Energy Scaling of MB Tunes

P. Skands (CERN)
with H. Schulz

Two Issues

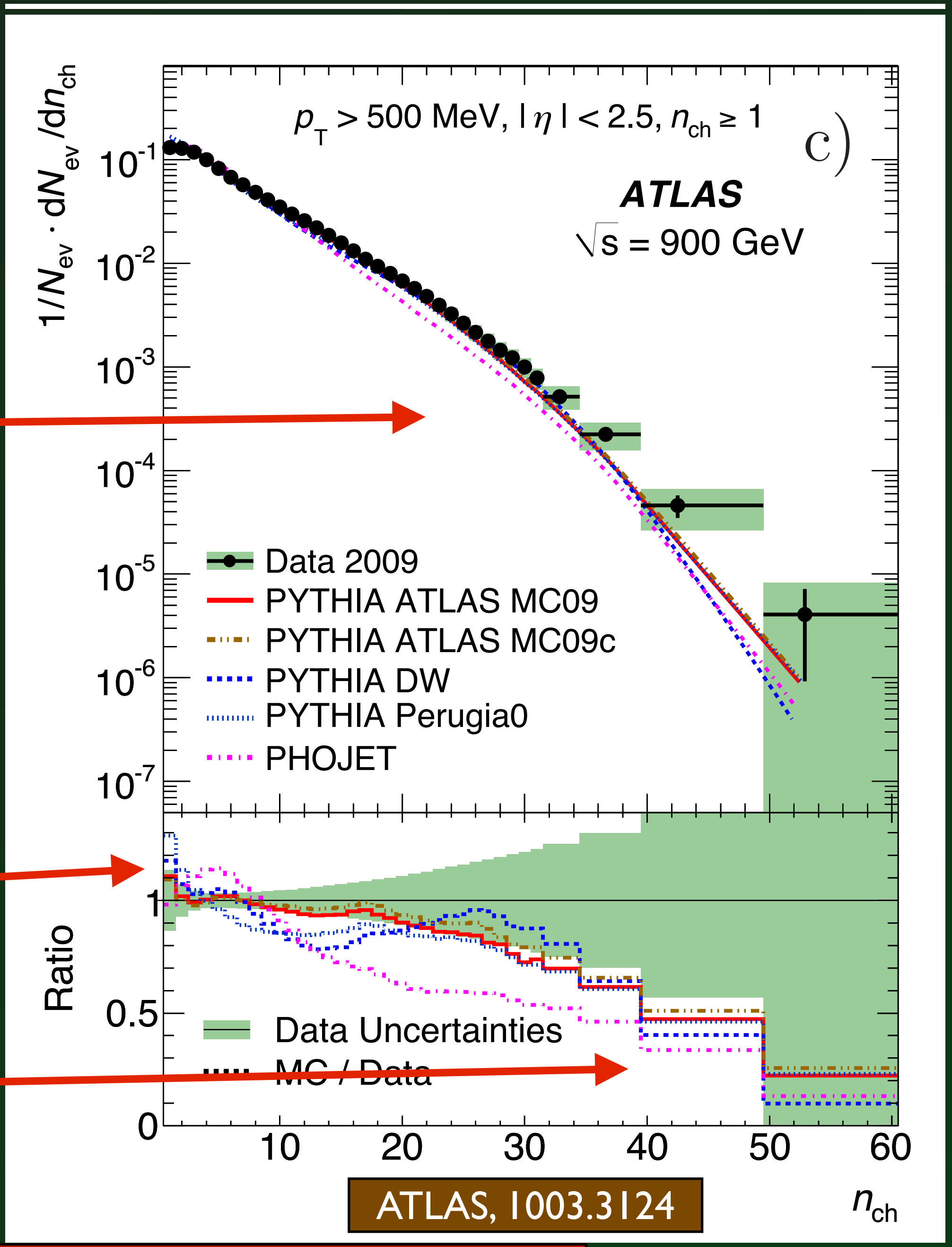
Multiplicities are TOO LOW

Many models/tunes are slightly low even at 900 GeV

(though ≈ 20% on IR sensitive quantity not bad)

Diffraction?

Slightly wrong asymptotic slope?



