Evolution of Safeguards and Nuclear Nonproliferation Technologies in Japanese Nuclear Fuel Cycle

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External Events Resulting in Promotion of Safeguards Technologies Development for Nuclear Fuel Cycle
核燃料サイクルの保障措置技術開発推進に繋がった外的イベント

- **TASTEX（Tokai Advanced Safeguards Technique Exercise）**
  1978～1981　Development of Safeguards Techniques for Tokai Reprocessing Plant by Japan, US, France, IAEA

- **HSP（HEXAPARTITE, Hex Partite SG Project）**
  1980～1983　Development of safeguards approach for Centrifuge Enrichment Facility by Japan, US, UK, Germany, Holland, Australia, IAEA, EURTAOM

- **LASCAR（Large Scale Reprocessing Plant Safeguards ）**
  1988～1992　Technical forum to discuss safeguards approach for large scale reprocessing plant by Japan, US, UK, France, Germany, Holland, Australia, IAEA, EURTAOM

Development of Safeguards Technologies for Reprocessing Plant
再処理に係る保障措置技術開発

1975 1980 1985 1990 1995 2000 2005

Tokai Reprocessing Plant (TRP)

TASTEX

TRP Improvement Plan

SRD

HMMS/VWCC

Xe measurement, LASW measurement, Pulse filter measurement

SMMS

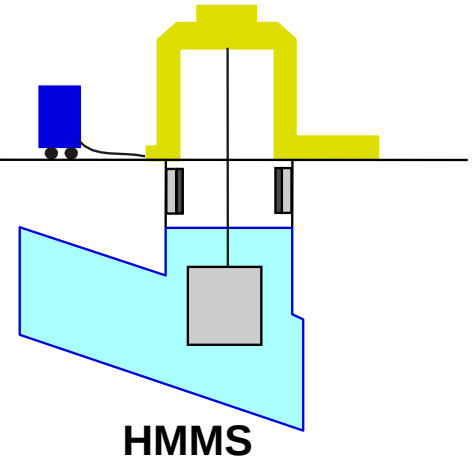
OSL cooperation

K-edge、NRTA

Waste

Reprocessing

Physical Model



Plutonium Conversion Development Facility (PCDF)

