^{242,240,238}Pu fission cross sections with the EPIC setup

SESSION : Setups for Cross sections

^{242,240,238}Pu fission cross sections with the EPIC setup

[EPIC] Even Plutonium Isotopes fission Cross-section measurement

CEA A. Chatillon, B. Mauss, J. Taïeb *et al.*

JRC-Geel A. Plompen, D. Vanleeuw *et al.*

LANL M. Devlin, K. Kelly

LLNL A. Tonchev

APRENDE

ΣVEN PLUTONIUM ISOTOPES FISSION CROSS SΣCTION

P(ND)²-3 : Perspectives on Nuclear Data for the Next Decade

SESSION : Setups for Cross sections

1. The EPIC project

- Why?
- Which setup?

2. Feasibility studies

- In beam test at LANSCE
- In beam test at GELINA

3. Conclusions

- Milestones

1. EPIC

1) nuclear data need
2) experimental set-up

Why measuring ^{even}Pu fission cross section

Nuclear data need for fast reactors

- Fast reactor performance strongly driven by Pu nuclear data uncertainties
- ^{242,240,238}Pu: role in Pu-based fuels (MOX and **multi-recycling scenarii**)
- But, significant uncertainties in neutron-induced fission cross section
- New high-precision measurements are required (cf. HPRL)

https://www.oecd-nea.org/jcms/pl_68746/

NEA Nuclear Data High Priority Request List - HPRL

The NEA Nuclear Data High Priority Request List (HPRL) is a compilation of the most important nuclear data requests that have been rigorously reviewed by the NEA Working Party on International Nuclear Data Evaluation Co-operation (WPEC) .

ID	Type	Target	Reaction (n,f)	Quantity SIG	Energy Min	Energy Max	Accuracy (%)
39	H	94-Pu-242	(n,f)	SIG	200 keV	20 MeV	4-15
37	H	94-Pu-240	(n,f)	SIG	0.5 keV	5 MeV	2-13
19	H	94-Pu-238	(n,f)	SIG	9 keV	6 MeV	3-24

Why measuring ^{even}Pu fission cross section

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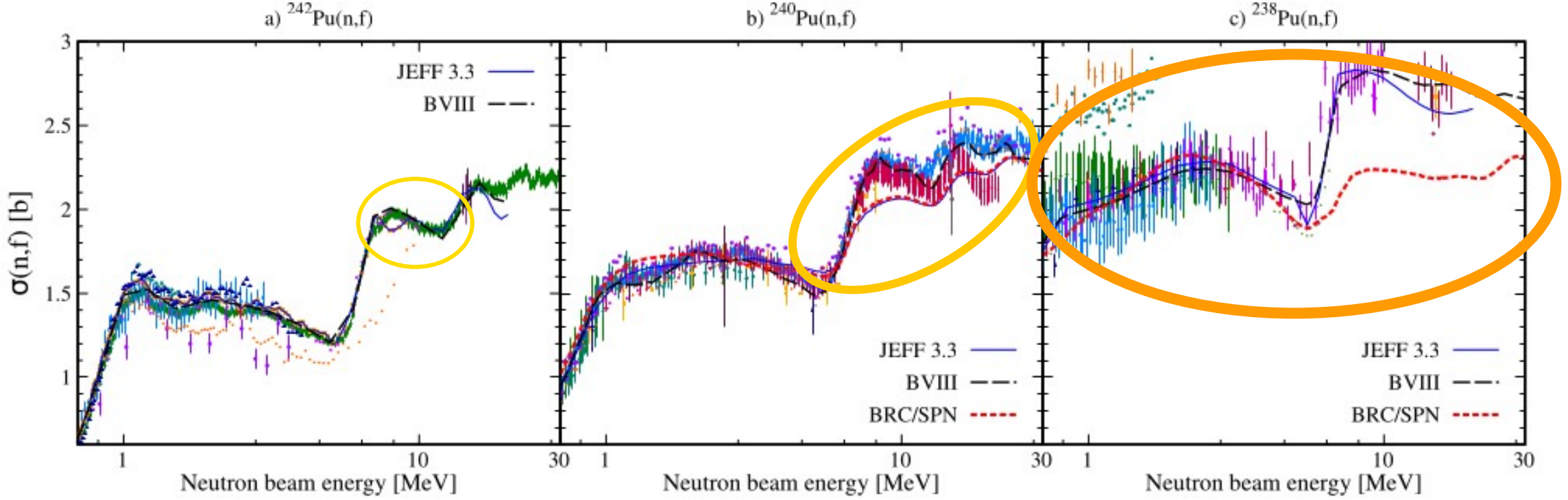
GOAL: provide new data at [1:25] MeV, with 3% accuracy

GOAL: ^{even}Pu(n,f) cross section relative to ^{235}U(n,f)

For neutron beam energy from 1 MeV up to 20 MeV, with 3% uncertainty

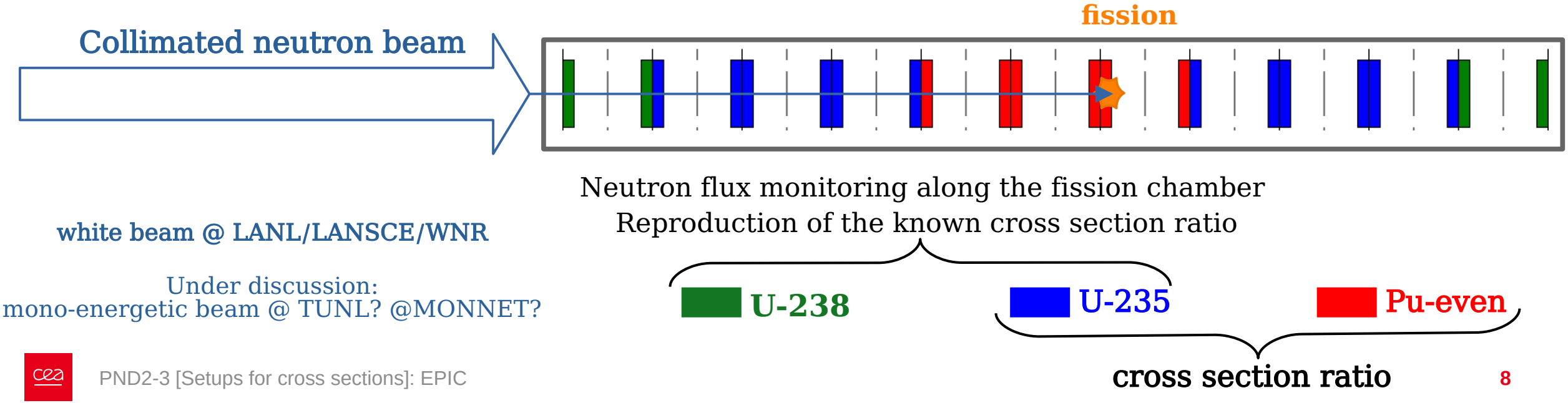
- Comparison data sets / evaluations
- ^{238}Pu: very difficult case due to high alpha activity ($T_{1/2}$=82.5y)



METHOD: ^{even}Pu(n,f) cross section relative to ^{235}U(n,f)

For neutron beam energy from 1 MeV up to 20 MeV, with 3% uncertainty

- Experimental set-up: **multi-body fission chamber** in a collimated neutron beam
- Ratio ^{even}Pu/^{235}U: modulo fission anisotropy, all sources of efficiency loss are the same
  no need to have an absolute measurement of the neutron flux

