Particle production as a function of UE activity measured with ALICE at the LHC

Valentina Zaccolo
University and INFN – Trieste

for the ALICE Collaboration

Strangeness in Quark Matter
SQM Bari 2019

Introduction

At LHC high collision energies -> significant contributions from hard processes

- pQCD precise calculations

Nevertheless particle production dominated by **soft-QCD** processes $\boldsymbol{p_{\mathrm{T}}}$ **~ few GeV**

- non perturbative phenomenology
- modelling

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Underlying Event

- Multiple parton interactions (MPI): more than one hard scattering
- semi-hard + soft interactions (ISR/FSR and beam remnants)

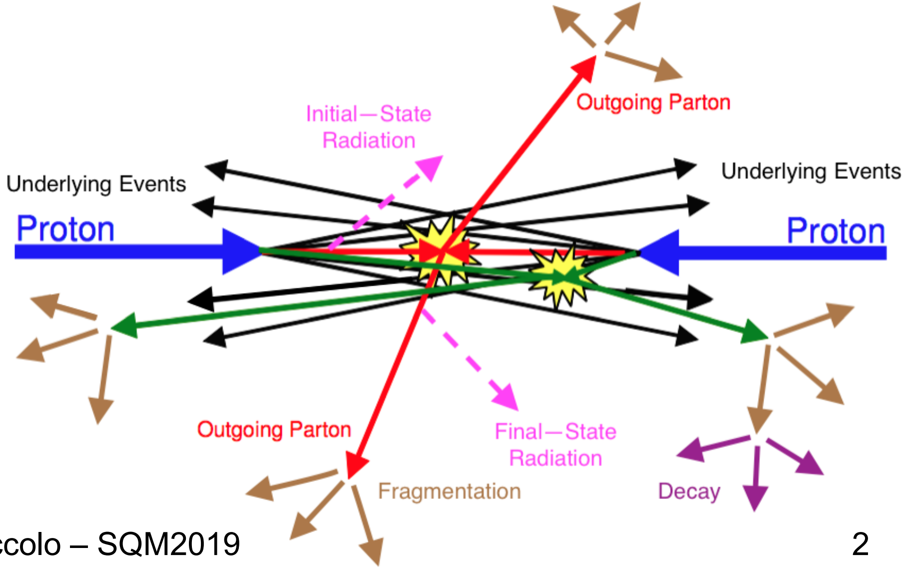
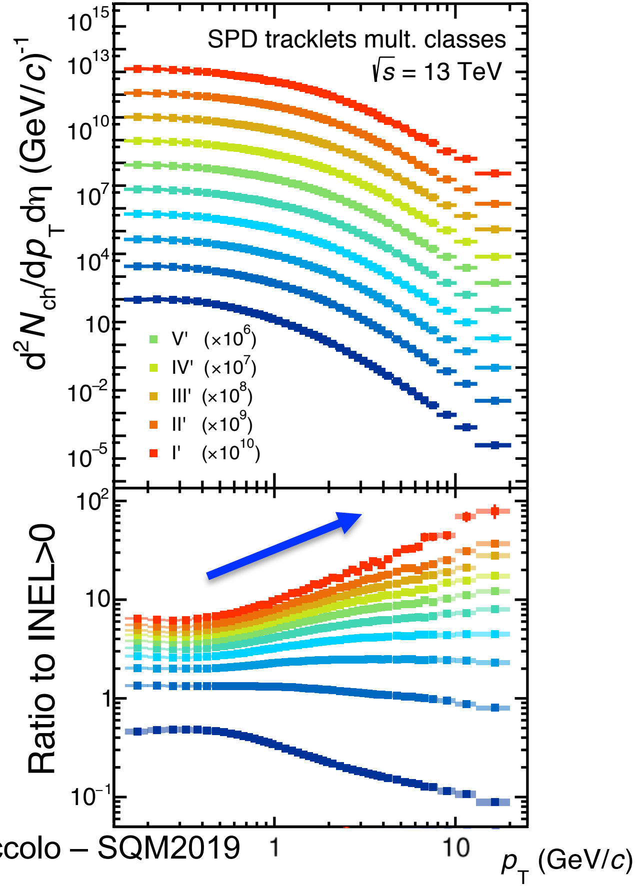


Figure adapted from Eur.Phys.J. C62 (2009) 237-242

Motivation

p_T spectra versus multiplicity

Midrapidity multiplicity selection → particle production above 0.8 GeV/c increases with increasing multiplicity



ALICE
arXiv:1905.07208

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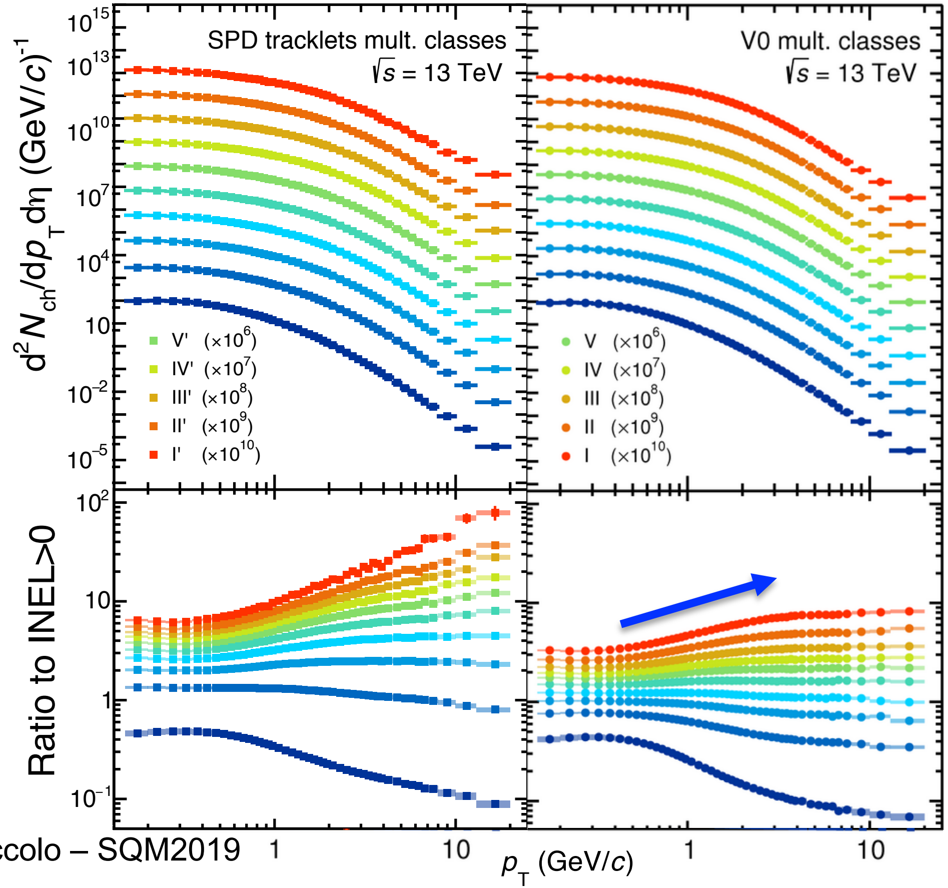

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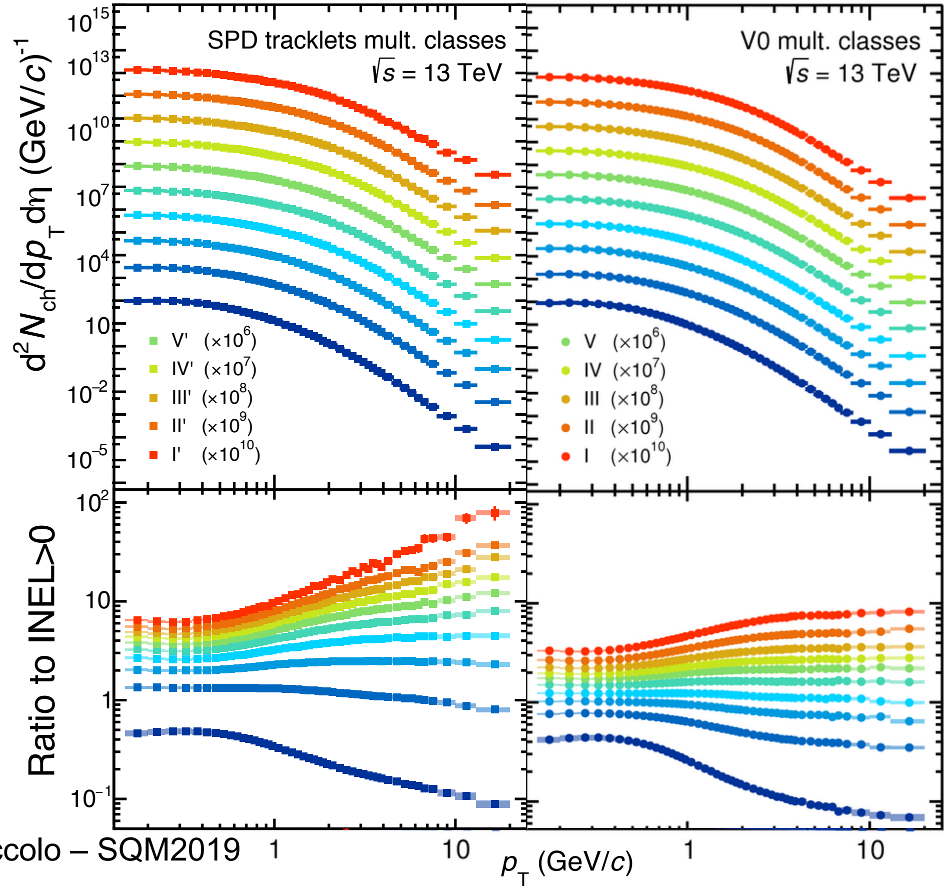
- Is it due to the presence of **jets** which bias the selection?

- Could a **jet free multiplicity estimator** help to understand the correlation between low and high p_T particle production?



