Herwig++ for users

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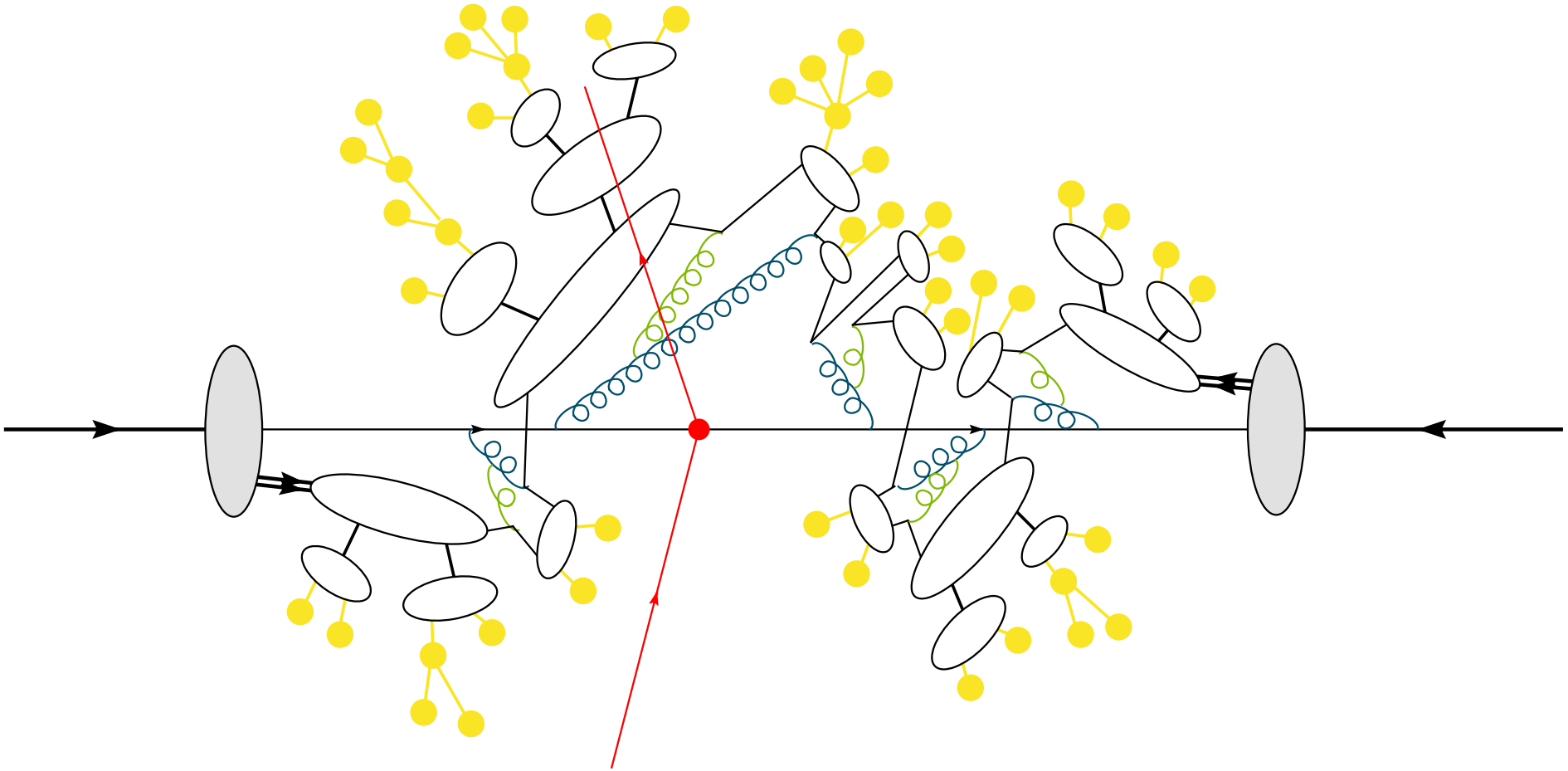
pp Event Generator



Full event generator (mainly) for LHC. Underlying event not shown. Physics covered by Leif.

What's inside Herwig++?

- Many useful hard processes available. Mainly $2 \longrightarrow 2$, SM and BSM (SUSY, extra dimensions). All the rest as well via LH interface.
- Completely new parton shower for IS, FS, t–decay.
- ME corrections in $e^+e^- \longrightarrow q\bar{q}g$, DY, t–decay.
- Full pp simulations possible in Herwig++. Many new features wrt old `HERWIG`.
- Cluster hadronization.
- Much improved hadronic decayers (including sophisticated τ and B decays!).
- Spin correlations. (talk tomorrow!)
- Photon radiation in decays.
- BSM (mostly MSSM) physics included (from v2.1).
- Multiple Parton Interaction (MPI) underlying event simulation (similar to JIMMY).

News, Wiki, downloads. . .

Current version is 2.2.0.

http://projects.hepforge.org/herwig/
mailto: herwig@projects.hepforge.org

Mailing list, user wiki with FAQ, examples, downloads, bug/issue tracker etc.
Also in GENSER distribution.

- Need `ThePEG`, `gsl`.
- Useful `HepMC`.
- Builds with `autotools`.
- `./configure`, `make`, `make install`.
- Successfully built with `gcc`'s from 3.2.x to 4.2.x
- Also on OS X (intel).

