Stony Brook University | The State University of New York

ATLAS EXPERIMENT

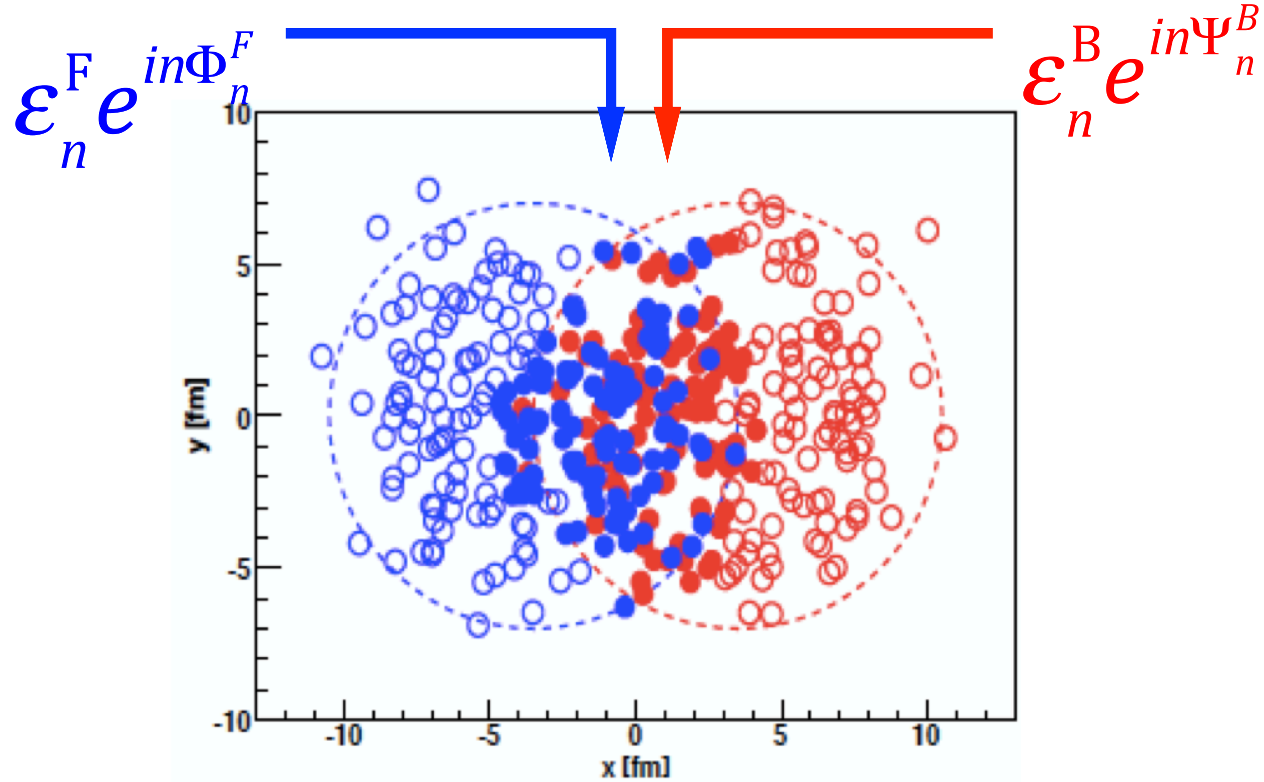
# Longitudinal flow decorrelation in PbPb collisions from ATLAS

Peng Huo

ATLAS-CONF-2017-003

# Origin of flow decorrelation

Shape of overlap region is driven by eccentricities of F-going and B-going participants



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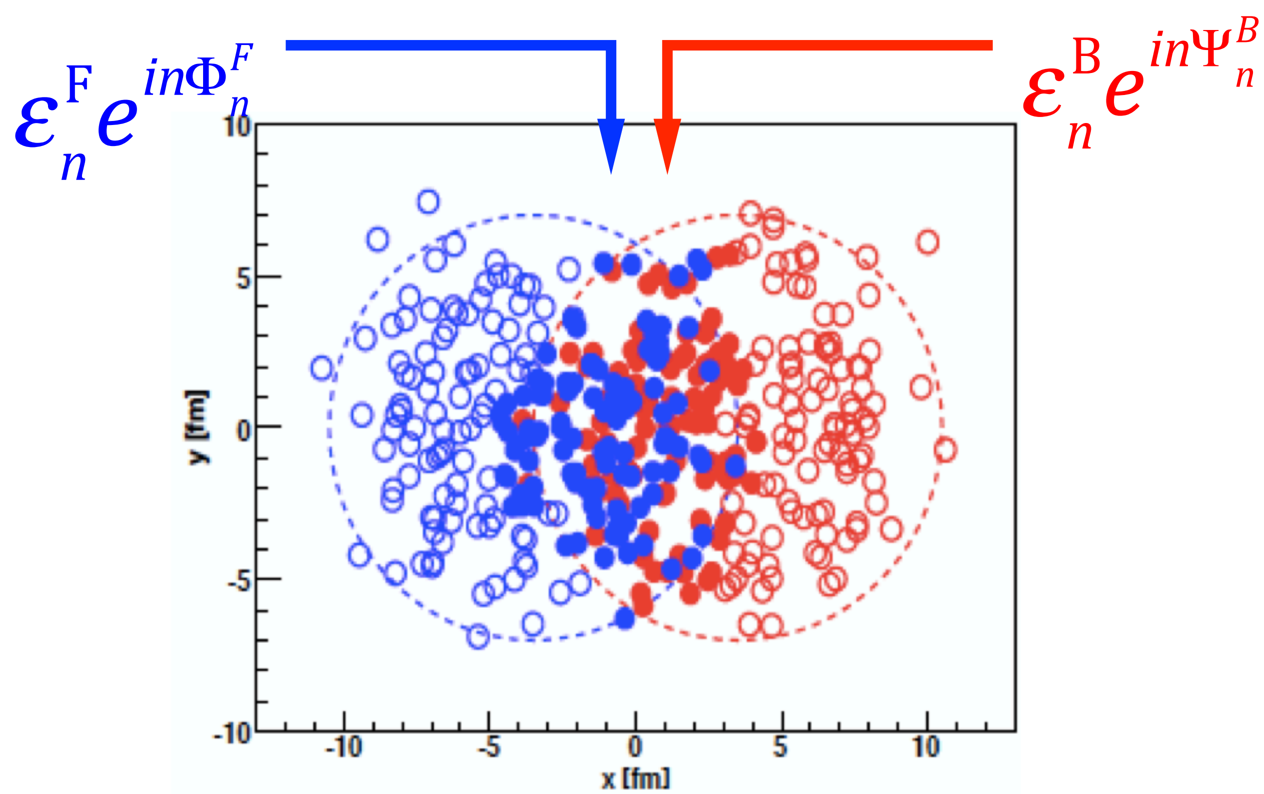
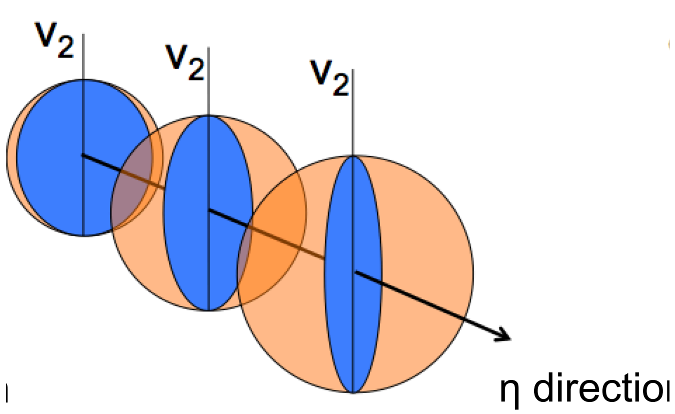


