IWM-EC 2018:

Dynamical properties and secondary decay effects of projectile fragmentation in ^{124}Sn,^{107}Sn + ^{120}Sn at 600 MeV/nucleon

Jun Su, Long Zhu, Wen-Jie Xie, Feng-Shou Zhang, and Wolfgang Trautmann

Sino-French Inst. of Nucl. Engineering and Technology, Sun Yat-sen University

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Sun Yat-sen University
Yuncheng University
IMP-CAS Lanzhou
Beijing Normal University
GSI Darmstadt

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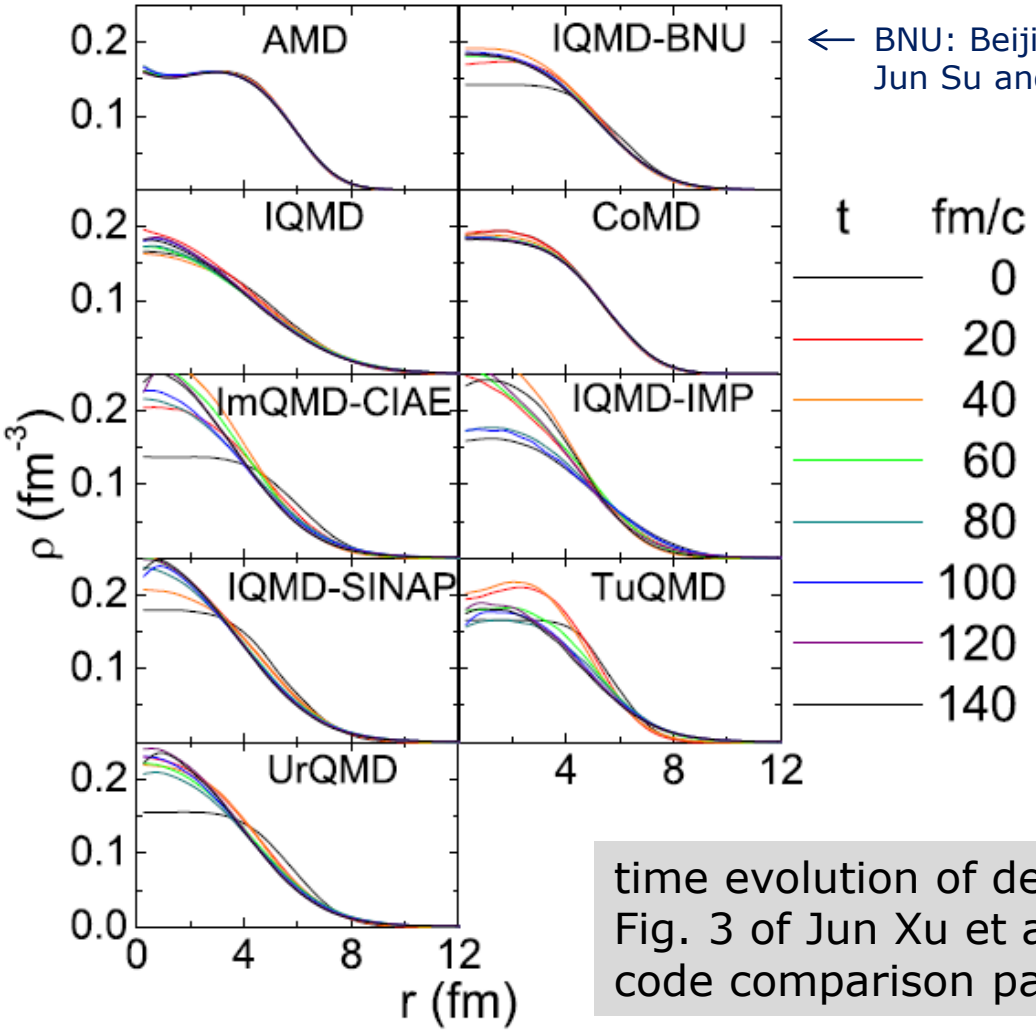
Intro I: Pauli blocking and projectile fragmentation?



← BNU: Beijing Normal University
Jun Su and Feng-Shou Zhang

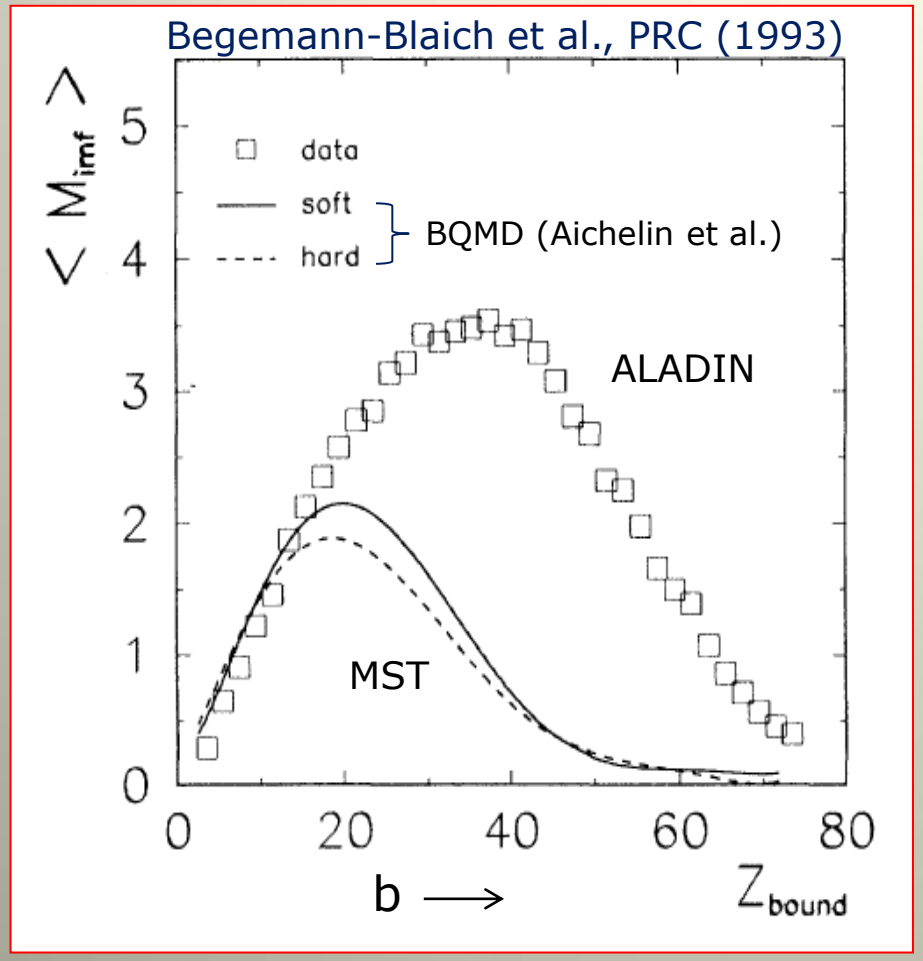
^{197}Au

stability of the initial configurations with time

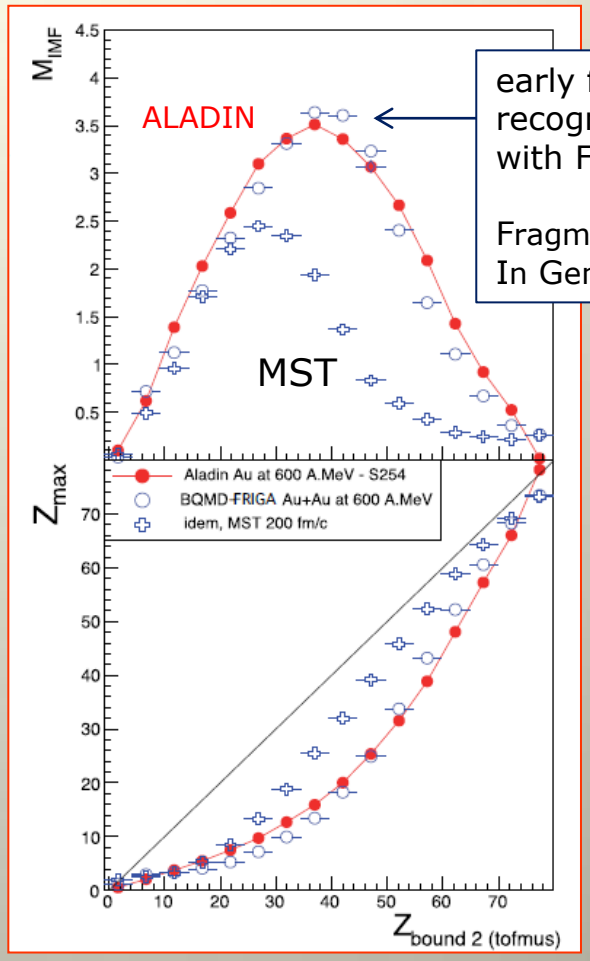
time evolution of density profiles
Fig. 3 of Jun Xu et al., PRC (2017)
code comparison paper

Intro II: the MST puzzle

^{197}Au + Cu @ 600 MeV/nucleon



^{197}Au + ^{197}Au @ 600



early fragment recognition with FRIGA (60 fm/c)

Fragment Recognition In General Application

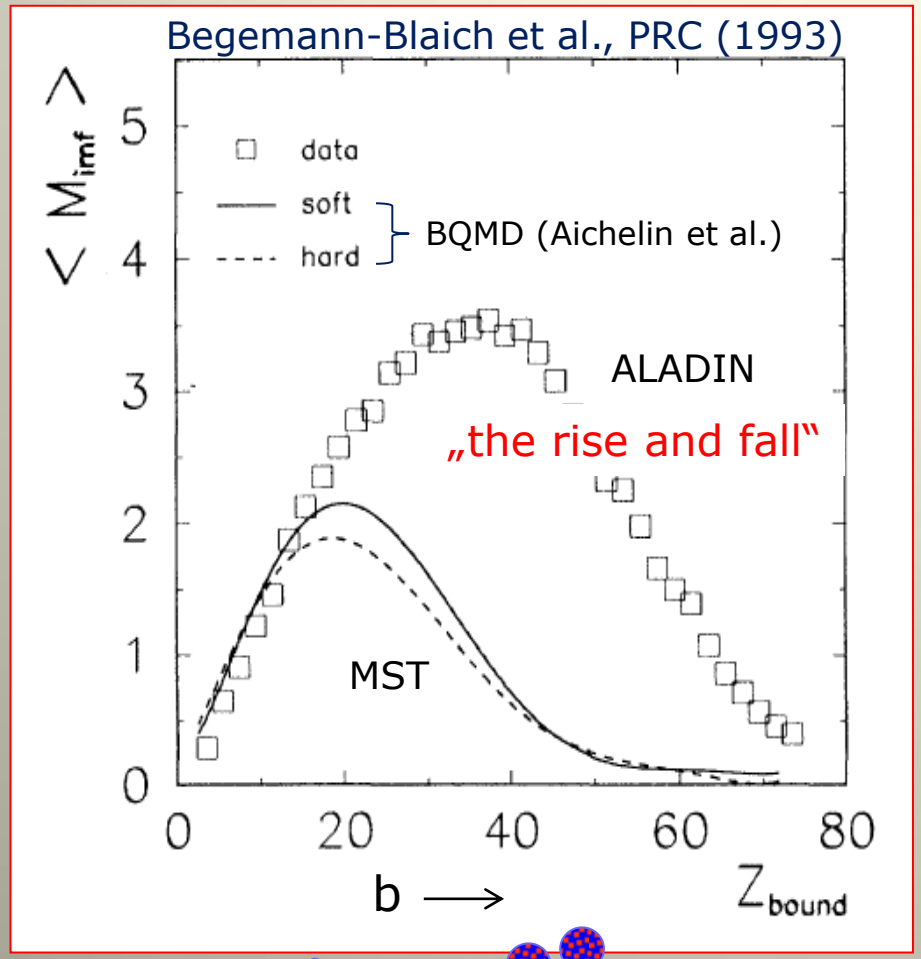
$Z_{bound} = \Sigma Z_i$ with $Z_i \geq 2$

