Symposium in honor of *Guy Paić*

Instituto de Ciencias Nucleares UNAM

Underlying Event (UE) to study the new phenomena

Courtesy of Guy's grandson

2005

- Identify the opportune time for action
- Explain complex things using simple ideas
- If you end up against the mainstream, you did it well!
- Be persistent

First exercise (2008)

- Study pp physics within a heavy-ion experiment
- Look for something new, do not follow the mainstream

First exercise (2008)

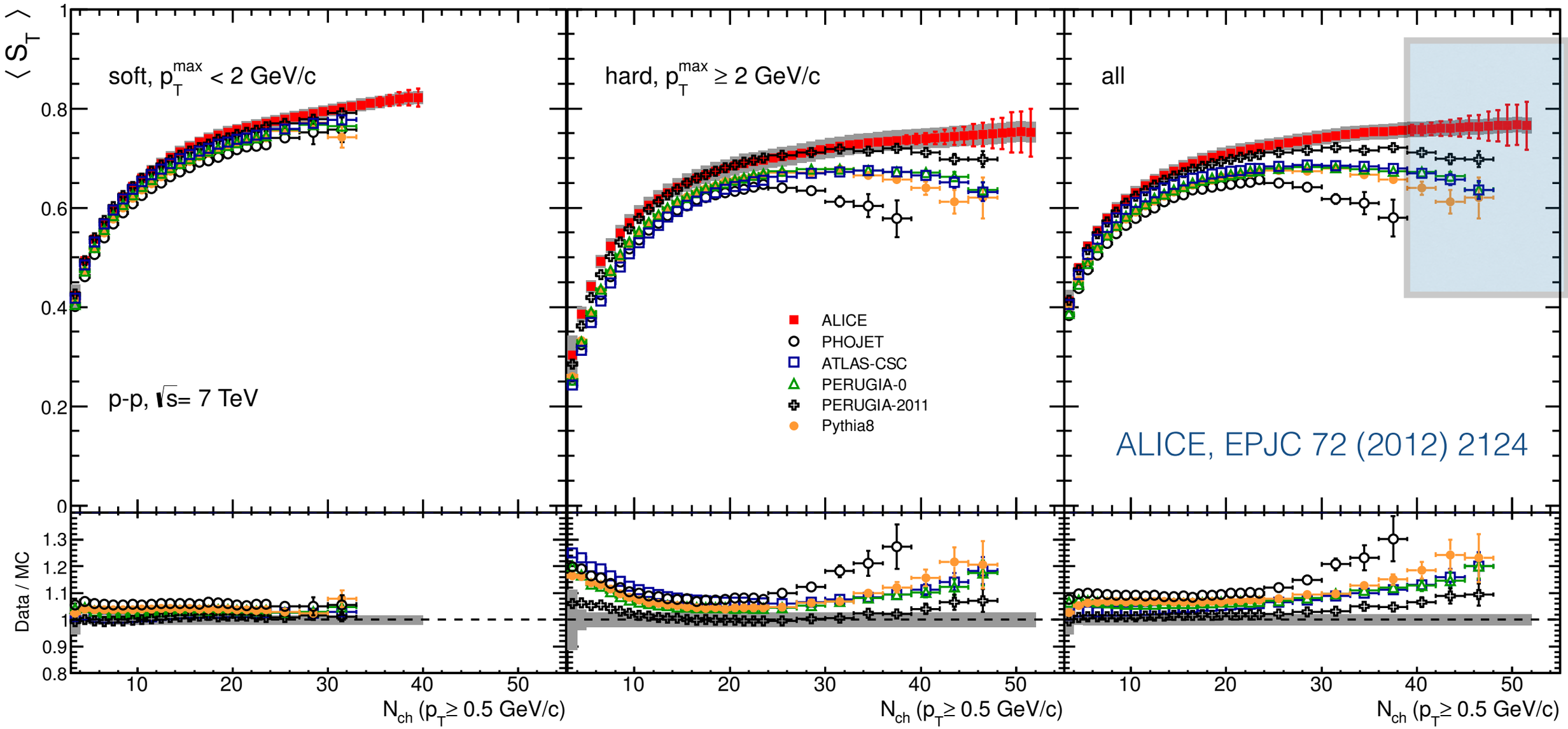
Study pp physics within a heavy-ion experiment

Look for something new, do not follow the mainstream

Event shape analysis applied to soft pp collisions

(inputs from Jean Pierre Revol and Andreas Morsch)

ALICE publication



Preliminary results available since 2010, more or less at the time of the memorial LHC Seminar on…

Ridge in pp collisions

LHC Seminar

Long-Range Near-Side Angular Correlations in Proton-Proton Interactions in CMS.

by Guido Tonelli (Universita' di Pisa, INFN, CERN) , Gunther Roland (Massachusetts Institute of Technology (MIT))

Tuesday 21 Sep 2010, 17:00 → 18:00 Europe/Zurich

500-1-001 - Main Auditorium (CERN)

Description The CMS Collaboration Results on two-particle angular correlations for charged particles emitted in proton-proton collisions at center of mass energies of 0.9, 2.36 and 7TeV over a broad range of pseudorapidity (η) and azimuthal angle (φ) are presented using data collected with the CMS detector at the LHC. Short-range correlations in Δη, which are studied in minimum bias events, are characterized using a simple independent cluster parameterization in order to quantify their strength (cluster size) and their extent in η (cluster decay width). Long-range azimuthal correlations are studied more differentially as a function of charged particle multiplicity and particle transverse momentum using a 980nb−1 data set at 7TeV. In high multiplicity events, a pronounced structure emerges in the two-dimensional correlation function for particles in intermediate pT's of 1-3GeV/c, 2.0< |Δη|<4.8 and Δφ≈0. This is the first observation of such a ridge-like feature in two-particle correlation functions in pp or p-pbar collisions.

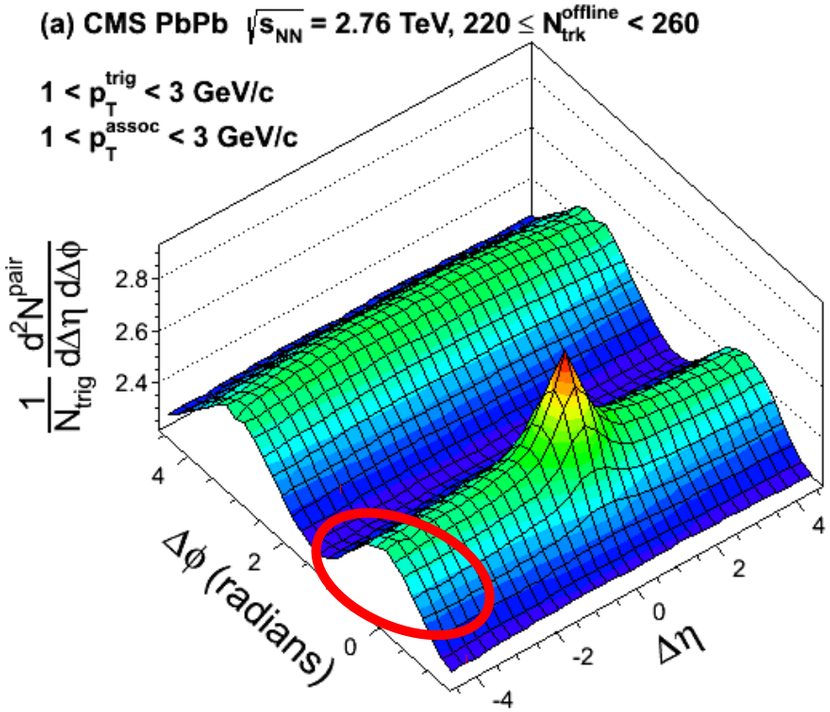
EVO Universe, password "seminar"; Phone Bridge ID: 2330444 Password: 5142

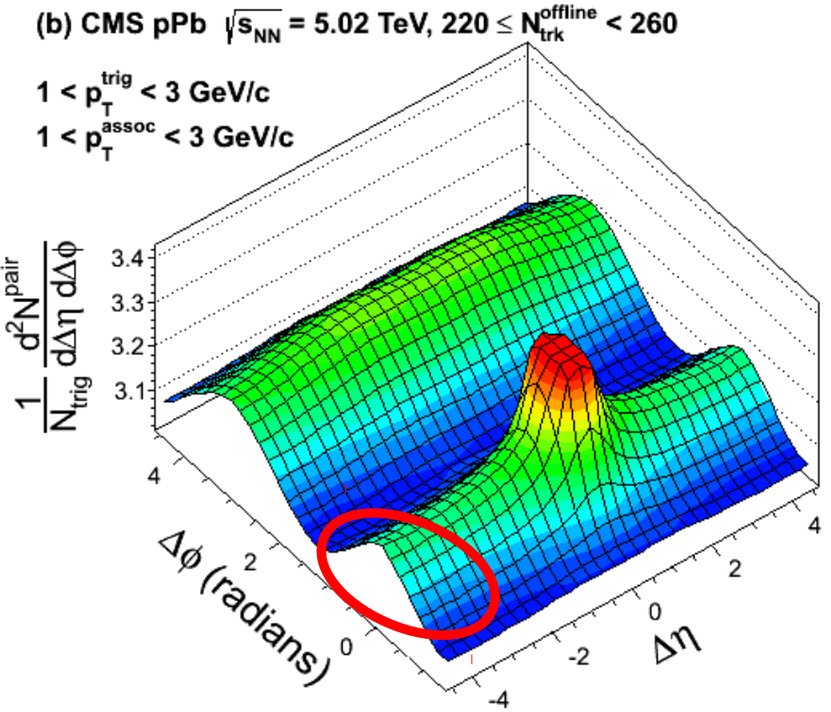
GR-slides | GT-slides | Joint LPCC/EP/PP CERN seminar | Poster | Video in CDS

Organized by M.Mangano, M.Spiropulu, G.Unal.....**Tea and Coffee will be served at 16:30

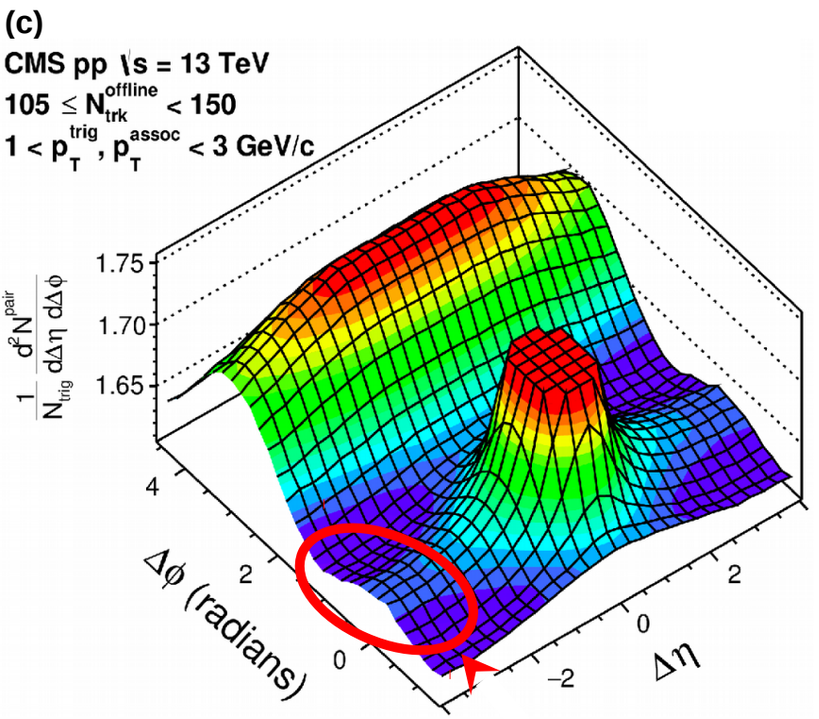
Webcast There is a live webcast for this event — Watch

Ridge structure in pp





CMS, PLB 724 (2013) 213

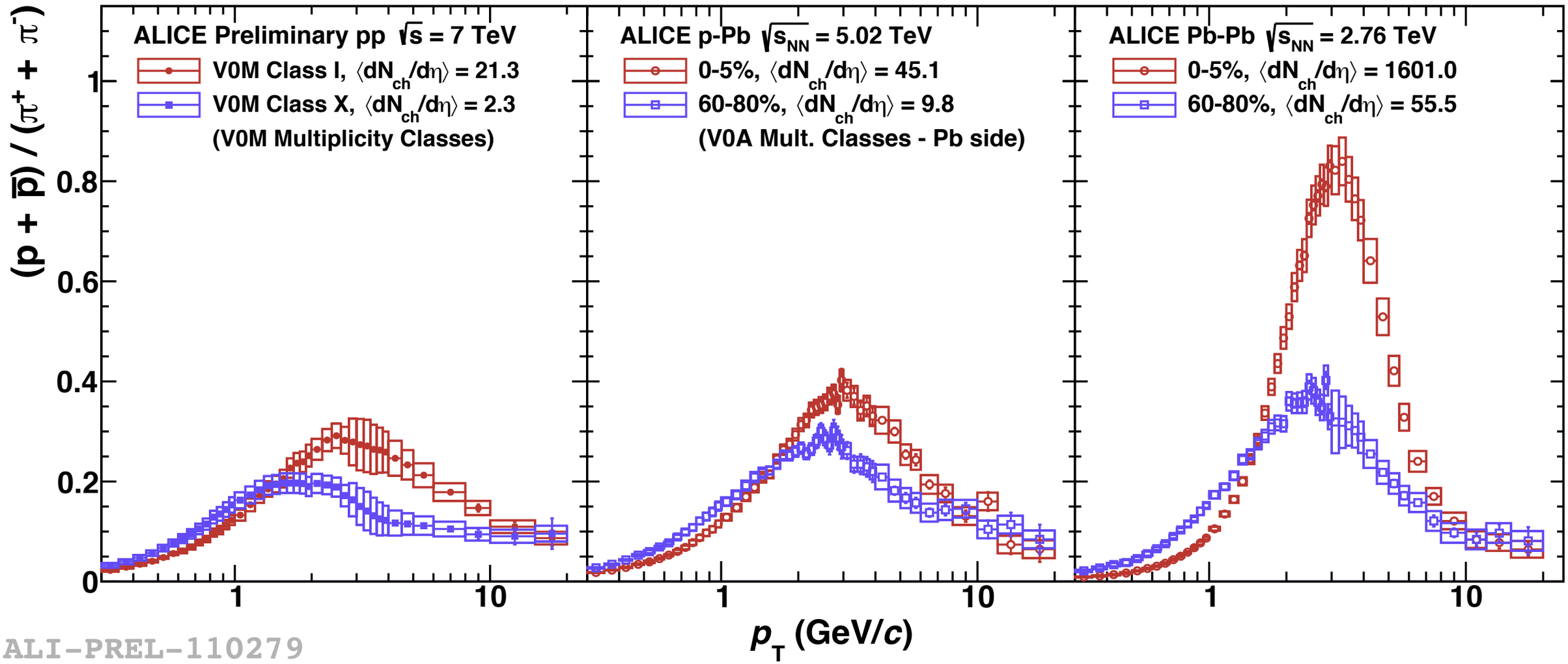


CMS, PLB 765 (2017) 193

Two-particle correlations with inclusive charged particles

And more for small systems

Identified particle production vs multiplicity in pp, p-Pb and Pb-Pb collisions exhibits remarkable similarities

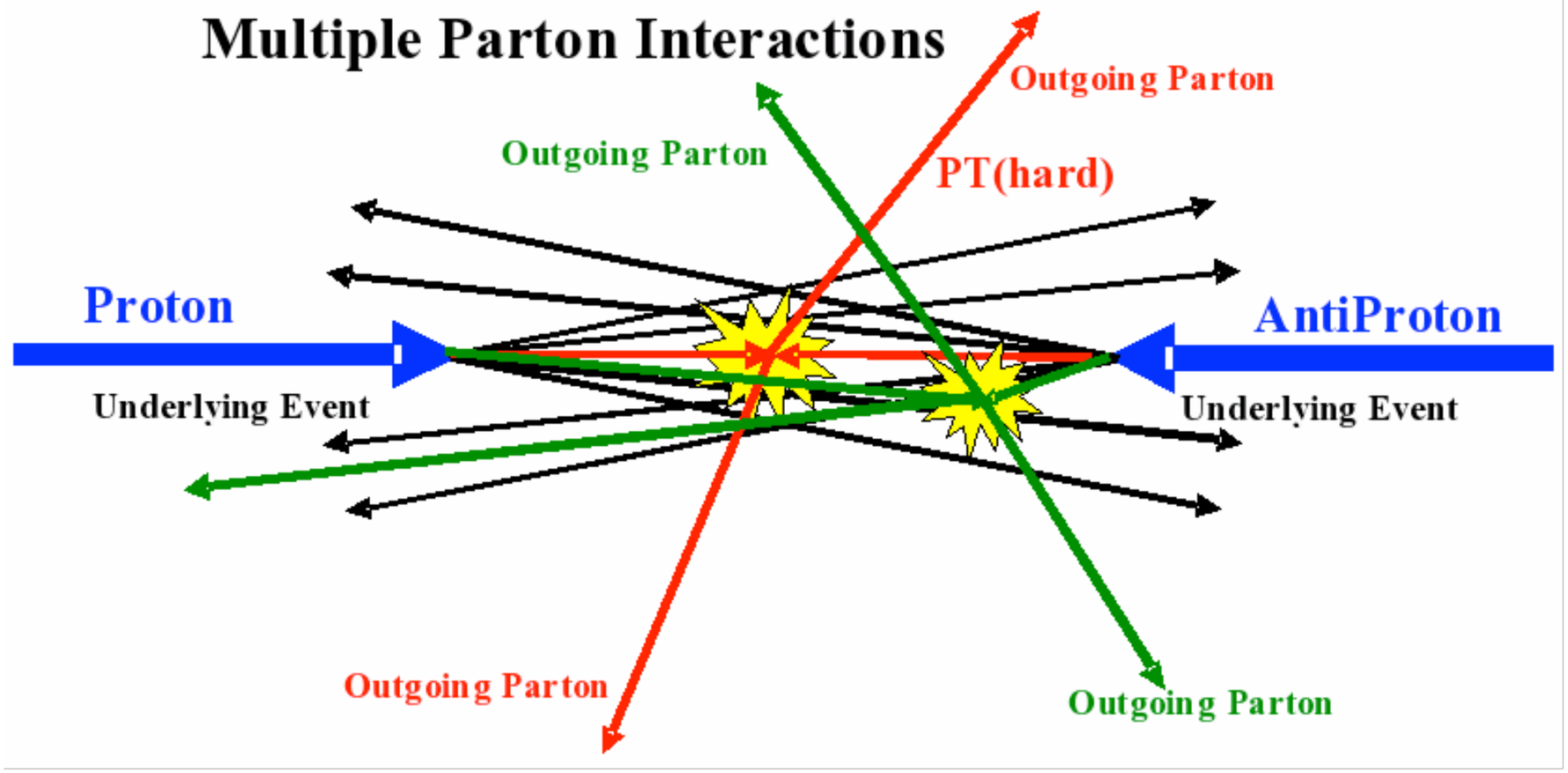


Mass dependent modification of the p_T spectral shapes going from low to high multiplicities

