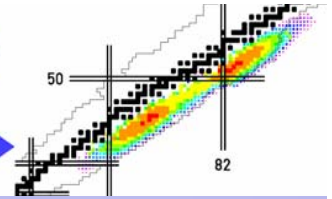


Grand Accélérateur National d'Ions Lourds

GANIL

Laboratoire commun CEA / DSM - CNRS / IN²P³

**Spiral 2**



Neutronic Perturbation of the Uranium Target Activation and its impact on the criticality potential

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First Workshop on Actinide Target Development

TRIUMF

April 27-29, 2006 - Vancouver, British Columbia

Summary



Methodology and Simulation Tools



Results and Discussion

SPIRAL2 PROJECT

OBJECTIVE :

Production of neutron-rich exotic nuclei

$A > 40$; $N \nearrow$

very intense beams

TOOL :

Nuclear fission

Applications :

fundamental research in nuclear physics

measurement of nuclear data

nuclear reactions of astrophysics

material sciences, atomic, plasma and surface physics

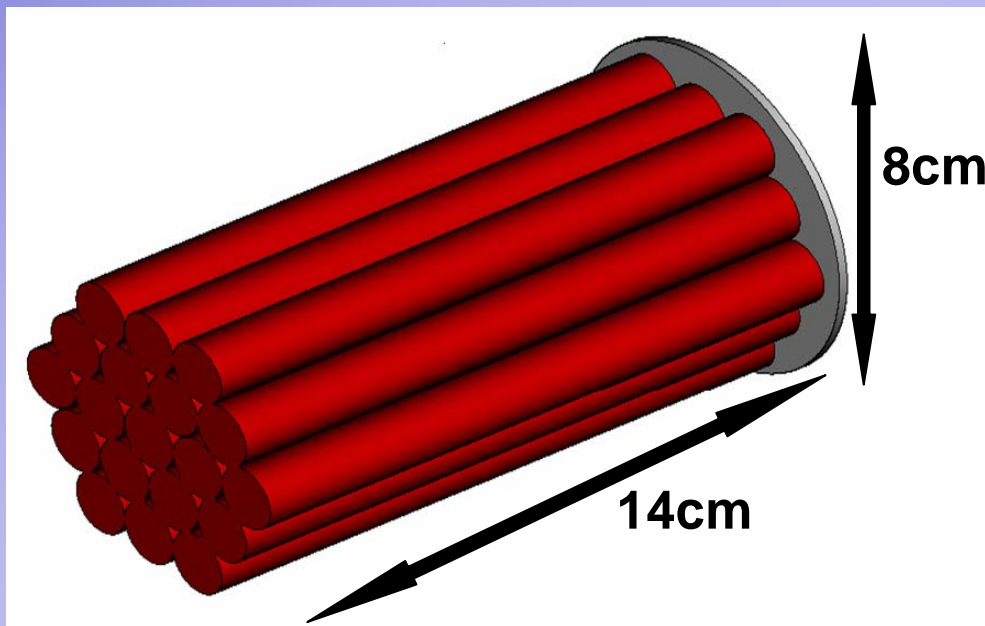
Graphite converter

Deuteron beam
40MeV, 5mA, 200kW

Neutron
flux

UCx
Target

10^{14}
fissions/s



UCx : natural
uranium

^{238}U : 4670g

^{235}U : 32,5g

C : 474,5g

Objective

Quantify the reactivity of the UCx target

Motivation

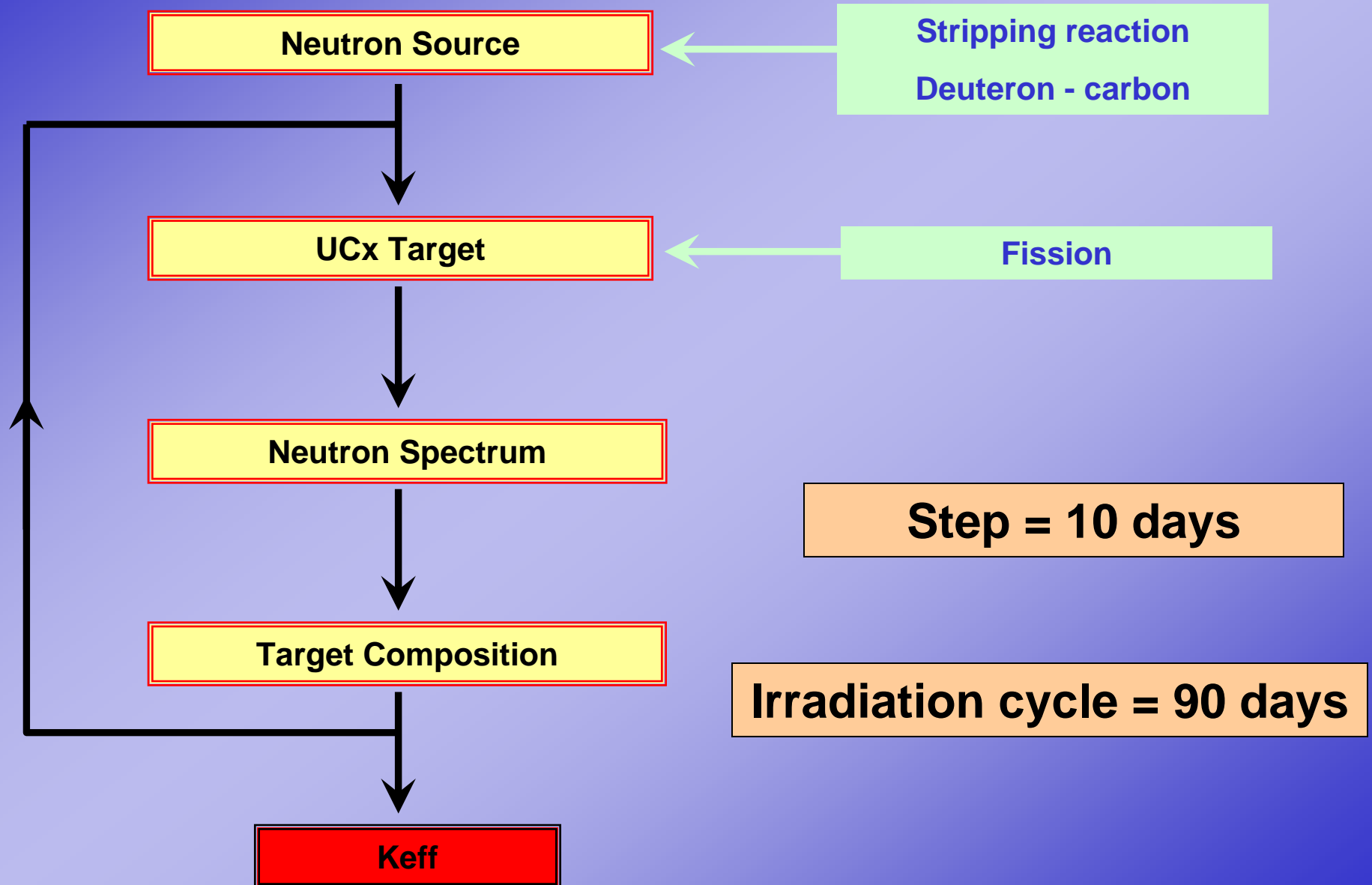
Irradiation of the target under fast neutron spectrum

