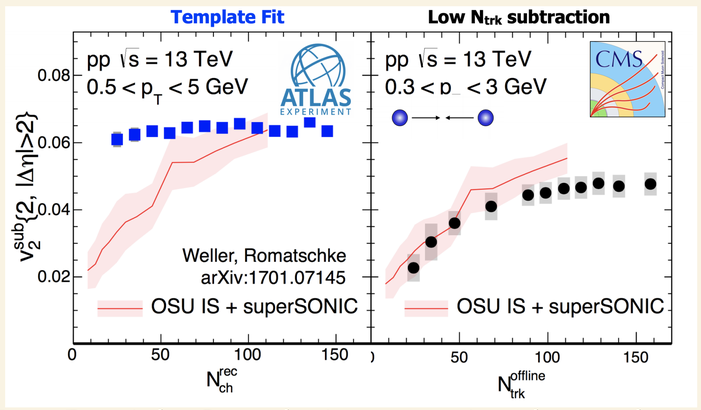
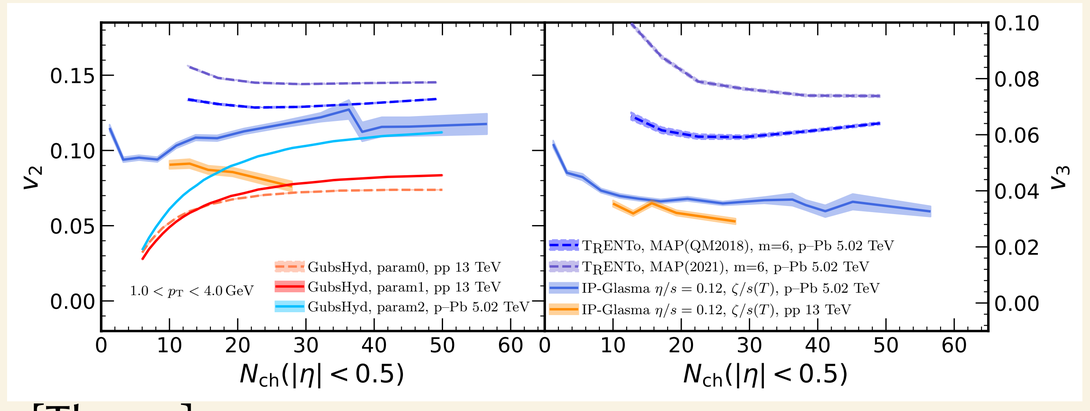
Testing the multiplicity limit on the collective flow measurements in small system collisions at the LHC

Signs of collective behaviour also in small systems → QGP?



[Experiment]

- Cumulants and Two-Particle Correlations previously used → jet contributions are not fully understood
- Multiplicity definition and Jet acceptance are different between experiments → how to compare?

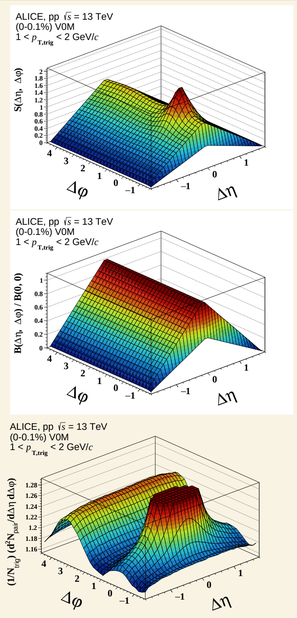


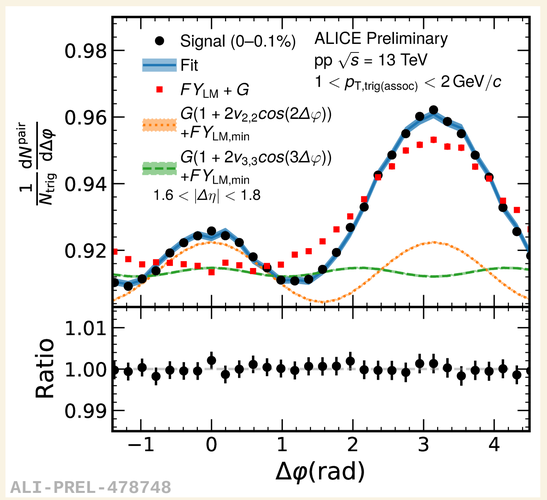
[Theory]

