Summary of WG5 'MC Tools'

VICTOR LENDERMANN
University of Heidelberg
H1 Collaboration

Conveners:
V. LENDERMANN, A. NIKITENKO, E. RICHTER-WAS, P. ROBBE, M. SEYMOUR

HERA–LHC Plenary Meeting CERN, Oct 13, 2004

Projects in WG5 'MC Tools' (1)

- LHAPDF development
  M. Whalley, D. Bourilkov
- Diffractive PDF library
  F.-P. Schilling
- HzTool development and MC tuning: UE/MI models *(common with WG2)*
  J. Butterworth, B. Waugh, ? (ZEUS);
  D. Beneckenstein, S. Lausberg, V. Lendermann,
  K. Lohwasser, S. Maxfield (H1)
- HzTool development and MC tuning: Heavy Flavours *(common with WG3)*
  New project $\longrightarrow$ to discuss today with WG3 conveners
- PYTHIA tuning with HERA data for meson resonance production
  A. Kropivnitskaya
- MC tuning to describe leading proton distributions
  G. Iacobucci

Projects in WG5 'MC Tools' (2)

- Comparisons of CASCADE and leading order MCs at LHC
  G. DAVATZ, A. NIKITENKO: jet veto efficiency for $gg \longrightarrow H$ at CMS
- CASCADE development – inclusion of quarks and multiple interactions
  H. JUNG
- RAPGAP development – inclusion of proton dissociation models
  H. JUNG, S. VINOKUROVA
- MC@NLO development – making a HERA version
  S. FRIXIONE, ?
- NLOLIB development
  K. RABBERTZ – inclusion of pp programs
  T. SCHÖRNER-SADENIUS – inclusion of JetViP
- Non-Markovian MC algorithm for QCD evolution *(common with WG2)*
  S. JADACH, M. SKRZYPEK

Projects in WG5 'MC Tools' (3) – "Brave New World"

- Next generation tools – Overview
  - ThePEG
    L. Lönnblad, S. Gieseke, A. Ribon, P. Richardson
  - PYTHIA 7
    L. Lönnblad, T. Sjöstrand
  - HERWIG++
    S. Gieseke, A. Ribon, P. Richardson, M. Seymour, P. Stephens, B. Webber
  - ARIADNE
    L. Lönnblad, N. Lavesson
  - SHERPA
    T. Gleisberg, S. Höche, F. Krauss, A. Schälicke, S. Schumann, J. Winter
- JetWeb – WWW interface to HzTool
  J. Butterworth, B. Waugh
- RunMC – C++ object-oriented framework for running MC models
  S. Chekanov
- Sbumps – C++ framework for automatic peak searching and identification
  S. Chekanov

LHAPDF Version 3

Started by W. GIELE, continued by M. WHALLEY

- Replacement for PDFLIB
- PDFLIB no longer maintained and does not have the latest PDF sets
- The "error PDF sets" would not easily be included in PDFLIB

- On-the-fly QCD evolution of PDFs starting from fitted f(x) at Q_0^2
  as produced by the PDF authors (MRST, CTEQ, ..)
  Small external xxxx.LHpdf files (plug-and-play)
- Now also interpolation code methods of the authors (like PDFLIB)
  big xxxx.LHgrid files
  ⟶ can include older legacy PDF sets
  ⟶ much faster

New:

- ZEUS 2002 – LHpdf file using QCDNUM (thanks to A. Cooper-Sarkar)
- H1 2000 – LHgrid file (thanks to C. Pascaud)
- MRST2003c (NLO and NNLO) – LHpdf and LHgrid files

Legacy:

- CTEQ4, CTEQ5, GRV98
  all using the original interpolation codes, i.e. LHgrid files

LHAGLUE

PDFLIB like interface to LHAPDF (by D. Bourilkov and Craig 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 PYTHIA or HERWIG codes

10000-19999	CTEQ
20000-29999	MRST
30000-39999	Fermilab
40000-49999	Alekhin
50000-59999	Botje
60000-69999	ZEUS
70000-79999	H1
80000-89999	GRV

See online manual: http://durpdg.dur.ac.uk/lhapdf/

PDF Library – Further Issues

What about

- photon PDFs ?
- unintegrated PDFs ?
- diffractive PDFs ?

dPDFLIB or dLHAPDF

F.-P. SCHILLING – talk in WG4

Two philosophies possible:

- Provide independent library for diffraction
- Provide add-on for LHAPDF:
  - $\mathcal{P}/\mathcal{R}$ pdfs+errors via LHAPDF
  - Fluxes and all diffraction specific rest as add-on library

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 collisions of LEP (OPAL)
- Easily extendable to TEVATRON and LHC data
- One routine per publication includes histos filled with published data and histos being filled by running MCs for comparison
  DESY–XX–XXX $\Longleftrightarrow$ hzXXXXX.F

Documentation: http://hztool.hep.ucl.ac.uk/
http://www.desy.de/~carli/hztool.html

