First measurement of high p_T azimuthal anisotropy using subevent cumulants in pPb collisions at CMS

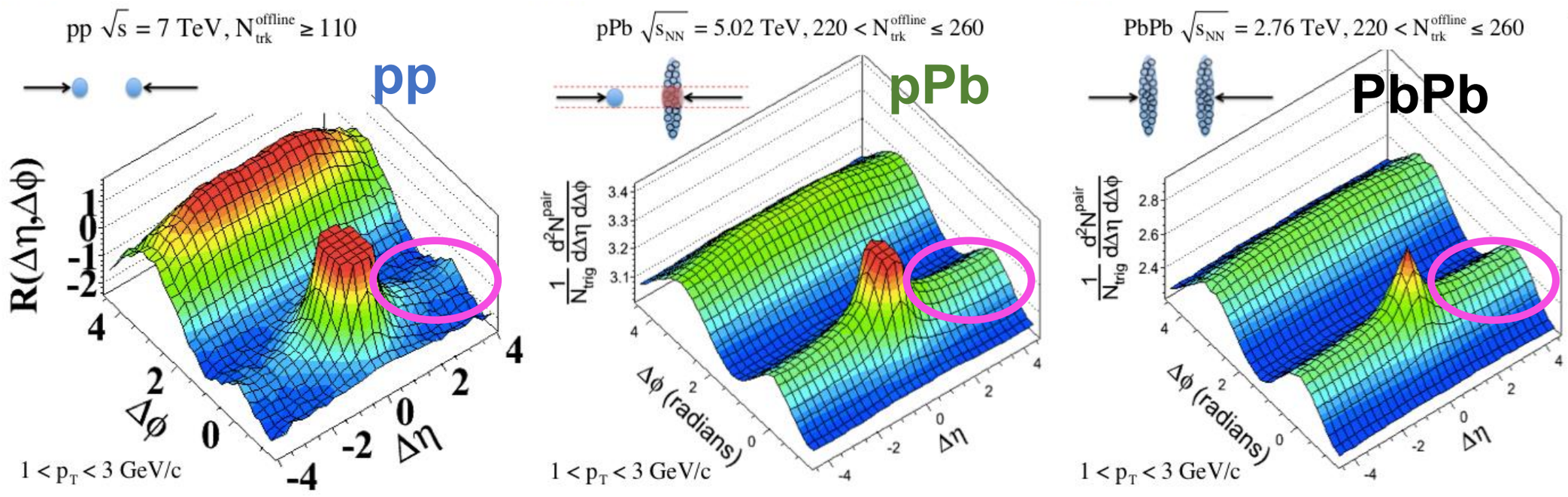
Rohit Kumar Singh

(For the CMS Collaboration)

Indian Institute of Technology Madras

Date: Jan 15, 2025

Ridge is everywhere



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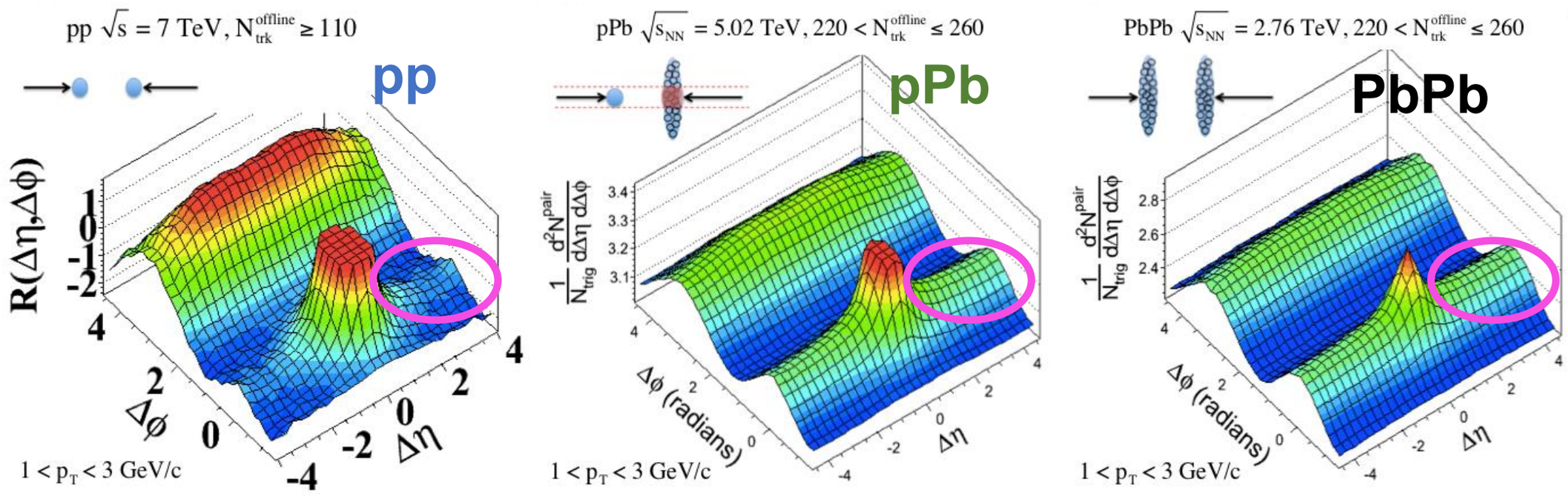

The first unexpected discovery at LHC: **Ridge** in high multiplicity pp & pPb collisions from CMS

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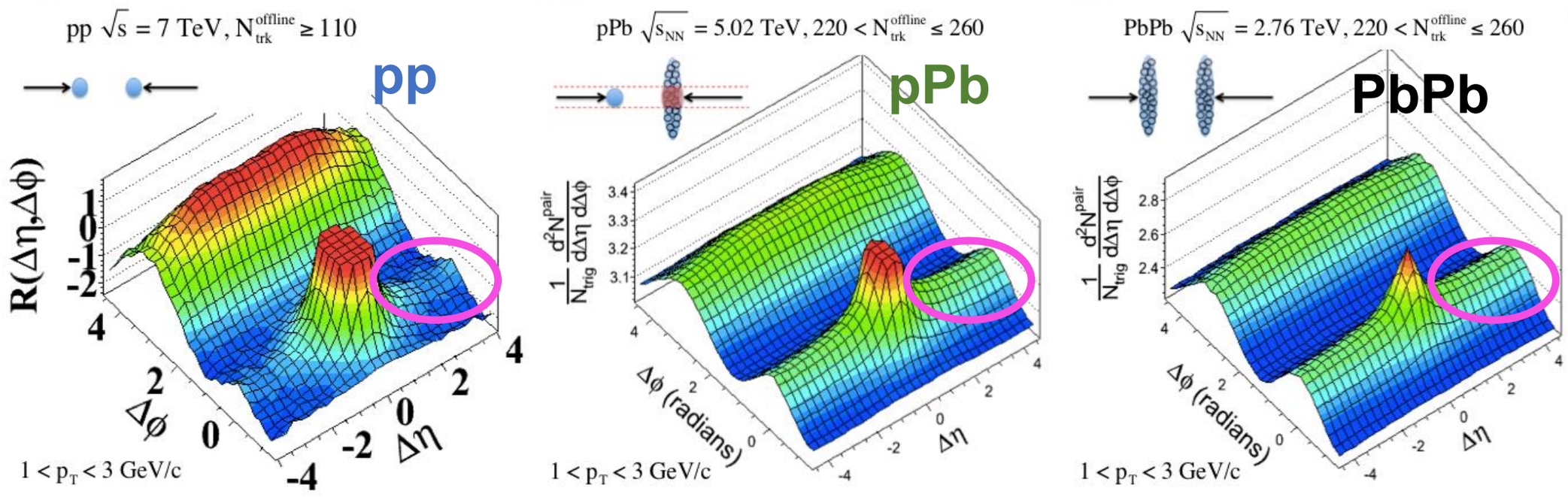

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  => sign of collectivity? same origin?
- **Geometry + Fluctuations**
- **Well described by hydrodynamics**
- **Similar trend of v_2 in three systems**

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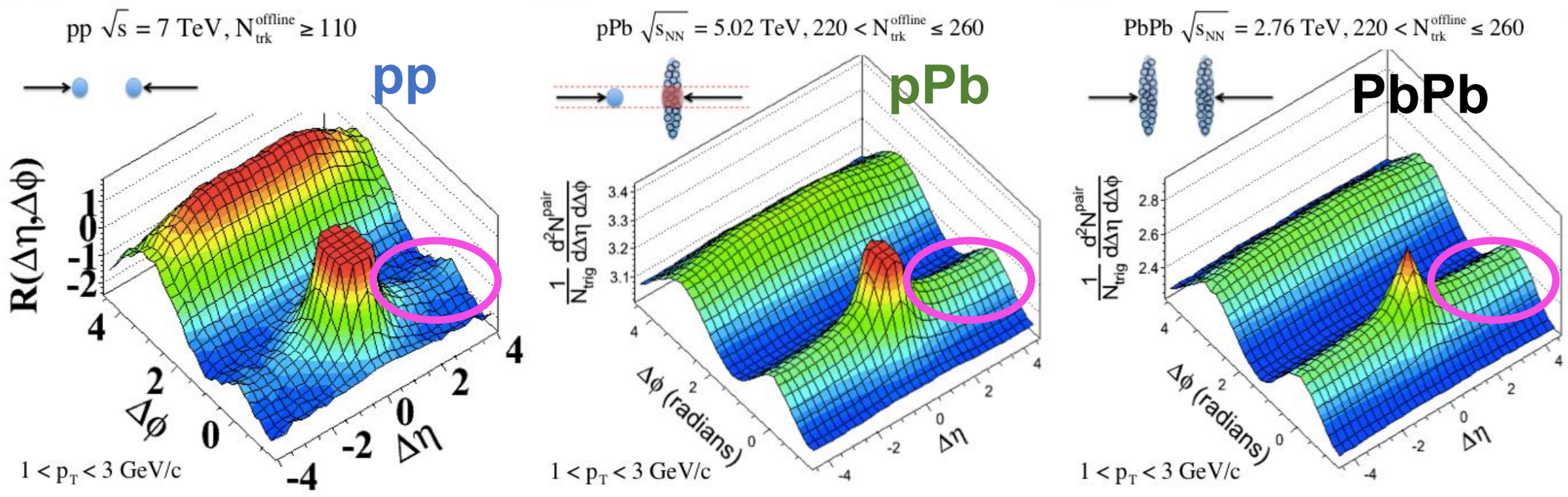

