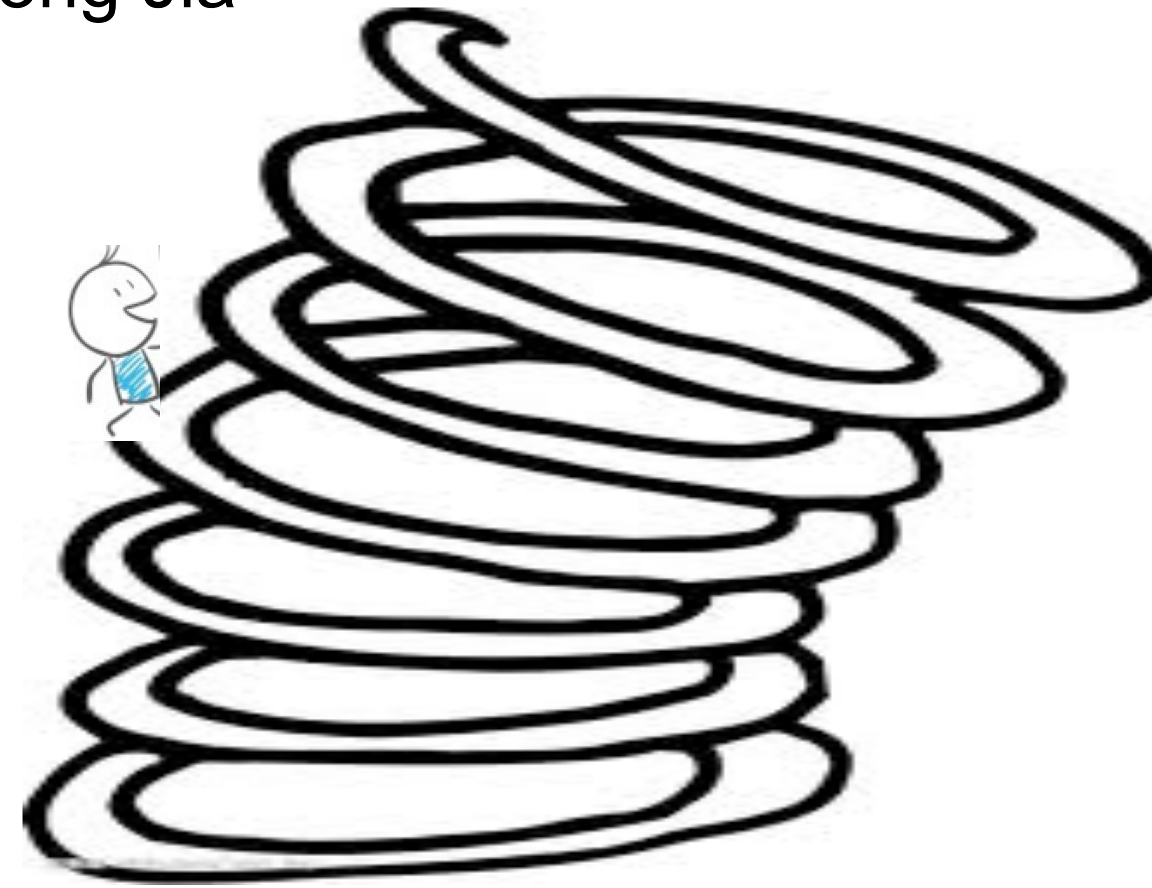
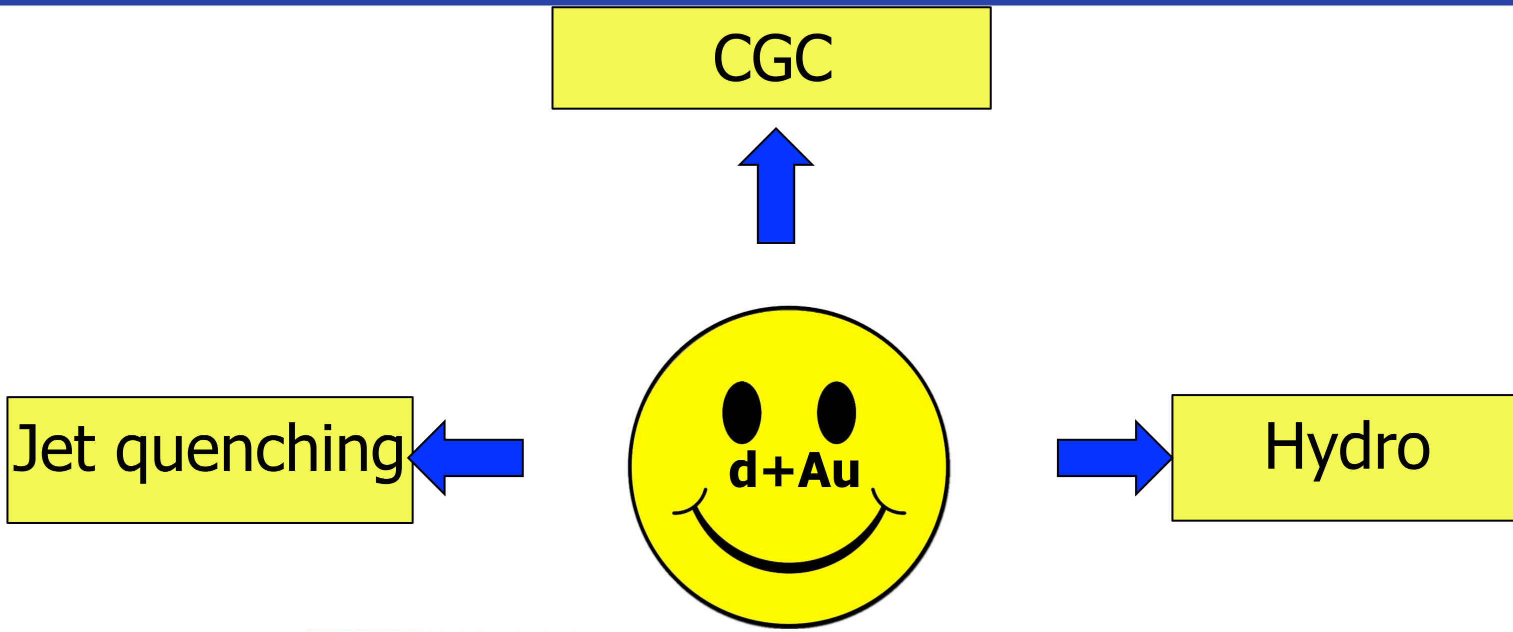
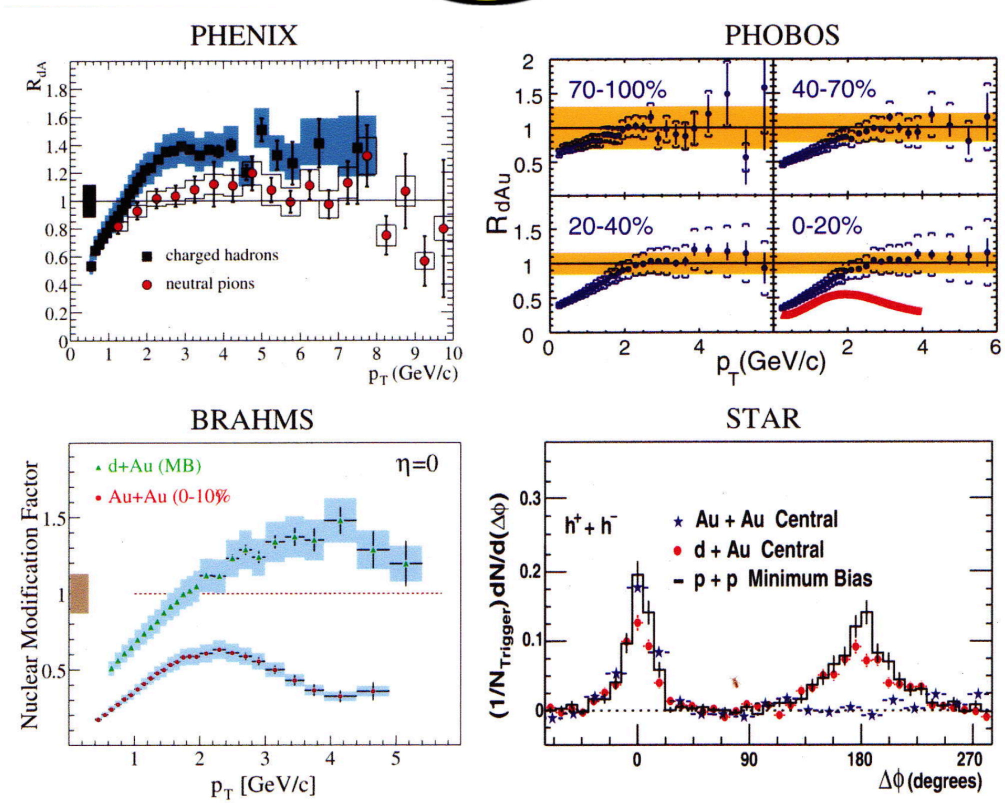
Some personal opinions

