JAEA's Efforts on Developing Nuclear Forensics Technology

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Japan's National Statement at Nuclear Security Summit (Washington D.C. April 2010)

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.**

Response of Japan Atomic Energy Agency (JAEA)

JAEA, which possesses sufficient capabilities to fulfill the mission of analytical technology development for nuclear forensics (NF), has initiated R&D project from 2011 JFY.

Challenges towards Establishment of NF Capabilities in Japan

Japan's Challenges

1. Establishment and improvement of NF analysis technologies
2. Development of National Nuclear Forensics Library (NNFL)
3. Establishment of NF analysis Lab. (Analytical devices and system)
4. Human resource development
5. Establishment of national framework including national response plan
6. Collaborations with traditional forensics
7. Establishment of international cooperative system

Contributive Area of JAEA-ISCN

JAEA R&D Project for NF

NF Analysis Technologies:

Followings are key elements for NF

1. Isotope ratio measurement
2. Impurity measurement
3. Uranium age determination
4. Particle/Morphology analysis

Others

5. Development of prototype NFL and data analysis methodologies
6. International collaborations

	2011JFY	2012JFY	2013JFY	2014JFY~
R&D Topics /Phase	Establishment of fundamental technologies			Implementation and development of advanced technologies
Isotope ratio measurement	←	—	→	←
Impurity measurement	← - - →	←	→	←
Particle analysis		←	→	←
Uranium age determination	←	—	→	←
Prototype of national nuclear forensics library	← - - →	←	→	←

Isotope Ratio Measurement

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Isotope Measurement by TIMS (*Thermal Ionization Mass Spectrometry*)

