

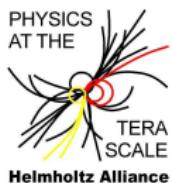
Adding Rates as Observables to Fittino

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Outline

Introduction

Implementation

Cross Section

The two observables

Rate Information in Fittino

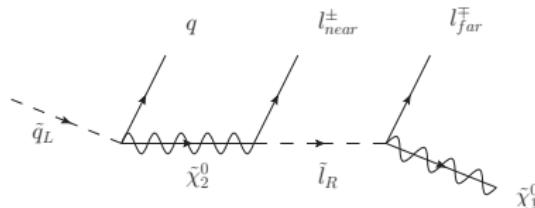
Two quick examples

Outlook

Motivation

- ▶ Much theory effort has gone into calculating sparticle production total cross-sections (LO, NLO, NLL).
- ▶ Several programs exist to calculate sparticle branching ratios.
- ▶ Rates do vary significantly within errors of parameter fit using only edges!
- ▶ Rate information already available very early.
- ▶ In many parameter regions additional observables necessary (Three-Body decays, Split-SUSY etc.).

OS-SF Example:



	SPS1a	M_{0+}	M_{0-}	$M_{1/2+}$	$M_{1/2-}$	A_{0+}	A_{0-}	$\tan \beta +$	$\tan \beta -$
$\sigma(\tilde{q}_L)$	25.27	25.05	29.03	24.44	37.12	27.68	29.25	29.16	28.49
$\sigma \times BR$	1.45	1.47	1.52	1.24	2.26	2.21	0.82	0.82	3.83

Problems

- ▶ Theoretical uncertainties are expected to be too large (100% @ LO).
- ▶ Computation of rate signatures is too time consuming to be efficiently used in fit algorithms (or not feasible due to statistical fluctuations in MC calculation)

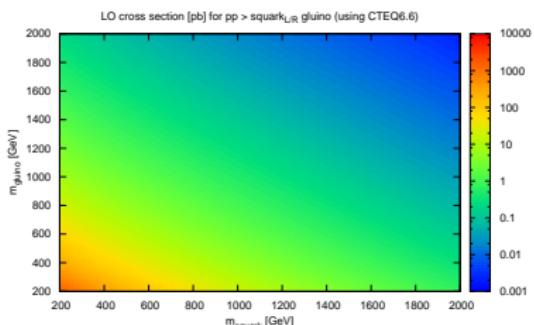
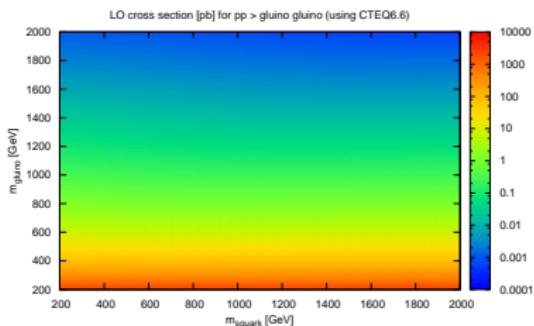
With the approach shown here a fast and reliable estimate of

$$\frac{N}{L} = \sigma_{theo} \times BR \times \text{Acceptance}$$

is possible with

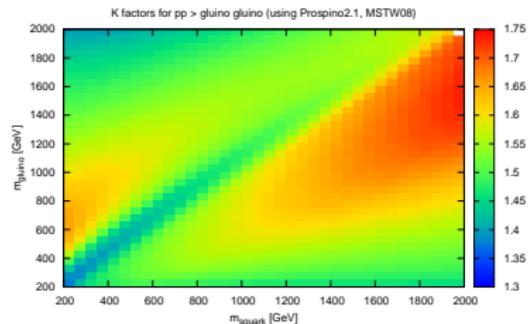
$$\Delta N = \sqrt{(\Delta\sigma_{\text{theo.}})^2 + (\Delta\sigma_{\text{acc.}})^2 + (\Delta\sigma_{\text{exp.}})^2} \lesssim 20\%$$

Cross Section



LO and NLO K-Factors:

- ▶ Very smooth.
- ▶ Parameterizable by two parameters: $m_{\tilde{g}}$ and $m_{\tilde{q}}$.
- ▶ Easy to access via a grid (like PDFs).
- ▶ Channels: $\tilde{g}\tilde{g}$, $\tilde{g}\tilde{q}$, $2 \times \tilde{q}\tilde{q}$, $\tilde{t}\tilde{t}$.



