IWSMT-12
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Recent Progress in R&D Efforts toward Construction of J-PARC Transmutation Experimental Facility

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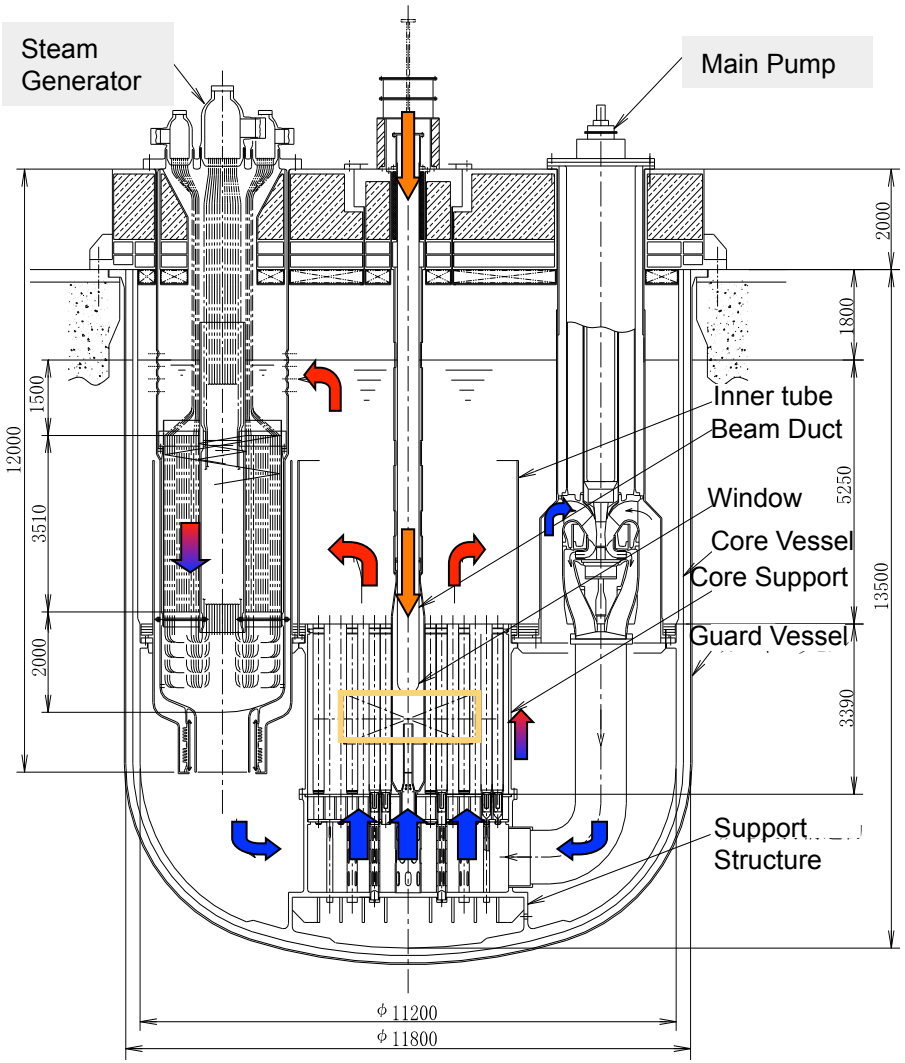
ADS Proposed by JAEA - LBE Target/Cooled Concept -

- Proton beam : 1.5GeV ~20MW
- Spallation target : Pb-Bi
- Coolant : Pb-Bi
- Subcriticality : $k_{eff} = 0.97$
- Thermal output : 800MWt
- Core height : 1,000mm
- MA initial inventory : 2.5t
- Fuel composition :

  (60%MA + 40%Pu) Mono-nitride
- Transmutation rate :

  10%MA / Year (**10 units of LWR**)
- Burn-up reactivity swing : 1.8%Δk/k



R&D Issues for ADS Development

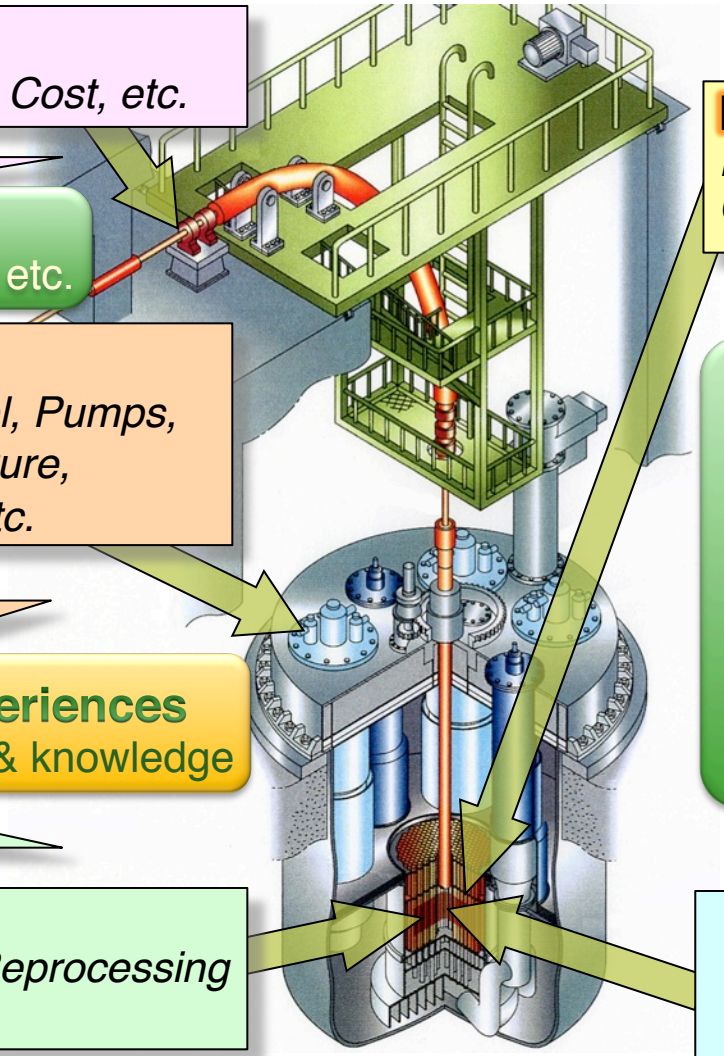
Accelerator
High Power, Reliability, Cost, etc.

