Activities of the Monte Carlo Working Group (II)

Convenors: P. Bartalini, S. Gieseke, T. Kluge, F. Krauss

- Underlying Events (Joint Session with Multi-jet final states and energy flows)
- Validation
MC - tools: Underlying Events
(Joint Session with Multi-jet final states and energy flows)

- The Underlying Event at the LHC (Livio Fano')
- The Underlying Event at ZEUS (Tim Namsoo)
- How to subtract the underlying event from jets? (Pavel Starovoitov)
- Sensitivity of the Muon Isolation Cut Efficiency to the Underlying Event Uncertainties (Alexey Drozdetskiy)
The measurement plan - UE

From charged jet

Topological structure of p-p collision from charged tracks
Charged jet definition -> ICA algorithm with massless charged tracks as input

The leading Ch\_jet1 defines a direction in the $\phi$ plane

The transverse region is sensitive to the UE

Main observables:
+ $dN/d\eta d\phi$, charged density
+ $d(PT_{sum})/d\eta d\phi$, energy density

From D-Y muon pairs production

observables are the same but defined in all the $\phi$ plane

(after removing the $\mu$ pairs everything else is UE)

Idea from R. Field
A lot of emphasis on the reconstruction of soft tracks!

**PY-Atlas Tune**  
(-> optimized also for MB)  
has a softer PT distribution than **PY-DW** (done at CDF)  
(-> optimized for UE)
Reconstruction studies - charged jet - transverse region

Ratio PT>0.9 / PT>0.5

Events re-weighted with corresponding x-sec.
(error bars dominated by MC statistics, arbitrary luminosity but scaling correctly)

Really Good RECO/MC agreement.
RECO/MC Differences absorb in the ratio, no need to apply corrections.
What is the momentum limit?

- Tracker is in principle sensitive to soft tracks
  - $P_T = 400$ MeV - tracks reach end of TRT
  - $P_T = 150$ MeV - tracks reach last SCT layer
  - $P_T = 50$ MeV - tracks reach all Pixel layers

→ Do not need to run with low field
ISOL efficiency from data. (2)

Very close to ZZ "real" $\mu$
(dashed – Z-inclusive)

Illustration (not every sample is suitable): tt is too different.
ISOL efficiency from data. (3) Efficiency per event.

<table>
<thead>
<tr>
<th>process/case</th>
<th>efficiency (default)</th>
<th>efficiency (−3σ)</th>
<th>efficiency (+3σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>signal, $m_H = 150$ GeV</td>
<td>0.775 ± 0.004</td>
<td>0.707 ± 0.005</td>
<td>0.812 ± 0.004</td>
</tr>
<tr>
<td>ZZ background</td>
<td>0.780 ± 0.004</td>
<td>0.721 ± 0.005</td>
<td>0.838 ± 0.004</td>
</tr>
<tr>
<td>4 RND muons, Z-inclusive events</td>
<td>0.762 ± 0.007</td>
<td>0.706 ± 0.007</td>
<td>0.821 ± 0.006</td>
</tr>
<tr>
<td>$t\bar{t}$ background</td>
<td>0.016 ± 0.001</td>
<td>0.013 ± 0.001</td>
<td>0.015 ± 0.001</td>
</tr>
</tbody>
</table>

- Numbers for Signal, ZZ and Z-inclusive samples are in agreement with each other for all the three different tested UE scenarios.
- Range of efficiencies for the ZZ spans from ~0.72 to ~0.84.
  - Prediction uncertainties!!! (from theoretical uncertainties in the UE physics)
- From data: shift is ~2% and not dependant on UE scenario.
  - Smaller than other known uncertainties.
Conclusions

- Jets at HS+UE becomes broader
- Jet axis in HS+UE is not the same as in HS.
- UE changes the response of the jet algorithm
  - UE produce a bias to the Jet Algorithms

Hard Scale HS+UE Difference

Plan

- Future: We want to study uncertainties for different Jet Algorithms: Cone & $K_T$
Three-Jet Cross Section

Four-Jet Cross Section

- $M_{3j} \geq 25.0$ GeV
- $M_{4j} \geq 25.0$ GeV

- jet broadness: $B_j = \left( \sum_i |h_i \times p_j| \right) / \left( \sum_i |h_i||p_j| \right)$ (sensitive to transverse energy flow in jet)
- note: different PYTHIA $k$-factors - want to observe how each model affects the jet shape.
- clearly the MC without MPIs predicts too narrow jets - MPIs could account for the broadening
- PYTHIA simple model and JIMMY predictions very similar in 4-jet case but less so in 3-jet.
Both MCs with MPIs give a poor description of the shape of $d\sigma/dy$...

