

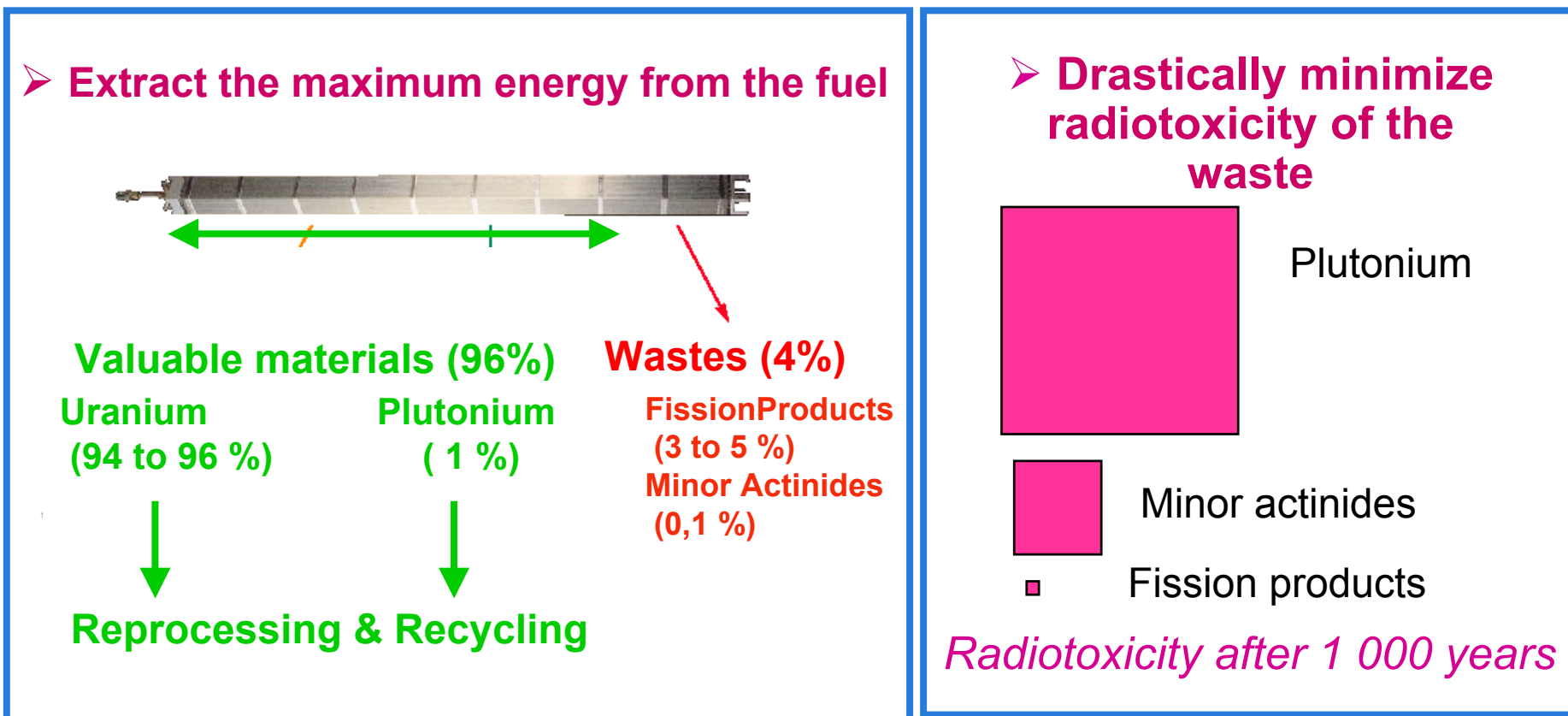


# **Advances in Treatment of Wastes from Reprocessing of Spent Fuel**

**P. Bernard**

***Director of Nuclear Development  
and Innovation***

# Reprocessing & Recycling, a cornerstone for future energy needs



➤ **Pu stockpile stabilisation : the Pu produced is consumed in LWR**

# R&D for long term management of HLLW in France



3 areas of R&D set out by law of December 30, 1991 :

- **minimization** of the **quantity** and **toxicity** of **waste**, by **partitioning** and **transmutation**,
- packaging and **conditioning**, for safe long lasting containment, and also studying **long term surface storage**,
- feasibility of **deep geological disposal**, whether reversible or irreversible.

