>>> Quark matter 2018 impressions
>>> and photos

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>>> Content

1. Photos

2. Talks summary

3. Brief news

>>> Impressions

This edition of Quark Matter took place in an extraordinary location!

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Palazzo del Cinema and Palazzo del Casino Lido di Venezia, where Venice International Film Festival takes place there every year

>>> Impressions

Can you find LUHEP team members?

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Machine learning cluster recognition is needed!

>>> Impressions

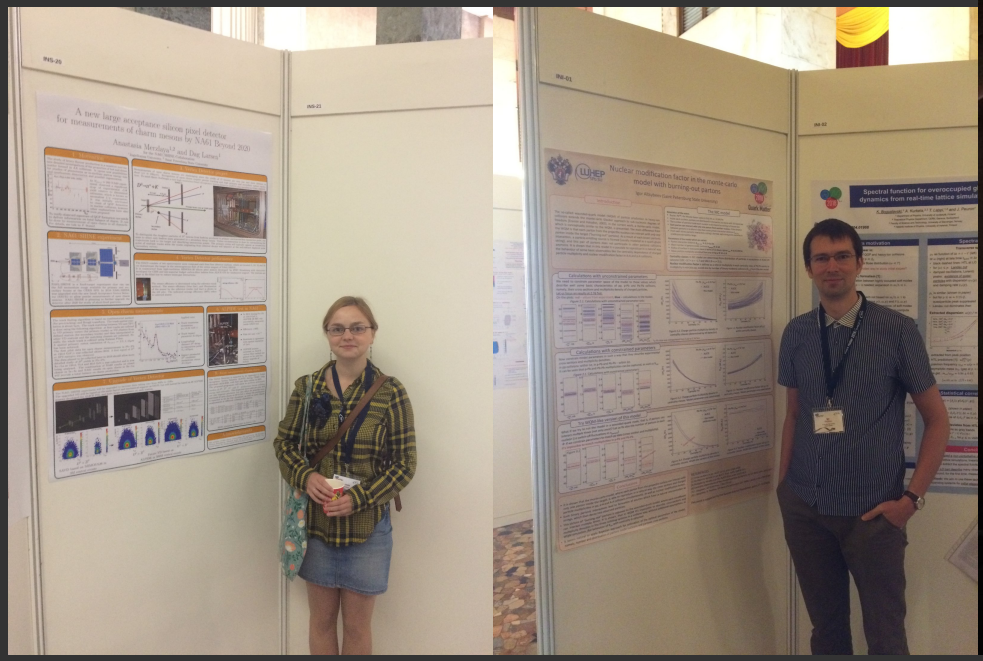
After application of magic machine learning techniques

>>> Impressions

After application of magic machine learning techniques

Absolutely unsupervised learning!

>>> Impressions



Significant contribution to the full program

280 talks, 400 posters in total

And hard work paid off

>>> Impressions



Significant contribution to the full conference program

280 talks, 400 posters in total!

And hard work paid off

>>> Spoiler alert!

No major breakthroughs and discoveries were claimed.
In this presentation we will discuss only topics and ideas that we liked and understood to some extent.

General Balance Function Measurement

$$B(\Delta y)=\frac{1}{2}\left[C_2^{+-}-C_2^{++}+C_2^{-+}-C_2^{--}\right]$$

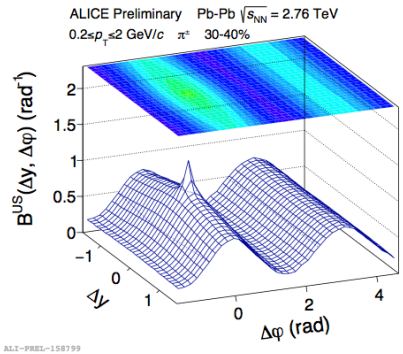
Bass, Danielewicz, Pratt PRL. 85, 2689 *(2000)*

$$C_2^{a,b}(\Delta y)=\frac{\langle N^{a,b}(\Delta y)\rangle}{\langle N^{a}(y_1)\rangle} \qquad a,b\in\{+,-\}$$

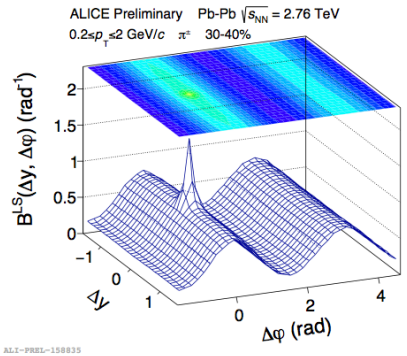
same for $\Delta\varphi$ and Δp_T

General charges:
- e: (±)electric charge
- S: (anti)strangeness
- B: (anti)baryon number