Flow-like effects

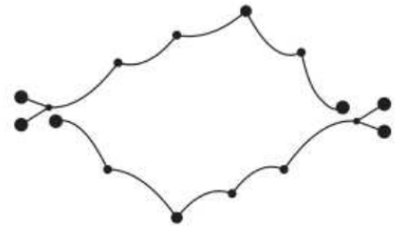
in a 2CD-inspired model: PYTHIA

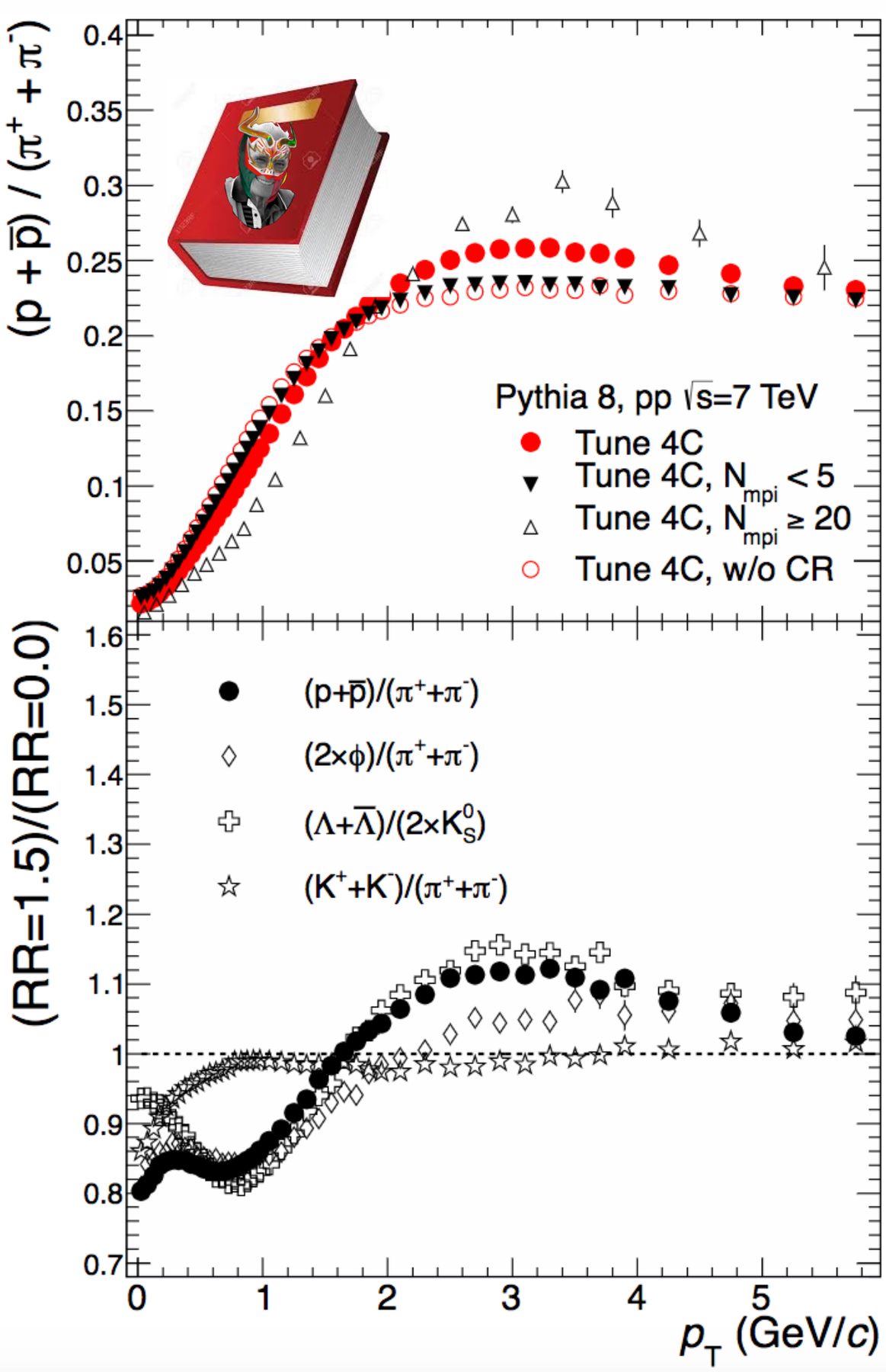
(in collaboration with Peter Christiansen and Eleazar Cuautle)



+

Color reconnection: Interaction among final partons just before the hadronization



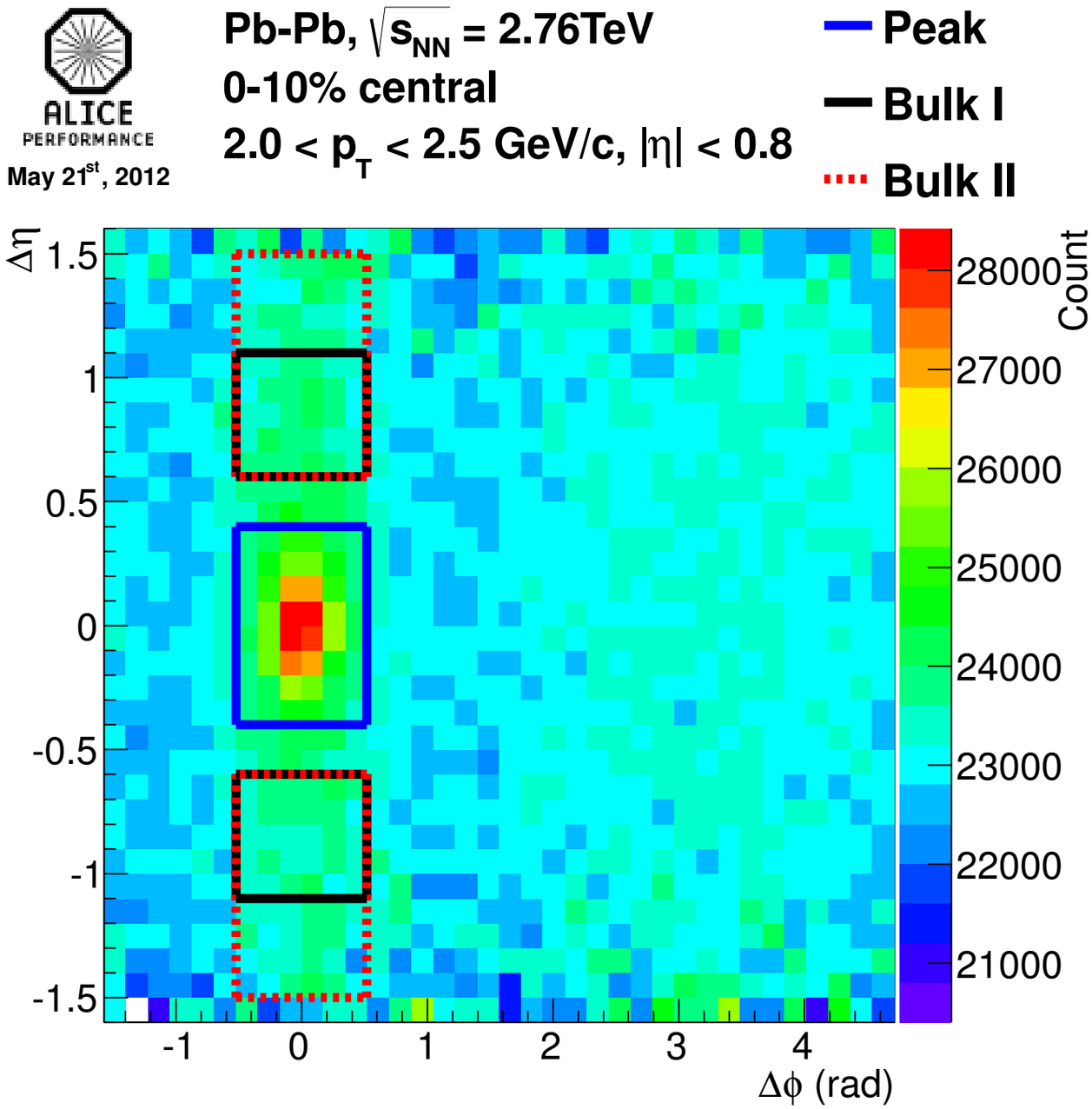


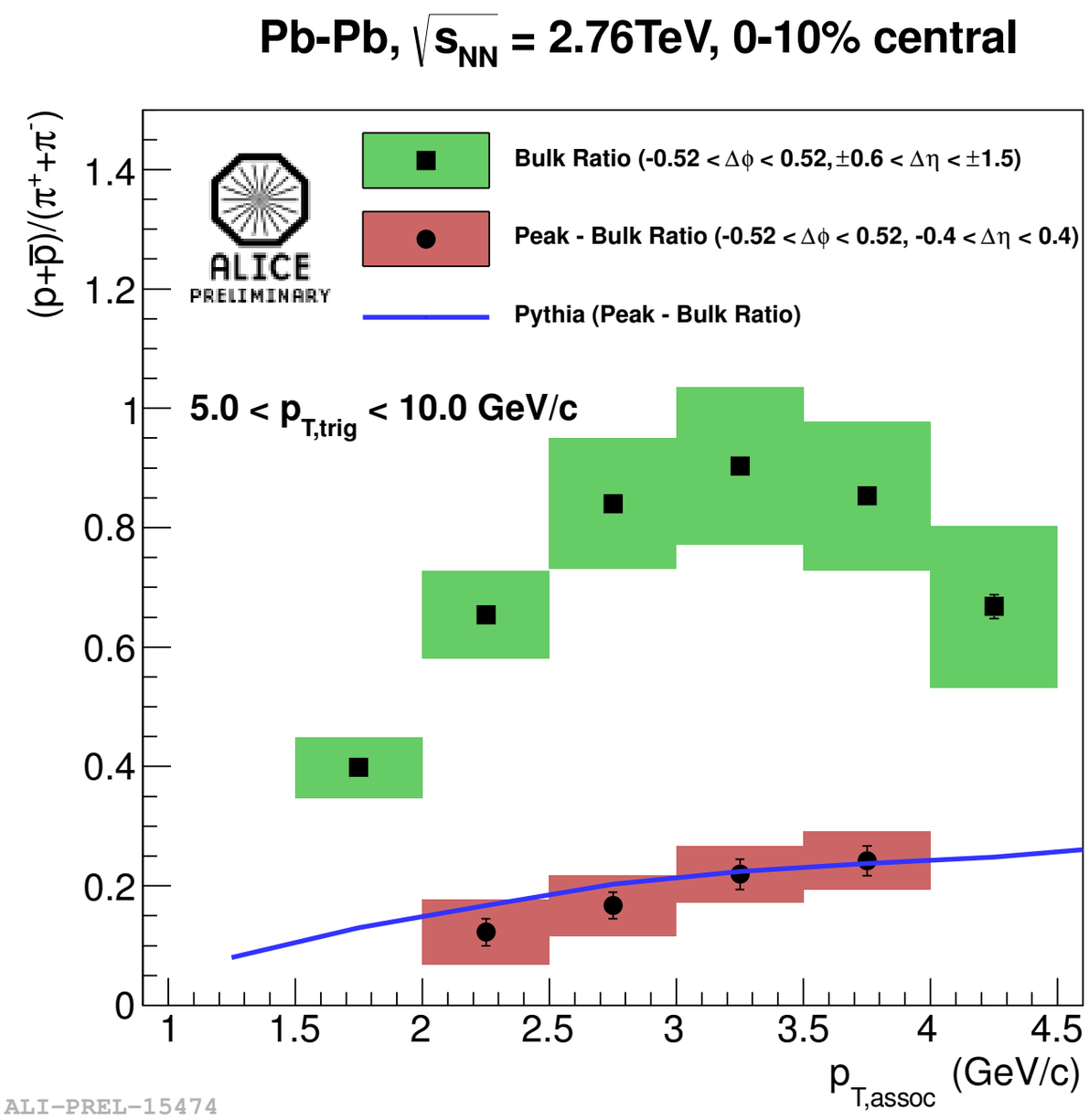
Color Reconnection and Flowlike Patterns in p p Collisions

Authors	A Ortiz Velasquez, Peter Christiansen, E Cuautle Flores, IA Maldonado Cervantes, Guy Paić
Publication date	2013/7/22
Journal	Physical review letters
Volume	111
Issue	4
Pages	042001
Publisher	American Physical Society
Description	Abstract Increasingly, with the data collected at the LHC we are confronted with the possible existence of flow in pp collisions. In this work, we show that PYTHIA 8 produces flowlike effects in events with multiple hard subcollisions due to color string formations between final partons from independent hard scatterings, the so-called color reconnection. We present studies of different identified hadron observables in pp collisions at 7 TeV. Studies have been done both for minimum bias and multiplicity intervals in events with and without color ...
Total citations	Cited by 119

Scholar articles
Color Reconnection and Flowlike Patterns in p p Collisions
AO Velasquez, P Christiansen, EC Flores… - Physical review letters, 2013
Cited by 119 Related articles All 9 versions

How to study the new phenomena?



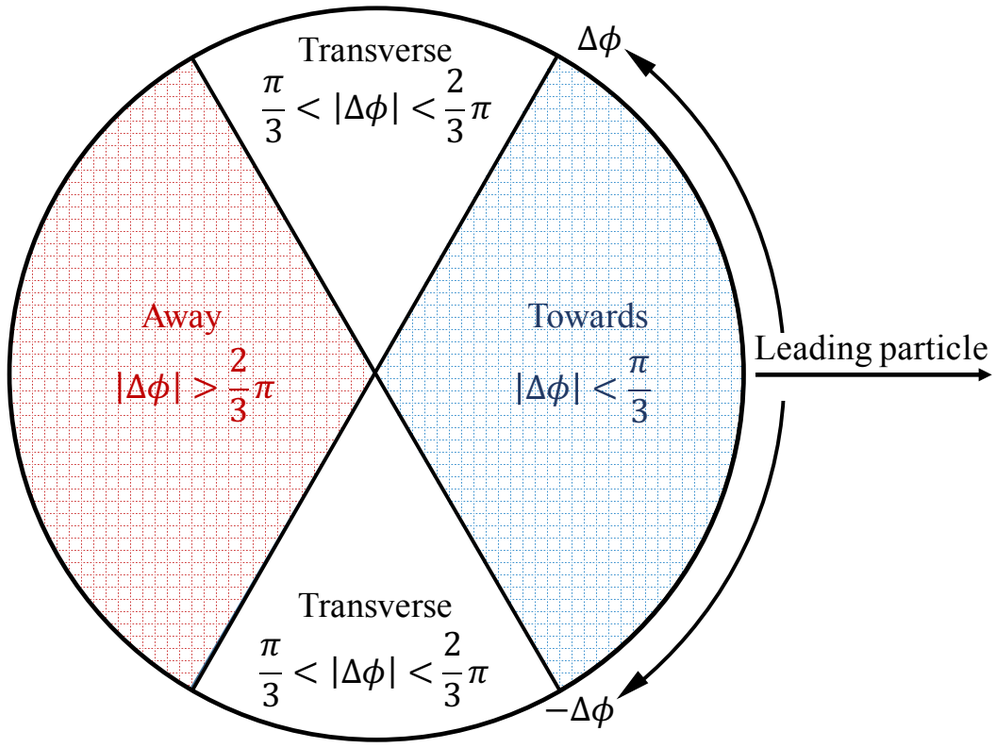


Figures taken from: M. Veldhoen (ALICE), NPA 910-911 (2013) 306-309

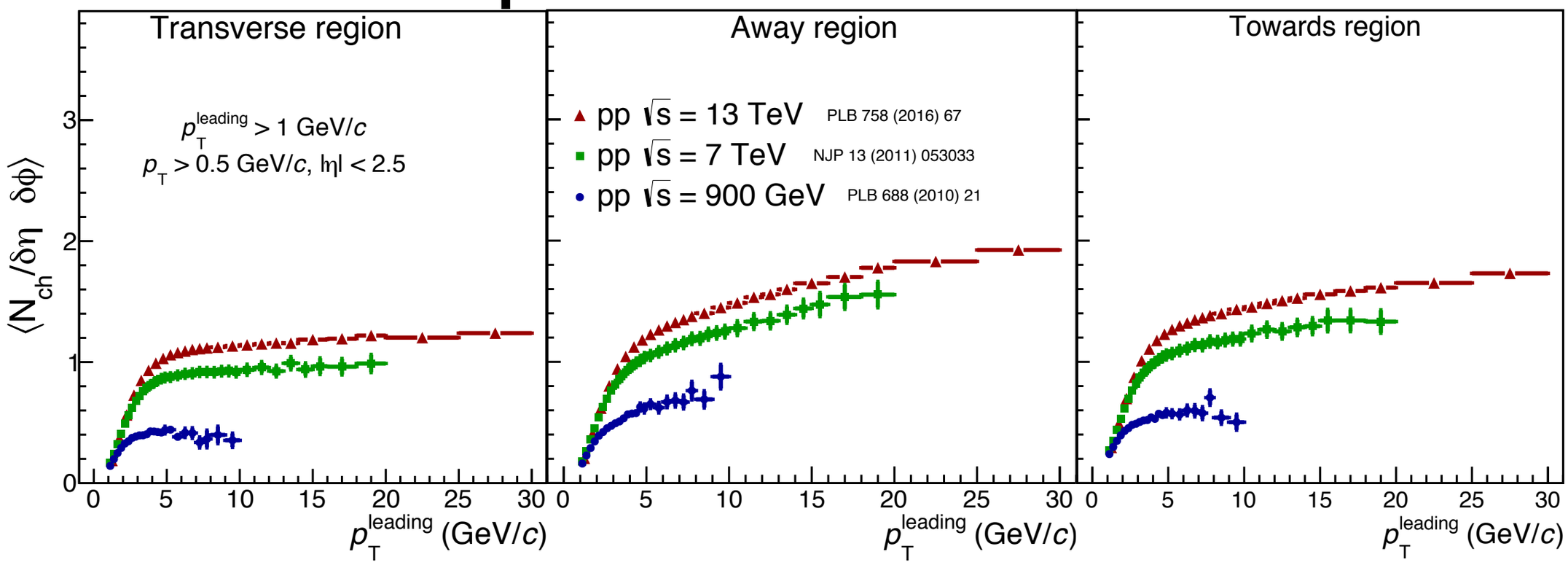
Underlying Event (UE)

