Nuclear Forensics Analytical Potential in JAEA

Nuclear Forensics WS

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Background

Japan's National Statement at the Nuclear Security Summit

Development of Technology related to Measurement and Detection of Nuclear Material and Nuclear Forensics based on International Cooperation

As Japan and U.S. recently reached agreement on cooperation in the development of technology that contributes to the advancement of the measurement and control of nuclear material, as well as technologies related to the detection of nuclear material and nuclear forensics that contribute to the identification of the sources (countries and facilities) of nuclear material illicitly trafficked or used in terrorist attacks, Japan will make increased contributions to the international community by establishing these technologies with more precise and accurate capabilities in detection and forensics within an approximate three year time frame and sharing the fruits of these new technologies with the international community.

Potential Analytical Capability

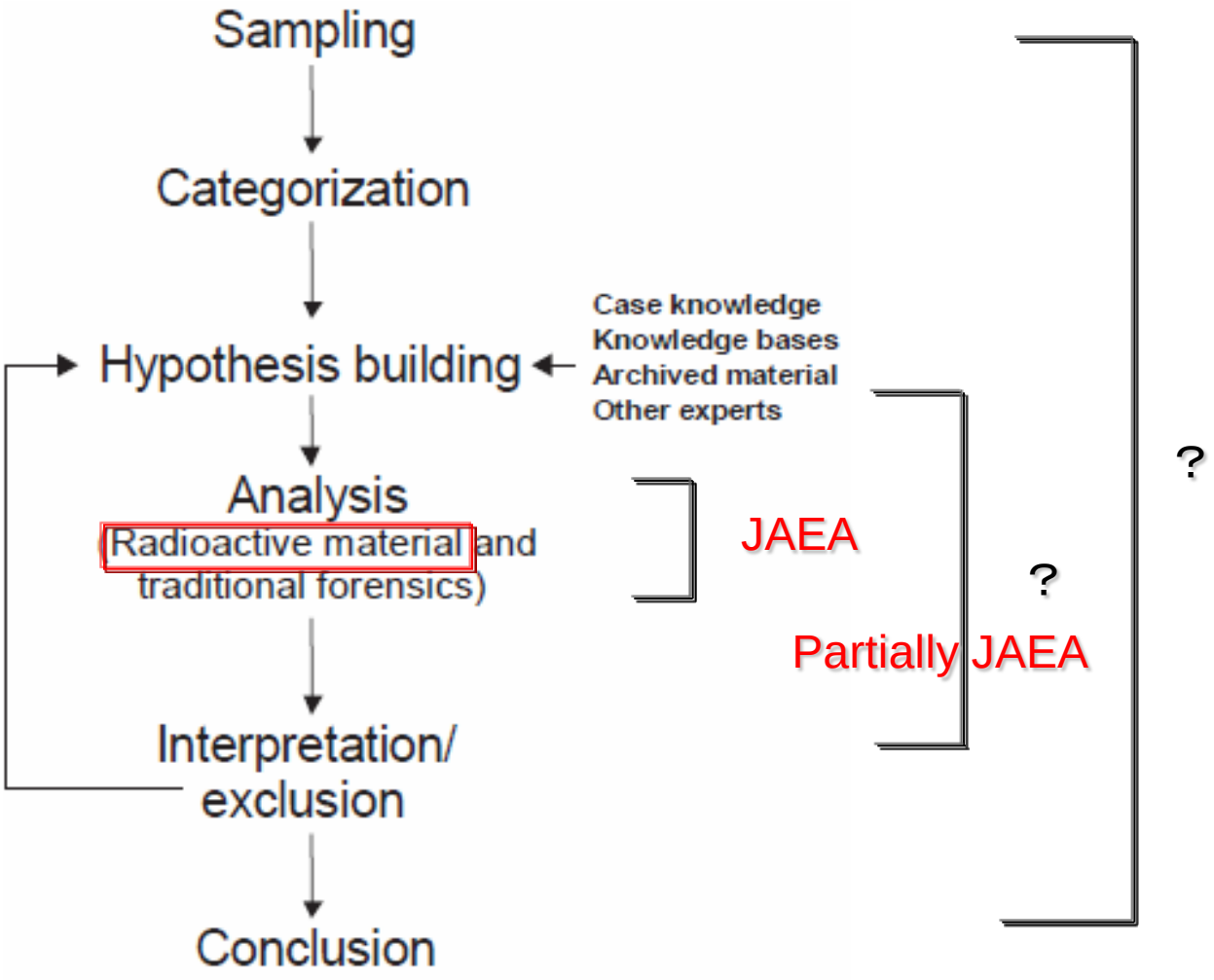


FIG. 2. The nuclear forensics process.