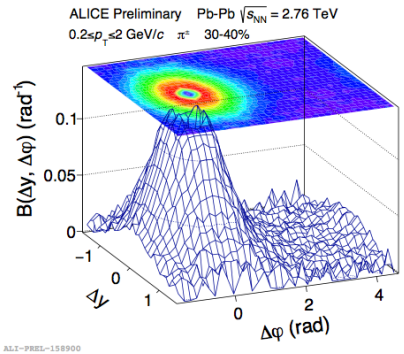
$$B^{US}(\Delta y)=\frac{1}{2}\left[C_2^{+-}+C_2^{-+}\right]$$



$$B^{LS}(\Delta y)=\frac{1}{2}\left[C_2^{++}+C_2^{--}\right]$$



$$B(\Delta y)=B^{US}(\Delta y)-B^{LS}(\Delta y)$$



✧ Remove charge independent effects

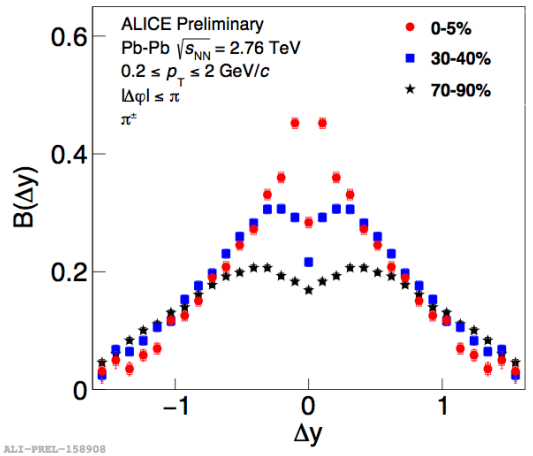
✧ Keep effects related to balancing pairs

Experiment Method 1: $R_2^{a,b}(\Delta y)=\frac{\langle N^{a,b}(\Delta y)\rangle}{\langle N^{a}(y_1)\rangle\langle N^{b}(y_2)\rangle}-1$ ⇒ $B(\Delta y)=\frac{1}{2}\frac{dN}{dy(N_{ev})}\left[R_2^{+-}-R_2^{++}+R_2^{-+}-R_2^{--}\right]$

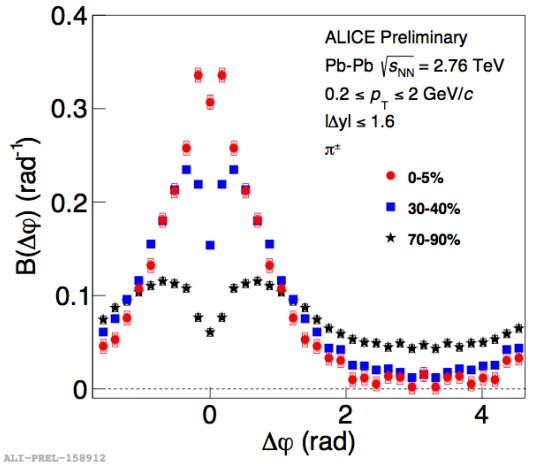
Experiment Method 2: Directly measure $B(\Delta y)=\frac{1}{2}\left[C_2^{+-}-C_2^{++}+C_2^{-+}-C_2^{--}\right]$

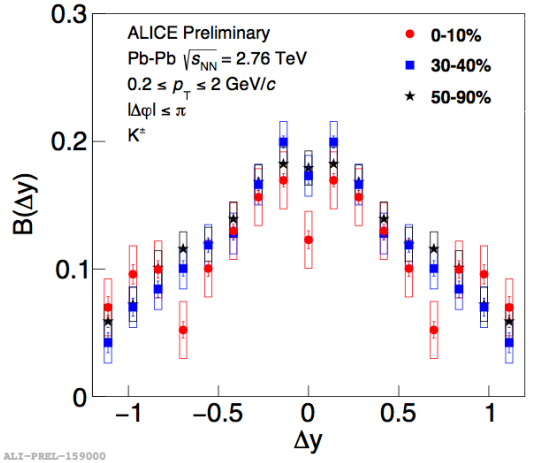
✧ mixed events technique
-> detector acceptance and inefficiency correction

Balance Function Projections (Pb-Pb @ 2.76 TeV)

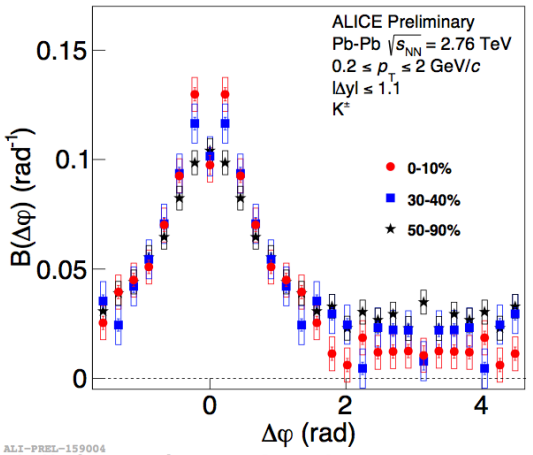


$\pi^{\pm}$





$K^{\pm}$



BF changes with centrality:

