju_k\overline{u}_k$ | 10 total |
| | $e^+ u_j\overline{u}_jd_k\overline{d}_k$ | 20 total |
| | $e^+ d_j\overline{d}_jd_k\overline{d}_k$ | 21 total |

### 8-fermion

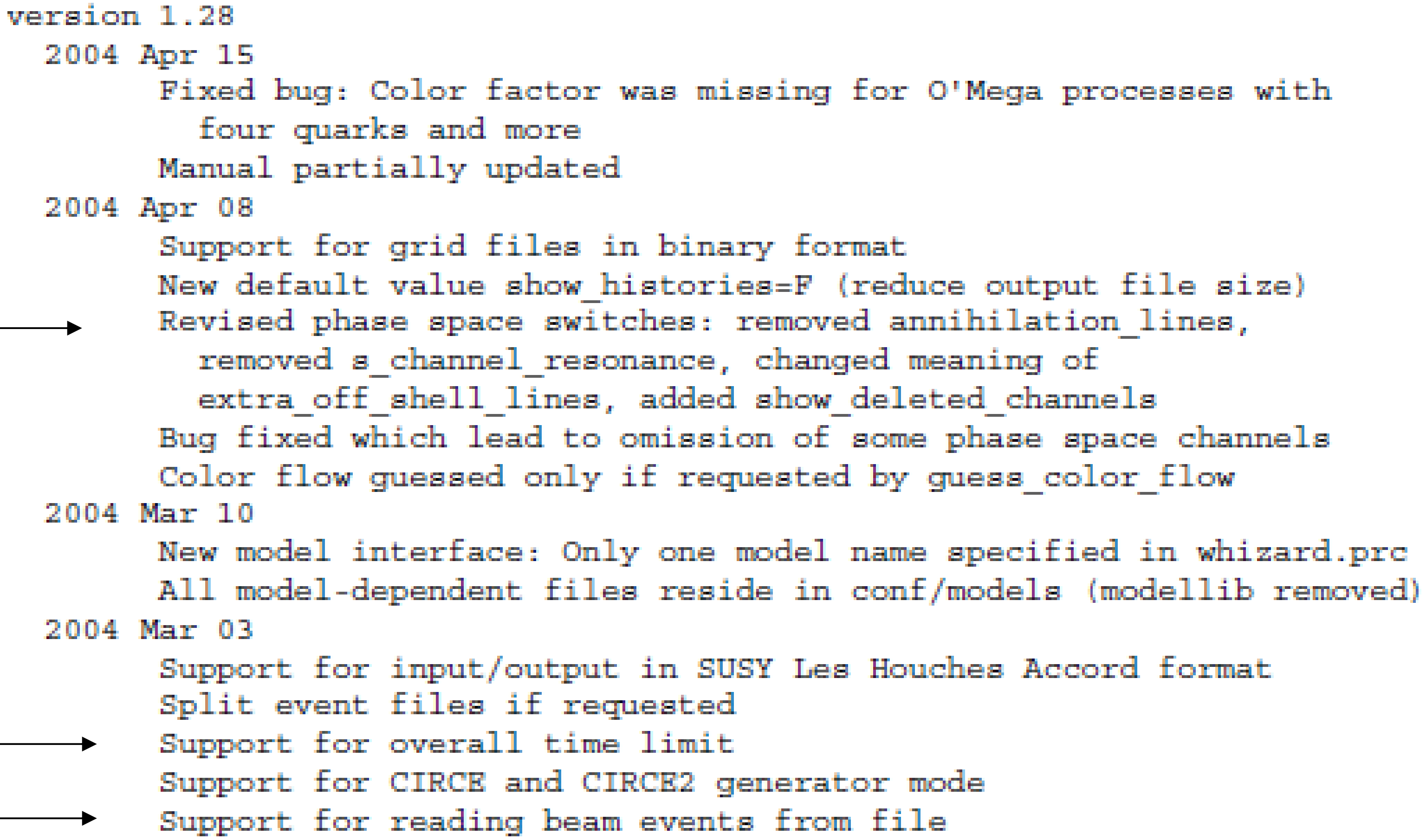
| | |
|---|---|
| $e^+e^- \to$ | $f\overline{f}t\overline{t}$ |
| $\gamma\gamma \to$ | $t\overline{t}$ |
| $e^-\gamma \to$ | $e^- t\overline{t}$ |
| | $\nu_e b\overline{t}$ |
| $\gamma e^+ \to$ | $e^+ t\overline{t}$ |
| | $\overline{\nu}_e t\overline{b}$ |