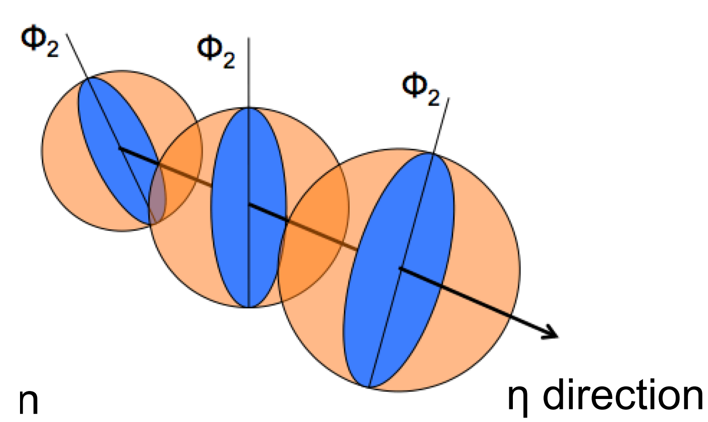

- Consequence: $\boldsymbol{v}_n(\eta) = v_n(\eta) e^{in\Psi_n(\eta)}$

Asymmetry of flow magnitude




$$v_n(\eta_1) \neq v_n(\eta_2)$$

Torque/twist of event plane

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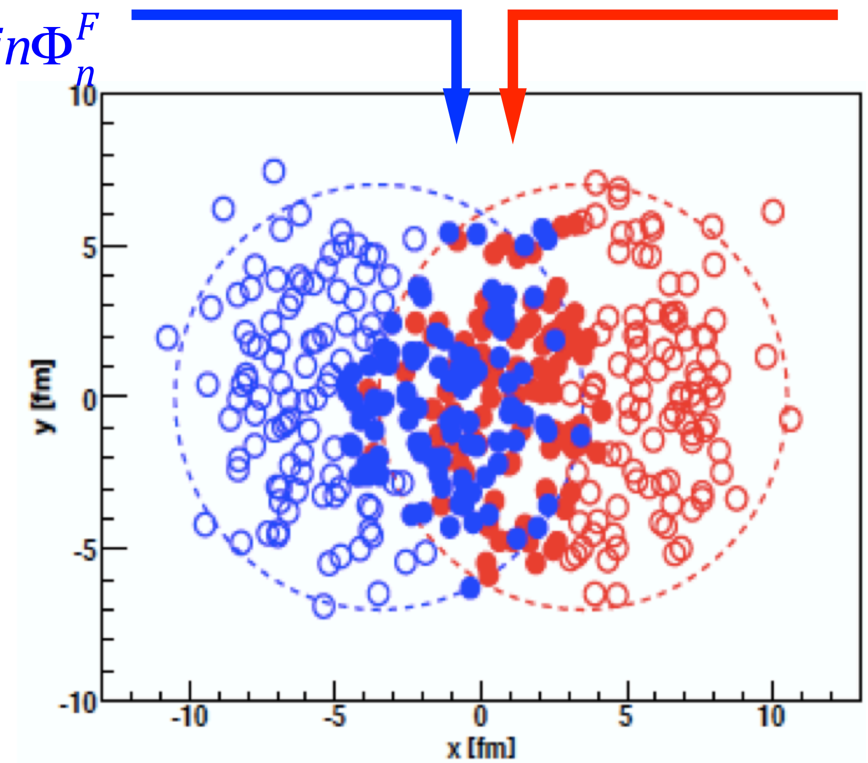
$\varepsilon_n^{\mathrm{F}} e^{in\Phi_n^F}$ $\varepsilon_n^{\mathrm{B}} e^{in\Psi_n^B}$

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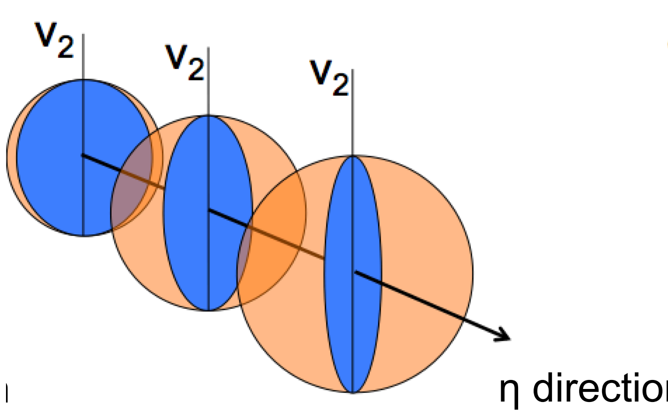


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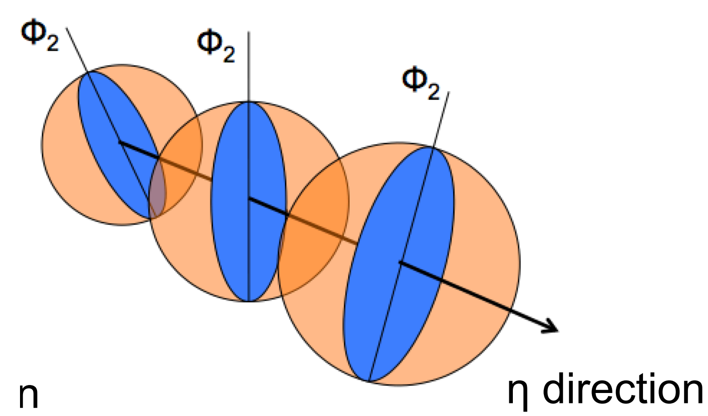


$\Psi_n(\eta_1) \neq \Psi_n(\eta_2)$

$\langle \boldsymbol{v}_n(\eta_1) \boldsymbol{v}_n^*(\eta_2) \rangle$

# Quantify flow decorrelation



- Observable: measures flow decorrelation between $\mathbf{v_n}(-\eta)$ and $\mathbf{v_n}(\eta)$

$$r_{n|n}(\eta) = \frac{\langle \boldsymbol{v}_n(-\eta)\boldsymbol{v}_n^*(\eta_{\rm ref})\rangle}{\langle \boldsymbol{v}_n(\eta)\boldsymbol{v}_n^*(\eta_{\rm ref})\rangle} = \frac{\langle v_n(-\eta)v_n(\eta_{\rm ref})\cos n(\Psi_n(-\eta)-\Psi_n(\eta_{\rm ref})\rangle}{\langle v_n(\eta)v_n(\eta_{\rm ref})\cos n(\Psi_n(\eta)-\Psi_n(\eta_{\rm ref})\rangle}$$

