



Tokyo Tech

Nuclear nonproliferation and security research and education at Tokyo Tech



Tokyo Institute of Technology
Lab. Zero-Carbon Energy

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The 2021 International Forum on Peaceful Use
of Nuclear Energy, Nuclear Non-Proliferation
and Nuclear Security

65 Years of Nuclear Research & Education at Tokyo Tech



- 1956 Research Laboratory for Nuclear Reactors (RLNR) Established
- 1957 Dept. of Nuclear Engineering (Graduate Program) Established
 - ⋮ Nuclear / Radioactive Materials, Radiation Generators, ...
 - ⋮ Advanced Education and R&D on Nuclear Energy, Radiation, ...
- 2011 “The Global Nuclear Safety and Security Dojo Program” Supported by MEXT
 - ; 3S Education to Develop Global Leaders
- 2016 Graduate Major in Nuclear Engineering by Education Reform Laboratory for Advanced Nuclear Energy (LANE)
- 2017 “The Advanced Nuclear 3S Education and Training (ANSET) Program”**
Supported by NRA Japan for 5 years
- 2021 Laboratory for Zero-carbon Energy (ZC)**



Laboratory for Zero-carbon Energy

Established in 2021, reorganized from LANE (Lab Adv. Nucl. Energy)

To contribute to the realization of a carbon-neutral (CN) society by constructing a carbon and material circulation system based on zero carbon energy (ZCE)