J-PARC Accelerator
Operation Experience, etc.

Structure
Design of Reactor Vessel, Pumps, SGs, Quake-proof Structure, Beam Duct & Window, etc.

R&D using JAEA Experiences
Utilize existing resources & knowledge

Fuel, Cycle
Fabrication, Irradiation, Reprocessing of MA-bearing Fuel, etc.



MA-loaded Subcritical Core
Physics and Control of Subcritical Core with MA-bearing Fuel, etc.

J-PARC Transmutation Experimental Facility
・2 Individual Facilities

Transmutation Physics Experimental Facility：TEF-P
Neutronics Tests by Low Power Beam

ADS Target Test Facility：TEF-T
Material Irradiation by High Power Beam

Pb-Bi Spallation Target
Material Irradiation, Operation, Lifetime Evaluation, etc.

Transmutation Experimental Facility (TEF)

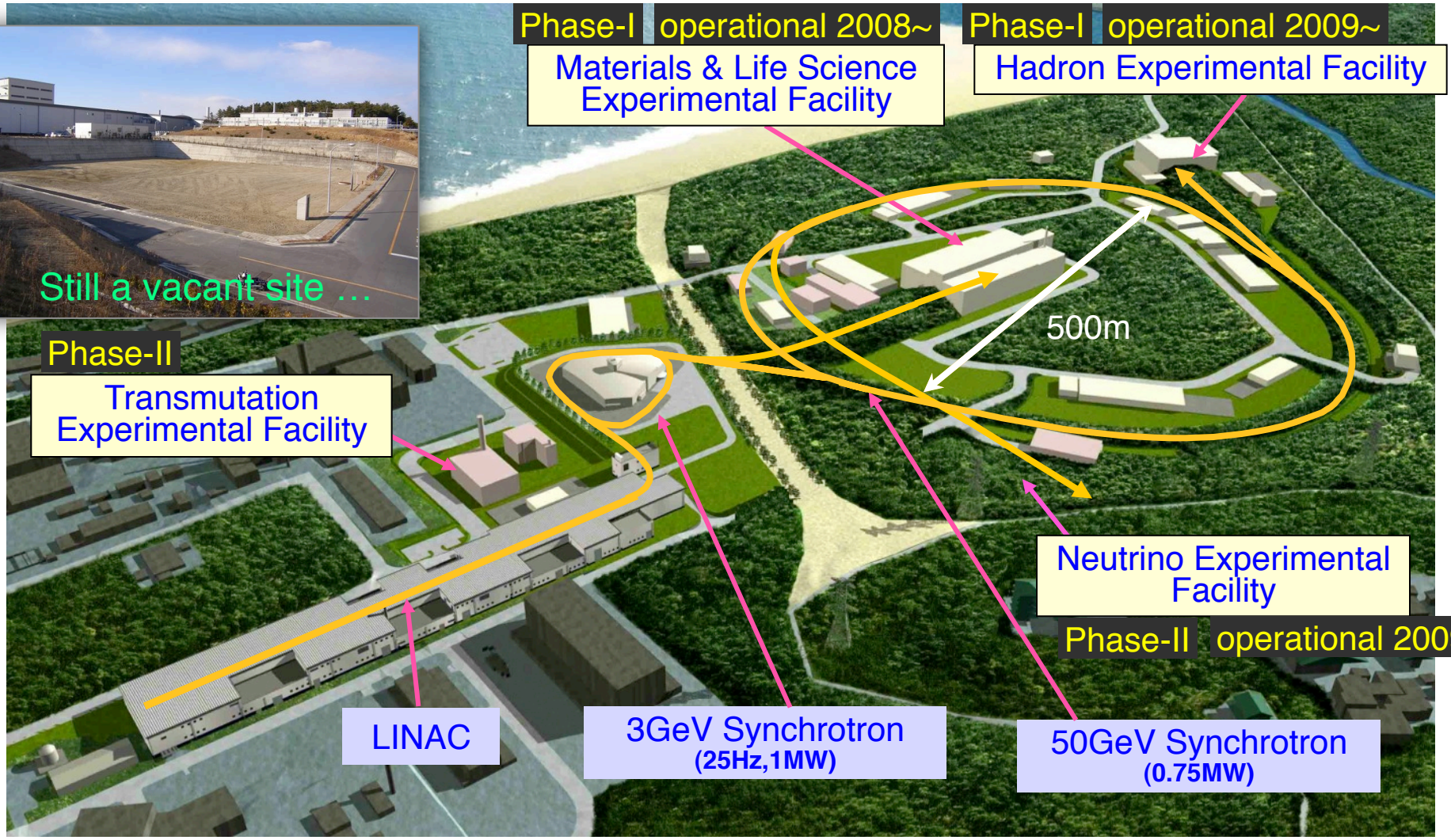
TEF-P: Transmutation Physics Experimental Facility

Purpose: Reactor Physics
Category: Critical Assembly
Proton Power: 400MeV-10W
Thermal Output: Less than 500W

TEF-T: ADS Target Test Facility

Purpose: Material Irradiation
Category: Radiation Application
Proton Power: 400MeV-250kW
Target Material: Lead-Bismuth

J-PARC: Japan Proton Accelerator Research Complex



"Strategic Energy Plan" issued in April, 2014

(excerpted, provisional translation)

The first GOJ's long-term, comprehensive and systematic energy policy after the Great East Japan Earthquake in 2011

- GOJ will promote technology development on volume reduction and mitigation of degree of harmfulness of radioactive waste.
- Specifically, development of technologies for decreasing the radiation dose remaining in radioactive waste over a long period of time and enhancing the safety of processing and disposal of radioactive waste, including **nuclear transmutation technology using fast reactors and accelerators**, will be promoted by utilizing global networks for cooperation.
- Also, while GOJ examines the situation of study and progress in terms of final disposal, it studies the feasibility of integrated implementation of the R&D for final disposal and reduction of volume, international research cooperation and a researcher resource development related to them.

