Dynamical Fragment Formation in CoMD Simulations

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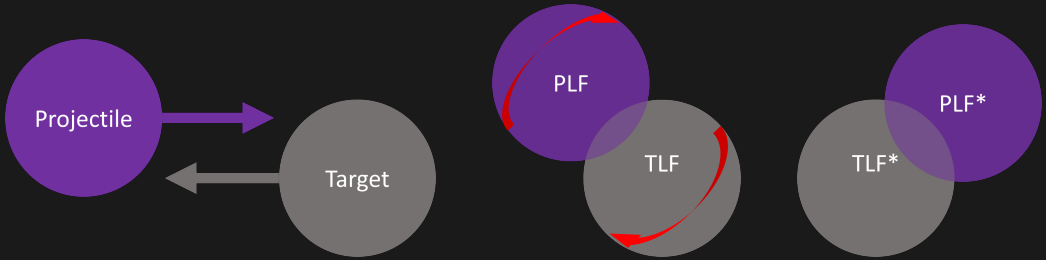
Dynamical Breakup

Order of Events in a Peripheral Collision

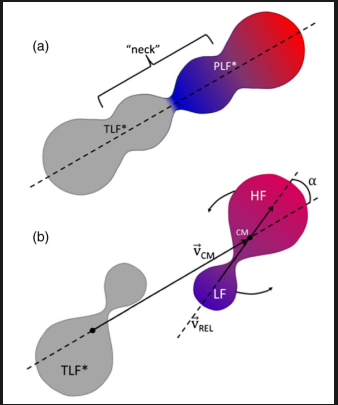
- Heavy nuclei collide
- Projectile Like Fragment (PLF) and Target Like Fragment (TLF) Rotate



Dynamical Breakup

Order of Events in a Peripheral Collision

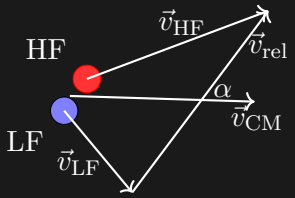
- Heavy nuclei begin to separate (neutron rich neck forms)
- PLF* splits into two heavy fragments (Heavier Fragment, HF, and Lighter Fragment LF) some time later
- On the order of zs ($10^{-21}\,\mathrm{sec} \simeq 300\,\mathrm{fm/c}$)



A. Jedele et al., PRL 118, 062501 (2017)

Big Question #1

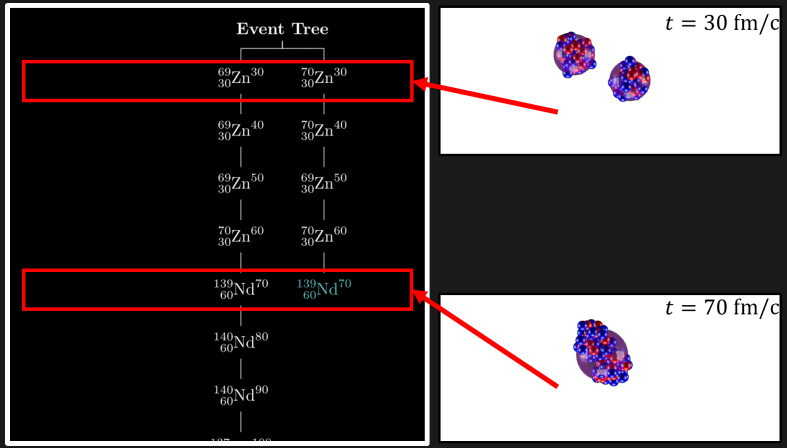
Does a correlation exist between contact time and average alignment angle?



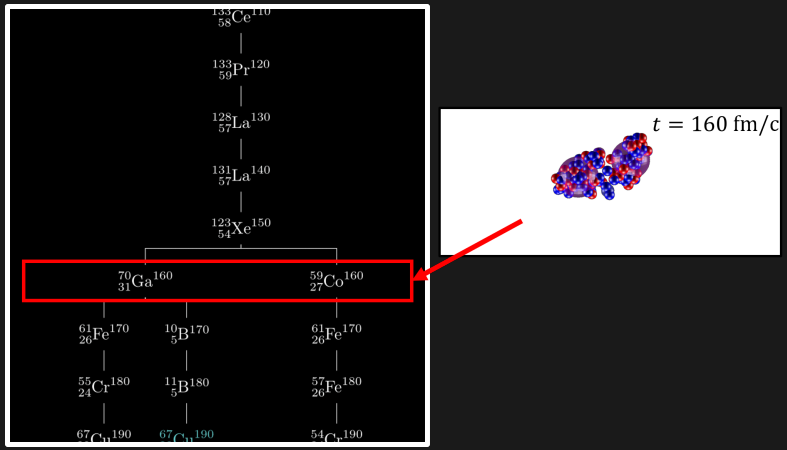
- **Angular Alignment:** $|\overrightarrow{v_{cm}}||\overrightarrow{v_{rel}}|\cos\alpha = \overrightarrow{v_{cm}} \cdot \overrightarrow{v_{rel}}$
  - Accessible through both simulation and experiment
- **Contact Time:** t_c is time between PLF*/TLF* separation and HF/LF split
  - Only directly accessible through simulation

Specifically using Constrained Molecular Dynamics simulations for ^{70}Zn+^{70}Zn at 35 MeV/nucleon.