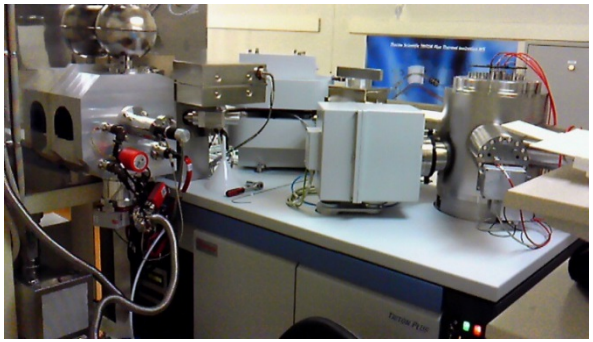


Fig : TIMS

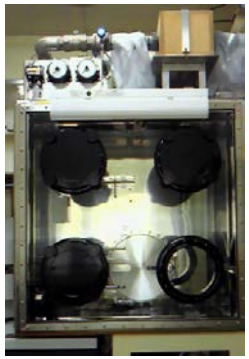
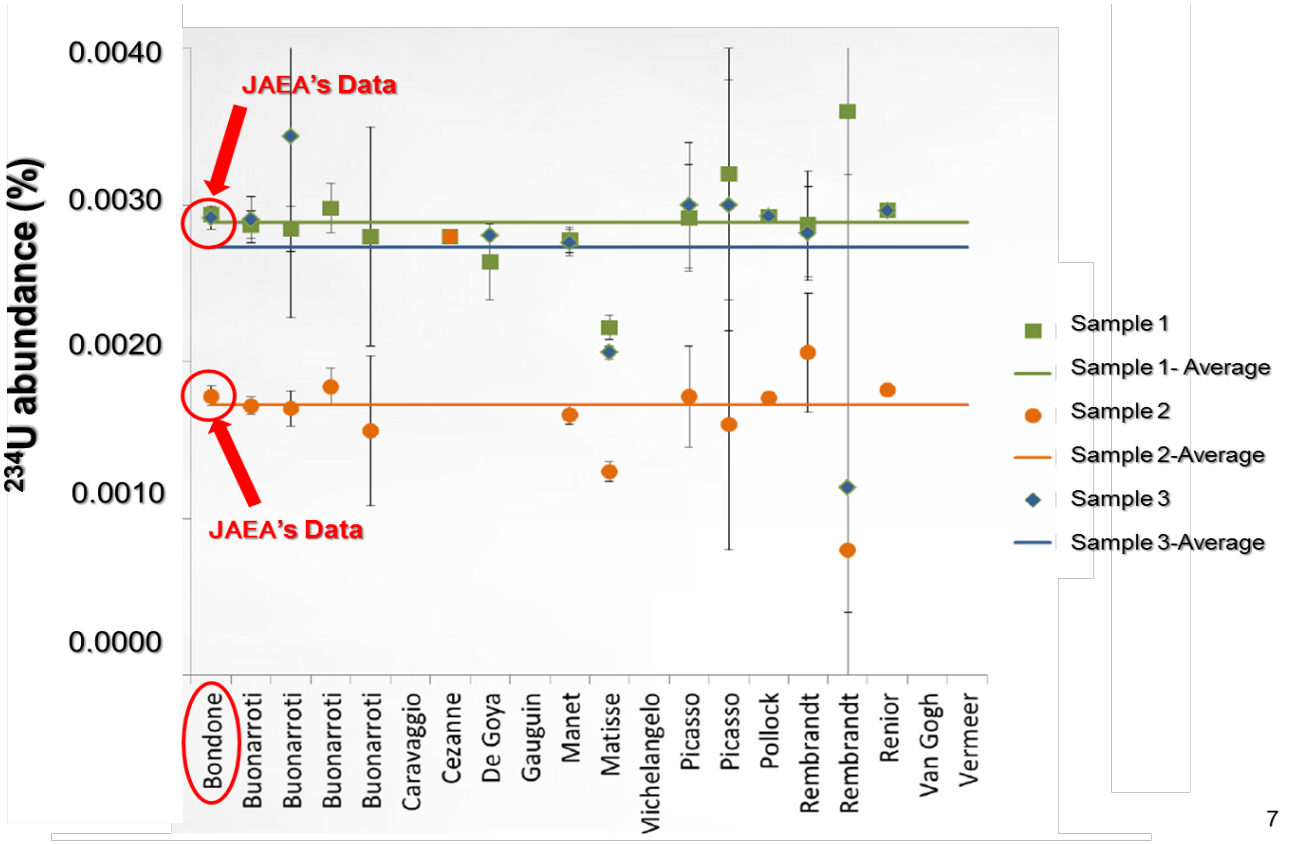


Fig : Sample Loading Box



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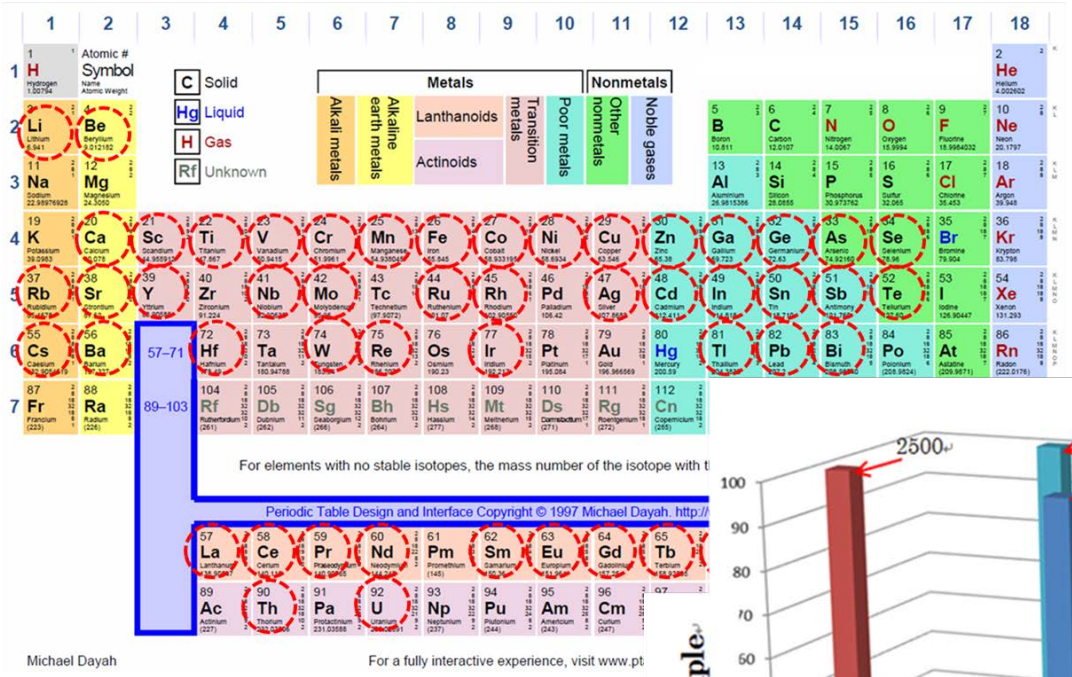
Result of Nuclear Forensics International Technical Working Group (ITWG) Collaborative Material Exercise 4 (CMX-4)

