Los Alamos
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^{133}Cs neutron-induced capture cross section measurement with DANCE

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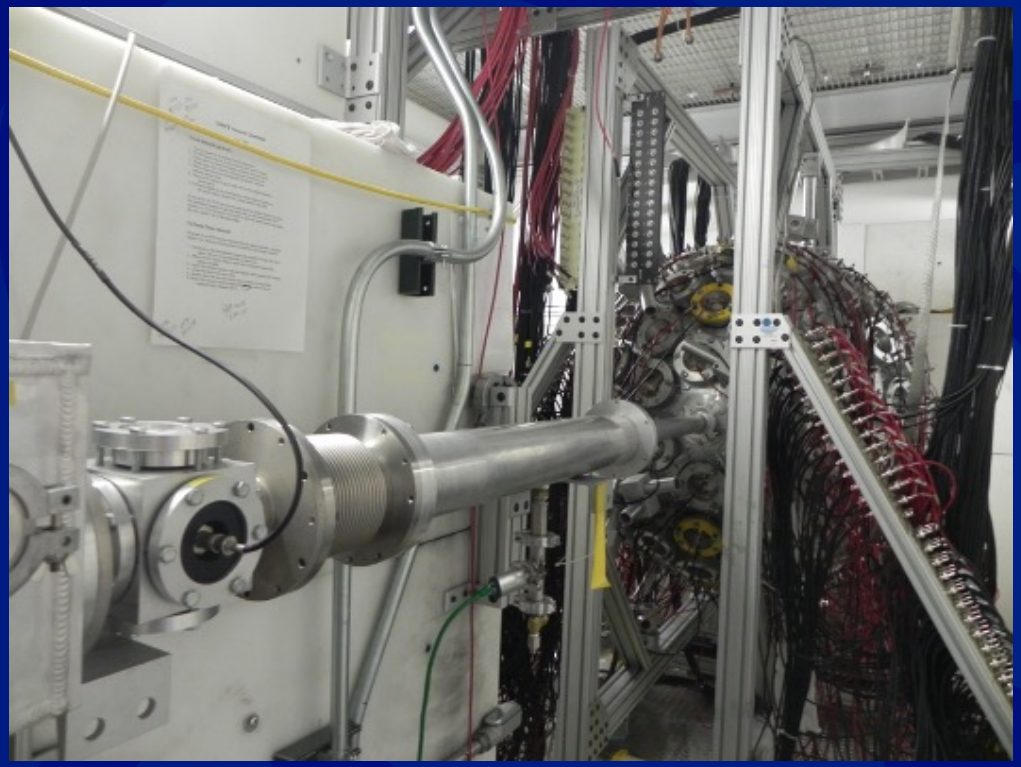

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Motivation

- The capture cross section on ^{133}Cs was measured as a part of **NSCP**.
- ^{133}Cs is an important fission product for burn-up applications.
- Recent studies suggest that the **thermal** cross section is **overestimated** in the JEFF evaluation. Only data of three resonances in **RRR** available in EXFOR.
- **Covariance** information is needed for **uncertainty propagation**.
- New experiment proposed at **LANSCE** to measure the capture cross section at thermal energies & RRR. The experiment took 2 weeks. Two pressed samples of 2g and 1g were made at LANL. The data analysis to extract the cross section is in progress.

