Centrality determination in NA49 experiment for Au-Au collision system at 40A GeV

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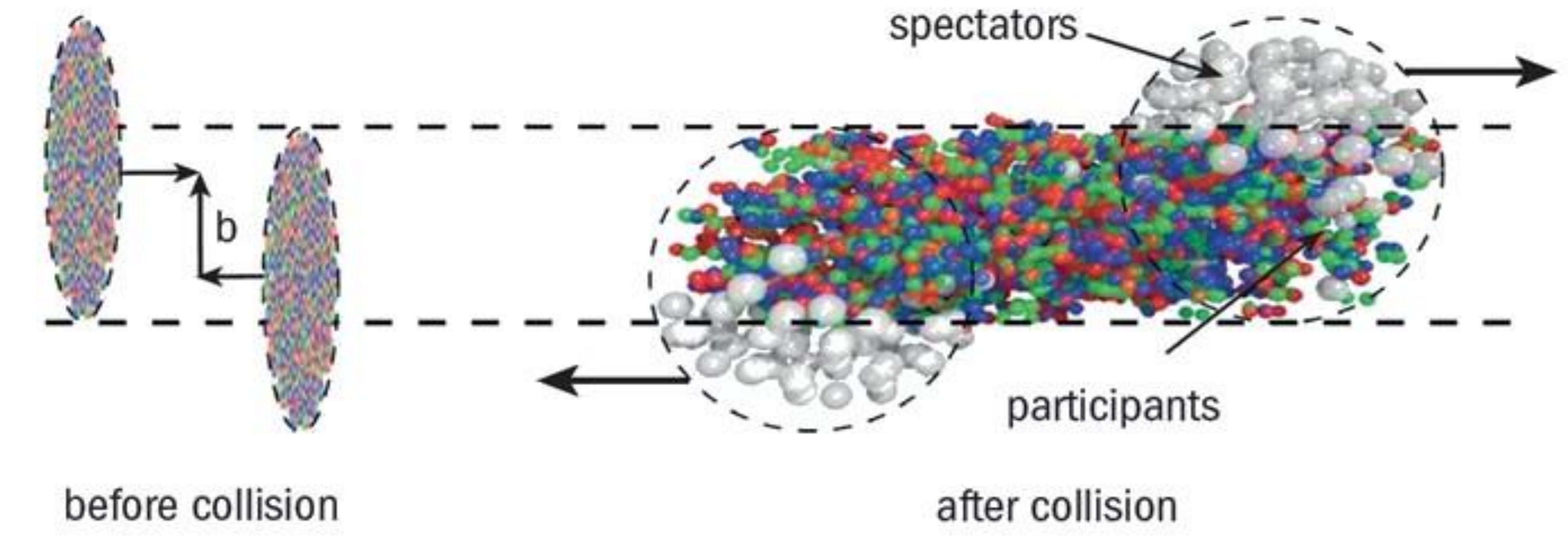
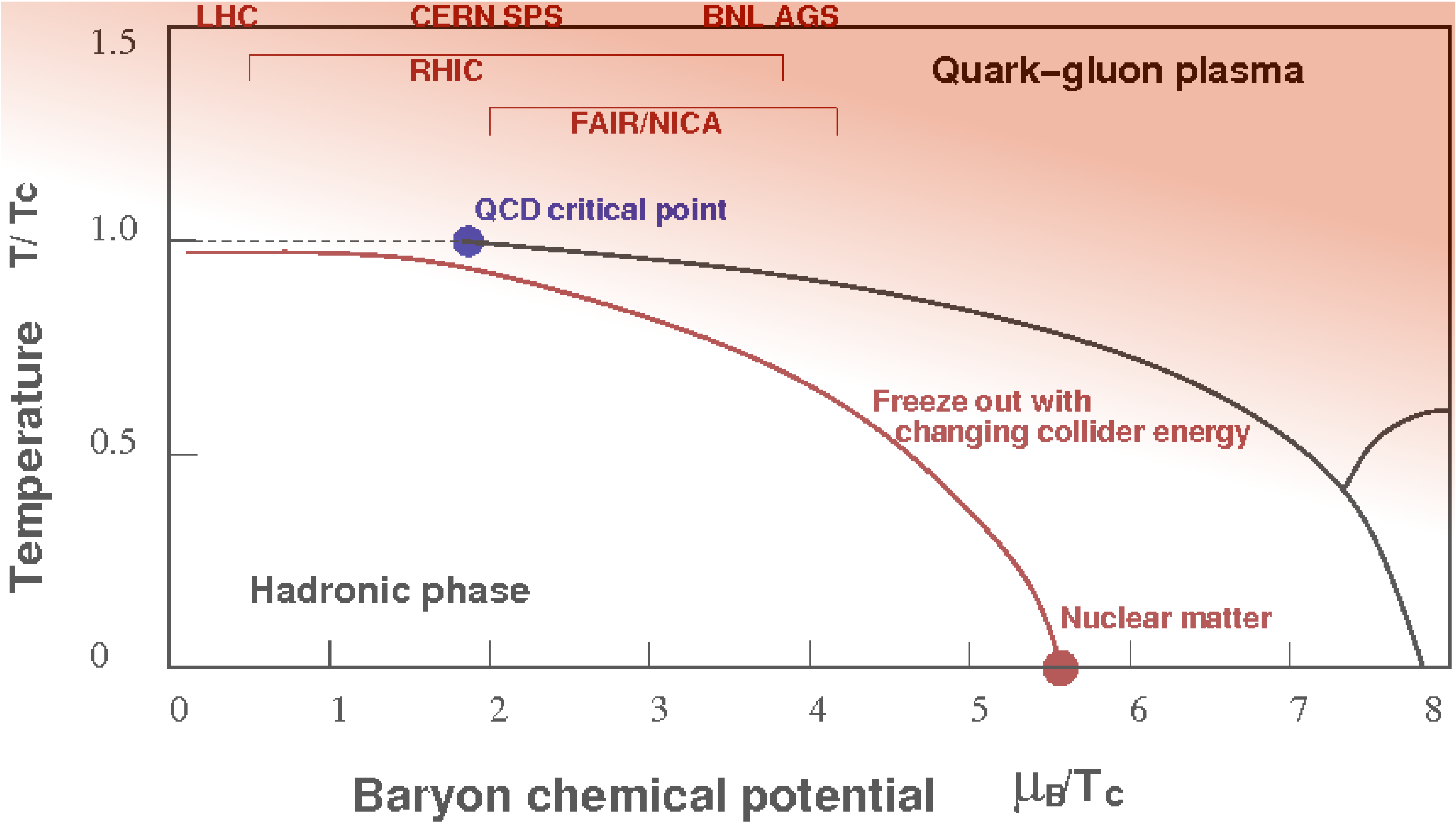
Collision geometry