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

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

To Be Implemented

After the meeting in June 2004

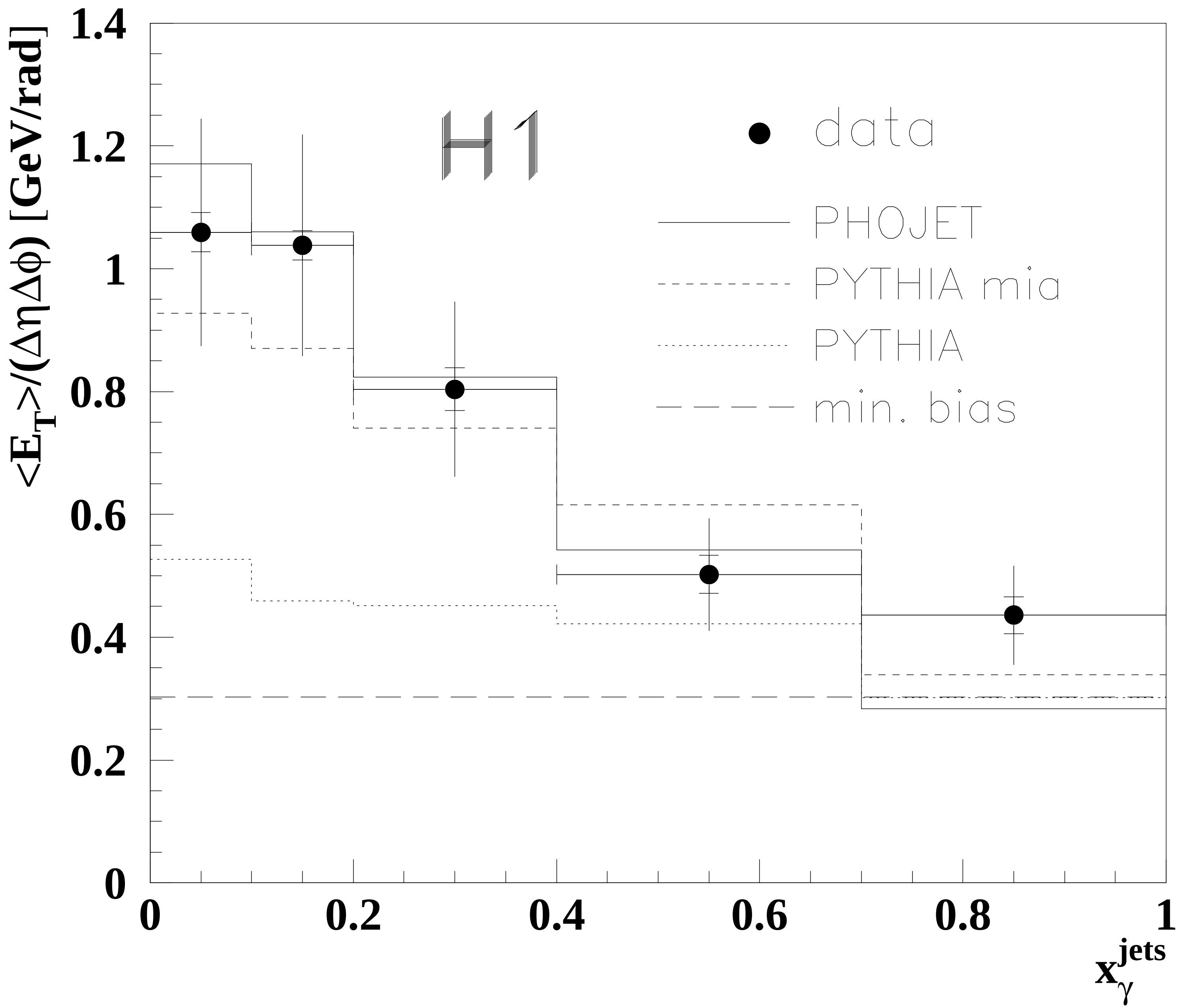
H1

- DESY–95–219 : *Jets and Energy Flow in γp at HERA,*
  Fig. 4 and Fig. 2 $\longrightarrow$ S. Maxfield
- DESY–98–148 : *Charged Particle Cross-Sections in γp,*
  Fig. 3 (a,b) $\longrightarrow$ S. Lausberg, V.L.
- DESY–00–085 : *Inclusive γp of π^0 in the Photon Hemisphere,*
  Fig. 5 + possibly 2, 3, 6 $\longrightarrow$ D. Beneckenstein, V.L.
- DESY–02–225 : *Inclusive Jet Cross Sections in γp*
  Lots of plots $\longrightarrow$ K. Lohwasser, V.L.