Le Fèvre et al., IWM-EC 2016

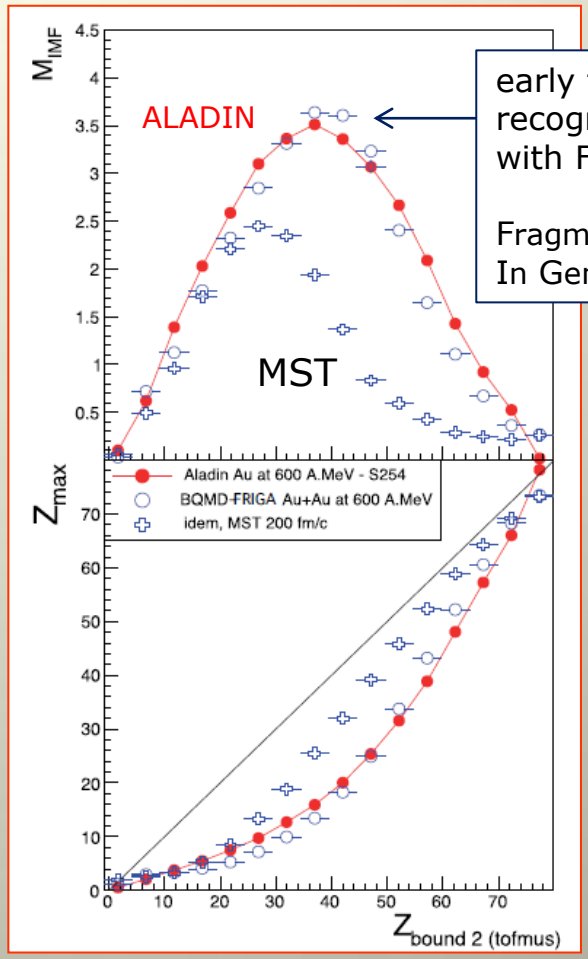
Intro II: the MST puzzle

^{197}Au + Cu @ 600 MeV/nucleon

Begemann-Blaich et al., PRC (1993)

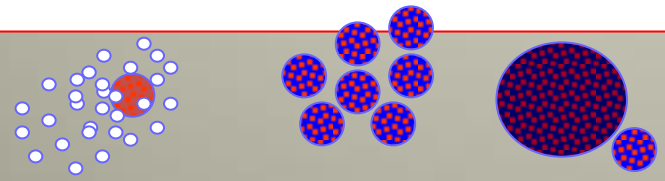


^{197}Au + ^{197}Au @ 600



early fragment recognition with FRIGA (60 fm/c)

Fragment Recognition In General Application



Le Fèvre et al., IWM-EC 2016

Intro II: the MST puzzle

^{197}Au + Cu @ 600 MeV/nucleon

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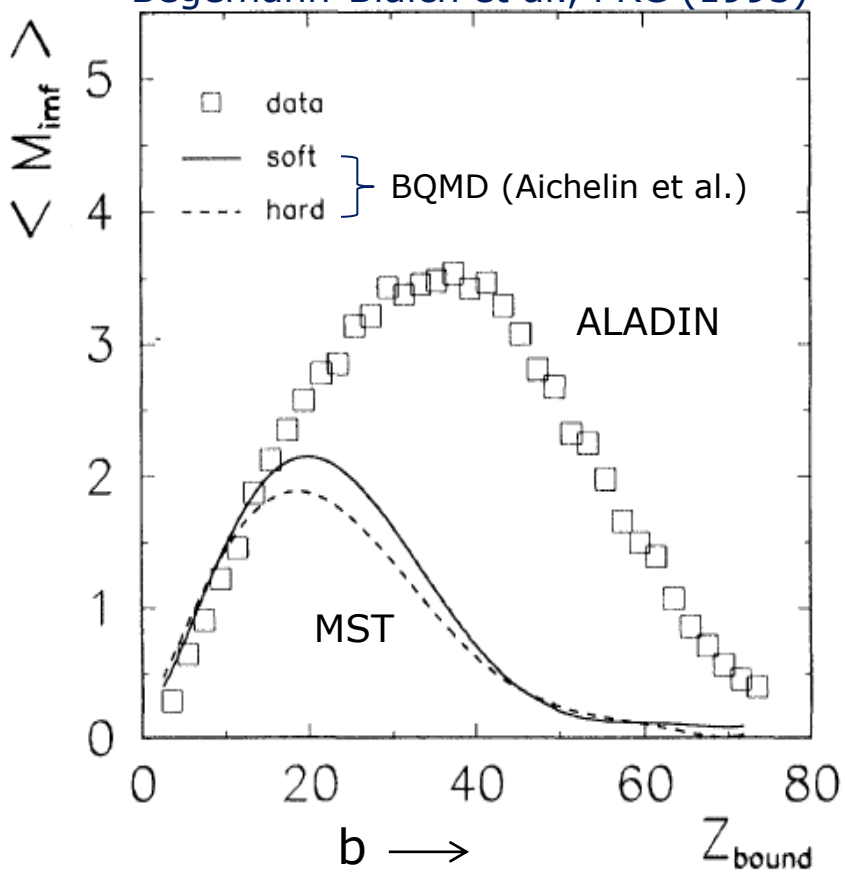
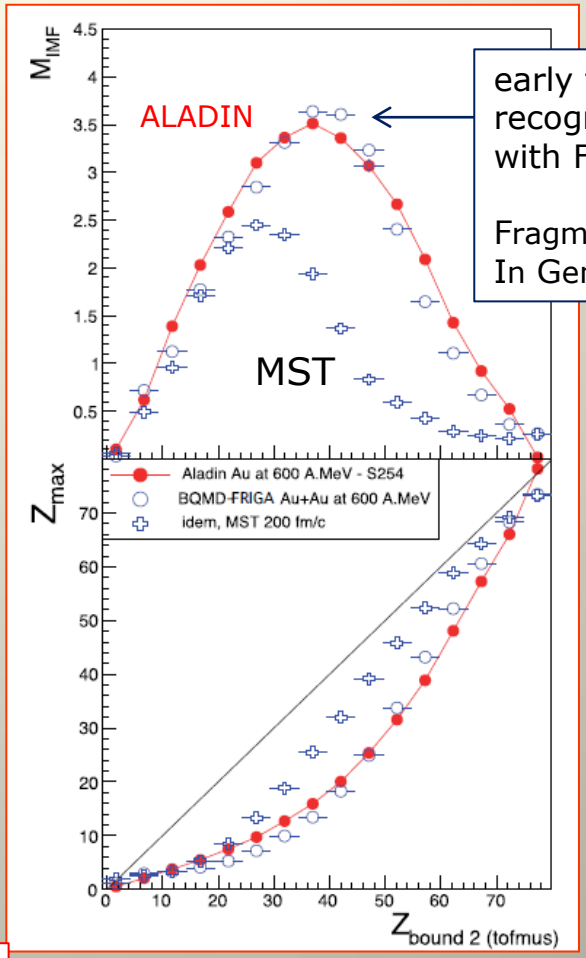


^{197}Au + ^{197}Au @ 600



early fragment recognition with FRIGA (60 fm/c)

Fragment Recognition In General Application

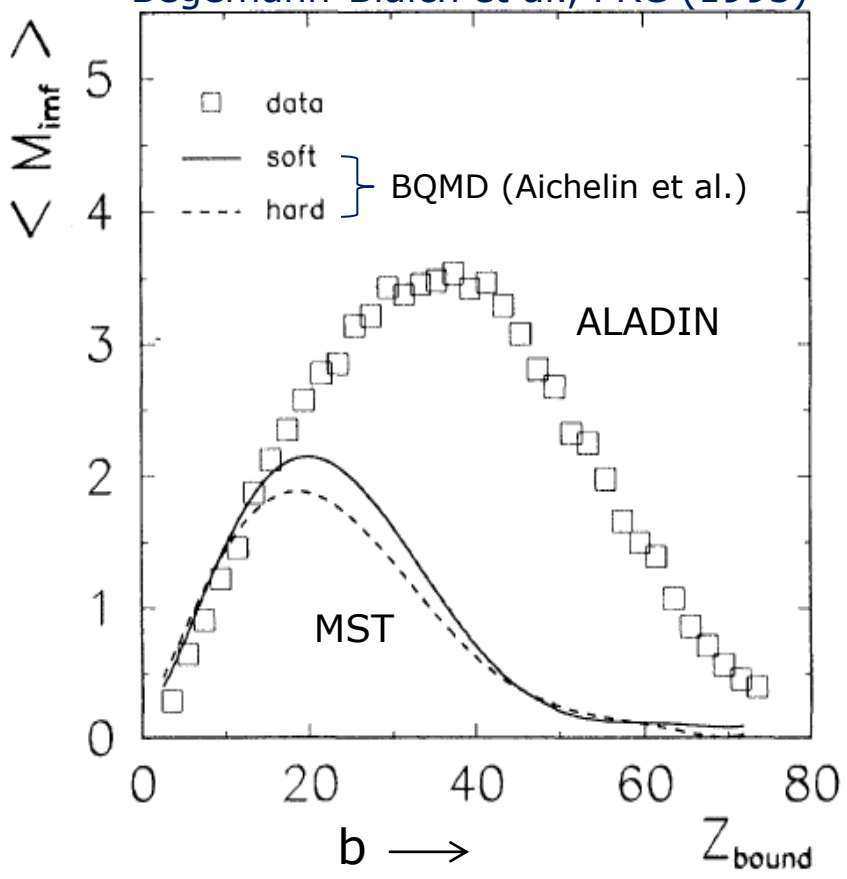
Le Fèvre et al., IWM-EC 2016

... it is not possible to reproduce the fragment distributions and the light-particle multiplicities observed in this experiment at relativistic energies.

