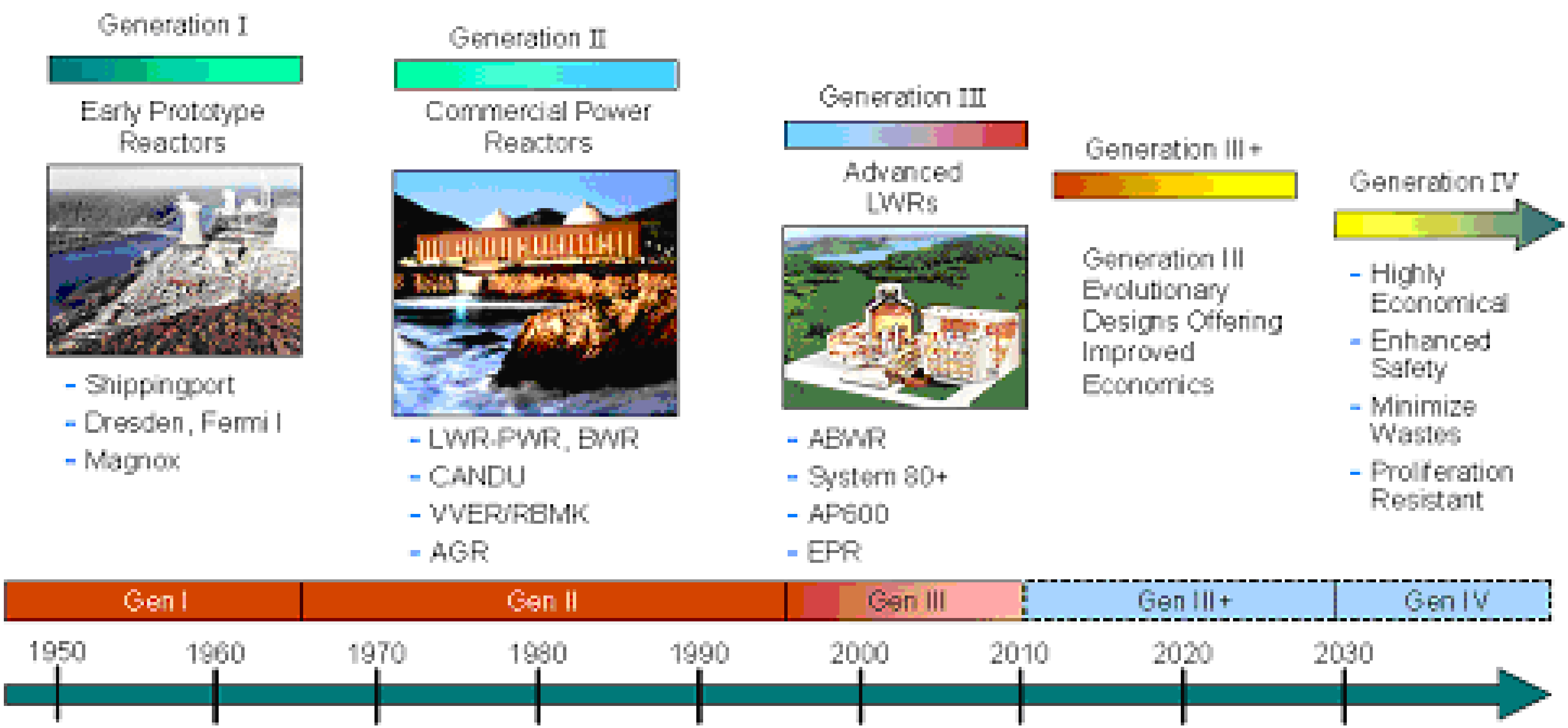
Nuclear Data Needs from Core Design
炉心設計側からの核データに対する要求

