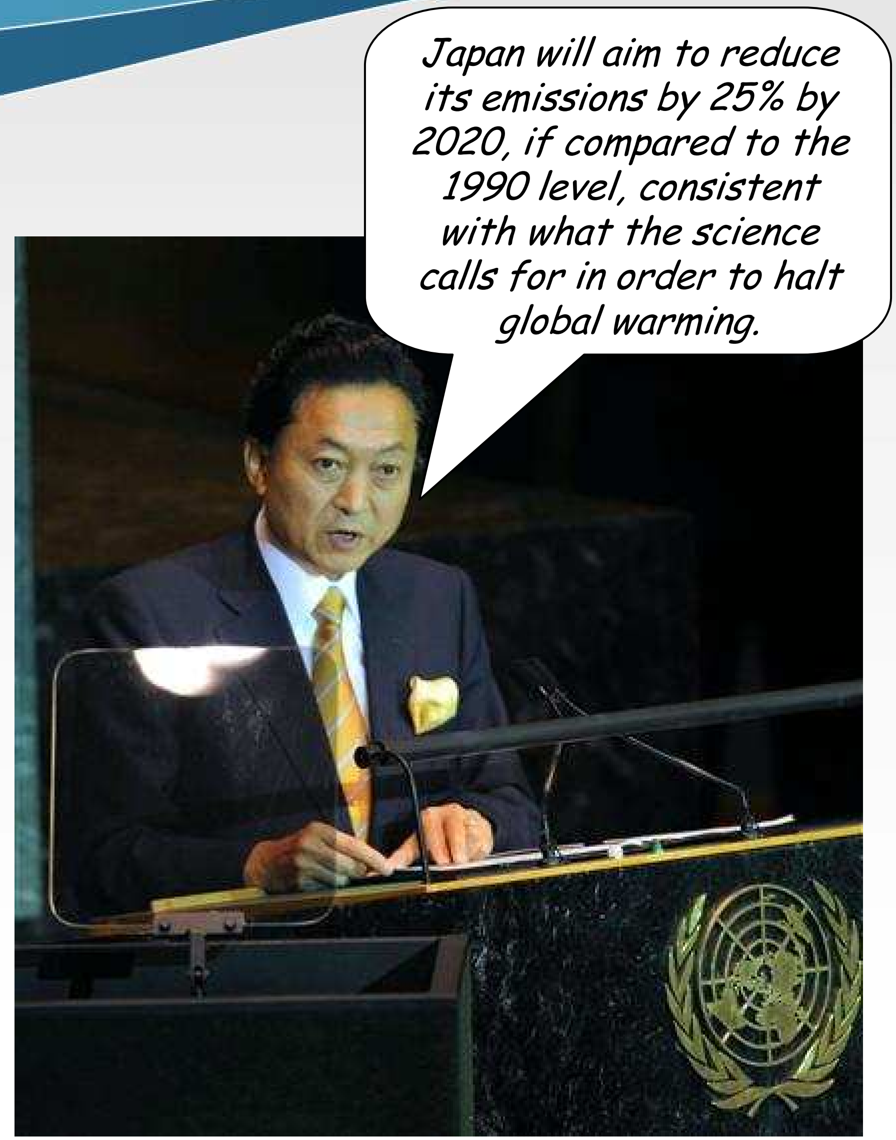
Japan ADS Program

Toshinobu Sasa

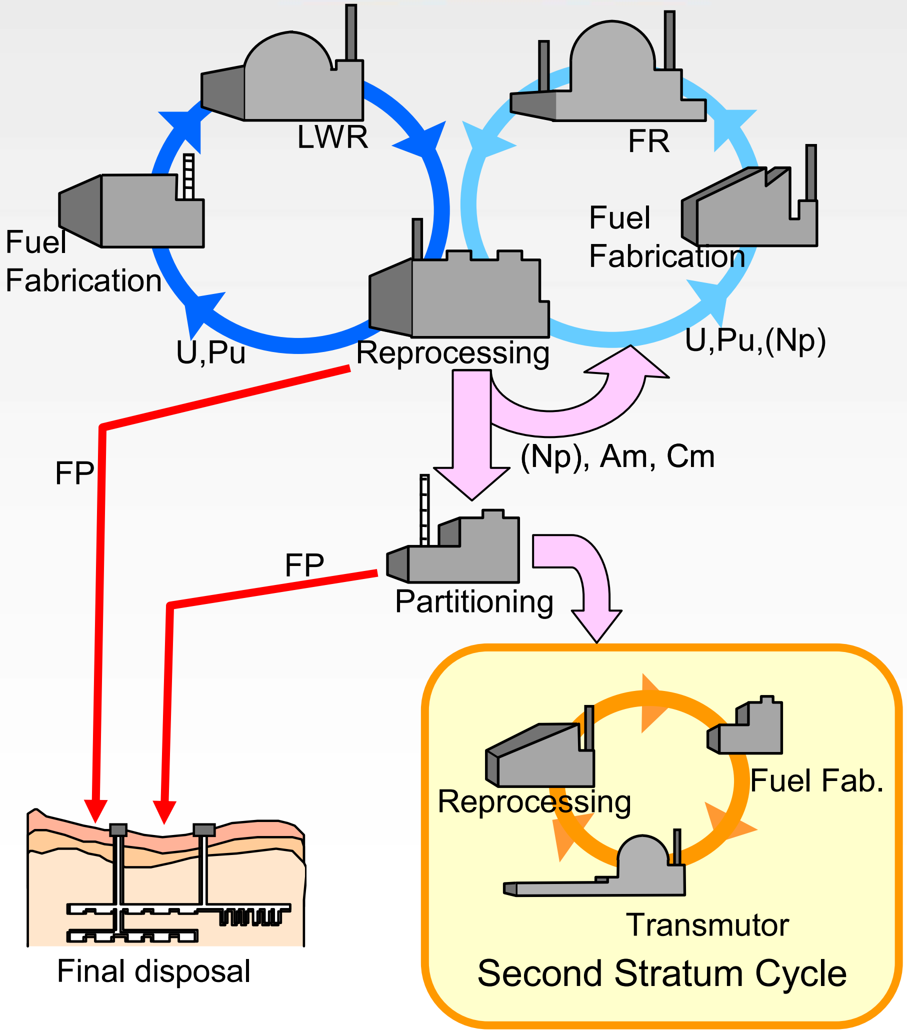
J-PARC Center, Japan Atomic Energy Agency

Waste Management and P-T

- New “Hatoyama” administration proposes 25% of Green House Gas reduction
- At this point of view, nuclear power is indispensable
- One of the important issue of sustainable nuclear power generation is waste management
- Waste management is also important to match nuclear power to CDM
- It is necessary to proceed rational disposal scenario including reprocessing by national effort

