

Last Twenty Years Experiences with Fast Reactor in Japan

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Fast Reactor Winter

□ FBR project terminations

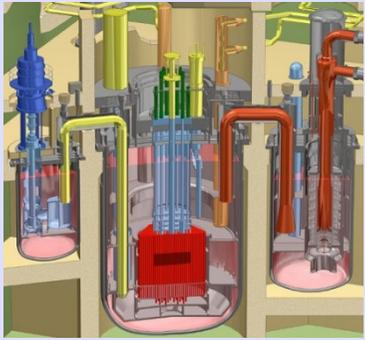
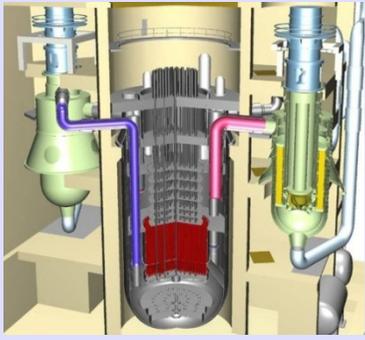
- The U.S.: Clinch River Breeder Reactor (1983)
- Germany: SNR-300 (1991)
- UK: PFR (1994)
- France: Superphénix (1998), [Phénix (2009)]

□ Long shutdown

- Japan: Monju secondary sodium leak (1995)



Japan Fast Reactors

Item	Joyo	Monju	DFBR	JSFR
Reactor				
Electric Output	-	280 MW	660 MW	1500 MW
Thermal Output	140 MW (Mk-III)	714 MW	1600 MW	3570 MW
Fuel	MOX	MOX	MOX	MOX
Configuration	Loop	Loop	Loop	Loop
Number of Loop	2	3	3	2
Output per Loop	70 MW	238 MW	533 MW	1785 MW
Sodium Temp.	500 deg-C	529 deg-C	550 deg-C	550 deg-C
Piping Material	SS304	SS304	SS316	Mod. 9Cr-1Mo
Operation Cycle	60 days (Mk-III)	6 month	12 month	26 month



Joyo since 1977



- ❑ First criticality 1977
- ❑ Mark-II 1982
- ❑ Mark-III 2003

- ❑ Accumulate 70,798 operation hours until 2007
- ❑ Breeding demonstration (Mk-I)
- ❑ FR cycle demonstration (Mk-I to Mk-II)
- ❑ Advanced fuel irradiation (Mk-II)
- ❑ MA bearing fuel irradiation (Mk-III)