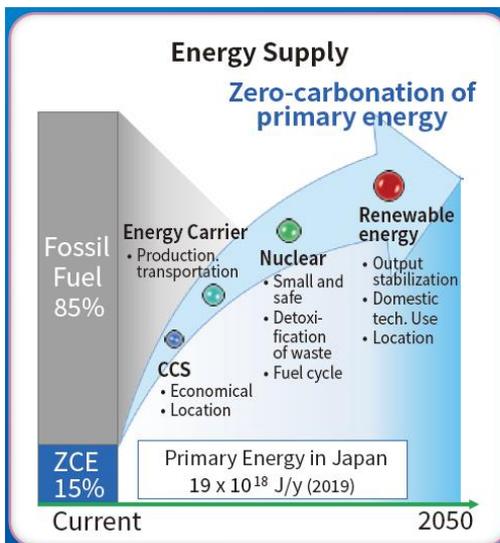


Fig. 1 Prospects for zero carbonization of primary energy

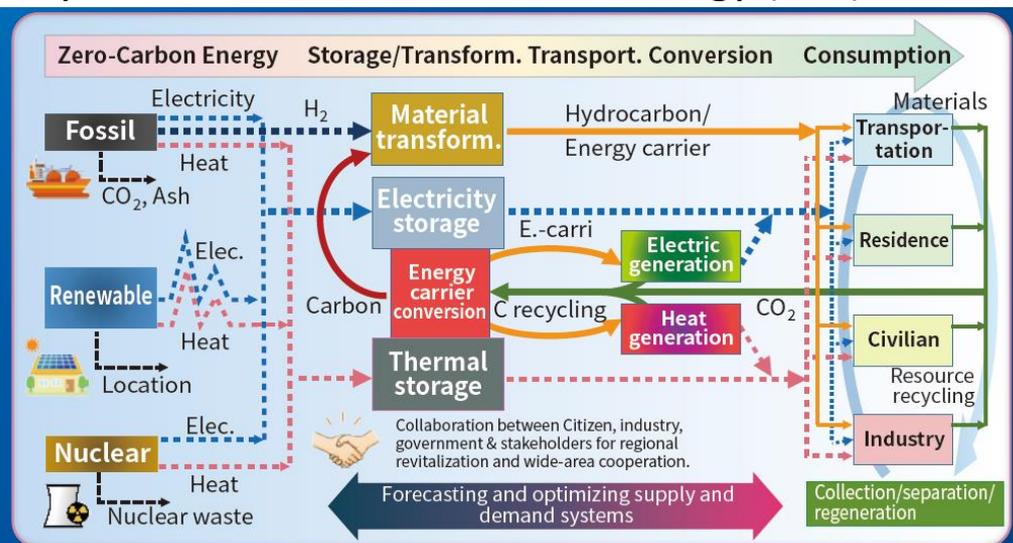
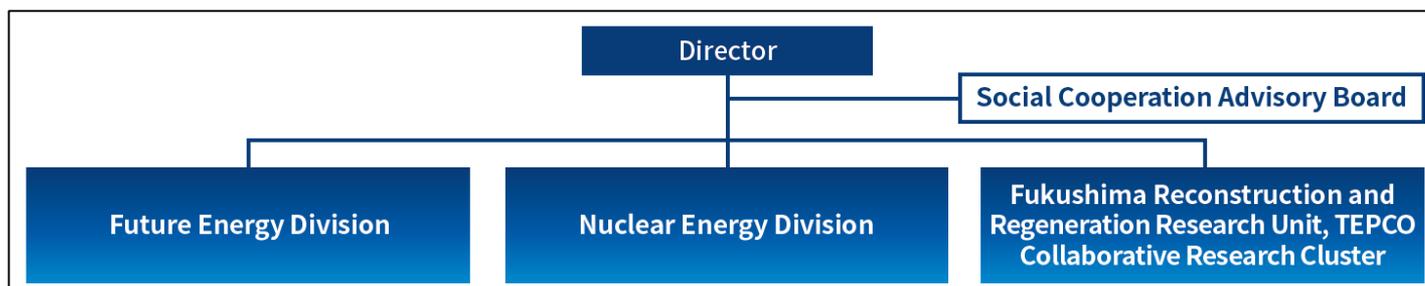


