International Symposium on Present Status and Future Perspective for Reducing Radioactive Wastes - Aiming for Zero-Release –

Demonstration of partitioning & transmutation of MA by metal fuel with pyroreprocessing

放射性廃棄物低減に向けた現状と将来の展望
～ゼロリリースを目指して～
平成26年10月10日(金)

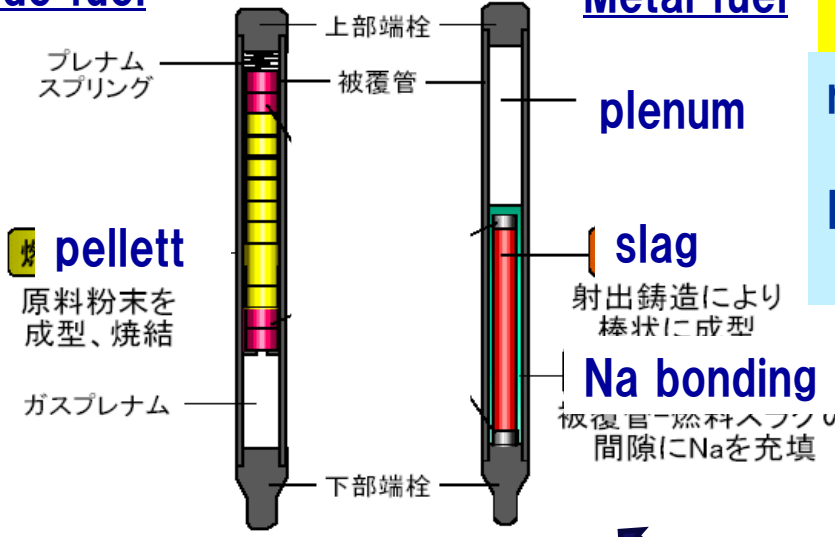
Tadafumi Koyama (CRIEPI)

本報告は、文部科学省のエネルギー対策特別会計委託事業による委託業務として、財団法人電力中央研究所が実施した平成21年度「実用化に向けた金属燃料サイクルの工学技術実証に関する研究開発」の成果の一部を含みます。

