Supporting Accelerator-Driven Systems (ADS) Development

A Sustainable Solution to Nuclear Waste: The Transmutex Technology

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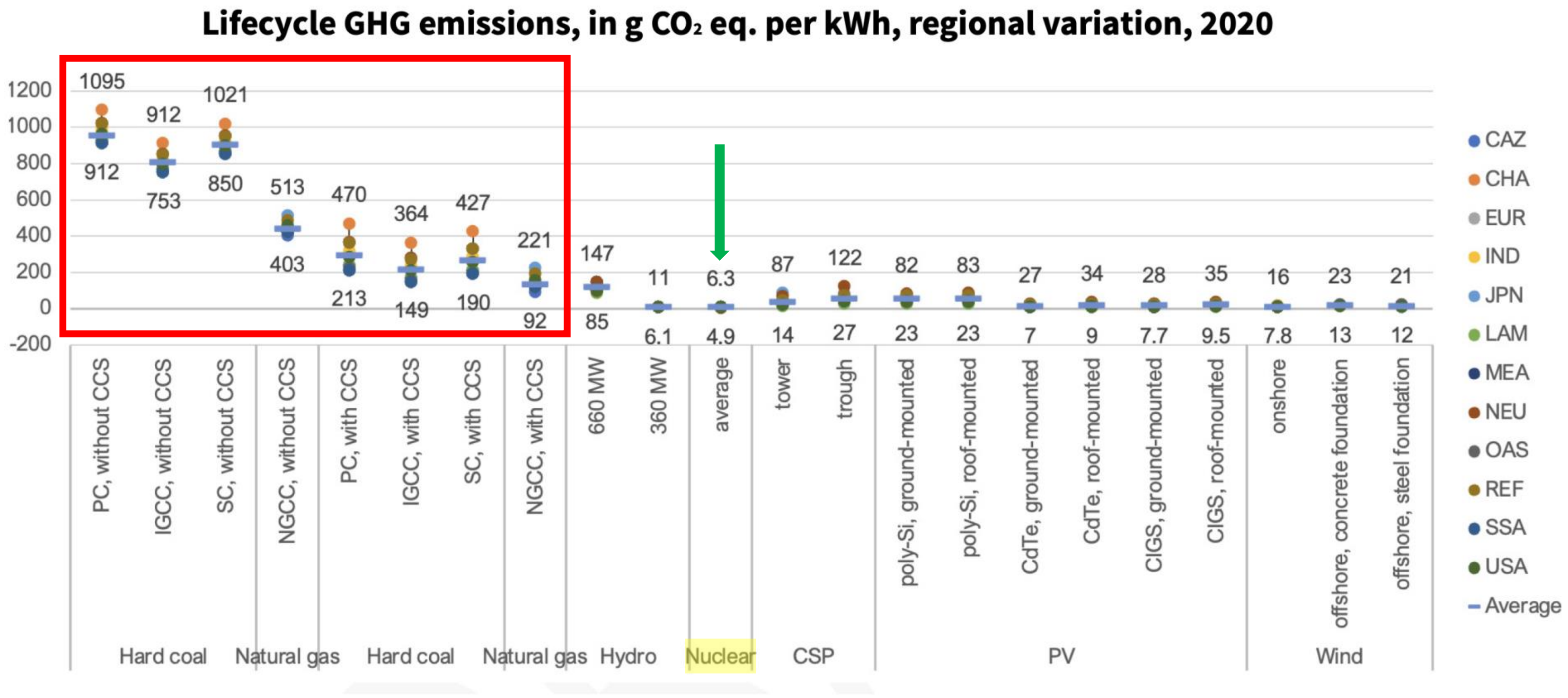
Nuclear: Reliable Power for a Cleaner Planet

- **Nuclear energy** as key source of **carbon-free power**, crucial for **fighting climate change**



