SHERPA: Overview

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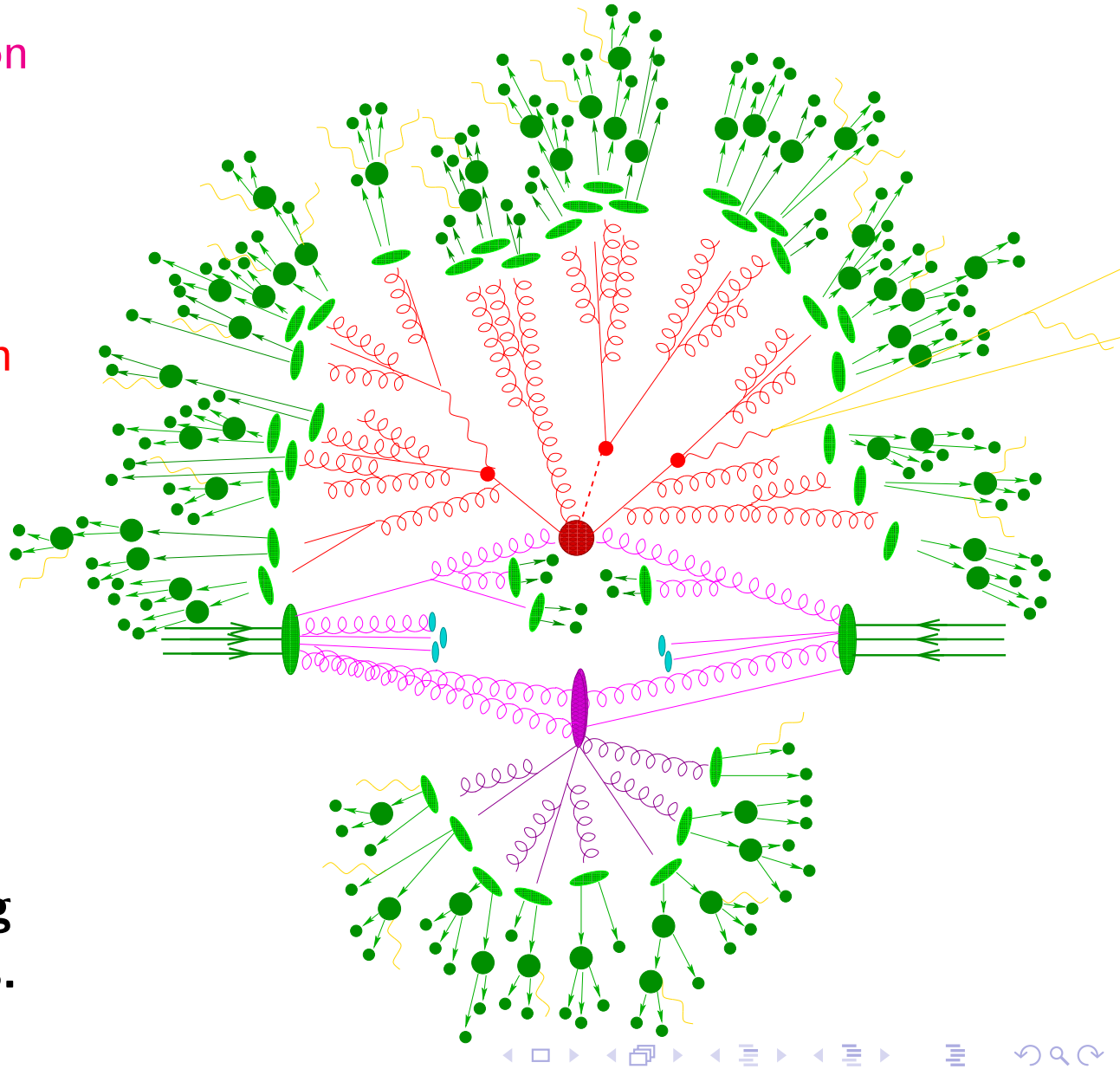
Contents

arXiv:0811.4622, JHEP 0402 (2004) 056

- 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.

