OECD Nuclear Energy Agency

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Progress in Partitioning: Activities in ATALANTE

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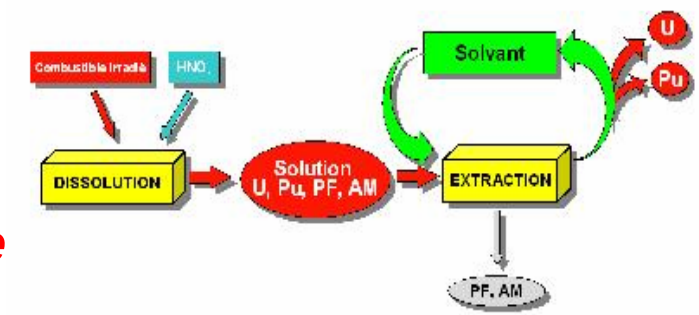
COMPLEMENTARY SEPARATIONS : WHICH PROCESSES ?

1. **MAIN CRITERIA :**

- *safety, efficiency, cost, secondary waste,…*
- *robust technical elements for 2006*

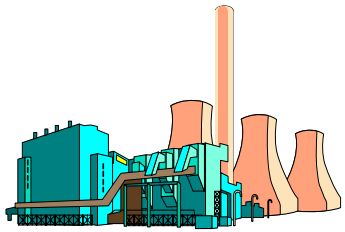
2. **REFERENCE ROUTE : SOLVENT EXTRACTION**

- *used for U and Pu recovery*
- *La Hague feedback :*
  - ∗ *high separation yields*
  - ∗ *low amount of technological waste*



3. ***ALTERNATIVE ROUTE: PYRO-PROCESSES***
(molten salts, high temperature)