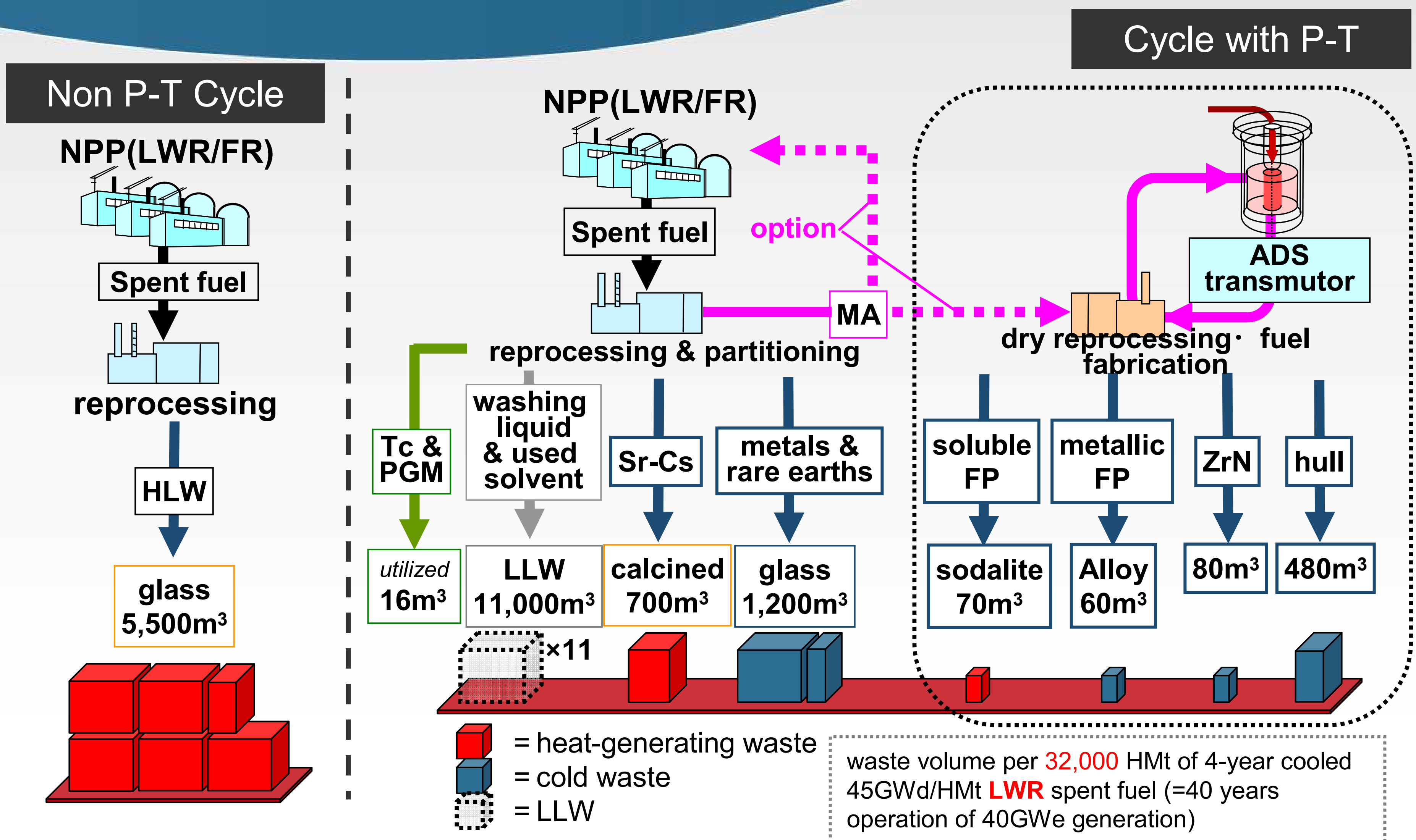


Fuel Cycle with Minor Actinides
- Homogeneous / Heterogeneous / Dedicated -



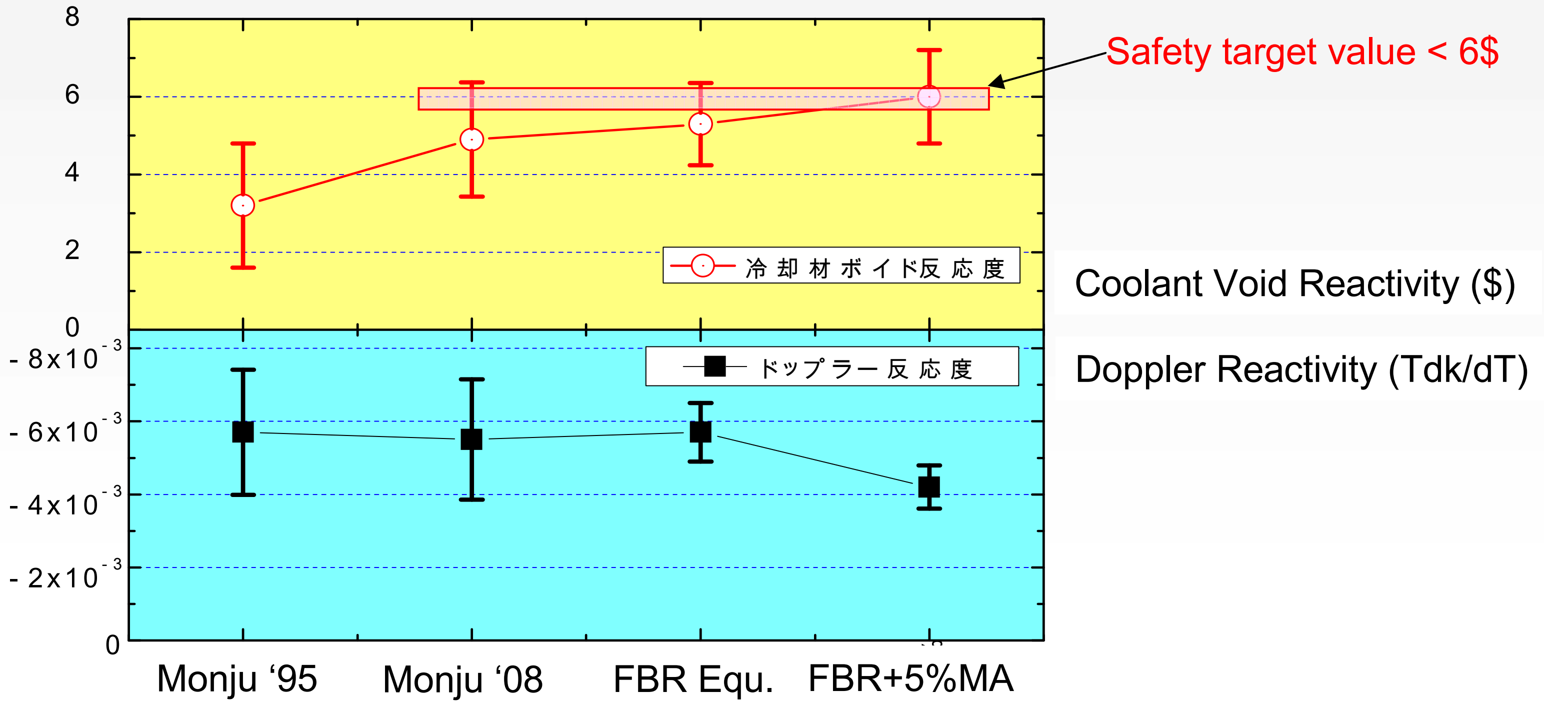
- Management of HLW
  - Key for sustainable energy
  - MA and Specific FP are important
- Different MA management methods
  - Homogeneous recycle to all FR
  - Heterogeneous recycle to selected FR
- Partitioning-Transmutation
  - Dedicated cycle (Double-strata)
  - Receptive to upper cycle condition
    - Needs of electricity
    - Transition term from LWR to FR
    - Installation by economical requirements
  - Separate harmful materials
  - Optimized cycle for transmutation

Wastes from P-T cycle



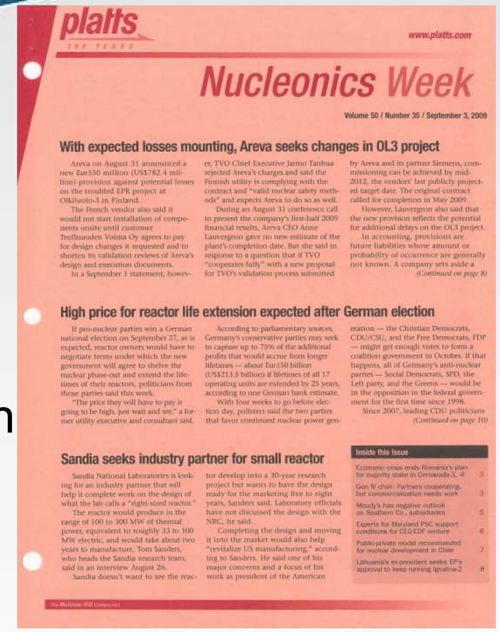
MA Transmutation by power reactor (1)

- Transmutation by power reactor have some difficulties
  - Safety review of FBR "Monju" gives serious increase of coolant void reactivity.



MA Transmutation by power reactor (2)

- Dr. Bouchard (GEN-IV Chair) said how to fabricate MA-spiked fuel is not simple and has to be done remotely, as does reprocessing. He also express concern that SFR technology, including safety and nonproliferation measures will prove difficult to deploy at a reasonable cost (even in non MA-spiked fuel).
  Nucleonics Week Vol.50, No.35 (Sep. 3, 2009)



platts

www.platts.com

Nucleonics Week

Volume 50 / Number 35 / September 3, 2009

With expected losses mounting, Areva seeks changes in OL3 project

Areva on August 31 announced a new Eur550 million (US$782.4 million) provision against potential losses on the troubled EPR project at Olkiluoto-3 in Finland.

The French vendor also said it would not start installation of components onsite until customer Teollisuuden Voima Oy agrees to pay for design changes it requested and to shorten its validation reviews of Areva's design and execution documents.

In a September 1 statement, however, TVO Chief Executive Jarmo Tanhua rejected Areva's charges and said the Finnish utility is complying with the contract and "valid nuclear safety methods" and expects Areva to do so as well.

During an August 31 conference call to present the company's first-half 2009 financial results, Areva CEO Anne Lauvergeon gave no new estimate of the plant's completion date. But she said in response to a question that if TVO "cooperates fully" with a new proposal for TVO's validation process submitted by Areva and its partner Siemens, commissioning can be achieved by mid-2012, the vendors' last publicly projected target date. The original contract called for completion in May 2009.

However, Lauvergeon also said that the new provision reflects the potential for additional delays on the OL3 project.

In accounting, provisions are future liabilities whose amount or probability of occurrence are generally not known. A company sets aside a

(Continued on page 8)

High price for reactor life extension expected after German election

If pro-nuclear parties win a German national election on September 27, as is expected, reactor owners would have to negotiate terms under which the new government will agree to shelve the nuclear phase-out and extend the lifetimes of their reactors, politicians from those parties said this week.

"The price they will have to pay is going to be high, just wait and see," a former utility executive and consultant said.

According to parliamentary sources, Germany's conservative parties may seek to capture up to 75% of the additional profits that would accrue from longer lifetimes — about Eur150 billion (US$213.5 billion) if lifetimes of all 17 operating units are extended by 25 years, according to one German bank estimate.

With four weeks to go before election day, pollsters said the two parties that favor continued nuclear power generation — the Christian Democrats, CDU/CSU, and the Free Democrats, FDP — might get enough votes to form a coalition government in October. If that happens, all of Germany's anti-nuclear parties — Social Democrats, SPD, the Left party, and the Greens — would be in the opposition in the federal government for the first time since 1998.

Since 2007, leading CDU politicians

(Continued on page 10)

Sandia seeks industry partner for small reactor

Sandia National Laboratories is looking for an industry partner that will help it complete work on the design of what the lab calls a "right-sized reactor."

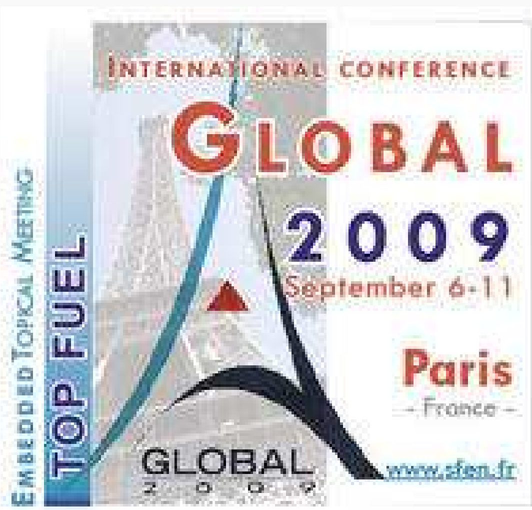
The reactor would produce in the range of 100 to 300 MW of thermal power, equivalent to roughly 33 to 100 MW electric, and would take about two years to manufacture, Tom Sanders, who heads the Sandia research team, said in an interview August 26.

Sandia doesn't want to see the reactor develop into a 30-year research project but wants to have the design ready for the marketing five to eight years, Sanders said. Laboratory officials have not discussed the design with the NRC, he said.

Completing the design and moving it into the market would also help "revitalize US manufacturing," according to Sanders. He said one of his major concerns and a focus of his work as president of the American

Inside this Issue

The McGraw-Hill Companies



- From EDF's point of view, a partial recycling of MAs in heterogeneous blankets may then be adopted if it is feasible and if technological and economic advantages outweigh possible drawbacks. Heat load and the associated activity from glass canisters will have to be managed in the fast reactor themselves, the reprocessing plants, the fabrication plants, the reactor fuel handling sections, the transport casks and interfaces.
  - N. Camarcat et al., Global'09, Paper 9079

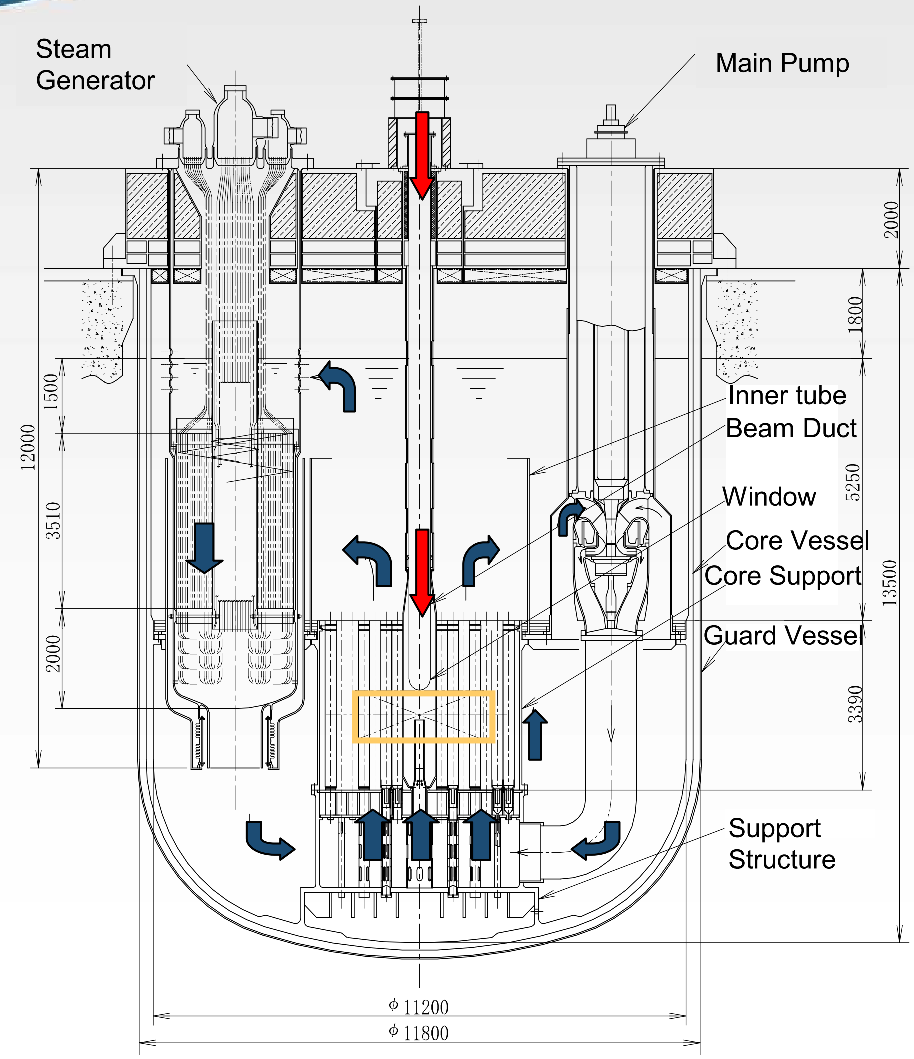
J-PARC JAEA

Transmutation by ADS
- 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 : 1000mm
- 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



