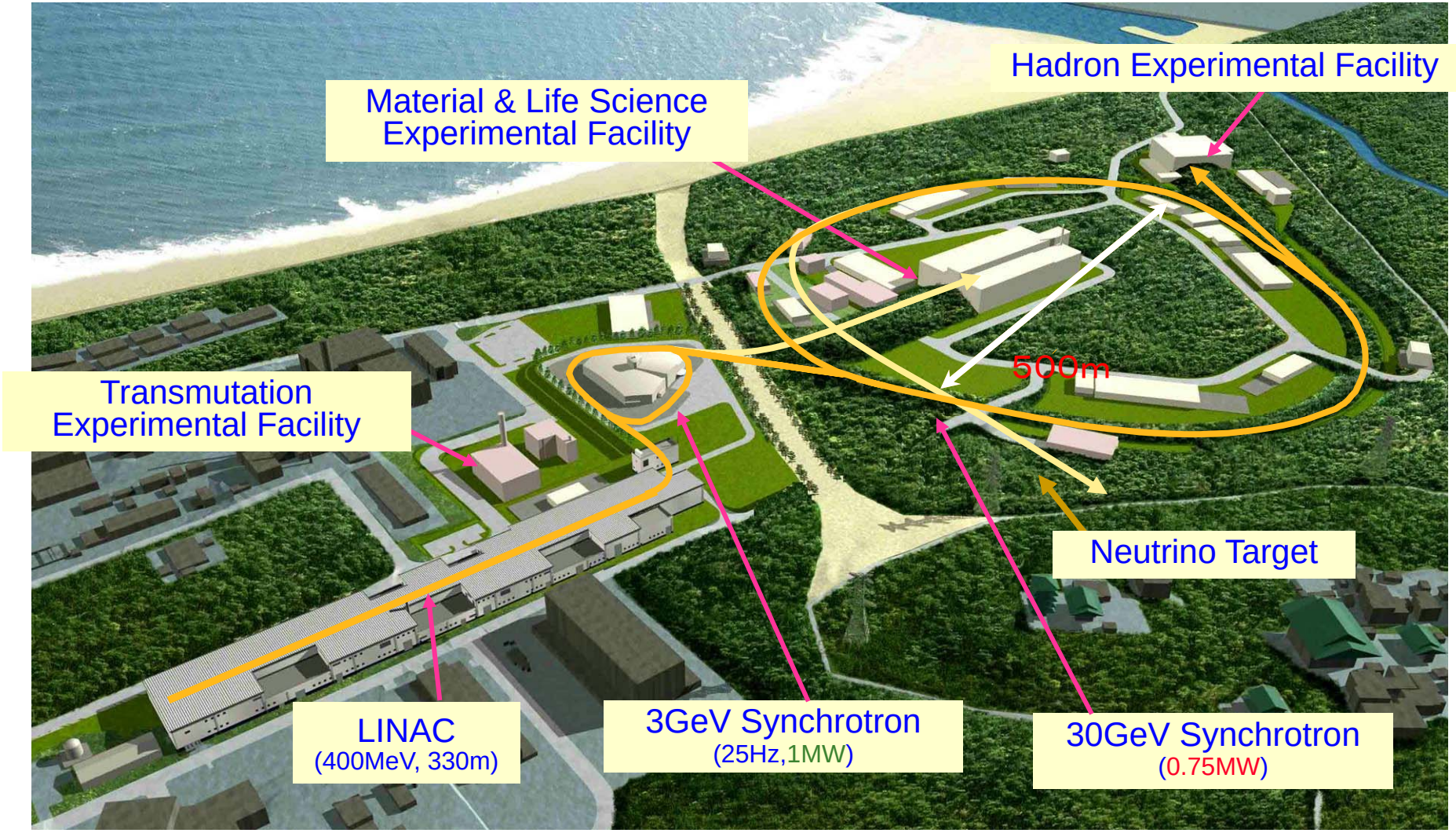
Multipurpose application of the J-PARC Transmutation Experimental Facility

10th ASRC International Workshop
"Nuclear Fission and Decay of Exotic Nuclei"
2013.3.21 JAEA Nuclear Science Research Center

J-PARC Center, Transmutation Section

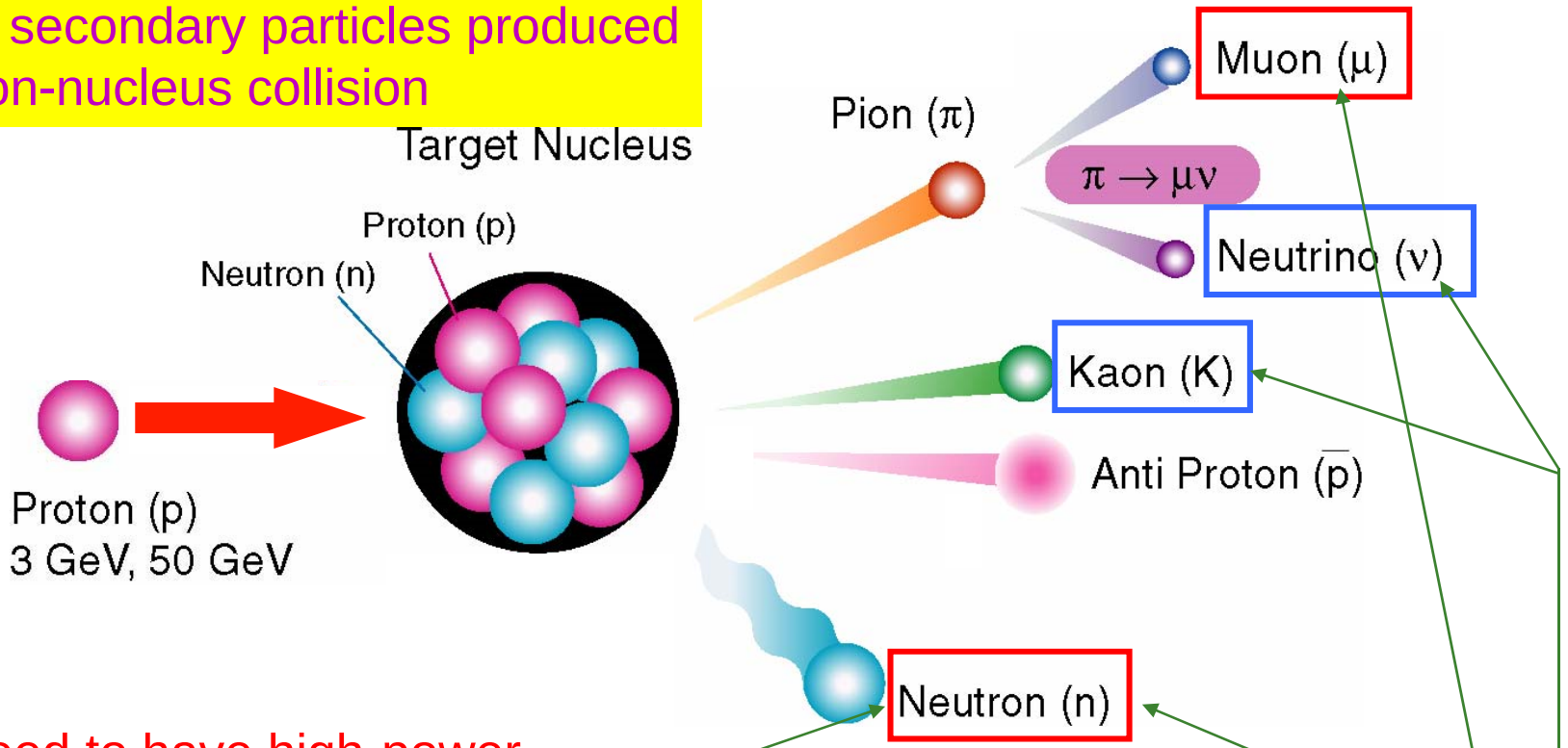
Toshinobu Sasa

J-PARC: Japan Proton Accelerator Research Complex



Science Goals at J-PARC

Various secondary particles produced by proton-nucleus collision



Need to have high-power proton beams

→MW-class proton accelerator

Intensity Frontier

Materials & Life Science at 3 GeV
Nuclear & Particle Physics at 50 GeV
R&D toward Transmutation at 0.6 GeV

MULTI-PURPOSES

A Brief History of J-PARC

2000 Aug. Pre-Review

2003 Dec. Gov't Review 1
2007 Jun. Gov't Review 2

2010 Oct. Upgrade Plan included in the Master Plan of Japan Science Council and the Roadmap of MEXT

2012 Jun. Gov't Review 3 (next 5 –years plan)

2000

2008

2010

2012

2001Start Construction

2008.5 1st Neutron beam
2008.9 1st Muon beam
2009.2 1st beam to Hadron Exp.
2009.4 1st beam to Neutrino Exp.