...but MCs without MPIs describe shape well. MPI models causing the problem?

if so, $d\sigma/dy$ good for tuning/testing models but hard not to imagine MPIs not (slightly) $y$ dependent.

suggests MPIs not the only problem?

same observations made in the 4-jet $d\sigma/dy$ distributions.
Underlying Events

Bottom Line

- Experimental methodologies
  - Extension to DY
  - New observables (ratios)
  - Emphasis on reconstruction of soft tracks

- Tuning of the Models
  - Still painful to achieve a global picture
    - Describing UE and MB with the same settings
    - Common Tevatron + LHC (+HERA) tuning ???
  - Having the best parameters is not enough:
    we also need the errors!

- Spin offs of UE comprehension
  - New methodologies to calibrate lepton isolation
MC - Tools: Fragmentation and hadron decays (CERN(40-S2-A01))

- Heavy Quarkonia sector in PYTHIA 6.324: test and validation (Marianne Bargiotti)
- EvtGen at the LHC (Maria Smizanska)

MC - Tools: Validation of Monte Carlos

- MC validation in ATLAS (Borut Paul Kersevan)
- Validation of simulation packages in LCG (Mikhail Kirsanov)
- MC validation, HZtool (Christiane Risler)
- CEDAR & HZTool (Jon Butterworth)
- CEDAR: HepData, HepML and HepForge (Andy Buckley)
Current status

- Integration of the original code (by Stefan Wolf) made by T. Sjostrand in PYTHIA 6.324.
  - This PYTHIA implementation for NRQCD already existed since a few years, but it was not validated and never included in official releases.
  - PYTHIA 6.324 now relays both to charmonia and bottomonia sector
  - The code is now under validation;
  - Realistic parameter values (e.g. NRQCD MEs) have to be fixed.

⇒ OTHER VISIBLE IMPLICATIONS:

- Possibility to produce simultaneously J/ψ and Y (introduced as different processes)
- is still not possible to generate Y’ and ψ’ simultaneously, but can be implemented ‘in locum’

Marianne Bargiotti

HERA-LHC Workshop, CERN
6-8 June 2006
Preliminary Results using PYEVWT for Event-by-Event Reweighting

\[ \text{WEIGHT} = \left( \frac{P_T^{**2}}{(P_{T0}^{**2} + P_T^{**2})} \right)^{**2} \]

\[ P_{T0} = 2.5 \text{ GeV} \]

HERA-LHC Workshop, CERN
6-8 June 2006

Inspired by the running of the PT-cut-off in the Multiple Interactions Framework --> Extrapolation
**Lambda_b polarization and decay**

Use of EvtGen to generate polarized Lambda_b in the cascade decay:

\[ \Lambda_b \to J/\psi \Lambda_0 \]

**Probability function**

\[ \rho(\Omega, \Omega_1, \Omega_2) = \frac{1}{(4\pi)^3} \sum_{i=0}^{19} f_i f_0 \left( P_{\Lambda}, \alpha_{\Lambda} \right) F_i(\theta, \theta_1, \theta_2, \phi_1, \phi_2) \]

Angular distribution \(\Lambda_b \to J/\psi(\mu \bar{\mu})\Lambda(\pi p)\) depends on 5 angles + 6 parameters of the 4 complex helicity amplitudes + polarization \(P_\Lambda\). Helicity amplitudes and \(P_\Lambda\) have to be simultaneously determined.

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CERN, June 9th 2006

M. Smižanská

Paolo Bartalini (University of Florida)
Generators used at ATLAS

- We try to use as many generators as reasonable:
  - The final answer which is best will be given only by the data.
  - Need some overlap: different generators for the same processes.
- So far tried:
  - AcerMC
  - Alpgen (+ MLM matching)
  - Charbydis
  - CompHEP
  - Hijing
  - HERWIG (+ Jimmy)
  - MadEvent
  - MC@NLO
  - Phojet
  - Photos (both with HERWIG and Pythia)
  - Pythia (old and new showering and UE algorithms)
  - Tauola (both with HERWIG and Pythia)
  - Sherpa
  - TopReX
Common validation procedures at ATLAS

- There are in general two approaches:
  - We take into account the experience and results at the Tevatron (tunings) and/or we try to tune/check the generators using available Tevatron information ourselves.
  - We compare the results of different MC generators in the quantities where they should match (to a certain precision) either at the generator level or by performing full analysis studies.
- In all cases we of course check the obvious parameters (masses, resonance shapes, angular (a)symmetries etc.)
- We also check the stability of the algorithms and their sensitivity to parameter changes (e.g. cutoff parameters in MLM matching algorithm etc..)
- Detailed checks when switching versions of the same MC tool.
Validation using generator comparisons

- Comparison between PHOTOS (supposed to be an approximate algorithm in principle) and HORACE (exact QED DGLAP solution):
  - Turns out that PHOTOS is doing an excellent job!

