Long range two-particle correlations with K^0_S and Λ in pPb and PbPb collisions

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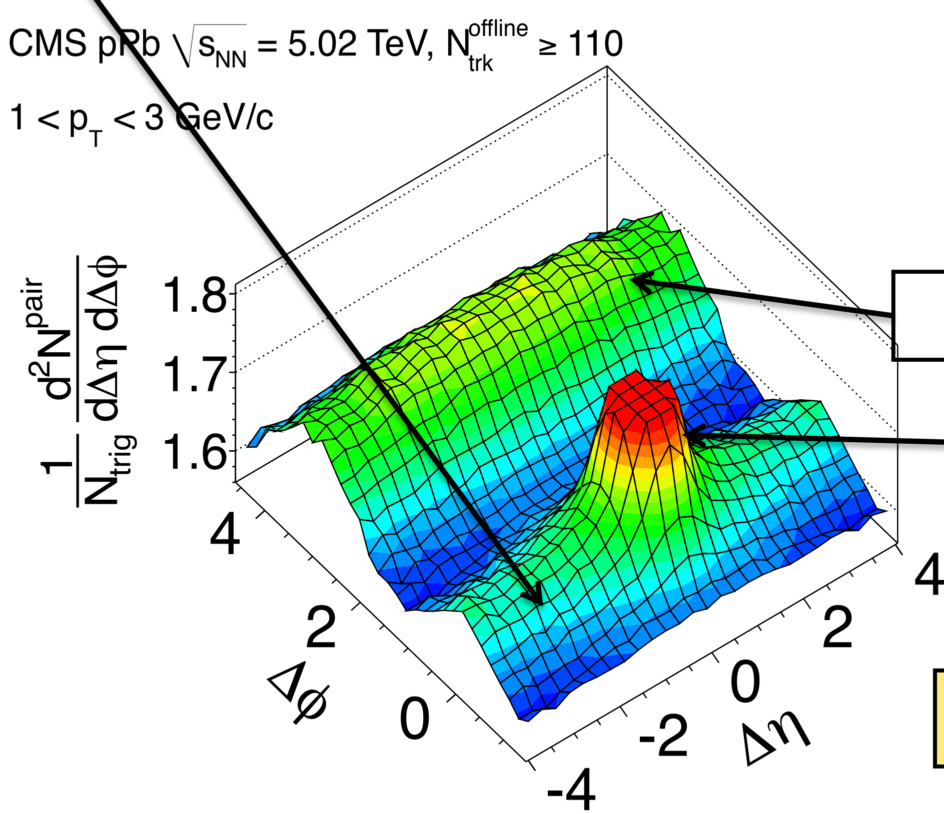
Discovery of long range correlation: "ridge" in pPb

Phys. Lett. B 718 (2013) 795

JHEP 09 (2010) 091

Near side long range correlations

Long range rapidity correlations Seen in AA collisions and only in high multiplicity pp and pPb collisions



Away side ridge + jet, $\Delta\phi \sim \pi$

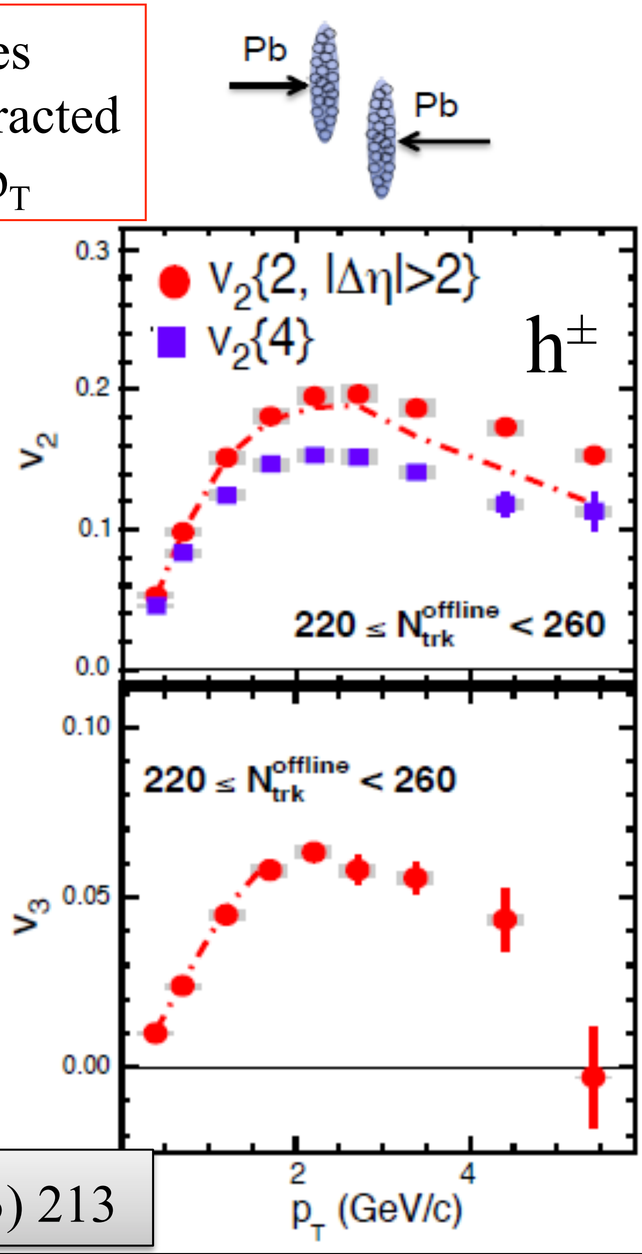
Near side jet, $\Delta\phi \sim 0$

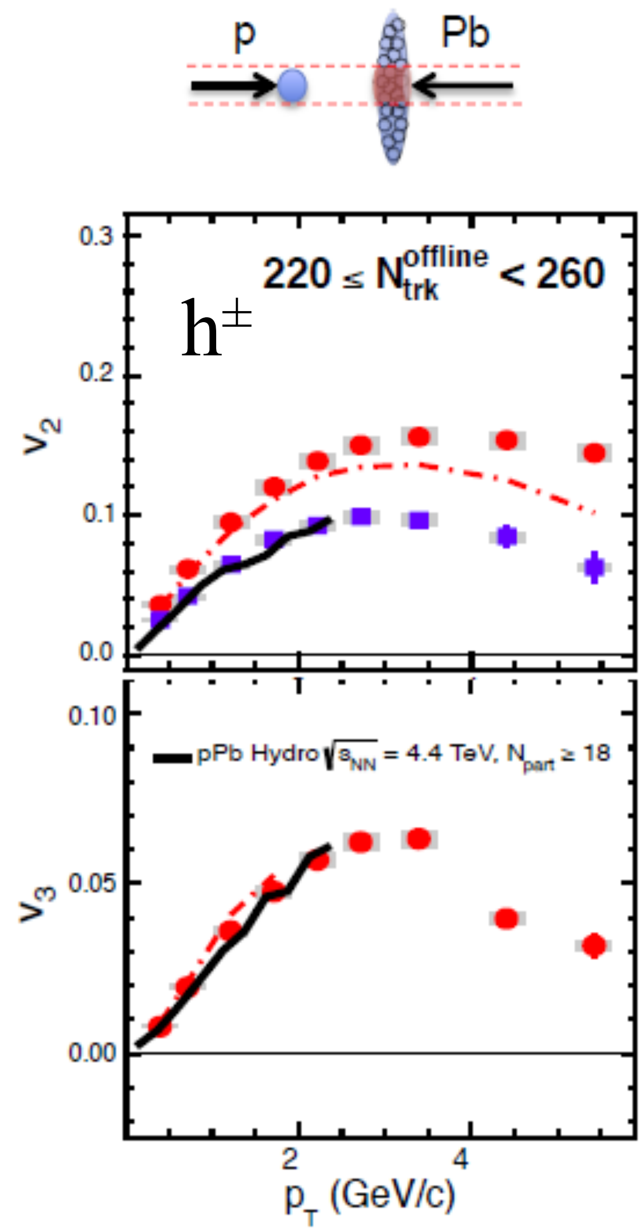
What is new from the latest pPb run?

