Flow effects on multifragmenting sources formed in symmetric & asymmetric reactions

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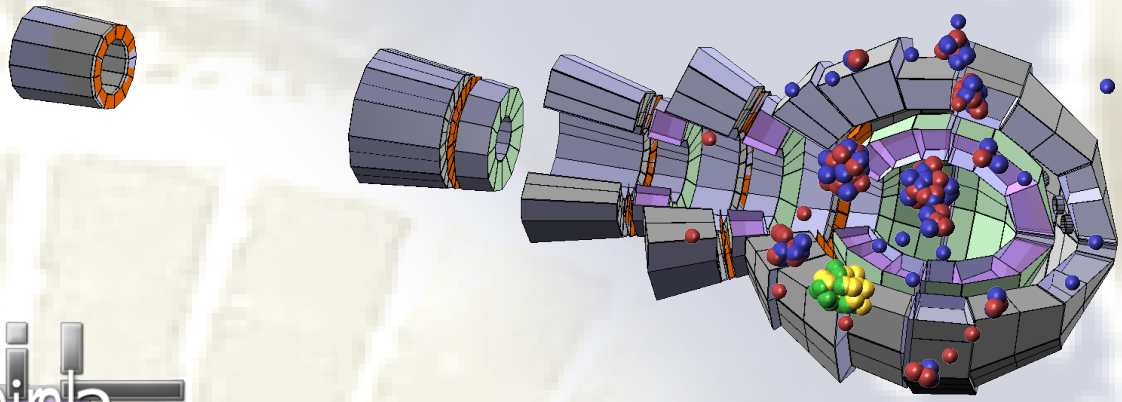
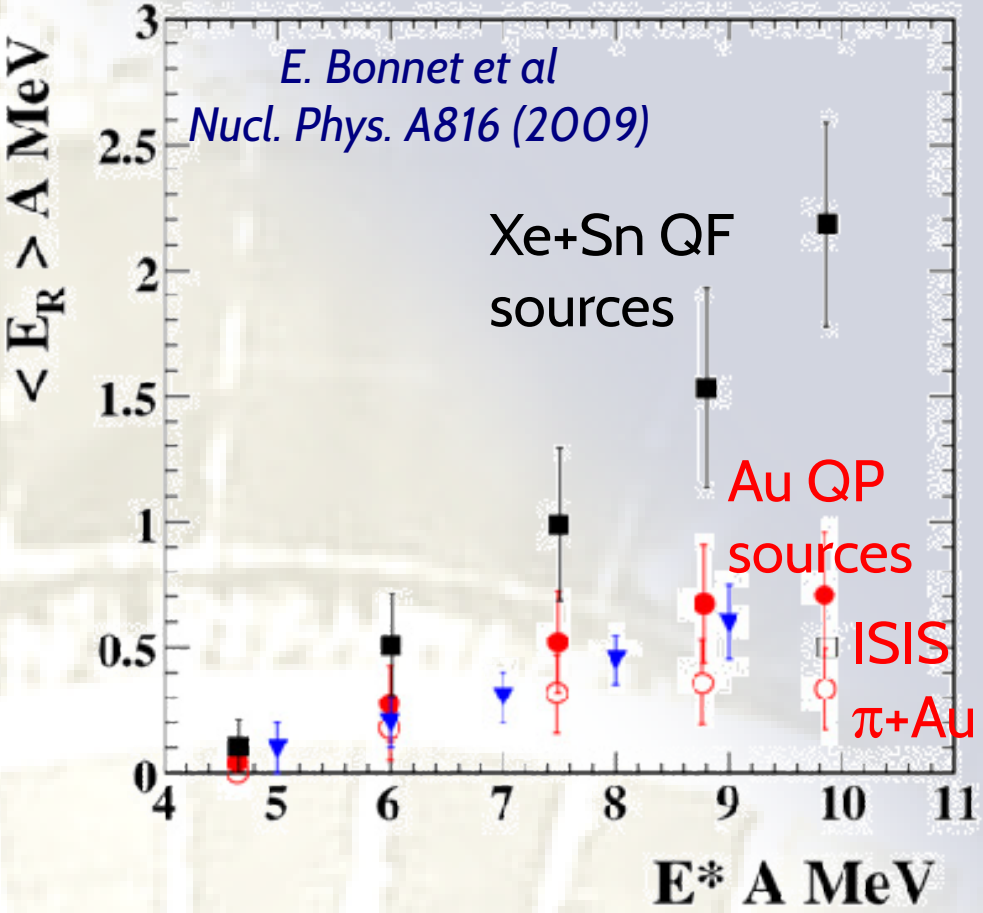


GANIL laboratoire commun CEA/DSM spiral2 CNRS/IN2P3

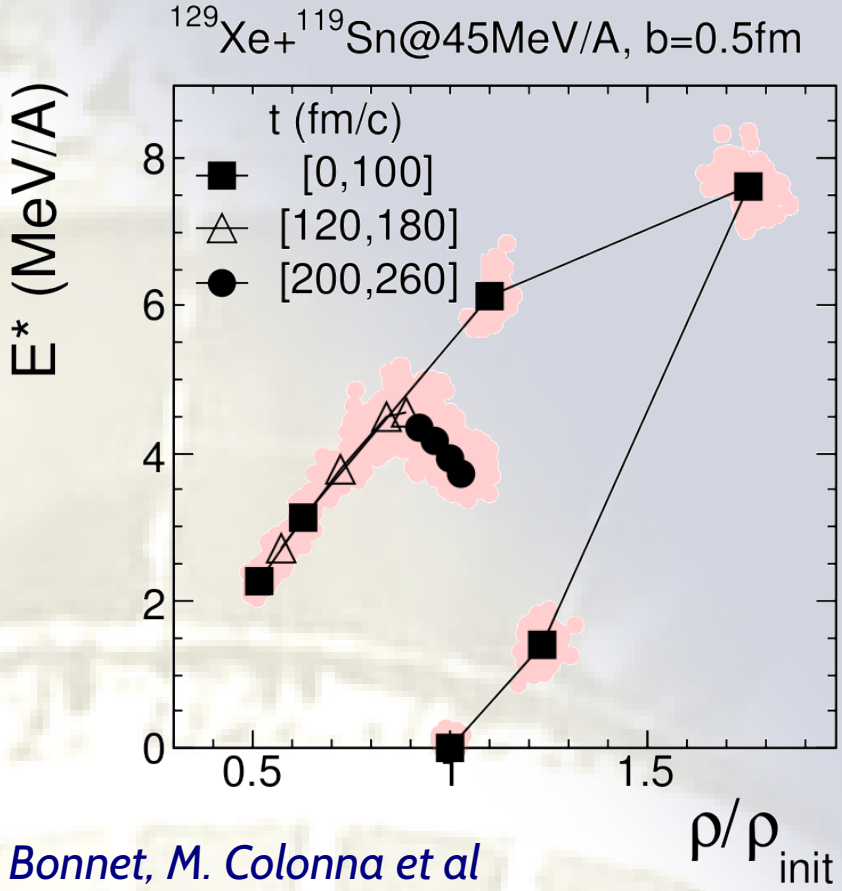
Radial flow & multifragmentation



More radial flow in central collisions

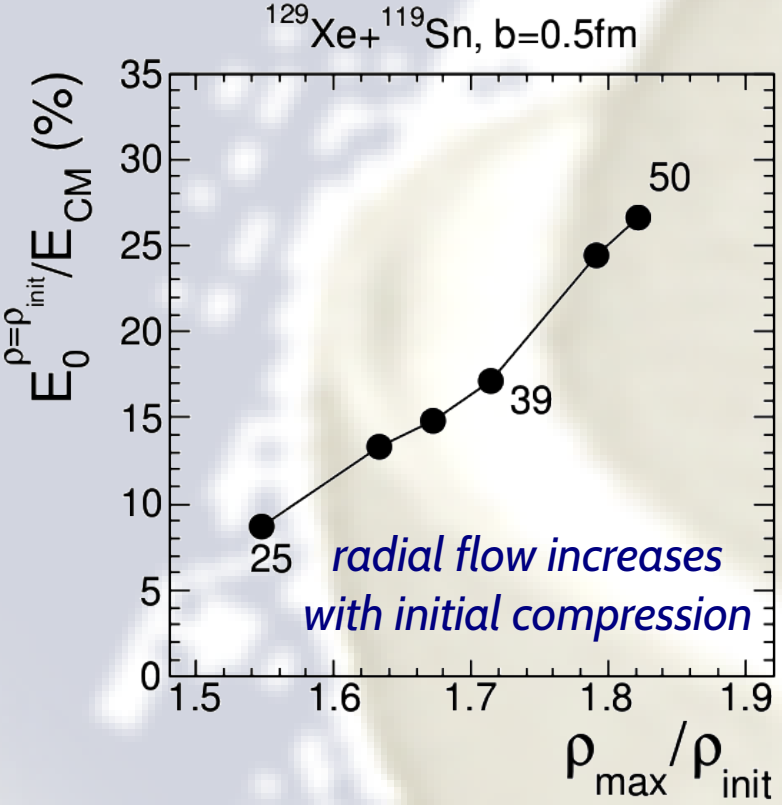
- *Quasi-Fused (QF) sources*
- *compression/expansion cycle*

