

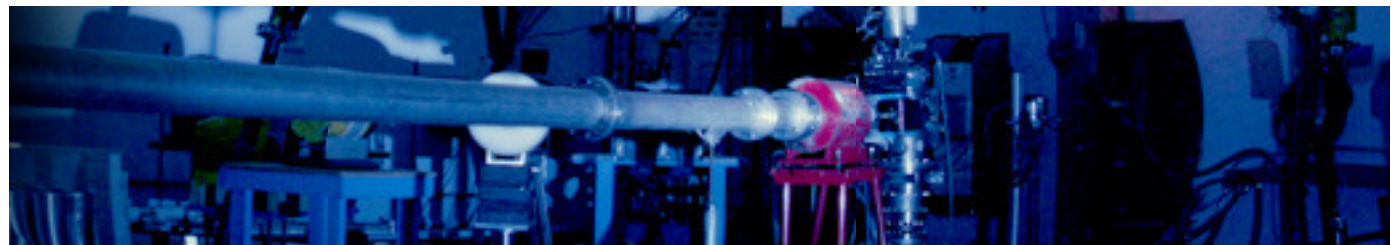


# Nuclear cross-section measurements at the Manuel Lujan Jr. Neutron Scattering Center

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G. Muhrer, F. Tovesson, J. Ullmann

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Applications and Utilization of Accelerators, AccApp'09



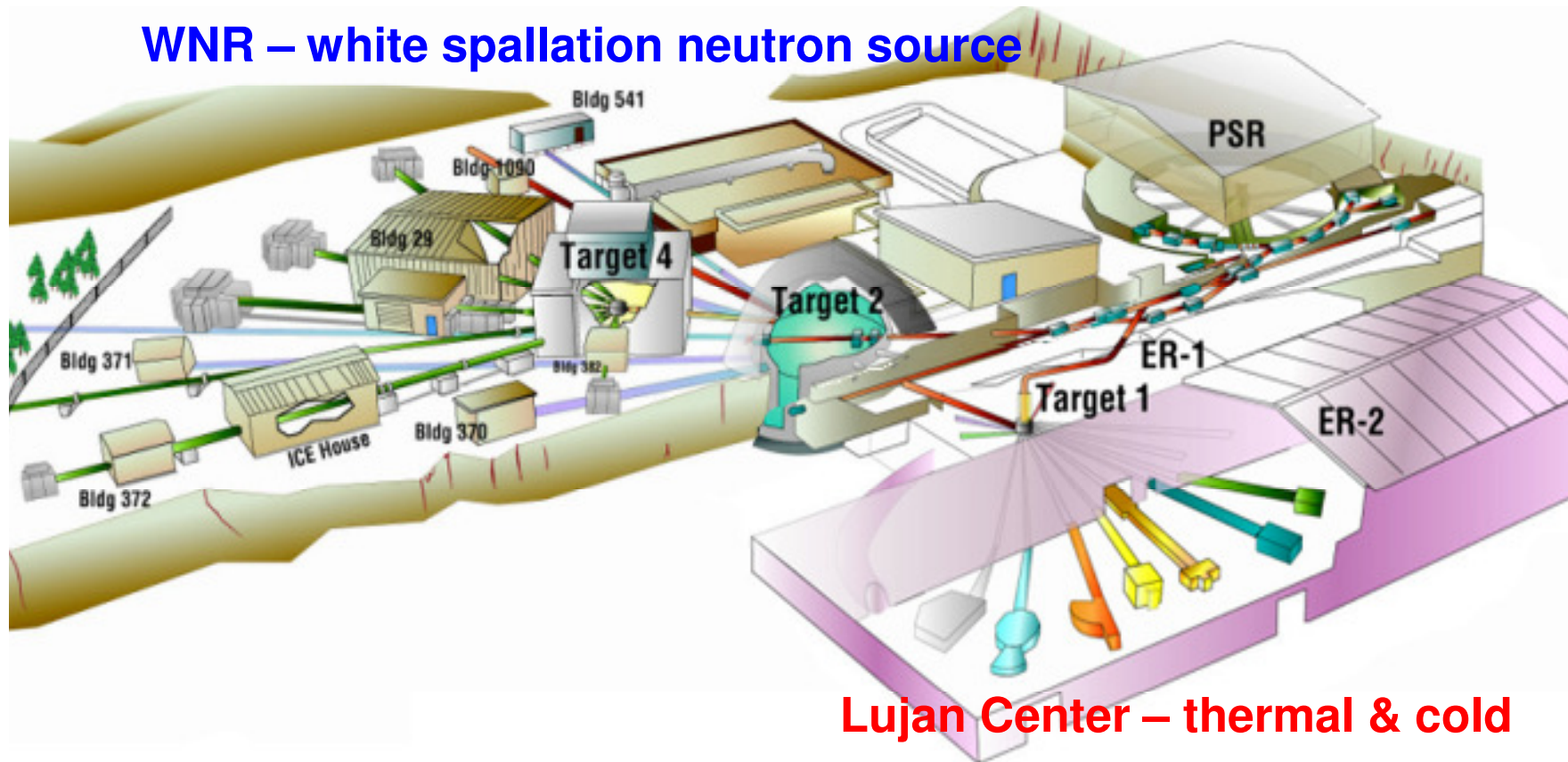
# LANSCCE facility



- Los Alamos Neutron Science Center
- Lujan Center
- WNR facility
- Ultra Cold Neutron source
- Proton RADiography
- Isotope Production Facility

# Lujan Center and WNR facilities

**WNR – white spallation neutron source**



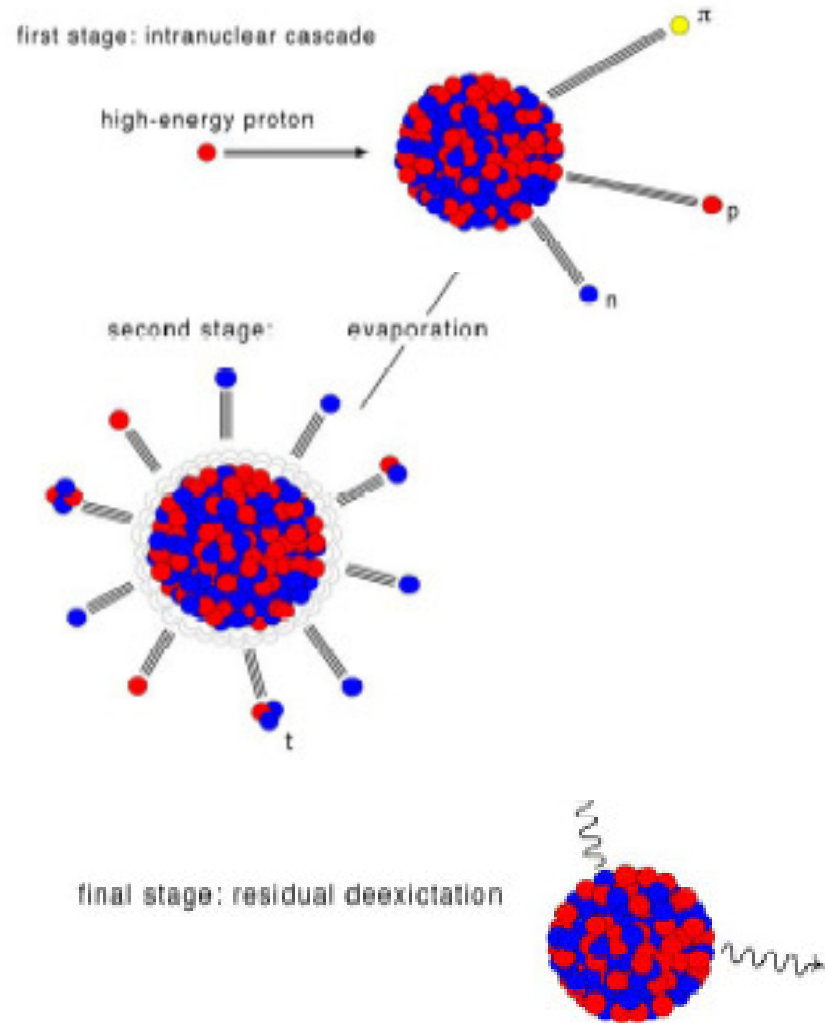
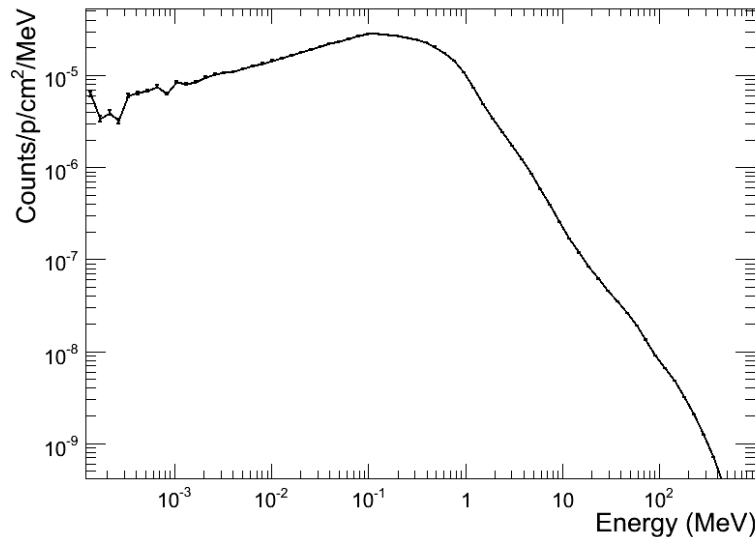
**Lujan Center – thermal & cold**