- In AA collision, long range correlations arise from collective flow
- Are these correlations in pPb also related to hydrodynamic flow as in PbPb?

Similarities between pPb and PbPb collisions

Dashed-dotted curves
are data with N<20 subtracted
Important for high-p_T

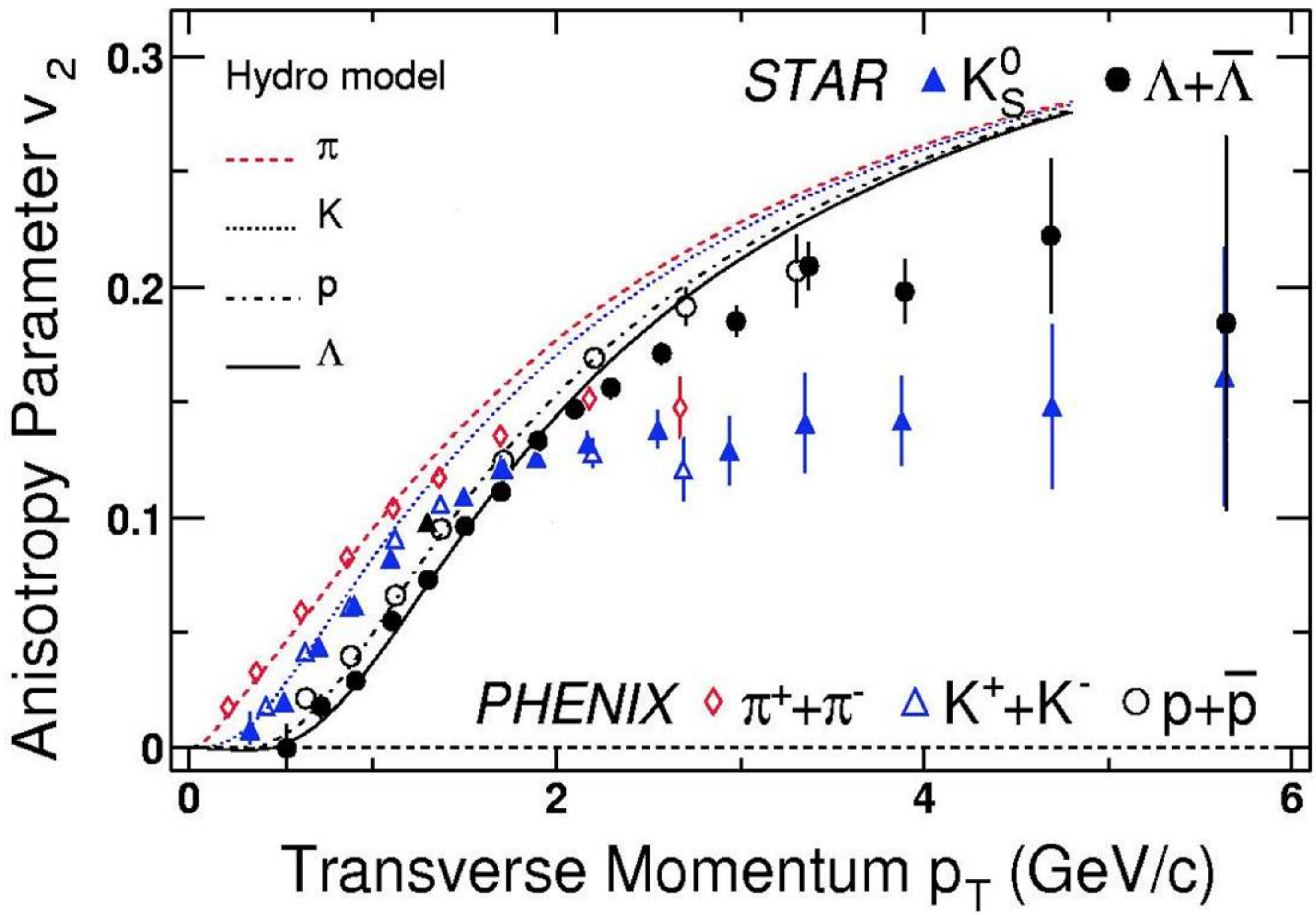




Phys. Lett. B 724 (2013) 213

Remarkable similarities in PbPb and pPb for same multiplicities

Identified particles v_2 in AuAu collisions

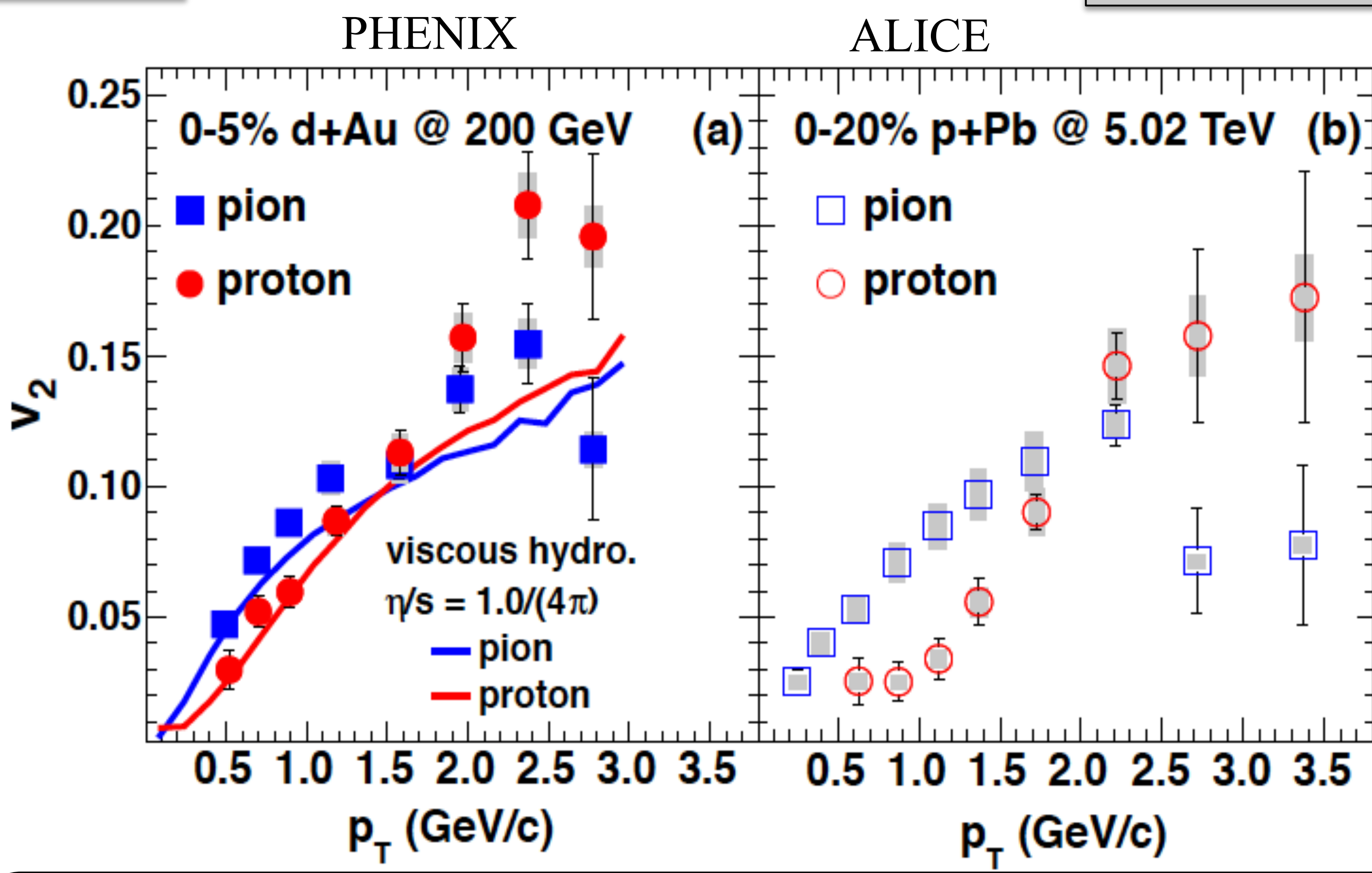


Mass ordering and crossing over seen in heavy-ion collisions

What about identified particles in dAu/pPb collisions?