Source: LCA_3_FINAL March 2022.pdf

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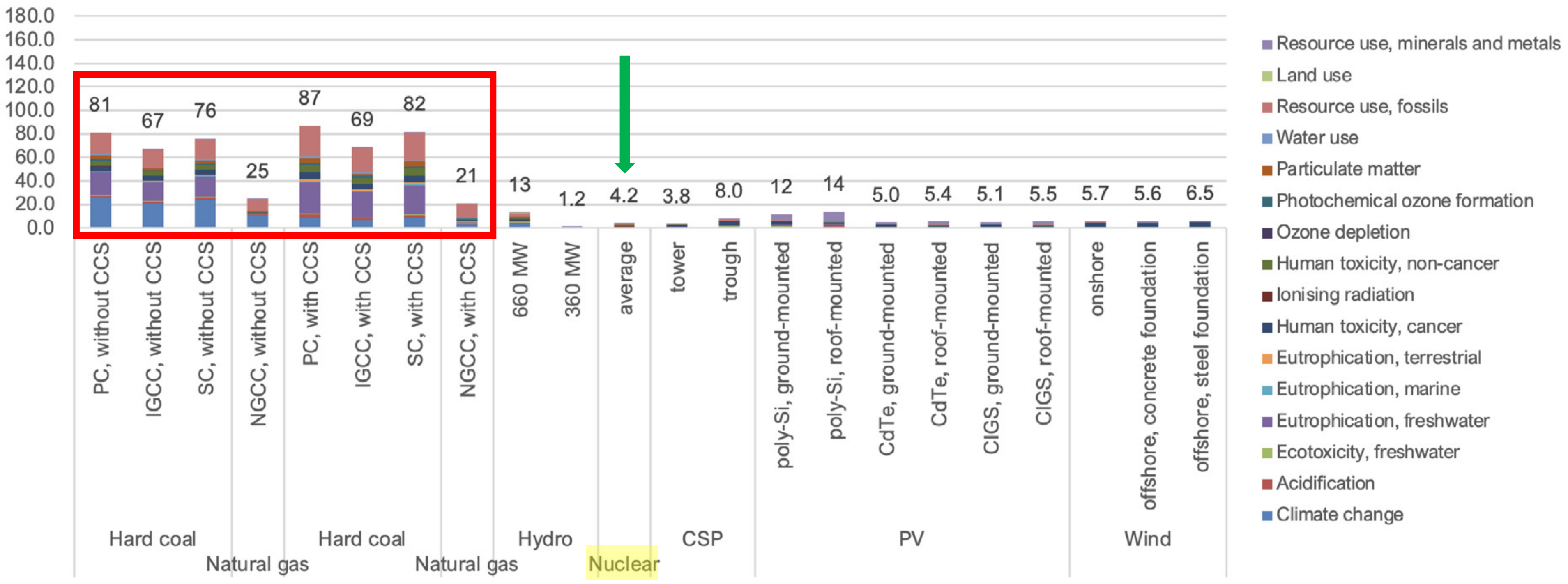
Normalised lifecycle impacts, weighted, of the production of 1 TWh, per technology, Europe, 2020



