Multiplicity dependence of jet-like two-particle correlations in pp @ √s = 7 and 13 TeV with ALICE

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on behalf of the ALICE Collaboration

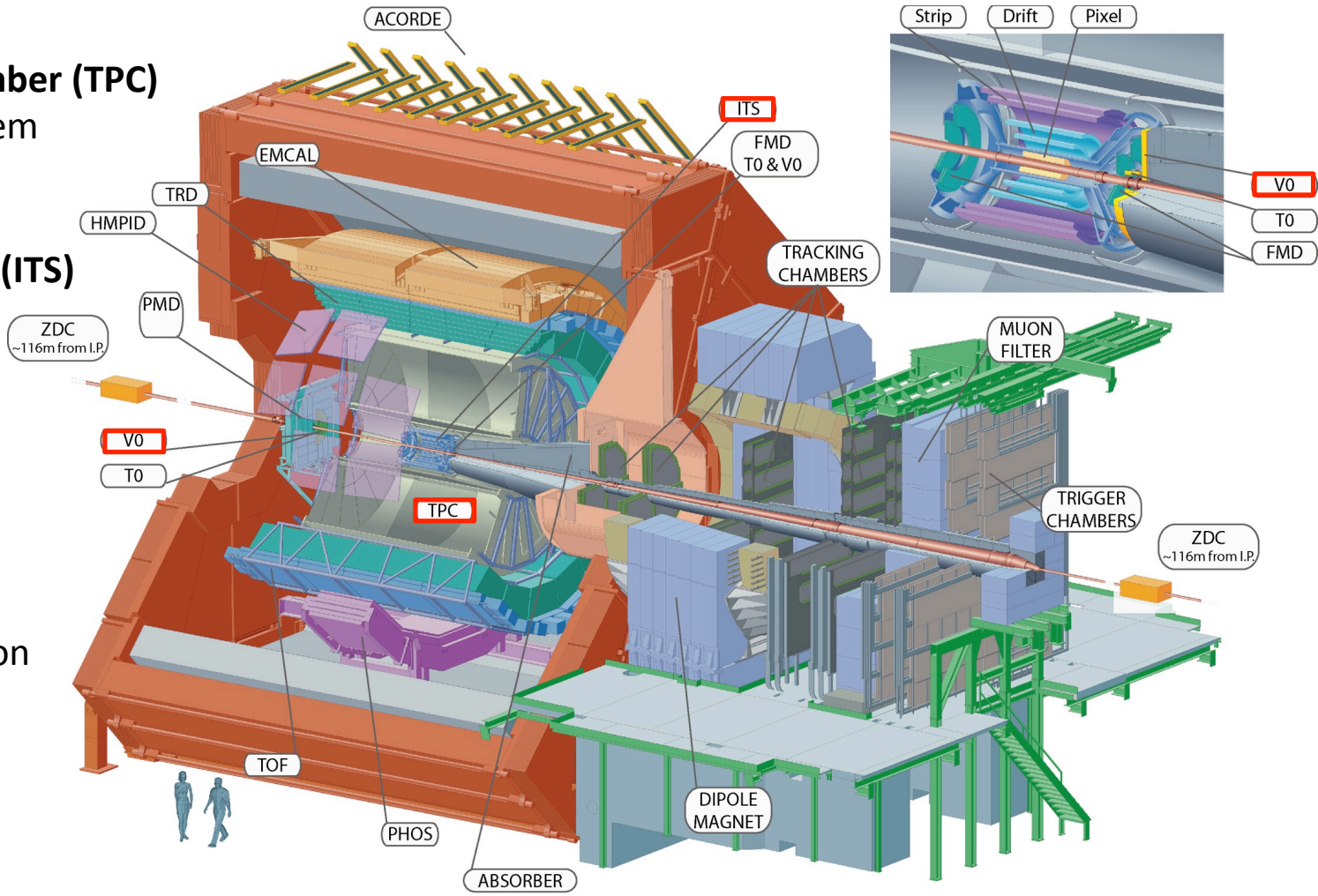
XXVI international conference on ultrarelativistic heavy-ion collisions
Quark Matter 2017
Chicago, USA, 7th February 2017

ALICE apparatus

Time Projection Chamber (TPC)
- ✓ main tracking system

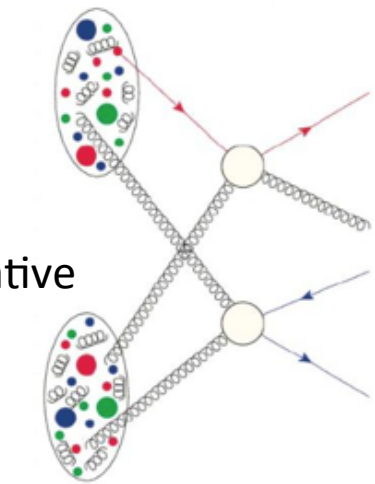
Inner Tracker System (ITS)
- ✓ trigger
- ✓ tracking at low p_T
- ✓ vertexing

V0
- ✓ trigger
- ✓ multiplicity selection



MPI and two-particle correlations in pp

- Particle production in high-energy pp collisions at the LHC is expected to have a substantial contribution from Multiple Parton Interactions (MPI).
- Cross-section for 2-->2 process exceeds total pp cross-section at perturbative scales.



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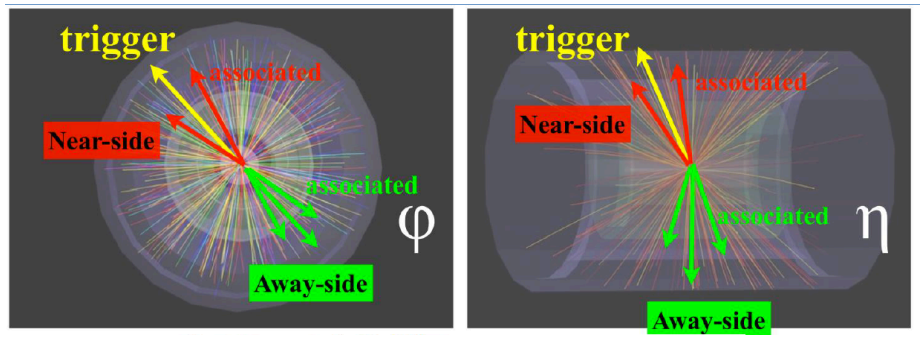
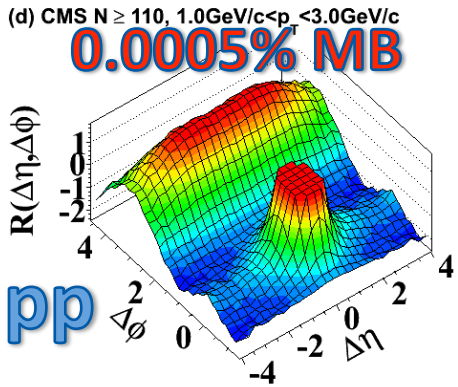


Away-side jet, $\Delta\varphi \approx \pi$ along $\Delta\eta$ (back-to-back jets)

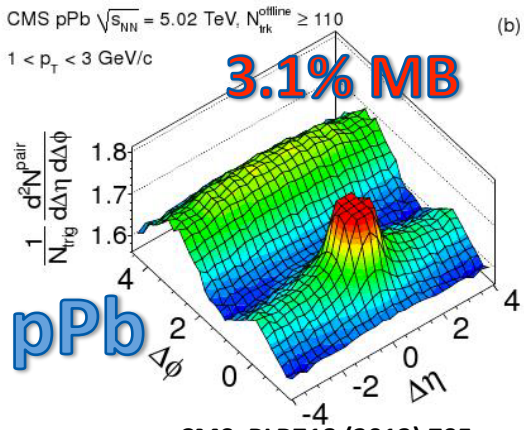
Near-side jet peak, $\Delta\eta \approx \Delta\varphi \approx 0$ (jet fragmentation)

- Pair yields provide information about parton fragmentation at low p_T, as well as the contribution of MPI to particle production.