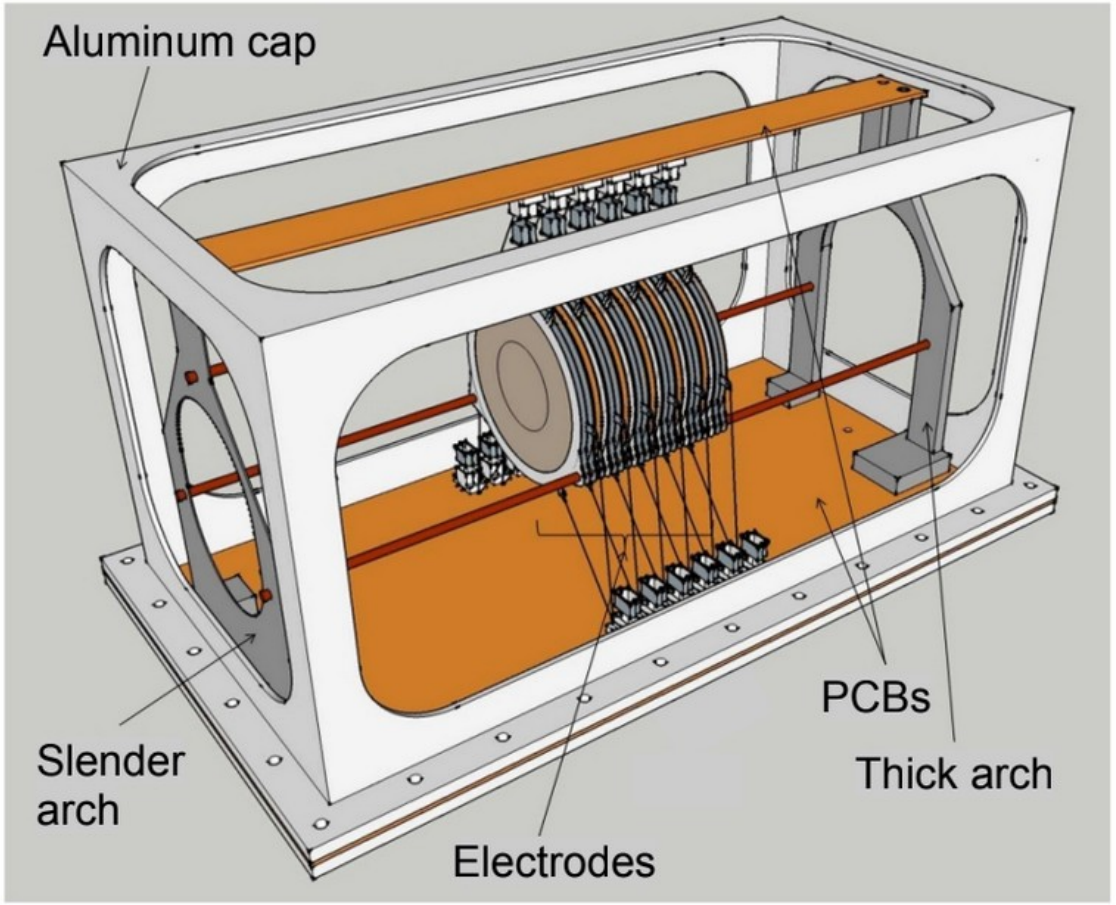


white beam @ LANL/LANSCE/WNR

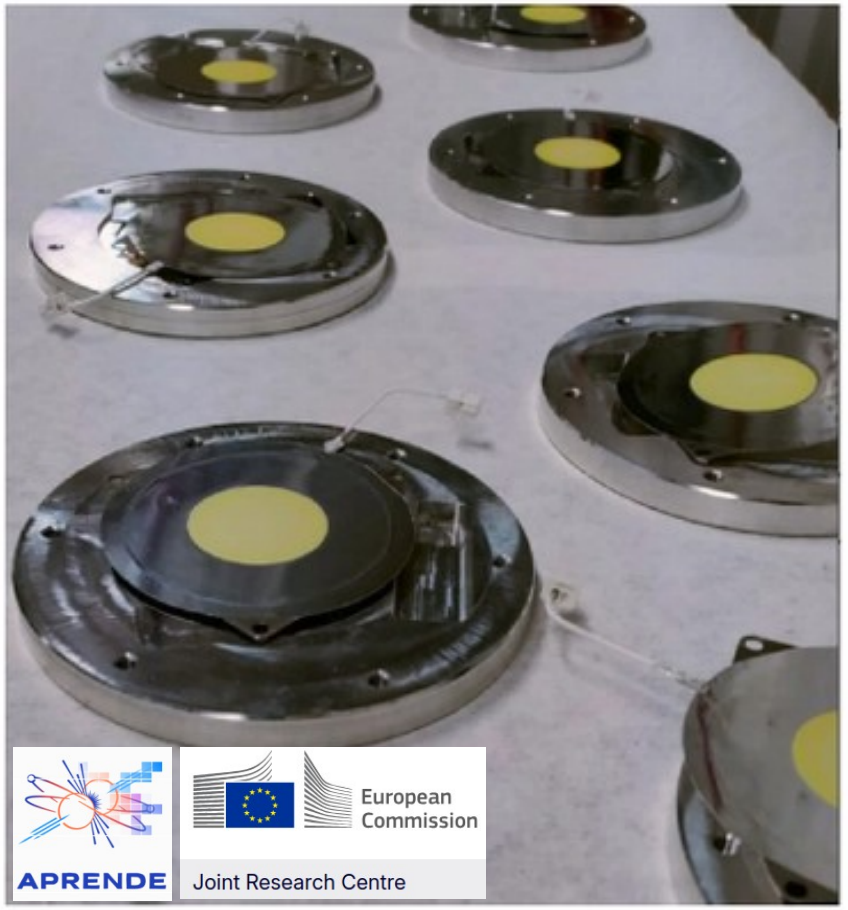
Under discussion:
mono-energetic beam @ TUNL? @MONNET?

The fission chamber

Scheme of the fission chamber

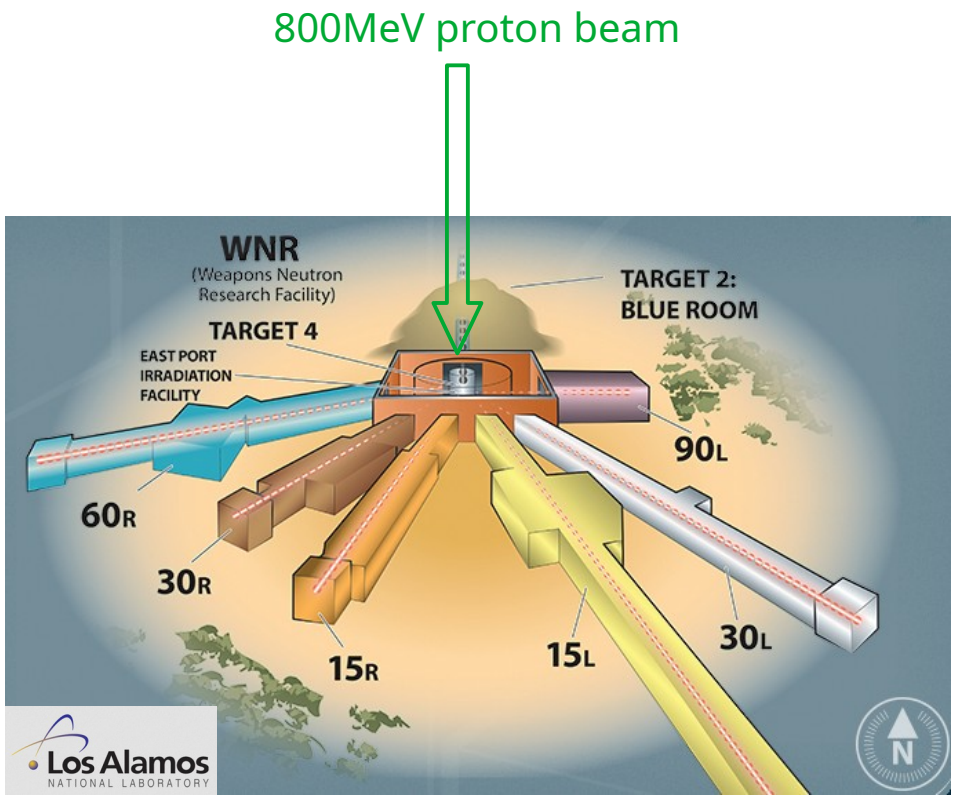


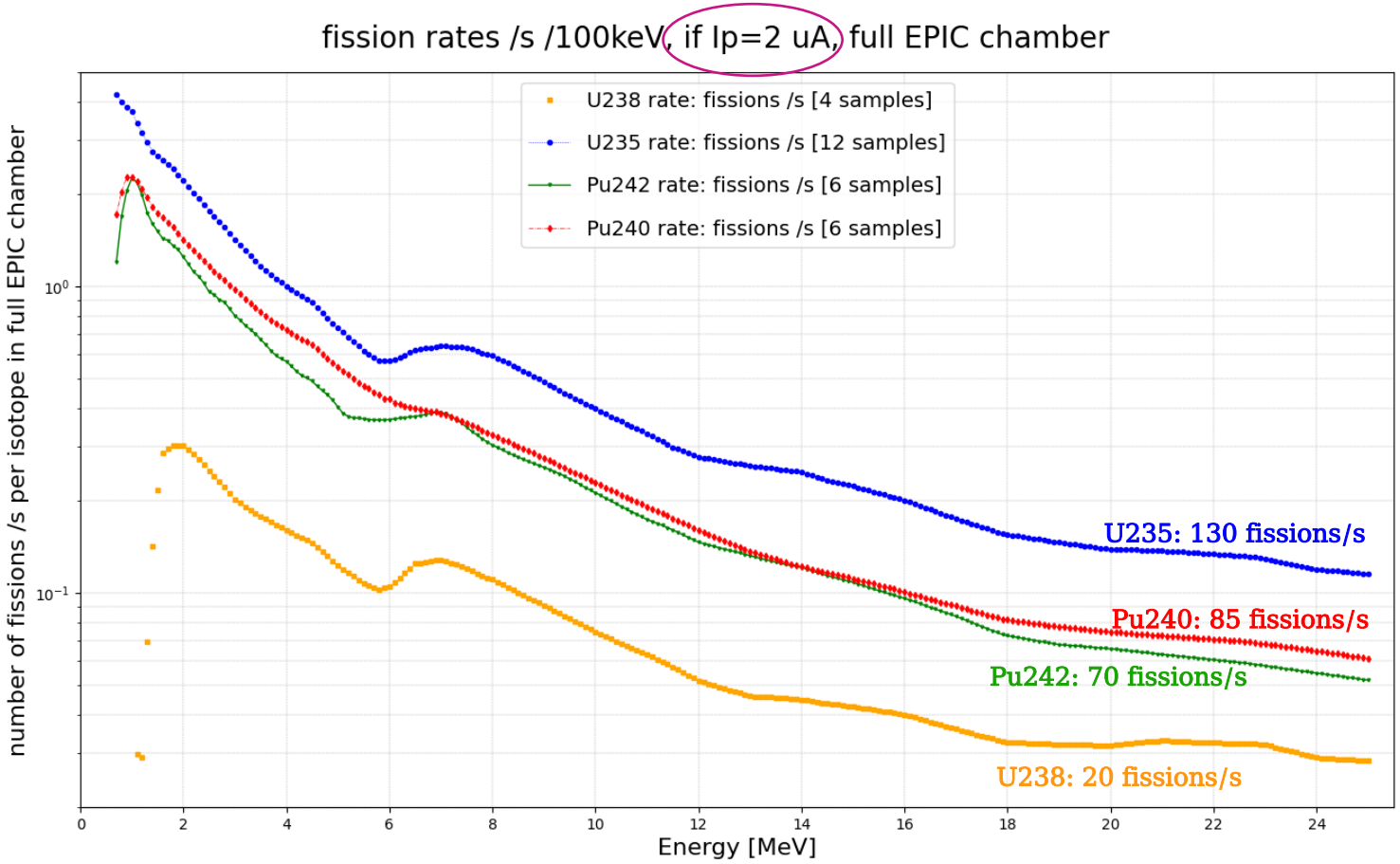
Samples are produced at [JRC-Geel]



The neutron beam at WNR / T4 / FP15L

WNR facility : neutron produced by spallation from 800MeV-p on W target





Full energy range in one single experiment

DIFFICULTY: accuracy

For neutron beam energy from 700 keV up to 25 MeV, with 3% uncertainty

- Need to fully master (and maximize) **the efficiency of the chamber**
  - **alpha / fission discrimination** : alpha-decay and (n,α) reactions
  - **thin 50 µg/cm^2 actnide targets**: to recover all fragments stopped in thicker targets
    to minimize the energy loss of FF versus alpha pile-up
    operation at higher pressure
  - new electronics