- $\pi^{\pm}$ shape & magnitude change
- $K^{\pm}$ no shape & magnitude change

Experimental flow observables

- Single particle distribution

Flow vector: $\boldsymbol{V}_n = v_n e^{in\Phi_n}$

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

$$= N(p_T,\eta)\left[\sum_{n=-\infty}^{\infty} \boldsymbol{V}_n(p_T,\eta)e^{in\phi}\right]$$

Radial flow

Anisotropic flow

- Two-particle correlation function

$$\left\langle \frac{dN_1}{d\phi d\eta dp_T}\frac{dN_2}{d\phi d\eta dp_T}\right\rangle \Rightarrow \left\langle \boldsymbol{V}_n(p_{T1},\eta_1)\boldsymbol{V}_n^*(p_{T2},\eta_2)\right\rangle$$

v_n from 2PC

- Multi-particle correlation function

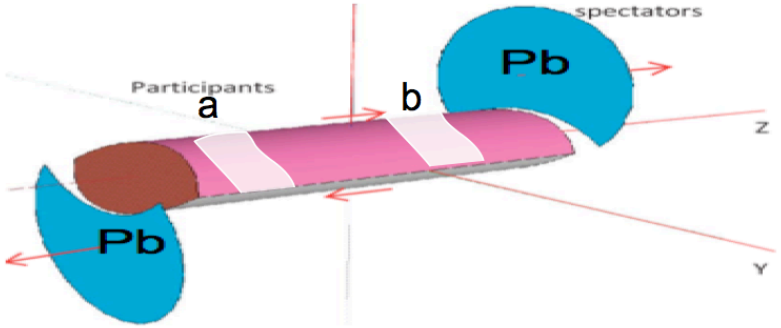
$$\left\langle \frac{dN_1}{d\phi d\eta dp_T}..\frac{dN_m}{d\phi d\eta dp_T}\right\rangle \Rightarrow \left\langle \boldsymbol{V}_{n_1}\boldsymbol{V}_{n_2}...\boldsymbol{V}_{n_m}\right\rangle \quad n_1+n_2+...+n_m=0$$

$$\downarrow$$

$$p(v_n, v_m, ..., \Phi_n, \Phi_m, ...) = \frac{1}{N_{\mathrm{evts}}}\frac{dN_{\mathrm{evts}}}{dv_n dv_m ... d\Phi_n d\Phi_m ...}$$

How to measure flow? $V_n = v_n e^{in\Phi_n}$

By particle correlations!



Determine flow vector in one subevent:

$$q_n = \frac{\Sigma_i e^{in\phi_i}}{\Sigma_i} = v_n e^{in\Phi_n} + \delta$$

Statistical noise

Noise uncorrelated between two subevents, average over events:

$$\left\langle q_n^a q_n^{b*} \right\rangle = \left\langle (v_n^a e^{in\Phi_n^a} + \delta^a)(v_n^b e^{-in\Phi_n^b} + \delta^{b*}) \right\rangle = \left\langle V_n^a V_n^{b*} \right\rangle$$

We often assume $p(v_n)$ independent of p_T and η, i.e. ignoring intra-event fluctuation $p(V_n) = f(p_T,\eta)p(\bar{v}_n)$

$$\left\langle V_n^a V_n^{b*} \right\rangle = f(p_T^a,\eta^a) f(p_T^b,\eta^b) \left\langle v_n^2 \right\rangle$$

Event-plane or scalar-product methods, e.g. measure flow in subevent **c** wrt symmetric subevents **a&b**:

$$f(p_T^a,\eta^a) = f(p_T^b,\eta^b)$$

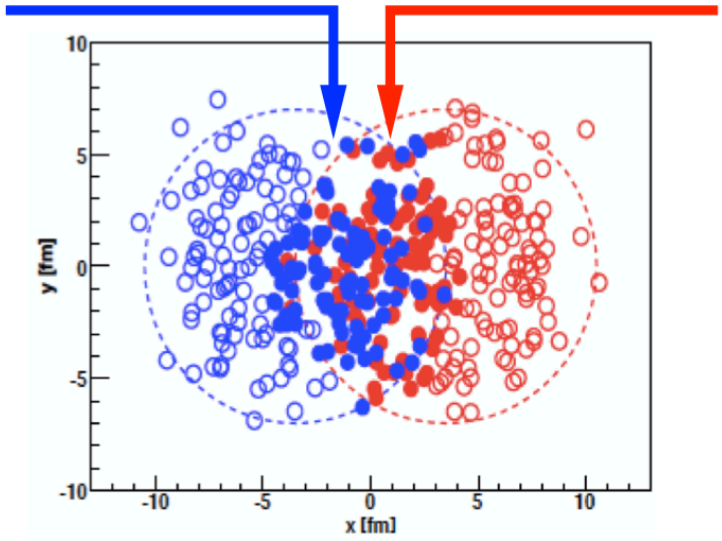
$$v_n^{meas} = \frac{\left\langle q_n^c q_n^{a*} \right\rangle}{\sqrt{\left\langle q_n^a q_n^{b*} \right\rangle}} = \frac{f(p_T^c,\eta^c)\cancel{f(p_T^a,\eta^a)}\left\langle \bar{v}_n^2 \right\rangle}{\sqrt{\cancel{f(p_T^a,\eta^a)}\cancel{f(p_T^b,\eta^b)}\left\langle \bar{v}_n^2 \right\rangle}} = f(p_T^c,\eta^c)\sqrt{\left\langle \bar{v}_n^2 \right\rangle} = \sqrt{\left\langle v_n^c v_n^c \right\rangle}$$