Intro III: early fragment recognition

^{197}Au + Cu @ 600 MeV/nucleon

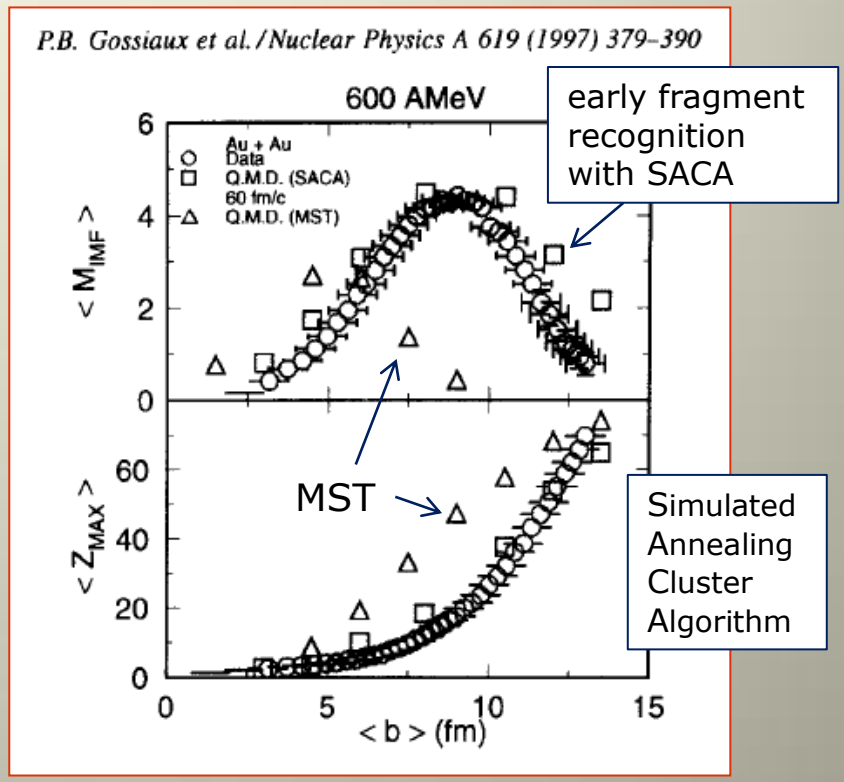
Begemann-Blaich et al., PRC (1993)



$Z_{bound} = \Sigma Z_i$ with $Z_i \geq 2$

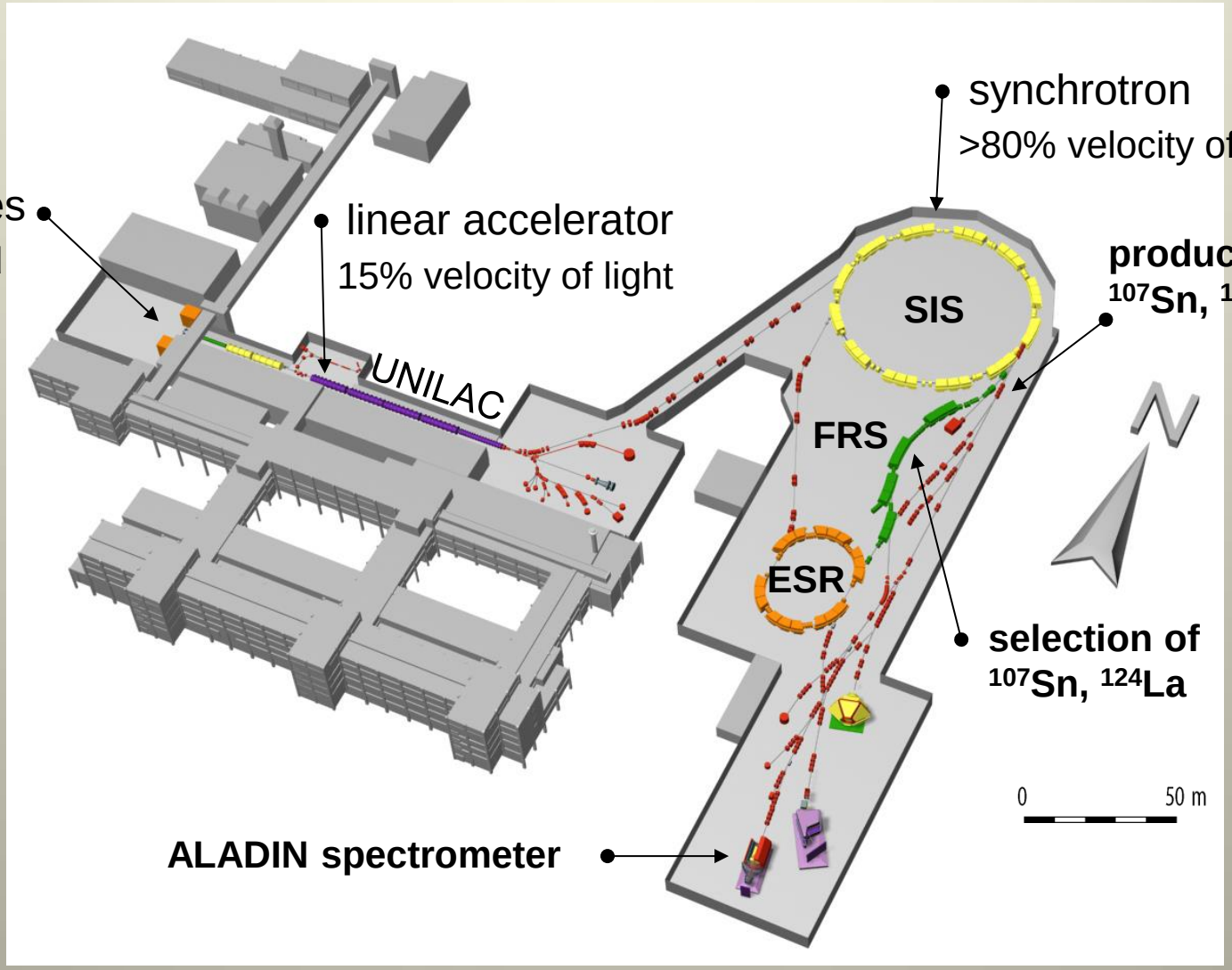
long history:

Dorso & Randrup 1991
Puri, Hartnack, Aichelin 1996
Vermani & Puri 2009
Le Fèvre et al. 2015



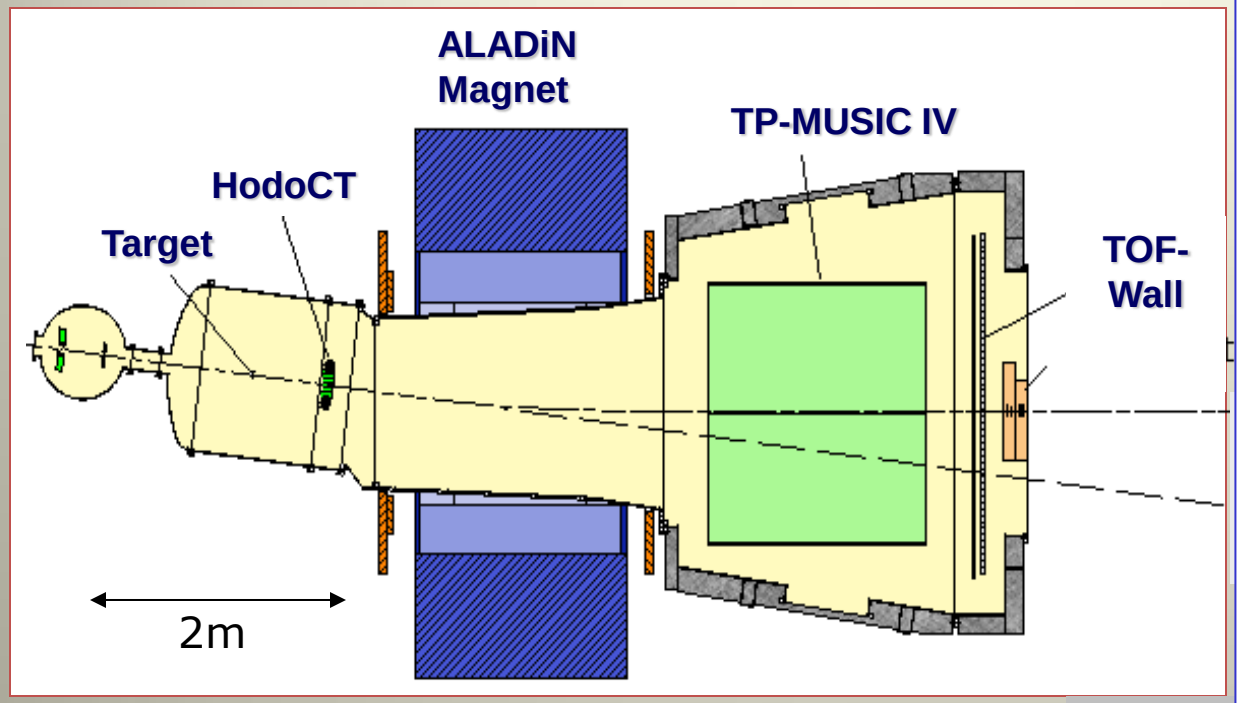
Gossiaux et al., NPA (1997)

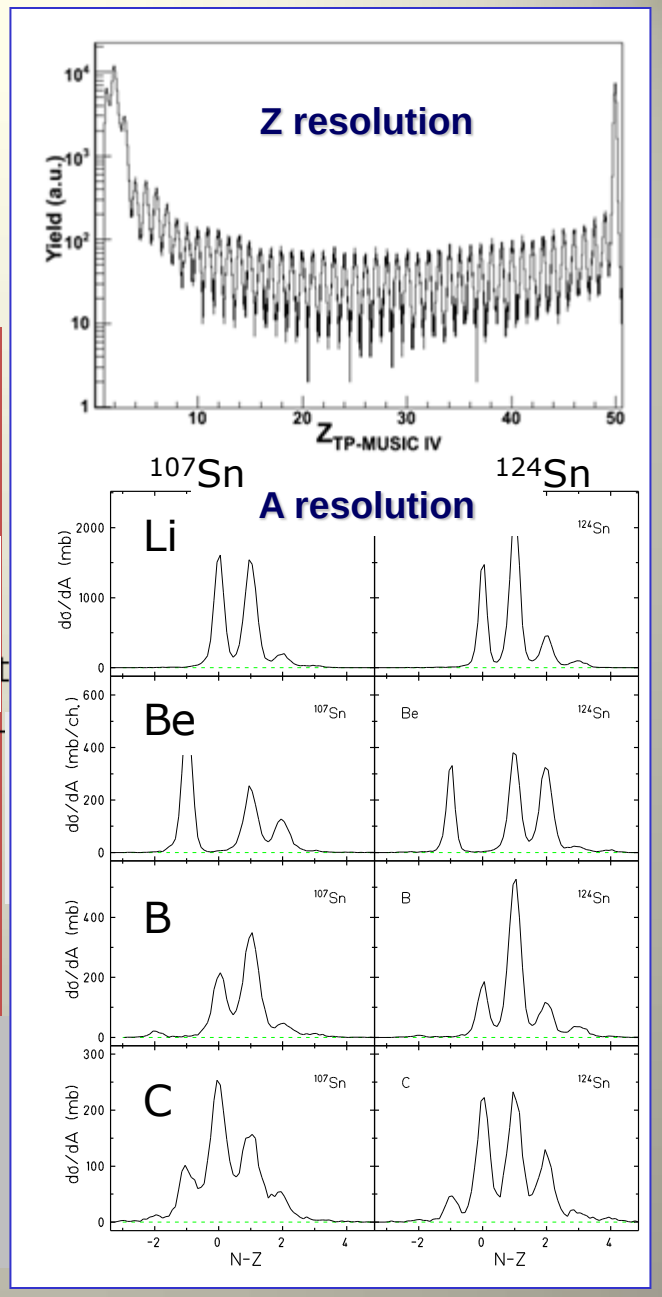
experiment S254: UNILAC + SIS-FRS + ALADIN