Fig. 2 Energy society aimed at the ZC

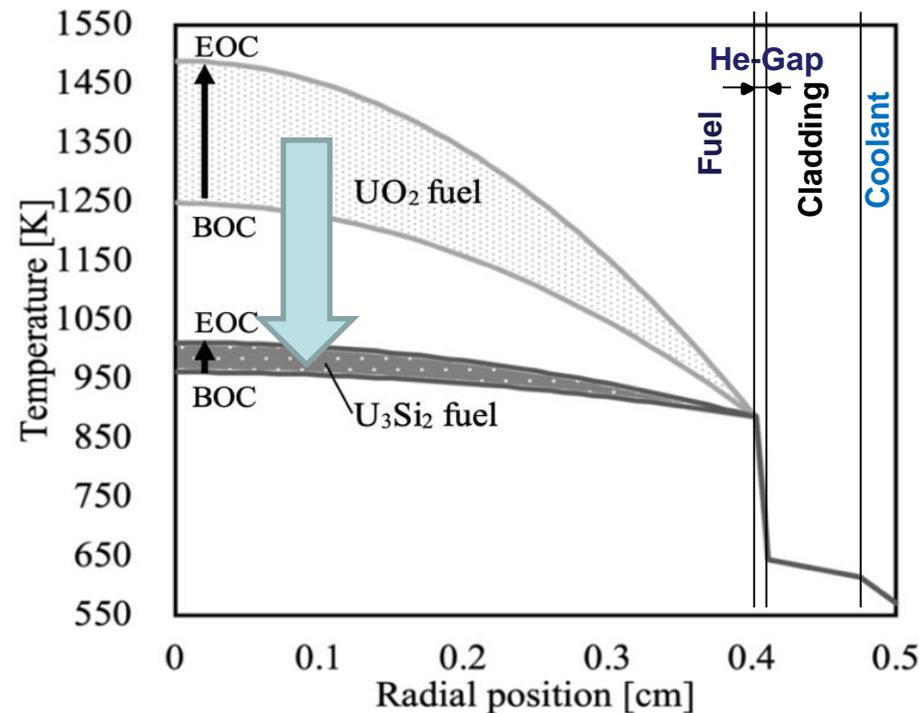
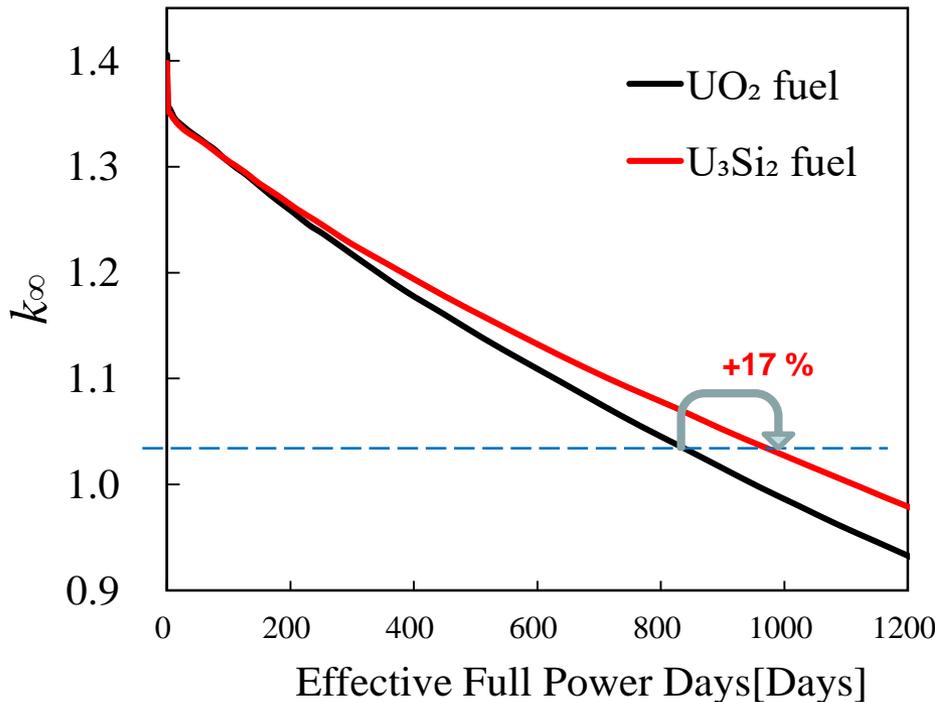


Nuclear Fuels with Intensive Safety-Security by design

- Accident Tolerant Fuels(ATFs) have been developed, **U₃Si₂** Fuel is one of the candidates
- Due to its high **metallic density** and **heat conductivity**, performance improvement is expected in both **neutron economy and safety**
- Its **chemical stability** also contribute to **reduce the Material Attractiveness** by **the Pu separation difficulty**