- Need of **high statistics** per bin, at least 10^4 per bin of neutron energy
  - Measurement foreseen with the white spallation neutron beam at LANSCE / WNR
    3 weeks measurement for ^{242}Pu and ^{240}Pu cases for 100 keV bin
  - ^{242}Pu experiment accepted, will be scheduled in 2026

2. Feasibility study

1) starting point: fission chamber for PFNS
2) first in-beam test at LANSCE in Nov. 2025
3) second in-beam test at GELINA in Jun. 2026

Fission chamber for PFNS ^{239}Pu(n,f)

Alpha / fission discrimination capability for 10 MBq / anode

- P. Marini et al., PRC 101, 044614 (2020)
- Fission chamber efficiency ~ 95%
- Maximum activity : 10 MBq / anode

  → targets produced at JRC Geel
  → start with ^{242,240}Pu cases with 50 µg/cm^2
  → on-going development for 2µg/cm^2 ^{238}Pu

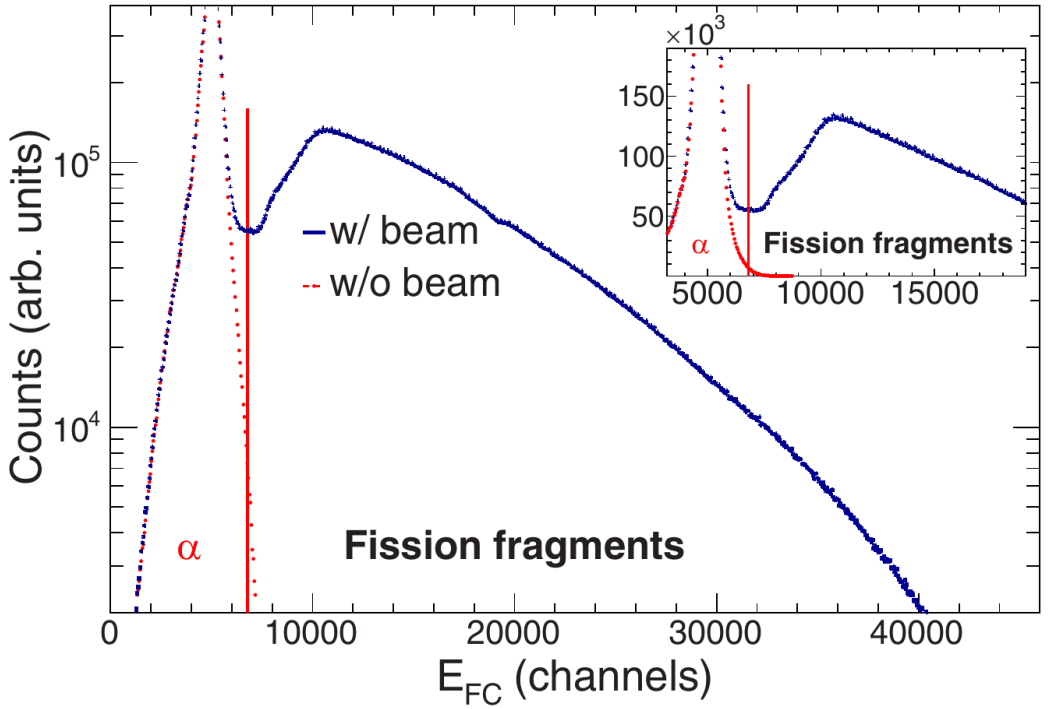


FIG. 4. Pulse height spectra of ^{239}Pu fission chamber obtained with (blue) and without (red) beam. The vertical red line indicates the cut used in the data analysis to separate α particles from fission fragments (see Sec. III A 1).

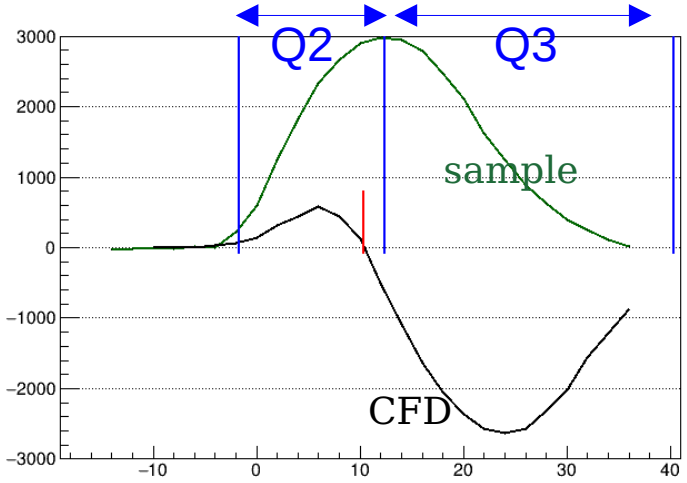
First in-beam test at LANSCE in Nov. 2025

Parasitic mode behind a set-up with a lot of scattered neutrons

- With a **U8/U5** chamber with available thicker samples:
  → **250 µg/cm² samples** in EPIC chamber to sustain high gas pressure
  → limitation to observe influence of gas pressure
  → equipped with former PA generation (stable PA)

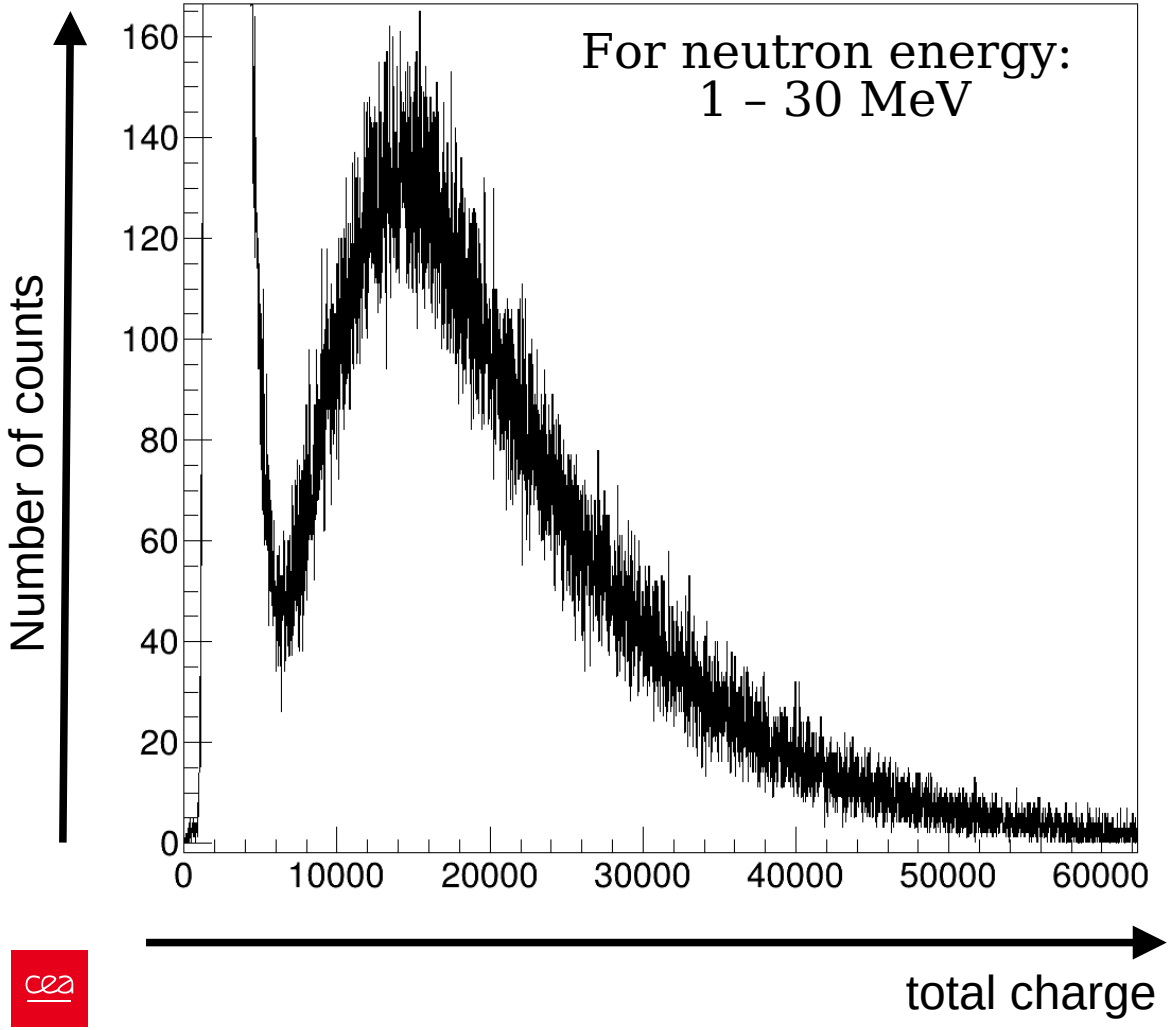
- With a **^{240}Pu** chamber
  → **50 µg/cm² samples** in standard PFNS chamber
  → new PA with high bandwidth
  → encouraging despite instability (5PA max)

