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SPA

SUPERSYMMETRY PARAMETER ANALYSIS

Convention and Project

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for the SPA Collaboration

[authors from America, Asia and Europe]

Motivation

- LHC will see SUSY if realised at LE scale
- Many channels from squark and gluino decays
- ILC needed for precision and model-independent studies
- SUSY – a bridge between EW and GUT/Pl scales

From theory: important to achieve

- accurate theoretical calculations to match the experimental data
- model-independent reconstruction of Lagrange parameters
- extrapolate to high scale => SUSY breaking mechanism

to achieve these goals we propose

the SPA Project

The SPA Conventon and Project

- SPA Convention

  renorm. schemes / LE parameters / observables

- Program repository

  th. & exp. analyses / LHC+ILC tools / Susy Les Houches Accord

- Theoretical and experimental tasks

  short- and long-term sub-projects

- Reference point SPS1a'

  derivative of SPS1a, consistent with all data

- Future developments

  CP-MSSM, NMSSM, R_pV, effective string th., etc.

1. SPA Convention

- The masses of the SUSY and Higgs: pole masses
- The SUSY Lagrangian parameters: mass parameters and couplings, including tanβ, defined in the DRbar scheme at the scale M= 1 TeV
- Gaugino/higgsino and scalar mass matrices, rotation matrices and the corresponding mixing angles defined in the DRbar, except for the Higgs, in which mixing is defined in the on-shell scheme at m_h
- The SM input parameters: G_F, α, M_Z, $\alpha_s^{MSbar}(M_Z)$
  - lepton masses on-shell
  - t quark mass on-shell
  - b, c quark masses in MSbar taken at masses themselves
  - light quarks in MSbar at a scale of 2 GeV
- σ, Γ, BR, …, calculated for parameters as above

DRbar scheme

- DRbar = DRED + modified min. subtraction
- most convenient, natural for GUT-inspired parameter sets
- but problems with DRED?

SUSY, Consistency

- Does DRED preserve SUSY?
- Mathematical inconsistency [Siegel'80]
- Symmetry-restoring countert-erms necessary in calculations?

QCD-Factorization

- Hadron processes in DRED:

$$\sigma_{\text{had}} = f_{\text{parton}} \otimes \sigma_{\text{parton}} + \text{non-factorizing terms?}$$

[Beenakker,Kuijf,Neerven,Smith'88]
[Beenakker,Höpker,Spira,Zerwas'96]

D. Stockinger
A. Signer

$$\begin{array}{ccccc} \sigma(G,\ \ldots) & = & \sigma(g,\ \ldots) & + & \sigma(\phi,\ \ldots) \\ \downarrow & & \downarrow & & \downarrow \\ \text{4-dim gluon} & & D\text{-dim gluon} & & 4-D \text{ scalars} \end{array}$$

2. Program Repository

- Scheme translation tools

  DRbar ⟺ MSbar ⟺ on-shell

- Spectrum calculators: Lagrangian ⟺ masses

  ex: FeynHiggs, SPheno, SuSpect, SoftSusy,IsaJet, ...

- Other observables: cross sections, decay rates, LE param., astrophysics, cosmology

  ex: HDecay, NMHDecay, SDecay, Prospino, micrOMEGAs, ...

- Event generators: IsaJet, Phytia, Whizard, ...

- Analysis programs: SFitter, Fittino

- RGE: M ⟺ $M_{GUT/Pl}$: SPheno, SoftSusy, IsaJet/IsaSusy, ...

➡ **http://spa.desy.de/spa**

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SPA
SUPERSYMMETRY PARAMETER ANALYSIS

The SPA project is a joint study of theorists and experimentalists working on LHC and Linear Collider phenomenology. The study focuses on the supersymmetric extension of the Standard Model. The main targets are

- High-precision determination of the supersymmetry Lagrange parameters at the electroweak scale
- Extrapolation to a high scale to reconstruct the fundamental parameters and the mechanism for supersymmetry breaking

The SPA convention and the SPA Project are described in the report SPA.draft.ps.