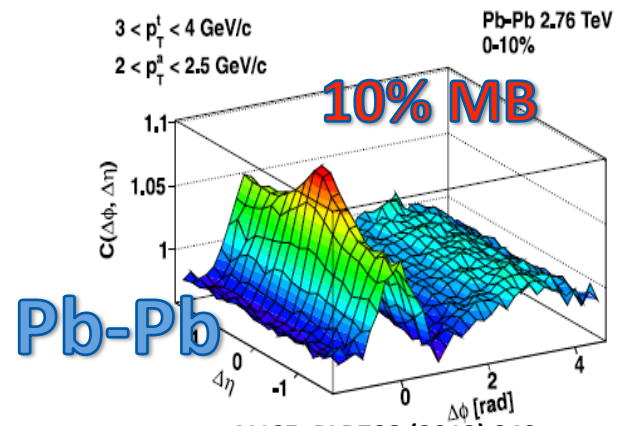
Near side ridge at high multiplicity



CMS, JHEP09 (2010) 091



CMS, PLB718 (2013) 795



ALICE, PLB708 (2012) 249

- ✧ Near-side ridge in small systems at high multiplicity similar to Pb-Pb (anisotropic flow).
- ✧ Origin of the ridge in small systems? (Incoherent) superposition of MPI? Collective effects?
- ➢ Multiplicity-dependent studies in pp collisions are needed.

- ➢ In this talk they will be addressed in the following three multiplicity-dependent analyses:

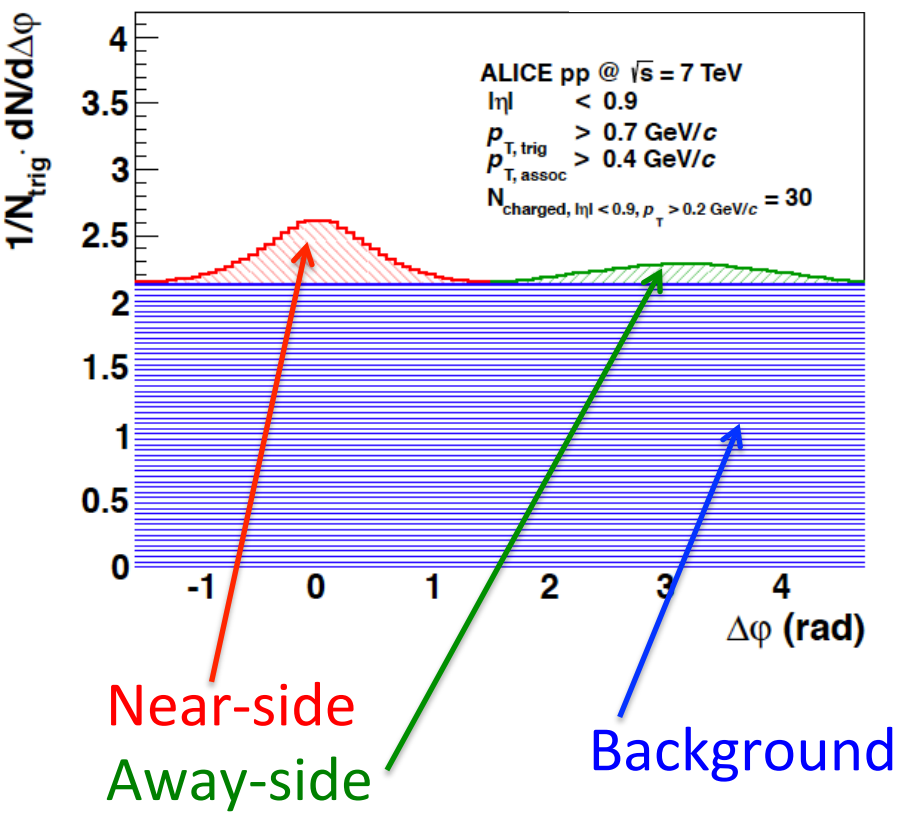
✓ **Minijets analysis in pp**

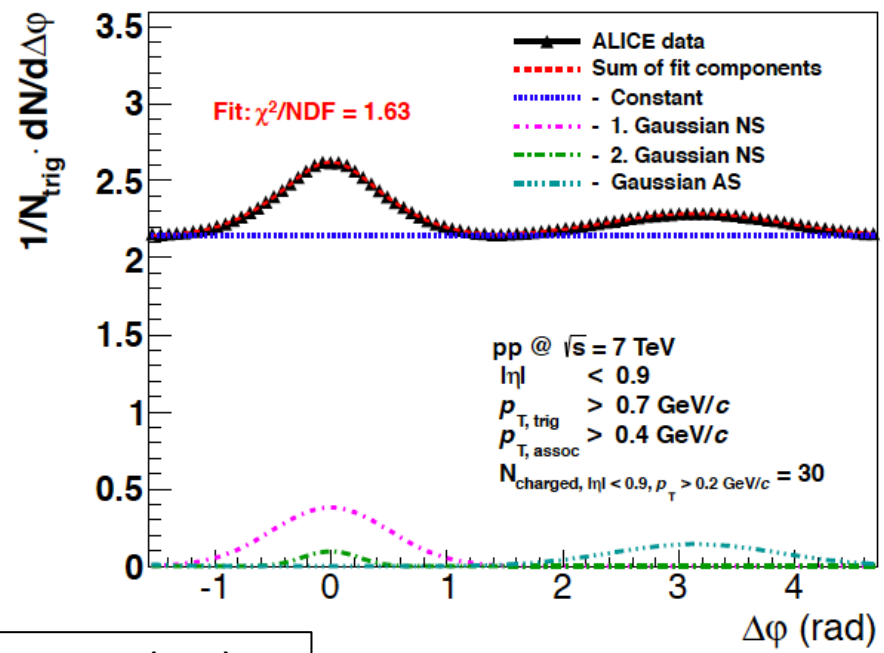
✓ **Near-side jet peak in pp**

✓ **Long-range correlations in pp**

Per-trigger pair yields extraction in 1-D

- Correlation function is constructed in 1-D (no corrections to 2-D correlation function).
- Pair-yield per trigger: $$\frac{dN}{d\Delta\varphi} = \frac{1}{N_{trig}} \frac{dN_{assoc}}{d\Delta\varphi}$$



