SiD Benchmarking Plans

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I. SID RESPONSE TO BENCHMARKING LIST

The reduced benchmarking list of 7+1 processes described in section IV of http://arxiv.org/pdf/hep-ex/0603010 (page 9) has been proposed as the starting point for the list of common LOI benchmarks. The SiD proposes that the list be pared down a little, and that physics observables be defined explicitly for each process. The SiD recommends the following for the common LOI physics benchmarks:

0. Single $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, π^0, $K^{\pm}$, K^0_s, γ, u, s, c, b, W, Z; $0 < |\cos\theta| < 1$, $0 < p < 500$ GeV

Measure identification efficiency, misidentification efficiency, and energy resolution as a function of $|\cos\theta|$ and particle energy. Note that W and Z bosons have been added to the list; only light quark decays of the W and Z bosons should be considered. Here the u, s, c, b quark jets are generated using the process $e^+e^- \to q\bar{q}$ with parton showering turned off. These processes are not physics benchmarks as much as they are benchmarks for lepton id, flavor id, V0 reconstruction, and PFA performance.

1. $e^+e^- \to f\bar{f}$, $f = \mu$, c, τ at $\sqrt{s}$=1.0 TeV;

The muon pair final state is used to measure the luminosity-weighted center-of-mass energy. This will challenge the momentum measurement of very high energy charged particles in both the central and forward regions.

The $c\bar{c}$ final state is used to examine the coupling of the charm quark to a 7 TeV Z' boson through the measurement of the charm quark left-right forward-backward asymmetry A_{FB}^{LR} . This measurement requires good vertex detector performance to isolate charm jets and to measure the charm quark charge.

The $\tau^+\tau^-$ final state is used to extract the vector and axial-vector couplings of the tau lepton to a 7 TeV Z' boson through tau polarization measurements. These measurements will test the performance of the EM calorimeter, as well as the vertex detector.

2. $e^+e^- \to Zh$, $\to \ell^+\ell^- X$, $m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV;

Classic measurement of Higgs mass and $\sigma(e^+e^- \to Zh)$. Note the center-of-mass energy.

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3. $e^+e^- \to Zh$, $h \to \mu^+\mu^-$, $m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV;

Measure the signal significance and branching fraction for the rare Higgs decay $H \to \mu^+\mu^-$. Another challenge for the measurement of charged particle momentum.

4. $e^+e^- \to \nu_e\bar{\nu}_e hh$, $m_h = 120$ GeV at $\sqrt{s}$=1.0 TeV;

Measure the triple Higgs coupling using all Higgs decay modes at $\sqrt{s}$=1.0 TeV. This center-of-mass energy is a more rational choice for the measurement of the triple Higgs coupling than the much-studied but problematic $\sqrt{s}$=0.5 TeV. Excellent benchmark for integrated detector performance. Tests ability of detector to measure jet-jet masses and separate b and c jets. A measurement of the b quark charge may also come into play. Many of the Higgs decay modes that were dropped from bullet (3) will be utilized in this analysis. Forward detectors will play a more important role at $\sqrt{s}$=1.0 TeV.

6. $e^+e^- \to \tilde{\tau}_1\tilde{\tau}_1$, at Point 3 at $\sqrt{s}$=0.5 TeV;

Measure the mass of the stau lepton and $\sigma(e^+e^- \to \tilde{\tau}_1\tilde{\tau}_1)$. Classic low visible energy benchmark which challenges the far forward detector and many other detector components.

7. $e^+e^- \to \chi_1^+\chi_1^-/\chi_2^0\chi_2^0$ at Point 5 at $\sqrt{s}$=0.5 TeV;

Measure the mass of the second lightest neutralino χ_2^0 and $\sigma(e^+e^- \to \chi_2^0\chi_2^0)$. In this scenario the lightest chargino and second lightest neutralino decay to on-shell W and Z bosons, respectively. This is primarily a W/Z separation benchmark that is used to test calorimeter and PFA performance.

Other LOI Benchmarking Issues

- SiD's proposed list of processes already stresses the capabilities of the benchmarking group and the whole SiD collaboration; we should push hard to prevent the list from growing.
- Common background and signal MC Generator event samples should be used by all detector concepts for the compulsory LOI benchmark analyses
- "Rules of the Game" need to be established for simulation of the passage of particles through the detector and for event reconstruction (level of detail of detector material included in the simulation, amount of cheating allowed in pattern recognition and track reconstruction, etc.). Also, some mechanism is needed for choosing the subset of background processes that are to be fully simulated.
- Analyses of physics benchmarks 1-7 will use LCIO reconstructed particles as input. Analyses will be developed using the FASTMC, cheated PFA output, or some mixture of the two. When the final PFA is ready the existing analyses should work after some automated calibration/training.
- Some dress rehearsals of the full SiD analysis chain are required in early 2008 to estimate the computing resources required to perform all of the LOI benchmark analyses. Perhaps we can make arrangements with SLAC SCCS, and other SiD computing centers in advance in order to ensure sufficient computing resources for summer, 2008.