LA-UR-12-28843

The Progress on LANSCE Experimental Activity



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Cross Section Evaluation Working Group : Measurement , US National Nuclear Data Week 2016, Nov. 14-18



Outline

- Neutron-capture study : DANCE Status and Upgrade of NUANCE
 - 236 U(n, γ) results
 - ${}^{63}Cu(n,\gamma)$ results
 - ²³⁹Pu(n,γ) results
- Photon Strength Function Study for unstable nuclei : Apollo at ANL
 - ⁹⁶Zr(d,pγ) updates
 - ⁵⁷Fe(d,pγ) updates
- NZ study : LENZ status
 - ¹⁶O(n, α) updates
 - ${}^{95}Mo(n,p) {}^{52}Cr(n,\alpha)$ reactions
 - ^{60,61,62}Ni(n,p) reaction

NEUANCE – NEUtron detector Array at daNCE

- High detection efficiency and energy sensitivity
- Fast time response
- Quality of Pulse Shape Discrimination
- Compact size that can fit inside the DANCE calorimeter





Pulse Shape Discrimination and Time of Flight measurement using Stilbene crystal



- Threshold is about 40 keVee, with a dynamic range of up to 2 MeVee
- Total efficiency of detecting neutrons is estimated to be 28-40 % per ²⁵²Cf fission

Dance : ²³⁶U(n, γ) result led by B. Baramsai



 $^{236/235}$ U (89%/10%) targets with each mass of 64 μg and 30 mg, so 235 U cross section was used as a reference

11/16/16 | 5

~2.2 %

1.7%

1%

4-8%

Experimental Corrections

Width fluctuation

Total

Reference CS (235U)

Dance : ${}^{63}Cu(n,\gamma)$ cross section



The ${}^{63}Cu(n,\gamma)$ cross section measured via 25 keV activation and time-of-flight



Dance : 239 **Pu**(**n**, γ) **cross section led by S. Mosby**



Thin ²³⁹Pu target DANCE measurement by S. Mosby et al. PRC 89,034610 (2014)

Uncertainty is dominated by systematic uncertainty **Thick target** measurement with a beam

time less than 14 days No fission tagging, so only y-ray multiplicity = 7&8 was used for identifying fissions

How to improve 239 Pu(n, γ) measurement



- Use a less contaminated ²³⁹Pu target
- Optimized closed packed geometry at DANCE will improve photo-peak efficiency by more than 10 %
- Optimize moderator design inside DANCE ball will increase NEUANCE efficiency to play as more efficient and active fission veto detector
- Overall systematic uncertainty will be improved by a factor of 2-4
- Background contribution of DANCE ²³⁹Pu measurement at Lujan is sensitive to timing resolution
- Fission induced BG is the largest, so subtracting BG vs. vetoing BG out will impact final signal to noise ratio tremendously

⁹⁶Zr(d,p) using Apollo and Helios at ATLAS



⁵⁷Fe(d,p) using Apollo and Helios at ATLAS



- 2d plot of the gamma-ray cascade vs. the excitation energy in ⁵⁸Fe
 - Complementary to DANCE measurements, since this allows to measure γ-ray decays below the neutron separation energy of 10.04 MeV

¹⁶O(n, α) measurement updates

Detected particle energy vs. neutron Time-of-Flight

Reaction Q-value vs. detected LAB angles



Cross section is being deduced from the experimental yields by applying corrections and normalizations for the amount ¹⁶O and a beam flux

¹⁶O(n, α) data : Forward Propagation Analysis

With well characterized experimental response functions and systematically varying input cross sections, we plan to analyze data "inclusively" by fitting yields in Monte Carlo framework



Measured detector resolution & efficiency





Forward Propagation Analysis requires to validate MC simul. in order to achieve the reduced systematic unc.



LENZ : Scheduled experiment in 2016

- Reaction model study including level density, strength functions, etc. through (n,p) and (n,α) measurements at LANSCE, in particular to up to 20 MeV neutron energy
- Plots show the Hauser-Feshbach calculations on Mo isotopes (LEFT) and the lack of experimental data on ⁵²Cr(n,α) in comparison to evaluations (RIGHT)



Development of direct (n,z) measurement on radioactive nuclei produced at Isotope Production Facility (IPF)

IPF at LANL can provide a radioactive target to be used at LANSCE for measuring (n,z) reactions directly. For the interest of heavy ion production via vp process in explosive environment, we are developing a ⁵⁶Ni target to study (n,p) cross section





Benchmark measurements on stable ^{60,61,62}Ni(n,p) reactions are scheduled in Dec. to guide the radioactive production and study beam induced backgrounds

Summary

• DANCE and LENZ at LANSCE and Hellos+Apollo at ANL can provide high quality data for neutron capture and neutron-induced charged particle reactions, in particular expanding our reactions studies to radioactive nuclei directly

Collaborators:

- P-27 : A. Couture, H.Y. Lee, A. Long, S. Mosby, C. Prokop, J.Winkelbauer, J. Ullmann
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