Nuclear Forensics Support

Technical Guidance Reference Manual

IAEA Nuclear Security Series No. 2

TABLE 2. SUGGESTED SEQUENCE FOR LABORATORY TECHNIQUES AND METHODS

Techniques/methods	24 hours	One week	Two months
Radiological	Estimated total activity Dose rate (α, β, γ, *n*) Surface contamination		
Physical	Visual inspection Radiography Photography Weight Dimensions Optical microscopy Density	SEM/EDS XRD	TEM (EDX)
Traditional forensic	Fingerprints, fibres		
Isotope analysis	γ spectroscopy α spectroscopy	Mass spectrometry (SIMS, TIMS, ICP-MS)	Radiochemical separation
Elemental/chemical		ICP-MS XRF Assay (titration, IDMS)	GC-MS

JAEA can play a role.

JAEA can technically support.

SEM/EDS: Scanning electron microanalysis with energy dispersive sensor; TEM: transmission electron microscopy; SIMS: secondary ion mass spectrometry; TIMS: thermal ionization mass spectrometry; ICP-MS: inductively coupled plasma mass spectrometry; XRF: X ray fluorescence analysis; IDMS: isotope dilution mass spectrometry; GC-MS: gas chromatography-mass spectrometry. (See Appendix II for further references.)

TABLE 1. CATEGORIES OF NUCLEAR

Category	Type of material or device	Radioactive components
Unirradiated direct use nuclear material	High enriched uranium (HEU)	>20% U-235
	Plutonium and mixed U–Pu oxides (MOX)	<80% Pu-238
	U-233	Separated isotope
Irradiated direct use nuclear material	Irradiated nuclear fuel material	In irradiated nuclear fuel elements or in spent fuel reprocessing solutions
Alternative nuclear material	Americium (Am-241)	Separated element or present in irradiated nuclear material, in separated plutonium or in mixtures of uranium and plutonium
	Neptunium (Np-237)	
	Depleted uranium (DU)	<0.7% U-235
Indirect use nuclear material	Natural uranium (NU)	0.7% U-235
	Low enriched uranium (LEU)	>0.7% U-235 and <20% U-235, (typically 3–5%) U-235
	Plutonium (Pu-238)	>80% Pu-238
	Thorium	Th-232
Radioactive sources	Radioisotope thermoelectric	Pu-238, Cm-244 and Sr-90

