Sherpa Status Report

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CMS Monte Carlo Use and Tuning Strategies Meeting

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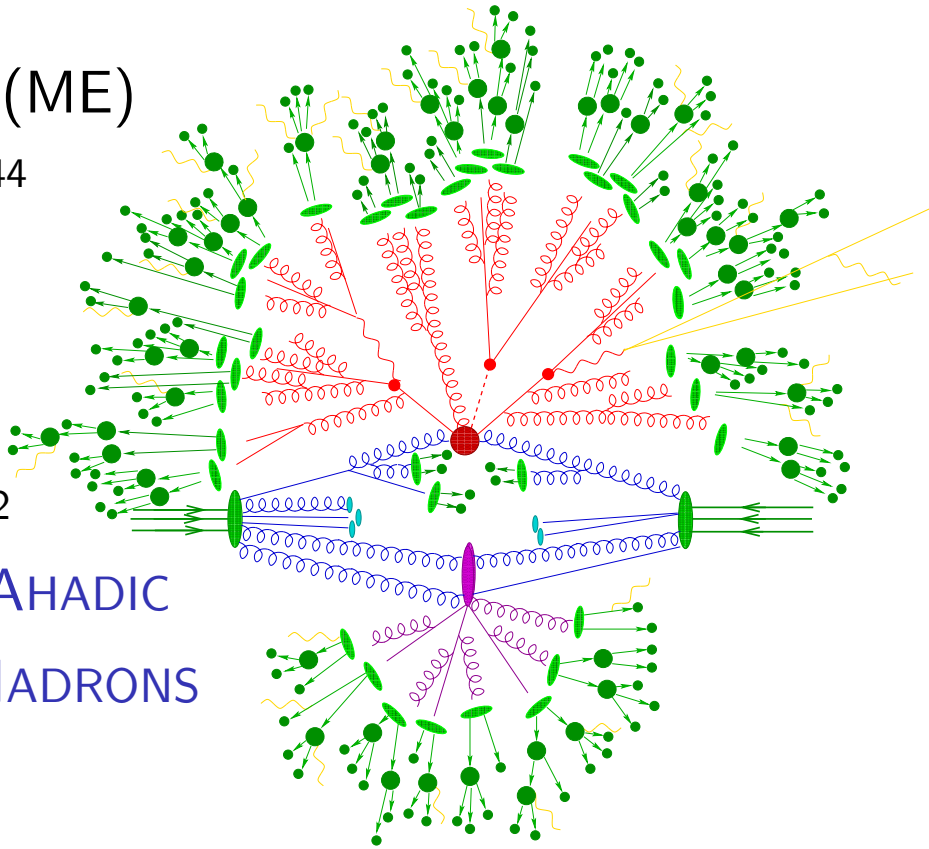
[1] For Sherpa: T. Gleisberg, S.H., F. Krauss, M. Schönherr, S. Schumann, F. Siegert, J.-C. Winter

Sherpa's event generation framework

What's currently in the box ?

- A multi-purpose Matrix Element (ME) generator AMEGIC++ JHEP02(2002)044
- A Parton Shower (PS) generator APACIC++ CPC174(2006)876
- A multiple interaction simulation à la Pythia AMISIC++ hep-ph/0601012
- A cluster fragmentation module AHADIC
- A hadron and τ decay package HADRONS
- A photon radiation generator à la YFS PHOTONS JHEP12(2008)018



Sherpa's traditional strength is the perturbative part of the event

NLO real ME's are consistently combined with PS using CKKW JHEP11(2001)063

AMEGIC++

The generator-generator approach

- Input is a set of Feynman rules and the desired process
- AMEGIC++ constructs the ME and the phase-space integrator
- Corresponding code is compiled by the user
- AMEGIC++ finds the libraries, integrates and generates events

What can AMEGIC++ do for me ?