LLRNs recovery : CEA general flowsheet



Spent fuel

Uranium and Plutonium

PUREX

I

Tc

Np

Additional Separations

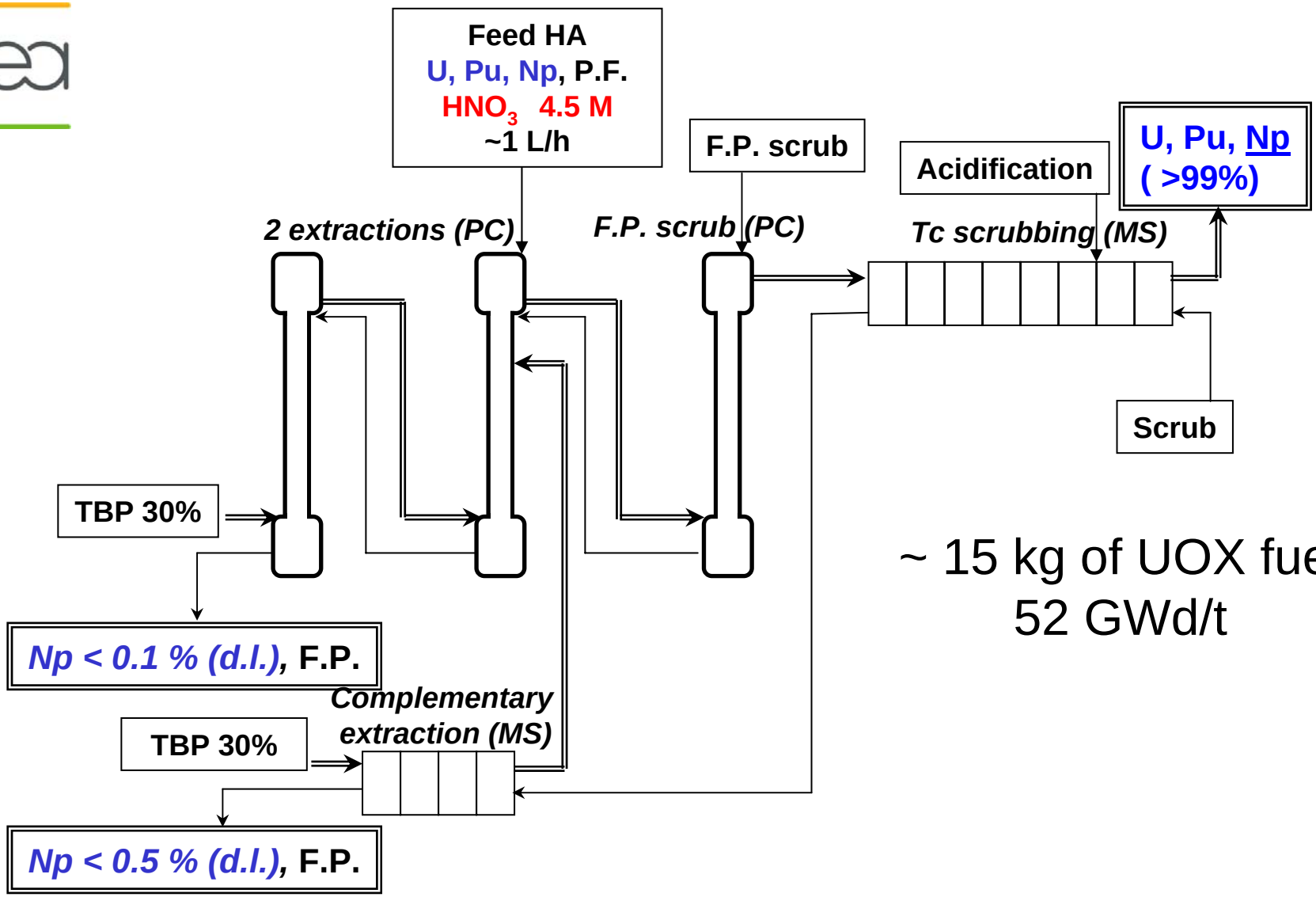
Fission Products

Cs

Am

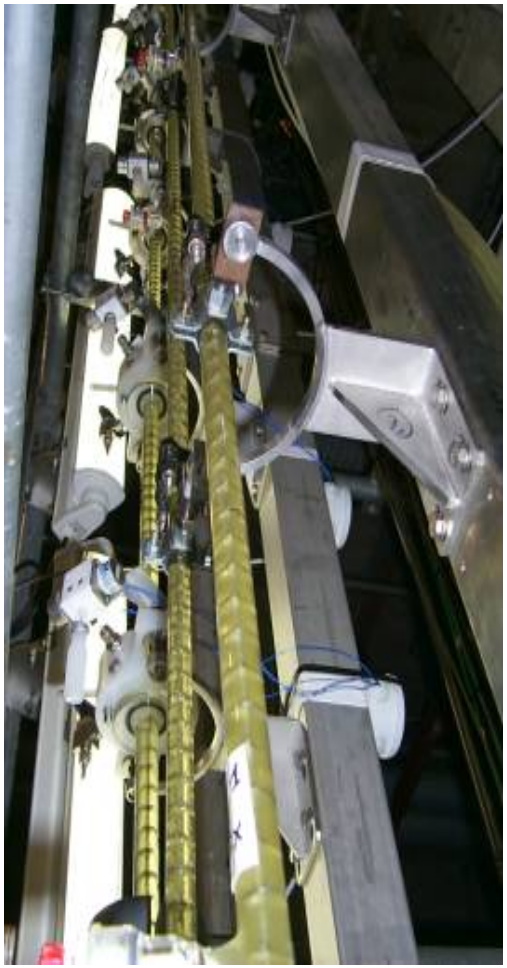
Cm

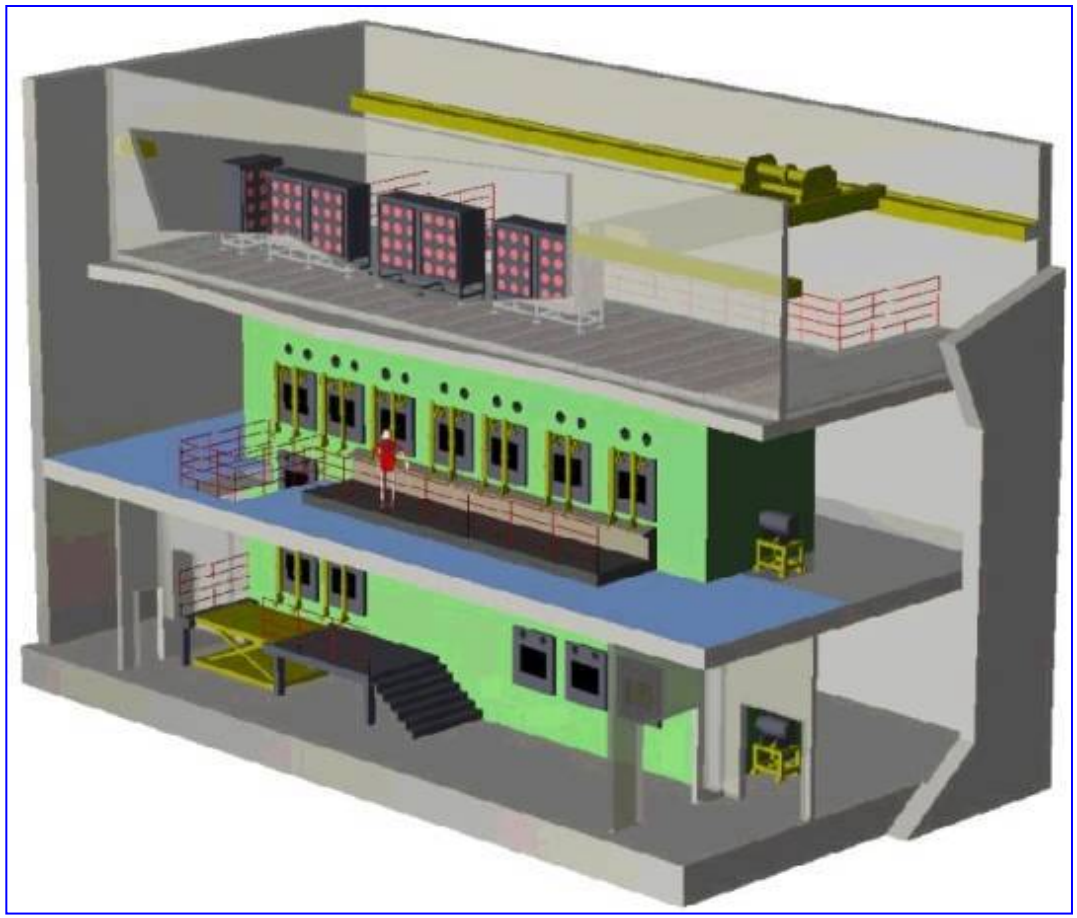
Np extraction : CBP hot run, april 2005



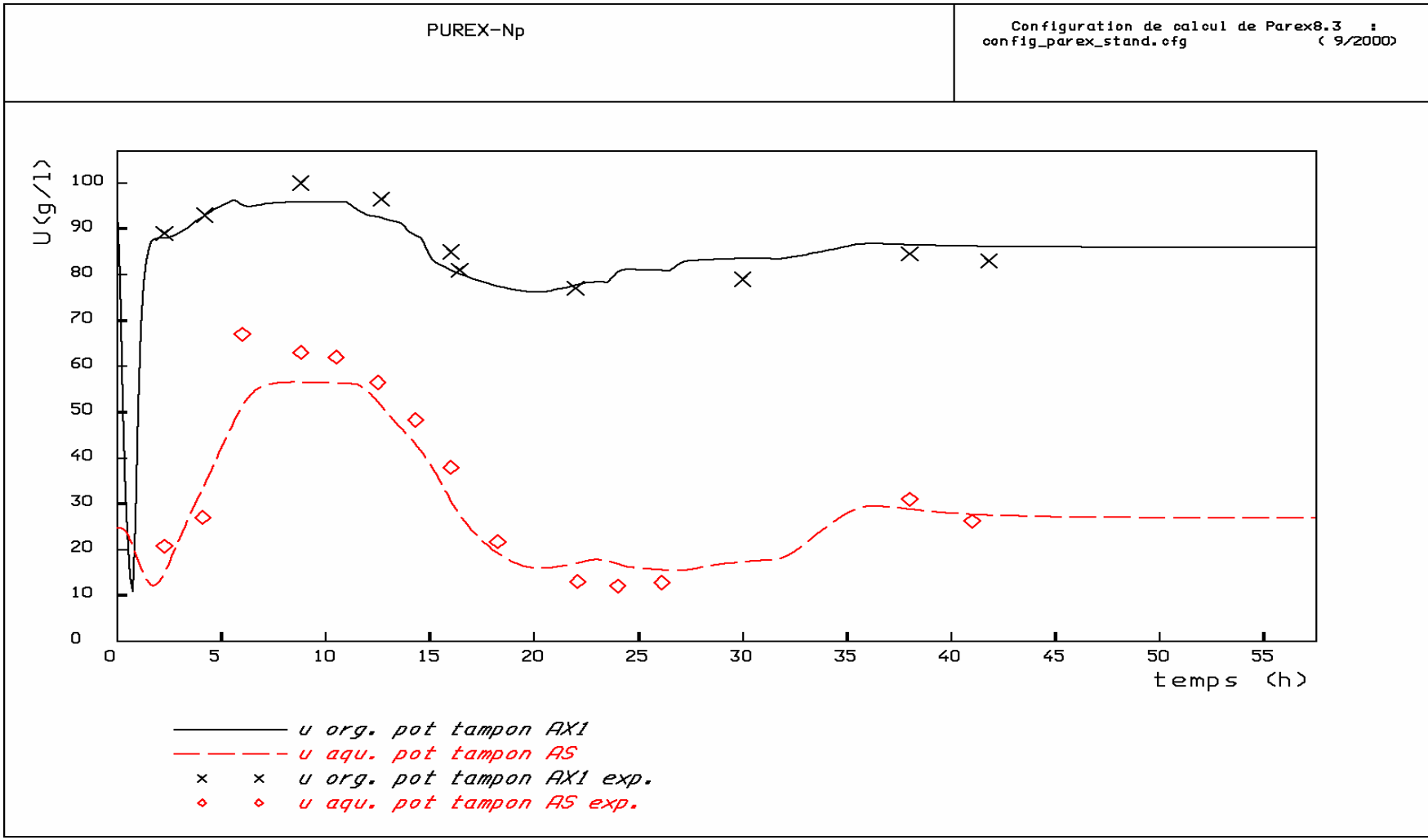
~ 15 kg of UOX fuel
52 GWd/t

ATALANTE « CBP » HOT CELL *(commissioned 2003)*