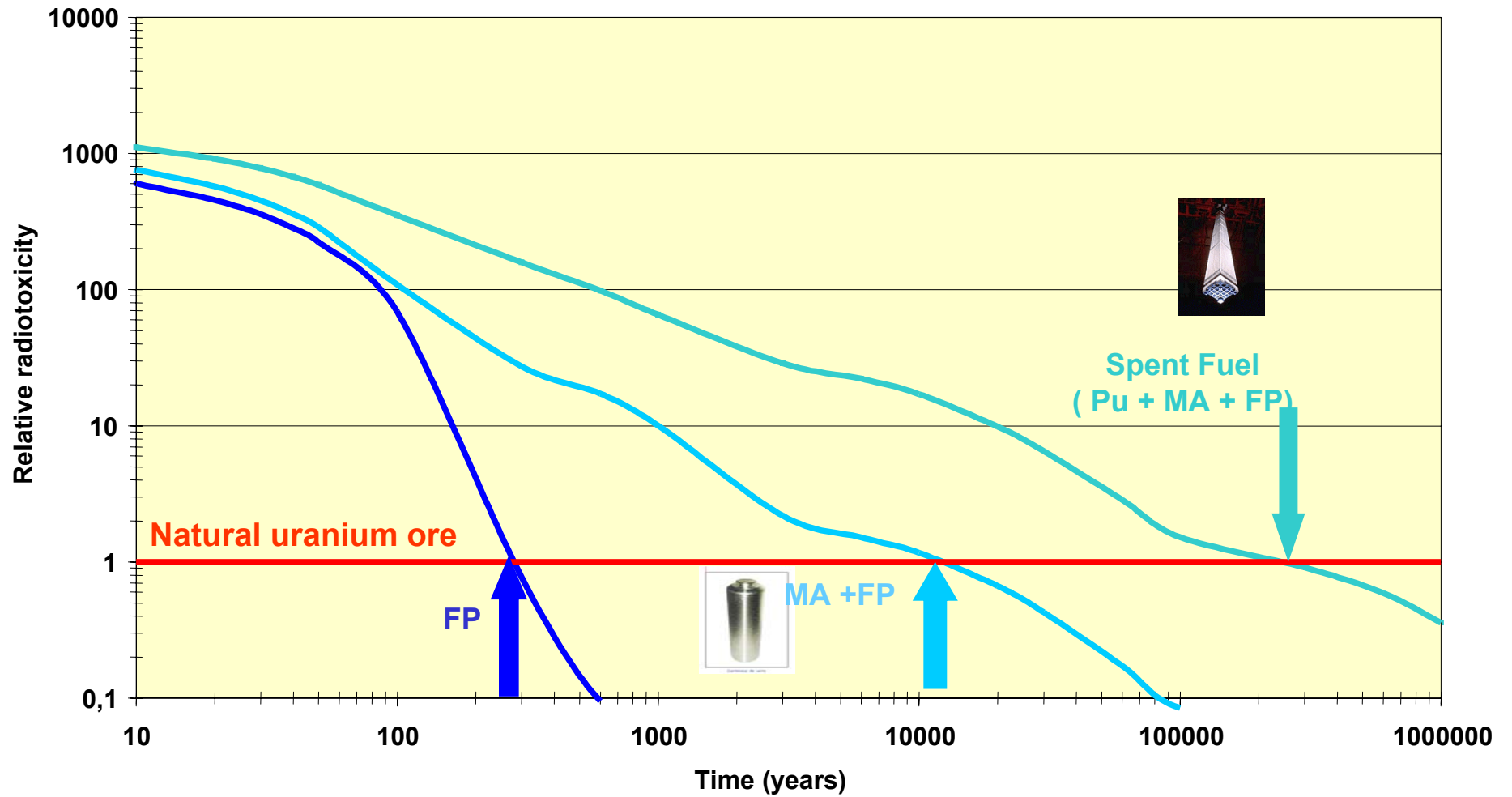
≤ 15 years of R&D ⇒ ≤ 2006 ; evaluation by National Evaluation Commission



