Energy Scaling of MB Tunes

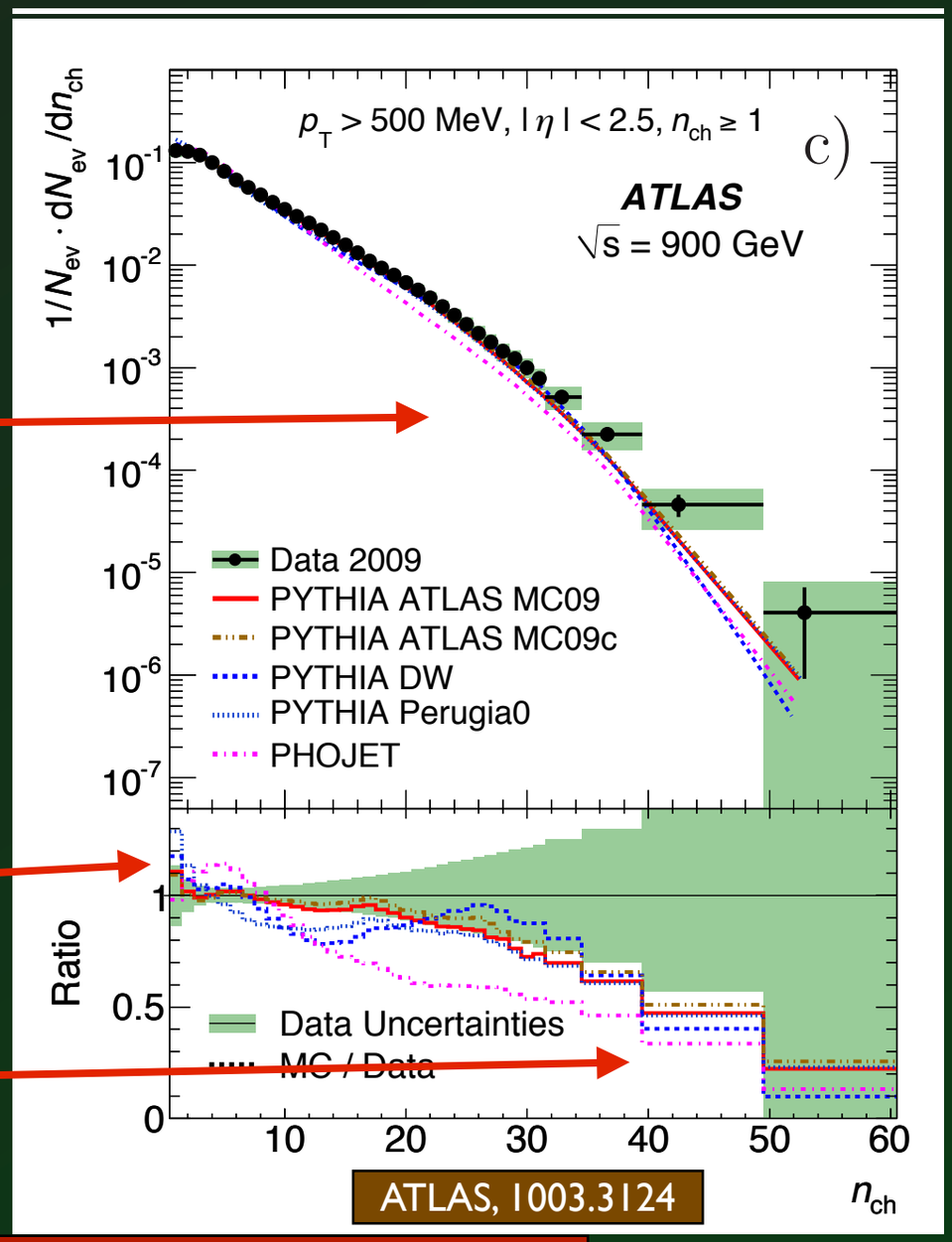
P. Skands (CERN)
with H. Schulz

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

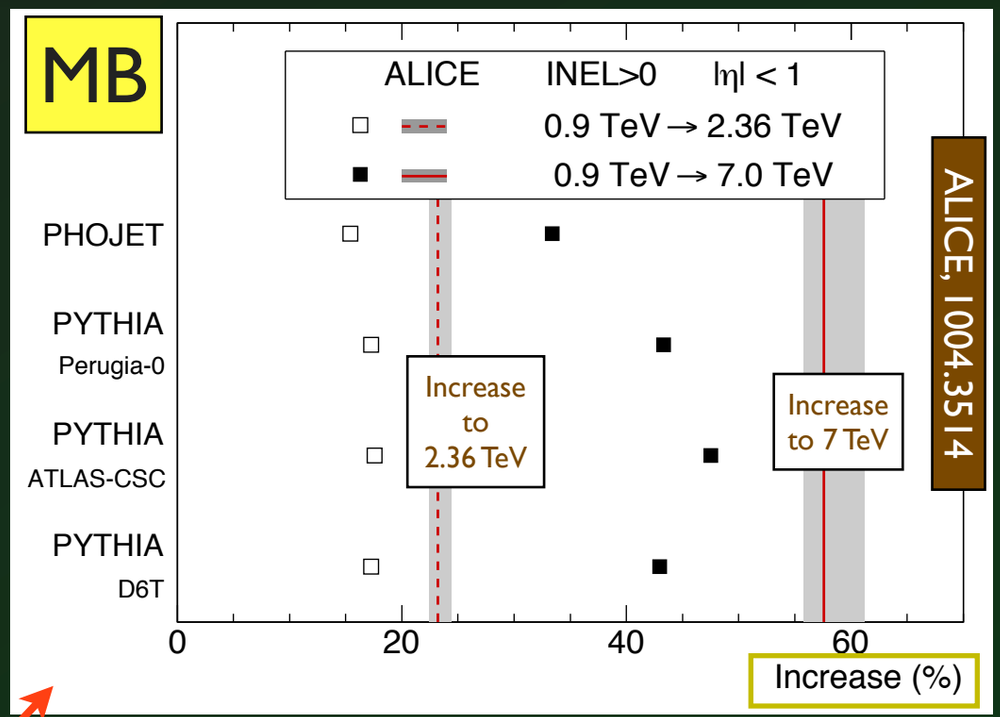
Many models/tunes are slightly low even at 900 GeV