**Spallation neutron source**



# Neutron production – spallation process

- Typically light energetic projectile impinging onto a heavy nucleus forcing it to disintegrate
  - Neutron production
  - Transmutation (waste or RI production)
- Understanding
  - Projectile nuclear cascade ( $\sim 10^{-23}$  s)
  - Evaporation of excited residues ( $\sim 10^{-17}$  s)





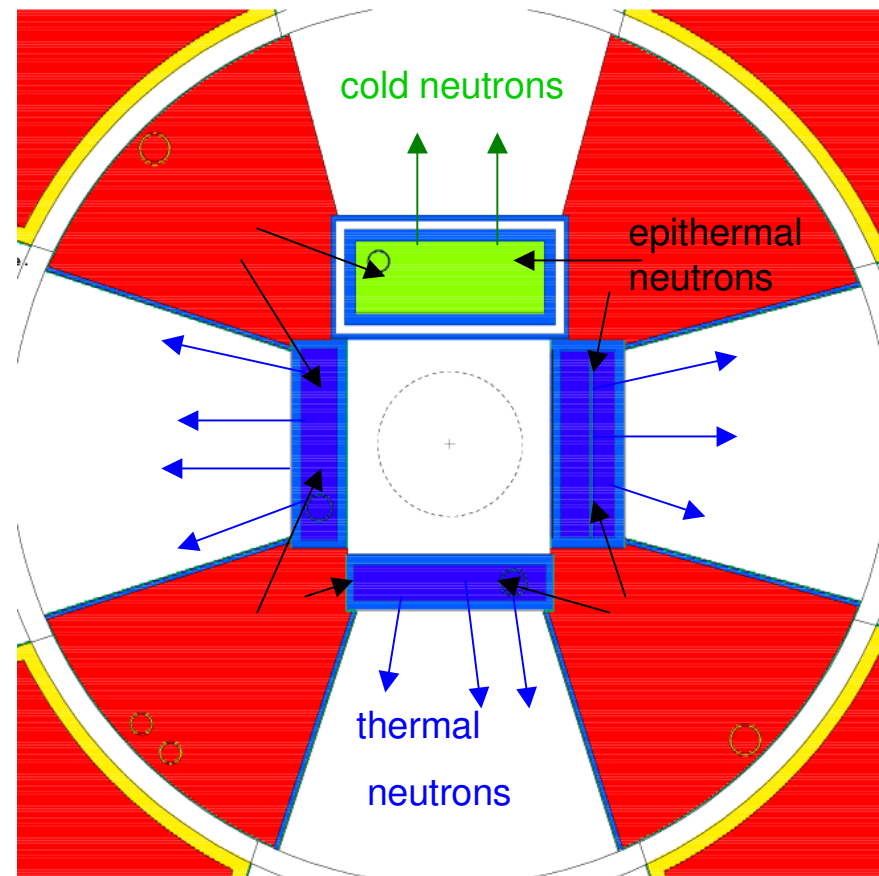
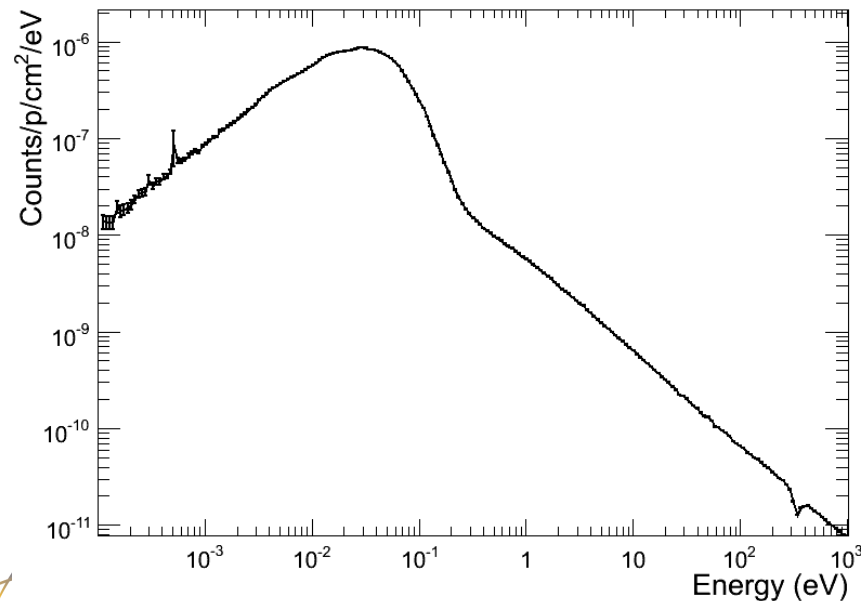
# Neutron transport