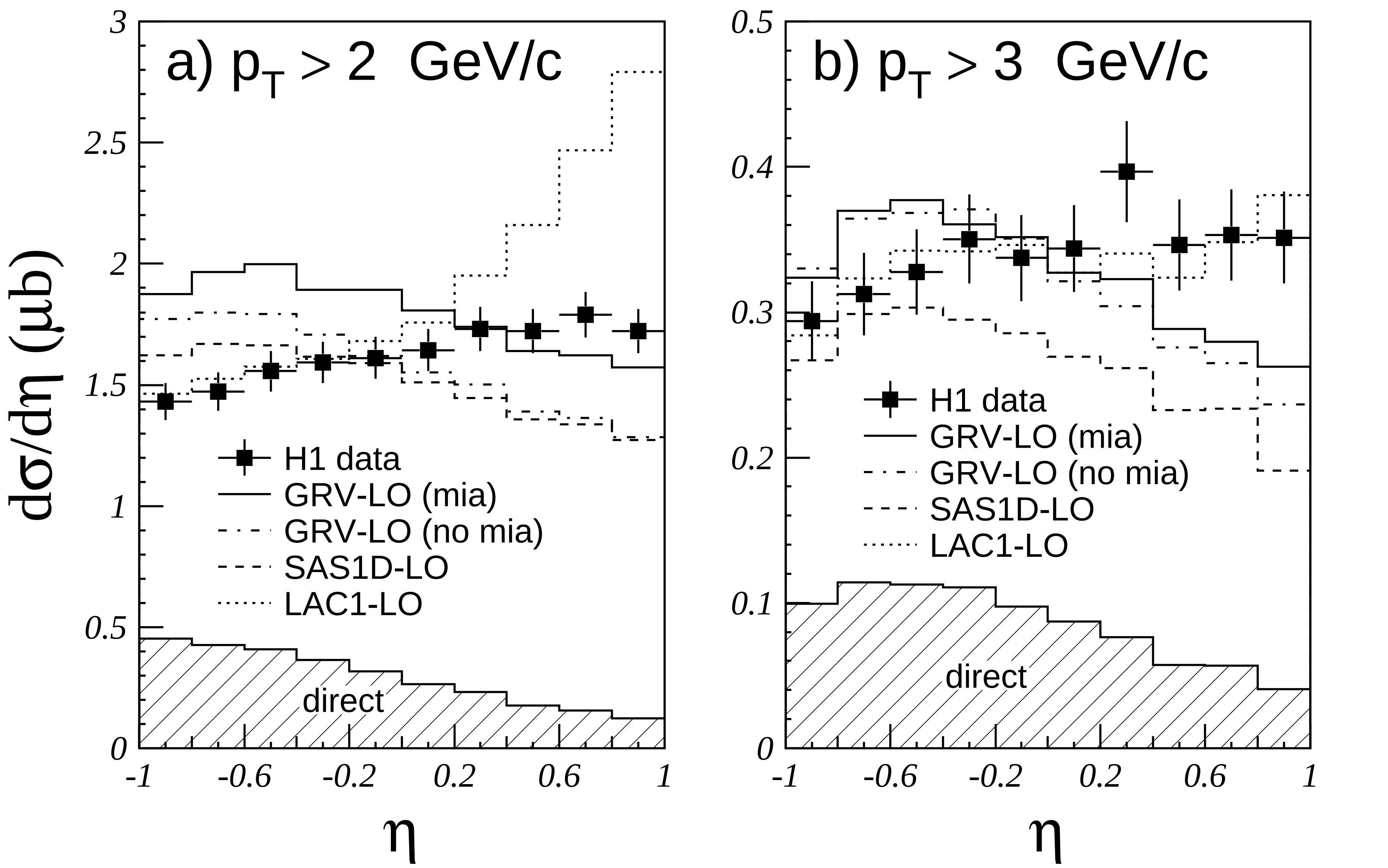
ZEUS

- DESY–95–083 : *Photon Remnant in Resolved γp*
  difficult to implement $\longrightarrow$ J. Butterworth

DESY–95–219, Jets and Energy Flow



DESY–98–148, Charged Particles in γp



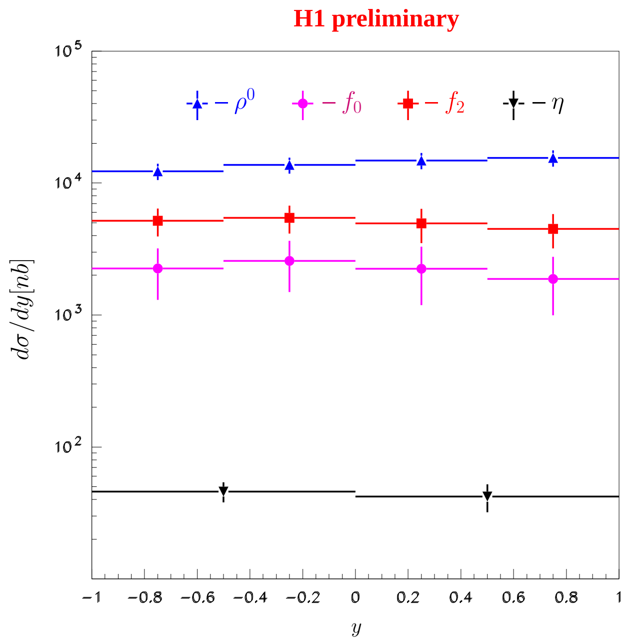
Production of Higher Meson Resonances

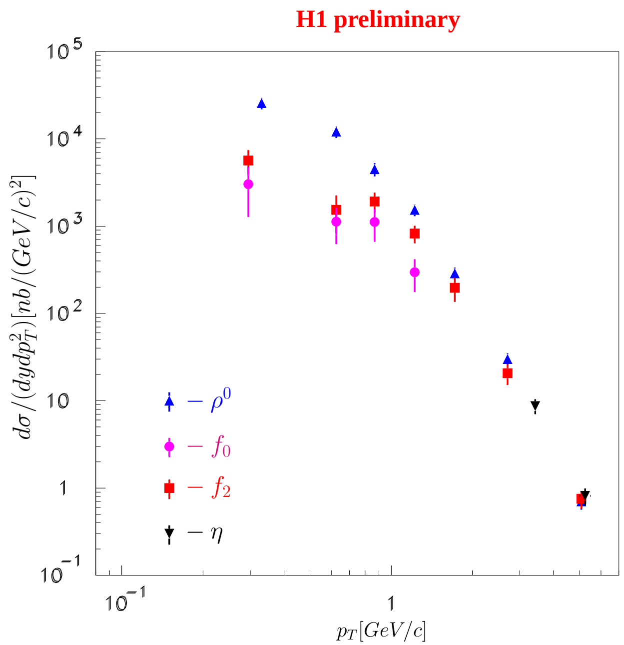
H1prelim–03–037 for DIS'03

Measurement of Inclusive γp of η, ρ^0, f_0 and f_2 Mesons at HERA

Test PYTHIA tunes by LEP at HERA $\longrightarrow$ A. KROPIVNITSKAYA ●

PARJ(14)	P(S=0,L=1,J=1)	Axial
PARJ(15)	P(S=1,L=1,J=0)	Scalar
PARJ(16)	P(S=0,L=1,J=1)	Axial
PARJ(17)	P(S=0,L=1,J=2)	Tensor

