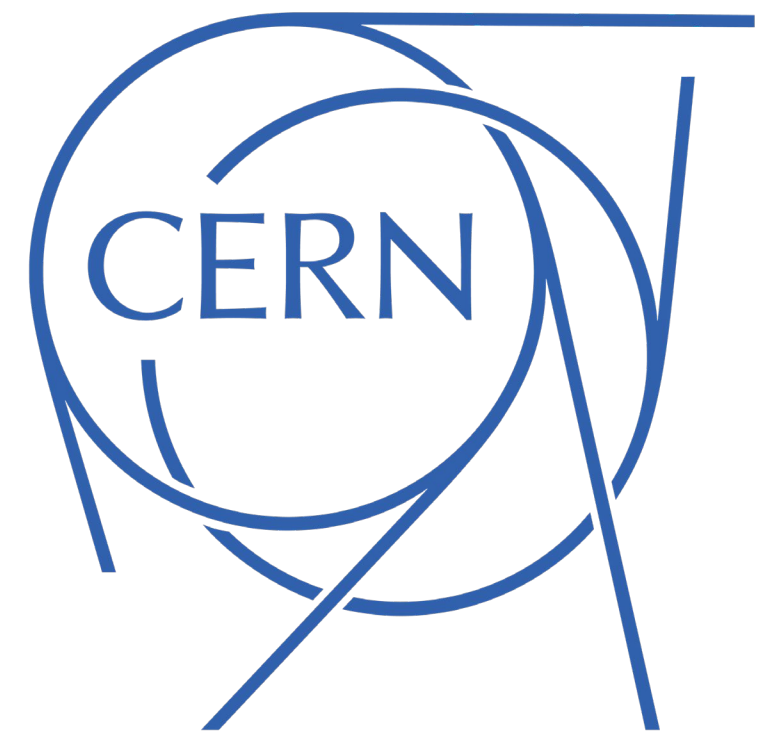


# High-precision measurement of neutron-induced fission cross sections and angular distributions

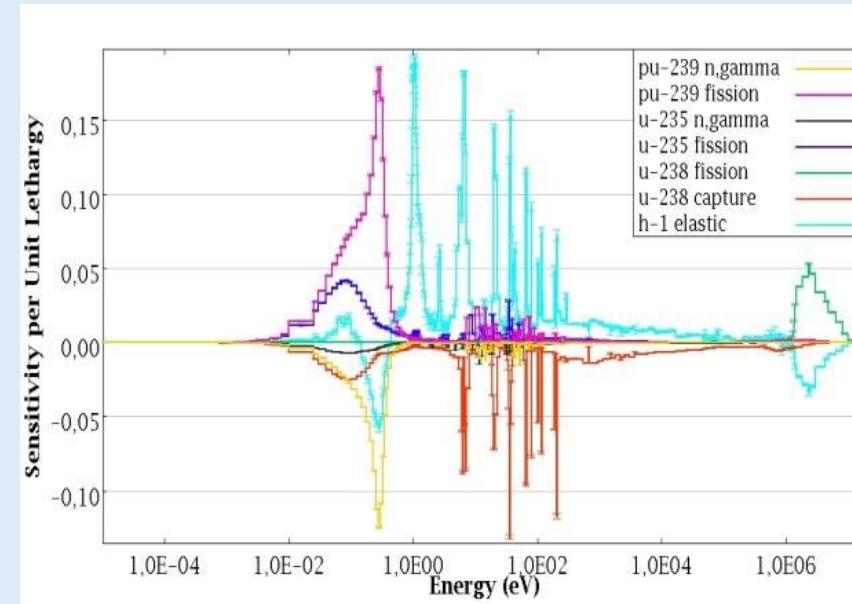
Laurent Audouin, Claire Le Naour, Laurent Tassan-Got