Incompressibility and flow

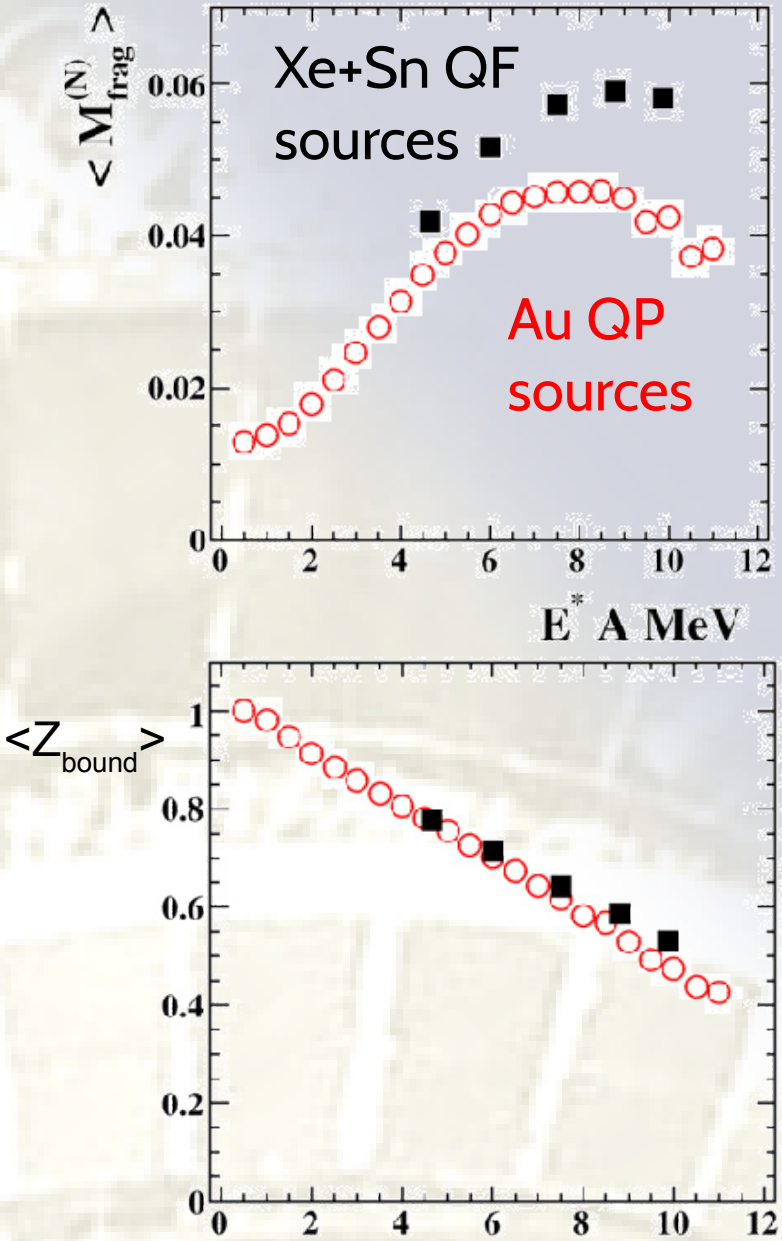


E. Bonnet, M. Colonna et al
Phys. Rev. C89 (2014)

Compression-expansion cycle for QF reactions calculated in Stochastic Mean Field approach



Effect of flow on partitions



E. Bonnet et al
Nucl. Phys. A816 (2009)
Phys. Rev. Lett. 105 (2010)

For a given E^* and source size, radial flow determines fragment multiplicity and partition asymmetry

- *higher degree of fragmentation in central collisions due to larger expansion energy*
- *different exploration of phase diagram*

Experiment E613

Hypothesis:

- *For QF sources formed in asymmetric reactions, we expect less compression, thus less radial flow*
- *The same "bound" charge should be partitioned into less fragments compared to the symmetric reaction*