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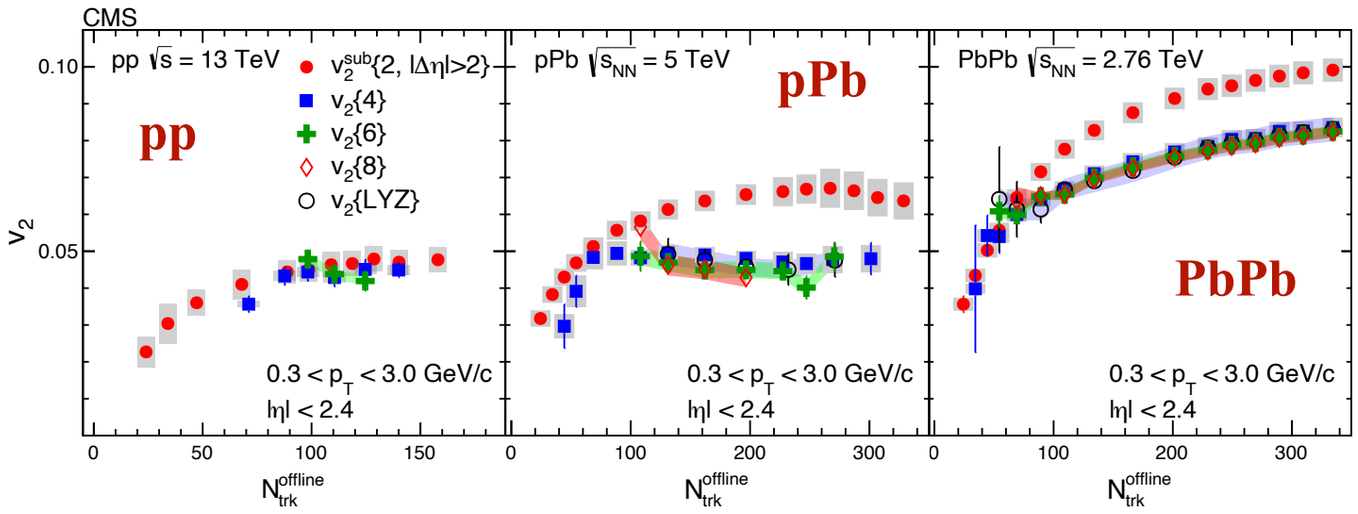
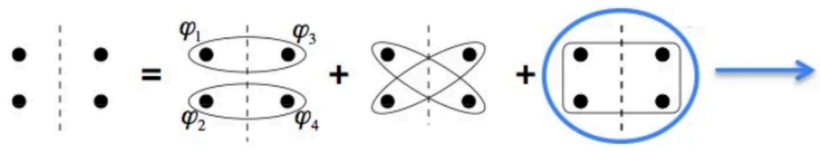


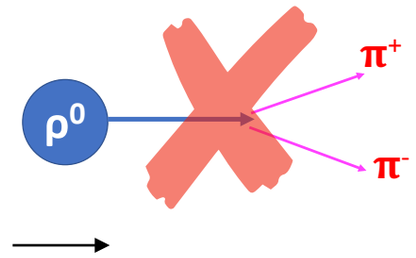
Analysis Method

✺ Cumulant method:

- ❖ Multiparticle correlation technique
- ❖ Non-flow suppression in a data-driven way



$$c_n\{4\} = \langle\langle 4\rangle\rangle - 2 \cdot \langle\langle 2\rangle\rangle\langle\langle 2\rangle\rangle$$



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1 POI **3 RFPs**

=> Differential Flow : $v_n'\{4\} = -\dfrac{d_n\{4\}}{(-c_n\{4\})^{3/4}}$

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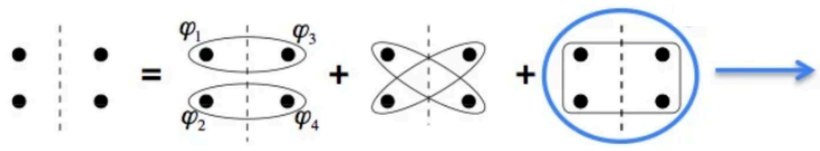

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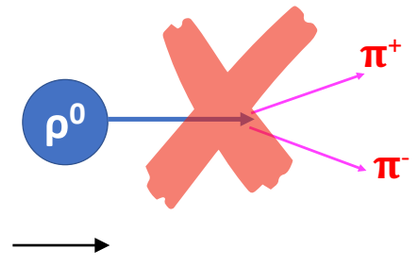

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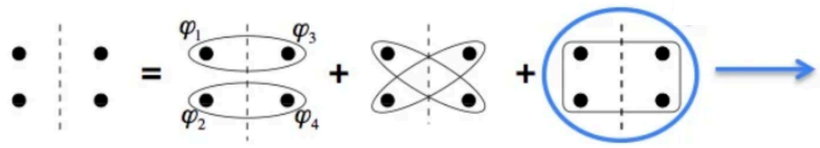

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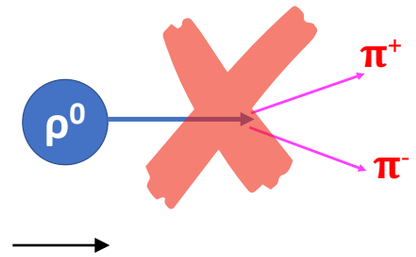

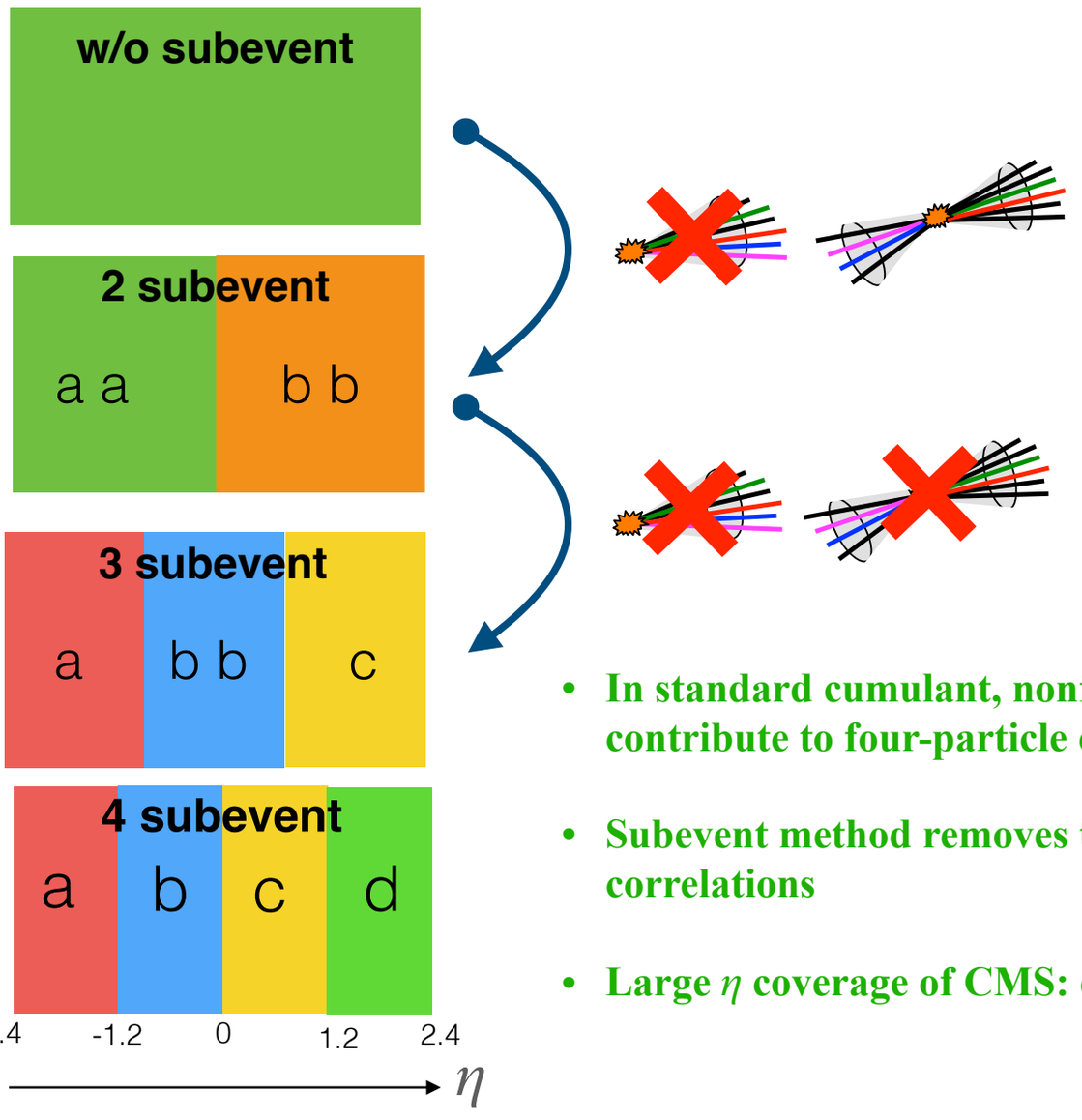

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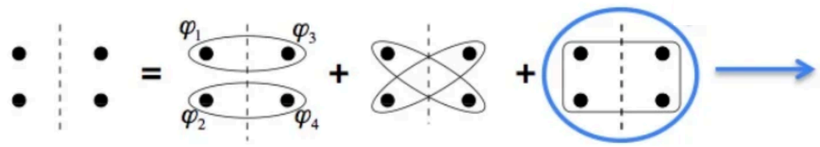

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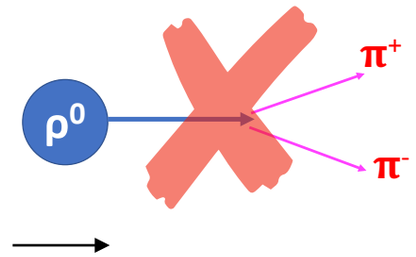