2. Advanced Reactors
2．革新炉の核データニーズ

T. Yoshida

Musashi Institute of Technology

The Evolution of Nuclear Power



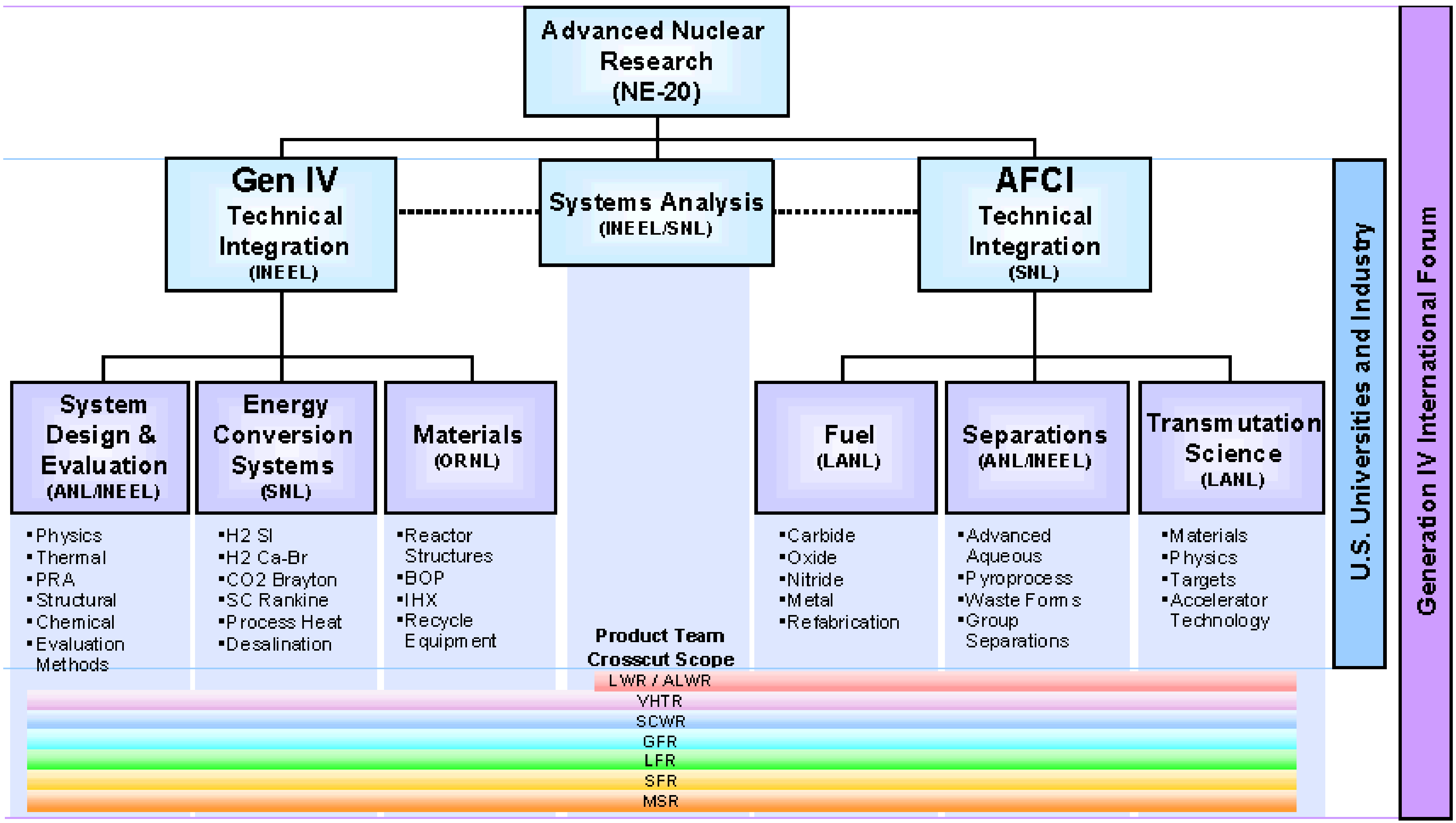


図5　米国の統合原子力研究プログラム組織図

[出所]W.D. Magwood: The Nuclear Energy Future, ANS Annual Meeting, June 2, 2003, ANS2003anuMagwood.pdf

GFR:Gas-Cooled Fast reactor

- features a fast-neutron-spectrum, helium-cooled reactor and closed fuel cycle

VHTR:Very High Temperature Reactor

- a graphite-moderated, helium-cooled reactor with a once-through uranium fuel cycle

SCWR:Supercritical-Water Cooled Reactor

- a high-temperature, high-pressure water-cooled reactor that operates above the thermodynamic critical point of water

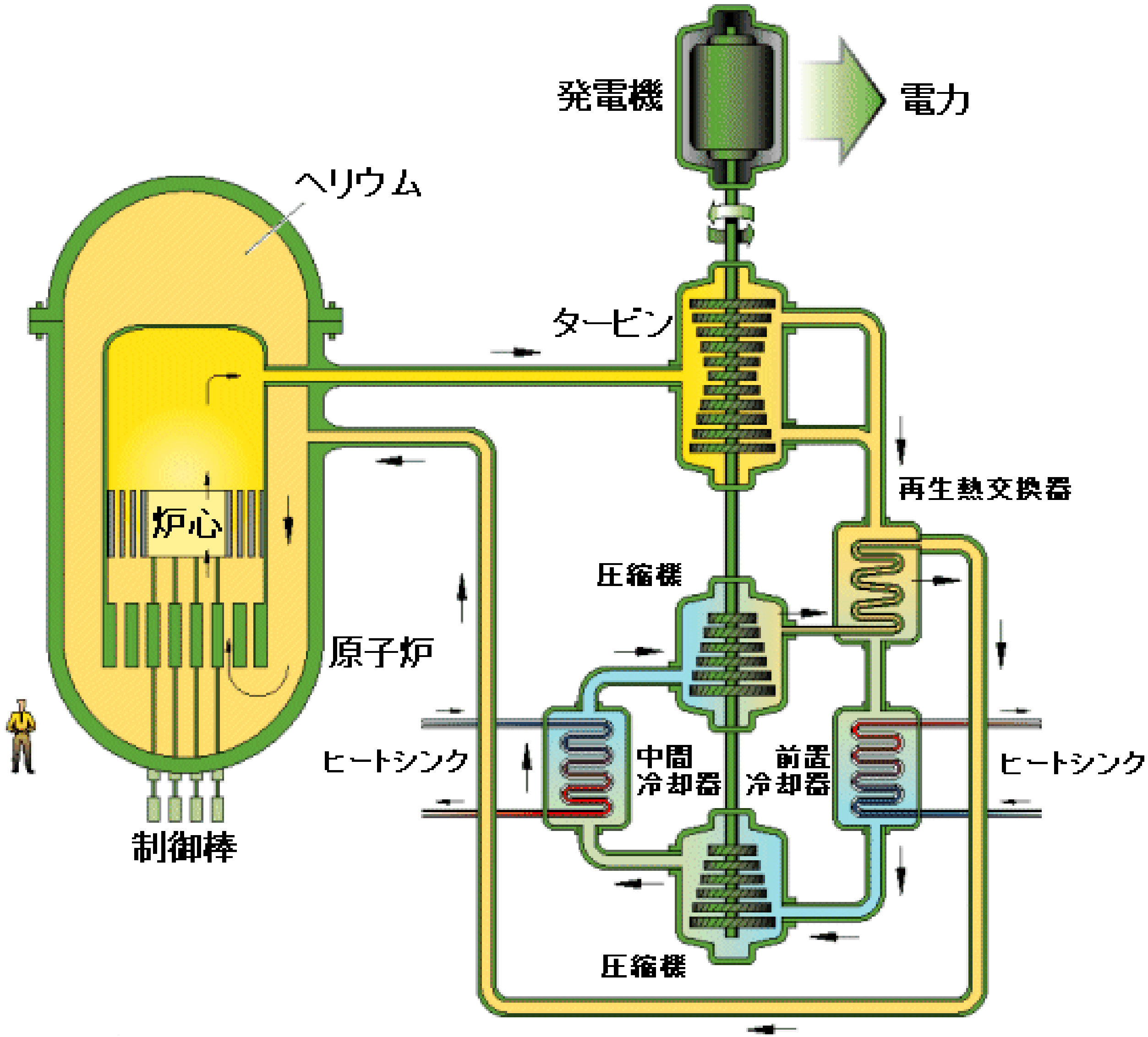


図6　第4世代原子炉概念(5)：ガス冷却高速炉

[出所] U.S.DOE：A Technology Roadmap for Generation IV Nucear Energy Systems, http://gif.inel.gov/roadmap/generation_iv_technology_roadmap.pdf,28/97

