

## Advanced Nuclear Measurements and Systems for Facilitating the Implementation of Safeguards and Safeguards-By-Design in SMR, AMR and Microreactor

**Authors :** Massimo Morichi

**Abstract :** Over the last five years, starting in 2019, several nuclear measurement systems have been conceived and realized for specific nuclear safeguards applications, as well as for nuclear security, implementing some innovative technologies and methods for attended and unattended nuclear measurements. Some of those technologies imply the integration of combined gamma and neutron detection systems both for counting and spectroscopic applications that allow the SNM (Special Nuclear Material) verification and quantification through specific simultaneous measurements (gamma and neutron) from standard to high count rate due to high flux irradiation. IAEA has implemented some of these technologies in key international safeguards inspections worldwide, like a Fast Neutron Collar Monitor for fresh fuel verification of U235 mass (used during inspections for material declaration verification) or for unattended measuring systems with a distinct shift register installed in an anti-tampering sealed housing in unattended mode (remote inspection and continuous monitoring) together with an Unattended Multichannel Analyzer for spectroscopy analysis of SNM like canisters. Such developments, realized with integrated mid-resolution scintillators (FWHM: <3,5%) together with organic scintillators such as Stilbene detectors or Liquid sealed scintillators like EJ-309 with great pulse shape discrimination managed by a fast DAQ and with a high level of system integration, are offering in the near term the possibility to enhance further their implementation, reducing the form factor in order to facilitate their implementation in many critical parts of the Nuclear Fuel Operations as well as of the Next generation of Nuclear Reactors. This will facilitate embedding these advanced technical solutions in the next generation of nuclear installations, assuring the implementation of the Safeguards by Design requested by IAEA for all future/novel nuclear installations. This work presents the most recent designs/systems and provides some clear examples of ongoing applications on the Fuel Cycle-Fuel Fabrication as well as for the SMR/AMR and microreactors. Detailed technology testing and validation in different configuration is provided together with some case-studies and operational implications.

**Keywords :** nuclear safeguard, gamma and neutron detection systems, spectroscopy analysis, nuclear fuel cycle, nuclear power reactors, decommissioning dismantling, nuclear security

**Conference Title :** ICRRP 2025 : International Conference on Radioactivity and Radiation Protection

**Conference Location :** Bangkok, Thailand

**Conference Dates :** December 16-17, 2025