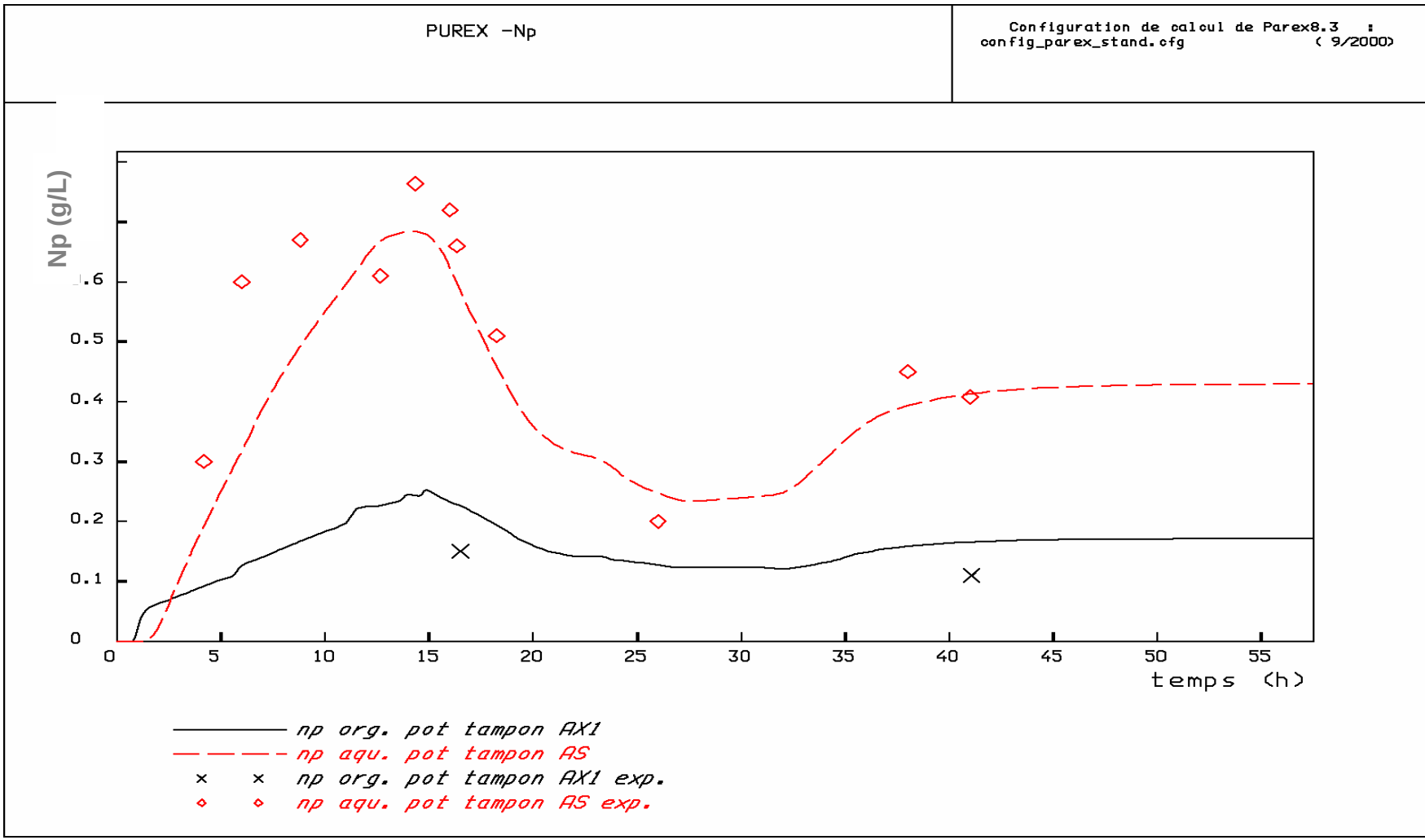




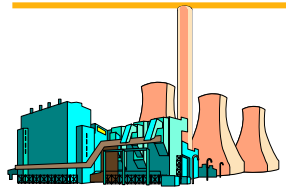
[U] in loaded solvent and scrubbing



[Np] in loaded solvent and scrubbing



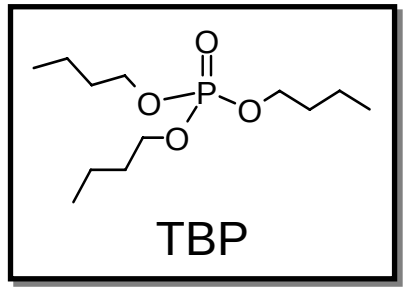
ACTINIDE SEPARATION STRATEGY



Spent Fuel

PUREX

U, Pu, Np



Two step strategy

Fission Products

DIAMEX

CO-EXTRACTION of MAs and Ln

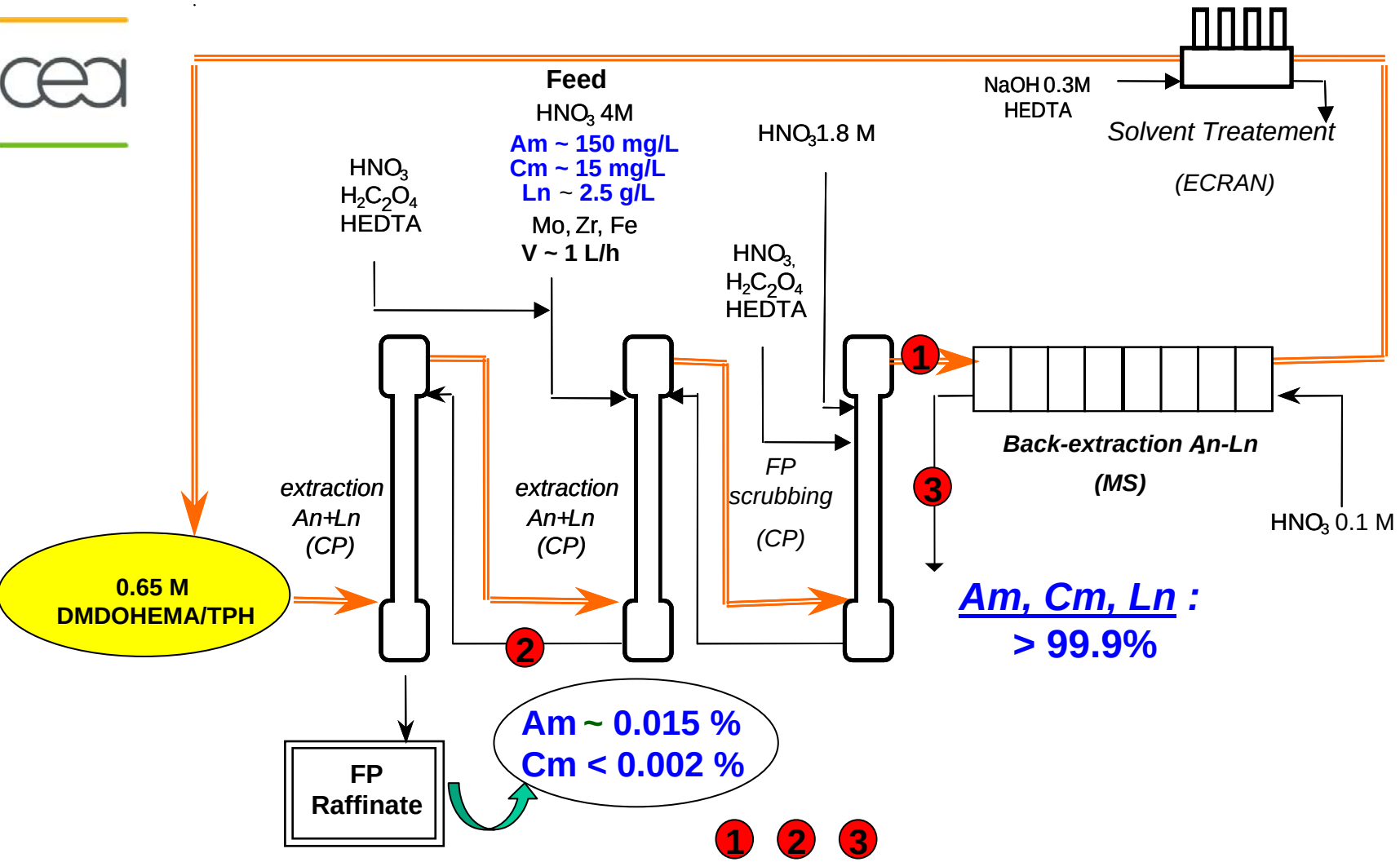
Ln

SANEX

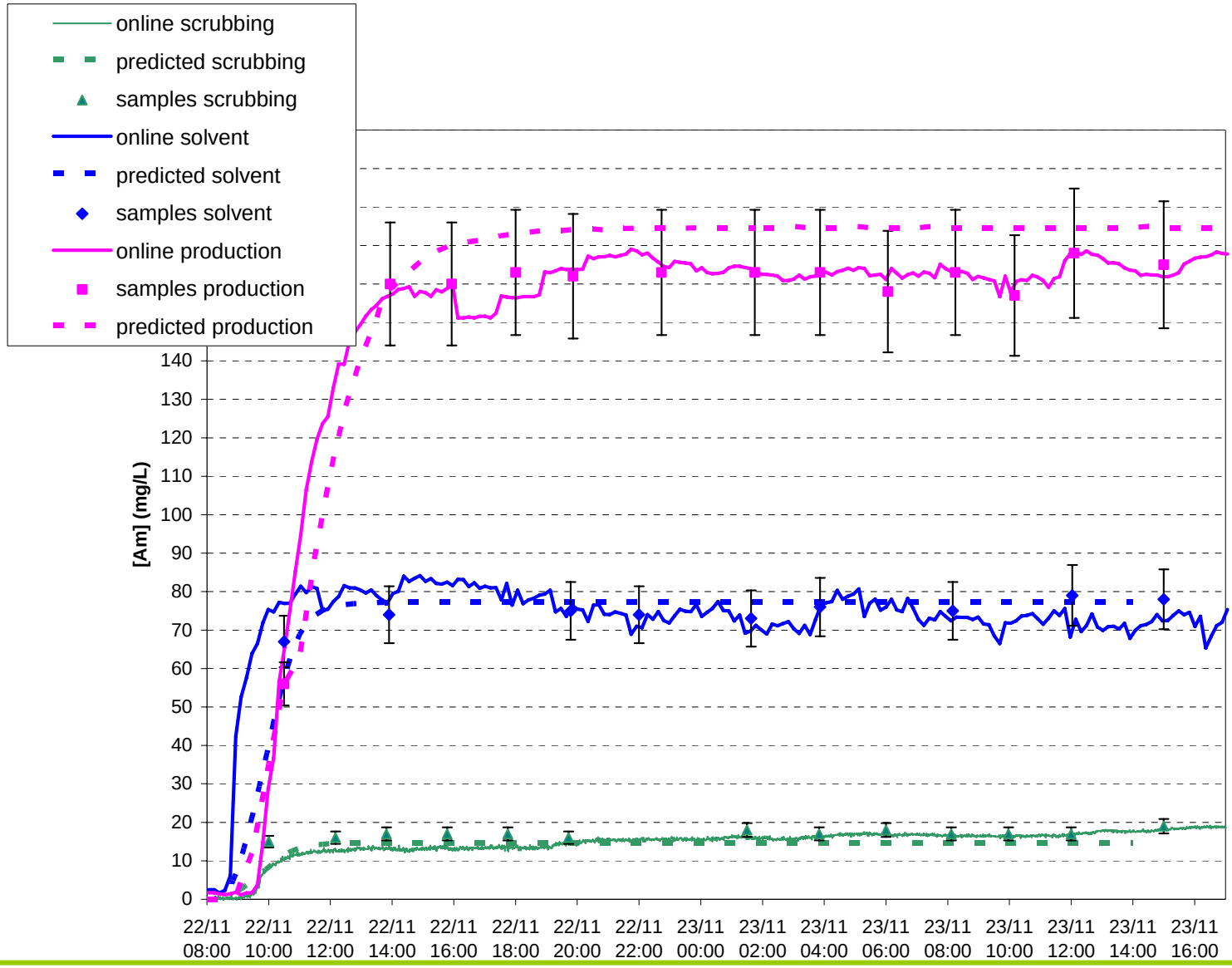
