International Workshop “QCD challenges from pp to AA collisions”

Antonio Ortiz (UNAM, Mexico)

Is flattenicity a better activity estimator than multiplicity (e.g. V0M) to study high-pT physics in pp collisions?

Flattenicity

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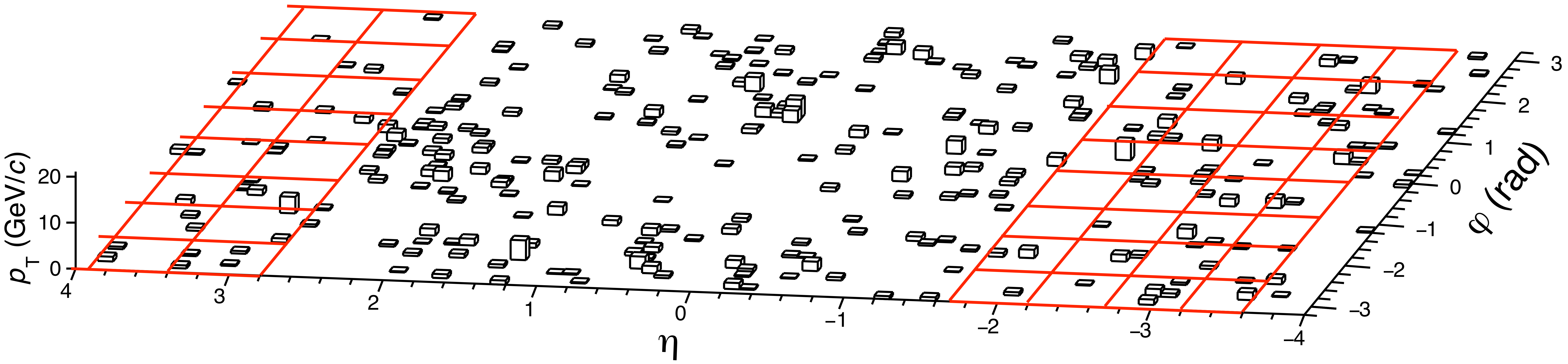
Event-by-event selection based on the relative standard deviation of the multiplicity measured in the 64 V0 channels, $N^{(\mathrm{ch.}\,i)}$

A. Ortiz et al., Phys. Rev. D107 (2023) 7, 076012

$$\rho = \sqrt{\sum_{i}^{64}\left(N^{(\mathrm{ch}.i)} - \langle N^{(\mathrm{ch})}\rangle\right)^2/64^2} \Big/ \langle N^{(\mathrm{ch})}\rangle$$

PYTHIA 8.303 (Monash 2013), pp $\sqrt{s}$ = 13 TeV, N_{mpi}=24

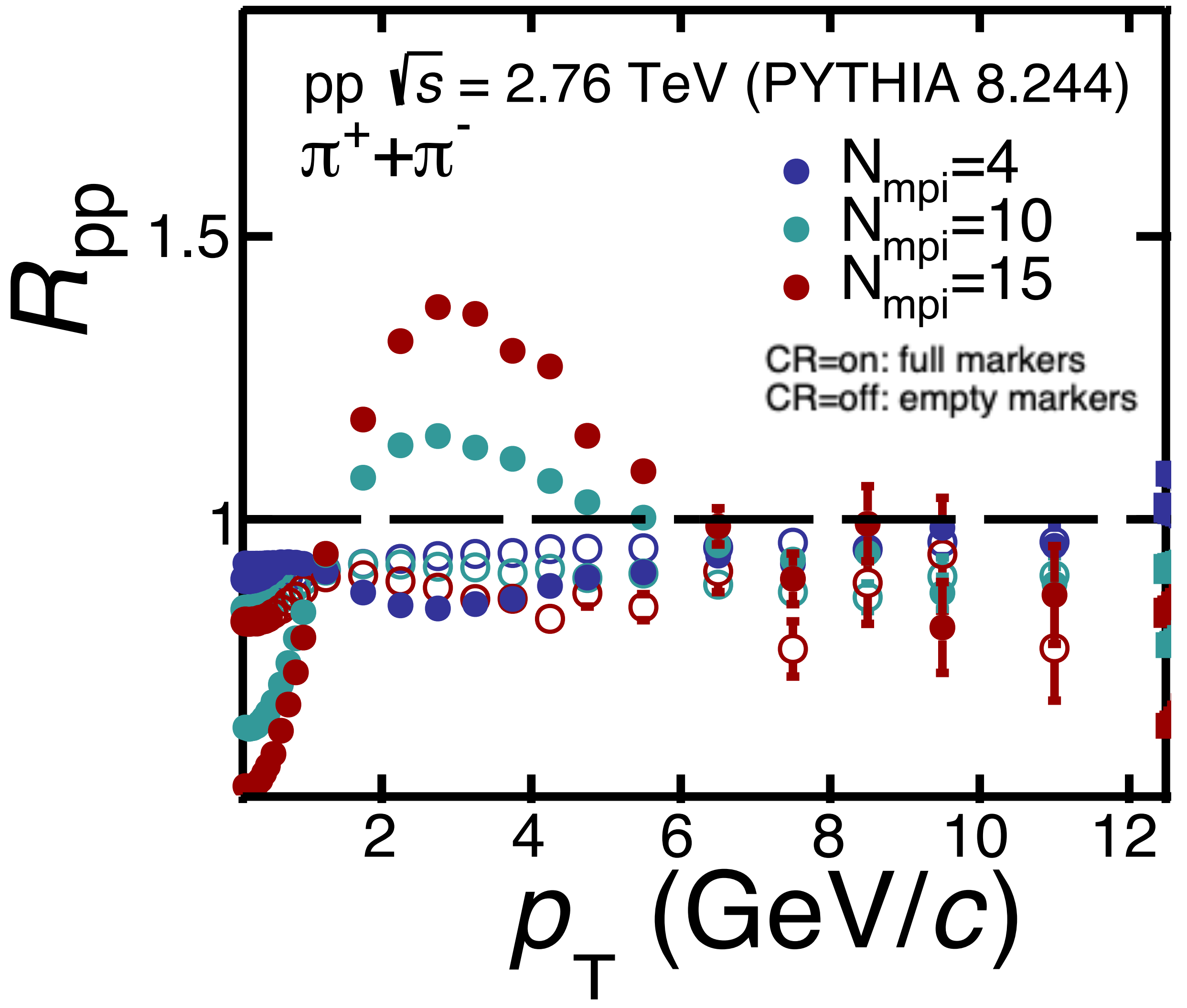


Small local $N^{(\mathrm{ch.}\,i)}$ fluctuations in the V0 acceptance: small flattenicity values

- "isotropic" distribution of particles in the V0 acceptance (large multiplicities)

High-p_T physics: V0M vs flattenicity

A. Ortiz et al., Phys. Rev. D102 (2020) 7, 076014



$$R_{\rm pp}(p_{\rm T}) = \frac{\left.\frac{1}{N_{\rm ev}}\frac{{\rm d}N_{\rm ch}}{{\rm d}p_{\rm T}}\frac{1}{\langle N_{\rm mpi}\rangle}\right|_{\rm high\,MPI}}{\left.\frac{1}{N_{\rm ev}}\frac{{\rm d}N_{\rm ch}}{{\rm d}p_{\rm T}}\frac{1}{\langle N_{\rm mpi}\rangle}\right|_{\rm MB}}$$

- Intermediate p_T: CR peak
- High p_T: the ratio is flat and in the vicinity of unity