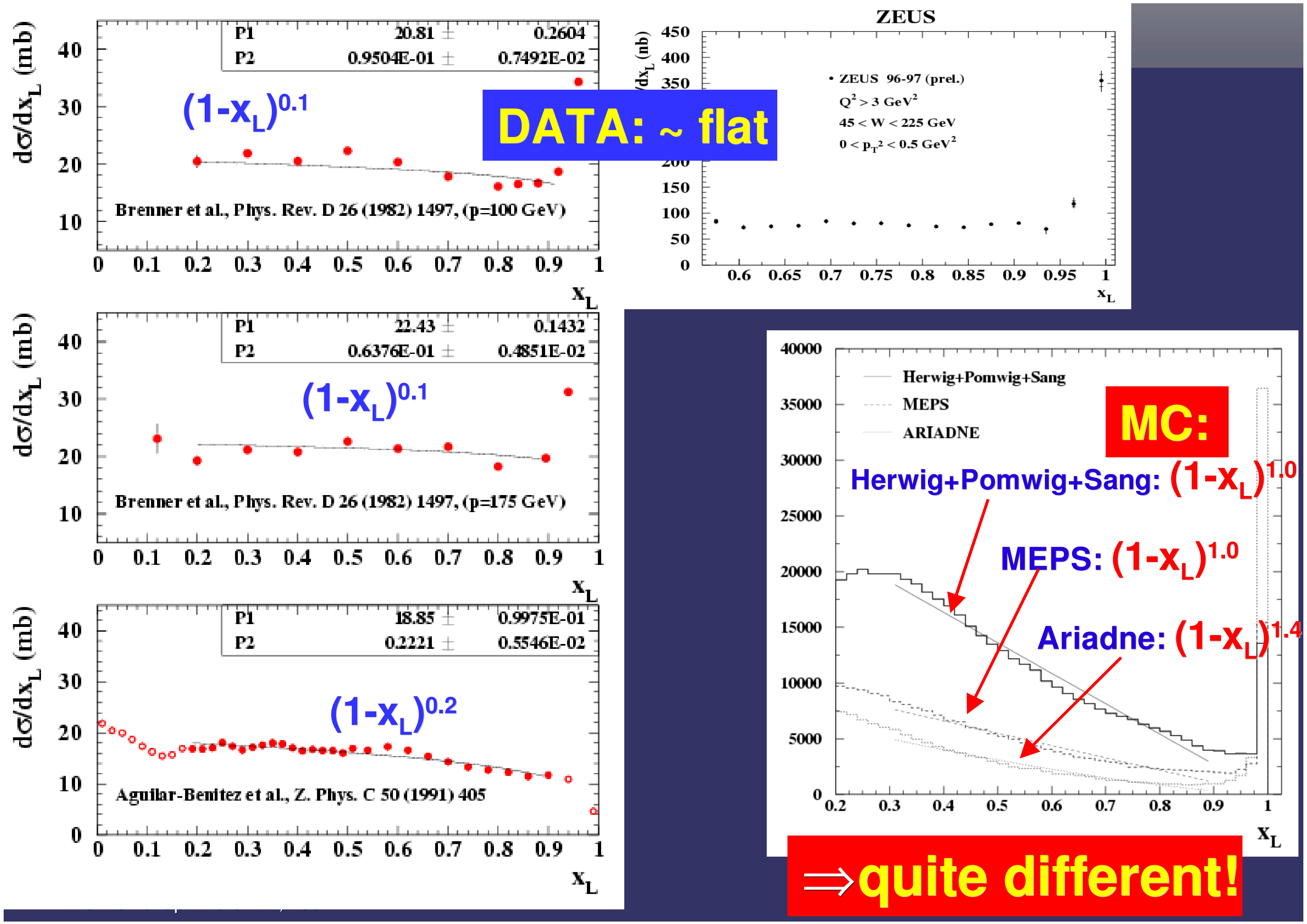




(T.S.) But what about "basic", e.g., strangeness fragmentation (WG2)?

Leading Protons in DIS at HERA

by G. Iacobucci



Seems to be quite difficult task for tuning

NLOLIB

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
- Examples how to run it and how to implement your own code
- Allows comparisons to experimental results via HzTool

Already implemented:

- DISASTER++, Disent and Mepjet: jet production in ep
- Racoon: electroweak physics in e^+e^-

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

NLOLIB Development

Current project by T. SCHÖRNER:

- JetViP: NLO jets in ep/e^+e^- with direct and resolved contributions

Status:

- ep basically implemented but still some bugs
- e^+e^- to be done
- considering pp program by M. KLASEN with similar structure

Outlook:

- Refine modular structure
- Implement NLOJET
- Hope to have pp NLO programs in NLOLIB by the end of the Workshop
- Give a tutorial in one of next meetings

$gg \longrightarrow H$ Uncertainties due to Jet Veto

G. Davatz

Signal: $gg \longrightarrow H \longrightarrow WW \longrightarrow l\nu l\nu$
2 isolated leptons, small opening angle between leptons, missing p_T, no jets