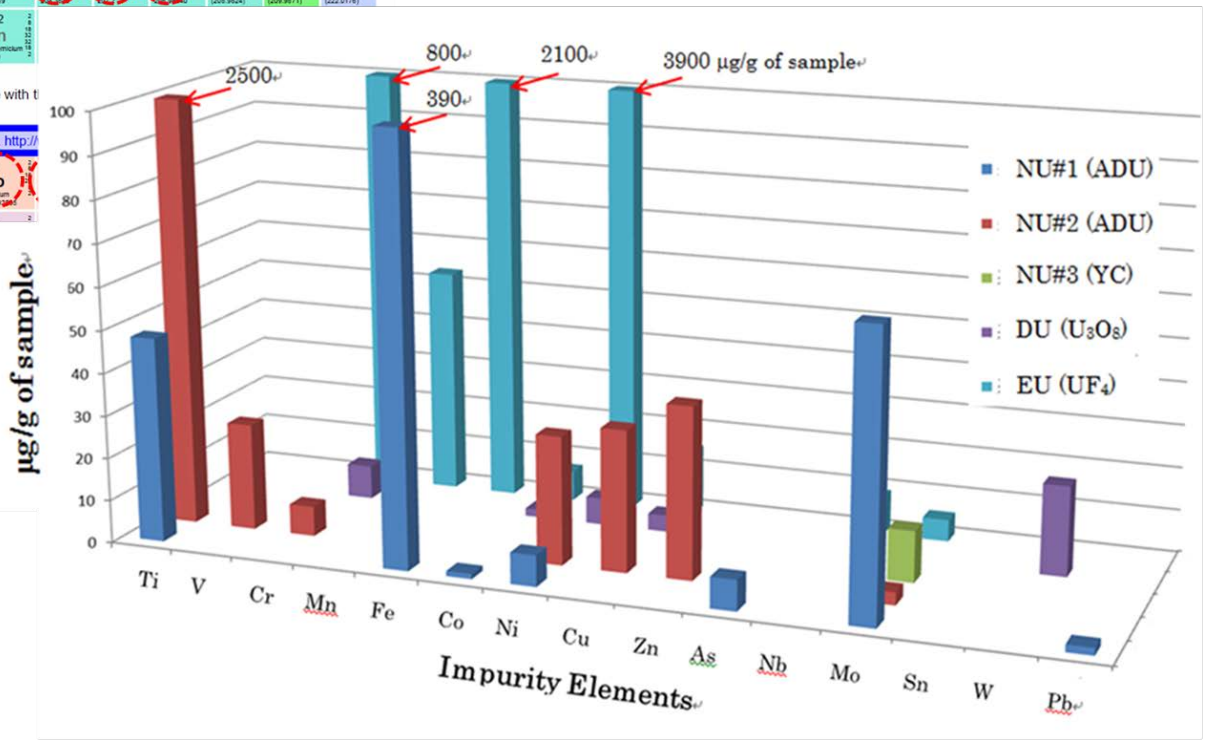
Example of Impurity Measurement result



All impurity elements could be important "Signature" in NF analysis.

