SHERPA an event generator for the LHC

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Scope:

- Full simulation of high energetic particle reactions at existing and future collider experiments, incl. e^+e^-, $\gamma\gamma$, $e\gamma$, ep, $p\bar{p}$ and pp collisions

Method:

- Account for multi-jet production through tree level matrix elements
- Combine them with the parton showers and hadronization according to the CKKW prescription

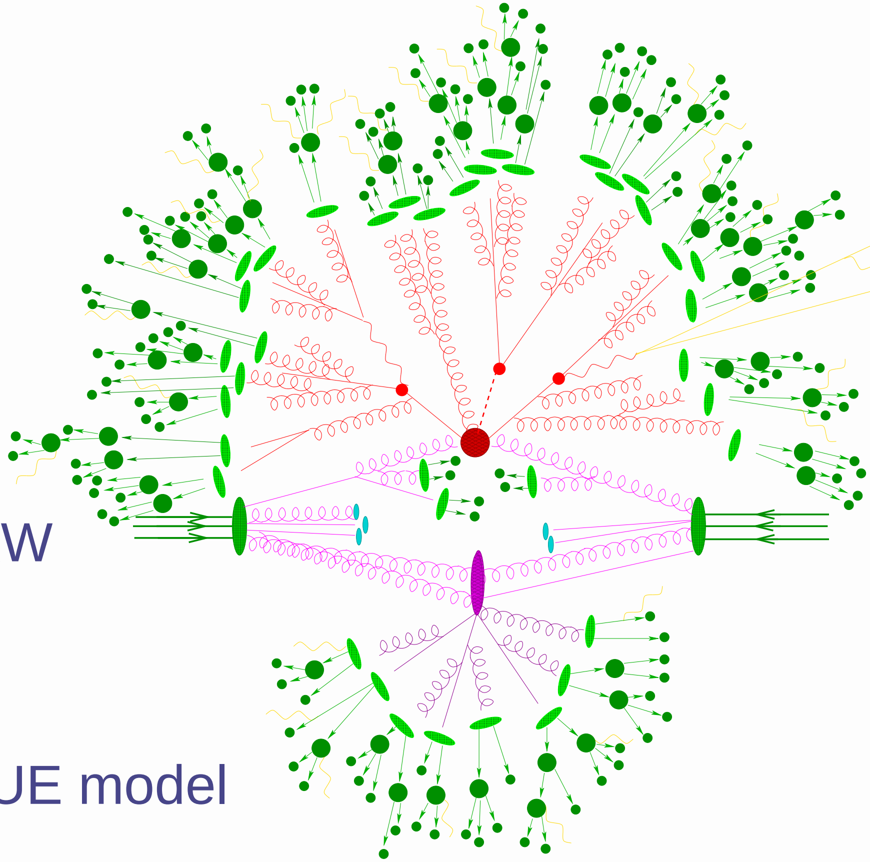
[a] For the SHERPA collaboration: T. Gleisberg, S. Höche, F. Krauss, A. Schälicke, S. S., J. Winter

SHERPA: An event generator for the LHC

T. Gleisberg, S. Höche, F. Krauss, A. Schälicke, S. S. and J. Winter, JHEP 0402:056,2004

In its current version SHERPA includes:

- the ME generator AMEGIC++
  (providing the ME's for hard processes and
  decays in the SM, MSSM and the ADD model)
- the parton shower module APACIC++
  (containing a virtuality ordered initial
  and final state parton shower)
- combination of ME's and PS's á la CKKW
- an interface to the Pythia string fragmentation and hadron decays
- next release will contain a simple hard UE model
  (see talk by S. Höche)



➔ **Sherpa is the framework responsible for the initialization of the different phases and for steering the event generation**

The Matrix Elements: AMEGIC++

Validation against other codes: results of MC4LHC workshop

X-sects (pb)	Number of jets						
$e^-\bar{\nu}_e + n$ QCD jets	0	1	2	3	4	5	6
Alpgen	3904(6)	1013(2)	364(2)	136(1)	53.6(6)	21.6(2)	8.7(1)
CompHEP	3947.4(3)	1022.4(5)	364.4(4)				
MadEvent	3902(5)	1012(2)	361(1)	135.5(3)	53.6(2)		
Amegic++/Sherpa	3908(3)	1011(2)	362(1)	137.5(5)	54(1)		

X-sects (pb)	Number of jets				
$e^-\bar{\nu}_e + b\bar{b}$	0	1	2	3	4
Alpgen	9.34(4)	9.85(6)	6.82(6)	4.18(7)	2.39(5)
CompHEP	9.415(5)	9.91(2)			
MadEvent	9.32(3)	9.74(1)	6.80(2)		
Amegic++/Sherpa	9.37(1)	9.86(2)	6.87(5)		

AMEGIC++ proved to work for up to six particle final states: State of the art.