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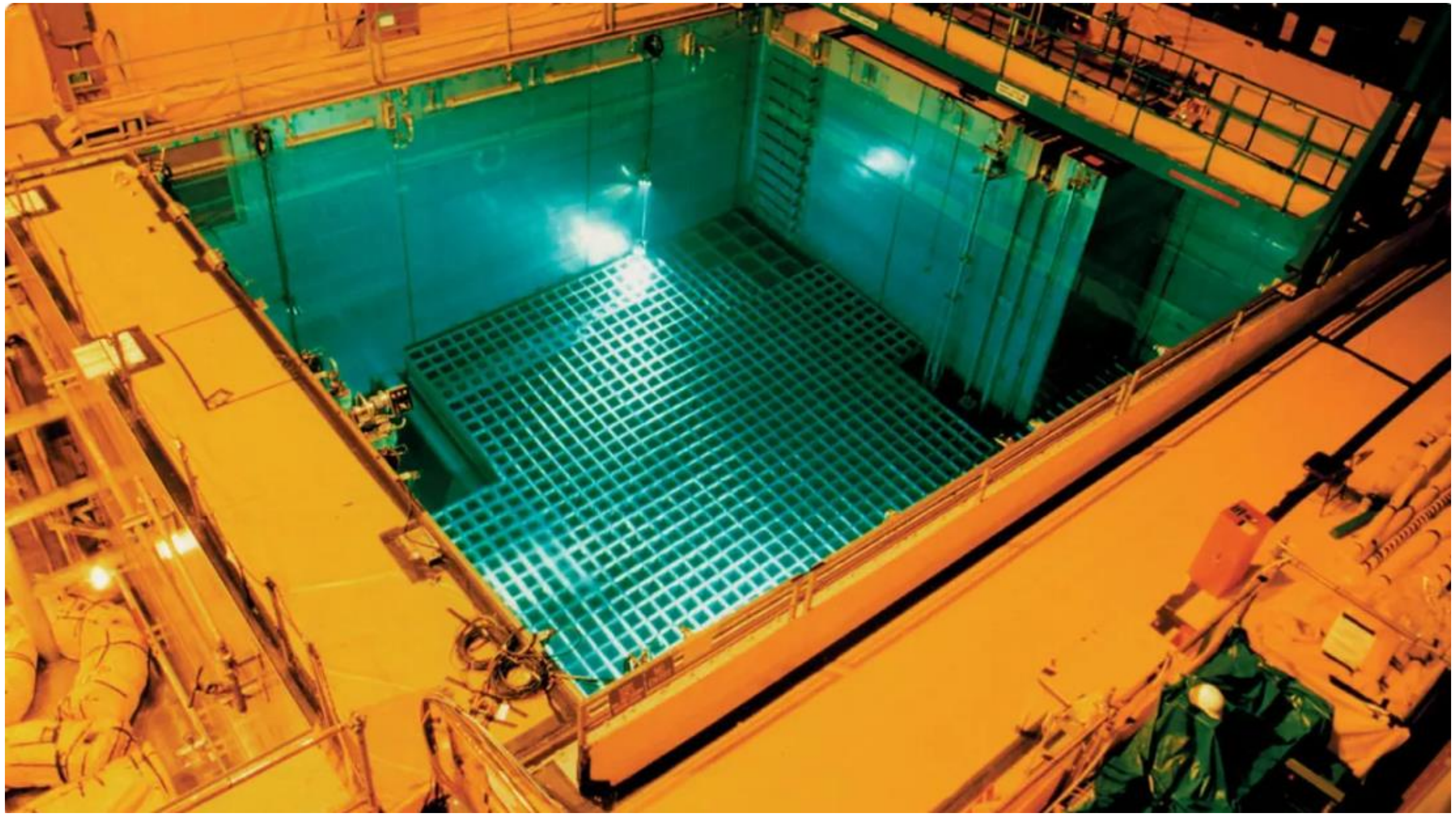
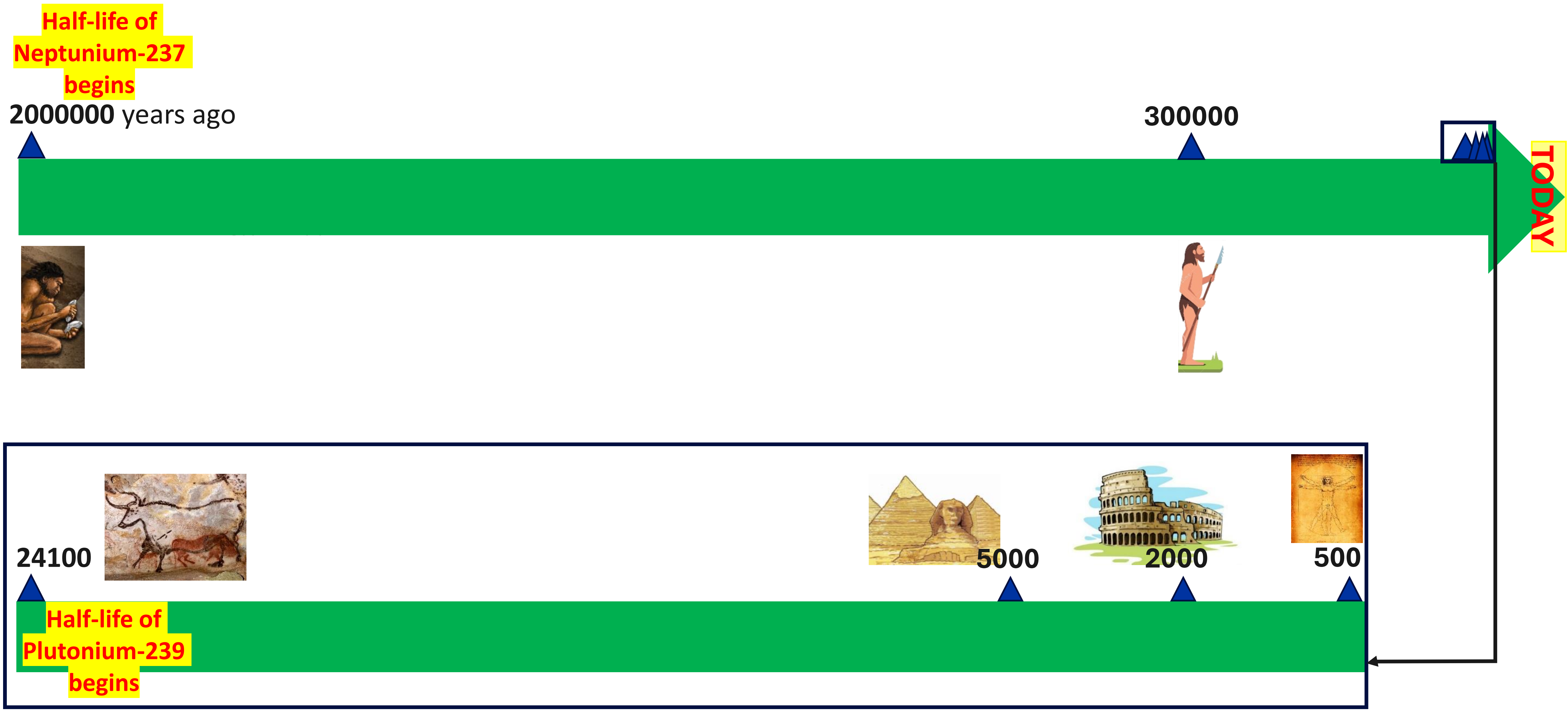
Global Sustainability Challenge: Nuclear Waste



Source: Utility Dive (Aug 2023), U.S. Court ruling on NRC authority for private spent fuel storage

Global Sustainability Challenge: Nuclear Waste



The Current Nuclear Paradigm

Source: The Plan for Storing US Nuclear Waste Just Hit a Roadblock | WIRED

Key Challenges for Future Deployment:

- **Long-Term Waste Management**
- **Public Confidence in Reactor Safety**

A Real Potential Solution: ADS and Transmutation

What is TRANSMUTATION?

- A process that converts one element or isotope into another, **transforming long-lived isotopes into shorter-lived or stable ones** by bombarding them with neutrons or other particles.
- The process - on an industrial scale - it's **still an area of active research and development** rather than a fully industrialized solution.
- **The Result:** The **lifetime** of the most dangerous waste could be **significantly reduced**.

