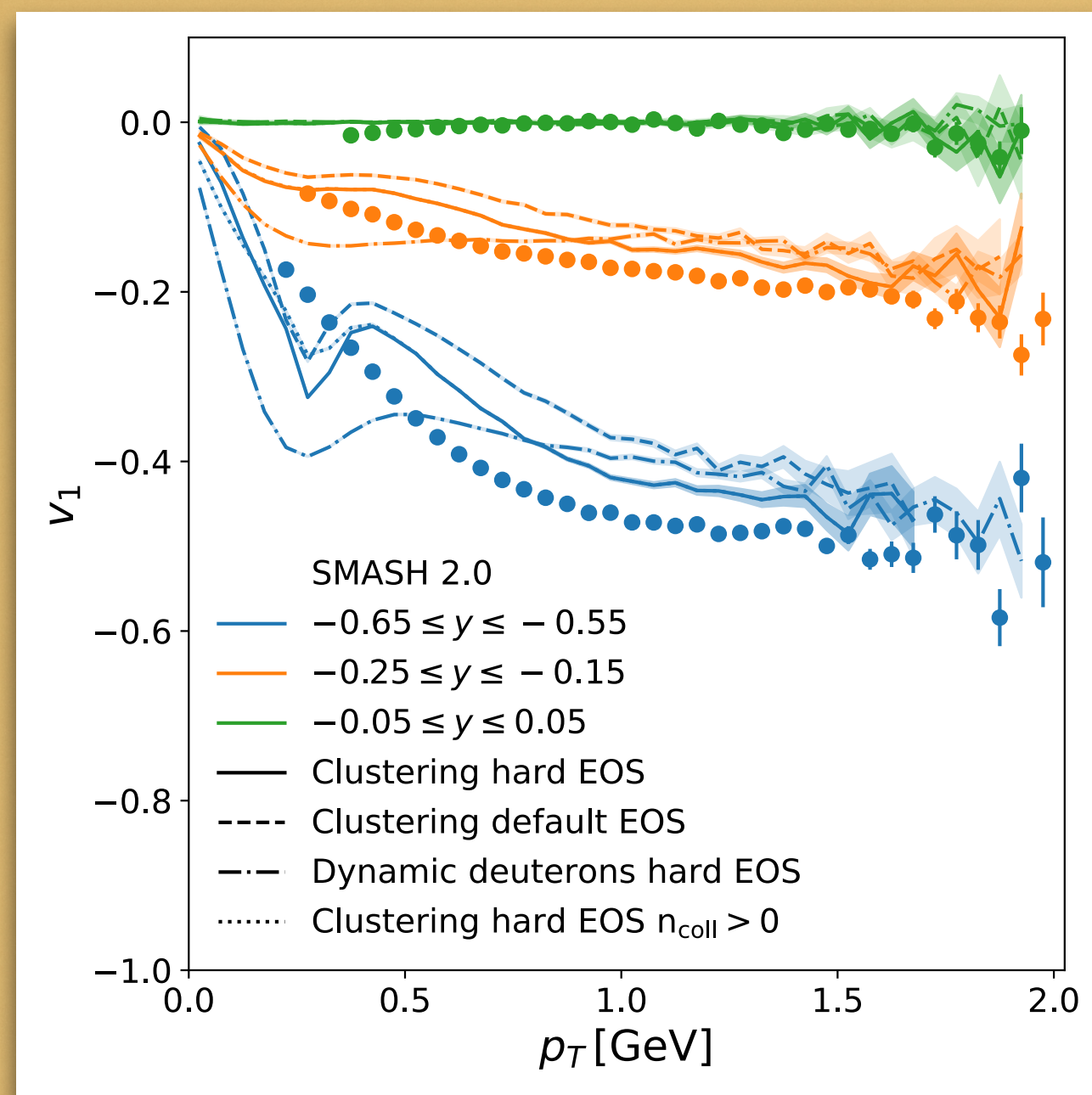


COLLECTIVE FLOW AT SIS ENERGIES WITH A HADRONIC TRANSPORT APPROACH: INFLUENCE OF LIGHT NUCLEI FORMATION AND EQUATION OF STATE