Combining ME and PS – CKKW

Combine LO Matrix Elements and Parton Showers according to CKKW

S. Catani,F. Krauss, R. Kuhn, B. Webber, JHEP 0111:063,2001

F. Krauss, JHEP 0208:015,2002

Aim:

- Good description of soft and hard region
- Avoid double counting of equivalent phase space configurations
- Universality of fragmentation (energy independent)

Solution:

- Divide multi-jet phase space into two regimes (Durham measure $Q_{\rm cut}$)
  - Jet production by ME (if available)
  - Jet evolution down to fragmentation scale by the PS
- Reweight ME's to get exclusive samples at resolution scale $Q_{\rm cut}$

  $\Rightarrow$ This allows to add samples of different jet multiplicities
- Veto on PS configurations that have already been taken into account by a higher order ME

Combining ME and PS – CKKW

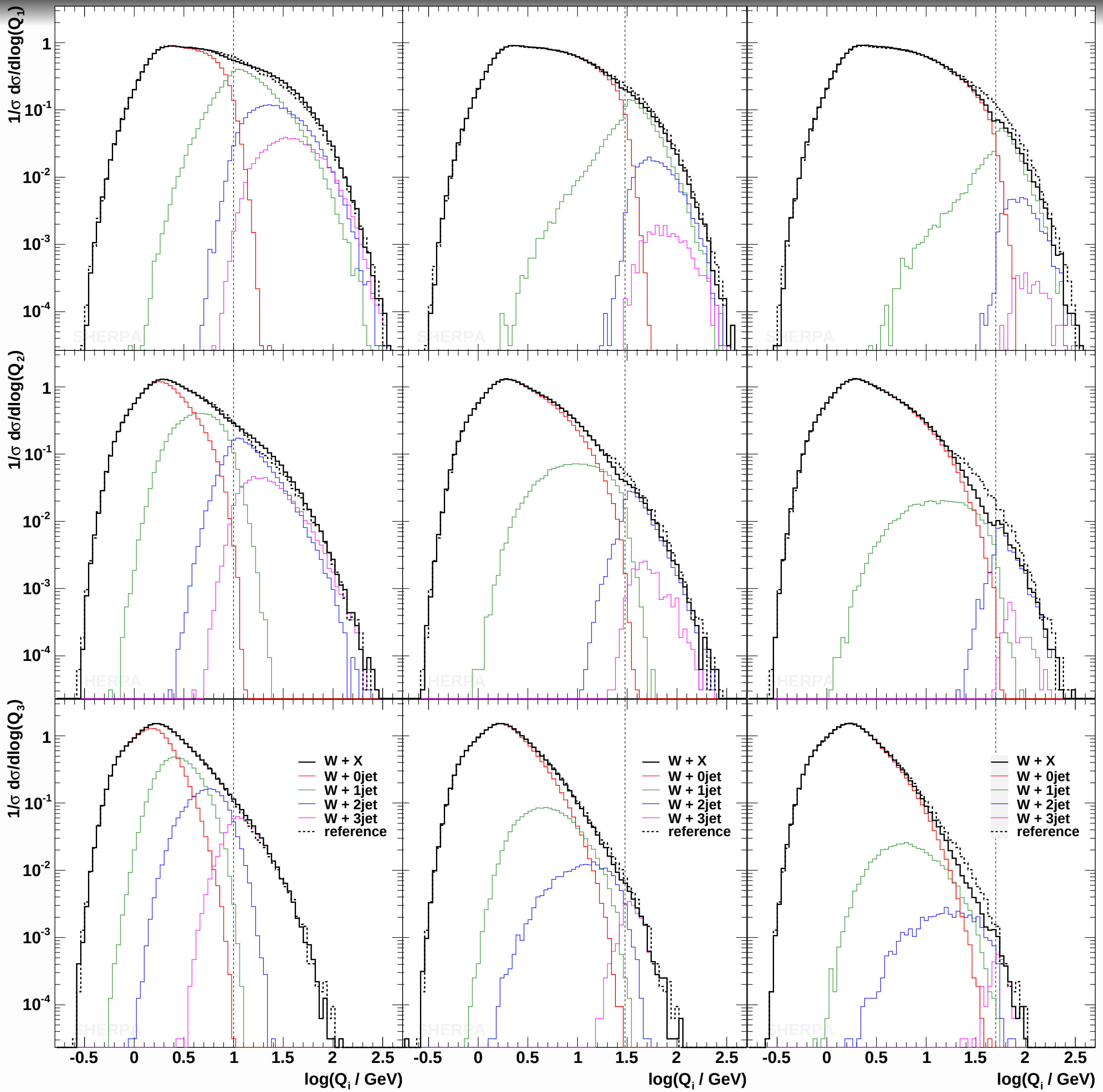
The CKKW method has been implemented in SHERPA in full generality

- Proofed to be successful in e^+e^- collisions
  (delivers the right description of various four jet correlations)
- For hadron collisions the study of systematics is still ongoing
- Study the dependence on resolution $Q_{\rm cut}$ in various distributions
- Find the optimal treatment for the highest multiplicity ME
- Investigate the impact of different scale choices

➔ **First results for W/Z+jets production presented in hep-ph/0409106**
See talk on Tuesday!