*CMS PRC.92.034911*

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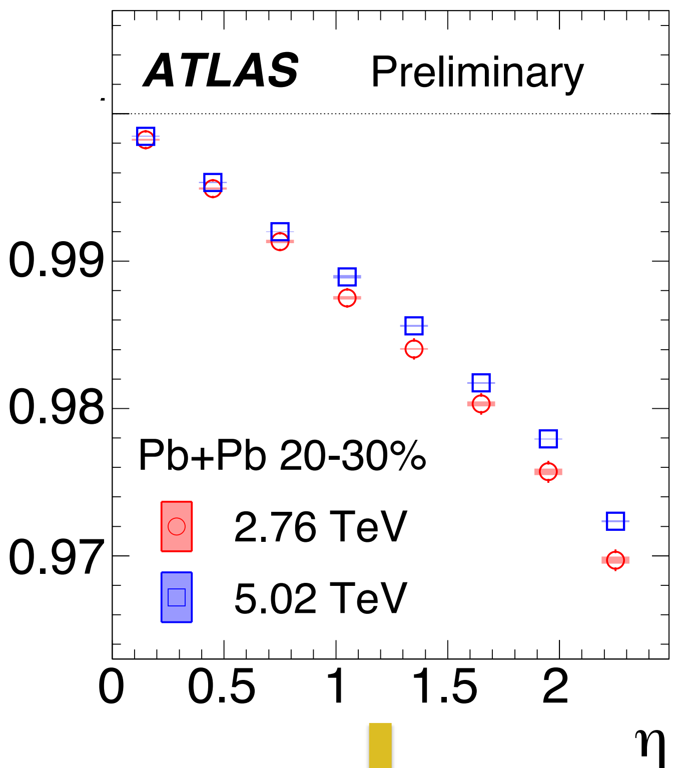
$r_{2|2}$




Fit with a linear function

$r_{2|2} = 1 - 2F_2\eta$

$F_2 = F_2^{twist} + F_2^{asy}$

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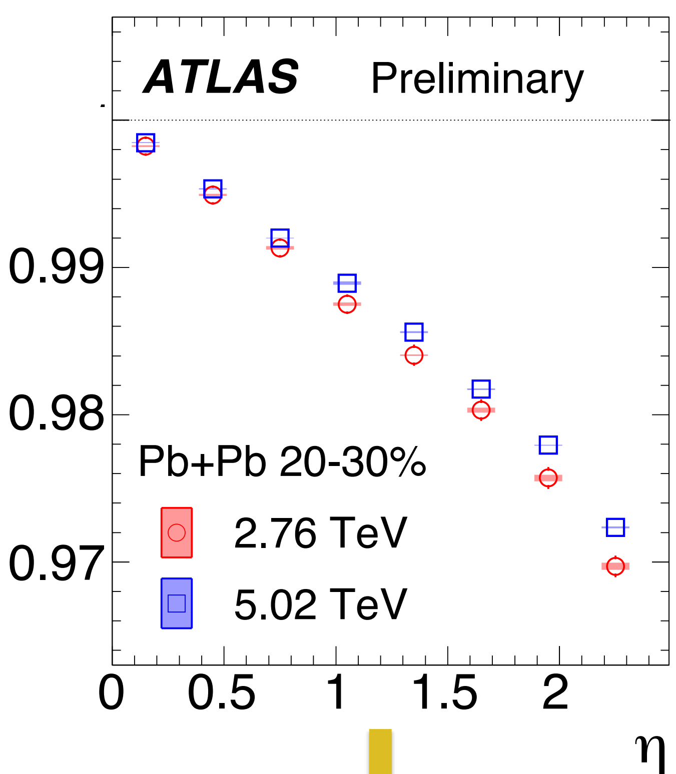


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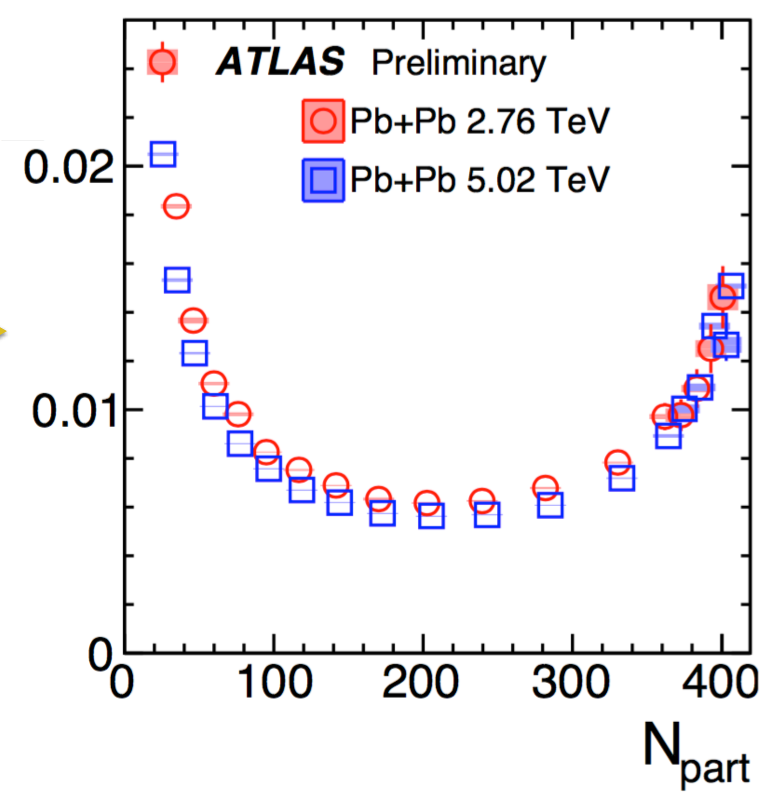


$v_2$ decorrelation is smallest in mid-central collisions

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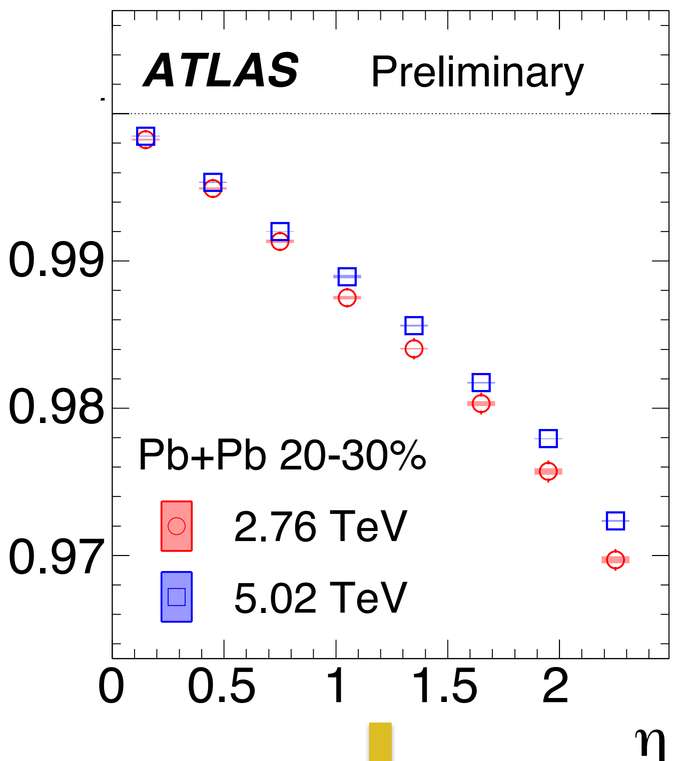