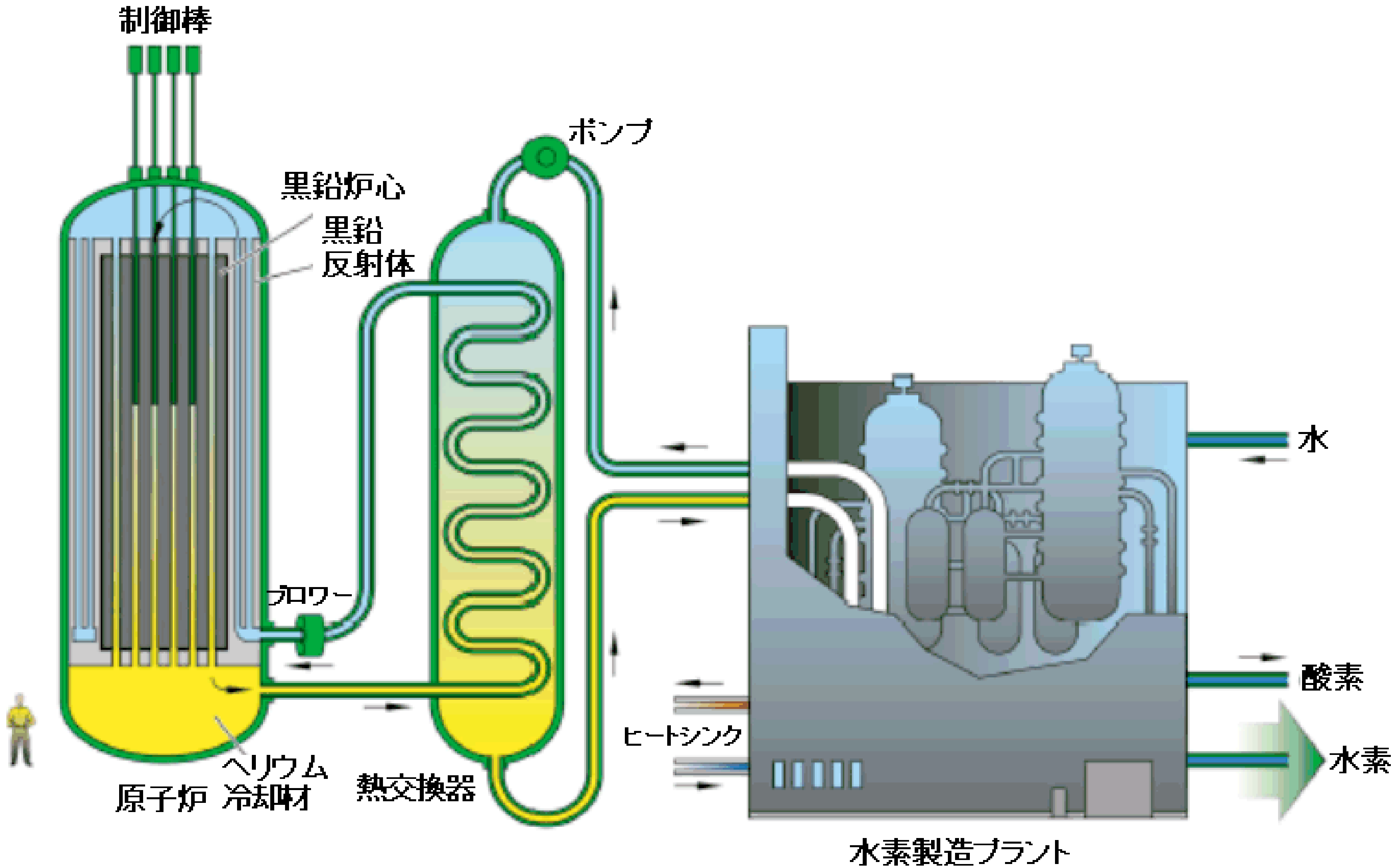


図5　第4世代原子炉概念(4)：超高温ガス炉

[出所] U.S.DOE：A Technology Roadmap for Generation IV Nucear Energy Systems, http://gif.inel.gov/roadmap/generation_iv_technology_roadmap.pdf,54/97

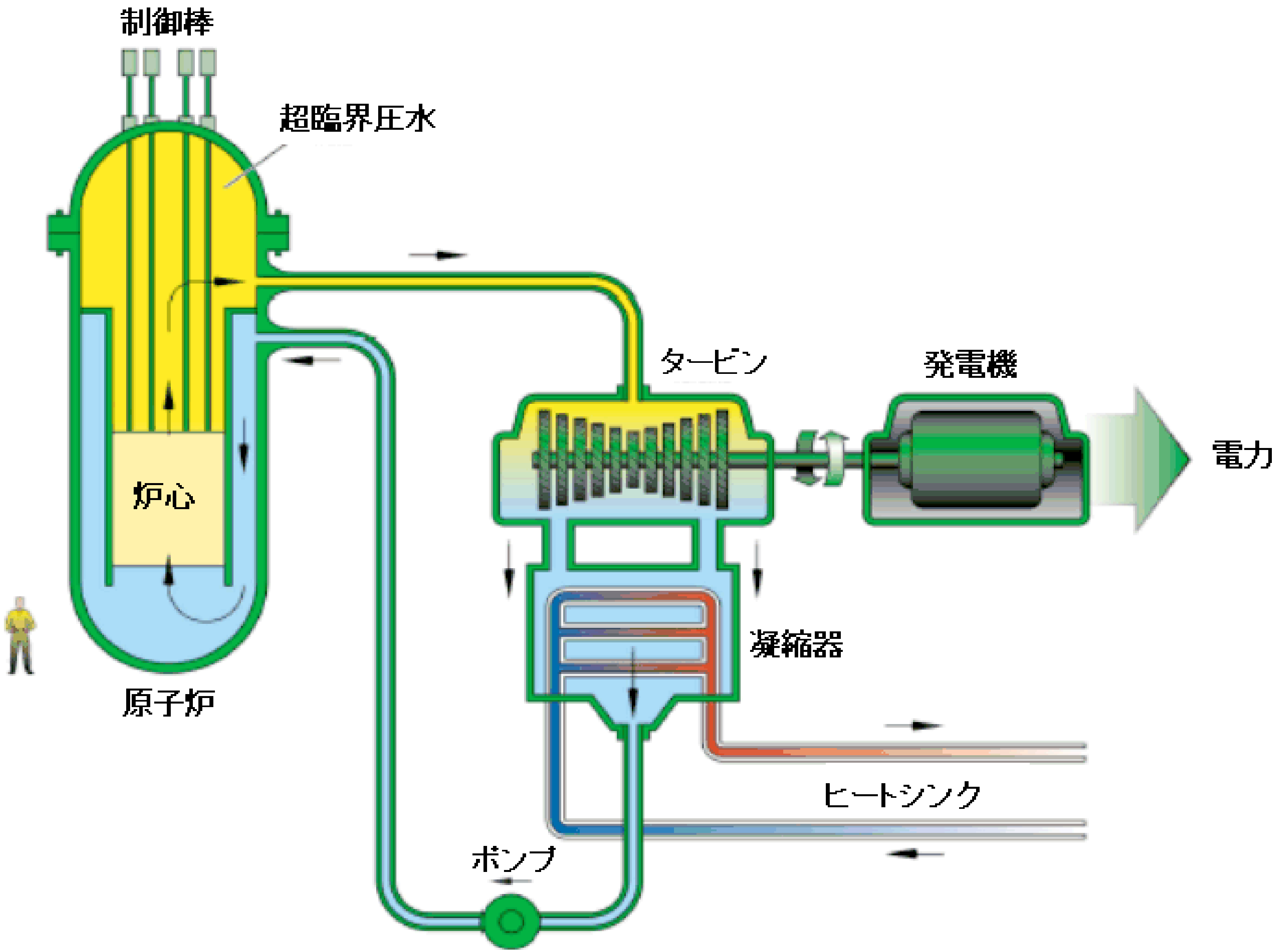


図2　第4世代原子炉概念(1): 超臨界圧軽水冷却炉

[出所] U.S.DOE: A Technology Roadmap for Generation IV Nucear Energy Systems, http://gif.inel.gov/roadmap/generation_iv_technology_roadmap.pdf,48/97