Note: can't see very much from dN/dη alone

Two Issues

Multiplicities are TOO LOW

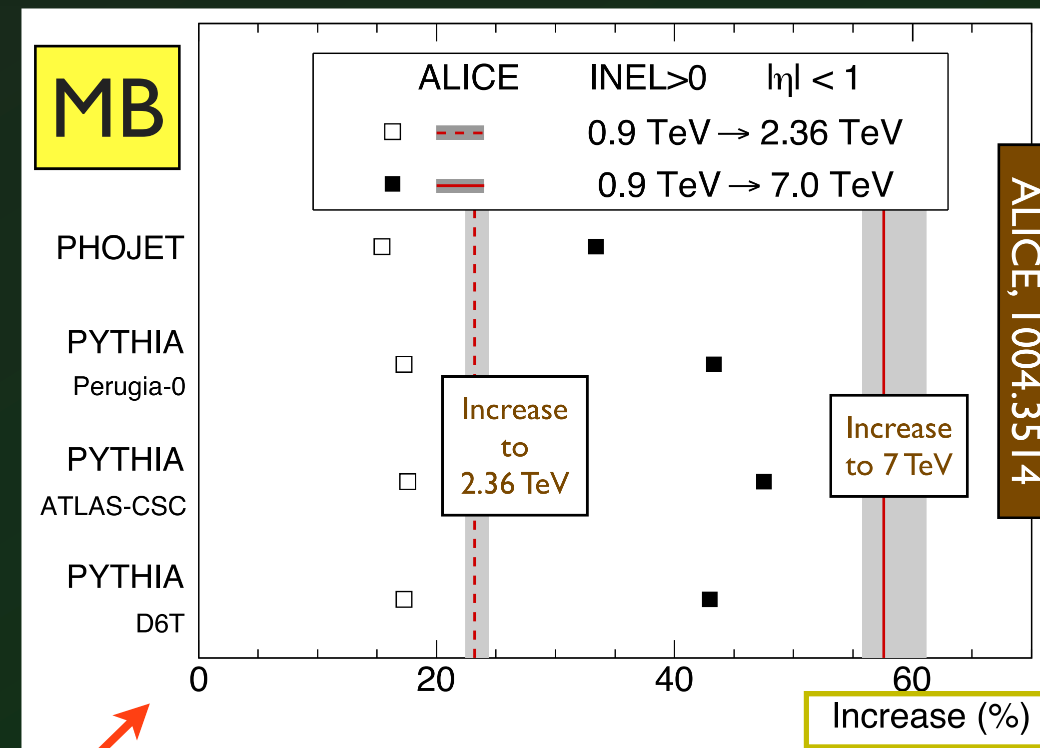
Many models/tunes are slightly low even at 900 GeV

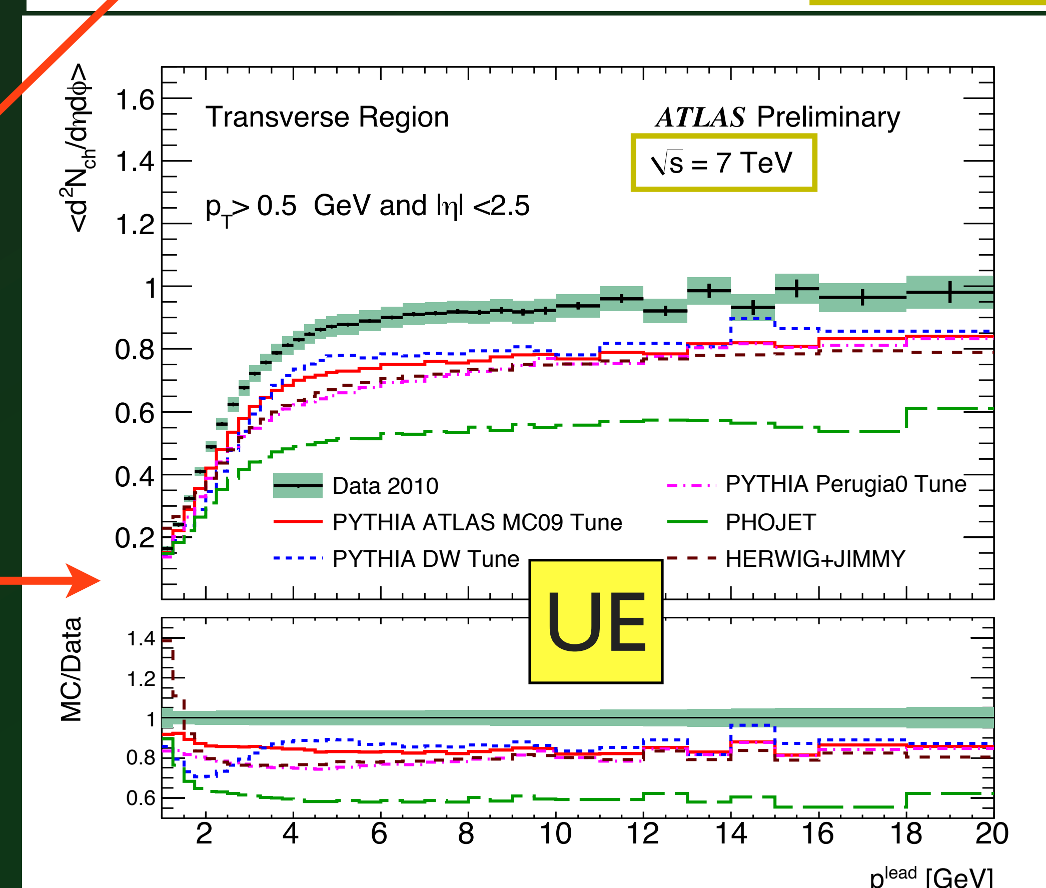
(though ≈ 20% on IR sensitive quantity not bad)

+ 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"