Contact : audouin@ijclab.in2p3.fr



## Nuclear data : metrology meets basic physics

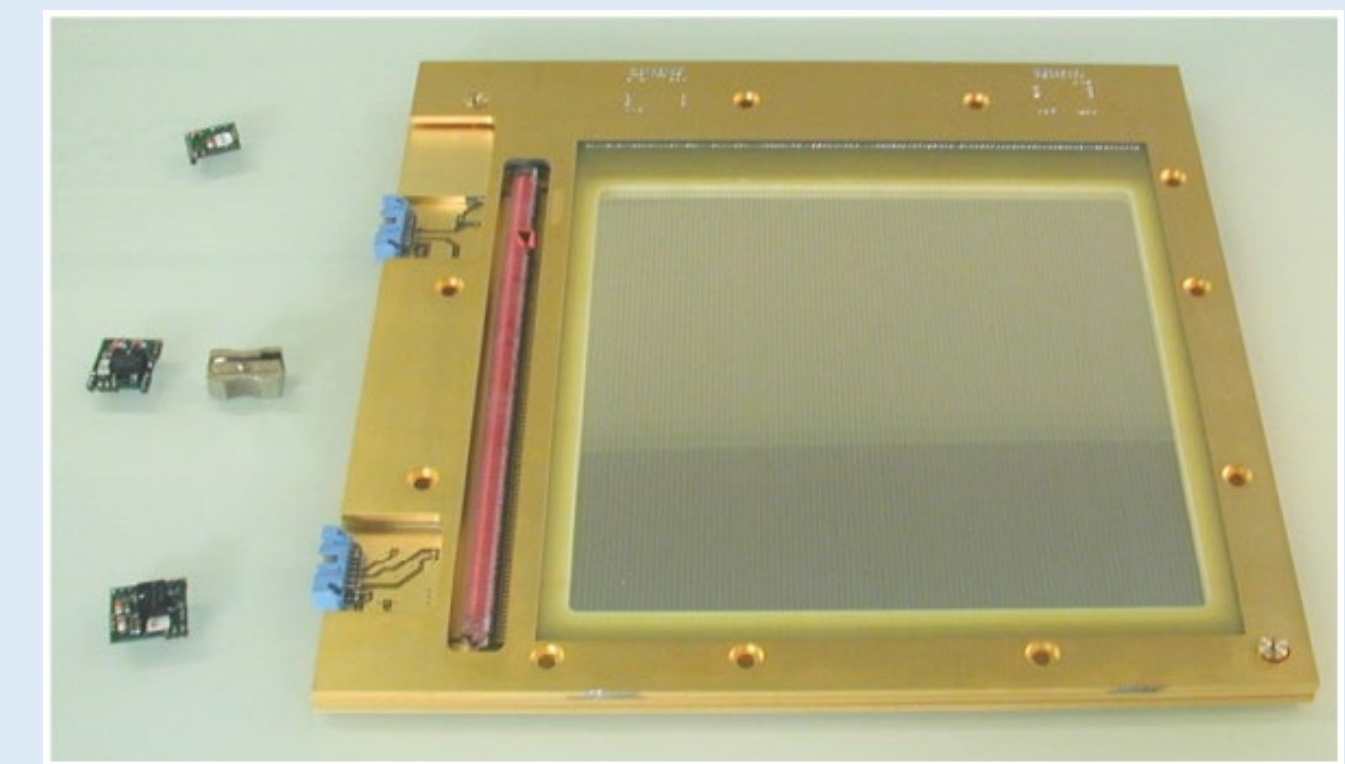
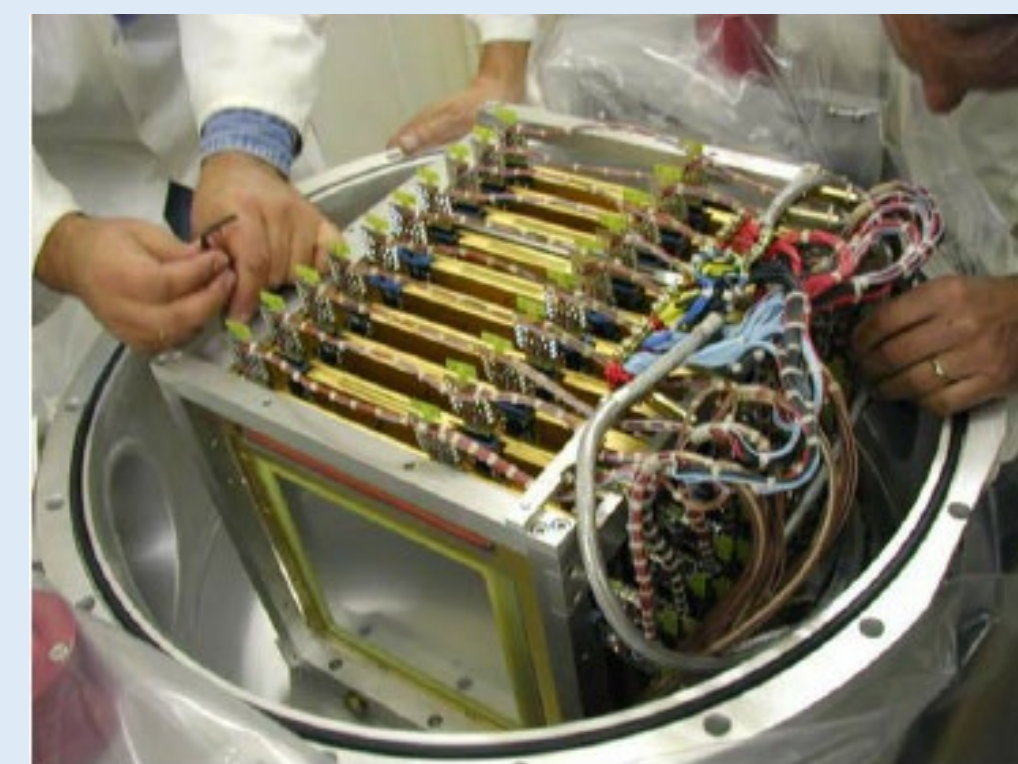
- Simulation of nuclear systems rely on many nuclear physics data
- Fission cross sections must be known with few-% uncertainties
- Metrology measurements using the tools of basic nuclear science
- Of course, fission is also worth studying for basic science... Still a very challenging phenomena !



R. Ichou, Burn-up effect on nuclear data sensitivity and uncertainty for reactor safety applications (2018)

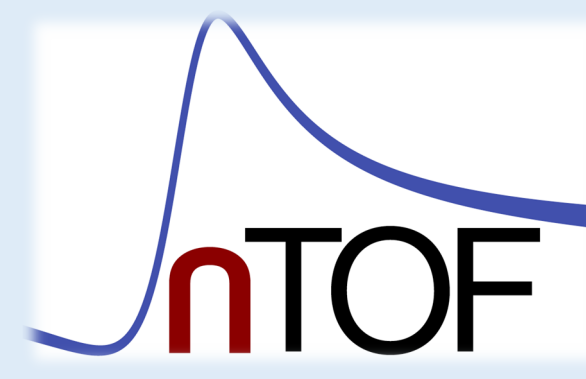
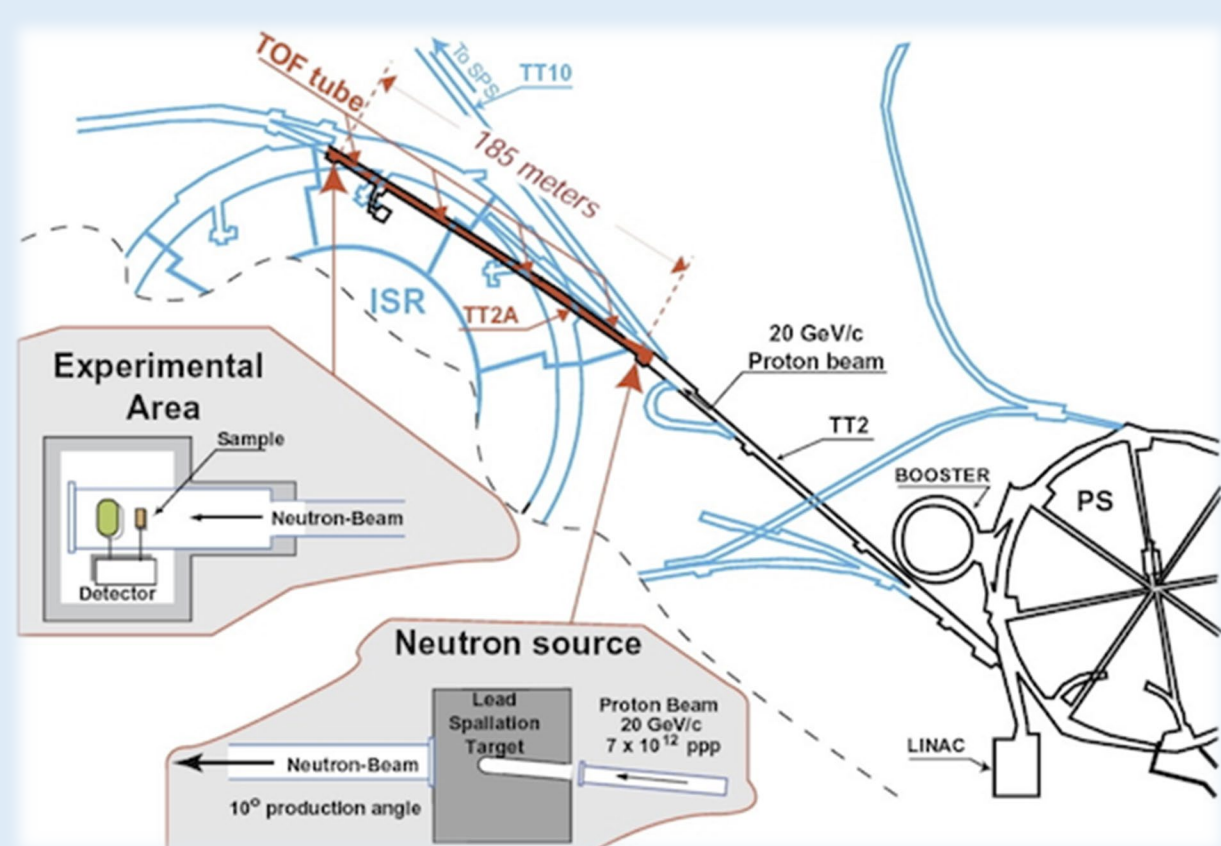
## Experimental system