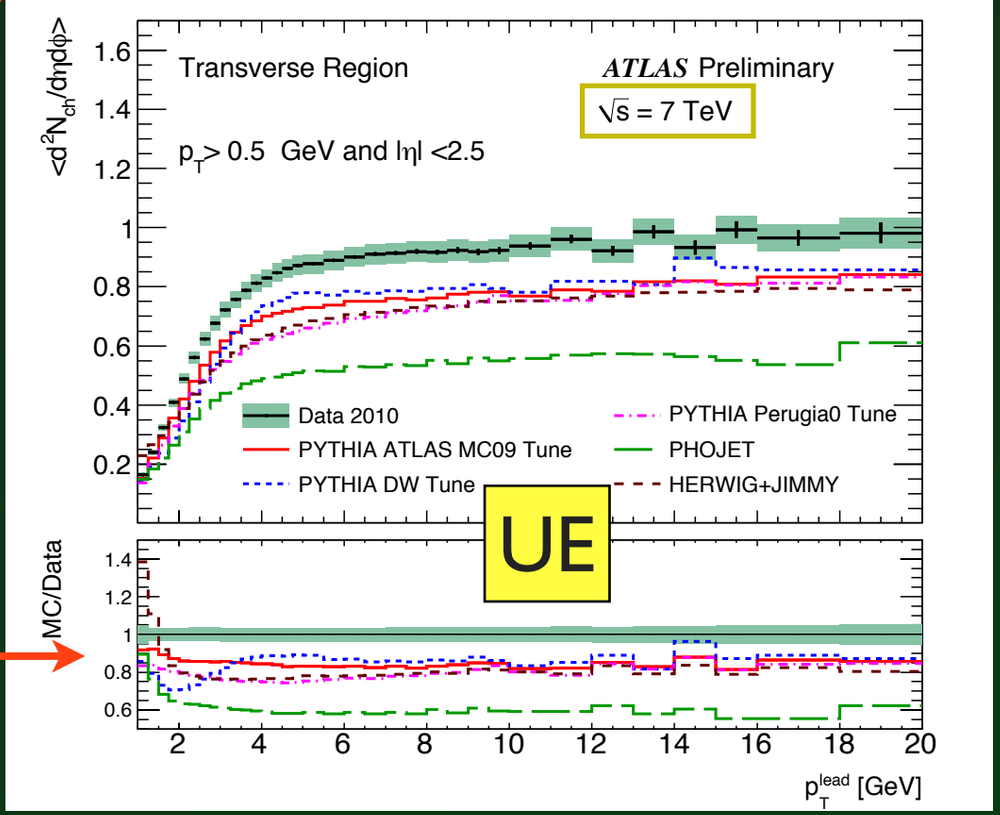
(though ≈ 20% on IR sensitive quantity not bad)

+ SCALE TOO SLOWLY

→ Even lower at 7 TeV

→ too low UE





Beyond Multiplicities

ESSENTIAL to consider several distributions simultaneously:

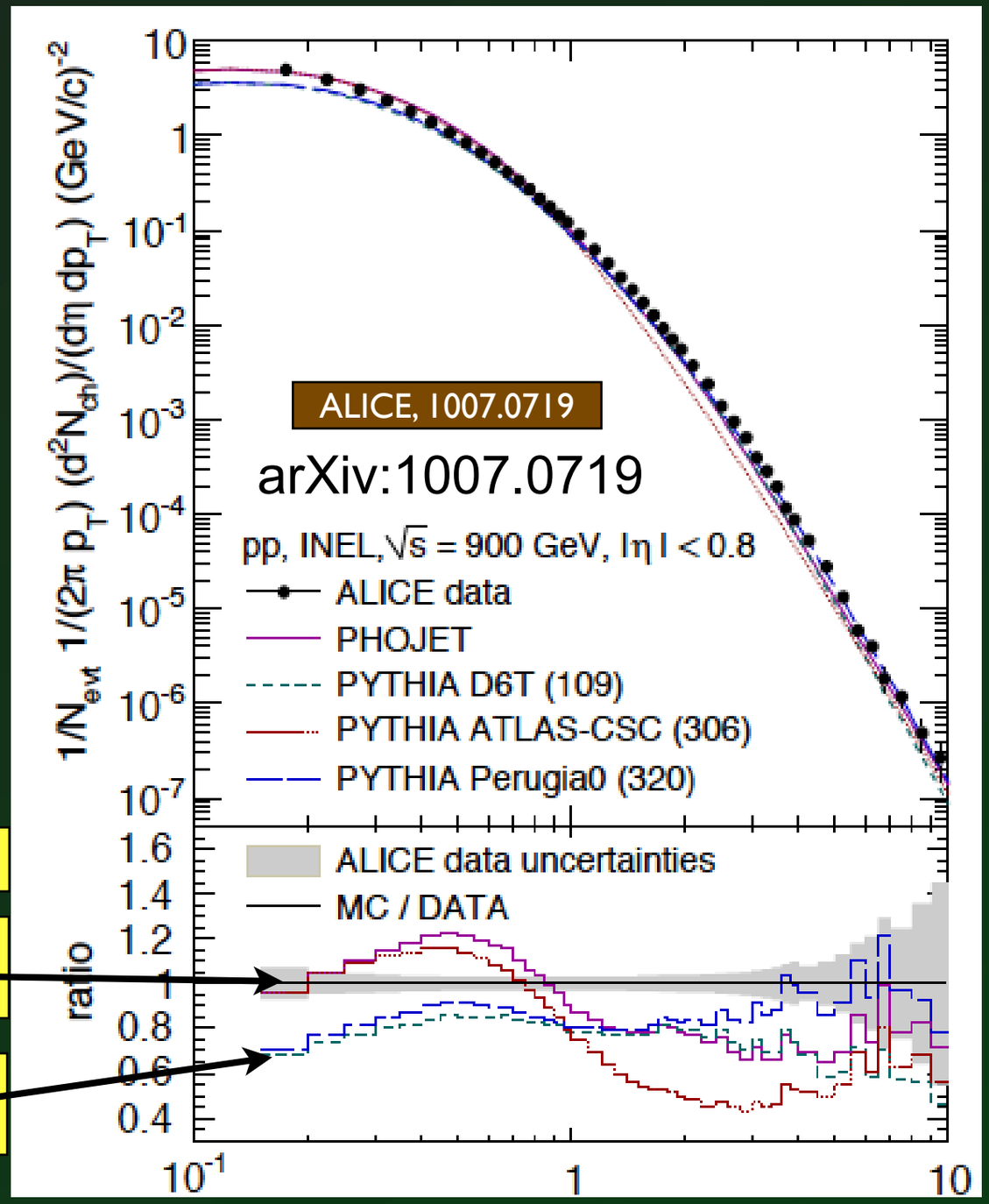
"Those that reproduce the multiplicity don't reproduce the p_T distributions and vice versa"

J. Fiete Grosse-Oetringhaus

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

Normalization fine, shape wrong

Normalization wrong, shape fine



An Organized View

1. Where is the energy going?

   Sum(pT) 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_{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, … …

IR Safe

IR Sensitive

More IR Sensitive

Action Items

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

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

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, $\langle p_T \rangle (N_{ch})$

+ 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)