2011.3.11 East-Japan Earthquake stopped operation

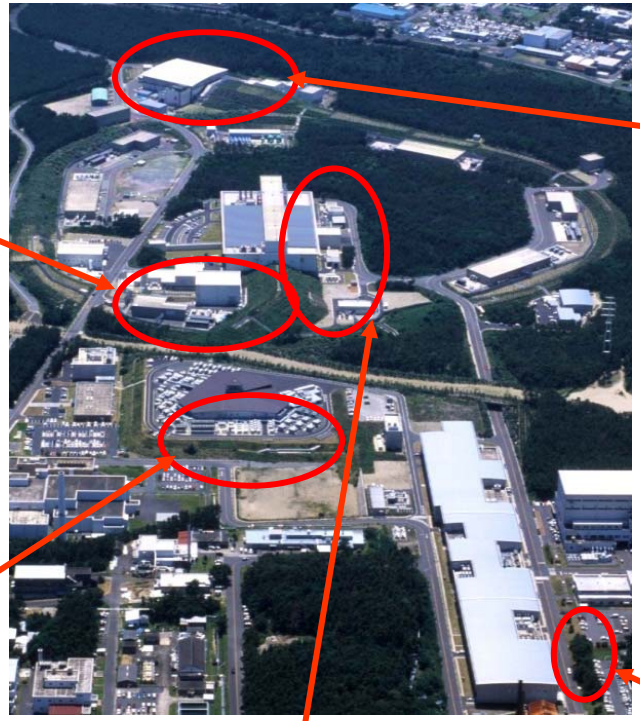
Ex. J-PARC Director, Prof. Nagamiya restarted J-PARC accelerators after recovery from the earthquake.

