HERWIG

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Introduction

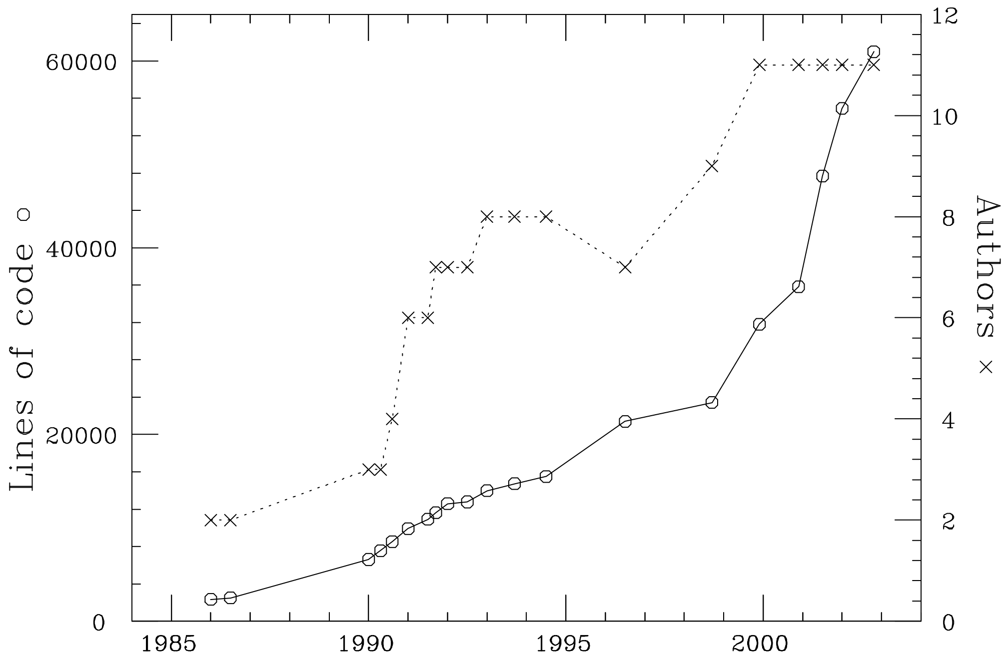
- HERWIG is a general-purpose event generator.
- As with all these programs the main emphasis is on the simulation of SM processes.
- BSM physics was added later but a lot of processes are now included in a sophisticated way.
- The main program is available from

  http://hepwww.rl.ac.uk/theory/seymour/herwig/

- There is a long history of developments and improvements to the program.
- I will first briefly recall the basic models and then mention the most recent changes for the FORTRAN program.
- This is the version that will probably be used for any work in this workshop.

HERWIG++

- We are currently in the middle of a major programme to produce a new program using the same philosophy and physics ideas but with many improvements.



- This was necessary as many physics changes were impossible due to the structure of the code and maintenance was becoming harder.

- Given the experimental change to C++ that was the natural language.

HERWIG++

- This program is based on the same code framework as Pythia7, ThePEG.
- This allows HERWIG and PYTHIA physics models to be used together.
- This will be the HERWIG generator for the LHC era.
- We have made a decision to reduce the level of support for the FORTRAN program.
- This means at the moment we will no longer add new features (with the possible exception of some things we have been working on for a long time.)
- We will still fix bugs and provide other user support.
- At the moment the generator only works for lepton collisions and therefore for this workshop the FORTRAN code will probably be used.

