The Monte Carlo Event Generator
AcerMC version 2.0
With Interfaces to
Pythia 6.2, Herwig 6.5 and Ariadne 4.1

http://cern.ch/Borut.Kersevan/AcerMC.Welcome.html

Borut Kersevan
Jozef Stefan Institute, Ljubljana, Slovenia
Faculty of Mathematics and Physics, University of Ljubljana, Slovenia
Elzbieta Richter-Was
Institute of Physics, Jagellonian Uiversity,Cracow, Poland
Institute of Nuclear Physics PAS, Cracow, Poland

Project started in 2001:

Published: Comp. Physics Commun. 149:142-194,2003; hep-ph/0201302
major upgrade of phase-space: EPJC 39 (2005) 439; hep-ph/0405248
major upgrade of documentation: ATL-PHYS-2004-020, hep-ph/0405247

Main goal: provide implementation of missing background processes
for the Higgs searches at LHC

Corresponding author: borut.kersevan@cern.ch

Currently implemented:

Native processes

gg,qq -> ttbb 92->4)

qq-> W(->fν)bb (2->4)

qq-> W(->fν)tt (2->4)

gg,qq-> Z/γ*(->ff)bb (2->4)

gg,qq->Z/γ*(->ff)tt (2-4)

gg,qq->(Z/W/γ* ->)ttbb (2-4)

gg,qq-> (tt->)bbffff (2->6)
gg,qq->(WbWb->)bbffff (2->6)
gg,qq->WbWb (2->4)

gg,qq->tttt (2->4)

Control processes:
qq->Z->ff
qq->W->ff
gg,qq->tt

Design requirements:

=> Compact tool -> *all-in-one*

=> Extensibility -> *modular design*

=> Exact massive LO matrix elements
MADGRAPH/HELAS

=> Full phase-space coverage (massive particles);
high generation efficiency ->
native phase-space algorithm

=> Use of standard libraries ->
CERNLIB, PDFLIB, LHAPDF *(new)*

=> Interfaced to
PYTHIA, HERWIG, ARIADNE *(new)*
for ISR/FSR/hadronisation

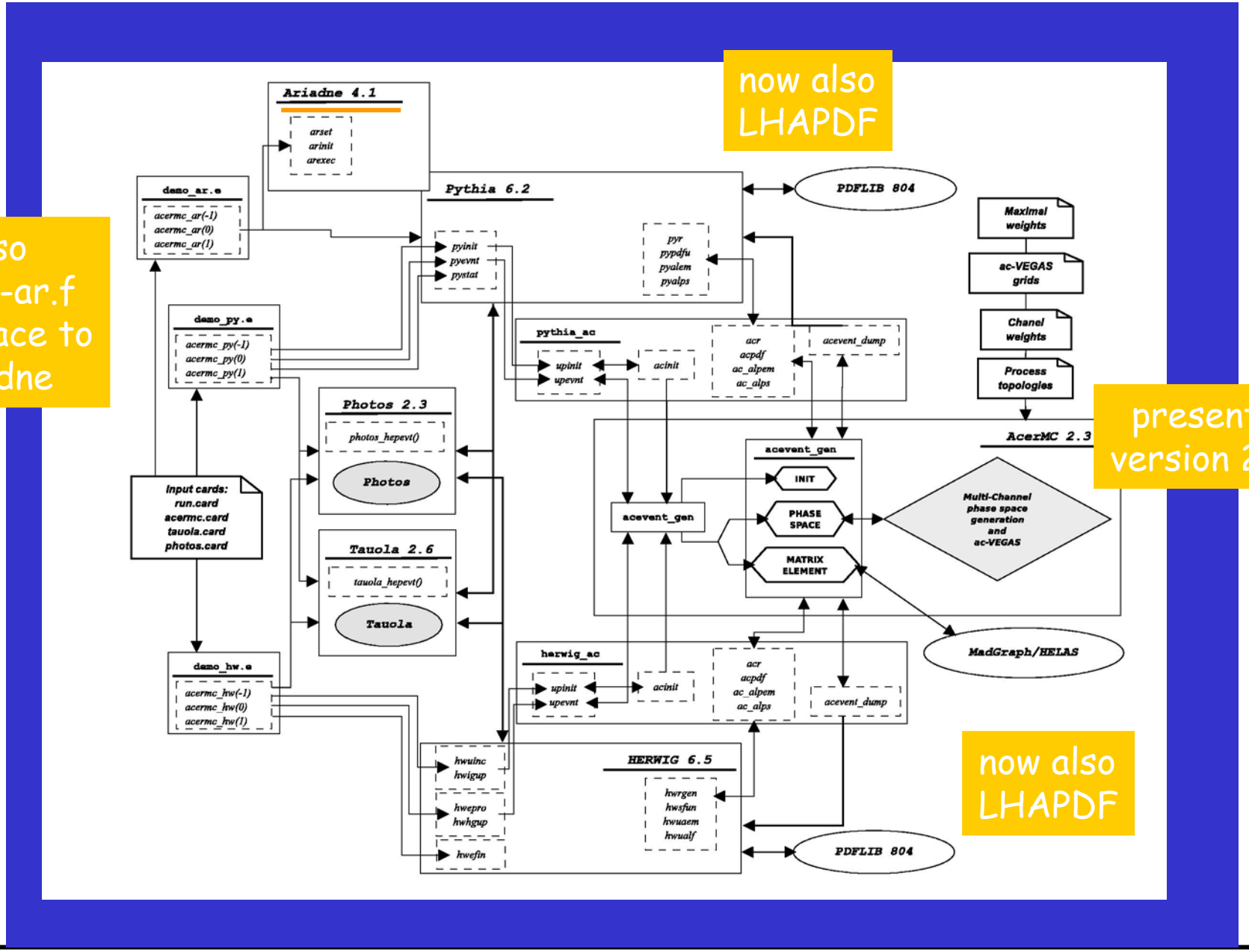
=> Interfaced to
TAUOLA, PHOTOS
for better precision in treatment of
tau decays and QED radiative decays