- Low limit of the multiplicity where Hydrodynamics works?
- The large discrepancies between the model predictions

Two-Particle Correlations and Improved flow extraction method

- $S(\Delta\eta, \Delta\varphi) = \frac{1}{N_{\mathrm{Trig}}} \frac{\mathrm{d}^2 N_{\mathrm{Same}}}{\mathrm{d}\eta \mathrm{d}\varphi}$
  - N_{Trig}: the number of tracks.
  - N_{Same} : the number of track pairs.
  - $\Delta\eta(\varphi) = \eta(\varphi)_{\mathrm{Trig}} - \eta(\varphi)_{\mathrm{assoc}}$
- $B(\Delta\eta, \Delta\varphi) = \frac{1}{N_{\mathrm{Trig}}} \frac{\mathrm{d}^2 N_{\mathrm{Mixing}}}{\mathrm{d}\eta \mathrm{d}\varphi}$
  - N_{Mixing} denotes the number of track pair using mixed events.
- $C(\Delta\eta, \Delta\varphi) = B(0,0)\frac{S(\Delta\eta, \Delta\varphi)}{B(\Delta\eta, \Delta\varphi)} = \frac{1}{N_{\mathrm{Trig}}} \frac{d^2 N_{\mathrm{pair}}}{d\Delta\eta d\Delta\phi}$



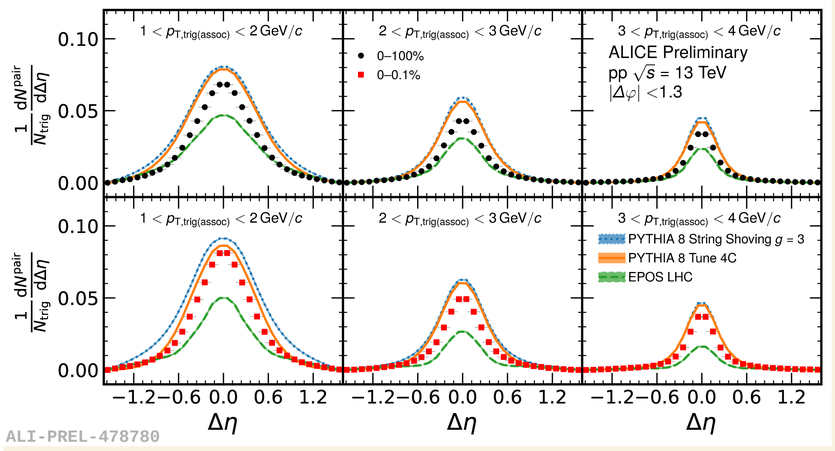


$$Y(\Delta\varphi) = G(1 + 2v_{2,2}\cos(2\Delta\varphi) + 2v_{3,3}\cos(3\Delta\varphi)) + FY_{\mathrm{LM}}(\Delta\varphi)$$

