9th Information Exchange Meeting on
Actinide and Fission Product Partitioning & Transmutation
Nîmes, France
26-29 September 2006

Research and Development Activities on Partitioning and Transmutation of Radioactive Nuclides in Japan

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Japan Atomic Energy Agency

JAEA

- On October 1st, 2005, the Japan Atomic Energy Agency was established
  - as a result of integration of the Japan Atomic Energy Research Institute (JAERI) and the Japan Nuclear Cycle Development Institute (JNC)
- JAEA is the only institute in Japan dedicated to comprehensive research and development in the field of nuclear energy

- Employees: ~ 4,400
- Budget: ~ 200B JPY

Japan Atomic Energy Agency

R&D Centers

Tsuruga
Prototype fast reactor Monju, Decommissioning of advanced thermal reactor Fugen


Tono
High-level rad-waste research

Horonobe
High-level rad-waste research

Mutsu
Decommissioning of nuclear ship

Tokai
Basic research, Safty studies, Neutron Science, Nuclear fuel cycle technologies, Rad-waste management and disposal, etc.

Ningyotoge
Decommissioning of uranium enrichment plants

Kansai
Photon & synchrotron radiation science


Takasaki
Radiation science

Naka
Fusion R&D, ITER support

Oarai
Experimental reactors Joyo, HTTR and JMTR, Advanced reactor R&D including FBR cycle commercialization

Nuclear Fuel Cycle Strategy in Japan

Current Status

- "Framework for Nuclear Energy Policy" (Oct., 2005)
- "Science and Technology Basic Plan" (March, 2006)
- "New National Energy Strategy" (May, 2006)
- "Nuclear Power Nation Plan" (Aug., 2006)
- "R&D Plan for Nuclear Energy" (tentative) (Sept., 2006)

Framework for Nuclear Energy Policy (1/4)

Atomic Energy Commission of Japan

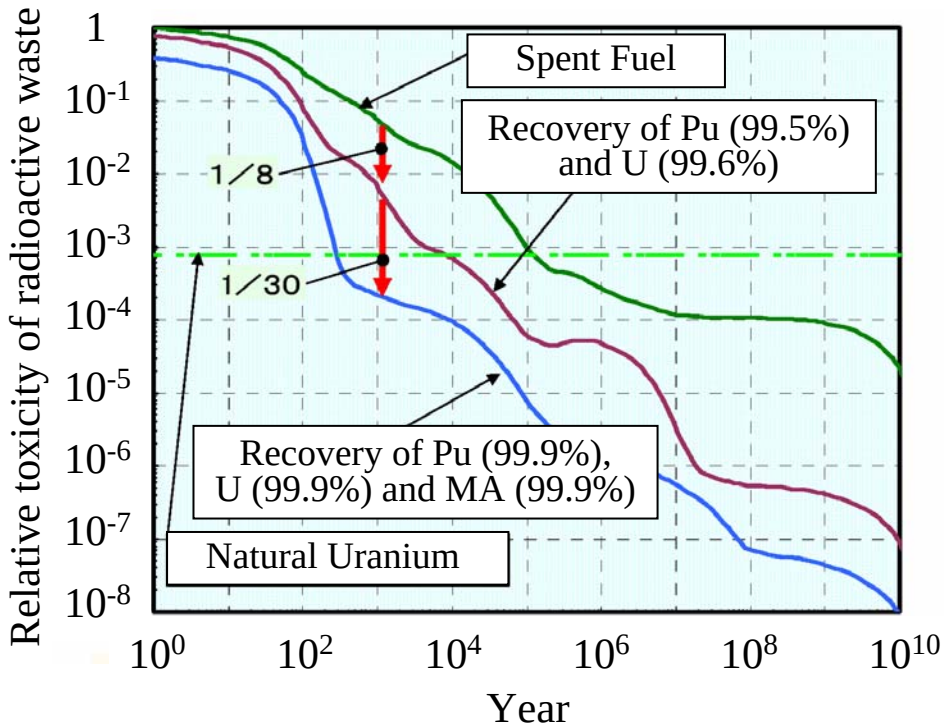
- *On October 11, 2005*, the Atomic Energy Commission of Japan decided the *"Framework for Nuclear Energy Policy"*
  - » A basic principle for the nuclear energy policy that promotes research, development and utilization of nuclear science and engineering

- *On October 14, 2005*, the Government of Japan decided to respect the "Framework for Nuclear Energy Policy"

Framework for Nuclear Energy Policy (2/4)

Atomic Energy Commission of Japan

- Basic and fundamental research and development activities on *partitioning and transmutation* technologies, which would reduce the burden of disposal of radioactive waste, are to be conducted to support the utilization of nuclear energy in Japan