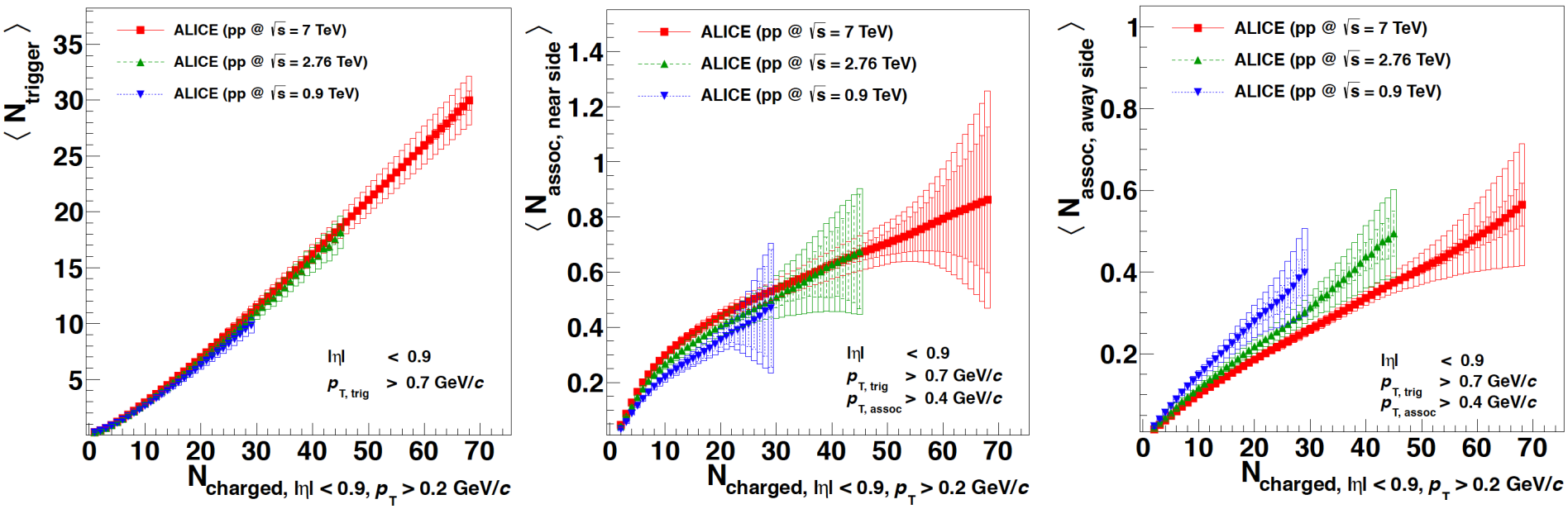


ALICE, JHEP 1309 (2013) 049

- Background is subtracted using ZYAM ("zero-yield-at-minimum") method.

Previous studies at lower energies

ALICE, JHEP 1309 (2013) 049



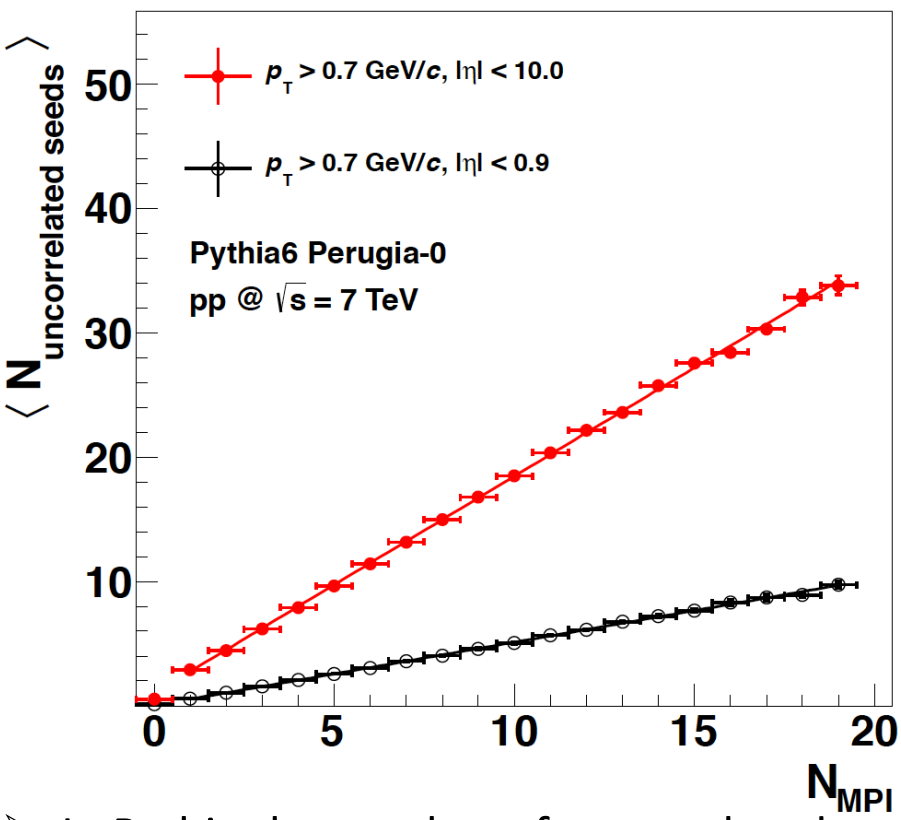
- Average number of triggers, near- and away-side yields increase with multiplicity.
  - ✓ Autocorrelations contribute to the strong increase in the yield.
- Away-side yield decreases with increasing energy.

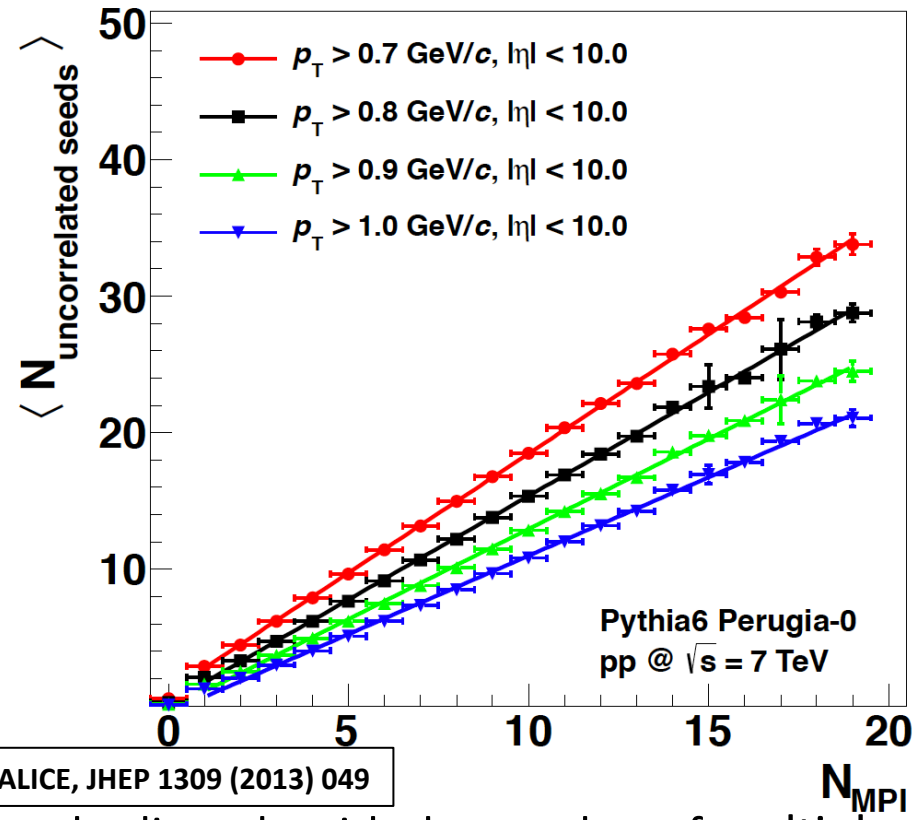
- The data is compared to PYTHIA6 (Perugia-2011) and PHOJET event generators:
  - ✓ PYTHIA6 calculations agree fairly well with the data for all the three observables.
  - ✓ PHOJET seems to disagree with the data both qualitatively and quantitatively.

