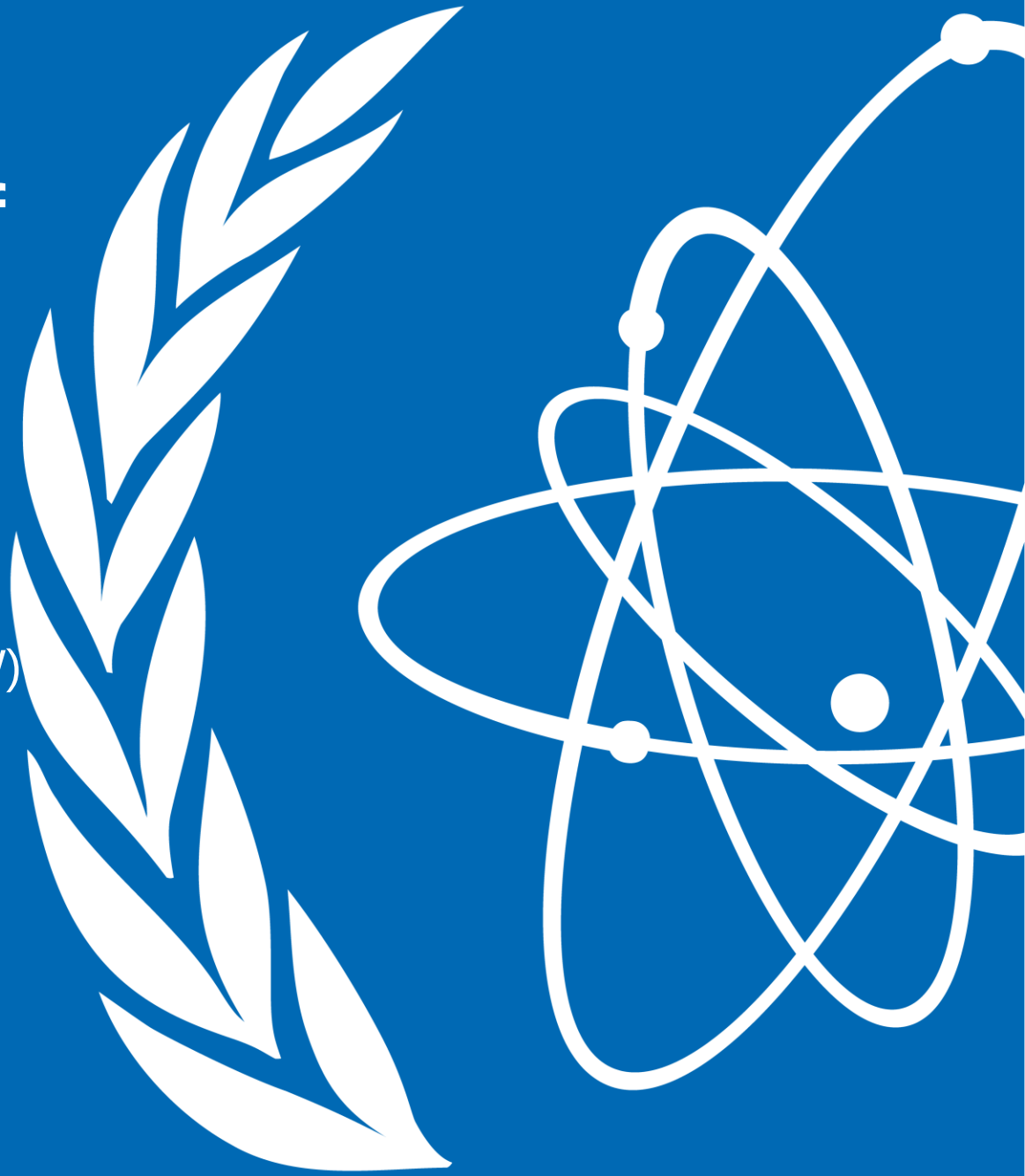
Safety Standards, the Role of AI in Safety During Decommissioning

Duriem Calderin Morales
Decommissioning and Remediation Unit (DRU)
Division of Radiation, Transport, and Waste Safety (NSRW)
Department of Nuclear Safety and Security

DORADO (Digital twins and Ontology for Robot Assisted Decommissioning Operations)

April 7th 2025, online, Vienna-AT



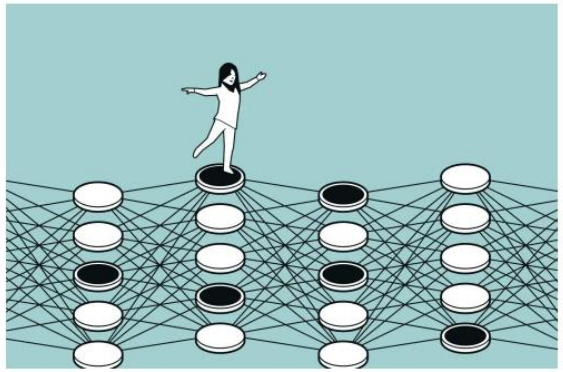
Highest Honor Recognition

They used physics to find patterns in information

This year's laureates used tools from physics to construct methods that helped lay the foundation for today's powerful machine learning. John Hopfield created a structure that can store and reconstruct information. Geoffrey Hinton invented a method that can independently discover properties in data and which has become important for the large artificial neural networks now in use.

Related articles

Press release



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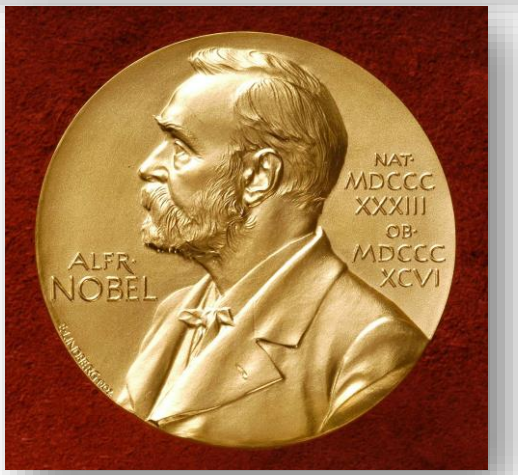

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Requested by Member States GC68

1.
General

1. Urges the Agency to continue to strengthen its efforts to maintain and improve nuclear, radiation, transport and waste safety and emergency preparedness and response, and to enhance its support and assistance to Member States, upon their request;

