New SUSY Fits for the ILC and CLIC

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Abstract

We review the **MasterCode** fits of several incarnations of the Minimal Supersymmetric Standard Model (MSSM). These include the GUT models based on mAMSB and SU(5), sub-GUT models as well as a model defined at low energies with 11 free parameters, the pMSSM11. The fit combines consistently measurements of Higgs boson properties, searches for additional Higgs bosons and supersymmetric (SUSY) particles, low-energy and flavor experiments as well as Dark Matter (DM) measurements. We predict the preferred SUSY mass spectra in these models and analyze the discovery potential of future $e^+e^-$ colliders such as the ILC and CLIC.
1 Introduction

Models invoking the appearance of supersymmetry (SUSY) at the TeV scale are being tested by the so far negative results of high-sensitivity searches for sparticles at the LHC [1, 2] and for the scattering of dark matter particles [3–6]. There have been many global analyses of the implications of these experiments for specific SUSY models, mainly within the minimal supersymmetric extension of the Standard Model (MSSM), in which the lightest supersymmetric particle (LSP) is stable and a candidate for cold dark matter (CDM). This may well be the lightest neutralino, \( \tilde{\chi}_0^1 \) [7], as is assumed here. Some of these studies have assumed universality of the soft SUSY-breaking parameters at the GUT scale, e.g., in the constrained MSSM (the CMSSM) [8–11] and in models with non-universal Higgs masses (the NUHM1,2) [9,12]. Other analyses have taken a phenomenological approach, allowing free variation in the soft SUSY-breaking parameters at the electroweak scale (the pMSSM) [13–15].

Here we review the results of studies of the GUT based minimal scenario for anomaly-mediated SUSY breaking (the mAMSB) [16], of the GUT based SU(5) framework [17], of SUSY models, in which universality of the soft SUSY-breaking parameters is imposed at some input scale \( M_\text{in} \) below the GUT scale \( M_\text{GUT} \) but above the electroweak scale [18,19], which are termed “sub-GUT” models, as well as of a “phenomenological MSSM” [13] defined at low energies with 11 independent parameters, the pMSSM11. These studies have been presented in Refs. [20–23], respectively.

These studies have been performed using the MasterCode framework [8, 9, 12, 14, 20–25]. MasterCode combines consistently experimental data from LHC Higgs-boson measurements, searches for additional Higgs bosons and SUSY particles at the LHC, low-energy and flavor experiments as well as CDM measurements. In all models we predict the preferred SUSY mass spectra at the 1 and 2 \( \sigma \) level [20–23].

Assuming that SUSY is realized in nature and the scalar quarks and/or the gluino are in the kinematic reach of the LHC, it is expected that these strongly interacting particles are eventually produced and studied. On the other hand, SUSY particles that interact only via the electroweak force, e.g., the scalar leptons or charginos/neutralinos, have a much smaller production cross section at the LHC. Correspondingly, the LHC discovery potential as well as the current experimental bounds are substantially weaker [1, 2]. However, at a (future) \( e^+e^- \) collider, depending on their masses and the available center-of-mass energy, the electroweak SUSY particles could be produced and analyzed in detail. Corresponding studies can be found for the ILC in Refs. [26–31] and for CLIC in Refs. [31–33]. Such precision studies will be crucial to determine their nature and the underlying (SUSY) parameters. Our analyses show which SUSY particles or additional Higgs bosons might be in the reach of the ILC or CLIC, depending on the assumed scenario.

It should be kept in mind that a precision analysis at ILC or CLIC also requires predictions of the production and decay properties of the SUSY particles or additional Higgs bosons with high precision. At least full one-loop calculations are necessary. A set of corresponding complete and consistent one-loop calculations (allowing also for complex parameters) has been published over the last years for SUSY/Higgs production cross sections at \( e^+e^- \) colliders [34] and SUSY/Higgs decays [35] (based on Ref. [36]).
The models under investigation

