Measurement of the ^{241}Am fission cross-section

A. Tsinganis[1], M.Diakaki[2], R. Vlastou[2], M. Kokkoris[2], N. Colonna[3], J. Heyse[4], L.Tassan-Got[1], N.Patronis[5], A. Stamatopoulos[2] and the n_TOF Collaboration

1) European Organisation for Nuclear Research (CERN), Geneva, Switzerland
2) Department of Physics, National Technical University of Athens, Greece
3) Istituto Nazionale di Fisica Nucleare (INFN), Bari, Italy
4) European Commission JRC, Institute for Reference Materials and Measurements, Geel, Belgium
5) Department of Physics, University of Ioannina, Greece

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Introduction

Motivation – Status of data

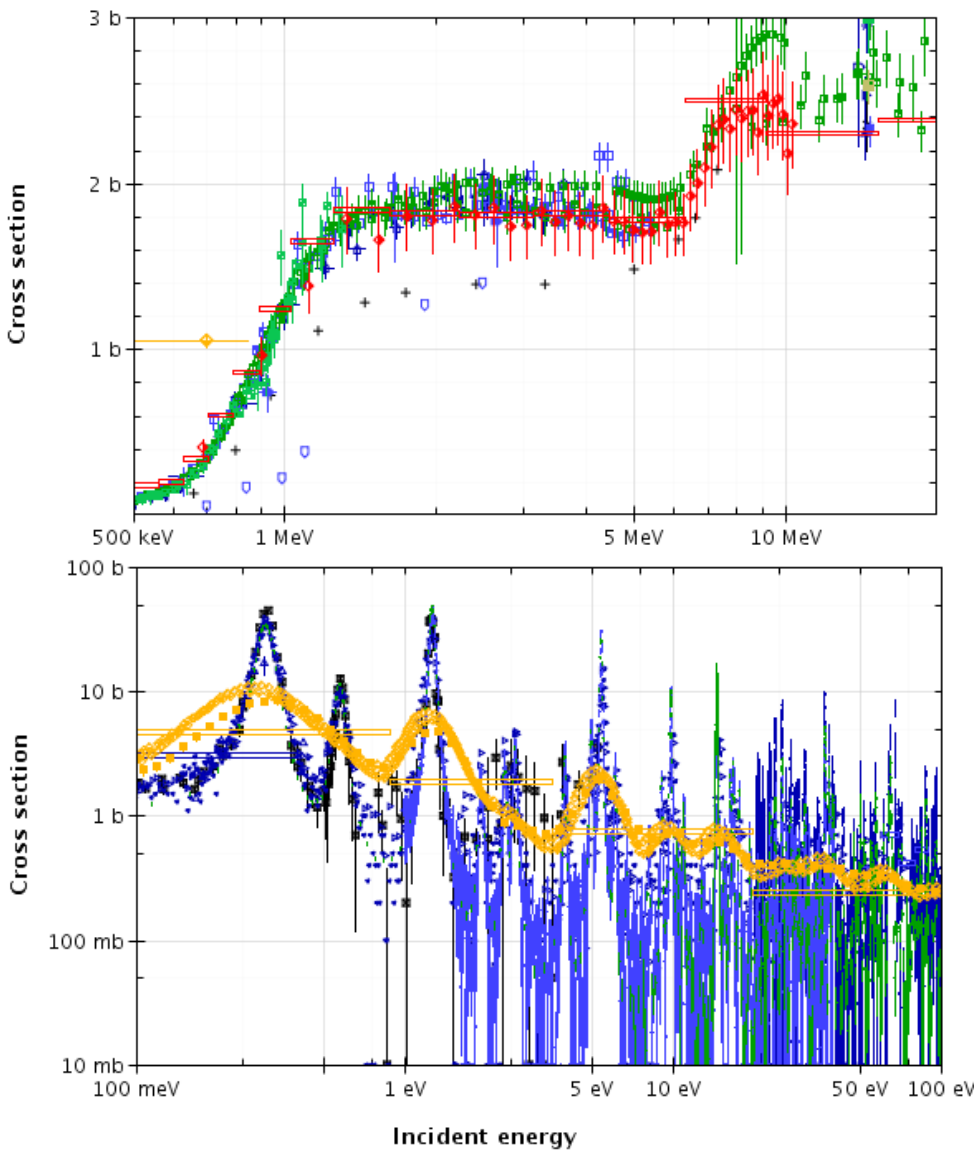