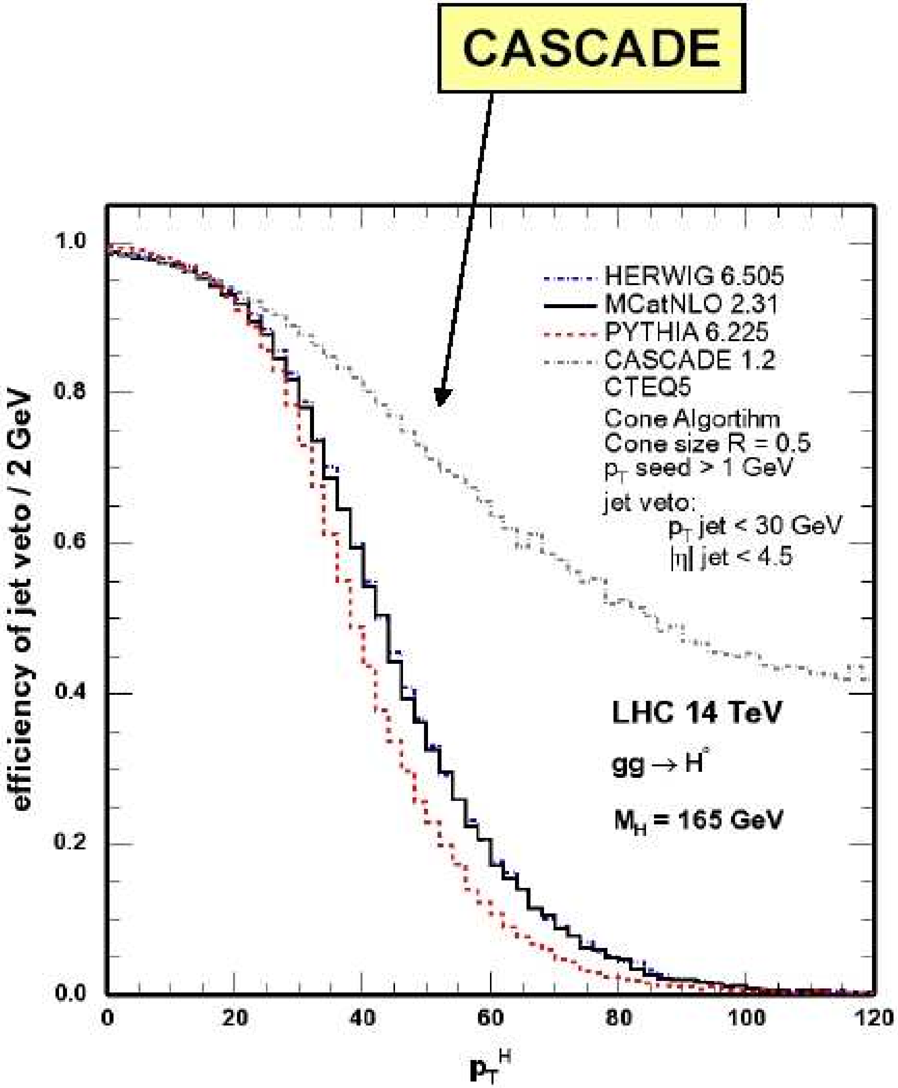
- Higgs discovery channel between $2M_W$ and $2M_Z$
- Dominant background: nonresonant WW, $t\bar{t}$ and Wtb

Jet veto crucial to reduce top-background
$\longrightarrow$ Get uncertainty of jet veto for different MC
PYTHIA, HERWIG, MC@NLO, CASCADE

For this study:

- Cone algorithm, $p_{t,\text{jet}} > 20\,\text{GeV}$, $|\eta|_{\text{jet}} < 4.5$, $R = 0.5$, $p_{t,\text{seed}} > 1\,\text{GeV}$
- Jet veto $p_t < 30\,\text{GeV}$

Efficiency for Jet Veto Including CASCADE



- Difference due to missing quark induced processes in CASCADE?
- If so, way to distinguish quark and gluon induced processes!
- Direct measurement at HERA for LHC
- Under study

CASCADE development (H. JUNG)

- Inclusion of quarks
- Inclusion of MI

Non-Markovian (constrained) MC Algorithm for QCD evolution

S. Jadach, M. Skrzypek

Basic facts:

- Markovian MC implementing the 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 the ISR cascade the elegant Backward Markovian MC algorithm of Sjöstrand (Phys.Lett. 157 B, 1985) is a widely adopted remedy
- Backward Markovian MC does not solve the QCD evolution eqs. It merely exploits their solutions coming from the external non-MC methods

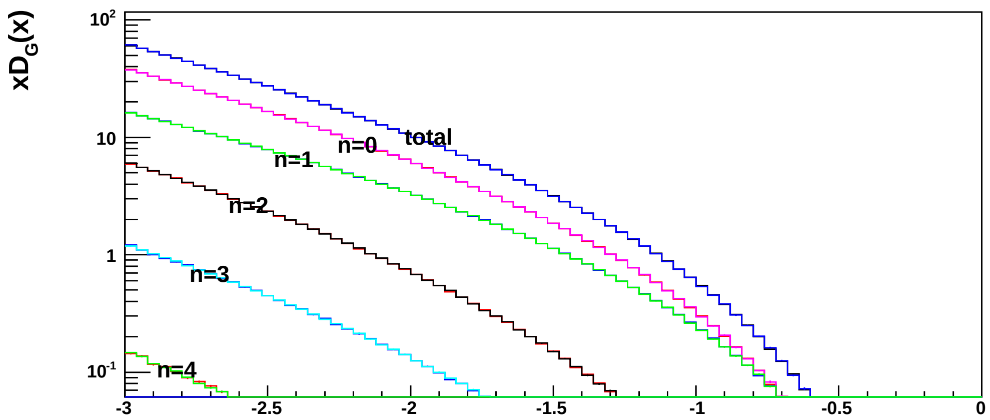
The problem:

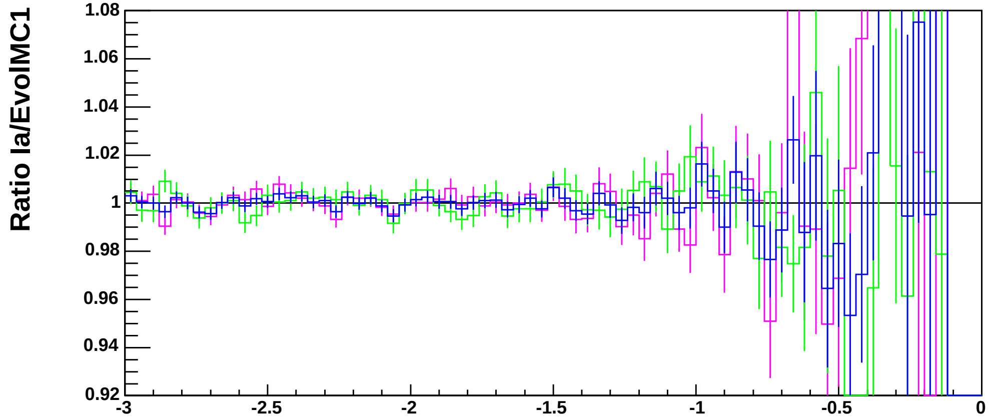
- Is it possible to invent an efficient MC algorithm, non-Markovian, solving internally the evolution eqs. by its own?