High-p_T physics: V0M vs flattenicity

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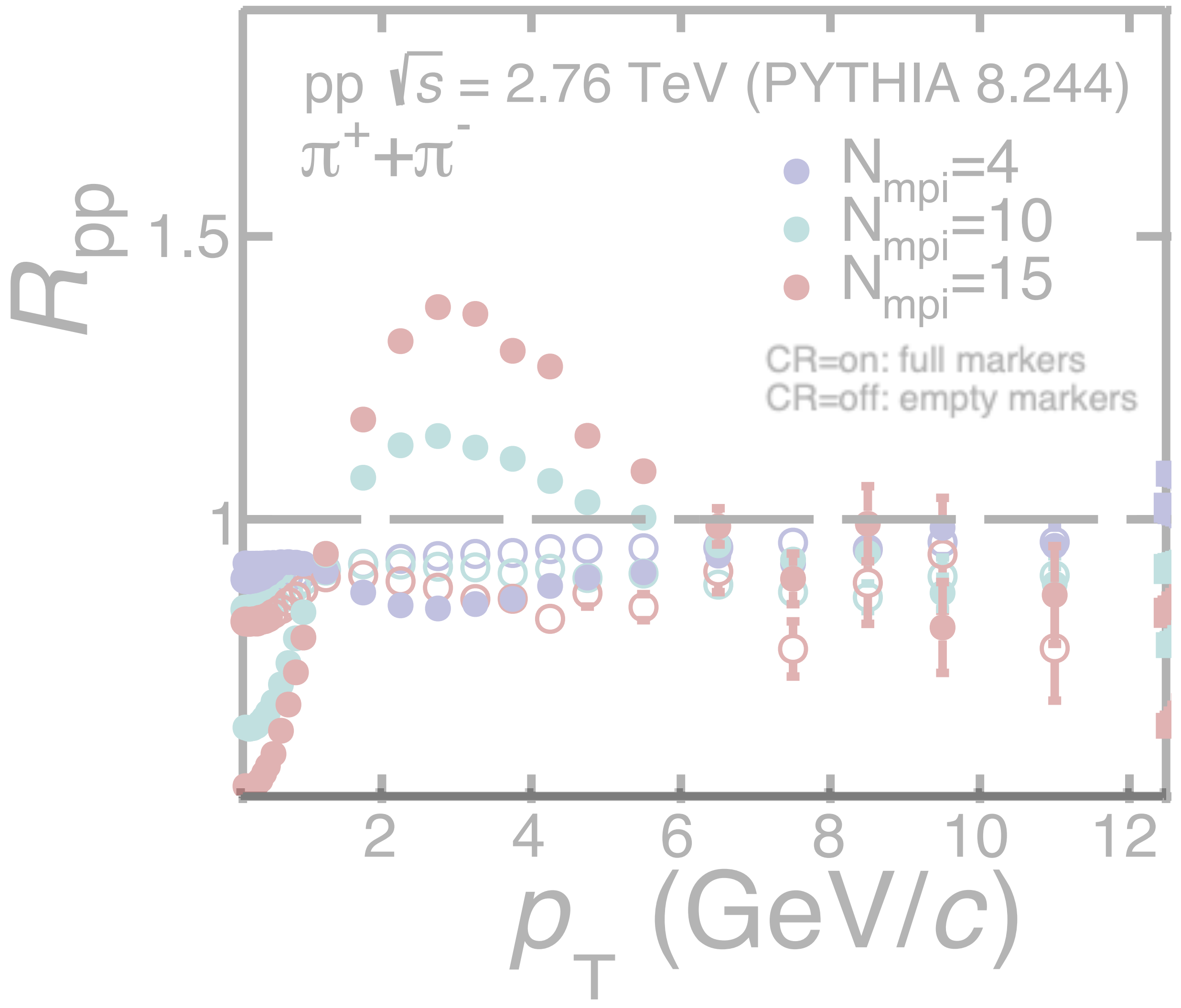
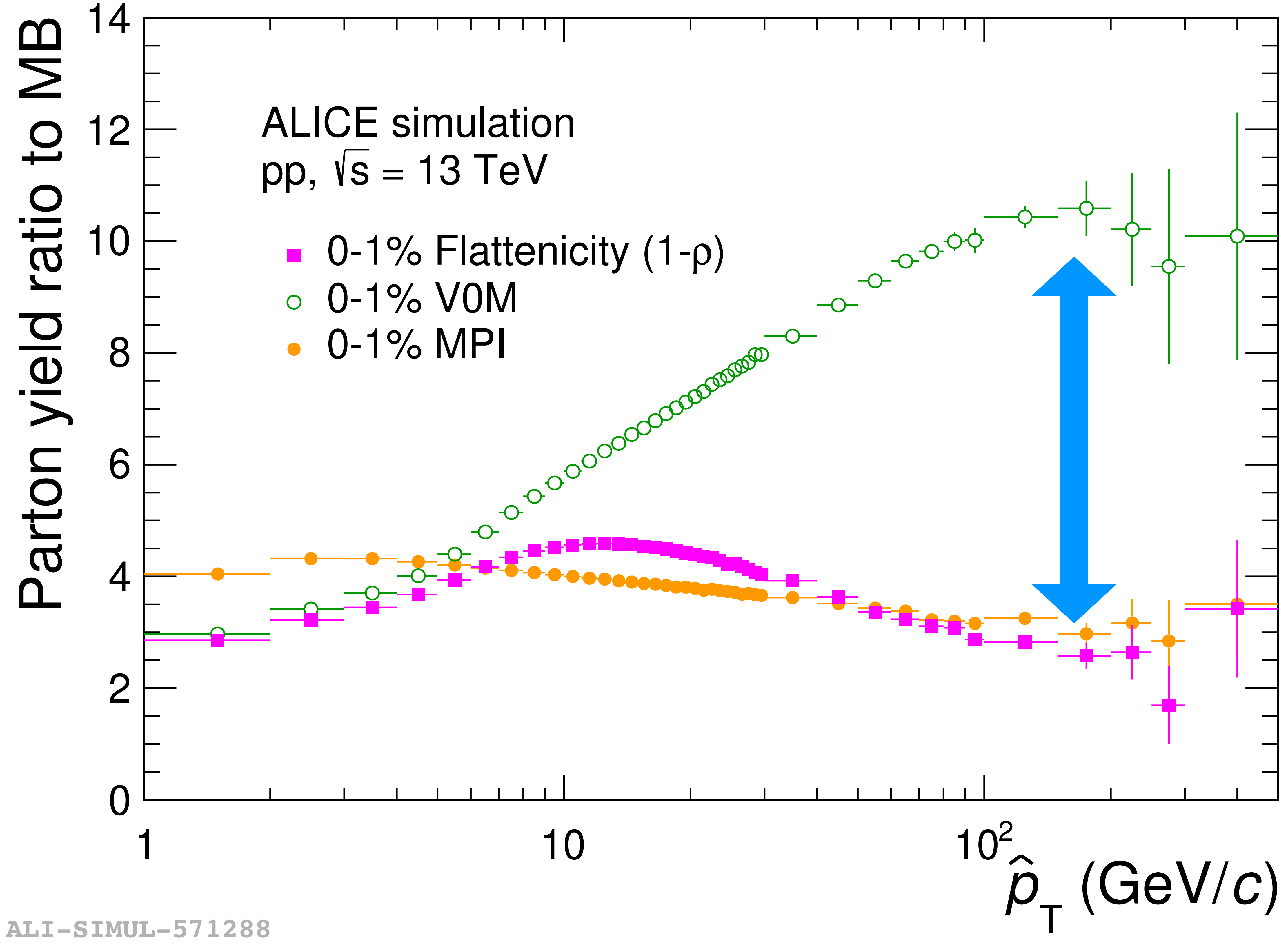


$$R_{\mathrm{pp}}(p_{\mathrm{T}}) = \frac{\frac{1}{N_{\mathrm{ev}}}\frac{\mathrm{d}N_{\mathrm{ch}}}{\mathrm{d}p_{\mathrm{T}}}\frac{1}{\langle N_{\mathrm{mpi}}\rangle}\Big|_{\mathrm{high\,MPI}}}{\frac{1}{N_{\mathrm{ev}}}\frac{\mathrm{d}N_{\mathrm{ch}}}{\mathrm{d}p_{\mathrm{T}}}\frac{1}{\langle N_{\mathrm{mpi}}\rangle}\Big|_{\mathrm{MB}}}$$

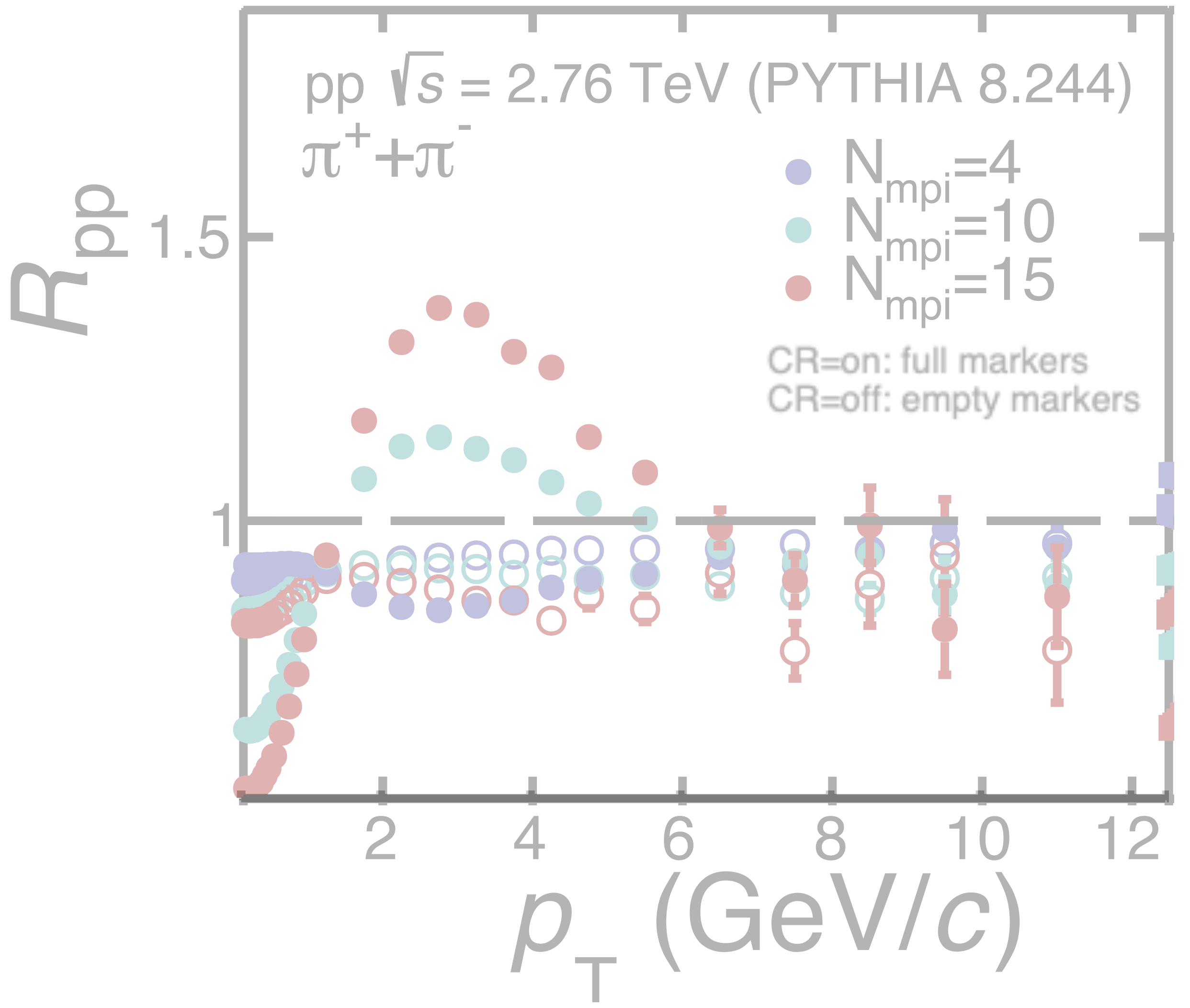
- Intermediate p_T: CR peak
- High p_T: the ratio is flat and in the vicinity of unity

$$\mathrm{ratio}(\hat{p}_{\mathrm{T}}) = \frac{\frac{1}{N_{\mathrm{ev}}}\frac{\mathrm{d}N_{\mathrm{parton}}}{\mathrm{d}\hat{p}_{\mathrm{T}}}\Big|_{1\%\,\mathrm{xsec}}}{\frac{1}{N_{\mathrm{ev}}}\frac{\mathrm{d}N_{\mathrm{parton}}}{\mathrm{d}\hat{p}_{\mathrm{T}}}\Big|_{\mathrm{MB}}}$$