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R&D Issues of ADS

J-PARC Project
SC-LINAC Development

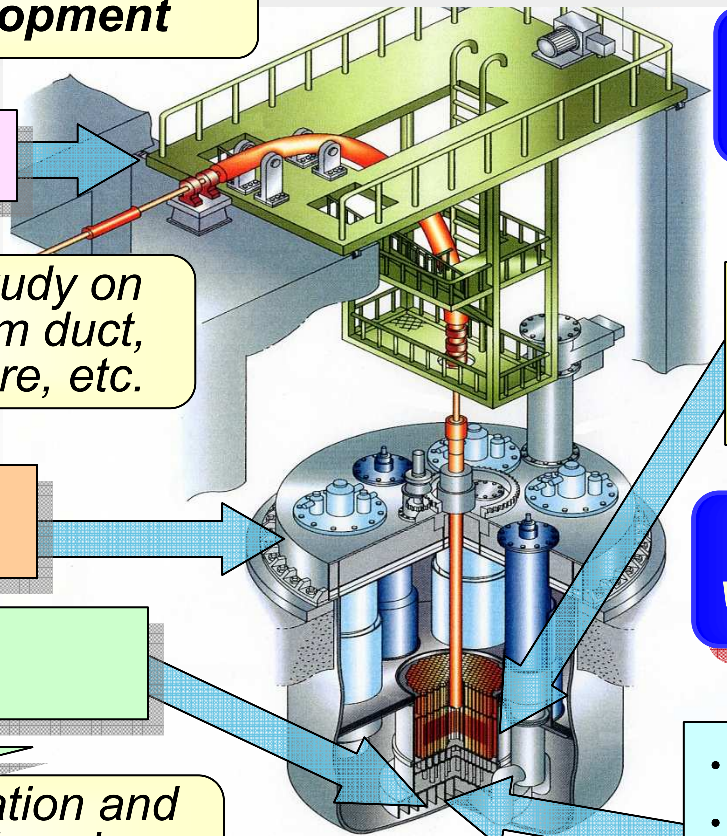
- **Accelerator**

Analytical design study on reactor vessel, beam duct, quake-proof structure, etc.

- **Structure**

- **Fuel**

Fabrication, irradiation and reprocessing tests using existing facilities



Low power proton beam with nuclear fuel : TEF-P

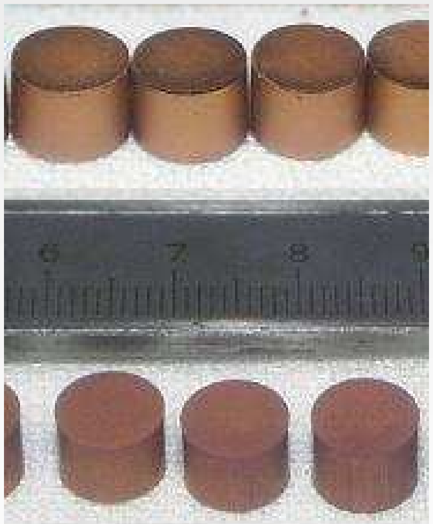
- **Reactor Physics**
- **Subcritical System Control**

High power proton beam without nuclear fuel : TEF-T

- **Spallation Target, Material**
- **Operation of Pb-Bi system**

Irradiation Test of U-free Nitride in JMTR

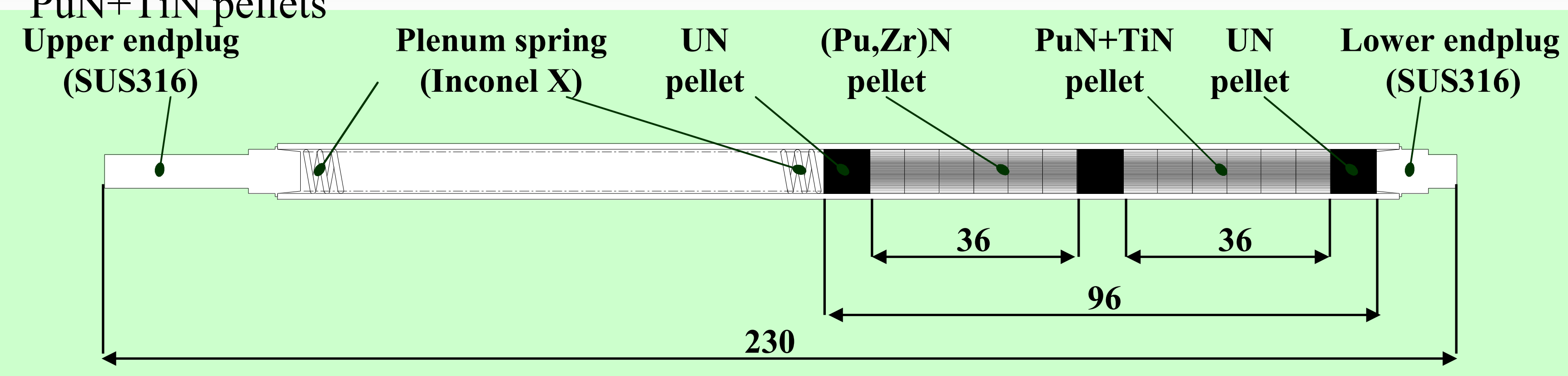
(Pu,Zr)N pellets



PuN+TiN pellets

	(Pu,Zr)N	PuN+TiN
Irradiation period	May 2002 ~ Nov. 2004 (246 EFPD)	
Av. linear power	408 W/cm	355 W/cm
Burnup	14.7 at%-Pu	17.0 at%-Pu
Max. fuel Temp. (Estimation)	1273 K	1083 K
Cladding tube	SUS316, 9.40 mm∅, 0.51 mmt	

PIEs have been completed in JAEA's hot cells.



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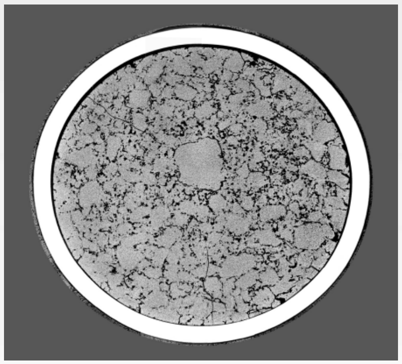
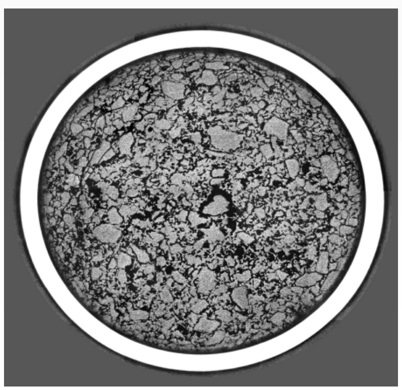
Results of PIEs for U-free Nitride

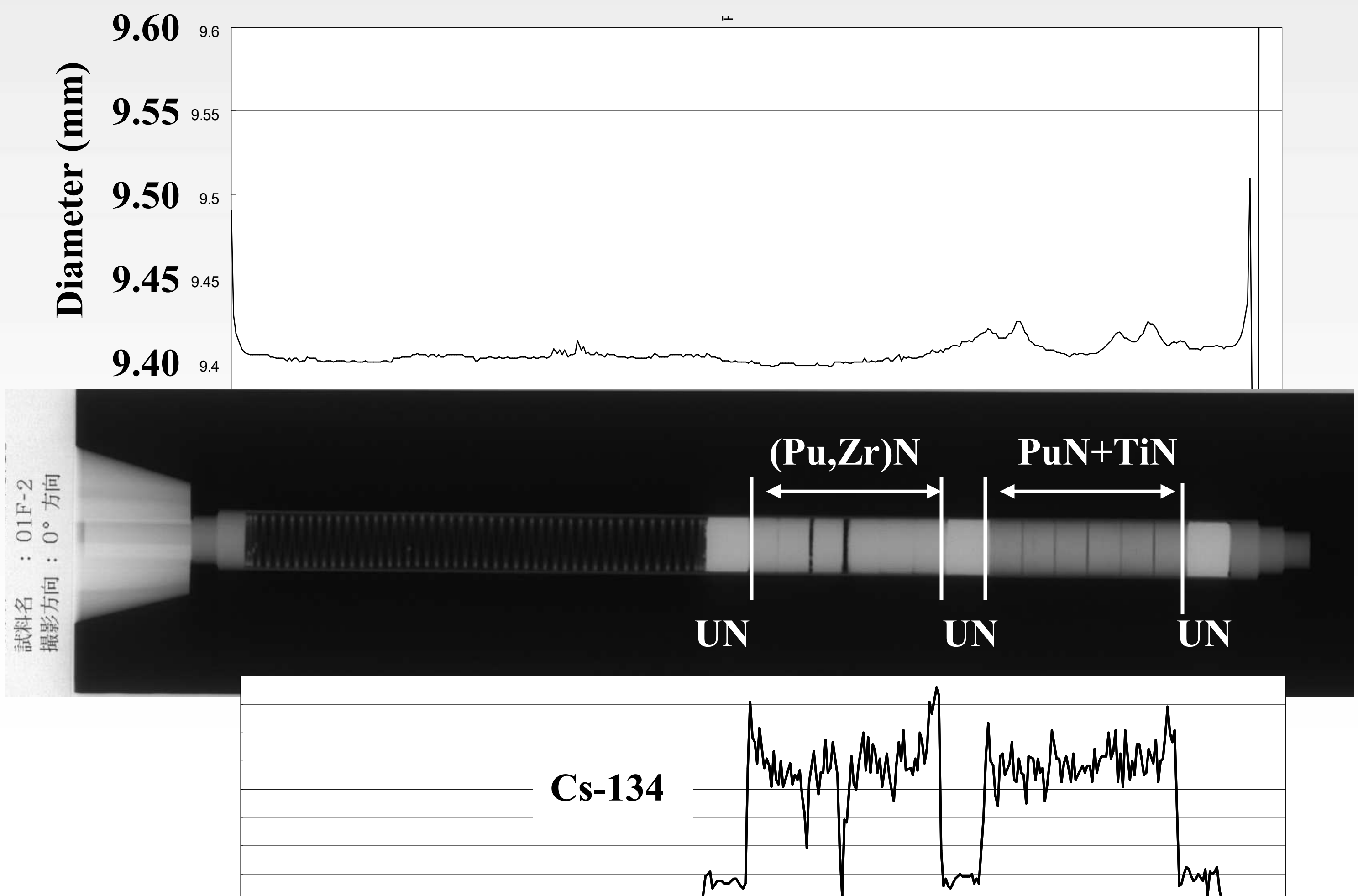
- Cross sections, profilometry, X-ray radiography and gamma scanning-