Jiangyong Jia

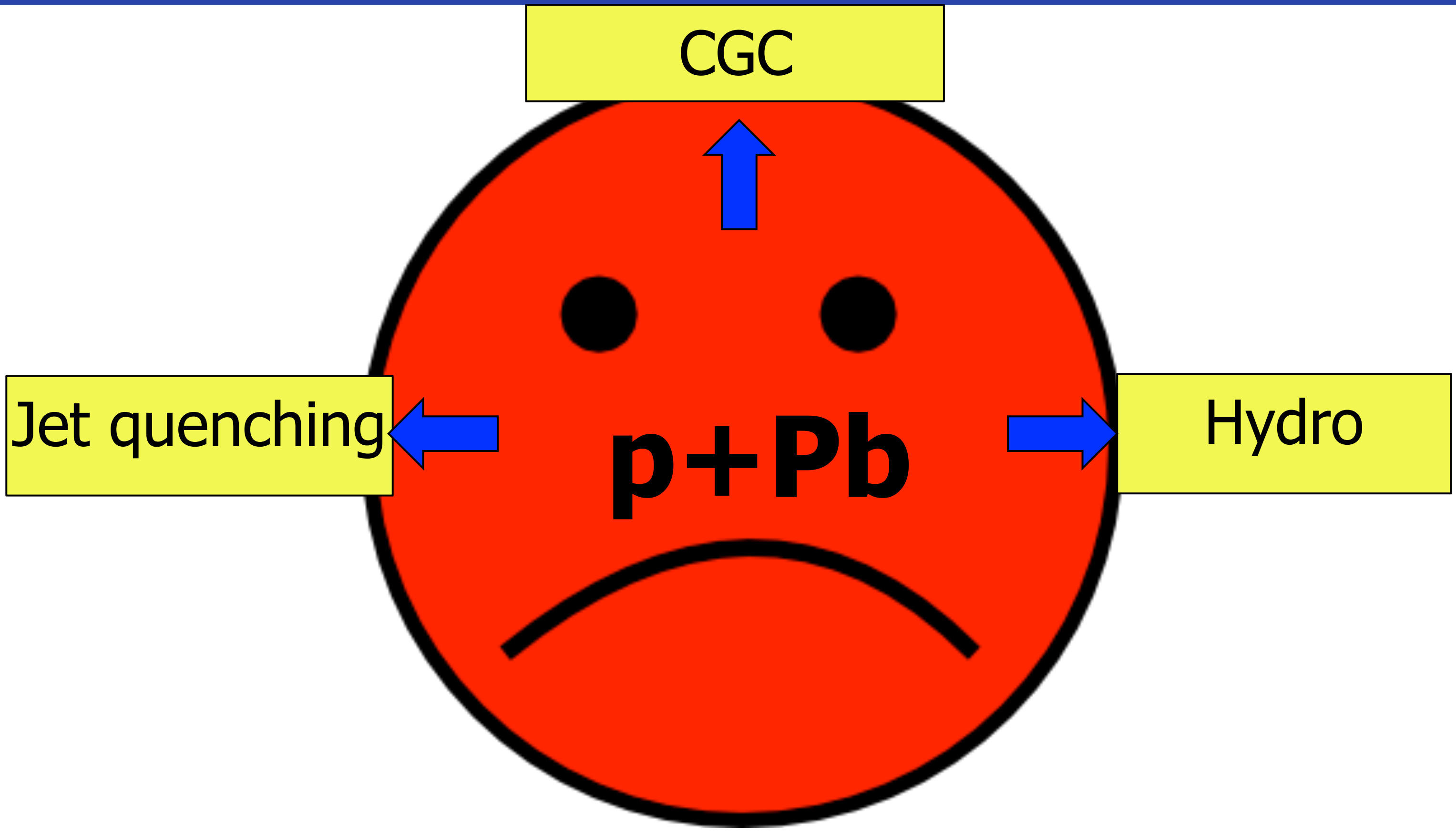


State of affair 2003

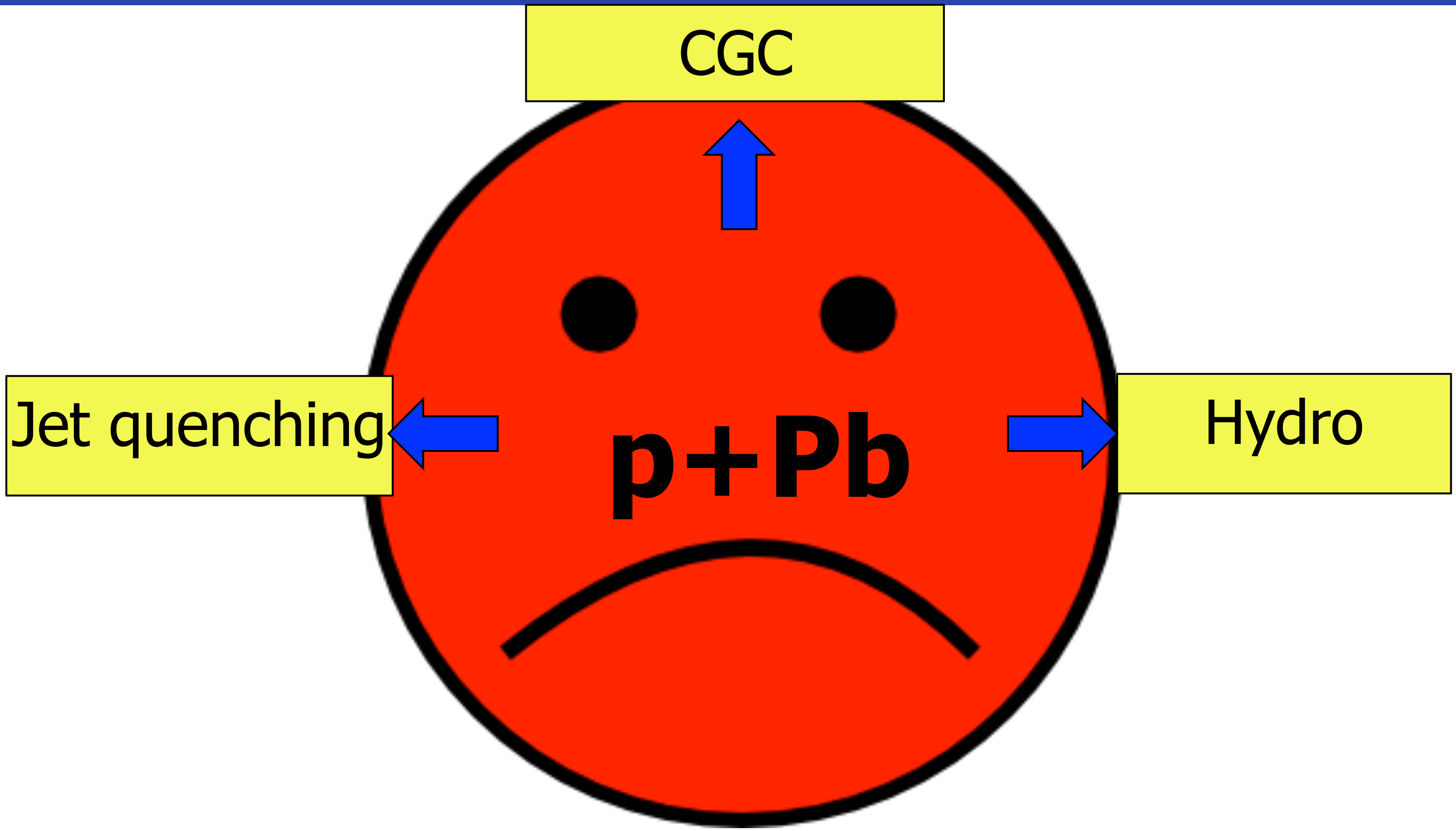




State of affair 2013



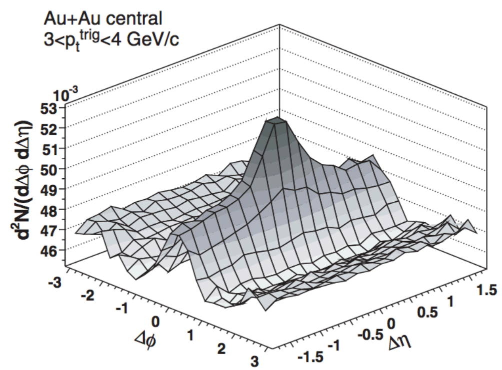
State of affair 2013

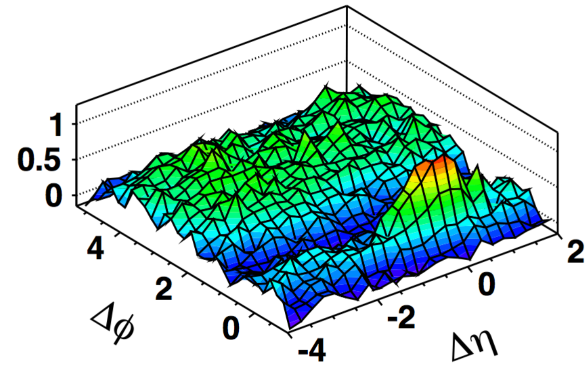


Miklos: My personal perspective is that instead of converging on a solid basis of null controls, we reached a **maximal entropy state both theoretically and experimentally**

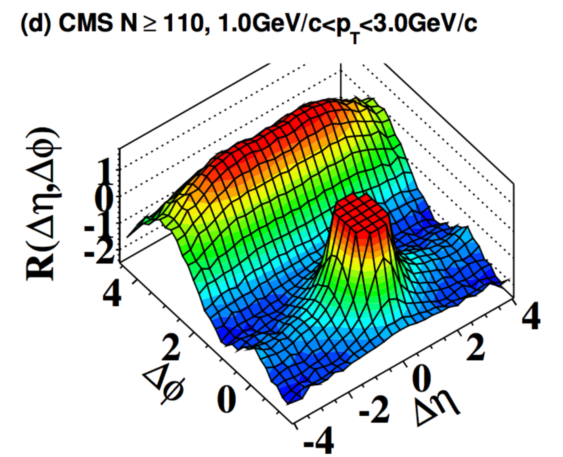
- Theory : Indeed…
- Experiment : undigested information $\neq$ more entropy

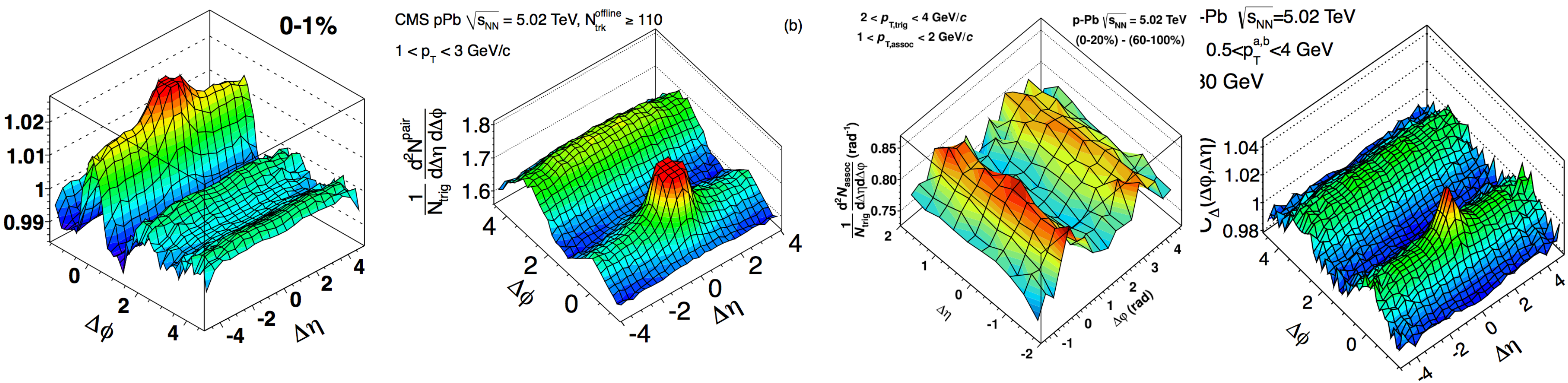
What is the effective picture/theory of QCD in high-density system??





(b) Au+Au 0%-30% (PHOBOS)



