Correlations with identified trigger particles in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

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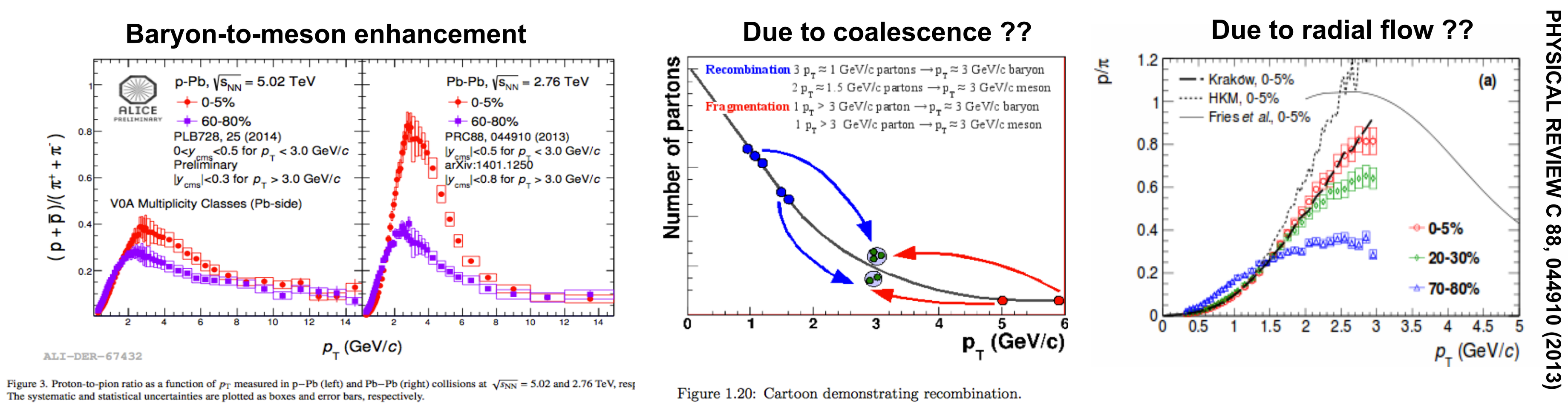
Abstract

We report results of baryon-hadron and meson-hadron correlations at intermediate p_T, where an anomalous enhancement in the inclusive baryon-to-meson ratio has been observed in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. The choice of the trigger p_T region (2.0 < p_T < 4.0 GeV/c) is of particular interest as it is believed to have contributions from both hard (fragmentation) and soft (hydrodynamics and/or coalescence model of hadronization) processes of particle production. The associated particles are charged hadrons with 1.0 < p_T < 4.0 GeV/c. Using the two particle correlation technique, the multiplicity evolution of the pion- and proton-triggered jet-like yields has been studied to explore the underlying mechanisms of particle production in the intermediate p_T (trigger p_T) region [1-4].