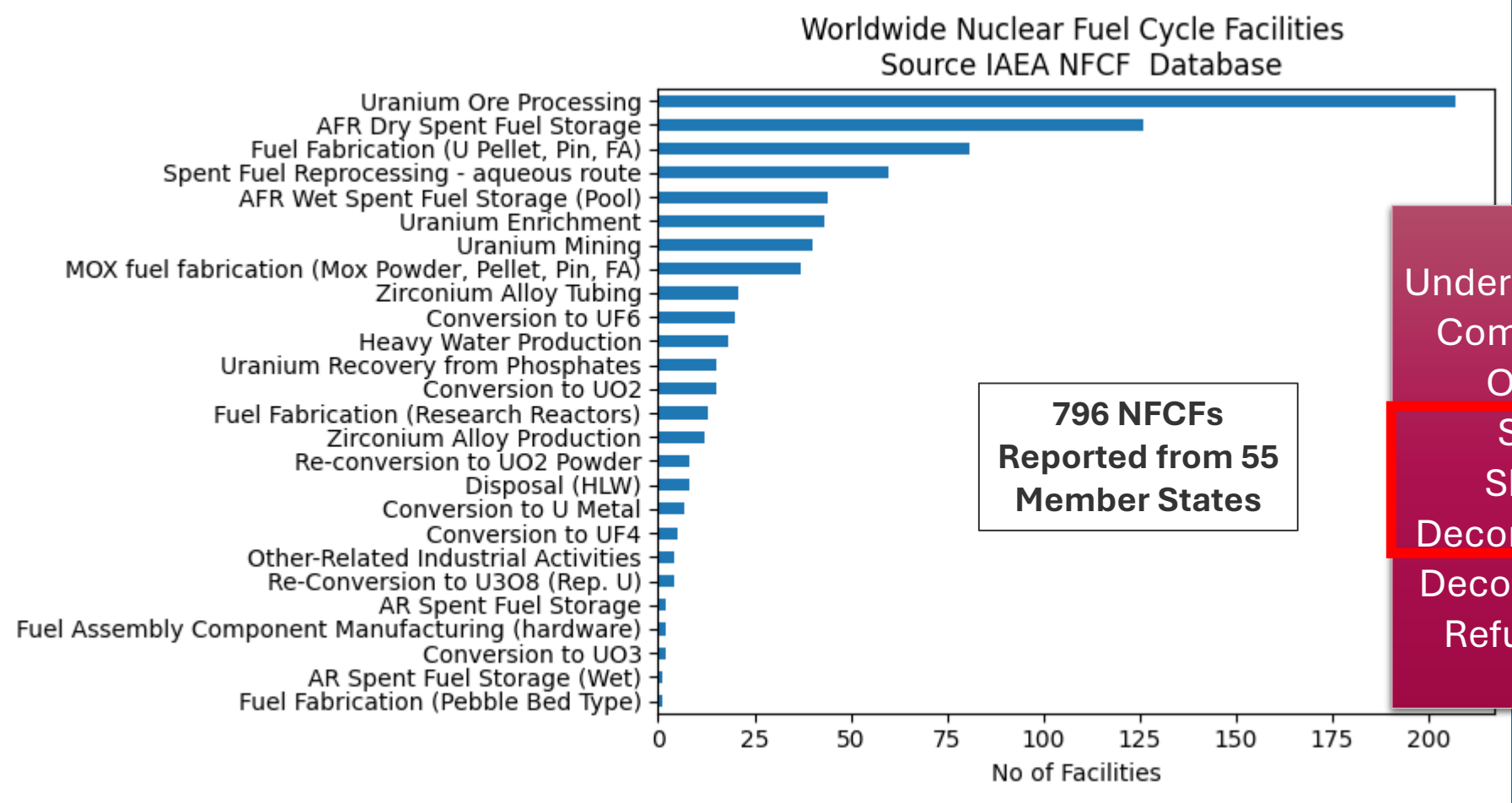
2. Encourages Member States to develop, maintain and improve their nuclear and radiation safety infrastructure and related scientific and technical capabilities, including through international nuclear cooperation; and both requests the Secretariat and encourages Member States in a position to do so, to assist in this regard, upon request, in a coordinated, efficient and sustainable manner;

3. Encourages Member States to develop and maintain strategies, approaches and contingency plans in managing extraordinary circumstances, such as the COVID-19 pandemic, extreme natural disasters and armed conflicts, in order to ensure nuclear and radiation safety;

4. Encourages the Agency to continue providing technical support and assistance to interested Member States in maintaining and improving nuclear safety and security for nuclear facilities and activities involving radioactive sources, including during armed conflicts, and to enhance this support and assistance upon request;

5. Requests the Secretariat, in close consultation with Member States, to continue identifying potential benefits and challenges of artificial intelligence in support of nuclear safety, to provide relevant technical assistance to Member States upon request, and to keep Member States informed of any progress;

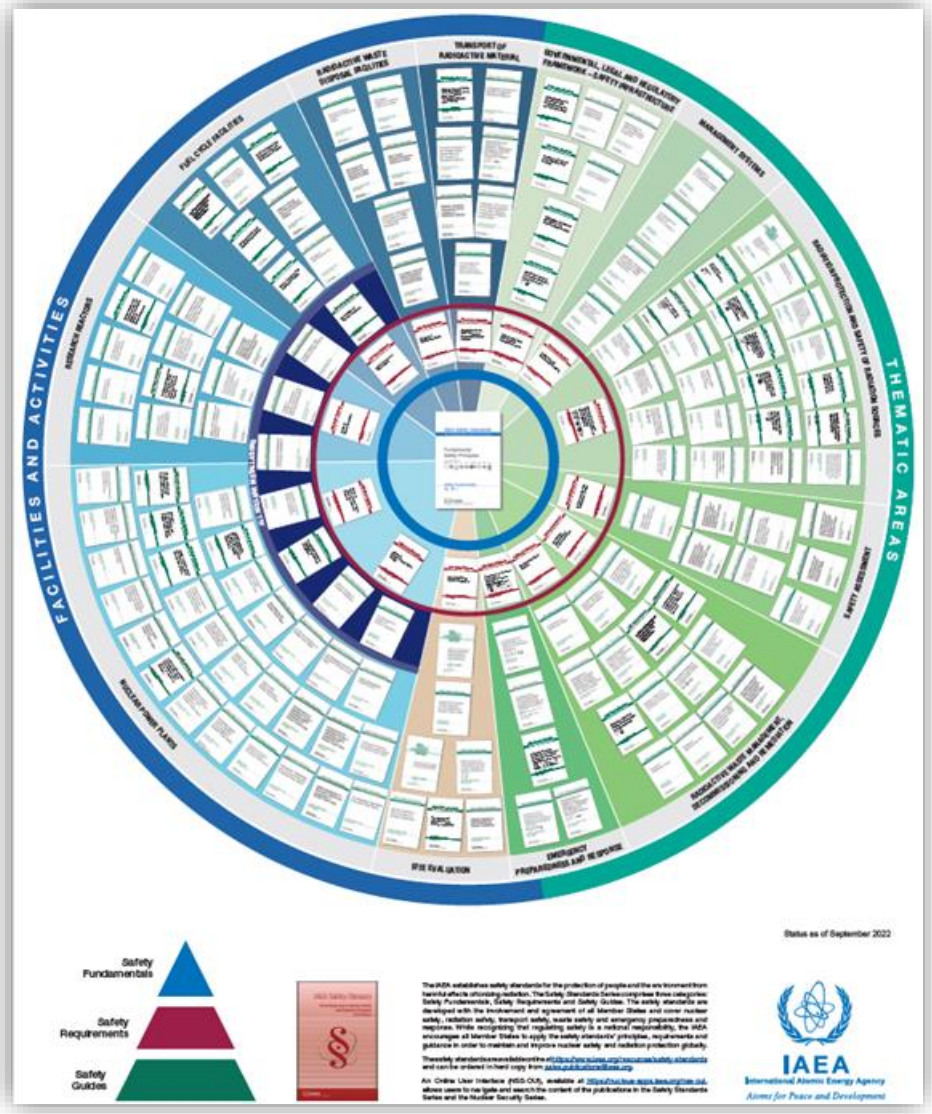
Nuclear Fuel Cycle Facilities Around the World are going to or expected to be Decommissioned



NFCF	No of NFCF
Under construction	36
Commissioning	4
Operation	353
Stand by	**31**
Shutdown	**93**
Decommissioning	**75**
Decommissioned	157
Refurbishment	2
Others	45

