Fission cross section measured at n_TOF with PPACs

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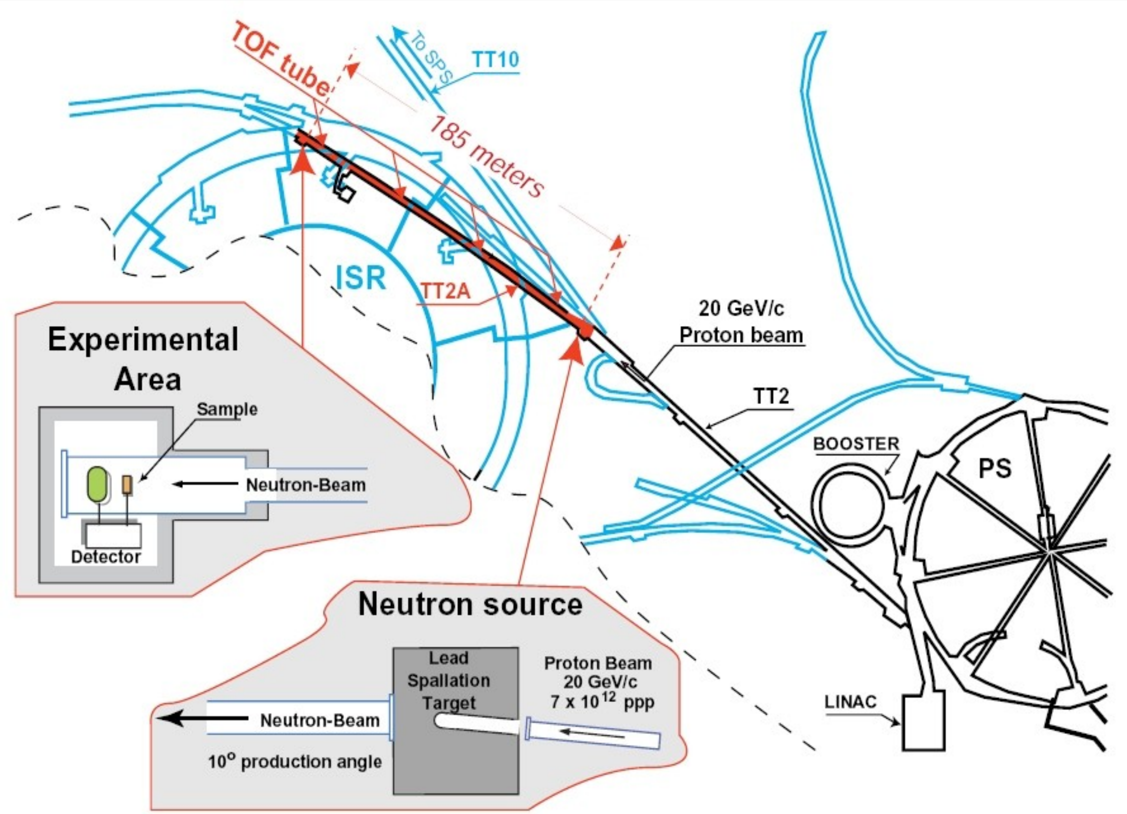
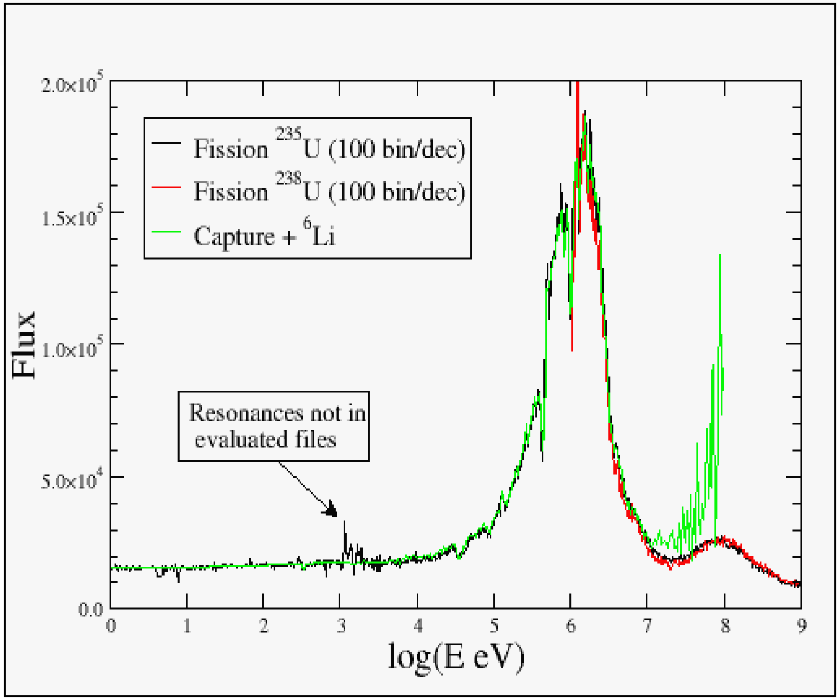
Motivation

- 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)

