Fluctuations in High Energy Nucleus-Nucleus Collisions from Microscopic Transport Approaches

Volodymyr Konchakovski
Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine

- **Basic concepts of HSD & UrQMD**
- **NA49 data and HSD & UrQMD results**
- **Multiplicity fluctuations in projectile and target hemispheres**
- **Transparency, mixing and reflection in A+A**
- **Conclusions**

Basic concepts of HSD & UrQMD

HSD – Hadron-String-Dynamics transport approach

UrQMD – Ultra-relativistic-Quantum-Molecular-Dynamics

- **Take into account:**

- elastic and inelastic hadronic reactions
- formation and decay of hadronic resonances
- string formation and decay

- **Show good description of :**

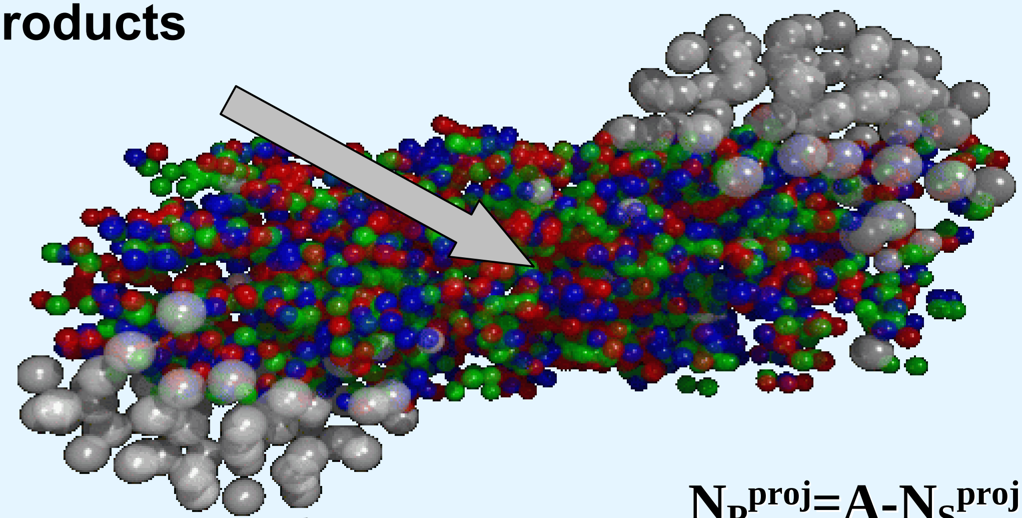
- particle production in p-p, p-A reactions
- nuclear dynamics from low (~100 MeV) to ultrarelativistic (21.3 TeV) energies

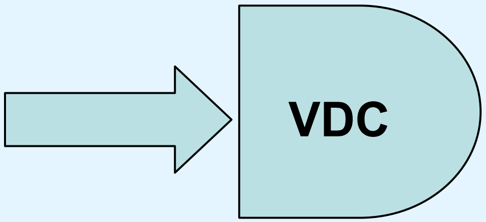
- **We calculate the multiplicity fluctuation in HSD & UrQMD**

