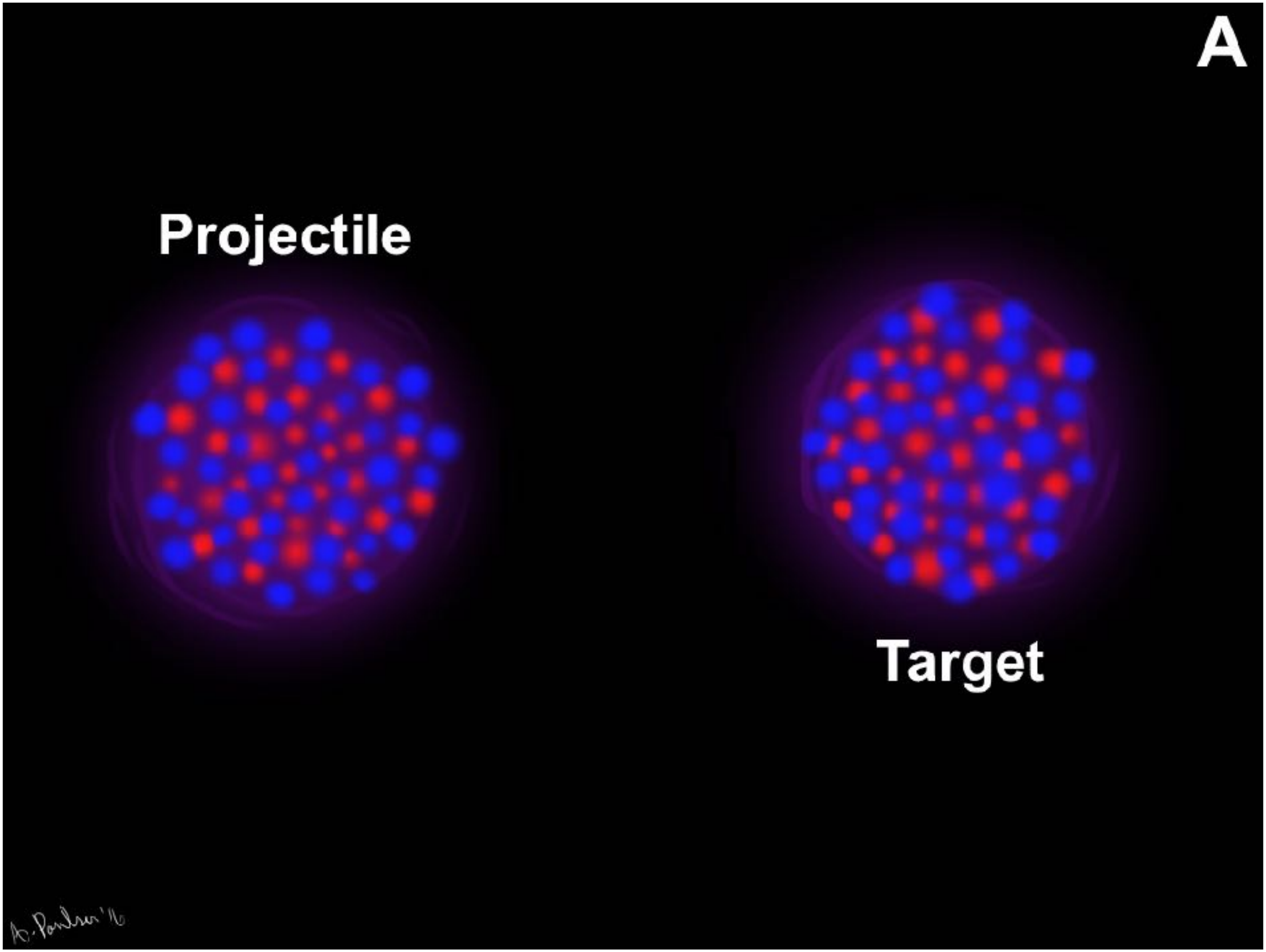
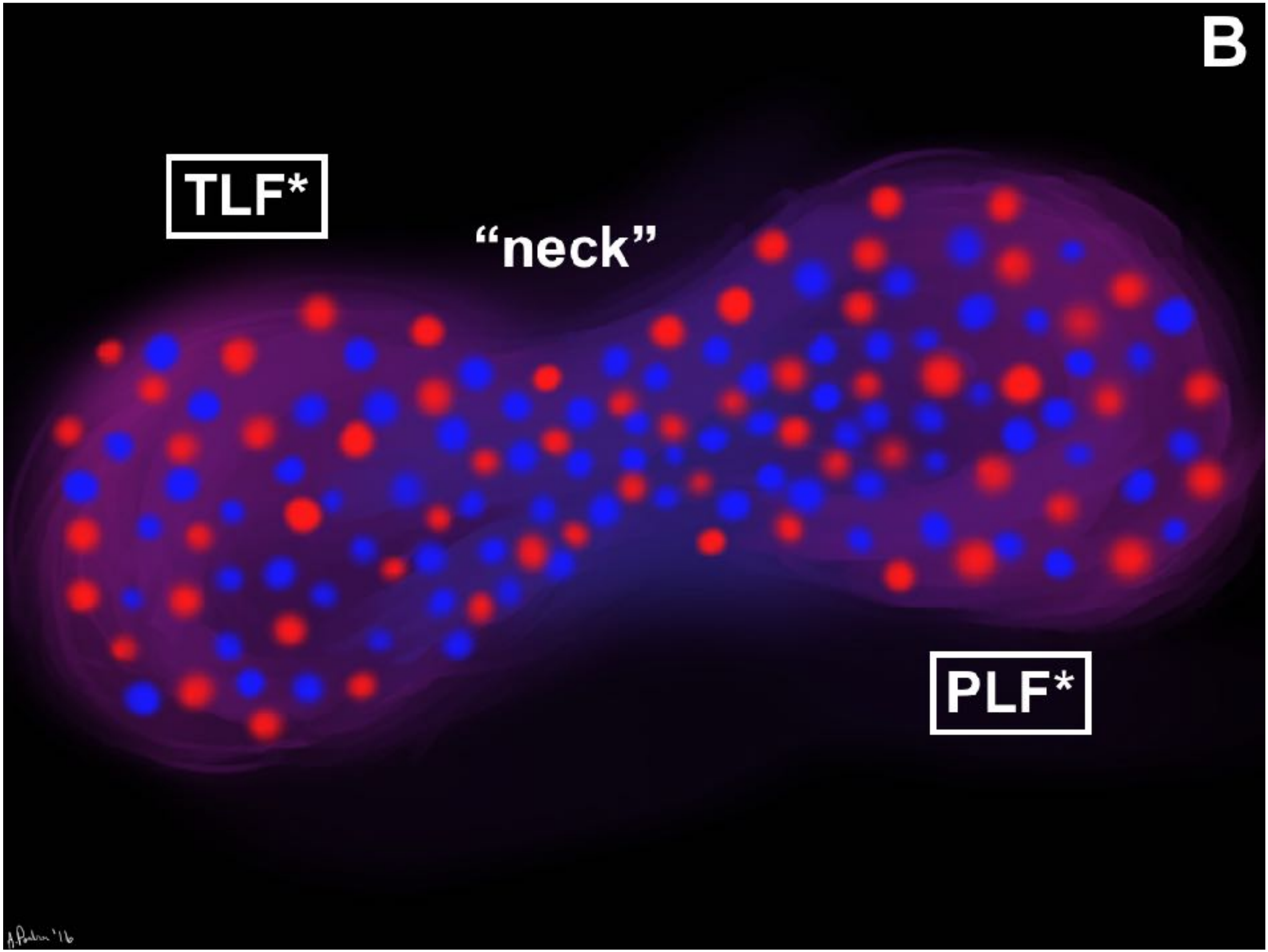
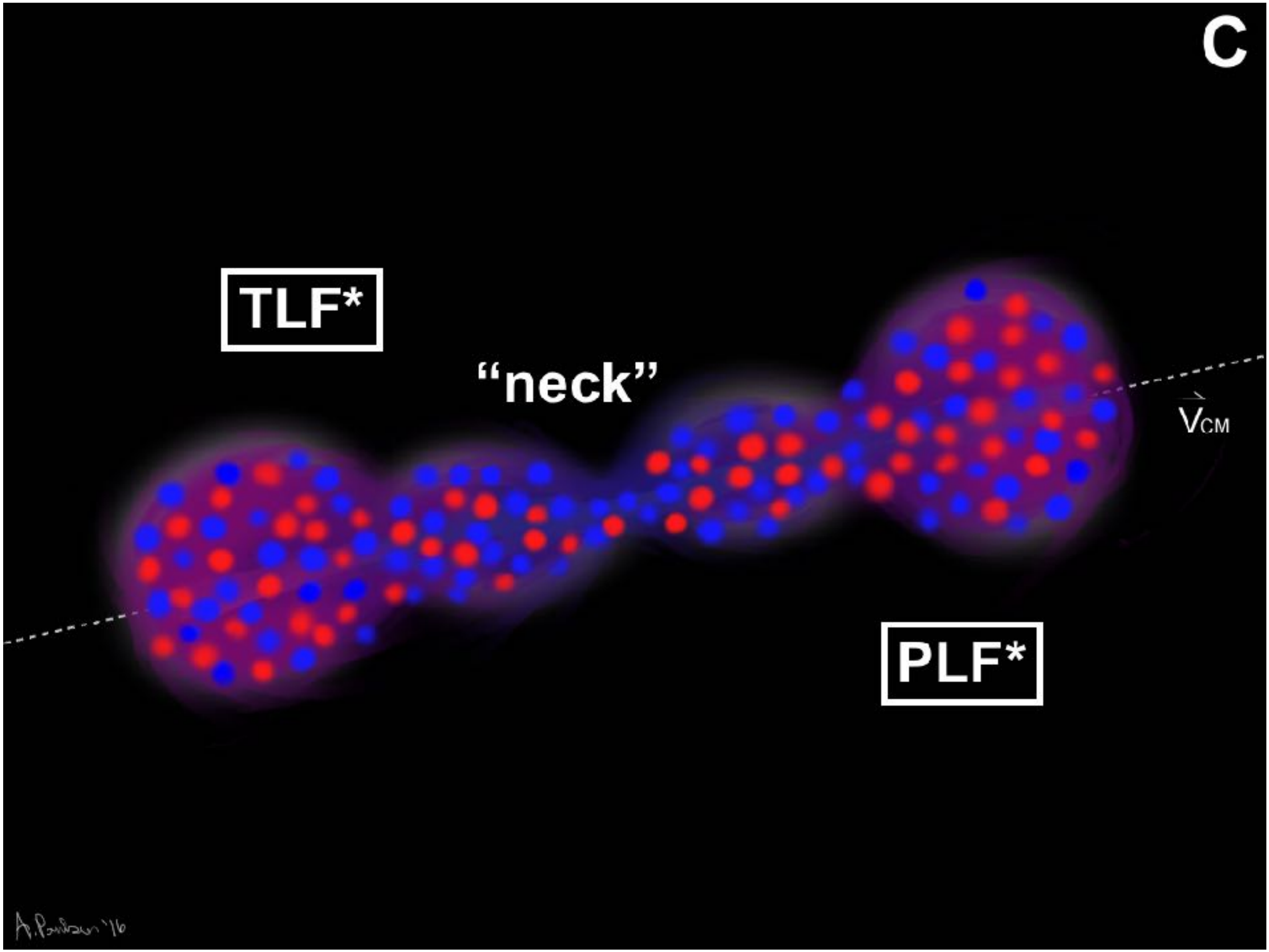
