Coulomb excitation of ^{14}C and ^{194}Pt

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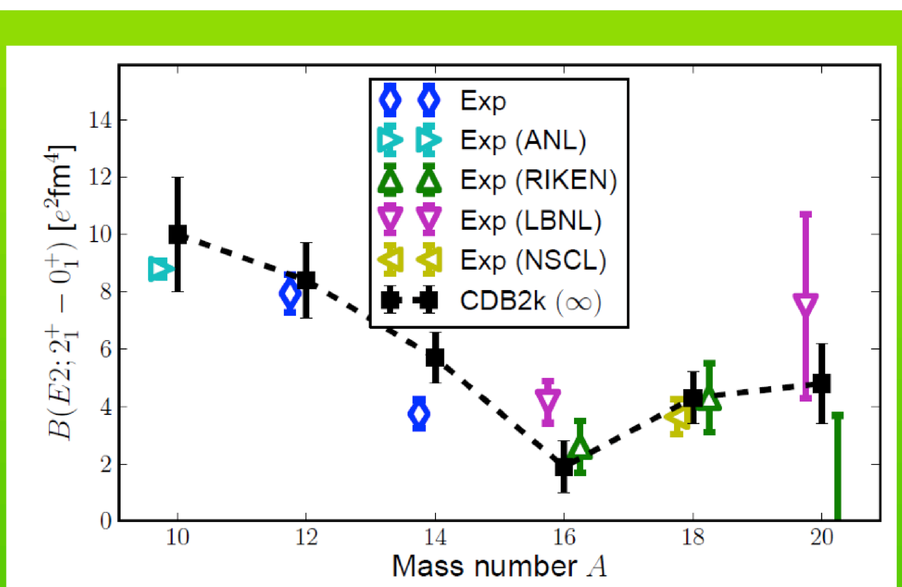
Introduction

Coulomb excitation can give useful information such as the electric quadrupole transition strength B(E2). This is a fundamental quantity to probe the collective behavior in nuclei. Experimental E2 transition strengths provide powerful information on deformation, interaction between protons and neutrons and the vanishing and emergence of shell gaps. B(E2) values provide information on the evolution of structural mechanisms and constraints for theoretical models. It is a basic observable in studies of nuclear structure in even-even nuclei. GOSIA, used for simulation and analysis of coulomb excitation experiments, was never used for such high energies and the modelers can extend GOSIA to higher energies.