High-p_T physics: V0M vs flatenicity

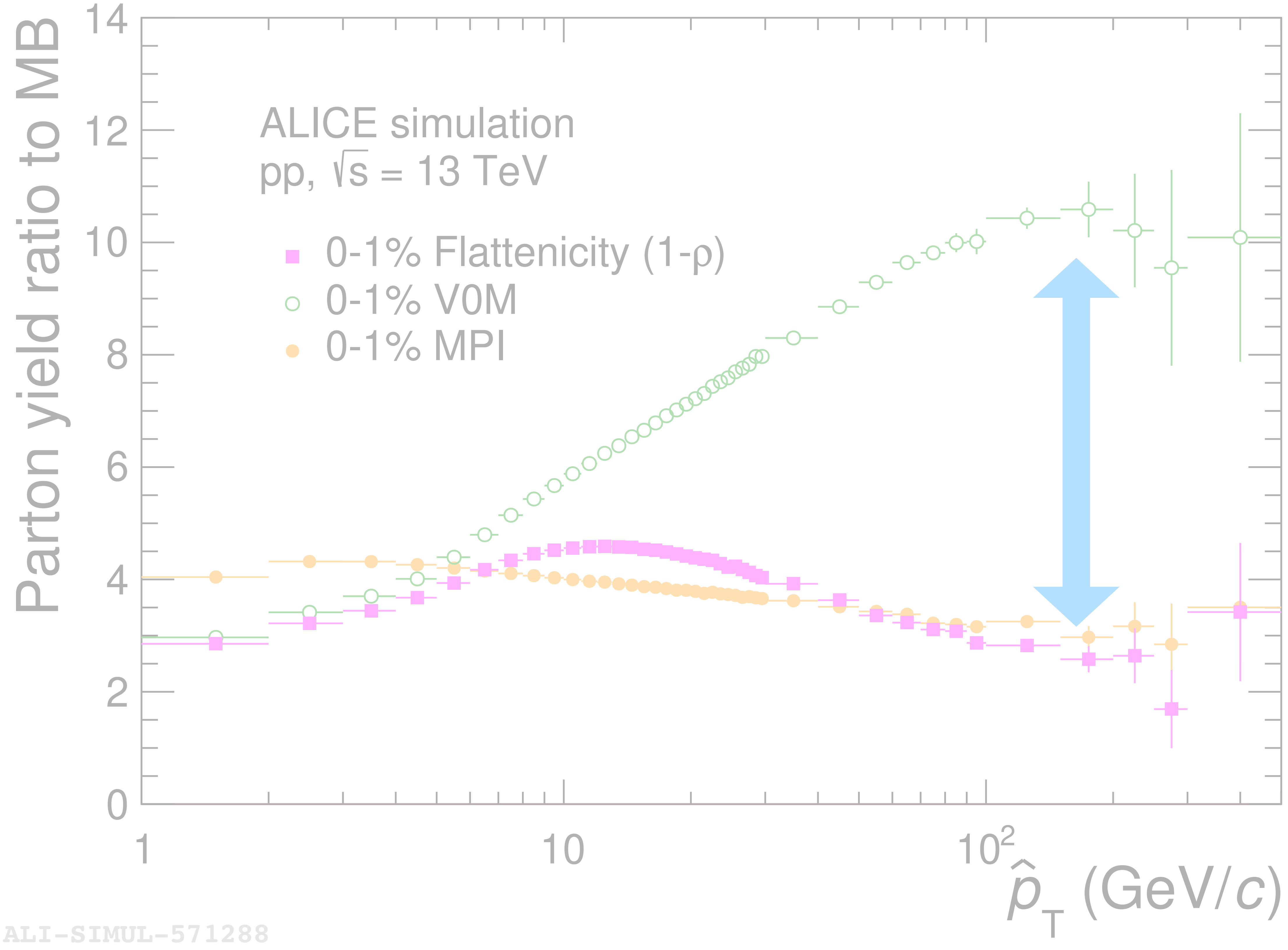
A. Ortiz et al., Phys. Rev. D102 (2020) 7, 076014



$$R_{pp}(p_T) = \frac{\frac{1}{N_{ev}}\frac{dN_{ch}}{dp_T}\frac{1}{\langle N_{mpi}\rangle}\Big|_{\text{high MPI}}}{\frac{1}{N_{ev}}\frac{dN_{ch}}{dp_T}\frac{1}{\langle N_{mpi}\rangle}\Big|_{\text{MB}}}$$

- Intermediate p_T: CR peak
- High p_T: the ratio is flat and in the vicinity of unity

$$\text{ratio}(\hat{p}_T) = \frac{\frac{1}{N_{ev}}\frac{dN_{\text{parton}}}{d\hat{p}_T}\Big|_{1\%\ \text{xsec}}}{\frac{1}{N_{ev}}\frac{dN_{\text{parton}}}{d\hat{p}_T}\Big|_{\text{MB}}}$$