Am, Cm

SEPARATION of Mas from Ln

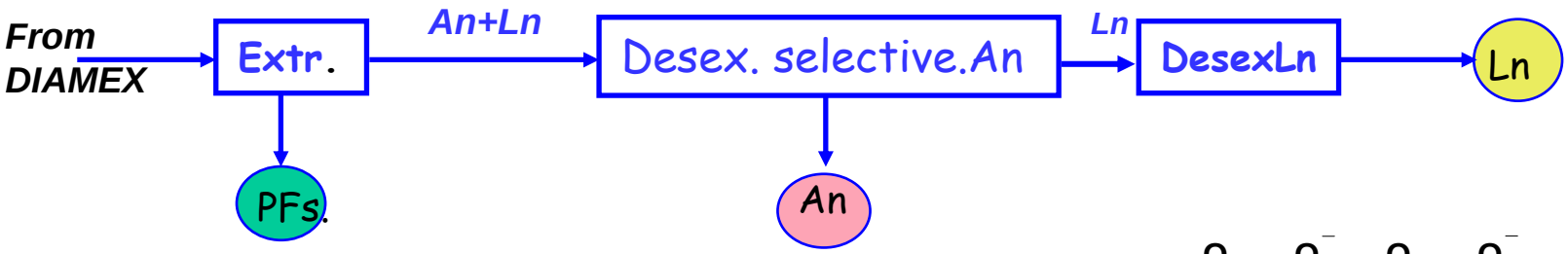
DIAMEX, « CBP » hot run, November 2005



[Am] on line measure

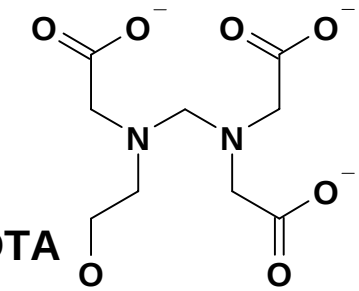


The second step : An/Ln Separation



The key* : an *An-selective complexant

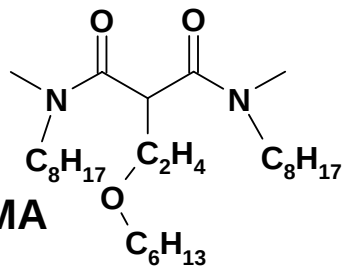
HEDTA



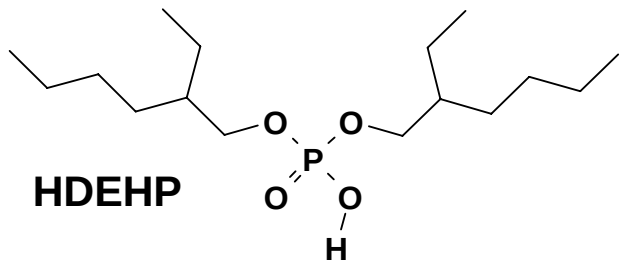
***The difficulty* : efficient only at low acid concentration**