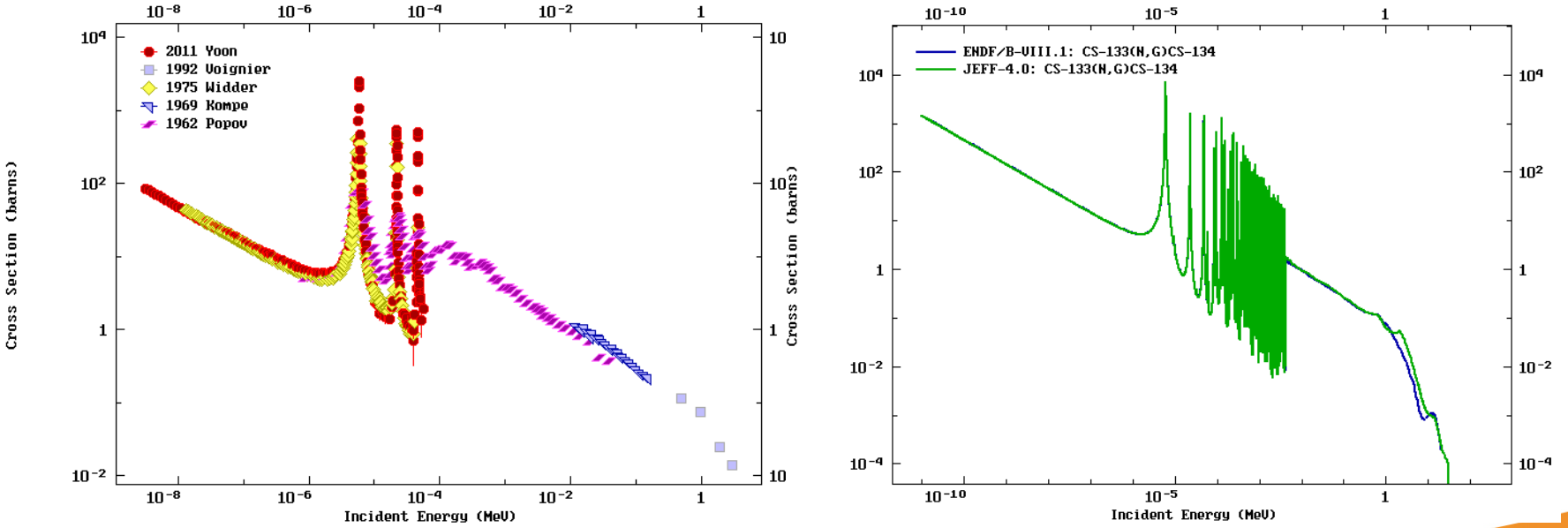
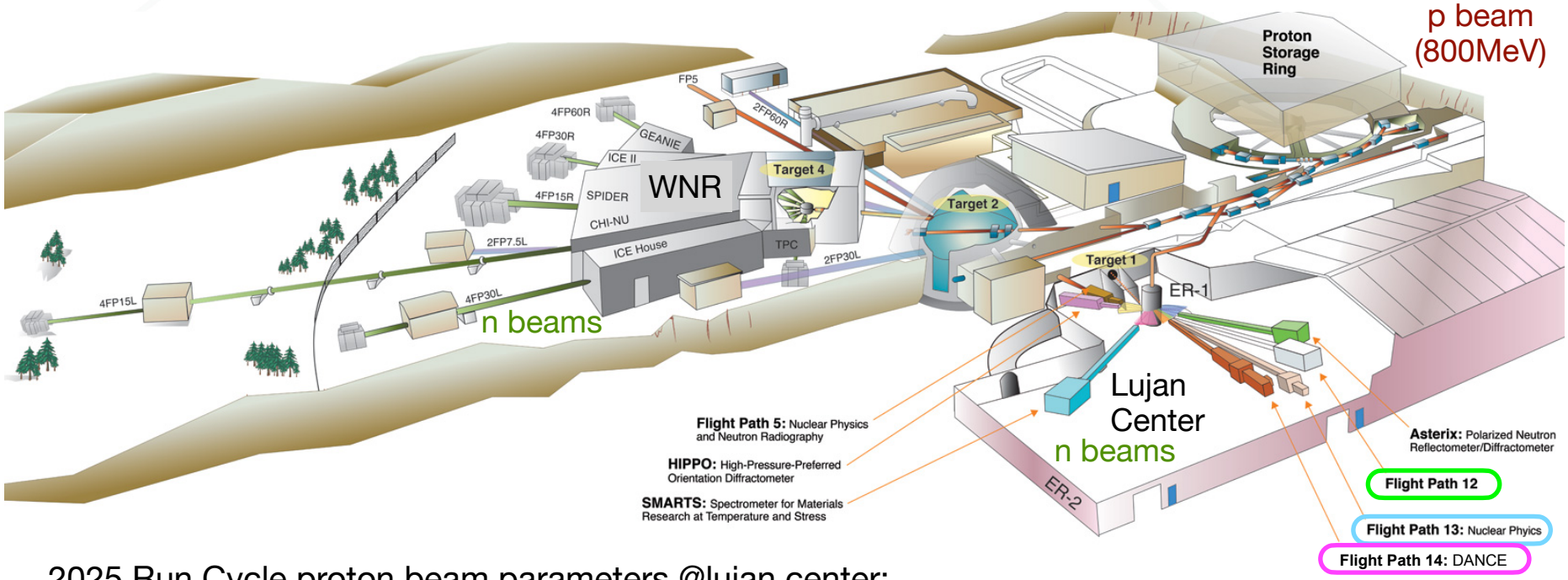


Figure 1: ^{133}Cs(n,γ) cross section data selected from EXFOR (left) and from the evaluated libraries (right).

LANSCE facility

Neutrons produced by proton spallation on a W target.

- Mark-IV spallation target increases neutron production in the keV region with respect to Mark-III.



2025 Run Cycle proton beam parameters @lujan center:

- RF repetition rate 60Hz: 20 pulses/s for Lujan.
- PSR Pulse width: ~290 ns
- Beam current: ~80 uA

Figure 2: LANSCE facility scheme.

Detector

DANCE (Detector for Advanced Neutron Capture Experiments)

- 4πBaF_2 γ-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.
- Single γ-ray detection efficiency of 85%.
- We can measure E_n, E_γ, and M_{cl}, providing more information than with C6D6 detectors.

Time-of-flight measurements

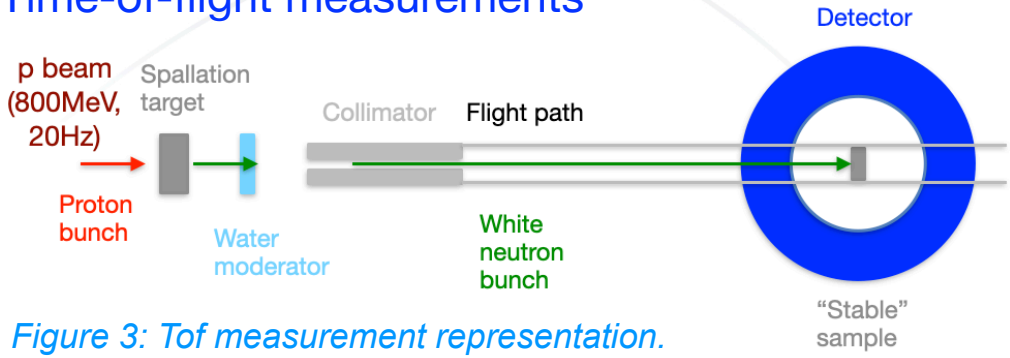
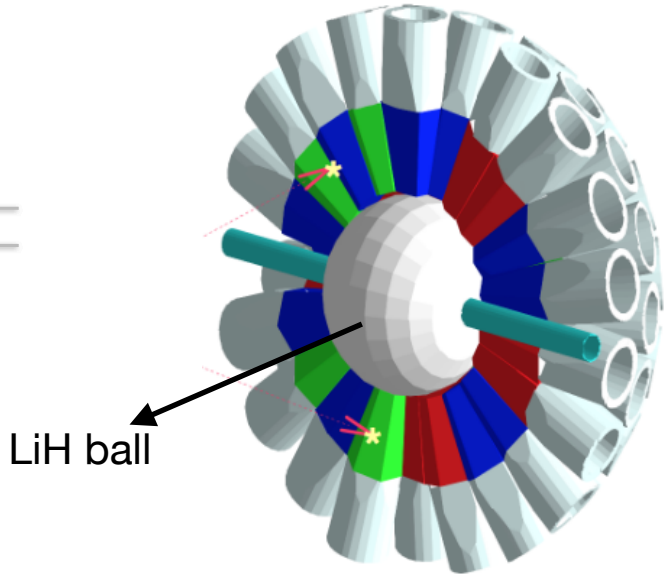


Figure 3: Tof measurement representation.

