# R&D of Partitioning and Transmutation using Accelerator-Driven System and role of J-PARC



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### Accelerator Driven System (ADS)





## **Double-strata Fuel Cycle Concept with ADS**



## **Conceptual Design of ADS by JAEA**



**Conceptual view of 800MWth LBE-cooled ADS** 

- Proton beam : 1.5GeV ~30MW
- Spallation target : Pb-Bi
- Coolant : Pb-Bi
- Subcriticality : k<sub>eff</sub> = 0.97
- Thermal output : 800MWt
- MA initial inventory : 2.5t
- Fuel composition :
  - (MA+Pu)Nitride + ZrN

**Initial loading** 

- Zone-1 : Pu/HM = 30.0%
- Zone-2 : Pu/HM = 48.5%
- Transmutation rate :

10%MA / Year (10 units of LWR)

• 600EPFD, 1 batch

## Superconducting Accelerator for ADS





Cryomodule

- Mockup of cryomodule (2 superconducting cavities) was fabricated and tested. The design study provided that the SC-LINAC consisting of 89 cryomodules and the length was estimated as 472m.
- The LINAC (400MeV, 25Hz) in J-PARC has been operated stably for injection to the following 3 GeV synchrotron.



Proton Linac (400MeV) in J-PARC

### Desing Study : Spallation Target and Beam Window

- Design condition
  - ✓ Proton beam: 1.5 GeV-20 mA(30 MW)
  - ✓ LBE velocity : < 2m/s</p>
  - ✓ Maximum beam window temperature : < 500°C</li>
- Beam window design in which the maximum temperature at the outer surface of the window is about 490 °C
- R&D issues : Material corrosion in LBE, thermalhydraulic of LBE, material irradiation effect



## **Thermal Hydraulics Study of LBE**





### Oxygen Sensor Calibration Device

- To prevent corrosion by flowing LBE, oxygen potential in LBE should be controlled in appropriate potential range.
- Development of oxygen potential sensor and loop tests for oxygen potential control mechanism are underway.





- OLLOCHI (Oxygen-controlled Lbe LOop for Corrosion tests in HIgh temperature)
  - Material corrosion database for various temperature, oxygen potential, LBE flow rate will be collected
  - The loop will be operated from next April
- IMMORTAL (Integrated Multi-functional MOckup for TEF-T Real-scale TArget Loop)
  - Purpose of experiments is demonstration of safe operation of LBE loop by reflecting operation condition of J-PARC LBE Spallation target.

### **Reactor physics experiments**

Collaboration study with Kyoto University Reactor physics experiment using KUCA and FFAG accelerator is planned to perform next year.



FFAG accelerator





KUCA A-core



<u>Kyoto</u> <u>University</u> <u>Critical</u> <u>Assembly</u> (KUCA) and <u>Fixed</u> <u>Field</u> <u>Alternating</u> <u>Gradient</u> (FFAG) accelerator



Core image to simulate ADS in KUCA



## **R&D** for MA nitride fuel for ADS







Liquid Cd cathode

after electrolyzation

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Recovered nitride powder

(U,Pu)N pellet

#### Irradiation performance

- Irradiation test of (Pu,Zr)N and PuN+TiN in JMTR/JAEA
- •Irradiation test of MA(Am,Np) in PHENIX by international collaboration

### J-PARC: Japan Proton Accelerator Research Complex





### Image of Transmutation Experimental Facility (TEF)

#### Transmutation Physics Experimental Facility: TEF-P

 Purpose: To investigate physics properties of subcritical reactor with low power, and to accumulate operation experiences of ADS.
 Licensing: Nuclear reactor: (Critical assembly)
 Proton beam: 400MeV-10W
 Thermal power: <500W</li>

#### **ADS Target Test Facility : TEF-T**

Purpose: To research and develop a spallation target and related materials with highpower proton beam.
Licensing: Particle accelerator
Proton beam: 400MeV-250kW
Target: Lead-Bismuth Eutectic (LBE, Pb-Bi)

**Pb-Bi Target** 

Critical Assembly

Multi-purpose Irradiation Area

10n

## ADS Target Test Facility (TEF-T)



- Experiments for irradiation damage of material by protons and neutrons
- Material irradiation test for material for beam window of ADS, structure material for FBR, and material for fusion reactor
- Development of database for engineering feasibility of ADS by experiments in various condition (ex. temperature and velocity of flowing LBE)



Candidate concept for LBE target in TEF-T



Test device for flow visualization by PIV method (Full-scale transparent acrylic model of target vessel

# Transmutation Physics Experimental Facility (TEF-P)

- TEF-P is designed to take over the experiences and functions of FCA to minimize the cost and risk for newly developed equipment.
- Low power critical facility for reactor physics and nuclear data of transmutation systems including ADS and FBR.
- By replacing central partial matrix tubes with pintype assembly, MA fuel can be used with cooling and remote handling.



Mock-up equipment for fuel loading for TEF-P



ADS experiments in "subctitical with proton beam"



## Conclusion



### JAEA has been promoted R&D activities on P&T technology

Accelerator-Driven System (ADS) is a candidate as a dedicated MA transmutation system.

### Current situation and future plan for R&D of ADS

- The technical challenges for ADS spread over wide range and various basic R&D have been implemented in JAEA.
- New experimental facility, TEF, is proposed in the J-PARC project in JAEA for the engineering feasibility of ADS.
- International collaboration is important in R&D of ADS.