- In the context of event simulation the Underlying Event refers to everything that does not originate from the hard scatter outgoing partons

- Experimentally we measure quantities which are sensitive to UE, however, it is difficult to isolate this component (e.g. interaction among coloured objects before the hadonization)



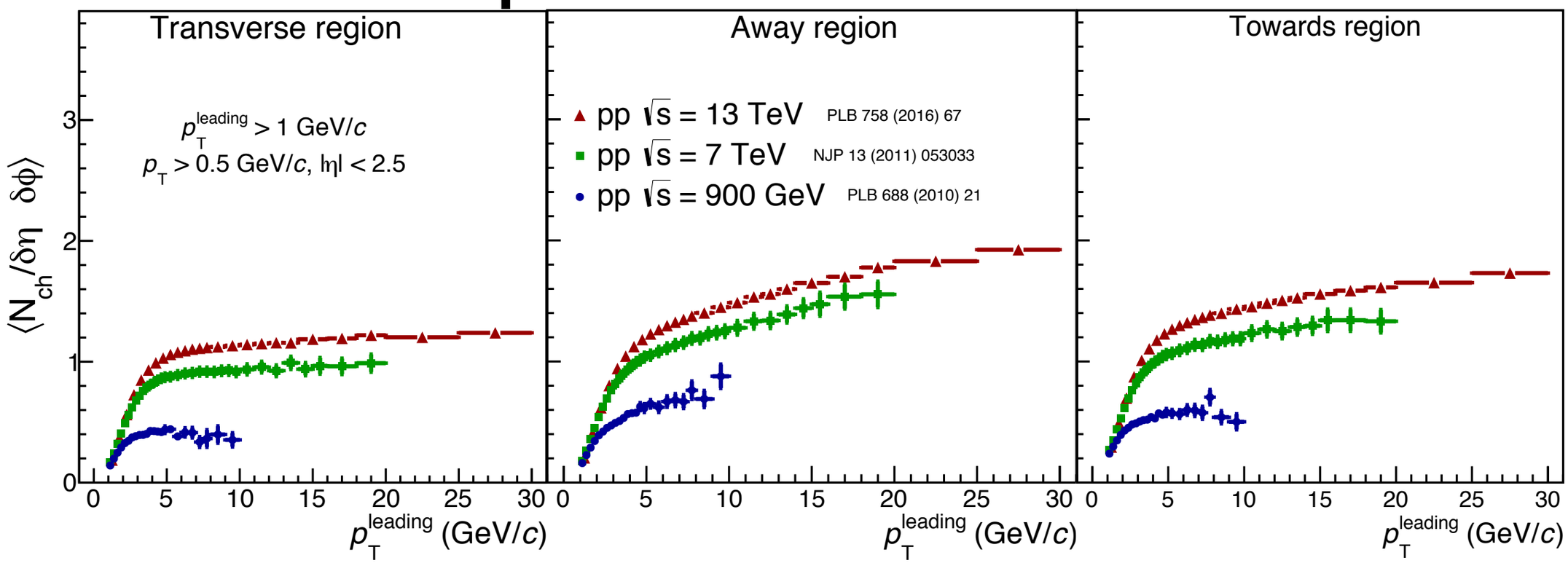
Properties of UE



ATLAS, JHEP 1703 (2017) 157

Multiplicity density of primary charged-particles (number density) as a function of the largest transverse momentum (leading charged particle) of the event

Properties of UE



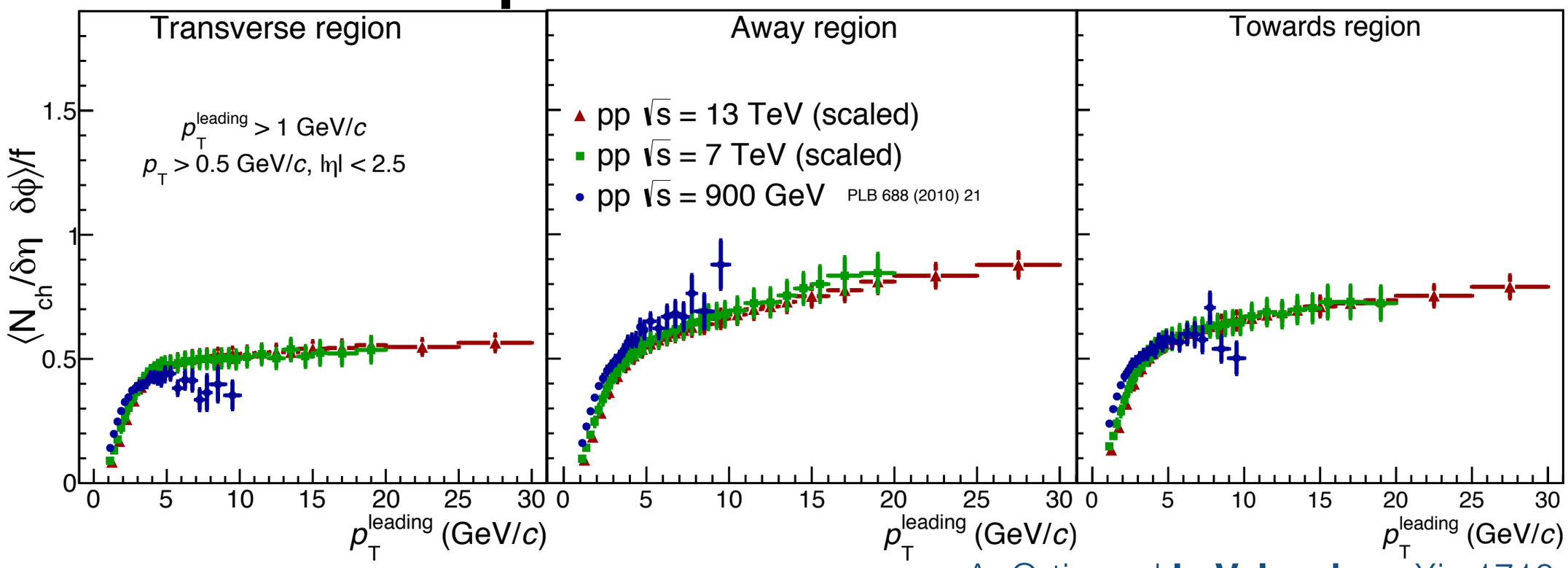
ATLAS, JHEP 1703 (2017) 157

$\sqrt{s}$ (TeV)

	0.9	7	13
$\langle dN_{ch}/d\eta \rangle$	1.306	2.405	2.862

$p_T > 0.5$ GeV/c
$|\eta| < 2.5$

Properties of UE

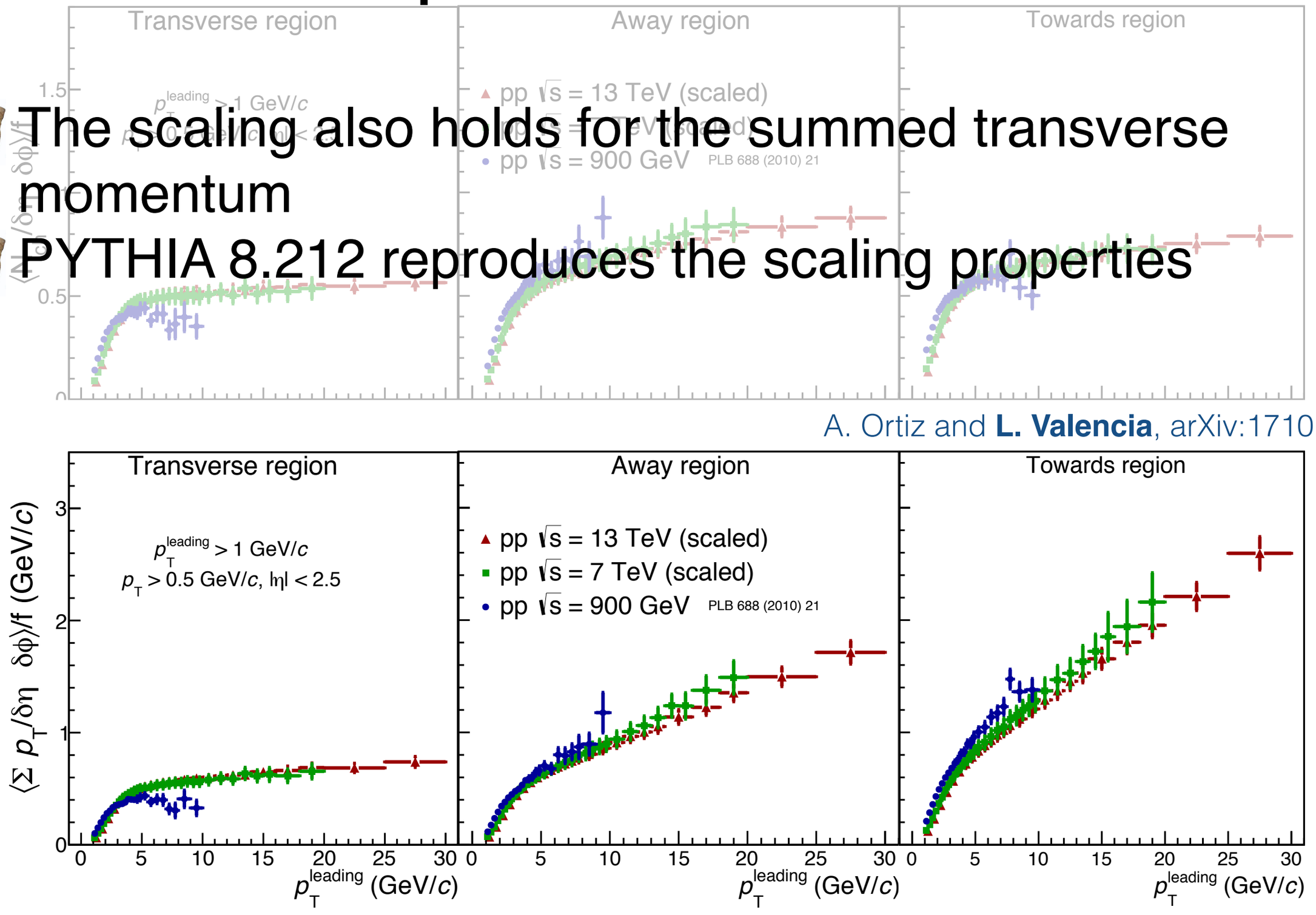


A. Ortiz and **L. Valencia**, arXiv:1710.04741

- Interesting scaling of the number density as a function of the leading p_T. The effect is unveiled once the number density is scaled according with the change variation of multiplicity wrt pp at $\sqrt{s}$ = 0.9 TeV
- Same factor for regions sensitive to different physics

Properties of UE

- The scaling also holds for the summed transverse momentum
- PYTHIA 8.212 reproduces the scaling properties

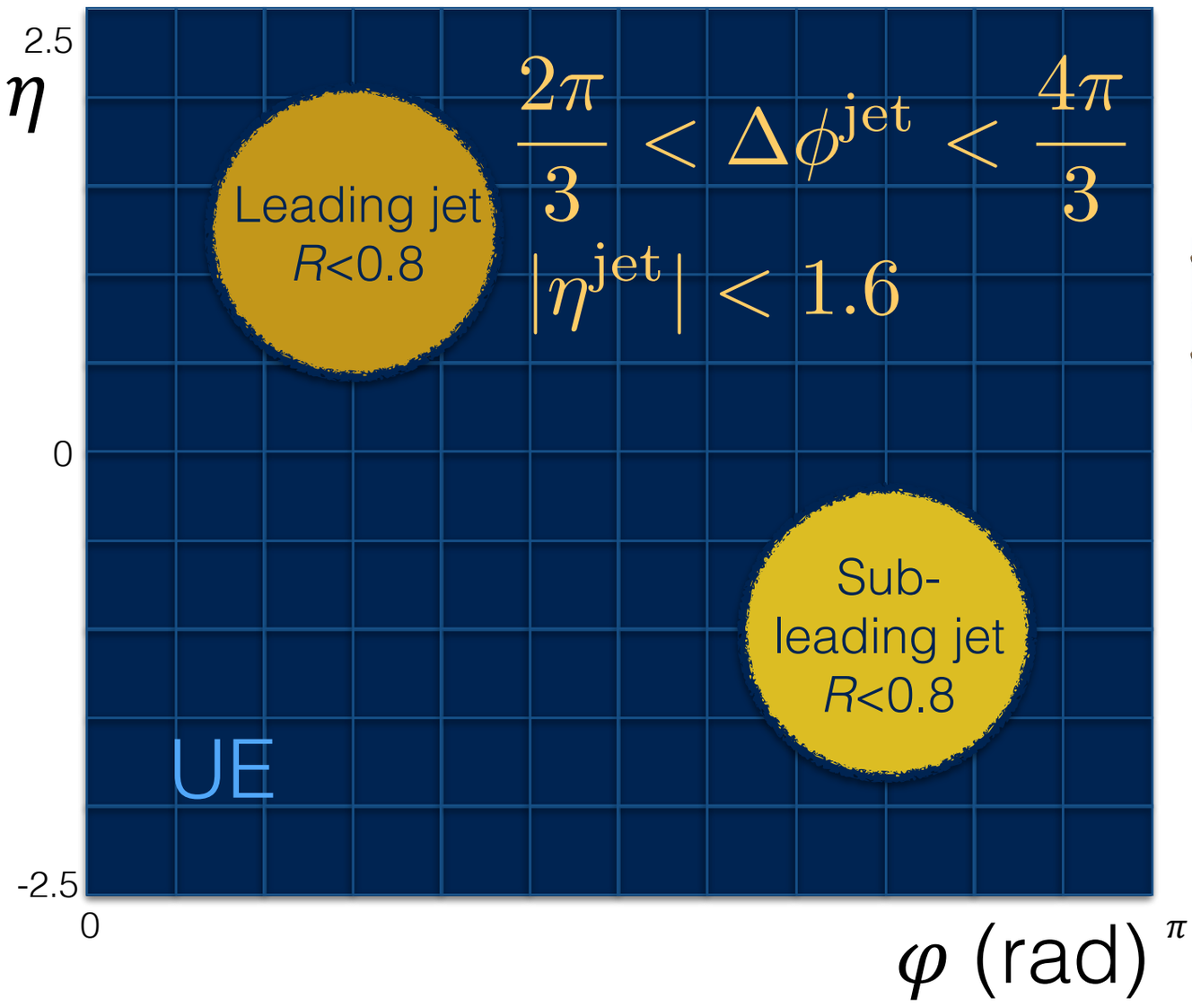


A. Ortiz and **L. Valencia**, arXiv:1710.04741

Study of UE properties using MC (PYTHIA 8.212, Monash 2013)

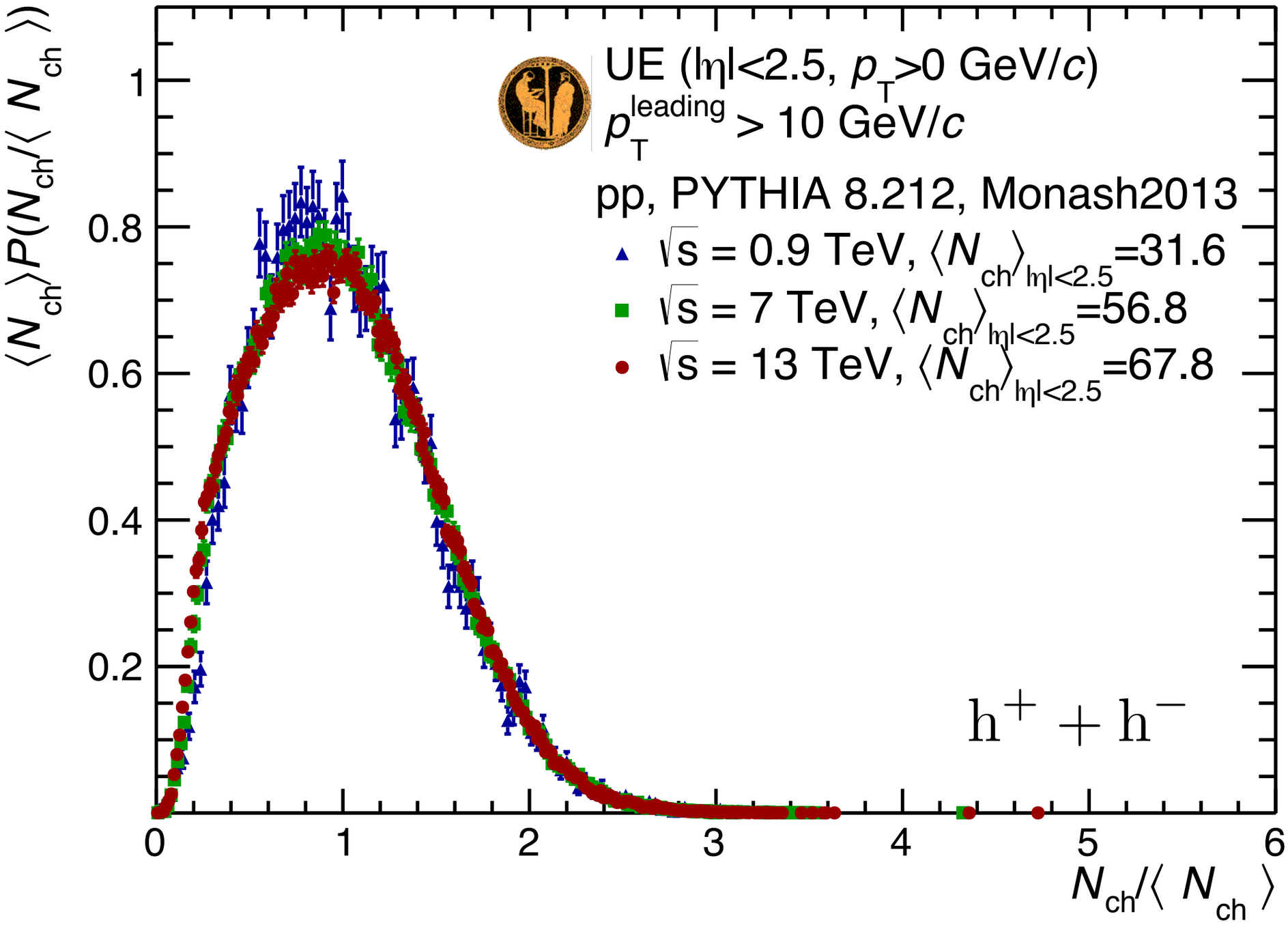
KNO scaling of UE?