電力中央研究所

Metal fuel : Hard neutron spectrum & experience in remote fuel fabrication

Oxide fuel

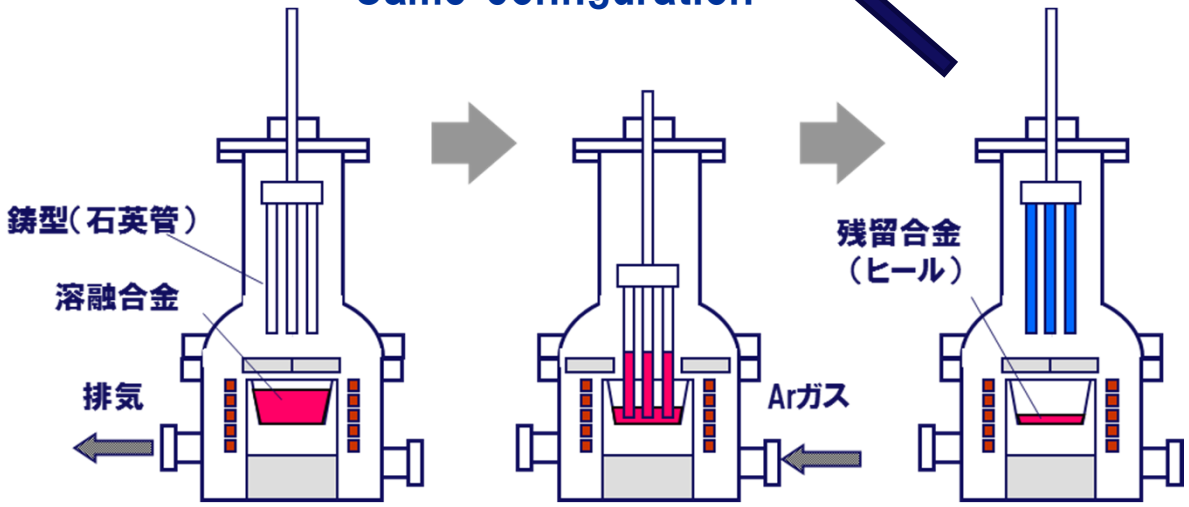


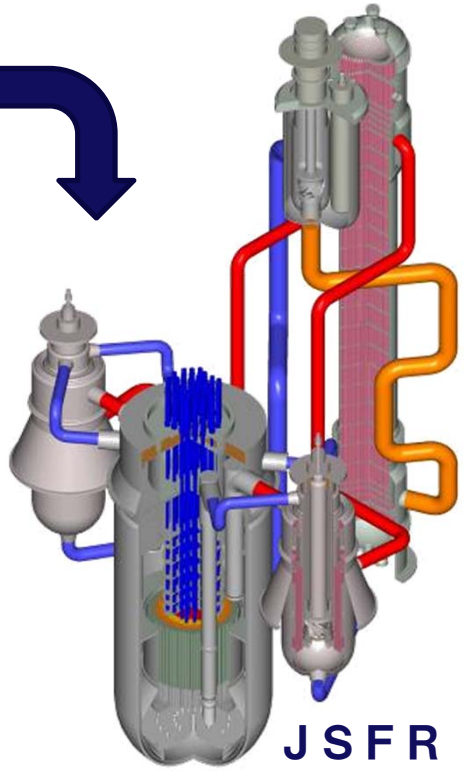
Metal fuel

U-Pu-MA-Zr-FP alloy

no oxygen⇒ hard neutron spectrum
⇒high MA Transmutation ratio
High thermal conductivity
⇒safety for transient

Same configuration

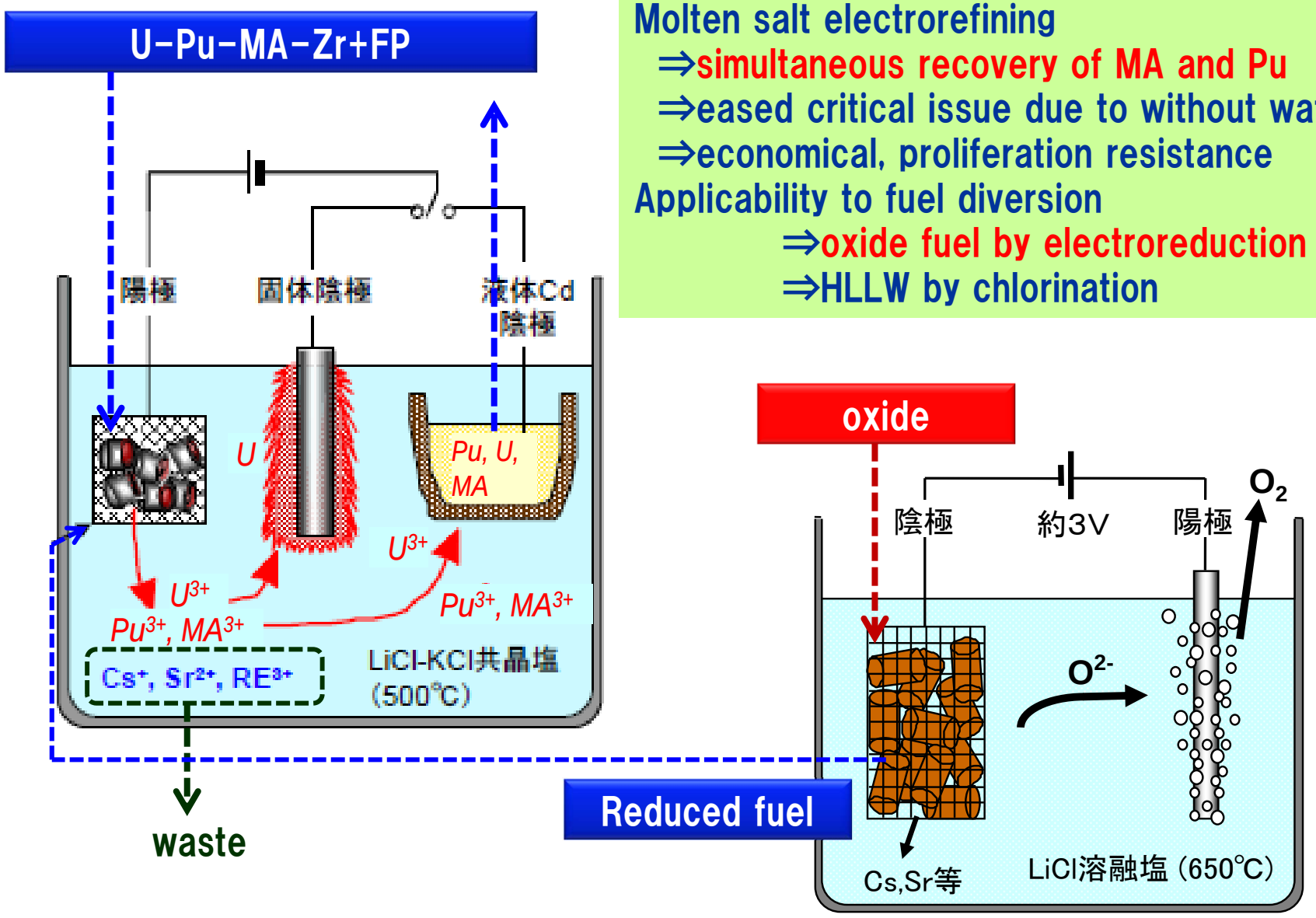




Injection casting

More than 17,000 recycled pins were remotely fabricated in ANL.
⇒ applicability for fabrication of Cm containing fuel.