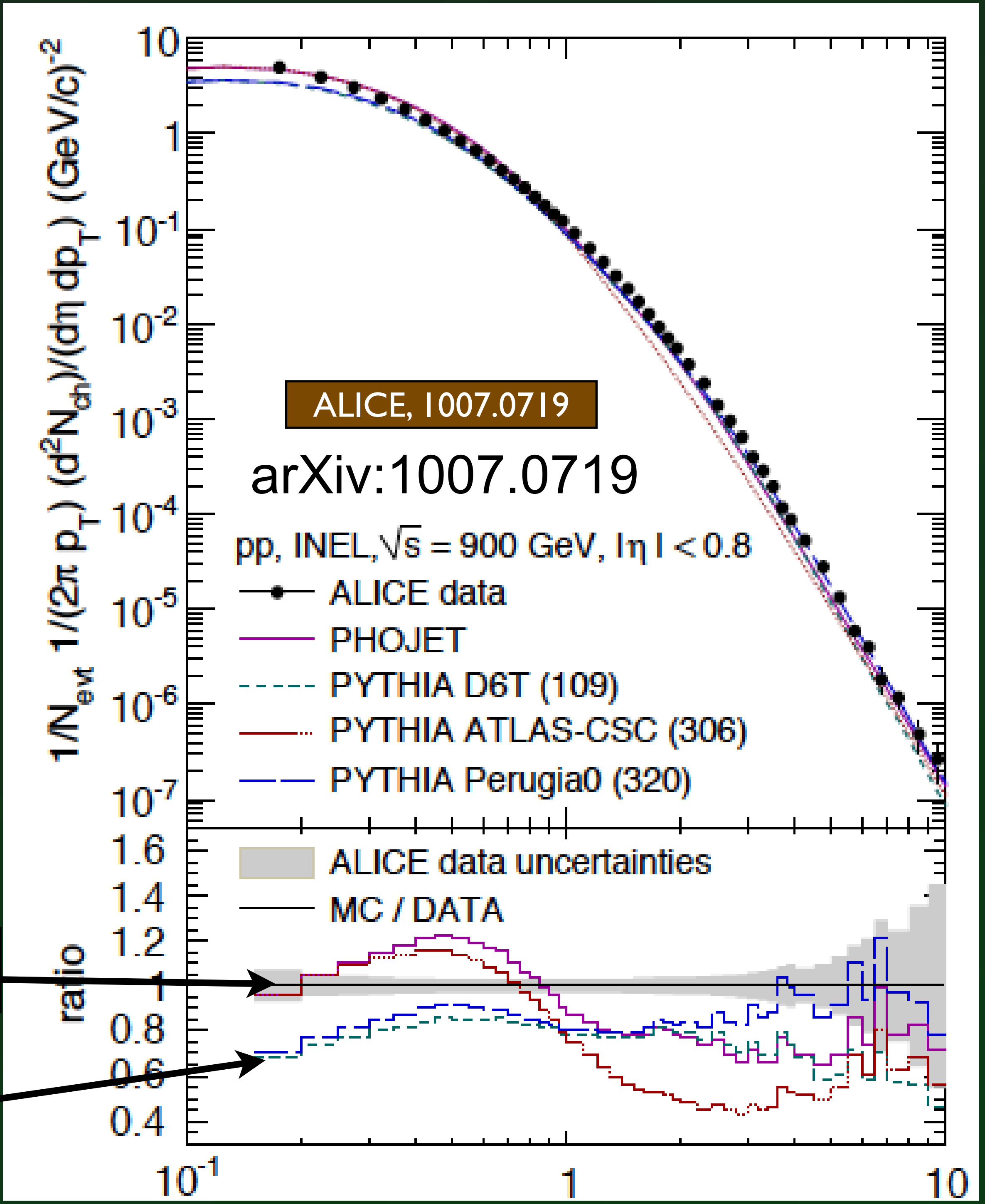
J. Fiete Grosse-Oetringhaus

+ "different tunes work best in different PS regions" C. Zampolli

Emphasises that maximal phase space is not the only game!

Normalization fine, shape wrong

Normalization wrong, shape fine



An Organized View

1. Where is the energy going?

Note: only <u>linearized</u> Sphericity is IR safe

Sum(pT) densities, event shapes, mini-jet rates, energy flow correlations…

2. How many tracks is it divided onto?

N_{tracks}, dN_{tracks}/dp_T, Associated track densities, track correlations…

3. What kind of tracks?

Strangeness per track, baryons per track, …

Further: strange baryons per strange, strange-antistrange correlations, … …

Action Items

1. Need better models for diffraction

Tuning is fast - but modeling takes time

cf., e.g.,
ATLAS (L. Tompkins)
CMS (H. Jung, M. Velasco)

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

Scaling according to Holger

(Schulz)

MCnet/LPCC Summer Student *(+co-author of Professor)*

Used CDF, UA5, and ATLAS data

$P(N_{ch})$, 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: *Starting point = Perugia 0*

1. Infrared Regularization Scale — p_{Tmin} — *PARP(82)*
2. Proton Transverse Mass Distributions — μ — *PARP(83)*
3. Strength of Color Reconnections — CR — *PARP(78)*

