Neutron Scattering Cross Sections: \((n,n') (n,\gamma) (n,n'\gamma)\)

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Current Team Members

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- UnivKY Lab Overview
- Primary Projects
- Secondary Projects
- Highlights

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University of Kentucky Accelerator Laboratory (UKAL)

- 7-MV single-ended Van de Graaff accelerator
- p, d, $^3$He and $\alpha$ beams
- pulsed and bunched beam:
  - $f = 1.875$ MHz and $\Delta t \sim 1$ ns
- primarily conducts neutron-induced reactions and scattering experiments

Basic Nuclear Science

- Nuclear structure via (n,n'\gamma)
  - Level Schemes and Transitions
  - Spectroscopic Information
  - DSAM Lifetimes

Applied Nuclear Science

- Cross section measurements
  - (n,n') - Elastic and inelastic cross sections
    - $^{23}$Na, $^{56}$Fe, $^{54}$Fe, $^{12}$C, $^{nat}$Si, $^{nat}$Li
  - (n,n'\gamma) - $\gamma$-ray production cross sections
    - Level cross sections
- Detector development
A gas cell 3 cm long contains a tungsten wedge and a 56Fe sample. The setup is pulsed with p, d, 3He.
1 fs to 1 ps

Main n detector

Goniometer rotates 0 to \( \sim 155 \text{ deg} \)
Long Counter

FM shelf (tof & psd)

FM track (tof & psd)
Primary Projects

**Carbon-12** is a component in ..... 4-6 additional angular distribution measurements are needed in the range 5-8 MeV to assist with \((n,n_1)\) resonance parameter analysis.

**Lithium-7** is a component in ..... Resolve ambiguity above threshold for \(n_1\) More ang distrib for resonance information

**Flourine-19**, Effectively no data since 1950s-1960s. Industrial manufacturers of compact molten salt reactors employ FLiBe as a base material and have called for an increased understanding of its properties.
Secondary Projects (if we have time)

**Sodium-23** is a component in ..... Measurements below 1.3 MeV. More ang distrib for resonance information

**Magnesium-24** is a component in ..... More ang distrib for resonance information

**Iron-56**, one of the most ubiquitous materials, .... Possible addn’l measurements upon request. Conversion of existing HE data to neutron emission spectra.

**Conversion of Previously Measured Angular Distribution Data to Differential Cross Sections.**
The list includes most major stable isotopes of the elements Na, Fe, Ge, Se, Zr, Mo, Ru, Pd, Cd, Sn, Te, I, Xe, Ba, Ce, Nd, Sm, Gd, Dy,

**Neutron capture.**
DANCE @ LANL: pulsed n beam w BaF detectors – total emission energy 130,132,134,136Xe proposed
FIPPS @ ILL: continuous n beam w HPGe – detailed $\gamma$-ray emissions btw levels CdTe(n,$\gamma$) 100Ru(n,$\gamma$)
Sarah Evans  Elizabeth Chouinard

On-site at Univ KY ~1 June to ~1 Aug

Participated in all Nucl Data & Nucl Structure expts

invited to join the Univ KY Nucl Phys REU sessions

\[(n,\text{elas})\]

45 energies
64 elas diff xs
12 inelas diff xs
Sarah Evans  Elizabeth Chouinard

low-energy \((n,\text{elas})\)  7 days
0.3, 0.2, 0.5 MeV

high energy \((n,n_1)\)  11 days
6.4, 6.5, 6.8, 7.25, 7.75 MeV

\((n,n_1)\)
Sarah Evans  Elizabeth Chouinard

2 presentations

Exploring Innovation in Appalachia:
an Undergrad Research Symposium
@ UWV Aug 2011

Eliz placed 4th (i.e. honorable mention) out of 65 presentations

future plans

Sarah: senior
1 year gap
professional Frisbee player

Elizabeth: junior
another REU
1 year gap
graduate school physics
Capture @ LANSCE: DANCE

completed
\(^{112,114}\text{Cd}(n,g)\) – onsite 2019,2020
\(^{110,111}\text{Cd}(n,g)\) – online 2020

attempted
\(^{130,132}\text{XeF}_2\)

Much effort in design and construction of the \(\text{XeF}_2\) target @ UnivKY

Scheduled 14 day Xe expt in Sept 2021
- LAMPF transformer fire
- target stuck in beampipe
- LiH absorber structural failure
  \(\rightarrow\) shifted to distant future

