IAEA
International Atomic Energy Agency

The Nuclear Science and Instrumentation Laboratory (NSIL)

Serving member states

Kalliopi Kanaki

Department Nuclear Sciences & Applications

Division Physical & Chemical Sciences

Physics Section

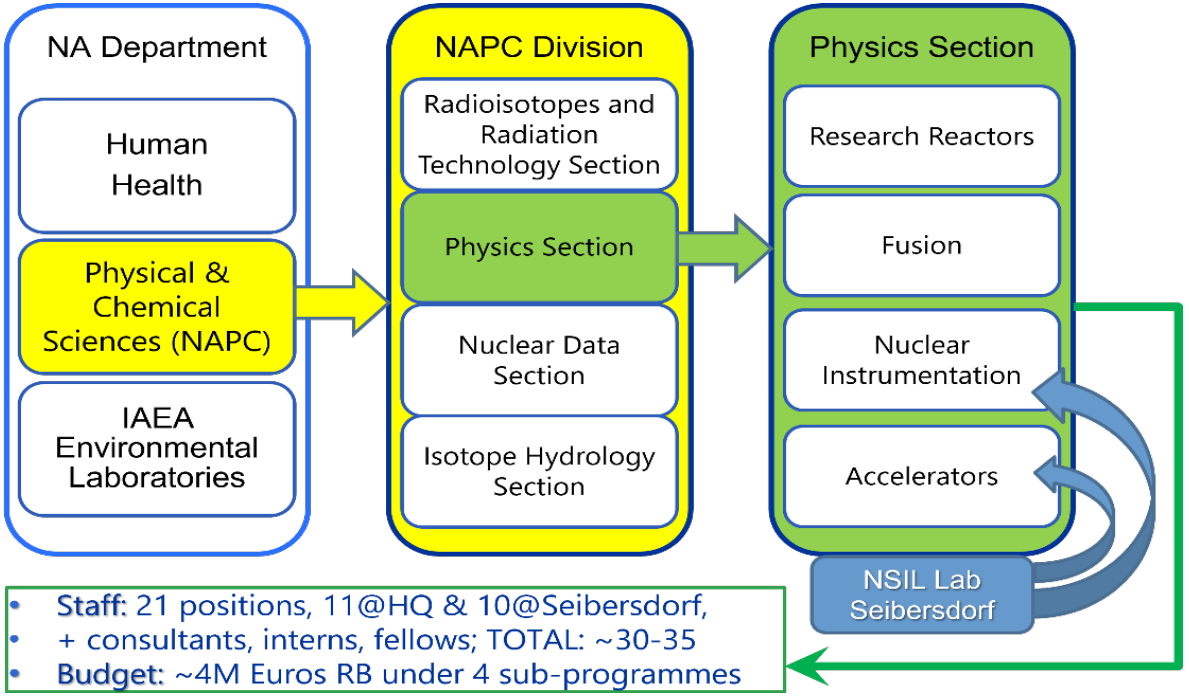
nsil@iaea.org & physics@iaea.org

An autonomous international organization within the United Nations system

173 Member States; 2500+ staff from over 100 Member States; HQ in Vienna

- Labs in Seibersdorf, Vienna and Monaco
- Regional offices in Toronto and Tokyo; Liaison offices in New York and Geneva

The Department of Nuclear Science and Applications (NA)



- **Staff:** 21 positions, 11@HQ & 10@Seibersdorf,
- + consultants, interns, fellows; TOTAL: ~30-35
- **Budget:** ~4M Euros RB under 4 sub-programmes

12 Laboratories@IAEA

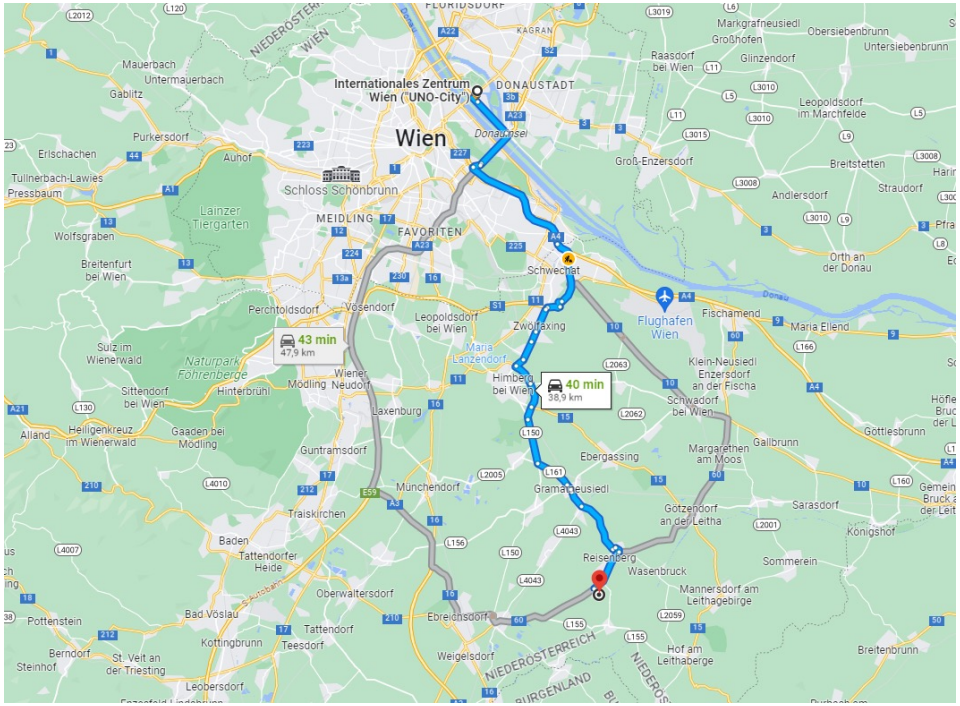
under the Department of Nuclear Sciences and Applications

- Vienna
  - Isotope hydrology
- Monaco
  - Radioecology
  - Radiometrics
  - Marine Environmental Studies
- Seibersdorf
  - Plant Breeding and Genetics
  - Soil and Water Management & Crop Nutrition
  - Animal Production and Health
  - Insect Pest Control
  - Terrestrial Environmental Radiochemistry
  - Dosimetry
  - Food Safety and Control
  - **Nuclear Science and Instrumentation**

https://www.iaea.org/virtual-tours/nuclear-sciences-and-applications

Location of NSIL

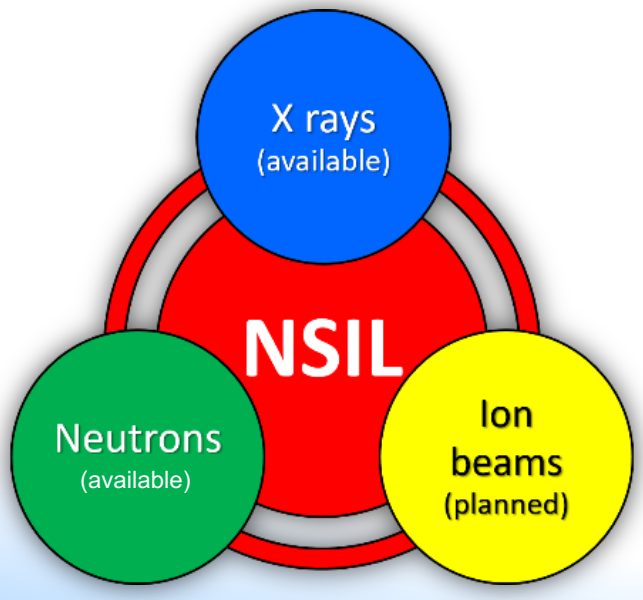
40 Km south of Vienna



“Sharing” site with
Austrian Institute of Technology &
CTBTO

Lab mission

- To assist the IAEA member states in introducing and extending the use of nuclear instrumentation and radiation measurement techniques, including related capacity building
- Achieved via dedicated trainings, fellowships, internships, scientific visits (duration 1 week – 1 year), expert missions, services, R&D projects



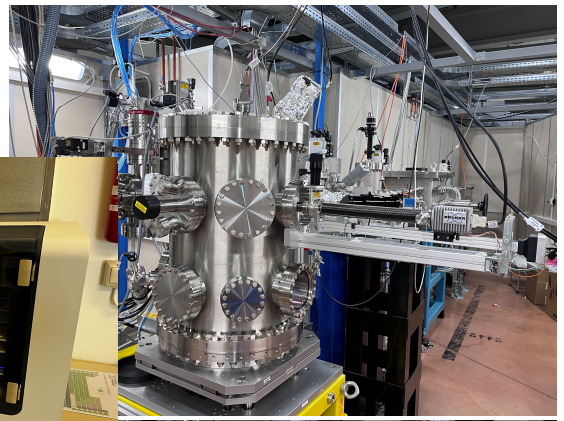
Nuclear Science and Instrumentation Portal