2012.1.24 Operation for users was resumed

Damages by Great East Japan Earthquake

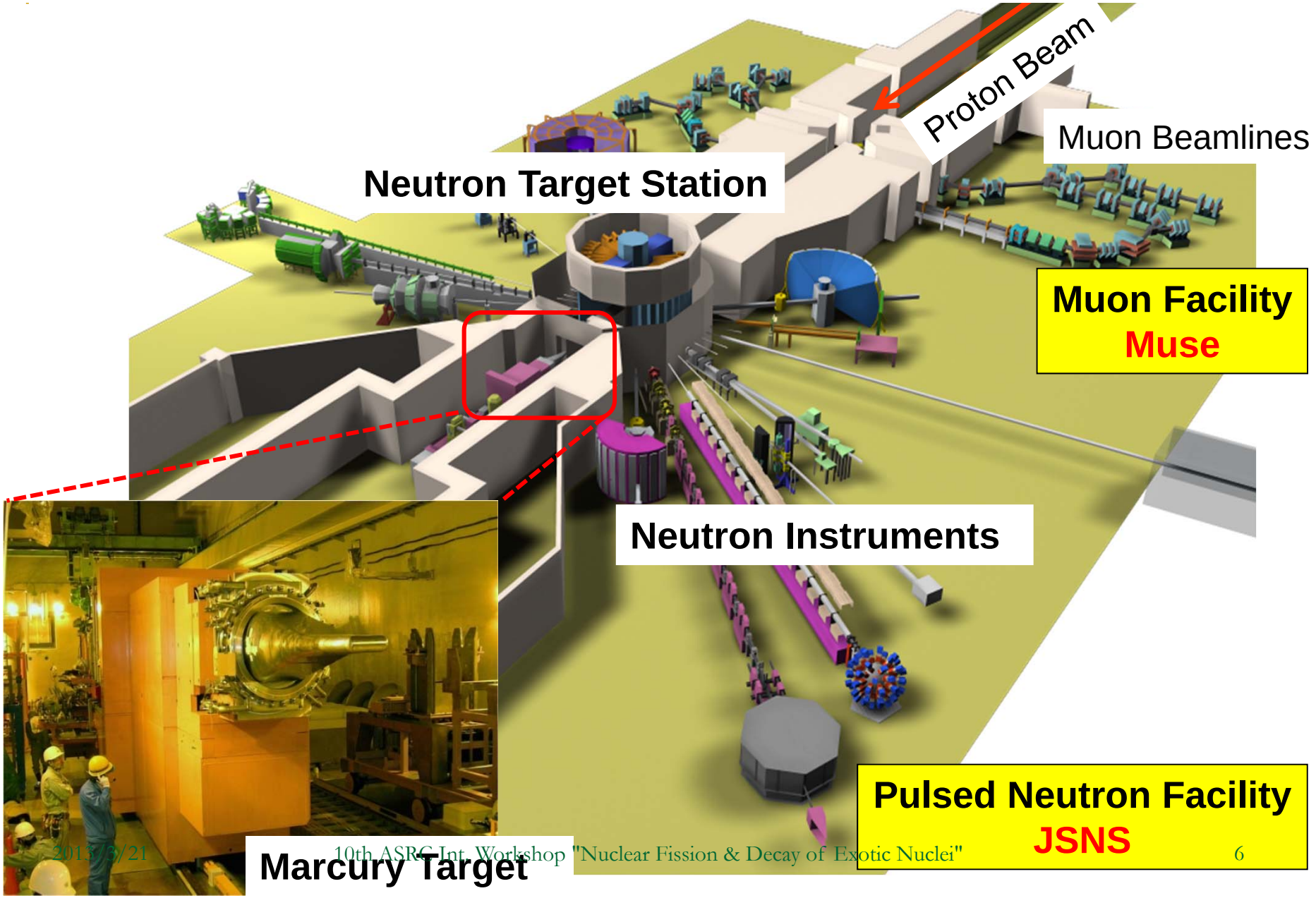




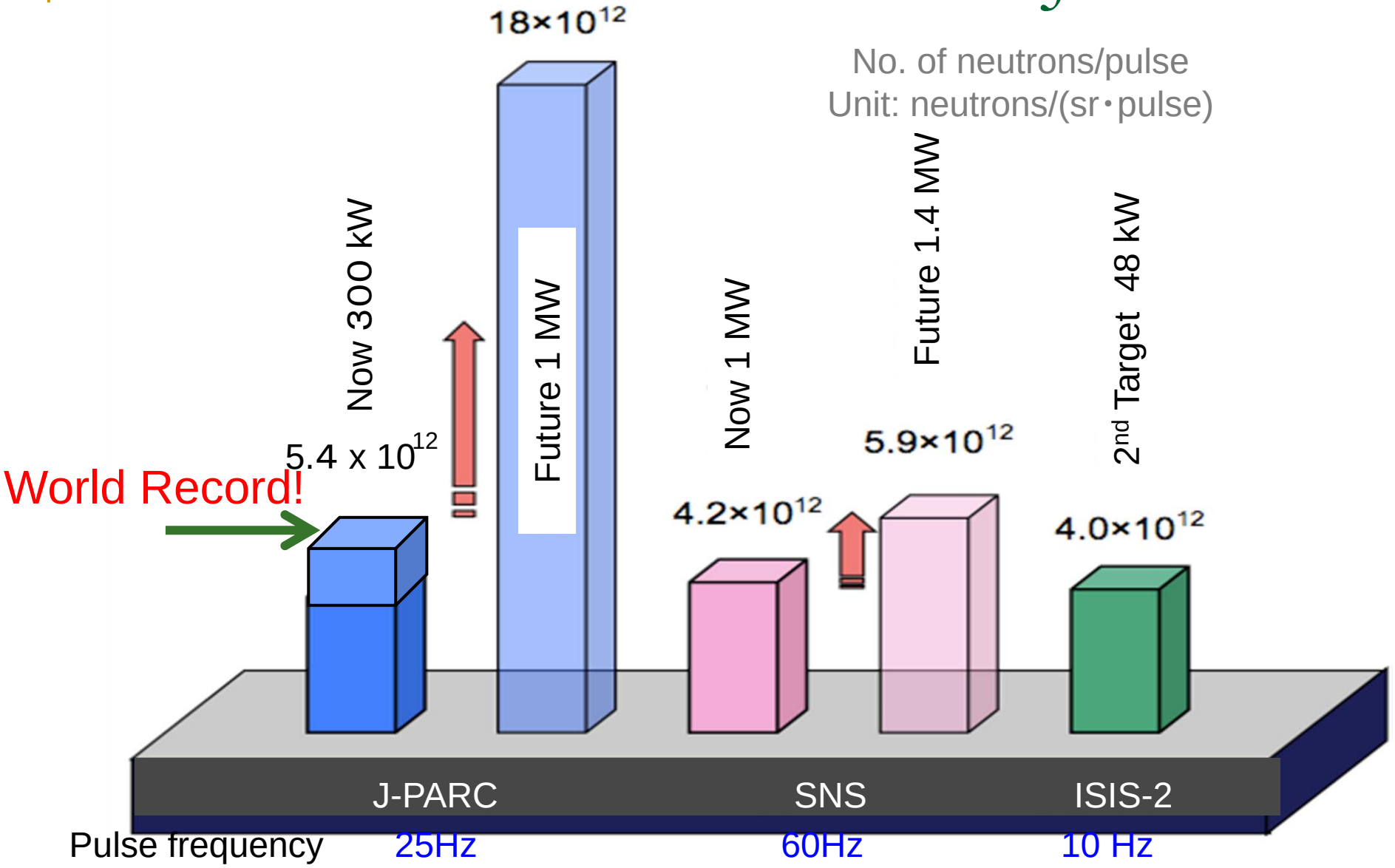




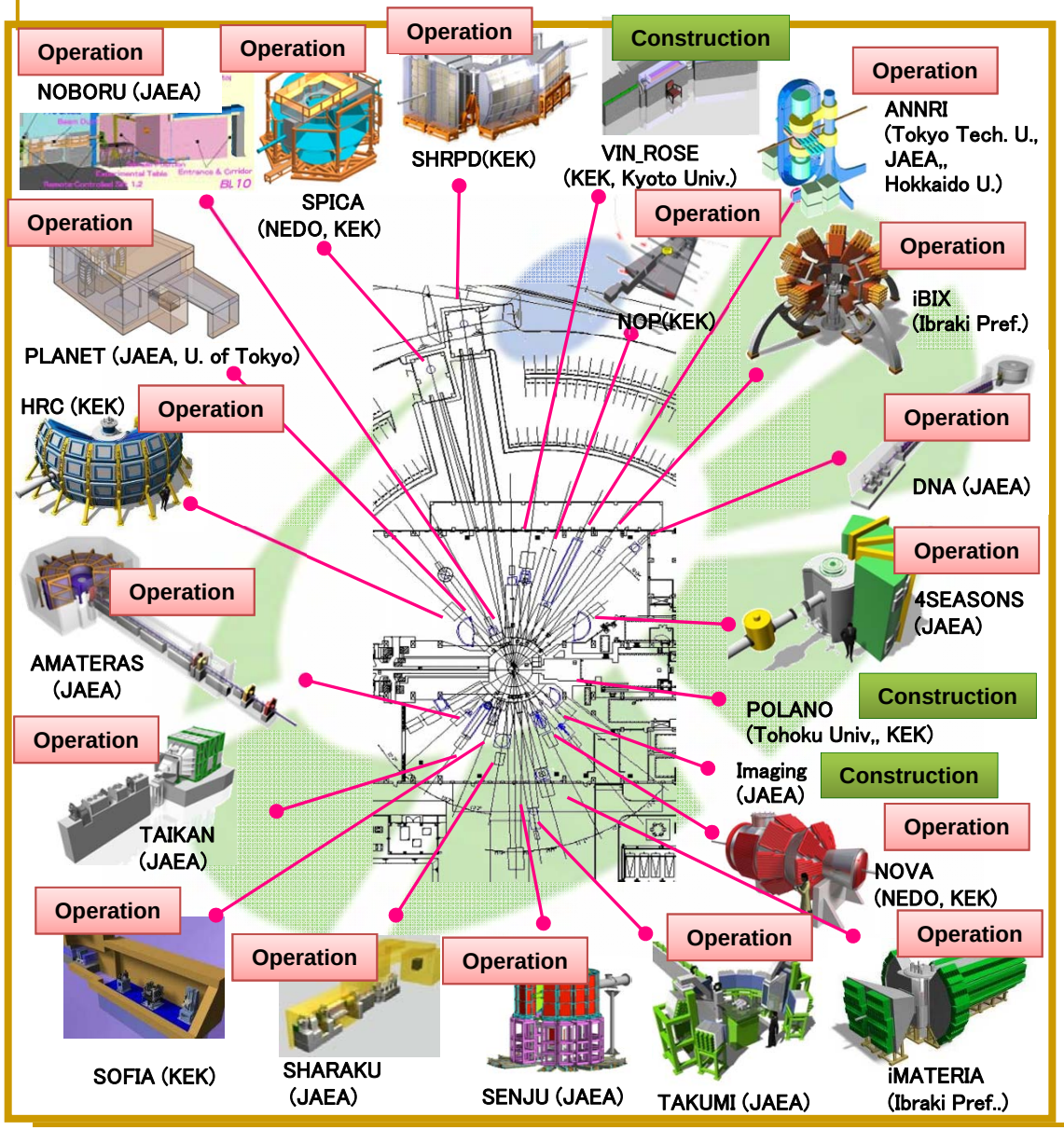

Materials & Life Science Experimental Facility (MLF) with Neutron and Muon Beams