Uncorrelated seeds and MPI

$$< N_{\text{uncorrelated seeds}} >= \frac{< N_{\text{trig}} >}{< N_{\text{correlated triggers}} >} = \frac{< N_{\text{trig}} >}{1 + < N_{\text{assoc,nearside}} > + < N_{\text{assoc,awayside}} >}$$

- number of independent particle sources, less sensitive to autocorrelations



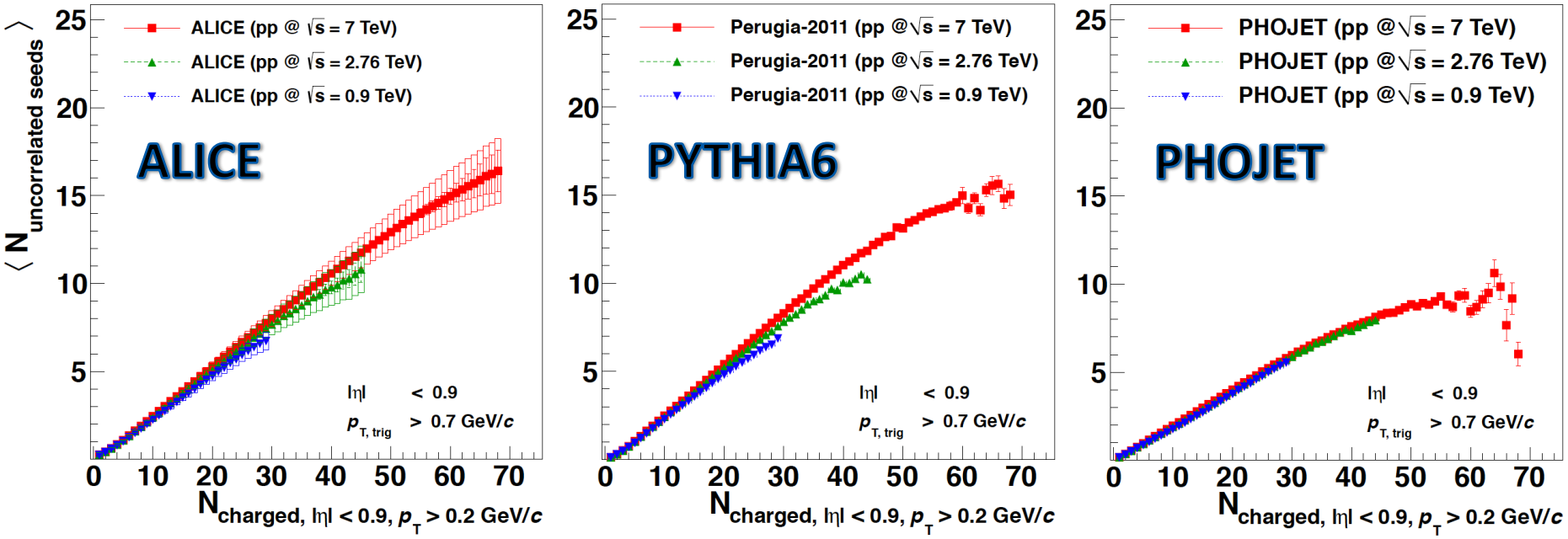


ALICE, JHEP 1309 (2013) 049

- In Pythia the number of uncorrelated seeds scales linearly with the number of multiple parton interactions (MPI).

Number of uncorrelated seeds

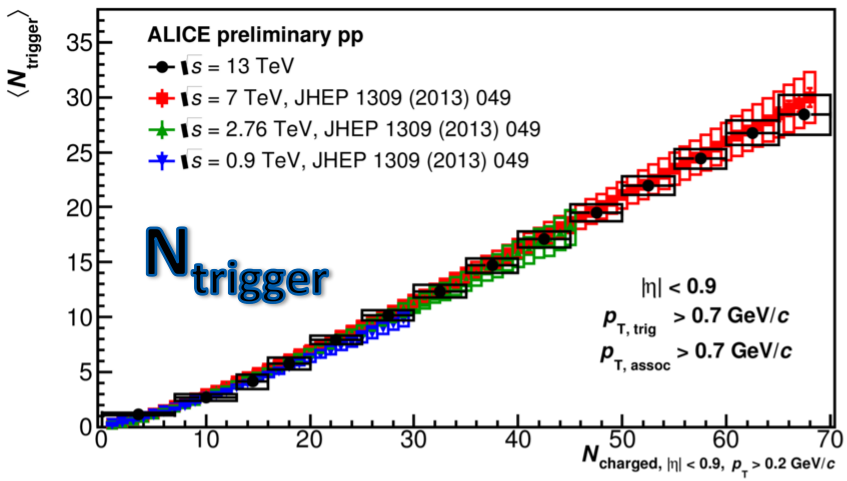
ALICE, JHEP 1309 (2013) 049

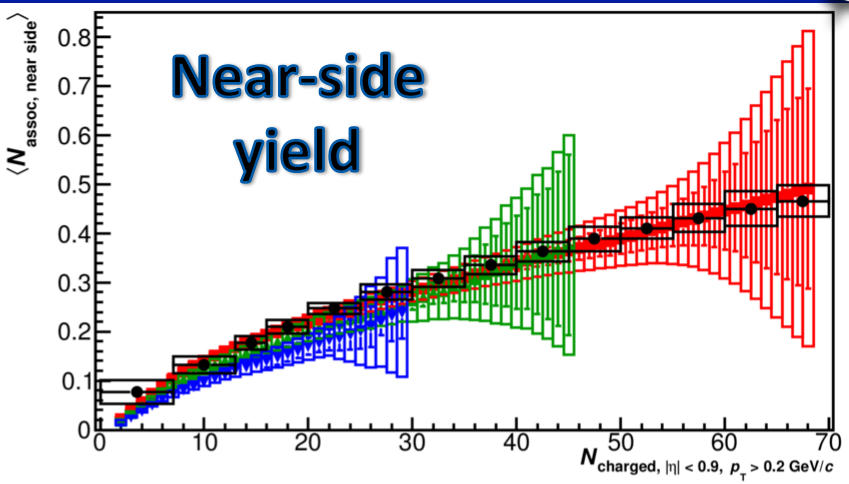


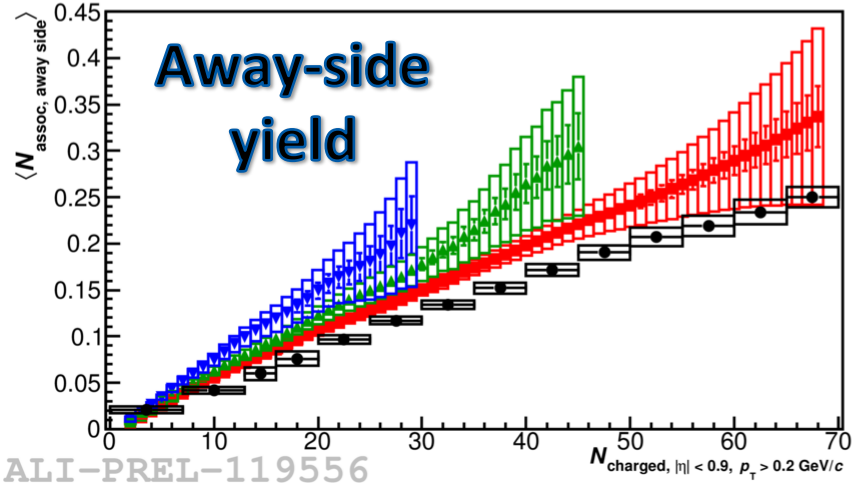
- Number of uncorrelated seeds increases with increasing multiplicity.
- At high multiplicities, hint of deviation from linear trend suggested at low multiplicities. -> a limit in MPI?