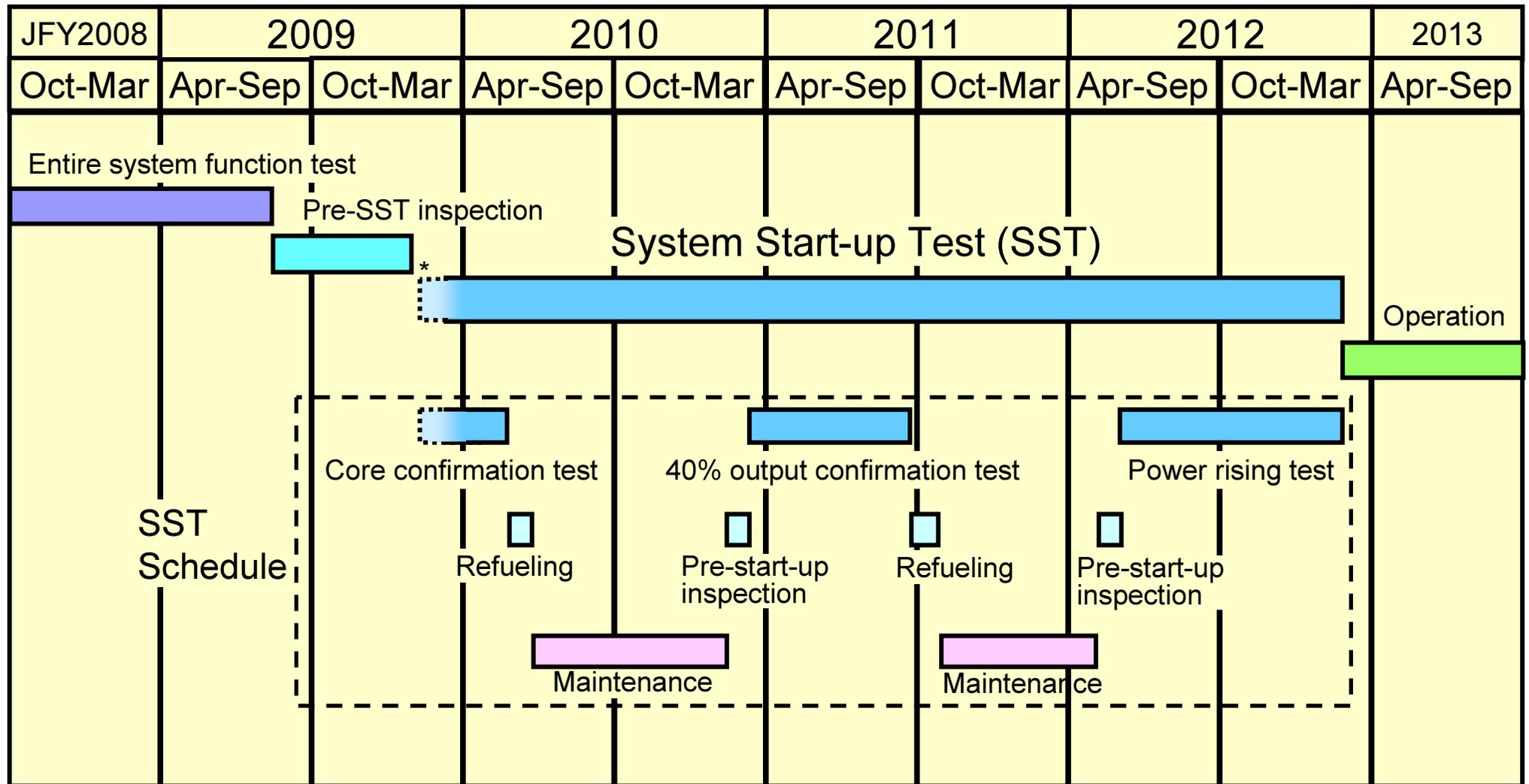


IHX renewal for Mark-III update

Visit Joyo 30 years operation poster



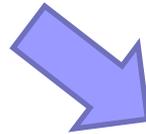
Monju ready to restart



