

Needs in radioactive targets for fission studies at NFS

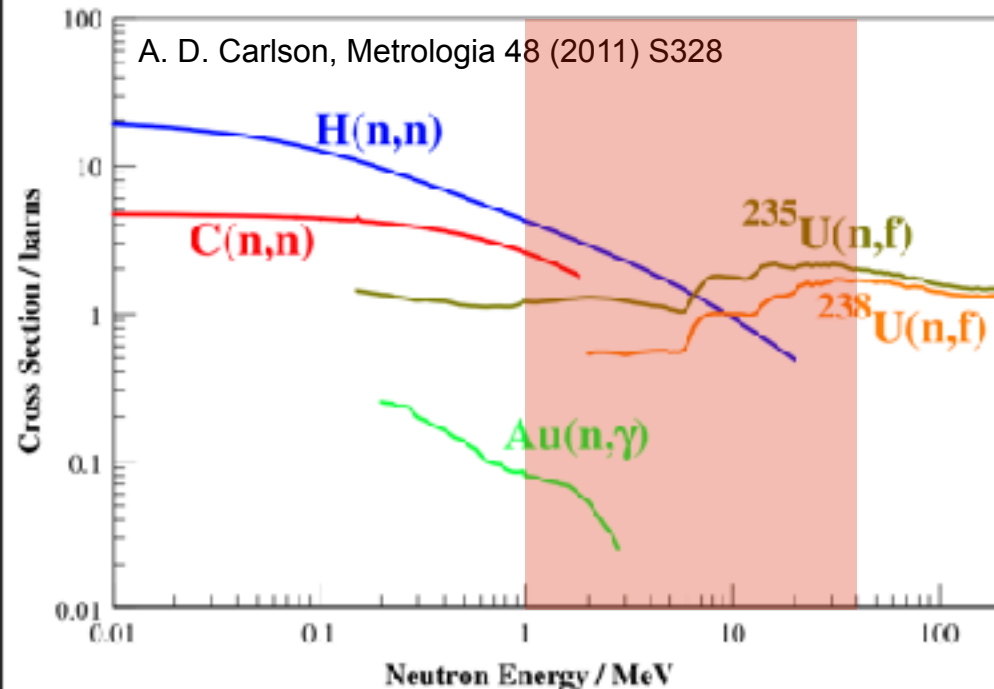
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- **Uppsala University** is active in EU-funded projects **SANDA** and **ARIEL** aimed at **nuclear data measurements, education and development** of new facilities (**GANIL-NFS**).
- Activities were initiated in the CHANDA project, but postponed because of a delay in licensing of the NFS facility.
- We propose to measure, simultaneously, the **neutron-induced fission** of ^{235}U , ^{238}U and the **neutron-proton elastic scattering**, using the white neutron beam at **NFS**.
- Therefore, we need suitable targets of ^{235}U and ^{238}U , deposited on **thin backings**.
 - The specifications of the targets will be discussed later in this talk.
 - Let me explain you the idea first...