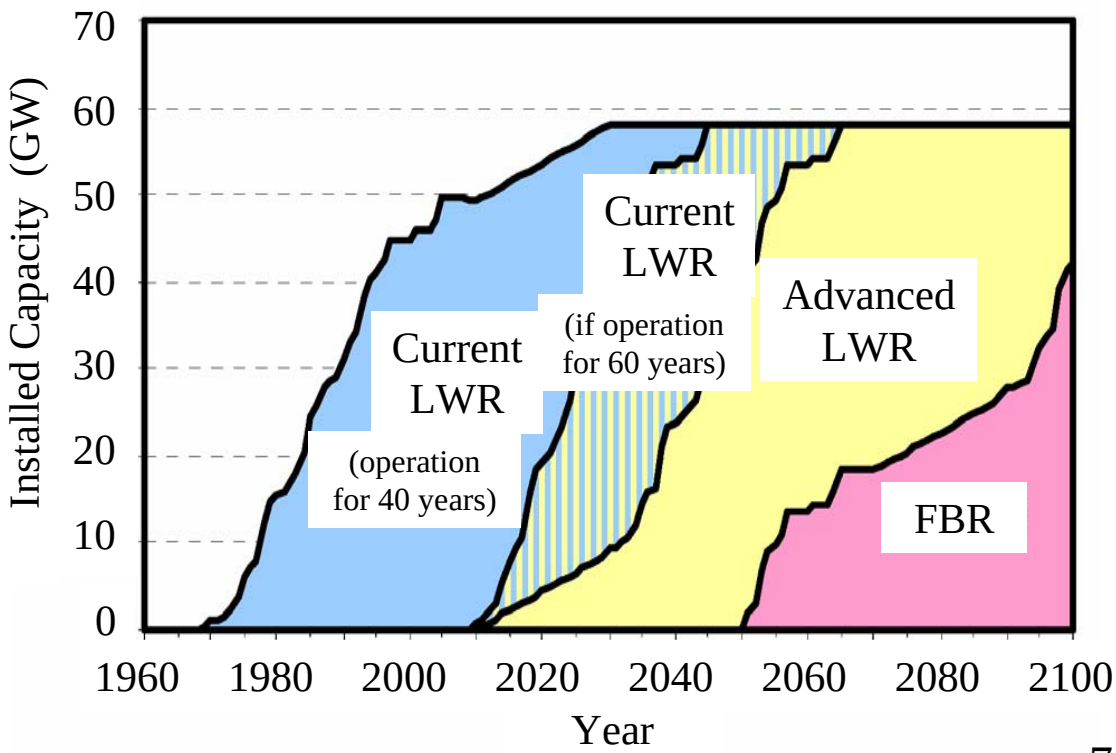


Framework for Nuclear Energy Policy (3/4)

Atomic Energy Commission of Japan

- It is appropriate to aim at maintaining or increasing the current level of nuclear power generation even after 2030
  - » 30 to 40% of the total electricity generation

- Advanced models of the LWR are to be prepared for the replacement of existing nuclear power plants
- The replacement will start around 2030



Framework for Nuclear Energy Policy (4/4)

Atomic Energy Commission of Japan

- *FR and its fuel cycle technology* have the potential of contributing to long-term energy security and *reduction of the effects of potential toxicity of radioactive waste*
- It is necessary to consistently promote the research and development toward its commercialization led by the Japan Atomic Energy Agency
- Feasibility study on commercialized FR cycle systems aims to establish the FR cycle technological scheme in around *2015*
- Development of FR cycle aims at its commercial introduction at around *2050*

Science and Technology Basic Plan

Council for Science and Technology Policy

- *On March 28, 2006*, the Government of Japan decided the *"The 3rd Science and Technology Basic Plan"*
  - for five years from FY2006 to FY2010
  - based on the report submitted to the prime minister by the Council for Science and Technology Policy on Dec. 28, 2005
- *FR cycle technology* has been selected as key technology of national importance
  - Intensive investment to FR cycle technology in the next five years

Nuclear Power Nation Plan

Ministry of Economy, Trade and Industry (METI)

- *On Aug. 8, 2006*, a committee of METI reported the *"Nuclear Power Nation Plan"*
- Created a concrete plan based on the "Framework for Nuclear Energy Policy"
  - » Being included in the *"New National Energy Strategy"*
- For the practical application of the FR cycle
  - » Re-commence the operation of *Monju* at an early date and establish sodium handling technology
  - » Promote necessary technological developments such as the mixed extraction of minor actinides
  - » Aim to realize the demonstration reactor and related cycle facilities *by 2025*
  - » Develop the commercial reactor *before 2050*

R&D Plan for Nuclear Energy (1/2)

Ministry of Education, Culture, Sports, Science and Technology (MEXT)

- *On Sept. 6, 2006*, the *"R&D Plan for Nuclear Energy"* was reported to *Council for Science and Technology*
  - » as a result of intensive discussion in the Subdivision on R&D planning and Evaluation, Council for Science and Technology
  - » a concrete plan based on the "Framework for Nuclear Energy Policy"

- Basic and fundamental research and development
  - » It is important to promote the R&D on the *partitioning and transmutation technologies* steadily

R&D Plan for Nuclear Energy (2/2)

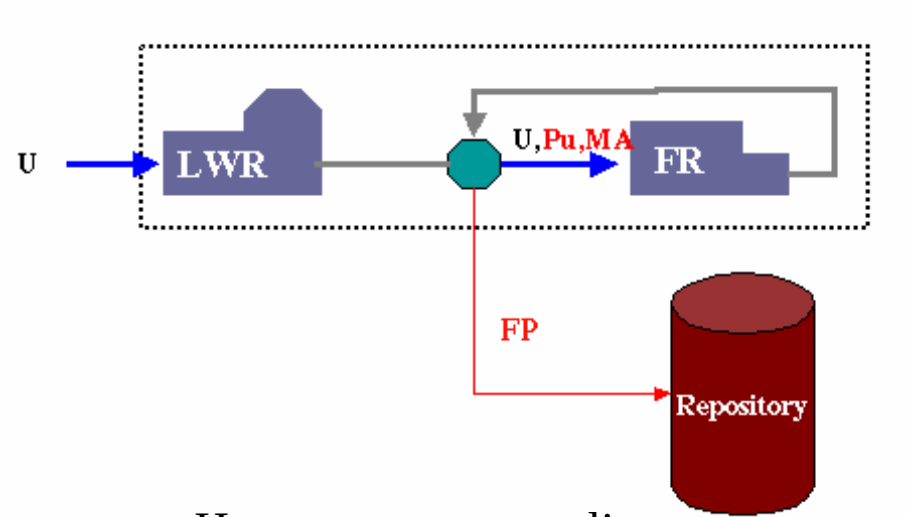
Ministry of Education, Culture, Sports, Science and Technology (MEXT)

