RESEARCH AND DEVELOPMENT PROGRAM ON ADS IN JAEA

Hiroyuki Oigawa

Nuclear Transmutation Technology Group
Nuclear Science and Engineering Directorate
&
Transmutation Section
J-PARC Center

Japan Atomic Energy Agency

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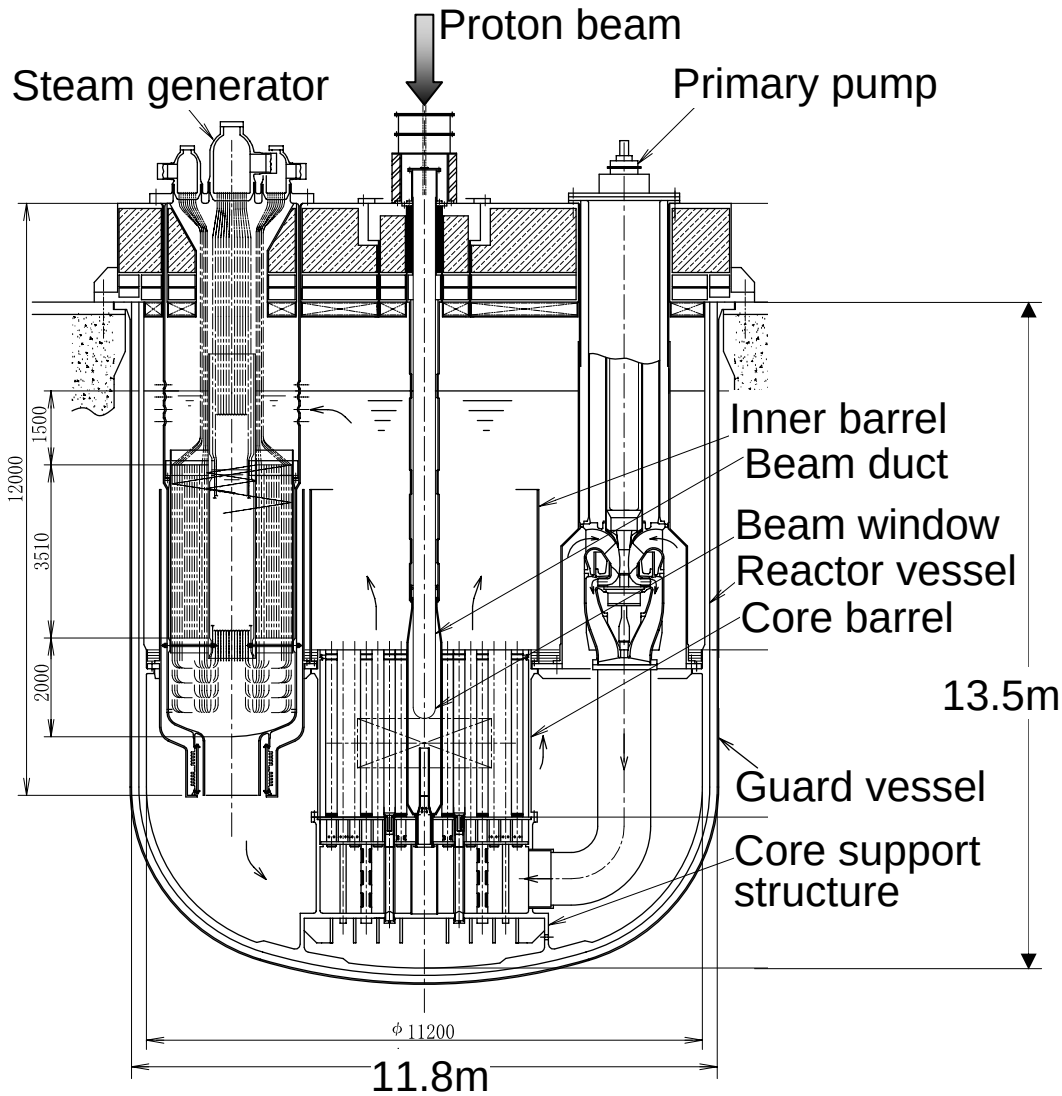
Conceptual Design Study: Reference ADS

- Proton beam : 1.5GeV
- Spallation target : Pb-Bi
- Coolant : Pb-Bi
- Max. k_{eff} = 0.97
- Thermal output : 800MWt
- MA initial inventory : 2.5t
- Fuel composition :
  (MA +Pu)N + ZrN
- Transmutation rate :
  250kgMA / Year
- 600EFPD, 1 batch



Conceptual Design Study: Feasibility Study on ADS

For feasible design of ADS, JAEA is mainly conducting following studies:

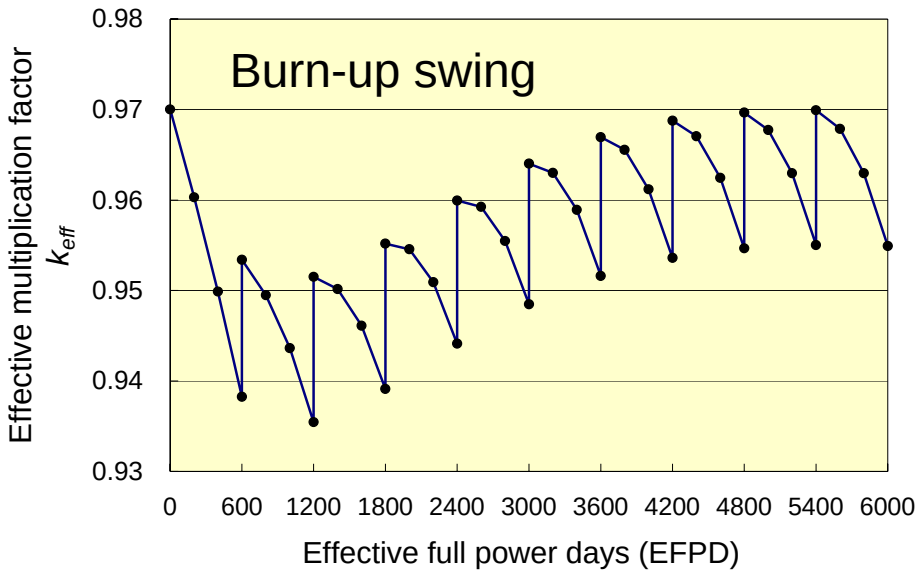
- **Reduction of power peaking near the spallation target**
  - ✓ Simultaneous achievement of both power flattening and minimization of burn-up swing is necessary.

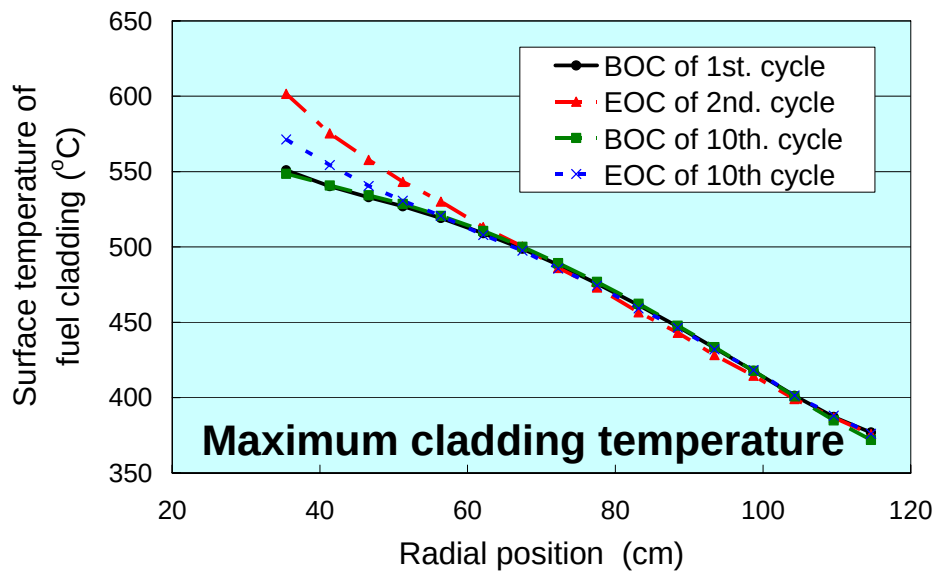
- **Verification of feasibility of the beam window**
  - ✓ Window-type target is currently selected in JAEA.
  - ✓ The feasibility is being discussed in terms of structural strength, irradiation effect, corrosion / erosion, heat removal, etc.
  - ✓ The success of MEGAPIE operation is a very important milestone.

- **Management of frequent beam trip of accelerator : already explained**
  - ✓ Analyses on causes of beam trip of accelerator and on transient behavior of subcritical reactor are being conducted in parallel.

Conceptual Design Study: Reduction of Power Peaking (1)

- Why "peaking factor" is so important?
  - ✓ The temperature range to be used for LBE-cooled ADS design is **300-550°C**.
  - ✓ The k_{eff} value of ADS varies **largely depending on the burn-up**.
  - ✓ Small k_{eff} value causes high power peaking.
  - ✓ Simple power flattening by multi-zone configuration will cause significant **increase of beam current** owing to the decrease of source effectiveness.