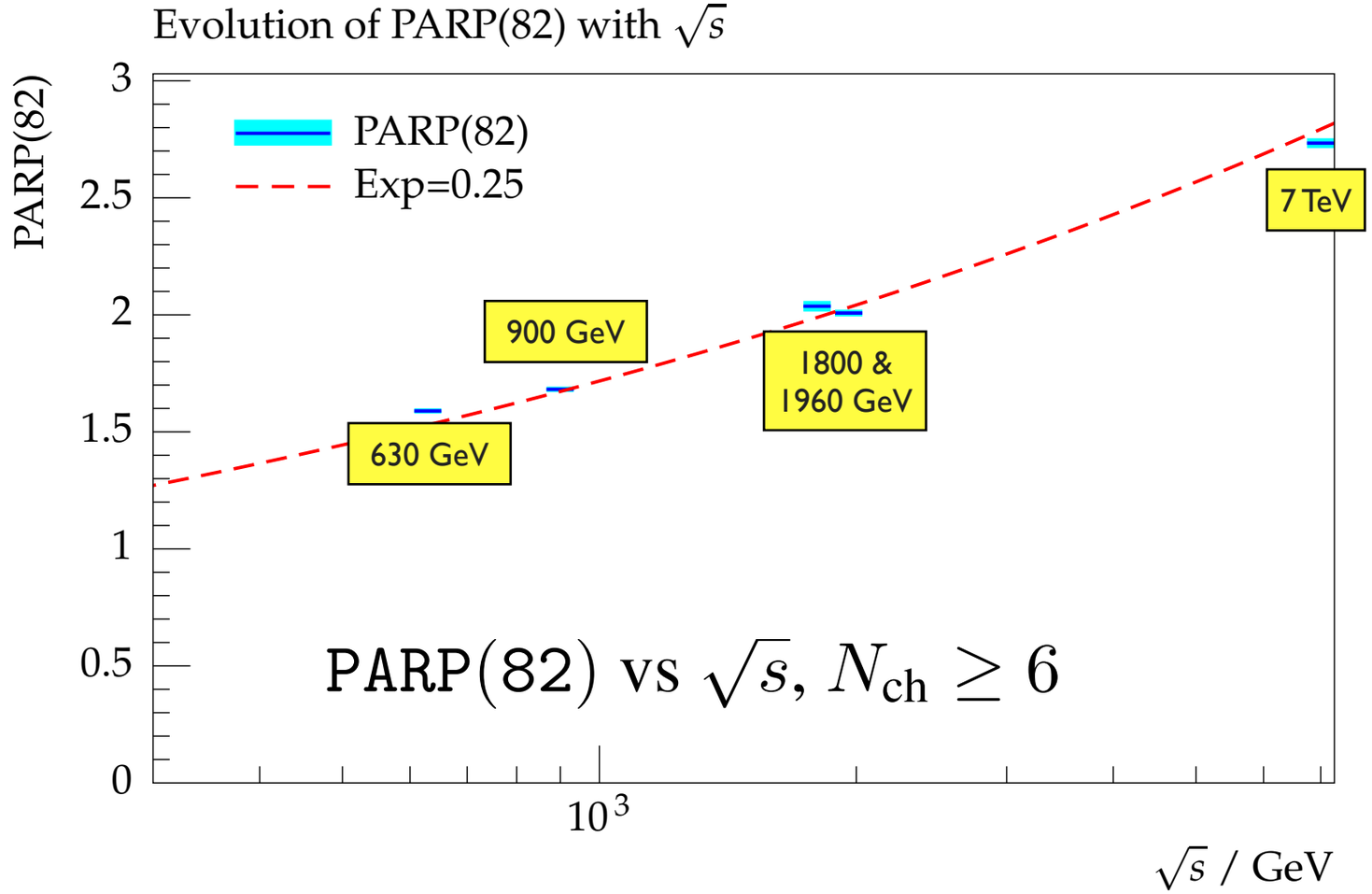
Reduce model to 3 main parameters: *Starting point = Perugia 0*

1. Infrared Regularization Scale — *PARP(82)*
2. Proton Transverse Mass Distributions — *PARP(83)*
3. Strength of Color Reconnections — *PARP(78)*