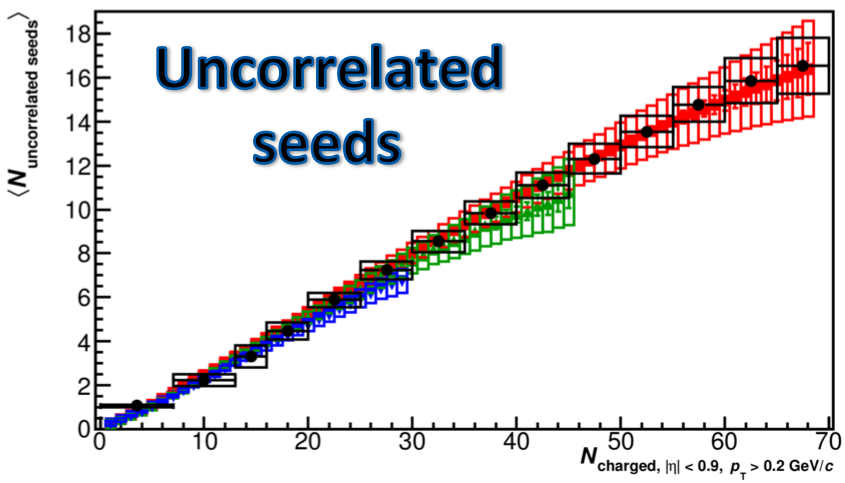
- PYTHIA calculations agree with the data at three energies quite well.
- PHOJET underestimates the data and shows similar shapes for all three energies.

Measurements in pp@13 TeV New





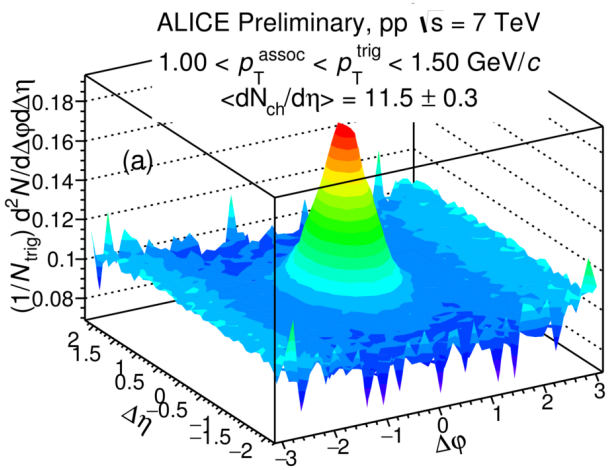




- New measurements are consistent with the previous energy-dependence studies.
- Larger statistics (+ high-multiplicity trigger) should give a higher reach in multiplicity.

Near-side jet peak extraction New

- In order to evaluate long-range correlations in small systems an understanding of short-range (mini-)jet-like structures is necessary.
- To reduce autocorrelations multiplicity is selected outside of the region where the correlations are measured.



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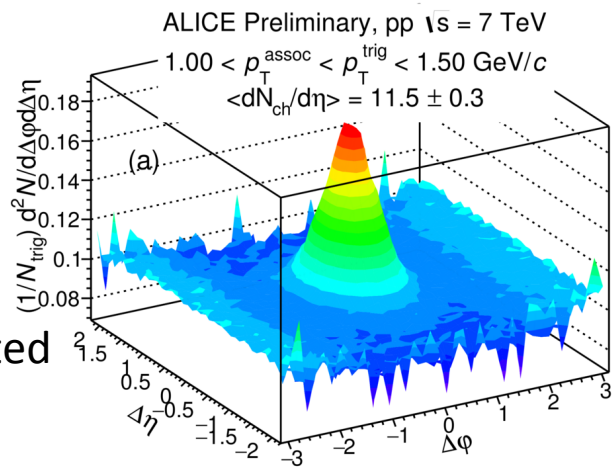
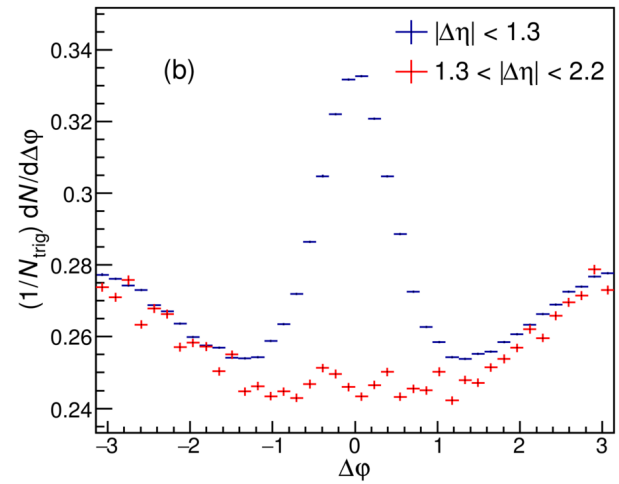
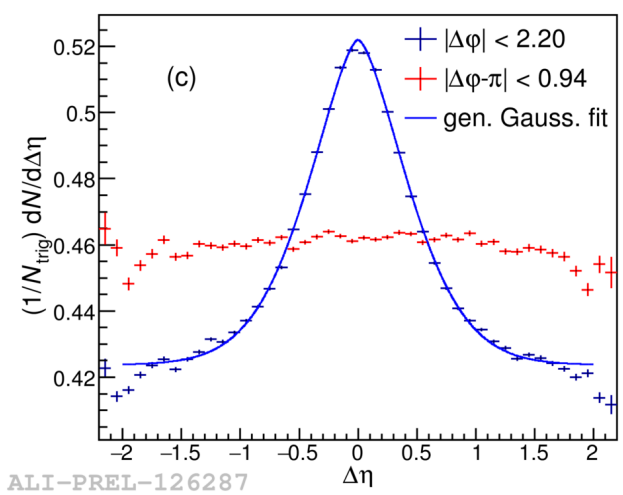




- Correlation function is projected onto Δη and onto Δφ.



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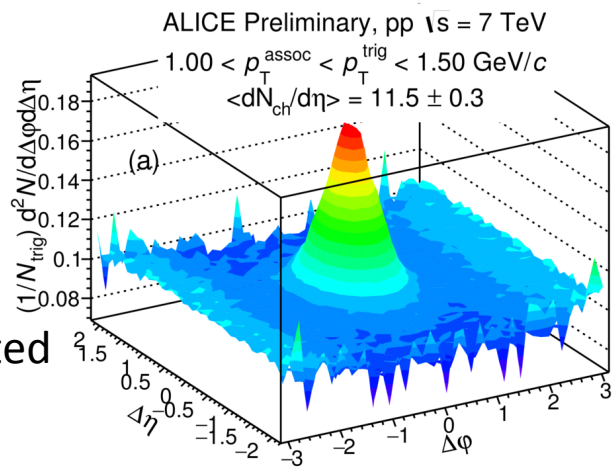
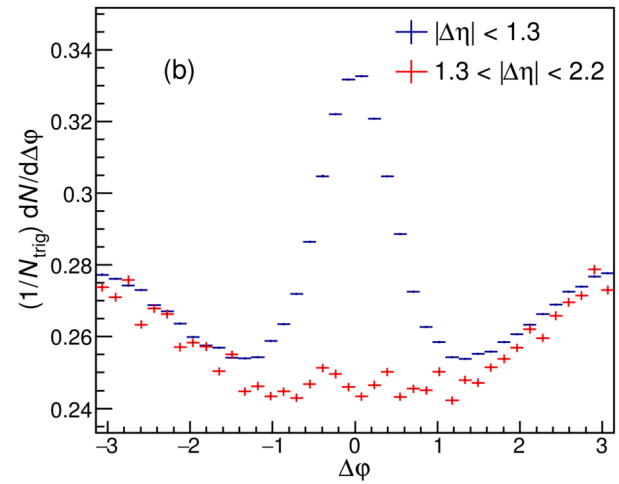