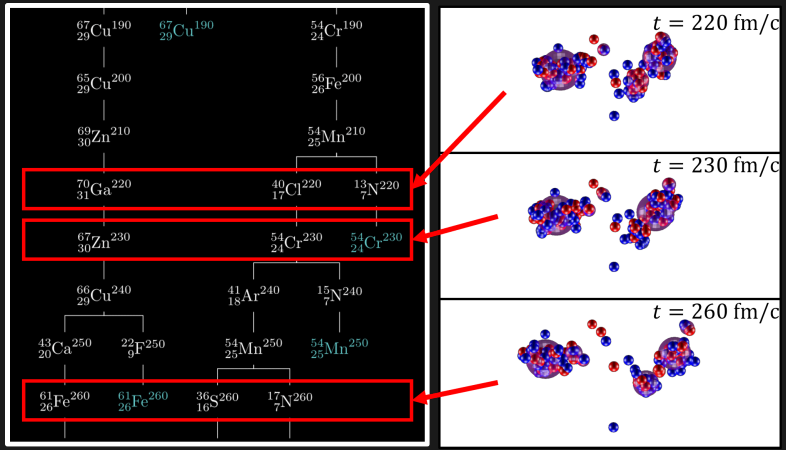
Event Visualization: Collision



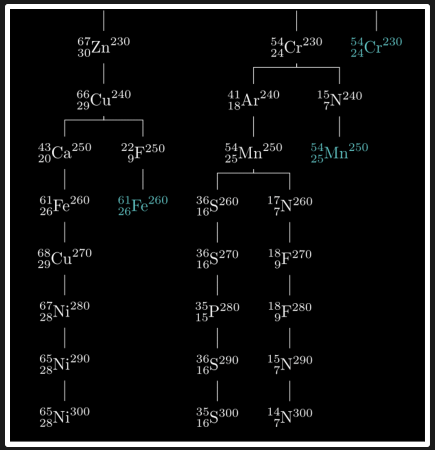
Event Visualization: PLF/TLF Separation

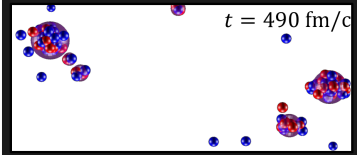


Event Visualization: HF/LF Split



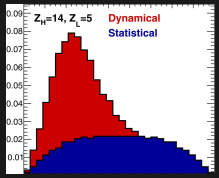
Event Visualization: The Story Ends



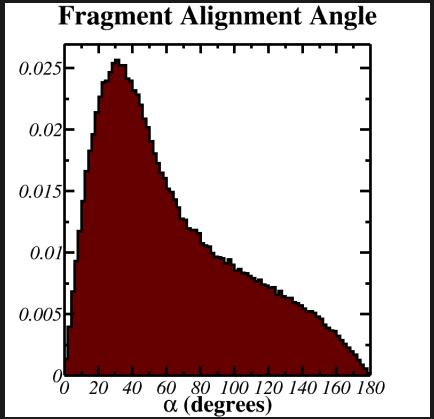


Angular Alignment

- Simulations Comparable to Experimental
- Statistical Background
- Dynamical Peak



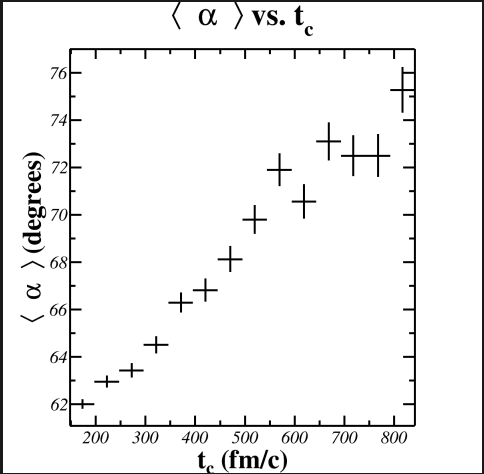
Experimental α Distribution for $Z_L = 5$ and $Z_H = 14$
A. Rodriguez Manso et al., Physical Review C 95, 044604 (2017)



Simulated α Distribution for $Z_L = 4$ and $Z_H \geq 11$

Contact Time and Angular Alignment

We do indeed see a correlation!

