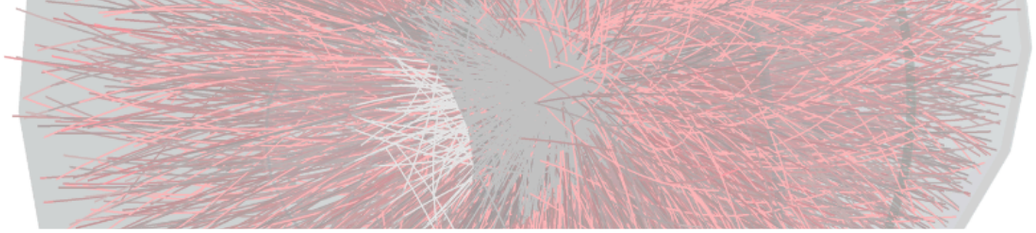

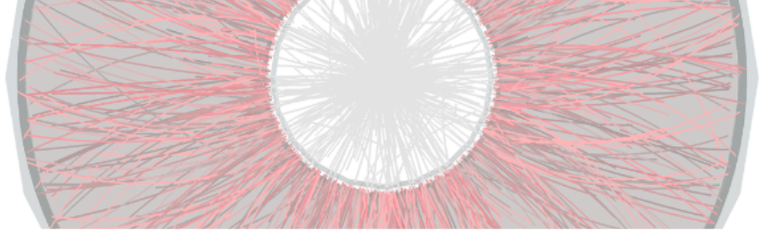

Two-particle correlations in p-Pb collisions at the LHC with ALICE

Leonardo Milano

CERN

On behalf of the ALICE Collaboration

Outline

- **Long range correlations**
  - the ridge structure in pp, Pb-Pb and p-Pb collisions
- **A Large Ion Collider Experiment (ALICE)**
  - Particle identification in ALICE
- **Two-particle correlations (2PC)**
  - event multiplicity selection in p-Pb
  - associated yield per trigger particle
  - v_2 from 2PC in high and low multiplicity events
- **Reduction of the jet component using the subtraction procedure**
  - the subtraction procedure
  - v_2 from 2PC after the subtraction procedure
- **Summary**

Long range correlations

η, φ correlation between trigger and associated particle in a given p_T interval

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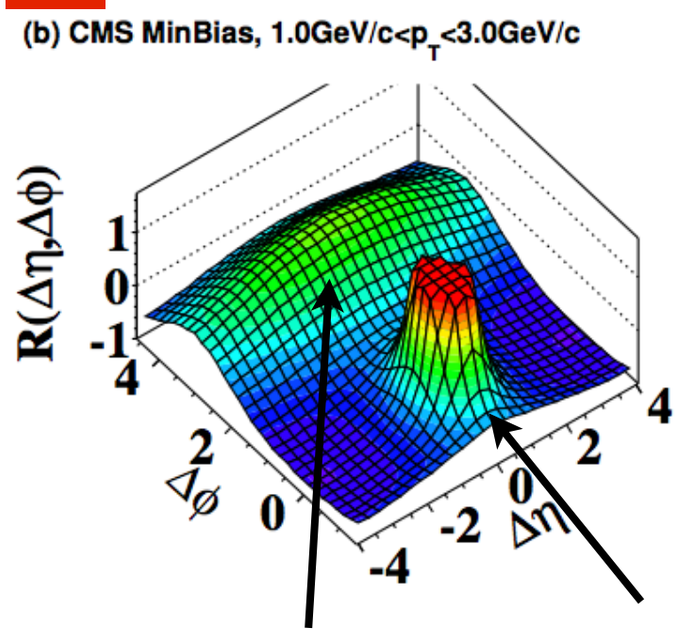
pp



away side (ΔΦ≈π) near side (ΔΦ≈0, Δη≈0)

Minimum-bias pp:
- **jet peak** on the near side (+ resonances)
- **recoil jet** on the away side

CMS JHEP 09 (2010) 091

Long range correlations

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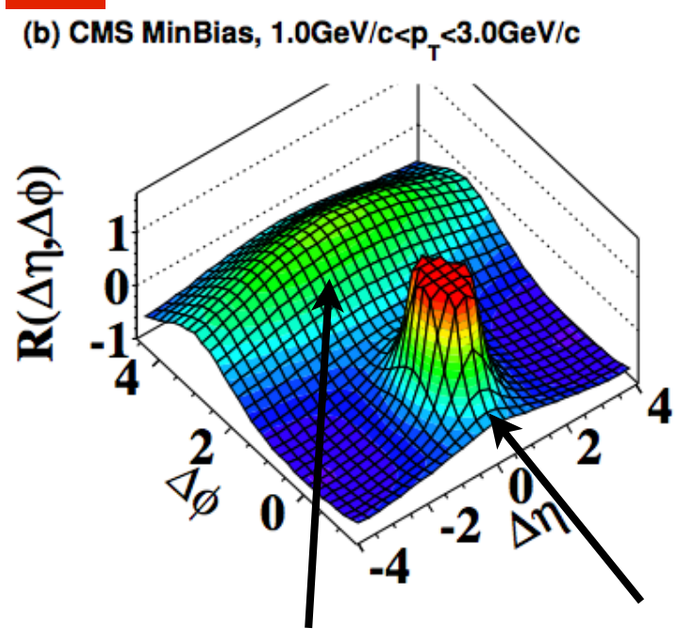

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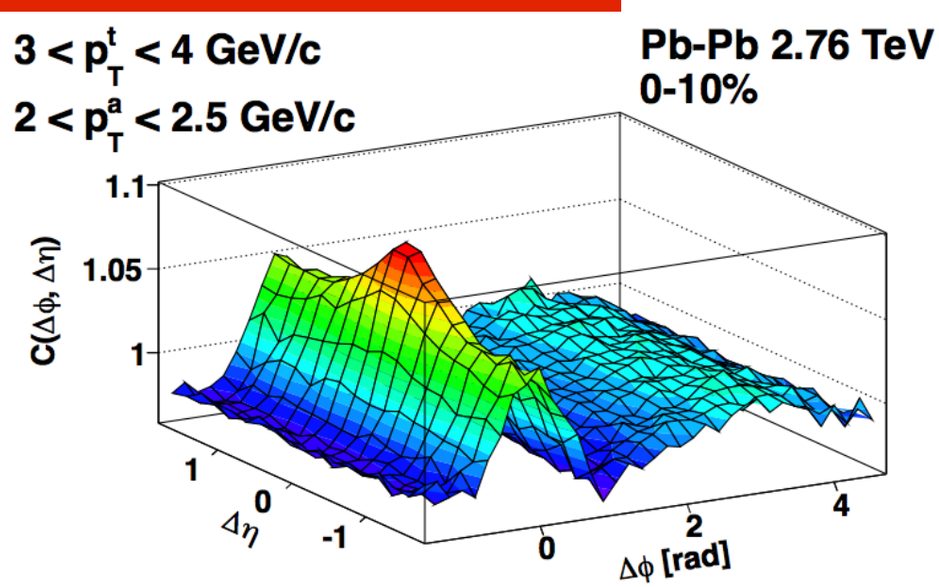
In Pb-Pb there is more...



"Bulk-dominated" p_T region:
- near side ridge structure, typical of collective systems
- **long range** in Δη
- reproduced by hydro models

ALICE Phys.Lett. B708 (2012) 249-264

B. Schenke, S. Jeon, and C. Gale, Phys.Rev.Lett. 106 (2011) 042301

Long range correlations

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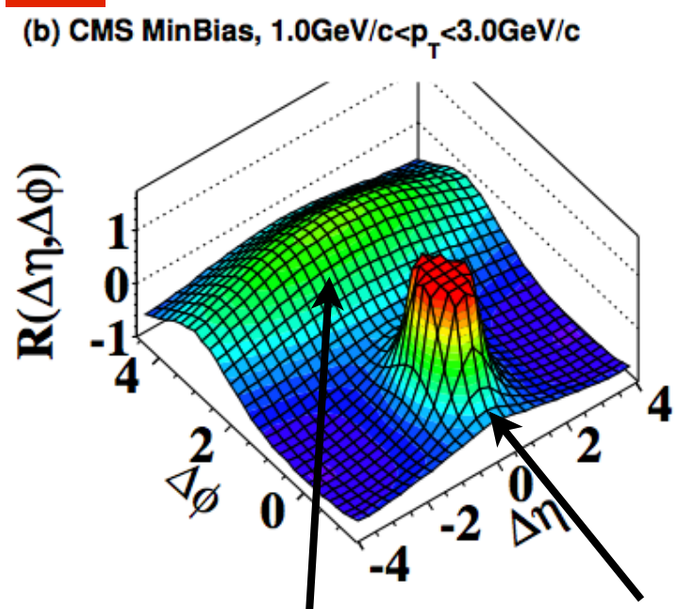

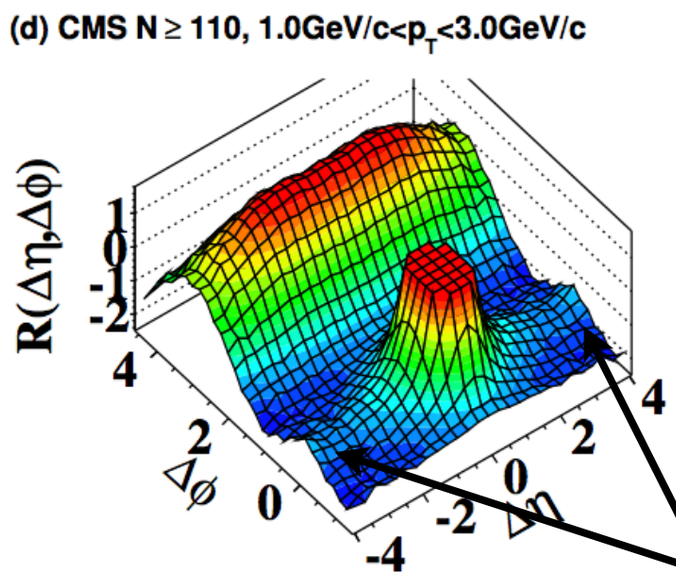

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Minimum-bias pp:
- **jet peak** on the near side (+ resonances)
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High multiplicity (0.0005% of MB)
- near side ridge
- origin still to be fully understood

CMS JHEP 09 (2010) 091

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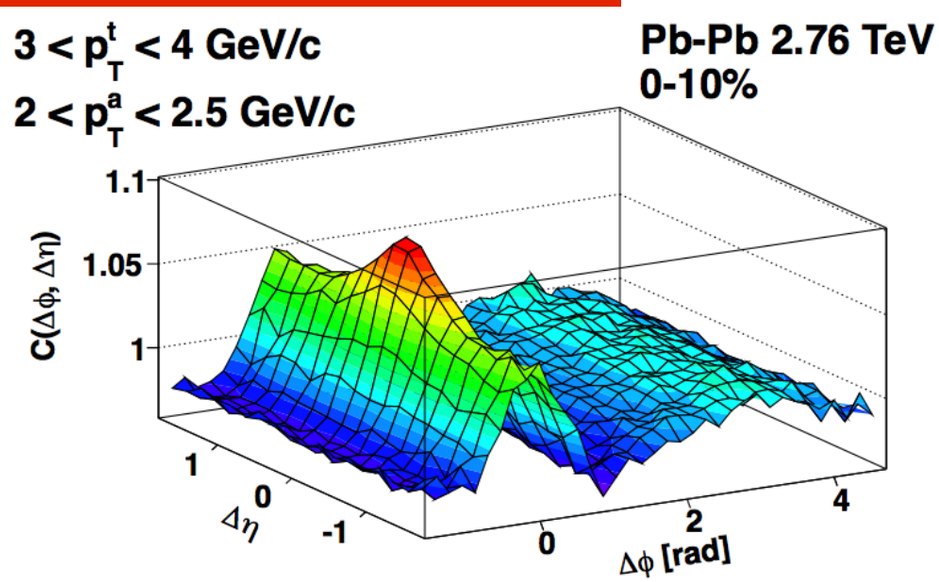

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The double ridge in p-Pb

p-Pb

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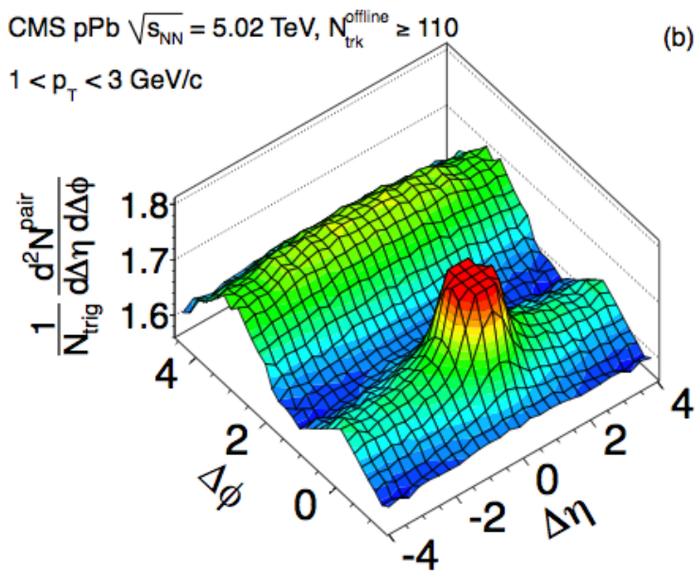

CMS arXiv:1210.5482 [nucl-ex].
ATLAS Phys.Rev.Lett. 110 (2013) 182302

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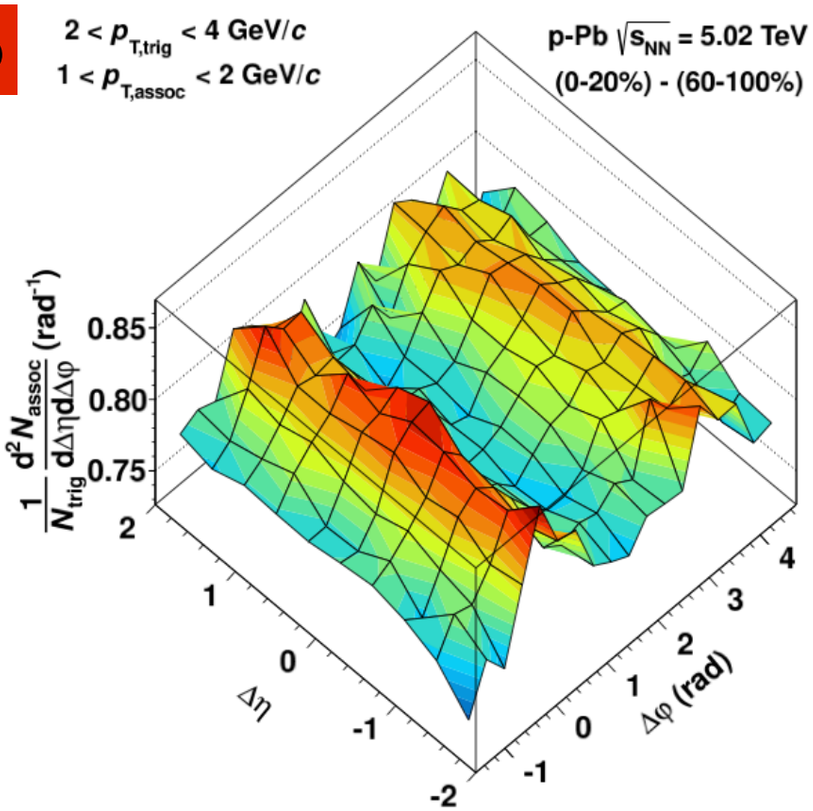

Same near side structure in high multiplicity p-Pb events

Jet contribution reduced by subtracting low multiplicity events

- **long range** structure on both the near and away side
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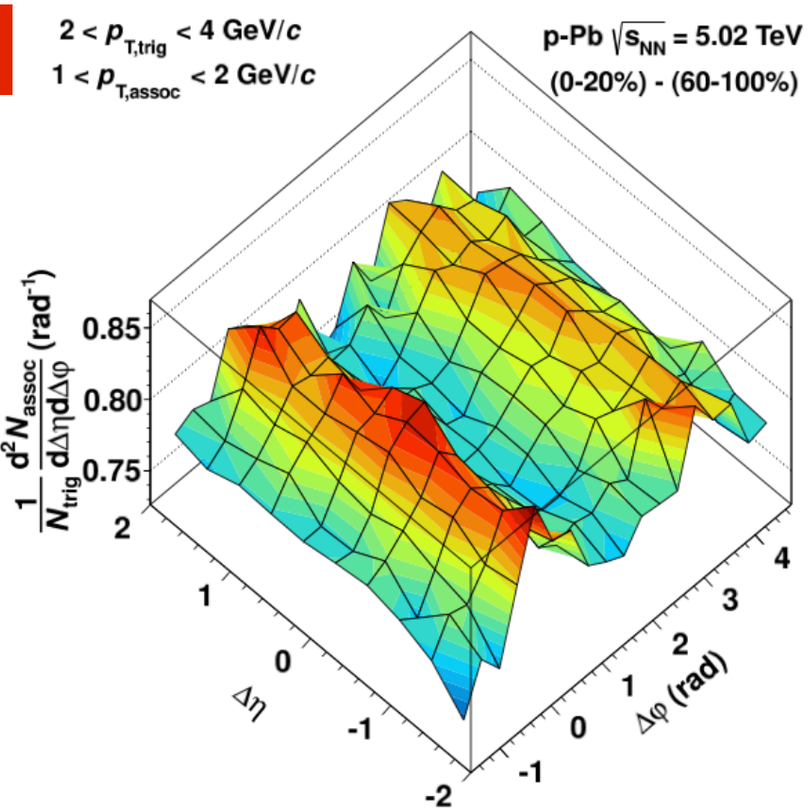

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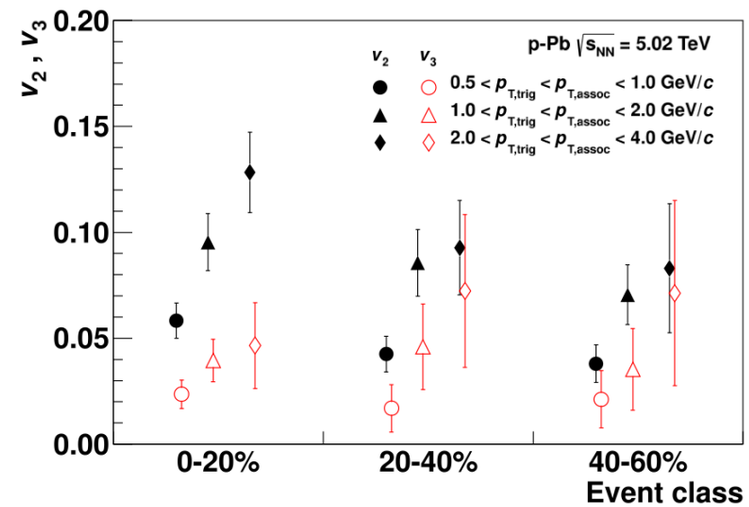

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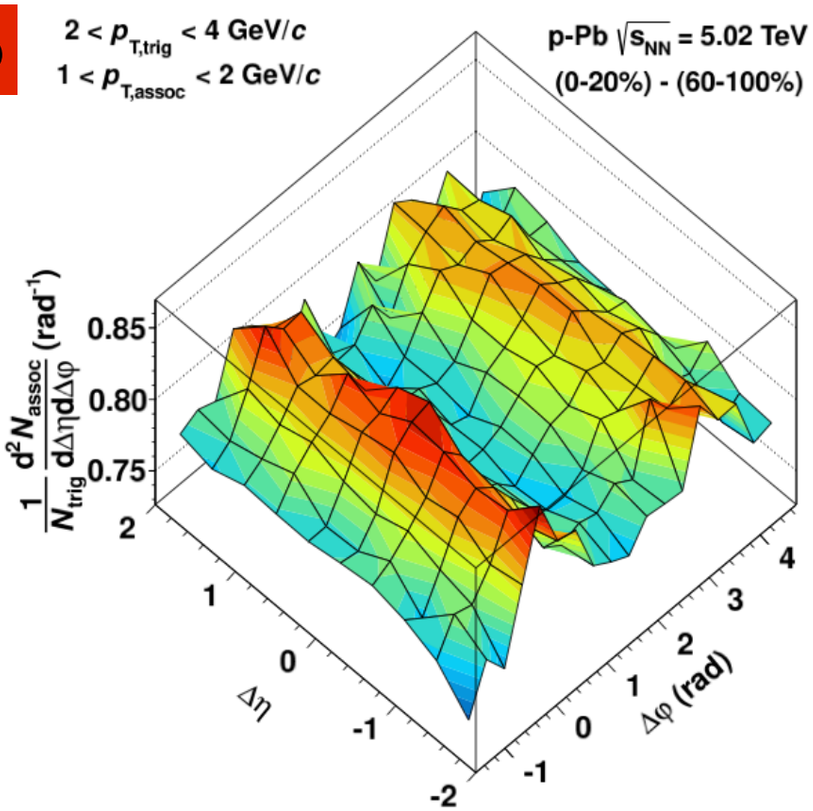

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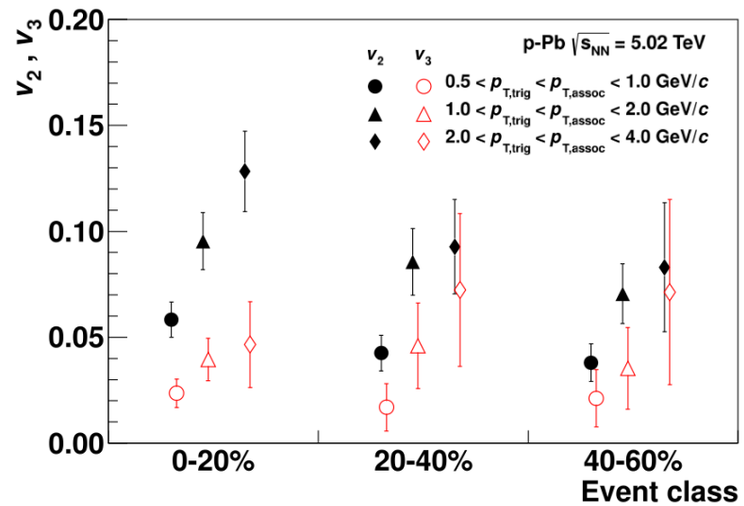

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Initial state effects

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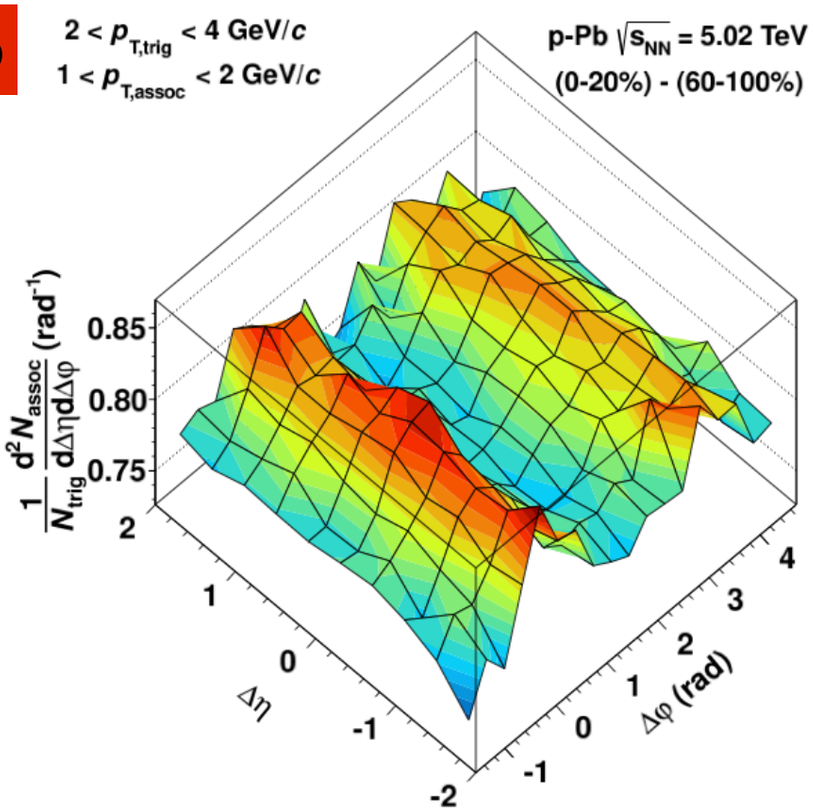

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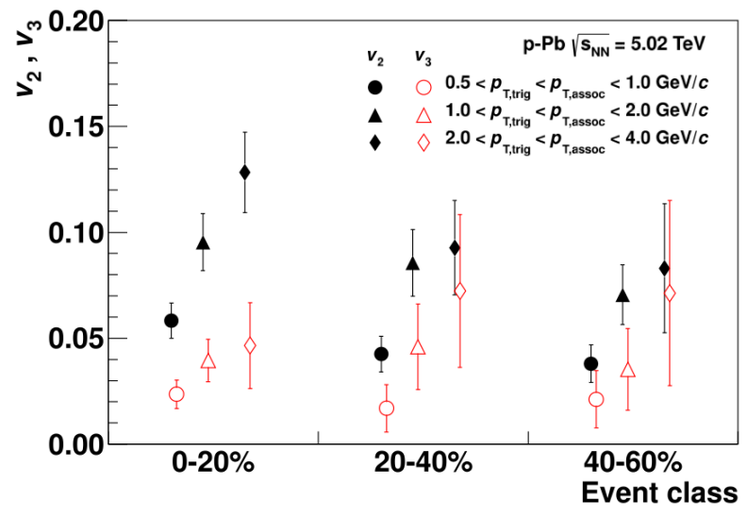

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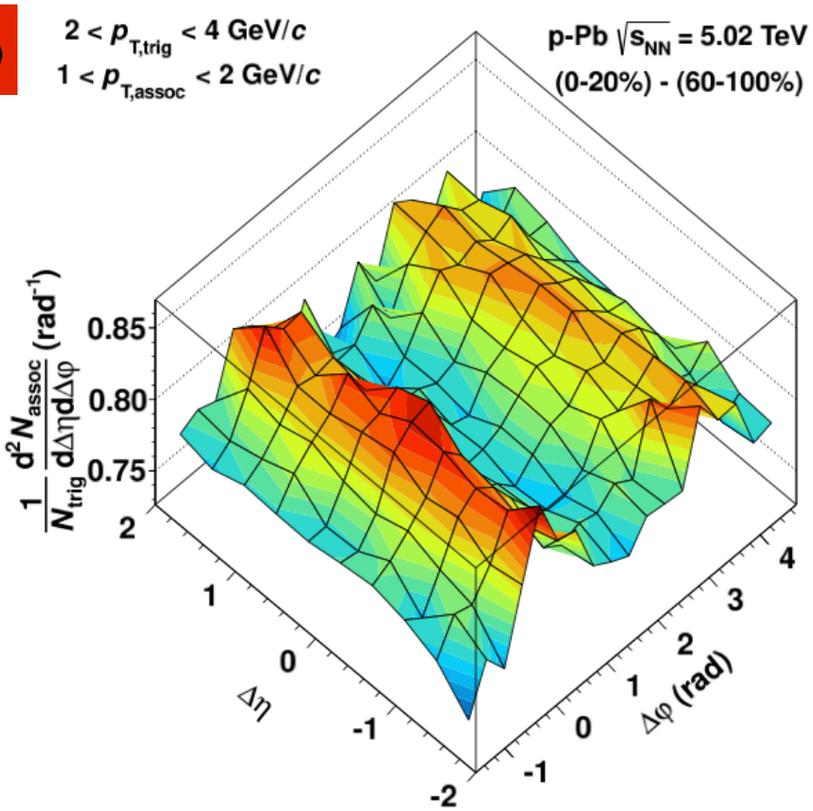

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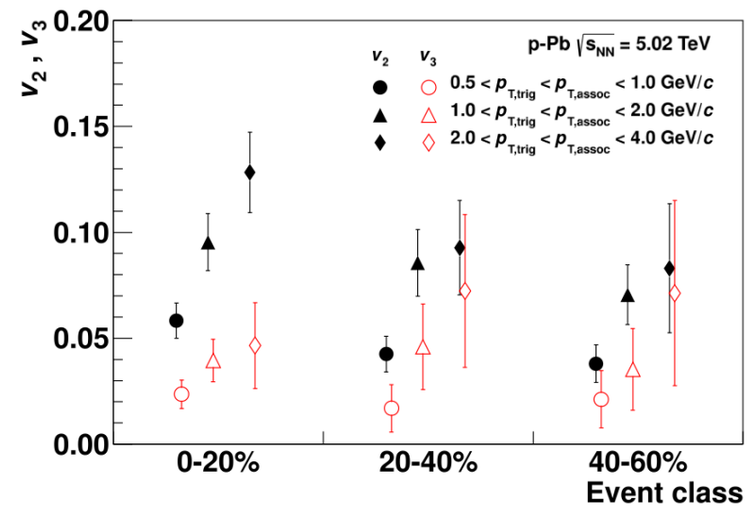

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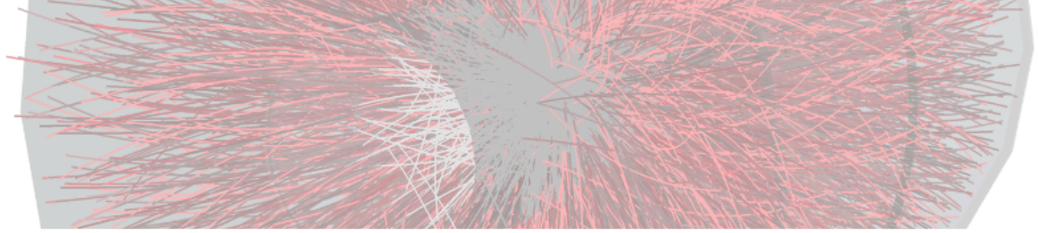
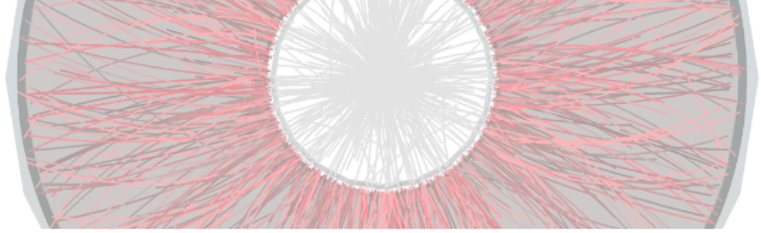
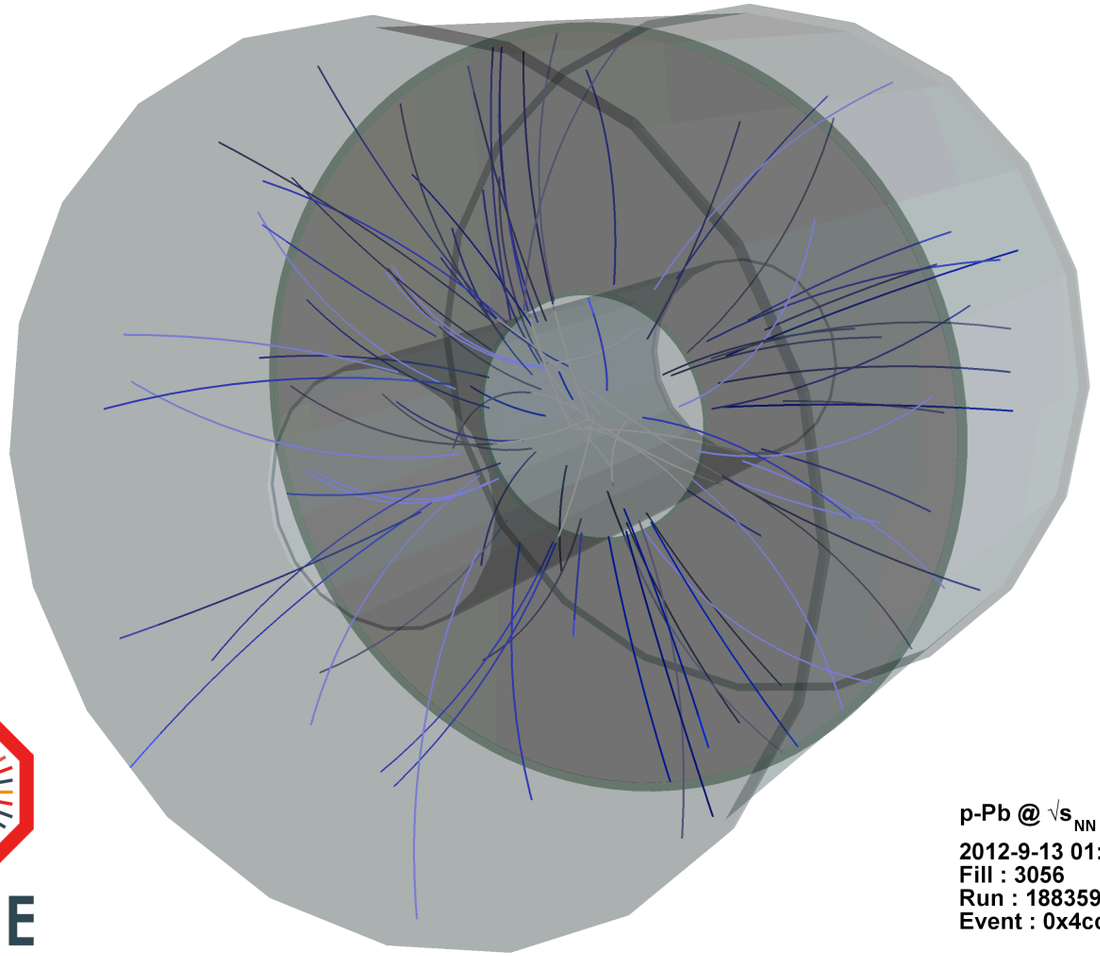
Does it flow or not?