➔ **Detailed comparison with MLM approach ongoing**

Differential jet rates in $p\bar{p} \to e^- \bar{\nu}_e + X$ @ $\sqrt{s} = 1.96\mathrm{TeV}$



$1 \to 0$

$2 \to 1$

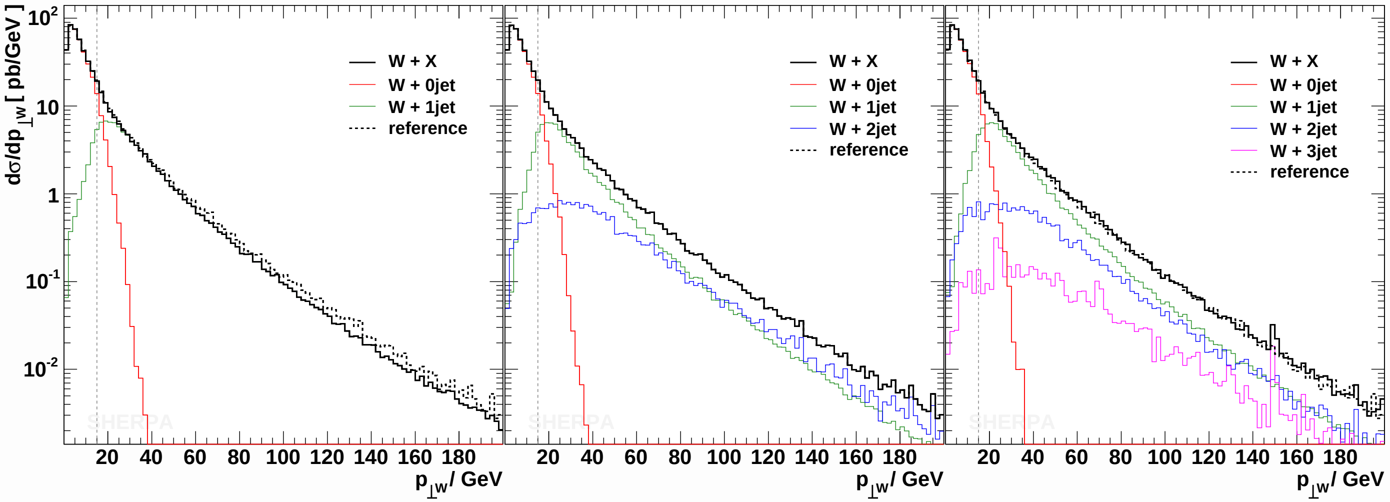
$3 \to 2$

Q_{cut}=10 GeV Q_{cut}=20 GeV Q_{cut}=50 GeV

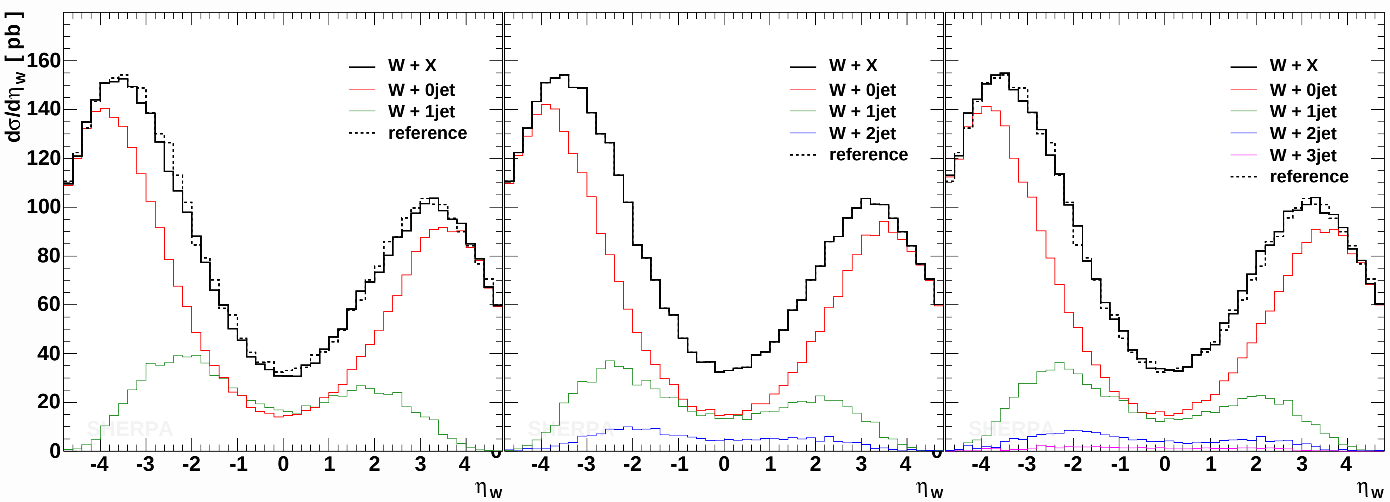
dashed Q_{cut}=30 GeV

$p_{\perp W^-}$ and η_{W^-} in $p\bar{p} \to e^- \, \bar{\nu}_e + X$ @ $\sqrt{s} = 1.96\,\mathrm{TeV}$

Variation of the maximal jet multiplicity provided by ME ($Q_{\mathrm{cut}} = 15$ GeV)



