Study of two and multi particle correlations in $^{12}C+^{24}Mg$ reaction at E=35 AMeV

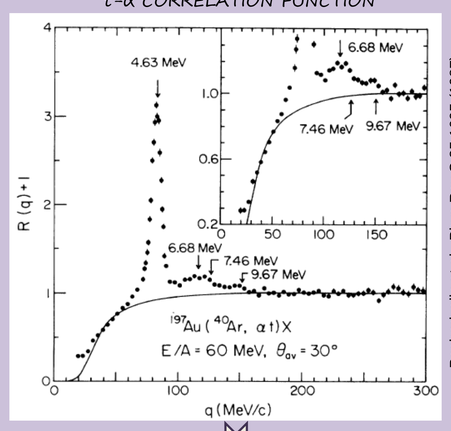
L. Quattrocchi[1,2], L. Acosta[2,3], L. Auditore[4], G. Cardella[1], A. Chbihi[5], E. De Filippo[1], S. De Luca[4], D. Dell' Aquila[8,11], L. Francalanza[8], B. Gnoffo[1,2], G. Lanzalone[6,10], I. Lombardo[8,11], I. Martel[7], N. S. Martorana[2,6], S. Norella[4], A. Pagano[1], E.V. Pagano[2,6], M. Papa[1], S. Pirrone[1], G. Politi[1,2], F. Porto[2,6], F. Rizzo[2,6], E. Rosato[8,11†], P. Russotto[1], A. Trifirò[4], M. Trimarchi[4], G. Verde[1,9], M. Veselsky[12], M. Vigilante[8,11]

[1] INFN Sezione di Catania, Catania (Italy), [2] Università di Catania Dip. di Fisica e Astronomia, Catania (Italy), [3] Instituto de Fìsica Universidad Nacional Autònoma de México, México City (Mexico), [4] Università di Messina Dip. di Scienze Matematiche ed Informatiche, Scienze Fisiche e Scienze della Terra, e INFN Sezione di Catania, Messina (Italy), [5] GANIL CEA-IN2P-CNRS, Caen (France), [6] INFN, Laboratori Nazionali del Sud , Catania (Italy), [7] Departamento de Fìsica Aplicada Universitad de Huelva, Huelva (Spain), [8] INFN Sezione di Napoli, Napoli (Italy), [9] IPN Orsay, Orsay (France), [10] Università Kore, Enna (Italy), [11] Università di Napoli Federico II Dipartimento di Fisica, Napoli (Italy), [12] Slovak Academy of Sciences, Bratislava (Slovakia), [13] CNR- IPCF, Messina (Italy), [†] Decease

Two and multi particle correlations

Two-particle correlations allow to explore dynamics of heavy ion collisions and also to access some structure properties of produced systems.

t-α CORRELATION FUNCTION



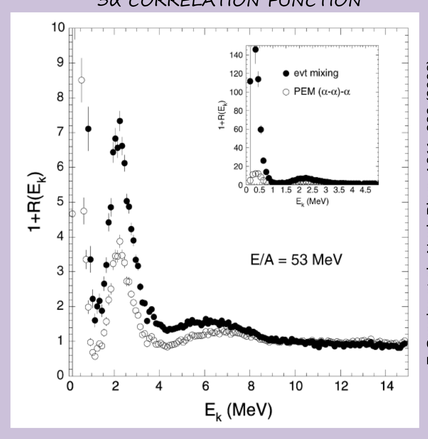
Pochodzalla et al., Phys.Rev.C.35.1695.(1987)

Information on excited states of ^{7}Li!

These techniques are also extended to multi particle correlations to explore the competition between direct and sequential decay of observed resonances.

$^{12}C+^{24}Mg$ E=53 and 95 AMeV with INDRA

3α CORRELATION FUNCTION



F. Grenier et al., Nucl. Phys. A811, 233 (2008).

Study of decay modes of resonances produced in ^{12}C

In order to study decay mechanisms of the observed resonances, possibly disentangling sequential decays from direct three-body ones, a procedure based on construction of Dalitz plots has been followed.

Hoyle State

Symmetric Dalitz plots

Kirsebom et al., Physical Review Letters 108 202501, (2012)

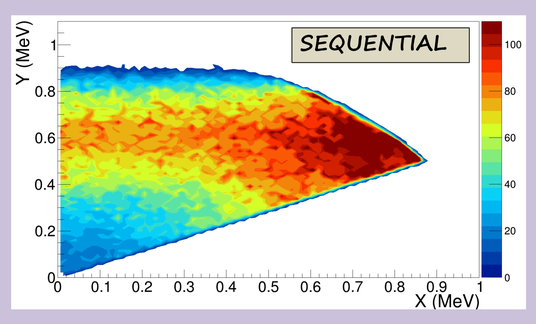
$$x = \sqrt{3}(\varepsilon_j - \varepsilon_k) \qquad \varepsilon_{i,j,k} = E_{i,j,k}/(E_i + E_j + E_k)$$