- Compute cross sections in processes with many external legs
- Generate exclusive decay chains, like
  $pp \to t\bar{t} \to W^+W^-b\bar{b} \to e^+\nu_e\mu^-\bar{\nu}_\mu b\bar{b}$
- Use SM, MSSM, ADD, AGC's and other models
- Incorporate new interactions
  - Implement the model yourself into an external library or
  - Use an interface to the `FeynRules` package arXiv:0806.4194 [hep-ph]

Example results in SM processes arXiv:0811.4622 [hep-ph]

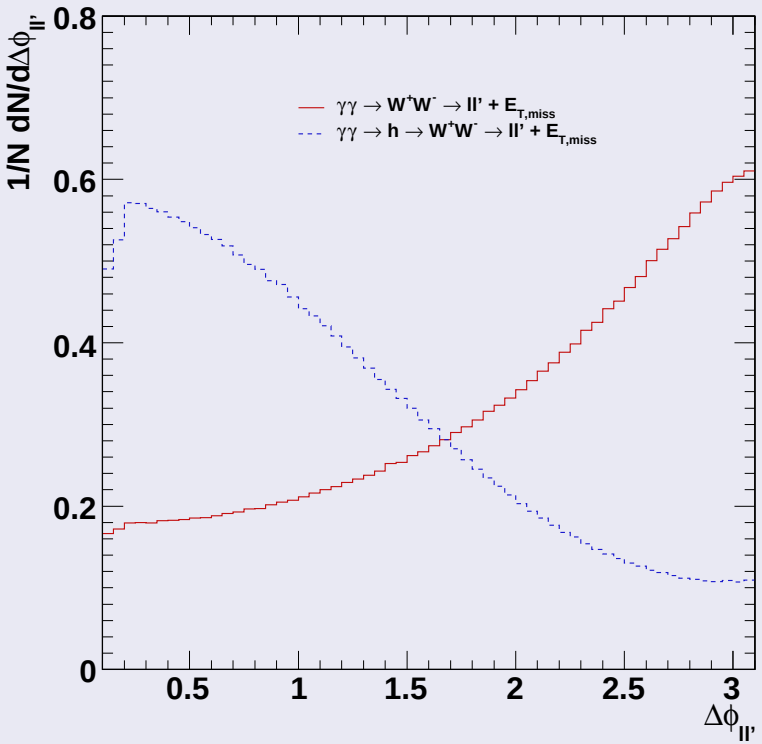
σ [pb]	Number of jets				
$e^+\nu_e$ + QCD jets	0	1	2	3	4
AMEGIC++	5432(5)	1279(2)	466(2)	185.2(5)	77.3(4)
Comix	5434(5)	1274(2)	465(1)	183.0(6)	77.5(3)

σ [pb]	Number of jets				
e^-e^+ + QCD jets	0	1	2	3	4
AMEGIC++	723.0(8)	188.2(3)	69.6(2)	27.21(6)	11.1(1)
Comix	723.5(4)	187.9(3)	69.7(2)	27.14(7)	11.09(4)

σ [μb]	Number of jets			
jets	2	3	4	5
AMEGIC++	331.0(4)	22.78(6)	4.98(1)	1.238(4)
Comix	331.0(4)	22.72(6)	4.95(2)	1.232(4)

