INVERSE-ALPHA:

A new approach to measure the elastic scattering of α particles in inverse kinematics at energies around the Coulomb Barrier for the astrophysical p-process

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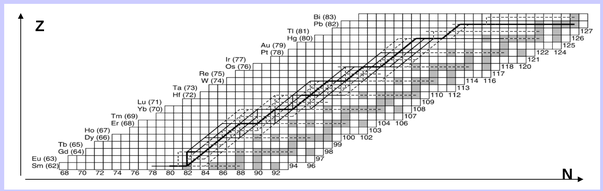
α-nuclear potential and nuclear synthesis

The **p-process** is the one responsible for the synthesis of certain **proton rich nuclei** that are not produced via the s-process nor via r-process.
One of the major uncertainties associated with the synthesis of p-nuclei is the α-nuclear potential in unstable nuclei. The nuclei for which this potential is crucial can be seen in the oblique segments of black-line in the nuclear chart below. This potential is also relevant for the r-process under certain circumstances

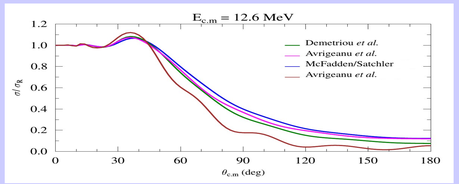


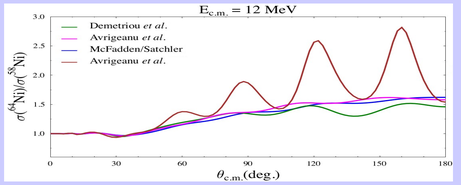
Nuclei chart

Motivation for the measurements

The first Figure on the right show the cross section of ^{4}He(^{58}Ni,α)^{58}Ni showing a discrepancy for the different α nuclear potentials. This supports the **study of this reaction for different energies**. The second shows the ratio between the ratio between ^{4}He(^{64}Ni,α)^{64}Ni cross section by ^{4}He(^{58}Ni,α)^{58}Ni cross section that motivate **measurements for different isotopes**.

Right now there are some models for the α-nuclear potential that try to predict the elastic scattering cross section of α particles. Nevertheless, these models are not coherent with each other neither for p-nuclei nor for some reactions with energies close to the Coulomb Barrier. Two of these reactions are the dispersion of ^{4}He(^{58}Ni,α)^{58}Ni and ^{4}He(^{64}Ni,α)^{64}Ni.

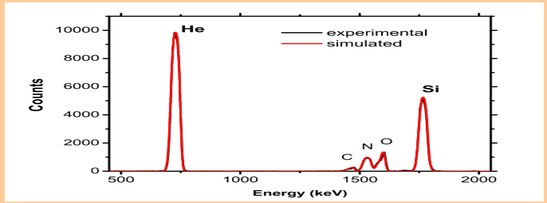


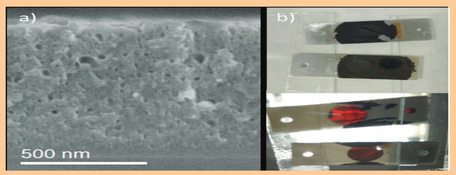


Novel He rich solid targets

The low abundance of stable p-nuclei in the region where the alpha-nuclear potential provides the biggest uncertainties. The production of stable targets to perform measurements in direct kinematics is really challenging.
One of the keystones for this experiment is the **new He targets** developed in Seville that have been characterized as a solid matrix of Si with an He relative abundance of barely half compared to Si and some contaminants. The He was found to be trapped in bubble like structures.

These will be particularly relevant to study the α-nuclear potential in RIB's facilities in order to reach the astronomical relevant region on the nuclei chart and in energy.

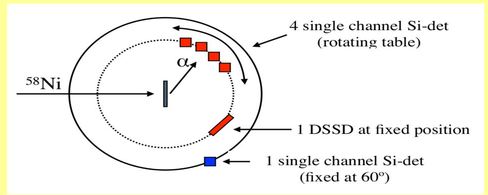




Element	Silicon	Helium	Oxygen	Carbon	Nitrogen	Hydrogen
No. atoms /cm^2 (x10^{15})	2820	1280	380	100	390	475

Experimental Approach

The experiment is scheduled for March 2020 in Laboratorio Nazionale del Sud, in Catania. We were given 3 shifts where we intend to perform measurements of the elastic cross sections for energies close to the Coulomb Barrier with ^{58}Ni and ^{64}Ni. These will allow us to get more data on the behavior of the α-nuclear potential and better determine which model should we use while approaching higher Z nuclei.
For this we will use 5 Single Channel Si detectors and a DSSD. Four of the five Si detectors will be angularly spaced by ten degrees covering from 80 to 40 degrees and the DSSD will be measuring the scattered particles for lower angles.



References: [1]Roland Schierholz et al 2015 Nanotechnology 26 075703
[2] V. Godinho, F. J. Ferrer, B. Fernandez, J. Caballero-Hern´andez, J. Gomez-Camacho, and A. Fernandez. ACS Omega 2016, 1 (6), 1229 (2016).
[3] E. A. George et al PHYSICAL REVIEW C VOLUME 56, NUMBER 1
[4] Talys Manual
[5] Ferrer, F.J., Fernández, B., Fernández-García, J.P. et al. Novel solid ^{4}He targets for experimental studies on nuclear reactions: ^{6}Li + ^{4}He differential cross-section measurement at incident energy of 5.5 MeV. Eur. Phys. J. Plus 135, 465 (2020). https://doi.org/10.1140/epjp/s13360-020-00482-w

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