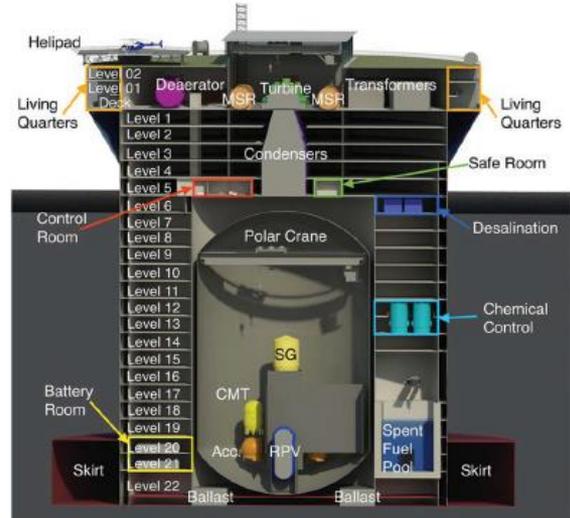


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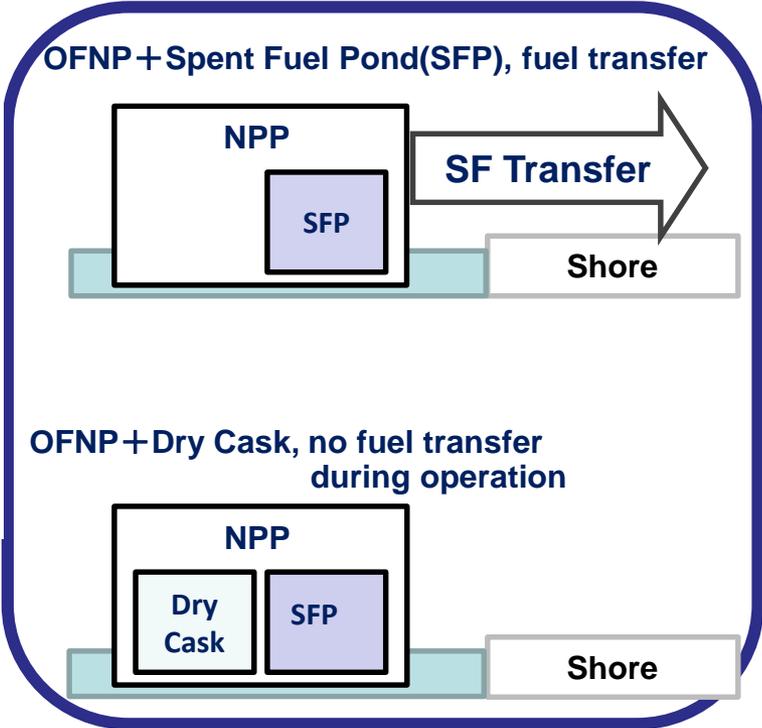


Modular Reactor and its nuclear safeguards/security approach

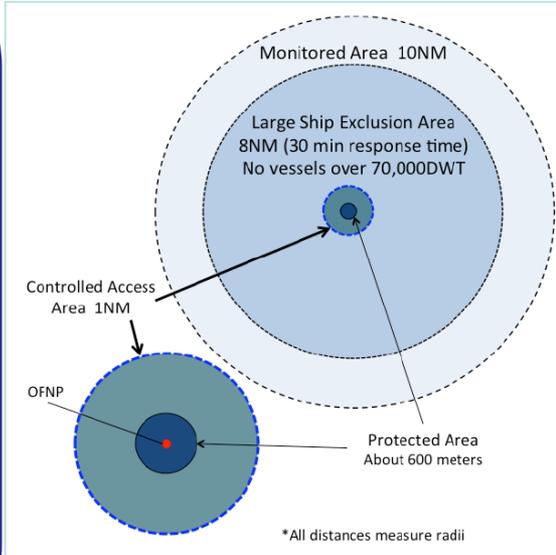
- Modular reactors are the key technology in future
- Offshore Floating Nuclear Plant (**OFNP**) is proposed ¹⁻⁴
- Its **nuclear safeguards/security approach** is needed to be researched for its installation in **non-weapon states**