All our models are certain realizations of the general MSSM [37–40], which predicts two scalar partners for all SM fermions as well as fermionic partners to all SM bosons. In particular, two scalar quarks or scalar leptons are predicted for each SM quark or lepton. Concerning the Higgs-boson sector, contrary to the case of the SM, in the MSSM two Higgs doublets are required. This results in five physical Higgs bosons instead of the single Higgs boson in the SM. These are the light and heavy $CP$-even Higgs bosons, $h$ and $H$, the $CP$-odd Higgs boson, $A$, and the charged Higgs bosons, $H^\pm$. The Higgs sector of the MSSM is described at the tree level by two parameters: the mass of the $CP$-odd Higgs boson, $M_A$, and the ratio of the two vacuum expectation values, $\tan \beta = v_2/v_1$. Higher-order corrections are crucial to yield reliable predictions in the MSSM Higgs-boson sector, see Refs. [41–43] for reviews. The lightest Higgs boson, $h$, can be identified [44] with the particle discovered at the LHC [45, 46] with a mass around $\sim 125$ GeV [47]. The neutral SUSY partners of the (neutral) Higgs and electroweak gauge bosons are the four neutralinos, $\tilde{\chi}_0^1$, $\tilde{\chi}_0^2$, $\tilde{\chi}_0^3$, $\tilde{\chi}_0^4$. The corresponding charged SUSY partners are the charginos, $\tilde{\chi}_{1,2}^\pm$. In the results reviewed here the Higgs mixing parameter $\mu$ is assumed to be positive. Furthermore, in all our models we assume the Minimal Flavor Violation (MFV) scenario in which generation mixing is described by the Cabibbo-Kobayashi-Maskawa (CKM) matrix. This is motivated by phenomenological constraints on low-energy flavor-changing neutral interactions.

2.1 The mAMSB

In the mAMSB there are 3 relevant continuous parameters, the gravitino mass, $m_{3/2}$, which sets the scale of SUSY breaking, the supposedly universal soft SUSY-breaking scalar mass, $m_0$, and the ratio of Higgs vacuum expectation values, $\tan \beta$. The sampled parameter ranges are shown in Tab. 1.

The LSP is either a Higgsino-like or a wino-like neutralino $\tilde{\chi}_1^0$. In both cases the $\tilde{\chi}_1^0$ is almost mass degenerate with its chargino partner, $\tilde{\chi}_1^\pm$. Within this mAMSB framework, it is well known that if one requires that a wino-like $\tilde{\chi}_1^0$ is the dominant source of the CDM density indicated by Planck measurements of the cosmic microwave background radiation, namely $\Omega_{\text{CDM}}h^2 = 0.1186 \pm 0.0020$ [48], $m_{\tilde{\chi}_1^0} \simeq 3$ TeV [49,50] after inclusion of Sommerfeld enhancement effects [51]. If instead the CDM density is to be explained by a Higgsino-like $\tilde{\chi}_1^0$, $m_{\tilde{\chi}_1^0}$ takes a value of about 1.1 TeV.

| Parameter | Range | Segments |
|-----------|-------|----------|
| $m_0$     | (0.1, 50 TeV) | 4        |
| $m_{3/2}$ | (10, 1500 TeV) | 3        |
| $\tan \beta$ | (1, 50) | 4        |

**Table 1:** Ranges of the mAMSB parameters sampled, together with the numbers of segments into which each range was divided (see Sect. 3), and the corresponding number of sample boxes.
2.2 The GUT based SU(5)

Here we assume a universal, SU(5)-invariant gaugino mass parameter \( m_{1/2} \), which is input at the GUT scale, as are the other SUSY-breaking parameters: we assume the conventional multiplet assignments of matter fields in the minimal supersymmetric GUT:

\[
(q_L, u^c_L, e^c_L)_i \in 10_i, \quad (\ell_L, d^c_L)_i \in \bar{5}_i, 
\]

(1)

where the subscript \( i = 1, 2, 3 \) is a generation index. The only relevant Yukawa couplings are those of the third generation, particularly that of the \( t \) quark (and possibly the \( b \) quark and the \( \tau \) lepton) that may play an important role in generating electroweak symmetry breaking. Following the MFV scenario, we assume that the soft SUSY-breaking scalar masses for the different 10\(_i\) and \( \bar{5}_i \) representations are universal in generation space, and are denoted by \( m_{10} \) and \( m_{5} \), respectively. In contrast to the CMSSM, NUHM1 and NUHM2, we allow \( m_{5} \neq m_{10} \).

We assume a universal soft trilinear SUSY-breaking parameter \( A_0 \).

