Intro - Staggering

Work in progress - Proposal

Work in progress - Hauser-Feshbach code

Staggering in measured Yields

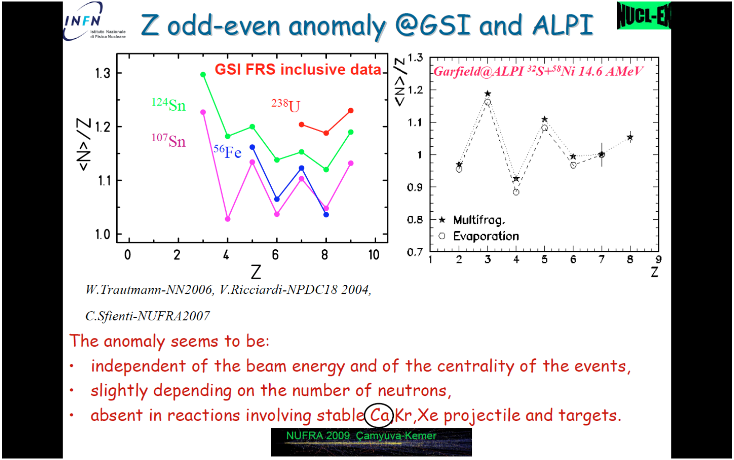

Figure: Transparency from the talk of M.D'Agostino, NUFRA 2009

Staggering in measured Yields - Proposed Interpretation - 1

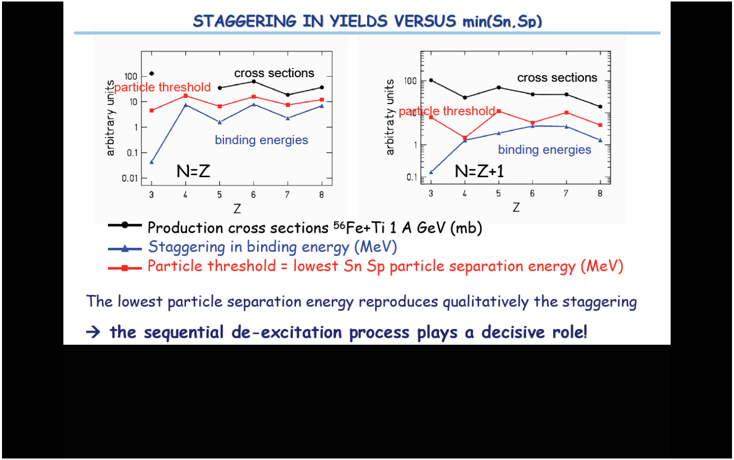

Figure: Transparency from the talk of V.Ricciardi, NUFRA 2009

Staggering from the last evaporation step? - 1

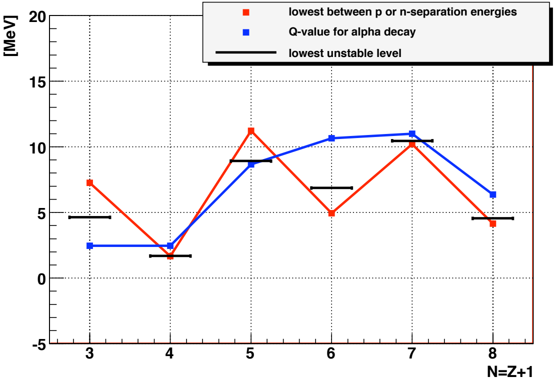

Figure: $N = Z + 1$ nuclei mainly decay through p or n emission

Staggering from the last evaporation step? - 2

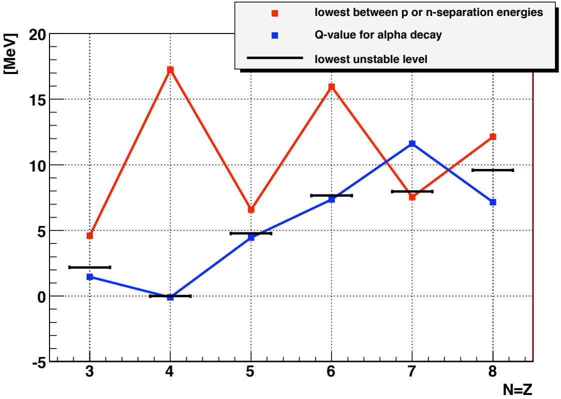

Figure: $N = Z$ nuclei mainly decay through α emission

Staggering BEFORE the last evaporation step!