Mississippi State: Dipangkar Dutta
Jeff Winger

National Lab partners: Aaron Couture
Catherine Fry
Matt Mumpower
Chris Prokop

Inside of the DANCE ball. The large gray sphere in the center is a \(^6\text{LiH}\) neutron absorber.
Kofi “TuTu” Assumin-Gyimah

Participated in all expts
DANCE onsite Aug-Dec 2021

114Cd

Ph.D. expected <Dec 2022

Finalized DANCE array calibration.
Corrections of & caused by target
Isolated 114Cd(n,g) yields
GEANT sim of thresholds & multiplicities
(w Milan Krticka & Standa Valenta)

Stephan Vajdic

112,113Cd

Started – several months in.

Daniel Araya

110,111Cd

Getting Started.

Example Raw Data: $\gamma$-energy deposited vs $E_n$
Avi Perkoff

knew C++, Learning python

Converting previous UnivKY $^{56}\text{Fe}$, $^{54}\text{Fe}$, $^{23}\text{Na}$ nTOF spectra($\theta$) into energy spectra($\theta$) (efficiency corrected and normalized)

4 shifts (remotely) at a recent $^{130}\text{Te}$ CoulEx measurement at ANL/ATLAS w CHICO / GRETINA arrays

Graduates May 2022 → USMC Pilot

USMC assigned him to continue with the project until Aug 2022.
+ can record time-dependent $\gamma$-ray spectra
+ trapezoidal filter can be fine-tuned for each detector
+ can replay data & change your mind abt settings

- can’t do detailed live-monitoring of data coming in
- time consuming development, testing, refining
- modules may not perform as expected,

CAEN may not have thought about some things

Presentation at 2021 DNP 11-14 Nov online
“Implementation and validation of a fully digital data acquisition system at the University of Kentucky Accelerator Laboratory”
• General Ideas

• Must do $\gamma$s in slow module and neutron in fast module
  • Fast module can’t sufficiently amplify HPGe pulses
  • Fast module doesn’t have adjustable trapezoidal filter required for $\gamma$s

• Time stamps btw modules loose precision synchronization when using fiber optic cables

• Can operate both modules with an external trigger, but require a secondary on/off light switch to take data after click CoMPASS

• Onboard-CFD vs RC-CR2 timing technique
  • The manual describes the techniques, but not how to customize them for specific needs.
• **γ-ray detection in slower V1782 100MHz. We can:**

  • take UnivKY-style data w HPGe, BGO, LongCounter w ext Ortec TAC for beam pulse timing info
  • take ang distrib data for Doppler-shift lifetimes (comparable to analog system)
  • fine tune BGO-Compton rejection during replay (better than previous analog system)
  • measure time dependence of γ-ray background btw beam pulses
  • do as-we-go corrections for HPGE gain drift (never possible before)

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DSAM method requires centroids to ~ 100ths of keV.

Took 1 wk of real Li(n,n\(1\)γ) in Nov2021 to prep for 19F isomer measurements.
• neutron detection in faster V1782 500MHz. We can:

  • digitize the beam pulse (after valid event)
  • take UnivKY-style neutron TOF data w MAIN scintillator, Forward Monitors, & beampulse

• fast module doesn’t have adjustable trapezoidal filter

We’ve been working on γ-ray capabilities since ~June 2021
Other Projects

- **Los Alamos LANSCE**
  - DANCE – BaF2 array
  - Cd(n,γ) capture online 😞
  - Xe(n,γ) to be rescheduled

- **ILL Grenoble**
  - FIPPS – clover array
  - Cd&Te capture online 😔
  - 2-9July21, 9-21Sept21, 24-30Sept21

- **ANL / ATLAS**
  - CHICO & GRETINA
  - $^{130}$Te CoulEx online & on-site 😊
  - 9-14Feb2021
SUMMARY:
Weekly collaboration meetings.
Many UnivKY runs during summer 2021 to catch up from covid shutdown. Pushing to get time-dependent \((n,n'\gamma)\) data functional – isomer in \(^{19}\text{F}\). Need \(^{7}\text{Li}\) metal ingot for good \((n,n')\) -- 3*\$ + other issues
The team is working with many projects.