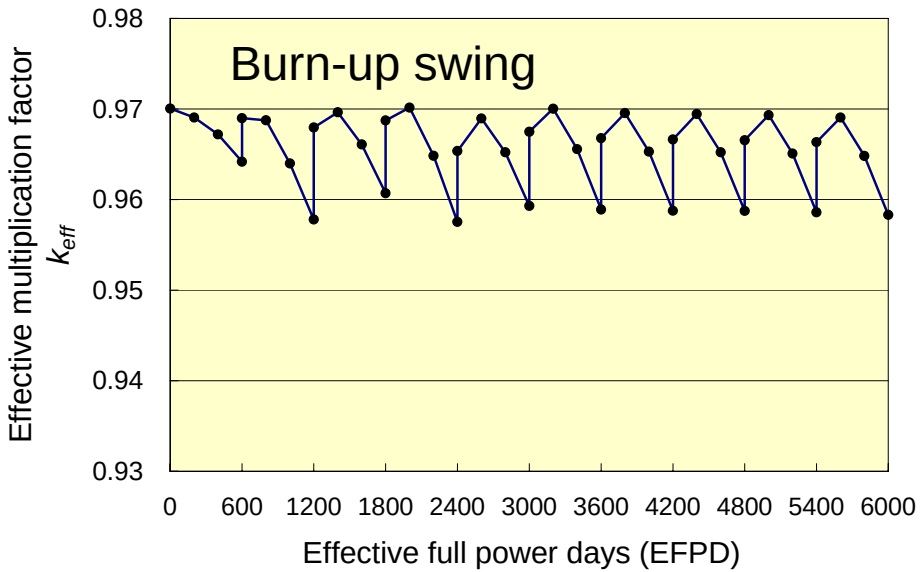


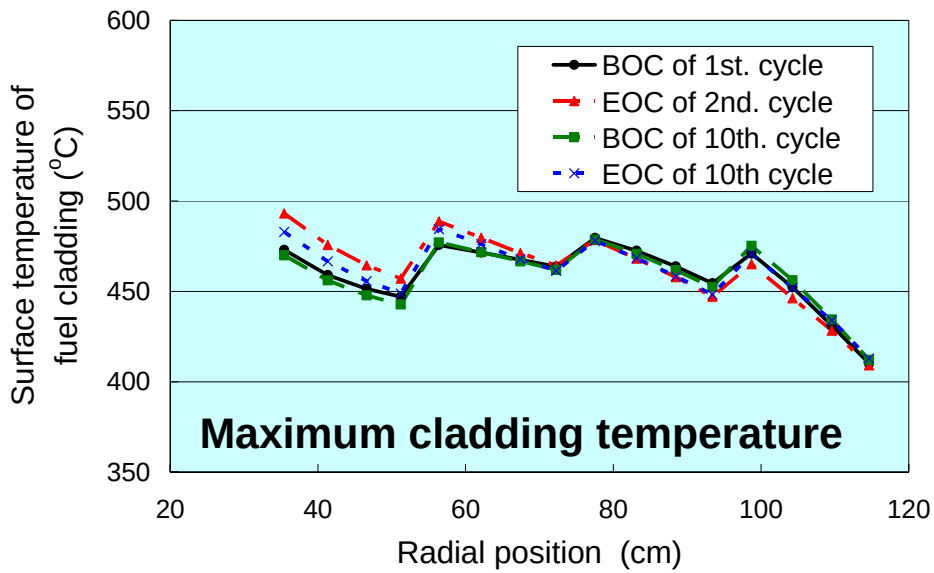


Characteristics of single-zone reference core

Conceptual Design Study: Reduction of Power Peaking (2)

- How to reduce power peaking
  - **Adjustment of inert matrix (ZrN) at every burn-up stage**
  - **Multi-zone configuration with attention to maximum beam current**
  - Adjustment of axial position of beam window
  - Adoption of partial height fuel
  - Adoption of reactivity adjustment rods, etc.

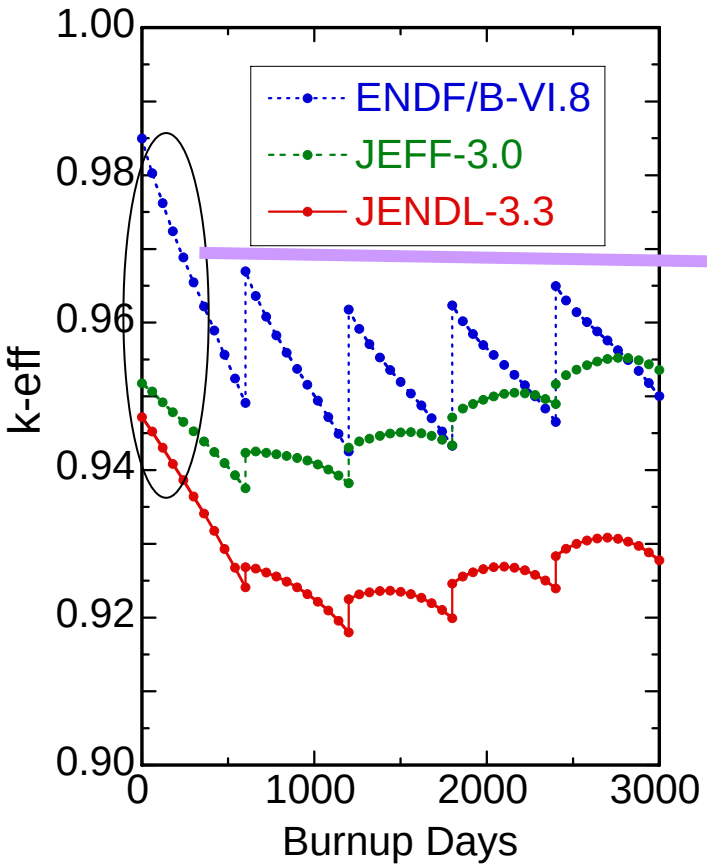


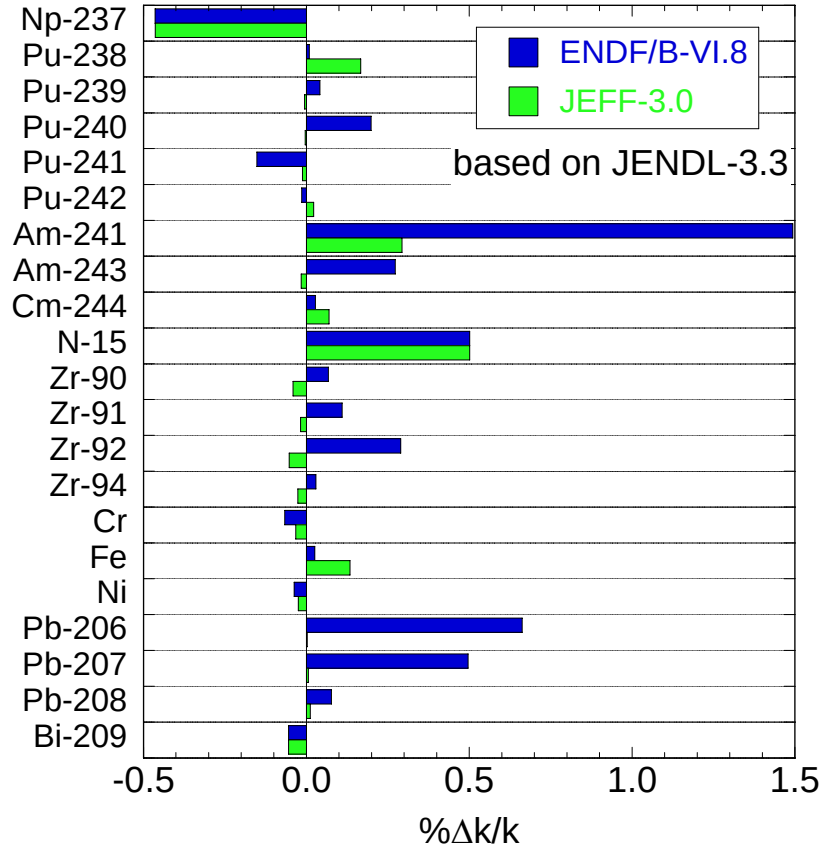


Characteristics of 4-zone core with ZrN adjustment for each cycle and zone

- The maximum beam power was reduced from 34 MW to 27 MW

Conceptual Design Study: Importance of Nuclear Data





Contribution of each nuclide for difference of k-eff with different nuclear data libraries at BOC.

- There are **large discrepancies in burn-up swing** as well as initial k_{eff} **values**.
- To make reliable design of ADS, **reduction of uncertainty caused by nuclear data** is indispensable.

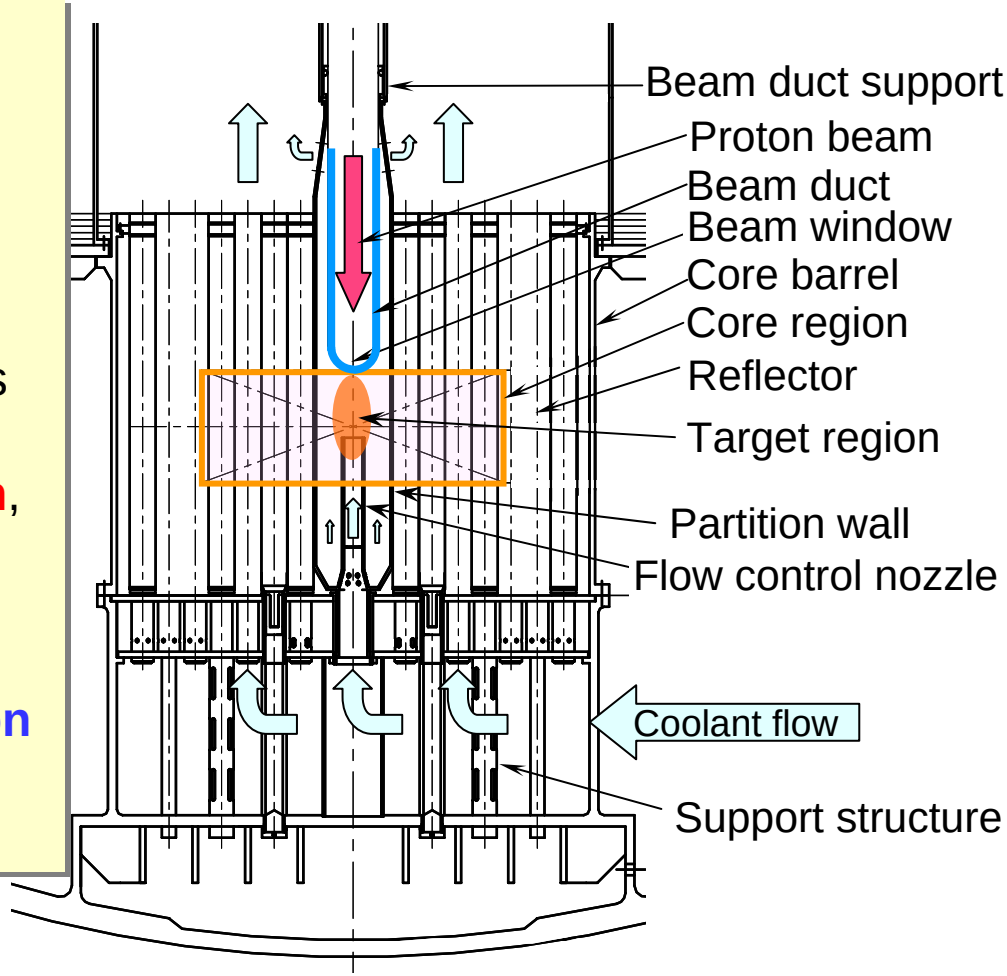
Conceptual Design Study: Spallation Target and Beam Window

- 30 MW proton beam with 1.5 GeV causes heat deposition of 15.7MW.

- Conditions and criteria for the beam window:
  - ✓ Inlet temp. : 300 ºC
  - ✓ LBE flow: < 2m/s
  - ✓ Temp. of outer surface: < 520ºC

✓The feasibility of the beam window was verified under the nominal operation conditions, but the effects of **corrosion**, **irradiation** and so on are being discussed.