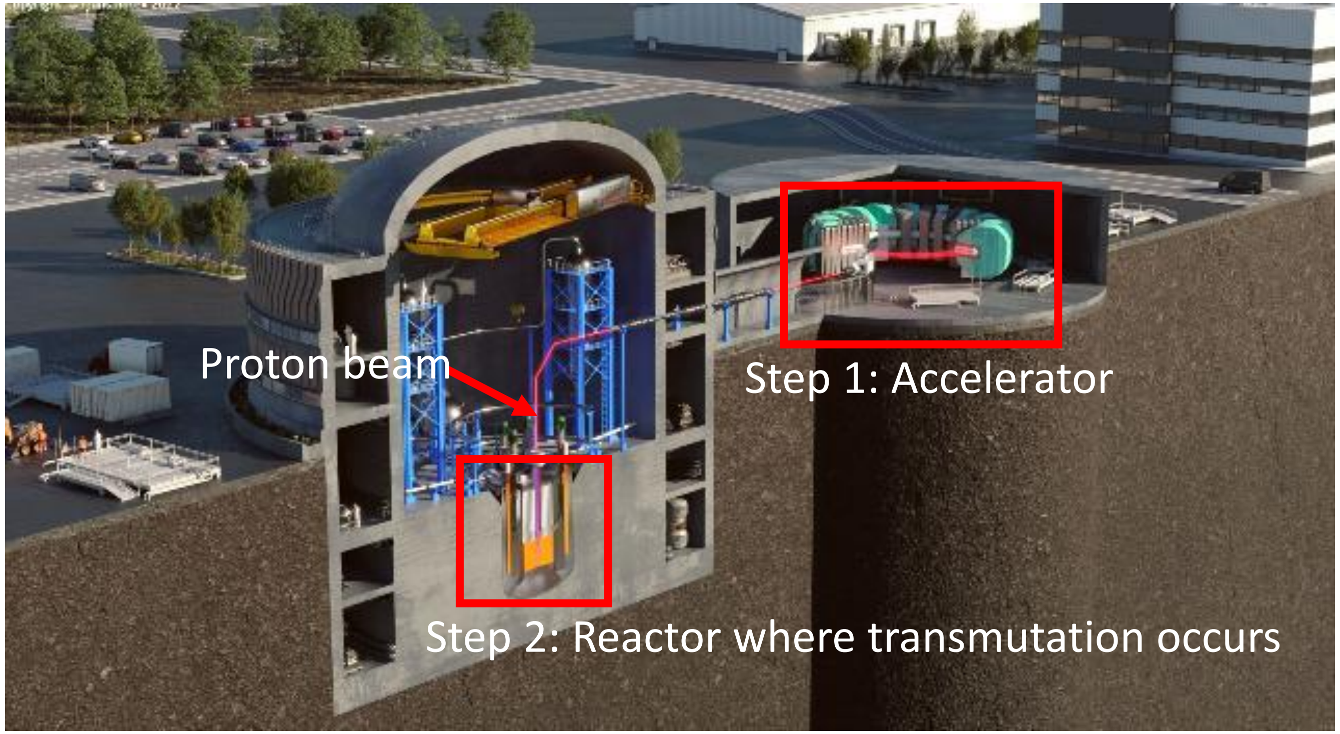
TRANSMUTEX: the company aiming at making it possible

Founded: July 2019 ● **Team:** 50+ empl. ● **Headquarters:** Geneva(Switzerland)

- **Mission:**
  - To develop a technology that **recycles part of the existing nuclear waste** to produce **safe, clean, and carbon-free energy.**
  - To unlock the **potential of the Thorium fuel cycle for** abundant and **sustainable power generation.**
- **The technology: Transmutation in ADS**
  - Sub-critical reactor technology that is externally **controlled by a particle accelerator,** ensuring **inherent safety**.

The ADS Concept: A Game-Changer for Sustainability

➢ **Accelerator-powered technology** that holds the promise of turning **existing nuclear waste into clean energy** and **unlocking the potential of new, sustainable fuel cycles like Thorium.**



Source: Transmutex SA – Venturelab

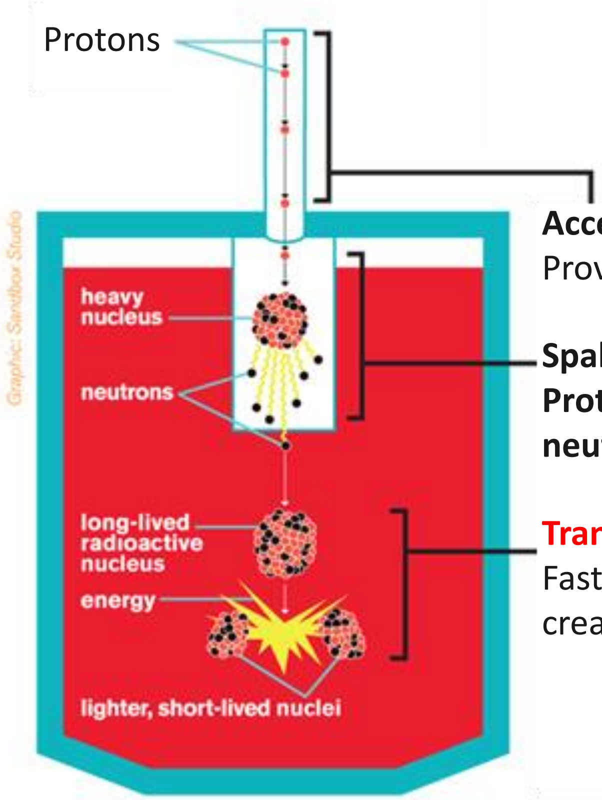
- **Inherent Safety by Design**: no self-sustaining chain reaction.