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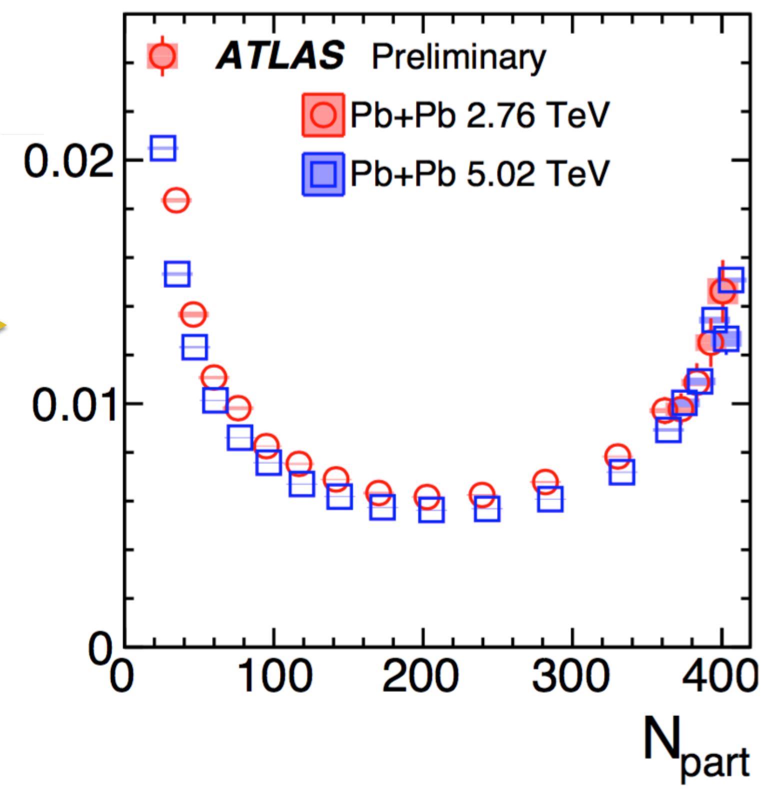


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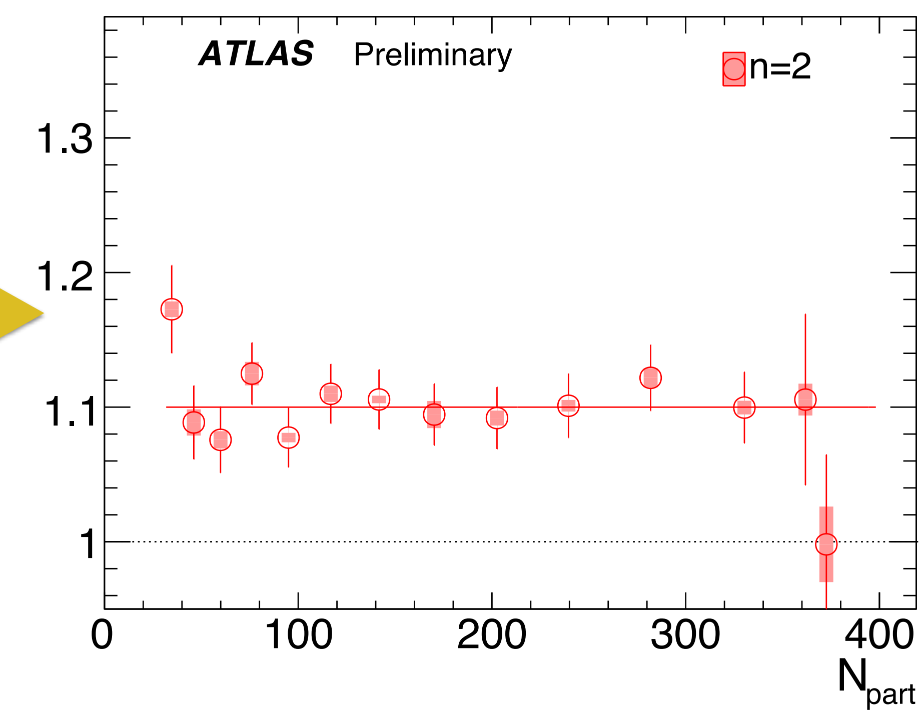
$$\frac{F_n(2.76\text{TeV})}{F_n(5.02\text{TeV})}$$




decorrelation stronger at 2.76TeV

10% / 16% higher for $\mathbf{v}_2$/ $\mathbf{v}_3$

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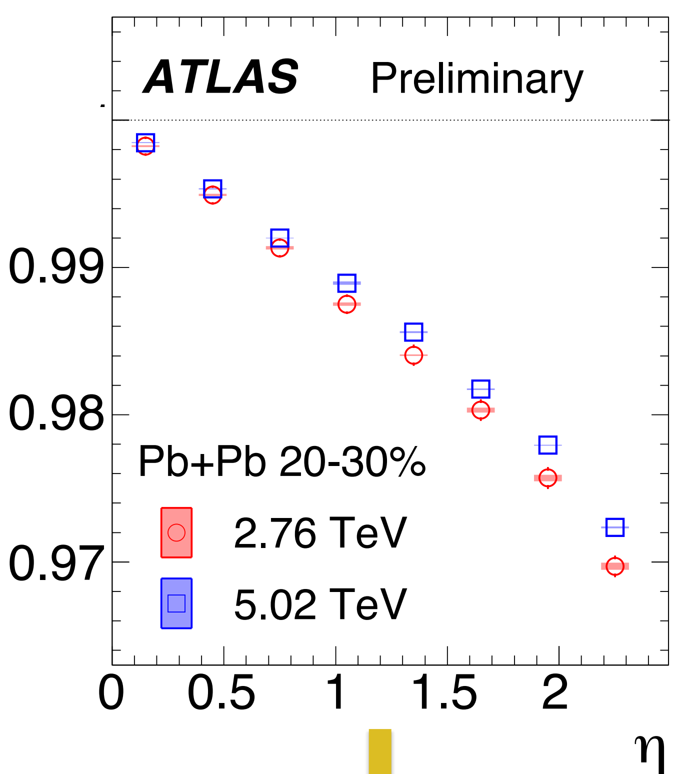


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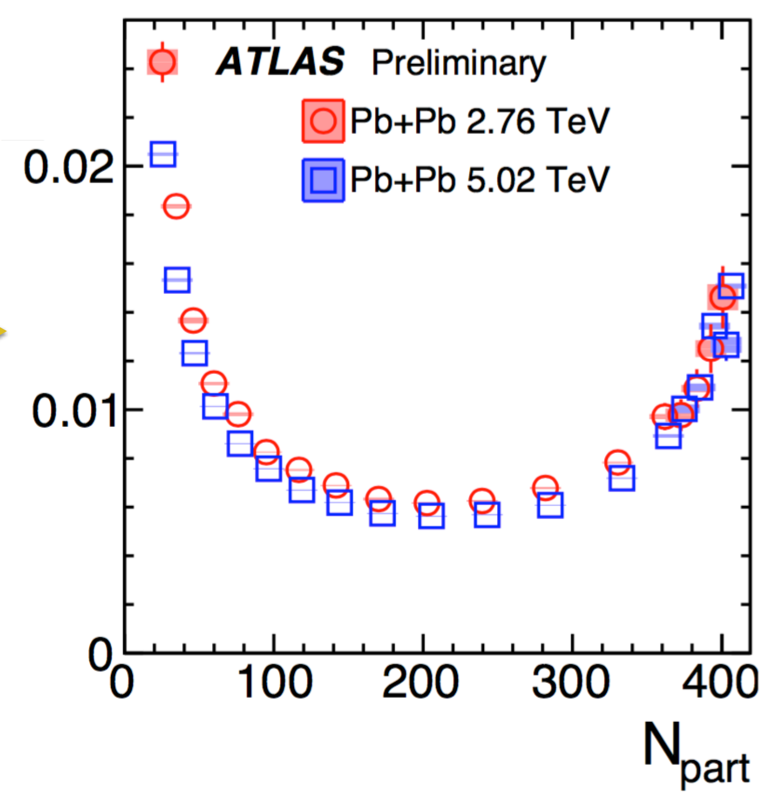