Example of OFNP¹



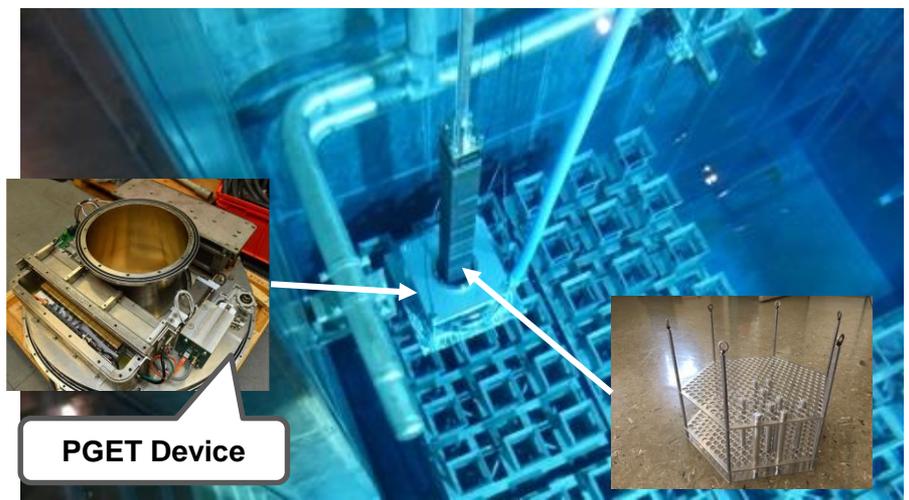
Example of Fuel Management of OFNP



Example of Physical Protection Layer¹⁻³

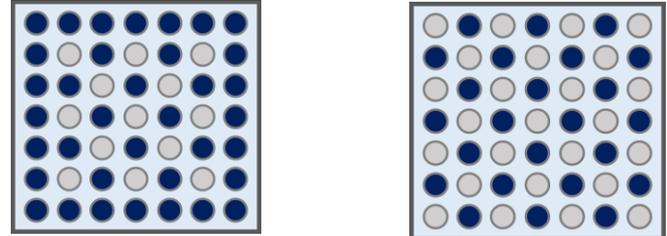
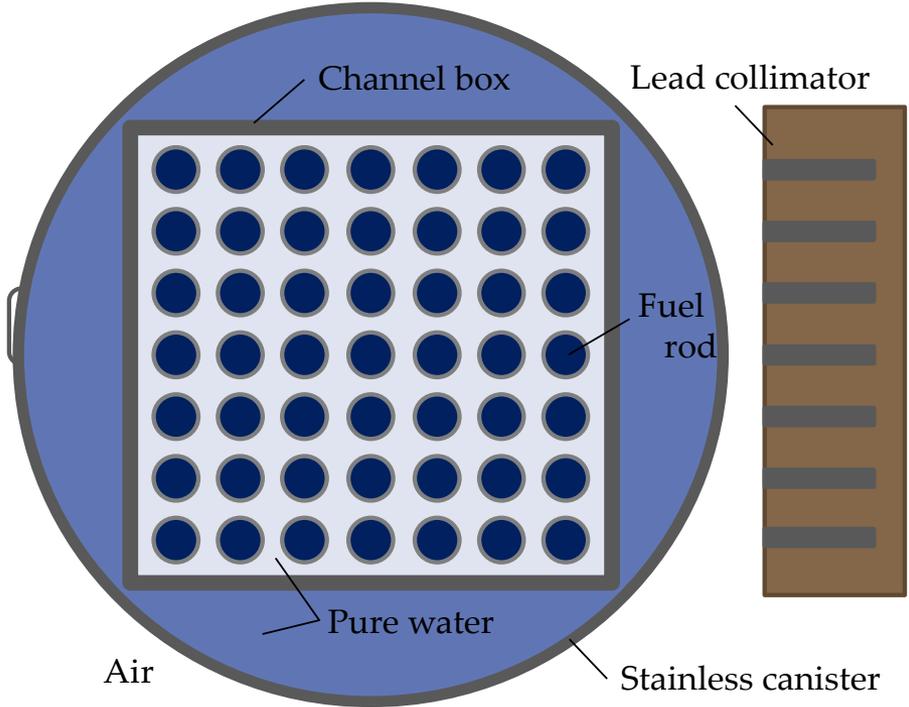
1. J. Bongiorno, et al., Nucl Technology Vol. 194, 1-14, 2016.
2. G. Genzman, et al (MIT)., "Ship Collision and the Offshore Floating Nuclear Plant (OFNP): Analysis of Possible Threats and Security Measures" (2016)
3. V. Kindfuller, et al (MIT)., "Overview of Security Plan for Offshore Floating Nuclear Plant" (2016;Article)
4. 浮体式原子力発電所, 産業競争力懇談会 (COCN) 2021年度 プロジェクト 中間報告