Nucleons: participants and spectators

participants products

projectile spectators N_S^{proj}





Pb-Pb
158 AGeV

target spectators N_S^{targ}

$N_P^{proj}=A-N_S^{proj}$ – projectile participants

$N_P^{targ}=A-N_S^{targ}$ – target participants

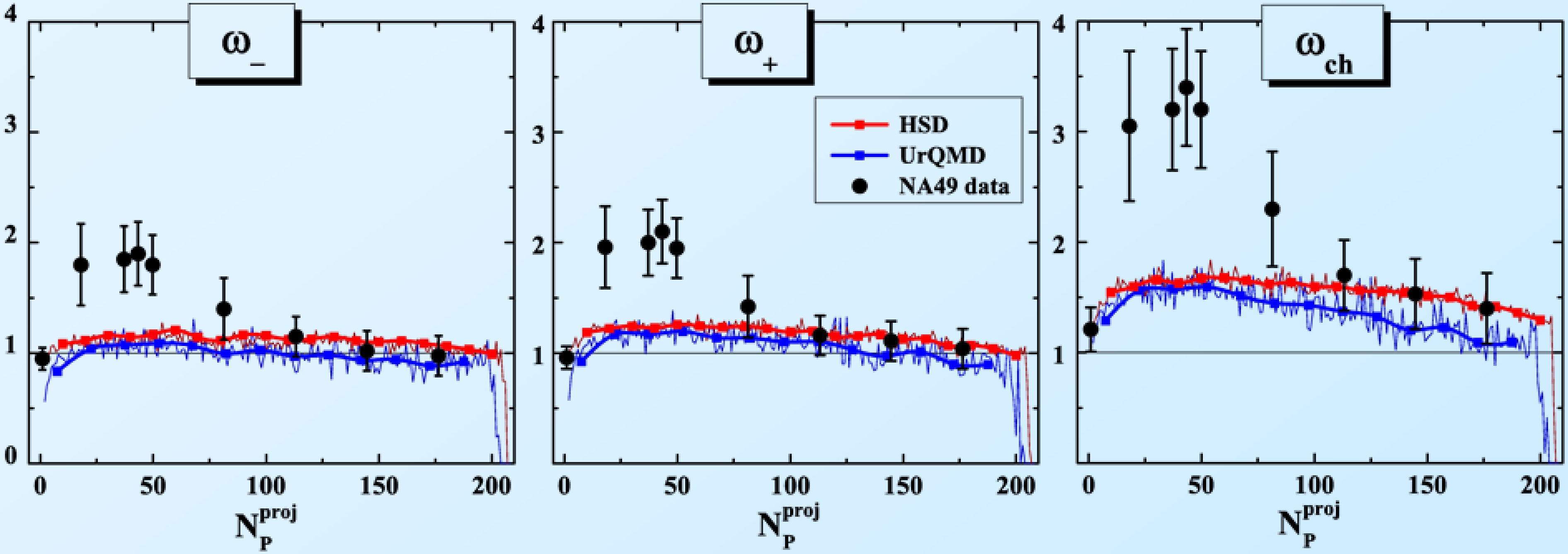
Scaled variance

$$\omega_i = \frac{\langle N_i^2\rangle - \langle N_i\rangle^2}{\langle N_i\rangle}, \quad \text{where} \quad i=-,+,ch$$

$$\omega_-^* = 1.5$$
$$\omega_+^* = 1.1$$
$$\omega_{ch}^* = 2.5$$

$\omega = 1$ for Poisson distribution

NA49 data and HSD & UrQMD results

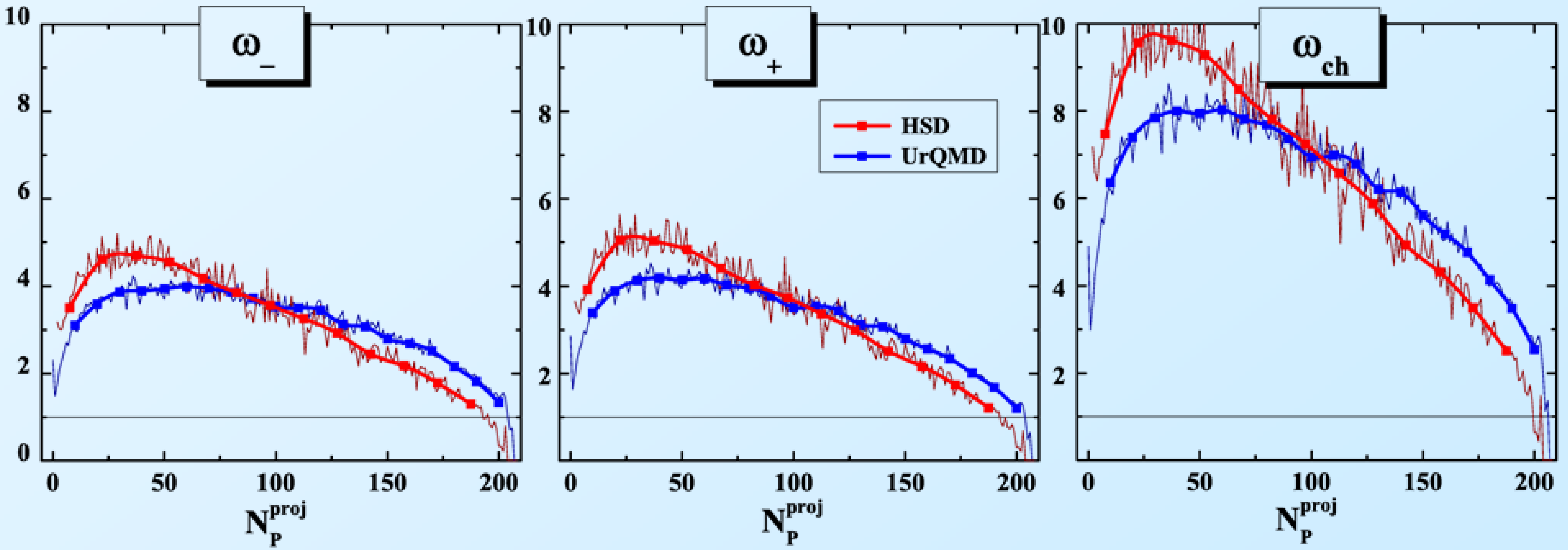


The observed by NA49 non-trivial centrality dependence of multiplicity fluctuations is not reproduced by HSD and UrQMD.

