# Experiments using transmutation set-ups

## Speaker : Wolfram Westmeier

**for**

## E&T RAW Collaboration

Participants of collaboration are JINR members or they have Agreements :

Russia, Germany, Armenia, Australia, Belarus, Bulgaria, China, Czech Republic, France, Greece, India, Khazakstan, Moldova, Mongolia, Poland, Serbia, Ukraine

## What is transmutation?

Conversion of long-lived nuclides into short-lived species via

(n, $\gamma$) or (n, *fission*) reactions

## Why is transmutation an important theme?

The ultimate goal is to get rid of highly radiotoxic long-lived nuclear waste such as

TRUs

$^{238-244}$Pu, $^{236,\,237}$Np
$^{241-243}$Am, $^{242-248}$Cm

Fission products

$^{129}$I, $^{135}$Cs, $^{99}$Tc, $^{93}$Zr,
$^{107}$Pd, $^{93}$Mo

# Conclusions

- We should no longer discuss
  - 'The future of P&T'
  - 'P&T is the future!' (hyperbole)
- P&T is essential for the sustainability of nuclear energy (more realistic)
- Geological disposal (GD) is indispensable
- Thus, both vectors 'Burn and Bury' are required for sustainability of nuclear energy
- GD and P&T (Advanced Fuel Cycle) communities should work together for the future of nuclear energy!

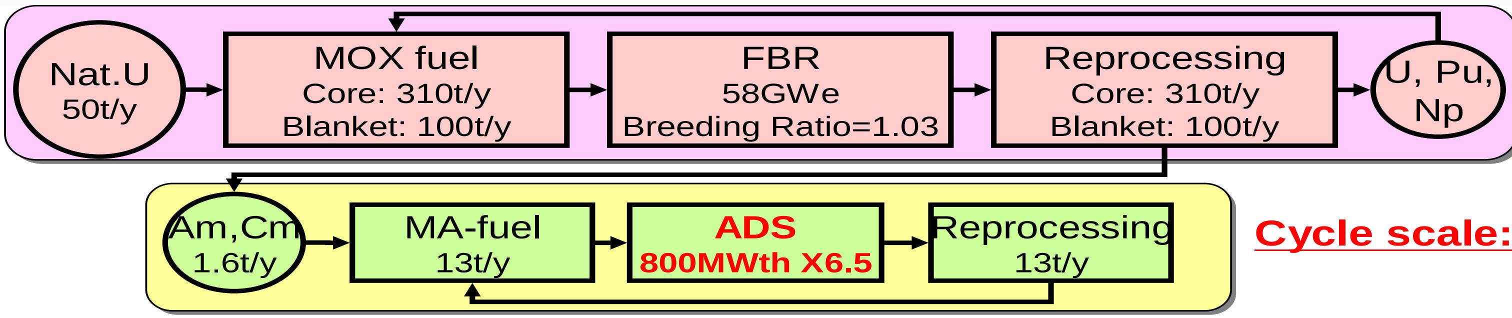
**It is unquestionably true that at tolerable risks**

- **ecological**
- **environmental**
- **financial**
- **health**
- **safety & security**

**only nuclear power can support mankind in the future.**

**But :** **Nuclear waste problem must be solved**

# Favourite : dual strata concept




**Cycle scale: 1/30**

PARTRA Cluster meeting, Feb.25-26, 2008, Karlsruhe Source: M. Touron, CEA, France 4

Four major technological units :

Generation IV reactor (FBR)*

Element separation (Partitioning)

Transmutation

Accelerator

* NO proliferation

# Key properties :

- **Generation IV reactor** ≡ **no proliferation**

- **Generation IV reactor**
  **+** ≡ **no long-lived waste**
  **Transmutation**

- **With modern technology** ≡ **no safety risk**

# Let us focus on Transmutation

**Effective and economical systems will have:**

- **Particle Energy 0.5 GeV ≤ $E_p$ ≤ 3 GeV**
- **Particle beam 5 mA ≤ $I_p$ ≤ 50 mA**
- **Heavy element spallation/fission target**
- **Maybe moderated neutrons**