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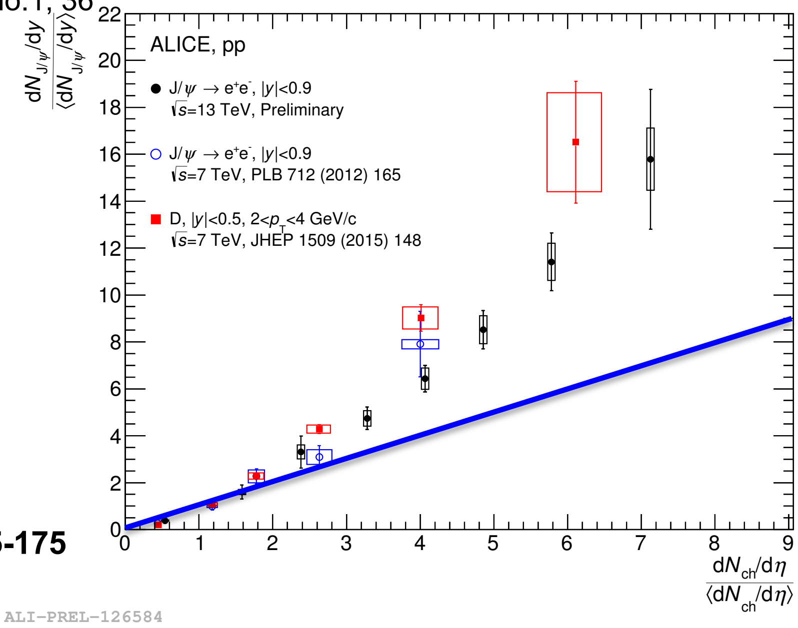
Motivation

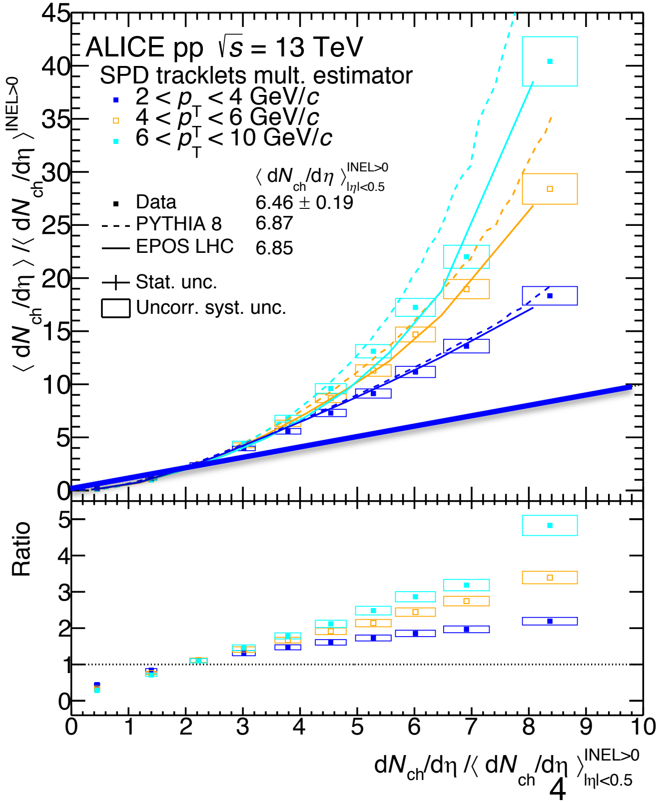
Multiplicity dependence studies

Non-linear heavy-flavour and high-p_T particle production increase with multiplicity

- effect of multiplicity saturation?
- interplay between multiplicity fluctuations of individual parton interactions and decrease of MPI?

Eur.Phys.J. C79 (2019) no.1, 36





ALICE
Phys.Lett. B712 (2012) 165-175
JHEP 1509 (2015) 148
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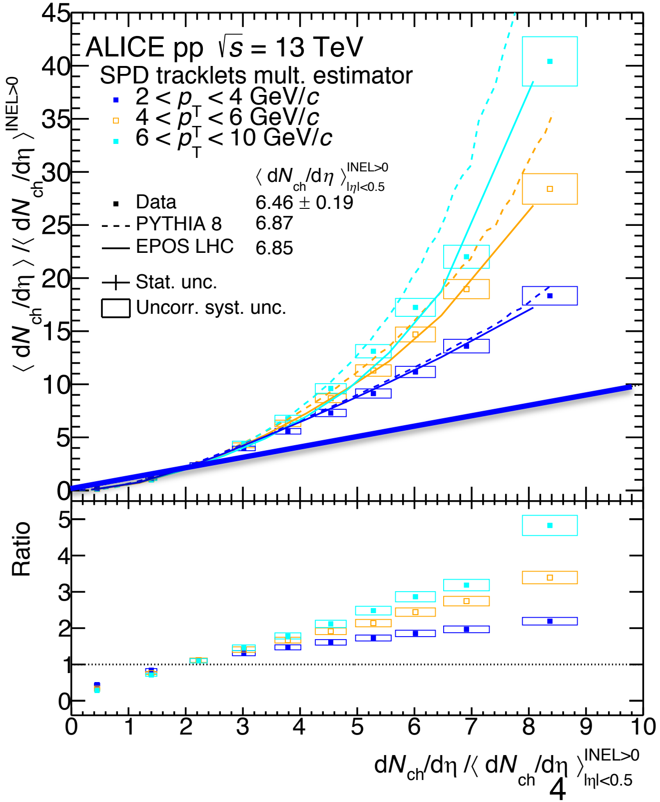
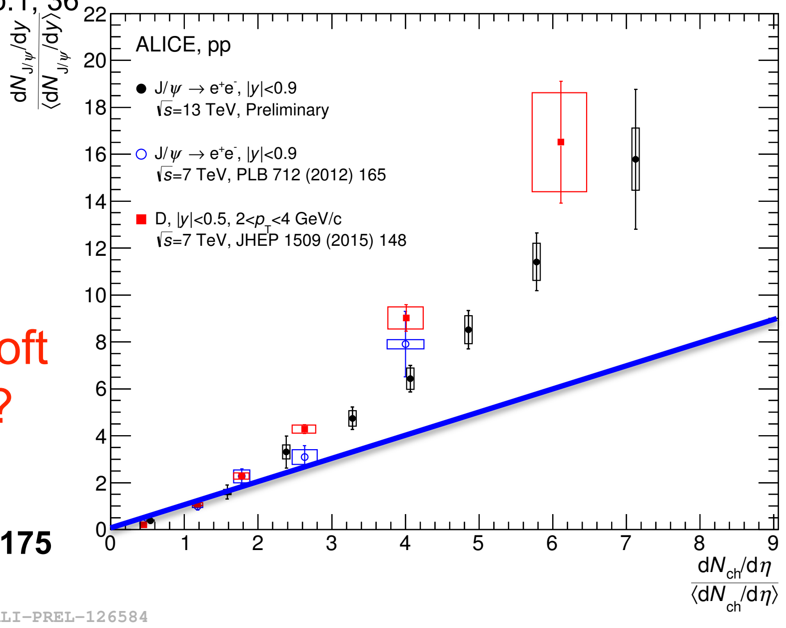


> Could a **jet free multiplicity estimator** help to understand soft QCD dynamics?



ALICE
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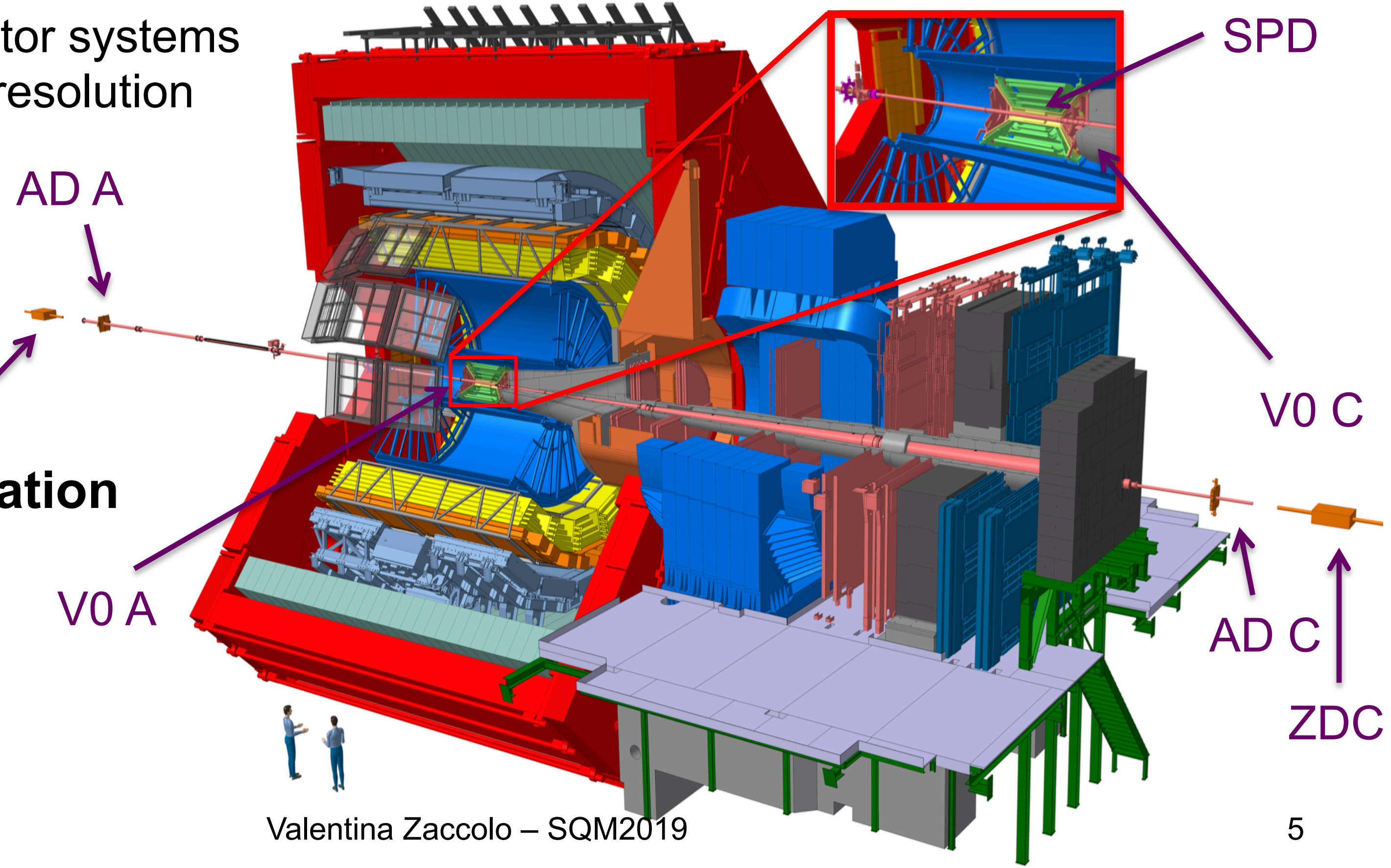
The ALICE detector