Motivation

- The isotope ^{241}Am is present in high-level nuclear waste
- Important for different waste transmutation and recycling scenarios
- ^{241}Am(n,f) reaction included in the NEA High Priority Request List
- The present experimental uncertainties do not meet the requirements set by sensitivity studies of advanced nuclear systems

	Uncertainty	
Range	**Initial**	**Target**
19.6 - 6.07 MeV	12.7	5.7
6.07 - 2.23 MeV	11.7	1.7
2.23 - 1.35 MeV	9.8	1.4
1.35 - 0.498 MeV	8.3	1.2
183 - 498 keV	8.3	4.0

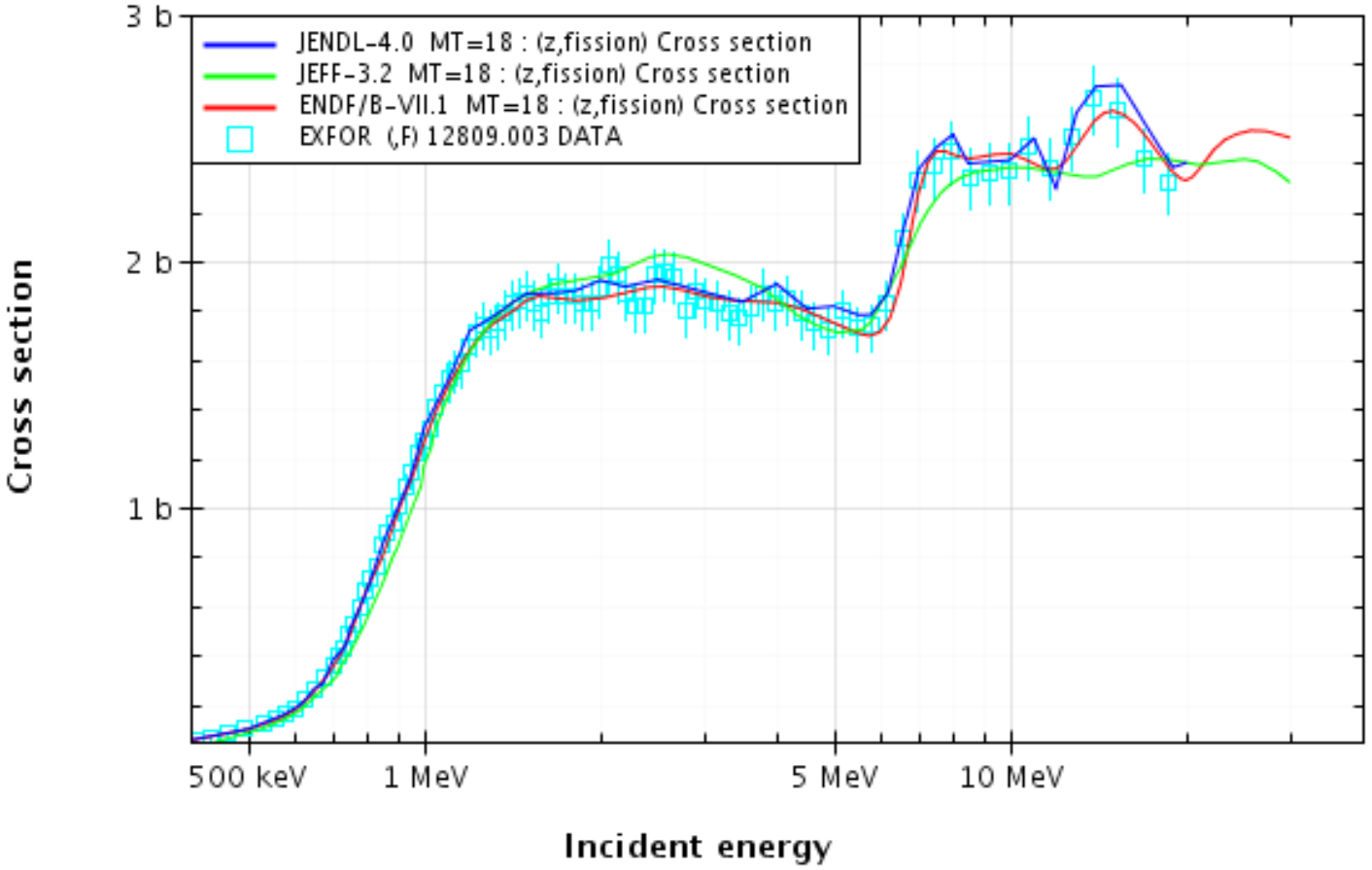
NEA Nuclear Data High Priority Request List, www.nea.fr/html/dbdata/hprl
OECD/NEA WPEC Subgroup 26 Final Report, www.nea.fr/html/science/wpec/volume26/volume26.pdf