arXiv:1404.7461

Phys. Lett. B 726 (2013) 164–177

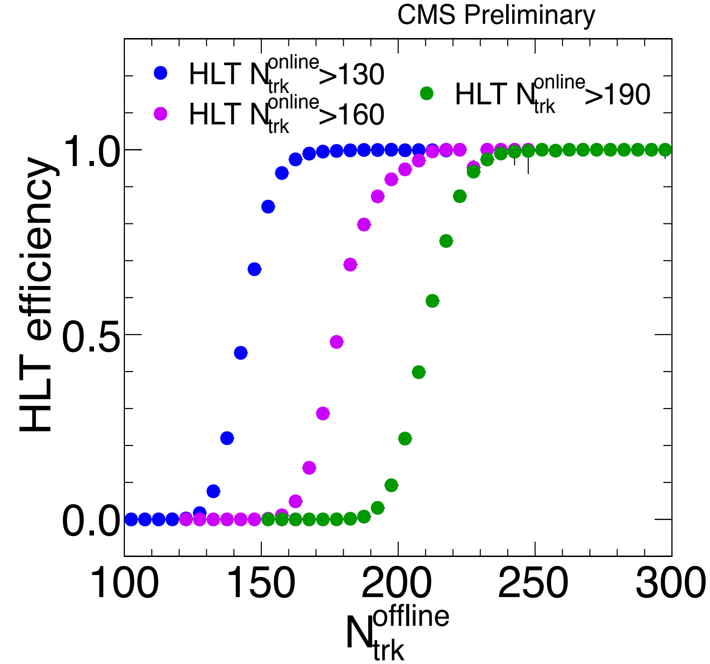


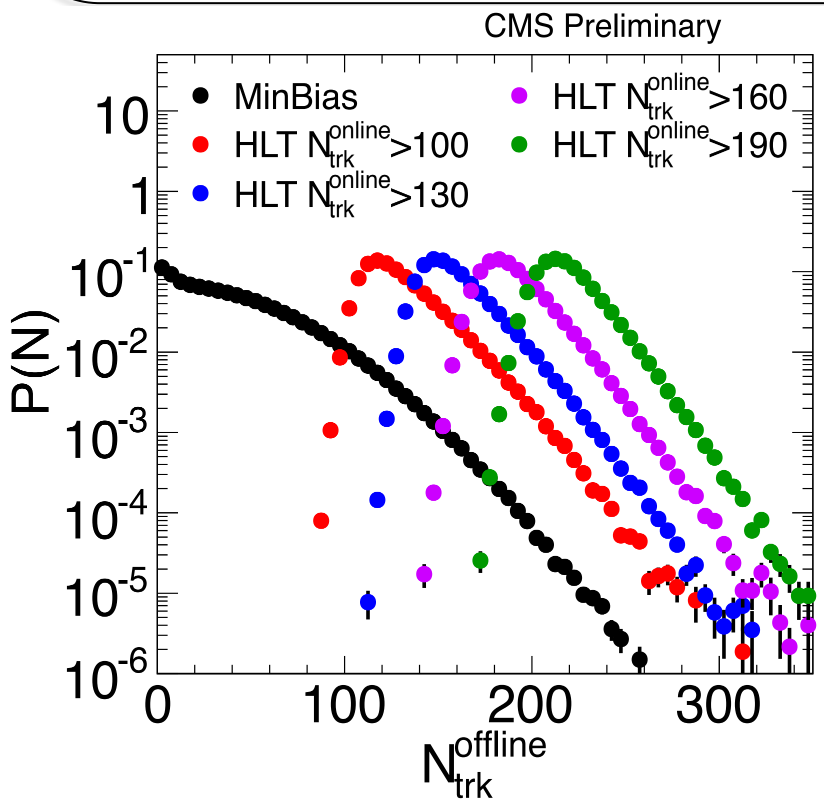
Study mass dependence and number of constituent quark (NCQ) scaling for a wide range of p_T in CMS:

- ✧ In high multiplicity pPb collisions
- ✧ Compare results with similar multiplicities in PbPb collisions

Data sets, trigger selection and multiplicity distribution

- Data sets
  - 2013 pPb + Pbp, 35 nb^{-1}
  - 2011 PbPb, 2.3μb^{-1} (50-100%)
- Triggers
  - High multiplicity triggers in 2013
  - Minimum bias trigger



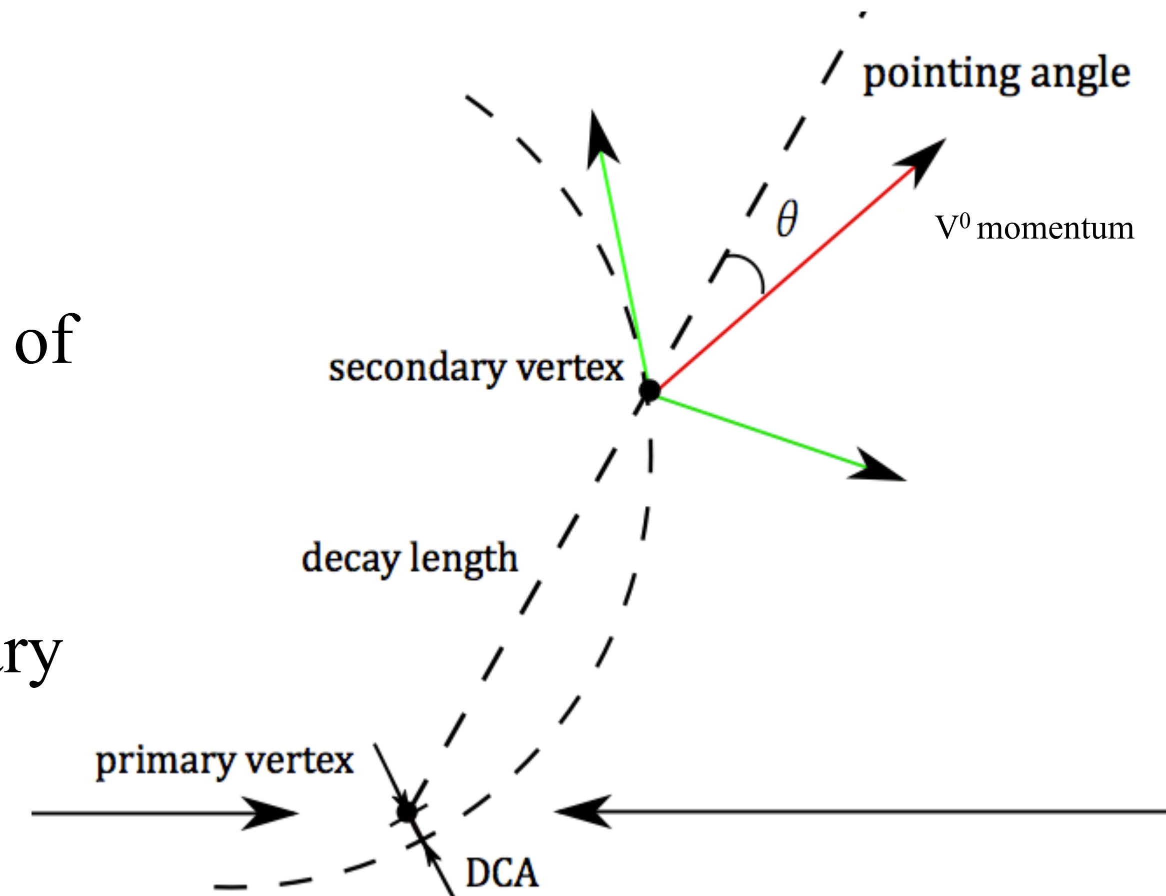


Track (p_T > 0.4 GeV/c, $|\eta|$ < 2.4) multiplicity distribution in pPb for different triggers

The fraction of events in $300 \leq N_{trk}^{offline} < 350$ ~ 10^{-7} with respect to all MinBias events.

