Fittino: An iterative approach to fit SUSY parameters to the observables

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DESY

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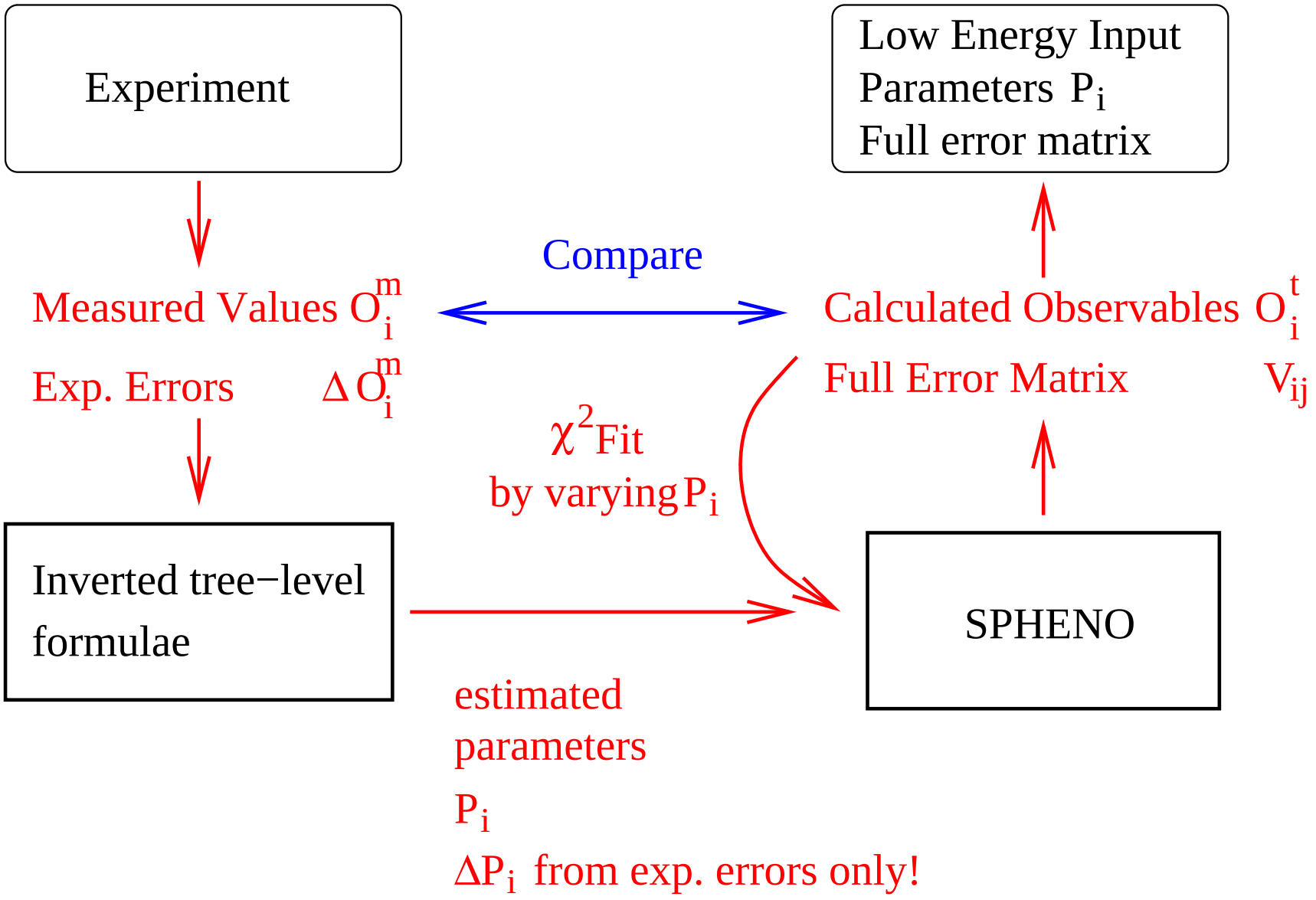
The Setup

- Fit the soft SUSY breaking MSSM paramaters to the observables from the LC and LHC
- Use no prior knowledge of the parameters at any step
- Include the possibility of unification of parameters
  In the following:
  Assume unification of first two generation mass parameters $M_{Q,U,D,L,E}$
- Fittino uses SPheno as a spectrum calculator
- SLHA used for communication with spectrum calculator, easily extendable to use other SLHA capable programs
- BR and Linear Collider cross sections for various $\sqrt{s}$ and polarisations from SPheno, including ISR

