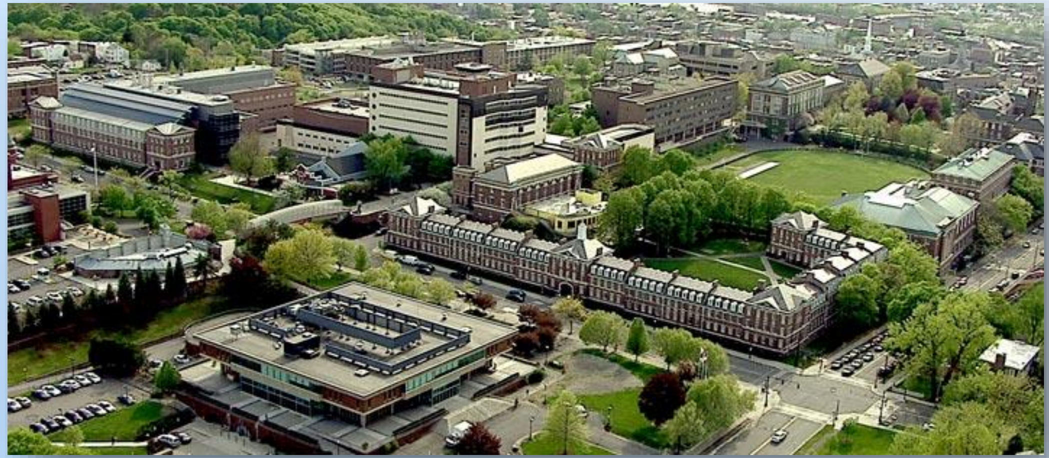
NCSP Related Nuclear Data Research at RPI

Y. DANON

Professor and Director, Gaerttner LINAC Center
Edward E. Hood Jr. Endowed Chair in Nuclear Engineering
Director, Nuclear Engineering Program
Department of Mechanical, Aerospace and Nuclear Engineering
Rensselaer Polytechnic Institute



NCSP Technical Program review, Santa Fe, New Mexico, December 2-5, 2024

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RPI Nuclear Data Group

- RPI Faculty
  - Prof. Yaron Danon - LINAC Director
  - Prof. Dominik Fritz – new faculty
- LINAC Technical Staff
  - 3 Engineers
  - 4 Technicians
- Graduate Students in 2024
  - 6 PhD students
  - 1 undergraduate researcher
- NNL @ RPI
  - 4 researchers (PhDs)

NR/NCSP technical review at RPI October 22, 2024

Rensselaer
NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM
NAVAL NUCLEAR LABORATORY
linac The Gaerttner LINAC Center

Overview of FY 2024 activity

- **ND1 – Cross section measurements ($488,392)**
  - Fe-54 measurements and evaluation (**Sukhjinder Singh**)
  - Evaluation work on Zr isotopes (**Gregory Siemers**)
  - F and Ta neutron scattering (**Gregory Siemers**)
  - Improvement to SAMMY URR capabilities (**Alec Golas**)

	Pre-FY2024	FY2024
Fluorine (^{19}F)	RPI	RPI
Tantalum (Ta)	RPI	RPI

Materials	Pre-FY2024	FY2024	FY2025	FY2026	FY2027
Zirconium ($^{90,91,92,94,96}Zr$)		ORNL	ORNL	ORNL	ORNL
		NNL	NNL	NNL	NNL
		RPI	RPI	RPI	RPI
		BNL	BNL		

- **ND3 – LINAC refurbishment ($50K)**
  - Improve NCSP and NR nuclear data measurement capabilities
    - Complete initial engineering plan for LINAC Control System.
    - Complete SAT of TPV Accelerator Section.
    - Place contract for refurbishment services support (RSS)
    - Place contracts for new RF Windows and elbows based on selection of UHV flange design.
    - Extend the Financial Assistance Award (FAA) funding grant through CY2025 with cost escalation.
  - A short update will follow

RPI ND-Group Research

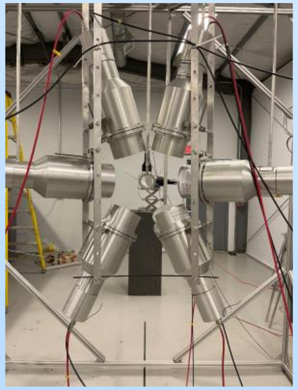
Research Topic	Student	Degree
Improvement to SAMMY for URR evaluation methods	Alec Golas	PhD.
Fe-54 neutron capture and transmission measurements and resonance parameter evaluation	Sukhjinder Singh	Ph.D.
Neutron die away experiments	Benjamin Wang	Ph.D.
Evaluation of ^{90,91}Zr isotopes and fast neutrons quasi-differential scattering from Ta and F	Gregory Siemers	PhD.
Neutron induced gamma production measurements in the RRR and URR	Katelyn Cook	PhD.
Development of benchmark measurements for capture gamma cascades	Ian Parker	PhD.