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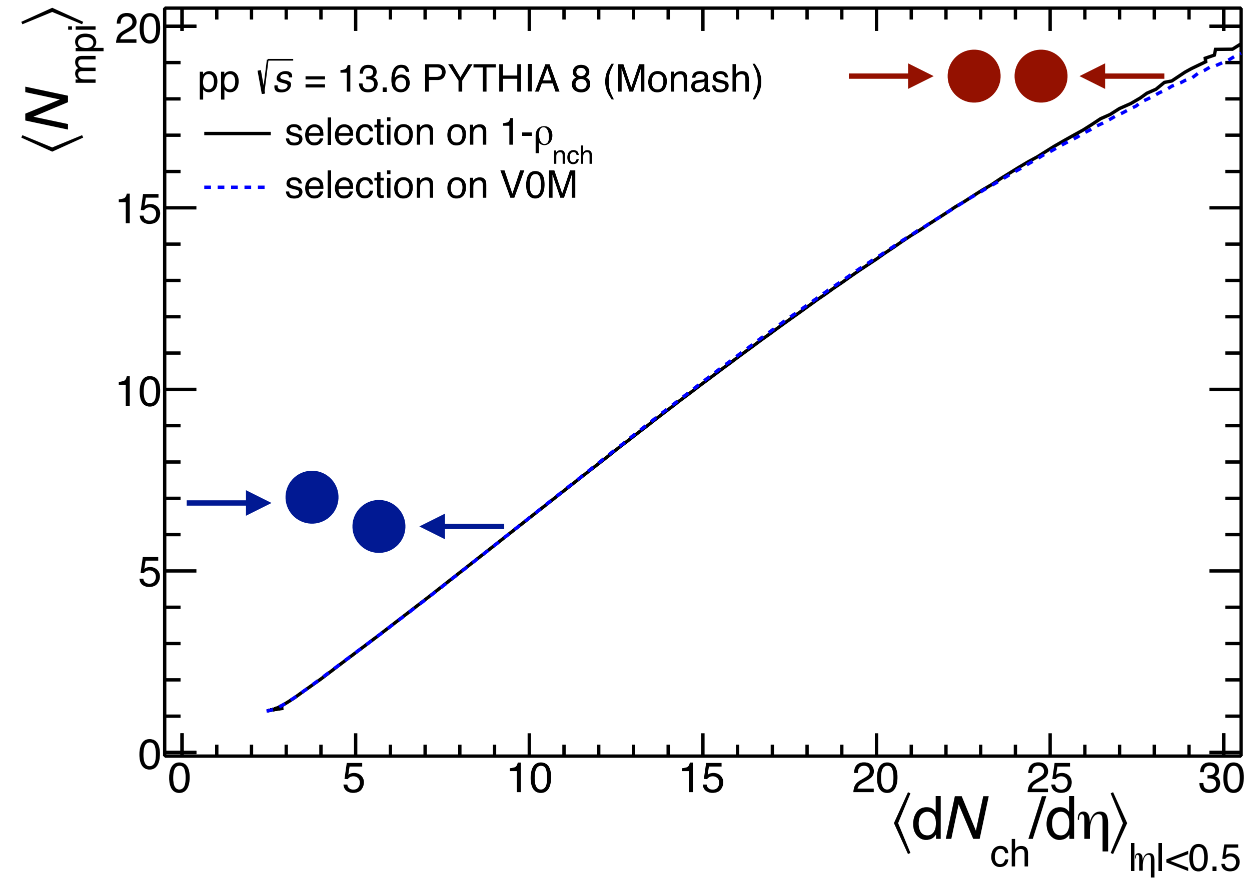
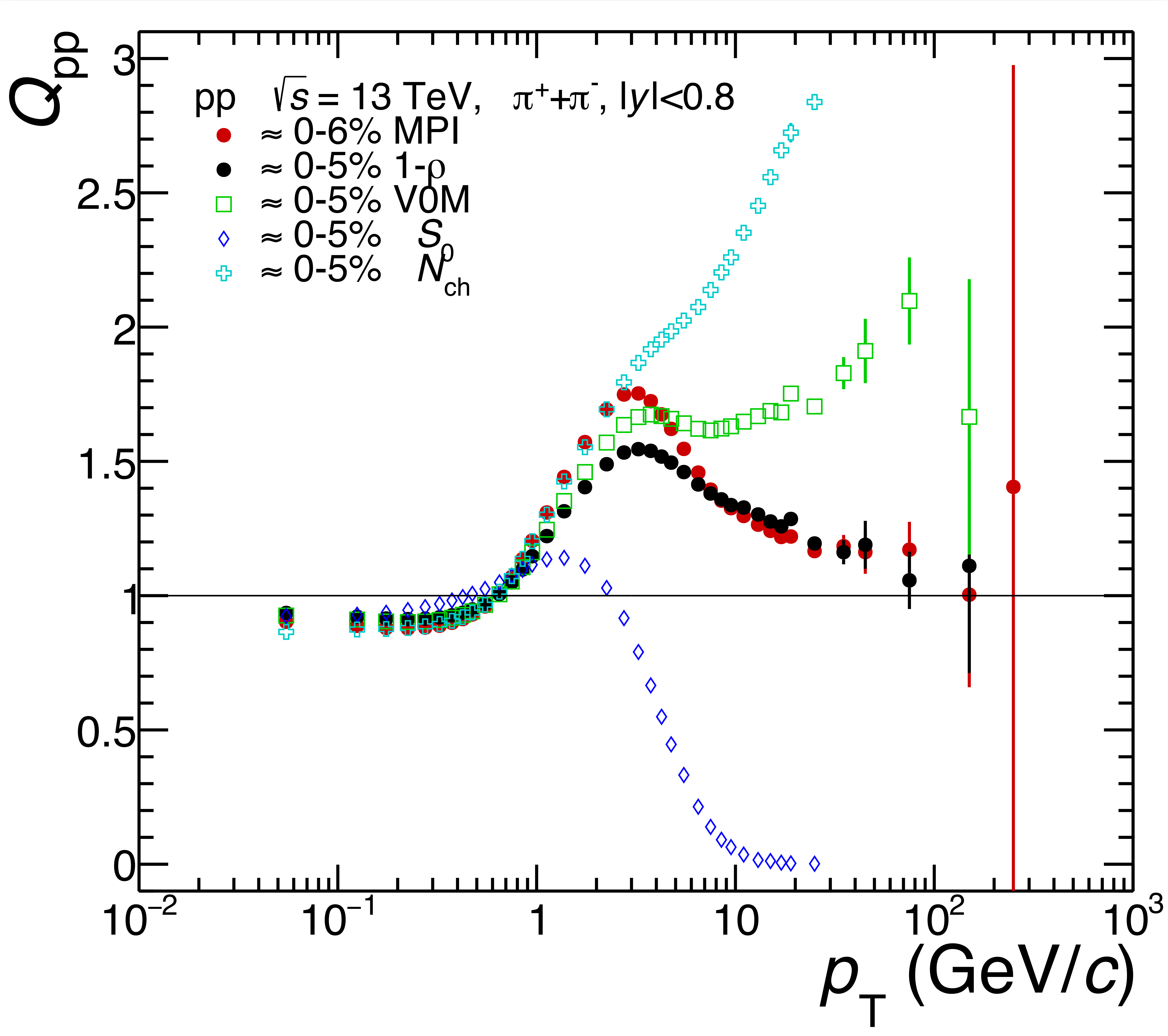


$$\left\langle \frac{dN_{ch}}{d\eta} \right\rangle \propto \langle N_{mpi} \rangle$$

Experimentally:

$$Q_{pp}(p_T) = \frac{\frac{1}{N_{ev}}\frac{dN_{ch}}{dp_T}\frac{1}{\langle N_{ch}\rangle}\Big|_{\text{HM}}}{\frac{1}{N_{ev}}\frac{dN_{ch}}{dp_T}\frac{1}{\langle N_{ch}\rangle}\Big|_{\text{MB}}}$$

Flattenicity vs other estimators



Q_{pp} as a function of p_T

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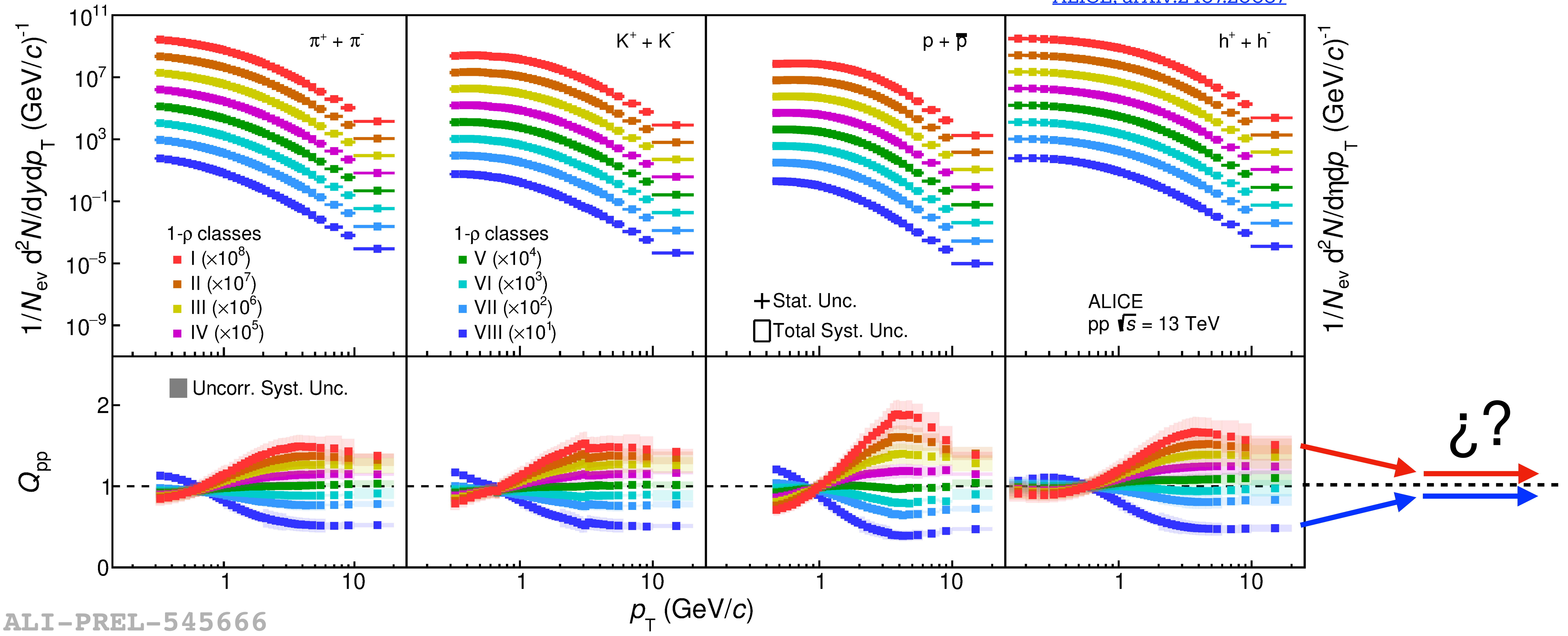
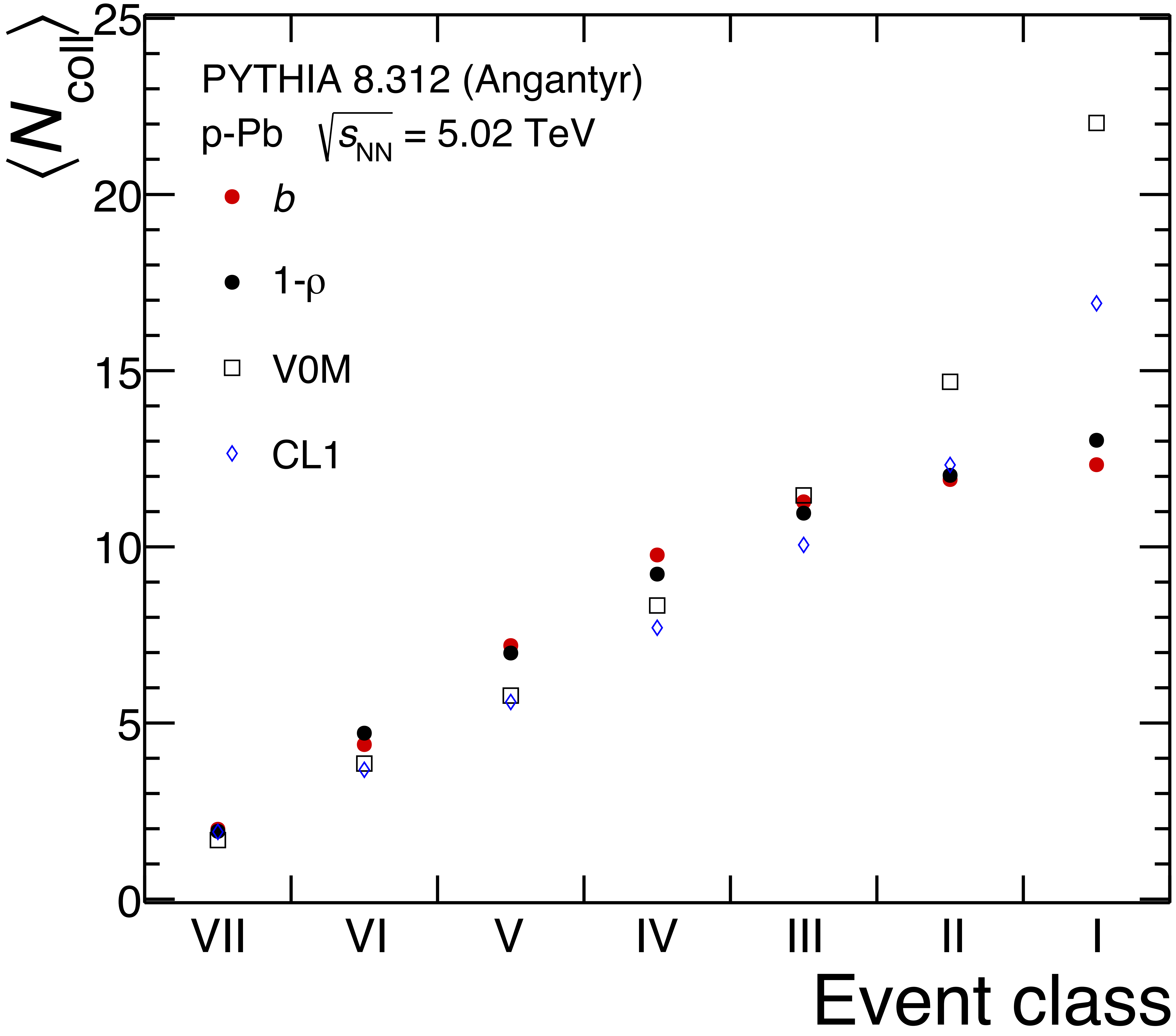
ALICE, arXiv:2407.20037