HORACE vs Photos (3)

- Photon multiplicity and transverse momentum spectrum done with standalone generators (outside Athena)
  
  perfect agreement for all $p_t$ range

with cut $p_t > 500$ MeV perfect agreement also in Athena interfaced version to third hard photon

- Pythia + HORACE
- Pythia + PHOTOS
The LCG Generator Library (status and plans 2006)

- **GENSER_1_3_0** - last major release, March 2006. 27 packages.
  - Pythia8 and Herwig++ inside GENSER (M.Kirsanov)
  - Two levels of release tests, development of level 1 (M.Kirsanov, O.Zenin)
  - Heavy ions generators: HIJING, PYQUEN, HYDJET
  - Release policy and tools (A.Pfeiffer)

Number of generators starts to saturate; accent being shifted towards convenience, tests, validation

- Further development of procedures for Light Bug Fix Releases
- Develop the package TESTS
- User support (versions 1_3_0 – 1_4_0)
- Increase support for Makefiles
- Continue testing with gcc 4
- Migrate to HepMC in the package TESTS to provide a general approach to c++ and Fortran generators.
- Update of already introduced Sub-package versions
  - Requests from the LHC experiments are welcome

CERN, June 9th 2006

M. Kirsanov

Paolo Bartalini (University of Florida)
HZTOOL - routines

Future routines: new analyses / wishlist for new routines

Heavy flavors:
DESY-05-147, ZEUS, *Measurement of Charm Fragmentation Ratios and Fractions in Photoproduction at HERA*
DESY-05-132, ZEUS, *Inclusive Jet Cross Sections and Dijet Correlations in D* Photoproduction at HERA*
DESY-06-039, H1, *Measurement of Charm and Beauty Dijet Cross Sections in Photoproduction at HERA using the H1 Vertex Detector*
DESY-05-110, H1, *Measurement of F_{2c} and F_{2b} at Low Q^2 and x using the H1 Vertex Detector at HERA (hep-ex/0507081)*
DESY-05-040, H1, *Measurement of Charm and Beauty Photoproduction at HERA using D* mu Correlations (hep-ex/0503038)*
DESY-04-209, H1, *Measurement of F_{2c} and F_{2b} at High Q^2 using the H1 Vertex Detector at HERA (hep-ex/0411046)*

Hztool and MC validation, HERALHC Workshop June 6-9 2006, CERN, Christiane Risler
CEDAR

Rivet and RivetGun

- Robust Independent Validation of Experiment & Theory
- Approximately equivalent to a C++ replacement of HZTool (Rivet) and HZSteer (RivetGun).
  - Will make greater use of existing external libraries (CLHEP, KtJet etc)
  - Rivet is generator independent.
  - RivetGun must interface to ThePEG, Sherpa, Pythia8 and existing Fortran generators.
  - Generators to be configured using HepML.
JetWeb

• Goals
  – Build up database of validated models using wide range of existing data
  – Running HZSteer and RivetGun on LCG
    • CEDAR now a registered VO
    • would like to use GENESIS distribution of generators
    • would like HZSteer (and eventually RivetGun) supported in GENESIS – discussion with/request to LCG team.
  – Add new generators and data rapidly as they appear
  – Add more user front-end facilities for interactive tuning and analysis

• See http://jetweb.cedar.ac.uk
CEDAR: Collaborative e-Science Data Analysis Resource

I expect Jon Butterworth will have already said this, but... CEDAR is an e-Science project with several sub-projects:

- **JetWeb**: Monte Carlo generator tuning
- **HepData**: archival of published experimental data
- **HepML**: XML formats for data sets and MC config
- **HepForge**: development environment for HEP software
- **HepCode**: centralised repository of pheno code/programs

www.cedar.ac.uk

Durham University
MC Validation

Bottom Line

- Software frameworks for MC certification and validation are growing well
  - LCG Generator <---> CEDAR
- However, physics validation is still a very complex problem that needs some actions in our working group and in the context of the forthcoming MC4LHC
  - MC authors suffer from a reduced access to the “fresh” data
  - There should be a general agreement on observables and tuning parameters
  - Some work needed to recover recent but not systematically organized information
  - Fragmentation measurements at LEP