Recent CMS Experiment Results on Multiparticle Aspects of High-Density Systems In Heavy Ion Collisions

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(MIT)
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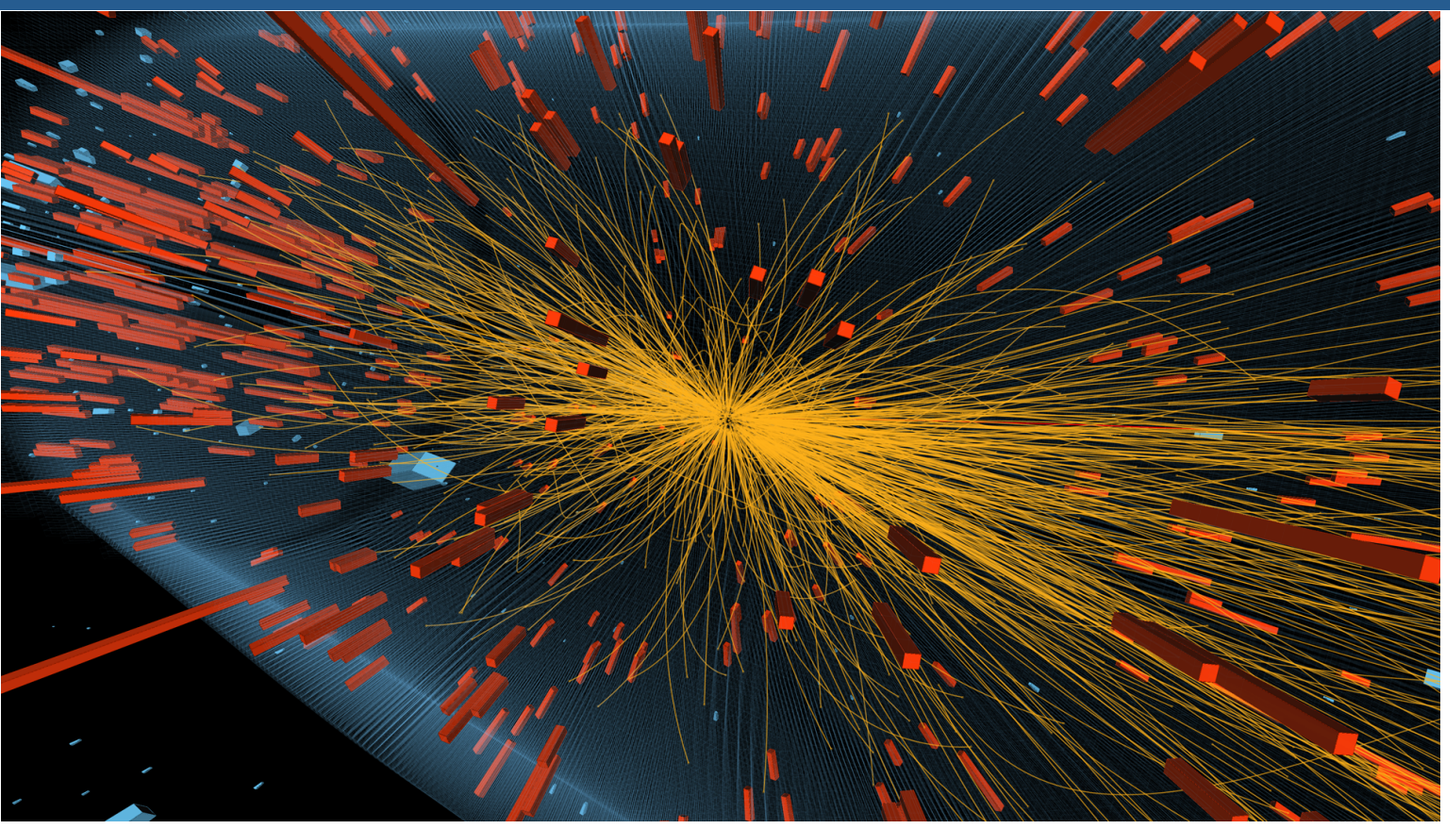
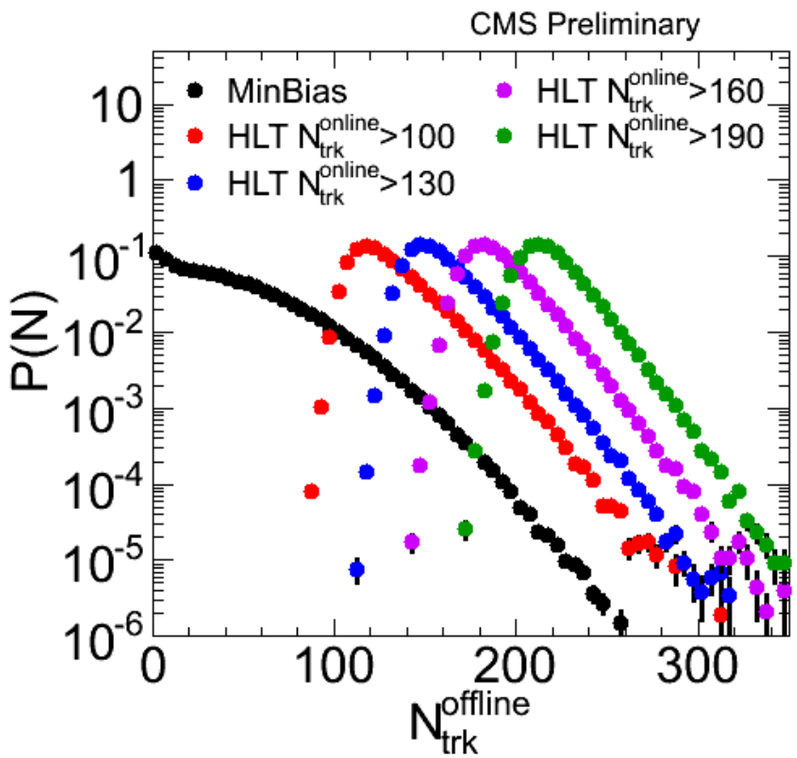
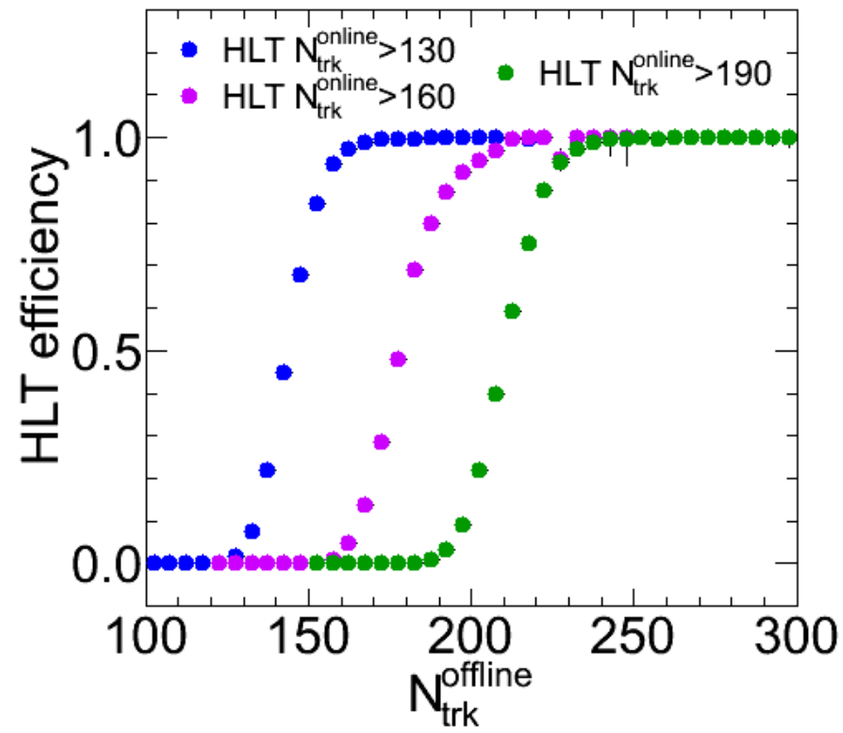
pPb Collisions 2013