HBAS/WDAS/BBAS

TAMS

iPCAS

Upgrade of HBAS

Discussion with IAEA and US

Recycle Equipments Test Facility

Safeguards System

Dry reprocessing

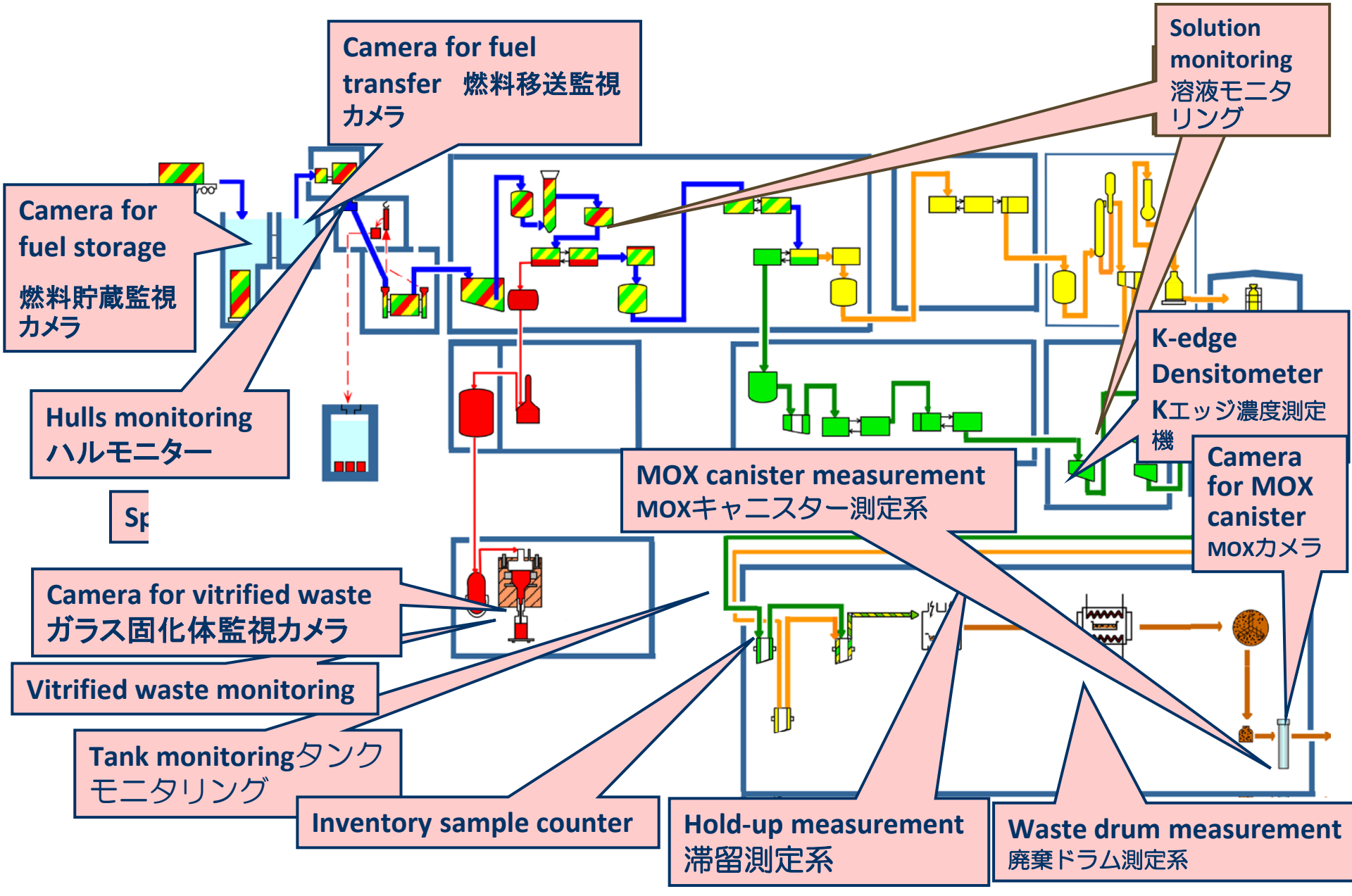
Safeguards System

LASCAR

Rokkasho Reprocessing Plant

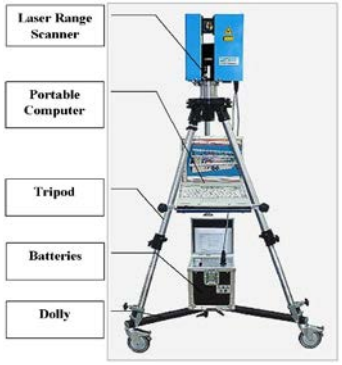
Safeguards Equipment at TRP and PCDF

東海再処理施設・プルトニウム転換施設における保障措置機器等

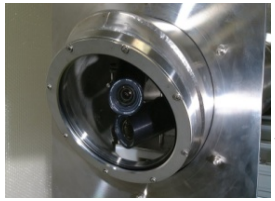


Safeguards for Rokkasho Reprocessing Plant
六ヶ所再処理工場の保障措置

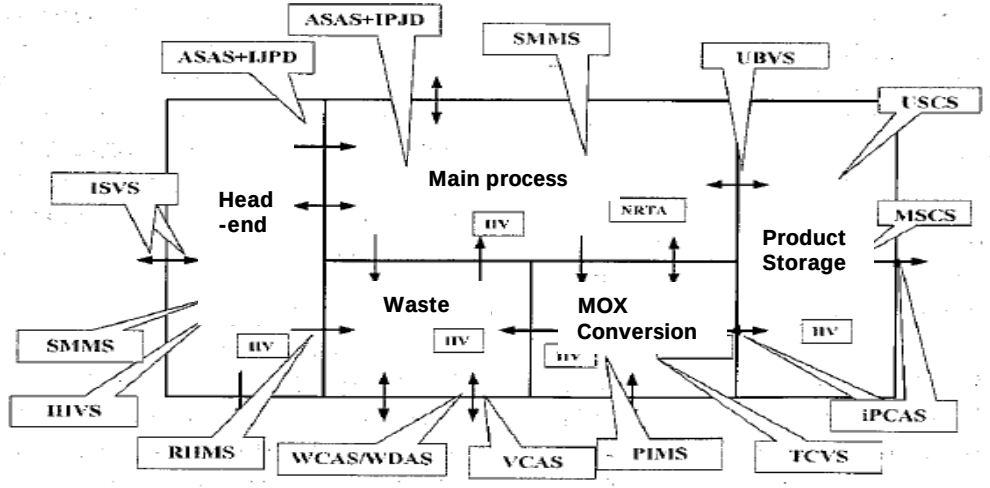
- DIQ/DIV (Design Information Questionnaire /Verification)　設計情報検認
- Dual C/S（Containment / Surveillance; Cameras, Radiation Detectors）封込め監視
- Process Monitoring（Hull Monitoring, Solution Monitoring, Process Inventory Measurement System　etc）　プロセスモニター（ハル・溶液移送・プロセス在庫用）
- NRTA (Near Real Time Accountancy)　ニア・リアルタイム(近実時間）計量法
- Unattended Mode Inspection, Centralized Collection of Inspection Data　非立会モード査察、中央査察データ集約
- Various NDAs (Non-destructive Assays)　さまざまな非破壊測定系
- Advanced Accountancy System 先進的な計量システム
- On-Site-Laboratory (Rapid Verification Measurement)　オンサイト査察分析所