* Monju will restart following the understanding of the local residents.

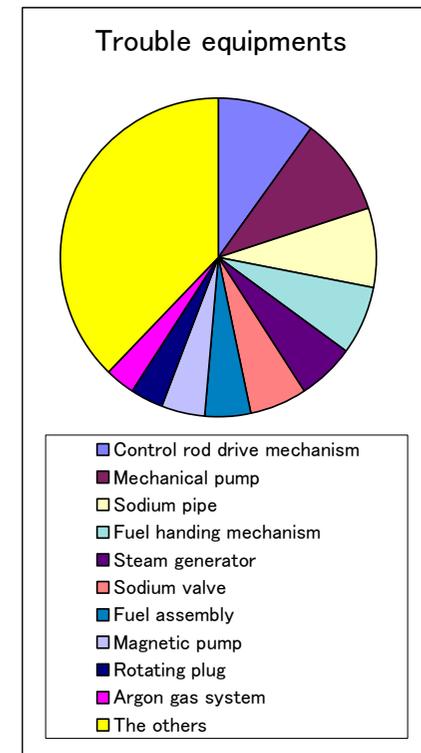
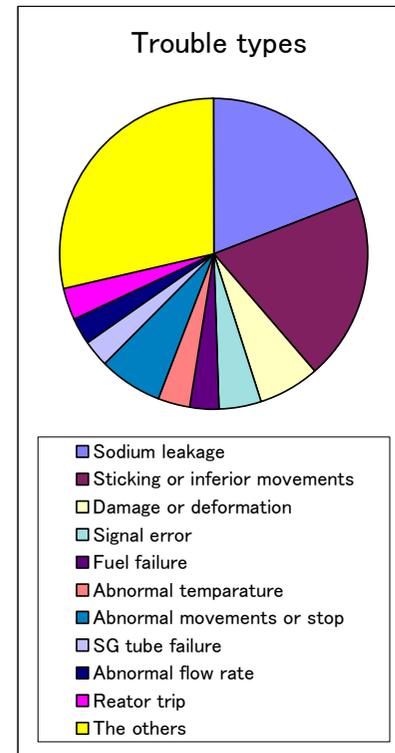