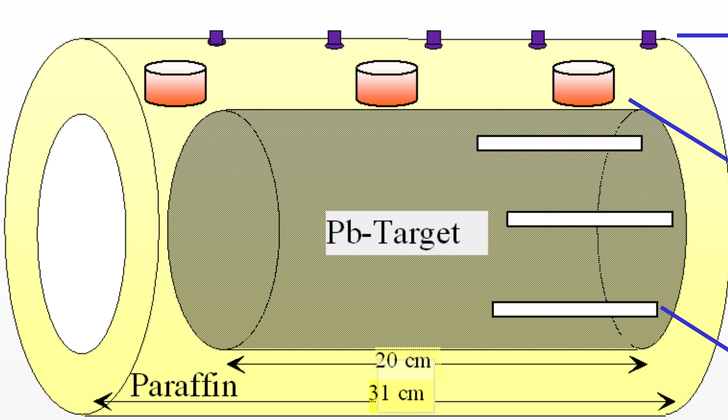
1) **There are many variables**
2) **There is a lot of energy (heat)**
3) **There is a lot of radioactivity**
4) **There is not much time**

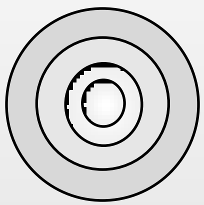
# The development task is huge

**Most details must be model-calculated on the basis of correct integral reference (=benchmark) data**

**These data are missing**

**Our Collaboration measures them**

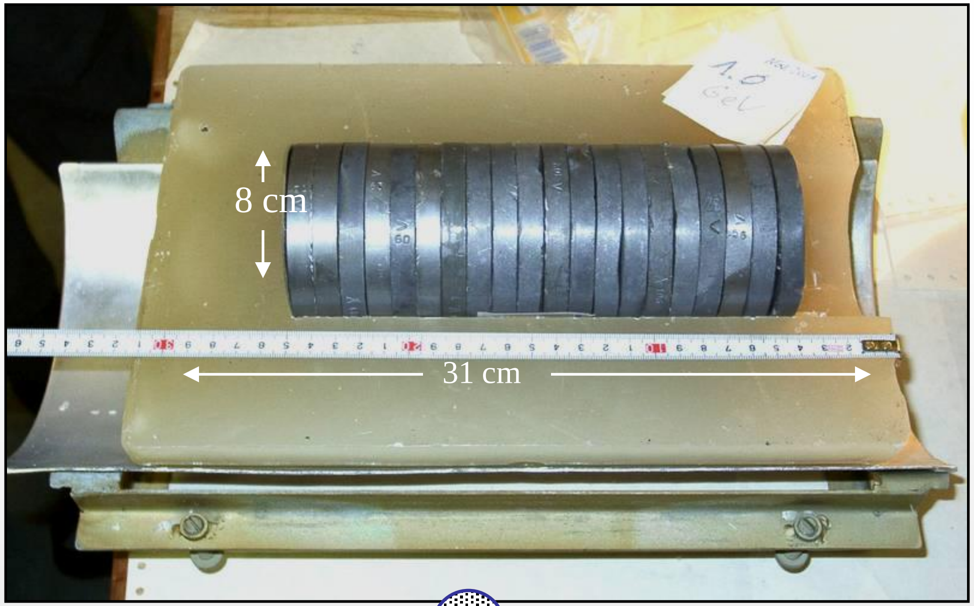