Symmetric reaction

Existing data for Xe+Sn reactions

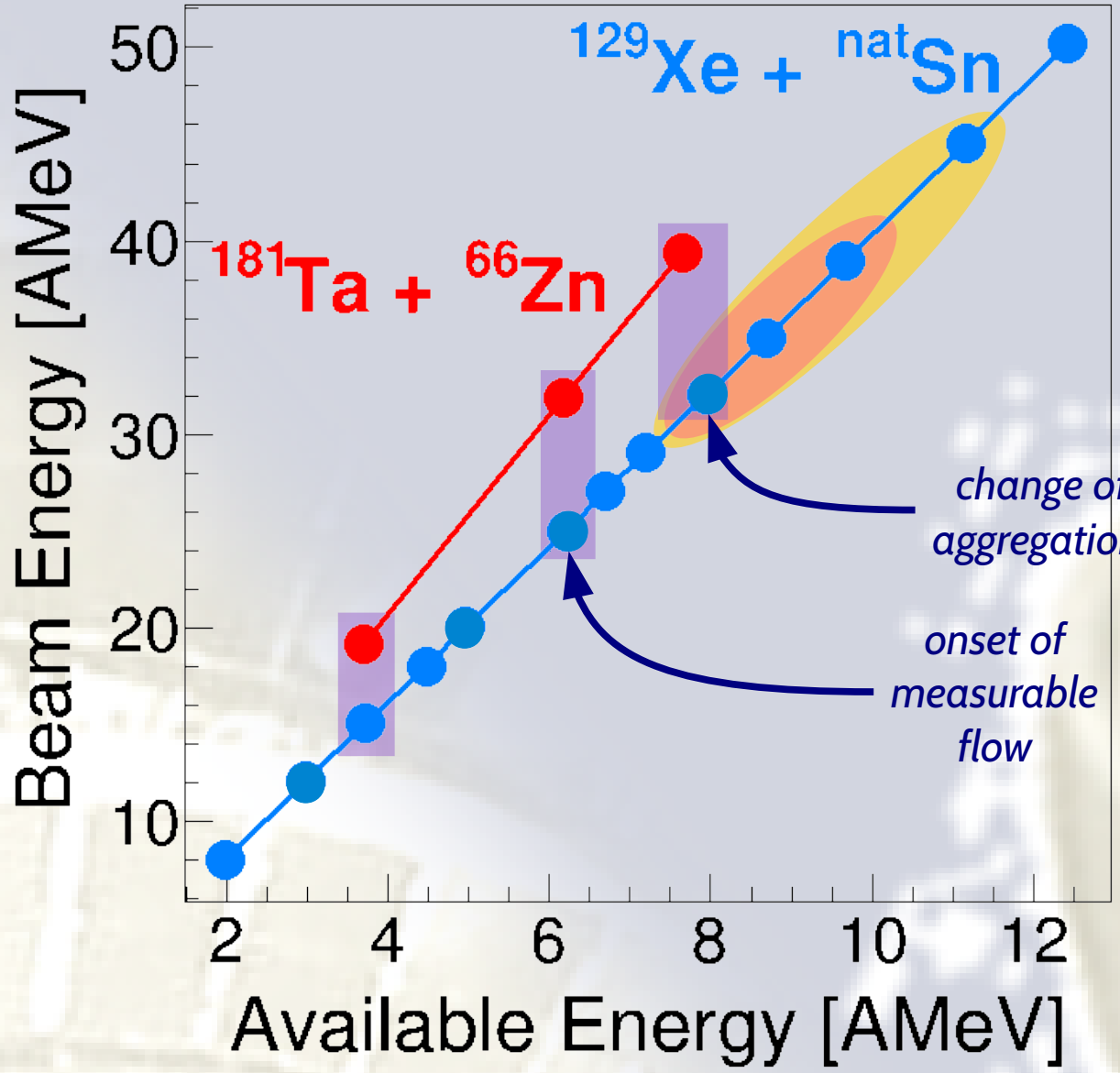
Asymmetric reaction

New experiment with $^{181}Ta+^{66}Zn$ reactions

performed at GANIL with INDRA in September-October 2011

Ph.D. thesis of Diego Gruyer

E613: New data points

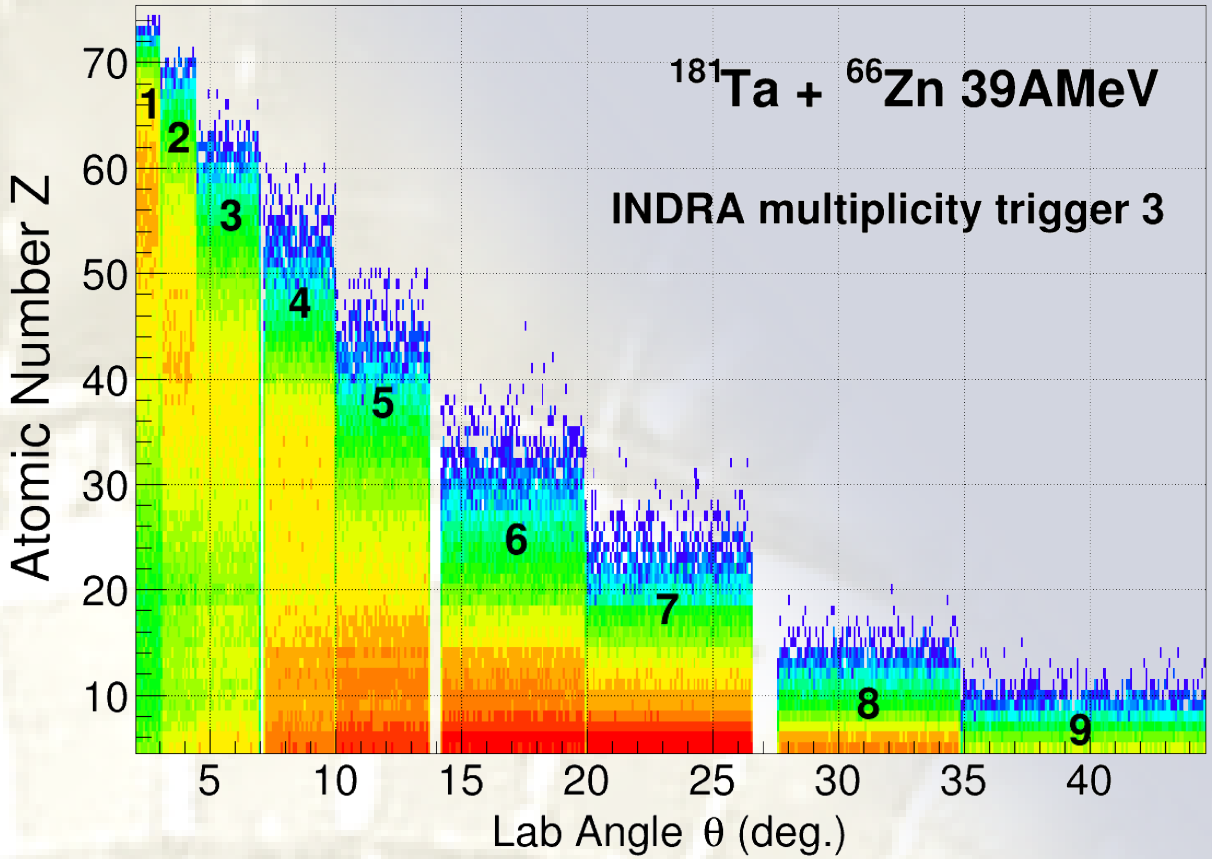


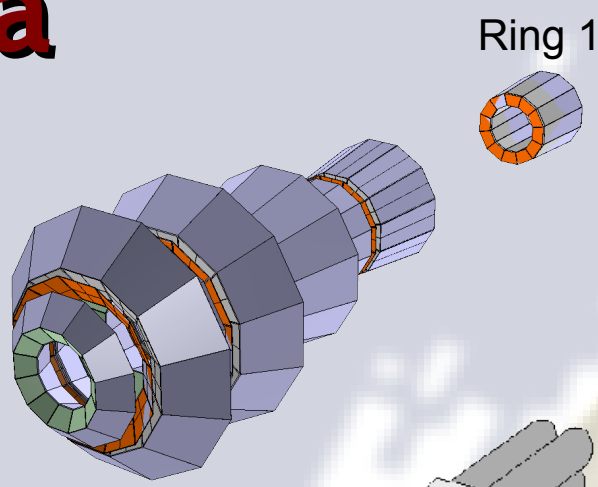
Negative heat capacity

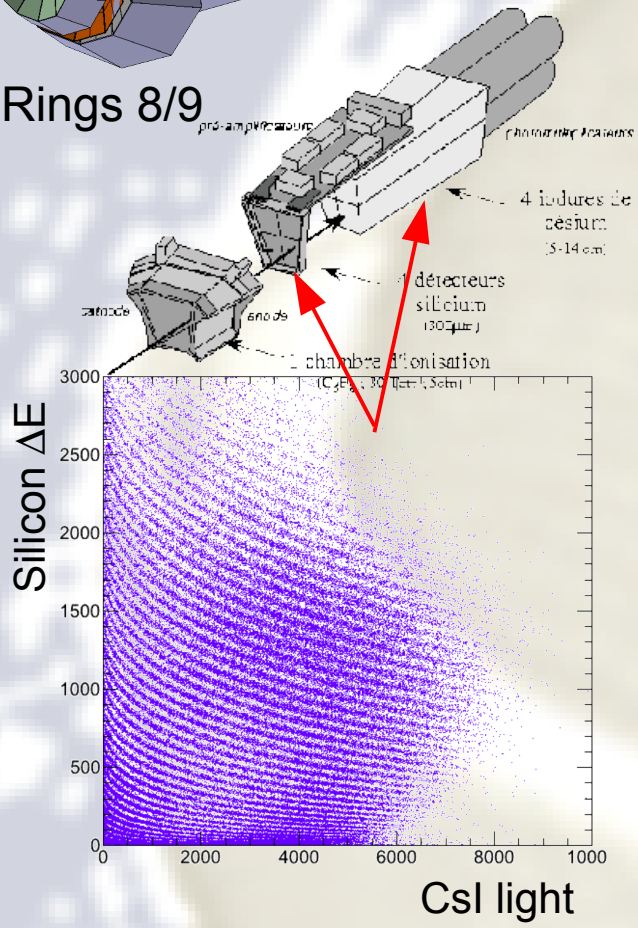
Spinodal decomposition

Overview of Ta+Zn data

Advantages of INVERSE KINEMATICS:
- nearly all fragments detected at forward angles
- most identified in hi-res Si-CsI maps