Justin Mohs, Hannah Elfner - Phys.Rev.C 105 (2022) 3, 034906

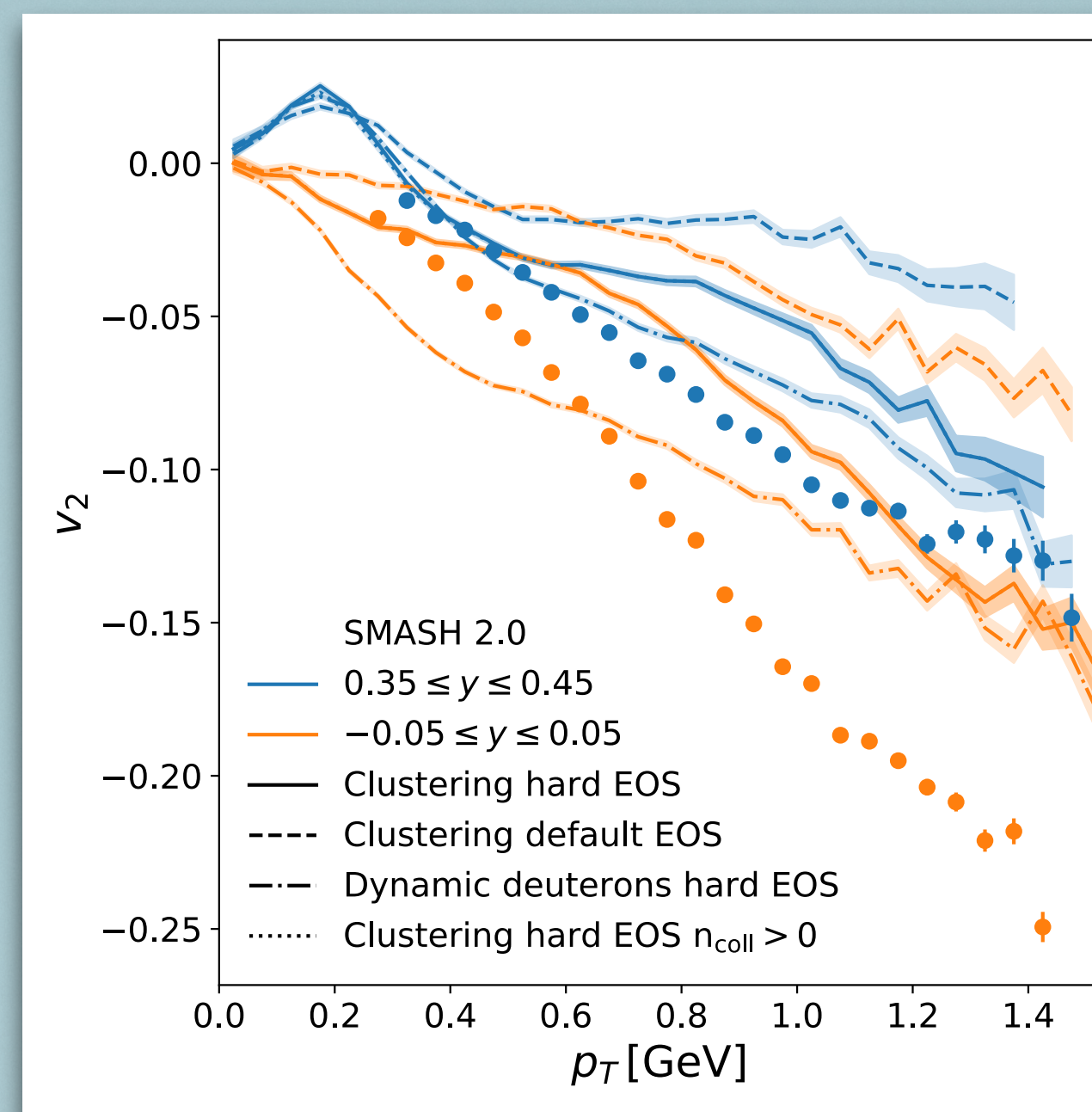
Directed Flow



- Observe best agreement with data using hard EoS
- Results are very sensitive to treatment of light Nuclei
- Directed flow well reproduced overall