We assume the existence of two Higgs doublets \( H_u \) and \( H_d \) in 5 and \( \bar{5} \) representations that break electroweak symmetry and give masses to the charge +2/3 and charge -1/3 and -1 matter fields, respectively. In the absence of any phenomenological constraints, we allow the soft SUSY-breaking contributions to the \( H_u \) and \( H_d \) masses, \( m_{H_u} \) and \( m_{H_d} \), to be different from each other, as in the NUHM2, as well as from \( m_{5} \) and \( m_{10} \). As in the CMSSM, NUHM1 and NUHM2, we allow the ratio of Higgs vacuum expectation values, \( \tan \beta \), to be a free parameter. The sampled parameter ranges are shown in Tab. 2.

| Parameter | Range      | Segments |
|-----------|------------|----------|
| \( m_{1/2} \) | (0, 4) TeV | 2        |
| \( m_{5} \)    | (−2.6, 8) TeV | 2        |
| \( m_{10} \)   | (−1.3, 4) TeV  | 3        |
| \( m_{H_u} \)  | (−7, 7) TeV  | 3        |
| \( m_{H_d} \)  | (−7, 7) TeV  | 3        |
| \( A_0 \)      | (−8, 8) TeV  | 1        |
| \( \tan \beta \) | (2, 68)    | 1        |

Table 2: Ranges of the SUSY SU(5) GUT parameters sampled, together with the numbers of segments into which each range was divided, and the corresponding total number of sample boxes.

2.3 The sub-GUT model

This class of models is based on the CMSSM, but the universality of the soft SUSY-breaking parameters is imposed at some input scale \( M_{\text{in}} \) below the GUT scale \( M_{\text{GUT}} \) but above the electroweak scale \[18\][19]. The sampled parameter ranges are shown in Tab. 3.

This type of models is well motivated theoretically, since the soft SUSY-breaking parameters in the visible sector may be induced by some dynamical mechanism such as gluino
condensation that kicks in below the GUT scale. Specific examples of sub-GUT models include warped extra dimensions [52] and mirage mediation [53].

Sub-GUT models are of particular phenomenological interest, since the reduction in the amount of renormalization-group (RG) running below $M_{in}$, compared to that below $M_{GUT}$ in the CMSSM and related models, leads naturally to SUSY spectra that are more compressed [18]. These may offer extended possibilities for ‘hiding’ SUSY via suppressed $E_T$ signatures, as well as offering enhanced possibilities for different coannihilation processes.

| Parameter | Range                  | Segments |
|-----------|------------------------|----------|
| $M_{in}$  | $(10^3, 10^{16})$ GeV  | 6        |
| $m_{1/2}$ | (0, 6) TeV             | 2        |
| $m_0$     | (0, 6) TeV             | 2        |
| $A_0$     | $(-15, 10)$ TeV        | 2        |
| $\tan\beta$ | (1, 60)              | 2        |
|           | Total number of boxes  | 96       |

**Table 3:** The ranges of the sub-GUT MSSM parameters sampled, together with the numbers of segments into which they are divided, together with the total number of sample boxes shown in the last row.

### 2.4 The pMSSM11

As mentioned above, in this paper we consider a pMSSM scenario with eleven independent parameters, namely

$$
\begin{align*}
3 & \text{ gaugino masses: } M_{1,2,3}, \\
2 & \text{ squark masses: } m_{\tilde{q}} \equiv m_{\tilde{q}_1}, m_{\tilde{q}_2} \\
    & \neq m_{\tilde{q}_3} = m_{\tilde{t}}, m_{\tilde{b}}, \\
2 & \text{ slepton masses: } m_{\tilde{\ell}} \equiv m_{\tilde{\ell}_1} = m_{\tilde{\ell}_2} = m_{\tilde{e}} = m_{\tilde{\mu}} \\
    & \neq m_{\tilde{\ell}_3} = m_{\tilde{\tau}}, \\
1 & \text{ trilinear coupling: } A, \\
Higgs\ mixing\ parameter: & \mu, \\
pseudoscalar\ Higgs\ mass: & M_A, \\
ratio\ of\ vevs: & \tan\beta,
\end{align*}
$$

where $q_{1,2} \equiv u, d, s, c$, we assume soft SUSY-breaking parameters for left- and right-handed sfermions, and the sneutrinos have the same soft SUSY-breaking parameter as the corresponding charged sfermions. All of these parameters are specified at a renormalisation scale $M_{SUSY}$ given by the geometric mean of the masses of the scalar top eigenstates, $M_{SUSY} \equiv \sqrt{m_{\tilde{t}_1}m_{\tilde{t}_2}}$, which is also the scale at which electroweak symmetry breaking conditions are imposed. The sampled parameter ranges are shown in Tab. 4.
Table 4: The ranges of the pMSSM11 parameters sampled, together with the numbers of segments into which each range was divided, and the corresponding total number of sample boxes.