## ■ Slowing down

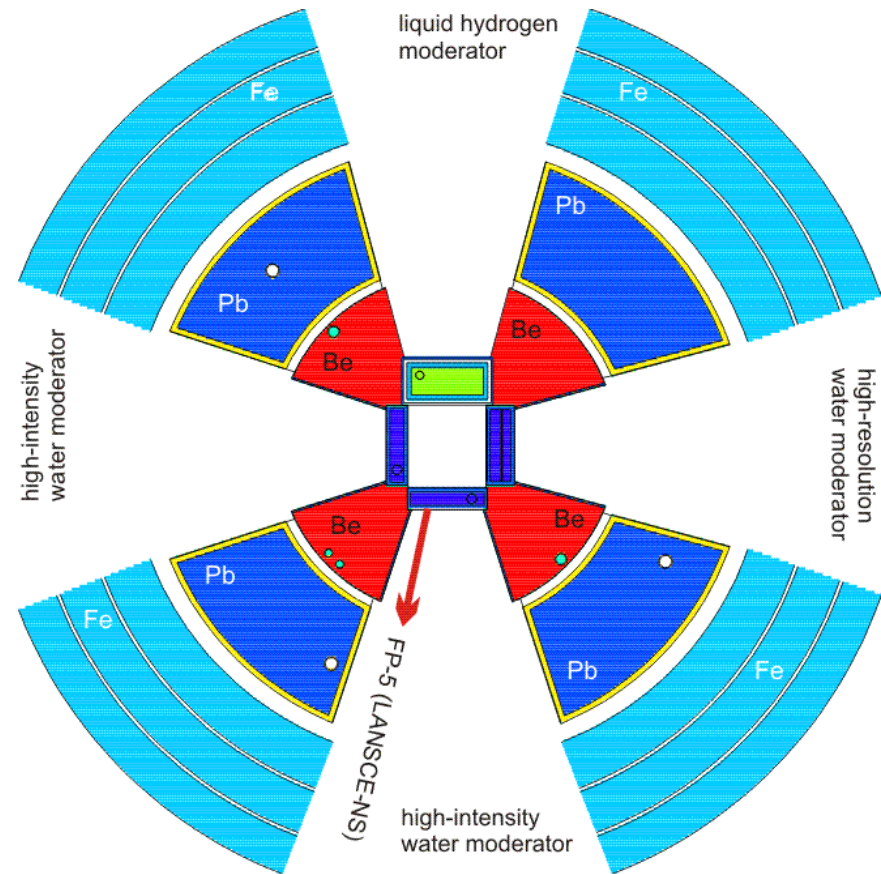
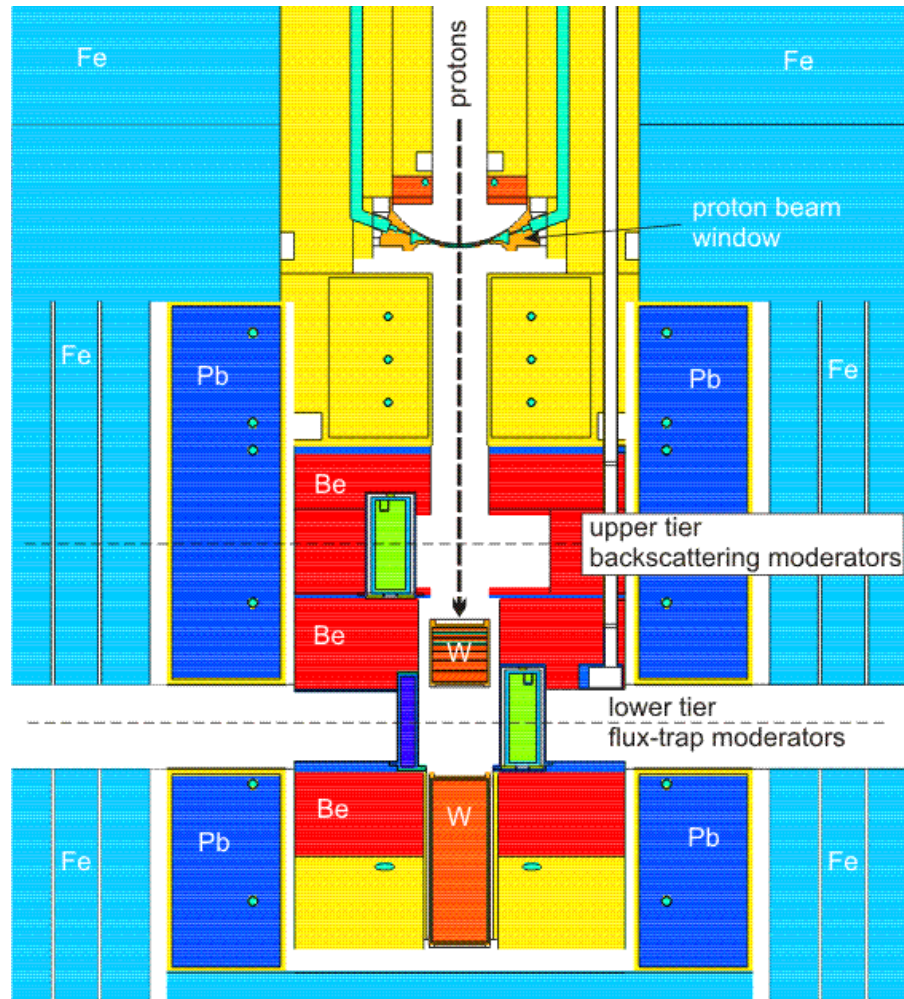
- Neutron wavelength  $<$  lattice parameters
- Energy loss due to collisions with medium particles

## ■ Thermalization and diffusion

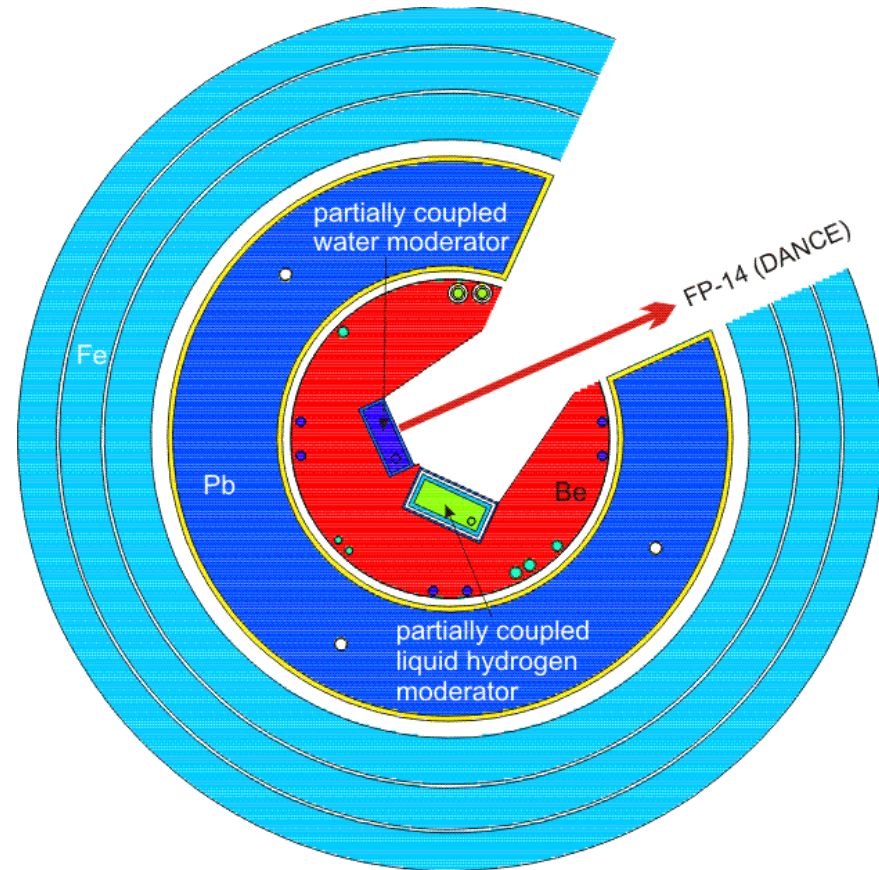
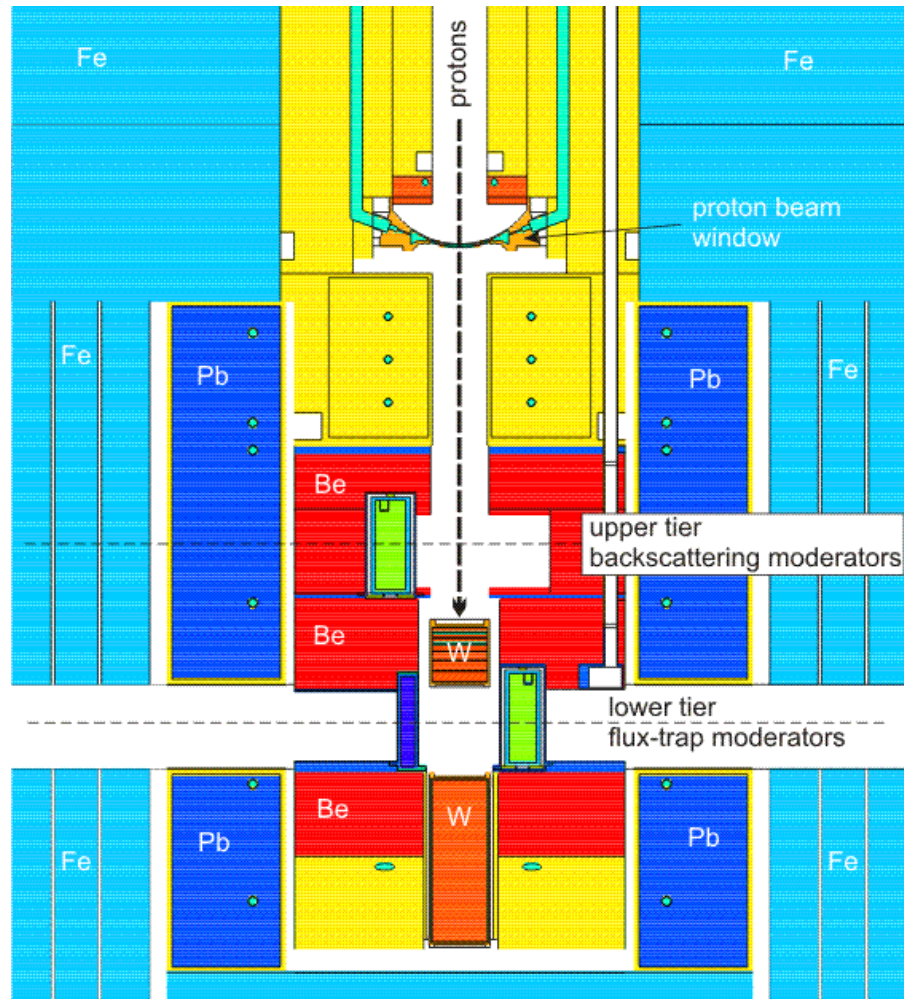
- Neutron wavelength  $\sim$  lattice parameters
- Bragg scattering, scattering on lattice modes