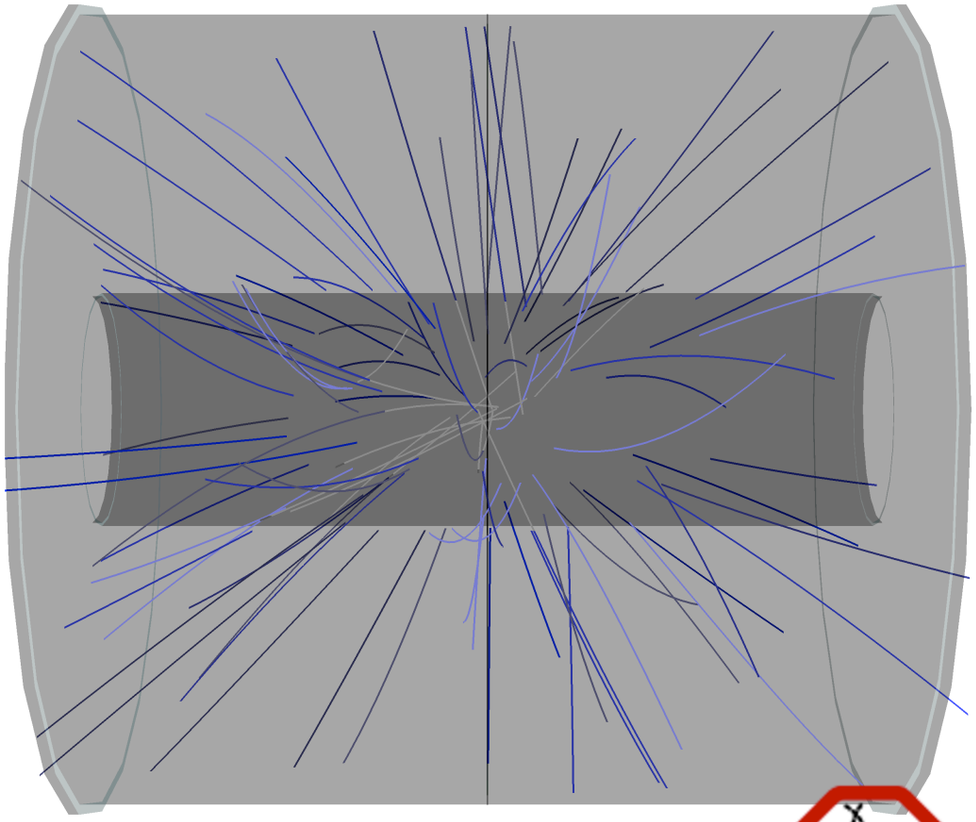
Particle identification could say something





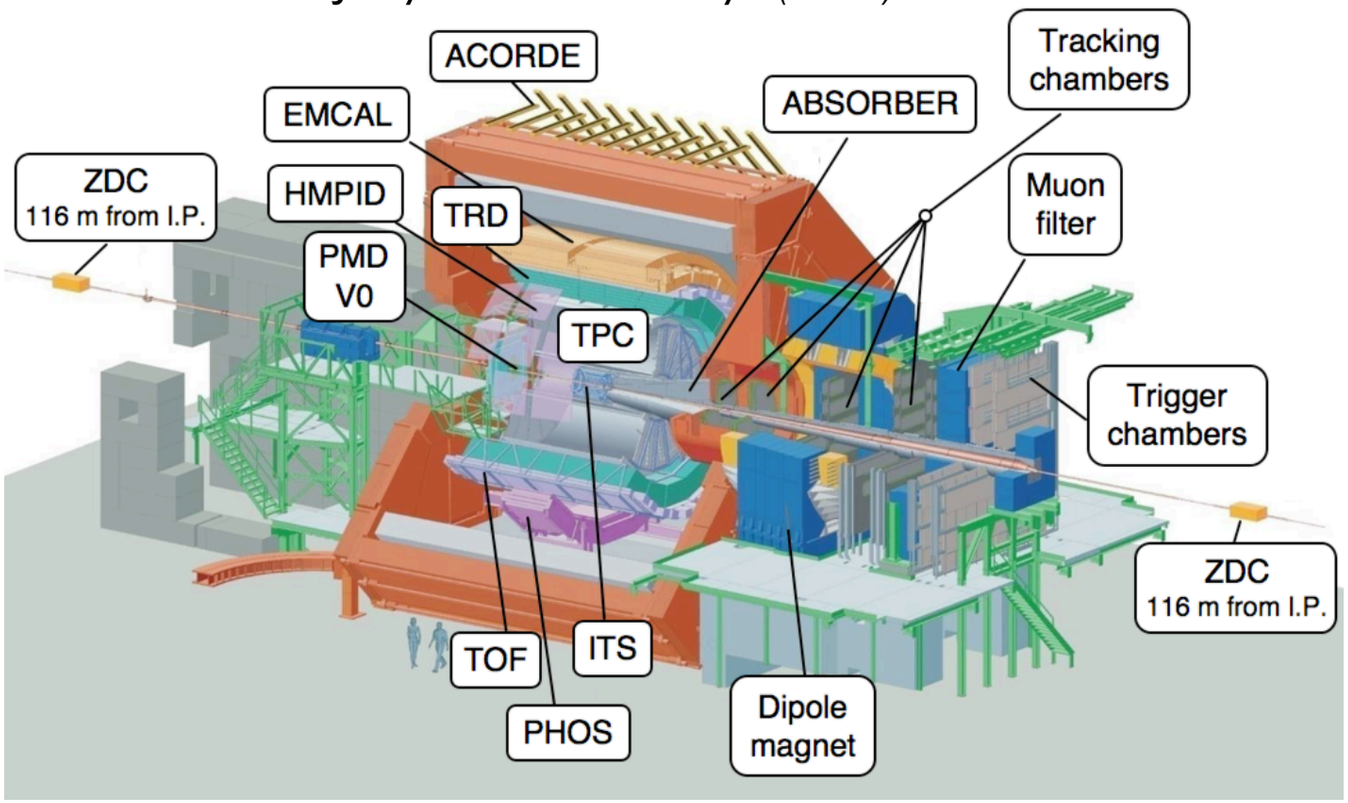
PID in ALICE: detectors and techniques





Detector description

ALICE J. Phys. G: Nucl. Part. Phys. (2004) 30 1517

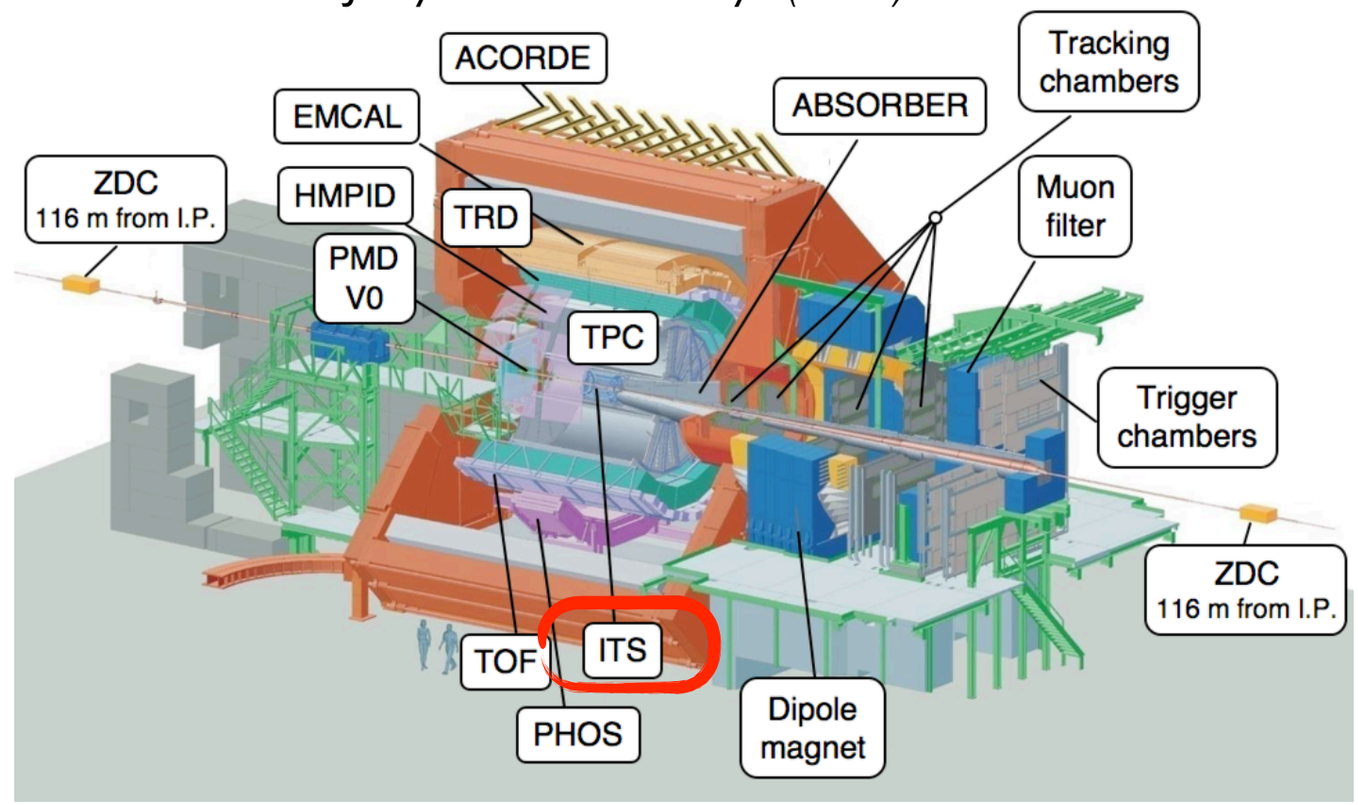


Detector description

In this analysis:

- **Inner Tracking System (ITS)**
  - tracking at low p_T
  - vertexing

ALICE J. Phys. G: Nucl. Part. Phys. (2004) 30 1517



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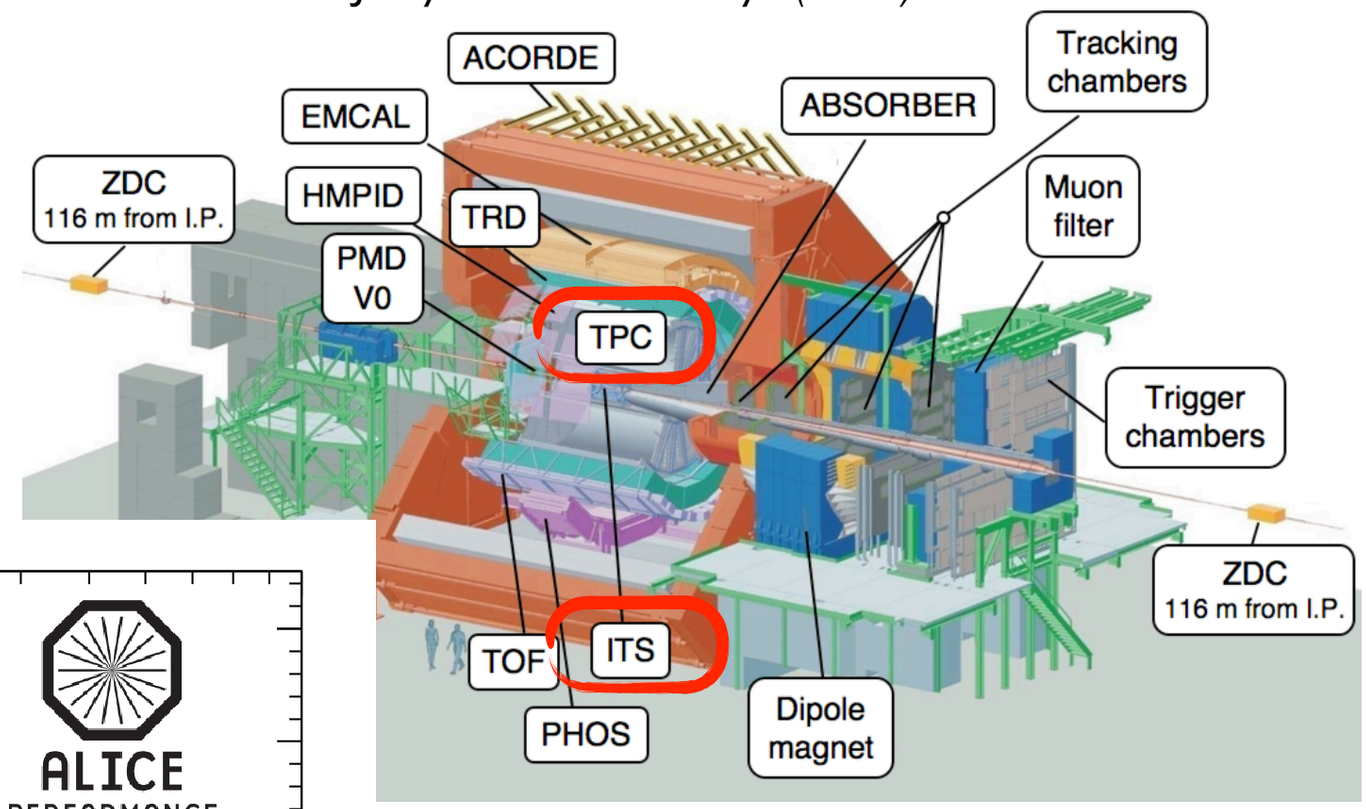

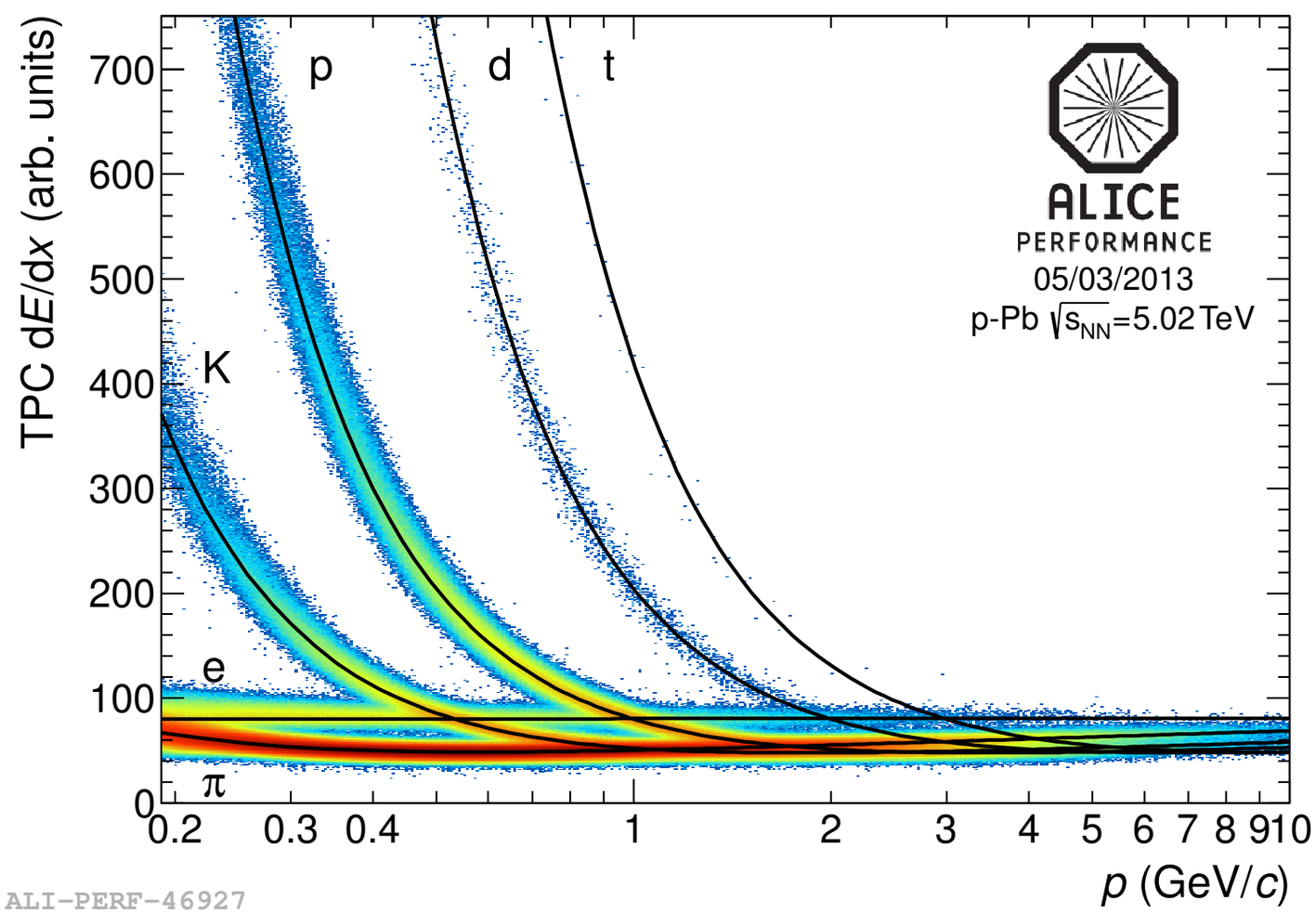

ALI-PERF-46927

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- **Time of Flight (TOF)**
  - tracks extrapolated from ITS-TPC
  - resolution ~85ps (high multiplicity p-Pb)

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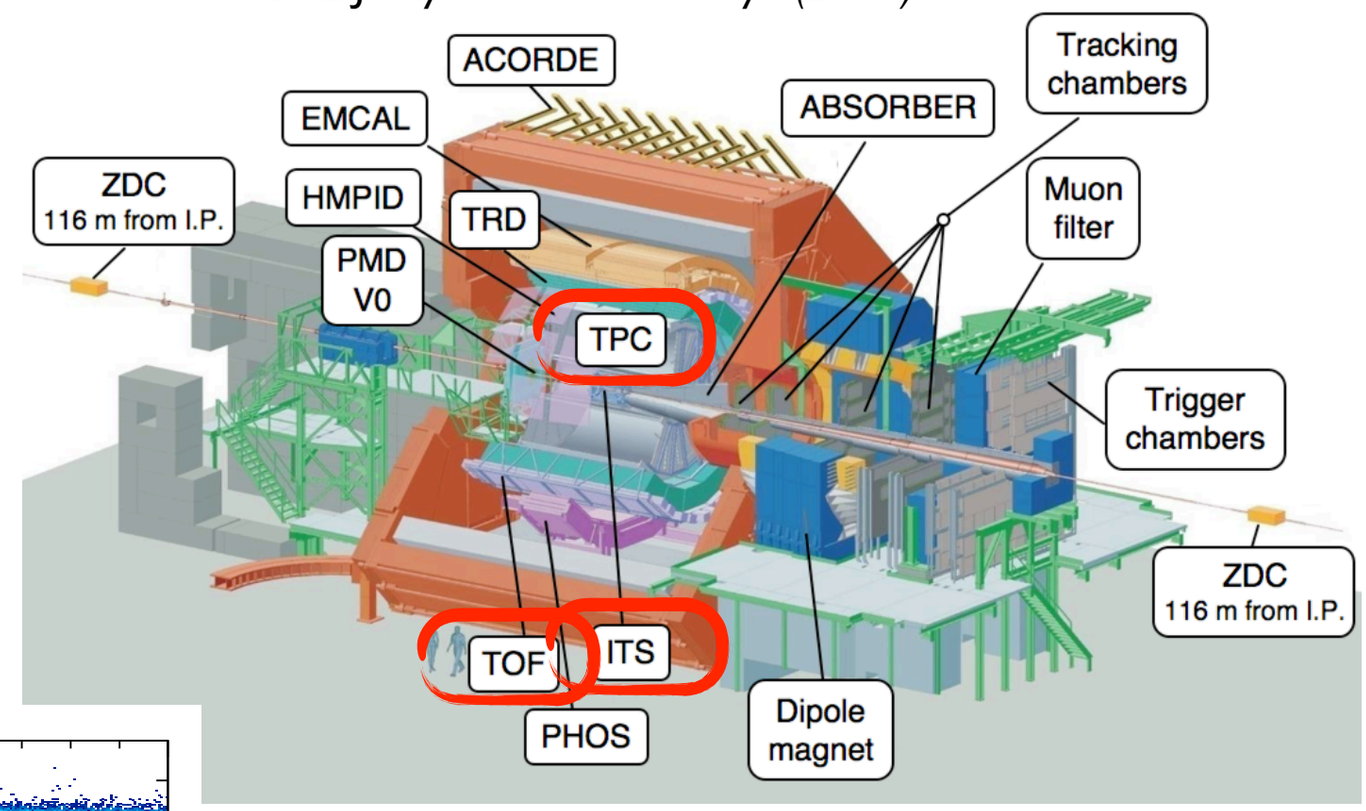