Large amount of data in different types of format

Safety and Artificial Intelligence

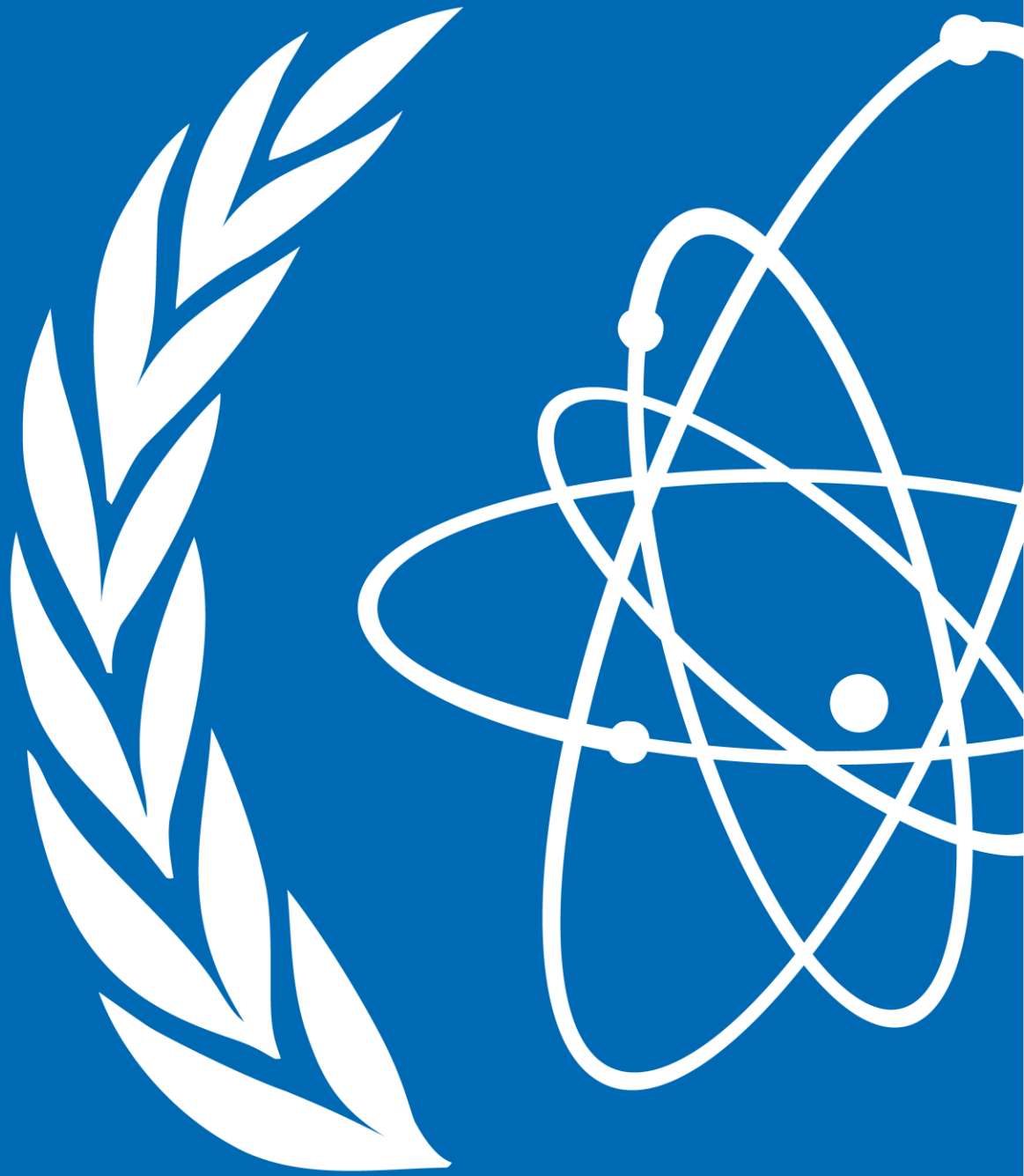


What safety considerations need to be put in place?

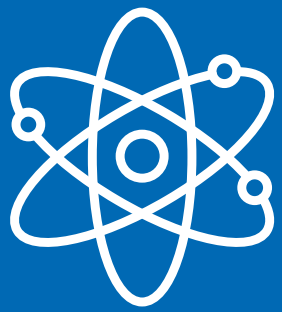
What requirements will it need?

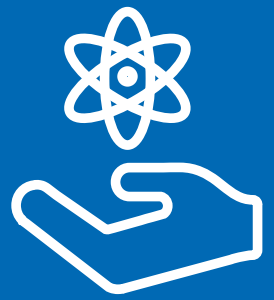
Consultancy Meeting on Application of AI Large Language Models for Safety in Decommissioning of Nuclear Fuel Cycle Facilities

Dates: 29 Oct- 1 Nov 2024
Location: Vienna Austria



Objectives





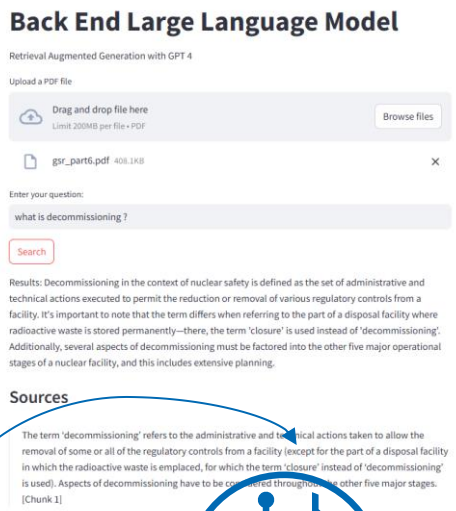
- Understand how Member States are Approaching Large Languages Models (LLMs) in the context of nuclear safety, especially in Decommissioning of Nuclear Fuel Cycle Facilities (NFCF)
- Develop a roadmap for future direction (workshops, technical meetings, trainings) of AI LLM applications in NFCF decommissioning safety for benefit of Member States.
- Share experience on AI Policy in nuclear safety

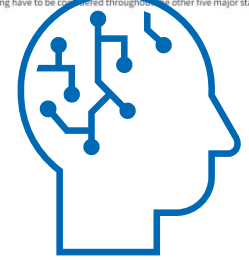
Consultancy Meeting Outcomes

Data Governance and Quality Frameworks: data validation, classification, quality control, and security.

Two step authentication factor

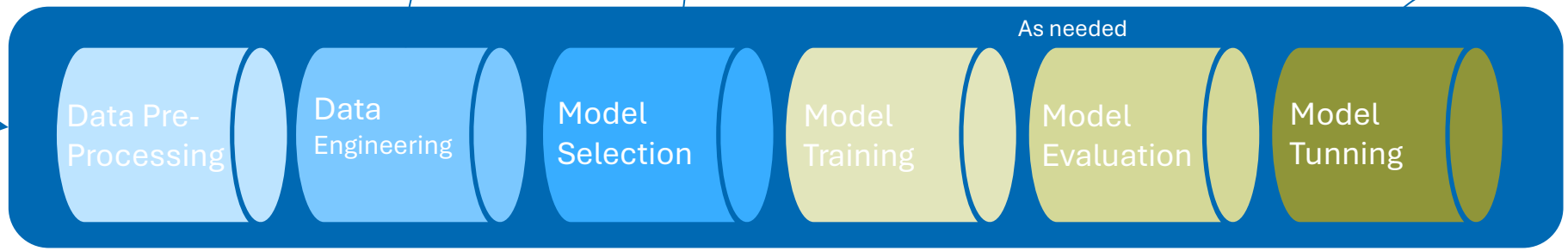
Nuclear Large language Models (**NLLMs**) **domain-specific**





Experts always in the loop

Prompt Engineering, Retrieval-Augmented Generation techniques to achieve desired outputs and enhance accuracy



Pipeline

Define **standardized data** protocols, such as APIs.

Advocate for targeted training programs, **eLearning** modules, and internal adoption of LLMs by the IAEA to **demonstrate proof-of-concept**.

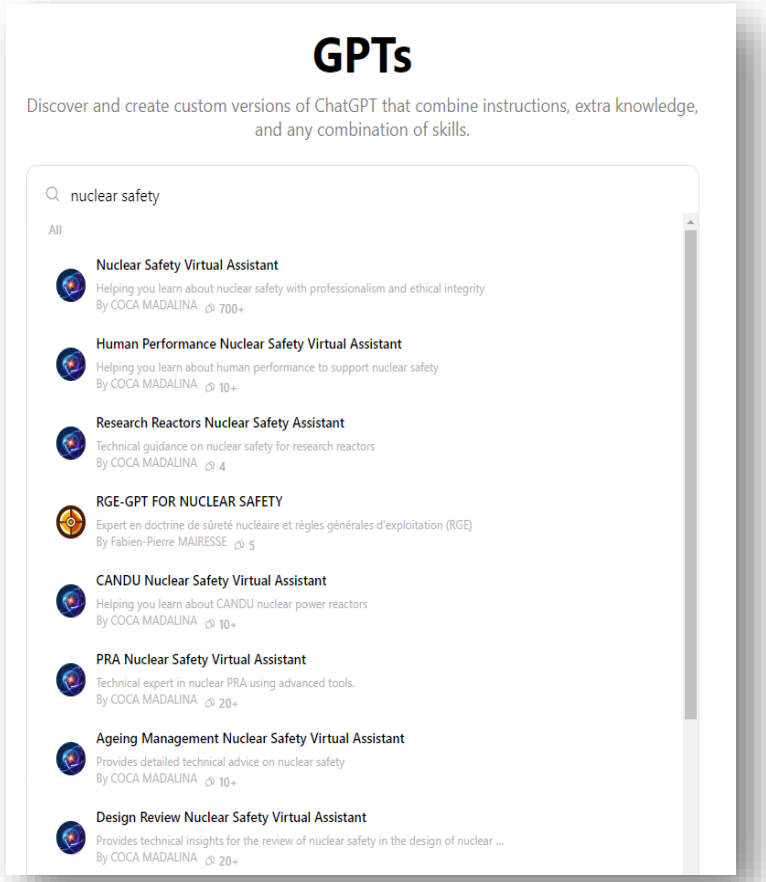
Consultancy Meeting Outcomes (*cont.*)