## Lujan target: lower tier (FP-5)



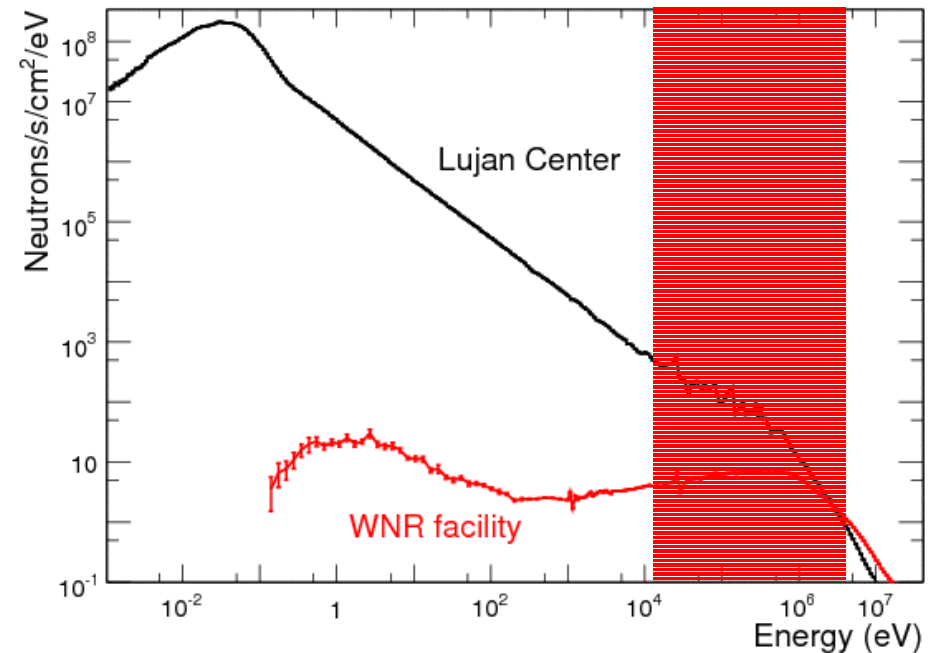
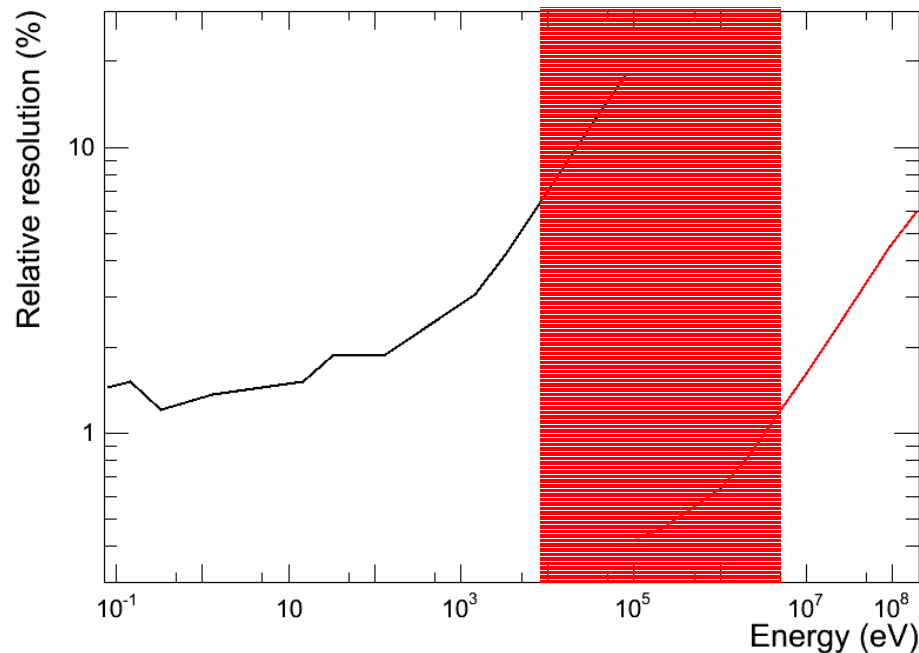
## Lujan target: upper tier (FP-14)





