Reduction and Resource Recycle of High Level Radioactive Waste with Nuclear Transmutation

核変換による高レベル放射性廃棄物の大幅な低減・資源化

Reiko FUJITA
藤田　玲子
Japan Science and Technology Agency
科学技術振興機構

革新的研究開発推進プログラム（ImPACT）

Impulsing PAradigm Change through disruptive Technologies

制度の目的・特徴

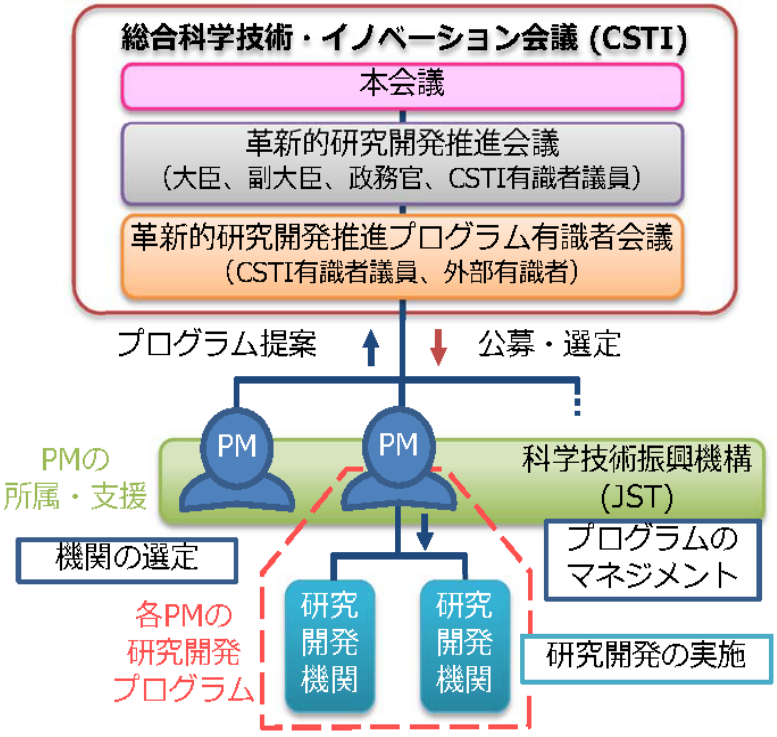
「実現すれば、社会に変革をもたらす非連続イノベーション*を生み出す新たな仕組み」
ハイリスク・ハイインパクトな挑戦を促し、我が国の研究開発マインドを一変させる
→成功事例を、我が国の各界が今後イノベーションに取り組む際の行動モデルとして示す

＊積み上げではない、技術の連続性がないイノベーション（例．ガソリン車→燃料電池車）

予算・法律上の措置

○平成25年度補正予算に550億円を計上
○基金設置のため、(独)科学技術振興機構(JST)法を改正

事業のスキーム



○CSTIがテーマを設定し、プログラム・マネージャー(PM)を公募
○PMが研究開発プログラムを提案し、CSTIが選定
○PMは、目利き力を発揮して優秀な技術と人材を結集し、自らの権限と責任で臨機応変にプログラムをマネジメント

CSTIが設定したImPACTのテーマ

1. 資源制約からの解放とものづくり力の革新
「新世紀日本型価値創造」
2. 生活様式を変える革新的省エネ・エコ社会の実現
「地球との共生」
3. 情報ネットワーク社会を超える高度機能化社会の実現
「人と社会を結ぶスマートコミュニティ」
4. 少子高齢化社会における世界で最も快適な生活環境の提供
「誰もが健やかで快適な生活を実現」
5. 人知を超える自然災害やハザードの影響を制御し、被害を最小化
「国民一人一人が実感するレジリエンスを実現」

PM選定の視点

①PMの資質・実績
・構想力、専門的知見、コミュニケーション能力、情報収集力、成し遂げる意欲、リーダーシップ、説明能力　等
②PMの提案する研究開発プログラム構想
・ハイリスク・ハイインパクトな挑戦が必要とされるものか
・実現可能性を合理的に説明できるか、成果が検証可能か　等

スケジュール

２６年3月 PM公募、6月 PM決定
研究開発プログラムの作り込みを経て秋ごろから実施

ImPACT Program

Reduction and Resource Recycle of High Level Radioactive Waste with Nuclear Transmutation