- FR cycle technology
  - A council is set up to investigate demonstration process of fast reactor cycle technology by MEXT, METI, JAEA, the electric utilities and fabricators
  - The most probable concept is sodium-cooled FR with advanced aqueous reprocessing and simplified MOX fabrication
  - Re-start the operation of *Monju* *by around 2008*
  - Optimization of conceptual designs of commercialized FR and its cycle facilities is made based on engineering-scale demonstration *by 2015*
  - Development of a demonstration FR aims at its introduction *by around 2025*

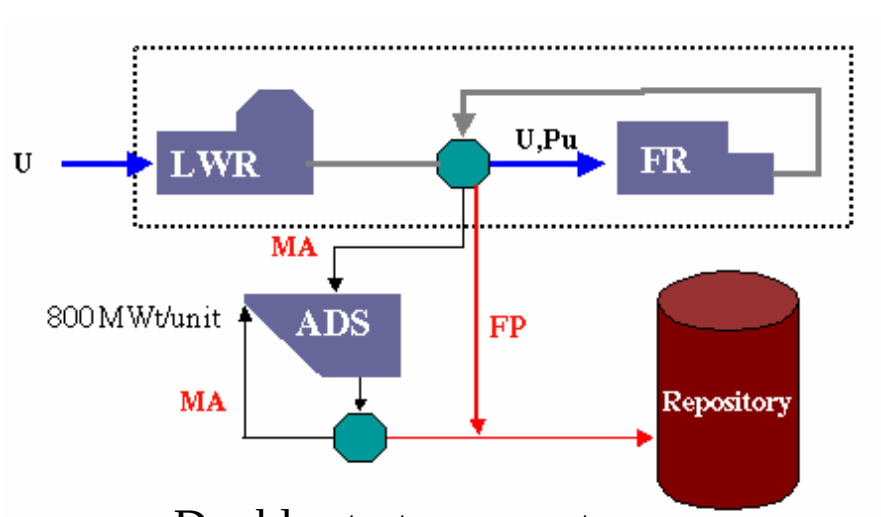
R&D Activities on P&T in Japan

Two Types of P&T Schemes

- *Homogeneous recycling* with commercialized FR
  - » MA-MOX fuel with aqueous reprocessing
  - » MA-bearing metal fuel with pyrochemical reprocessing
- *Double-strata concept* with accelerator driven system
  - » MA-bearing nitride fuel with pyrochemical reprocessing