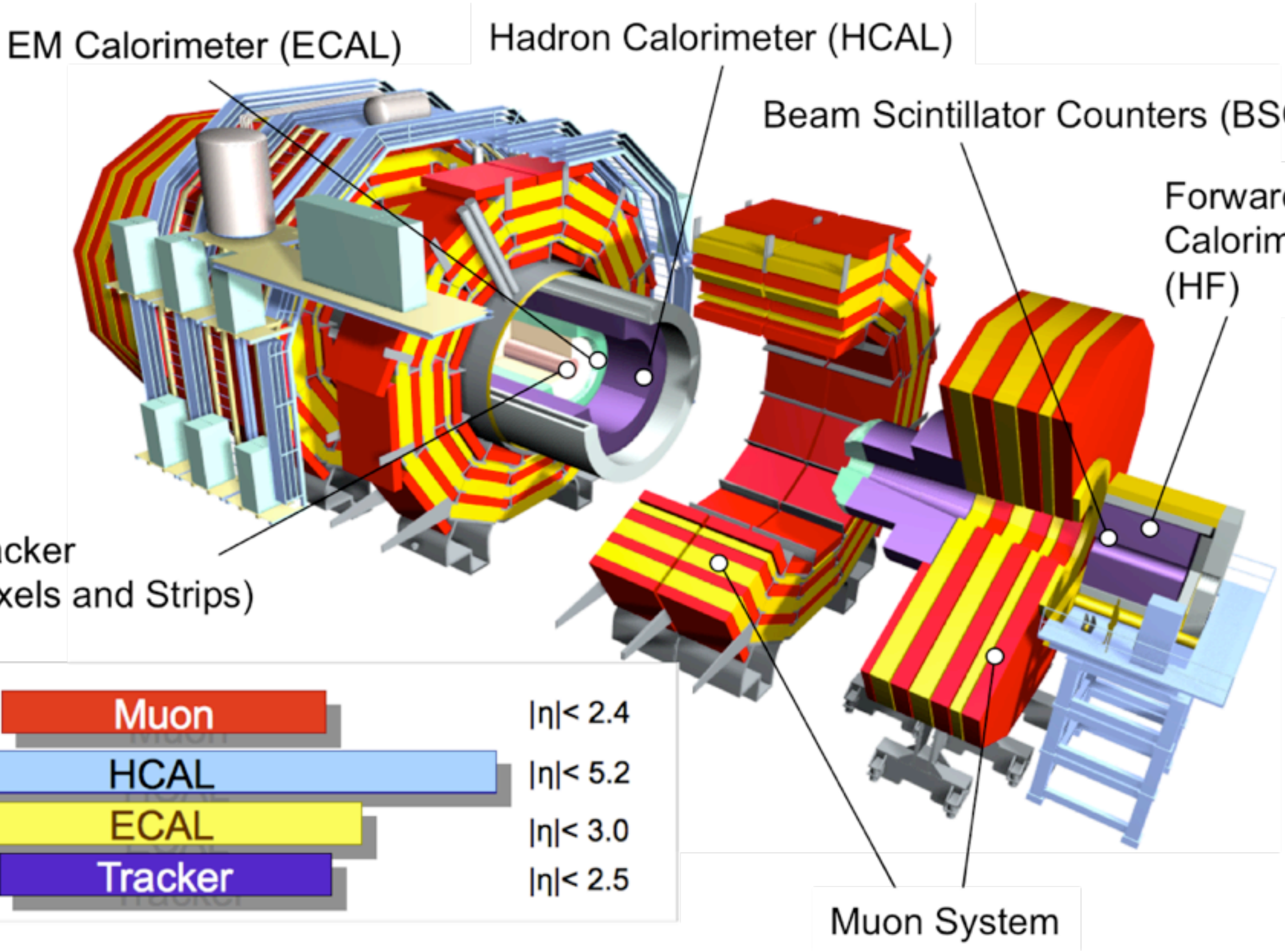


- 4 High-Multiplicity HLT trigger thresholds
- Each recorded 20M events over a 3-week period
- Integrated luminosity: 31nb^{-1}

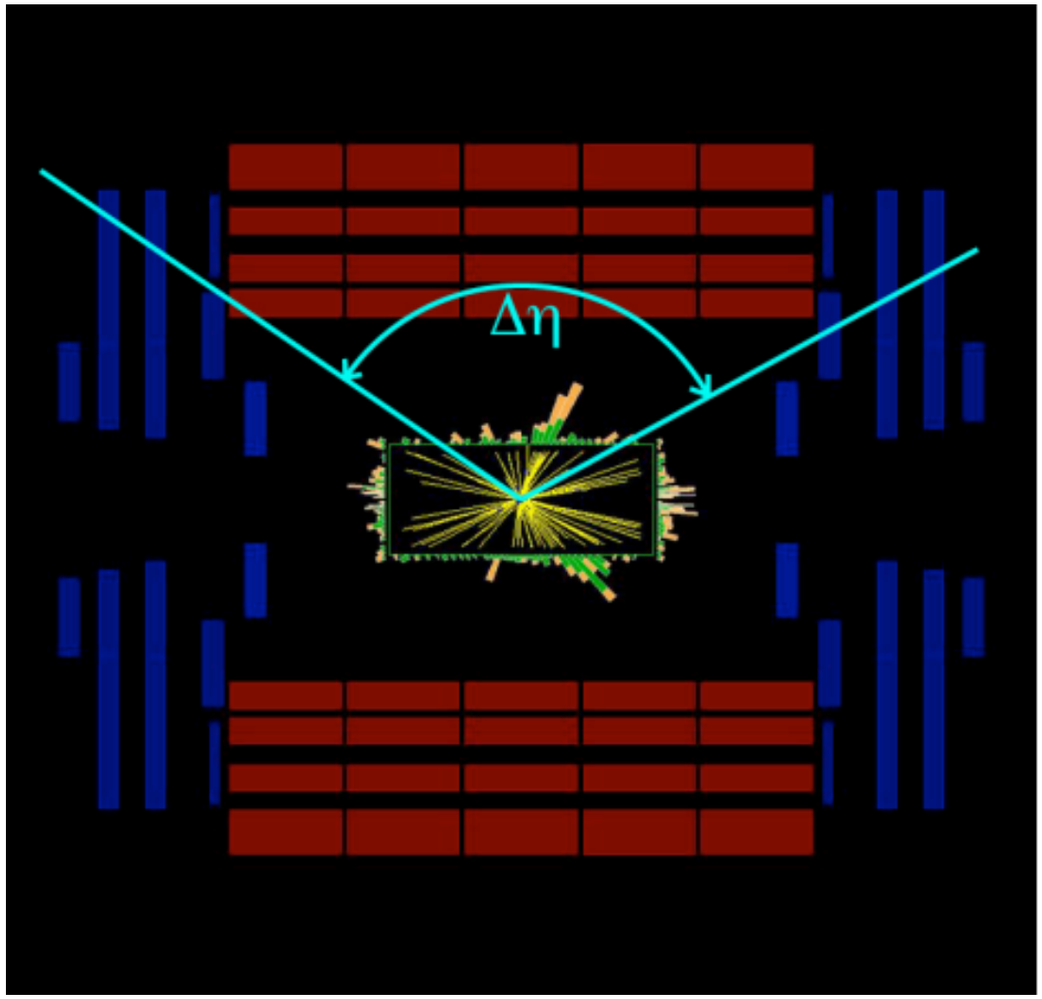
- re-analyzed PbPb data: 2.3μb^{-1} (50-100%)