- **We should accumulate experience on LBE spallation target, weather it is with window or without window.**

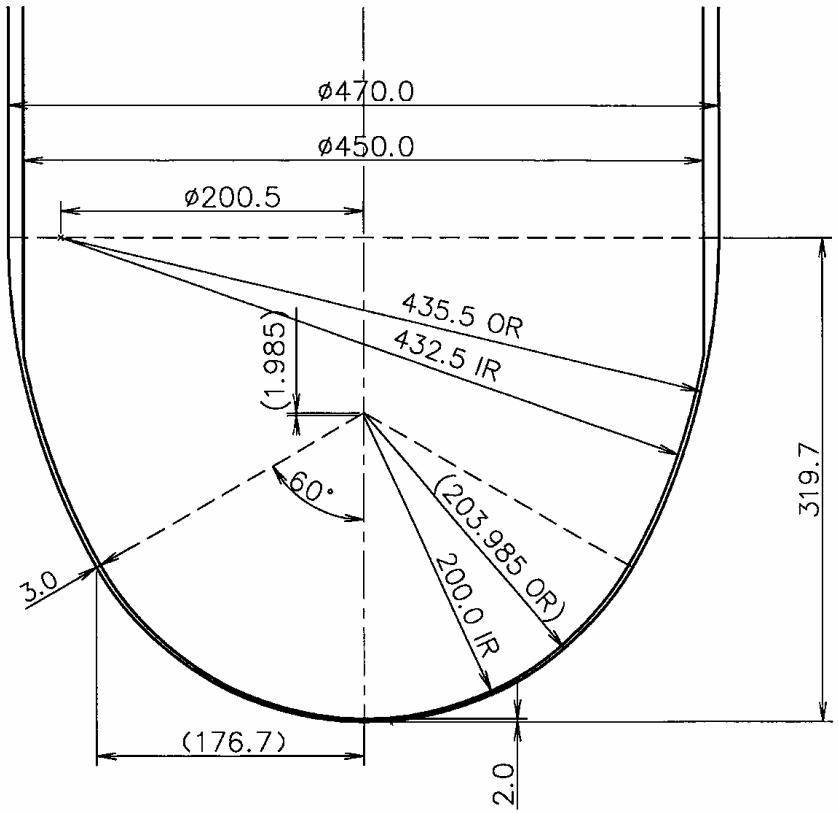


Conceptual Design Study: Beam Window Design

- **Design conditions**
  - ✓ Beam window will be **exchanged periodically**, preferably every two years.
  - ✓ Diameter and thickness are determined by considering **beam density, thermal stress and the structural strength** against the LBE pressure (about 0.8 MPa).
  - ✓ To assure the robustness against the **buckling failure**, the curvature of the window bottom is formed with a partial spherical shell.
  - ✓ The irradiation damage:
    - **4.5 - 9.0 DPA/year by protons**
    - **55 - 98 DPA/year in total**

    depending upon the burn-up swing.
  - ✓ The helium gas production:
    - **950 - 1,900 appm/year.**

    (Gaussian distribution was assumed for the proton beam profile.)
  - ✓ **Corrosion rate** will be restricted below 150-200 μm/year.



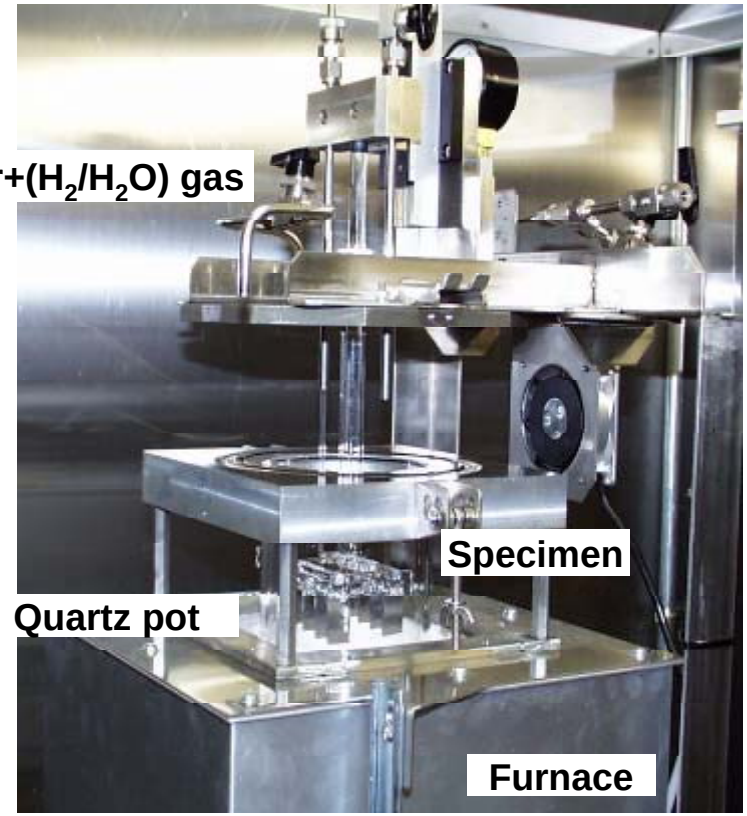
(unit: mm)

Conceptual Design Study: Other Issues to be Discussed

In addition to above-mentioned critical issues, we should discuss following points:

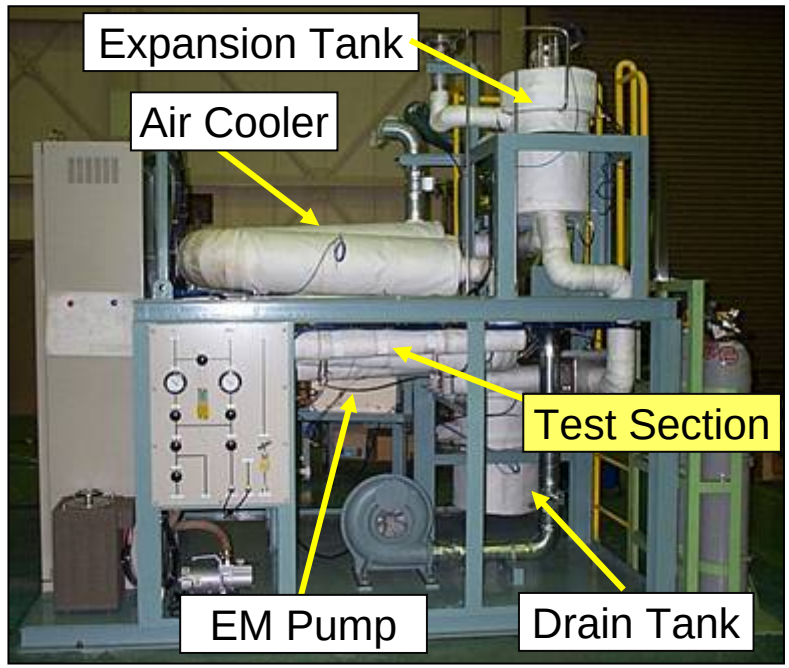
- **Accelerator:**
  - ✓ Cost, energy efficiency, beam trip frequency and recovery, beam stop system, power control, hands-on maintenance, etc.
- **Safety:**
  - ✓ The idea of reactor boundary and window break accident, design-basis accident, etc.
- **Dedicated MA fuel and its reprocessing:**
  - ✓ Fabrication technique, irradiation behavior, management of inert matrix, cooling, shielding, etc.
- **Materials:**
  - ✓ Fuel pin, permanent structure, possibility of other coolant, etc.
- **Structure:**
  - ✓ Accelerator – reactor coupling component, 3-D seismic isolation structure, etc.

R&D Activities: Corrosion Tests for LBE



Static corrosion equipment

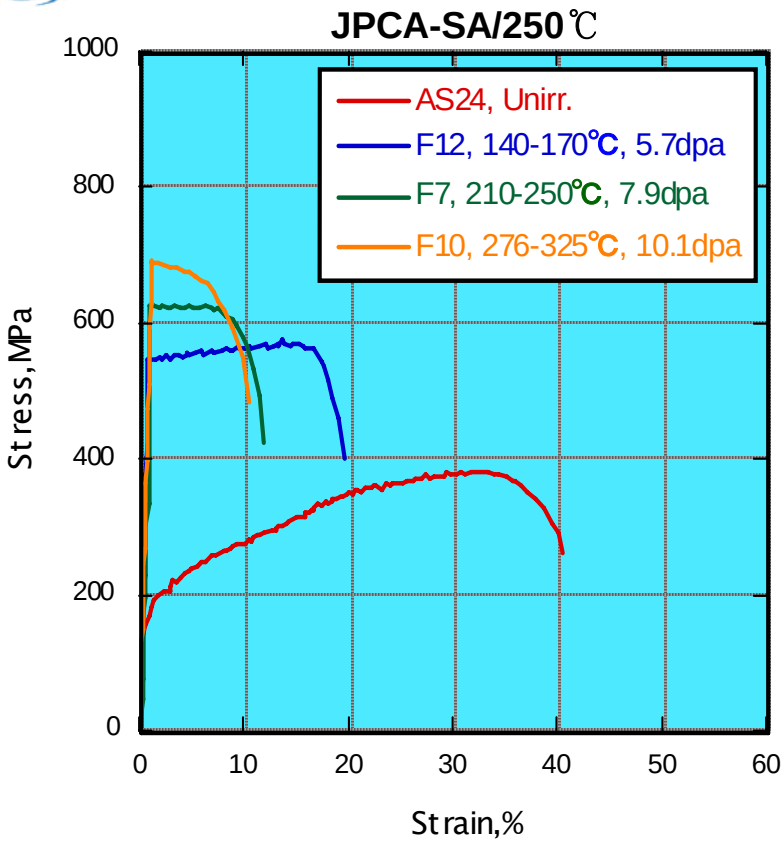
•Si-added alloys are being tested.



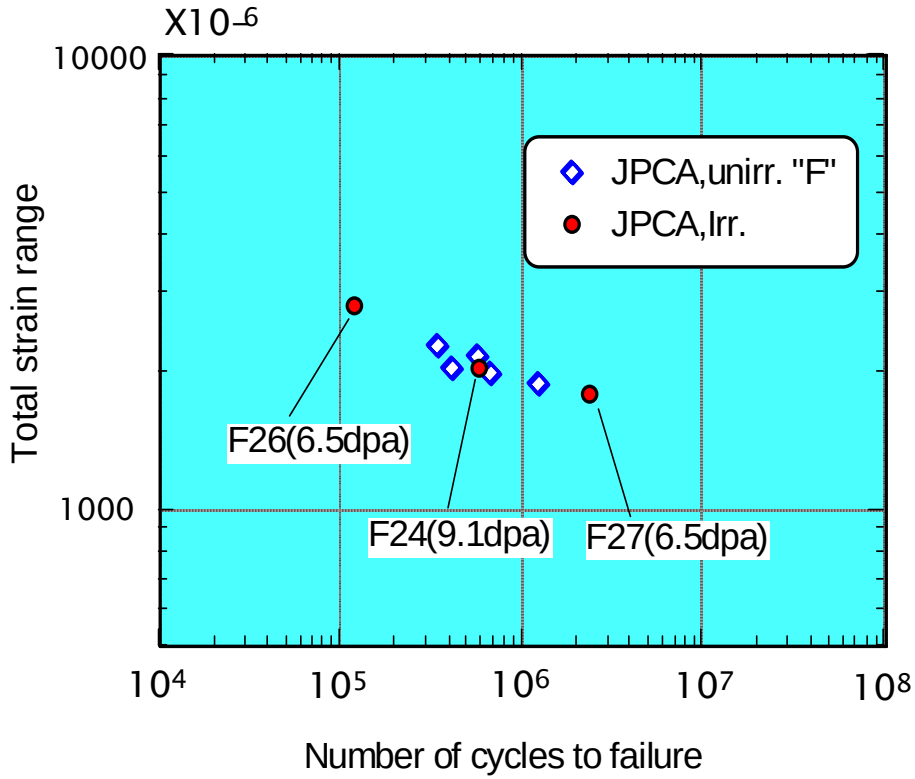
JAERI Pb-Bi Loop-1 (JLBL-1)
Flow rate : 5L/min.
Temperature : 450ºC

•Material transfer from high-temperature portion to lower one is being investigated.