- Check with PYTHIA 8.212 + FastJet 3.1
- Events with $p_T^{leading}$ >10 GeV/c within $|\eta|$<2.5



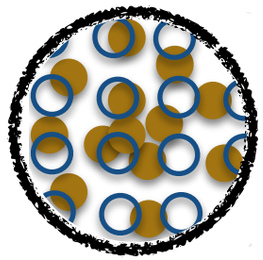
- Anti-k_T algorithm
- Background subtraction

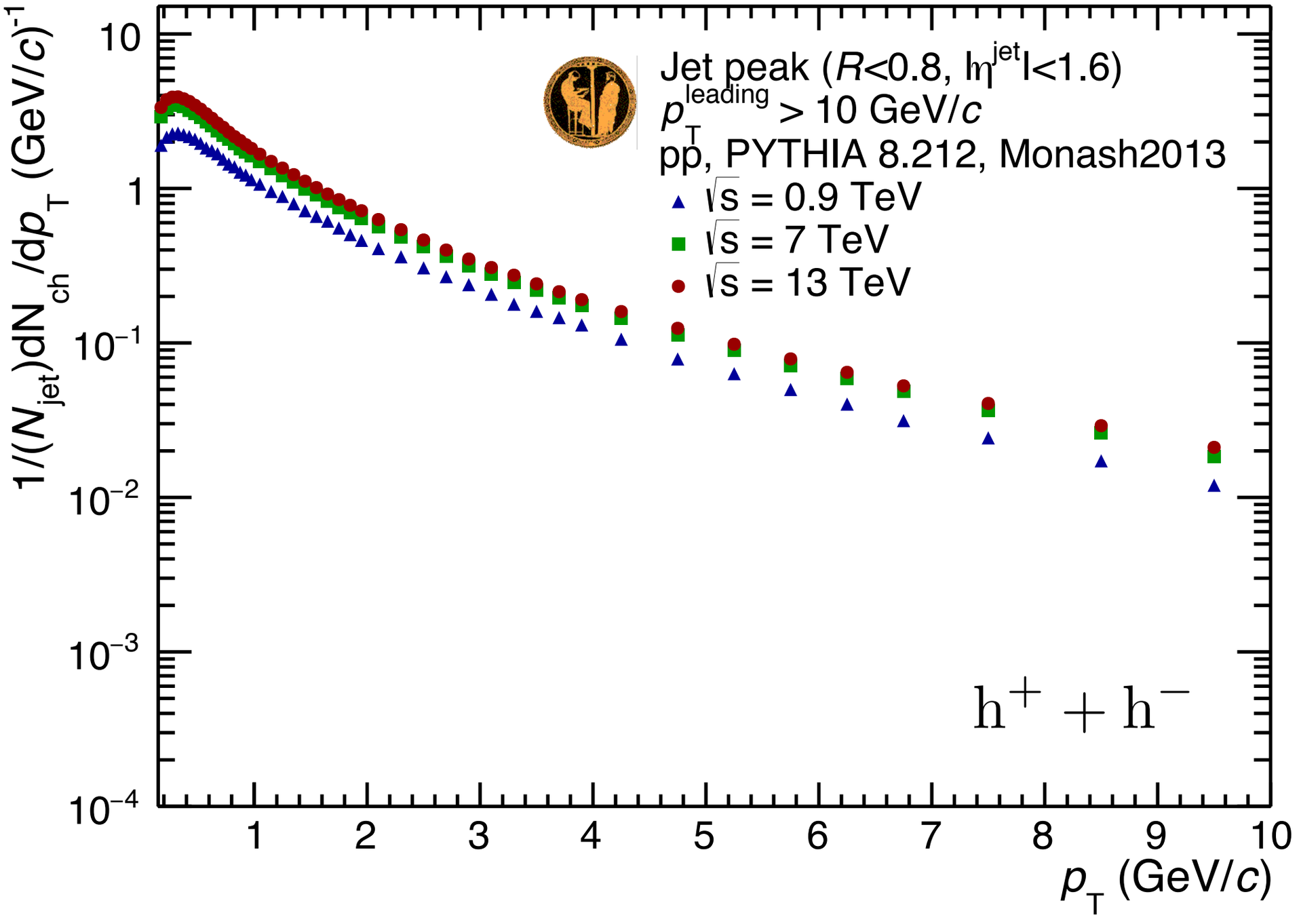
KNO scaling of UE?



- Check with PYTHIA 8.212 + FastJet 3.1
- Events with $p_T^{leading}$ >10 GeV/c within $|\eta|$<2.5