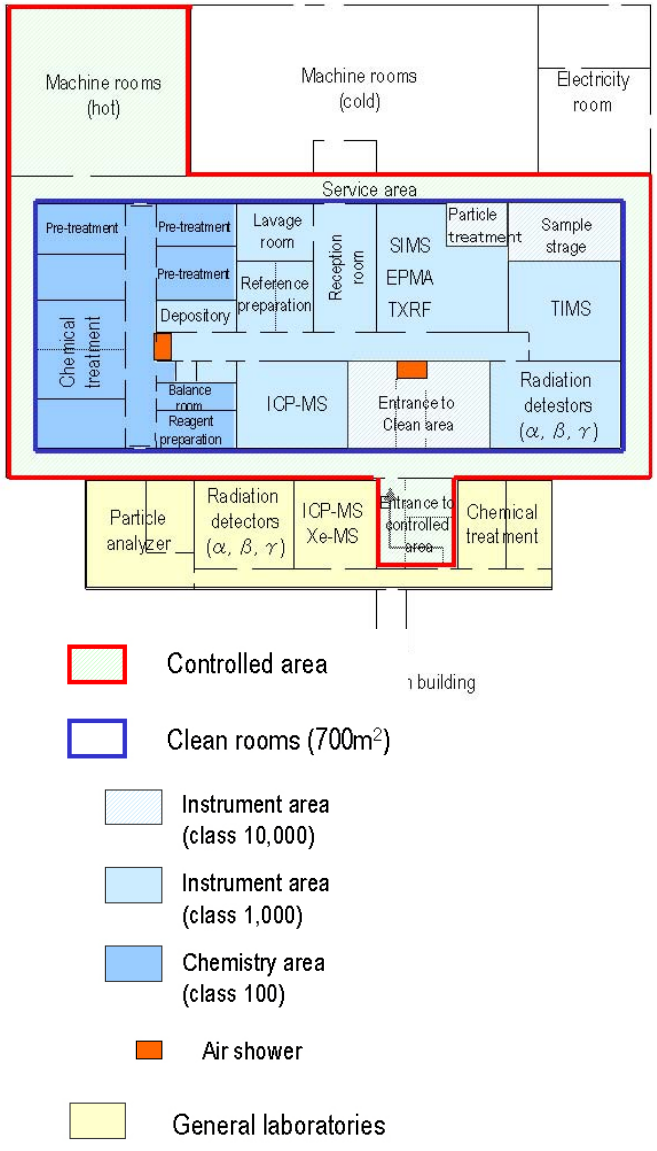
Analytical Labs in JAEA

JAEA's existing analytical laboratories can cover multi-purposes for detection of trace amount of nuclear materials, accountancy control, process control and quality control at following types of facility;

- CLEAR Laboratory / NUCEF
- Uranium refining and conversion
- Uranium enrichment
- Reprocessing
- Plutonium conversion
- MOX fuel fabrication
- Hot cell and R&D
- Research reactors
- Other

CLEAR

Laboratory for Environmental Analysis and Research



Cleanness class is defined as maximum number of particles (> 0.5μm) in 1 ft^3.
No cleanness-controlled rooms, e.g. normal office rooms, sometimes contain the particle more than one million.