ImPACT Program Manager

藤田　玲子　*Reiko FUJITA*

Present：Toshiba Corporation Power Systems Company
Chief Fellow, Power & Industrial Systems
Research & Development Center

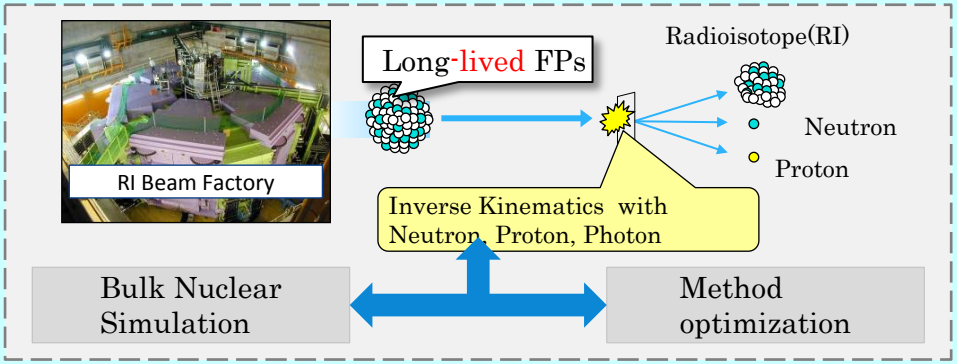
She graduated the Doctor Course of Tokyo Institute of Technology 1982 and got a Chemistry of Ph.D. She joined Toshiba Corporation 1983. She has been a Chief Fellow in Power & Industrial Systems Research & Development Center since 2012.
She has developed a metallic fuel reprocessing for Fast Breeder Reactor and a transuranium elements recovery process from high-level radioact waste. She is one of most famous researchers in Pyrochemical Process In Molten Salts. She got Awards of Atomic Energy Society of Japan and Award of Electrochemical Society of Japan.

＜研究開発プログラムの概要＞

We search for the nuclear reaction pathways to transmute long-lived fission products contained in the nuclear waste for which the only disposal option has been land burial. We also challenge to recycle platinum group and rare earth metals from the waste.

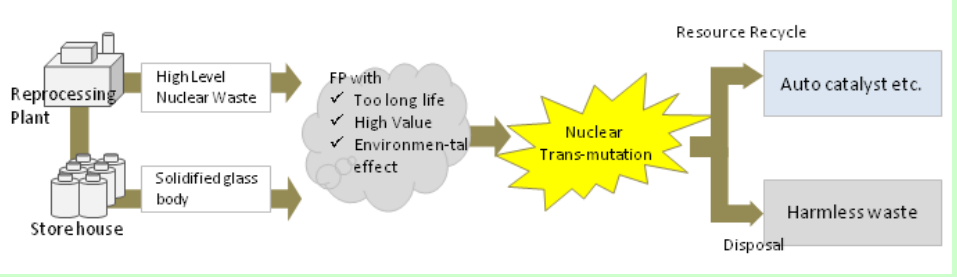
＜非連続イノベーションのポイント＞

Deriving the nuclear pathway data to transmute long-lived fission products to short half-life or stable nuclides has not been successfully accomplished to date. We will obtain such data by using state-of-the art accelerator facilities which are available at present.



＜期待される産業や社会へのインパクト＞

Application of such a process would decrease the load of processing and disposing of high level radioactive waste for future generations. Additionally, it would provide a new source of platinum group and rare earth metals not dependent on overseas markets.