Pulse Neutrons Performance at J-PARC



Neutron Instrument Status



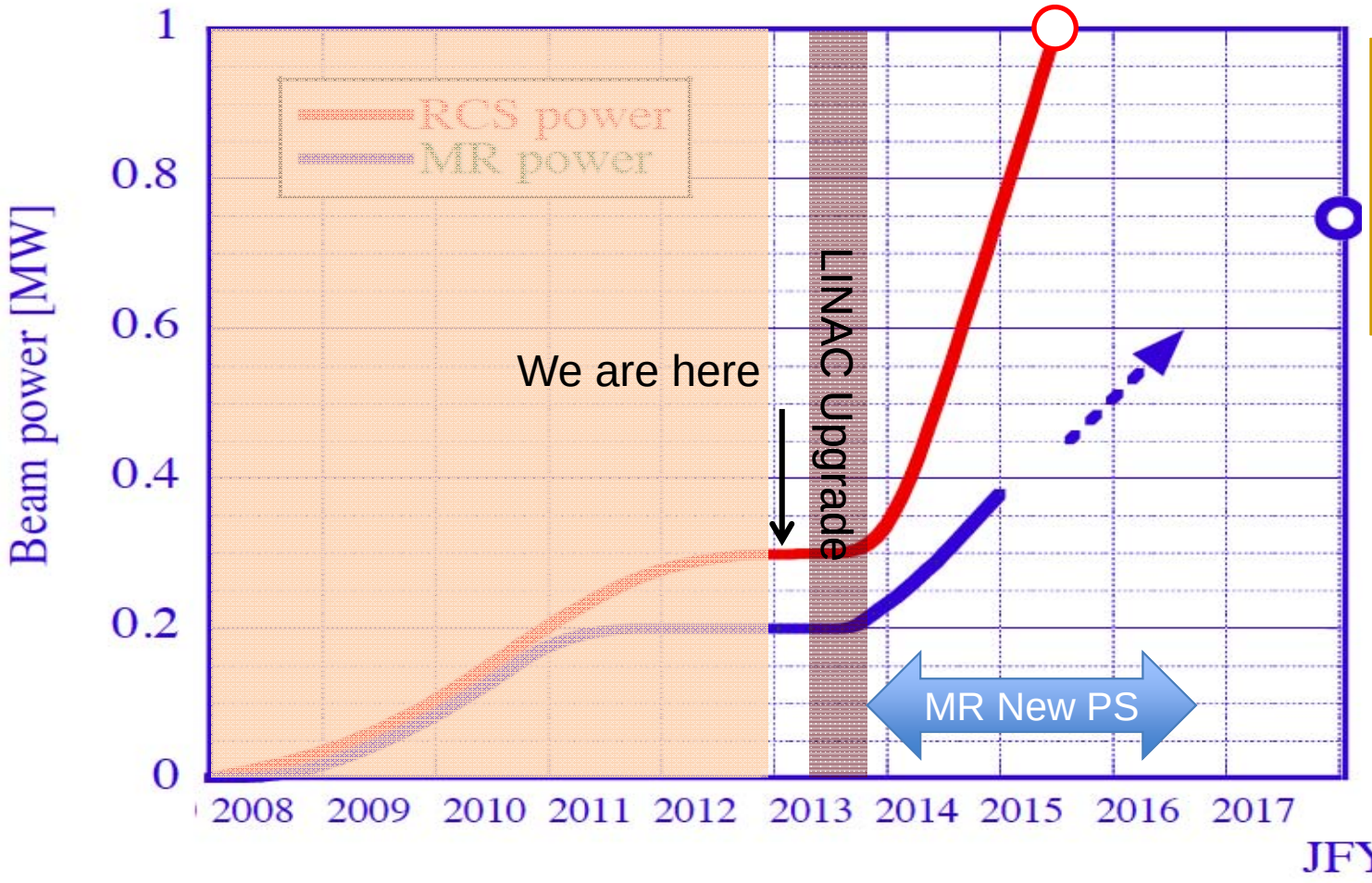
- 23 Neutron Beam Ports
- From academic to Industrial uses
- In operation: 18
  Under construction: 3
- Constructed by
  - KEK
  - JAEA