National Review Working Party for ADS based P-T Technology

- In July, 2013, GOJ's Ministry (MEXT) launched a Review Working Party to evaluate accelerator based PT technology. Discussed are …
  - Current PT research activities,
  - **Construction of the Transmutation Experimental Facility (TEF) in J-PARC,**
  - International collaboration
- After 5 meetings, an **Interim Report** was issued in November, 2013.

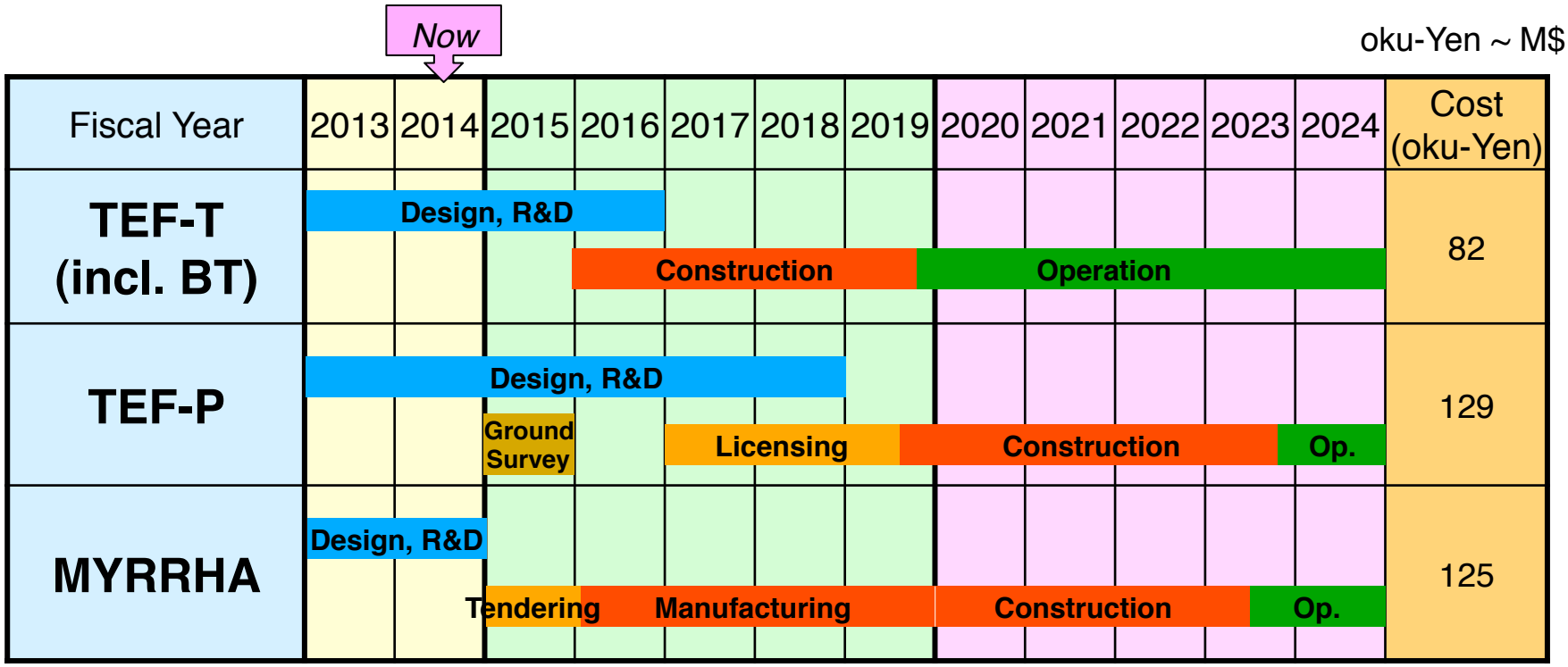
> ***For both TEF-T & TEF-P,***
> ***"It is appropriate to shift the R&D of the facility to the next stage."***

- In 2014, 2 meetings were held with giving a summary that **R&Ds for TEF is appropriate and steadily proceeded.**

> ***However, the TEF construction has not been approved yet.***

- In 2015, we will try to get approval for the TEF construction by showing JAEA has enough technical bases necessary for the construction.

Construction Schedule (Tentative)

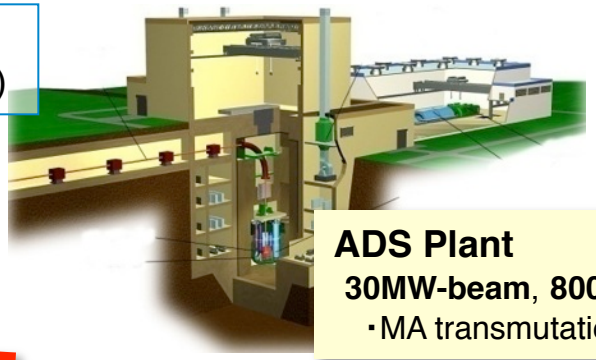


- If construction starts from 2016
  - TEF-T operates from 2019 with 25% beam power
  - Start Licensing for TEF-P from 2017
- Participation to MYRRHA
  - 10% of total cost（960M€）is assumed for Japanese contribution
  - Irradiation data taken in 2019 at TEF-T will be provided for MYRRHA full power operation
- Additional costs: New regulation adoption, LINAC upgrade, MA fuel fabrication etc.