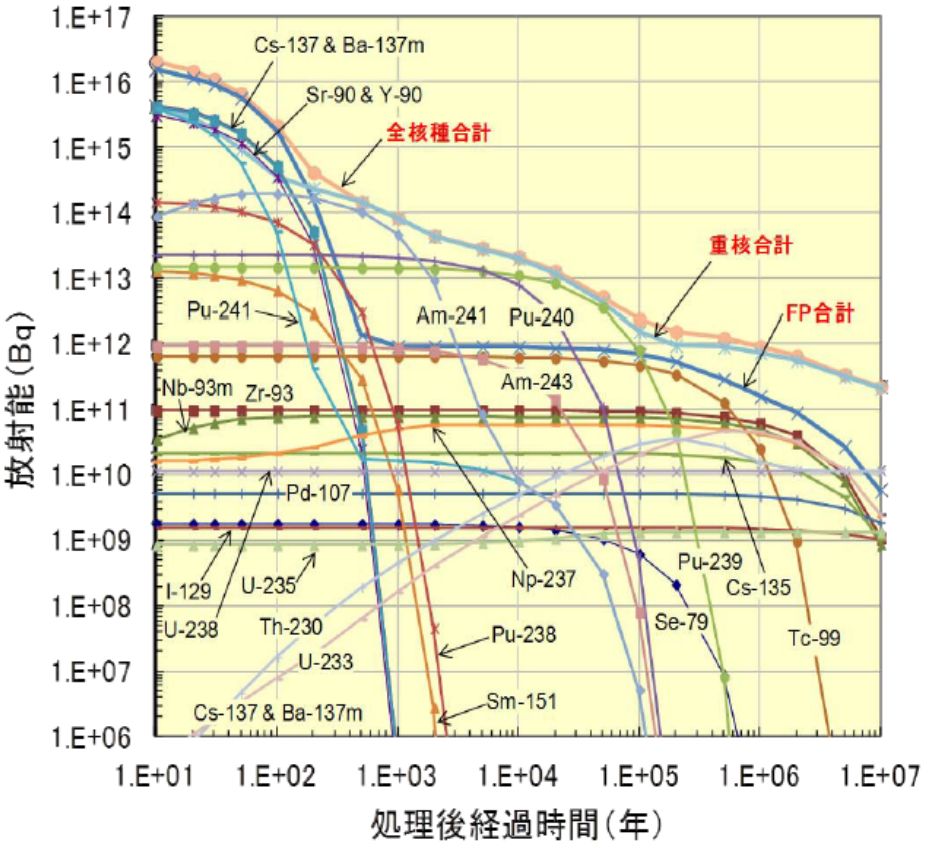
PM members

PM	R&D Program Title	Outline	Feature
 Kohzo ITO (University of Tokyo)	Super thin and tough polymer program	Create super thin and tough polymer exceeding the conventional limit, and change the society from materials innovation, leading to ultimate safe and energy-saving vehicles.	Materials innovation from great advantages of Japan
 Keisuke GODA (University of Tokyo)	Planned Serendipity for Life Innovation	Identify and isolate rare target cells from a large population of cells and perform a complete analysis of the target cells with extremely high accuracy at extremely high speed for diverse life innovations.	Turning serendipity into planned happenstance
 Yuji SANO (Toshiba Corp.)	Society of safe, secure and longevity implemented by ubiquitous power lasers	Develop small and high-power devices generating photon and quantum beam by merging laser and plasma technologies. Applicable to infrastructures, security and advanced therapy.	Expand application through miniaturization and cost reduction
 Satoshi TADOKORO (Tohoku University)	Tough Robotics Challenge	Develop key fundamental technologies for remote autonomous robots that can toughly complete missions under unknown changing disaster conditions.	Robotics for extreme disaster situations to open future outdoor services
 Reiko FUJITA (Toshiba Corp.)	Reduction and Resource Recycle of High Level Radioactive Waste with Nuclear Transmutation	Challenge to ecological recycle of platinum group and rare earth metals contained in nuclear waste by searching for nuclear reaction pathways to transmute long-lived fission products for which deep geological disposal has been the only option.	Decreasing the load of radioactive waste disposal for future generations
 Reiko MIYATA (Nagoya University)	Ultra high-speed multiplexed sensing system beyond evolution for the detection of extremely small amounts of substances	Establish a simple and effective method to protect ourselves against noxious and hazardous substances by using the nano-electronics technology exceeding the excellent ability of insects in order to realize a healthy and comfortable life. Detect harmful and hazardous risks rapidly and easily, and realize a society where we can really feel safety and security.	Implementation in society of the ability to exceed the human