- When the **accelerator** is **switched off**, the **transmutation** process **stops almost instantly**.

- **The Result:**
  - Hazardous lifetime of waste **significantly reduced** (Transmutex | Innovators in Sustainable Energy).
  - **Reduces the volume of required geological storage** to far **more manageable levels**.

Inside the Reactor: The Transmutation Process

- **A process that uses fast neutrons to change hazardous, long-lived atoms into stable or shorter-lived ones.**



Accelerator
Providing an intense, continuous **beam of protons**

Spallation target
Protons hit heavy nuclei and “shake loose” **neutrons**, which **enter the reactor vessel**

Transmutation
Fast neutrons hit and split long-lived nuclei creating **energy** and **short-lived nuclei**

Released in the form of **intense heat**

Source: [Taking the heat out of nuclear waste | symmetry magazine]

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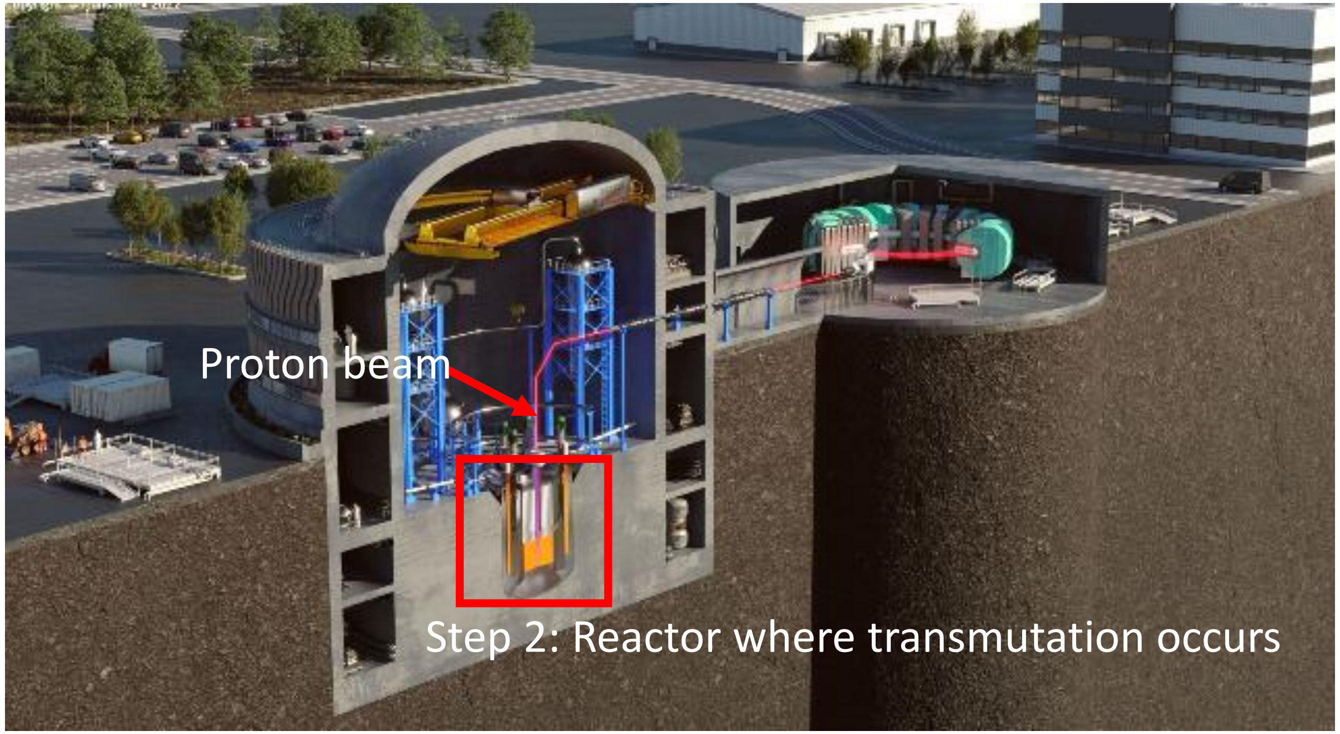