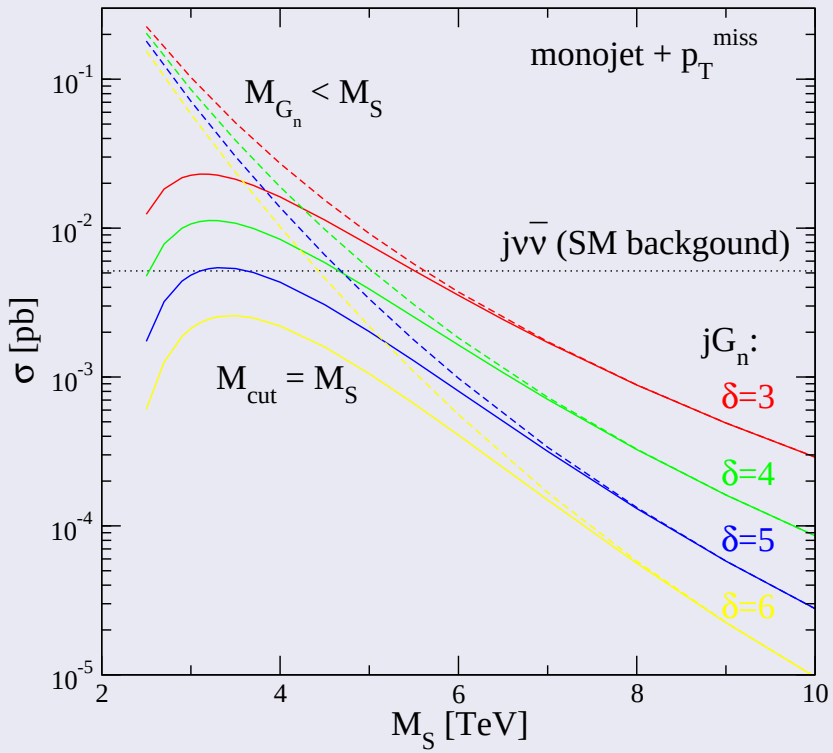
Parameter setup: http://mlm.home.cern.ch/mlm/mcwshop03/mcwshop.html

Example results decays



Lepton azimuthal separation in $\gamma\gamma \to W^+W^- \to ll' + E_T^{\text{miss}}$ with SM Higgs of 160 GeV vs. background

Example results ADD model



Total cross section for jet-graviton production depending on the ADD scale M_S at LHC for $p_T^{\text{miss}} > 1$ TeV

Combining ME & PS

Why should I combine ME and PS ... ?

Because accelerated QCD charges radiate !

Well-defined schemes to account for the bulk of radiation effects in certain regions of phase space exist (DGLAP, BFKL, ...)
Shower generators implement these schemes to simulate QCD events

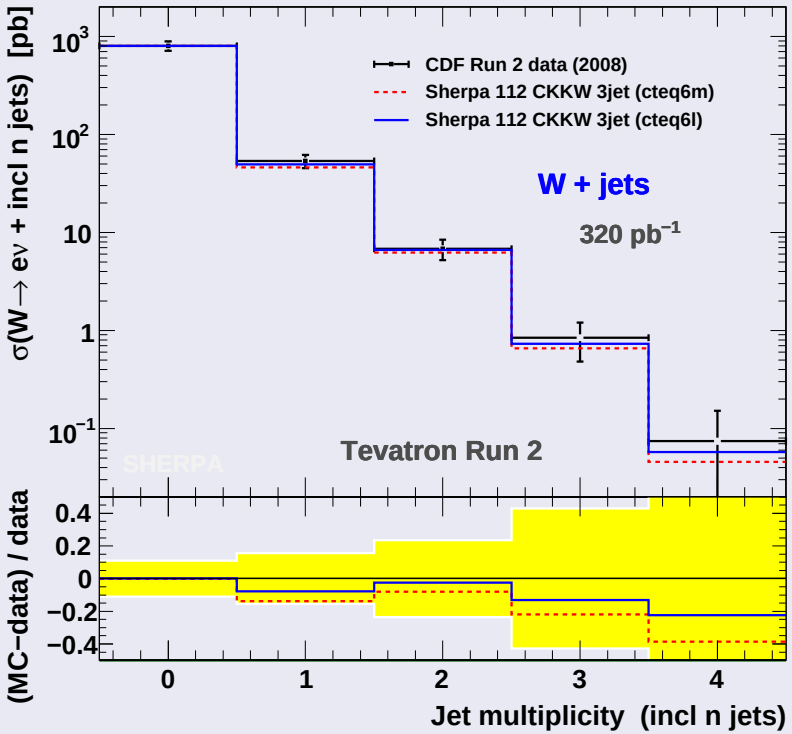
But this is not the end of the story !