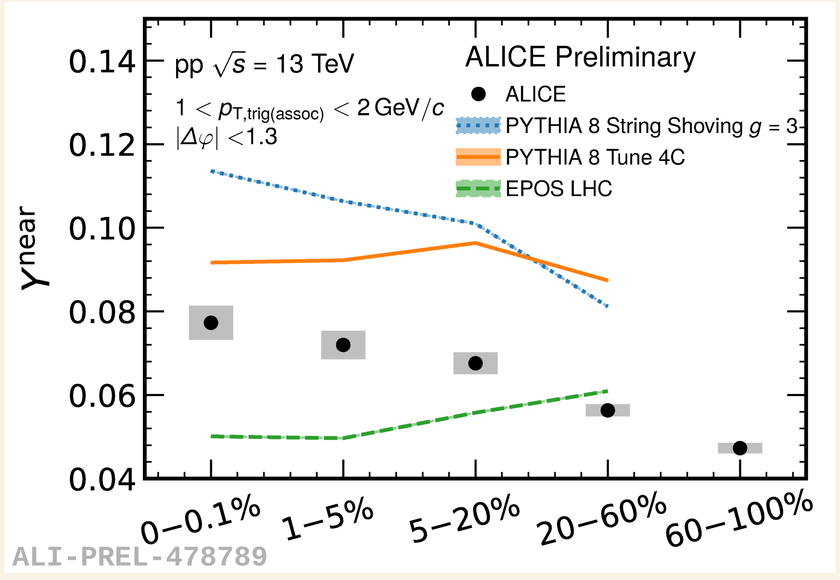
Low multiplicity template fit method

- Subtract the remaining away-side jet contribution in high multiplicity event relative to the low multiplicity term
- F: Ratio of away-side jet fragments in high-multiplicity to low-multiplicity events (60–100%), $F = 1.304 \pm 0.018$
- Assumptions
  - No ridge or flow in the LM-template
  - No away-side jet modifications (quenching) in HM events relative to the LM-template

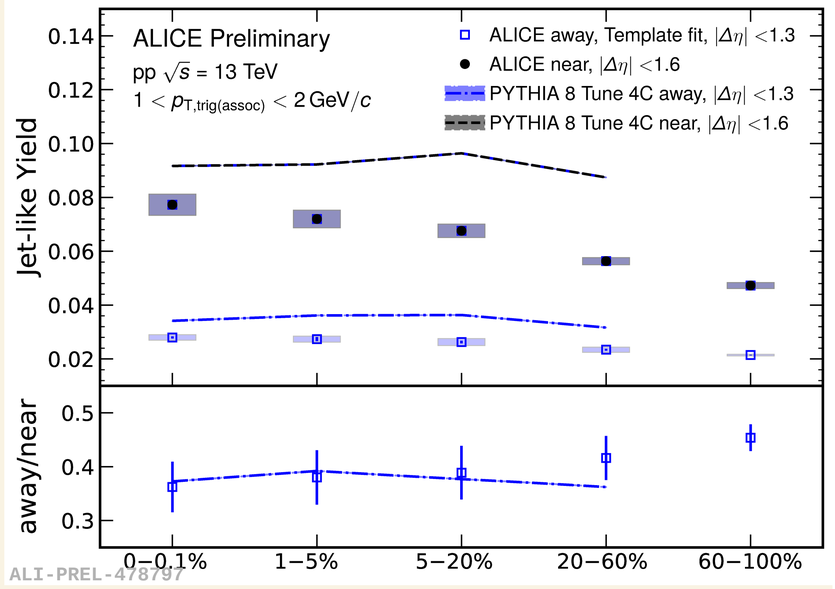
Verification of the Low multiplicity-template fit



- $\frac{1}{N_{\mathrm{trig}}} \frac{\mathrm{d}N_{\mathrm{pair}}}{\mathrm{d}\eta} = \int_{|\Delta\varphi|<1.3} \left(\frac{1}{N_{\mathrm{trig}}} \frac{\mathrm{d}^2 N_{\mathrm{pair}}}{\mathrm{d}\eta \mathrm{d}\varphi} \right) \frac{1}{\delta_{\Delta\varphi}} \mathrm{d}\varphi - D_{\mathrm{ZYAM}}$
- Description of jet fragmentation is compared with models: qualitative agreement of PYTHIA 8 Tune 4C
- Data and String Shoving show increasing near-side yield with increasing multiplicity, while that is not the case for EPOS LHC and PYTHIA 8 Tune 4C