$p_{\perp W^-}$ distribution



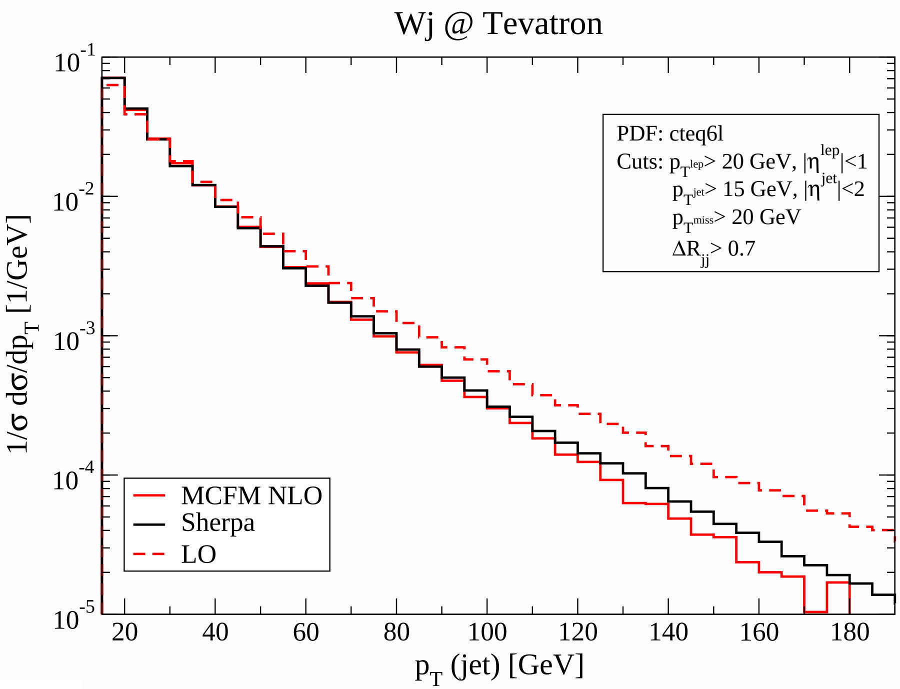
η_{W^-} distribution

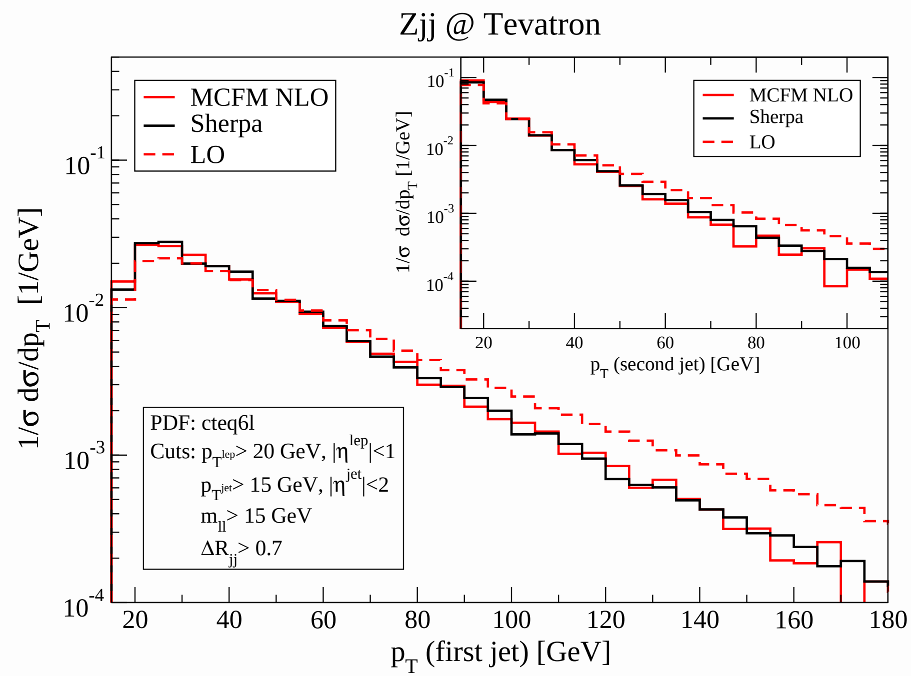
$n_{\max}$=1 $n_{\max}$=2 $n_{\max}$=3 dashed $n_{\max} = 2$

Exclusive W/Z+jet production @ Tevatron Run II

The $p_\perp$ of the jets in exclusive W/Z+jets production

Take pure Sudakov and α_S reweighted ME's, compare to naive LO and NLO predictions