Motivation:

- More freedom in the modeling the ISR parton shower
- Easier MC modeling of the unintegrated parton distributions $D_k(p_T, x)$
- MC modeling of the CCFM class of the QCD calculations/models

Test of Gluon Bremsstrahlung



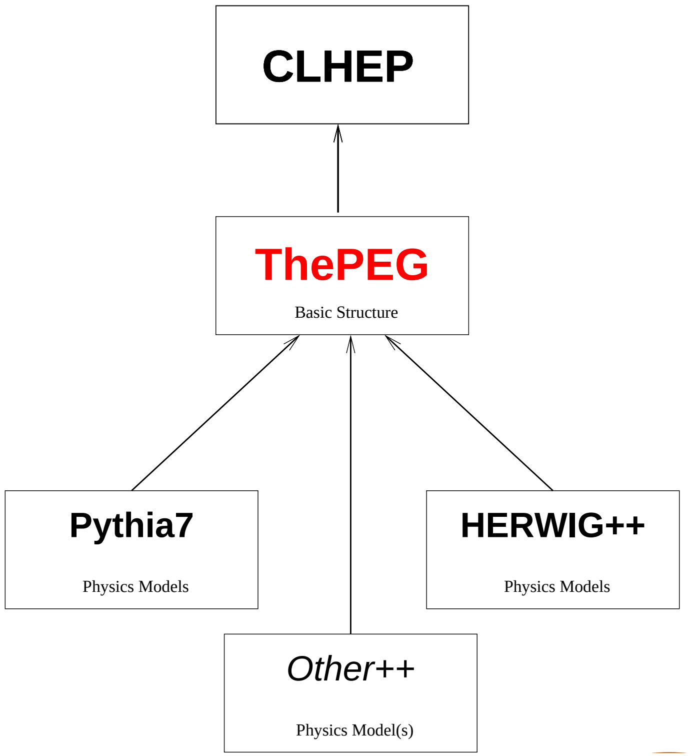


- Histogram $n = 0$ represents pure gluon bremsstrahlung out of gluon line
- Starting distr. is gluon in proton at Q = 1 GeV. Plotted distr. is at 1 TeV.
- Compared results from unconstrained Markovian MC (EvolFMC) and the new non-Markovian constrained MC (EvolCMC)
- They agree within statistical error of 0.25% (100M events)

Plans

- Aim: models/programs for unintegrated PDFs
  for W and Z production at LHC based on CCFM
- First complete MC by next summer?
- Fitting $F_2(x;Q^2)$ of DIS with non-markovian CMC at some point in future

ThePEG, PYTHIA 7, HERWIG++



ThePEG includes:

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

PYTHIA 7 / ThePEG includes:

- Some basic $2 \longrightarrow 2$ matrix elements
- Couple of PDF parameterizations
- Remnant handling
- Initial- and final-state parton showers
- Lund string fragmentation and particle decays

HERWIG++ includes:

- New parton shower algorithm
- Improved cluster fragmentation

Mainly e^+e^-. Hadronic collisions in progress

Work in Progress

ThePEG:

- Documentation
- Java GUI

PYTHIA 7:

- Rework fragmentation to include junction strings
- Multiple Interactions
- All the rest. . .

HERWIG++:

- Initial state PS
- Underlying Event
- SUSY/BSM stuff
- Better hadronic decays, Spin and Helicity stuff ready (RICHARDSON)
- All the rest. . .

ARIADNE:

- Dipole shower
- LDC model with multiple interactions

Particle Data Exchange

- Particles in event generators cannot simply be inputted from the PDG
- For many particles the data are far from complete
- Branching ratios rarely sum to one and are sometimes useless
- What decay modes are included depends on how you simulate the decay

Herwig++ Particle Data Base

MySQL database (P. RICHARDSON)

- Include comments and other information
- Generate the data files for event generation automatically
- Allows the data to be viewed and edited more easily via a Web interface

Users will be able to:

- View the particle data in a way they can understand
- Know what came from the PDG or experimental data
  and what logic was used to make up the rest