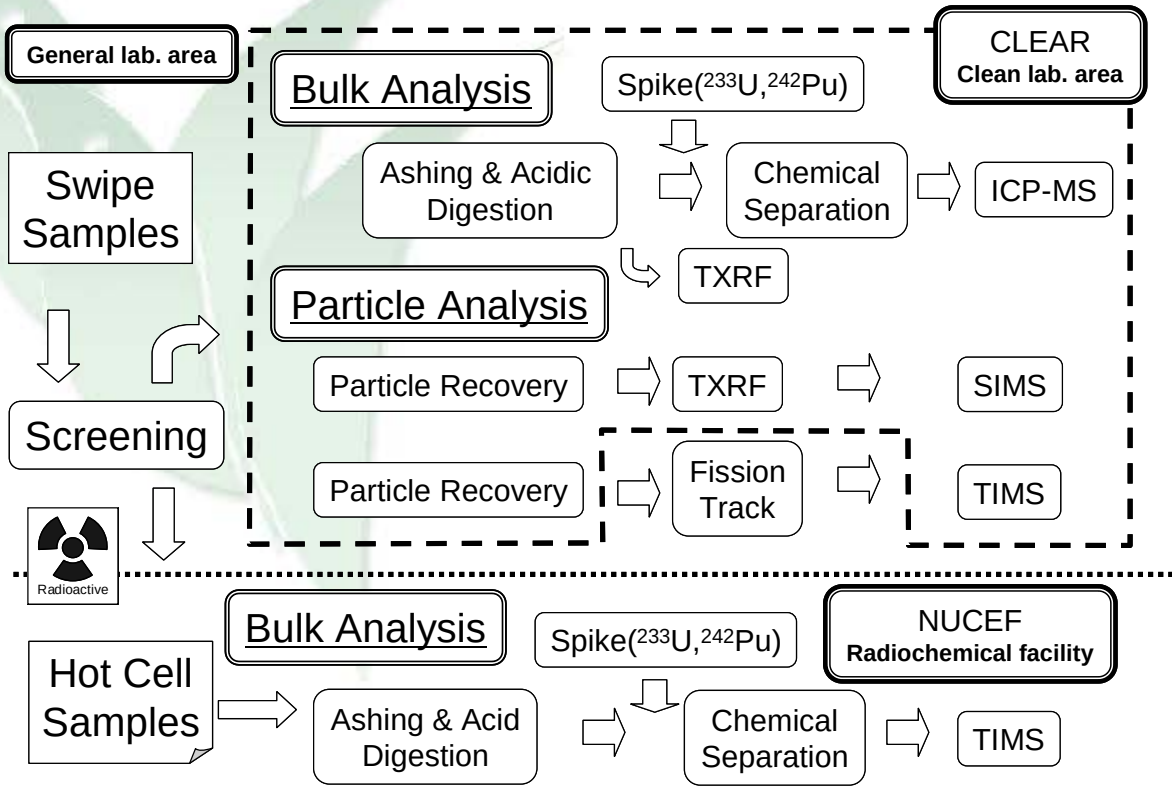


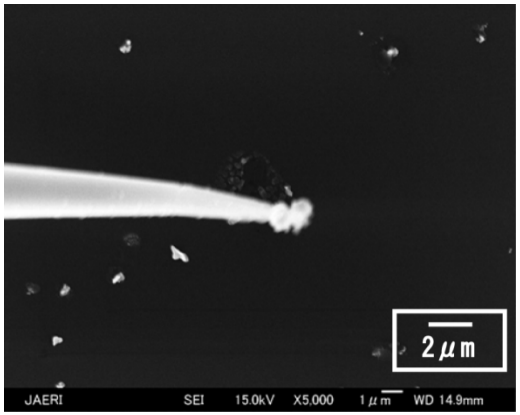
Figure 1 : Flow diagram of environmental sample analysis in JAEA

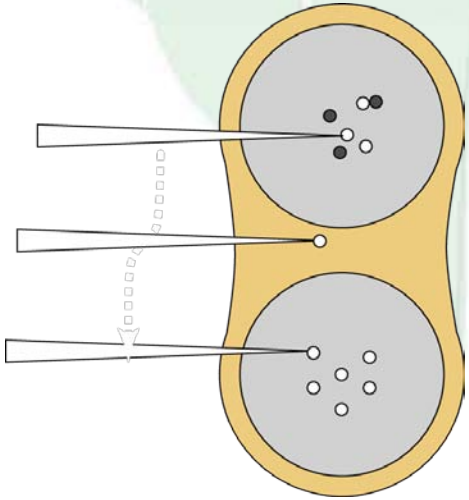
Pick-up Particles (SIMS)

- Particles pick up

Particle recovery (Vacuum impactor)

Scanning electron microscopy (SEM)