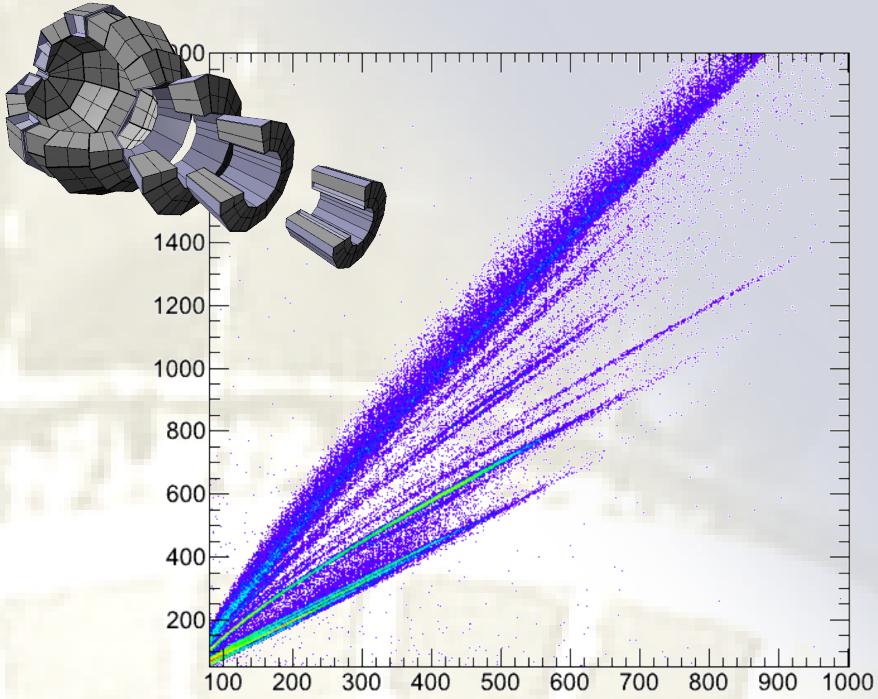




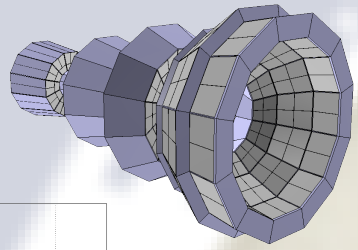


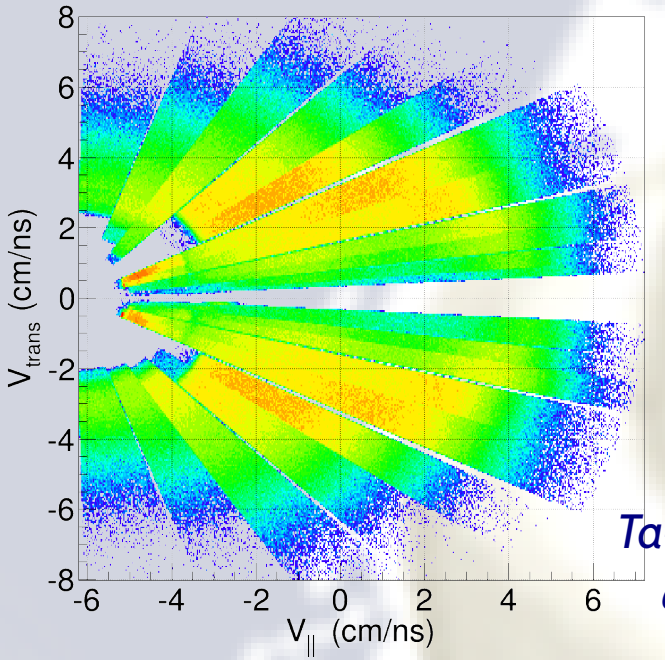
Overview of Ta+Zn data

Light charged particles (Z<4) identified over all angles
- CsI fast-slow matrices



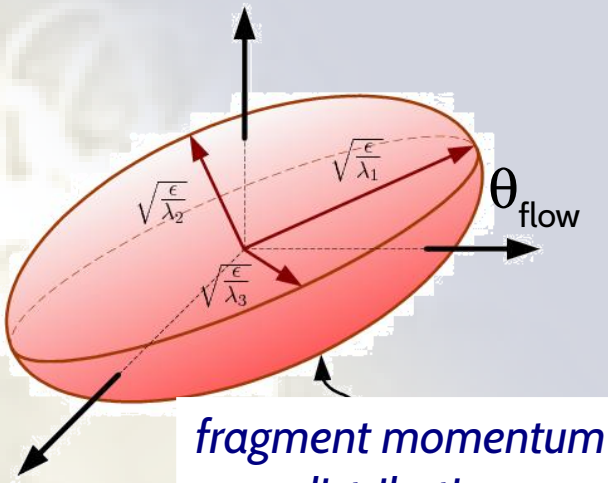
Calibrated LCP for lab angles 0-90°





Ta+Zn 39AMeV
α particles

Selection of QF sources

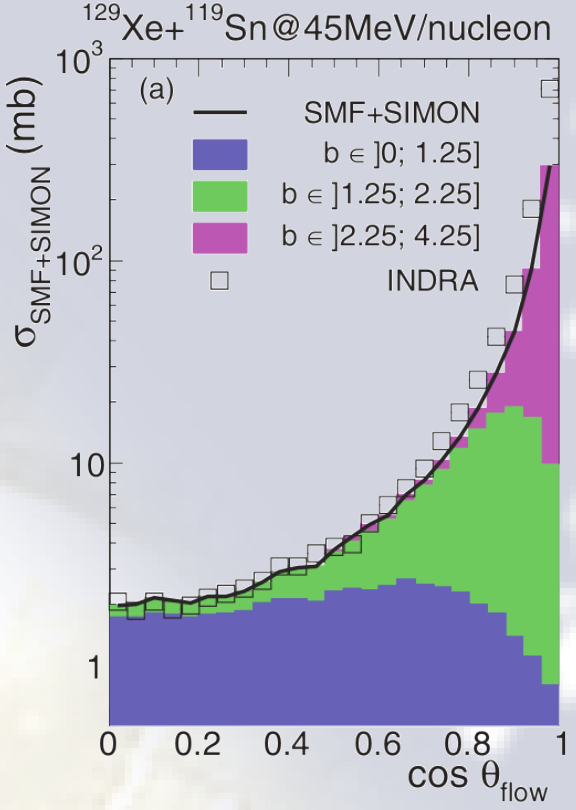


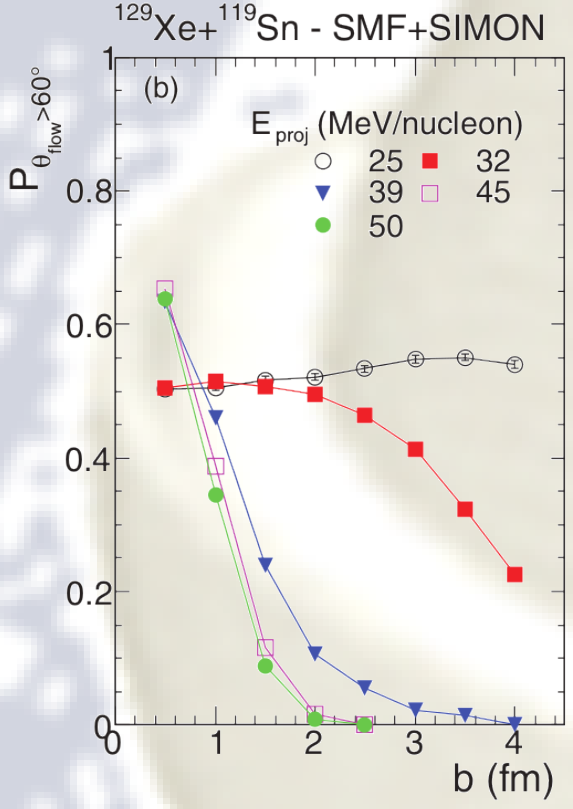
fragment momentum distribution

Global orientation of fragment momentum distribution, θ_{flow}

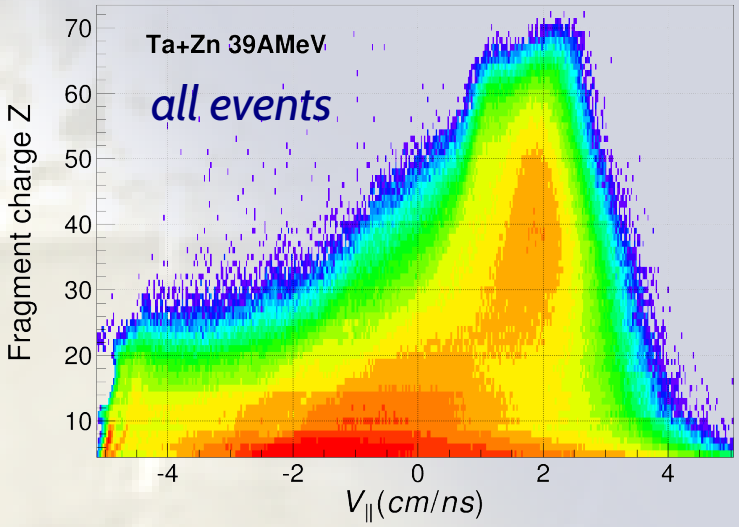
QF sources lose memory of entrance channel and populate large θ_{flow} angles