Infrared Regularization

Independent tunings compared to Perugia 0

Rather striking agreement with the assumed functional form
(Tunes A, DW, Perugia-0 use PARP(90) = 0.25)

cf., also, e.g., CMS talk by R. Field

&

Sjöstrand & van Zijl, PRD36(1987)2019

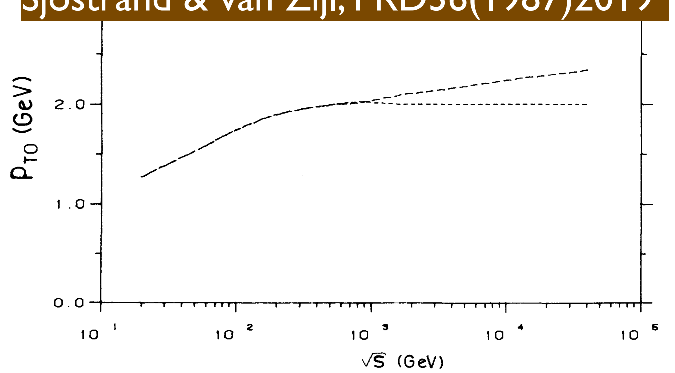
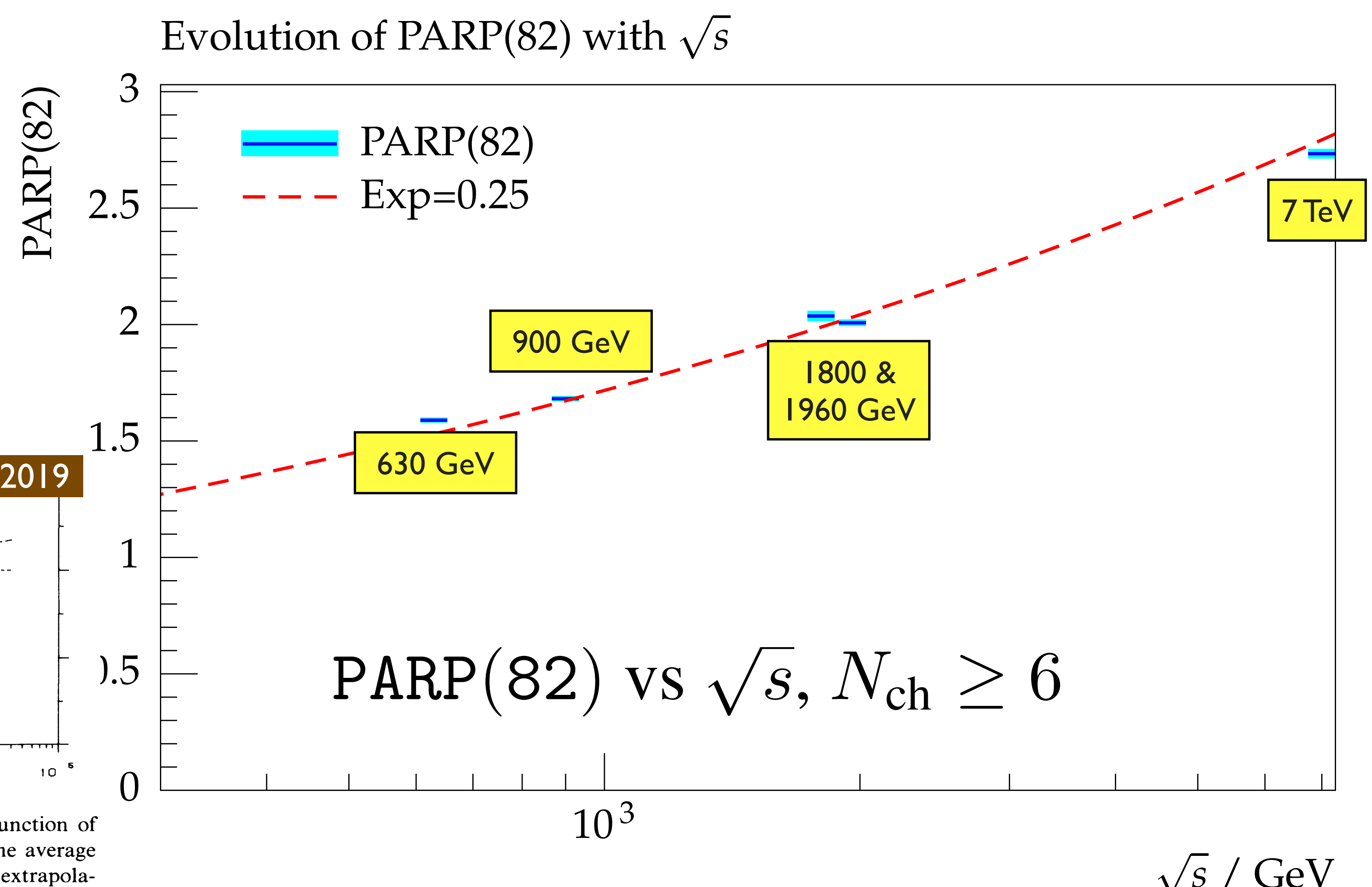


FIG. 8. Values for the cutoff parameter p_{T0} as a function of c.m. energy , as determined from comparisons with the average charged multiplicity. Dashed line, with a logarithmic extrapolation to higher energies, Eq. (38); dotted line, if assumed constant above 900 GeV.