- Parallel Plates Avalanche Counters
- Transparent, fast, position-sensitive detectors (mm resolution)
- Reconstruction of fission location on target + angle
- Stack of 10 detectors and 9 targets: direct comparison between nuclei



- "Tilted" configuration: disentangles intrinsic efficiency from fission anisotropy

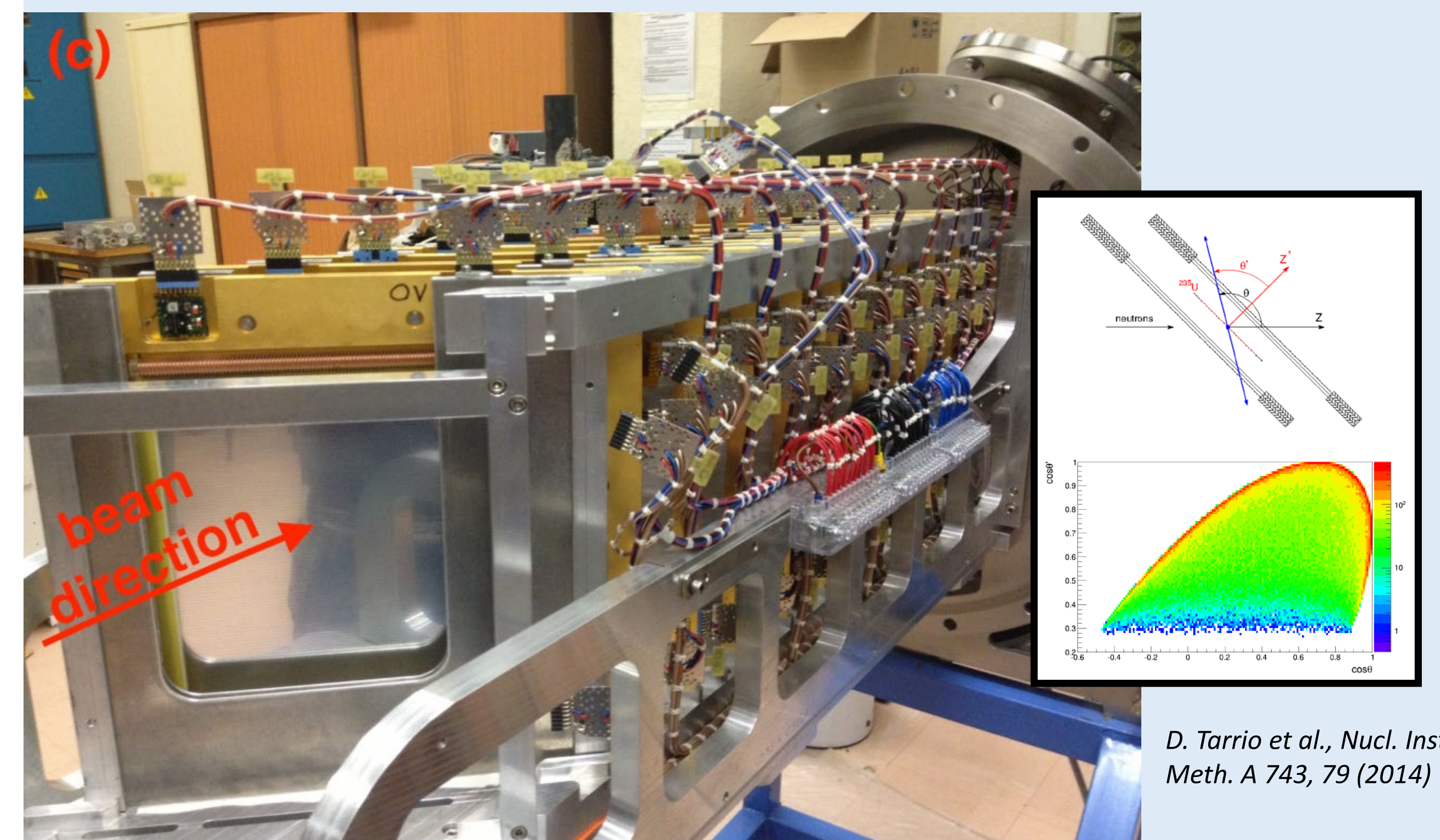
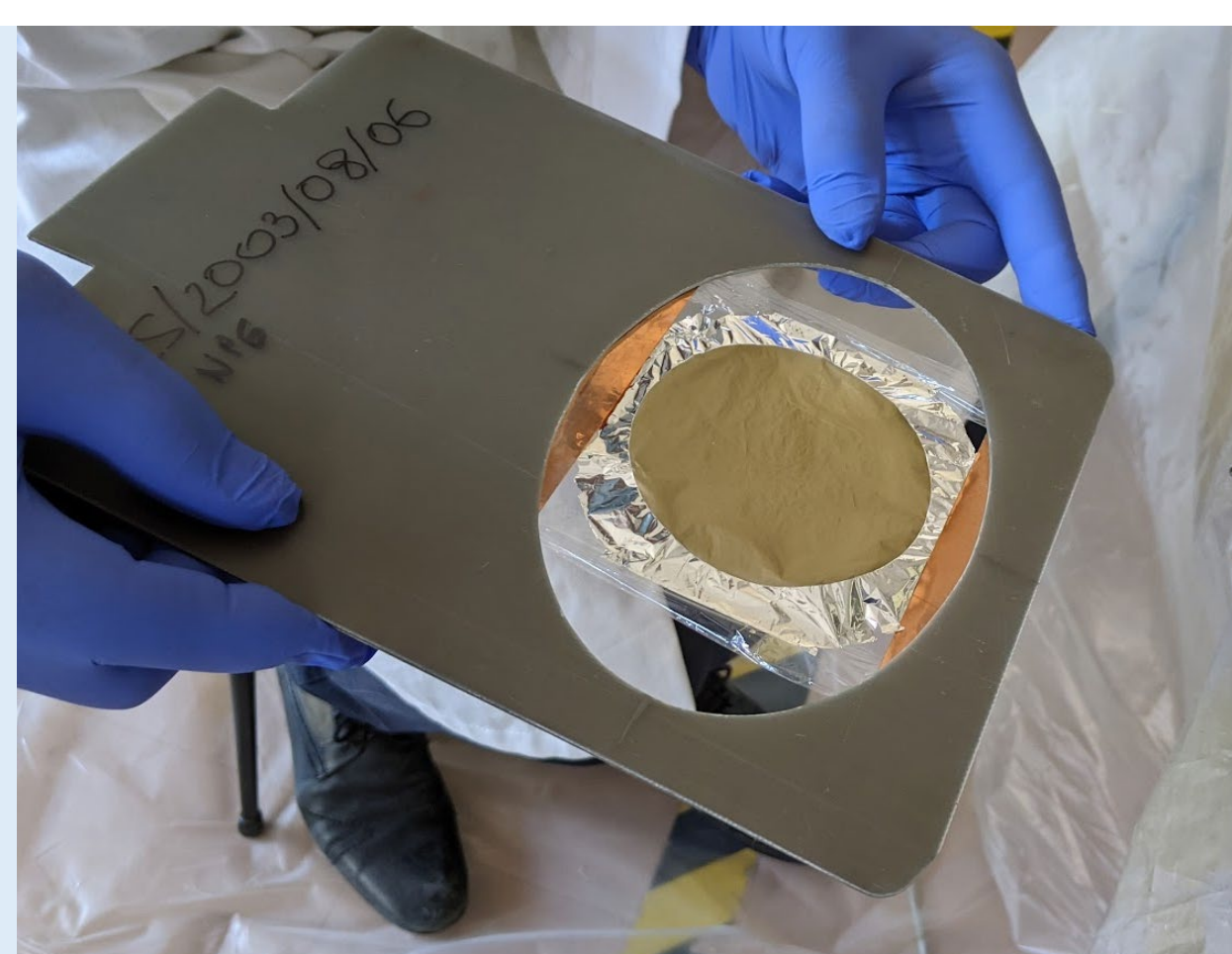
## The n\_TOF facility at CERN