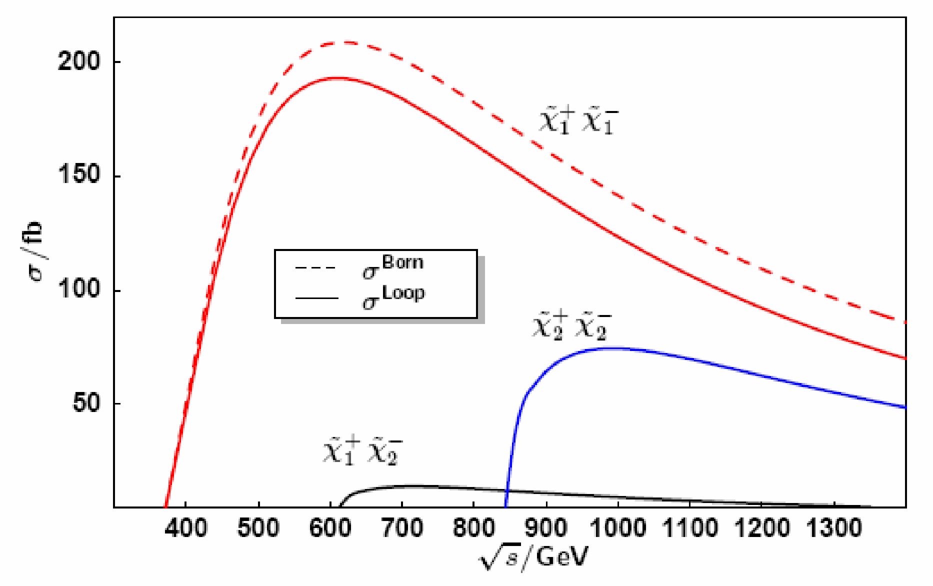
Coordinators

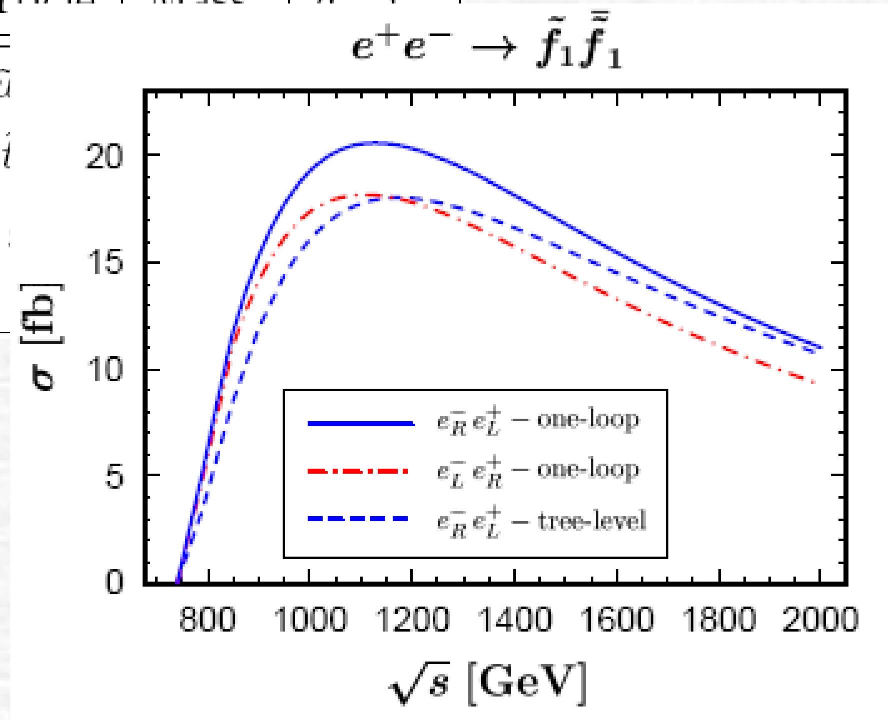
This list contains the coordinators from Europe only; for each sector, the coordinators from America and Asia will be added soon.

- Higher order calculations mandatory

shift $M = 1$ TeV *to* 100 GeV $\Rightarrow$ next loop!