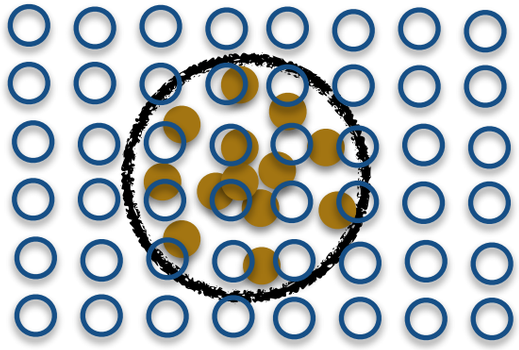
Charged hadrons

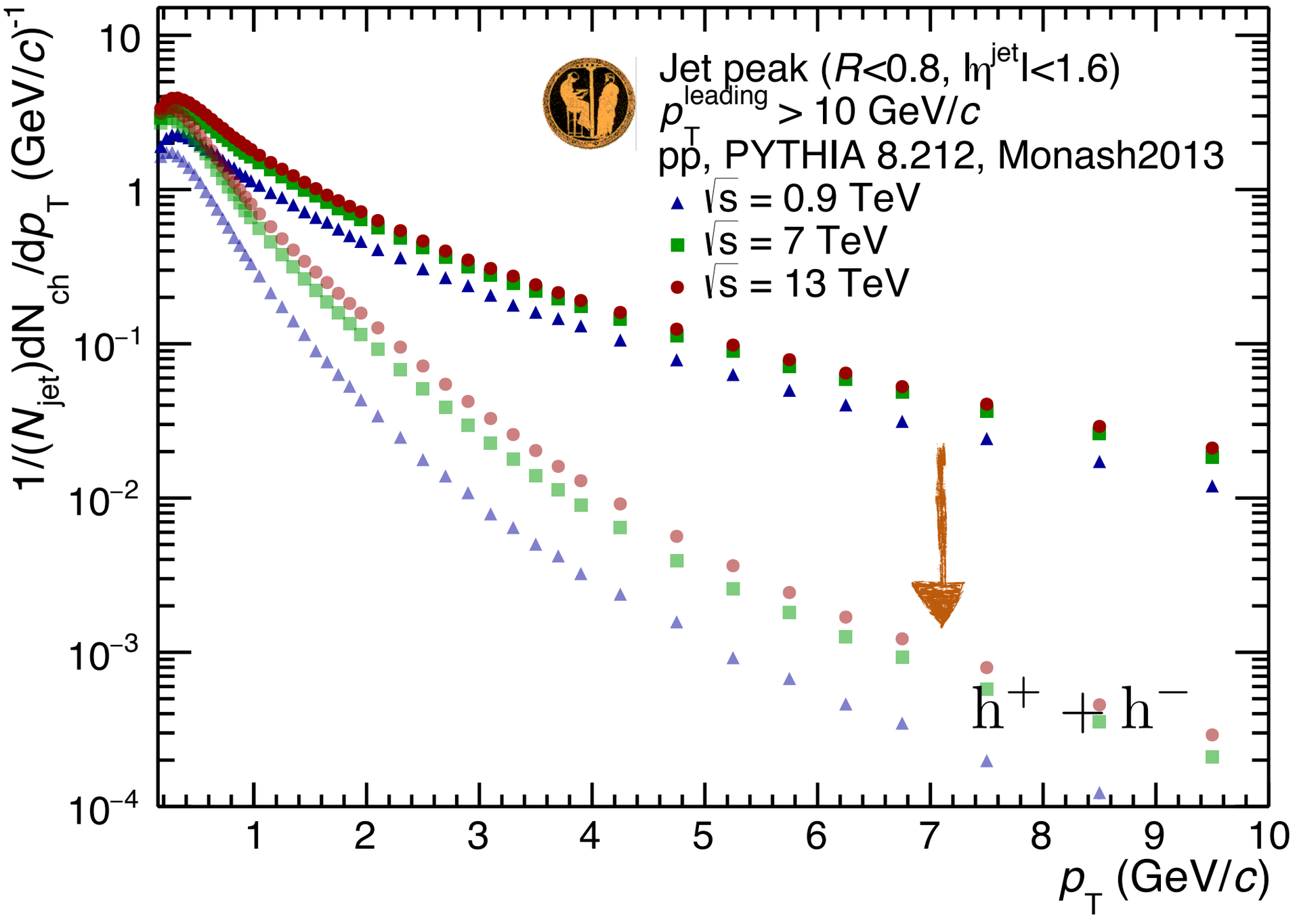




Jet + UE

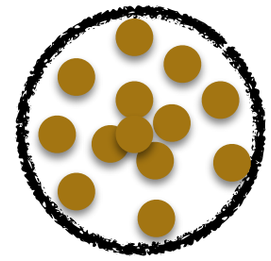
Charged hadrons

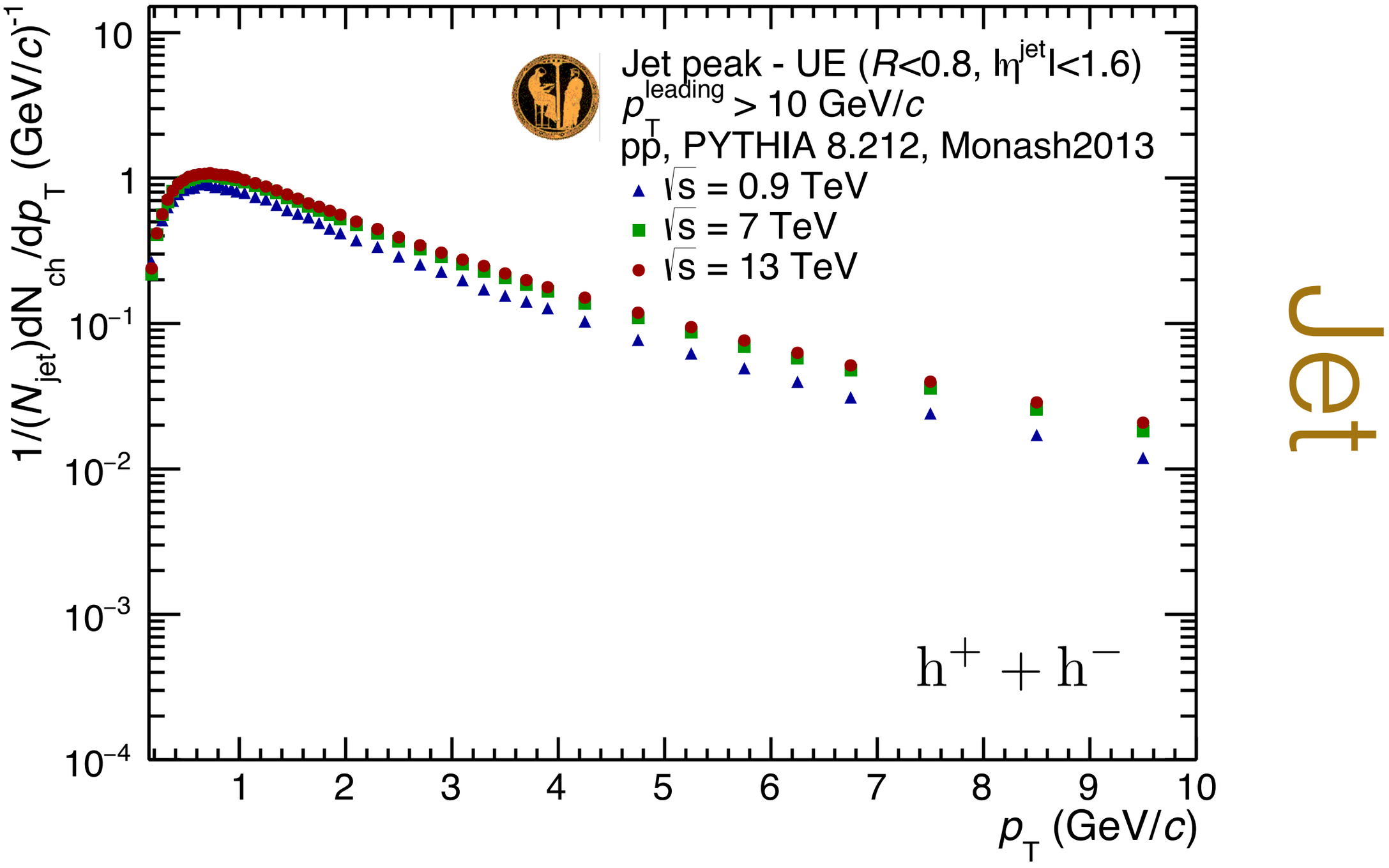


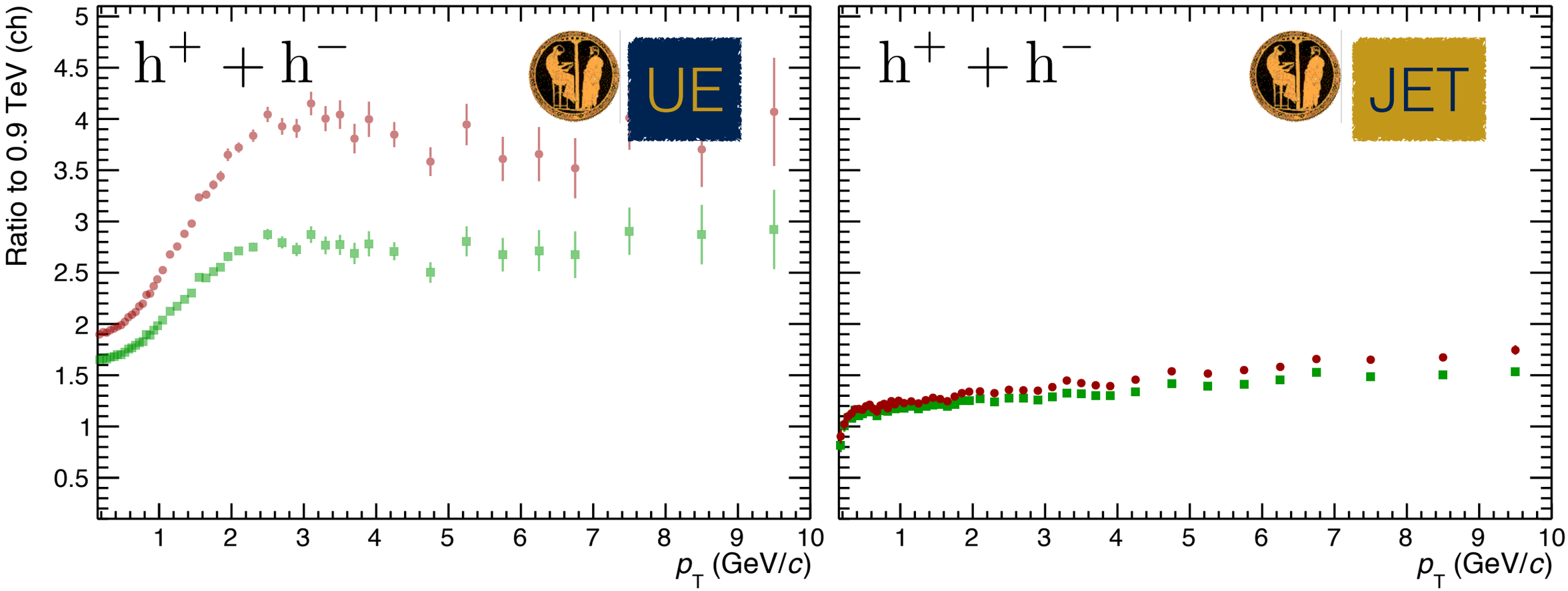


Jet + UE) vs UE

Charged hadrons

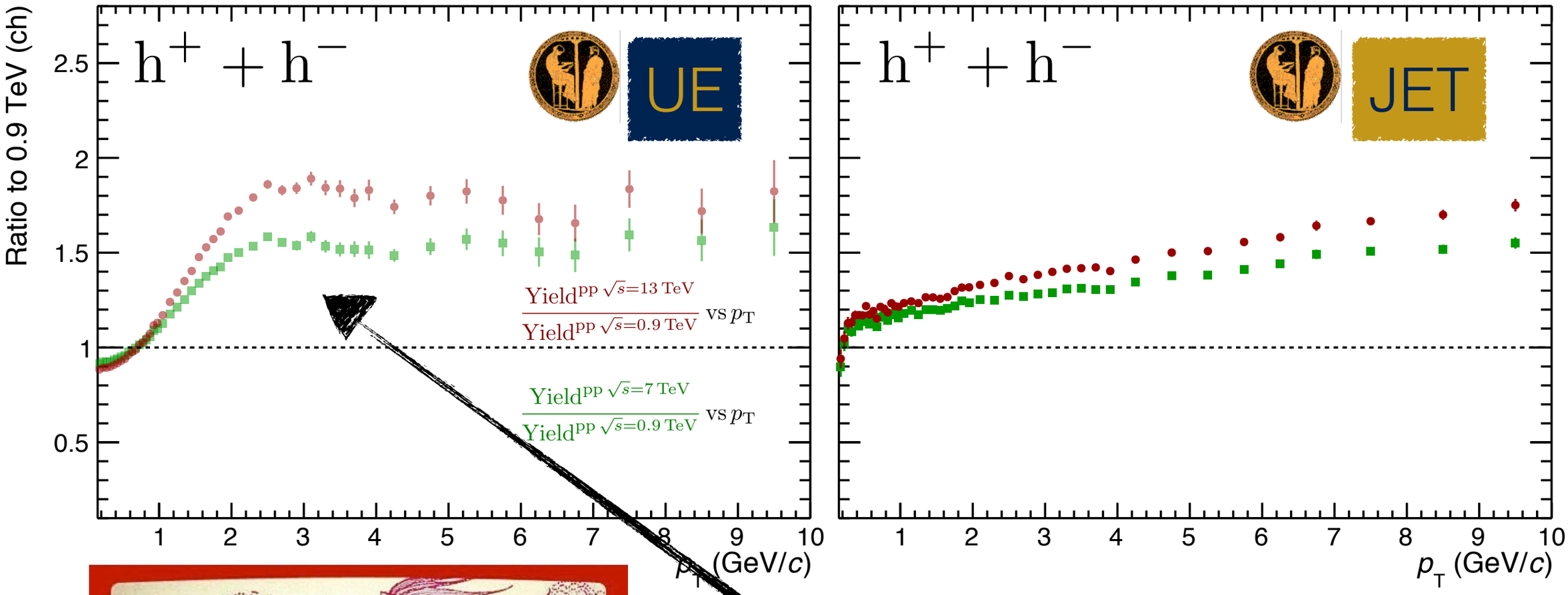


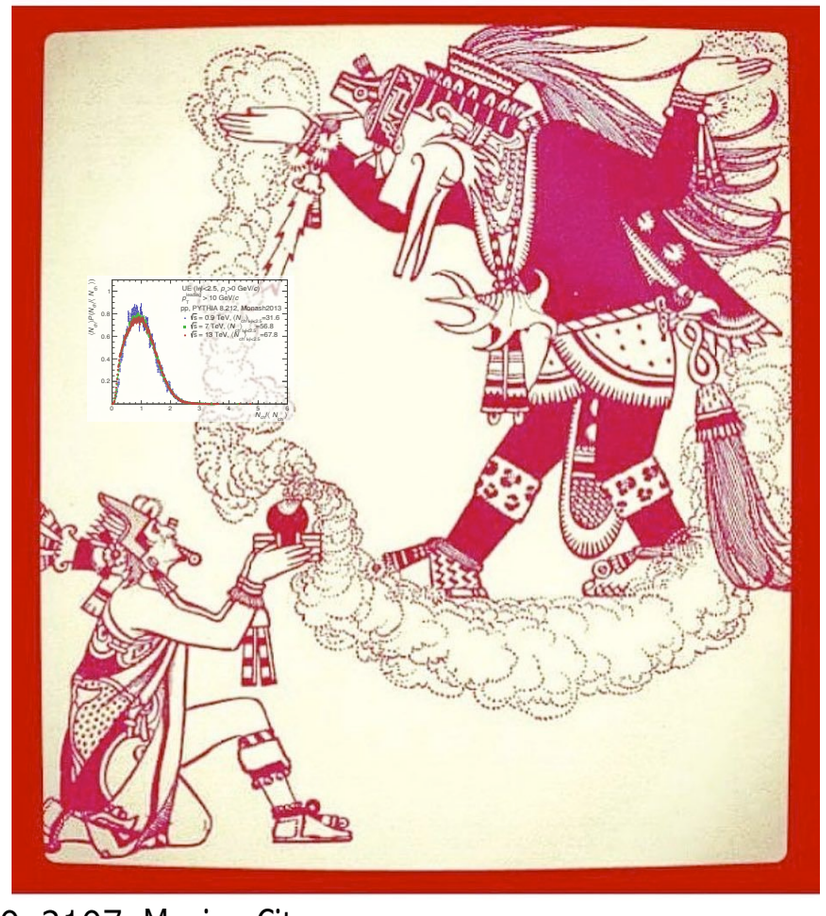




$$\frac{\text{Yield}^{\text{pp}\ \sqrt{s}=13\ \text{TeV}}}{\text{Yield}^{\text{pp}\ \sqrt{s}=0.9\ \text{TeV}}}\ \text{vs}\ p_{\text{T}}$$

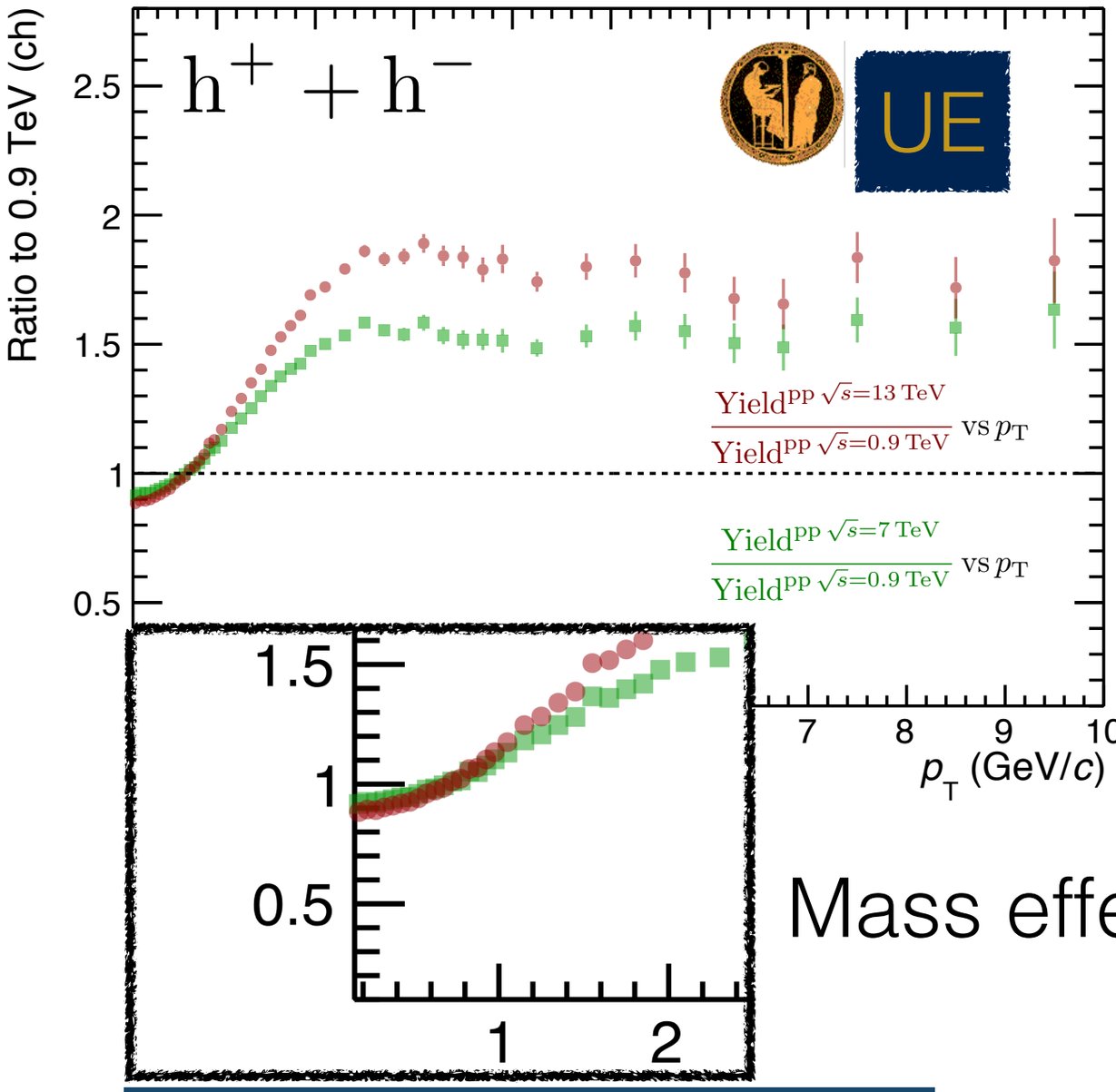
$$\frac{\text{Yield}^{\text{pp}\ \sqrt{s}=7\ \text{TeV}}}{\text{Yield}^{\text{pp}\ \sqrt{s}=0.9\ \text{TeV}}}\ \text{vs}\ p_{\text{T}}$$

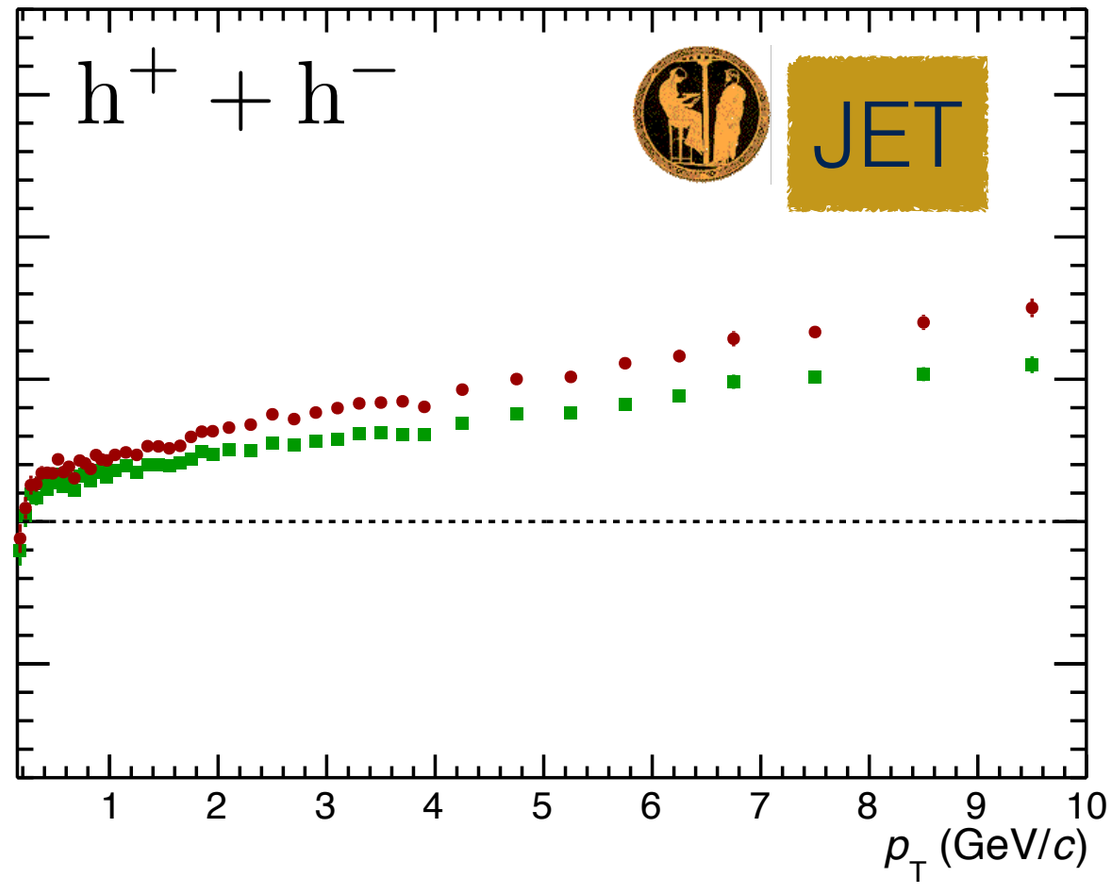




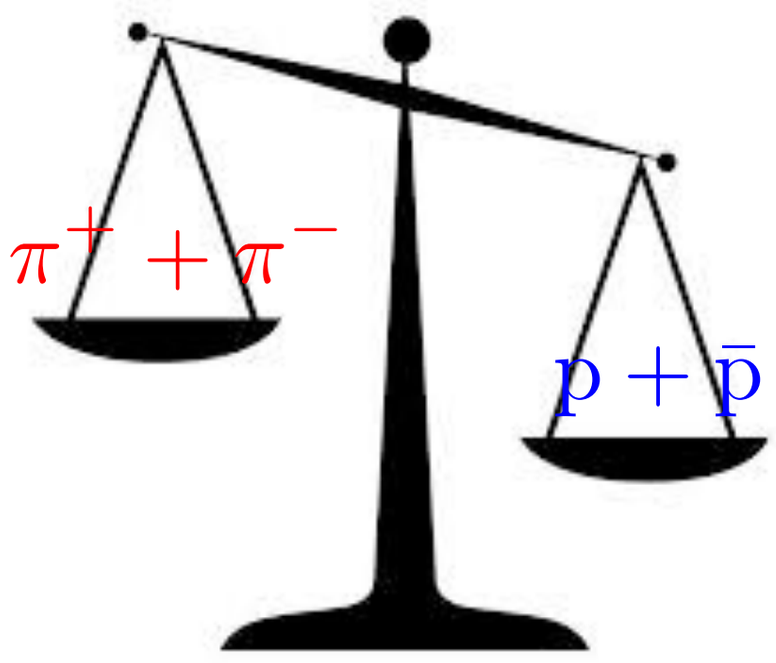
Invoking the KNO scaling of UE

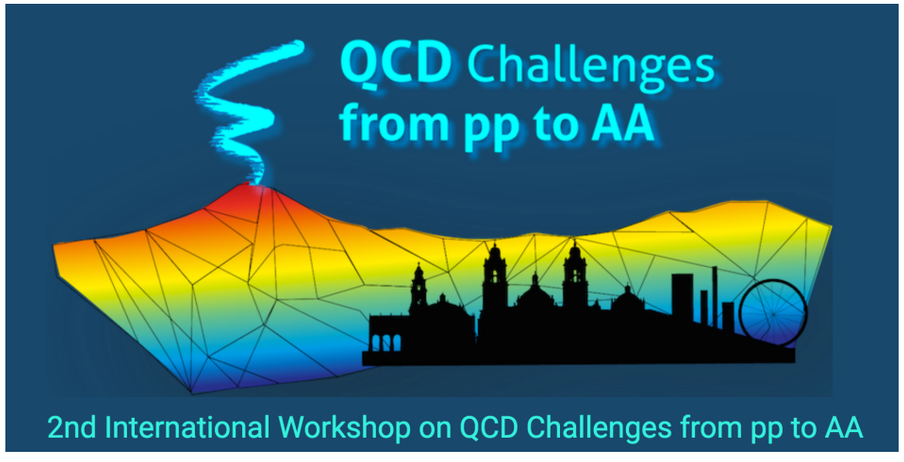
A. Ortiz and **L. Valencia**, arXiv:1710.04741

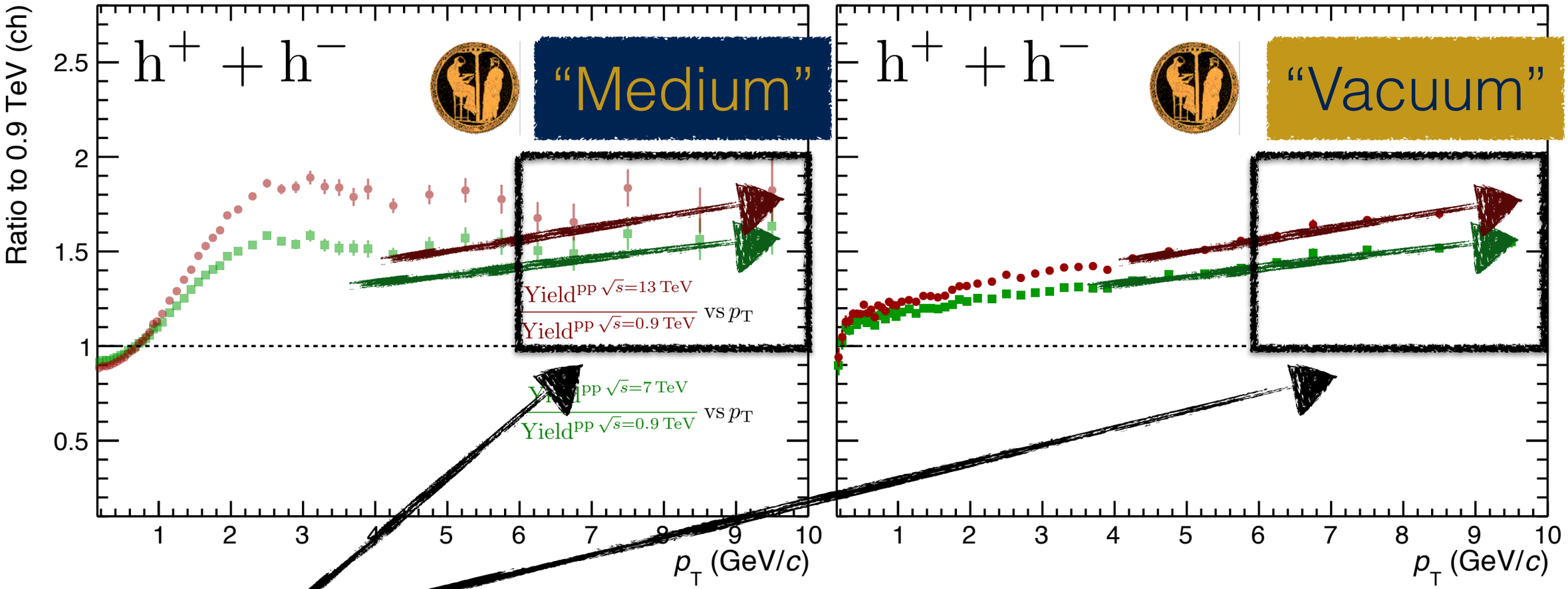

$h^+ + h^-$
UE
Ratio to 0.9 TeV (ch)
$\frac{\text{Yield}^{pp}\ \sqrt{s}=13\ \text{TeV}}{\text{Yield}^{pp}\ \sqrt{s}=0.9\ \text{TeV}}$ vs p_T
$\frac{\text{Yield}^{pp}\ \sqrt{s}=7\ \text{TeV}}{\text{Yield}^{pp}\ \sqrt{s}=0.9\ \text{TeV}}$ vs p_T
p_T (GeV/c)


$h^+ + h^-$
JET
p_T (GeV/c)

Mass effect?