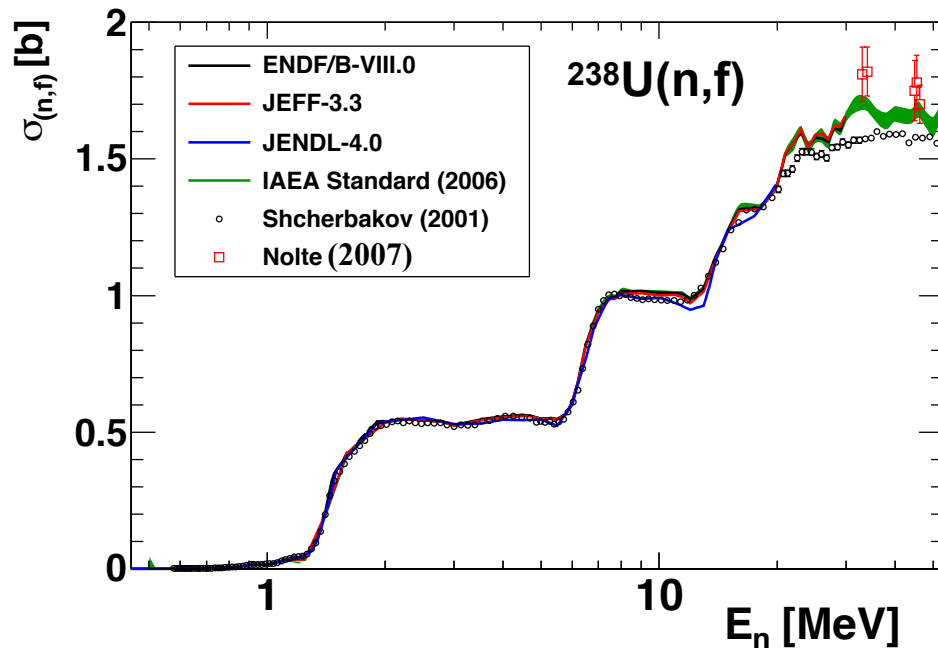
Improving neutron standards



NFS energy range

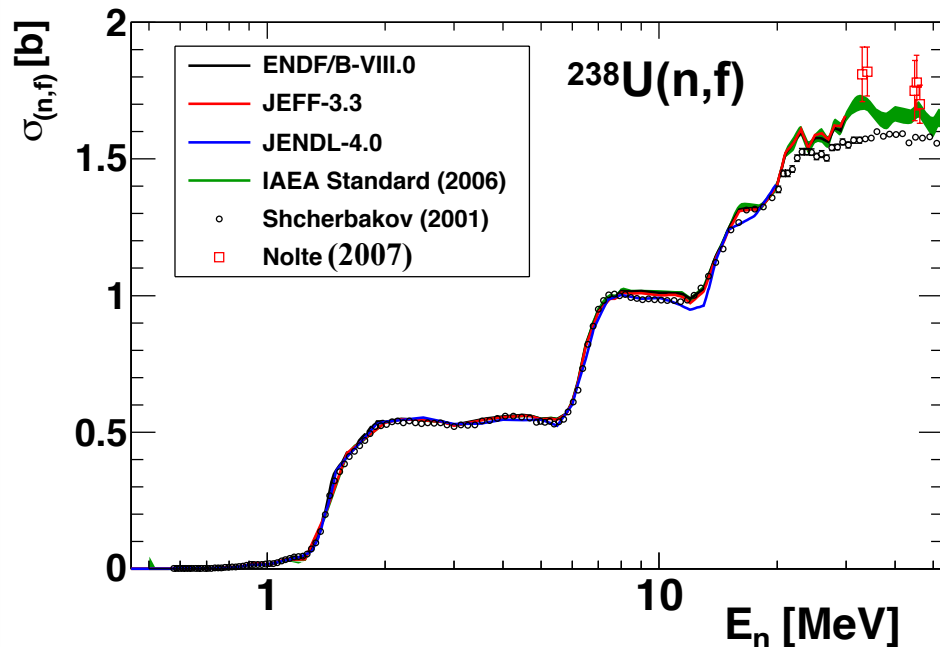
- Our aim is to improve the knowledge in the **neutron-induced fission cross-sections and fragment angular distributions in actinides**.
- Neutron-induced **cross sections are measured relative to one of the neutron standards**, thus eliminating the need in neutron fluence measurements.
- **Uncertainties in the standards** will propagate to all measurements of other neutron cross-sections.
- **Goal:** to improve the knowledge in neutron-induced fission standards $^{235}U(n,f)$ and $^{238}U(n,f)$, relative to **neutron-proton elastic scattering**, in the range 1-40 MeV.
 - We aim at reaching 2% uncertainty.

Current status of data



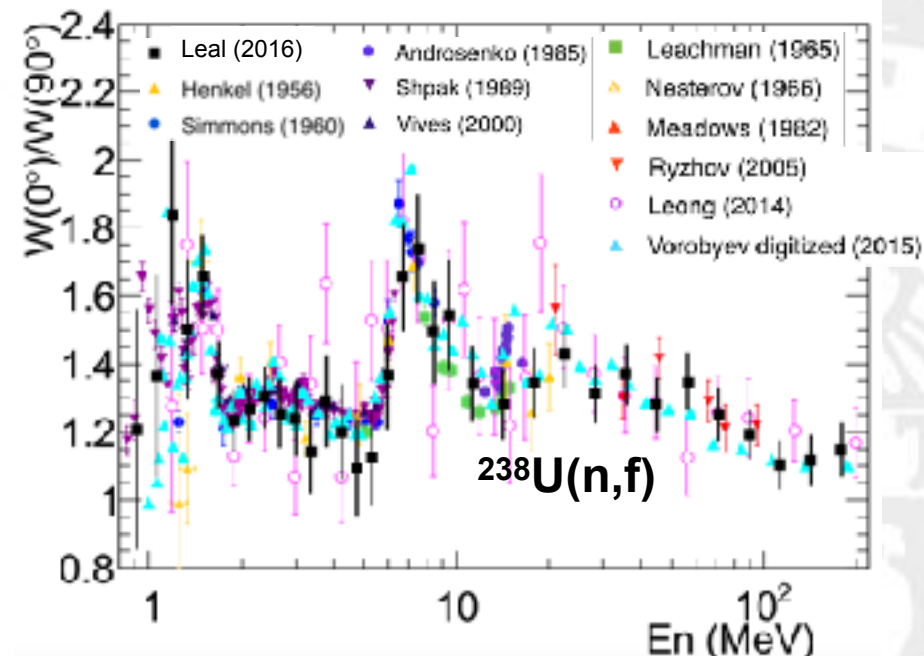
- The newest version of the IAEA standard library is from 2006.
- The only recent data on $^{238}\text{U}(n,f)$ with respect with (n,p) differs by ~7% (Nolte 2007).
- Similar situation for $^{235}\text{U}(n,f)$ vs. (n,p).
- An experiment has been done very recently at n_TOF, but only above 20 MeV.