(Pu,Zr)N

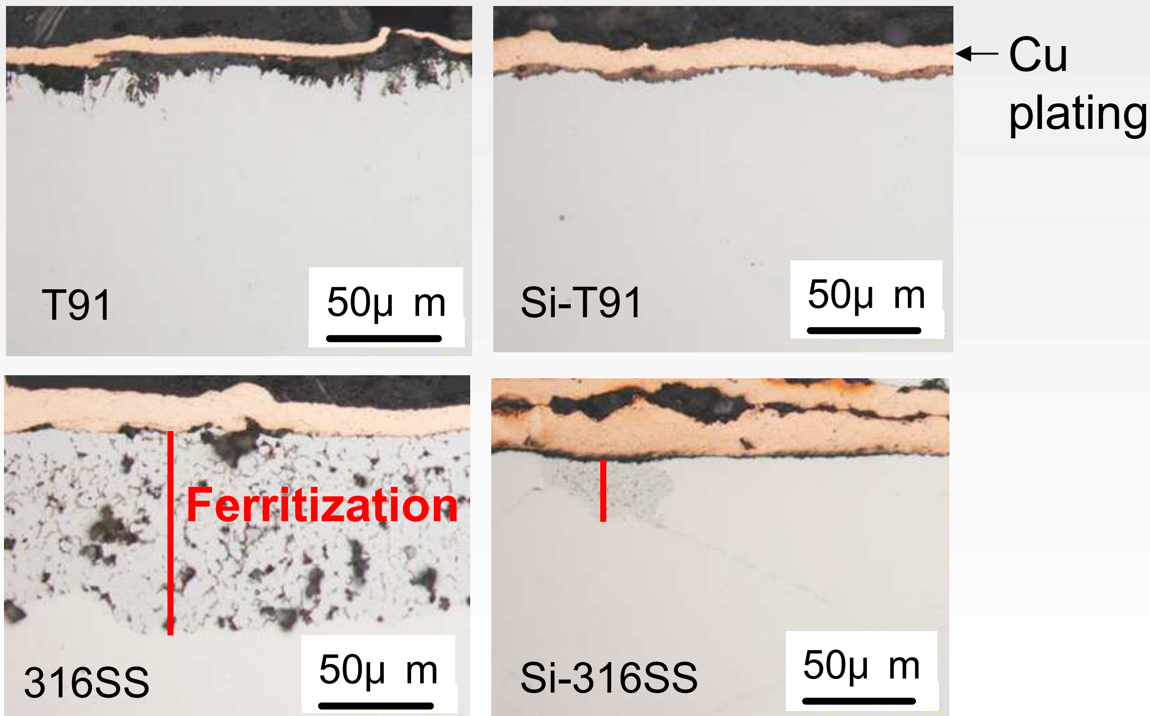


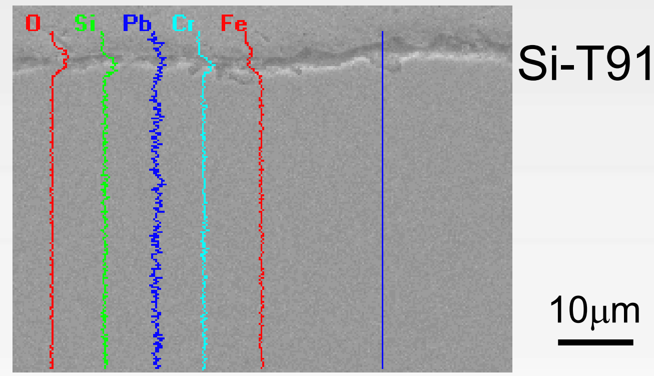
PuN+TiN

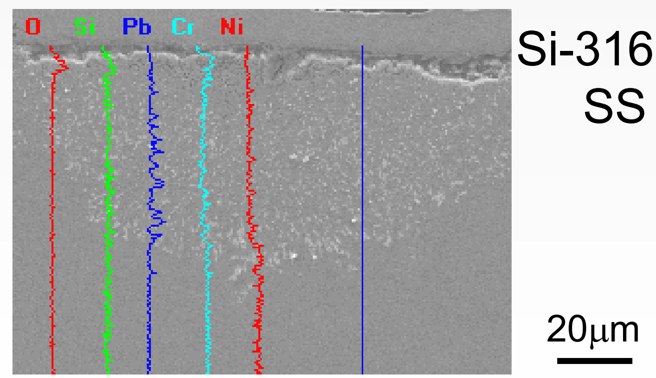


Effect to develop Si-enriched steels
- Si-T91 and Si-316SS -

Materials: T91(Mod.9Cr-1Mo steel), Si-enriched T91(1.5%Si)
316SS, Si-enrichd 316SS(2.5%Si)
Static Corrosion Test in LBE (oxygen-saturated) at 550 °C for 3000h







- ❑**Si addition to T91 → Thin oxide film including Si and Cr(and Fe)**
- ❑**Si addition to 316SS → Mitigation of ferritization (Ni dissolution) and LBE penetration, but not enough**

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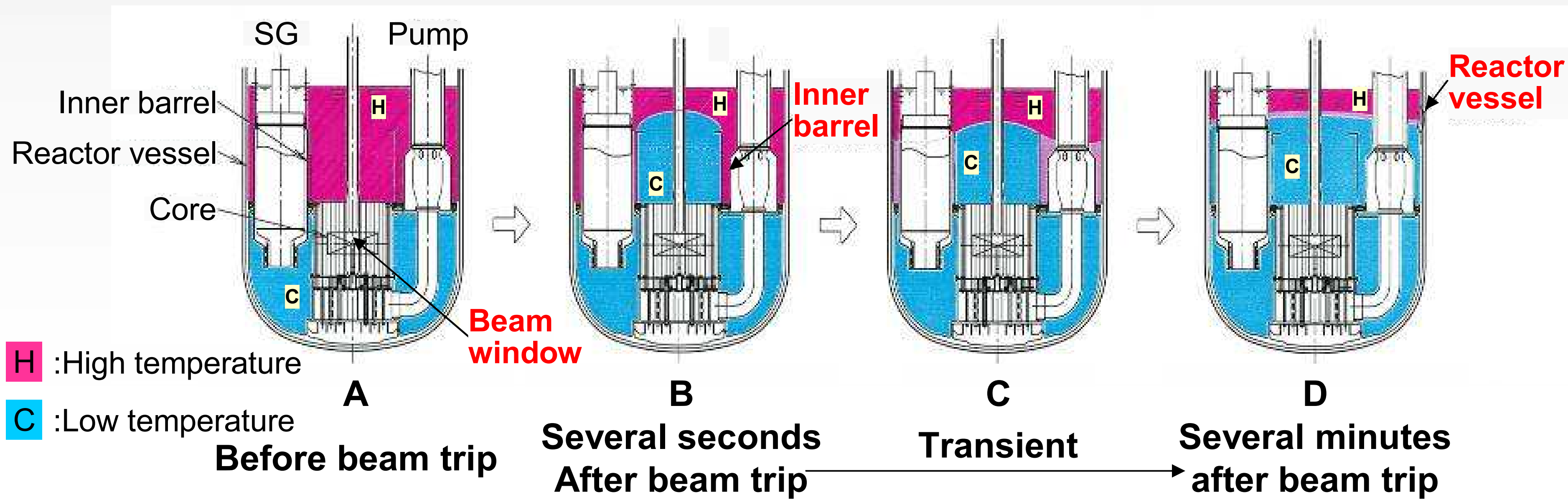
Reliability:
Acceptable Beam Trip Frequency

- **Thermal stress caused by beam trip** is estimated to know acceptable frequency of beam trip.
  - **Beam window**
  - **Inner barrel**
  - **Reactor vessel**
- The influence of the beam trip to the power generation system is also estimated.



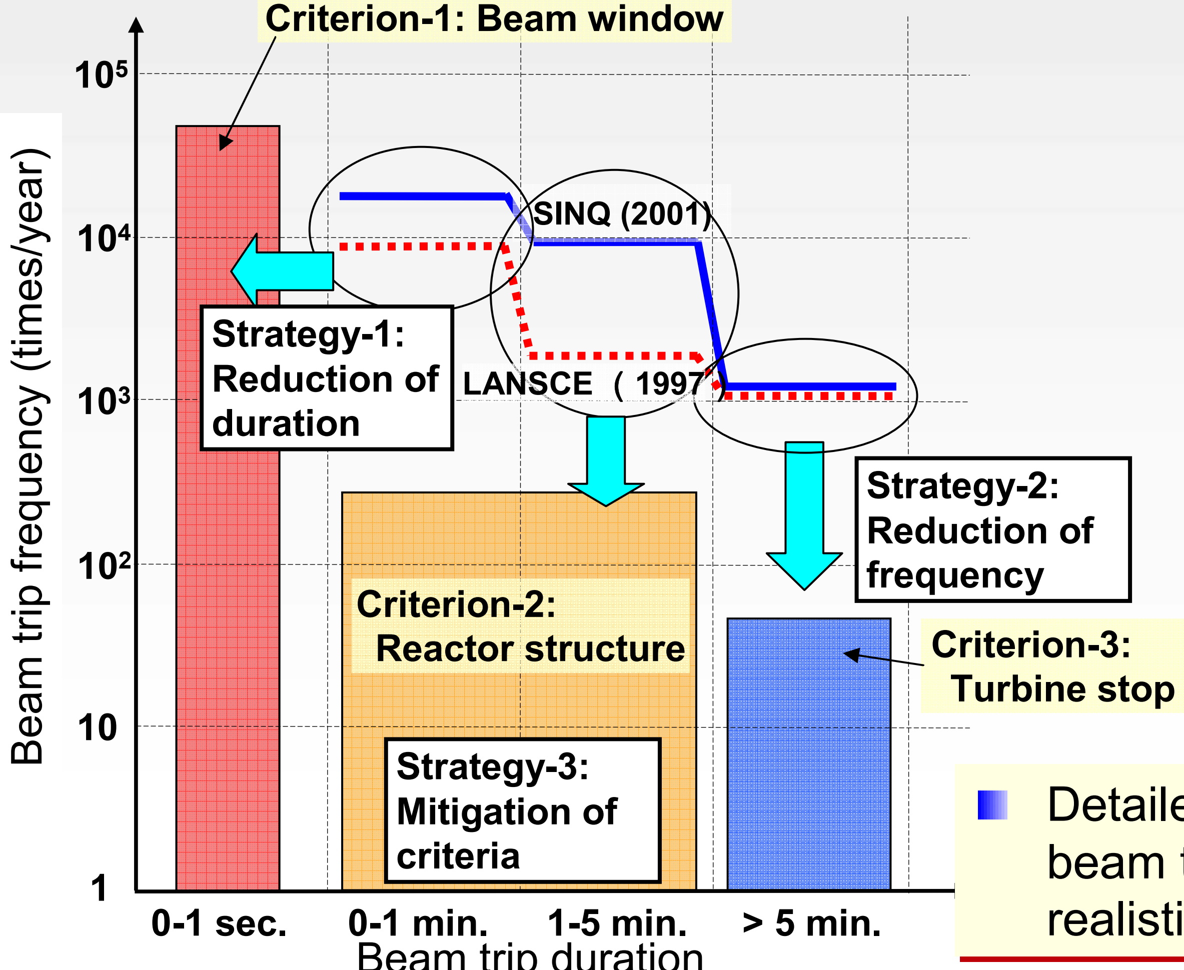
Reliability: Summary of Allowable Criteria

- Three criteria depending on the beam trip duration T

Beam trip duration *T*	Acceptable frequency	Remarks
T < 1 sec.	10^5 / 2 year (50,000 / y)	Beam window life time
1 sec. < *T* < 5 min.	10^4 / 40 year (250 /y)	Fatigue failure of reactor structure
T > 5 min.	Once a week (50 /y)	System availability

Reliability: Strategy to Reduce Beam Trip Frequency

- SINQ and LANSCE experiences show **1 or 2 orders** of frequency reduction might be necessary to meet the criteria