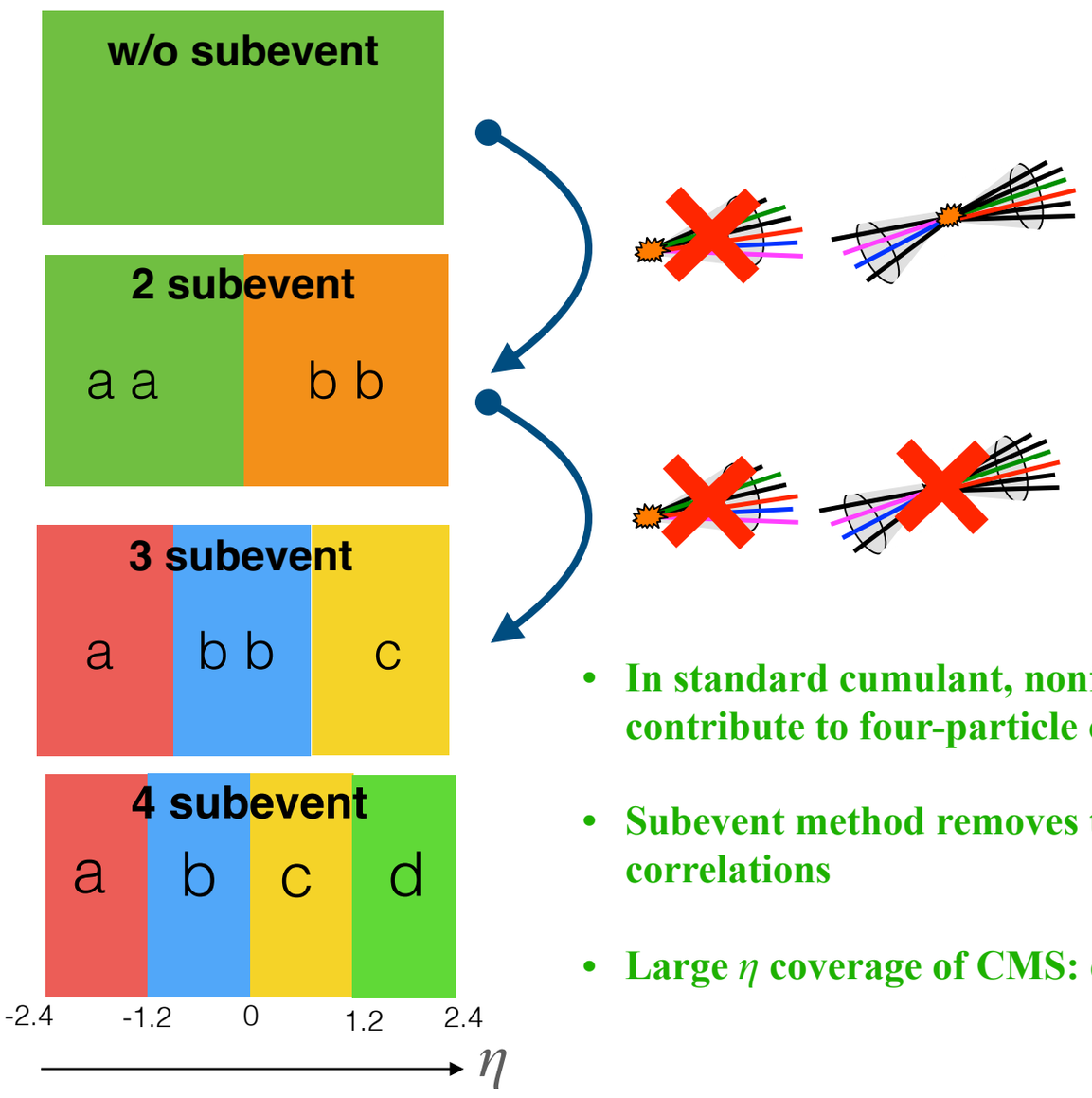

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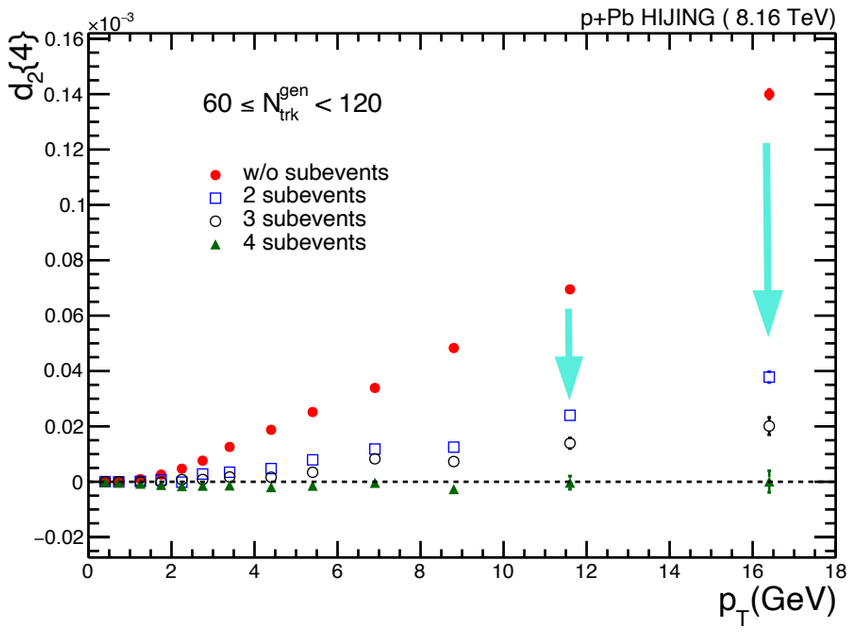
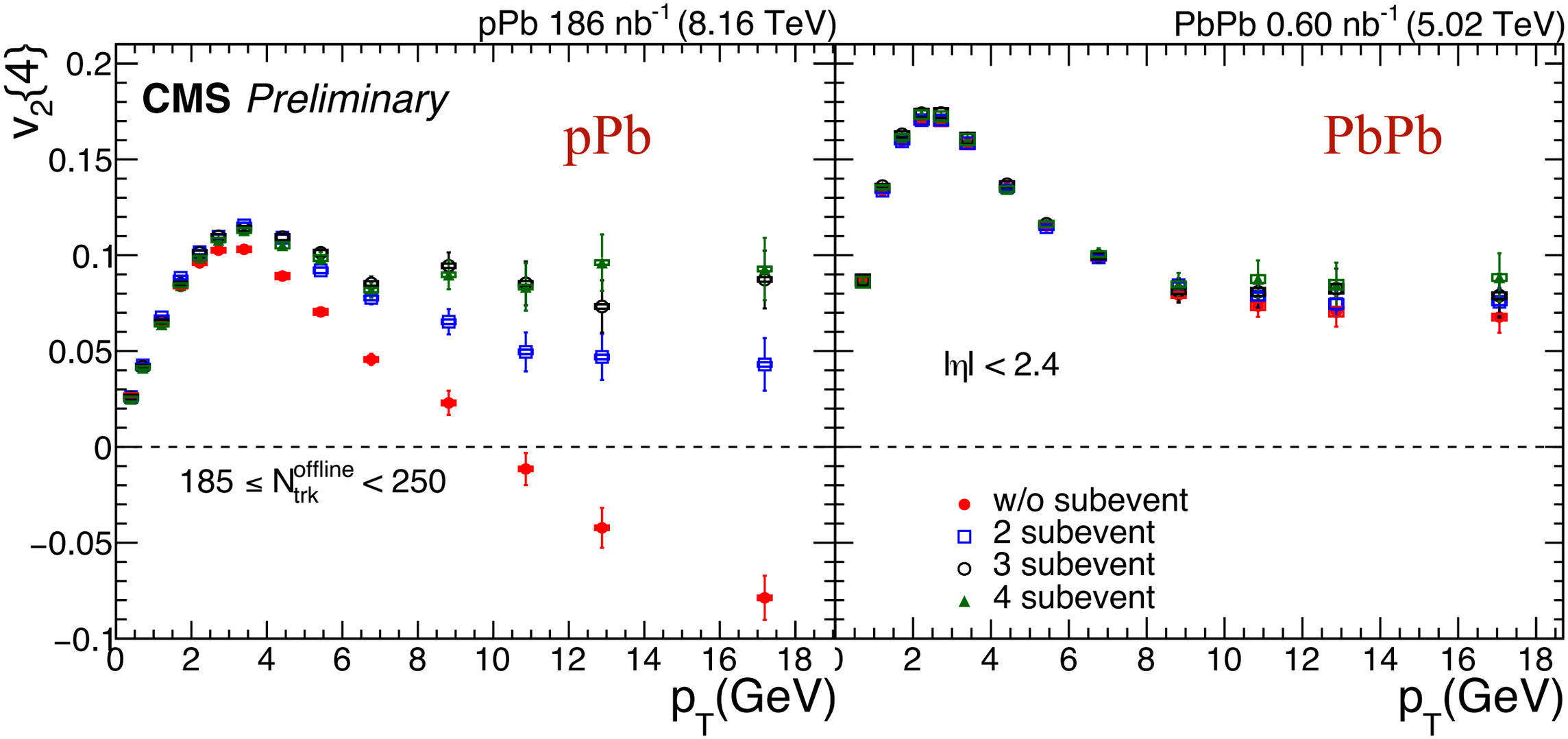