Quantifiable Elements by ICP-MS:
54 Elements (+U)

ICP-MS; inductively coupled plasma Mass spectrometry



Ex. Impurities contained in several uranium samples

Uranium Age Determination

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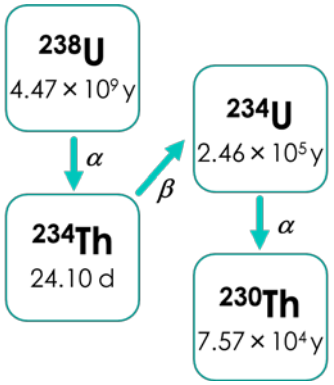
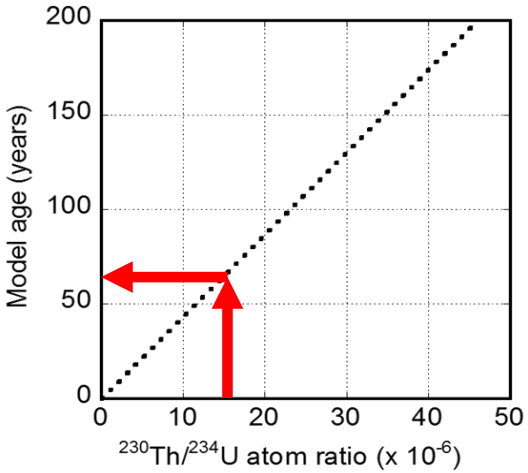
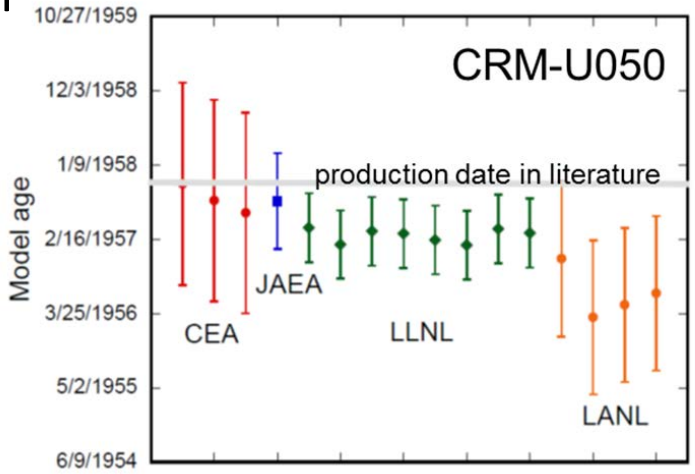
- The age of nuclear material = elapsed time since the last chemical separation
  - ✓ essential information to identify the source of the material
  - ✓ ^{234}U-^{230}Th chronometer is widely applied to NF



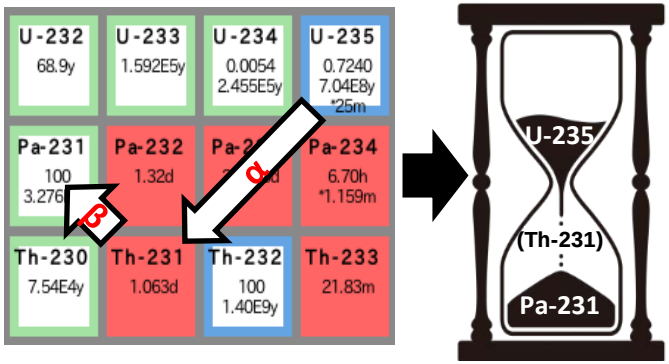




Estimated production date for Certified Reference Material U050

Development of New Uranium Age Determination method

1. Pa-231/U-235 method



2. in-situ isotopes method

Th isotope ratio U isotope ratio

$$\left(\frac{^{230}Th}{^{234}Th}\right) \times \left(\frac{^{234}Th}{^{238}U}\right) \div \left(\frac{^{234}U}{^{238}U}\right) = \frac{^{230}Th}{^{234}U}$$

