European Vision in P&T

Advances in Transmutation Technology

Prof. Dr. Hamid Aït Abderrahim
SCK•CEN, Boeretang 200, 2400 Mol, Belgium
haitabde@sckcen.be or myrrha@sckcen.be

SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

After a very good year 2010

- 4.03.2010: Inauguration of GUINEVERE, a zero power mock-up of MYRRHA;
- 5.03.2010: Decision of the Belgian federal government to support the MYRRHA project (40% of 960 M€ total investment);
- 15.11.2010: Launch of the ESNII (European Sustainable Nuclear Industrial Initiative) of SNETP including MYRRHA & ASTRID;
- 29.11.2010: Promotion of MYRRHA to the high priority list of ESFRI (European Strategic Forum for Research Infrastructures);
- 13.12.2010: Selection of ISOL@MYRRHA by NuPPEC in their long range plan 2010 for nuclear physics facilities;

SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

MYRRHA- Accelerator Driven System

Accelerator
(600 MeV - 4 mA proton)

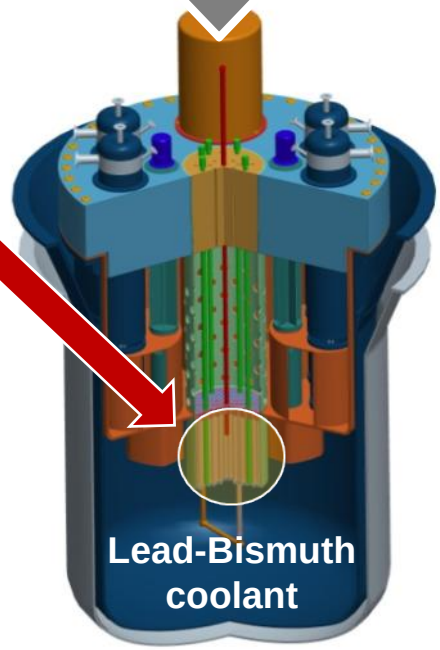
Reactor
- Subcritical mode (65 -100 MWth)
- Critical mode (~100 MWth)

Innovative & Unique

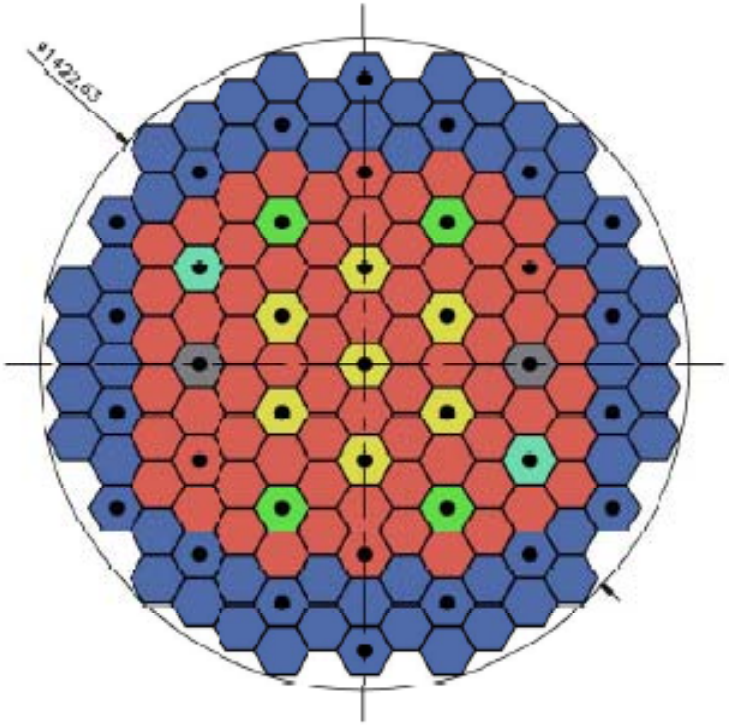
Spallation Source

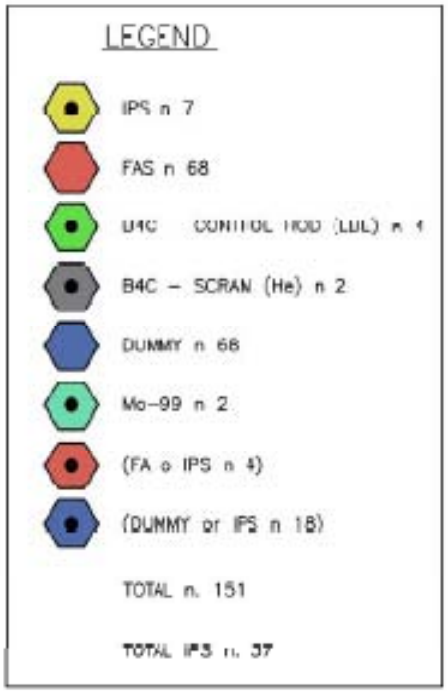
Fast Neutron Source

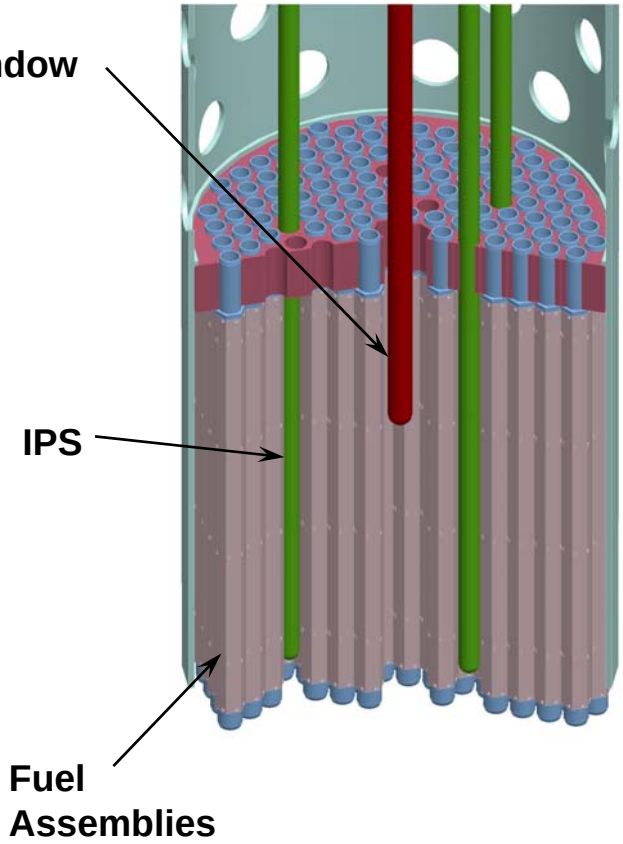
Multipurpose Flexible Irradiation Facility