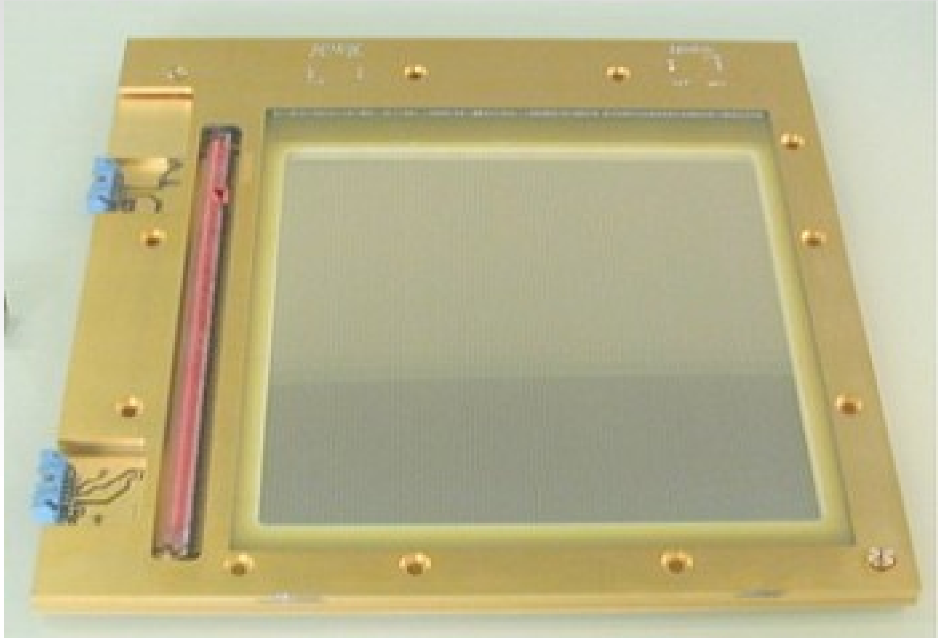
n_TOF facility

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



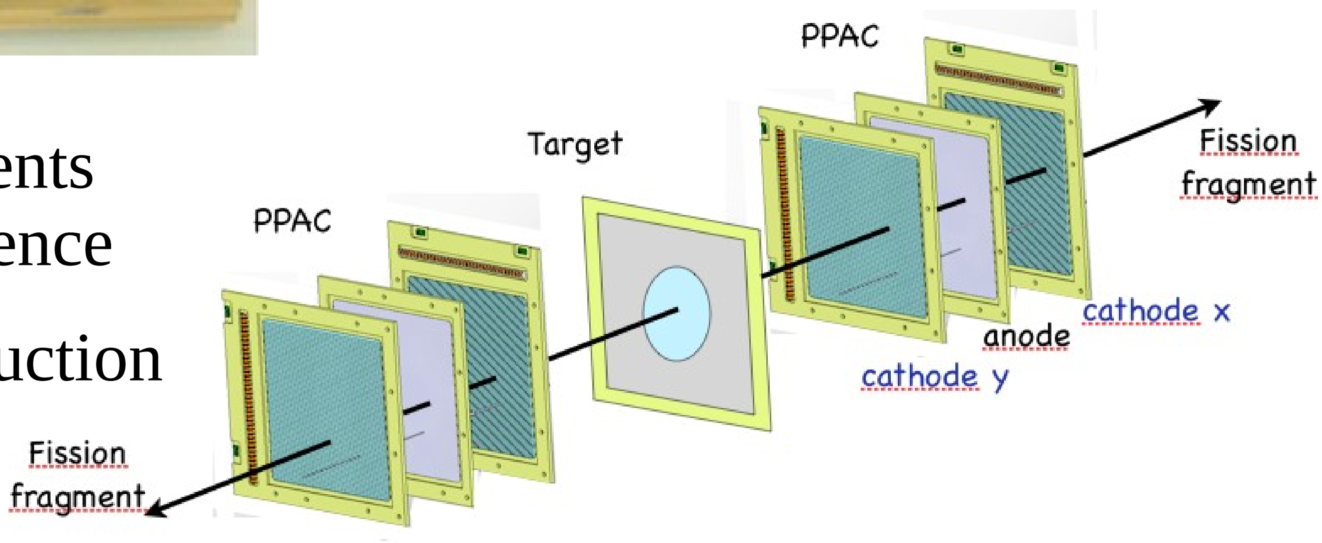


Fission setup: PPACs



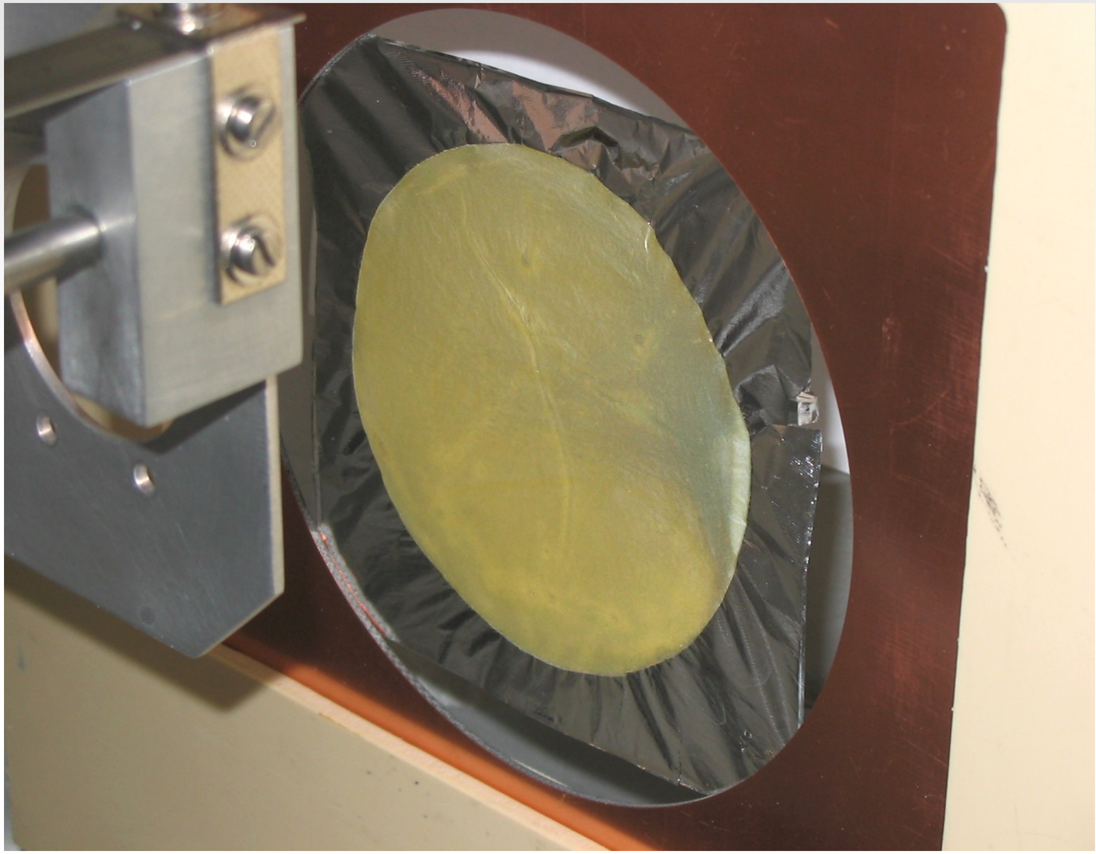
- Thin gas detectors (transparent to neutrons)
- Fast anode singal (~500 ps time resolution)
- Position information from cathodes