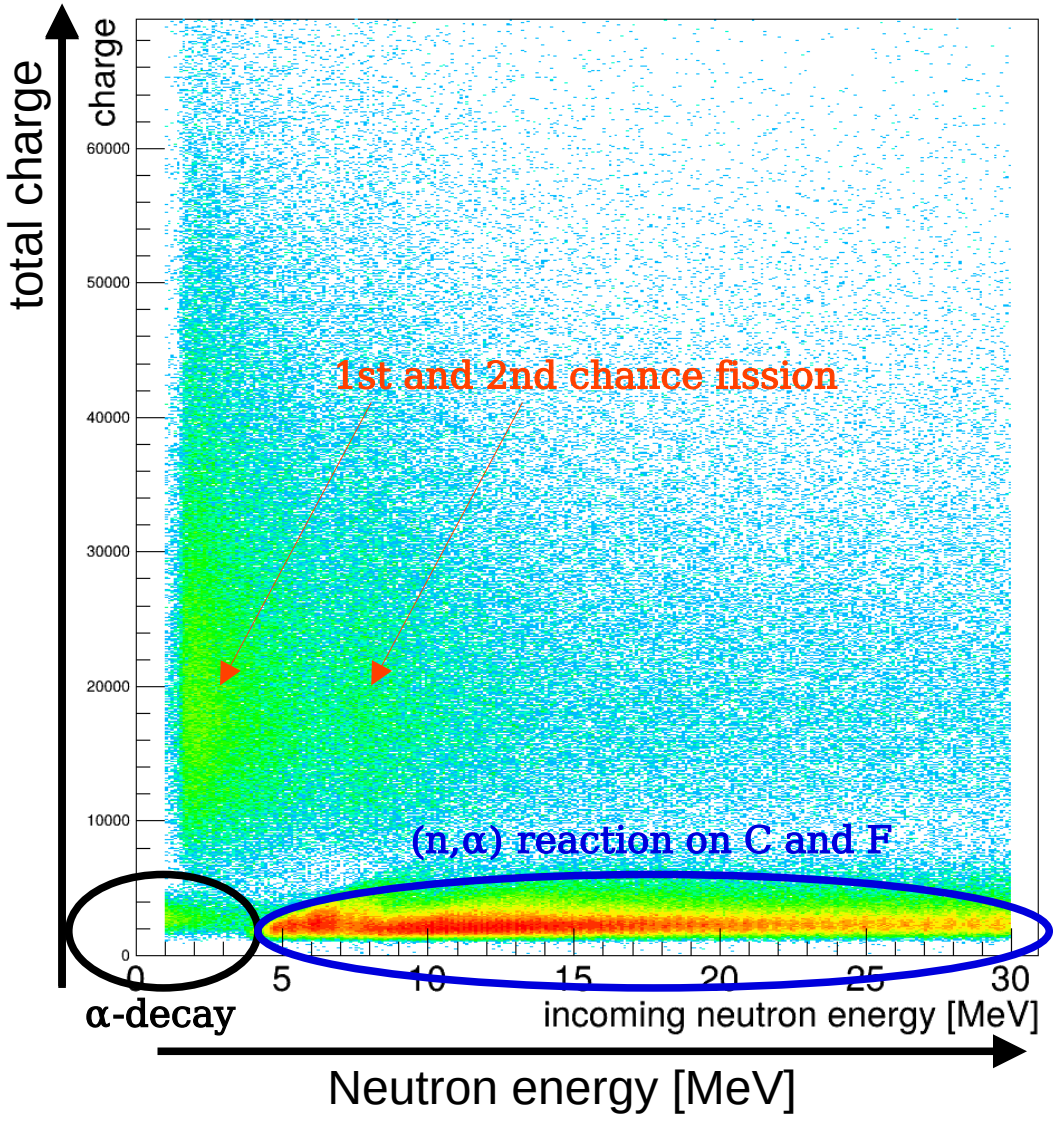
- All signals sampled for PSD (= Q2/Q3 vs Qtot)



α and fission charge spectra (I)

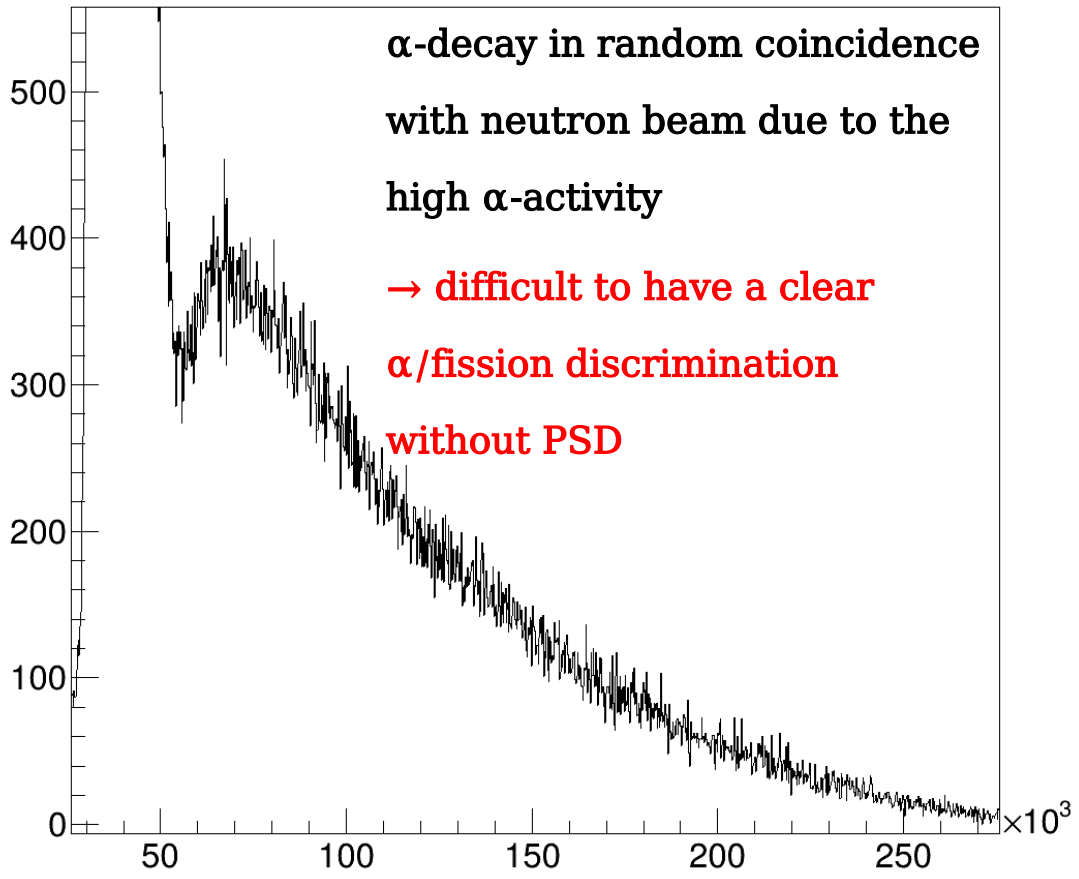
^{238}U easy case, former PA, no need of PSD

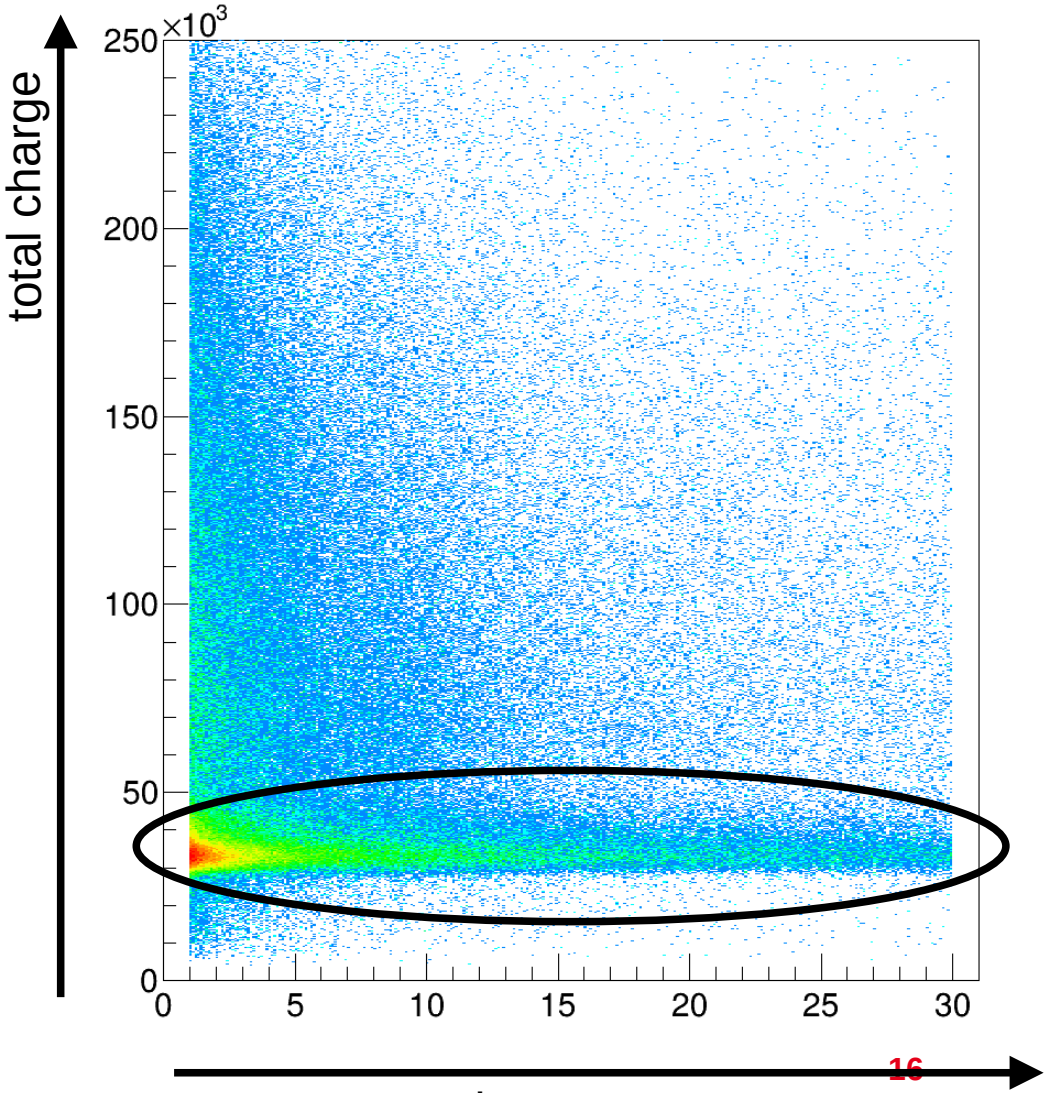




α and fission charge spectra (II)