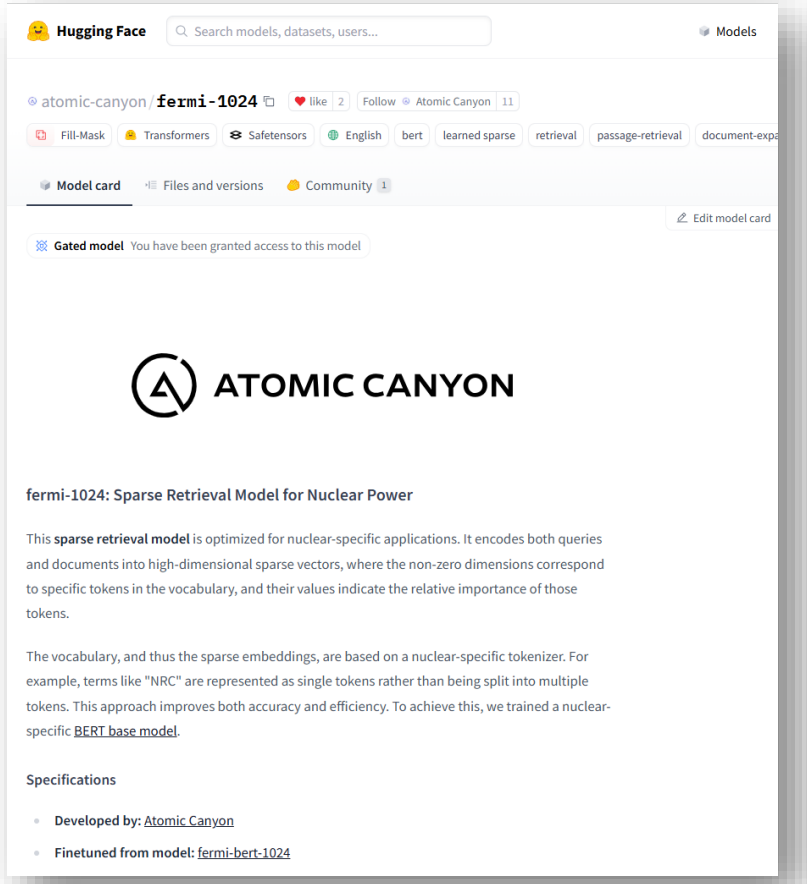
Collaborative Knowledge Sharing

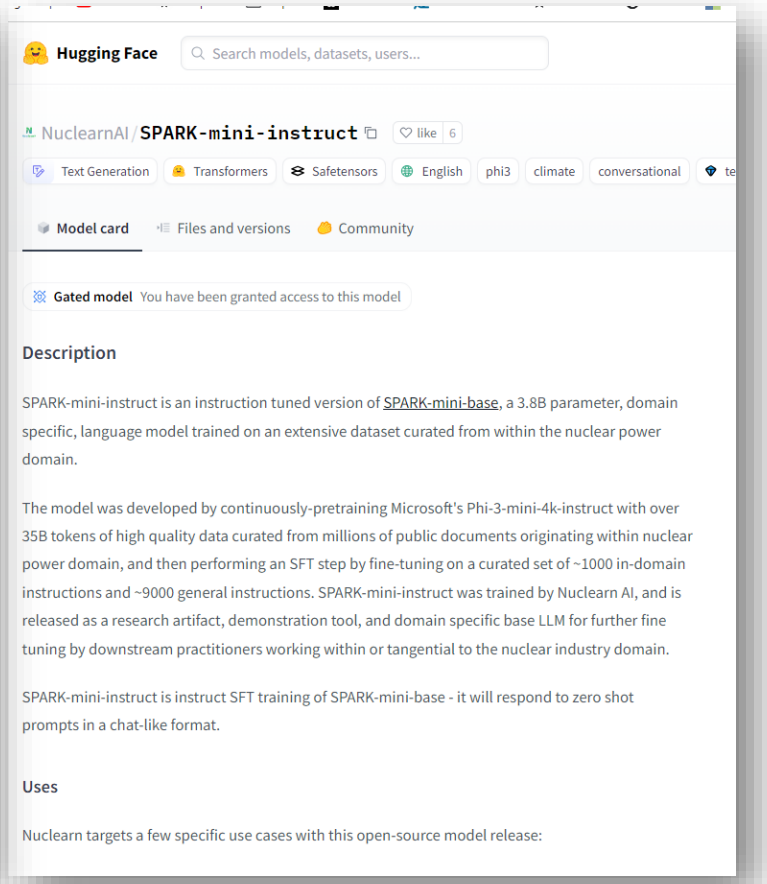
Capacity Building and Internal Adoption

Data Accessibility and Integration

Examples of AI –LLMs in Public Platforms



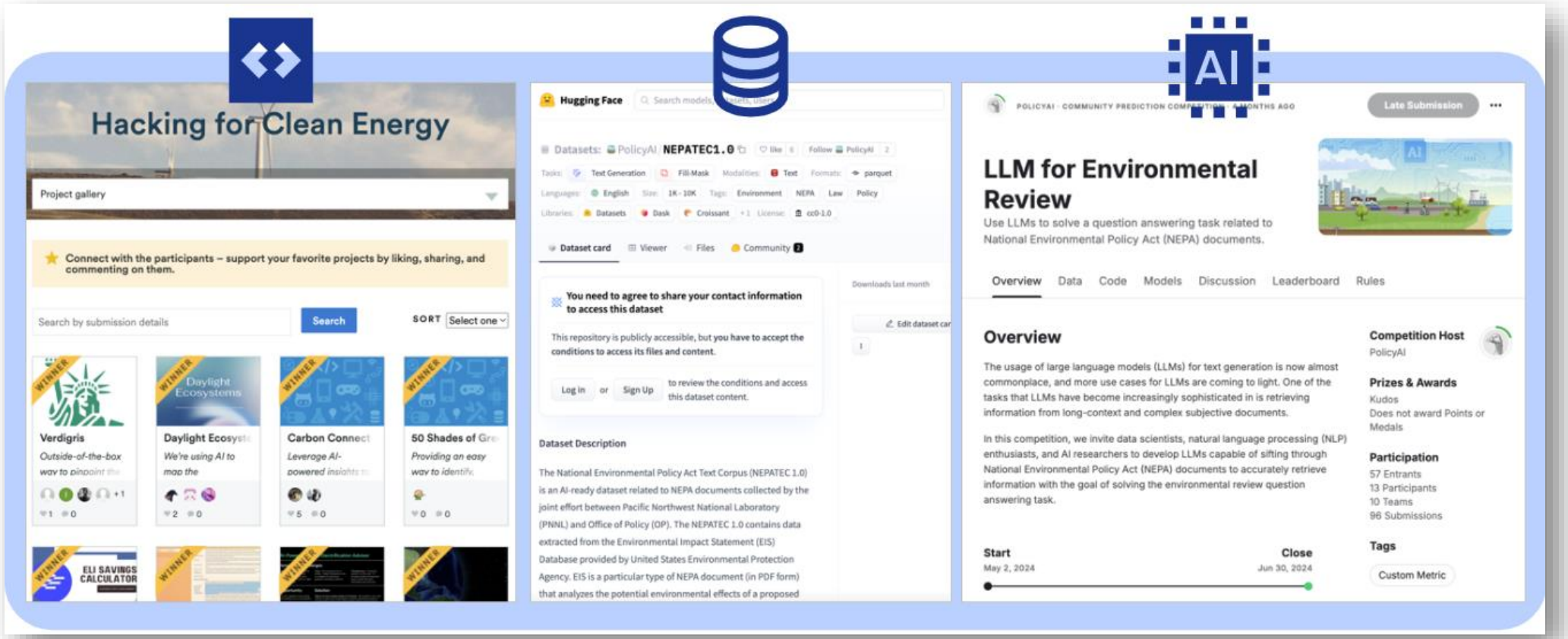




Minimum code requirements, user “intuitively” defines prompt for system and users, enable with latest GPT-model