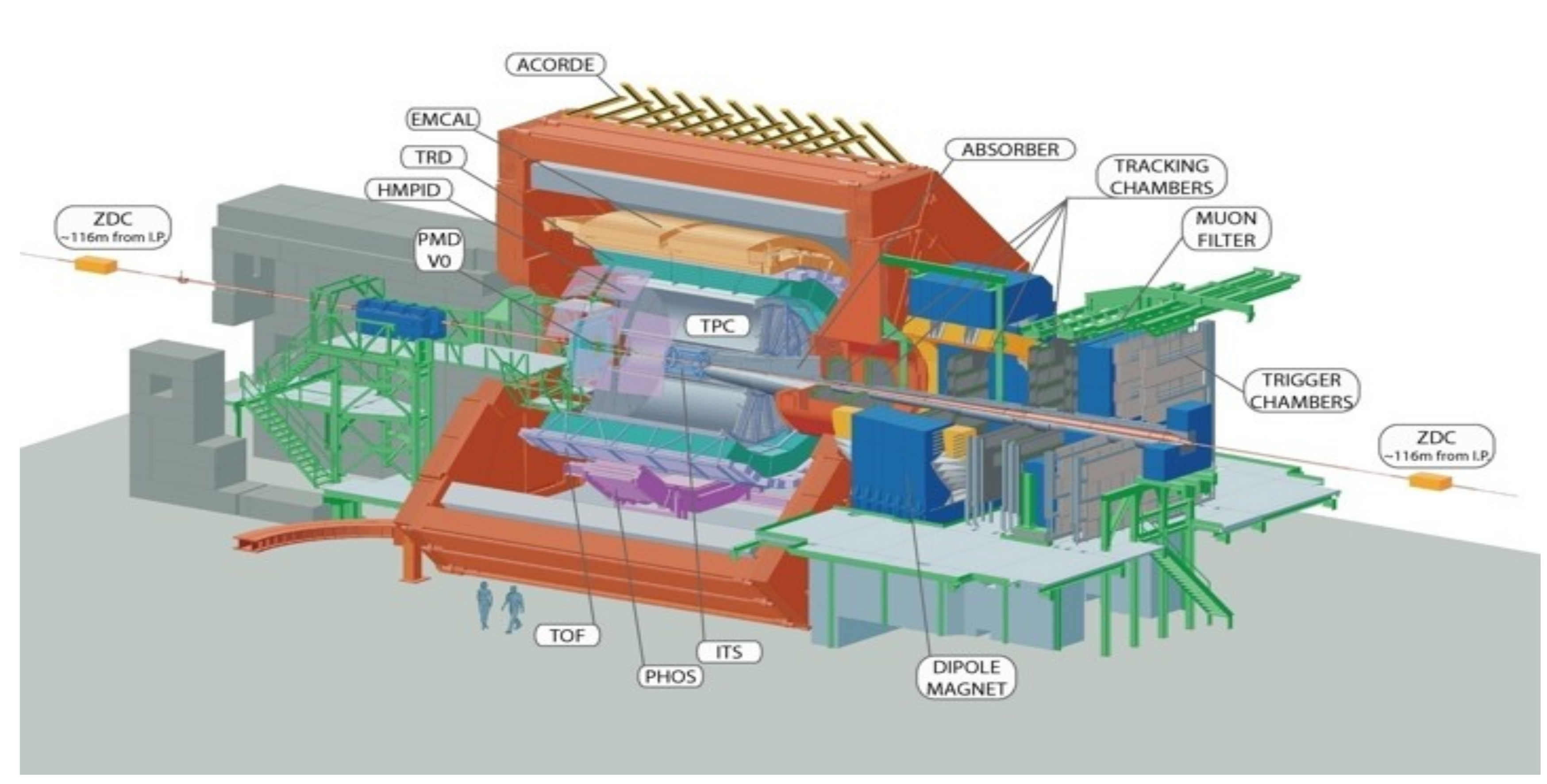
Physics Motivation

A large baryon-to-meson enhancement at intermediate p_T has been observed in central heavy ion collisions both at the RHIC and the LHC. While at RHIC, the interpretation is given in terms of coalescence, at the LHC, data has also been explained in terms of radial flow. A similar baryon-to-meson enhancement is also observed in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV as well.



Hadrons pushed from lower to higher p_T by radial flow or generated by coalescence are expected not to exhibit a short range jet-like correlation beyond the expected flow (ridge) like correlation. Thus the bulk/flow subtracted near-side jet peak is dominated by the hard triggered (jet) correlation. Since the correlation functions are normalized by both hard and soft triggers, the soft triggers without any jet-like correlated partners are expected to cause the "trigger dilution" effect in the per trigger jet-like yield [1-4].

ALICE Detector



The detectors used in this analysis are:

- V0A (2.8 < η <5.1) for multiplicity class estimation.
- ITS (Inner Tracking System).
- TPC (Time Projection Chamber).
- TOF (Time-of-Flight).
- The ITS and the TPC are used for track reconstruction in the pseudorapidity range |η| < 0.8. The TPC and TOF are used for particle identification, in particular for identifying pions and protons in the trigger p_T region (2.0 < p_T < 4.0 GeV/c) .

Analysis Strategy

Correlation Function:

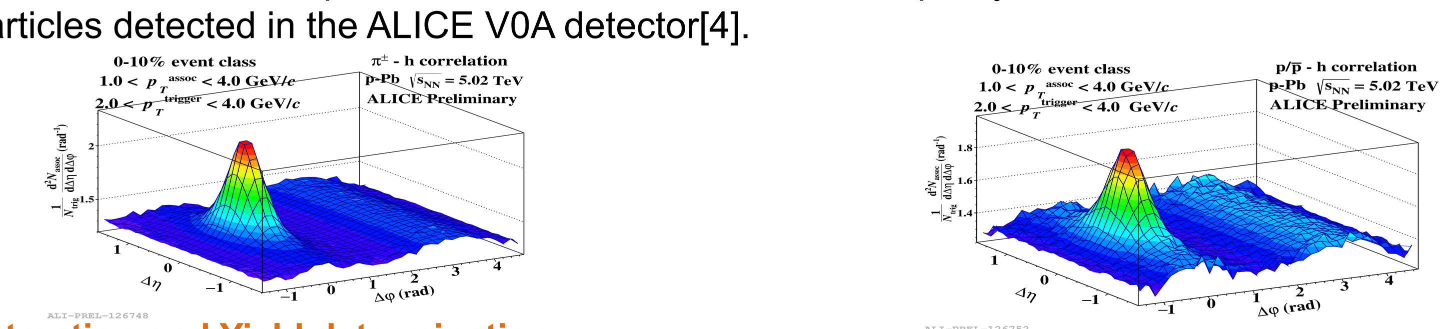
Two particle correlation function is obtained among two sets of particles classified as trigger and associated with a p_T ordering ($p_T^{assoc} < p_T^{trigger}$).
The correlation function is defined as:

$$\frac{1}{N_{trig}}\frac{d^2N_{assoc}}{d\Delta\eta d\Delta\varphi}$$

Trigger p_T range (2.0 < p_T < 4.0 GeV/c)

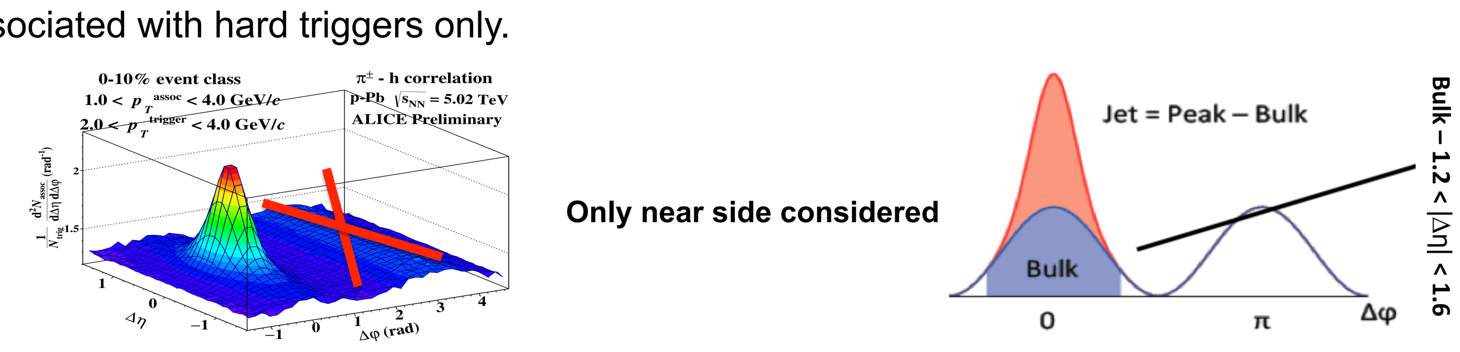
Associated p_T range (1.0 < p_T < 4.0 GeV/c)

The entire minimum bias sample has been divided into five multiplicity classes based on the total number of charged particles detected in the ALICE V0A detector[4].



Bulk subtraction and Yield determination:

Observable: Integrated yield of the bulk subtracted near-side (|Δφ| <π/2) jet peak in all multiplicity classes → the yield associated with hard triggers only.



- The bulk is estimated from large |Δη| (|Δη| ≥ 1.2) and subtracted from the near side jet peak (|Δη|< 1.2).
- Bulk subtraction – subtraction of soft triggered correlation as the particles originating from the soft processes (hydrodynamics and/or coalescence model of hadronization) are expected not to have correlated partners beyond the "ridge" or flow like correlations.
- Bulk Subtracted near side jet peak contains hard triggered correlation only.

Larger dilution is expected for proton triggered correlation!!

- **Lowest multiplicity event class (no ridge / soft physics):**

Total trigger sample = *Hard Triggers mainly*; $\frac{1}{N_{trig}}\frac{d^2N_{assoc}}{d\Delta\eta d\Delta\varphi}$ ⇒ *Area under the bulk subtracted jet peak Yield associated with hard triggers*

- **Highest multiplicity event class (ridge / soft physics is present):**

Total trigger sample = *Hard + Soft Triggers*; $\frac{1}{N_{trig}}\frac{d^2N_{assoc}}{d\Delta\eta d\Delta\varphi}$ ⇒ *Area under the bulk subtracted jet peak Yield associated with hard triggers*

- **Detectors can't distinguish between particles originating from hard and soft processes. Trigger particles originating from soft processes (such as coalescence or radial flow) are not expected to have correlated partners in the bulk subtracted near-side jet peak, and therefore create a dilution in the measured per-trigger jet-like yield.**