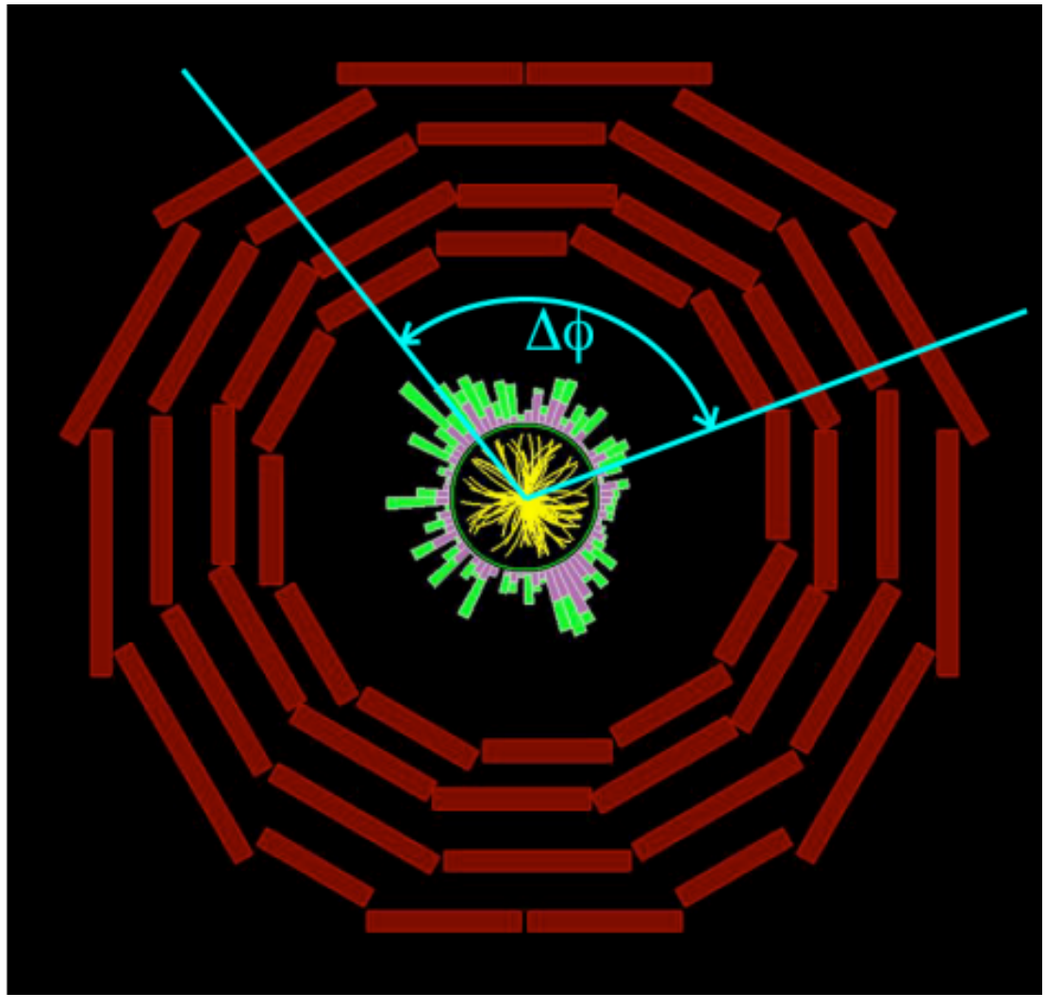


CMS Experiment at the LHC



Two-Particle Correlations





Two-particle azimuthal angular correlation function:

- was first observed at RHIC
- have been investigated over a broad range of energy for different colliding systems

Method

Signal pair distribution:

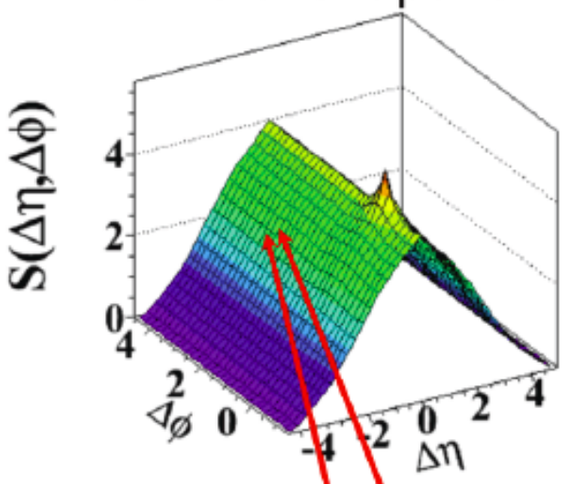
$$S(\Delta\eta,\Delta\varphi) = \frac{1}{N_{trig}} \frac{d^2N^{same}}{d\Delta\eta d\Delta\varphi}$$

Background pair distribution:

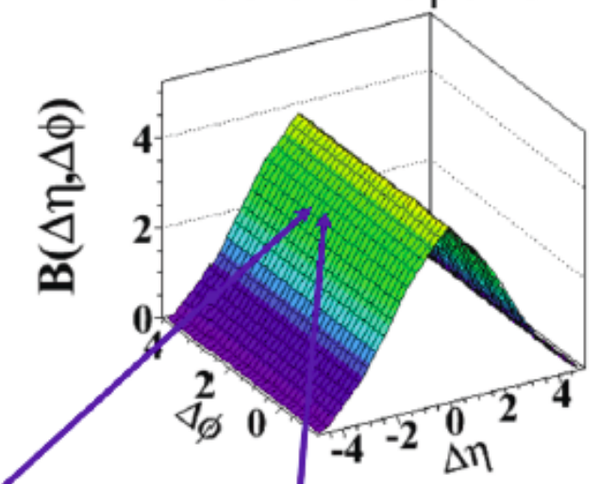
$$B(\Delta\eta,\Delta\varphi) = \frac{1}{N_{trig}} \frac{d^2N^{mix}}{d\Delta\eta d\Delta\varphi}$$

$$\Delta\eta = \eta^{assoc} - \eta^{trig}$$
$$\Delta\phi = \phi^{assoc} - \phi^{trig}$$

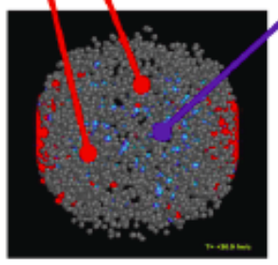
same event pairs



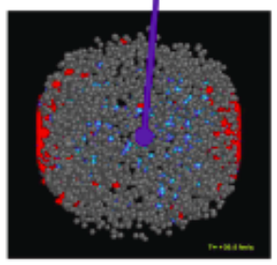
mixed event pairs



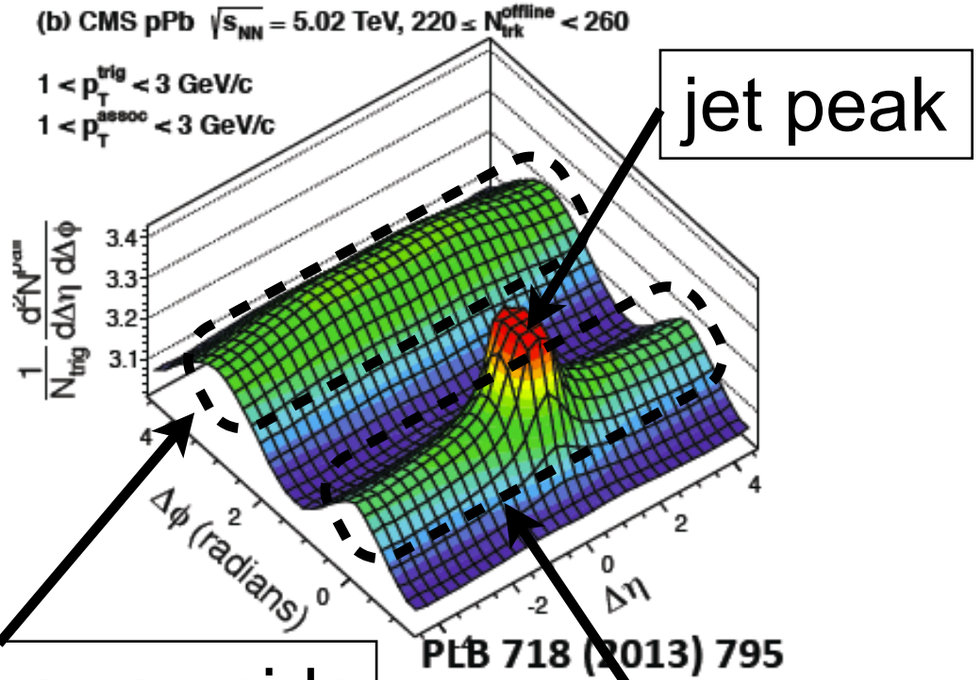
Event 1:



Event 2:



$$\frac{1}{N_{trig}} \frac{d^2N^{pair}}{d\Delta\eta d\Delta\phi} = B(0,0) \times \frac{S(\Delta\eta,\Delta\phi)}{B(\Delta\eta,\Delta\phi)}$$