| Parameter | Range          | Segments |
|-----------|----------------|----------|
| $M_1$     | $(-4, 4)$ TeV | 6        |
| $M_2$     | $(0, 4)$ TeV  | 2        |
| $M_3$     | $(-4, 4)$ TeV | 4        |
| $m_{\tilde{q}}$ | $(0, 4)$ TeV | 2        |
| $m_{\tilde{q}_3}$ | $(0, 4)$ TeV | 2        |
| $m_{\tilde{\ell}}$ | $(0, 2)$ TeV | 1        |
| $m_{\tilde{\tau}}$ | $(0, 2)$ TeV | 1        |
| $M_A$     | $(0, 4)$ TeV  | 2        |
| $A$       | $(-5, 5)$ TeV | 1        |
| $\mu$     | $(0, 5)$ TeV  | 1        |
| $\tan\beta$ | (1, 60)     | 1        |

Total number of boxes | 384

3 The MasterCode

We perform a global likelihood analysis of the various MSSM incarnations including constraints from direct searches for SUSY particles at the LHC, measurements of the Higgs boson mass and signal strengths, LHC and LEP searches for additional SUSY Higgs bosons, precision electroweak observables (including $(g - 2)_\mu$) flavor constraints from $B$- and $K$-physics observables, the cosmological constraint on the overall CDM density, and upper limits on spin-independent and -dependent LSP-nuclear scattering. We treat $m_t$, $\alpha_s$ and $M_Z$ as nuisance parameters. Details about the explicit constraints employed in each of the analyses can be found in Refs. [20–23].

The observables contributing to the likelihood are calculated using the MasterCode tool [8,9,12,14,20–25], which interfaces and combines consistently various public and private codes using the SUSY Les Houches Accord (SLHA) [54]. The following codes are used in the analysis (for the specific versions employed in the various analyses, see Refs. [20–23]): SoftSusy [55] for the spectrum, FeynWZ [56] for the electroweak precision observables, FeynHiggs [57] for the Higgs sector and $(g - 2)_\mu$, SuFla [58] and SuperIso [59] for the flavor physics observables, Micromegas [60] for the CDM relic density, SSARD [61] for the spin-independent and -dependent elastic scattering cross-sections $\sigma_{SI}^p$ and $\sigma_{SD}^p$. The uncertainties in the cross-sections are derived from a straightforward propagation of errors in in the input quantities which determine the cross-section. The dominant uncertainties are discussed in Ref. [23]. SDECAY [62] is used for calculating sparticle branching ratios, and HiggsSignals [63] and HiggsBounds [64] for calculating constraints on the SUSY Higgs sector. For the LHC searches we mainly rely on the Fastlim [65] approach (see Refs. [20,23] for details concerning each analysis).
The sampling is done using the MultiNest package [66]. The segments defined in Tabs. 1-4 define boxes in the respective parameter spaces, which are sampled. In order to ensure a smooth overlap between boxes and eliminate features associated with their boundaries, we choose for each box a prior such that 80% of the sample has a flat distribution within the nominal box, and 20% of the sample is in normally-distributed tails extending outside the box.

4 Predictions for the ILC and CLIC

In this section we review the predictions for various SUSY and heavy Higgs-boson masses and their implications for the ILC and CLIC. The ILC is now proposed with a staged machine design, with the first stage at $\sqrt{s} = 250$ GeV [67]. However, here we will focus on later stages with $\sqrt{s} = 500$ GeV (ILC500) and a hypothetical final stage with $\sqrt{s} = 1000$ GeV (ILC1000). For CLIC we assume a center-of-mass energy of $\sqrt{s} = 3$ TeV. In the plots in the subsections below several horizontal lines indicate the reach of the future $e^+e^-$ colliders: The green lines show the reach for SUSY particle pair production at the ILC500; the red line corresponds to the ILC1000, the purple line to CLIC. It should be kept in mind that by the production of a lighter and a heavier SUSY particle (e.g. $e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_3^0$) the actual reach can be higher than indicated by the horizontal lines.