PM	R&D Program Title	Outline	Feature
 Masashi SAHASHI (Tohoku University)	Realization of ultimate eco-IT devices for long-time use without charging	Record on magnetic memory using voltage only, without current flow. Reduce the power consumption of IT devices, and realization of an eco-society with no charging- stress.	100 times energy saving Revival of Japan as an electronics nation
 Yoshiyuki SANKAI (Univ. of Tsukuba)	Innovative Cybernic System for a ZERO intensive nursing-care society	Develop technology which is a fusion of human, robot and other devices, to improve the independence of people who require nursing care as well as to dramatically reduce the physical burden of caregivers. Challenge to fuse neural systems, the body and various devices through contact, implantable and non-contact methods, and to construct personal-care/life-support infrastructure.	Dramatic extension of residual physical function Implementation of innovative personal-care / life-support tech connecting robot to human
 Takane SUZUKI (Kojima Industries Corp.)	Material industrial revolution by super sophisticated configuration protein	Enable the production of sophisticated configuration protein over the spider thread performance which toughness per weight is over 340 times as much as steel. Material industry revolution by utilize bio function.	Challenge of biofunction reproduction
 Takayuki YAGI (Canon Inc.)	Innovative visualization technology to lead to creation of a new growth industry	Establish an innovative 3D imaging method with combination of cutting-edge laser and ultrasound to visualize invisible portions, and contribute to a healthier and prosperous society.	Real-time 3D imaging with laser and ultrasound
 Yoshinori YAMAKAWA (NTT Data Institute of Management Consulting Inc.)	Actualize Energetic Life by visualizing and controlling brain information	Visualize and control brain information to build a platform for manufacturing and service innovation, which include equipments controlled by thoughts, or support multilingual communication.	New society brought by "visualization" of "thoughts"
 Yoshihisa YAMAMOTO (National Institute of Informatics / RIKEN)	Quantum artificial brain and secure network for an advanced information society	Establish the infrastructure for an advanced information society by developing the three key technologies: quantum artificial brain, quantum secure network and quantum simulation.	Quantum artificial brain for solving various combinatorial optimization problems

High Level Waste (HLW) for Zero

- **Minor Actinide（MA）and Long Lived Fission Products (LLFP*） should be reduced.**
- **MA is made progress in the research of Nuclear Fuel Cycle because of use for Nuclear fuel by ADS-PJ JAEA.**
- **LLFP is treated in glass solidification for deep disposal but has issue in the suitability of location.**

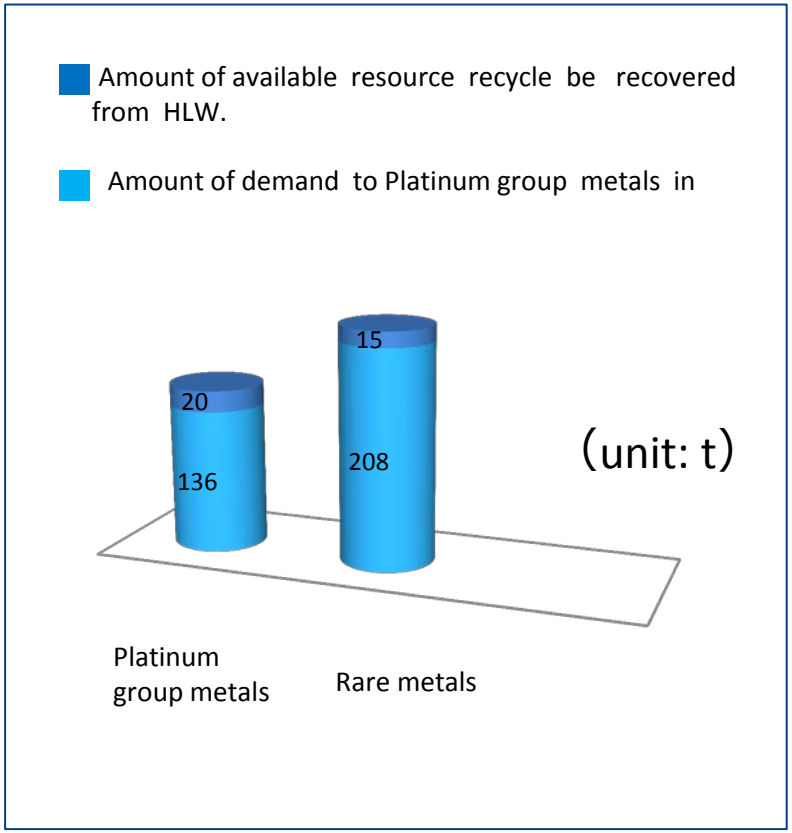


*LLFP：Long Lived Fission Products, Cesium（Cs）-135, Palladium（Pd)-107 etc.

New alterative option for Japanese people should be showed for HLW disposal by research of LLFP.

High Level waste (HLW) for resource recycle

- LLFP in HLW contains rare metals for variable elements.
- Rare metals were recovered from HLW but it is impossible to recycle for use because the rare metal contains radioactive materials.
- Transmutaion research has been started since 1980 but the various data could not be got because the facility had not yet installed.



Both partitioning and transmutation are necessary to recycle for natural materials.