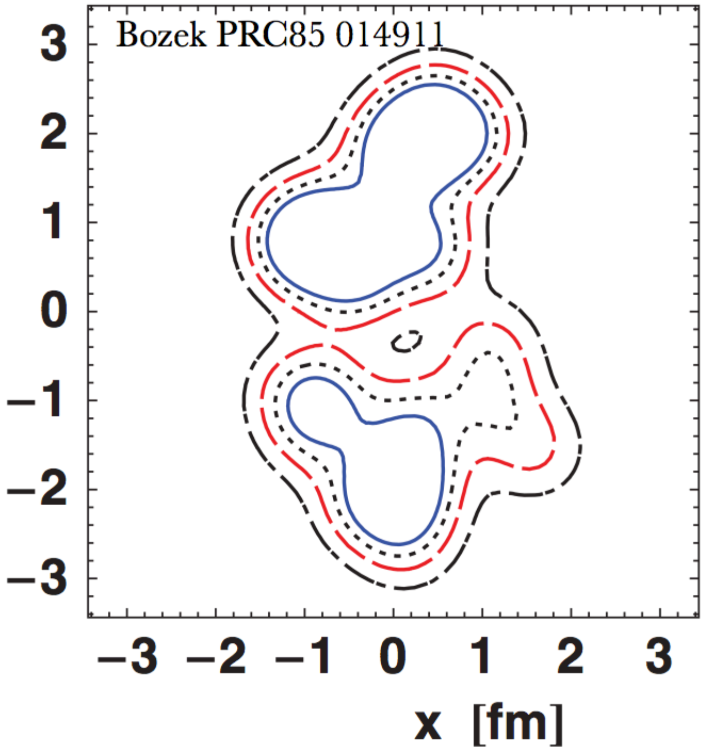


PROJECT

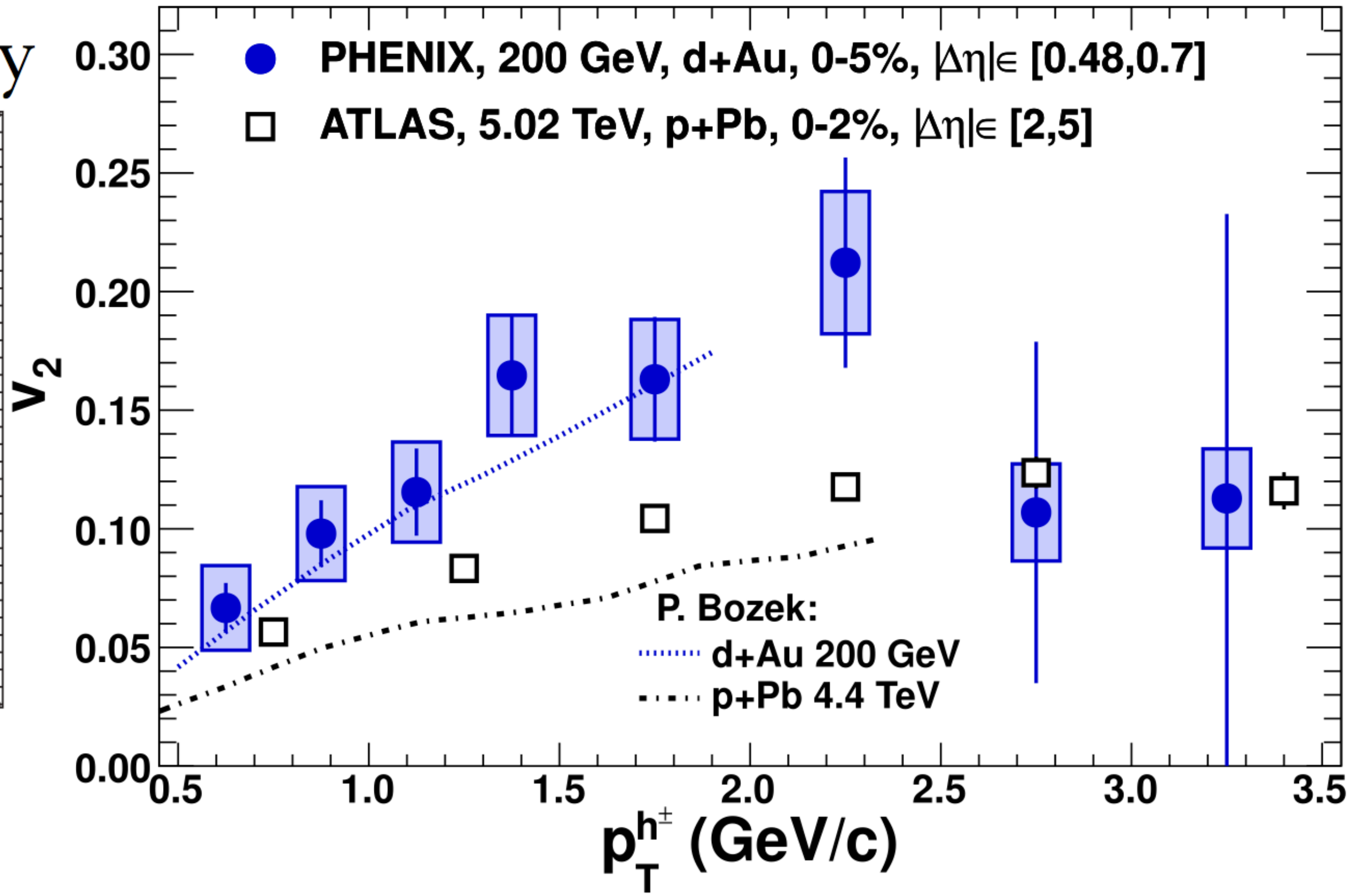
THE RIDGE AT RHIC & THE LHC

leveraging RHIC/LHC differences

initial entropy densitiy



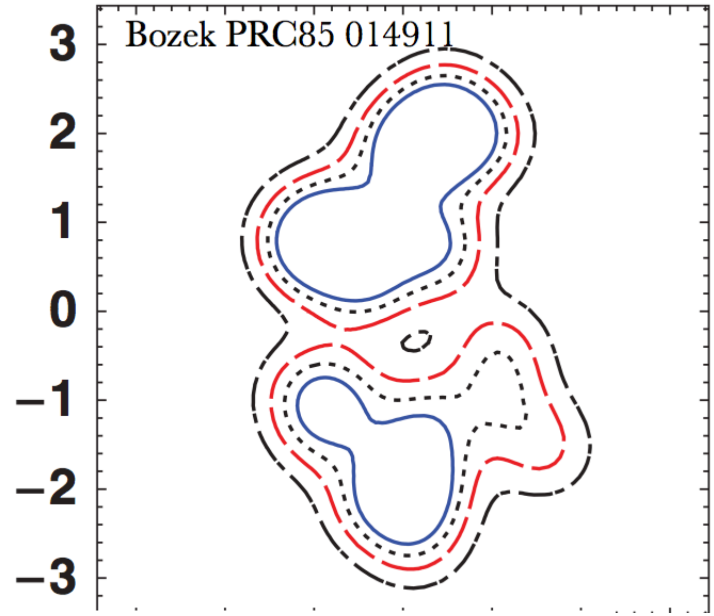
1303.1794

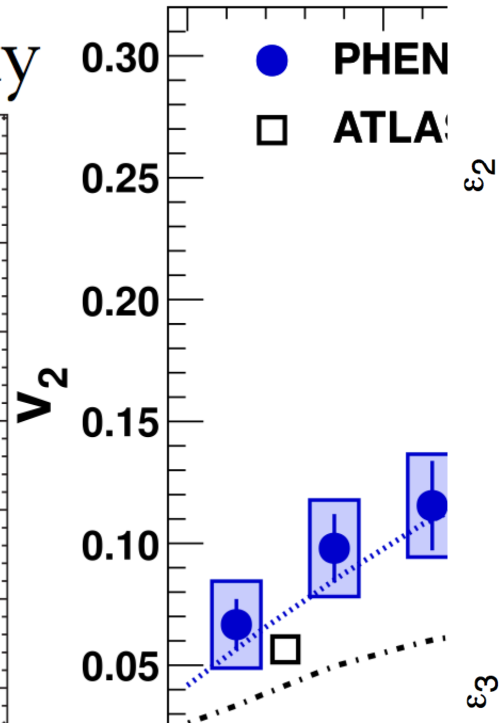


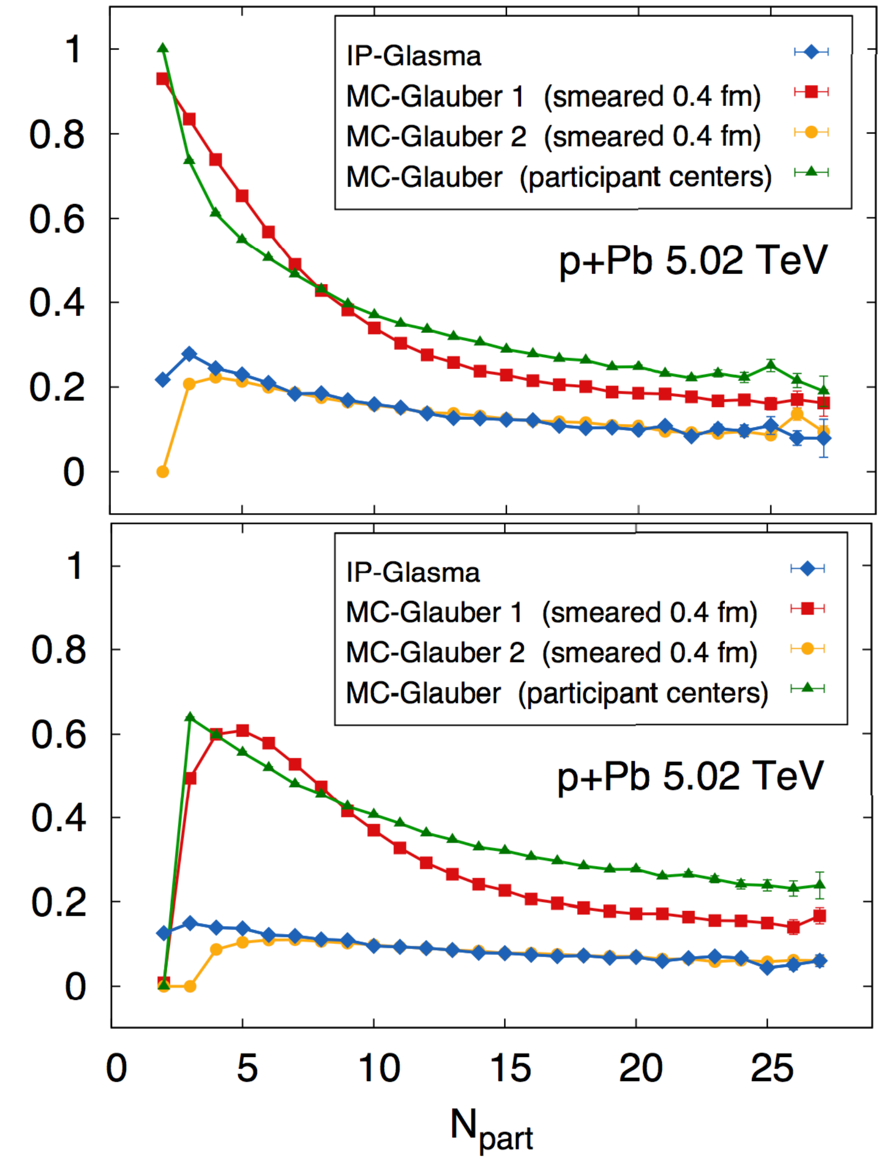
- changing both the collision energy and the shape of the initial system as compared to the ridge seen in pPb

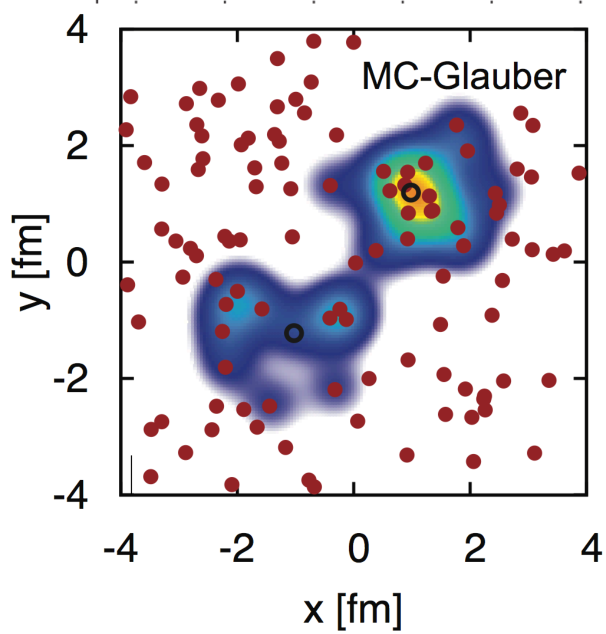
leveraging RHIC/LHC differences

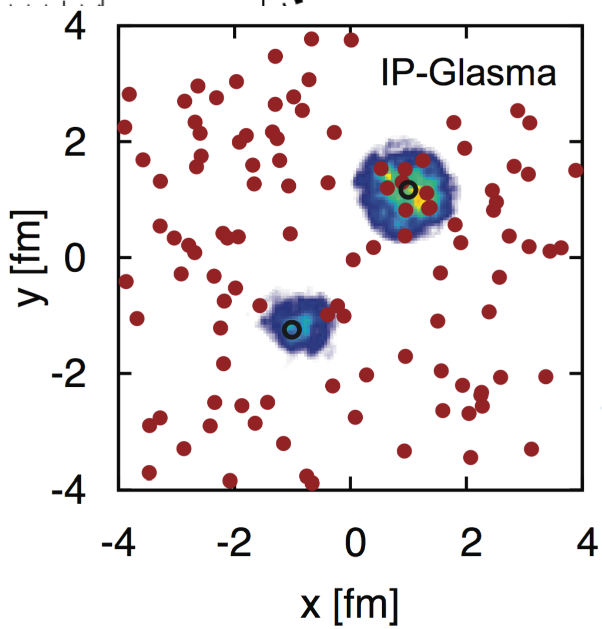
initial entropy densitiy









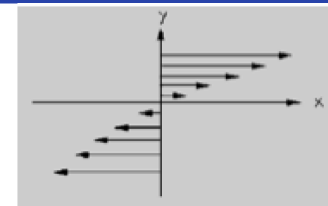


the shape of the initial system

Bzdak et.al. 1304.3403

Hydrodynamics in small system?

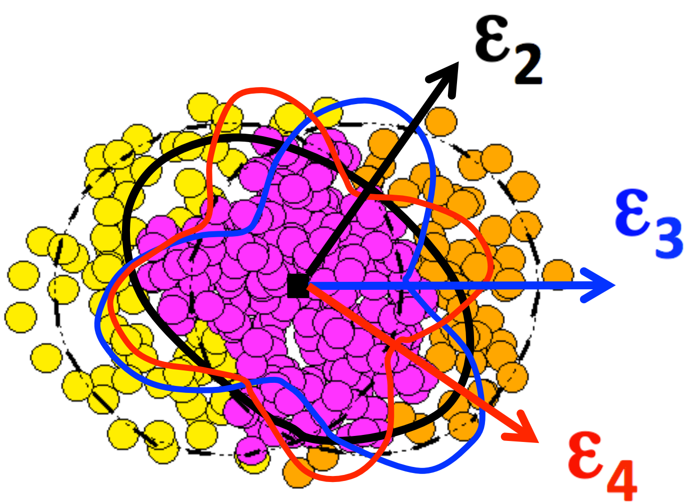
- Flow depends on shape and size/gradient