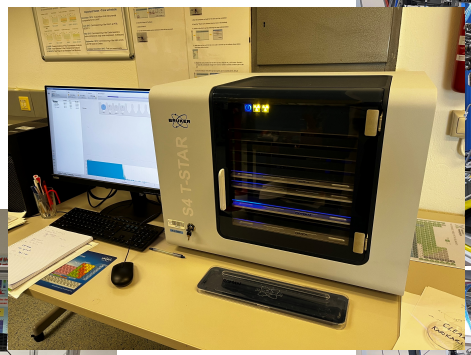
X-ray instrumentation available

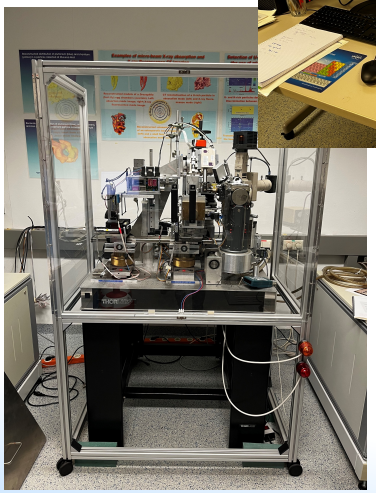
- Secondary Target – Energy Dispersive XRF
- Wavelength Dispersive XRF
- Total reflection XRF
- μ and confocal XRF
- Full Field XRF
- SEM-EDS
- XRF 2D scanner (under development in cooperation with ICTP-MLAB)
- Handheld XRF
- Transportable XRD
- Sample preparation for solids and liquids

Elettra Sincrotrone, Trieste

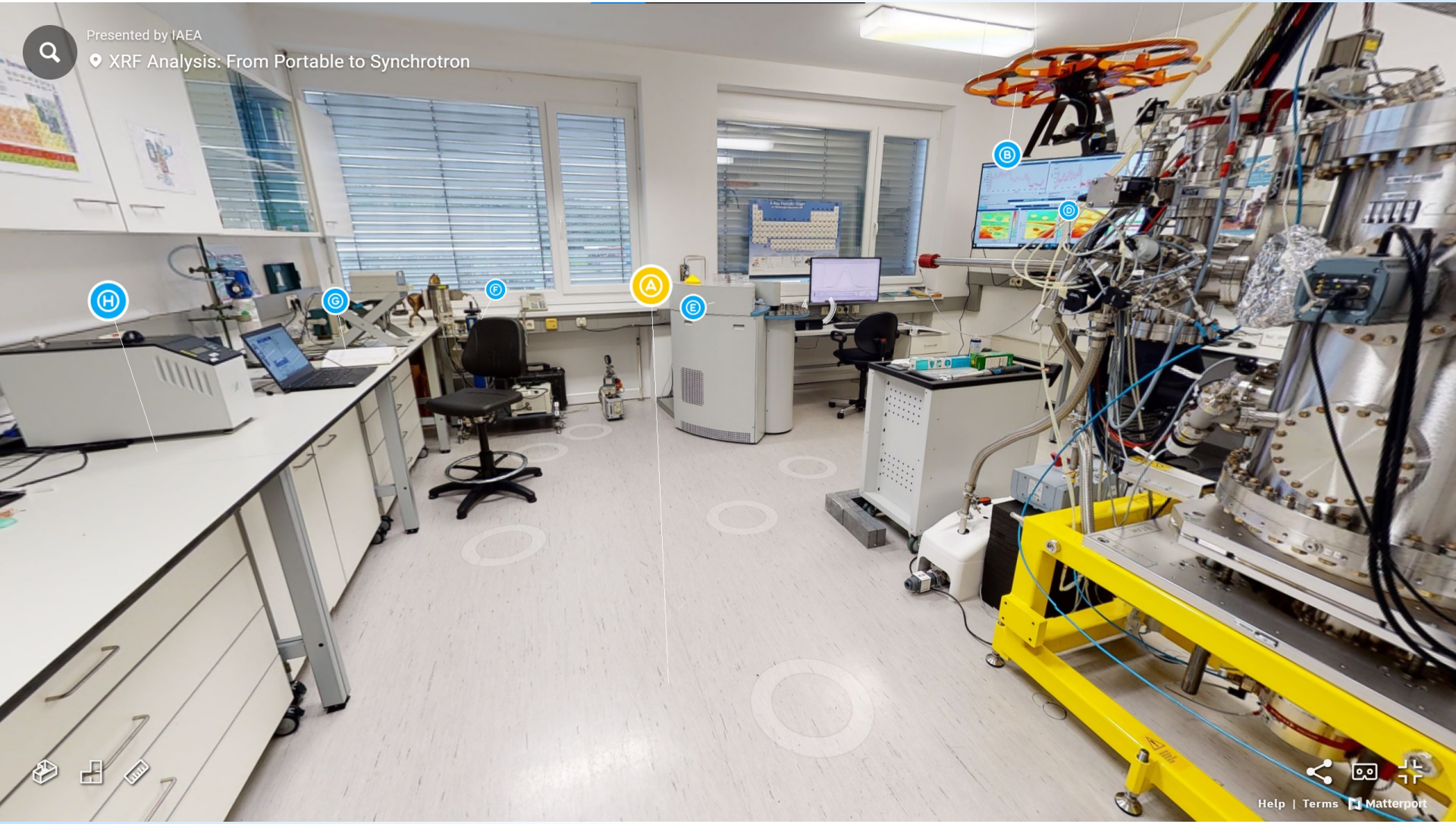
XRF beamline:
https://iaea.mediasite.com/Mediasite/Play/9e939d26d0fe4bc1b4174e72a3ebb0c81d



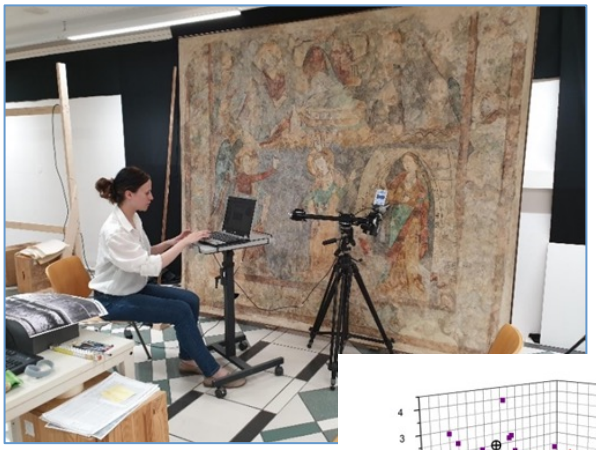




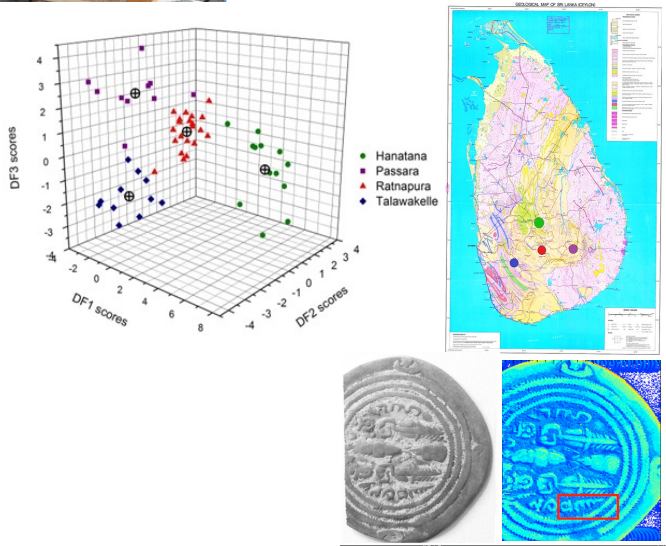
Wide view of one of the NSIL XRF rooms



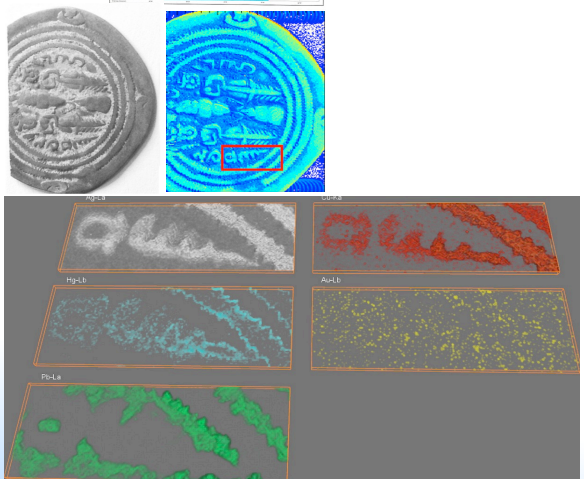
Examples of past and current projects



Inspection of a mural painting at the Vienna Institute of Conservation and Restoration



Identification of Sri Lankan tea regional provenance based on their elemental and stable isotope contents