R&D Activities: PIE of SINQ Irradiated Materials



Tensile test



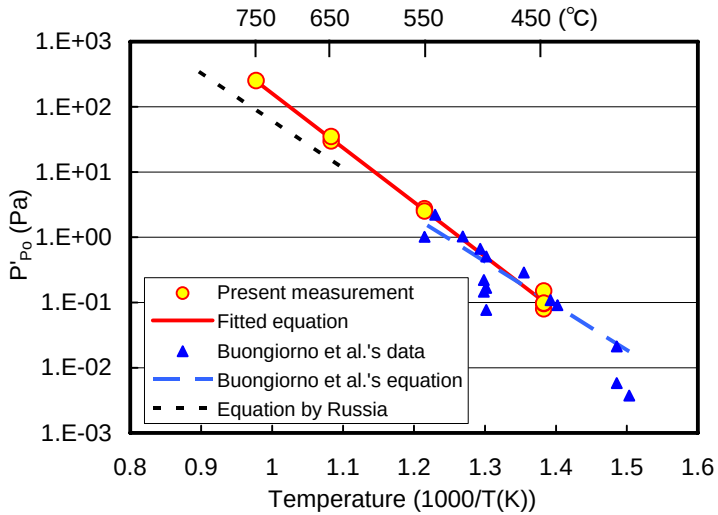
Fatigue Test

PIE on STIP-1 (~10DPA) was completed.
PIE on STIP-2 (~20DPA) is under way.

R&D Activities: LBE Technologies

JLBL-2 for mock-up of TEF-T target and UDM velocimetry

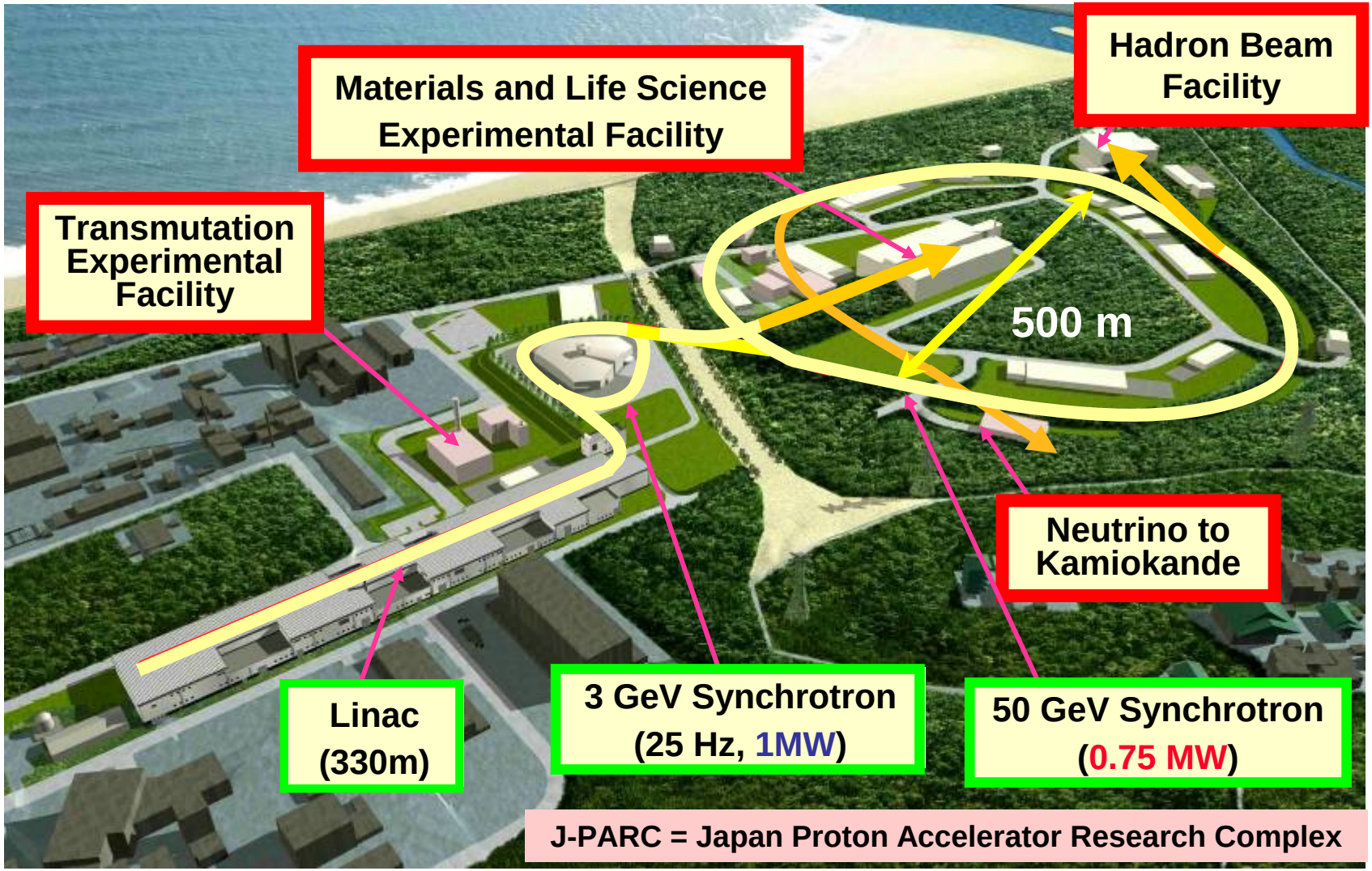
JLBL-3 for thermal-hydraulics of beam window



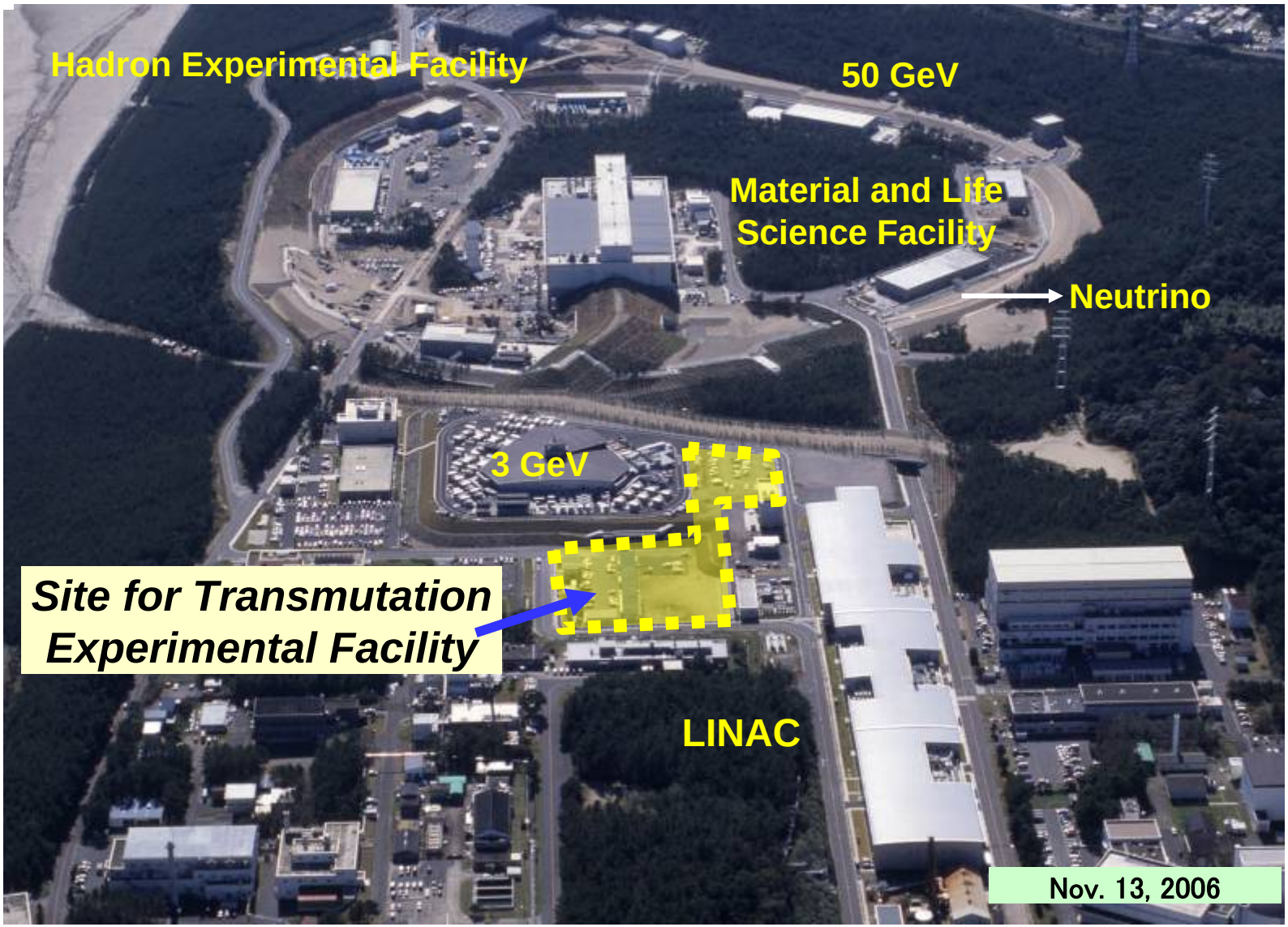
Irradiated Pb-Bi for Po evaporation test

Various R&D are under way in parallel.