ALADiN experiment S254

Projectile fragmentation of
neutron-rich and **neutron-poor**
projectiles: ^{124}Sn, **^{107}Sn, ^{124}La** (all 600 MeV/u)





full acceptance for projectile fragments with Z≥3
vertical ± 5 deg
horizontal ± 10 deg

C. Sfienti et al., PRL 102 (2009), R. Ogul et al., PRC 83 (2011)

IQMD-BNU: Pauli blocking

Jun Su et al., PRC 89, 014619 (2014)

Phase-Space Density Constraint (PSDC)
as in CoMD (Papa, Maruyama, and Bonasera, 2001)

from PRC 89:

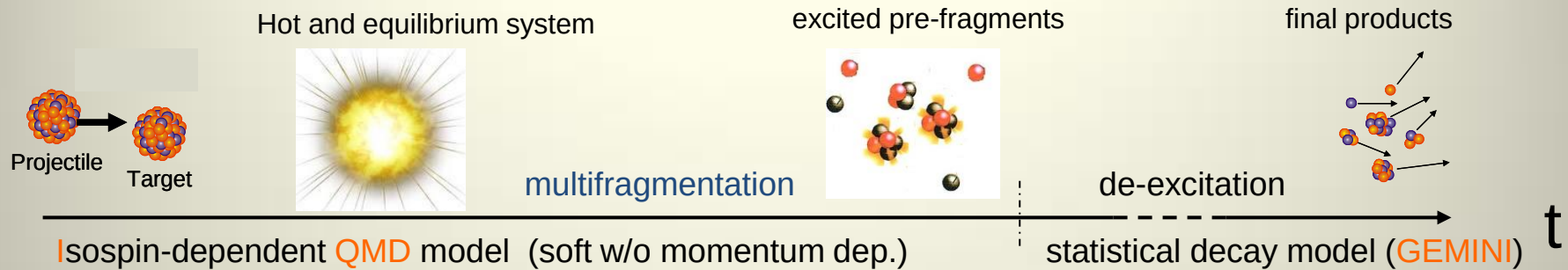
At each time step and for each nucleon, the phase space occupation $\overline{f}_i$ is checked. If phase space occupation $\overline{f}_i$ has a value greater than 1, the momentum of the ith nucleon is changed randomly by many-body elastic scattering.

collisions:

usually allowed with probability $(1-f'_i)(1-f'_j)$ where f'_i and f'_j are the phase space densities **before** the scattered particle is placed there;

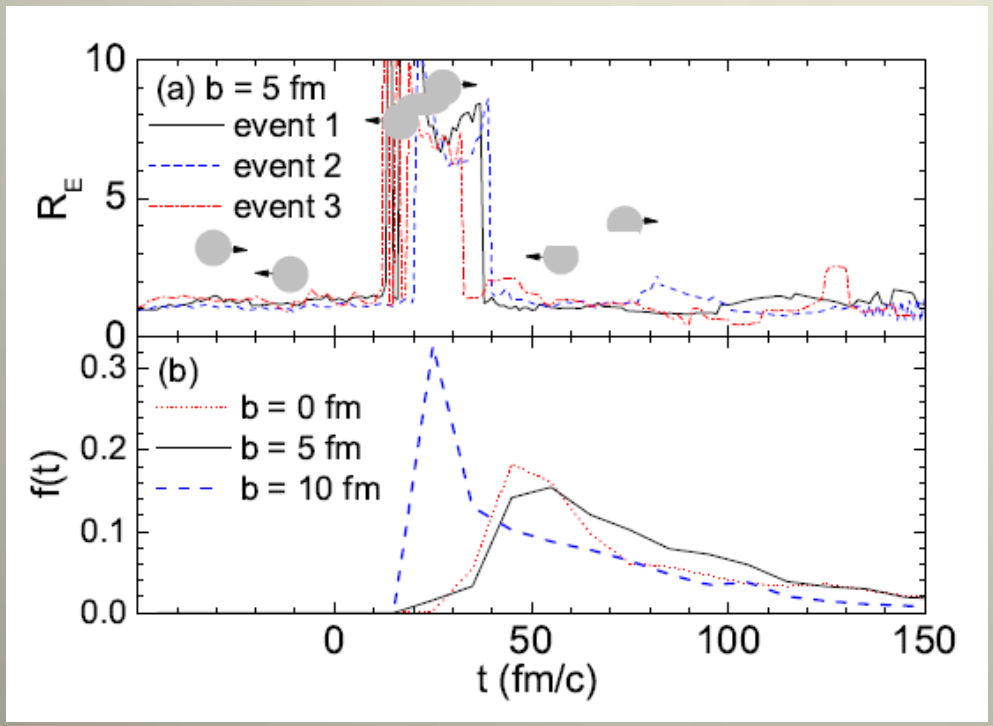
here the Pauli blocking method related to the phase-space density constraint (PSDC) is used. If $\overline{f}_i$ and $\overline{f}_j$ at the **final states** are both less than 1, the collision is accepted.

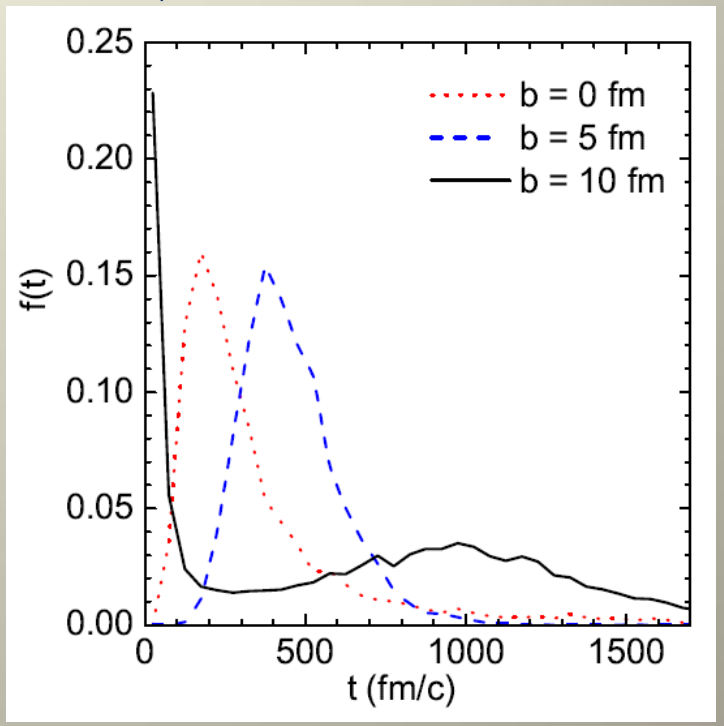
IQMD-BNU: evolution with time



equilibrium:
momenta isotropic

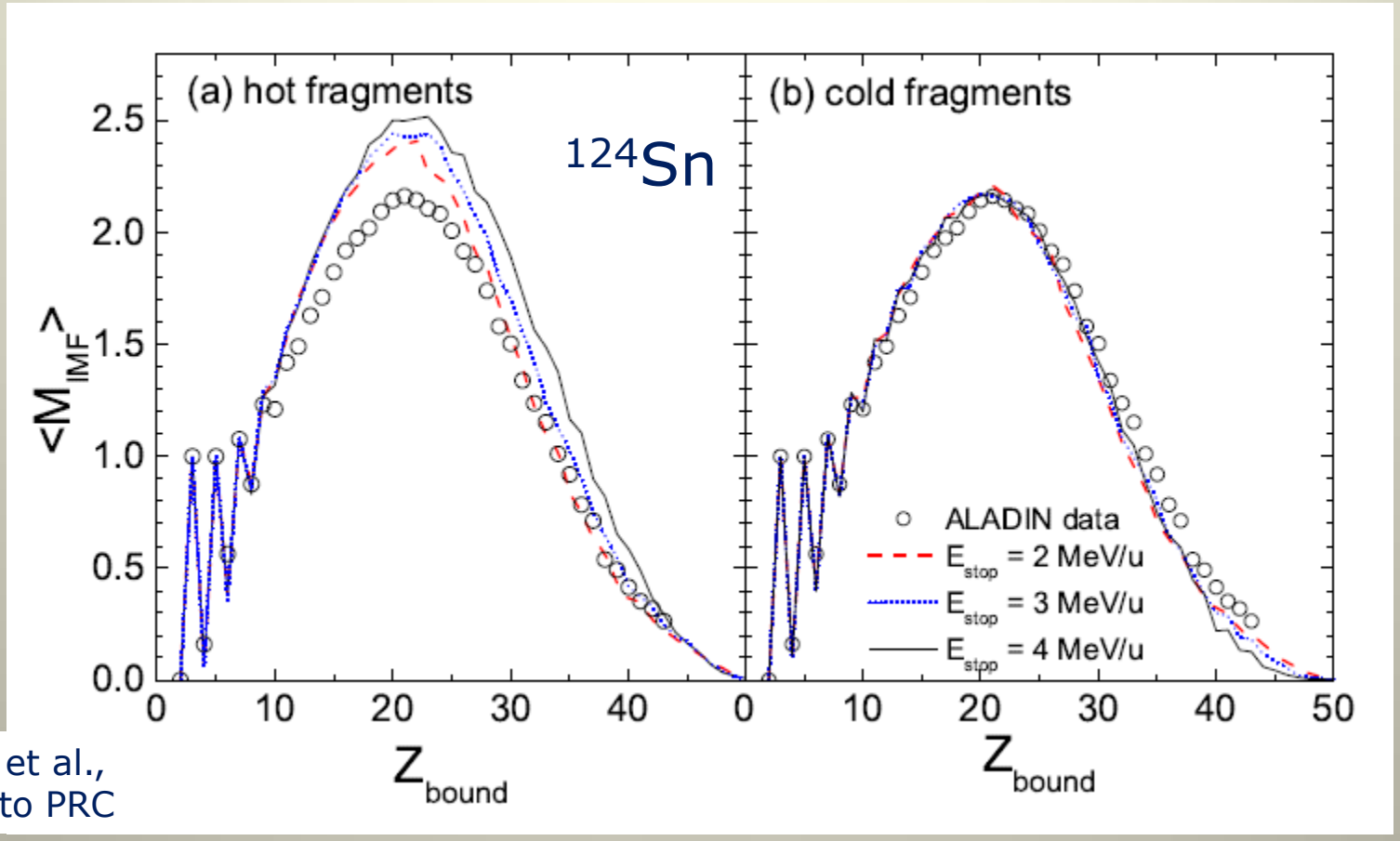
switching:
excitation energy of two heaviest prefragments lower than E_{stop} (~3 MeV/u)





all graphics by Jun Su

hot ⟶ cold fragments (IMF: Z=3-20)