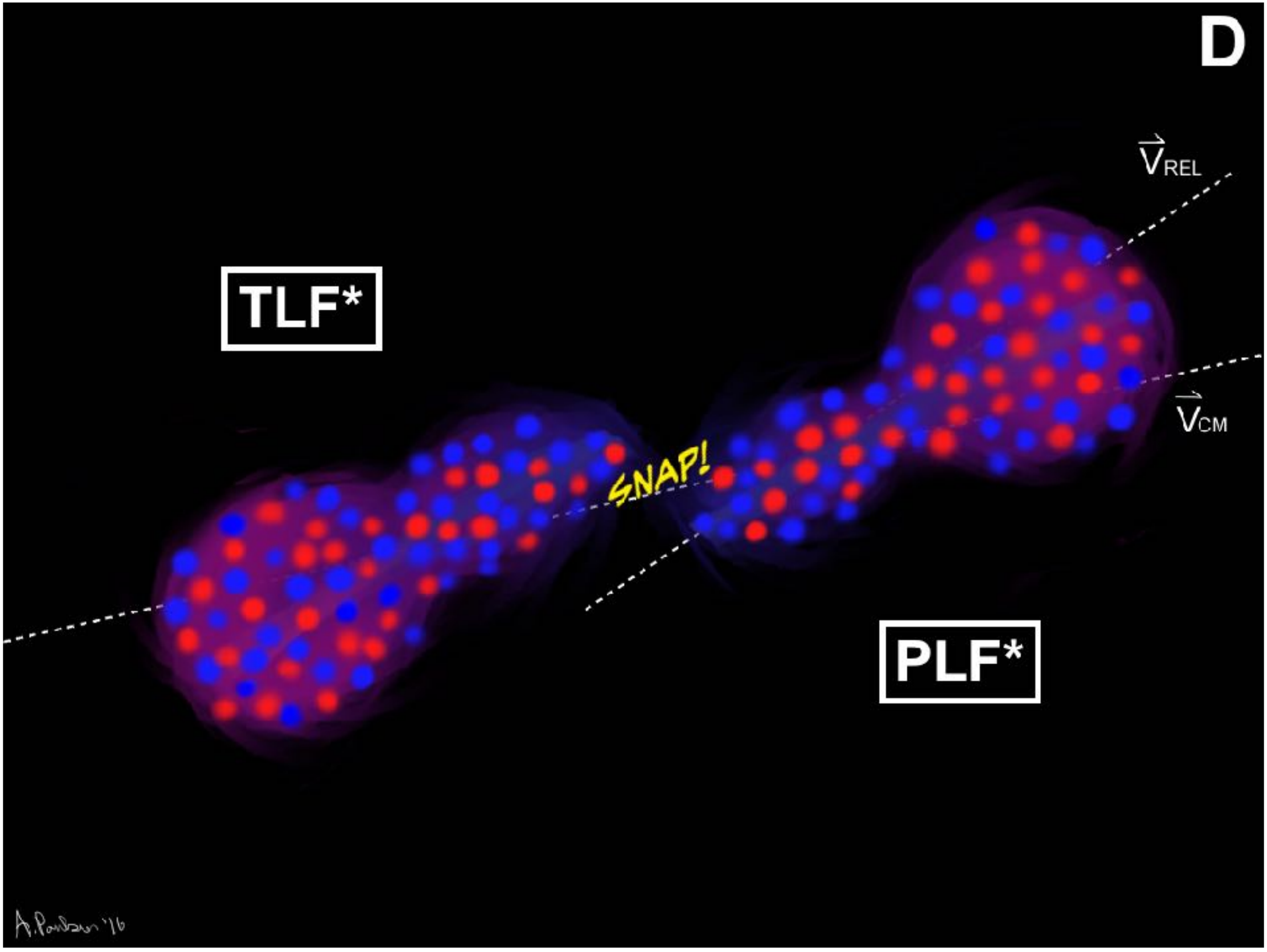
Characterizing N-Z equilibration in nuclear reaction with sub-zeptosecond resolution.