- Both fission fragments detected in coincidence
- Trajectory reconstruction



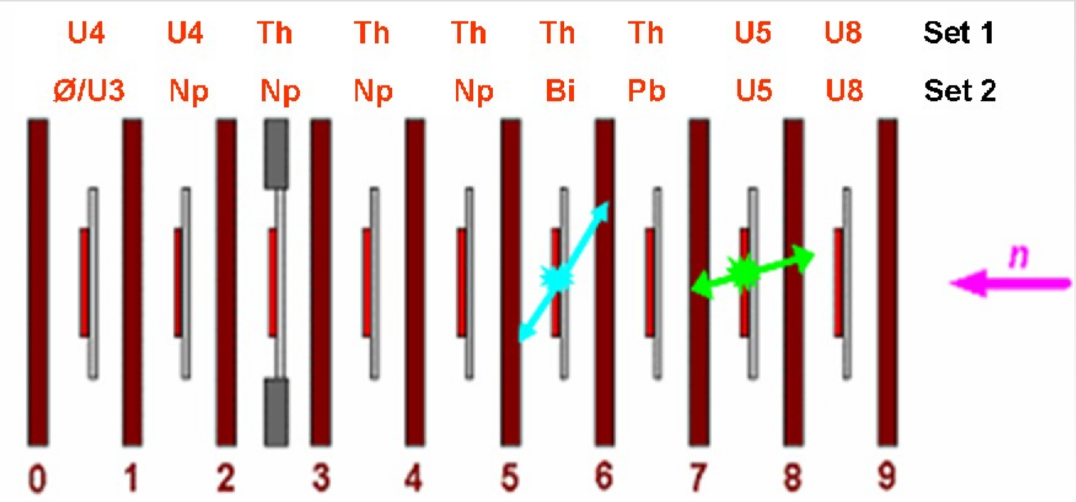
Fission setup: targets

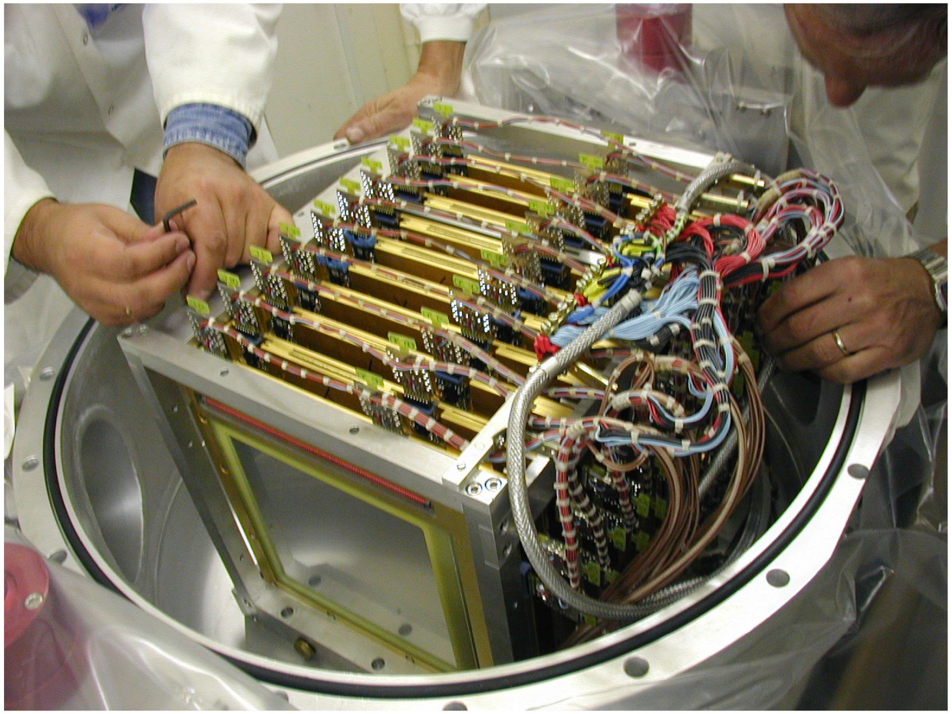
- 8 cm diameter targets to take advantage of the n_TOF fission collimator
- Thin samples (300 μg/cm^2) and backings (2 μm de Al)
- Target characterization by alpha counting and RBS (total mass, oxygen content, sample inhomogeneities)
- Verification of the backing thickness by alpha energy loss



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

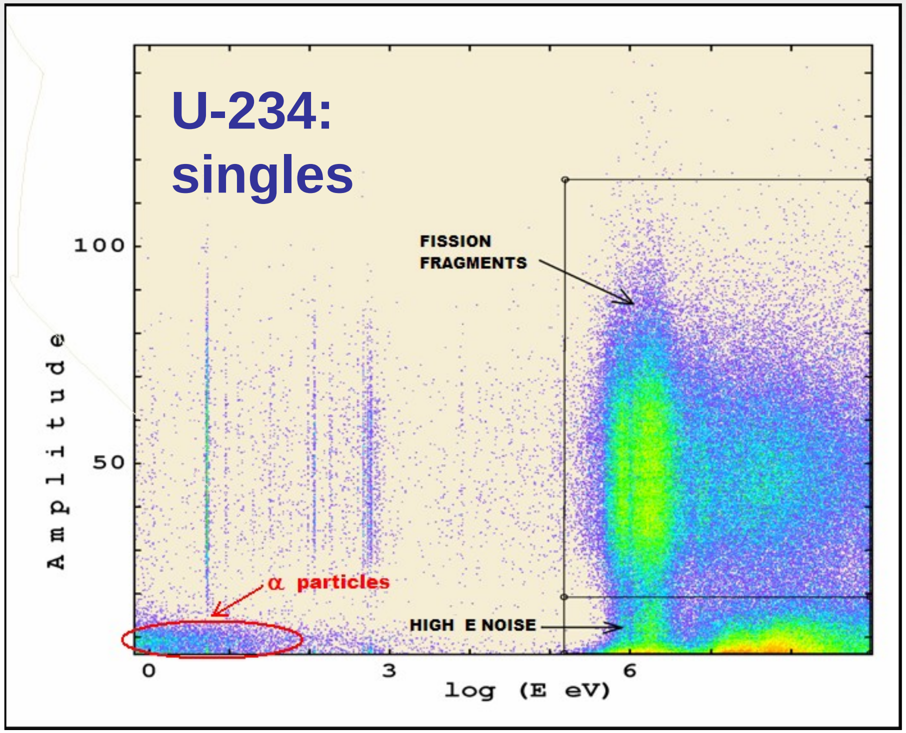


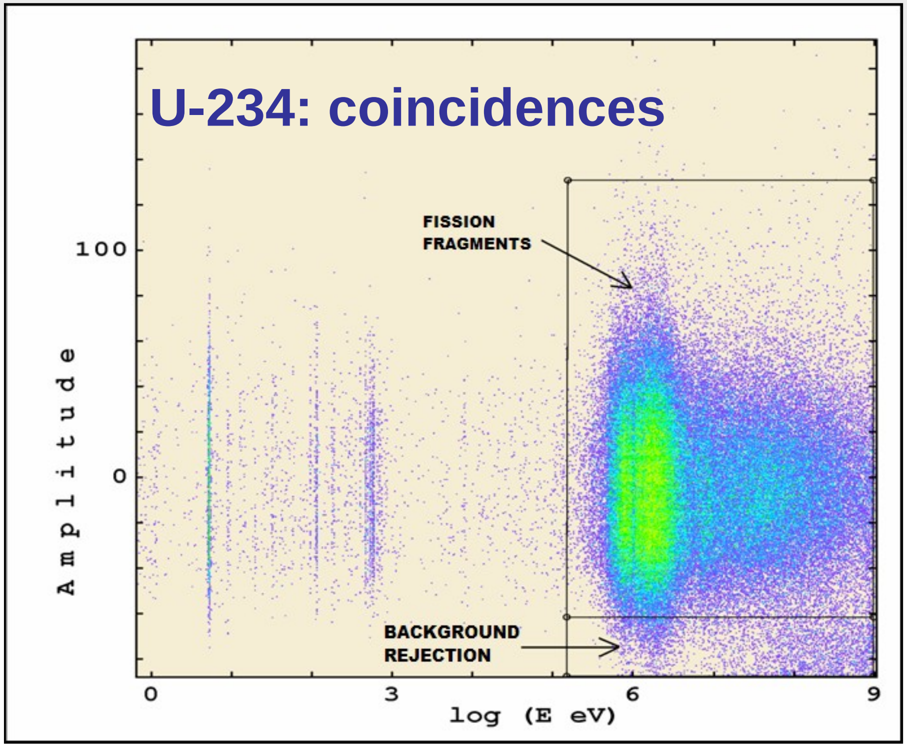


PPAC characteristics

- 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)