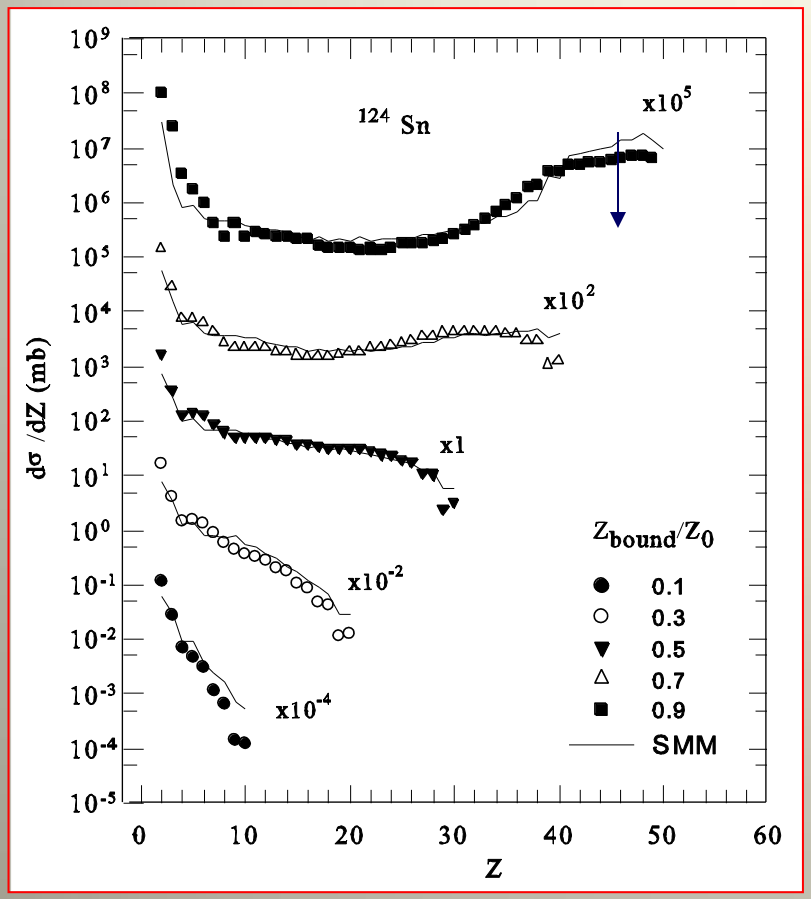


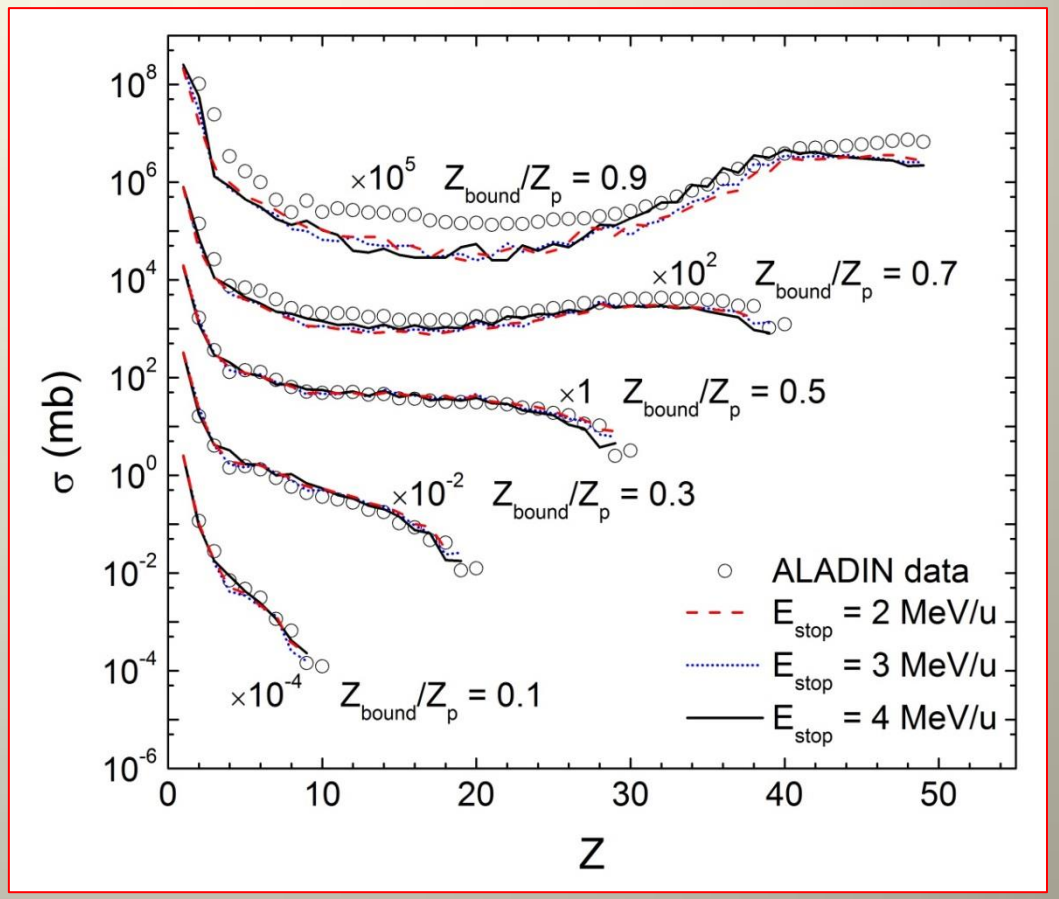
Jun Su et al.,
subm. to PRC

no E_{stop} dependence of final fragment multiplicity

SMM ensemble calculations
statistical description

IQMD + GEMINI
dynamical description





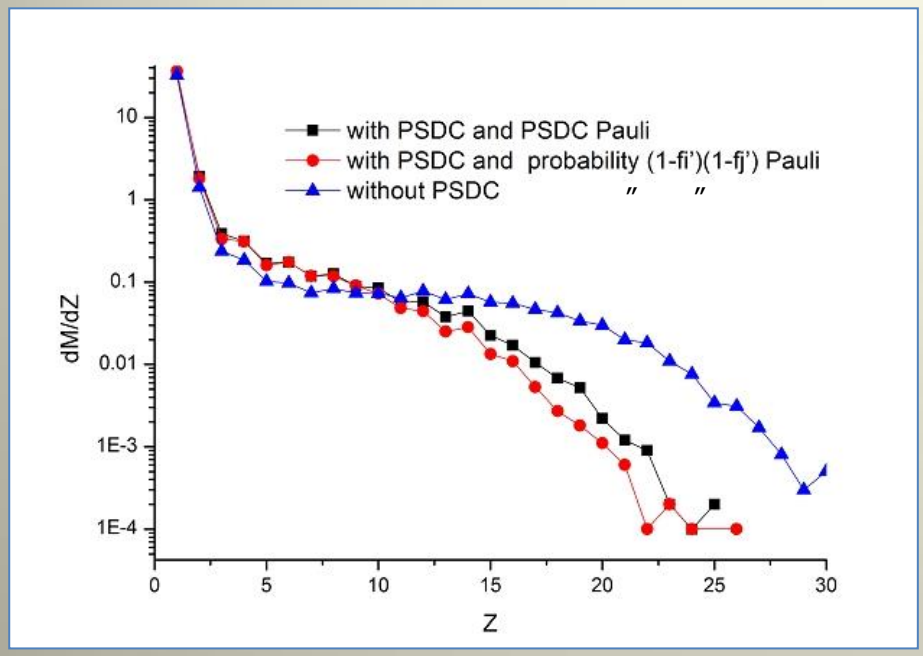
R. Ogul et al., PRC 83 (2011)

Jun Su et al., submitted to PRC

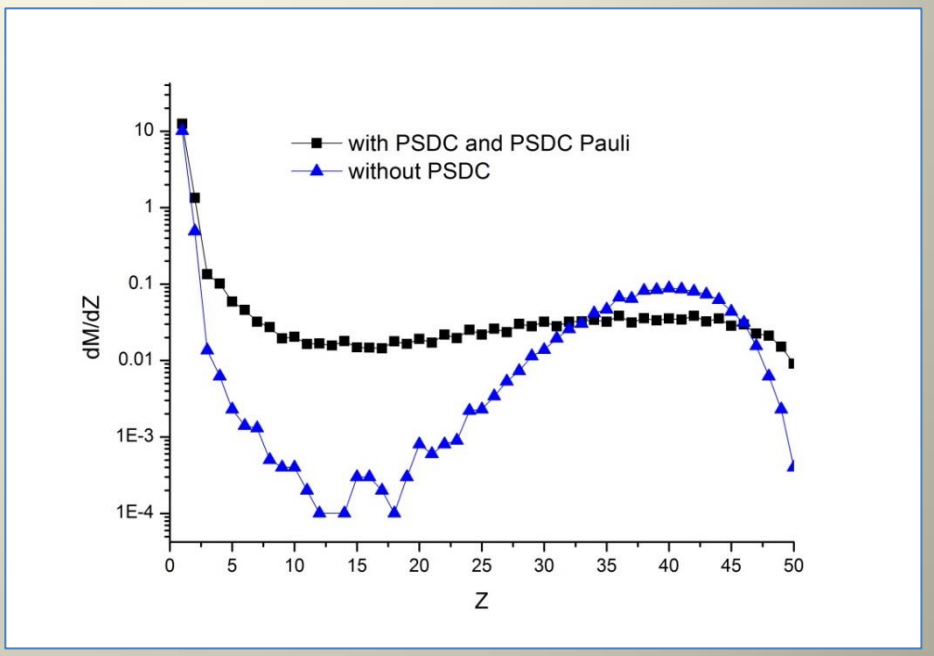
IMFs and the Phase-Space Density Constraint (PSDC)

