



# R-Matrix analysis of the neutron-induced cross sections on $^{143}\text{Nd}$ measured at LANSCE

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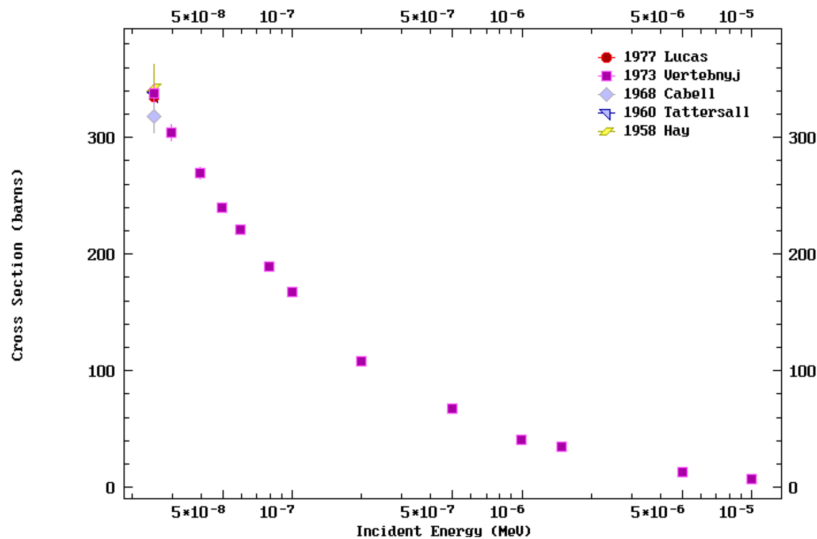
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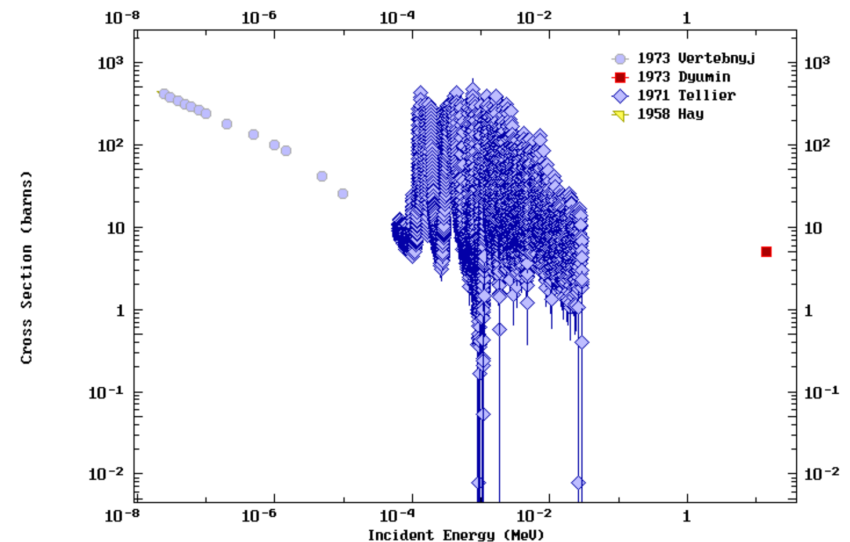
# Motivation - $^{143}\text{Nd}$

- $^{143}\text{Nd}(n,\gamma)$  and  $^{143}\text{Nd}(n,\text{tot})$  cross section data available in EXFOR:
  - $(n,\gamma)$  data are very scarce and only up to 10 eV.
  - Only a few  $(n,\text{tot})$  data.
  - Both channels data were last measured in the 70s.
  - Resonance parameters are provided for Tellier's  $(n,\text{tot})$  measurement, but new parameters for a combined analysis using capture and transmission data would provide more complete results.