  } J-PARC MLF
  - Ibaraki Prefecture
  - Kaken-hi (Gov. direct funding)
- Operation days/year
  200 days/year (Goal)
  (176 days in 2012)
- Number of staffs including out-sourcing 150+70

Schedule for Power Upgrade

FY2013: Linac 400MeV, FY2015: RCS MW

Development of PS, FY2018: MR 0.75 MW



Issues for MR
- PS
- High gradient Cavity
- High repetition
- Shielding

Interest for Transmutation in Japan

Recommendations of the Science Council of Japan as an answer to the Atomic Energy Commission's independent review request (Reported at 11.9.2012)

- Requires a fundamental review of waste disposal policy
- Manage the total amount and temporal safe storage of waste
  - Ensure Reversibility and Retrievability (Several hundred years)
  - During the SF storage, following study should be enhanced
    - Waste Transmutation
    - Safety of Fuel Storage
    - Stability of Geological Layer
- Construct a consensus building mechanism
- Take tenacious efforts to establish waste disposal site

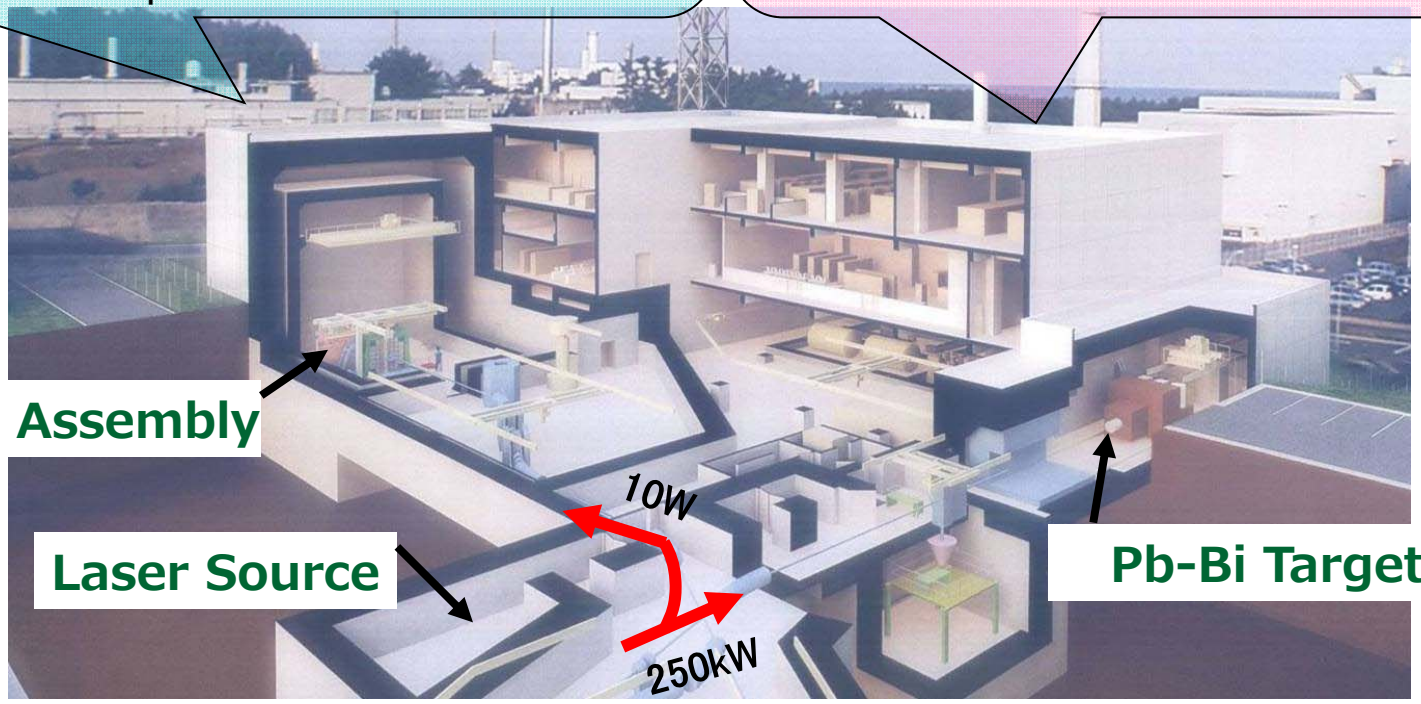
Transmutation Experimental Facility

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



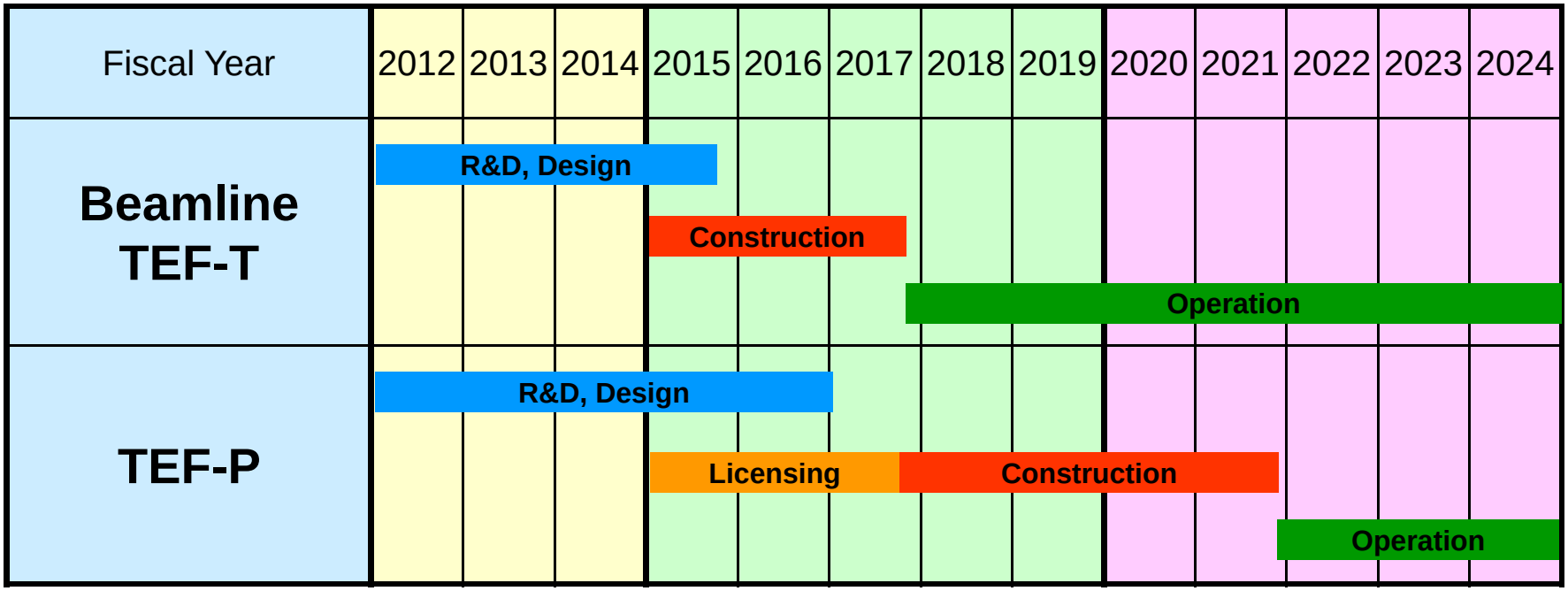
R&D Items using TEF-T

Purpose of R&D	*R&D items*
Irradiation damage of beam window and structural material by protons and neutrons	**Evaluation of soundness and lifetime of beam window**
	Duplicated irradiation damage by protons and neutrons
	Establishment of material database for fast neutron irradiation
	Irradiation effect under stressed condition
Compatibility of material with flowing liquid metal under strong irradiation condition	**Liquid metal corrosion and liquid metal embitterment under proton and neutron irradiations**
	Compatibility of material with liquid metal as a function of temperature, velocity and oxygen concentration of the liquid
	Affect of spallation products
Operation and control of liquid metal spallation target system	**Demonstration of performance of pump, flow meter, heat exchanger, oxygen controller under actual liquid metal spallation target**
	Transient behavior of system at beam trip and re-start
	Containment of spallation products and polonium
	Technical issues on system operation and maintenance

R&D items using TEF-P

Purpose of R&D	*R&D items*
Validation of data & method to predict the neutronics in a fast subcritical system with a spallation source	**Measurement of power distribution in sub-critical system**
	Determination of k_{eff} and effective source strength
	Evaluation of influence of high energy neutrons
	Evaluation of influence of target, window and void in beam duct
	Simulation of Pb-Bi coolant
Performance test of a hybrid system driven by an accelerator	**Feedback control of reactor power by beam intensity adjustment**
	Investigation of system behavior at beam trip and re-start
	Evaluation of temperature effect of core and target
	Investigation of instability of system caused by subcriticality and annular arrangement of core
	Determination of energy gain factor
Transmutation performance of MA and LLFP	**Measurement of cross section data by TOF technique**
	Measurement of MA transmutation rate
	Measurement of MA and LLFP sample reactivity worth
	Study of moderated region for LLFP transmutation
	Simulation of MA-loaded nitride core

Construction Schedule (Tentative Plan)



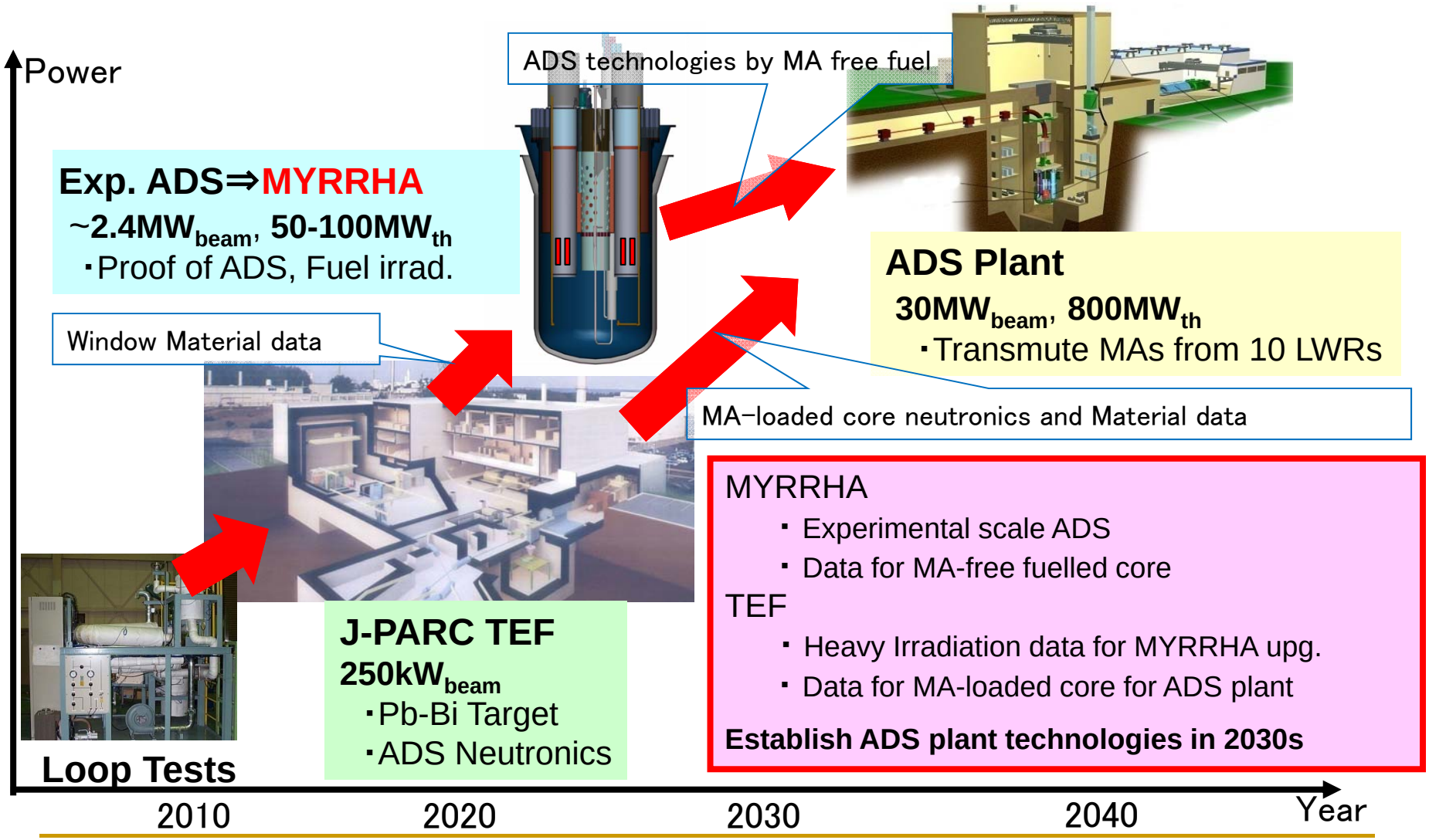
- The construction of Beam line and TEF-T will be started in 2014 and the operation with 1/4 beam power will be started in 2017
- To start the construction of TEF-P in 2017, just after the completion of TEF-T, a few years of licensing activities should be started in 2015

Construction Budget (Tentative Plan)

Year	Cost (M$)												
	Sum	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
R&D	8.9	1.0	2.1	2.9	2.9								
ADS-BT	17.3			8.6	8.7								
TEF-T	64.1			22.5	22.6	19.0							
TEF-P	129.4					12.6	29.2	29.2	29.2	29.2			
Total	219.7	1.0	2.1	34.0	34.2	31.6	29.2	29.2	29.2	29.2			

- Budget for 2013 is not directly related to construction but it includes
  1) TEF design,
  2) Construction of mockup for Pb-Bi spallation target loop,
  3) Laser source preparation, and
  4) Survey for MA fuel preparation