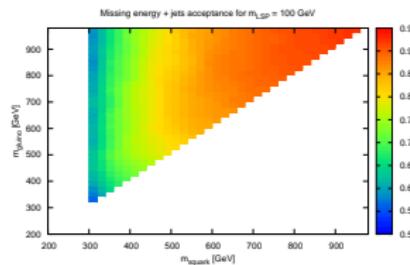
First new observable: Inclusive R^j

Defined by:

- more than 2 jets with $p_j^T > 50\text{GeV}$, $|\eta_j| < 2.5$.
- Missing $E_T > 100\text{GeV}$.

This can be parameterized by three parameters: $m_{\tilde{g}}$, $m_{\tilde{q}}$, $m_{\tilde{\chi}_1^0}$, obeying:

$$200 \text{ GeV} < m_{\tilde{q}} < m_{\tilde{g}} < 2 \text{ TeV} \quad 0 < m_{\tilde{\chi}_1^0} < m_{\tilde{q}} - 200 \text{ GeV}$$



Dicrepancy from proper Monte Carlo $\lesssim 5\%$ (random scan)

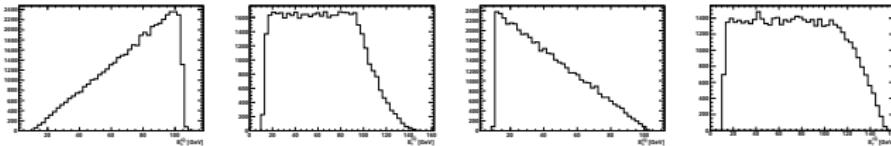
Second new observable: Leptonic R'

Defined by:

- ▶ same as R^j
- ▶ exactly two OS-SF leptons with $p_T^l > 10\text{GeV}$, $|\eta_l| < 2.5$.

In the limit of infinite statistics only decay chains with an on-shell $\tilde{\chi}_2^0$ (and Z/h) contribute → use OS-DF subtraction.

Energy distributions in the the squark rest-frame for different chirality combinations can be calculated analytical:



- ▶ These depend on all masses in the decay chain.
- ▶ During the fit we convolute with energy distributions in squark rest frame parameterized still by just two parameters: $m_{\tilde{g}}$ and $m_{\tilde{q}}$.

Dicrepancy from proper Monte Carlo $\lesssim 5\%$ (random scan).

Rate Information in Fittino

1. Rate information specified in fittino.in file?
2. Reading in the lookup tables once at the start of Fittino.
3. Reading in SLHA file with sparticle masses and BRs for each point.
4. Checking that hierarchy is such that we can provide rate information for the two given signatures.
5. Calculating R^j acceptance, R^l acceptance, using values stored in lookup tables.
6. Looking up σ_{theo} from grids.
7. Looking up NLO K-Factors from grids.
8. Multiplying σ_{theo} by BRs for lepton signature and by acceptances, whilst considering combinatorics.
9. Returning result to Fittino.

This is implemented in a self-containing C++ class linked to fittino.

Fitting SPS1a @ 14 TeV and 10 fb⁻¹

Observable	Nominal Value	Uncertainty
$m_{ll}^{\max}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{l_R})$	80.4	$\pm 0.5 \pm 0.08$ (LES)
$m_{\tau\tau}^{\max}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{\tilde{\tau}_1})$	83.4	$\pm 4.0 \pm 8.3 \pm 0.8$ (JES)
$m_{qll}^{\max}(m_{\tilde{\chi}_1^0}, m_{\tilde{q}_L}, m_{\tilde{\chi}_2^0})$	452.1	$\pm 4.2 \pm 2.3$ (JES)
$m_{ql}^{\text{low}}(m_{l_R}, m_{\tilde{q}_L}, m_{\tilde{\chi}_2^0})$	318.6	$\pm 3.5 \pm 1.6$ (JES)
$m_{ql}^{\text{high}}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{l_R}, m_{\tilde{q}_L})$	396.0	$\pm 4.5 \pm 2.0$ (JES)
$m_{qll}^{\text{thres}}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{l_R}, m_{\tilde{q}_L})$	215.6	$\pm 4.8 \pm 1.1$ (JES)
R^I [pb]	31.7	± 6.4
R^I [pb]	1.06	± 0.21