# Goals for Summer 2005

- Produce 1 $ab^{-1}$ MC data sample at Ecm=350 GeV using the ILC design with nominal luminosity
- Produce 1 $ab^{-1}$ MC data sample at Ecm=500 GeV using the ILC design with nominal luminosity
- Produce 2 $ab^{-1}$ MC data sample at Ecm=1000 GeV using the ILC design with nominal luminosity



```
version 1.40
  2004 Dec 13
        compatibility fix: preprocessor marks in helas code now commented out
        minor bug fix: format string in madgraph source
  2004 Dec 03
        support for arbitray beam energies and directions
        allow for pT kick in structure functions
```



```
version 1.28
  2004 Apr 15
        Fixed bug: Color factor was missing for O'Mega processes with
          four quarks and more
        Manual partially updated
  2004 Apr 08
        Support for grid files in binary format
        New default value show_histories=F (reduce output file size)
        Revised phase space switches: removed annihilation_lines,
          removed s_channel_resonance, changed meaning of
          extra_off_shell_lines, added show_deleted_channels
        Bug fixed which lead to omission of some phase space channels
        Color flow guessed only if requested by guess_color_flow
  2004 Mar 10
        New model interface: Only one model name specified in whizard.prc
        All model-dependent files reside in conf/models (modellib removed)
  2004 Mar 03
        Support for input/output in SUSY Les Houches Accord format
        Split event files if requested
        Support for overall time limit
        Support for CIRCE and CIRCE2 generator mode
        Support for reading beam events from file
```

# Specific Tasks Before Production

- Produce sufficient number of Guinea-Pig files for stable MC integration (what is sufficient to be determined throught trial and error).
- Test new features of WHIZARD 1.40:
  - Time limit
  - Output file size limit
  - Pt kick
  - Improved phase space treatment for complicated final states such as $e^+e^- \rightarrow e^+e^-e^+e^-e^+e^-$

# Specific Tasks Continued

- Try writing data to local disk first rather than directly to mass storage

# There are 11 process groups:

- 0-2-4-fermion
- 6-fermion/ddi-udj-duk
- 6-fermion/eminus-gamma
- 6-fermion/gamma-eplus
- 6-fermion/gamma-gamma
- 6-fermion/uui-udj-duk
- 6-fermion/zzz_1
- 6-fermion/zzz_2
- 8-fermion/
- ffh
- ffhh

The process group directories are located in
/afs/slac.stanford.edu/g/nld/whizard/xxxx
where xxxx=0-2-4-fermion e.g.
(xxxx will stand for a process group from here on)

# For each Process Group There are 5 Steps Needed to Produce MC Data Sets: (corresponding shell script is shown in italics)

1. Generate Executable
   ***/afs/slac.stanford.edu/g/nld/whizard/whizard-1.22/remake_process_class***
2. Submit MC Integration Jobs
   ***/afs/slac.stanford.edu/g/nld/whizard/NORIC/multiple_whiz_ini***
3. Repair MC Integration Jobs
   ***/afs/slac.stanford.edu/g/nld/whizard/NORIC/multiple_whiz_ini_cleanup***
4. Submit First Set of Event Generation Jobs
   ***/afs/slac.stanford.edu/g/nld/whizard/NORIC/multiple_whiz_run***
5. Submit More Event Generation Jobs
   ***/afs/slac.stanford.edu/g/nld/whizard/NORIC/multiple_whiz_run_cleanup***

# 1. Generate Executable

***remake_process_class*** copies the file **`xxxx/whizard.prc`** to WHIZARD's conf directory, does 'make prg', and then copies the results of the make to **`xxxx/results`**.