# Nuclear physics experiments at Lujan Center

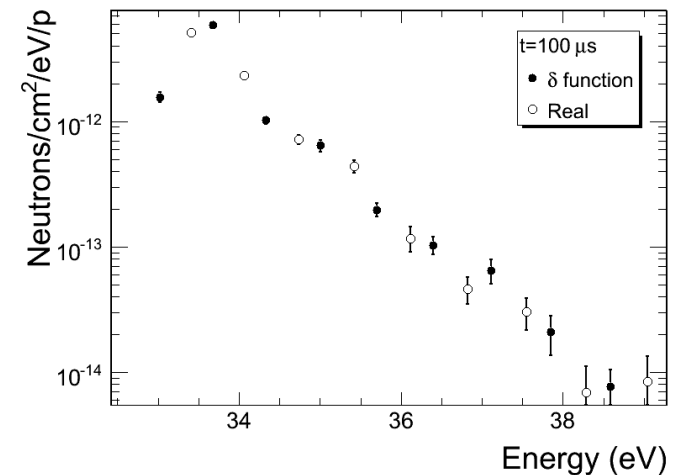
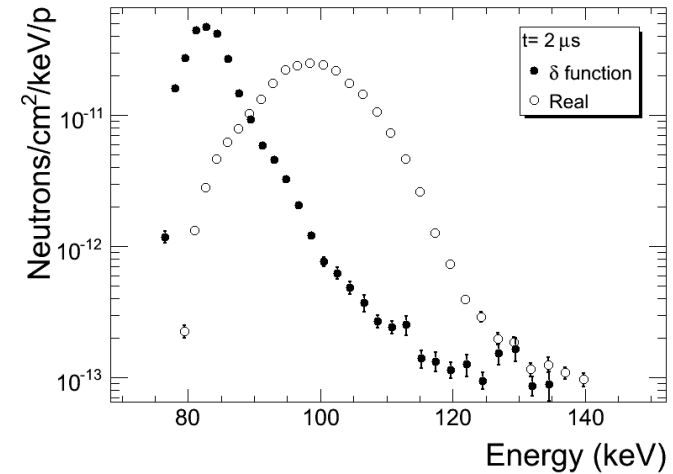
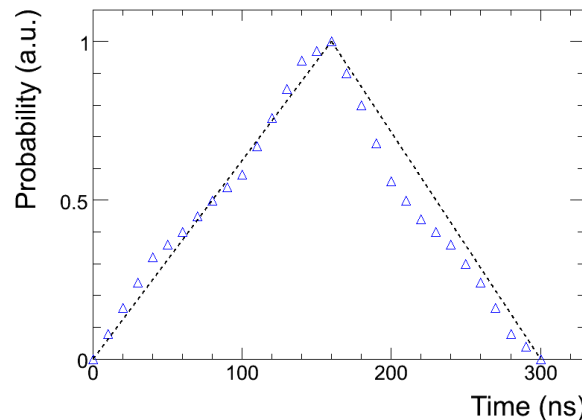
- **Advantages**
  - Neutron flux
- **Limitations**
  - Resolution



125  $\mu$ A versus 5  $\mu$ A

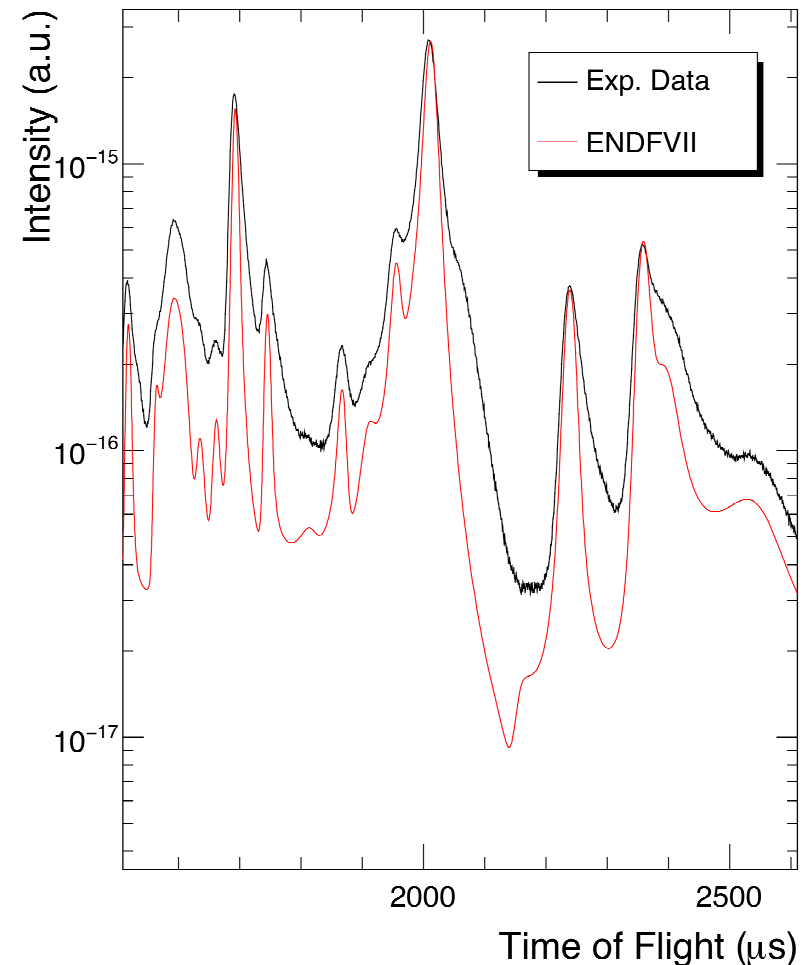
# Simulations for FP-5: issues addressed

- energy emission spectra (as compared to time emission)
- pulse shape evolutions as a function of time
- proton pulse time distribution
- contributions from neighboring moderators
- total energy spectrum
- gamma background



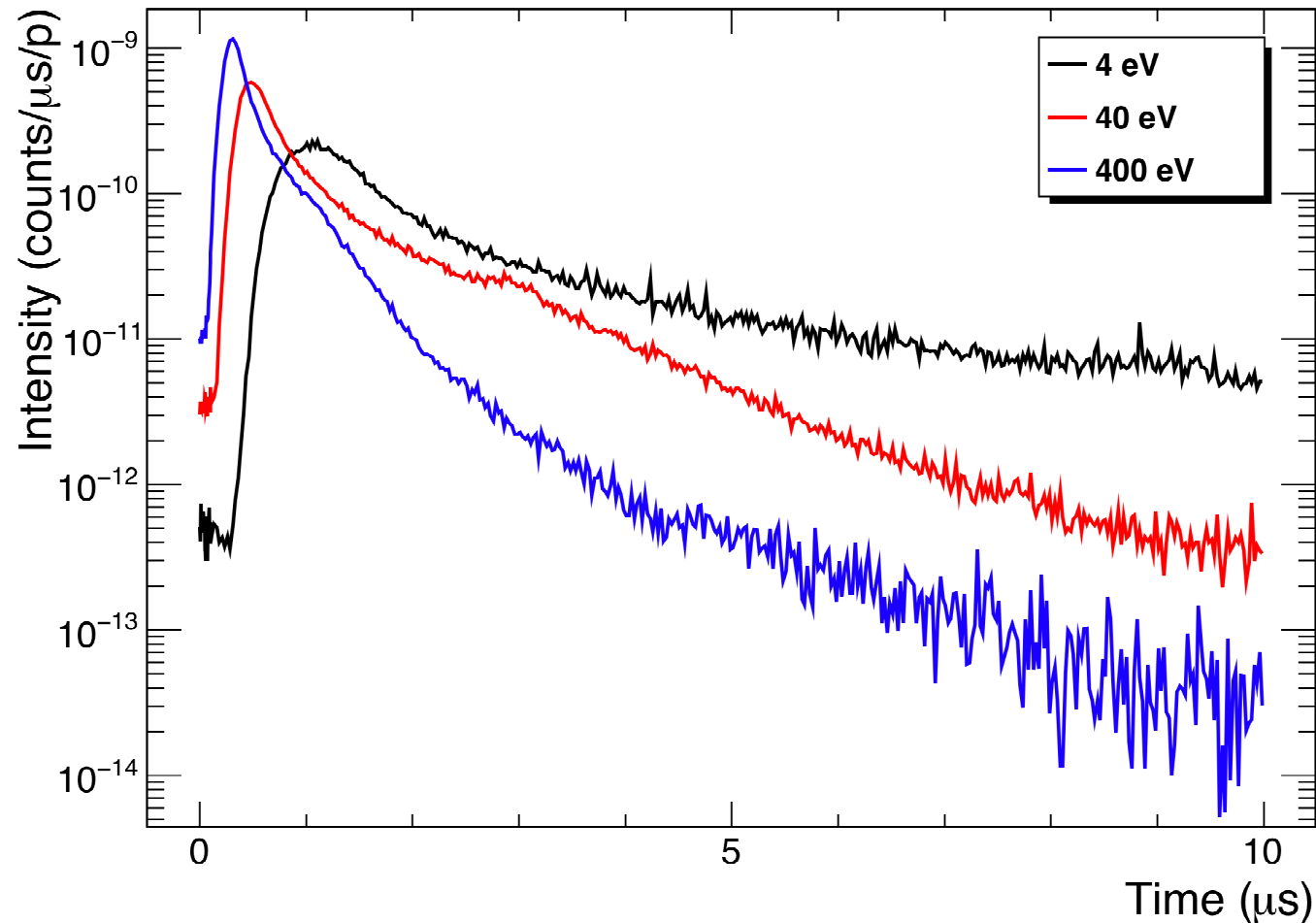
# Simulations: Why?

