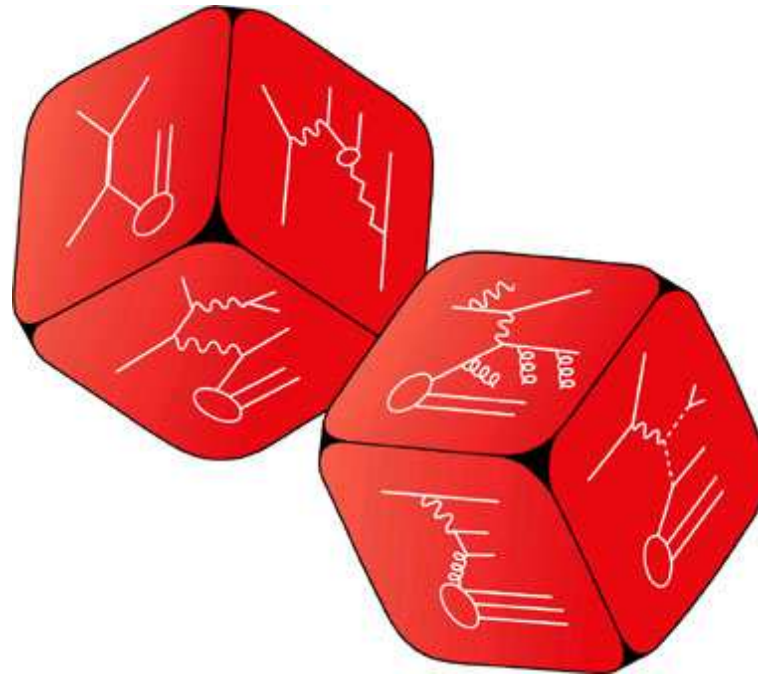


## *Summary of WG5 'MC Tools'*

Conveners: V. LENDERMANN (H1), A. NIKITENKO (CMS),  
E. RICHTER-WAS (ATLAS), P. ROBBE (LHCb), M. SEYMOUR (Theory)



VICTOR LENDERMANN  
University of Heidelberg

HERA-LHC Plenary Meeting  
DESY, Hamburg, Mar 24, 2005

## *Projects in WG5 'MC Tools'*

- ▶ PDF libraries
- ▶ MC generators, models
- ▶ MC running, validation and tuning tools

## *Physics topics common with WG2*

- ▶ Multiple interactions / Underlying event → WG2
- ▶ Multijet final states → WG2
- ▶ Matrix element – parton shower matching
- ▶ New developments for parton showers

Started by W. GIELE, continued by M. WHALLEY  
Replacement for PDFLIB which is no longer maintained

Goals:

- ▶ Give access to the latest PDF sets
- ▶ Be able to handle the multiple error PDF sets (*necessary for LHC!*)
- ▶ Be more flexible than PDFLIB in updating.

*Several version updates during this Workshop*

Current **version 4** includes:

- ▶ Recent and legacy sets by theory groups:  
CTEQ 4/5/6, MRST 2001/2/3c/4, GRV 98, Alekhin, ...
- ▶ **Recent fits by HERA collaborations:** H1 2000, ZEUS 2002
- ▶ **Photon and pion PDFs** from PDFLIB (*necessary for HERA!*)

## *LHAPDF (Continued)*

PDFs are included as external files. Two methods:

- ▶ On-the-fly QCD evolution when initialized → small .LHpdf files
- ▶ Grids like in PDFLIB → big .LHgrid files

LHAGLUE – PDFLIB like interface to LHAPDF

by D. BOURILKOV and C. GROUP

*The LHAGLUE package, plus a unique PDF numbering scheme, enables LHAPDF to be used in the same way as PDFLIB, without requiring any changes in the generator codes.*

Online manual: <http://durpdg.dur.ac.uk/lhapdf/>

Plans for future:

- ▶ New PDF sets
- ▶ New evolution codes
- ▶ C++ rapper (already have basis, courtesy of S. GIESEKE)
- ▶ ...

# *Diffraction PDF Library*

F.-P. SCHILLING – talk in WG4 in October 2004

Should provide:

- ▶  $\mathcal{P}/\mathcal{R}$  PDFs + Errors
- ▶ Fluxes and all diffraction specific rest

Two approaches possible:

- ▶ Provide independent library for diffraction
- ▶ Provide add-on for LHAPDF

Time scale still unclear

## *MC Generators*

- ▶ General presentations of generators:  
*Cascade, RapGap, AcerMC, Photos*
- ▶ C++ generators: *Pythia 7, Herwig++, Sherpa*
- ▶ UE models (*Pythia 6.3, Jimmy/Herwig*) → WG2
- ▶ Predictions for multijet final states at LHC → WG2
- ▶ ME/PS matching
- ▶ New developments of parton shower models

H. JUNG

## Applications:

- ▶ Inclusive and diffractive DIS
- ▶ Inclusive and diffractive photoproduction in  $ep$
- ▶ Direct and resolved photons
- ▶ Choice between MEPS and CDM parton cascades
- ▶ QED radiative corrections using HERACLES
- ▶ Single diffraction in  $p\bar{p}$

## New developments:

- ▶ Les Houches Accord interface for fragmentation:  
Choose between PYTHIA 6.2 and Herwig 6.5 –  
Allows better estimation of hadronisation corrections
- ▶ Hadronisation of low mass final states –  
important for diffraction