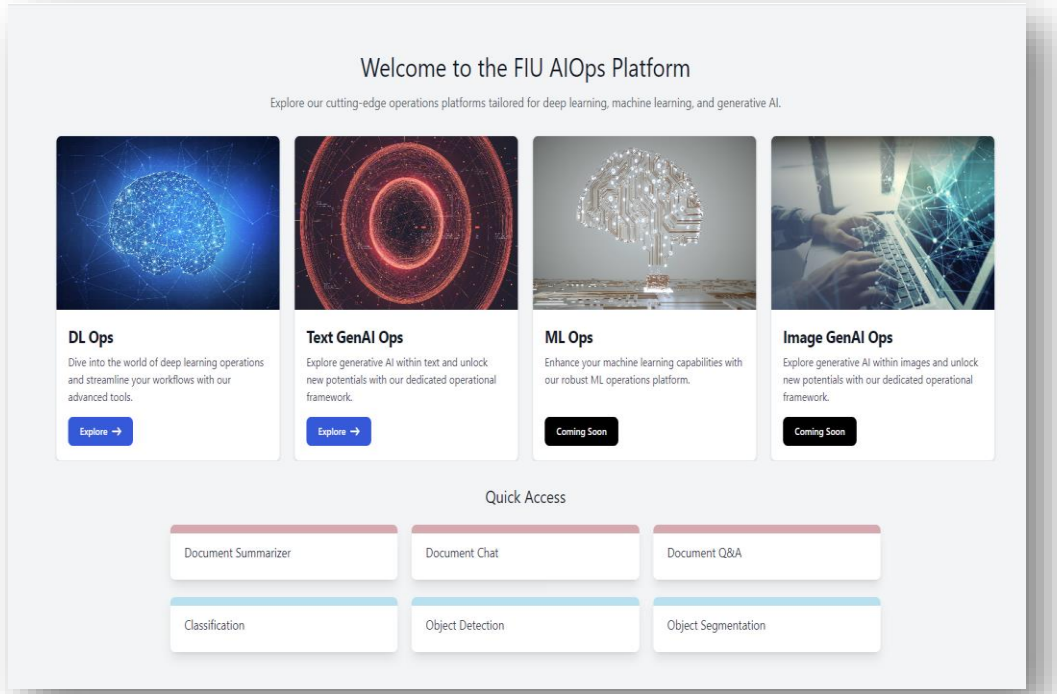
Pre-trained on nuclear specific datasets by Atomic Canyon (left) and NuclearnAI (right),

Examples of AI –LLMs in Public Platforms

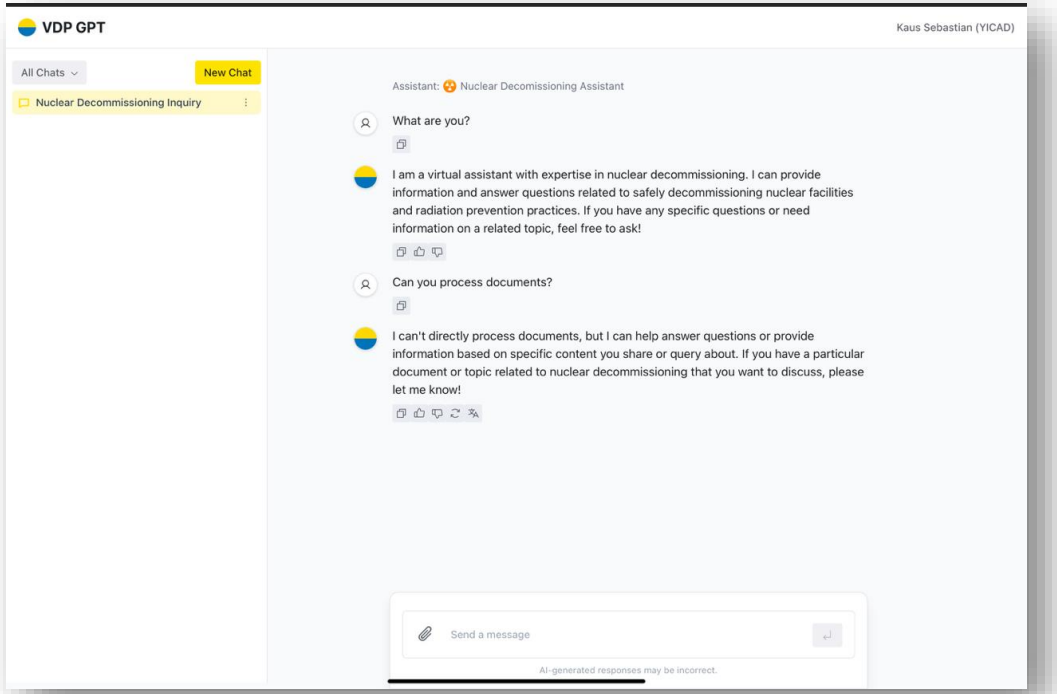


Open, Standardized, and AI-Compatible For Community Engagement,
Pacific Northwest National Laboratory (PNNL), USA

Examples of AI –LLMs in development for decommissioning and waste

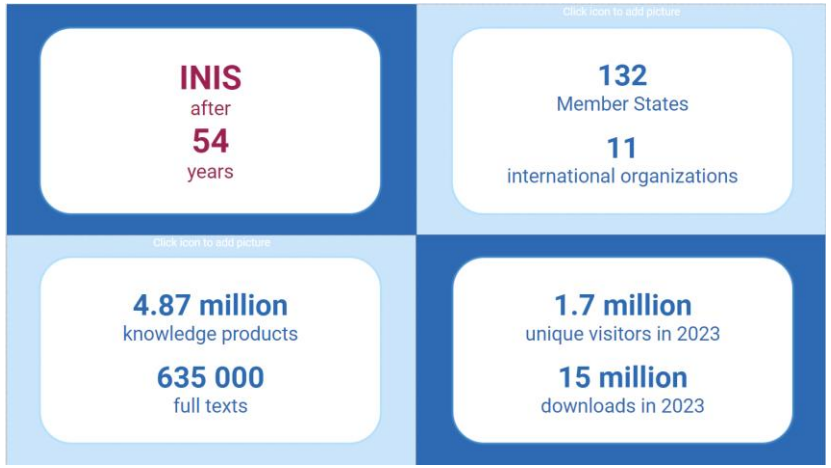


Florida International University, (FIU) over 30 years supporting D&D in the USA.



Vattenfall customizable LLM (gpt 4o, possibility to use others) assistant (ability to prompt, RAG on the fly)

Example of IAEA AI Model: NADIA Using AI to Index Nuclear Information



NADIA

Neural Artificial Intelligence
for
Document Indexing Automation

Some criteria for a successful machine learning project:

- A lot of data for training
- Data should be well-labelled
- Project should replace a repetitive, boring, unrewarding task

Thank You to the Experts

Integrated AI-Work

AI Working Group

International **knowledgeable stakeholders**

Nuclear utilities, Nuclear regulators, AI vendors (developers/providers), Research institutes and Universities, Other organizations

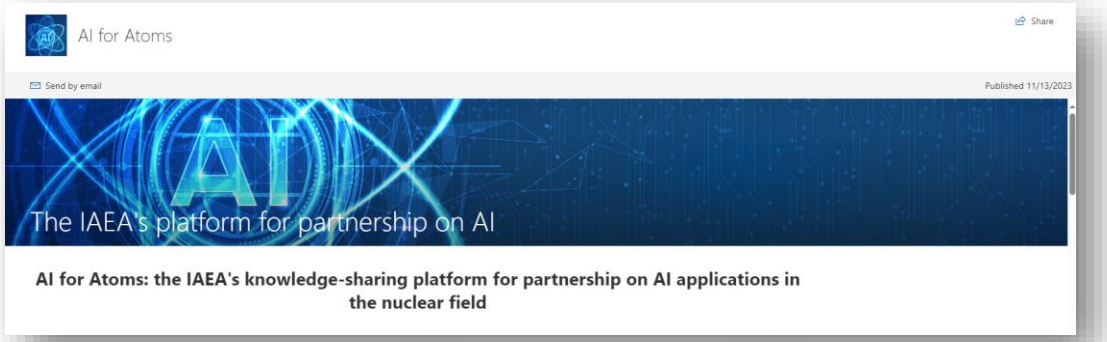
Experts pool available for all IAEA activities