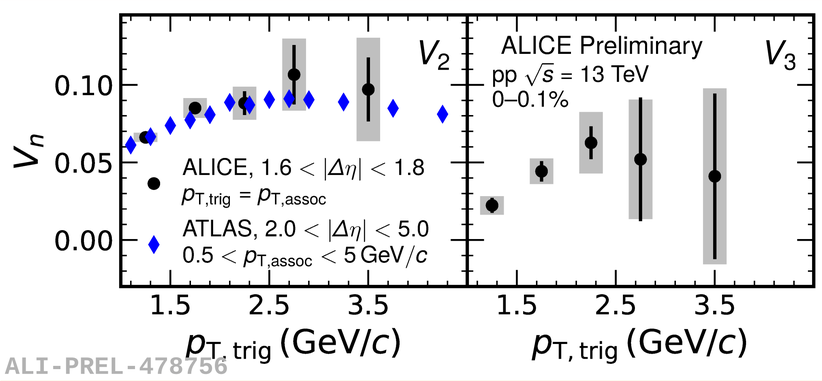


- Near-side jet yield measured by short-range correlations
- $Y^{\mathrm{near}} = \int_{|\Delta\eta|<1.6} \mathrm{d}\eta \left(\frac{1}{N_{\mathrm{trig}}} \frac{\mathrm{d}N_{\mathrm{pair}}}{\mathrm{d}\eta} \right)$
- Away-side jet yield : $Y_{\mathrm{jet}}^{\mathrm{Away}} = F Y_{\mathrm{jet}}^{\mathrm{Away,LM}}$



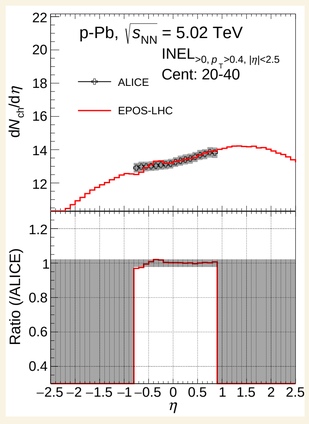
- The relative away-side jet contribution, F, can be tested by comparing the ratio which only are caused by the jet acceptance.
- Limited η acceptance as ratio (Phys.Rev.D74:072002,2006)

Results and Discussions



- Comparable with ATLAS result
- Note that multiplicity class for ATLAS is classified with central particles ($|\eta|$ <2.5, p_T >0.4 GeV/c), $N_{\mathrm{Mult}}^{\mathrm{ATLAS}} > 60$

Multiplicity mapping between experiments



- The EPOS LHC is scaled to the measurements.
- Addition p_T cut applied to have the same kinematic cut as ATLAS.
- MAP between ATLAS and ALICE

Exp.	ALICE	ATLAS
Mult. Class (%)	$N_{\mathrm{ch}}(\|\eta\| < 0.5)$	$N_{\mathrm{ch,ATLAS}}^{rec}$ ($p_T > 0.4, \|\eta\| < 2.5$)
0–0.1	31.33	84.07 (80.33)
1–5	20.02	50.10(48.83)
5–20	13.99	33.70(29.15)
20–60	7.2	16.11(14.12)
60–100	N/A	5.23

Summary

- LM-template fit subtracts the remaining away jet contribution properly.
- The effect is 30% for 0-0.1% multiplicity in pp 13 TeV, must be considered.
- Different experimental multiplicity definitions can be compared by using the measured $dN/d\eta$ distributions.
- Multi-jet effect for larger η acceptance should be studied further.
- Multiplicity dependence of v_2 in pp collsions, accessing lower multiplicities, on progress.

Anna Önnerstad[1,2], D. J. Kim[1,2]

anna.onnerstad@cern.ch

[1]*University of Jyväskylä,* [2]*Helsinki Institute of Physics*

UNIVERSITY OF JYVÄSKYLÄ

CoE QM

HELSINKI INSTITUTE OF PHYSICS

XVth Quark Confinement and the Hadron Spectrum Conference 2022 - University of Stavanger