- Participants in the collision (N_{part})
- Spectators (N_{spec})
- Impact parameter (b)



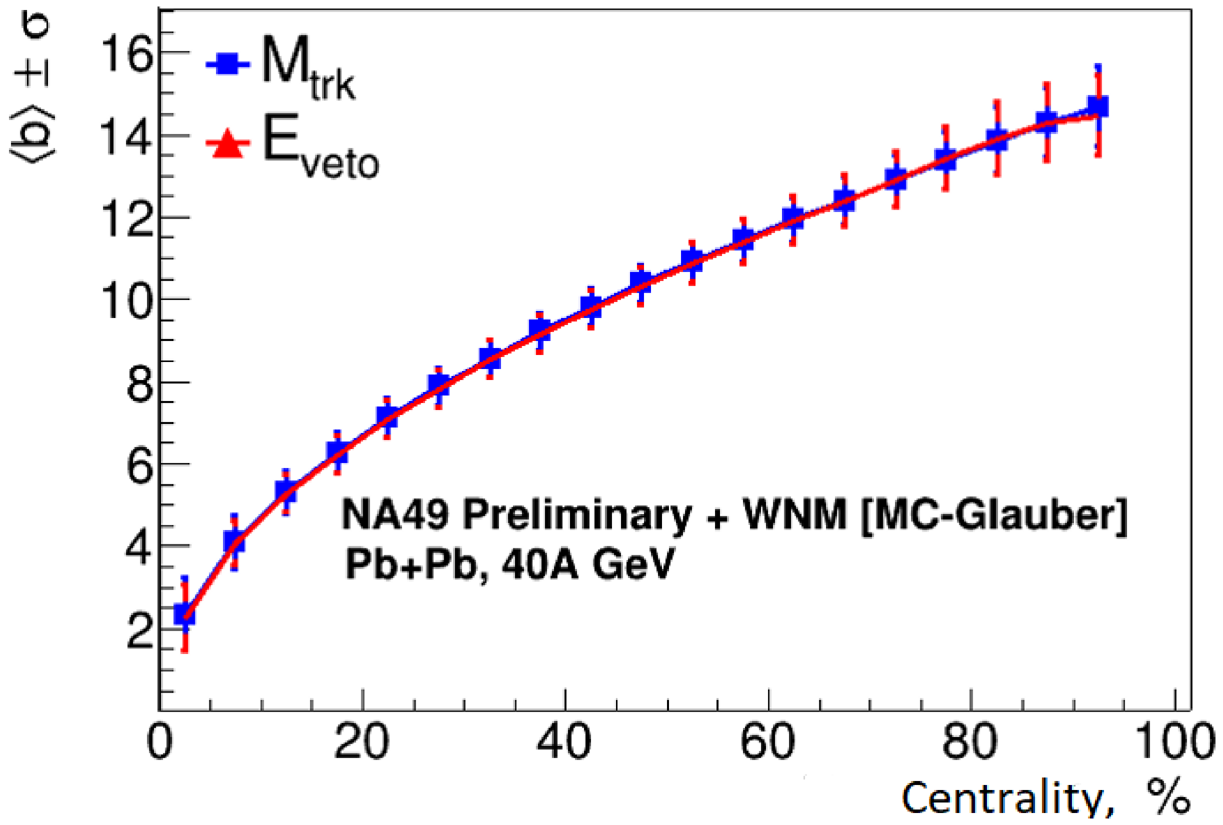
Compressed Baryonic Matter (CBM) research program



Exploring the QCD phase diagram with heavy-ion collisions.

