The influence of transport variables on isospin transport ratios

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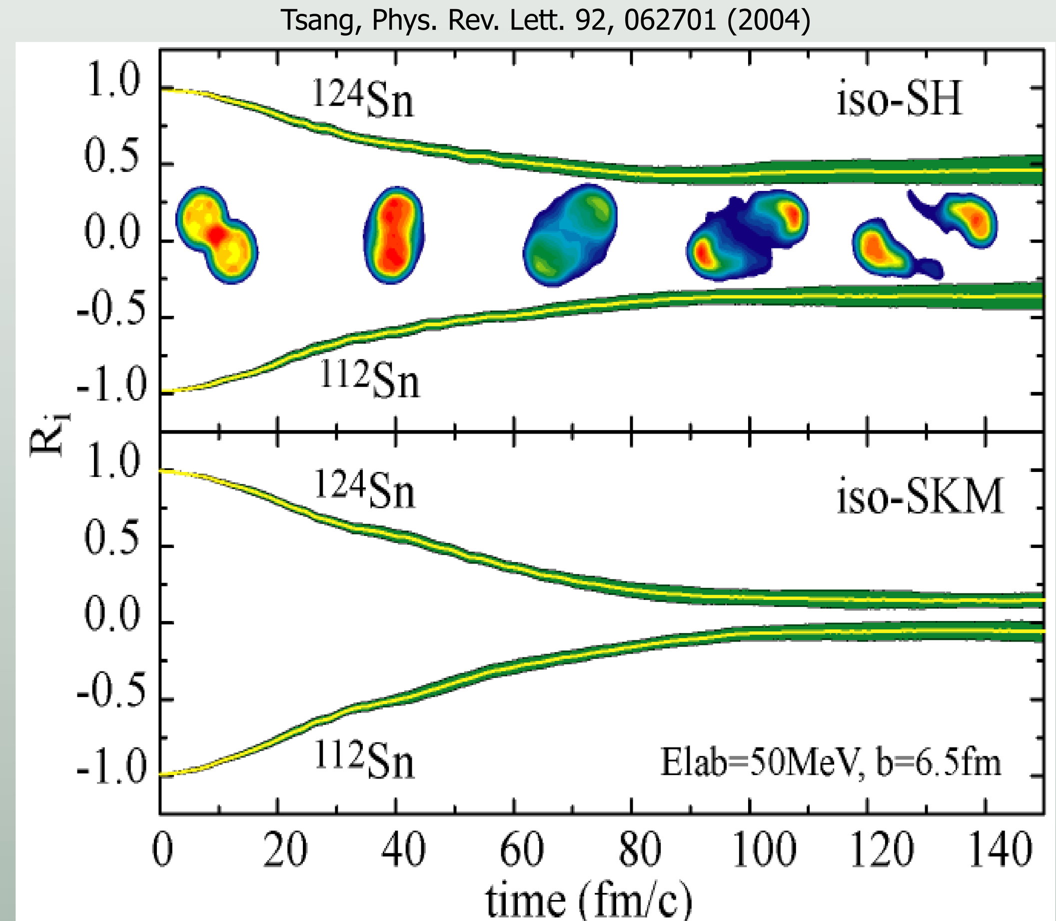
Motivation

Isospin Diffusion occurs in isospin asymmetric, peripheral heavy ion collisions.

→ During the collision, the Symmetry Energy in the low density "neck" region moves the system towards isospin equilibrium

→ If the time scale of equilibration is slightly longer than the time scale of the reaction, the asymmetry of the projectile residue is sensitive to the Symmetry Energy at $\rho < \rho_0$.