Current status of data



- Scarce data on angular distributions for $^{235}\text{U}(n,f)$ and $^{238}\text{U}(n,f)$ reactions.
- Few data available above 20 MeV.
- Angular distributions and cross-sections are required to parametrize the fission barrier in actinides, thus improving the existing nuclear models.
[M. Sin et al., Phys. Rev. C 74, 014608 (2006)]

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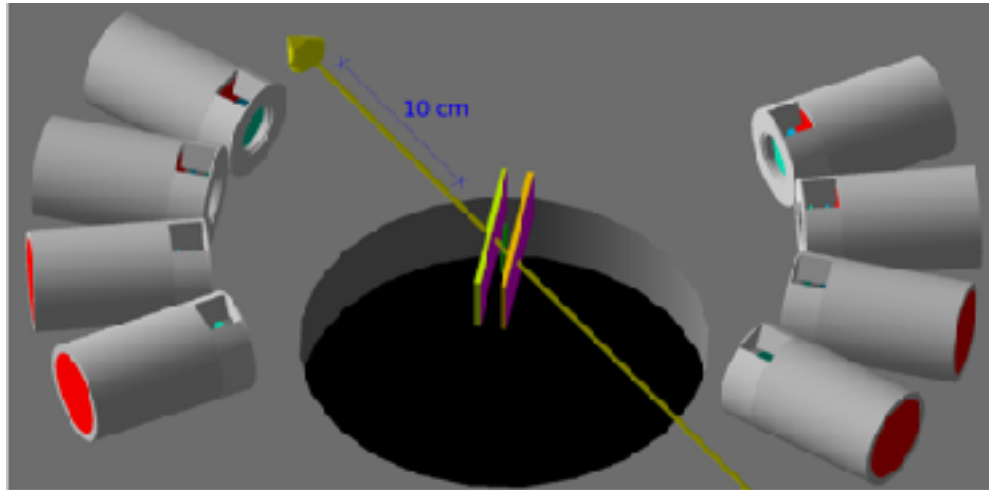


Our proposal

- We plan to use the white neutron beam at GANIL-NFS to measure, **simultaneously**, the **neutron-induced fission of ^{235}U , ^{238}U and the neutron-proton elastic scattering**.
- **All the targets receive the same flux**, thus removing systematic effects caused by variations on the beam intensity.
- As part of the experiment, we will also measure the **angular distributions** of $^{235}\text{U}(n,f)$, $^{238}\text{U}(n,f)$ in the same neutron energy range.
- Our **proposal submitted** to GANIL PAC on September 2020 **has been accepted**, and about **10 days of beam time are granted**.

Upgrade of the Medley setup for fission

- Original Medley: 8 telescopes Si-Si-CsI(Tl) at 20° intervals. The upgrade consists on:
- 2 PPACs (Parallel Plate Avalanche Chambers)
- 3 simultaneous targets: ^{238}U + CH_2 + ^{235}U