Nucleons, Au+Au @ 1.23A GeV 20-30% centrality

Elliptic Flow

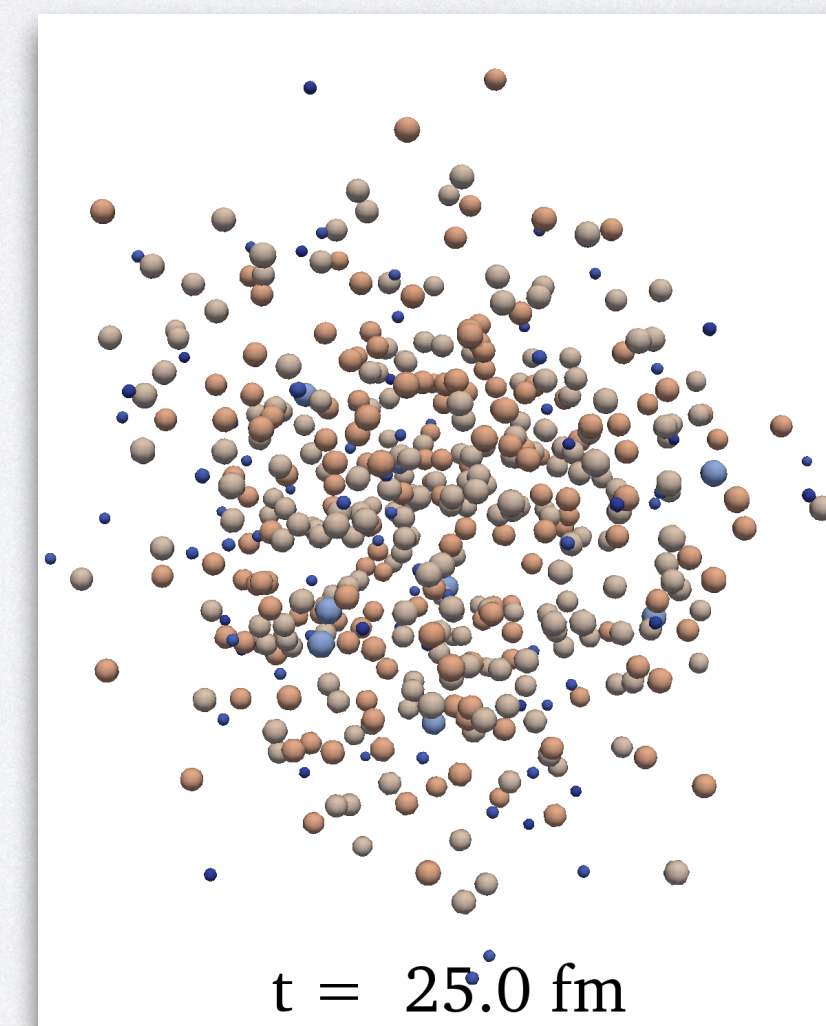