E. Bonnet, M. Colonna et al Phys. Rev. C89 (2014)

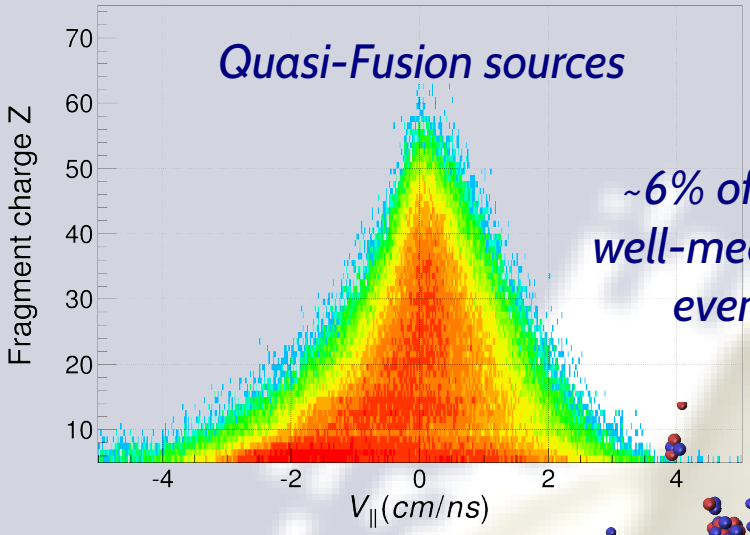




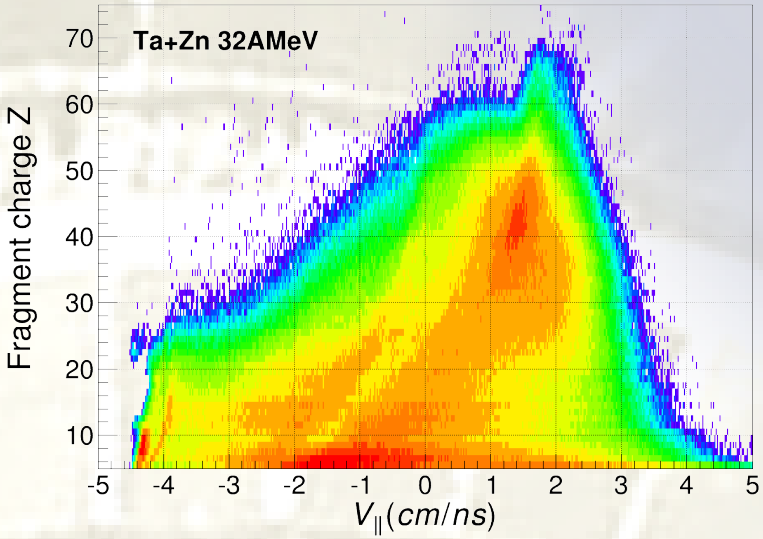
Selection of QF sources



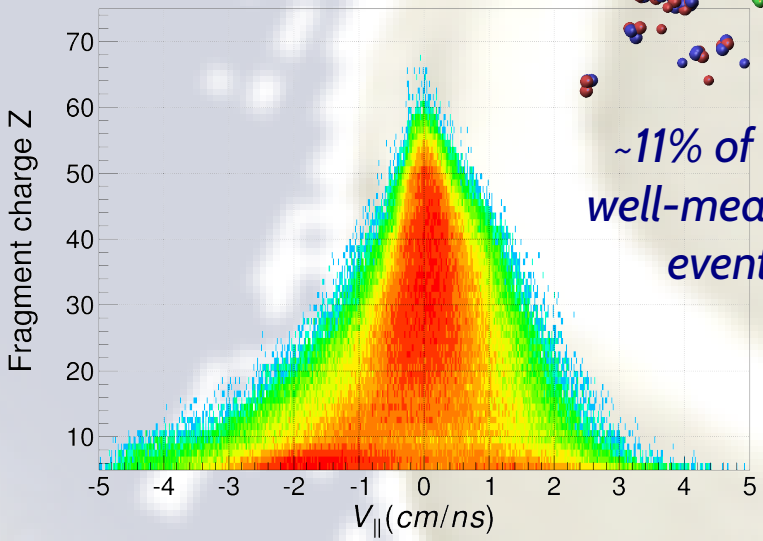
θ_{flow}>70°



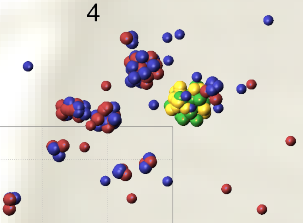
~6% of very well-measured events



θ_{flow}>70°



~11% of very well-measured events



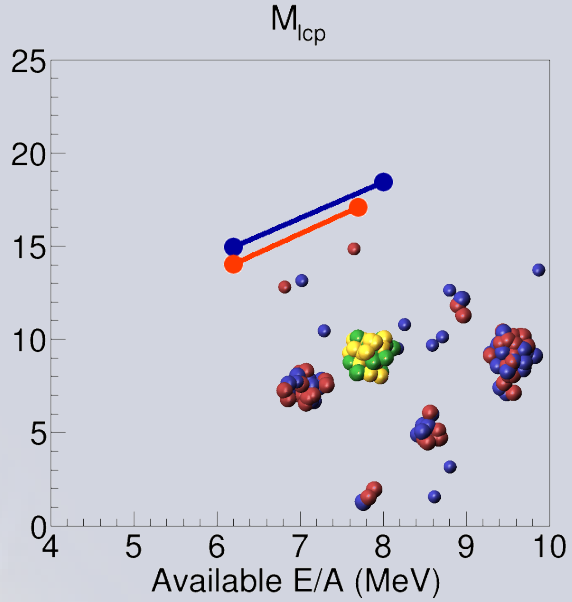
Comparison of QF sources

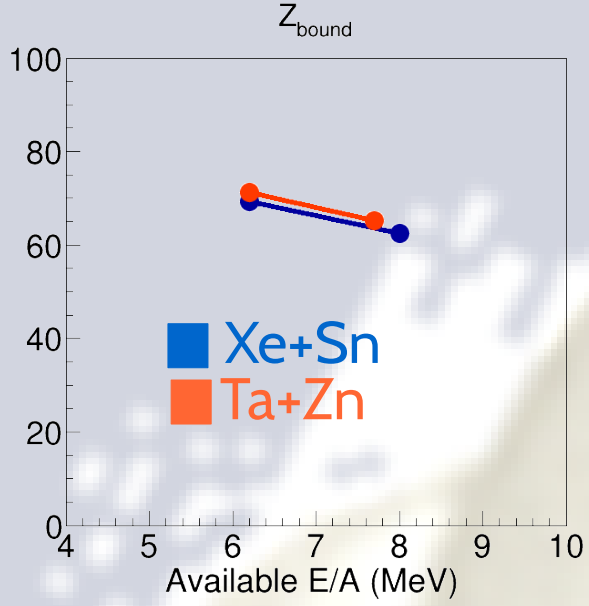
Same LCP multiplicities
- same dissipation/ thermal energy

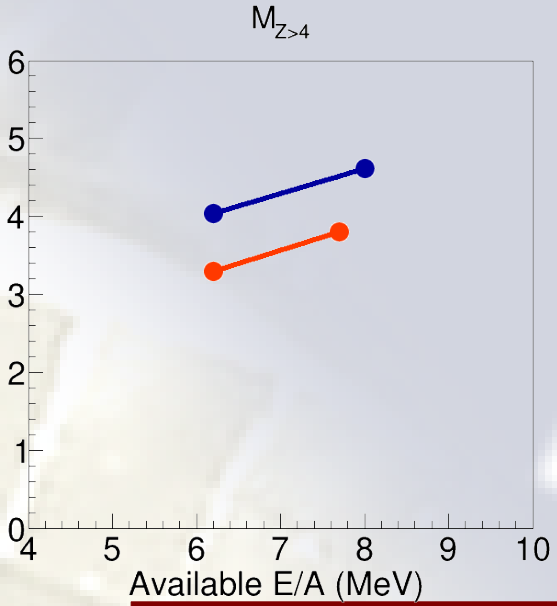
Same charge bound in fragments, Z_{bound}

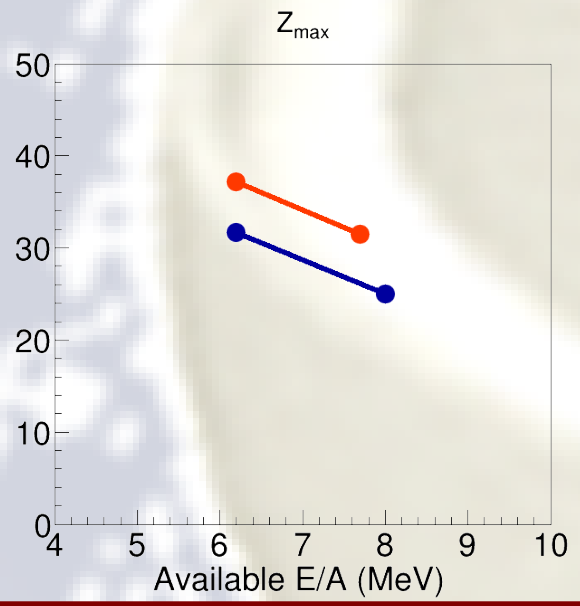
Ta+Zn: smaller mean fragment multiplicity