Present status of data



- Measurements of ^{241}Am(n,f) are challenging for two main reasons:
  - Relatively short half-life of 433y (127 MBq/mg, 100% α)
  - Steep fission threshold with value decreasing rapidly below 1 MeV, reaching 100 mb already at 500 keV incident neutron energy
- Significant discrepancies among existing data can be observed both above the fission threshold and at lower energies

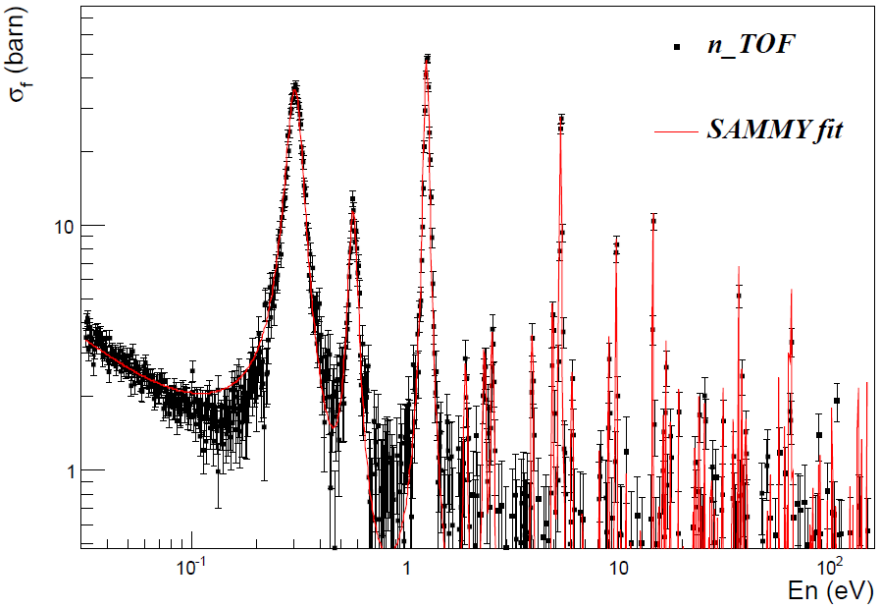
Present status of data

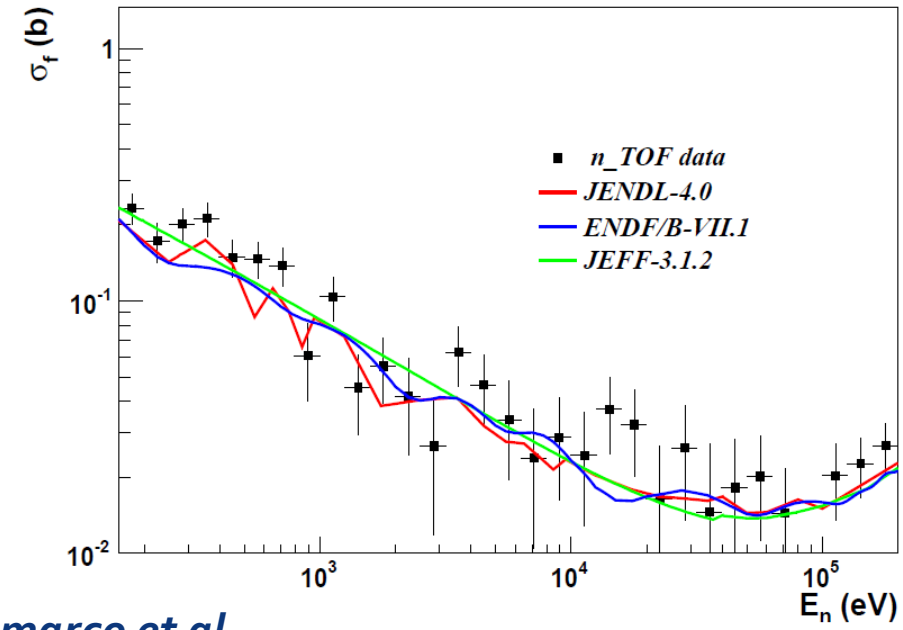