HERWIG++

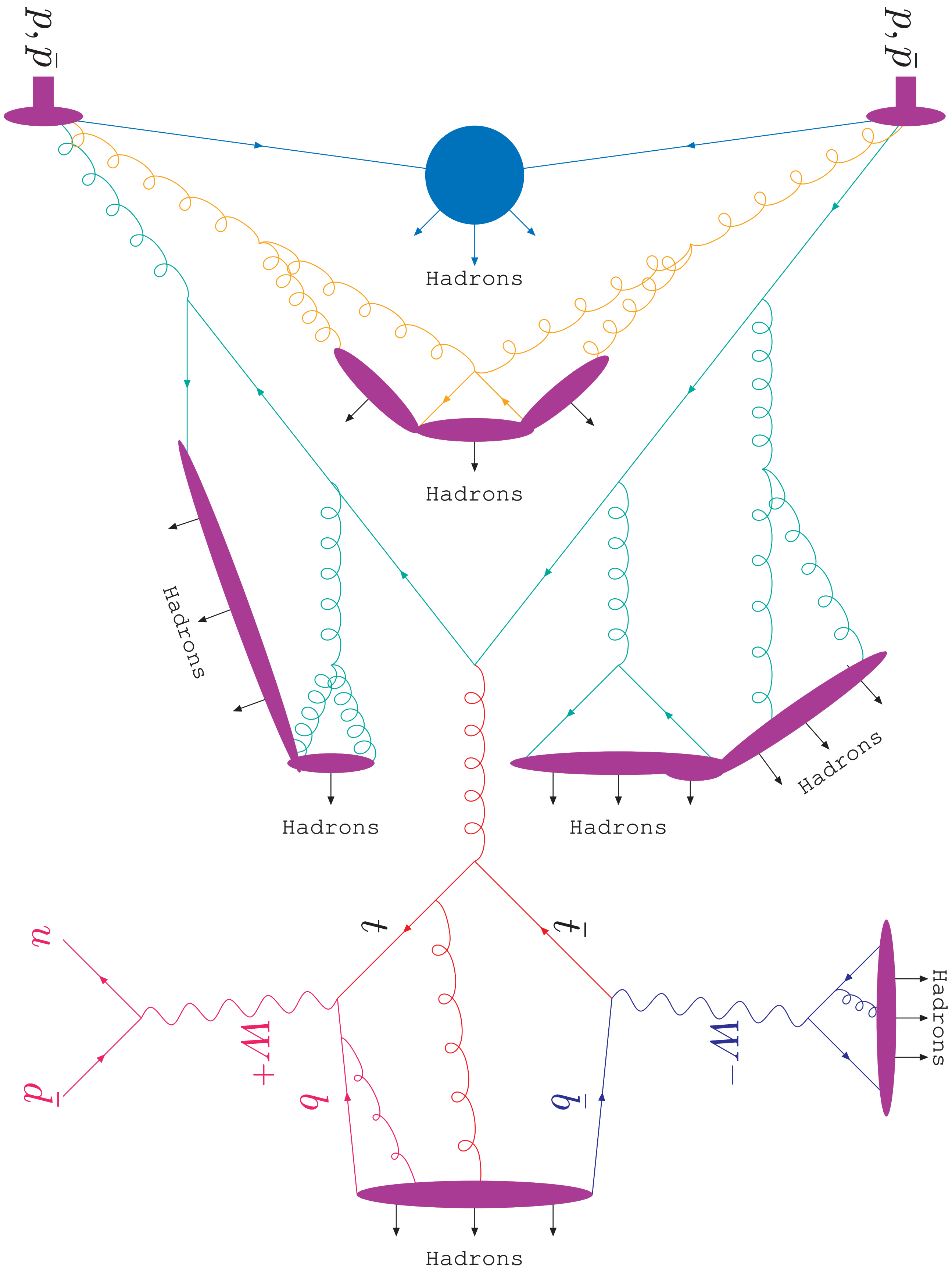
- When the hadron-hadron version is ready we will start to encourage its use rather than the FORTRAN.

- At some point after this all support of the FORTRAN will be withdrawn for the LHC experiments.

- We envisage providing bugs fixes to the currently running experiments until they have finished taking data.

Basic Models in HERWIG

- As with all event generators HERWIG splits the simulation up into a number of parts:
  - Hard Process;
  - Parton Shower;
  - Secondary Decays;
  - Multiple Scattering/Soft Underlying Event;
  - Hadronization;
  - Hadron Decays.