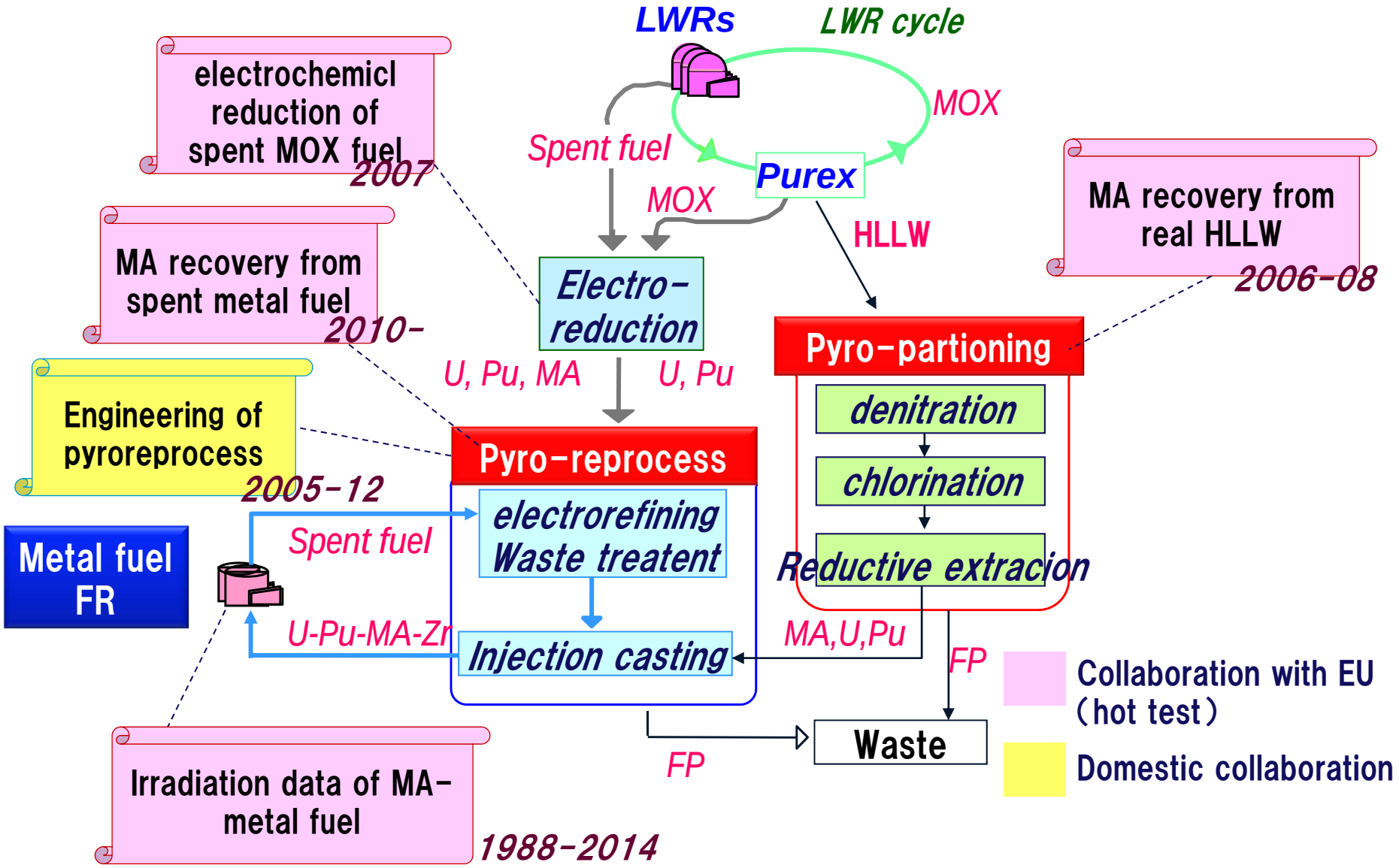
Pyro-reprocessing: MA recycle in reasonable investment