Results

- $v_2\{4\}$ **in** $185 \leq N_{trk}^{offline} < 250$ **as a function of** p_T



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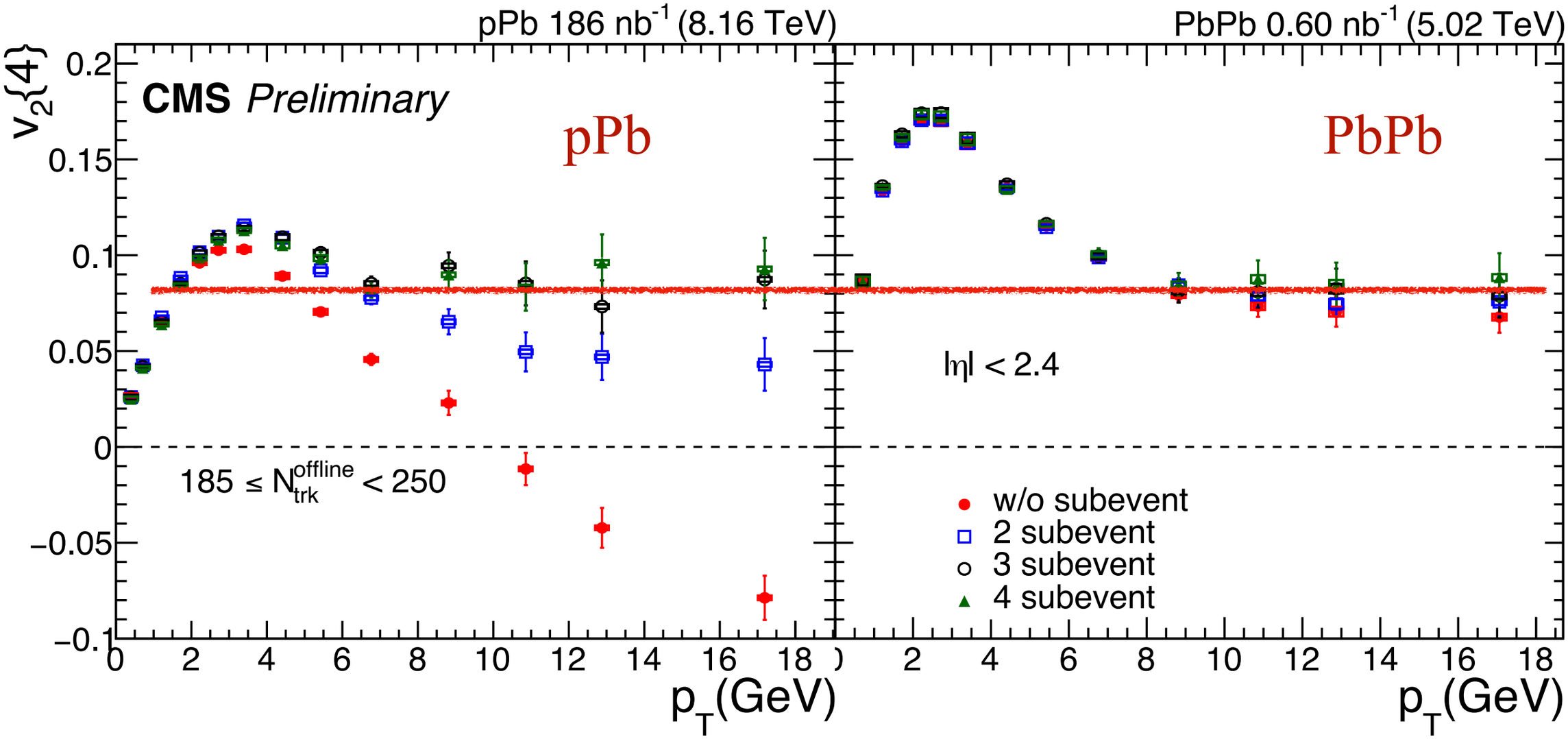

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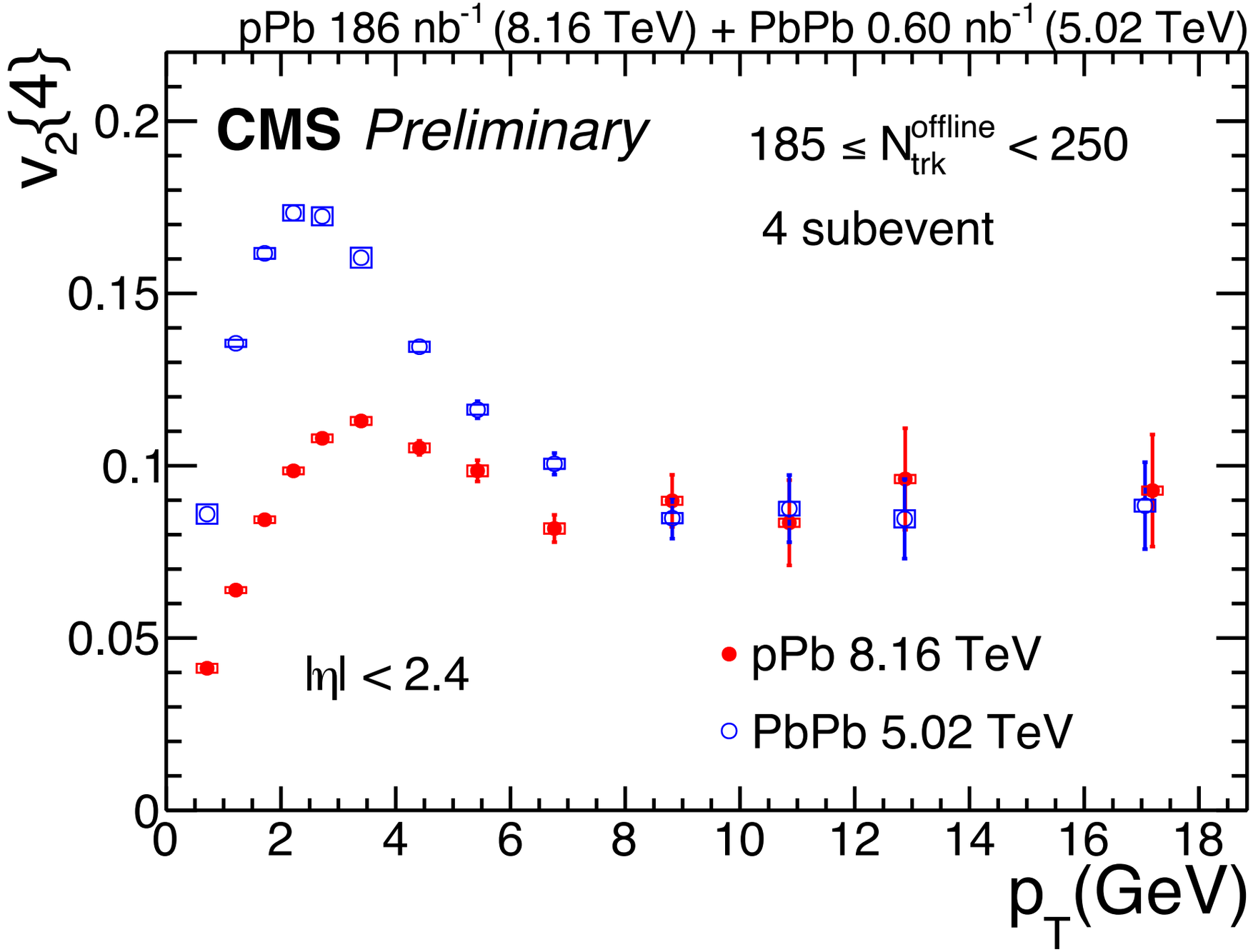

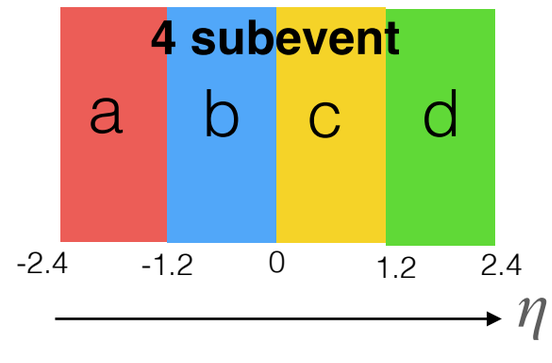

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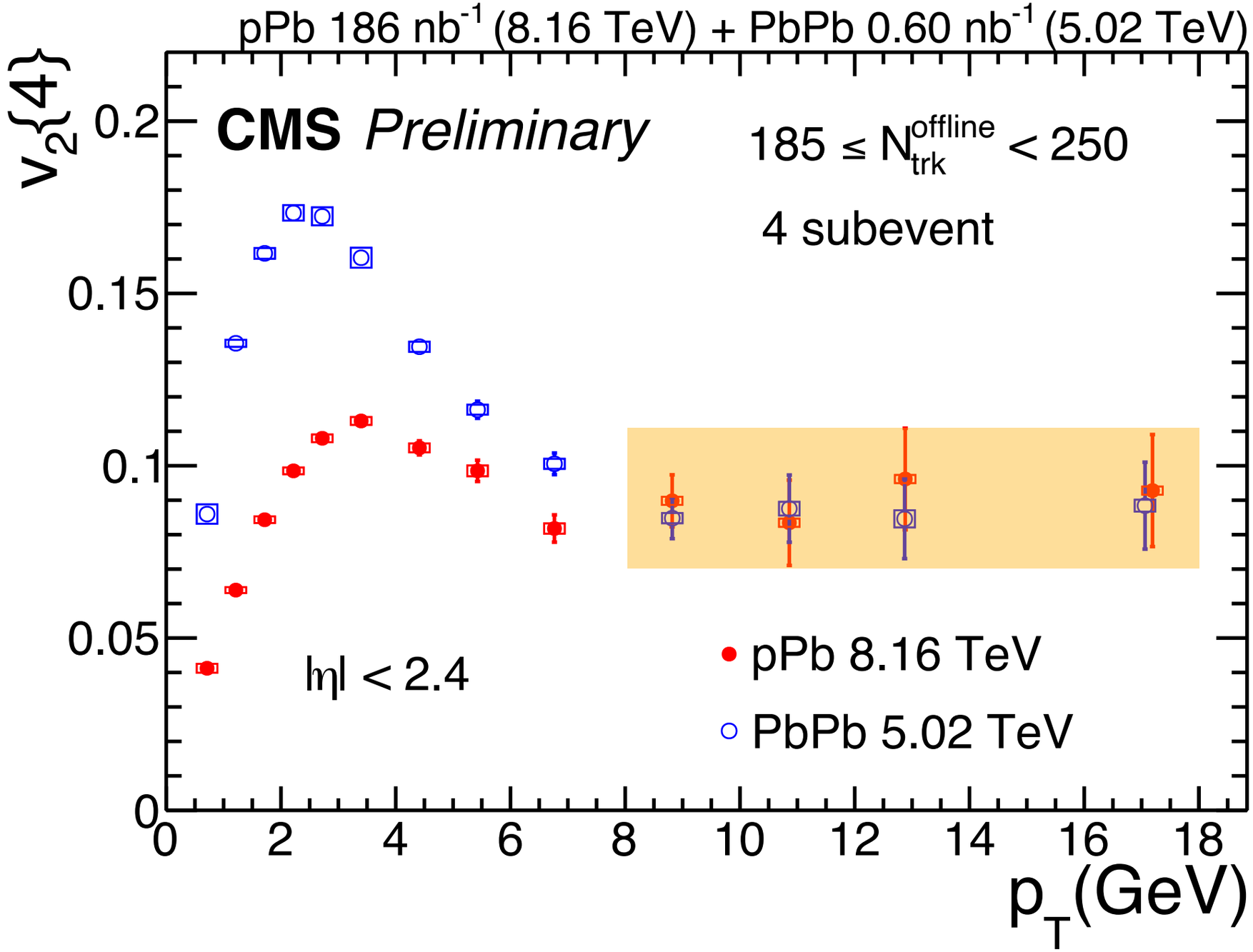