SFR:Sodium Cooled Fast Reactor

- features a fast-spectrum, sodium-cooled reactor and closed fuel cycle for efficient management of actinides and conversion of fertile uranium

LFR: Lead Cooled Fast Reactor

- features a fast-spectrum lead of lead/bismuth eutectic liquid metal-cooled reactor and a closed fuel cycle for efficient conversion of fertile uranium and management of actinides

MSR: Molten Salt Reactor

- produces fission power in a circulating molten salt fuel mixture with an epithermal-spectrum reactor and a full actinide recycle fuel cycle

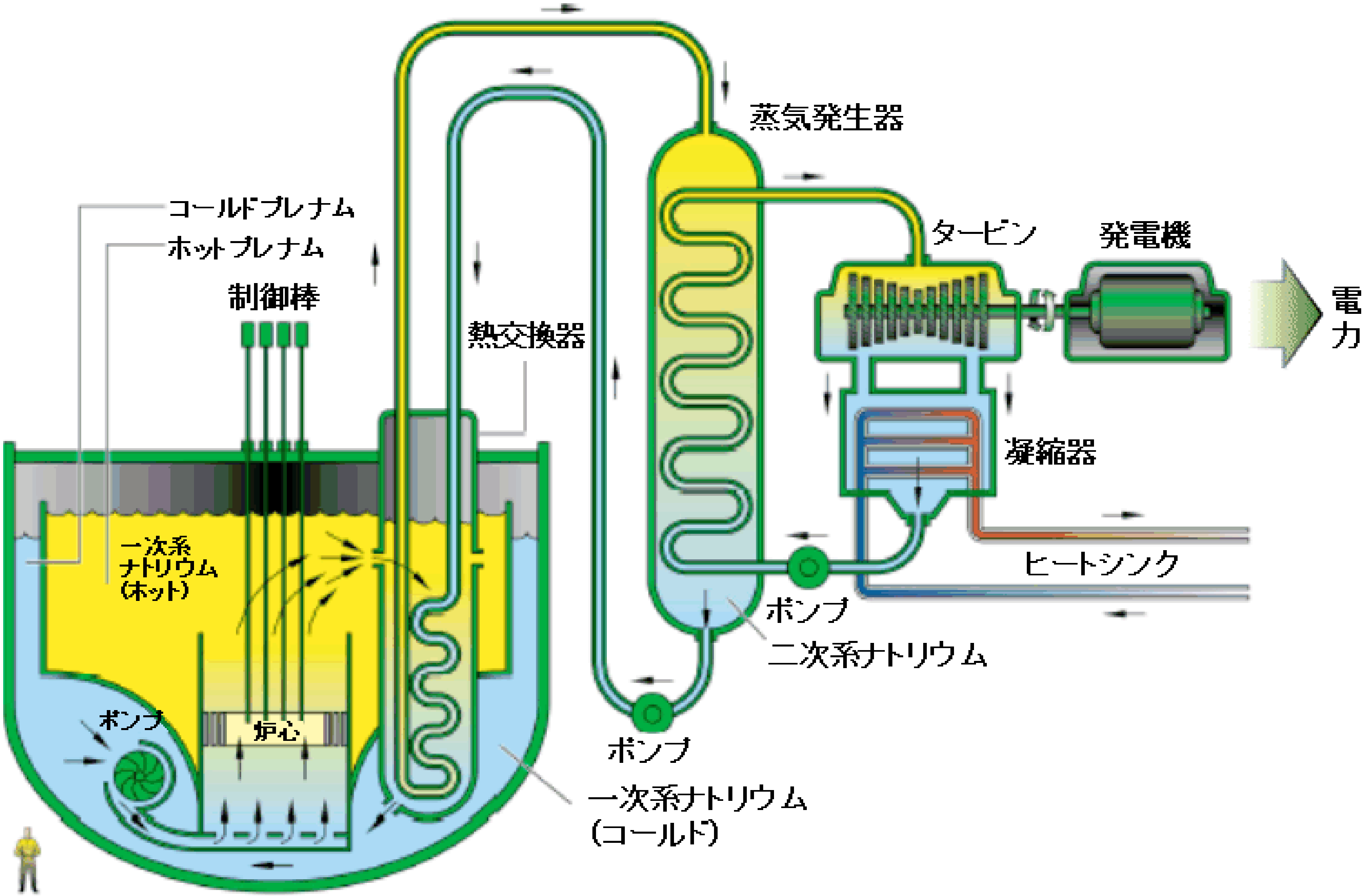


図3　第4世代原子炉概念(2)：ナトリウム冷却高速炉

［出所］U.S.DOE：A Technology Roadmap for Generation IV Nucear Energy Systems, http://gif.inel.gov/roadmap/generation_iv_technology_roadmap.pdf,44/97