$^{124}Sn + ^{120}Sn$ @ 600 MeV/nucleon

b = 5 fm



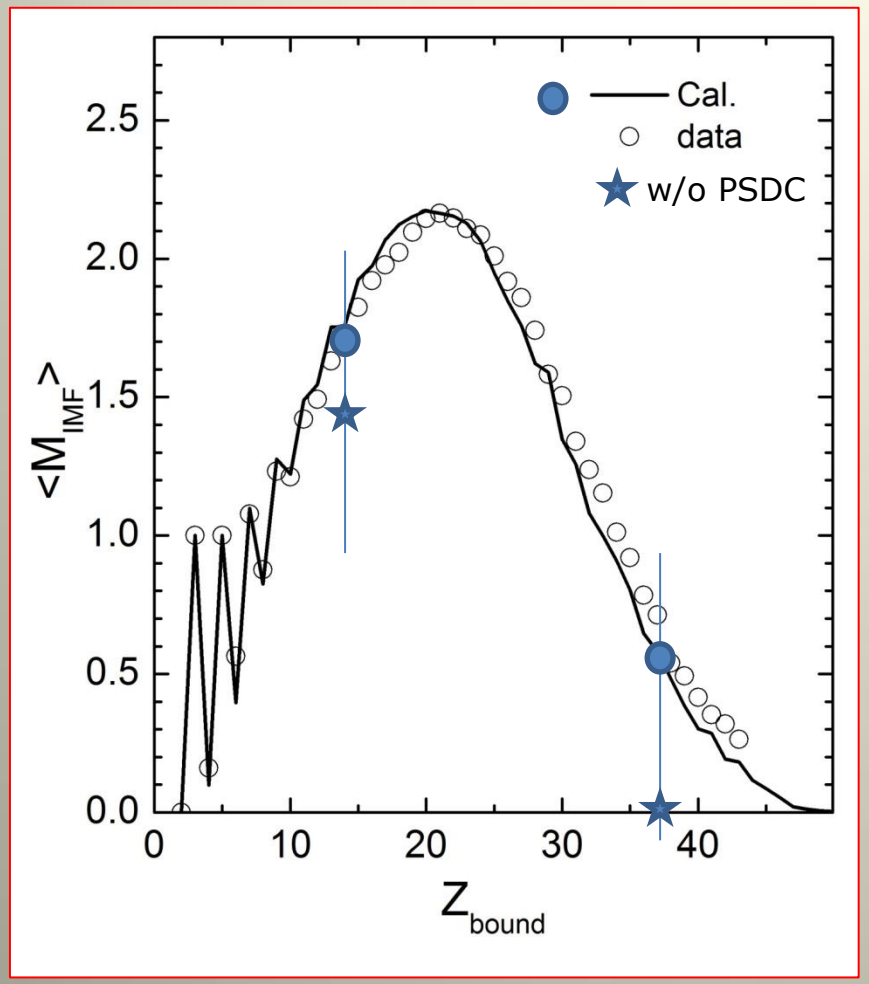
b = 9 fm



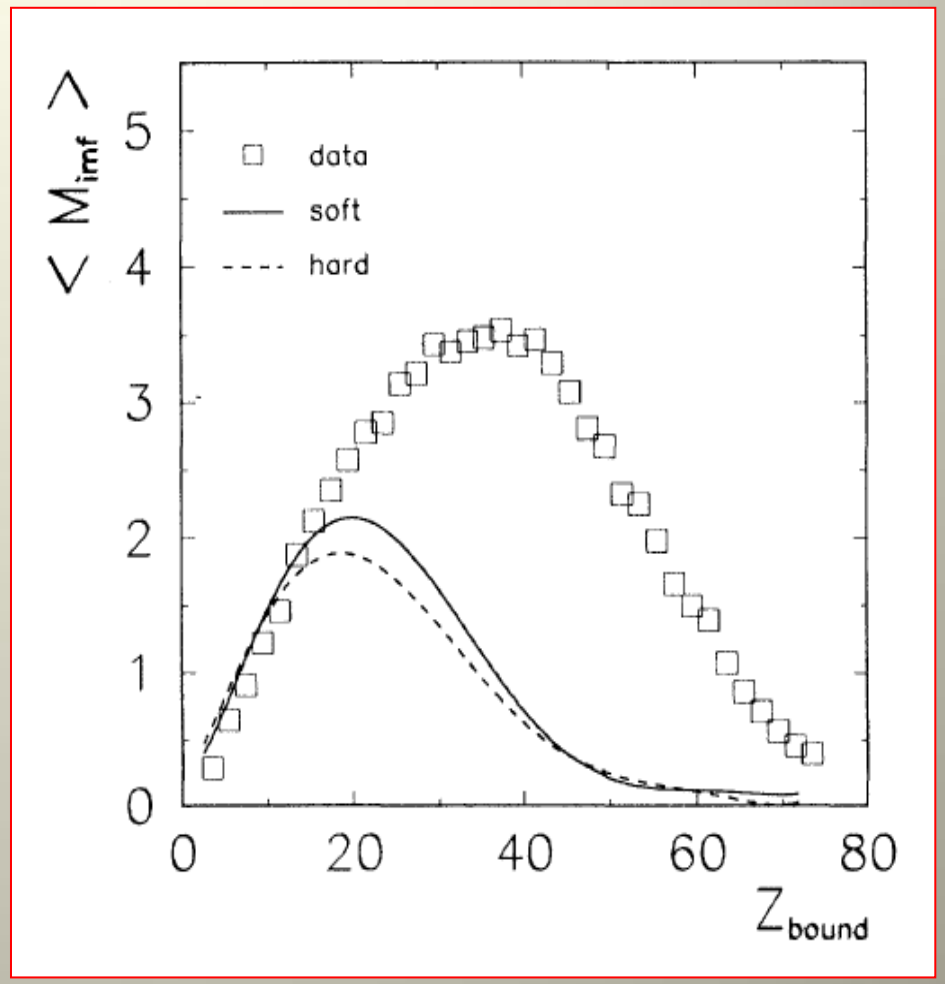
M_{IMF} (3≤Z≤20)	w/o PSDC	w. PSDC and PSDC Pauli	w. PSDC and (1-fi')(1-fj') Pauli
b = 5 fm	1.46912	1.73146	1.56738
b = 9 fm	0.02923	0.60661	-

solving the MST problem?

$^{124}Sn + {}^{120}Sn$ @ 600



$^{197}Au + {}^{197}Au$ @ 600

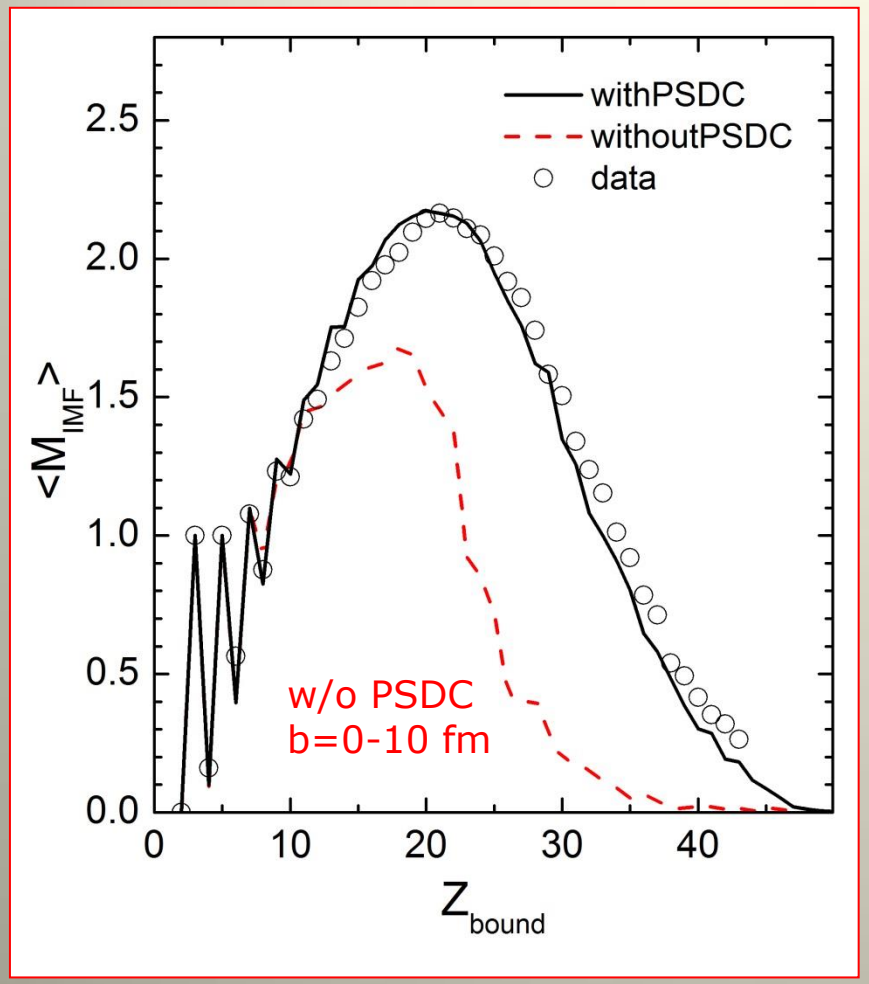


Jun Su et al., work in progress

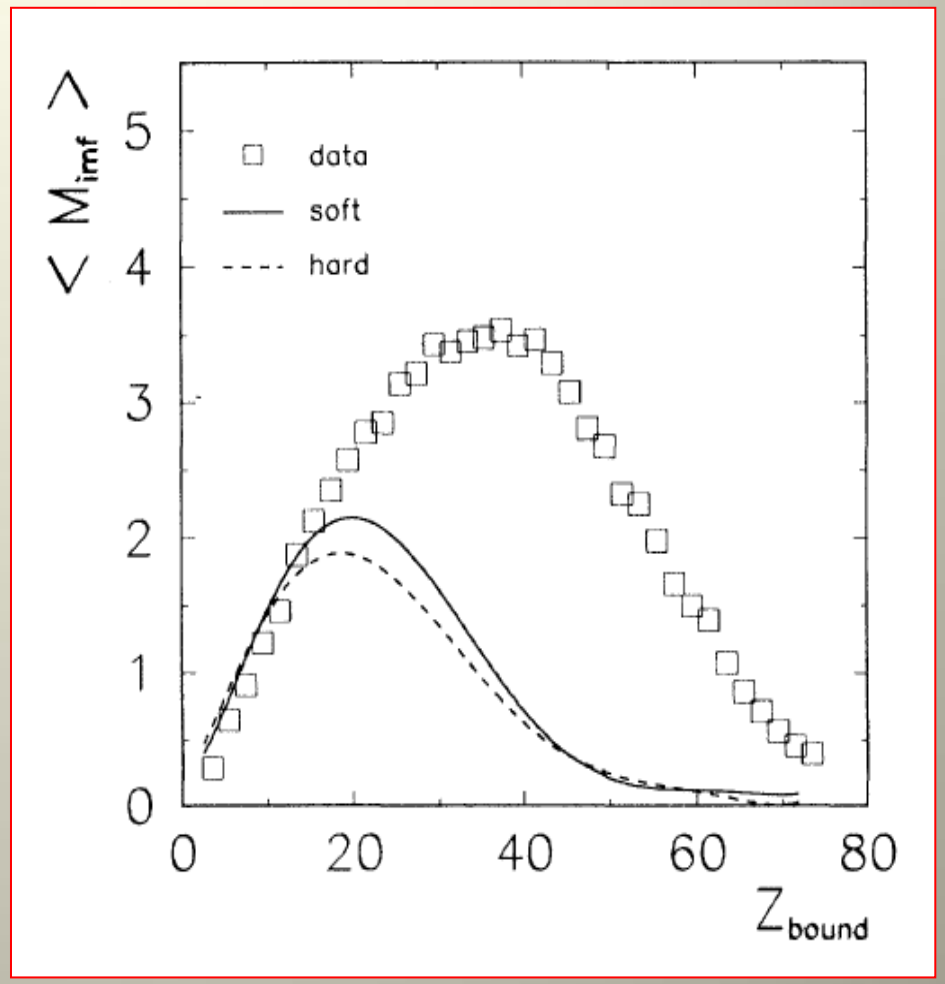
Begemann-Blaich et al., PRC (1993)

solving the MST problem?