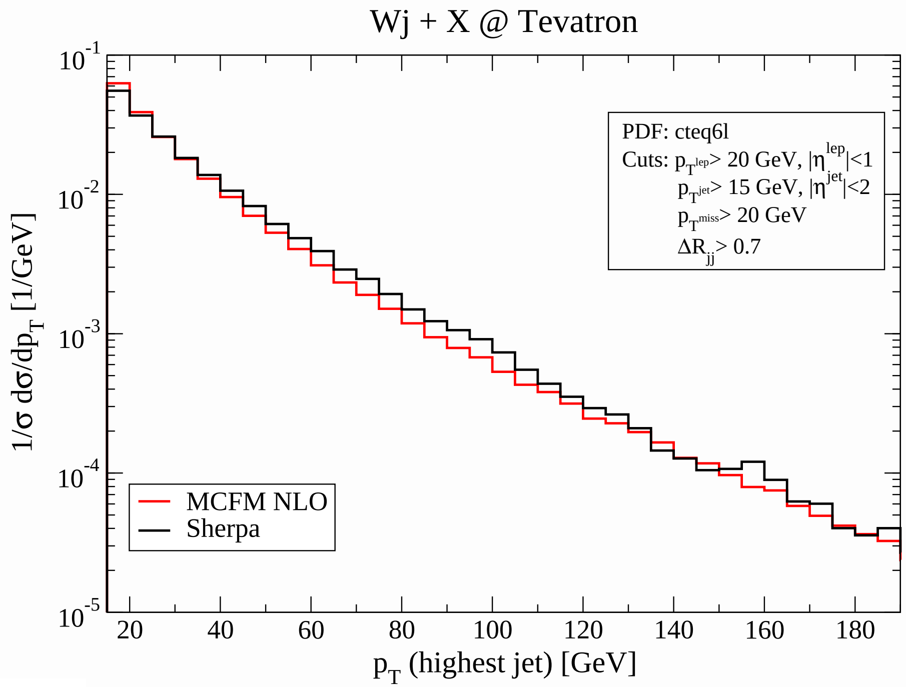


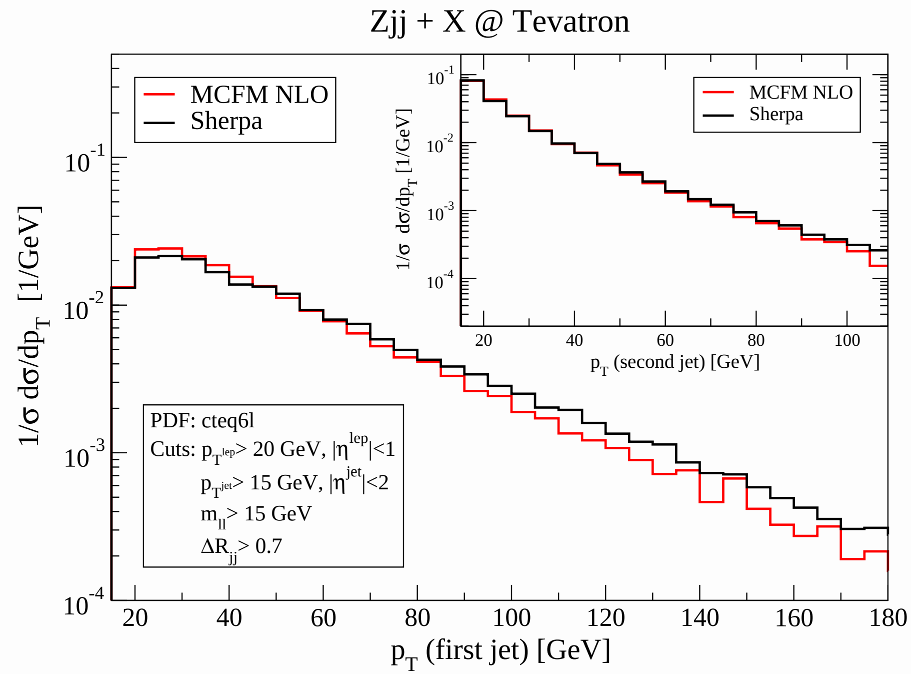


- At NLO a high $p_\perp$ jet is very likely to emit a further jet passing the jet criteria, removing the event from the sample
- SHERPA's reweighting has very similar impact on distributions

The $p_\perp$ of the jets in inclusive W/Z+jets production

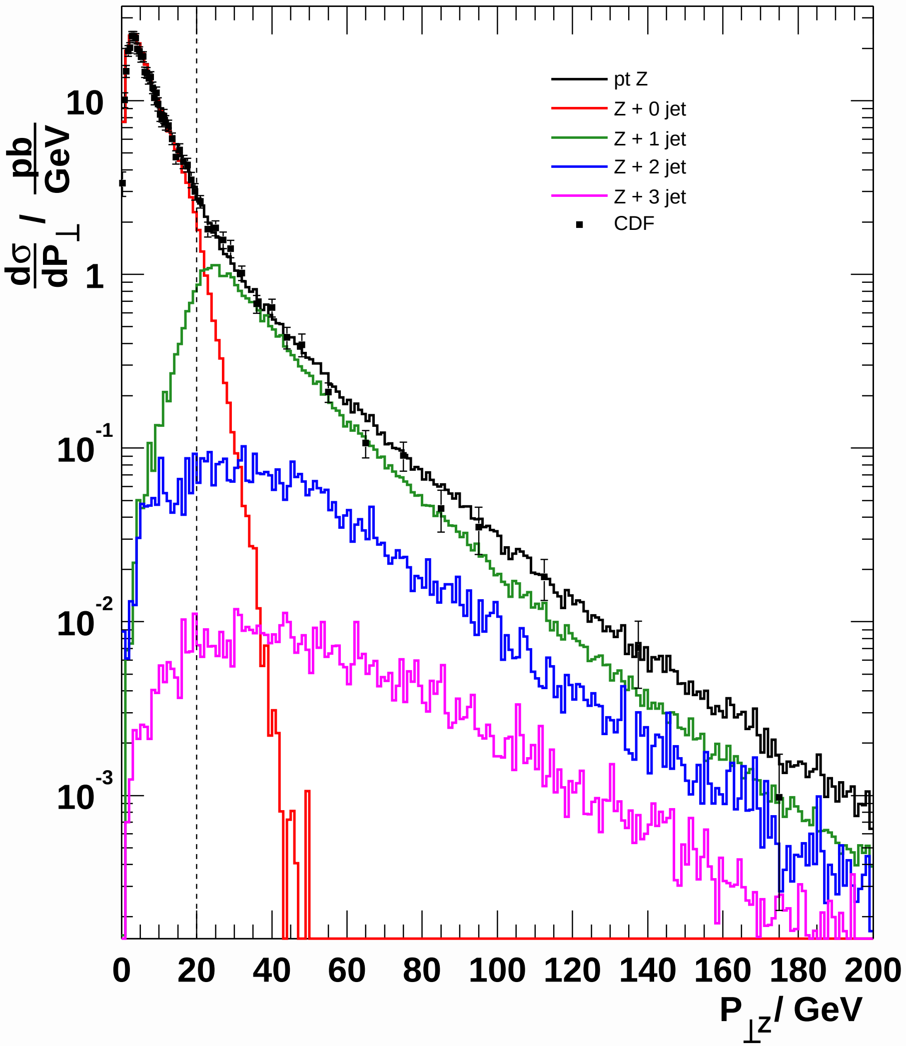
Take Sudakov and α_S reweighted ME's with the showers attached, compare to naive LO and NLO predictions