TEF-MYRRHA Joint Roadmap to Accelerate Establishment of ADS Transmutation

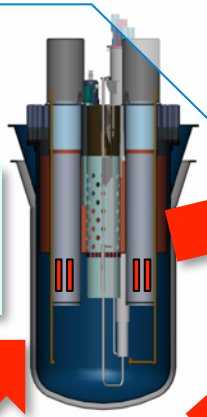
Power

ADS technology without MA fuel
(Pb-Bi core, Accelerator, Operation Experience)



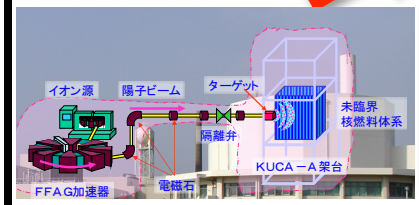
ADS Plant
30MW-beam, 800MW$_{th}$
・MA transmutation

ADS Demo⇒MYRRHA
~2.4MW-beam, 50~100MW$_{th}$
・Demonstration of ADS



Physics of MA fuel and Target Development

Improve Window Material



J-PARC Transmutation Experimental Facility
250kW-beam
・Pb-Bi target ・ADS core

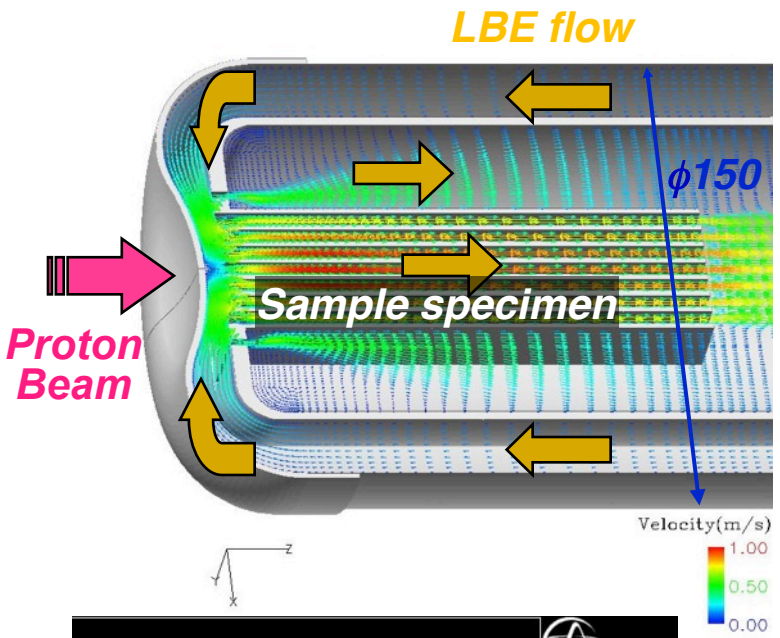
	J-PARC	MYRRHA
Pur-pose	Elemental Technology（Target、Physics）	System demonstration
Power	Proton:250kW Core：500W(10W$_{beam}$)	Proton:2.4MW Core:50～100MW
MA	Simulate MA loaded core (Several tens kg)	Small Amount Irradiation

- Lead the worldwide RD&D for transmutation technology in cooperation with J-PARC and MYRRHA
- Obtain knowledge & experience to realize ADS in 2030th

Basic tests (Pb-Bi loop, KUCA, etc.)

2010 2020 2030 2050 Year

Spallation Target Design



Thermal-hydraulics Analysis by STAR-CD

Geometry	3D 1/4 sector ~220,000 cells
Pb-Bi Flow	1 Litter/sec
Inlet Temp.	330ºC
Solver	Standard k-ε for High Re nr.
Material	316SS or T91 2mm thick
Proton	400MeV-250kW
Beam Prof.	Gauss (Peak: 20μA/cm^2)