Evolution of the target composition

Perturbation of neutrons spectrum

Evolution of the reactivity

Calculus Methodology



Criticality factor

keff

Ratio of two successive neutron generations

Keff < 1

Keff = 1

Keff > 1

Subcriticality

Criticality

Supercriticality

ADS systems

Classical reactors

Little Boy

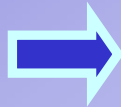
Simulation tools

MCNPX 2.5.e



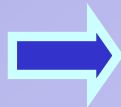
Deuterons transport & stripping reaction on the converter

TRIPOLI-4.3



Neutrons transport & spectrum on the target

DARWIN-
PEPIN2



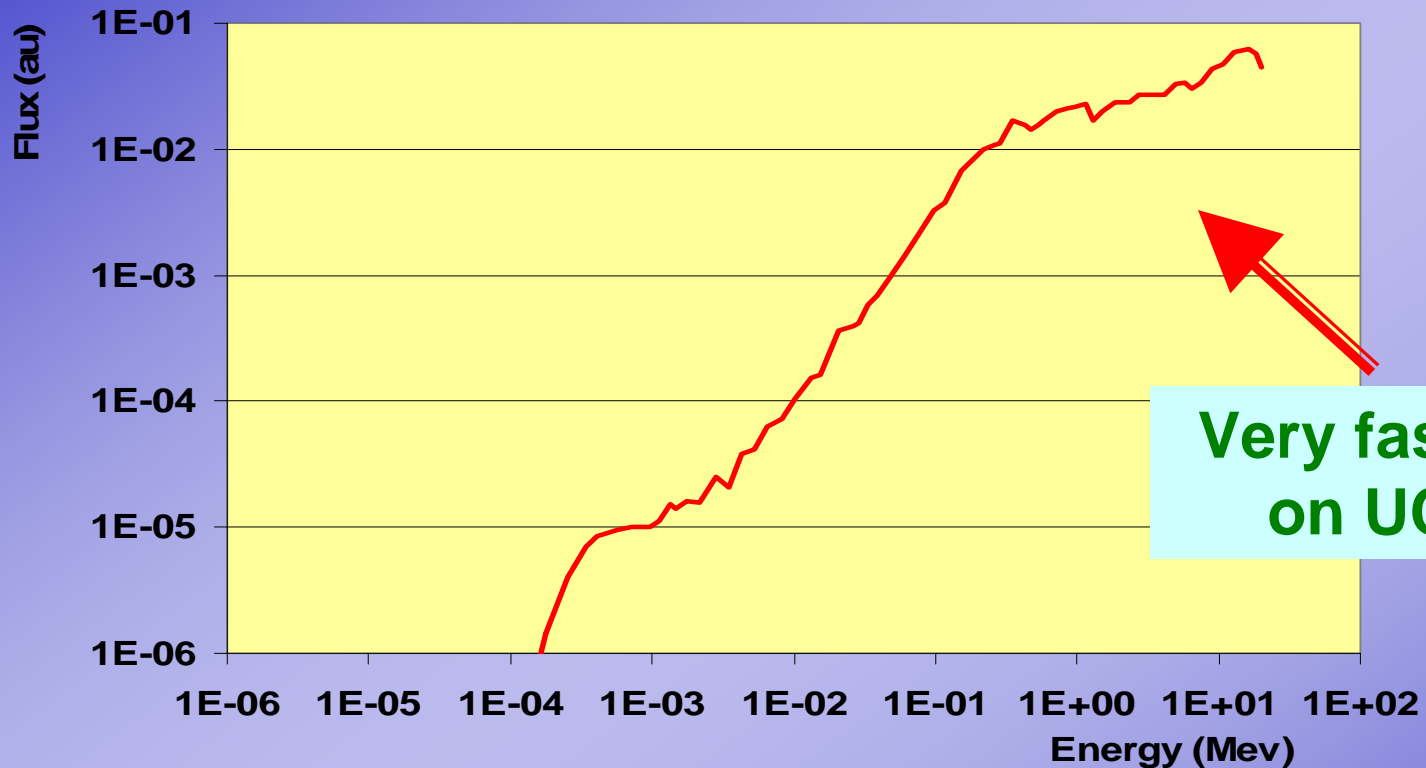
Evolution of atomic composition of the target

