Getting started with SHERPA

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June 29, 2008

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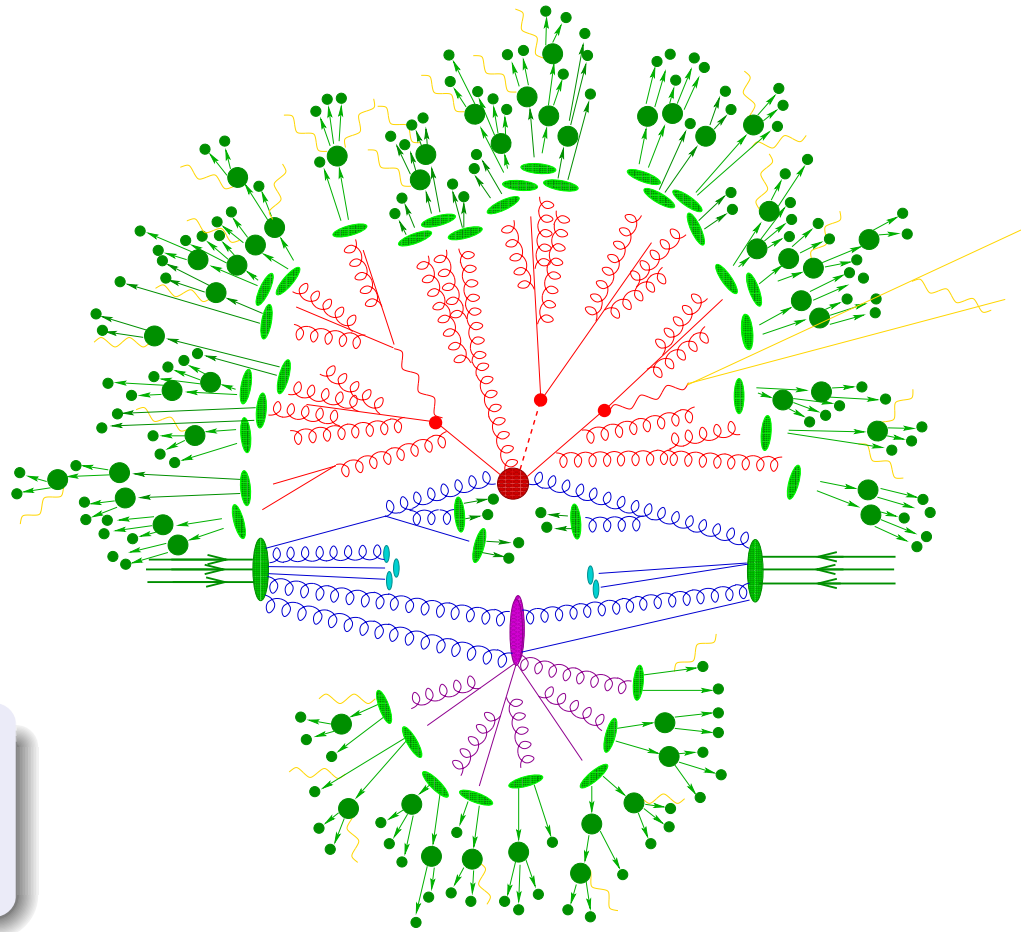
Scope: Complete simulation of LHC events

- Initial state parton shower (QCD)
- Underlying event
- Signal process
- Final state parton shower (QCD)
- Fragmentation
- Hadron decays
- QED radiation



SHERPA is the framework steering these event phases.

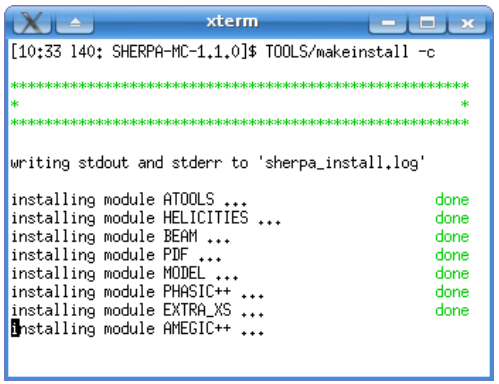
Installation

Prerequisites

- SHERPA tarball from `http://sherpa-mc.de`
- C++ compiler (g++), fortran compiler (g77+libg2c or gfortran)
- Autotools: automake, autoconf, libtool

Installation procedure

- `tar xzf Sherpa-x.y.z.tar.gz`
- `cd SHERPA-MC-x.y.z`
- `TOOLS/makeinstall -c`
- That's it. Should take 10-20 mins.



Linking to optional external packages

- HepMC library version 2.x: For output in HepMC event record
  `TOOLS/makeinstall --copt --enable-hepmc2=/path/to/hepmc/`
- LHAPDF: For using common interface to many PDF sets
  `TOOLS/makeinstall --copt --enable-lhapdf=/path/to/lhapdf/`

Input files

Example run card `Run.dat` for Drell-Yan@LHC

```
(beam){
  BEAM_1 = 2212
  BEAM_ENERGY_1 = 7000.
  BEAM_2 = 2212
  BEAM_ENERGY_2 = 7000.
}(beam)

(processes){
  Process : 93 93 -> 11 -11 93{1}
  Order electroweak : 2
  End process
}(processes)

(selector){
  JetFinder sqr(20/E_CMS) 1.
  Mass 11 -11 66 116
}(selector)
```

- Non-existent sections/parameters can be specified in files, syntax: `PROCESS_FILE=Filename` in fallback locations.
- Typical: use (optimised) default values, especially in parton showering, hadronisation, etc..
- Command line overwrites parameters: `KEYWORD=VALUE` allows for automatic scans over parameters.
- Tag replacing functionality (e.g. `E_CMS` allowed).

