Benchmarking Action Plan

Tracking Group Presentation

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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_{Λ}, 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, Λ^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 ΔE_{jet}* can be calculated before full simulation and reco software is completed, however.
- Try to parameterize detector response in terms of ΔE_{jet} (+few more variables?) once full Calorimeter Simulation & Reco system is working.

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

where sums are over objects in same thrust hemisphere for

$e^+e^- \rightarrow u\overline{u} \quad \sqrt{s} = 500\,GeV$ 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

#3: Physics Benchmark Processes

M. Battaglia, LCWS05 Benchmark Report:

Summary

✧ Tentative sets of Benchmark Physics Reactions with quantitative, well-defined requirements have been proposed for optimisation of detector designs and some are already being considered by Detector Concept studies:

✧ Timeline for deployment of a set of common physics benchmarks, more than list content, has been focus of discussion in parallel session;

✧ It is proposed to setup group with the task to further develop and follow benchmark definition process across detector studies:

T. Barklow, M. Battaglia, Y. Okada, M. Peskin, S. Yamashita, P. Zerwas

✧ Aim to prepare document summarising list of physics processes with needed accuracies and proposal for benchmark matrix before ACFA Study Meeting in Korea in July;

✧ Following further discussion, first (sub-)set of reactions could be made available before Snowmass as inputs to the summer study.

March 21, 2005
LCWS05

Report from the Benchmark Session
M. Battaglia

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#3: Physics Benchmark Processes

Draft Table of Benchmark Processes :

	Process and Final states	Energy (TeV)	Observables	Target Accuracy	Detector Challenge
Higgs	$ee \to ZH \to \ell\ell X$	0.35	M_{recoil}, σ_{ZH}, BR_{bb}	ΔM_H=100 MeV, $\delta\sigma_{ZH} = 2.5\%$, $\delta BR_{bb} = 1\%$	T
	$ee \to ZH, H \to bb$ / $cc/\tau\tau$	0.35	jet flavour , jet $(E, \vec{p})$	ΔM_H=40 MeV, $\delta(\sigma_{ZH} \times BR)$=1%/5%/5%	V
	$ee \to ZH, H \to WW^*$	0.35	M_Z, M_W, σ_{qqWW^*}	$\delta(\sigma_{ZH} \times BR_{WW^*})$=4%	C
	$ee \to ZH, H \to$ invisible	0.35	$\sigma_{qqE_{missing}}$	5σ Evidence for $BR_{invisible}$=1%	C
	$ee \to \nu\nu H$	0.5	$\sigma_{bb\nu\nu}$, M_{bb}	$\delta(\sigma_{\nu\nu H} \times BR_{bb}) = 1\%$	C
	$ee \to ttH$	1.0	σ_{ttH}	δg_{ttH}=5%	C
	$ee \to ZHH, \nu\nu HH$	0.5/1.0	σ_{ZHH}, $\sigma_{\nu\nu HH}$, M_{HH}	δg_{HHH}=20/10%	C
Strong SB	$ee \to WW$	0.5	σ & final-state	$\Delta\kappa_\gamma, \lambda_\gamma = 2 \cdot 10^{-4}$	V
	$ee \to \nu\nu WW/ZZ$	1.0	fermion $(E, \vec{p}), Q$	$\Lambda_{*4}, \Lambda_{*5} = 3$ TeV	C
SUSY	$ee \to \tilde{e}_R\tilde{e}_R$ (SPS1a)	0.5	E_e	$\delta M_{\tilde{\chi}_1^0}$=50 MeV	T
	$ee \to \tilde{\tau}_1\tilde{\tau}_1$ (SPS1a)	0.5	E_{tau}	$\delta(M_{\tilde{\tau}_1} - M_{\tilde{\chi}_1^0}$=50 MeV	
	$ee \to \tilde{t}_1\tilde{t}_1$ (SPS1a)	1.0		$\delta M_{\tilde{t}_1}$=2 GeV	
	$ee \to \tilde{\tau}_1\tilde{\tau}_1$ (D')	0.5	soft $\tau^\pm$ above $\gamma\gamma$ bkgd	$\delta M_{\tilde{\tau}_1}$, $\delta M_{\tilde{\chi}_1^0}$	F
	$ee \to \tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_2^0\tilde{\chi}_2^0$ (LCC2')	0.5	$\sigma_{\tilde{\chi}_1^0\tilde{\chi}_1^0 WW}$, $\sigma_{\tilde{\chi}_1^0\tilde{\chi}_1^0 ZZ}$	$\delta\sigma_{\tilde{\chi}_1^+\tilde{\chi}_1^-}$, $\delta\sigma_{\tilde{\chi}_2^0\tilde{\chi}_2^0}$, $\delta M_{\tilde{\chi}_1^+}$, $\delta M_{\tilde{\chi}_2^0}$ =	C
	$ee \to HA \to bbbb$ (LCC4)	1.0	Mass constrained M_{bb}	δM_A=1 GeV	C
	$\chi_1^0 \to \gamma + \not{E}$	0.5	non-pointing γ	$\delta c\tau$=10%	C
	$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 + \pi^\pm_{soft}$	0.5	soft $\pi^\pm$ above $\gamma\gamma$ bkgd	5σ Evidence for $\Delta\tilde{m}$=200 MeV	F
Precision SM & New Physics	$ee \to tt \to 6$ *jets*	1.0		5σ Sensitivity for $(g-2)_t/2 \leq 10^{-3}$	V
	$ee \to ff\ [e, \mu, \tau; b, c]$	1.0	σ_{ff}, A_{FB}, A_{LR}	5σ Sensitivity to $M[Z_{LR}] = 15$ TeV	V
Energy/Lumi Measurements	$ee \to ee_{fwd}$	0.3/1.0		δM_{top}=50 MeV	T
	$ee \to Z\gamma$	0.5/1.0			T

