Extracting the fundamental parameters

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Abstract. If supersymmetry is discovered at the LHC, the extraction of the fundamental parameters will be a formidable task. In such a system where measurements depend on different combinations of the parameters in a highly correlated system, the identification of the true parameter set in an efficient way necessitates the development and use of sophisticated methods. A rigorous treatment of experimental and theoretical errors is necessary to determine the precision of the measurement of the fundamental parameters. The techniques developed for this endeavor can also be applied to similar problems such as the determination of the Higgs boson couplings at the LHC.

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INTRODUCTION

A summary of the discussion of the extraction of the fundamental parameters can be found in [1]. Here only the main results of Refs. [2, 3, 4] as well as new work which was prepared specifically for the BSM-LHC and SUSY conferences will be summarized in the following section.

SUPERSYMMETRY AND HIGGS

If Supersymmetry and/or the Higgs boson are discovered and measured at the LHC (and the ILC), sophisticated tools such as SFitter, Fittino and others are required to determine the fundamental parameters from the experimental measurements. The measurements have several error components. Statistical errors are treated as Gaussian and treated as Poisson in the low statistics region. Systematic errors such as the energy scale uncertainty can be correlated among several measurements. The most precise predictions are used to confront the data. The associated uncertainties with the predictions are treated as flat errors in order not to privilege any particular parameter value within the interval of the theoretical error.

Two issues have to be addressed: can the correct parameter set be found and what is the precision with which the parameters can be measured. For the first question, techniques such as Markov chains have been developed. For the second question toy experiments are used where the data are smeared according to their errors. The RMS or sigma of a Gaussian fit of the central value distribution is the error on the parameter.

In the case of SPS1a, the mSUGRA parameter determination serves as example for a scenario where only few parameters have to be determined and these parameters are defined at the GUT scale. The correct parameter set can be determined in this case even with a simple gradient search (fit). Typically the LHC will allow to measure the parameters of mSUGRA at the percent level, whereas the ILC will increase the precision by an order of magnitude. However it is important to note that at the LHC (and ILC) the current precision of the theoretical predictions increases the expected error on the parameters with respect to the expected experimental errors.

The MSSM is defined at the electroweak scale with many parameters. Determining its parameters allows to test the unification of Supersymmetry breaking parameters at the GUT scale. To find the correct parameter set a sophisticated mix of methods is necessary. At the LHC in SPS1a an eightfold ambiguity remains in the gaugino sector. Adding the ILC resolves this ambiguity. Extrapolating the eight ambiguous LHC parameter solutions to the GUT scale, only one of them truly unifies the gaugino mass parameters. With the ILC GUT unification can be measured.

The same techniques as those developed for the determination of the supersymmetric parameters can also be applied to the determination of the Higgs boson couplings at the LHC. Here the additional technical challenge is the combination of Gaussian and Poisson errors. The typical precision for the coupling determination at the LHC is of the order of 30% to 50%. From the measurement of the coupling and its correlations, limits on new physics scenarios can be obtained/measured.

CONCLUSION

Sophisticated techniques will be necessary to determine the fundamental parameters from the future experimental data. The correct parameter set has to be found and alternative secondary minima either discarded or at least identified. These techniques have been applied successfully to supersymmetric scenarios and to the Higgs boson coupling determination.

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REFERENCES

1. Dirk Zerwas, *E*xtracting the fundamental parameters, BSM–LHC 2009 in Boston, North-Eastern University, to be published by Elsevier.
2. R. Lafaye, T. Plehn and D. Zerwas, arXiv:hep-ph/0404282.
3. R. Lafaye, T. Plehn, M. Rauch and D. Zerwas, Eur. Phys. J. C **54** (2008) 617 [arXiv:0709.3985 [hep-ph]].
4. R. Lafaye, T. Plehn, M. Rauch, D. Zerwas and M. Duhrssen, JHEP **0908** (2009) 009 [arXiv:0904.3866 [hep-ph]].