With increase in multiplicity (Lowest Multiplicity → Highest Multiplicity)

Proportion of soft triggers within the trigger sample (particles with 2.0 < p_T < 4.0 GeV/c) will increase

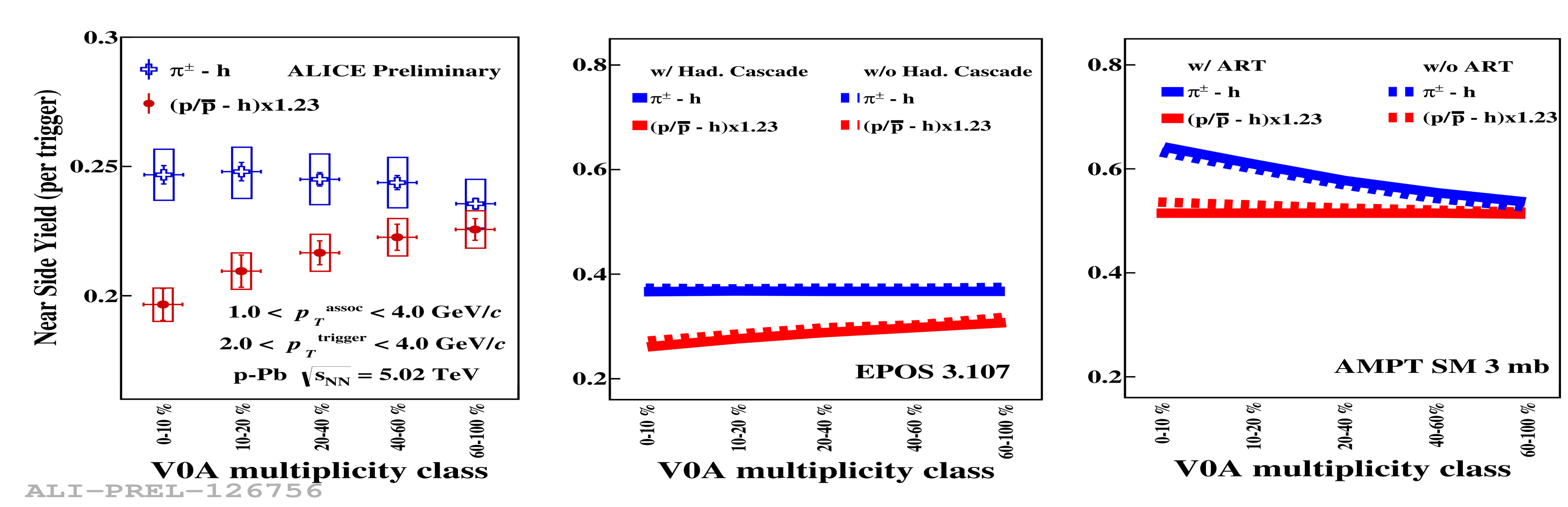
Dilution in the per trigger jet-like yield will increase

Rate of dilution → Rate of increase of soft triggers

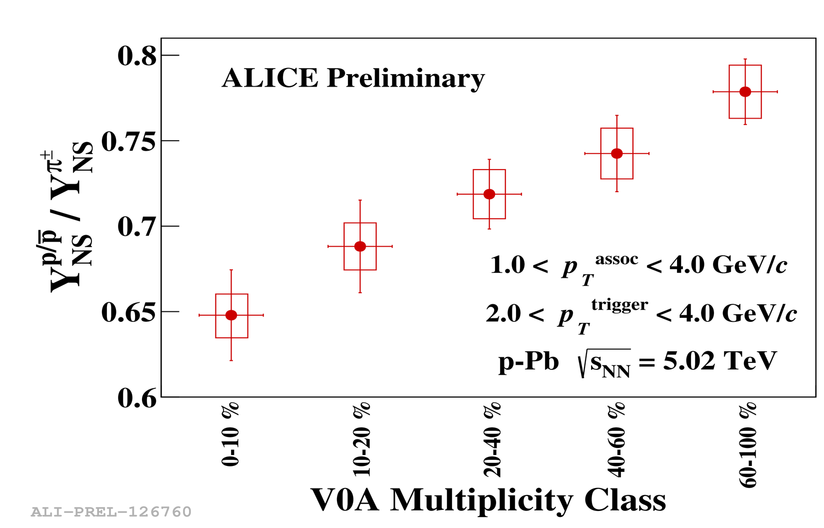
Trigger p_T range (2 – 4 GeV/c) → region of baryon to meson enhancement → soft processes like coalescence and/or radial flow favor proton production over the pion at intermediate p_T. So, the rate of increase of the soft protons is more compared to the soft pions in the trigger p_T region.

