Multi-Probe Tomography for Scientific Applications and Nuclear Safeguards

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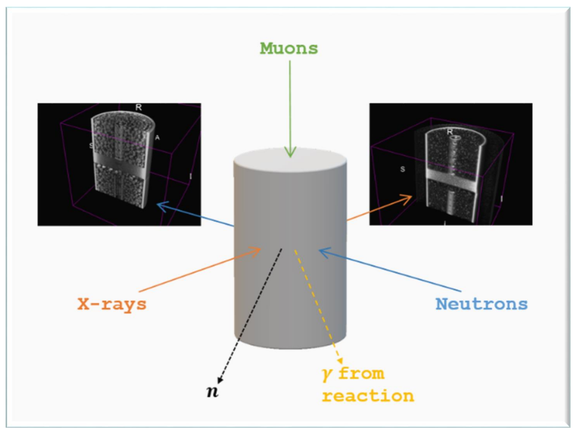
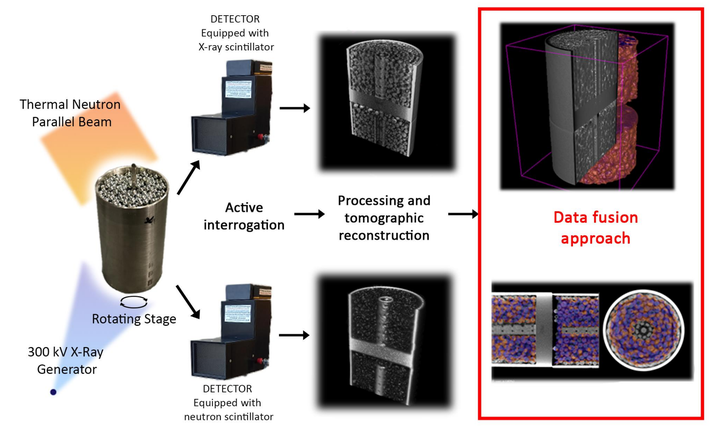
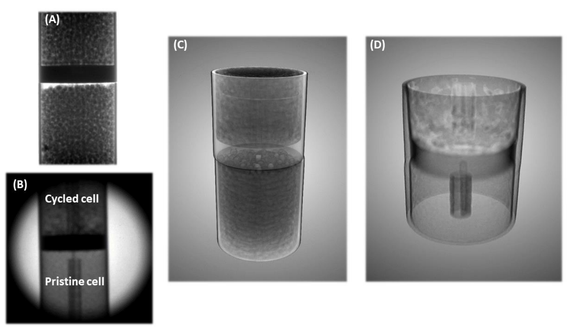


- **Multi probe imagining** (e.g. keV to MeV X-rays, meV to 10's MeV neutrons, electrons, protons, muons…) is a modality in which multiple species are utilized to provide additional information on the interpretation of data compared to single species radiography.
- Evolution of the active and passive approaches developed in nuclear material detection for safeguards applications
- **Signatures** (e.g., correlated neutron, gamma spectra in the detection and assay of nuclear material…) are key outputs of the method

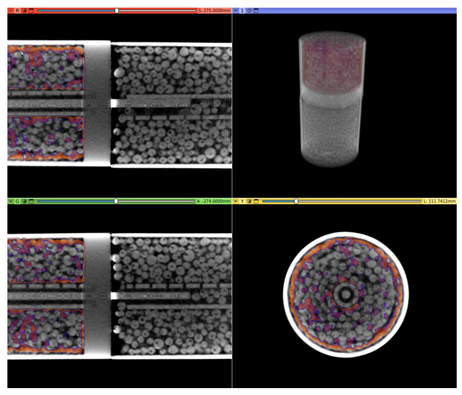
A multi-probe imaging and signatures approach

Applications:
Multi-probe 4D tomography for morphological and electrochemical features of Zn-based battery technologies





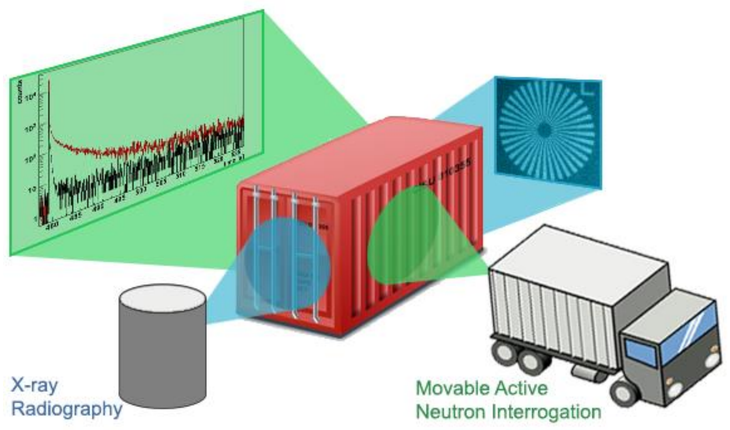
- ✓ X-ray, neutron imagining radiography and 3D reconstruction



- ✓ Combining X-ray and neutron tomography: color highlights the distribution of hydrogenated materials

Applications:
Nuclear safeguards and security application

Increase the performance of diagnostic systems
to respond to the increasing complexity of nuclear technology



(from: A.Favalli et al, Multi-probe radiography with laser-driven particle/X-ray sources, 2021 EAPPC, BEAM, MEGAGAUS, Invited talk, September 2021)

- ✓ Multi-probe active interrogation of special nuclear material
  - ✓ Use of external neutron source to induce fission (detection of signatures, e.g. Delayed and prompt neutrons and time correlated neutron) and for imagining
  - ✓ Use external X-ray to image contents as complementary to neutrons
- ✓ Neutron & Muon dual-probe imagining and nuclear material signatures of spent nuclear fuel casks

Multi-probe imaging and signatures technique enhances material discrimination and assay for nuclear safeguards and scientific applications.

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