Monju ready to restart



- ❑ Construction start 1985
- ❑ Construction completed 1991
- ❑ First criticality 1994
- ❑ Secondary sodium leak 1995
- ❑ Restart 2010 (early spring)

- ❑ Risk communication material development
- ❑ Human resource development
- ❑ International collaboration test
- ❑ International human resource developmet





Development of human resources in Joyo

University Students

Undergraduate student (3rd or 4th grade) or graduate student

Courses

- (1) Reactor physics analysis
- (2) Reactor physics experiments using the training simulator
- (3) Neutron dosimetry
- (4) Tag gas (xenon and krypton) measurement using RIMS
- (5) Chemical analysis of coolant Sodium

CEA's internship
trainee

2009



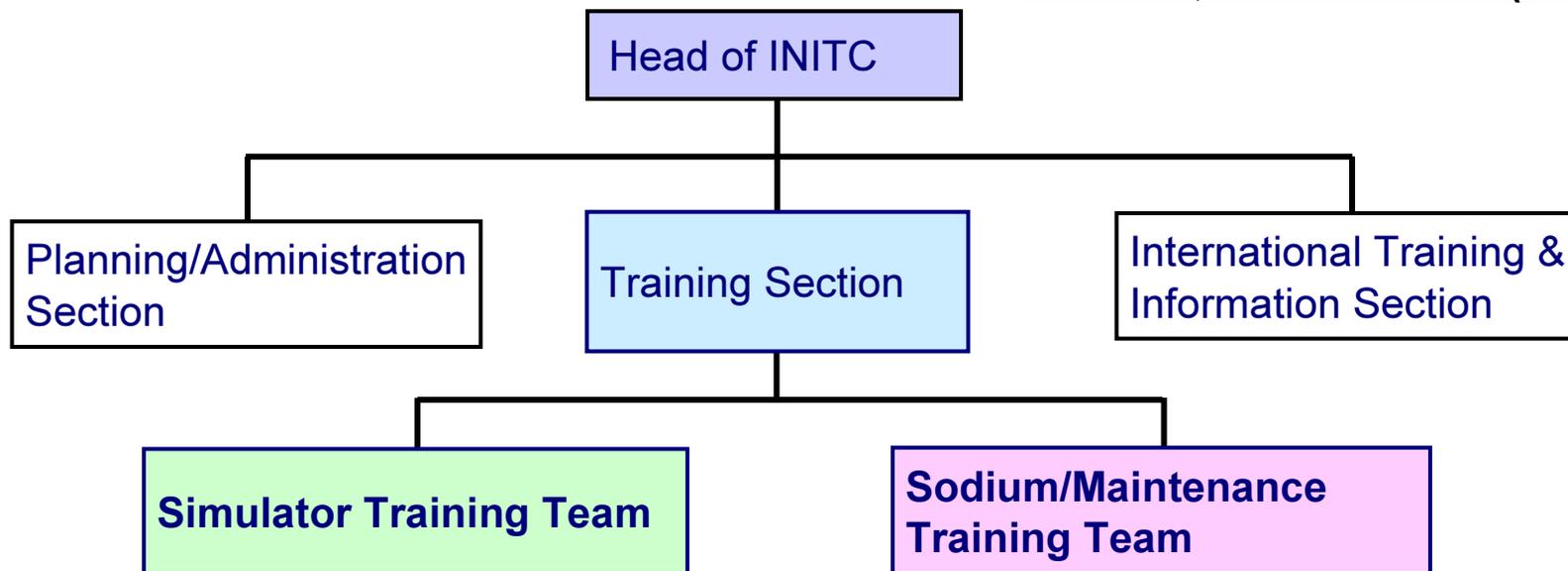
28 students from 7 universities participates in 2009.