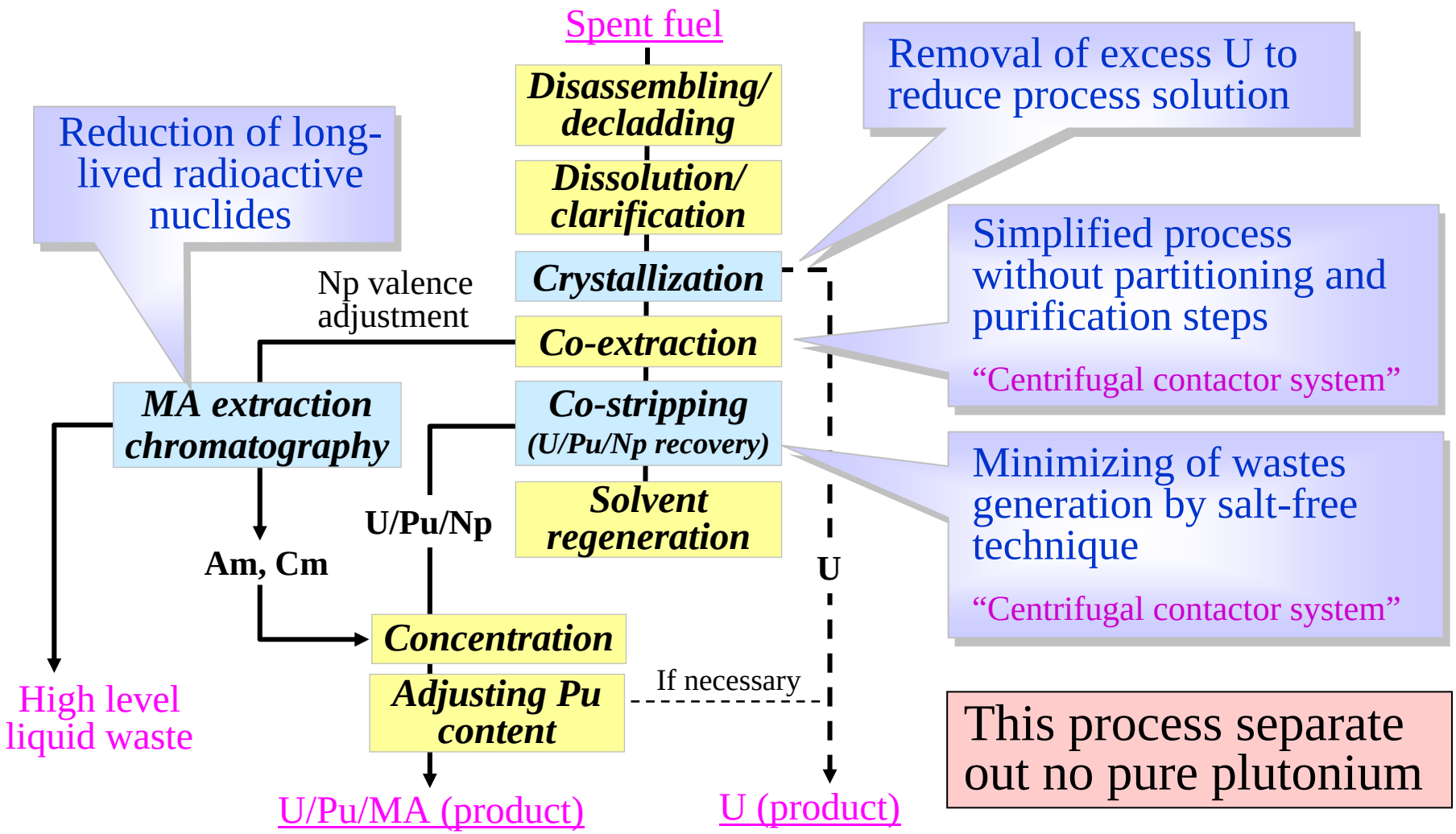
Homogeneous recycling



Double strata concept

Advanced Aqueous Reprocessing

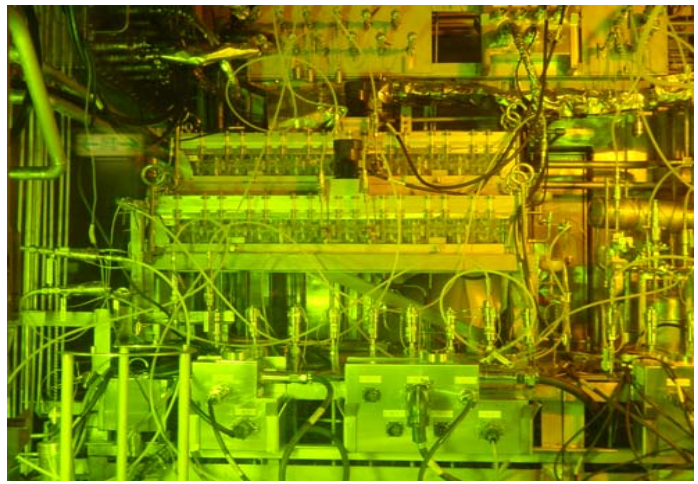
NEXT (New Extraction systems for TRU recovery) Process



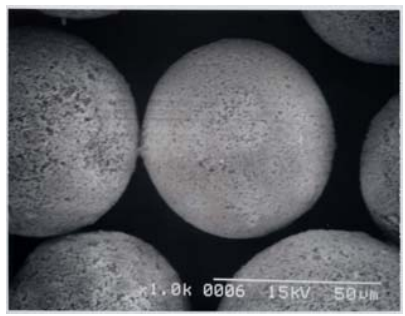
Advanced Aqueous Reprocessing

Experimental Validation

- U/Pu/Np co-recovery
  - » Collection of data by hot tests
  - » Development of centrifugal contactor
    - – U extraction tests by multi-stage centrifugal contactors (10 kg-HM/h)
  - » Development of the instrumentation system
- MA recovery by extraction Chromatography
  - » Collection of data by hot tests
    - – SiO_2-P: porous SiO_2 covered by SDB polymer
    - – Resin: extactants (CMPO, TODGA, BTP, etc.) immobilized on SiO_2-P
  - » Development of the engineering setup