=> Event record dump to LesHouches format

Used "as standard" in ATLAS collaboration for respective background studies

Stand-alone fortran setup

now also demo-ar.f interface to Ariadne



Structure of the distribution version

presently version 2.4

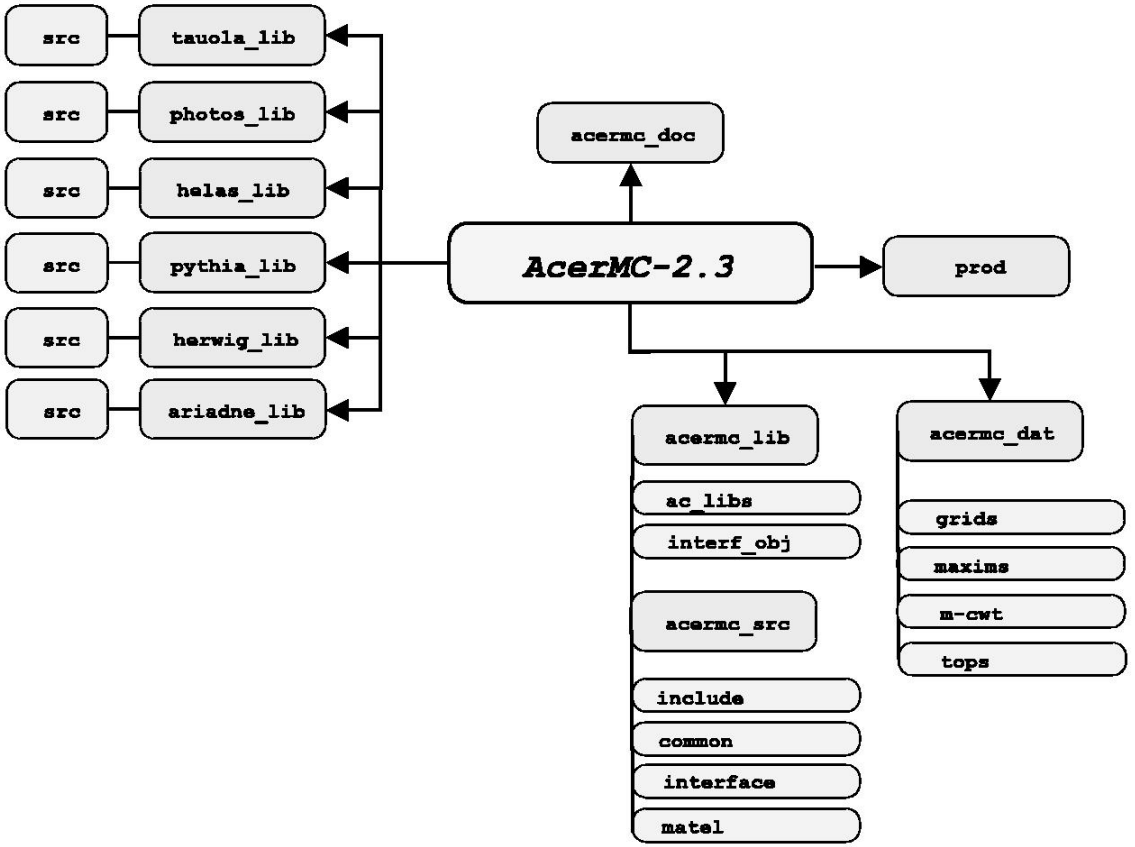


Fig. 17: *The structure of the* **AcerMC** *directories.*

Event generation elements (1)

Matrix elements coded by MADGRAPH/HELAS

T. Stelzer and W. F. Long, Comp. Phys. Commun. 81 (1994) 357.

Structure function provided by PDFLIB or LHAPDF

$\alpha_{QEC}(Q^2)$, $\alpha_{QCD}(Q^2)$ either by AcerMC or by supervising generator. (PYTHIA 6.2, HERWIG 6.5)

H. Burkhard and B. Pietrzyk, Phys.Lett.B513:46-52,2001

W. J. Marciano, Phys. Rev. D29 (1984), 580.

Phase-space sampling done by native AcerMC routines:

-> multi-channel approach