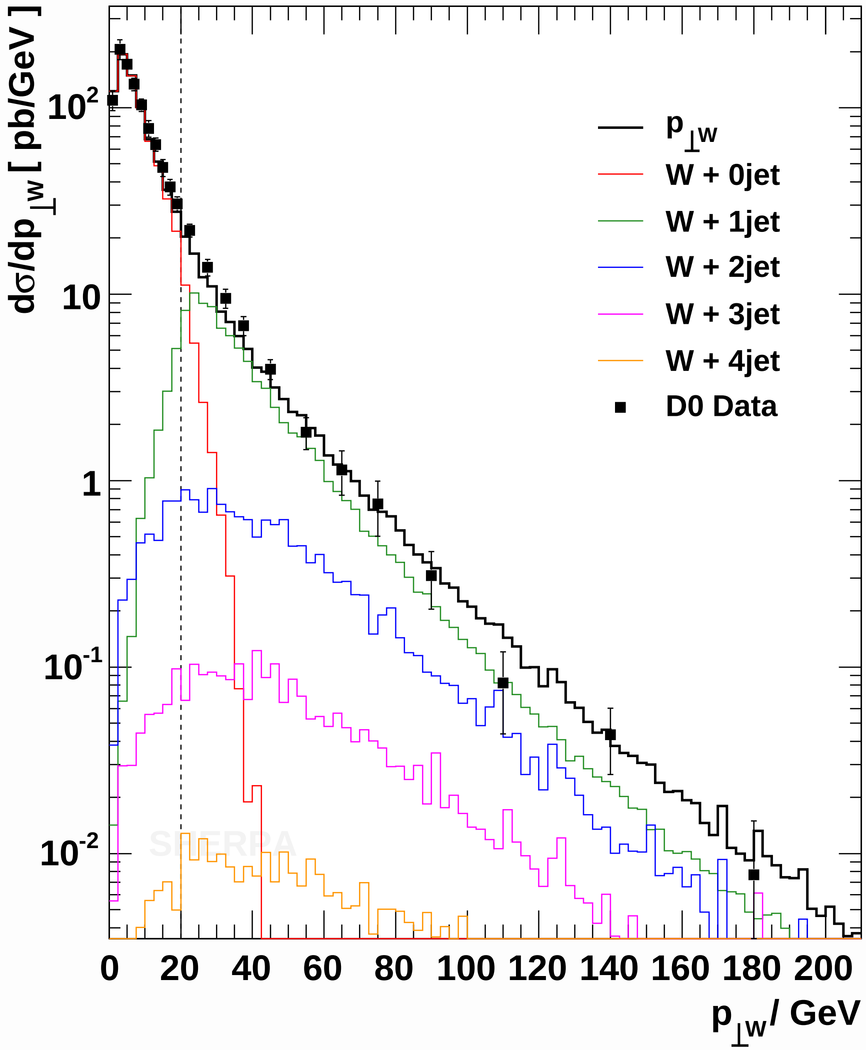




- The CKKW method seems to reproduce the NLO shapes for the jet distributions in the exclusive and inclusive case
- Note: The rates are not NLO

Comparison with Tevatron data @ $\sqrt{s} = 1.8\text{TeV}$





CDF Data : Phys.Rev.Lett.84:845-850,2000 **DO Data :** Phys.Lett.B513:292-300,2001

Distributions multiplied by appropriate K-factors!