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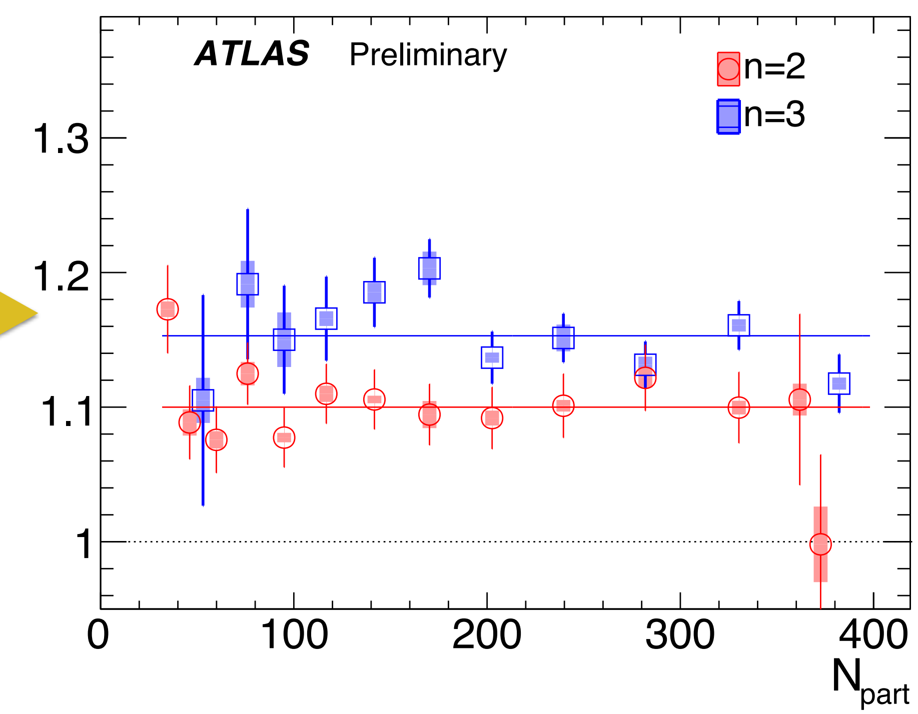


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10% / 16% higher for $\mathbf{v_2}$/ $\mathbf{v_3}$

$F_2 = F_2^{twist} + F_2^{asy}$

Much stronger decorrelation expected at RHIC energy!

# Flow decorrelation for $\boldsymbol{v}_4$

**$\mathbf{v_4}$** has Linear & Nonlinear contribution $\boldsymbol{v}_4 = \boldsymbol{v}_{4L} + \chi_{224}\boldsymbol{v}_2^2$

$$\langle \boldsymbol{v}_2^2 \boldsymbol{v}_4^* \rangle = \langle \boldsymbol{v}_2^2 \boldsymbol{v}_{4L}^* \rangle + \chi_{224} \langle \boldsymbol{v}_2^2 \boldsymbol{v}_2^{2*} \rangle$$

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$$r_{2,2|4} = \frac{\langle \boldsymbol{v}_2^2(-\eta) \boldsymbol{v}_4^*(\eta_{\mathrm{ref}}) \rangle}{\langle \boldsymbol{v}_2^2(\eta) \boldsymbol{v}_4^*(\eta_{\mathrm{ref}}) \rangle} \approx \frac{\langle \boldsymbol{v}_2^2(-\eta) \boldsymbol{v}_2^{2*}(\eta_{\mathrm{ref}}) \rangle}{\langle \boldsymbol{v}_2^2(\eta) \boldsymbol{v}_2^{2*}(\eta_{\mathrm{ref}}) \rangle} \equiv r_{2|2;2}$$

decor. of $\mathbf{v}_2^2$-$\mathbf{v}_4$ dominated by decor. of $\mathbf{v}_2^2$-$\mathbf{v}_2^2$

# Flow decorrelation for $v_4$

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decor. of **$v_4$-$v_4$** contain decor. of both **$v_{4L}$-$v_{4L}$** and **$v_2^2$-$v_2^2$**

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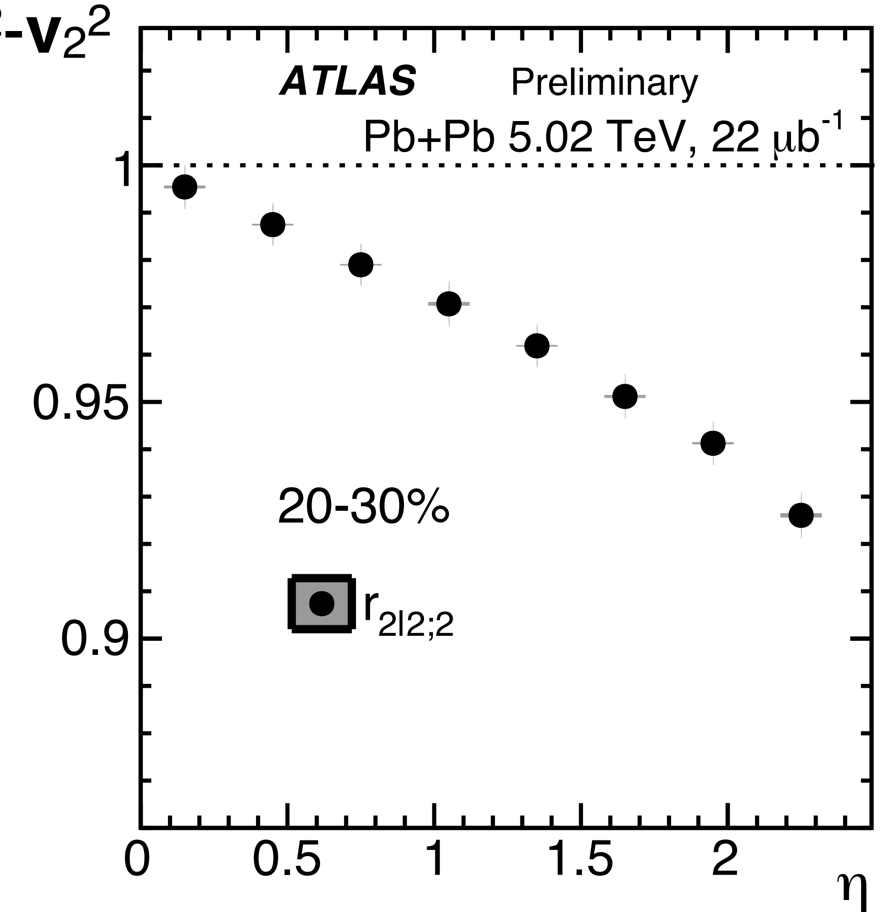