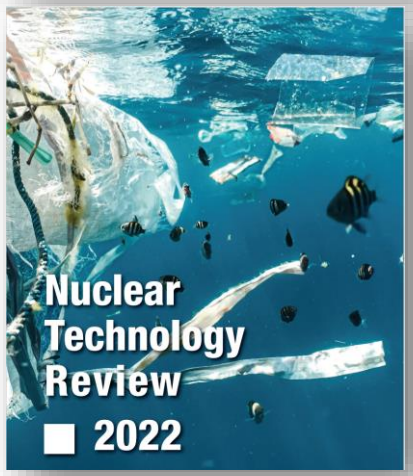
Inclusive group:

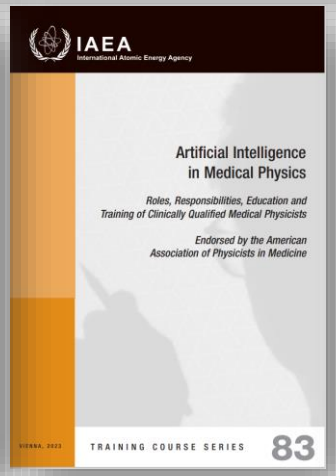
All knowledgeable stakeholders from IAEA Member States
Active members

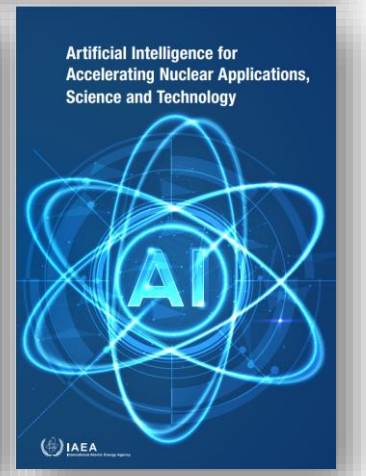
- ✓ 106 Members
- ✓ EPRI
- ✓ WANO
- ✓ IEC
- ✓ NEI

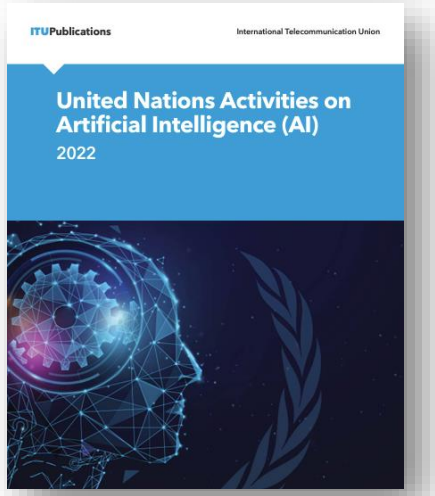
Collaboration with IEC SC45A – WG12, WG9











Upcoming Events on AI at the IAEA

Technical Meeting on the Application of Artificial Intelligence for Nuclear Security

- **Date:** 20-24 October 2025
- **Purpose:** The purpose of the event is to enhance the cooperation and information exchange among Member States in the areas of artificial intelligence and machine learning for nuclear security.
- **Contact:** Rodney Busquim E Silva, r.busquim@iaea.org

International Workshop on Instrumentation and Control and Computer Security for Small Modular Reactors

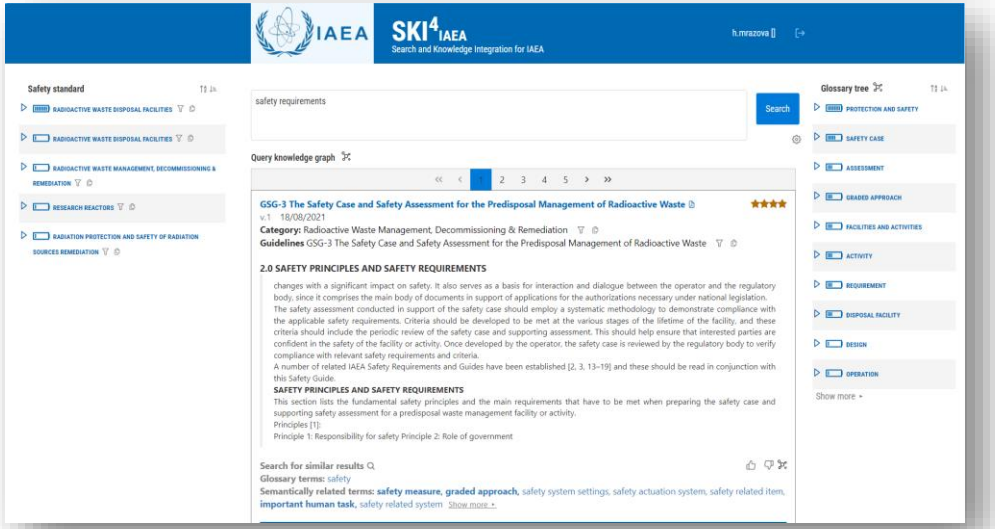
- **Tentative date**: 4-8 August 2025, MIT, USA
- **Purpose**: This event aims to enhance participants understanding of instrumentation and control, computer security aspects related to innovations on digital technologies a, including AI/ML for small modular reactors.
- **Contact:** Rodney Busquim E Silva, r.busquim@iaea.org

Technical Meeting on Safety Considerations in the Use of Artificial Intelligence in Nuclear Power Plants with a Focus on Human Factors Engineering and Instrumentation and Control Systems

- **Date**: 10 – 14 November 2025, ROK
- **Purpose:** The purpose of the event is to provide a platform for Member States to advance discussions on the safety implications of the use of artificial intelligence in the nuclear field, with a focus on the design of nuclear power plants.
- **Contact:** Yun Goo Kim**,** y. y.g.kim@iaea.org

Technical Meeting on Innovations in Data Analysis and Retrieval for Nuclear Decommissioning

- NEFW/DERS event scheduled on **18 - 22 August 2025** with support of NSRW/DRU
- Key Objectives:
  - Enhance discussion on the **role of digital technologies** in facilitating decommissioning data management.
  - **Innovations** in **access and retrieval** of decommissioning knowledge.
  - Exploring challenges of verification, reliability and quality of data.
  - Understanding of Large Language Models and other Semantic technologies in the domain of nuclear decommissioning.
  - **Promoting** wider access to knowledge useful for planning and implementation of decommissioning.



ADVANCED ACCESS AND RETRIEVAL OF DATA

Helena Mrazova
Decommissioning Technology Specialist

h.mrazova@iaea.org

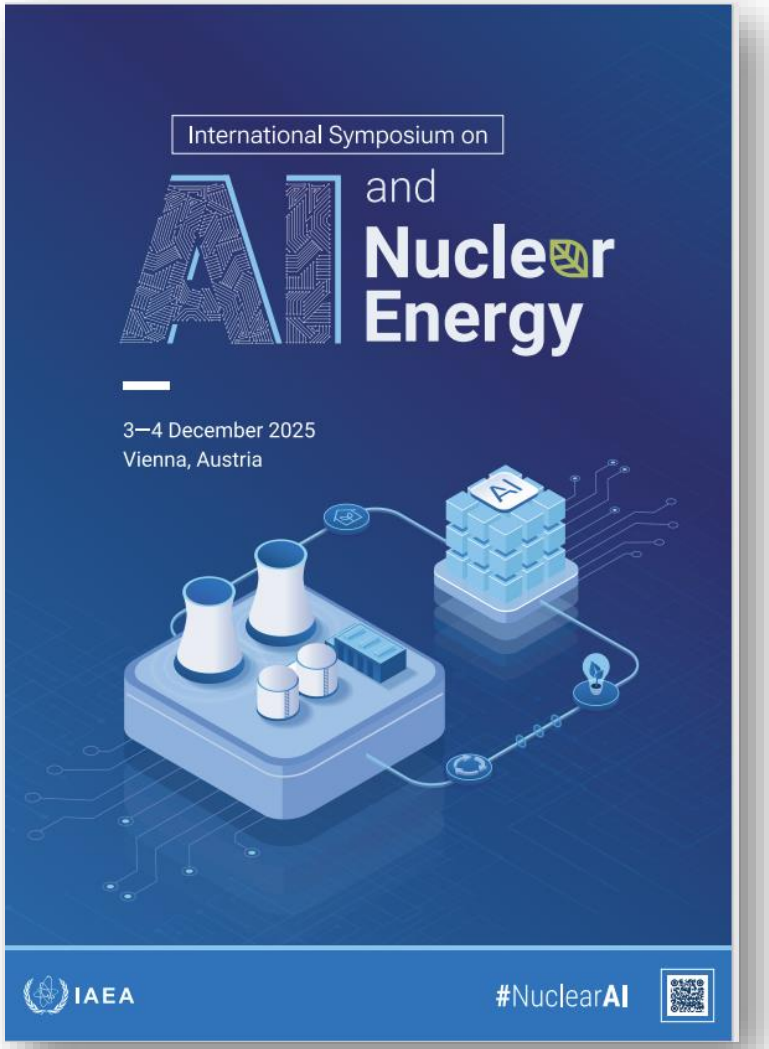
Technical Meeting on the Role of Artificial Intelligence in Emergency Communication

