

Herwig++ and related projects: Activities at Karlsruhe

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[Herwig++ Physics and Manual, arXiv:0803:0883]

Outline

- Status of Herwig++
- Activities at Karlsruhe
 - Underlying event
 - VBF processes
 - Shower(s) and higher orders
- Conclusions

[Stefan Gieseke, Manuel Bähr]

[Stefan Gieseke, Kristov Hackstein (ITP & EKP)]

[Luca D'Errico, Stefan Gieseke, SP]

Outline

- Status of Herwig++
- Activities at Karlsruhe
- Underlying event [Stefan Gieseke, Manuel Bähr]
- VBF processes ← Joint theory/experiment project [Stefan Gieseke, Kristov Hackstein (ITP & EKP)]
- Shower(s) and higher orders [Luca D'Errico, Stefan Gieseke, SP]
- Conclusions

Herwig++

- Cambridge - Bryan Webber, Sasha Sherstnev, Seyi Latunde-Dada
- CERN - Mike Seymour
- Durham - Peter Richardson, David Grellscheid, Martyn Gigg, Jon Tully
- Karlsruhe - Manuel Bähr, Luca D'Errico, Stefan Gieseke, SP
- Louvain - Keith Hamilton

Herwig++

- Improved coherent shower algorithm + ME corrections

[S. Gieseke, P. Stephens, B.R. Webber - JHEP 12 (2003) 045, hep-ph/0310083]

- Cluster hadronization

- Sophisticated decay library including spin correlations, soft photons

[D. Grellscheid, K. Hamilton, P. Richardson]

- Eikonal multiple interaction model

[M. Bähr, S. Gieseke, M.H. Seymour]

- Flexible BSM physics module

[M. Gigg, P. Richardson]

- POWHEG matching (from 2.3.0)

[K. Hamilton, P. Richardson, J. Tully]

Herwig++

- Current version 2.2.1 - 2.3.0 coming soon
- Requires ThePEG and GSL
- GNU conforming build:
`configure, make, make install`
- Each release is tested extensively
- Comparisons/tunes to lots of data
- Hadron-hadron, lepton-hadron and e^+e^- collisions

Downloads, Wiki, bug tracker..

`http://projects.hepforge.org/herwig
herwig@projects.hepforge.org`

Underlying Event

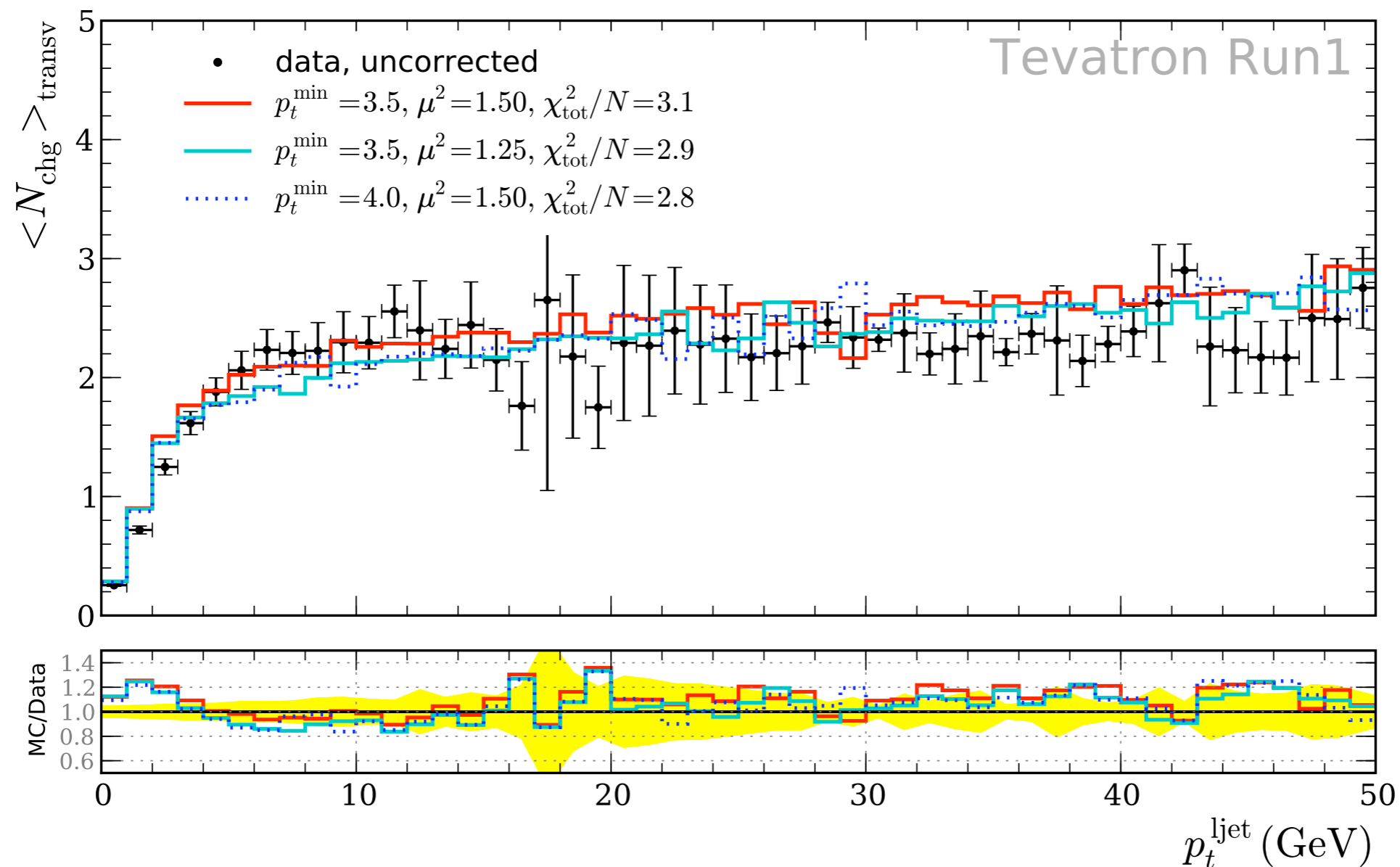
[Stefan Gieseke, Manuel Bähr]