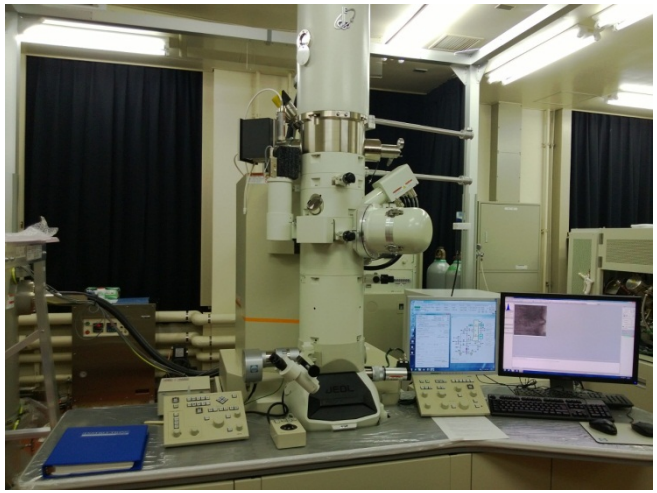
measured $=1.45 \times 10^{-11}$ (Radioactive equilibrium) measured

$^{230}Th / ^{238}U$

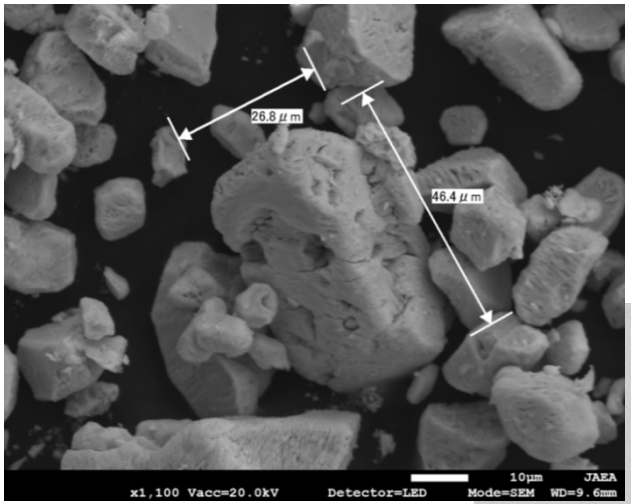
Particle/Morphology Analysis

- Morphology (Particle) Analysis by SEM & TEM

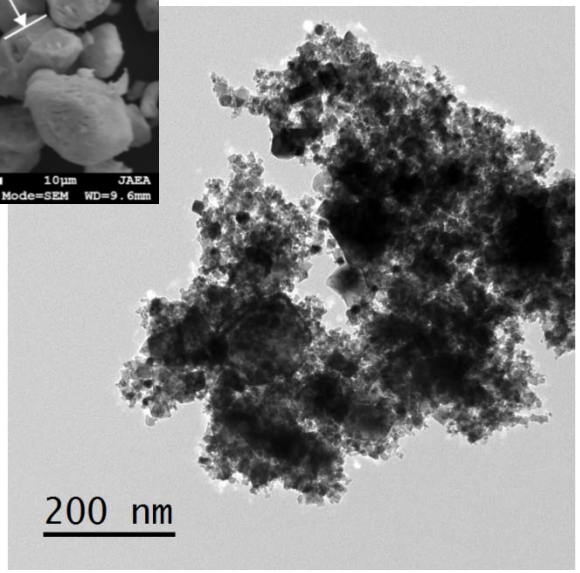
SEM: Scanning Electron Microscope
TEM: Transmission Electron Microscope