- Neutron source based on the CERN PS accelerator
- Measurement across 11 orders of magnitude of neutron energy
- 20 m & 200 m flight path : high-accuracy on neutron energy
- Low duty-cycle : ideal for radioactive samples, low-background, allows full trace digitalization

## Actinide targets

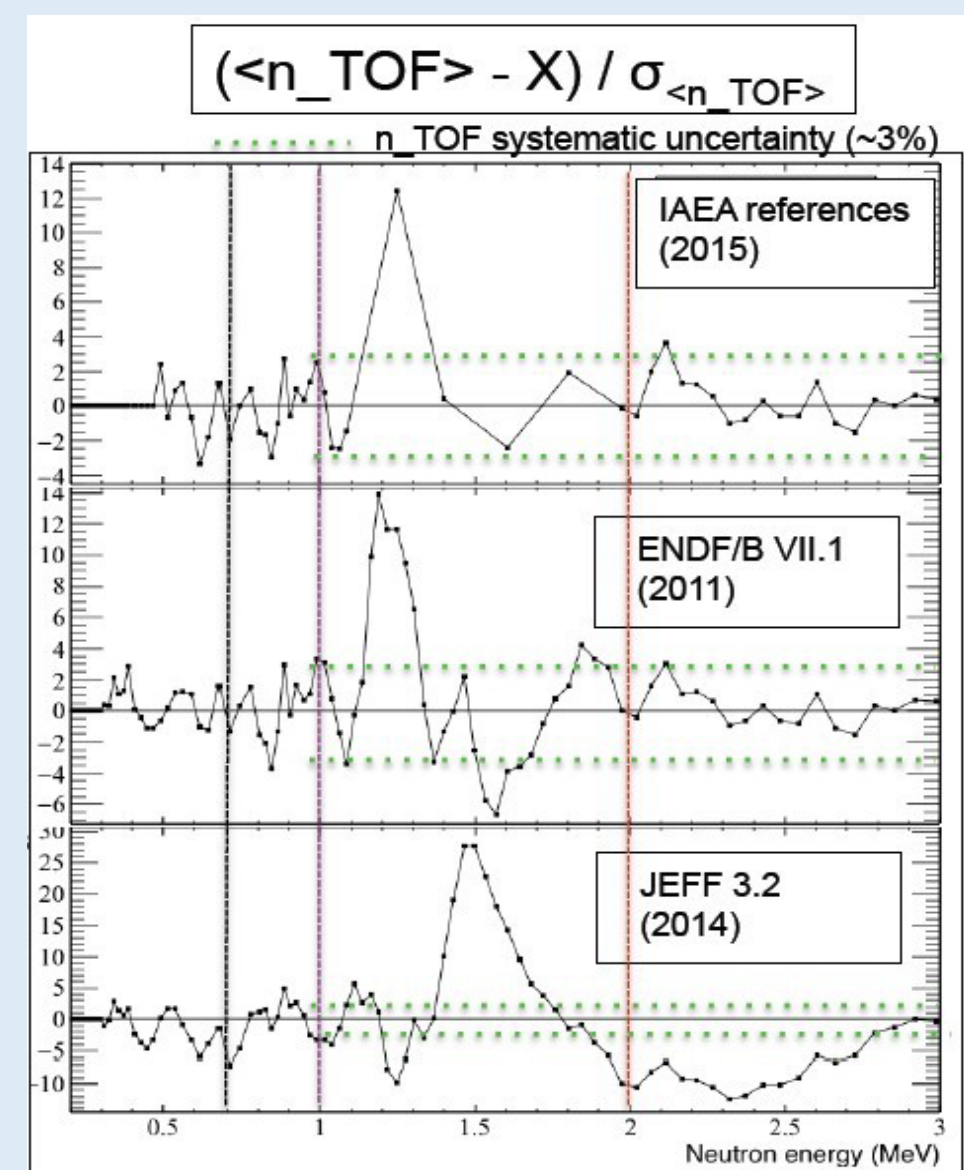
- Thin (50 to 300 microg/cm<sup>2</sup>), large (8 cm) targets
- Ultra-thin backing: fragile but transparent for fragments
- Purification and electroplating at Orsay
- High-resolution characterization (RBS + alpha scan)