Centrifugal contactor bank for U/Pu/Np co-recovery experiment

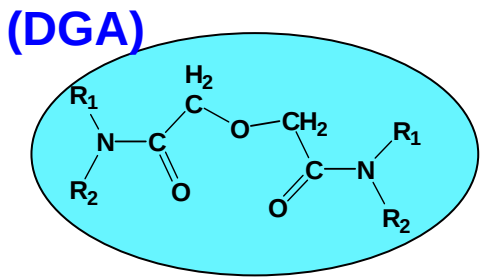


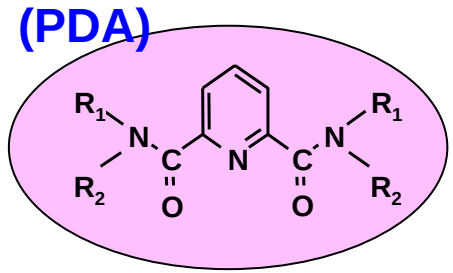
Adsorbent: CMPO/SiO_2-P

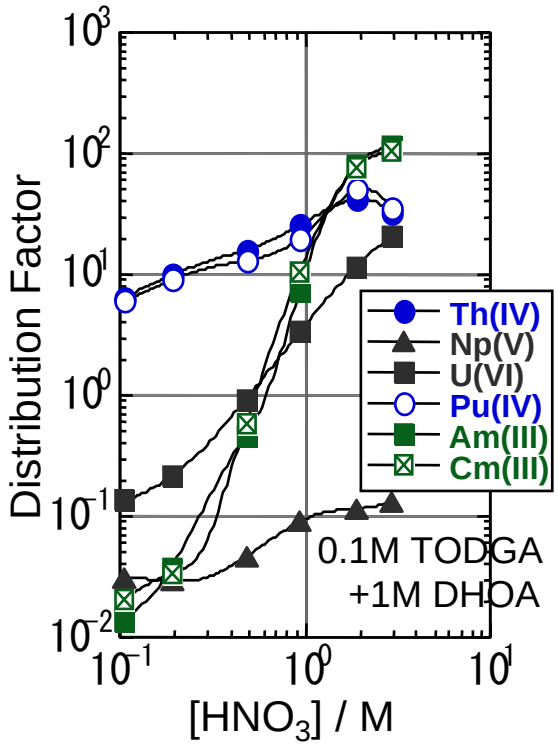
Novel Extractants for MA Separation

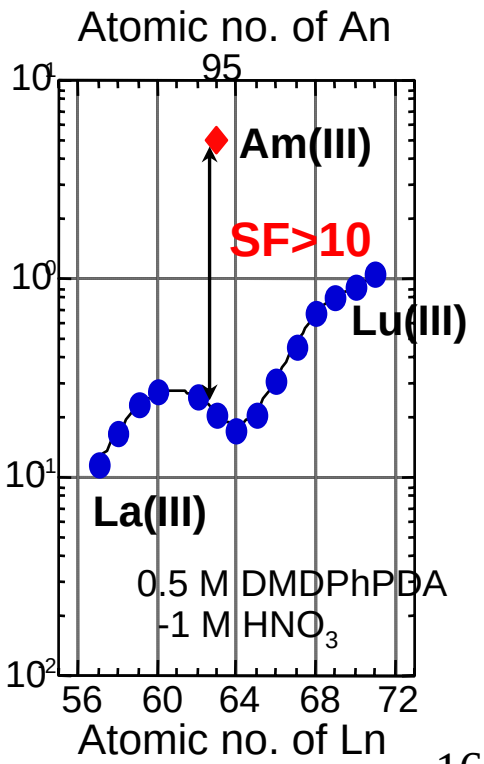
Development of DGA and PDA

- Diglycolamides (DGA) for TRU recovery
  - » High solubility in n-dodecane
  - » Very high extraction ability for An(III) and An(IV) from HNO_3 solution
- Pyridine dicarboxyamides (PDA) for MA/Ln separation
  - » PDA can separate An(III) from Ln(III) in HNO_3 solution
- DGA and PDA consist of C, H, O, and N





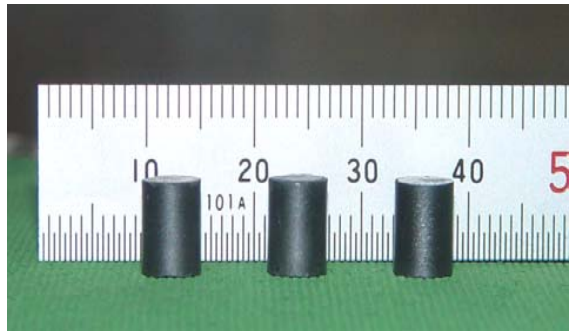




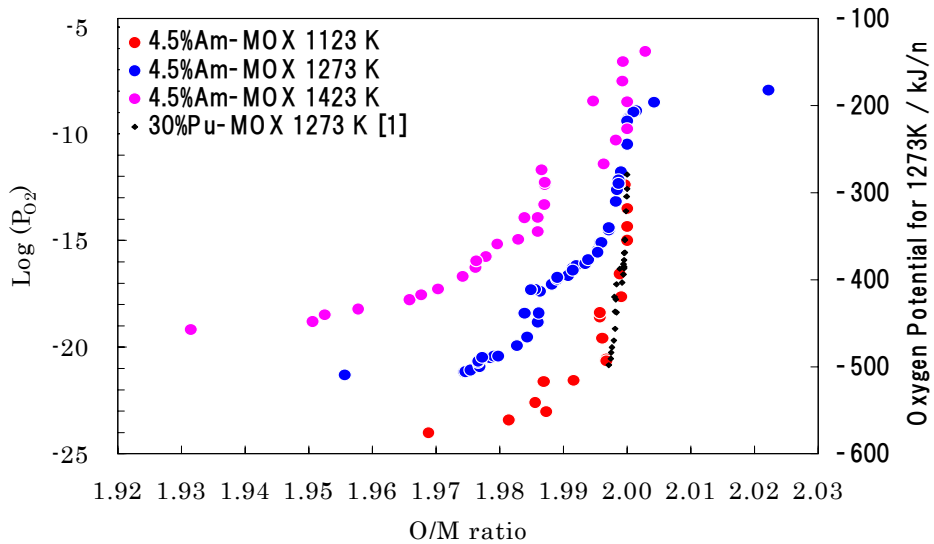
MA-bearing MOX Fuel

Fabrication and Characterization

- Simplified pelletizing method
  - » Die wall lubrication pelletizing, Sintering, O/M adjustment
    - – Good accuracy of Pu content adjustment by solution mixing
    - – Pellet fabrication with die wall lubrication
    - – Good Sintering of Am/Np/simulated FP pellet with low O/M ratio
- Property measurements
  - » MA and simulated FP bearing MOX fuel
    - – Melting point
    - – Thermal conductivity
    - – Oxygen potential, etc.