The solution proposed* : an appropriate extractant *system

DMDOHEMA

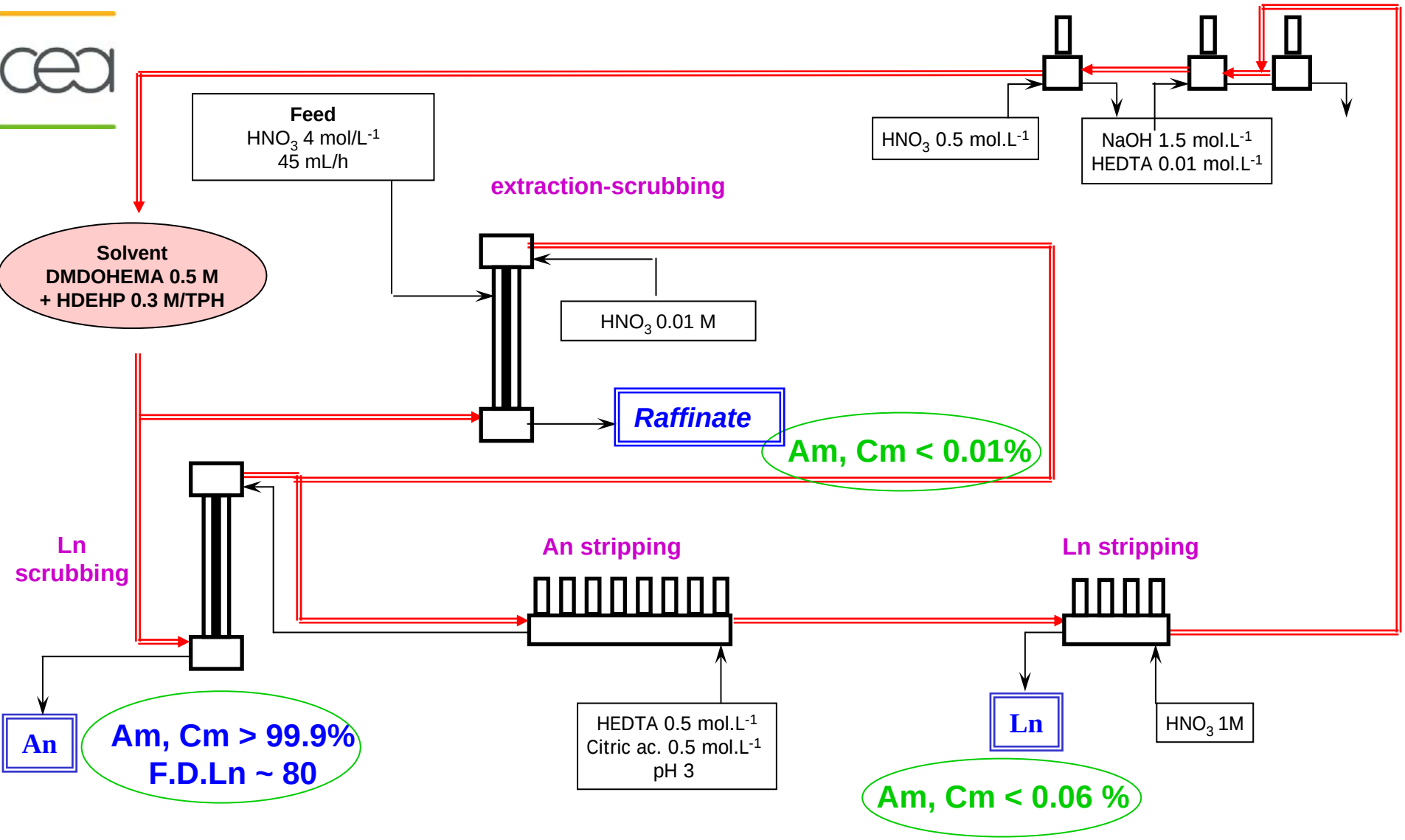


HDEHP



…and towards a single-cycle concept !

SANEX Process, hot run, December 2005



Minor Actinide : *Main results*

- **Neptunium :**

  ⇨ ***recovery yield : > 99 % (adaptation of PUREX process)***

- **Américium et curium :**

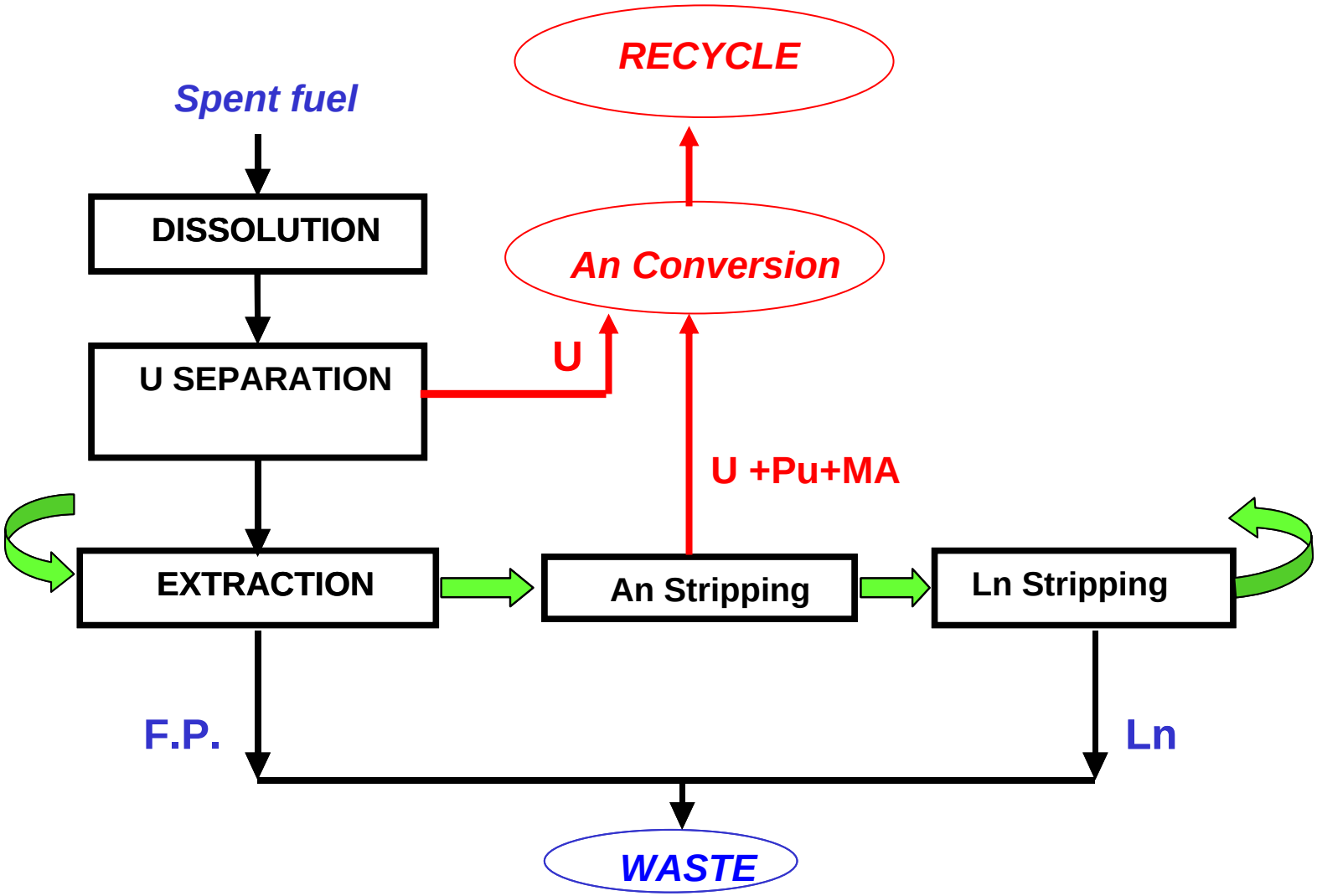
  ⇨ ***recovery yield : 99,9 % Am + Cm***

