The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific
and Cultural Organization

International Atomic
Energy Agency

Workshop on

ROLE OF PARTITIONING AND TRANSMUTATION IN THE MITIGATION OF THE POTENTIAL ENVIRONMENTAL IMPACTS OF NUCLEAR FUEL CYCLE

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ICTP - Trieste, Italy

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Comparative Evaluation

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Comparative Evaluation

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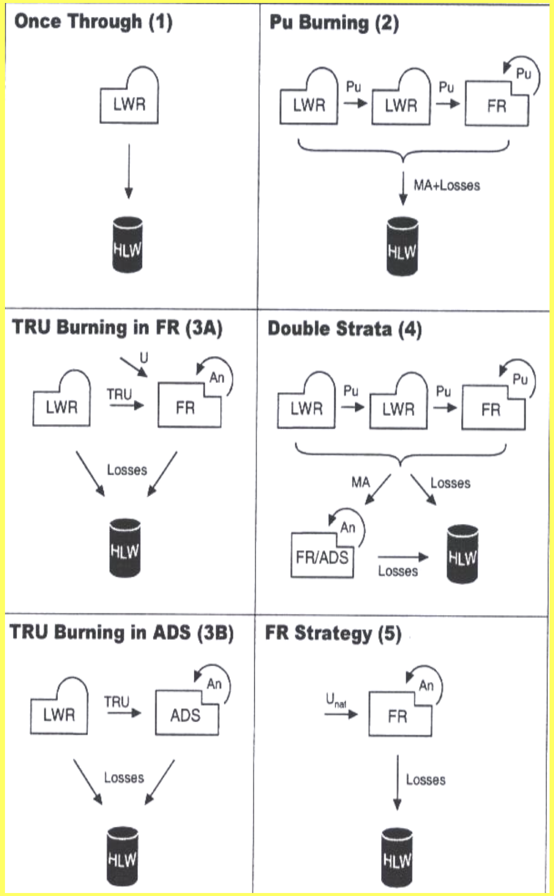
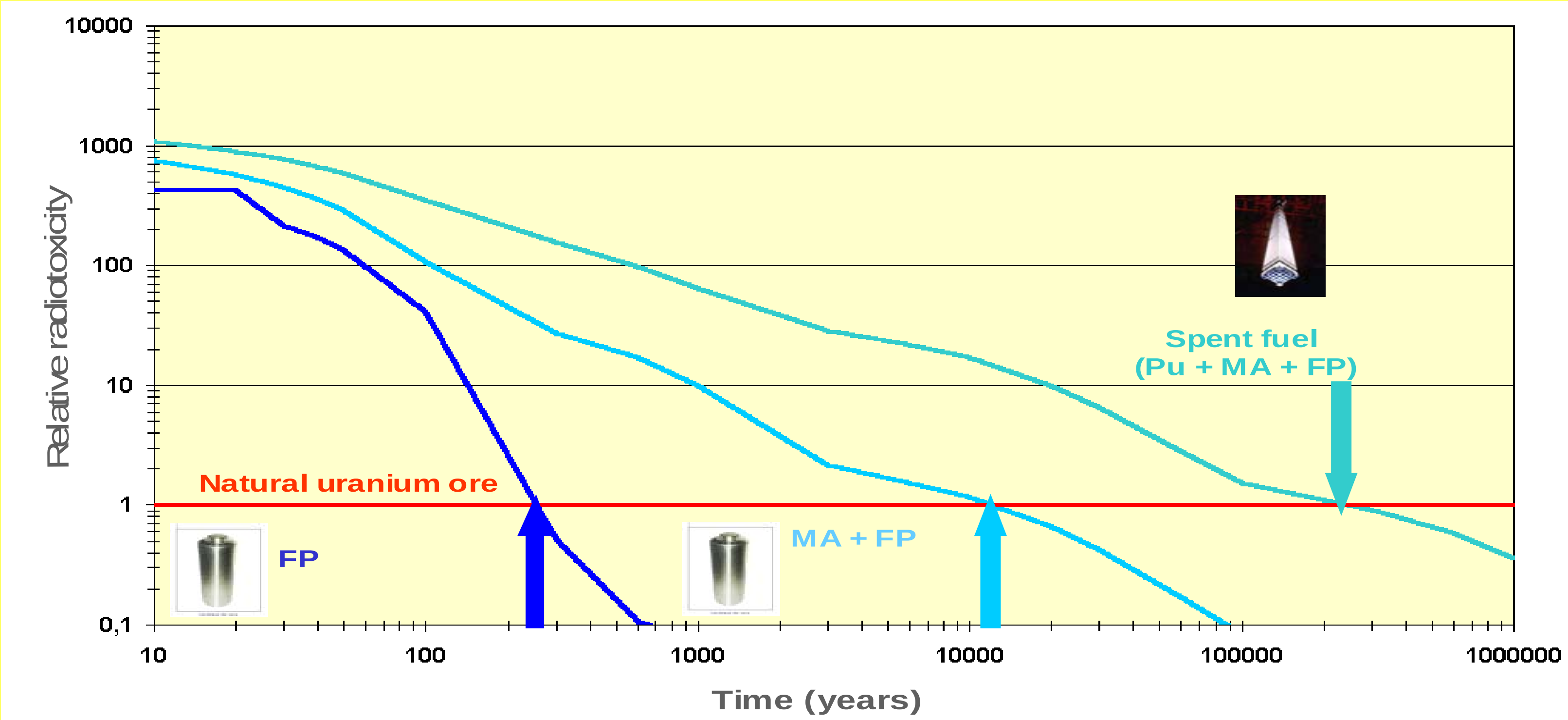
Enrico Fermi: "***It is not certain that the public will accept an energy source that produces vast amounts of radioactivity as well as fissile material that might be used by terrorists***."