$(n,\gamma)$

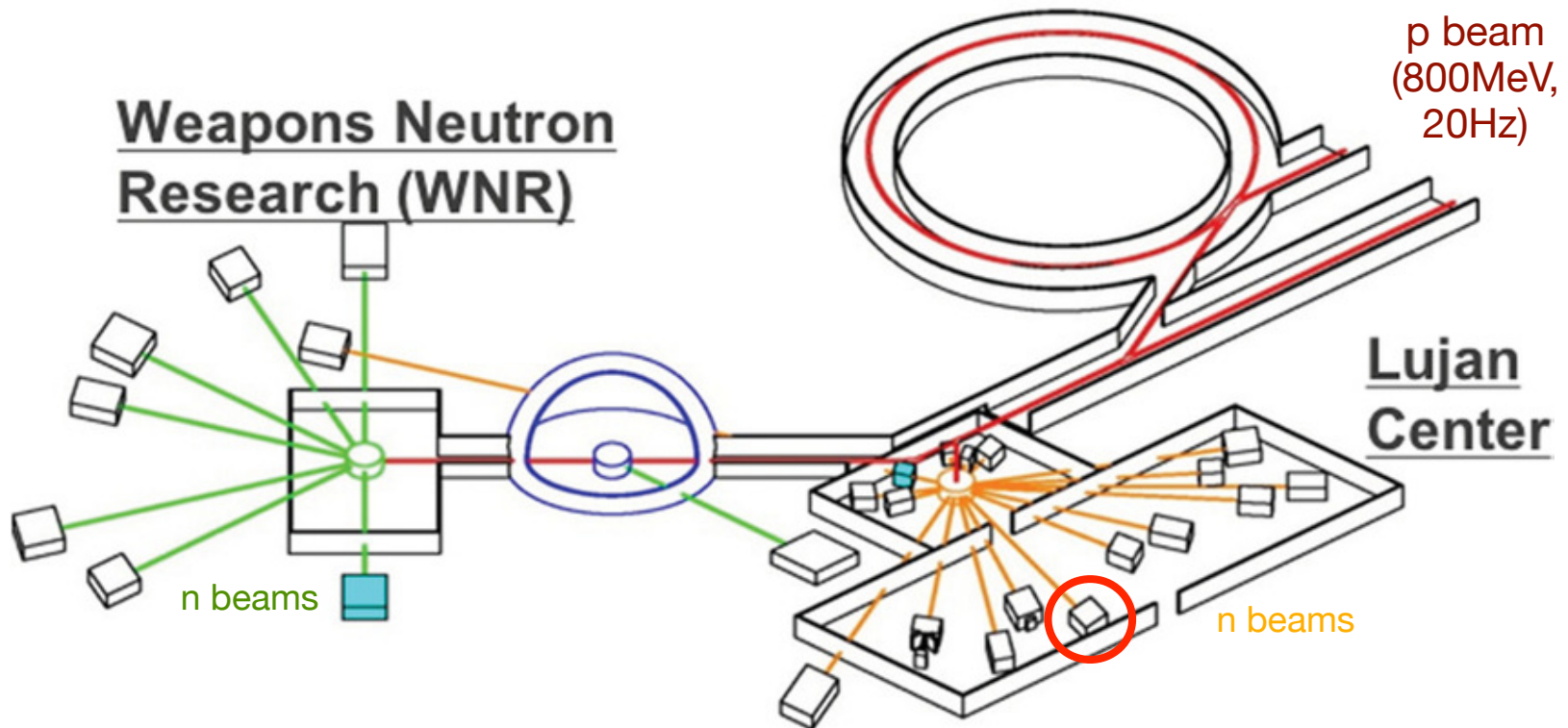


$(n,\text{tot})$

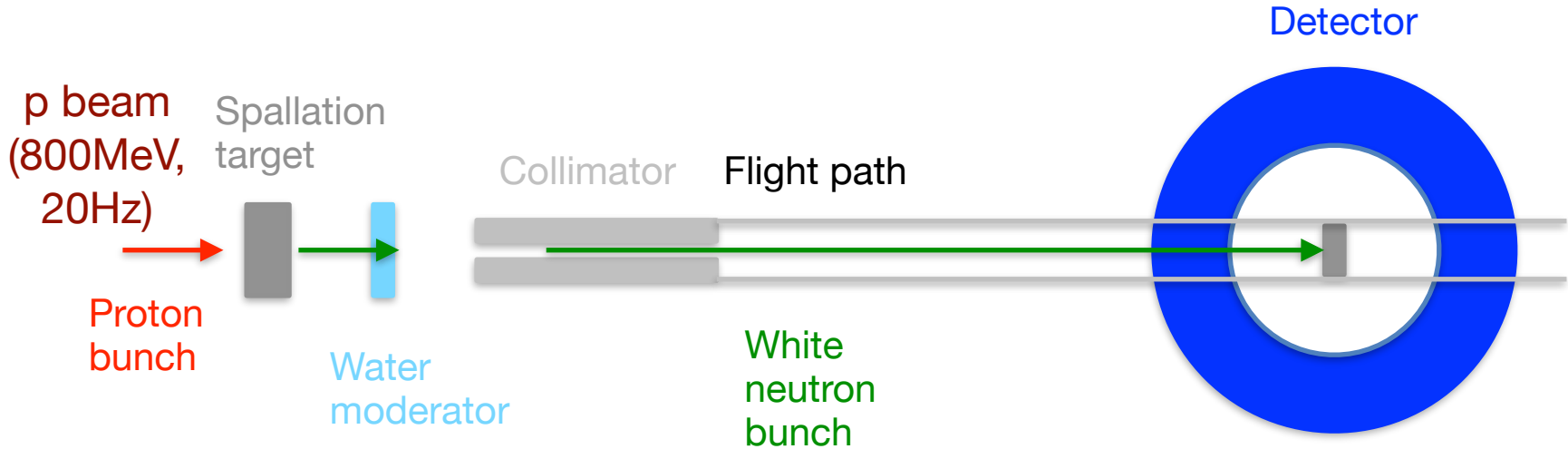


# LANSCCE facility

- Neutrons produced by proton spallation on a W target.
  - Mark-III spallation target used in these measurements.
- **DANCE:**
  - Flight path 14 (20m).
  - White neutron spectrum ( $E_n = \text{meV} - 100\text{s keV}$ ).