- This situation is also reflected in the discrepancies among evaluated libraries, which mostly follow the data by Dabbs et al. (1983)

Previous n_TOF measurement

- Performed in Phase-I (2001-2004) (EAR-1 with large collimator)
- Total mass: 2.26mg (35MBq/sample, 8 samples)
- High amplitude threshold applied to deal with the high α-activity
  - Data normalized to 3rd resonance in Dabbs data
- Results at low energies (e.g.):





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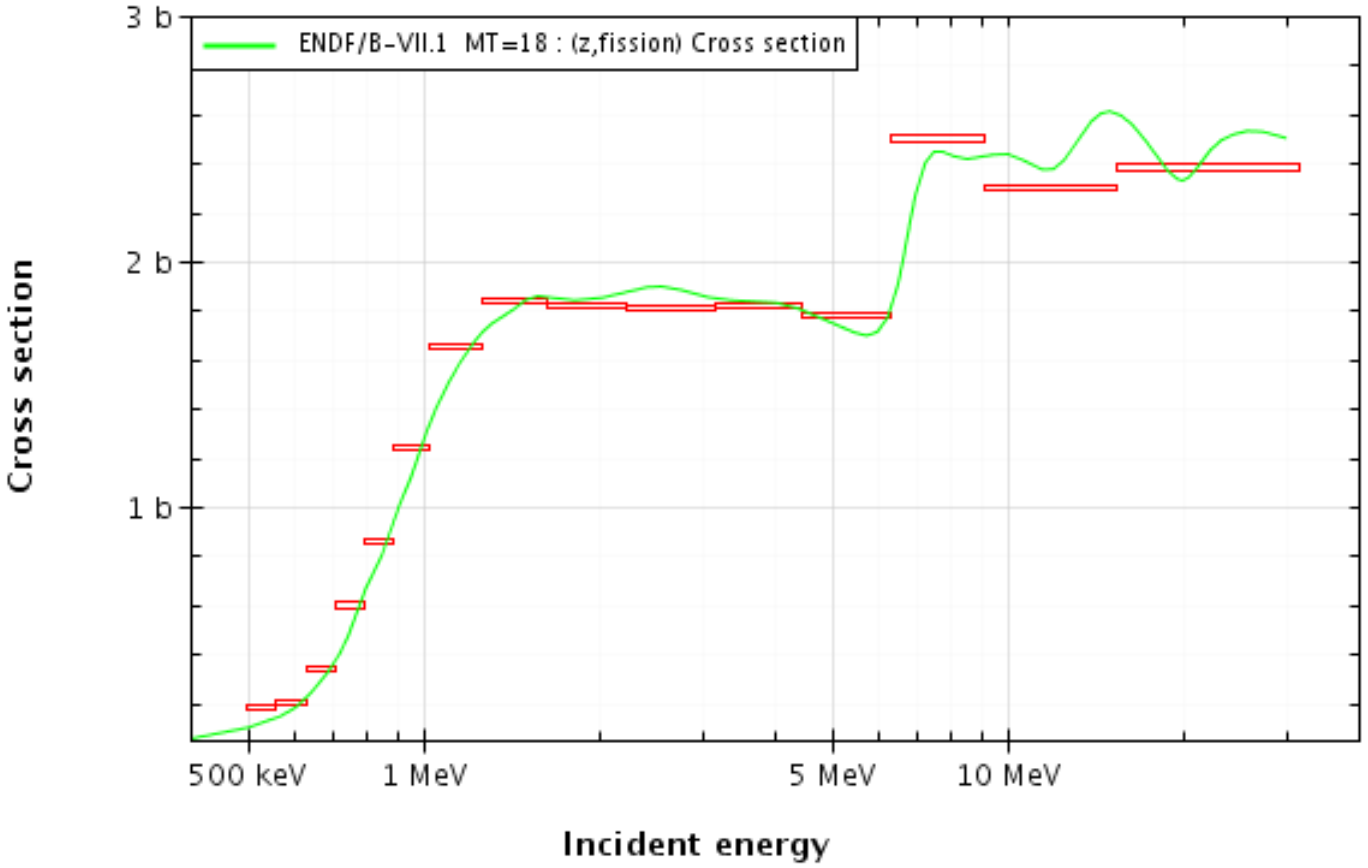
Previous n_TOF measurement