Fast spectrum irradiation facility



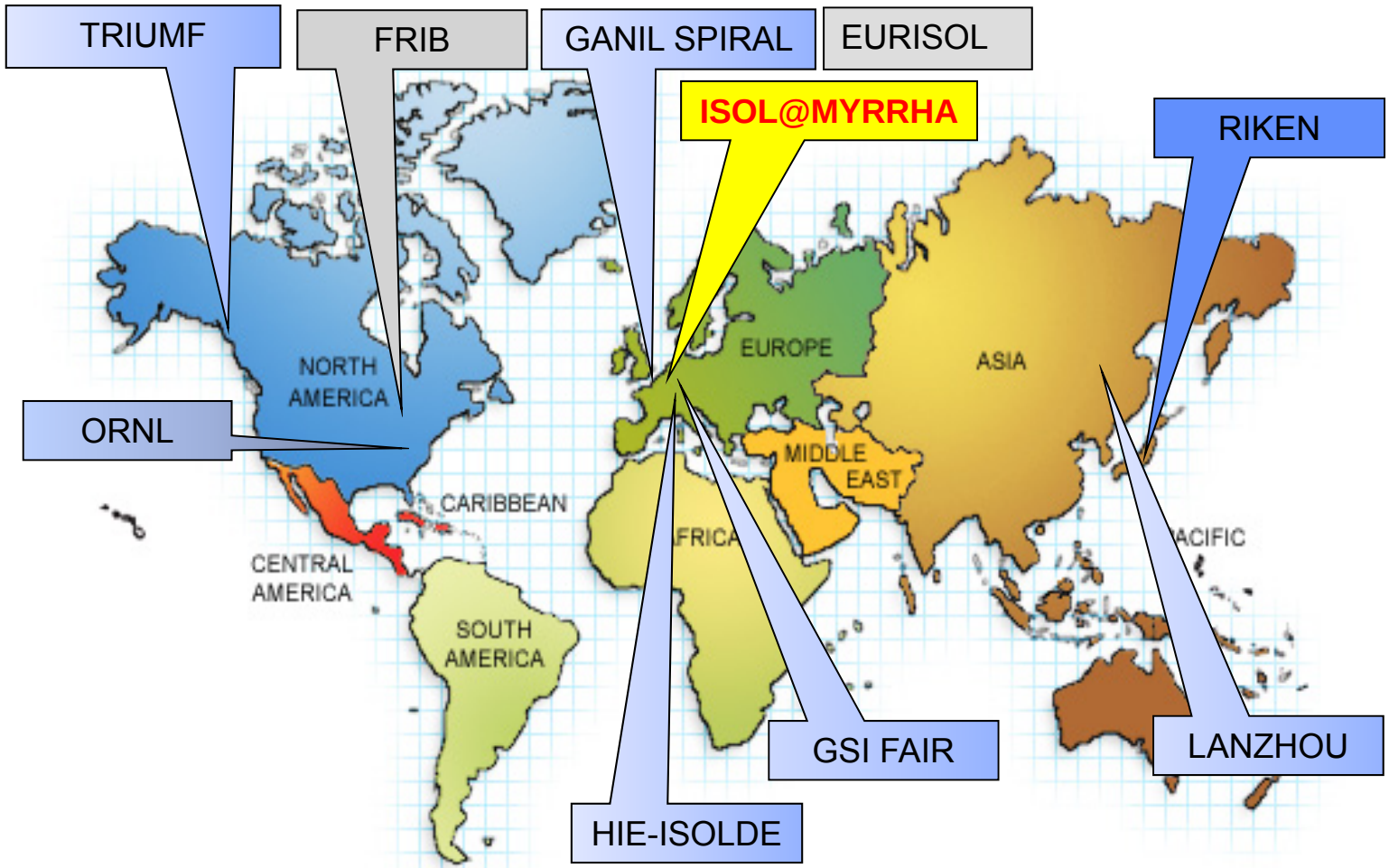




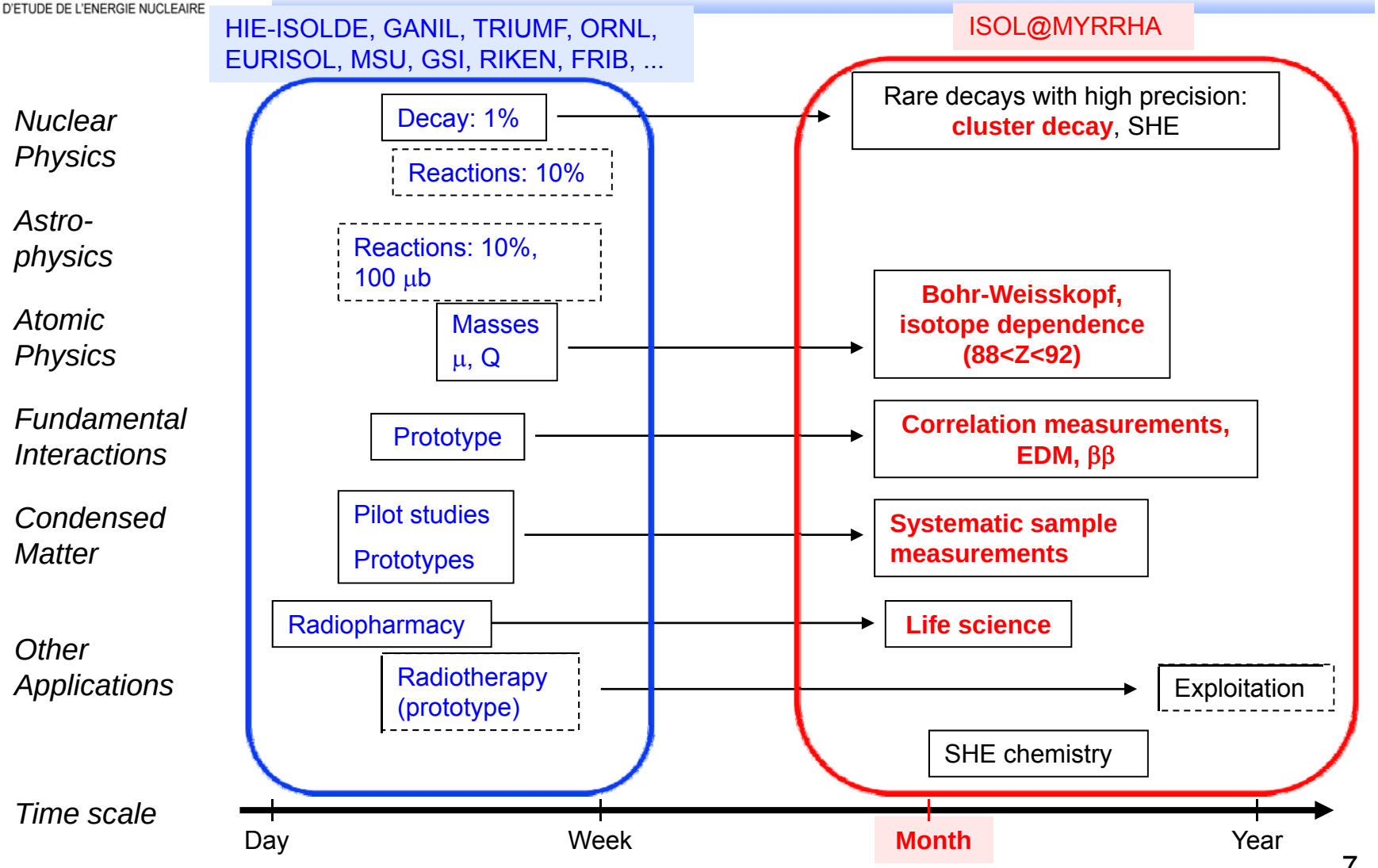
k_{eff}≈0.95 (ADS mode)

SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

High-intensity RIB facilities worldwide



ISOL@MYRRHA in NuPPEC Plan



SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

At the crossroads of ESFRI and SET Plan

Knowledge Economy

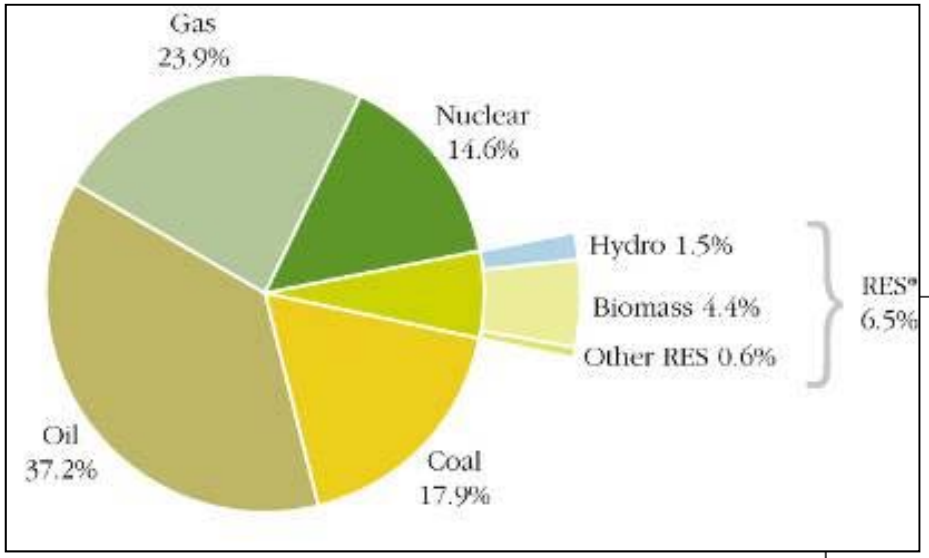
MYRRHA

Energy Independence

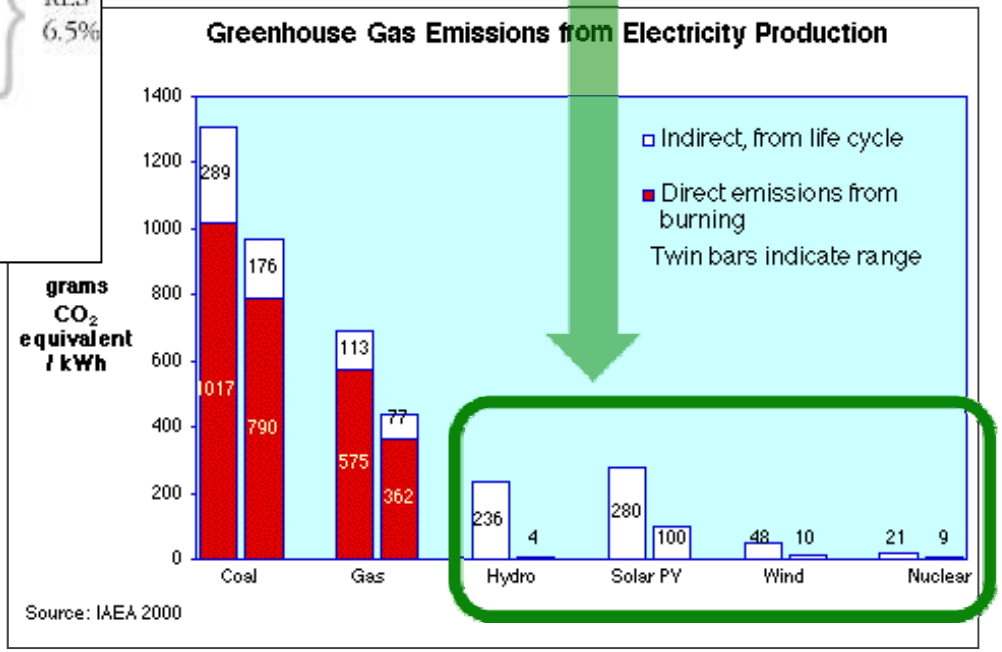
The only ESFRI project for Belgium

STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Facing the Energy Challenge



Energy production shares in EU-25 (2005)



SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Sustainable Nuclear Fission