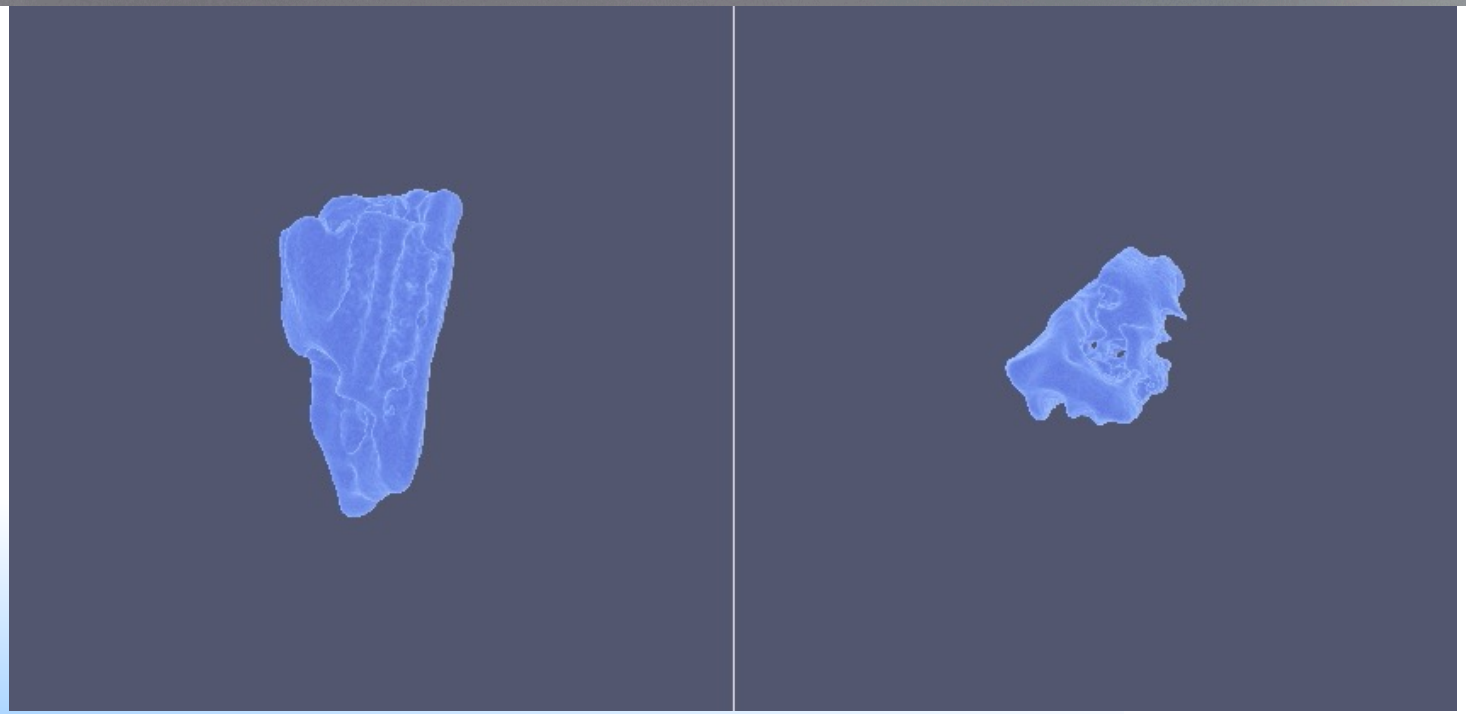
2D and 3D distribution of elements in the altered surface of ancient silver coins

2D XRF scanner (ICTP-NSIL collaboration)

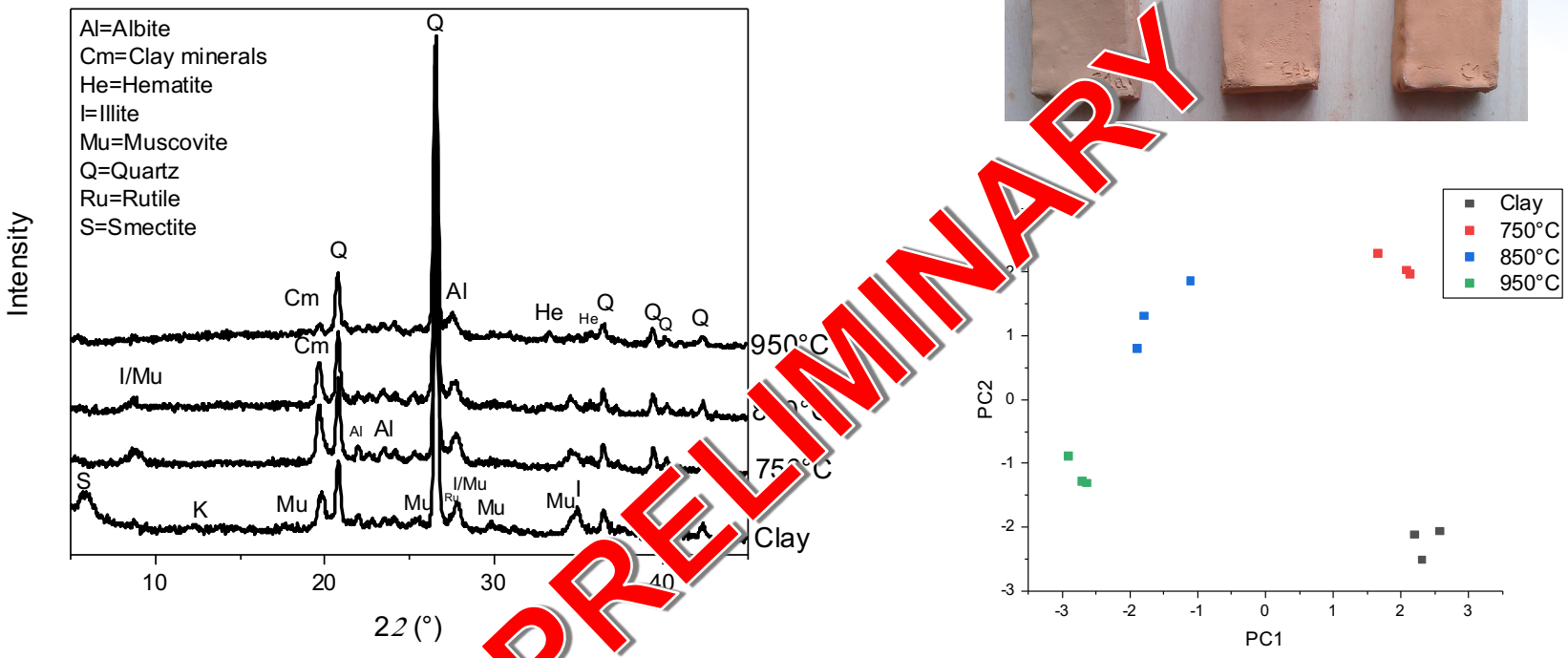
Applications in cultural heritage, e.g. scanning of painting surfaces

Coral slab XRF spectrometry and X-ray tomography

Quantification of Ba, Sr, Ca concentrations for extraction
of water acidity/temperature information

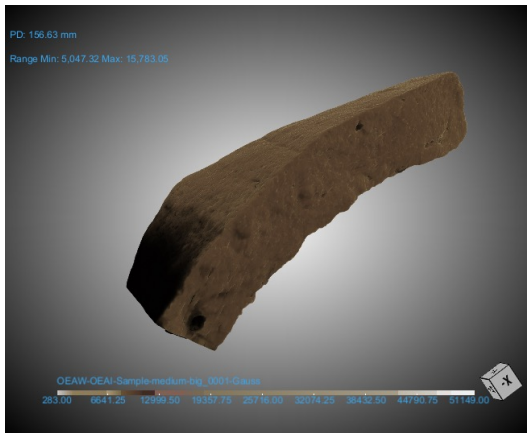


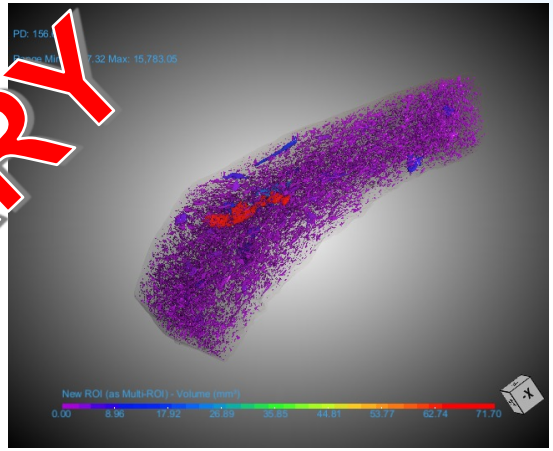
XRD analysis of Roman roof tiles from Noricum (modern day Italy-Slovenia)



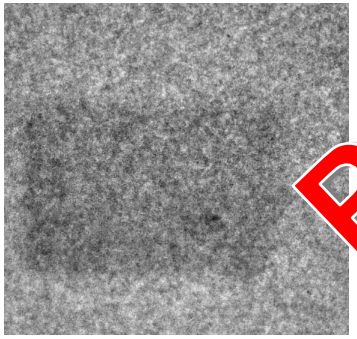
XRD patterns of raw clay and experimental bricks prepared fired at different temperatures (left) and PCA analysis of the XRD patterns (right). The PCA analysis helps create a reference for estimating the firing temperature of ancient bricks just by examining their diffractograms.

