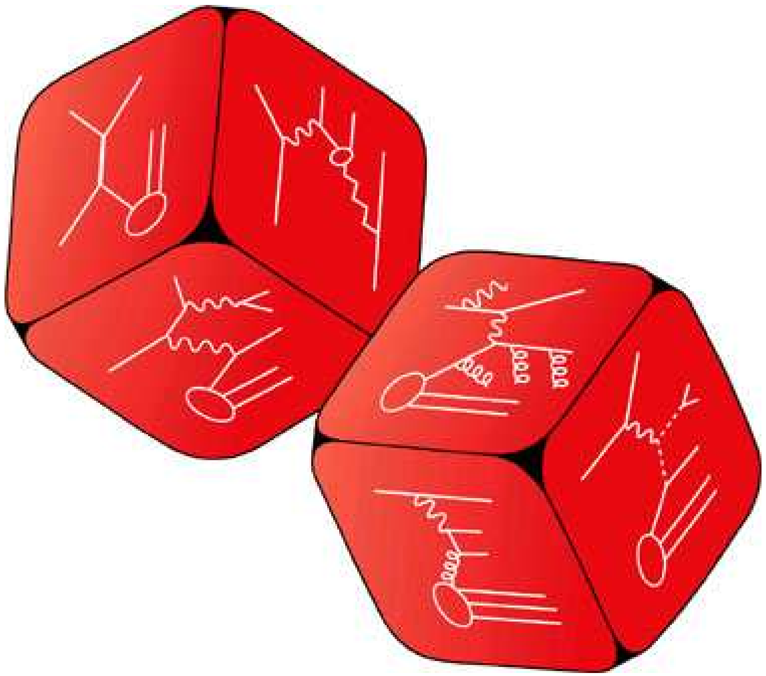
Summary of WG5 'MC Tools'

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 $\longrightarrow$ WG2
- Multijet final states $\longrightarrow$ WG2
- Matrix element – parton shower matching
- New developments for parton showers

LHAPDF – Les Houches Accord PDF Library

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Replacement for PDFLIB which is no longer maintained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 $\longrightarrow$ small .LHpdf files
- Grids like in PDFLIB $\longrightarrow$ 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)
- …

Diffractive 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) $\longrightarrow$ WG2
- Predictions for multijet final states at LHC $\longrightarrow$ WG2
- ME/PS matching
- New developments of parton shower models

RapGap

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/

AcerMC version 2.0

B. Kersevan, E. Richter-Was

Simulation of background processes for Higgs searches at LHC

Processes:

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

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

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

AcerDET

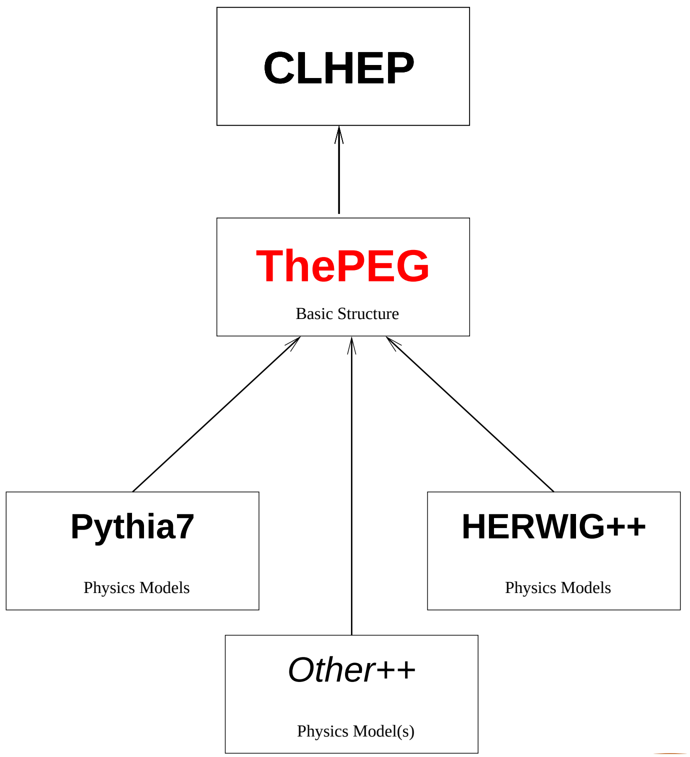
E. RICHTER-WAS

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

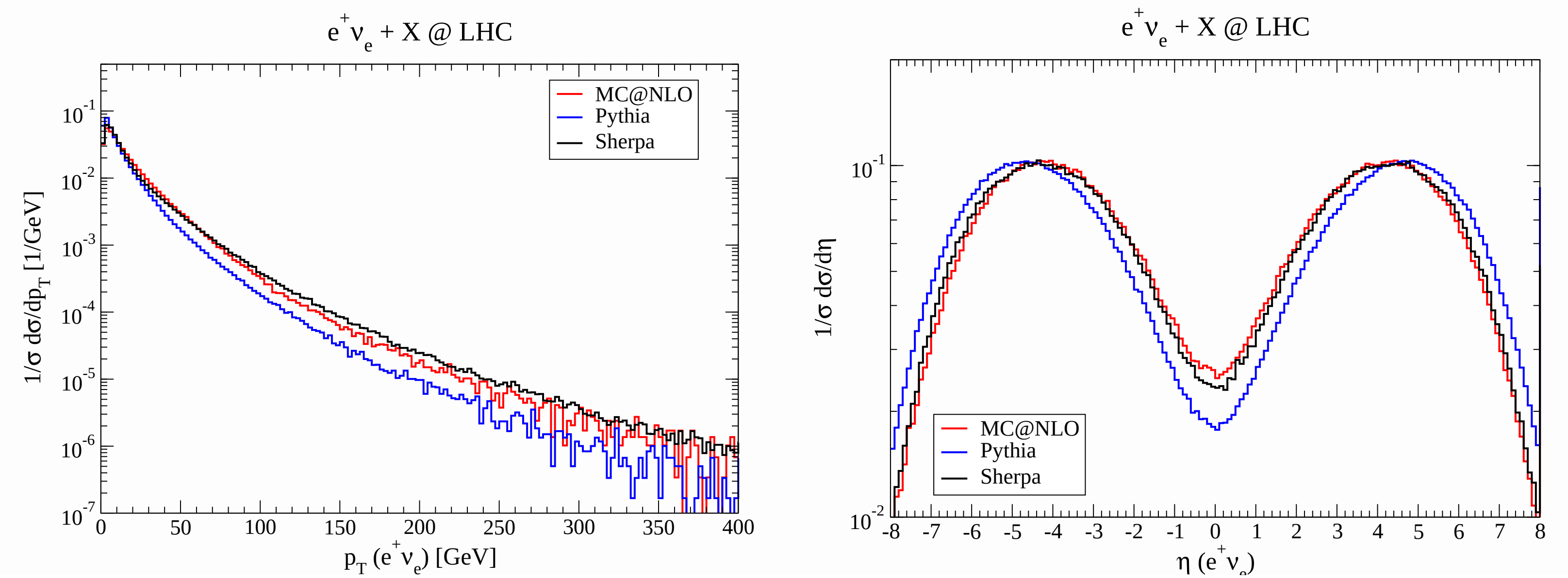
Combine LO Matrix Elements and Parton Showers according to CKKW

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 + jet production at Tevatron (and LHC)
- However, the rates are not NLO

Outlook:

- Comparisons with MLM and ARIADNE

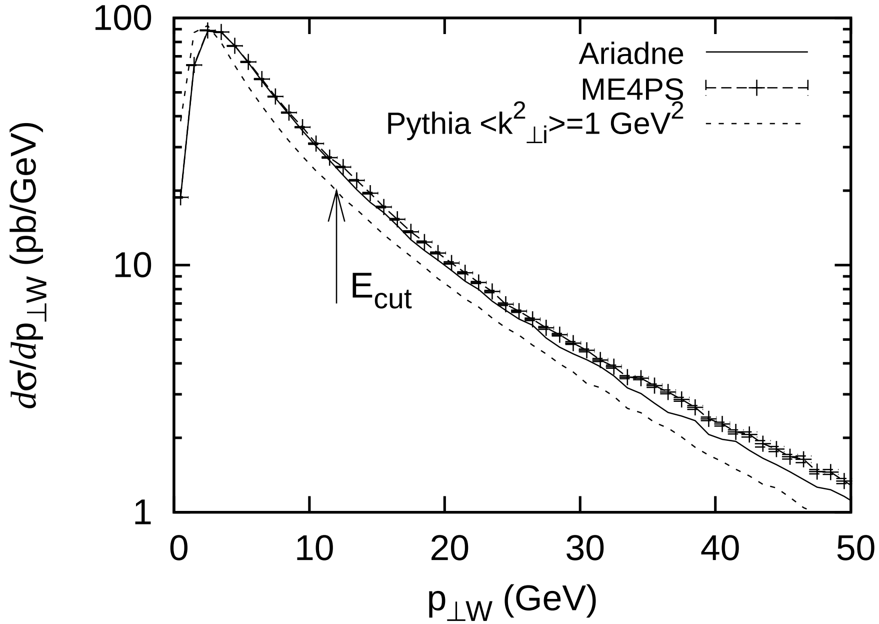
W + Jets Matrix Elements and ARIADNE

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 bremstrahlung 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:

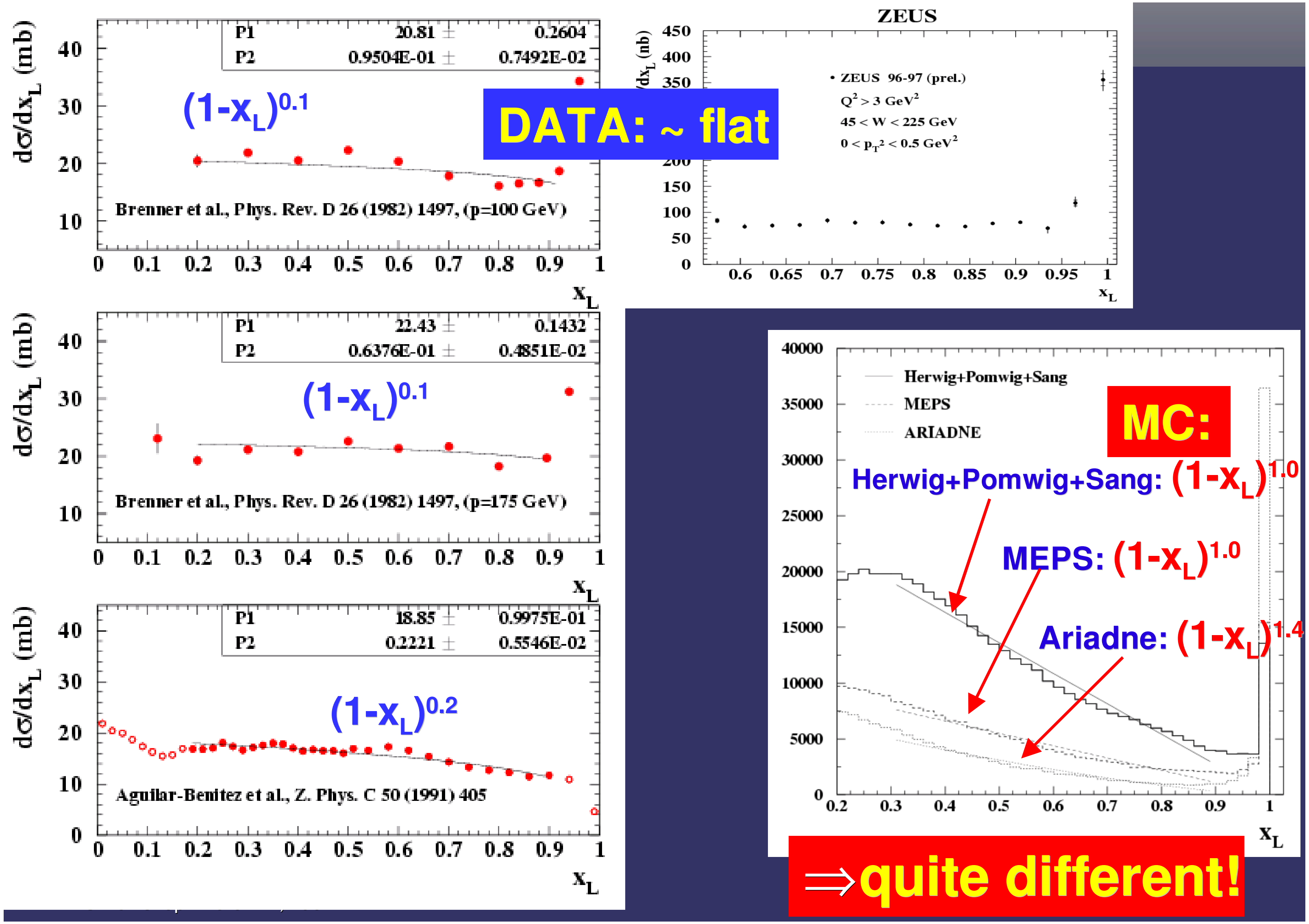
- New efficient CMC algorithm for $\overline{\rm MS}$ DGLAP evolution in October
- Key points are MC efficiency and numerical stability
- Pure bremsstrahlung is the critical part of the CMC algorithm
- Now checked to work efficiently for HERWIG evolution.
  Still to check quark-gluon transitions