SNETP
SUSTAINABLE NUCLEAR ENERGY TECHNOLOGY PLATFORM

nuclear waste

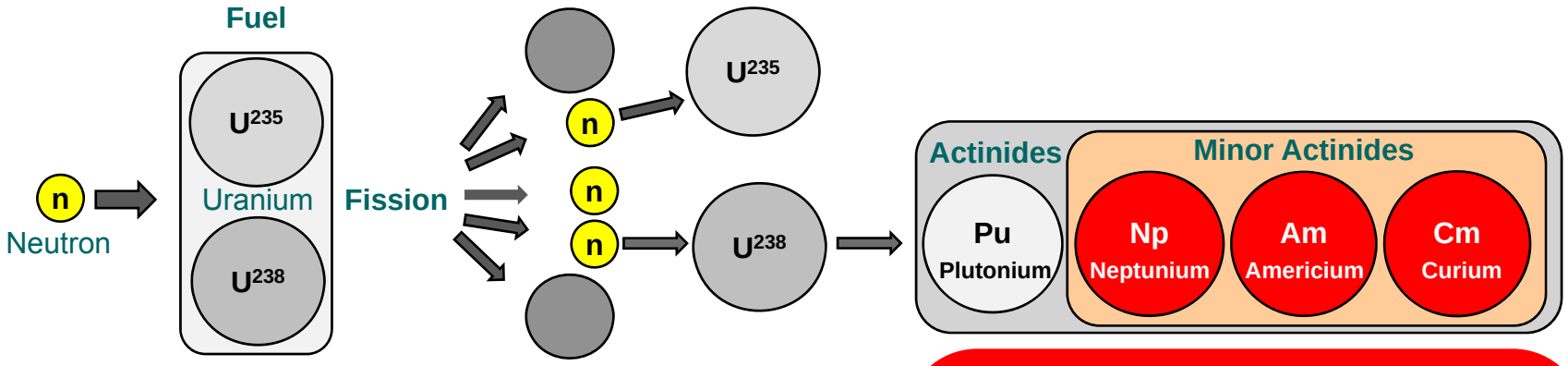
ressource utilisation

safety

proliferation risk

SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

High Level Nuclear Waste



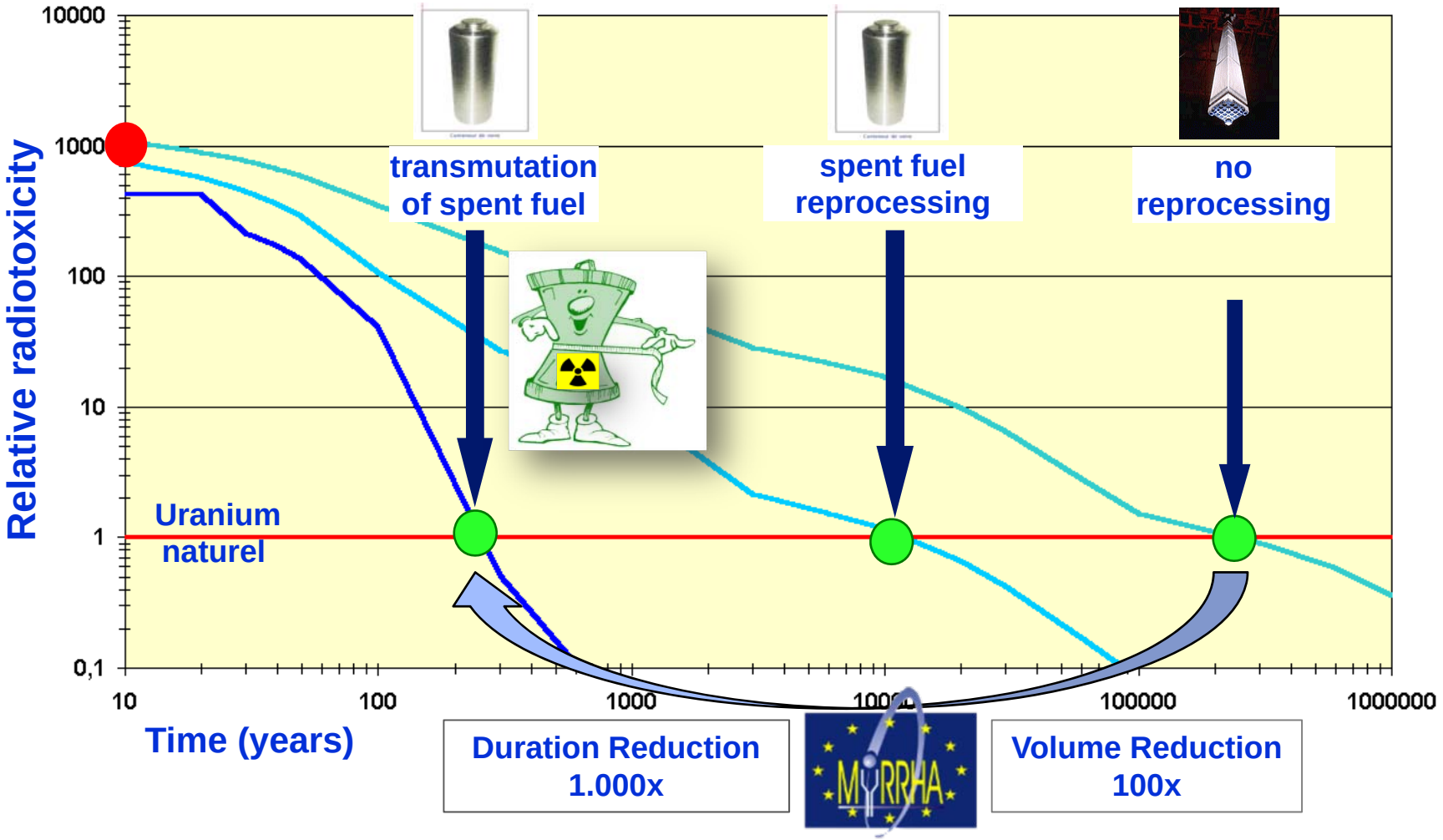
Minor Actinides

high radiotoxicity long lived waste that are difficult to store due to:

- **Long lived (>1,000 years)**
- **Highly radiotoxic**
- **Heat emitting**

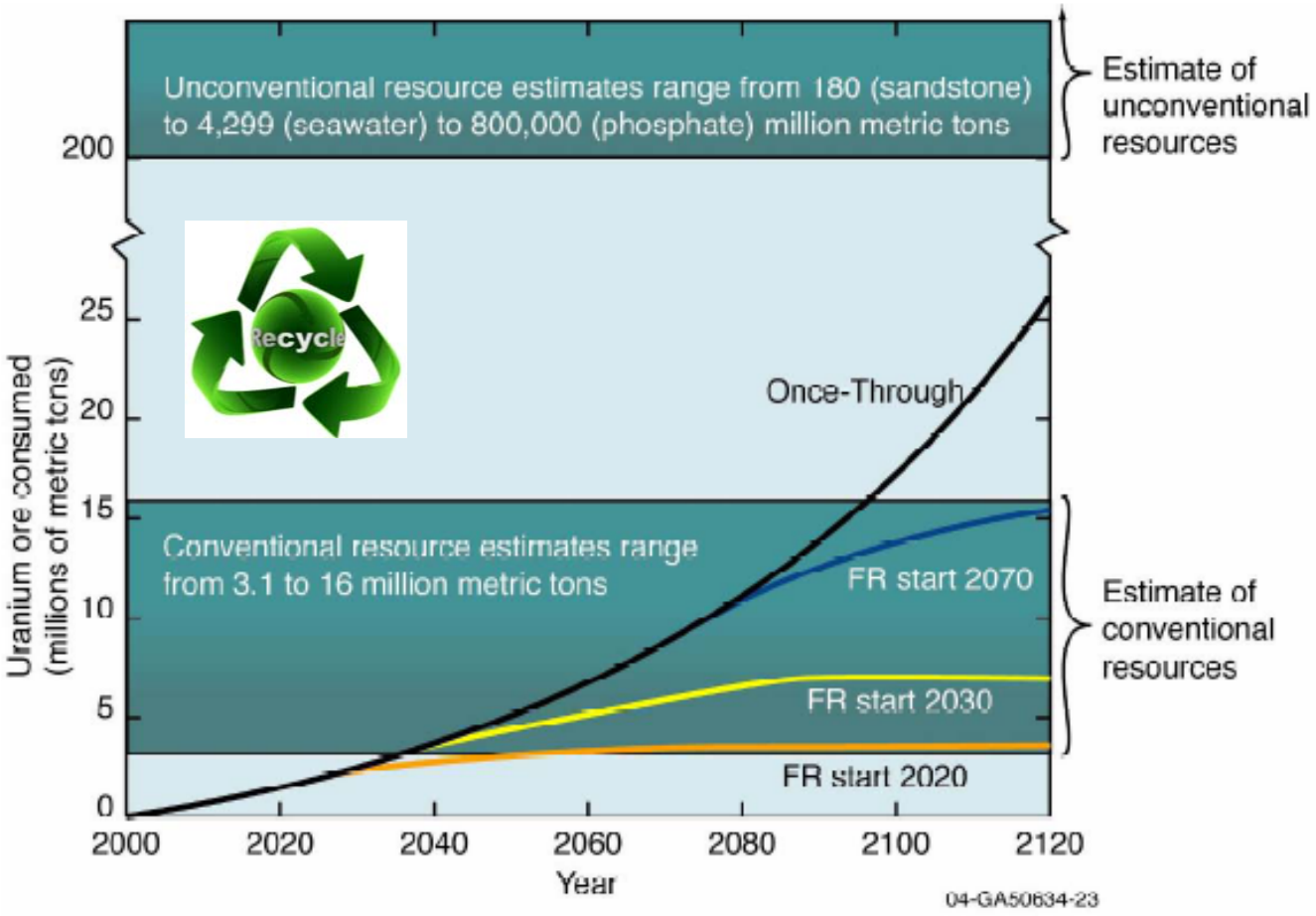
SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Motivation for Transmutation



SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Better ressource utilisation



SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

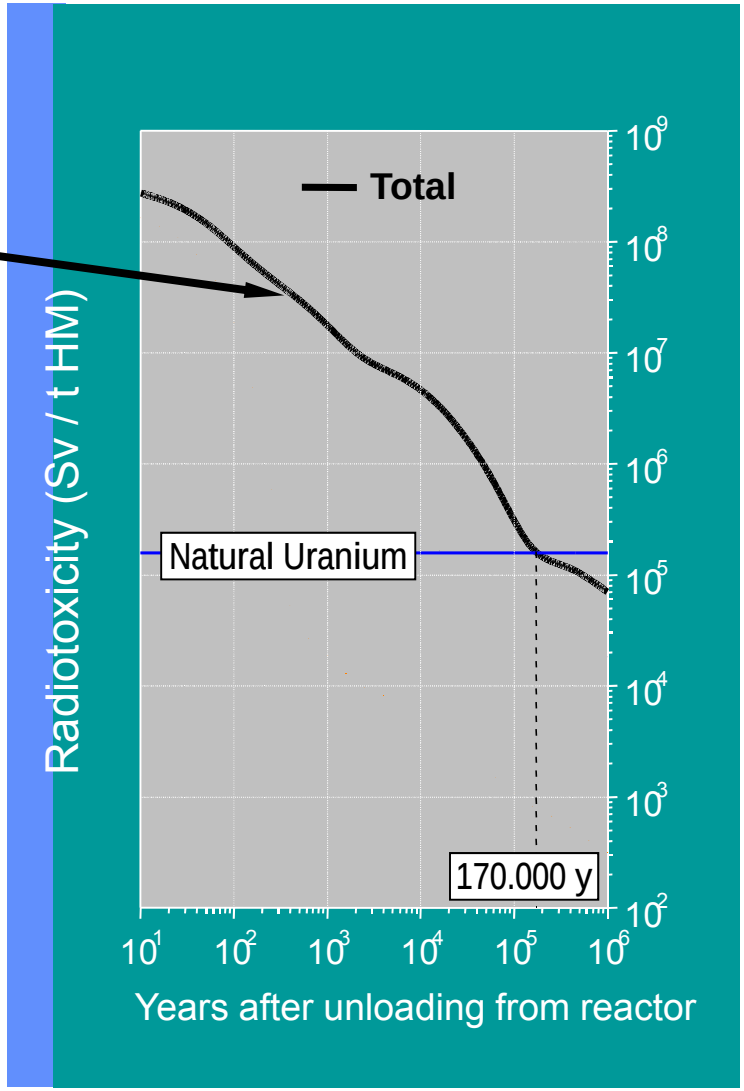
European Vision for Implementation of P&T Strategy