All resummation calculations are, in the end, approximate
If we are interested in a particular QCD final state, however,

We should correct this approximation with a matrix element without spoiling the inclusive picture of the event

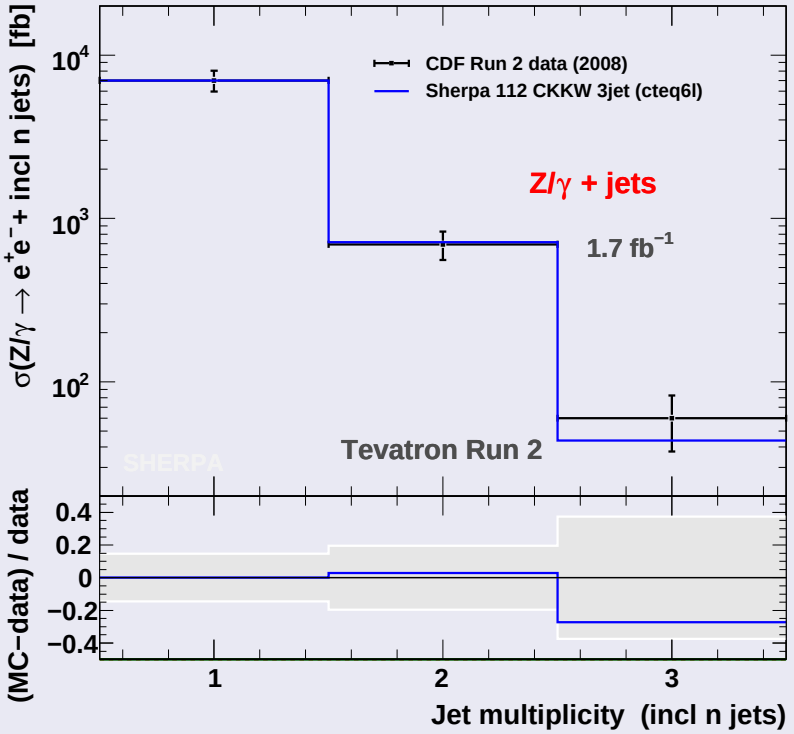
ME & PS: AMEGIC++ ⊕ APACIC++

Example results for W+multijets



Inclusive n jet cross sections compared to CDF Tevatron Run II data for W+jets production PRD77(2008)011108