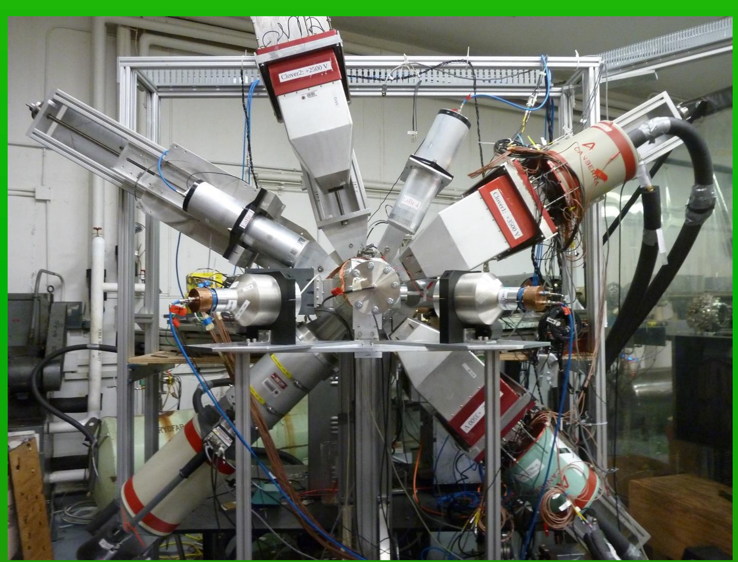


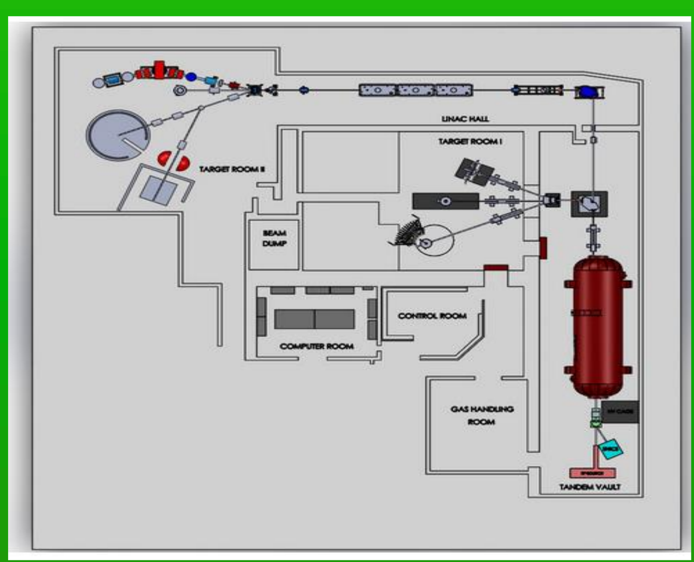
The B(E2) value has been measured for all even-even C isotopes [1-6]. When the measured values are compared to a recent no-core shell model [7] with NN and NNN interactions ^{14}C's B(E2) is the only nucleus that cannot be reproduced.

Experimental setup

For the safe coulomb excitation 45 MeV ^{14}C with an intensity of 3 pnA was bombarded on a 2 mg/cm2 ^{194}Pt target for 3 weeks. This coulomb excites both the target and the beam.

For calibration, efficiency and detector response some supporting experiments were also performed. 8.5 MeV protons are impinged for 30 min on 0.01mm thick ^{nat}Zn target. The ^{nat}Zn(p,γ)^{xx}Ga reaction is then used for energy calibration up to 4.8 MeV. 6 MeV deuterons are used for the 13C(d,p)14C reaction to measure the efficiencies at 6.093-7.3 MeV.