# Time-of-flight measurements

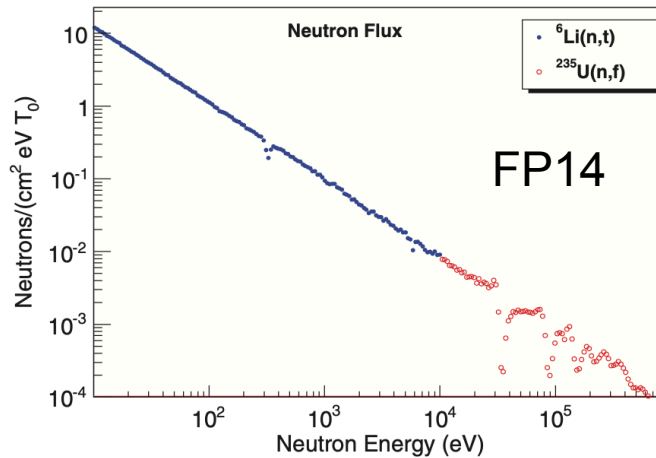


Neutron Energy:

$$E_n = m_n c^2 \frac{1}{\sqrt{1 - (\frac{v}{c})^2}} - 1$$

with:

$$v = L/T$$

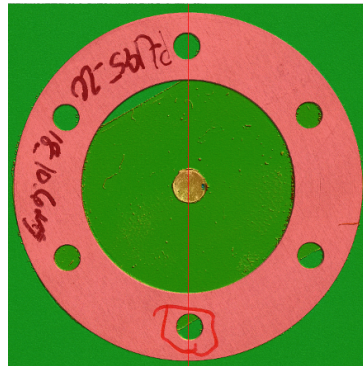


$$\text{Flux}_n = 3 * 10^5 \text{ n/s/cm}^2/\text{dec}$$

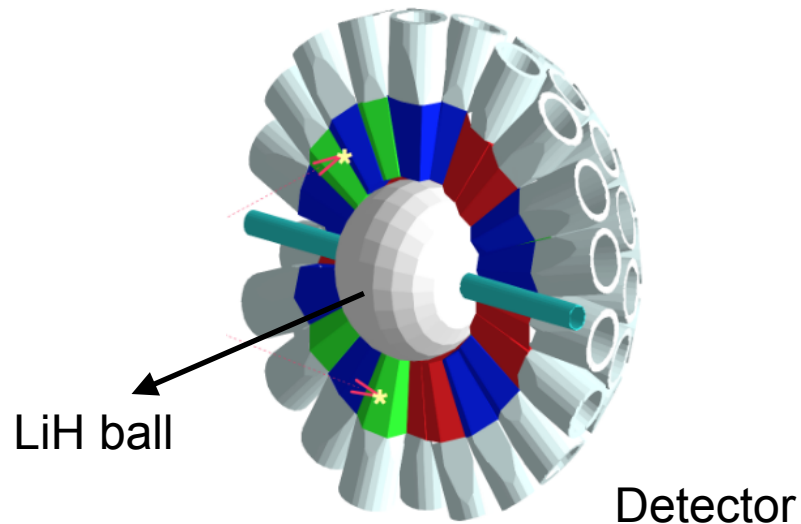
# Detector

## DANCE (Detector for Advanced Neutron Capture Experiments)

- Capture measurements.
- $4\pi\text{BaF}_2$   $\gamma$ -ray calorimeter composed by 160 crystals with an inner cavity of 17 cm radius [1].
- Used to measure neutron capture cross section data on small quantities of radioactive isotopes.
- We can measure  $E_n$ ,  $E_{\text{sum}}$ ,  $E_{\text{cl}}$ , and  $M_{\text{cl}}$ , providing more information than with C6D6 detectors.



Sample

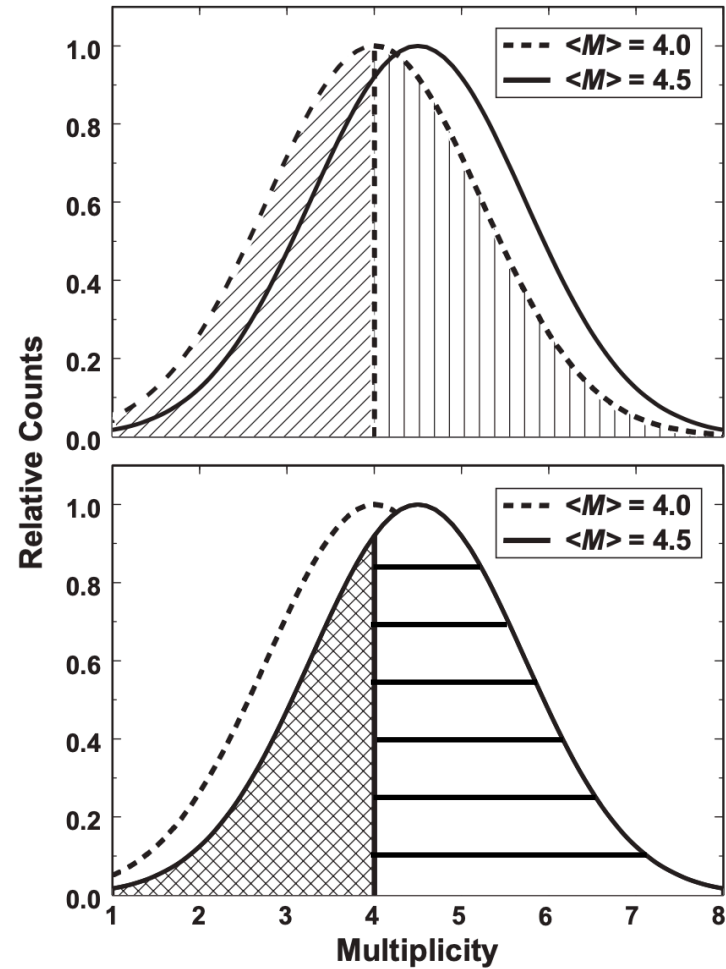
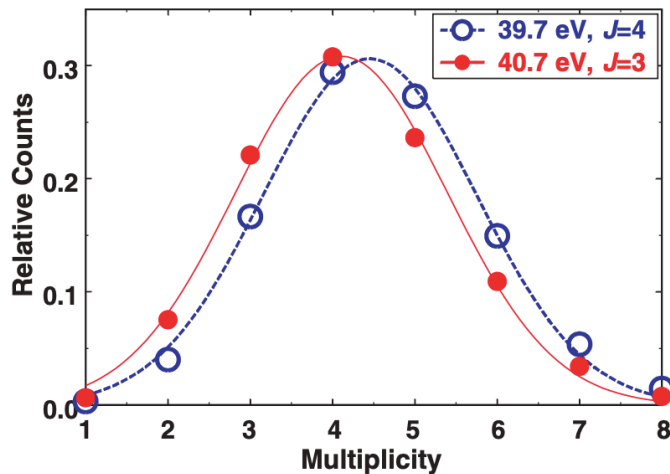