- Understanding the response function of a complicated target/moderator system (Lujan Target)
- **Extremely important for high precision analysis of nuclear physics experimental data**
- Spallation neutron source → Time of Flight (ToF) measurement
- ToF measured: neutron pulse resolution of target/moderator, detector setup, plus physics
- **High precision experiments → neglect detector setup contributions**
- **Time emission spectra: neutron pulses, time distribution of neutrons for a given energy**





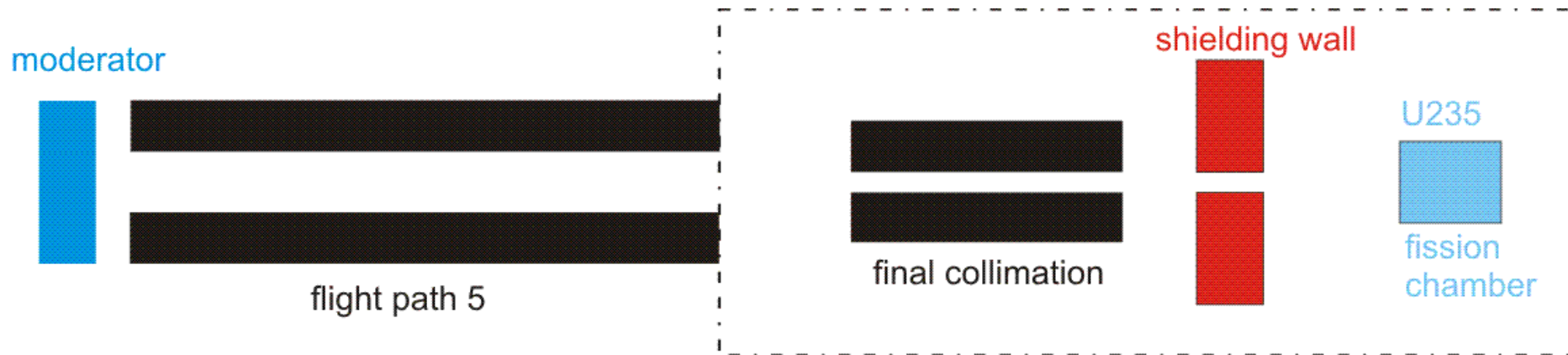
## Simulations for FP-5: time emission spectra



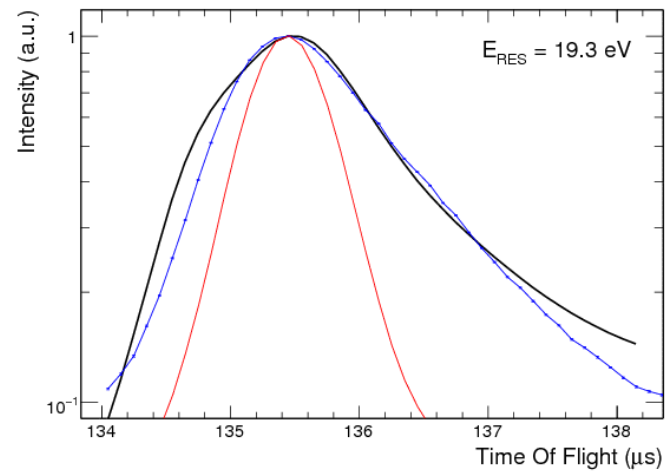
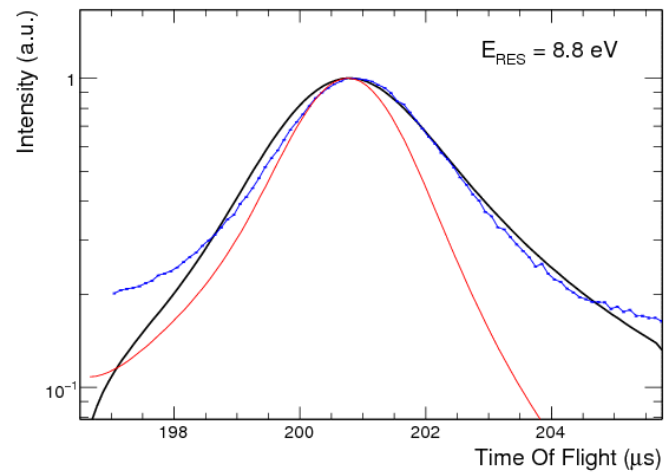
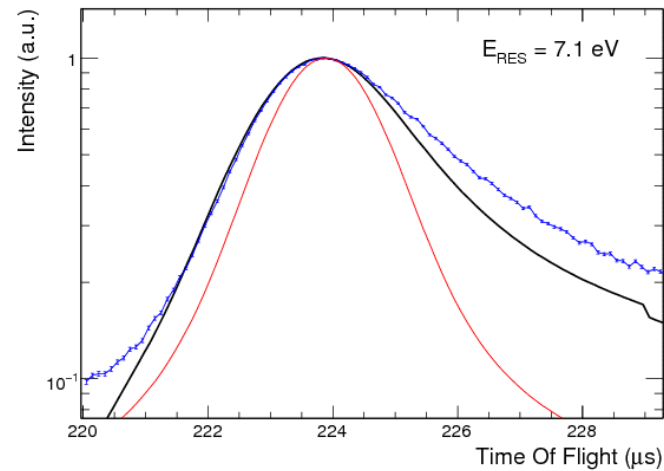
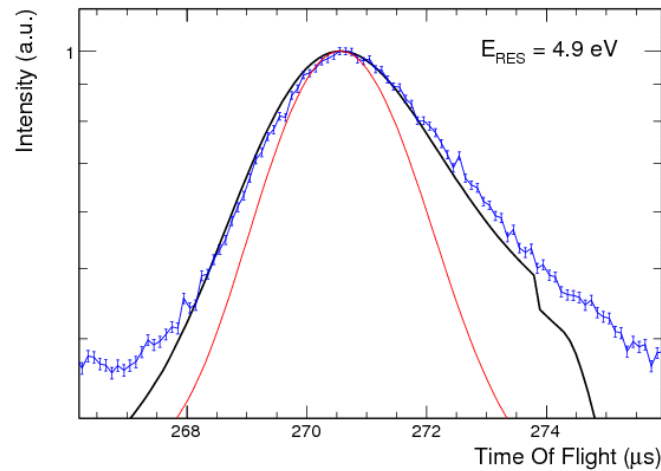
newly-added cpu  
capacity allows  
for much more  
detailed  
calculations

# Simulations for FP-5: versus experimental data

- We need to test the results with experimental data
- Transmission cross section experiment (July 2008) at FP-5
- U235 fission spectrum
- U238 total cross sections
- Use ENDF-evaluated and experimental data to validate simulations