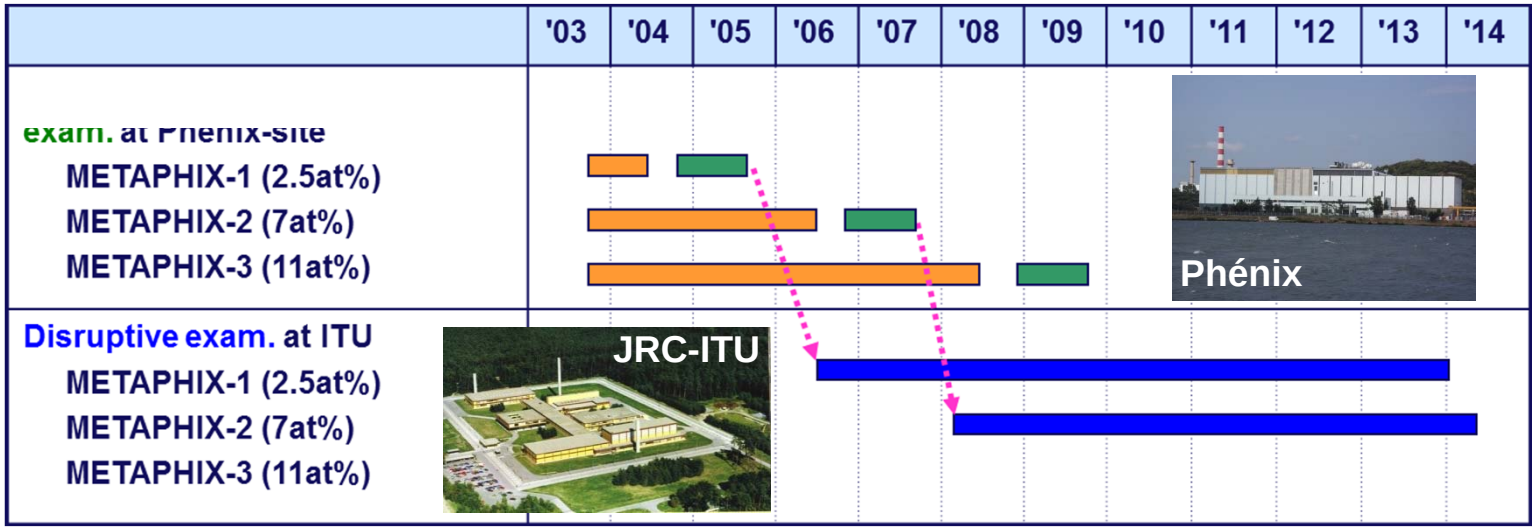
Molten salt electrorefining
- ⇒simultaneous recovery of MA and Pu
- ⇒eased critical issue due to without water
- ⇒economical, proliferation resistance

Applicability to fuel diversion
- ⇒oxide fuel by electroreduction
- ⇒HLLW by chlorination

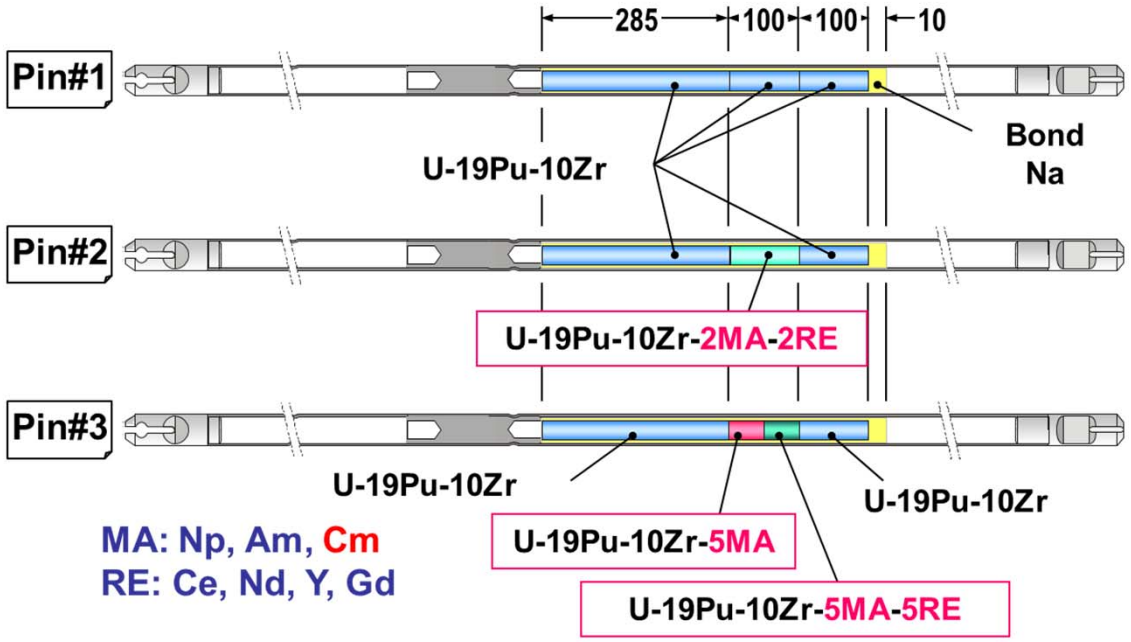
Issues on pyro-processing and metal fuel for P&T