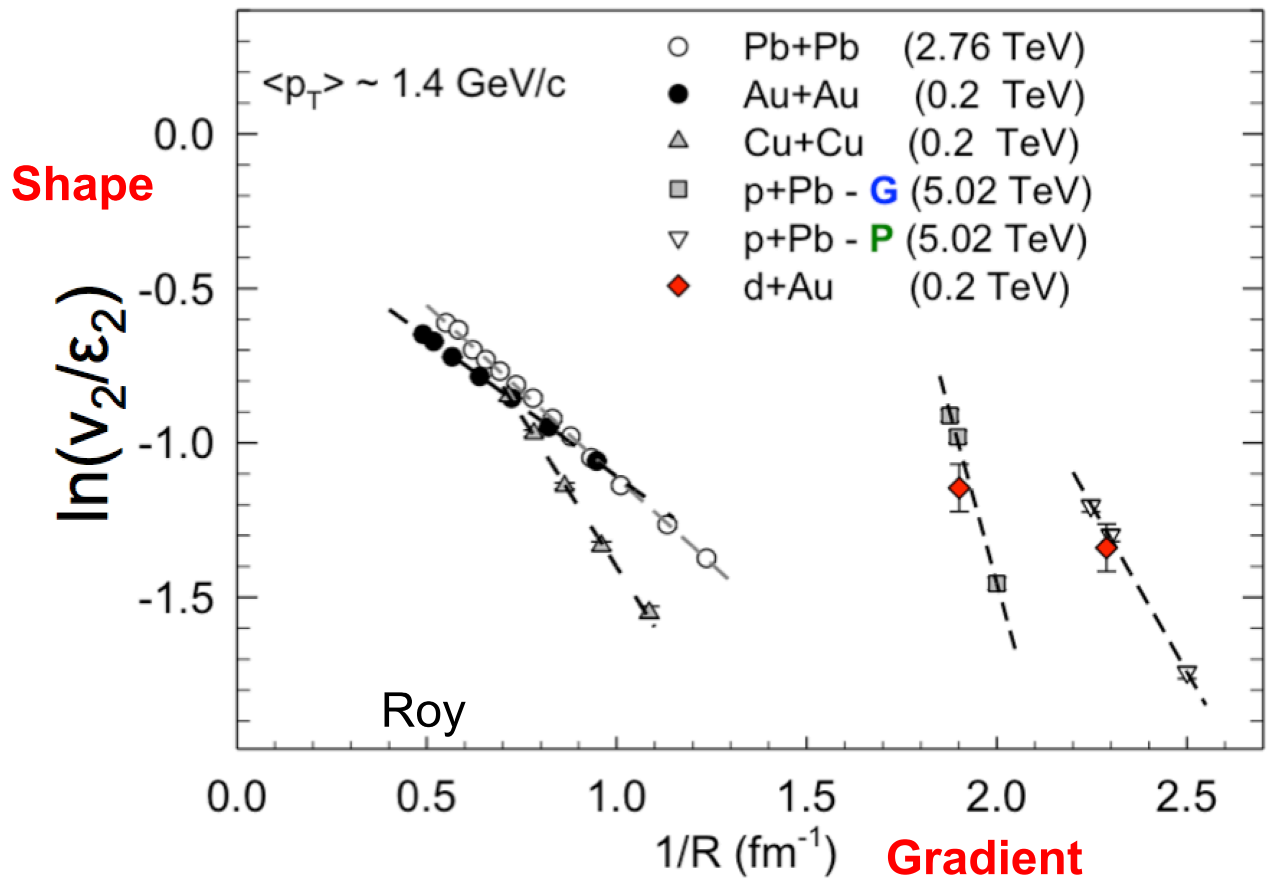


$$\frac{F_x}{A} = -\eta \frac{\partial v_x}{\partial y}$$

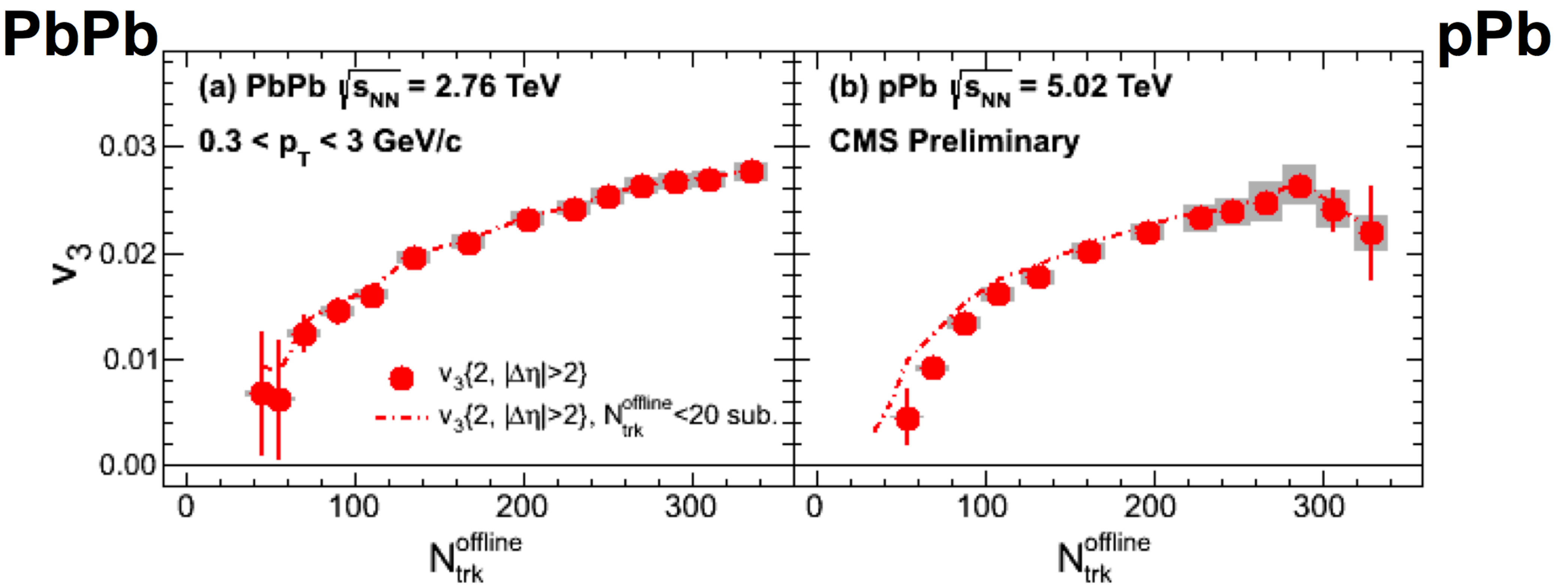
- HM pp and pA have larger density (η/s) but much larger gradient!

$$\rho\left(\phi, r\right)$$





v_3 in pPb and PbPb



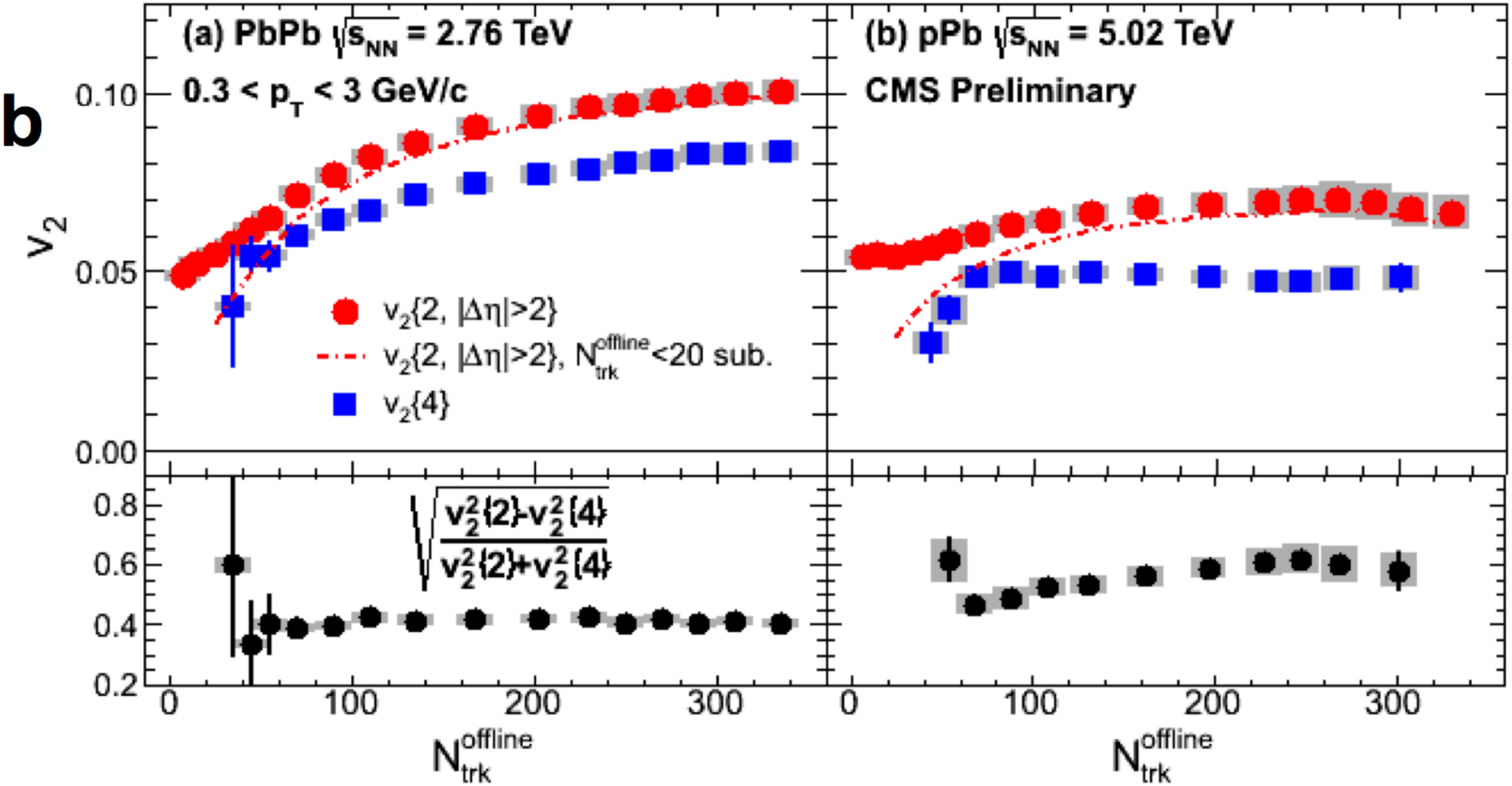
v_3 shows similar shape in pPb and PbPb; magnitude comparable

“Peripheral subtraction” makes essentially no difference

v_2 in pPb and PbPb

PbPb

pPb



"Fluctuations" larger in pPb, with moderate multiplicity dependence

$$v_2\{2\} = \sqrt{< v_2 >^2 + \sigma_{v_2}^2}$$
$$v_2\{4\} = \sqrt{< v_2 >^2 - \sigma_{v_2}^2},$$

$$\frac{\sigma_{v_2}}{v_2} = \sqrt{\frac{v_2^2\{2\} - v_2^2\{4\}}{v_2^2\{2\} + v_2^2\{4\}}}.$$

Flow fluctuation & $v_n\{4\}$

- Bessel-Gaussian

$$p(\vec{v}_n) \propto \exp\left(\frac{-(\vec{v}_n - \vec{\bar{v}}_n)^2}{2\delta_n^2}\right)$$

$$p(v_n) \propto v_n \exp\left(\frac{-(v_n^2 + (\bar{v}_n)^2}{2\delta_n^2}\right) I_0\left(\frac{v_n \bar{v}_n}{\delta_n^2}\right) \quad I_0(x) \approx e^{\frac{x^2}{4}}\left[1 - \frac{x^4}{64}\right]$$

For pure fluctuations $\bar{v}_n = 0 \Rightarrow \quad p(v_n) \propto v_n \exp\left(\frac{-(v_n^2)}{2\delta_n^2}\right)$

- When $\alpha = \frac{\delta_n}{\bar{v}_n} >\approx 1$ distribution is very close to pure Gaussian with a redefinition of δ

$$\begin{pmatrix} \delta_n^2 \\ \bar{v}_n \end{pmatrix} \rightarrow \begin{pmatrix} \delta_n^{2'} = \delta_n^2 + \left(\bar{v}_n\right)^2/2 \\ \bar{v}_n' = 0 \end{pmatrix}$$

Valid when $\frac{v_n \bar{v}_n}{\delta_n^2} << 64^{1/4} = 2.8 \text{ or } v_n << 2.8\delta_n\alpha$