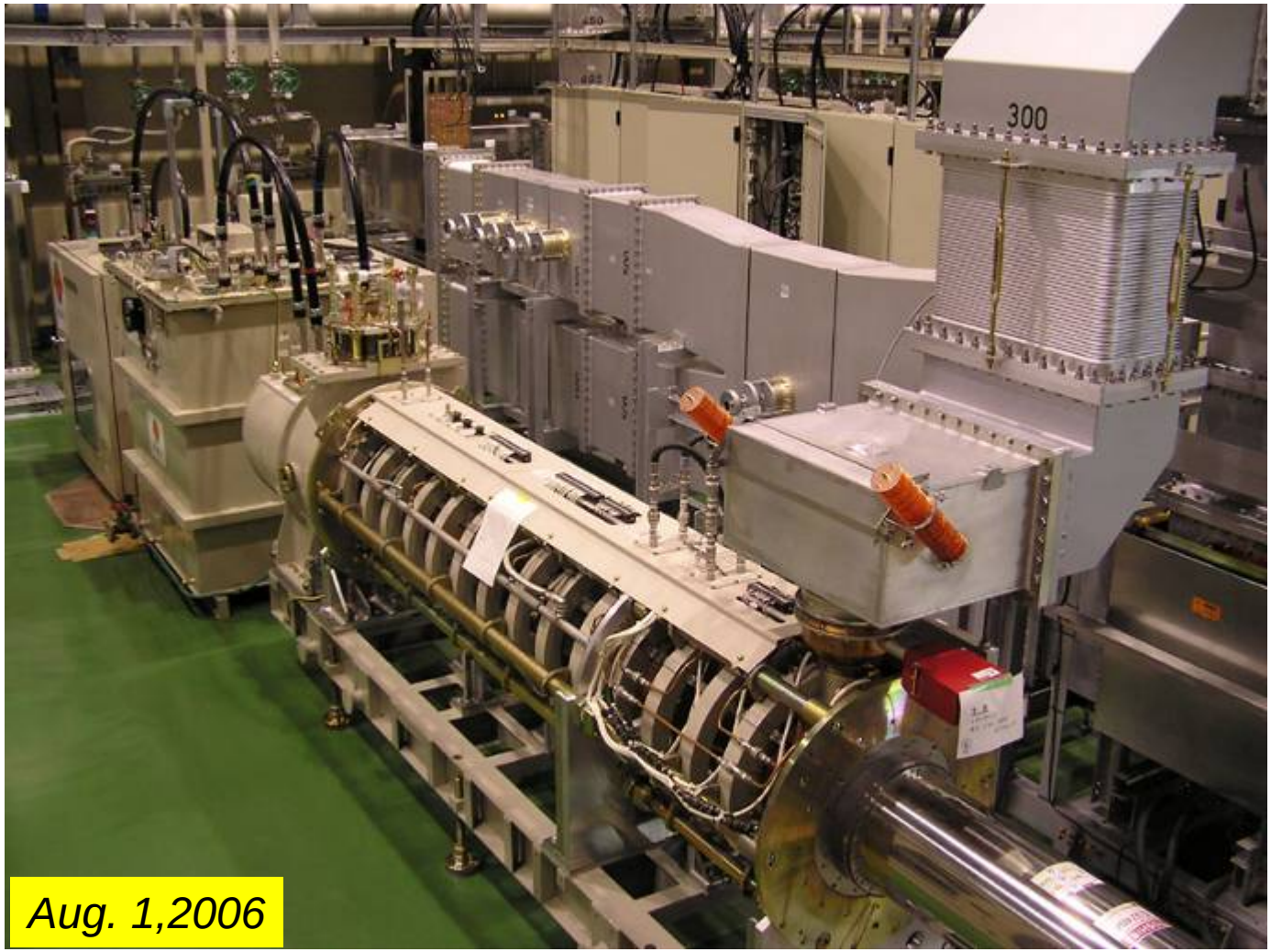
Current Status of J-PARC Project: Site Plan



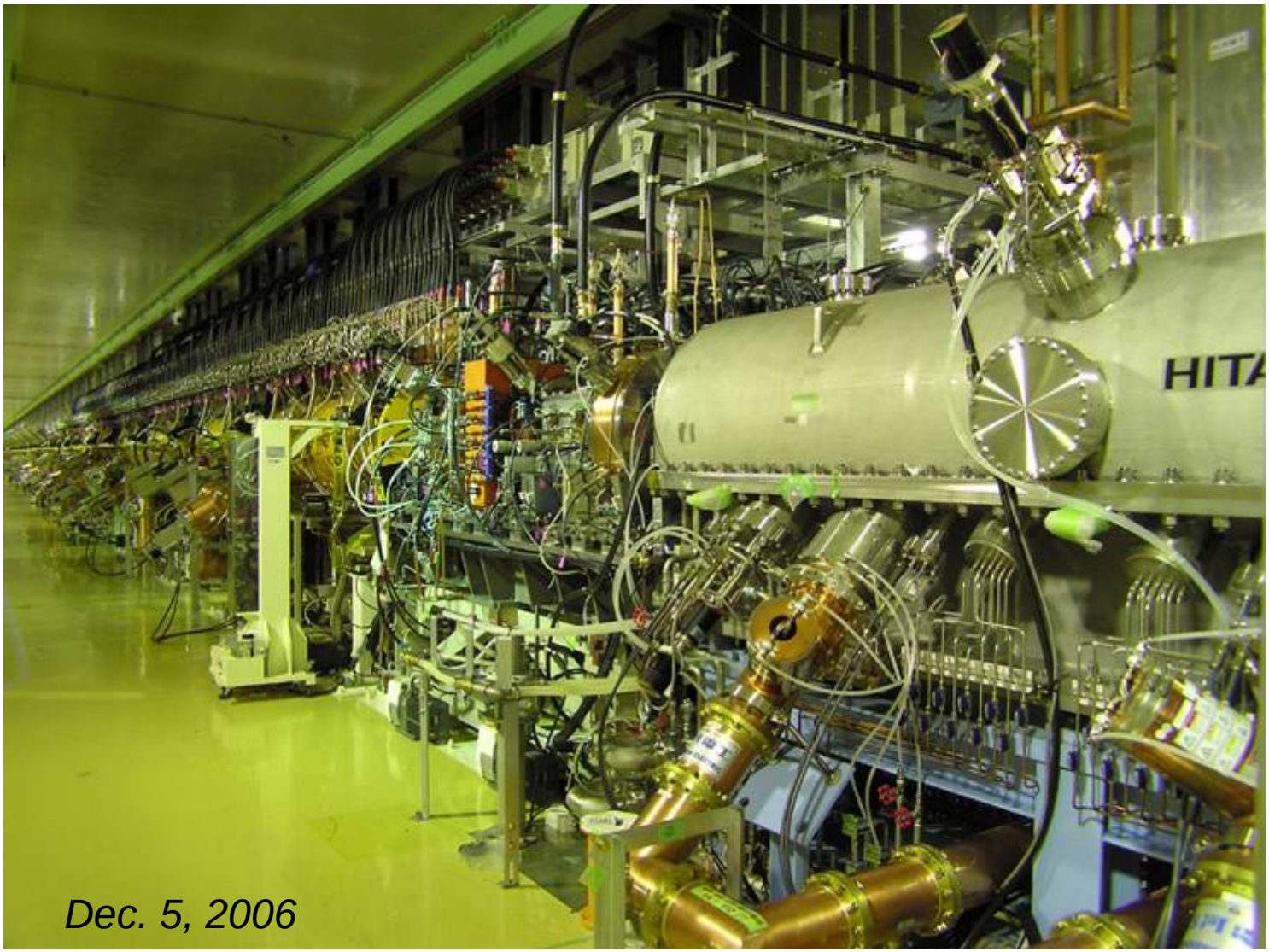
Current Status of J-PARC Project: Photo of Site



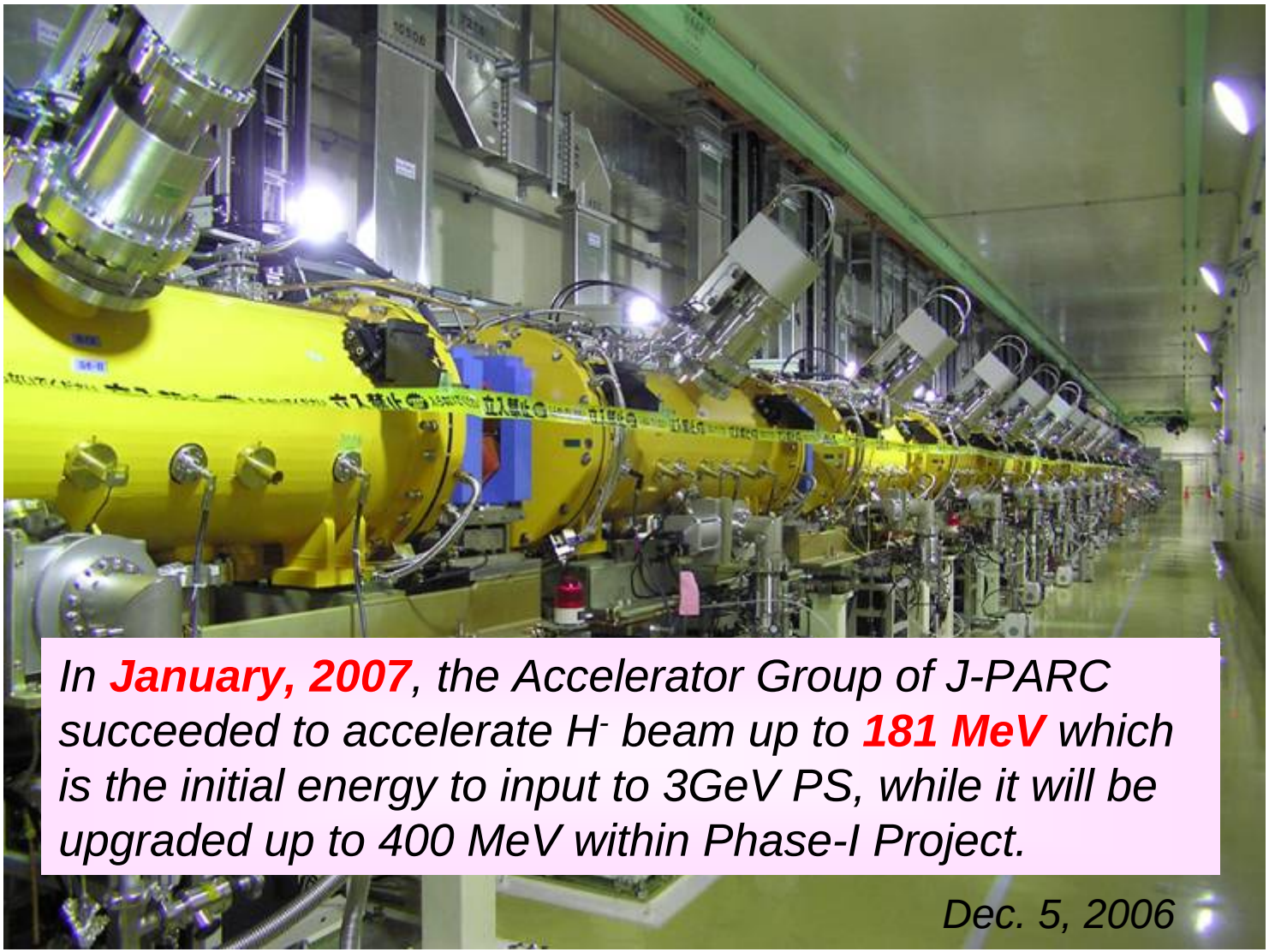
Current Status of J-PARC Project: LINAC Klystron Gallery