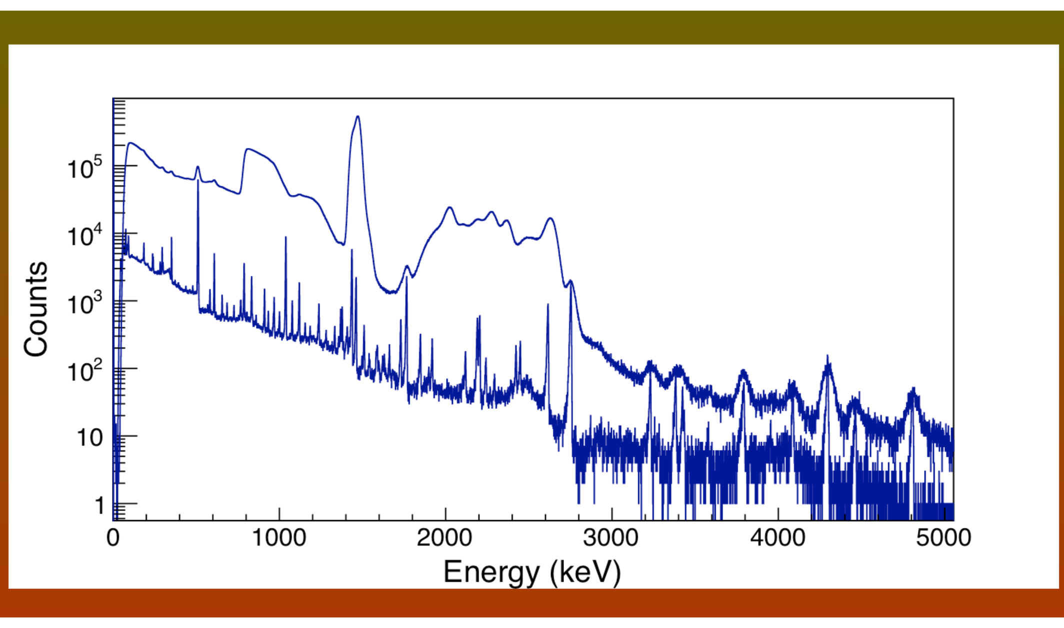




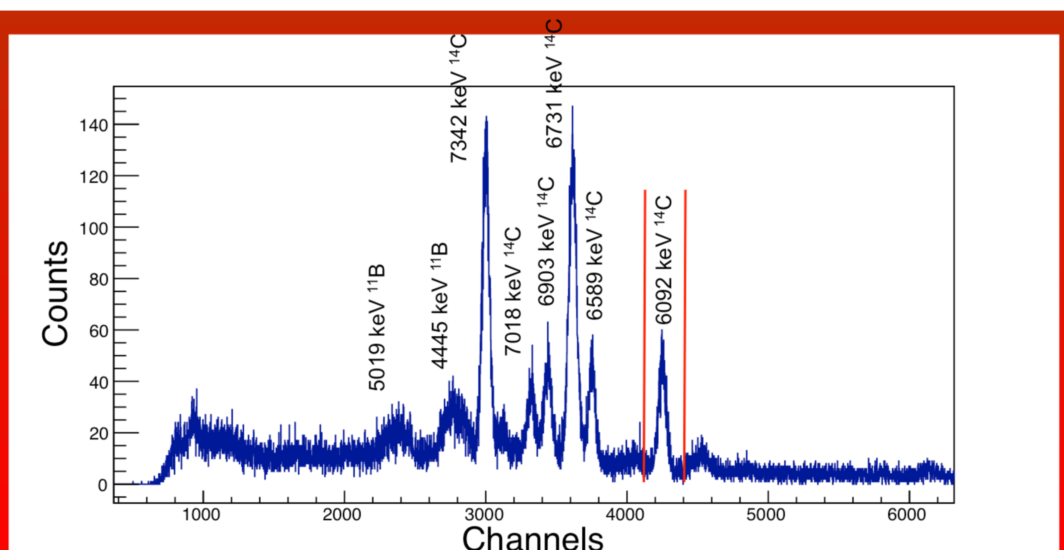
The experiment was performed at John D. Fox Superconducting linear Accelerator laboratory at Florida state university (FSU). The setup consisted of 4 $LaBr_3$ from the University of Oslo, 2 $LaBr_3$ from the US army research laboratory, 2 HPGe clovers and a single crystal Ge from FSU, 1 S3 silicon detector at backward angles from the University of Western Cape. The target chamber was borrowed from iThemba LABS.

Results

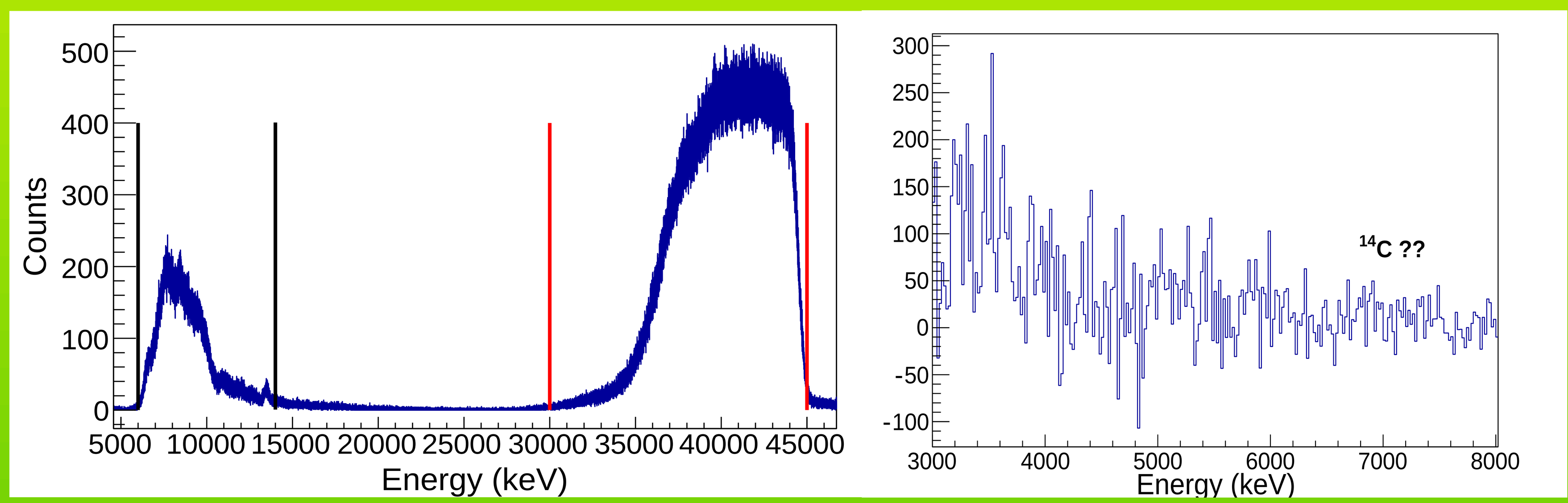
The ^{66}Ga γ-ray spectrum is shown for the $LaBr_3$ and HPGe. The HPGe has good resolution and the $LaBr_3$ has good efficiency. These γ-rays are used for calibrating between 100-4800 keV. The internal activity of ^{138}La and the Th alpha chain can also be observed. The internal activity is virtually removed through gates and coincidences.



The particle spectra from ^{13}C(d,p)^{14}C shows all the ^{14}C states excited. Gating on a specific state, the γ-rays decaying from that state can be observed. Using the ratio of single particles to particle-γ coincidences the absolute efficiency can be obtained for 6-7.3 MeV. The detector response at 7 MeV can also be measured.

