Implications for e^+e^- Linear Colliders

The so far negative searches for new physics at the LHC based on signatures with missing transverse energy (MET) put high experimental challenges for all kind of future experiments and implies first of all an even higher motivation for precision measurements not only of the Higgs boson candidate itself but also of the top quark, which is expected to play an important role in the understanding of electroweak symmetry breaking. A top quark mass determination from the threshold is mandatory to be sensitive for consistency checks of the SM at quantum level [5, 4, 6]. The precision measurements of the top forward-backward asymmetry as well as its left-right asymmetry may be crucial for finding traces of new physics. Exploiting this observable available due to the foreseen beam polarisation at a Linear Collider will probe deviations from the SM up to scales of several tens of TeV [1, 2, 3].

The missing E_T based searches at the LHC have so far predominantly been interpreted in the context of the constrained MSSM (cMSSM) where the mass scale of the coloured SUSY partners is closely tied to those of the electroweak SUSY partners. Just relaxing the relation between the coloured and electroweak section in the cMSSM completely changes the scene and practically no exclusion bounds can be drawn in the electroweak part even in the cMSSM. The LHC results are therefore still a concordance with low-energy precision measurements as, for instance, $g_(\mu - 2)$ which predicts a low scale of new physics models, and the results from global fits.

In this sense the main implication of absence of signal in the MET searches is that the new physics needed to explain Dark Matter, to solve the hierarchy problem and sufficient CP violation is more envolved and diverse than suggested by the most simple models and may require a multiple set of different experimental analyses in order to fill the puzzle of new physics. The large flexibility of a Linear Collider from low energy up to the multi-TeV region is perfectly suitable to resolve this picture.

WIMPs

At the LHC, the monojet searches constrain the process $pp \to \chi\chi$ [12, 13]. At a Linear Collider, the a priori completely independent process $e^+e^- \to \chi\chi$ can be observed and it has been studied that spin dependent WIMP-nucleon cross-sections down to a few 10^{-42} cm^{-2} can be probed [15]. The the WIMP mass, the size and helicity structure of its coupling to SM fermions as well as the dominant partial wave of the WIMP annihilation can precisely be determined [14] at a LC thanks to the availability of polarized beams, the precise inital energy and the clean experimental environment.

Light electroweakinos

A characteristic pattern of Susy models with light electroweakinos is a very small mass splitting between the χ_1^0 and $\chi_1^\pm$ / χ_2^0 of typically a few GeV or smaller. While being very difficult to impossible to resolve at the LHC, these states can be discovered and disentangled at a Linear Collider by using ISR recoil techniques to overcome the background from 2-photon processes in combination with the detection of the very soft visible decay products of the $\chi_1^\pm$ / χ_2^0 [17]. Together with the measurements of the polarised cross-sections, the different models can be distinguished and the parameters of the electroweak gaugino sector can be reconstructed and via loop effects even other SUSY parameters and heavier masses, for instance $m_{\tilde{t}}$, can be constrained [18].

Light SUSY scalars

For naturalness reasons, at least one of the top squarks should even be light. A light bottom squark with a few GeV mass splitting to the LSP is a valid WIMP Dark Matter scenario where the right relic density is achieved by sbottom-coannihilation. The same is true for staus, while a light smuon would explain the observed value of $(g-2)_\mu$ [19, 20]. The experimental capabilities of a Linear Collider have been studied for all these cases [21, 22, 23]. Even in cases where only parts of the light spectrum of new physics are kinematically accessible at a Linear Collider powerful predictions for the heavy part of the spectrum can be done via the high precision measurements of the directly accessible low mass particles. Polarized beams test directly the chiral structure of the underlying physics model [24] and offer sufficient experimental observables to determine the parameters.

In case the absence of new coloured states remains in the LHC data more emphasis should be put to explore the electroweak BSM sector. In this case measurements at the LC at the Z pole with high luminosoty and polarized beams ("GigaZ") improve the experimental uncertainty of $\sin\theta_{\text{eff}}$ by one order of magnitude one becomes sensitive to loop effects of new particles allowing predictions of the scale of new physics, even if no BSM particle has been discovered by direct searches at the LHC [10].

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