Lessons: 1) We often report RMS value of v_n, 2) relies on factorization assumption!

Flow fluctuation in longitudinal direction

Fluctuation of sources in two nuclei → fluctuation of transverse-shape

v_n^F, Ψ_n^F



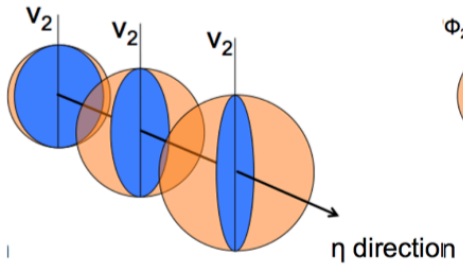
v_n^B, Ψ_n^B

Bozek et.al., arXiv:1011.3354

$$v_n = v_n e^{in\Psi_n}$$

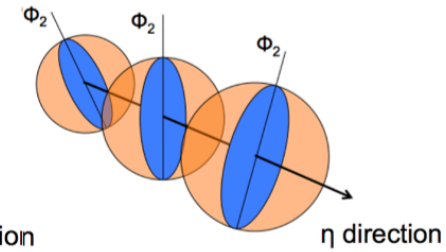
Consequences:

Asymmetry of a flow magnitude



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

Torque/twist of an event plane

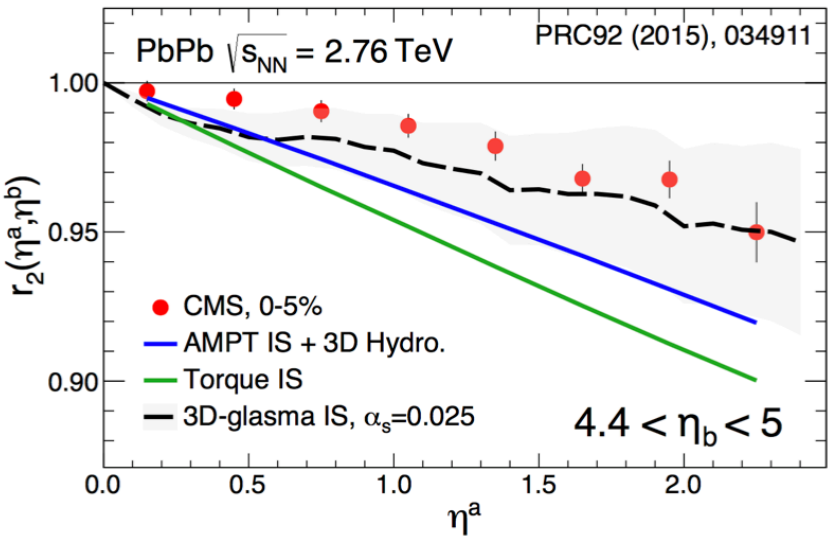


$\Psi_n(\eta_1) \neq \Psi_n(\eta_2)$

Flow fluctuation in longitudinal direction

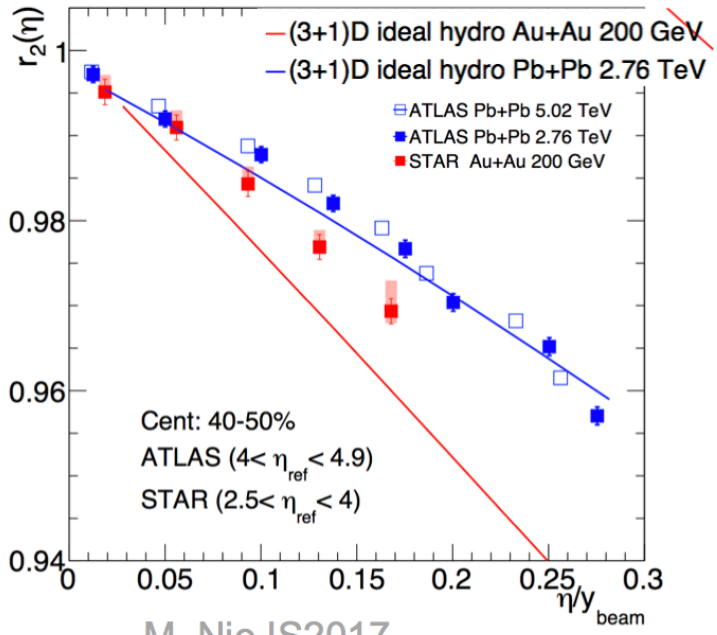
Observables: $$r_n^{\eta} = \frac{V_n(-\eta)V_n^*(\eta_{\rm ref})}{V_n(\eta)V_n^*(\eta_{\rm ref})} \sim \langle \cos n[\Phi_n(\eta) - \Phi_n(-\eta)] \rangle$$

