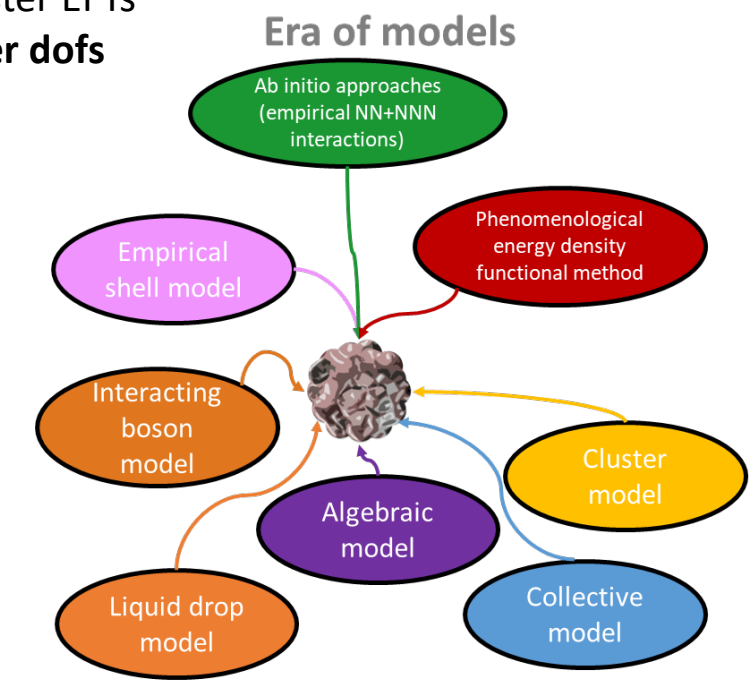
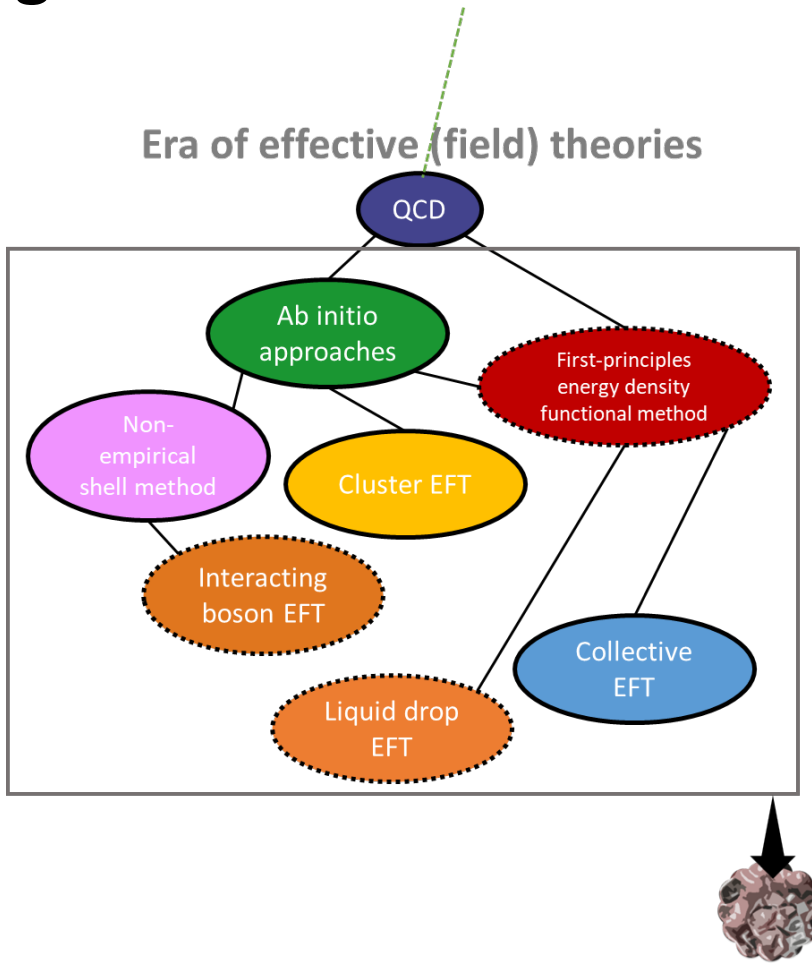
Theoretical framework for clustering

1. Need for articulation between microscopic and cluster EFTs
   - ► **No belittling in going from microscopic to cluster dofs**
   - ► **Not the same domain of applicability**
   - ► **Not the same computational complexity**





2. Experimental smoking gun for what is inferred to be nucleonic clustering

Definition: All ***but*** the observables whose reproduction to a given accuracy ***cannot*** be achieved via the use of cluster dofs (i.e. via low order of a cluster EFT), i.e. all observables for which the use of cluster dofs is ***sufficient***

► ***The faster it converges in a cluster EFT the more "smoking" it is***

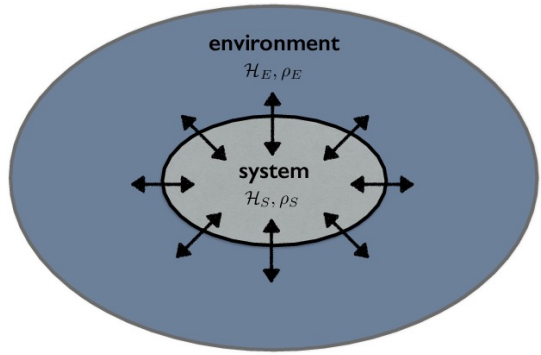
Ex1: what is used in cluster EFT to postulate cluster dofs: alpha separation energy vs clusterized nucleus separation energy

Ex2: moment of inertia, specific EM transitions, alpha knockout cross section, alpha decay width, …

Conditions for clustering

1. Threshold and open-system character dictate clustering

► **Unitarity of quantum mechanical formulation crucial**



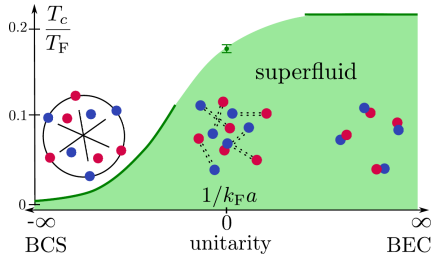
Remark: Universal character shared by many-body systems, i.e. atomic/molecular systems

► **Intrinsically interdisciplinary (workshop to be organized ?)**

2. Nuclei are near "unitarity" (not the same thing as above!) = $a_s^{-1} \leq k \leq R^{-1}$

-Discrete scale invariance in A≥3 body systems (bosons or more-than-3 component fermions)

► Geometric series excitation spectrum (e.g. Efimov) + specific relation between A-body ground-state energies



-The shallow character of the two-body system (unitarity) is postulated to bring specific states above threshold

► **Drives nuclear clustering**

3. Strength of correlations triggering localization/bound state formation

► **Dominance of localization for low density light nuclei**

$$\sqrt{\Lambda} \equiv \sqrt{\frac{\langle V \rangle}{\langle T \rangle}} = \sqrt{2}\left(\frac{3}{4\pi}\right)^{\frac{1}{6}} (2MU)^{\frac{1}{4}} (An)^{-\frac{1}{6}} \sim \alpha_{\mathrm{loc}}$$

Nucleon mass — Depth of the confining potential

Number of nucleons — Mean density