NCSP funded

NCSP related

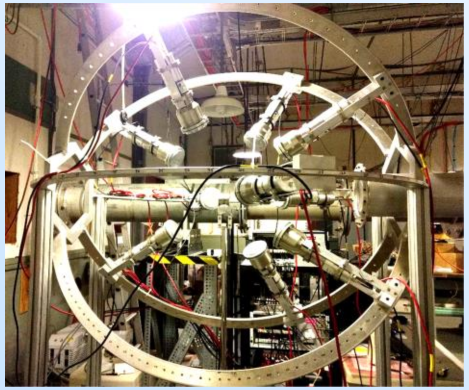
Thermal neutron target

C_6D_6 detector array

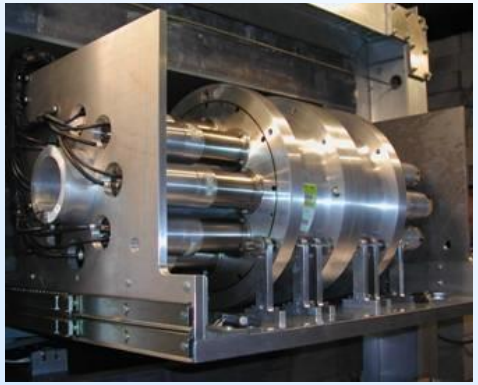


Neutron die away

KeV neutron scattering

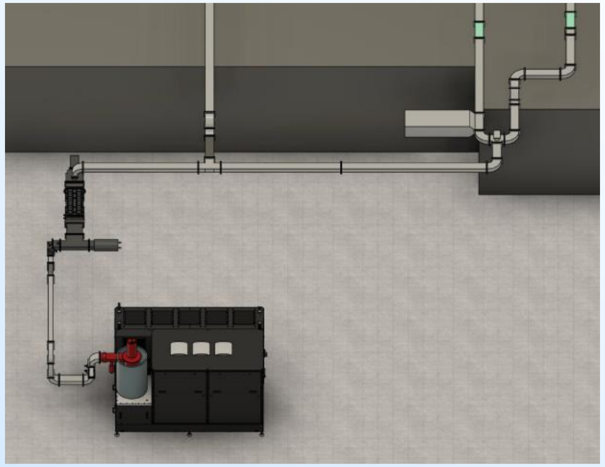


Capture detector



Refurbishment last years accomplishments

- Speed of light accelerator section SAT successfully completed
- Accelerator sections production contract amended, and sections are in production, delivery date set to the end of 2025.
- Parallel section baking is in construction and will be ready to help expedite section testing.
- TPV section passed its acceptance test.
- RPI facilities installed a new service entrance transformer and switch gear.
- **Phase II (connecting one new modulator to two old sections) was successfully completed in September 2024, and the LINAC was restored to a 9-section accelerator with performance like in 2014.**
  - 2014 was when it was decided that capabilities upgrades were needed.
- Phase III to connect all new modulators to the existing LINAC is not expected to increase the performance
  - Will extend the longevity of the existing LINAC (we have a spare klystron).
  - Sets the stage to complete the upgrade when and if direction changes.



RPI LINAC research contributions to the ENDF 8.1 big paper

ENDF/B-VIII.1: Updated Nuclear Reaction Data Library for Science and Applications

G.P.A. Nobre,[1,*] R. Capote,[2] M.T. Pigni,[3] A. Trkov,[4] C.M. Mattoon,[5] D. Neudecker,[6] D.A. Brown,[1] M.B. Chadwick,[6] A.C. Kahler,[6] N.A. Kleedtke,[6] M. Zerkle,[7] A.I. Hawari,[8] C.W. Chapman,[3] N.C. Fleming,[8] J.L. Wormald,[7] K. Ramić,[3] Y. Danon,[9] N.A. Gibson,[6] P. Brain,[9] M.W. Paris,[6] G.M. Hale,[6] I.J. Thompson,[5] D.P.

