

About This Publication and the Outline of the Organization of JAEA	8
--	---

## 1 *Research and Development Related to the Accident at TEPCO's Fukushima Daiichi NPS*

<b>Aiming to Provide Research and Development Results to Promote Environmental Recovery, Early Repatriation, and Decommissioning</b>	10
1. Evaluation of the Temperature Range of Melted Debris in the Reactor at the Nuclear Accident	13
– The Influences of Pu and Zr upon the Melting Temperatures of (U, Pu, Zr)O <sub>2</sub> –	
2. Laser Remote Analysis of Nuclear Fuel Debris	14
– Evaluation of Uranium Spectra by Laser Induced Breakdown Spectroscopy (LIBS) –	
3. Development of a Cutting Technique for Core-Structural Materials and Fuel Debris	15
– Cutting and Crushing of Core-Structural Materials and Fuel Debris with a Plasma Jet –	
4. Elucidation of the Core-Meltdown Procedure in Severe Accidents using Supercomputers	16
– Development of A Numerical Simulation Method for Evaluating the Influences of Chemical Reactions of Core Materials –	
5. Behavior of Radioactive Cesium Deposited in the Nuclear Reactor	17
– Investigation of Cesium-Deposition Behavior onto Stainless Steel –	
6. Integrity Evaluation of a Storage Vessel Containing Spent Cesium Adsorption Material	18
– Investigating the Possibility of Localized Corrosion of the Vessel Material under Irradiation –	
7. Toward the Recovery of Uranium from Fuel Debris	19
– Development of a Chlorination Method for Slightly Soluble Components –	
8. Visualization of the Radioactive-Cesium Distribution using a New Compton Camera Mounted on an Unmanned Helicopter	20
– Field Test of the Ce:Gd <sub>3</sub> (Al,Ga) <sub>5</sub> O <sub>12</sub> (GAGG) Scintillator Compton Camera –	
9. Accurate Measurement and Evaluation of Environmental Dose Rates in Air	21
– Dose-Rate Evaluation in the Environment using Monte Carlo Simulation –	
10. Evaluating Air-Dose Rates due to Radiocesium using a Supercomputer	22
– Calculation of Air-Dose Rates from Radioactive Cesium Distributed in the Ground –	
11. Transfer of Radioactive Cesium in the Hardwood Forest	23
– Study of Radioactive-Cesium-Transport Behavior in Trees in a Forest –	
12. Spatial Variation in Radioactive-Cesium Deposition Caused by Topographical Factors	24
– Detailed Examination of the Air-Dose Rate in a Mountainous Forest Catchment –	
13. Environmental Behavior of a Minute Amount of Radioactive Cesium	25
– Cs-Sorption/Desorption Behavior of Clay Minerals Considering the Actual Contamination Condition in Fukushima –	
14. Elucidating the Adsorption States of Cesium in Clay Minerals	26
– Analysis via First-Principles-Based Simulations –	
15. New Technology for Suppressing Cesium Migration from Forests	27
– Mild Regeneration of Village Forests with Polymers and Clay –	
16. Safety of Burial of Contaminated Soil at Public Parks	28
– In situ Experiments on the Migration of Radioactive Cesium from the Buried Soil –	
17. Realization of Automatic Analysis of Radioactivity in Samples	29
– Development of an Automatic Analysis System for Strontium-90 in an Environmental Sample –	

## 2 *Nuclear Safety Research*

<b>Implementing Continuous Improvements in Safety</b>	30
1. Prediction of Hydrogen Behavior in a Reactor Containment Vessel during a Severe Accident	31
– Thermal-Hydraulic Safety Research on Reactor Containment Vessels by the ROSA-SA Project –	
2. Evaluating the Degree of Deformation of the Fuel-Cladding Tube during Loss-of-Coolant Accidents	32
– Effect of Oxidation and Crystal-Phase Condition of the Cladding Tube –	
3. Chemistry of Fission Products during Severe Accidents	33
– Effect of the Chemical Form of the Fission Products upon the pH of Coolant Water –	

4. A New Attempt to Compare Radiation Risks with the Other Health Risks	34
– Radiation-Health-Risk Estimation in Disability-Adjusted Life Years (DALY) –	
5. Acquisition of Data Required for Severe-Accident Evaluation in a Reprocessing Plant	35
– Understanding the Release Characteristics of Ruthenium from Highly Active Liquid Waste during a Drying Step –	
6. Evaluation of the Criticality Characteristics of Fuel Debris	36
– Study of the Critical Experiment using the Modified STACY –	