- **Implementation of P&T of a large part of the high level nuclear wastes in Europe needs demonstration of the feasibility of several installations at an "engineering" level leading to arrangement of R&D activities in four "building blocks", so as:**
  1. **To process a sizable amount of spent fuel from commercial power plants (i.e. LWR) in order to separate Pu and MA,**
  2. **To fabricate at semi-industrial level the dedicated fuel needed to load a dedicated transmuter,**
  3. **To make available one or more dedicated transmuters,**
  4. **To process the dedicated fuel unloaded from the transmuter and fabrication of new dedicated fuel.**

SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Reduction of Radiotoxicity

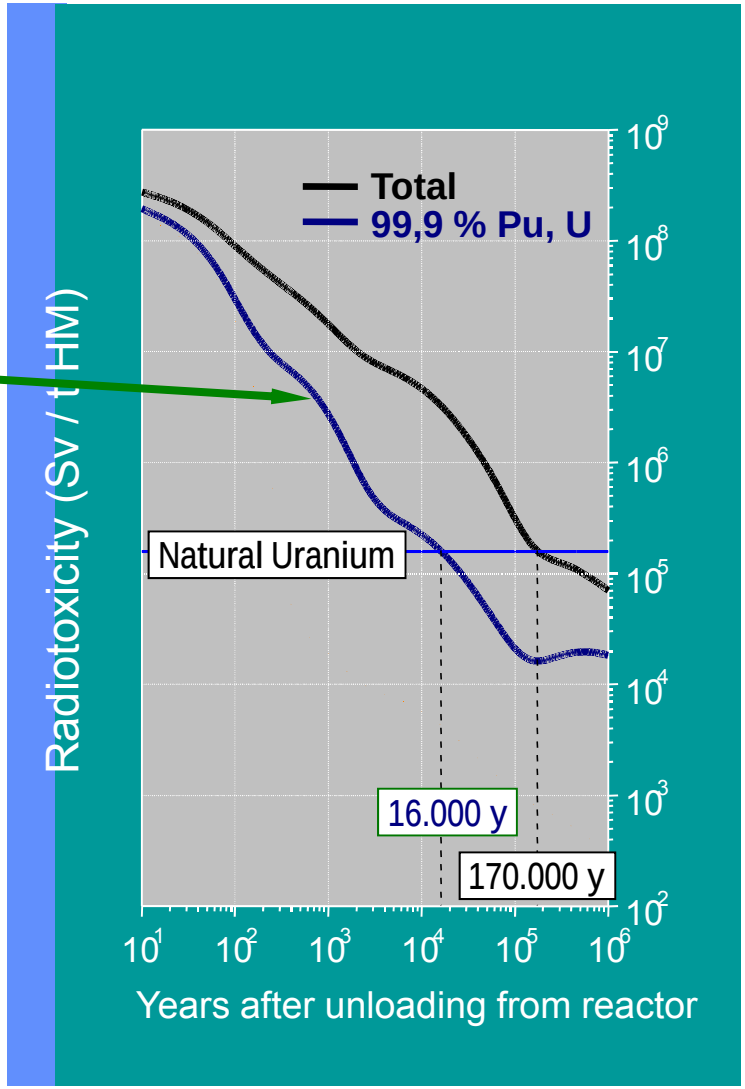
- **Direct disposal of the overall nuclear wastes**



SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Reduction of Radiotoxicity

- **Partitioning and transmutation of 99.9% of Pu and U**



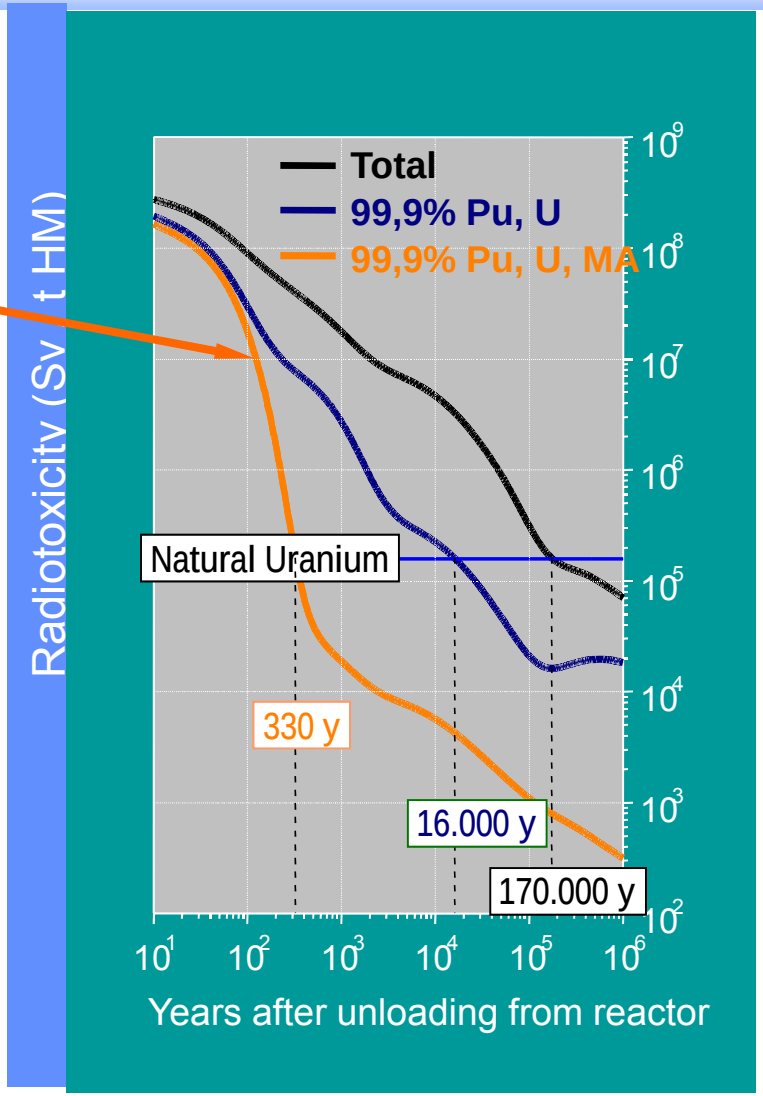
SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Reduction of Radiotoxicity

- **Partitioning and transmutation of 99.9% of Pu, U and MA**

Achievement

Disposal times are shifted from geological to historical time scales in nuclear waste disposal.



SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Benefits of Transmutation

- **Transmutation allows to minimize radiotoxicity, heat load and volume of high level wastes which have to go to a final repository.**

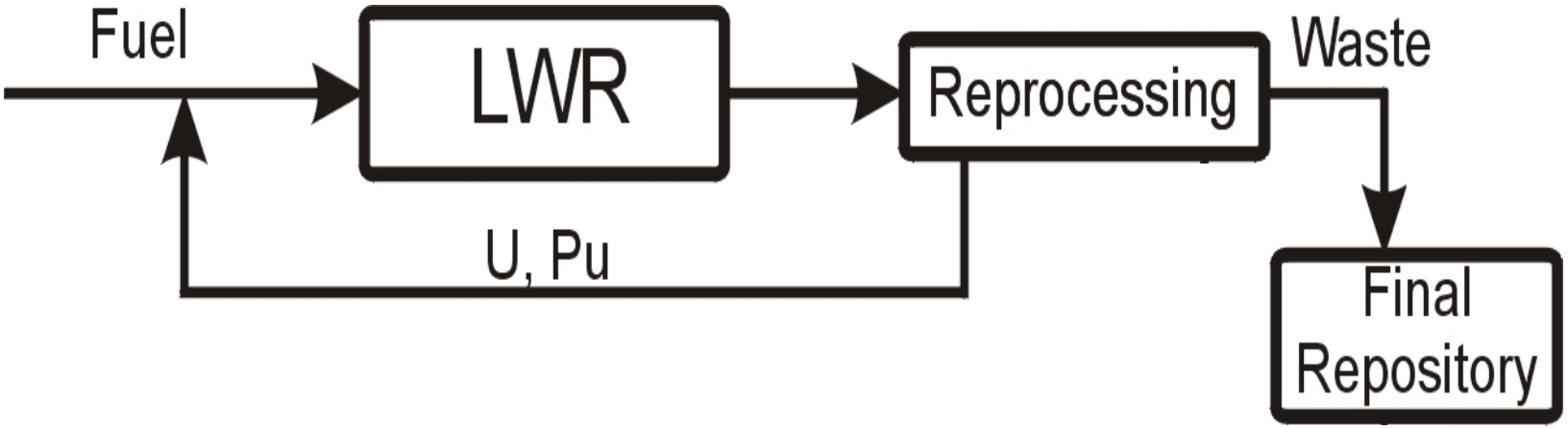
- **Anticipated volume reduction of HLW: factor 100**
- **Anticipated radiotoxicity reduction of HLW: factor 1000**
- **Transmutation does not replace a final repository.**
- **Introduction of transmutation systems closes the nuclear fuel cycle.**

SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

How does P&T work in a Closed Fuel Cycle?

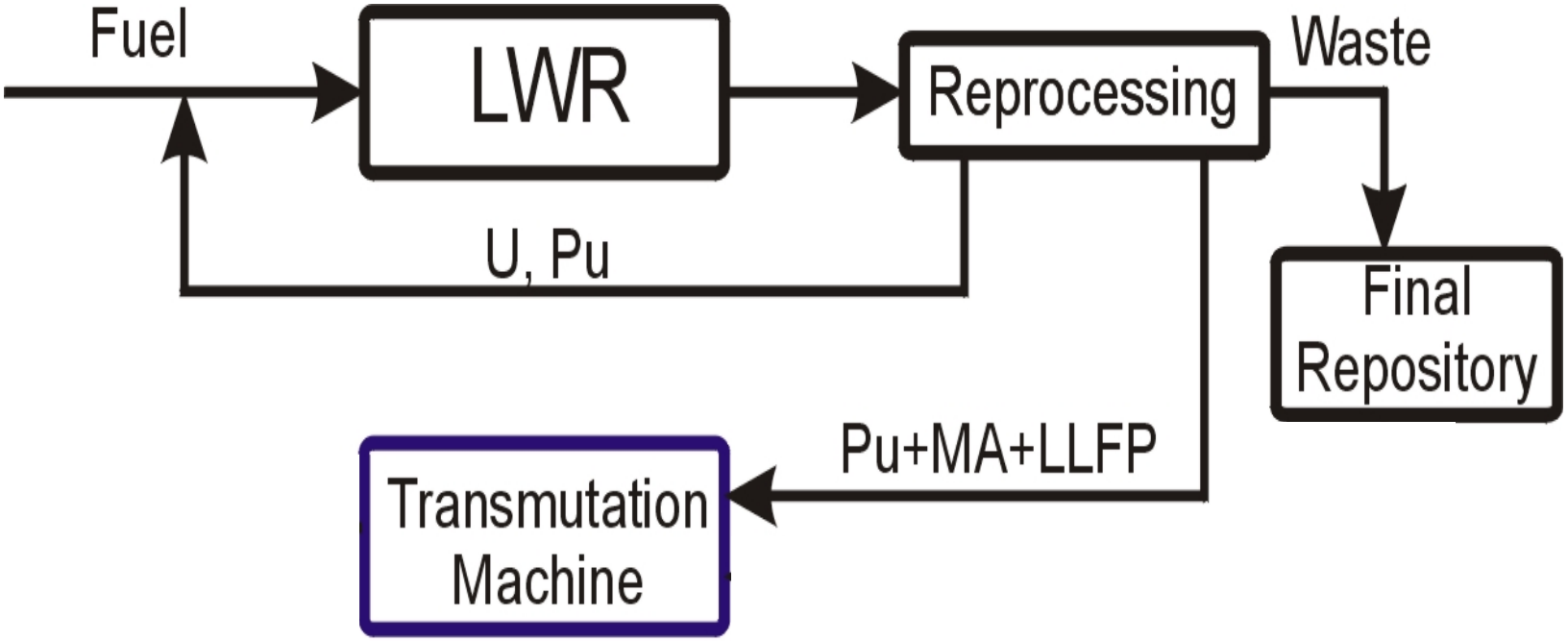
SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Simple Recycling of Fuel



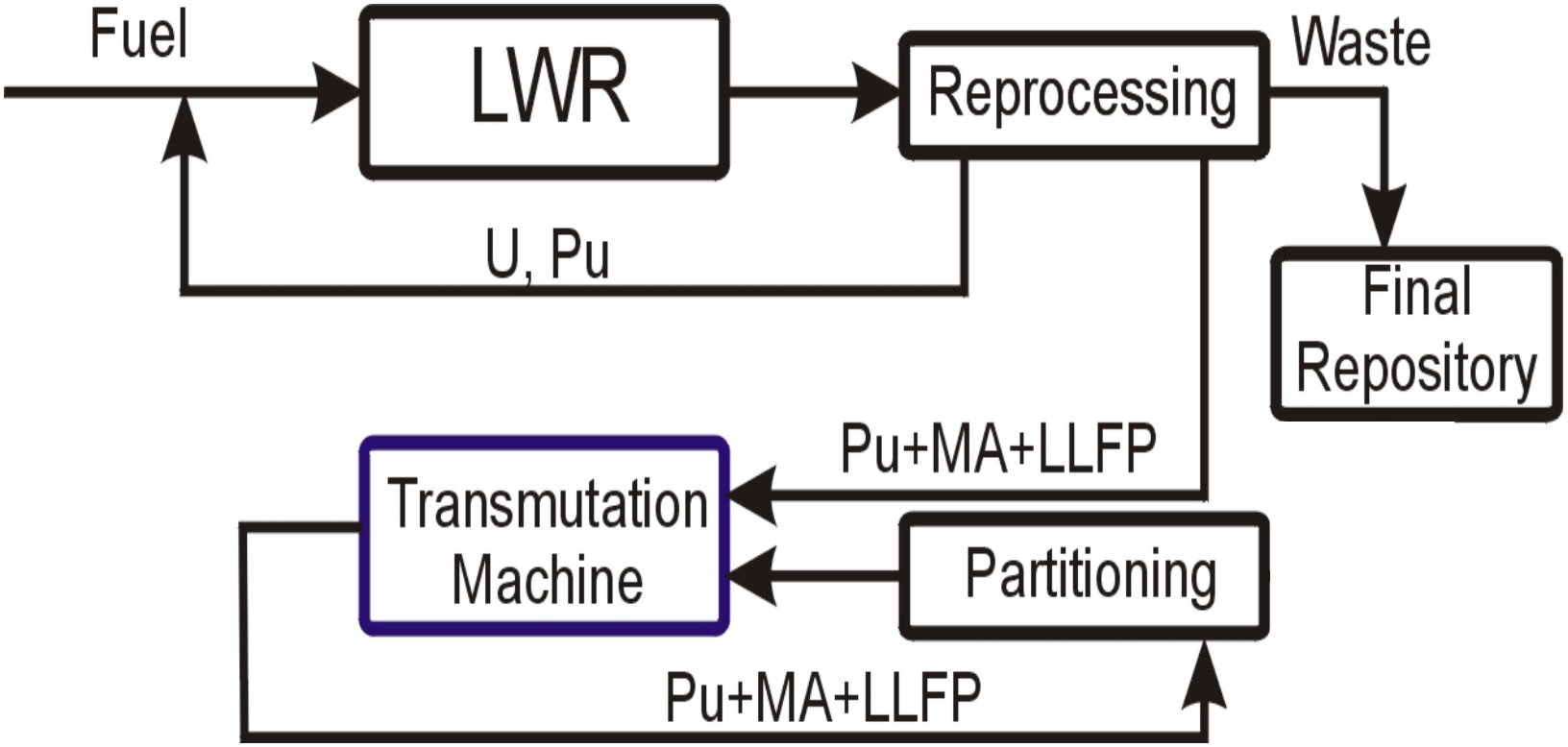
SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Closed Fuel Cycle with P&T