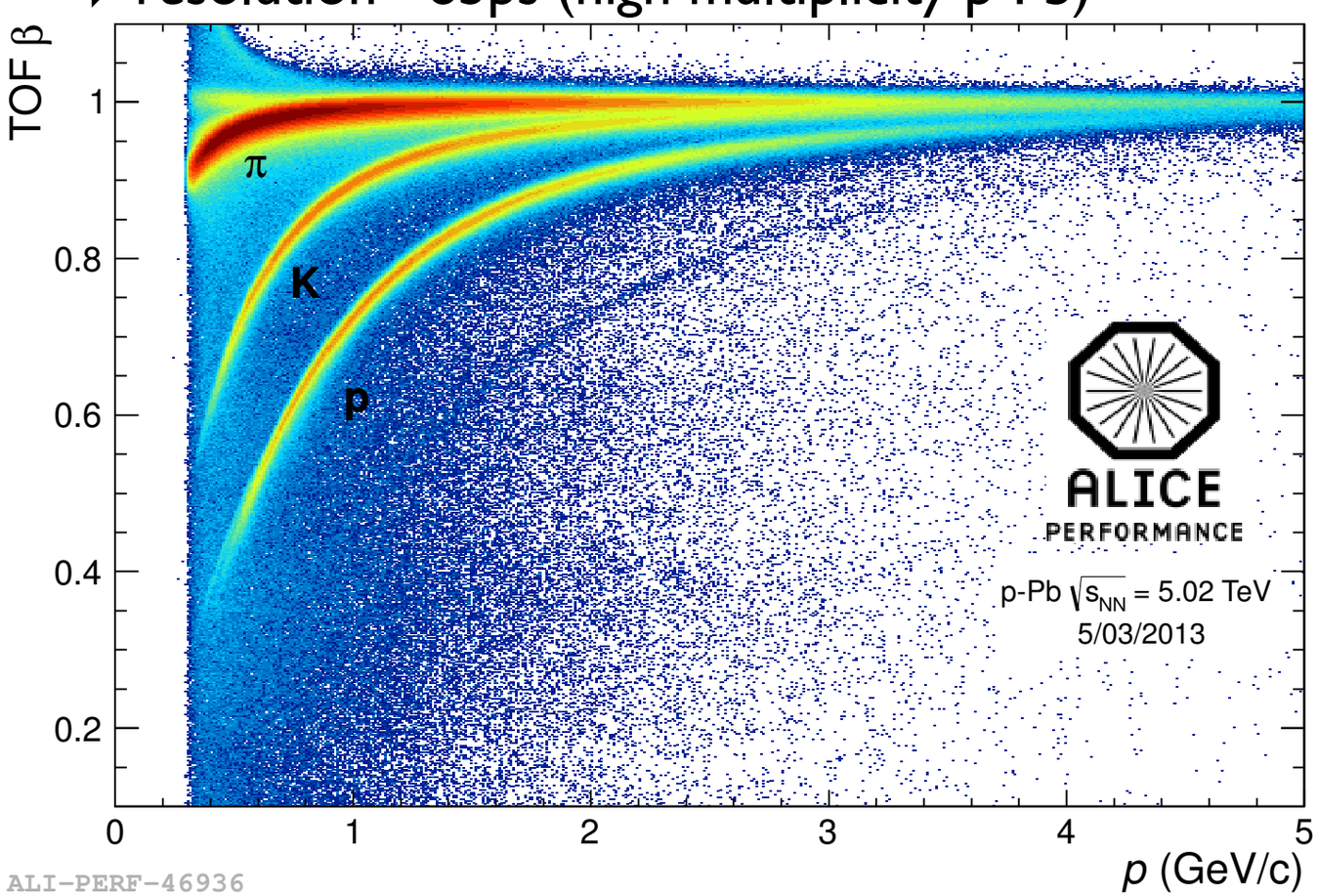

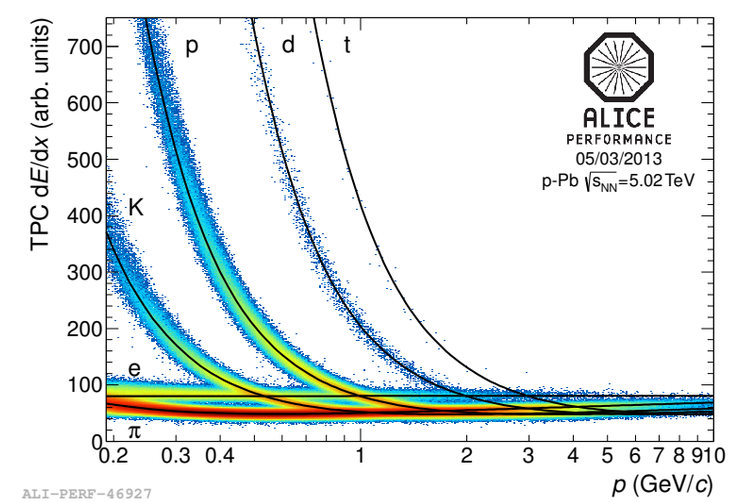

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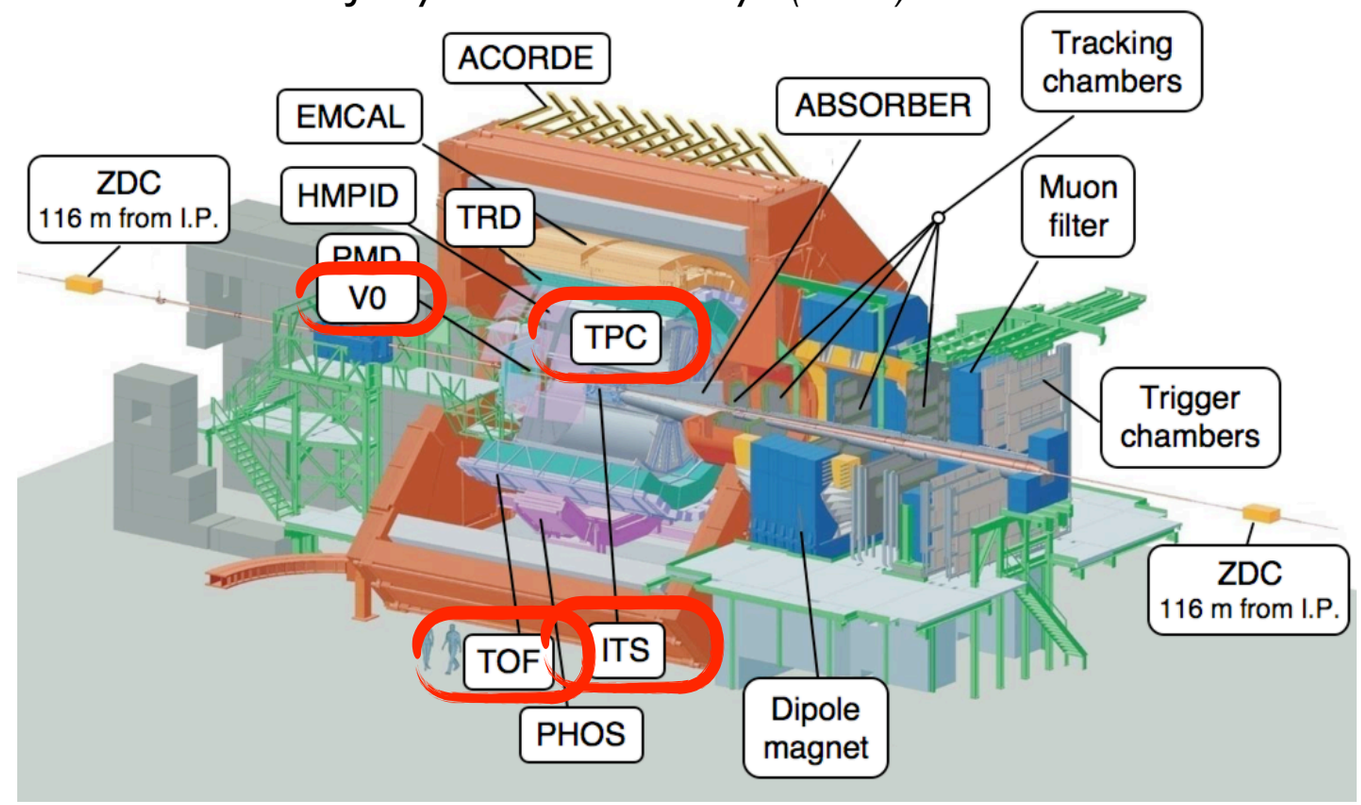
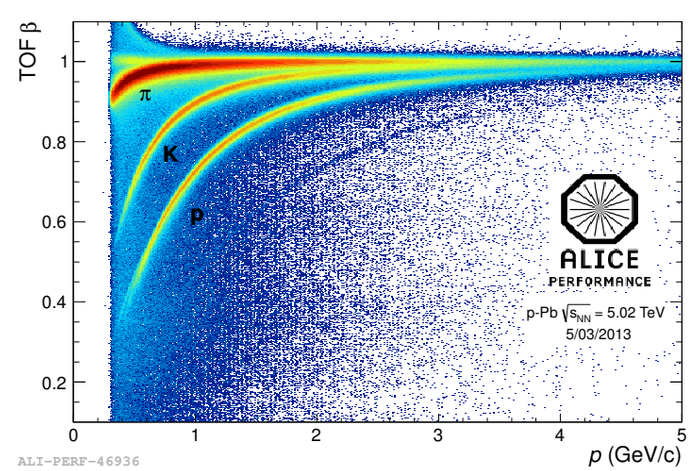
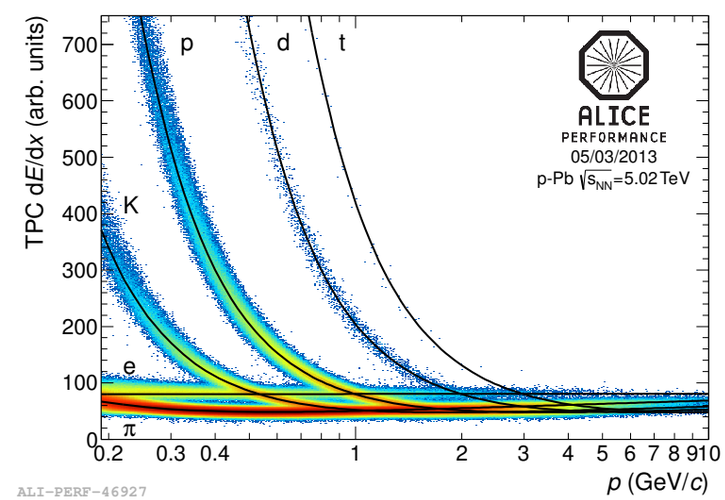
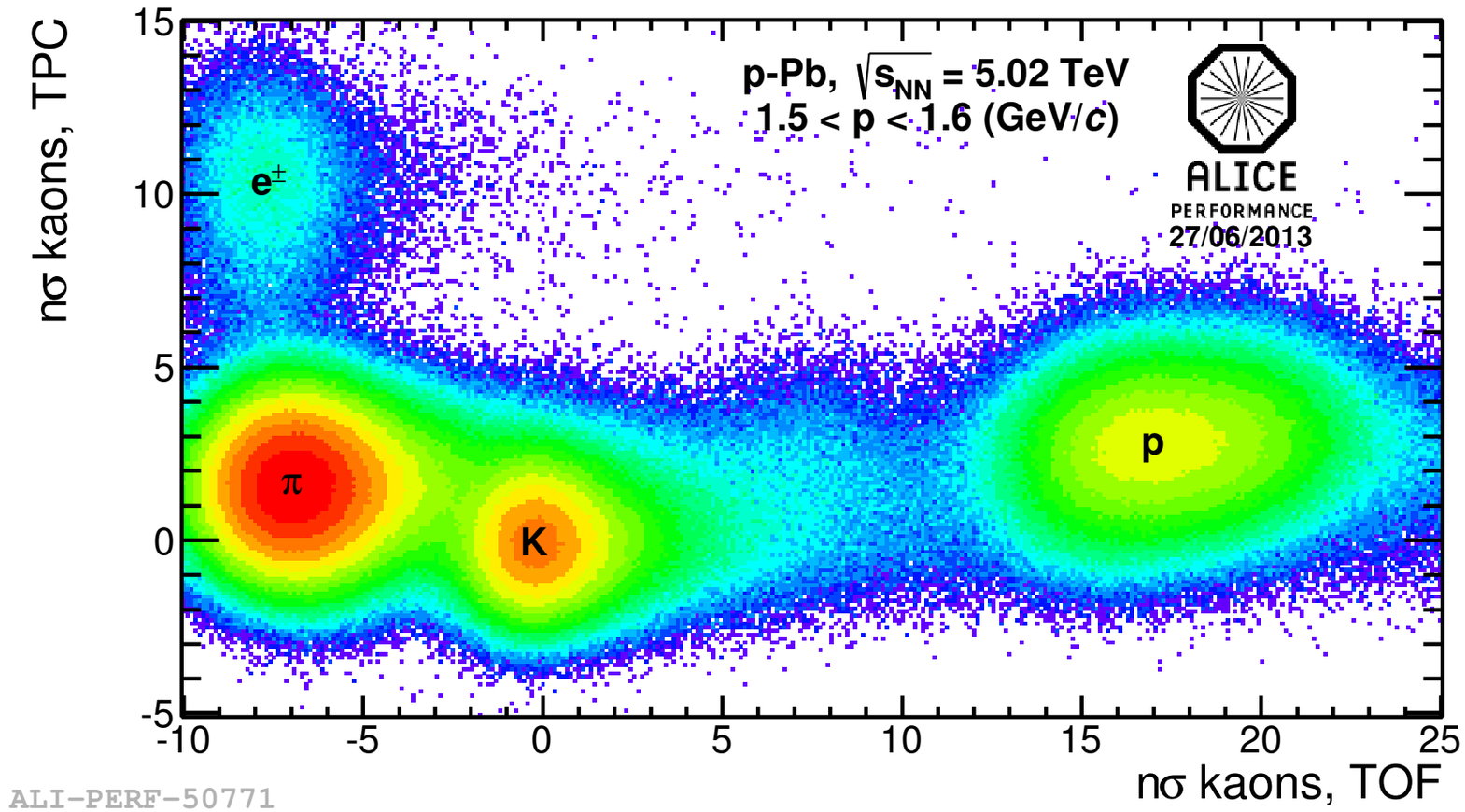
- **VZERO**
  - VZERO A (2.8<η<5.1)
  - VZERO C (-3.7<η<-1.7)
  - trigger, multiplicity selection







Particle identification



$$N^2_{\sigma,\mathrm{PID}} = N^2_{\sigma,\mathrm{TPC}} + N^2_{\sigma,\mathrm{TOF}}$$

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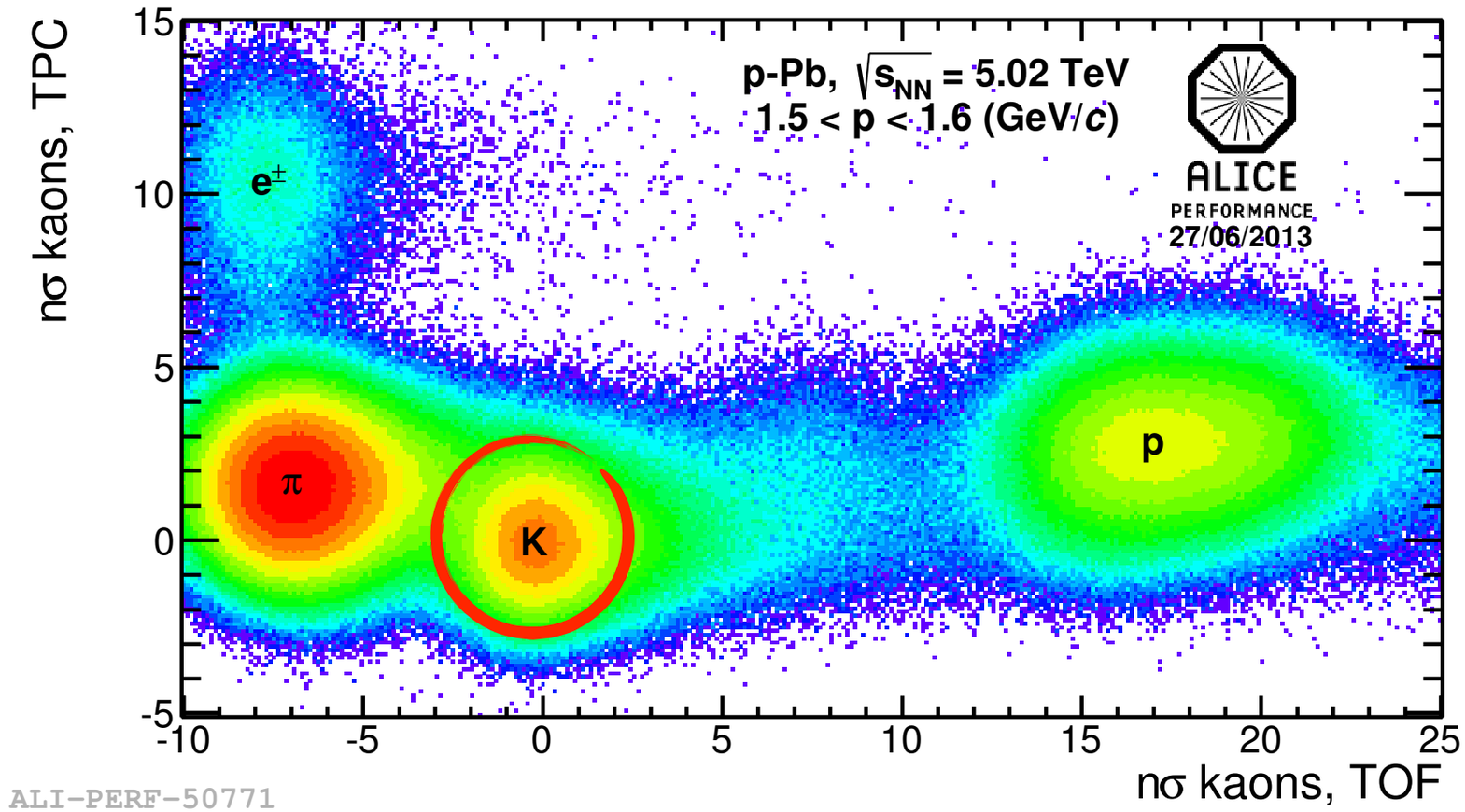

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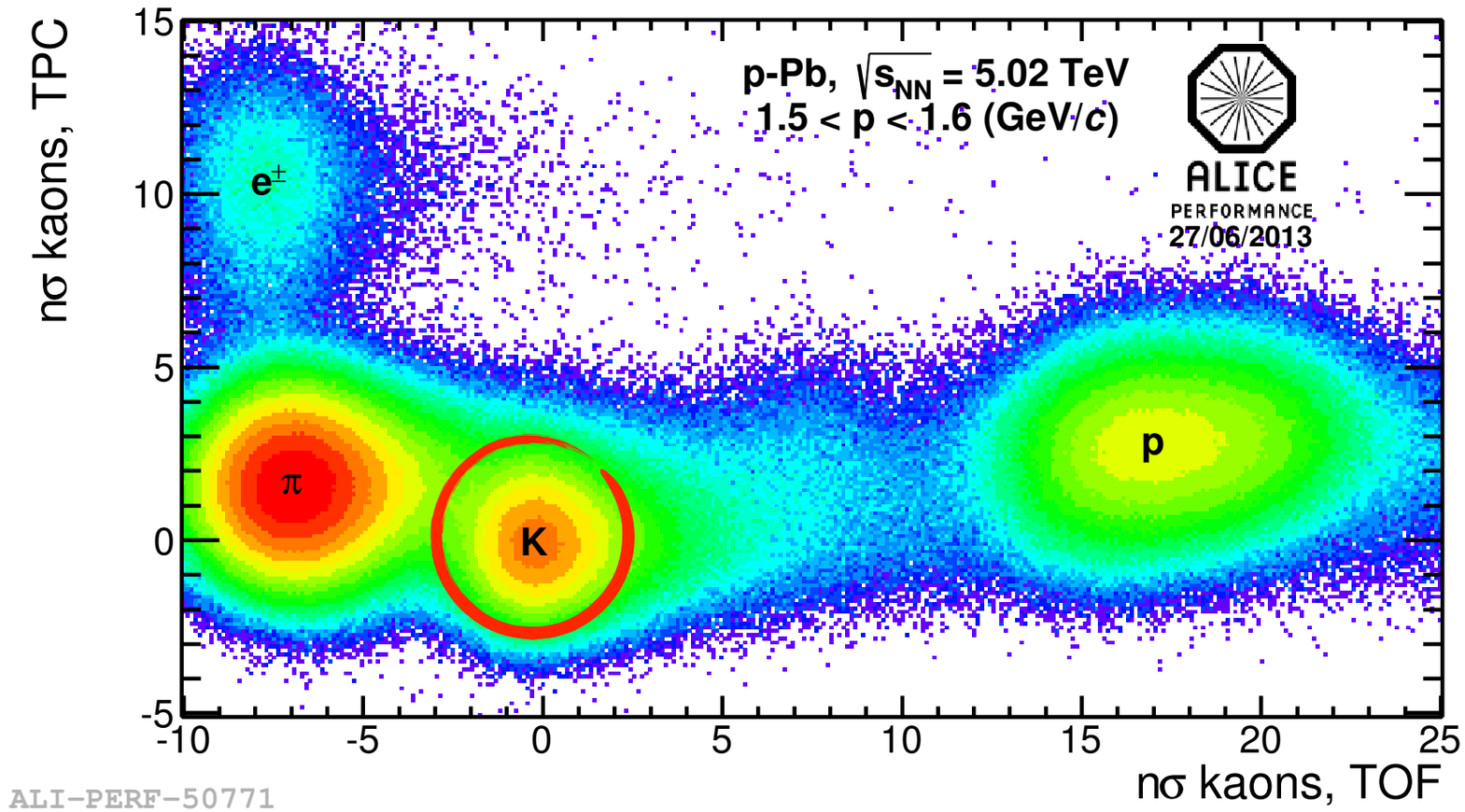

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high (> 85%) purity in the considered p_T range

2PC, event selection

- not easy to define centrality in p-A because of biases *see Andreas Morsch, 25 Jul 2013 at 11:30*

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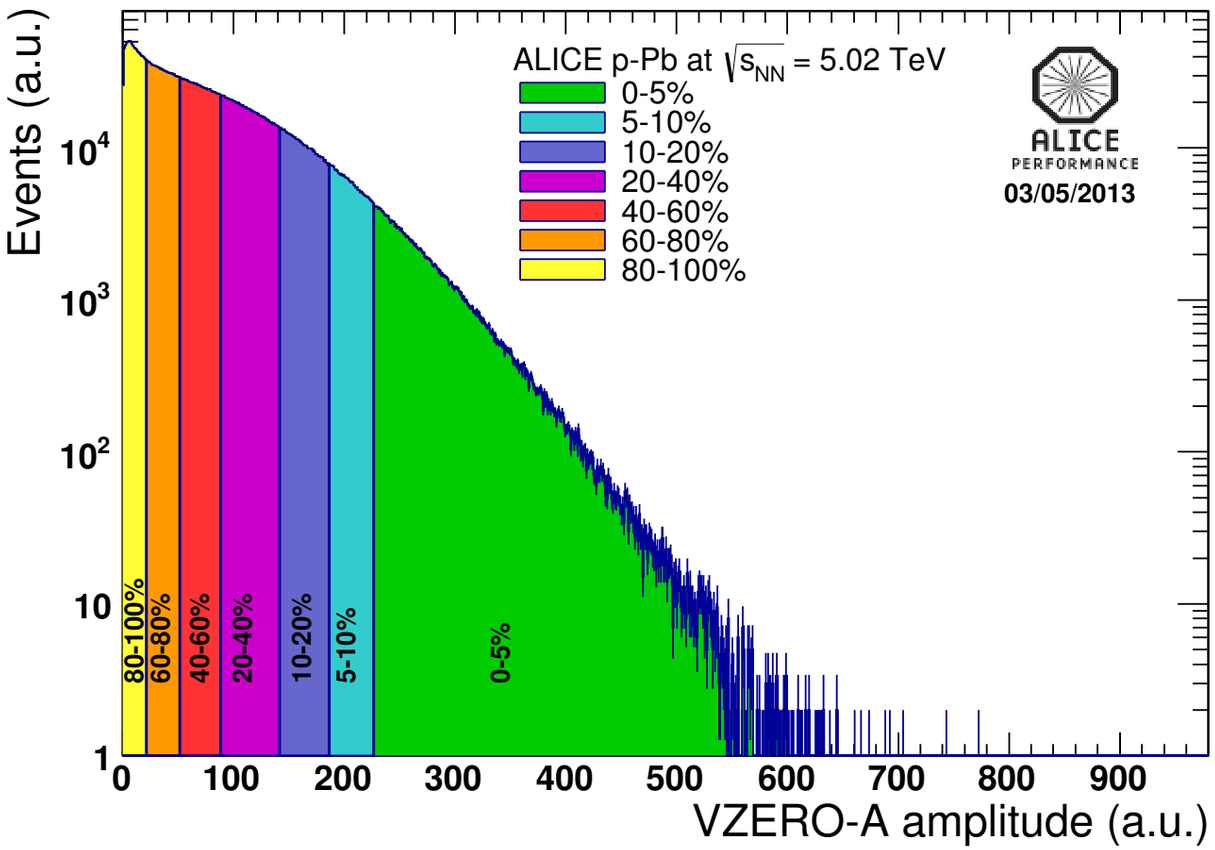

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  - VZERO A in the flight direction of the Pb beam (fragmentation of the nucleus)

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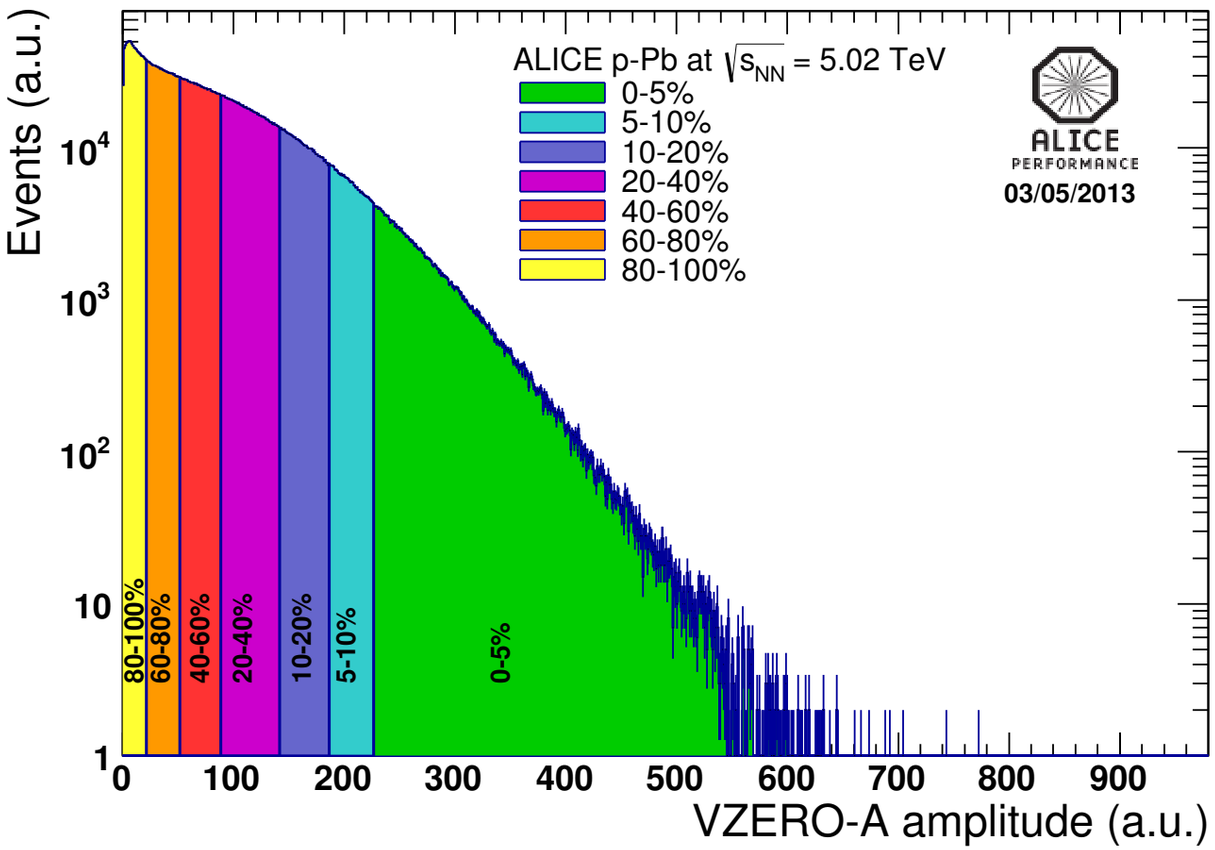

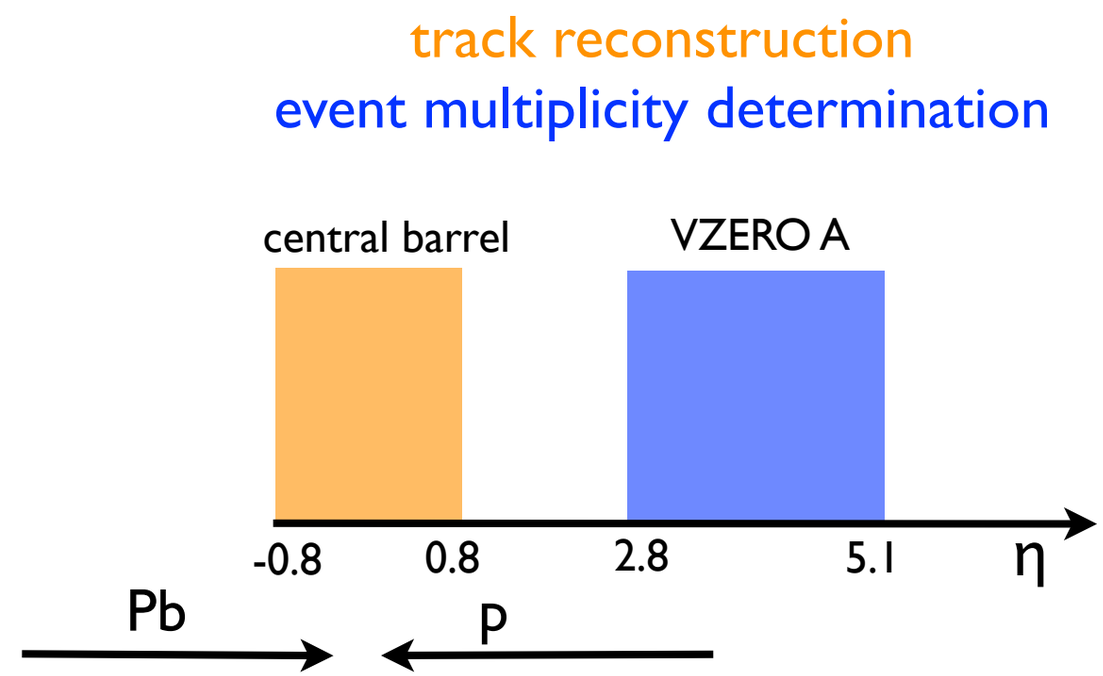

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  - VZERO A in the flight direction of the Pb beam (fragmentation of the nucleus)
  - large η gap between multiplicity determination and track selection

2PC, associated yield

Associated yield per trigger particle

$$\frac{1}{N_{\mathrm{trig}}}\frac{\mathrm{d}^2 N_{\mathrm{assoc}}}{\mathrm{d}\Delta\eta\,\mathrm{d}\Delta\varphi} = \frac{S(\Delta\eta,\Delta\varphi)}{B(\Delta\eta,\Delta\varphi)}$$

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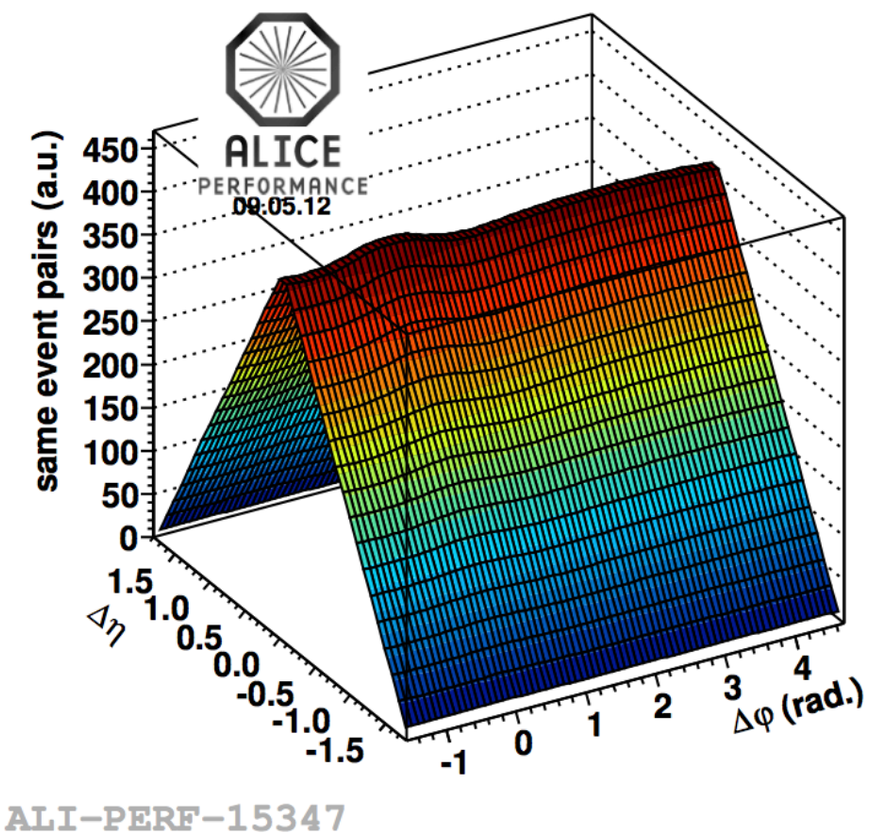
- S(Δη,ΔΦ) from same events



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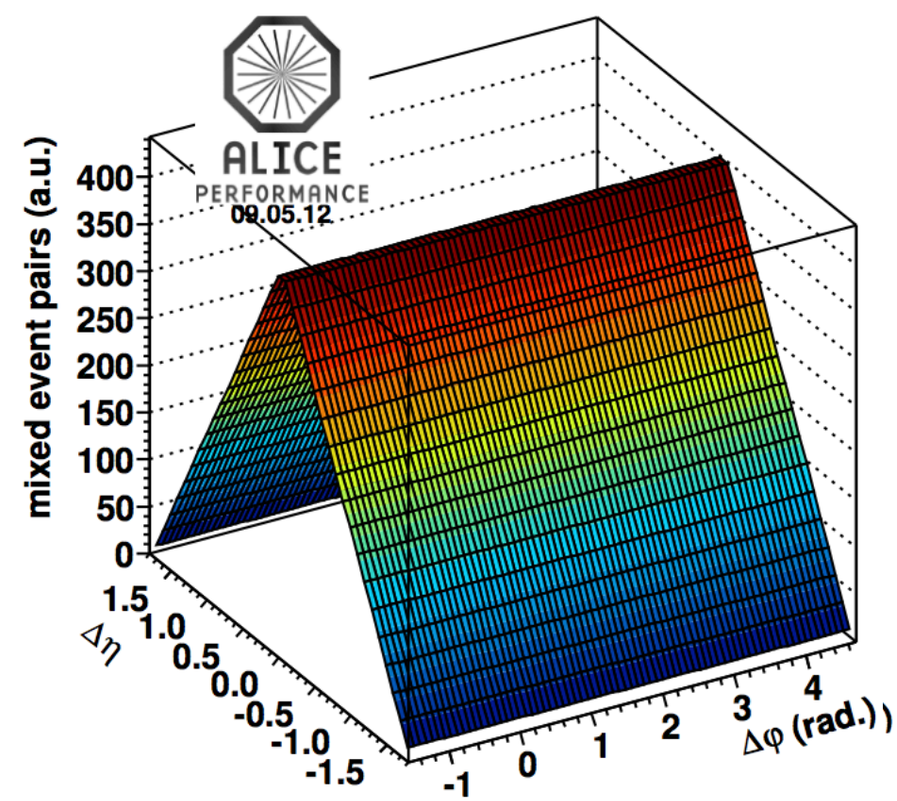
$$B(\Delta\eta,\Delta\varphi)=\alpha\ \mathrm{d}^2N_{\mathrm{mixed}}/\mathrm{d}\Delta\eta\,\mathrm{d}\Delta\varphi$$

- S(Δη,ΔΦ) from same events
- B(Δη,ΔΦ) from mixed events (normalized such that B(0,0)=1)