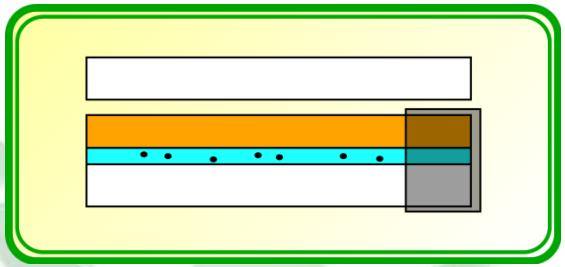


Particles pick up and transfer

SIMS

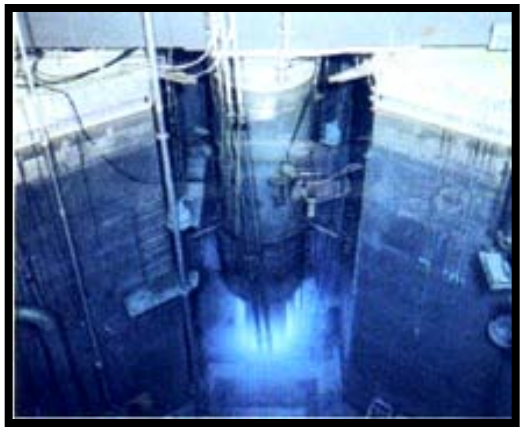
FT-TIMS Method

Collect particles on filter

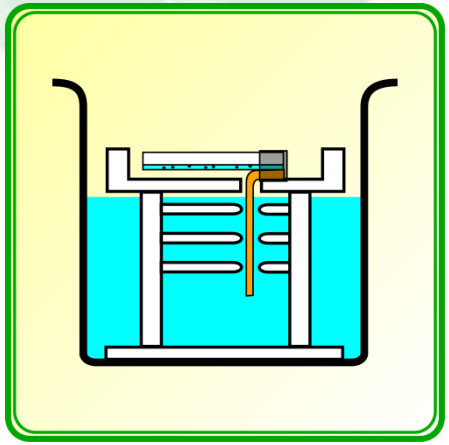


Prepare irradiation sample

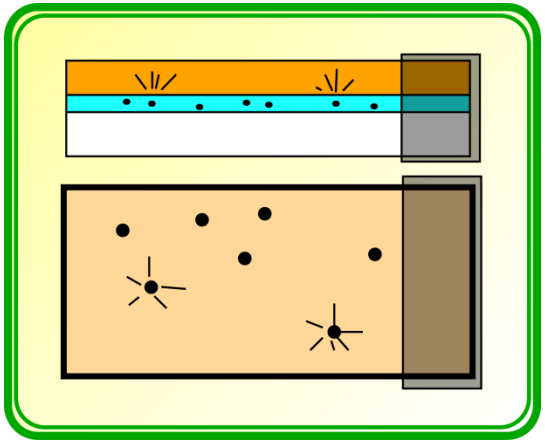
TIMS



Neutron irradiation

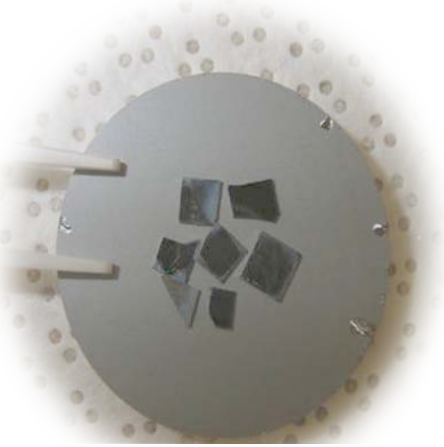


Etching



Accurate method
A lot of time to measure

Pu Age Determination for Pu and MOX Particle

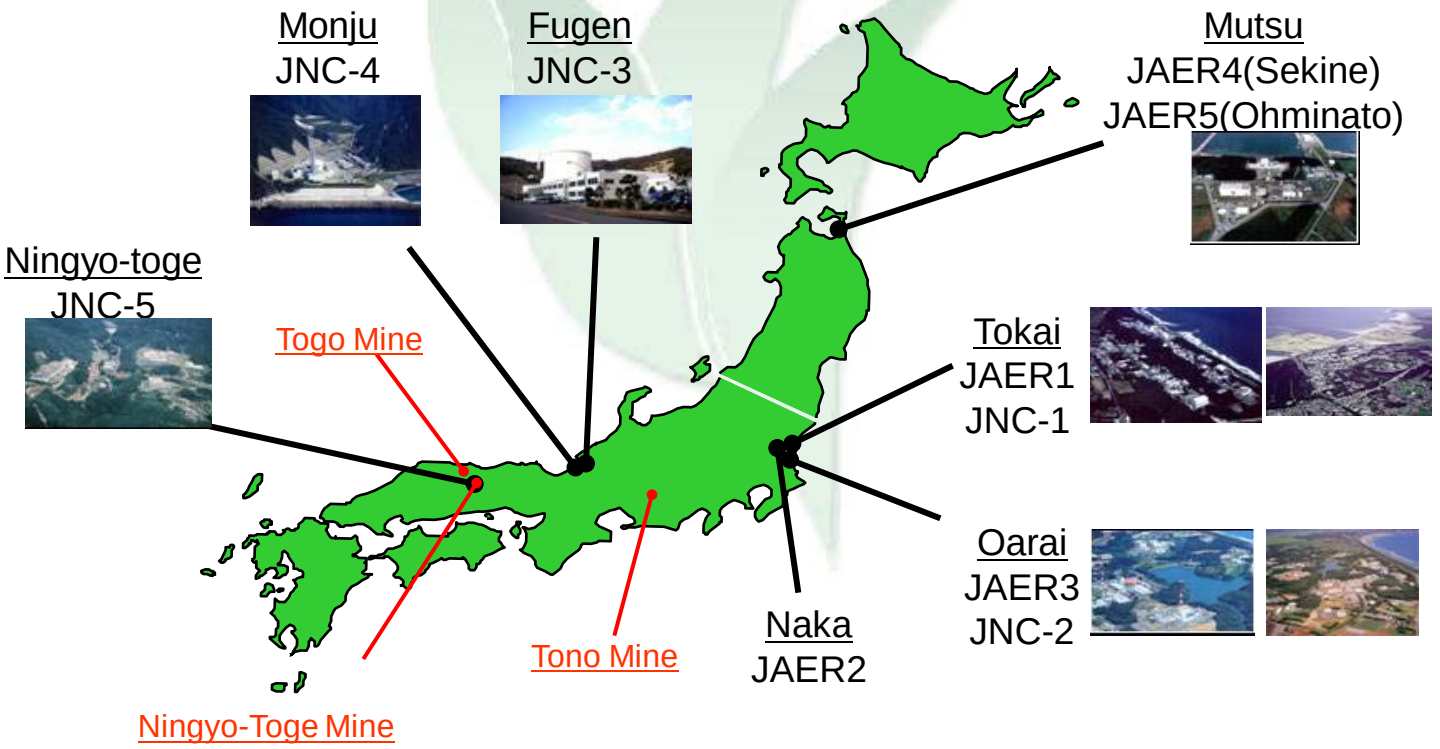


Single particle dissolution

Chemical separation

Isotope ratio measurement
Pu/Am ratio measurement

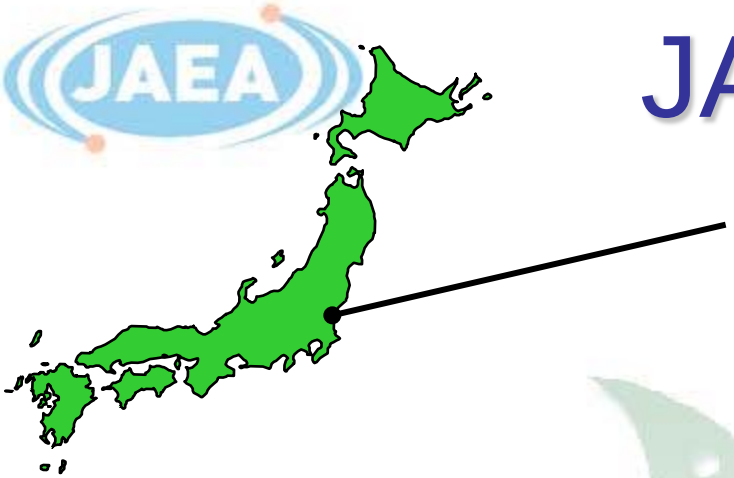