Passive Gamma/Neutron Emission Tomography



PGET Device

Source: Winning Entries to IAEA Tomography Reconstruction and Analysis Challenge to Aid Safeguards Activities
<https://www.iaea.org/newscenter/news/winning-entries-to-iaea-tomography-reconstruction-and-analysis-challenge-to-aid-safeguards-activities>



● Fuel rods
● Dummy rods

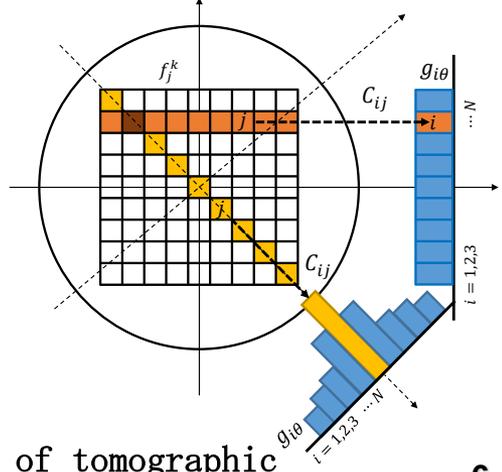
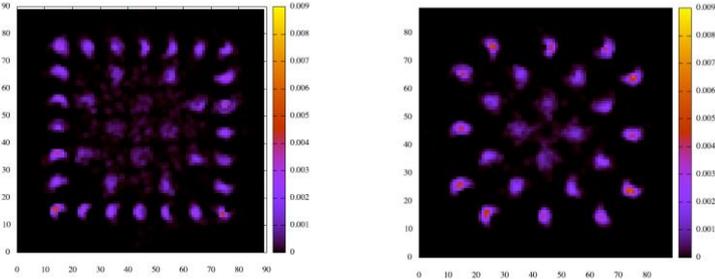
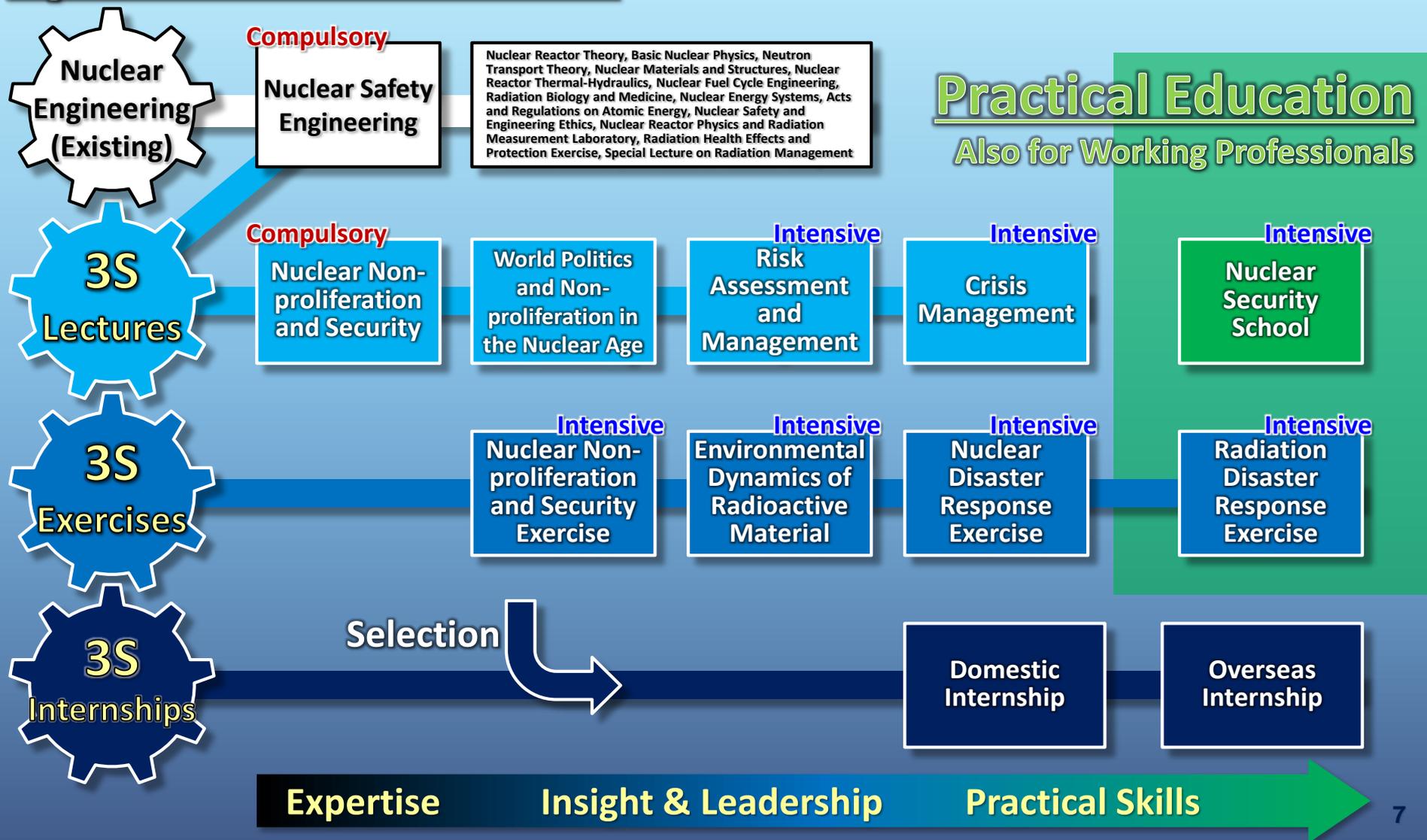


