Non-equilibrium Hadronisation and Event-by-Event Fluctuations of Rapidity Distributions

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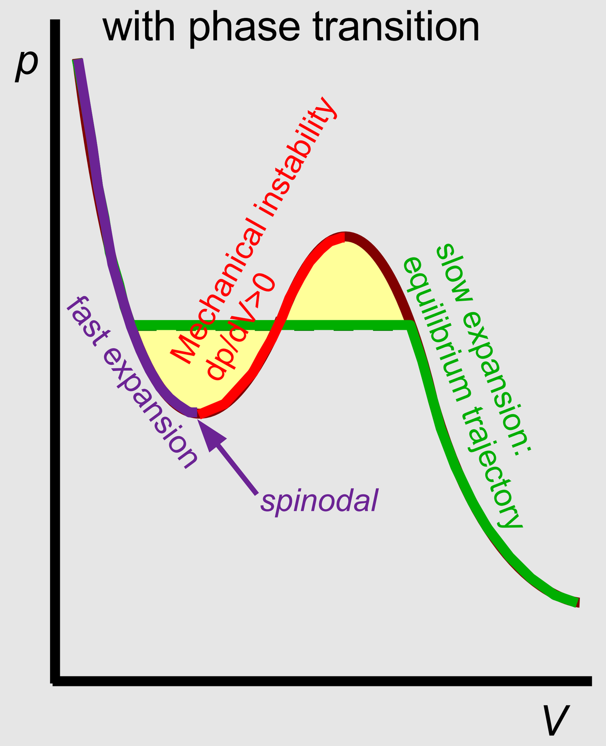
Rapid passage through first order phase transition => spinodal decomposition

fast enough expansion:
expansion rate > nucleation rate

This **is** typicaly realised in ultrarelativistic nuclear collisions

Typical size of fragments:
- from fastest growing modes [1]
- from energy considerations [2]

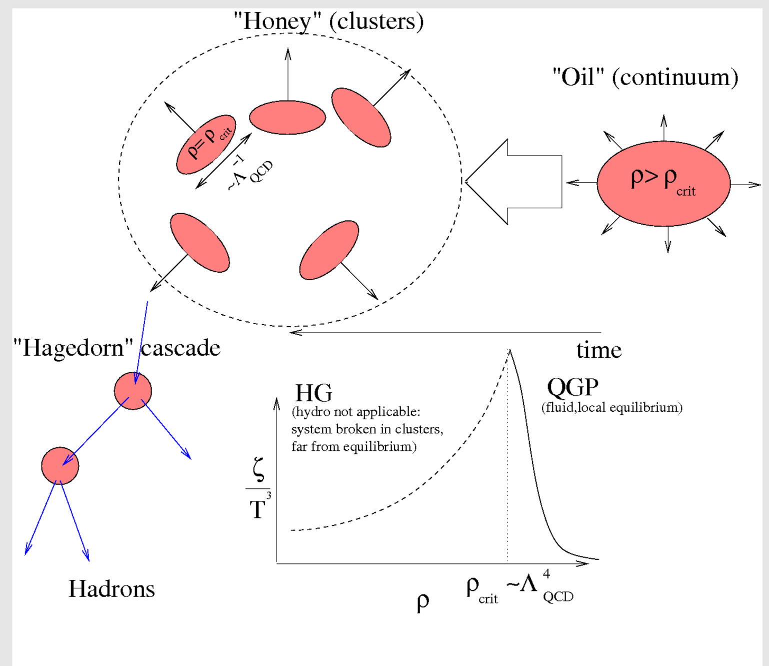
Example:
Van der Waals isotherm with phase transition



Fragmentation in case of smooth but rapid crossover => poster by Giorgio Torrieri [3]

Sudden rise of **bulk** viscosity at critical temperature [4,5]

1. (s)QGP expands easily
2. Bulk viscosity singular at critical temperature
3. System becomes rigid
4. Inertia may win and fireball will fragment
5. Fragments evaporate hadrons