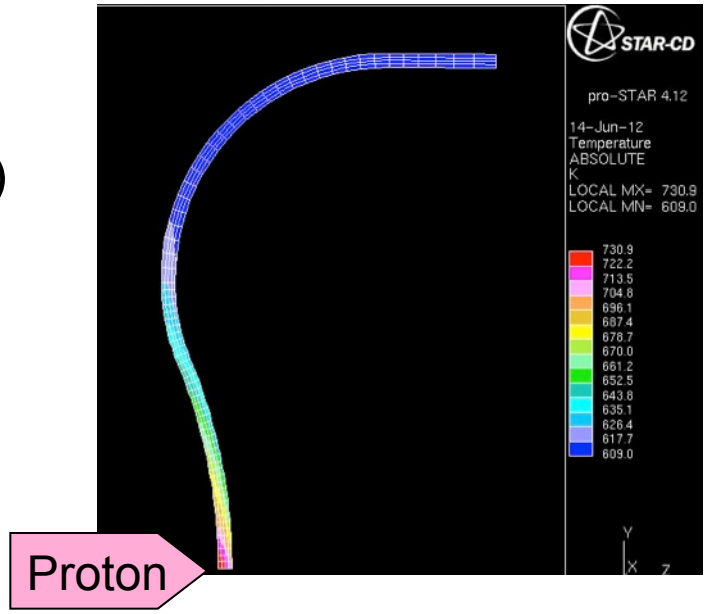
Structural Analysis by ABAQUS

Static Stress	0.3~0.5 MPa (Pb-Bi)
Thermal Stress	Data from THA

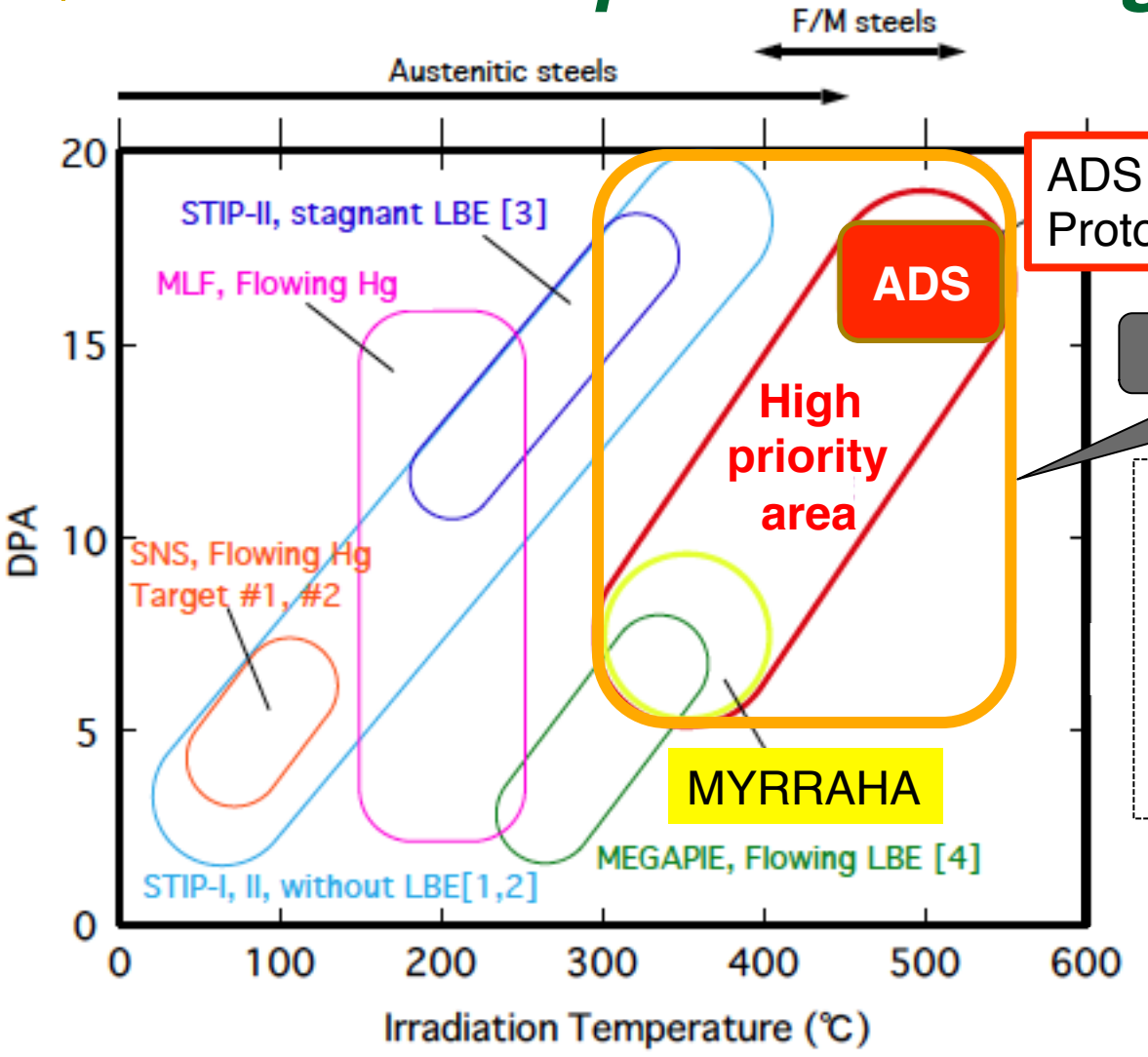
Acceptable Beam Density: < 30μA/cm^2

Expected value @20μA/cm^2

8 dpa/y, 250 appmHe/y



PIE Data Required to Design ADS Plants



ADS plant, 1.5 GeV
Proton + Spallation neutron

TEF-T, Flowing LBE

STIP-I,II
Irradiation in Stagnant Pb-Bi performed at PSI

MEGAPIE
World's first Pb-Bi spallation target with 1MW proton beam performed at PSI

SNS
High power spallation neutron source in USA

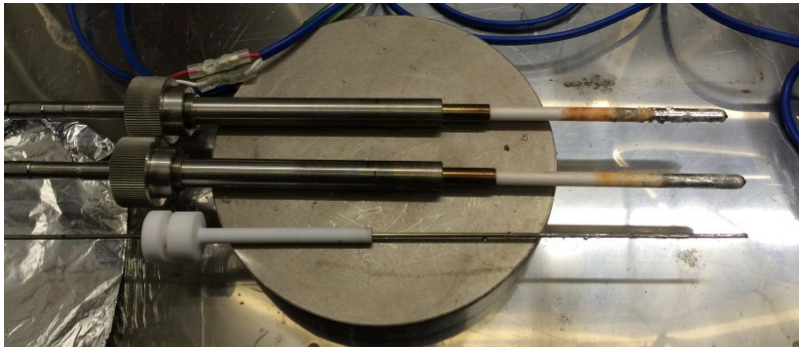
MLF
1MW Mercury spallation target of J-PARC

[1] Y. Dai, G. S. Bauer, J. N ucl. Mater., 296(2001)43.
[2] Y. Dai, et. al, J. N ucl. Mater., 343(2005)33-43.
[3] Y. Dai, et. al, J. N ucl. Mater., 377(2008)225-231.
[4] M. Wohlmuther, et. al, tp be published in J. N ucl. Mater.
[5] K. Nishihara, et. al, J. N ucl. Mater., 377(2008)298-306.