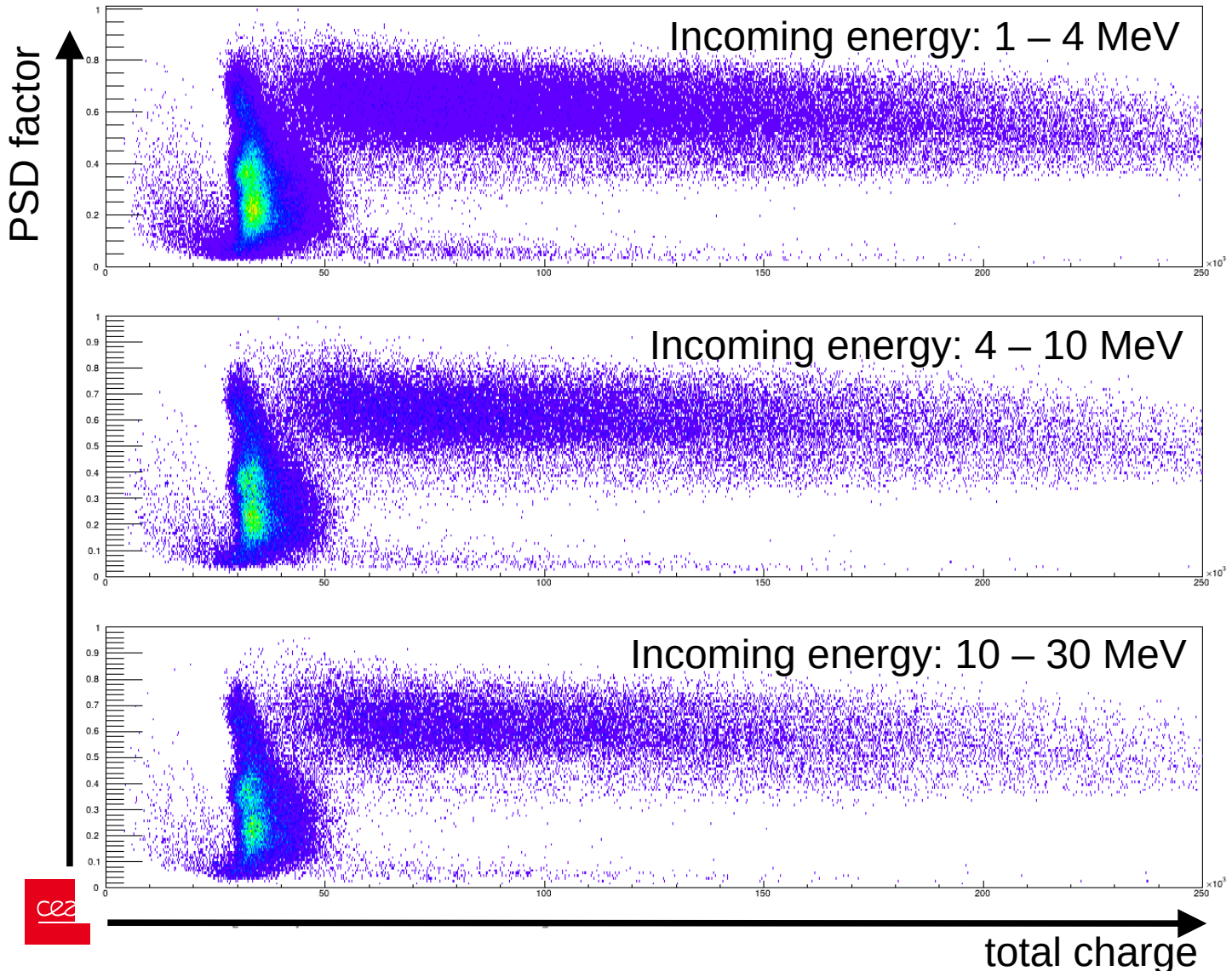
^{240}Pu case @ 10 MBq / channel

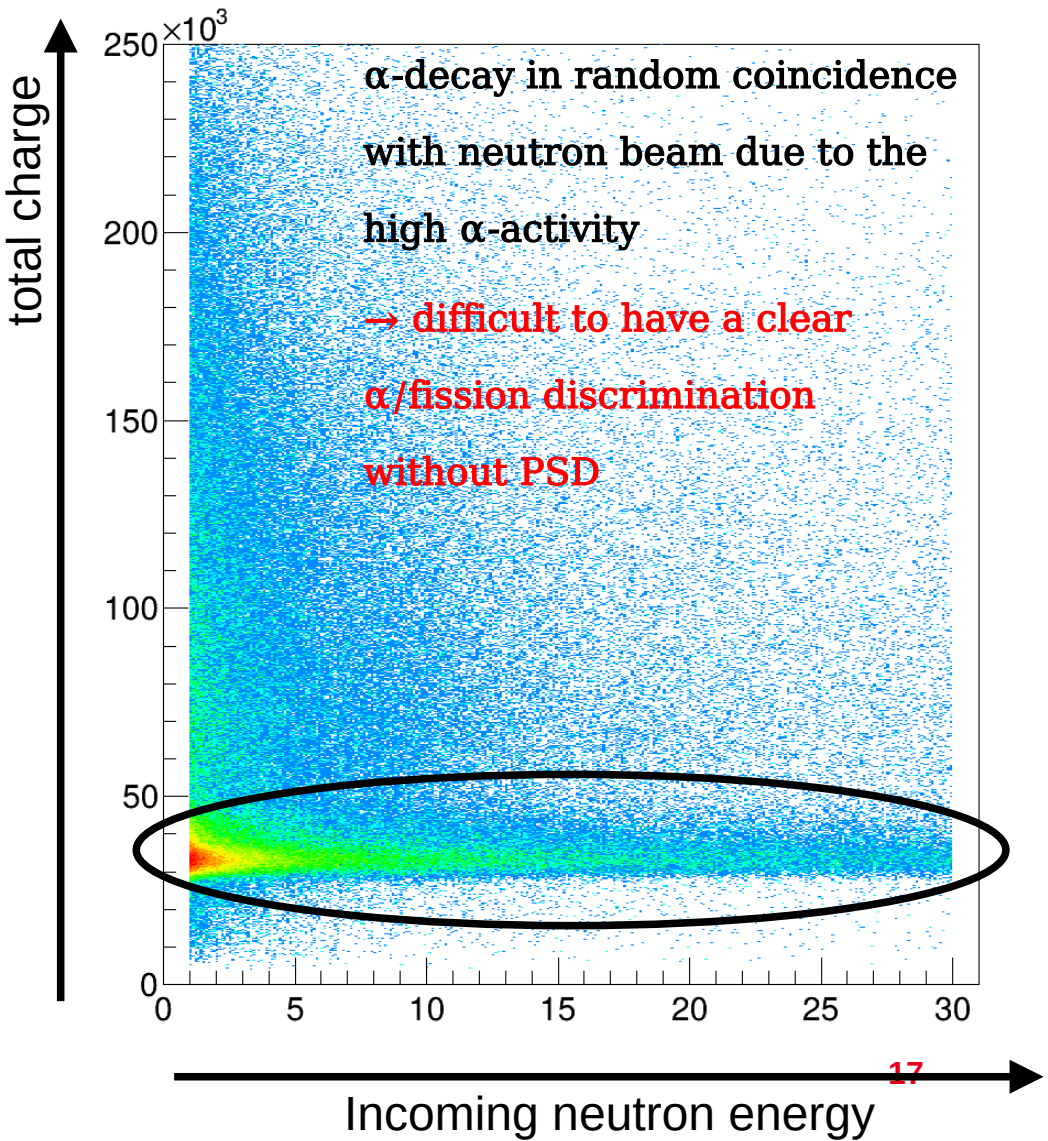




α and fission charge spectra (II)

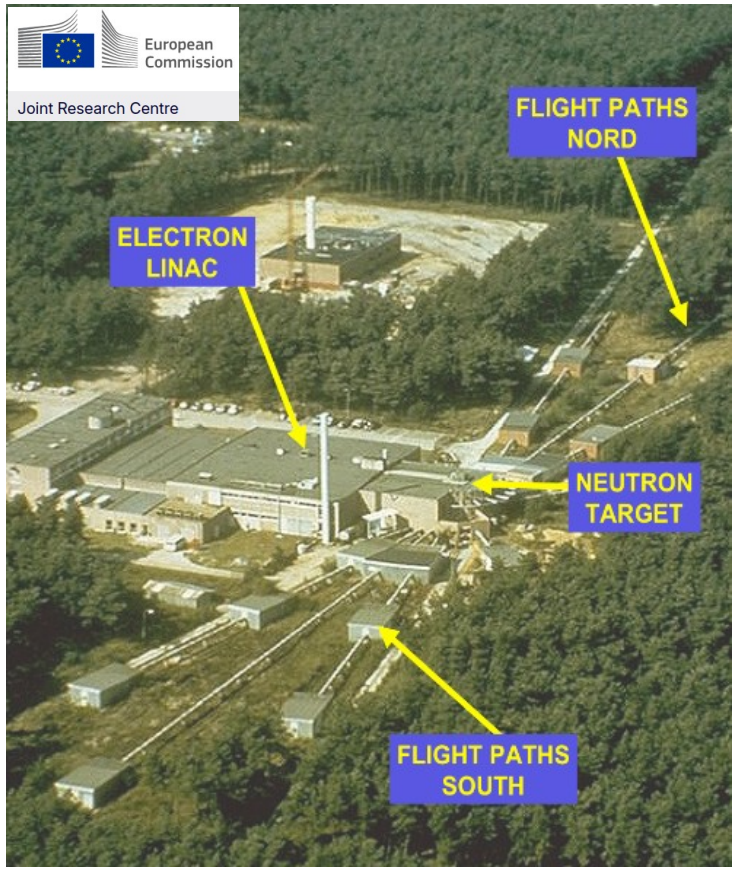
^{240}Pu case @ 10 MBq / channel, PSD analysis with new PA