$^{124}Sn + ^{120}Sn$ @ 600



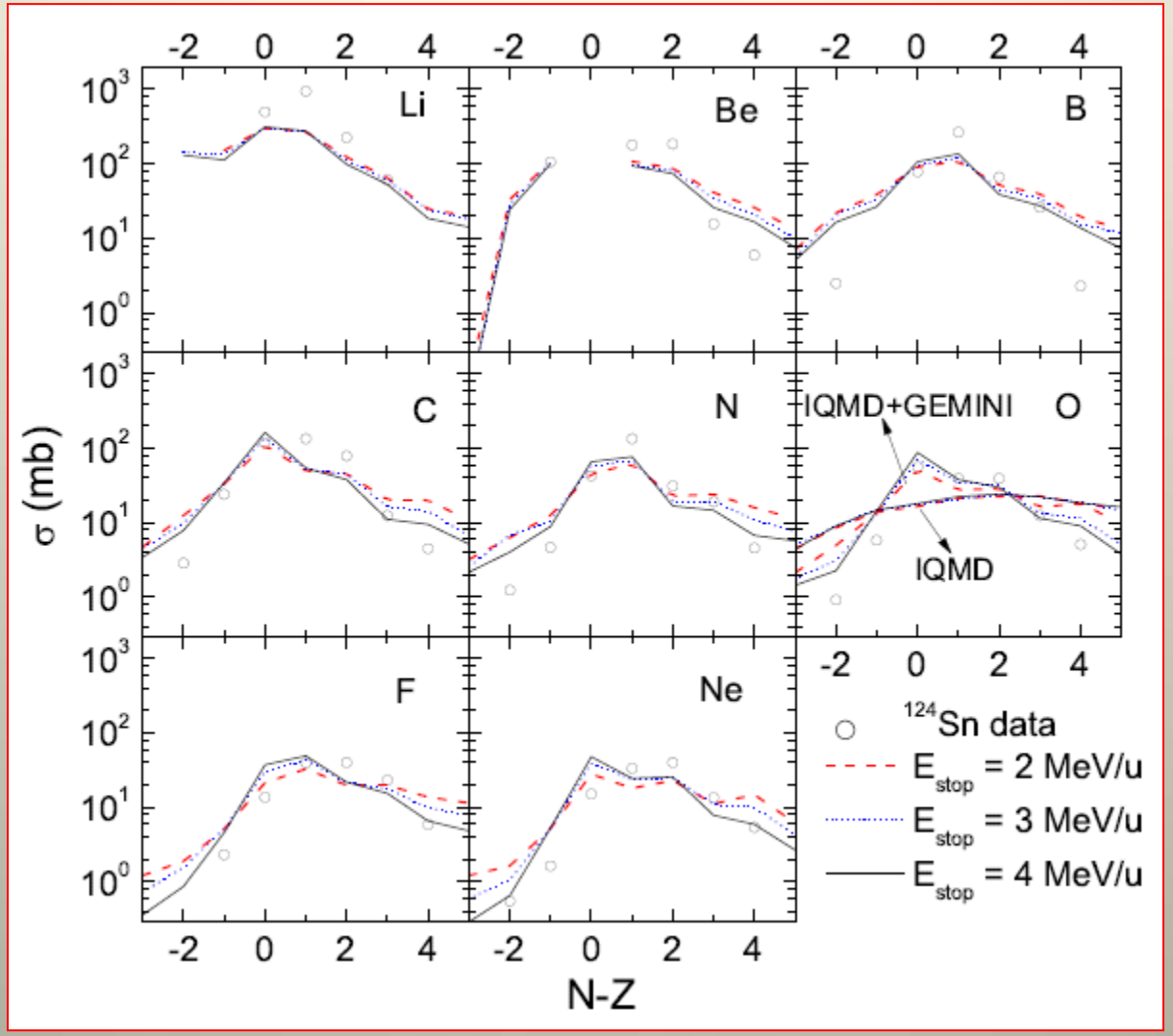
$^{197}Au + ^{197}Au$ @ 600



Jun Su et al., work in progress

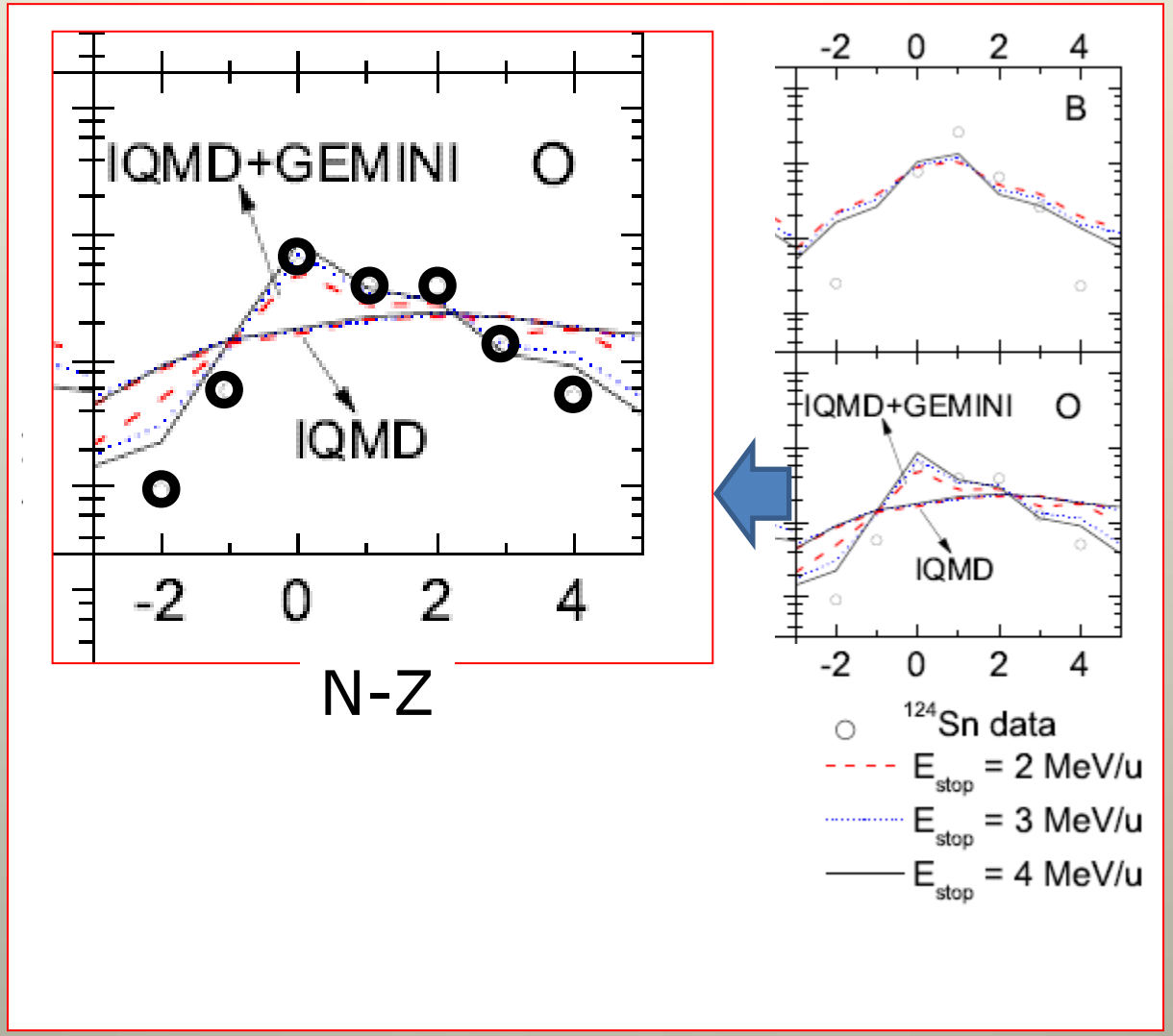
Begemann-Blaich et al., PRC (1993)

