Anisotropic flow

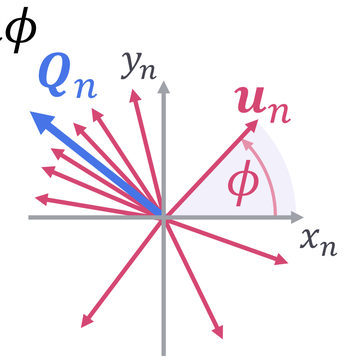
Fourier decomposition of the particle-production density

$$\rho(\phi - \Psi) \propto \frac{1}{2\pi}\left[1 + 2\sum_{n=1}^{\infty} v_n \cos n(\phi - \Psi)\right]$$

Single particle and flow vector formalism

$$u_n \equiv x_n + i\, y_n = \cos n\phi + i \sin n\phi$$

$$Q_n \equiv \sum_i w_i u_{n,i}$$



$$\langle u_n \rangle \equiv \int_0^{2\pi} \frac{1}{2\pi} d\phi\, u_n\, \rho(\phi - \Psi)$$

$$\langle u_n \rangle = v_n[\cos n\Psi + i \sin n\Psi]$$

$$\langle Q_n \rangle = V_n[\cos n\Psi + i \sin n\Psi] \quad \Psi \text{ cannot be measured}$$

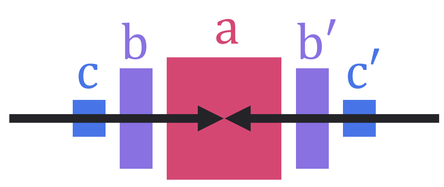
Correlation and flow observables

v_n observables made of u and Q-vector correlations

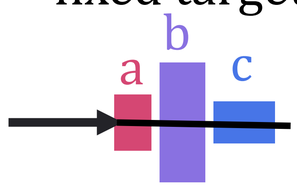
Using various detectors and kinematic ranges

$$\left\langle \left\langle u_n^a(p_T,\eta) \ldots u_m^c Q_k^\alpha \ldots Q_l^\gamma \right\rangle \right\rangle = \int_0^{2\pi} \frac{d\Psi}{2\pi} \langle u_n^a \rangle \ldots \langle u_n^c \rangle \langle Q_n^\alpha \rangle \ldots \langle Q_n^\gamma \rangle$$

collider



fixed target



Experimental setups have different phase-space coverage

Goal: develop a unified formalism for all experiments

A framework for multidimensional acceptance correction and anisotropic flow analysis

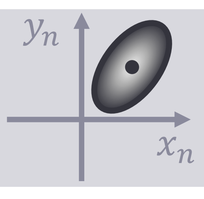
Lukas Kreis [a,b]
Victor Gonzalez [a,c]
Ilya Selyuzhenkov [a,d]

[a]GSI, [b]Universität Heidelberg, [c]CIEMAT, [d]MEPhI

Correction steps of non-uniform acceptance effects[1]

Bias in the single particle / flow vector (n = m)

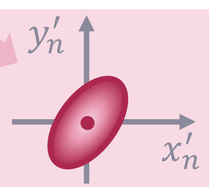
recenter



$$\langle x_n \rangle = \overline{c_n} + v_n a_{2n}^{+}[\cos n\Psi + \lambda_{2n}^{s+} \sin n\Psi]$$

$$\langle y_n \rangle = \overline{s_n} + v_n a_{2n}^{-}[\sin n\Psi + \lambda_{2n}^{s-} \cos n\Psi]$$

twist



$$\langle x_n' \rangle = v_n a_{2n}^{+}[\cos n\Psi + \lambda_{2n}^{s+} \sin n\Psi]$$

$$\langle y_n' \rangle = v_n a_{2n}^{-}[\sin n\Psi + \lambda_{2n}^{s-} \cos n\Psi]$$

rescale

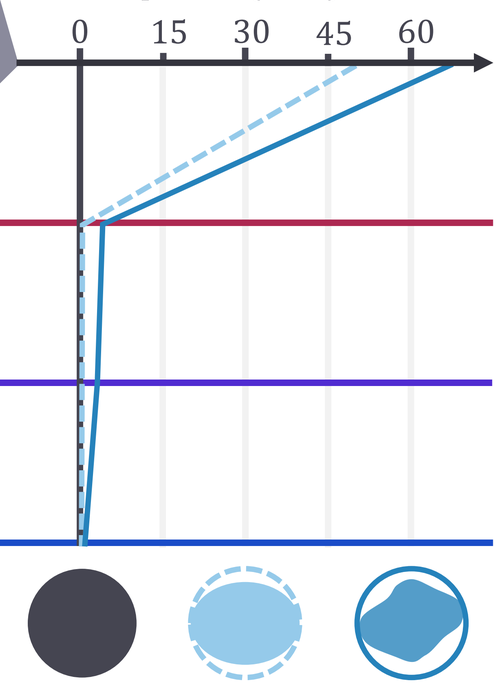
$$\langle x_n'' \rangle = v_n a_{2n}^{+} \cos n\Psi$$

