ON THE EFFECTIVENESS OF THE ELSY CONCEPT WITH RESPECT TO MINOR ACTINIDES TRANSMUTATION CAPABILITIES

Giacomo Grasso[1], Carlo Artioli[2], Stefano Monti[2], Federico Rocchi[1] and Marco Sumini[1]

Carlo.artioli@bologna.enea.it

1) Nuclear Engineering Laboratory (LIN) of Montecuccolino, DIENCA, University of Bologna, Italy
2) Italian National Agency for New Technologies, Energy and the Environment (ENEA), Italy

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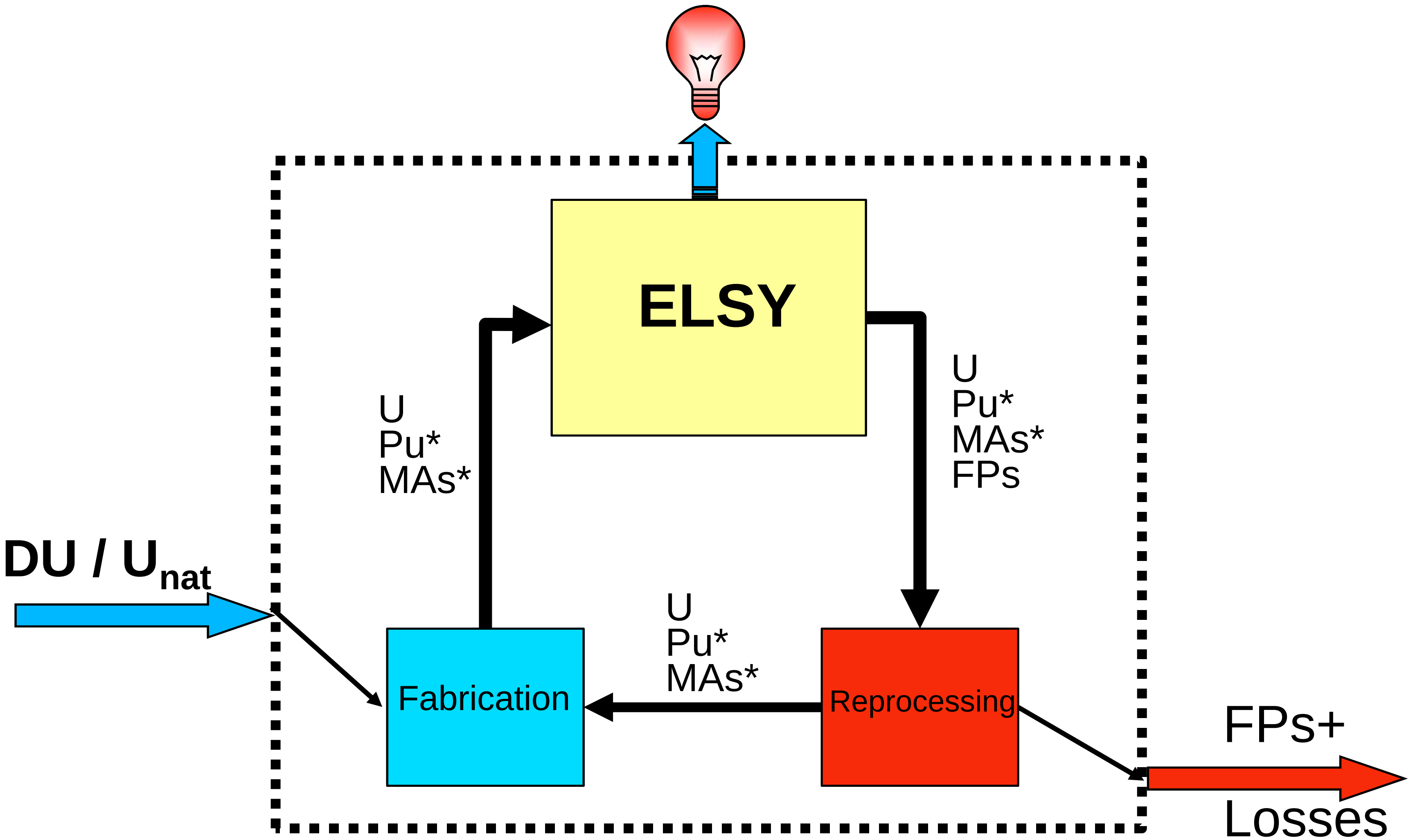
Via Martiri di Monte Sole 4, 40129 Bologna, Italy