isotope distributions ^{124}Sn



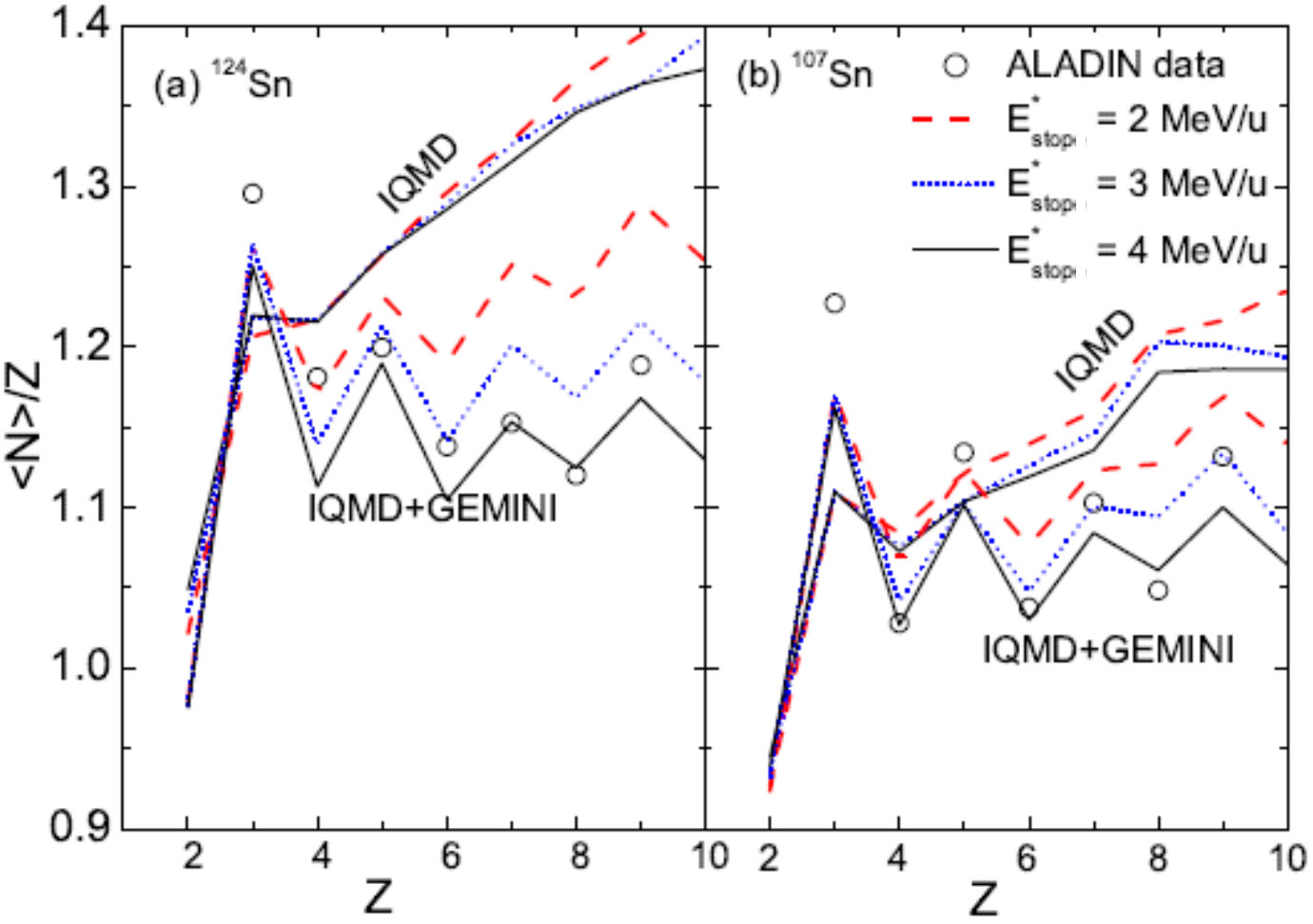
Jun Su et al., subm. to PRC

isotope distributions ^{124}Sn



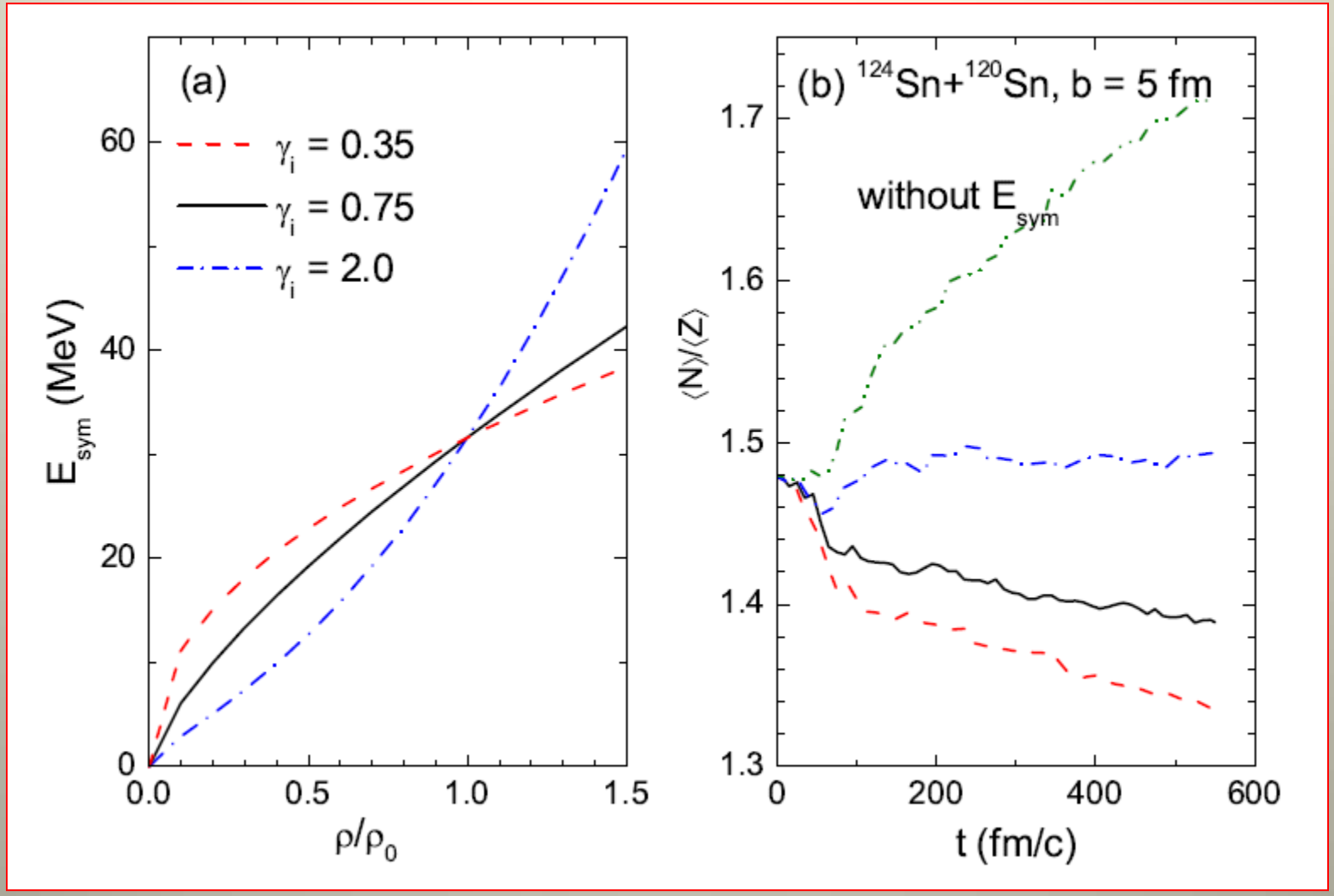
Jun Su et al., subm. to PRC

significance of <N>/Z



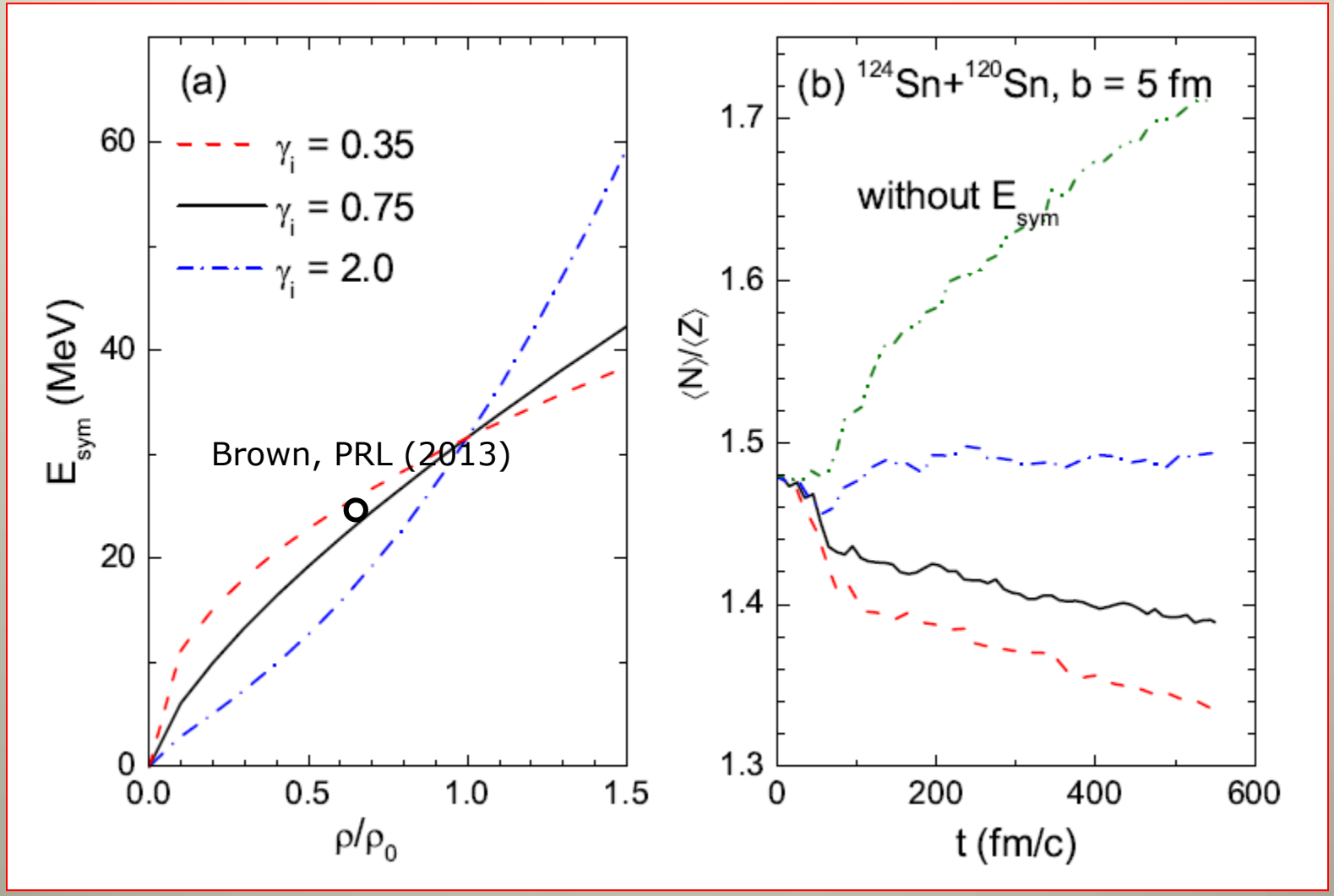
Jun Su et al., subm. to PRC

stiffness of the symmetry energy



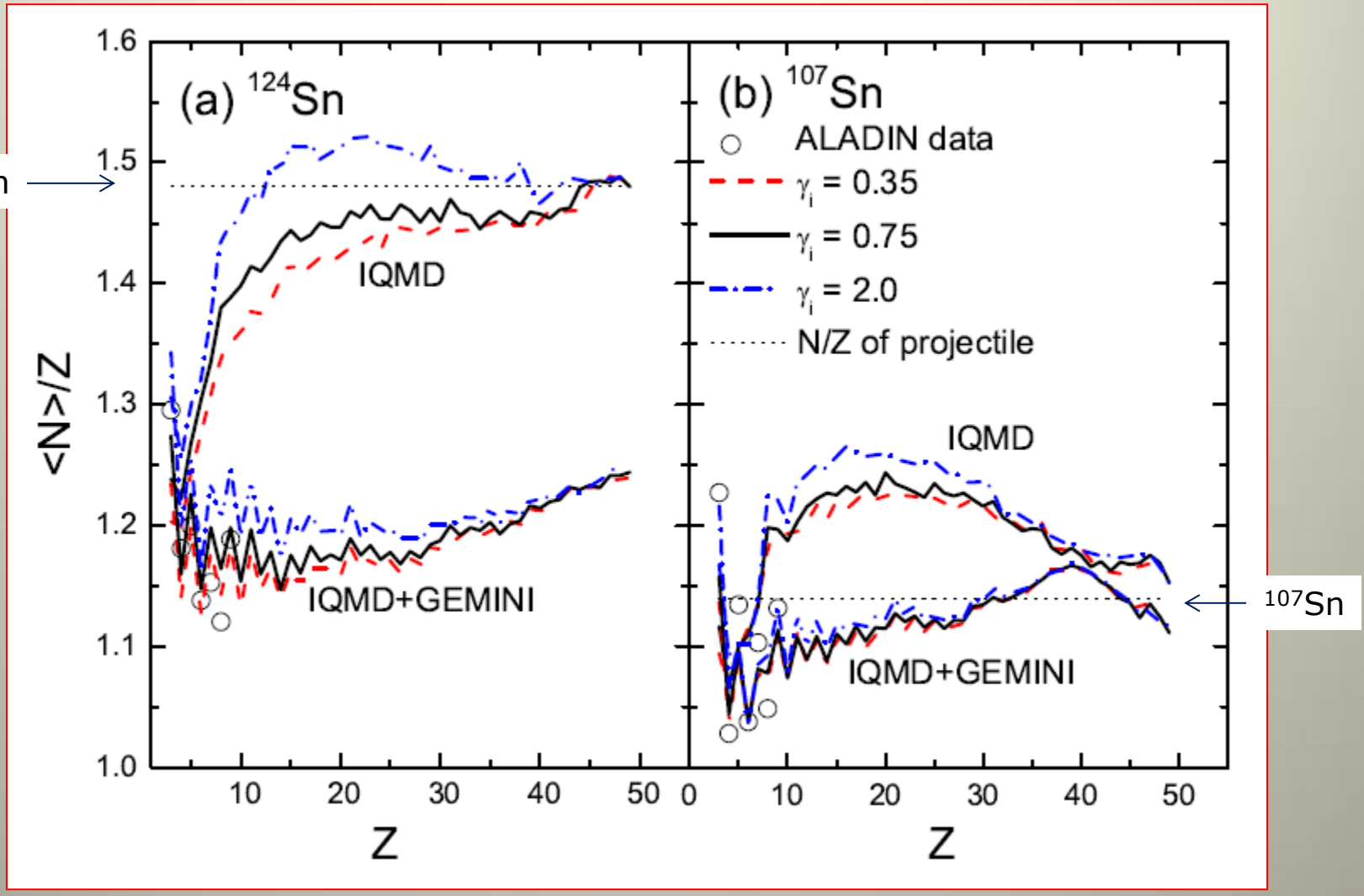
Jun Su et al., in preparation

sensitivity to density



Jun Su et al., in preparation

significance of <N>/Z



Jun Su et al., in preparation

summary

- satisfactory description achieved with IQMD+GEMINI
- **phase space density constraint (PSDC) is important**
- provides solution to the "MST problem"
- consistent with Müller, Begemann-Blaich, Aichelin, PLB 298 (1993)
- **isotope distributions approached with GEMINI**
- minor sensitivity to strength of E_{sym} chosen for IQMD
- **projectile fragmentation probes subsaturation densities**

FAIR construction site

May 9, 2018