Neutron Energy:

$$E_n = m_n c^2 \frac{1}{\sqrt{1-(\frac{v}{c})^2}} - 1 \quad \text{with:} \quad v = L/T$$



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

CsF Samples

- The pressed samples were made using CsF dry powder.
- Two 2” diameter samples of ~2g and ~1g were built at LANL.
- They were wrapped in kapton tape.
- They were kept in vacuum to keep them dry.

Figure 4: CsF pressed sample (left). Samples fabrication (right).

DANCE Crystals Calibrations

- Intrinsic radioactivity of BaF_2 used to calibrate the DANCE crystals.
- Using the Alpha-decay chain of the ^{226}Ra present in the BaF_2.
  - ^{226}Ra (4.8 MeV)
  - ^{222}Rn (5.5 MeV)
  - ^{218}Po (6.0 MeV)
  - ^{214}Po (7.7 MeV)

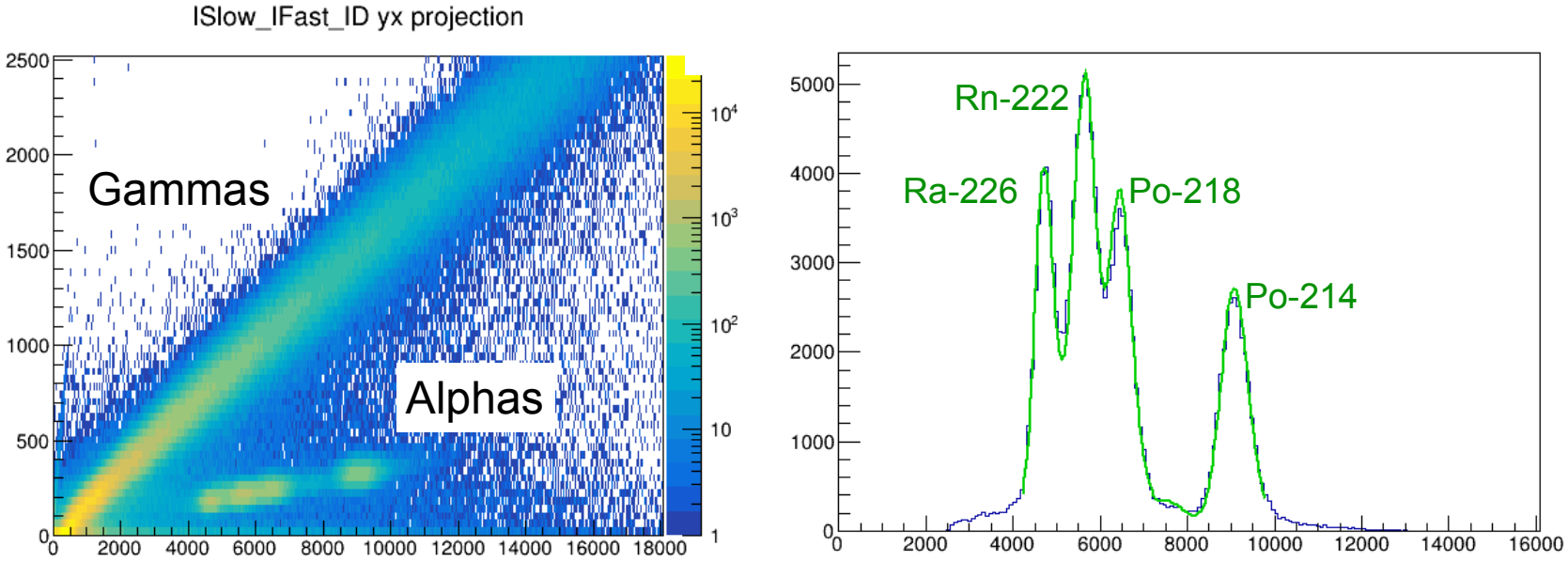


Figure 5: PSD plot to separate α/γ (left) and α-spectrum used for one the DANCE crystals calibration.