J. Hilgart, R. kleiss, F. Le Dibider, Comp. Phys. Commun. 75 (1993) 191.

F. A. Berends, C. G. Papadopoulos and R. Pittau, Comp. Phys. Commun. 136 (2001) 148.

-> revised Kajantie-Byckling phase space factorisation

F. Byckling, K. Kajantie, Nucl. Phys, B91 (1965) 568.

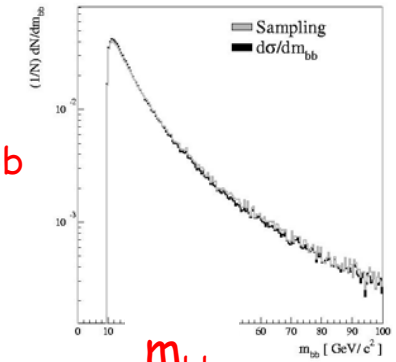
-> native sampling routines (plot)

-> aditional ac-VEGAS smoothing

G. P. Lepage, J. Comput. Phys. 27 (1978) 192.

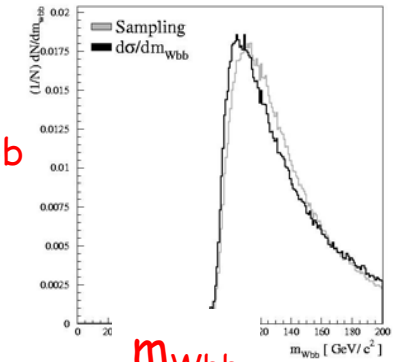
Colour flow information retrieved from modified MADGRAPH/HELAS code.

qq->Wbb



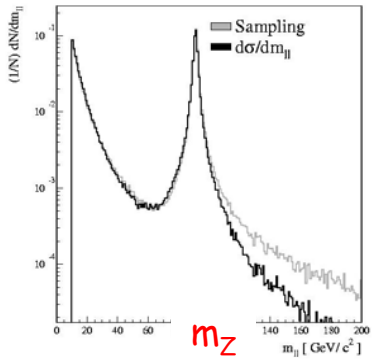
m_{bb}

qq->Wbb



m_{Wbb}

qq->Zbb



m_Z

Event generation elements (2)

Efficient and fast event generation:
- -> unweighting efficiencies in the range 10%-40%
- -> ~ 100 unweighted events/second generated on a 2 GHz PC