The "Adiabatic" Core Concept



* Equilibrium vector

Constraints

Pu Equilibrium:

- vector (Pu*) gets richer in even isotopes and poorer in odd ones

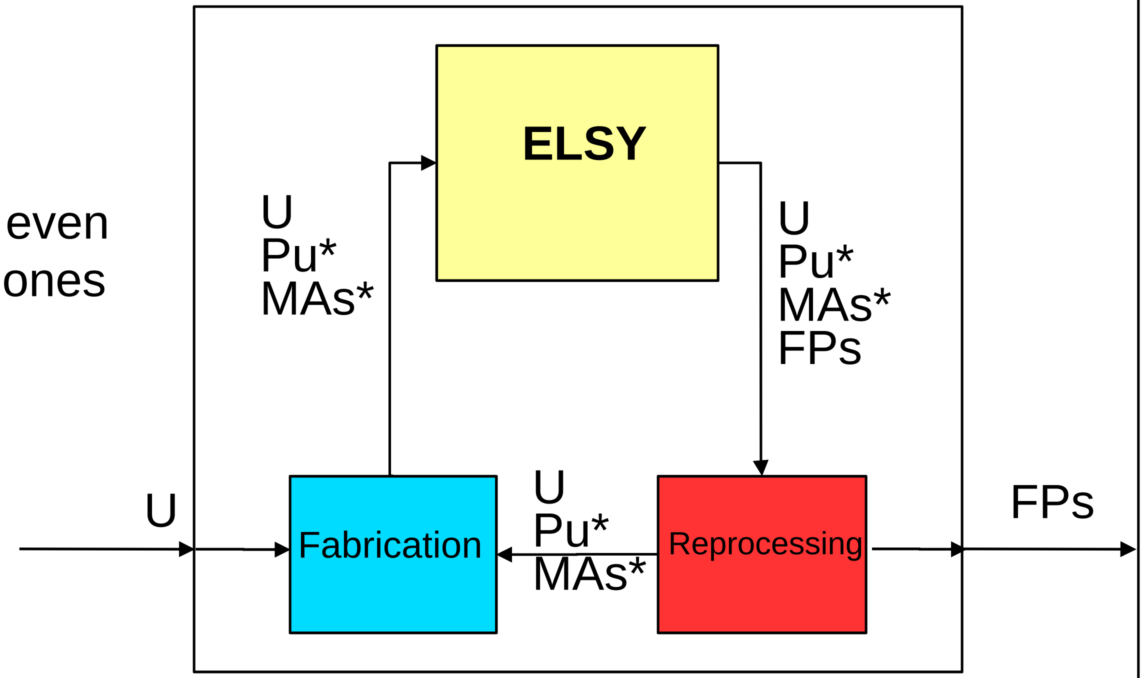
→ criticality decreased

→ fuel must be more enriched in Pu

→ Breeding decreases

MAs Equilibrium:

- its concentration must be acceptable for the system dynamics



Vectors:

Plutonium	
Isotope	[w/o]
Pu238	2.333
Pu239	56.873
Pu240	26.997
Pu241	6.104
Pu242	7.693