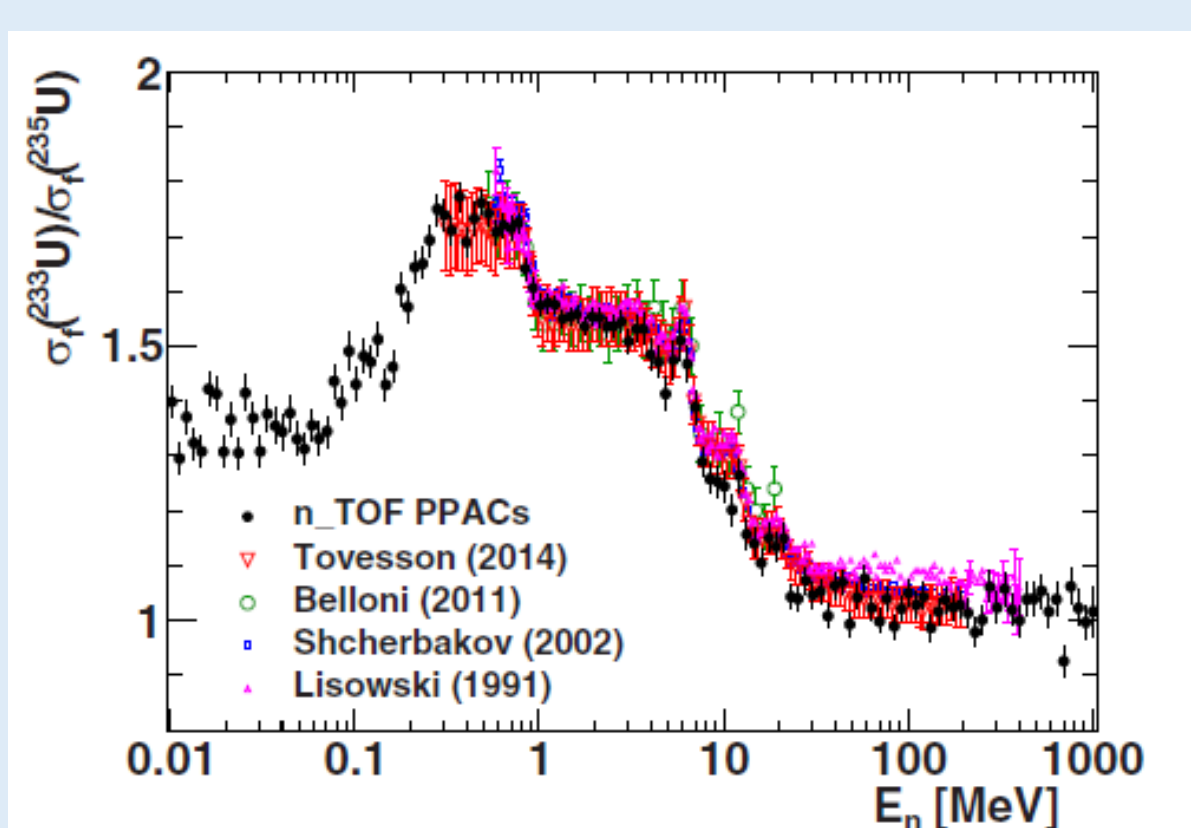
D. Tarrío et al., Nucl. Instr. Meth. A 743, 79 (2014)