A Large Ion Collider Experiment

- 18 different detector systems
- high-momentum resolution
- excellent PID

solenoidal magnet: 0.5 T

Trigger and event characterisation detectors



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Data-taking detectors

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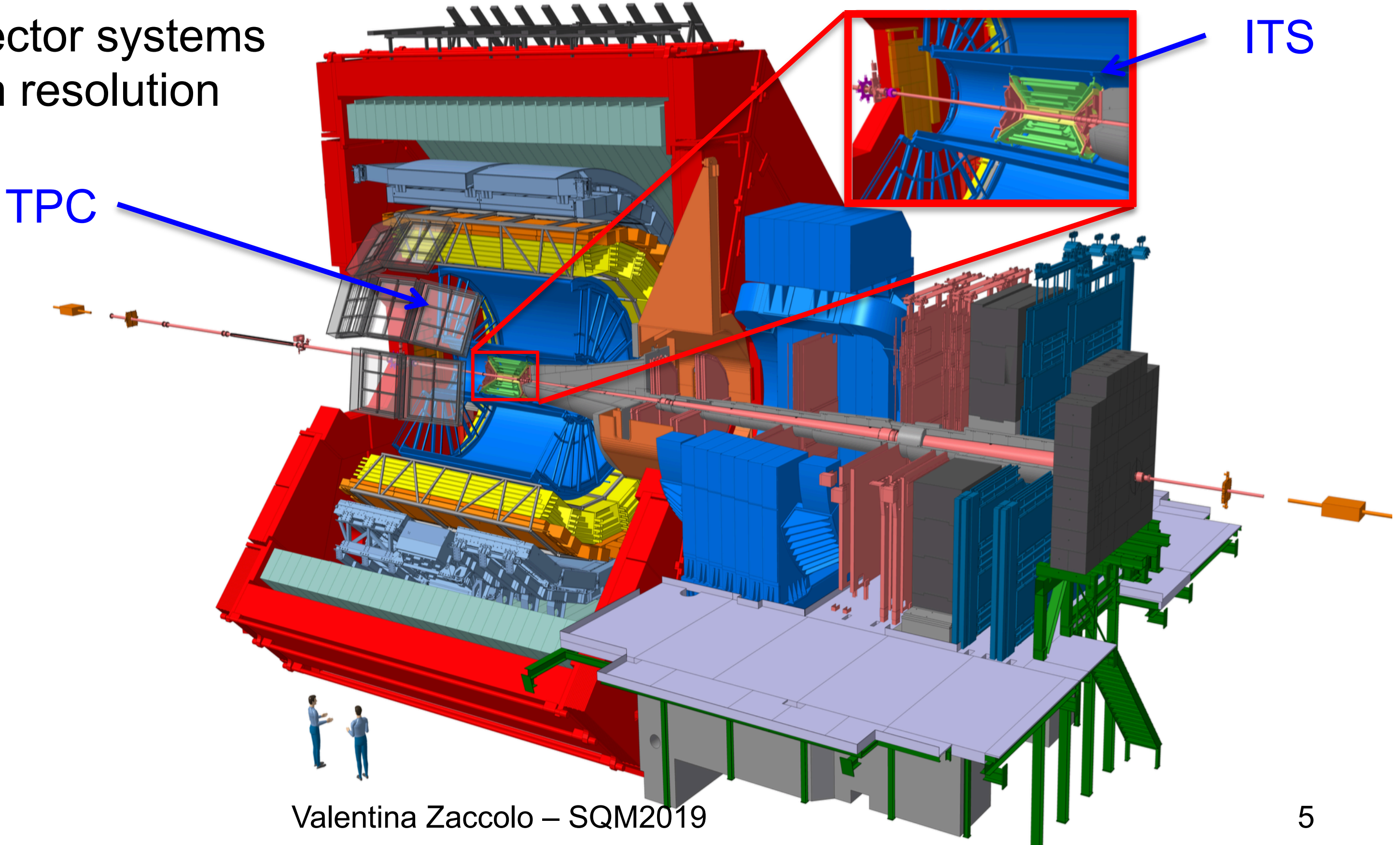

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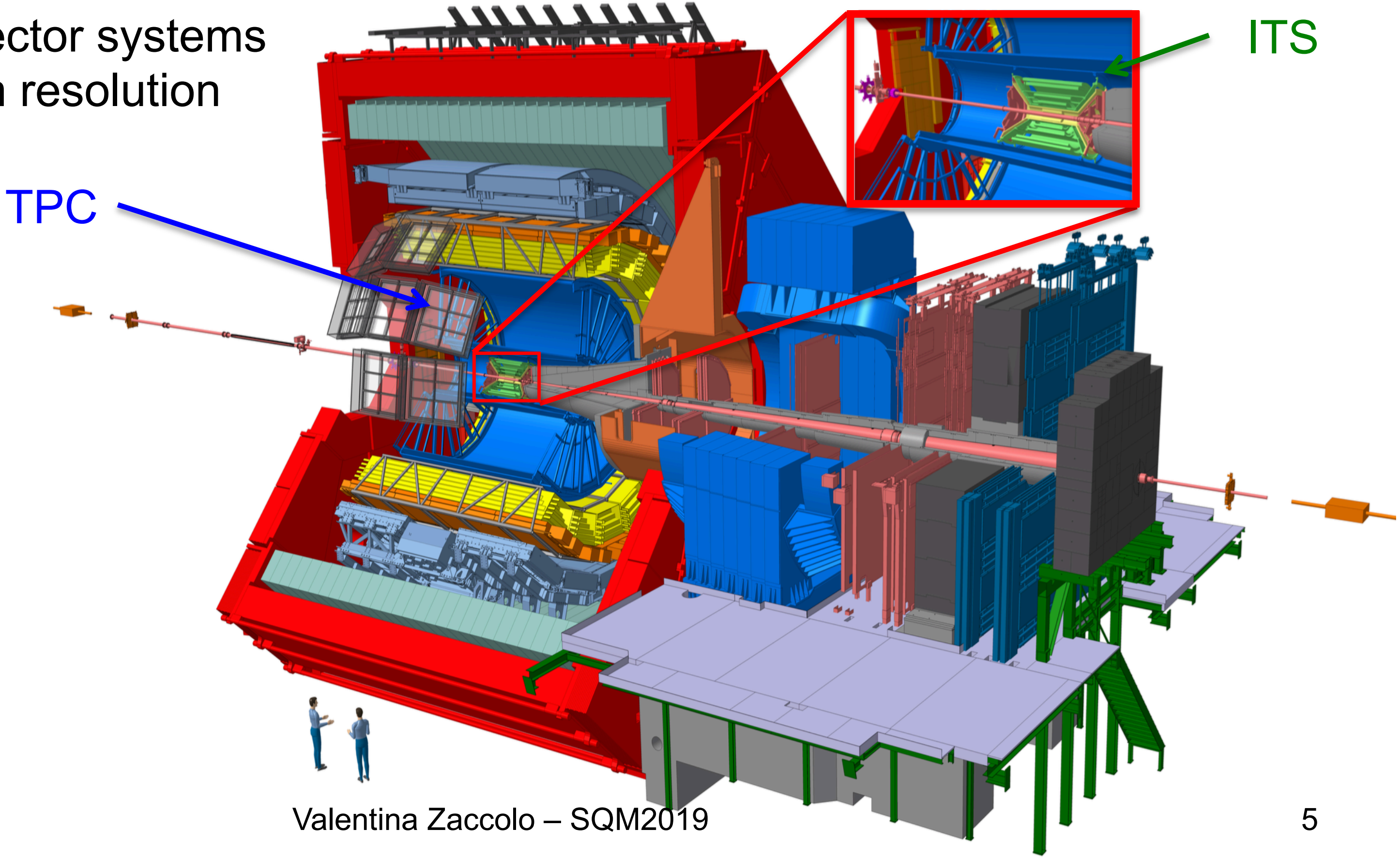