Comparison of Nuclear Fuel Cycle Schemes regarding radiotoxicity and proliferation

- Scheme 1 „once through“ relies on U-235 enrichment
- Scheme 2 and 4 separates out weapon useable Pu, but reduces radiotoxicity and future danger of a “Pu-mine“
- Scheme 3 and 5 are apt for An group separation, with less future radiotoxicity



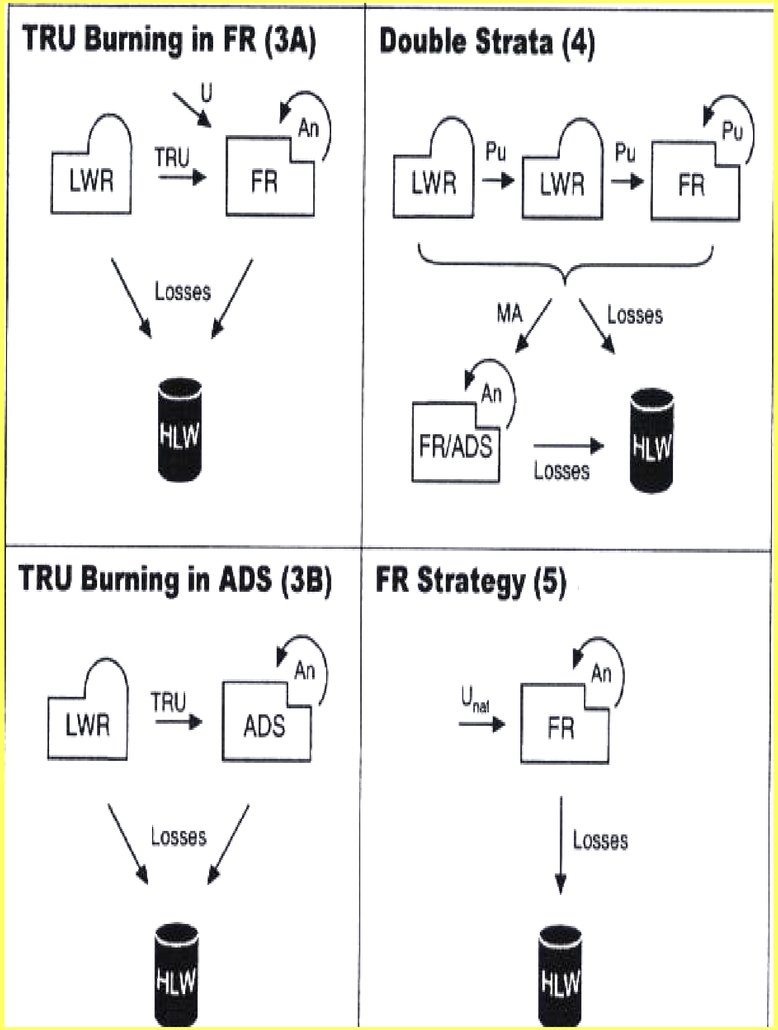


Relative radiotoxicity
10000
1000
100
10
1
0,1
10
100
1000
10000
100000
1000000
Time (years)
Natural uranium ore
FP
MA + FP
Spent fuel
(Pu + MA + FP)

Instead of closing the fuel cycle only with Pu from spent fuels of thermal reactors with PUREX - a proliferation-sensitive technology – one might wait until fast reactors are in use and could transmute the Minor Actinides, MA, too .