TRIPOLI-4.3



Criticality calculation (K_{eff})

Neutron spectrum on the Target and criticality at = 0



At t = 0



$K_{eff} = 0.78$

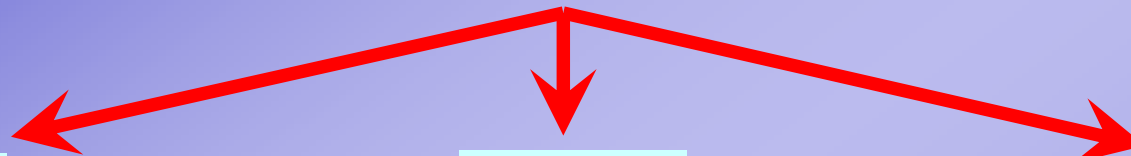
Evolution of UCx Target under neutrons

Main nuclear reactions
on the Target

(f,n)

(n,2n)

(n, γ)



Evolution of UCx Target under neutrons

Main nuclear reactions on the Target

(f,n)

(n,2n)

(n, γ)

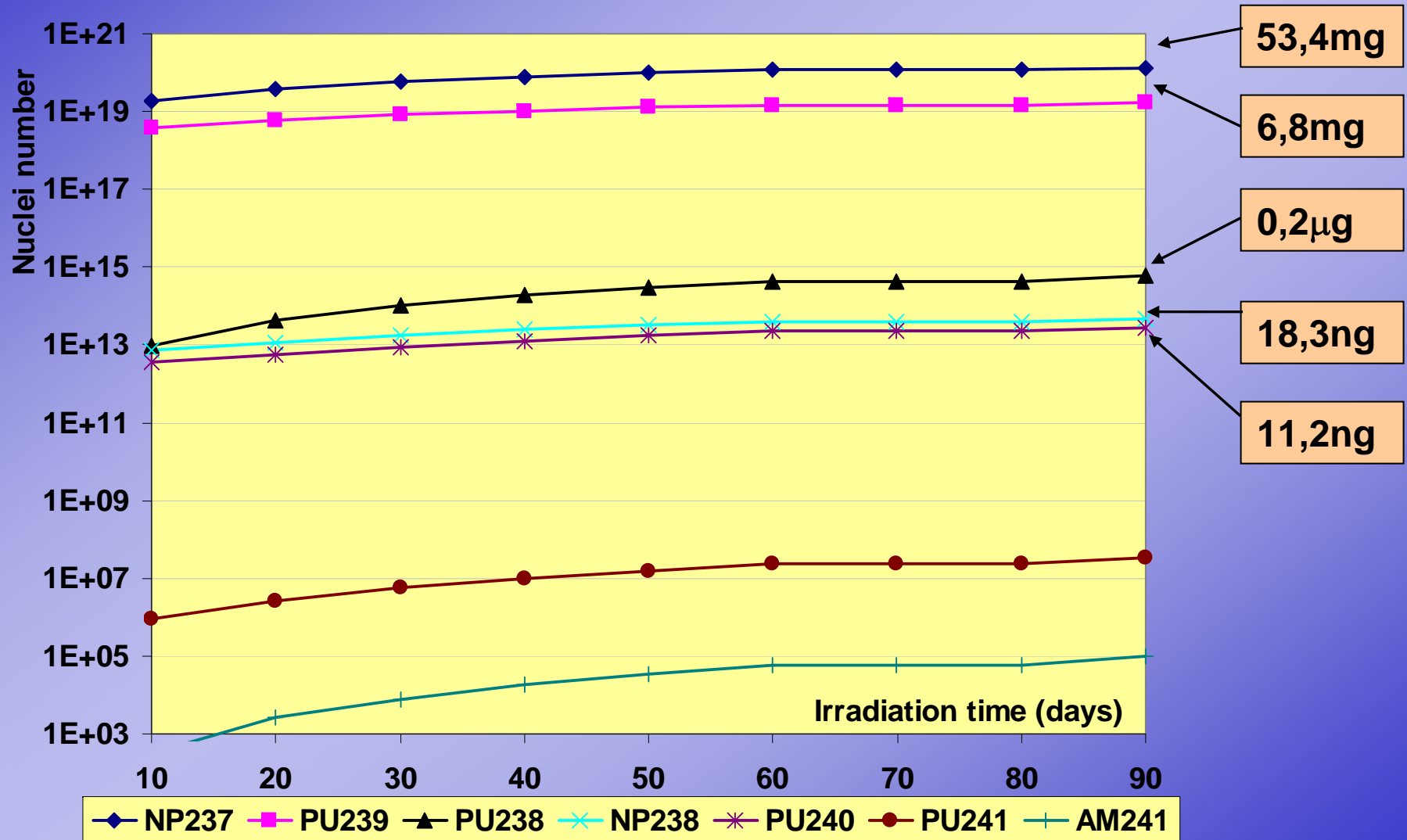
Fission Products

Actinides