Figure : Principle of tomographic acquisition and geometric considerations.

3Ss Education ANSET Program



Systematic Education



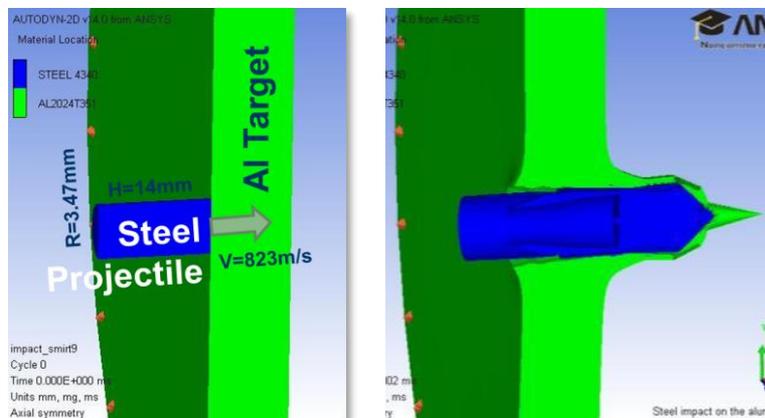
核不拡散・核セキュリティ学実習

Nuclear Non-proliferation and Security Exercise

☐ Uranium Enrichment Verification



☐ Numerical Simulations of Shock Wave Impact on Structural Materials

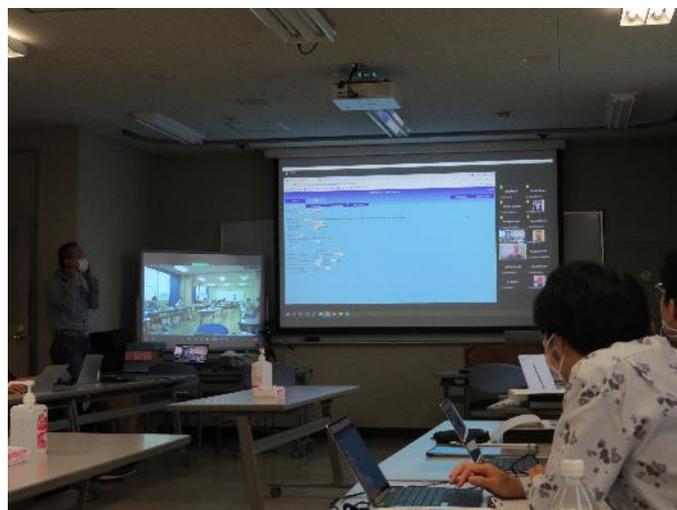
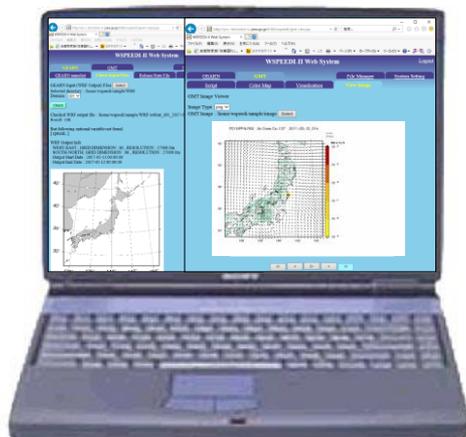
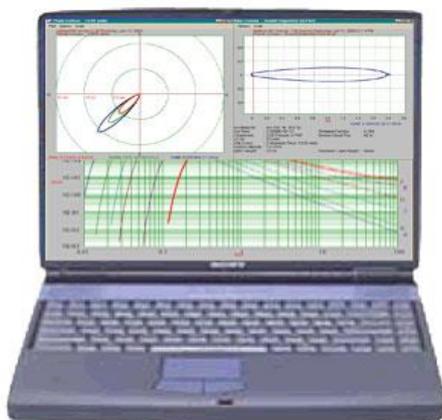


☐ Facility visit to JAEA PP Field and Nuclear Fuel Cycle Engineering Laboratories @Tokai

放射性物質環境動態実習

Environmental Dynamics of Radioactive Material

□ Small-Scale and Large-Scale Atmospheric Dispersion of Radioactive Material



Face to face and Remote Hybrid Exercise



放射線災害対応実習

Radiation Disaster Response Exercise, collaboration with TEES, US.

☐ Radiological Source Identification and Recovery, Emergency Response



@ Texas A&M Engineering Experiment Station in 2019



@ Tokyo Tech in 2021

Results for 5 years in ANSET

Number of registrations in each course, as of August 2021.

Japan Fis. Year	2017	2018	2019	2020	2021	total
Lecture	15	121	112	113	74~	435~
Exercise	-	18	16	19	10~	63~
Intern	-	9	8	0!	9~	26~
Working Professionals	-	10	28	11	22~	61~

- More than **500 Tokyo Tech students** have taken the courses
- **25** Students Awarded Certificate
- More than **60 working professionals** from outside have joined
- Internship agreement with **JAEA, NMCC, and IAEA!**
- Due to **COVID-19, negative impacts** in 2020, especially on internship
- But, **Online lecture** makes **positive impact** to working professionals

Impact by COVID-19 in university

- **Difficulty to access abroad or other facilities**
 - No internship, business trip were performed in 2020
 - Physical experiments or exercises were limited
 - Good to establish the alternative experimental contents virtually or locally
- **Information sharing and R&D**
 - Remote working has good compatibility with numerical simulations with software
 - Problem; Interictal properties, licenses
 - Difficulty to make “small talks” by online,
- **Verification activity at LOF**

- **Sharing PDI with regional regulators**
 - IAEA HQ and Regional office
 - IAEA and State/region regulators
- **Unattended monitoring technologies**
 - Needed to efficient IAEA Safeguards activities
 - Needed to expansion of SMRs
(Monitoring technology for NM movement and design information, ex., Muon tomography, Neutron/Gamma tracers, etc.)
- **Information sharing, R&D and Education**
 - Open source wares based on web based such as OpenMC by MIT, IAEA software
 - Virtual nuclear reactor and fuel cycle facility