<http://www.desy.de/~jung/rapgap/>

B. KERSEVAN, E. RICHTER-WAS

## Simulation of background processes for Higgs searches at LHC

Processes:

- ▶  $gg, qq \rightarrow ttbb(2 \rightarrow 4)$
- ▶  $qq \rightarrow W(\rightarrow f\nu)bb$  or  $tt(2 \rightarrow 4)$
- ▶  $gg, qq \rightarrow Z/\gamma^*(\rightarrow ff)bb$  or  $tt(2 \rightarrow 4)$
- ▶  $gg, qq \rightarrow Z/W/\gamma^* \rightarrow ttbb(2 \rightarrow 4)$
- ▶  $gg, qq \rightarrow tt \rightarrow bbffff(2 \rightarrow 6)$
- ▶  $gg, qq \rightarrow WbWb \rightarrow bbffff(2 \rightarrow 6)$
- ▶  $gg, qq \rightarrow WbWb(2 \rightarrow 4)$
- ▶  $gg, qq \rightarrow tttt(2 \rightarrow 4)$
- ▶  $qq \rightarrow Z \rightarrow ff$
- ▶  $qq \rightarrow W \rightarrow ff$

First studies on inclusive  $W$  and  $Z$  production at LHC  
using ARIADNE (WG2 summary)



E. RICHTER-WAS

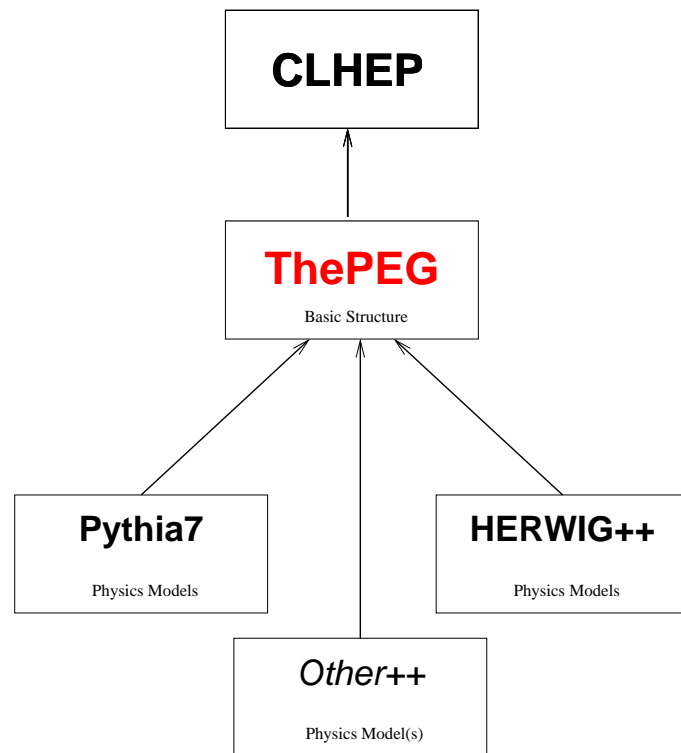
Simplified detector simulation and reconstruction á la ATLAS

- ▶ Parametrized resolutions (basic Gaussian shapes)
- ▶ Jets reconstruction using cone algorithm
- ▶ Crude isolation criteria
- ▶ Crude reconstruction of missing energy

# ThePEG, PYTHIA 7, HERWIG++

L. LÖNNBLAD, T. SJÖSTRAND, N. LAVESSON ;

S. GIESEKE, A. RIBON, P. RICHARDSON, M. SEYMOUR, P. STEPHENS, B. WEBBER



**ThePEG** library:

Basic infrastructure, Kinematics, Repository,  
Handler classes, Event record, Particle data

Physics models:

**PYTHIA 7, HERWIG++, ... (ARIADNE)**

No *ep* versions so far  
Currently development for LHC

# SHERPA

T. GLEISBERG, S. HÖCHE, F. KRAUSS, A. SCHÄLICKE, S. SCHUMANN, J. WINTER

GOAL: full simulation of high energetic particle reactions at existing and future collider experiments, including  $e^+e^-$ ,  $\gamma\gamma$ ,  $e\gamma$ ,  $ep$ ,  $p\bar{p}$ ,  $pp$

- ▶ ME generator AMEGIC++  
providing the MEs for hard processes and decays in SM, MSSM and ADD
- ▶ PS module APACIC++  
containing a virtuality ordered initial and final state parton showers
- ▶ combination of MEs and PSs á la CKKW  
(Results for  $W/Z$ +jets production presented)
- ▶ Interface to PYTHIA string fragmentation and hadron decays
- ▶ Hard UE model AMISIC++ similar to PYTHIA  
(Comparisons SHERPA  $\longleftrightarrow$  PYTHIA 6.2 presented)