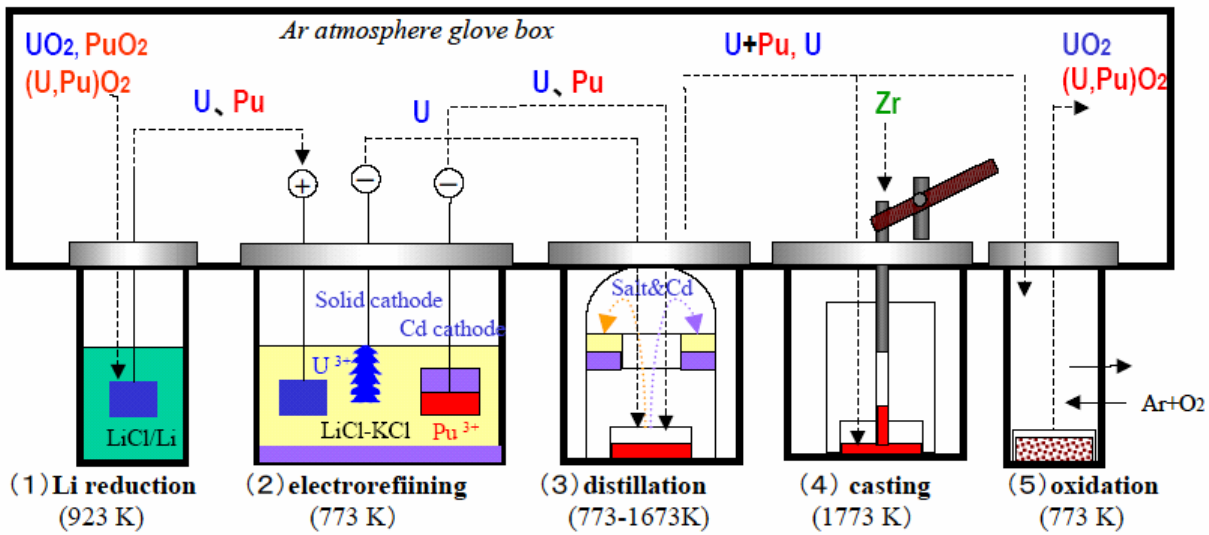
5%Am-MOX fuel pellets for JOYO irradiation test



Electrometallurgical Process

Integrated Experiments

- Whole process was demonstrated in one continuous operation using UO_2 with good mass balance
  - » Li reduction, electro-refining and distillation
- Test with PuO_2 was successfully finished
- Integrated test with MOX fuel is underway



Solid cathode deposit

Cd cathode deposit

Recovered Pu-U-Cd

CRIEPI- JAEA collaboration

Phenix Irradiation of MA-metal Fuel

METAPHIX

- Irradiation of metal fuel pins with U-Pu-Zr containing minor actinides (Np,Am,Cm) and rare earths
- Fuel fabrication, PIE and recycling with pyro-process in ITU

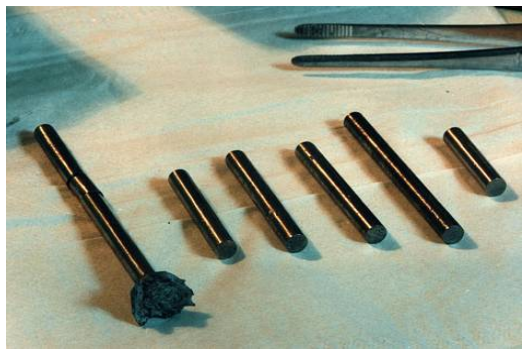
Burnup	2003	2004	2005	2006	2007	2008	2009	2010
2.4 at.%	Irrad.	→		Trans.	PIE			
7.0 at.%	Irrad.	→	→	→	Trans.	PIE		
11.0 at.%	Irrad.	→	→	→	→	Trans.	PIE	→

U-Pu-Zr-MA-RE

MA; Np, Am, Cm

RE; Ce, Nd, Y, Gd

(Fabricated by arc-melting)



Composition, wt%

U-19Pu-10Zr

U-19Pu-10Zr-2MA-2RE

U-19Pu-10Zr-5MA-5RE

CRIEPI- ITU collaboration

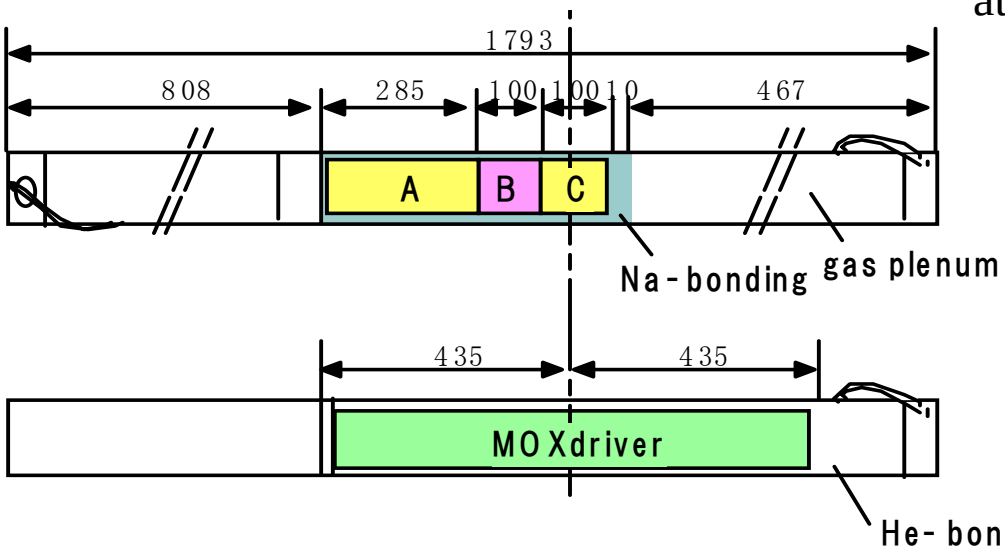
Phenix Irradiation of MA-metal Fuel

METAPHIX

- The non-destructive analysis on pins with 2.4 at% burnup at Phenix was finished
  - » *No failure* and *no deformation* were visually observed
  - » To be transported to JRC-ITU for destructive PIE