Data analysis

One hour of data taking

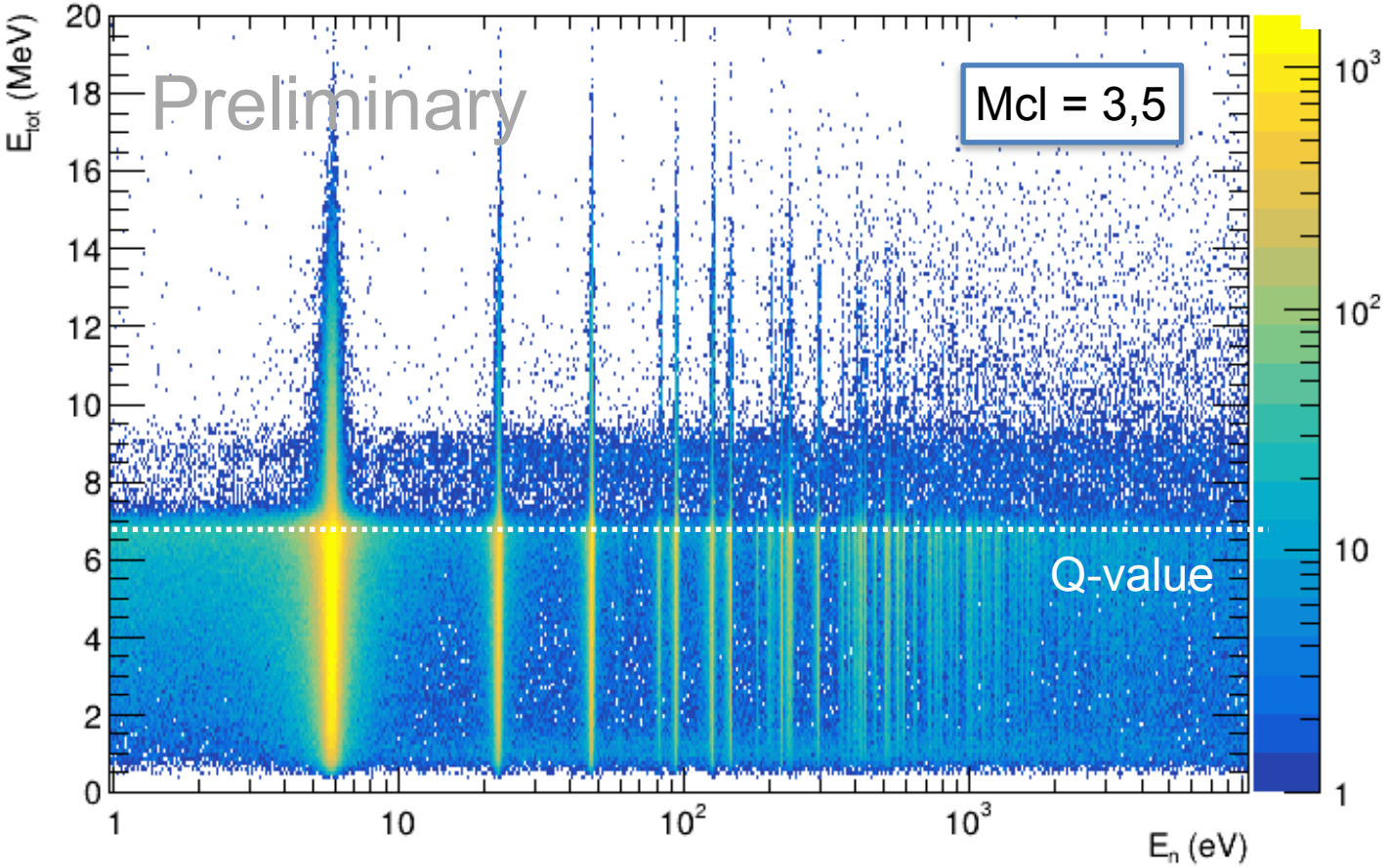


Figure 6: Raw counts showing the total energy of the γ-rays vs incident neutron energy.

Data analysis

- The first resonance at 6 eV obtained with the 2 g sample is saturated.
- This effect is reduced using the 1 g sample.

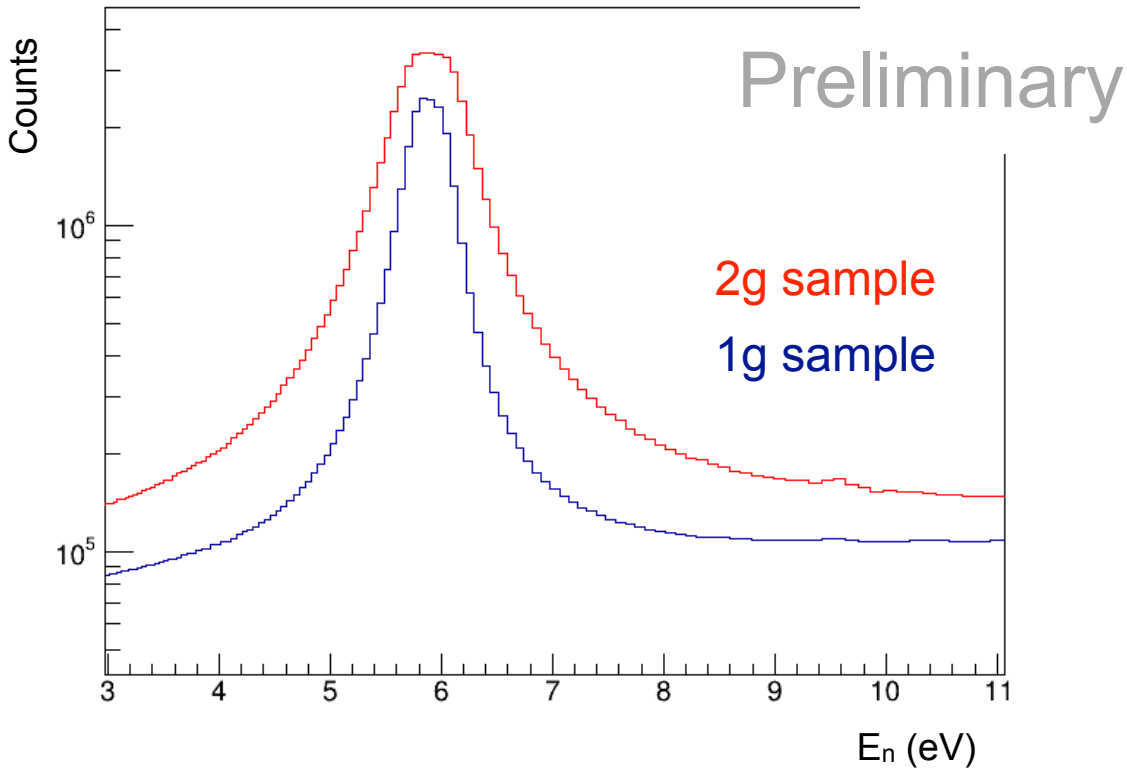


Figure 7: Comparison between the raw data obtained with the two CsF samples.