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

# *W or Z + Jets Production with SHERPA*

S. SCHUMANN

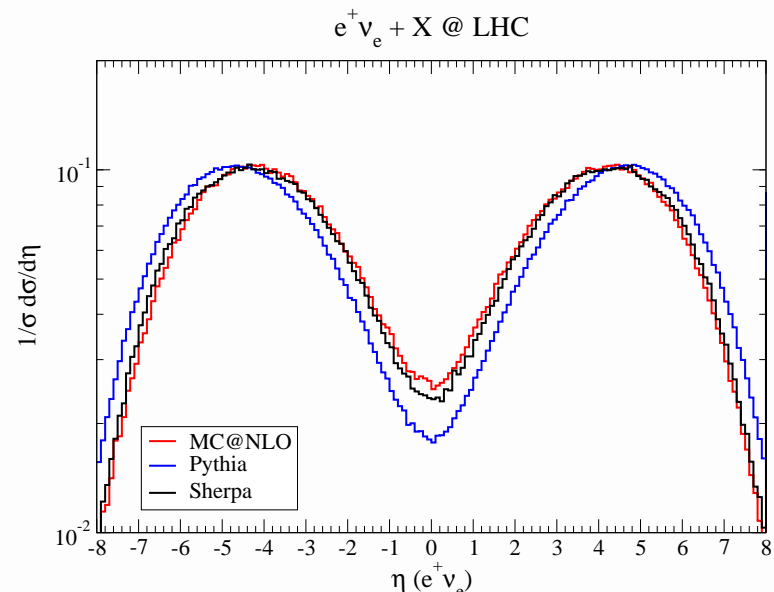
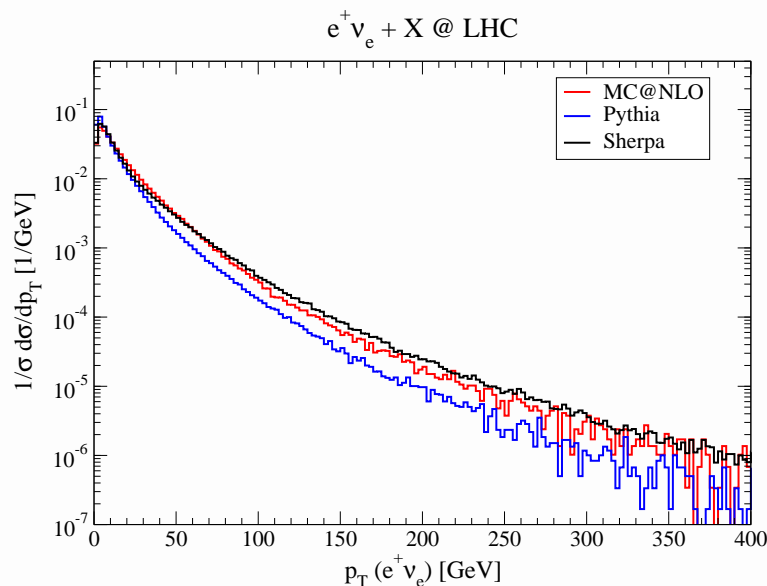
Combine LO Matrix Elements and Parton Showers according to CKKW

Aim:

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

Studies:

- ▶ Comparisons to Tevatron data on Z and W
- ▶ Comparisons to Pythia and MC@NLO at LHC



## *W or Z + Jets Production with SHERPA*

### Conclusions:

- ▶ LHC provides a lot more phase space for extra emissions
- ▶ Inclusion of higher order MEs seems to be more important than at Tevatron
- ▶ SHERPA with CKKW is able to reproduce the shapes for exclusive and inclusive  $W/Z + \text{jet}$  production at Tevatron (and LHC)
- ▶ However, the rates are not NLO

### Outlook:

- ▶ Comparisons with MLM and ARIADNE

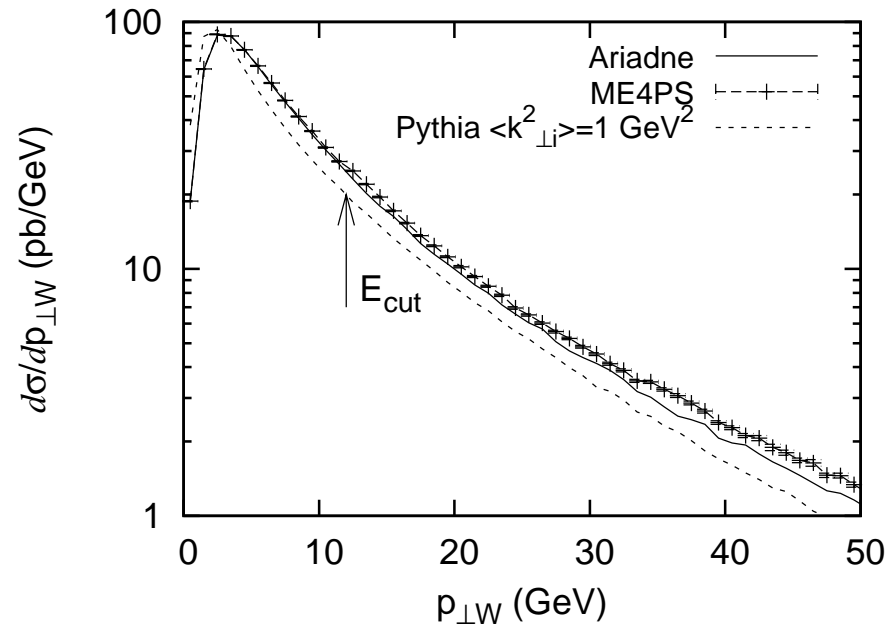
# *W + Jets Matrix Elements and ARIADNE*

N. LAVESSON

Modifications to standard CKKW algorithm in ARIADNE

Studies:

- ▶ Comparisons to Pythia on  $W$  production at Tevatron run II



Outlook:

- ▶  $W$  and Higgs production at LHC
- ▶ DIS at HERA
- ▶ Implement ARIADNE in C++