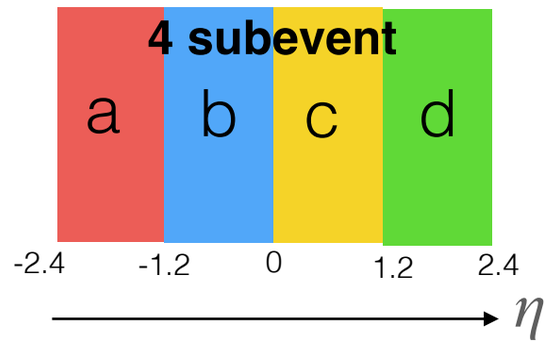

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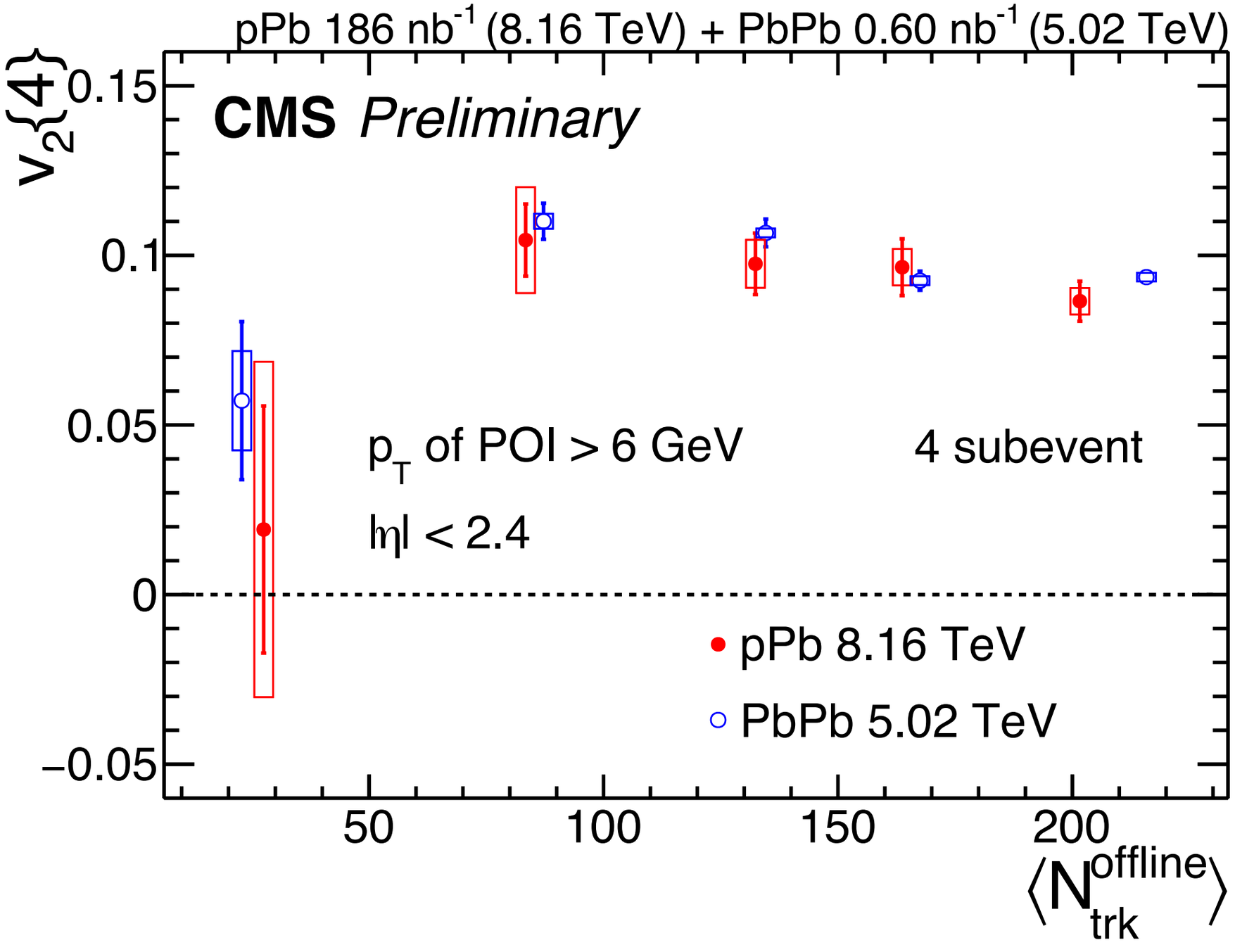
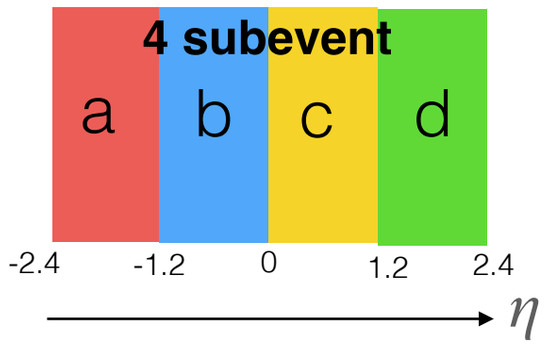
Results

- $v_2\{4\}$ **in different** $N_{trk}^{offline}$ **bins with** $p_T^{\mathrm{POI}} > 6$ **GeV**





- **Similar magnitude and trend for both PbPb and pPb when** $p_T^{\mathrm{POI}} > 6$ **GeV across all multiplicity bins**

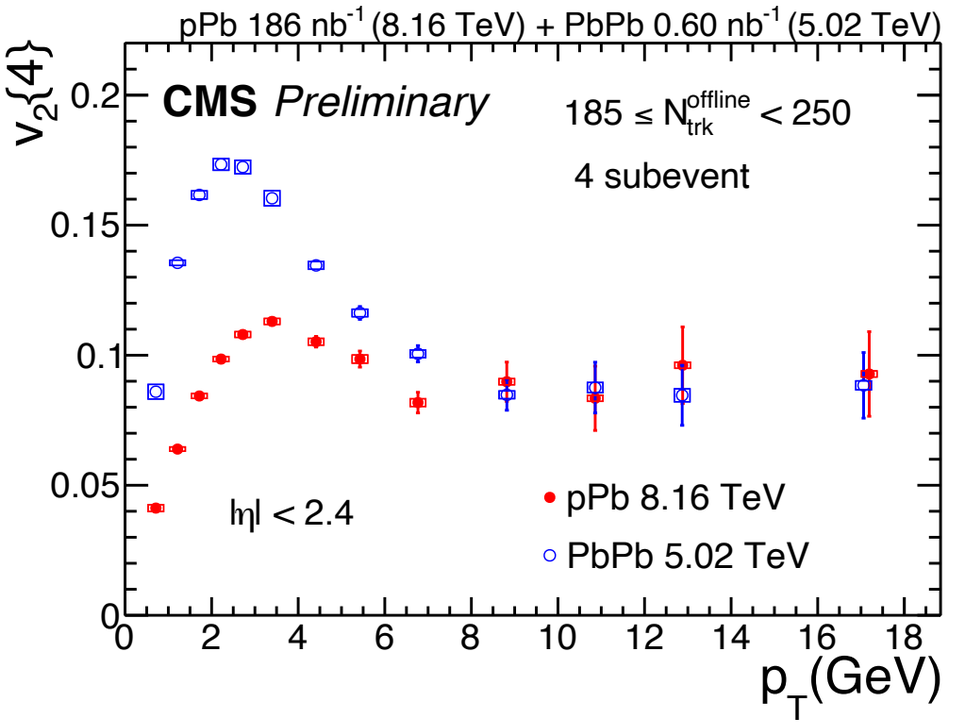
Summary & outlook

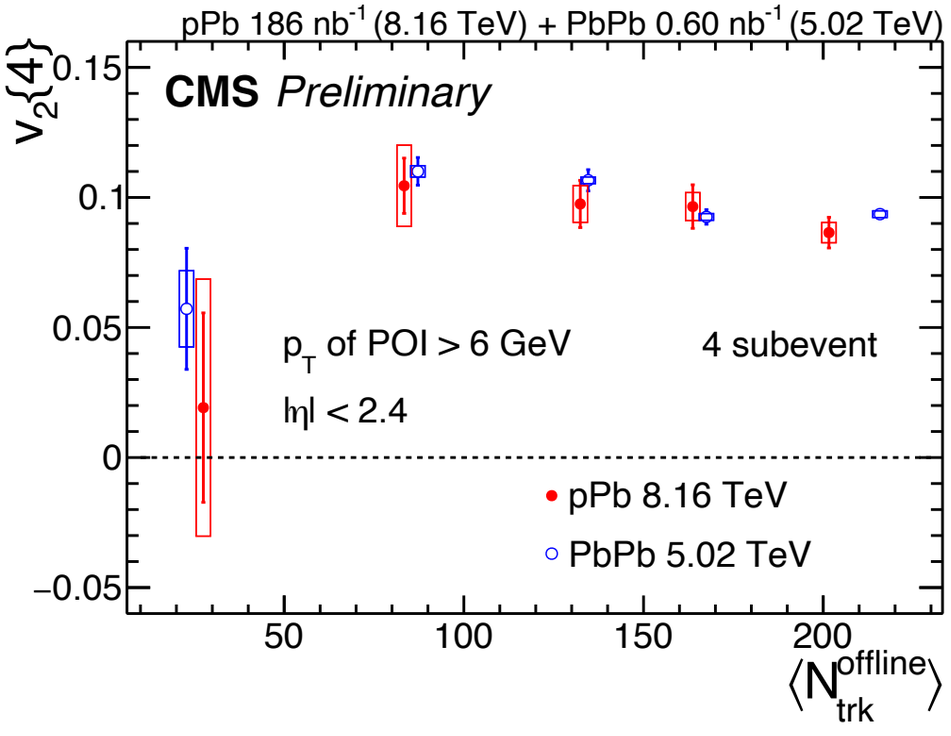
❖ **The results of $v_2\{4\}$ with subevents for pPb & PbPb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV & $\sqrt{s_{NN}}$ = 5.02 TeV, resp.**