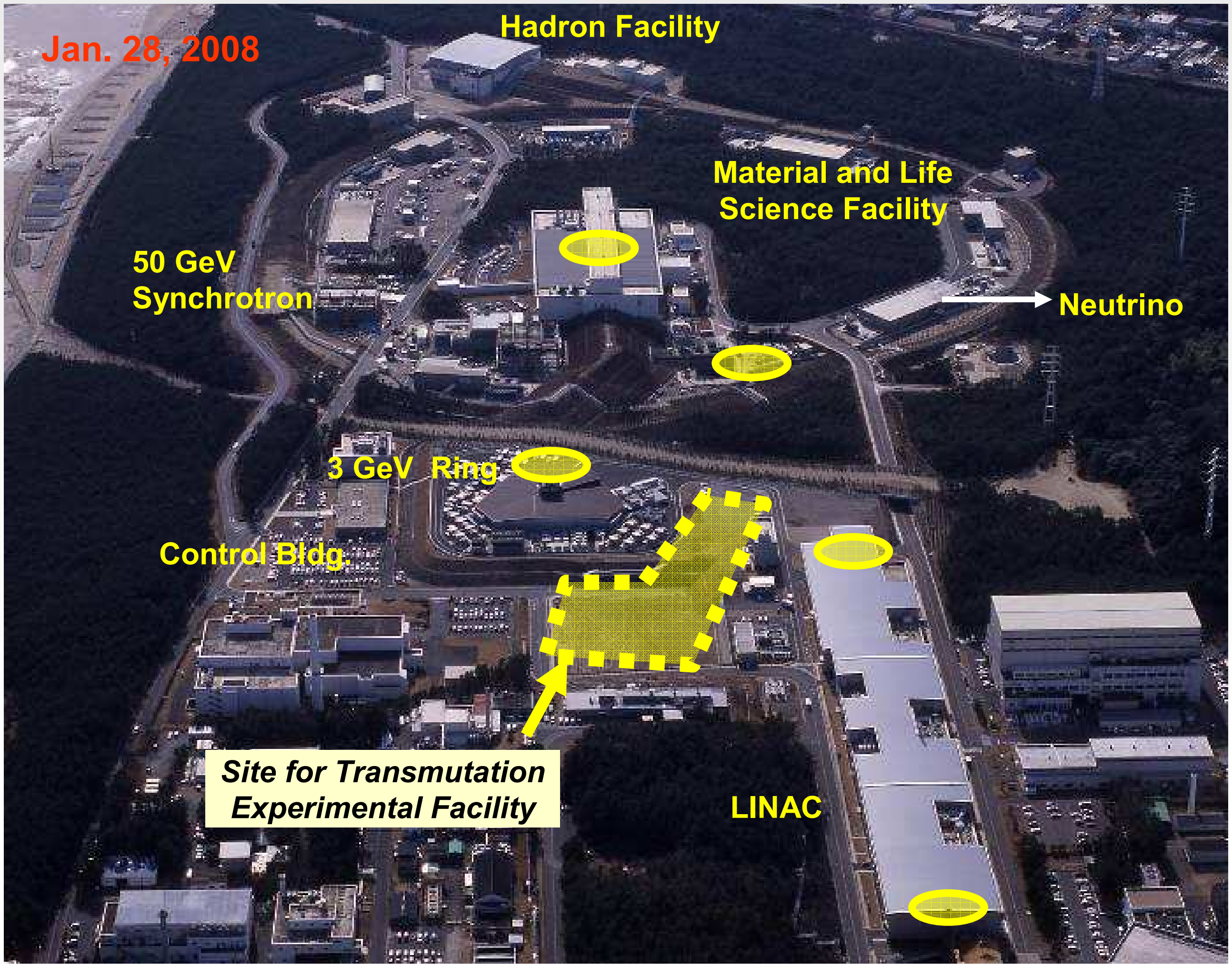
Three strategies for reduction:

1. Reduction of the beam trip **duration** down to 1 sec.
2. Reduction of **frequency** for relatively long beam trip
3. Mitigation of the **criteria** by design consideration and detailed transient analysis.

- Detailed analysis on the causes of the beam trips is underway to explore the realistic solutions for Strategy-1 and 2.

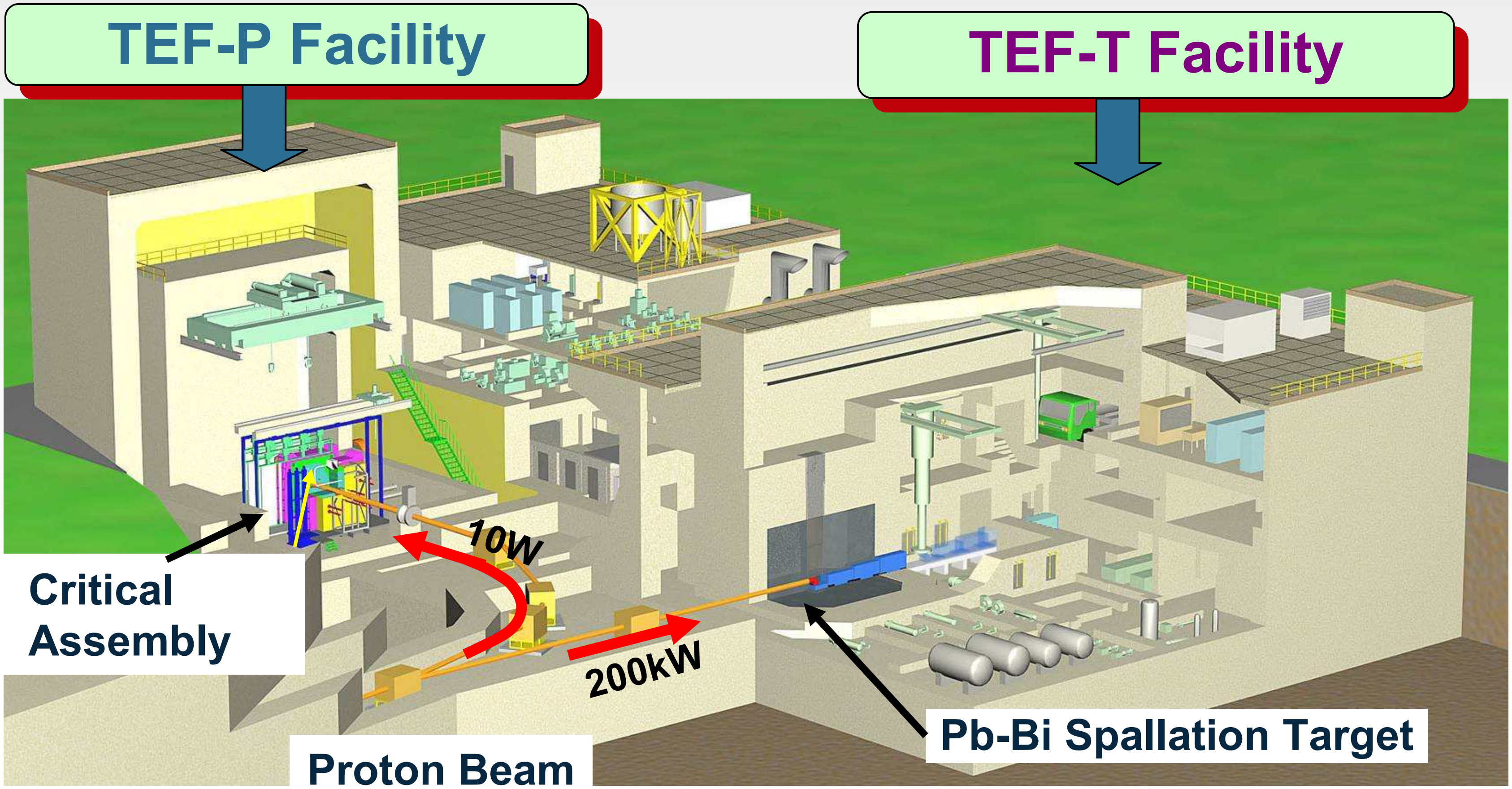
J-PARC JAEA

Current Status of J-PARC



- Start Construction
  - March, 2002
- Produce First Proton Beam
  - Nov. 22, 2006
- Accelerate proton to 181 MeV
  - Jan. 24, 2007
- Accelerate beam to 3 GeV
  - Oct. 31, 2007
- Inject beam to 50GeV ring
  - May 27, 2008
- Produce spallation neutron
  - May 30, 2008
- Open for public usage
  - Dec., 2008

Transmutation Experimental Facility - Initial Plan -



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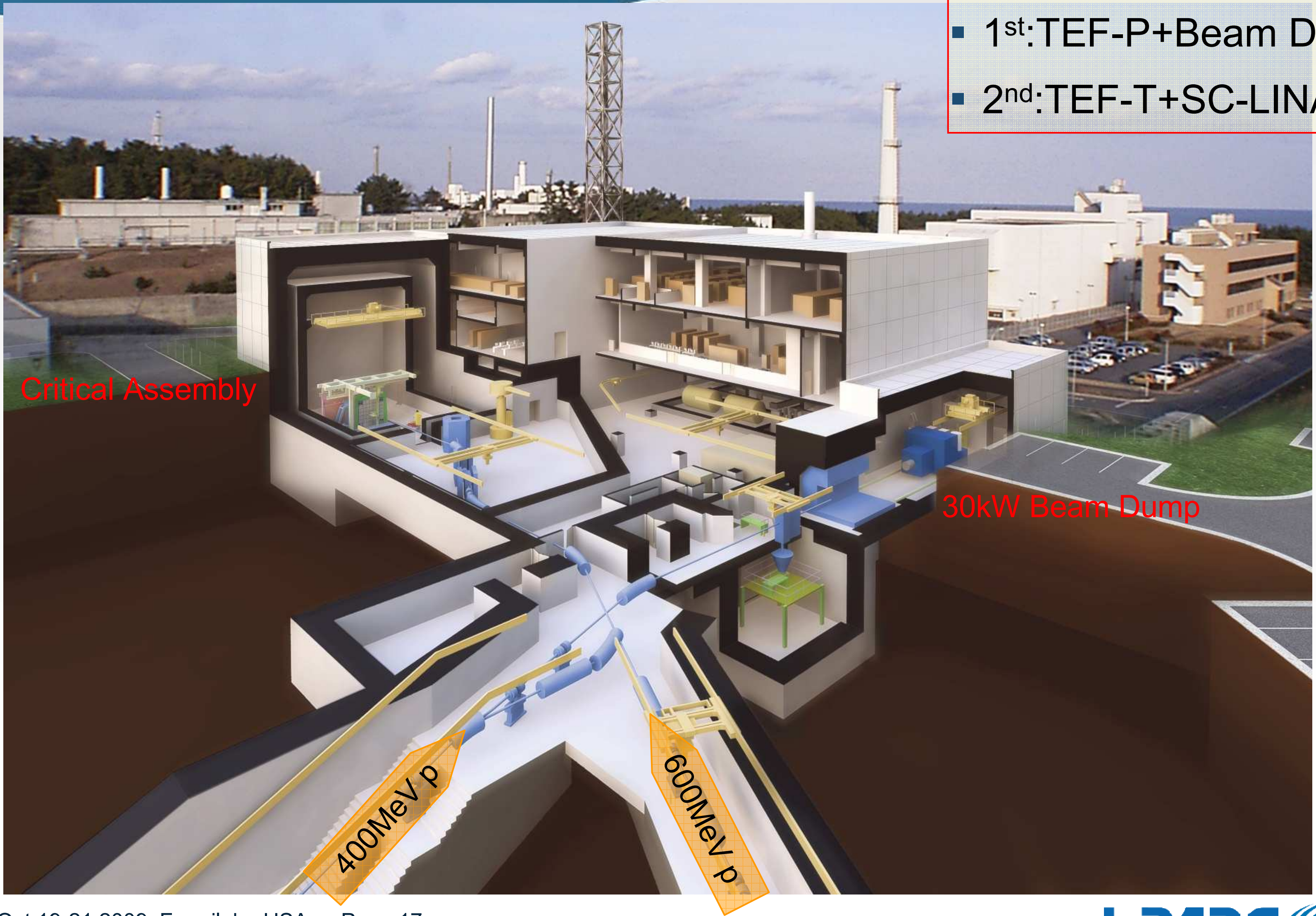
Facility Plan of TEF first phase (TEF-P)