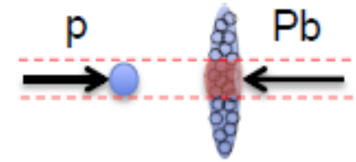
V^0 candidate reconstruction

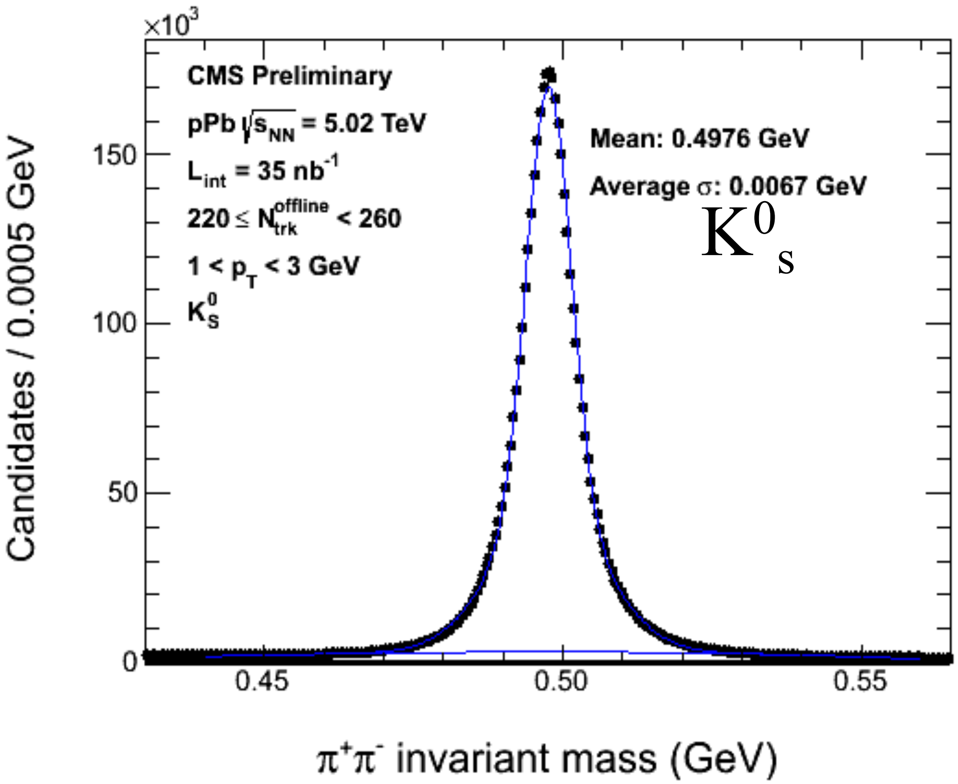
- The K^0_s and Λ candidates (referred to as V^0) reconstructed by combining oppositely-charged pairs of tracks which are detached from the primary vertex and form a good secondary vertex with an appropriate invariant mass
- $K^0 \rightarrow \pi^+\pi^-$, $c\tau = 2.68$ cm
- $\Lambda \rightarrow p^+\pi^-$, $c\tau = 7.89$ cm
- $\mathrm{Cos}(\theta^{point}) > 0.999$
- Distance-of-closest approach of V^0 momentum vector and primary vertex < 0.5 cm
- 3D separation between primary and V^0 vertex > 5σ

