Elliptic flow at RHIC with NeXSPheRIO

R.Andrade[1],F.Grassi[1], Y.Hama[1], T.Kodama[2], O.Socolowski Jr.[3], B.Tavares[2]
grassi@if.usp.br

[1]Instituto de Física, Universidade de São Paulo, Brazil

[2]Instituto de Física, Universidade Federal do Rio de Janeiro, Brazil

[3]Instituto Tecnológico de Aeronáutica, Centro Técnico Aeroespacial, Brazil

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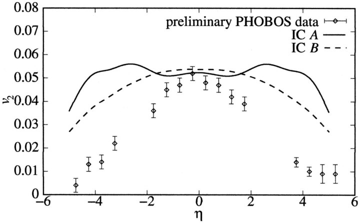
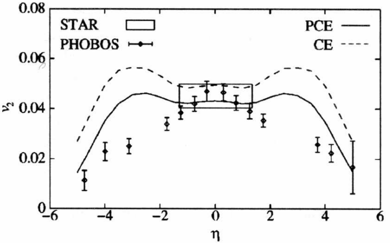
Outline

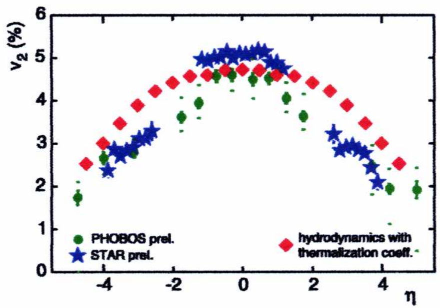
Motivation: elliptic flow is a tool to study thermalization

Hydrodynamics seems a correct tool to describe RHIC collisions however $v_2(\eta)$ is not well reproduced as shown by Hirano et al. results (PRC 65(2001)011901, 66(2002)054905)





Hirano suggested this might be due to lack of thermalization.
Heinz and Kolb presented a model with partial thermalization (QM2004) to account for this:



Question: lack of thermalization is the only explaination?

Our tool: NeXSPheRIO

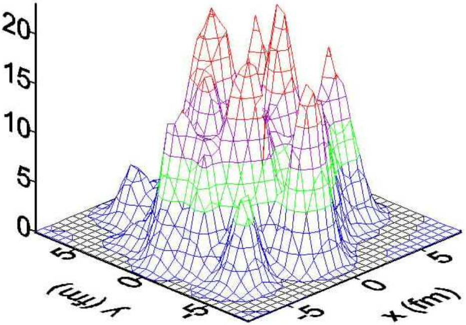
NeXSPheRIO is a junction of two codes.

SPheRIO is used to compute the hydrodynamical evolution

- Smoothed Particle Hydrodynamics was originally developped in astrophysics and adapted to relativistic heavy ion to collisions

  C.E.Aguiar, T.Kodama, T.Osada & Y.Hama, J.Phys.G27(2001)75
- Advantage: incorporate any geometry in the initial conditions

NeXus is used to compute the initial conditions
H.J. Drescher et al. PRC 65(2002)054902; Y.Hama, T.Kodama & O.Socolowski Jr. Braz.J.Phys. 35(2005)24



In other codes, initial conditions are adjusted to reproduce some selected data AND are very smooth.

Method:

NeXSPheRIO is run many times and an average over final results is performed.

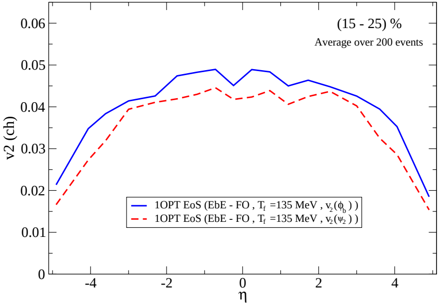
This mimicks experimental conditions.