# 2. Submit MC Integration Jobs

***multiple_whiz_ini*** loops through the processes in **`xxxx/results/whizard.prc`** and submits 4 batch jobs for each process (1 job for each initial state $e^+e^-$ helicity combination).

For each job a directory **`/nfs/slac/g/lcd/mc/mmmm/whizyyyyy`** is created where **`mmmm`** is the center-of-mass energy in GeV and **`yyyyy`** is a unique 5-digit job number.

***multiple_whiz_ini*** uses the file **`xxxx/results/multiple_cardswhiz_in`** to build the batch job's **`whizard.in`** file

***multiple_whiz_ini*** uses the file **`/afs/slac/g/nld/whizard/NORIC/iniwhiz`** to build the batch job's executable script.

# 3. Repair MC Integration Jobs

***multiple_whiz_ini_cleanup*** loops through the job output in the directories **`/nfs/slac/g/lcd/mc/mmmm/whizttttt`** through **`/nfs/slac/g/lcd/mc/mmmm/whizyyyyy`** and verifies that the integration was completed successfully. Here **`mmmm`**, **`ttttt`**, **`yyyyy`** are input arguments to the script.

If the integration failed then ***multiple_whiz_ini_cleanup*** resubmits the job. WHIZARD saves intermediate integration results, so the new job essentially picks up where the old one left off.

# 4. Submit First Set of Event Generation Jobs

***multiple_whiz_run*** loops through the MC integration job output directories **`/nfs/slac/g/lcd/mc/mmmm/whiztttt`** through **`/nfs/slac/g/lcd/mc/mmmm/whizyyyy`** and submits a run job for every MC integration job which had a cross-section above some minimum value.

For each run job a directory **`/nfs/slac/g/lcd/mc/mmmm/run_output/wkkkkk/run_01`** is created where **`mmmm`** is the center-of-mass energy in GeV and **`kkkkk`** is the 5-digit MC integration job number.

***multiple_whiz_run*** copies most of the files in the directory **`/nfs/slac/g/lcd/mc/mmmm/whizkkkk`** into the directory **`/nfs/slac/g/lcd/mc/mmmm/run_output/wkkkkk/run_01`** . Parameters specific to event generation are added to the **`whizard.in`** file before it is copied to **`/nfs/slac/g/lcd/mc/mmmm/run_output/wkkkkk/run_01.`**

***multiple_whiz_run*** uses the file **`/afs/slac/g/nld/whizard/NORIC/runwhiz`** to build the batch job’s executable script.

# 5. Submit More Event Generation Jobs

***multiple_whiz_run_cleanup*** loops through the MC run job output directories **`/nfs/slac/g/lcd/mc/mmmm/run_output/wttttt/run_01`** through **`/nfs/slac/g/lcd/mc/mmmm/run_output/wyyyyy/run_01`** and determines how many more run jobs are required to generate the required number of events. If additional runs are required it will submit new run jobs after creating directories of the form

**`nfs/slac/g/lcd/mc/mmmm/run_output/wkkkkk/run_02`**
**`nfs/slac/g/lcd/mc/mmmm/run_output/wkkkkk/run_03`**

.

.

.
**`nfs/slac/g/lcd/mc/mmmm/run_output/wkkkkk/run_nn`**

# Schedule Assuming Snowmass 05 ILC Machine Design Available Now

| | |
|---|---|
| Apr 25 – Apr 29 | Test New Whizard 1.40 features & initiate Guinea-Pig file production |
| May 2 - May 13 | Ecm= 350 GeV Guinea-Pig file production & small tests of complete MC data production process (steps 1-5) |
| May 14 - Jun 10 | Ecm=350 GeV MC Production & Guinea-Pig File production for Ecm=500 & 1000 GeV |
| Jun 13 – Jul 1 | Ecm = 500 GeV MC Production |
| Jul 4 – Jul 22 | Ecm = 1000 GeV MC Production |