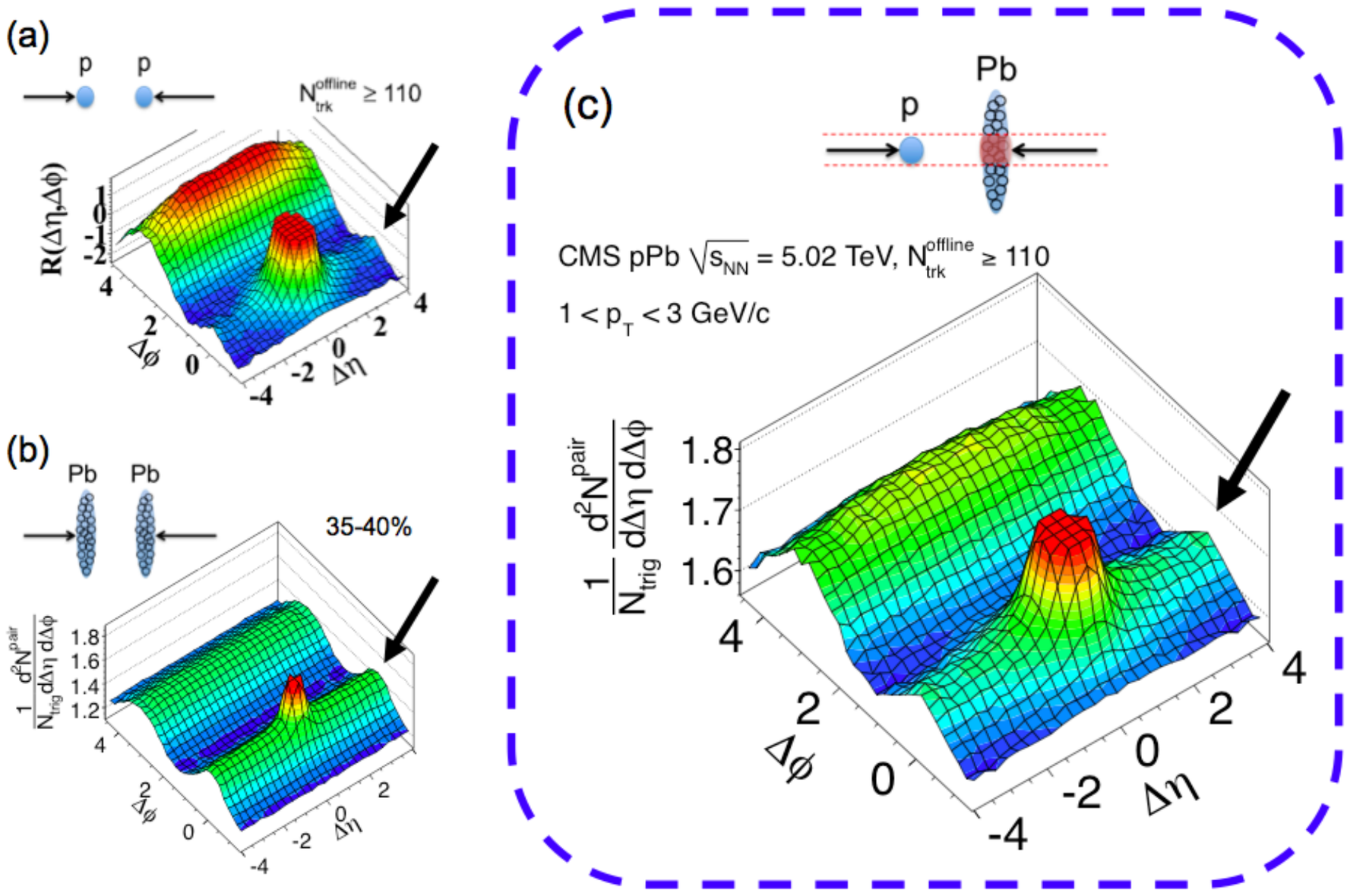


jet peak

long range away-side

long range near-side(ridge)

Ridge(s)!



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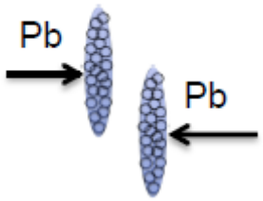
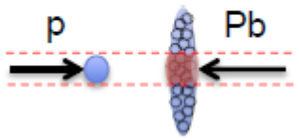
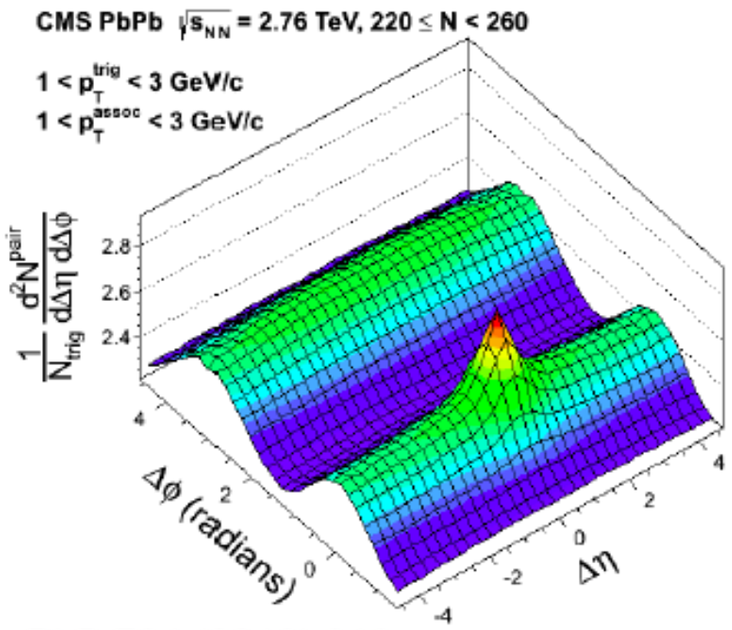
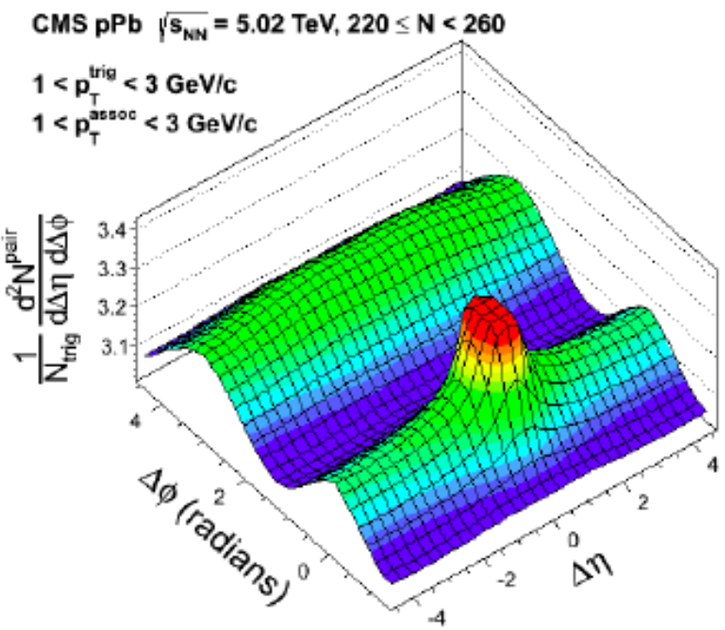
2013 pPb results









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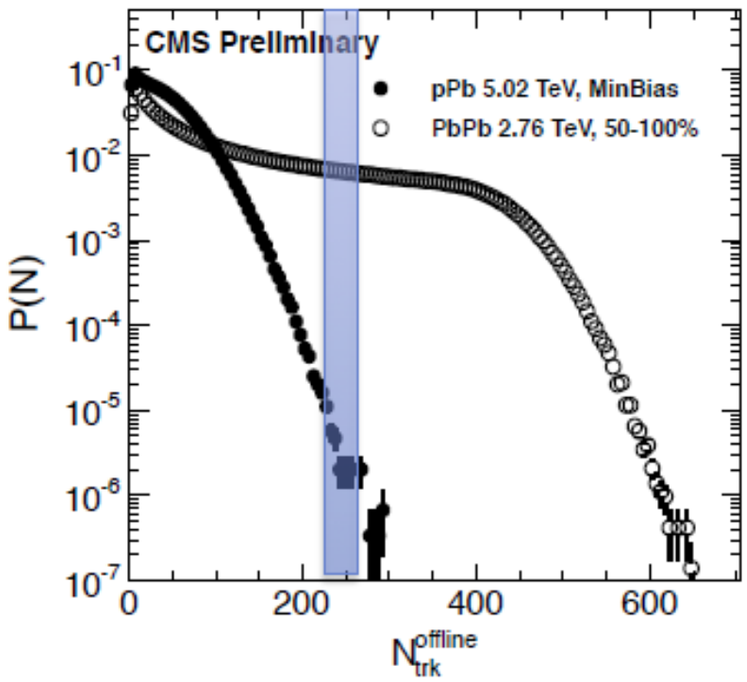


Unexpected remarkable similarity between pPb and PbPb!

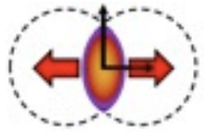
The Questions To Be Answered:

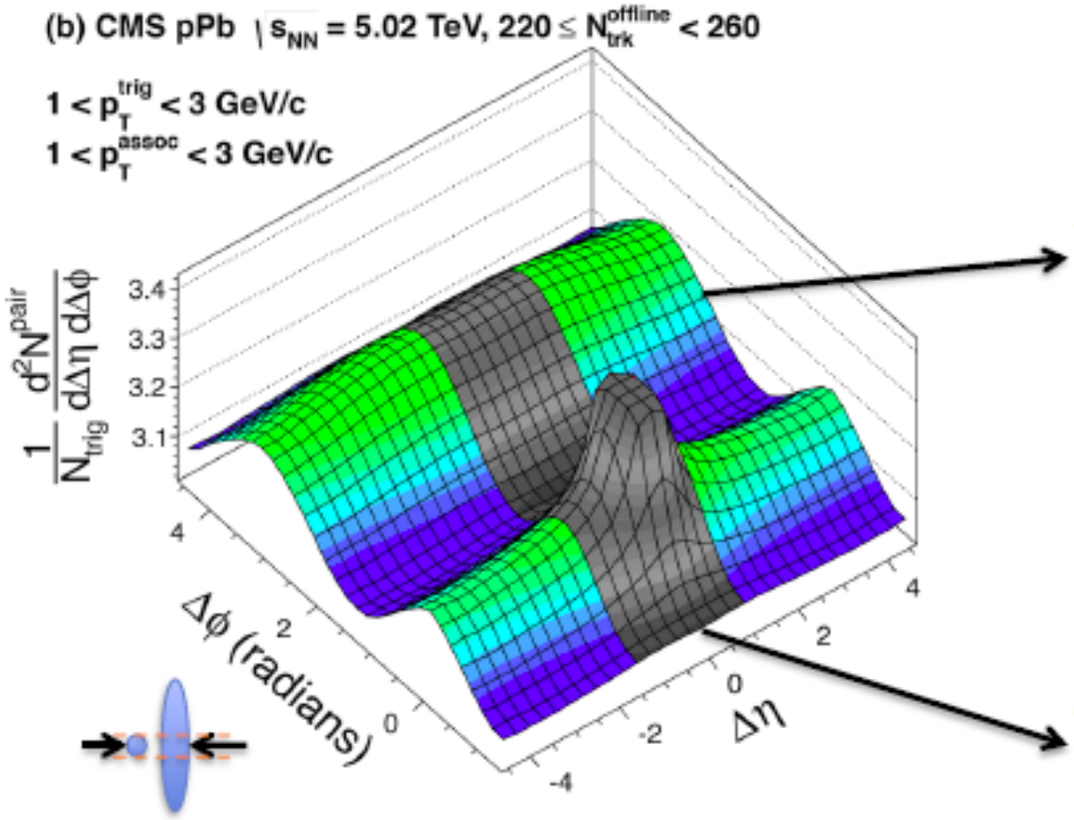
- What is the origin of the ridge in small systems ?
  - Collective flow ?
  - Quantum interference of gluons (CGC) ?
  - … or something else ?
- What are the initial state fluctuations ?

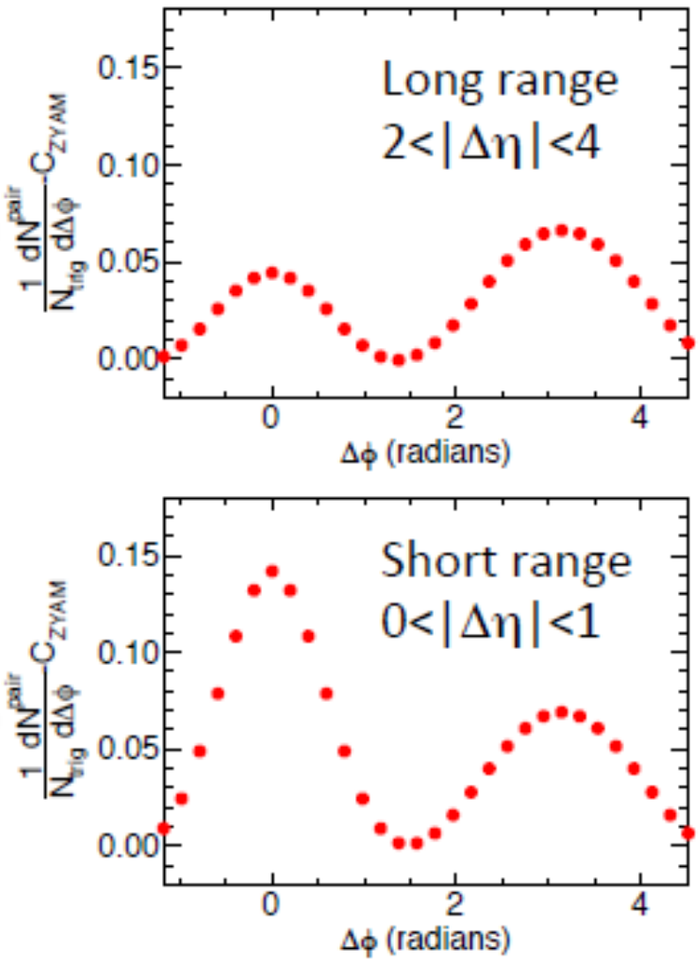
- Methods:
  - Compare 2- and 4-particle correlations in different collision systems
  - Study high-order harmonics
  - multiplicity dependence