Significant decorrelation, not described by any models



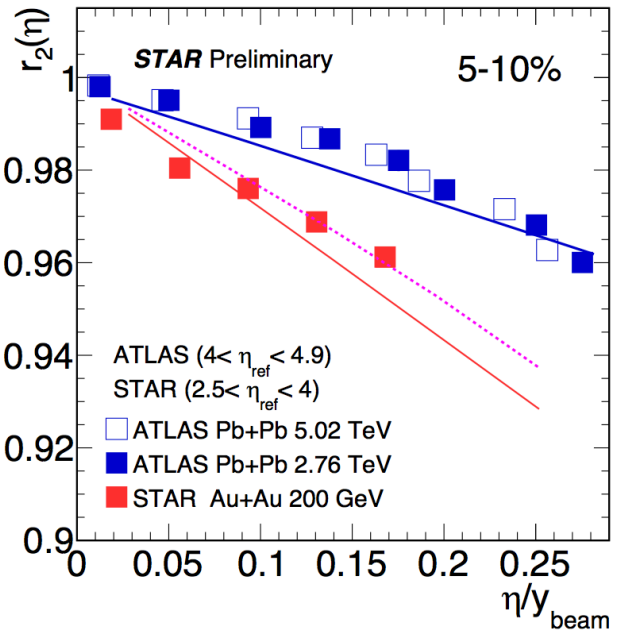
Wei Li QM2017

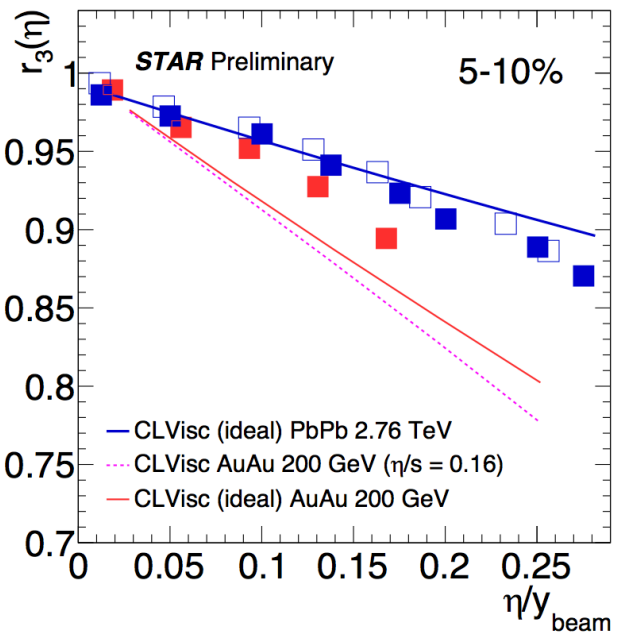
Can't be explained by beam-rapidity scaling, not described by hydro model



M. Nie IS2017

Longitudinal Flow Decorrelation in 200 GeV Au+Au Collisions





$$r_n(\eta) = \frac{\langle v_n(-\eta) v_n(\eta_{\rm ref}) \cos n(\Psi_n(-\eta) - \Psi_n(\eta_{\rm ref}))\rangle}{\langle v_n(\ \eta) v_n(\eta_{\rm ref}) \cos n(\Psi_n(\ \eta) - \Psi_n(\eta_{\rm ref}))\rangle}$$

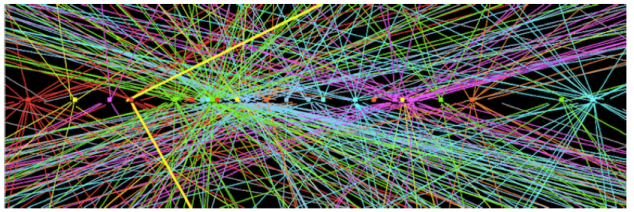
- Stronger longitudinal flow decorrelation at RHIC than at LHC
- Hydro calculations can not simultaneously describe LHC and RHIC data