#3: Physics Benchmark Processes

Draft Short List of Benchmark Processes :

	Process and Final states	Energy (TeV)	Observables	Target Accuracy	Detector Challenge
Higgs	$ee \to ZH \to \ell\ell X$	0.35	M_{recoil}, σ_{ZH}, BR_{bb}	ΔM_H=100 MeV, $\delta\sigma_{ZH} = 2.5\%$, $\delta BR_{bb} = 1\%$	T
	$ee \to ZH, H \to bb$ / $cc/\tau\tau$	0.35	jet flavour , jet $(E, \vec{p})$	ΔM_H=40 MeV, $\delta(\sigma_{ZH} \times BR)$=1%/5%/5%	V
	$ee \to ZHH$, $\nu\nu HH$	0.5/1.0	σ_{ZHH}, $\sigma_{\nu\nu HH}$, M_{HH}	δg_{HHH}=20/10%	C
SUSY	$ee \to \tilde{e}_R \tilde{e}_R$ (SPS1a)	0.5	E_e	$\delta M_{\tilde{\chi}_1^0}$=50 MeV	T
	$ee \to \tilde{\tau}_1 \tilde{\tau}_1$ (D')	0.5	soft $\tau^{\pm}$ above $\gamma\gamma$ bkgd	$\delta M_{\tilde{\tau}_1}$, $\delta M_{\tilde{\chi}_1^0}$	F
	$ee \to \tilde{\chi}_1^+ \tilde{\chi}_1^-$, $\tilde{\chi}_2^0 \tilde{\chi}_2^0$ (LCC2')	0.5	$\sigma_{\tilde{\chi}_1^0 \tilde{\chi}_1^0 WW}$, $\sigma_{\tilde{\chi}_1^0 \tilde{\chi}_1^0 ZZ}$	$\delta\sigma_{\tilde{\chi}_1^+ \tilde{\chi}_1^-}$, $\delta\sigma_{\tilde{\chi}_2^0 \tilde{\chi}_2^0}$, $\delta M_{\tilde{\chi}_1^+}$, $\delta M_{\tilde{\chi}_2^0}$ =	C
Precision SM	$ee \to ff$ $[e, \mu, \tau; b, c]$	1.0	σ_{ff}, A_{FB}, A_{LR}	5σ Sensitivity to $M[Z_{LR}]$ = 15 TeV	V
Energy/Lumi	$ee \to ee_{fwd}$, $Z\gamma$	0.3/1.0		δM_{top}=50 MeV, etc.	T

#4: Is Fast MC Sufficiently Detailed to Reliably Estimate Physics Meas. Errors?

- 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 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 SID - No LDC – No GLD - No
Full Detector MC with Reco Particle LCIO output	TESLA -Yes SID - No LDC – No 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, ννH
  - 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 ΔE_{jet} , ….

#2: Physics Error vs Tracker Parameters

- What tracker parameters should the benchmarking be varying?
- How should tracker parameter variation be incorporated into the Fast MC?

#4: Is Fast MC Sufficiently Detailed to Reliably Estimate Physics Meas. Errors?

- What is the status of the Fast MC simulation of the tracker?
- Can we get a parameterization of K^0_S, Λ^0 detection efficiency vs. pion polar angle/momentum ?
- Would it be useful to have a parameterization of tracking efficiency vs. polar angle/momentum ?
- Other effects?