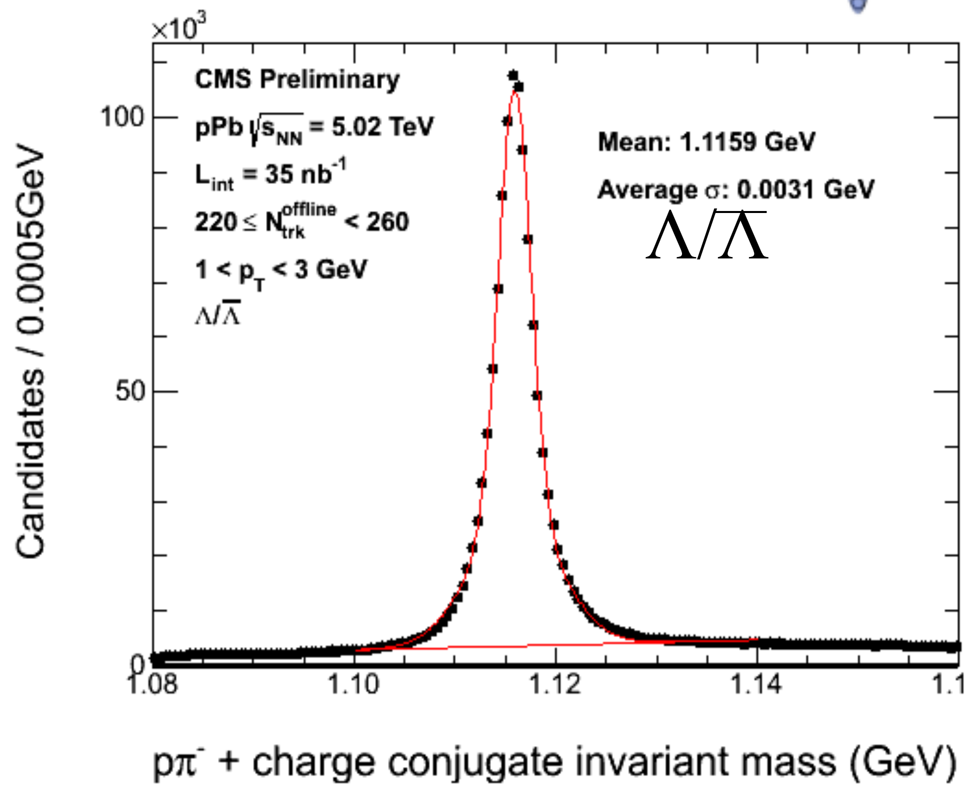


V^0 candidate reconstruction

HIN-PAS-14-002

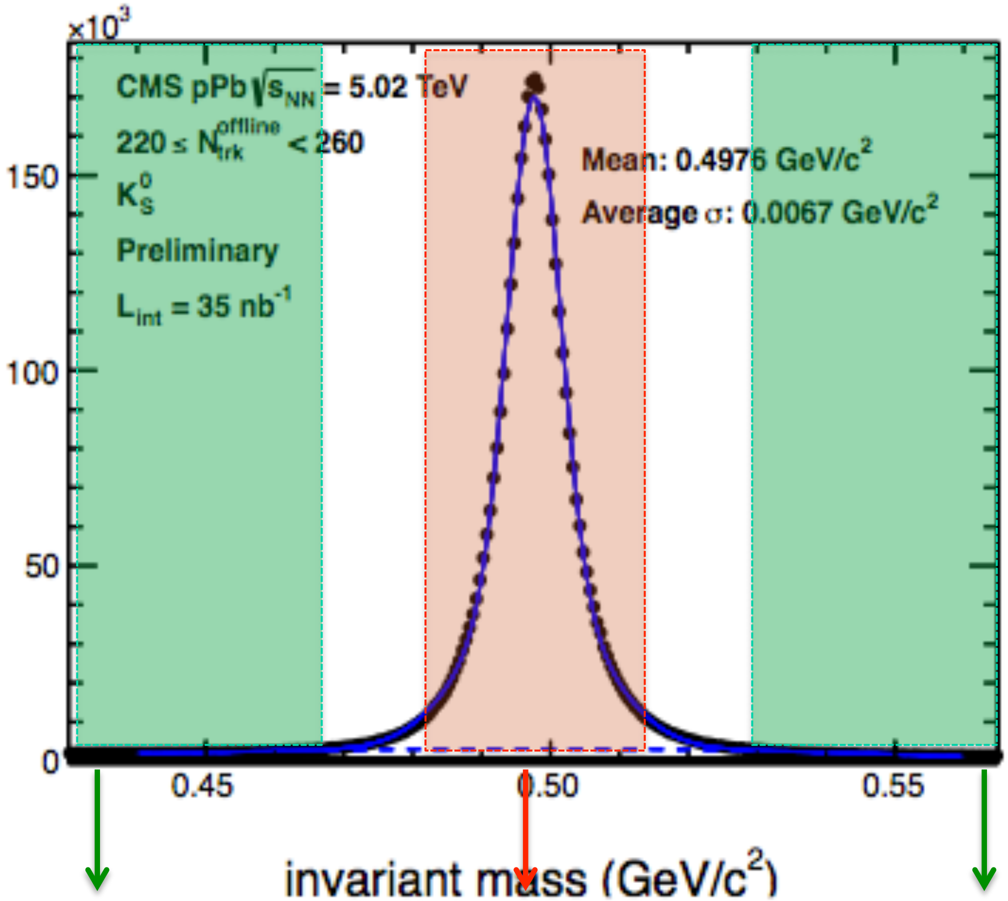






- Clean signal of $K^0{}_S$ and Λ reconstructed over a wide range of p_T and η
- Mass values very close to PDG numbers

Extraction of v_2 signal



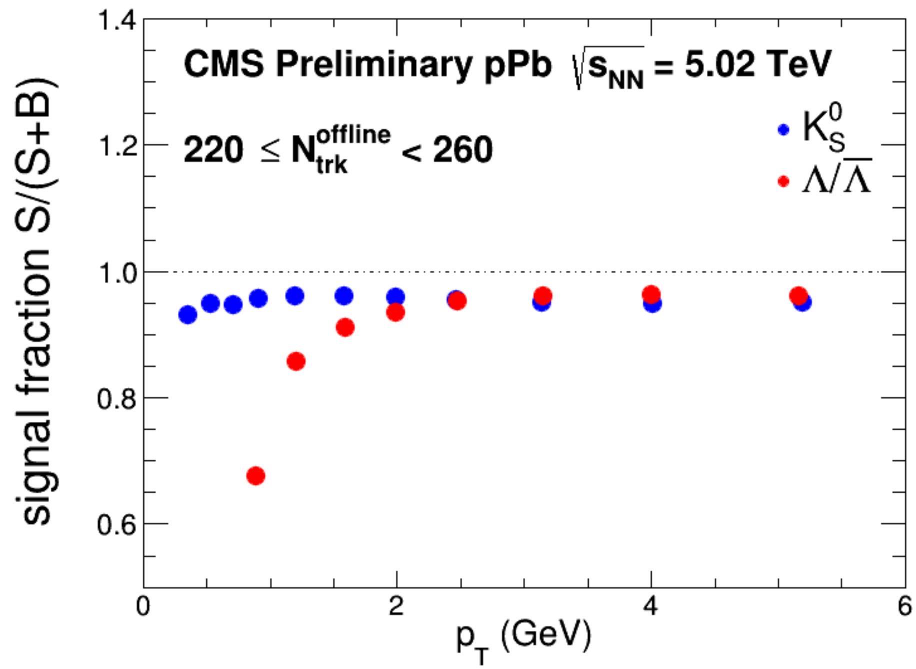
Sideband background region > -3σ

±2σ Peak region

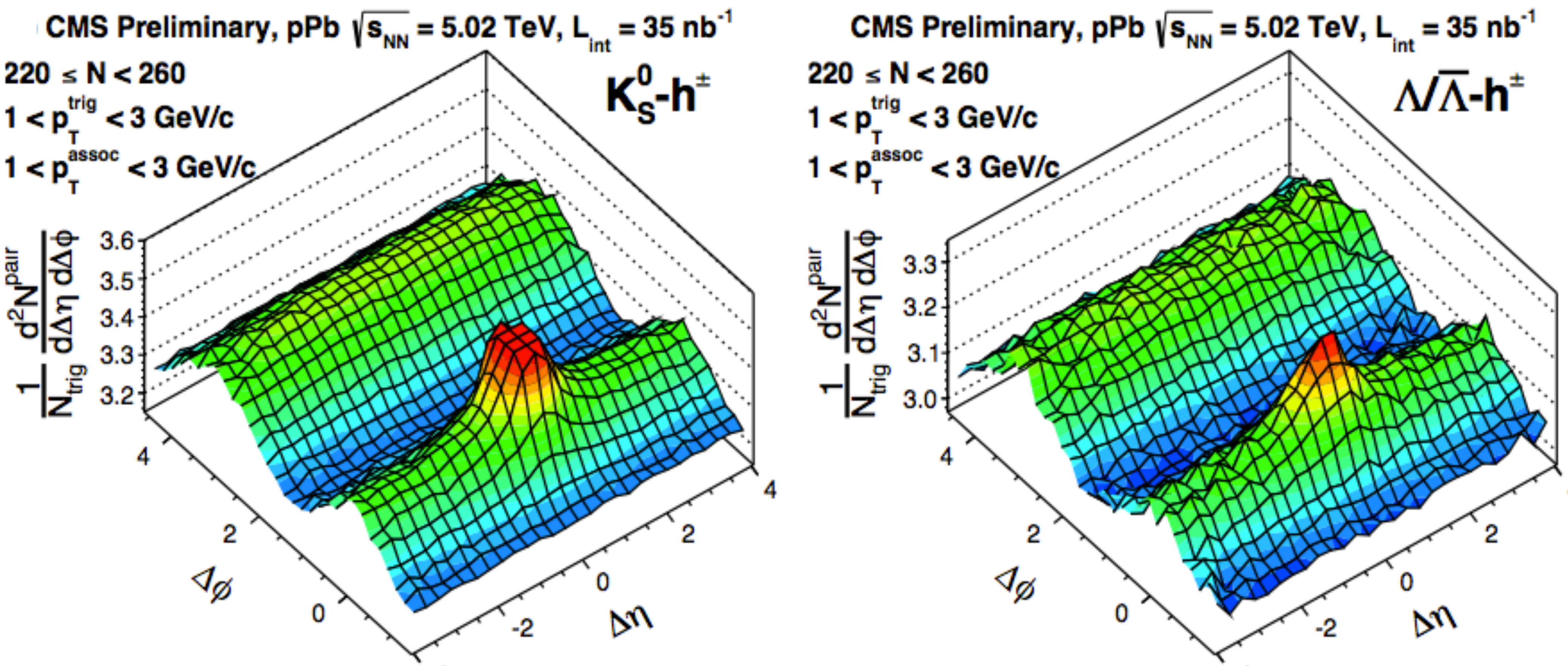
Sideband background region > 3σ

Peak region:
Background + signal candidates,
Extraction of v_n^{obs},
Calculation of signal fraction
f = signal yield/total yield = S/(S+B)

Sideband background region:
Only background candidates,
Extraction of v_n^{bkg}



Two-particle correlation function



- ❑ Two-particle correlation functions constructed for:
  - K^0_S as trigger, charged hadron as associated, K^0_S-h$^{\pm}$
  - Λ as trigger, charged hadron as associated, Λ-h$^{\pm}$