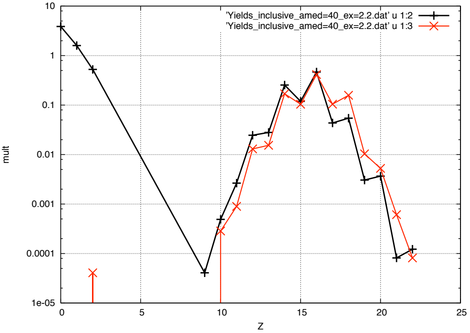

Figure: A statistical evaporation model based on the Weisskopf formalism with experimental binding energies as input predicts staggering in the final yield distribution, but also at the last but one step of the decay chain, i.e. at finite temperature. (Calculation by A.Raduta)

Temperature dependence of the Staggering

Interplay of different T dependences:

$$BR_i = \frac{\Gamma_i^{CONT}}{\sum_i \Gamma_i} = \frac{1}{\sum_i \Gamma_i} \times \frac{1}{\rho_{parent}} \cdot \int_{K_{min}}^{K_{max}} dK \sum_{J_d=J_{low}}^{J_{plus}} \sum_{j=|J-J_d|}^{J+J_d} \sum_{l=|j-s_p|}^{l+s_p} \cdot TC_{(A,Z,A_p,Z_p,K,l)} \rho(E^* - Q - K, Jd, A_{res}, Z_{res})$$

$$Branching\ Ratio\ for\ particle\ decay\ in\ the\ Hauser-Feshbach\ formalism$$

$$\rho(E^*, J, A, Z) = \frac{\pi^{1/6}}{48} 6^{-1/3} (2J+1) a(T) \left(\frac{a(T)}{2I_{mom}}\right)^{2/3} \frac{\exp(2\sqrt{a(T)(E^* - E_{rot} - \delta(T))})}{(a(T)(E^* - E_{rot} - \delta(T)))^{7/4}}$$

$$Level\ Density\ Parametrization$$

Experimental Reconstruction of the last but one step

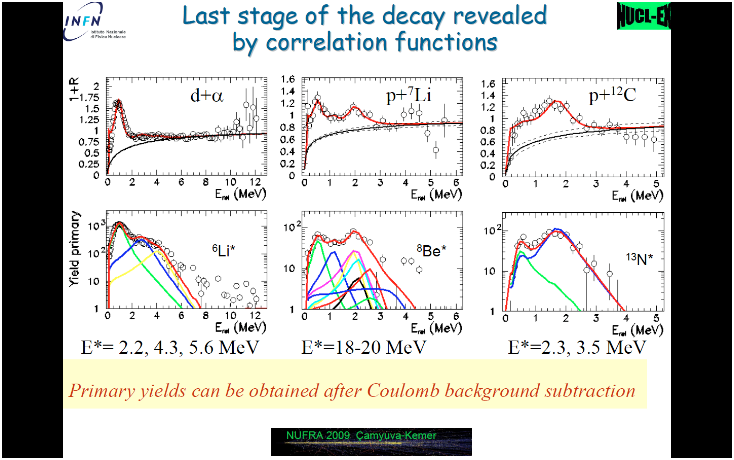

Figure: Transparency from the talk of M. D'Agostino, NUFRA 2009

Physics case

Temperature dependence of a and δ in the level density.
We need:

- a CN system excited in the CONTINUUM
  $\rightarrow$ sensitivity to ρ
- an evaporation chain whose last steps are in the DISCRETE, involving nuclei with well - spaced discrete levels, in order to be able to apply the correlation functions technique
  $(5 \leq Z_{res} \leq 7)$
  $\rightarrow$ reconstruction of the population of discrete states
- an evaporation code which takes into account the experimentally known discrete levels and predicts their population (*work in progress*!)

Work in progress - Proposal

Reaction under study:

$$^{12}C(@95MeV) +^{9} Be \rightarrow^{21} Ne^{*}(@2.8AMeV)$$

- $^{12}C(@95MeV)$ beam delivered by TANDEM (@LNL);
- GARFIELD and RCo apparatuses for the measurement of fragments and LCP;
- RCo (angular coverage $5^{\circ} \leq \theta \leq 18^{\circ}$) granularity and isotopic resolution (up to $Z = 8$) are suited to the use of the correlation functions technique!

Hereafter, preliminary calculation with the newly developed Hauser Feshbach evaporation code.

Multiplicity distribution

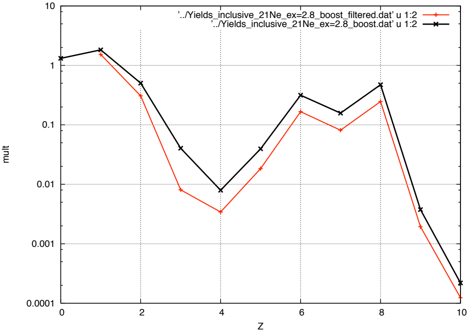

Figure: Multiplicity distribution of final products as a function of Z, before (black curve) and after (red curve) the raw filter for the apparatus.

Occupation probability of the CONTINUUM/DISCRETE

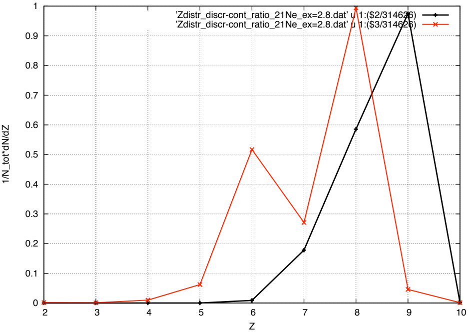

Figure: As a function of Z, population of a given daughter nucleus integrated over the whole decay chain, in its continuous (black curve) or in its discrete part of the energy spectrum (red curve), normalized to the total number of events ($\frac{1}{N_{tot}}\frac{dN}{dZ}$).