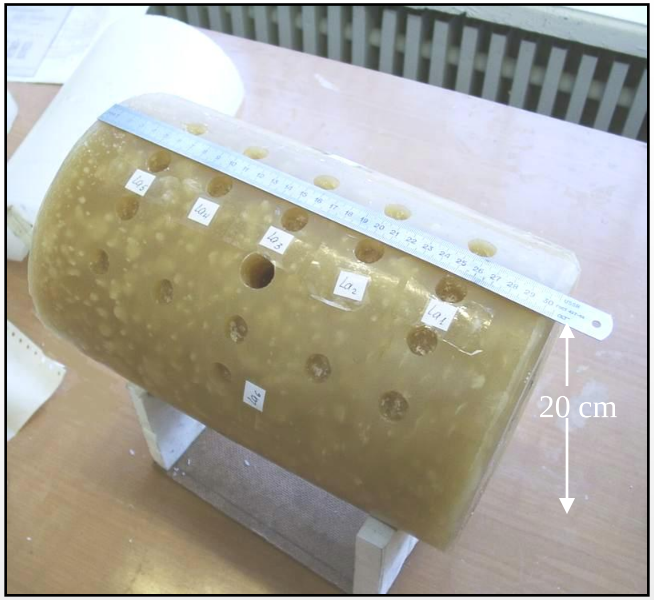



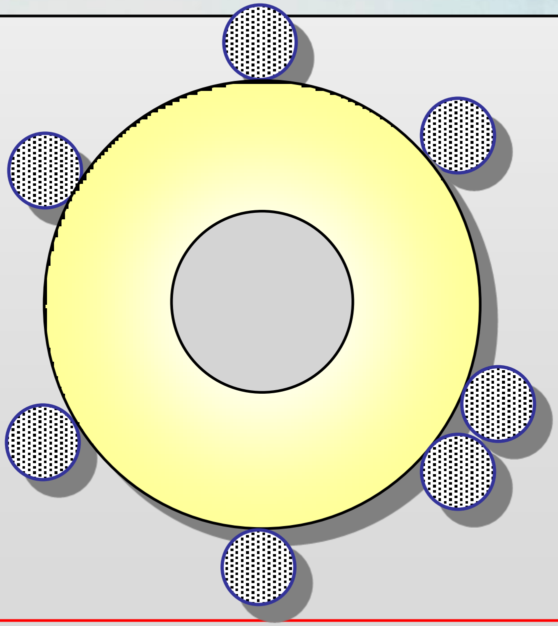
γ -Ray Spectrometry

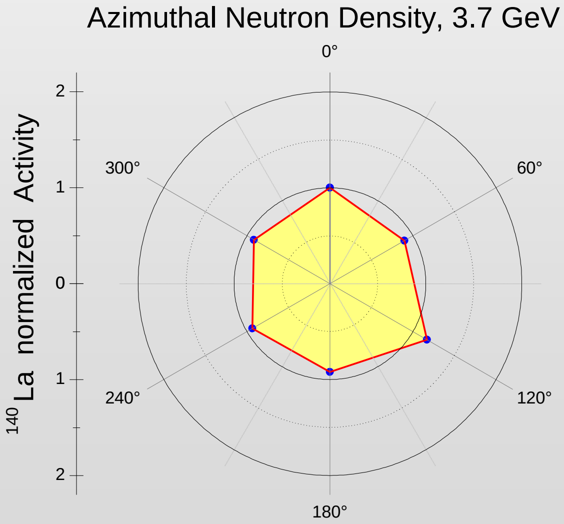
- $^{139}$La - measurement of B values to show slow neutron intensity and distribution in/on the setup
- Long-lived highly radiotoxic nuclides $^{237}$Np, $^{129}$I, etc. for transmutation studies
- Threshold detectors (and SSNTDs) for neutron measurements
- Al foil
  Proton flux monitor
- Nuclotron accelerator building, Laboratory of High Energies