HOW TO GO FURTHER ?

- **<u>DIAMEX-SANEX Optimization</u> : single cycle !**

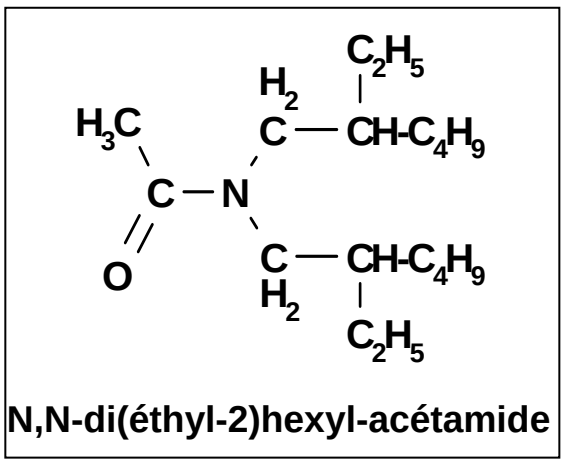
- ***ALL-ACTINIDE <u>GROUPED</u> EXTRACTION***
  - ***adapted DIAMEX-SANEX (with U, Pu,Np…)***
  - ***other new molecules…***

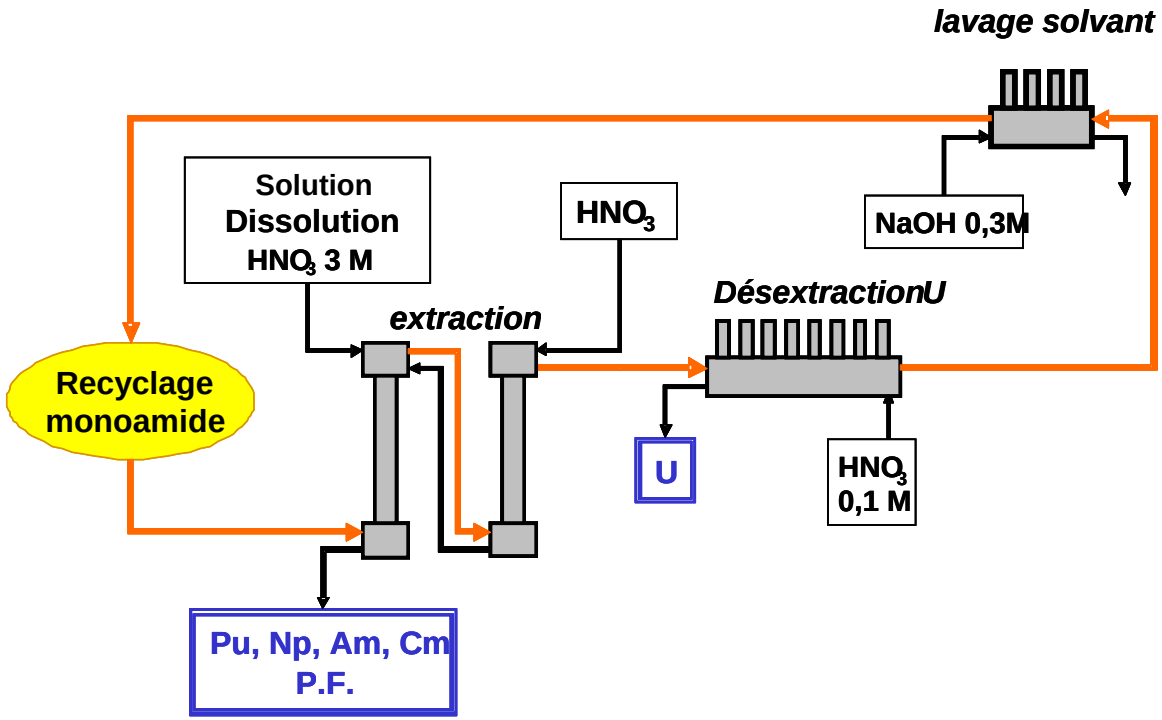
The GANEX Concept



Preliminary Uranium extraction

- ***U(VI) / other actinides separation, based on selective mono-amide extraction of uranium.***





«*Poly-actinide* » oxalate coprecipitation

1999 : U 70 % - Pu 30 %

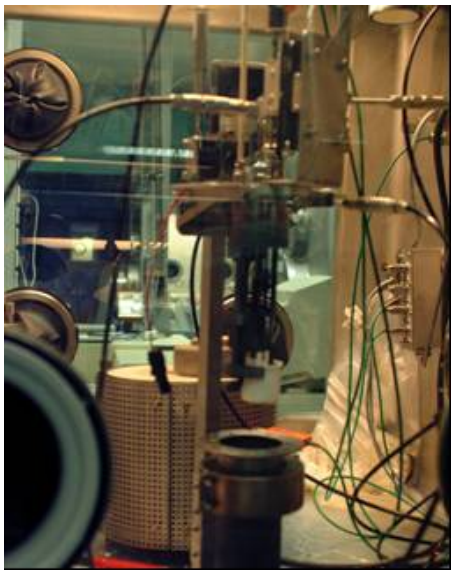
2003 : U, Pu,Np

2005 : U, Np, Pu, Am

U 78 % - Np 1% - Pu 20 % - Am 1 %

ACTINIDE RECOVERY BY SALT/METAL EXTRACTION : *ATALANTE HOT RUNS, 2004*

Assessment of the Pu-Am co- extraction & separation from F.Ps by using salt/metal extraction in $LiF-AlF_3$ / Al(Cu) at 830°C



High Temperature Salt/Metal Contactor in glove-box (Atalante)

Run 2 : Extraction (Al)

Salt before extraction: $LiF-AlF_3$ (85-19.5 mole %) + **PuF_3 (11,1 wt%) + AmF_3 (0,12 wt%)** + CeF_3 (2,50 wt%) + SmF_3 (0,52 wt%) + EuF_3 (0,51 wt%) + LaF_3 (0,52 wt%)