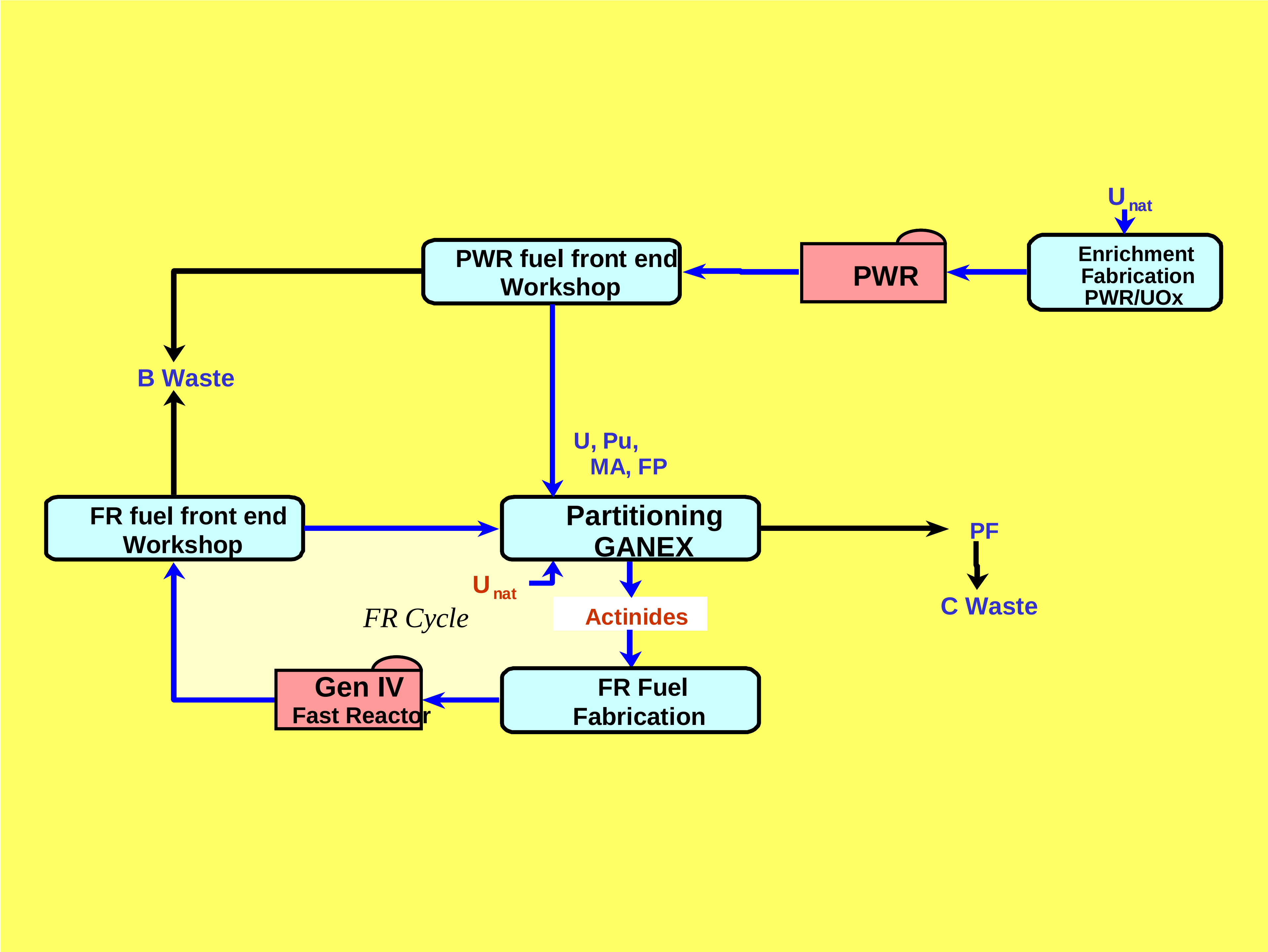
The idea to partition the heating and radiotoxic MA together with Pu and to transmute them into less radiotoxic fission products would improve the public acceptance in regard to environmental friendliness and to proliferation resistance

- All schemes will reduce radiotoxicity burden
- ADS has the greater potential to transmute llfp
- Except for scheme 4 the fuel material is proliferation resistant