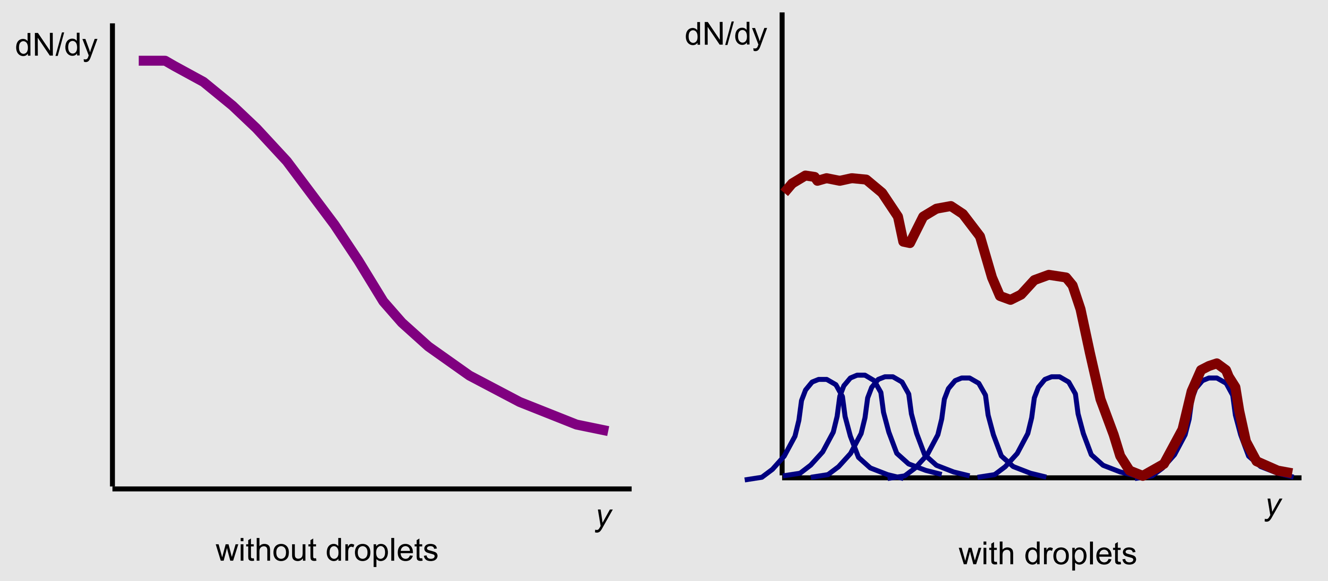
Fragmentation is likely mechanism of hadronisation in the collision

Fragments would influence:

- **Proton-proton (h-h) rapidity correlations [6,7]**
- **$\langle p_t \rangle$ fluctuations [8]**
- **Multiplicity fluctuations**
- **HBT radii (HBT puzzle) [3]**
- **Shape of correlation function**
- **Eventwise rapidity distributions**
- **...**

Droplets and rapidity distributions

rapidity distribution in single event



In case of fragmetnation each event will look differently

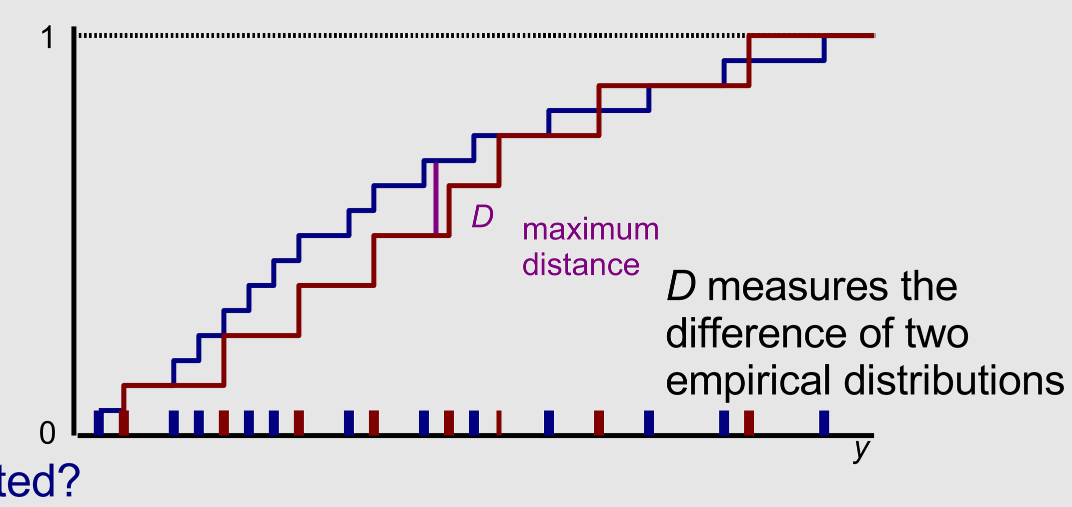
QuaG: MC generator of particles emitted from droplets

Used in generating the results shown here

- some particles are emitted from droplets (clusters)
- resonance decays included
- droplets are generated from a blast-wave source (tunable parameters)
- droplets decay exponentially in time (tunable time, T)
- tunable size of droplets: Gamma-distributed or fixed
- no overlap of droplets
- also directly emitted particles (tunable amount)
- chemical composition: equilibrium with tunable parameters
- rapidity distribution: uniform or Gaussian
- possible OSCAR output

The measure of difference between two rapidity distributions => Kolmogorov-Smirnov test

Are two empirical distributions (rapidities measured in two events) generated from **the same** underlying distribution (rapidity distribution)?



How are the D's distributed?