Current Status of J-PARC Project: LINAC Beam Line (RFQ, DTL)



Current Status of J-PARC Project: LINAC Beam Line (SDTL)



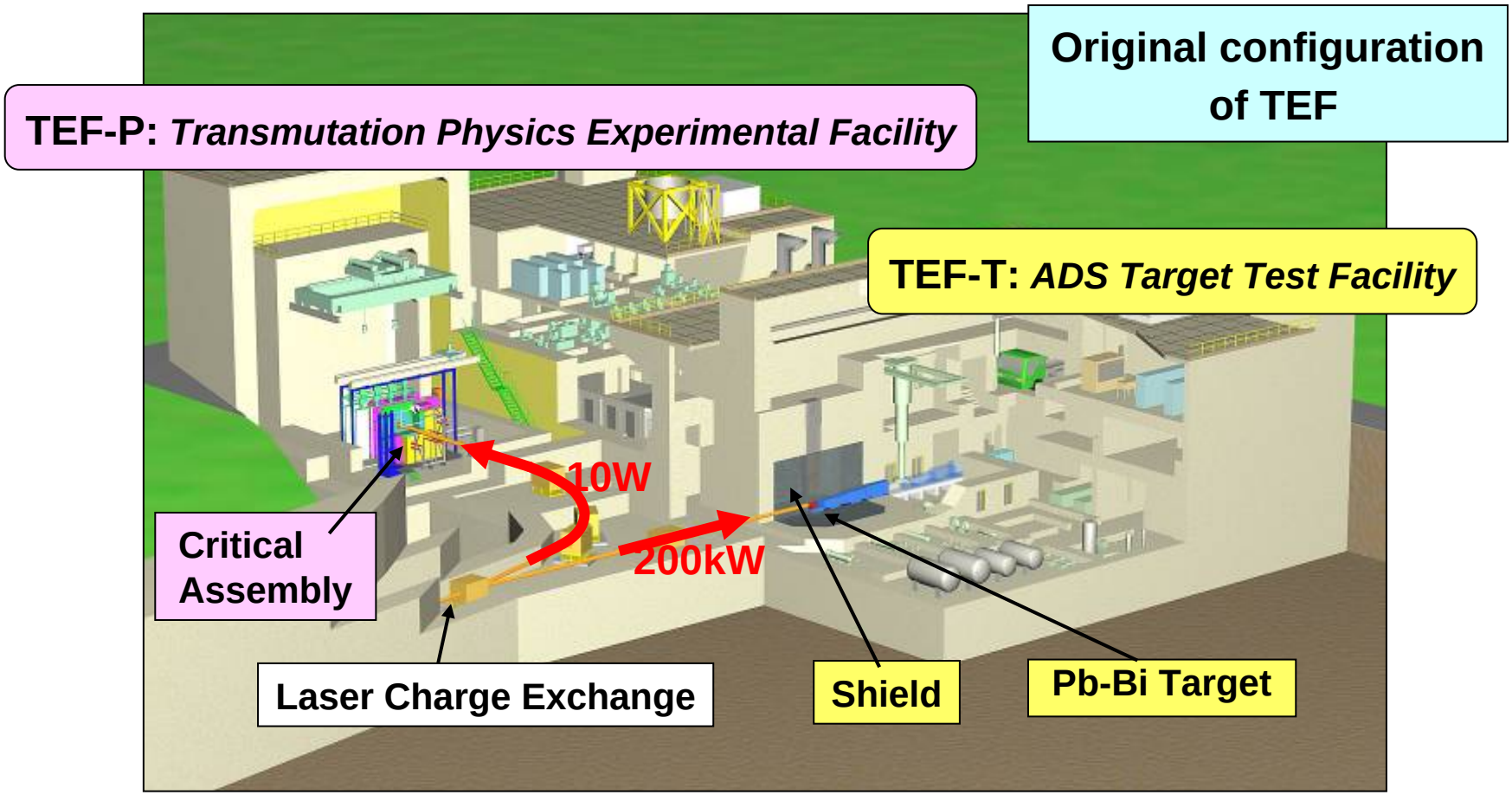
*In **January, 2007**, the Accelerator Group of J-PARC succeeded to accelerate H^- beam up to **181 MeV** which is the initial energy to input to 3GeV PS, while it will be upgraded up to 400 MeV within Phase-I Project.*

Dec. 5, 2006

Current Status of J-PARC Project: MLF

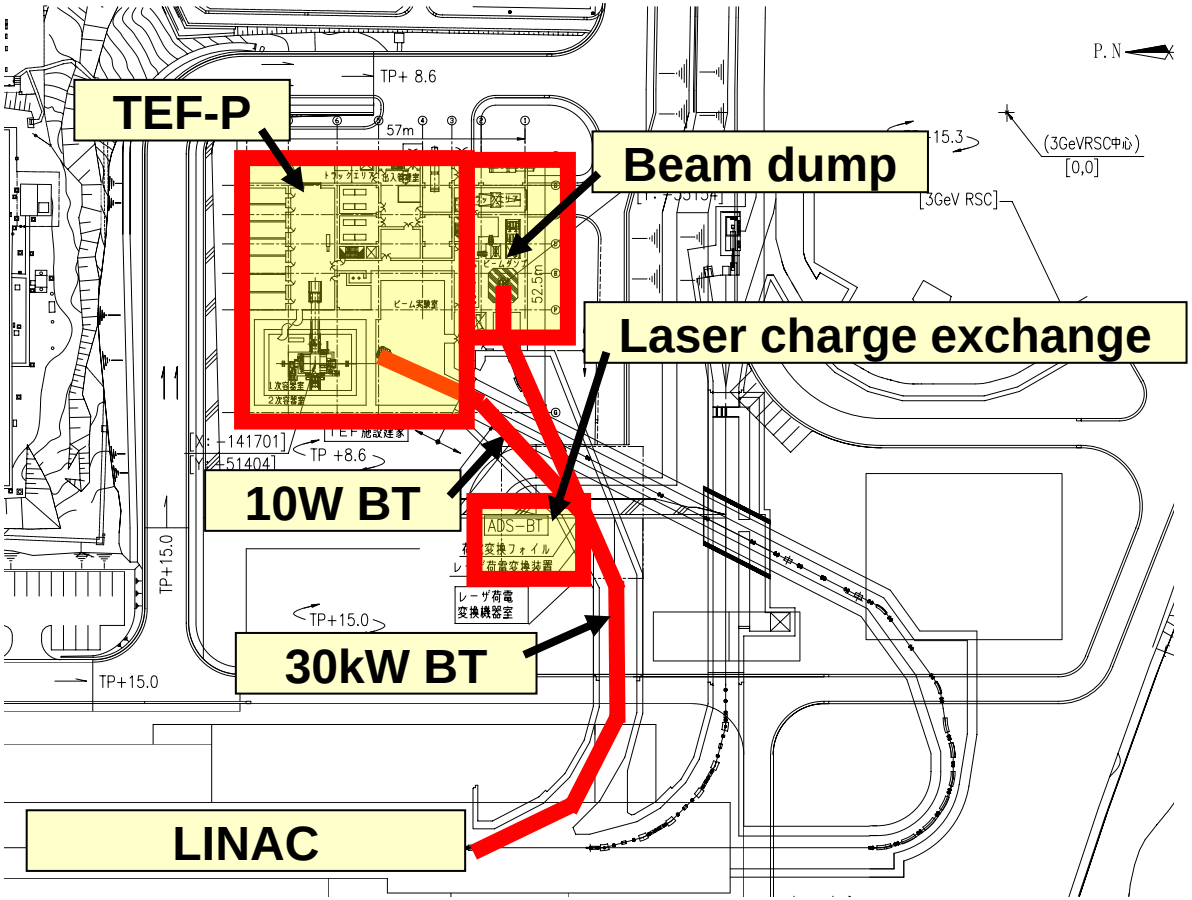
Original Configuration of Transmutation Experimental Facility

- Transmutation Experimental Facility (TEF) : **Phase-2 Program**.
- Original configuration of TEF consists of the Transmutation Physics Experimental Facility (**TEF-P**) and the ADS Target Test Facility (**TEF-T**).
- Because of the budget shortage, **step by step construction** will be necessary.



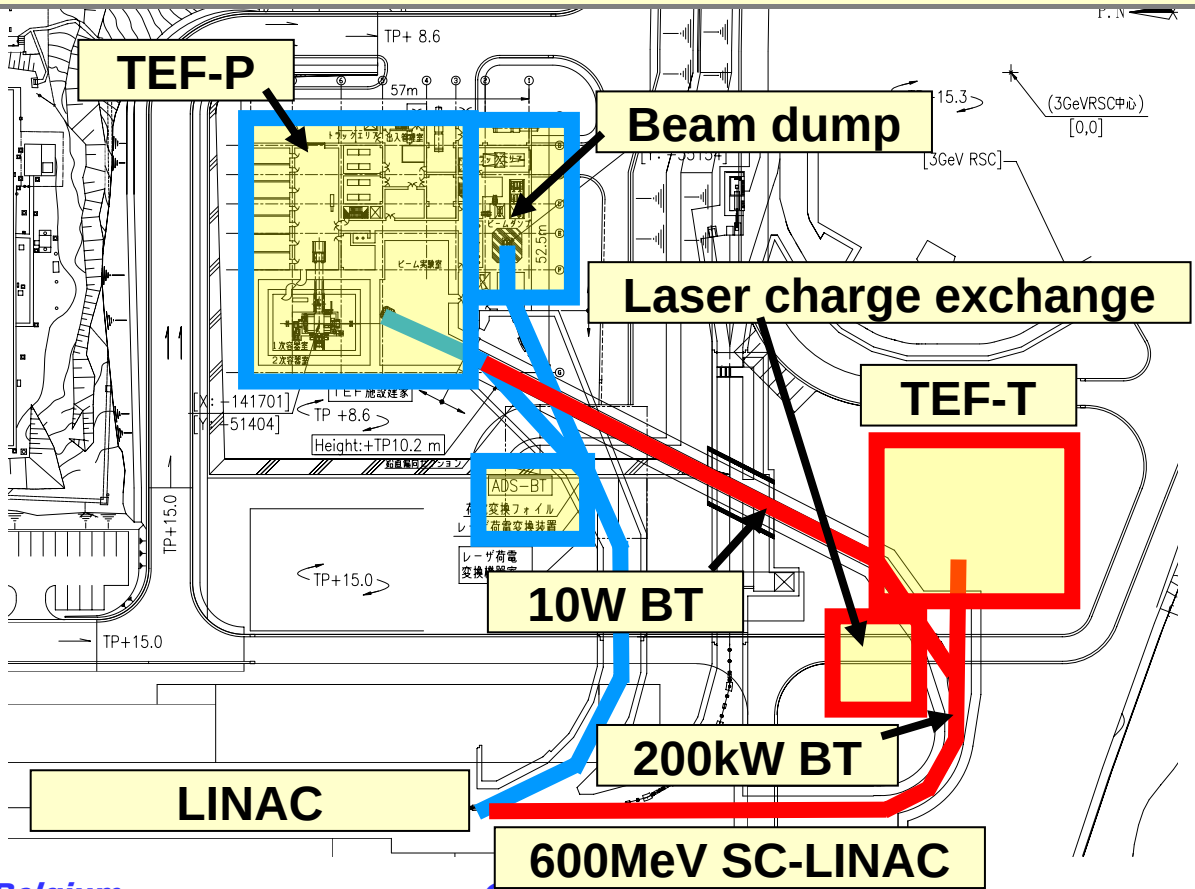
Site for Part-1 Construction

- 400MeV, 30kW proton beam will be introduced into the beam dump.
- Laser charge exchange will extract 400MeV, 10W beam which is transported to TEF-P.