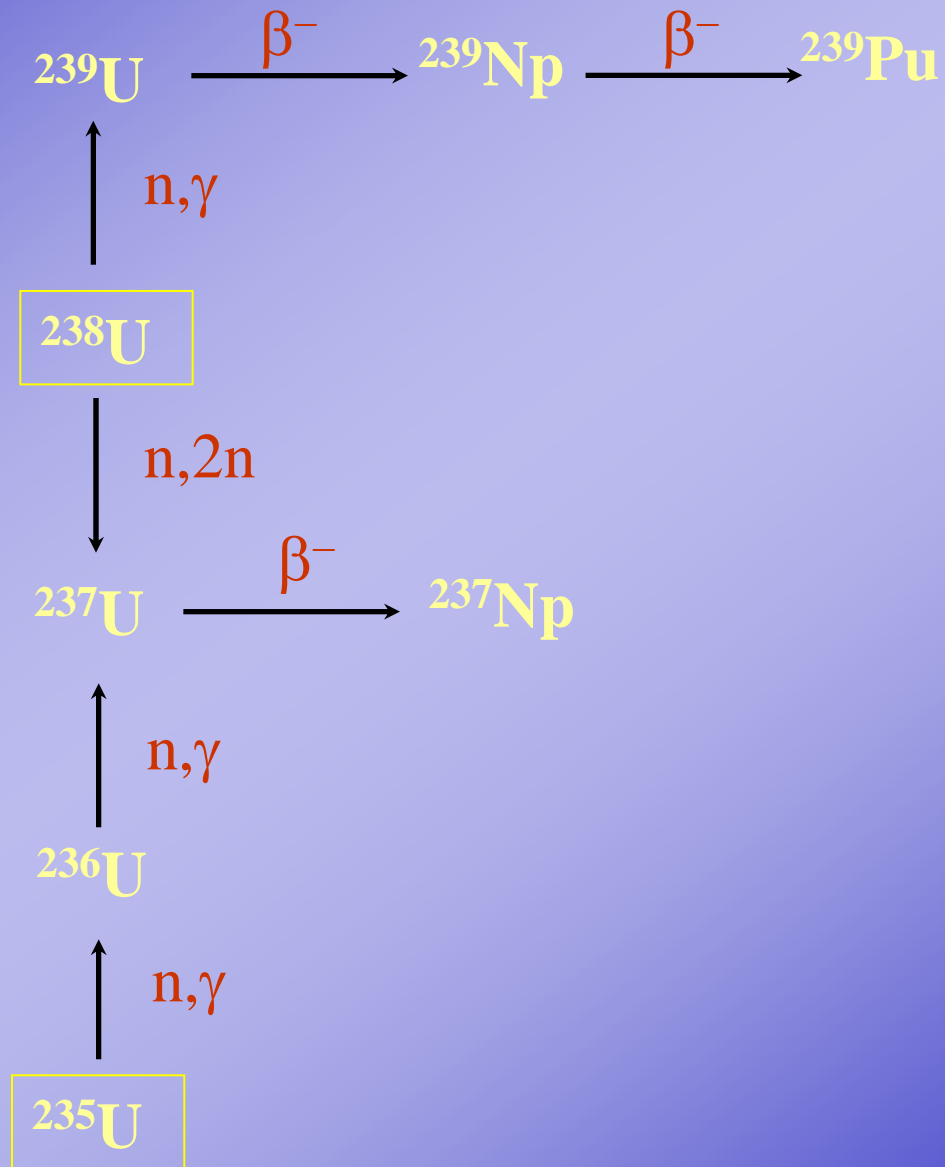
Neutrophile

Fissile

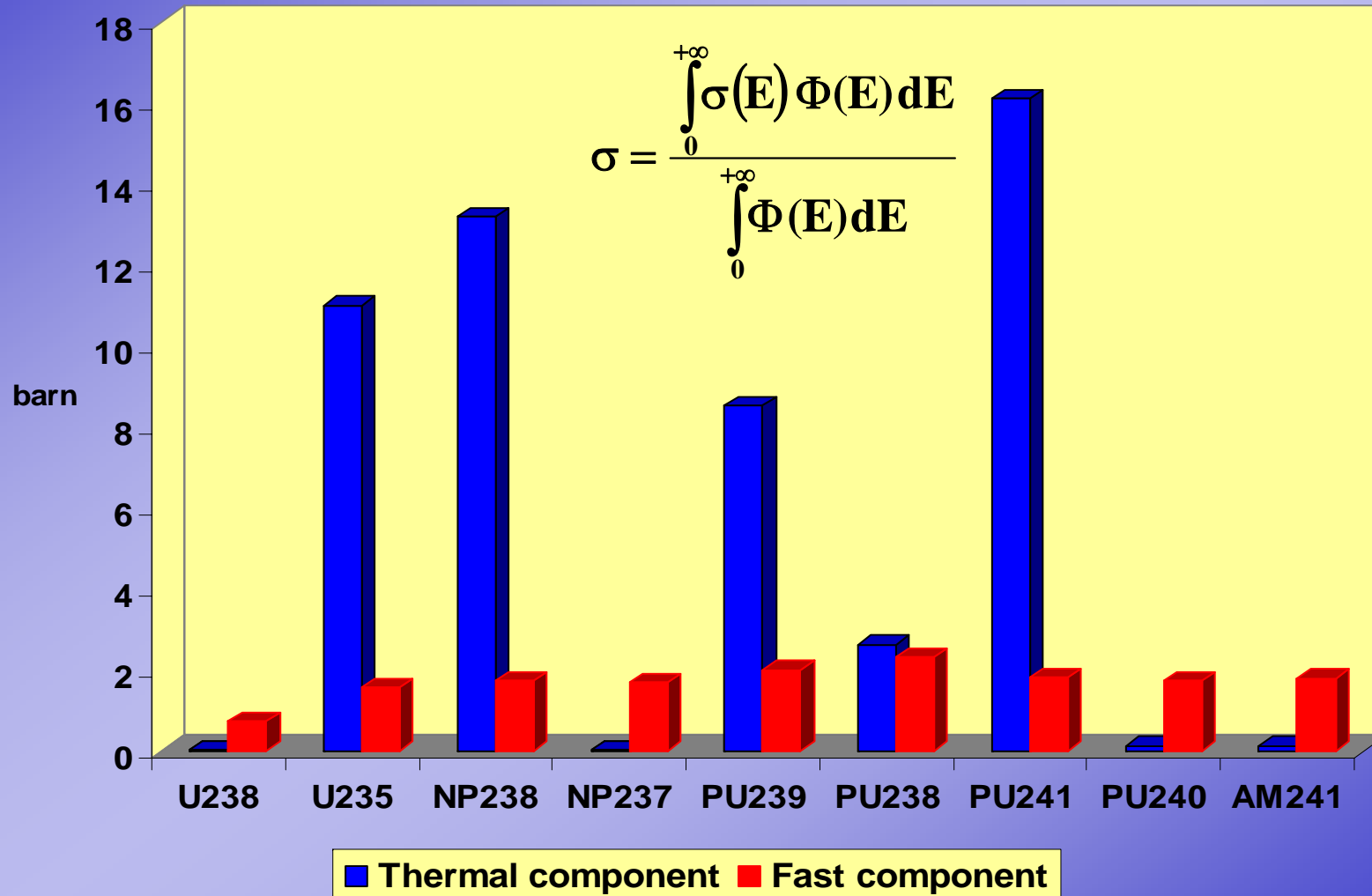
Actinides Production



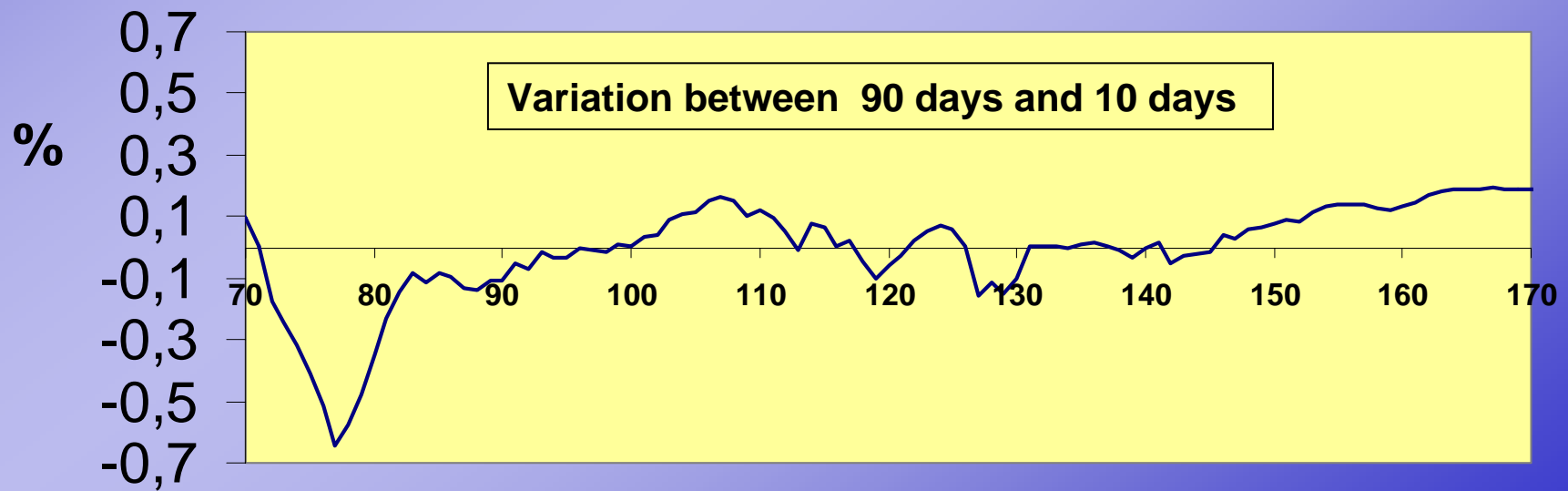
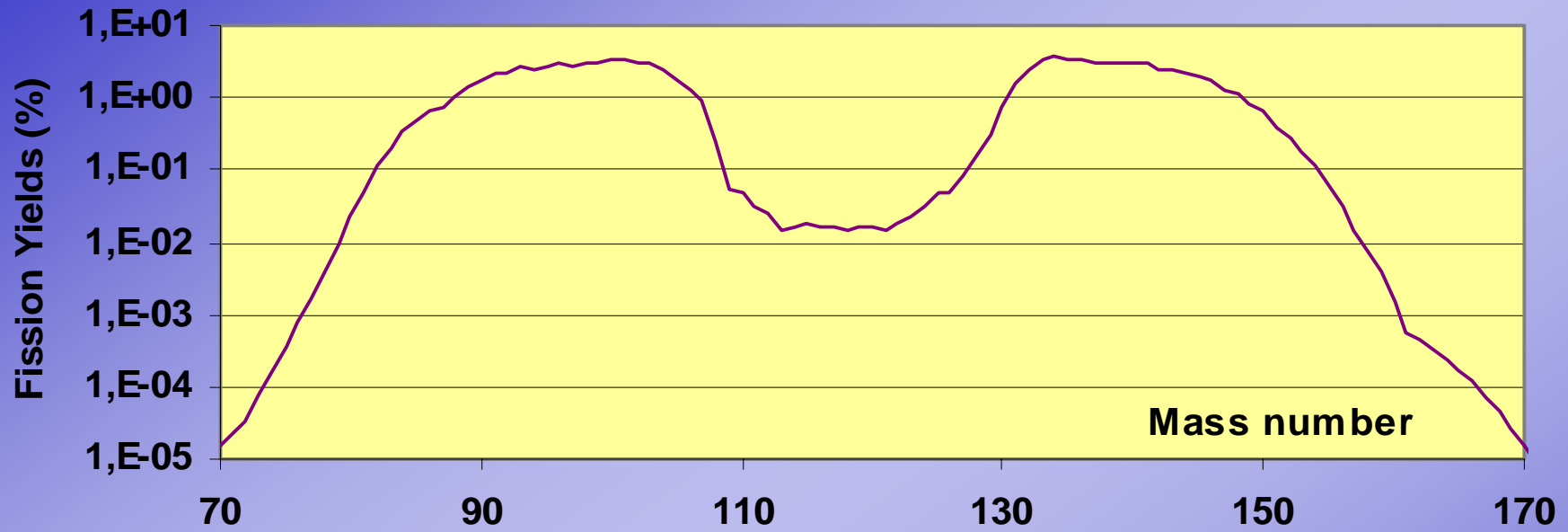
Production ways of ^{239}Pu and ^{237}Np