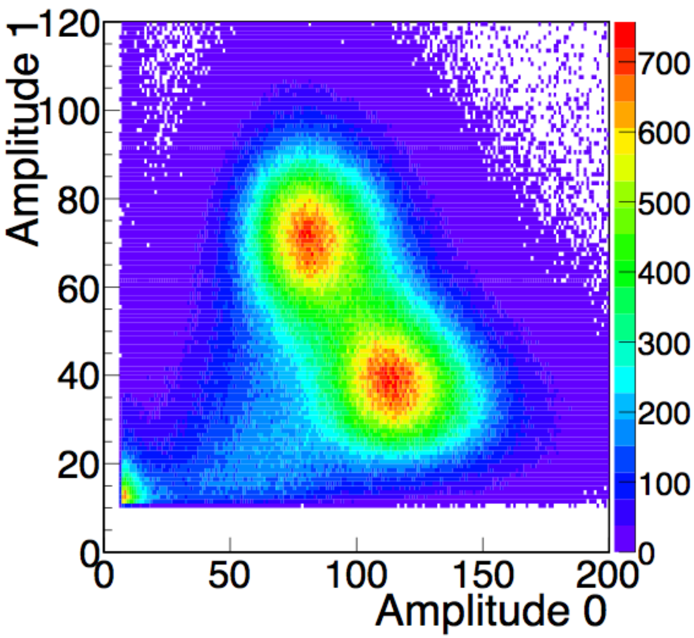
The coincidence method

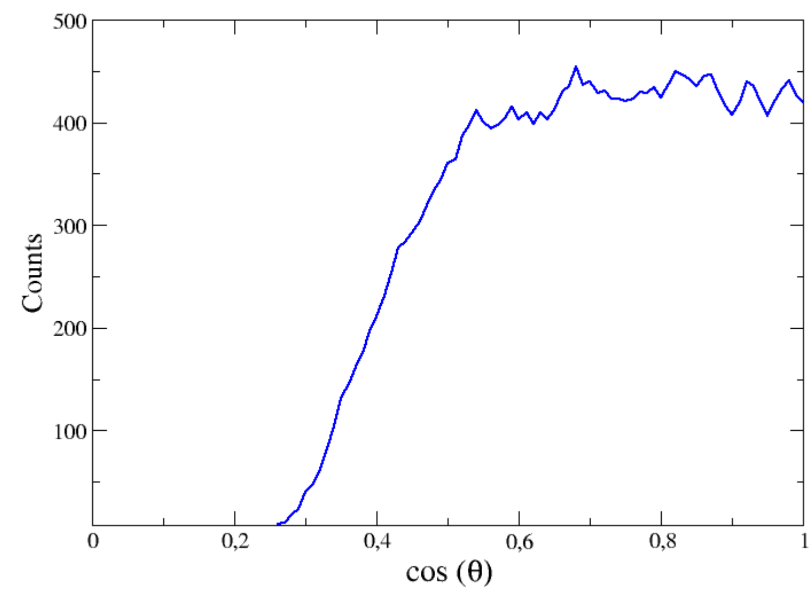




PPAC characteristics

- Possibility of having more than one detector crossed by a FF (timing conditions for target selection)
- Signal amplitude information improves background sustraction
- 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

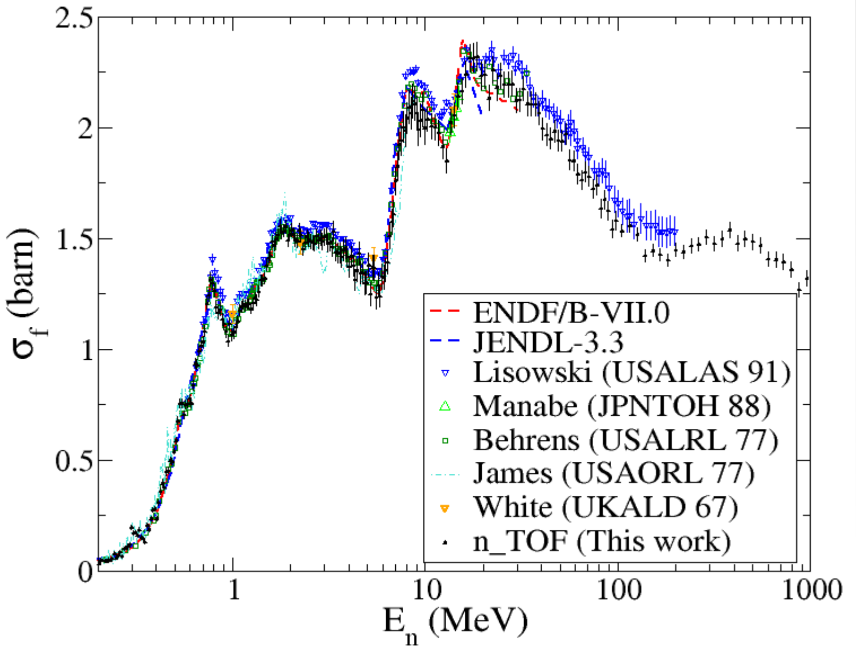




Main results (I)

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

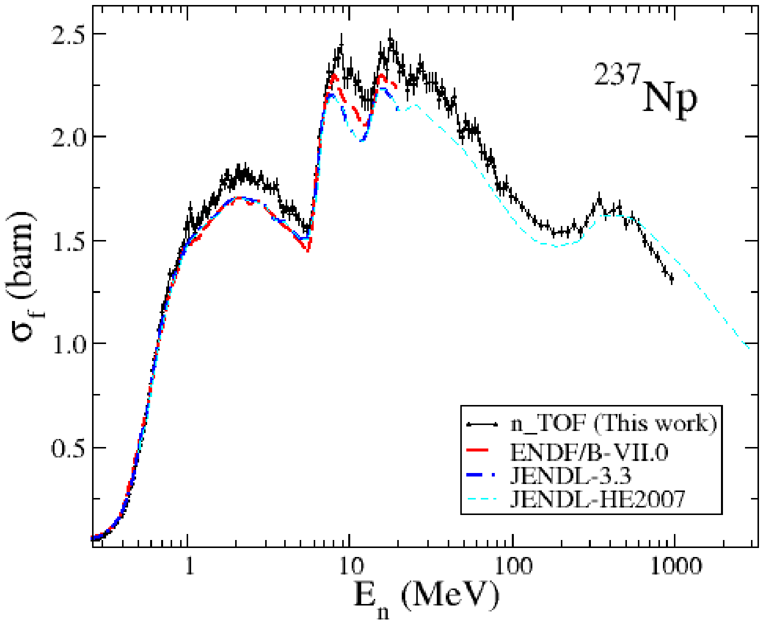
Phys. Rev. C 82 034601 (2010)