Human Resource Development in Monju Area

- International Nuclear Information and Training Center (INITC)

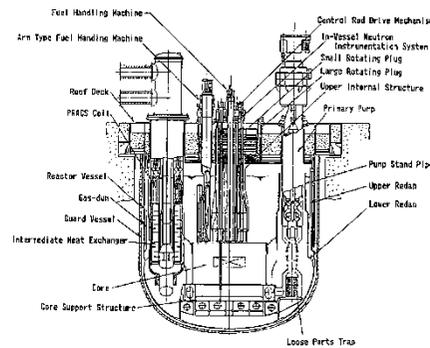
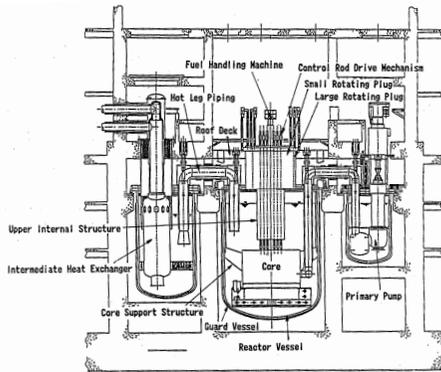
Total: 4,856 Trainees (800 Times)



- University of Fukui has established Research Institute of Nuclear Engineering in April 2009



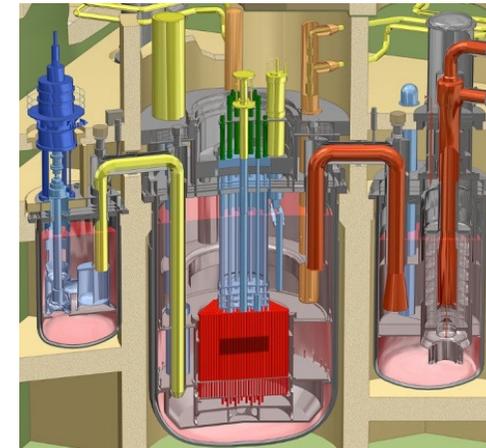
DFBR from 1984 to 1999



Loop/Pool Comparison

- ❑ International circumstance change
- ❑ Monju secondary sodium leak in 1995

- ❑ 1.5 times construction cost of LWR
- ❑ As safe as LWR
- ❑ As operable as LWR
- ❑ As maintainable as LWR



DFBR project was terminated in 1999 and continued to the next Feasibility Study



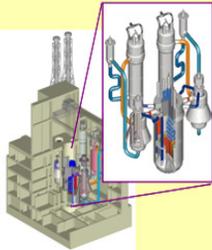
Feasibility Study on Commercialized FR Systems (1999-2006)

- ❑ Competitive against future LWR and other future energy sources
- ❑ Meet Generation IV Reactor goals

<Phase I (1999-2000)>

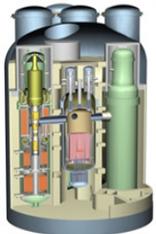
Category	System concepts
SFR	4 and more (loop x 1 and pool x 3)
GFR (CO ₂ and He)	4 and more CO ₂ -cooled and He-cooled
LFR LBFR	4 and more
Water-cooled	3 (BWR, PWR and SCFR)
Small SFR	LBFR x 1 SFR x 3
Multi-purpose	Hydrogen production x 2
Advanced SFR	Advanced IHX concept x 8 Advanced energy conversion x 3

