Fission cross section measured at n_TOF with PPACs

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Motivation

- Need of accurate nuclear data for innovative nuclear reactors, advanced fuel cycle and nuclear waste incineration

- Fission reactions: Nuclear structure and dynamics of deformed nuclei

- Measurements focused on isotopes involved in the thorium fuel cycle (also of interest for THFB)
n_TOF facility

- Intense spallation source
- Neutrons from thermal to GeV energies
- Excellent time resolution and low background
Fission setup: PPACs

- Thin gas detectors (transparent to neutrons)
- Fast anode signal (~500 ps time resolution)
- Position information from cathodes

- Both fission fragments detected in coincidence
- Trajectory reconstruction
Fission setup: targets

- 8 cm diameter targets to take advantage of the n_TOF fission collimator
- Thin samples (300 µg/cm²) and backings (2 µm de Al)
- Target characterization by alpha counting and RBS (total mass, oxygen content, sample inhomogeneities)
- Verification of the backing thickness by alpha energy loss
Detection setup

- 10 PPACs + 9 Targets
- $^{235}$U and $^{238}$U as references
- 5 signals per detectors registered by FADC
- Analysis off-line for fully-digitized neutron pulses
PPAC characteristics

- Insensitivity to gamma-flash and very fast signals allowing to measure GeV fission at n_TOF
- Thin material layers and low pressure gas minimize the neutron beam attenuation
- Coincidence method implies a better rejection of backgrounds (alpha radioactivity or spallation reactions)
The coincidence method

U-234: singles

U-234: coincidences
PPAC characteristics

- Possibility of having more than one detector crossed by a FF (timing conditions for target selection)
- Signal amplitude information improves background subtraction
- Detection efficiency strongly depends on the emission angle and the target thicknesses. Very sensitive to the angular distribution. Need to use anisotropy for correction
- FF trajectory reconstruction => FFAD in a limited angular range
Main results (I)

- $^{234}\text{U}(n,f) \sigma_f$
  

- $^{237}\text{Np}(n,f) \sigma_f$
  
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Main results (II)

- $^{209}\text{Bi}(n,f) \ & \ ^{nat}\text{Pb}(n,f) \ \sigma_f$

- $^{233}\text{U}(n,f) \ & \ ^{232}\text{Th}(n,f)$
  ND2007 (Article in preparation)
Main results (III)

- $^{238}\text{U}(n,f)/^{235}\text{U}(n,f)$ $\sigma_f$ ratio (Paper in preparation)

- All results include efficiencies corrected by anisotropies (EXFOR experiments). Results with about 4% systematic uncertainties.
Phase II setup

- New setup with PPACs tilted with respect to neutron beam direction
- Full angular coverage. FFAD studies.
- Some new targets with a thinner backing (0.7 µm)

Figure 1: stainless steel cylinder  
Figure 2: aluminum bottom + detectors and targets
Phase I vs Phase II setups

Geant4 simulations

n beam

FF1

FF2

θ

FF1

FF2

Geant4 simulations

efficiency

0 0.2 0.4 0.6 0.8 1

0 0.2 0.4 0.6 0.8 1

0 0.2 0.4 0.6 0.8 1

0 0.2 0.4 0.6 0.8 1
First results at Phase II

2010-2011: FFAD for $^{232}$Th, $^{237}$Np and $^{238,235}$U

D. Tarrío and L.S. Leong PhD's (NIM submitted).

**Complete FFAD required to correct the cross section**
$^{238}\text{U}/^{235}\text{U}$ ratio

New measurements with a different setup (different efficiency dependence)
Last campaing (2012)

- FFAD for $^{234}$U.

Preliminary data presented in Final Erinda Workshop (E. Leal-Cidoncha)

Setup included two $^{235}$U and three $^{238}$U targets with different backings. *To be analysed yet*
Conclusions and perspectives

- PPACs used with coincidence method at n_TOF have provided neutron-induced fission data for an extended energy range.
- Samples and backings are carefully characterized to improve the data accuracy.
- FFAD is needed to proper treatment of the detection efficiency.
- New method of efficiency determination in progress. Revision of cross section to improve the 4% accuracy.
- U-235 & U-238 targets have been included as references in all the measurements. Systematic studies are foreseen.
Thanks for your attention