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#6-272 The photofission reaction against the illicit transport of nuclear material in cargo containers: A review on recent achievements and future challenges in active photon interrogation

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The photofission reaction, which forms the basis of the Active Photon Interrogation (API) nuclear measurement technique, is of great interest from fundamental to applied physics, in particular as part of security checks on cargo containers to detect Special Nuclear Material (SNM) at border controls, as uranium and plutonium isotopes could be potentially involved in terrorist attacks. To prevent illicit trafficking of SNM in Europe, inspection of cargo containers is required at borders and X-ray scanning techniques are widely used by customs to control visually containers. If the images show a suspicious area, a second line technology based on the photofission reaction could be used to detect SNM in a non-destructive manner. This paper reviews recent developments in photofission through a saga built around three successive projects of the European Union's Horizon 2020 research and innovation programme, and identifies future challenges to be addressed in API. In the frame of the C-BORD project (2015–2018), the largest seaport in Europe (*Maasvlakte*, in the suburbs of Rotterdam, Netherlands), was chosen to test the first stationary photofission measurement system dedicated to SNM detection in cargo containers in Europe, where 9 MeV electron accelerators are used day-to-day in industrial operations by Dutch customs for X-ray scanning. Experimental tests have been carried out on depleted uranium samples and mock-ups of cargo containers. Setting up a temporary API system on an industrial facility initially designed for X-ray scanning was a challenge, which has been successfully met. In the frame of the ENTRANCE project (2020–2023), the capability of SNM detection in cargo containers at the European borders was tested with a mobile system including a more compact 7 MeV X-ray scanner, thereby challenging the 5–6 MeV energy threshold of the photofission reaction on actinides (²³⁵U, ²³⁸U, ²³⁹Pu, etc.). We go through the field tests conducted at the *Škrljevo* container terminal at the port of Rijeka, Croatia, using the 7 MeV mobile X-ray scanner operated in photofission mode, samples of depleted uranium and a mock-up of cargo container. The performance as well as the limitations of such a system are examined. More recently, in the frame of the MULTISCAN 3D project (2022–2025), a major breakthrough in the field of API has been achieved. The feasibility of implementing the photofission reaction on depleted uranium using an Inverse Compton Scattering (ICS) source based on a femtosecond laser was demonstrated experimentally. This world first, at the frontier of three physics –laser, plasma, nuclear –paves the way for groundbreaking technologies in nuclear security and border control, which steers future researches and developments in the field of API towards a technological revolution in the fight against illicit trafficking of SNM by photofission.

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