Lenght of the evaporation chain

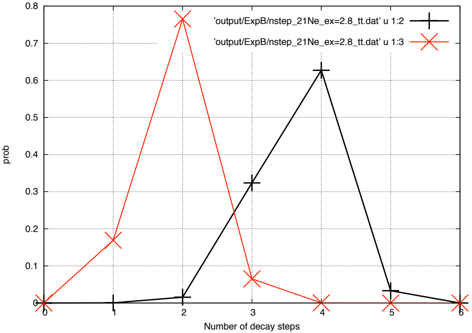

Figure: Probability distributions of: the total number of decay steps (black curve); the number of decay steps leaving the daughter nucleus in a discrete state (red curve).

Example - ideal case: 3 decay steps

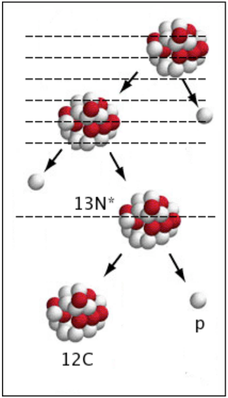

Figure: Representative picture of a decay chain

→ Initial CN in the CONTINUUM
→ first decays still in the CONT.
→ last steps in the DISCRETE

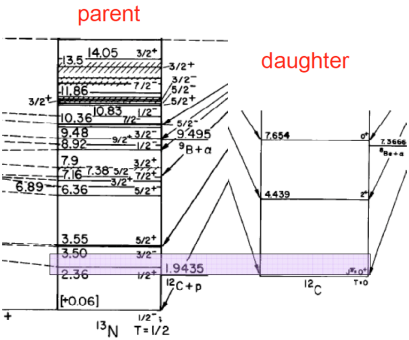

Figure: Level scheme

Example - ideal case: 3 decay steps

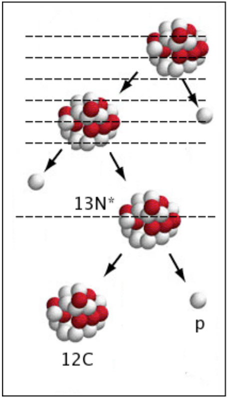

Figure: Representative picture of a decay chain

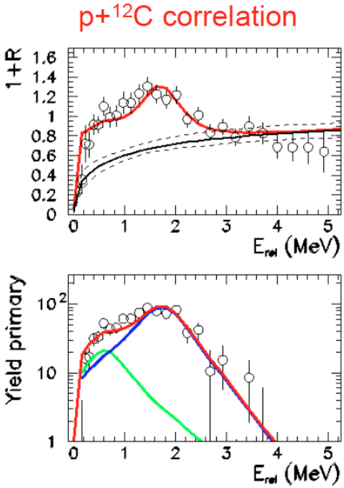

Figure: Correlation function

Test of the HF code reliability - Kinematics 1

HF previsions are preliminarly validated through comparison with PACE4:

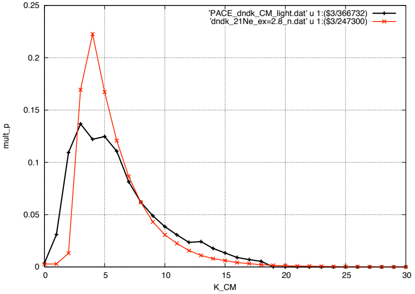

Figure: dN/dK distributions for p, CM energies: black curve - PACE4; red curve - HF.

Test of the HF code reliability - Kinematics 2

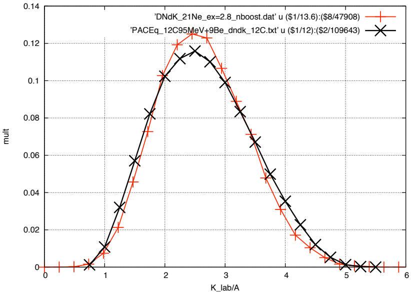

Figure: $dN/d(K/A)$ per Z=6 (HF, $A_{med} = 13.6$) e ^{12}C (PACE), LAB energies: black curve - PACE4; red curve - HF.

There are still adjustments to be done, but the code is ready to be runned!

Simulations

Studied reactions:

- $^{12}C(@95MeV) +^{9} Be \rightarrow^{21} Ne^{*}(@2.8AMeV)$
- $^{12}C(@60MeV) +^{7} Li \rightarrow^{19} F^{*}(@2AMeV)$
  $\rightarrow$ scarce occupation of the CONTINUUM
- $^{12}C(@95MeV) +^{7} Li \rightarrow^{19} F^{*}(@2.7AMeV)$
  $\rightarrow$ are the previsions of the code still valid?

In any case, to address this kind of physics with these methods, we need an evaporating source

- with $8 \leq Z \leq 12$;
- with $2AMeV \leq e^{*} \leq 3AMeV$