- Intermediate p_T: a bump structure is developed with increasing multiplicity

Flattenicity as centrality estimator in p-Pb?

Flattenicity in p-Pb collisions?



Flattenicity in p-Pb seems to be a good candidate to classify the collisions in terms of the centrality

More studies will come

Collective-like effects in low multiplicity pp, UPC. Why not in jets?

Proposal: A. Baty, P. Gardner, and W. Li, PRC 107 (2023), 064908

CMS paper recently accepted by PRL

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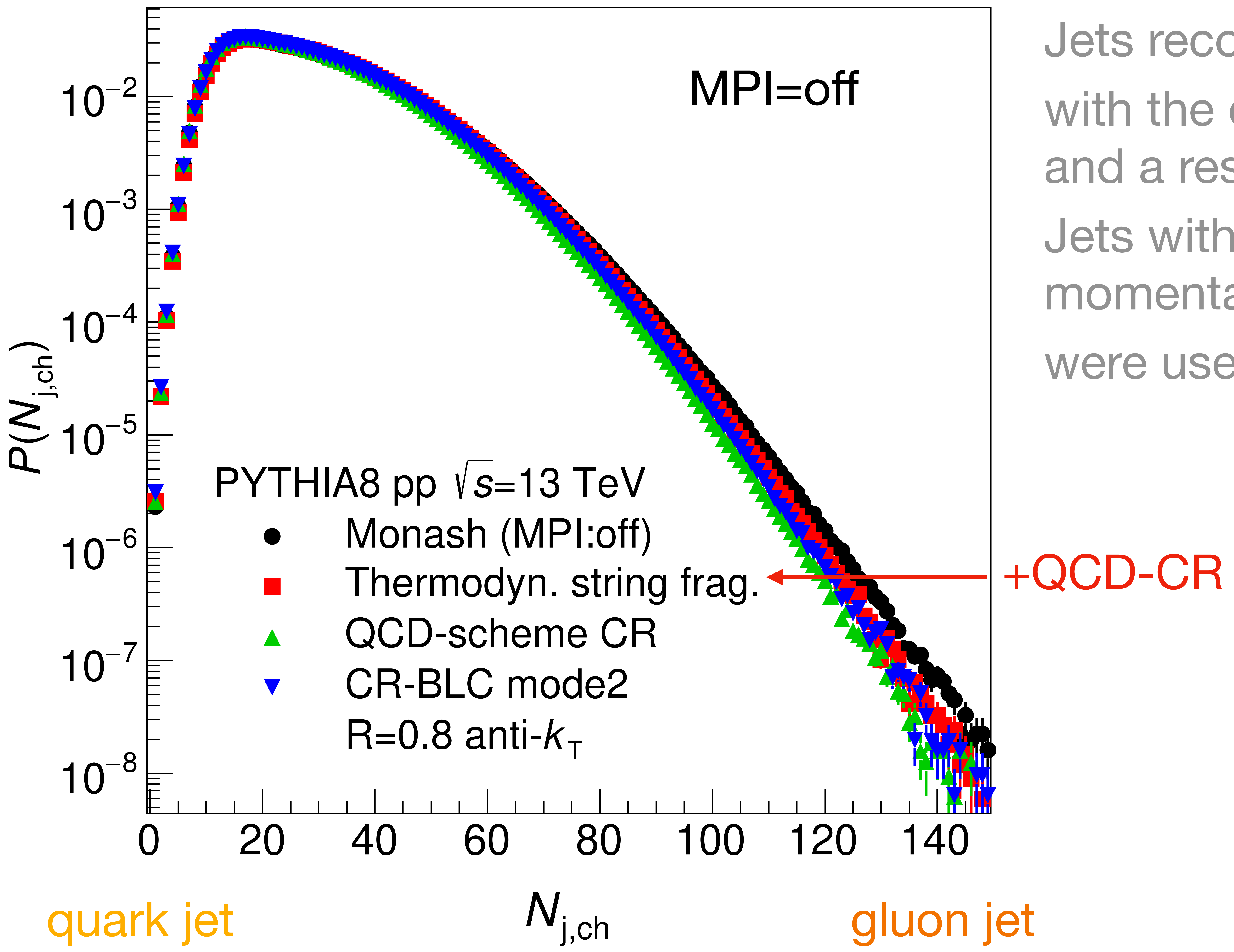
Accepted Paper

Observation of enhanced long-range elliptic anisotropies inside high-multiplicity jets in pp collisions at $\sqrt{s} = 13$ TeV

Phys. Rev. Lett.

A. Hayrapetyan et al.

Accepted 27 August 2024



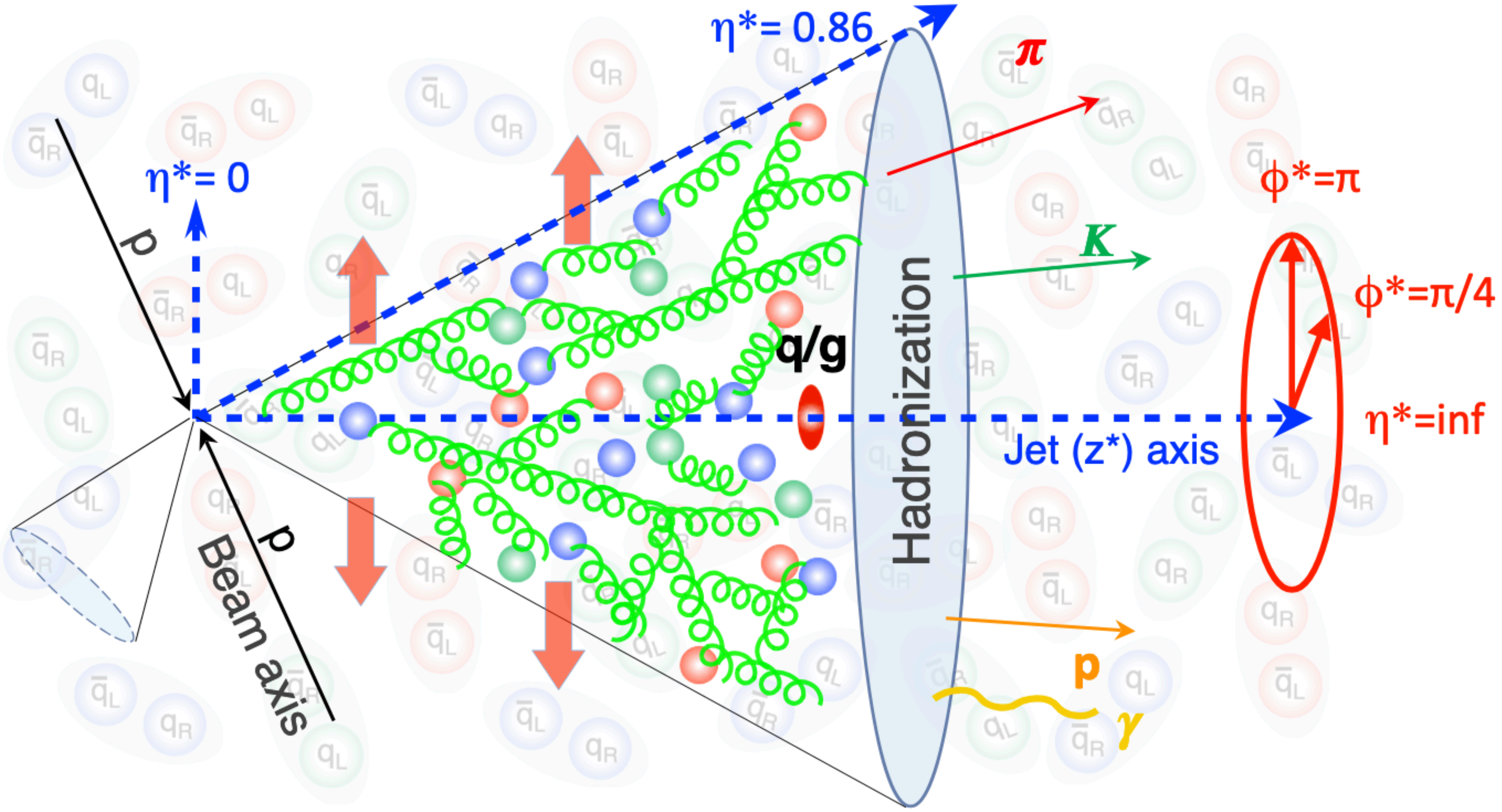
Jets reconstruction: anti-kT algorithm with the energy recombination scheme and a resolution parameter R = 0.8.