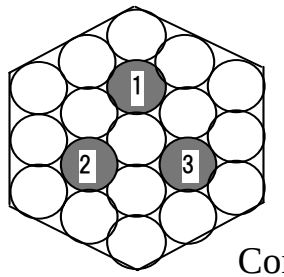
<Pin configuration>

A,C: U-Pu-Zr B: U-Pu-Zr-MA-RE



<Configuration of capsule>

Irradiation of 3 pins in the same capsule at different burnup



MOX Driver pin

Metal fuel pin with MA

Composition of region B, wt%

Pin1 : U-19Pu-10Zr

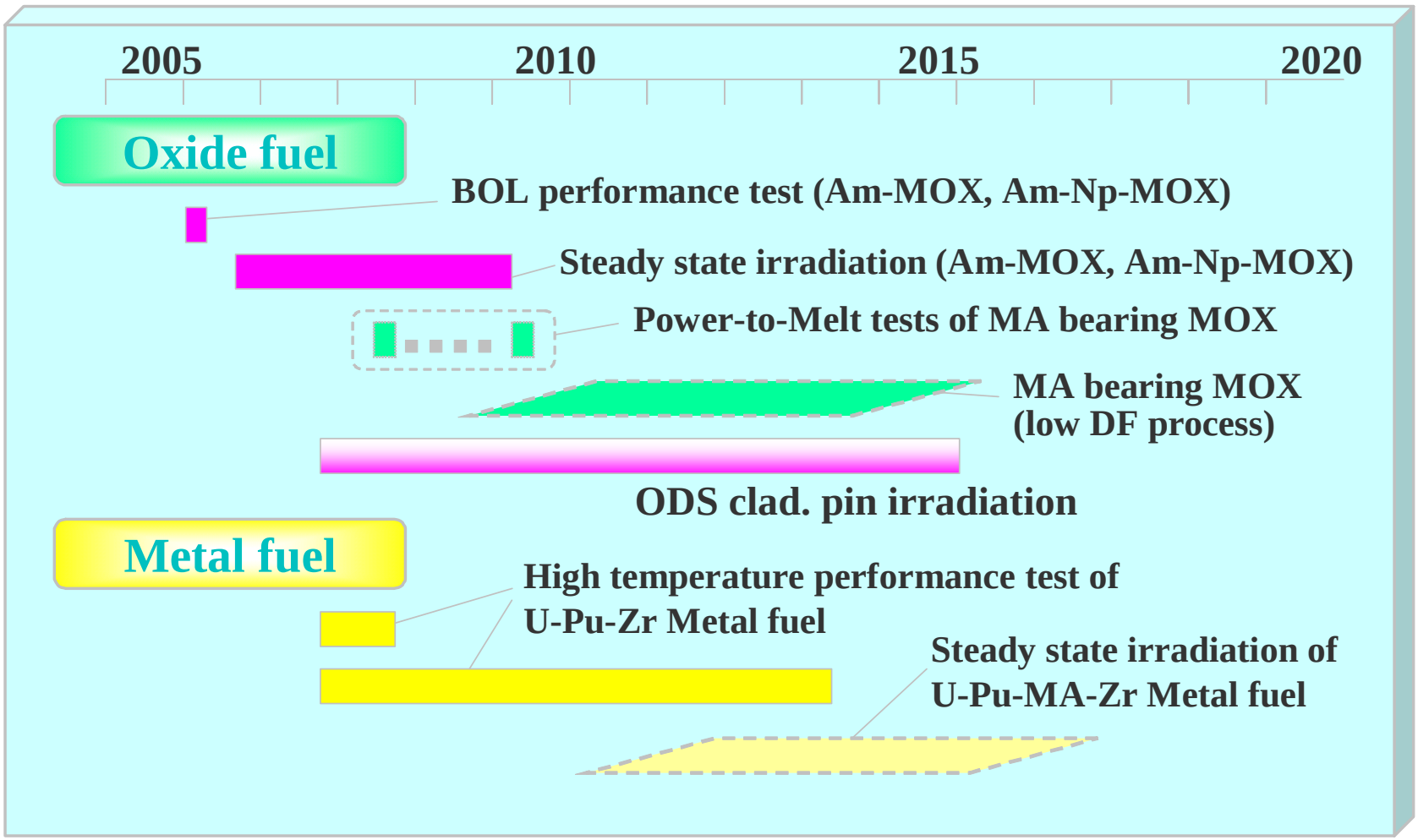
Pin2 : U-19Pu-10Zr-2MA-2RE

Pin3 : U-19Pu-10Zr-5MA-5RE

CRIEPI- ITU collaboration

Fuel Irradiation Test Plan

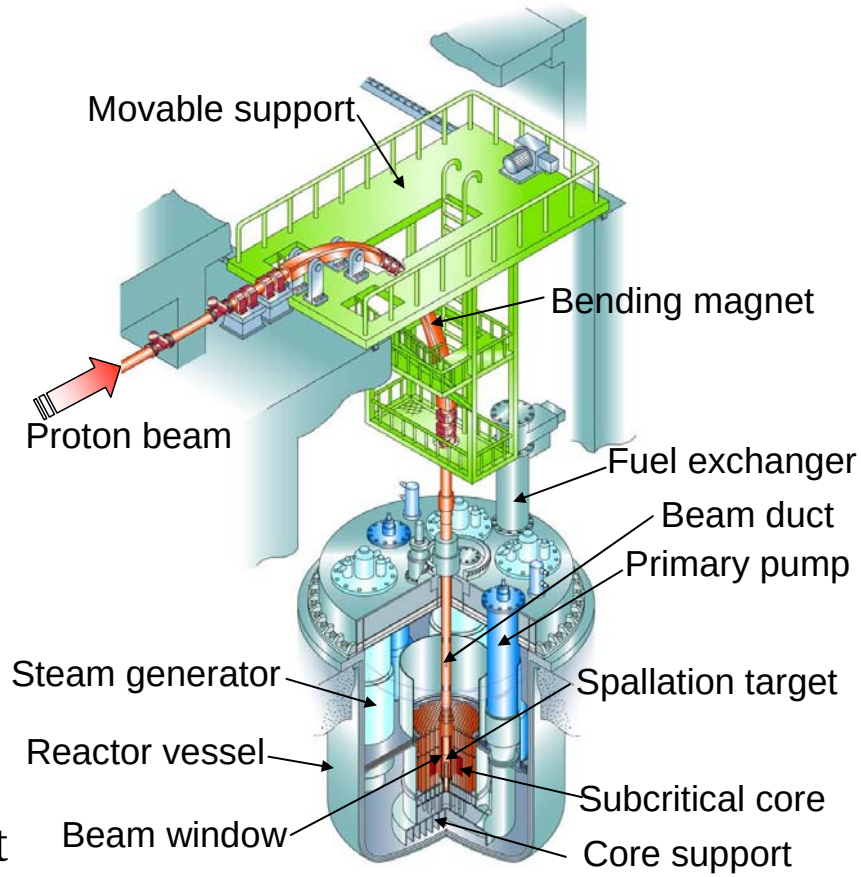
Oxide and Metal Fuels in JOYO



Accelerator Driven System

Design and Key Technology Development

- Accelerator
  - » Superconducting LINAC
  - » High-intensity proton accelerator (J-PARC Project)
  - » Assessment and improvement of reliability
- Spallation Target
  - » Development of Pb-Bi technology
  - » Design and material for feasible beam window
- Sub-critical Reactor
  - » Reduction of power peaking
  - » Management of beam trip transient
  - » MA fuel handling
  - » Transmutation of 250 kg-MA/y

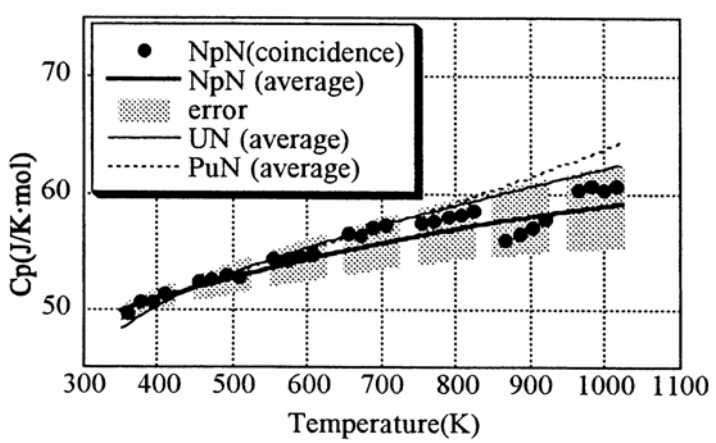


Conceptual view of 800 MWth LBE-cooled ADS

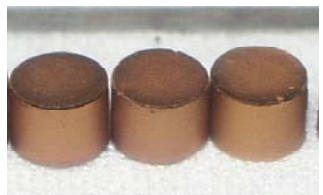
MA-bearing Nitride Fuel

Fabrication, Characterization and Pyrochemical Process

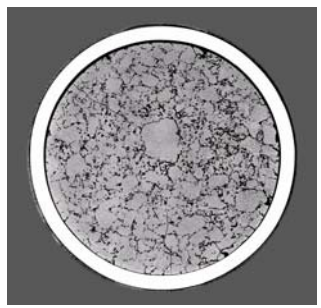
- Nitride Fuel
  - » Fabrication of (Np,Pu,Am,Cm)N, etc.