- $^{237}Np(n,f)\ \sigma_f$

J. of Korean Phys. Soc. 59, 1908 (2011)

Annals of Nuclear Energy 54, 36 (2012)



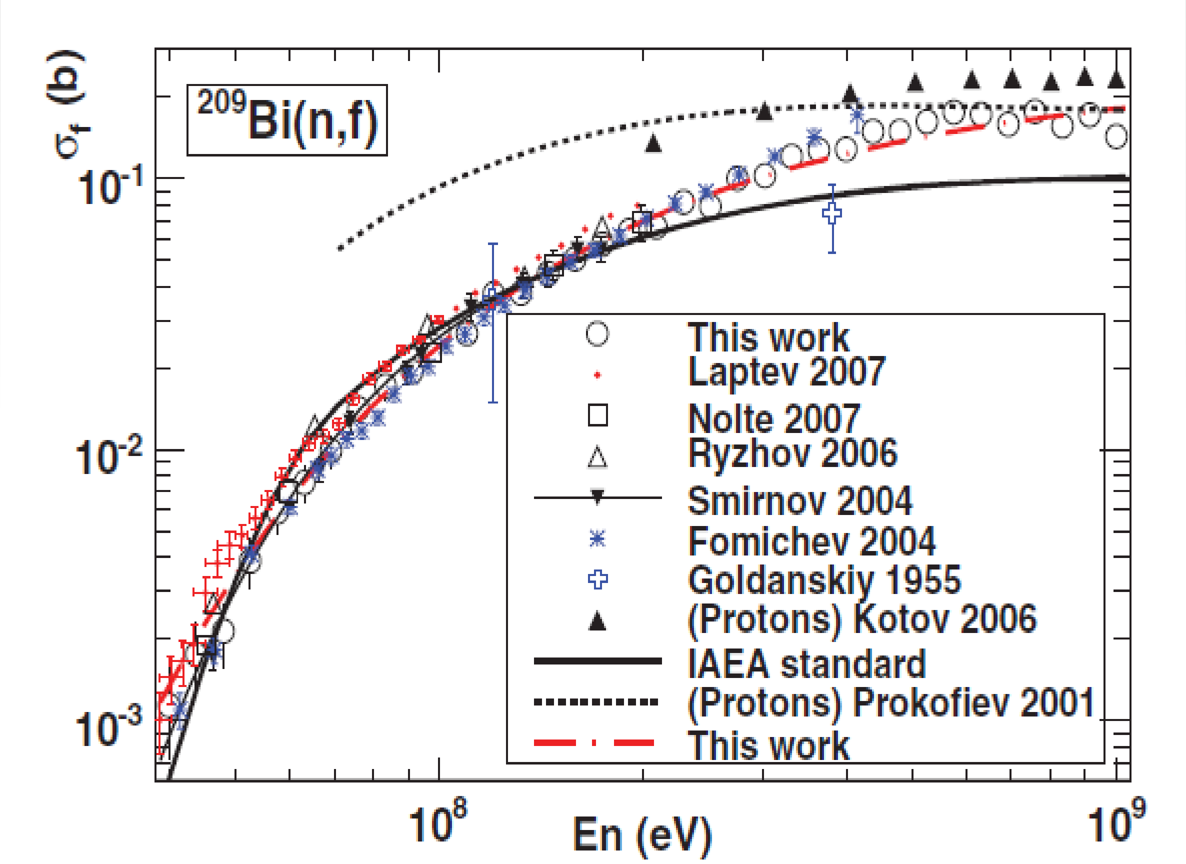
Main results (II)

- $^{209}Bi(n,f)$ & $^{nat}Pb(n,f)$ σ_f

Phys. Rev. C 83, 044620 (2011)