Hadrons
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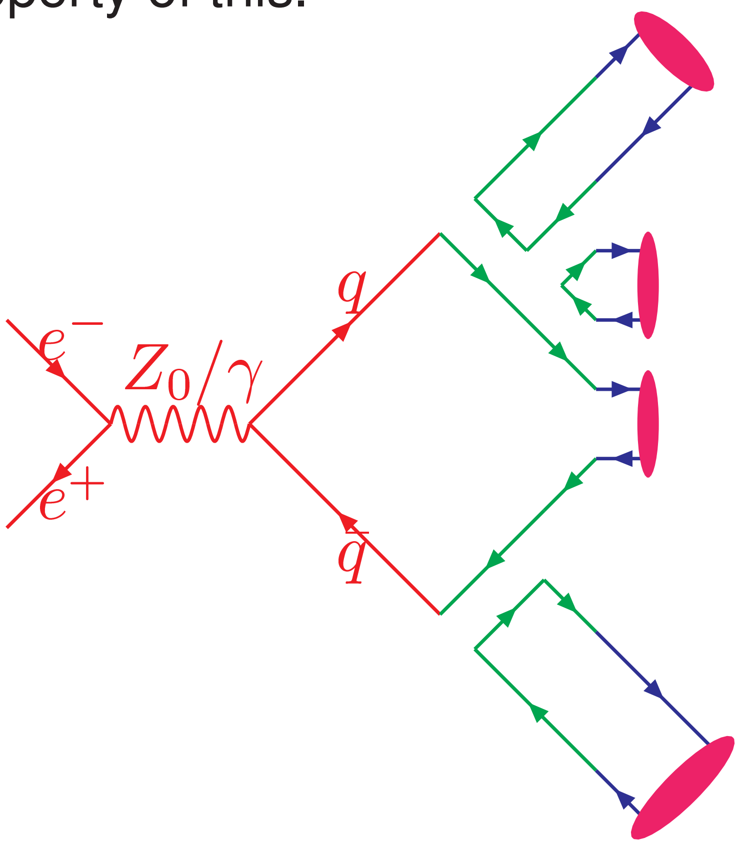
Models in HERWIG

- HERWIG uses the angular ordered parton shower algorithm which resums both soft and collinear singularities.

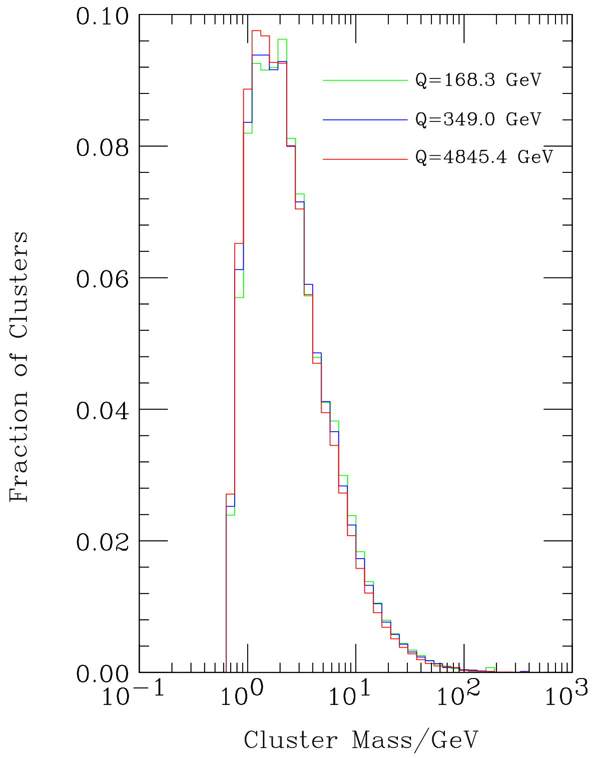
- The hadronization model is based on one property of this.



- First split the gluons into $\mathrm{q\bar{q}}$ pairs.

- Each quark is then uniquely paired with an antiquark in a colour singlet cluster.

Cluster Hadronization Model



- The mass spectrum of pairs of colour singlet clusters after gluon splitting.
- Called colour 'pre-confinement'.
- Assume these clusters are superpositions of resonances.
- Decay according to phase space to hadrons.
- The hadrons decays are then performed using phase space and the measured branching ratios.

Underlying Event/Multiple Scattering

- The basic model for the underlying event in HERWIG is a soft phase-space model based on the UA5 event generator.
- This is basically a parameterisation of the UA5 data modified to use the cluster model.
- There is also a separate program, JIMMY, available which uses a multiple scattering model.
- This is almost unusable as an underlying event model as all the scatterings have the same minimum transverse momentum.
- Mike Seymour has been working on rectifying this problem and this is one of the few remaining changes we hope to make to the FORTRAN program.