Physics Modules

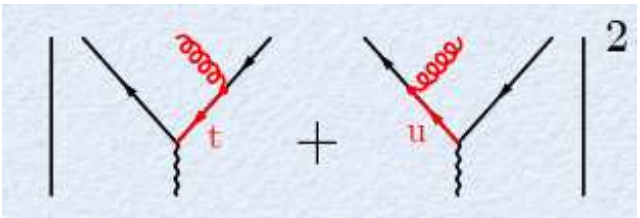
- physics version SHERPA-1.1 released in April '08
- current bugfix version SHERPA-1.1.3

Physics modules

- AMEGIC++: tree level ME generator
- APACIC++: parton shower
- AMISIC++: multiple parton interactions
- AHADIC++: cluster fragmentation
- HADRONS++: hadron and τ decay module
- PHOTONS++: higher order QED corrections

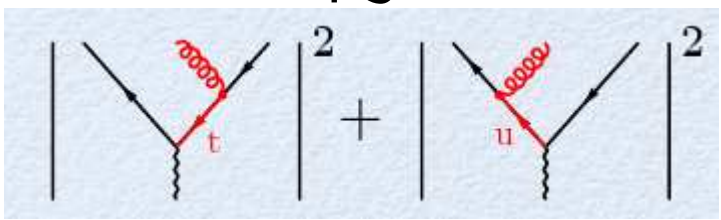
CKKW ME-PS merging

ME



+ Exact fixed order
+ All interference terms
− Calculable only for low FS multiplicities (n $\leq$ 6-8)

PS



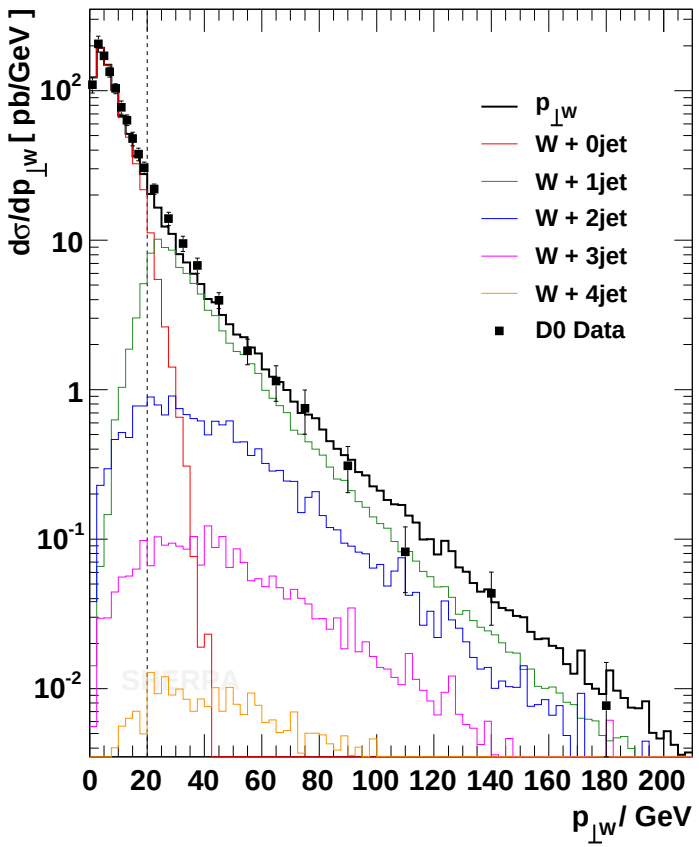
+ Resum all (next-to) leading logs to all orders
− Interference effects only through angular ordering

Combine advantages of both approaches

- Good description of hard emission (ME)
- Correct intrajet evolution (PS)