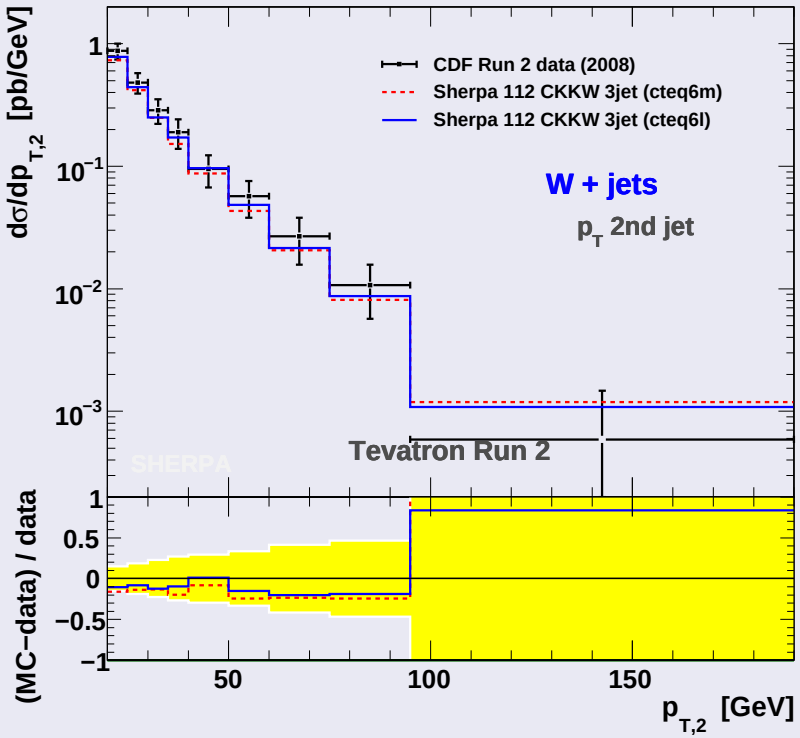
Example results for Z+multijets



Inclusive n jet cross sections compared to CDF Tevatron Run II data for Z/γ^*+jets production PRL100(2008)102001

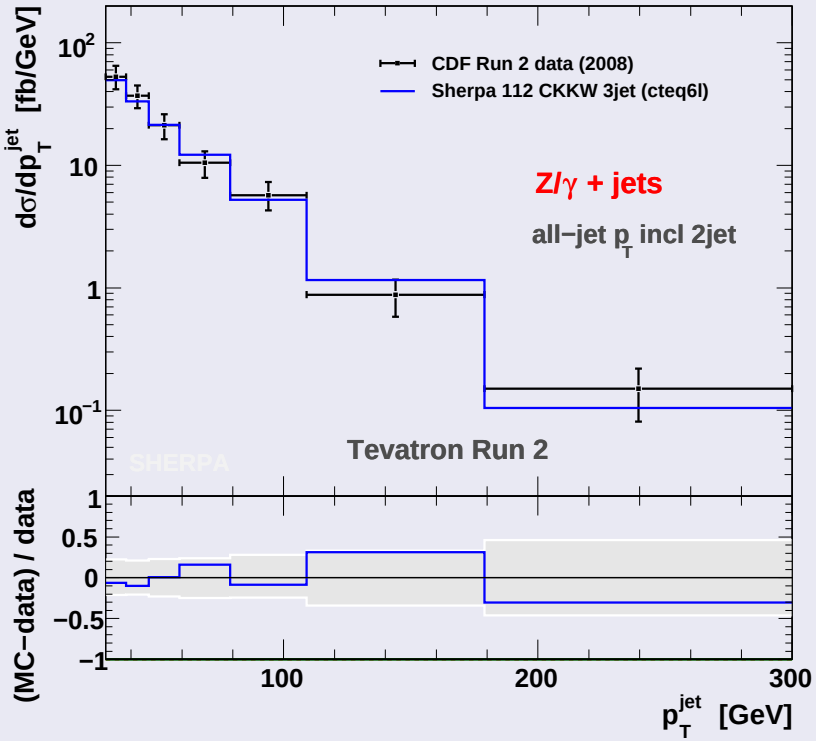
ME & PS: AMEGIC++ ⊕ APACIC++

Example results for W+multijets



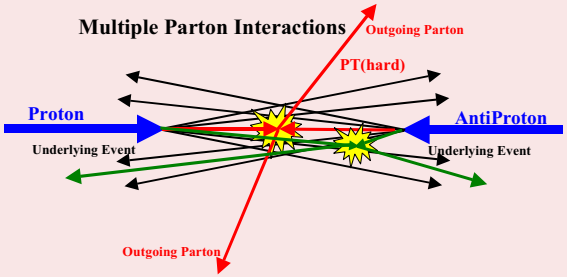
Jet p_T of 2^{nd} jet compared to CDF Tevatron Run II data for W+jets production PRD77(2008)011108