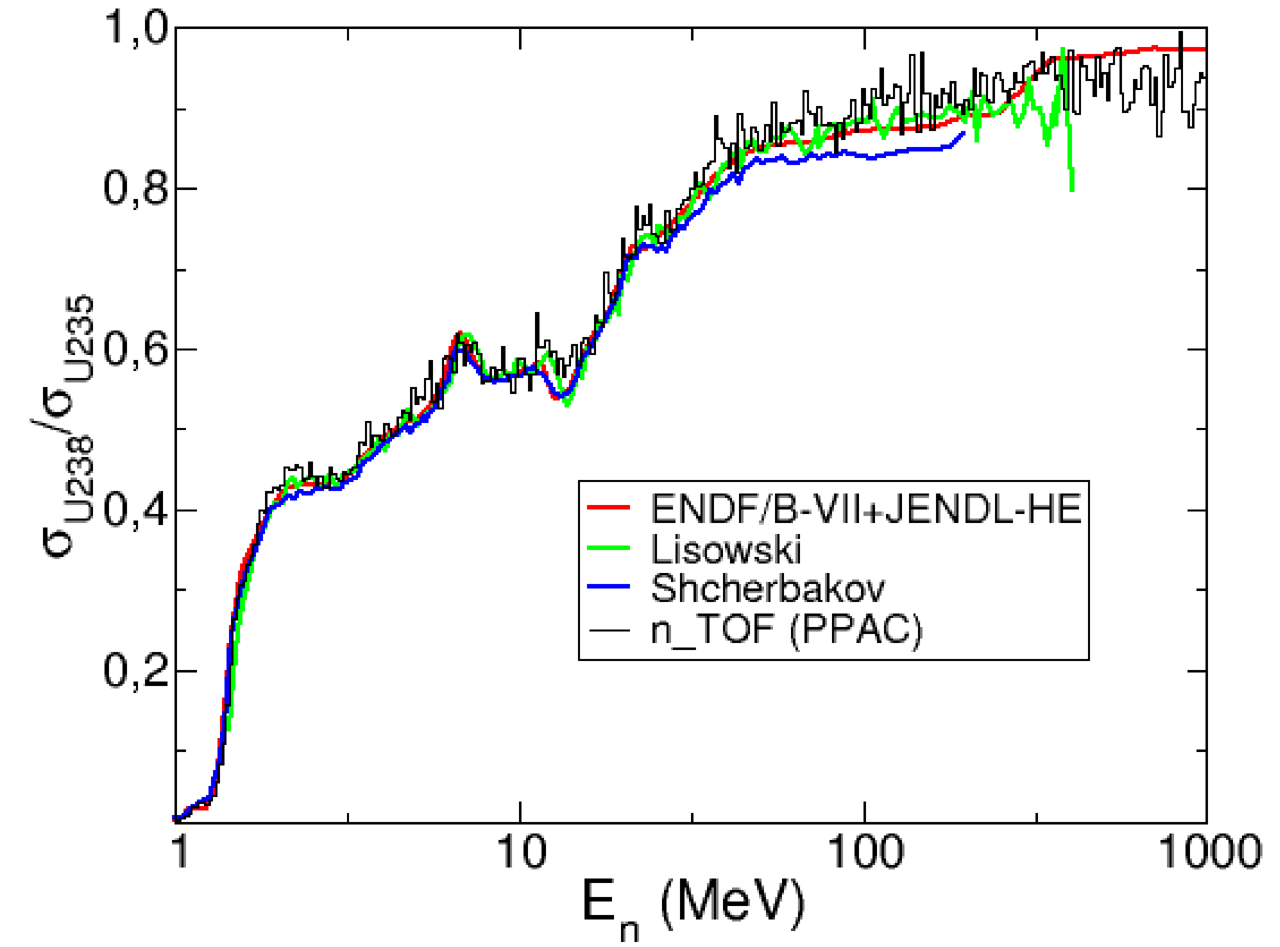
- $^{233}U(n,f)$ & $^{232}Th(n,f)$

ND2007 (Article in preparation)



Main results (III)

- $^{238}U(n,f)/^{235}U(n,f)$ σ_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)

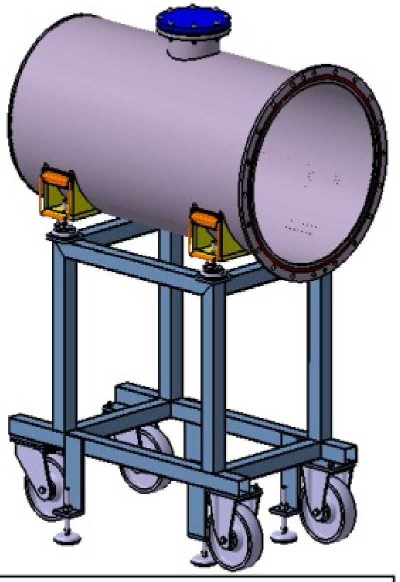


Figure 1 : stainless steel cylinder

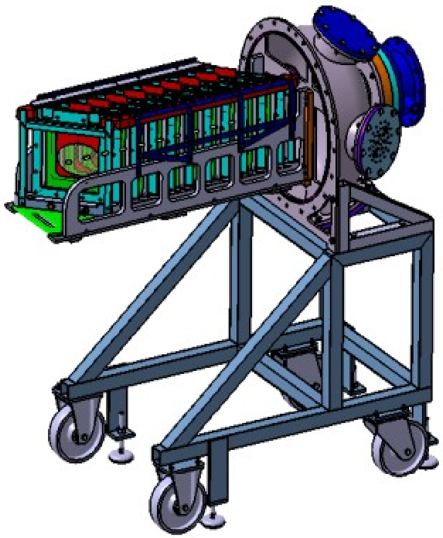
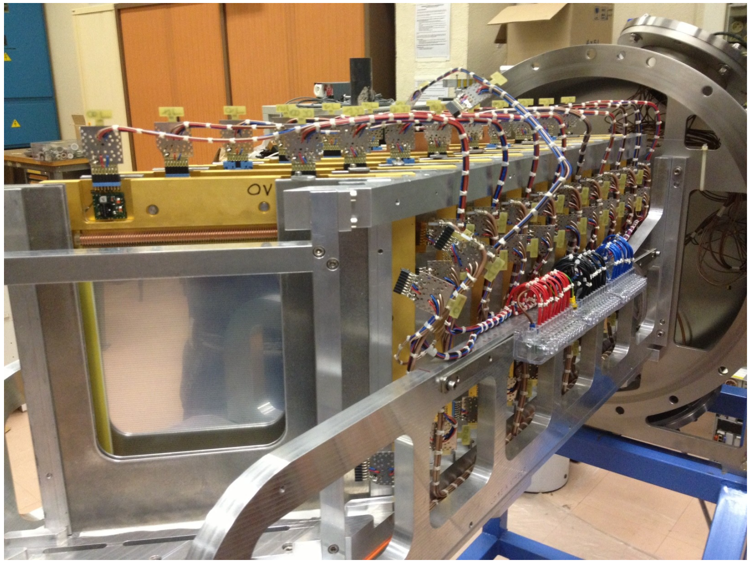
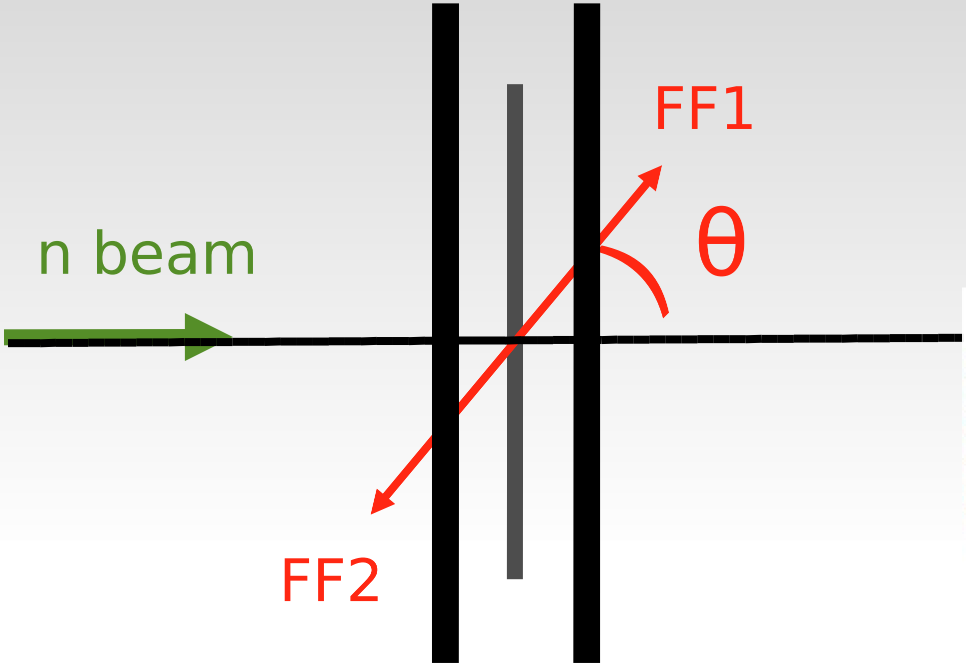
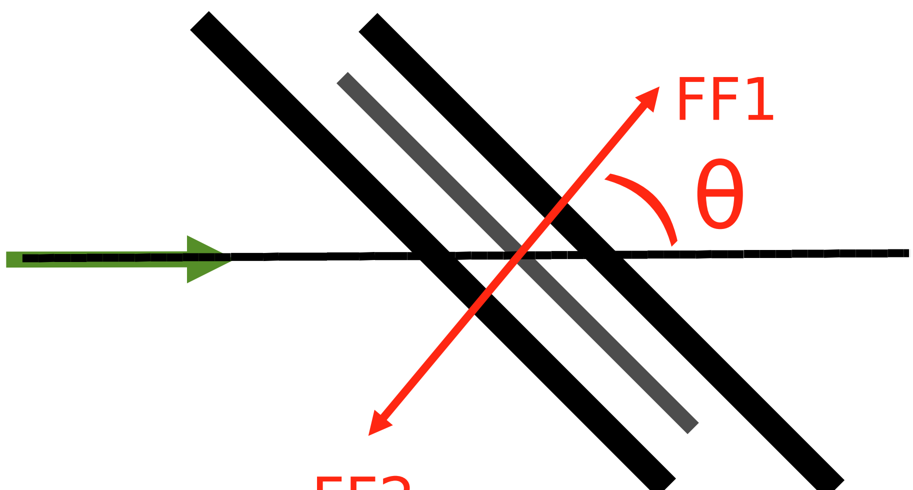