Fig：TEM-2100F



Fig：SEM Image (YC)



Fig：TEM Image (Ceria)

Expected Analysis by TEM

- Particle analysis (particle/lattice image)
- Other crystal analysis
- Elemental compositions and their chemical-bonding states by EELS (electron energy-loss spectroscopy)

Prototype Nuclear Forensics Library (NFL)

Current international trend of NFL :

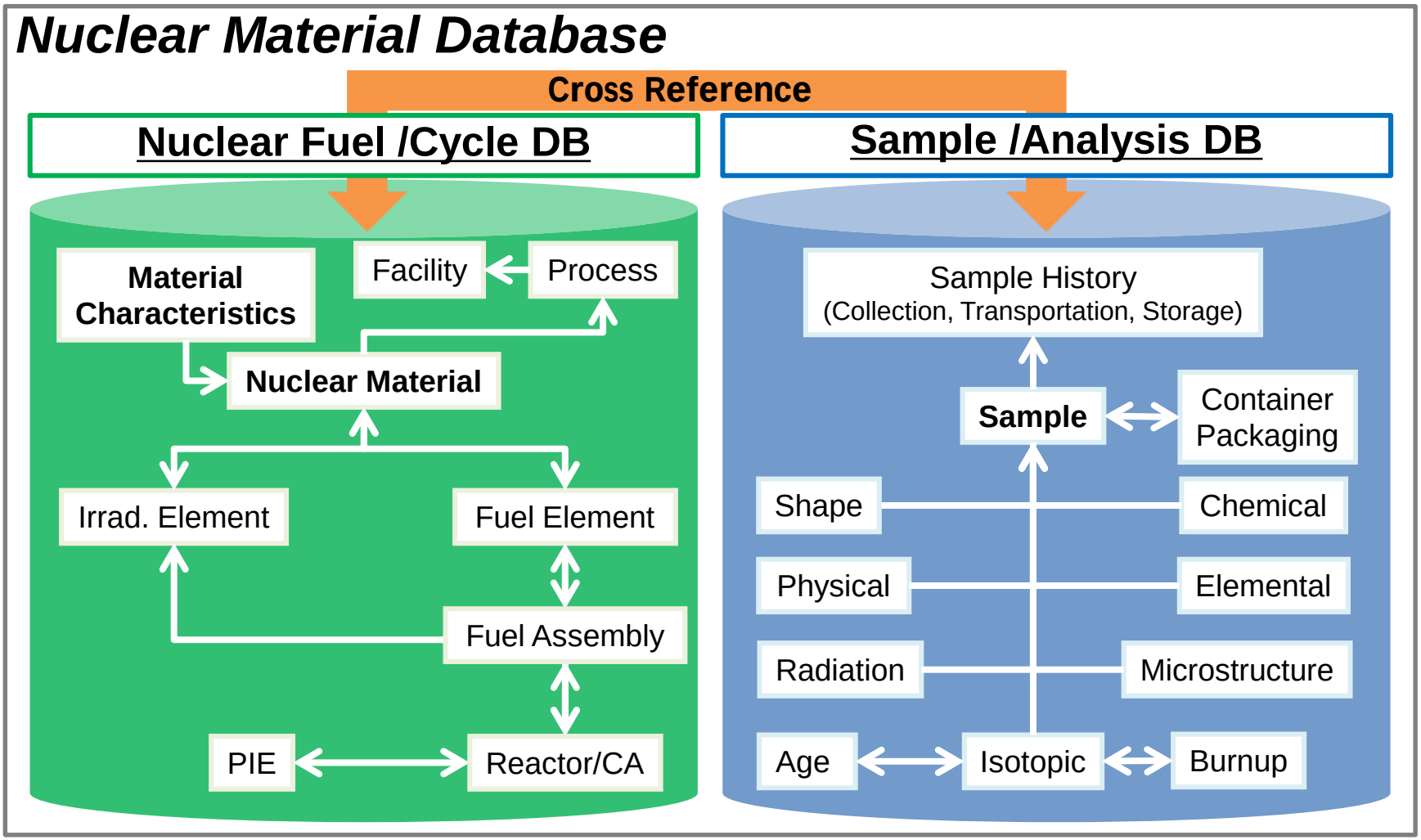
- "National" NFL (NNFL) collecting all the materials in a country.
- Point-of-Contact (POC) should be prepared for reference from other countries.