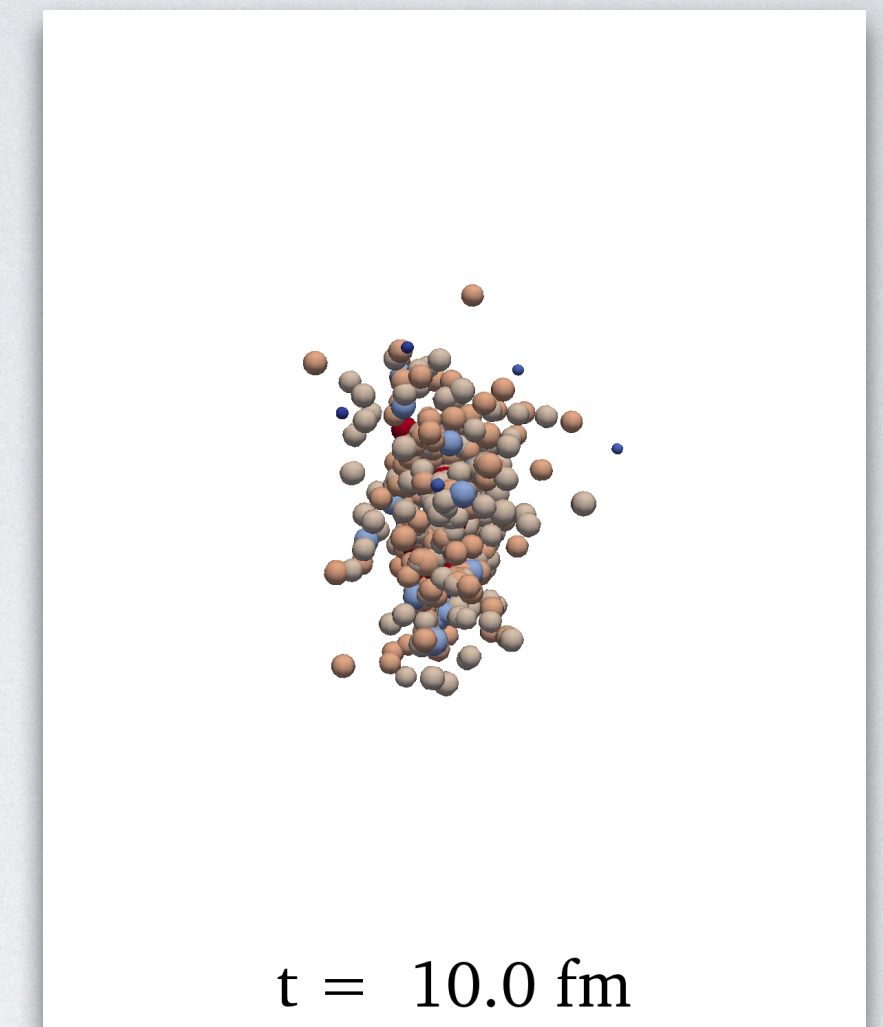
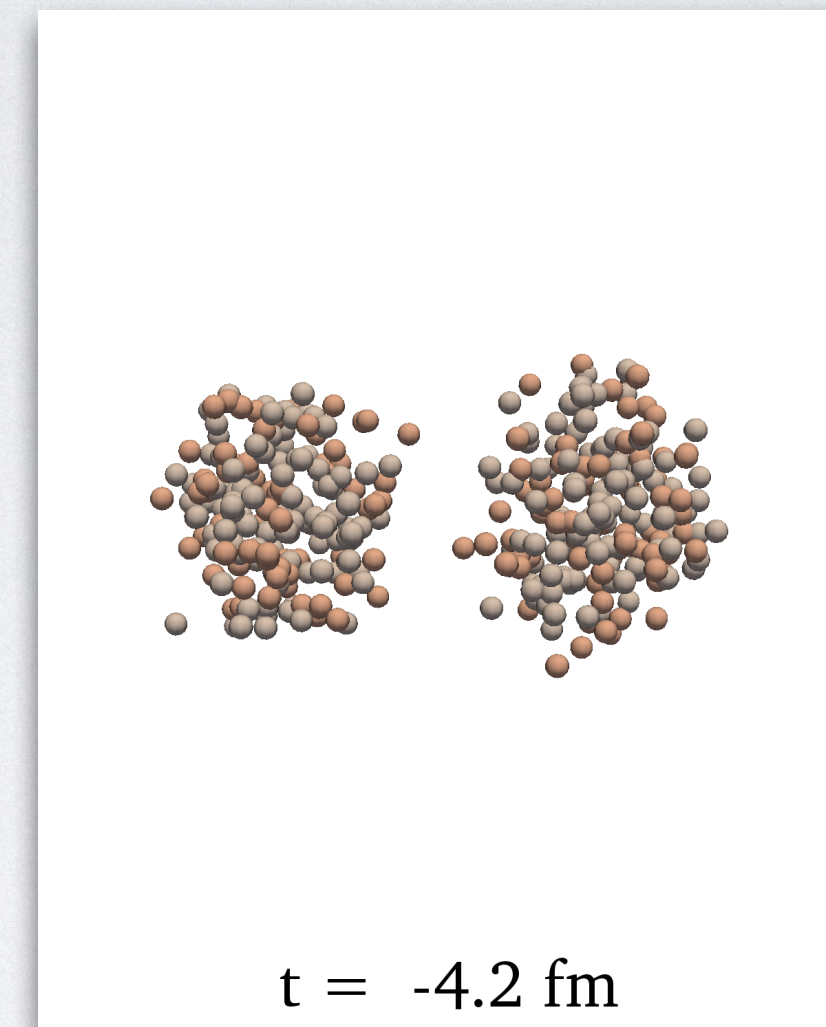