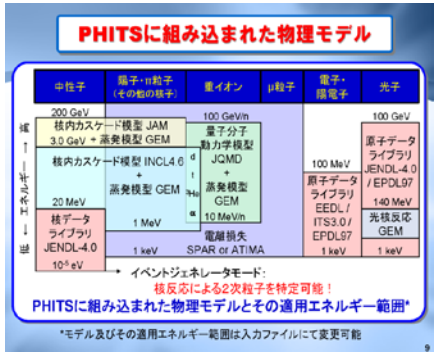
Scientific Progress and present situation

- Recently , the most powerful RI beams (x 100 of any other facilities at present) has been completed and any kind of nuclear data is possible to be available by innovative technique.
- The excellent simulation software and evaluated nuclear data base are useful in Japan.

RI Beam Factory（RIBF)

J-PARC

PHTIS included physical model



The first transmutation system is possible to be developed by combination with partition technique

Outline of this program

- Goal: Completing of plant concept design of Partitioning and Transmutation (P&T) system
- Scenario of P&T and system concept design for international patents
- Research and development for leading P&T studies in the world

Reprcessing Plant

High Level Waste

Storage facility

Glass solid

Partitioning and Recovery

Alkali metals Alkali earth metals

Platinum group metals Rare earth metals

Resource recycle

Stable isotopes for disposal

Nucluide medicine

Catalyst | magnet | Nucluide medicine | Stable waste

Pd Nd Dy Xe

Y Mo Rh Ru

Ba Zr

Sr Se

Useful elements Useful RI

Short Lived FP

Transmutation plant for practical use ~2050

Pilot plant for demonstration ~2030

Conceptual P&T System ~2019

Nuclear data for transmutation

(*half life)

★世界一の施設により世界初データ取得が可能に

Cs-135(230万年*)

RI

Neutron

Photon

Inverse Kinematics with Neutron, Proton,Photon

Sr-90(28.5年*)

Muon, Neutron Capture

Pd-107(650万年*)
Zr-93 (153万年*)

Fast neutron, slow neutron reaction

Nuclides keeping high radioactivity for over 10 thousand years

Tc-99, I-129, Se-79, Pd-107, Sn-126, Zr-93, Cs-135

Useful elements

Pd, Rh, Ru, Nd, Dy, Xe, Y, Eu

Nuclides for eco problem

Cs-137, Sr-90

※I-129 and Tc-99 have already been promised transmutation by(n,γ) reaction.

Method Optimization

Energy region
Beam Species
Target
Accelerator
Even-Odd separation

New control of nuclear reaction

W/O Isotope separation
Energy controlled Neutron selective mutation
Transmutation in condensed matter