2 phase construction

- 1^{st}:TEF-P+Beam Dump
- 2^{nd}:TEF-T+SC-LINAC



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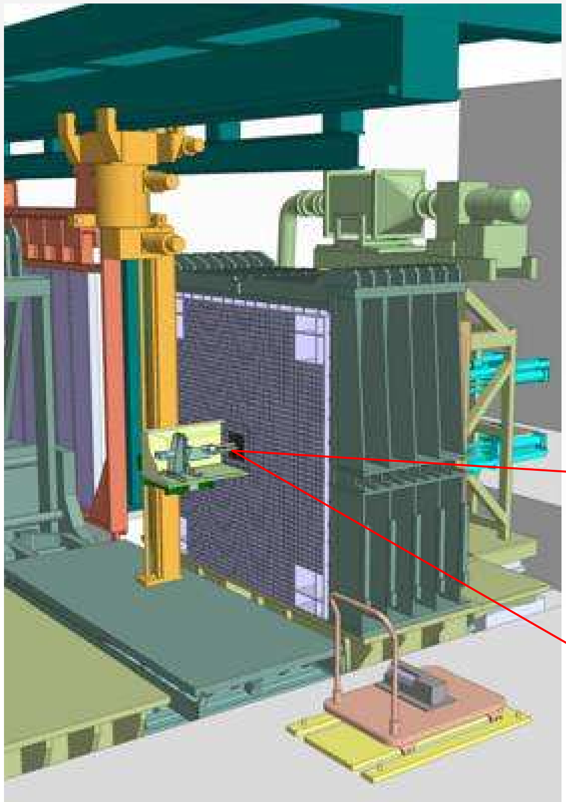
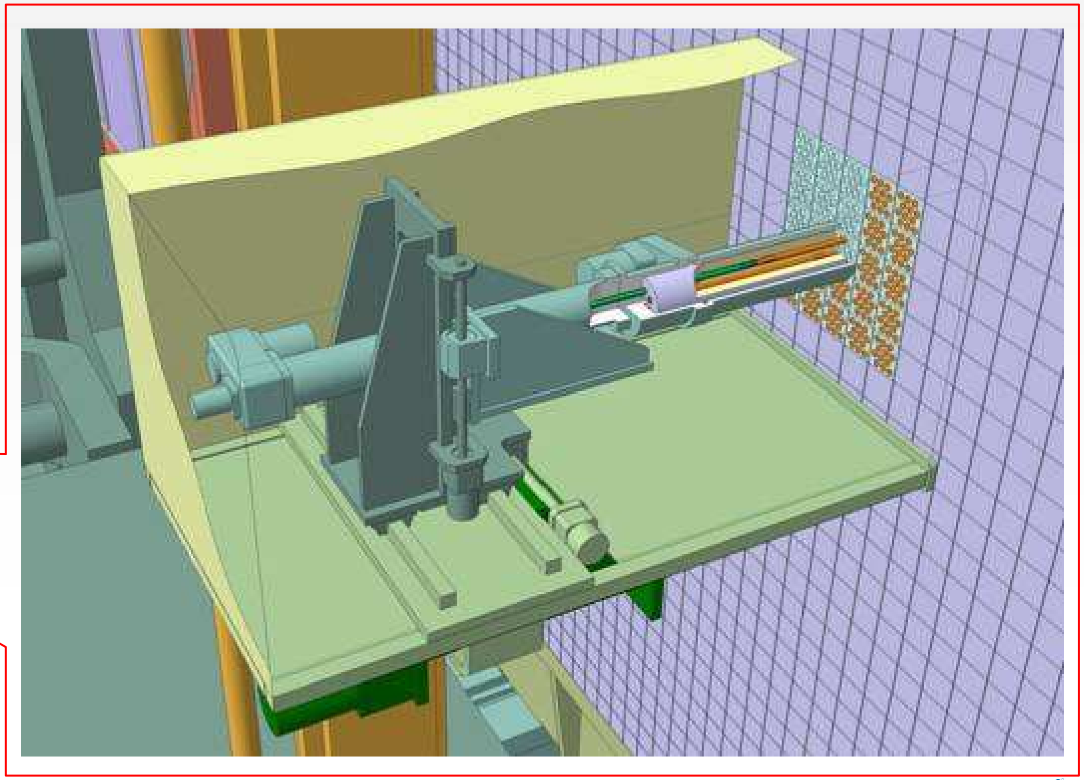
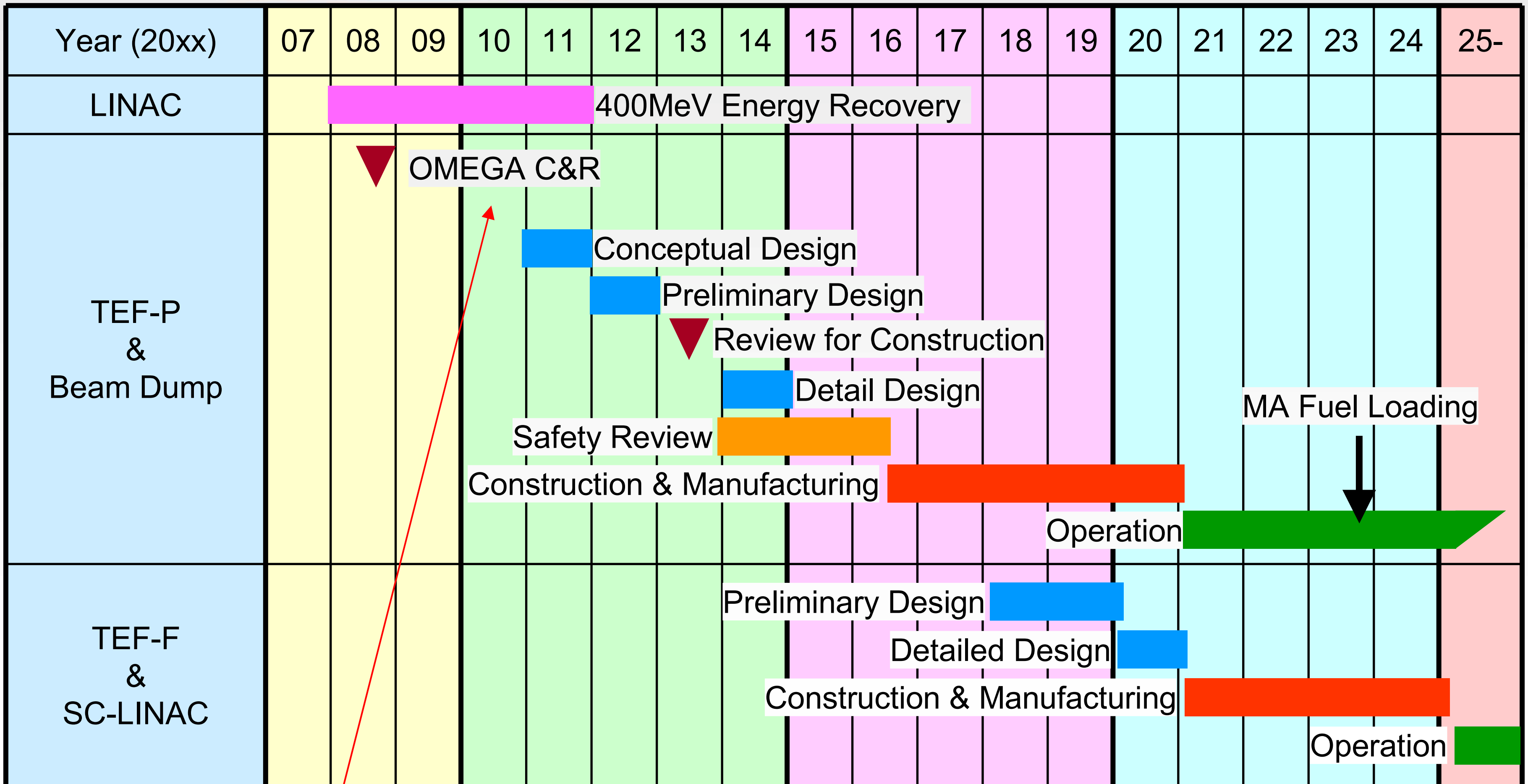
Application of MA-bearing Fuel in TEF-P

- MA-fuel is stored in cylindrical cartridge to prevent gamma and neutron exposure and critical accident
- Requires remote handling device to storage/transport/loading of MA fuel
- Constant Air-conditioning is required for MA storage and fuel loading zone





Schedule for J-PARC 2nd Phase
- Considering National C&R of P-T -



Blank between C&R and Design caused by the term of JAEA Mid-term Plan

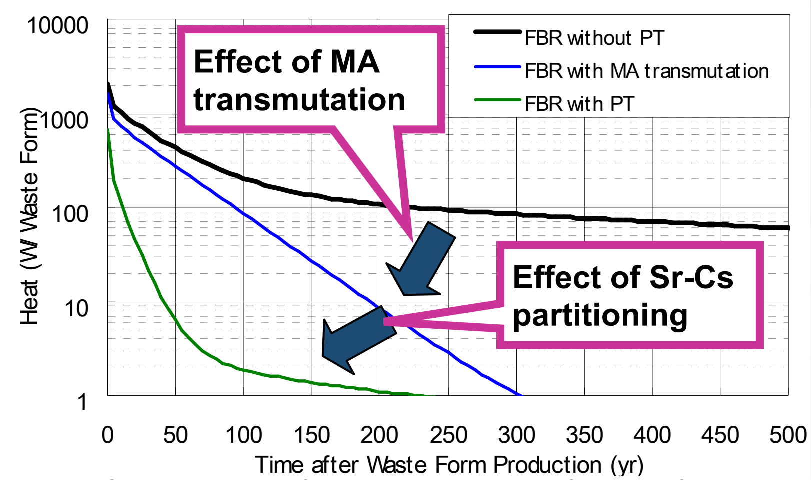
J-PARC JAEA

National Check and Review of P-T
- Purpose and committee member -

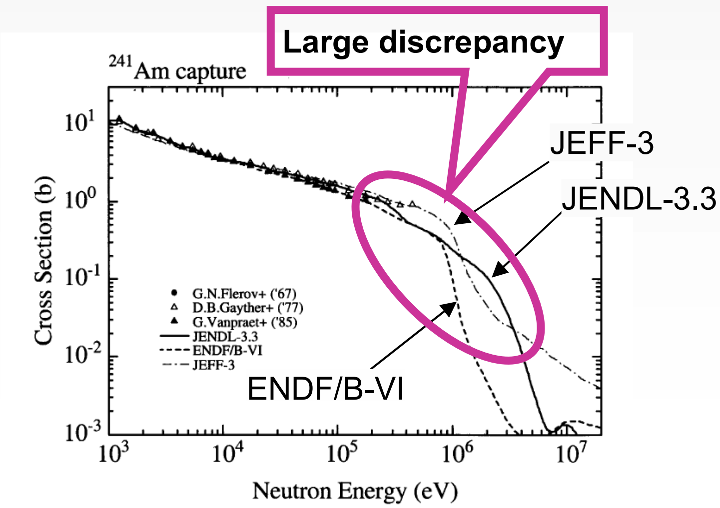
- Purpose
  - Organize current state of the art concerning P-T technology in Japan
  - Analyze the effectiveness and significance of P-T
  - Examine how to advance future R&D
- Committee member
  - Hajimu Yamana, Professor of KURRI, Chair
  - Shinsuke Yamanaka, Professor of Osaka Univ.
  - Tomio Kawada, Director of Nuclear Waste Management Organization of Japan (NUMO)
  - Shinya Nagasaki, Professor of Tokyo Univ.
  - Tetsuo Fukazawa, Hitachi-GE Nuclear Energy Corp.
  - Shigeyasu Yano, Director of Nishina Accelerator Research Center, RIKEN
  - Yoshihiro Yamane, Professor of Nagoya Univ.
  - Toshio Wakabayashi, Professor of Tohoku Univ.