Nucleons, Au+Au @ 1.23A GeV 20-30% centrality

- Elliptic flow signal in general underestimated
- Hard EoS still works best
- Need improved potentials and centrality selection

SMASH

- Effective solution of the relativistic Boltzmann equation
- Hadron degrees of freedom including resonances from Particle Data Group
- Collisions between hadrons according to geometric collision criterion $d_{\text{trans}} < \sqrt{\sigma/\pi}$
- Publicly available at smash-transport.github.io



POTENTIALS AND EQUATIONS OF MOTION

- Simple Skyrme and symmetry potentials, so far, without momentum dependence
- Different equations of state defined by parameter set

$$U_{\text{Sk}} = A \left(\frac{\rho_B}{\rho_0} \right) + B \left(\frac{\rho_B}{\rho_0} \right)^\tau$$

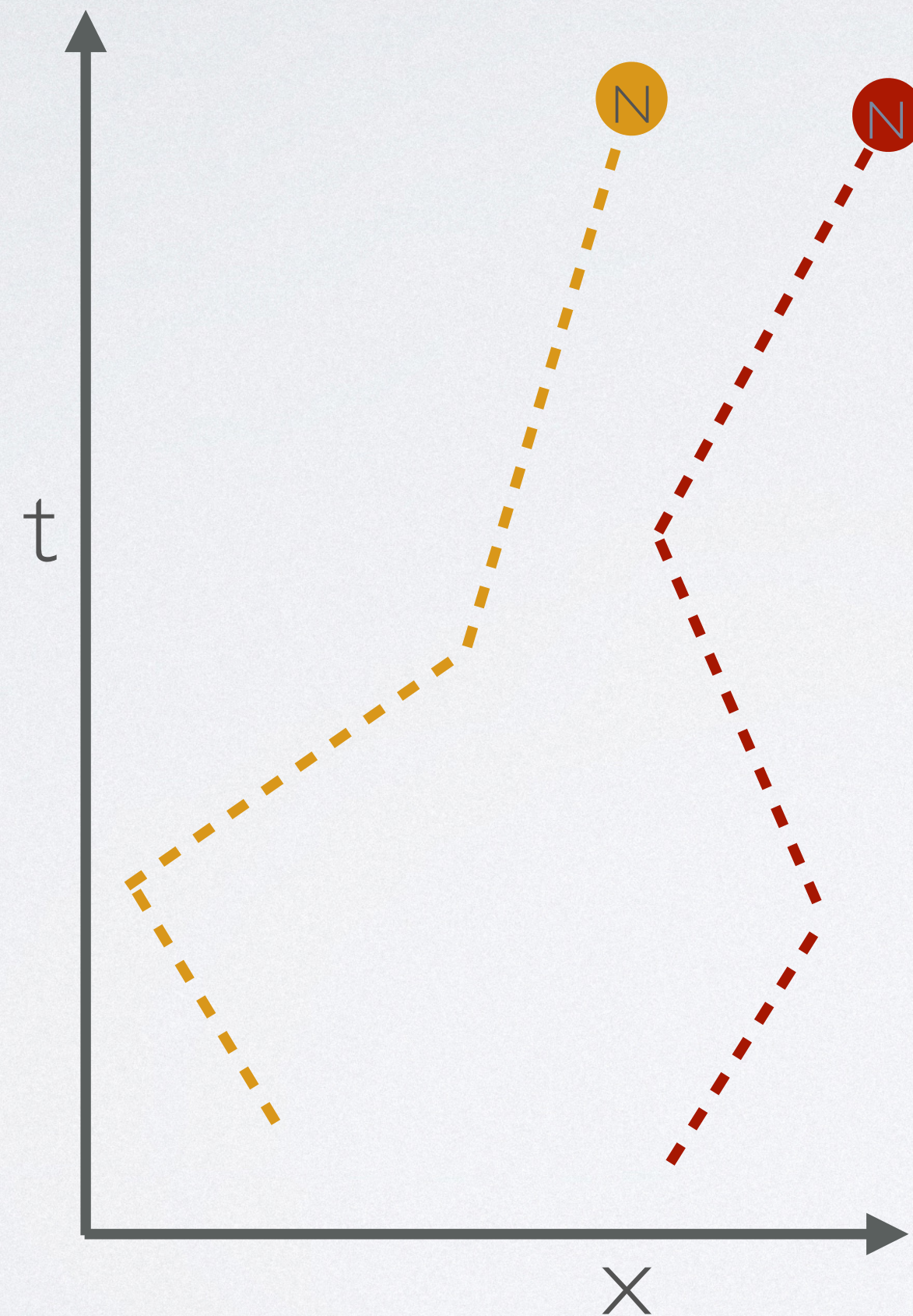
$$U_{\text{Sym}} = \pm 2S_{\text{pot}} \frac{\rho_{I_3}}{\rho_0}$$

	Soft	Default	Hard
<i>A</i>	-356 MeV	-209.2 MeV	-124 MeV
<i>B</i>	303 MeV	156.4 MeV	71 MeV
τ	1.17	1.35	2.0
<i>K</i>	200 MeV	240 MeV	375 MeV