Ta+Zn: larger mean Z_{max}







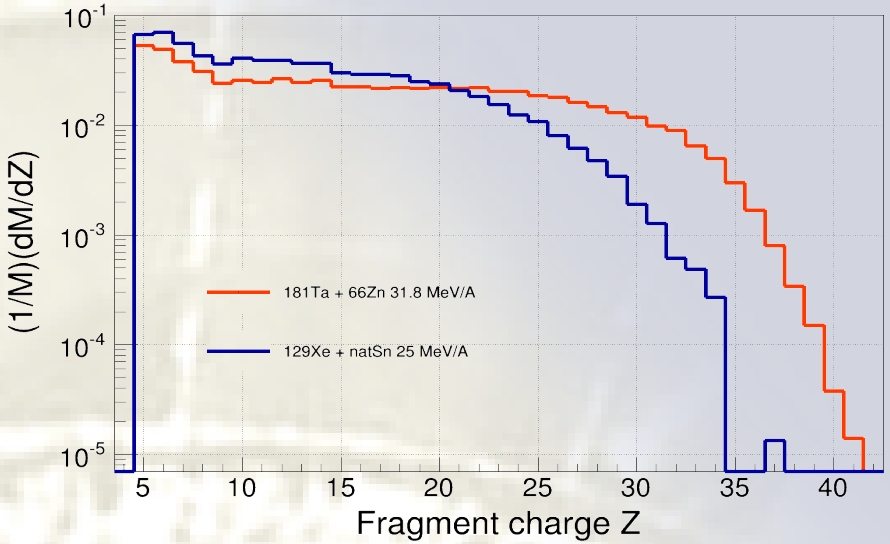


PRELIMINARY RESULTS!

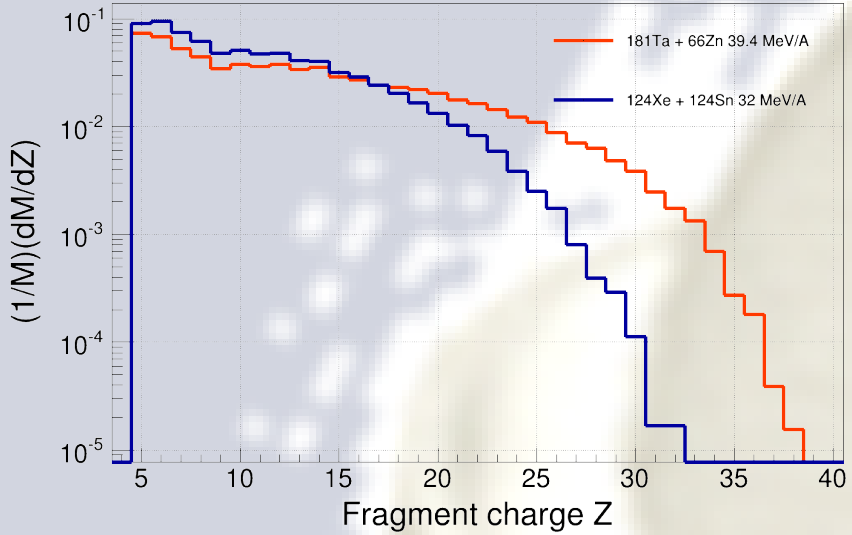
Comparison of QF sources

charge distributions
(largest fragment excluded)

E/A~6 MeV



E/A~8 MeV



Xe+Sn
Ta+Zn

All fragments are on average larger for the asymmetric system

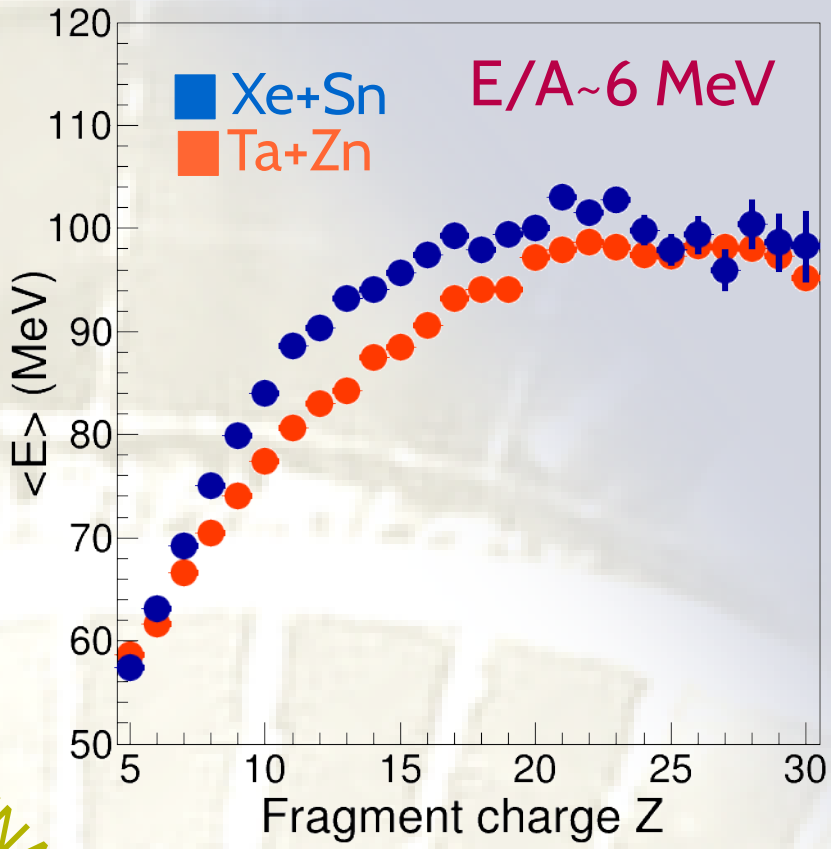
PRELIMINARY RESULTS!

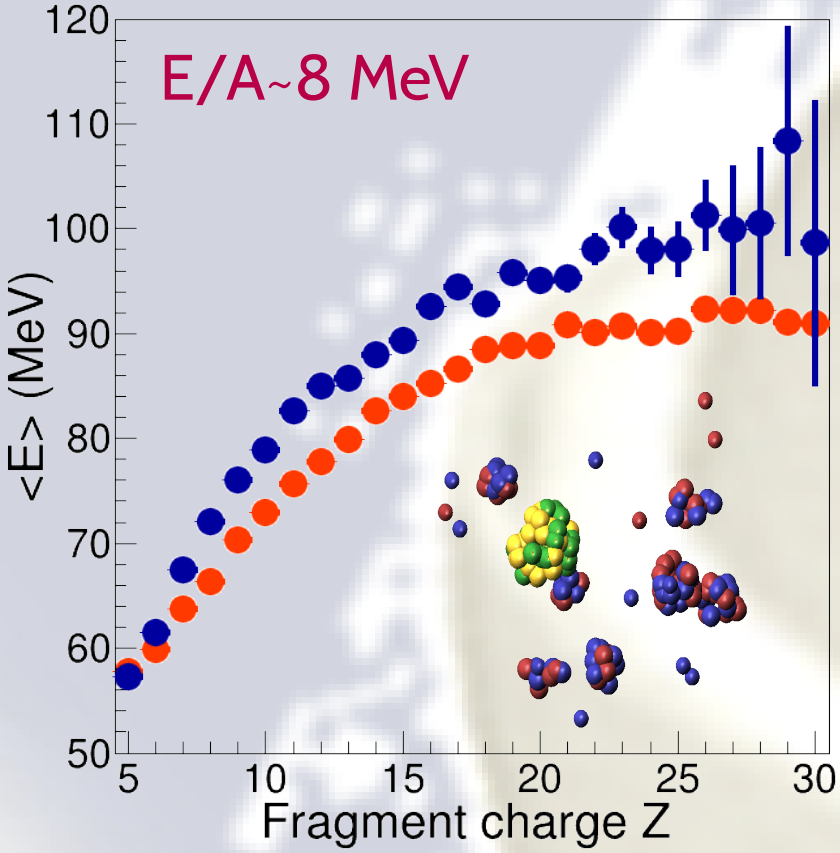
Radial flow observables

Mean fragment KE is systematically smaller Z by Z for the asymmetric system

=> smaller radial flow (same thermal+Coulomb) ?