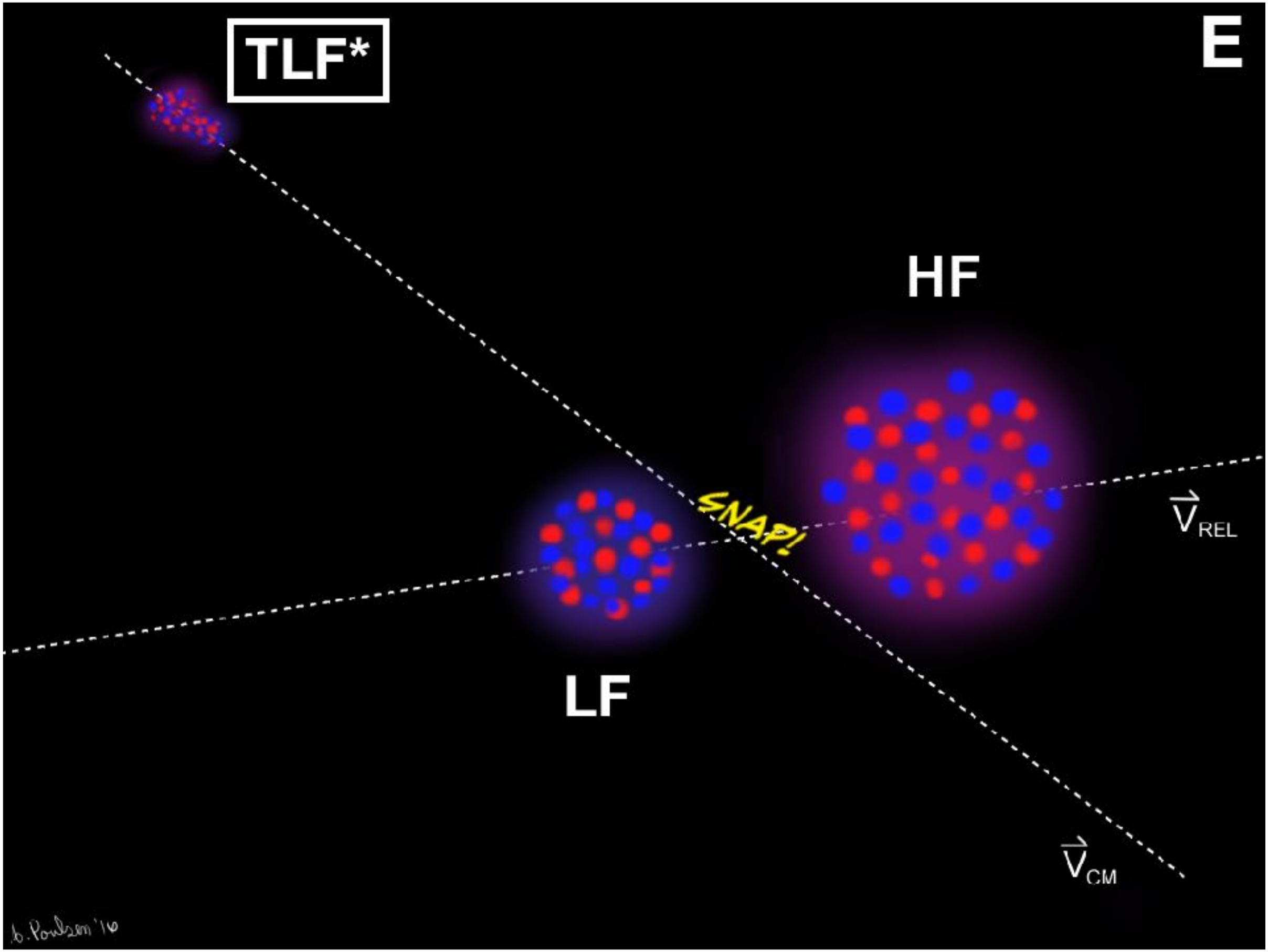
Dr. Alis Rodriguez Manso[1]
[1]Texas A&M University, TAMU