# Experimental data FP-5: pulses



Data

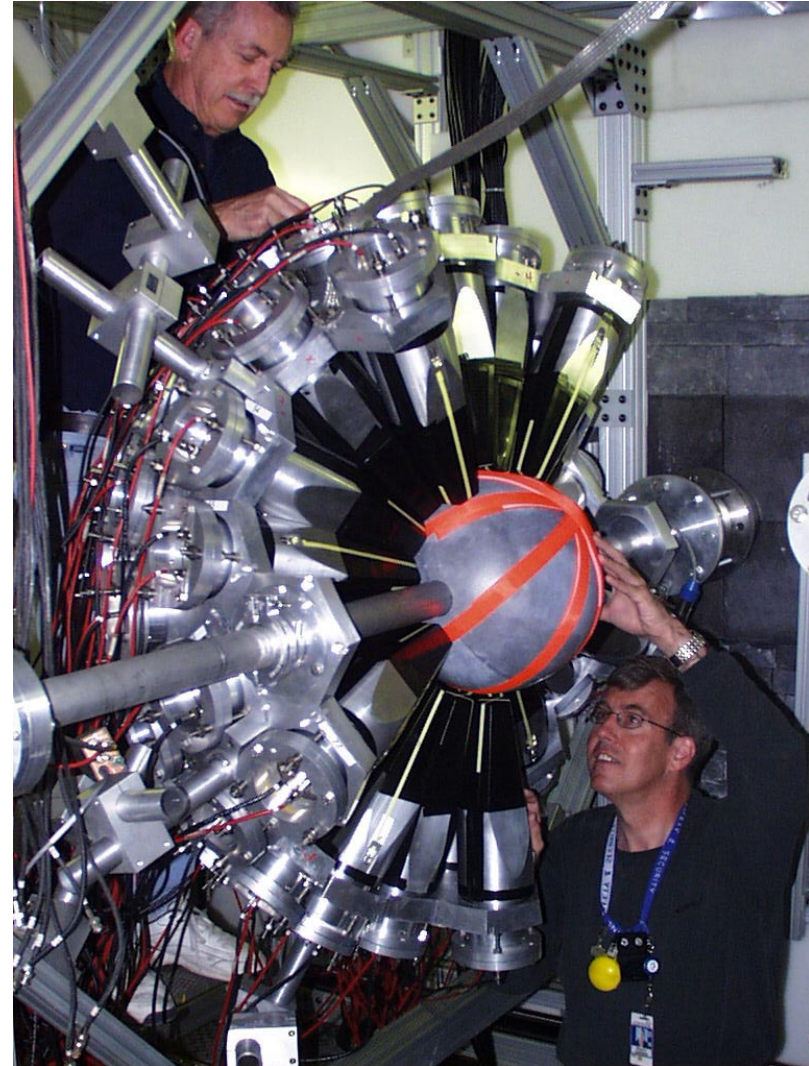
ENDF

ENDF $\otimes$ SIM

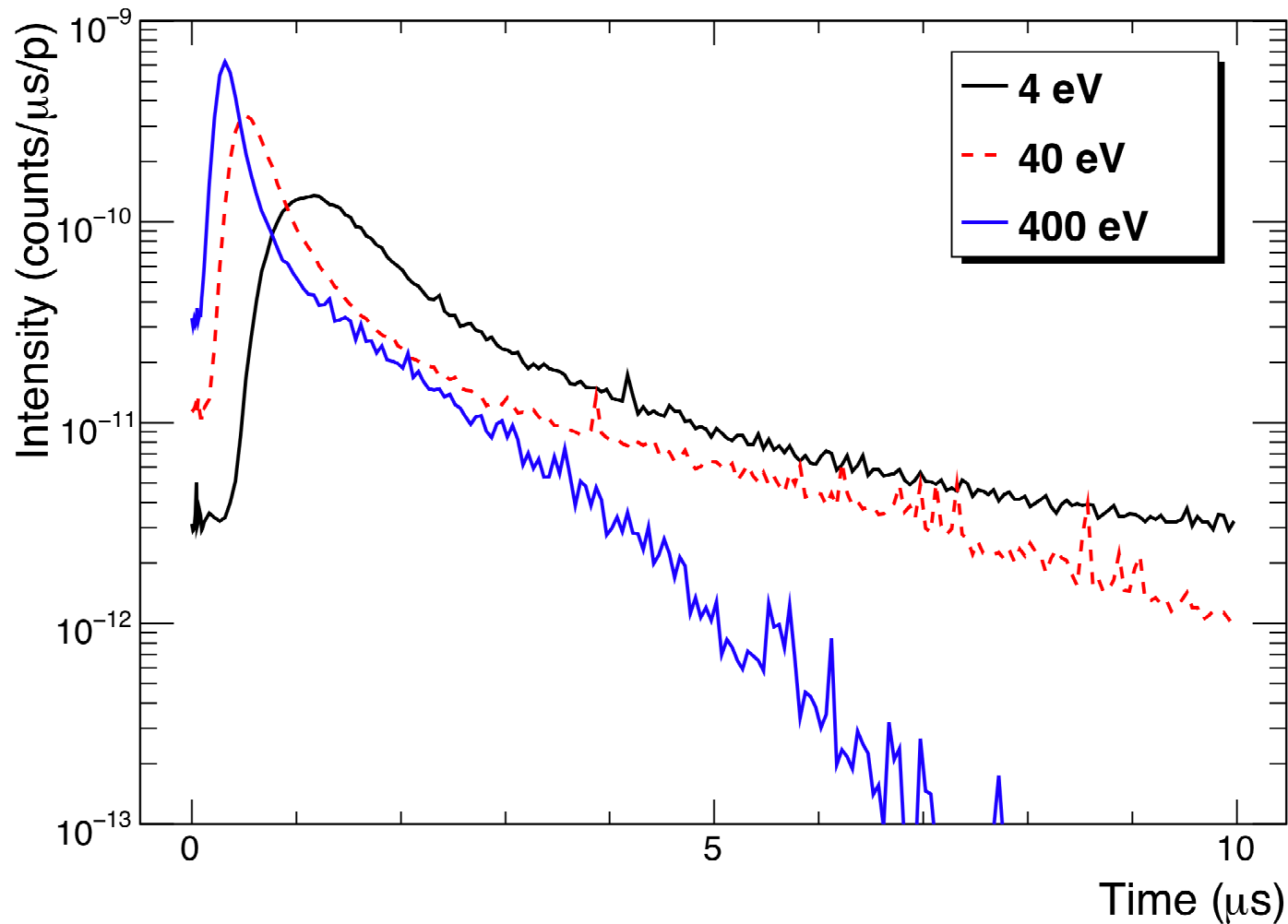


## FP-14: DANCE

- Detector for **A**dvanced **N**eutron **C**apture **E**xperiments
- $4\pi$  geometry allowing measurement of the total gamma ray energy
- 160 equal-area **BaF** of four different shapes
- ${}^6\text{LiH}$  sphere to minimize neutron background
- $E_n \approx 30 \text{ meV} - 100 \text{ keV}$