Detector

[1] M. Heil et al., Nucl. Instrum. Methods Phys. Res. A **459**, 229 (2001).

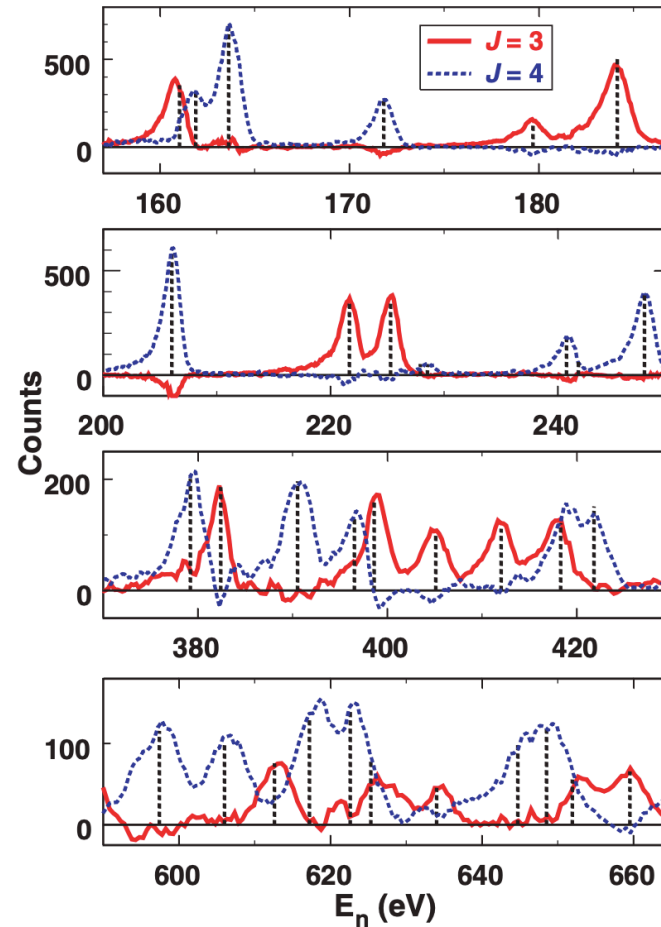
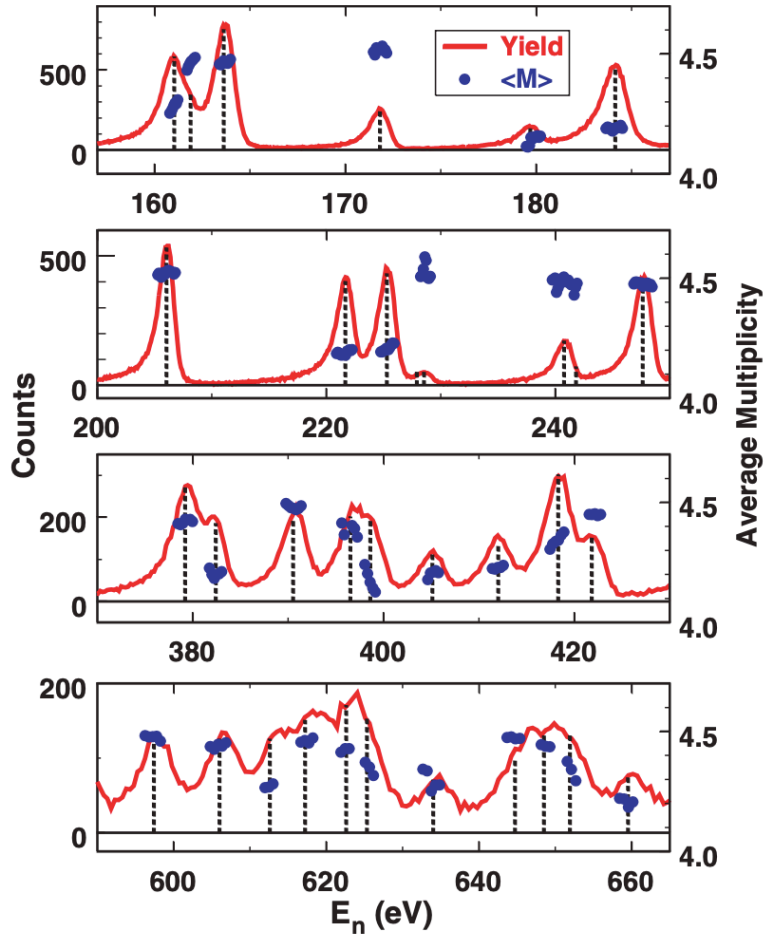
# Spin assignment with DANCE

- Previous technique: Using  $\langle M \rangle$ .
- New technique: Using  $\langle M \rangle$  and the shapes of the distributions [3].
  - Advantage: it works for several un- and partially-resolved resonances for which the previous technique failed.