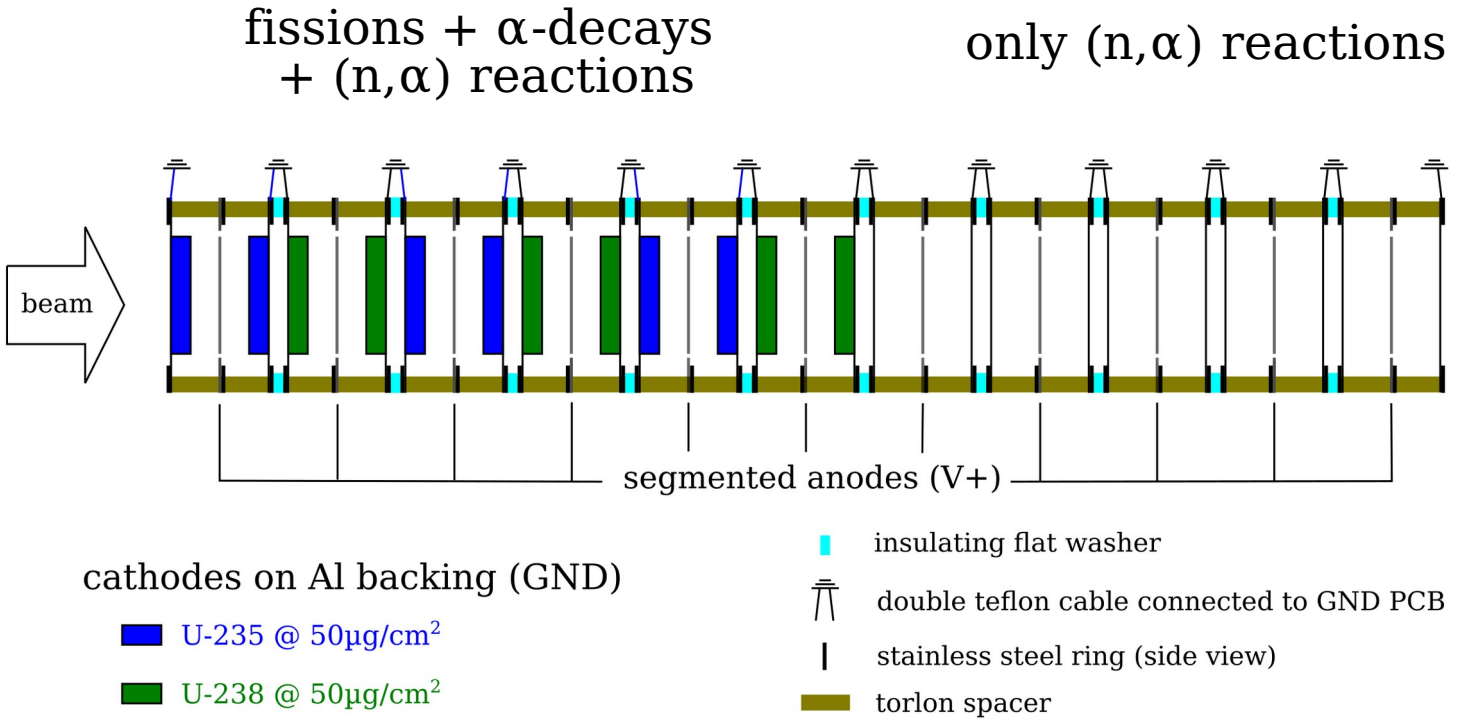




Second in-beam test at GELINA with fast neutrons

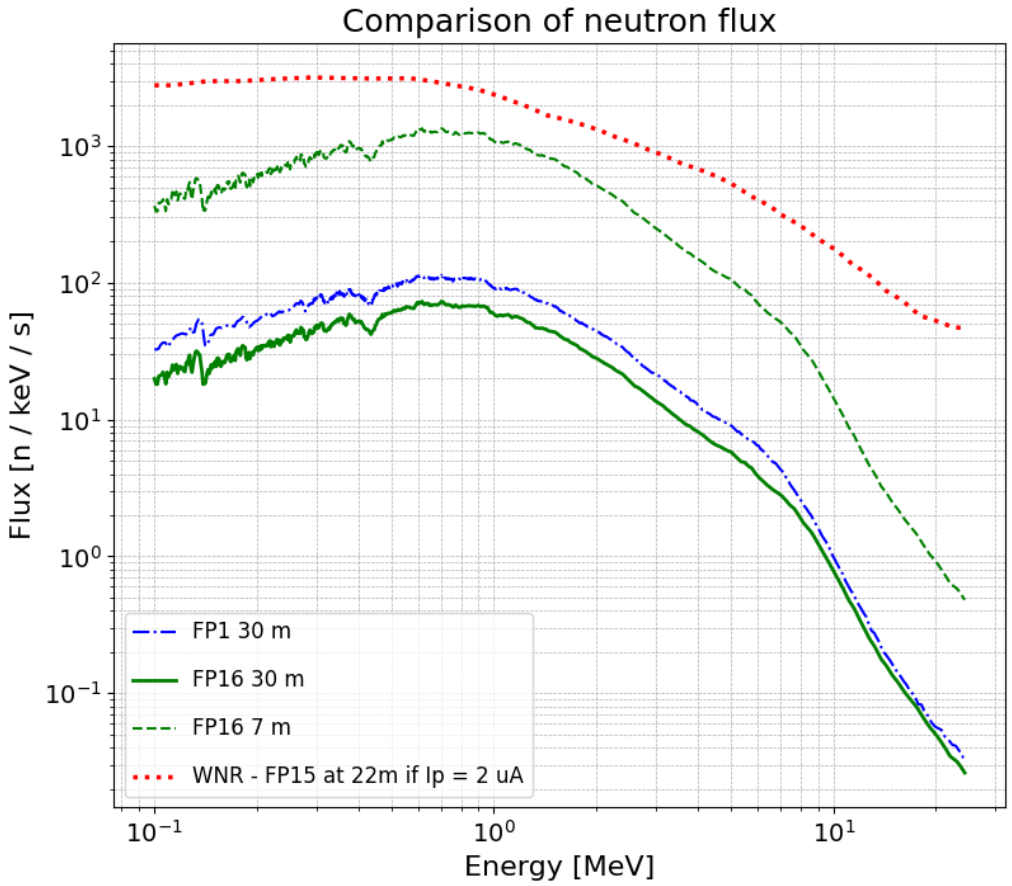
EPIC fission chamber with new PA, thin ^{235,238}U samples at different gas pressures

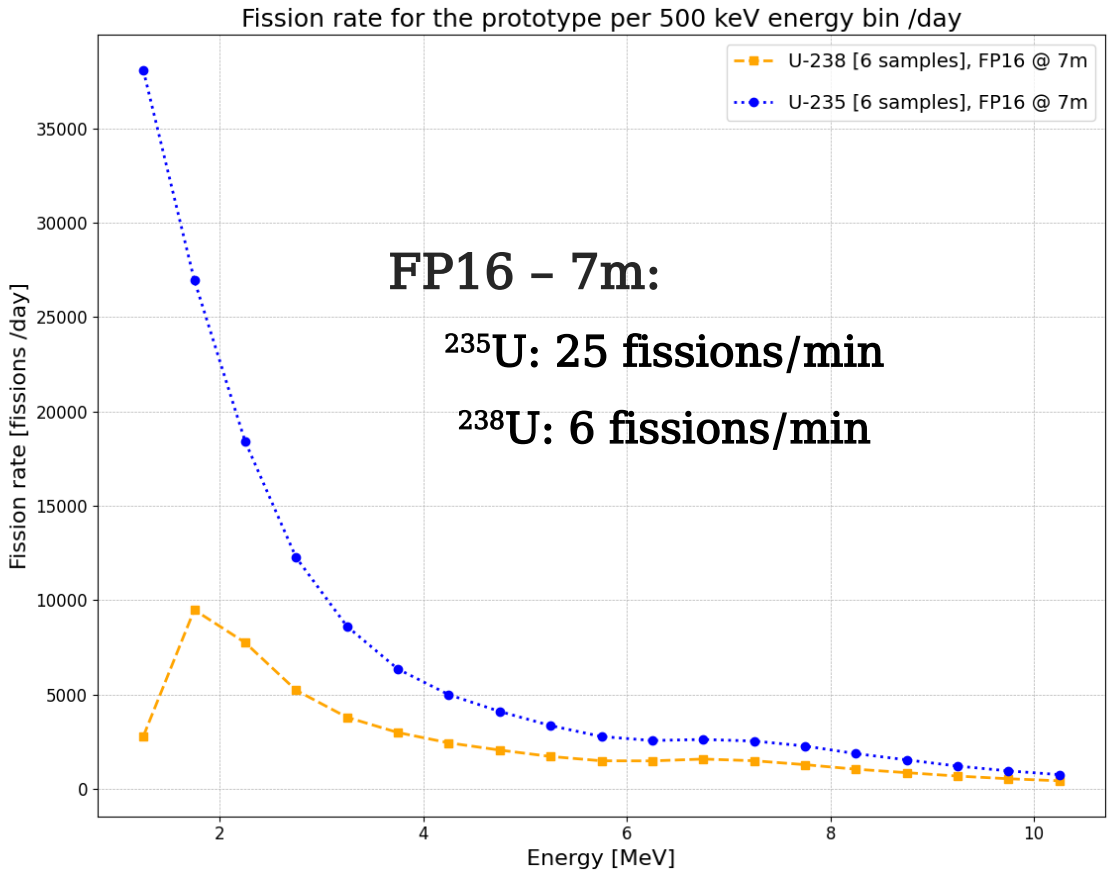




Second in-beam test at GELINA with fast neutrons

On FP16 – 7m (thanks to Maelle *et al.* and the GELINA team)





3. Conclusions

EPIC milestones planning

Possible additional experiments at TUNL/GELINA/MONNET

All ^{235,238}U and ^{242,240}Pu targets are ready at JRC-Geel

- First test in parasitic mode: **in-beam test in 12-16 November 2025 @LANL**
  - Chamber with **^{238}U , ^{235}U @ 250 µg/cm^2** : **new mechanics** and existing thick samples
  - Chamber with **^{240}Pu @ 50 µg/cm^2** samples (thin), and equiped with **new high bandwidth PA**

- First test in parasitic mode: **in-beam test in June 2026 @GELINA**
  - Chamber with **^{238}U , ^{235}U @ 50 µg/cm^2** : **new mechanics, new high bandwidth PA**