Combined porosity analysis of a Roman roof tile by μ-CT and neutron radiography

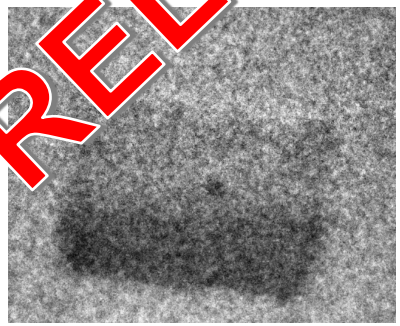




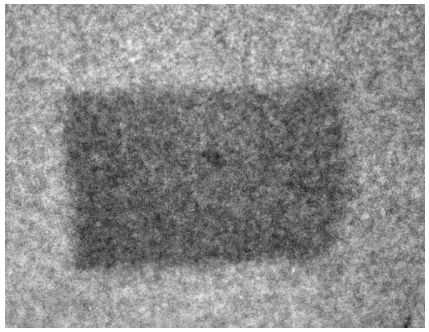
PRELIMINARY



Water uptake Time 0



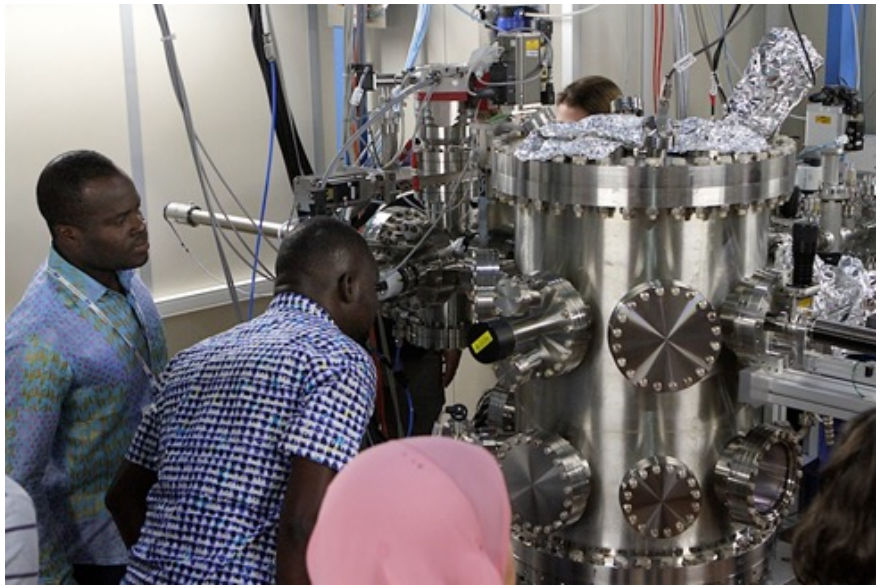
Time: 10 min



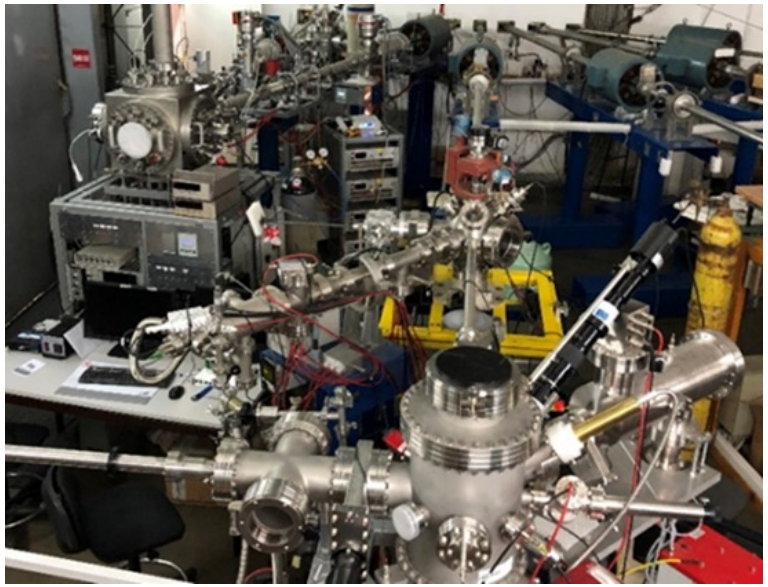
Time: 40 min

Access to accelerator facilities

- Collaboration with Elettra synchrotron (Trieste, Italy)
  - Annual Training Workshop on Synchrotron Technologies and Techniques and their Applications
- Collaboration with Rudjer Boskovic Institute ion beam facility (Zagreb, Croatia)
  - Biannual Training Workshop on Accelerator Technology, Associated Instrumentation, Including Operation and Maintenance Aspects



Researchers attending hands-on-training at the IAEA X-ray spectrometry end-station at the X-ray Fluorescence beamline in Elettra Sincrotrone



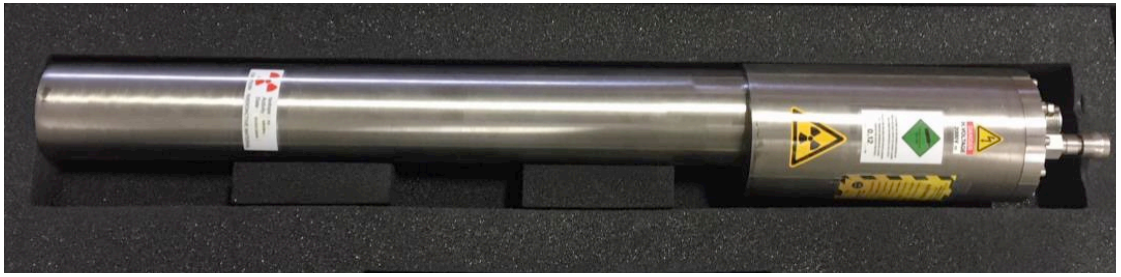
Beamlines at the RBI accelerator facility

The Neutron Science Facility (NSF)

Neutron sources at the NSF

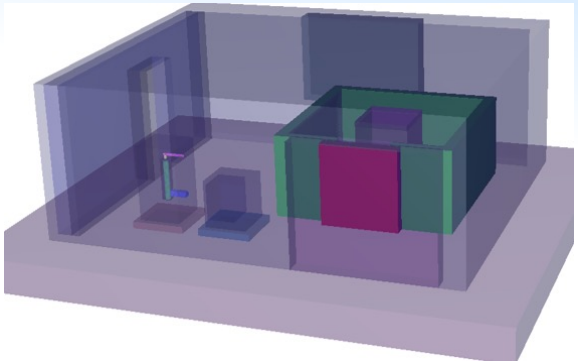
Sealed tube neutron generators

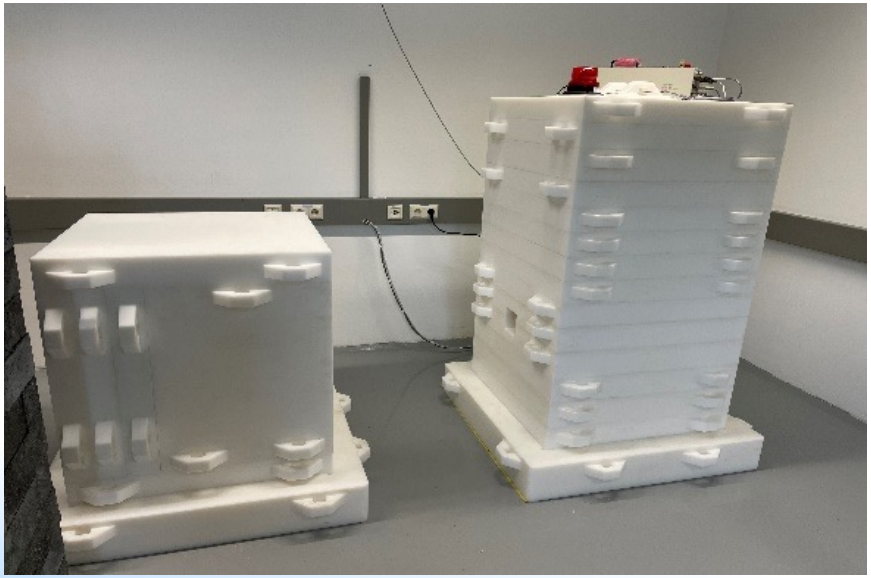
- DD (Thermo Fisher): 2.45 MeV neutrons, emission rate up to 5e6 n/s
- DT (Sodern, donated by CSIRO, Australia): 14.1 MeV neutrons, emission rate up to 2e8 n/s
- To be commissioned: DT (Thermo Fisher): 14.1 MeV neutrons, emission rate up to 5e8 n/s

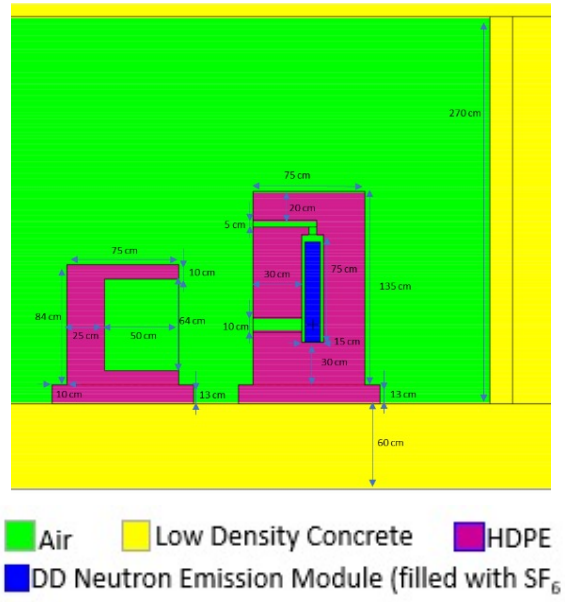


DD shielding setup

- DD operated in polyethylene shielding
- 1 horizontal closable beam channel available
- Activation possible inside the shield along the way of the channel
- Beam stop in front of the channel