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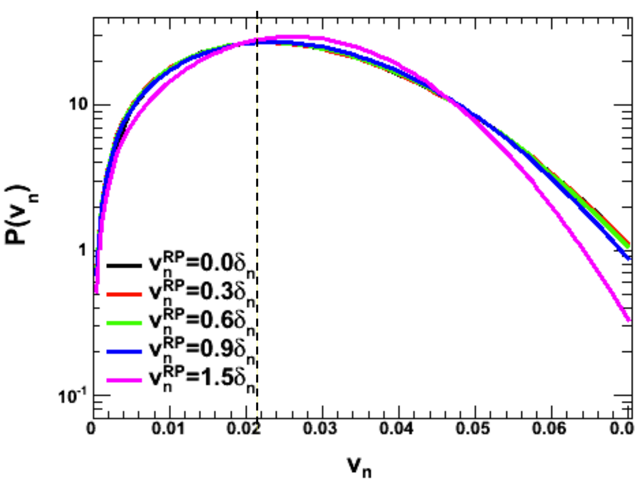
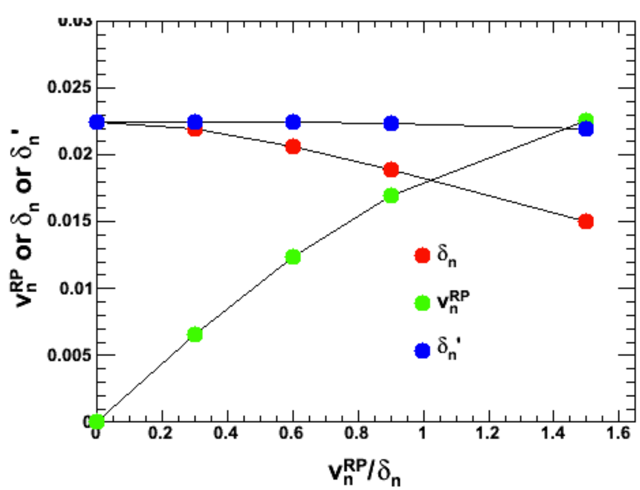
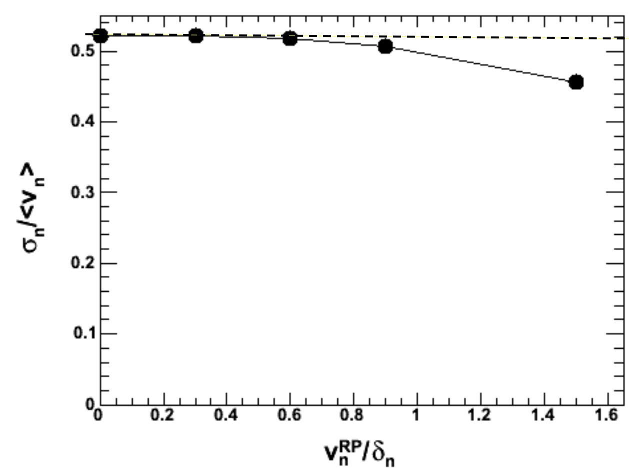
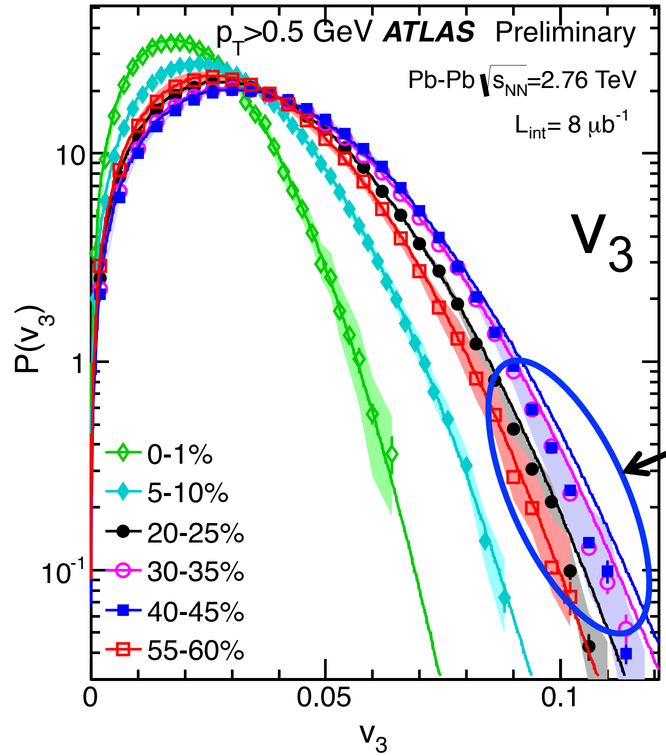
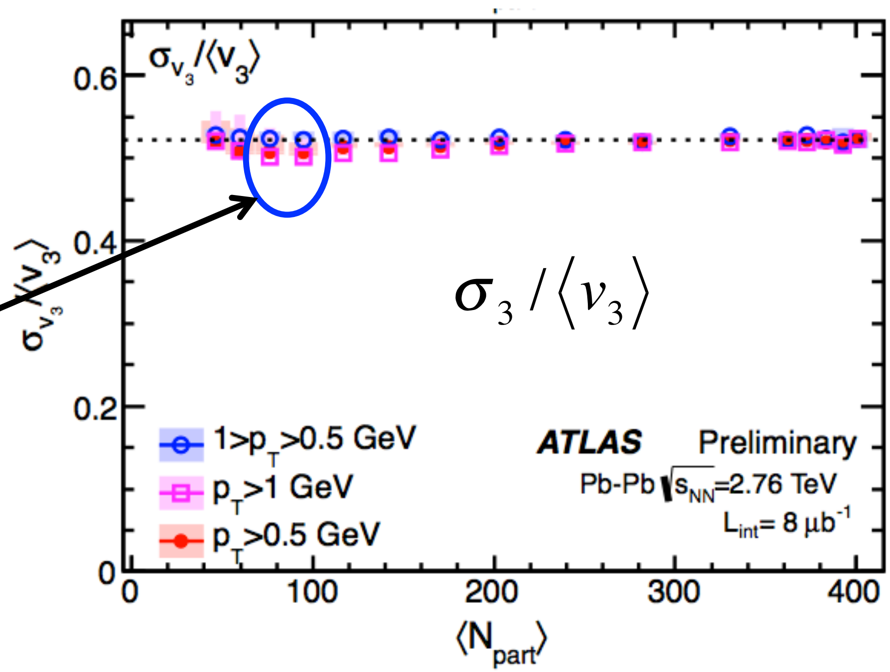






Flow fluctuation & $v_n\{4\}$





- Even a small deviation will give a large v_n^{RP} or large $v_n\{4\}$

$$v_n\{4\} = \left[2\left\langle v_n^2 \right\rangle^2 - \left\langle v_n^4 \right\rangle \right]^{1/4}$$

a 4% difference gives a $v_n\{4\}$ value of about 45% of $v_n\{2\}$

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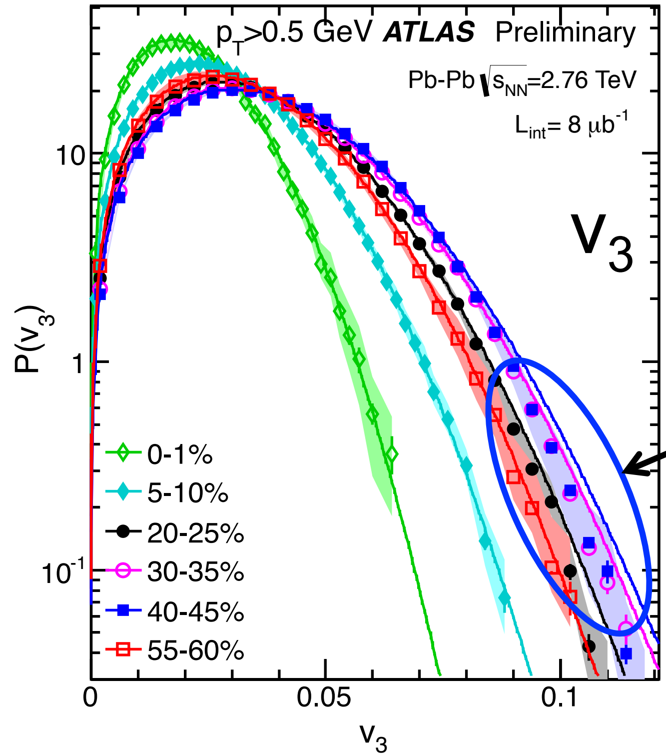

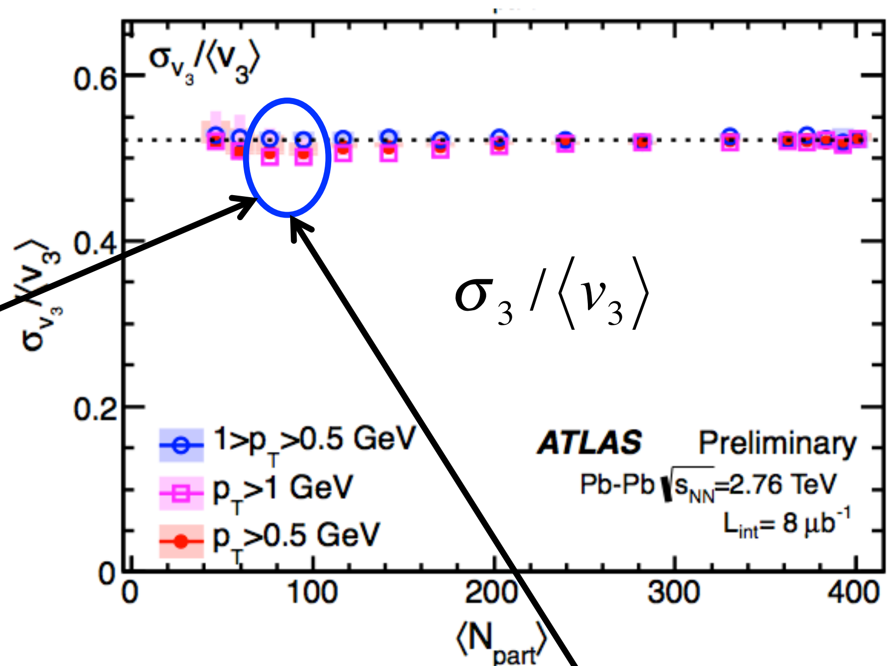

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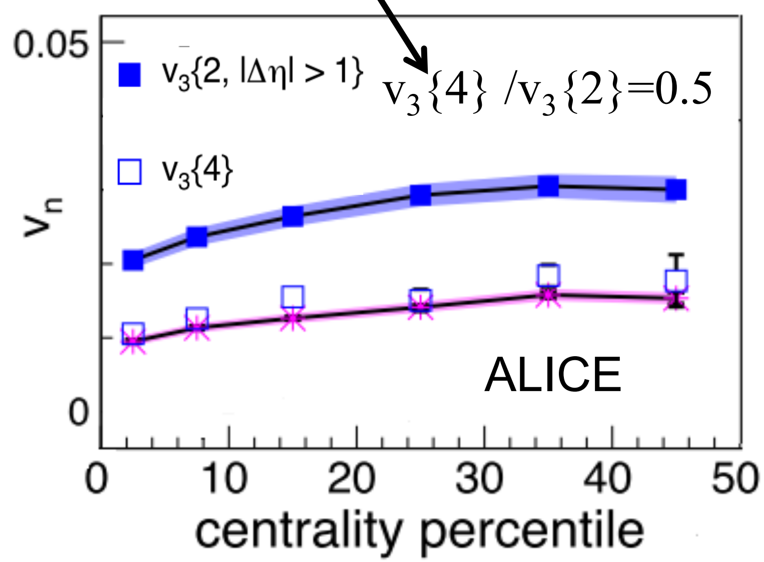
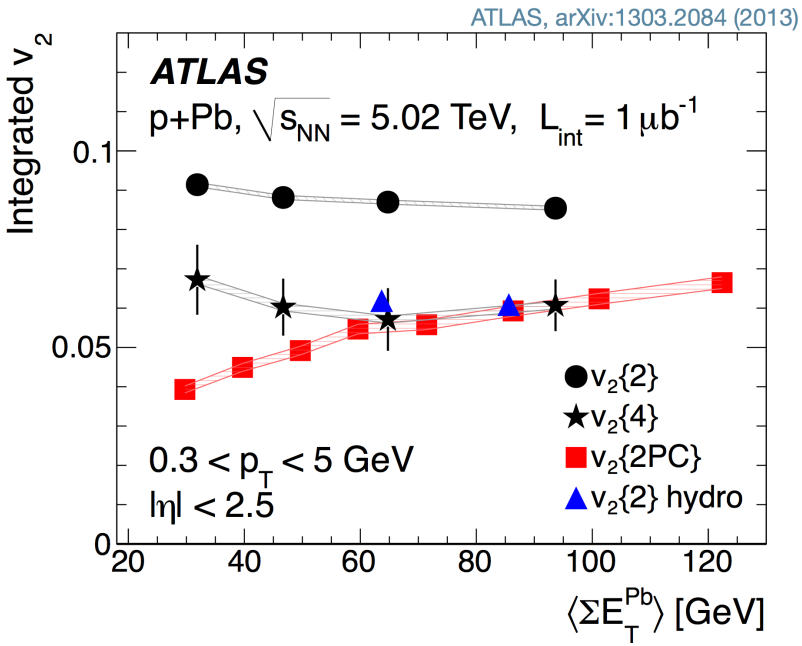
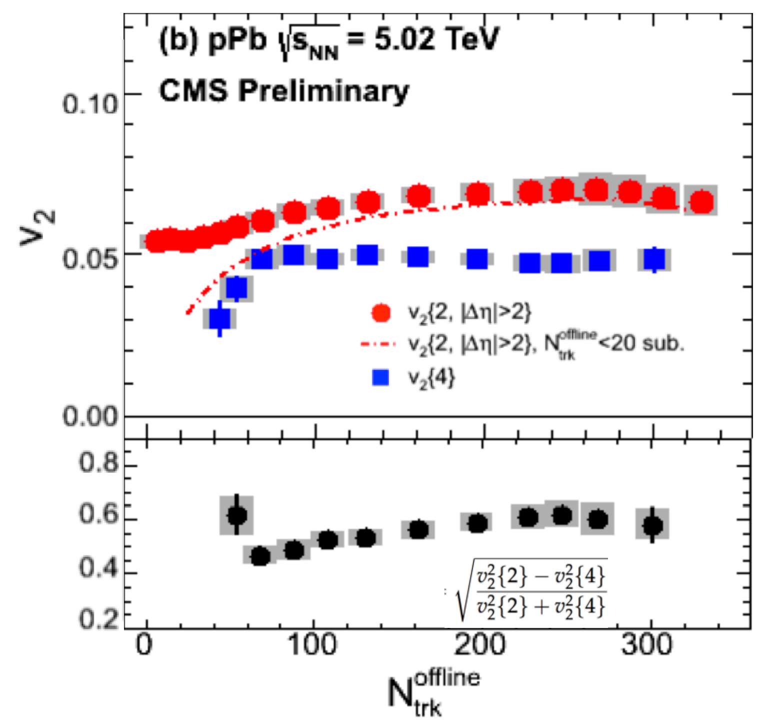