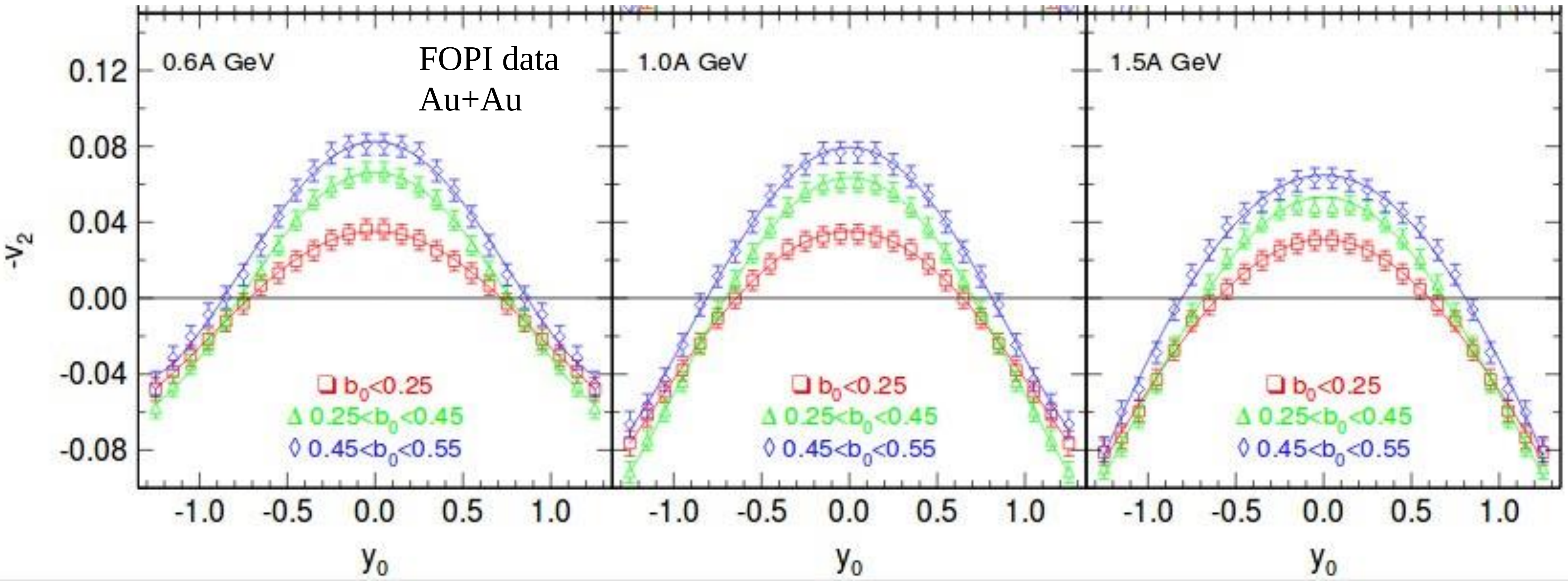
Centrality of the collision

- The most central class corresponds to highest multiplicity of produced particles (smallest spectators energy) and small values of the impact parameter.



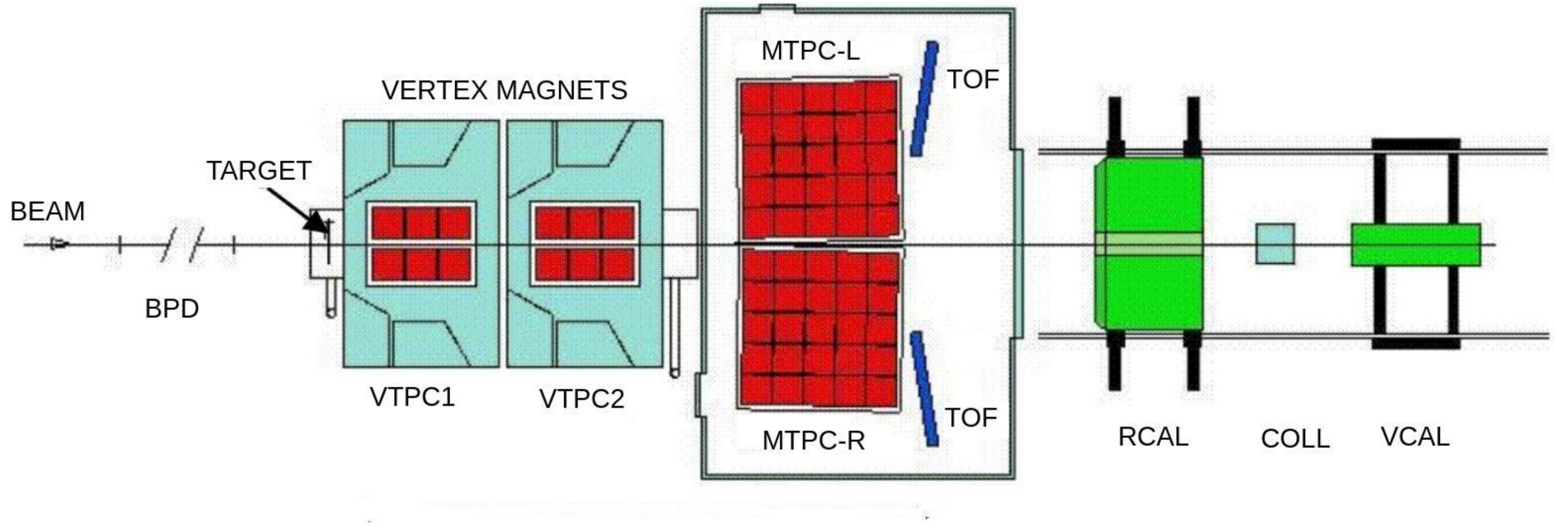
- Directly related to the initial overlap region of the colliding nuclei.

Dependence of collective flow effects on centrality



- The elliptic flow (n = 2) strongly depends on centrality.
- Centrality determination allows to provide data-model and data-data from different experiments comparison.

Centrality determination in the NA49



Veto-calorimeter (VCAL) measures the energy of spectators.
Time-projection chambers (TPC) measure the multiplicity of produced particles.

VCAL and TPC are used for centrality determination.