2PC, associated yield

Associated yield per trigger particle

$$\frac{1}{N_{\mathrm{trig}}}\frac{\mathrm{d}^2N_{\mathrm{assoc}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi}=\frac{S(\Delta\eta,\Delta\varphi)}{B(\Delta\eta,\Delta\varphi)}$$

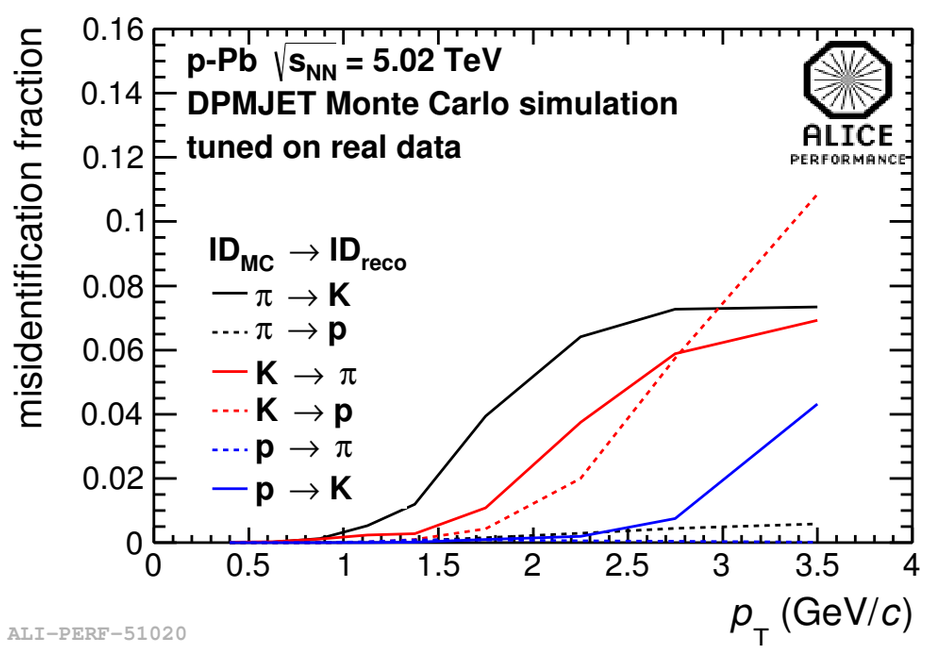
$$S(\Delta\eta,\Delta\varphi)=1/N_{\mathrm{trig}}\ \mathrm{d}^2N_{\mathrm{same}}/\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi$$

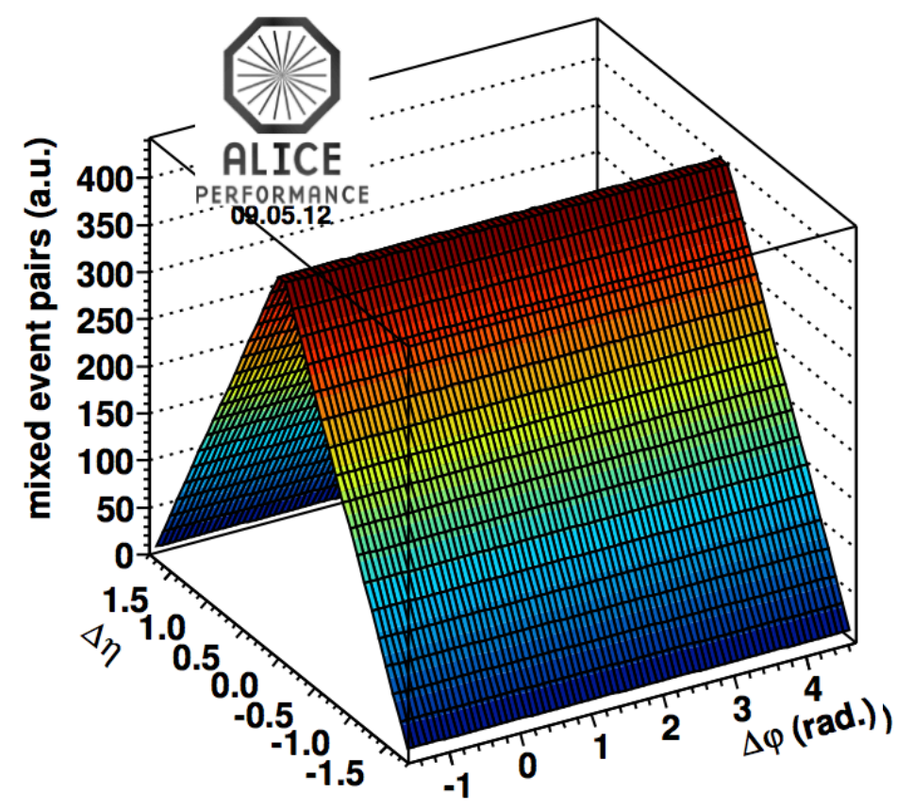
$$B(\Delta\eta,\Delta\varphi)=\alpha\ \mathrm{d}^2N_{\mathrm{mixed}}/\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi$$

- S(Δη,ΔΦ) from same events
- B(Δη,ΔΦ) from mixed events (normalized such that B(0,0)=1)

- tracking efficiency and contamination from secondary particles as single particle weights
- data driven correction for misidentification:

$$Y^{K}_{corrected}(\Delta\eta,\Delta\phi)=Y^{K}_{measured}(\Delta\eta,\Delta\phi)-\alpha_{\pi\to K}Y^{\pi}_{measured}(\Delta\eta,\Delta\phi)$$





2PC, Fourier coefficients

trigger particle: unidentified hadron
associated particle: identified particle → same p_T interval

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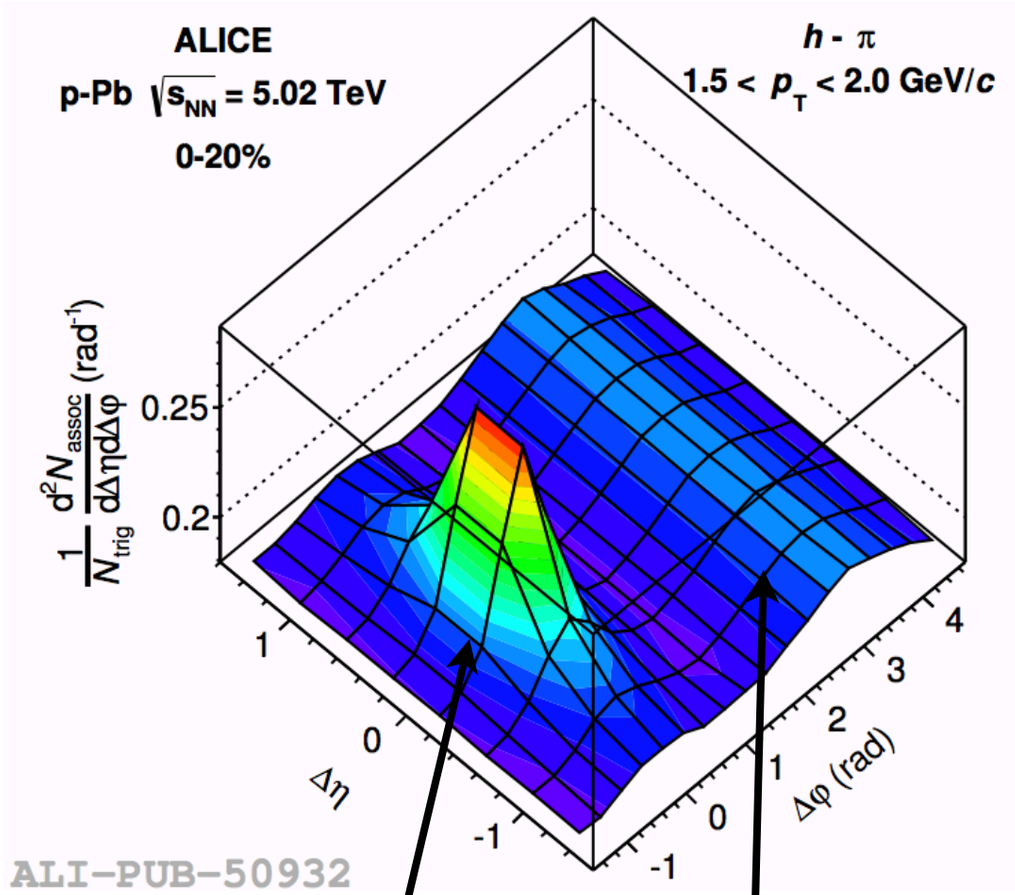

Near side jet peak

Away side recoil-jet peak

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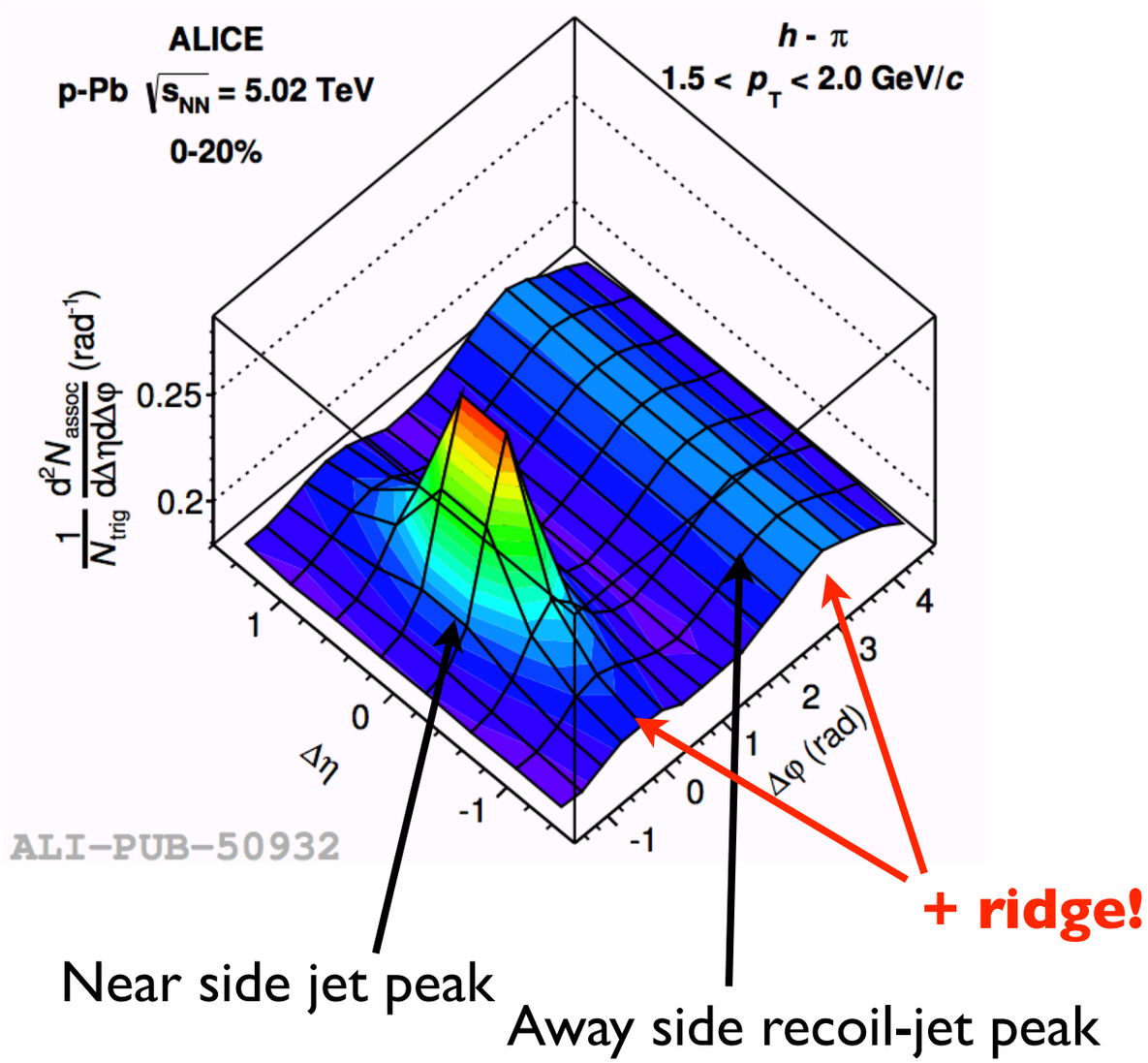

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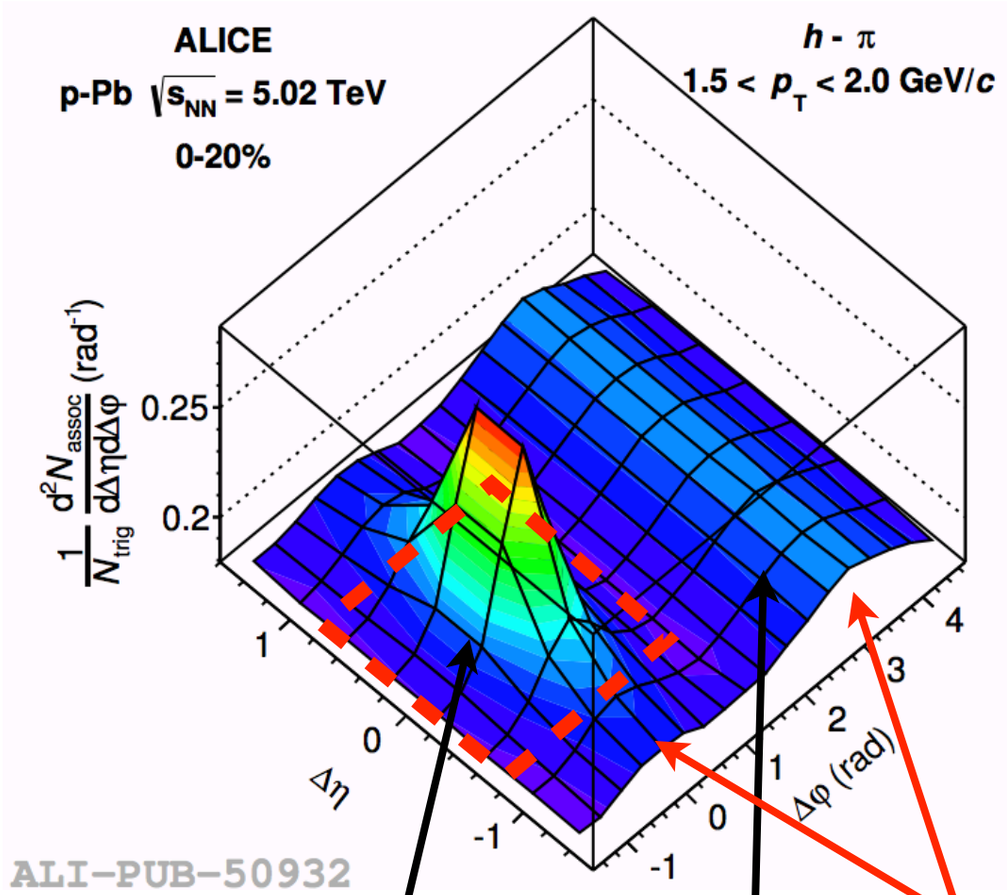
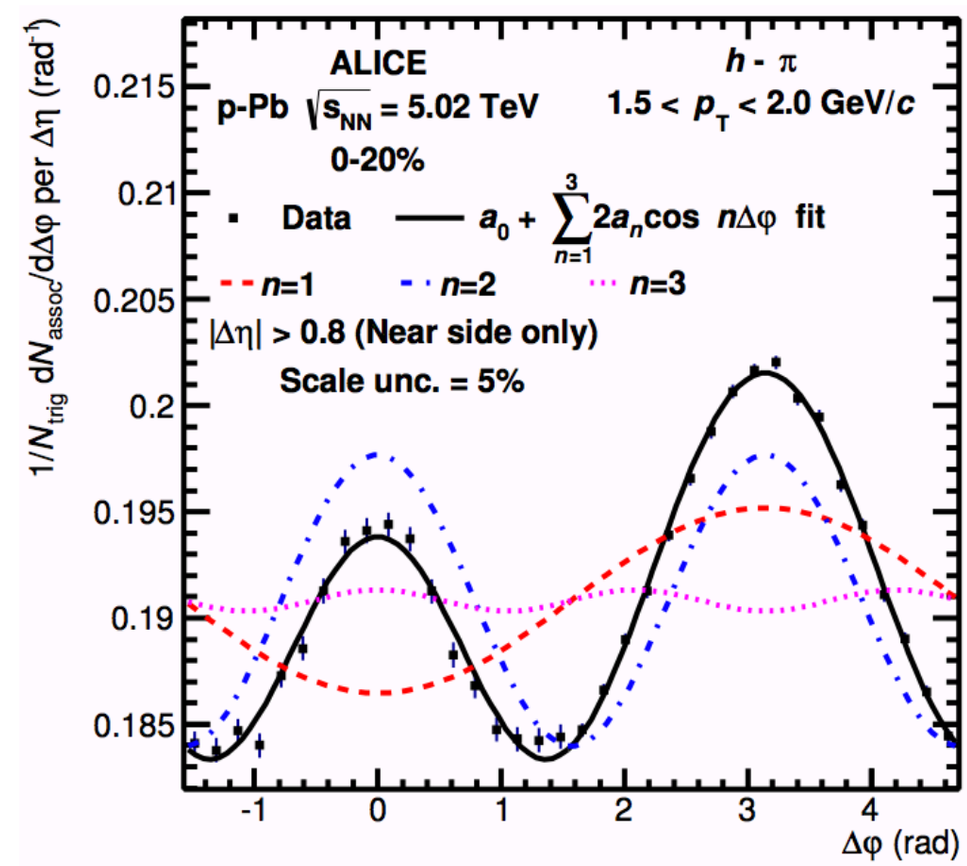


Jet peak in the near side excluded ($\Delta\eta$<0.8) →



+ ridge!

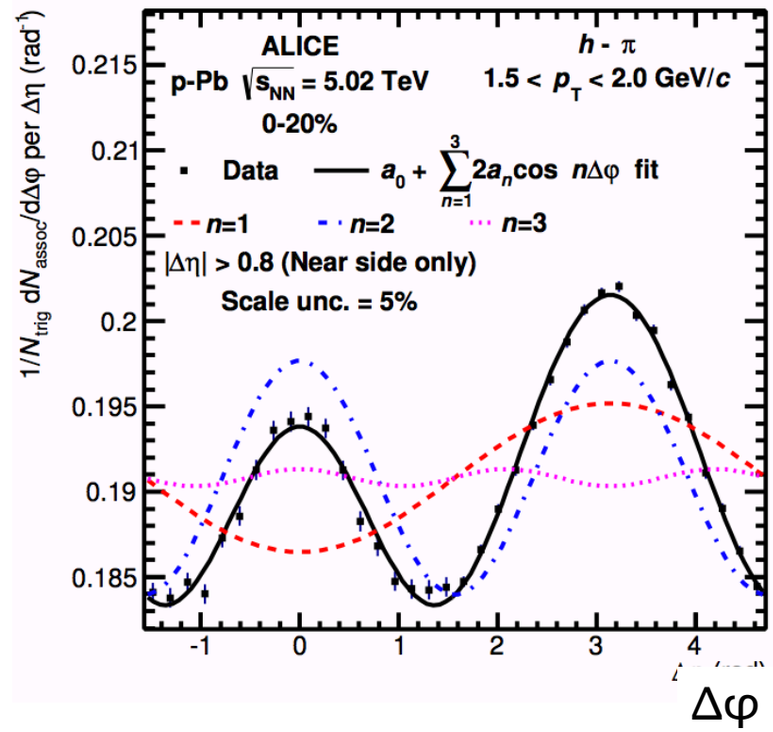
Near side jet peak

Away side recoil-jet peak

good fit with 3 components:
- first component large due to recoil jet
- a_2 given by jet+ridge
- a_3 much smaller than the other coefficients

2PC, v_2 coefficients

From a_2 we get v_2: $V_{n\Delta}^{h-i}\{2PC\} = a_n^{h-i}/a_0^{h-i}$ $v_n^i\{2PC\} = V_{n\Delta}^{h-i}/\sqrt{V_{n\Delta}^{h-h}}$



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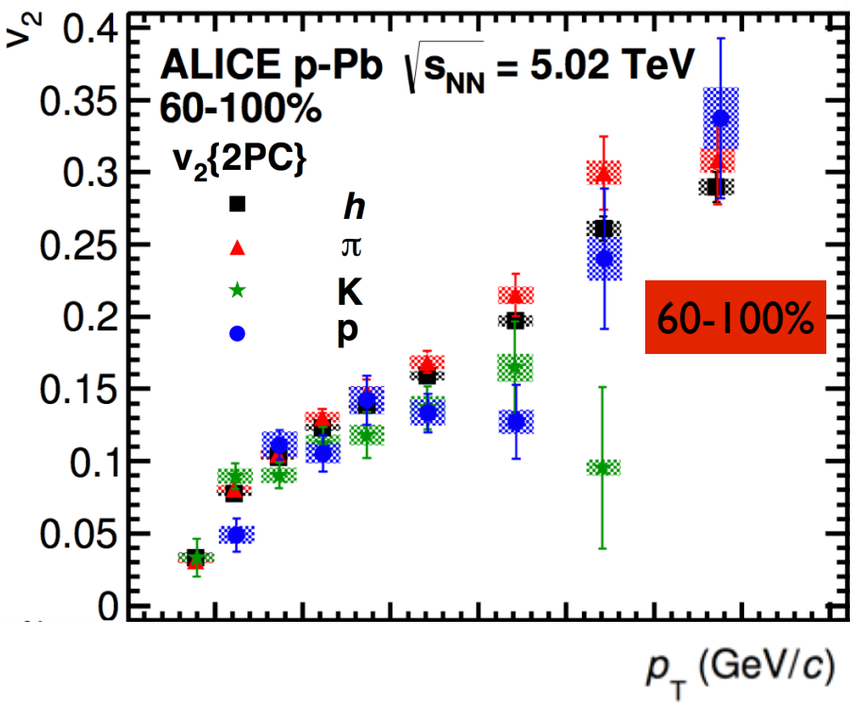

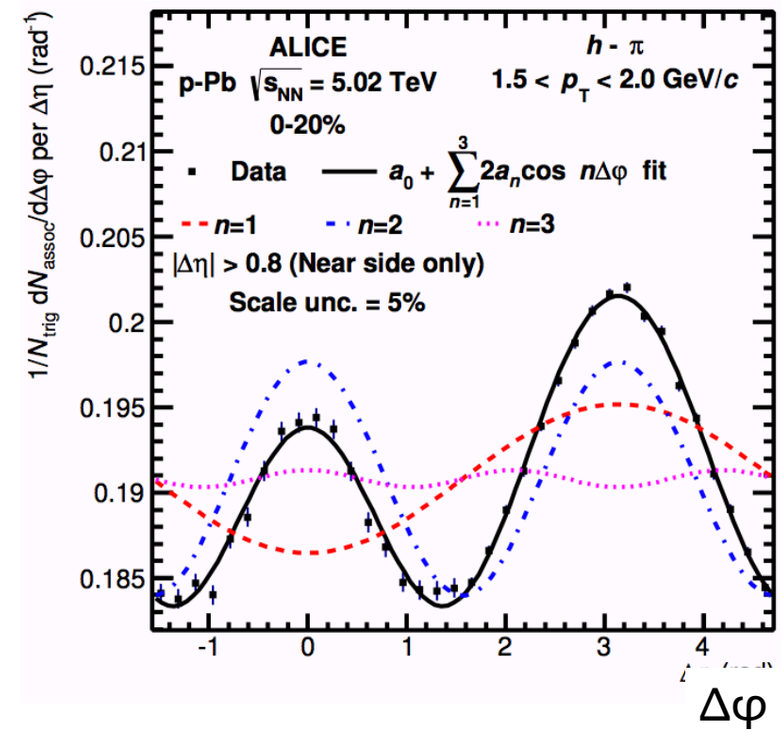

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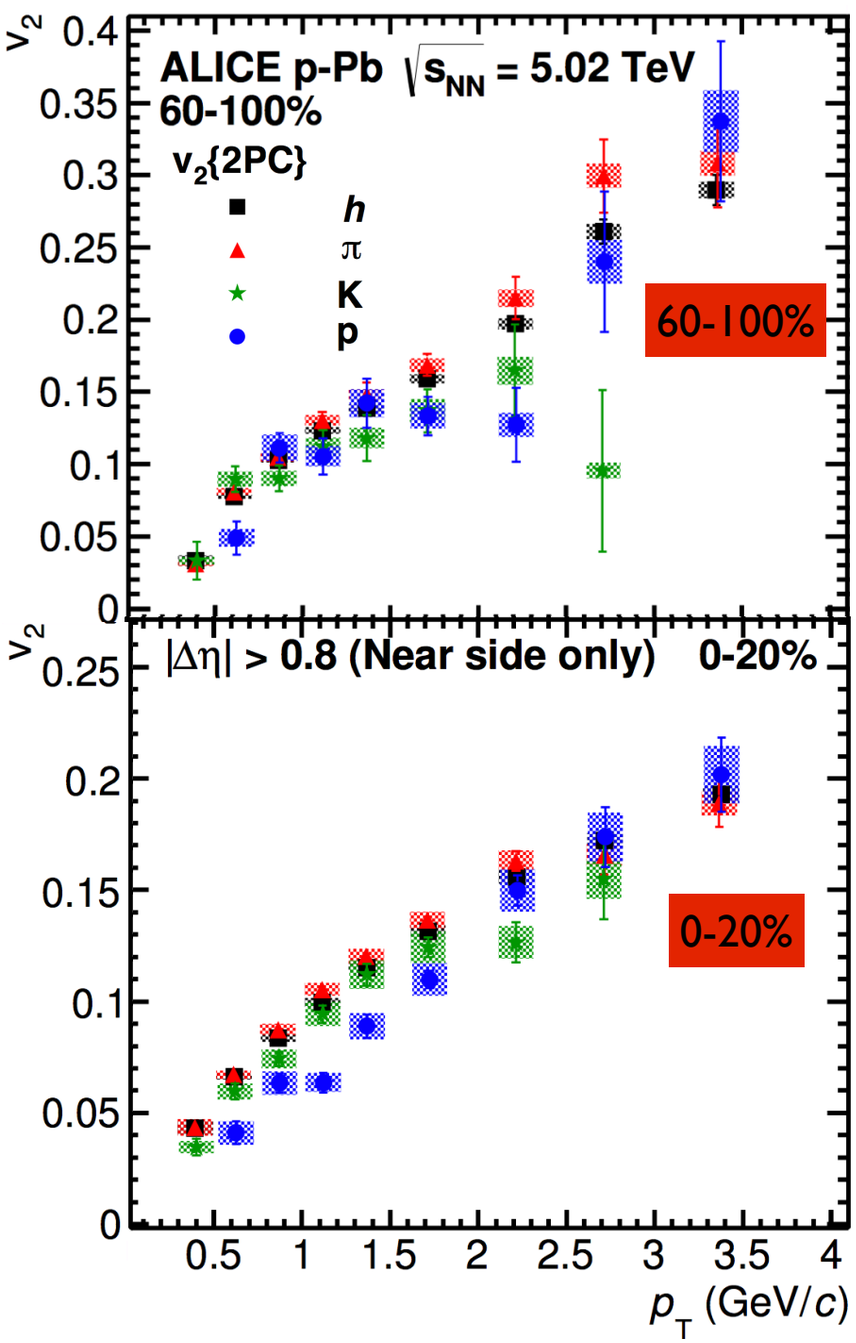

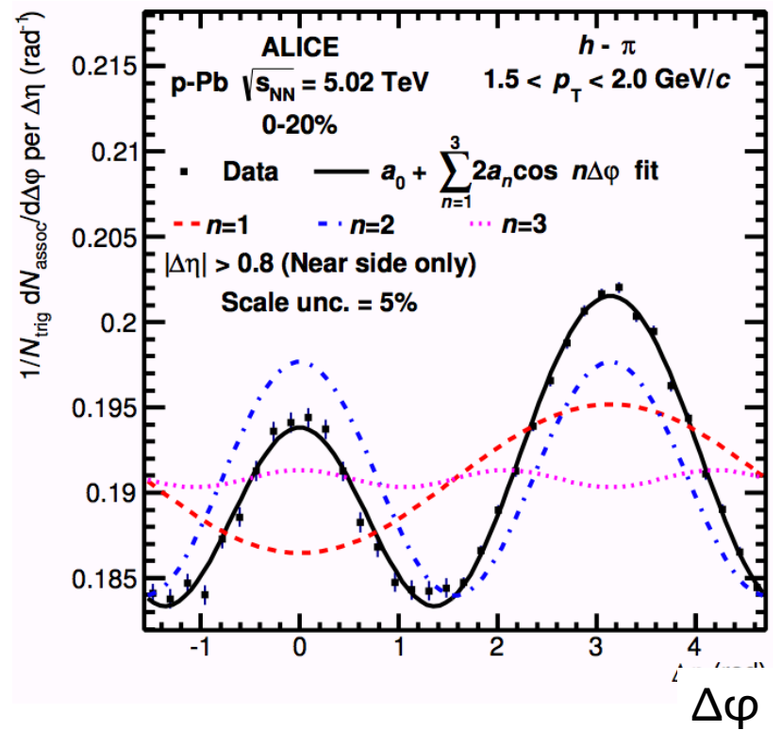

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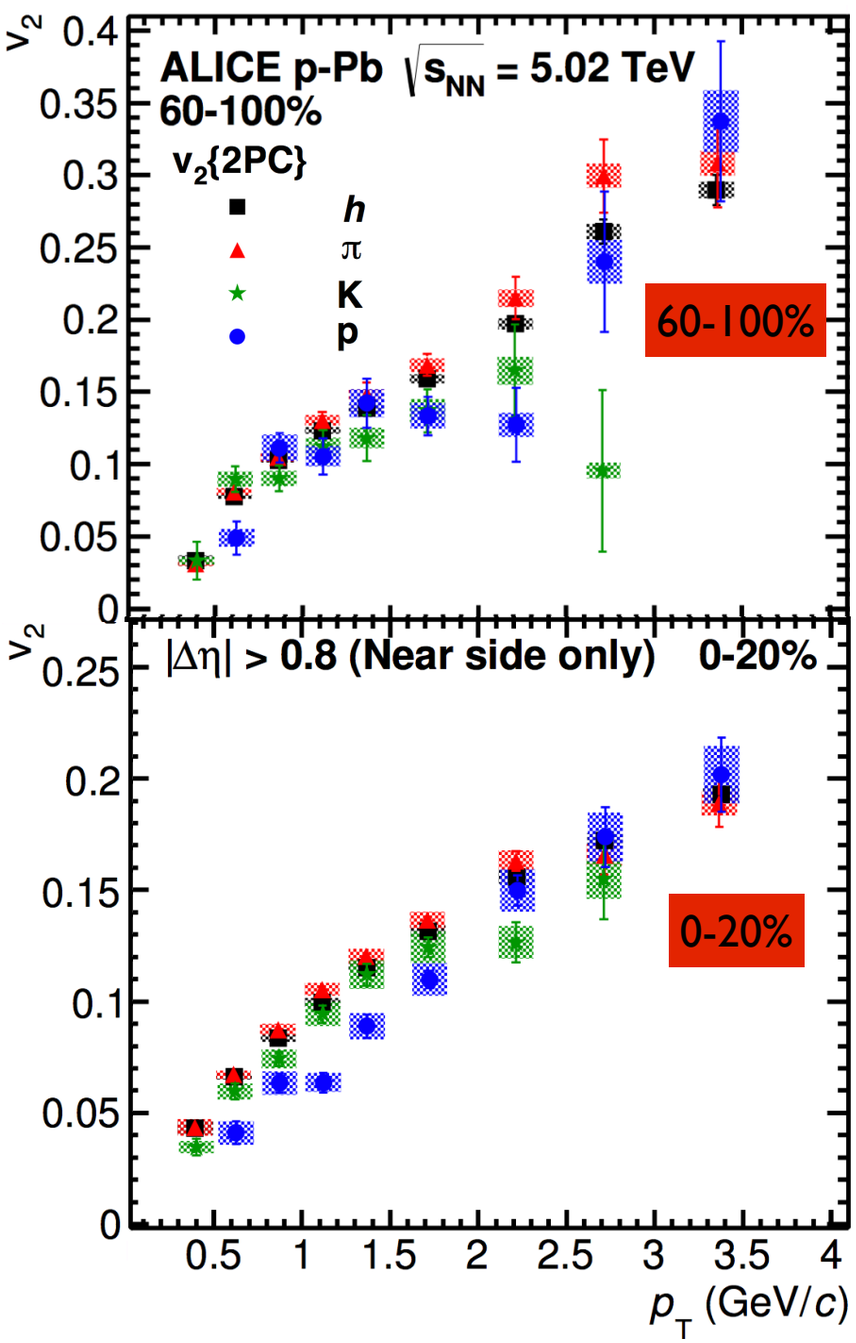

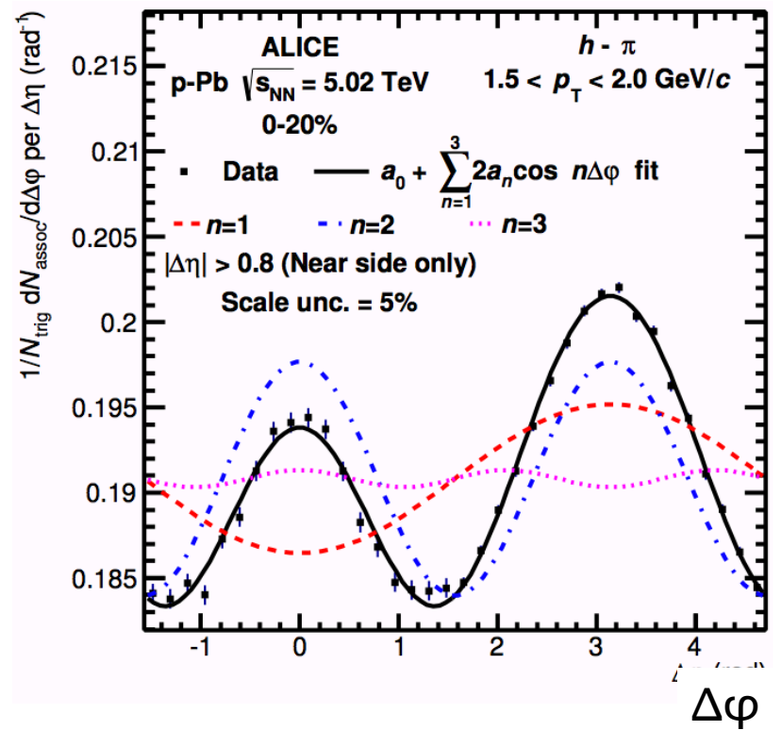

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...But we can do more...