Method for extracting v_n

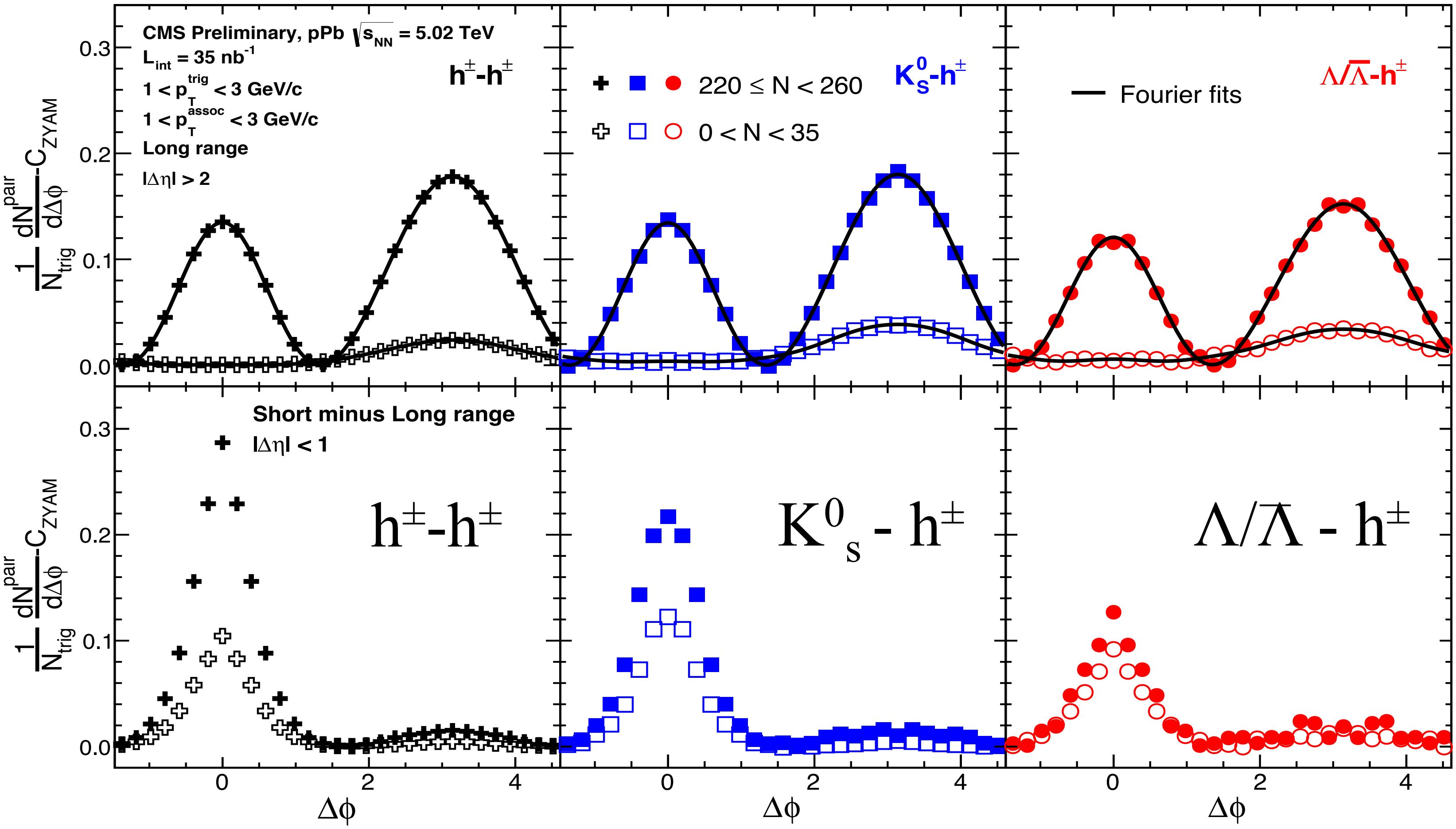
Two-particle correlation functions are projected in ridge range ($|\Delta\eta|>2.0$), fit by a Fourier decomposition to get $V_{n\Delta}$: $\frac{1}{N_{trig}}\frac{dN^{pair}}{d\Delta\phi} = \frac{N_{assoc}}{2\pi}\left\{1+\sum_n 2V_{n\Delta}\cos(n\Delta\phi)\right\}$

$$v_n^h = \sqrt{V_{n\Delta}^{h-h}}$$

Assume factorization

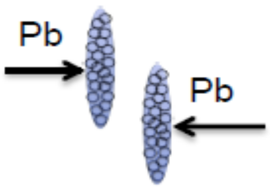
$$v_n^{K_s^0} = \frac{V_{n\Delta}^{K_s^0-h}}{v_n^h}$$

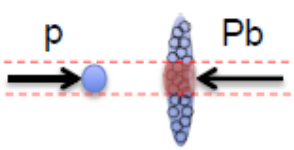
$$v_n^{\Lambda} = \frac{V_{n\Delta}^{\Lambda-h}}{v_n^h}$$