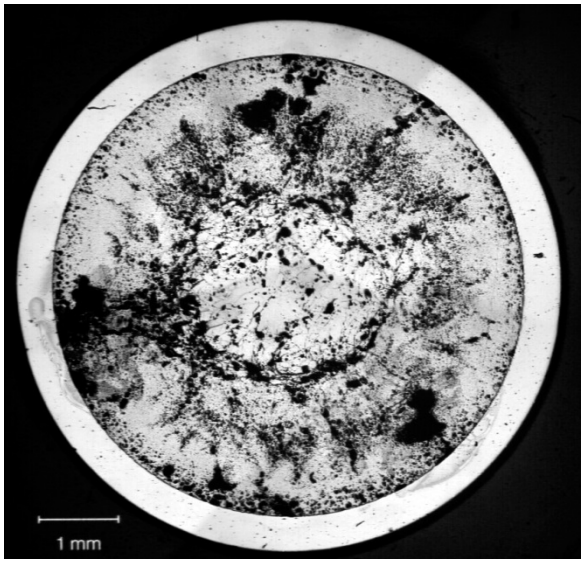


1．Irradiation test of MA containing metel fuel at Phenix reactor



*) 1988-1995 fuel fabrication

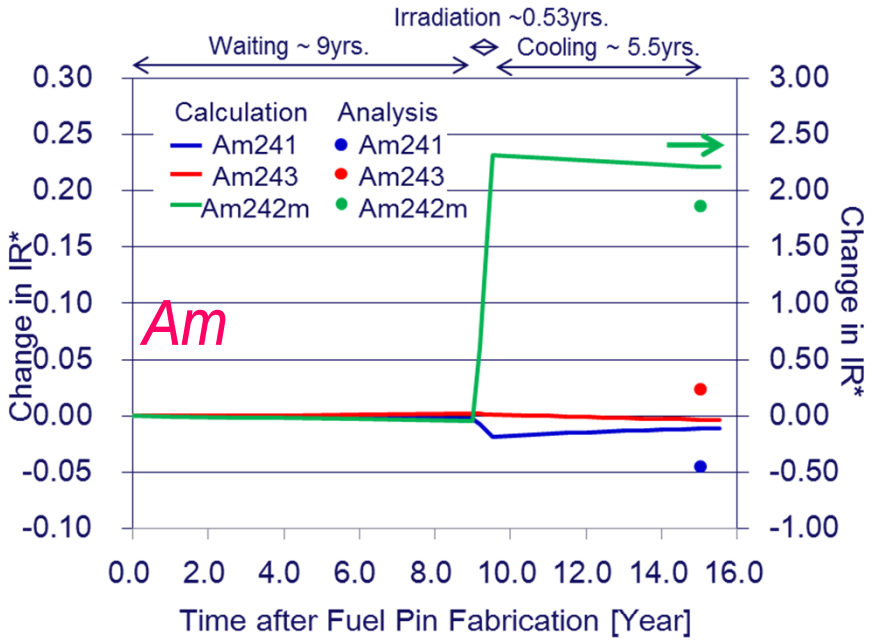


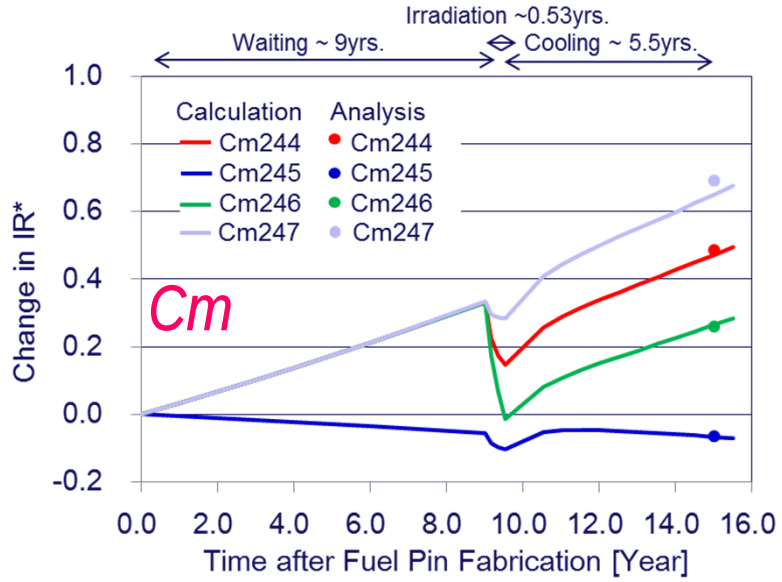


1．Irradiation test of MA containing metel fuel at Phenix reactor

Actinide isotope ratios before and after METAPHIX-1 & -2 irradiation experiments were evaluated and compared with ORIGEN2 calculations.

- Even in low-burnup experiment, isotope ratios of Pu, Am and Cm change significantly,
- MA burnups and radioactive decay reactions after fuel fabrication can be simulated by ORIGEN2 code.
- Pu, Am and Cm nuclides in U-Pu-Zr alloy are properly transmuted as expected.