## Cross sections

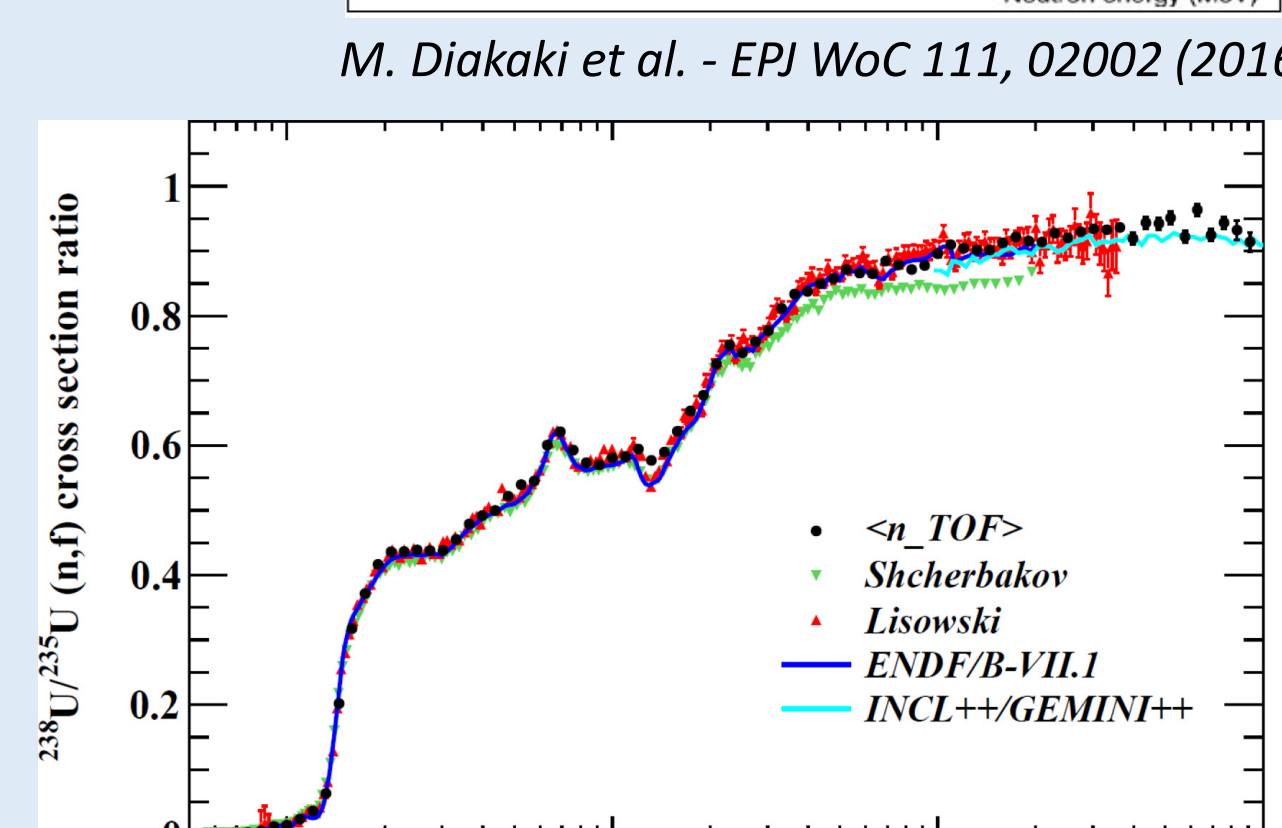
- 8 systems : <sup>233,234,235,238</sup>U, <sup>237</sup>Np, <sup>232</sup>Th, <sup>209</sup>Pb, <sup>nat</sup>Pb
- Continuous measurement from thermal to spallation regime
- Systematics errors down to 3%
- Detailed comparisons with models and databases



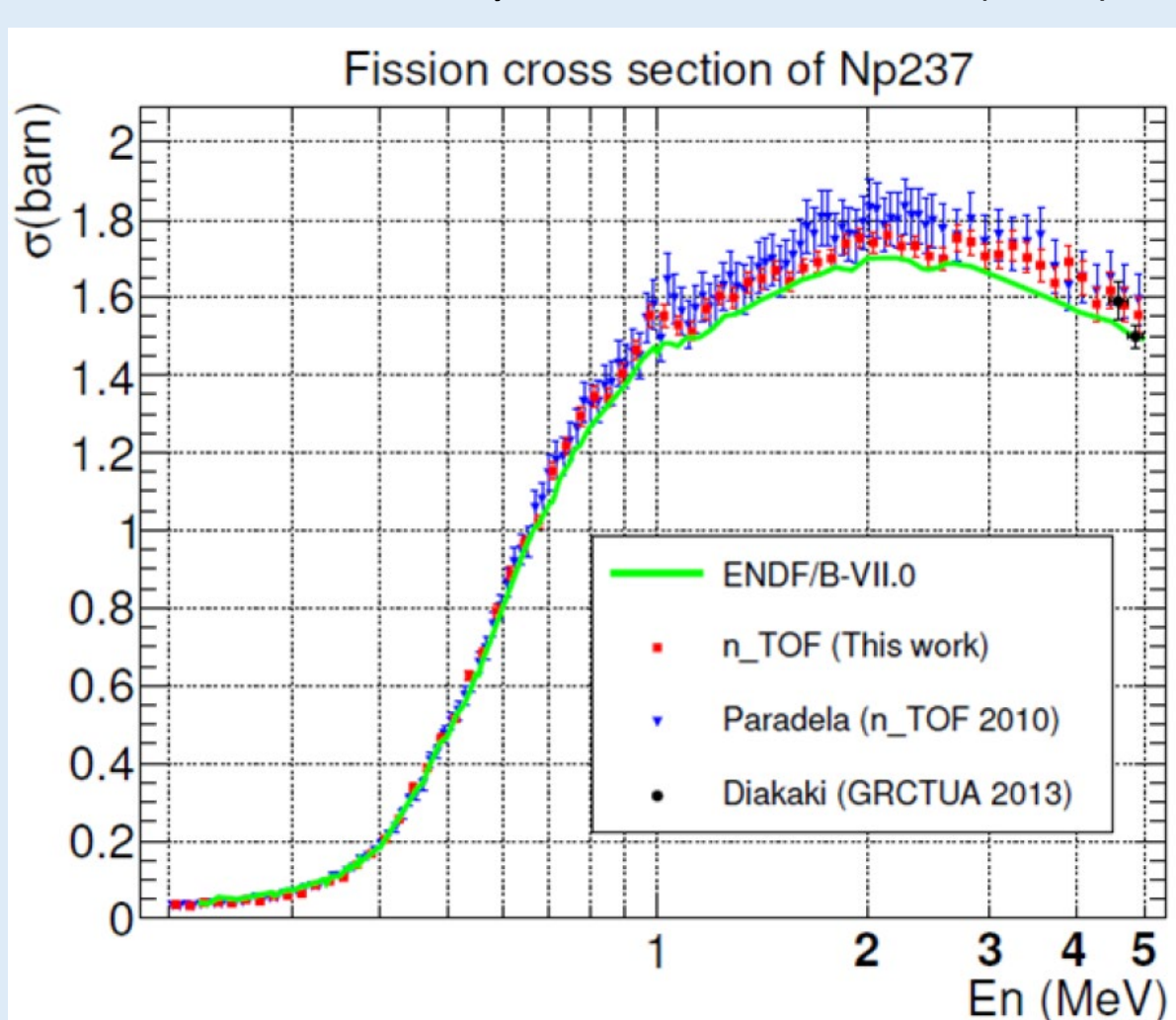
M. Diakaki et al. - EPJ WoC 111, 02002 (2016)