2PC, the subtraction procedure

jet contribution reduced assuming:

- Mostly jet contribution (i.e. no significant ridge) in low multiplicity p-Pb events

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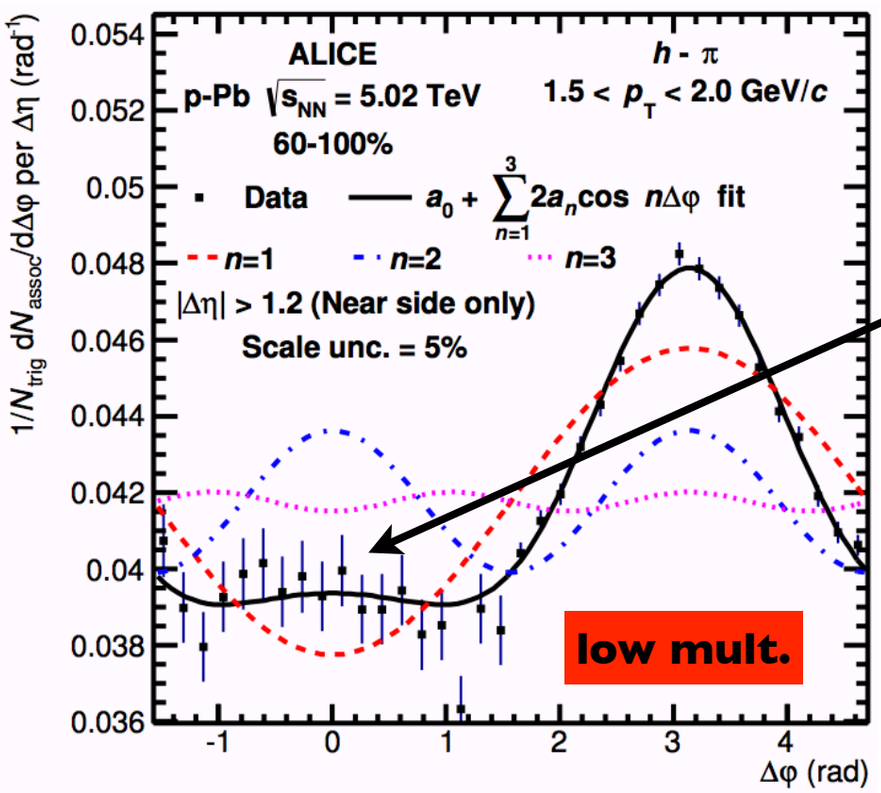

No significant ridge in 60-100%

ALICE, arXiv:1307.3237 [nucl-ex]

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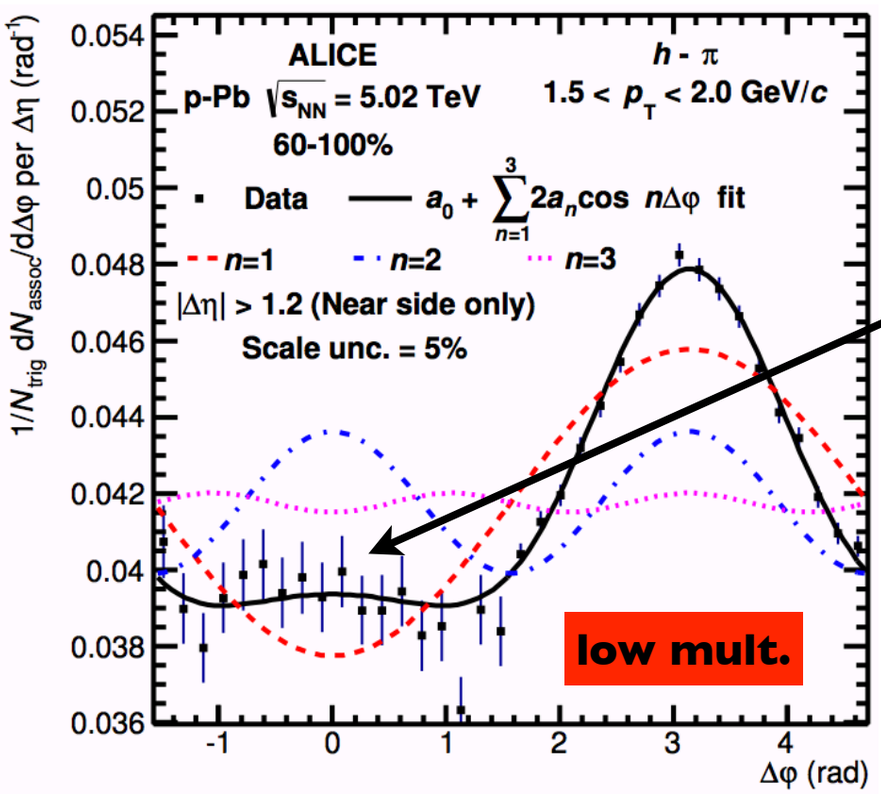

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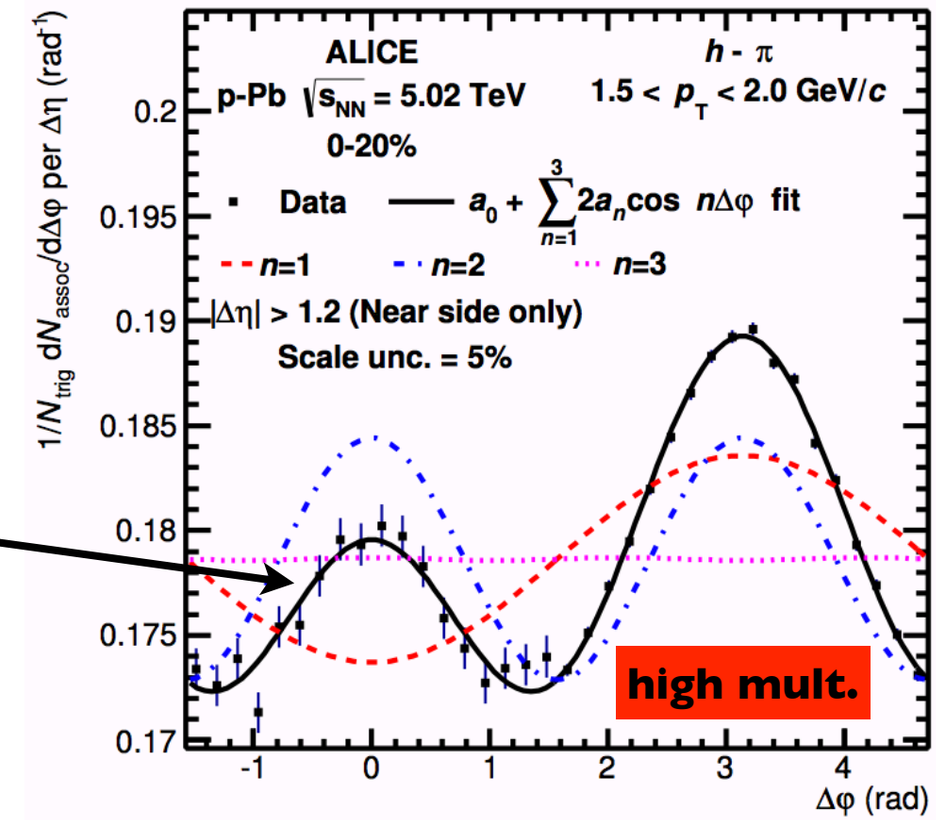
Not the case for 0-20%



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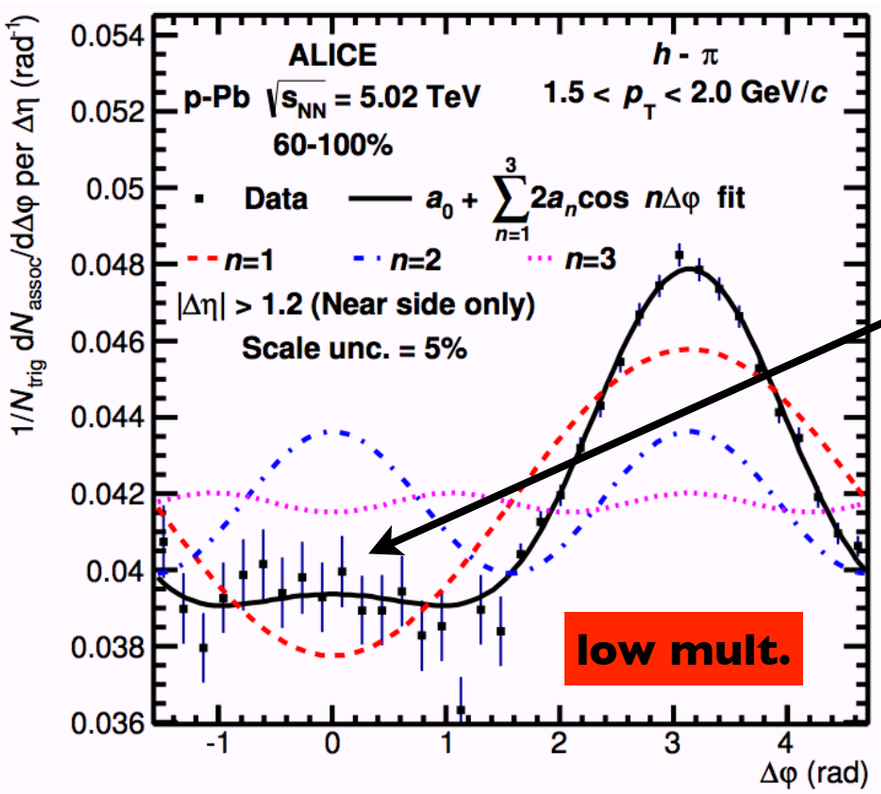

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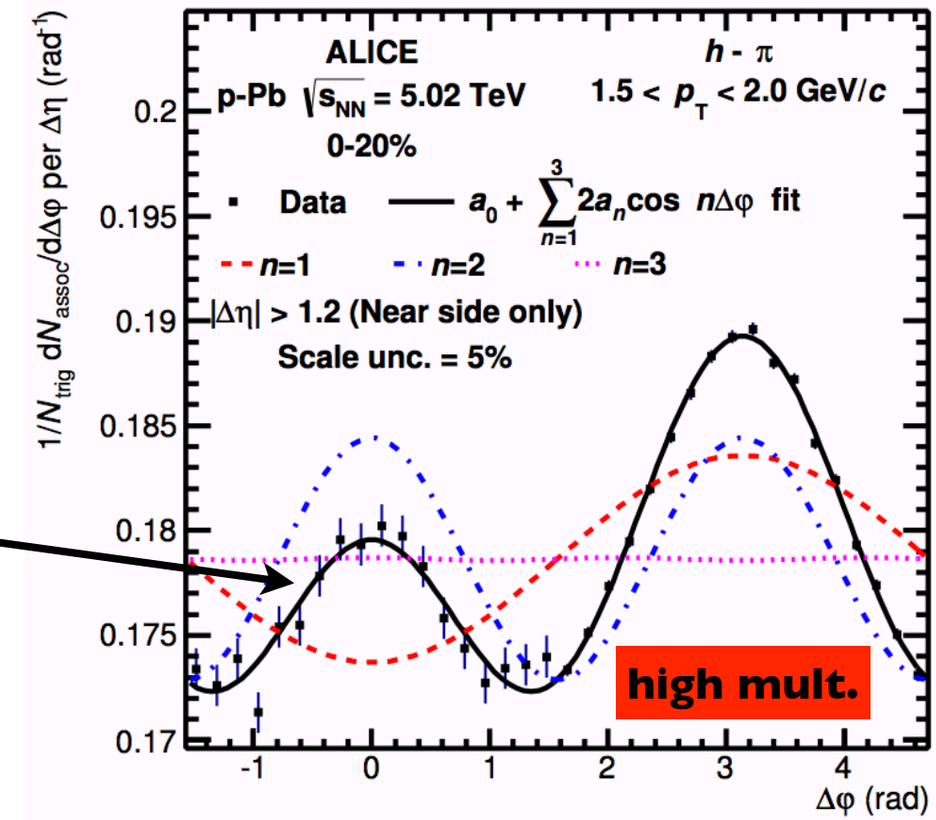

- per-trigger jet contribution independent of the event multiplicity

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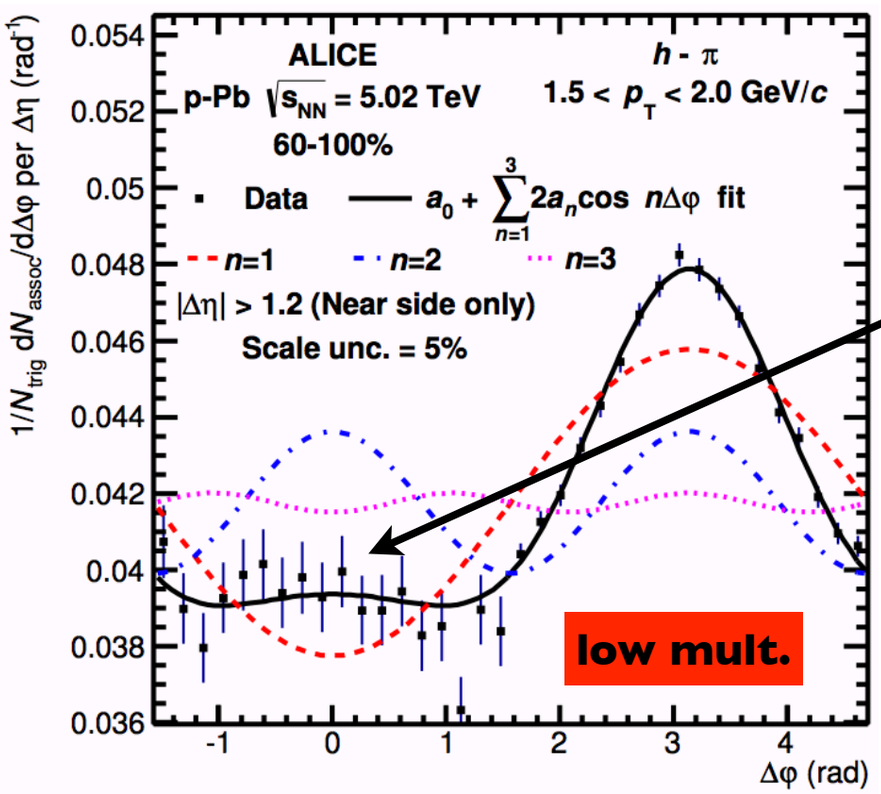

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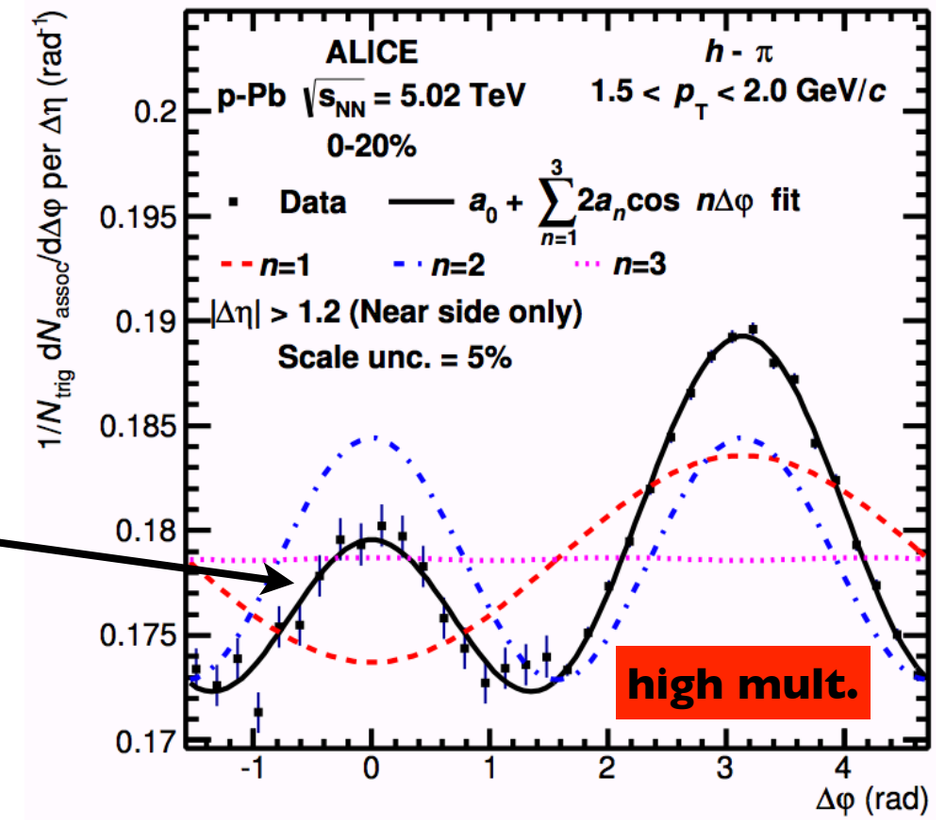

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high multiplicity (0-20%) - low multiplicity(60-100%)

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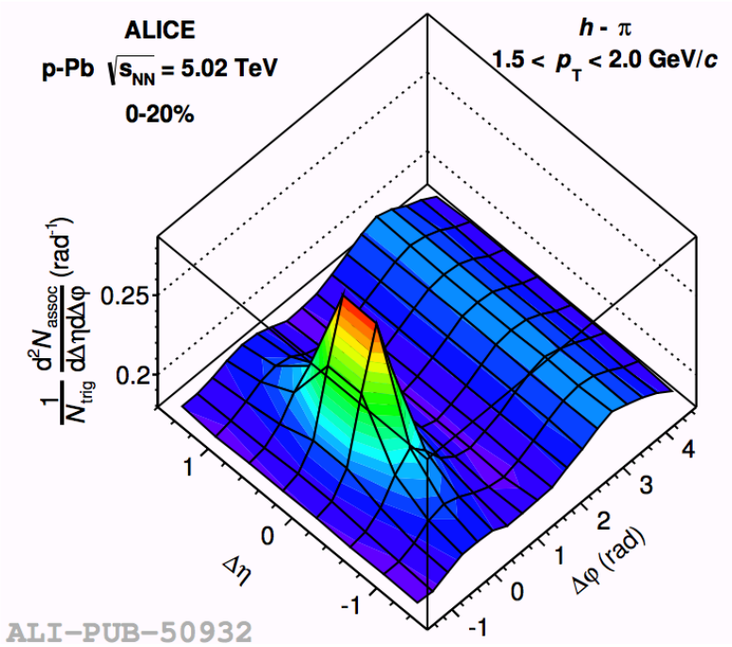

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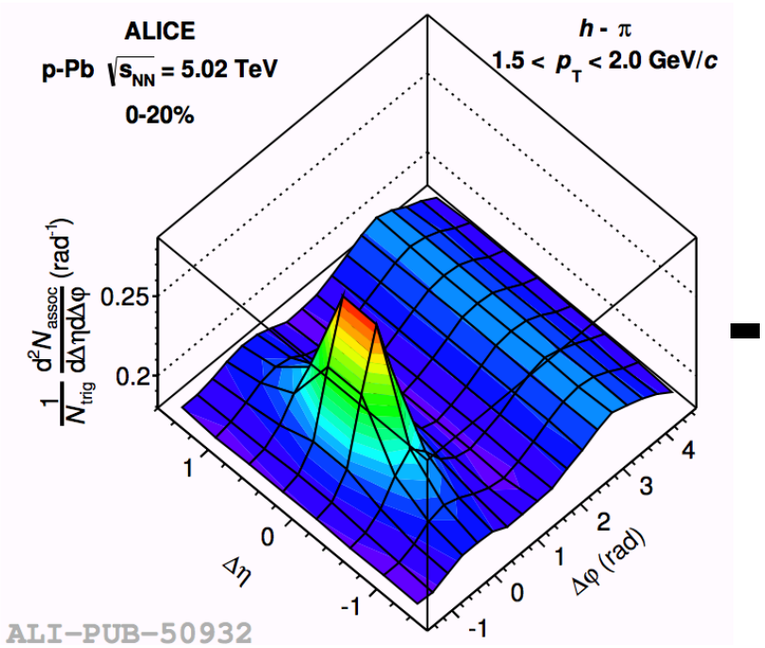

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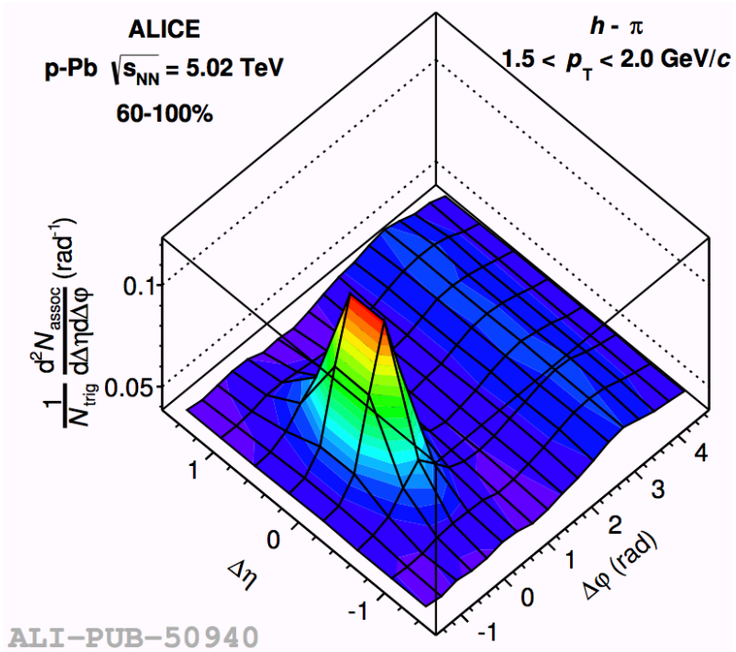

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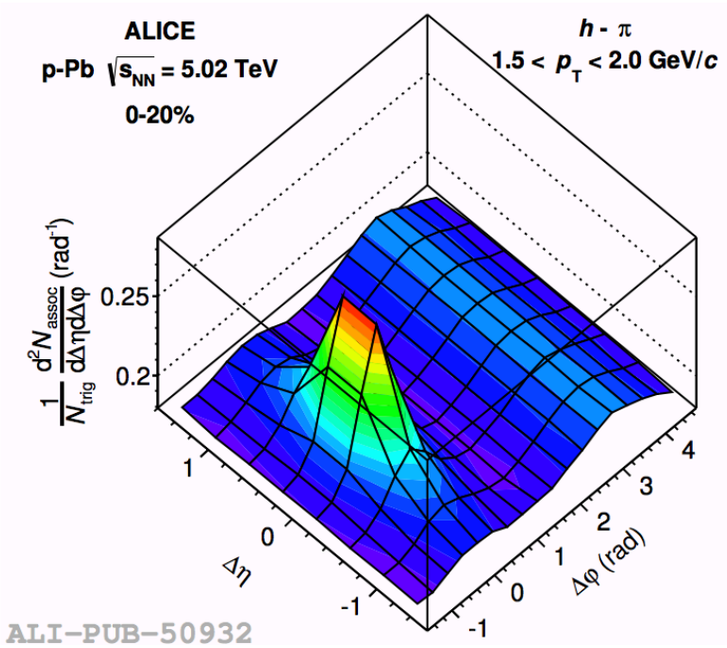

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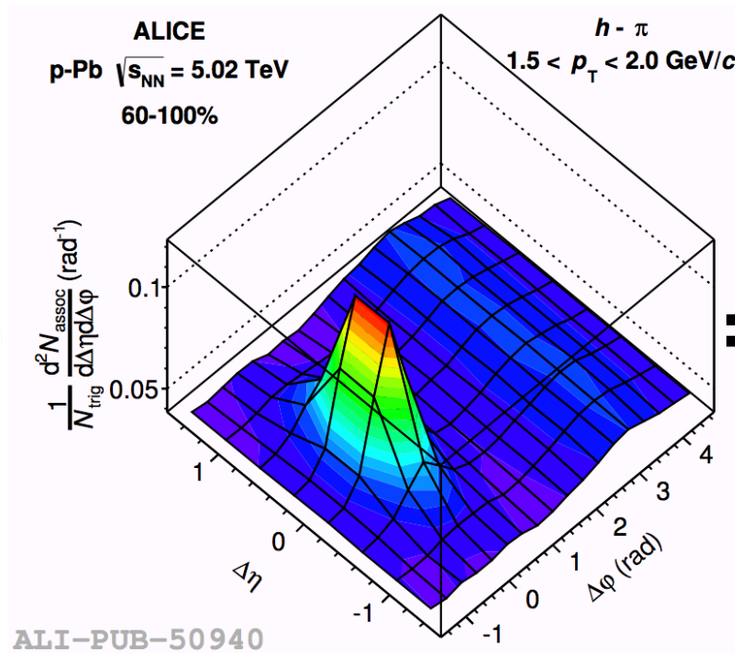