## 3 Advanced Science Research

### Advanced Science Pioneers the Future

1. Reentrant Superconductivity Induced by a Strong Magnetic Field	38
– New Functional Properties of Uranium Compounds Controlled by a Magnetic Field –	
2. Electrical Generation from Liquid-Metal Flow	39
– Discovery of a New Principle of Electrical Generation via Electron-Spin Motion –	
3. Positron Diffraction Technique Reveals an Interface Structure between Graphene and Metal Substrates	40
– Elements in Substrate Change the Bonding Character of Graphene –	
4. A “Strange Particle” Breaks the Charge Symmetry of a Nucleus	41
– Successful Measurement of the Energy Levels of a Helium Hypernucleus –	
5. Exploring the Mystery of Neutrino Masses with Nuclear Physics	42
– High-Precision Calculation of $\beta\beta$ Decay using the K Supercomputer –	

## 4 Nuclear Science and Engineering Research

### Promoting Basic R&D on Nuclear Energy and Creation of Innovative Technology to Meet Social Needs

1. Pursuit of Accurate Nuclear-Reaction Cross-Sections in the Resonant Region	44
– Synergy between Nuclear-Data Measurement and Theory –	
2. Nuclear-Material Quantification by Observation of Transmitted Neutrons	45
– A Non-Destructive Assay Technique for Measurement of Complex Nuclear Fuel using a Neutron-Resonance Reaction –	
3. Measurement of the Corrosive Environment in High-Temperature, High-Pressure Water within Light Water Reactors	46
– Development of an Electrochemical Measuring Technique and Evaluation of the Corrosive Condition in High-Temperature Pure Water –	
4. Predicting the Property Changes in Nuclear Reactor Materials	47
– Understanding the Hardening Mechanism owing to Nano-Sized Defects: Molecular Dynamics Simulation –	
5. Exploring the Valence of Uranium by Luminescence	48
– Time-Resolved Laser-Induced Fluorescence Spectroscopy for Short-Lived Species –	
6. Preparation of a Micro-Sized Solid-Phase Extraction Cartridge	49
– Separation Cartridge Designed for Trace Analysis of Difficult-to-Measure Nuclides –	
7. Understanding the Migration Behavior of Transuranic Elements from Forests to Rivers	50
– Migration Behavior Research using Rare Earth Elements that Exhibit Chemical Similarity to Transuranic Elements –	
8. Toward Detailed Prediction of the Radiation Damage to Structural Materials in Accelerators	51
– Development of a Cryogenic Irradiation Device for Validation of the Radiation-Damage Model –	
9. Visualization of Water-Steam Fractions under High-Pressure and High-Temperature Conditions in Reactor Cores	52
– Development of Technology for the Measurement of Steam Volumetric Fractions in Fuel Assemblies with Wire-Mesh Sensors –	
10. Prevention of Severe-Accident Progression by Delaying Core Overheating and Melting	53
– Development of Fuel-Cladding Materials with High Resistance to Oxidation –	
11. Investigation of a New Transmutation System Concept	54
– Implementation of an Analysis Code for an Accelerator-Driven System with a Subcriticality Adjustment Mechanism –	
12. Recovery of Valuable Rare Metals from High-Level Radioactive Waste	55
– Separation of Rhodium with Ion-Exchange Resin –	
13. Toward the Establishment of a Method for Treating MA Transmutation Fuels	56
– Development of the Technology for Pyrochemical Treatment of MA Nitride Fuel –	