3D laser scanning device for DIV

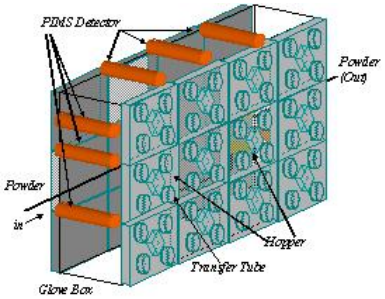


Camera/Radiation of IHVS



注）
ＩＳＶＳ：Integrated Spent fuel Verification System
ＩＨＶＳ：Integrated Head-end Verification System
ＡＳＡＳ：Automatic Sampling Authentication System
ＷＣＡＳ：Waste Crate Assay System
ＶＣＡＳ：Vitrified Canister Assay System
ＴＣＶＳ：Temporary Canister Verification System
ＭＳＣＳ：MOX Storage C/S System
ＵＳＣＳ：Uranium Storage C/S System
ＳＭＭＳ：Solution Monitoring and Measurement System
ＲＨＭＳ：Rokkasho Hulls Drum Measurement System
ＩＪＰＤ：Inspector Jug Passage Detector
ＷＤＡＳ：Waste Drum Assay System
ＰＩＭＳ：Plutonium Inventory Measurement System
ｉＰＣＡＳ：Improved Plutonium Canister Assay System
ＵＢＶＳ：Uranium Bottle Verification System

On-Site-Laboratory with Automated Sampling System



PIMS on Glove Boxes

Development of Safeguards Technologies for MOX Fabrication Facilities
MOX燃料製造施設に係る保障措置技術開発

ENMC

1975 1980 1985 1990 1995 2000 2005

PPFF

PFPF

Holdup

Discussion with IAEA and US

WCAS, SBAS

RMS, ENMC, Spike

ATR process

Discussion with IAEA and US

Safeguards System

GUAM

JMOX

Unattended Verification System and Material Accountancy System at JAEA-PFPF

JAEA−プルトニウム燃料製造施設における計量管理システムおよび非立会い検認システム

SBAS
(Hold-up Measurement System滞留プルトニウム測定システム)

Advanced Accountancy System先進計量システム

Near Real Time Accountancy 近実時間計量
Non Destructive Assay System 非破壊分析

INPUT

Feed Storage → Process → Product Storage

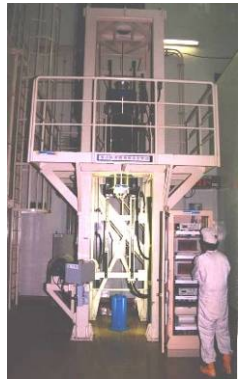
OUTPUT

WDAS (Waste Drum Measurement System 廃棄物ドラム測定システム)

PCAS
(Plutonium Canister Measurement System プルトニウムキャニスター測定システム)