D. Tarrío et al., EPJ Web of Conf. 146, 03026 (2017)
K. Jansson et al., Nucl. Inst. Meth. A 794, 141 (2015)

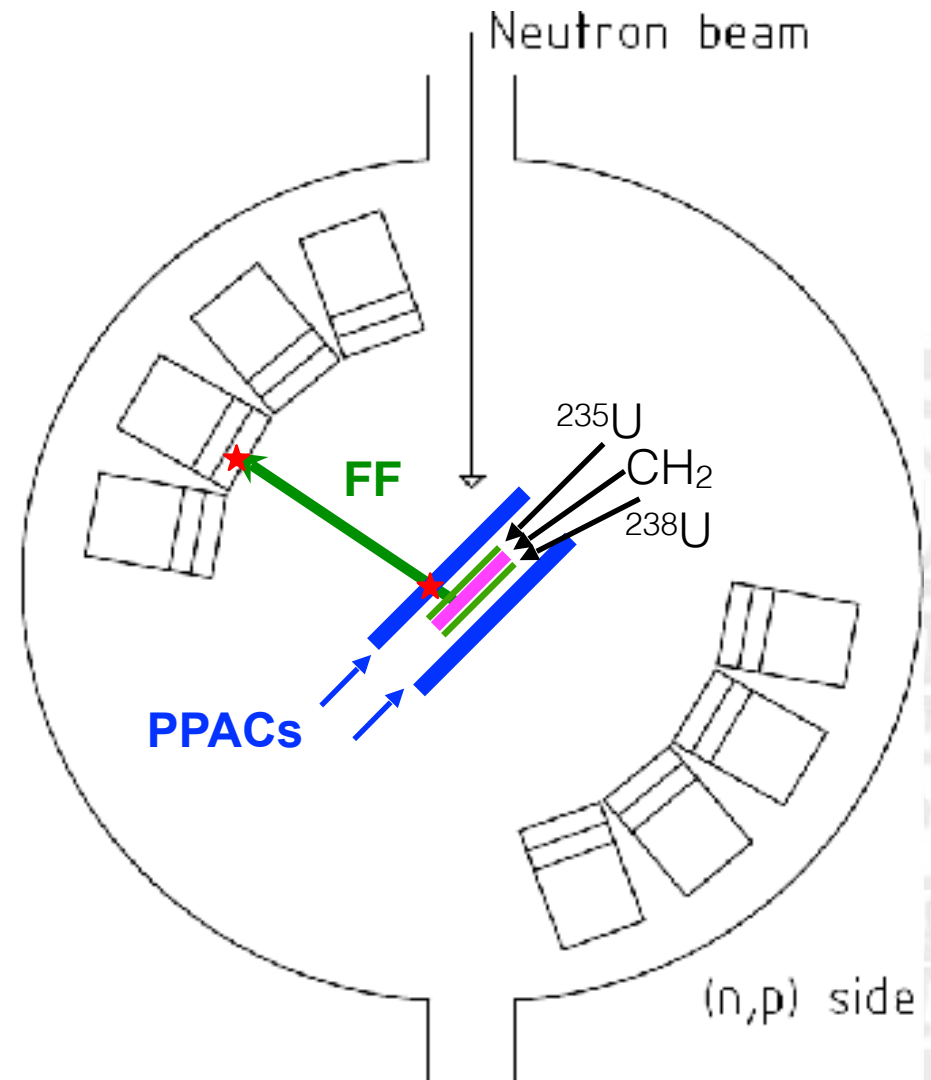
Upgrade of the Medley setup for fission

- ❖ Three targets at a time:



- ❖ Timing detectors (**PPACs**) will be used to determine the neutron energy by the time of flight (TOF).

- ❖ Development of dedicated PPACs is ongoing progress at Uppsala University.