**At present time :**

- 1) Significant results have been produced by R&D since 1991,**
- 2) Technical solutions do exist, that can be implemented in a progressive manner.**

# Evolution of the radiotoxicity



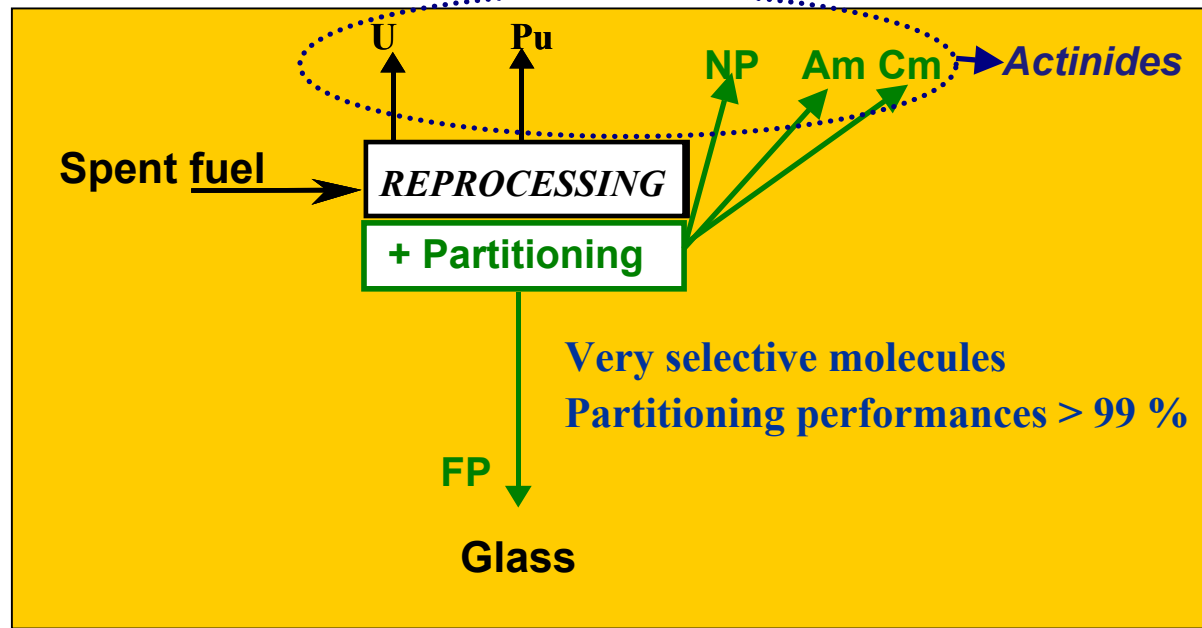
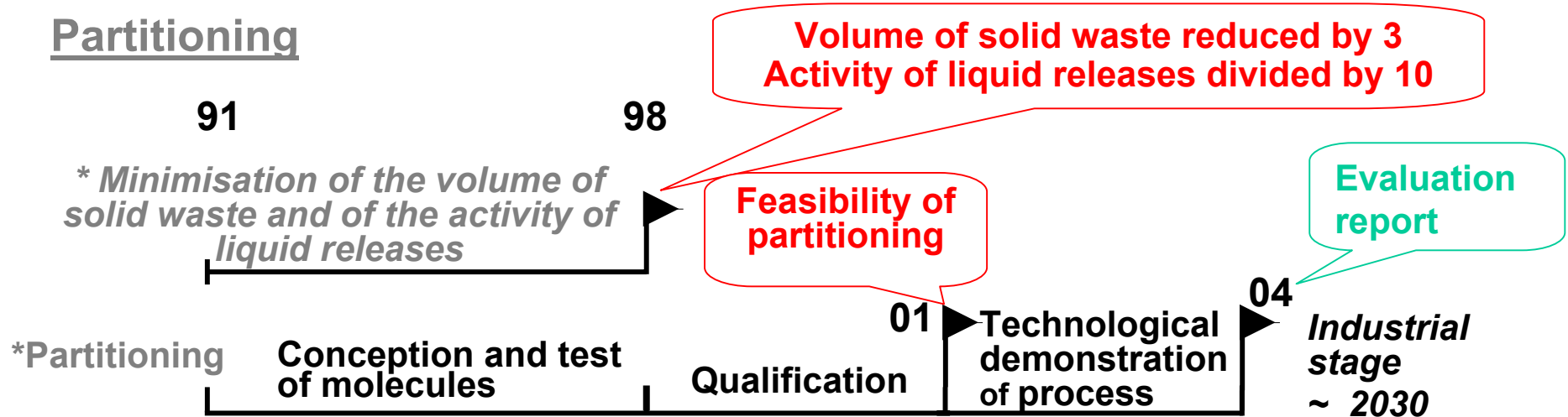