- Quasi differential scattering from Ta-181 and F-19
- keV scattering from Copper.
- Ta-181 RRR and URR measurements and evaluation
- U-235 capture and fission yields (cross sections)
- Neutron transmission and capture in Rh-103 measurements and evaluation
- Neutron capture in Dy isotopes
- Lead isotopes evaluation and quasi-differential scattering measurements
- Thermal transmission of polystyrene, Lucite, and polyethylene

ENDF/B-8.1 ^{235}U

TABLE XI. C/E of energy-grouped fission and capture yields for both RPI experiments compared to ENDF/B-VII.1 (B7.1), ENDF/B-VIII.0 (B8.0) and the ENDF/B-VIII.1 (B8.1) ^{235}U resonance evaluation.

E1 (eV)	E2 (eV)	Fission yield B7.1	Fission yield B8.0	Fission yield B8.1	Capture yield B7.1	Capture yield B8.0	Capture yield B8.1
From Thermal experiment:							
0.01	0.0206	1.01	1.00	1.00	1.02	1.01	1.01
0.02	0.03	1.00	1.00	1.00	0.99	0.99	0.99
0.0206	0.0623	1.00	1.00	1.00	0.98	0.99	0.99
0.0623	0.6	0.99	1.01	1.01	0.99	1.05	1.03
0.6	7.8	0.97	0.99	1.00	0.99	1.05	1.02
0.0253	9.4	0.98	0.99	1.01	0.99	1.06	1.02
7.8	11.	0.98	0.98	1.01	1.00	1.10	1.02
From Epithermal experiment:							
9.4	150	1.02	1.01	1.01	1.04	1.03	1.03
150	250	1.02	1.00	1.00	1.07	1.03	1.03
250	350	1.04	1.02	1.02	1.06	0.96	0.96
350	450	1.03	1.04	1.04	1.12	0.99	0.99
450	550	1.02	1.02	1.02	1.17	1.00	1.00
550	650	1.03	1.01	1.01	1.18	1.00	1.00
650	750	1.03	1.02	1.02	1.17	1.02	1.02
750	850	1.03	1.03	1.03	1.17	1.03	1.03
850	950	1.00	1.01	1.01	1.17	1.07	1.07
950	1500	1.02	1.00	1.00	1.25	1.02	1.02

- The fission and capture yields measured by RPI and submitted to EXFOR, were used to update the resonance evaluation.
  - Part of INDEN collaboration on Actinides
  - Impacts many systems containing ^{235}U
- Table XI was generated for INDEN meeting at IAEA.
  - ENDF/B-8.1 was modified to better agree with our resonance capture yield measurement.