Nuclear Fuel Cycle Facilities and Research Reactors



JNC-1(Tokai)

- TRP (Tokai Reprocessing Plant)
- PCDF (Plutonium Conversion Development Facility)
- PPFF (Plutonium Center Plutonium Fuel Facility)
- PFPF (Plutonium Fuel Fabrication Facility)
- JNC Tokai R&D

JAER1(Tokai)



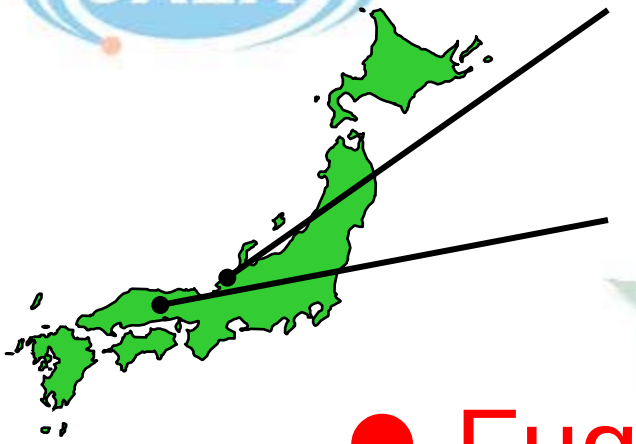
- JPDR (dismantled)
- JRR-1 (dismantled)
- JRR-2 (closed)
- Old JRR-3 (dismantled)
- JRR-3
- JRR-4
- SCF (NUCEF)

- TCA (Tank-type Critical Assembly)
- FCA (Fast Critical Assembly)
- NSRR
  (Nuclear Safety Research Reactor)
- VHTRC (closed)
  (Very High Temperature Reactor Critical Assembly)
- JAERI Tokai R&D
- JRTF (closed)
  (Reprocessing Test Facility)