Infrared Regularization

Independent tunings compared to Perugia 0

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

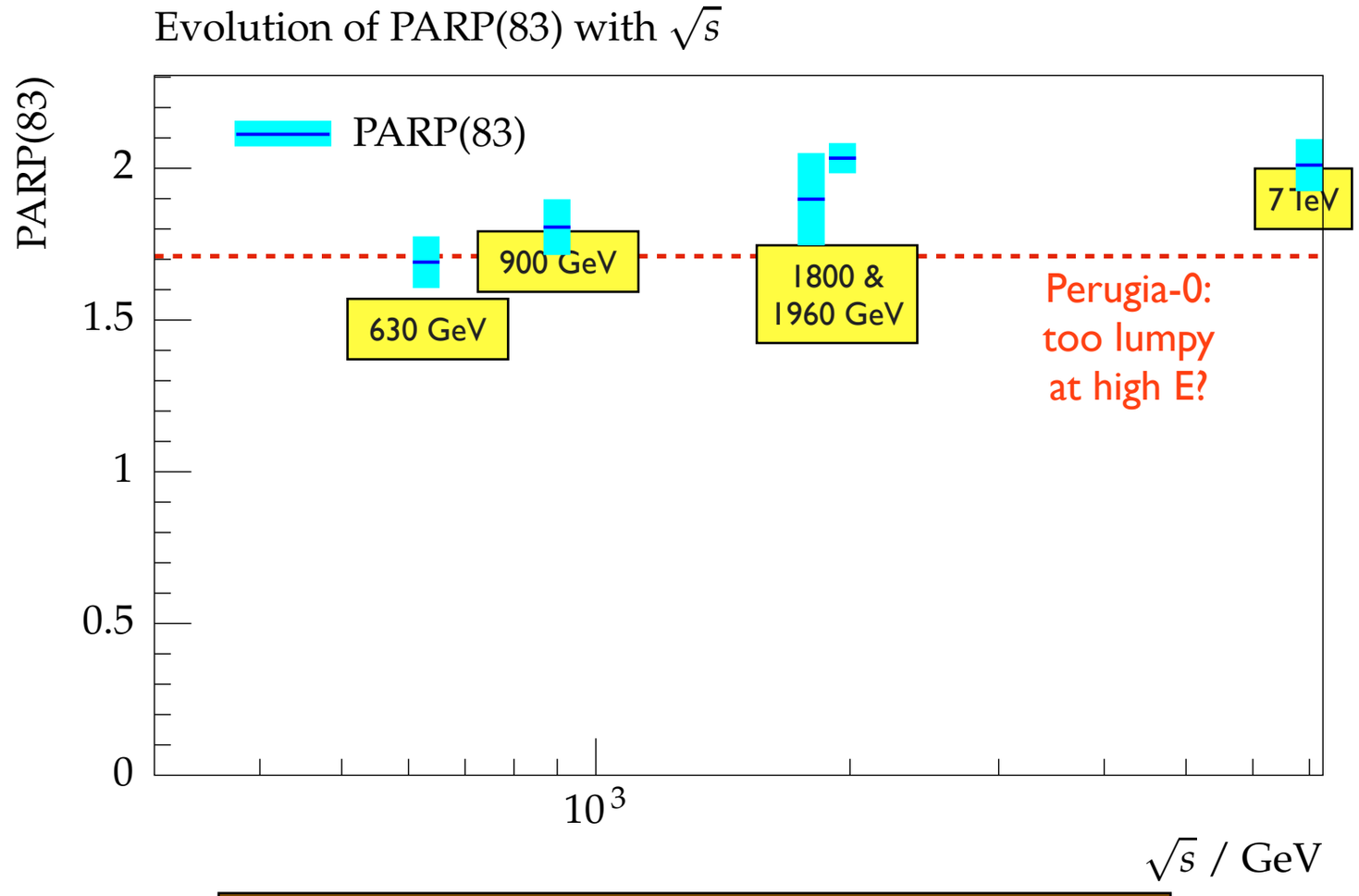


"Energy Scaling of MB Tunes", H. Schulz + PS, in preparation

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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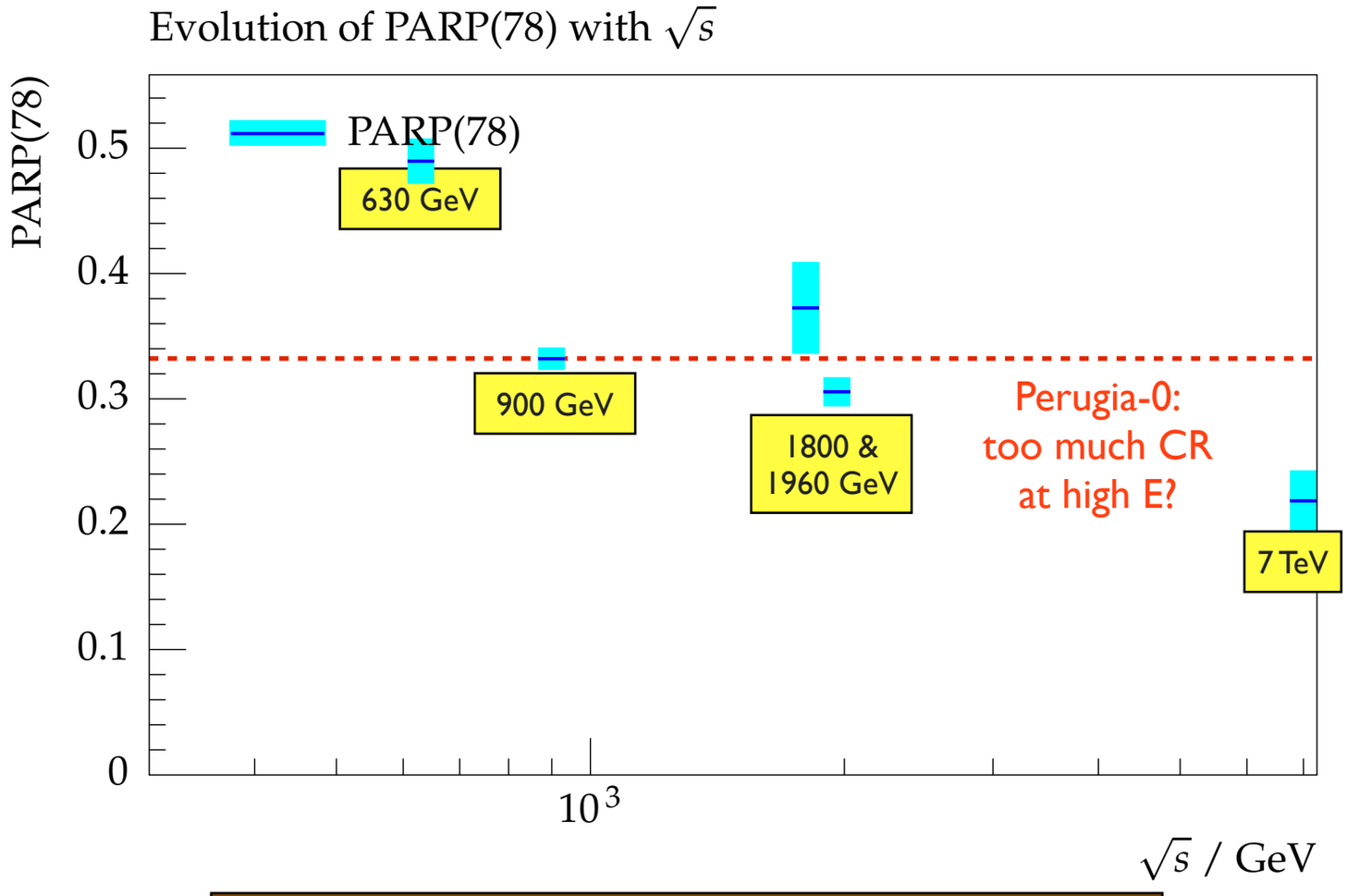
Color Reconnections