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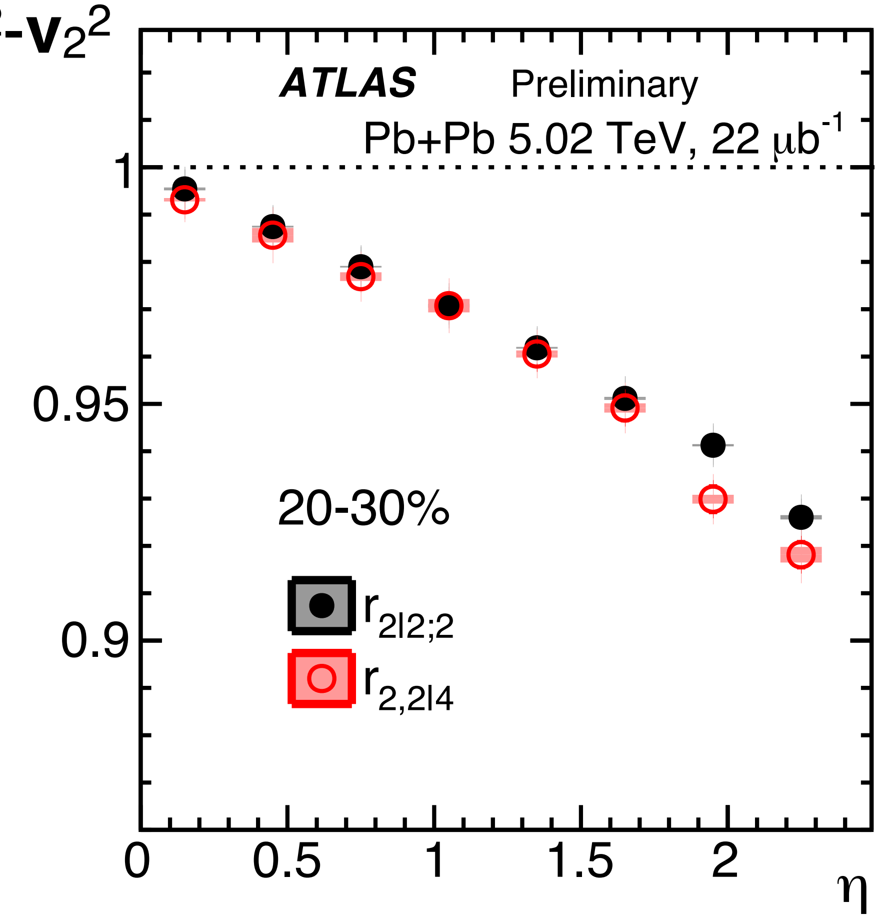

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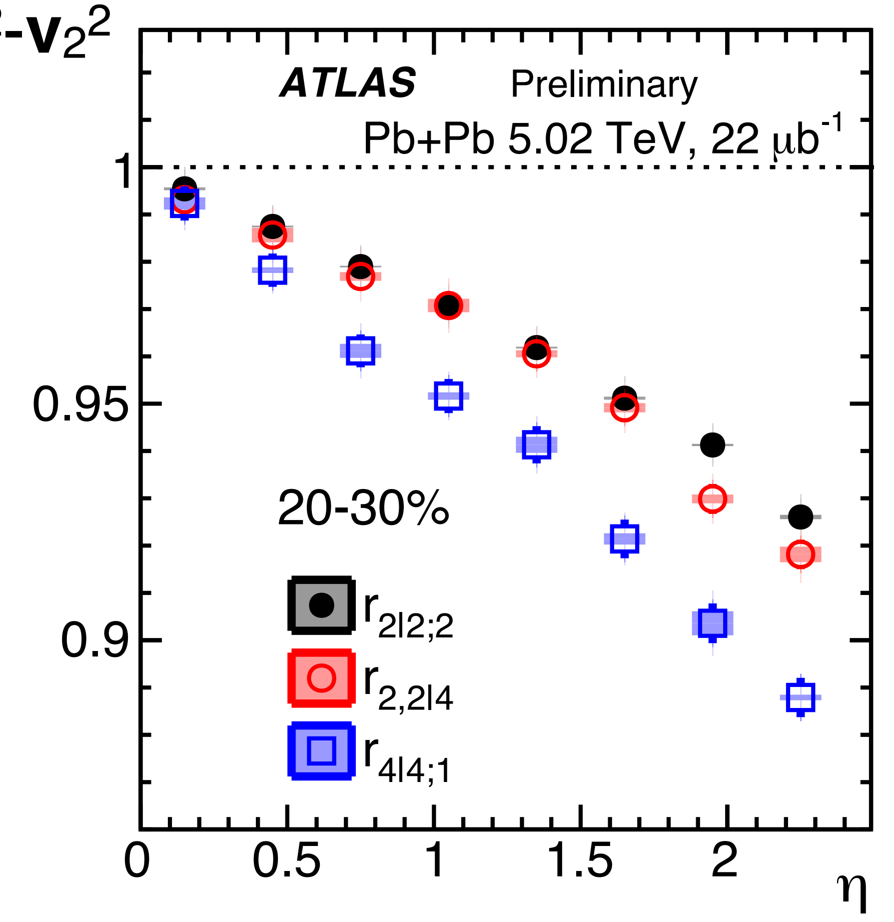
decorrelation of $v_{4L}$ and decorrelation of $v_2^2$ are different !!



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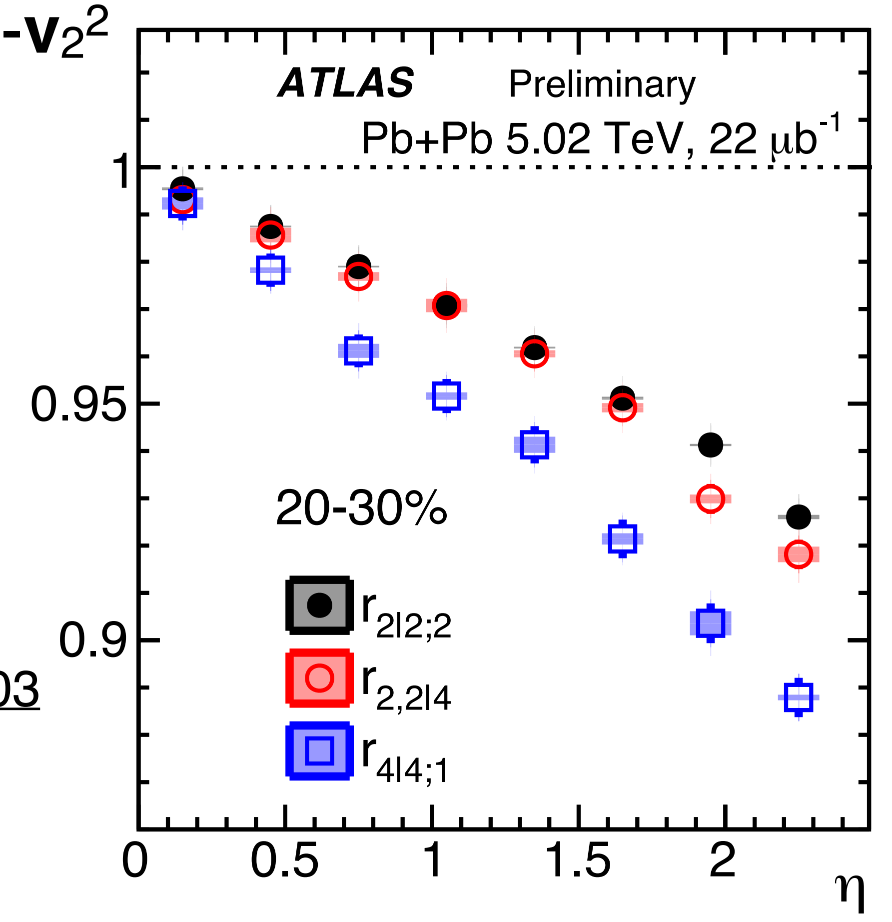



decorrelation of $v_{4L}$ and decorrelation of $v_2^2$ are different !!