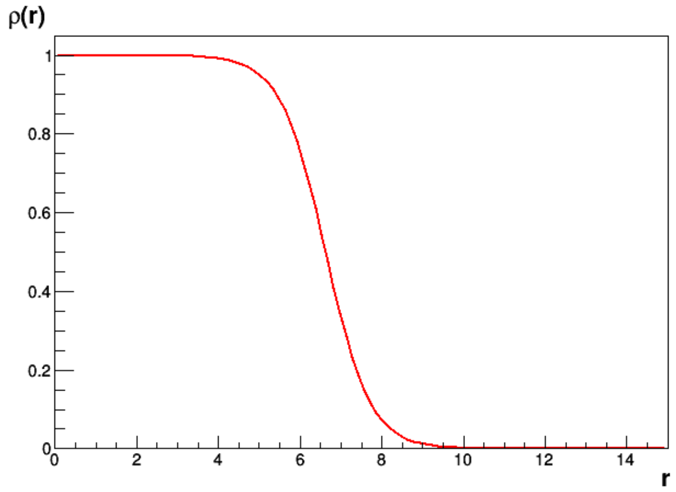
Glauber Model

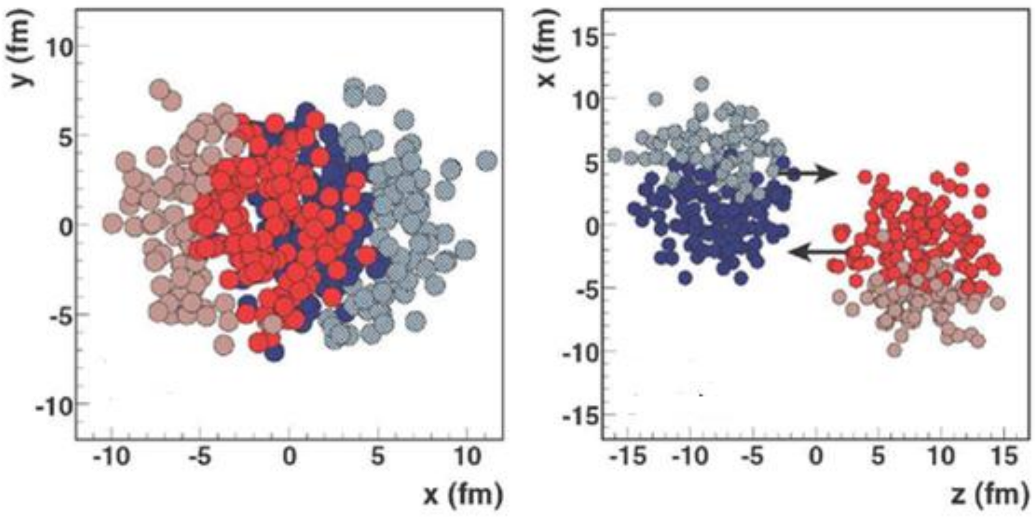
The goal: to associate with the classes of centrality the range of model parameters

Input values:

The density of the nuclear charge (ρ (r))

Cross section of inelastic nucleon-nucleon interactions





Output values:

- The number of participants- N_{part}
- The number of nucleon-nucleon collisions- N_{coll}
- Eccentricity - ϵ_n

MC-Glauber fit

Fitting data with Glauber Model based function.

$\mathbf{N_{ancestors}}$ -independently emitting sources of particles

P(μ,σ) - negative binomial distribution (NBD), gives the probability of measuring n hits per ancestor.

Fit function:

$$\frac{dN_{ev}}{dM_{trk}}(f_M, \mu, \sigma) = P(\mu, \sigma) \cdot N_a = P(\mu, \sigma) \cdot [f_M N_{part} + (1 - f_M) N_{coll}]$$

$$\frac{dN_{ev}}{dE_{spec}}(f_E, \mu, \sigma) = P(\mu, \sigma) \cdot N_a = P(\mu, \sigma) \cdot [f_E N_{part} + (1 - f_E) N_{spec\ projectile}]$$

Fit parameters:

μ - the mean value of NBD

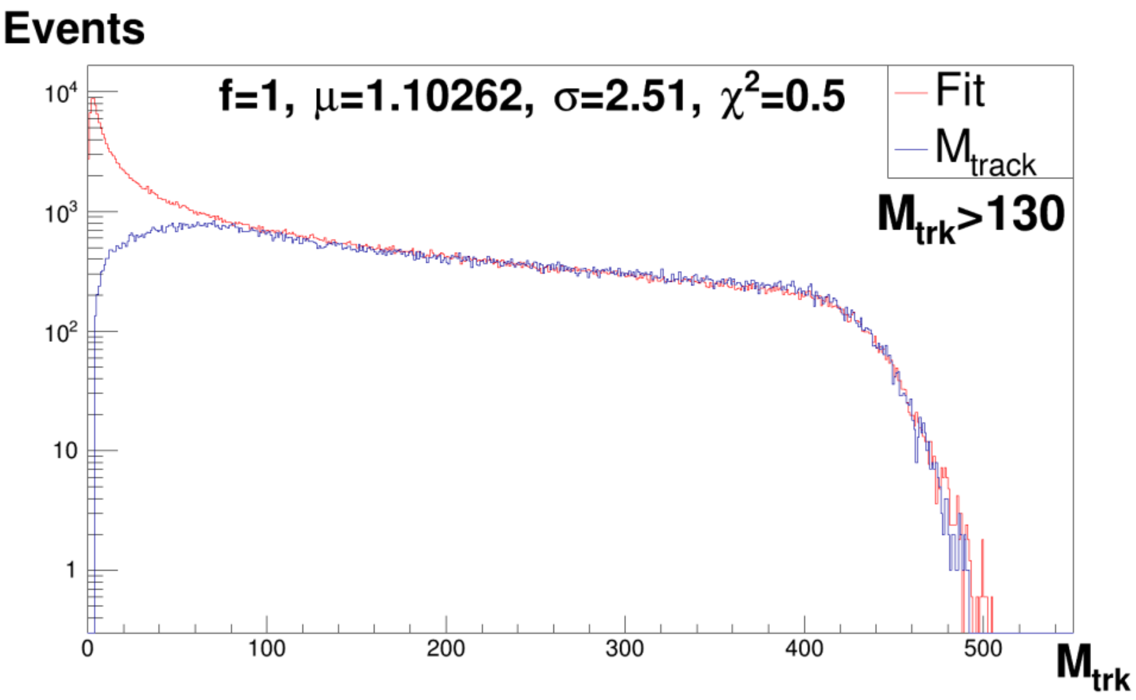
σ - the width of NBD

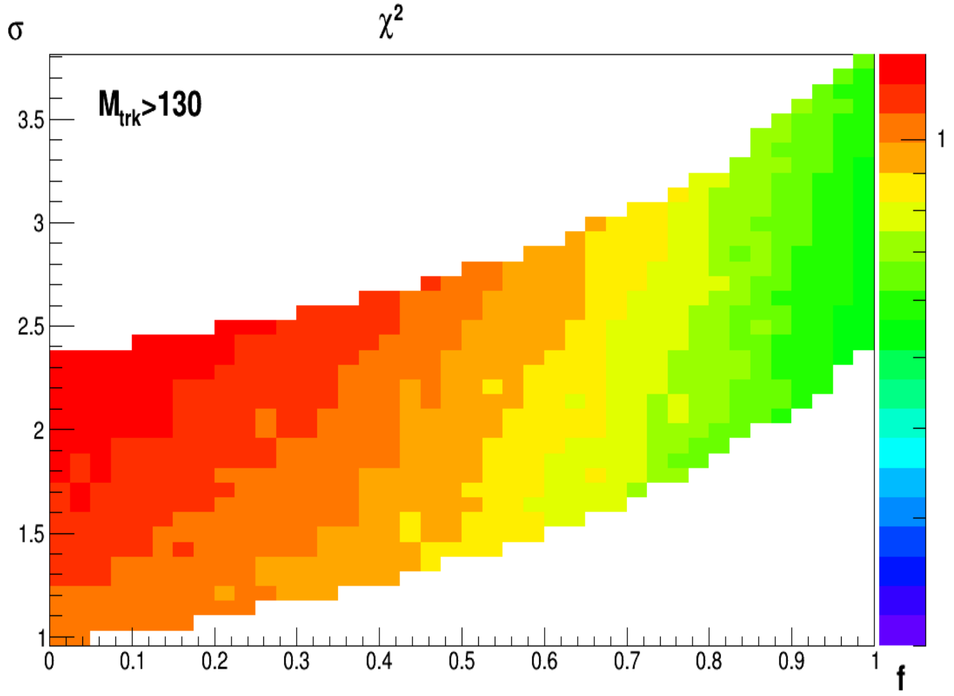
f - contribution from soft and hard processes

Fitting procedure in the NA49 at CERN SPS

$$\frac{dN_{ev}}{dM_{trk}}(f_M, \mu, \sigma) = P(\mu, \sigma) \cdot N_a = P(\mu, \sigma) \cdot [f_M N_{part} + (1 - f_M) N_{coll}]$$

For multiplicity distribution:



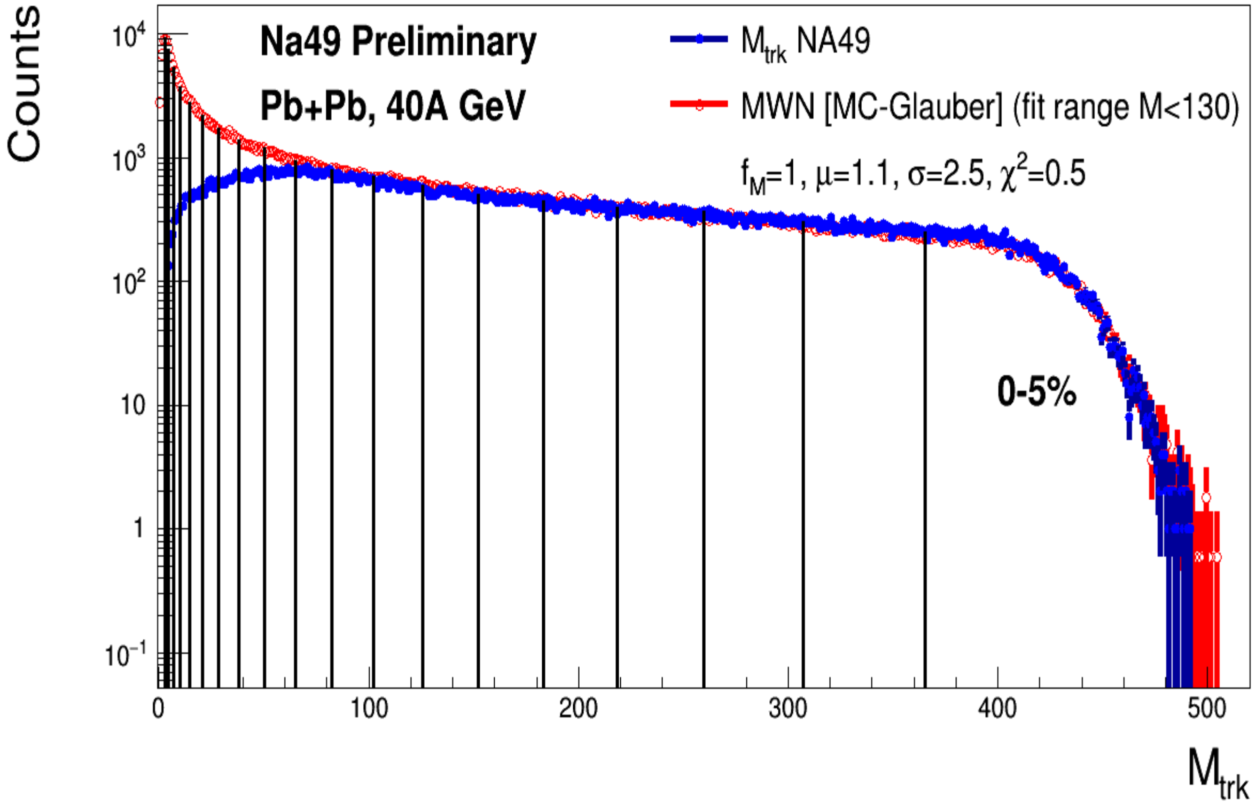


Procedure allows to choose best parameters for fit function.

Centrality classes in NA49 experiment

$$\frac{dN_{ev}}{dM_{trk}}(f_M, \mu, \sigma) = P(\mu, \sigma) \cdot [f_M N_{part} + (1 - f_M) N_{coll}]$$

$P(\mu,\sigma)$ - negative binomial distribution (NBD), gives the probability of measuring n hits per ancestor.