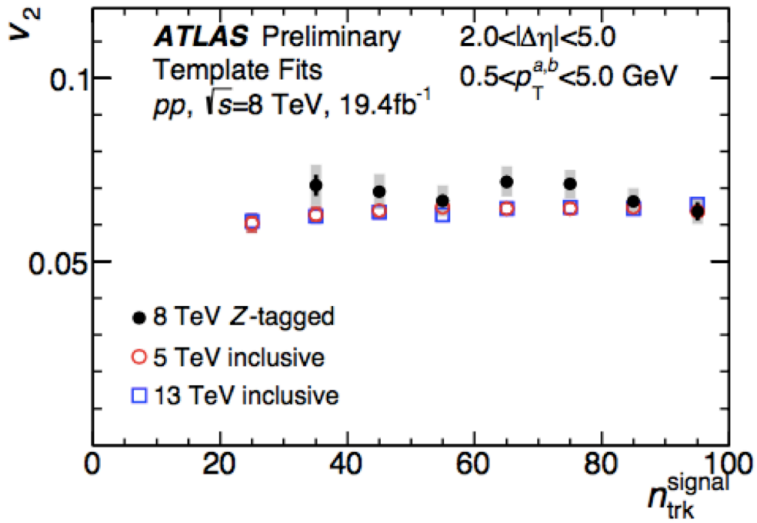
Maowu Nie
#332, May 15 19:10

RIDGE IN Z-TAGGED PP COLLISIONS

ATLAS-CONF-2017-068

- First attempt to control the impact parameter of pp by selecting a high-Q2 process
- 2PC for hadrons in events with Z bosons
- Analysis based on full 2012 pp data at 8 TeV with L=19.4 1/fb with 6.2M Z bosons
- Main challenge is high pileup: average μ is 20 (c.f. μ =1 in previous ATLAS ridge studies)
- **New technique** is **developed** to subtract the pileup contribution in 2PC (~20% correction)
- **v_2 is found to be 8±6% above that in the inclusive collisions at 13 TeV**

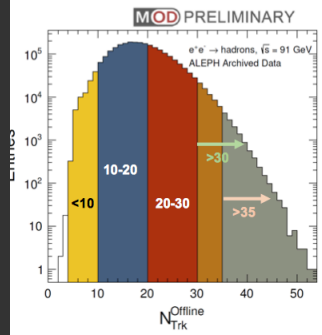




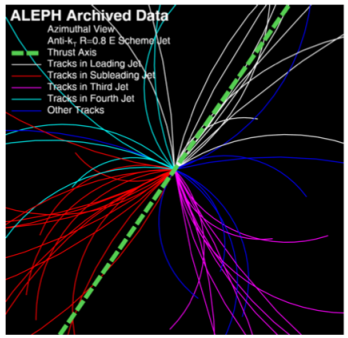
Talk by B.Cole on Tue 15:40
Poster by A.Milov

Switching off the flow: e⁺e⁻

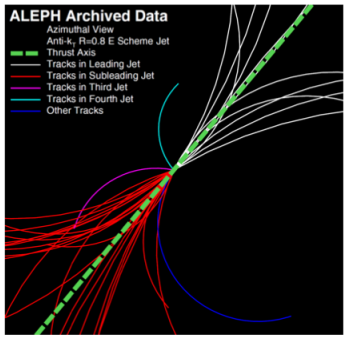
Talk: J-Y Lee



High-multiplicity events



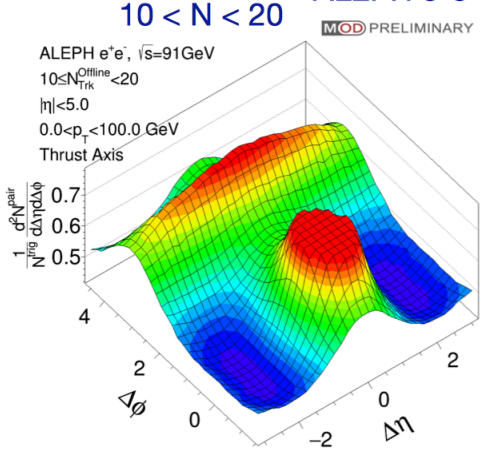
Low T; 'multi-jet'



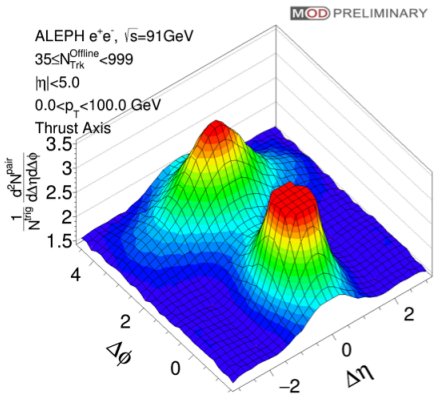
High T; 'di-jet'