Phys. Rev. C 73, 034902 (2006)

V. K, S.Haussler, M.I.Gorenstein, E.L.Bratkovskaya, M.Bleicher, H.Stöcker

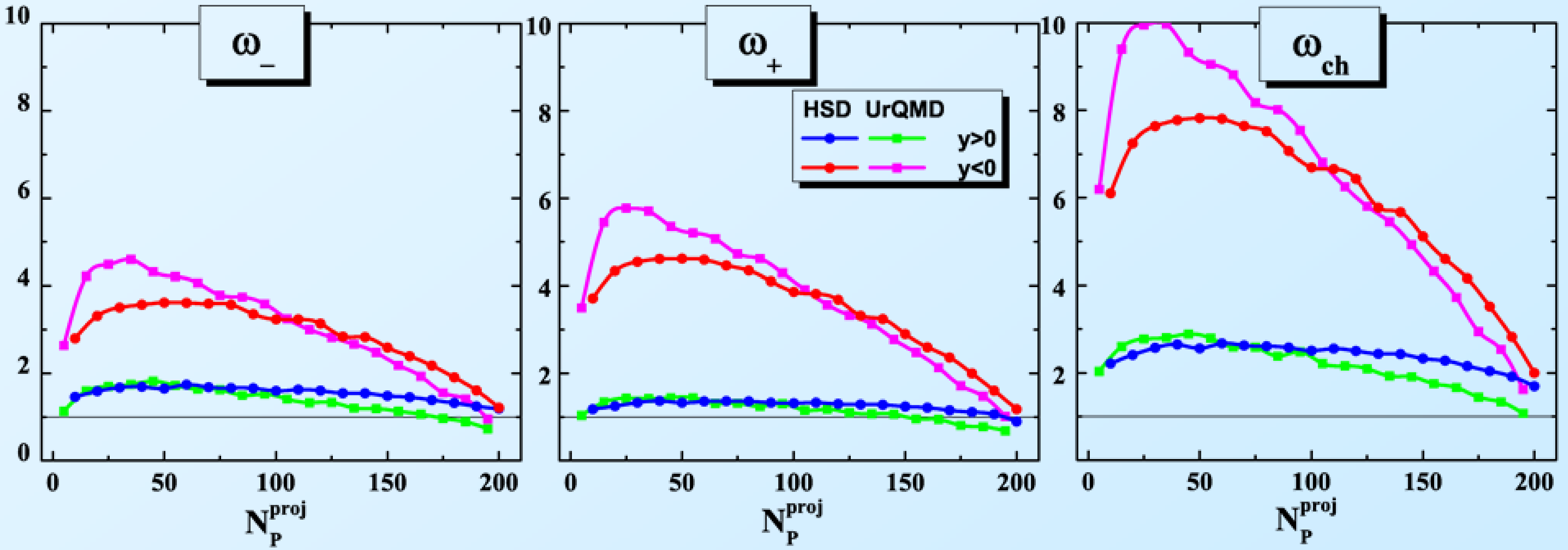
Full acceptance:



In full acceptance HSD and UrQMD show:

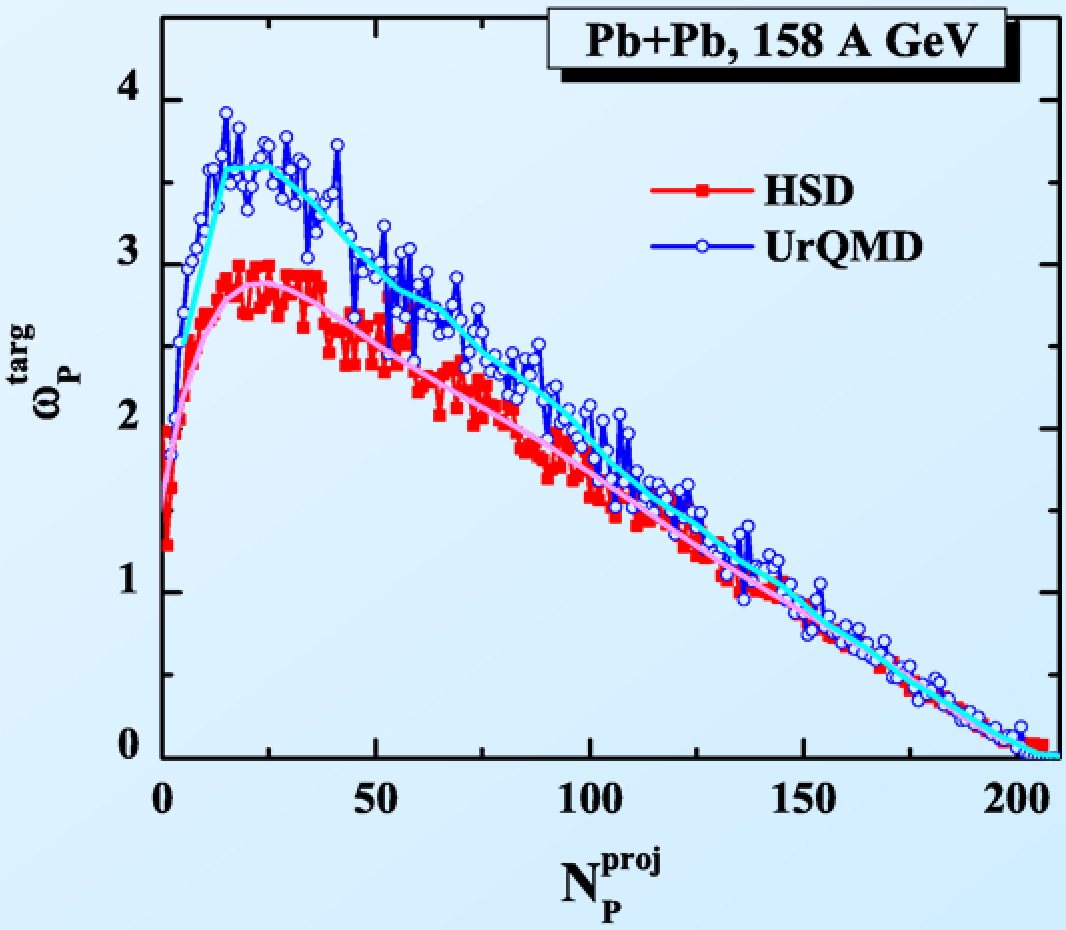
- **strong multiplicity fluctuations**
- **strong dependence of ω on centrality (similar to experimental data)**