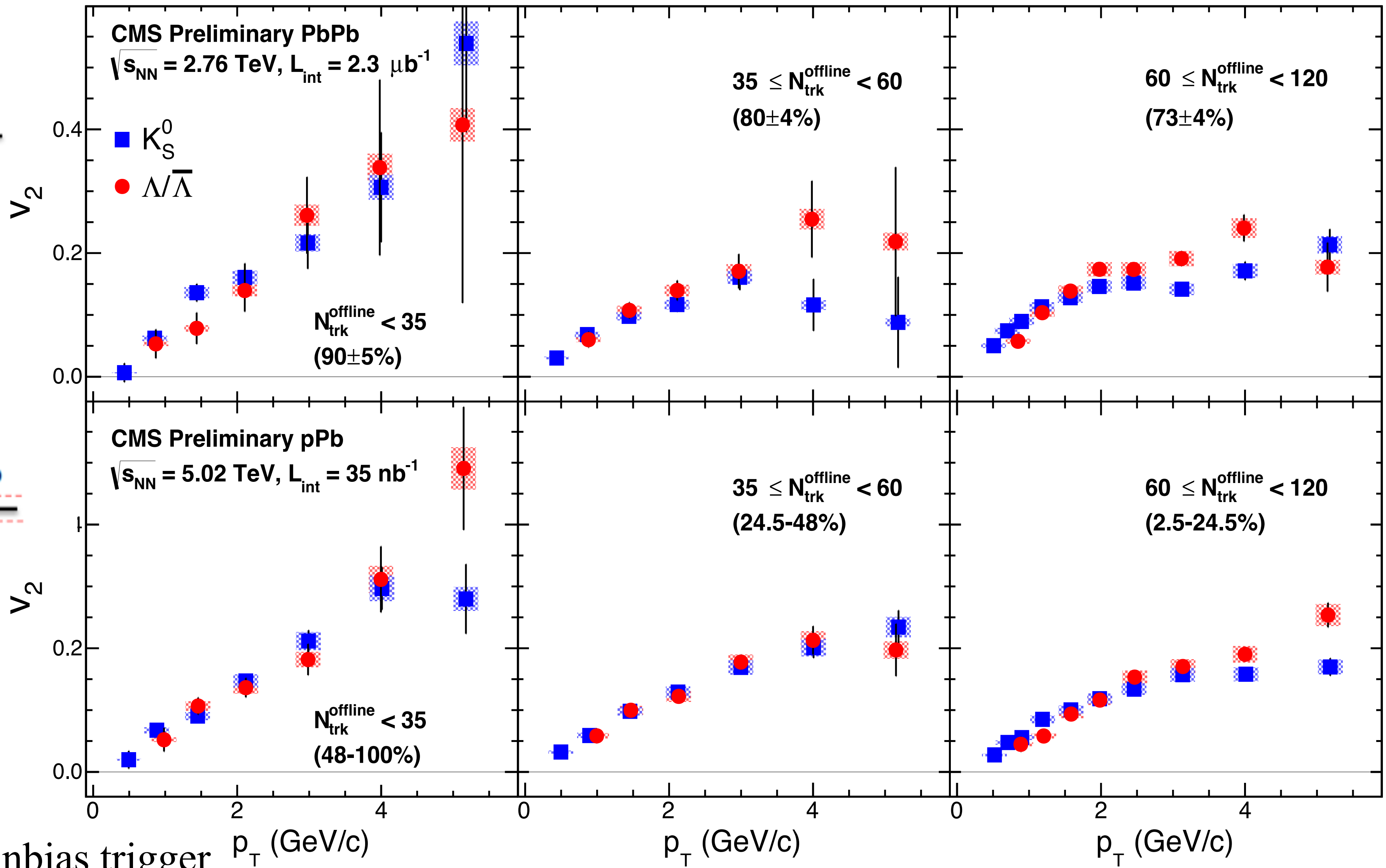


$$v_n^{obs} = f.v_n^{sig} + (1-f).v_v^{bkg}$$

Low multiplicity: pPb and PbPb collisions





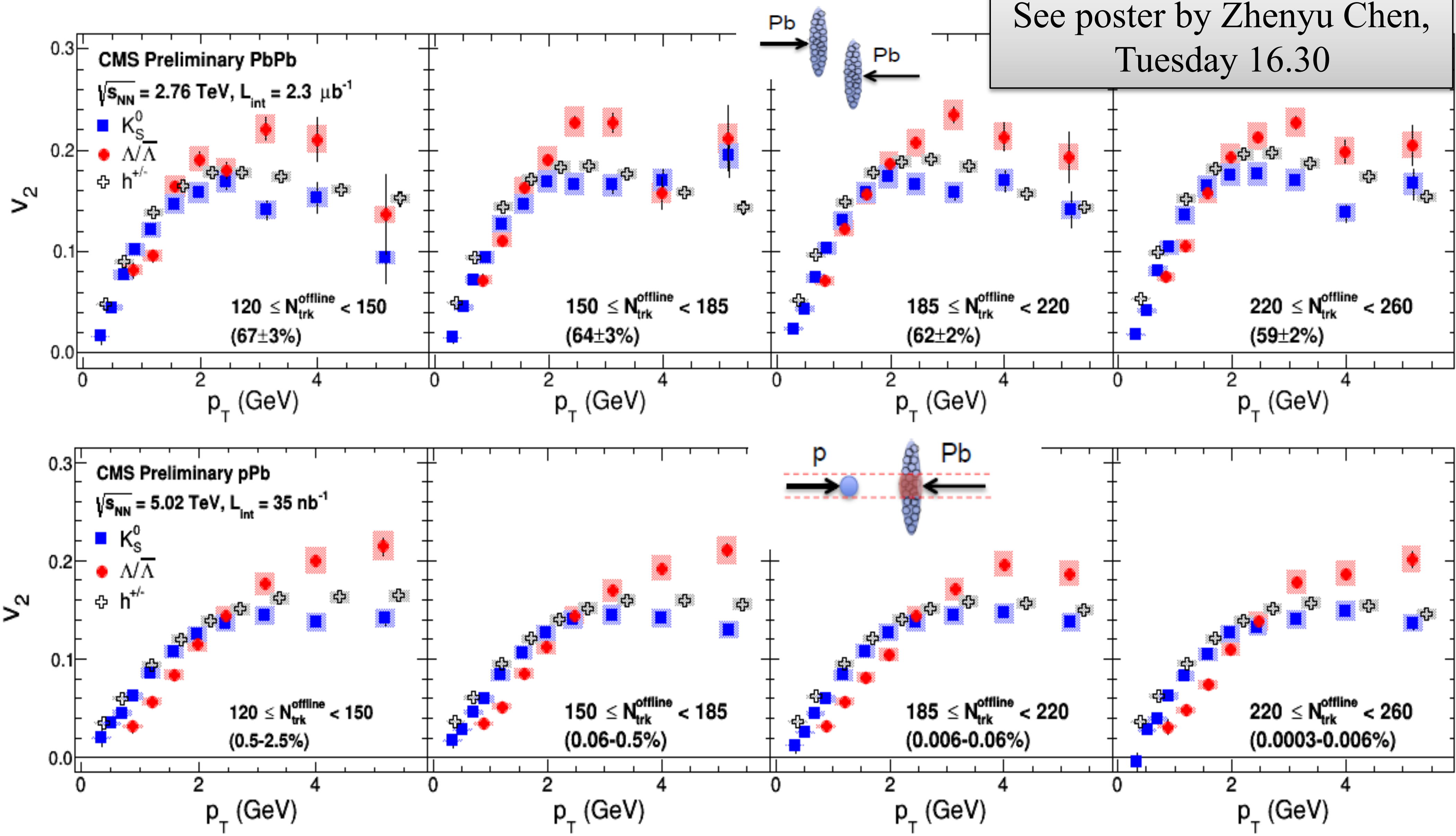


Data from Minbias trigger

- v_2 patterns almost the same for K^0_S and Λ at low multiplicity in both collision systems
- Crossing over observed for p_T around 2 GeV/c for 60 – 120 multiplicity range

Higher multiplicity class: pPb and PbPb collisions

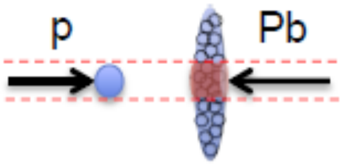
See poster by Zhenyu Chen, Tuesday 16.30