ALEPH e⁺e⁻ thrust axis

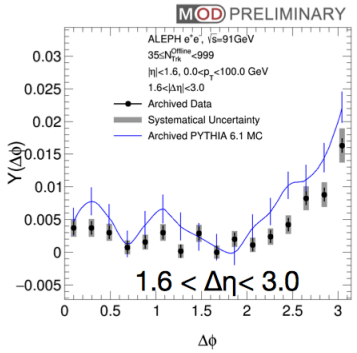
10 < N < 20



N ≥ 35



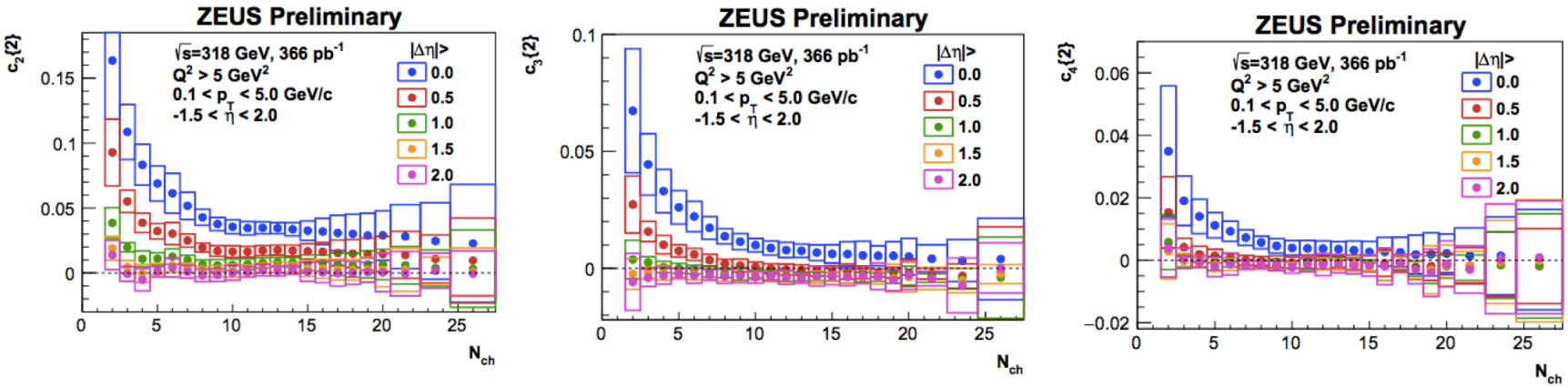
No evidence of long-range correlations beyond Pythia expectation



Cumulants from in e-p data from ZEUS

J Onderwaater

c_2 c_3 c_4



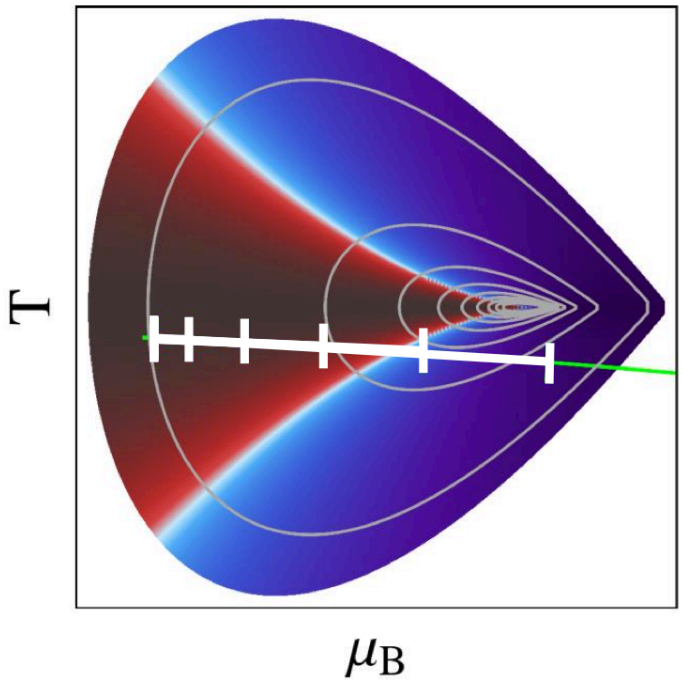
Familiar behaviour: non-flow dominates at small multiplicity and without eta-gap