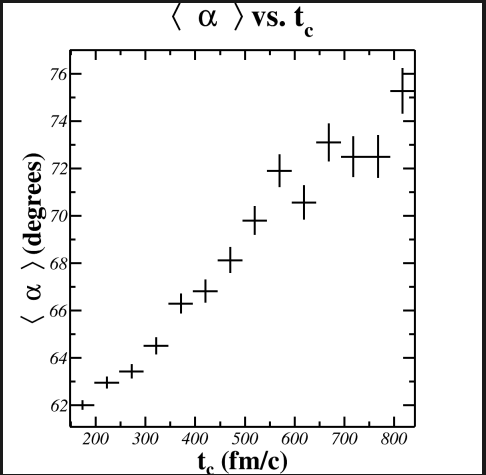


Alignment/Contact Time Correlation for $Z_L = 4$ and $Z_H \geq 11$

Contact Time and Angular Alignment

We do indeed see a correlation!

- What can we do with this?

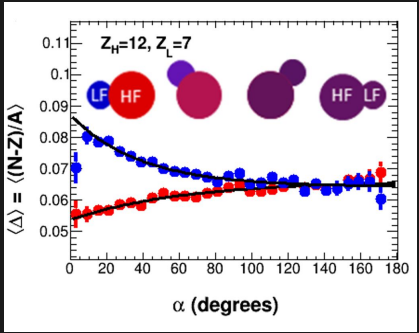


Alignment/Contact Time Correlation for $Z_L = 4$ and $Z_H \geq 11$

Equilibration Through Neutron-Proton Exchange

During the PLF* Rotation

- PLF* has two components
- Small component is neutron rich
- Large component is relatively proton rich
- Exchange occurs during the contact period



A. Jedele et al., PRL 118, 062501 (2017)

Big Question #2

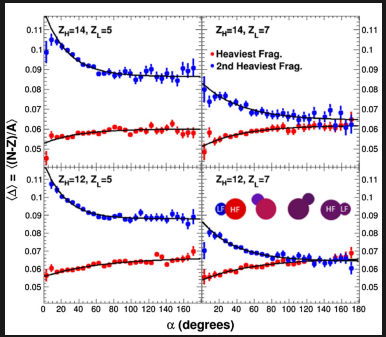
Does a correlation exist between contact time and *composition*?

- **Average Composition:** $\langle \Delta_{LF} \rangle = \left\langle \frac{N-Z}{A} \right\rangle$
  - Accessible through both simulation and experiment

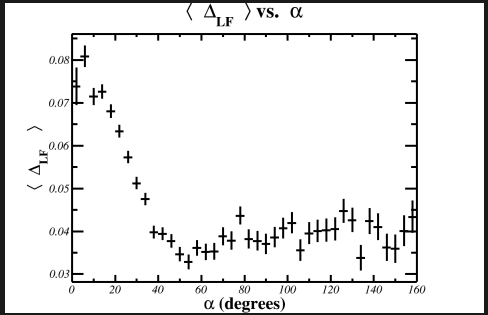
Same method as before.

Composition and Alignment

$$\langle \Delta \rangle = \left\langle \frac{N - Z}{A} \right\rangle$$

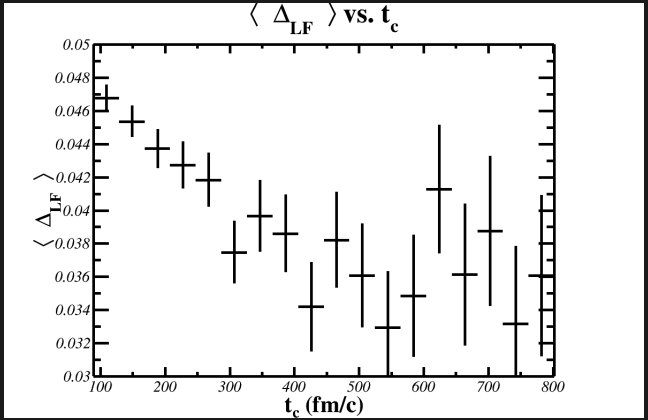


A. Jedele et al., PRL 118, 062501 (2017)



Simulated events with $Z_L = 4$ and $Z_H \geq 11$

Composition and Contact Time



Summary

- We have new tools that are useful for analysis and visualization
- Correlation exists between average alignment and contact time
- We see the expected relationships between contact time and fragment composition

Thank you

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References


K. et al. Brown.
Phys. Rev. C, 87:061601, Jun 2013.


M. Papa et al.
Journal of Computational Physics, 208(2):403 – 415, 2005.


S. et al. Hudan.
Phys. Rev. C, 86:021603, Aug 2012.


A. et al. Jedele.
Phys. Rev. Lett., 118:062501, Feb 2017.


Massimo et al. Papa.
Phys. Rev. C, 64:024612, Jul 2001.


A. et al. Rodriguez Manso.
Phys. Rev. C, 95:044604, Apr 2017.


K. et al. Stiefel.
Phys. Rev. C, 90:061605, Dec 2014.