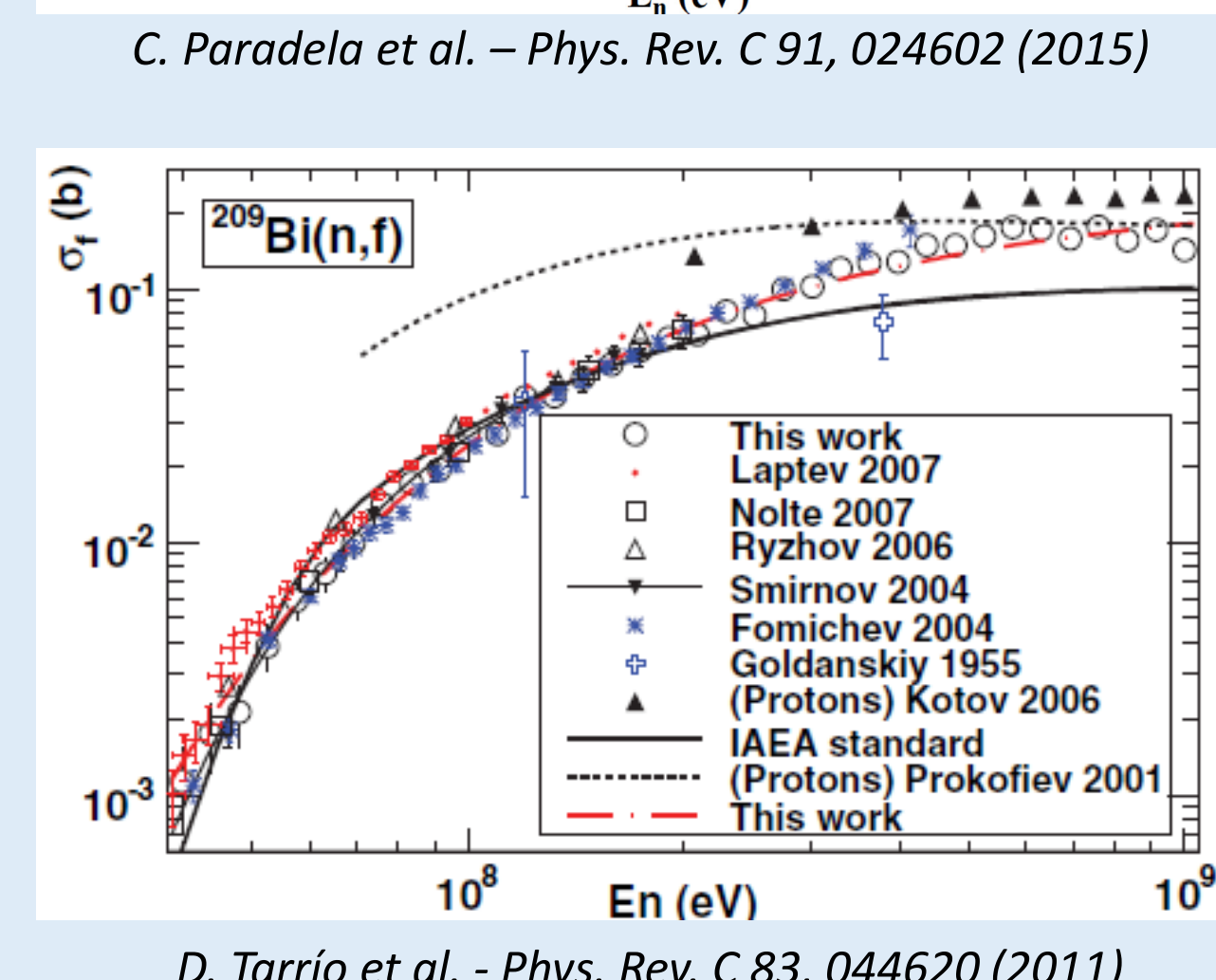
D. Tarrío et al. - Phys. Rev. C 107, 044616 (2023)



C. Paradela et al. - Phys. Rev. C 91, 024602 (2015)



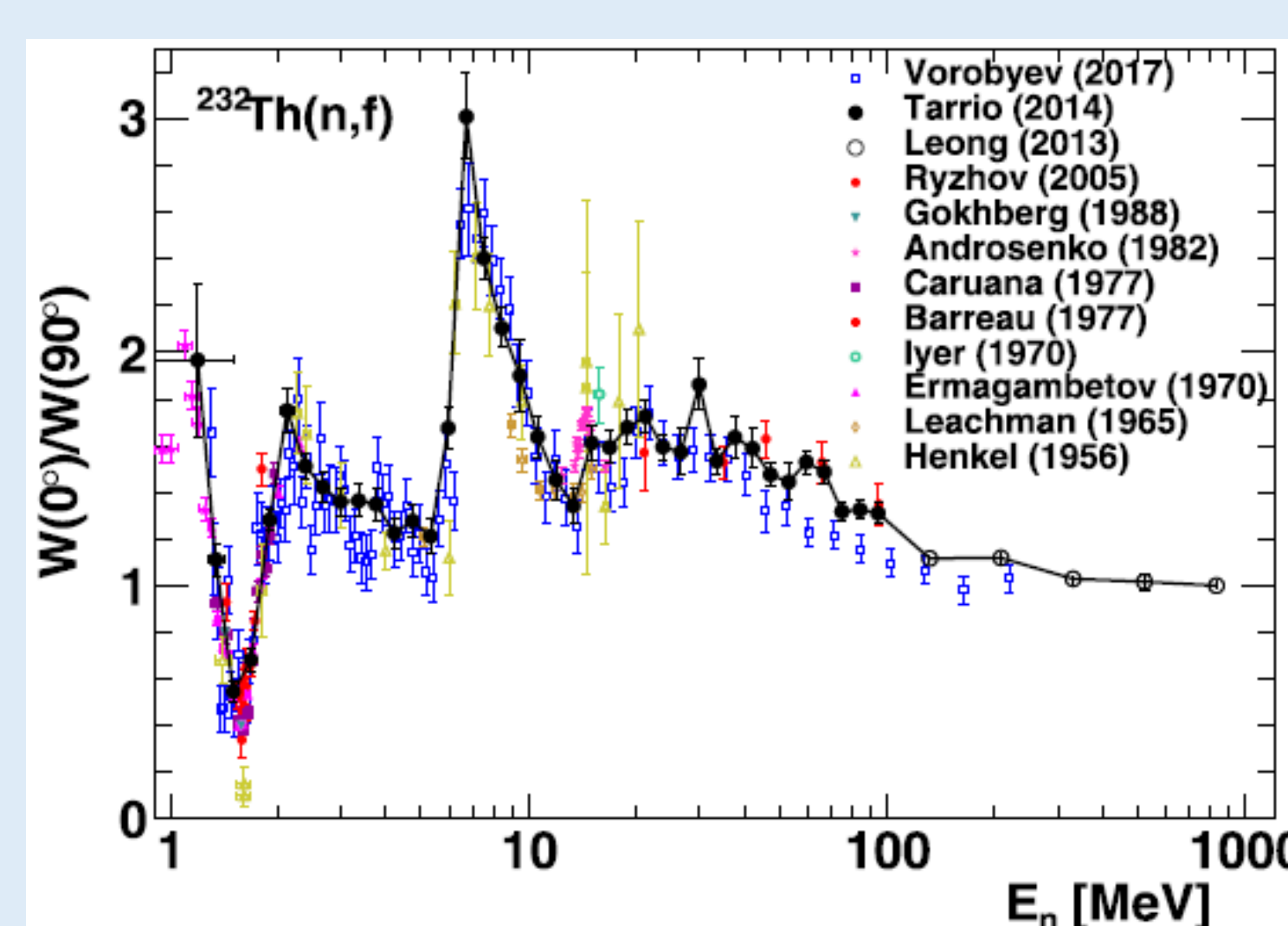
L. Tassan-Got et al. - EPJ WoC 211, 03006 (2019)