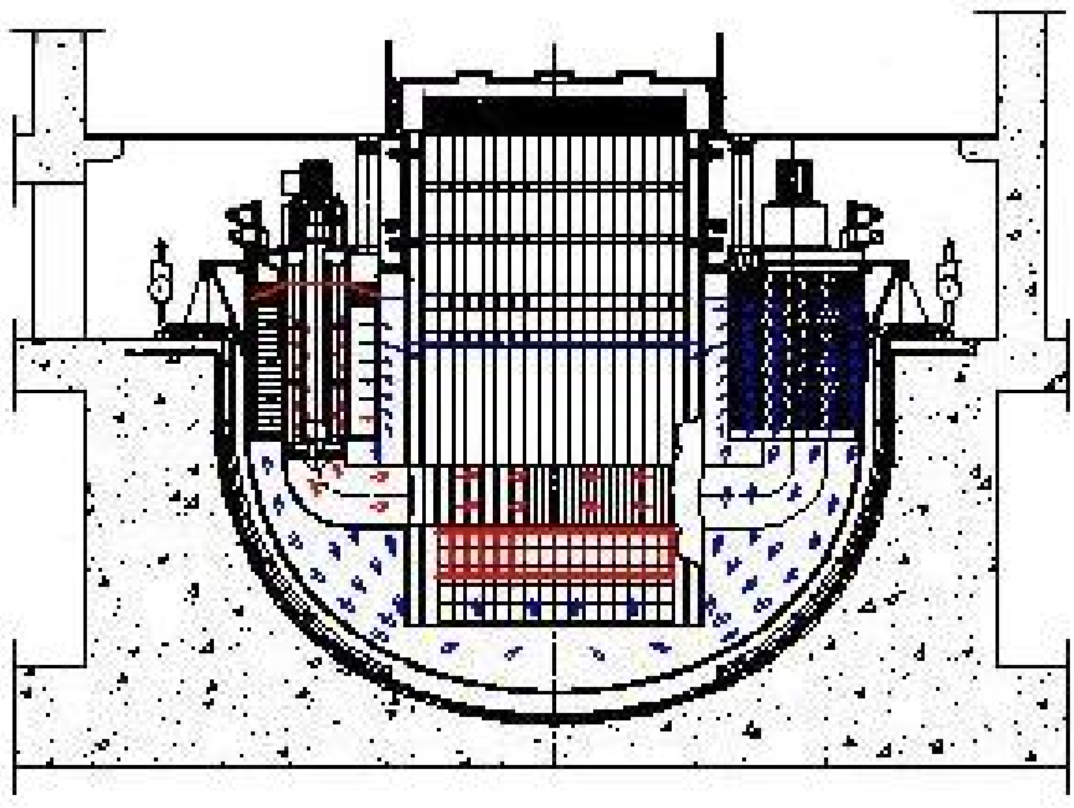
Uranium	
Isotope	[w/o]
U234	0.003
U235	0.404
U236	0.001
U238	99.583

Americium	
Isotope	[w/o]
Am241	82.118
Am242F	0
Am242M	0.277
Am243	17.605

Curium	
Isotope	[w/o]
Cm243	1.533
Cm244	69.763
Cm245	26.588
Cm246	2.074
Cm247	0.039

Neptunium	
Isotope	[w/o]
Np237	100
Np239	0

ELSY – European Lead-cooled SYstem



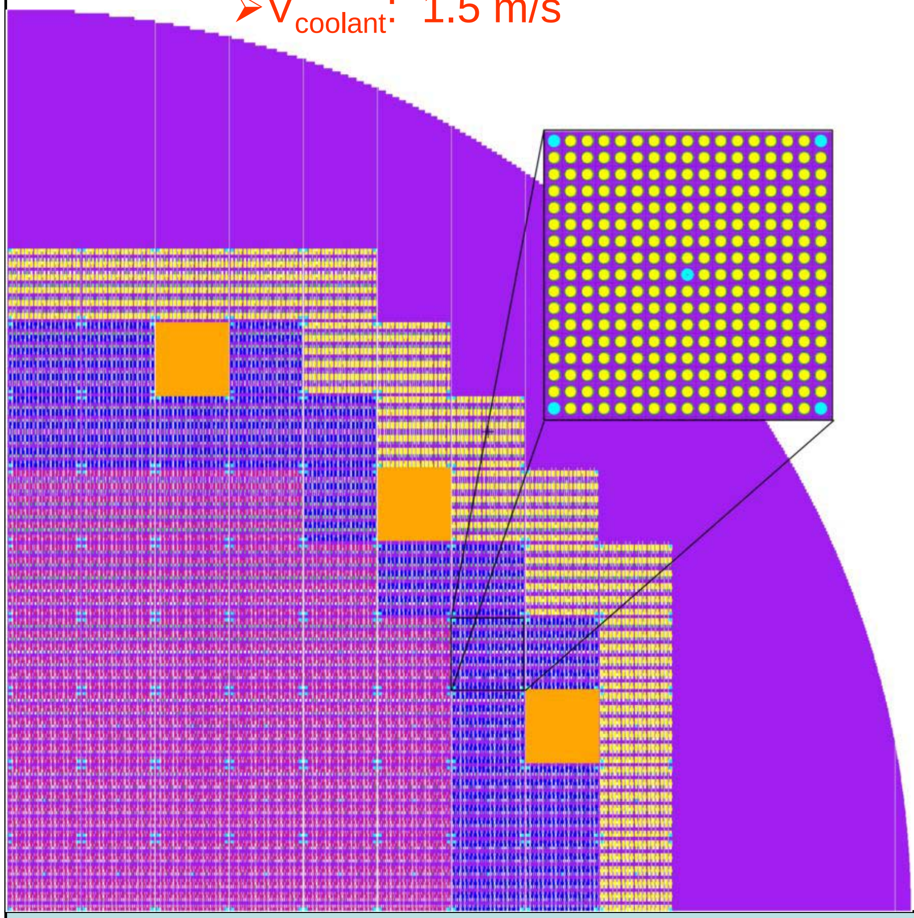
Main features:

- lead cooled;
- 1500 Mwth;
- innovative integrated compact design:
  - reduction “parasitic” material (wrapperless)
  - reduced H and D for sloshing. →

ELSY Core (mar 2008)

Constraints:

- Lead corrosion to SS T91 cladding
  - $T_{cladding}$: 550 °C
  - $T_{coolant}$: 400 °C in – 480 °C out
- Natural circulation (low pressure drop)
  - $V_{coolant}$: 1.5 m/s



Two configurations:

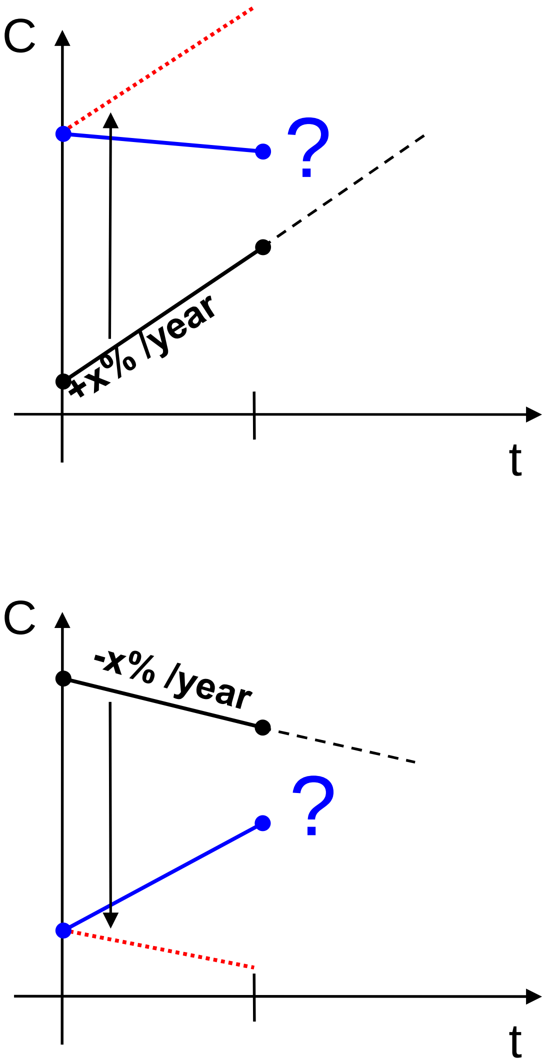
1. hexagonal FAs with wrapper in triangular lattice (fall-back solution);
2. wrapper-less square FAs in square lattice (reference configuration)
   - pros:
     - ✓ less steel;
     - ✓ economics of manufacturing;
   - cons:
     - ✓ no T_{out} flattening by coolant flow rate tuning.