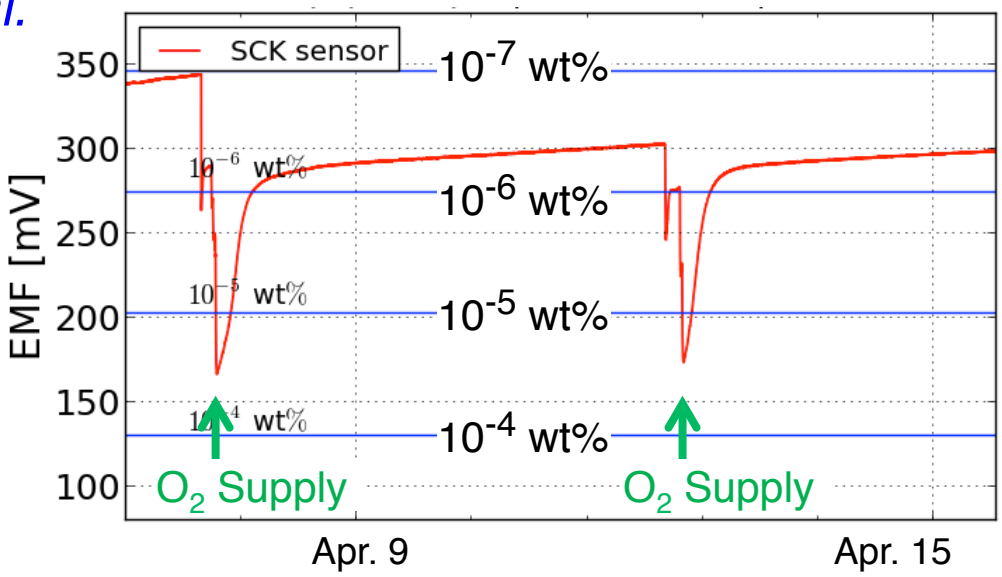
TEF condition can cover the high priority area for MYRRHA & ADS plants.

LBE Instruments: Oxygen Control

To prevent corrosion of structural steel materials, control of oxygen concentration (C_O) in LBE is crucial.



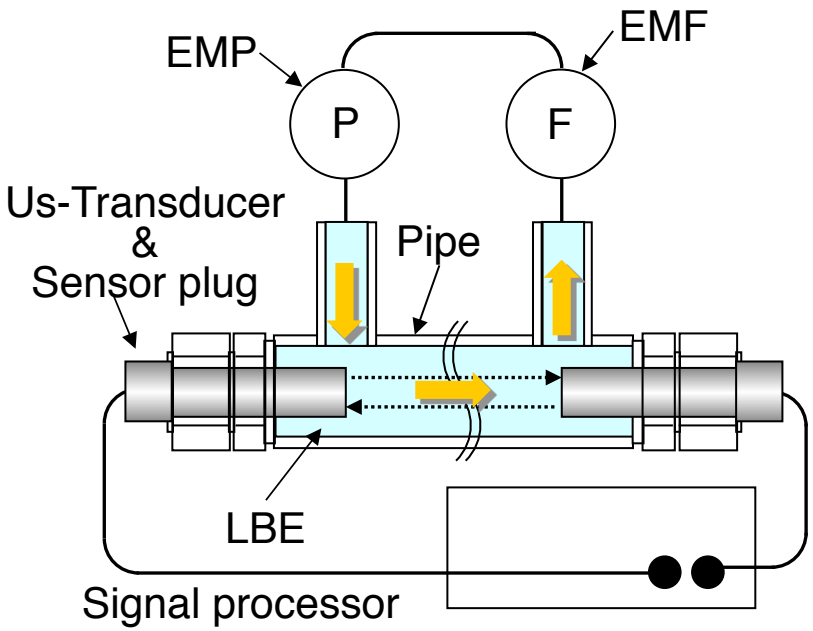
Tow types of oxygen sensors developed by SCK•CEN & KIT

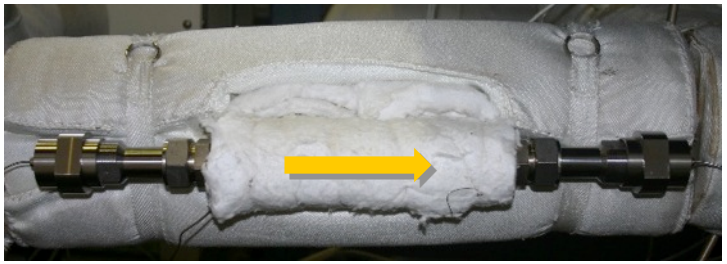


Trend of Oxygen Potential Control

- C_O was measured in static conditions at 450ºC.
  - Measurement in flowing conditions will be conducted.
- C_O was controlled in a target range: 10^{-7} ~ 10^{-5} wt%.
  - Development of automatic controlling system is under way.
- JAEA's original sensor is being developed.