$v_2\{4\}$ in p+Pb

- Just need a small deviation from Gaussian
  - Small N_{part}, or Negative binomial fluctuation (Bozek)
  - Fluctuation of M and v_n aren't de-coupled

$$\frac{dN}{d\phi} = M\left[1 + \sum_n 2\mathrm{v}_n \cos n\left(\phi - \Phi_n\right)\right]$$





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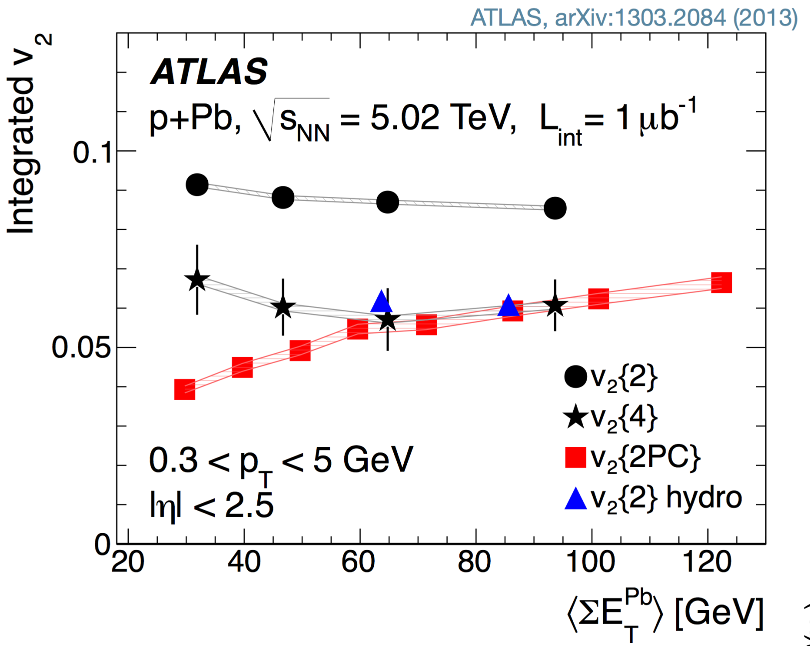
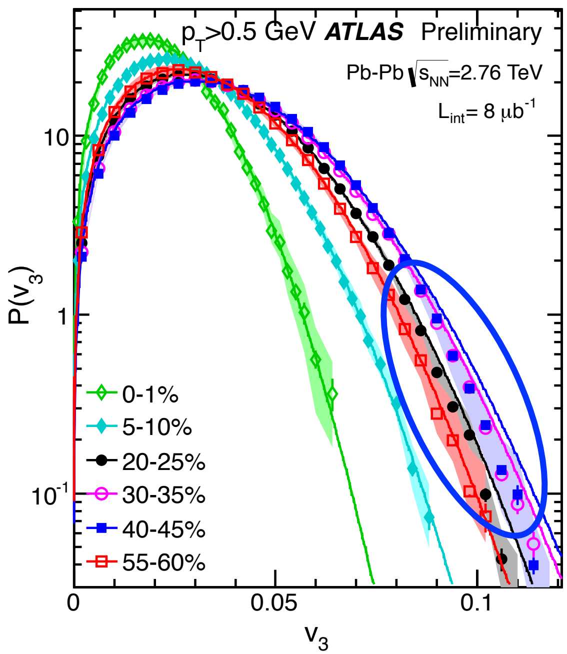
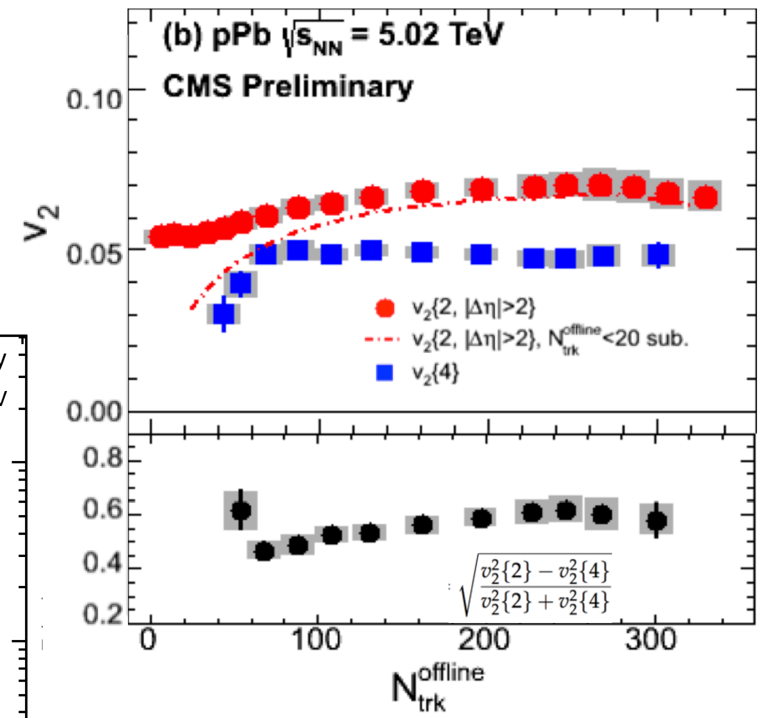
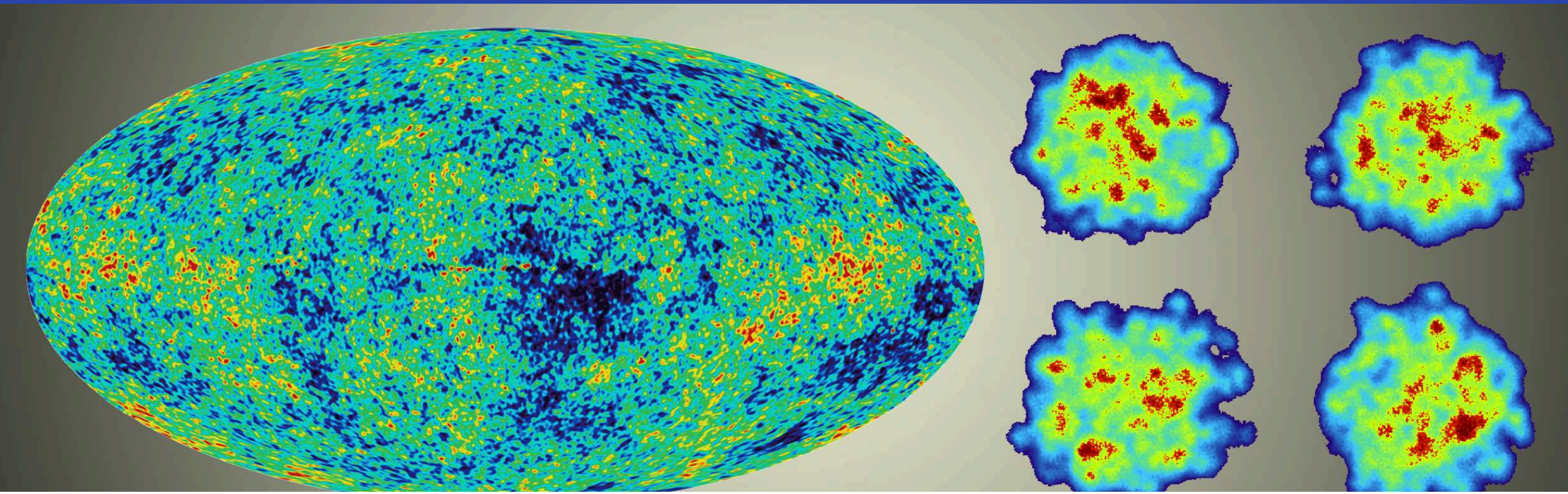