- Low statistics at and above fission threshold
- Variable bin width chosen to keep statistical uncertainty <2%



F. Belloni et al., Eur. Phys. J. A (2013) 49: 2, 10.1140/epja/i2013-13002-3

The new proposal

- Perform the measurement in EAR-2
  - Maximization of the flux with the large collimator
  - Lower activity per sample
  - Stronger background suppression
  - → Higher statistics in wide energy range

Experimental setup

Samples – Detectors and electronics

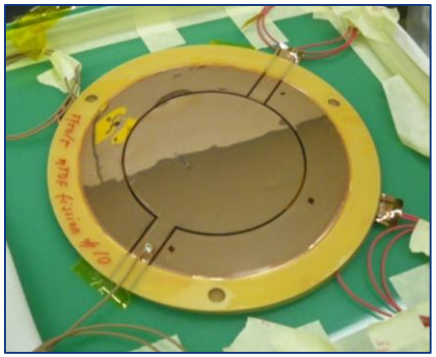
Samples

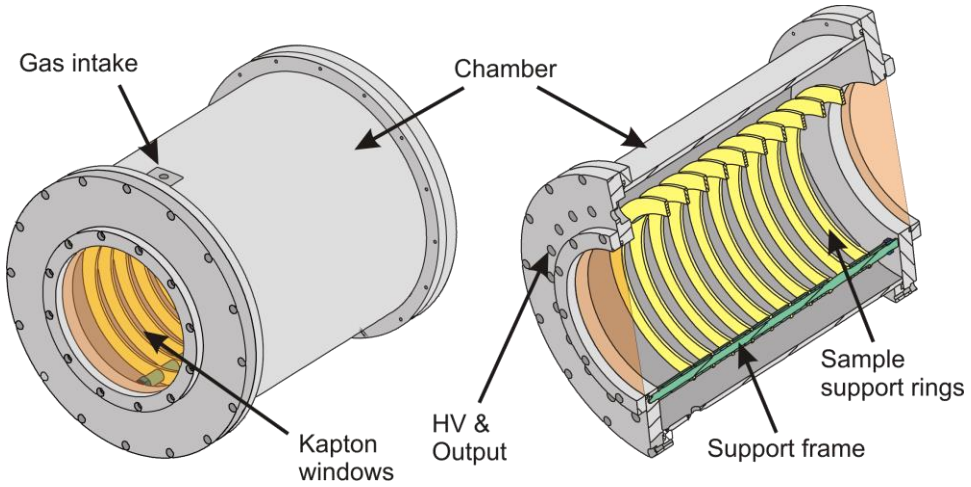
- To be prepared at JRC-IRMM
- Proposed sample characteristics
  - Low mass/activity per sample (~half of EAR-1)
  - 6cm diameter for large EAR-2 collimator
- Total mass ~2.5 times lower than EAR-1 measurement
- A further ~30% reduction of the activity could be achieved by reducing the diameter to 5cm, with small loss of flux, depending on the beam profile (to be checked)
- Exact information (e.g. ^{242m,243}Am) on impurities not yet available
- Reference samples:
  - ^{235,238}U, ^{10}B