❖ **After using subevent to remove nonflow, we have obtained a significant positive value for $v_2\{4\}$ at high p_T in pPb**

❖ **A remarkable similarity in high multiplicity pPb and peripheral PbPb collisions**

(Ready for journal submission (PRL) and selected for a talk at QM 25)





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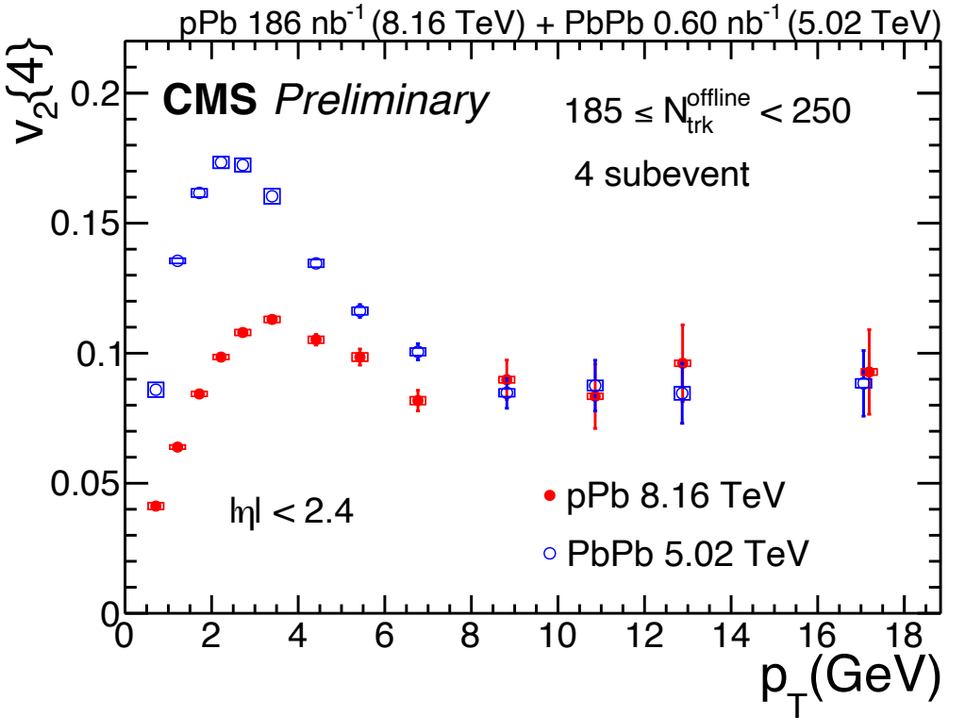

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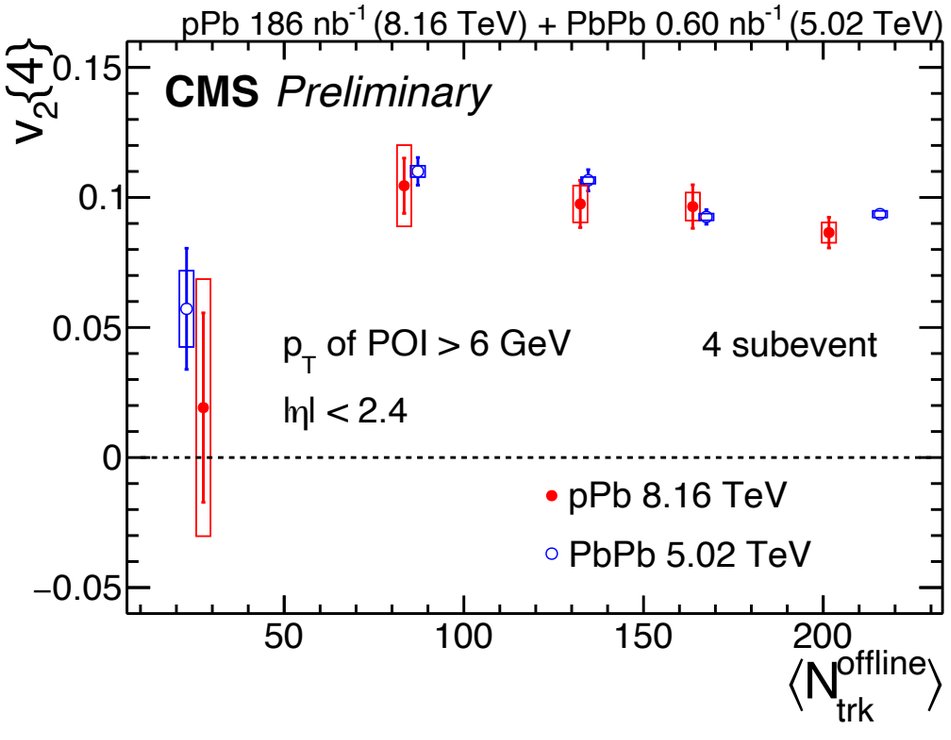
❋ **Final thoughts:** 

❖ **Enough evidence to show QGP is created in small and large systems!**

❖ **Conditions under which QGP formation is possible needs further discussion**

❖ **Where in system size is the onset of particle suppression?**

❖ **Strong motivation for system size scan at the LHC (O-O, p-O)**

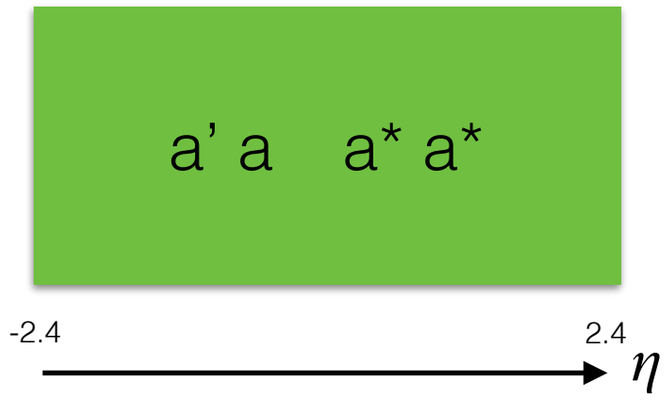


Thank you

BACK-UP

Analysis Method

- **Differential cumulant $d_2\{4\}$ calculation in standard and 2 subevent method**
  - **Standard (w/o subevent)**



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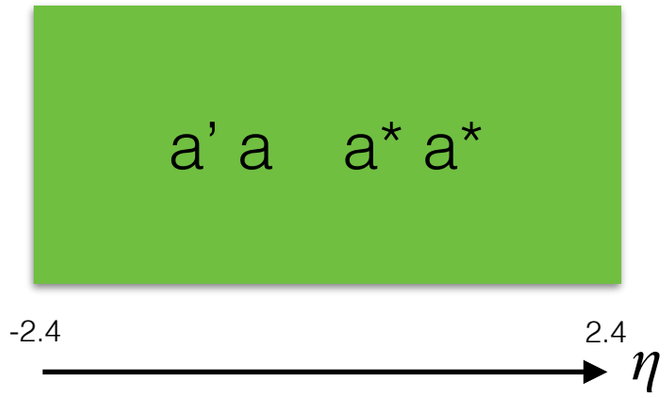

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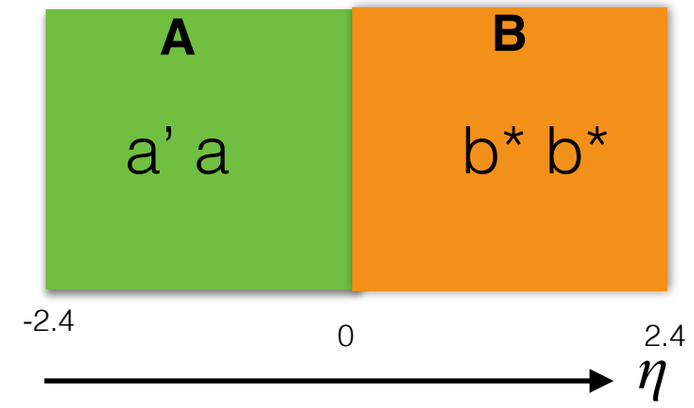

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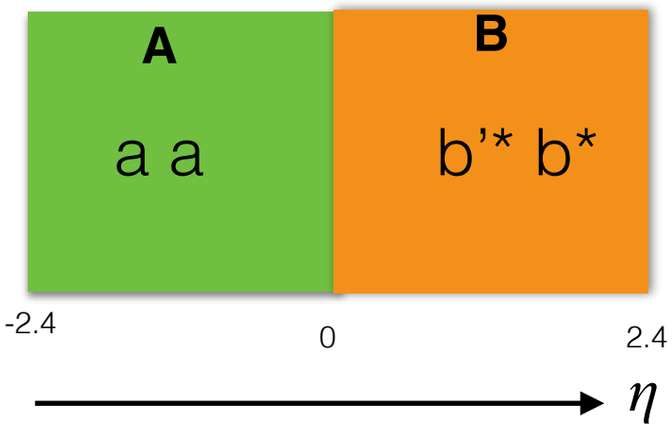