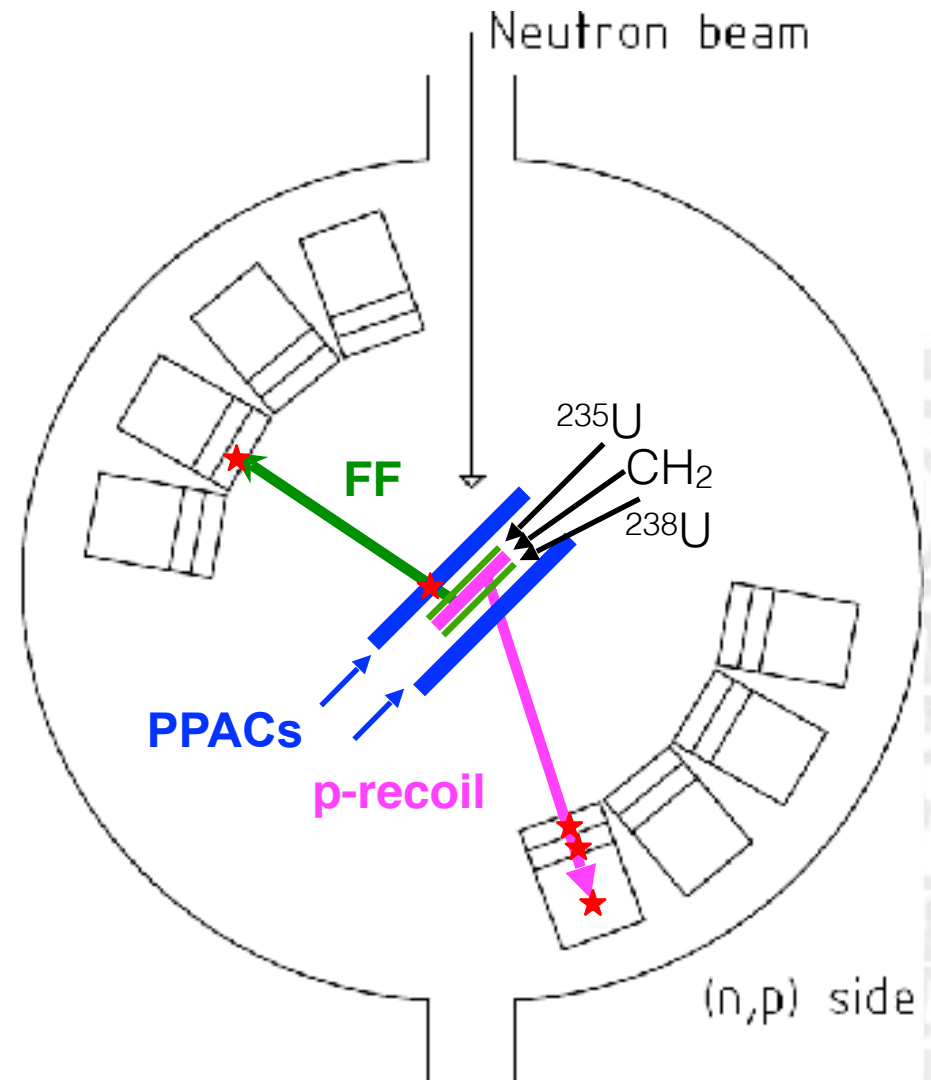
D. Tarrío et al., EPJ Web of Conf. 239, 17004 (2020)
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Upgrade of the Medley setup for fission

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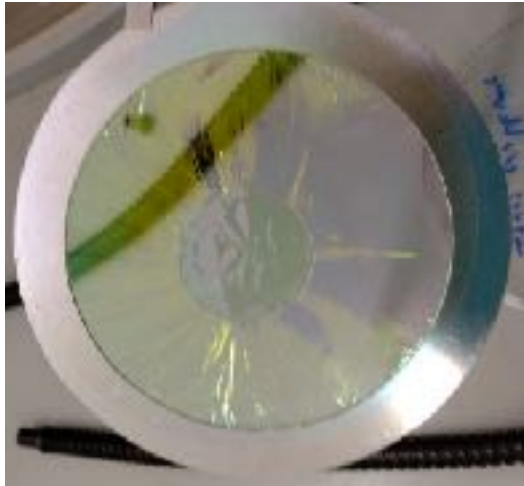
- ❖ Timing detectors (**PPACs**) will be used to determine the neutron energy by the time of flight (TOF).
 - ❖ Development of dedicated PPACs is ongoing progress at Uppsala University.
- ❖ Proton recoil from n-p scattering detected and identified in a forward telescope.



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Target needs and current status

- The development work of the ^{238}U and ^{235}U targets was initiated during CHANDA (in 2015), and the specifications have been agreed with **JRC-Geel**:
 - deposits of **25 mm in diameter**, small enough to fit into the central uniform part of the NFS neutron beam;
 - **$\sim 400 \mu\text{g}/\text{cm}^2$** of the isotope on **$40 \mu\text{g}/\text{cm}^2$ polyimide backings**;
 - mounted in a **1-mm thick Al ring** with **70 and 90 mm** inner and outer **diameter** (provided by JRC-Geel);
 - mechanical stability tests were done at JRC;



^{238}U target recently produced

- **isotopic purity: as high as reasonable achievable** (>99.9% for ^{238}U , and fissile contaminants should be avoided);
- **homogeneity: as good as reasonable achievable** (ideally <3%);
- **uncertainty in average thickness or total mass: as good as reasonable achievable** (ideally <1%).

Target needs and current status



^{238}U target recently produced



*Empty polyimide backing
glued to the mounting Al ring*

- **3 targets of each isotope** (^{235}U and ^{238}U) are requested;
- **3 empty polyimide backings** mounted in Al rings are needed to perform background measurements;
- **Targets of ^{238}U ready** ($360 \mu\text{g}/\text{cm}^2$). Being shipped to GANIL.
- **Targets of ^{235}U are expected to be ready in spring 2022.**

Final remarks

- The GANIL-NFS neutron facility is finally ready. The first experimental campaign is starting in September.
- Considering the good progress on the target production at JRC-Geel, hopefully we will be able to do this experiment in a near future.
- Many thanks to the JRC group and, specially, to Goedele, for finding solutions to our requests!

Thank you for your attention!