Sample characteristics	
Area density (µg/cm²)	5
Diameter (cm)	6
Activity (MBq)	17.9
Mass (mg)	0.14
No. of samples	6
Total mass (mg)	0.85
Total activity (MBq)	107.7

Experimental setup

- Based on Micromegas microbulk detectors
- Existing chamber houses up to 10 sample-detector modules
  - Filled with circulating Ar:CF_4:isoC_4H_{10} mixture (88:10:2) at 1 bar





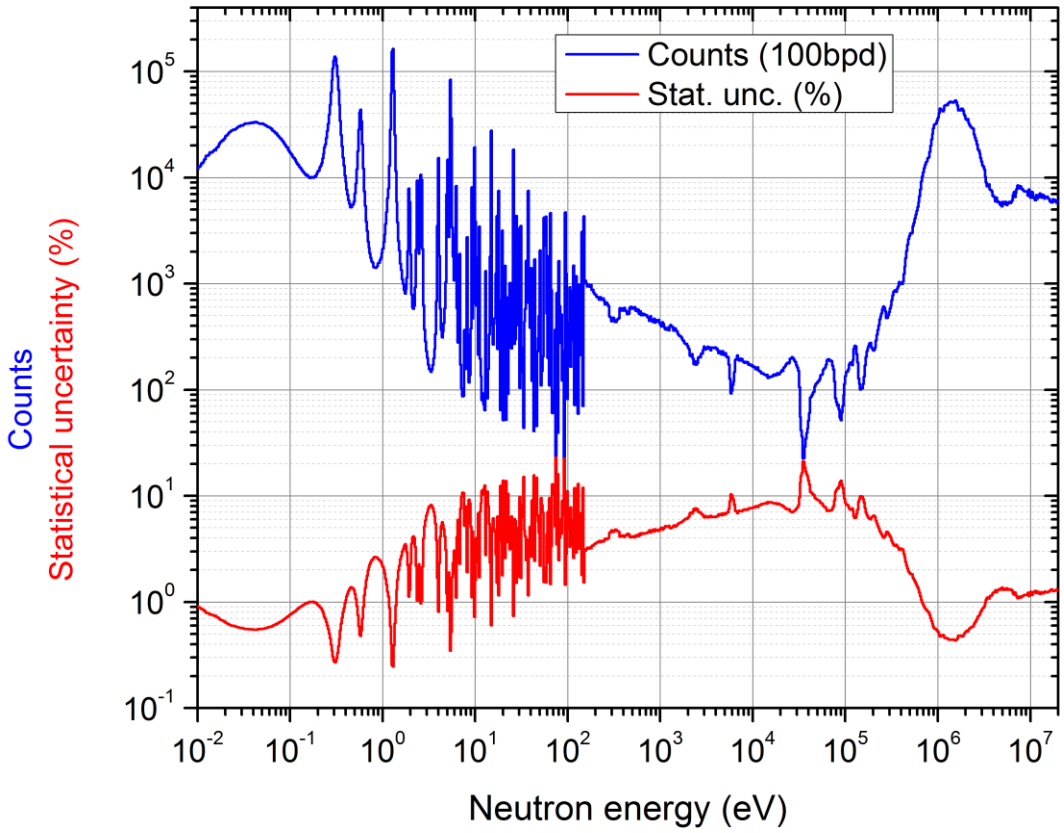
- Various improvements based on past experience
  - Electronics
    - Preamplifier modules with one channel each (no cross-talk)
    - Compact, shielded modules (better response to γ-flash)
  - Drift gap reduction (faster signal)