Multiplicity fluctuations in projectile and target hemispheres



- Fluctuations in target hemisphere are much larger than in projectile hemisphere
- There is no N_P^{proj} dependence of fluctuations in projectile hemisphere but there is strong N_P^{proj} dependence for target hemisphere

The scaled variance for the fluctuations of the number of target participants N_P^{targ}



$$N_P^{tar} \neq N_P^{proj}$$
$$\left\langle N_P^{tar} \right\rangle = N_P^{proj}$$

In each sample with N_P^{proj} = const the number of target participants N_P^{targ} fluctuates considerably.

These fluctuations originate from:

- **geometrical fluctuations**
- **probabilistic character of collisions**

Model of independent sources

Let: ω_i^* **is not depend on** N_P

$$\overline{\overline{N}}_i = N_P n_i$$

$$n_i = \frac{\langle \overline{\overline{N}}_i \rangle}{\langle N_P \rangle}$$ **- the particle number of i-th type per participant**

$$\boxed{\omega_i = \omega_i^* + \tfrac{1}{2}\,\omega_P^{tar}\, n_i}$$ **, where** $i = -, +, ch$

HSD
N+N
158 GeV

the fluctuation from one source

$$\omega_-^* = 1.5$$
$$\omega_+^* = 1.1$$
$$\omega_{ch}^* = 2.5$$

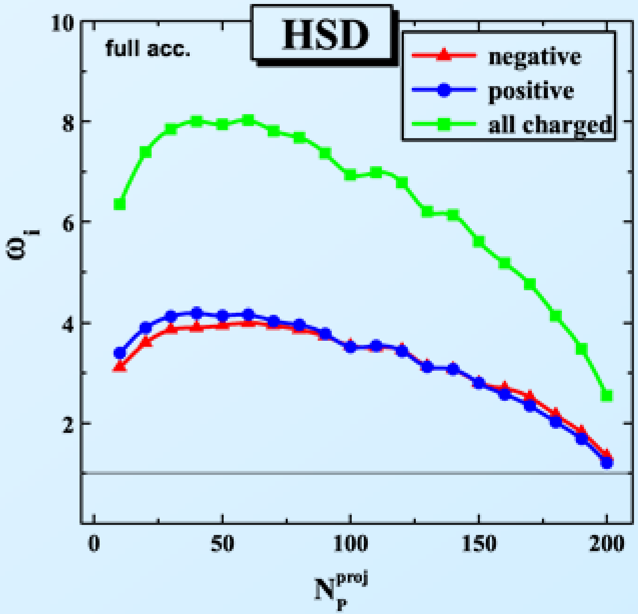
HSD at $N_P^{proj} = N_P^{proj} = const$

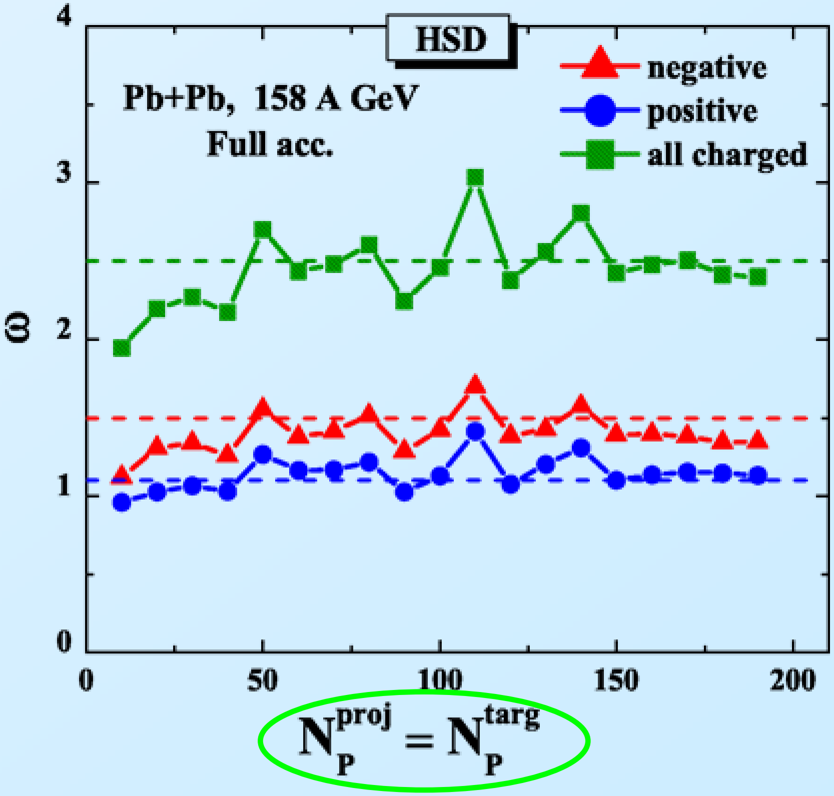
For $N_P^{proj} = N_P^{targ}$ it follows

$$\omega_P^{targ} = 0$$

and fluctuations in A+A collisions are dominated by the fluctuations of the particle number in a single N+N collision.