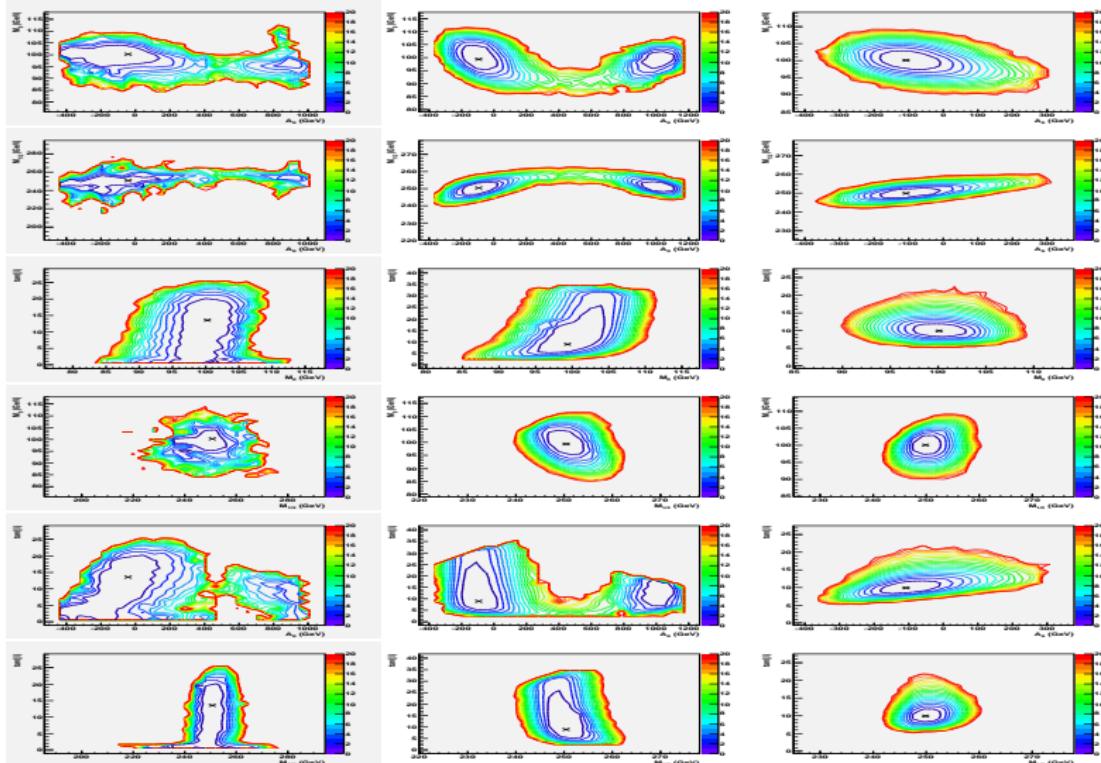
only endpoints

M_0 [GeV]	100.3	+3.2	-5.4
$M_{1/2}$ [GeV]	250.7	+7.4	-13.7
A_0	-42.5	+155.6	-382.8
$\tan \beta$	13.5	+6.0	-13.4

endpoints and rates

M_0 [GeV]	100.1	+2.3	-2.1
$M_{1/2}$ [GeV]	249.9	+2.2	-1.5
A_0	-107.8	+85.0	-58.6
$\tan \beta$	9.9	+1.5	-1.1