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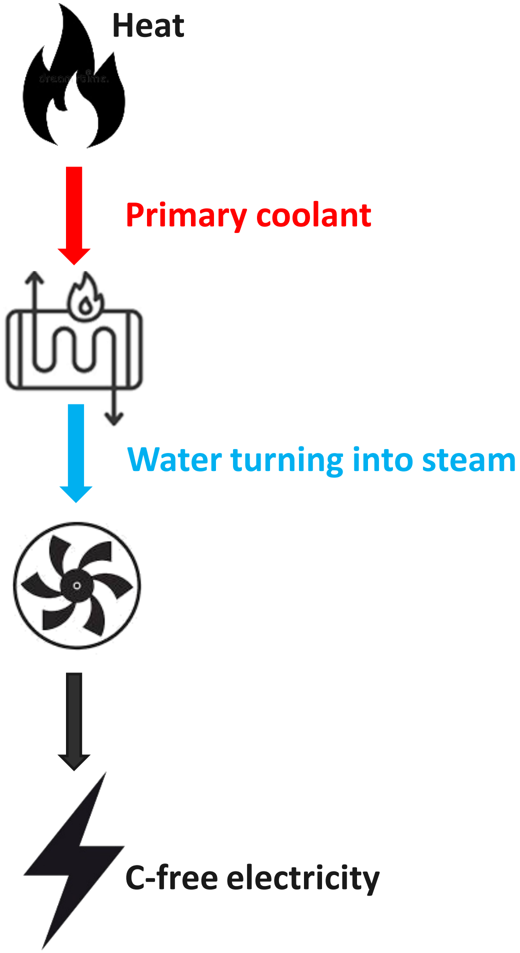
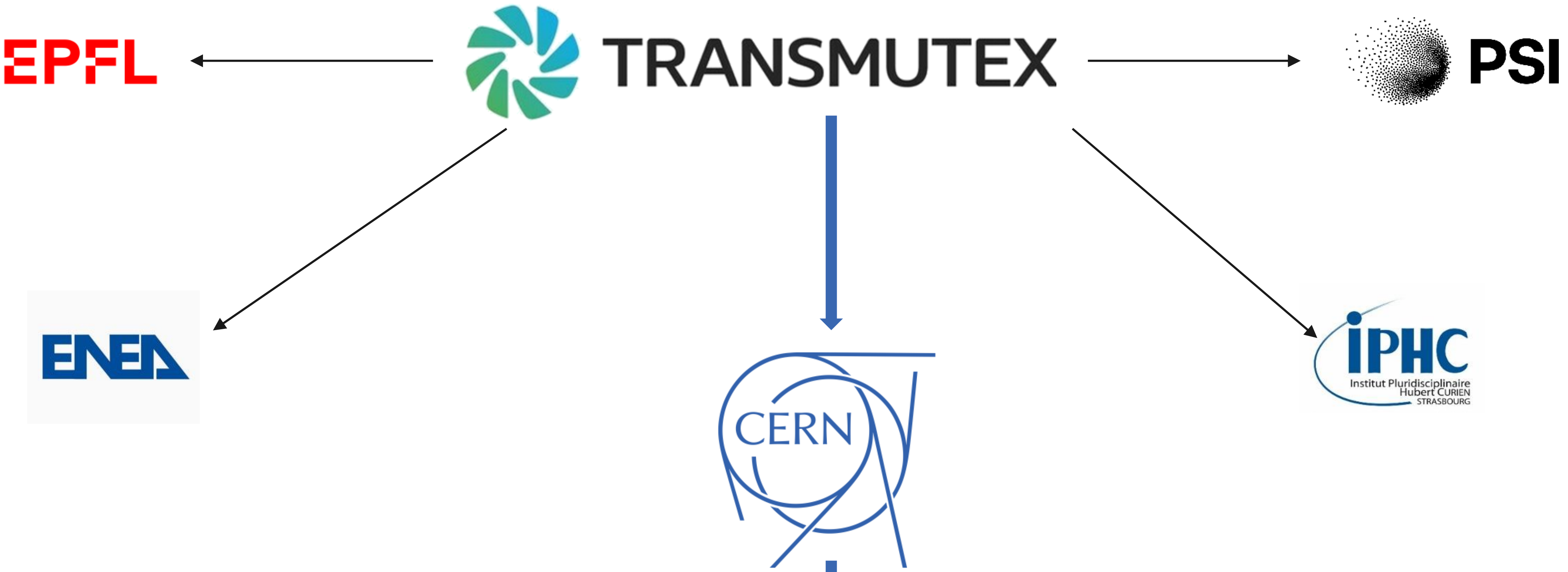


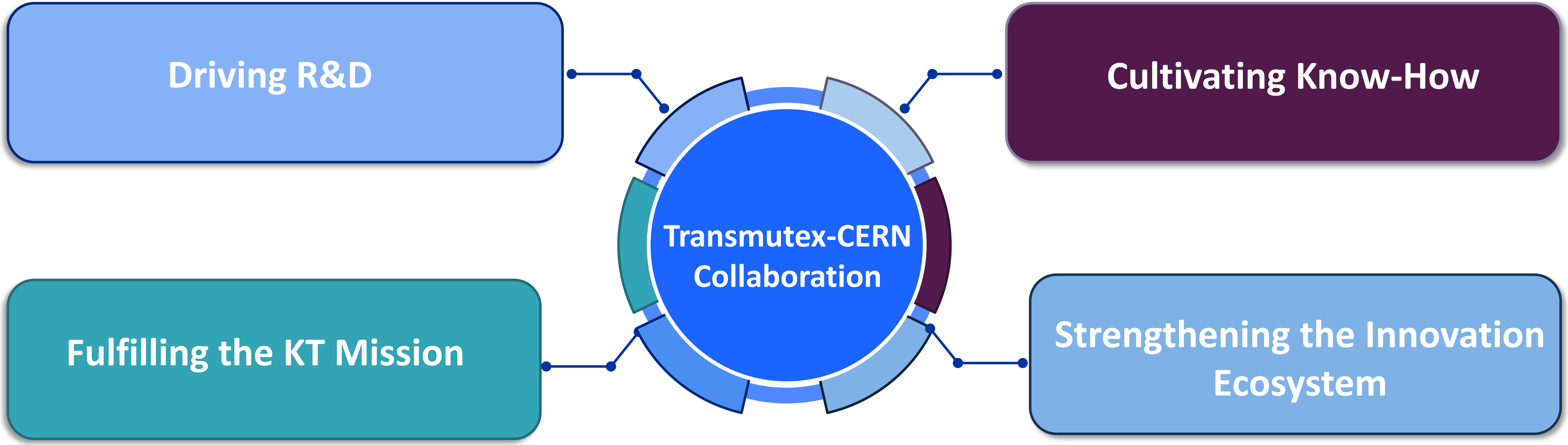
A Scientific Collaboration for a Safer, Cleaner Future