Main Results of recent C&R

- Main Results
  - P&T technology has potential to reduce the radiotoxic inventory, to reduce the requirement for geological disposal, and to enhance design options of nuclear waste disposal system.
  - R&D on P&T should be linked strongly with that of FBR cycle for which the achievement of safety, economy, environmental-friendliness, saving resource, and non-proliferation is required.
  - The basic data to judge the feasibility of P&T are insufficient. It is, therefore, necessary to continue the accumulation of the basic data which are commonly utilized for both FBR and ADS.



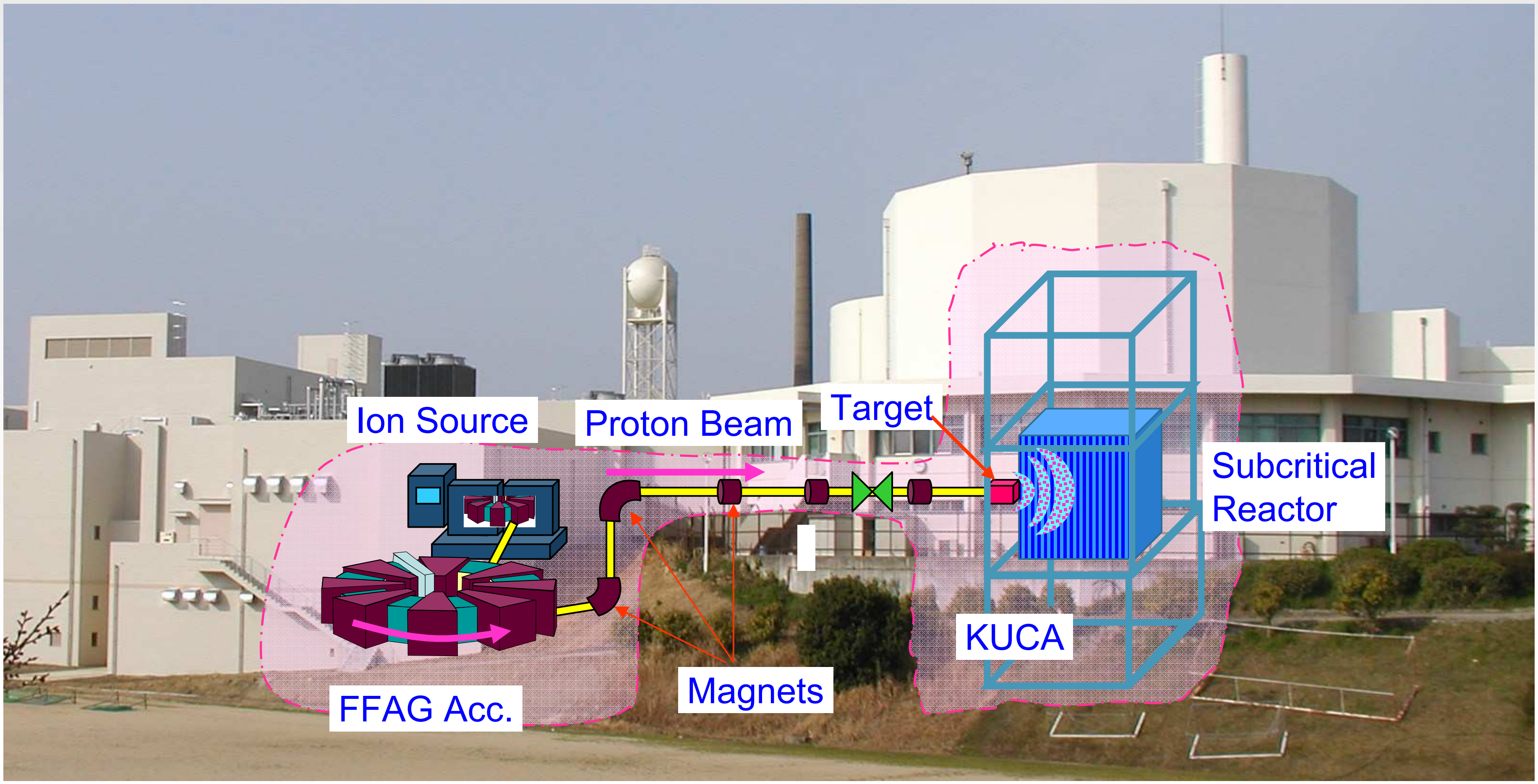
Comparison of heat generation of waste forms



Comparison of Am-241nuclear data

T. Nakagawa, et al, JAERI-Data/Code 2002-025

FFAG-KUCA Experimental Configuration



First injection of spallation neutrons

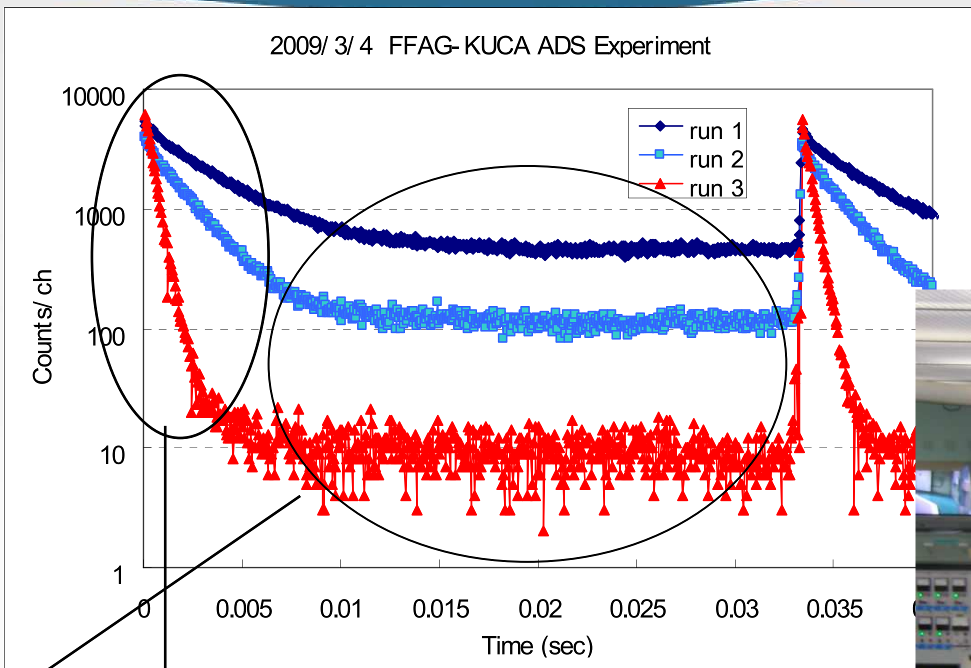


Fig. Time series of neutrons

Spallation neutrons from target

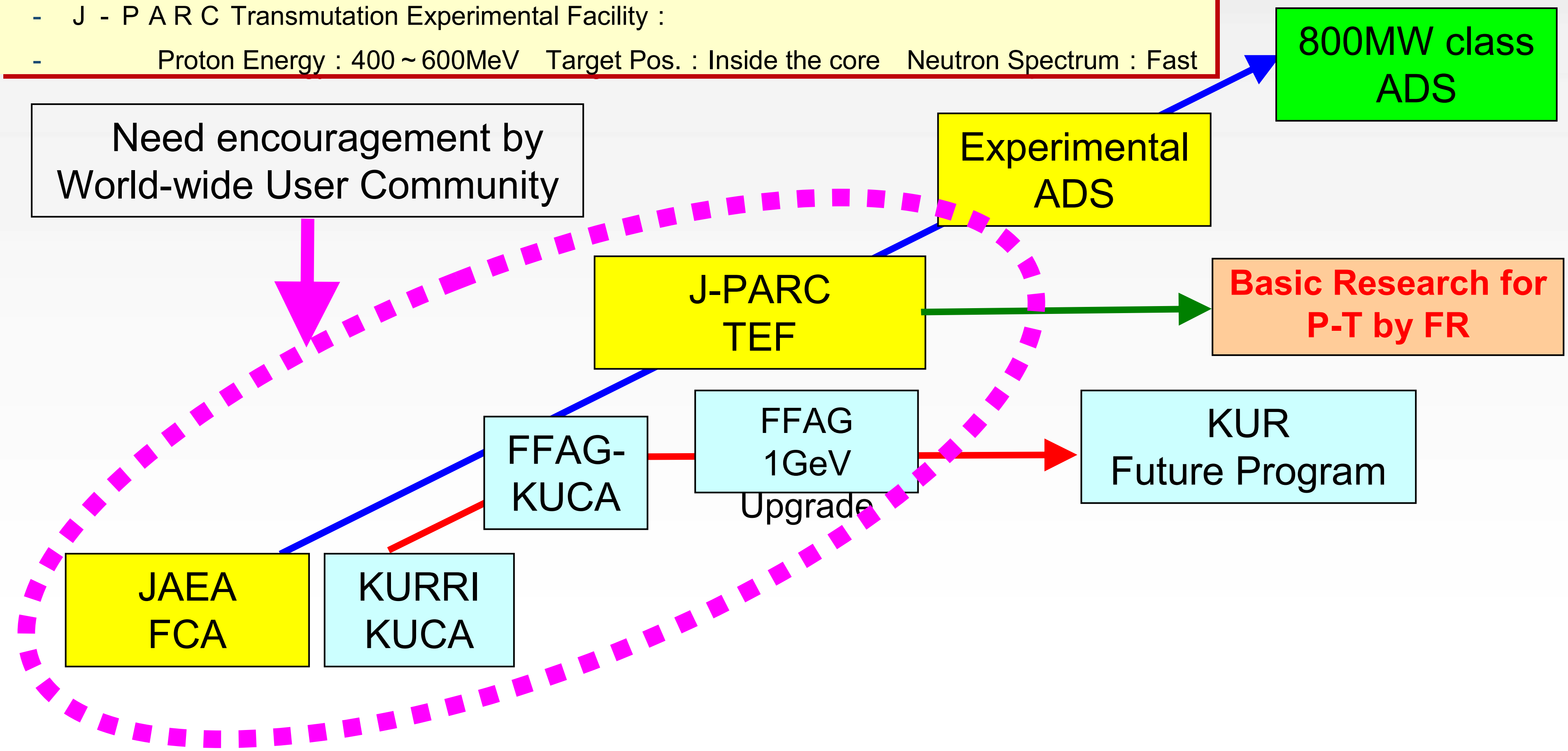
Delayed neutrons in core

<u>Neutron multiplication by spallation neutrons generated by protons</u>

J-PARC JAEA

Joint Roadmap of KART&LAB & J-PARC

- Joint Research Activities for Innovative Nuclear Systems
  - FFAG Accelerator (KURRI) :
  - Proton Energy : ~150MeV　Target Position : Outside the core　Neutron Spectrum : Thermal
  - J - P A R C Transmutation Experimental Facility :
  - Proton Energy : 400~600MeV　Target Pos. : Inside the core　Neutron Spectrum : Fast