<Phase II (2001-2006)>



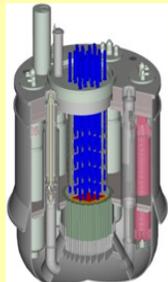
- Economical system design by adapting innovative technologies
- Compact and high performance Core with MOX fuel

Sodium-cooled FR



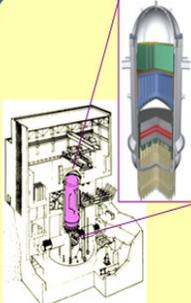
- higher thermal efficiency and robustness for multipurpose usage (e.g. hydrogen production)
- Reactor core performance is lower than SFR and LFR

Helium Gas-cooled FR



- Mild chemical activity
- Compact and High performance core by adopting nitride fuel
- Scale restriction due to heavy coolant weight

Lead-Bismuth-cooled FR

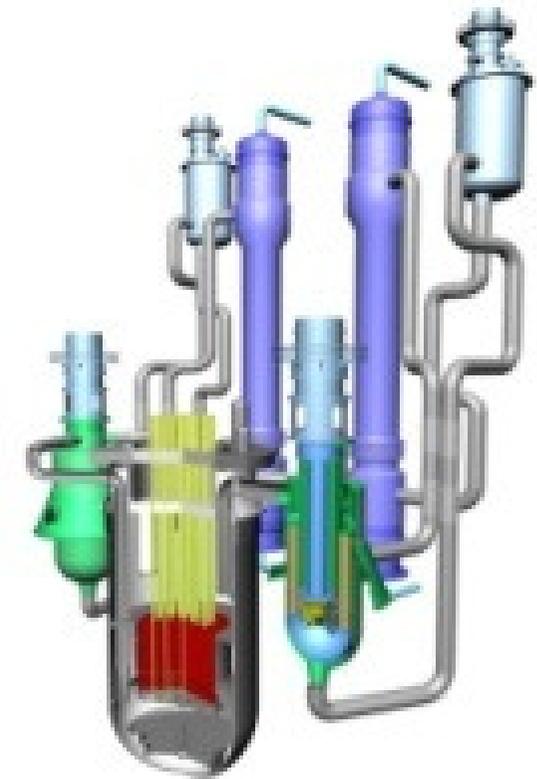
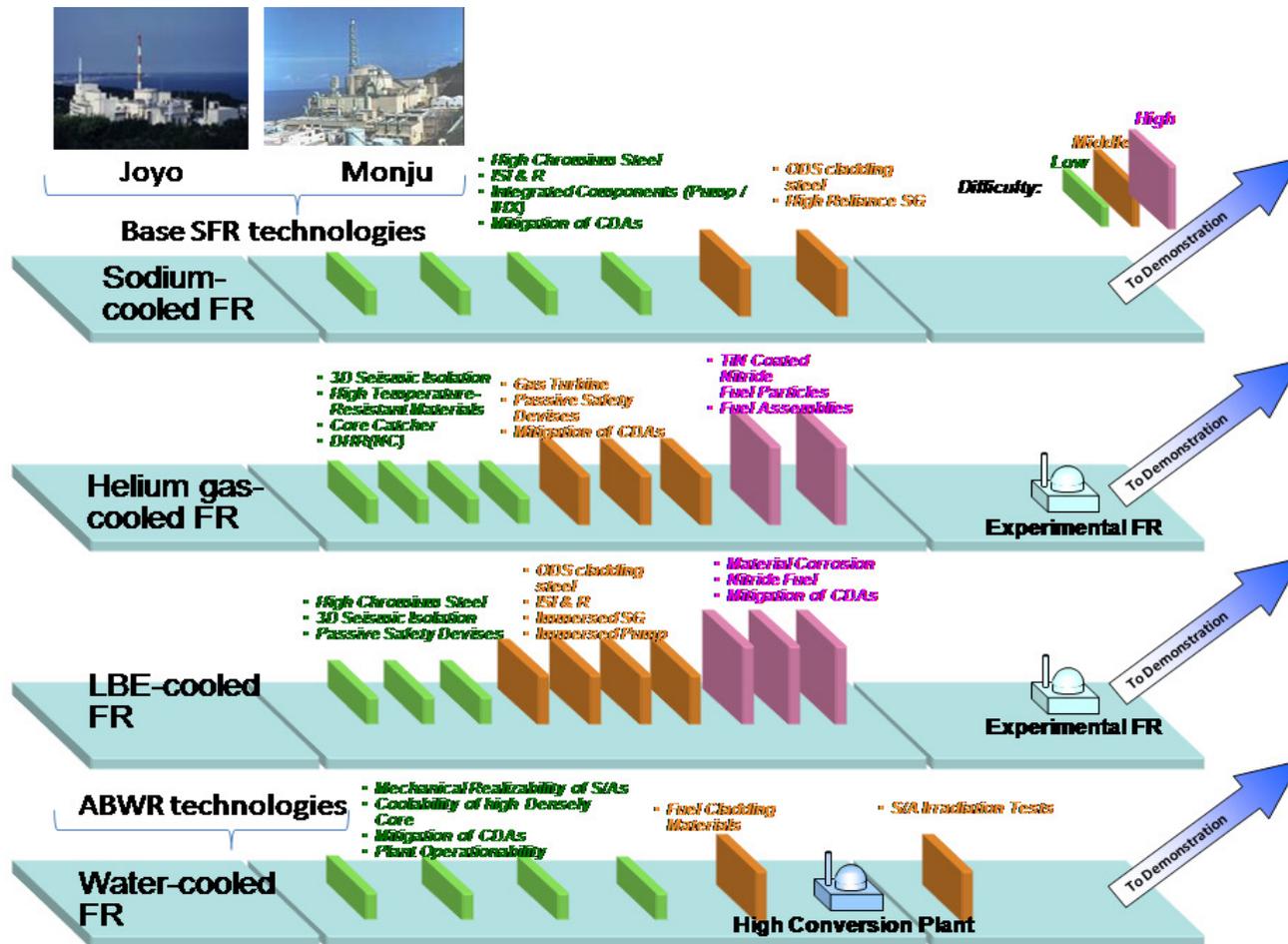