- **The Cradle of the Concept:** The idea of using an accelerator to transmute waste (the "Energy Amplifier") was pioneered at CERN in the 1990s by Nobel laureate **Carlo Rubbia**.
- **From Research to Reality:** Transmutex was co-founded by **CERN physicists**, turning decades of fundamental research into a real-world application.
- **A Hub of Expertise:** Our collaboration leverages CERN's world-leading knowledge in **particle accelerators, materials science, and simulation tools.**

Additional info: Transmutex | Innovators in Sustainable Energy

Transmutex-CERN: Pushing Boundaries, Creating Impact



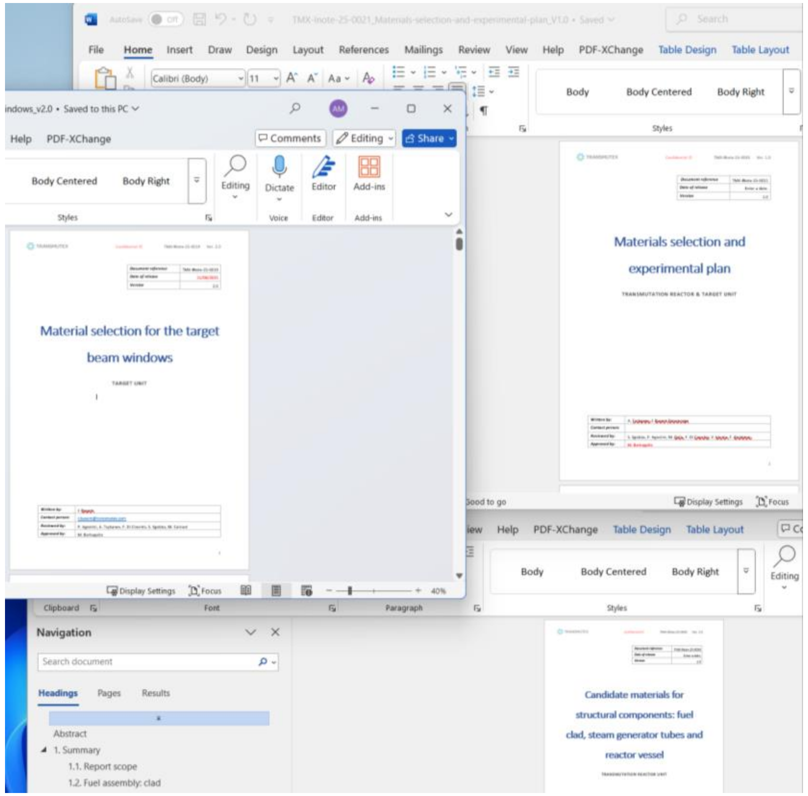
MME-MM: Support in Materials Selection for the Reactor Critical Components

➢ Materials consultancy and support in specific characterisation techniques

- Feedback on **materials selection for different critical components within the reactor** and on their capabilities to withstand extreme conditions (irradiation, high T, potential corrosion by liquid metal coolant…)

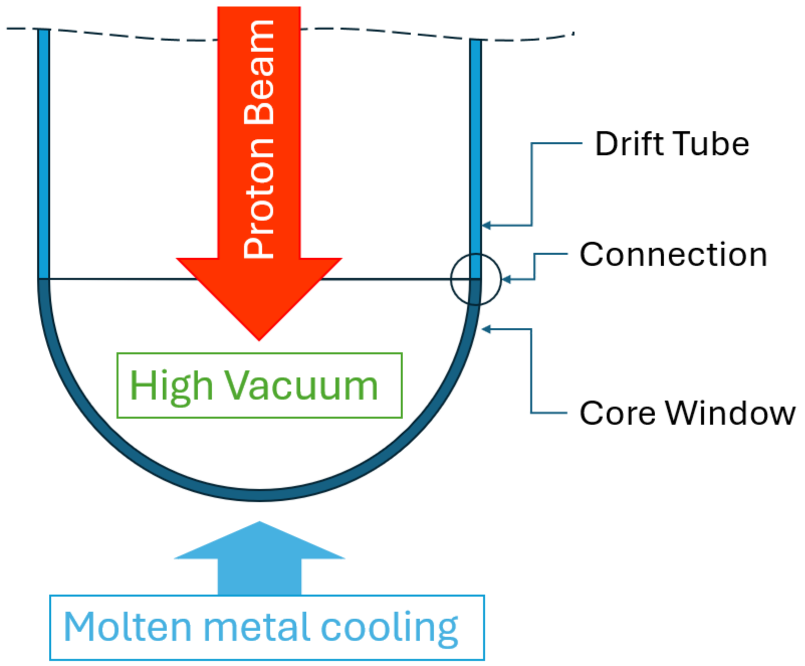
- **Supporting the characterisation of nano-mechanical properties** for some of the potential material candidates