Example results for Z+multijets



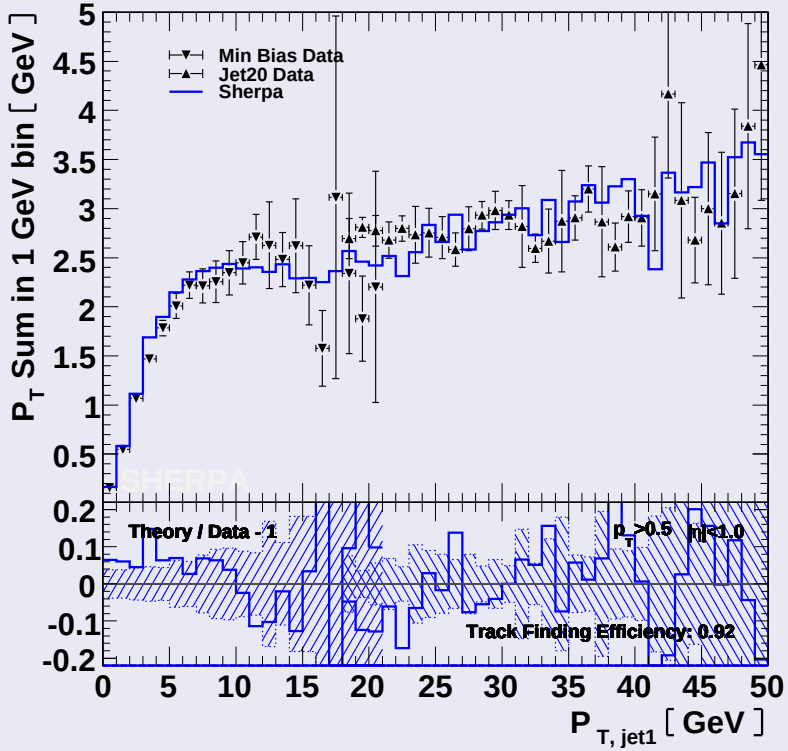
Jet p_T of all incl. 2^{nd} jet compared to CDF Tevatron Run II data for Z/γ^*+jets production PRL100(2008)102001

Sherpa's MPI simulation



- Basic model according to Sjöstrand and van Zijl PRD36(1987)2019
- Added parton showering to any additional interaction
- Merged with CKKW to respect (eventual) hard jets from primary interaction

Example results

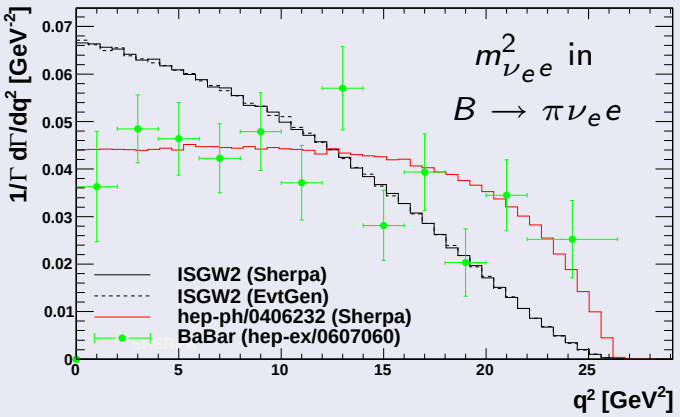


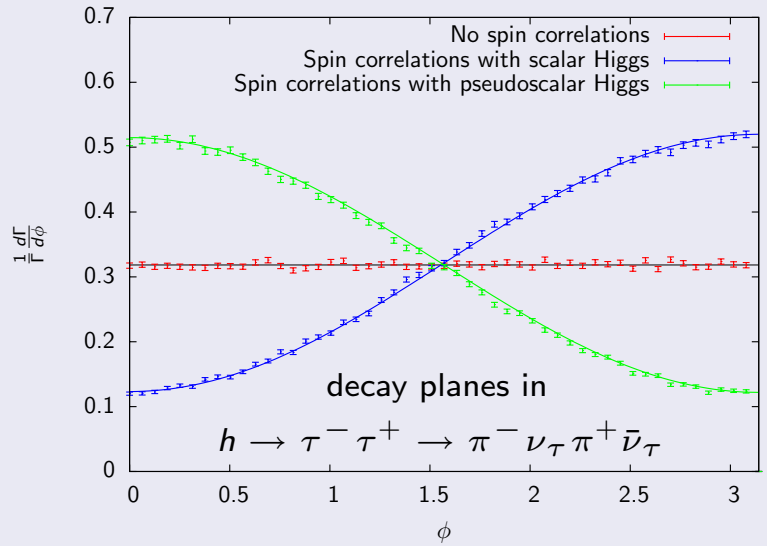
Average scalar p_T sum versus p_T of leading charged particle jet vs. CDF Tevatron Run I data PRD65(2002)092002