Fitting SPS1a @ 14 TeV and 10 fb⁻¹



Fitting SPS1a with non-universal gaugino masses @ 14 TeV and 10 fb⁻¹

Observable	Nominal Value	Uncertainty
$m_{ll}^{\max}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{\tilde{l}_R})$	80.4	$\pm 0.5 \pm 0.08$ (LES)
$m_{\tau\tau}^{\max}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{\tilde{\tau}_1})$	83.4	$\pm 4.0 \pm 8.3 \pm 0.8$ (JES)
$m_{qll}^{\max}(m_{\tilde{\chi}_1^0}, m_{\tilde{q}_L}, m_{\tilde{\chi}_2^0})$	452.1	$\pm 4.2 \pm 2.3$ (JES)
$m_{ql}^{\text{low}}(m_{\tilde{l}_R}, m_{\tilde{q}_L}, m_{\tilde{\chi}_2^0})$	318.6	$\pm 3.5 \pm 1.6$ (JES)
$m_{ql}^{\text{high}}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{\tilde{l}_R}, m_{\tilde{q}_L})$	396.0	$\pm 4.5 \pm 2.0$ (JES)
$m_{qll}^{\text{thres}}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{\tilde{l}_R}, m_{\tilde{q}_L})$	215.6	$\pm 4.8 \pm 1.1$ (JES)
$m_{\tilde{g}} - m_{\tilde{\chi}_1^0}$	507.7	$\pm 13.7 \pm 10.0 \pm 2.5$ (JES)
$\sqrt{m_{\tilde{q}_R}^2 - 2m_{\tilde{\chi}_1^0}^2}$	531.0	$\pm 6.2 \pm 10.0 \pm 5.3$ (JES)
$m_{ll}^{\max}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{\tilde{l}_L})$	280.6	$\pm 12.6 \pm 0.3$ (LES)
$m_{bll}^{\text{thres}}(m_{\tilde{\chi}_1^0}, m_{\tilde{\chi}_2^0}, m_{\tilde{l}_R}, m_{\tilde{b}_1})$	195.9	$\pm 19.7 \pm 1.0$ (JES)
R^j [pb]	31.7	± 6.4
R^l [pb]	1.06	± 0.21

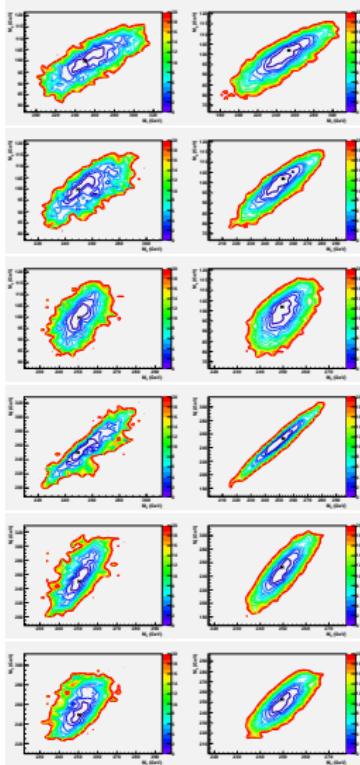
only endpoints

M_0 [GeV]	99.8	-3.8	+6.3
M_1 [GeV]	250.0	-14.0	+17.5
M_2 [GeV]	249.4	-6.0	+11.8
M_3 [GeV]	250.4	-4.6	+4.2
A_0	-101.8	-71.9	+530.5
$\tan \beta$	13.4	-10.3	+2.9

endpoints and rates

M_0 [GeV]	101.9	-8.2	+3.8
M_1 [GeV]	253.2	-22.0	+11.4
M_2 [GeV]	252.7	-11.7	+6.4
M_3 [GeV]	249.6	-4.0	+3.3
A_0	-110.6	-43.8	+71.8
$\tan \beta$	9.6	-0.9	+1.7

Fitting SPS1a with non-universal gaugino masses @ 14 TeV and 10 fb⁻¹



Outlook

Still to do:

- ▶ Compare results with MC (including detector effects) in larger parts of parameter space.
- ▶ on-shell Z/h contributions.
- ▶ general OS-SF signature (no OS-DF subtraction).

Possible Extensions (in order of perceived importance):

- ▶ muons and electrons from tau leptons.
- ▶ Other signatures ($> 3j + \ell\ell$ (OS-SF), $> 2j + \ell\ell$ (SS-SF), etc.).
- ▶ Three-body decays of $\tilde{\chi}_2^0$ and/or up the chain for the \tilde{g} .

Questions:

- ▶ What to do when we can not offer rate information?
- ▶ How do we know our results are stable?