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



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 — jet production in ep
- DISASTER++ 1.0.1 — jet production in ep
- MEPJET 2.2 *(numerical problems)* — jet production in ep
- RacoonWW 1.1 — electroweak physics in e^+e^-
- JetViP 2.1 *(not fully finished)* — jet production in ep and e^+e^-
- NLOJET++ 2.0.1 *(work in progress)*

Examples:

- Event shape calculations for ep collisions
- $ee \to WW \to 4f$ 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 $\Longleftrightarrow$ hzXXXXX.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	*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

Being Implemented

After the meeting in June 2004

H1

- DESY–95–219 : *Jets and Energy Flow in γp at HERA,*
  Fig. 4 and Fig. 2 $\longrightarrow$ A. BUNYANTYAN, 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. 2, 3, 5, 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*
  . $\longrightarrow$ 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

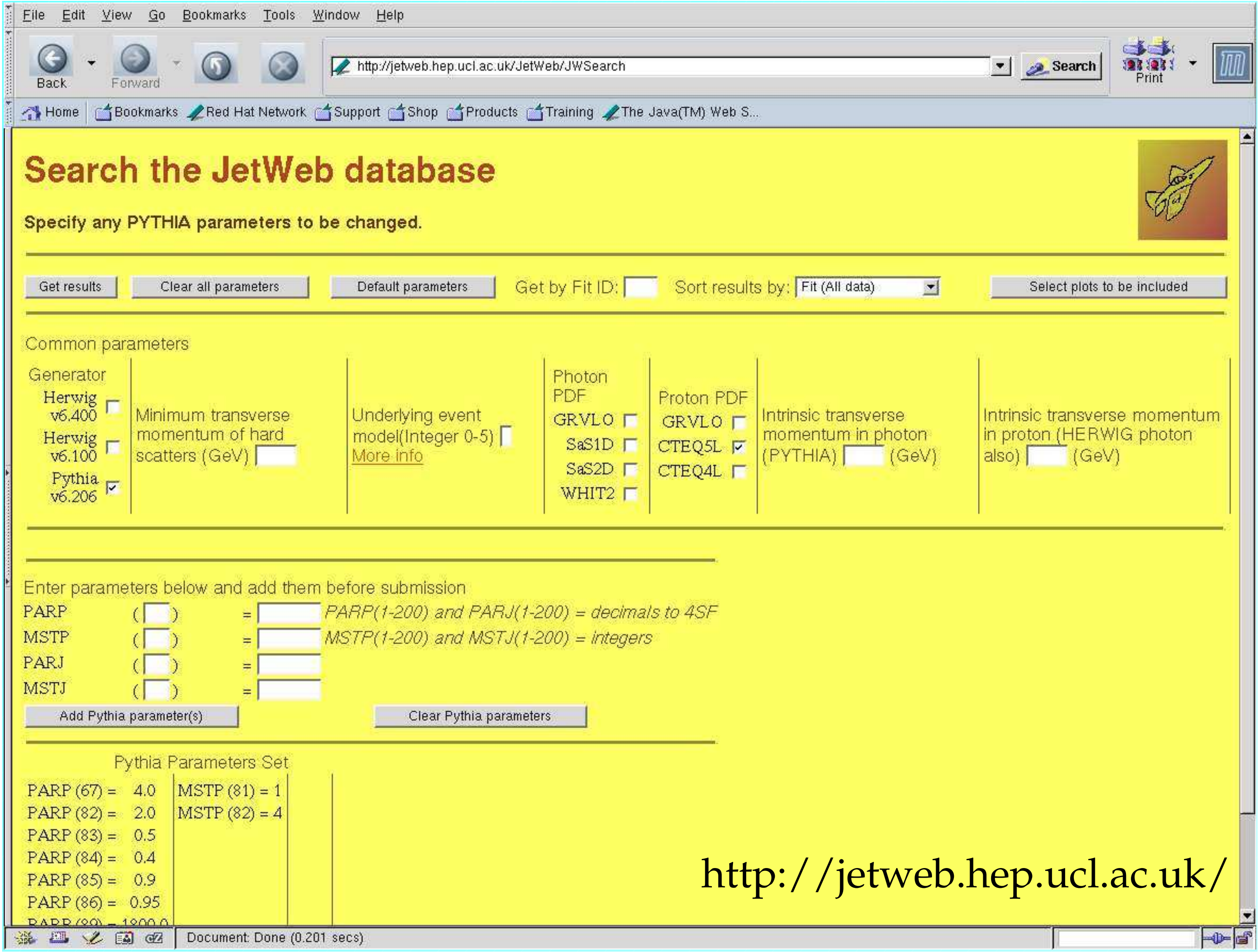
O. Gutsche, A. Geiser (WG3)