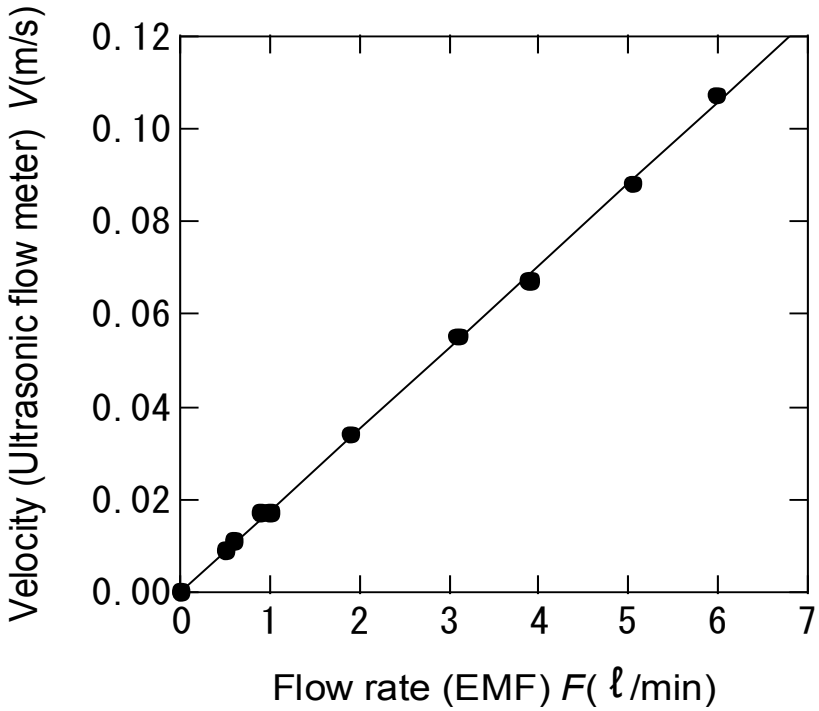
LBE Instruments: Ultra-sonic Flowmeter



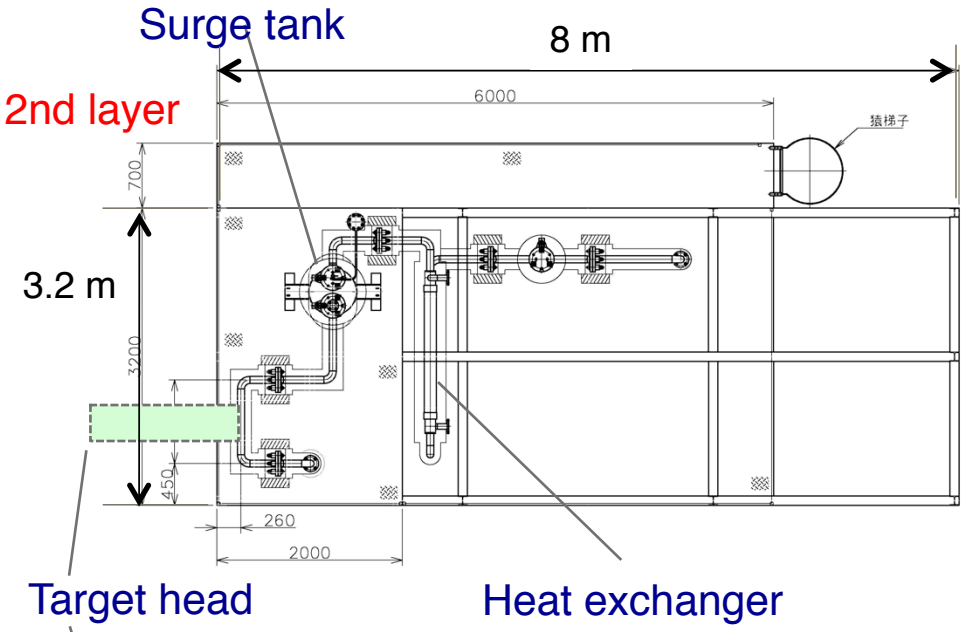


Propagation time of US signal depends on velocity of the flowing medium.

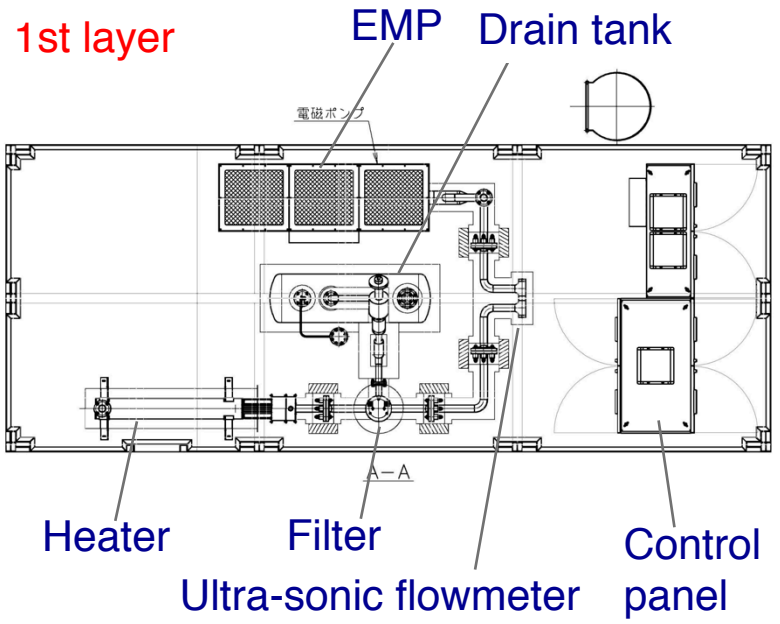
- Measured results by US flowmeter and EMF (reference) were compared, and good agreement was confirmed.
- To be developed:
  - Remotely attachable/detachable cassette type