LIGHT NUCLEI FORMATION

Clustering

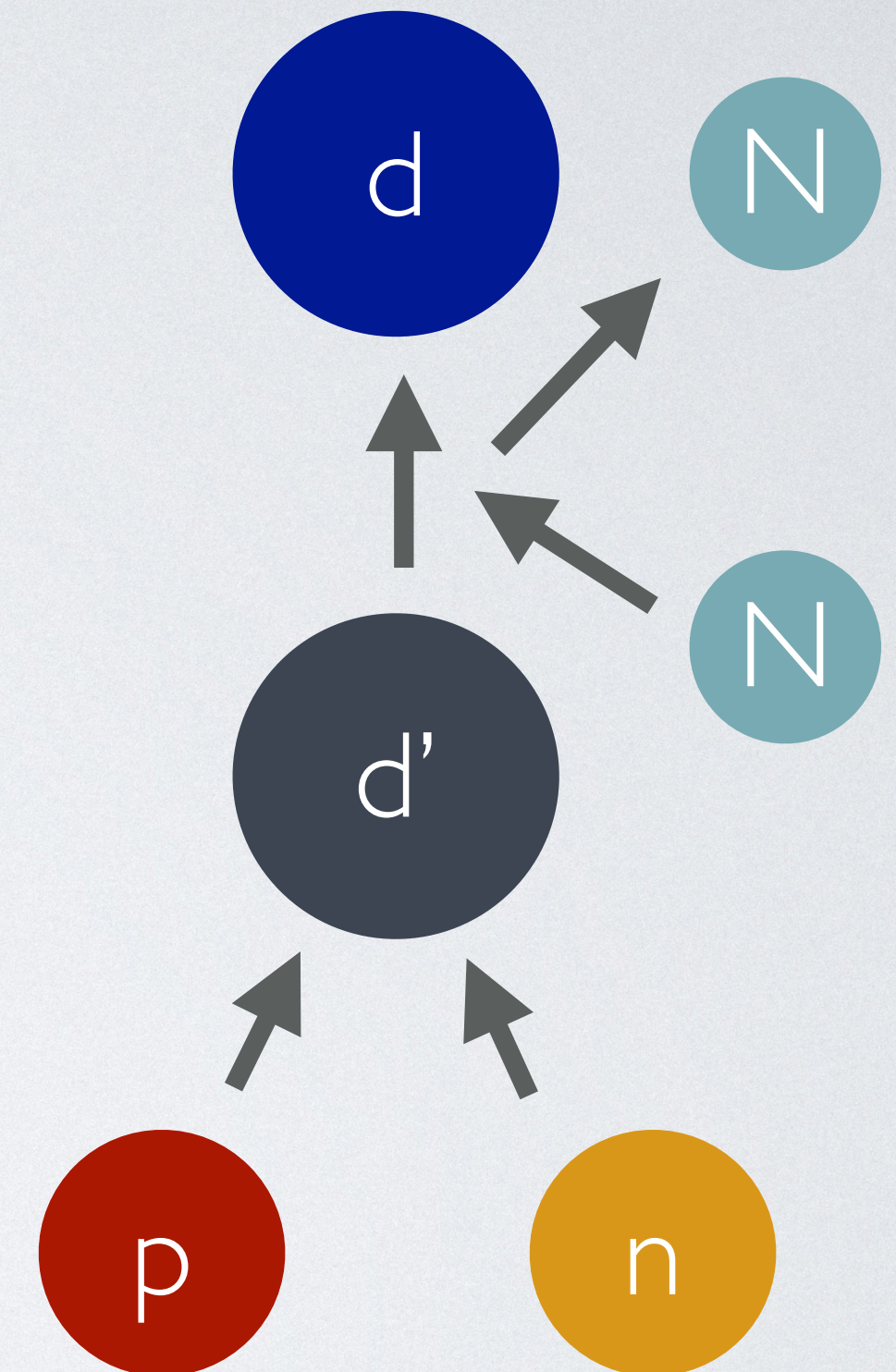
- Perform calculation without deuterons and identify light nuclei afterwards
- For each pair of nucleons
 - Look at the distance and momentum difference in their center of mass frame at the time of the latest collision of the two
 - Consider particles as clustered if $\Delta r < r_0$ and $\Delta p < p_0$