mean centre of mass energies vs. Z (largest fragment excluded)



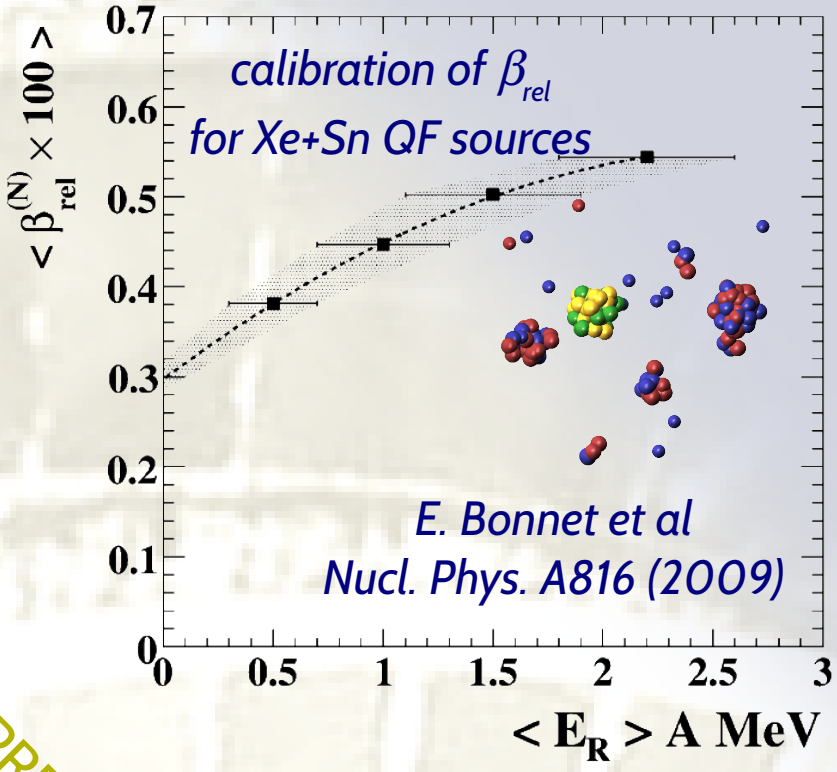


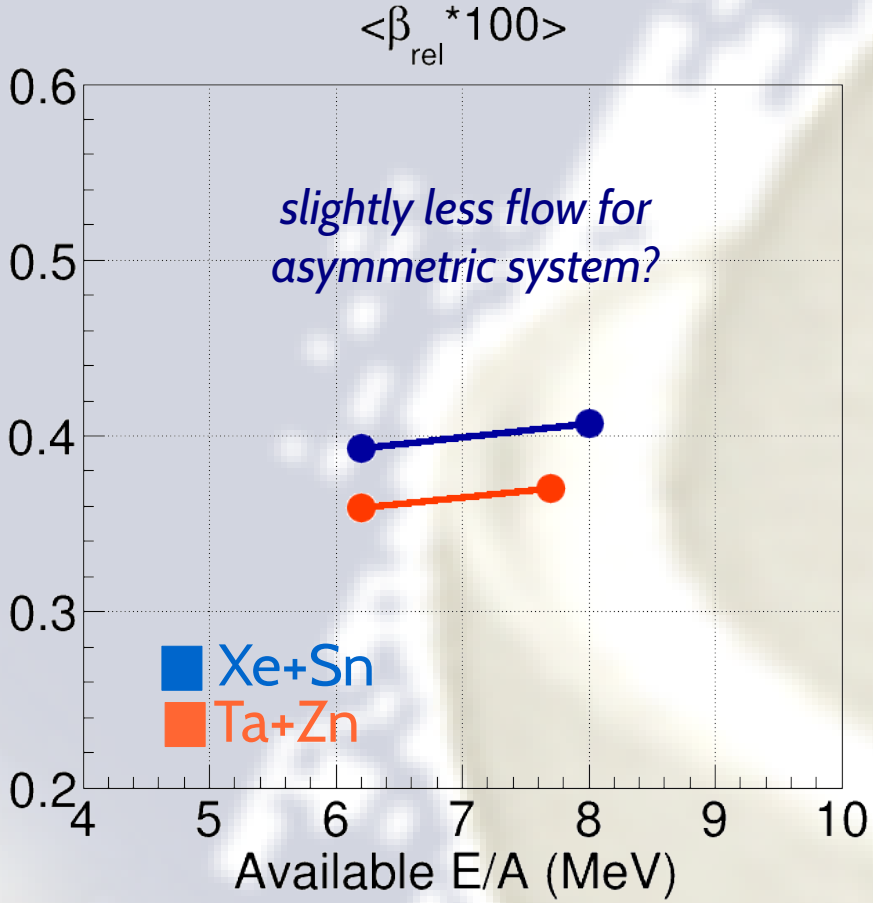
PRELIMINARY RESULTS!

Radial flow observables

Mean relative velocity between all pairs of fragments

$$\beta_{\mathrm{rel}} = \frac{2}{M_{\mathrm{frag}}(M_{\mathrm{frag}}-1)} \sum_{i<j} \left| \vec{\beta}^{(ij)} \right|$$





PRELIMINARY RESULTS!