$\pi^+ + \pi^-$
$p + \bar{p}$


QCD Challenges
from pp to AA
2nd International Workshop on QCD Challenges from pp to AA

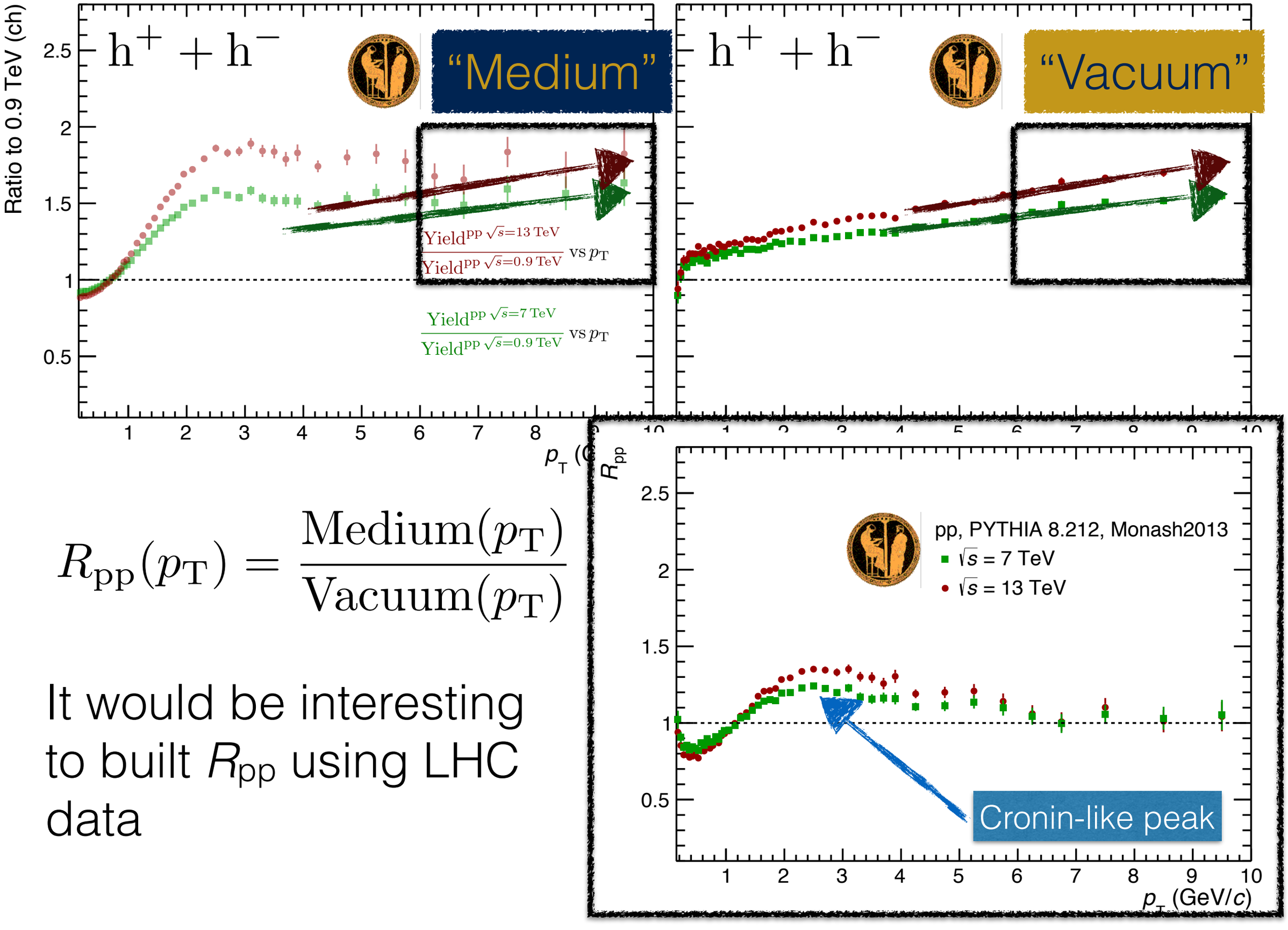


~Same slope (same origin)

Remaining hard component

To remove the remaining jet contamination (from UE) we can compute the ratio:

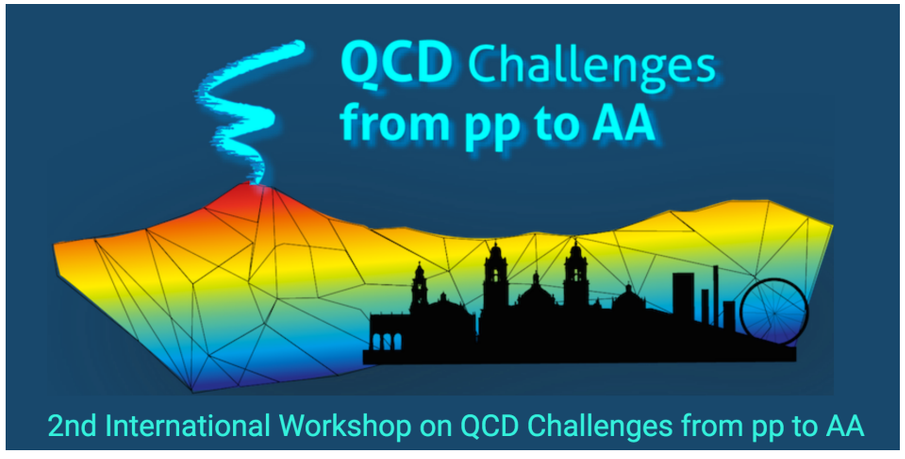
$$R_{\rm pp}(p_{\rm T}) = \frac{\rm Medium(p_{\rm T})}{\rm Vacuum(p_{\rm T})}$$

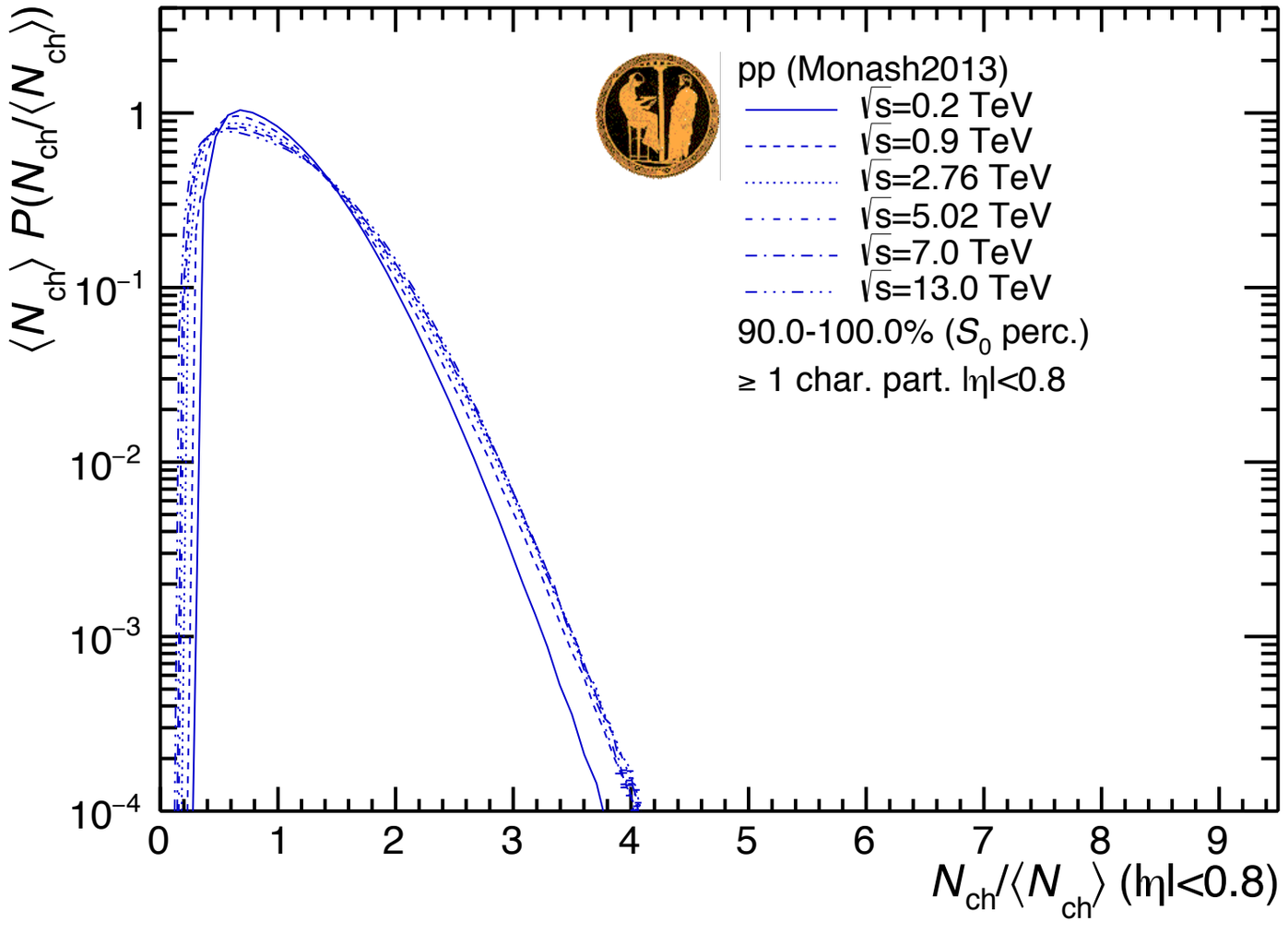


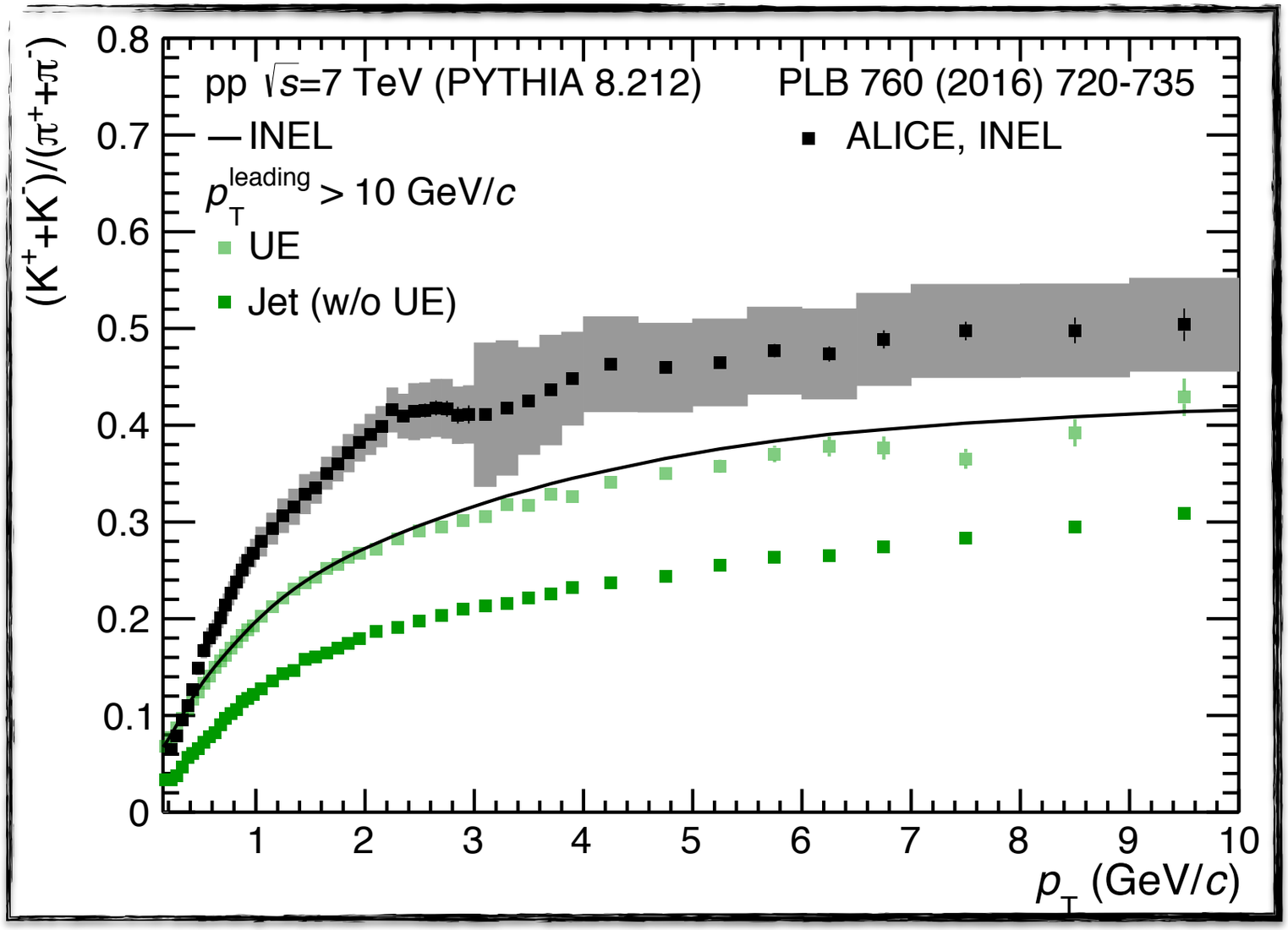
$$R_{\rm pp}(p_{\rm T}) = \frac{\rm Medium(}p_{\rm T}\rm)}{\rm Vacuum(}p_{\rm T}\rm)}$$