An insight into AcerMC 2.4 capabilities

the gg,qq -> bbffff process (2 -> 6)

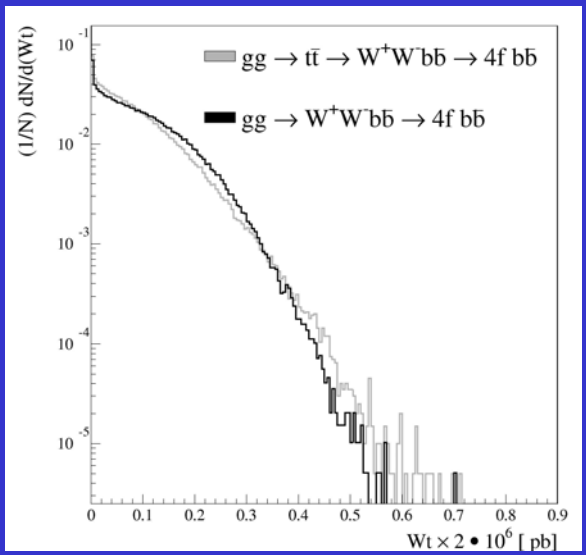
Events generated with 2->6 matrix element.
- gg->(tt->) bbffff 3 diagrams
- gg->(bbWW->) bbffff 31 diagrams

Process	$\sigma(Q^2 = (2\ m_t)^2)$ [pb]
gg->(tt->)bbμνμν	4.49
qq->(tt->)bbμνμν	0.75
gg->(WbWb->)bbμνμν	4.77
qq->(WbWb->)bbμνμν	0.77

Difference is an effect from non-resonant contributions

In agreement with **N. Kauer, D. Zeppenfeld Phys. Rev. D65 (2002) 014021**

weight distribution



spin correlations of l^+ l^- from tt->lνblνb

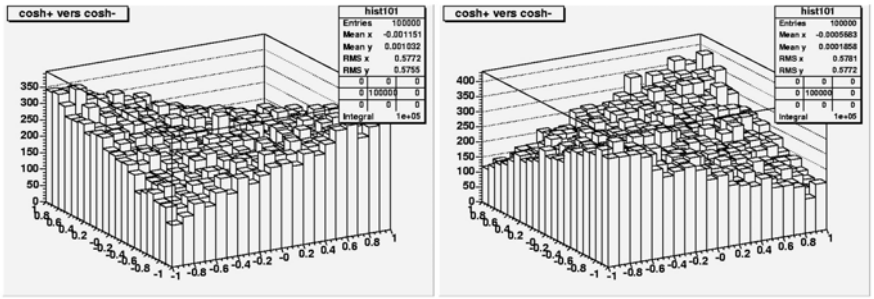


Fig. 2: *The correlations between* $\cos\Theta$ *(azimutal angle) of lepton and antylepton from* $t\bar{t} \to \ell\bar{\nu}b\bar{\ell}\nu\bar{b}$ *decays measured in the rest frame of the top-quark with respect to the anty-top quark direction. Left plot is for* $gg \to (WWb\bar{b} \to) f\bar{f}f\bar{f}b\bar{b}$ *process, right plot for* $q\bar{q} \to (WWb\bar{b} \to) f\bar{f}f\bar{f}b\bar{b}$ *process.*

Also provided interface to AcerDET package

E. Richter-Was,
AcerDET: a particle level fast simulation and reconstruction package for phenomenological studies on high p_T physics at LHC.
hep-ph/0207355
source code available from the same web page
http://cern.ch/Borut.Kersevan/AcerMC.Welcome.html

Simplified detector simulation and reconstruction "a la ATLAS at LHC"
=> parametrisated resolutions (basic gaussian shapes)
=> jets reconstruction with cone algorithm
=> crude isolation criteria
=> crude reconstruction of missing energy

Examples:

=> see talk by Zofia Czyczula during this WG session
=> comparison of transverse momenta spectra for inclusive W and Z production at LHC (next slides).