Fit parameters:

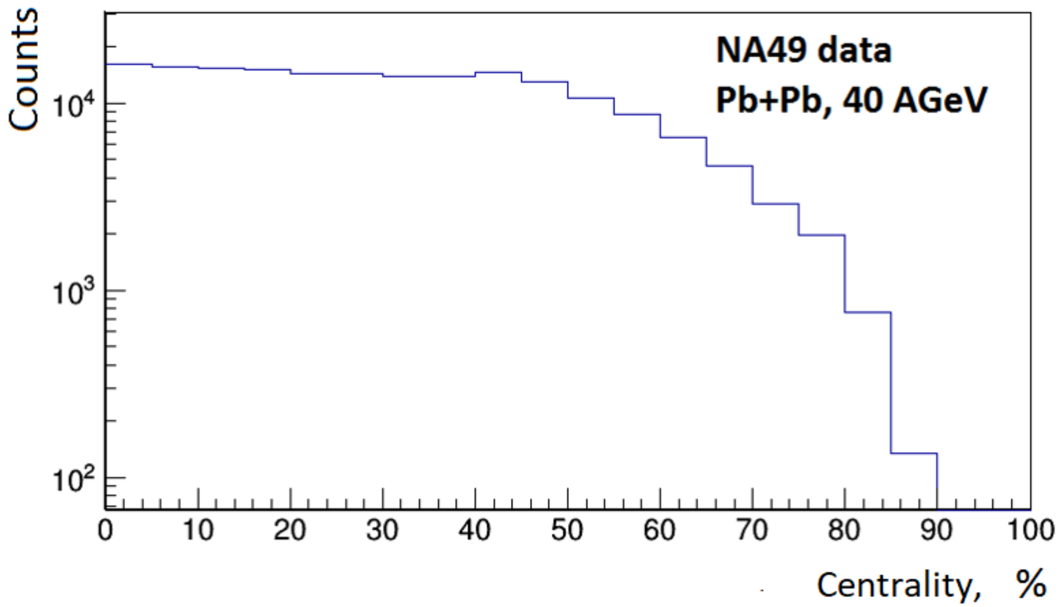
μ - the mean value of NBD

σ - the width of NBD

f_M - contribution from soft and hard processes

Determination of the “anchor point” in the NA49 experiment

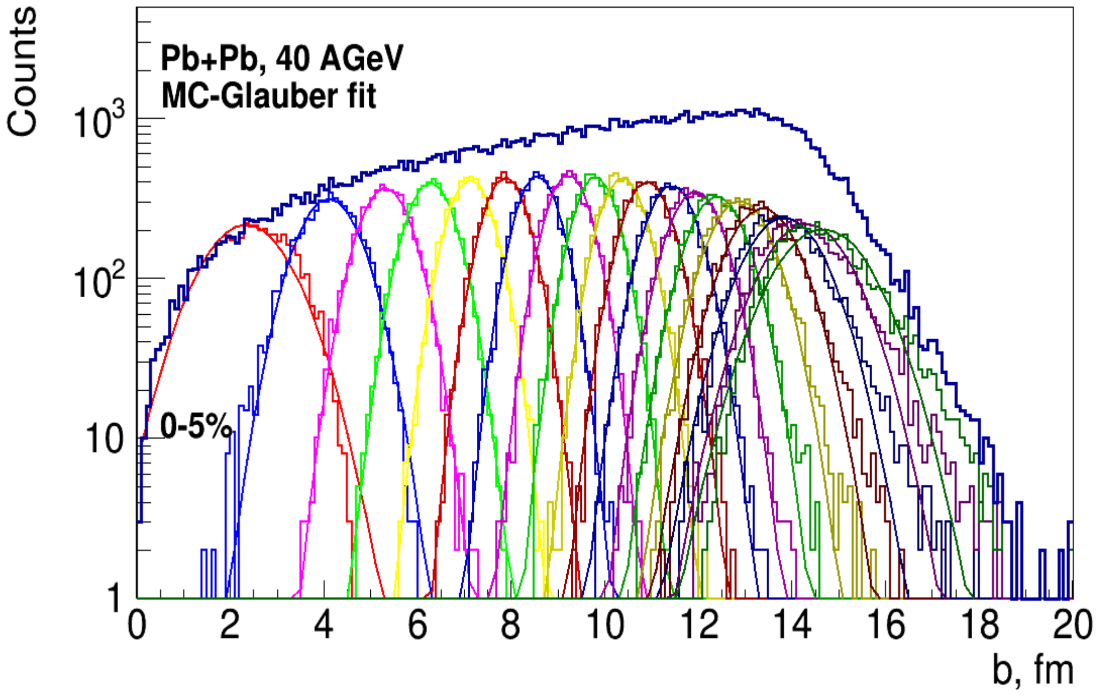
For multiplicity distribution:

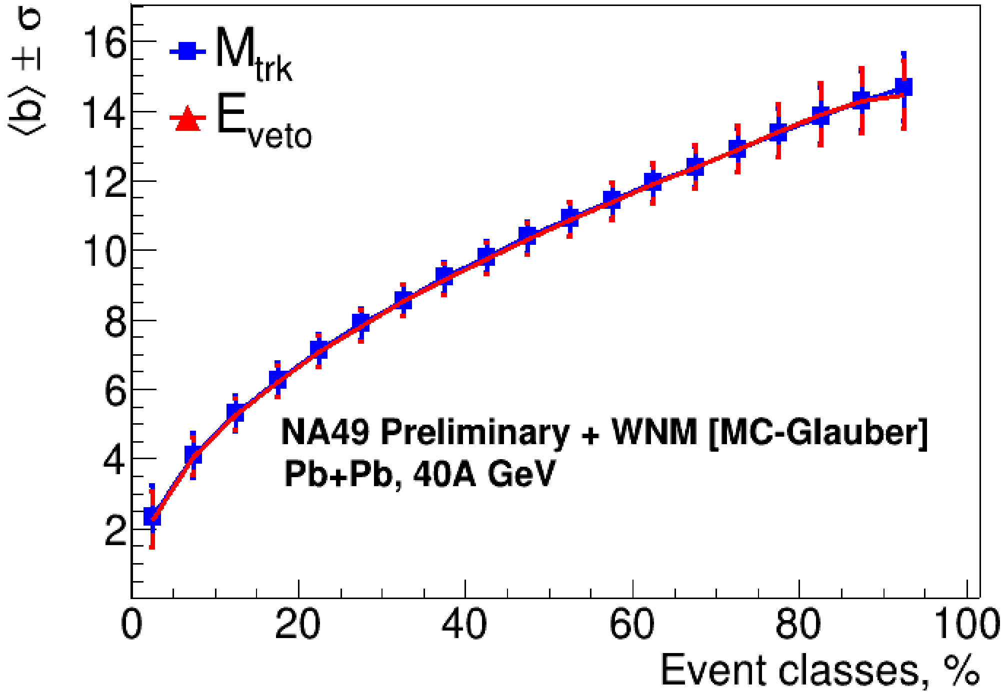


Distribution of centrality classes allows to determine the point beyond which determination of centrality isn’t reliable.