Experiments with proton energies $0.5\ \text{GeV} \le E_p \le 4.7\ \text{GeV}$


8 cm
31 cm


20 cm

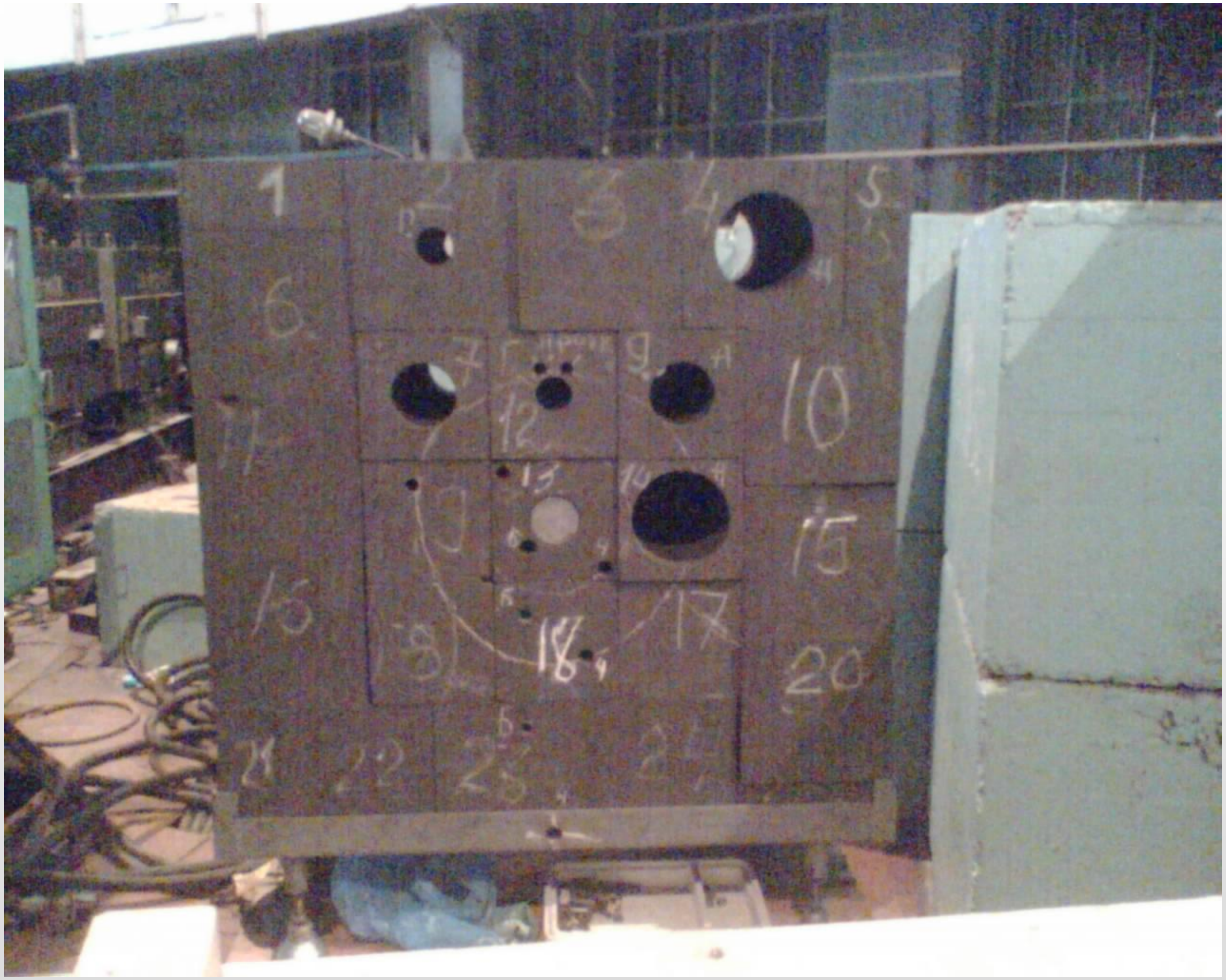



Azimuthal Neutron Density, 3.7 GeV
0°
60°
120°
180°
240°
300°
$^{140}$La normalized Activity
2
1
0
1
2

## GAMMA-2 target characteristics:

very small and simple

- 20 cm or 50 cm long Pb-core
- very symmetric (good for modelling)
- low- and high-energy neutron spectrum
- available with Pb-, Cu- and Pb/U-core



**GAMMA-3 :**

Graphite block

110 cm *

110 cm *

60 cm

with several

through holes

Center hole holds the 60 cm long Pb-target

## GAMMA-3 target characteristics:

medium size and simple

- 60 cm long Pb-core, 0.7 $m^3$ graphite
- very symmetric (good for modelling)
- low- and high-energy neutron spectrum
- very many experimental positions inside