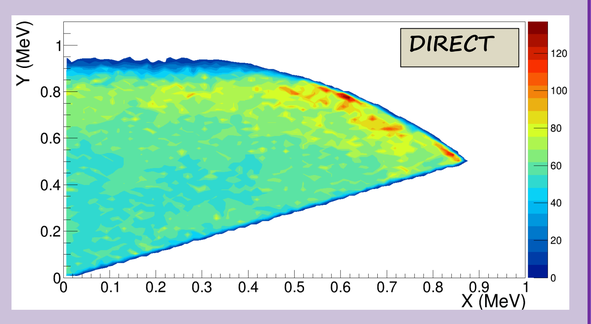
$$y = 2\varepsilon_i - \varepsilon_j - \varepsilon_k$$

→ Particles energies in $^{12}C^*$ frame normalized to the total energy of 3α decay

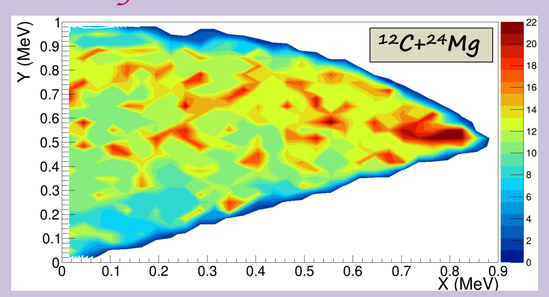
Monte-Carlo Simulations

filtered through the geometry and detector response of CHIMERA.





Experimental results



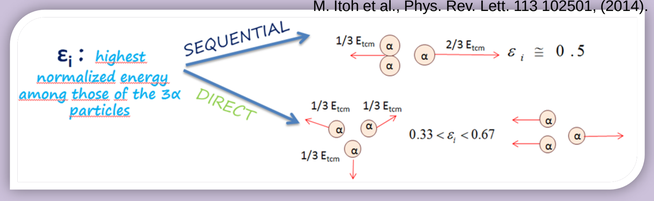
Experimental plot exhibits a more uniform distribution that does not allow us to exclude any of the two decay mechanisms…

For better evaluation ε_i distribution has been analyzed!

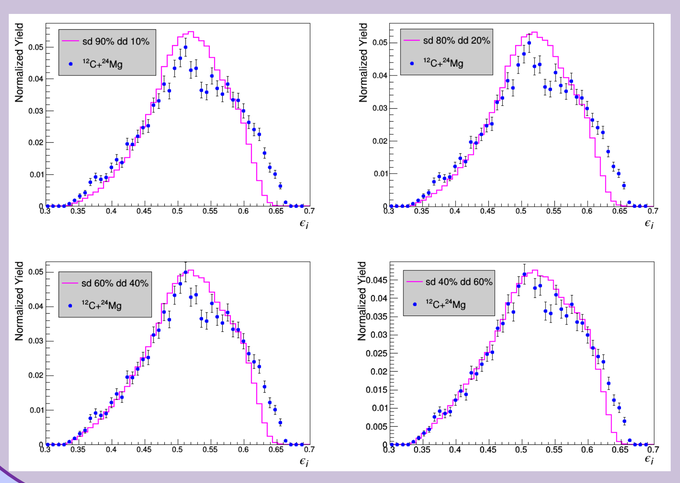
ε_i DISTRIBUTION

M. Itoh et al., Phys. Rev. Lett. 113 102501, (2014).

ε_i distribution gives us information about decay processes



FIT OF ε_i DISTRIBUTION



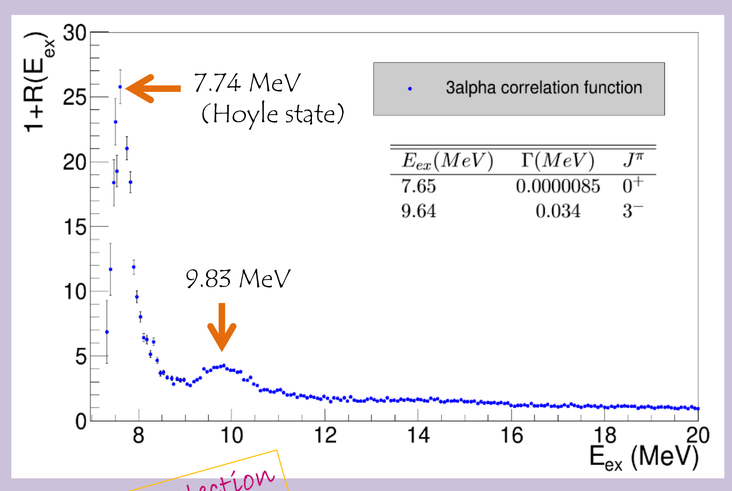
The agreement between simulated and experimental data improves when increasing the percentage of direct decay component

CORRELATION experiment at LNS

A study of two and multi particle correlations in $^{12}C+^{24}Mg$ reaction at E=35 AMeV has been performed at Laboratori Nazionali del Sud of Catania by using the forward part of CHIMERA 4π multi detector.