- Event scheduled on **23-27 June 2025 in Vienna**

- **Key Objectives:**
  - Develop resilient and effective measures to **mitigate harms from human-made and AI-generated disinformation**

  - Support emergency response organizations, regulatory authorities, and operators in **detecting dis/misinformation,** and enhancing emergency **public communication preparedness** and response during routine operations and emergencies **through AI-enabled solutions**

Upcoming Events on AI at the IAEA



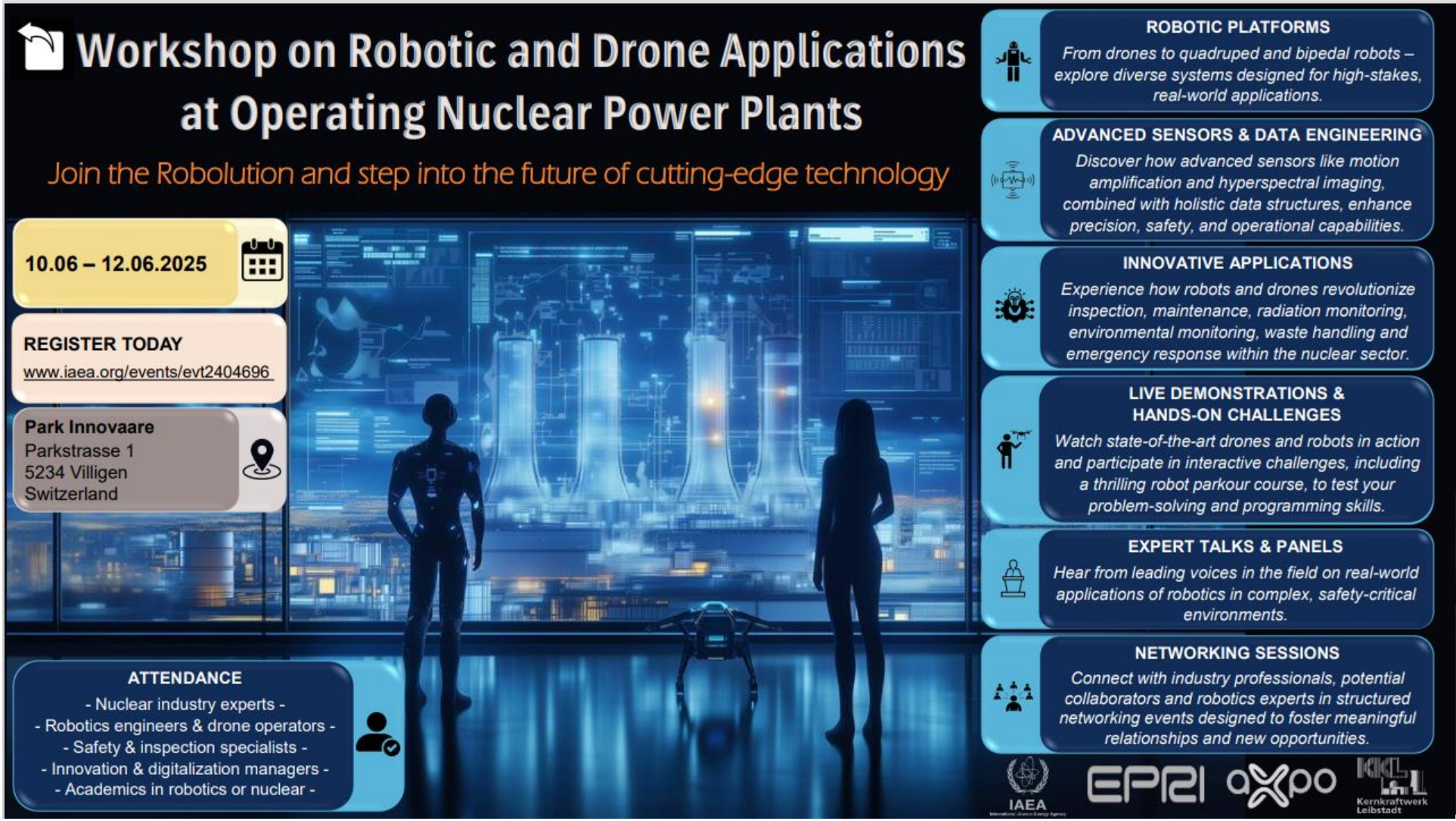
https://www.iaea.org/events/ai-symposium-2025

Key Themes & Topics

- Powering Data Centres with Nuclear Energy
- Opportunities and Challenges for AI in the Nuclear Sector
- Regulatory Frameworks, Safety and Security Protocols
- Current State of Play

Contact: Ed Bradley
email: E.Bradley@iaea.org

Upcoming Events on AI at the IAEA



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2025 International Network on Innovation to Support Operating Nuclear Power Plants award

SCOPE

- All forms of innovation are welcome. Topical awards are foreseen in the existing ISOP working groups (AI, Advanced Manufacturing, Robotics & Drones and Advanced Instrumentation and Control). A fifth award can be considered for a significant technical or non-technical deployment outside of these three areas.
- Submissions are welcome from the broader nuclear industrial sector: nuclear utilities, regulators, laboratories / R&D organizations, commercial suppliers, academia, etc.
- **The submitted example MUST describe an implemented deployment delivering tangible impact on at least 1 operating nuclear power plant.**

SUBMISSION

- Examples must be summarized using the **Use Case template**, following the guidance.
- Examples must be submitted as MS Word / editable files.
- There is **no limit to the number of Use Cases a person**, team or organization may submit.
- Each example must be fully **deployed in at least 1 operating nuclear power plant**. In the case of, for example, innovations implemented by a regulatory authority; the example must demonstrate a tangible benefit that extends to 1 or more operating nuclear power plants.
- Email completed templates to e.bradley@iaea.org

DEADLINE

Submissions must be received by **Friday, 30 May 2025**.

Contact: Nelly Ngoy Kubelwa N.Ngoy-Kubelwa@iaea.org

Upcoming Webinars

AI/ML/LLM

Advanced Manufacturing

Conclusions

- Continue work on analyzing Large Language Models (LLMs) for decommissioning safety
  - Create data-driven processes for decision making
  - Repository of Radioactive Waste Management and Decommissioning
- Development of understanding for a Data Governance approach for nuclear safety among all Member States
- Need of more experience by Member States on application of LLMs for decommissioning safety and lessons learned

Thank you!