- **SUSTAINABLE NUCLEAR ENERGY WITH REPROCESSING AND RECYCLING**
  - ✓ Recover and recycle valuable materials
  - ✓ Minimise waste : volume/5, radiotoxicity/10
  - ✓ No plutonium in ultimate waste
  - ✓ Vitrification of ultimate waste : very safe conditioning providing long lasting confinement of radioactive waste
  - ✓ Open strategy to the future
  
- **MATURE INDUSTRIAL IMPLEMENTATION AND COMPETITIVE**
  - ✓ > 18 000T reprocessed at La Hague
  - ✓ 20 reactors in France recycling plutonium

# Minimisation of the quantity and the toxicity of waste



## Partitioning





# Transmutation

\* *Physics and scenarios studies*

91

Physics

98

Feasibility of transmutation

01

scenarios

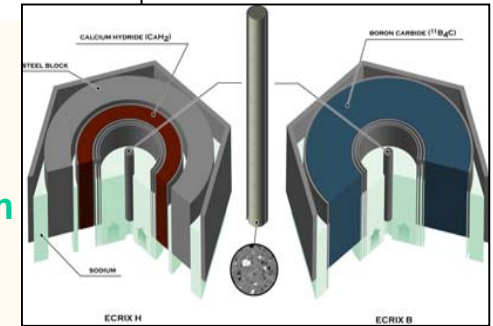
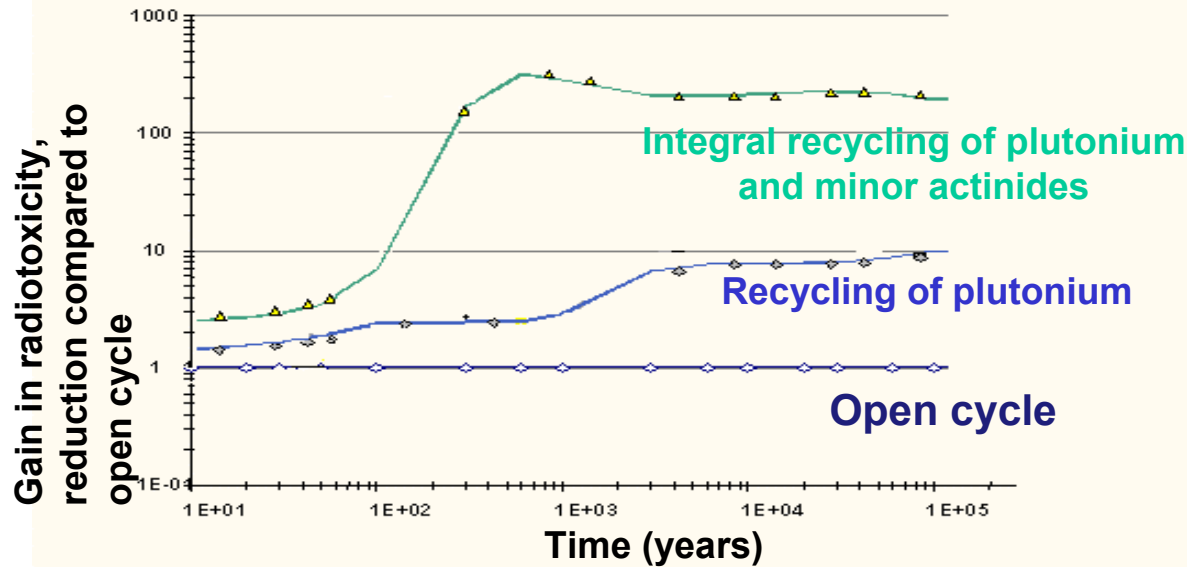
and systems