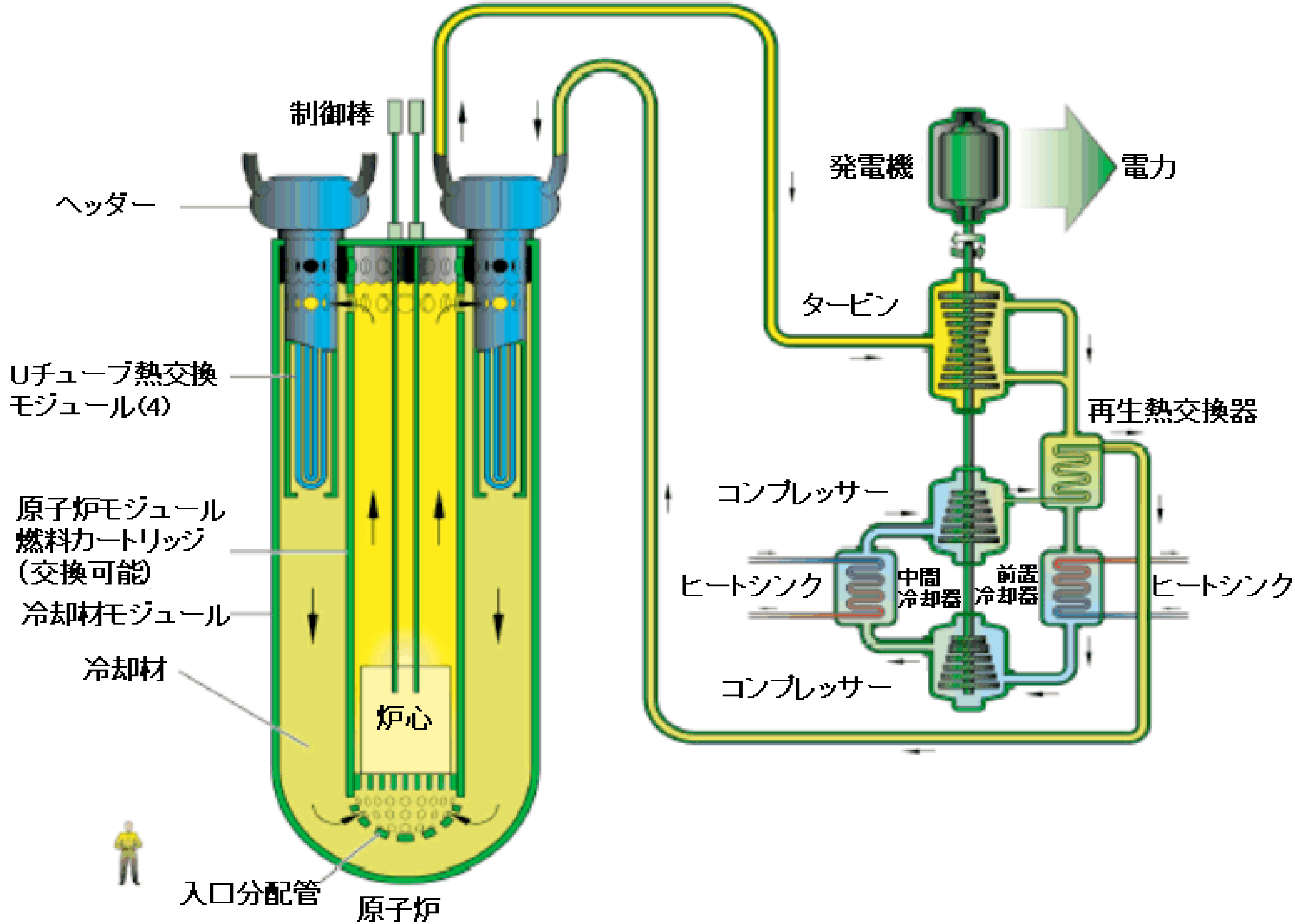


図4　第4世代原子炉概念(3):鉛合金冷却高速炉

[出所]U.S.DOE:A Technology Roadmap for Generation IV Nucear Energy Systems,
http://gif.inel.gov/roadmap/generation_iv_technology_roadmap.pdf,33/97

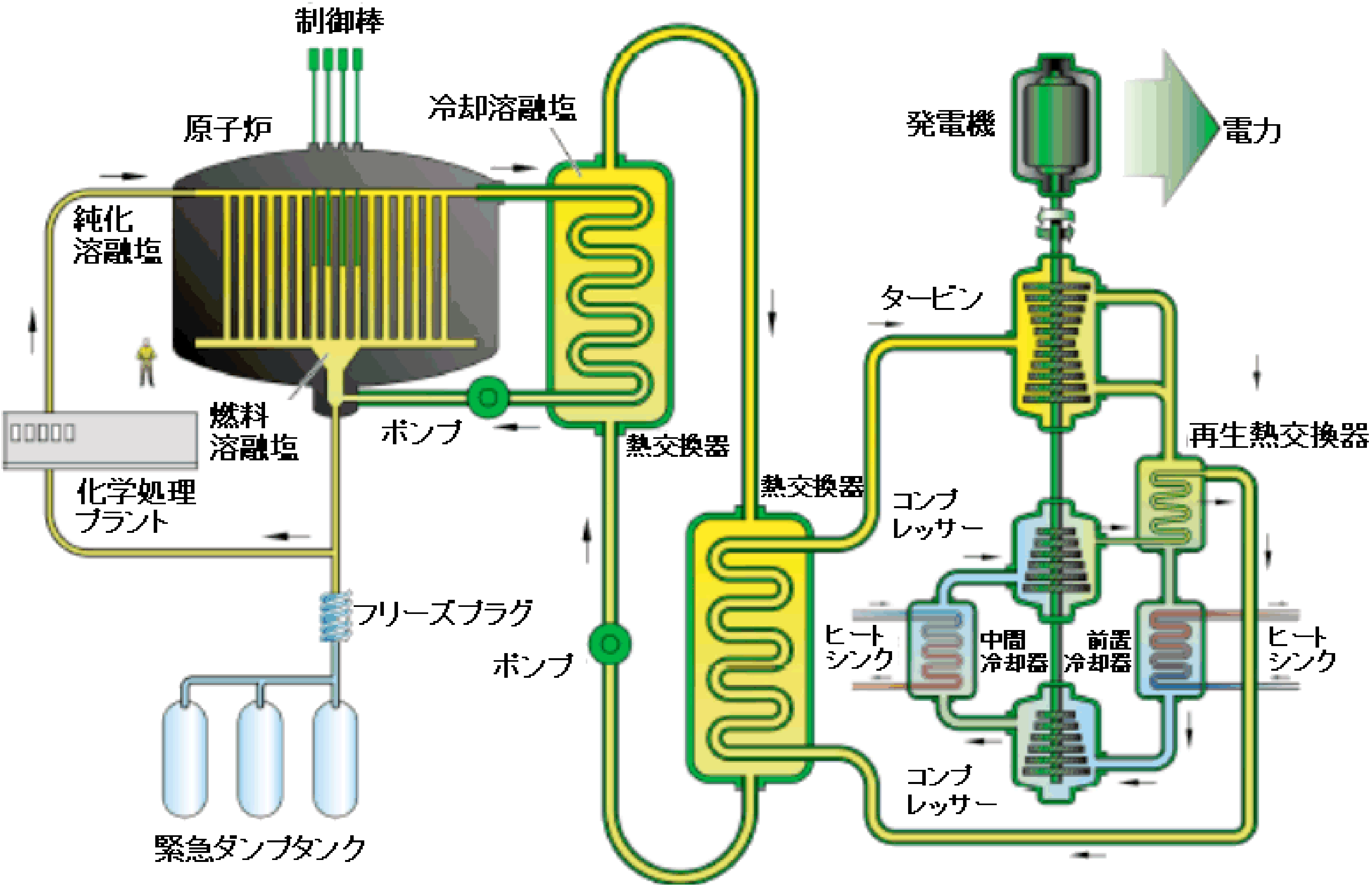
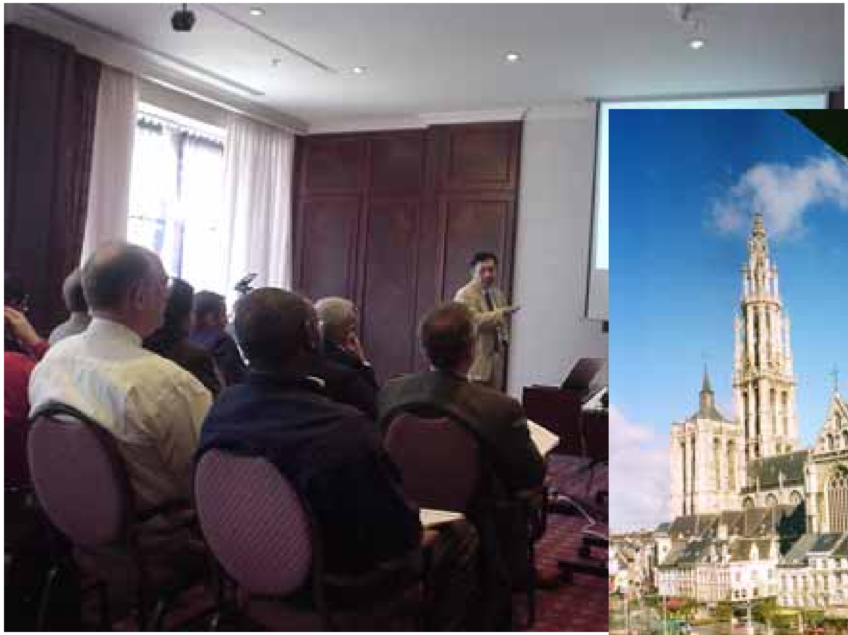


