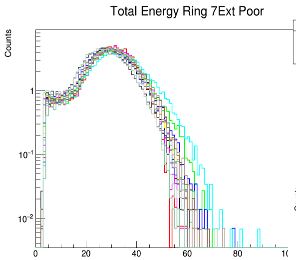
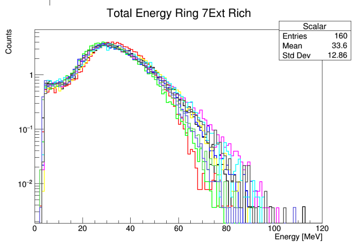


Energy spectra of the outer ring 7 for neutron poor system.



Energy spectra of the outer ring 7 for neutron rich system.

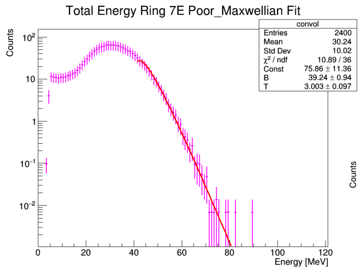
It can be noted that the spectra in the two systems, neutron poor and neutron rich, show a trend of the Maxwellian type, apparently more extended in energy the spectra of the neutron rich system.

NUCLEAR TEMPERATURE

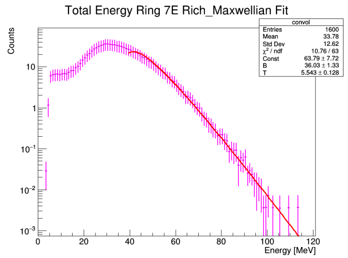
The concept of temperature was introduced in nuclear physics by Weisskopf in a statistical model describing neutron emission from a hot nucleus. We should be able to reproduce the energy spectrum of a given type of particle by the following function:

$$\frac{dN(\varepsilon)}{d\varepsilon} = C \cdot \frac{(\varepsilon - B)}{T^2} \cdot e^{-\frac{(\varepsilon - B)}{T^2}}$$

- C represents the normalization factor of the function;
- T represents the average apparent temperature of the emitting system;
- B associated Coulomb barrier of alpha and emitting source.



Maxwellian fit for the outer ring 7 for neutron poor system



Maxwellian fit for the outer ring 7 for neutron rich system.

From the various fits, performed on each cumulative spectrum relative to a given ring, the "average" temperature was obtained, which is reported in the following tables.

$^{78}Kr + ^{40}Ca$	Ring 4	Ring 5	Ring 6	Ring 7
Average Temperature	2.50 ± 0.22	3.73 ± 0.13	3.35 ± 0.08	2.86 ± 0.06

$^{86}Kr + ^{48}Ca$	Ring 4	Ring 5	Ring 6	Ring 7
Average Temperature	4.84 ± 0.21	5.36 ± 0.12	5.46 ± 0.10	5.54 ± 0.13

The values of average temperature we obtain from evaporated alpha particles detected at different laboratory angles seem to be quite coherent for each one of studied reaction. Reported error are simply related to the above-mentioned fluctu- ations in the laboratory energy spectra. This should mean that there is a dominant reaction mechanism producing the alpha, namely fusion and evaporation from the generated compound nucleus. The measured temperature is different between the two systems, having a higher value for the neutron rich one. This is in agreement with results observed at similar energies and even at very higher energies.

UNIVERSITA' DEGI STUDI DI CATANIA

UNIVERSITÀ degli STUDI di CATANIA

Dipartimento di Fisica e Astronomia "Ettore Majorana"

Dipartimento di Fisica e Astronomia "Ettore Majorana"

Master's Degree in Physics

Nuclear thermometry for alpha particle in the reactions $^{78,86}Kr + ^{40,48}Ca$ at 10*AMeV* with the 4π multi-detector CHIMERA at *Laboratori Nazionali del Sud*

ELISABETTA DI FRANCO

SUPERVISOR:
CHIAR.MO PROF. G. POLITI
CO-SUPERVISOR:
DOTT.SSA B.GNOFFO

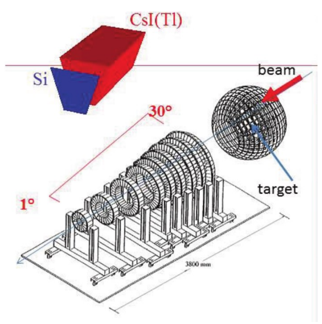
Academic Year: 2019/2020

In this thesis the two reactions, ^{78}Kr +^{40}Ca e ^{86}Kr +^{48}Ca, carried out in the context of the ISODEC experiment, are studied and they lead to the formation of two composite systems that differ overall for sixteen neutrons and for this reason they are called neutron poor (^{78}Kr +^{40}Ca) and neutron rich (^{86}Kr +^{48}Ca). The purpose of the thesis work is to deepen the analysis of a dynamic reaction mechanism different from fusion-evaporation and fusion-fission processes, showing differences between the two systems.