Geometrical quantities from the Glauber Model in centrality classes in the NA49 at CERN

From TPC multiplicity:





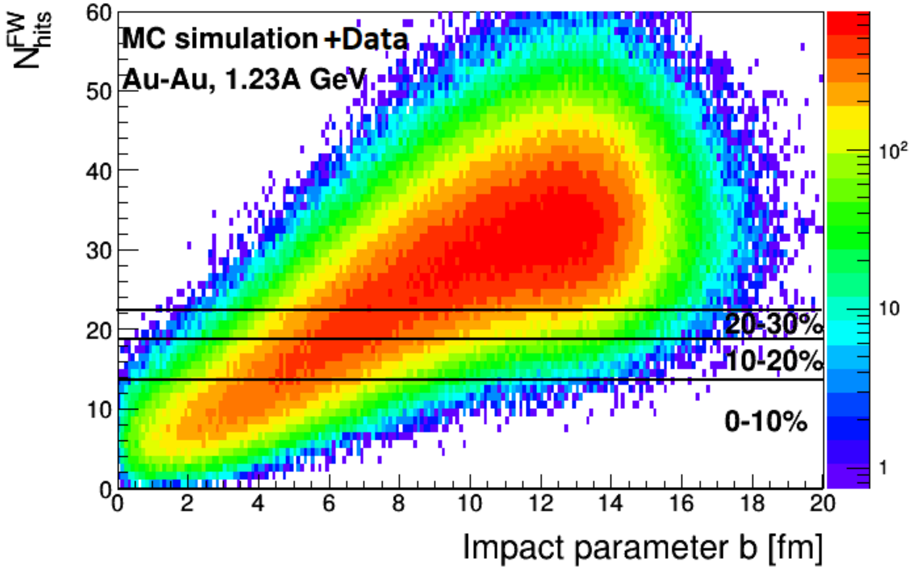
Extracted mean values of the Glauber model parameters can be used to compare data and model calculations with other experiments.

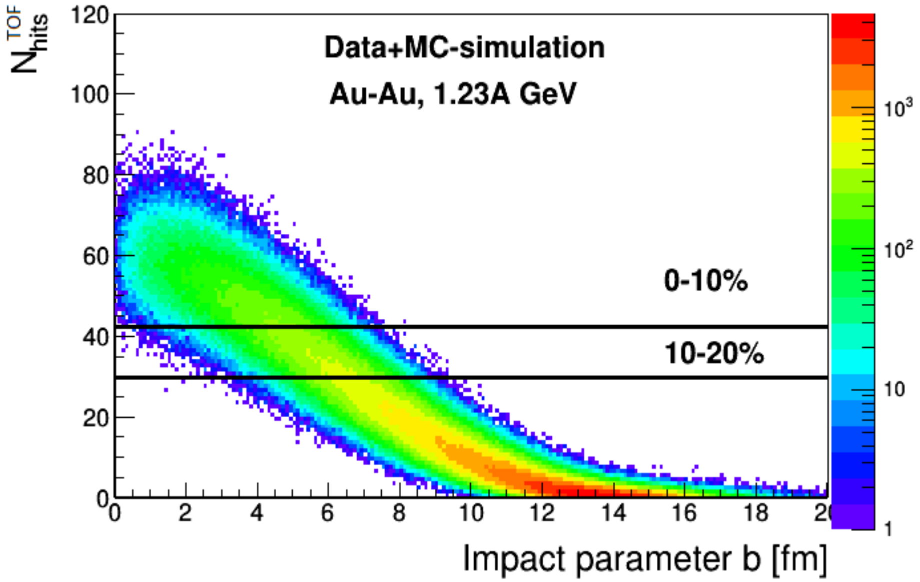
Summary

- Centrality is a key parameter to study properties of strongly interacting matter
- Centrality classes using spectators will allow to expand the field of research on large pseudorapidity
- The candidate has experience in centrality determination in the other experiment

Back up

Centrality classes in HADES experiment (for FW and TOF)





Experience in the field

Current time: participation in the analyses of Au-Au data in the HADES experiment.

Negative binomial distribution

$$P_{\mu,k}(n) = \frac{\Gamma(n+k)}{\Gamma(n+1)\Gamma(k)} \frac{({}^{\mu}/_{k})^{n}}{({}^{\mu}/_{k}+1)^{n+k}}$$

Gives the probability of measuring n hits per independently emitting sources of particles, where μ is the mean multiplicity per ancestor and k controls the width.