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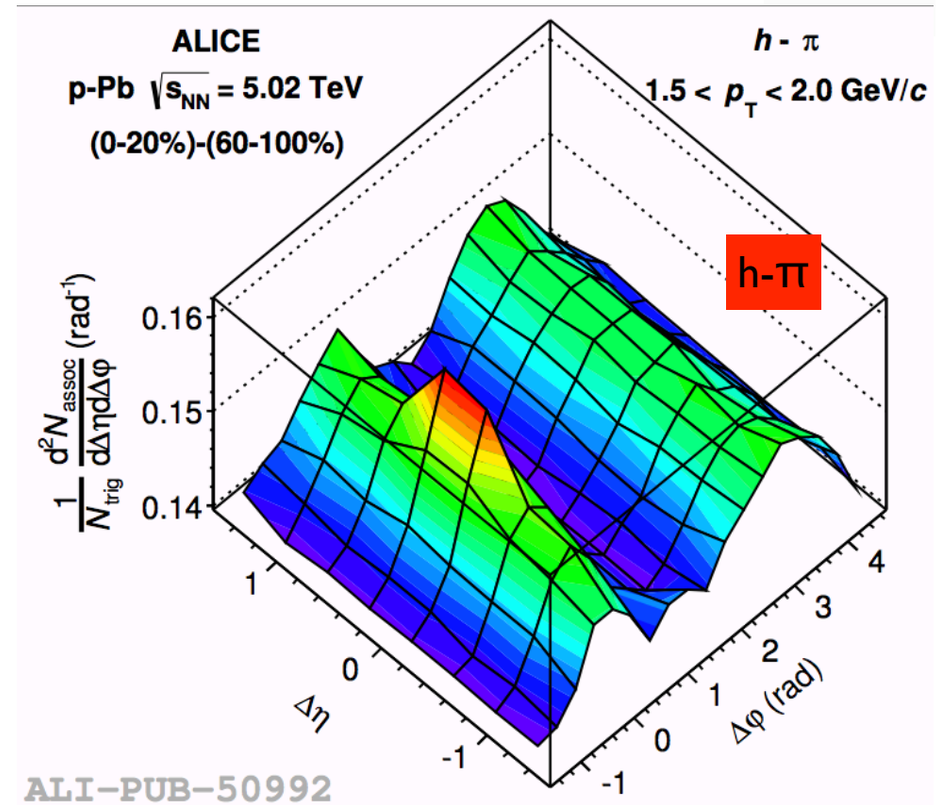
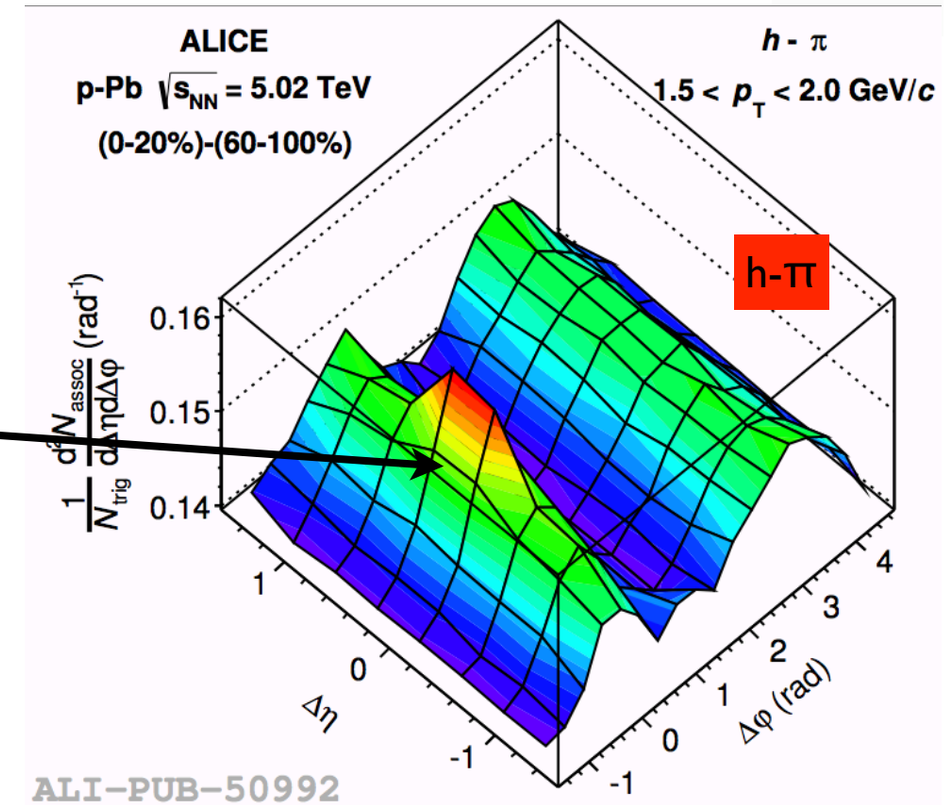


2PC, the subtraction procedure

residual of jet, particularly important for pions
- most likely event selection bias on jet fragmentation
- excluded on the near side (|Δη|>0.8)
- systematic on the away side taken into account



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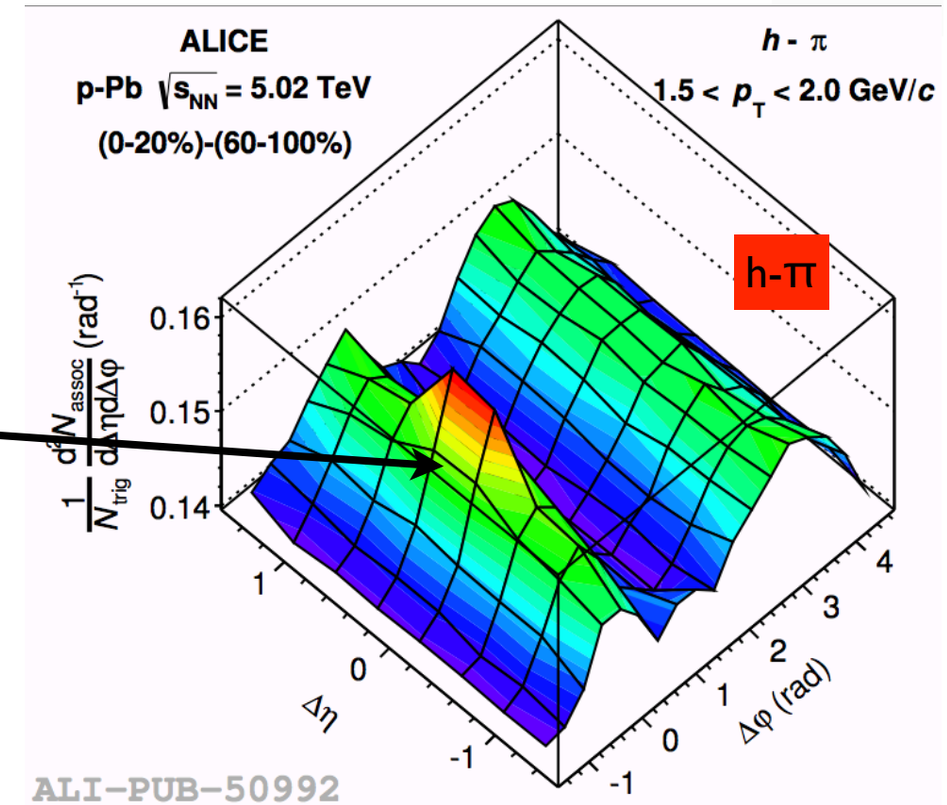

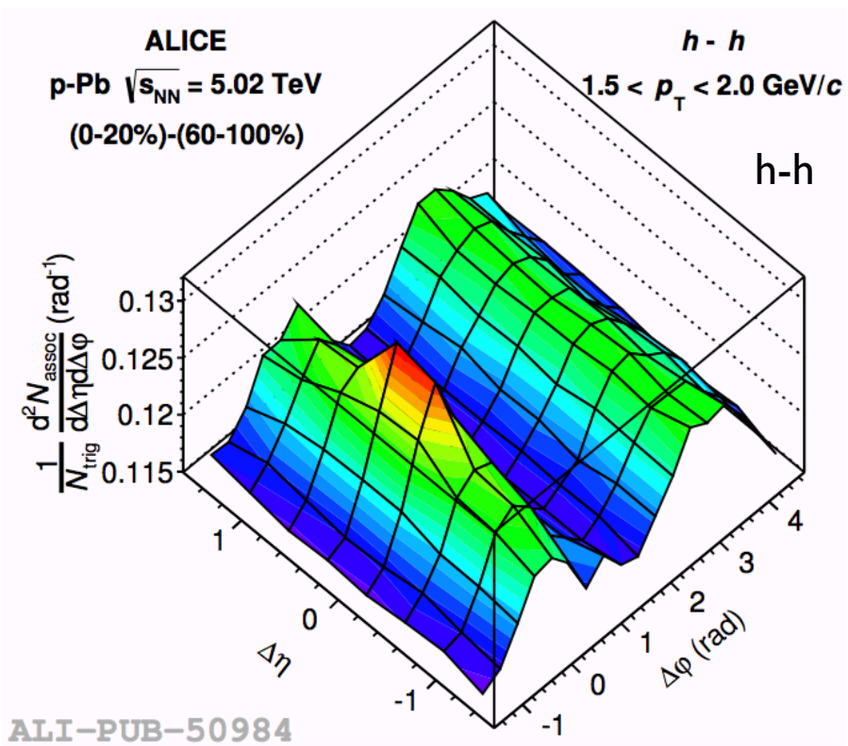

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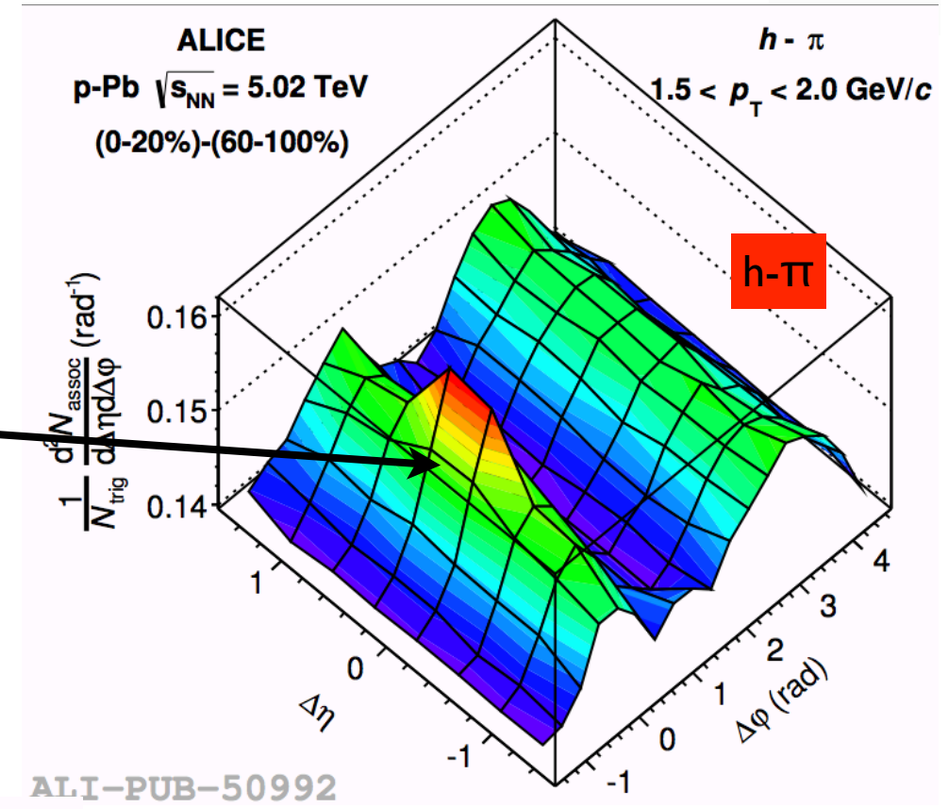

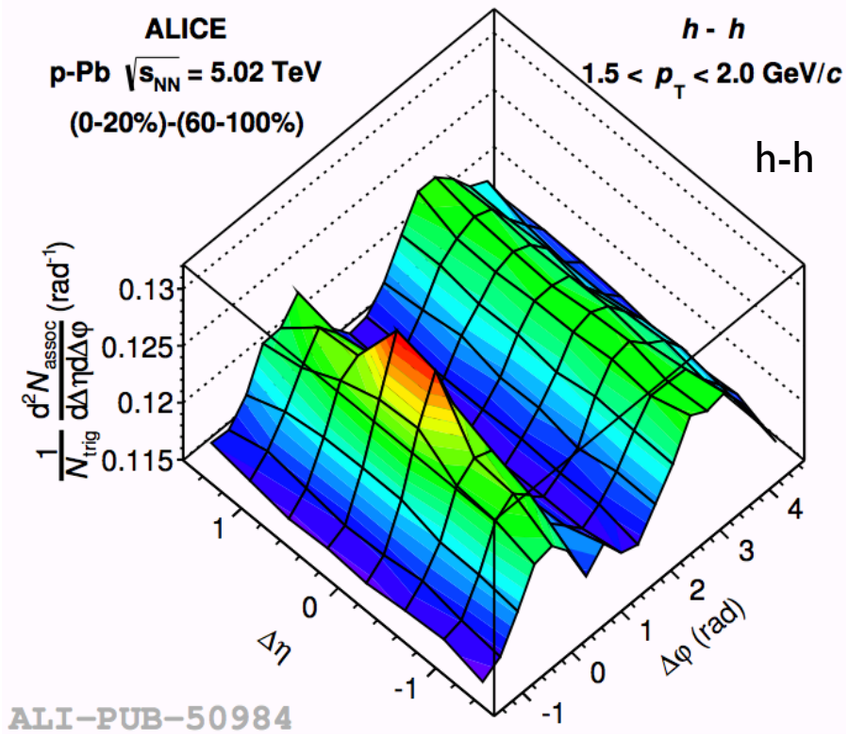

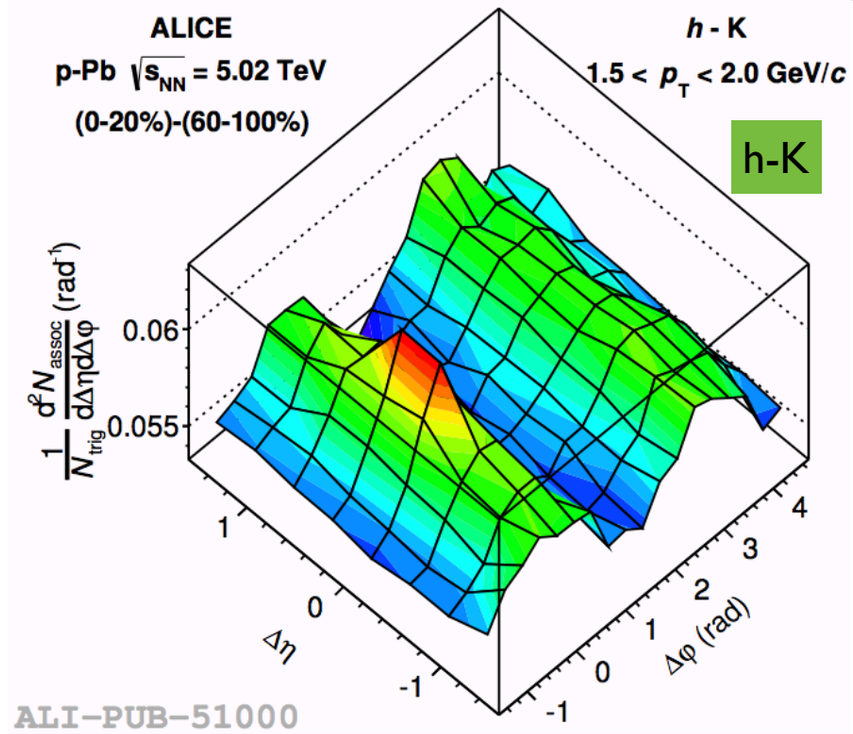

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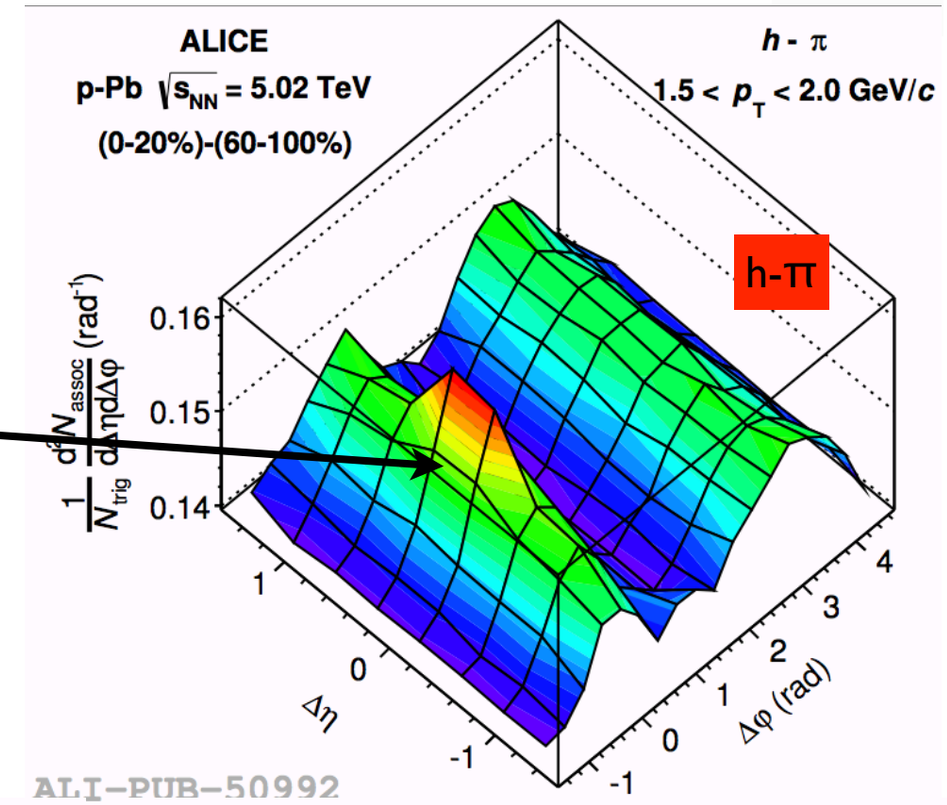

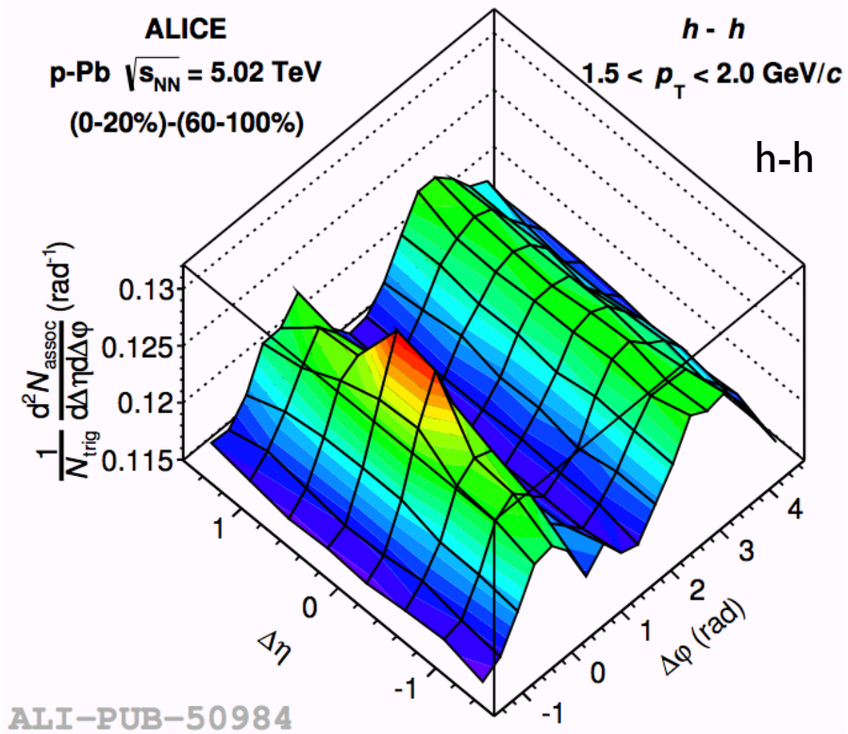

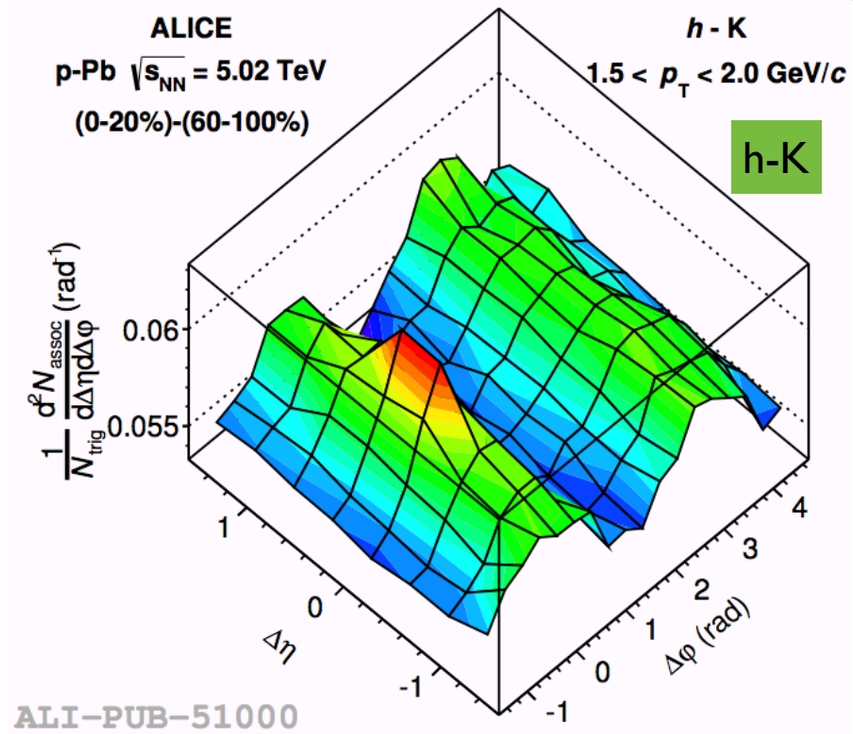

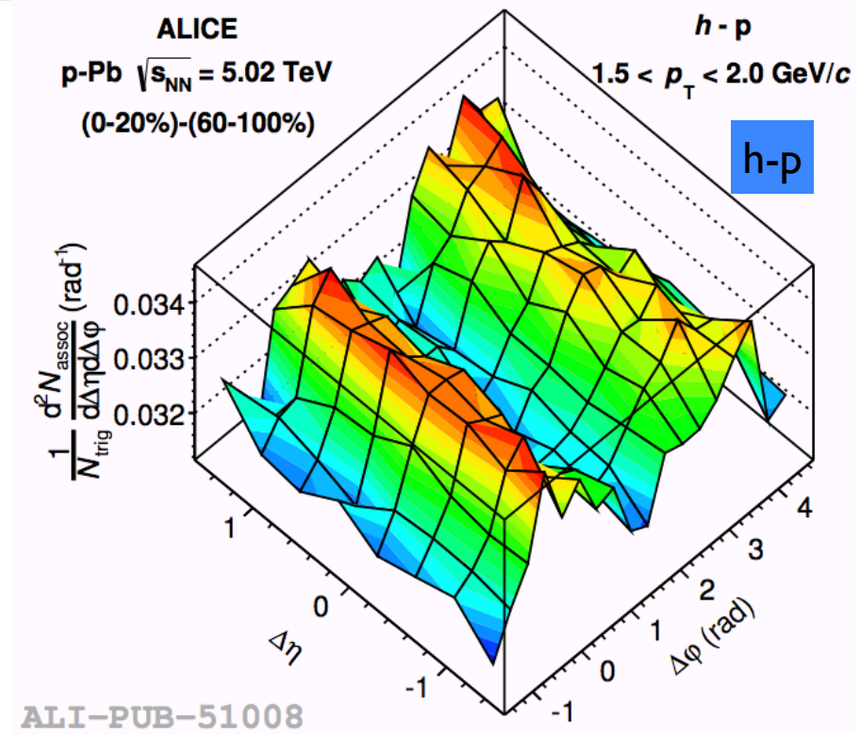

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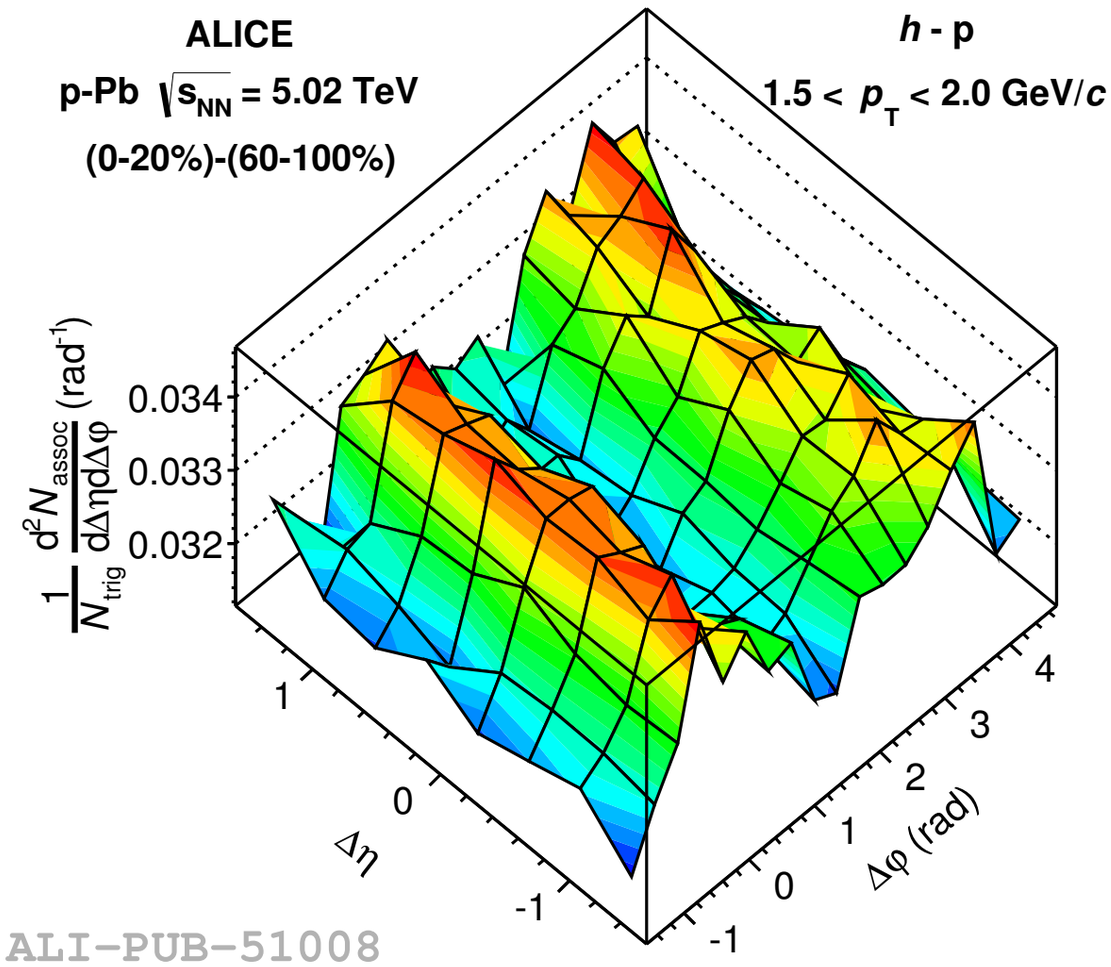

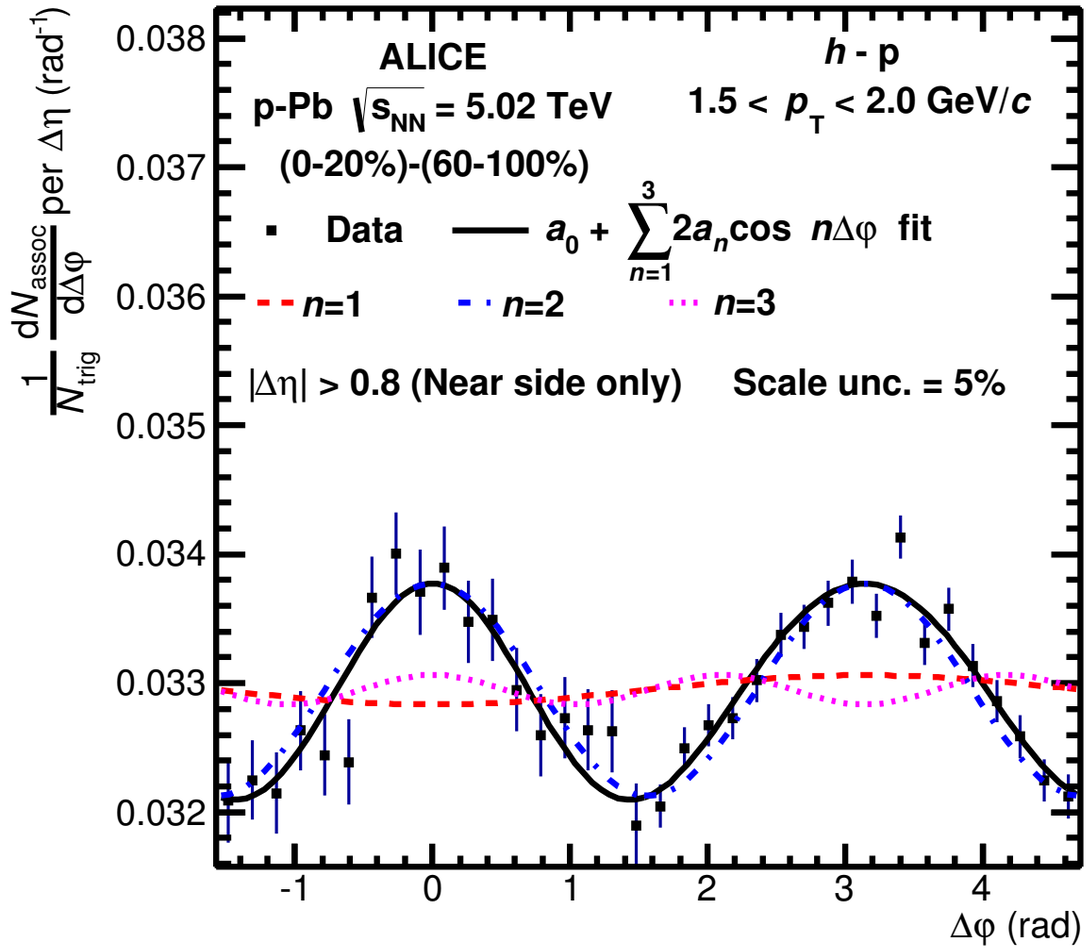

Only significant contribution from second Fourier coefficient

First coefficient smaller w.r.t. the case without subtraction (up to ~10 times smaller)