Figure 2: aluminum bottom + detectors and targets

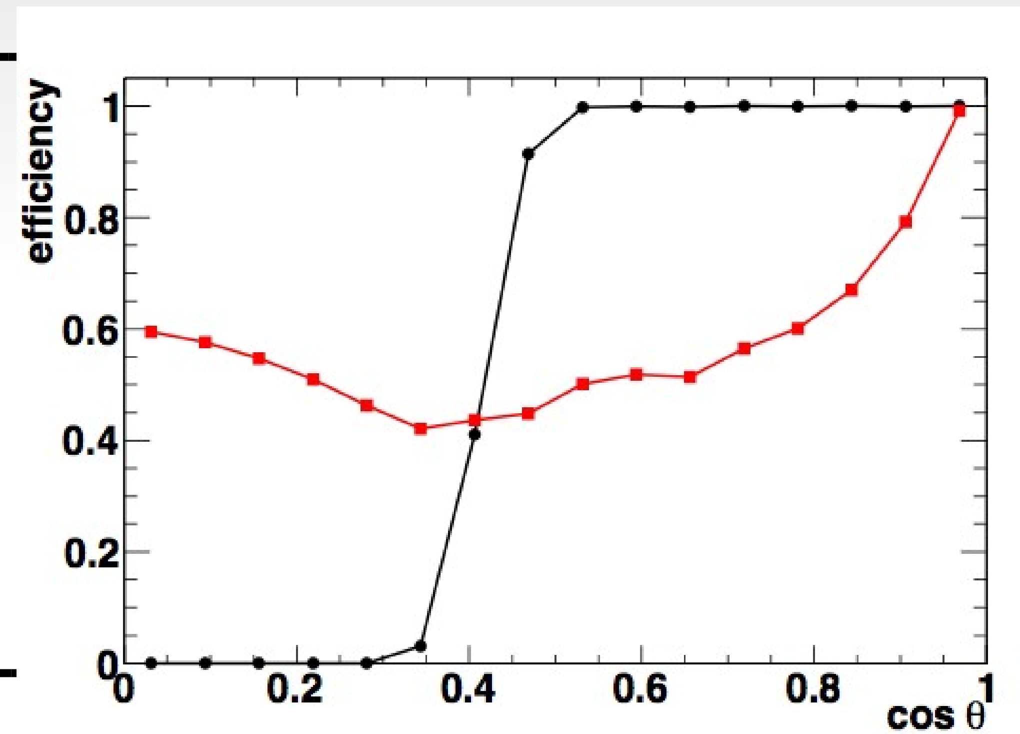


Phase I vs Phase II setups





Geant4 simulations

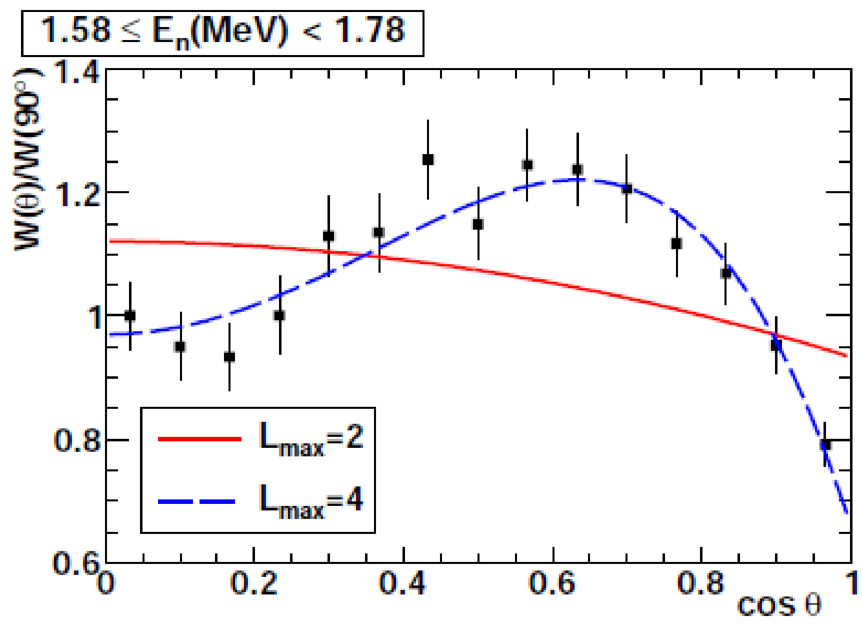


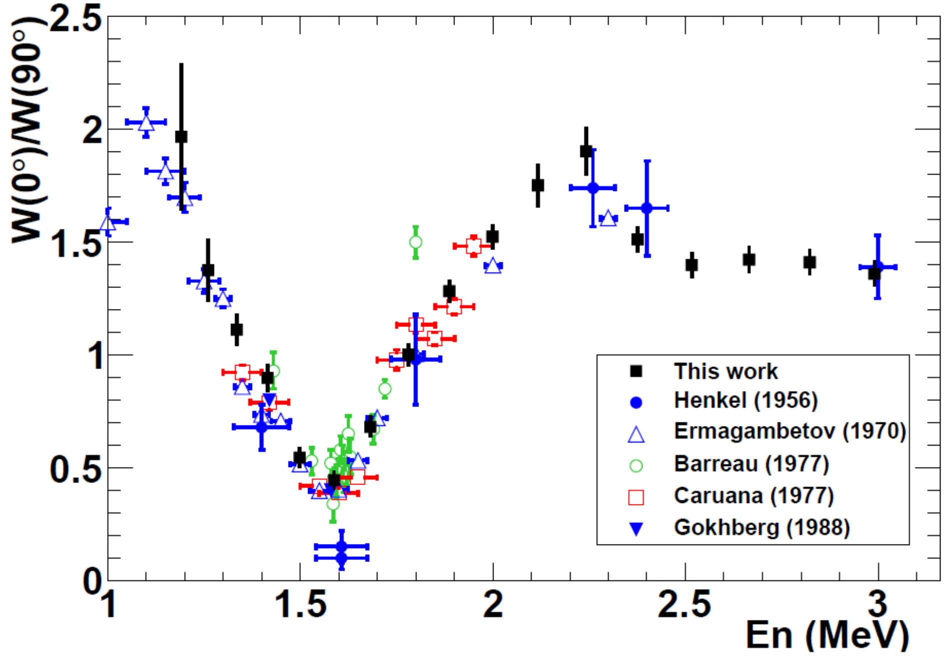
First results at Phase II

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