$$\boxed{\omega_i = \omega_i^*} \cancel{+\frac{1}{2}\omega_P^{targ} n_i}$$





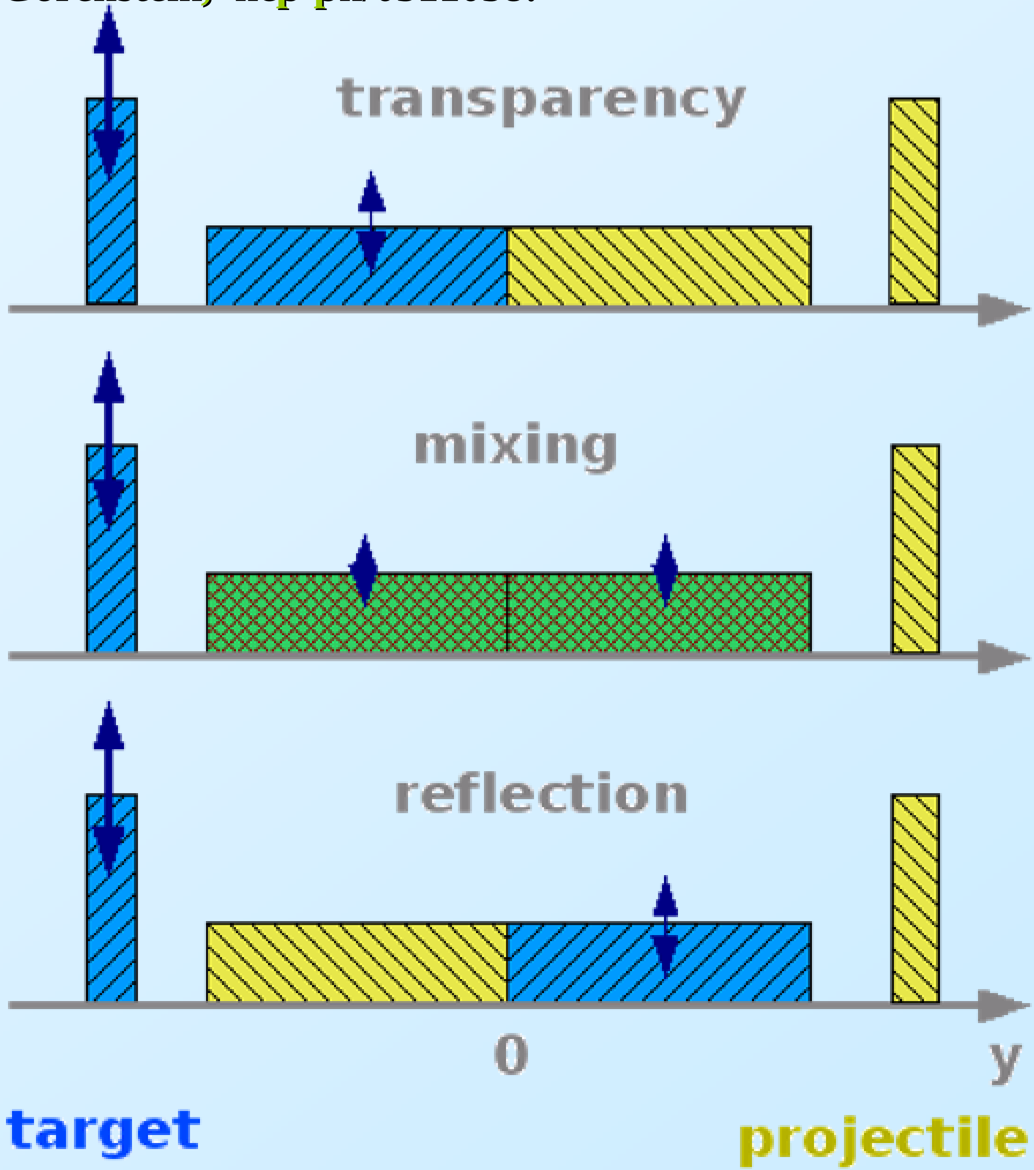
$$\omega_{ch}^* = 2.5$$

$$\omega_-^* = 1.5$$

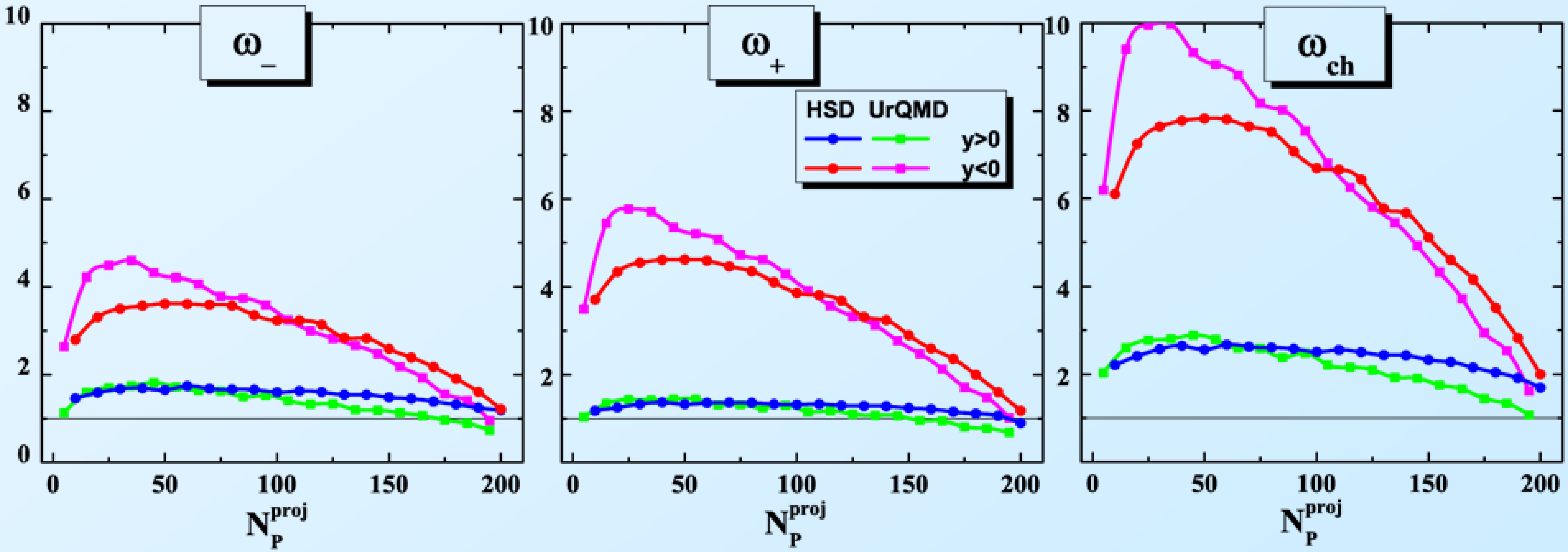
$$\omega_+^* = 1.1$$

Transparency, mixing and reflection in A+A

M.Gazdzicki, M.Gorenstein, hep-ph/0511058:

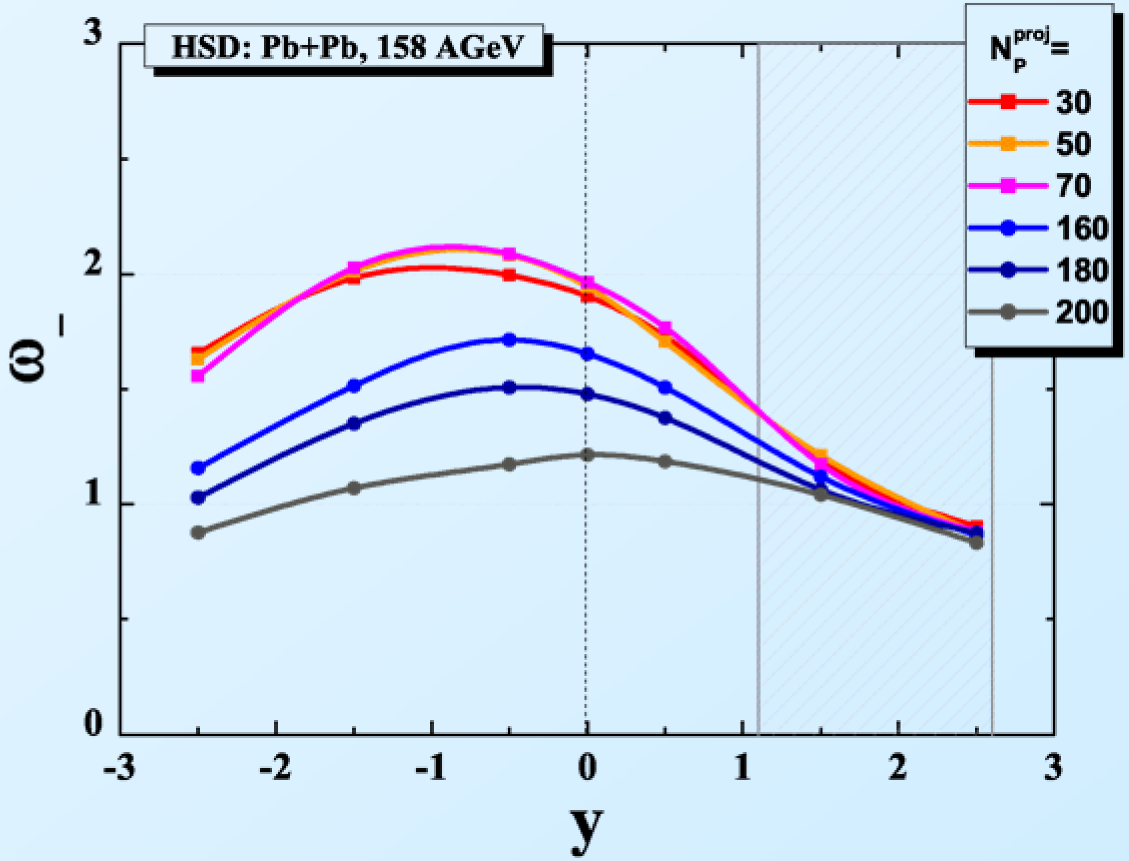


HSD & UrQMD in projectile and target hemispheres



- HSD & UrQMD are **too transparent** and can not explain the NA49 data.
- Experemental data are close to the **mixing** scenario for 158 Pb+Pb

Multiplicity fluctuations versus rapidity



- We do not see the centrality dependence of multiplicity fluctuations in the NA49 rapidity interval (1.1<y<2.6)
- In the projectile hemisphere the centrality dependence is only seen near midrapidity (0<y<1)

Conclusions:

- The fluctuations of number of participants strongly influence the multiplicity fluctuations.

- Fixation of number of projectile participants cannot kill the volume fluctuations in the system for peripheral collisions. Only at $N_P^{proj} \approx A$ these fluctuations become small.

- HSD and UrQMD models are too transparent and cannot reproduce the NA49 results for Pb-Pb 158 AGeV on multiplicity fluctuations.

- A comparison of the fluctuations in the projectile and target hemisphere at $N_P^{proj} = const$ tells us about hadron's mixing.

  It gives us quantitative measure of the mixing.

- The fluctuations of the baryonic number and electric charge are also important for understanding the mechanisms of A+A collisions [nucl-th/0606047]

- Related analysis in comparison with RHIC data are in progress.

Thanks to:

Mark Gorenstein

Viktor Begun

Marek Gazdzicki

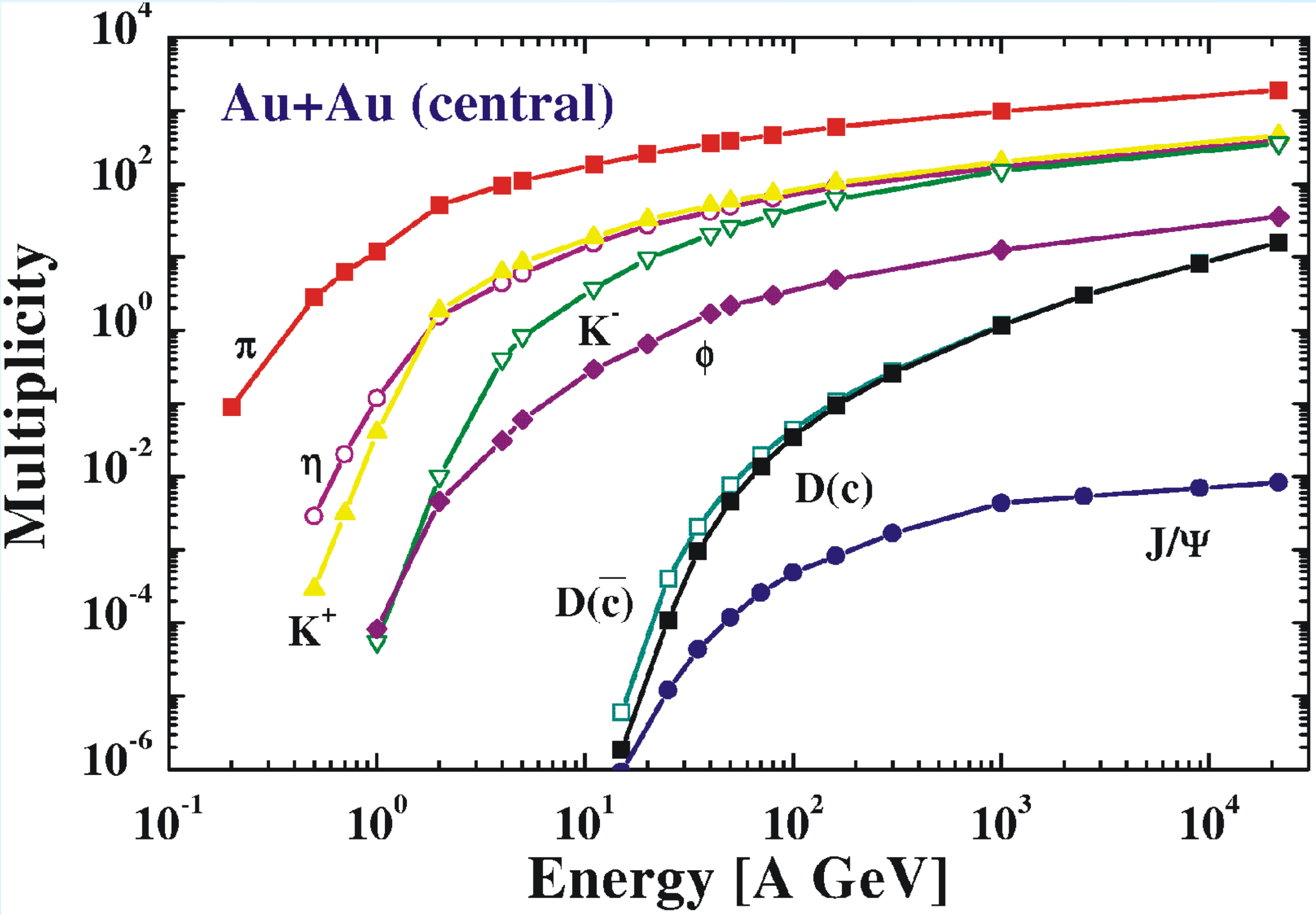
Benjamin Lungwitz

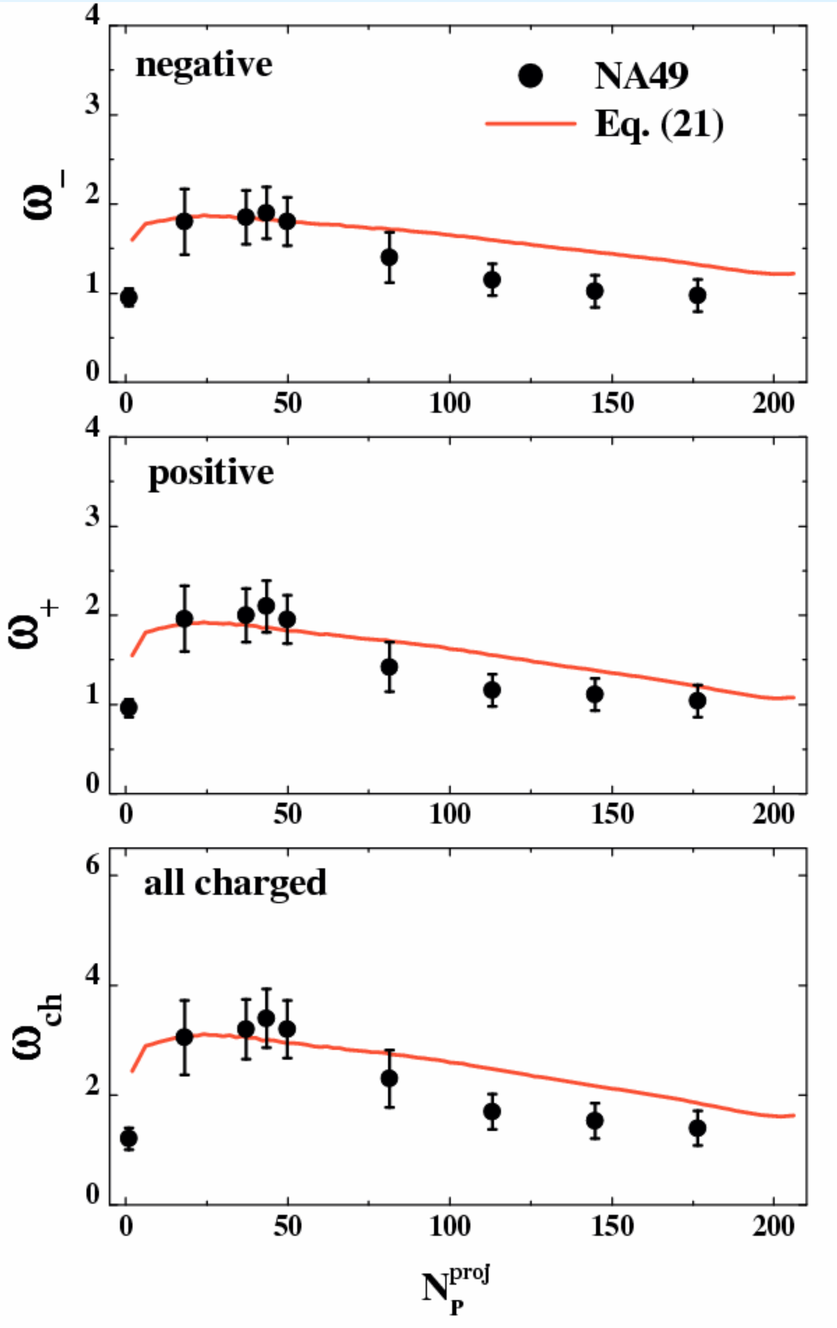
Elena Bratkovskaya

Horst Stöcker

Marcus Bleicher

Stephane Haussler


Au+Au (central)
Multiplicity
Energy [A GeV]
π
η
K+
K-
φ
D(c)
D(c̄)
J/Ψ
10^4
10^2
10^0
10^-2
10^-4
10^-6
10^-1
10^0
10^1
10^2
10^3
10^4



negative
NA49
Eq. (21)
positive
all charged
ω_-
ω_+
ω_{ch}
N_P^{proj}
0
1
2
3
4
6
50
100
150
200