04

Evaluation report

Industrial stage

~ 2040



ECR IX ( 2,75 g of Am)





# Conditioning and long term interim storage

## Conditioning

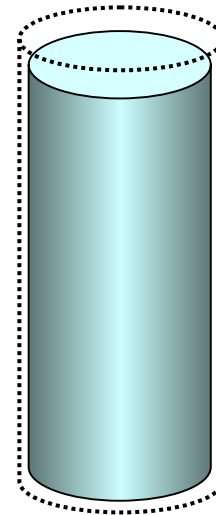
\* *processes*

Processes available for various categories of waste

91 Development and qualification of processes

02 Technological qualification

04 Evaluation Report



Alteration of glass by water



Operational models

\* *Long term behaviour of waste packages*

Phenomenology - modelisation

01 qualification

05 Evaluation report

\* *Containers*

**Functional demonstrators**

**Technological demonstrators**

02

04

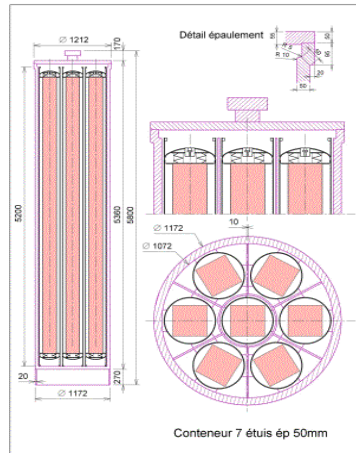
Specification, fabrication of demonstrators

qualification

**Evaluation report**



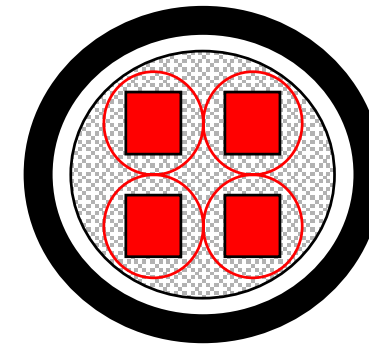
**CECER**  
(Centre d'Expertise sur le Conditionnement et l'Entreposage des matières Radioactives) at Marcoule