Zhu et al. Phys.Rev.C 92 (2015), Sombun et al. Phys.Rev.C 99 (2019)

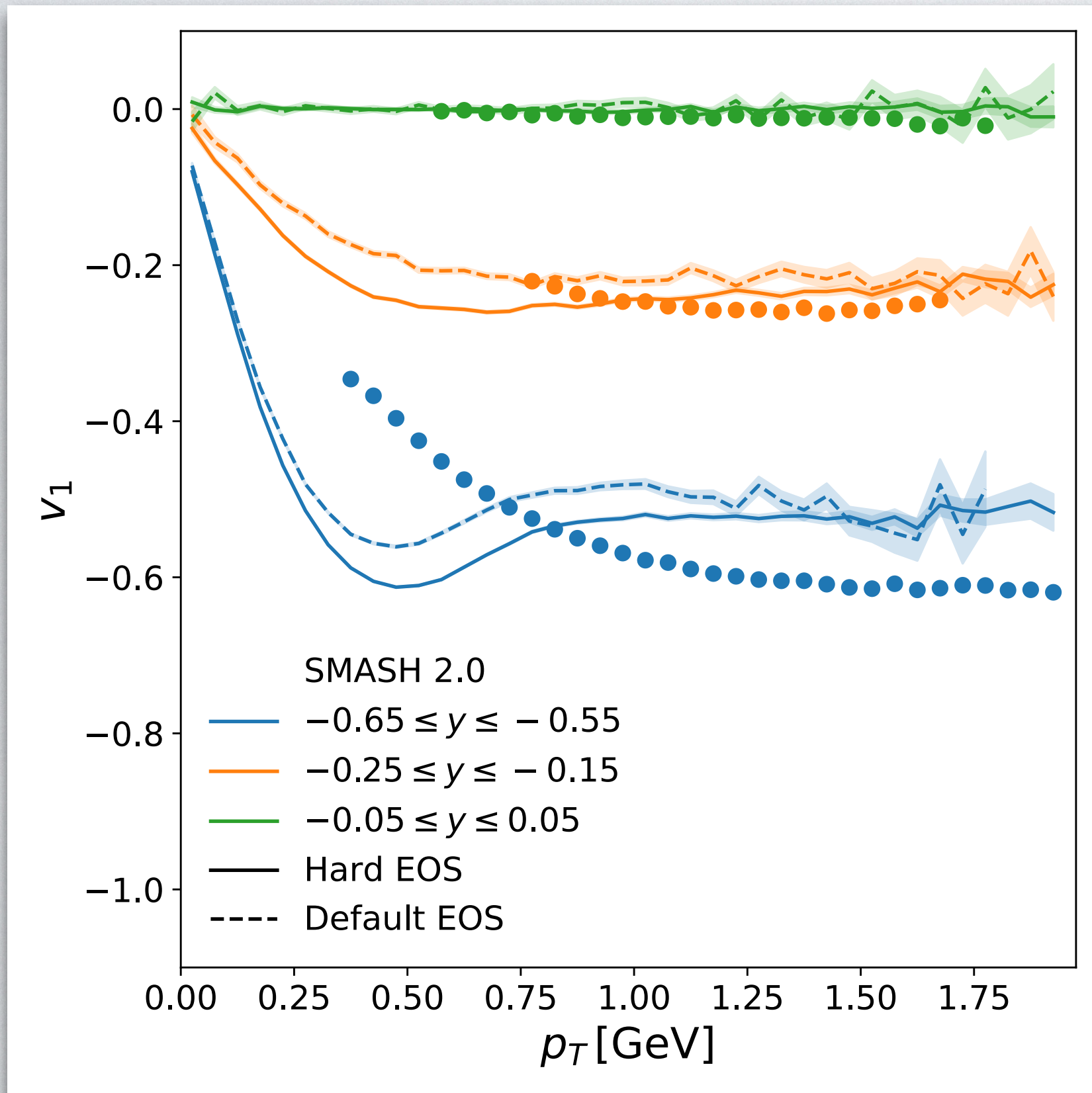
Dynamic deuterons

- Deuteron represented as a single particle
- Produced in $3 \leftrightarrow 2$ reactions
 $pnN \leftrightarrow dN$ and $pn\pi \leftrightarrow d\pi$
- Reactions modelled in two steps via “fake” dibaryon resonance $pn \leftrightarrow d'$ and $Nd' \leftrightarrow Nd$
- Deuterons contribute to densities with baryon number 2 and are affected by potentials