TEF-MYRRHA Joint Roadmap to Accelerate Establishment of ADS Transmutation



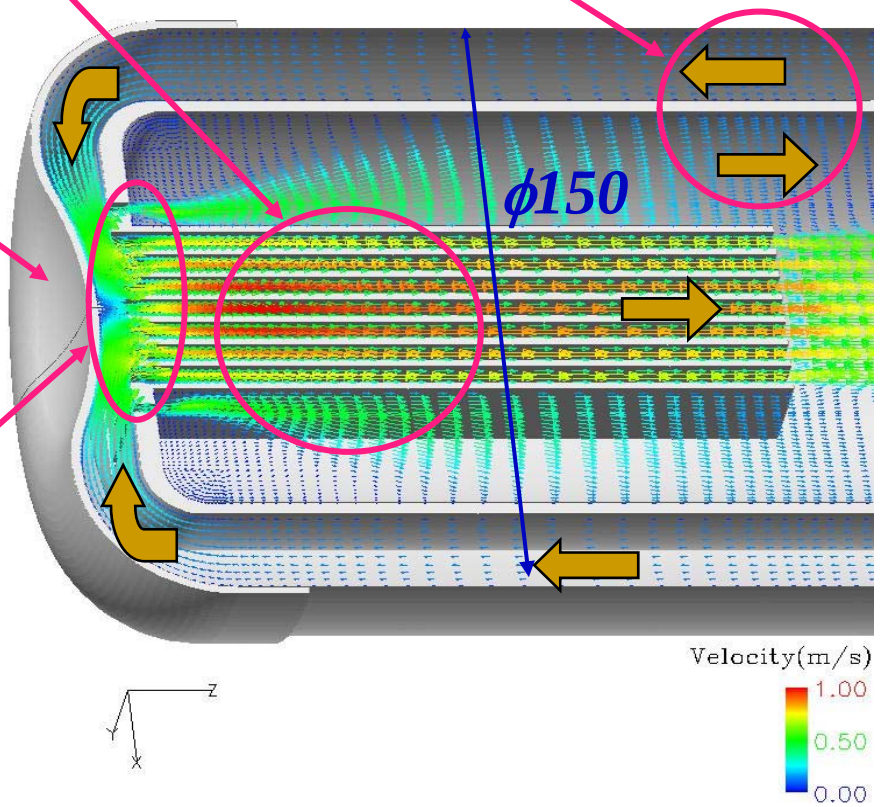
Design of Target Head - Concept

Irradiation sample holder:
To install plate specimens

Annular channel :
To flow Pb-Bi

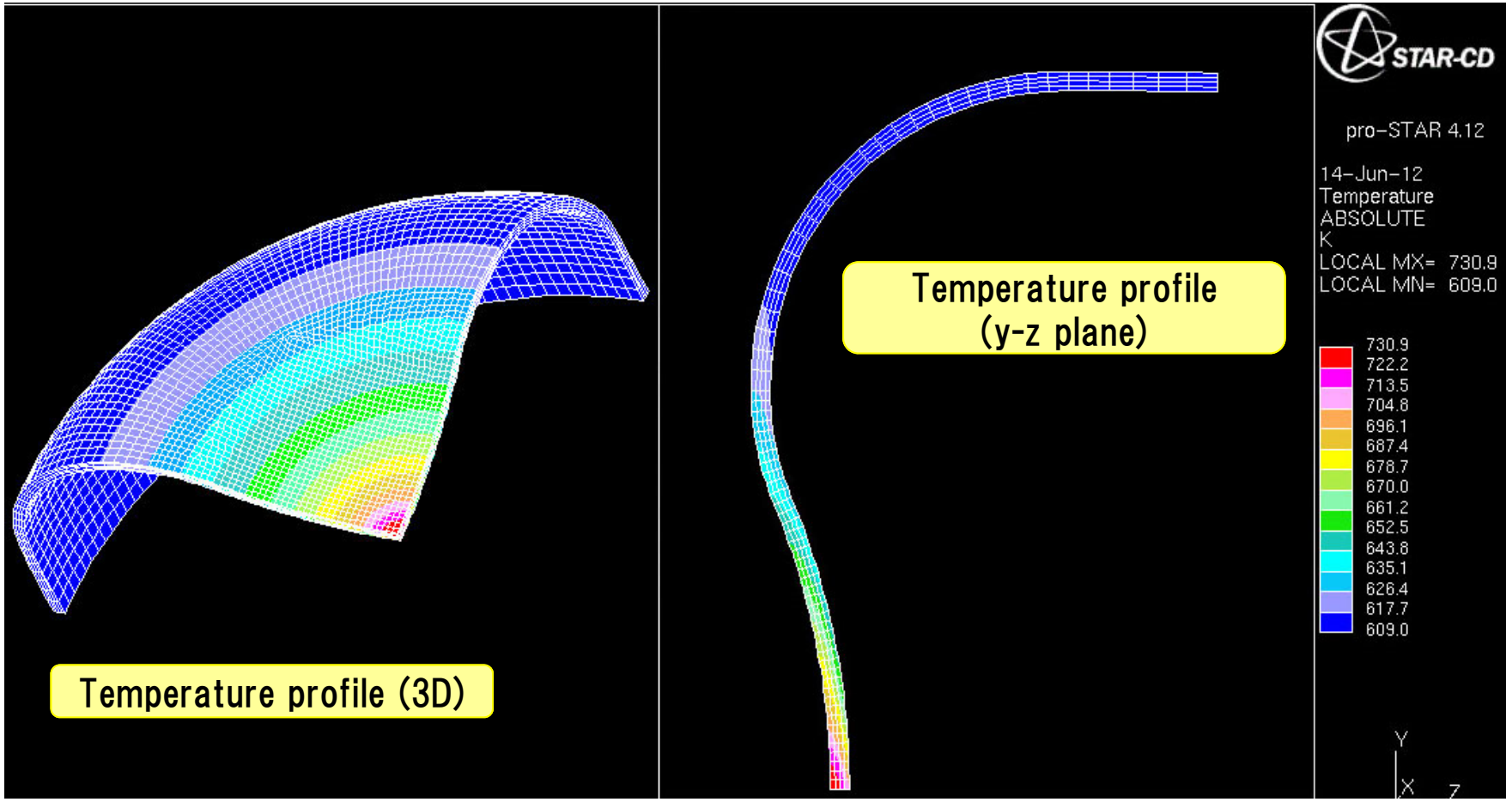
Beam window :
To assist returned flow and reduce the thermal stress.

Proton Beam



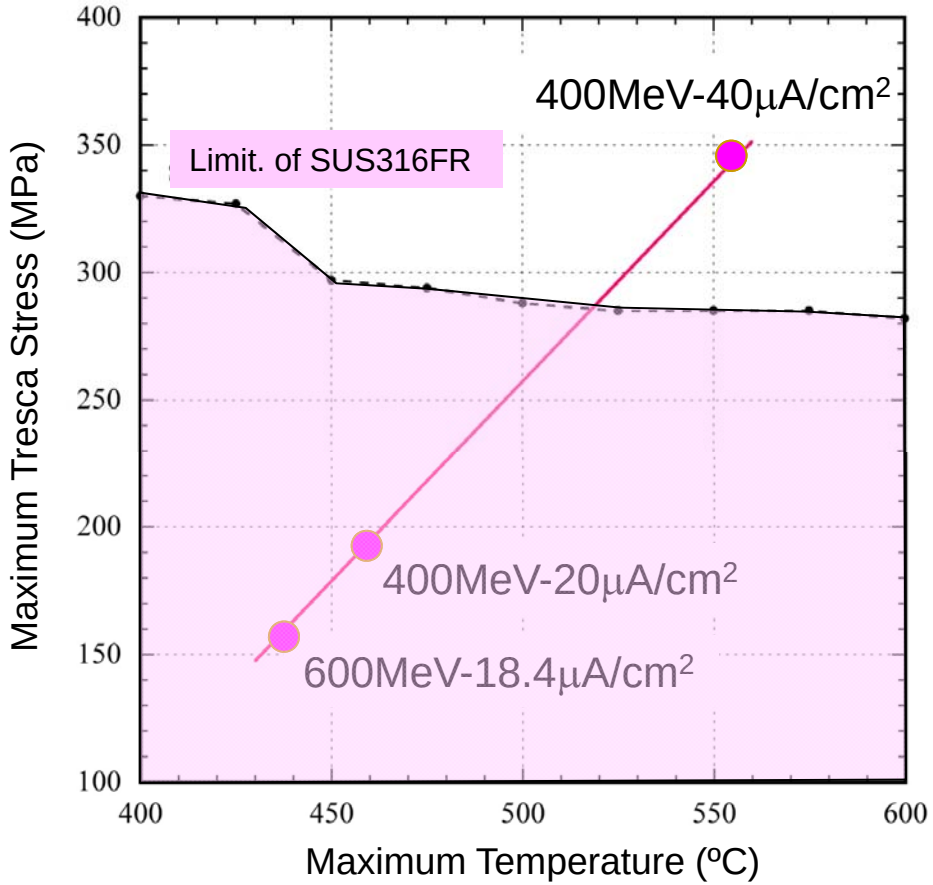
Perforated plate :
To improve heat removal at beam window and control a flow in sample region.