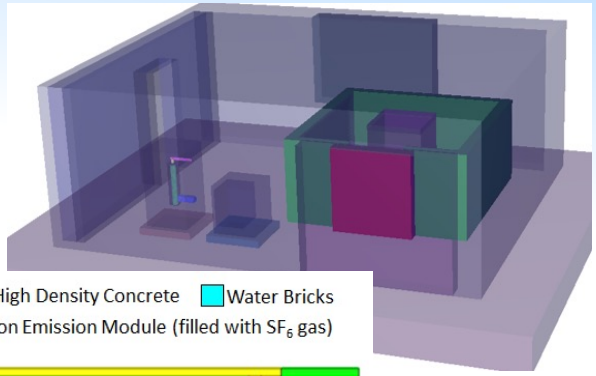


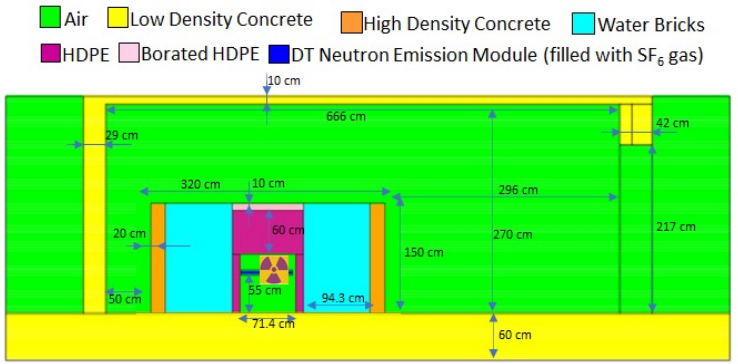


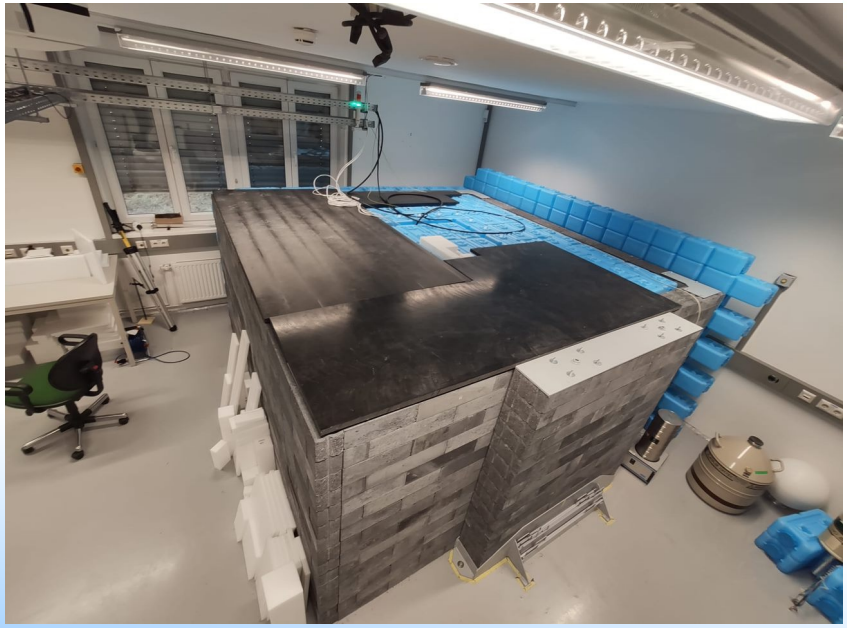


DT shielding setup

- DT operates in mixed water-bricks /polyethylene/conrete shielding
- Irradiation cavity accessible from top through vertical channel 12 cm x 15 cm

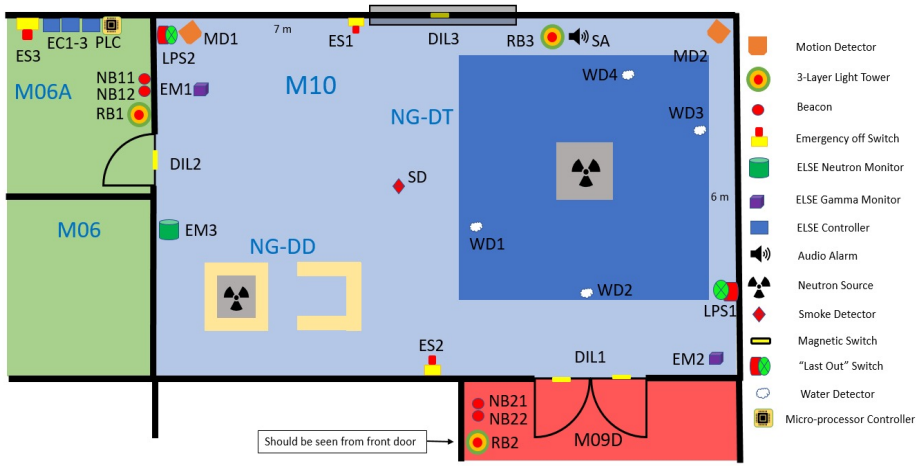






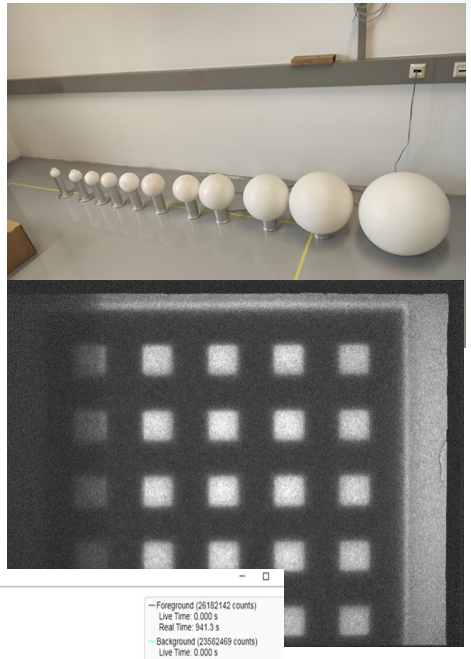
Safety and radiation monitoring systems

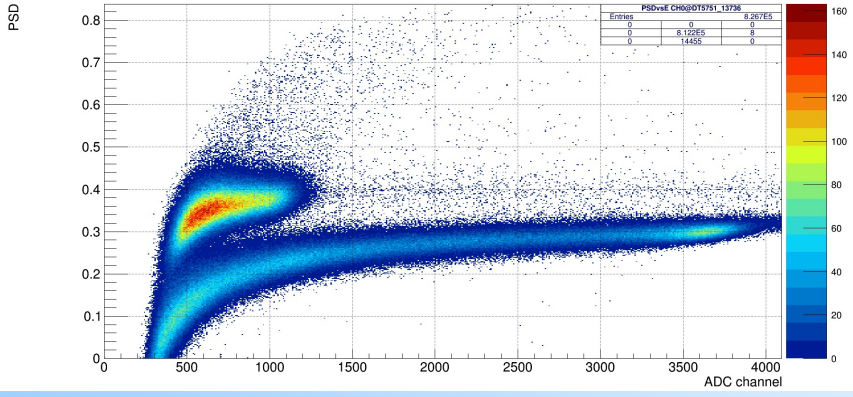
- The facility safety system resembles bigger facilities for training purposes
- One neutron (BF_3 based) and two gamma dose rate meters
- Several TLDs at the boundary of control area
- Interlock system includes emergency-off buttons, motion sensors, magnetic trip switches placed on the doors and windows, smoke detector and four water leak detectors, “last person” out switches, and radiation monitoring system.