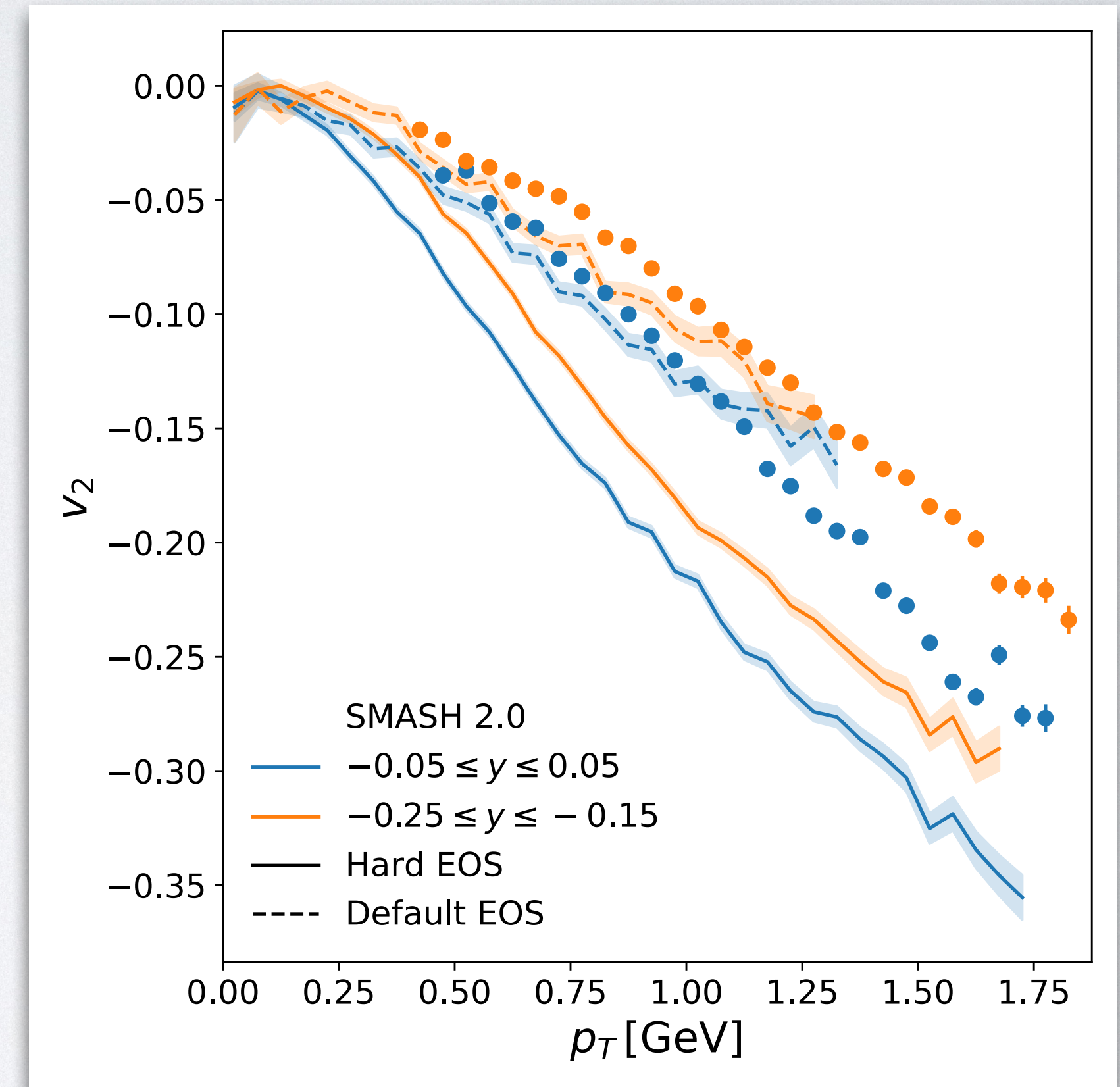
Oliinychenko et al. Phys.Rev.C 99 (2019)

DEUTERON FLOW



Deuterons, Au+Au @ 1.23A GeV 20-30% centrality

- Flow calculated with deuterons as active degree of freedom
- Reasonable agreement with the data for directed flow with hard EOS
- Elliptic flow would require a softer EoS



Deuterons, Au+Au @ 1.23A GeV 20-30% centrality