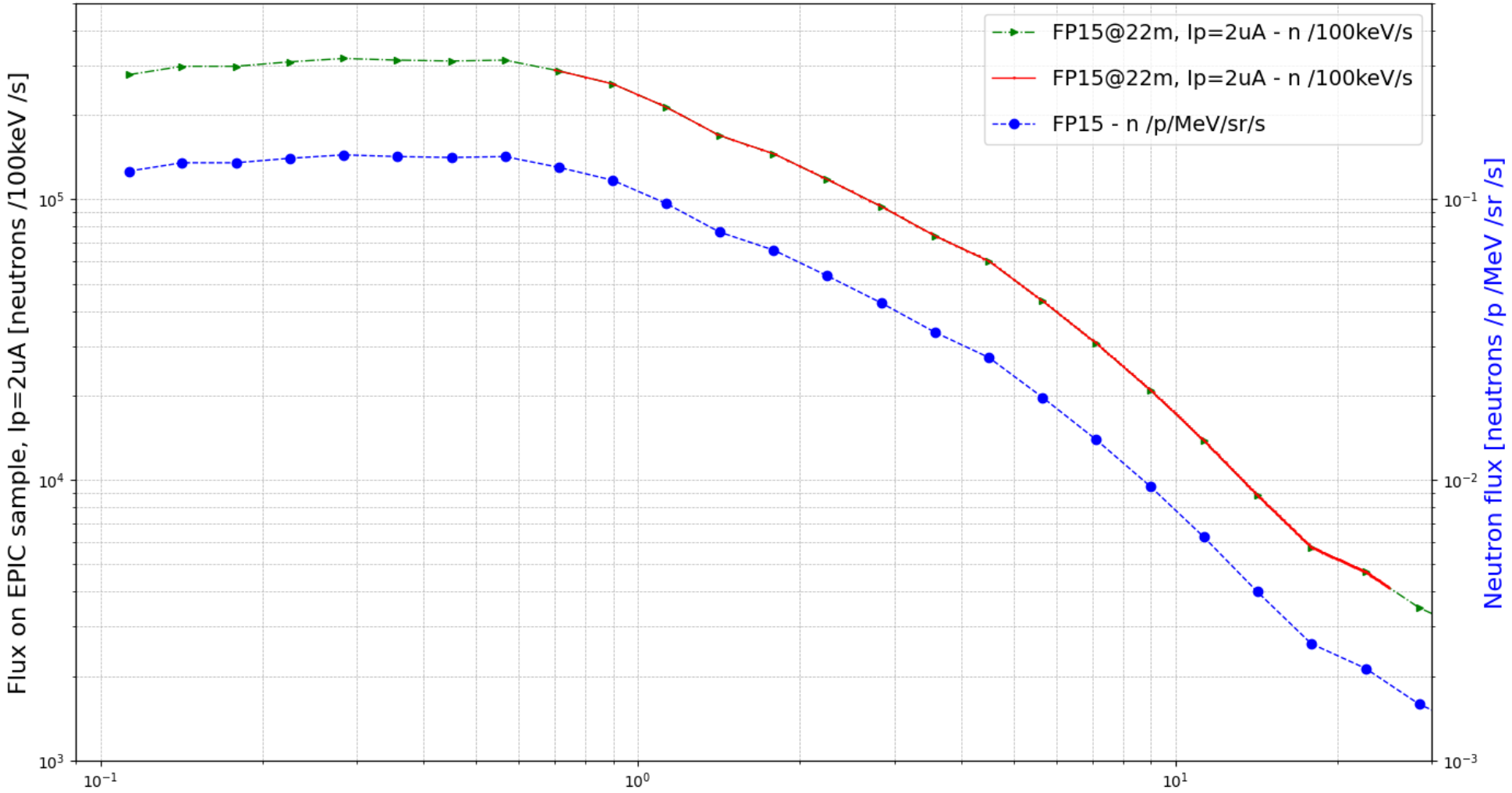
- Start with two ”easier” cases from high priority request list
  - **^{242}Pu**(n,f) / ^{235}U(n,f) : $T_{1/2}$ = 3.75 E5 y [**accepted, experiment in 2026**]
  - **^{240}Pu**(n,f) / ^{235}U(n,f) : $T_{1/2}$ = 6561 y [**targets available, experiment forseen in 2027**]

- GOAL : challenging measurement due to the very high alpha activity
  - **^{238}Pu**(n,f) / ^{235}U(n,f) : $T_{1/2}$ = 82.5 y [**experiment expected in 2028 (?)**]