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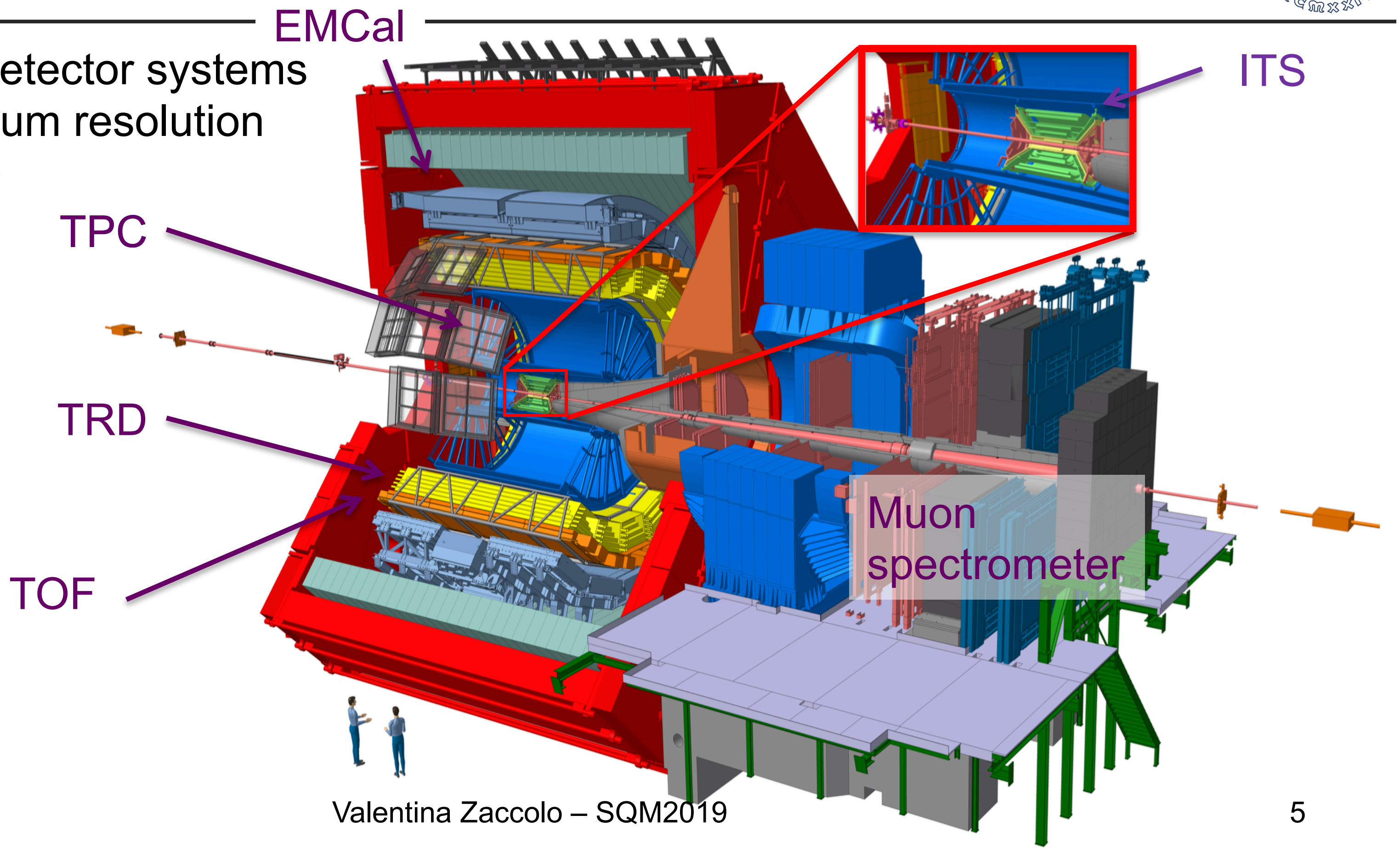


$\langle p_T \rangle$ vs multiplicity

Unfolding of p_T spectra

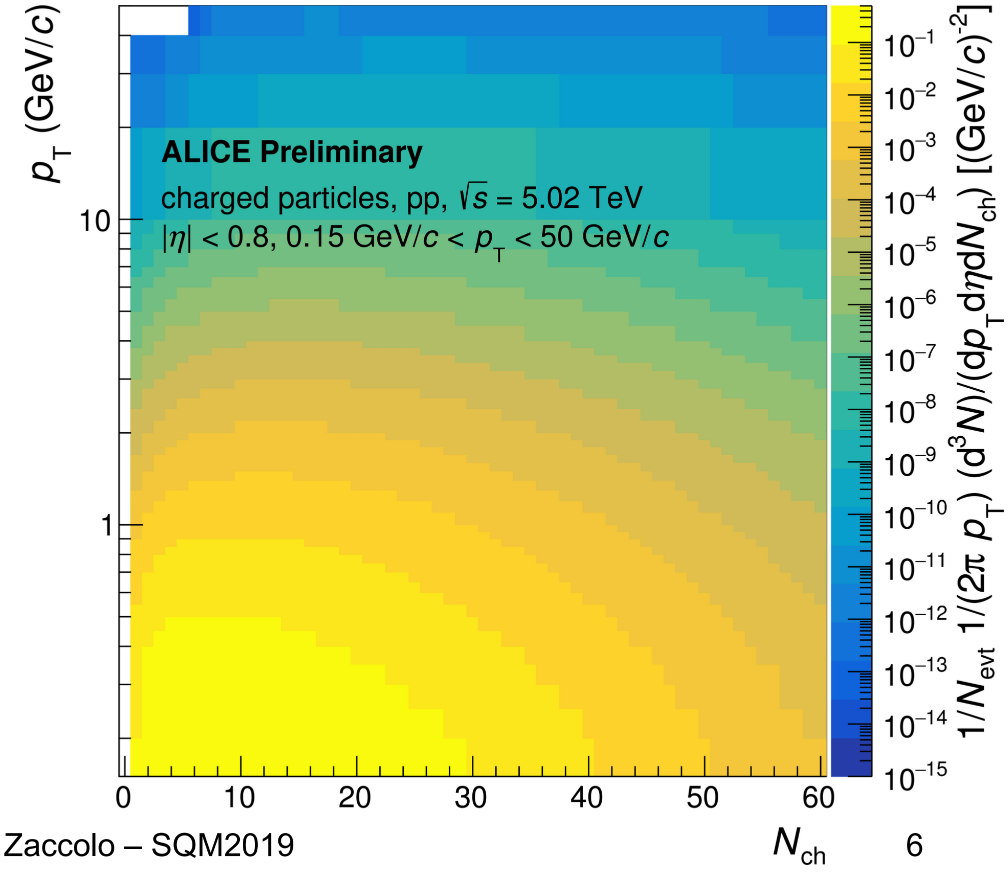
The correlation between N_{ch} and p_T is experimentally unknow (biased by acceptance and secondaries)

Unfolding of p_T spectra

The correlation between N_{ch} and p_T is experimentally unknow (biased by acceptance and secondaries)

- high resolution response matrix available from MC
- benefit from unfolding application from Bayes' theorem

Nucl.Instrum.Meth. A362 (1995) 487-498

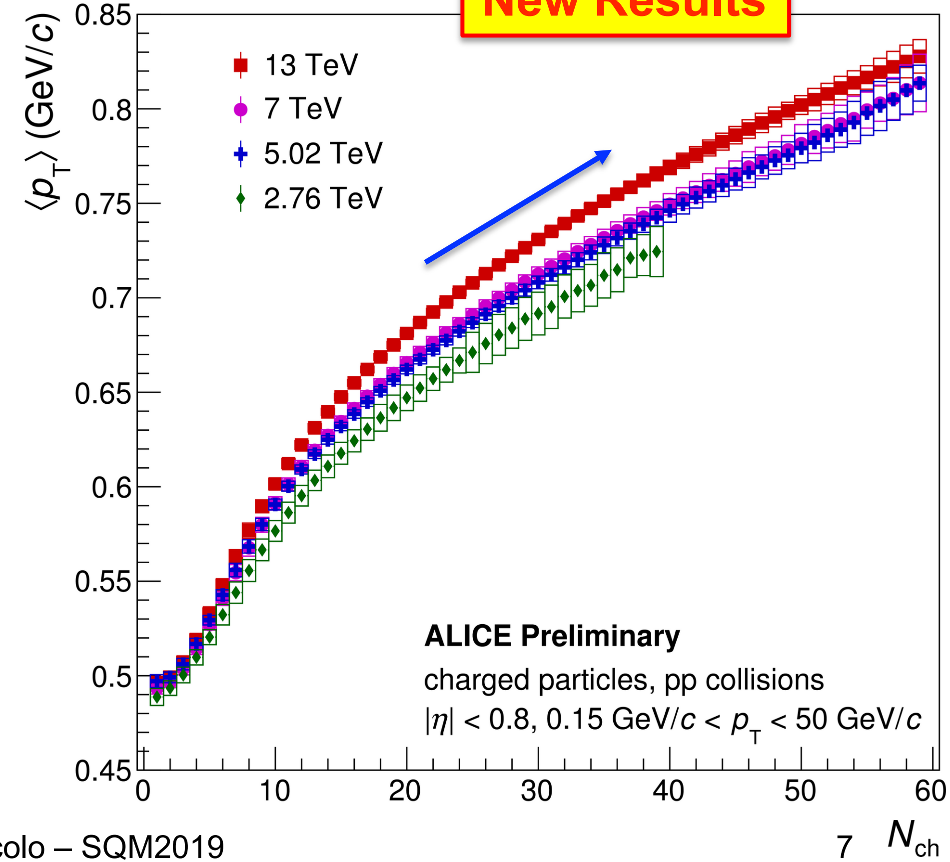


Energy and system–size dependence

Energy dependence of $<p_T>$ versus multiplicity in pp collisions

- $<p_T>$ increases with increasing multiplicity for higher energy

New Results



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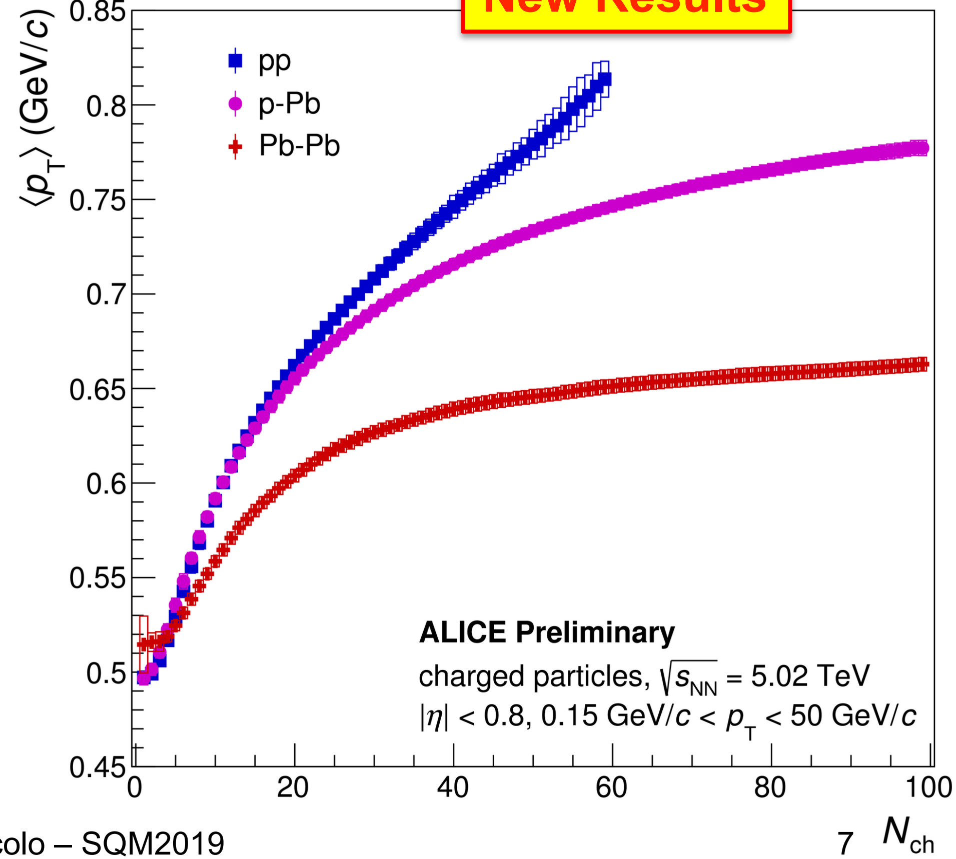
System-size dependence of <p_T> versus multiplicity results