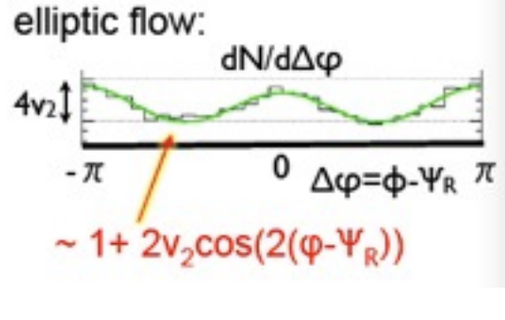
Long and short range explained

Collective effects :
decompose in Fourier components





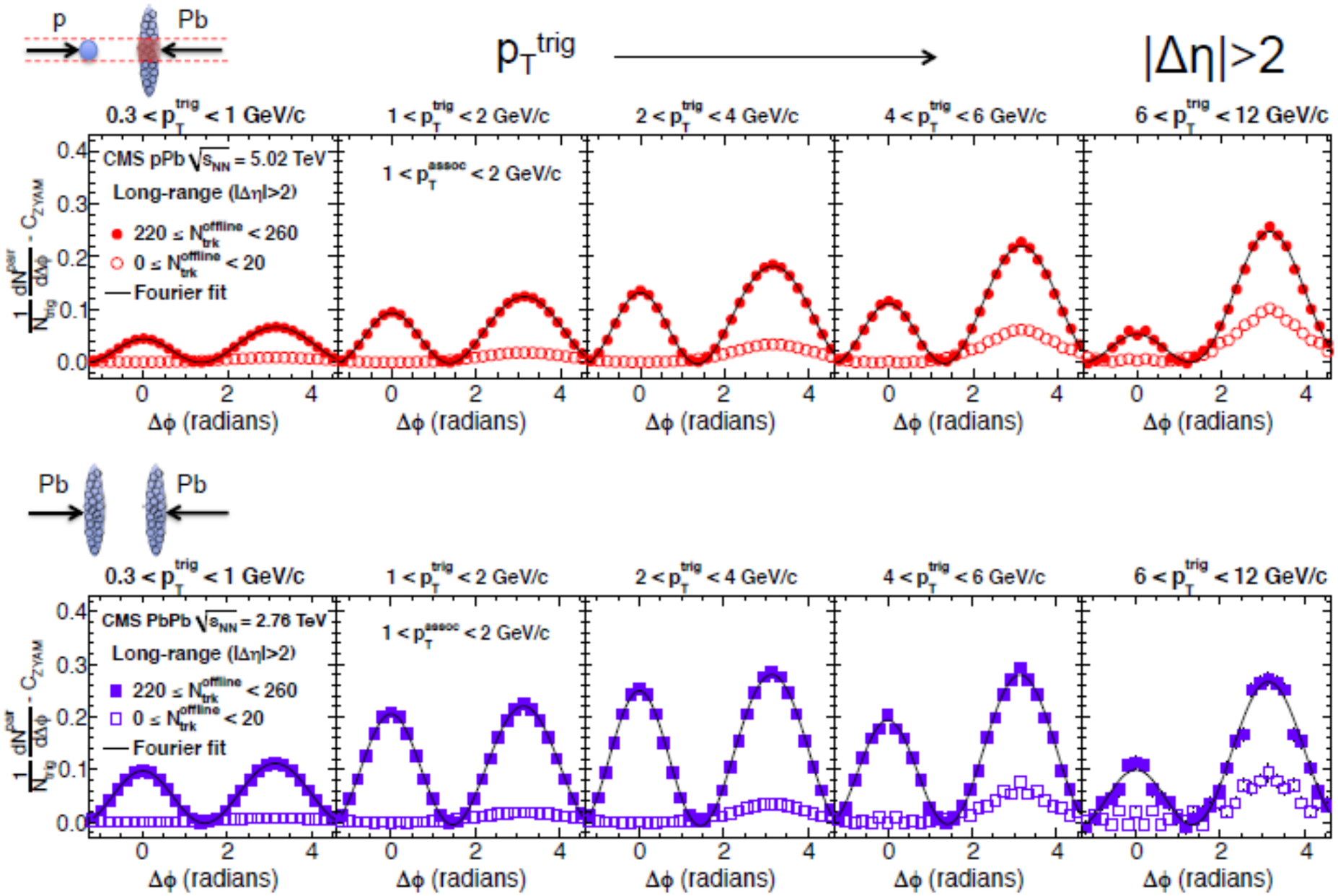




- Long range 2<|Δη|<4
- Short range 0 < |Δη|<1

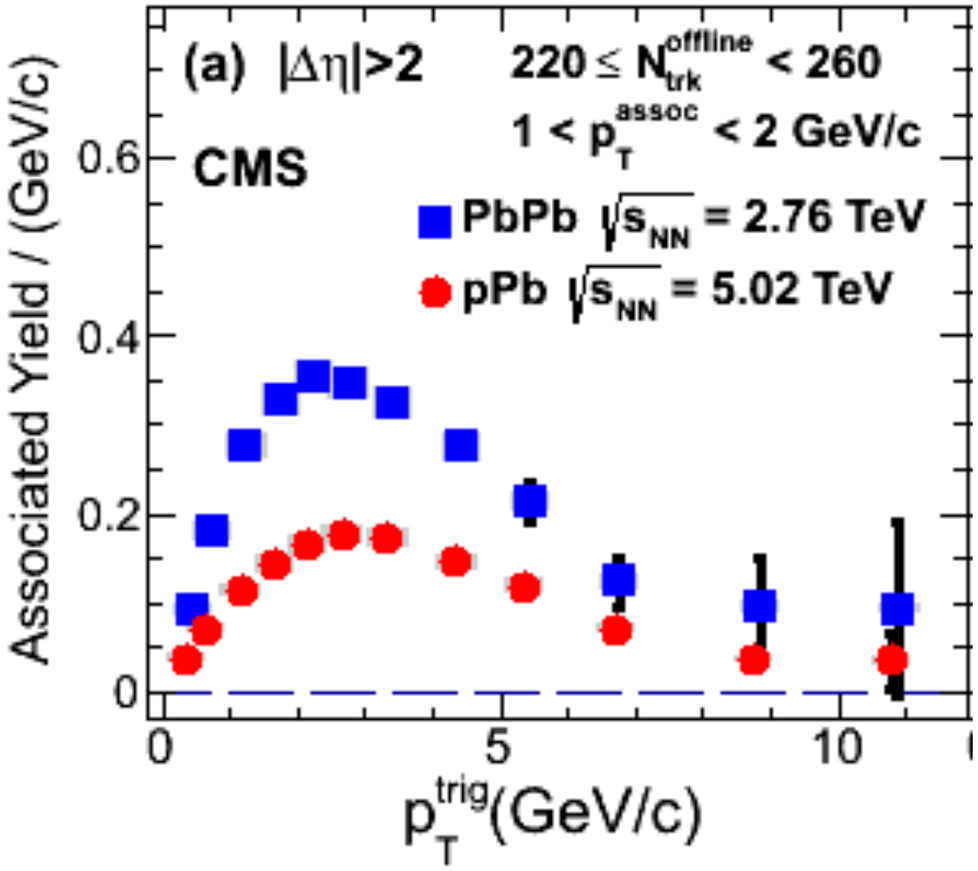
Jet-like correlations

1D Δϕ Correlation Functions

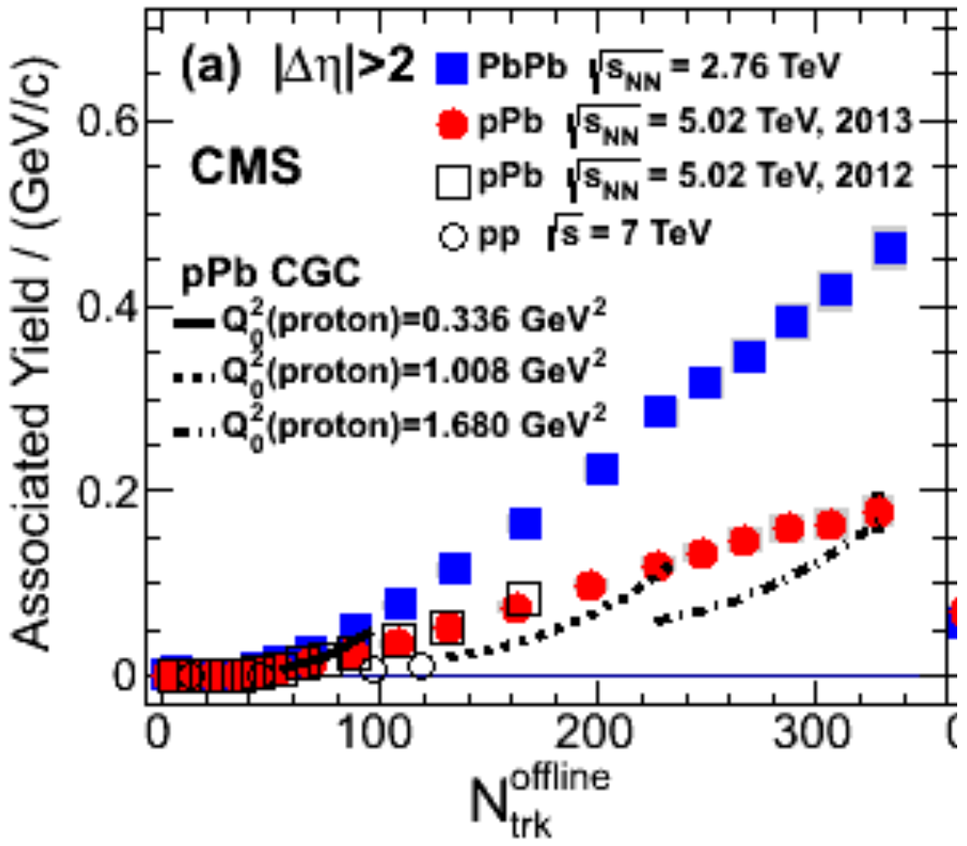


The pPb and PbPb yields show similar correlation structure and p_T dependence over a wide range of p_T ^{trig}.