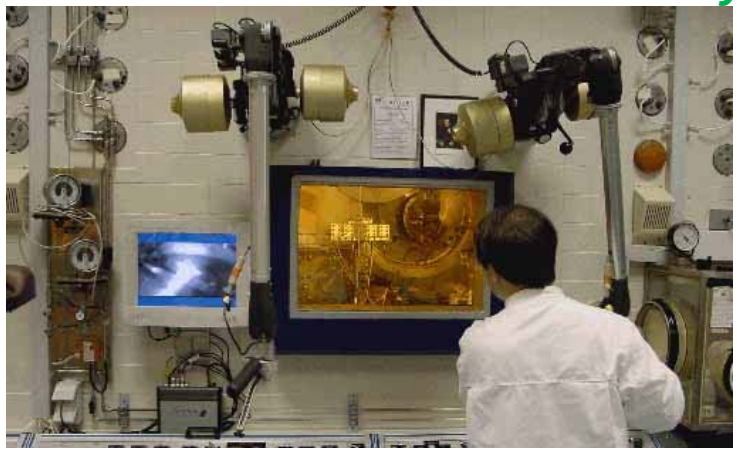


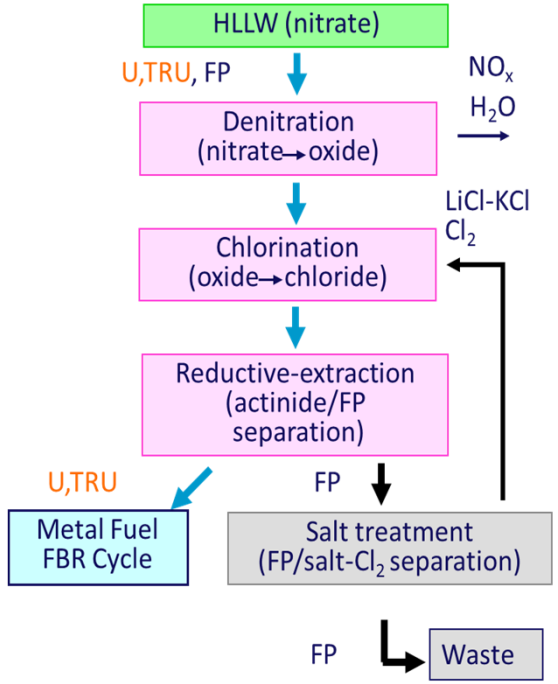


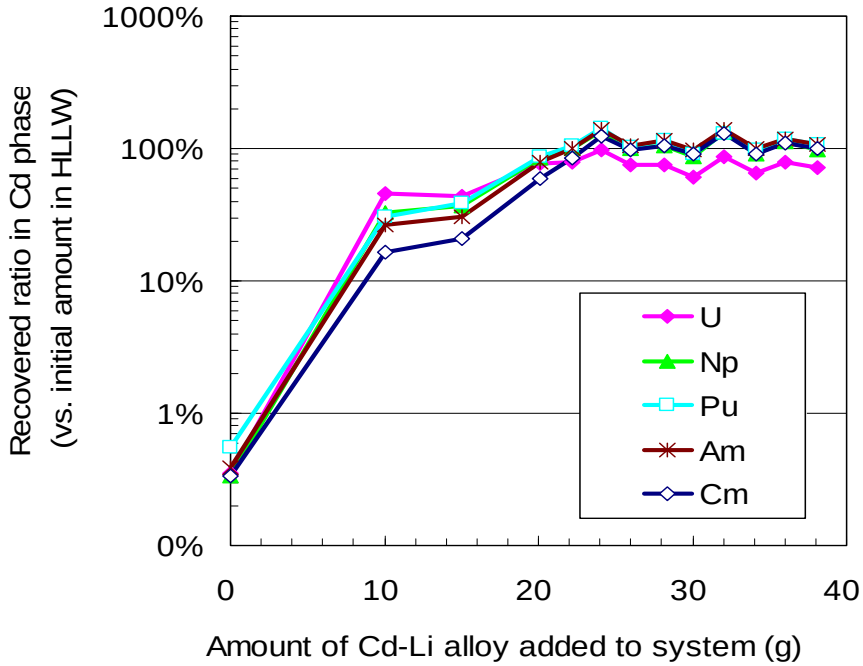
2. Pyro-partitioning of MAs from Actual HLLW

- **Recovery and separation of actinides from genuine HLLW by pyrochemical process was carried out.**
- **High recovery yield was obtained for Np, Pu, Am and Cm.**

CRIEPI & JRC-ITU Joint study







3 . Pyrochemical processing of irradiated MOX fuel

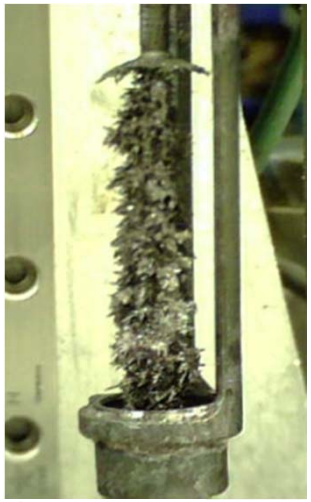
- ***Pyrochemical technology will process metal, nitride, oxide and nitric acid solution.***