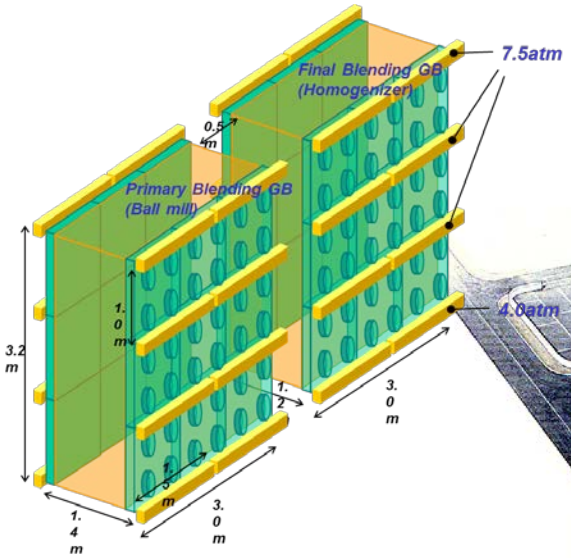
FAAS (Fuel Assembly Measurement System燃料集合体測定システム)

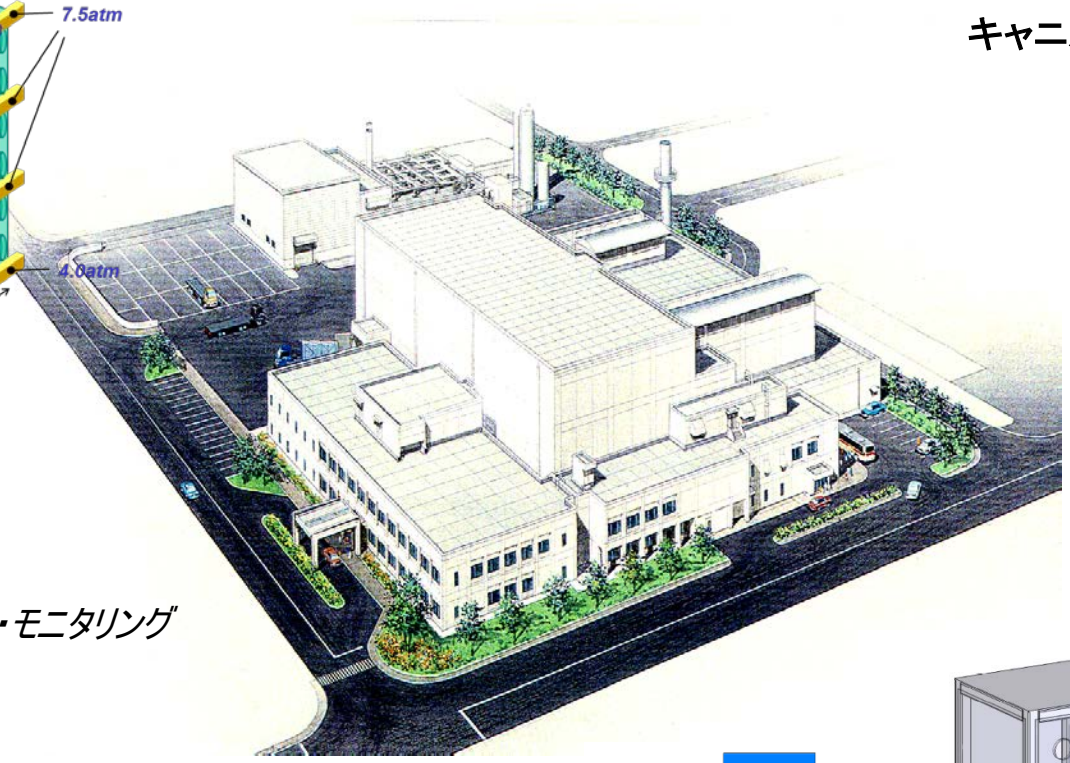
Advanced Containment and Surveillance
Unattended Verification System
先進封じ込め監視システム / 非立会い検認



Further evolution for J-MOX

JMOX施設のための更なる保障措置測定技術の進化



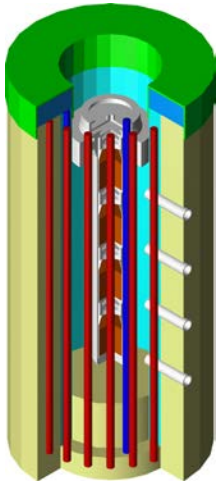


GUAM

グローブボックス内非立会い測定・モニタリングシステム

- ***Continuous holdup monitoring for Pu mass***
- ***Also, verifies absence of activity***