No flow-like signal seen in high-multiplicity, large eta gap for c_2, c_3, c_4

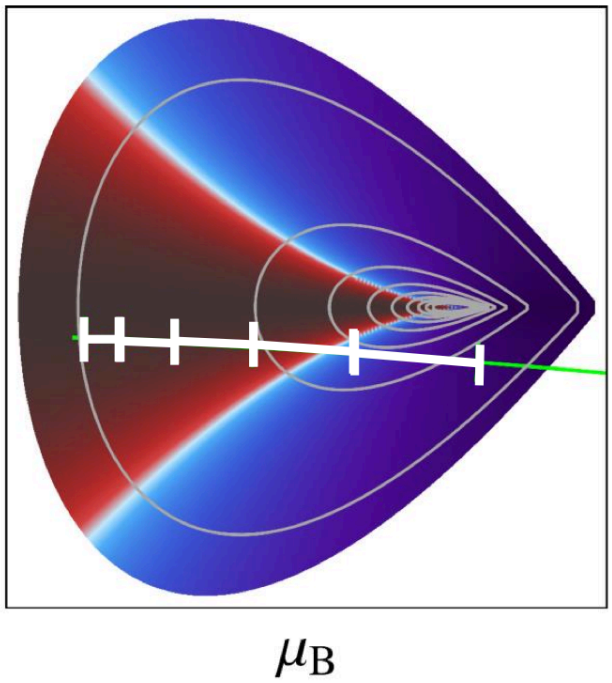
No flow with 'single string' ⇒ Need multiple interactions to set up initial geometry

There are several different ways to look at the rapidity dependence

Total rapidity acceptance



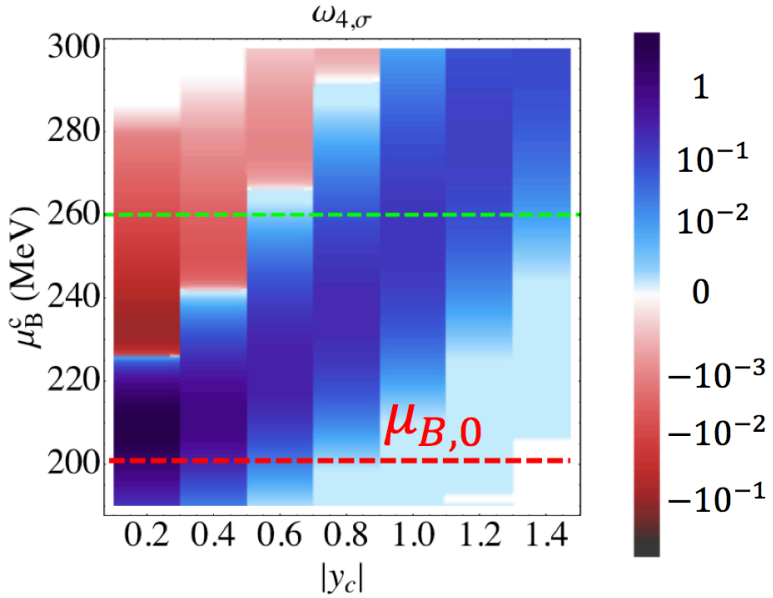
Binning in rapidity



More crisp picture of the critical region

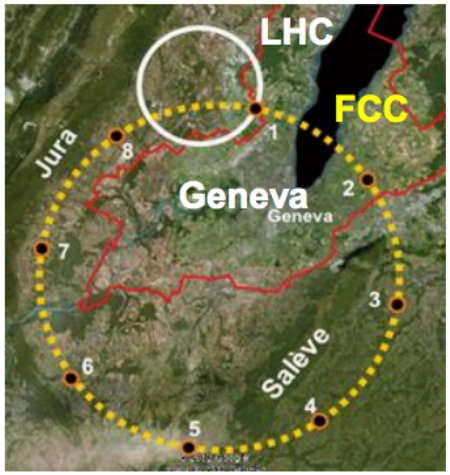
ne Brewer (MIT)

Whether cumulants binned in rapidity increase or decrease as a function of rapidity **switches** when a critical point is passed



Independent test of critical behavior from $\sqrt{s}$-dependence of cumulants

Future Collider Projects (2040-50)



- 100 km circumference
  - $\sqrt{s_{NN}}$ = 39 TeV (Pb-Pb) | 63 TeV (p-Pb) | 100 TeV (pp)

Pb-Pb		
	$dN_{ch}/d\eta$	3600
	V	11000 fm^3
	ε (τ = 1 fm/c)	35-40 GeV/fm^3

- Future Circular Collider @ CERN
  - 35-110 nb^{-1} per month (12-40x LHC)
  - Conceptual Design Report by fall 2018
  - Further reading: Physics case | FCC week
- SPPC in China
  - Combined with e^+e^- machine
  - Funding for R&D available
  - Further reading: Physics case | Pre CDR

Manqi Ruan, Hard Probes 2016

>>> Brief news

1. PYTHIA is now available for heavy ions - Angantyr

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2. SMASH event generator (Frankfurt group; hadronic transport) results are in a reasonable agreement with the NA61 data on p+p collisions

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1. PYTHIA is now available for heavy ions - Angantyr
2. SMASH event generator (Frankfurt group; hadronic transport) results are in a reasonable agreement with the NA61 data on p+p collisions
3. Azimuthal anisotropy and flow coefficients for p+Pb can be successfully described without hydro by slightly non-standard kinetic theory (but initial (sub-nucleonic) conditions are important)
4. CEP (from the Black Hole model (holography approach) fitted to selected lattice results) is located at $\mu_B = 724$ MeV, $T = 89$ MeV - NICA energies


Fin