CRIEPI & JRC-ITU Joint study

- ***Recovery and separation of actinides from irradiated MOX fuel was demonstrated with small scale test.***

  -MOX fuel; 5g/batch -Current; 1A (~2.5g MOX/h)

U deposit

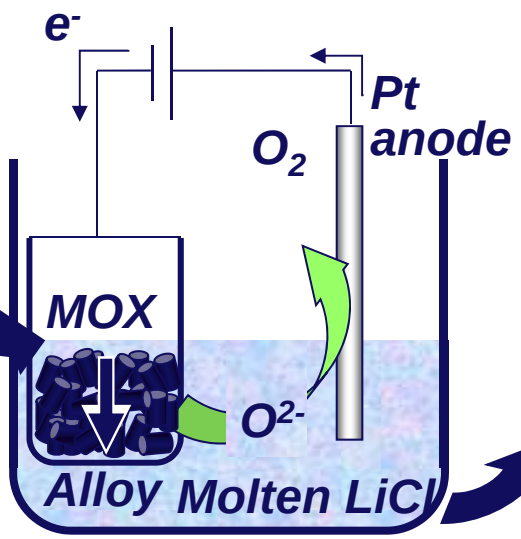


Decladded MOX

5g MOX

(45 GWd/tHM)

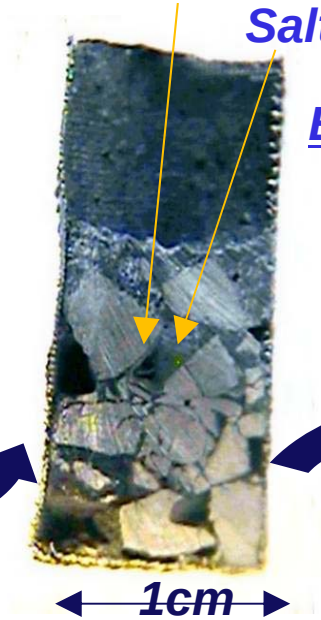
Electrochemical reduction



Reduced MOX

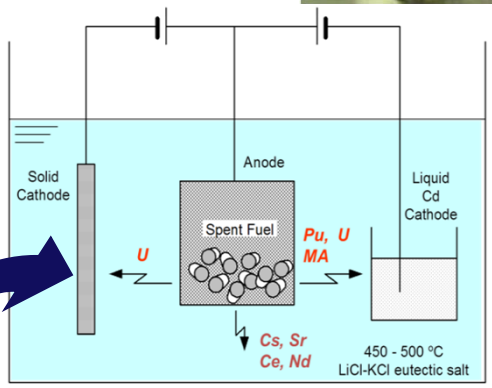
Fuel fragment

Salt



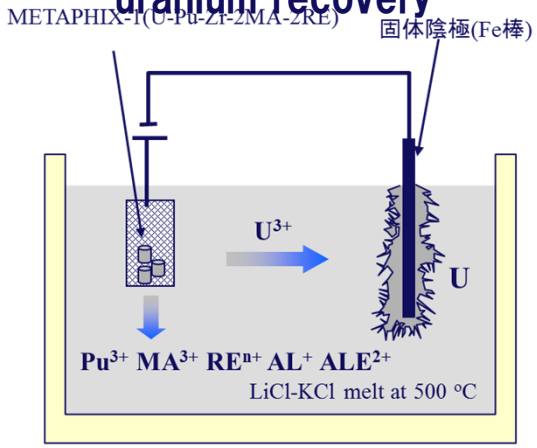
1cm

Electrorefining

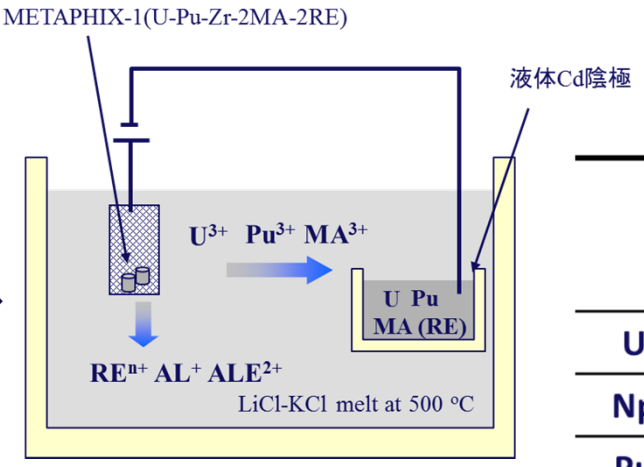


4. Electrorefining of irradiated METAPHIX

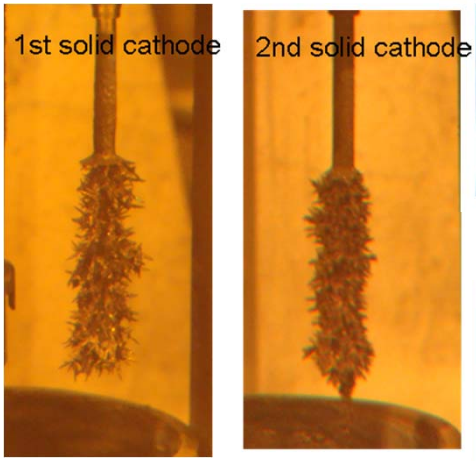
RUN1 fuel dissolution & uranium recovery



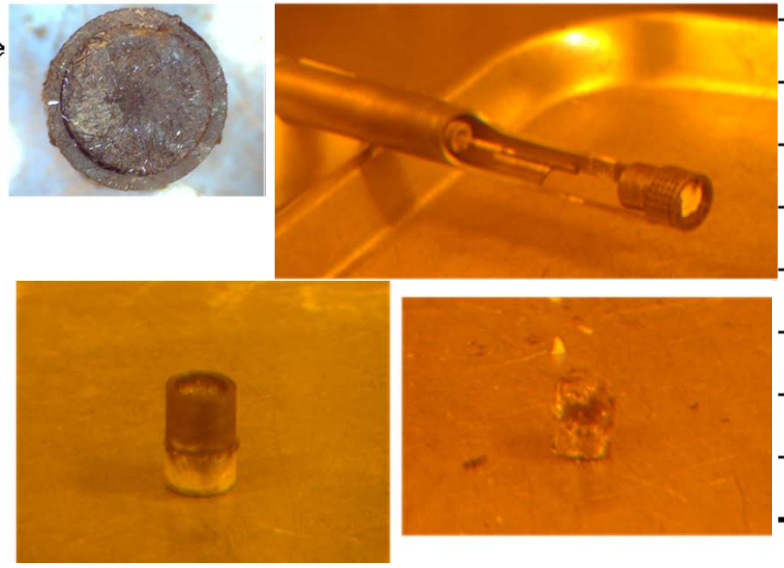
RUN2 fuel dissolution & Pu,U,MA recovery



	RUN1 Solid cathode (mg)	RUN2 Cd cathode (ppm in Cd)
U	3840	9560
Np	0.01	118
Pu	0.1	7525
Am	0.004	44
Cm	0.001	12
La	ND	0.5
Ce	ND	11
Pr	ND	0.7
Nd	ND	10
Gd	ND	0.3
Y	ND	0.05



Solid cathode depoist



Liquid Cd cathode deposit (about 2wt% in Cd)

5. Engineering test with uranium