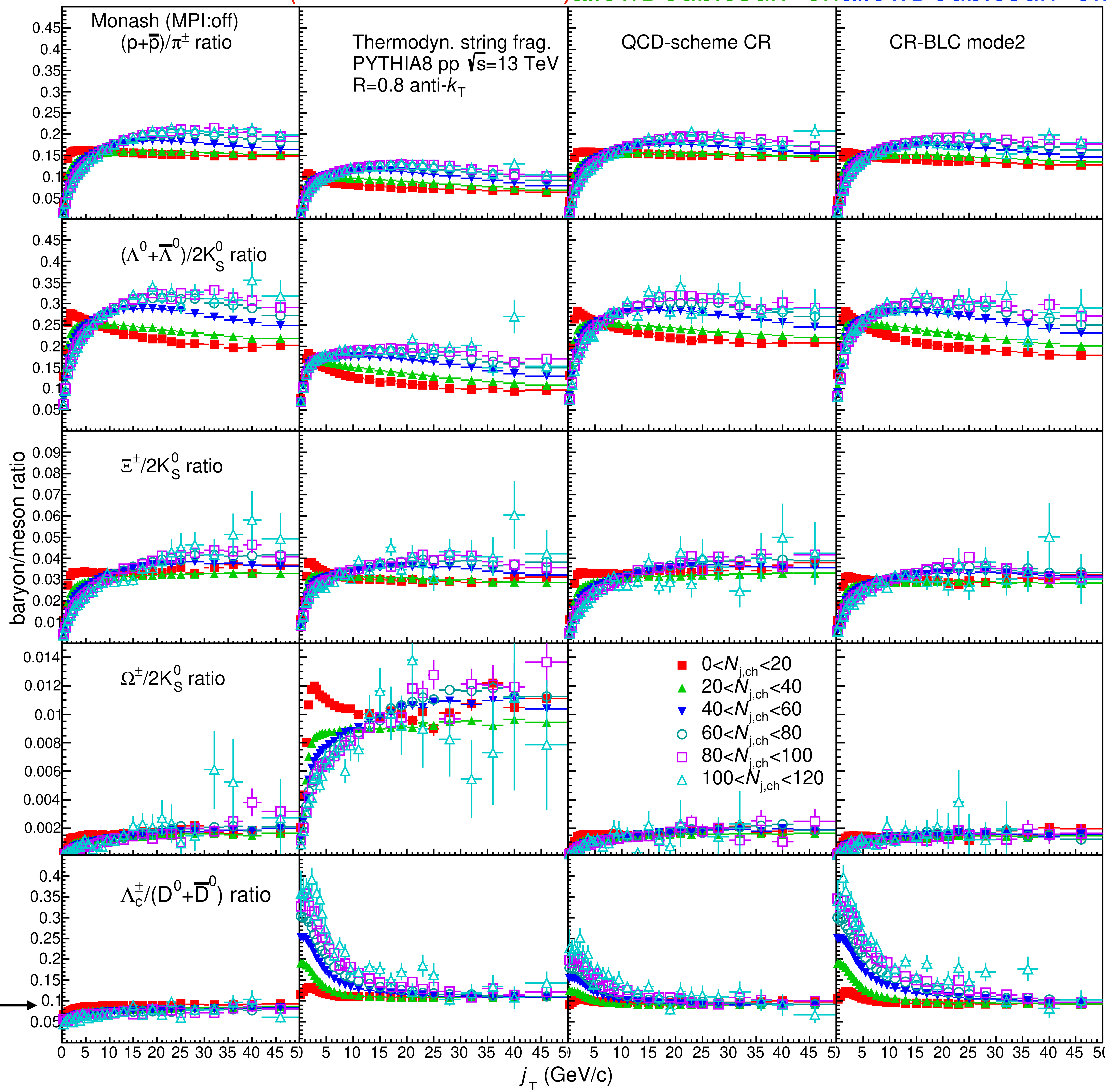
Jets with charged-jet transverse momenta 550 < $p$jetT < 1000 GeV/c were used

2408.06340

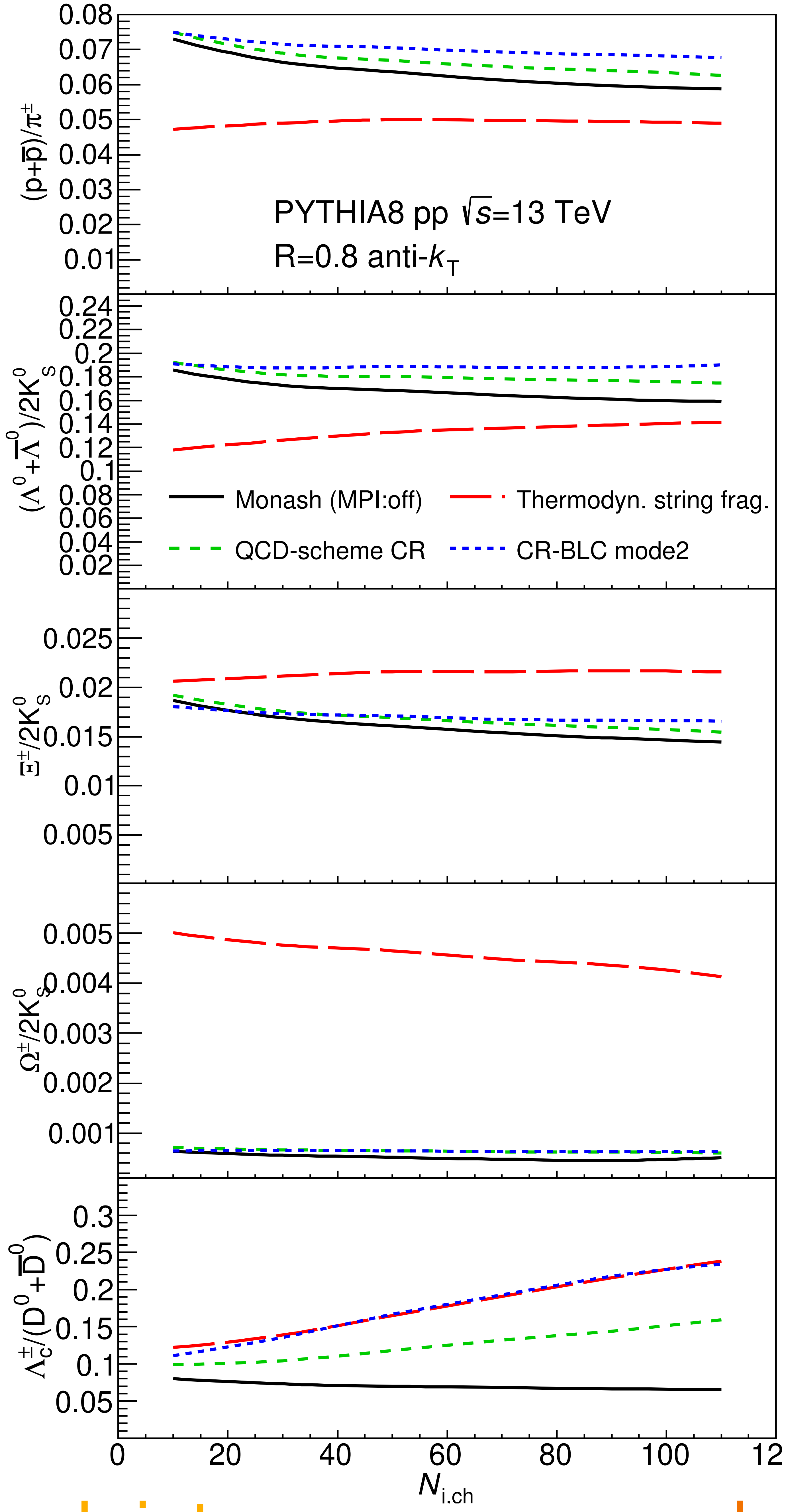
+QCD-CR (allowDoubleJun=on) allowDoubleJun=on allowDoubleJun=off