Particle	Mass	δ_{scale}	Particle	Mass	δ
h^0	115.4	1.2	$\tilde{u}$		





3. Project tasks

- better understanding DRbar scheme
- include new channels, observables, …
- improve bkgd & signal simulation with realistic estimates of theoretical errors
- cover new theoretical scenarios
- coherent LHC/ILC analyses (-> G. Weiglein)

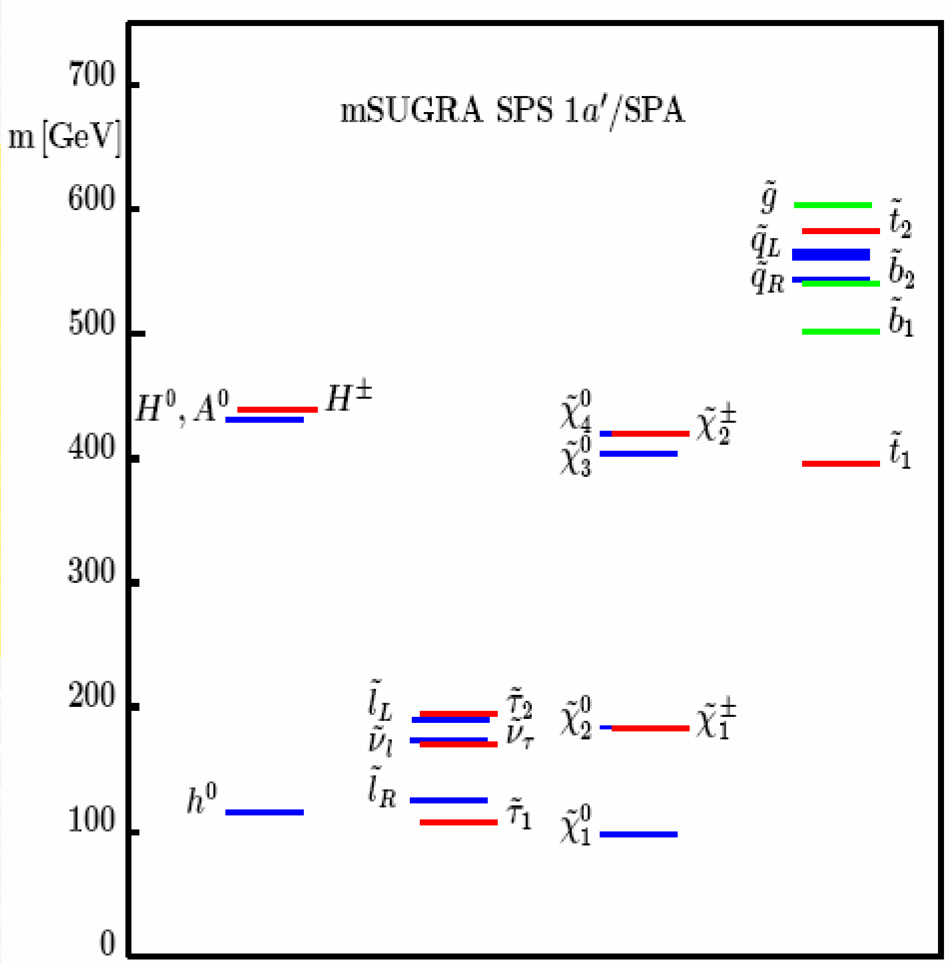
4. Reference point SPS1a'

- SPS1a'- derivative of the SPS1a point

  mSUGRA values:

m_0	70 GeV
$m_{1/2}$	250 GeV
A_0	-300 GeV
$\tan\beta$	10
sign μ	$+$

$$BR(b \to s\gamma) = 3.0 \times 10^{-4}$$
$$\Delta[g_\mu - 2]/2 = 33 \times 10^{-10}$$
$$\Omega_{cdm} h^2 = 0.10$$



SPS1a': Measurements

- edges at LHC
- decay spectra at ILC

$\tilde{\ell}_L \to \tilde{\chi}_2^0 \ell \to \tilde{\ell}\ell\ell \to \tilde{\chi}_1^0 [\ell\ell$

- threshold scans at ILC

$\tilde{e}_R \to e + \tilde{\chi}_1^0$

$e^+e^- \to \chi_1^+\chi_1^-$

- results:

	Mass	"LHC"	"LC"	"LHC+LC"
h^0	115.4	0.25	0.05	0.05
H^0	431.1		1.5	1.5
$\tilde{\chi}_1^0$	97.75	4.8	0.05	0.05
$\tilde{\chi}_2^0$	184.4	4.7	1.2	0.08
$\tilde{\chi}_4^0$	419.6	5.1	$3-5$	2.5
$\tilde{\chi}_1^\pm$	184.2		0.55	0.55
$\tilde{e}_R$	125.2	4.8	0.05	0.05
$\tilde{e}_L$	190.1	5.0	0.18	0.18
$\tilde{\tau}_1$	107.4	$5-8$	0.24	0.24
$\tilde{q}_R$	547.7	$7-12$	–	$5-11$
$\tilde{q}_L$	565.7	8.7	–	4.9
$\tilde{t}_1$	368.9		1.9	1.9
$\tilde{b}_1$	506.3	7.5	–	5.7
$\tilde{g}$	607.6	8.0	–	6.5

Reconstructing Lagrange param.