Data analysis: Background subtraction

- The scattering background was measured using a C target.
- The scattering E_{tot} spectrum was normalized to the total counts in the scattering peak & subtracted.
- A Q-value window was applied around the Q-value to select the capture events on ^{133}Cs.

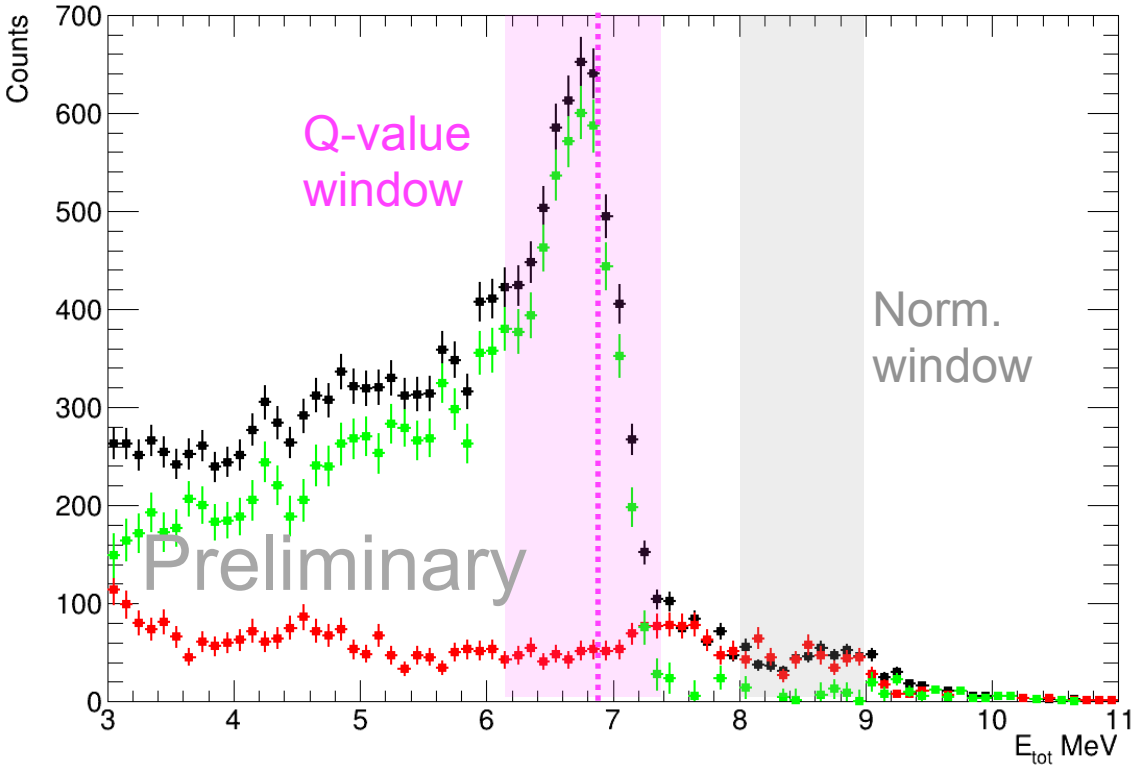


Figure 8: Total energy of the γ-rays for 3eV incident neutrons.

Data analysis: Neutron flux

The neutron flux is obtained with monitors measuring the ^{6}Li(n,t) and the ^{235}U(n,f) reactions with Si detectors and a fission chamber.