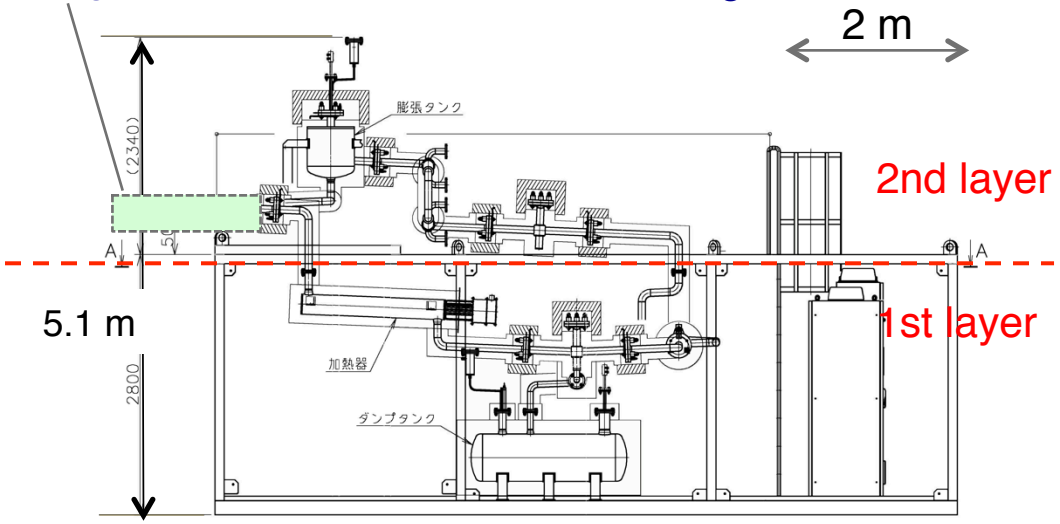


Mock-up LBE Loop for TEF-T



To be completed in March 2015



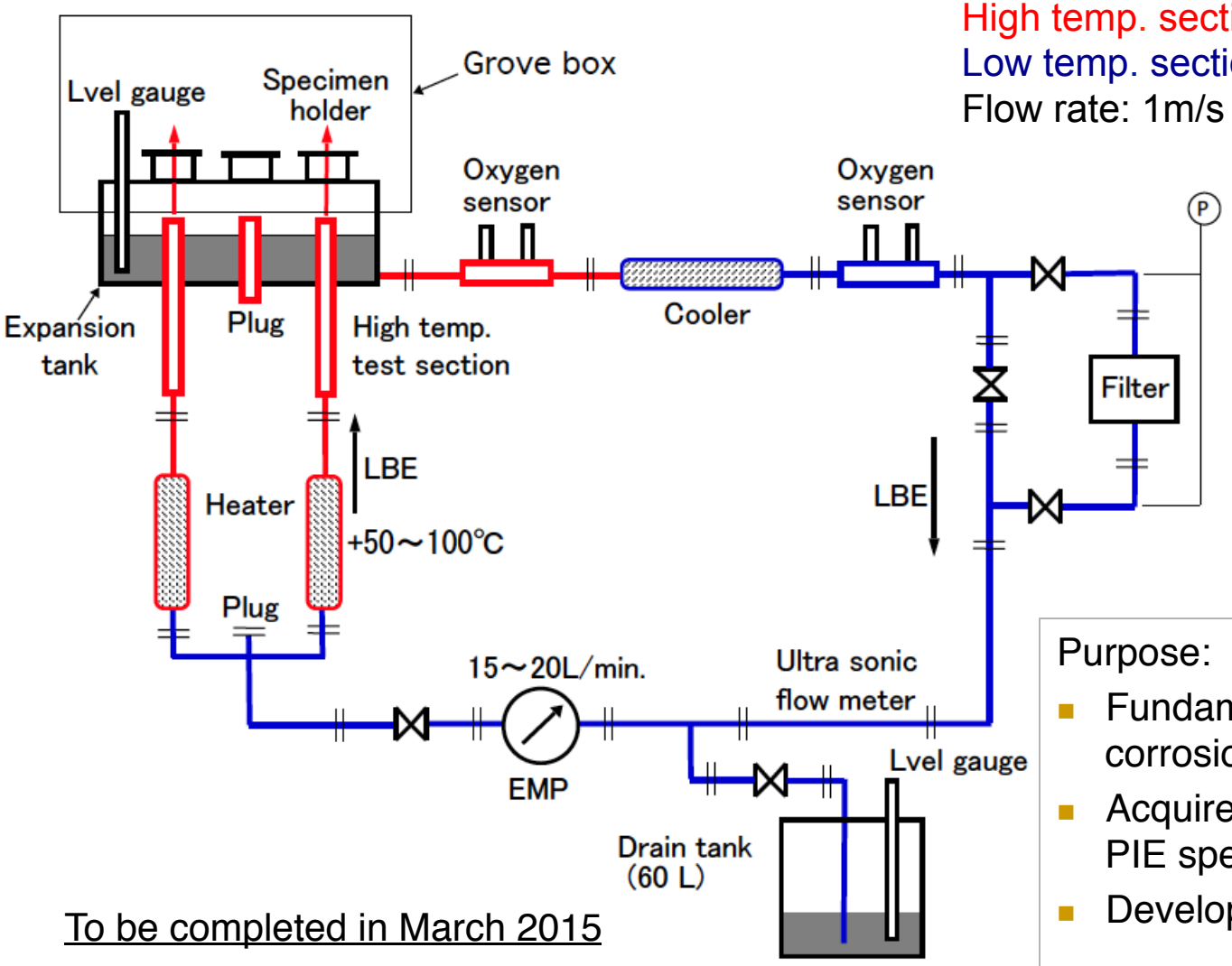


Purpose:

- Dynamic behavior testing of LBE heat removal
- Performance test of EMP & HEX
- Establishment of operation procedure
- Integral test of individual instruments, i.e. US flowmeter, O_2 sensor, level gauge

High-temp. Material Corrosion Test Loop

High temp. section: max.550°C, T91
Low temp. section: max.450°C, SS316L
Flow rate: 1m/s at high temp. test section



To be completed in March 2015

Purpose:

- Fundamental study of material corrosion phenomena
- Acquirement of corrosion data for PIE specimen without irradiation
- Development of filtering system

Summary

- P&T is an option of the GOJ's energy policy.
- JAEA is promoting R&D activities for P&T technology with FR and ADS.
- National Review Working Party suggested JAEA's R&D activities for TEF is appropriate and steadily proceeding.
- We will start construction of J-PARC TEF in FY2016 if GOJ will approve our plan.
- TEF-T will provide a materials irradiation field in flowing LBE in succession to MEGAPIE.
- International collaboration is essential for the TEF construction and the realization of ADS plants in the future.

Thank you for your attention!