[3] P. Koehler et al., Phys. Rev. C **76**, 025804 (2007).

# Spin assignment with DANCE



[3] P. Koehler et al., Phys. Rev. C **76**, 025804 (2007).

# SAMMY analysis

## Input experimental information

- Experimental capture and transmission cross section.

### Transmission

- Measured by Tellier in Saclay (France):  $(n, \text{tot})$  cross section published in EXFOR.
- Measured by Vertebyj.

### Capture

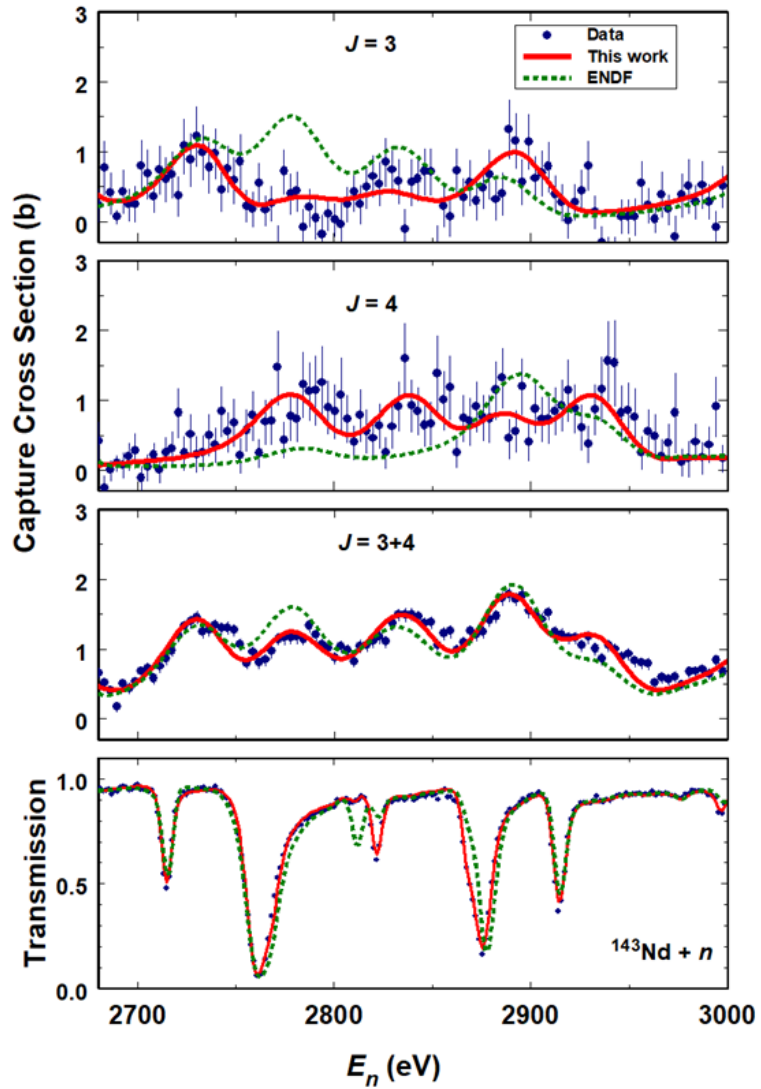
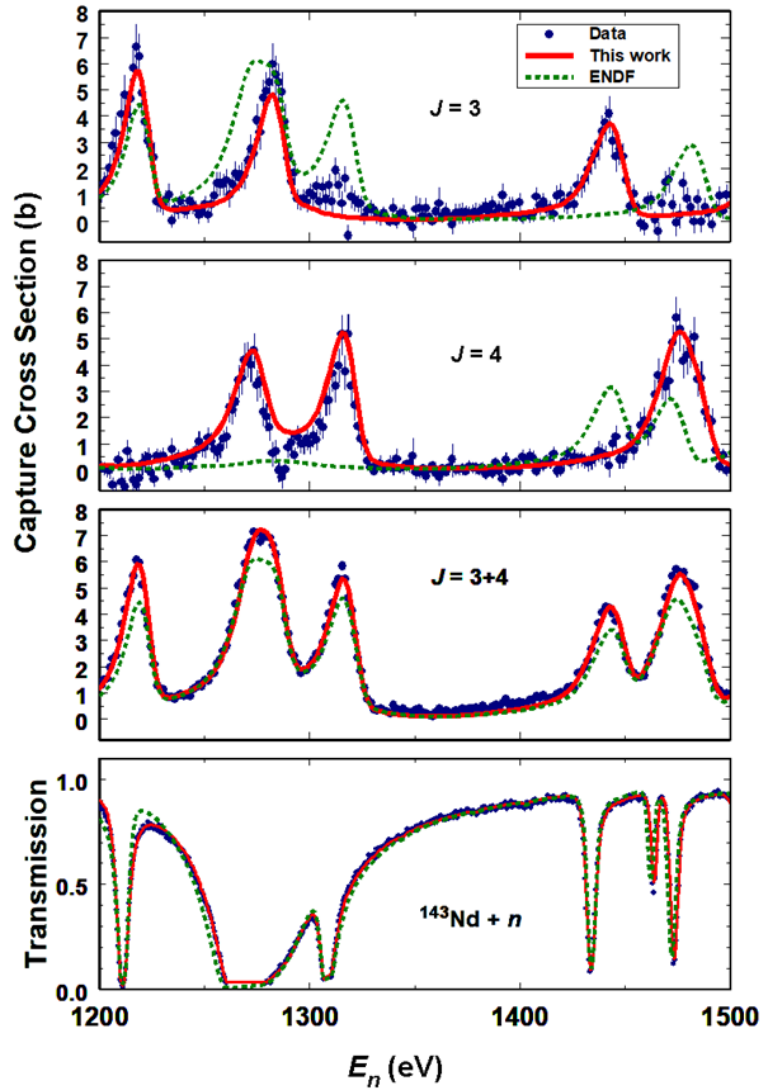
- Measured with DANCE:  $(n, \gamma)$  and the spin separated  $(n, \gamma)$  for  $J=3$  and  $J=4$ .
- Measured by Vertebyj.
- Resolution function.
- Experimental information:
  - Flight path length.
  - Samples features.