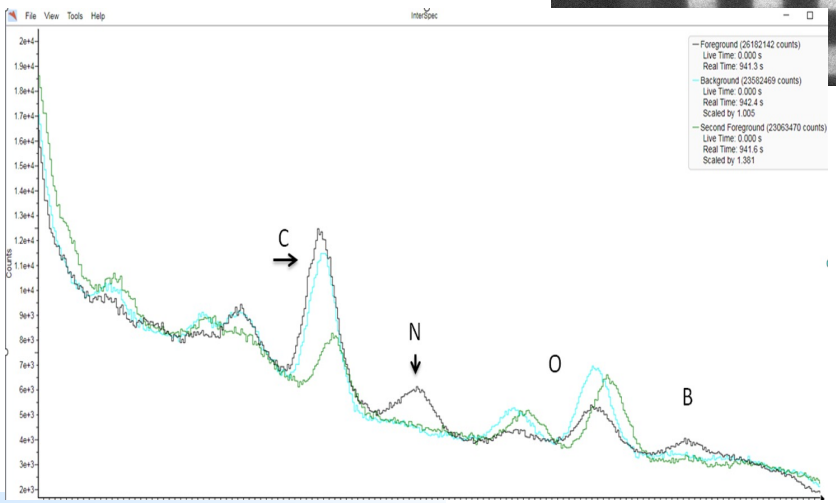


Training topics with neutrons

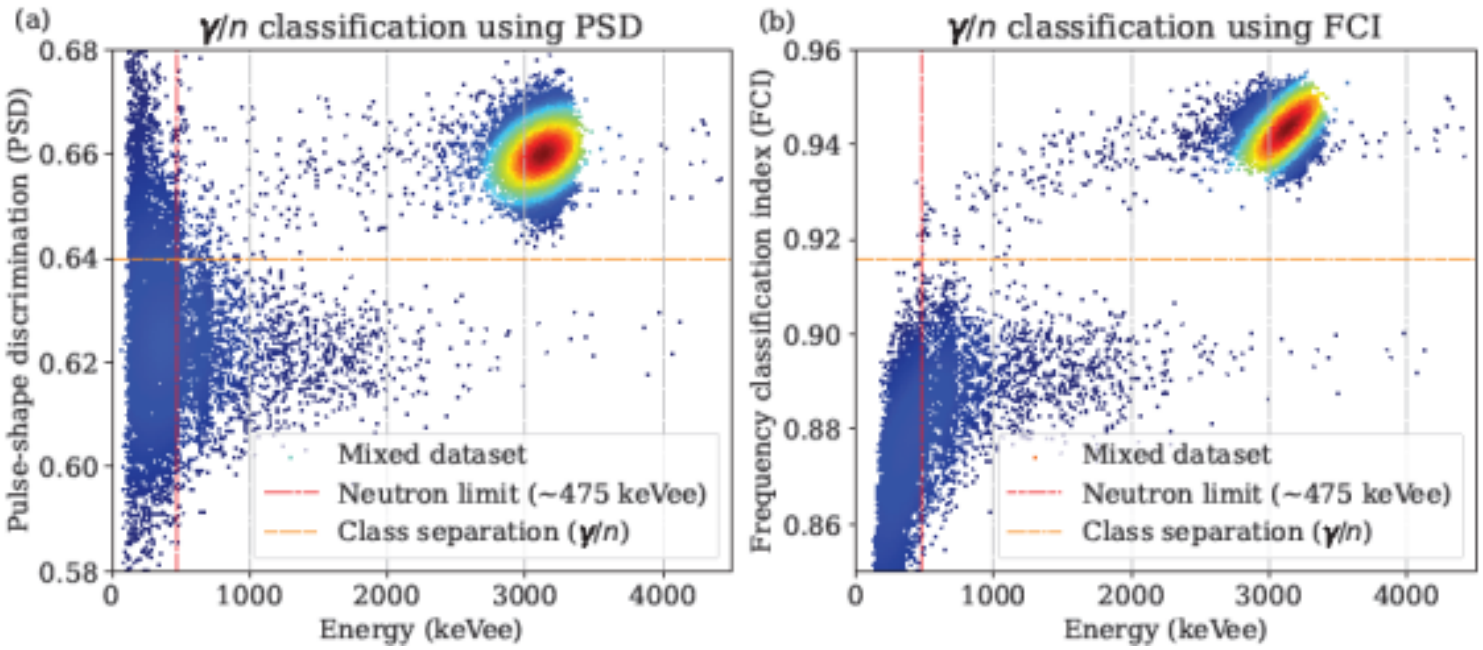
- Operation & maintenance of neutron facility based on DD/DT generators
- Radiation protection with neutron and gamma fields
- Neutron instrumentation
  - Neutron detection
  - Neutron spectrometry
- Dual neutron/X-ray imaging
- Neutron activation analysis (NAA)
- Prompt and delayed gamma analysis
- Delayed neutron counting
- Demonstration of radiotracer production and usage (in progress)







Use of NSF for R&D



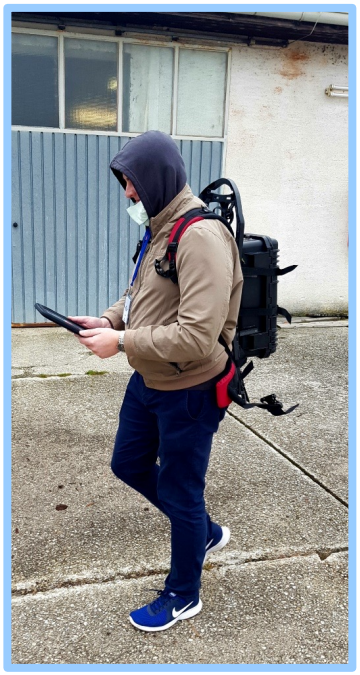
Ivan Morales et al., "Gamma/neutron classification with SiPM CLYC detectors using frequency-domain analysis for embedded real-time applications“,
DOI: https://doi.org/10.1016/j.net.2023.11.013

Nuclear Instrumentation - In-Situ

RSS-131
High Pressure
Ionization Chamber

μ-DETECTIVE
HPGe In-Situ Gamma
Spectroscopy System

AEGIS
HPGe In-Situ Gamma
Spectroscopy System



PGIS (Upgrade)
Backpack Gamma
Spectrometer

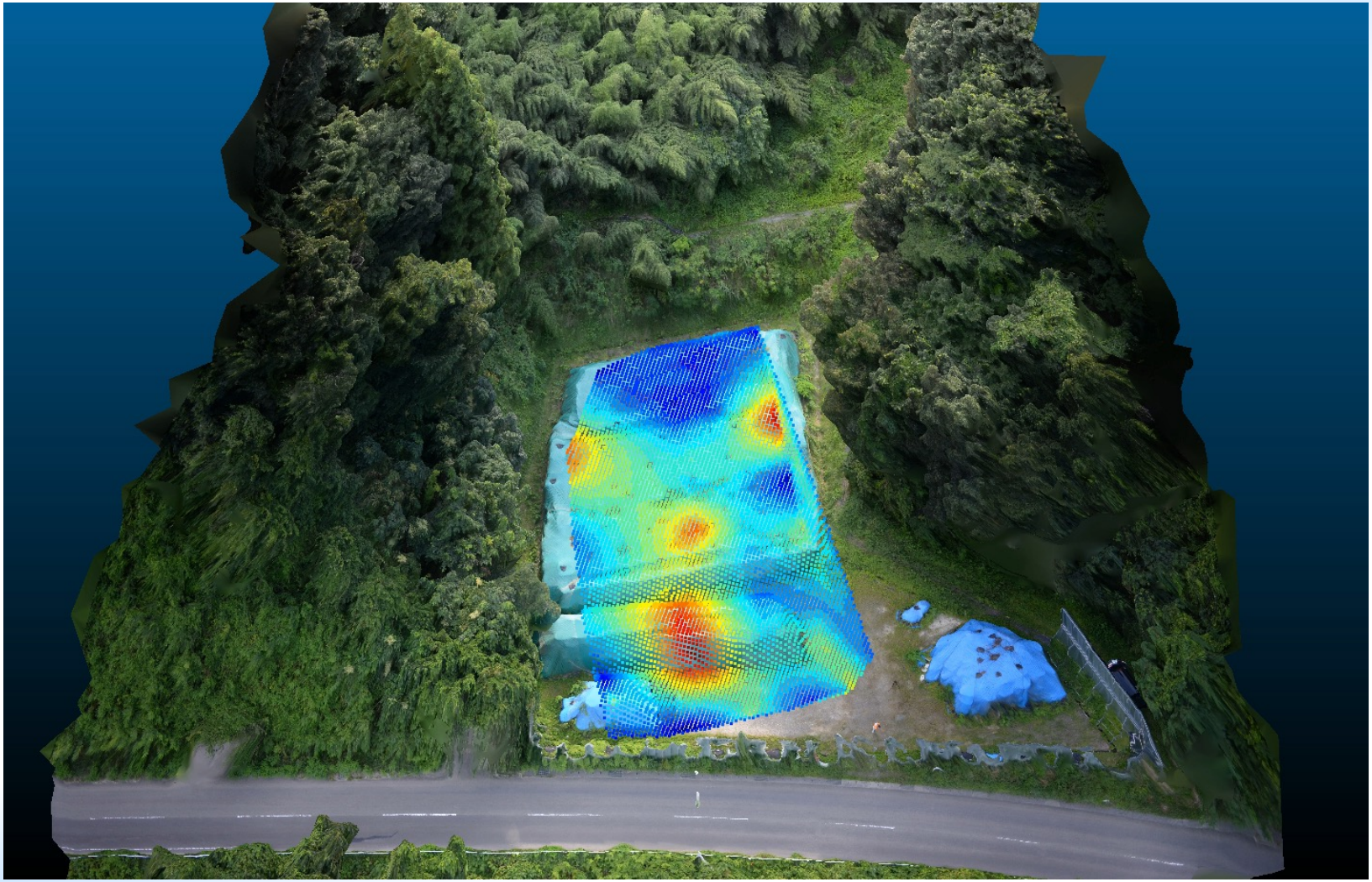
Nuclear Instrumentation - Mobile & UAV

Mobile & Backpack Techniques of Radiological Mapping

Aerial (UAV) Techniques of Radiological Mapping

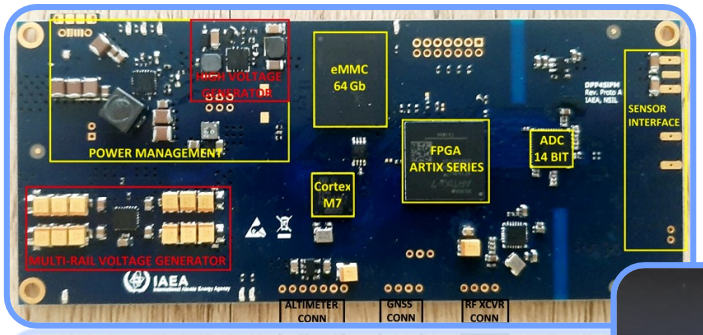
Support to Fukushima Prefecture

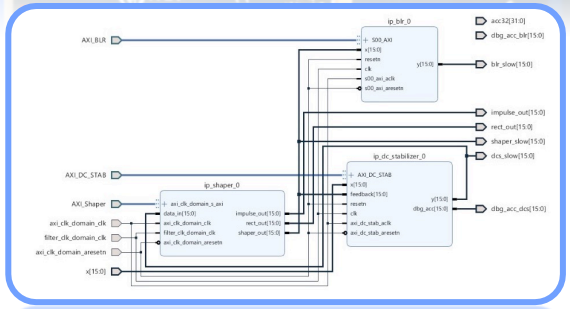
3D Photogrammetry Results:
Characterization of Temporary Waste Storage Site



Development work on UAV

Digital Pulse Processor for UAV (MCA)