Energy and system–size dependence

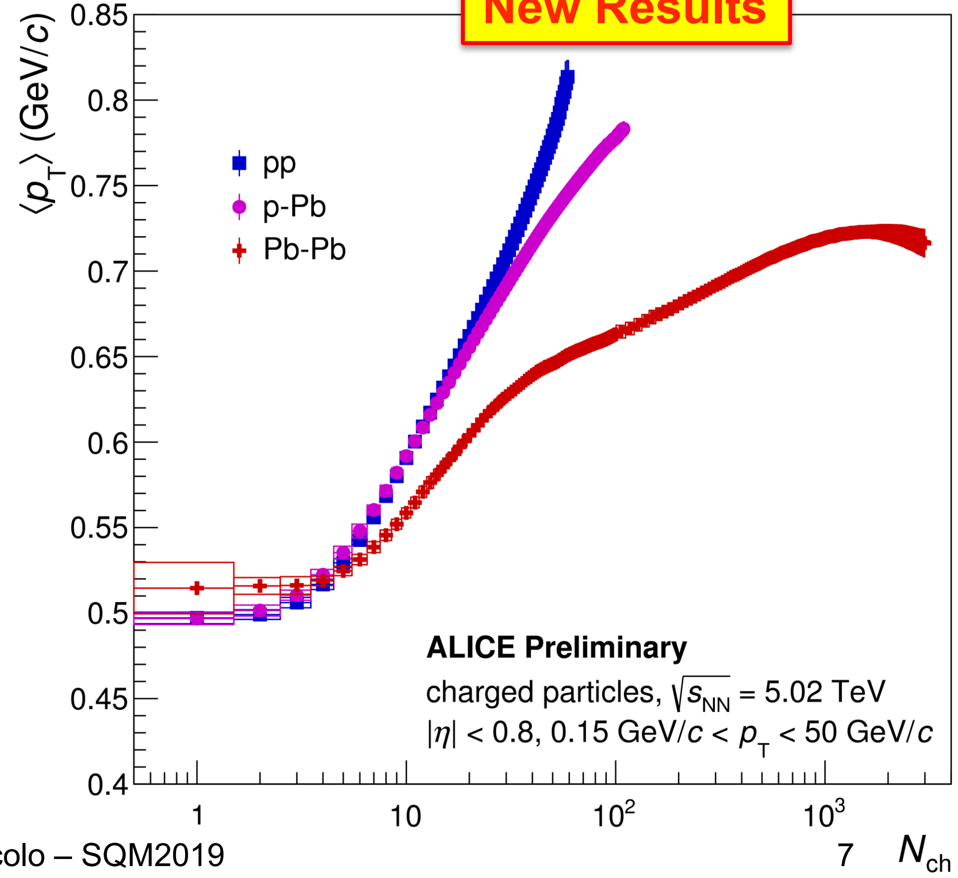
Energy dependence of <p_T> versus multiplicity in pp collisions

- <p_T> increases with increasing multiplicity for higher energy

System-size dependence of <p_T> versus multiplicity results

- possibility to reach higher N_{ch} to study the full shape thanks to unfolding

New Results



p_T spectra vs UE activity

A jet–free multiplicity estimator

What is R_T?

We look for a variable that

1. is not influenced by the initial hard parton scattering
2. can discriminate among soft and hard events

A jet–free multiplicity estimator

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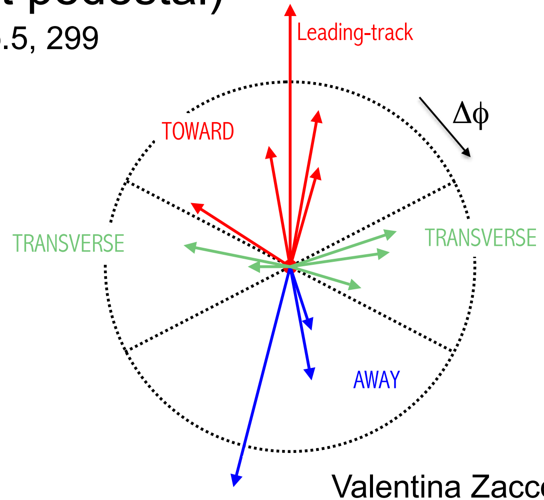
We look for a variable that

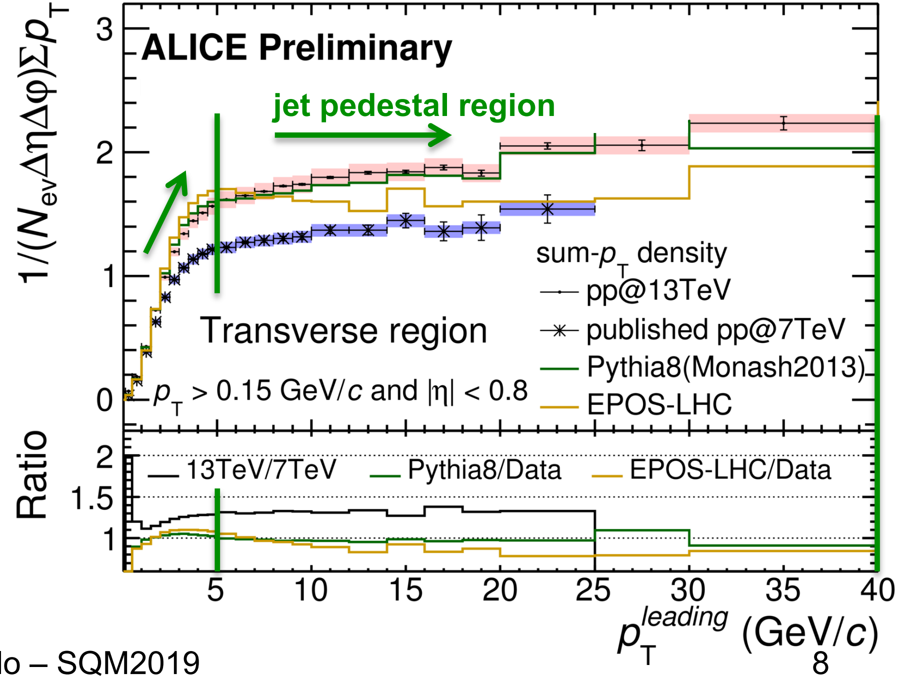
1. is not influenced by the initial hard parton scattering
2. can discriminate among soft and hard events

➢ define the relative transverse activity classifier R_T in the plateau region (jet pedestal)

Eur.Phys.J. C76 (2016) no.5, 299

$$R_T = \frac{N_{inclusive}}{\langle N_{inclusive} \rangle}$$





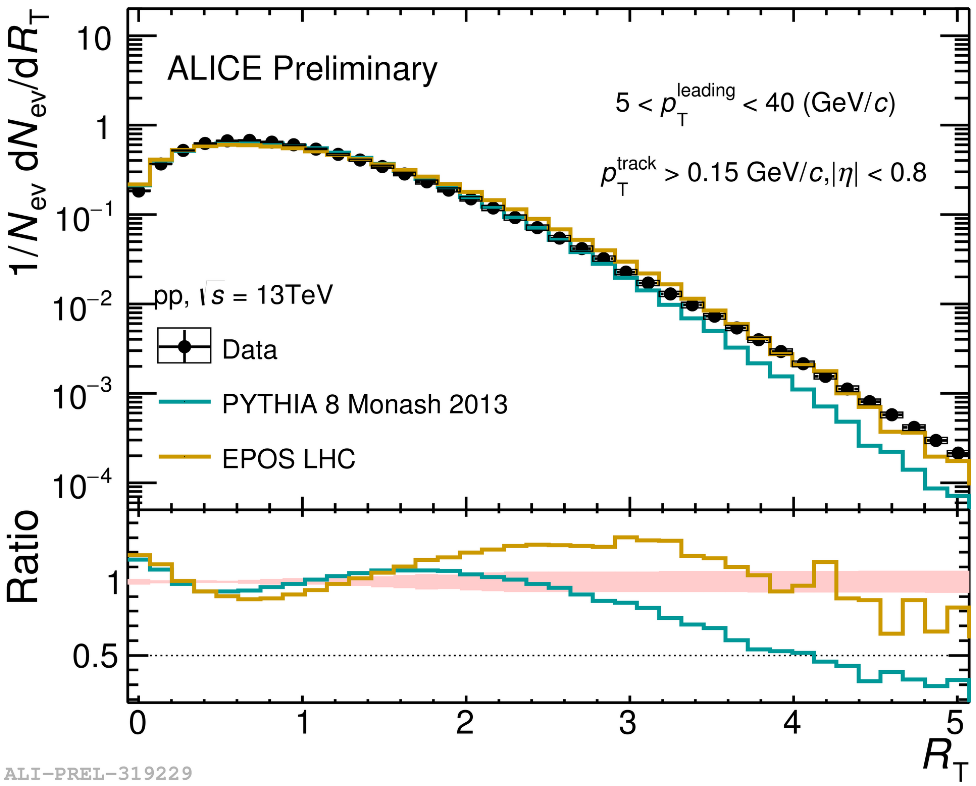
A jet–free multiplicity estimator

R_T distribution

New Results

Selection done in:

- transverse multiplicity
- plateau region $5 < p_T^{\text{leading}} < 40$ GeV/c



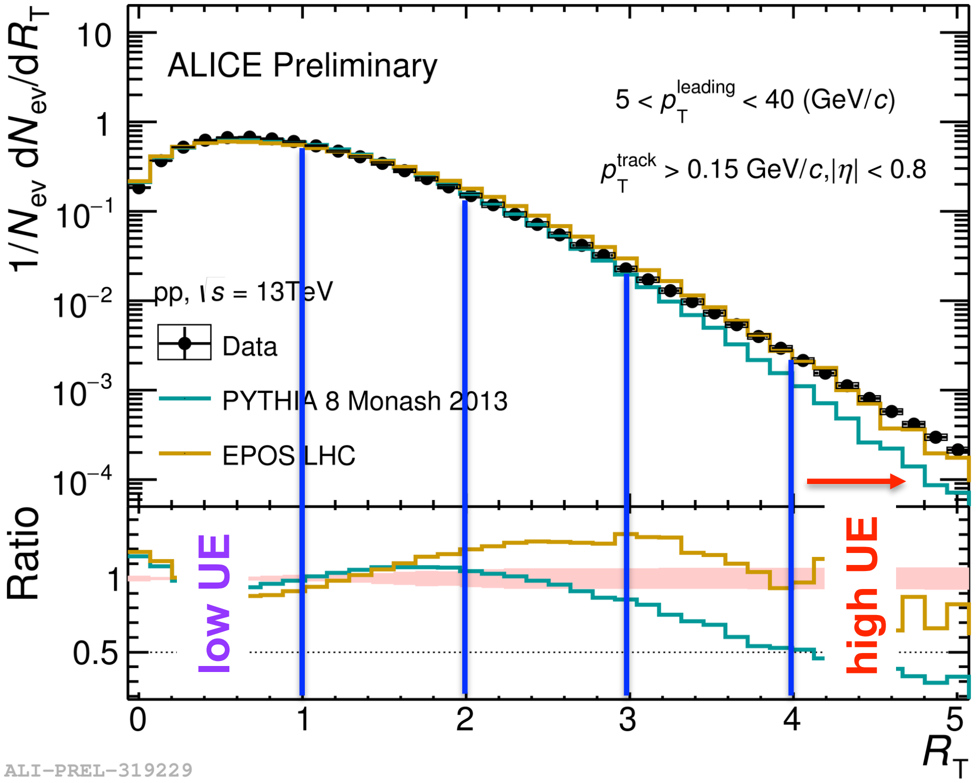
ALI-PREL-319229

A jet–free multiplicity estimator

R_T distribution

Selection done in:

- transverse multiplicity
- plateau region $5 < p_T^{leading} < 40$ GeV/c
- several R_T bins to allow to distinguish among low and high UE activity

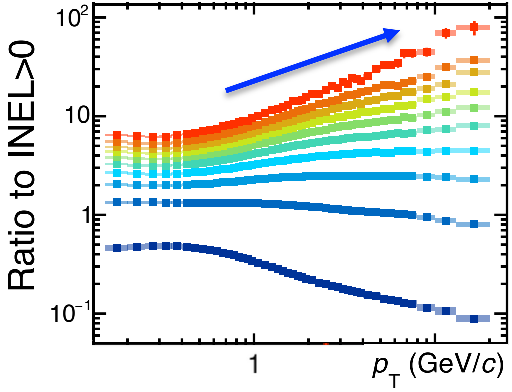


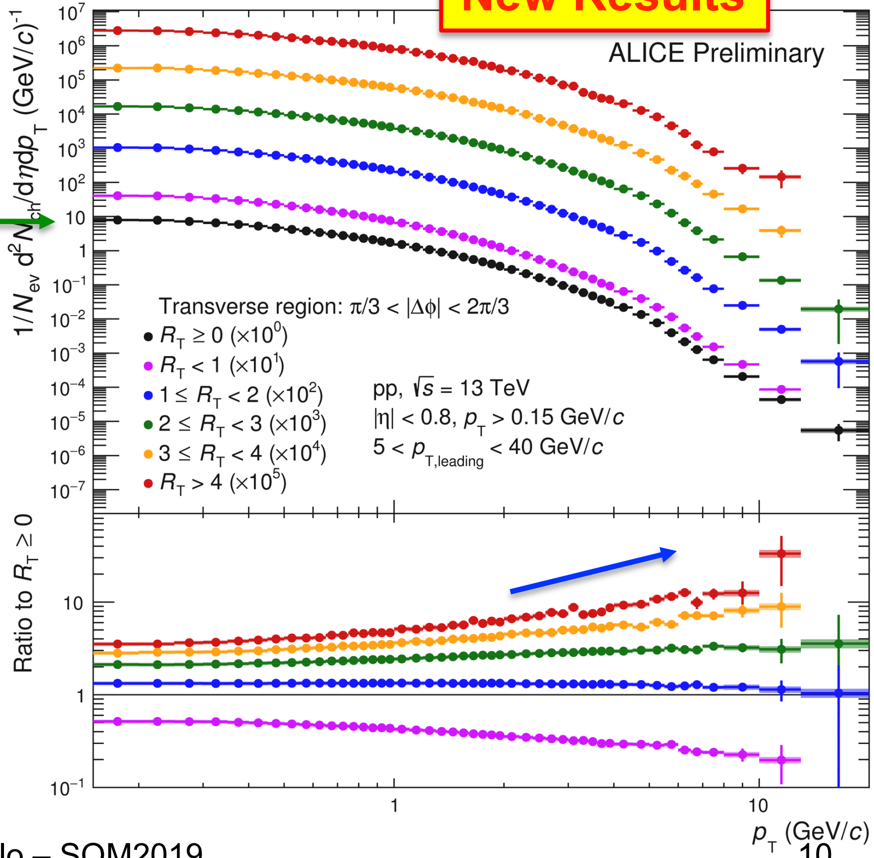
Transverse p_T distributions

New Results

Comparison to inclusive transverse spectra

- clear p_T hardening at high multiplicity in the transverse region → same trend observed for the midrapidity-based multiplicity estimator





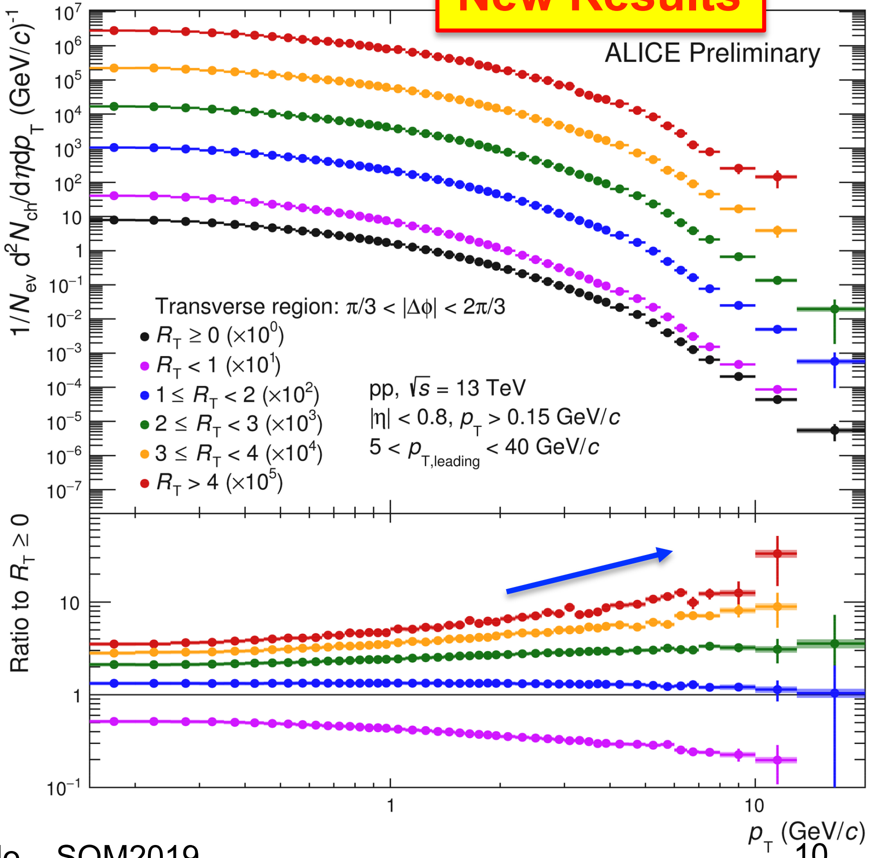
N.B.: The figure has been updated after the conference to account for a change in the normalisation factor of the R_T-integrated p_T spectrum for the transverse region

Transverse p_T distributions

Comparison to inclusive transverse spectra

- clear p_T hardening at high multiplicity in the transverse region → same trend observed for the midrapidity-based multiplicity estimator
- measurement (p_T) and selection (multiplicity) are done in the same pseudorapidity region