Design of Target Head - Window temp.



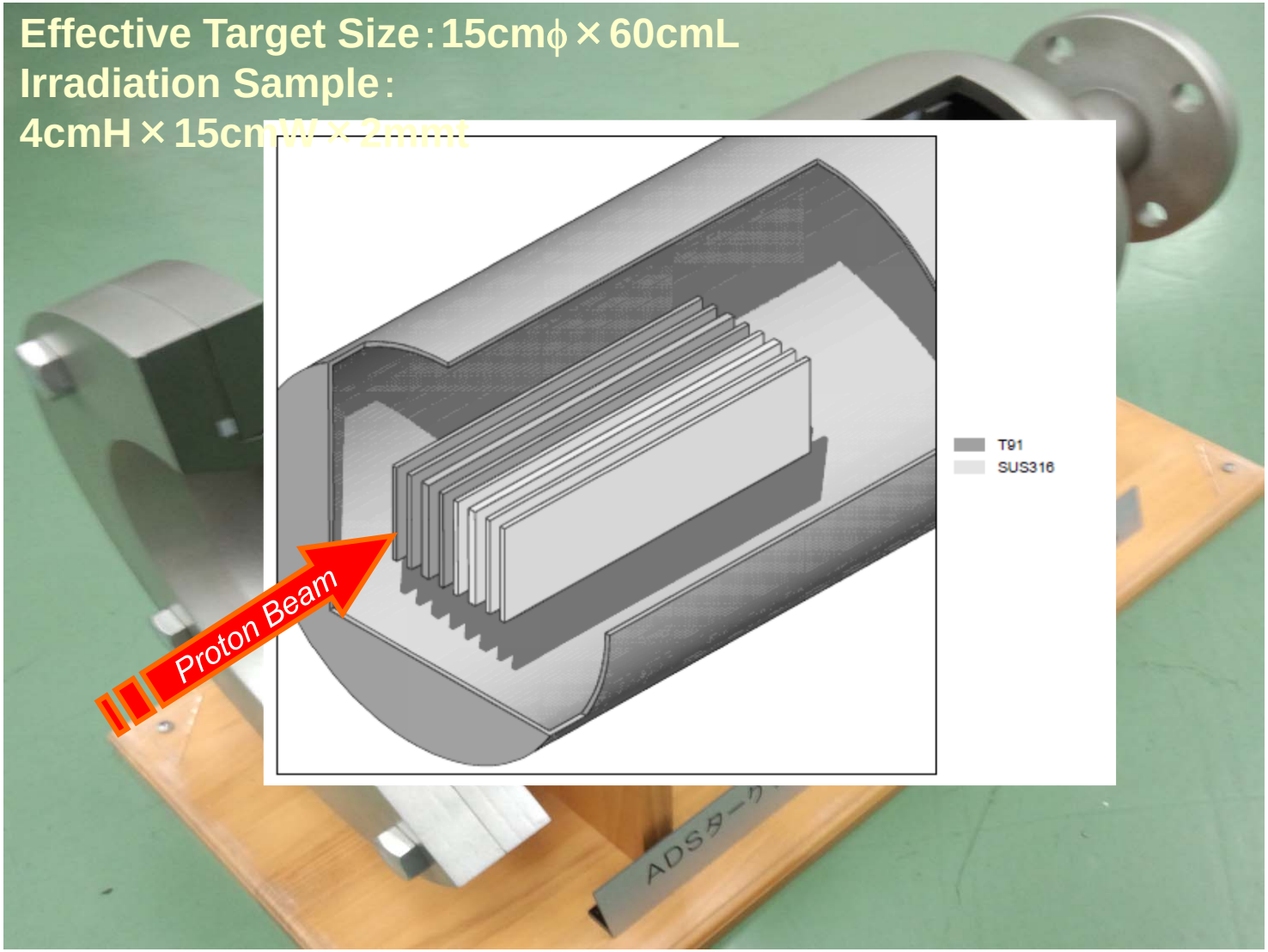
- Max. temp : 458 ºC at window center
- Min. temp : 336 ºC at coolant inlet edge

Design of Target Head - Stress Analysis

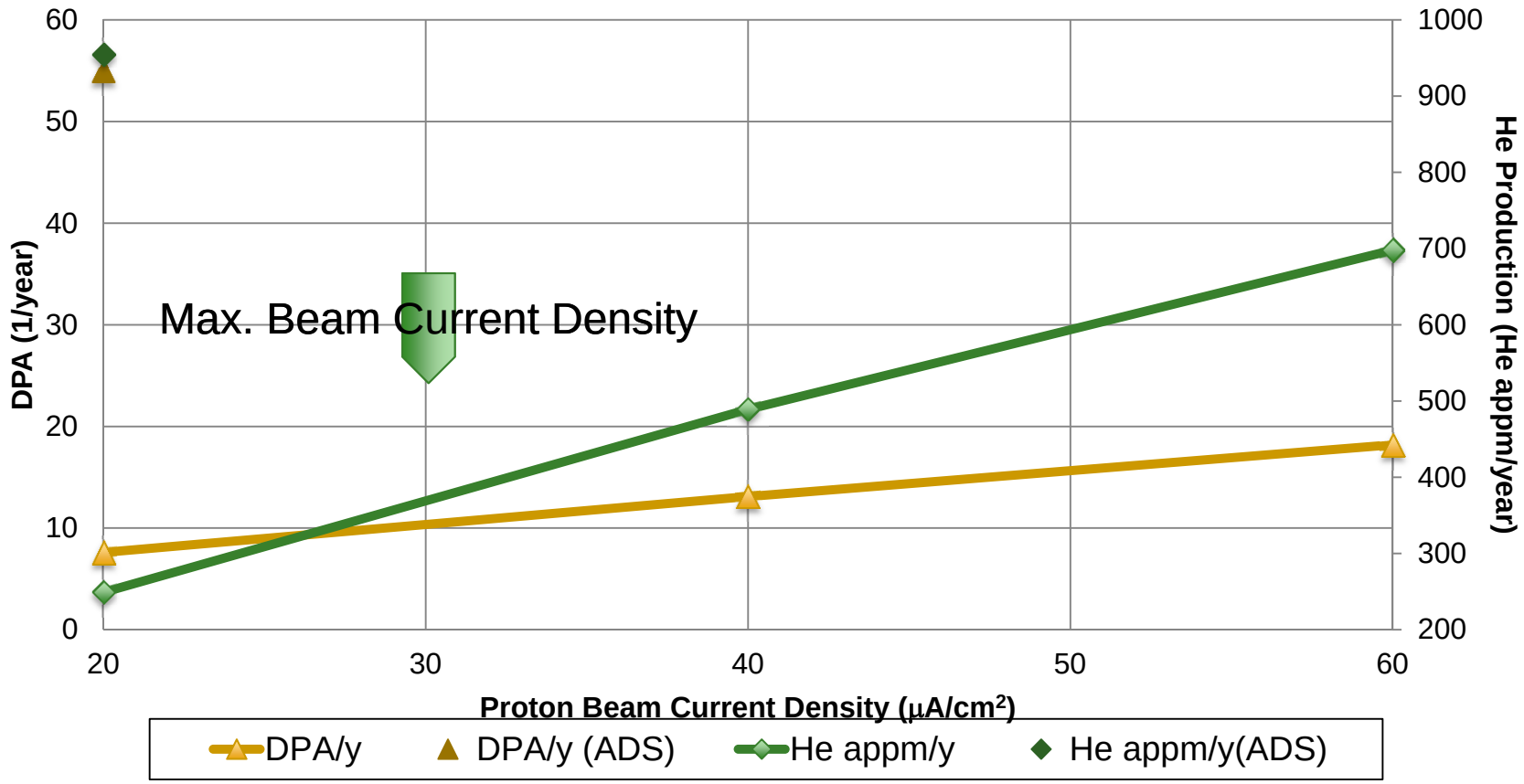


- Pb-Bi flow amount : 1 litter/sec
- Allowable Operation Condition : Lower than 400MeV – 30μA/cm^2