- Eikonal multiple interaction model similar to JIMMY
- **New:** Soft scatters added, allows to use Herwig++ for min bias
- Tuned against Tevatron data, well reproduced
- Extrapolations to LHC studied: able to constrain model validity

Underlying Event

[slides stolen from Manuel Bähr]

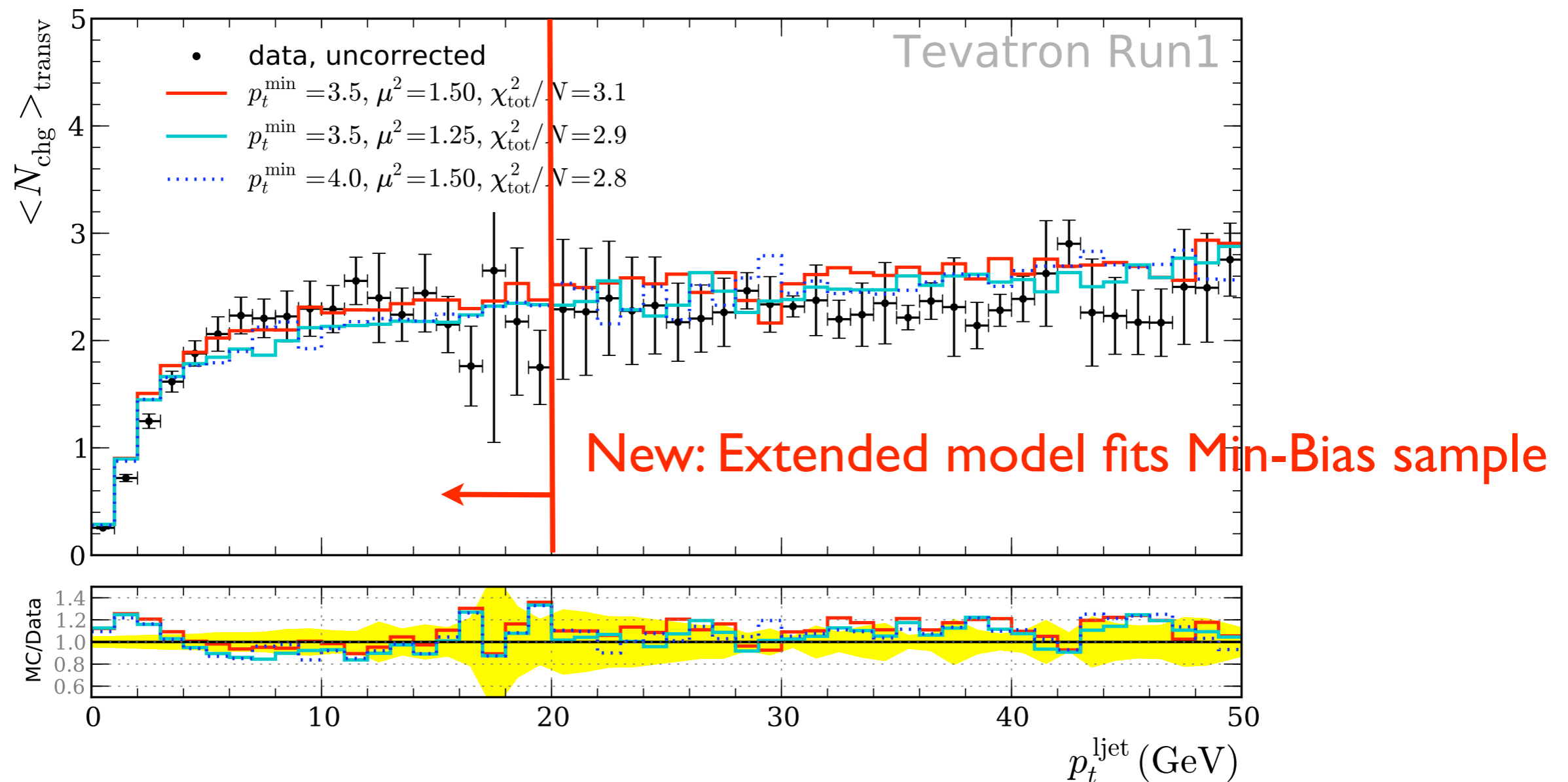
Detailed look at observables: Transverse Region