A
Projectile
Target


B
TLF*
“neck”
PLF*


C
TLF*
"neck"
$\vec{V}_{CM}$
PLF*


D
$\vec{V}_{REL}$
TLF*
$\vec{V}_{CM}$
SNAP!
PLF*
A. Poulsen '16


TLF*
E
HF
SNAP!
$\vec{V}_{REL}$
LF
$\vec{V}_{CM}$

Angular (α) distributions:

- Lifetime of PLF* correlated with rotation angle:

$$\alpha = \cos\left(\frac{\vec{v}_{rel} \cdot \vec{v}_{CM}}{\|v_{rel}\|\|v_{CM}\|}\right)$$

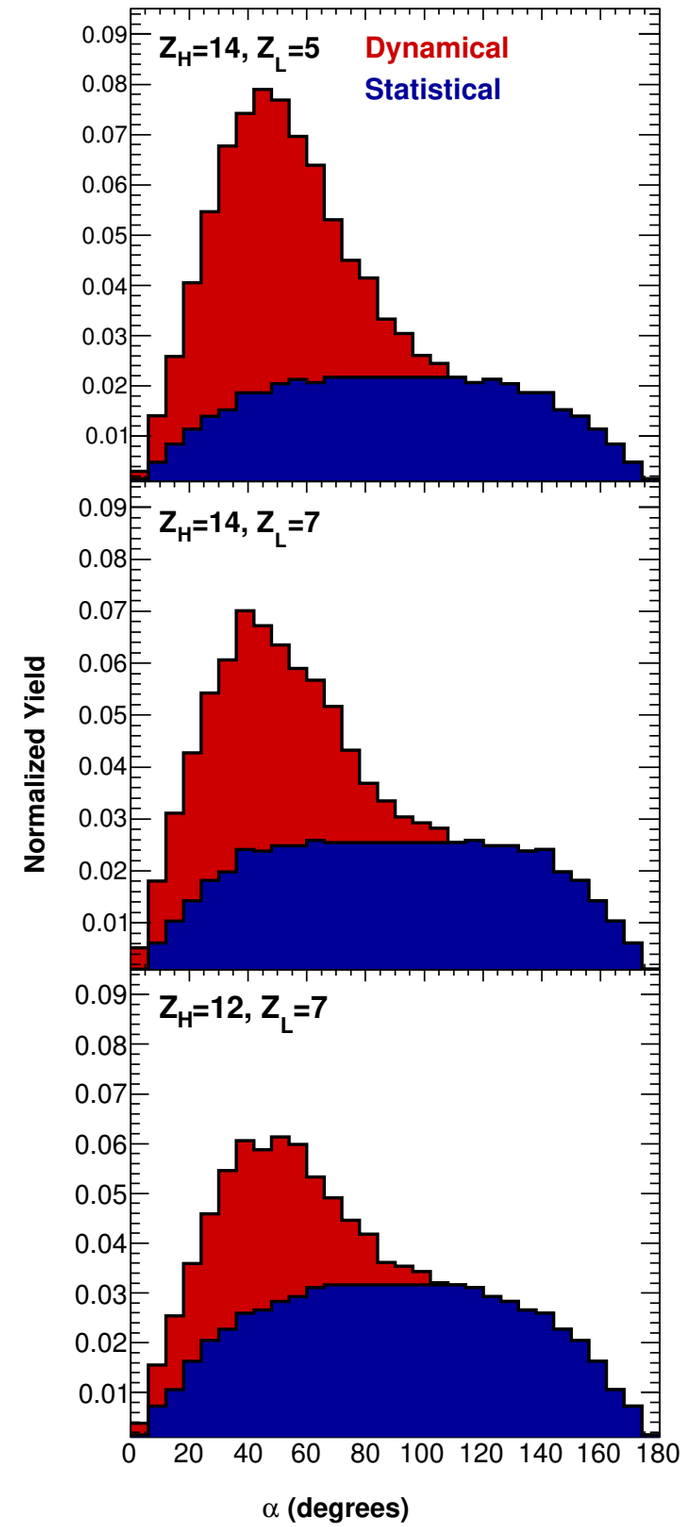
- Angular distribution peaked for most aligned configuration. Decreases in yield with decreasing alignment.

- Excess yield largest and most strongly aligned for most asymmetric splits.

- Less aligned decays represent longer decay times.

$$Y_T = Y_d + Y_s$$

- Dynamical yield dominates at small angles and decreases as α increases.



Composition vs decay alignment:

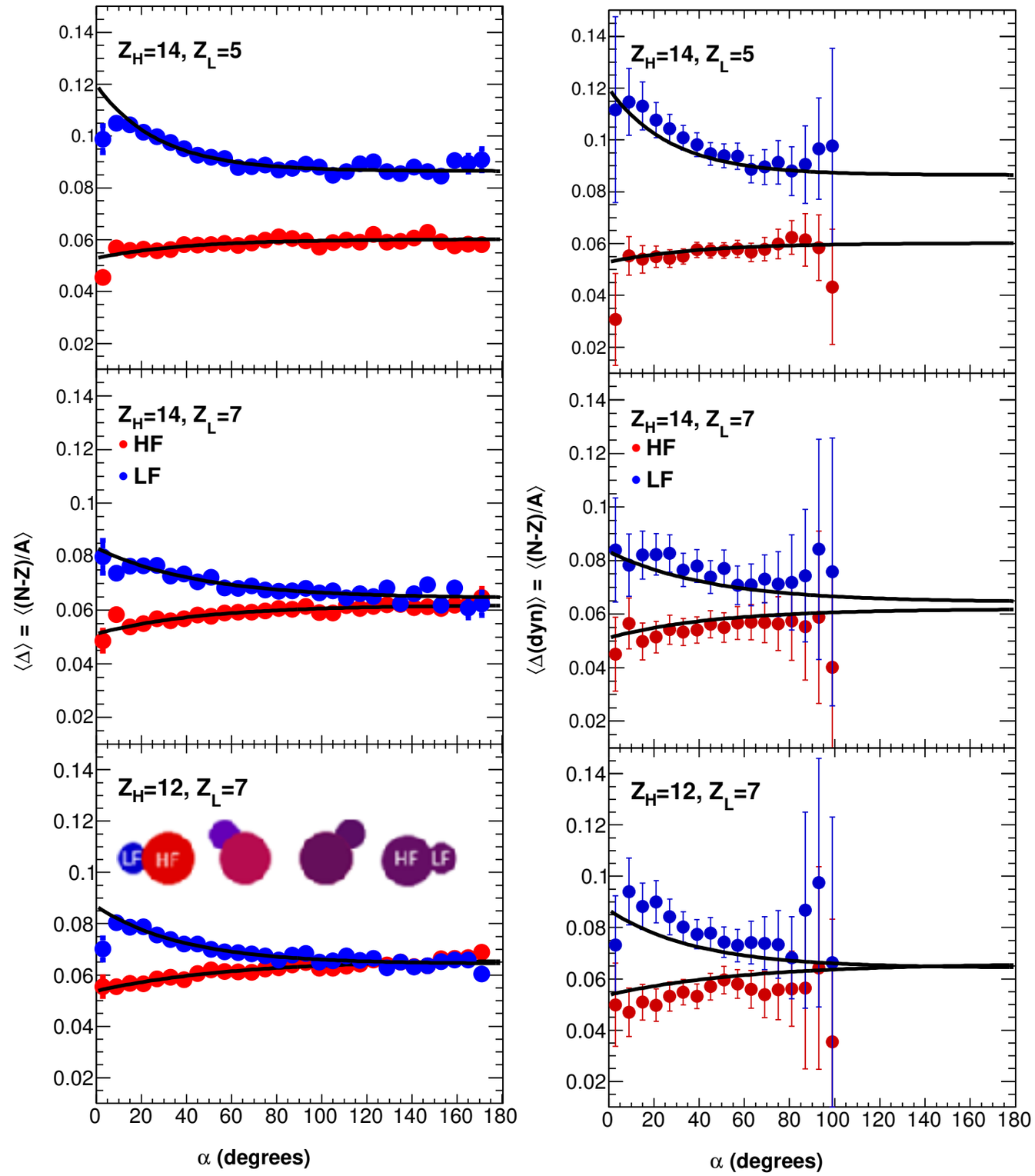
$$\Delta_{Observable} = \Delta_S Y_s + \Delta_d Y_d$$

- As angle of rotation increases, Δ_{HF} (Δ_{LF}) start off very n-poor (n-rich), then evolve towards each other.

- Exponential fit: $a + b\, e^{-c(\alpha)}$
  - a = equilibrium value
  - c = rate constant for equilibration

- First order kinetics.

- Dynamical composition generally follows the same trend as the overall composition (more extreme).