## Summary

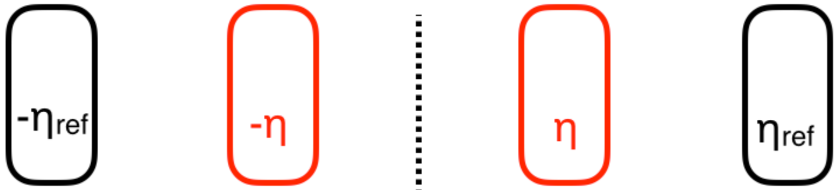
- A lot more additional results can be found in ATLAS-CONF-2017-003
- Important info on non-boost-invariantness of initial condition & final state dynamics

# Back up

# Separate twist and asymmetry

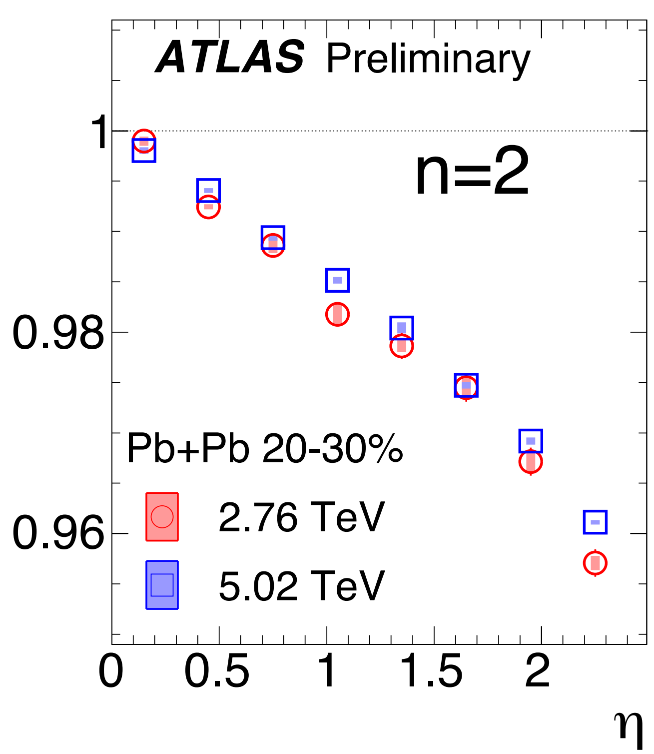
- A new four-particle correlator: only sensitive to event-plane twist arXiv:1701.02183

$$R_{n,n|n,n} = \frac{\langle \boldsymbol{v}_n(-\eta_{\rm ref})\boldsymbol{v}_n(-\eta)\boldsymbol{v}_n^*(\eta)\boldsymbol{v}_n^*(\eta_{\rm ref})\rangle}{\langle \boldsymbol{v}_n(-\eta_{\rm ref})\boldsymbol{v}_n^*(-\eta)\boldsymbol{v}_n(\eta)\boldsymbol{v}_n^*(\eta_{\rm ref})\rangle}$$

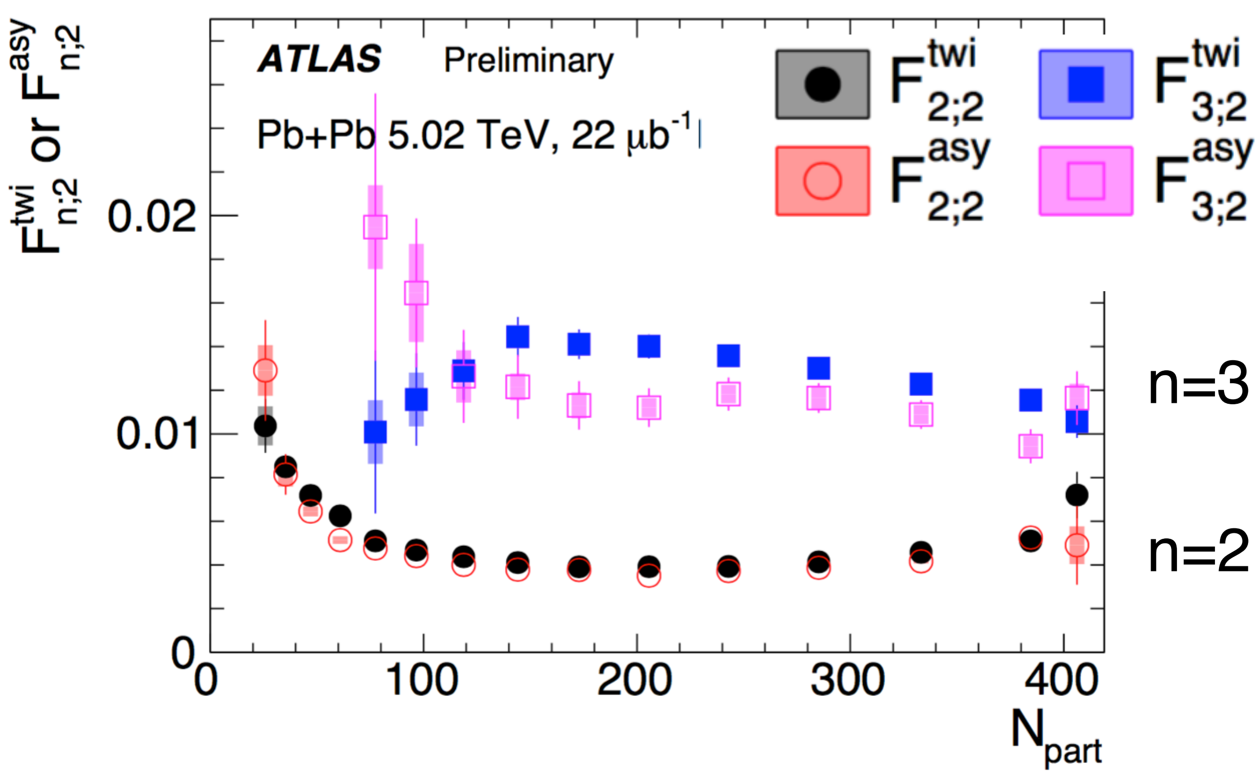



$$= \frac{\langle v_n(-\eta_{\rm ref})v_n(-\eta)v_n(\eta)v_n(\eta_{\rm ref})\cos n\left[\Psi_n(-\eta_{\rm ref})+(\Psi_n(-\eta)-\Psi_n(\eta))-\Psi_n(\eta_{\rm ref})\right]\rangle}{\langle v_n(-\eta_{\rm ref})v_n(-\eta)v_n(\eta)v_n(\eta_{\rm ref})\cos n\left[\Psi_n(-\eta_{\rm ref})-(\Psi_n(-\eta)-\Psi_n(\eta))-\Psi_n(\eta_{\rm ref})\right]\rangle}$$