Underlying Event

[slides stolen from Manuel Bähr]

Detailed look at observables: Transverse Region

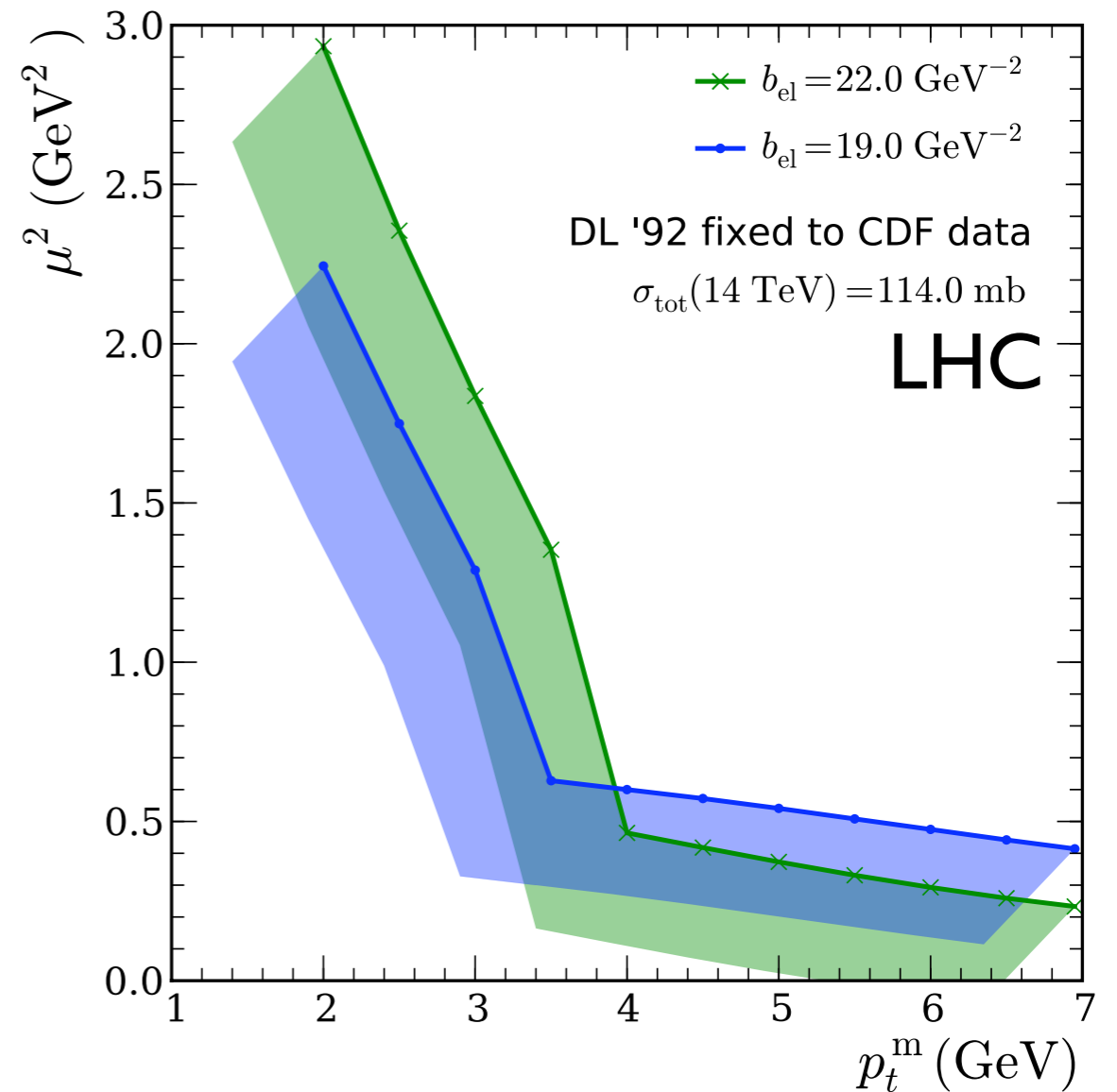
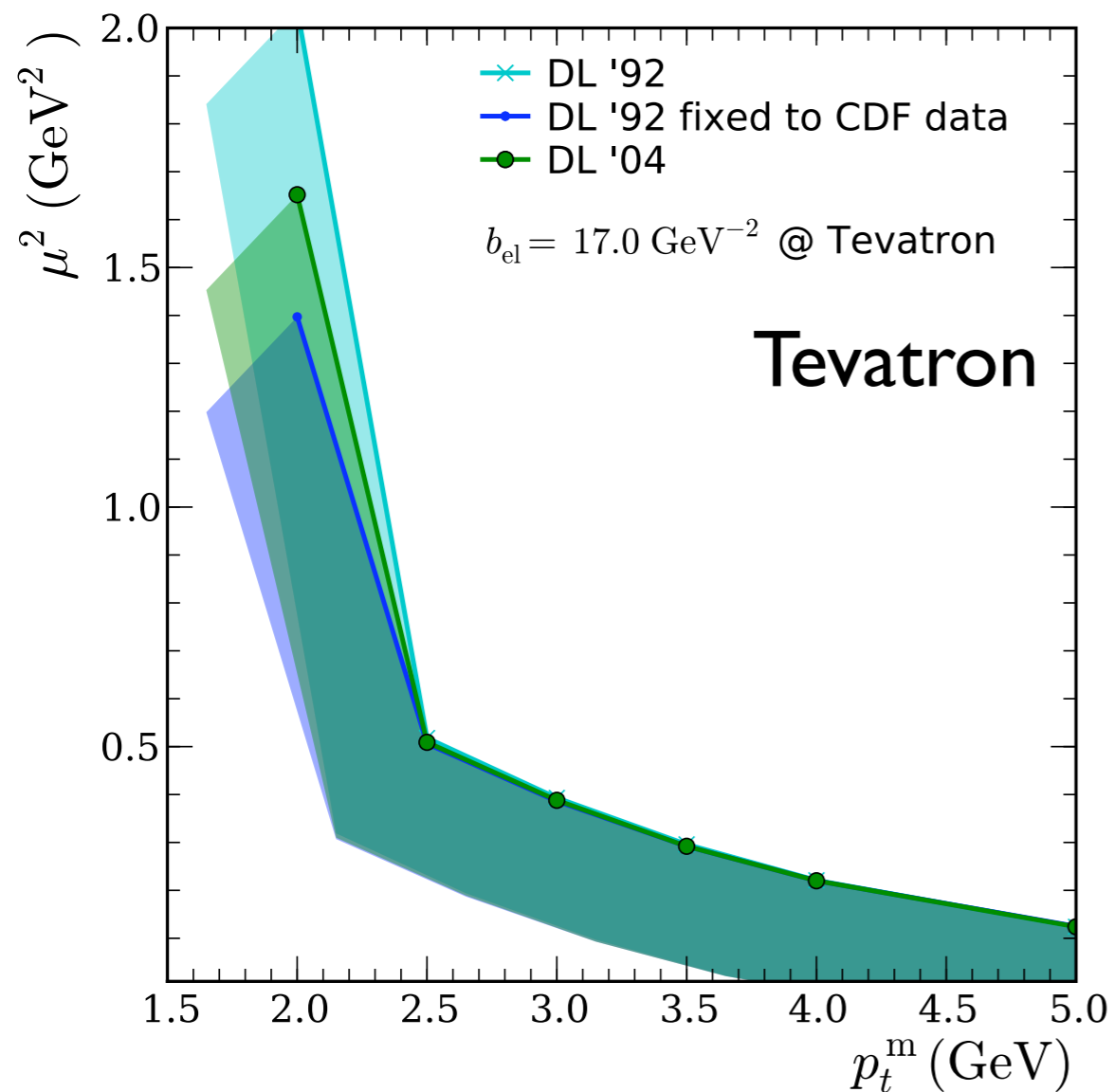