- Applicable to ABWR plant technologies
- Reactor core performance is lower than SFR and LFR

Light-water-cooled Boiling FR



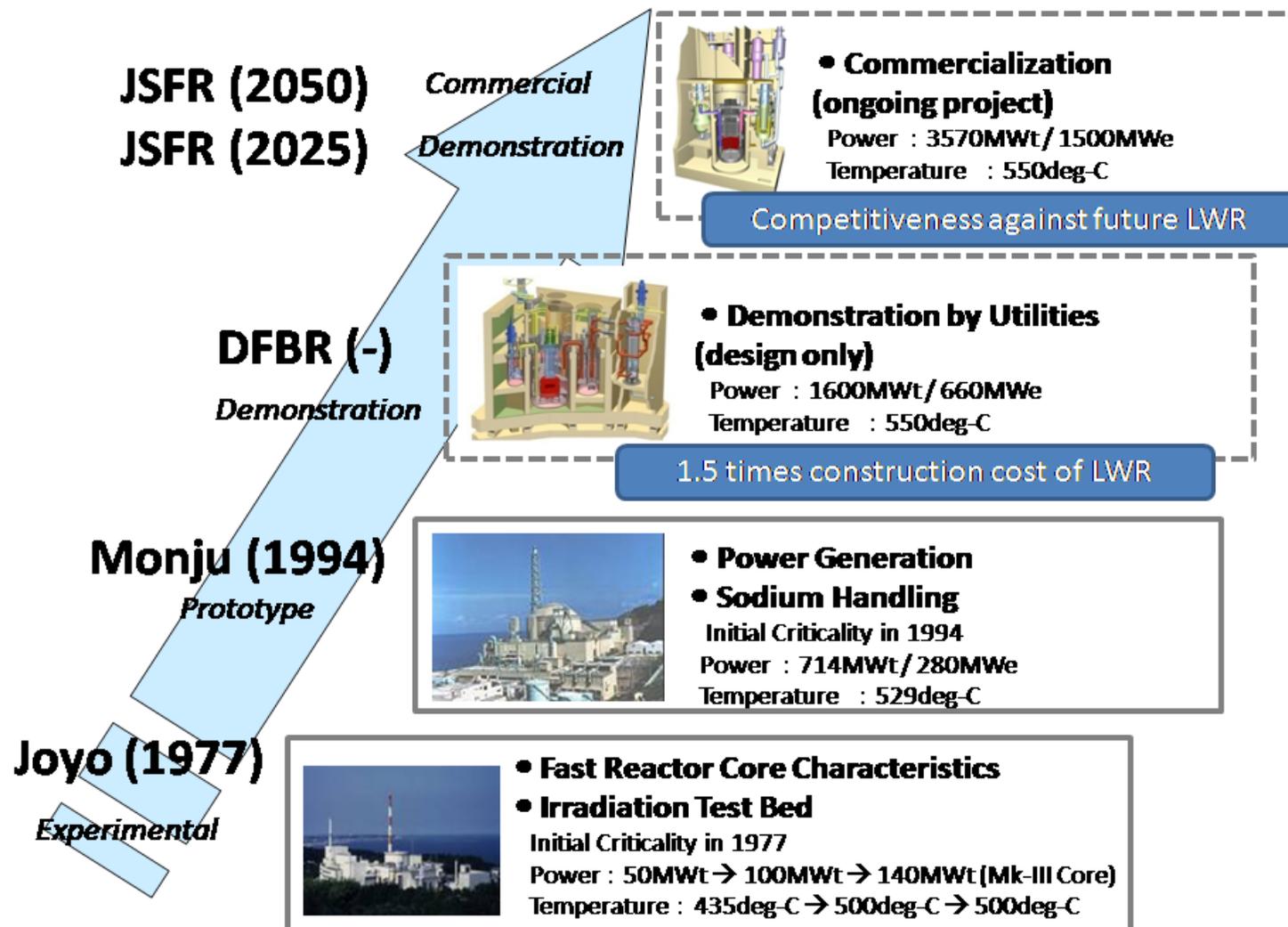
Roadmap Comparison



JSFR selected for FaCT



Stream of Japan Fast Reactor





Other FR Activities in Japan

□ 4S: Toshiba and CRIEPI

- Galena in Alaska has offered a siting acceptance in 2004.
- Pre-application review by NRC in 2007.

*:T. Tsuboi, et. al. "Development of the 4S and related technologies (1) plant system overview and current status," Proc. of ICONE-9, Tokyo, Japan, Oct 2009

□ Super FR (Super-critical water cooled): the University of Tokyo

- Joint study (TEPCO, Kyushu University, JAEA)
- One of GIF concepts

*:Y. Oka, et. al, "Research Program of a Super Fast Reactor," Proc. of ICAPP'06, No, 6353, Reno, USA, June, 2006