New Firmware for DPP

New Type of
SiPM Detectors

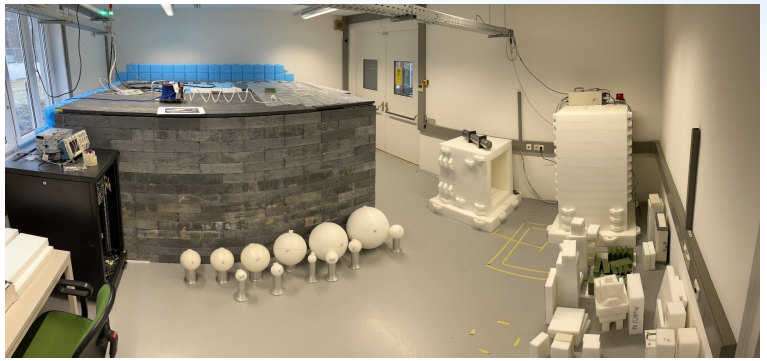
Application of DPP Module on UAV

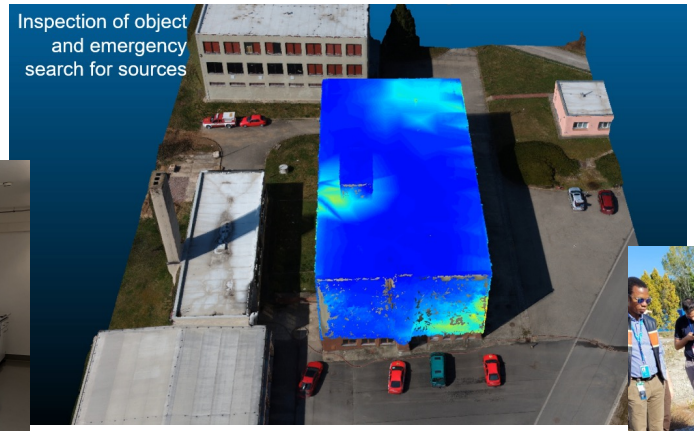
Module Components:
1x2” SiPM NaI Detector, GNSS Receiver, Laser Altimeter, RF Communication, Battery, …

Installed on DJI Matrice 200 V2

Highlights of 2022-2023

- **Neutron Science Facility (NSF)** fully operational**!**
- **Periodic hands-on-training workshops** under 3 main topics: nuclear instrumentation, XRF techniques and neutron techniques
- **Hosting numerous TC fellows and interns, 3-12 months**
- **New CRP K41023** Improving External Dosimetry for Terrestrial Animals and Plants (2022-2027)
- **Expansion of mobile instrumentation to nuclear security** applications: drones, backpacks and ground mobile devices
- Organization of **PT exercises** for 100+ analytical laboratories
- **Neutron building refurbishment** done!





NSIL modernization – ReNuAL2

- **Strategy:** enhance and improve the IAEA laboratories not yet benefiting from the ReNuAL project
- **Main objectives:** modernization of NSIL to meet the current standards and clustering of facilities/offices for the Laboratories
  - Increase in the number of training activities in current fields
  - Development of activities in collaboration with other Laboratories and Units

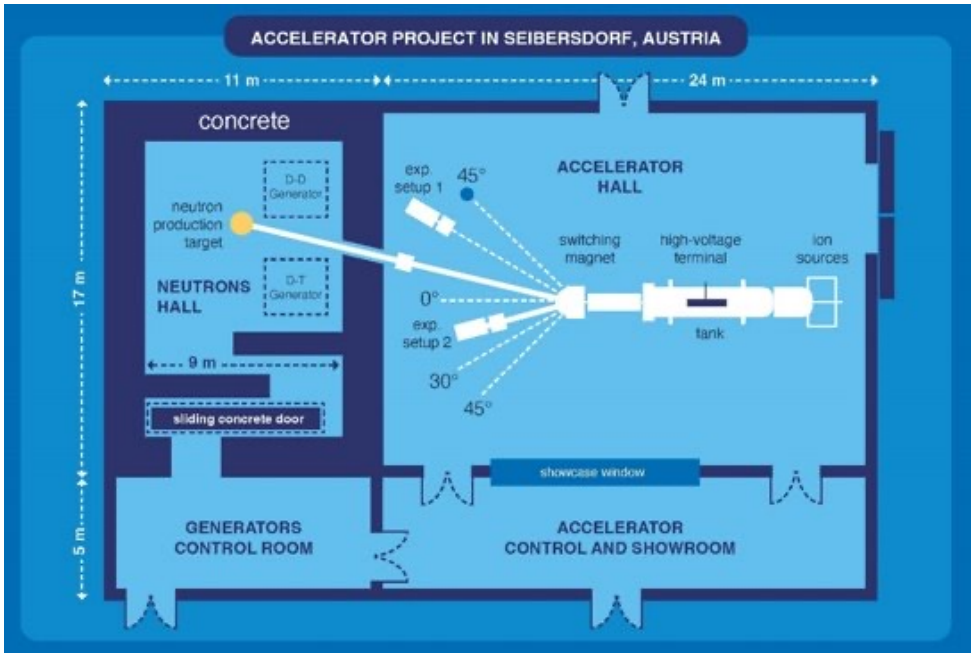
NSIL on site


VIC >
NSIL (future)
NSIL (current locations)
GHs
FML2
YAL
MPB
DOL
NSF
IPCL

Construction site – to host 3 IAEA labs by 2025

The (hopefully near) future: an Ion Beam Facility

- All labs have or will be moved to completely new facilities designed & built from scratch
- 3 MV electrostatic (TANDEM) accelerator equipped with ion sources delivering a wide variety of ions (p to Au)
- Experimental hall dedicated to the production of fast neutrons with accelerated proton beam and neutron generators
- IBA techniques for training and research activities



Modes of collaboration/interaction with the IAEA

Contract types

- Internships (3-12 months), non-extendable, not repeatable
- IAEA Marie Sklodowska Curie fellowships (3-12 months)
- Fellowships (via Technical Cooperation Department)
- PhD consultancies & full consultancies
  - Home based assignments
  - Expert missions

Event types

- Technical meetings
- Training events
- Consultancy meetings

Formal collaboration types

- Practical arrangements
- MoU
- Collaboration agreements
- Collaboration centres

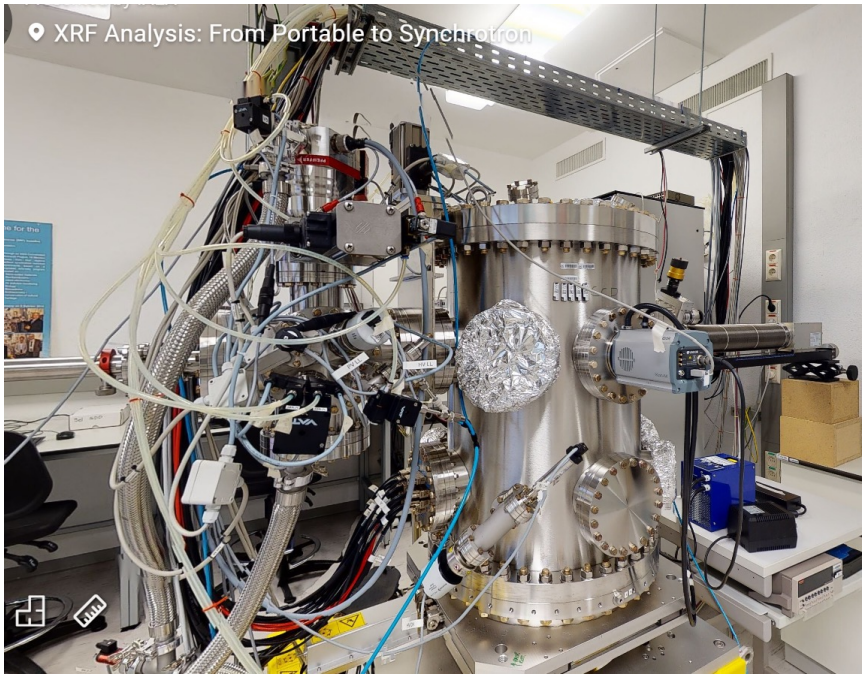
IAEA
International Atomic Energy Agency

Thank you!

BACKUP

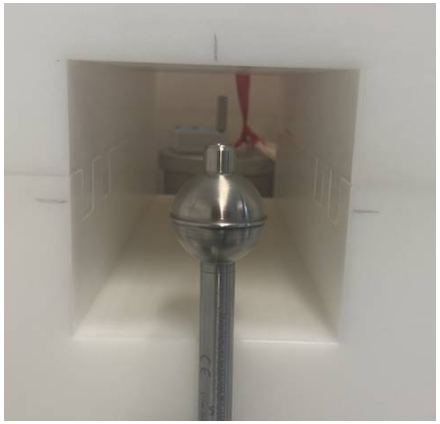
Possibility to exploit our UHV chamber

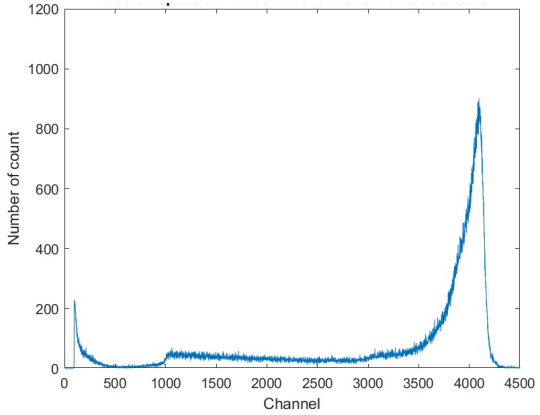
- Replace source with MetalJet
- Liquid metal jet anode
- Beam size: ≤ 0.8 x 0.8 mm
- Divergence ≤ 1 mrad
- Flux > 1e9 ph/s (Ga-Ka)
  - > 1e7 ph/s (In-Ka)