It would be interesting to built $R_{\rm pp}$ using LHC data

Alternative procedures to isolate the UE

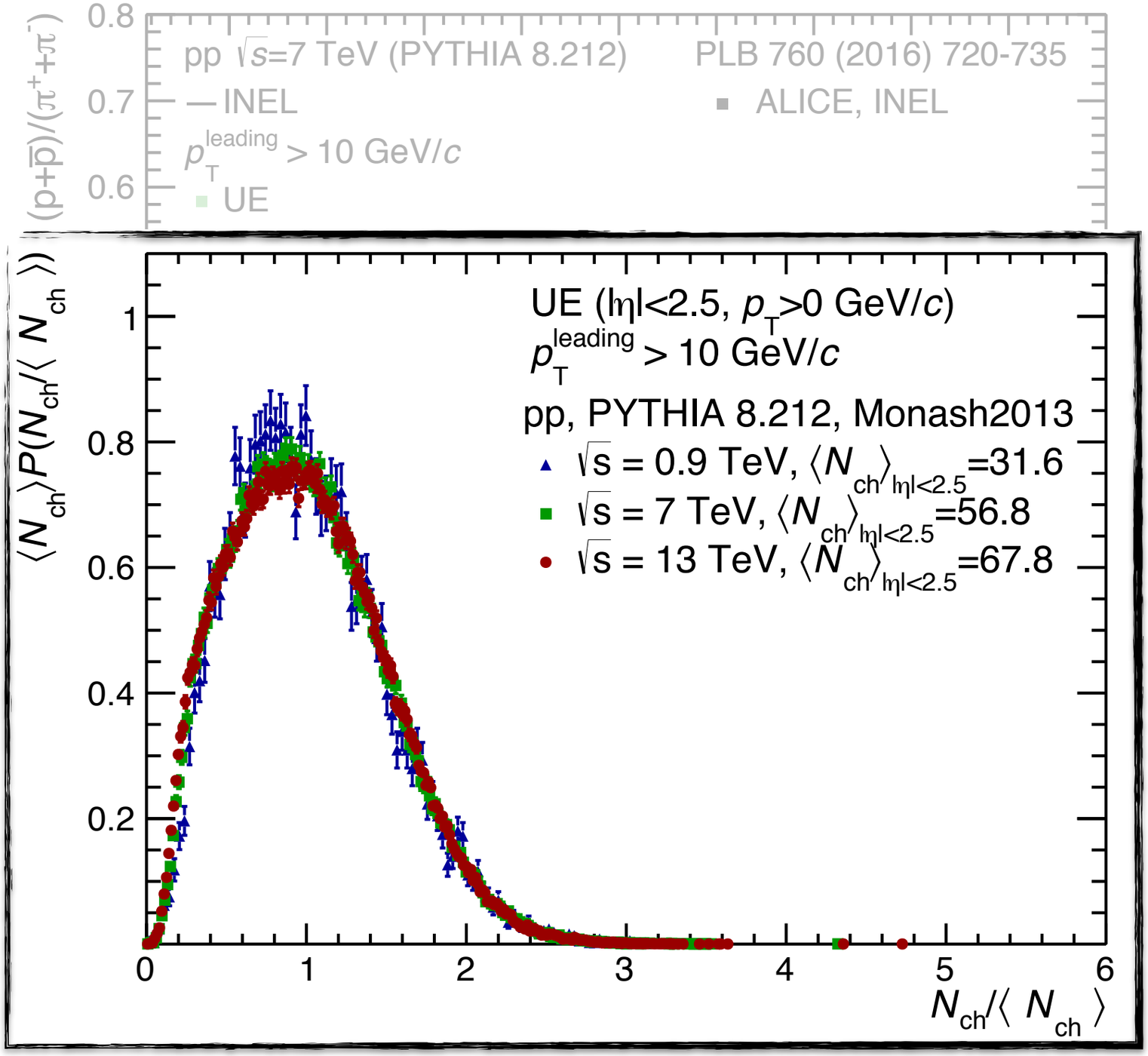






Summary

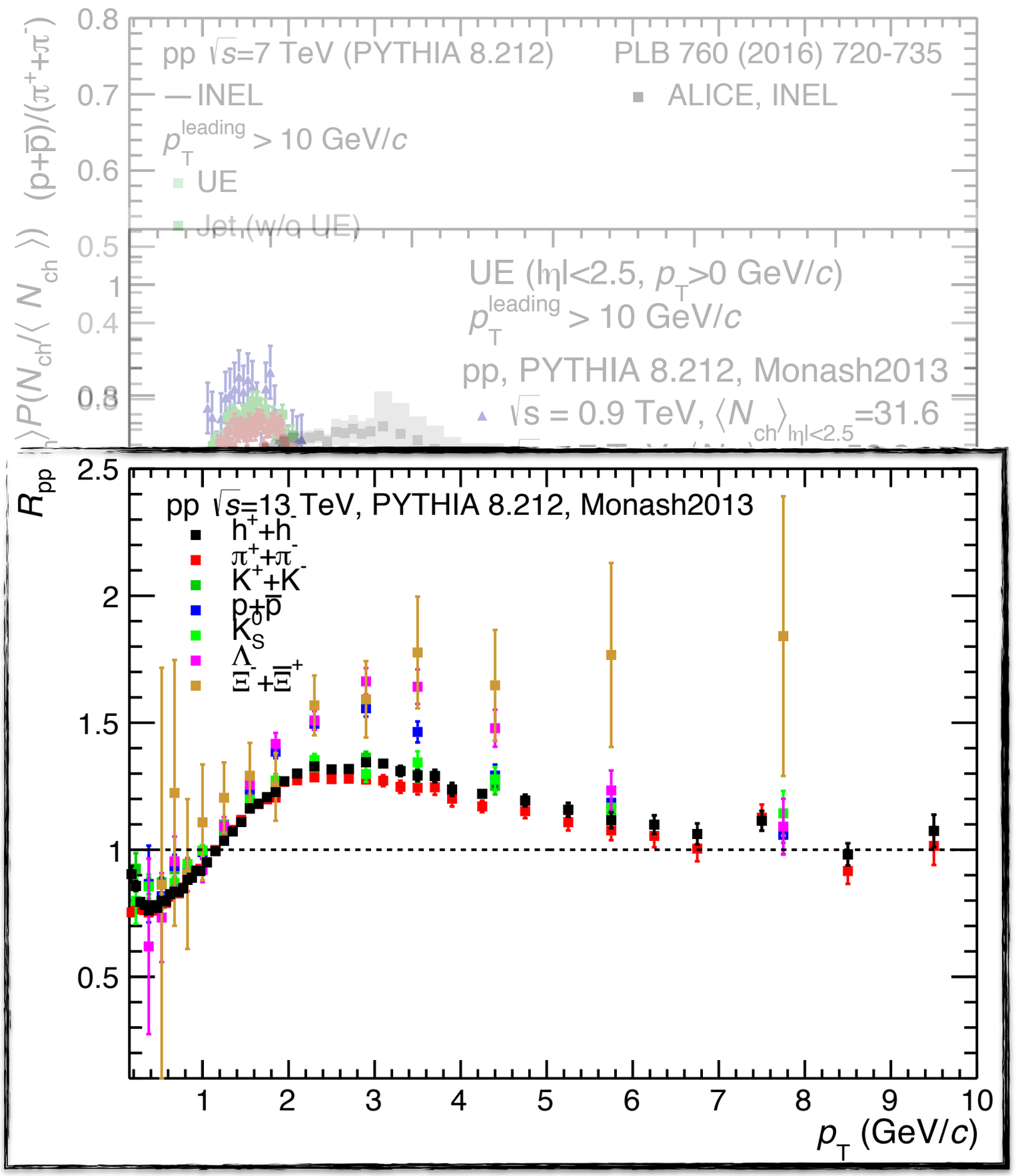
The UE encodes the physics of the new phenomena



Summary

The UE encodes the physics of the new phenomena

It shows scaling properties



Summary

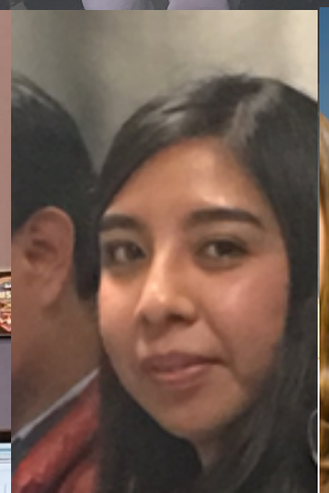
The UE encodes the physics of the new phenomena

It shows scaling properties

Exploiting its properties, novel effects can be unveiled

Thanks and

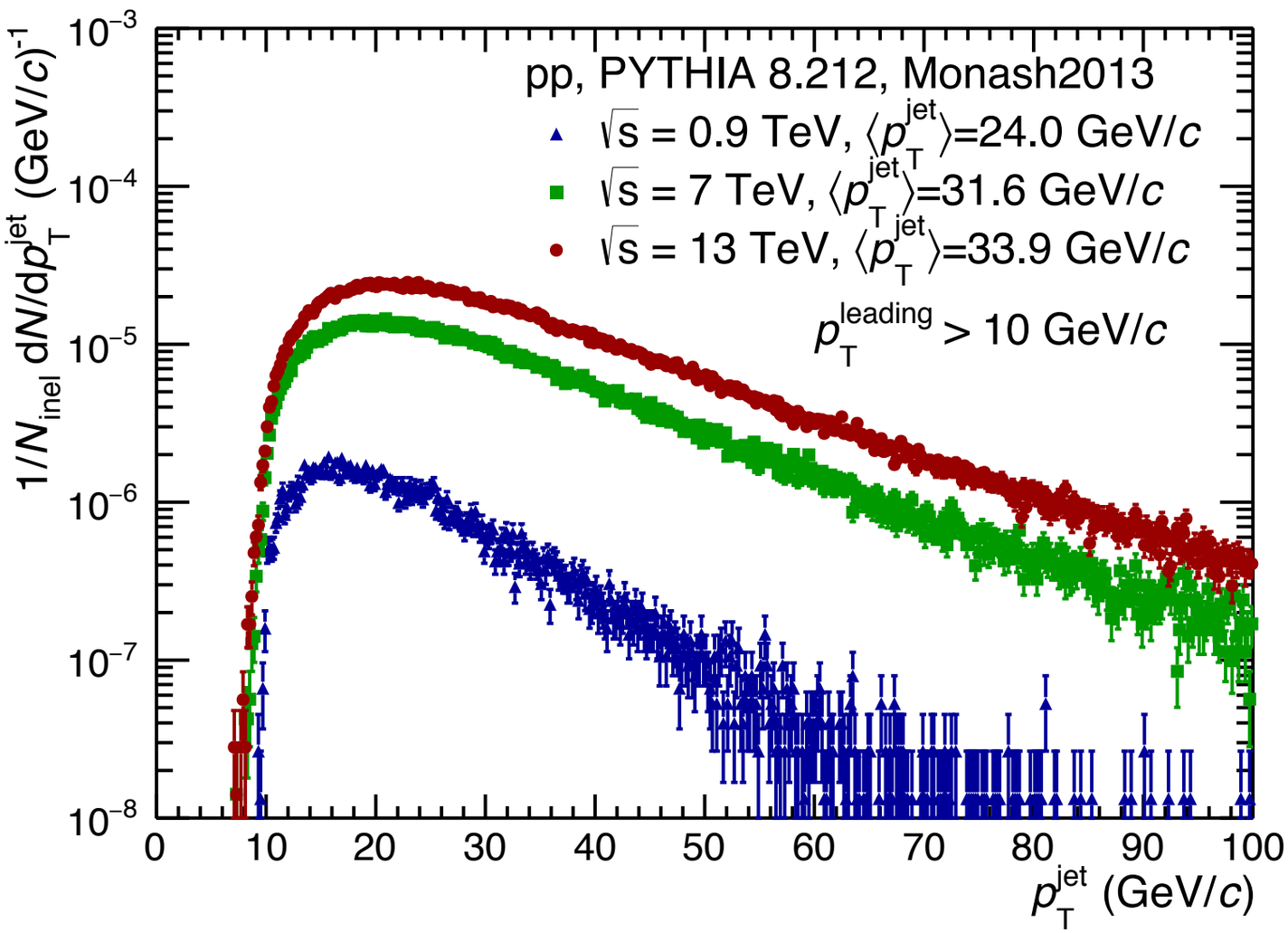
Happy birthday Guy!



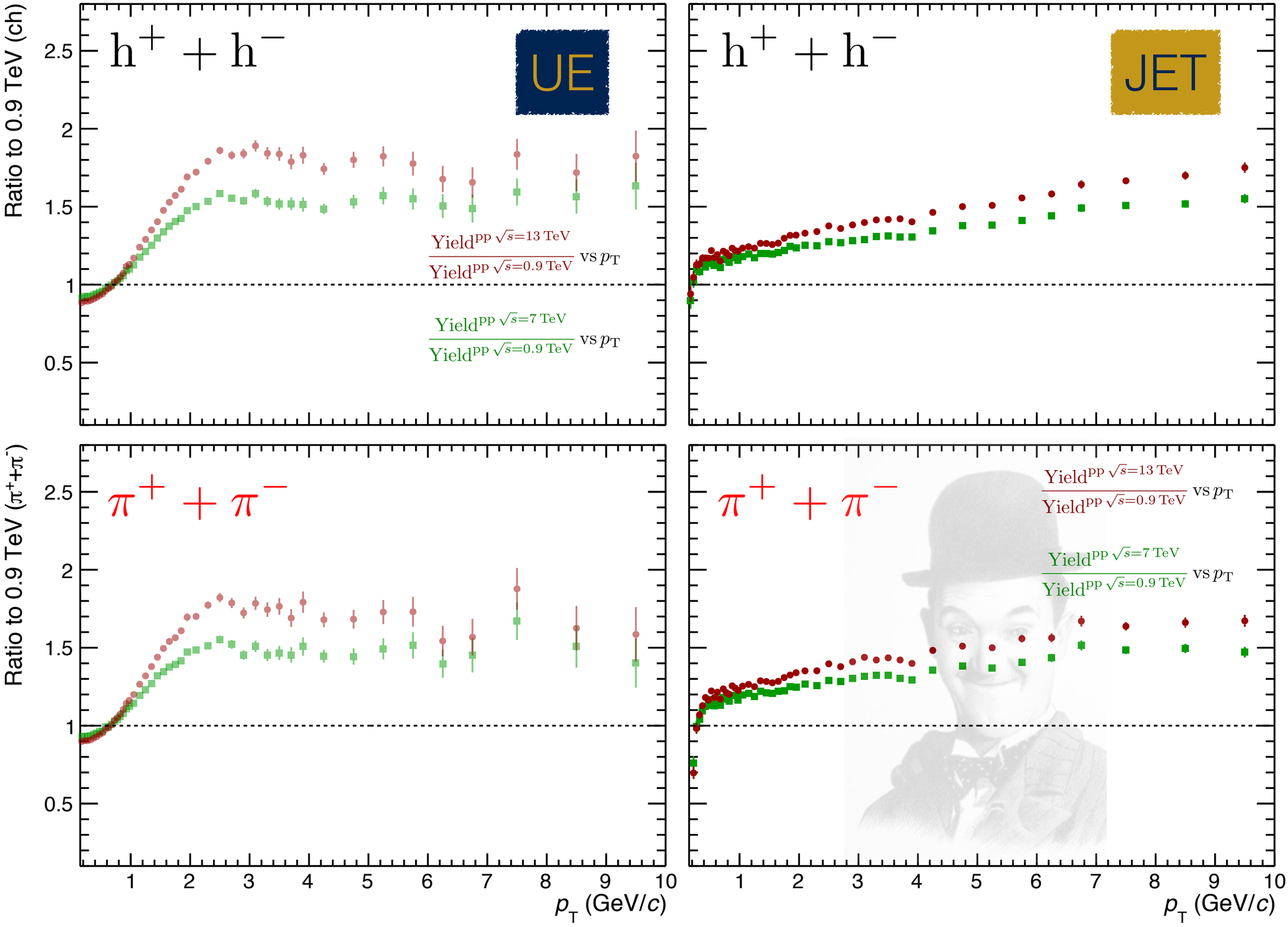
BACKUP

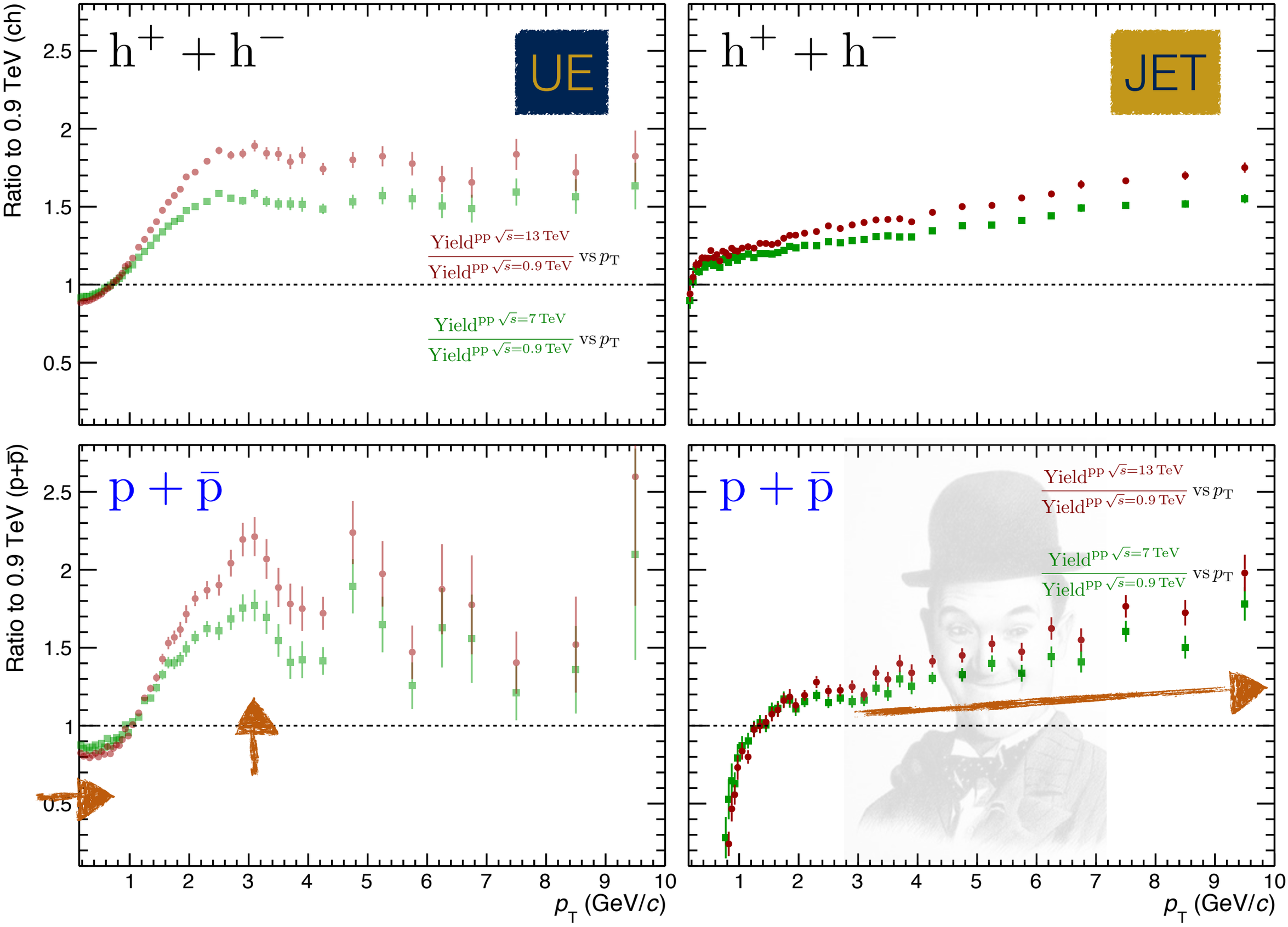
KNO scaling of UE?