Alloy/Salt ratio = 1

Alloy ~ 15-17 g

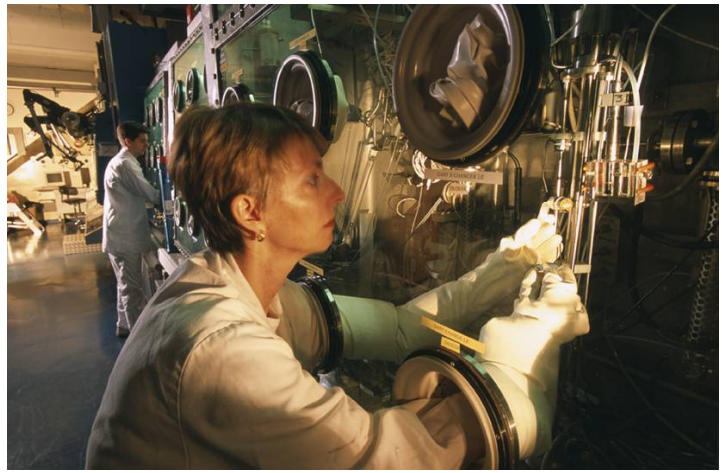
*Salt **before** extraction*

*Salt **after** extraction*

en résumé….

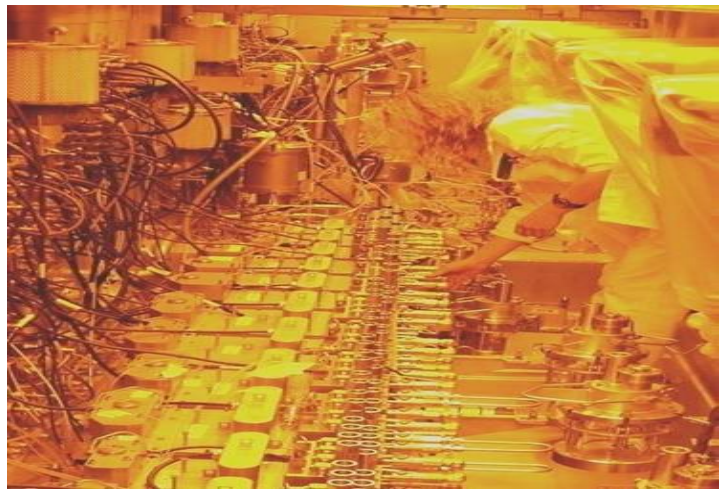
- **actinides, the main target !**
- **Solvent extraction, *a powerfull, clean, mature technology* !**
  - **Many options studied for An recovery : molecules and extraction processes have been experimented at lab-scale and « large-lab » scale.**
  - **co-precipitation, a very promising route to get An solid compounds**
- **Pyro-processesses : an attractive alternative !**
  - **CEA launched a R&D program**
  - **Encouraging results, to be pursued (technological issues!)**

The ATALANTE facility…



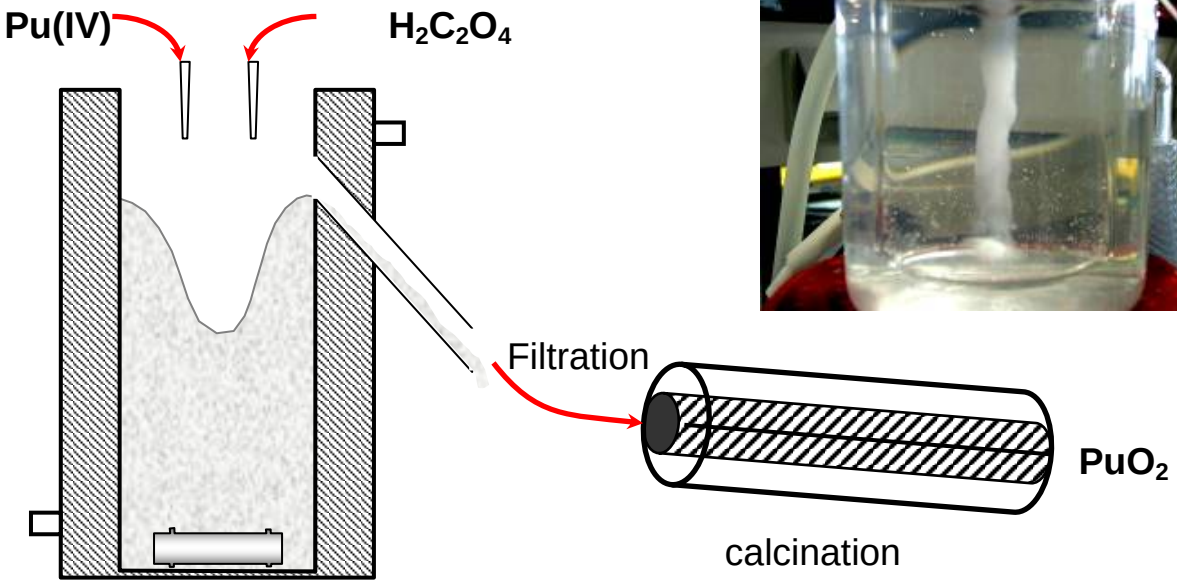
From basic studies to demonstrative experiments …

… up to kgs of spent fuel

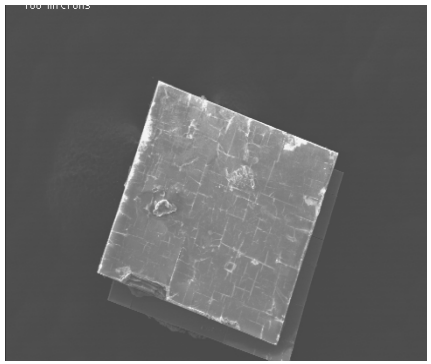


Pu industrial conversion : *oxalic precipitation*

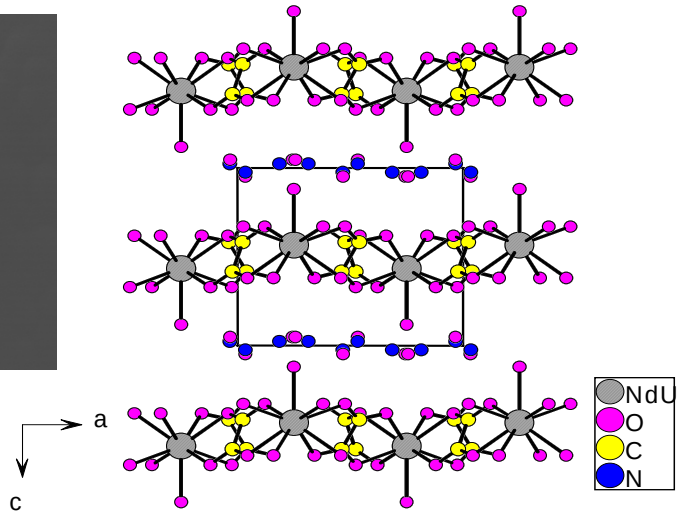
- **2 steps :**
  - $Pu(IV)(C_2O_4)_2,6H_2O$ *precipitation*
  - *Calcination* to PuO_2
- **Operated in La Hague plant (R4/T4)**



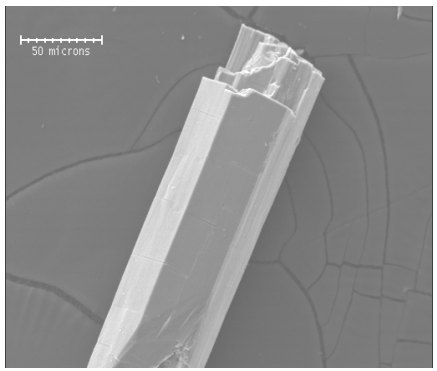
All-actinide coprecipitation ?