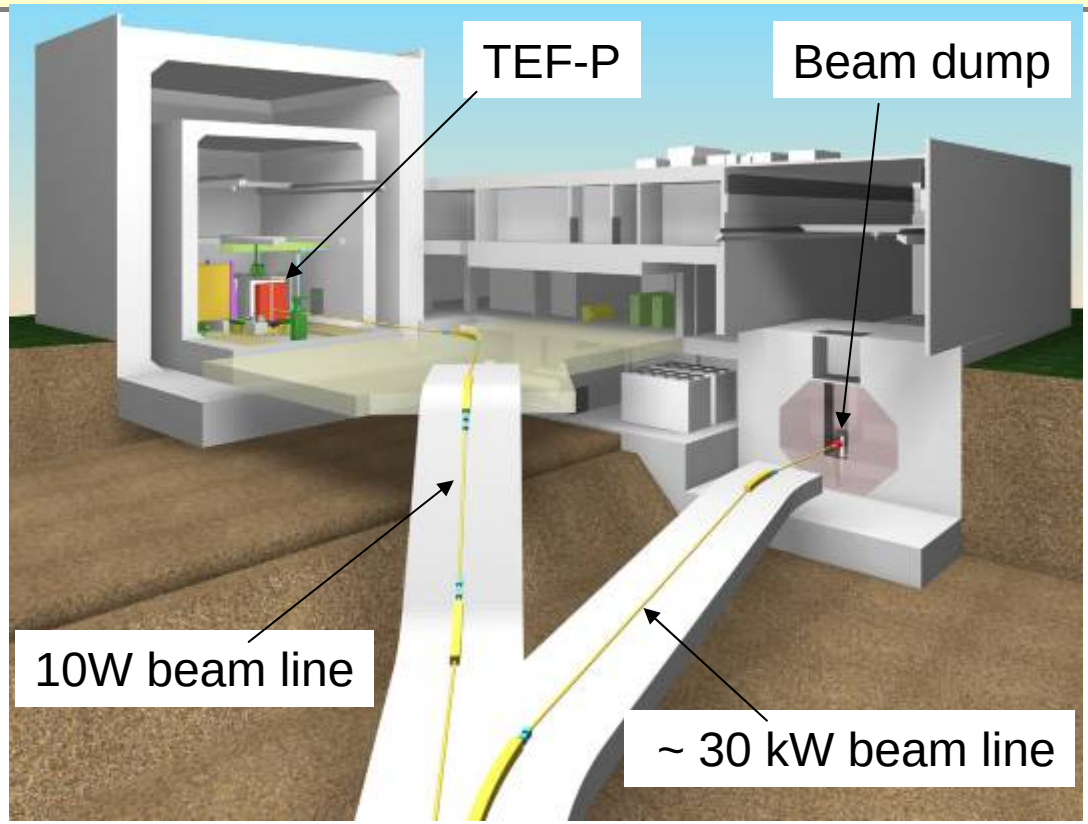
Site for Part-2 Construction

- 600MeV, 200kW (Maximum) proton beam accelerated by SC-LINAC will be introduced into TEF-T.
- Laser charge exchange will extract 600MeV, 10W beam which is transported to TEF-P.



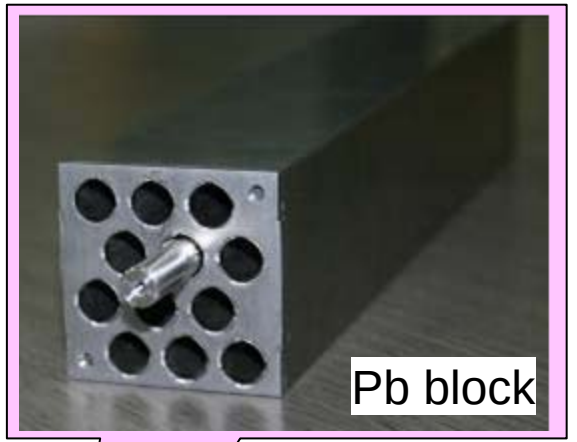
Conceptual View of Part-1 Construction

- TEF-P can include subcritical and critical experiments for both ADS and FBR.
- Beam dump is necessary to introduce proton beam into TEF-P, where experiments for radiation engineering can be performed.
- **By combining these facilities, wide rage of experimental study for nuclear engineering can be conducted.**

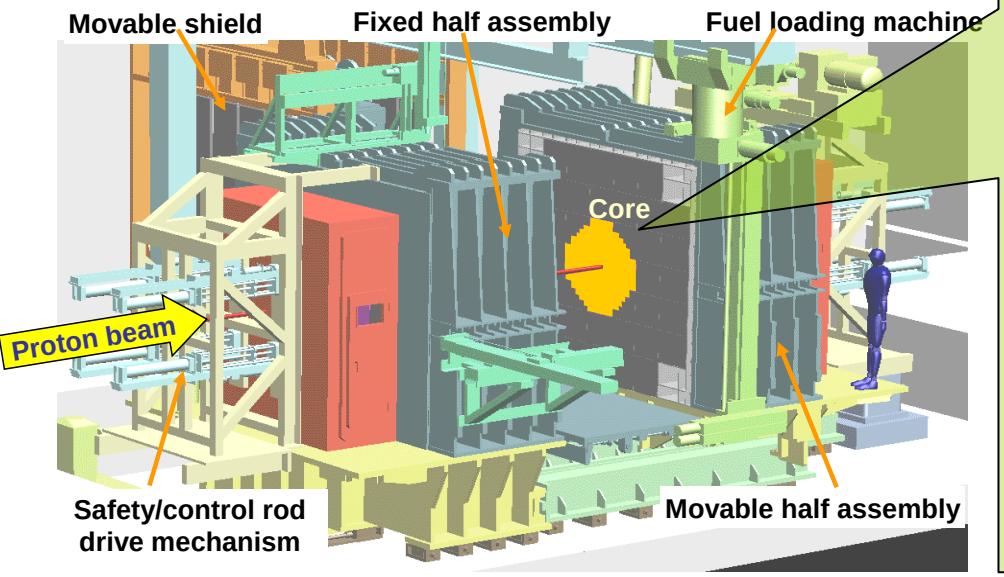


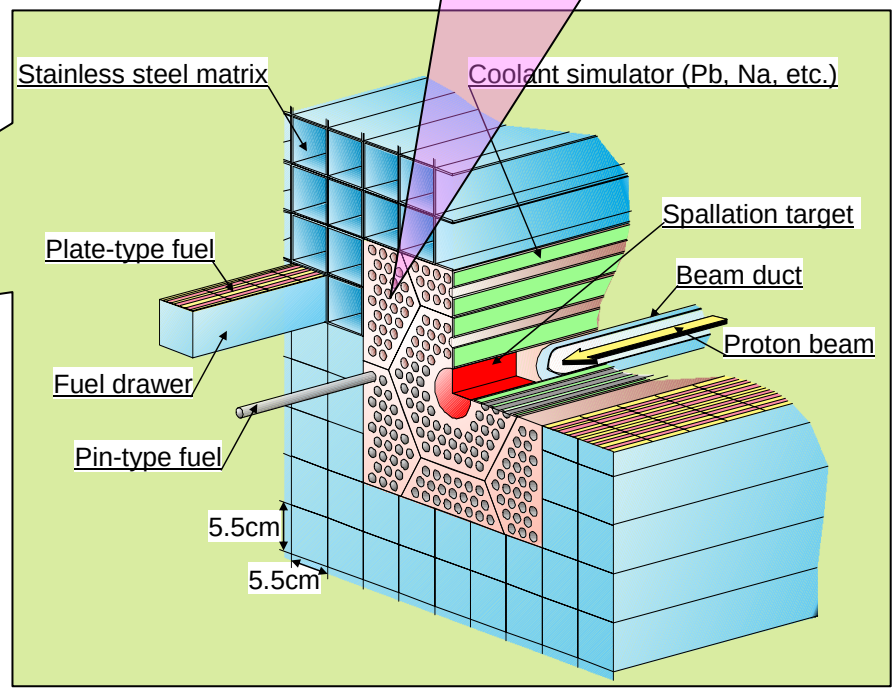
Outline of TEF-P

- **Critical facility for reactor physics and nuclear data of transmutation systems: both ADS and FBR.**
- **Neutron source: 10^{12}n/s, 25Hz. 1ns pulsed beam is available by laser charge exchange technique.**
- **Pin-type MA fuel can be used with appropriate cooling and remote handling.**



Maximum thermal power : 500W





Call for Preliminary Letters of Intent (LOI) for TEF

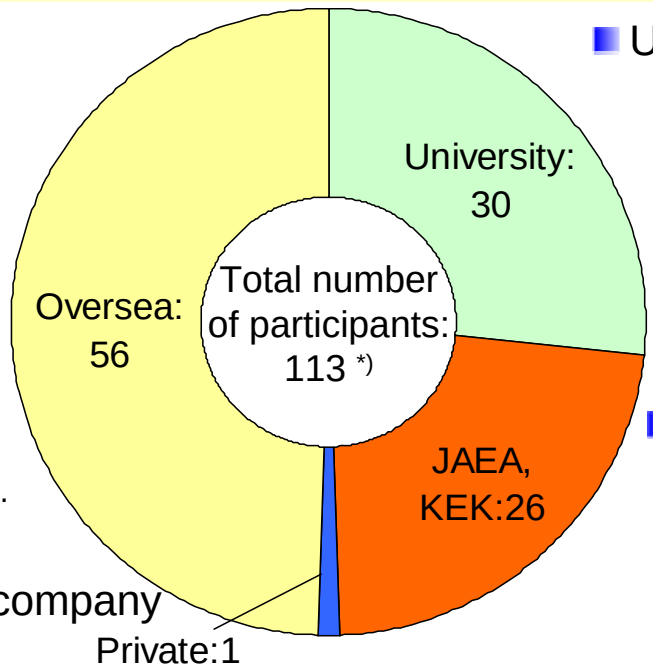
- The project team called for the ***Preliminary Letters Of Intent (Pre-LOI)*** for TEF.
- Purposes:
  - To know which groups have an interest in this activity .
  - To reflect the proposals on the specifications and layout of the TEF
  - To establish an appropriate collaboration scheme between J-PARC and the anticipated outside users.