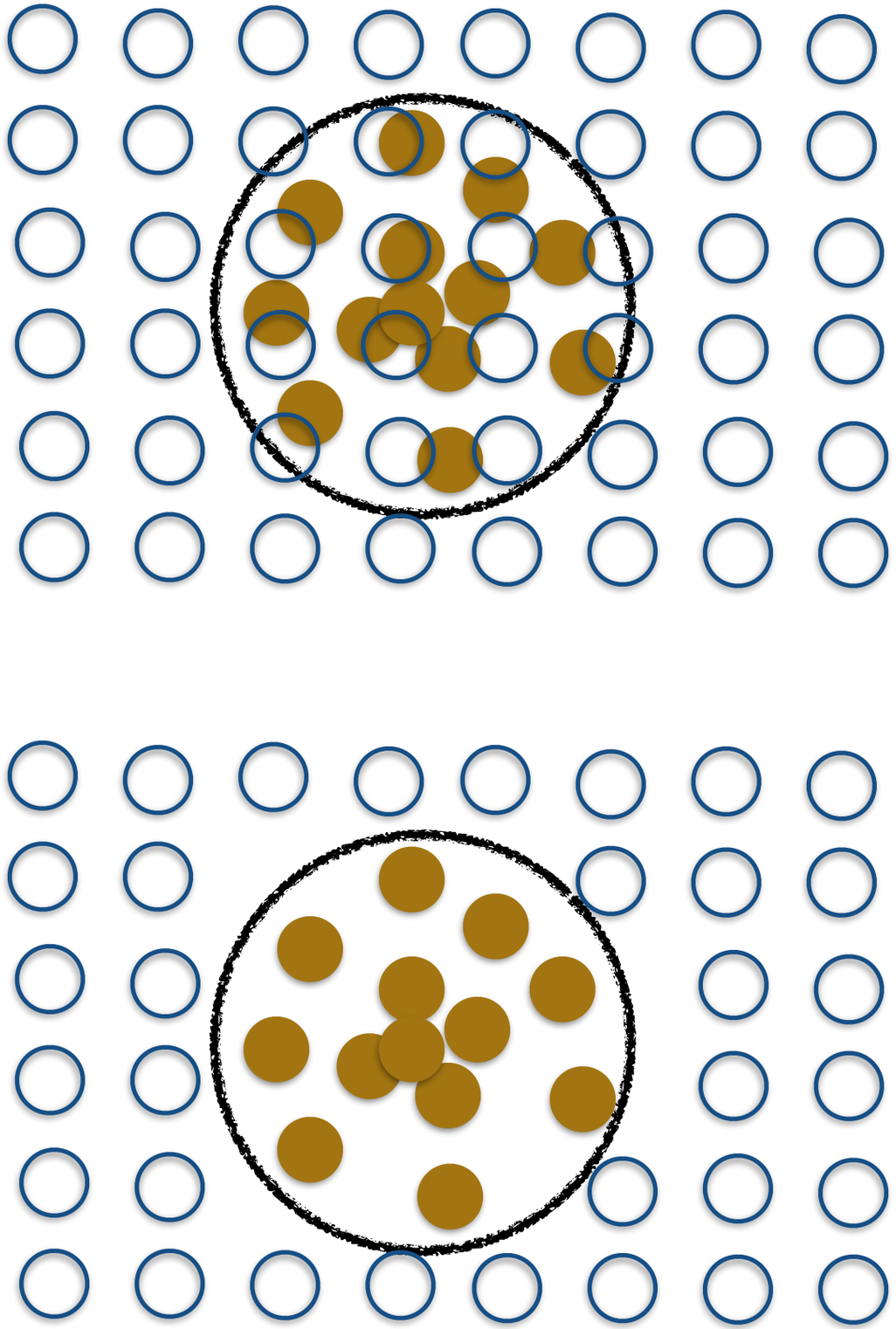
- Check with PYTHIA 8.212 + FastJet 3.1
- Events with $p_T^{leading} > 10$ GeV/c within $|\eta|<2.5$



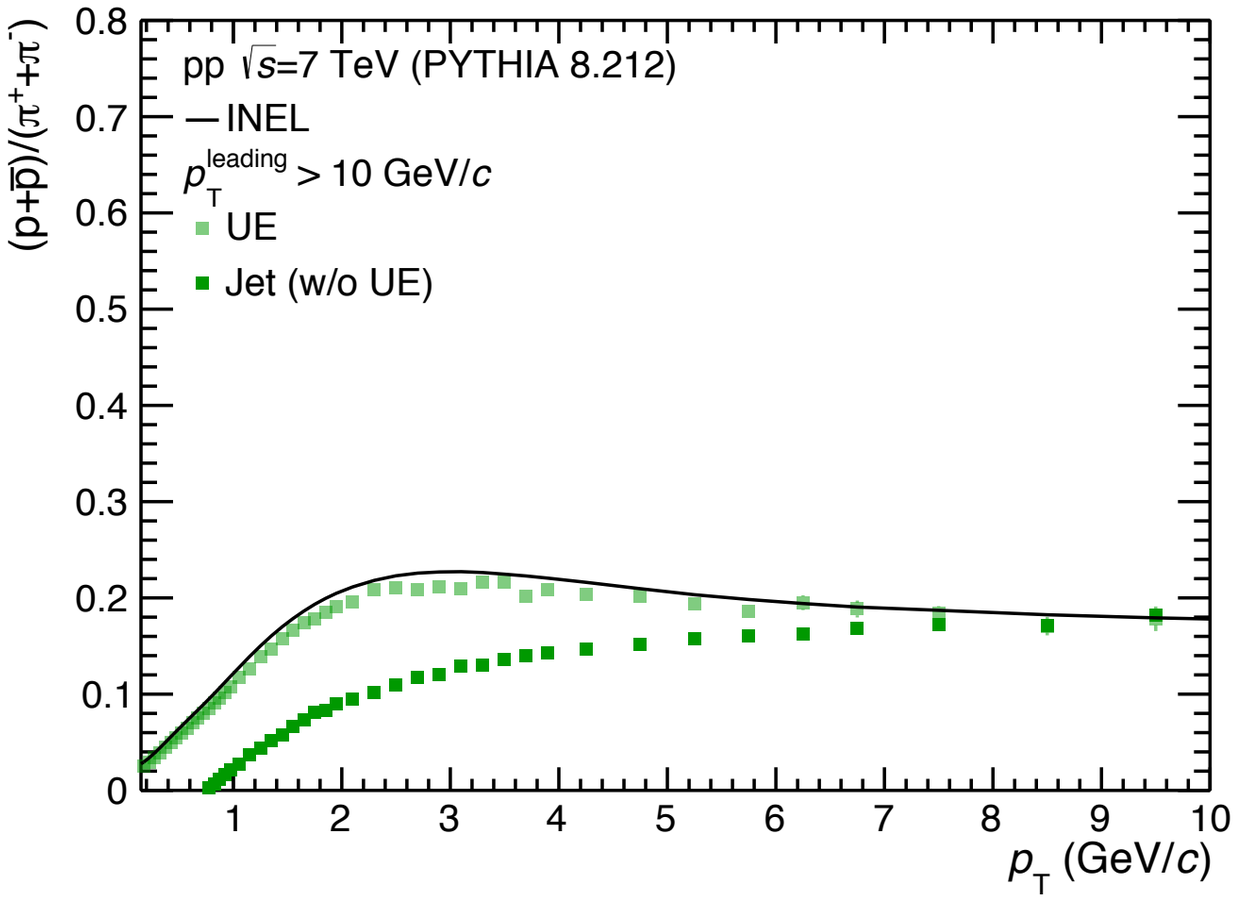
In this study I considered visible particles

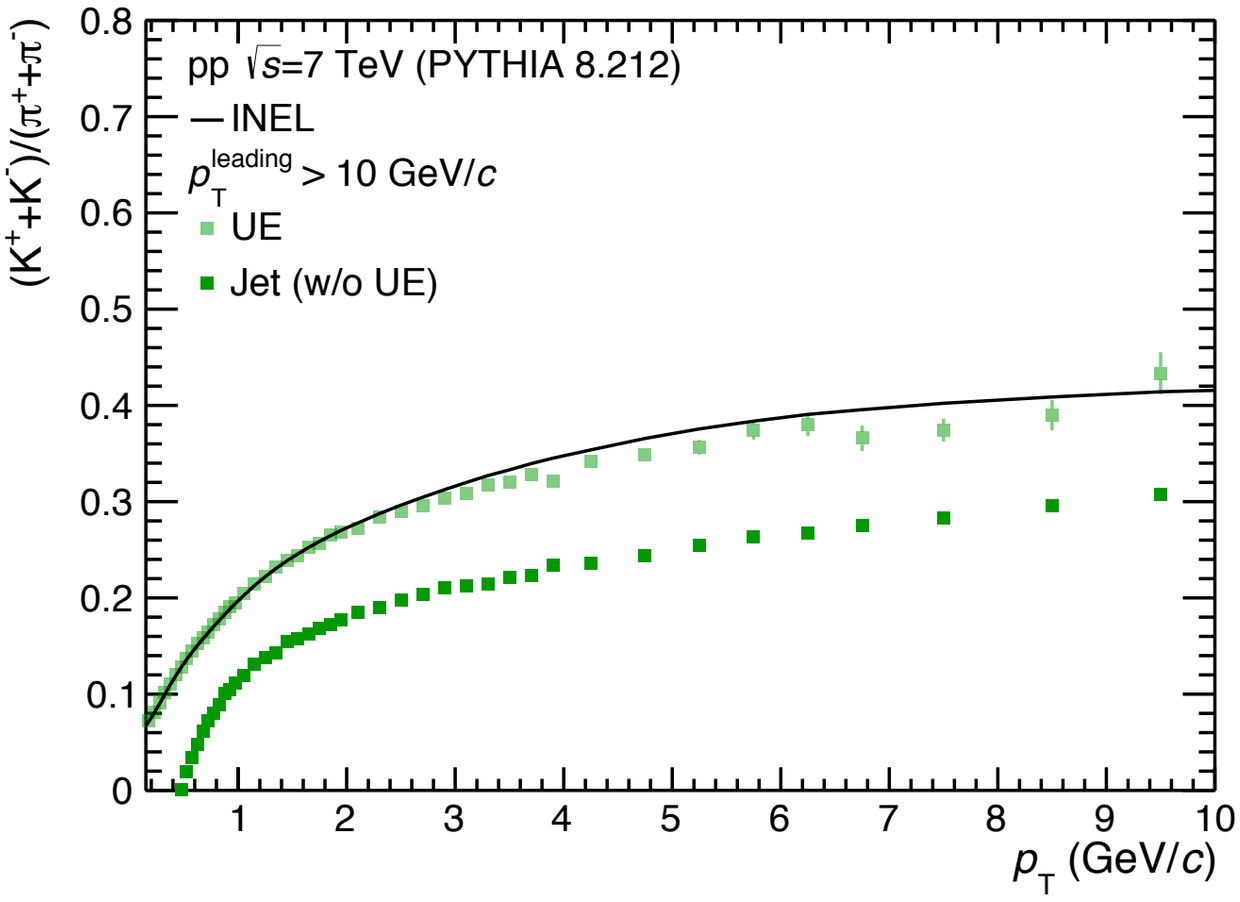

Ratio to 0.9 TeV (ch)
$h^+ + h^-$
UE
JET
$\frac{\text{Yield}^{pp}\ \sqrt{s}=13\ \text{TeV}}{\text{Yield}^{pp}\ \sqrt{s}=0.9\ \text{TeV}}$ vs p_T
$\frac{\text{Yield}^{pp}\ \sqrt{s}=7\ \text{TeV}}{\text{Yield}^{pp}\ \sqrt{s}=0.9\ \text{TeV}}$ vs p_T
Ratio to 0.9 TeV ($\pi^+ + \pi^-$)
$\pi^+ + \pi^-$
p_T (GeV/c)


h⁺ + h⁻
UE
JET
p + p̄
Ratio to 0.9 TeV (ch)
Ratio to 0.9 TeV (p+p̄)
Yield^pp √s=13 TeV / Yield^pp √s=0.9 TeV vs p_T
Yield^pp √s=7 TeV / Yield^pp √s=0.9 TeV vs p_T
p_T (GeV/c)



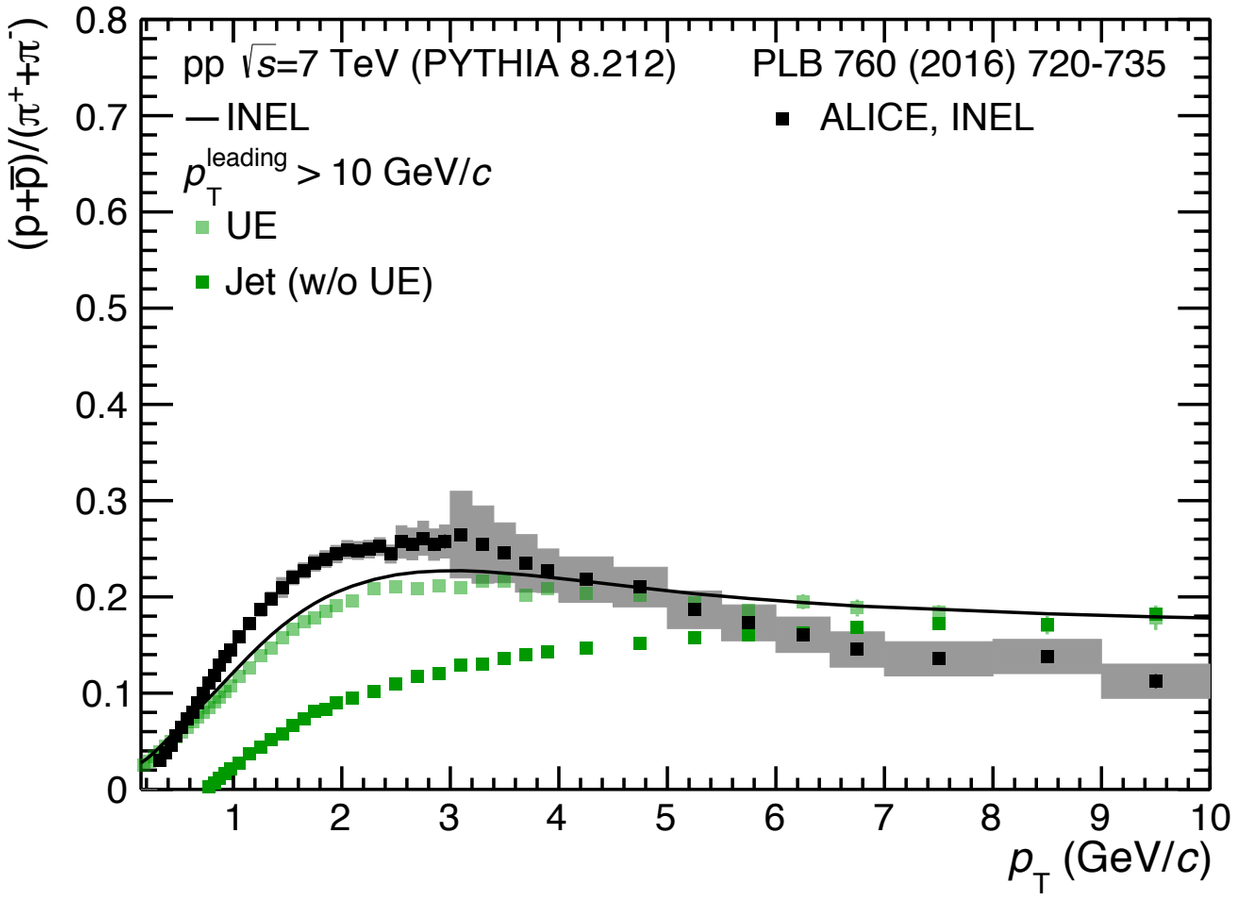
Particle Ratios (MC)

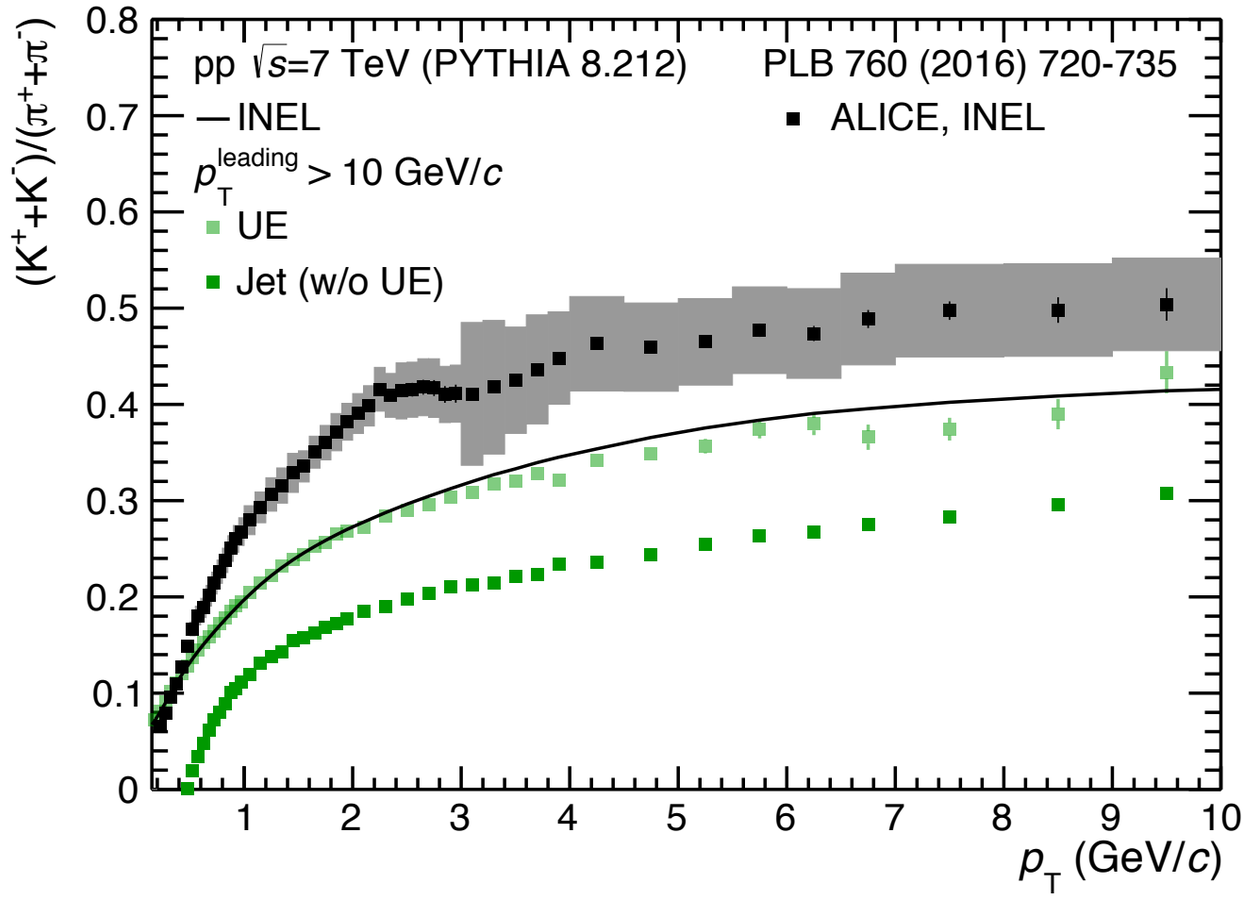




- Inclusive (INEL) particle ratios are dominated by UE effects
- Hard physics reduces the particle ratios

MC vs Data





Does this observation suggest that the UE component is harder in MC than that in data?