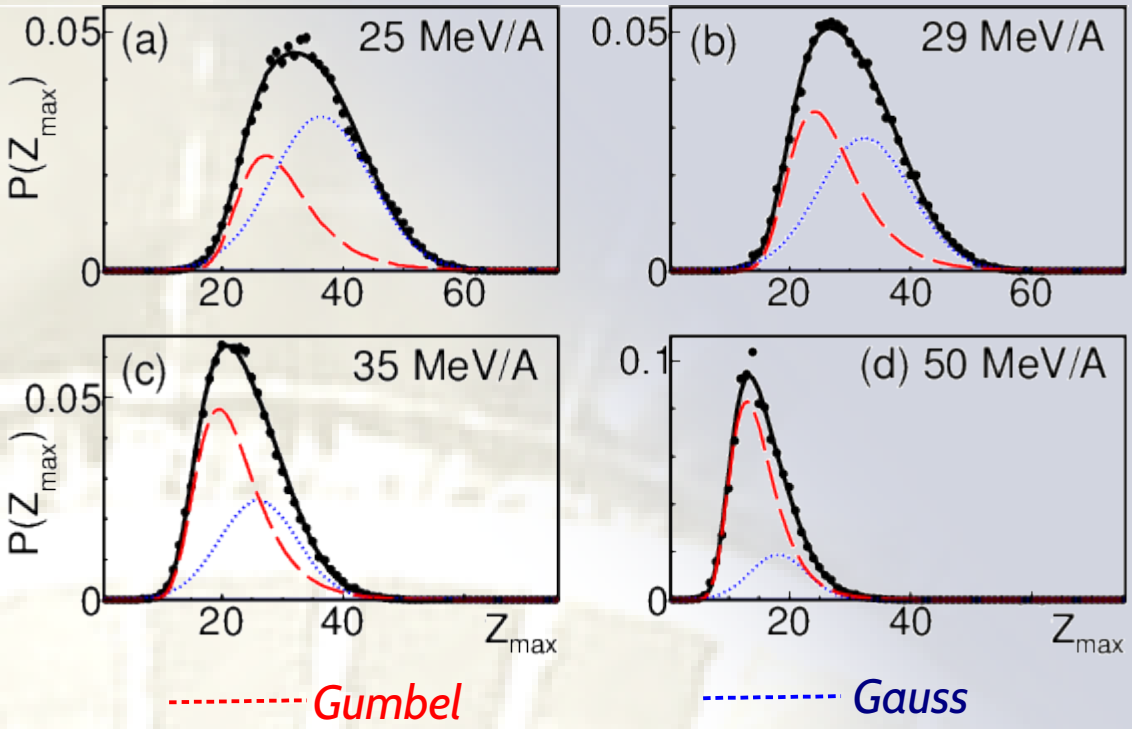
Radial flow observables

Z_{max} distribution reflects time-scale of multifragmentation

- *relative weight of Gauss/Gumbel contributions*

D. Gruyer et al
Phys. Rev. Lett. 110 (2013)

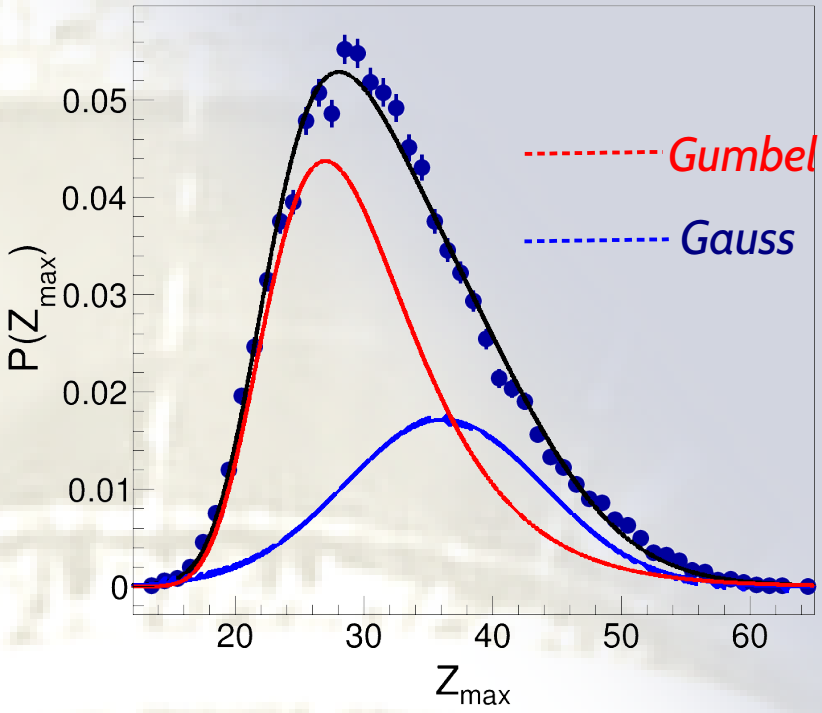
Xe+Sn QF sources



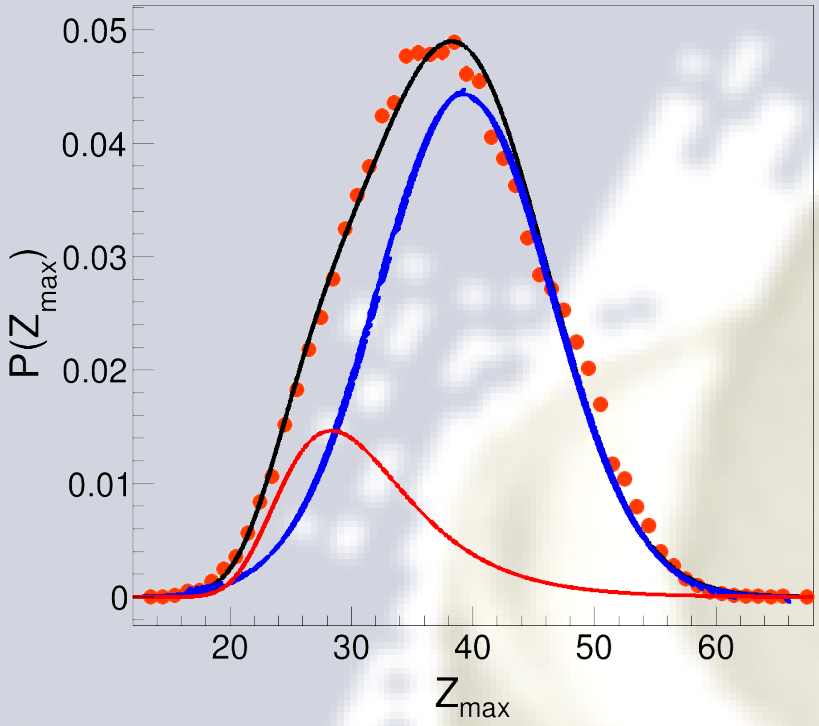
More flow means less time for aggregation i.e. more dominant Gumbel component

Radial flow observables

Xe+Sn 25AMeV



Ta+Zn 32AMeV



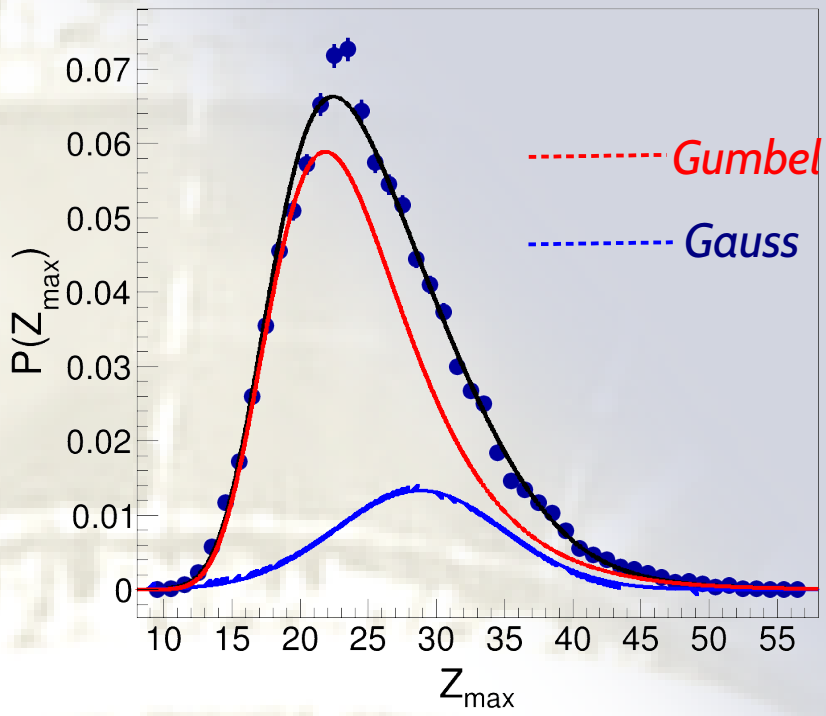
Gumbel component less dominant for asymmetric system

- *longer time-scales, smaller flow*

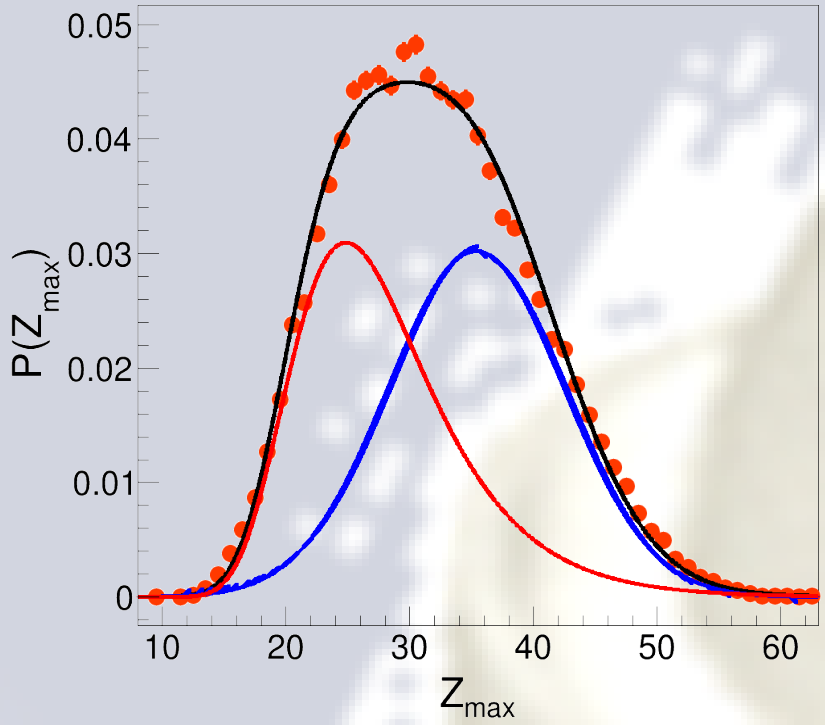
PRELIMINARY RESULTS!

Radial flow observables

Xe+Sn 32AMeV



Ta+Zn 39AMeV



Gumbel component less dominant for asymmetric system
- *longer time-scales, smaller flow*

PRELIMINARY RESULTS!

Summary

- Multifragmentation in central heavy-ion collisions is linked to a compression-expansion cycle
- Radial flow determines fragment multiplicity and partition asymmetry for given E^*, Z, A
- E613: expected difference in compression-expansion between symmetric & asymmetric collision systems
- Less flow & less fragments for Ta+Zn than Xe+Sn