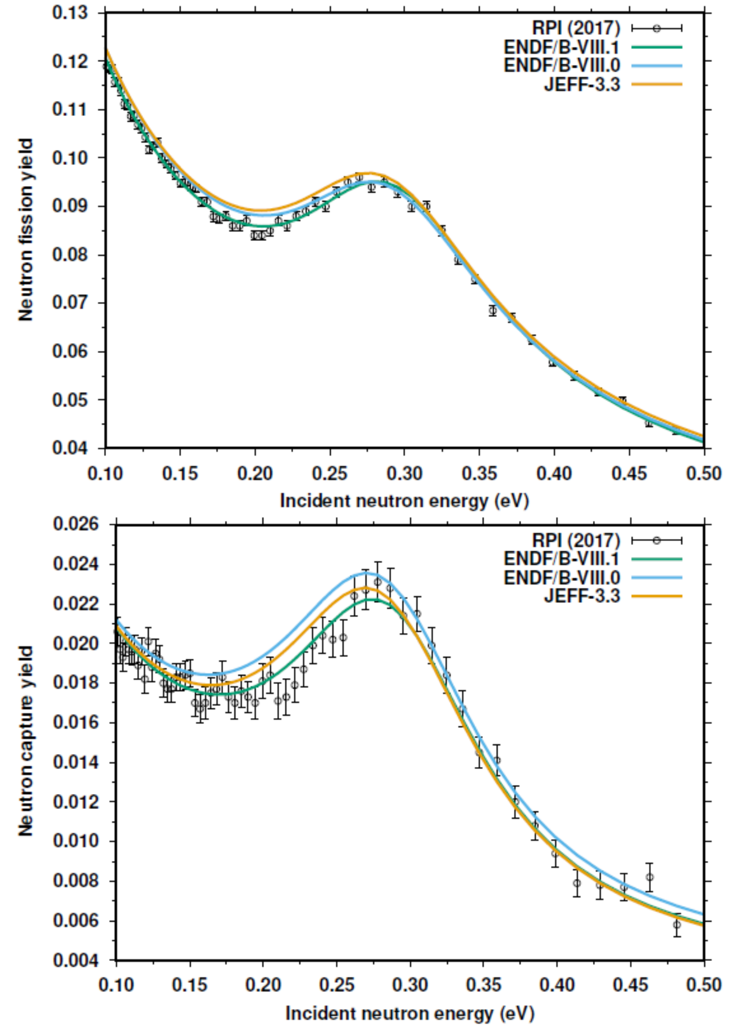
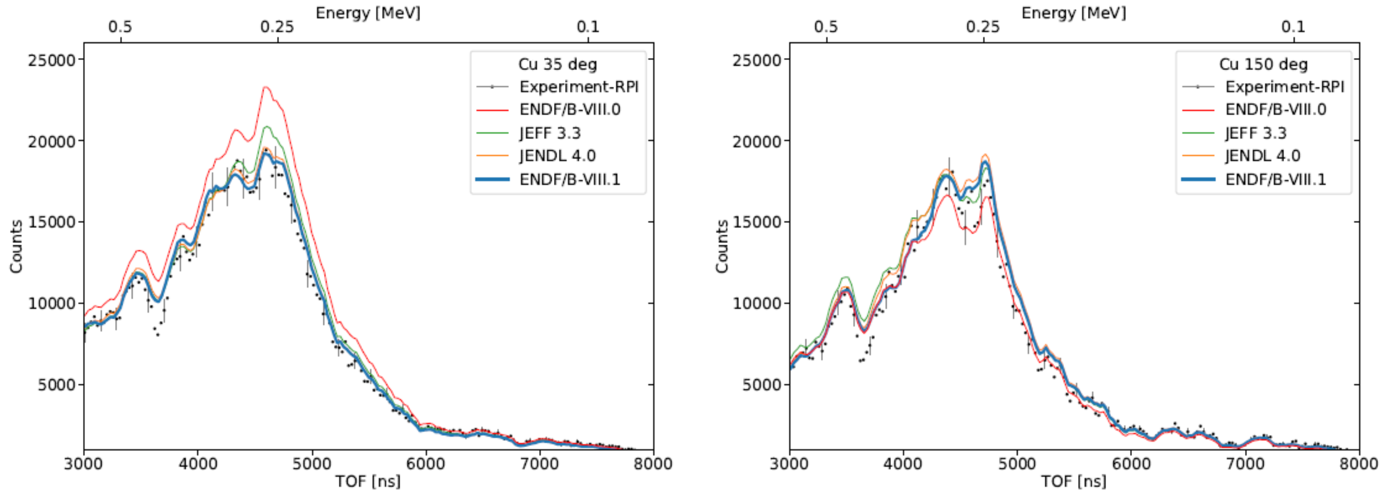


FIG. 57. n+^{235}U fission and capture neutron yield data calculated for three nuclear data libraries are compared with the RPI measured data [180] below 0.5 eV.

Y. Danon, D. Williams, R. Bahran, E. Blain, B. McDermott, D. Barry, G. Leinweber, R. Block and M. Rapp, "**Simultaneous Measurement of ^{235}U Fission and Capture Cross Sections From 0.01 eV to 3 keV Using a Gamma Multiplicity Detector**", Nuclear Science and Engineering, vol. 187, no. 3, pp. 291-301, 2017, DOI:10.1080/00295639.2017.1312937

Copper in ENDF/B-8.1

- Our keV quasi-differential scattering measurements for Copper highlighted issues in ENDF/B-8.0 and used to show the improvement in ENDF/B-8.1
  - Better prediction of copper benchmarks.



(a) Detector at 35 deg

(b) Detector at 150deg

FIG. 42. Quasi differential copper scattering data measured with 35 deg and 150 deg detectors by Blain *et al.* [156] below 600 keV is compared with simulations using different evaluated libraries.

E. Blain, Y. Danon, D. P. Barry, B. E. Epping, A. Youmans, M. J. Rapp, A. M. Daskalakis and R. C. Block, "**Measurements of Neutron Scattering from a Copper Sample Using a Quasi-Differential Method in the Region from 2 keV to 20 MeV**", Nuclear Science and Engineering, vol. 196, no. 2, pp. 121-132, 2022, DOI:10.1080/00295639.2021.1961542