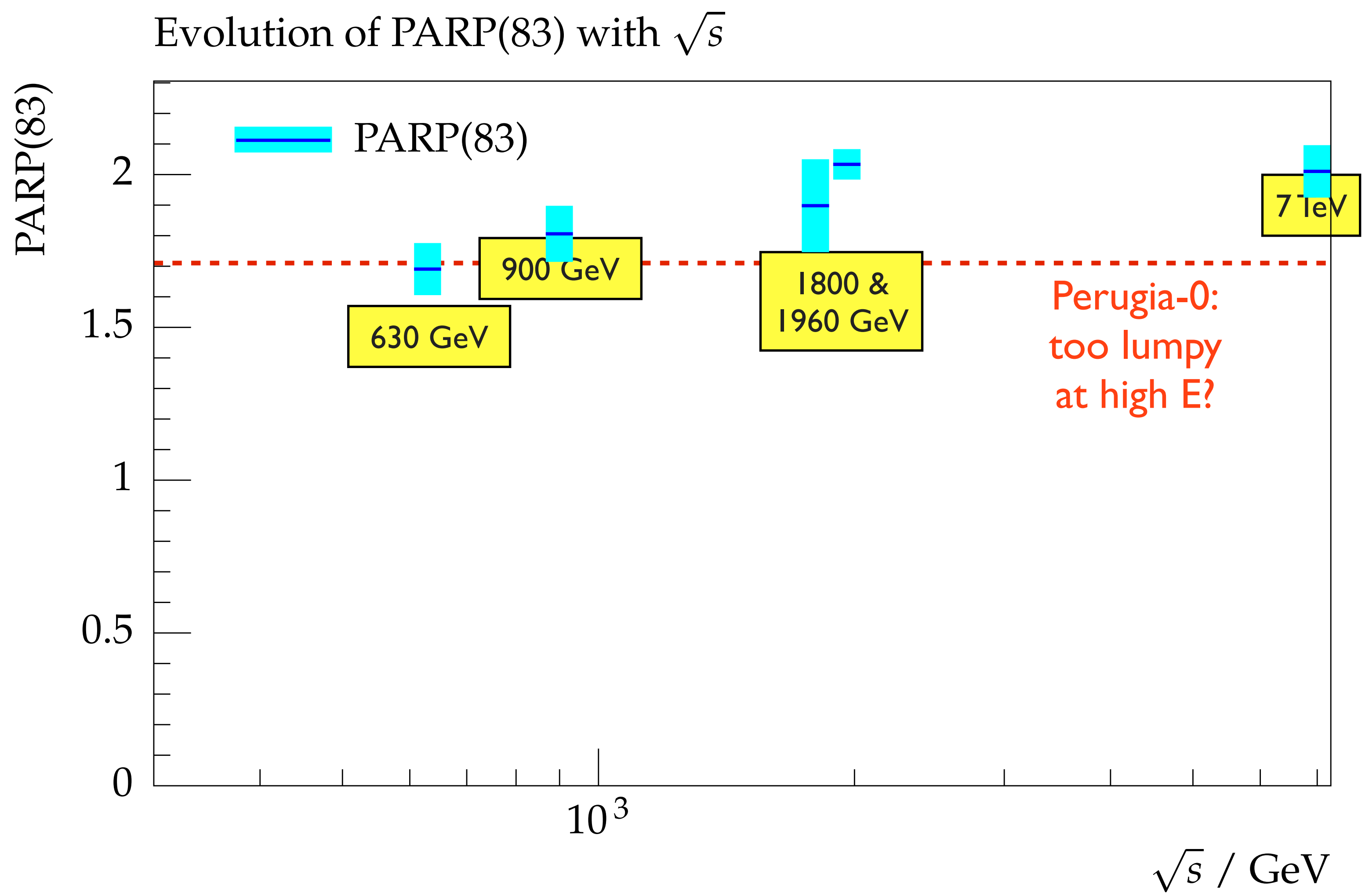


"Energy Scaling of MB Tunes", H. Schulz + PS, in preparation

Mass Distribution

Independent tunings compared to Perugia 0

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