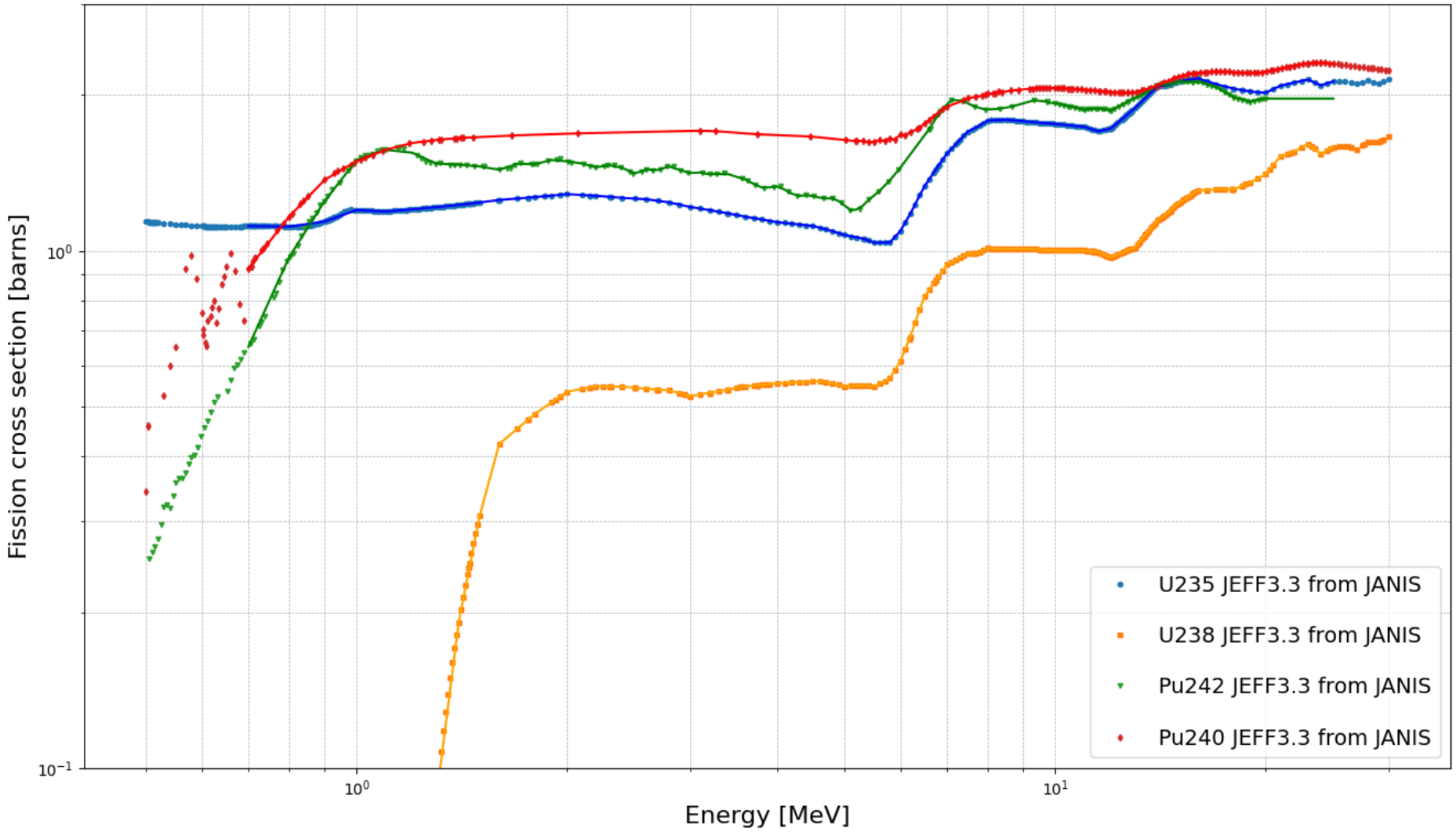
THANK YOU FOR YOUR ATTENTION

4. Spare slides

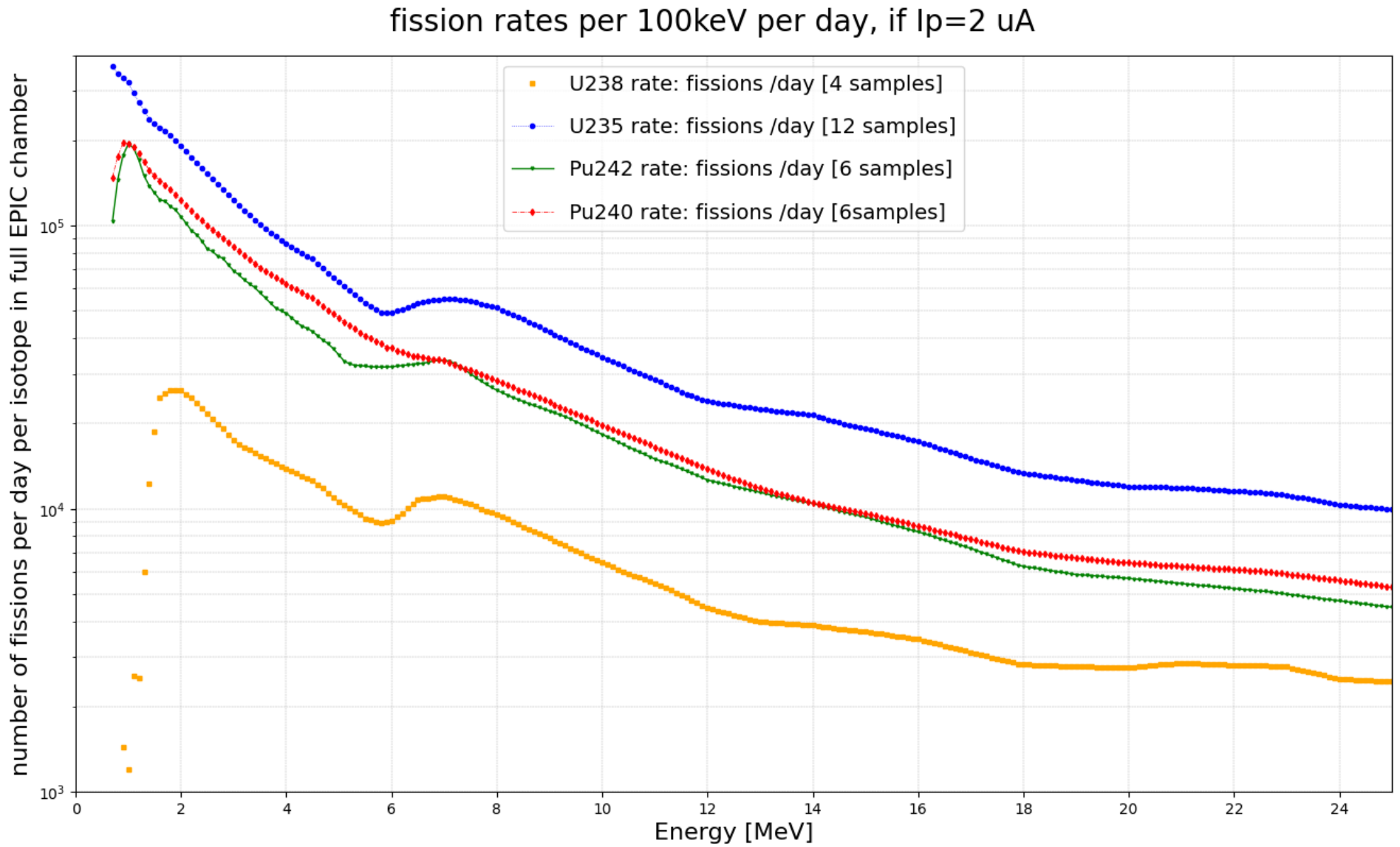
Neutron flux at WNR / T4 / FP15L



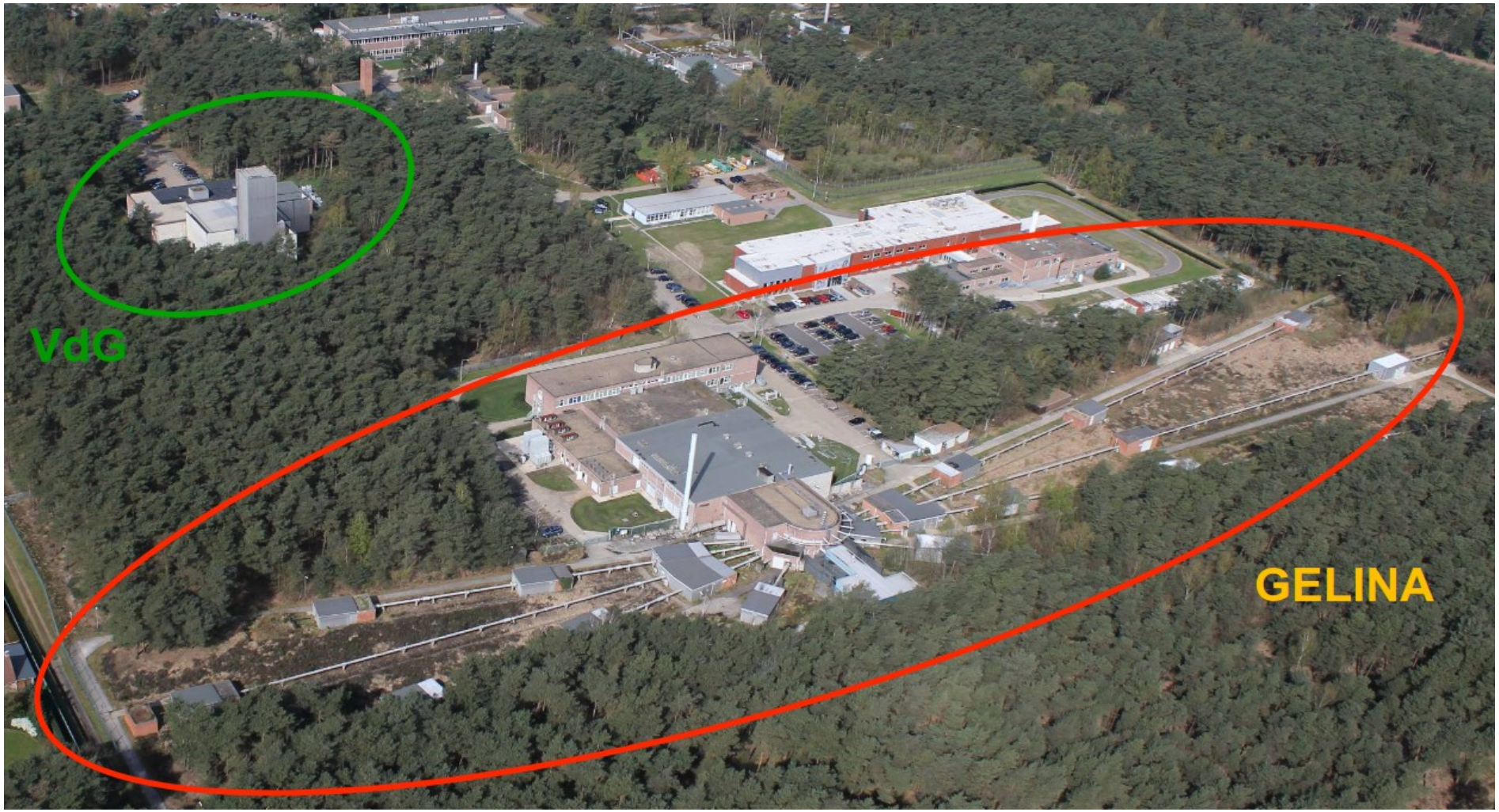
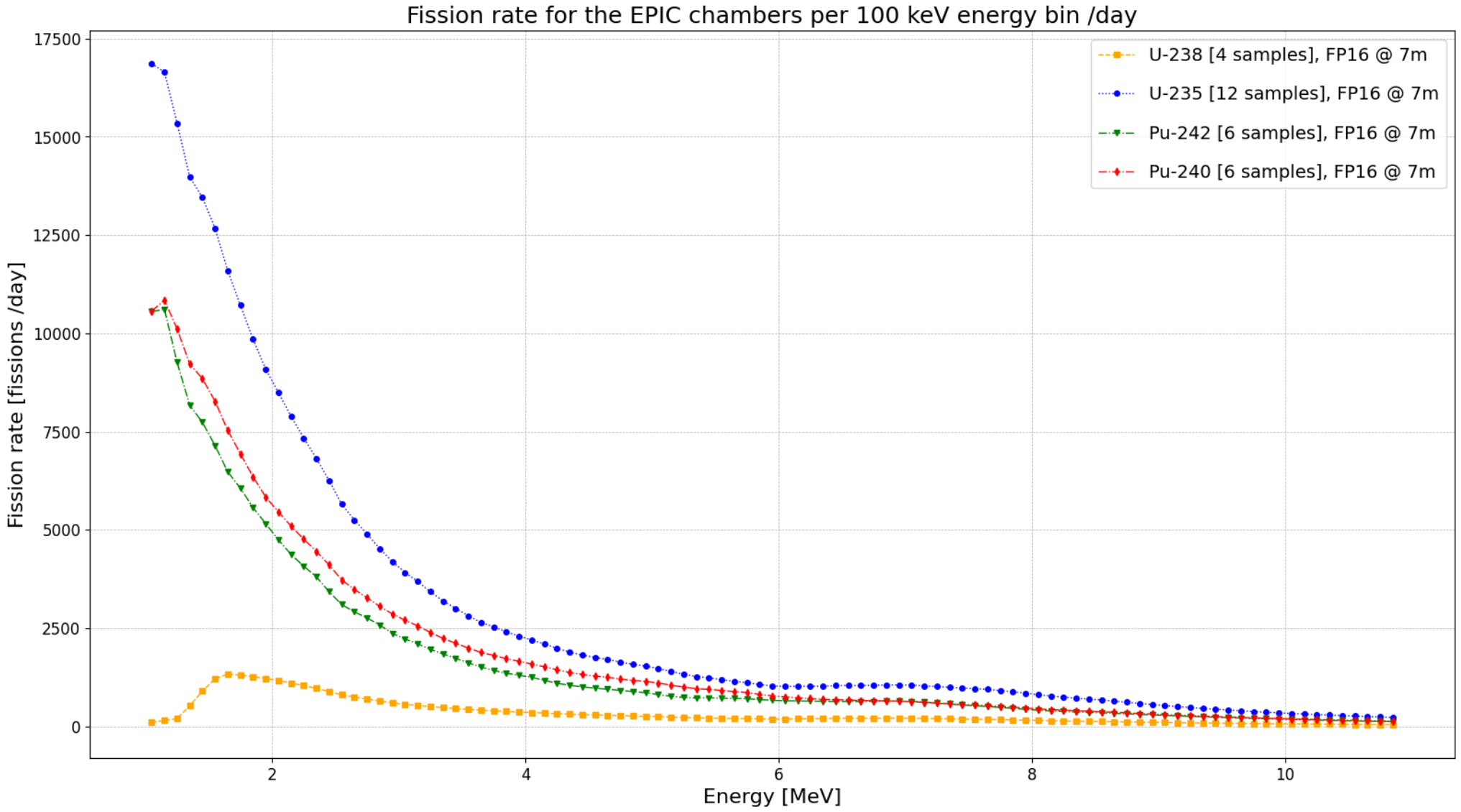
Fission cross sections from JEFF 3.3



Expected statistics per day at WNR / T4 / FP15L



Neutron beams at JRC-Geel



Fission rates @GELINA / fast-n beam line at 7m