Strategy

- Separate phase space:
  $\longrightarrow$ ME region $k_\perp > Q_{cut}$
  $\longrightarrow$ PS region $k_\perp < Q_{cut}$
  (for $n_{Jet} \leq N$)
- Select final state multiplicity and kinematics according to σ_i
- Create shower history by backwards clustering (in $k_\perp$) and identify $2 \longrightarrow 2$ core process
- Reweight ME to obtain exclusive sample
- Start shower at hard scale and veto emission above Q_{cut}

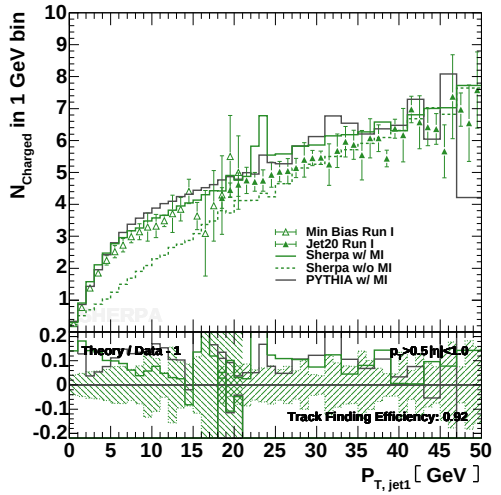


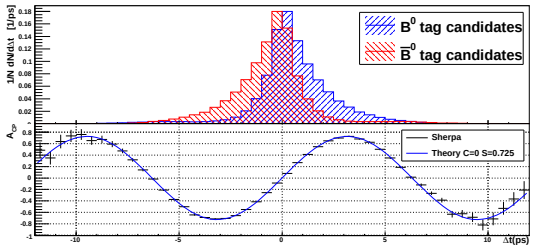
$p_\perp$ of W in W+Jets at DØ

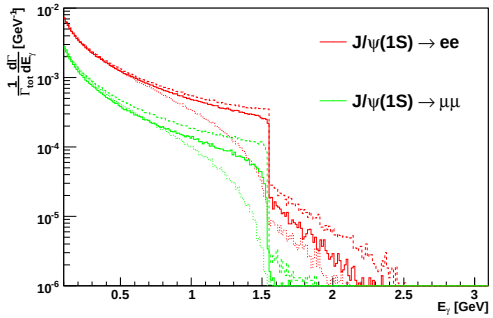
$\longrightarrow$ Free parameter Q_{cut}

Soft Physics

- AMISIC++
  → underlying event on basis of the Lund model
  hep-ph/0601012
  → not tuned with new hadronisation
- AHADIC++
  → modified cluster hadronisation
  in preparation
- HADRONS++
  → extensive hadron and τ decay library
  Krauss, Laubrich, Siegert: in preparation
- PHOTONS++
  → higher order QED corrections to hadron decays
  JHEP 0812 (2008) 018







Installation, Documentation

- homepage
  `http://sherpa-mc.de`
- current version
  `http://www.hepforge.org/archive/sherpa/Sherpa-1.1.3.tar.gz`
- manual
  `http://www.hepforge.org/archive/sherpa/howto-1.1.3.pdf`

Steering

- input card `Run.dat` holds all steering parameters, can be back-uped in default locations, most parameters have defaults
- parameter override on command line possible
- all mass units in GeV

Run.dat

```
(run) {
  EVENTS = 1000
  OUTPUT = 2
  HEPMC2_GENEVENT_OUTPUT = event_file
}(run)
```

→ sets global run parameters

Run.dat – necessary components

```
(beam){
  BEAM_1 = 2212
  BEAM_ENERGY_1 = 980.
  BEAM_2 = -2212
  BEAM_ENERGY_2 = 980.
}(beam)
```

→ beam particle specification

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

→ process declaration
use of particle containers, e.g.
93 - jets (massless q,$\bar{q}$,g)

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

→ matrix element cuts

Run.dat – further settings

```
(me){
  SCALE_SCHEME    = CKKW
  KFACTOR_SCHEME = 1
  SUDAKOV_WEIGHT = 1
}(me)
```