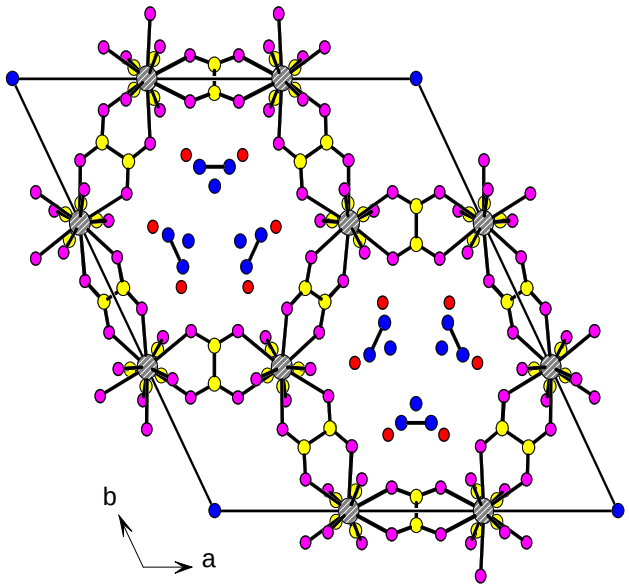
Quadratic



Same cristallographic site
For An(IV) and An(III)



Hexagonal



and solid solutions for oxides !

PYROPROCESSES : THE ALTERNATIVE ROUTE

- **Frame :**
  - *launched in the frame of the french legislative act, Dec. 1991, on the management of nuclear waste*
  - *since 2003, extended to **Gen IV** **cycle studies***

- **Very preliminary goal :**

- all actinide quantitative recovery (> 99 %)

- with a "high enough" purity level

- both electro-recovery and molten metals extraction

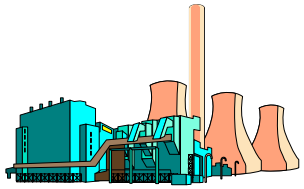
ACTINIDE RECOVERY BY SALT/METAL EXTRACTION : *MAIN RESULTS*

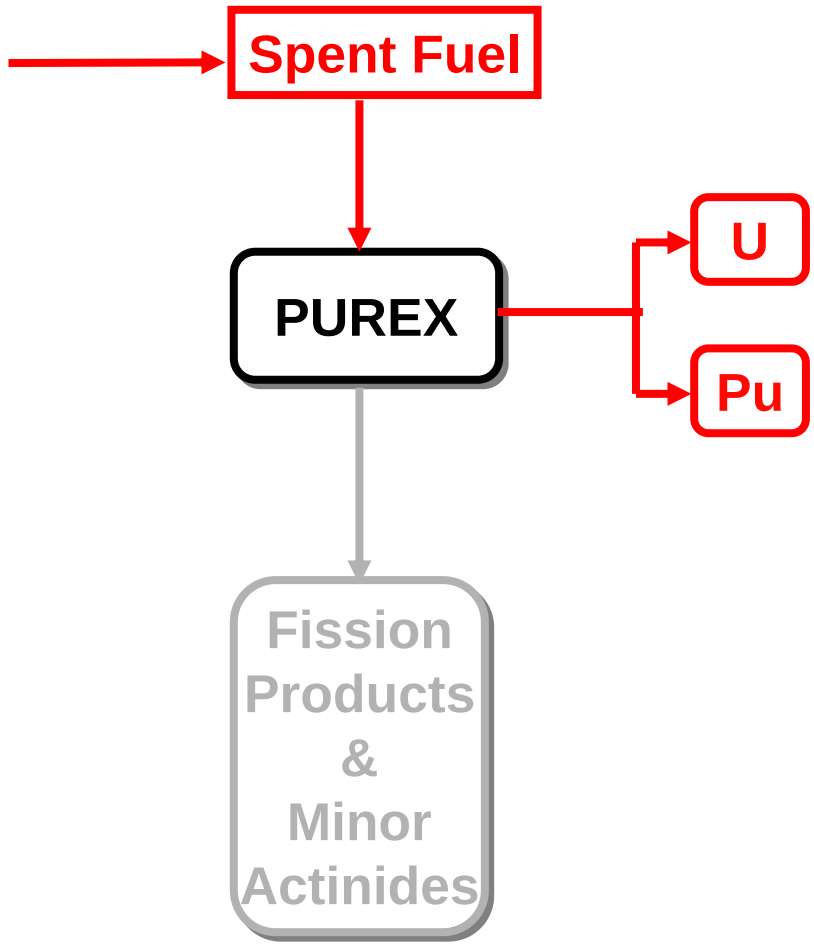
> 98 wt% of Pu and Am have been transfered to the Al-based alloy after one contact

Pure Al		
Element M	**D_M**	**$S_{Am/M}$**
Pu	**273 ± 126**	**0,78 ± 0,47**
Am	**213 ± 30**	**1**
Ce	**0,162 ± 0,02**	**1315 ± 289**
Sm	**0,043 ± 0,004**	**4954 ± 1139**
Eu	**< 0,029**	**> 7345**
La	**0,03**	**7100**

D_{Cm} = 185+/-32 with pure Al *(measured from Cm traces)*

SPENT FUEL REPROCESSING

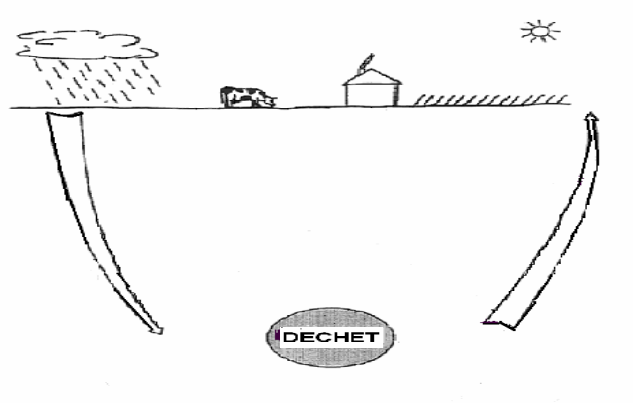




COMPLEMENTARY SEPARATIONS : THE MAIN TARGETS

- **MINOR ACTINIDES : *Am - Cm - Np***

  (Mains contributors to long term radiotoxicity, after plutonium)



- ***SOME FISSION PRODUCTS : I – Cs – Tc***
  - ***Significant abundance of long-lived isotope***
  - ***More « mobile » in repository conditions***

ACTINIDE PARTITIONING : R&D SUCCESSIVE STEPS…

1. BASIC RESEARCH *(very wide cooperative frame)*

- *innovative : new extractant systems*
- *fundamental : mecanism studies*

Several hundred new molecules

2. DEVELOPMENT

- *process design*
- *hots runs with genuine spent fuel*

Scale 1/10000

- *demonstrative tests*
  (integration, representativeness, robustness)

Scale 1/100 à 1/1000