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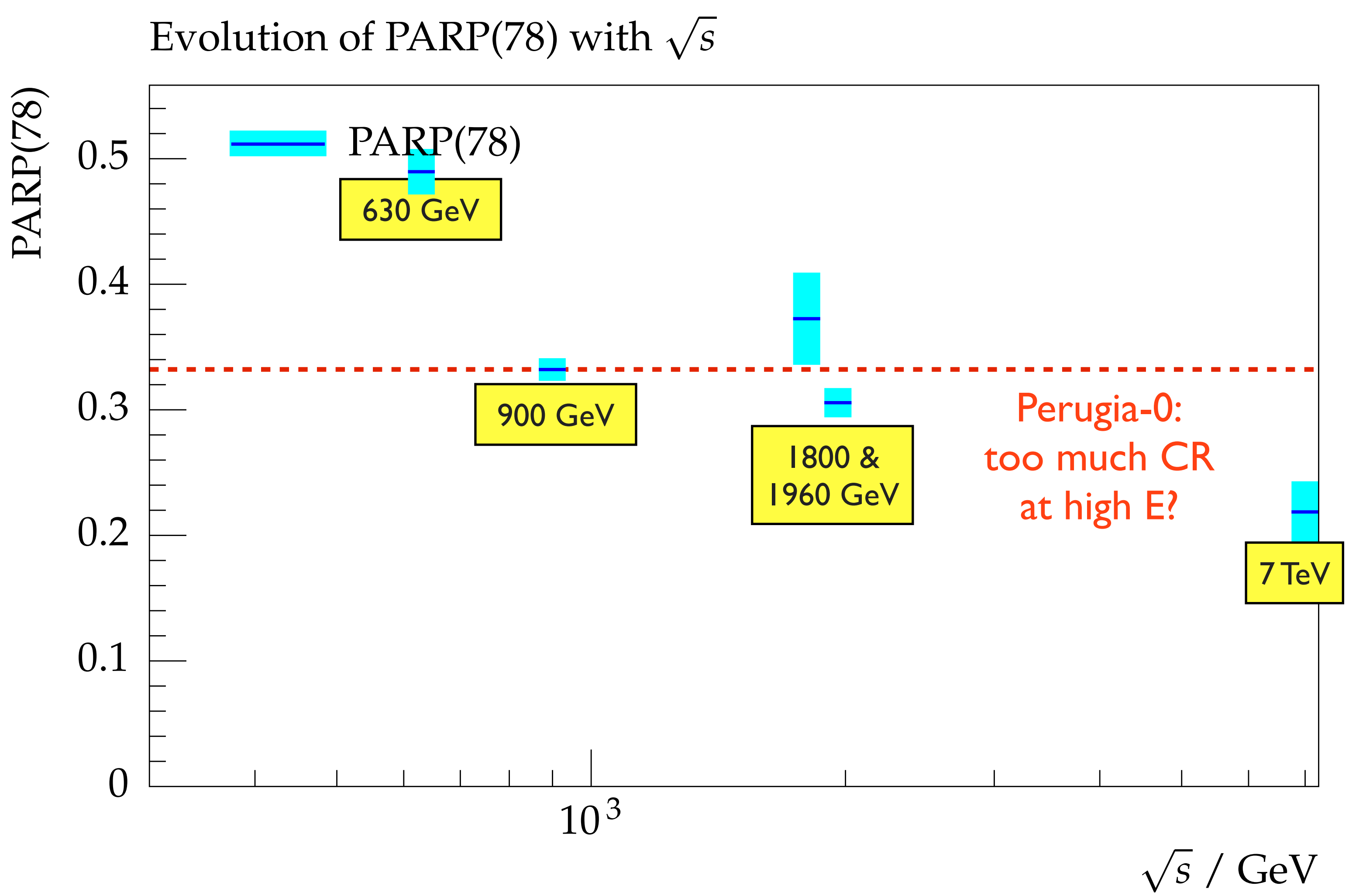
Color Reconnections

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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PYTHIA Updates