no	DESY–03–115	*charm in DIS*
yes	DESY–98–085	*charm in γp*
no	DESY–04–070	*beauty in DIS*
yes	DESY–03–212	*beauty in γp*
no	DESY–03–015	*charm + jets in γp*
yes	DESY–00–166	*charm & beauty in γp*

+ several preliminary results

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/

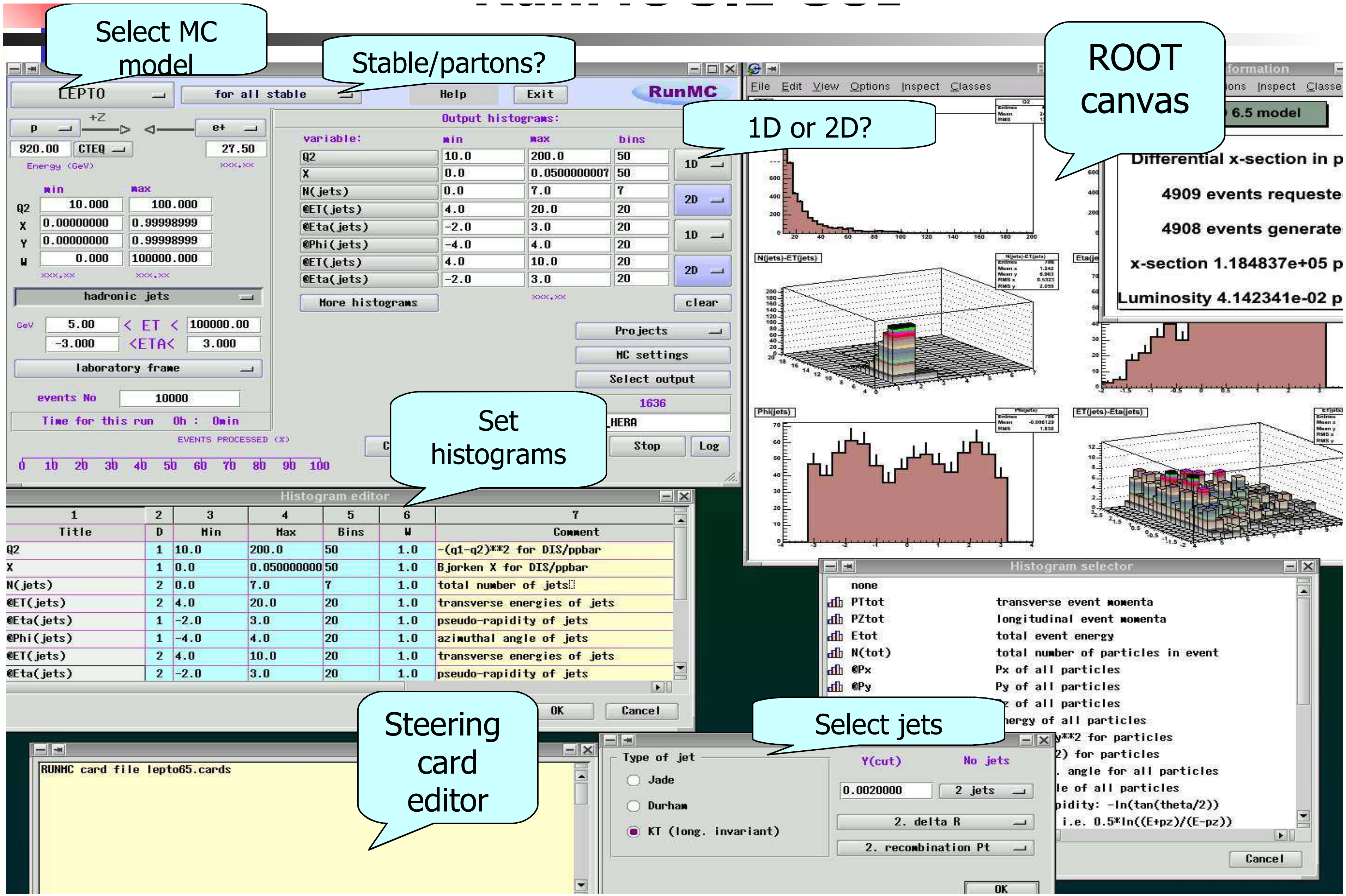
RunMC

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

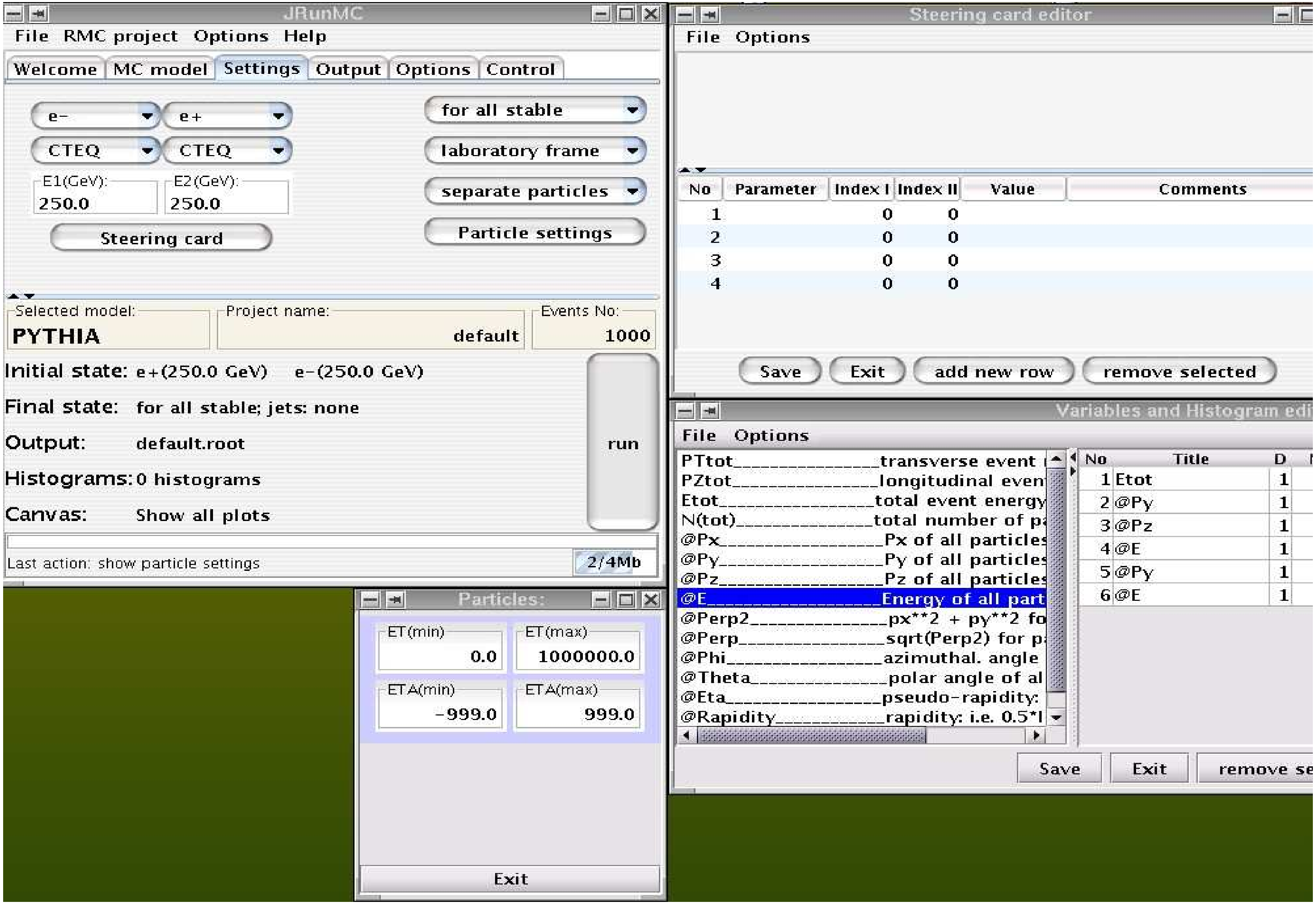
- Desktop application (Linux, Windows/Cygwin) with graphical front-end