More dilution is expected in proton triggered jet-like yield…

Results



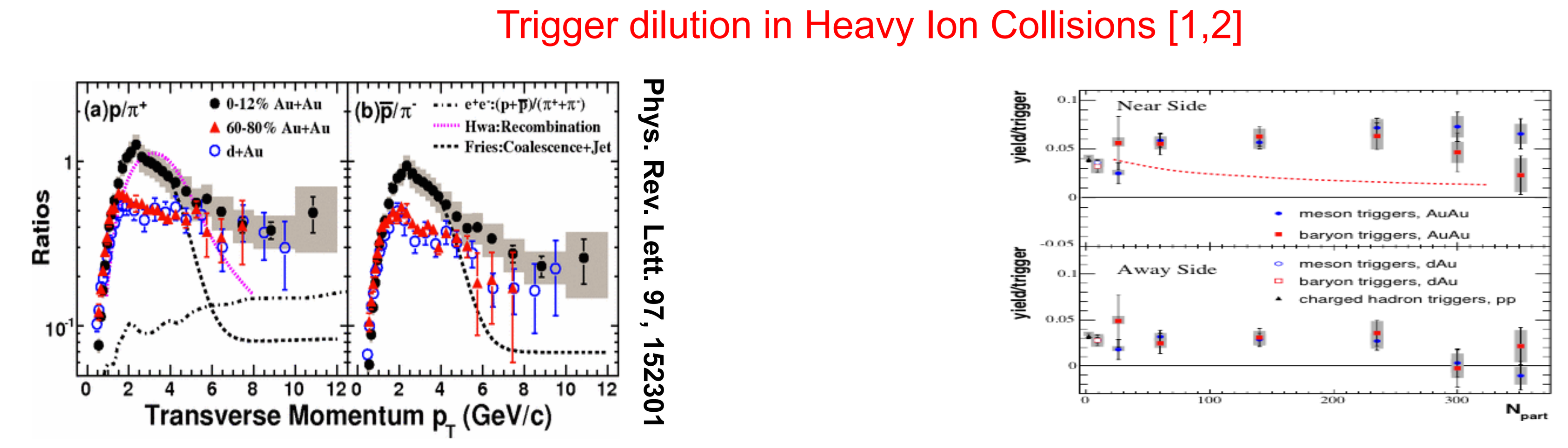
- **Proton triggered jet-like yield decreases gradually with multiplicity whereas the pion triggered jet-like yield remains almost constant. EPOS 3 (3+1D event-by-event hydro model) and AMPT with string melting (incorporates coalescence model of hadronization) can not reproduce the data quantitatively. But, EPOS 3 can qualitatively mimic the multiplicity evolution of the pion- and proton-triggered jet-like yields.**



Trigger dilution !!

- **Multiplicity evolution of the per trigger jet-like yield has trigger species dependence and it may help to understand the underlying physics processes responsible for the inclusive baryon to meson enhancement at intermediate p_T (trigger p_T region in this analysis).**

Trigger dilution in Heavy Ion Collisions [1,2]



Trigger p_T range : 2.5 – 4.0 GeV/c
Associated p_T range : 1.7 – 2.5 GeV/c

- **In the case of heavy ion collisions where severe jet quenching is present, the quenched energy is expected to manifest itself in terms of particles at low and intermediate p_T possibly affecting both jet and bulk in a way which is yet to be understood unambiguously – making it difficult to disentangle the effect of soft physics (coalescence model of hadronization, radial flow) from the jet-medium interplay.**

Summary and Outlook

- **In the absence of jet quenching, trigger dilution can be used as a probe for soft physics in small collision systems. Multiplicity evolution of the pion- and proton-triggered near side jet-like yields can also shed light on the particle production mechanism at intermediate p_T .**
- **EPOS 3 can qualitatively reproduce the multiplicity evolution of the pion- and proton-triggered jet-like yields – indicating radial flow as a possible source of trigger dilution in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV.**

References

[1] S. Adler et al. (PHENIX collaboration) Phys. Rev. C 71, 051902(R)
[2] L. Adamczyk et al. (STAR Collaboration) Physics Letters B 751 (2015) 233–240
[3] D. Sarkar, S. Choudhury, S. Chattopadhyay. Physics Letters B 760 (2016) 763–768
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[5] B. Abelev et al. (ALICE collaboration) Physics Letters B 741 (2015) 38–50

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