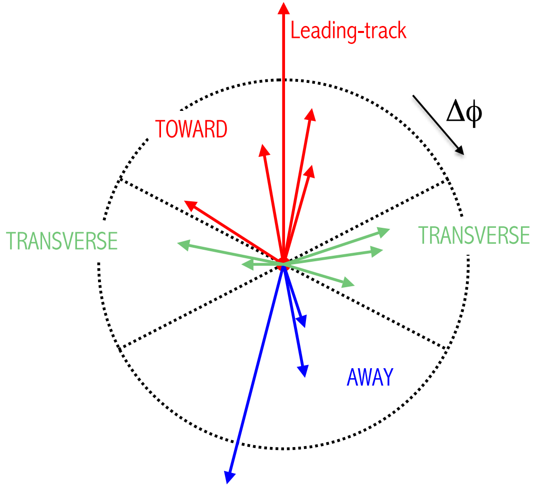
New Results

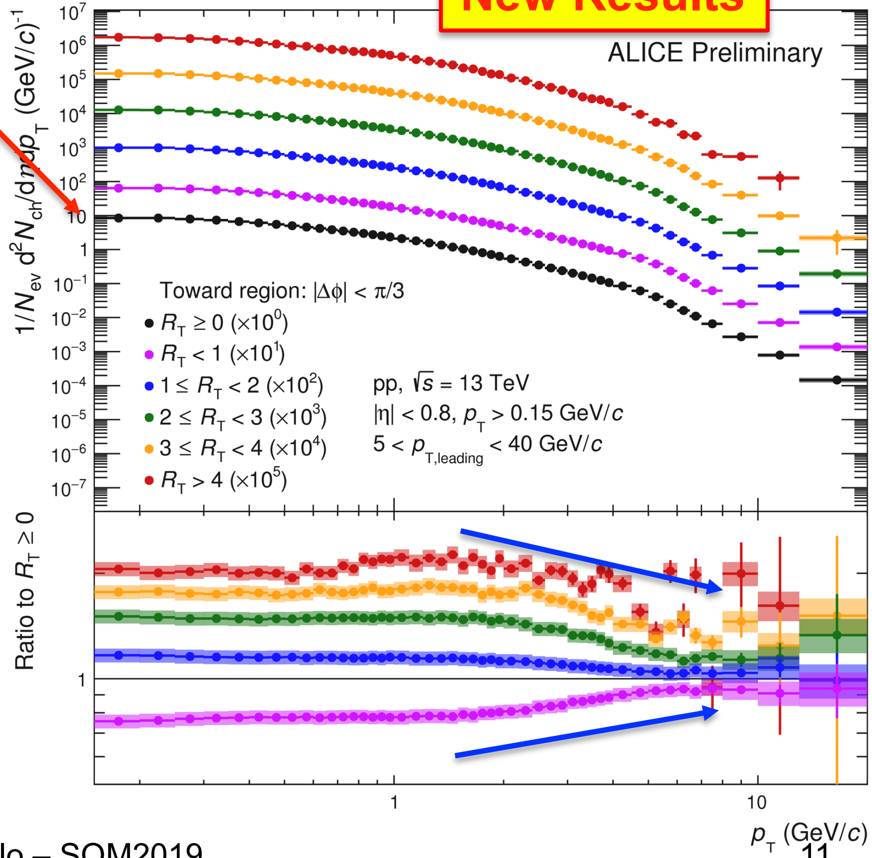


Toward p_T spectra distributions

Comparison to inclusive toward spectra

- If the multiplicity is determined in the transverse region, the spectra in the toward (jet) region clearly show the opposite trend





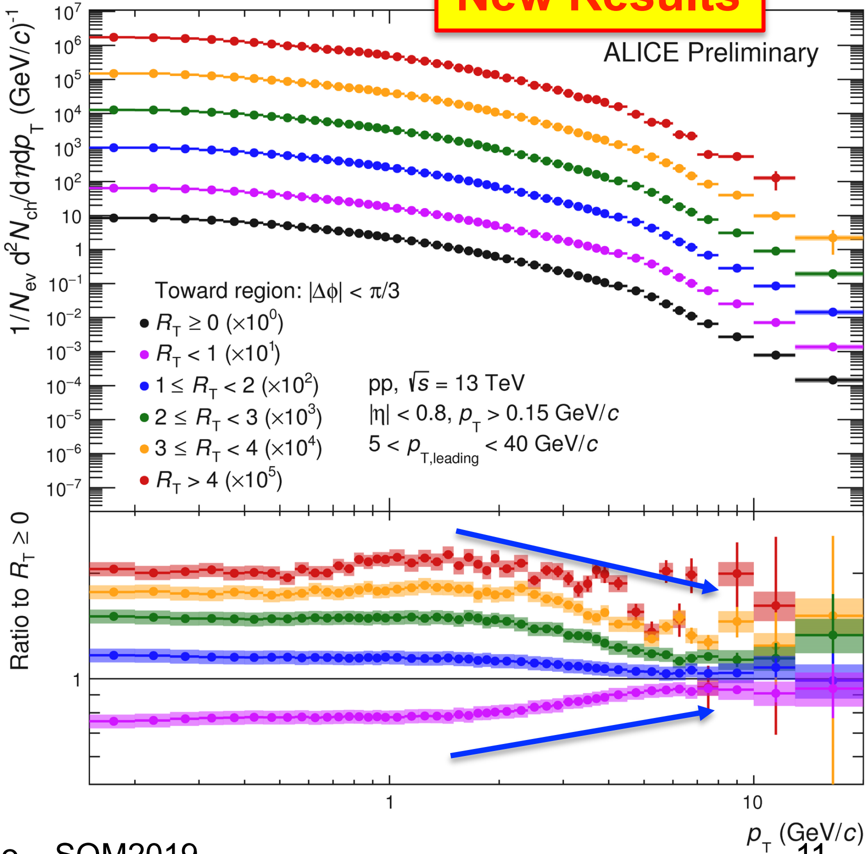
Toward p_T spectra distributions

New Results

Comparison to inclusive toward spectra

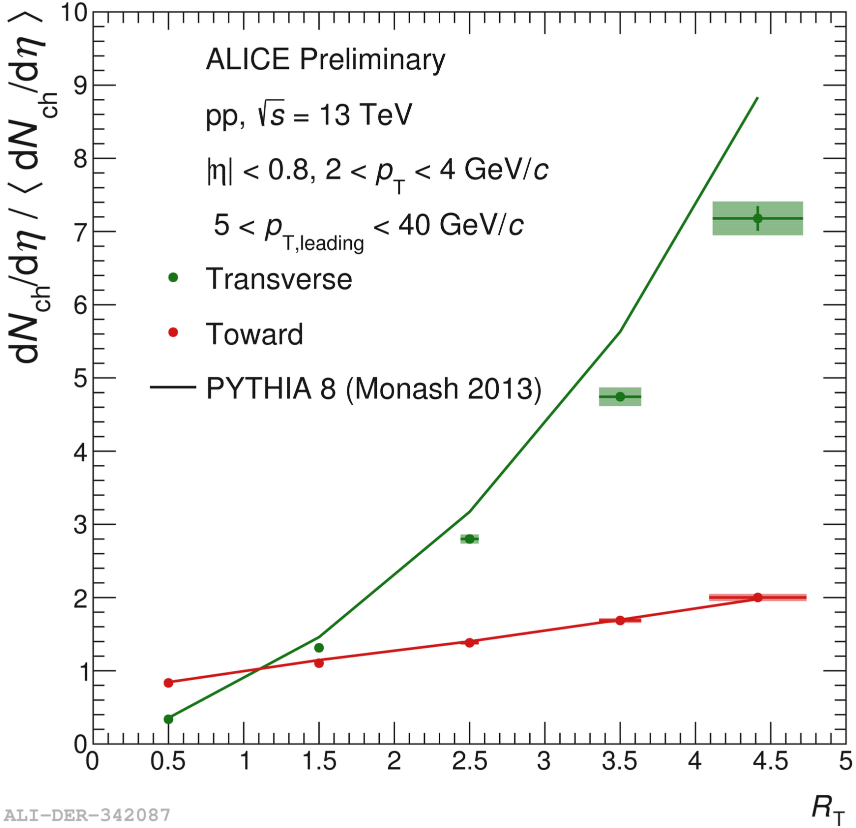
- If the multiplicity is determined in the transverse region, the spectra in the toward (jet) region clearly show the opposite trend

- we observe convergence to the jet:
  - complete separation among soft (UE) and hard (jet) part of the event at high p_T
  - correlation effects are significantly reduced



R_T dependence for transverse and toward

New Results



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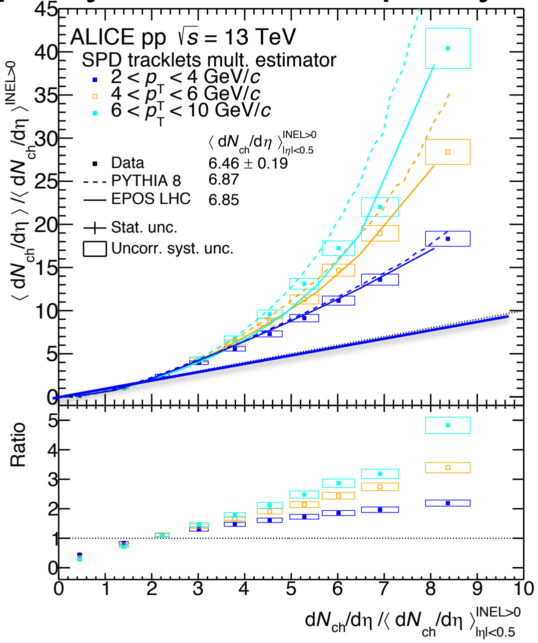
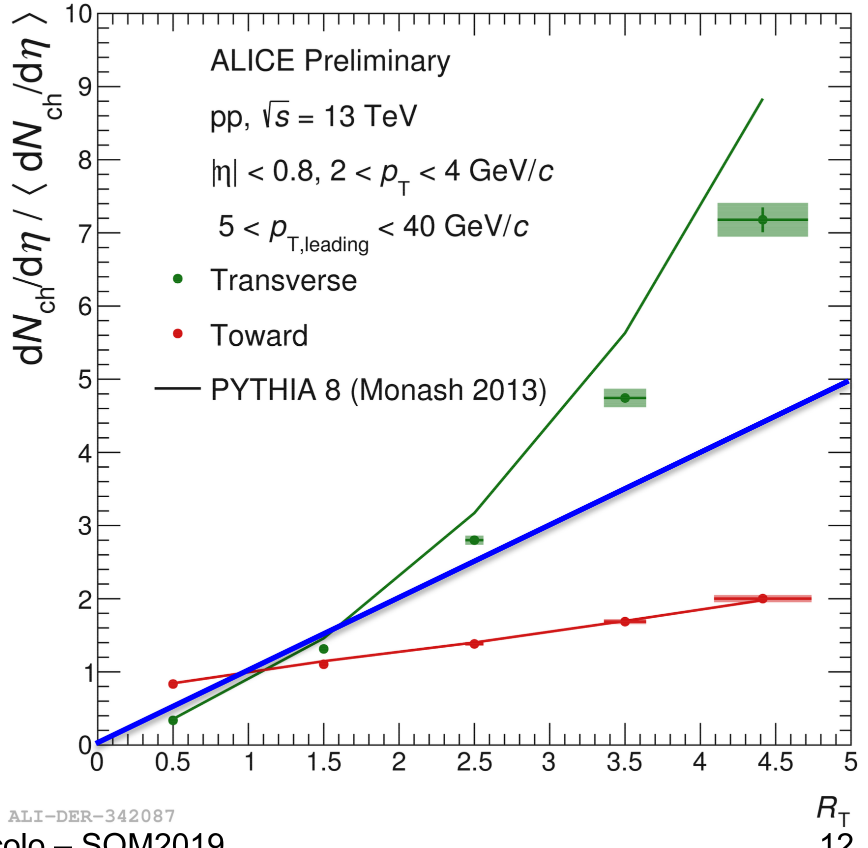
R_T dependence for transverse and toward