- Expert technical **review and validation for key project documentation**



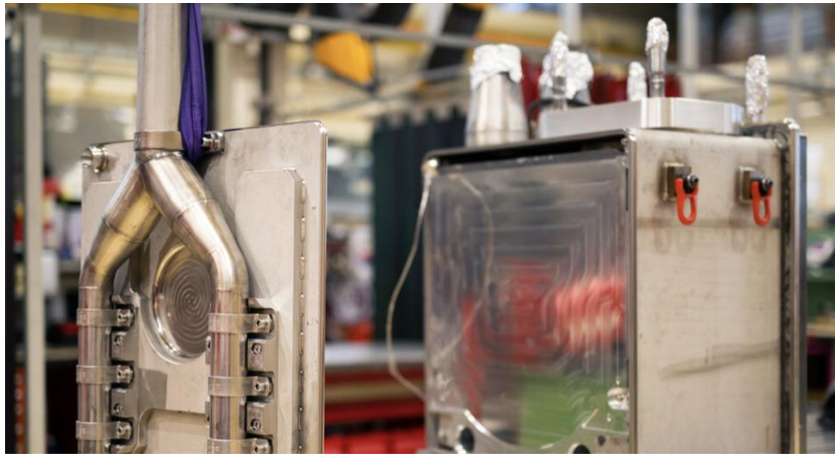
MME Workshop: Support in design for Manufacturing

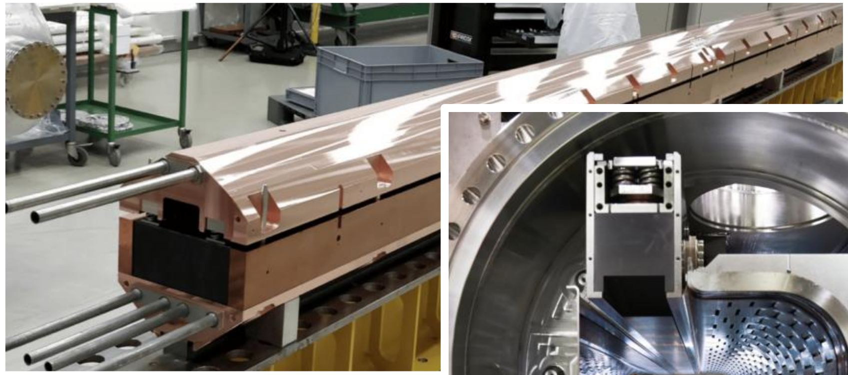
- **Manufacturability assessments**
  - Feedback on specific **production and assembly processes**
  - Advising on **design optimization** for manufacturing
  - Expertise on specific **fabrication technologies**: multi-technology, machining of complex components/materials, …

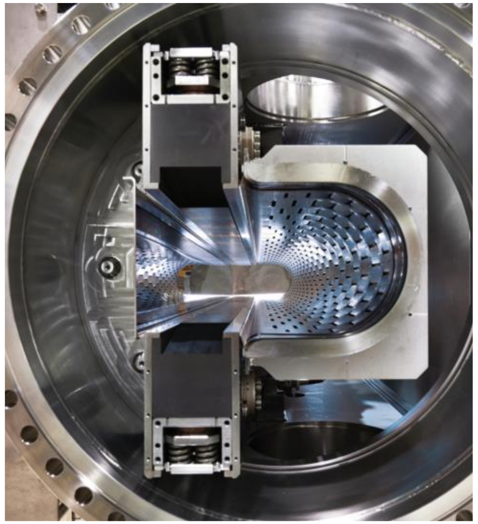


SY-STI Support (beam intercepting devices)

- Support in **concept design review**, towards operation **of target systems and beam intercepting devices** required for the ADS
- Expertise sharing in **full lifecycle management** from concept development, to FEA, **maintenance in radioactive environment** as well as **waste packaging** in view of final disposal
- Feedback and active support in the **use of refractory metals for application as beam intercepting devices**, employed as absorbers and targets
- Sharing expertise in **high power spallation target design and development** thorough reviews and advisory







SY-STI Support (FLUKA beam matter interaction)

The excellent physics record of FLUKA,

its extensive validation,

its user-friendly interface Flair,

and key recent developments such as:

Point wise treatment for low energy neutrons (En<20MeV), with fast, accurate, and correlated sampling, able to use any available neutron database at any temperature

CAD geometries importing into FLUKA

Flair's capability to run from the same FLUKA input multiple MC codes (Geant4, Phits, OpenMC)

direct integration of the results into FEA codes

make the CERN software contribution a valuable asset for Transmutex in neutronics and radiation protection studies.

Concluding remarks

- **Transmutex** aims at transforming **nuclear waste into clean energy**:

  - This inherently safe **technology born from CERN** research addresses the past (existing waste), the present (clean energy production), and the future (a cleaner planet for generations to come).

- It unlocks the potential of the **Thorium fuel cycle for abundant and sustainable power** generation.

- Our collaboration is a powerful example of how **CERN expertise can accelerate sustainable innovation**.

Thank you for your attention!

CIPEA

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