Figure from CMS, 2312.17103





e+e- limit

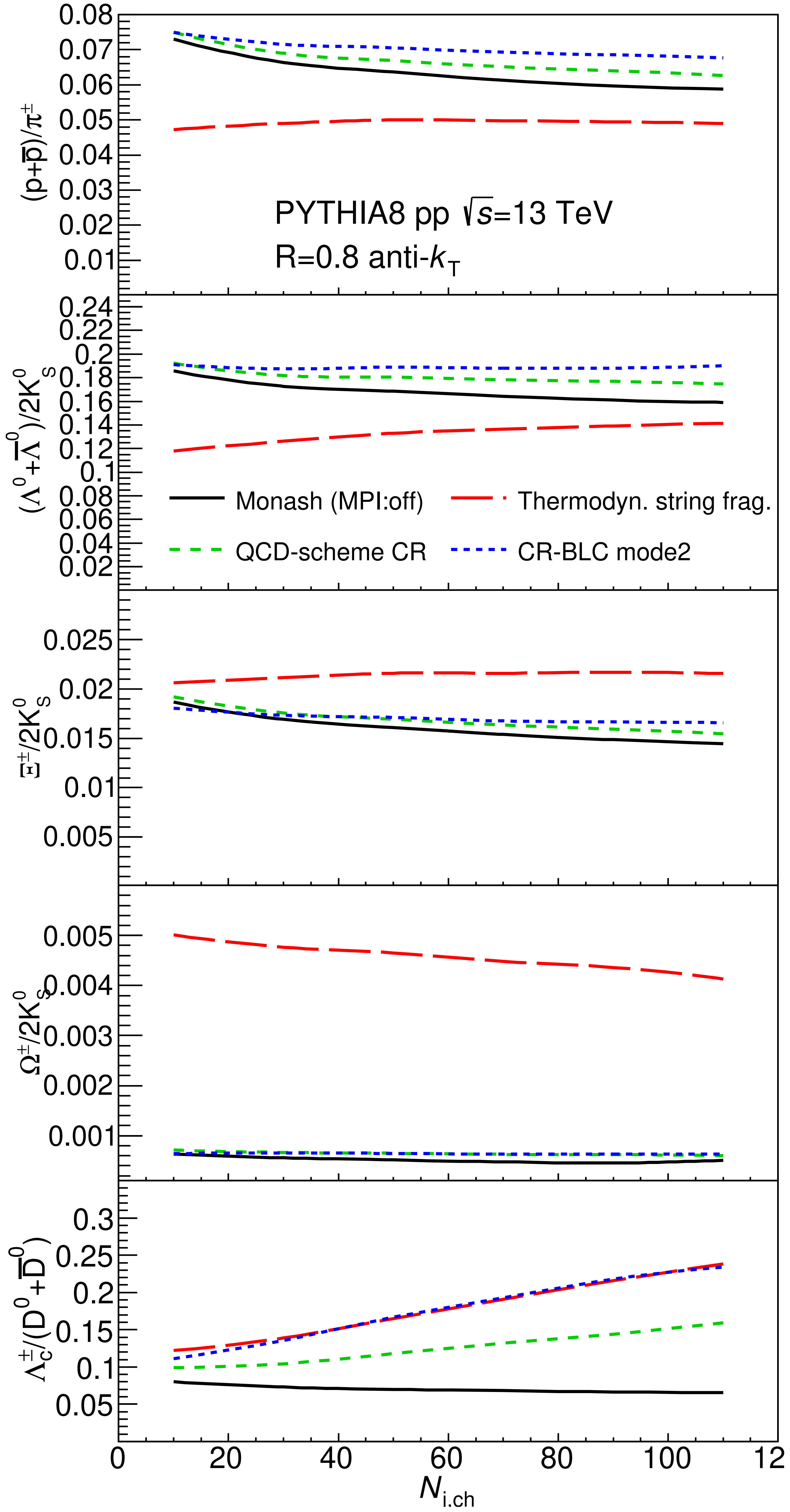


quark jet   gluon jet

2408.06340

Hint of baryon enhancement in high multiplicity jets?

Normally CR effects are negligible in jets. However, in a high-parton density environment, can CR produce this type of effects?



2408.06340

Hint of baryon enhancement in high multiplicity jets?

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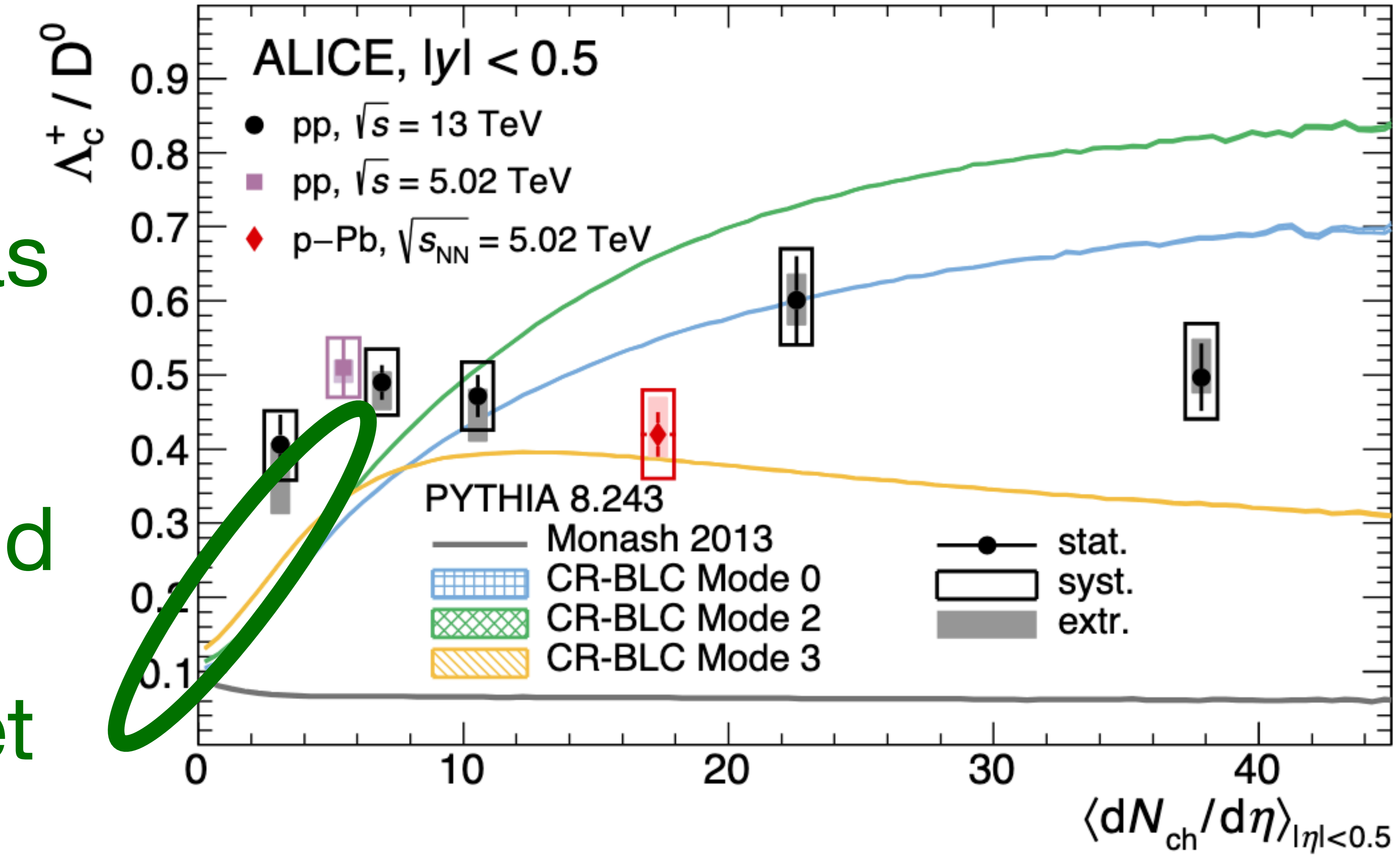
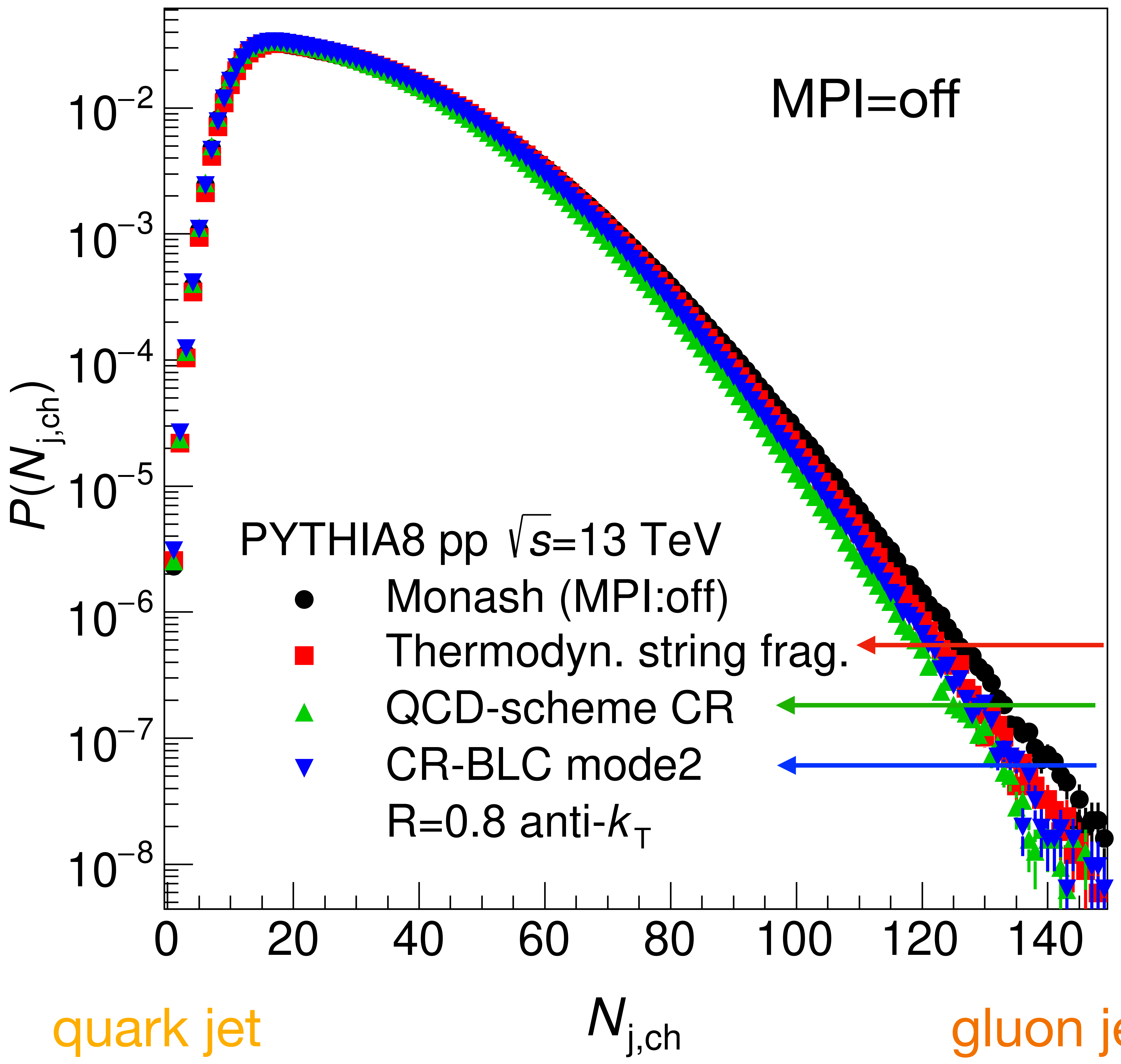
Can an analysis as a function of jet multiplicity could help to understand the HF ratio? (quark vs gluon jet fragmentation)