Recent Changes

- The most recent changes in HERWIG fall into three main groups.
  - The addition of some new processes.
  - The addition of spin correlations to SM and SUSY processes
  - MC@NLO

- I won't go through the new processes which were added in recent versions, you can either ask or look it up.

- There has also been some work on matrix element matching
  - Higgs+jet (Corcella and Moretti)
  - CKKW (Richardson)

- The first may be added in the near future, the second will probably wait for the C++.

Spin Correlations

- Until recently all generators assumed the production and decay of heavy particles took place independently.

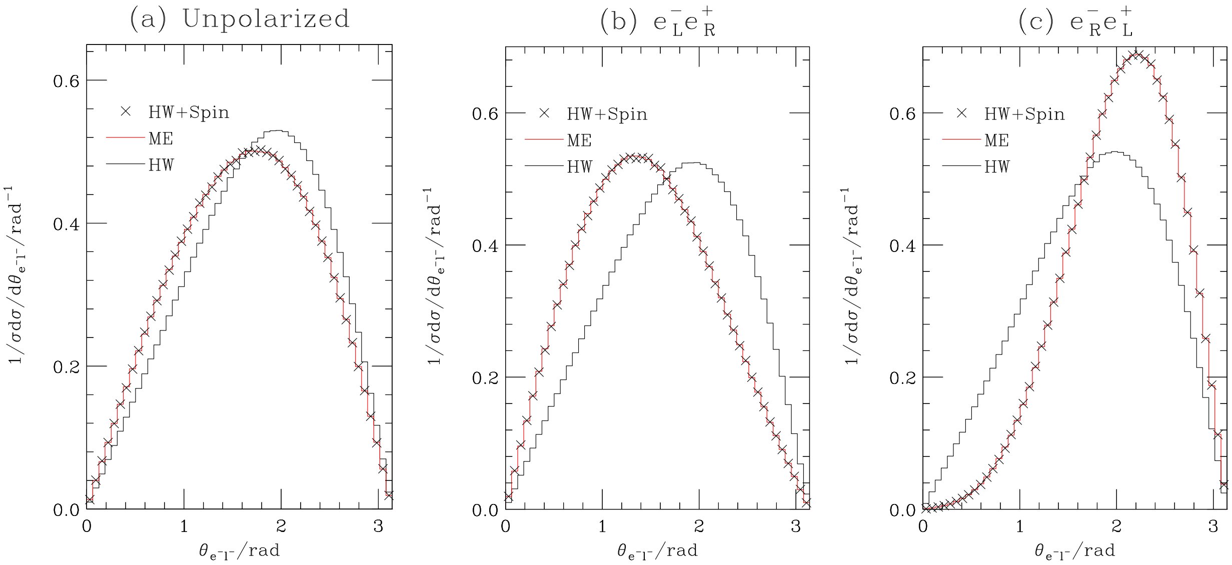
- We have recently included the correct correlations for all top and SUSY production processes.

- This uses a method which performs the production and decay separately and has a complexity which grows linearly with the number of final-state particles.

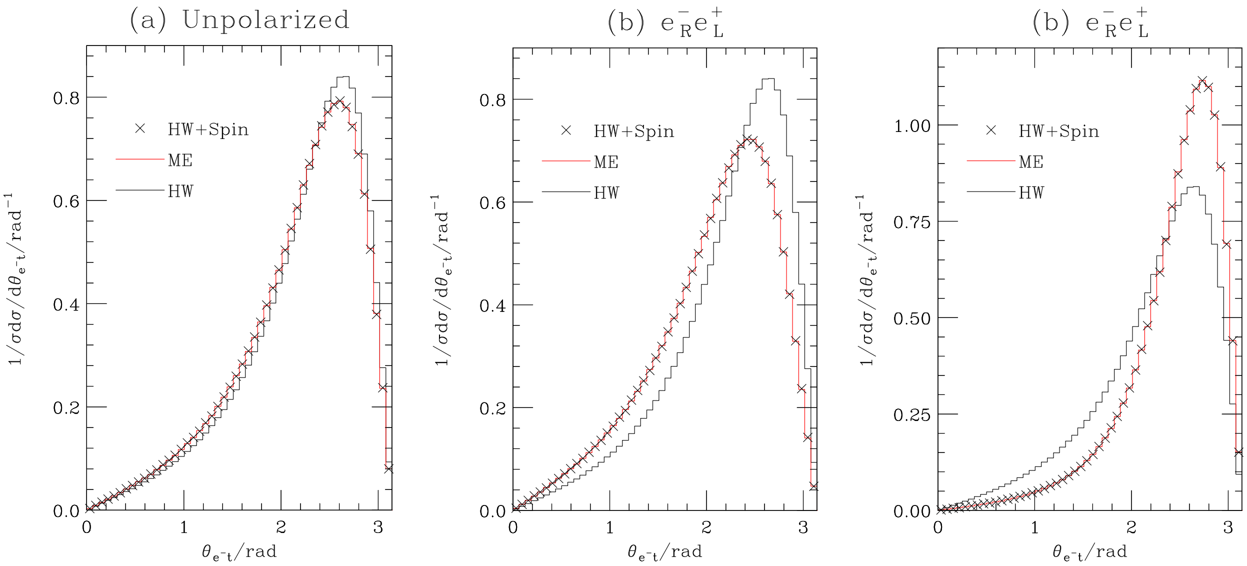
Top pair production in e^+e^- collisions