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

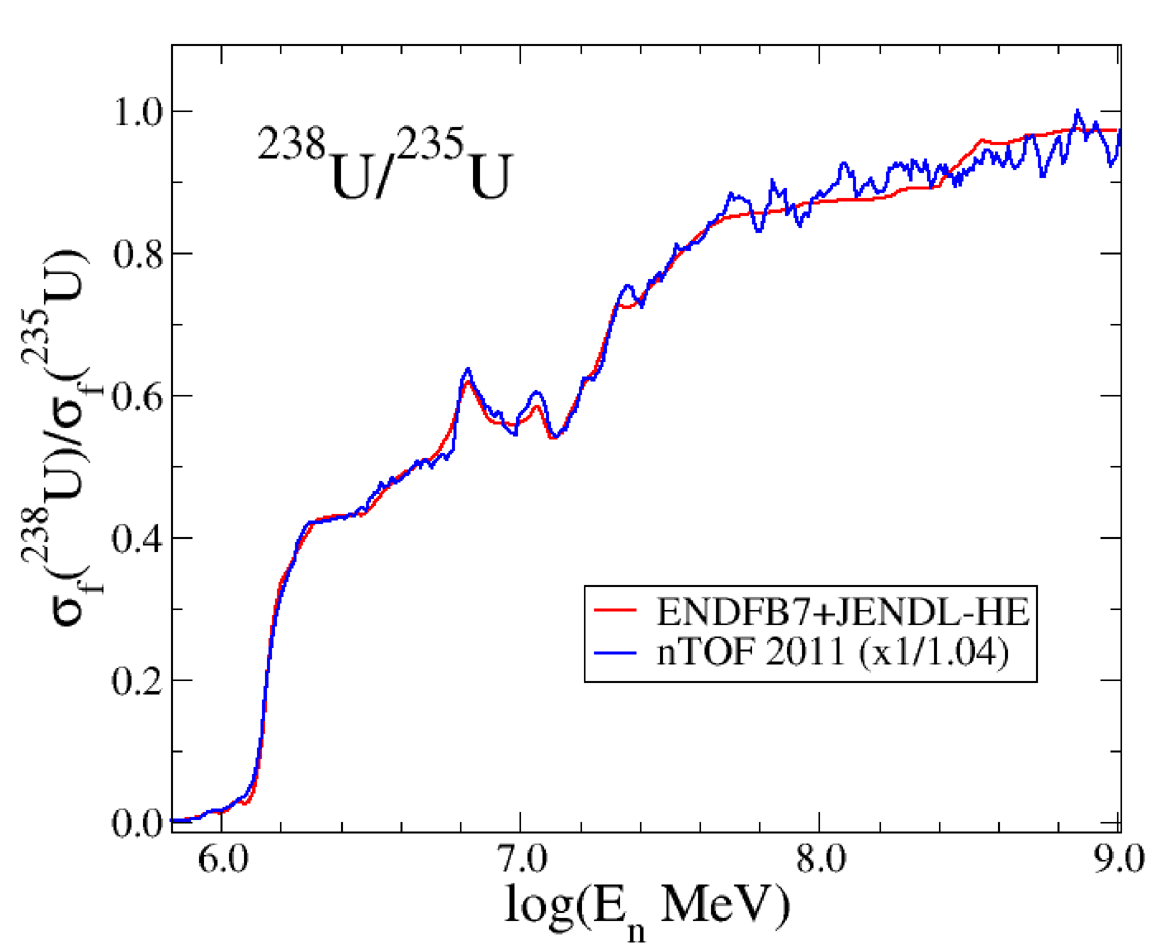
**Complete FFAD required to correct the cross section





$^{238}U/^{235}U$ ratio

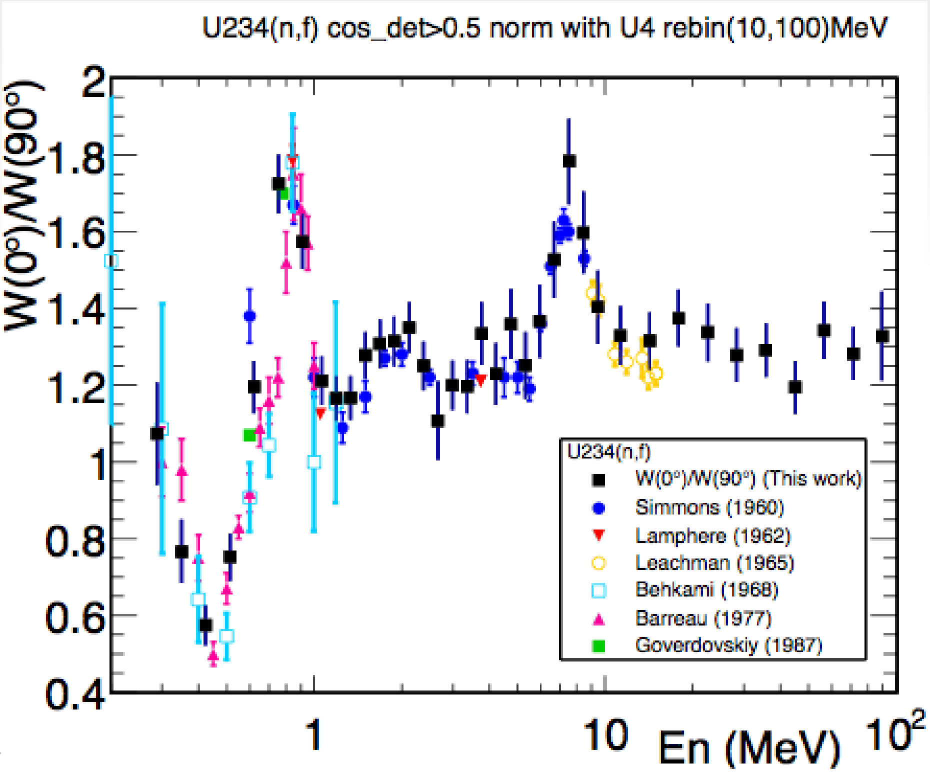
New measurements with a different setup (different efficiency dependence)



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