Beam request

Expected count rates and beam request

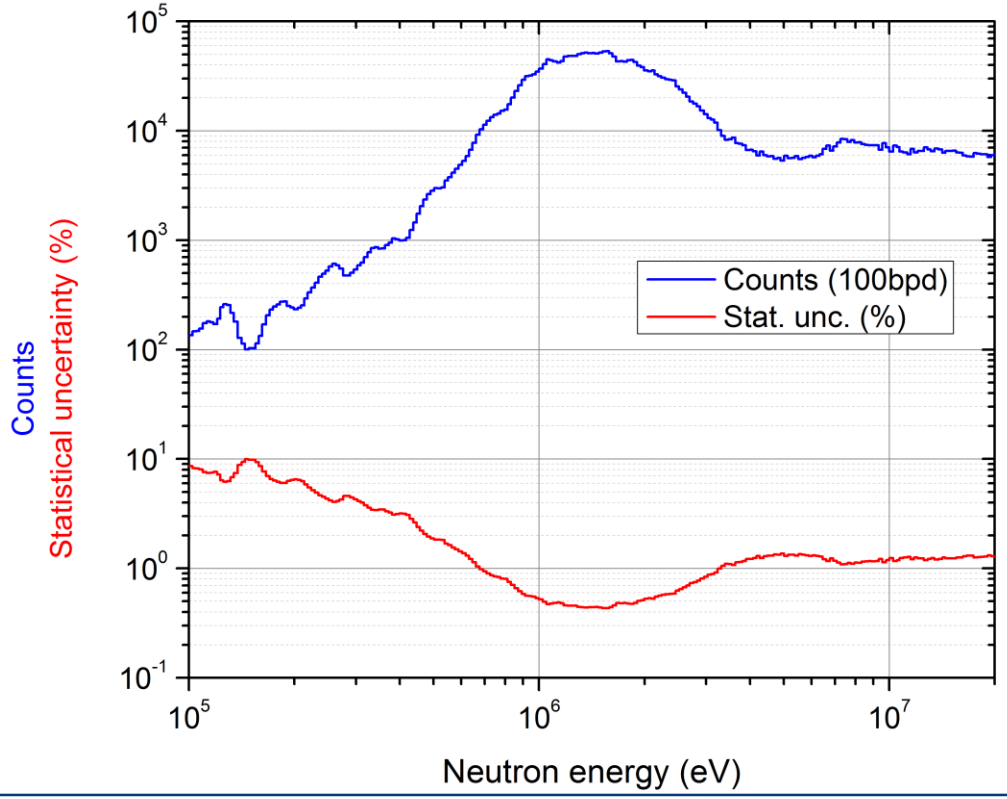
Beam request

- **We request 3x10^{18} p.o.t. in EAR-2 with the large collimator**
- Continuous data can be obtained almost in the entire energy range <100keV, with certain exceptions in the RRR



Beam request

- **We request 3x10^{18} p.o.t. in EAR-2 with the large collimator**
- Statistical uncertainty <2% above 500keV at 100 bpd, <10% above 100keV
  - Very significant improvement in statistics compared to EAR-1



Summary

- The fission cross-section of ^{241}Am remains in the NEA High Priority Request List; it is important for waste transmutation and recycling applications
- Existing data do not meet the accuracy requirements for the design of future nuclear systems
- A significant improvement upon the previous n_TOF data can be achieved by exploiting the features of EAR-2
- Accurate data can be provided in a wide energy range
- We request **3x10^{18} p.o.t.** in **EAR-2** with the **large collimator**



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nTOF

EAR-1 & EAR-2 comparison

- Increased flux
- Stronger background suppression

Example: same ^{240}Pu sample (6.5MBq) in both areas