Rate of equilibration:

Average rate constant degree^{-1}:

Symmetric systems:

LF 0.03 ± 0.01

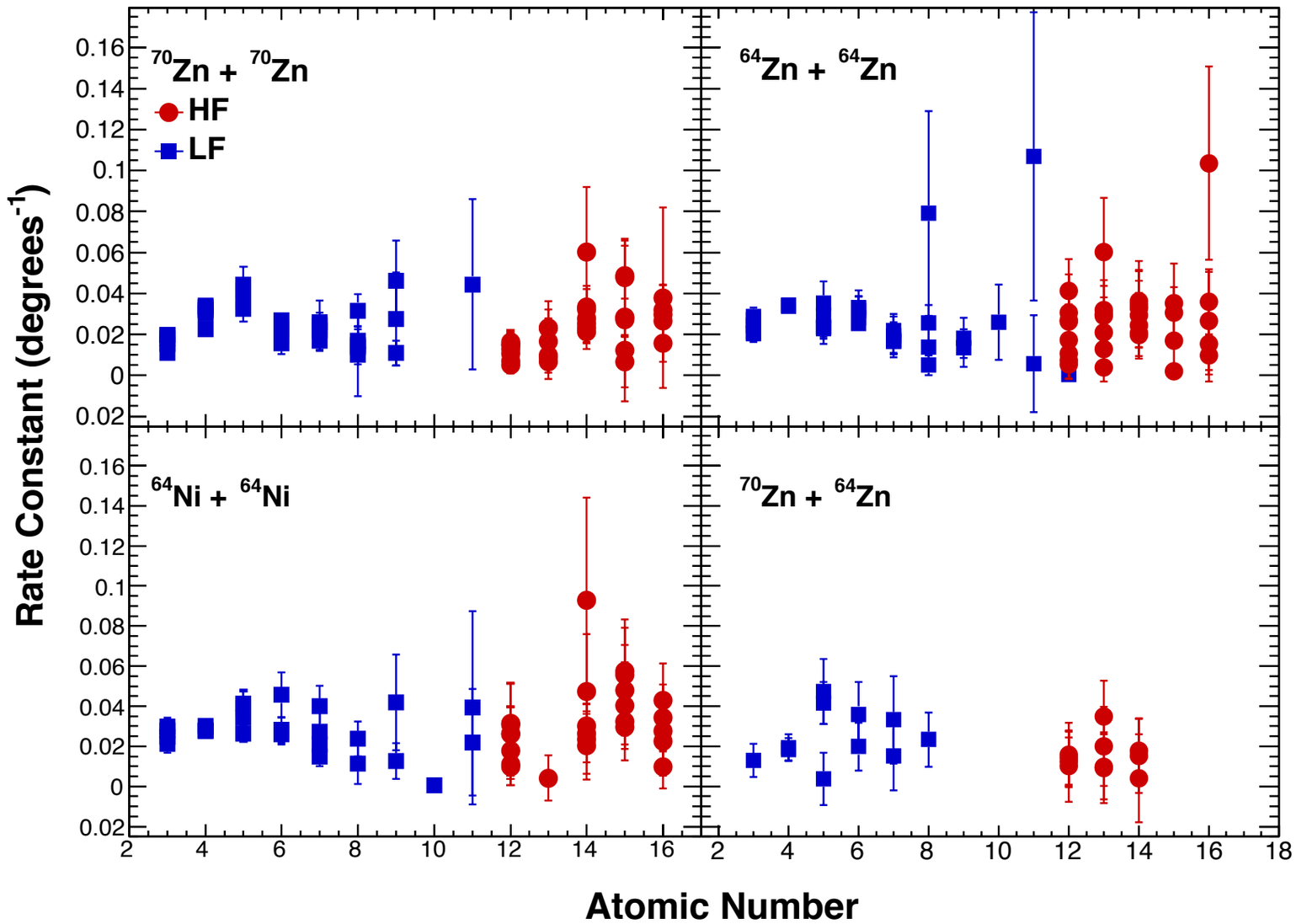
HF 0.02 ± 0.01

Asymmetric system:

LF 0.02 ± 0.01

HF 0.01 ± 0.02

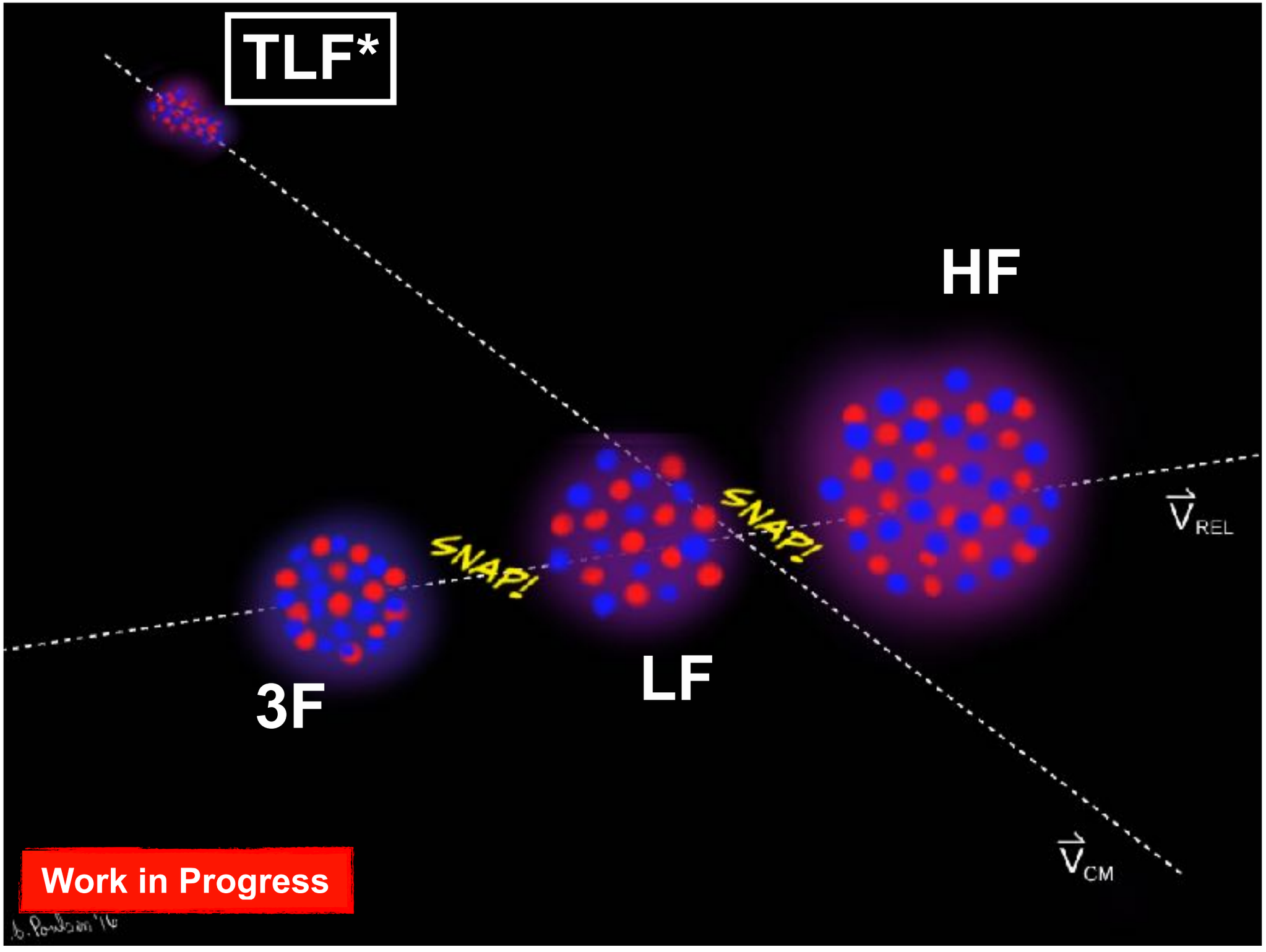
- Relevant parameter to calculate the equilibration times.
- Describes how fast the equilibration occurs within the PLF*.