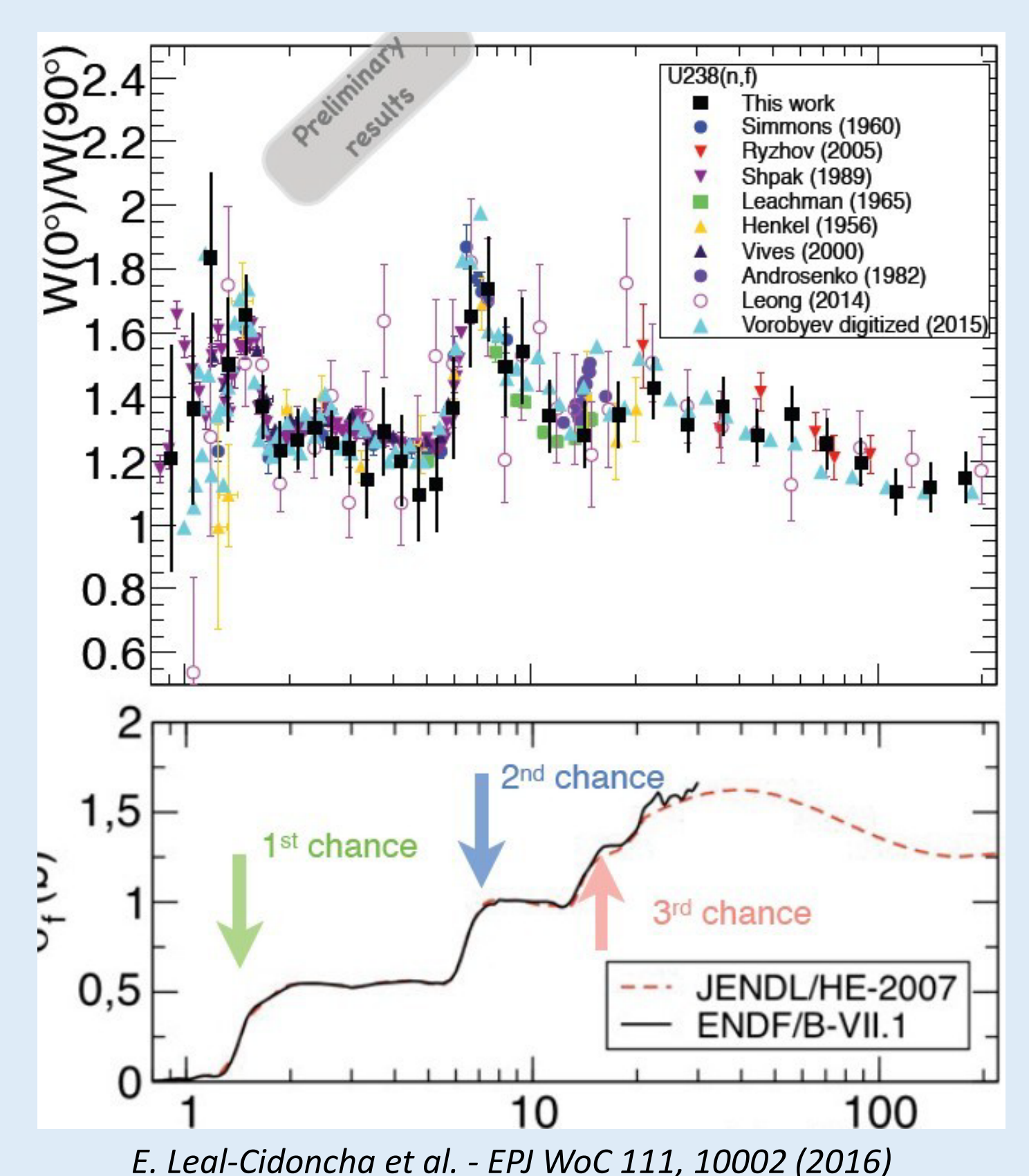
D. Tarrío et al. - Phys. Rev. C 83, 044620 (2011)

## Fission anisotropy

- Low-energy fission presents strong anisotropies
- Signature of transition states at scission



D. Tarrío et al. - Phys. Rev. C 107, 044616 (2023)



E. Leal-Cidoncha et al. - EPJ WoC 111, 10002 (2016)

## Outcome of the program

- Most measurements integrated to data libraries
- Optimized detection system, beam monitoring at nTOF and NFS
- IN2P3 canceled the participation to nTOF...
- ... but at least one experiment is planned there on low-Z fission...
- ... and Pu isotopes await.