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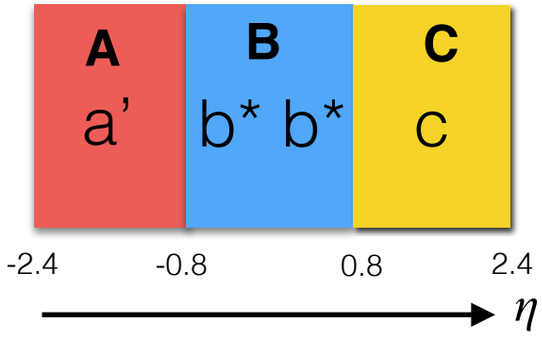

POI : (-2.4<η<0.8)

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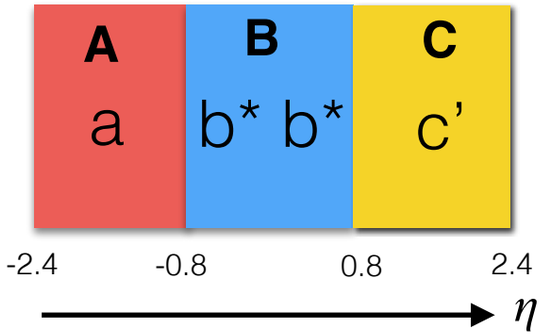

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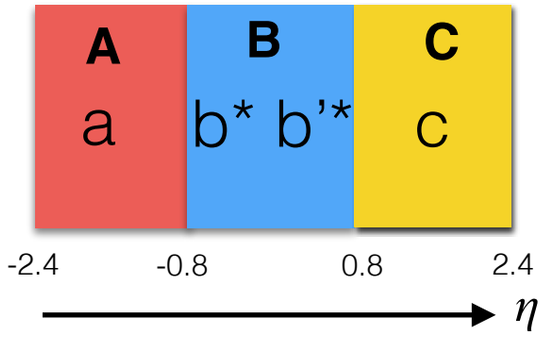

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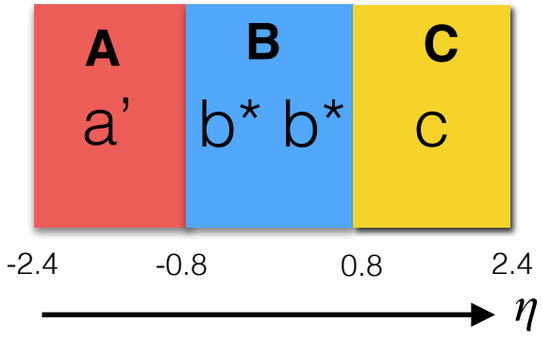

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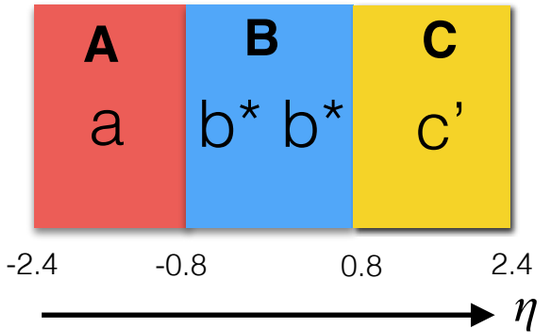

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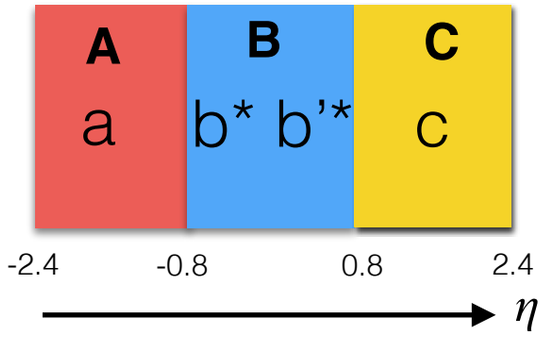

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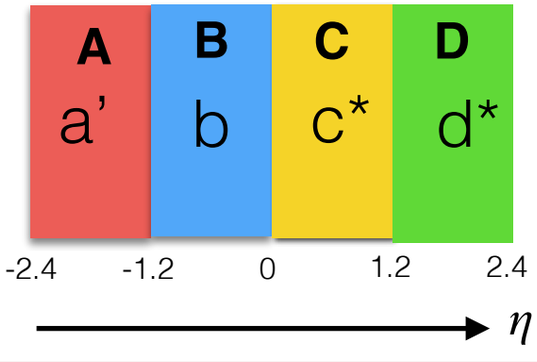

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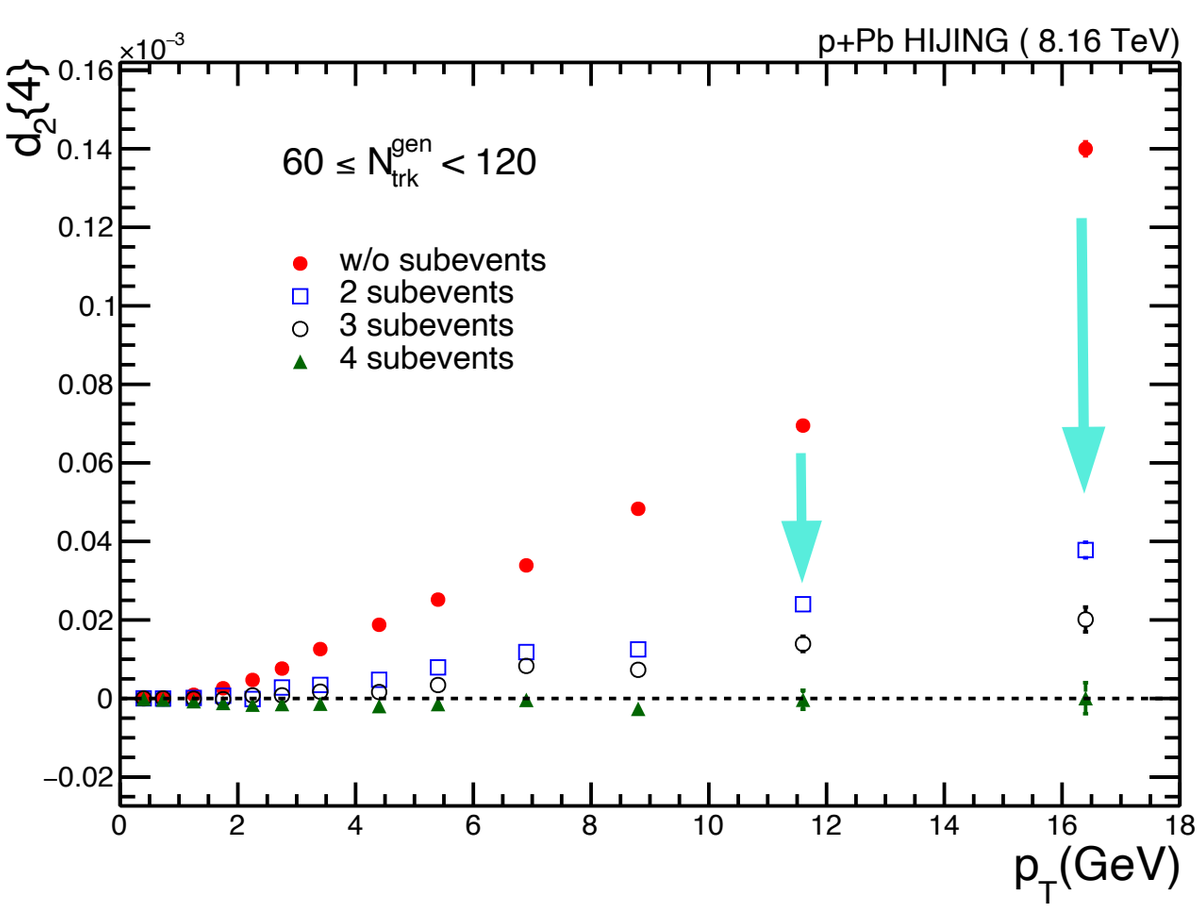
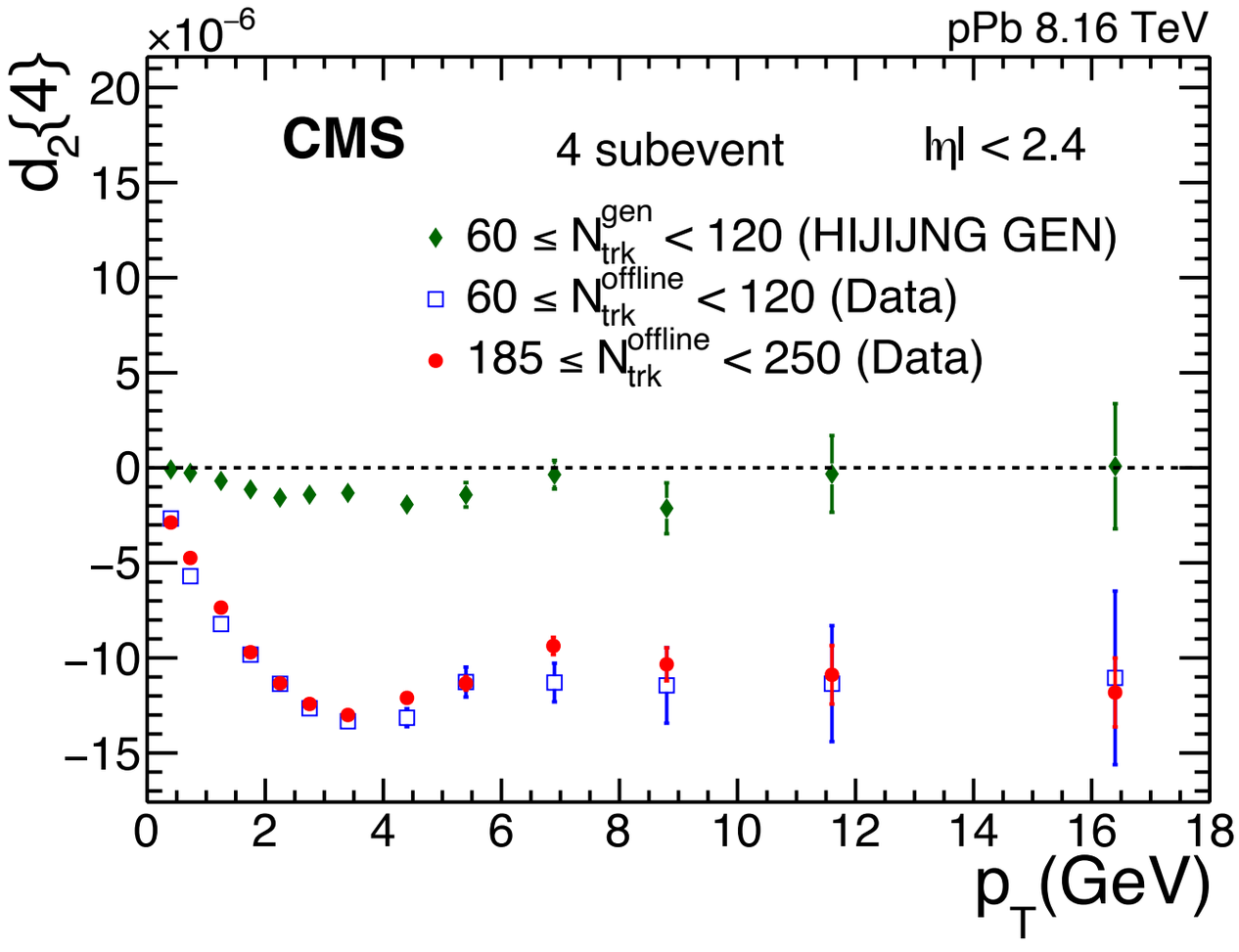
Cross-check