Thanks



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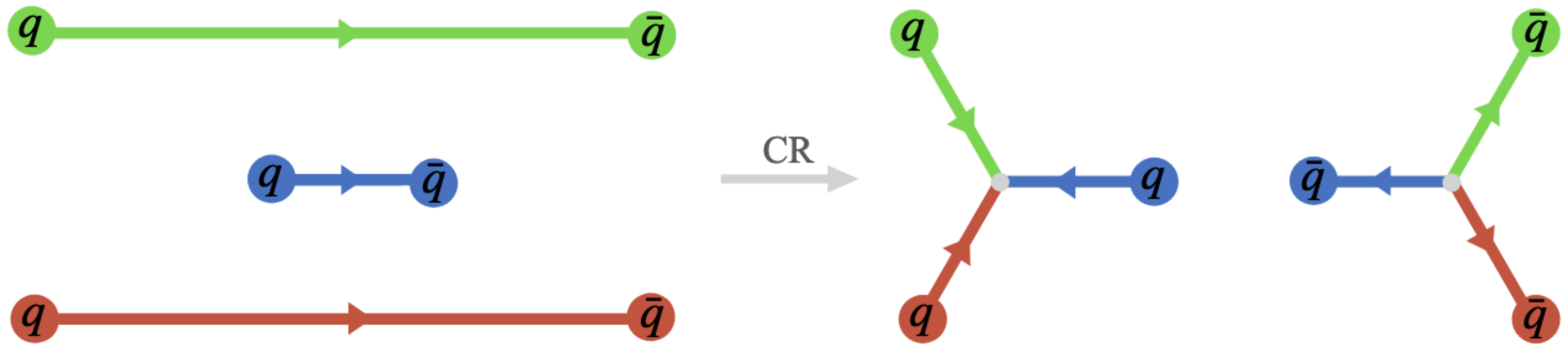

Figure 4. The left image shows an LC string configuration consisting of three dipole strings. The coloured lines here represent the strings, with arrows indicating the direction of the colour flow (conventionally flowing from colour to anticolour). The right side image shows a possible alternative string configuration given a junction-type colour reconnection, resulting in the formation of a junction and an antijunction string system.

J. Altmann, and P. Skands, arXiv:2404.12040

Beállítás	Monash	CR-BLC	CR-QCD
Beams:eCM	13000		
Tune:pp	14 (Monash 13[35])		
SoftQCD:nonDiffractive	on		
SoftQCD:singleDiffractive	on		
SoftQCD:doubleDiffractive	on		
HardQCD:hardbbbar	off		
HardQCD:hardccbar	off		
StringPT:sigma	0.335		
StringZ:aLund	0.68		0.36
StringZ:bLund	0.98		0.56
StringFlav:probQQtoQ	0.081		0.078
StringFlav:ProbStoUD	0.217		0.2
StringFlav:probQQ1toQQ0join	0.5, 0.7, 0.9, 1.0		0.0275, 0.0275, 0.0275, 0.0275
StringFlav:probQQ1toQQ0join	2.28		2.15
BeamRemnants:remnantMode	0	1	
BeamRemnants:saturation	5		
ColourReconnection:mode	0	1 (QCD)	
ColourReconnection:allowDoubleJunRem	on		off
ColourReconnection:m0	0.3		
ColourReconnection:allowJunctions	on		
ColourReconnection:junctionCorrection	1.20		
ColourReconnection:timeDilationMode	2		
ColourReconnection:timeDilationPar	0.18		

Quark-level suppression:

$$\exp\left(-\pi m_{\perp q}^2/\kappa\right) = \exp\left(-\pi m_q^2/\kappa\right)\,\exp\left(-\pi p_{\perp q}^2/\kappa\right)$$ (standard Lund model)

→

$$\exp(-m_{\perp \mathrm{had}}/T) \quad \text{with} \quad m_{\perp \mathrm{had}} = \sqrt{m_{\mathrm{had}}^2 + p_{\perp \mathrm{had}}^2}$$ (thermodynamical string fragmentation)

N. Fischer and T. Sjostrand, JHEP01(2017)140

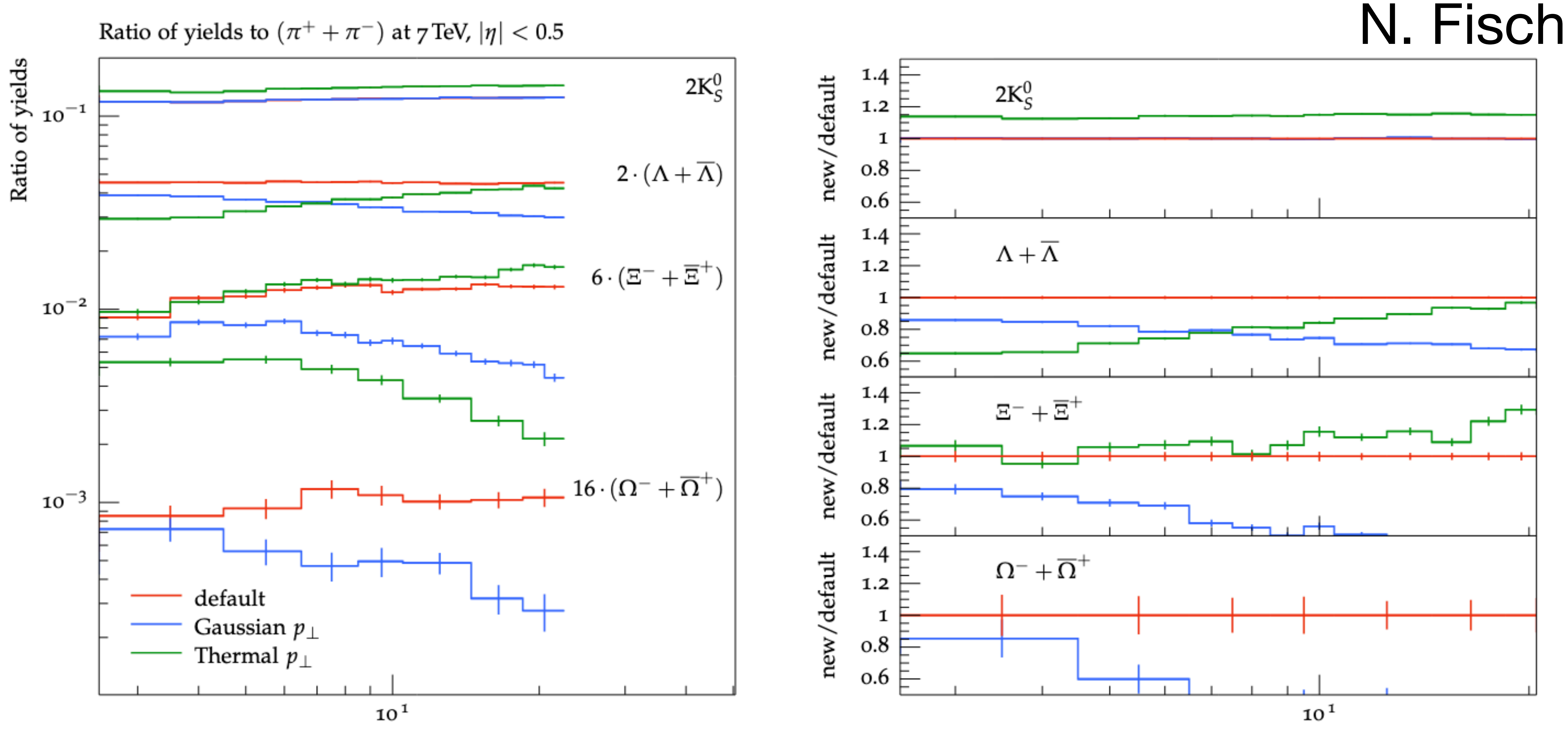

Figure 16: Ratio of yields with respect to $(\pi^+ + \pi^-)$ as a function of the charged multiplicity. Predictions of default PYTHIA, the Gaussian and thermodynamical model with modifications. The ALICE measurement can be found in [10].