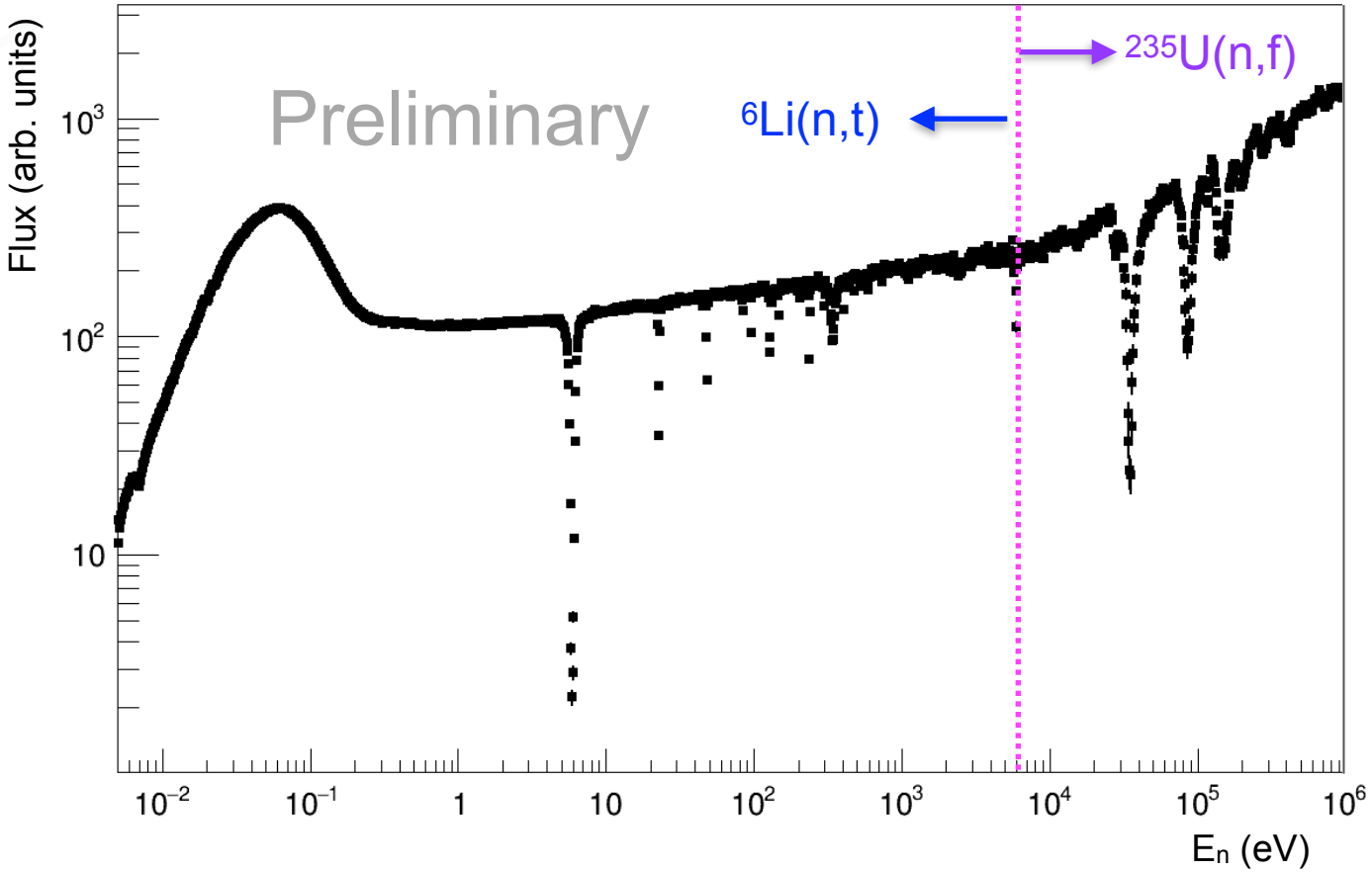


Figure 9: Neutron flux shape obtained with the flux monitors.

Data analysis: Counts/flux shape

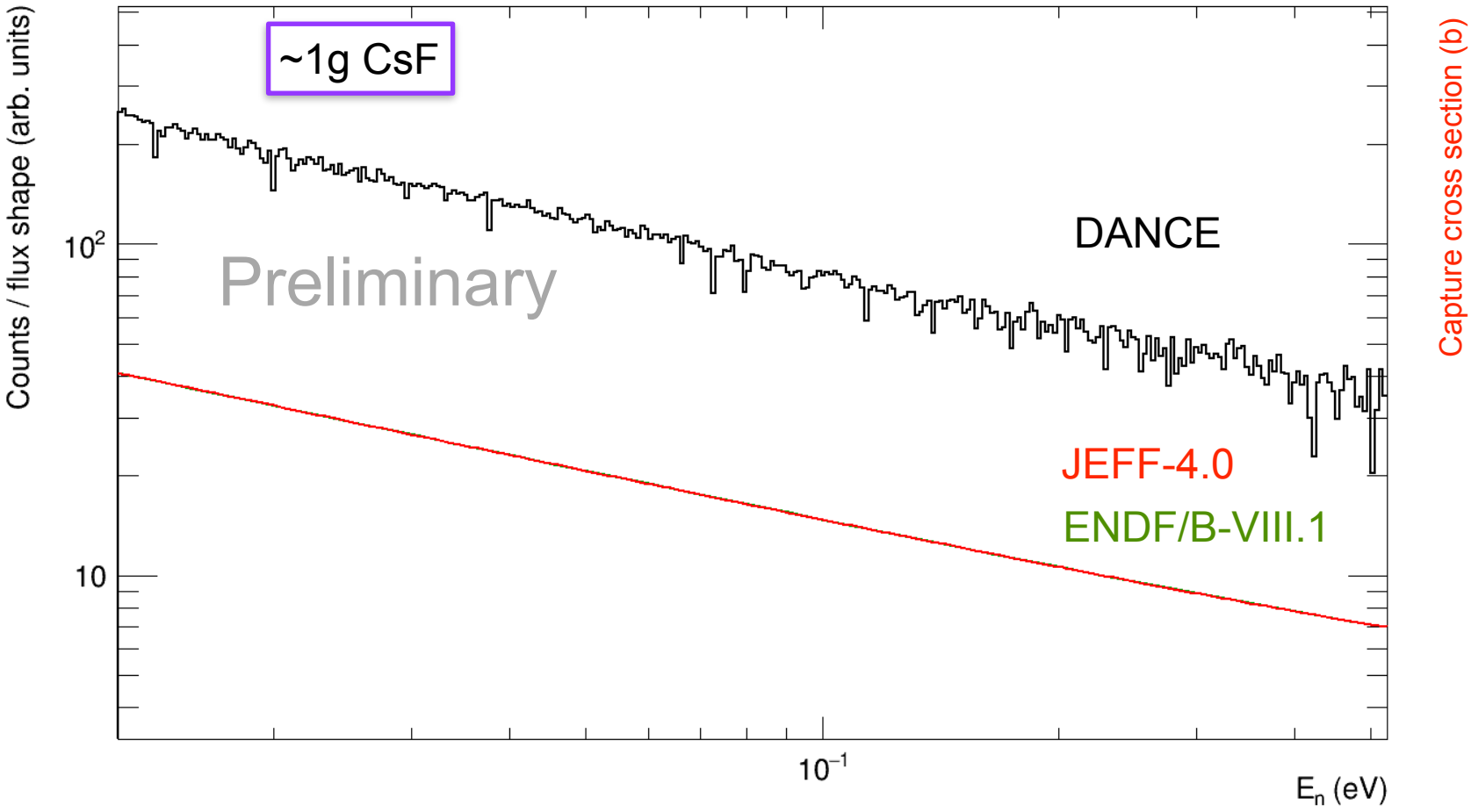


Figure 10: Background subtracted counts divided by neutron flux shape for the 2g sample.