# PHOTOS

P. GOLONKA, Z. WAS et al.

QED radiative corrections for  $W$  and  $Z$  decays  
and also for  $t$  and  $H$  decays

Applications:

- ▶ Measurements of CKM at  $B$ -factories
- ▶  $W$  and  $Z$  mass and coupling measurements at Tevatron/LHC

Principle of work:

- ▶ Reads HEP event record and adds bremsstrahlung photons
- ▶ Iterative solution like “parton shower”

For leptonic decays 0.1% precision is reached

The iterative solutions can be useful for development of future parton shower models

<http://wasm.home.cern.ch/wasm/goodies.html>

<http://piters.home.cern.ch/piters/MC/PHOTOS-MCTESTER/>

# *Non-Markovian Constrained MC Algorithm for QCD evolution*

S. JADACH, M. SKRZYPEK

Basic facts:

- ▶ Markovian MC implementing QCD/QED evolution equations is basic ingredient in all parton shower type MCs
- ▶ Unconstrained forward Markovian MC, with evolution kernels from perturbative QCD/QED, can only be used for FSR (inefficient for ISR)
- ▶ For ISR cascades elegant Backward Markovian MC algorithm by Sjöstrand (Phys.Lett. 157 B, 1985) is widely adopted
- ▶ Backward Markovian MC does not solve the QCD evolution eqs. It merely exploits their solutions coming from the external non-MC methods

The problem:

- ▶ Is it possible to invent an efficient MC algorithm, non-Markovian, solving internally the evolution eqs. by its own?

**Constraint** = the distributions are the same as in normal Markovian evolution, but the final energy  $x = \sum z_i$  and the parton type  $k = g, q_j, \bar{q}_j$  are predefined, i.e. constrained.



# *Constrained Non-Markovian MC*

## Motivation:

- ▶ More freedom in the modeling the ISR parton shower,  
More friendly for inclusion of NLL and NNLL into parton shower MCs
- ▶ Easier MC modeling of the unintegrated parton distributions  $D_k(p_T, x)$ ,  
MC modeling of the CCFM class of the QCD calculations/models

## Status:

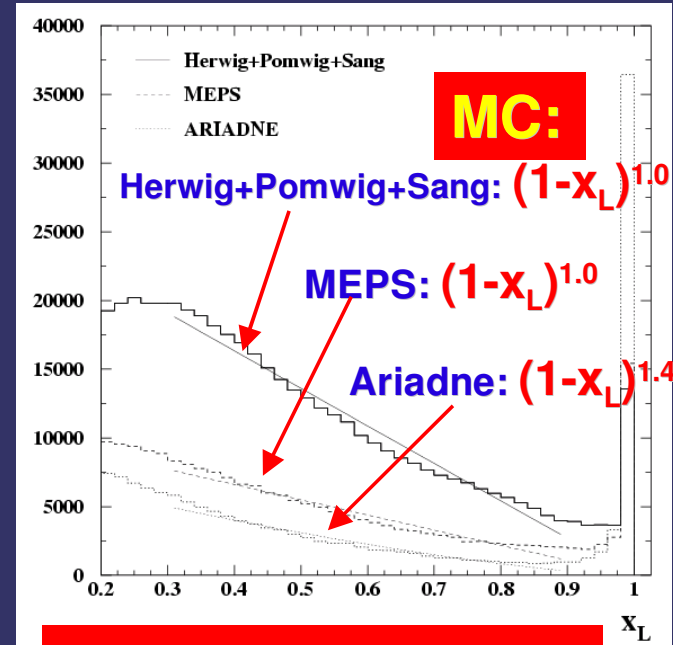
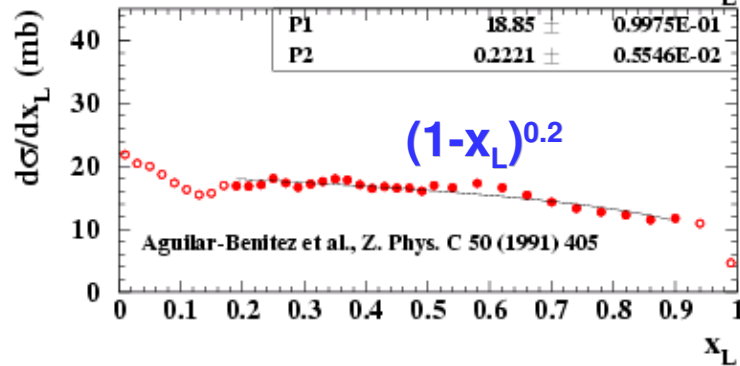
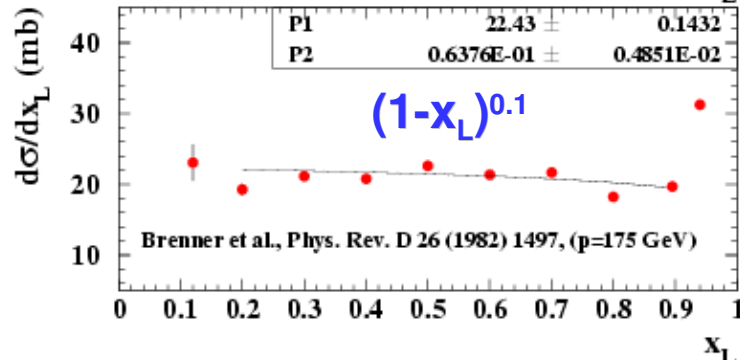
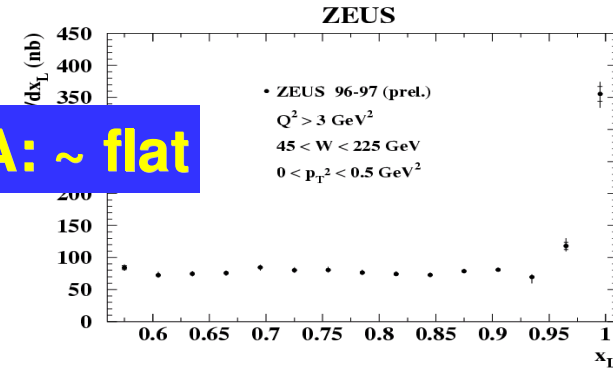
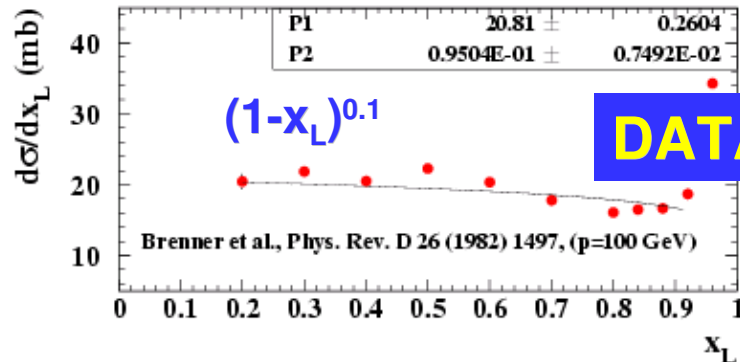
- ▶ New efficient CMC algorithm for  $\bar{M}S$  DGLAP evolution in October
- ▶ Key points are MC efficiency and numerical stability
- ▶ Pure bremsstrahlung is the critical part of the CMC algorithm
- ▶ Now checked to work efficiently for HERWIG evolution.  
Still to check quark-gluon transitions