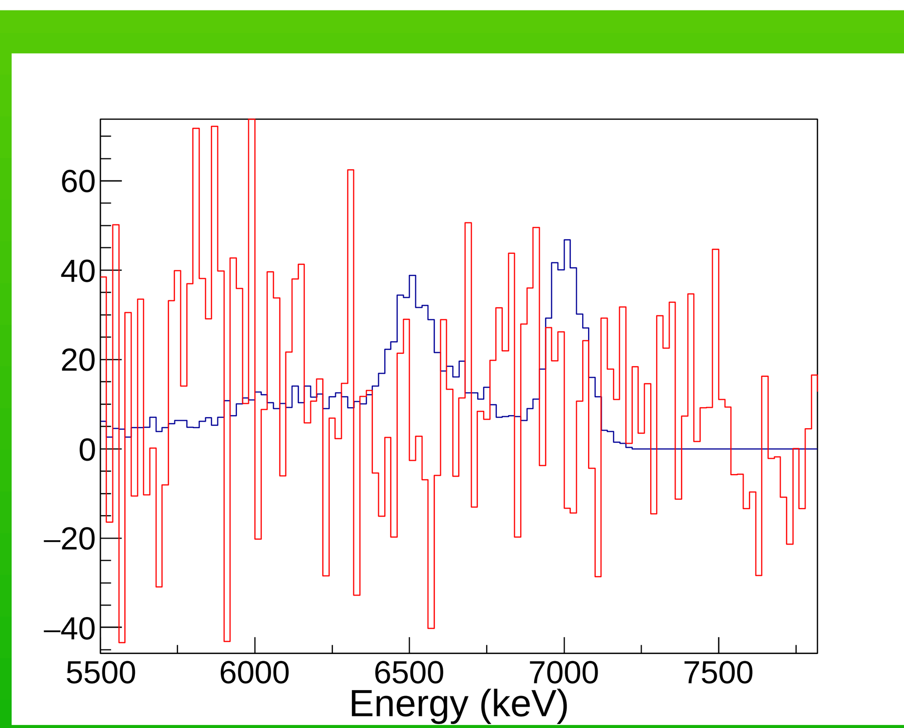


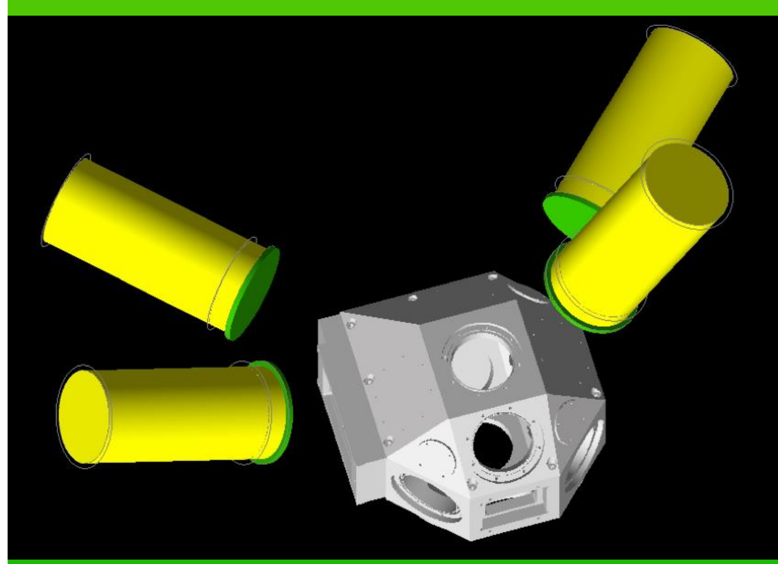
The particle spectra for the coulex of ^{14}C shows only one broad peak between 35-45 MeV. With the S3 at backward angles the elastic and inelastic peaks cannot be separated. The Doppler corrected γ-ray spectrum for all detectors show no peak for ^{14}C, however there is an increase in the counts between 6.8 – 7.2 MeV. These counts can be used to put an upper limit on the B(E2, 2+ → 0+)