Results of Preliminary Letters Of Intent for TEF

- **Total number of received Pre-LOI : 37**
- Areas
  1. Reactor physics of ADS: 11
  2. Reactor physics of advances nuclear system including MA-loaded experiments: 10
  3. Nuclear data and neutron spectrum measurements: 6
  4. High-energy physics, shielding: 5
  5. Nuclear physics (neutrino measurement, ultra cold neutron): 2
  6. Pb-Bi spallation target: 2
  7. Boron Neutron Capture Therapy: 1

- Oversea
  - EUROTRANS
  - PSI (Switzerland)
  - CIAE (China)
  - Seoul National Univ. (ROK)
  - MINT (Malaysia)
  - NTI (Serbia)

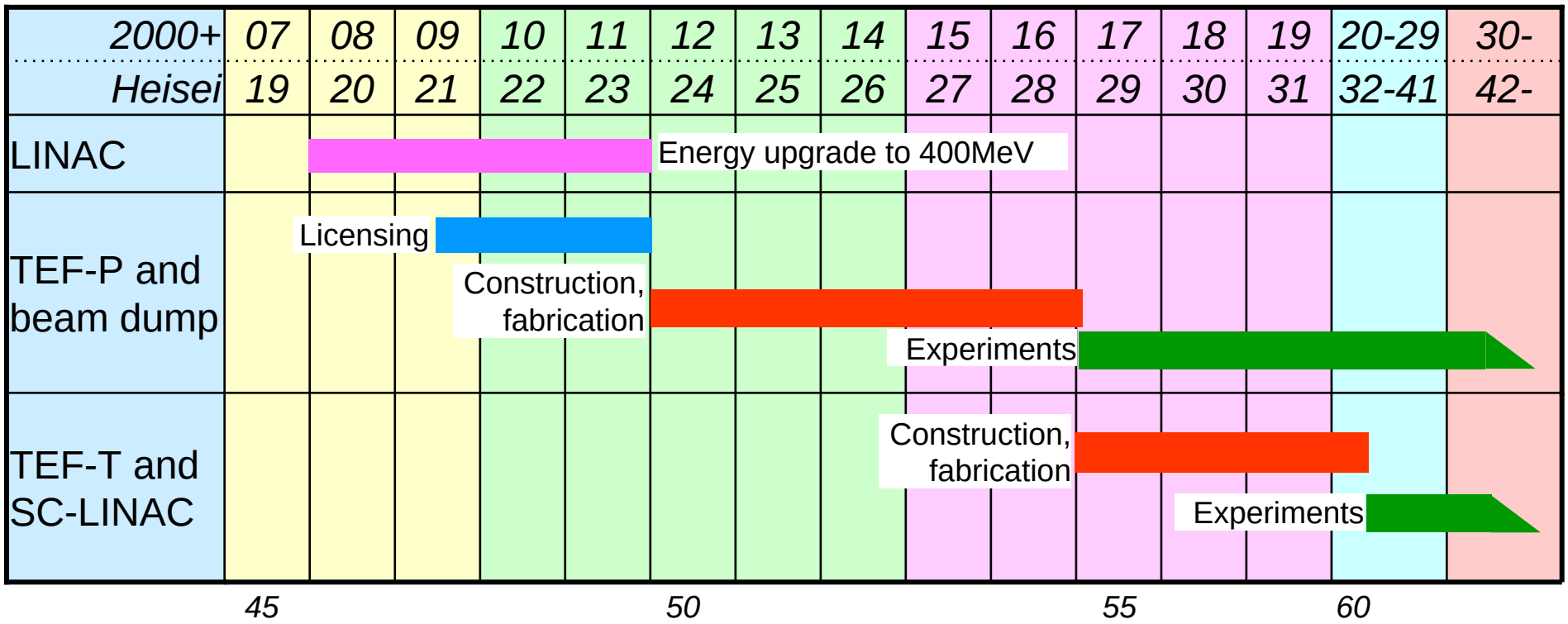
  *) Number of participants from EUROTRANS is not included.
- Private
  - Japanese engineering company



- University
  - Hokkaido
  - Tohoku
  - TIT
  - Niigata
  - Nagoya
  - Osaka
  - Kyoto
  - Kinki
  - Kyushu
- JAEA & KEK
  - Quantum Beam Science
  - Nuclear Science & Engineering
  - Advanced Nuclear System
  - J-PARC Center

Preliminary Time Schedule of TEF

- To start the construction of TEF in 2012, just after LINAC energy upgrade, a few years of licensing activities should be finished.
- The next "5-year plan" of JAEA will start 2010.

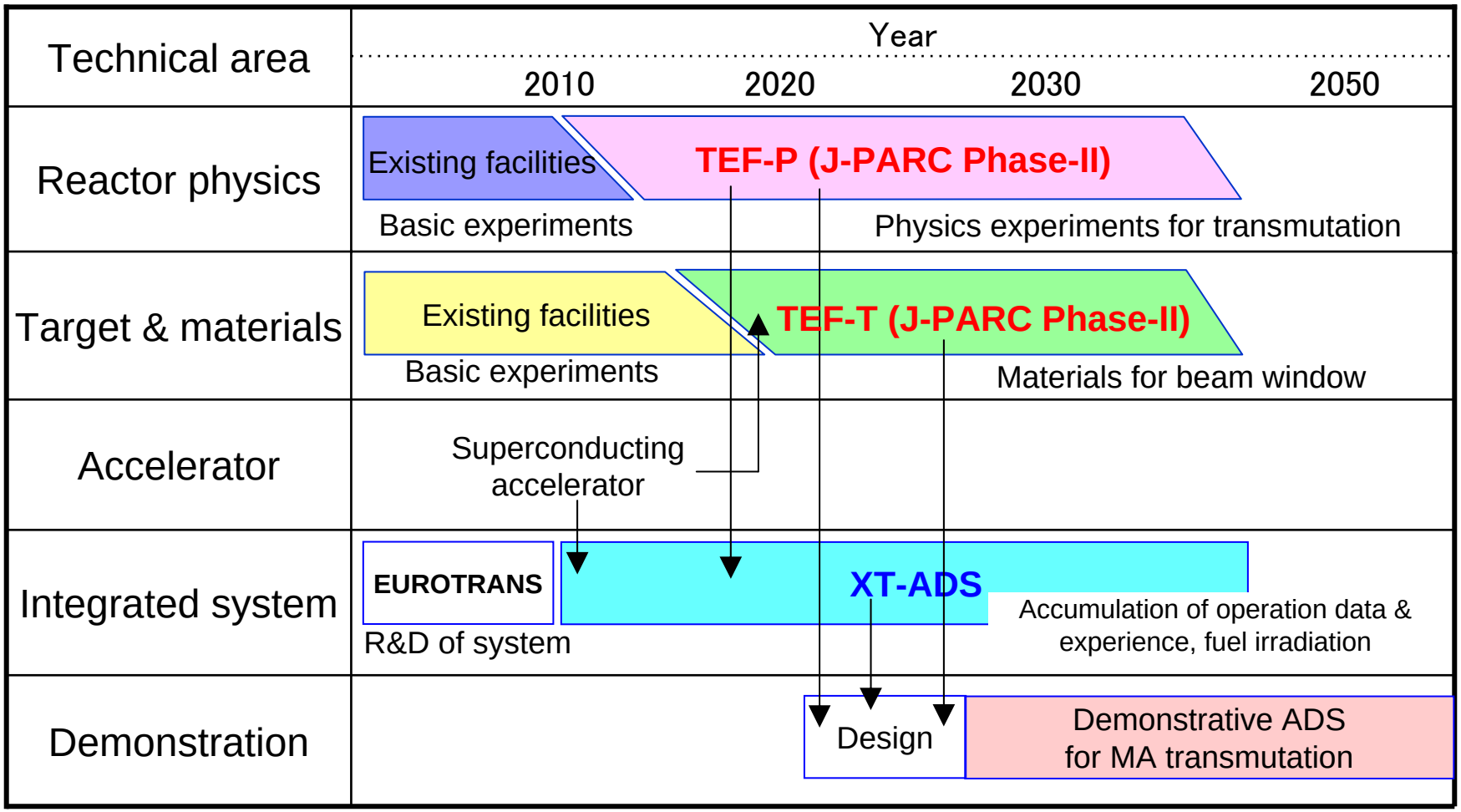


Importance of International Common Roadmap

- The ADS and the transmutation technology are increasingly important for the sustainable utilization of the nuclear energy.
- However, the technical challenges for ADS spread over wide range of scientific and engineering fields.
- It is, therefore, strongly desirable to share the experimental efforts in a systematic way by many countries.
- An intermediate goal before the realization of the transmutation by the ADS must be an experimental ADS. **European XT-ADS project should be extended to more global one**.
- In parallel, establishment of technical base **to deal with MA** and **to couple a proton accelerator with a fast-spectrum reactor** is extremely important for the purpose of **reliable design** of the system, **safety assessment** and **education** of young scientists and engineers.
- From this viewpoint, **TEF under the J-PARC project is expected to play important roles**.

Proposed Outline of International Common Roadmap

- International common roadmap would be established by **coupling TEF and XT-ADS** as complementary facilities.



Concluding Remarks

- JAEA has been promoting **various R&D** activities on ADS.
  - Design study: reduction of cladding temperature, feasibility of the beam window, etc.
  - R&D: LBE and related materials
- TEF under J-PARC, **step-wise construction** is now considered
  - Part-1: TEF-P and a beam dump
  - Part-2: TEF-T and a superconducting LINAC
- **Preliminary LOI for TEF** was called for and 37 proposals were received.
  - The proposals were mainly in the fields of reactor physics experiments for ADS and MA-added FBR as well as wide range of basic experiments such as LBE spallation target.
- The importance of the **international collaboration** to realize the ADS and the transmutation technology was emphasized
  - **TEF and XT-ADS** should be promoted as international complementary and indispensable projects on the **common roadmap**.