Next generation critical assembly for innovative nuclear system studies

- Management of MA is indispensable to establish sustainable nuclear energy production
- MA fuel is difficult to handle in existing critical assembly facilities
  - Remote handling is requires to prevent high radioactivity of Am/Cm
  - Continuous heat removal devices for both core and storage
- Requires new critical assembly reflecting various innovative concepts
  - MA handling devices
  - Proton beam application
  - Keeping many knowledges for existing systems are also very important

Research Committee was launched by Atomic Energy Soceiety of Japan to discuss next generation facilities

J-PARC JAEA

Asia ADS Network Initiative

- Started from 2003 and held meetings annually
- Exchange R&D information for national programs, accelerator, neutronics, nuclear data, material issues including innovative HLM systems
- Next meeting will be held at J-PARC on this Dec. with participants from China, Korea and India

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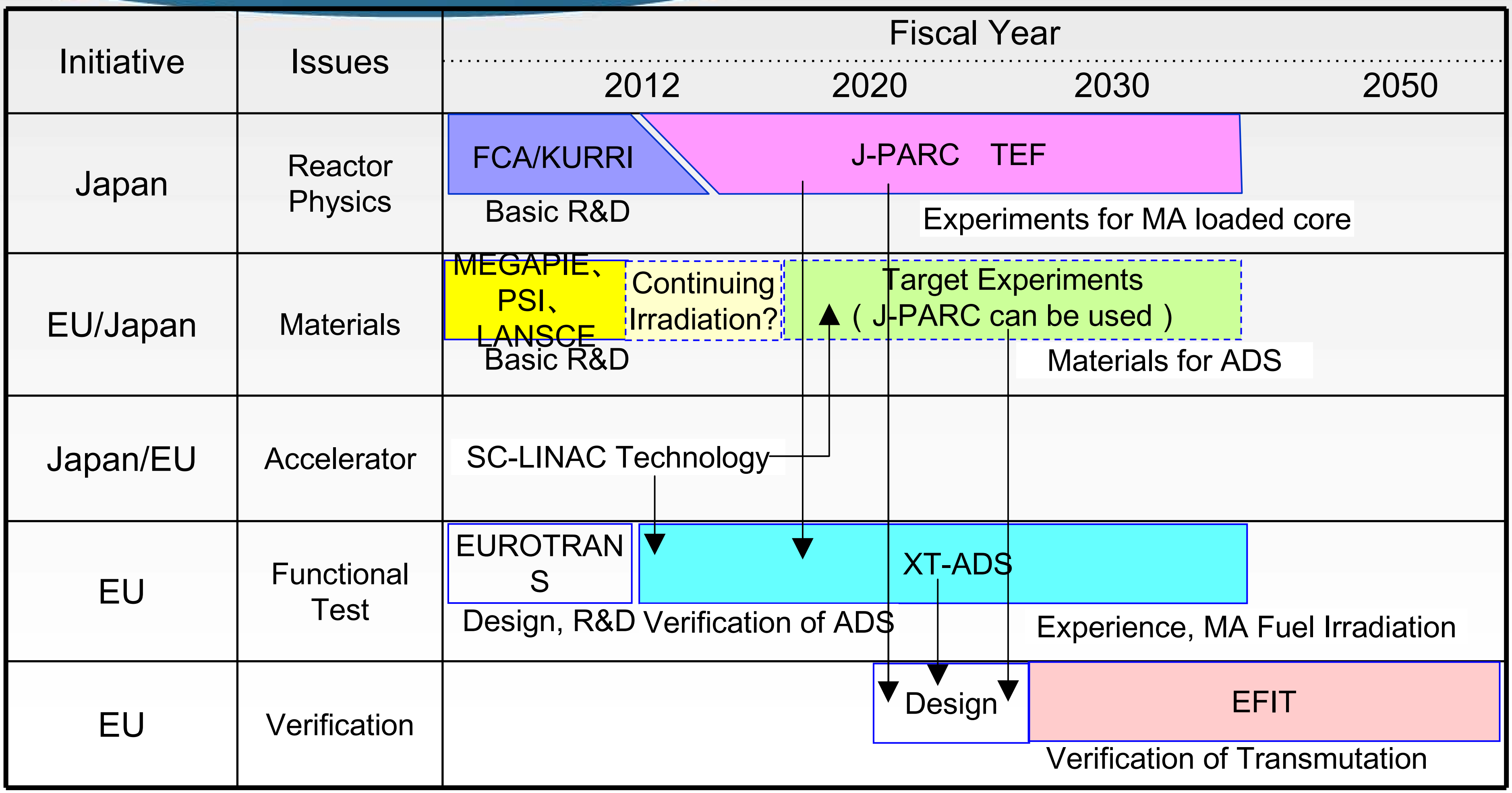
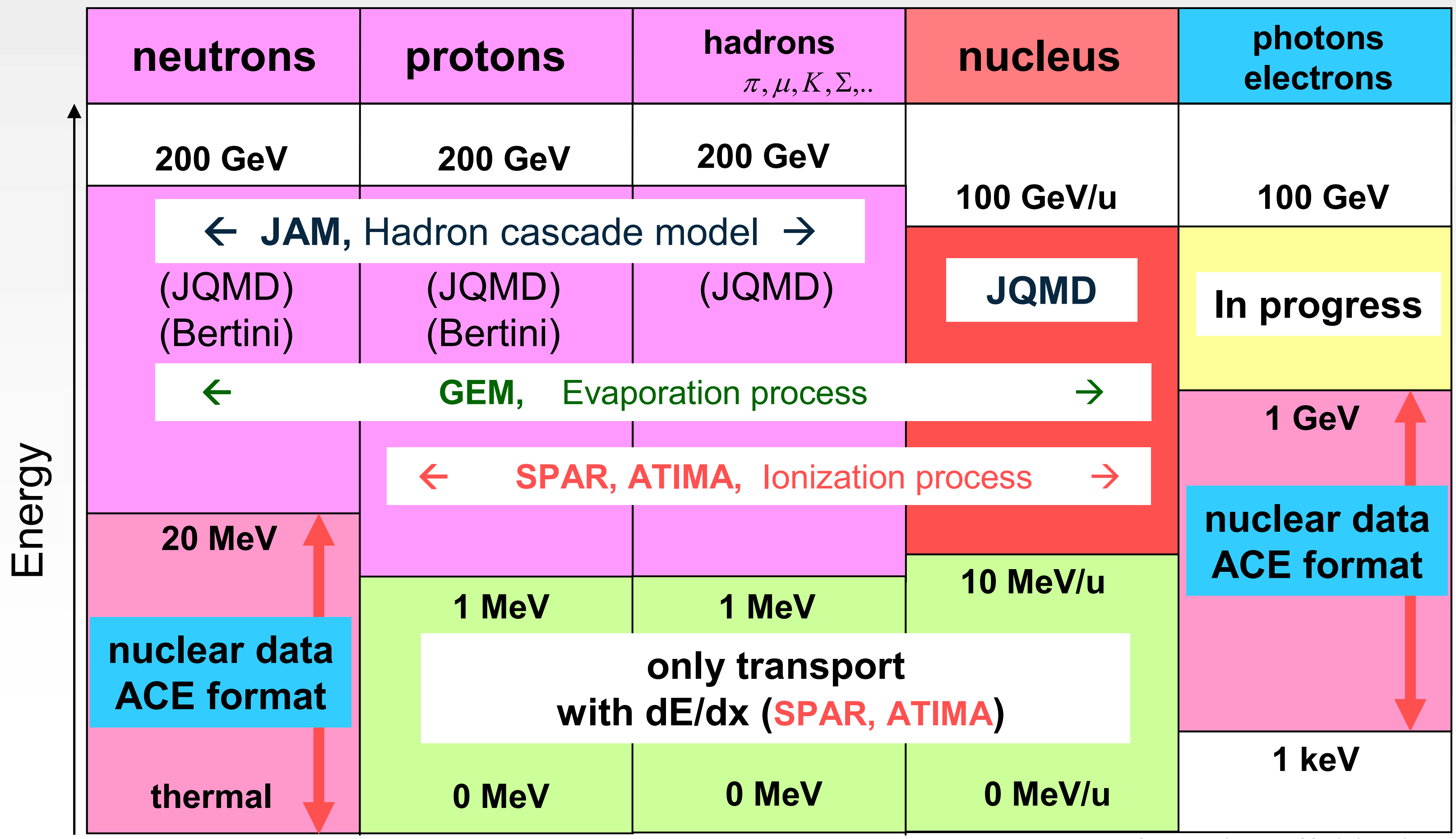
Relationship with EUROTRANS



- **Complemented R&D :** Advanced Test by XT-ADS **in EU and** Basic Research by TEF/KUCA **in Japan**
- **Practical use of existing facilities must be considered for material developments**

Physics model in Phits

A “Japan made” transport code will be prepared within next mid-term



Developed by JAEA, RIST, KEK and Chalmers Univ.

Refer to http://phits.jaea.go.jp/

Summary

Impact of P-T technology introduction

- Waste can be reduced by separating HLW and P-T can prolong lifetime of waste repository
- Transmutation by power reactor is not easy (Especially in France, it's not expected)

ADS studies at JAEA

- Pb-Bi Target/Cooled ADS has been studied as a primary candidate
- Issues concerning fuel, structure, material, neutronics and accelerator has been studied

J-PARC Transmutation Experimental Facility

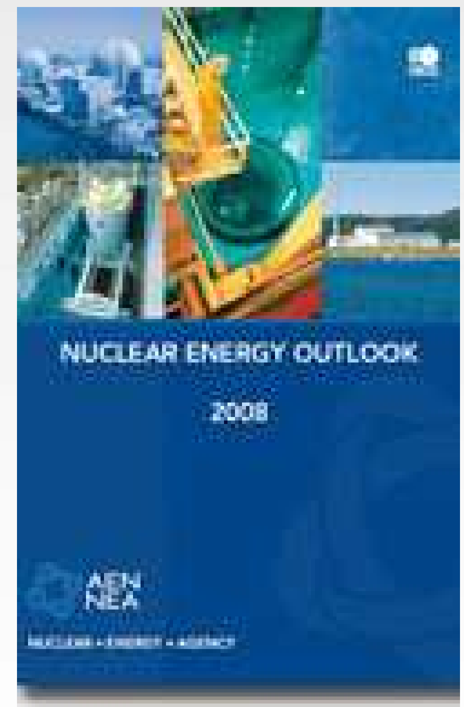
- Design works continues focusing on MA-fuel handling and Multipurpose use
- R&D activities alined with FFAG-KUCA has been performed

R&D Frameworks to promote P-T with ADS

- National review recommends P-T should be studied as a part of power generation cycle
- Domestic and International collaborations (OECD nations and asian sector) is underway

Uranium Demands

- World electricity demand forecast (Assumed 100-million kW/unit) by OECD/NEA outlook 2008
  - Lower case: Replacement only before 2030, 14 units replacement + 9 new units from 2030 to 2050
  - Higher case: Replacement + 14 new units before 2030, 54 (14replace + 40new) units/year at 2030 ~ 2050
- Uranium Market (Price)
  - After 2006, price saturates around 46$/kgU ~ 56$/kgU
- Uranium Resources
  - Known resources 4.54 Million tons (<80$/kgU) and 5.47 Million tons (<130$/kgU)
  - Unknown resources 10.50 Million tons
  - U in Phosphorus ore 22.0 Million tons (1979, USDOE evaluation)
- Uranium Demands
  - Assumption: All NPP at 2050 applies once-through cycle and use 175tU/yr/100-Million kW
  - U consumption at Higher case : 0.25 Million tons/yr
  - Total U consumption up to 2050 : 5.40 Million tons/yr



Even in Higher case (NPP increase 3 times more!) by once through cycle, we can use more than 100 years by known uranium resources.