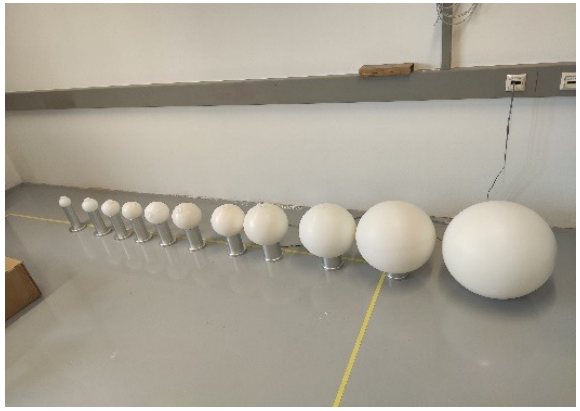


Neutron detection and spectrometry

- ELSE ^{3}He and Bonner spheres system available for neutron spectrometry
  - Tested with ^{252}Cf and DD detector / used in NSF trainings
- Six ^{3}He tubes available as a part of delayed neutron counting system
- BF_3 detector
- Plastic scintillator for fast neutron/gamma discrimination







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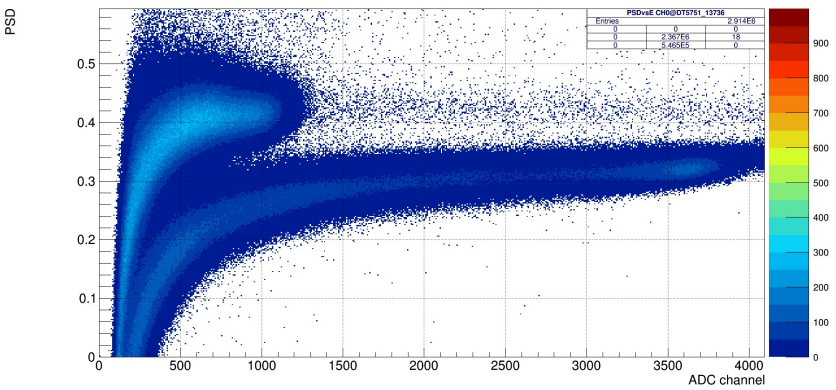
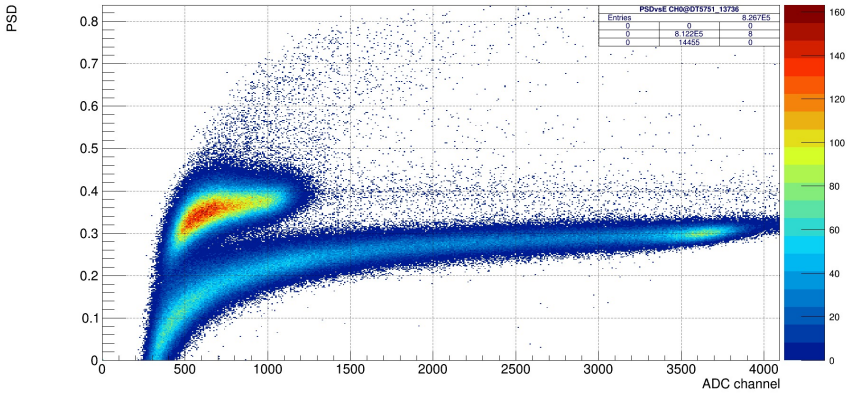
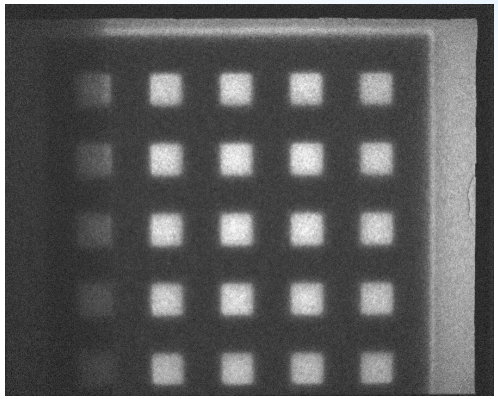
- Plastic scintillator for fast neutron/gamma discrimination



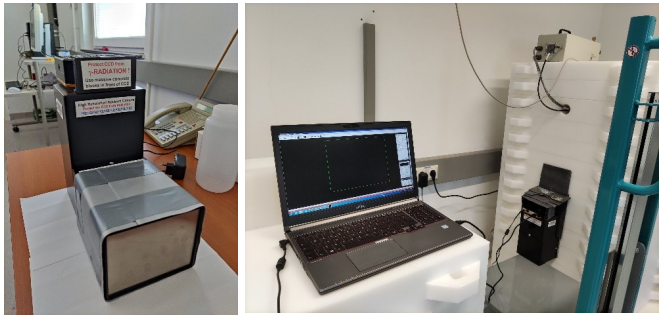


Neutron radiography

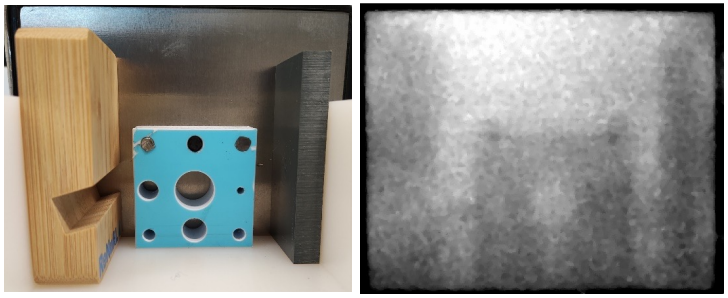
- Dual neutron/X-ray imaging system available
- Fast and thermal neutron radiography with DD and DT generator demonstrated
- Optimisation of setup in progress
  - Camera-object distance
  - Configuration/definition of “beam”
  - Shielding
  - Quantification of figures-of-merit for low flux sources



Thermal neutron radiography with BN grid



Radiography camera and measuring set-up with DD neutron generator



Fast neutron radiography with plastic and wooden objects

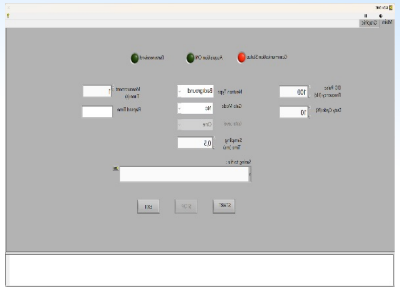
Neutron activation and delayed gamma spectrometry (NAA)

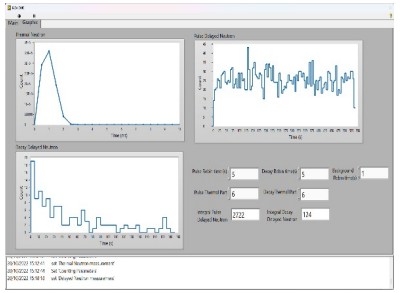
- Activation foils available: Al, Au, Cu, Fe, In, Mg, Ni, Sc, Ti, V, Zr
- HPGe system available
- Performed activities
  - DD emission rate estimation through Au foil activation
  - DT emission rate estimation through Cu, and Ni (Ti, Al) foil activation
  - Cadmium ratio measurement using Au and In foils in DD beam channel
  - Test of NAA with soil and water samples

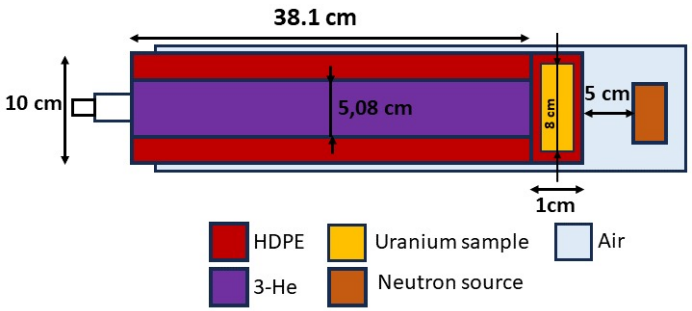
- Training lecture using artificial coin with determination of elements (Au, Ag, Cu, Ni) and quantification of Au

Delayed neutron counting

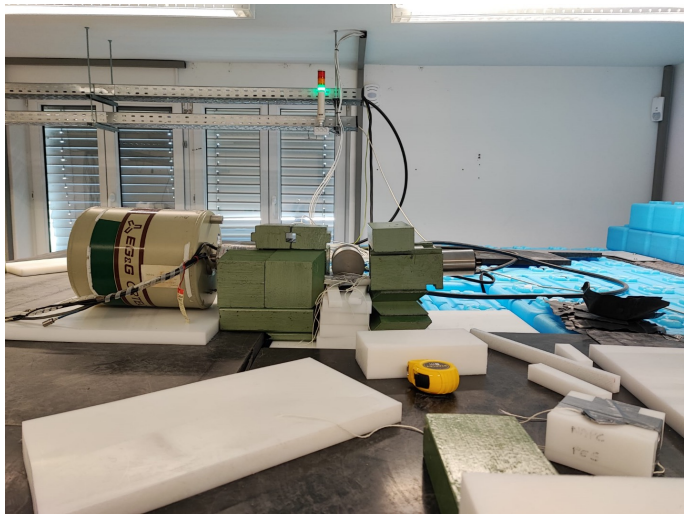
- Delayed Neutron Counting system
  - Based on donated ^{3}He tubes
  - In house developed RedPitaya FPGA DAQ system
  - Working in short pulsing mode







PGNAA and short half life NAA in continuous and pulsed mode
(under development)



- HPGe, NaI detectors, BGO for high energy gamma-rays
- Focus on tests of explosives, drugs and some industrial applications (cement quality)