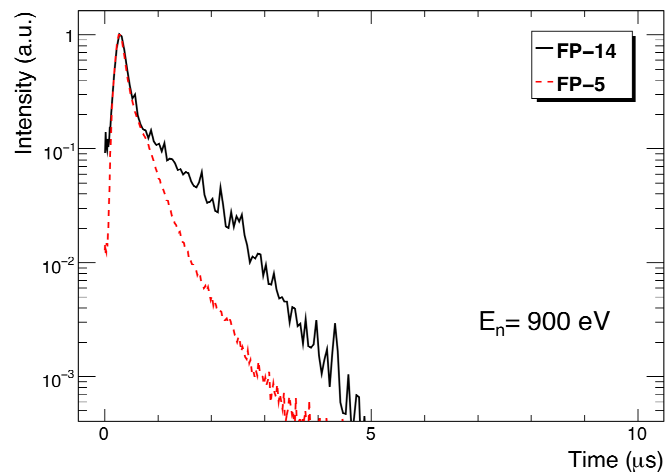
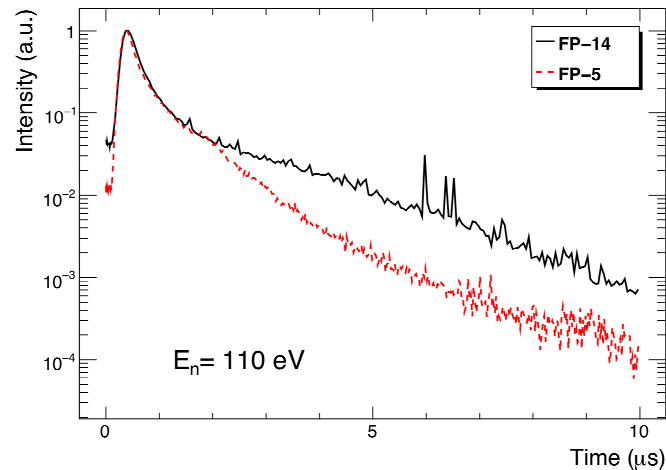
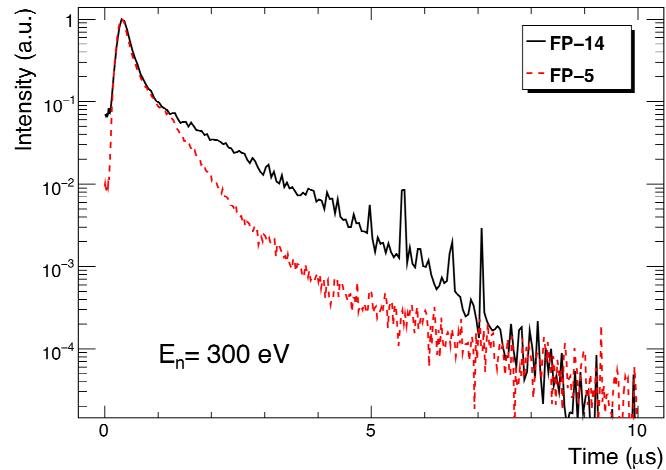
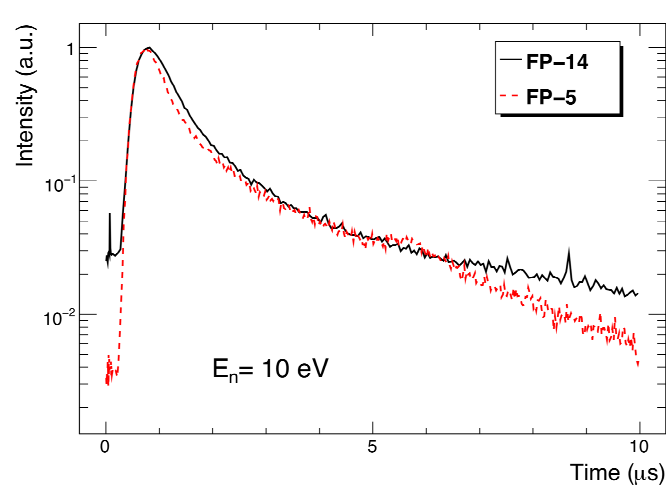


## FP-14 DANCE: time emission spectra



Moderator coupled  
with surrounding  
reflector materials

# FP-5 versus FP-14 time emission spectra



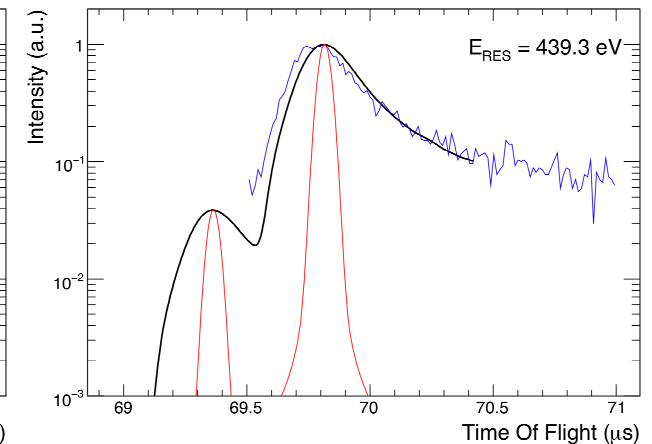
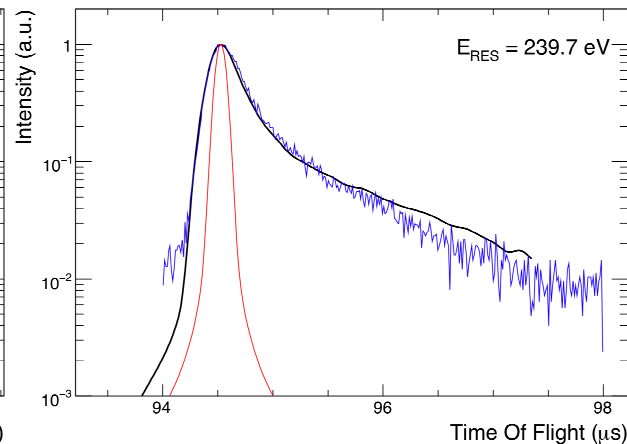
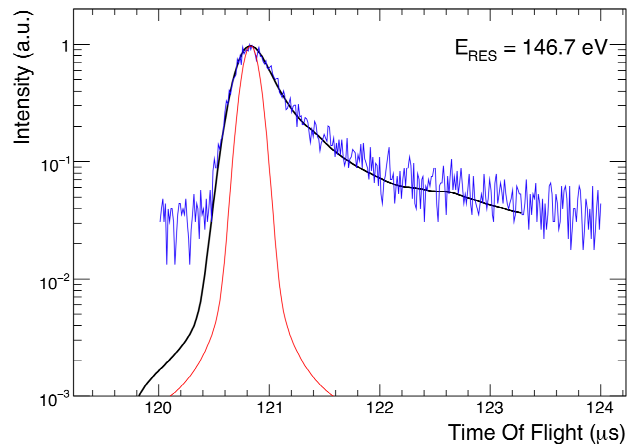
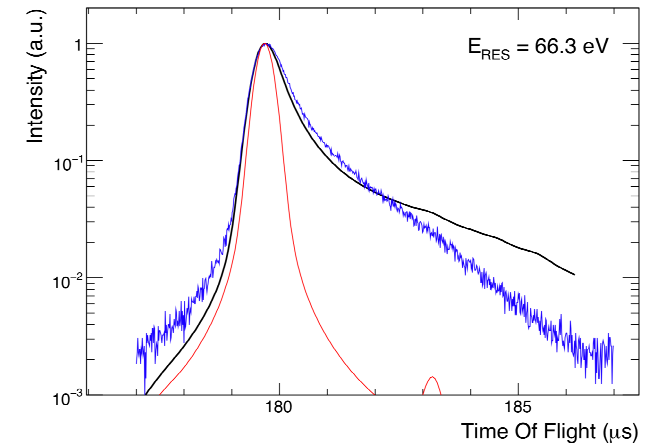
Prolonged tails for FP-14

Moderator is coupled with the surrounding reflector materials



# FP-14 DANCE: simulation efforts

- Better understand the resolution and energy calibration
- Detailed simulations with real proton pulse distribution for FP-14
- Time emission spectra 1 eV - 1 keV
- Experimental data for  $^{238}\text{U}(n,\gamma)^{239}\text{U}$



# Summary

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- Overview of two experimental facilities at LANSCE (Lujan & WNR)
- Modeling efforts in support of nuclear physics cross-section measurements at LANSCE
- Validation of Monte-Carlo simulation results at 2 nuclear physics FPs (5&14)