Beyond Standard Model Physics in Herwig++

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Method Outline

Created method enabling the implementation of new physics models in Herwig++ easier.

1. MatrixElement and Decayer classes based on external spins;
2. Vertex classes encode Feynman rules that are used in the calculation of amplitudes through HELAS formalism.

Implementation of a new model requires only a set of Feynman rules and specification of any new particles.

Details can be found in hep-ph/0703199.

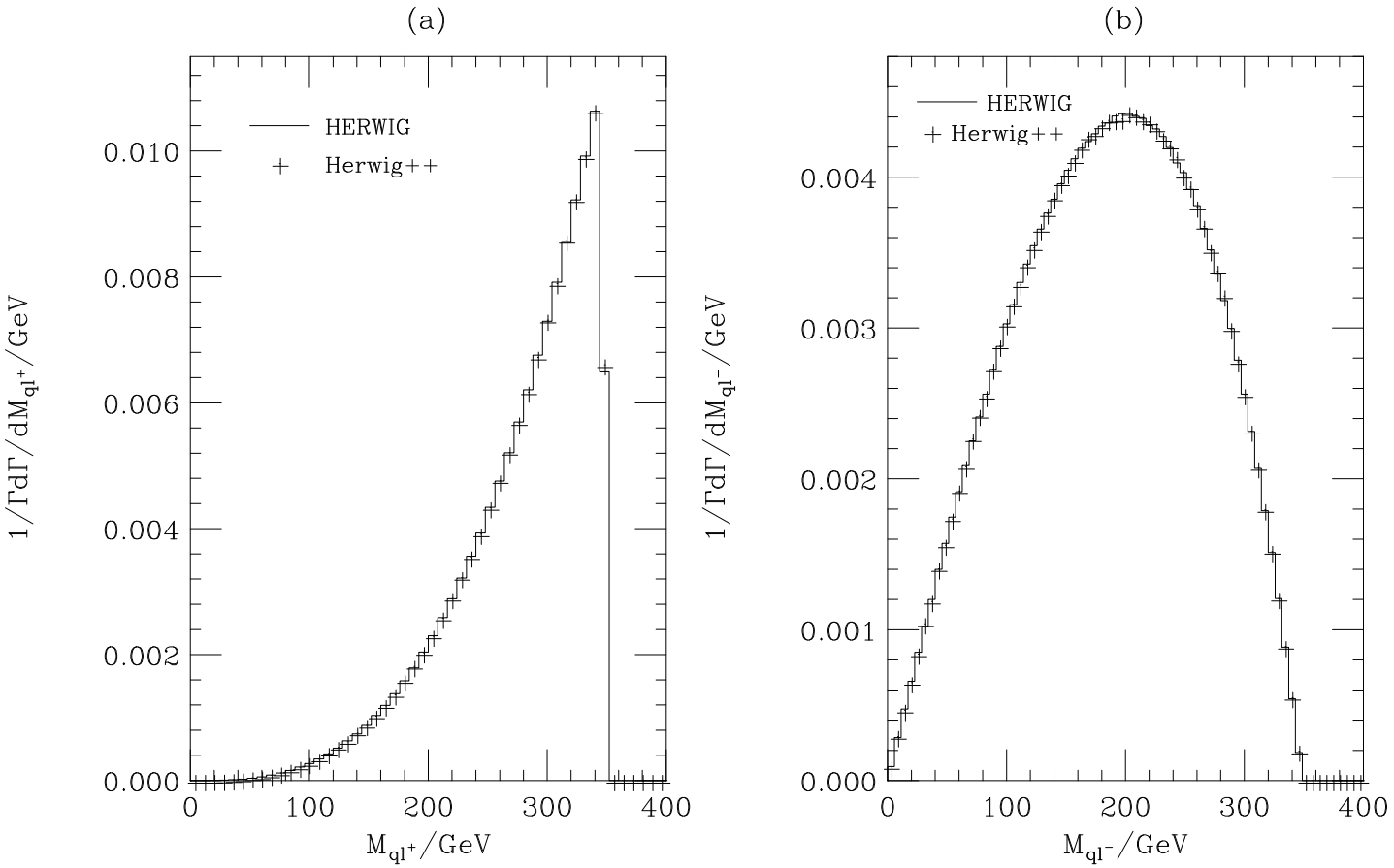
Current Release

- As of Herwig++ 2.1, BSM physics is included for the first time
- Release includes:
  - Minimal Supersymmetric Standard Model (CP and flavour conserving),
  - Minimal Universal Extra Dimensions,
  - Randall-Sundrum.

Spin correlations included in $2 \longrightarrow 2$ production matrix elements and $1 \longrightarrow 2$ decay matrix elements.