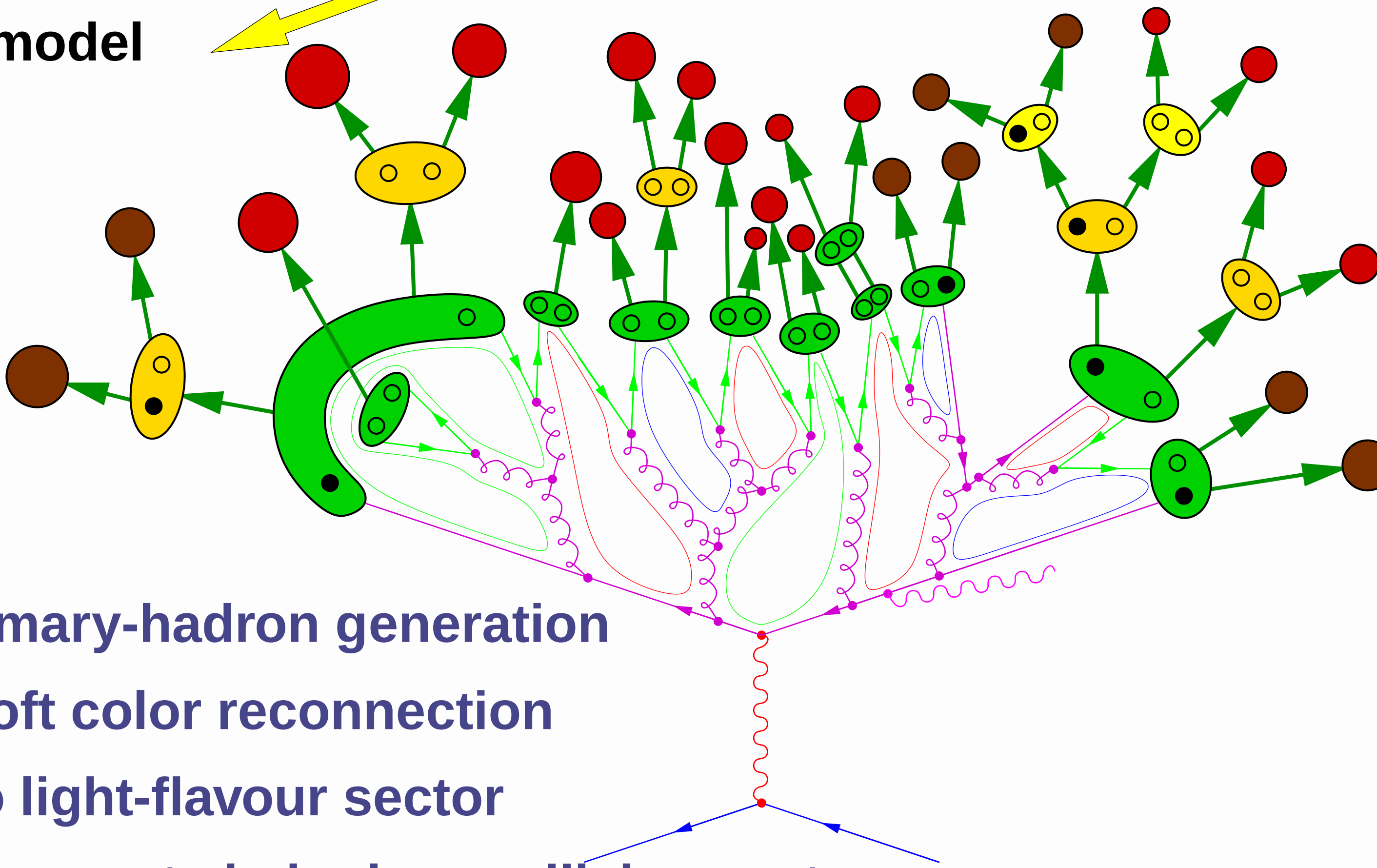
Towards a cluster hadronization model for SHERPA