The Ridge Yield in Different Systems



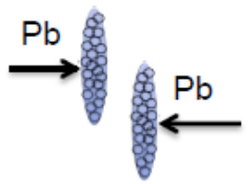
Similar p_T dependence in PbPb and pPb

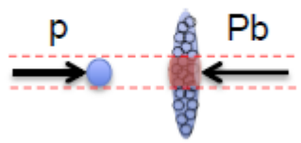


Emergence around Ntrk ~ 50
Independent of system size

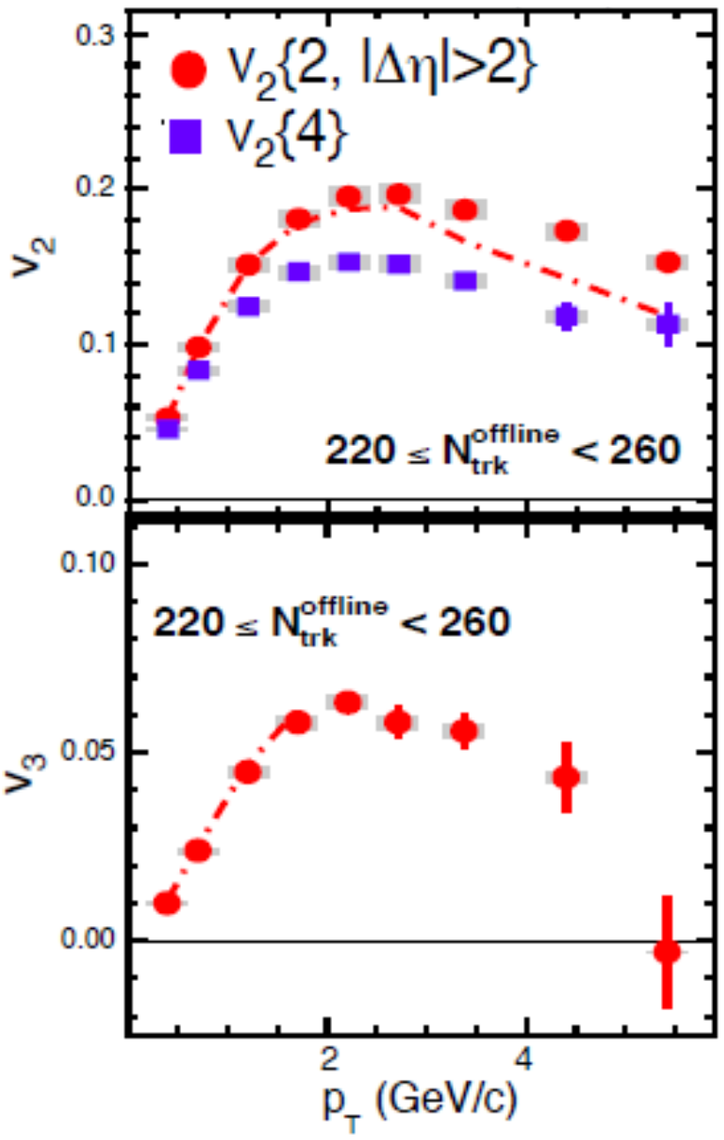
p_T Dependence of v_n

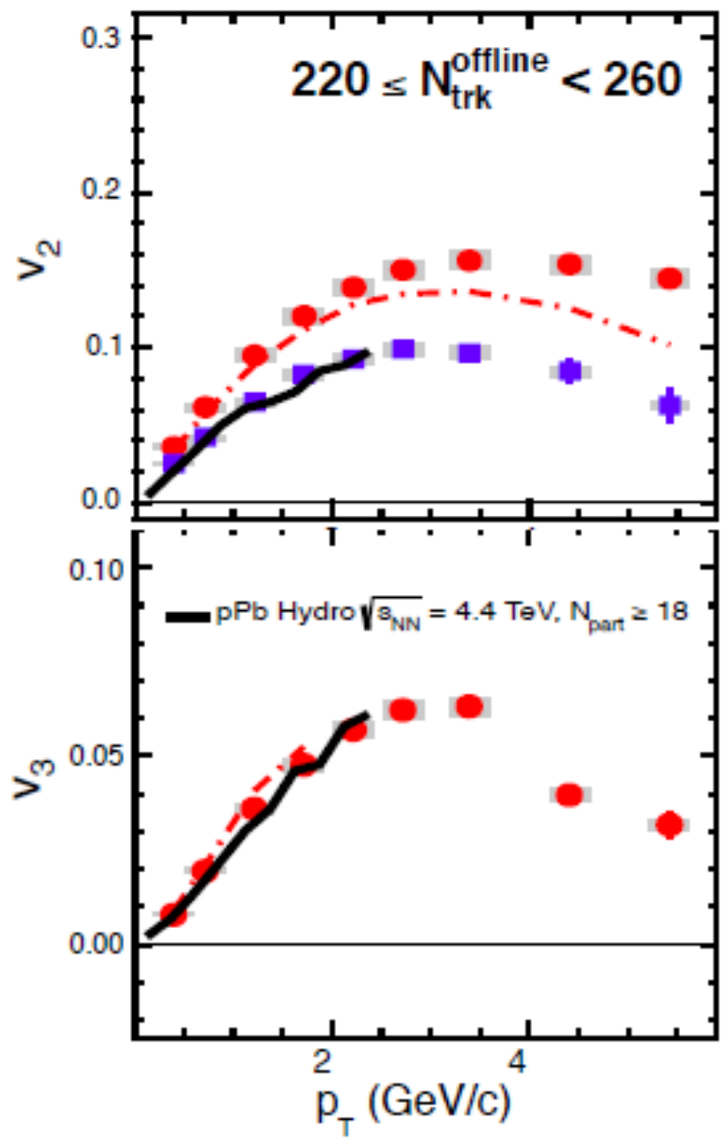
Dashed-dotted curves
N<20 subtracted





n = 2

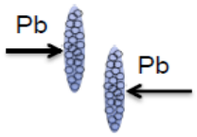


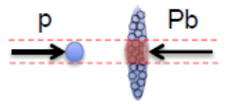


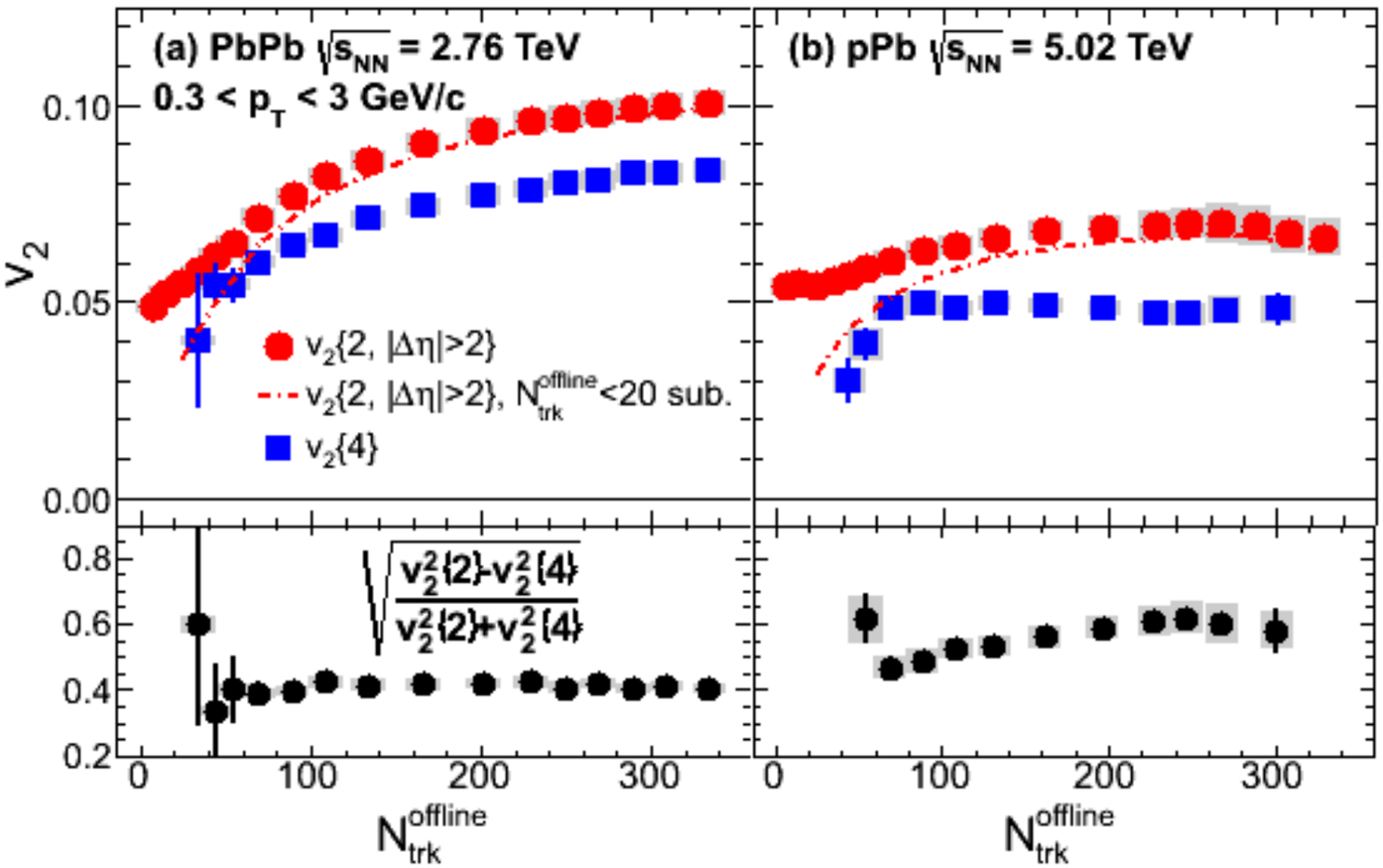
n = 3

Remarkable similarity in PbPb and pPb for same multiplicity

Multiplicity Dependence of v_2

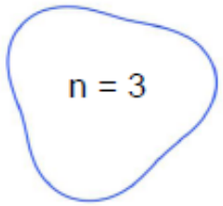


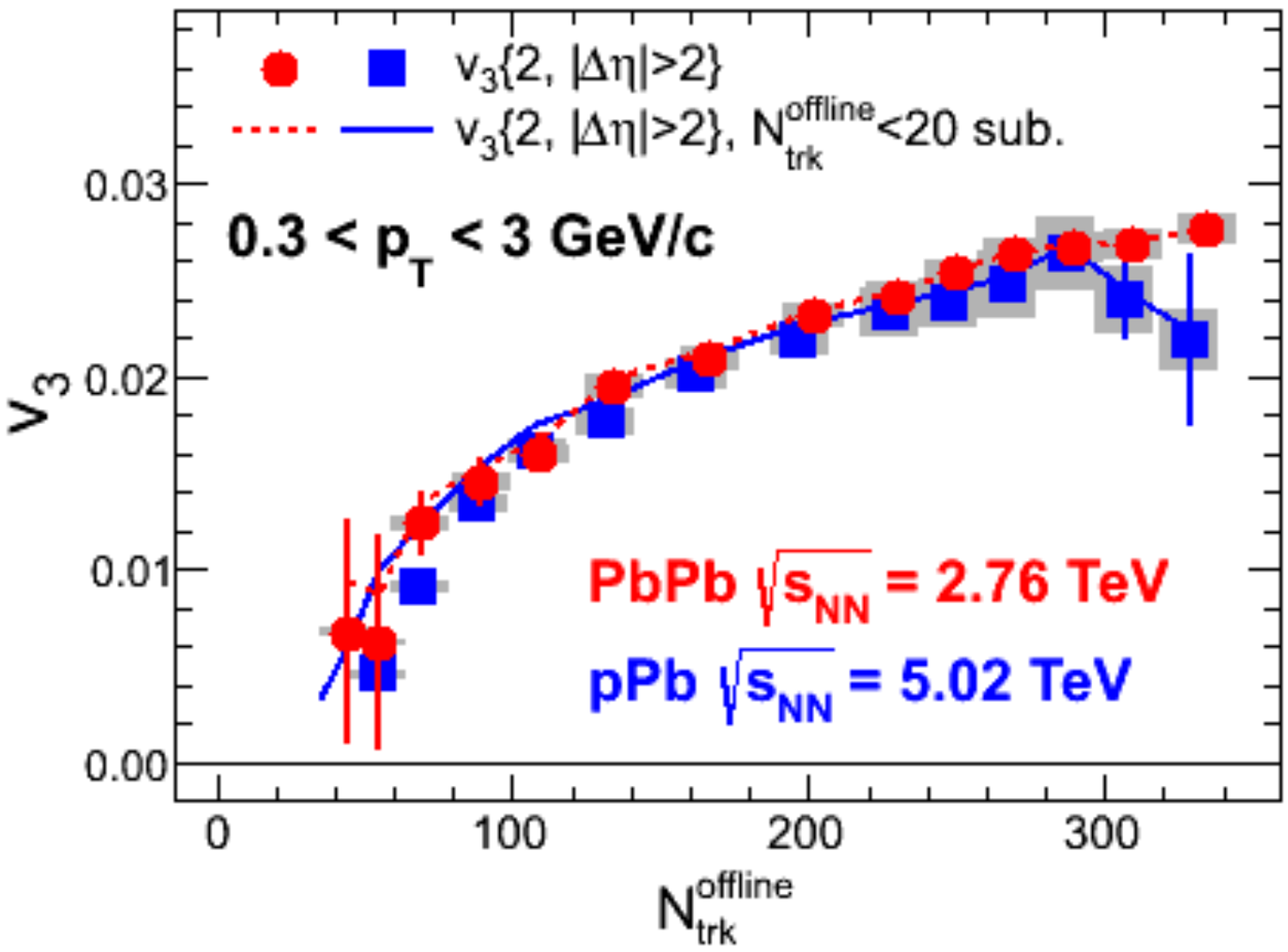




$v_2\{4\}$ turn-on around N_{trk} ~ 50; weak multiplicity dependence