- Study the semi-leptonic decays of both top quarks and look at the correlations.

- Between the lepton produced in the antitop decay and the beam.

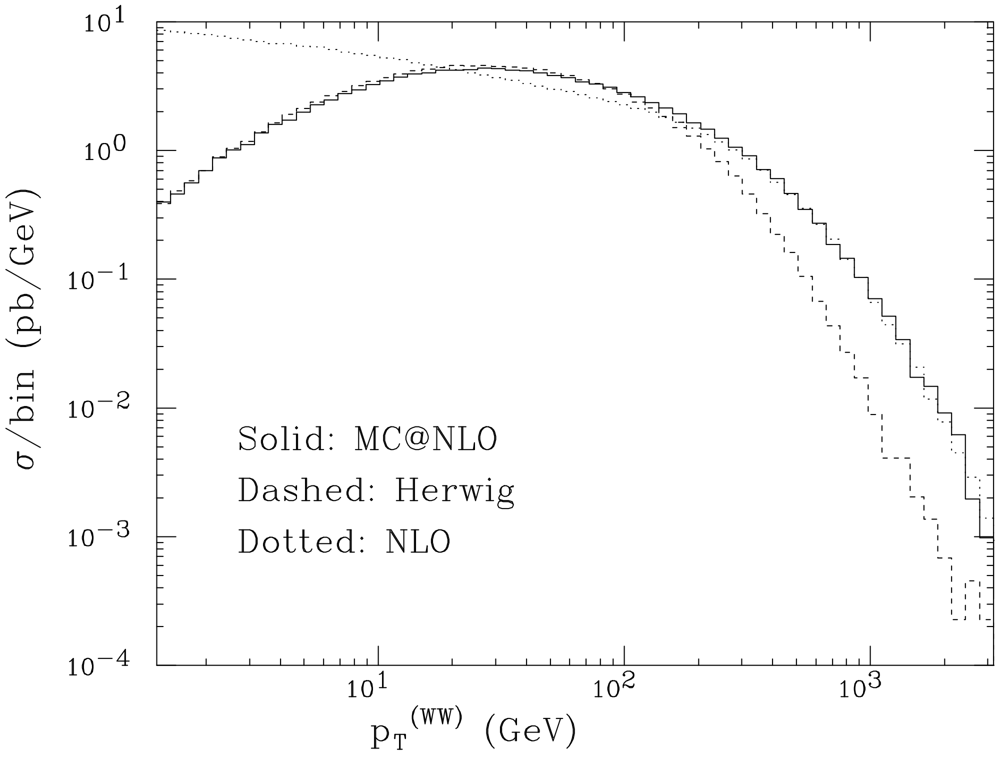


- Between the lepton and the top quark.



MC@NLO

- While not strictly a change to HERWIG itself Bryan Webber and Stefano Frixione have produced the MC@NLO program which
  - Has the correct NLO normalisation for a given process.
  - Gives the NLO behaviour for high p_T emission
  - and the HERWIG result for soft emission



- This is now available for a number of processes.

Conclusions

- HERWIG is an advanced tool for the simulation of hadronic physics.
- The FORTRAN program is a state of the art generator but is reaching the end of a successful life.
- Any major changes will now be incorporated in the C++ program.