ISODEC Experiment

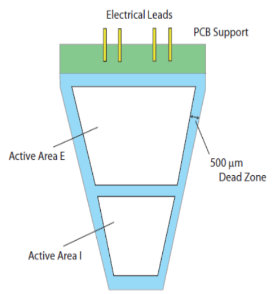
The ISODEC experiment was carried out with the intention of studying the region of the intermediate masses of the compound nucleus. studying the reactions 78,86Kr +40,48 Ca at 10 AMeV, it will be highlighted how the N/Z ratio of these systems, connected to isospin, influences practically all the characteristics of the emission process. This experiment aims to investigate the competition between the various decay modes of the excited compound nuclei 118;134Ba* obtained by bombarding a plate with beams of 78;86Kr at 10AMeV , accelerated by the superconducting cyclotron to the Laboratori Nazionali del Sud (LNS).

Multi-detector 4π CHIMERA



It is made up by 1192 telescopes, each formed by a silicon detector followed by a thallium activated cesium iodide scintillator, CsI(Tl), arranged with cylindrical geometry around the part, instead 504 modules are placed on 17 crowns, which form a sphere centered on the target. The sphere has a radius of 40 cm and covers a polar angle from 30° to 176°.

TELESCOPES

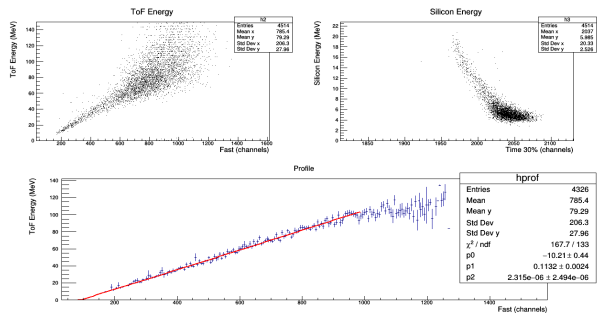


Silicon Detectors has the following characteristics: good energy resolution, short response times, relatively low costs, compact size and linearity of the response function. The choice of cesium iodide crystals activated with thallium was dictated by the various advantages deriving from the known characteristics of this type of scintillator: high density (4.5 gr/cm^3) and therefore high braking power and therefore less thickness needed to stop the high energy particles, easy processing, good resistance to damage from radiation and external factors (shocks and humidity), good light yield when coupled to a photodiode and possibility to perform isotope discrimination using the properties of the light pulse shape product.

CALIBRATION

In order to calibrate the CsI(Tl) detectors for alpha particles through the calculated t_0, two-dimensional histograms have thus been produced for each telescope in which the energy in MeV released in the crystal is reported as a function of the emitted light, related to the fast component reported in channels.

Released energy is calculated by using the time of flight to obtain the total energy and by subtracting to this latter the energy loss measured in the Silicon detector. By observing the profile of the 2D histogram it can be ob- served that between the two quantities, the energy E_{t0} and the fast component fast, there is a polynomial correlation. Therefore, in order to obtain a good calibration it was decided to proceed with a second degree polynomial fit.



$$E_{t0} = p_0 + p_1 \cdot fast + p_2 \cdot fast^2$$

Thanks to the analytical formula 3.1 and known the fast variable, the mass A and the charge Z of the alpha particle detected, it is possible to trace its residual energy, that is, the energy that the particle possesses when it arrives on the CsI detector, for all the particles impinging into the detector ad various energies.

ENERGY SPECTRA

It will be very useful to perform a transition to the center of mass reference system, assuming the hypothesis of complete fusion between projectile and target, that has been found to be the dominant process in these reactions. To do this, the transformation is applied:

$$E_{cm} = \frac{1}{2} m_\alpha v_{cm}^2$$