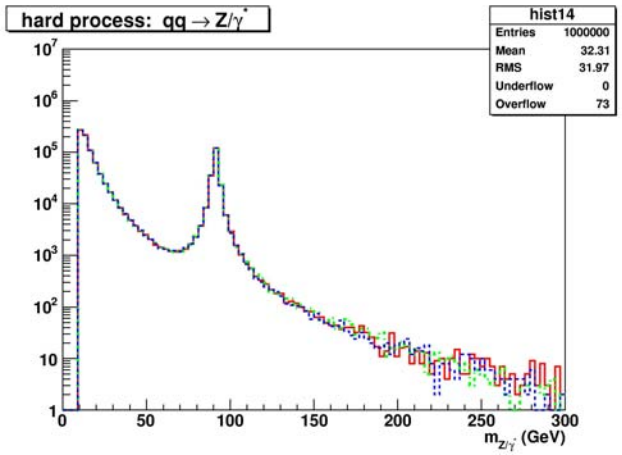
=> generated with native AcerMC processes
=> ISR/FSR from PYTHIA, HERWIG, ARIADNE
=> structure functions from LHAPDF

Example 1: inclusive Z production at LHC

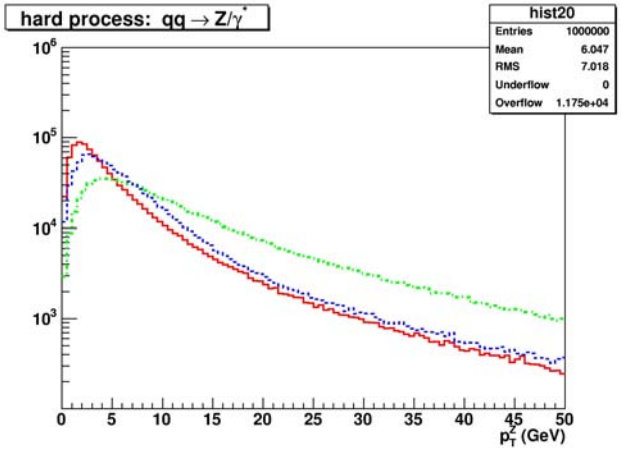
pythia
ariadne
herwig

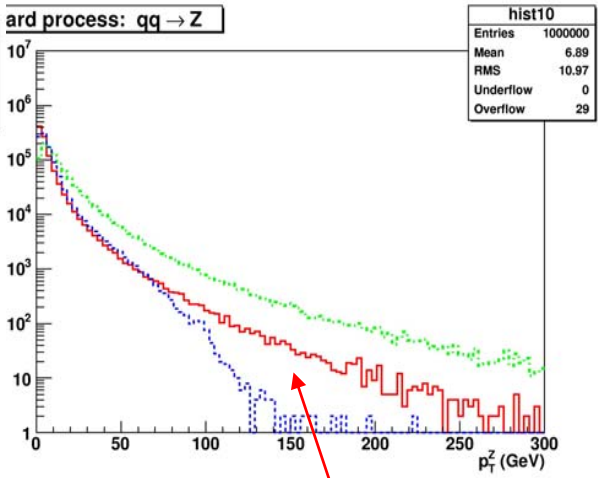
Native ME of AcerMC used

Transverse momenta from ISR only



Invariant mass of the Z/γ*,

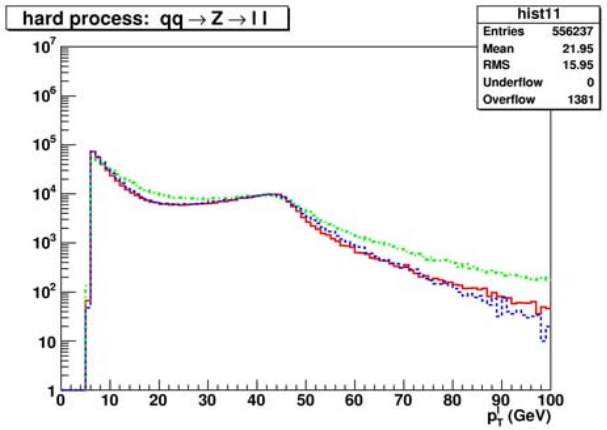




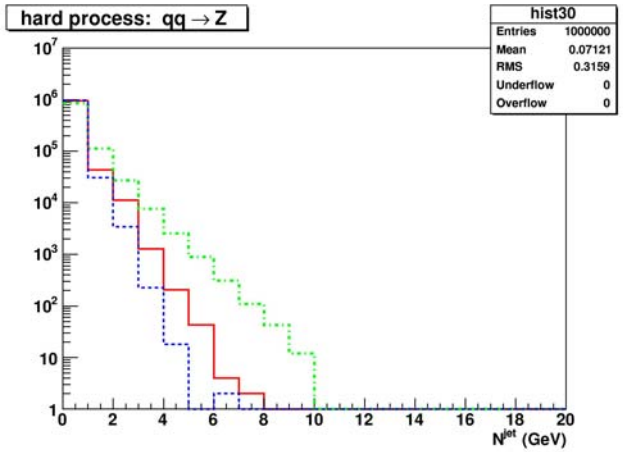
Transverse momenta for Z/γ*, from parton shower

" improved parton shower"