Third coefficient still small

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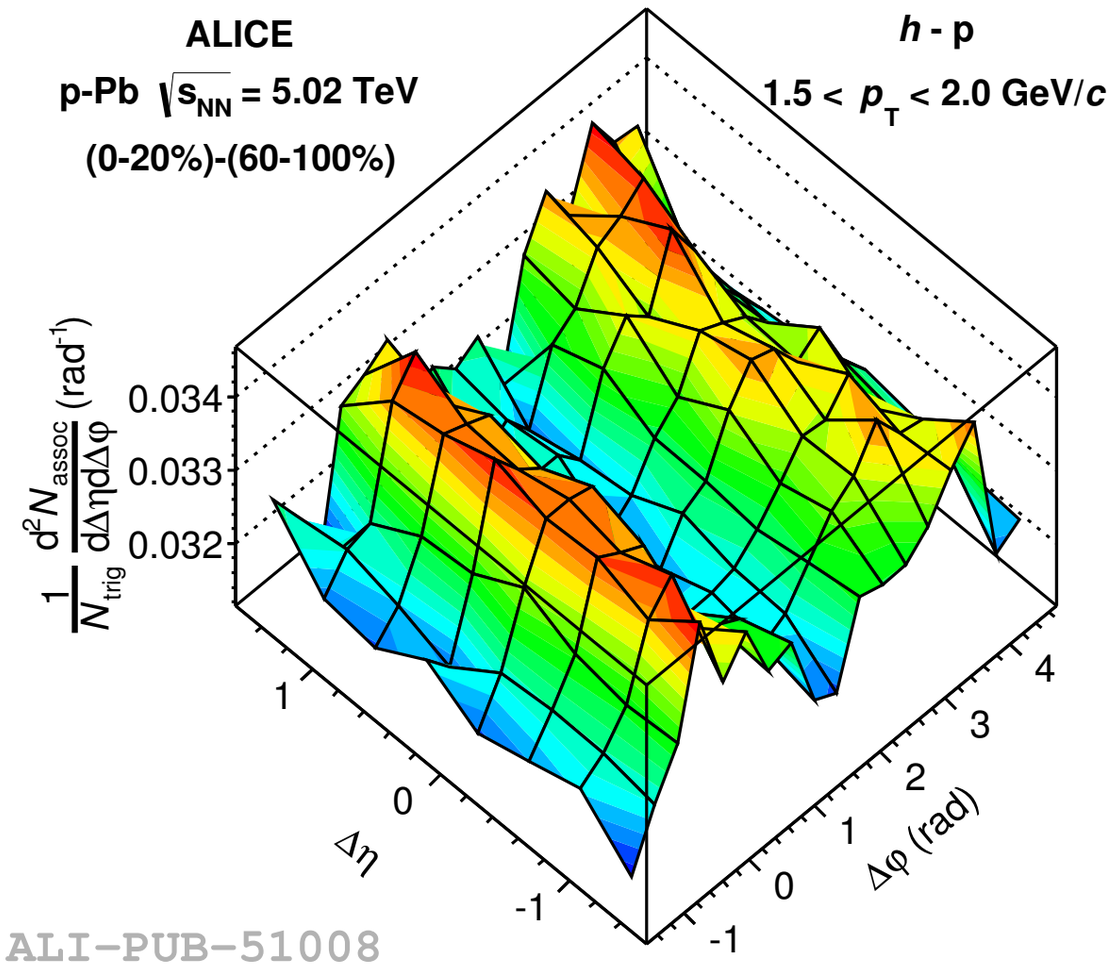
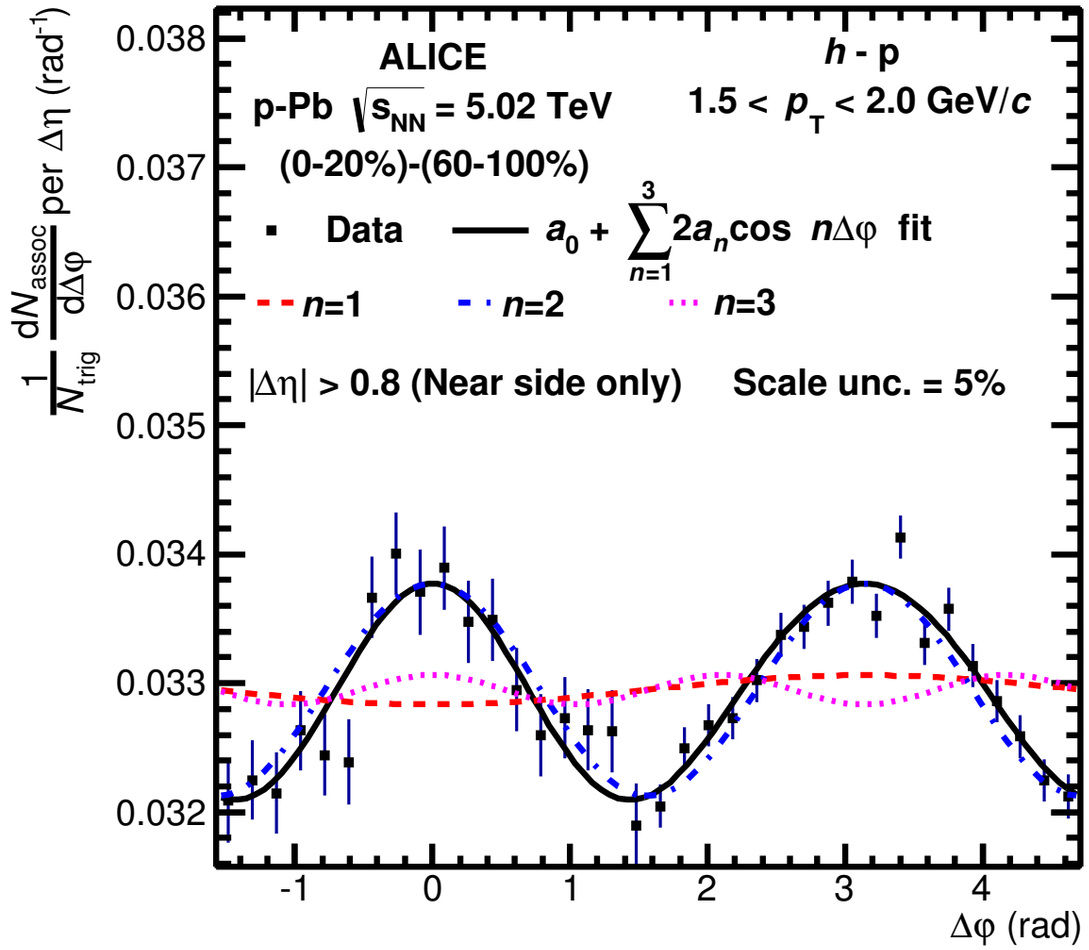




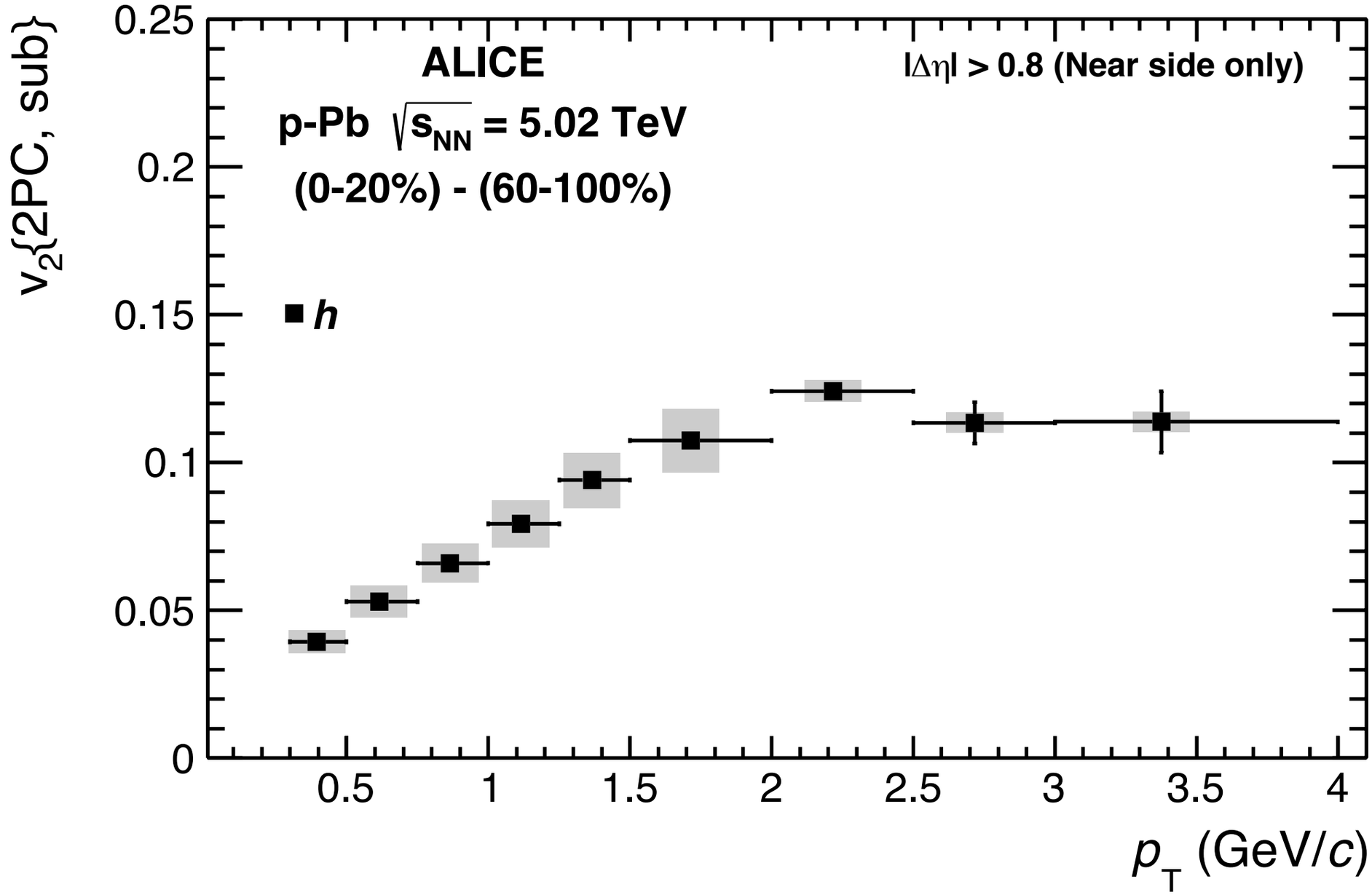
Only significant contribution from second Fourier coefficient
First coefficient smaller w.r.t. the case without subtraction (up to ~10 times smaller)
Third coefficient still small

Not only the jet is subtracted but also the baseline:

$$V_{n\Delta}\{2\mathrm{PC}, \mathrm{sub}\} = a_n/(a_0 + b)$$

*b calculated in 60-100% class

2PC, v2 of π, K and p



- $v_{2,h}$ same as our earlier results *ALICE, Phys.Lett. B719 (2013) 29–41*

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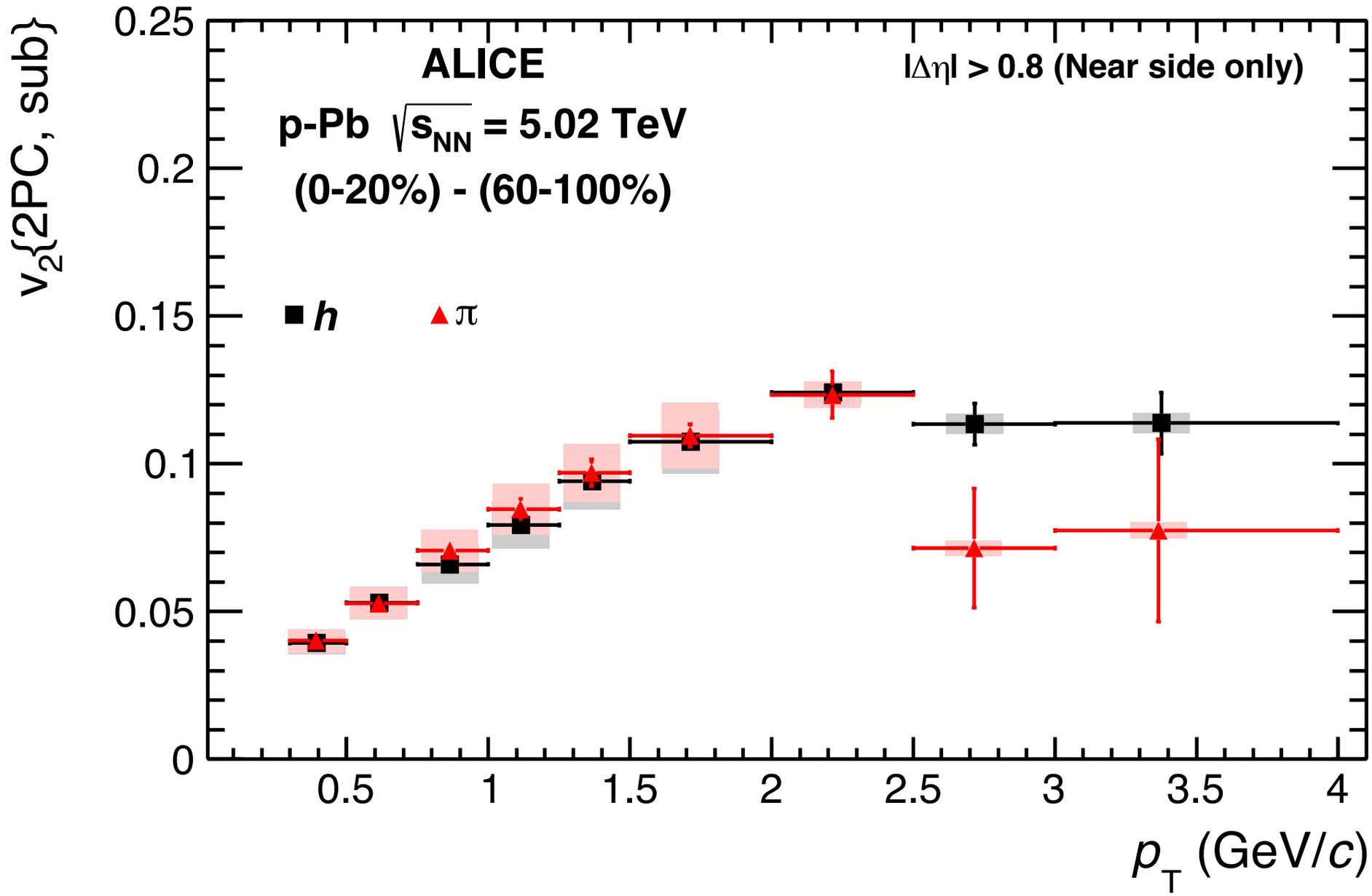

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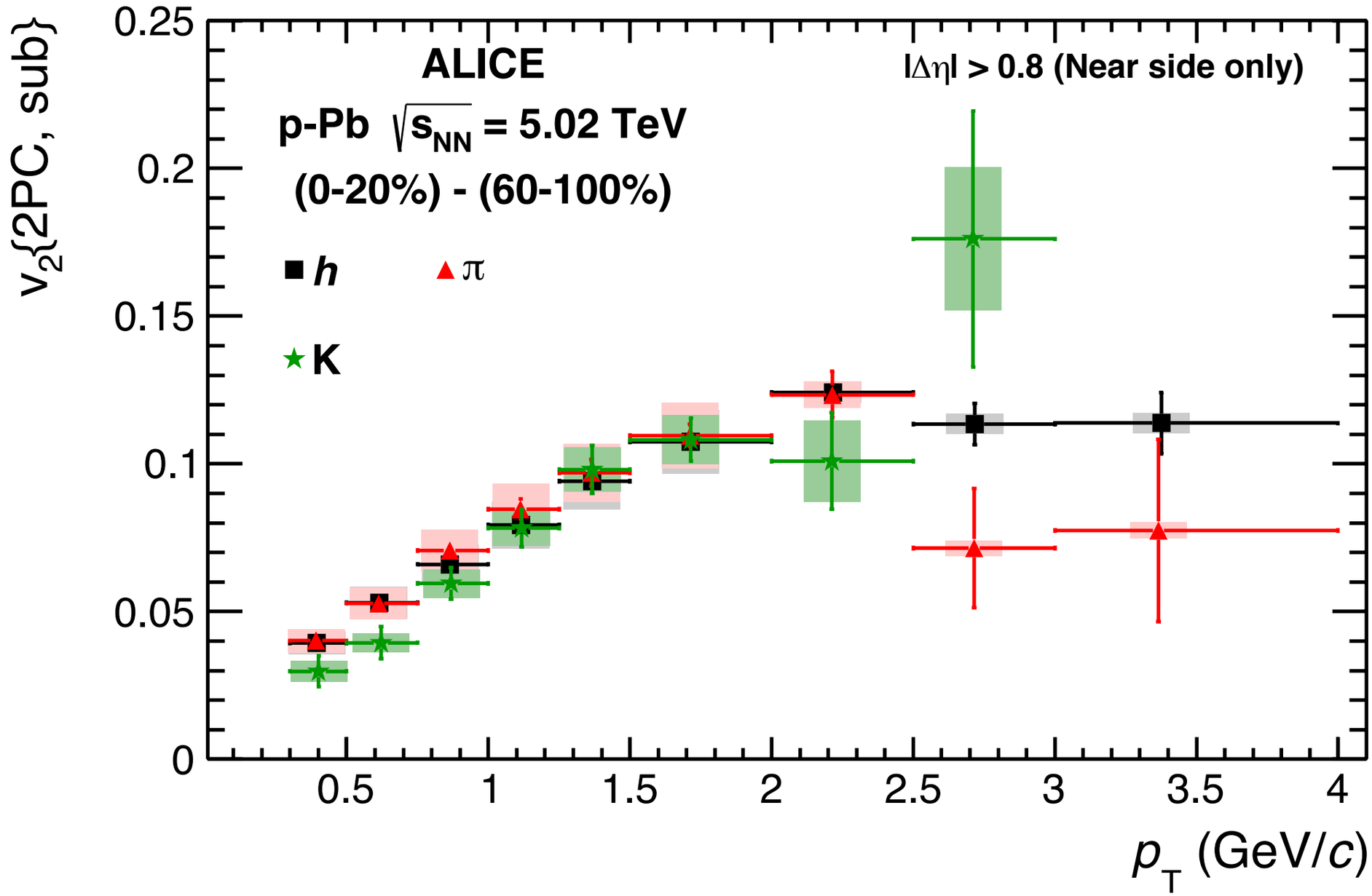

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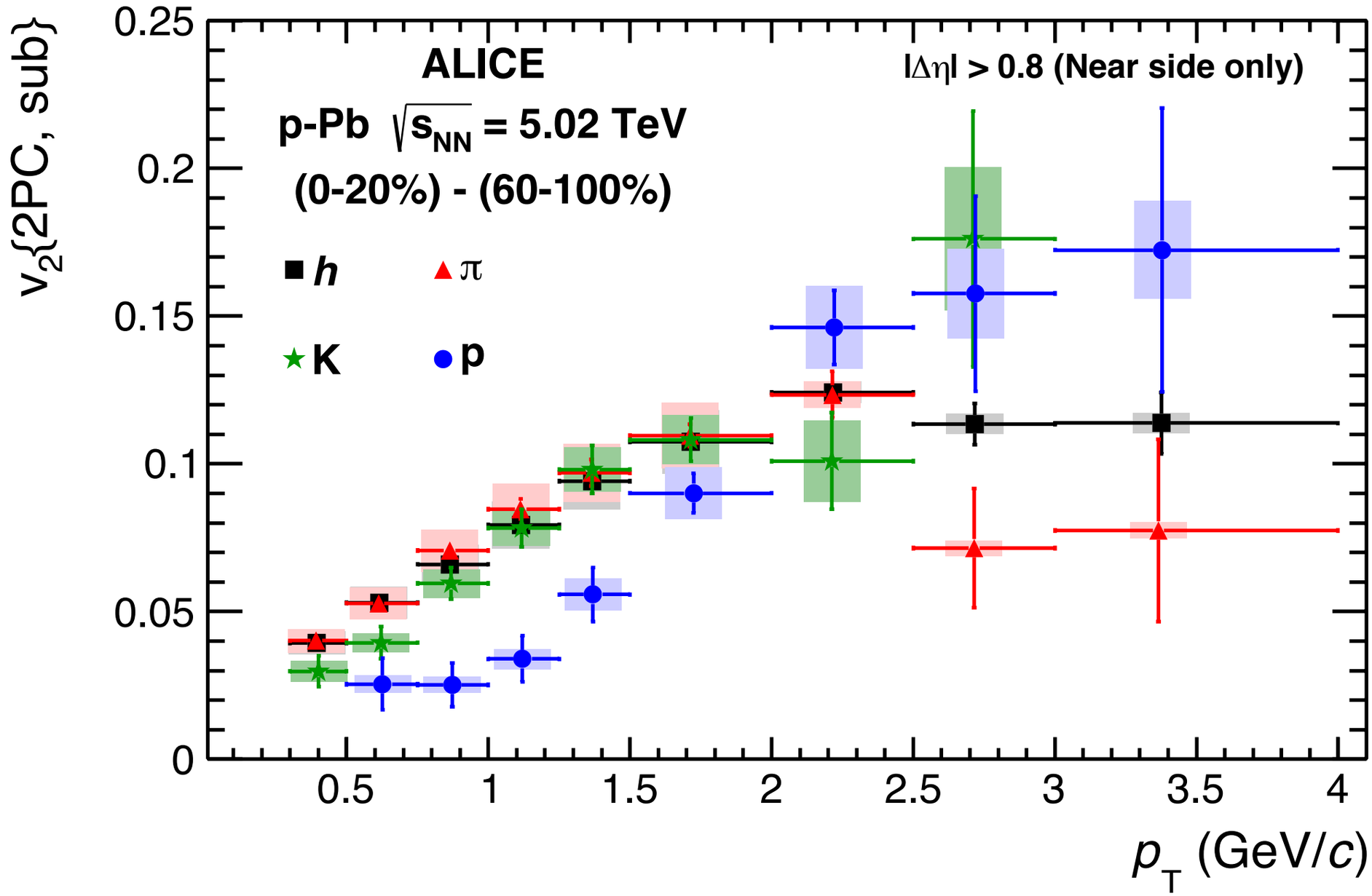

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- hint of $v_{2,K}$ smaller than $v_{2,\pi}$ at low p_T
- $v_{2,p}$ smaller than $v_{2,\pi}$ below 2 GeV/c and larger above
- crossing at about 2 GeV/c

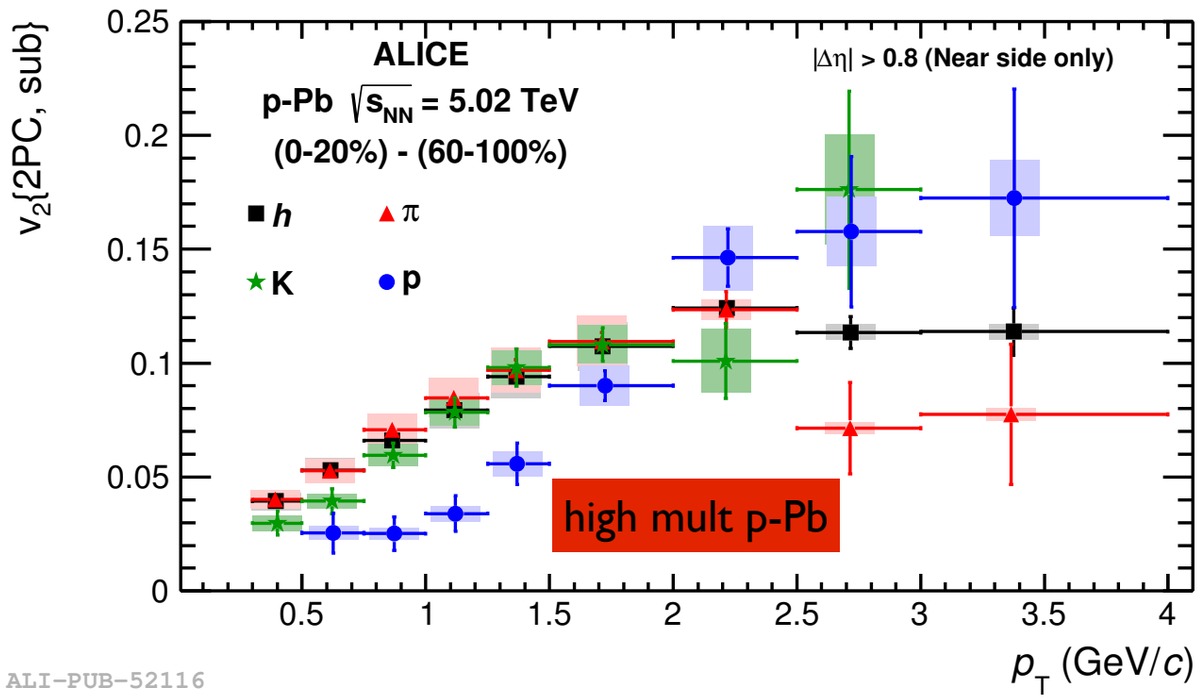
ALICE, arXiv:1307.3237 [nucl-ex]

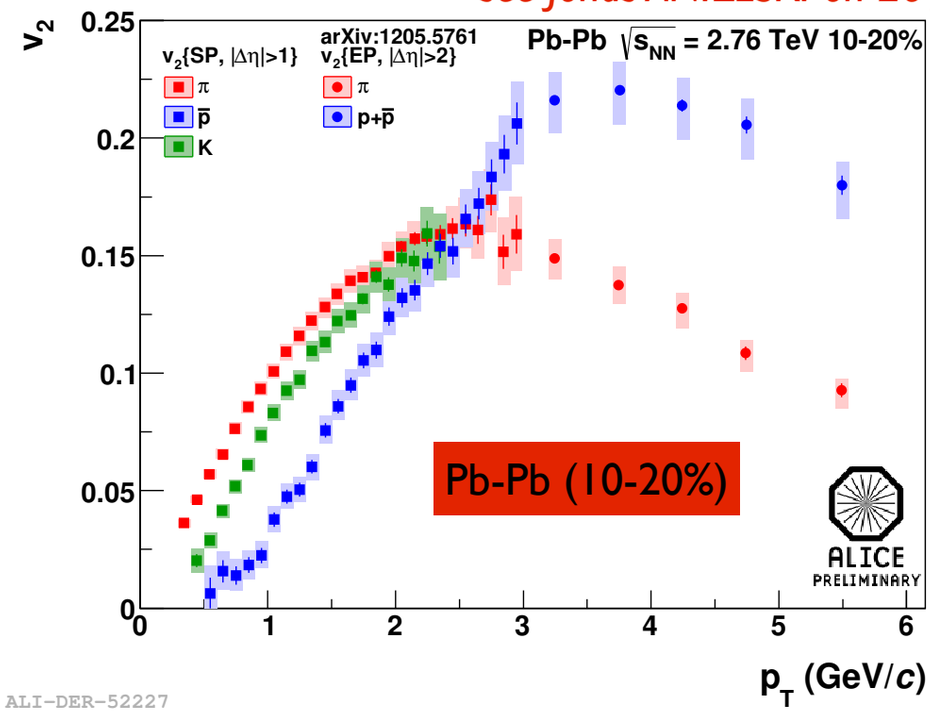
2PC, v2 of π, K and p

- behavior similar to PbPb collisions (also seen in the p_T spectra)

ALICE, arXiv:1307.6796 [nucl-ex]

see Jonas ANIELSKI on 26 Jul 2013 at 15:40



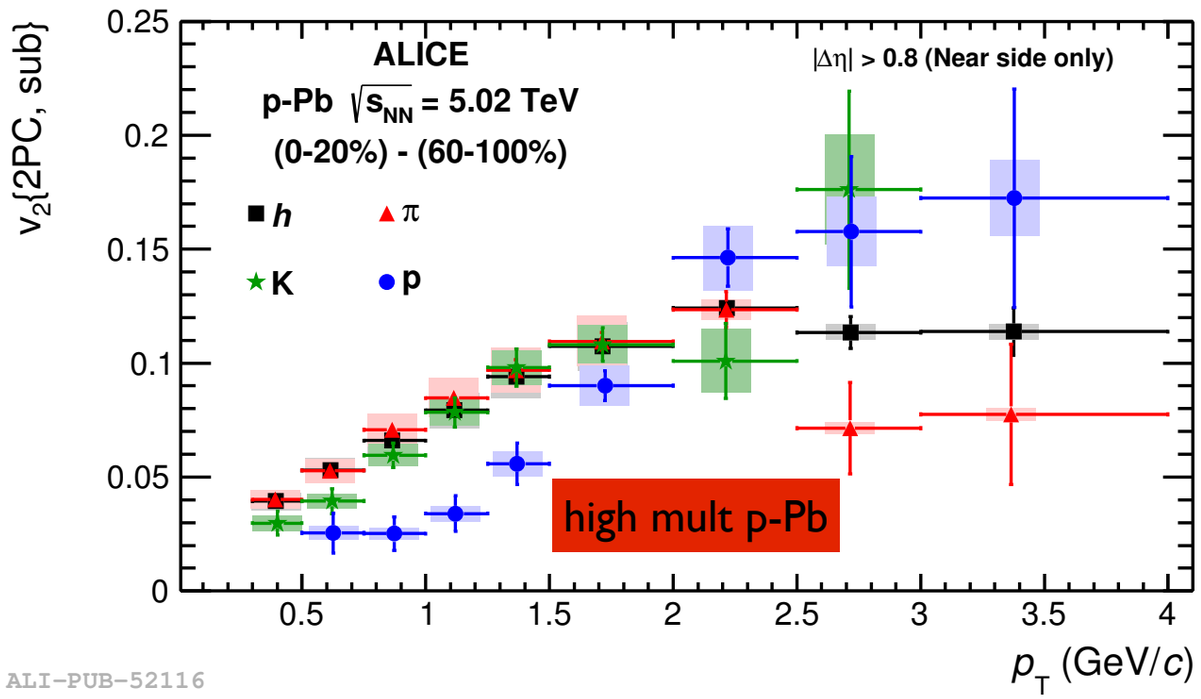


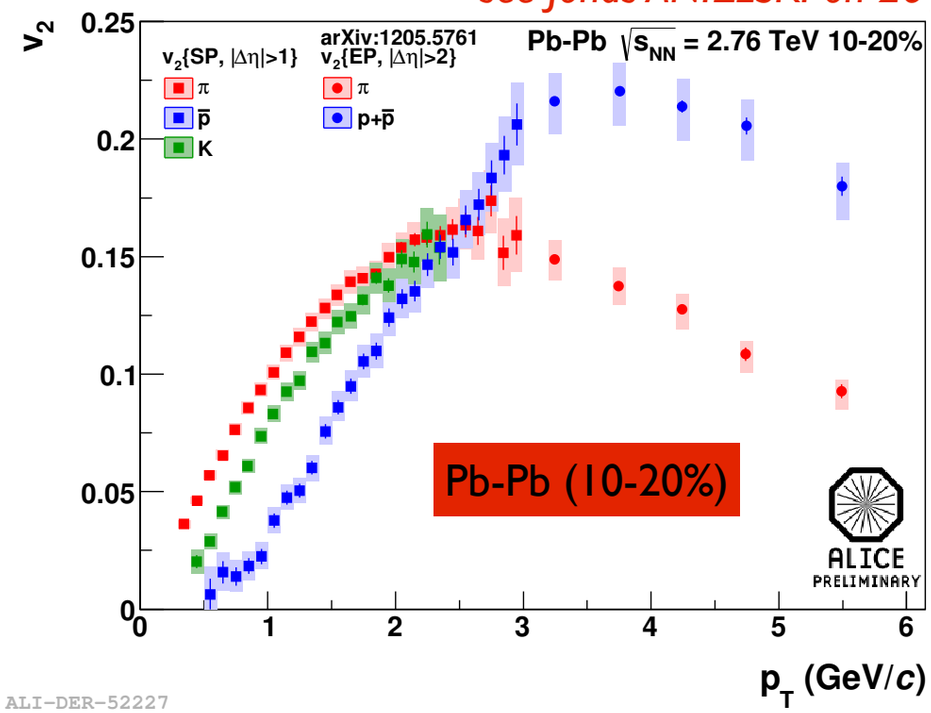
2PC, v2 of π, K and p

- **behavior similar to PbPb collisions (also seen in the p_T spectra)**

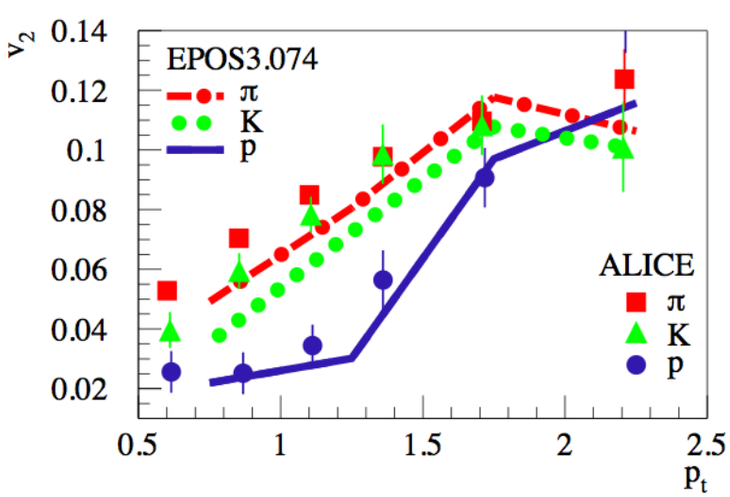
ALICE, arXiv:1307.6796 [nucl-ex]

