First measurement for Halflives of Zn and Ga r-process isotopes

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ORNL support

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Decay Spectroscopy group

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VANDLE colaboration

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Why beta decay?



Beta decay as a tool to study nuclear properties

Studies possible at low production rates. Very important exploratory role !



Beta decay of neutron rich nuclei

$$\frac{1}{T_{1/2}} = \sum_{E_i \ge 0}^{E_i \le Q_\beta} S_\beta(E_i) \times f(Z, Q_\beta - E_i) \qquad S_\beta(E_i) = \langle \psi_f | \hat{O}_\beta | \psi_{mother} \rangle$$



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Studies of neutron-rich nuclei at HRIBF Production and separation of neutron rich isotopes

"ISOL" technique - intense beam of light ions and thick targets. Effective utilization of the beam and the target material.

but ... ion "so(u)rce(ry)"

Unique HRIBF capability *ISOBAR SEPARATOR !* enables selective studies of ions with given A and Z. Much easier to operate than e.g. laser ion source !



Injector for Radioactive Ion



High Resolution Spectroscopy: the Clover Array for Radioactive Decay Studies



- Radioactive species implanted in moving tape collector
- Gamma-ray detection: 4 HPGe,
 ε= 6% at 1 MeV
- Beta detection: 2 plastic scintillators, ε=60 %





Half-lives in the vicinity of ⁷⁸Ni

- ➤Z=28 N=50 shell closures
- ➢Progenitors of r-process nuclei
- Beta decay between different parity subshells:
 - First forbidden transitions play a fundamental role in the half life

"Speeding-up the classical r-process" P.Moeller et al. Phys. Rev. C 67, 055802 (2003)





E, (KeV)



Benchmarking theoretical predictions: Zn half-lives





New calculated half-lives for spherical nuclei effect on r-process abundances



β-decay in hot r-process

Beta decay rate sensitivity study

J. Cass, G. Passucci, R. Surman, A. Aprahamian



Predicting neutron branching ratios



PHYSICAL REVIEW C 67, 055802 (2003)



Peter Möller Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545



VANDLE at LeRIBSS:

The Versatile Array for Neutron Detection at Low Energies

- > 2 clovers, 3% efficient @ 1MeV
- > 48 x 60 cm VANDLE bars
 - 45% efficiency/bar @ 1MeV
 - Ω = 26% of 4π
 - 12% total efficiency @ 1MeV
- Fully instrumented using XIA's Pixie
 16 digitizers





More details in talks by W.A. Peters and S.V. Paulauskas

The Versatile Array of Neutron Detectors at Low Energy Beta-delayed neutron emitters near r-process path studied at the HRIBF/LeRIBSS in February 2012





Light output vs Time of Flight: Neutron gate



February 2012 VANDLE highlights: ⁷⁷Cu



- Gammow-Teller decays at 0.5 and 2 MeV above Sn
- 100 keV neutrons detected!
- ~70 keV neutrons?
- Level 50 keV above Sn previously observed @ LeRIBSS

S.V Ilyushkin et al. PRC 80, 054304 (2009)

February 2012 VANDLE highlights: Resonant decay of ⁸⁴Ga



Counts / 0.5 ns

¹⁰⁰Rb at LeRIBSS:

neutron emission populates rotational bands





- 4 new half-lives of r-process relevant nuclei. Validation of new theoretical model of beta-decay in the 78Ni region. Profound influence on beta decay rates
- IRIS 2 commission great success! Clean, high intensity high quality data. <u>Laser Ion Source commissioned:</u> <u>Observation of ⁸⁶Ga</u>

Neutron spectroscopy: low energy states in ⁷⁷Cu, giant resonance in ⁸⁴Ga, population of rotational bands in ¹⁰⁰Rb beta decay

Outlook: Experiment proposed at NSLC, Lol approved at TRIUMF

Segmented

- 2 HPGe clovers
- 48 VANDLE bars = 12% efficient @ 1 MeV
- New segmented plastic implantation detector (R. Grzywacz and M. Al-Shudifat)