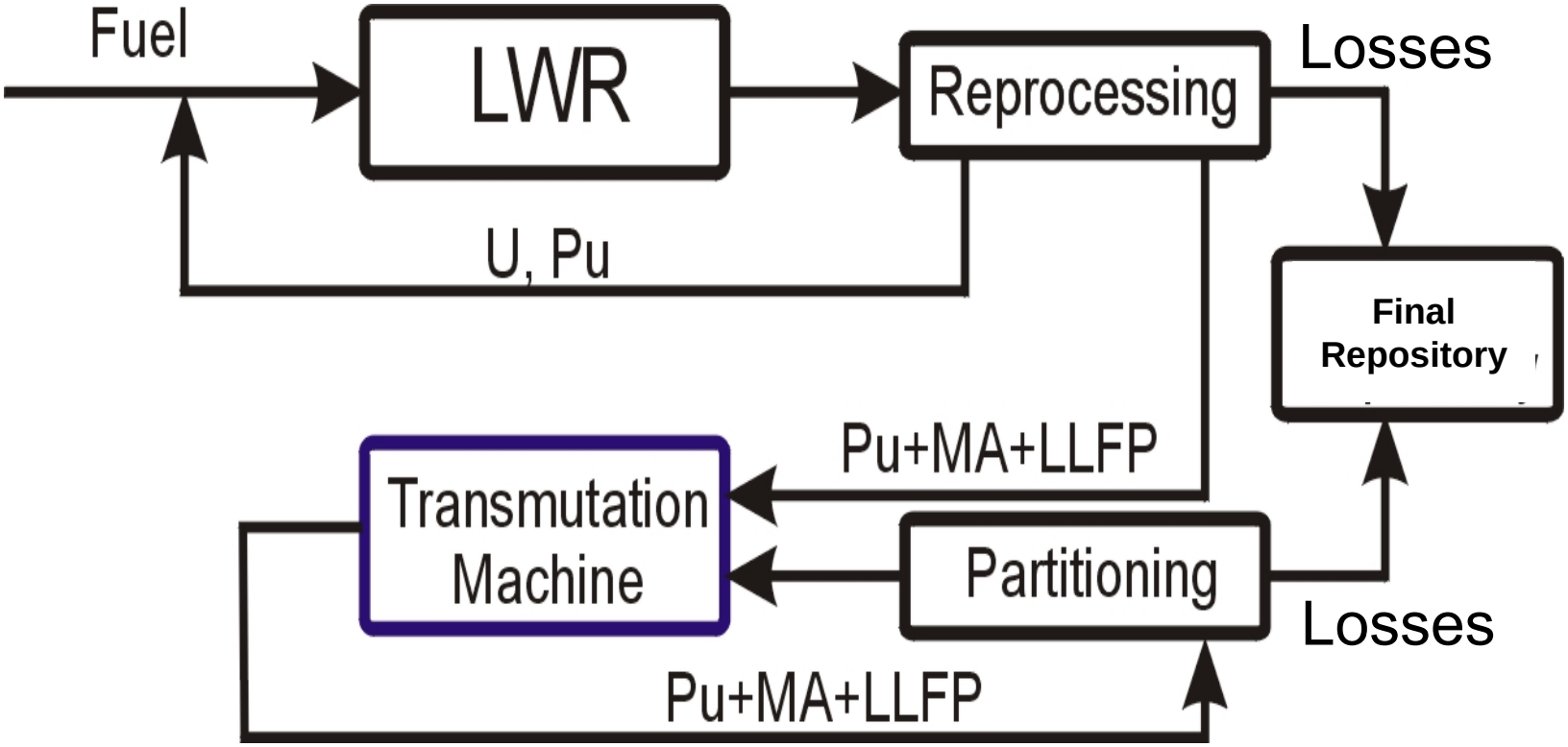
SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Closed Fuel Cycle with P&T



SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Closed Fuel Cycle with P&T



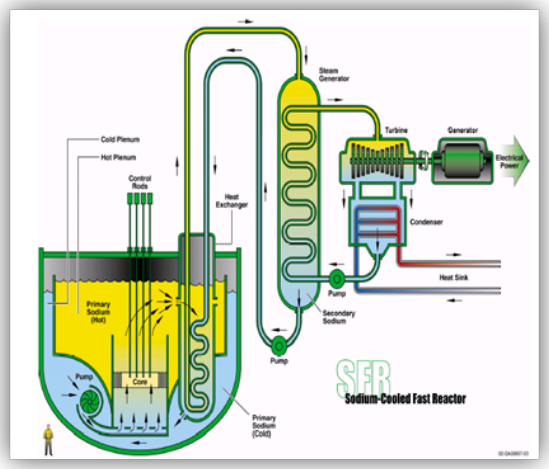
SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

What is a Transmutation Machine?

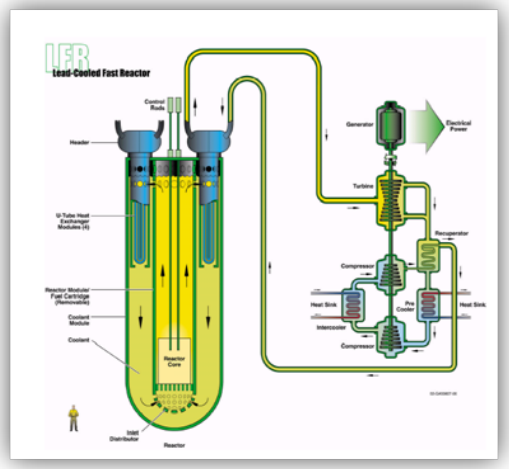
What is a Transmutation Machine? (1/2)

- **Fast Power Reactors of Generation IV**
  - **Sodium Fast Reactor**
  - **Lead Fast Reactor**
  - **Gas Fast Reactor**

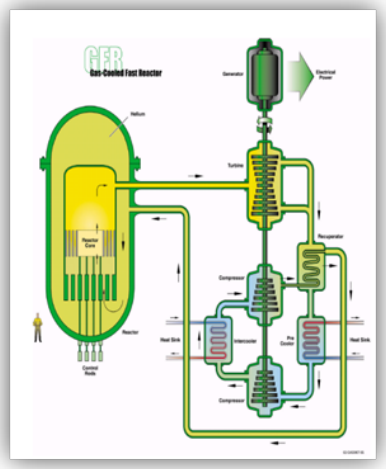
➔ **Stabilisation of highly radioactive inventory!**