## Input parameters information

- Initial values for the parameters.
- Spin information.



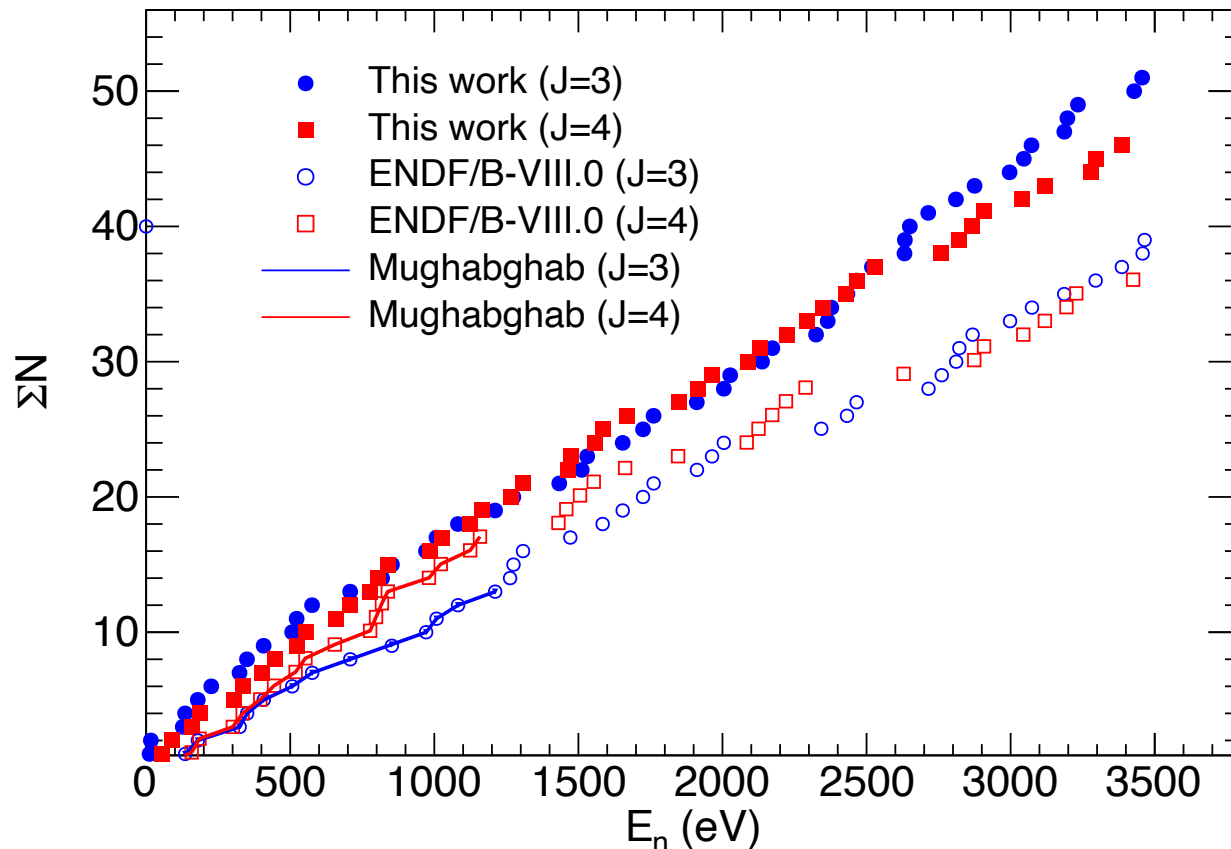
# SAMMY analysis - $^{143}\text{Nd}$



# Statistical analysis - $^{143}\text{Nd}$

## Cumulative number of resonances

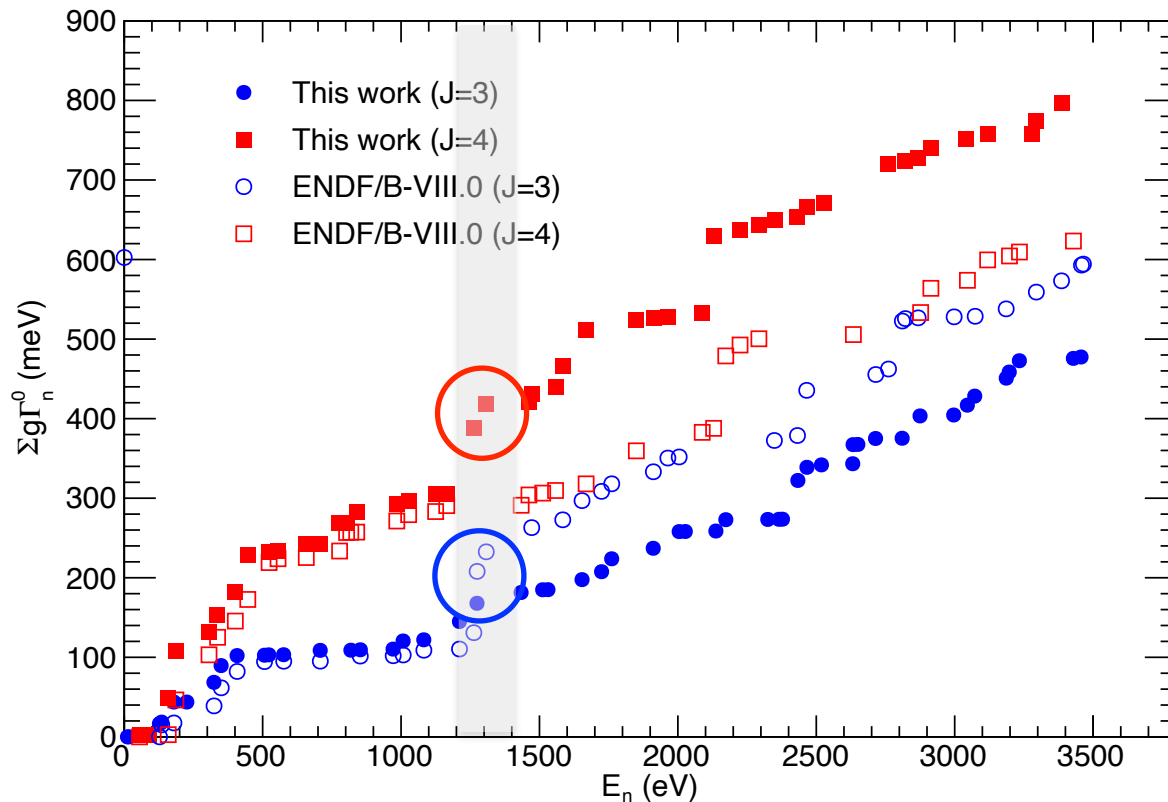
- 14 (J=3) and 7 (J=4) additional resonances found in this work compared to ENDF/B-VIII.0.