JAEA: "Prototype" NFL Development for Future NNFL

- Database of nuclear materials and other radioactive materials produced, used and stored in JAEA
- DB system (queries & user interface)
- Seizure analysis tools (morphology, multivariate, others)

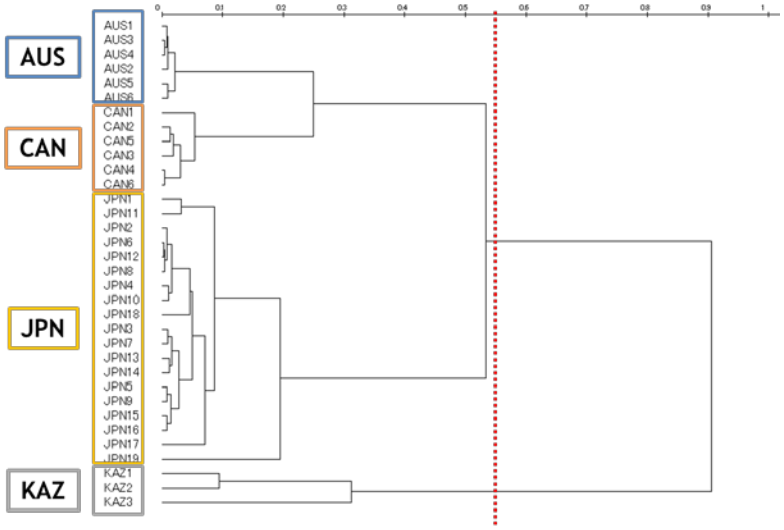
➢ Prototype NFL and the knowledge obtained from its development will be transferred to the future responsible authority

Overview of Nuclear Material DB

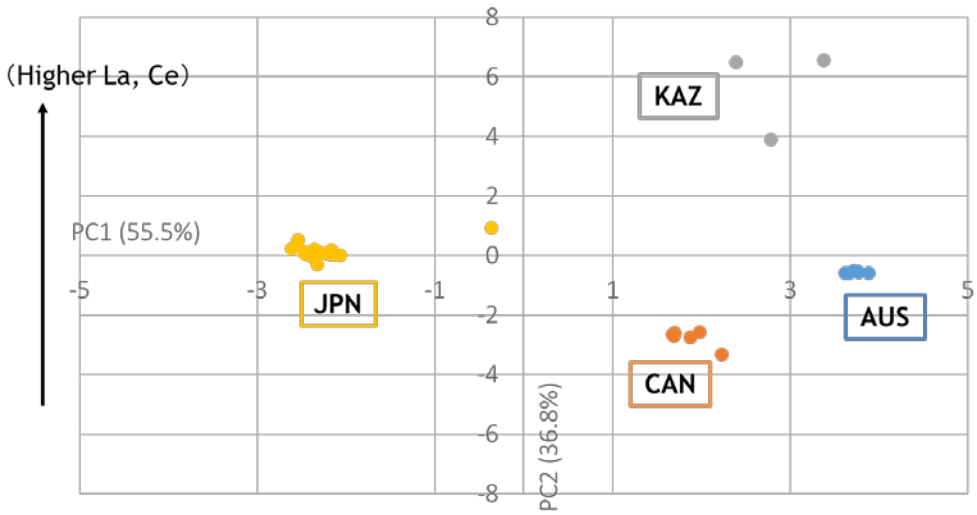


Material discrimination technique

Multivariate Analysis (MVA)