Tsang, Phys. Rev. Lett. 92, 062701 (2004)



- Stronger density dependence
- Weaker symmetry energy at low densities
- Less equilibration

- Weaker density dependence
- Stronger symmetry energy at low densities
- More equilibration

To make conclusions about the Symmetry Energy from Isospin Diffusion data, we need to understand the dependence on other transport model parameters

Model space

We use the well-documented pBUU model, which includes:

Danielewicz, NPA673, 375 (2000)

- Tunable Symmetry Energy

  $S(\rho) = S_{kin} \cdot (\rho/\rho_0)^{2/3} + S_{int} \cdot (\rho/\rho_0)^{\gamma_i}$

- Momentum dependent or independent EOS
- Several parameterizations of the in-medium cross sections
- Optional light cluster production, for A <= 3

  → Allows some comparison between BUU and QMD models

We construct the Isospin Transport Ratio Ri to reduce the influence of non-diffusion effects

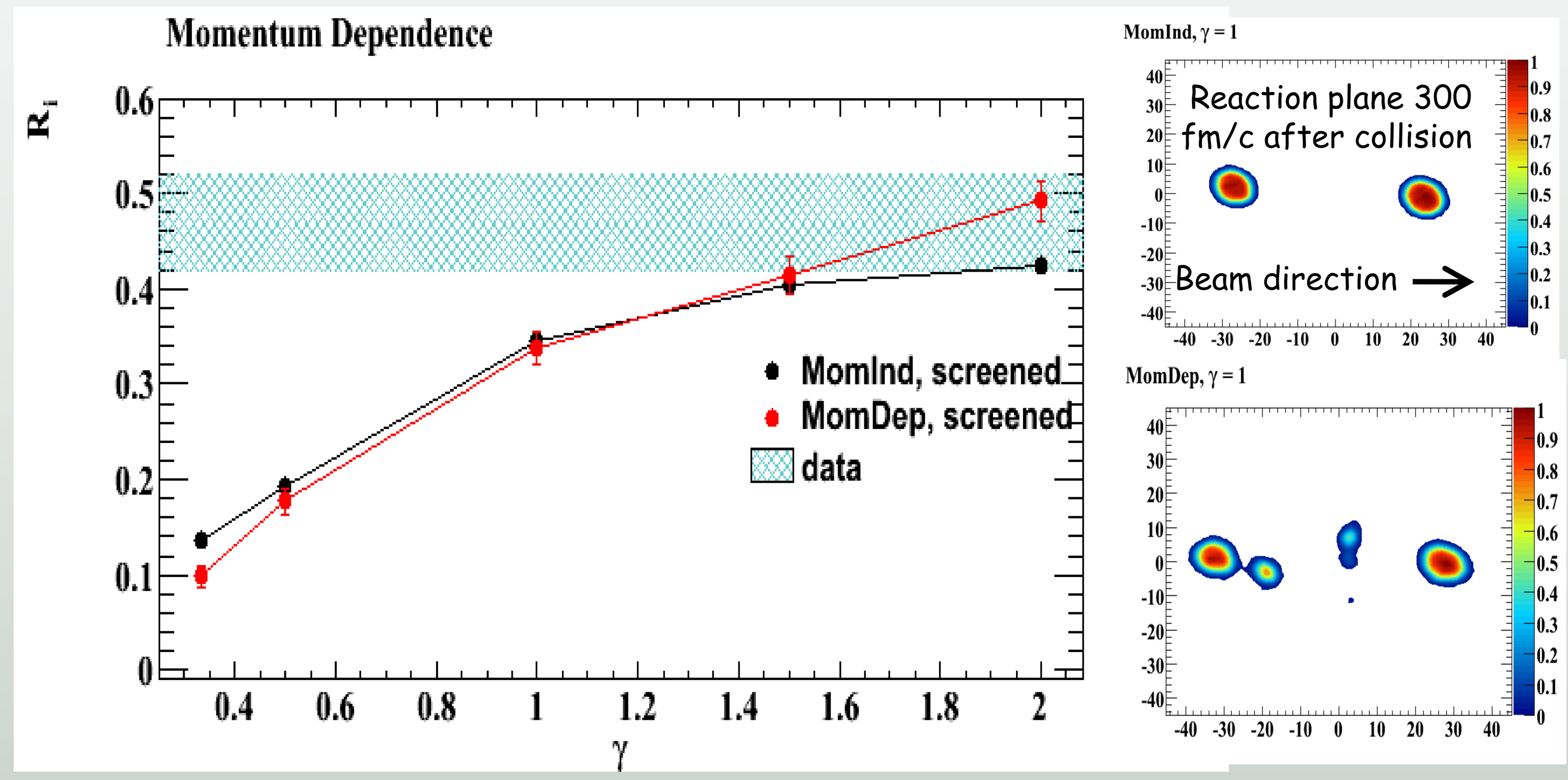
$$R_i = 2\frac{\delta_{AB} - (\delta_{AA} + \delta_{BB})/2}{\delta_{AA} - \delta_{BB}}$$