- 15 (J=3) and 6 (J=4) compared to JEFF-3.3.
- 18 (J=3) and 6 (J=4) compared to JENDL-5.



# Statistical analysis - $^{143}\text{Nd}$

## Cumulative $g\Gamma_n^0$

- Good agreement with ENDF/B-VIII.0 below 1.2 keV (where ENDF takes the values from Mughabghab).
- Discrepancies around 1.2 keV in spin assignment.

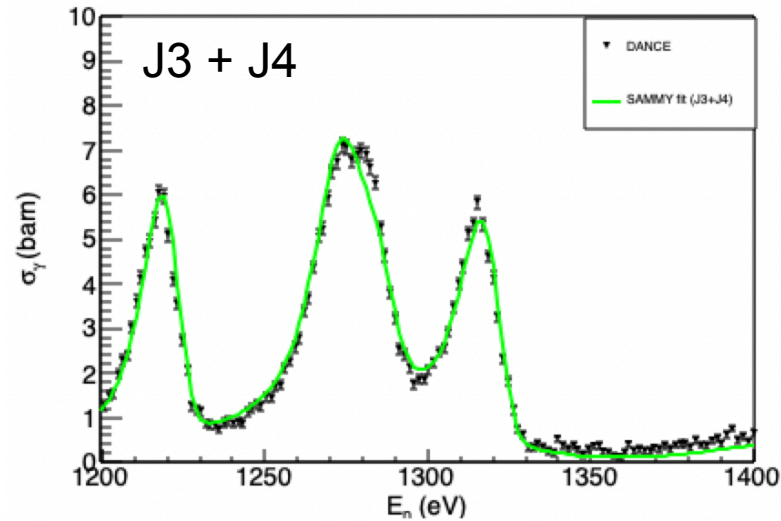


- Wrong spin assignment:

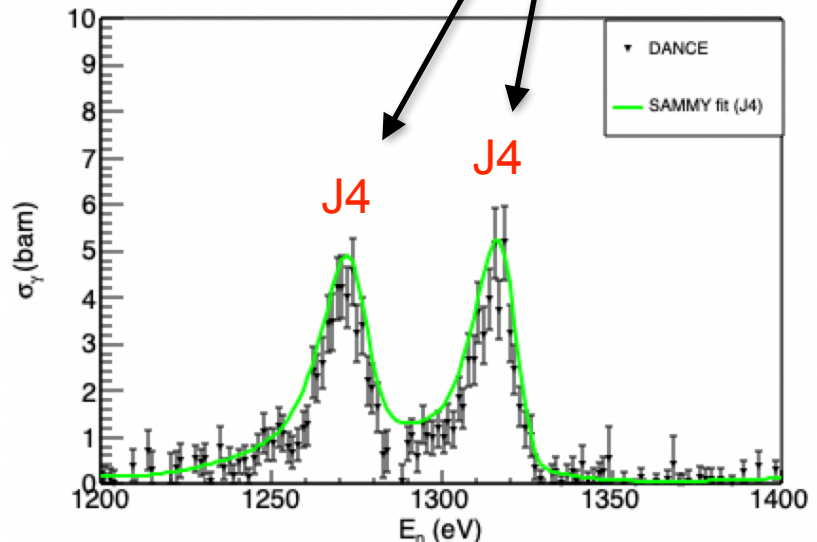
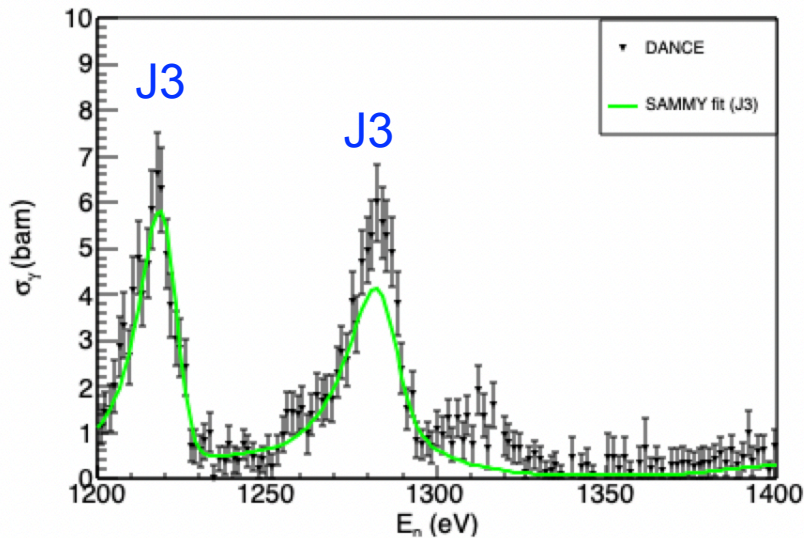
- **23** resonances in ENDF/B-VIII.0.
- **25** resonances in JEFF-3.3.
- **26** resonances in JENDL-5.

# Statistical analysis - $^{143}\text{Nd}$

Preliminary



Wrong spin assignment in **ENDF/B-VIII.0** for these two resonances!

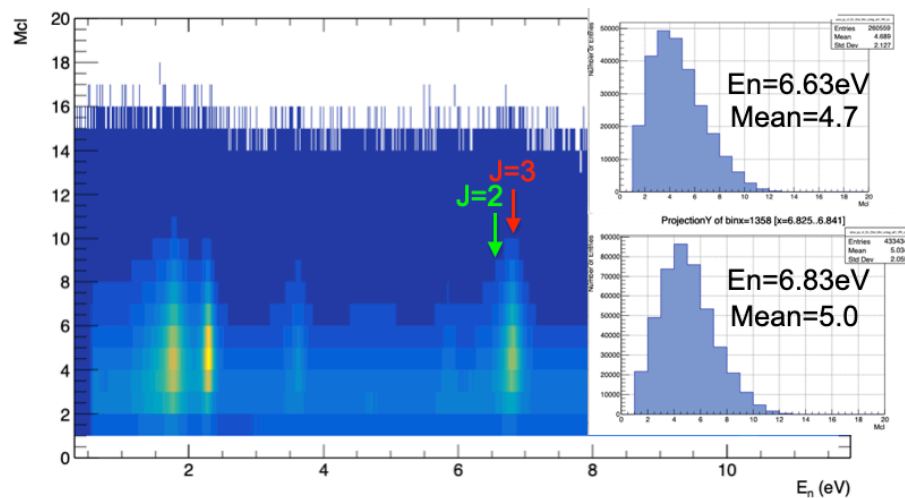


# Conclusions

- An established used of R-Matrix codes is being implemented at LANSCE.
- There are unique features accessible with detectors at LANSCE that can be used to perform more complete R-Matrix analysis.
  - Spin separation is a powerful technique that can be applied in DANCE measurements.
- Transmission and capture data were analyzed in this work. The study can be extended to other channels.
- The results of the  $^{143}\text{Nd}$  data are presented in this work.
  - New resonances found in this work: 21 compared to ENDF/B-VIII.0 and JEFF-3.3, and 24 compared to JENDL-5.
  - Wrong spin assignment in 23 resonances in ENDF/B-VIII.0, 25 in JEFF-3.3 and 26 in JENDL-5.
- The  $^{143}\text{Nd}$  and  $^{147,149}\text{Sm}$  have been analyzed.
- Exciting future for new measurements and analysis!

# Future work

- $^{233}\text{U}$  capture measurement with DANCE performed in 2020-2021.
  - The capture-to-fission cross section was calculated and sent to the evaluators.
- It would be interesting to extend the work on the  $^{233}\text{U}$  data to calculate the spin of the resonances in the Resolved Resonance Region.
  - Required as input information for R-Matrix analysis.
  - To provide realistic spins for ENDF/B evaluation.
  - Of interest for other codes, ...
- First look to the spin information of the  $^{233}\text{U}$  experimental data:



# Acknowledgements

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