**Containers for spent fuel**

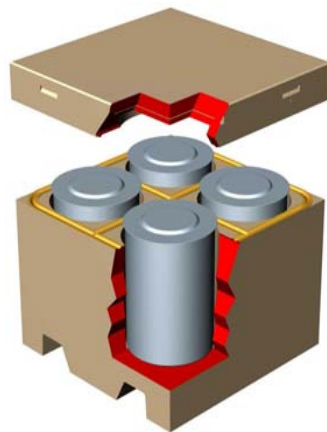


Storage



Storage - Disposal

**Containers for ILLW**



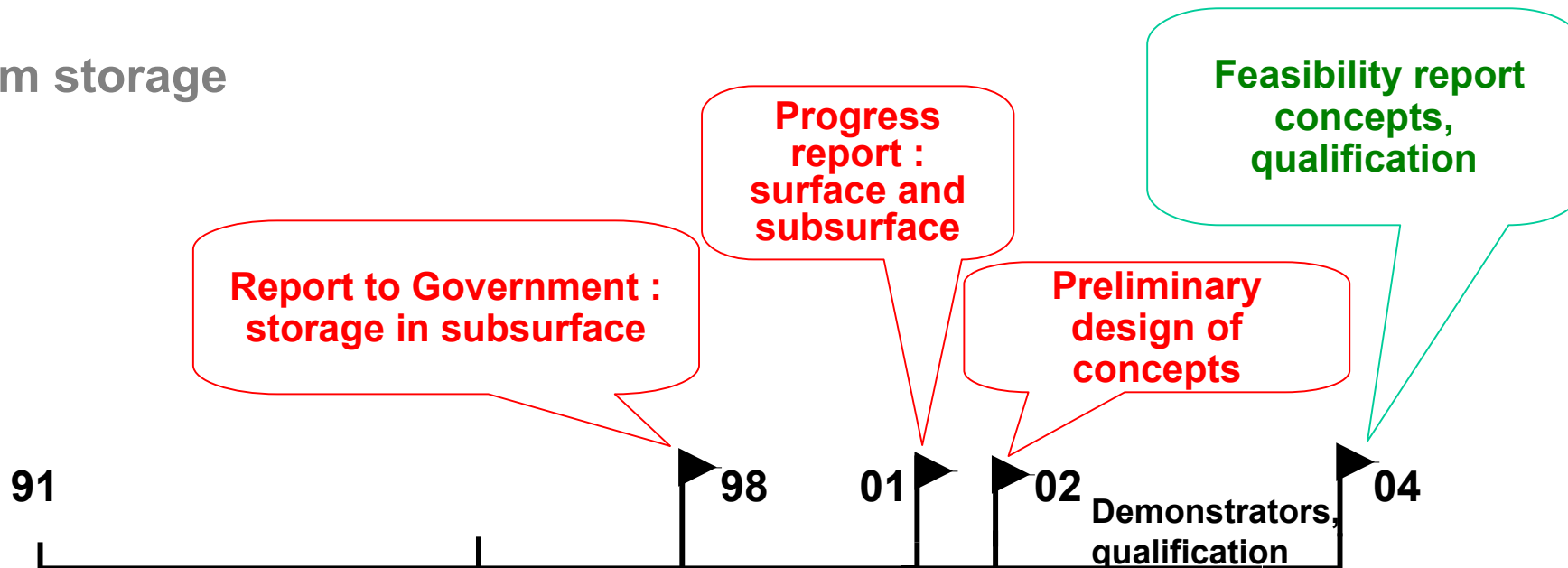
Internal barrel in ceramics



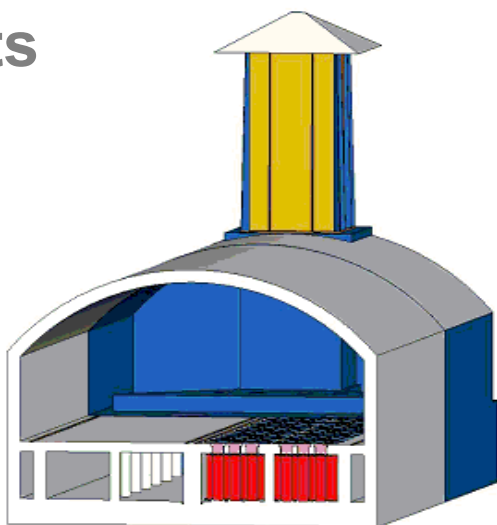