New Results

- yield in transverse vs R_T
  same behavior observed using the midrapidity–based multiplicity estimator



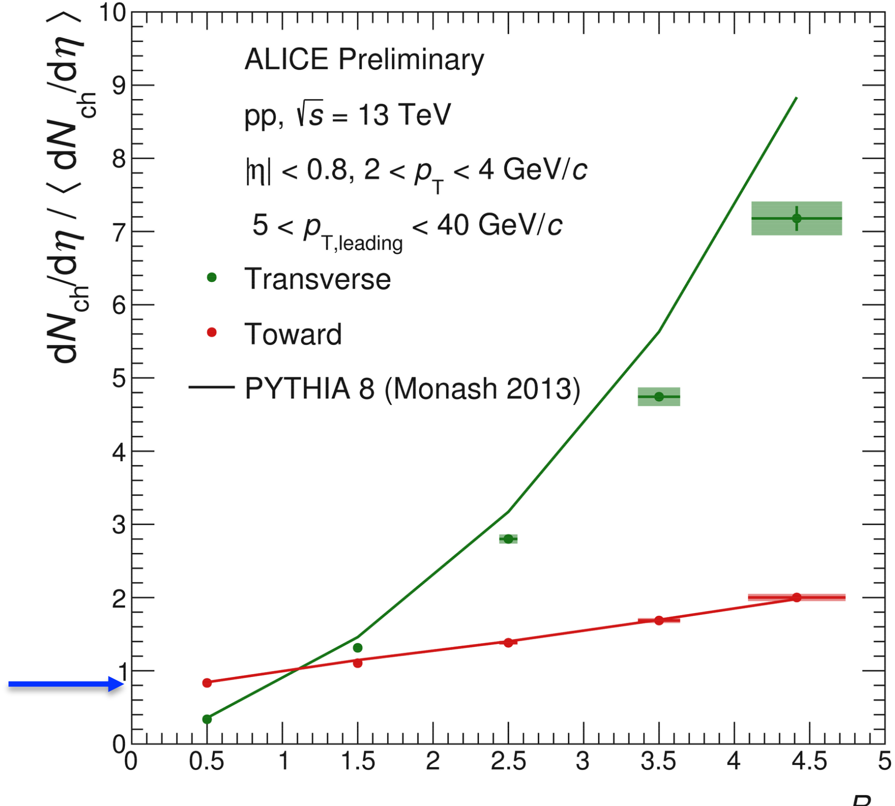


ALICE arXiv:1905.07208

R_T dependence for transverse and toward

New Results

- yield in toward vs R_T
  - does not converge to 0
    → at R_T = 0 we can have a jet
    → possibility to study hard object with almost no UE activity!



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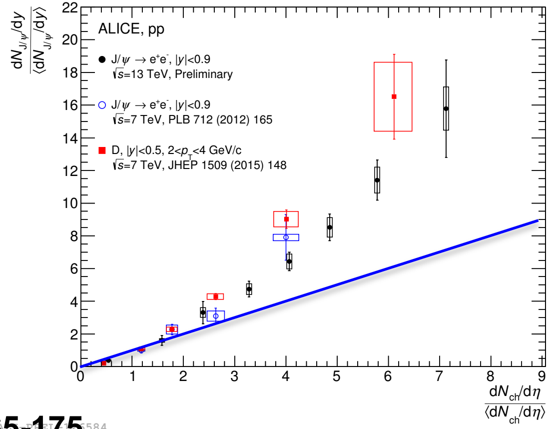
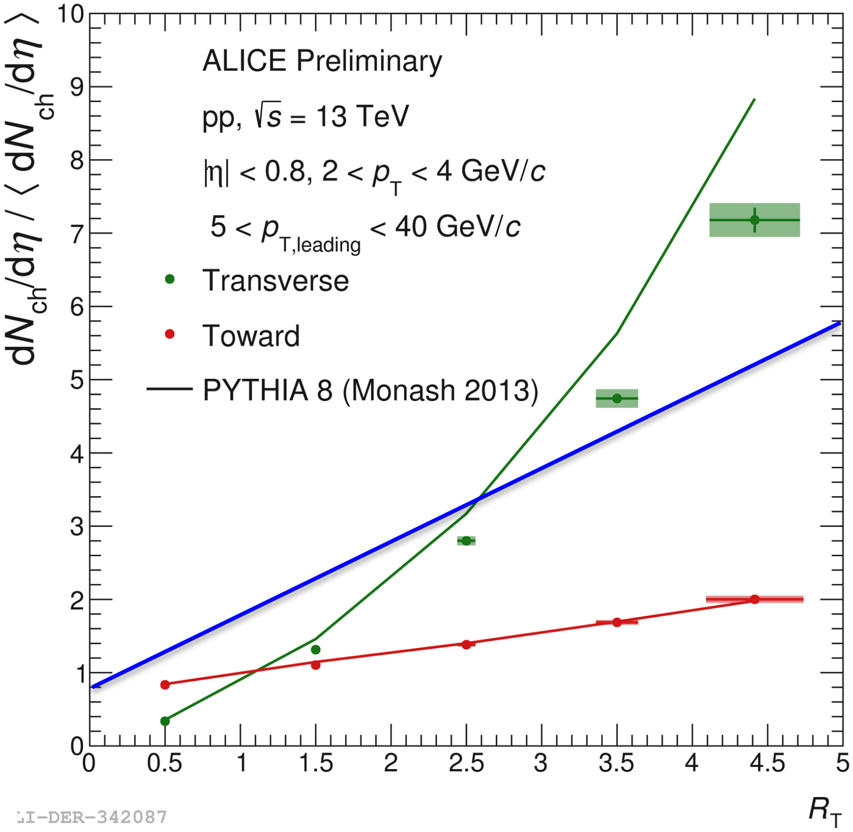
    → not the same as heavy flavours!





ALICE
Phys.Lett. B712 (2012) 165-175
JHEP 1509 (2015) 148

R_T dependence for transverse and toward

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- ➤ yield in toward vs R_T
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    → at R_T = 0 we can have a jet
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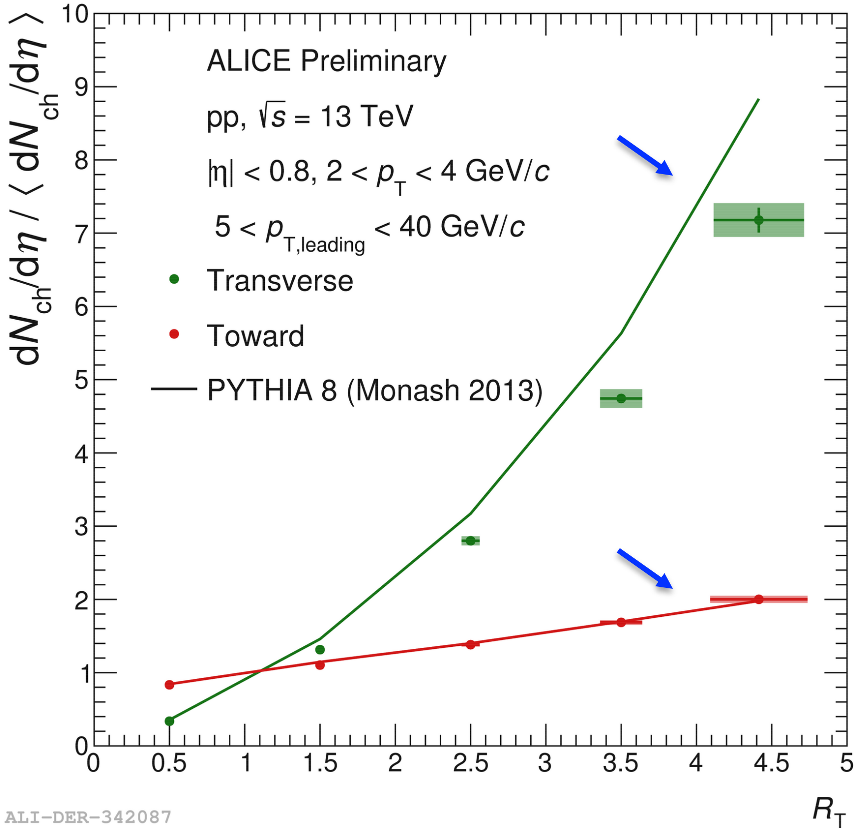
  - it is linear
    → not the same as heavy flavours!
  - PYTHIA 8.2 reproduces well the observed trends



Summary and outlook

- <p_T> vs multiplicity:
  - high resolution energy and system-size study capabilities due to unfolding
- Transverse p_T spectra:
  - hardening at high multiplicity → confirms the trend observed using the midrapidity multiplicity estimator
- Toward p_T spectra:
  - separation among soft (UE) and hard (jet) part of the event, at high p_T
  - no R_T saturation → no autocorrelation effects at play!
  - still possible to have a jet at ~ 0 UE activity
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R_T is an effective instrument
to disentangle jet and UE components of the spectra

→ *Promising for identified particle yields study, both for light and heavy flavours*

Backup slides