JAER3, JNC-2 (Oarai)

- JMTR
  (Japan Material Testing Reactor)
- JMTRC (closed)
  (Japan Material Testing Reactor Critical Assembly)
- HTTR
  (High Temperature Engineering Test Reactor)
- JAERI Oarai R&D

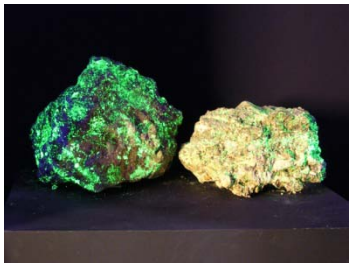
- Joyo
- DCA (closed)
  (Deuterium Criticality Assembly)
- IRAF
  (Irradiation Rig Assembling Facility)
- FMF
  (Fuels Monitoring Facility)
- JNC Oarai R&D

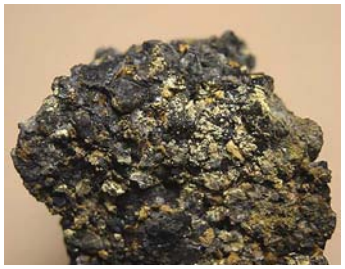


JNC-3, JNC-4 JNC-5

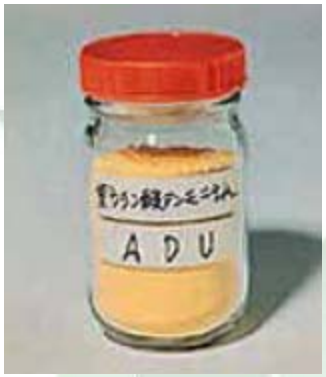
- Fugen (closed)
- Monju
- Ningyo-Toge Uranium Enrichment Plant (closed)
- Ningyo-Toge Refining and Conversion Plant (closed)