4.1 Predictions for the mAMSB

As discussed in Sect. 2.1, within this mAMSB framework one finds $m_{\tilde{\chi}_1^0} \simeq 3$ TeV for wino DM and $m_{\tilde{\chi}_2^0} \simeq 1.1$ TeV for Higgsino DM. Both yield very heavy mass spectra, where in the Higgsino DM case the $\tilde{\chi}_1^0$ and $\tilde{\chi}_1^\pm$ are in the (pair production) reach of CLIC. If, on the other hand, the LSP is not the only component of the CDM, $m_{\tilde{\chi}_1^0}$ may be smaller, and $m_{3/2}$ may also be lowered substantially, and the overall mass spectrum can be substantially lighter. We concentrate on this more favorable case here.

The overall fit using MasterCode yielded for both DM cases a $\chi^2$/dof of about 36.5/27, corresponding to a $p$-value of about 0.105 [20]. In Fig. 1 [20] we show the best-fit spectra in the mAMSB for wino DM (upper plot) and Higgsino DM (lower plot), relaxing the assumption that the LSP contributes all the CDM density. The one- and two-$\sigma$ CL regions are shown in dark and light orange respectively, and the best-fit values are represented by blue lines. The colored horizontal lines indicate the reach of the future $e^+e^-$ colliders, as described above.

In the wino DM case one can see that the ILC has hardly any chance to see SUSY particles, and might observe the $\tilde{\chi}_1^0$, $\tilde{\chi}_1^\pm$ and $\tilde{\tau}_1$, with the other sleptons having part of the 1 $\sigma$ range within the kinematical reach. However, all SUSY particles can be outside the reach even of CLIC at the 2 $\sigma$ level. In the Higgsino DM case the $\tilde{\chi}_1^0$, $\tilde{\chi}_2^0$ and $\tilde{\chi}_1^\pm$ are nearly mass degenerate and possibly in the reach of the ILC, and for sure in the reach of CLIC, which could also possibly observe the $\tilde{\chi}_3^0$ and $\tilde{\chi}_2^\pm$. All other SUSY particles and heavy Higgs bosons are likely outside the reach of CLIC. Overall the reach for SUSY particles at future $e^+e^-$ colliders is not overly favorable in the mAMSB.
Figure 1: Best-fit spectra (taken from Ref. [20]) in the mAMSB for wino DM (upper plot) and Higgsino DM (lower plot), relaxing the assumption that the LSP contributes all the CDM density. The one- and two-$\sigma$ CL regions are shown in dark and light orange respectively, and the best-fit values are represented by horizontal blue lines. The green lines shows the reach for SUSY particle pair production at the ILC500; the red line corresponds to the ILC1000, the purple line to CLIC.

4.2 Predictions for the GUT based SU(5)

The overall fit in the SU(5) model using MasterCode yielded a $\chi^2$/dof of about 32.4/23, corresponding to a $p$-value of about 0.09 [21]. The mass predictions for the GUT based SU(5) model are shown in Fig. 2 [21] with the color coding is as in Fig. 1. As before the green/red/purple lines shows the reach for SUSY particle pair production at the ILC500/ILC1000/CLIC. Contrary to the mAMSB case we now demand that the LSP saturates the Planck CDM bound. One can see that the ILC500 cannot produce any new SUSY particles, while the ILC1000 might have the $\tilde{\chi}_0^1$ and $\tilde{\tau}_1$ in reach. CLIC, on the other hand, with its higher center-of-mass energy could possibly observe all sleptons (which masses are correlated), as well as the $\tilde{\chi}_1^{0,\pm}$ and $\tilde{\chi}_1^\pm$. However all SUSY particles could be out of reach even of CLIC at the 2$\sigma$ level.
4.3 Predictions for the sub-GUT model

The overall fit in the sub-GUT model using MasterCode yielded a $\chi^2$/dof of about 28.9/24, corresponding to a $p$-value of about 0.23 \cite{22}. Part of the reason for the better value as compared to the other two GUT based models is that the best-fit point of the sub-GUT model is in somewhat better agreement with the measurement of $\text{BR}(B_s \rightarrow \mu^+\mu^-)$, where the experimental value is slightly below the SM prediction. In Fig. 3\cite{22} the MasterCode results for the mass predictions in the sub-GUT model are displayed, with the color coding as in the previous subsections. Also in this model one can observe that the ILC will not have sufficient energy to produce SUSY particles. CLIC covers parts of the 1 $\sigma$ ranges of the $\tilde{\chi}_1^0$, $\tilde{\chi}_2^0$, and $\tilde{\tau}_1$. However, all new particles have 1 $\sigma$ ranges outside the reach of CLIC. The overall reach for SUSY particles at future $e^+e^-$ colliders is not very favorable in the sub-GUT model.