## Plans:

- ▶ Including the rest of NLL corrections into CMC
- ▶ Aim: models/programs for unintegrated PDFs  
for  $W$  and  $Z$  production at LHC based on CCFM
- ▶ Fitting  $F_2(x, Q^2)$  of DIS with non-markovian CMC at some point in future

# Leading Protons in DIS at HERA

G. IACOBUCCI



⇒ quite different!

Seems to be quite difficult task for tuning

# NLOLIB

So far MC@NLO is available only for some specific processes in  $pp$ .  
No  $ep$  version at all. Use analytic calculations

Common framework for running different NLO calculations for various processes  
Created by T. HADIG and K. RABBERTZ, cont'd by K. RABBERTZ and T. SCHÖRNER

- ▶ Container for slightly modified NLO programs
- ▶ Setup for compiling and linking these programs on diverse UNIX platforms
- ▶ Unified access to the NLO event records
- ▶ Unified steering for common parameters and settings
- ▶ Unified access to PDF libraries
- ▶ Examples how to run it and how to implement your own code
- ▶ Allows comparisons to experimental results via HZTool

<http://www.desy.de/~nlolib>

**Significant development of the framework during this workshop:**  
structure, installation, new programs

# NLOLIB Development

## Implemented programs:

- ▶ **DISENT 0.1**
- ▶ **DISASTER++ 1.0.1**
- ▶ **MEPJET 2.2** (*numerical problems*)
- ▶ **RacoonWW 1.1**
- ▶ **JetViP 2.1** (*not fully finished*)
- ▶ **NLOJET++ 2.0.1** (*work in progress*)

jet production in  $ep$

jet production in  $ep$

jet production in  $ep$

electroweak physics in  $e^+e^-$

jet production in  $ep$  and  $e^+e^-$

## Examples:

- ▶ Event shape calculations for  $ep$  collisions
- ▶  $ee \rightarrow WW \rightarrow 4f$  angular distributions

## *NLOLIB Wishlist for Future*

Work continues to integrate fully NLOJET++, JetVIP and MEPJET.  
But there are more (in particular  $pp$ ) programs:

- ▶  $pp$  program from Klasen
- ▶ MCFM
- ▶ JETRAD/DYRAD
- ▶ PHOX family
- ▶ FMNR
- ▶ AYLEN/EMILIA
- ▶ HVQDIS

*Volunteers?*

Users/authors of NLO programs are encouraged to port them into NLOLIB

# *HZTool*

by N. BROOK, T. CARLI, H. JUNG, J. BUTTERWORTH, B. WAUGH, *et al.*

A library of generic fortran routines to allow easy access to experimental published data distributions and to calculate predictions of Monte Carlo generators for these distributions

- ▶ Developed at HERA, where MC have difficulties to describe the data, but where MC are needed for precision physics
- ▶ Common project between ZEUS and H1  
Includes (not yet all) H1 and ZEUS published measurements
- ▶ Extended to  $\gamma\gamma$  at LEP (OPAL) and some Tevatron data
- ▶ Easily extendable to LHC
- ▶ One routine per publication includes histos filled with published data and histos being filled by running MCs for comparison

DESY-XX-XXX  $\iff$  hzXXXXXX.F

Documentation: <http://hztool.hep.ucl.ac.uk/>

Tutorial by H. JUNG in HERA-LHC June meeting:

<http://agenda.cern.ch/fullAgenda.php?ida=a041878>

## *Available Routines for Tuning UE/MI Models*

Used for MC tuning by J. BUTTERWORTH and M. WING

HZ01225	<i>Di-Jets in <math>\gamma p</math></i>	H1
HZ01220	<i>Di-Jets in <math>\gamma p</math> and Photon Structure</i>	ZEUS
HZ00035	<i>Di-Jets in <math>\gamma p</math> and Photon Structure</i>	H1
HZ99057	<i>Di-Jets in <math>\gamma p</math> at high <math>E_T</math></i>	ZEUS
HZ98162	<i>Three-Jets in <math>\gamma p</math></i>	ZEUS
HZC98113	<i>Di-Jets in <math>\gamma\gamma</math></i>	OPAL
HZ98085	<i>Inclusive <math>D^*</math> and Associated Di-Jets</i>	ZEUS
HZ98018	<i>Inclusive Jets at High <math>E_T</math></i>	ZEUS
HZ97196	<i>Di-Jets in <math>\gamma p</math></i>	ZEUS
HZ97191	<i>Jet Shapes in <math>\gamma p</math></i>	ZEUS
HZ97164	<i>Inclusive Di-Jets in <math>\gamma p</math> and Parton Distributions in Photon</i>	H1
HZC96132	<i>Inclusive Jets in <math>\gamma\gamma</math></i>	OPAL
HZ96094	<i>Di-Jet Angular Distributions in Resolved and Direct <math>\gamma p</math></i>	ZEUS
HZ95219	<i>Jets and Energy Flow <math>\gamma p</math></i>	H1
HZ95194	<i>Rapidity Gaps between Jets in <math>\gamma p</math></i>	ZEUS
HZ95033	<i>Di-Jets in <math>\gamma p</math></i>	ZEUS
HZ94176	<i>Inclusive Jets in <math>\gamma p</math></i>	ZEUS
	<i>Charged Jet Evolution and Underlying Event in <math>p\bar{p}</math></i>	CDF
	<i>Multijet Photoproduction</i>	ZEUS

Many not dedicated UE measurements but “incidentally” sensitive to UE models

## *Being Implemented*

After the meeting in June 2004

### **H1**

- ▶ **DESY-95-219** : *Jets and Energy Flow in  $\gamma p$  at HERA,*  
Fig. 4 and Fig. 2 —→ A. BUNYANTYAN, S. MAXFIELD
- ▶ **DESY-98-148** : *Charged Particle Cross-Sections in  $\gamma p$ ,*  
Fig. 3 (a,b) —→ S. LAUSBERG, V.L.
- ▶ **DESY-00-085** : *Inclusive  $\gamma p$  of  $\pi^0$  in the Photon Hemisphere,*  
Fig. 2, 3, 5, 6 —→ D. BENECKENSTEIN, V.L.
- ▶ **DESY-02-225** : *Inclusive Jet Cross Sections in  $\gamma p$*   
Lots of plots —→ K. LOHWASSER, V.L.

### **ZEUS**

- ▶ **DESY-95-083** : *Photon Remnant in Resolved  $\gamma p$*   
—→ J. BUTTERWORTH



# Heavy Flavours in HZTool

After the October Meeting

Basically all open charm and beauty results

## H1

no	DESY-04-209	$F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ at high $Q^2$	P. D. THOMPSON
new	DESY-04-156	Inclusive $D^+$ , $D^0$ , $D_s^+$ and $D^*$ + Mesons in DIS	A. W. JUNG
new	DESY-01-105	$D^{*\pm}$ Production in Diffractive DIS	P. D. THOMPSON
yes	DESY-01-100	$D^{*\pm}$ Production and $F_2^c$ in DIS	
yes	DESY-99-126	Open Beauty Production at HERA	
yes	DESY-98-204	$D^*$ Production and Gluon Density	
yes	DESY-96-138	Inclusive $D^0$ and $D^\pm$ Production in DIS	
no	DESY-96-055	Photoproduction of $D^*$ Mesons	

+ several preliminary results

## ZEUS

O. GUTSCHE, A. GEISER (WG3)

no	DESY-03-115	charm in DIS
yes	DESY-98-085	charm in $\gamma p$
no	DESY-04-070	beauty in DIS
yes	DESY-03-212	beauty in $\gamma p$
no	DESY-03-015	charm + jets in $\gamma p$
yes	DESY-00-166	charm & beauty in $\gamma p$

+ several preliminary results

Web server/interface for MC tuning based on HZTool, implemented in Java  
(J. BUTTERWORTH, B. WAUGH)

The screenshot shows a web browser window with the URL `http://jetweb.hep.ucl.ac.uk/JetWeb/JWSearch`. The page has a yellow background and is titled "Search the JetWeb database". It includes a search bar, navigation buttons (Back, Forward, Home, Bookmarks), and a list of bookmarks. The main content area contains a form for specifying PYTHIA parameters to be changed. The form includes sections for "Common parameters" and "Enter parameters below and add them before submission".

**Search the JetWeb database**

Specify any PYTHIA parameters to be changed.