The Iterative Approach



The Interface

- Free text-file interface for observables
  - Masses, limits on masses of unobserved particles
  - Widths
  - Cross-Sections
  - BR
  - Edges in mass spectra
  - Correlations among observables
  - Both experimental and theoretical errors can be given
  - Both SM and MSSM observables
- Free text-file interface for parameters
  - Fix parameters at a given value
  - Fit parameters
  - Unify parameters
  - Both SM and MSSM parameters

Fit Strategy

- Start with tree-level relations for the parameters
  - $\mu, m_A, \tan\beta, M_1, M_2, M_3$ from gaugino and Higgs sector
  - A_t, A_b, M_Q, M_U, M_D from squark sector masses, assuming no mixing
  - A_τ, M_L, M_E from slepton sector masses, assuming no mixing
- Then first fit only the slepton sector to get a better estimate of $A_\tau, M_{\tau,L,R}$
  All non-slepton sector parameters fixed to their tree-level values
- Then fit only the squark sector to improve on A_t, A_b, M_Q, M_U, M_D
  All non-squark sector parameters fixed to their current values
- Then mostly the trilinear couplings are not optimally modelled, therefore first clean up: Fit only $A_t, A_b, A_\tau, M_{t,L,R}, \tan\beta$ (correlations!)
- Then release all parameters and fit again
- Perform a MINOS error analysis to get full correlation matrix, asymmetrical errors and 2D error contours

Results: Input for SPS1a test

- Observables:
  - SM observables $m_Z, m_W, G_F, m_t, \ldots$
  - Higgs sector masses from 500 GeV and 1 TeV LC
  - All sparticle and gaugino masses with unified 0.5% error (a la SFITTER)
  - LC cross sections at 500 GeV, polarisation LL and polarisation RR
  - h BR's
- Assumptions for this test:
  - No theory errors, no free SM parameters (m_t!)
  - Unification in the first two generations
  - Fix A_τ, basically unmeasurable with these observables
  - Unify A_t and A_b

Results: Output

- Fit converges to correct minimum, but covariance matrix is not positive definite $\rightarrow$ no prediction of the uncertainty
- Probably correlations too strong
- Try $A_t = A_b = A_\tau = \mathrm{const}$: Converging fit with correct uncertainties
- Results:

1	TanBeta	10.00 +- 0.19	9	MSupR	530.2 +- 2.07
2	Mu	358.6 +- 1.15	10	MStopR	424.3 +- 2.91
3	MSelectronR	135.8 +- 0.52	11	MSupL	548.7 +- 0.11
4	MStauR	133.3 +- 0.87	12	MStopL	499.9 +- 2.65
5	MSelectronL	195.2 +- 0.49	13	M1	101.8 +- 0.49
6	MStauL	194.3 +- 0.78	14	M2	191.7 +- 0.55
7	MSdownR	528.1 +- 2.18	15	M3	588.7 +- 3.82
8	MSbottomR	524.7 +- 3.36	16	massA0	399.7 +- 0.69

- $\Rightarrow$ Have to increase handling of correlations among A and $\tan\beta$ $\rightarrow$ Polarisation as additional observables in the fit?

Results: Output

- Fit with realistic LHC/LC uncertainties (Table 4.25), plus LC Cross-Sections and Higgs BR:

1	TanBeta	9.990	+- 1.025	10	MSupR	530.2	+- 12.7
2	Mu	358.6	+- 6.307	11	MStopR	424.4	+- 5.51
3	MSelectronR	135.7	+- 0.243	12	MSupL	548.7	+- 5.58
4	MStauR	133.3	+- 1.617	13	MStopL	499.9	+- 7.68
5	MSelectronL	195.2	+- 0.096	14	M1	101.8	+- 0.22
6	MStauL	194.4	+- 1.396	15	M2	191.7	+- 0.93
7	Atop	-506.5	+- 15.4	16	M3	588.7	+- 8.19
8	MSdownR	528.1	+- 17.9	17	massA0	399.7	+- 0.72
9	MSbottomR	524.7	+- 8.513				

- VERY HOT, Errors not yet confirmed by MINOS
- Probably detailed study of the correlations between A_t and $\tan\beta$ will further increase error on $\tan\beta$ . . .

Summary and Outlook

- Results show the importance of the combination of LHC and LC:
  Without prior knowledge of the observables NO convergence without information on ALL sectors from BOTH LHC and LC
- The use of a priori knowledge of parameters at any intermediate step of the fit is problematic, since this tends to shadow impacts from correlations among parameters on the fit
- Fit with idealized observable uncertainties converges to correct minimum, but correct description of the uncertainties not yet confirmed
- Studies with realistic LHC/LC uncertainties underway, convergence very good, parameter uncertainties hopefully available soon
- For fit with fixed A, precise parameter determination is possible
- More observables, strongly constraining certain parameters (A_t, A_b, A_τ), badly needed (Polarisations? Need them in SLHA!)