Data analysis: Counts/flux shape

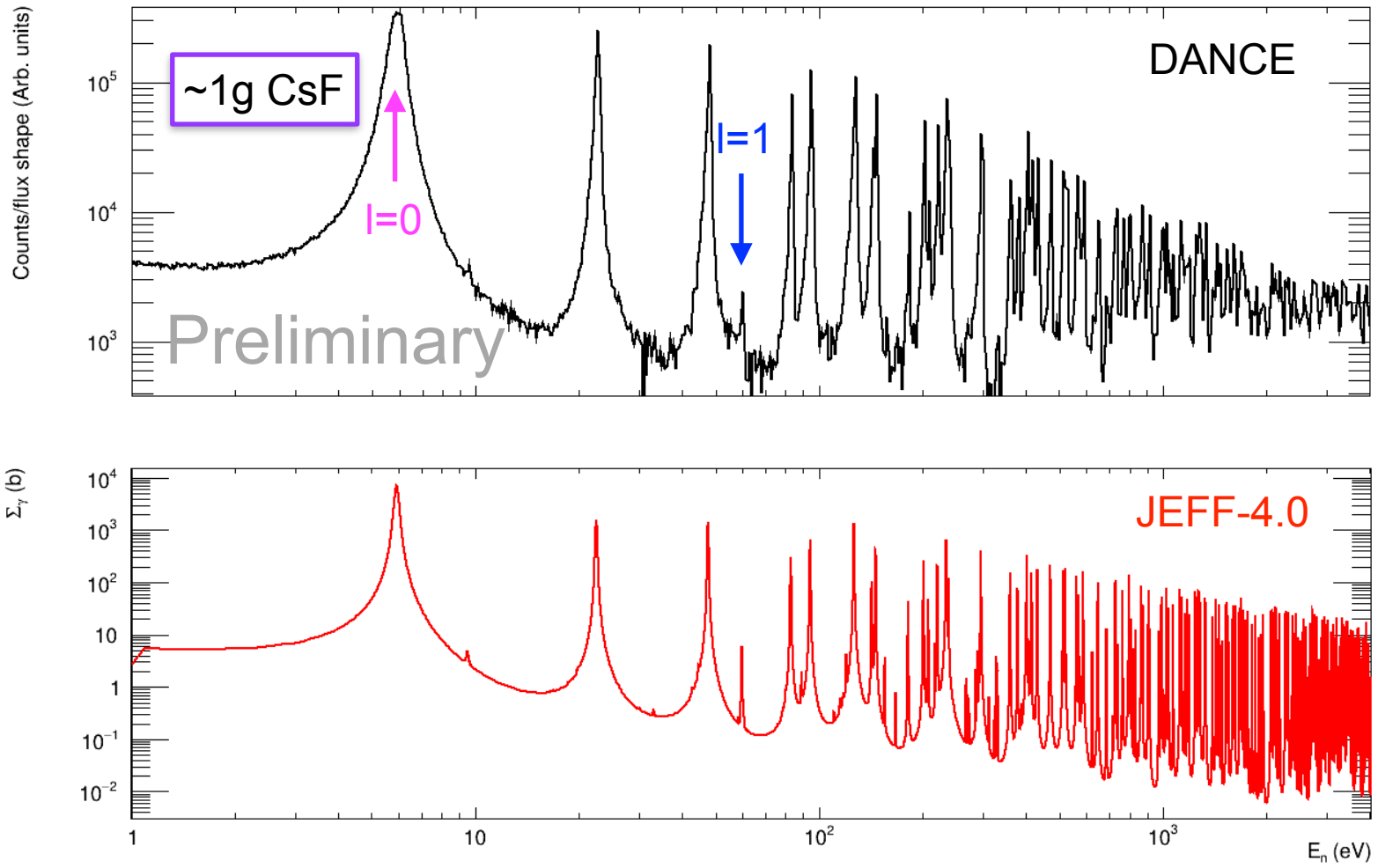


Figure 11: Background subtracted counts divided by neutron flux shape for the 1g sample.