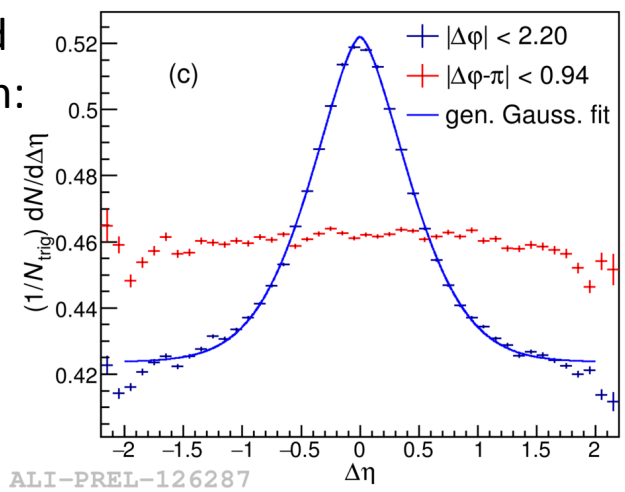


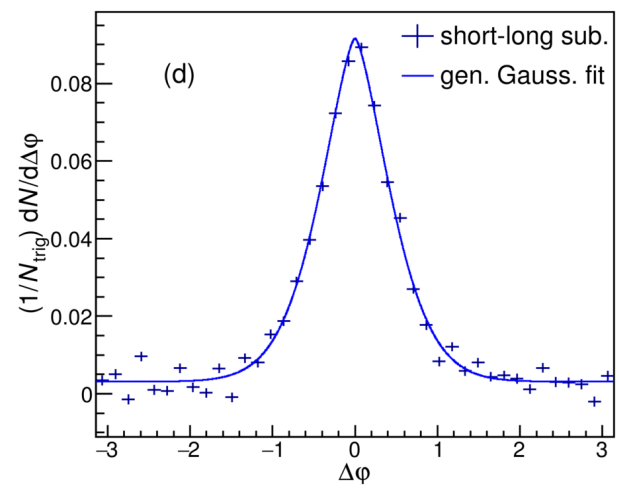
- Correlation function is projected onto Δη and onto Δφ.

- Near side peak is isolated and fitted by generalized Gaussian:

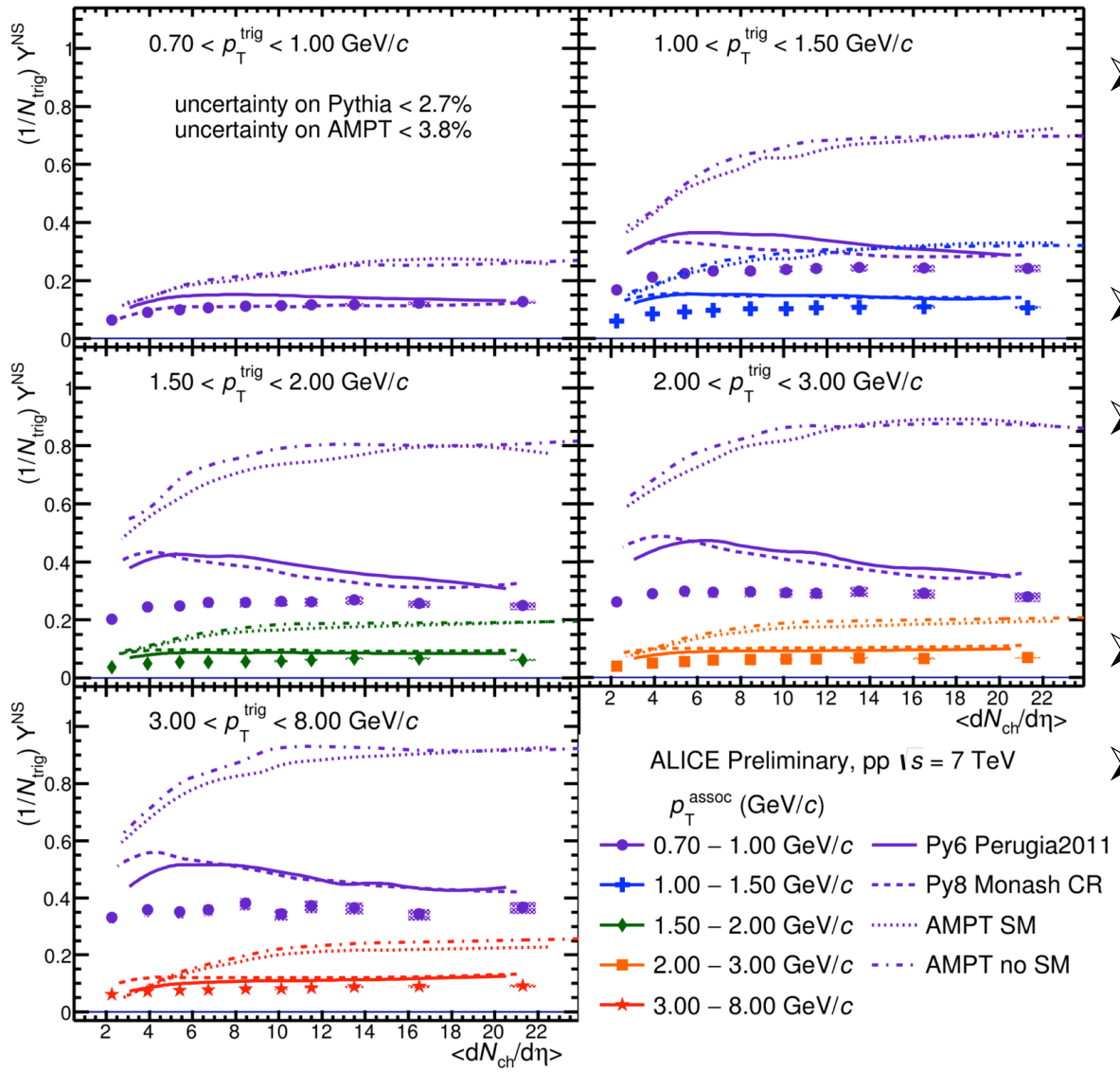
$$f_{GenGauss}(x) = \frac{Y\beta}{2\alpha\Gamma(1/\beta)} e^{-(|x|/\alpha)^{\beta}}$$

$$\sigma = \sqrt{\frac{\alpha^2\Gamma(3/\beta)}{\Gamma(1/\beta)}}$$ – "width"





Near-side yields in pp@7 TeV New



- Data show a multiplicity dependence of the yields, especially at low multiplicity.
- AMPT drastically overestimates the near-side jet peak yields.
- The yields in AMPT also show much stronger multiplicity dependence than in the data.
- PYTHIA8-Monash shows fair agreement with the data.
- PYTHIA8 model with color reconnection demonstrates a decreasing yield with multiplicity in some p_T bins, not observed in the data.