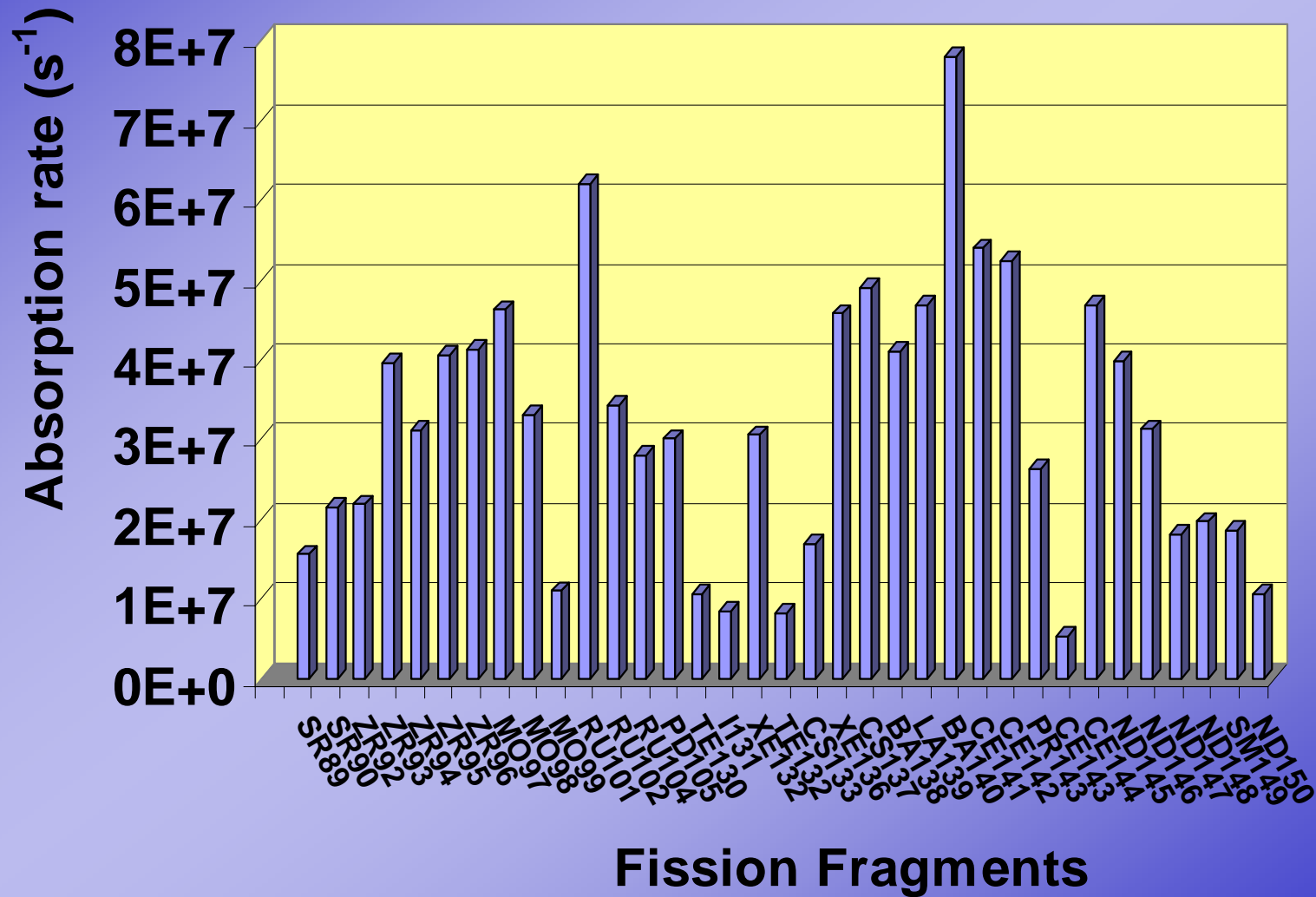
Condensed fission cross sections of actinides