Data analysis: Counts/flux shape

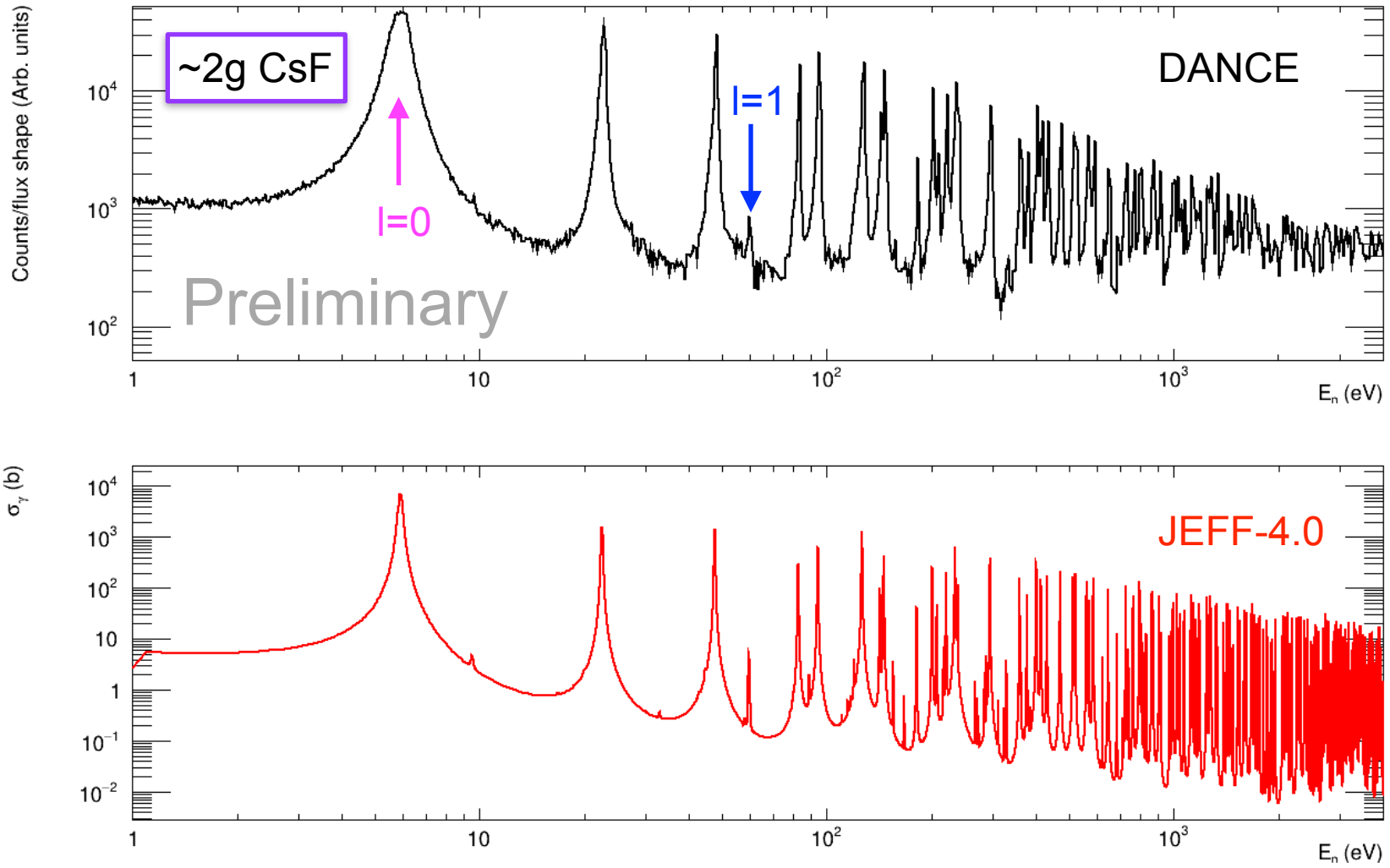


Figure 12: Background subtracted counts divided by neutron flux shape for the 2g sample.

Data analysis: Efficiency

The efficiency is calculated using **DICEBOX** + **Geant4** simulations.

- DICEBOX is used to simulate the γ-ray cascades.
- Geant4 uses the DICEBOX input to simulate the experiment.

Contribution of s-waves & p-waves in the RRR.

- Calculate the Etot γ-ray spectra for isolated s-wave & p-wave resonances and compare with the γ-ray cascades for each.

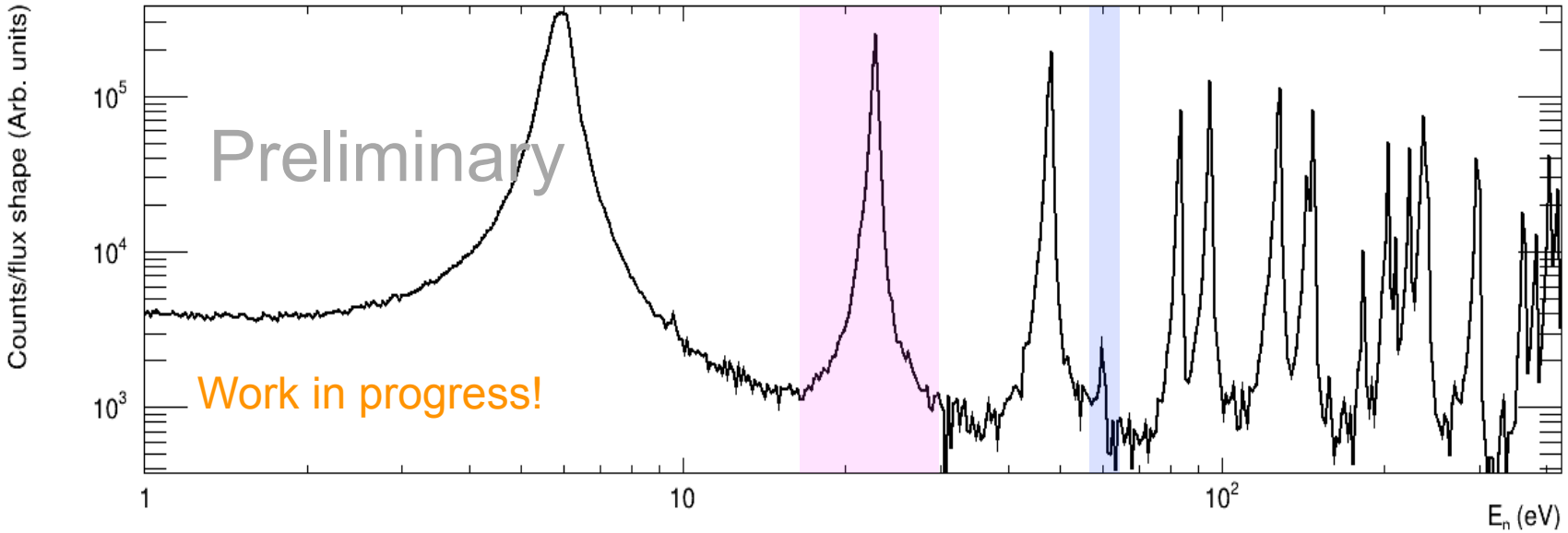


Figure 13: Background subtracted counts divided by neutron flux shape indicating s-wave & p-wave resonances.

Summary

- The ^{133}Cs(n,γ) reaction has been measured with DANCE at LANSCE.
- Two dry CsF pressed samples of ~2 g and ~1 g were built at LANL.
- The experiment took 2 weeks and was successfully performed in the 2025 Run Cycle.
- Data analysis in progress to extract the capture cross sections.
  - ✓ Background subtraction
  - ✓ Flux shape
    - ↻ Flux shape normalization -> in progress
  - ↻ Efficiency calculation -> in progress
  - ✓ Sample mass

Acknowledgements

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