- global analysis codes:
  SFitter and Fittino
- fit masses + xsectic
- radiative correction included
- ex: Fittino
- results (based on 82 simulated measurements at the LHC and ILC)

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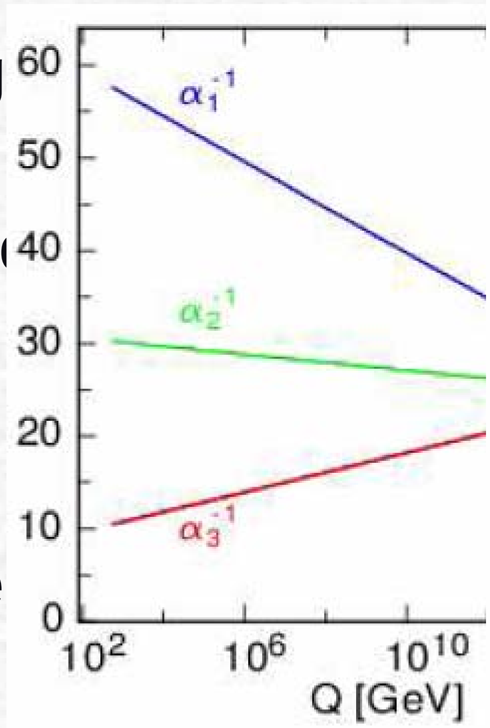
- Err

Parameter	SPS1a′value	Fit error [exp]
M_1	103.3	0.1
M_2	193.4	0.1
M_3	568.9	7.8
μ	400.4	1.1
$M_{\tilde{e}_L}$	181.3	0.2
$M_{\tilde{e}_R}$	115.6	0.4
$M_{\tilde{\tau}_L}$	179.5	1.2
$M_{\tilde{u}_L}$	523.2	5.2
$M_{\tilde{u}_R}$	503.9	17.3
$M_{\tilde{t}_L}$	467.7	4.9
m_{A}	374.9	0.8
A_{t}	-525.6	24.6
$\tan\beta$	10.0	0.3

High-scale extrapolation

- gauge couplings α
- g
- s
- e



mSUGRA	Parameter, ideal	"LHC+LC" errors
M_1	250. GeV	0.18 GeV
M_2	*ditto*	0.26 GeV
M_3		2.8 GeV
M_{L_1}	70. GeV	4.1 GeV
M_{E_1}	*ditto*	7.9 GeV
M_{Q_1}		11. GeV
M_{U_1}		31. GeV
M_{H_1}	*ditto*	7.5 GeV
M_{H_2}		72. GeV
A_t	−300. GeV	44. GeV

gaugino ~0.1%, sleptons ~1%, squarks ~ 10%

- universality can be tested in bottom-up approach

If high-scale theory known

- top-down approach: high quality mSUGRA fit

	Parameter, ideal	Experimental error
M_U	$2.47 \cdot 10^{16}$ GeV	$0.02 \cdot 10^{16}$ GeV
α_U^{-1}	24.17	0.06
$M_{\frac{1}{2}}$	250 GeV	0.2 GeV
M_0	70 GeV	0.2 GeV
A_0	-300 GeV	13.0 GeV
μ	402.9 GeV	0.3 GeV
$\tan\beta$	10	0.3

- caveat: deviations may hide in badly measured obs. which do not spoil top-down fit
- but which can become manifest in bottom-up approach

Summary and outlook

- SPA: a joint interregional theoretical and experimental effort
- It provides:
  - a well defined framework for SUSY analyses
  - all necessary theoretical and computational tools
  - a well defined testground SPS1a'
  - a platform for future extensions/developments

- LHC+ILC – telescope to GUT/Pl physics

Report: Supersymmetry Parameter Analysis:

SPA Convention and Project

Summary and outlook

- many things to work on both:

  experimental and theoretical side

You are invited to join as a co-author of the report

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END