J. Winter et al, Eur.Phys.J.C36:381,2004

modelling the non-perturbative dynamics of a partonic system

- **Cluster-formation model**
- **Cluster-decay model**

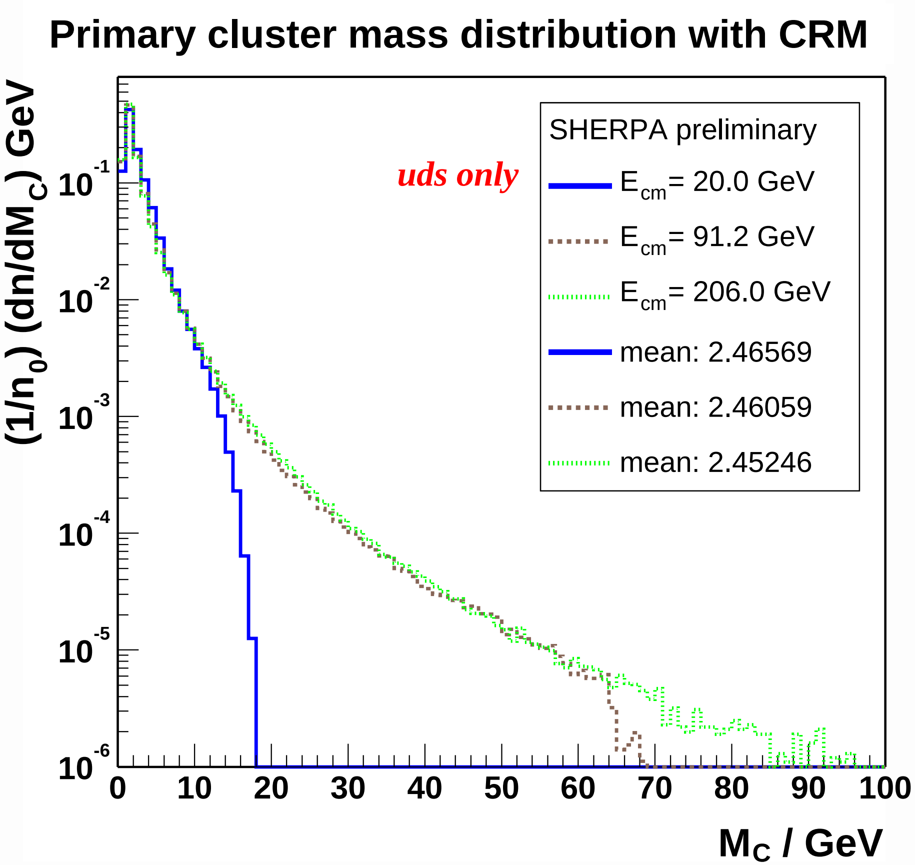
light flavour pair production

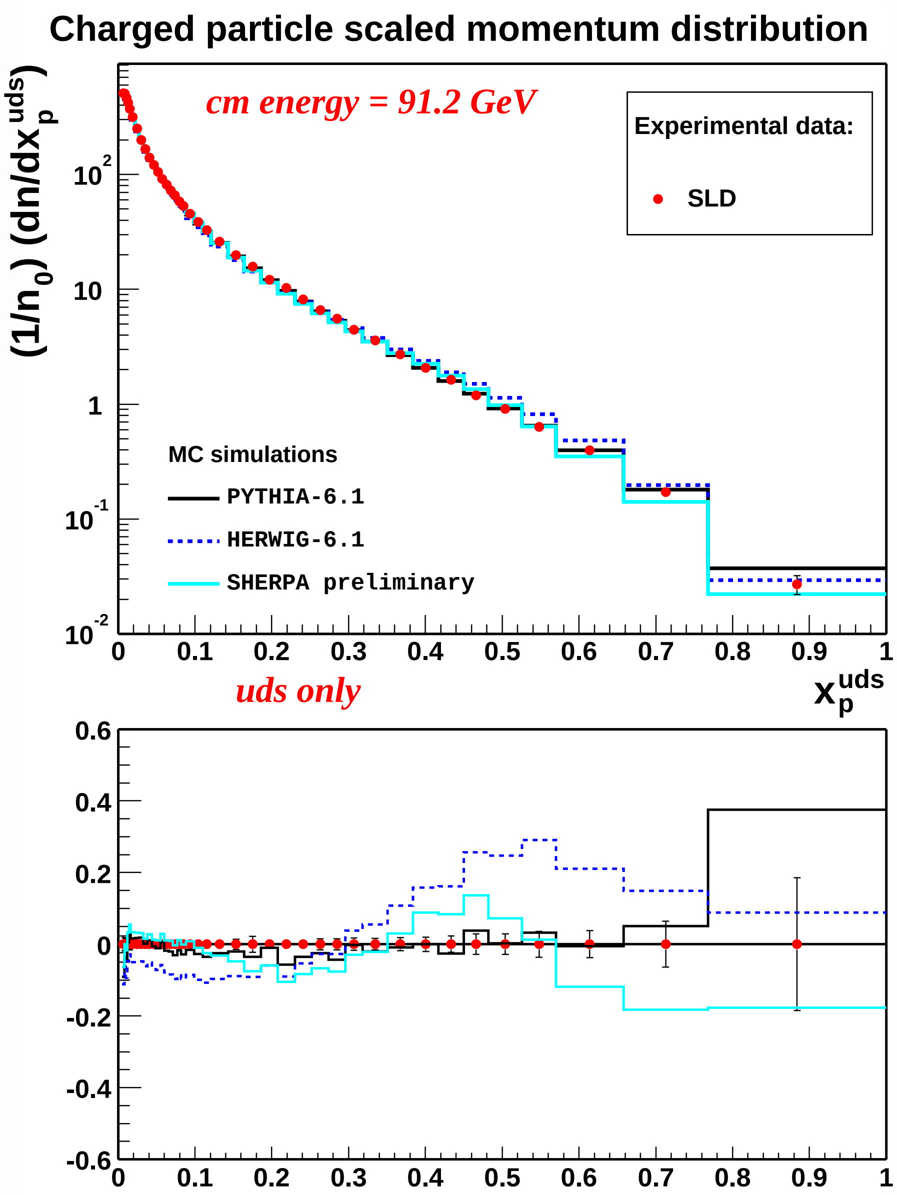


Features:

- **Parametrization of primary-hadron generation**
- **Includes a model of soft color reconnection**
- **Currently restricted to light-flavour sector**
- **No fragmentation of remnants in hadron collisions yet**

Towards a fragmentation model for SHERPA





- Universality of the primary cluster mass spectrum

Conclusions/Outlook

SHERPA including the ME's of AMEGIC++ and the CKKW prescription to combine them with the PS is a powerful tool to attempt the description of present-day Tevatron data and to study the extrapolation to LHC energies.

The next release will include:

- The simple hard underlying event model
- Revision of the phase space integration

  (enhanced integration performance and unweighting efficiencies)
- Support of the SLHA for MSSM spectrum input

Sources:

- T. Gleisberg, S. Höche, F. Krauss, A. Schälicke, S. S. and J. Winter, JHEP 0402:056,2004
- download (`SHERPA`α`-1.0.4`), manual, bug reports etc. under

  `http://www.physik.tu-dresden.de/~krauss/hep`