- Agreement of rates → force driving the equilibration is independent of the size of both partners only depends on the difference in asymmetry

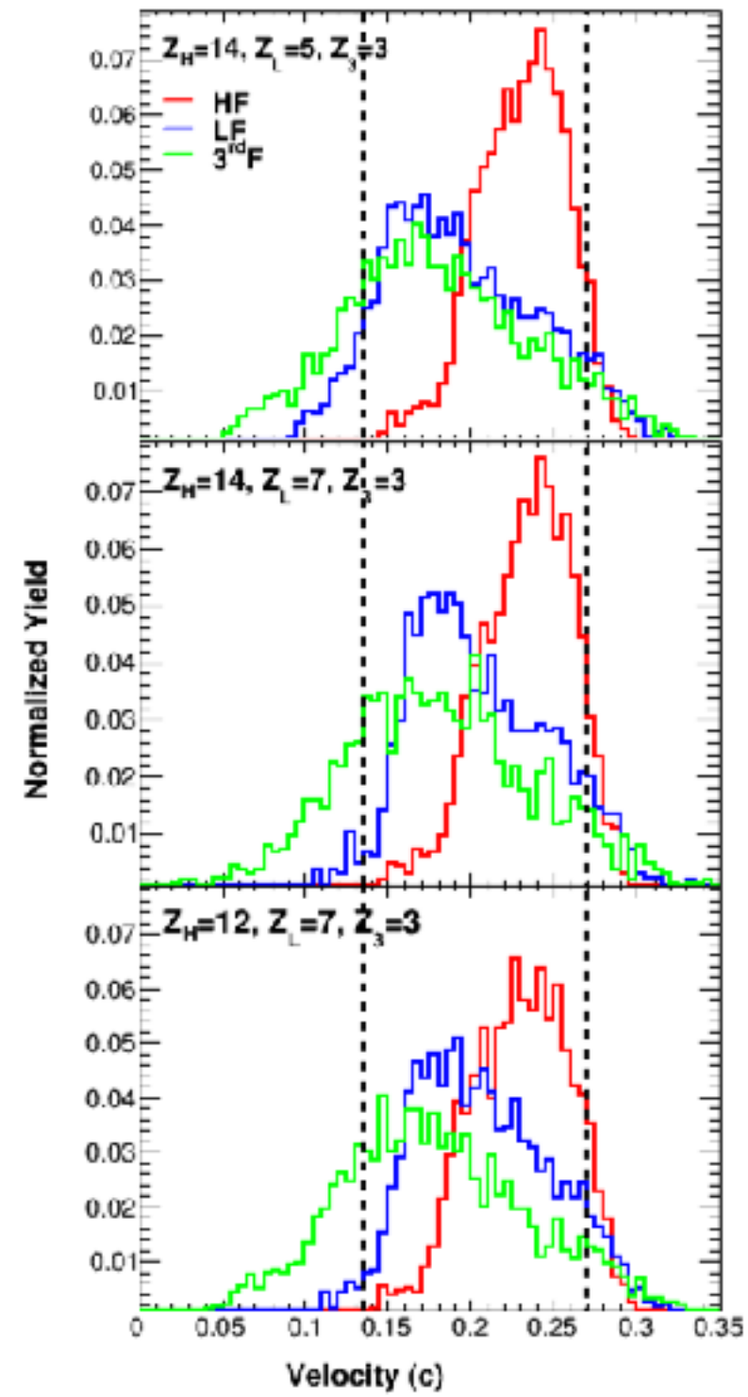
Would be very INTERESTING and NICE to do a follow up comparing our results to model calculations!

Our plan for the 3er Fragment:



Velocity distributions of HF, LF and 3^{er}F

- Dashed lines = beam velocity (i.e. 0.27c) and mid-velocity (i.e. 0.13c).
- The three of them peaked above mid-velocity (indicating that HF, LF and 3^{er}F originate from the PLF*).
- LF produced at velocities > than mid-velocity and < than the HF.
  HF produced closer to beam velocity.