The HADRONS module

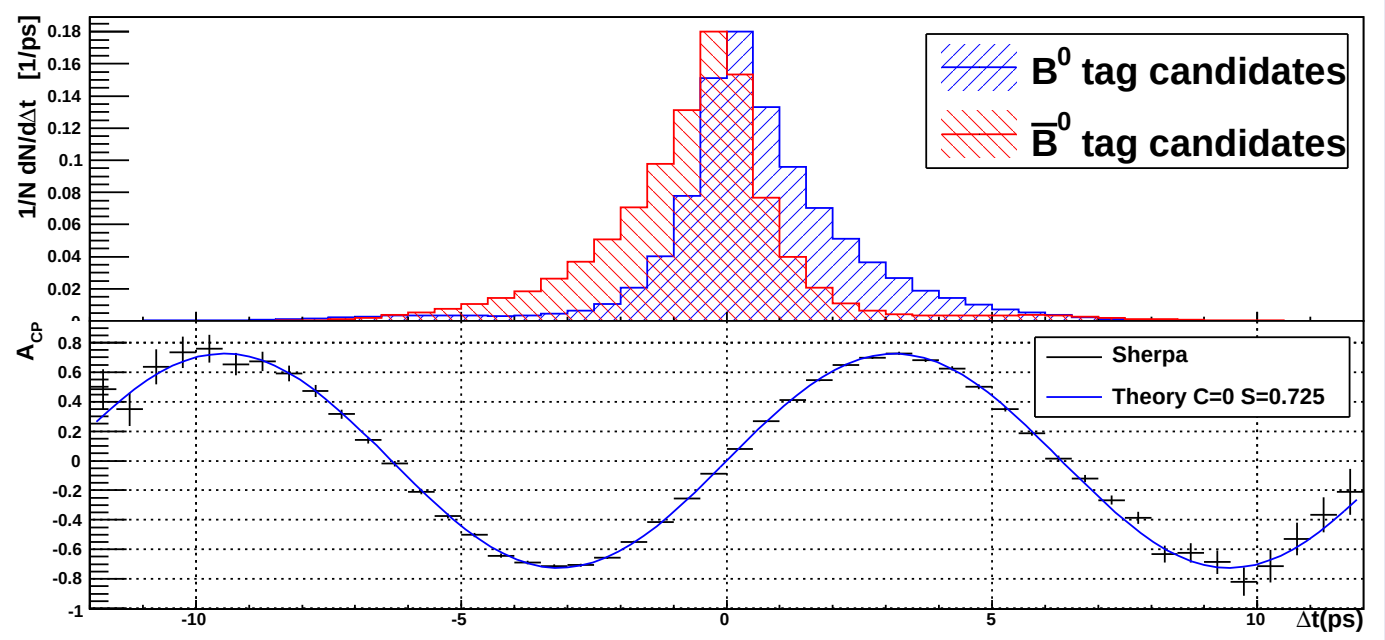
- Flexible implementation of a general decay package
- Includes a τ-decay library
- Covers $\approx$200 hadron decay tables with about 2500 decay channels
- Many matrix elements and form factors implemented already, easy to extend
- Accounts for spin correlations
- Implements general mixing algorithm to simulate meson oscillations and CP-violation

Example results arXiv:0811.4622 [hep-ph]





Example results for B-mixing arXiv:0811.4622 [hep-ph]