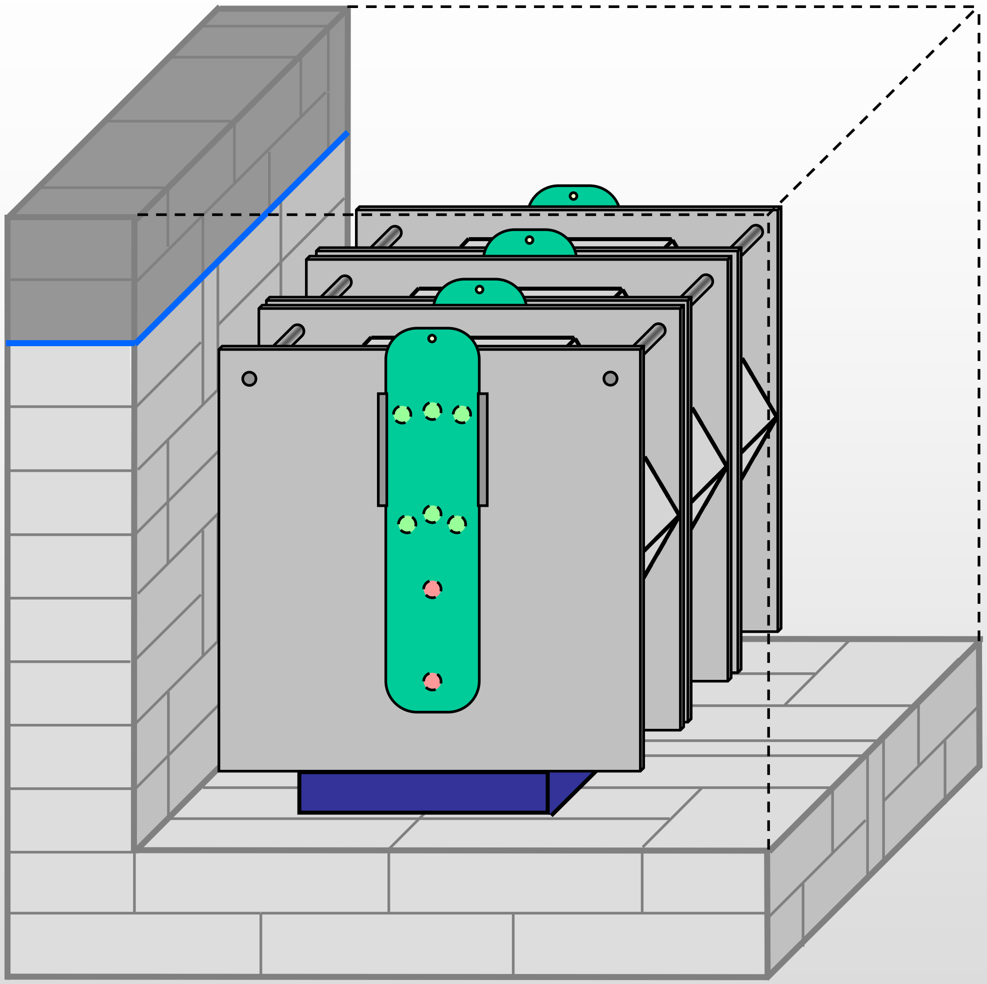

Energy + Transmutation target
(E+T)

# E + T target characteristics:

medium size and simple

- 50 cm long Pb-core, U n-enhancer
- biological (neutron) shield
- high-energy neutron spectrum