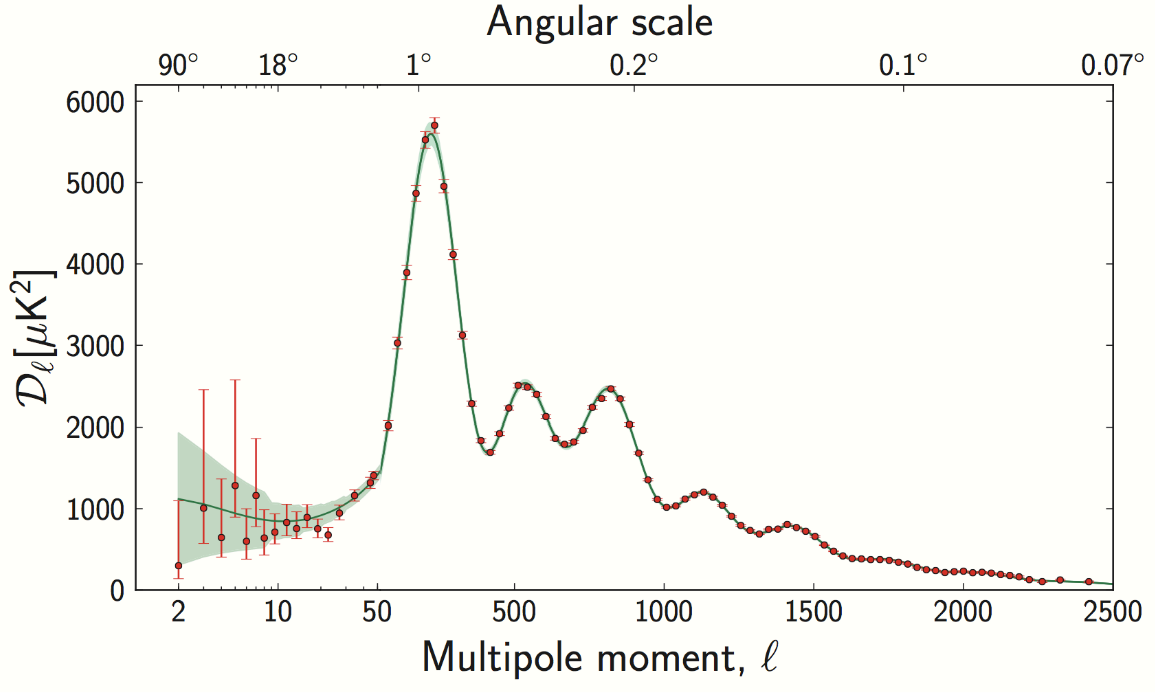




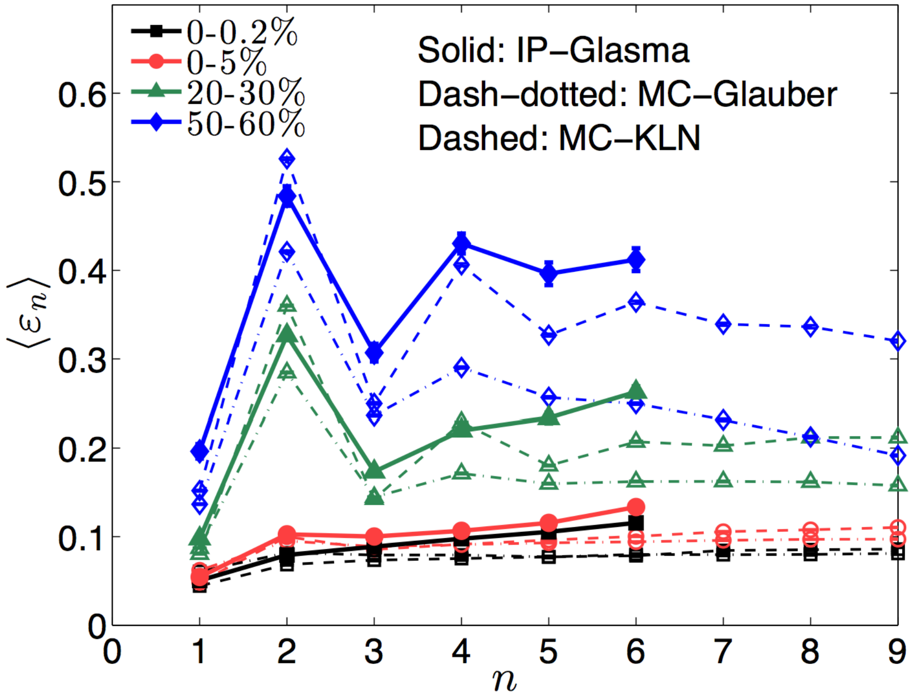
Power spectrum



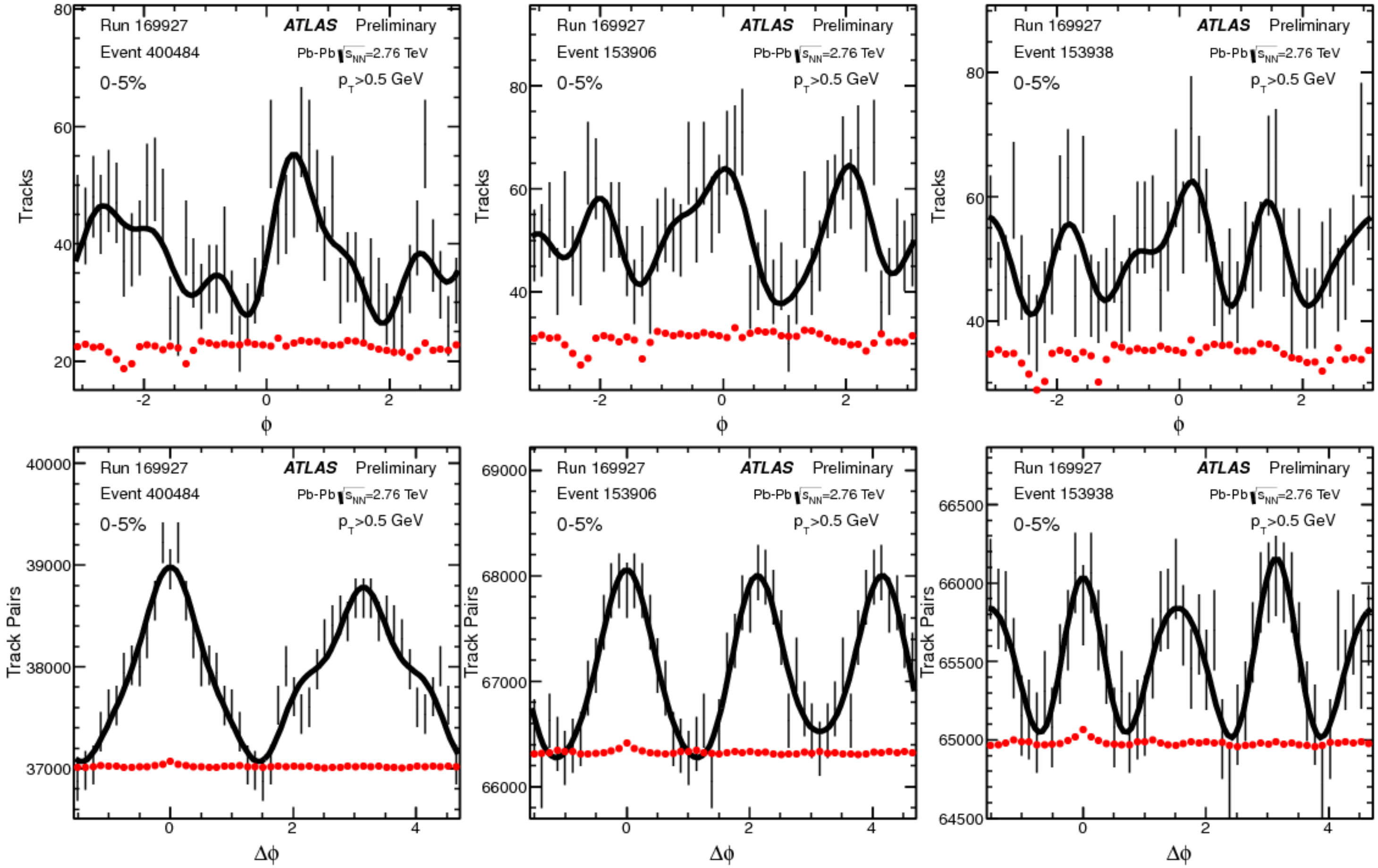
Planck 2013 CMB temperature power spectrum



Little Bang density power spectra 2013



Ripples of “little-bangs”



- Data-driven unfolding the key:

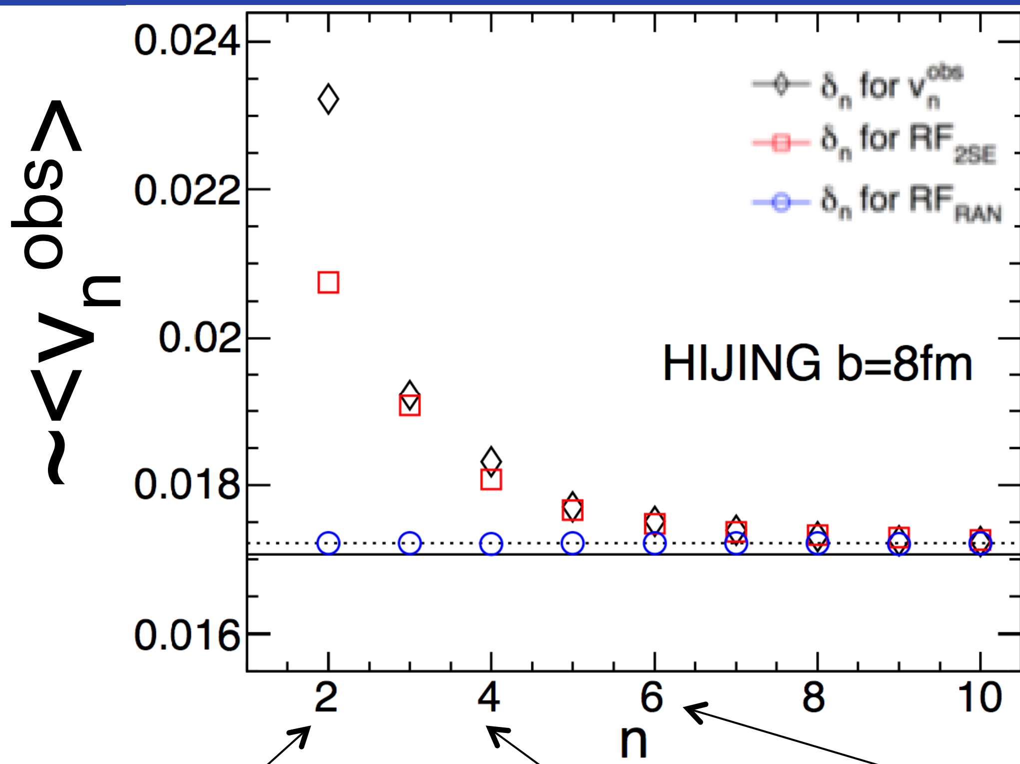
Sub-event “A” – Sub-event “B” = { Signal : cancelled; Fluctuations+short-range corr. : √2 larger }

$$(\vec{v}_n^{\,\mathrm{obs}})^{\mathrm{a}} - (\vec{v}_n^{\,\mathrm{obs}})^{\mathrm{b}} = \mathrm{nonflow} + \mathrm{noise}$$

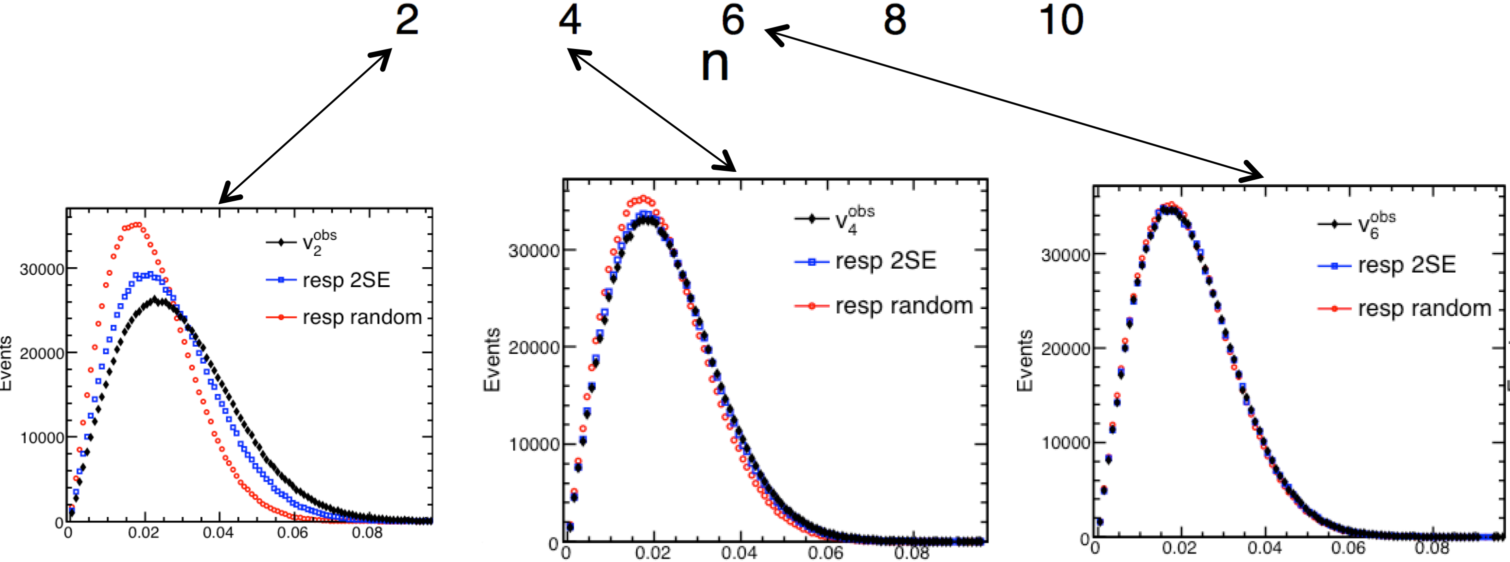
$$(\vec{v}_n^{\,\mathrm{obs}})^{\mathrm{a}} + (\vec{v}_n^{\,\mathrm{obs}})^{\mathrm{b}} = 2\vec{v}_n$$

J.Jia, S. Mohapatra: arxiv:1304.1471

Azimuthal power spectrum in hijing: (non-flow)



- Unfolding method allow extraction of EbE distribution of short-range and long-range correlations
  - Well-defined noise limit



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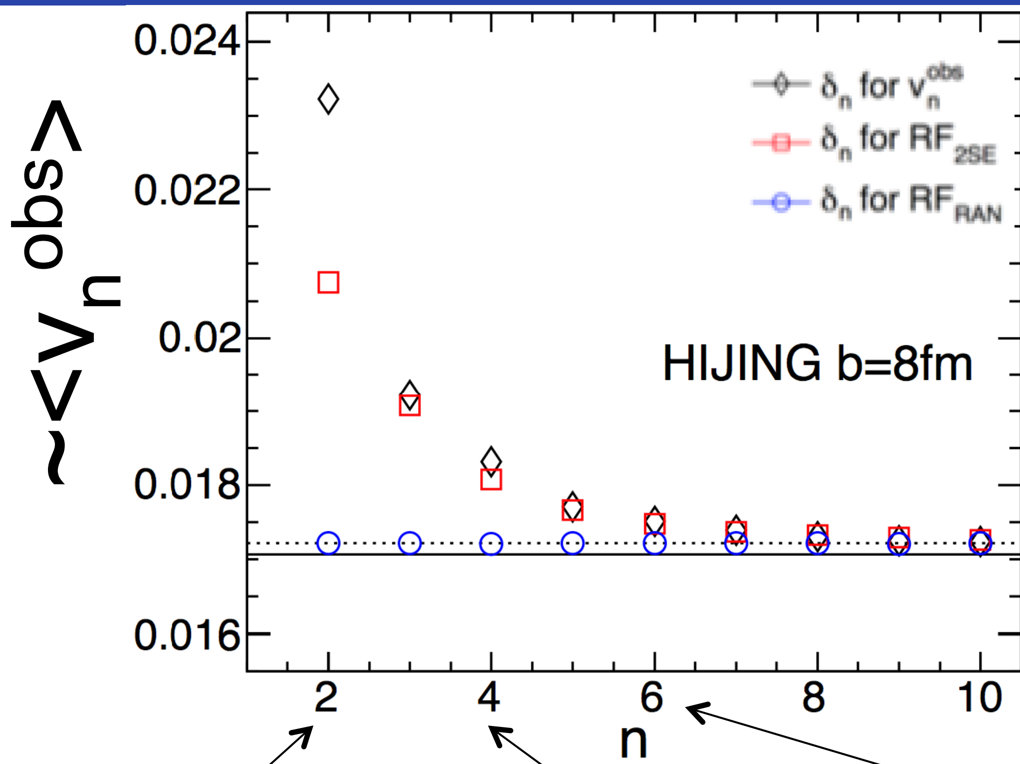