272 FAs with standard 17x17 pins lattice:

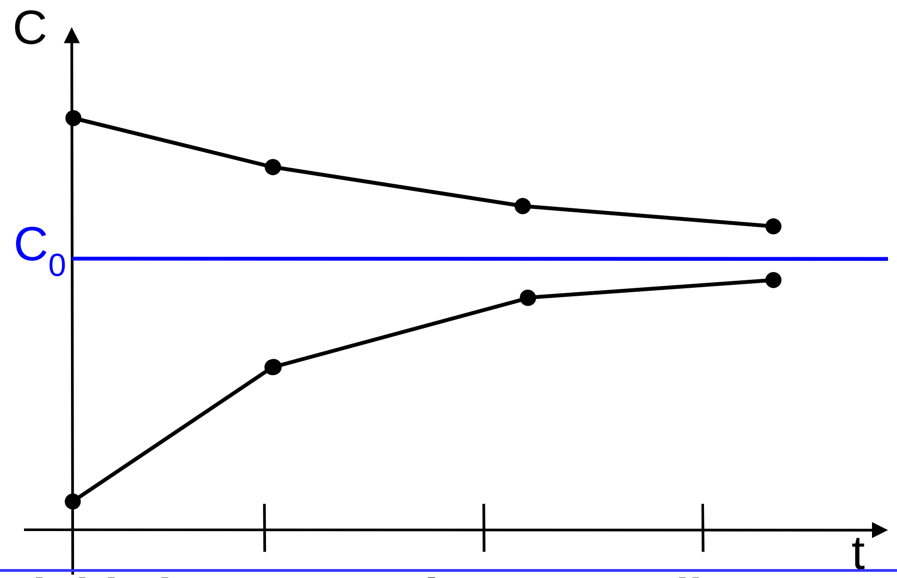
- 132 in INNER region with 13.4 $^{v}/_{0}$ Pu
- 72 in INTERMEDIATE region with 15.0 $^{v}/_{0}$ Pu
- 68 in OUTER region with 18.5 $^{v}/_{0}$ Pu

G. Grasso, C. Artioli, S. Monti, F. Rocchi & M. Sumini

The Equilibrium Concentration



M I S L E A D I N G !



Each Actinide isotope evolves according to a rather exponential behavior, due to balancing production (by transmutation) and removal (by fission) mechanisms.

Therefore expressing their behaviour in term of velocity of relative variation (positive or negative Δ % /year) could be rather misleading.

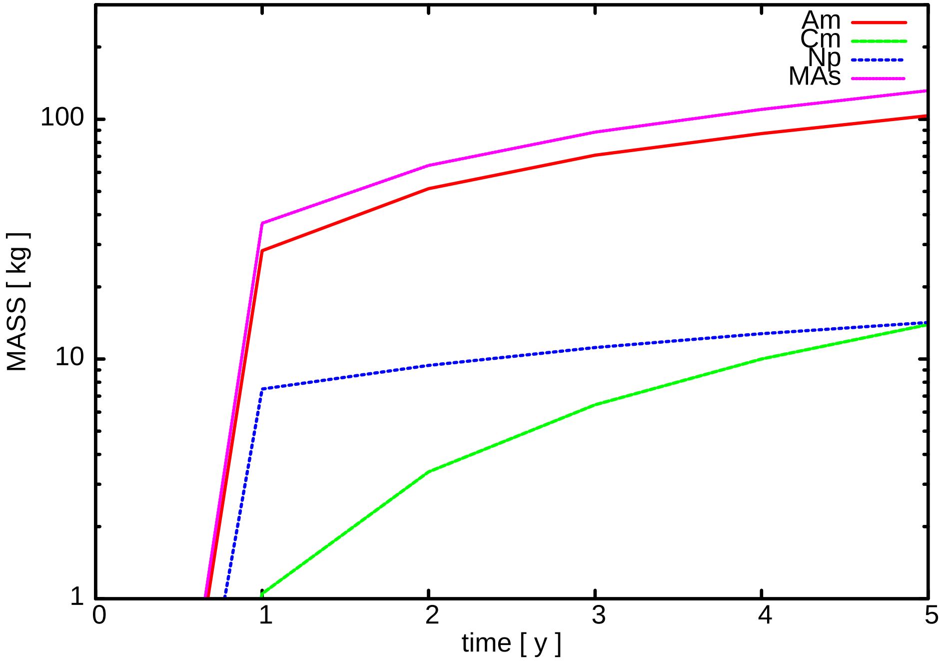
The behaviour is indeed characterized by

-Equilibrium (asymptotic) concentration and

-Time constant

The equilibrium concentration is ruled by the reactor spectrum.