Sodium Fast Reactor



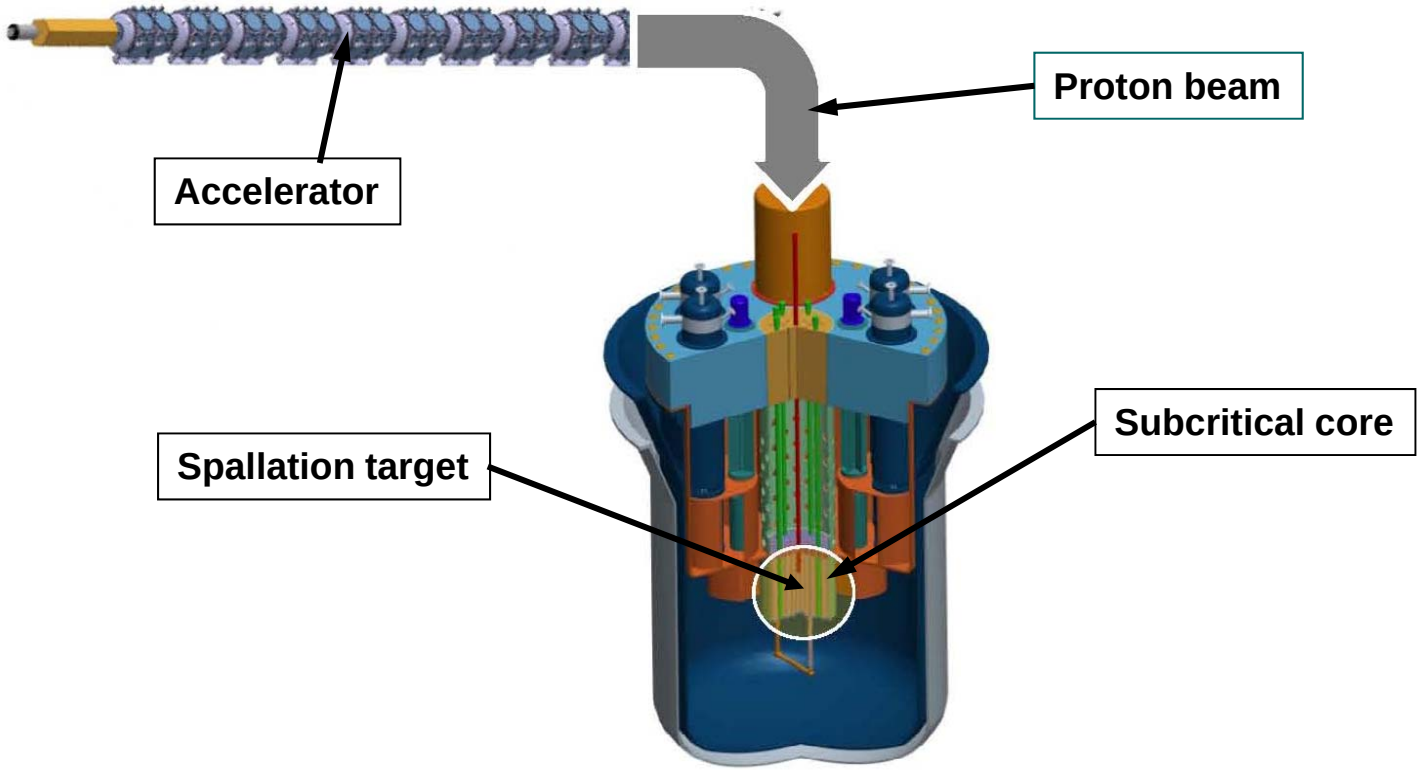
Lead Fast Reactor



Gas Fast Reactor

What is a Transmutation Machine? (2/2)

- **Accelerator Driven subcritical System (ADS)**



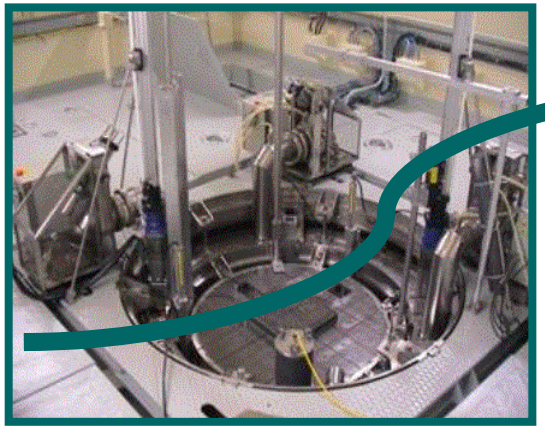
➔ **Improved safety characteristics.**

➔ **Reduction of highly radioactive inventory (radiotoxicity)!**

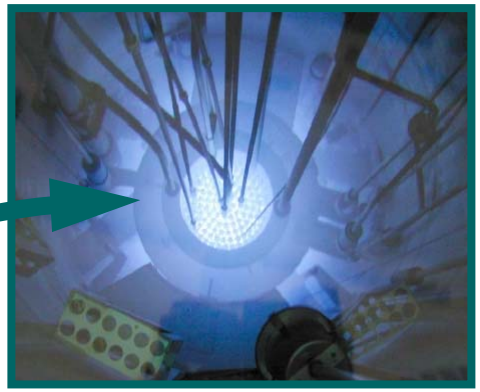
8 Scientific Challenges, being …

(1) partitioning
(2) accelerator components
(3) fuel development
(4) structural materials
(5) thermal-hydraulics
(6) heavy liquid metal technology
(7) nuclear data, and …
(8) finally the coupling of the major ADS components.

From Fundamental Research



… Prototypic Experiment…



to Demonstrator

SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Conclusion (1)

- International Collaboration is a must in P&T
- National motivated initiatives are paramount triggers
- Belgium is contributing through MYRRHA to the 3rd Building Block of the European Vision on P&T

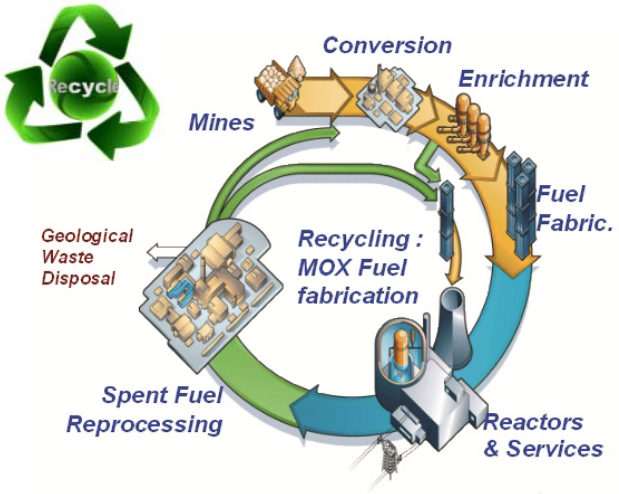
SCK·CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Global Dimension for Nuclear Energy

Common needs

Burning legacy of the past

Reducing cost of ultimate waste



Providing new resources

MYRRHA: EXPERIMENTAL ACCELERATOR DRIVEN SYSTEM

A pan-European, innovative and unique facility

- Time horizon: full operation ~ 2023
- Costs: ~ EUR 960 million

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

MYRRHA

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Copyright notice

SCK•CEN
Studiecentrum voor Kernenergie
Centre d'Etude de l'Energie Nucléaire

Stichting van Openbaar Nut
Fondation d'Utilité Publique
Foundation of Public Utility

Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSEL
Operational Office: Boeretang 200 – BE-2400 MOL