Herwig++ Physics and Manual is out on `arXiv:0803.0883`

Getting started with Herwig++

Download and install ThePEG, download Herwig++ and

- `./configure --prefix=HERWIGPATH`
- `make`
- (`make check`)
- `make install`

You'll get Herwig++ installed in HERWIGPATH. Important for you:

- `HERWIGPATH/bin/Herwig++`
- `HERWIGPATH/share/Herwig++/*.in`
- `HERWIGPATH/share/Herwig++/defaults/*.in`

For the example sessions:
`HERWIGPATH=/afs/desy.de/group/alliance/mcg/public/MCGenerators/herwig++/2.2.0/i586_rhel40`

Use of ThePEG

- Herwig++ uses ThePEG (Toolkit for high energy Physics Event Generation).
- Organized as *Repository* of objects that are loaded from `.so` libraries. Compiling required only once.
- All required objects for an `EventGenerator` are
  - setup
  - loaded
  - interfaced
  - supplied with parameters
  - linked to other objects

  from configuration files (`*.in`).

Use of ThePEG

The `EventGenerator` is run eventually. It has an `EventHandler`.

The most important objects of the `EventHandler` are

- Beam/collider information
- `SubProcessHandler`
- `CascadeHandler`
- `HadronizationHandler`
- `DecayHandler`
- `AnalysisHandler`(s)

(Guess what these are for :-)

In addition the *Repository* contains information about Particle data and Decayers.

First steps

- Upon `make install` we create a *Repository* file `HerwigDefaults.rpo` from the main configuration file

  `HERWIGPATH/share/Herwig++/defaults/HerwigDefaults.in`

  which reads in other files with some meaningful name, e.g. `quarks.in`, `Shower.in` etc.
  This is always used when you run Herwig++. You could create a new one in your working directory with

  ```
  $ ./Herwig++ init
  ```

  (By default, the default *Repository* is read from a default location.)
- Copy a collider specific configuration file from `HERWIGPATH/share/Herwig++/defaults`, e.g. `LHC.in` to your working directory.

  ```
  $ ./Herwig++ read LHC.in
  ```

  will read the settings and create a run file `LHC.run` out of it.
- Run some events!

  ```
  $ ./Herwig++ run LHC.run -N 100
  ```

  Find some results about your run in `LHC.log` and `LHC.out`.

Sample output

```
------------------------------------------------------------------------------
Step 1
--- intermediates:
  3         g      21 [31] (5,6)   {+1,-2}
                                  0.000    -0.000   177.989   177.989     0.000
  4         g      21 [50] (7)   {+2,-3}
                                  0.000     0.000  -497.245   497.245     0.000
  5      tbar      -6 [3] (7)   {-2}
                                209.598   -25.943   205.493   -97.159  -278.194
--- final:
  6         t       6 [3] (53)  >8 {+1}
                               -209.598    25.943   -27.504   275.148   174.200
  7      tbar      -6 [4,5] (52)  9> {-3}
                                209.598   -25.943  -291.752   400.086   174.200
  8    Rem:p+      82 [1] (98)  6>>9 {+2,-1}
                                  0.000     0.000  6822.011  6822.011     0.926
  9    Rem:p+      82 [2] (99)  8>>7 {+3,-2}
                                 -0.000     0.000 -6502.755  6502.755     0.904
------------------------------------------------------------------------------
     Sum of momenta:                 0         0         0   1.4e+04   1.4e+04
------------------------------------------------------------------------------
```

Get more familiar

- Look at `HERWIGPATH/share/defaults/HerwigDefaults.in`. It contains a lot of useful comments.
- Taking e.g. `LHC.in` as a template, create your own file `myrun.in`. Only modify defaults within this file!
- Look into the original files for hints towards the names of parameters and switches. Full documentation via class headers or `doxygen`

  `http://projects.hepforge.org/herwig/doxygen/`

Some first modifications

- Choose $t\bar{t}$ Matrixelement:

```
cd /Herwig/MatrixElements
insert SimpleQCD:MatrixElements[0] MEHeavyQuark
```

- Switch off Hadronization/Hadronic Decays/Multiple Interactions by setting the specific StepHandler to NULL

```
cd /Herwig/EventHandlers
set LHCHandler:HadronizationHandler NULL
set LHCHandler:DecayHandler NULL
set /Herwig/Shower/ShowerHandler:MPI No
```

- Switch on/off initial and final state parton showers with Yes/No

```
cd /Herwig/Shower
set SplittingGenerator:ISR Yes
set SplittingGenerator:FSR Yes
```

HepMC output

- Insert the `AnalysisHandler` for writing HepMC output:

```
cd /Herwig/Generators
# erase LHCGenerator:AnalysisHandlers 0 Basics
insert LHCGenerator:AnalysisHandlers 0 /Herwig/Analysis/HepMCFile
```

- Select output format, some useful switches.

```
cd /Herwig/Analysis/
set HepMCFile:Format 1
set HepMCFile:PrintEvent 1000000
set HepMCFile:Filename myfile.hepmc
set HepMCFile:Units GeV_mm
```

Schematic event view

```
cd /Herwig/Generators
insert LHCGenerator:AnalysisHandlers 0 /Herwig/Analysis/Plot
```

This will write a file `myrun-Plot-1.dot` which you can process with

```
$ dot -Tsvg myrun-Plot-1.dot > plot.svg
```

to give you a svg schematic display of the first event (see manpage for different output formats).

Tutorial

- Tue, Wed 14.00–18.00
- Approx. 3-4h: Familiarize yourself with 1–2 generators.
- Goal: create several `hepmc` files with $t\bar{t}$ events. Switch on/off several simulation steps.
- Will be anaylised with `ROOT`. (2-3h).
- We'll hand out a *worksheet* with further information during the tutorial session.