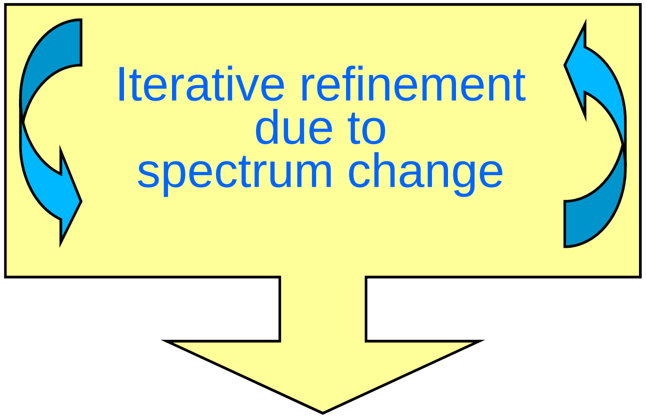
ELSY MAs Concentrations at Equilibrium



Preliminary results

(by M. Sarotto
on the ELSY cycle initially
loaded with pure MOX, MAs free).

$$C(t) = C_0\left(1 - e^{-t/\tau}\right)$$



	C_0 (MA/HM)	τ [y]
Am	7.60E-03	7.9
Cm	2.75E-03	62.5
Np	9.23E-04	2.2
TOT	1.13E-02	

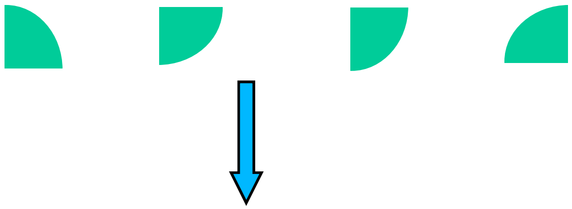
Acceptable concentration of Mas for the system dynamics!

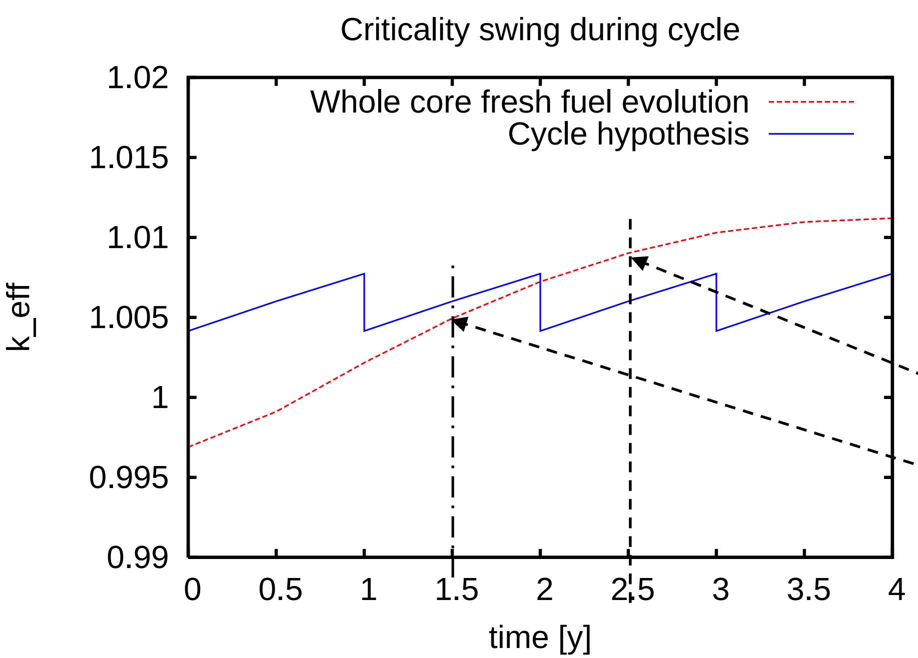
ELSY adiabatic cycle analysis

Fuel Cycle hypothesis:

- 4 years fuel residence in core;
- refueling of ¼ of the fuel each year.

BoL	0	0	0	0
1 y	1	1	1	1 -> 0
2 y	2	2	2 -> 0	1
3 y	3	3 -> 0	1	2
4 y	4 -> 0	1	2	3
5 y	1	2	3	4 -> 0
6 y	2	3	4 -> 0	1
…	…	…	…	…



