Comments on benchmarks

Steve Martin

Northern Illinois University

spmartin@niu.edu

The large $\sqrt{s} = 3$ TeV for CLIC suggests several benchmarks processes that would receive less emphasis at a lower energy machine. Besides the ones reviewed in the ILD letter of intent, the following come to mind as things that might be better for CLIC emphasis:

Study of pair-production of heavy Higgs bosons in supersymmetry (and other two Higgs doublet models).

$$\begin{aligned} e^+e^- &\rightarrow H^+H^- \rightarrow t\bar{b}\bar{t}b \\ e^+e^- &\rightarrow H^0A^0 \rightarrow b\bar{b}\tau^+\tau^- \text{ or } b\bar{b}b\bar{b} \end{aligned}$$

In the decoupling limit found in many SUSY models, these cross-sections should both be unsuppressed. The masses are all close together, with:

$$\begin{aligned} m_{H^\pm} &\approx m_{A^0} + \frac{m_W^2}{2m_{A^0}} \\ m_{H^0} &\approx m_{A^0} + \sin^2(2\beta)\frac{m_Z^2}{2m_{A^0}} \end{aligned}$$

To first approximation, the most important choice is just that of m_{A^0}, which can probably be taken well over 1 TeV at CLIC with $\sqrt{s} = 3$ TeV.

Higgsino-like chargino and neutralino production.

In many SUSY models, the heavier, higgsino-like charginos and neutralinos $\tilde{C}_2^{\pm}$ and $\tilde{N}_{3,4}$ can nearly decouple from the LHC. So although these are relatively tough things to study, the stakes may be high. (They might easily also be too heavy for a lower energy linear collider; for example, in the SPS1a$'$ benchmark point, pair production of higgsinos requires $\sqrt{s} > 800$ GeV, and other benchmarks usually have even heavier higgsinos.)

Unfortunately, both production and decay of these states can be quite model dependent.

However, the following decay modes often have significant branching ratios:

$$\begin{aligned} \tilde{C}_2 &\rightarrow Z\tilde{C}_1 \text{ or } W\tilde{N}_{1,2} \\ \tilde{N}_{3,4} &\rightarrow W^{\pm}\tilde{C}_1^{\mp} \text{ or } Z\tilde{N}_{1,2} \text{ or } h^0\tilde{N}_{1,2} \end{aligned}$$

Right-handed squark production:

$$e^+e^- \rightarrow \tilde{q}_R\bar{\tilde{q}}_R \rightarrow qq\tilde{N}_1\tilde{N}_1$$

Can look at endpoints, angular distributions, etc.

Again, many SUSY models predict squark masses too large for a lower energy linear collider to reach.