## 5 Quantum Beam Science Research

### Contributing to the Production of Innovative Outcomes in Science and Technology using Quantum Beam Facilities

1. Realization of High-Accuracy Orbit Control of a High-Intensity Proton Beam	59
– Development of a New Pulsed Power Supply for Eliminating Current Ripple –	
2. A New Tuning Apparatus for High-Intensity Beams in a Linac	60
– Beam-Phase-Distribution Measurement for Loss Reduction –	
3. Successful Impact Mitigation with Microbubbles in Liquid Metal	61
– Development of a Microbubble Generator in Mercury for Realizing the Most Intense Spallation Neutron Source in the World –	
4. Opening up a New Frontier of Material Science using Single-Crystal Neutron Diffraction	62
– Development of the Extreme Environment Single Crystal Diffractometer SENJU –	
5. Probing Novel Characteristics of Unconventional Superconductors via Neutron Scattering under a Magnetic Field	63
– Magnetic-Field-Enhanced Antiferromagnetism in Unconventional Superconductors –	
6. Elucidation of the Selective Separation of Cesium by Small-Angle Neutron Scattering	64
– Toward Selective Separation of Cesium using a $\pi$ - $d$ Hybrid Orbital –	
7. Electric Power Generation by Temperature Variation	65
– Observation of Ferroelectric Materials under Power Generation using Synchrotron X-ray Diffraction –	
8. Unmasking the Ferromagnetism in Magnetically-Doped Topological Insulators	66
– Toward Ultra-Low Power-Consumption Spintronic Devices –	
9. Nondestructive Three-Dimensional Elemental Analysis using an Ion Microbeam	67
– Development of Particle-Induced X-ray-Emission Tomography –	
10. The Challenge of Realizing Unexplored Super-Strong Electromagnetic Fields with a Laser	68
– J-KAREN-P Laser Development –	
11. Dual Treatment and Diagnosis Role Played by Simultaneous Emission of $\beta$ - and $\gamma$ -rays	69
– Production of Highly Purified Lutetium-177 for Radioimmunotherapy –	
12. Elucidation of the Reaction Mechanism of an Anti-Cancer Drug at the Atomic Level	70
– Precise Structural Analysis of a Drug’s Target Protein using Synchrotron X-ray Radiation –	
13. Toward Advancement of Heavy-Particle Cancer Therapy	71
– Successful Development a New Radial Dose-Simulation Model –	
14. Which Liver-Sashimi was Treated by Radiation?	72
– Development of a Method to Distinguish Disinfected Liver –	
15. A Polymer-Electrolyte-Membrane Fuel Cell with the World’s Highest Power Density	73
– Preparation of Polymer-Electrolyte Membranes by Radiation-Induced Graft Polymerization –	
16. Toward the Realization of Quantum-Information Communication and Quantum Computing	74
– Exploring Single-Photon Sources in Silicon Carbide –	
17. Isotope Separation Utilizing Control of Molecular Rotation	75
– An Isotope-Separation Method Effective for Heavy Isotopes –	
18. A Quantitative Liquid-Analysis Method using Laser-Induced Plasma-Emission Light	76
– A Highly Sensitive In situ Liquid-Analysis Technique under Severe Environments –	
19. Real-Time Observation of Lattice Deformation in Nitride Semiconductors	77
– Proposal for a New Lattice-Deformation Model that Defies Conventional Theory –	

## 6 HTGR Hydrogen and Heat Application Research

### Research and Development of HTGR, Hydrogen Production, and Heat Application Technologies

1. Development of International Safety Standards for Commercial HTGRs	79
– Safety Requirements for the Design of HTGRs Based on the Inherent Safety Features Demonstrated by HTR –	
2. Toward Enhancing the Safety of Plutonium-Burner High Temperature Gas-Cooled Reactors	80
– Prevention of Internal Gas-Pressure Failure of Fuel Particles Coated by Oxygen Getters –	
3. Development of Oxidation-Resistant Graphite Materials for High Temperature Gas-Cooled Reactor Cores	81
– Collaborative Study with the Institute of Nuclear Physics in Kazakhstan –	

4. Investigation of the Process Conditions of Inhibition Reactions for Thermal-Efficiency Improvement ----- 82  
– Effects of Impurity Contamination in an HI Concentrator –
5. Demonstration of Hydrogen-Cogeneration Technology using the HTTR ----- 83  
– Designing the Helium Gas Turbine to Enable an Operability-Demonstration Test –
6. Proving the Seismic Integrity of the High-Temperature Gas-Cooled Reactor ----- 84  
– Integrity Confirmation of Graphite Components by Seismic Evaluation and Visual Inspection –

## 7 Research and Development of Fast Reactors

- R&D of Fast Reactor Cycle Technology** ----- 85
1. Leading the World in Safety with the Next-Generation Sodium-Cooled Fast Reactor ----- 86  
– Development and Standardization of Safety Design Criteria and Safety Design Guidelines –
  2. Fast-Reactor-Core Design for Enhanced Radioactive-Waste Reduction ----- 87  
– Harmonizing Safety and Nuclear Transmutation –
  3. Improving Fast Reactor Safety ----- 88  
– Experimental Confirmation of Fuel-Subassembly Melt and Discharge Behavior –
  4. Clarification of the Wastage Phenomena of the Heat-Transfer Tubes of a Steam Generator in a Sodium-Cooled Fast Reactor ----- 89  
– Evaluation on Corrosion Behavior with High-Temperature Sodium Hydroxide Flow –
  5. The Effect of Am upon the Thermophysical Properties of MA-MOX Fuel ----- 90  
– The Relationship between Oxygen Potential and the O/M Ratio of  $(\text{Pu}_{0.928}\text{Am}_{0.072})\text{O}_{2-x}$  –
  6. Dating of Crush-Zone Slip Episodes under a Subsurface High-Temperature Condition ----- 91  
– Insights from Thermal-History Analyses Based on the Fission-Track Dating Method –

## 8 Research and Development Related to the Backend of the Nuclear Fuel Cycle and the Reprocessing of Spent Nuclear Fuel