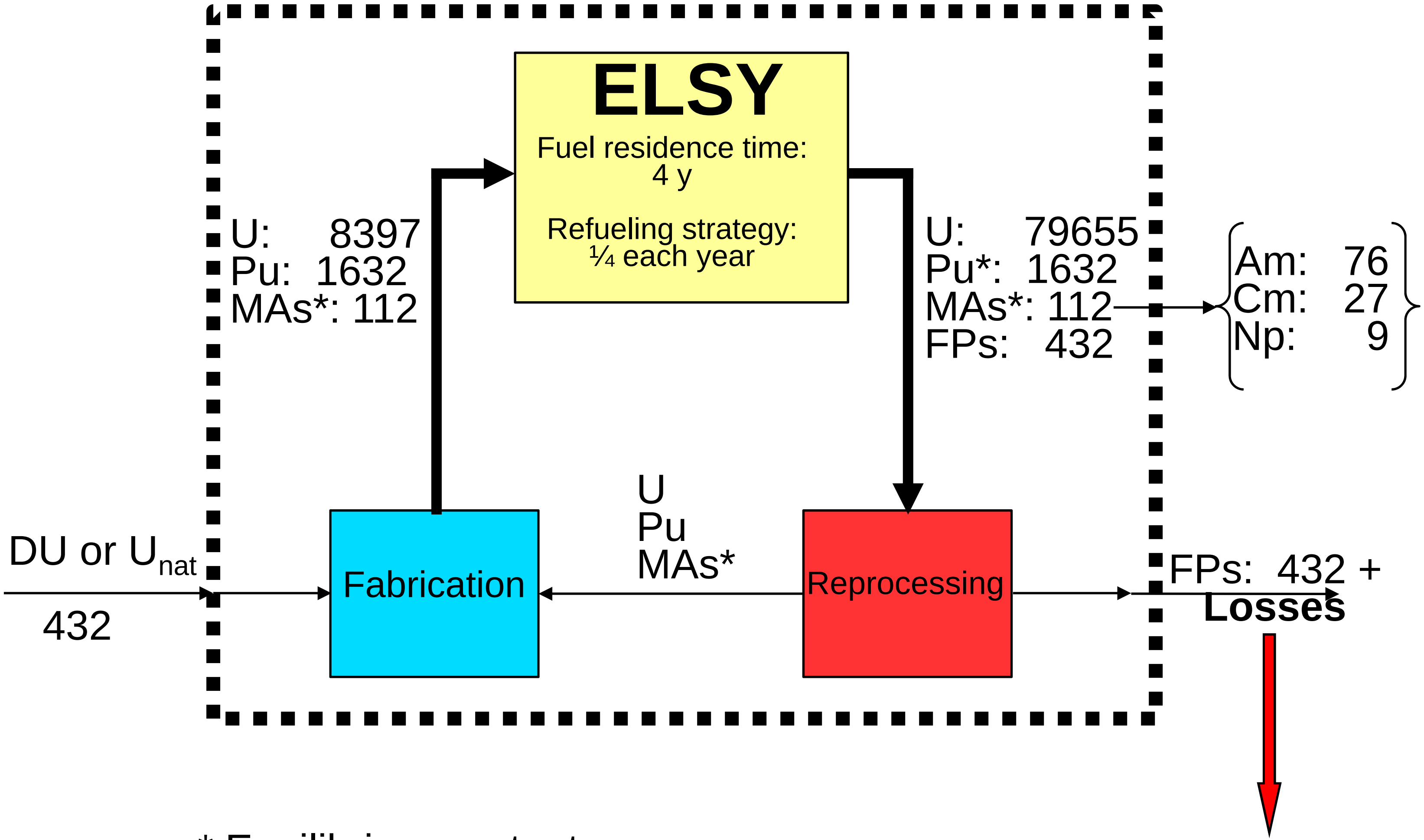


Mean age of the fuel:

2.5 y at EoC

1.5 y at BoC

Mass flows (kg/y, LF 80%)



* Equilibrium content

High BU is required!!

Conclusions

- The viability of an adiabatic core has been demonstrated for the ELSY Lead Fast Reactor (as far as the MA equilibrium concentration is concerned);

- The immobilization of the MAs equilibrium mass within the system inhibits the further production of Long-Lived Radioisotopes (LLRs);

- The input stream is only cheap U natural or depleted, while

- the output stream results in FPs only + losses, strongly reducing the radiotoxicity load in the final disposal, which could be ruled by the losses;

- .Therefore to decrease the losses, along the efficiency of the process, a high BU is required for reducing the number of reprocessing steps.

Next steps

- The full viability must be demonstrated using the Pu equilibrium vector at in a system with a unitary BR.

Thank you for your attention