Internal barrel in enameled steel



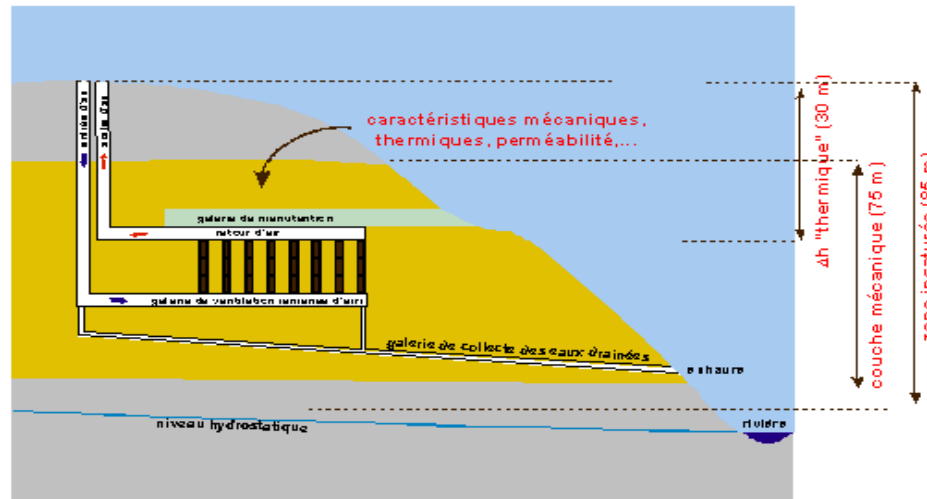
# Long term storage



## Concepts



Storage in surface



Storage in subsurface

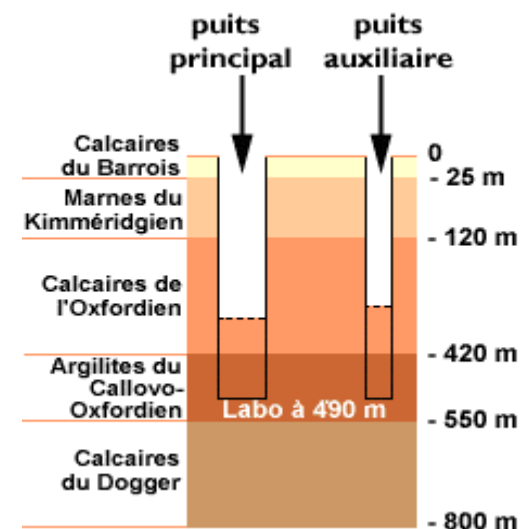
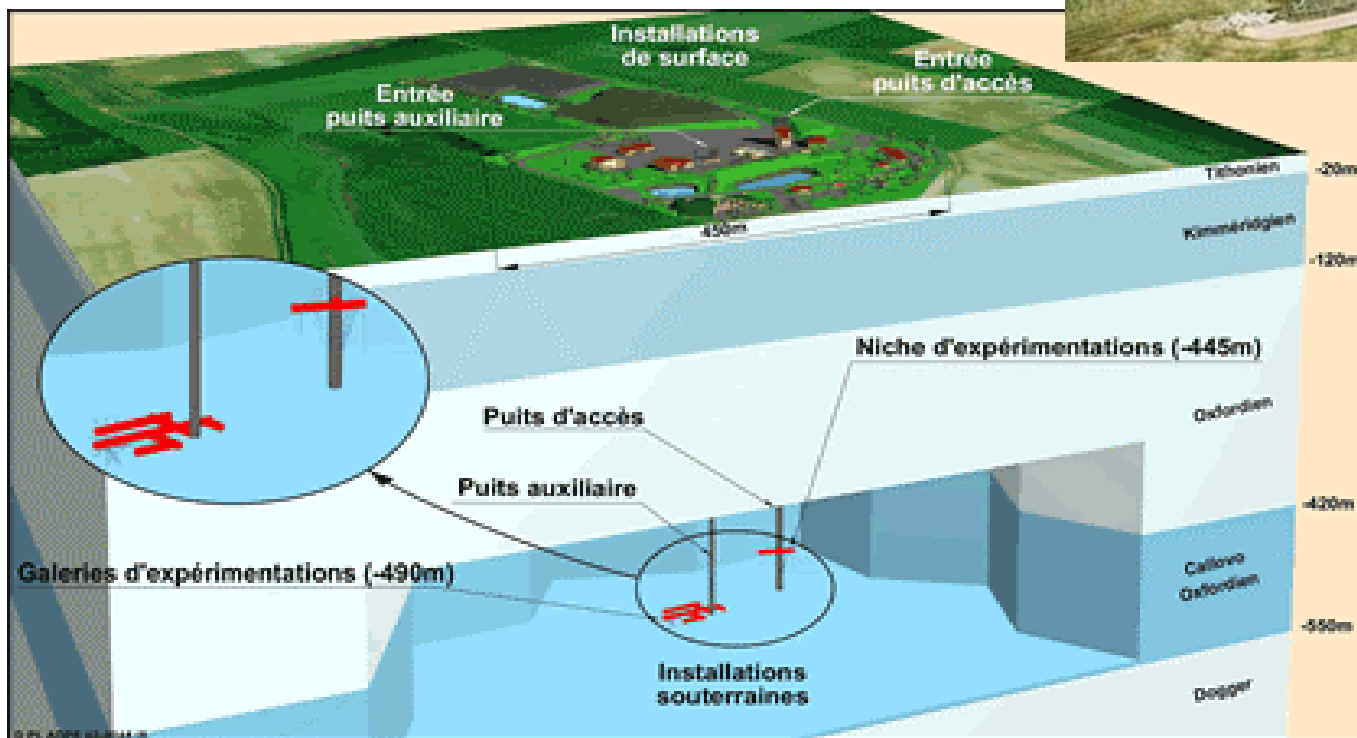
# Deep geological disposal