- $d_2\{4\}$ **in HIJING in** $60 \leq (N_{trk}^{gen}) < 120$

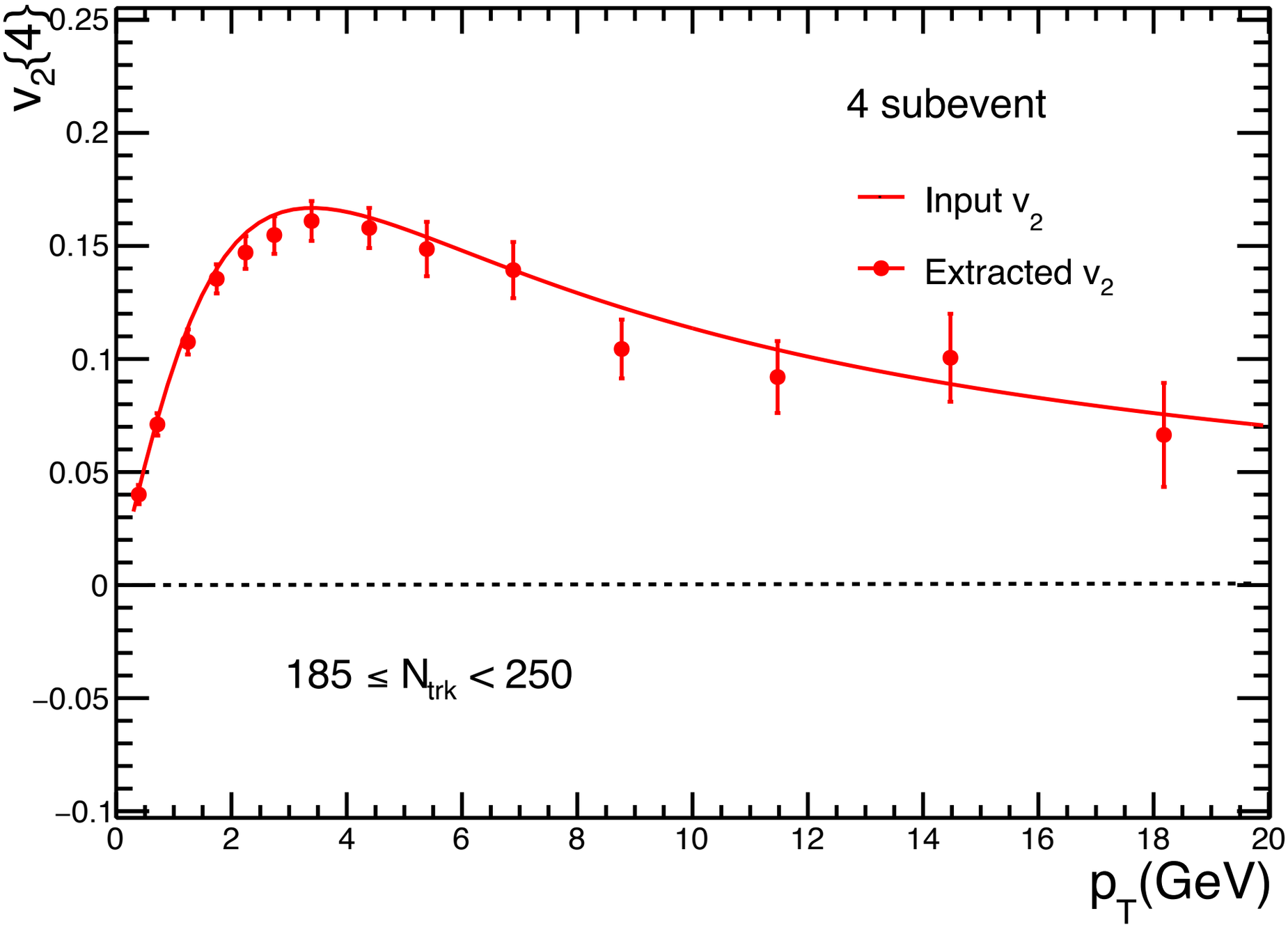




- **HIJING lacks collectivity => used to cross check non-flow subtraction of subevent cumulant**

Cross-check

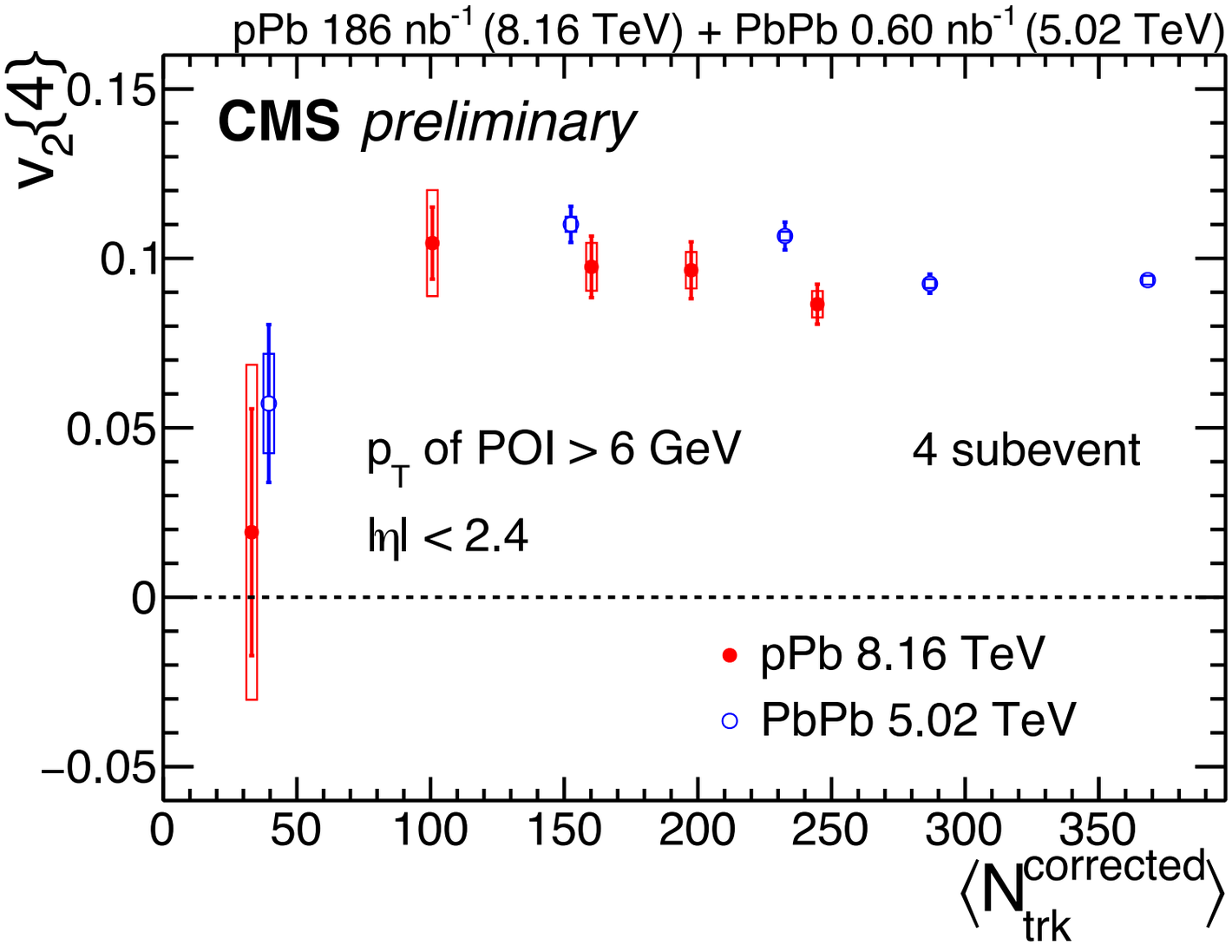
❋ $v_2\{4\}$ **with toy model simulation**



- **Able to extract almost all input v2 with 4 subevent**

Supplementry plot

- $v_2\{4\}$ **in different** $N_{trk}^{corrected}$ **bins with POI** $p_T > 6$ **GeV**



	pPb		PbPb	
$N_{trk}^{offline}$ range	$\langle N_{trk}^{offline} \rangle$	$\langle N_{trk}^{corrected} \rangle$	$\langle N_{trk}^{offline} \rangle$	$\langle N_{trk}^{corrected} \rangle$
$(0, 60)$	27	33±1	23	39±2
$[60, 120)$	83	101±4	87	152±6
$[120, 150)$	132	160±6	135	233±10
$[150, 185)$	164	198±7	168	287±12
$[185, 250)$	202	245±10	216	368±16