DUAL USE

PHITS. Reaction Model

Bulk Nuclear Simulation

- Composition
- Cross section data

Feedback

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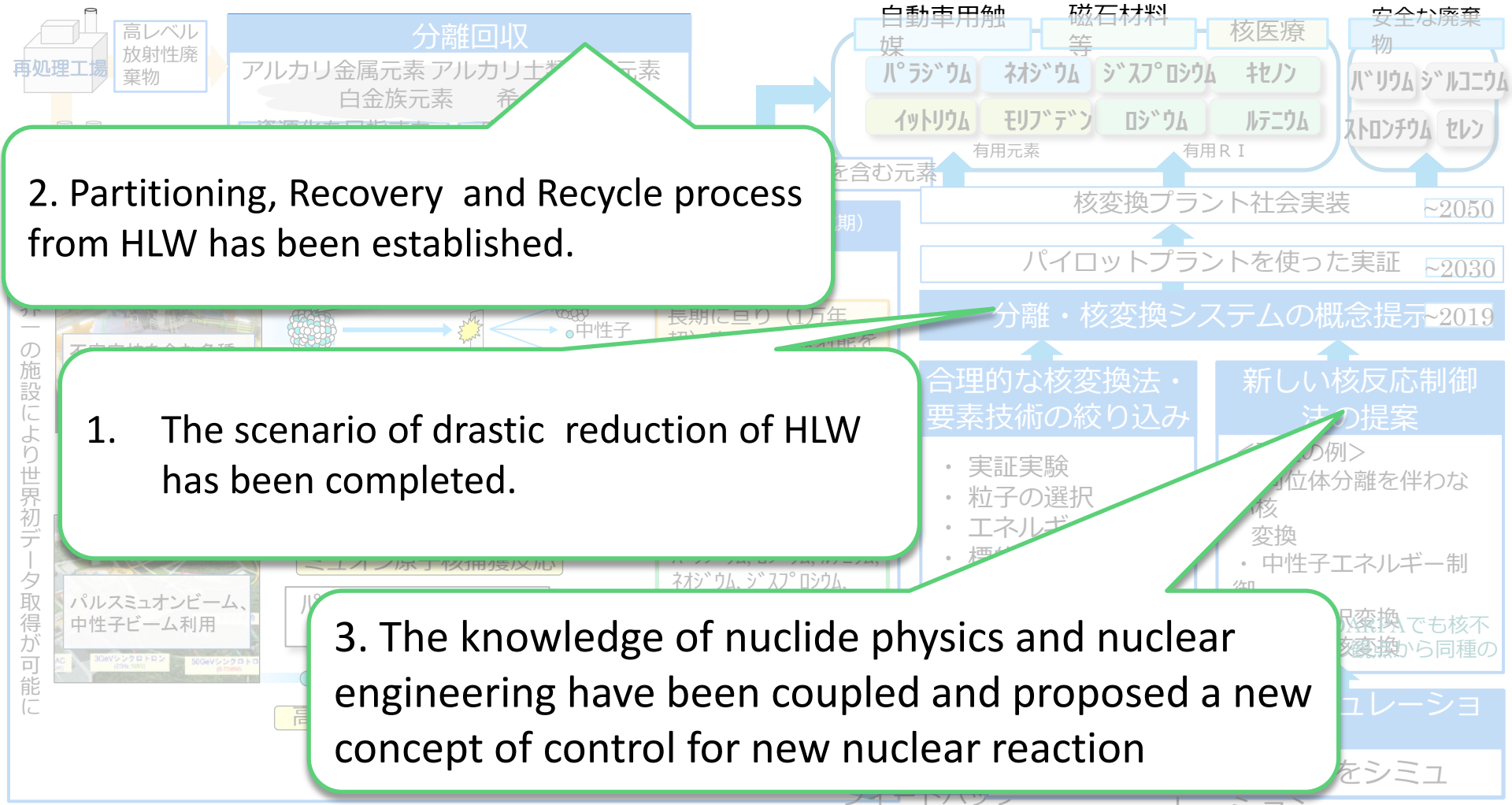

2. Partitioning, Recovery and Recycle process from HLW has been established.

1. The scenario of drastic reduction of HLW has been completed.

3. The knowledge of nuclide physics and nuclear engineering have been coupled and proposed a new concept of control for new nuclear reaction

Organization of this program

P M （Reiko FUJITA）

Related to social science

一般の方々にも参加いただいたタウンミーティング等の開催により、**社会科学的観点**を

Colaboration of nuclear physics and nuclear engineering for scientific solution

Data of Nuclide reaction

櫻井博儀主任研究員(理研)

Colaboration of Nuclear research

J-PARCで計画が進んでいる**MA核変換実験施設**

Leadership for practical use and formation of open platform between industry, government and universities

に向けて再処理を担う**日本原燃㈱**からの意見

緒方一介准教授（阪大）
仁井田浩二研究センター長（RIST）

All Japan system for development

The organization beyond independent sectors and different flame work established for long period

（※現時点での候補：東工大、東北大、東芝、JAEA等）

の情報を取り入れると共に国際的に原子核物理グループ協力を得る。

Impact for Industry and Society

Realization of Final Goal	Impact for Industry	Impact for Society
Reduction of storage period for HLW （Earlier reduction and reduction of control period for disposal）	• Unnecessary to disposal site for HLW • Decrease of disposal cost	• HLW disposal in our generation • 3S improvement
Resource recycle of valuable metals in HLW	• New industry in Partitioning and recovery • Independent of global market	• Resource recycle of negative legacy in HLW • Increase of price negotiation by self-support
Realization of new nuclear reaction	• Proposal of new nuclear system	• Realization of saving energy and eco society

In the end

- Desirable Research & Development in Japan is to realize the new concept based on the first data which is available in using the first and the most powerful facility in the world.

- Organization of Research & Development of overcoming the Valley of Death and the Darwinian Sea

- Contribution of resource recycle in poor resource nation ‘s Japan

- It is most important to give young generation the dream which is shown in challenge for difficult research issues and solving steadily the problems and overcome .

Thank you for attention !