$R_{n,n|n,n} = 1-4F_n^{twist}\eta$

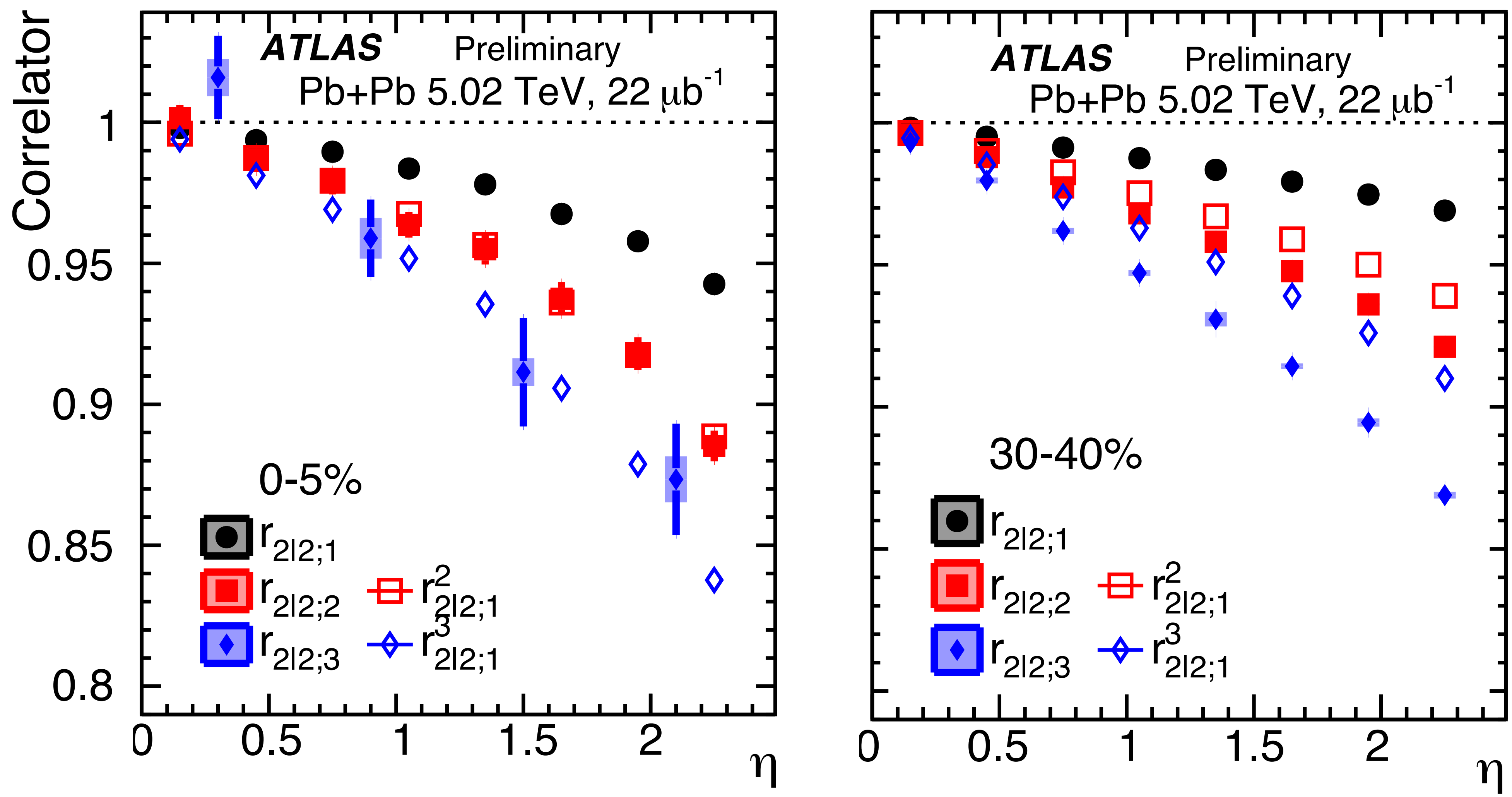



together with the $r_{2|2;2}$ (back up), one can separate the twist and asymmetry contribution




Equal contribution from twist & asymmetry

# higher order decor relations for n=2

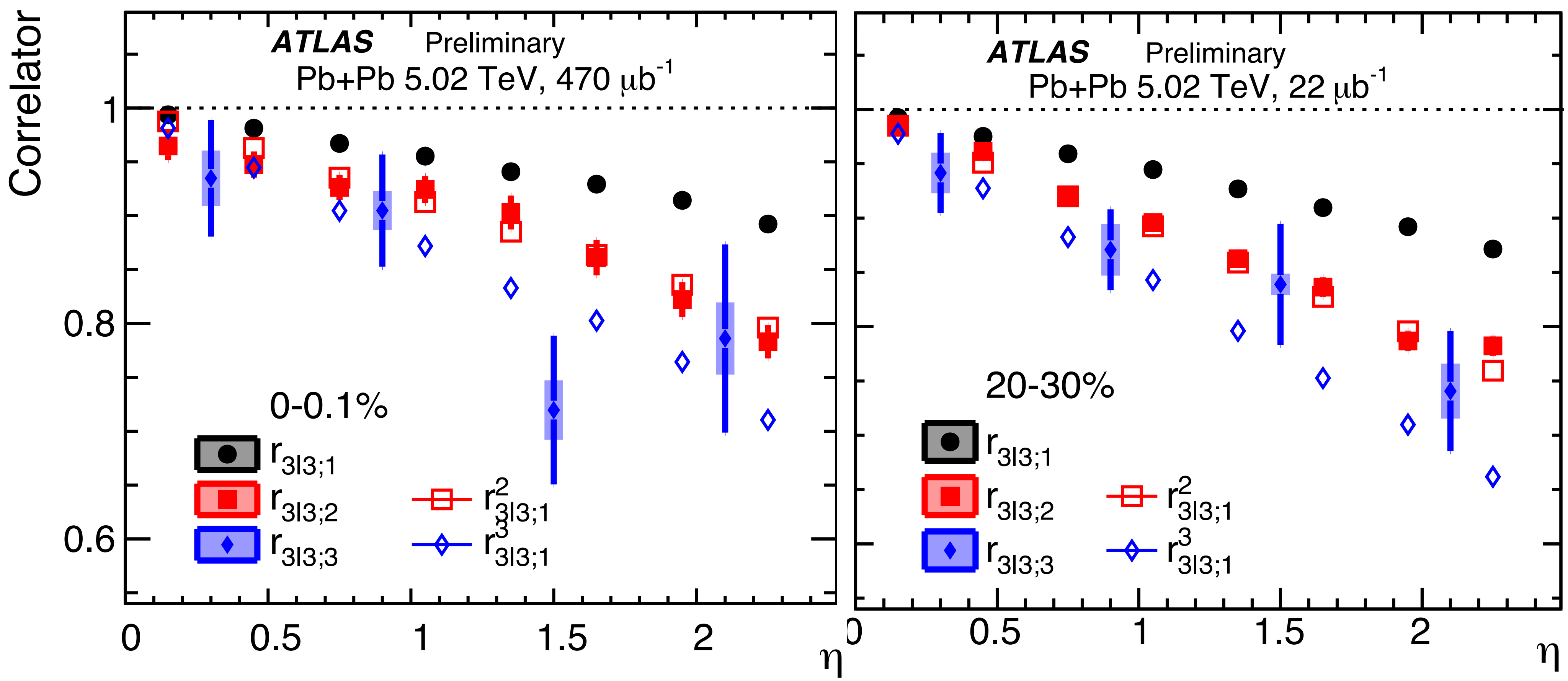



- Also study decorrelation for *k^th* power of flow vectors
- Expect (for fluctuation driven $v_n$)

$$r_{n|n;k}(\eta) = \frac{\langle \boldsymbol{v}_n^k(-\eta)\boldsymbol{v}_n^{k*}(\eta_{\rm ref})\rangle}{\langle \boldsymbol{v}_n^k(+\eta)\boldsymbol{v}_n^{k*}(\eta_{\rm ref})\rangle} \approx \frac{\langle \boldsymbol{v}_n(-\eta)\boldsymbol{v}_n^*(\eta_{\rm ref})\rangle^k}{\langle \boldsymbol{v}_n(+\eta)\boldsymbol{v}_n^*(\eta_{\rm ref})\rangle^k}$$

- For n=2 the scaling holds in central events only

# higher order decor relations for n=3




- Also study decorrelation for *k^th^* power of flow vectors
- Expect (for fluctuation driven $v_n$) $$r_{n|n;k}(\eta) = \frac{\langle \boldsymbol{v}_n^k(-\eta)\boldsymbol{v}_n^{k*}(\eta_{\mathrm{ref}})\rangle}{\langle \boldsymbol{v}_n^k(+\eta)\boldsymbol{v}_n^{k*}(\eta_{\mathrm{ref}})\rangle} \approx \frac{\langle \boldsymbol{v}_n(-\eta)\boldsymbol{v}_n^{*}(\eta_{\mathrm{ref}})\rangle^k}{\langle \boldsymbol{v}_n(+\eta)\boldsymbol{v}_n^{*}(\eta_{\mathrm{ref}})\rangle^k}$$
- For n=3 the scaling holds everywhere