Rami et al., PRL, 84, 1120 (2000)

Momentum Dependence of EOS

A momentum dependent EOS matches elliptic flow data at high energies

- Shown to increase effective stiffness of EOS
- Decreases depth of potential

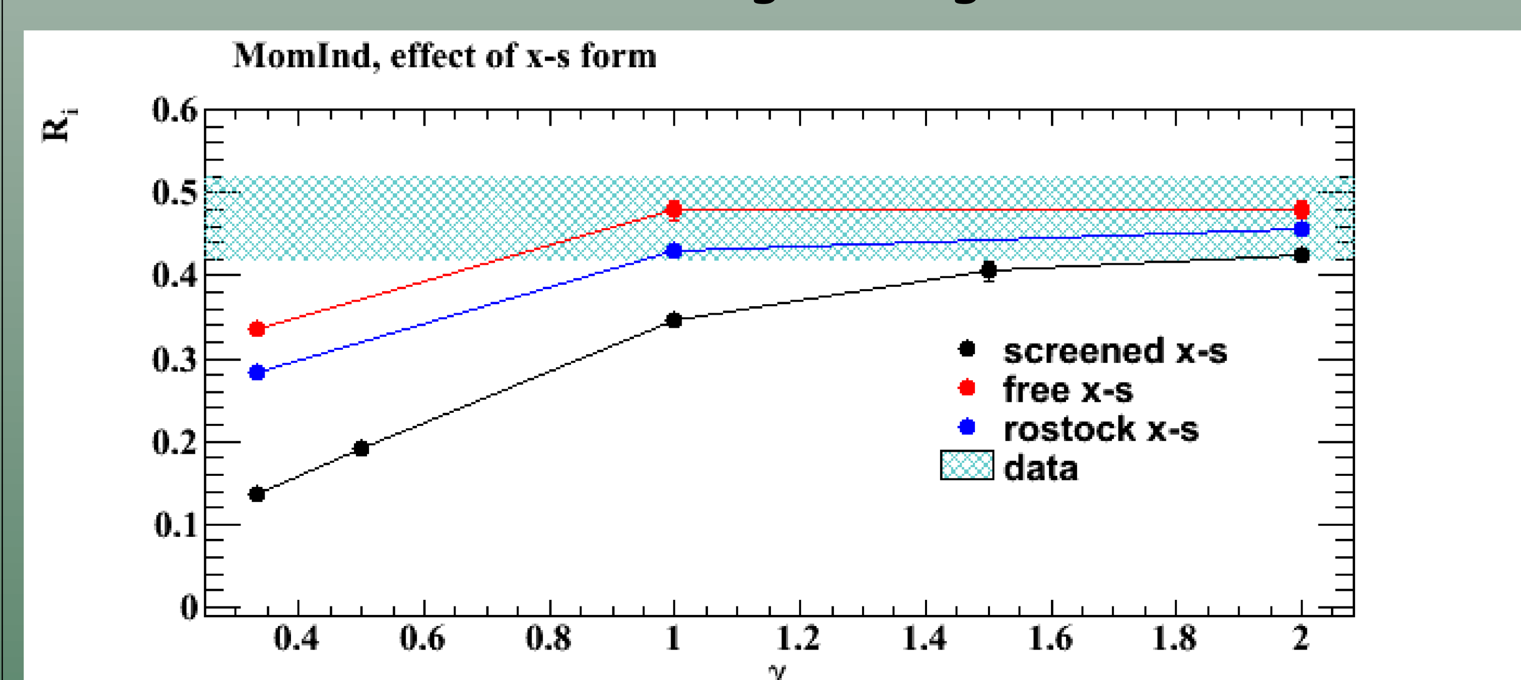


In medium cross section

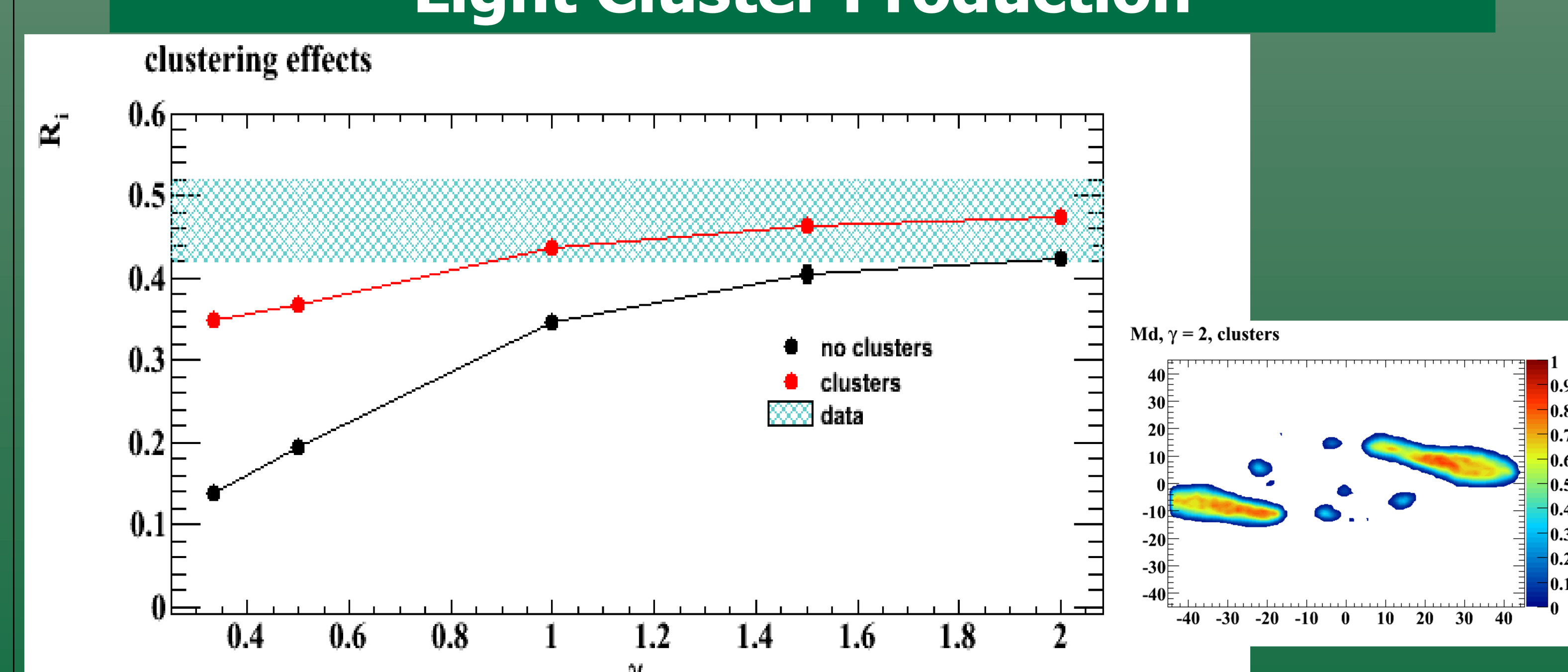
Examine three forms of the cross sections

Danielewicz, Acta Phys Pol B 33, 45 (2002)

- Free space cross sections
- Rostock - Energy and momentum dependent, parameterized from many-body theory near saturation density
- Screened – based on geometric arguments, fits data well at mid-to-high energies



Light Cluster Production



Discussion

Momentum Dependence:

Increases sensitivity of diffusion to symmetry energy

Changes dynamics, produces intermediate fragments

In medium Cross Sections:

Dramatically changes sensitivity to symmetry energy

Competition between viscosity and need for momentum change

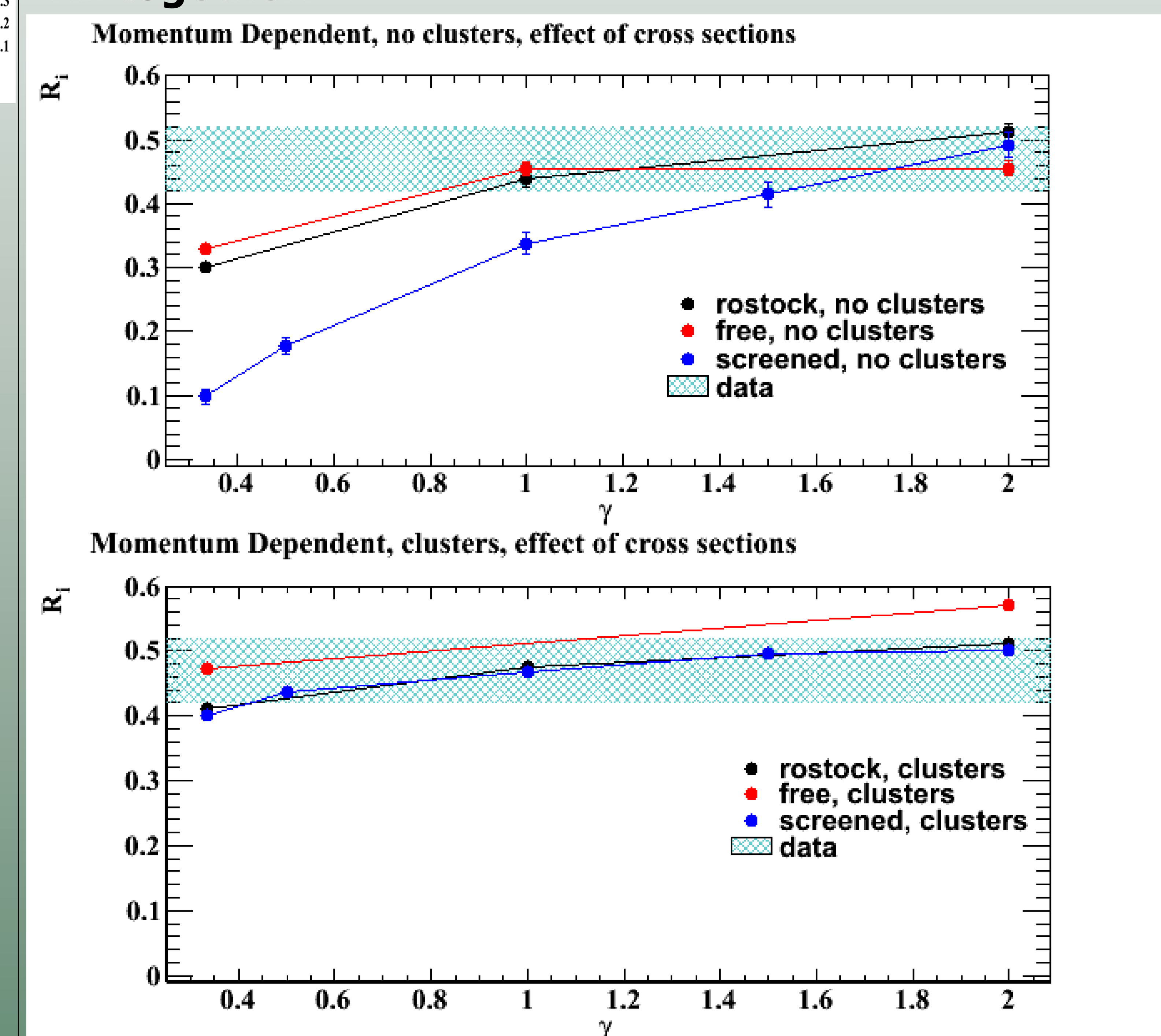
Light Cluster Production:

Reduces sensitivity to symmetry energy

Decreases diffusion

More and smaller fragments

All together:



Clustering is extremely important. We need a full clustering model to interpret isospin diffusion data.

Clustering reduces the sensitivity to the symmetry energy. More precise diffusion experiments are needed to place tighter constraints on the symmetry energy.

NSCL HiRA High Resolution Array

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