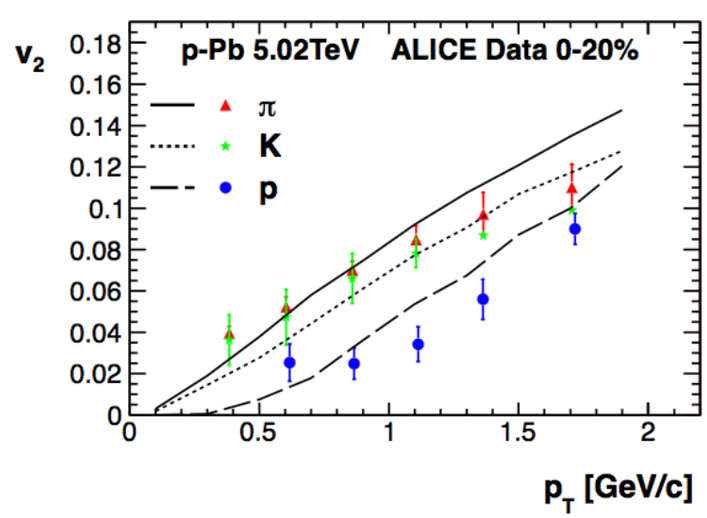
see Jonas ANIELSKI on 26 Jul 2013 at 15:40





- **Mass ordering at low p_T qualitatively consistent with hydro models**





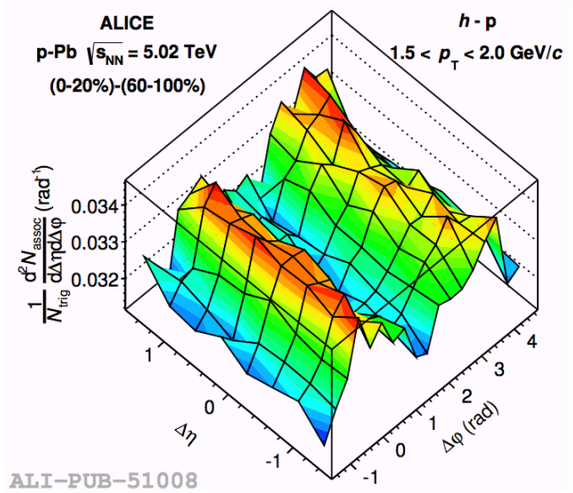
K. Werner, M. Bleicher, B. Guiot, Iu. Karpenko, T. Pierog, arXiv:1307.4379 [nucl-th]

Piotr Bozek, Wojciech Broniowski, Giorgio Torrieri, arXiv:1307.5060 [nucl-th]

Summary

ALICE has further characterized the double ridge structure from two particle correlations in p-Pb

- the jet contribution has to be subtracted to reveal the double ridge



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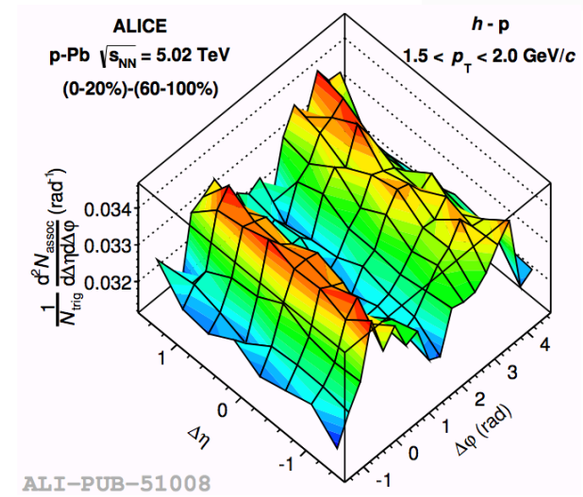
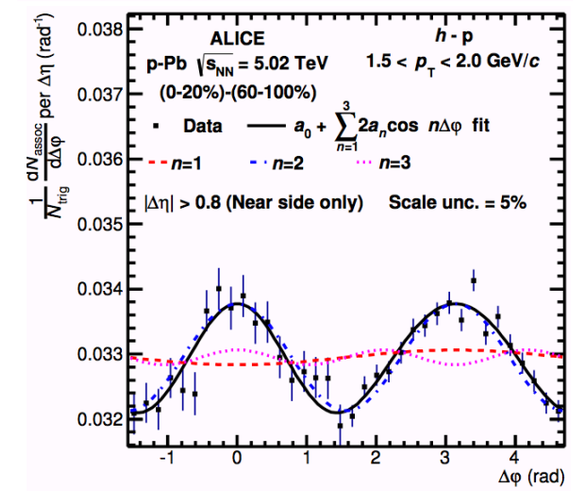


The double ridge can be studied using Fourier decomposition

- second Fourier coefficient much larger than the others



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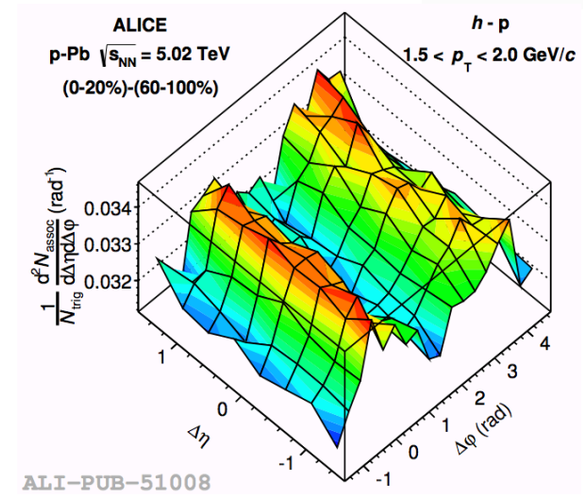

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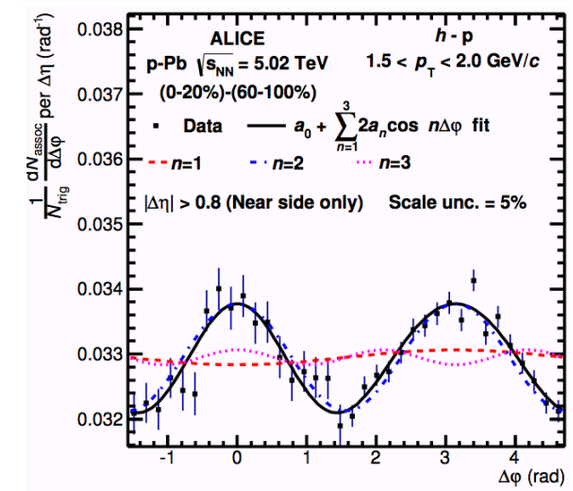
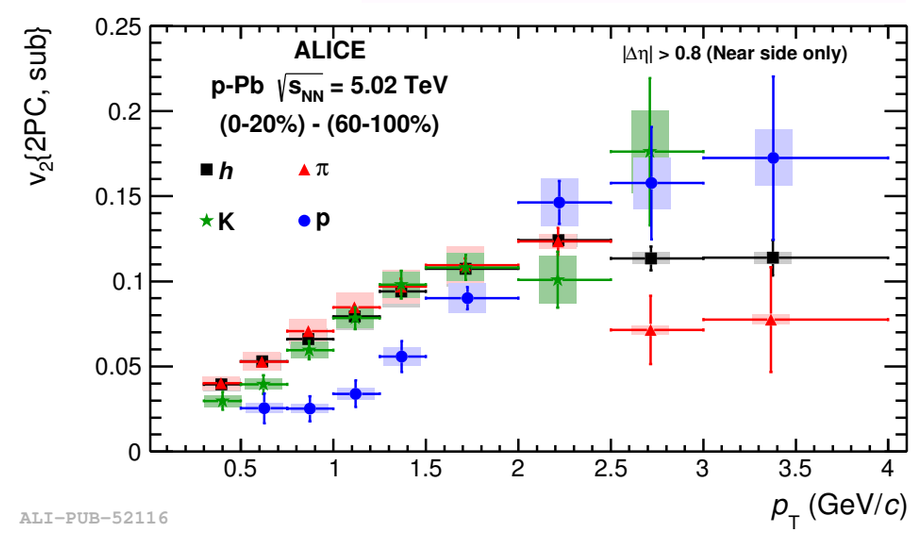


The behavior of the v_2 parameter is similar to the one observed in Pb-Pb collisions

- different mechanisms to explain such structure
- the question "**Does it flow or not?**" still open



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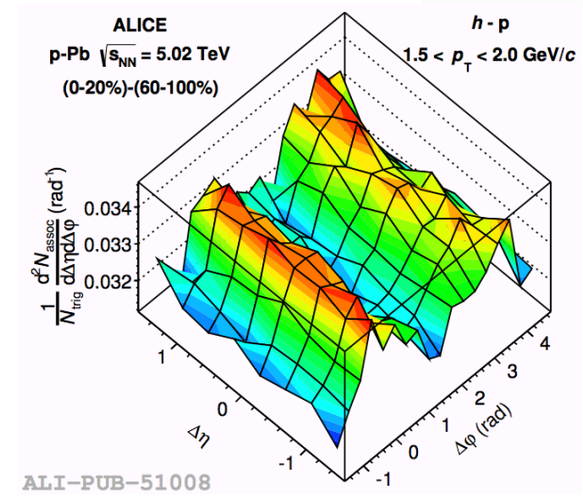

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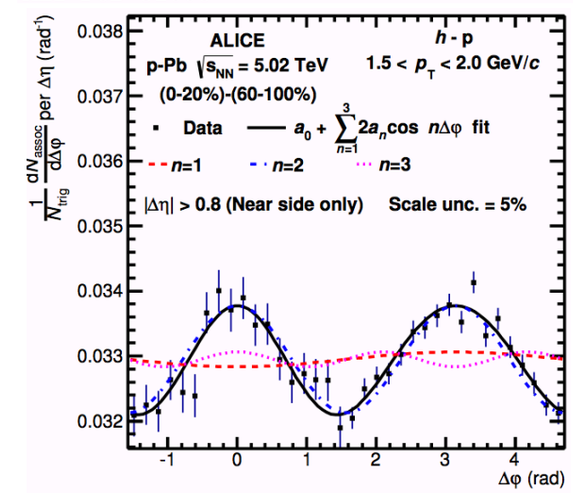

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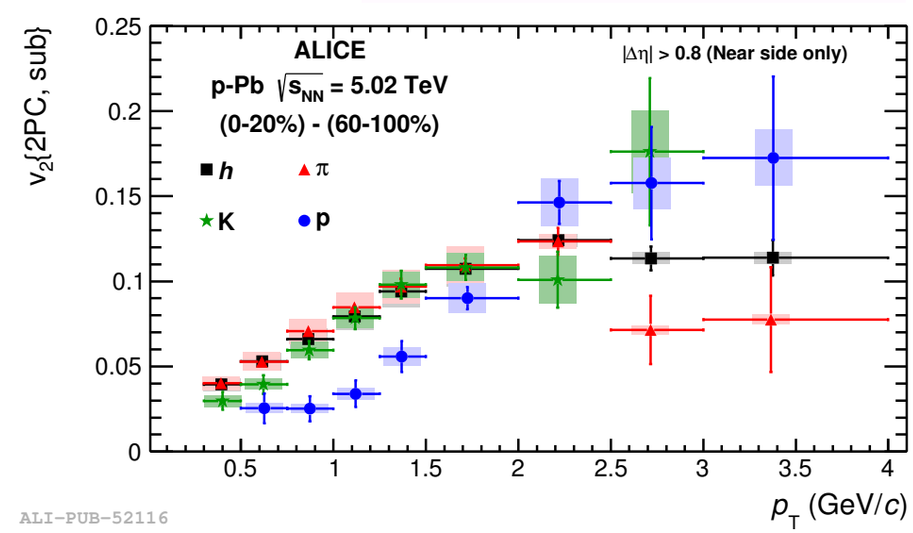
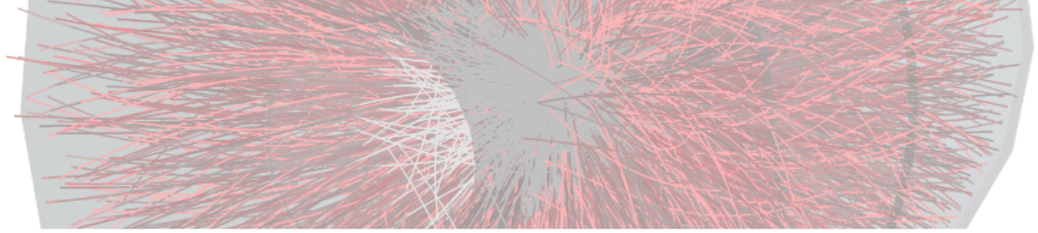
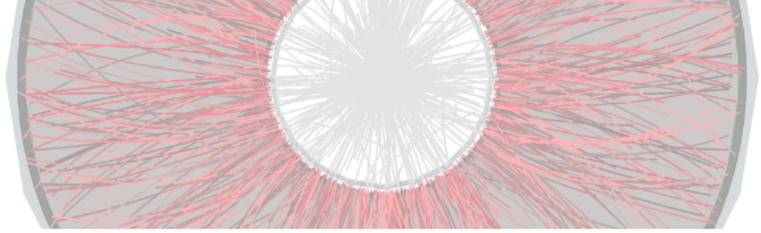
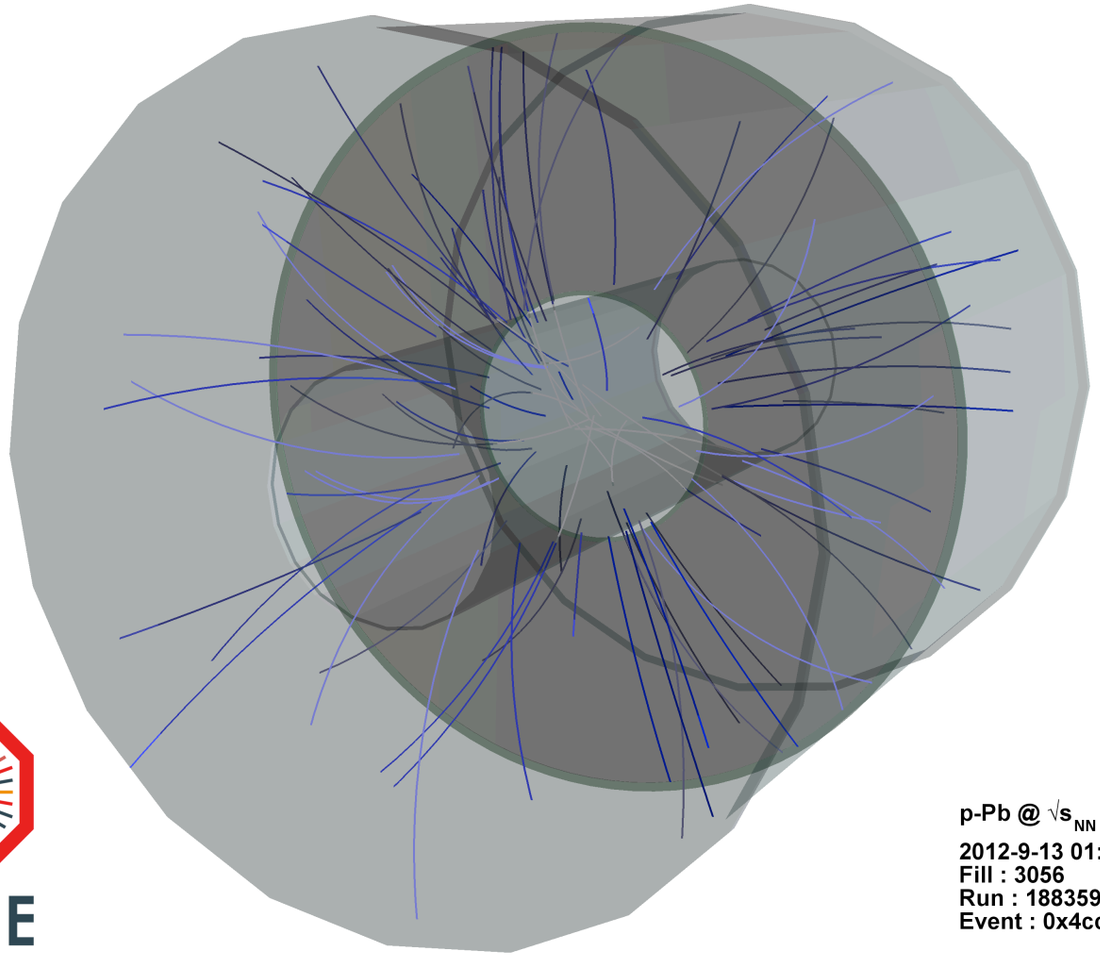


Thank you for your attention!





THANKS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2012-9-13 01:33:48
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Run : 188359
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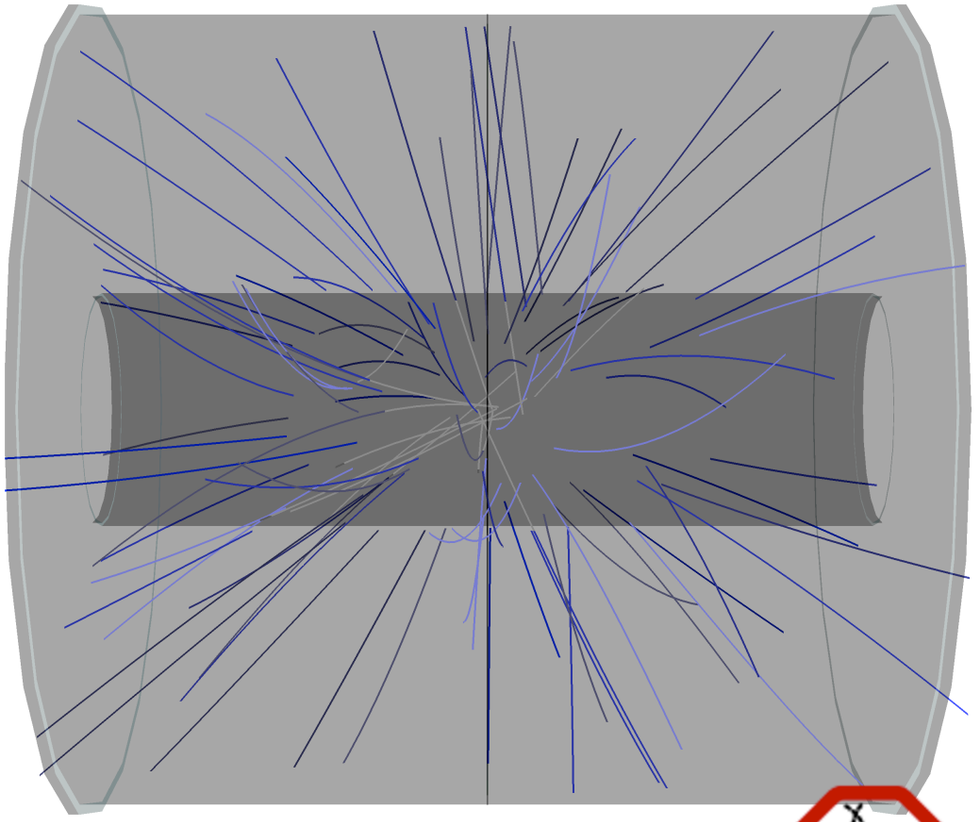
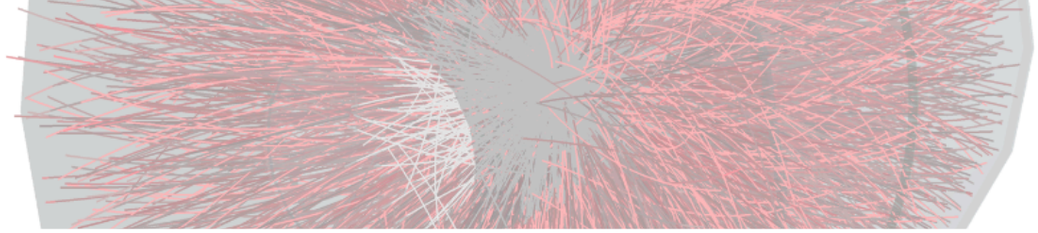
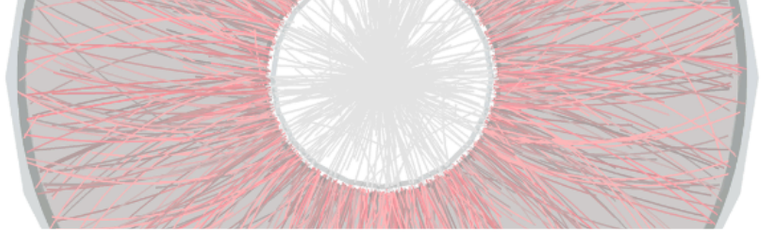
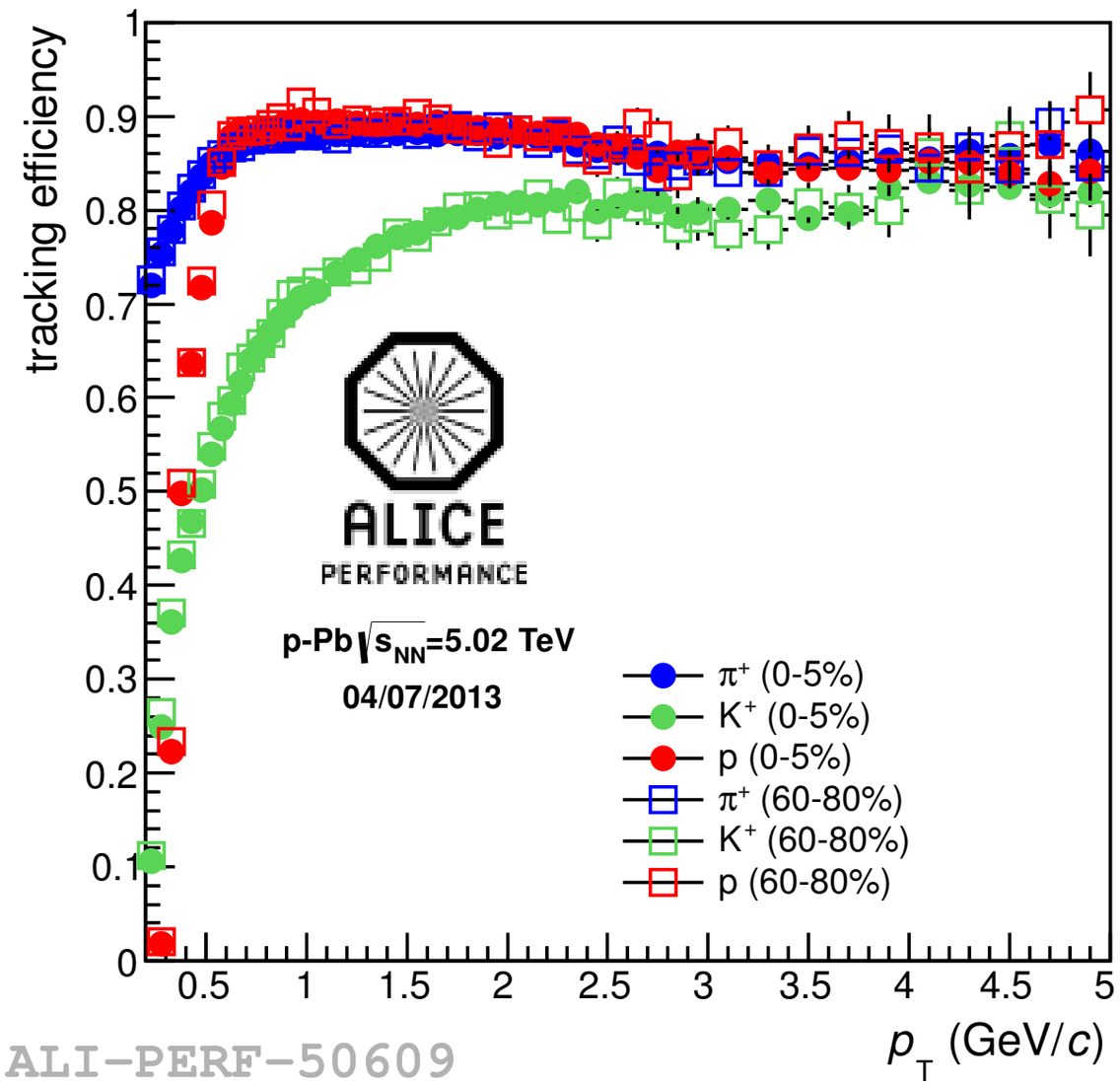


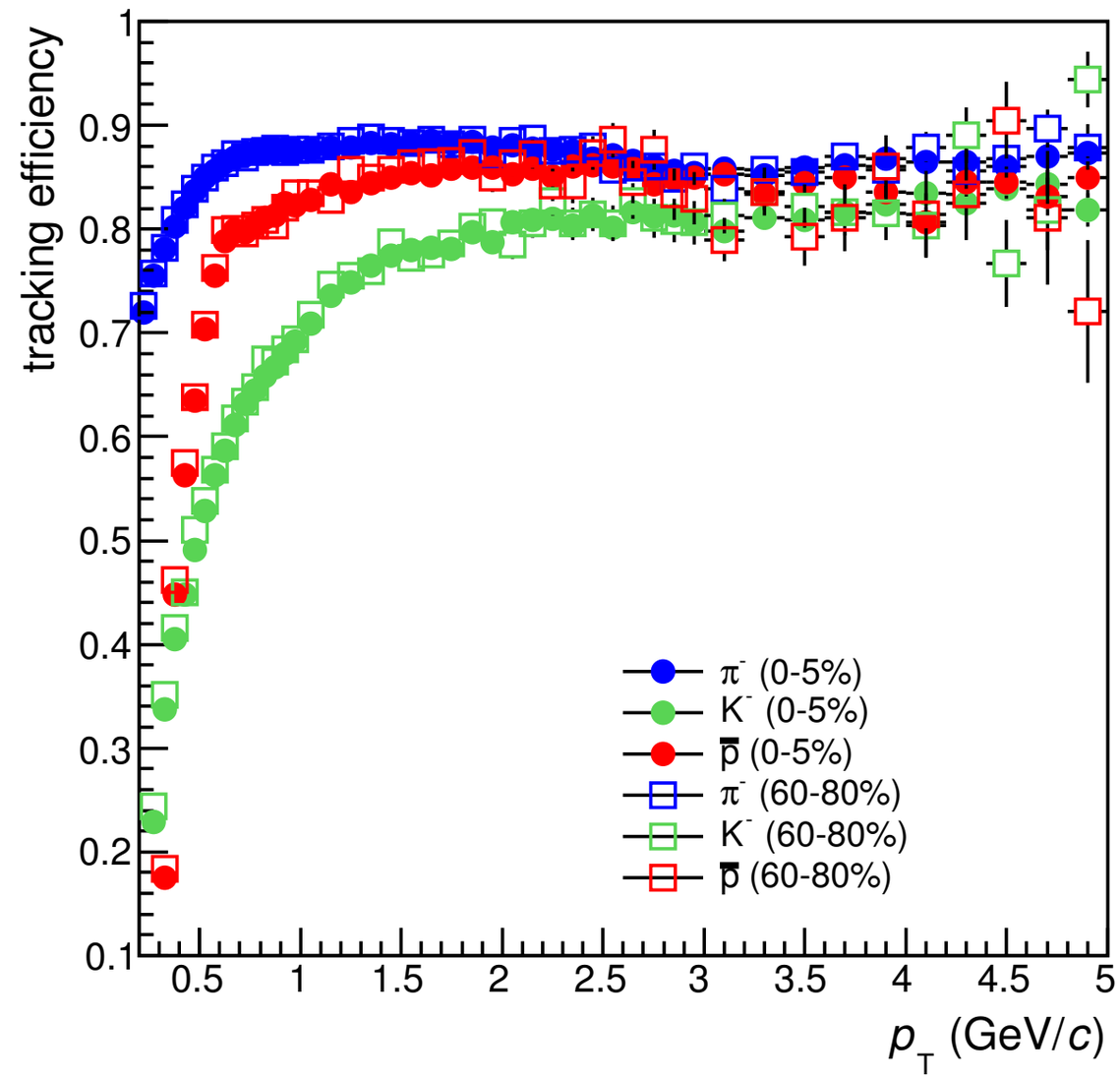




BACKUP

tracking efficiency





TOF matching efficiency