Results

Theoretical vs. experimental computation

- Theoretically, the impact parameter angle ϕ_b is known and varies in the range of the centrality window chosen:
$$v_2 = \frac{\int dN/d\phi \cos[2(\phi - \phi_b)]\, d\phi}{\int dN/d\phi\, d\phi}$$
- Experimentally, the impact parameter angle ψ_2 is reconstructed, for example in a Phobos-like way (PRL 89(2002)222301; nucl-ex/0407012):
$$v_2 = \frac{\sum_i dN/d\phi_i \cos[2(\phi_i - \psi_2)]}{\sum_i dN/d\phi_i} \times \frac{1}{\sqrt{2}\sqrt{<\cos[2(\psi_2^{<0} - \psi_2^{>0})]>}}$$
where
$$\psi_2 = \frac{1}{2} \tan^{-1} \frac{\sum_i \sin 2\phi_i}{\sum_i \cos 2\phi_i}$$
$\psi_2^{<0}$ and $\psi_2^{>0}$ are determined for subevents $2.05 <| \eta |< 3.2$

- After averaging on events, we get:



- There is some difference.
  In order to compare with PHOBOS data, we will use the second (reconstructed angle) method

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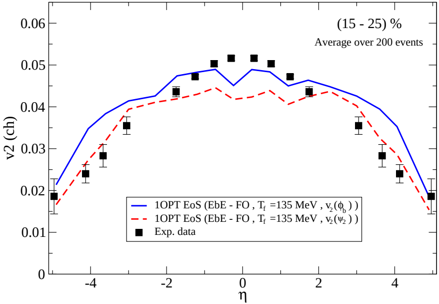

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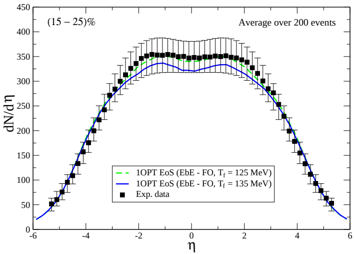
Results
Effect of T_{fout}

- In all comparisons, the same set of initial conditions is used, scaled to reproduce $dN/d\eta$ for $T_{f.out} = 135$ MeV



- v_2 and $dN/p_t\,dp_t$ favour $T_{f.out} = 135$ MeV, used thereafter.

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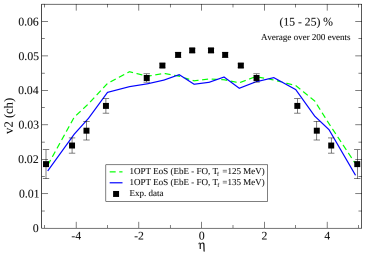

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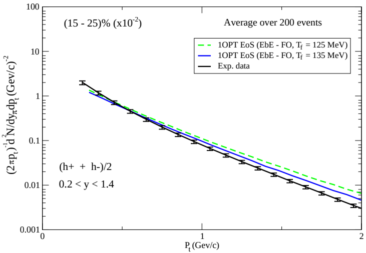

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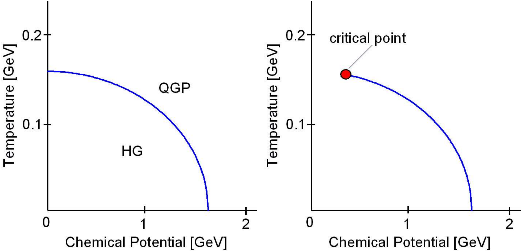
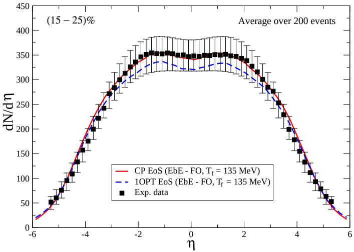
Effect of first order transition vs. cross over

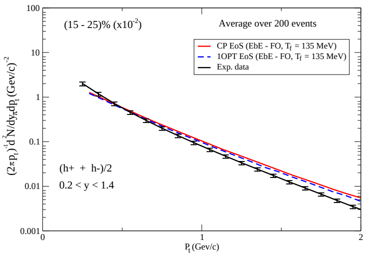
- We compare results obtained for a quark matter equation of state with first transition to hadronic matter and with a crossover