Uranium Ore, Yellow Cake and UF_6





Uranium Ore



Yellow Cake

Ningyo-toge Refining and Conversion Facility

UF_6

Ningyo-toge Uranium Enrichment Facility

UO_3

UF_4

Pu, MOX, FP and TRU

Spent fuel

Pu nitrate solution

TRP

PCDF

PFPF

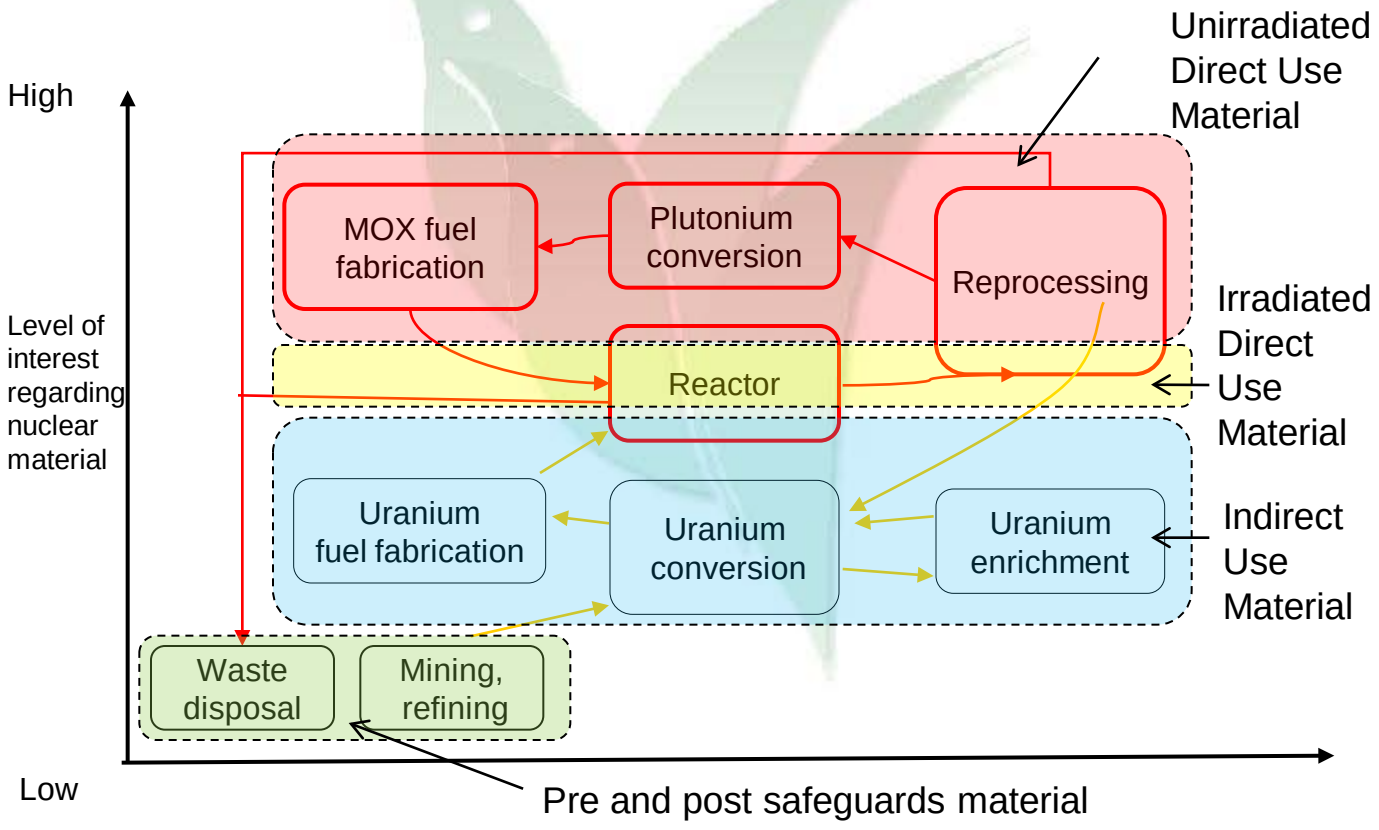
MOX

FP, TRU

Waste

MOX Fuel Assemblies

Nuclear Material



Preparation for Nuclear Forensics Analysis

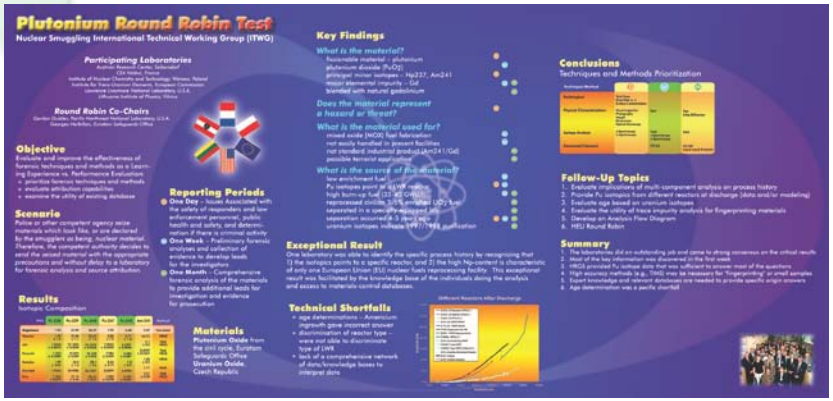
Goals Towards Establishment of Response System for Nuclear Forensics

- Technically establish elemental, isotopic and impurity measurement of nuclear materials.
- Establish morphology analysis of particles
- Establish age determination of U and Pu
- Create domestic database and develop wider database in cooperation with foreign countries
- Establish how to identify/specify origin of nuclear materials from obtained signatures (attribute evaluation)
- Establish response system and organization in JAEA and discuss wider response system with other organizations including Japanese government

Areas to be Involved and R&D Candidates for International Collaborations

Areas to Be Involved

- International activities as GICNT and ITWG
- Participation in international round robins
- International and bilateral communication on database sharing
- Cooperation programs with USA and EU in development of new technologies



Candidate R&D for International Collaborations

- U-age determination/Pu age determination
- Elemental/impurity analysis in small size samples
- Production of Reference certified materials of U, Pu for nuclear forensics
- Analysis of sample after explosion: U, Pu, FPs, RI (dirty bomb)
- Analysis of materials diffusion flow with simulation code
- Establishment of database (domestic data/international exchange)
- Training/education on nuclear forensics
- Establishment of international network
- HEU/Pu round robin
- Other QA/QC activities

Thank you