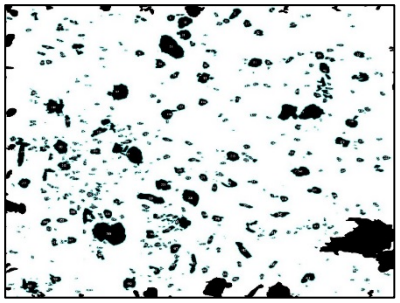
(Uranium ore clustering based on REE profile)

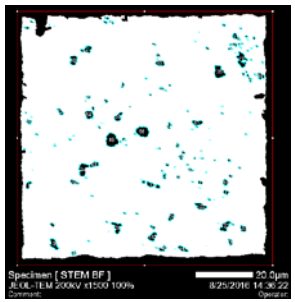


(PCA to find high contributing REE element for clustering)

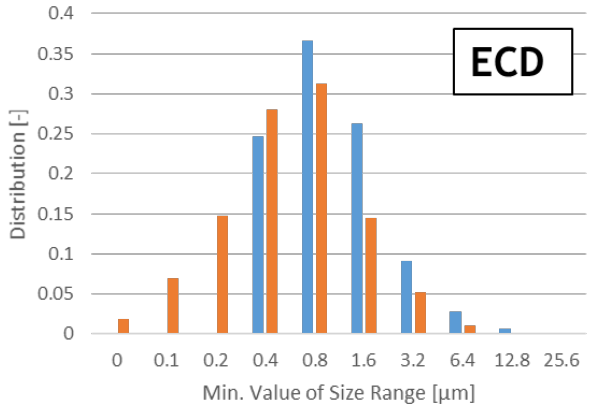
Microscopic Image Analysis

(Comparison Image Data)





(Morphology Data)



International Collaborations in progress

- **USDOE-JAEA（Project Arrangement: PA）**
  - New Uranium age determination technique ($^{231}Pa/^{235}U$ method) (PA-7): inter-laboratory comparison, information exchange
  - Topological Method for Nuclear Forensics Image Data (PA-8): exchange of procedures and analytical data to improve the abilities of automated morphology software packages
- **ECJRC-JAEA (Action Sheet: AS)**
  - Development of Analytical Technologies (AS-2): information exchange and workshop
  - New Uranium age determination technique (In-situ isotope method) (AS-8): inter-laboratory comparison
- **Others**
  - Contribution on the activities of GICNT, ITWG and IAEA
  - Participation to ITWG TTX on NNFL (*Galaxy Serpent*) and *CMX*
  - Information exchange for establishment of the national framework and response plan in Japan under US-Japan NSWG

Future Prospects

- Validation and Improvement of the Developed NF Measurement Methods
  - *Collaborative Material exercise* (ITWG)
  - New U age determination technique
- Development of NF technologies for post dispersion event
- Morphology Analysis by TEM application for NF Purpose
  - NF Morphology Analysis Tool
- Improvement of Prototype NFL
  - Multivariate Analysis (MVA) Tool
  - Radioactive Material DB
  - "Knowledge Base" of NF Measurements and Data Analysis using NFL
  - Data-collecting for JAEA Materials from nuclear cycle facilities

Introduction to the Panel Discussion

Panel Discussion 1

Discussion on direction of future R&D by reviewing current status of NF capability

It's difficult to sustain NF capability without developing NF framework and pursing technology improvement.

- What are the Technical Challenges and Needs for R&D?
- How to develop a Sustainable R&D Strategy?

Panel Discussion 2

Discussion on promotion of International and Regional Cooperation on Nuclear Forensics related to laboratory network, library and human resource development

- What are Needs for existing international cooperation frameworks based on the Needs from Emerging Countries?
- What is best approach to developing regional cooperation scheme for nuclear forensics capability buildings and participation of international organization?

Thank you for your attention.

Please visit our website! **http://www.jaea.go.jp/04/iscn/index_en.html**

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