SHERPA

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

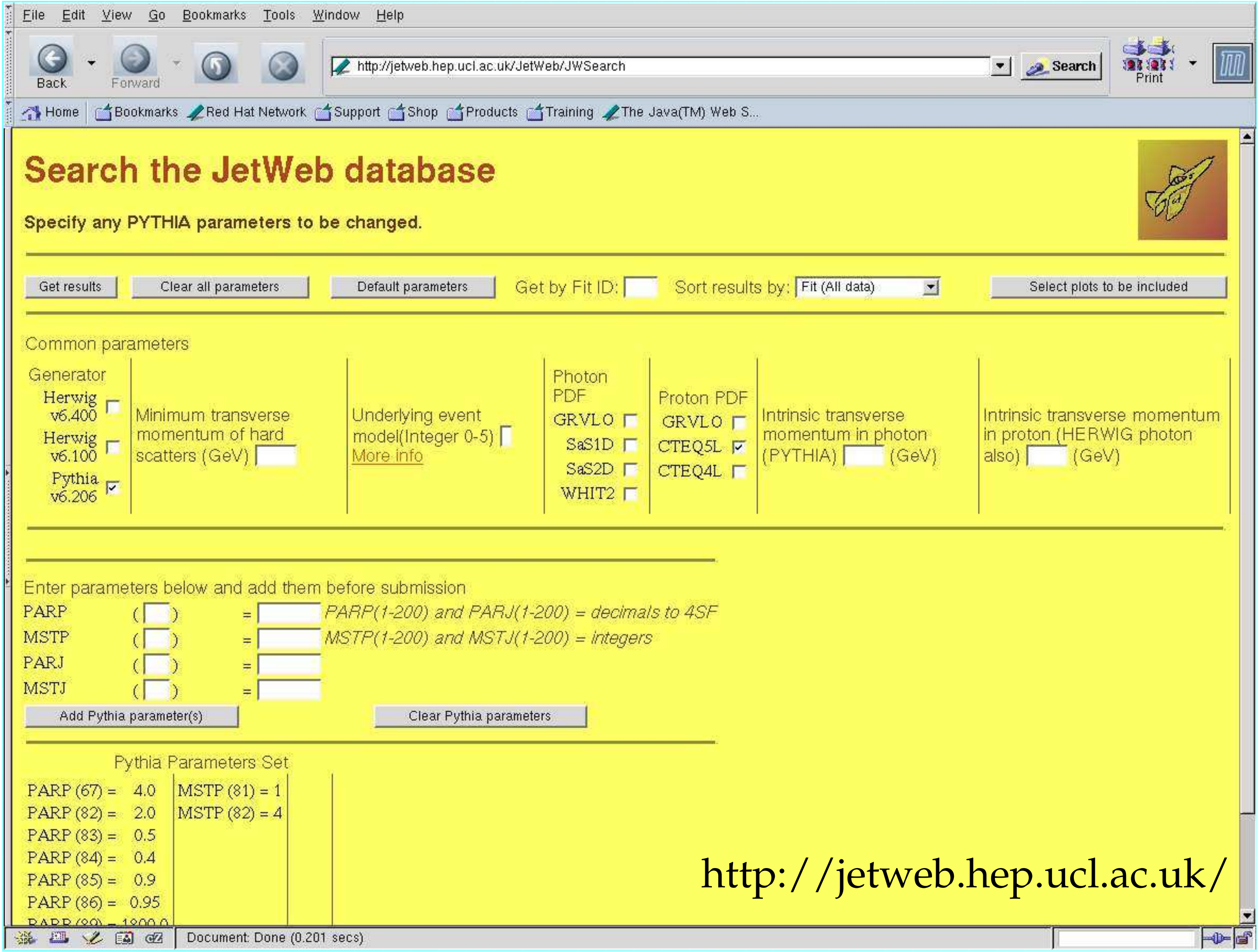
- ME generator AMEGIC++
  providing the MEs for hard processes and decays in SM, MSSM and ADD
- PS module APACIC++
  containing a virtuality ordered initial and final state parton showers
- combination of MEs and PSs á la CKKW
  (First results for W/Z+jets production presented – work ongoing)
- Interface to PYTHIA string fragmentation and hadron decays
- Next release: module AMISIC++
  providing hard UE model – similar to PYTHIA
  (Comparisons SHERPA $\longleftrightarrow$ PYTHIA 6.2 presented)
  Plan: UE model tuning for next meeting in January

“SHERPA is a powerful tool to attempt the description of present-day Tevatron data and to study the extrapolation to LHC energies”

JetWeb

Web server/interface for MC tuning based on HzTool, implemented in Java

(J. Butterworth, B. Waugh)



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/

RunMC

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

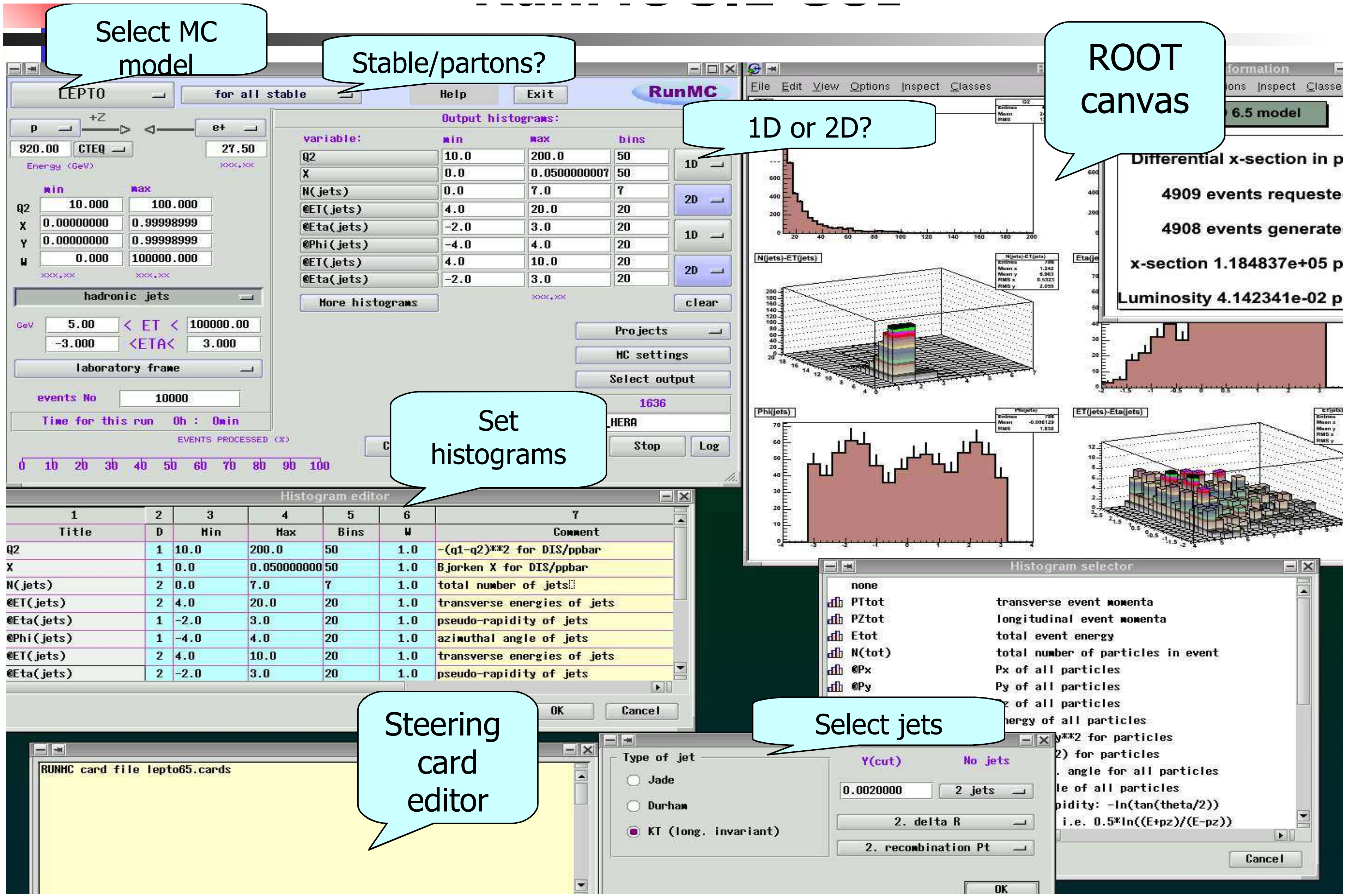
- Desktop application (Linux, Windows/Cygwin) with graphical front-end
- Interface to standard Fortran generators (can be extended to new C++ MCs)
- Good for validations, tuning, comparisons, calculations of correction factors
- Fully integrated with the ROOT analysis environment
- Differential cross section calculations, automatic normalizations
- Different types of output (stable, stable charged, partons)
- Histograms can be viewed during event generation
- Project files. Currently available:

default.rmc	No any MC settings and physics calculations. Only dummy functions
dis_kinematics.rmc	DIS kinematic variables for HERA (Q^2, x, ...)
charm_dis.rmc	Studies of D^* cross sections in DIS (HERA)
dis_strange.rmc	Strangeness production (cross sections for K^0, Λ ...)
jets_HERA.rmc	Jets at HERA using longitudinally-invariant KT algorithm (Breit frame)
jets_LHC.rmc	Jets at LHC using the longitudinally-invariant KT algorithm (Lab. frame)
jets+charm_LHC.rmc	Jets at LHC + charm production (Lab. frame)
invariant_mass.rmc	Invariant masses of two particles in e^+e^-
event_shapes.rmc	Event shape studies

- Disadvantage: no data – interface to HzTool missing

http://www.desy.de/~chekanov/runmc

RunMC GUI



Select MC model
Stable/partons?
ROOT canvas
1D or 2D?
Set histograms
Steering card editor
Select jets
LEPTO
for all stable
Help
Exit
RunMC
Output histograms:
variable:
min
max
bins
hadronic jets
laboratory frame
events No
10000
Time for this run
EVENTS PROCESSED (%)
More histograms
clear
Projects
MC settings
Select output
Stop
Log
Histogram editor
Histogram selector
Differential x-section in p
4909 events requeste
4908 events generate
x-section 1.184837e+05 p
Luminosity 4.142341e-02 p
RUNMC card file lepto65.cards
Type of jet
Jade
Durham
KT (long. invariant)
Y(cut)
No jets
OK
Cancel

Sbumps

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

Not MC, but useful tool for searches. Motivation:

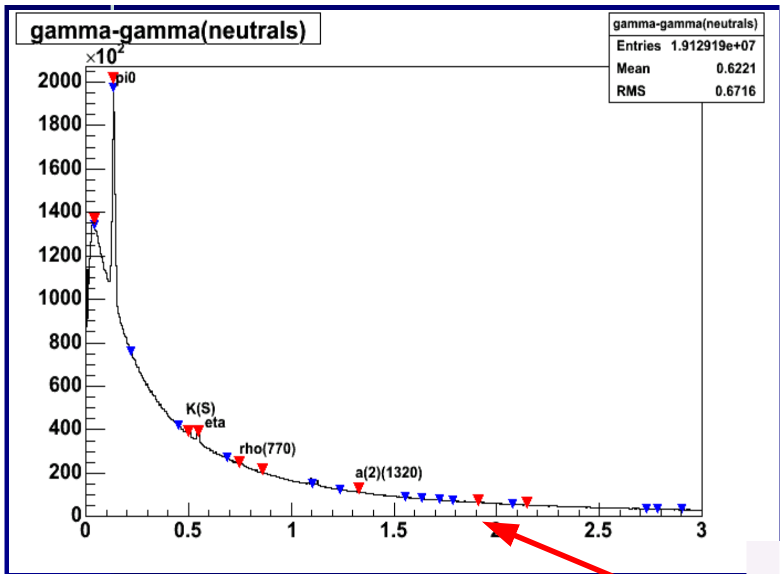
- To search peaks in invariant masses is a tedious task (especially if you do not know that your are looking for)
- Need to check many mass assumptions
- 2,3,4 etc. body decays should be looked at
- Reflections from known states should be removed

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

- New PDF library (LHAPDF, . . .)
- Generator development (CASCADE, RAPGAP, MC@NLO, non-Markovian, C++ generators)
- MC validation, tuning tools (HzTool, NLOLIB)
  tuning of UE models, heavy flavours
- OO based front-ends and tools (JetWeb, RunMC, Sbumps, . . .)