- Progress in the Decommissioning of Nuclear Facilities and the Treatment and Disposal of Radioactive Waste** ----- 92
1. The Rapid and Precise Large-Scale Classification of Waste Drums ----- 94  
– Feasibility Study on the Application of Machine Learning to Large Datasets for Rapid Classification –
  2. Removal of Nitrate Salts from Bituminized Waste Products ----- 95  
– Development of a Technology to Reduce the Impact of Nitrate Salts upon the Disposal Environment –
  3. Toward Radioactive-Waste Conditioning Suitable for Near-Surface Disposal ----- 96  
– Study on Standards Concerning a Solidification Method by using Mortar –
  4. Influence of Distant Earthquakes upon Groundwater Flow ----- 97  
– A Case Study in the Tono Area –
  5. Estimation of Underground Density Structure ----- 98  
– Development of a Technique to Estimate Underground Density Structure using Cosmic-Ray Muons –
  6. Time History of Hydraulic Diffusivity Related to URL Excavation ----- 99  
– A Poroelastic Analysis of Groundwater-Pressure Response to Atmospheric Loading –
  7. Technology for Long-Term Monitoring of Damage around a Shaft ----- 100  
– Monitoring the Excavation-Damaged Zone using Optical-Fiber Sensors –
  8. Powerful Tools for Dating of Sediments ----- 101  
– Development of High-Accuracy Analysis for Volcanic Glass Shards –
  9. Assessment of the Effect of Geological Disposal upon Human Beings ----- 102  
– Development of a Modeling Method for Biosphere Assessment Corresponding to Surface-Environmental Condition –
  10. Various Parameter Settings upon Radionuclide Release ----- 103  
– Review of the Release Behavior of Radionuclides for Spent-Fuel Disposal –
  11. In Microwave Ovens, the Height of the Heating Specimen Changes the Ease of Warming ----- 104  
– Heating Efficiency of the Nitric Acid by the Microwave –

## 9 Nuclear Fusion Research and Development

- Toward Practical Use of Fusion Energy** ----- 105
1. Controlling Robots in a Radiation Environment ----- 106  
– Using a Robot Vision-Based System to Position a Manipulator in a Fusion Reactor –
  2. Manufacturing Superconducting Coils with High Accuracy ----- 107  
– Establishing a Manufacturing Method for High-Circularity Superconducting Coils to Reduce the Error Magnetic Field –
  3. Measurement of Magnetic Fluctuation of Fusion Plasmas ----- 108  
– Development of Simple, High-Performance Magnetic Sensors –
  4. Improving the Estimation Accuracy of Plasma Shape ----- 109  
– Optimizing the Predictive Accuracy of the Plasma-Shape-Estimation System –
  5. Toward Safe Operation of Nuclear Fusion Reactors ----- 110  
– Discovery of a New Magnetohydrodynamic Instability that Causes Disruptive Events in Fusion Plasmas –
  6. Confining Tritium in a Fusion Facility ----- 111  
– A Catalytic-Reactor Design that Ensures Tritium Oxidation under All Possible Conditions –
  7. Achievement of a Prototype-Accelerator-Performance Goal for the International Fusion Material Irradiation Facility (IFMIF) ----- 112  
– Successful Injector-Beam Acceleration of the High-Current Deuterium Accelerator –
  8. Management Scenario for Radioactive Wastes with Consideration of Public Acceptance of a Fusion Reactor ----- 113  
– Study on Volume Reduction of Radioactive Wastes for a Fusion Reactor –
  9. Development of Highly Efficient Neutron-Multiplier Materials for Early Realization of a DEMO Reactor ----- 114  
– Research on Ternary Advanced Neutron Multipliers –

## 10 Computational Science and E-Systems Research

- Computational Science for Nuclear Research and Development** ----- 115
1. Advancement of Seismic-Response-Simulation Techniques for Nuclear Facilities ----- 116  
– Vibration Simulation of a Nuclear Facility Building using a Three-Dimensional Vibration Simulator –
  2. Determination of the Thermal Properties of Nuclear Fuels through Numerical Simulation ----- 117  
– First-Principles Calculations of the Heat Capacity of Plutonium Dioxide –
  3. Quest for Light Metals with Good Formability ----- 118  
– A Novel Deformation Mechanism in Hexagonal Metals Revealed by Quantum Calculations –
  4. Simulation Technology for Long-Time-Scale Analyses of Fusion Plasmas ----- 119  
– Progress Toward Multi-Time-Scale Analyses –

## 11 Development of Science & Technology for Nuclear Nonproliferation

- Development of Technology and Human Capacity Building in the Area of Nuclear Nonproliferation and Nuclear Security to Support Peaceful Use of Nuclear Energy** ----- 120
1. Estimating the Production Date of Nuclear Material ----- 121  
– Round-Robin Uranium-Age Dating for Nuclear Forensics –
- Promotion of Collaboration – Intellectual Property Held by JAEA ----- 122