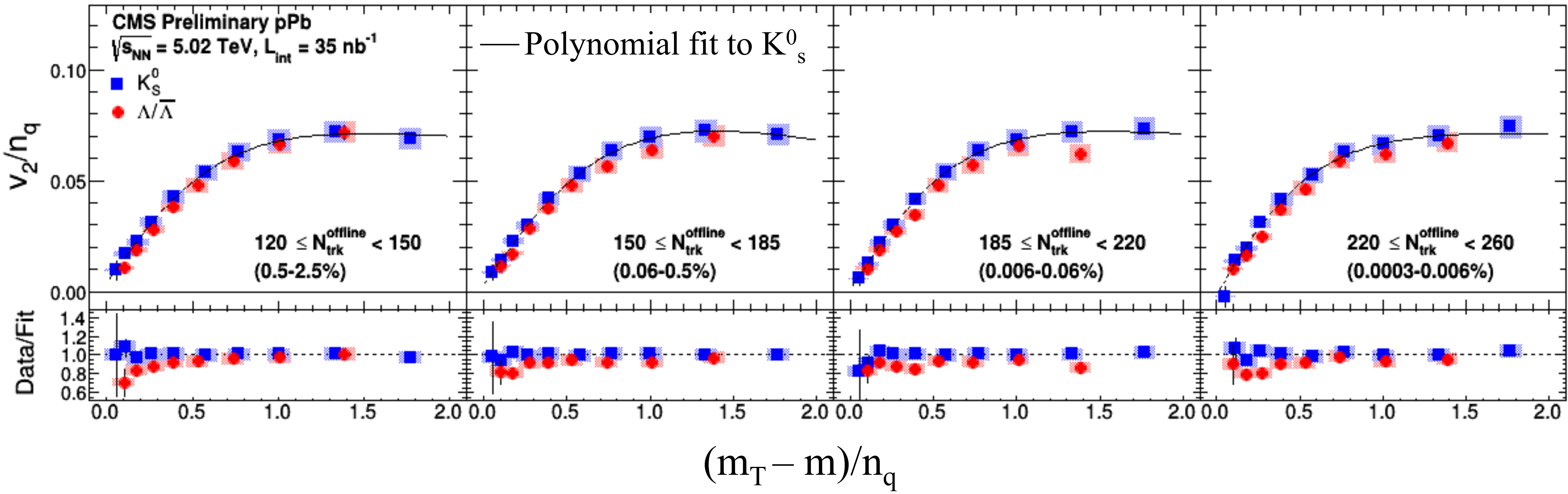


Mass ordering (below ~2 GeV/c) and cross-over (above ~ 2 GeV/c) observed

NCQ scaling in high multiplicity pPb collisions

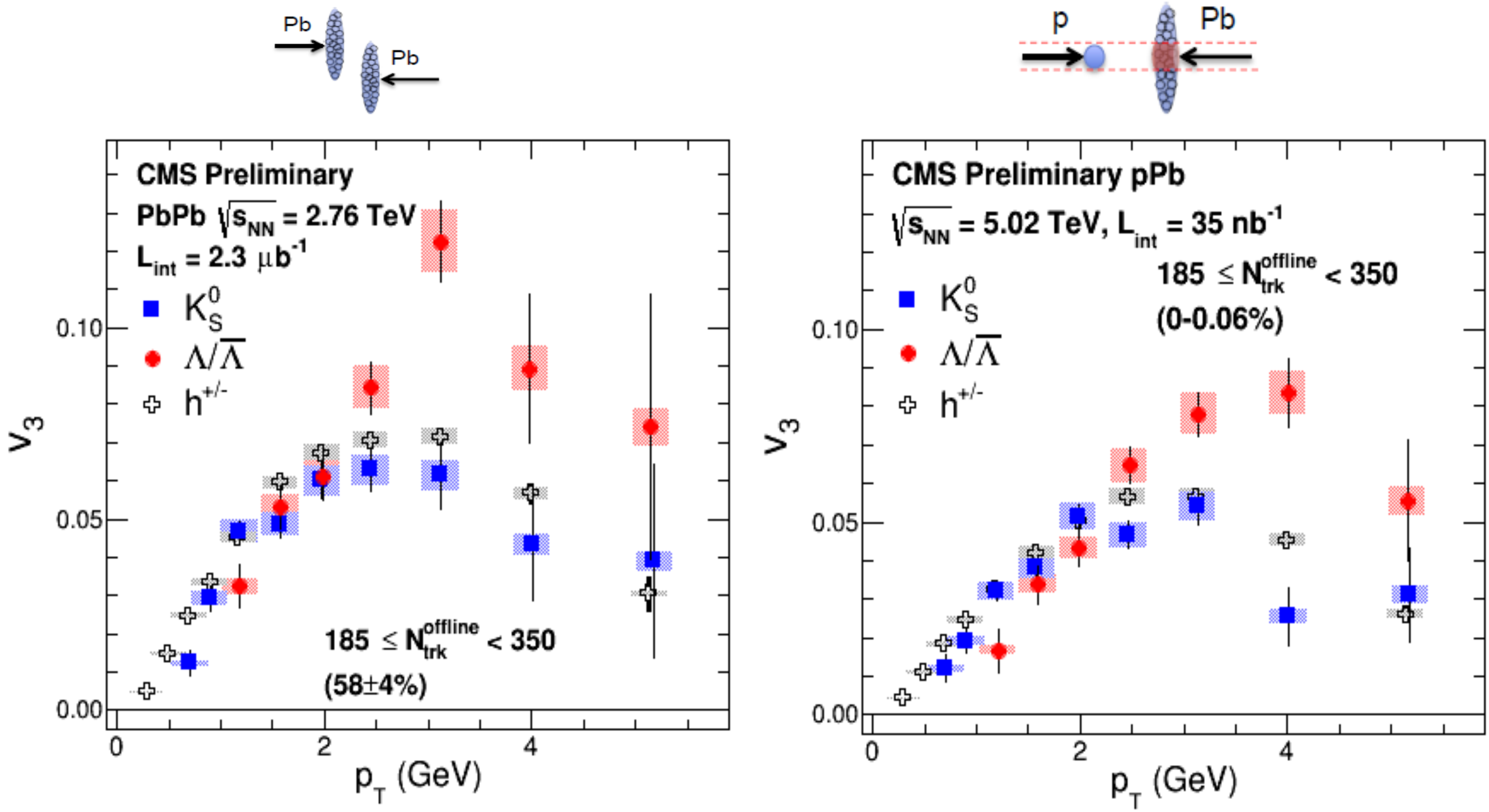
See poster by Zhenyu Chen, Tuesday: 16.30





Azimuthal anisotropy develops at the partonic level in pPb collisions?

v_3 in higher multiplicity



Cross-over (above ~ 2 GeV/c) observed

Conclusions

- Presented the second-order (v_2) and third-order (v_3) anisotropy harmonics of K^0_S and Λ for high-multiplicity in pPb collisions
  - Results were compared to similar multiplicities in PbPb collisions
- Low multiplicity in pPb and PbPb collisions:
  - v_2 patterns are almost the same for K^0_S and Λ
- Higher multiplicity in pPb and PbPb collisions:
  - Mass ordering prominently observed in pPb collisions compared to PbPb collisions
  - Cross-over is seen at p_T around 2 GeV/c
- NCQ scaling observed for v_2 in pPb collisions

HIN-PAS-14-002

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN

Back up

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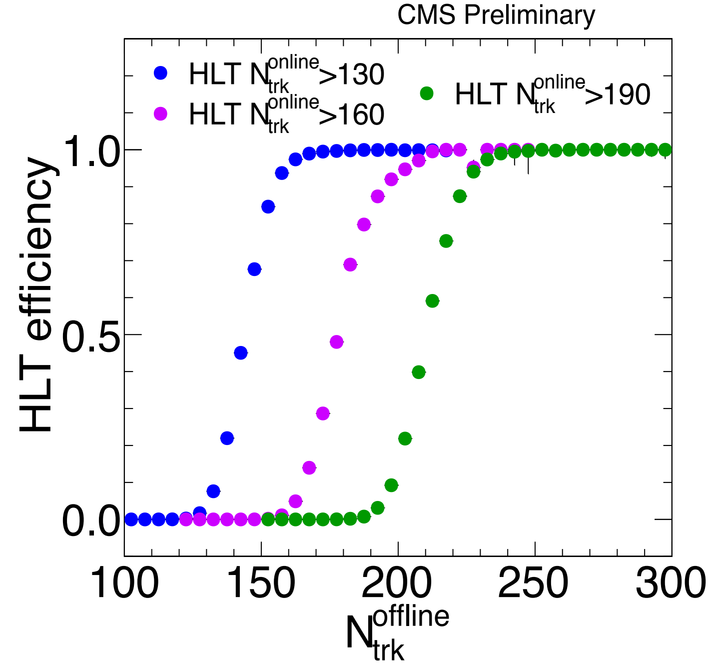
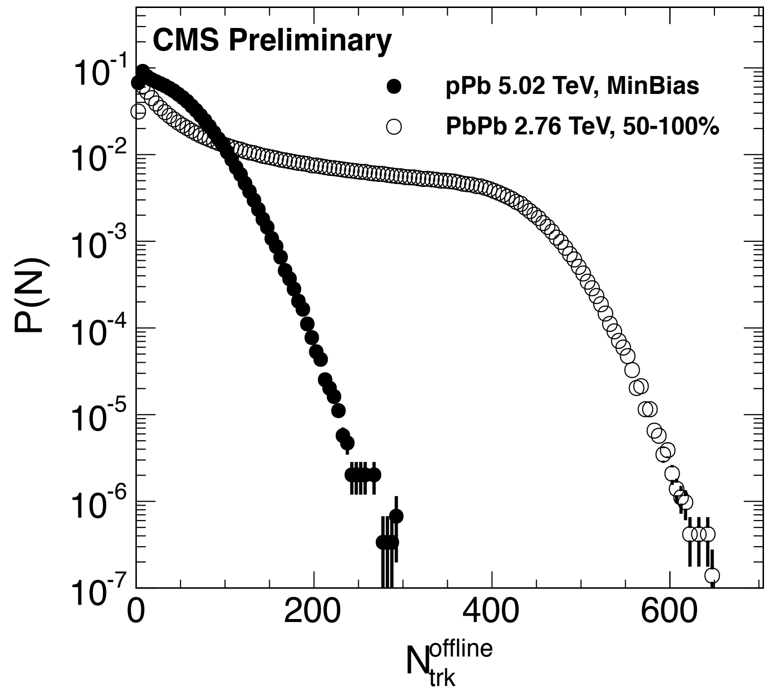
  - **2011 PbPb, 2.3μb^{-1} (50-100%)**
- **Triggers**
  - **Minimum bias trigger**
  - **High multiplicity triggers in 2013**





Track multiplicity distribution in minBias pPb and PbPb 50-100%

NCQ scaling in high multiplicity pPb collisions