If we have two sets of data generated from the same underlying distribution, then D's are distributed according to

$$\lim_{n_1,n_2\to\infty} P(\sqrt{n}D < t) = \sum_{k=-\infty}^{\infty} (-1)^k \exp\left(-2k^2t^2\right) \quad \text{with} \quad n = \frac{n_1 n_2}{n_1+n_2}$$

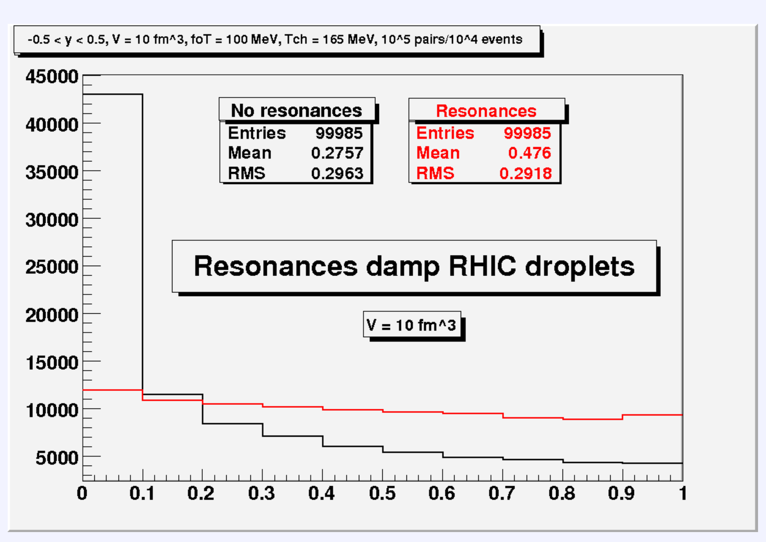
This is independent from the underlying distribution!

For each $t{=}D$ we can calculate

$$Q(\sqrt{n}D) = 1 - \sum_{k=-\infty}^{\infty} (-1)^k \exp\left(-2k^2\, n\, D^2\right)$$

For events generated from the same distribution, Q's will be distributed **uniformly**.

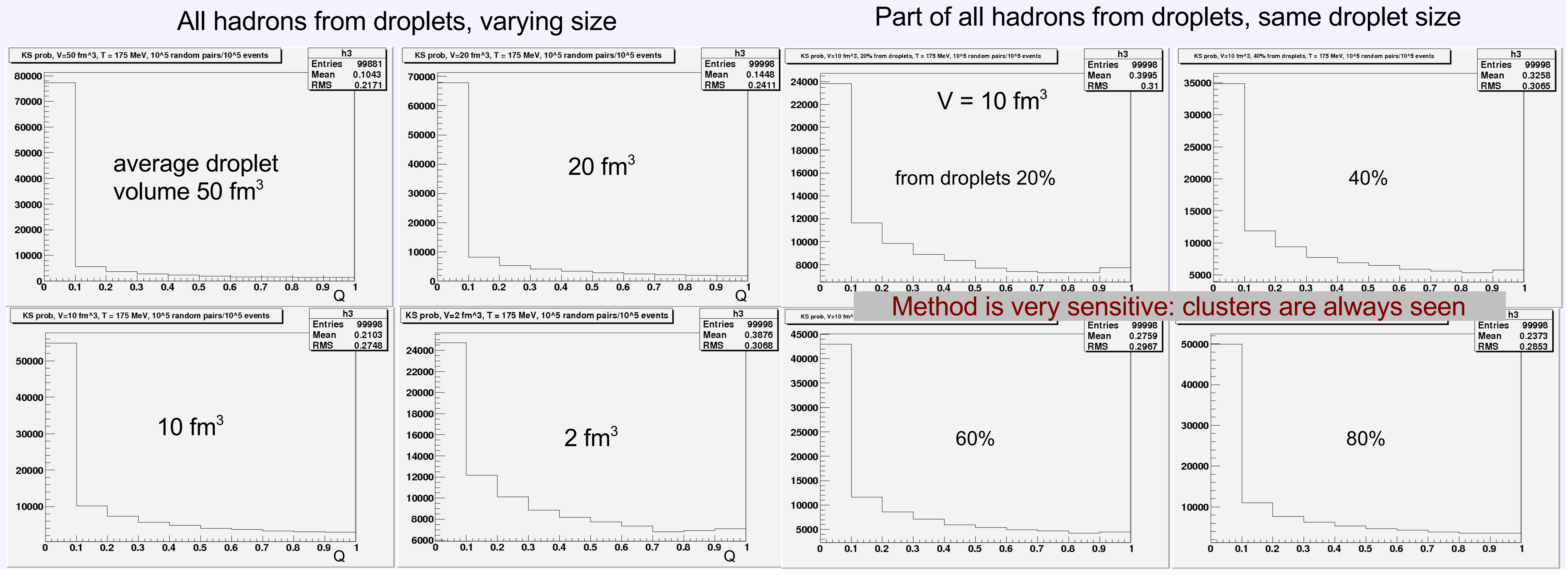
Results for RHIC, resonances included



Results for SPS, no resonances

All hadrons from droplets, varying size

Part of all hadrons from droplets, same droplet size



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