## Meuse-Haute-Marne Underground Laboratory



General architecture of the laboratory



# PERSPECTIVES

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**Closing the fuel cycle has a major impact on :**

- Minimization of waste
- Resources Extension

# Technical solutions do exist, progressive implementation



- Reprocessing and recycling for sustainable nuclear energy
- Quite advanced processes (minimisation of volume and radiotoxicity, safe conditioning) at competitive industrial maturity
- Recycling of plutonium in present LWR is demonstrated at large scale; further possible improvements with 3rd generation LWR type reactors

## *Next steps for the future*

- 4th generation systems with closed fuel cycle for integral recycling of actinides

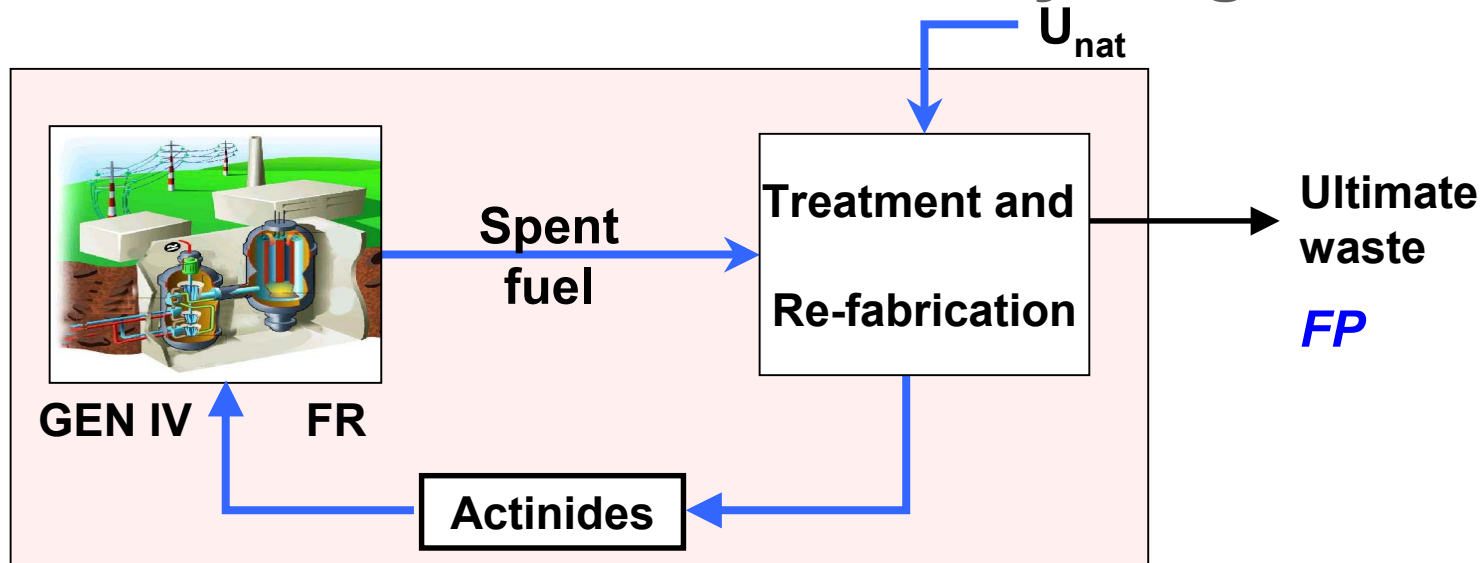
➔ *HLLW decay within some hundred years*

## *Safe long term management of waste*

- Geological disposal of ultimate waste = long term burden free solution , taking benefit from the most important reduction of the quantity and toxicity of waste brought by closed fuel cycle
- Storage of radioactive material ➔ flexibility



# 4th generation Systems : an integrated cycle with full actinide recycling



## ➤ A drastic minimization of ultimate waste :

- Very small volumes,
- Decrease the heat loading
- hundreds of years versus hundreds of thousands

## ➤ An optimal use of energetic materials

# Fuel cycle : Perspective for actinides management