In particular three α correlations have been explored with the aim of studying the competition between different decay processes of resonances produced in ^{12}C

3α Correlation Function



$$1 + R(E_{ex}) = \frac{Y_{coin}(E_{ex})}{Y_{uncorr}(E_{ex})}$$

Uncorrelated yield spectrum constructed with a randomization of experimental spectra

Coincidence yield spectrum constructed using three alpha particles detected in coincidence in the same event

Event selection

The α particles resulting from the decay of ^{12}C quasi-projectiles, are selected by requiring the parallel velocity, reconstructed from their center of mass, to be larger than 80% of beam velocity.

State at E*=9.64 MeV

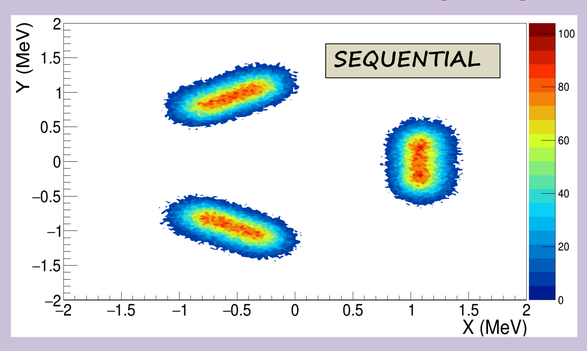
Dalitz parameters

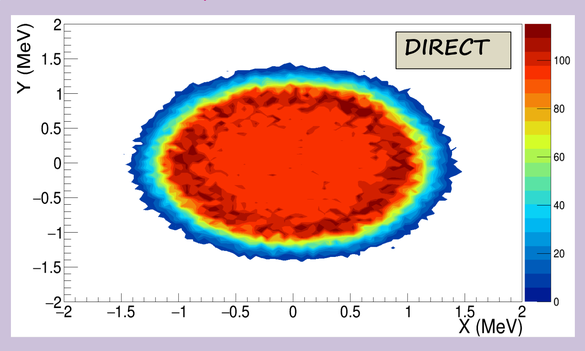
$$x = \sqrt{3}(E_{1CM} - E_{2CM})/3$$

$$y = (2E_{3CM} - E_{1CM} - E_{2CM})/3$$

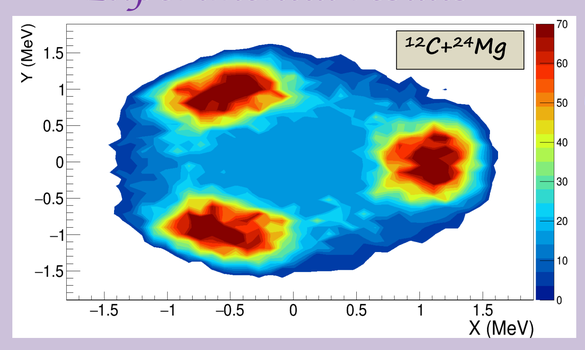
Monte-Carlo Simulations

filtered through the geometry and detector response of CHIMERA.





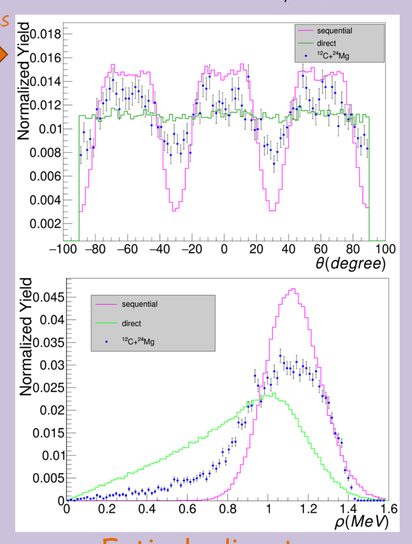
Experimental results



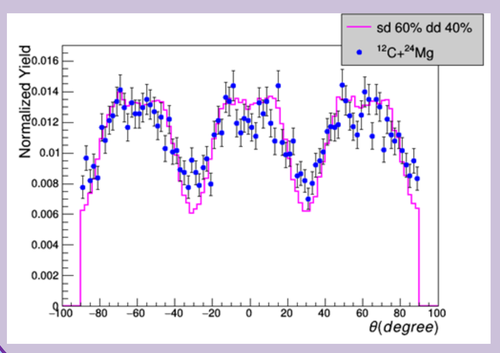
In order to extract a quantitative estimation of these relative contributions

Change of coordinates X,Y-> θ, ρ

$$\theta = A\tan\left(\frac{Y}{X}\right) \qquad \rho = \sqrt{X^2 + Y^2}$$



FIT OF θ DISTRIBUTION



The best fit is obtained mixing 60% of sequential processes with 40% of the direct ones.

Entirely direct or sequential mechanisms are not able to explain experimental data!

CONCLUSIONS

- A strong contribution of direct decay mechanism is present in both the analyzed resonances of ^{12}C.
- These observations could be related to In- medium effects on nuclear structure properties.
  - Analysis at different energies and reaction systems to evaluate possible medium effect!!