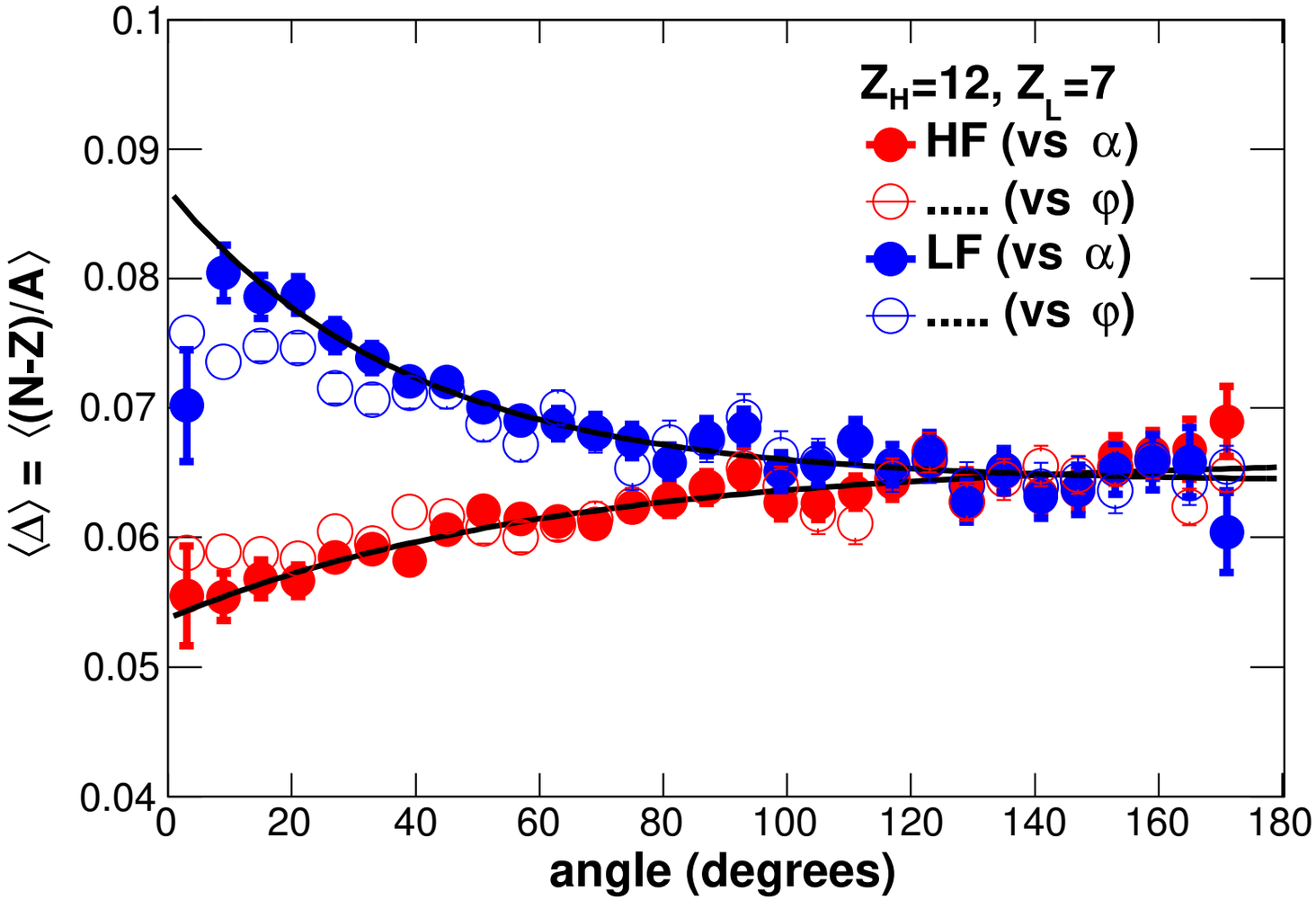


Work in Progress

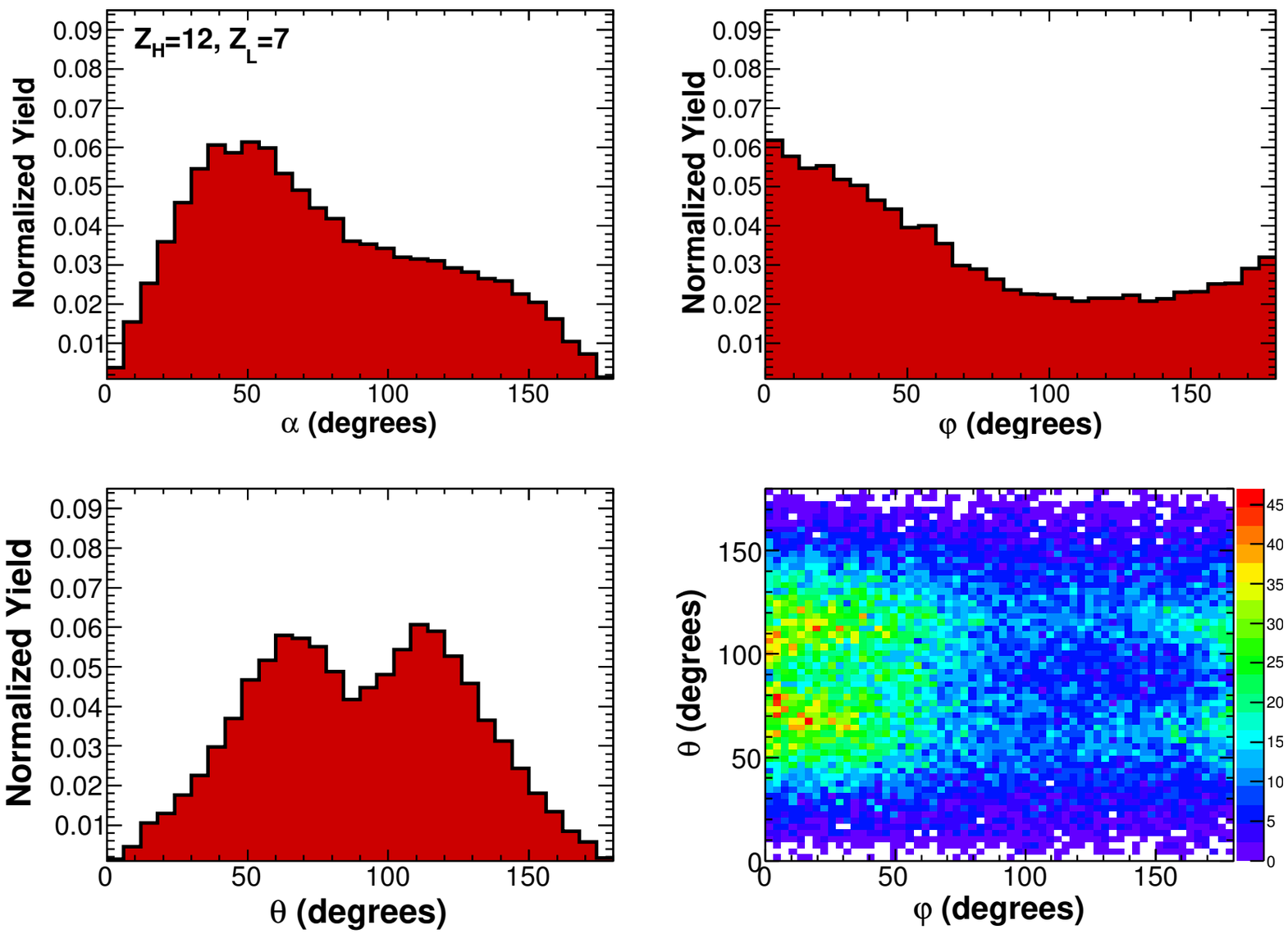
Thank you!