4.4 Predictions for the pMSSM11

Finally we turn to the low energy model with 11 independent parameters, the pMSSM11. The overall fit in the pMSSM11 using MasterCode yielded a $\chi^2$/dof of about 22.1/20, corresponding to a $p$-value of about 0.33 \cite{23}. The mass predictions of the MasterCode fit in the pMSSM11 are shown in Fig. 4\cite{23}, with the color coding as in the previous subsections. Contrary to the GUT based models in the pMSSM11 one can observe that even the ILC500 has the chance to observe the $\tilde{\chi}_1^0$, $\tilde{\chi}_2^0$, and $\tilde{\chi}_1^\pm$. The ILC1000 covers the 1 $\sigma$ ranges of the $\tilde{\chi}_1^0$ and of the sleptons of the first and second generation, and part of the 1 $\sigma$ ranges of the third generation sleptons. CLIC extends the reach by covering part of the 1 $\sigma$ ranges of the remaining charginos and neutralinos, and touching the 1 $\sigma$ ranges of some squarks and the heavy Higgs bosons.
Figure 3: Best-fit spectrum (taken from Ref. [22]) in the sub-GUT model. The color coding is as in the previous plots.

Figure 4: Best-fit spectrum (taken from Ref. [23]) in the pMSSM11. The color coding is as in the previous plots.

5 Conclusions

Using MasterCode [8,9,12,14,20 –25] we have performed global fits for various incarnations of the MSSM. MasterCode combines consistently experimental data from LHC Higgs-boson measurements, searches for additional Higgs bosons and supersymmetric (SUSY) particles at the LHC, low-energy and flavor experiments as well as CDM measurements.

Here we have reviewed the results of studies of the GUT based mAMSB, of the GUT based SU(5) framework, of the sub-GUT model as well as of the pMSSM11, a phenomenological model defined at low energies with 11 independent parameters. Details about these studies can be found in Refs. [20,23], respectively. In all models we have predicted the preferred
SUSY mass spectra at the 1 and 2σ level and compared them to the reach of the ILC500, the ILC1000 and CLIC.

We have found that the GUT based models offer substantially less prospects to observe SUSY particles as compared to the pMSSM11. The ILC500 touches some 1σ ranges in the GUT based models only in the Higgsino DM case of the mAMSB, and the situation does not improve substantially at the ILC1000, covering some best-fit points in the SU(5) model and the Higgsino DM case of the mAMSB. CLIC has a higher reach, but is mostly restricted to the lighter charginos and neutralinos in the GUT based models, as well as the slepton spectrum in the SU(5) model. In the pMSSM11, on the other hand, even the ILC500 could possibly observe the $\tilde{\chi}_1^0$, $\tilde{\chi}_2^0$ and $\tilde{\chi}_1^\pm$. The ILC1000 even covers the 1σ ranges of the $\tilde{\chi}_1^0$ and of the first generation sleptons, as well as some parts of the 1σ ranges of the sleptons of the third generation. CLIC also covers part of the 1σ ranges of the remaining charginos and neutralinos, and have a reach even for some lighter squarks and the heavy Higgs bosons.

The MasterCode analysis also yielded the $\chi^2$/dof values for the various analyses. The resulting values are summarized in Table 5. The three GUT based models have lowest p-values, where the sub-GUT model performs somewhat better due to a better fit to BR($B_s \rightarrow \mu^+\mu^-$). Should this measurement go to the SM value, the p-value of the sub-GUT model would become more similar to the ones of the mAMSB and the SU(5) model. The pMSSM11 has the best p-value, in particular because of a better fit of $(g-2)_\mu$ and the mass of the W boson. In this model the prospects of the potential future linear $e^+e^-$ colliders are very good, with some electroweak particles even in the reach of the ILC500. The pMSSM11, the model that fits the data best, would provide the possibility of many SUSY precision measurements.

“I am very optimistic.” [68]

| Model     | $\chi^2$/dof | p-value |
|-----------|--------------|---------|
| mAMSB     | 36.5/27      | 0.105   |
| SU(5)     | 32.4/23      | 0.09    |
| sub-GUT   | 28.9/24      | 0.23    |
| pMSSM11   | 22.1/20      | 0.33    |

Table 5: The $\chi^2$/dof values and the corresponding p-values of the four models under investigation.

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