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

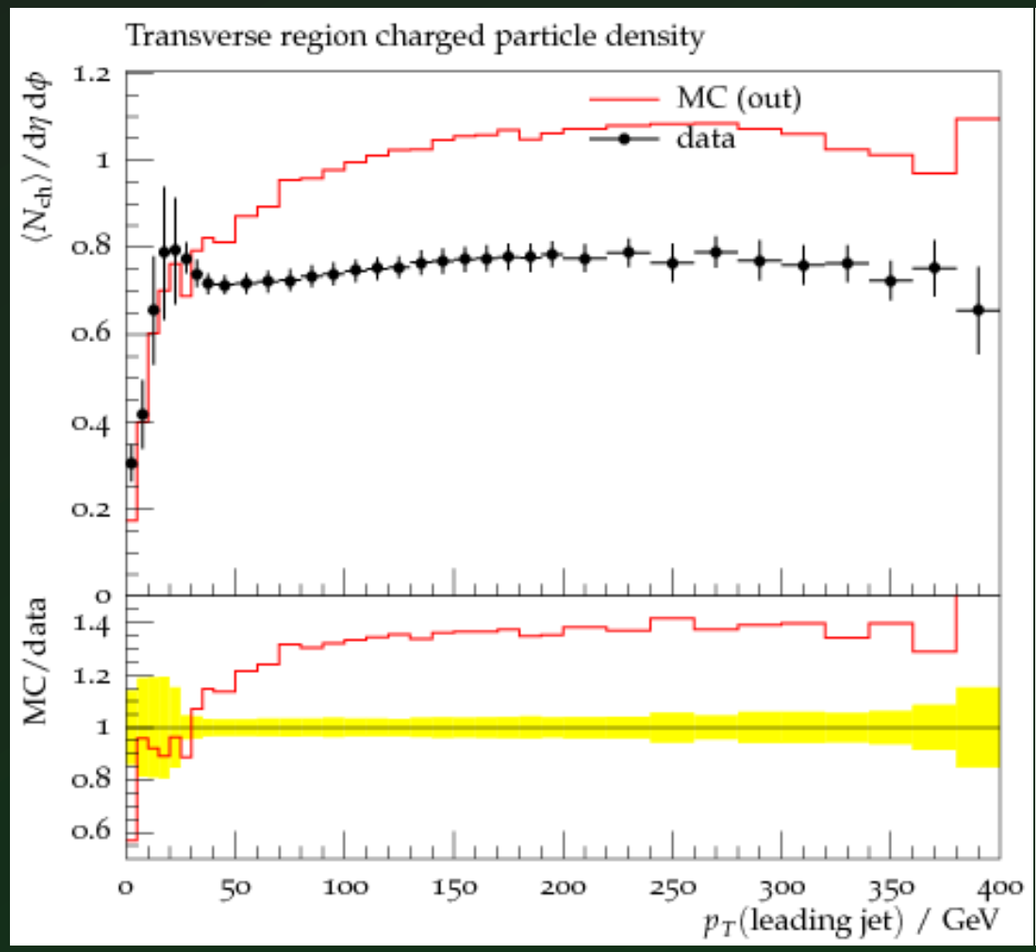
Status

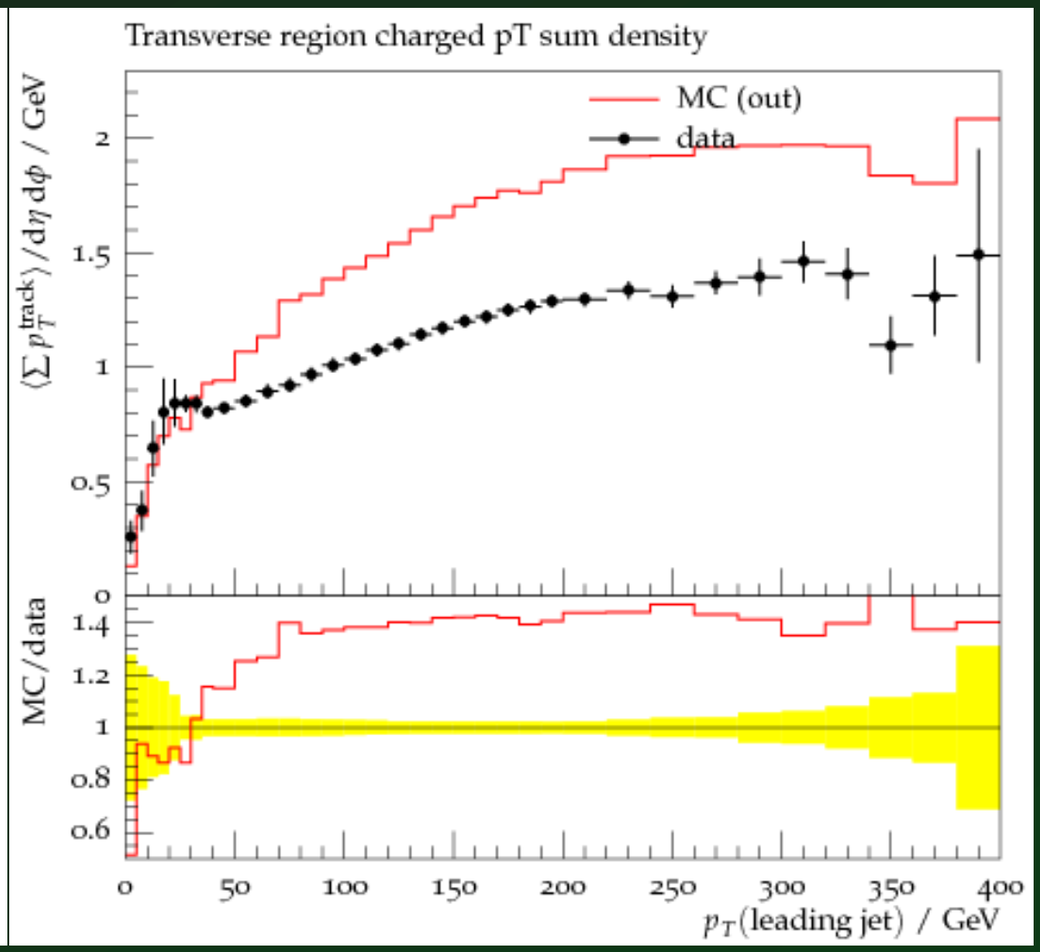
No longer actively developed

PYTHIA 8

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

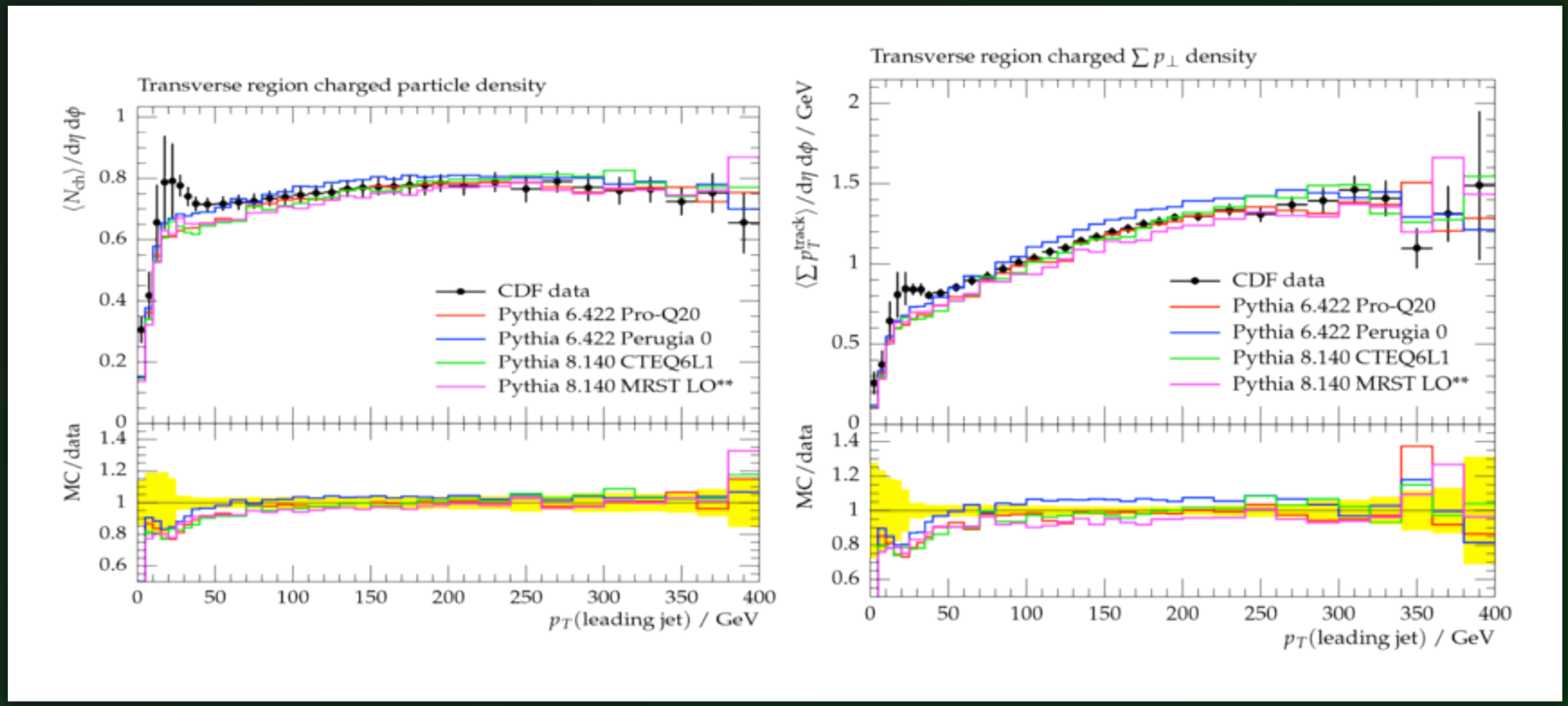