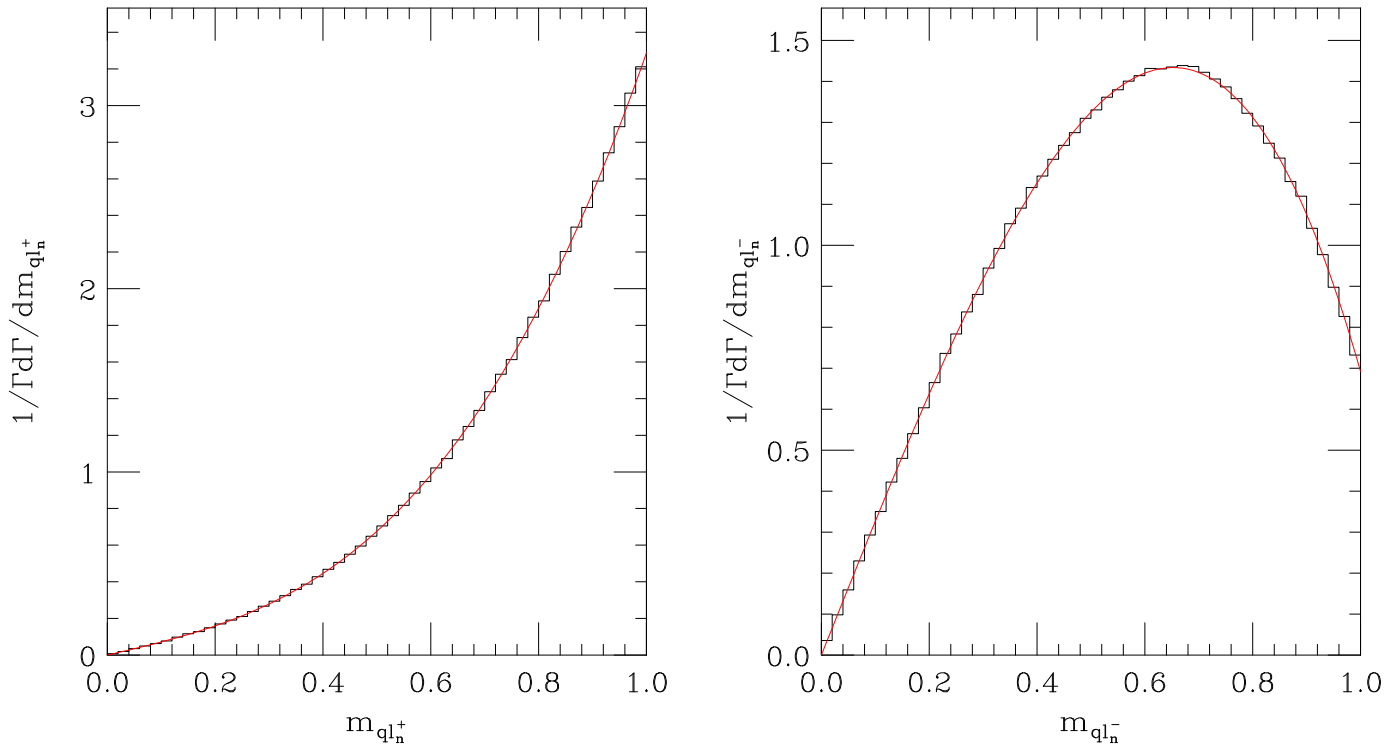
Minimal Supersymmetric Standard Model

$$\tilde{q}_L \longrightarrow q, \tilde{\chi}_{20} \longrightarrow \tilde{l}_R, q, l^{\pm} \longrightarrow q, l^{\pm}, l^{\mp}\tilde{\chi}_{10}$$



Minimal Universal Extra Dimensions, N=1

$$q^* \to q, Z_1^* \to l^*, q, l^\pm \to q, l^\pm, l^\mp \gamma_1^*$$



A contribution to the Les Houches 2007 proceedings, with Pedro Ribeiro of CMS, on the subject of the discovery potential of MUED at CMS and discrimination against SUSY.

Off-shell Effects

We don't want to limit ourselves to on-shell cascades of BSM particles, want to incorporate off-shell effects aswell.

When a particle is produced its mass is generated according to a Breit-Wigner,

$$\int dm^2 \frac{m\Gamma(m)}{(m^2 - M^2)^2 + m^2\Gamma(m)^2}$$

and the running width $\Gamma(m)$ is calculated using the Decayer classes.

Next-To-Minimal Supersymmetric Standard Model

The NMSSM is an extension of the MSSM which is mainly motivated to solve the so-called μ problem of the MSSM.

The MSSM superpotential has to contain a term like

$$\mu H_1 H_2$$

but μ is not "naturally" of the order of the EW scale as it should be phenomenologically.

The NMSSM solves this problem by adding an extra Higgs singlet field N. The μ term is then dynamically generated when this field acquires a VEV giving $\mu = \lambda \langle N \rangle$.

Next-To-Minimal Supersymmetric Standard Model

The particle content of the NMSSM is that of the MSSM with the addition of a CP-even and CP-odd Higgs and a fifth neutralino.

This introduces 2 Higgs mixing matrices one for the CP-even and one for the CP-odd sector and the neutralino mixing matrix becomes 5×5.

Implementation of the model simply requires replacing those vertices in the MSSM that contain a Higgs particle with the NMSSM counterpart.

The model is now implemented in Herwig++.

Summary

- Current release includes BSM physics; MSSM, MUED and RS Model,
- Also possible to simulate off-shell effects while using two body decayers,
- NMSSM has been implemented, Little Higgs hot on its tail.