Procedure for centrality determination

1. Glauber Monte-Carlo fit, finding best parameters of it.

2. Determine the ”anchor” based on a fit with a Glauber model based function.

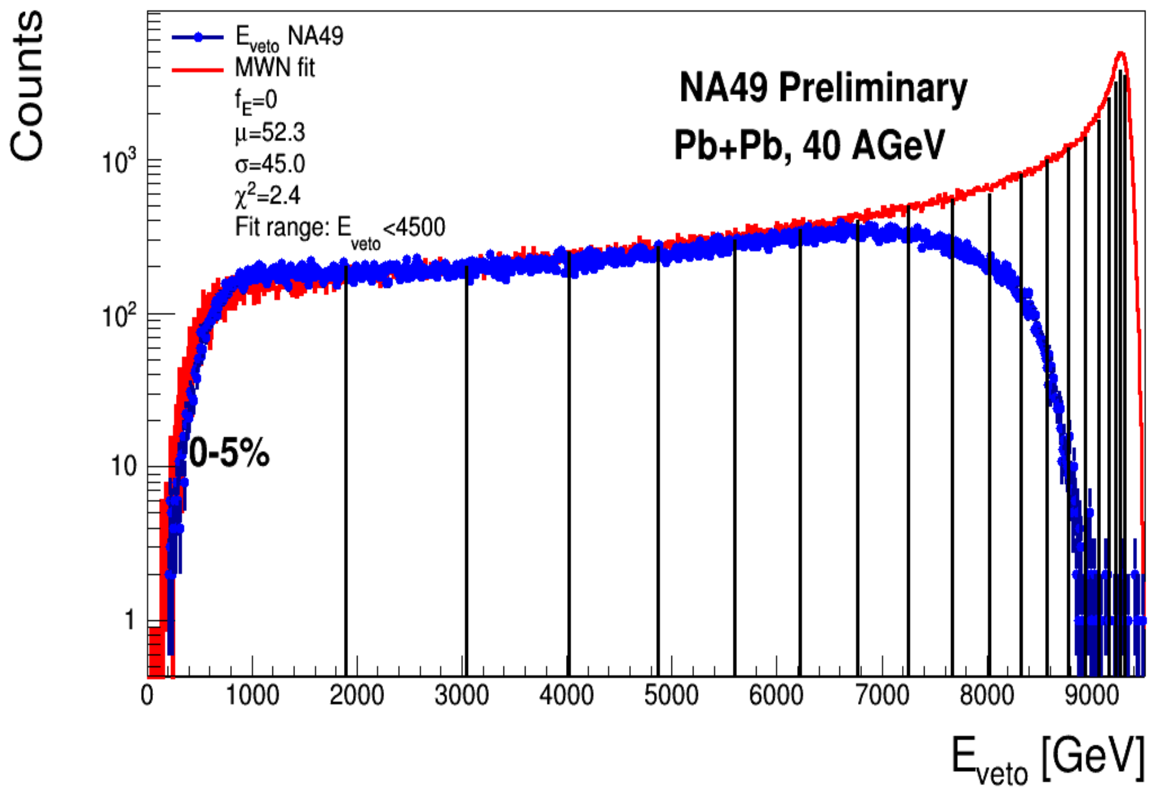
2. Parameterise the 2D correlation between multiplicity and/or spectators energy (in case of 2D analysis).

3. Slice the 2D correlation or 1D distribution on event classes.

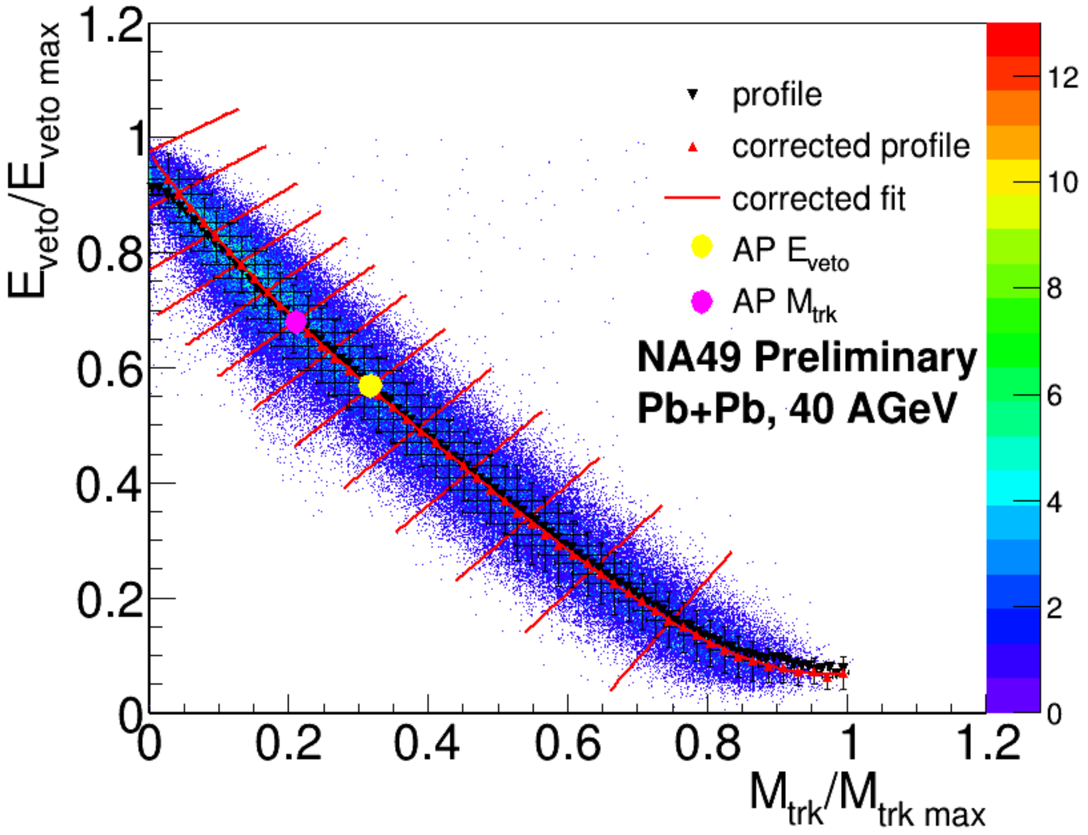
4. Extract geometrical quantities in event classes.

Centrality classes in NA49 experiment

$$\frac{dN_{ev}}{dE_{spec}}(f_E, \mu, \sigma) = P(\mu, \sigma) \cdot N_a = P(\mu, \sigma) \cdot [f_E N_{part} + (1 - f_E) N_{spec\,projectile}]$$



Parametrization of multiplicity and energy of spectators distribution in the NA49 at CERN SPS



Centrality determination procedure for 2D correlation:

- Iterative fitting (profiling, fitting, profile perpendicular to the fit, refit)
- Slicing perpendicular to refit

Procedure allows to determine centrality classes using different estimators.