→ set ME scales, CKKW parameters

```
(shower){
  FSR_SHOWER = 1
  ISR_SHOWER = 1
}(shower)
```

→ set shower parameters

```
(model){
  MODEL = SM
}(model)
```

→ set model for ME calculation (SM, MSSM, THDM, ADD, ...)

```
(fragmentation){
  FRAGMENTATION = Ahadic
  DECAYMODEL    = Hadrons
  YFS_MODE      = 2
}(fragmentation)
```

→ hadronisation model, decay model, soft QED settings

Run.dat – UE settings

```
(mi){
  MI_HANDLER     = None                  ! Amisic / None
  !
  CREATE_GRID 93 93 -> 93 93             ! processes to generate
  PS_ERROR            = 1.0e-2           ! error for integration
  MI_SCALE_SCHEME     = G_MEAN_PT2       ! Scale scheme
  MI_K_FACTOR_SCHEME  = 1                ! K-factor scheme
  REGULATE_XS         = 0                ! regulate cross section
  XS_REGULATOR        = QCD_Trivial      ! regulation scheme
  XS_REGULATION       = 2.225            ! regulation parameter
  SCALE_MIN           = 2.225            ! minimum scale
  JET_VETO            = 1                ! apply jet veto
  RESCALE_EXPONENT    = 0.25             ! rescaling exponent
  REFERENCE_SCALE     = 1800.0           ! reference energy scale
  PROFILE_FUNCTION    = Double_Gaussian  ! hadron profile function
  PROFILE_PARAMETERS  = 1.0 0.5 0.5      ! size (must be 1), coresize,
                                         ! matter fraction
}(mi)
```

Running the generator: **3-step strategy**

First run: Generating the ME libraries

```
$ 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_1
  ....
  Amegic::InitializeProcesses :
     Some new libraries were created and have to be compiled and linked.
     Type "./makelibs" in '/home/marek/work/YETI/z+jets/merging/max1jet' and rerun.
```

Compiling the libraries

- Written out in C++, using autotools for compilation setup
- Compile using `./makelibs`

Running the generator: **3-step strategy**

Second run: Integration, event generation

```
$ Sherpa EVENTS=1000 OUTPUT=2
....
All_Processes::CalculateTotalXSec for 2_3__j__j__e-__e+__j
Process_Group::CalculateTotalXSec(./Results)
Starting the calculation. Lean back and enjoy ... .
29.4538 pb +- ( 1.06829 pb = 3.627 % ) 5000 ( 45.5 % )
....
29.8696 pb +- ( 0.0743656 pb = 0.248967 % ) 130000 ( 69.7 % )
2_3__j__j__e-__e+__j : 29.8696 pb +/- 0.248967 %, exp. eff: 2.53925 %.
Store result : xs for 2_3__j__j__e-__e+__j : 29.8696 pb +/- 0.248967%,
       max : 3.021e-06
------------------------------------------------------------
-- 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 1000 ( 20 s elapsed / 0 s left / 20 s total )
In Event_Handler::Finish : Summarizing the run may take some time.
....
Time: 32.89 s (clocks=3289) on Sat Jan 10 14:32:43 2009
 (User: 27.49 s ,System: 0.39 s ,Children User: 0 s ,Children System: 0)
```

Process integration

Active modules

Event generation

Conclusion

- Complete hadron level event generator for ee, $e\gamma$, $\gamma\gamma$, ep, pp collisions
- Automated ME-PS merging with NLL accuracy

Immediate future – SHERPA-1.2

- New physics modules:
  COMIX – new ME-generator for large FS multiplicities
  CSSHOWER++ – new PS-generator based on Catani-Seymour dipole splitting functions
- Merging between all combinations of shower and matrix element generators
- Automated generation of CS subtraction terms

http://sherpa-mc.de

- Downloads, announcement mailing list, documentation