Running the generator: **2-step strategy**

First run: Initialisation run

Go to input directory, type `../../../bin/Sherpa OUTPUT=2`:

```
....
Single_Process::Tests for 2_2__d__db__e-__e+
   Prepare gauge test and init helicity amplitudes. This may take some time.
In String_Handler::Complete : this may take some time....
Single_Process::CheckLibraries : Looking for a suitable library. This may take some time.
Library_Loader::LoadLibrary(): Failed to load library 'libProc_P2_2_2_6_14_16_5_0.so'.
Single_Process::WriteLibrary :
   Library for 2_2__d__db__e-__e+ has been written, name is P2_2_2_6_14_16_5_0
....
Amegic::InitializeProcesses :
   Some new libraries were created and have to be compiled and linked.
   Type "./makelibs" in '/home/frank/sherpa/trunk/SHERPA/Run/LHC' and rerun.
```

Compiling the libraries

- Libraries written out in C++, automatic compilation setup by using autotools.
- Simply type `./makelibs`

Running the generator: **2-step strategy**

Second run: Production run

Type `../../../bin/Sherpa EVENTS=10000 OUTPUT=2`:

```
....
All_Processes::CalculateTotalXSec for 2_3__j__j__e-__e+__j
Starting the calculation. Lean back and enjoy ... .
523.701 pb +- ( 16.9984 pb = 3.24582 % ) 5000 ( 46.1 % )
full optimization:  ( 0 s elapsed / 45 s left / 45 s total )
....
508.574 pb +- ( 0.672573 pb = 0.132247 % ) 310000 ( 75.2 % )
2_3__j__j__e-__e+__j : 508.574 pb +/- 0.132247 %, exp. eff: 0.926893 %.
Store result : xs for 2_3__j__j__e-__e+__j : 508.574 pb +/- 0.132247%,
       max : 0.000140913
------------------------------------------------------------
-- SHERPA generates events with the following structure --
------------------------------------------------------------
Perturbative       : Signal_Processes:Amegic
Perturbative       : Hard_Decays:
Perturbative       : Jet_Evolution:Apacic
Perturbative       : Multiple_Interactions:None
Hadronization      : Beam_Remnants
Hadronization      : Hadronization: Ahadic
Hadronization      : Hadron_Decays
------------------------------------------------------------
  Event 600 ( 7 s elapsed / 114 s left / 121 s total )
```

Process integration

Active modules

Event generation

Event record

Internal event structure

- Event ($\approx$ `HepMC::GenEvent`) = list of linked `Blobs` ($\approx$ `HepMC::GenVertex`)
- Four-momentum conservation locally fulfilled
- Particle status codes similar to HepMC

Example `Blob` for signal process

```
Blob [0]( 1, Signal Process    , 2 -> 3 @ (0,0,0,0)
Incoming particles :
[G] 2 u        1 (   4 ->    1) [( 5.3229e+01,-3.7077e-01,-5.2213e-01, 5.3225e+01), p^2=-3.6380e-12, m= 0.0000e+00] (615,  0)
[G] 2 G        1 (   4 ->    1) [( 8.8449e+01, 2.3747e-01,-1.7765e-01,-8.8449e+01), p^2= 0.0000e+00, m= 0.0000e+00] (613,615)
Outgoing particles :
[H] 2 e-       2 (   1 ->    5) [( 5.1618e+01,-1.8670e+01,-4.8114e+01, 9.6923e-01), p^2= 0.0000e+00, m= 0.0000e+00] (  0,  0)
[H] 2 e+       3 (   1 ->    5) [( 5.5660e+01, 3.9427e+01, 2.0197e+01,-3.3698e+01), p^2= 4.5475e-13, m= 0.0000e+00] (  0,  0)
[H] 2 u        4 (   1 ->    5) [( 3.4400e+01,-2.0890e+01, 2.7217e+01,-2.4946e+00), p^2=-6.8212e-13, m= 0.0000e+00] (613,  0)
```

Other output formats

- HepEvt, HepMC, if linked with the HepMC package

New features in SHERPA release 1.1

- 1.1.0 released in April 2008, bugfix release 1.1.1 in May 2008
- Available on GENSER in ATLAS and CMS

New features

- AHADIC++– Cluster fragmentation module
- HADRONS++– Complete hadron and τ decay module
- PHOTONS++– QED radiation in the YFS formalism
- CKKW merging for processes with decay chains
- Expandability through dynamically linked user libraries

Important UI changes

- Particle ID's now PDG-compliant
- New default parameters, **see Changelog** before using old setups!
- One sectioned input file ("run card") instead of separate files