TEF-T Pb-Bi Spallation Target



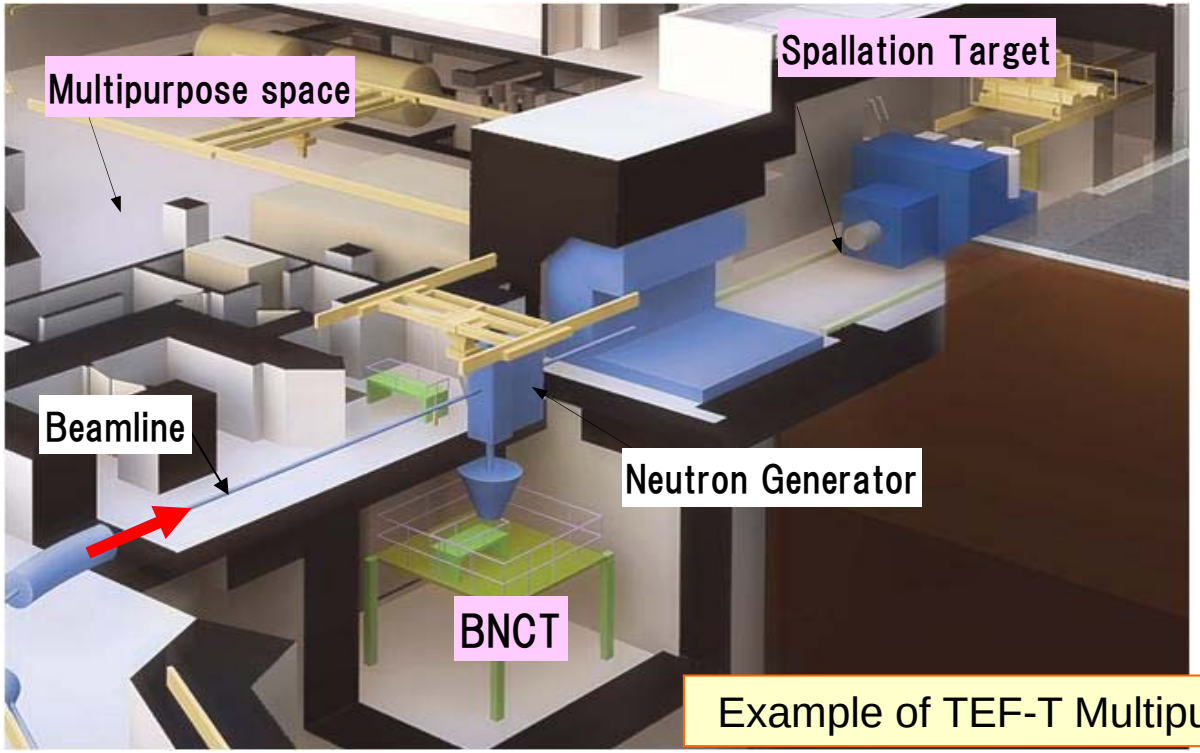
Sample Irradiation Amount



- Higher irradiation amount can be obtained by increasing beam density
- To simulate full scale ADS window, it requires 3-5 cycles of full power irradiation

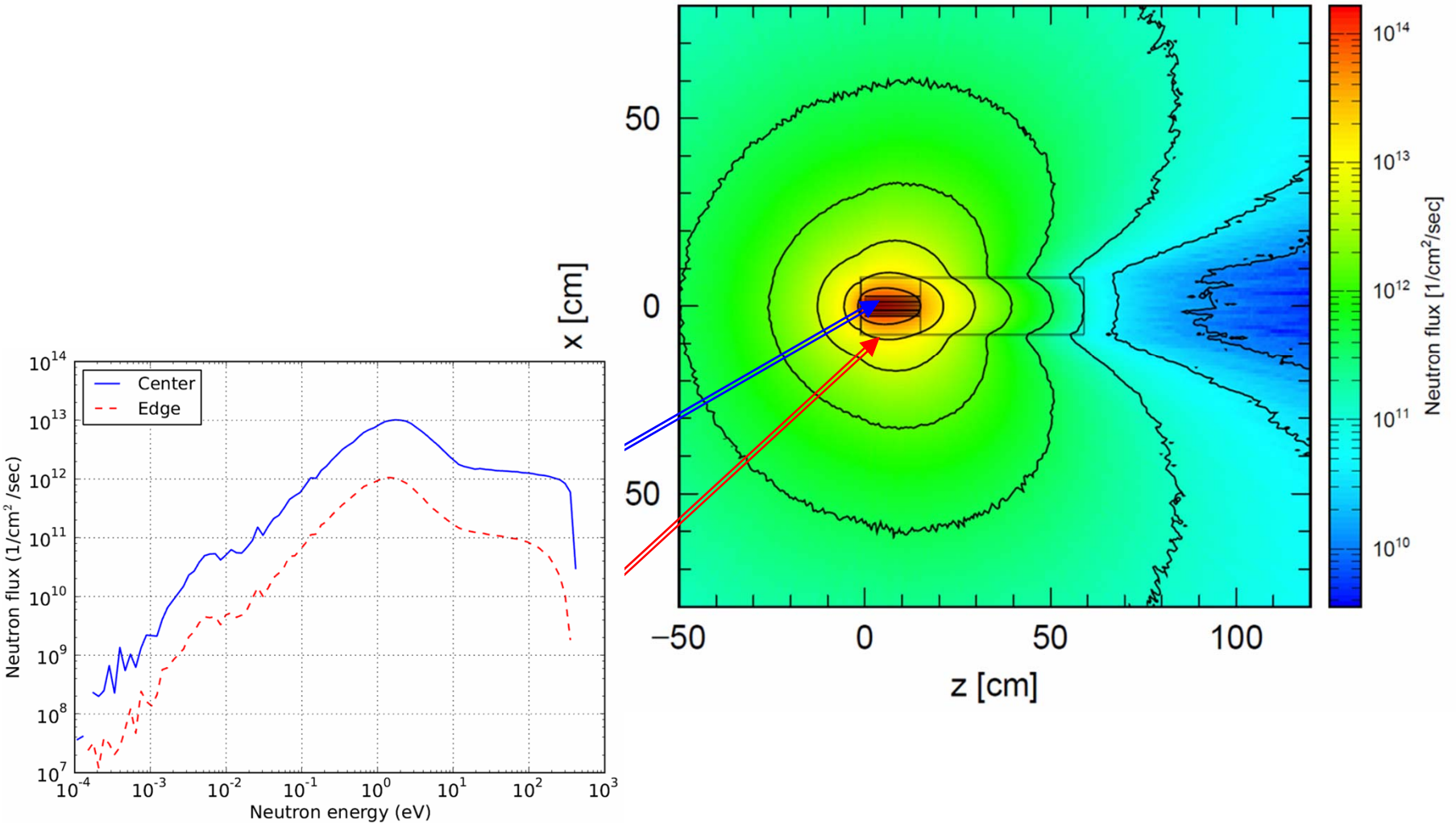
Multipurpose Utilization of TEF-T

- No proton/neutron irradiation fields exists in J-PARC
  - Material Irradiation ADS beam window
  - RI production Stable Supply for Medical/Industrial Use
  - Advanced Physics Ultra-cold Neutron, Short-lived nuclei beam



Example of TEF-T Multipurpose Use

Neutron Field around Target



- 10^{13} of fast neutrons【1-10% of JOYO(100MW$_{th}$) reactor】

Workshop for Multipurpose Use of TEF-T

- First workshop for multipurpose use of TEF-T has been held at 18th March, 2013
- About 90 persons from Research Institutes, Universities and Companies were gathered
- Agreed to launch user community for TEF

Summary

Transmutation Experimental Facility

- Facilities for structural material irradiation (TEF-T, 400MeV-250kW$_b$) and reactor physics (TEF-P 400MeV-10W$_b$)
- Construction Schedule
  - Larger-scale R&D will be planned to start in 2013
  - TEF-T will be built first and TEF-P will be constructed afterword
  - Licensing procedures for TEF-P construction will be processed simultaneously with TEF-T construction

Activities for TEF construction

- Two buildings for reactor and target will be constructed
- Low power beam extraction mechanism will also installed
- Cooperative work with Accelerator team, Mercury target team, Radiation Safety team and Building construction division
- Spallation Target design and analysis

User Application

- J-PARC user's committee
  - Proposals to use TEF-T as a multipurpose proton/neutron source
  - Around 10^{13} n/cm^2/s Fast Neutron Irradiation Field
  - Multipurpose proton beam line is now under discussion