iPCAS（改良プルトニウムキャニスター測定システム）



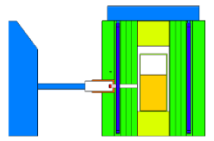
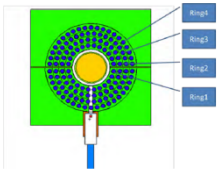
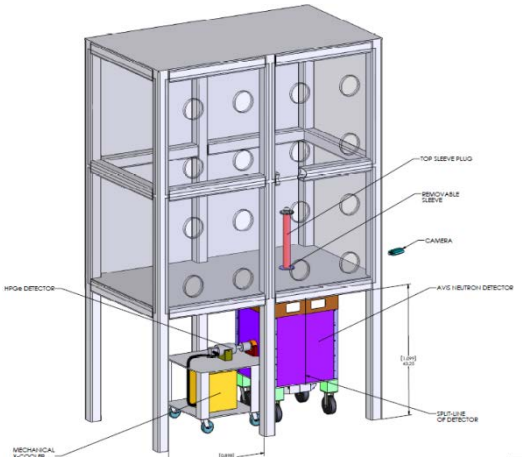


Figure 3 Vertical cross-section of ENMC-DS with large sample





AVIS (先進インベントリー試料検認システム)

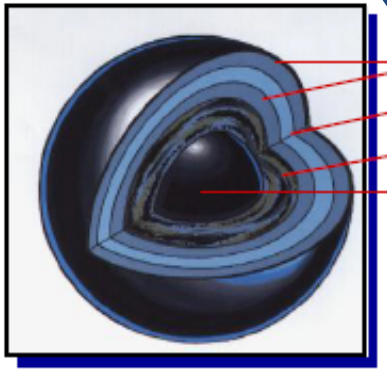
Another equipment

AMAGB, FPAS, FAAS etc.

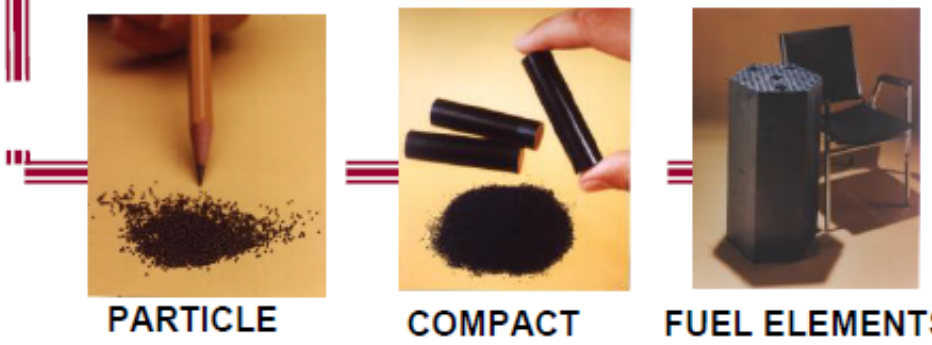
Potential Techniques for Future Pu Burn/Consumption
プルトニウムの非常に高い燃焼/消費の可能性のある技術

Example

Deep-Burn of TRISO Fuel at HTGR
高温ガス炉によりTRISO燃料を用いた高燃焼
（90 ~ 120 GWD/MT）



TRISO Coated fuel particles (left) are formed into fuel rods (center) and inserted into graphite fuel elements (right).



Initially charged Pu-239 > 50% （初期Pu239は50%以上）

Pu-239 at discharge < 10% （最終的Pu239は10%以下）

C. Rodriguez, et al.: Nuclear Engineering and Design 222 (2003)

Future Needs to Improve Safeguards and Nuclear Nonproliferation Technologies in NFC

核燃料サイクルにおける保障措置技術・核不拡散技術改良ニーズ

- Continue to pursue more effective and efficient measurement and C/S systems
- Improvement and more applications of unattended measurement and monitoring technologies
- Develop Proliferation Resistant Fuel Cycle Technologies (PRFCTs) to facilitate long-term Pu management
- SBD for the new PRFCTs
- Maintain and improve quality of operator and inspector's measurement / analysis systems
- Pursue further co-operations in SSAC
- Development of accountancy/safeguards concept and measurement technologies for Fukushima Daiichi Power Plants

- より効果的・効率的な測定および封込め監視技術の開発の継続
- 非立会い測定、リモートモニタリング技術の改良と更なる適用拡大
- 長期的観点でのプルトニウム取扱いを容易にする核拡散抵抗性の高い核燃料サイクルの開発
- 施設側/査察側の測定・分析の品質維持向上
- 国内計量管理システムおける更なる協力
- 福島第一原子力発電所の計量・保障措置の概念および測定技術の開発