  with epitermal neutrons from shield
- many experimental positions inside

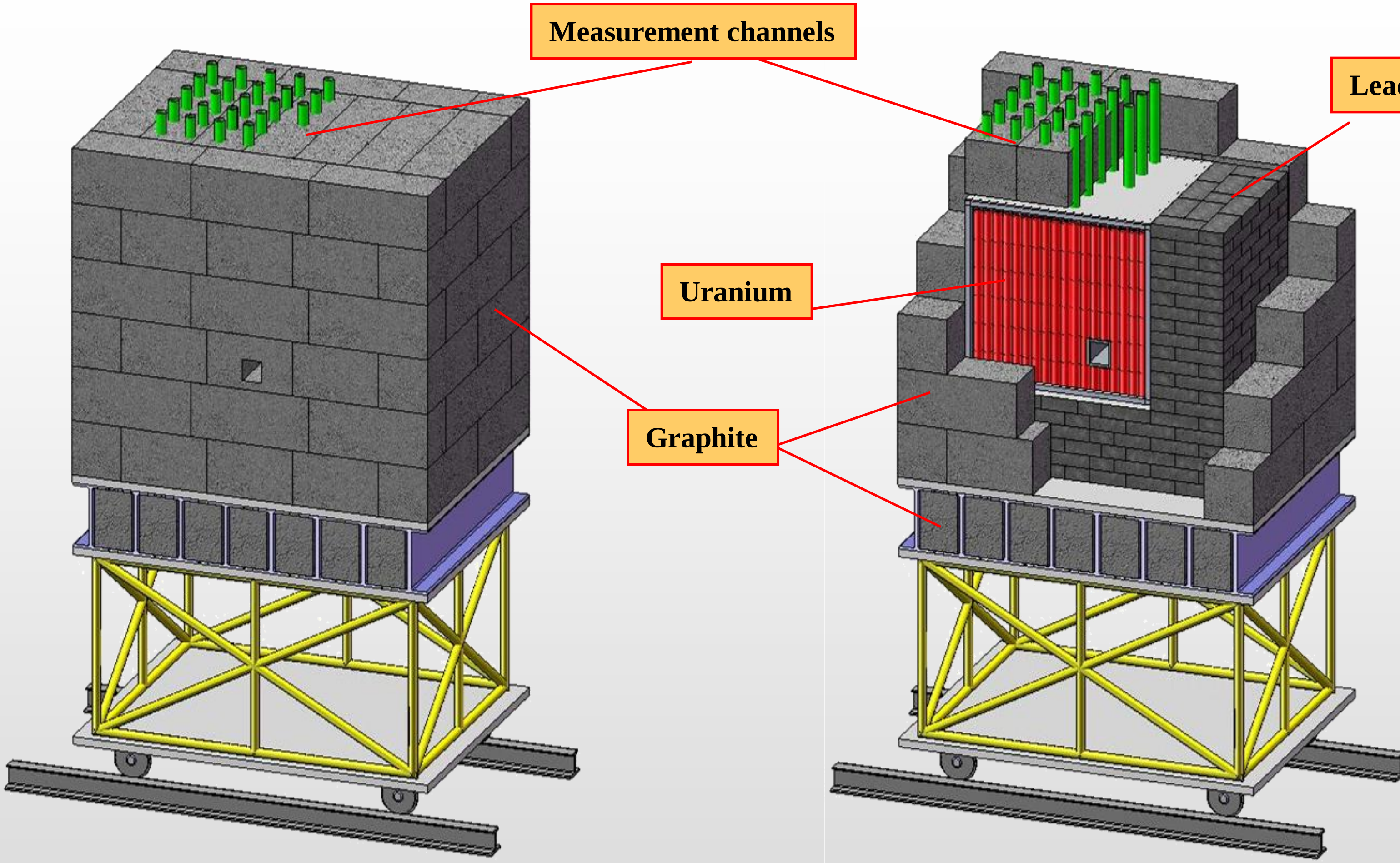


**«Quinta» target : ~300 kg of $^{nat}$U in 3 segments**

## Quinta target characteristics:

medium size

- U spallation target and U  n-enhancer
- symmetric (good for modelling)
- high-energy neutron spectrum
- very many experimental positions outside
- simulate Pu-buildup and equilibrium




# "EZHIK" target : 3000 kg of Pb- or U-target

## EZHIK target characteristics:

very large size

- Pb spallation target
- U spallation target and U n-enhancer
- not symmetric (difficult for modelling)
- high-energy neutron spectrum
- very many experimental positions
- simulate Pu-buildup and equilibrium

## Summary (9/2010):

**84 scientists from 23 groups in the Collaboration, working for more than 10 years**

**15 countries wordwide contributing**

**6 different targets**
**3 IAEA benchmark targets**

**Over 10 peer-reviewed papers every year**

## Objective:

**- measure neutron spectra & integral cross-sections**

# *Thank you*