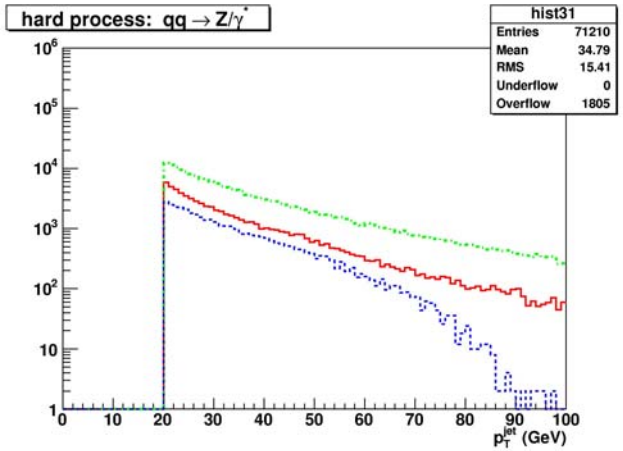
Jets reconstructed with AcerDET



Transverse momenta for leptons from Z/γ*->ll



Jets multiplicity



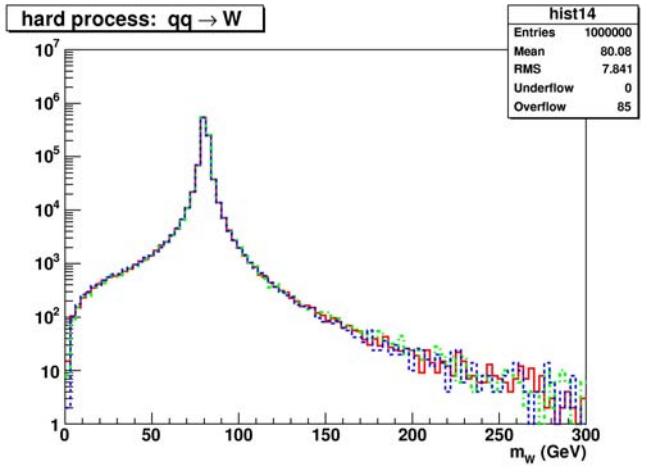
Transverse momenta for hardest jet

Example 2: inclusive W production at LHC

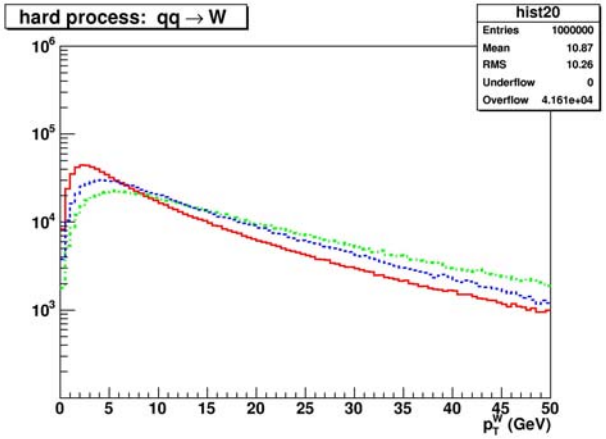
pythia
ariadne
herwig

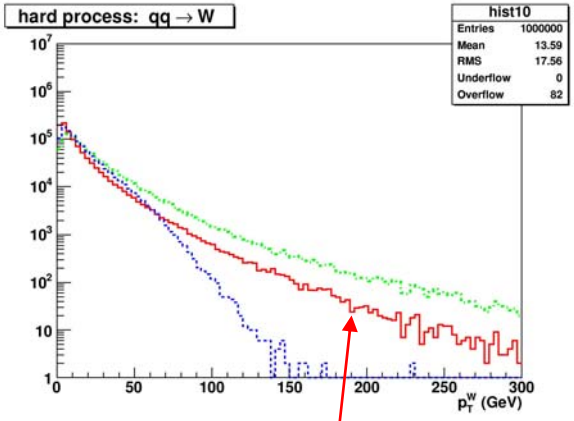
Native ME of AcerMC used

Transverse momenta from ISR only



Invariant mass of the W,

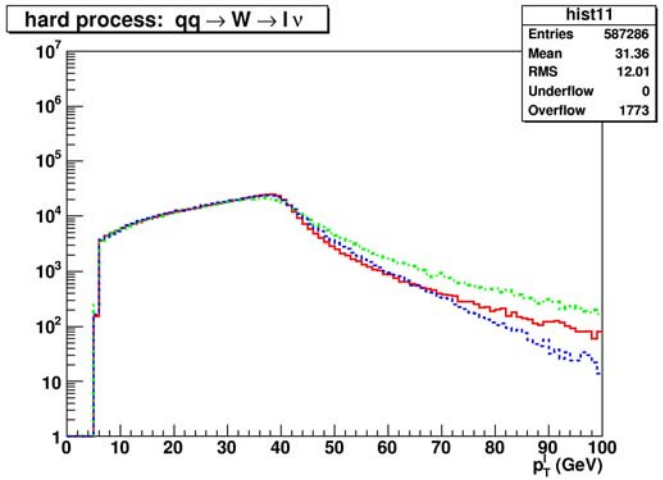


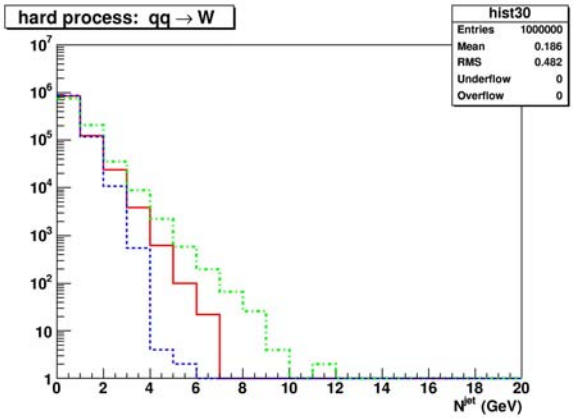


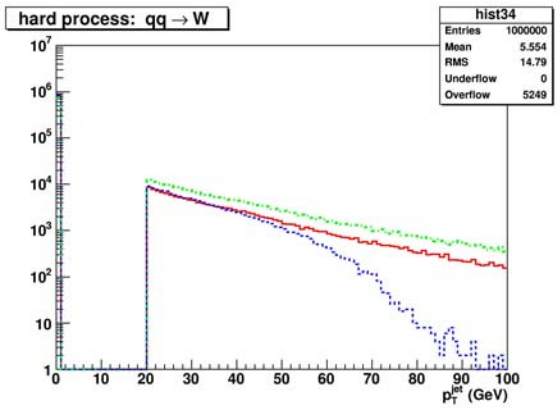
Transverse momenta for W, from parton shower

" improved parton shower"

Jets reconstructed with AcerDET







Transverse momenta for lepton from W->lν — Jets multiplicity — Transverse momenta for hardest jet

Summary

-> Main goal for creating Monte Carlo generator AcerMC was to have tool for efficient generation of specific (but key) background processes at LHC.

-> It provides also very friendly tool for comparing different parton shower models in the consistent framework (eg. consistent definition of α_{QED}, α_{QCD})

Impact from this workshop:

=> interface to ARIADNE 4.1
=> interface to LHAPDF

So far, Ariadne was very little (if at all) used for simulation in ATLAS and CMS. Certainly, we should validate this shower model at LHC environment,
First observations:

=> rather hard radiation from quarks (qq->W,Z)
=> not enough radiation from gluons (gg->H) (talk by Zofia)

and evaluate our predictions on signal and background topologies also with Ariadne.