  - » Property measurements
    - – Thermal conductivity, Thermal expansion, Heat capacity, etc.
  - » Post-irradiation examination of (Pu, Zr)N and PuN+TiN fuel
    - – No detrimental effect by addition of diluent materials of ZrN and TiN
- Pyrochemical Process
  - » Dissolution behavior of (Pu,Zr)N in LiCl-KCl eutectic melt was clarified
  - » Nitride formation of Pu and U from Pu-U-Cd alloy and pellet fabrication
    - – Nitridation/distillation combined method



Heat capacity of actinide nitrides



(Pu,Zr)N pellets



Cross-section of (Pu,Zr)N pellet after irradiation

Summary

- Nuclear Fuel Cycle Strategy in Japan
  - » Basic and fundamental research and development activities on *partitioning and transmutation technologies* are to be conducted to support the utilization of nuclear energy
  - » Development of a demonstration FR aims at its introduction *by around 2025*
  - » Development of FR cycle aims at its commercial introduction *before 2050*
- R&D activities for P&T technologies
  - » *Using commercialized FR*
    - – MA-MOX fuel with aqueous reprocessing
    - – MA-bearing metal fuel with pyrochemical reprocessing
  - » *Using ADS in double strata concept*
    - – MA-bearing nitride fuel with pyrochemical reprocessing