Get results | Clear all parameters | Default parameters | Get by Fit ID:  | Sort results by: Fit (All data) | Select plots to be included

**Common parameters**

Generator	Photon PDF	Proton PDF	Intrinsic transverse momentum in photon (PYTHIA) <input type="text"/> (GeV)	Intrinsic transverse momentum in proton (HERWIG photon also) <input type="text"/> (GeV)
Herwig v6.400 <input type="checkbox"/>	GRVLO <input type="checkbox"/>	GRVLO <input type="checkbox"/>		
Herwig v6.100 <input type="checkbox"/>	SaS1D <input type="checkbox"/>	CTEQ5L <input checked="" type="checkbox"/>		
Pythia v6.206 <input checked="" type="checkbox"/>	SaS2D <input type="checkbox"/>	CTEQ4L <input type="checkbox"/>		
	WHIT2 <input type="checkbox"/>			

Underlying event model(Integer 0-5)  [More info](#)

Minimum transverse momentum of hard scatters (GeV)

Enter parameters below and add them before submission

PARP	( <input type="text"/> )	=	<input type="text"/>	PARP(1-200) and PARJ(1-200) = decimals to 4SF
MSTP	( <input type="text"/> )	=	<input type="text"/>	MSTP(1-200) and MSTJ(1-200) = integers
PARJ	( <input type="text"/> )	=	<input type="text"/>	
MSTJ	( <input type="text"/> )	=	<input type="text"/>	

Add Pythia parameter(s) | Clear Pythia parameters

**Pythia Parameters Set**

PARP (67) = 4.0	MSTP (81) = 1
PARP (82) = 2.0	MSTP (82) = 4
PARP (83) = 0.5	
PARP (84) = 0.4	
PARP (85) = 0.9	
PARP (86) = 0.95	
PARP (89) = 1800.0	

<http://jetweb.hep.ucl.ac.uk/>

## *JetWeb Future – CEDAR*

### Combined E-science Data Analysis Resource

- ▶ Collaboration between UCL (JetWeb) and Durham (HEPDATA)
  - UCL: J. BUTTERWORTH, S. BUTTERWORTH, B. WAUGH
  - Durham: W. STIRLING, M. WHALLEY
- ▶ First full release in time for LHC start-up
- ▶ Three areas:
  - Reaction data: start with HEPDATA (Durham HEP database)  
migrate to relational database
  - Model validation: start with JetWeb  
replace Fortran HZTool by OO
  - Code repository with Web and Grid access

HEPDATA: <http://www-spires.dur.ac.uk/hepdata/>

## C++ Framework for Running MC Models (S. CHEKANOV)

- ▶ Desktop application (Linux, Windows/Cygwin) with graphical front-end
- ▶ Interface to major Fortran generators (will be extended to new C++ MCs):  
PYTHIA, HERWIG, ARIADNE, PHOJET, LEPTO, AROMA, RAPGAP, CASCADE
- ▶ For validations, tuning, comparisons, calculations of correction factors
- ▶ Fully integrated with the ROOT analysis environment
- ▶ Differential cross section calculations, automatic normalizations
- ▶ Different types of output (stable, stable charged, partons)
- ▶ Histograms can be viewed during event generation
- ▶ HZTool is included
- ▶ Further analysis (in C++) can be included as “physics modules”.  
Many C++ equivalents of HZTool utilities are included, e.g.
  - event kinematics,
  - jet finders,
  - event shapes,
  - ...

# RunMC C++ GUI - v 2.1

The screenshot shows the RunMC C++ GUI interface. Callouts highlight the following features:

- Select MC model:** Located at the top left, pointing to the 'LEPTO' and 'for all stable' options.
- Stable/partons?:** Located at the top center, pointing to the 'Help' and 'Exit' buttons.
- ROOT canvas:** Located at the top right, pointing to the ROOT window displaying histograms and a 3D plot.
- 1D or 2D?:** Located in the center, pointing to the histogram configuration table.
- Set histograms:** Located in the middle, pointing to the 'More histograms' button.
- Steering card editor:** Located at the bottom left, pointing to the 'RUNMC card file lept65.cards' window.
- Select jets:** Located at the bottom center, pointing to the 'Type of jet' selection dialog.

**Output histograms table:**

variable:	min	max	bins	
Q2	10.0	200.0	50	1D
X	0.0	0.0500000007	50	
N(jets)	0.0	7.0	7	2D
@ET(jets)	4.0	20.0	20	1D
@Eta(jets)	-2.0	3.0	20	1D
@Phi(jets)	-4.0	4.0	20	2D
@ET(jets)	4.0	10.0	20	
@Eta(jets)	-2.0	3.0	20	

**3D Plot Data:**

Variable	Mean x	Mean y	RMS x	RMS y
N(jets)-ET(jets)	798	1.342	0.862	0.525
@Eta(jets)	798	0.525	0.862	1.342

**Text on the right side of the ROOT canvas:**

Differential x-section in p  
 4909 events requeste  
 4908 events generate  
 x-section 1.184837e+05 p  
 Luminosity 4.142341e-02 p

**Histogram selector list:**

- none
- PTtot: transverse event momenta
- PZtot: longitudinal event momenta
- Etot: total event energy
- N(tot): total number of particles in event
- @Px: Px of all particles
- @Py: Py of all particles
- @Pz: Pz of all particles
- energy of all particles
- energy\*\*2 for particles
- angle for all particles
- angle of all particles
- rapidity: -ln(tan(theta/2))
- i.e. 0.5\*ln((E+pz)/(E-pz))

# RunMC Java GUI - v 3.3

The image displays the RunMC Java GUI interface, which is divided into several panels for configuring Monte Carlo simulation parameters.