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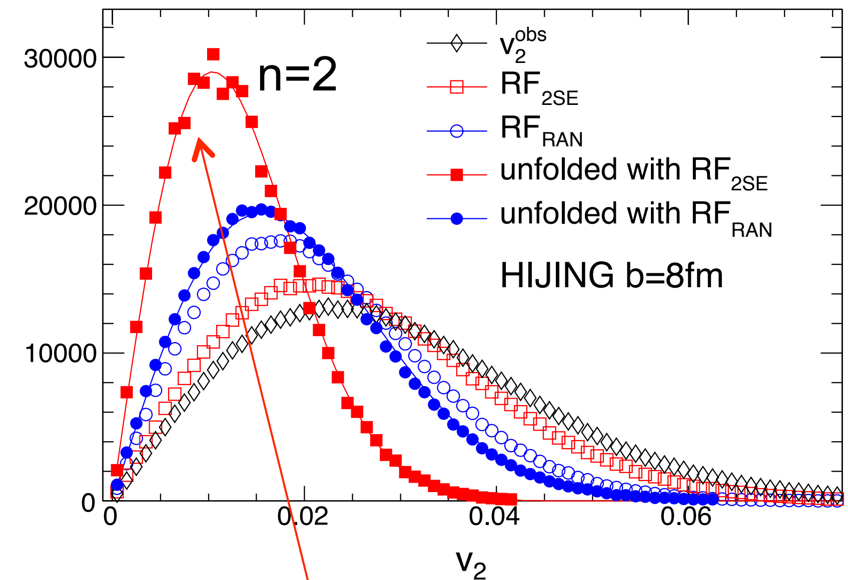
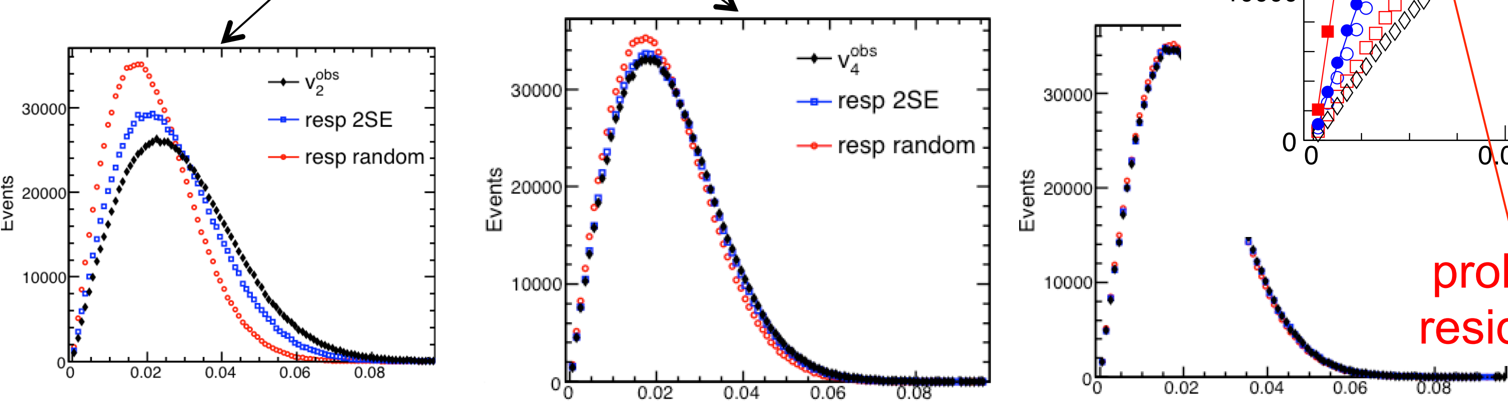
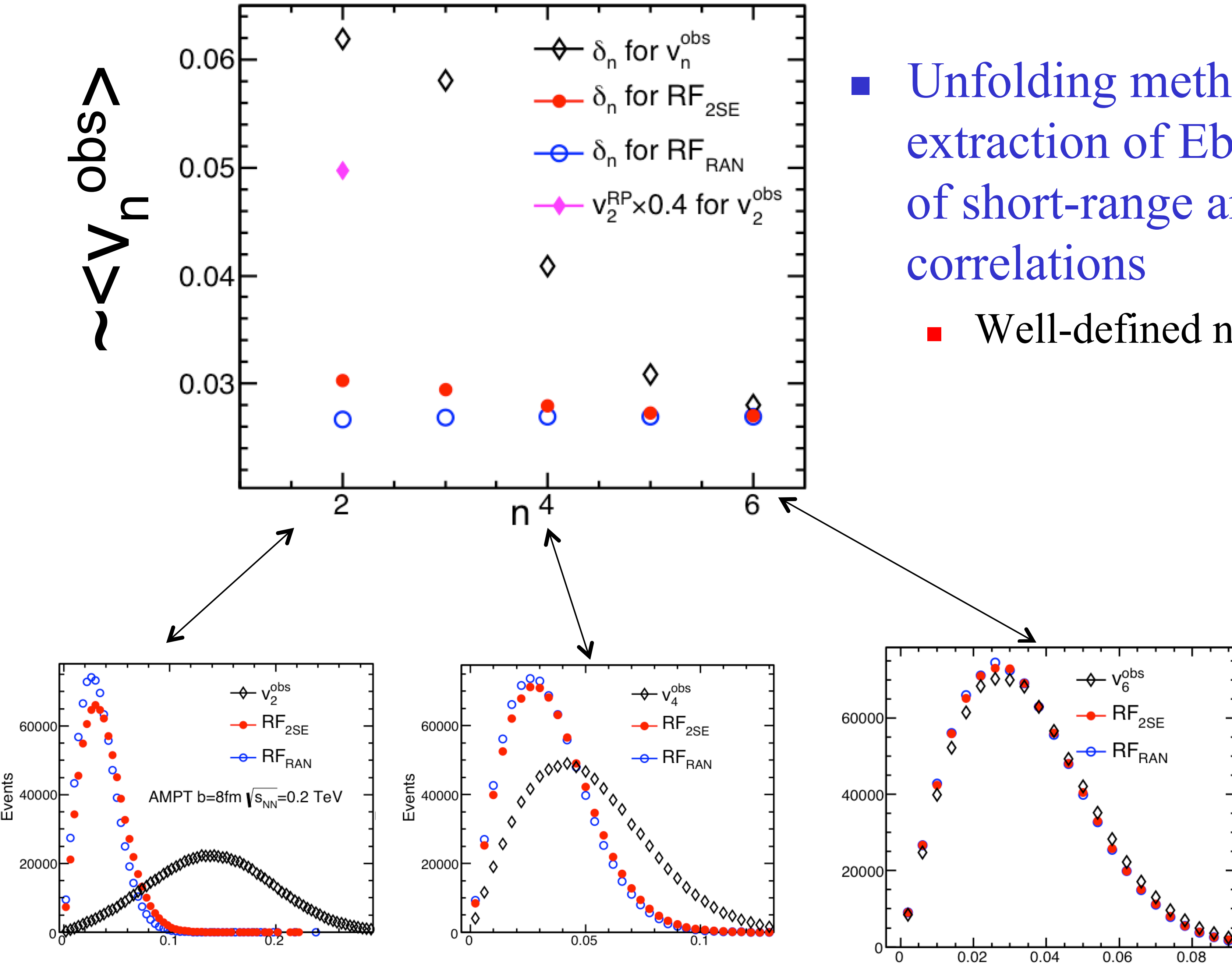


probability distribution of residual non-flow!!!



Azimuthal power spectrum in AMPT: (flow+non-flow)



- Unfolding method allow extraction of EbE distribution of short-range and long-range correlations
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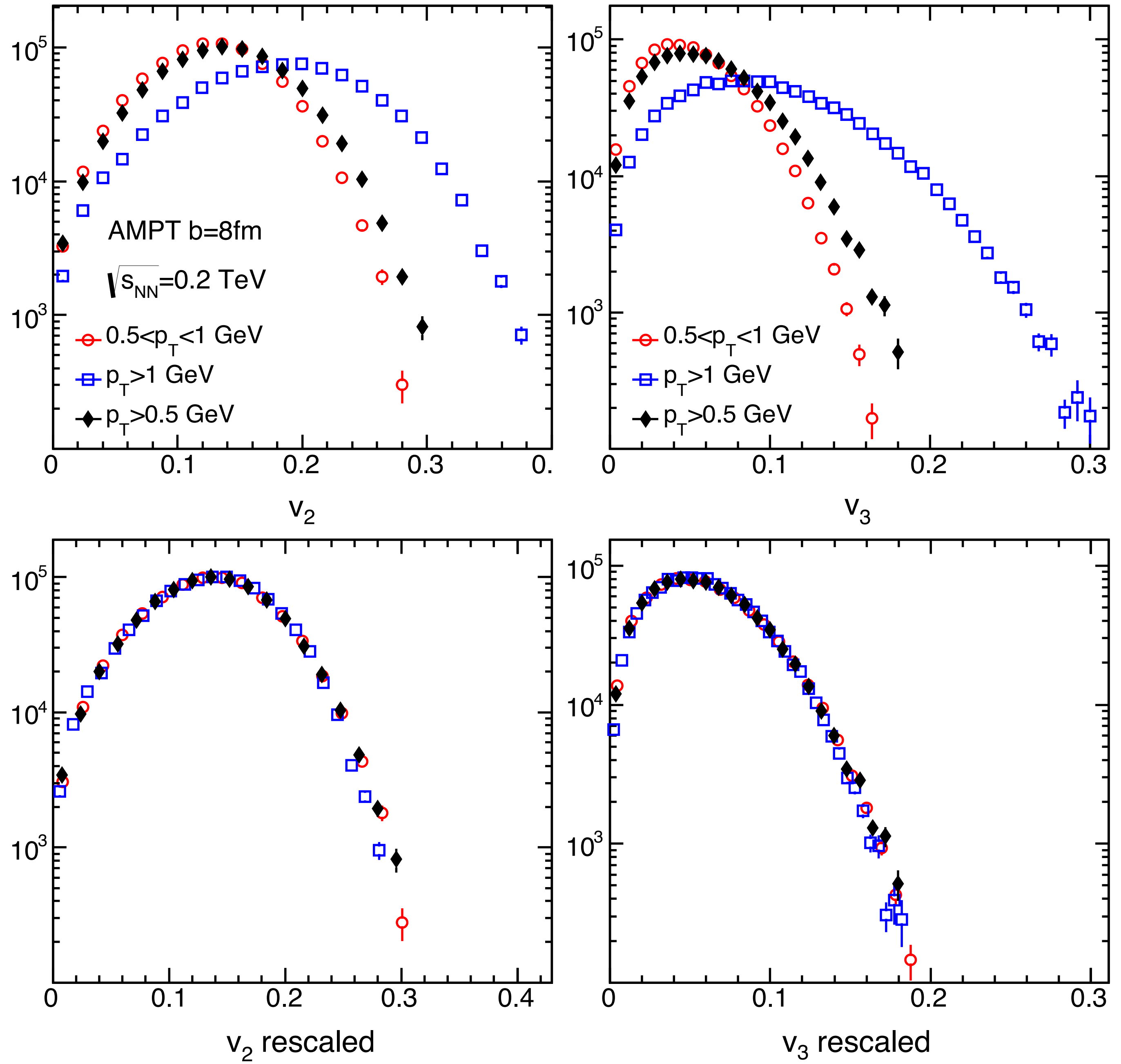
AMPT unfolded distributions

- Unfolded distribution scales well.



It was a memorable workshop

RBRC13 psyco SHOCK waves from super central pPb @ LHC