- Interface to major Fortran generators (will be extended to new C++ MCs):
  PYTHIA, HERWIG, ARIADNE, PHOJET, LEPTO, AROMA, RAPGAP, CASCADE
- For validations, tuning, comparisons, calculations of correction factors
- Fully integrated 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 inlcuded
- 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,
  - ...

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

RunMC C++ GUI – v 2.1



RunMC Java GUI – v 3.3



Sbumps

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

Not MC, but useful tool for searches. Motivation:

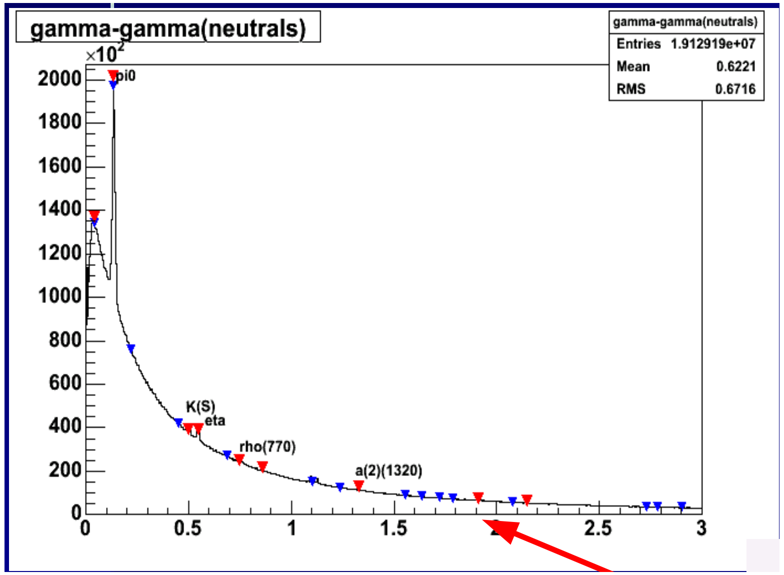
- To search peaks in invariant masses is a tedious task (especially if you do not know that your are looking for)
- Need to check many mass assumptions
- 2,3,4 etc. body decays should be looked at
- Reflections from known states should be removed

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

- 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!