図7　第4世代原子炉概念(6)：溶融塩炉

[出所] U.S.DOE：A Technology Roadmap for Generation IV Nucear Energy Systems,
http://gif.inel.gov/roadmap/generation_iv_technology_roadmap.pdf,39/97

International Workshop on Nuclear Data Needs for Generation IV Nuclear Energy Systems

Hotel Hilton Antwerp, Belgium April 5-7, 2005



Nuclear Data Needs for Generation IV Systems

Future of Nuclear Energy and the Role of Nuclear Data
P.Finck, ANL

Nuclear Data Needs for Generation IV Nuclear Energy Systems
T.A.Taiwo, H.S.Khalil, ANL

Nuclear Data Needs for the Assessment of Gen. VI Systems
G.Rimpault, Cadarache

Nuclear Data Needs for Generation IV- Lesson from Benchmarks
S.C. van der Marck et al., Petten

Report on the Workshop on Nuclear Data Needs for Generation IV Systems

BNL, April 24-25, 2003

Pavel Oblozinsky

National Nuclear Data Center

Brookhaven National Laboratory, Upton, NY 11973

Annual Meeting of the Cross Section Evaluation Working Group

BNL, November 4-6, 2003

Nuclear Data Needs for Gen IV: Conclusions

- **CSEWG role recognized**
  - Nuclear data methodology well established
  - 5-step CSEWG process -- data needs, measurements, evaluation, processing, validation
- **Data needs**
  - Strong emphasis on sensitivity analysis and assessment of uncertainties
  - High burn-up operation requires re-evaluation for some transuranics
  - Fast spectrum systems require new data for minor actinides
- **Measurements**
  - Strong need for maintenance of US experimental capabilities
  - Mechanism needed for maintenance and distribution of samples

Core Design Issues of the Super Critical Water Fast Reactor

M.Mori, et al., karlsruhe & V. Sinista, IPPE Obninsk

Comparative Study on Differential Phonon Frequency Spectra of Graphite

Young-Sik Cho, et al., KAERI

Innovative Fuel Types for Minor Actinide Transumutation

D.Haas, A.Fernandez, J.Somers, ITE, Karlsruhe

The Importance of Nuclear Data in Modeling and Designing Generation IV Fast Reactor

K.D.Weaver, Idaho

The GIF and Mexico “Everything Begins with a Wish”

C.A.Sanches, ININ

Benchmarks, Sensitivity Calculation, Uncertainty

Sensitivity of Advanced Reactor and Fuel Cycle Performance Parameters to Nuclear Data Uncertainties

G.Aliberti et al., ANL, NEA Data Bank, Cadarache

≀

Experiments

≀

Recent Measurements of Neutron capture Cross Section For Minor Actinides by a JNC and Kyoto University Group