$$\langle y_n'' \rangle = v_n a_{2n}^{-} \sin n\Psi$$

$$\langle x_n''' \rangle = v_n \cos n\Psi$$

$$\langle y_n''' \rangle = v_n \sin n\Psi$$

Toy MC simulation



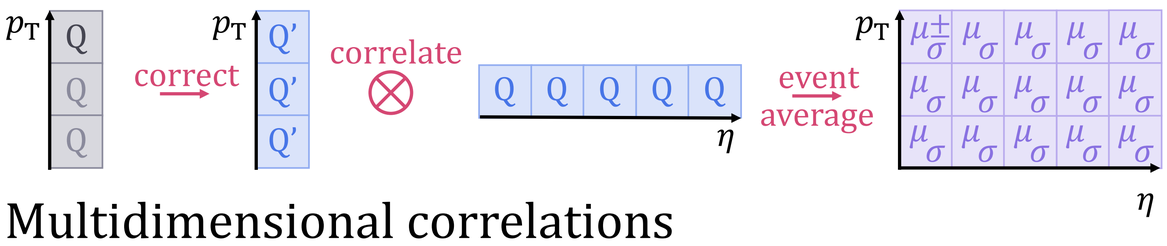
Framework features

Iterative correction procedure

Data-driven correction extraction

Experiment-independent formalisms

Configurable multidimensional corrections for each detector subsystem or kinematic window of a particle



Multidimensional correlations

Easily extendable with new observables

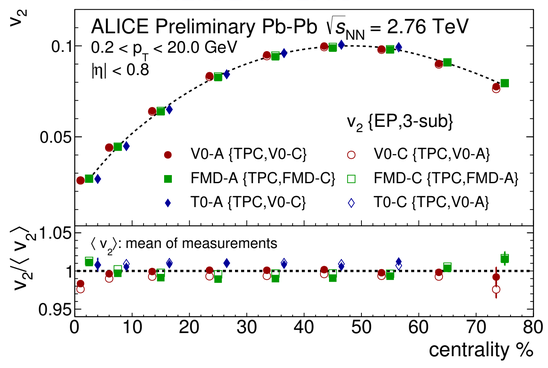
Native bootstrapping uncertainty calculated

Uses ROOT `RDataFrame` for a high level interface

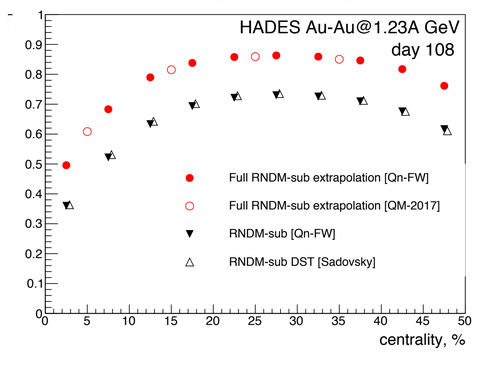
Application in experiments

Already used in collider and fixed-target experiments

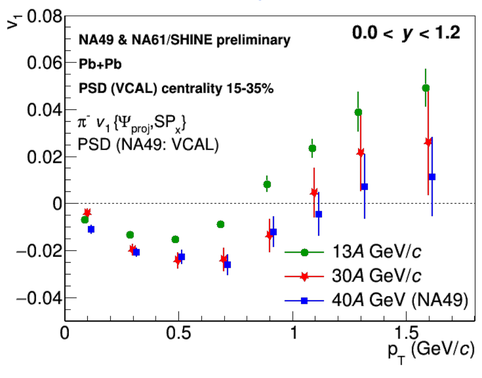
ALICE at LHC[4]



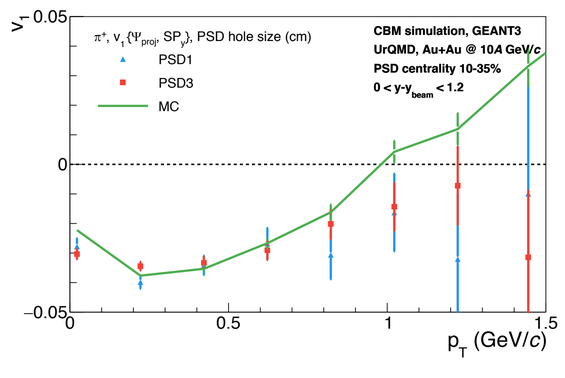
HADES at SIS18[5]



NA49 & NA61/SHINE at SPS[2,3]



CBM at SIS100[6]



References [1] Selyuzhenkov I., Voloshin S. *Phys.Rev. C* 77, 034904 (2008)
[2] NA61/SHINE *Nucl.Phys.* A982, 439-442 (2019)
[3] NA49 *EPJ Web Conf.* 204, 06011 (2019)
[4] ALICE *J.Phys.Conf.Ser.* 612 no.1, 012044 (2015)
[5] HADES Collaboration meeting (Feb. 2018)
[6] CBM *KnE Energ.Phys.* 3, 416-421 (2018)

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

GSI