# Benchmarking Action Plan

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April 25, 2005

# Critical Questions

1. What are the benchmark physics measurement errors* as a function of calorimeter parameters B, R, $N_{X0,}N_{layer}$(*ECAL*),Radiator(*HCAL*),$N_{\Lambda}$, $N_{layer}$(*HCAL*), & *HCAL* pixel size?
2. What are the benchmark physics measurement errors as a function of *VXD* and *tracker* material, $N_{layer}$(*tracker*), $K^0_S$, $\Lambda^0$ detection efficiency, and *VXD* inner radius?
3. What are the physics benchmark measurements?
4. Is the Fast MC Simulation program sufficiently detailed to reliably estimate physics measurement errors?

* Error means statistical $\oplus$ systematic (Ecm, pol, lumi, alignment, calibration)

# #1: Physics Error vs Calorimeter Parameters

- Cannot directly vary B, R, etc. until full Calorimeter Simulation & Reco is more fully developed.
- Physics error vs $\Delta E_{jet}$* can be calculated before full simulation and reco software is completed, however.
- Try to parameterize detector response in terms of $\Delta E_{jet}$ (+few more variables?) once full Calorimeter Simulation & Reco system is working.

$$* \ \Delta E_{\text{jet}} \equiv \sum_{i=reconstructed\ particles} E_i(reco) \quad - \quad \sum_{i=e^-,\mu^-,\pi^+,p^+,\gamma,K^0,n} E_i(true)$$

where sums are over objects in same thrust hemisphere for

$e^+e^- \to u\overline{u}$ $\sqrt{s} = 500\,GeV$ no beamstr, bremsstr, or final state QED/QCD rad.

# #2: Physics Error vs VXD, Tracker Parameters

- Bruce Schumm has software to parameterize tracker response, so fast MC simulation is straightforward.
- Can also study physics errors as a function of general curvature and multiple scattering parameters $\frac{\delta p_t}{p_t^2} = a \oplus \frac{b}{p_t \sin\theta}$
- Coordinate VXD studies with VXD working group

# #4: Fast MC vs Full MC

- Most physics analyses before Snowmass will be done with the Fast MC. However, these analyses will use reconstructed particle LCIO objects as input so that the same physics analysis software can be used for both the Fast and Full MC.
- Hope to do some physics analyses using the Full MC before Snowmass so that we can evaluate the quality of the Fast MC simulation. This will be an iterative process where the Fast MC program is continually improved.

# Simulation Tools

| TOOL | In Hand ? |
|---|---|
| MC Programs for Generating Physics Events | Yes |
| MC Data Sets of all SM processes at Ecm=350, 500, 1000 GeV | NLC-Yes<br>ILC - No |
| Fast Detector MC with Reco Particle LCIO output ↑ $E, \vec{p},$ impact params, charge, id$(e^-, \mu^-, \pi^+, \gamma, K_L^0)$ & errors | TESLA -Yes<br>SID - No<br>LDC – No<br>GLD - No |
| Full Detector MC with Reco Particle LCIO output | TESLA -Yes<br>SID - No<br>LDC – No<br>GLD - No |

# Products Delivered by the Beginning of Snowmass

- 1 $ab^{-1}$ MC Data Sets of all SM processes at Ecm=350, 500, 1000 GeV assuming nominal ILC machine parameters
- Fast SiD Detector MC with reco particle LCIO output
- Physics analysis software which uses reco particle LCIO as input and which produces as output the measurement error (stat+sys) for the following physics benchmark processes:
  - Cross section for $e^+e^- \rightarrow ZH, \nu\nu H$
  - Higgs BR to bb, WW*
  - Higgs self-coupling
  - Selectron, neutralino mass from selectron pair production
  - Chargino, neutralino cross sec & masses from focus point gaugino production
  - Ecm , lumi spectrum from Bhabhas & mu-pairs
- Software to parameterize calorimeter detector response in terms of $\Delta E_{jet}$ , ….