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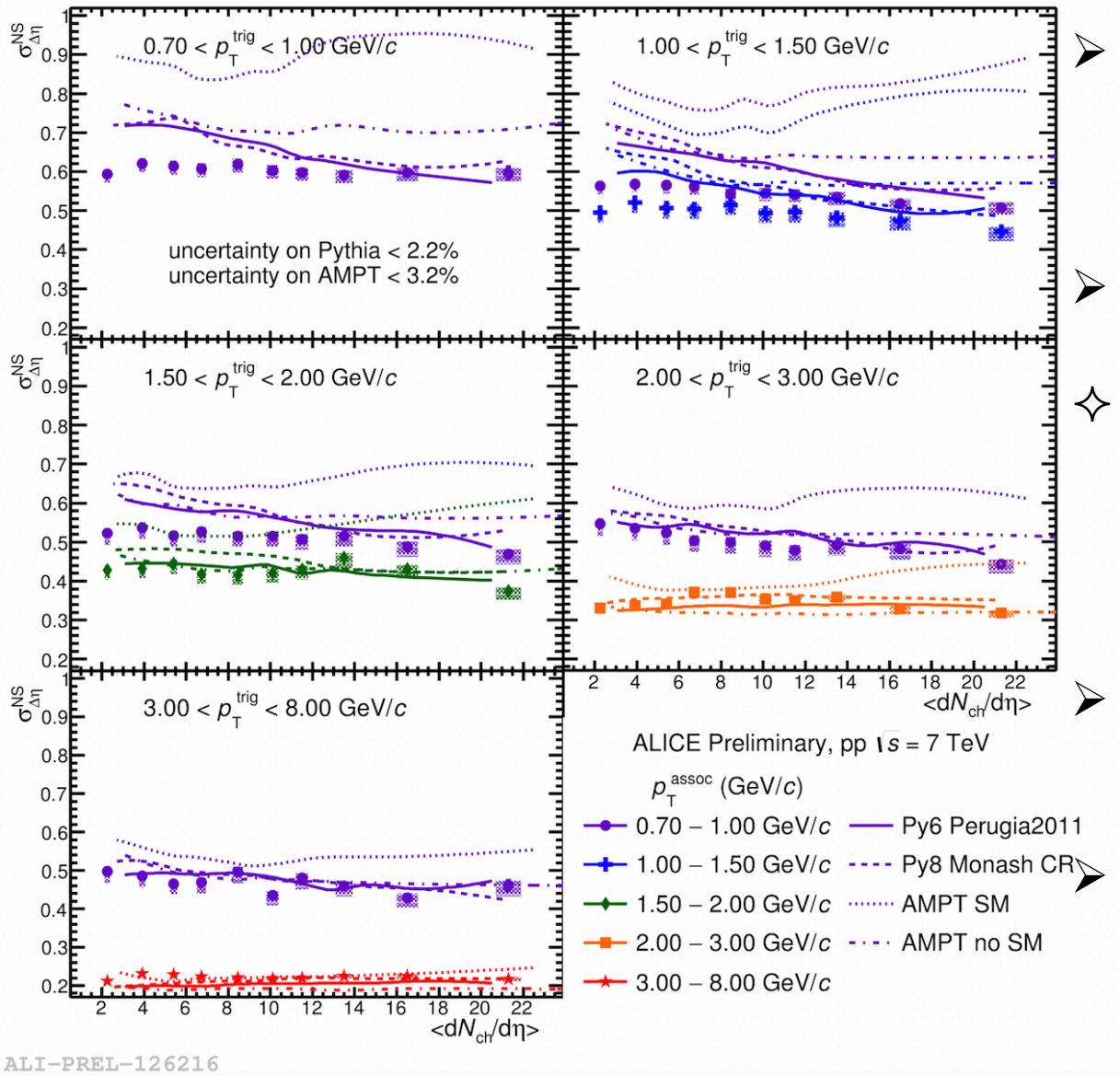
Near-side widths in Δη in pp@7 TeV New



- In general the data show little-to-no multiplicity dependence in the widths.
- The width varies from 0.2 to 0.6 depending on p_T range.
- It sets the scale for the Δη cuts that can be used to investigate long-range correlations in pseudorapidity.
- Models tend to overestimate the widths of the near-side jet peak at low p_T.
- At high p_T the models are either in agreement with or slightly below the data.

Long-range correlations in pp@7 TeV New

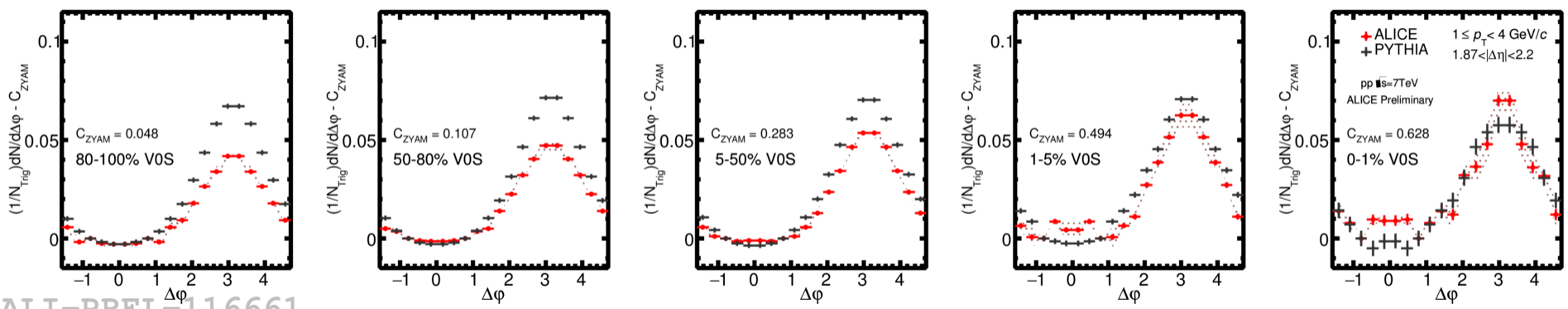
See poster by J.Bhom (#K06)

- ALICE also measured long-range correlations (1.87<|Δη|<2.2) in pp@7 TeV as a function of multiplicity.

- The background is subtracted using a ZYAM-like method: the yield is considered zero at $\Delta\varphi = 0.8$.

- The near-side and away-side yields are evaluated in the following $\Delta\varphi$ ranges:

$$|\Delta\varphi| < 0.8 \qquad \text{and} \qquad 2.4 < |\Delta\varphi| < 3.9$$



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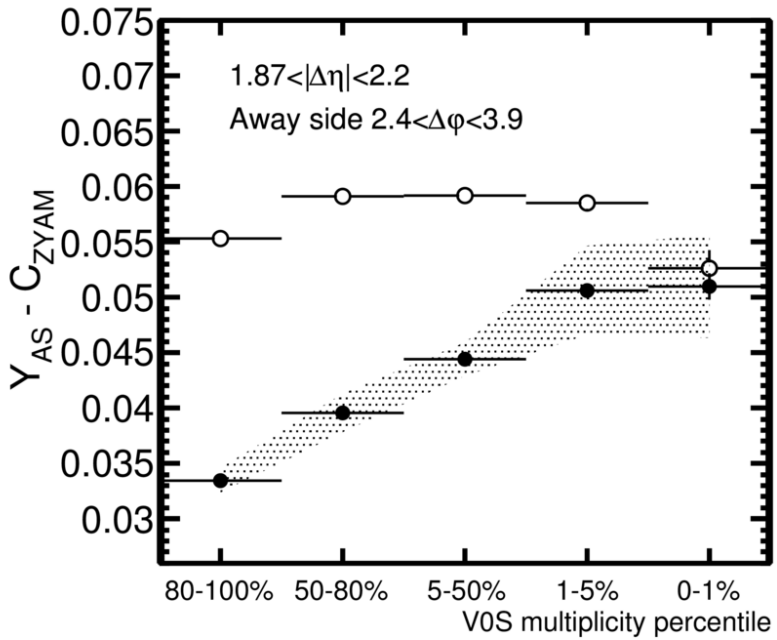
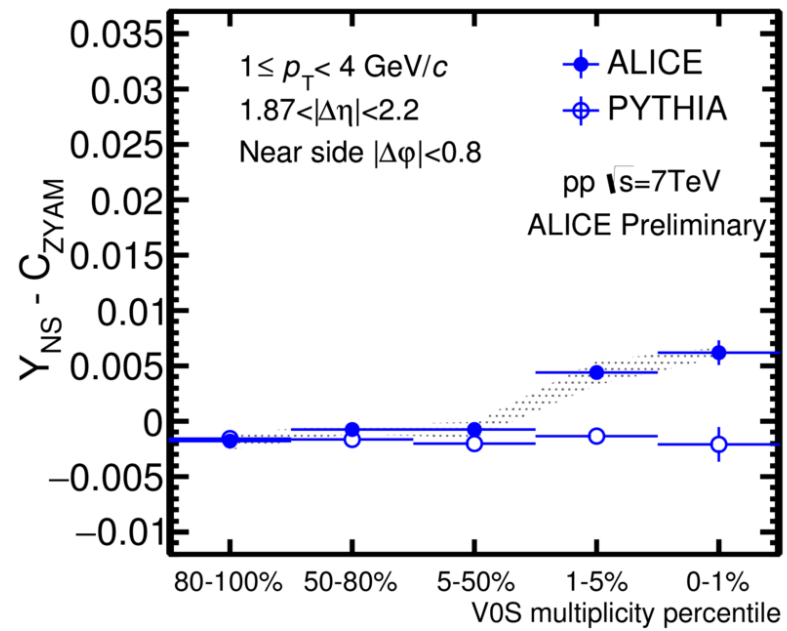
Long-range correlations in pp@7 TeV New

See poster by J.Bhom (#K06)





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- Data show a strong multiplicity dependence of the away-side yield but smaller dependence of the near-side yield.
- An enhancement of the long-range yield on the near side is seen in the data at high multiplicity which is not reproduced by PYTHIA.
- Away-side yield is also not described by PYTHIA calculations.

Summary

- MPI measurements in pp from 0.9 to 13 TeV:
  - ✓ Away-side yield demonstrates strong energy dependence.
  - ✓ Number of uncorrelated seeds: hint of non-linear dependence for high multiplicities -> limit in MPI?

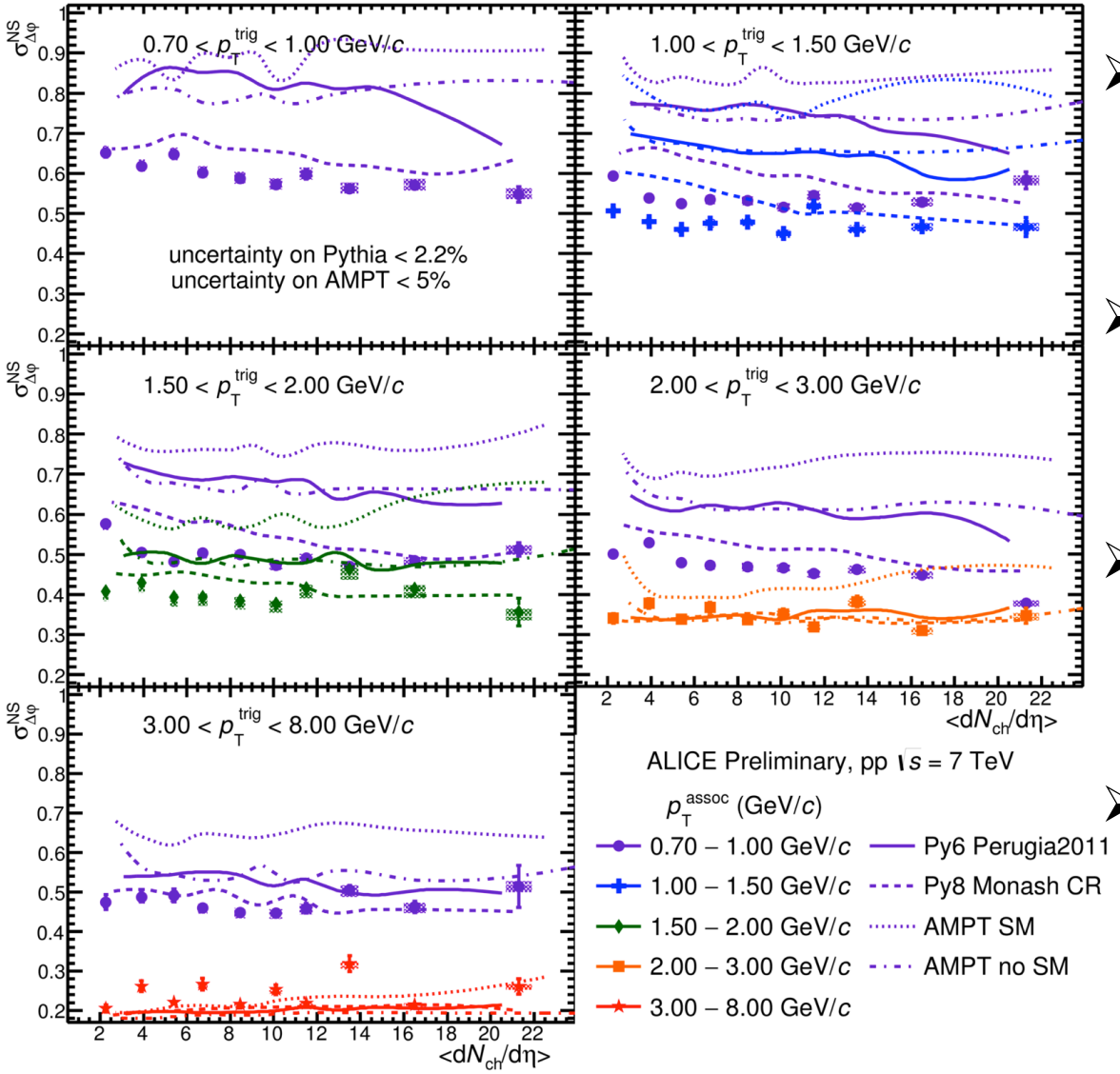
- Near-side jet peak measurements in pp@7 TeV:
  - ✓ Near-side yield shows multiplicity dependence at low multiplicities.
  - ✓ Little or no change in the peak widths with multiplicity.

- Long-range correlations in pp@7 TeV:
  - ✓ Data show onset of the near-side yield for multiplicity class <5%.

Thank you!

Backup slides

Near-side widths in Δφ in pp@7 TeV New



- Models tend to overestimate the widths of the near-side jet peak at low p_T.
- At high p_T the models are either in agreement with or slightly below the data.
- In general the data show little-to-no multiplicity dependence in the widths.
- At low-p_T PYTHIA8 with color reconnection indicates a stronger decreasing trend than observed in the data.

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