- We expect larger v_2 for cross over



- The η and p_t distributions are not much affected
- v_2 is higer, as expected



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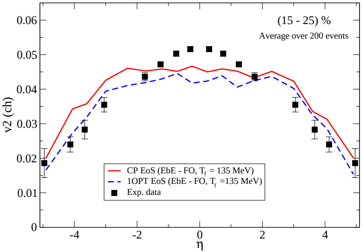

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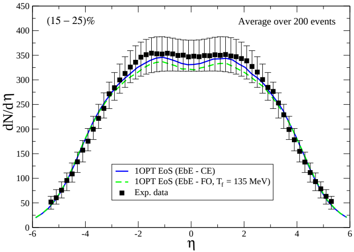
Results

Effect of emission mechanism

- We compare results obtained for freeze out and continuous emission
- We expect large momentum particles emitted earlier, with less flow, therefore, narrower $v_2(\eta)$



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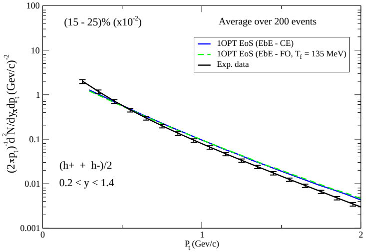

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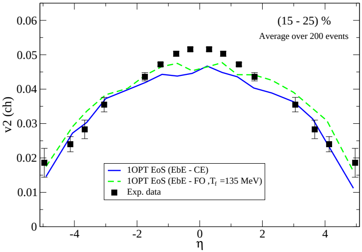

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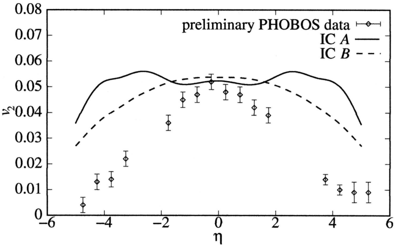
Results

Effect of initial conditions

- Compared to Hiranos' pioneering work with smooth initial conditions, the fact that we used event-by-event initial conditions seems crucial: we immediately avoid the two bumb structure



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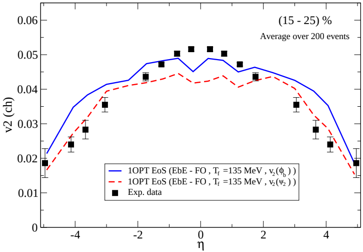

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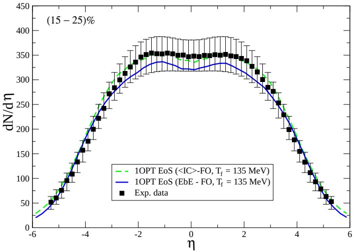

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- We get a two bump structure for $v_2(\eta)$
  (The small depression at $\eta = 0$ is probably numerical)

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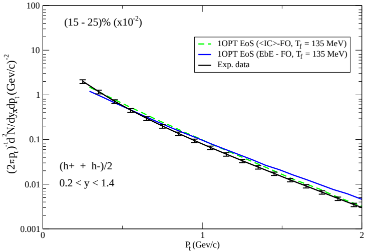

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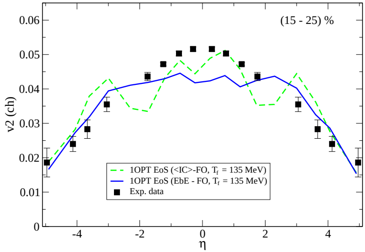

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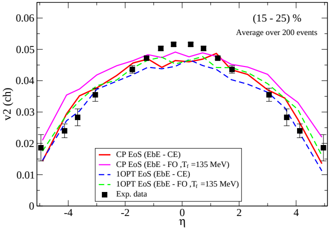
Summary

- Event-by-event initial conditions seem important to get right shape of $v_2(\eta)$ at RHIC
- Other features seem less important: reconstruction of impact parameter direction, f.out temperature, equation of state (w. or wo. crossover), emission mecanism.



- Lack of thermalization is not necessary to reproduce $v_2(\eta)$