Energy Scaling of MB Tunes

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with H. Schulz
Two Issues

Multiplicities are TOO LOW

Many models/tunes are slightly low even at 900 GeV
(though \( \approx 20\% \) on IR sensitive quantity not bad)

Diffraction?

Slightly wrong asymptotic slope?

Note: can’t see very much from \( dN/d\eta \) alone
Two Issues

Multiplicities are TOO LOW

Many models/tunes are slightly low even at 900 GeV
(though ≈ 20% on IR sensitive quantity not bad)

+ SCALE TOO SLOWLY

→ Even lower at 7 TeV
→ too low UE
Beyond Multiplicities

ESSENTIAL to consider several distributions simultaneously:

“Those that reproduce the multiplicity don’t reproduce the $p_T$ distributions and vice versa”

J. Fiete Grosse-Oetringhaus

+ C. Zampolli (different tune in different PS region)

Normalization fine, shape wrong

Normalization wrong, shape fine

Beyond Multiplicities

arXiv:1007.0719

ALICE, 1007.0719
1. Where is the energy going?

\[ \text{Sum}(pT) \text{ densities, event shapes, mini-jet rates, energy flow correlations...} \]

Note: only linearized Sphericity is IR safe

2. How many tracks is it divided onto?

\[ N_{\text{tracks}}, dN_{\text{tracks}}/dp_T, \text{Associated track densities, track correlations...} \]

3. What kind of tracks?

\[ \text{Strangeness per track, baryons per track, ...} \]

\[ \text{Further: strange baryons per strange, strange-antistrange correlations, ... ...} \]
1. Need better models for diffraction

Tuning is fast - but modeling takes time

*Physical observables, in diffractively enriched samples*

+ *data preservation (HEPDATA/Rivet) → can test any future model*

2. Get Organized

**Global View:** Consider each model on several observables in several phase-space regions simultaneously → better conclusions

**Factorized:** Order observables from IR safe to IR sensitive

3. Need better understanding of E-scaling

E-scaling allows to consolidate measurements from different colliders → powerful cross check on physics model

*While waiting for better model of diffraction, isolate and continue testing non-diffractive tail of MB + Systematically compare to LEP (jet fragmentation) & UE*
Energy Scaling

Can we be more general than this-tune-does-this, that-tune-does-that?

Yes.

*The new automated tuning tools allow us to get an Unbiased optimization at each collider separately*

→ counter-check the model assumptions on energy scaling

→ + counter-check the consistency of the interpolations

→ + differences give a new kind of uncertainty estimate

Critical for this task:

“Comparable” data set at each different collider
MCnet/LPCC Summer Student

Used CDF, UA5, and ATLAS data

\[ P(N_{ch}), \frac{dN_{ch}}{dp_T}, <p_T>(N_{ch}) \]

+ can even focus on \( N_{ch} \geq 6 \) sample separately!

From 630 GeV to 7 TeV (we would have liked to add STAR at 200 GeV, but we did not have a complete obs set from them)

Reduce model to 3 main parameters:

1. Infrared Regularization Scale
2. Proton Transverse Mass Distributions
3. Strength of Color Reconnections

Starting point = Perugia 0

PARP(82)
PARP(83)
PARP(78)
Independent tunings compared to Perugia 0

Rather striking agreement with the assumed functional form (Perugia-0 uses PARP(90) = 0.25)

Evolution of PARP(82) with √s

PARP(82) vs √s, Nch ≥ 6

Independent tunings compared to Perugia 0

Hint of departure from Gaussian (PARP(83)=2.0) at lower energies? Consistent with higher $x \rightarrow$ more lumpy?

"Energy Scaling of MB Tunes", H. Schulz + PS, in preparation
Independent tunings compared to Perugia 0

CR are the most poorly understood part of these models

Assumption of constant strength not supported by data!

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"Energy Scaling of MB Tunes", H. Schulz + PS, in preparation
PYTHIA Updates

with input from R. Corke, T. Sjöstrand
The Perugia Tunes

Intended to provide reasonable starting points for tuning efforts of the $p_T$-ordered framework

Mark the last development effort from the authors

Diffraction

Obsolete Model: no diffractive jet production

Status

No longer actively developed
Already significant improvements but there was one snag…

Where did we go wrong?
A problem with Initial-Final Dipoles (missing coherence), now addressed →

PYTHIA 8 now ready to replace PYTHIA 6 also for UE
A new way of using tuning tools

→ Check of consistency and universality of the model

*Not just the best tune*

**Power + Flexibility** of automated tools allow

*independent optimizations in complementary phase space regions*

We used different beam energies as our complementary regions

(→ tests of energy scaling assumptions)

Other complementary sets could be used to test other aspects

**Crucial: Need complete and comparable data sets in each region!**

+ get a data-driven idea of any non-universalities as a bonus → better uncertainties

**+ Time to move to PYTHIA 8**
Backup Slides
Baryon Transport

LESS than Perugia-SOFT
(at least for protons, in central region)

But MORE than Perugia-0
(at least for Lambdas, in forward region)