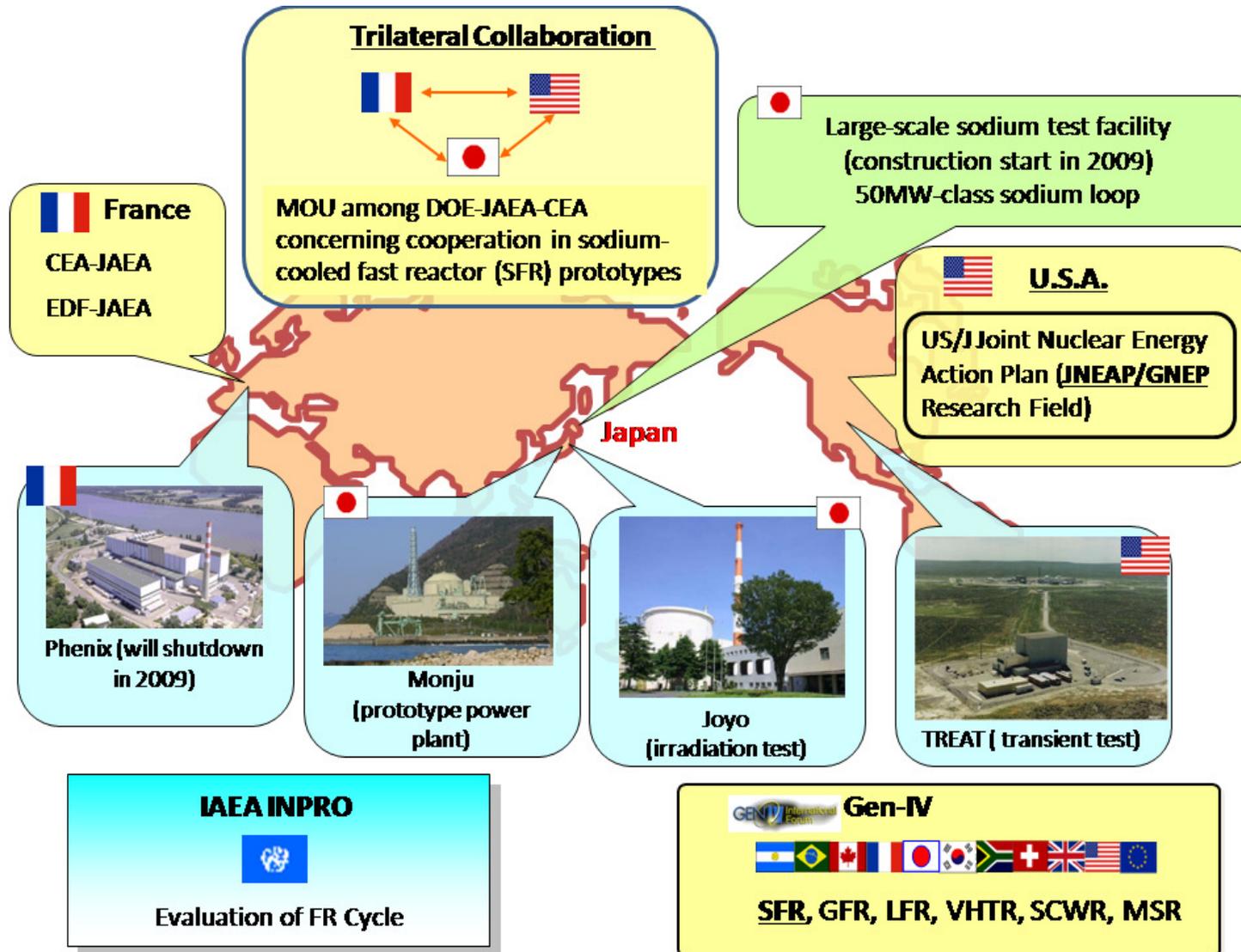


Fast Reactor Thaw (beginning of Spring)

- January 2006, France
president announcement
SFR prototype in 2020
- February 2006, the U.S.
Global Nuclear Energy Partnership (GNEP)
“Burner” prototype (pending)
- April 2006, Japan
Fast Reactor Cycle Technology Development Project (FaCT)
Monju restart in 2010
Demonstration SFR in 2025



International Collaboration





Conclusions

- Our last twenty years started from FR winter.
 - During twenty years, the FR goals have been enhanced.
 - ✓ e.g. 1.5 times construction cost of LWR
- ↓
- ✓ Competitive with future LWR and other future energy resources
 - Our twenty-year effort showed that FR could achieve enhanced goals and requirements.
 - During twenty-years, Joyo and Monju have contributed and are contributing as human development centers both domestically and internationally.
 - We overcome FR winter and FR spring has come.
 - Monju about restarts early next spring.
 - We expect demonstration FR in 2025.