Already significant improvements but there was one snag...





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

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

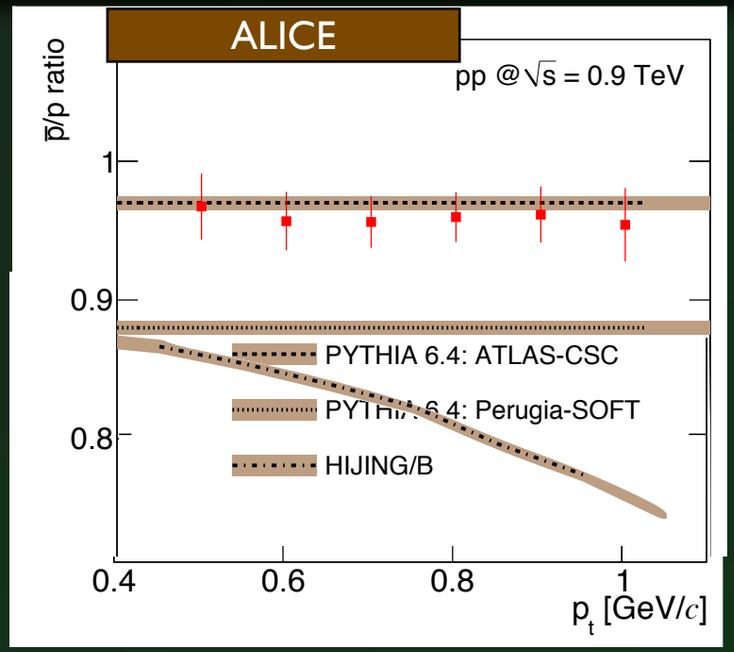
Baryon Transport

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