Introduction

- We investigate anisotropic flow for a 2D system of massless particles, within the approach of C. Gombeaud and J.-Y. Ollitrault [1].
- For controlled initial geometries, we study the change in $v_2$, $v_3$, $v_4$ as the Knudsen number $Kn$ is varied.
- Using a MC Glauber model as input for the initial condition, we show how the resulting fluctuations in $v_2$ and $v_3$ depend on the mean number of rescatterings in the system.

Dependence of anisotropic flow on Kn for controlled initial conditions

- The spatial part of our initial-state distribution function:
  
  $f(r, \theta) = \frac{1}{2\pi}e^{-\frac{r^2}{2\sigma^2}} \left[ 1 - 4xe^{-\frac{r^2}{2\sigma^2}} \left( \frac{r}{\sigma} \right)^2 \cos(2\theta) - \sqrt{\pi}xe^{-\frac{r^2}{2\sigma^2}} \left( \frac{r}{\sigma} \right)^2 \cos(3\theta) - \frac{1}{2}xe^{-\frac{r^2}{2\sigma^2}} \left( \frac{r}{\sigma} \right)^4 \cos(4\theta) \right]$.

- We performed calculations at different $Kn$ with only one $\varepsilon_n = 0.15$ and the other $\varepsilon_{pp,n} = 0$. To reduce statistical fluctuations of $v_n$, about 0 in the initial state, we averaged over 500 runs with $2.5 \cdot 10^5$ particles for each (initial) geometry.
- Every anisotropic flow harmonic behaves as $v_n = \frac{\rho_0 v_n}{n^\beta}$, as anticipated in [2] and observed in [1] for $v_2$.
- At fixed $Kn$, higher harmonics are more suppressed.
- As $n$ grows, $v_n$ sets on at increasingly larger number of rescatterings (smaller $Kn$).

Setup for MC initial condition

- Input: TGLauberMC [3] (Pb-Pb, $\sqrt{s_{NN}} = 5.02$ TeV) $\rightarrow N_{\text{coll}}(x, y), N_{\text{part}}(x, y)$
- Energy density: $e(x, y)$
  
  $- N(x, y) = (1 - \xi)N_{\text{part}} + \xi N_{\text{coll}}$ with $\xi \approx 0.15$.
  
  - Smear the energy density as a Gaussian with width $R_N = \frac{1}{2} \sqrt{\frac{2\xi}{\pi}}$.
- For the partonization we convert $e(x, y)$ to $n(x, y)$ with the equations for an ideal gas in 2D. We checked the energy conservation in the process.
- Momentum isotropy, i.e. $v_0 = 0$.
- We compute 10 runs over one initial condition with $5 \cdot 10^5$ particles each to reduce statistical errors.

Fluctuation characterization

- Fluctuations in the eccentricity probability distribution can be characterized by the elliptic-power law [4]:
  
  $p(\varepsilon_n) = \frac{2\varepsilon_n}{\pi} \left( 1 - \varepsilon_n^2 \right)^{n-1} \left( 1 - \varepsilon_n^2 \right)^{n+1} \int_0^\pi d\phi (1 - \varepsilon_n \cos \phi)^{-2n-1}$.

  - For vanishing mean anisotropy $\varepsilon_0$ in the reaction plane:
    
    $p(\varepsilon_0) = 2\varepsilon_0 \left( 1 - \varepsilon_0^2 \right)^{-1}$.

  - The relation between $\varepsilon_n$ and $v_n$ (for $n = 2, 3$) is: $v_n \approx \varepsilon_n \varepsilon_0$.

Fig. 2: Distribution of $e_2$ and $v_2$ (left) and the distribution of $e_3$ and $v_3$ (right) for $Kn = 0.29$.

- The anisotropic flow distribution reads:
  
  $p(v_n) = \frac{1}{v_n} \rho_0 p \left( \frac{v_n}{v_n} \right)$.

Propagation of fluctuations

- The integral form of the power law is better suited for the distributions with non vanishing mean anisotropy.

Fig. 3: Fitted distributions of $v_2$ (top row) and $v_3$ (bottom row) for $(Kn) = 0.29$ (left column) and $(Kn) = 0.07$ (right column).

- We find that for $e_2$ and $e_3$ the fluctuations in the distributions are washed out during the time evolution, resulting in larger values of $\alpha$ for the $v_n$ distributions.

- The value of $\alpha$ decreases and that of $v_n$ increases with growing number of rescatterings. The computation with the largest $Kn$, approaching the free-streaming limit, yields a peaked $p(v_n)$, for which the value of $\alpha$ is limited by numerical fluctuations in the initial momentum distribution.

<table>
<thead>
<tr>
<th>$Kn$</th>
<th>$v_2$ (top row)</th>
<th>$v_3$ (bottom row)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.29</td>
<td>$2\times e_2 &gt; 0.91$</td>
<td>$3\times e_2 &gt; 0.91$</td>
</tr>
<tr>
<td>0.07</td>
<td>$2\times e_2 &gt; 0.95$</td>
<td>$3\times e_2 &gt; 0.95$</td>
</tr>
</tbody>
</table>

Tab. 1: Fit values for the $e_2$ and $v_2$ distributions for collisions at $b = 6$ fm. Cells with a * indicate fits with the distribution function where $v_0 = 0$.

Outlook

Further transport calculations with smaller $Kn$ are needed to see if the value of $\alpha$ decreases further and finally approaches the $\alpha$ value of the initial state eccentricity distribution.

The calculation will also be performed for different impact parameters.

References