**Main Configuration Window (JRunMC):**

- Menu:** File, RMC project, Options, Help
- Tabs:** Welcome, MC model, Settings, Output, Options, Control
- Particle Selection:** e- and e+ dropdowns, "for all stable" dropdown.
- CTEQ:** Two dropdowns, both set to "CTEQ".
- Energy:** E1(GeV) and E2(GeV) input fields, both set to 250.0.
- Options:** "laboratory frame" dropdown, "separate particles" dropdown, and "Particle settings" button.
- Buttons:** "Steering card" button.
- Model and Project Info:** Selected model: **PYTHIA**, Project name: **default**, Events No: **1000**.
- Initial state:** e+(250.0 GeV) e-(250.0 GeV)
- Final state:** for all stable; jets: none
- Output:** default.root
- Histograms:** 0 histograms
- Canvas:** Show all plots
- Status:** Last action: show particle settings, 2/4Mb
- Run Button:** A large "run" button is present on the right side.

**Steering card editor:**

- Menu:** File, Options
- Table:**

No	Parameter	Index I	Index II	Value	Comments
1		0	0		
2		0	0		
3		0	0		
4		0	0		
- Buttons:** Save, Exit, add new row, remove selected

**Variables and Histogram editor:**

- Menu:** File, Options
- Table:**

No	Title	D
1	Etot	1
2	@Py	1
3	@Pz	1
4	@E	1
5	@Py	1
6	@E	1
- List of Variables:**
  - PTtot: transverse event
  - PZtot: longitudinal even
  - Etot: total event energy
  - N(tot): total number of p
  - @Px: Px of all particles
  - @Py: Py of all particles
  - @Pz: Pz of all particles
  - @E: Energy of all part
  - @Perp2: px\*\*2 + py\*\*2 fo
  - @Perp: sqrt(Perp2) for p
  - @Phi: azimuthal. angle
  - @Theta: polar angle of al
  - @Eta: pseudo-rapidity:
  - @Rapidity: rapidity: i.e. 0.5\*I
- Buttons:** Save, Exit, remove se

**Particles:**

- ET (min):** 0.0
- ET (max):** 1000000.0
- ETA (min):** -999.0
- ETA (max):** 999.0
- Button:** Exit

# *Sbumps*

Analysis framework for automatic search and identification of peaks (S. CHEKANOV)

Not MC, but useful tool for searches. Motivation:

- ▶ To search peaks in invariant masses is a tedious task (especially if you do not know that you are looking for)
- ▶ Need to check many mass assumptions
- ▶ 2,3,4 etc. body decays should be looked at
- ▶ Reflections from known states should be removed

Features:

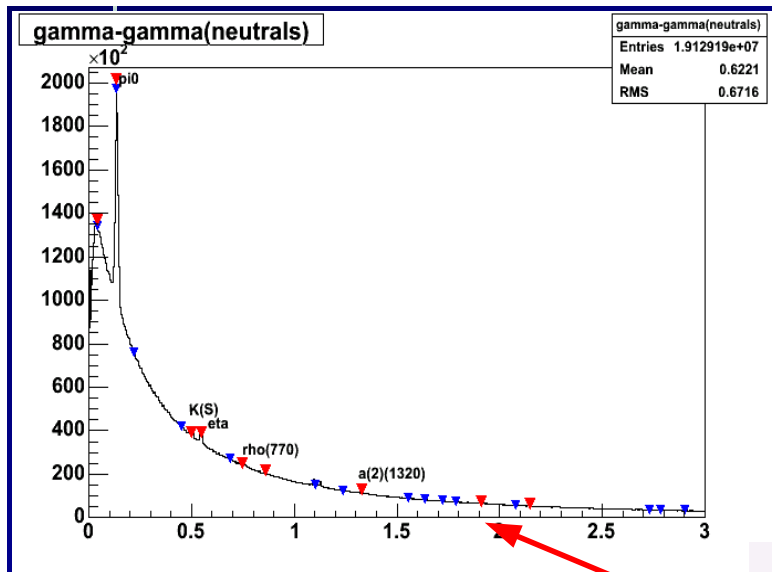
- ▶ Written in C++ using ROOT libraries
- ▶ Input: 3-momenta + probabilities for each particle
- ▶ For given mass assumptions, creates and fills histograms
- ▶ Automatically searches for peaks
- ▶ Identifies known PDG states and reflections
- ▶ Makes reports on unknown states
- ▶ Of course, it cannot do full physics analysis!

<http://www.desy.de/~chekanov/sbumps/>

# Sbumps

Approach:

- ▶ Fast algorithm using Markov approach for peak searching in presence of background and statistical noise
- ▶ It was developed for gamma-ray physics and usually does not work correctly for searches in invariant masses
- ▶ Therefore, this algorithm was used only to create seeds with suspected peaks
- ▶ Final peaks were identified after analysis of the seed peaks



Example results:

- ▶ 5 peaks are identified!
- ▶ 1 peak – background shape
- ▶ 3 peaks found, but could not be matched with known PDG states – reflections?



## *Summary of Projects*

- ▶ PDF libraries
- ▶ Generator and model developments
- ▶ MC validation, tuning tools

*Many developments during this Workshop!*

*Many fruitful discussions!*

*Thanks to the organisers!*

*Thanks to the co-convenors!*

*Thanks to the participants!*

*Thank you!*