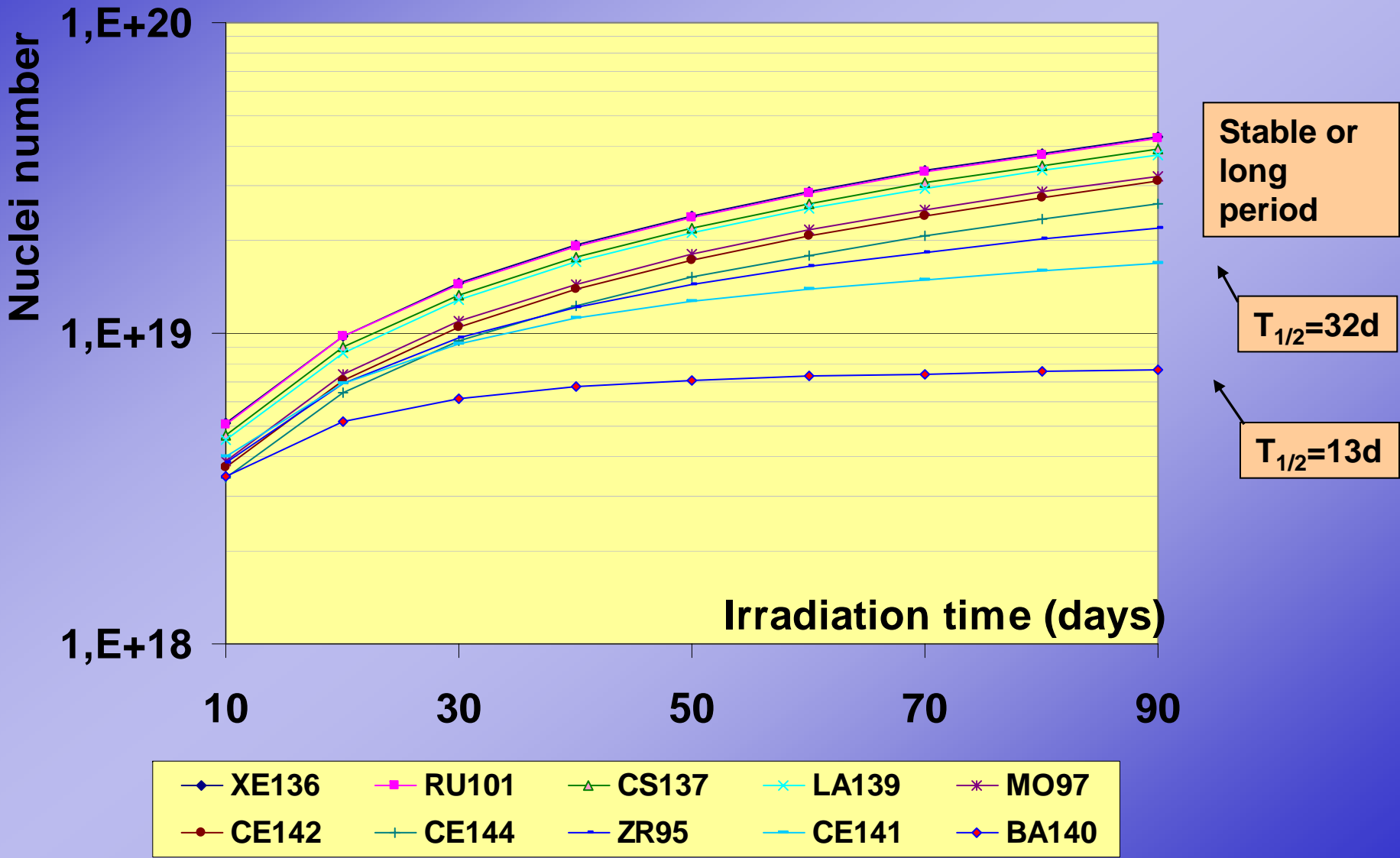
Fission products repartition



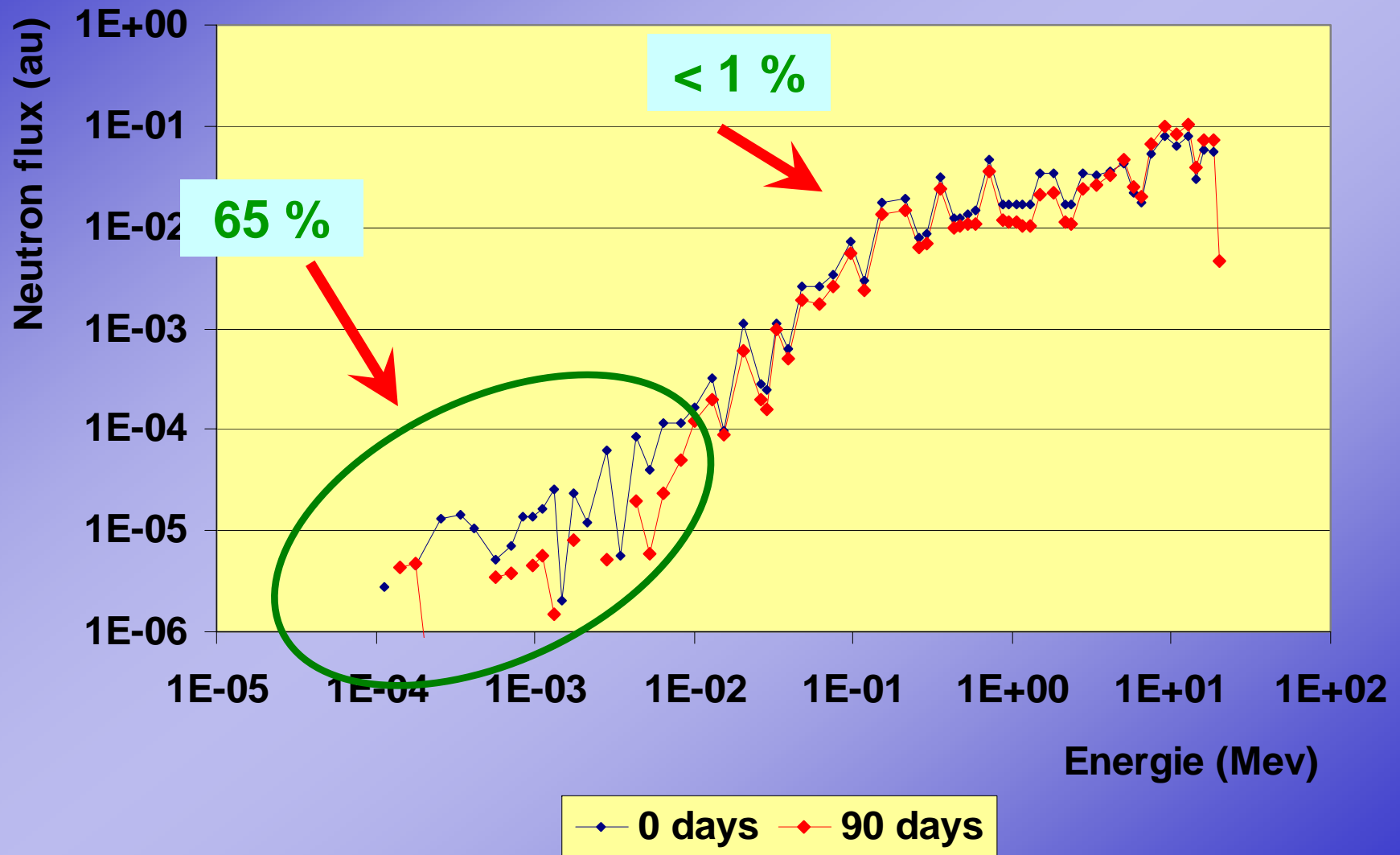
Absorption rates of fission products



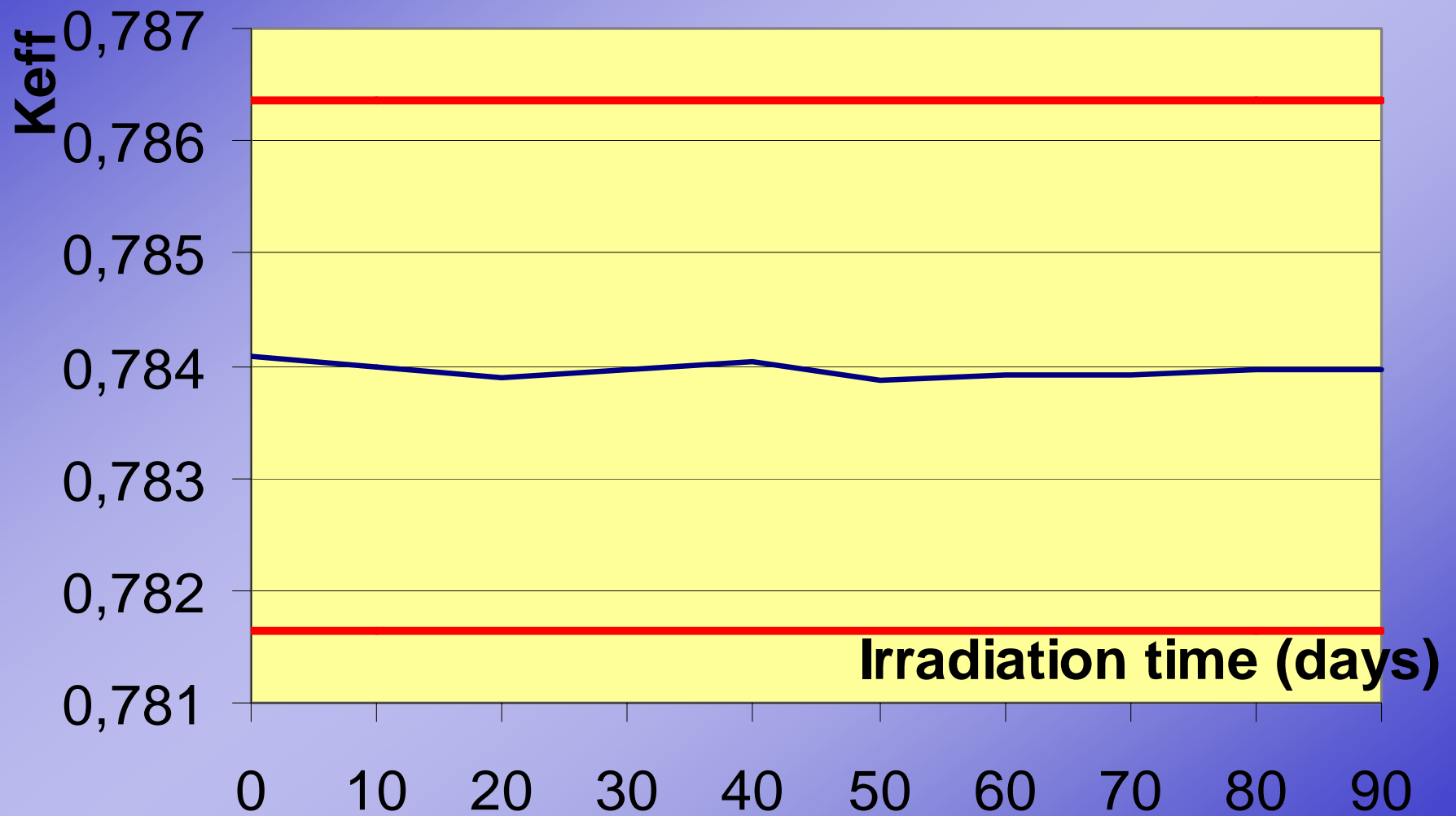
Fission products evolution



Neutronic spectrum perturbation



Criticality evolution



Conclusion

- ❑ UCx target initially subcritical ($k_{eff} = 0.78$)
- ❑ Weak burn-up of the uranium
(« insufficient » production of actinides)
- ❑ Weak and « inobservable » evolution of the criticality during the irradiation cycle
- ❑ Fast component of neutron spectrum invariable
(and strong evolution of the thermal component)

Prospects

- Use of MCNPX to confirm the criticality results

- Accidental cases to study :

 - ⇒ Flood of the target

 - ⇒ Destruction of the converter

 - ⇒ ...