H.Harada et al., JNC (now JAEA), Kyoto University

≀

Evaluated Data Libraries

SENSITIVITY OF ADVANCED REACTOR AND FUEL CYCLE PERFORMANCE PARAMETERS TO NUCLEAR DATA UNCERTAINTIES

G. ALIBERTI, G. PALMIOTTI, M. SALVATORES, T. K. KIM, T. A. TAIWO

Nuclear Engineering Division, Argonne National Laboratory

I.KODELI, E. SARTORI

NEA Databank

J.C. BOSQ, J. TOMMASI

DER/SPRC, CEA-Cadarache

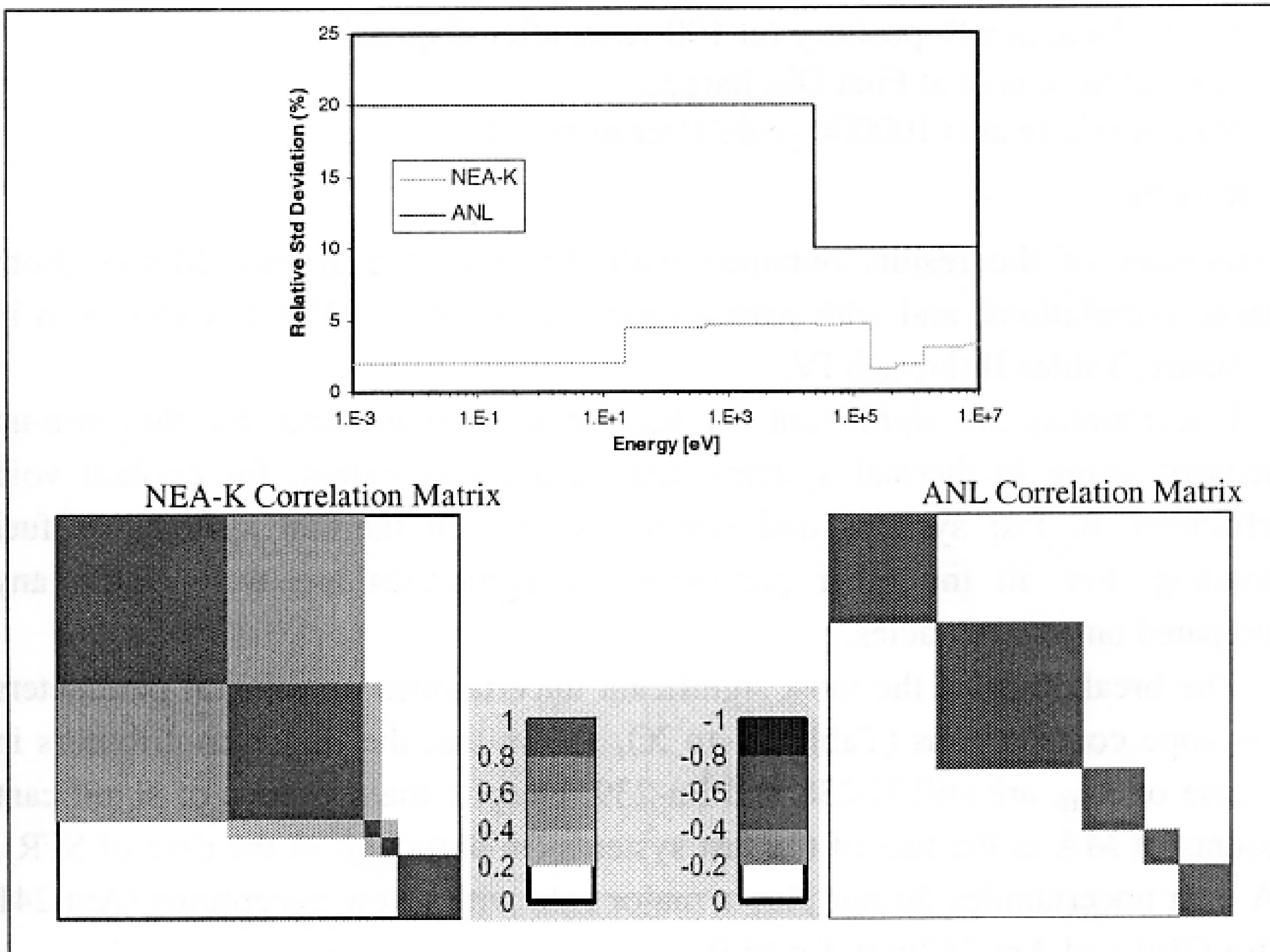


Figure 5. Am-241(n,f)

System Studied

GFR: 2400 Mwe - He cooled; SiC - (U-TRU)C fuel
Zr_3Si_2 reflector; enrichment :17%, MA:5%
irradiation cycle:415 d

VHTR: TRISO fuel; enrichment:14%; burnup: 90 GW d/Kg

SFR: (Burner: CR=0.25) 840 MWt - Na cooled;
U-TRU-Zr metallic alloy; SS reflector;
enrichment: 56%, MA:10%; irradiation cycle:415 d

LFR: 900 MWth - Pb cooled; UTRU-Zr metallic alloy;
Pb reflector; enrichment:21%, MA:2%,
irradiation cycle:310 d

In addition:EFR, Extennded BU PWR(8.5% enrichment)

Table Fast Neutron System - Total Uncertainty (%)

Reactor		K_{eff}	Power Peak	Doppler	Void	Burnup $\Delta\rho$ (pcm)
GFR	NC (*)	±1.20	±1.2	±3.6	±4.8	±240
	PEC	1.90	1.8	5.5	7.1	384
LFR	NC	1.51	0.8	5.2	13.0	177
	PEC	2.26	1.0	7.8	20.6	258
SFR	NC	1.10	0.4	4.1	17.8	156
	PEC	1.66	0.5	6.0	23.4	234
EFR	NC	1.02	0.7	3.4	8.4	652
	PEC	1.57	1.1	5.1	12.1	989

(*) NC: No correlation

Table GFR. Uncertainties (%) PEC - Breakdown by Isotope

(Major Contributions)

Isotope	K_{eff}	Doppler	Void	Burnup [pcm]
U238	±1.22	±3.2	±3.9	±63
Pu238	0.22	0.6	0.7	85
Pu239	1.03	2.6	2.6	203
Pu240	0.29	0.7	0.7	14
Pu241	0.57	1.5	1.7	189
Am241	0.43	1.8	1.2	73
Am242m	0.01	0.0	0.0	76
Cm242	0.00	0.0	0.0	90
Cm244	0.13	0.4	0.3	35
Cm245	0.17	0.4	0.5	38
C	0.31	1.9	1.7	8
Si28	0.42	1.2	0.7	12
Zr90	0.12	0.3	0.5	9

Table LFR. Uncertainties (%) PEC - Breakdown by Isotope

(Major Contributions)

Isotope	K_{eff}	Doppler	Void	Burnup [pcm]
U238	±0.73	±2.2	±3.7	±13
Pu238	0.24	0.5	0.9	25
Pu239	1.50	3.4	4.0	213
Pu240	0.41	1.1	0.9	18
Pu241	0.32	0.7	1.0	112
Am241	0.10	0.4	0.3	6
Am242m	0.06	0.1	0.2	14
Cm242	0.02	0.0	0.0	11
Cm244	0.13	0.3	0.2	12
Cm245	0.21	0.4	0.7	34
Fe56	0.24	1.6	2.0	5
Pb206	0.88	3.2	13.4	18
Pb207	0.80	3.4	12.2	16
Pb208	0.49	4.0	7.4	8