○Engineering-scale experiment with 5kg-U/batch/day (=1 ton-HM/y)

Sequential test

UO_2

Recycled U-Zr metal

Cycle test


reduction

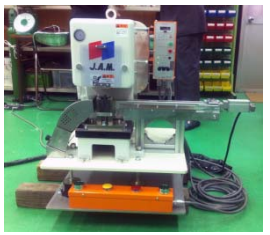

refining


Product recovery


distillation

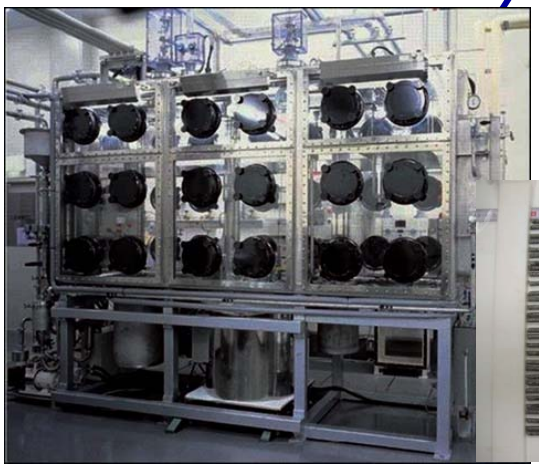

transport


Injection casting


Pin chopper

Recoered uranium


Glove biox for pyroreprocessing



Casted fuel

Globe box for fuel fabrication

Evaluation by repeated cycle⇒ throughput (>4.6kgU/d) , mass balance (>98%)

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conclusion

Demonstration tests with real fuels & irradiaton under the collaboration with JRC-ITU since1988 is successfully being finished. The data agreed with the prediction based on experiments with unirradiated actinides, and demonstrated the superiority of metal fuel and pyroreprocessing for P&T.

The engineering feasibility of pyroprocess fuel cycle was demonstrated with high material balance and high throughput in the repeated process tests of sequential mode.