Underlying Event - parameter space

[plots stolen from Manuel Bähr]

Hot-Spot model

fix soft parameters from total cross section and elastic slope



Underlying Event

[slides stolen from Manuel Bähr]

Conclusions

- We extended the existing model to soft partonic interactions.
First time MinBias is available in Herwig ever!
- The ue activity is directly coupled to the total and elastic cross section
 - Large impact of first measurements of these quantities at LHC
 - Extrapolation to larger energies constraint by predictions for these quantities
- **Hot-Spot model** to describe inconsistency between σ_{eff} and b_{el}
- Fully exclusive simulation of **multiple hard scatterings** + low p_t jets possible (again no time to talk about it), e.g. $\gamma j + jj$, like sign W 's, several b-jet pairs (... you name it) **with arbitrary and independent cuts.**

VBF processes

[Stefan Gieseke, Kristov Hackstein (ITP & EKP)]

- Expertise in Karlsruhe, parton-level MC including NLO corrections
- Joint pheno study including theory (ITP) / experiment (EKP CMS group)
- Comparative study of different generators: huge inconsistencies
- VBFNLO to cross-check descriptions
- Herwig++ well in agreement with theoretical expectations, Pythia not

VBF processes

[slide stolen from Kristov Hackstein]

Normalizing y^* to the size of the rapidity gap shows more clearly where the 3rd jet lies