Duriem Calderin Morales
Decommission and Remediation Unit (DRU)
Nuclear Safety and Radioactive Waste (NSRW)
Department of Nuclear Safety and Security
International Atomic Energy Agency | Vienna International Centre, PO Box 100, 1400 Vienna, Austria |
Email**: D.Calderin-Morales@iaea.org|** T: +(43) 1260022372

IAEA ORGANISATIONAL FRAMEWORK

Nuclear Energy

Nuclear Sciences and Applications

Nuclear Safety and Security

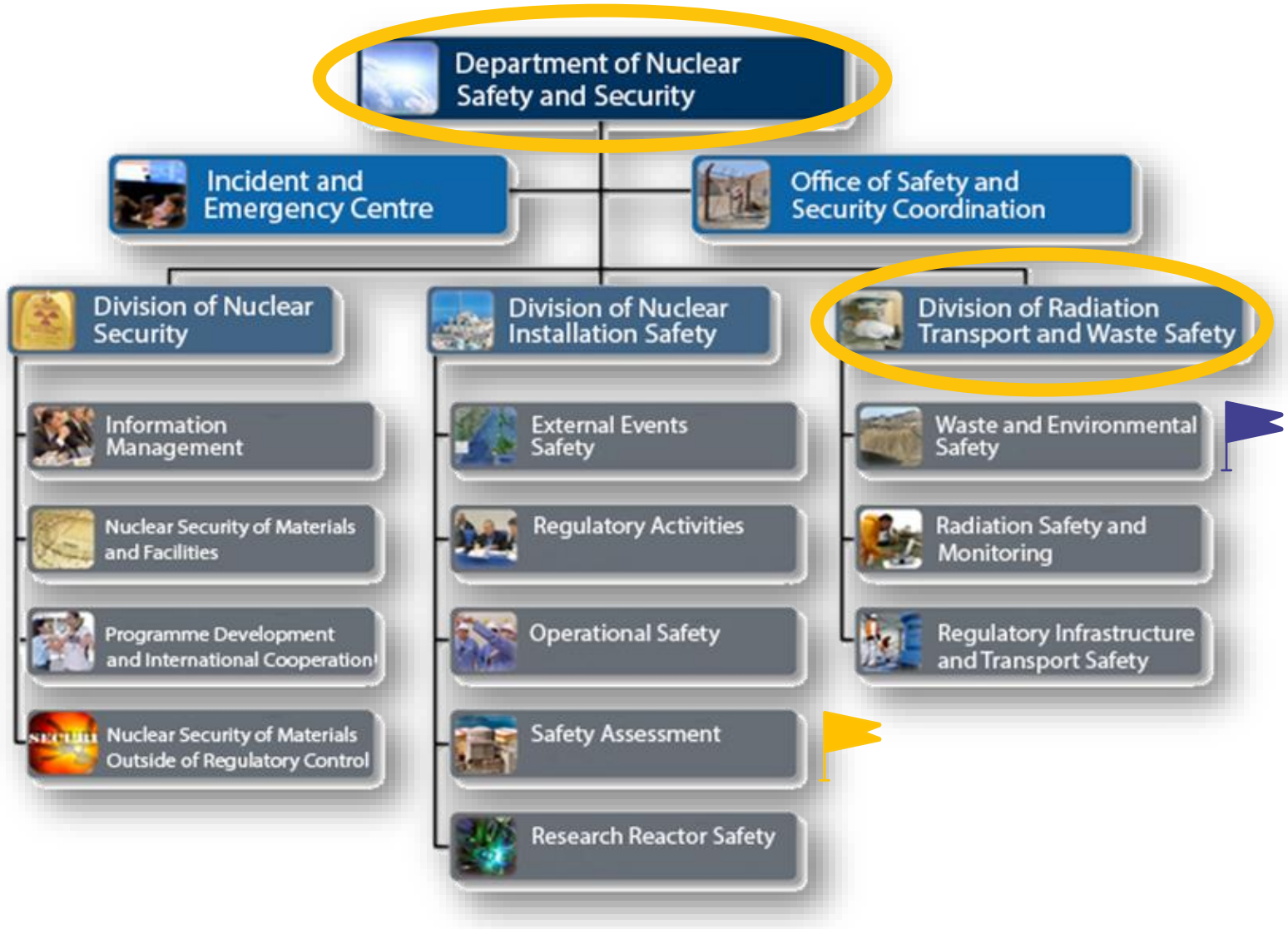
Safeguards

Technical Cooperation

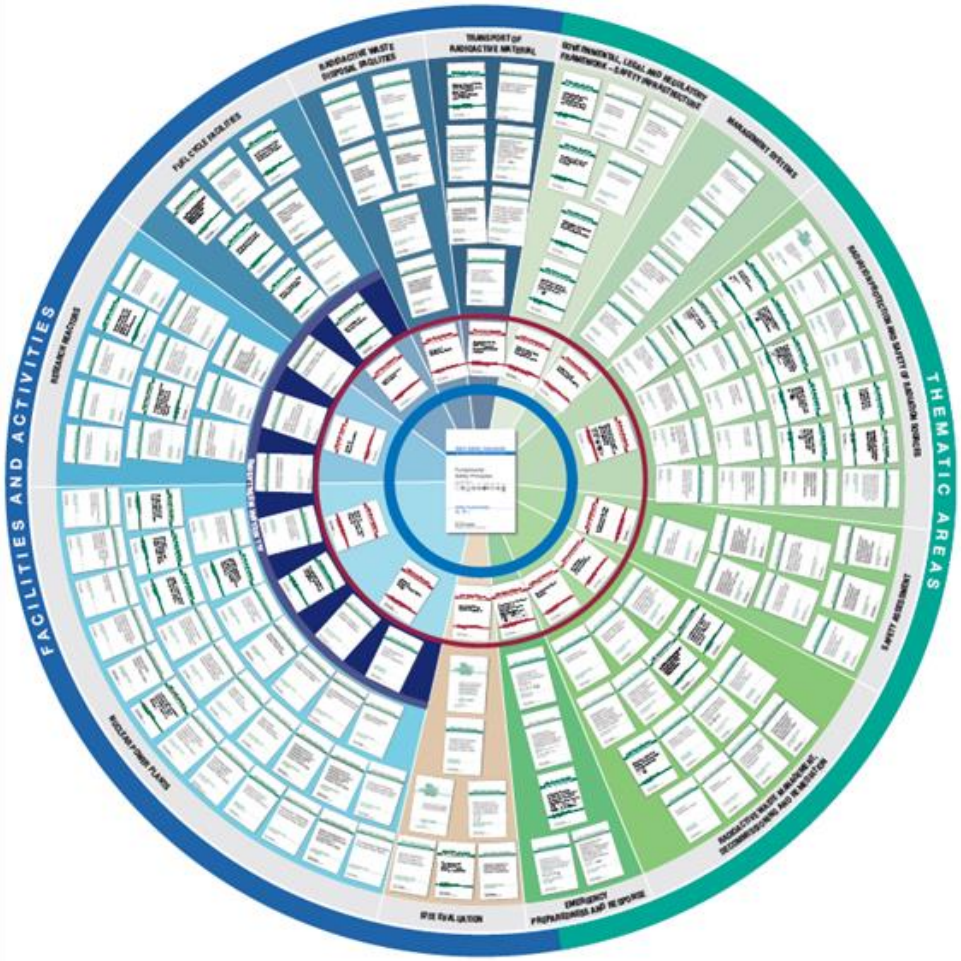
Management

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY (NS)

- The Division establishes safety standards for radiation protection, management of radioactive waste and environmental releases, decommissioning, remediation and transport.
- Supporting Member States with expertise on decommissioning, environmental remediation, and management of radioactive waste and spent fuel.
- Making sure we protect people and the environment while enabling nuclear science and technology.



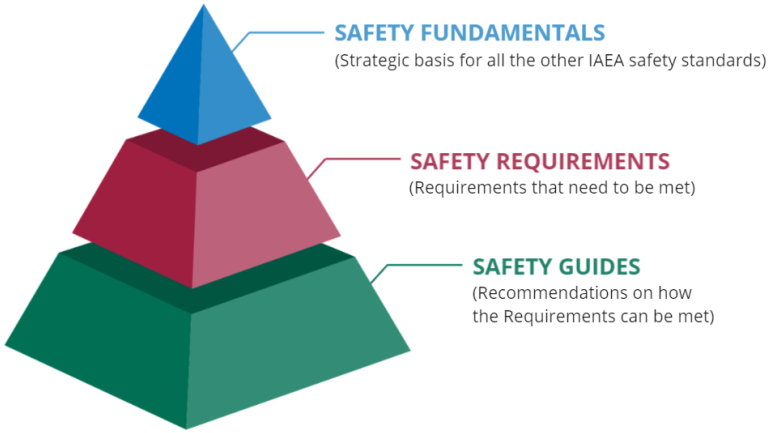
Safety Standards Review



Safety means **protecting people** and the **environment** from **harmful effects** of **ionizing radiation**, and the safety of **facilities** and **activities** that give rise to **radiation risks.**

The standards aims to:

1. control radiation exposure of people and the release of radioactive material to the environment;
2. restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation;
3. mitigate the consequences of such events if they were to occur.



International Consensus