with input from R. Corke, T. Sjöstrand

PYTHIA 6

The Perugia Tunes

PS, arXiv:1005.3457v2

- 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

→ PYTHIA 8: S. Navin, arXiv:1005.3894

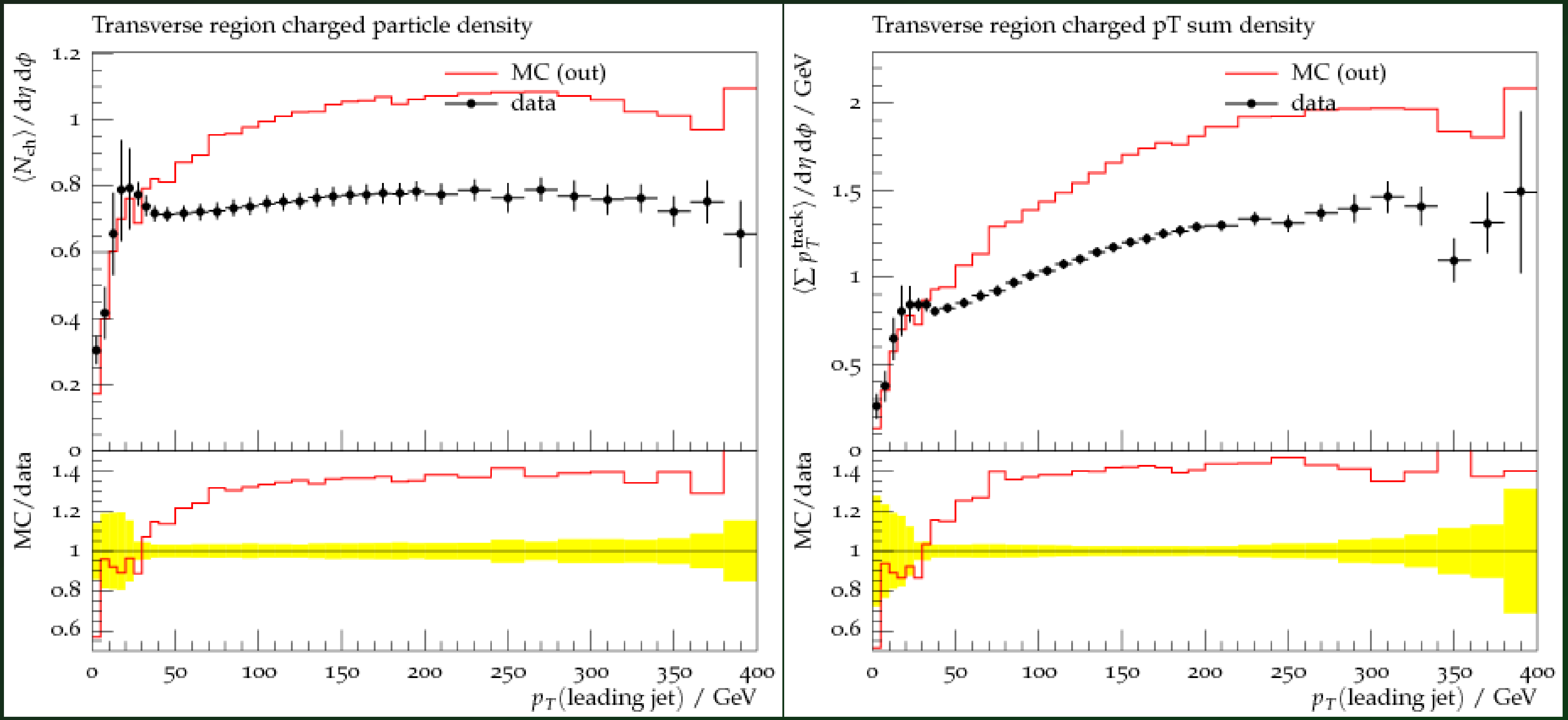
Status

- No longer actively developed

PYTHIA 8

Already significant improvements but there was one snag...

cf., e.g., yesterday's ATLAS talk (L. Tompkins)

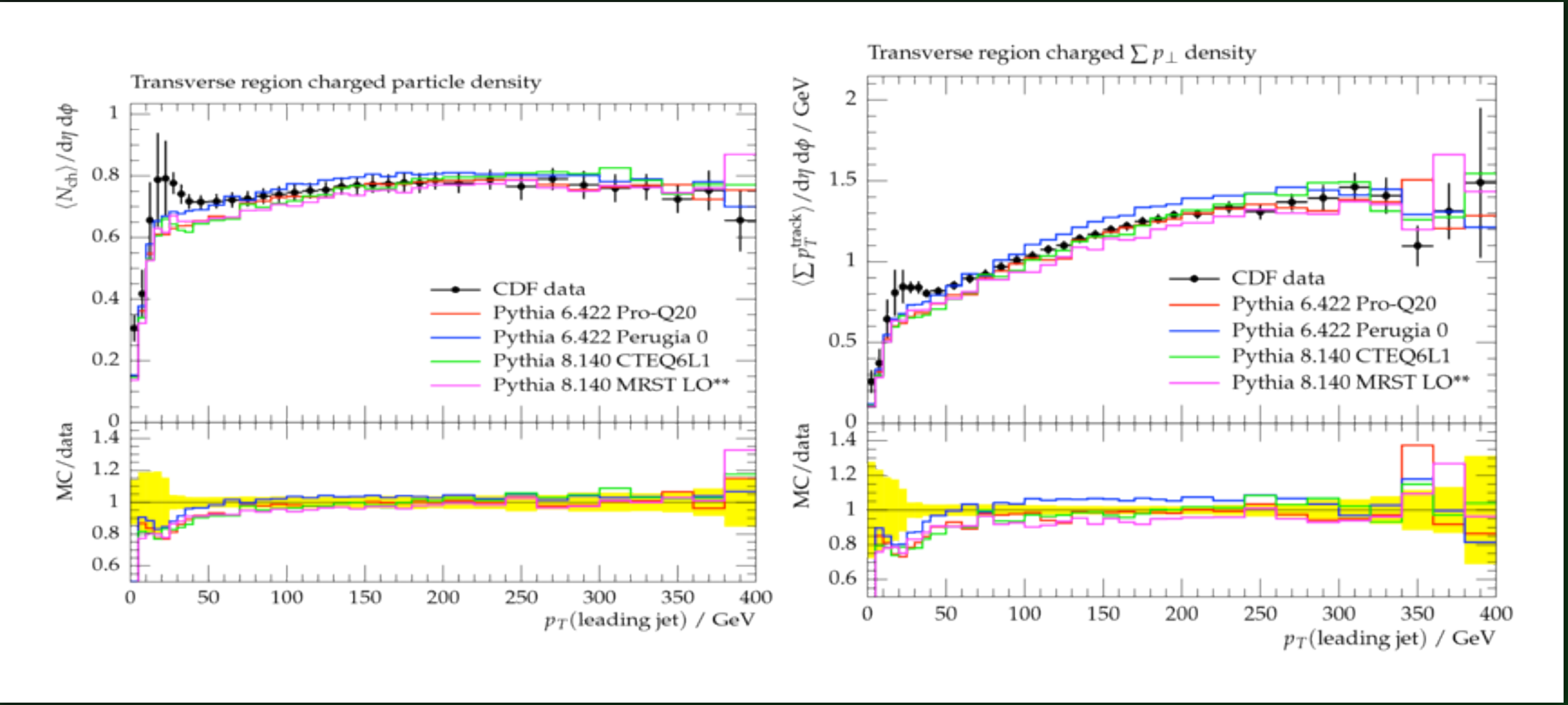


Where did we go wrong?