GEANT4

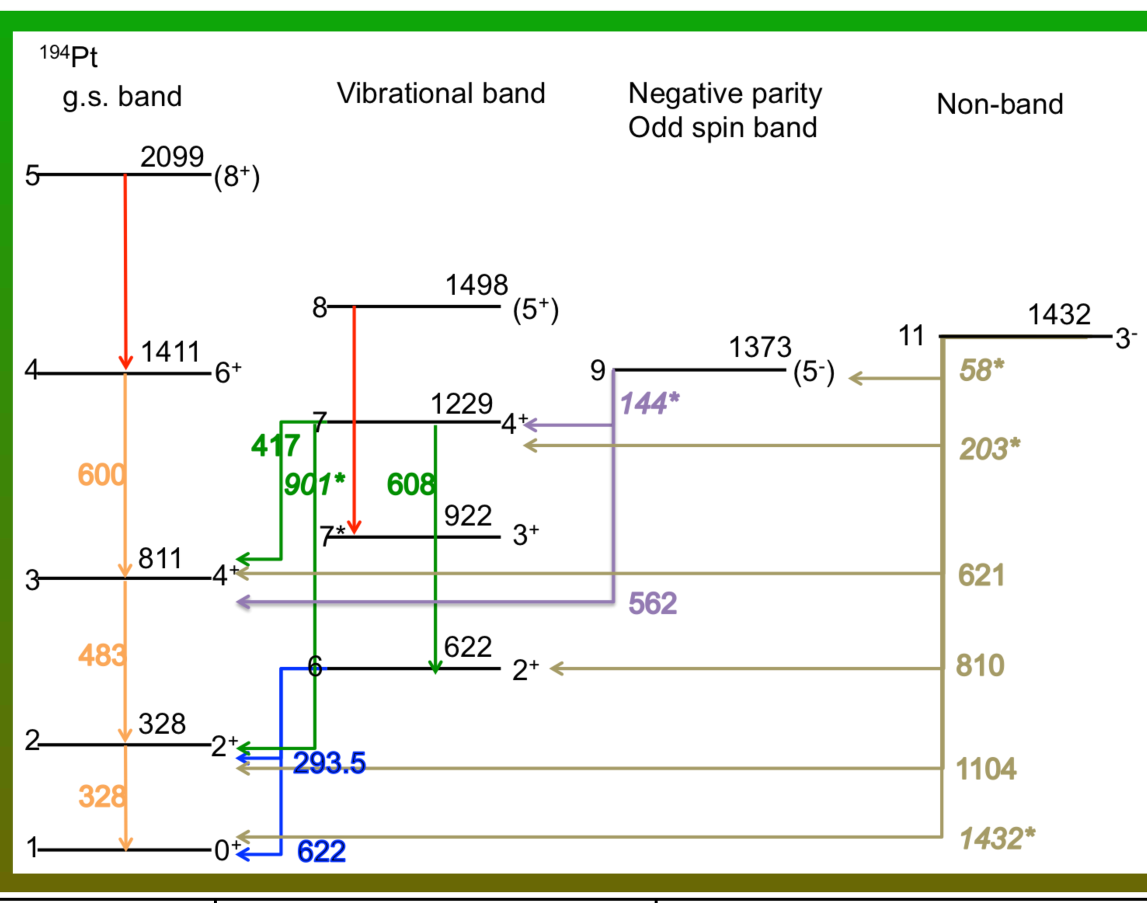
A GEANT4 simulation of the $2^+ \rightarrow 0^+$ is done to determine the line shape of the Doppler corrected γ-ray spectrum in the $LaBr_3$. Comparing the simulated data to the experimental data it can be concluded that the probability of ^{14}C being populated is very low.





GOSIA

The ^{194}Pt level scheme used in GOSIA to fit the electric quadrupole transition strength is shown here. The preliminary ground state and vibrational band matrix elements from the present work compared with other experiments are shown in the table.



$I_i \rightarrow I_f$	$<I_f \mid E2 \mid I_i>$ (e.b.)	other measurements
$2_1^+ \rightarrow 0_1^+$	1.29	1.21 / 1.37
$2_1^+ \rightarrow 2_1^+$	0.8	0.5 / 0.8
$4_1^+ \rightarrow 2_1^+$	2.34	1.94 / 2.26
$4_1^+ \rightarrow 4_1^+$	0.99	0.6 / 1.0
$6_1^+ \rightarrow 4_1^+$	2.56	2.04 / 2.9
$2_2^+ \rightarrow 0_1^+$	0.11	0.08 / 0.09
$2_2^+ \rightarrow 2_1^+$	1.78	1.45 / 1.7
$4_2^+ \rightarrow 2_2^+$	3.18	1.2 / 2.5
$4_2^+ \rightarrow 4_1^+$	2.16	1.5 / 2.8

Preliminary

Future work

- The ^{14}C experiment can be attempted at iThemba LABS using a ^{14}C targets with a full array of 23 $LaBr_3$ and the particle detector at forward angles.
- The experiment can be redone at FSU using their newly commissioned spectrograph with a ^{14}C beam, eliminating the γ-ray efficiency.

References

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