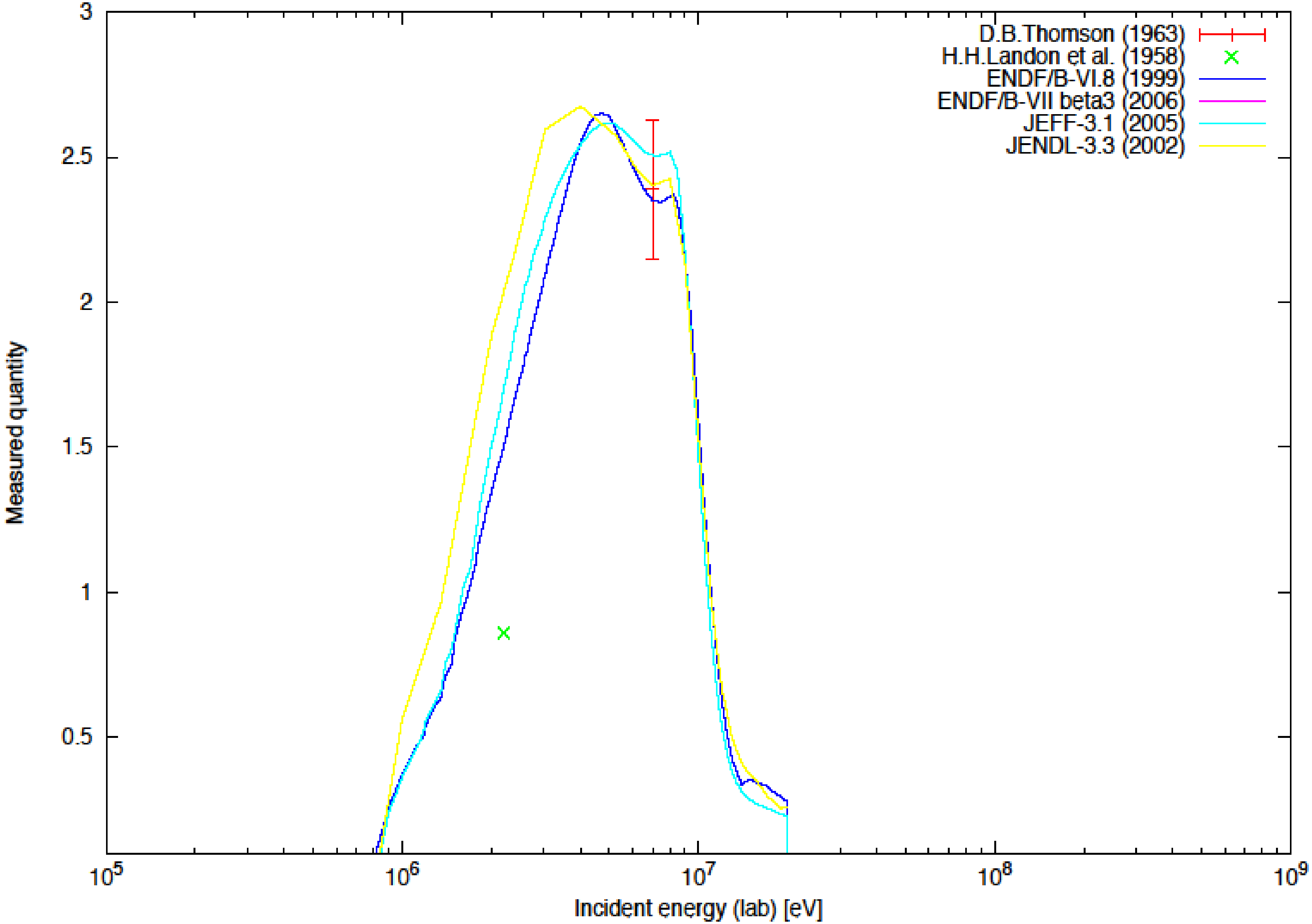


Fig. Pb-206 Inelastic Scattering Cross Section

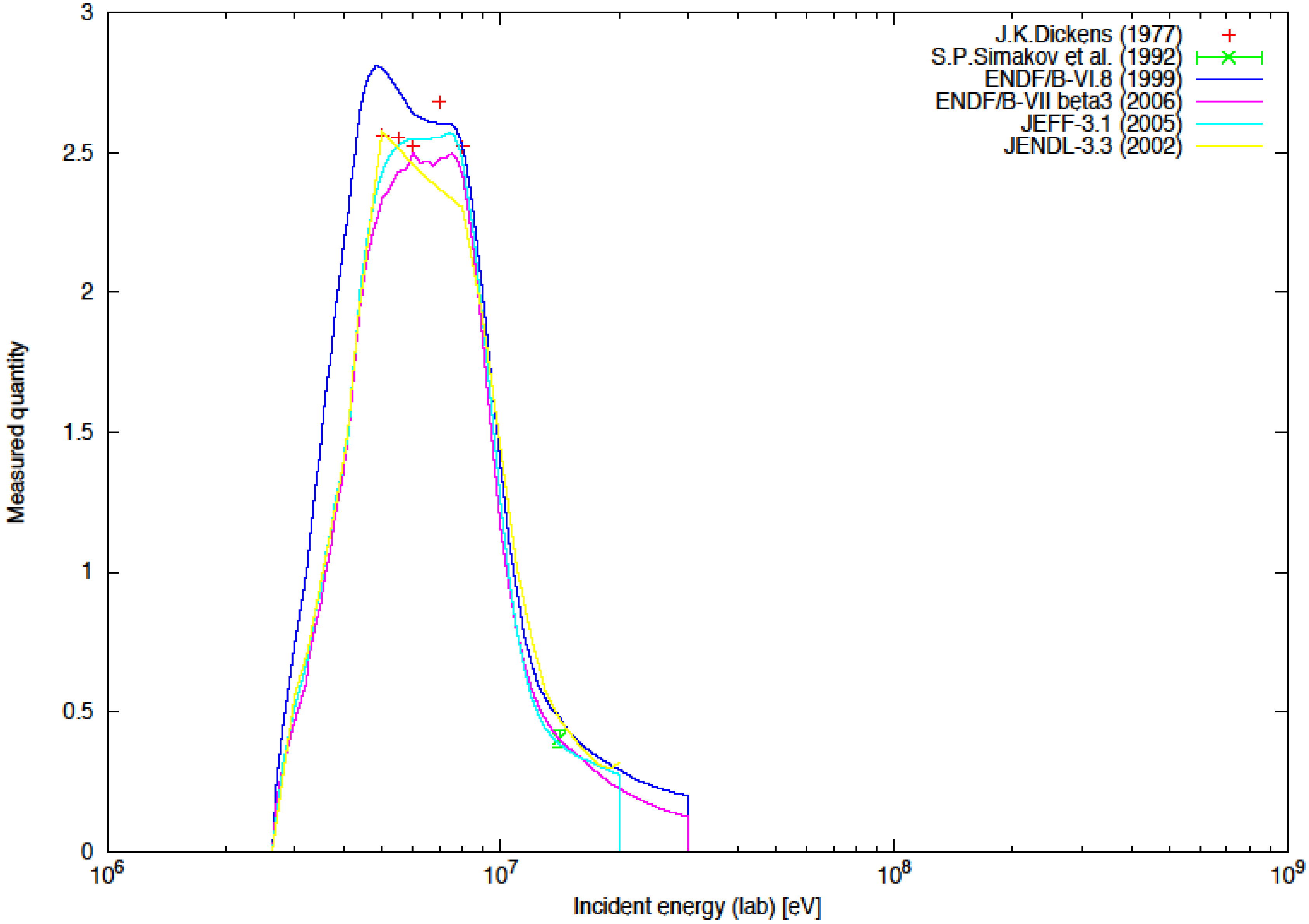


Fig. Pb-208 Inelastic Scattering Cross Section

Table LFR. Uncertainties (%) PEC - Breakdown by Isotope

(Major Contributions)

Isotope	K_{eff}	Doppler	Void	Burnup [pcm]
U238	±0.73	±2.2	±3.7	±13
Pu238	0.24	0.5	0.9	25
Pu239	1.50	3.4	4.0	213
Pu240	0.41	1.1	0.9	18
Pu241	0.32	0.7	1.0	112
Am241	0.10	0.4	0.3	6
Am242m	0.06	0.1	0.2	14
Cm242	0.02	0.0	0.0	11
Cm244	0.13	0.3	0.2	12
Cm245	0.21	0.4	0.7	34
Fe56	0.24	1.6	2.0	5
Pb206	0.88	3.2	13.4	18
Pb207	0.80	3.4	12.2	16
Pb208	0.49	4.0	7.4	8

Their Conclusions

Data uncertainty are significant only for a few parameters

- Keff for all systems
- Burup reactivity swing & isotopic density variations
- Void coefficient in FRs

Despite a significant MA recycling, MA data do not
play a major role with some exceptions

- Am-243 capture in the fast and thermal range
- Am-242m fission in the fast rang

As for major actinides, besides U-238, Pu isotope data uncertainties are very significant

Their Conclusions (cont'd)

As for structural/coolant materials, the most significant data are:

Fe inelastic in Fe, Pb and Si. Na elastic

Better and more complete covariance matrices are needed.

They do not need to be perfect, but reliable, and complete enough to make a relevant point clear.