Backup Slides

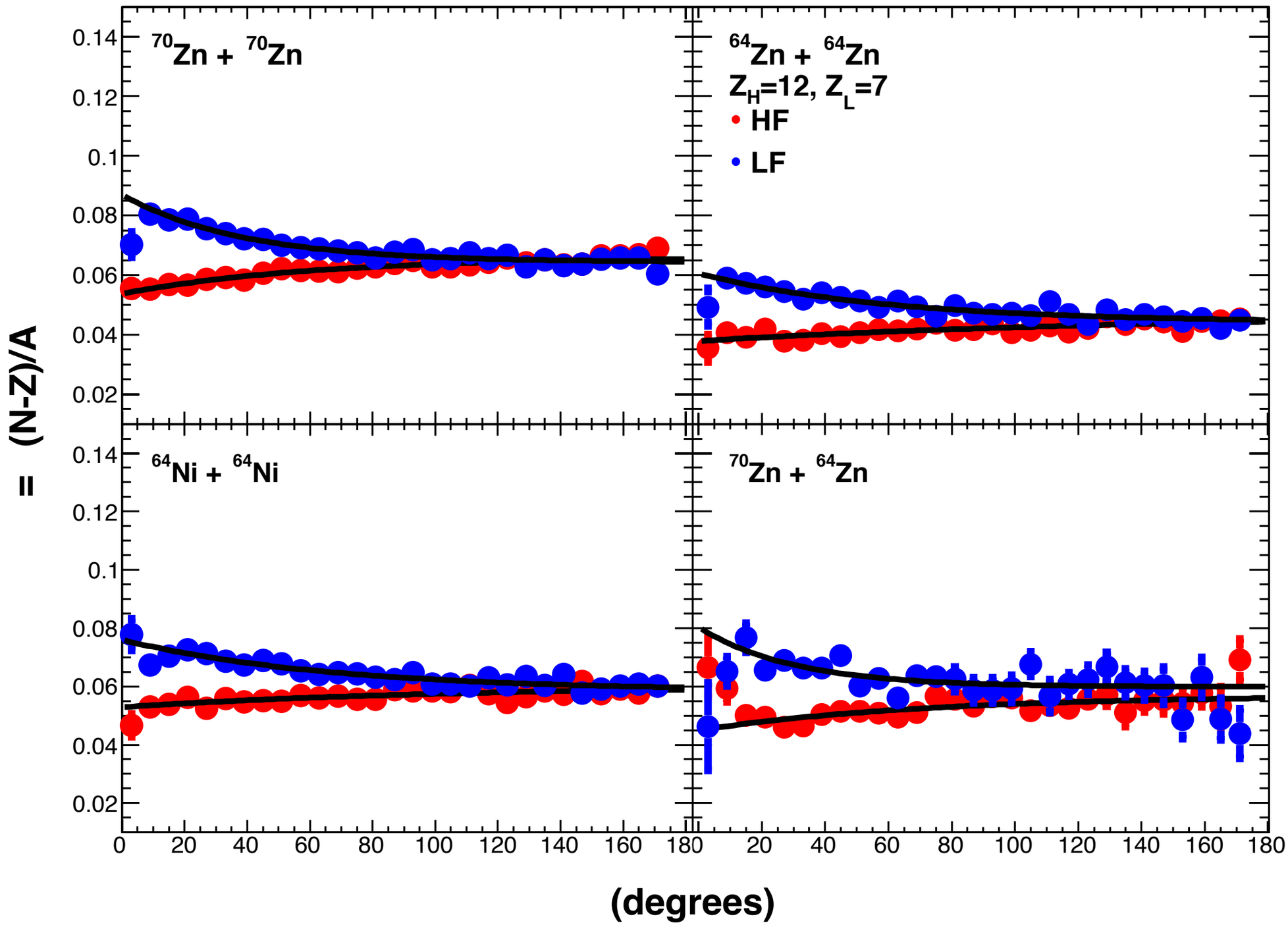
Composition vs decay alignment, for α, φ :



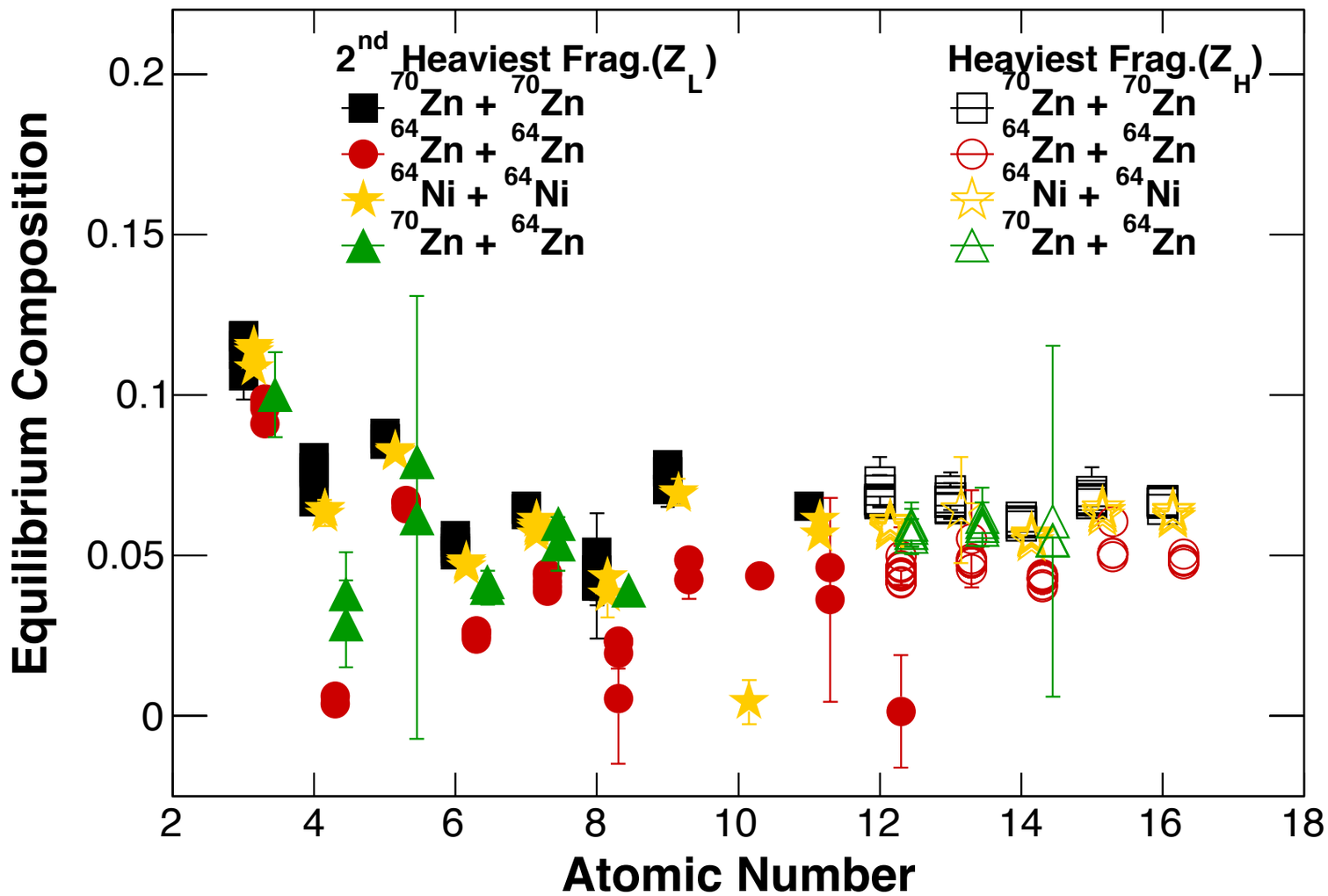
Angular (α, φ and Θ) distributions: why α?



Composition vs decay alignment:



Equilibrium composition



Summary:

- We study the time-dependence of n-p equilibration in dynamically deformed nuclear systems by examining the composition of fragments produced by a system out of equilibrium.
- We employ a method to measure the equilibration's time evolution by studying the fragments emitted from the PLF* in semi-peripheral collisions at 35 MeV per nucleon as a function of the breakup alignment angle.
- The alignment angle serves efficiently as an effective clock for equilibration.
- The variation of the composition as a function of the alignment angle clock shows an exponential behavior simultaneously for both the light and the heavy fragments, suggesting first order kinetics, for all the systems studied.
- The yield and measured composition are used to extract an estimate for the purely dynamical component (unencumbered by statistical background). No modification of our extracted equilibration rate constants is warranted.