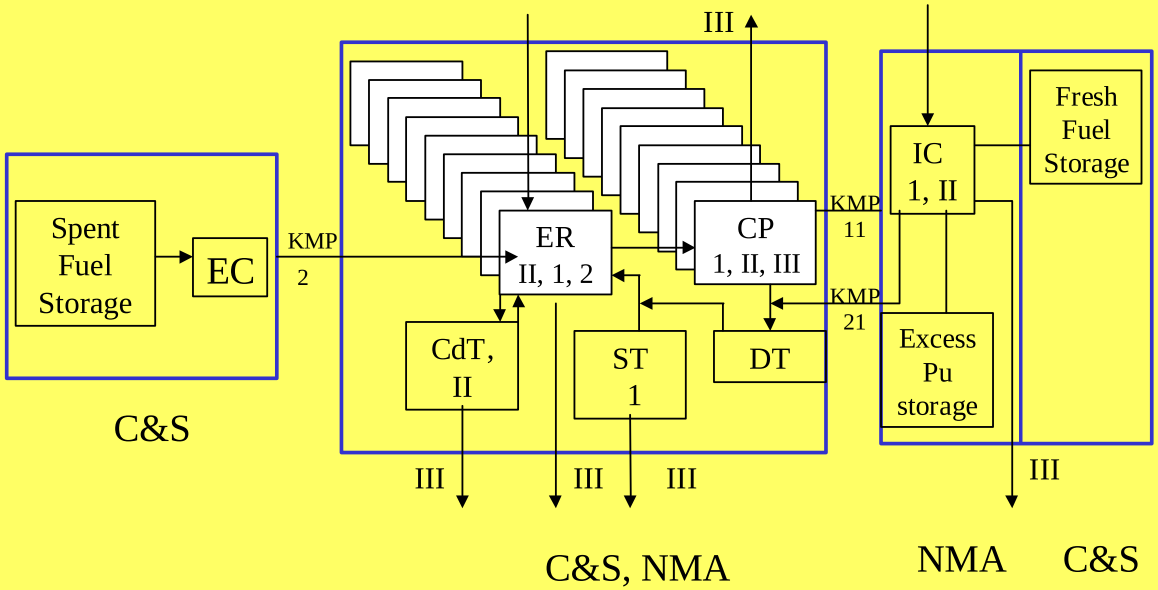
Proliferation Resistance

- Intermediate and final products of advanced partitioning process, when diverted, are not directly suited for nuclear explosive devices
- possible co-location of P&T plants eases C&S measures



U nat
Enrichment
Fabrication
PWR/UOx
PWR
PWR fuel front end
Workshop
B Waste
U, Pu,
MA, FP
FR fuel front end
Workshop
Partitioning
GANEX
PF
C Waste
U nat
Actinides
FR Cycle
Gen IV
Fast Reactor
FR Fuel
Fabrication

Measures of internationl safeguards applied to a pyro-processing and fuel fabrication plant



Comparison Aqueous vs. Dry Reprocessing

	aqueous	dry
Separation yields		
U		99.9%
Pu	> 99.85%	99.9%
Np	> 99.85%	99.9%
Am	> 99.97%	99.9%
Cm	> 99.97%	99.9%
Tc	95%	95%
Am-242 m critical mass	19 g	3.8 kg
f.p. decontamination	high	poor (Ln<25%)
radiolytic degradation	high	low

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Weapon grade plutonium will generate 0.1 neutrons by spontaneous fission during a spherical shock wave period of about 5 microsec. Depending to what extend Cm-244 has reached equilibrium concentration in repeated recycling, we will observe much more neutrons than for a nuclear device made of a one year old TU mix with 100 to 5000 neutrons.

If the spontaneous fission neutrons
(expressed as N -n/sec- in the device)
during the average neutron life time, t (7 nanosec)
exceeds one, then the fission chain reaction
starts at prompt criticality – or even before.
At this point the compaction is low.
Depending on the device's design
little energy is needed to destroy it.

Predicted preignition yields of TU-mix

With a neutron background of E8 to E9 n/sec in a 5 Kg mass device (with reflector), preignition will occur instantly (with detonation after ca.10 nsec) when criticality is reached. At this point the implosion shockwave has not yet compacted the mass strongly.

Cost of a P&T regime

- P&T of MA in FR may achieve a relatively limited increase in **electricity cost** of 10% - 50% (?), when compared with the cost of the open LWR fuel cycle
- This is due to less geological repository capacity
- Less U- mining and -consumption
- If the radiotoxicity reduction becomes a decisive social issues, the additional P&T cost may become affordable

Technological Challenges in P&T Development

- Actinide group separation throughout the partitioning process
- Proliferation resistant in-line processing for MSBR
- Concerning the accelerator itself, its coupling to the sub critical reactor, the U free fuels and implications to ADS safety

Environmental Friendliness of a P&T scheme compared to the open fuel cycle

- P&T limits land consumption by less U – mining
- It reduces size and number of geological repositories
- For future generation, P&T diminishes the radiotoxic hazard caused by intrusion into the repository or the migration of radionuclides to the biosphere

Generally Improving Public Acceptance

- Reduction of radiologigal hazard to future generations despite increased present risks of actinide processing
- MA containing fuels, when diverted by terrorist, cannot be abused for nuclear explosives
- On-site partitioning eliminates transports between plants
- FR transmutation of its self-generated waste might be preferred vs. a separate MA cycle in ADS with very high radiotoxicity content