CP violation in the interference between $B^0 \to J/\Psi K_S$ and $\bar{B}^0 \to J/\Psi K_S$ with $\Delta\Gamma = 0$, $S = 0.725$ and $C = 0$

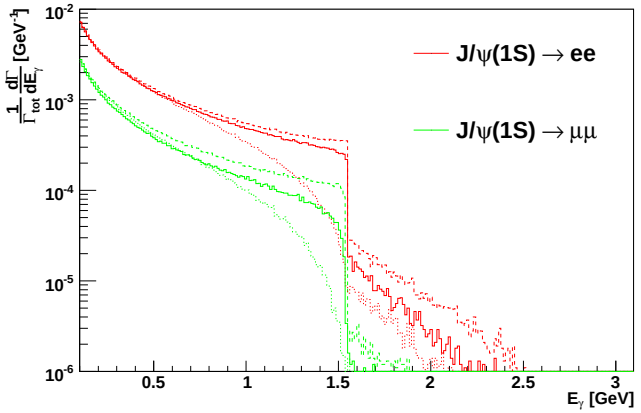
Sherpa's YFS generator

- Used in arbitrary decays
- No limit on final state complexity
- Hard emission effects up to $\mathcal{O}(\alpha)$ via approximate ME
- Important cases with $\mathcal{O}(\alpha)$ real and/or virtual exact ME

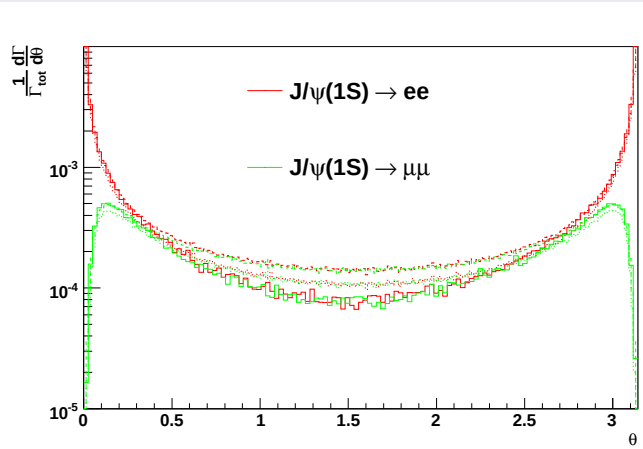
matrix element	real $\mathcal{O}(\alpha_{\mathrm{QED}})$	virtual $\mathcal{O}(\alpha_{\mathrm{QED}})$
$V^0 \to F^+F^-$	$\surd$	$\surd$
$V^0 \to S^+S^-$	$\surd$	$\surd$
$S^0 \to F^+F^-$	$\surd$	$\surd$
$S^0 \to S^+S^-$	$\surd$	$\surd$
$W^\pm \to \ell^\pm\nu_\ell$	$\surd$	$\surd$
$\tau^\pm \to \ell^\pm\nu_\ell\nu_\tau$	$\surd$	-
$S^0 \to S^\mp\ell^\pm\nu_\ell$	under construction	-
$S^0 \to V^\mp\ell^\pm\nu_\ell$	under construction	-

Generic and specific infrared subtracted squared real-emission and virtual-correction matrix elements (V - vector, F - spin-1/2 fermion, S - scalar).

Example results arXiv:0811.4622 [hep-ph]



Total photon energy in J/ψ rest frame



Angular radiation pattern in ℓ^+-ℓ^- frame

What's next ?

New modules and features

- A shower based on Catani-Seymour subtraction JHEP03(2008)038
- A dipole shower JHEP07(2008)040
- The matrix element generator Comix JHEP12(2008)039
- Automated Catani-Seymour subtraction for ME's EPJ C53(2008)501

Further developments

- Improved CKKW prescription
- NLO matrix elements
- POWHEG and CKKW@NLO

Updates on Sherpa are (mostly) found on

http://www.sherpa-mc.de

E-Mail us on

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