Multiplicity Dependence of v_3

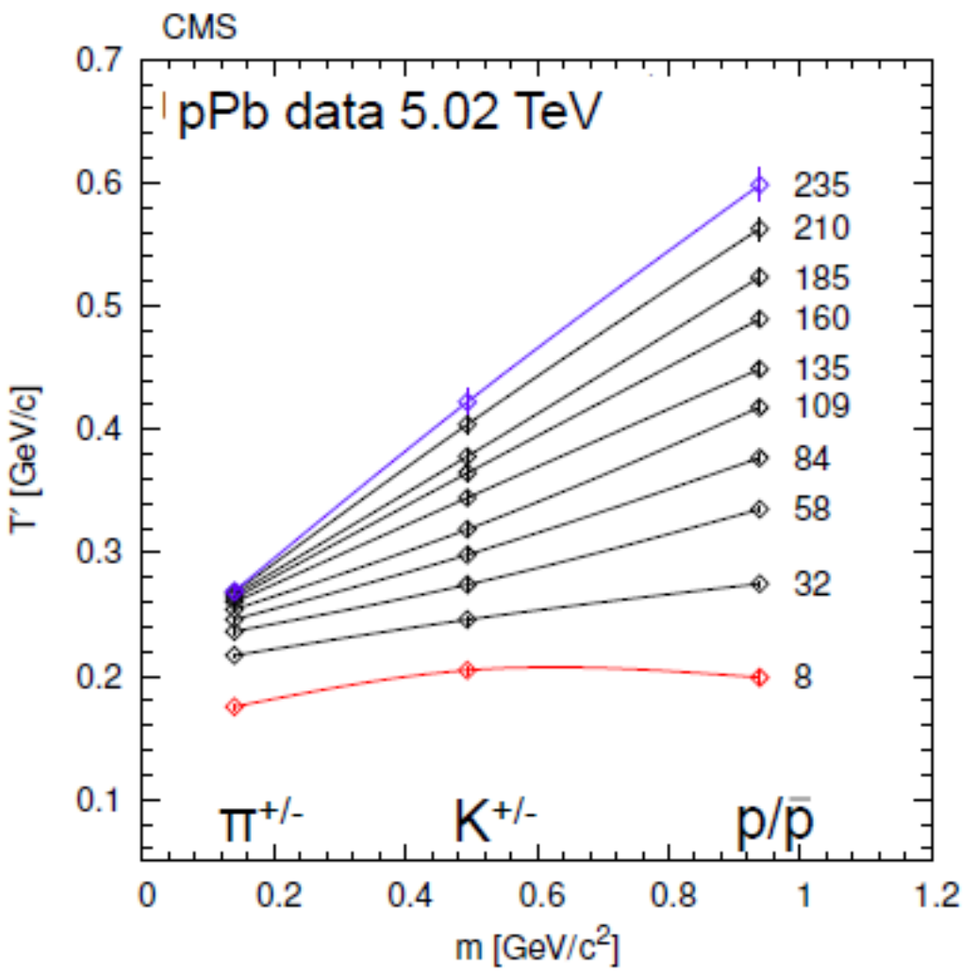


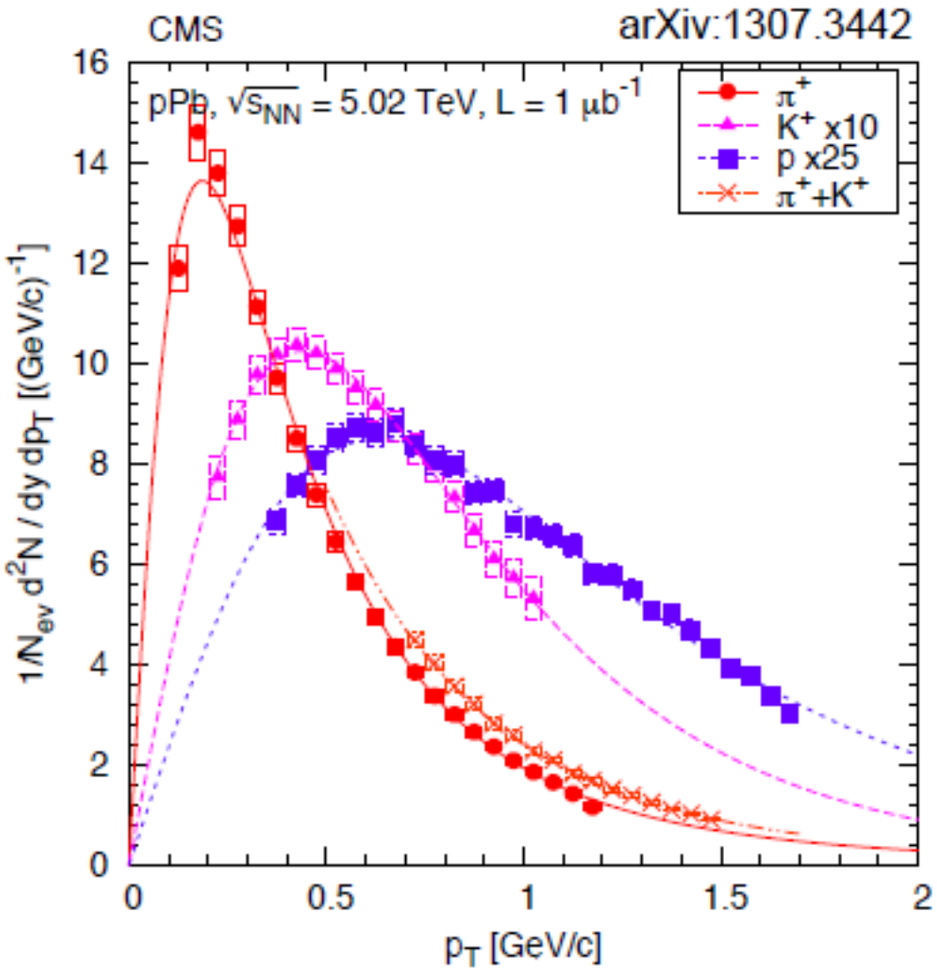


Independent of system size

Other Evidence of Hydro Flow in pPb?

Inverse slope of m_T distributions, T_{slope}: $\frac{1}{m_T}\frac{dN}{dm_T} \sim \exp(-\frac{m_T}{T_{slope}})$





Inverse slope increases with particle mass and with multiplicity. Reminiscent of radial flow.

Conclusions

- Unexpected similarity between pPb and PbPb ridge signal strength!
- CMS has measured v_2 and v_3 coefficients in pPb and PbPb.
- Similar p_T and multiplicity dependence is observed between pPb and PbPb.
- v_3 is identical in pPb and PbPb.
- The ridge becomes apparent at the same multiplicity independent of the system size.
- Other evidences for hydro behavior are observed.