$$z^* = \frac{y^*}{|y_1 - y_2|}$$

If the 3rd jet has the same rapidity as a tagging jet,

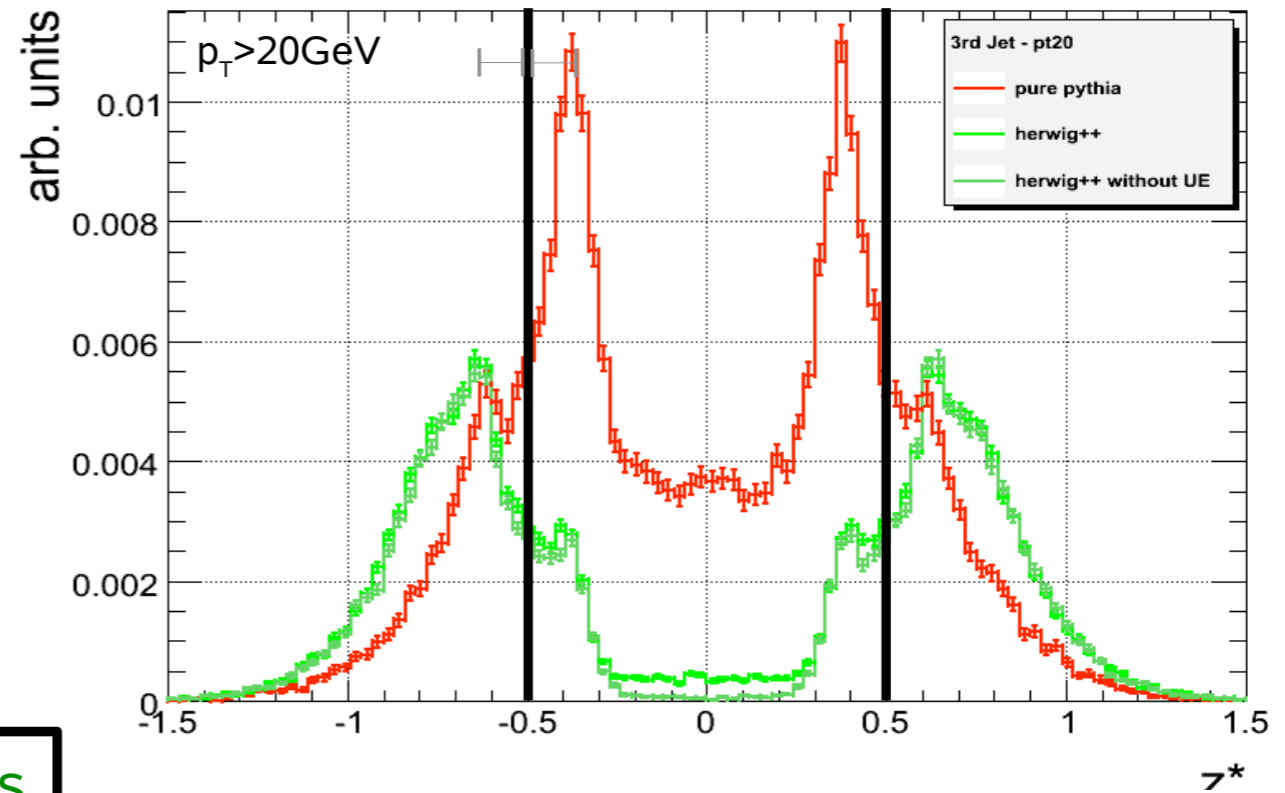
$$z^* = \pm 1/2$$

3rd jet between the tagging jets

$$|z^*| < 1/2$$

3rd jet outside the tagging jets

$$|z^*| > 1/2$$



The peaks near $\pm 1/2$ can be explained by the jet finder

Pythia and Herwig++ disagree strongly in their prediction!!

Shower(s) and higher orders

[SP, Stefan Gieseke]

- CKKW merging
- Analytic framework for shower predictions and matching
- Dipole shower
- NLO matching

[SP, Luca D'Errico, Stefan Gieseke]

CKKW merging

[SP, Stefan Gieseke]

- Flexible implementation for e^+e^- and hadron-hadron (testing required)
 - consistent setup using exact Sudakovs, aim on studying systematics
 - serious problems related to angular ordering revealed, see also work by Lund group [Lönnblad, Lavesson]
 - solutions in progress

Analytic frameworks

[SP, Stefan Gieseke - in preparation]

- New showers and matching require analytic understanding prior to any implementation
- Start from description of stochastic (Markov) process: calculate what MC does
- Analyze evolution structure, evolution equations, ...
- Detailed analysis of matching to fixed-order calculations
 - MC@NLO evident
 - POWHEG emergent from matching shower with ME correction
 - NNLO matching foreseen

Dipole showers

[SP, Stefan Gieseke - in preparation]

- Appealing from exact momentum conservation in each splitting, matching issues, ...
- For any predictive power need to know the shower's precision
 - Consistent NLO matching requires shower proven to be correct at the level of next-to-leading logs
 - “Soft-correctness” of splitting kernels is not sufficient
- Solve problem of transverse momentum distributions for outgoing system, e.g. boson pt in Drell-Yan
- Implementation in progress

NLO matching

[SP, Luca D'Errico, Stefan Gieseke]

- Focus on POWHEG-type, keep possibility of MC@NLO-type for comparison
- Framework and generic interface to existing NLO calculations
- Adaptive sampling of Sudakov-type distributions allows for automatization

$$F(x, \vec{z}|y) = \theta(y - x) f(x, \vec{z}) \exp \left(- \int_x^y \int_{V_{d-1}} f(t, \vec{\xi}) d^{d-1} \xi dt \right)$$

- Straightforward for hardness-ordered showers, implementation integrated with new dipole shower

Conclusions

- Herwig++ is now a fully functional MC for LHC physics
- Features shower, hadronization, decays, underlying event ... including lots of improvements
- Next major revision (3.0) will be considered a final replacement for the FORTRAN version
- Herwig++ at Karlsruhe [Manuel Bähr, Luca D'Errico, Stefan Gieseke, Kristov Hackstein, SP]
 - Contribute actively in development and user support
 - Expertise in shower(s), underlying event, LO multijet merging
 - Explore new developments and techniques for showers and higher orders

Get it, try it ...

`http://projects.hepforge.org/herwig`

`herwig@projects.hepforge.org`