PYTHIA 8

A problem with Final-Initial Dipoles

(doublecounting), **now addressed →**



PYTHIA 8 now competitive with or better than PYTHIA 6 also for UE

Summary

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

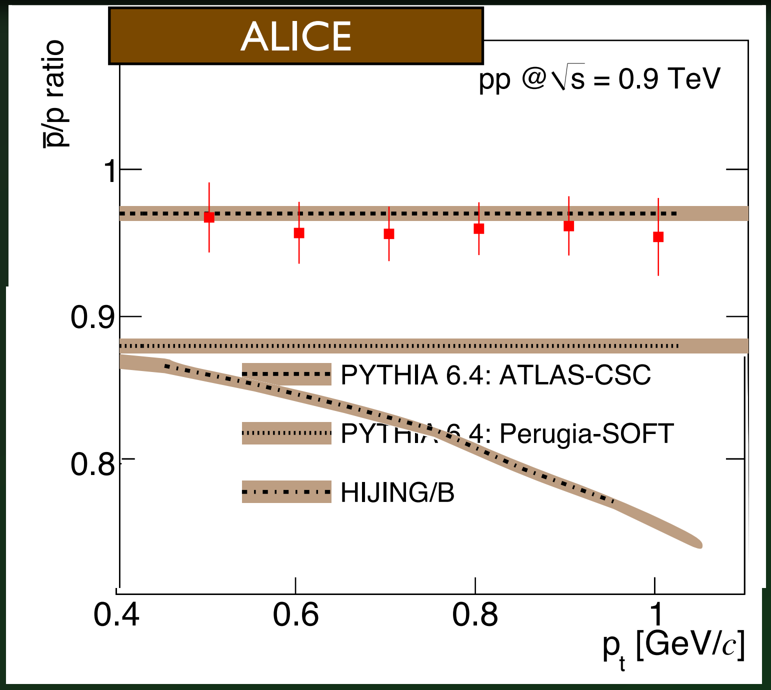
Baryon Transport

LESS than Perugia-SOFT

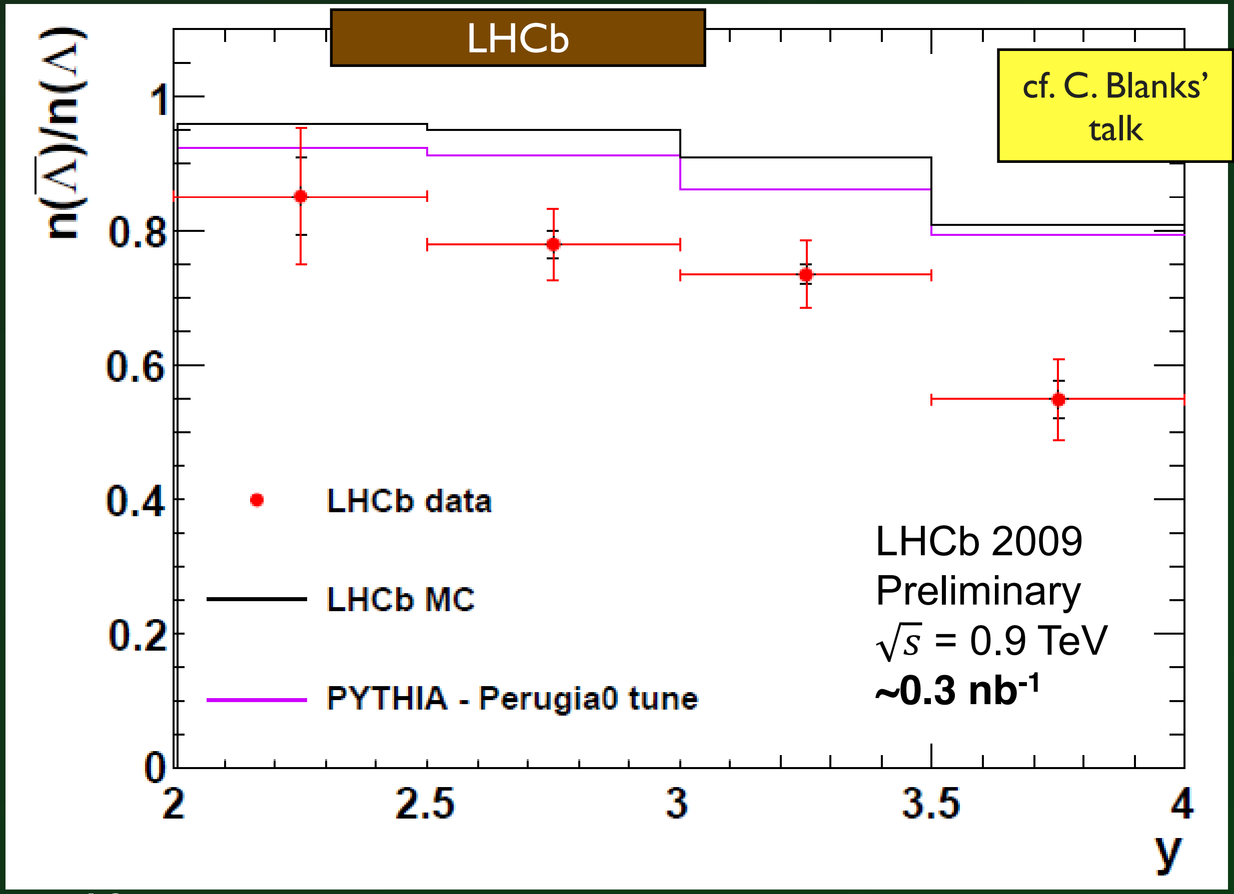
(at least for protons, in central region)

But MORE than Perugia-0

(at least for Lambdas, in forward region)



cf. J. Fiete's talk



cf. C. Blanks' talk