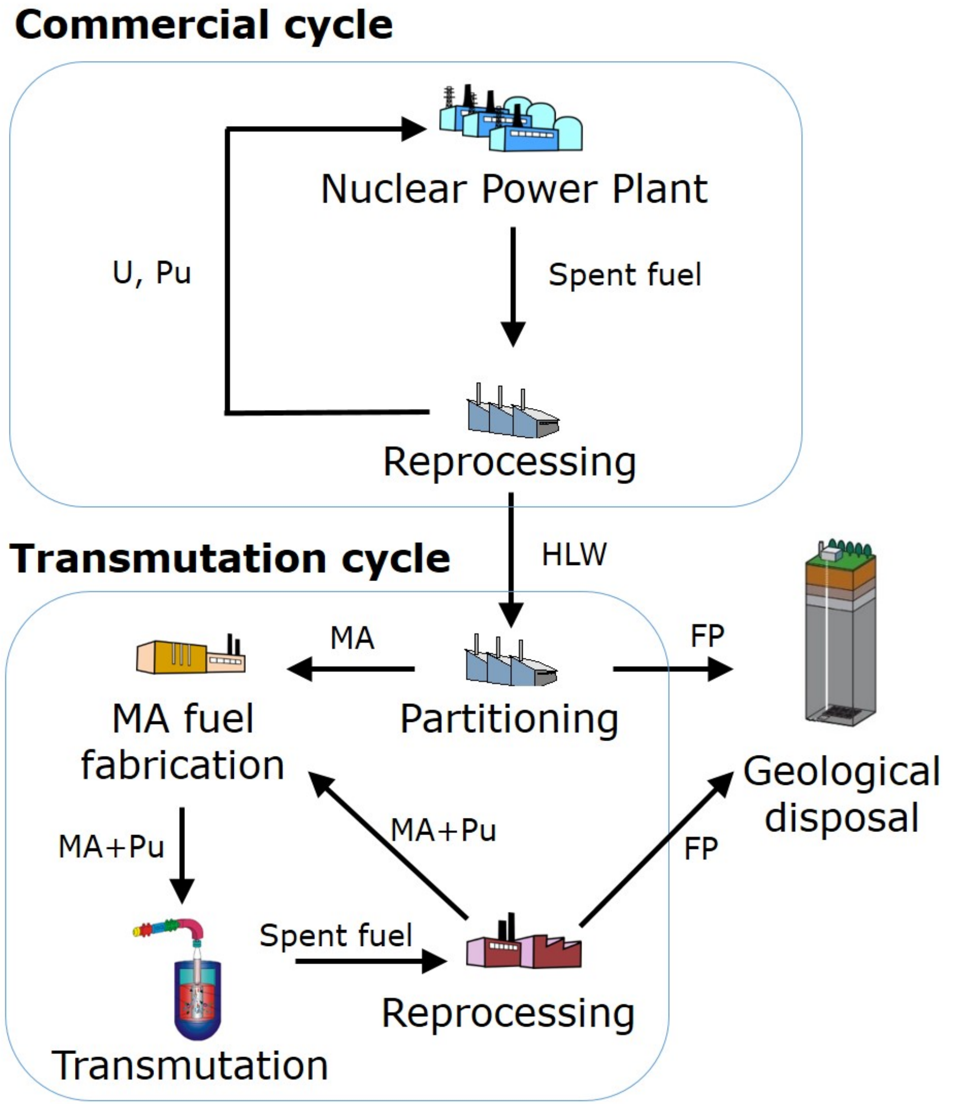
Proposal of Target Accuracy for ADS Neutronics Design

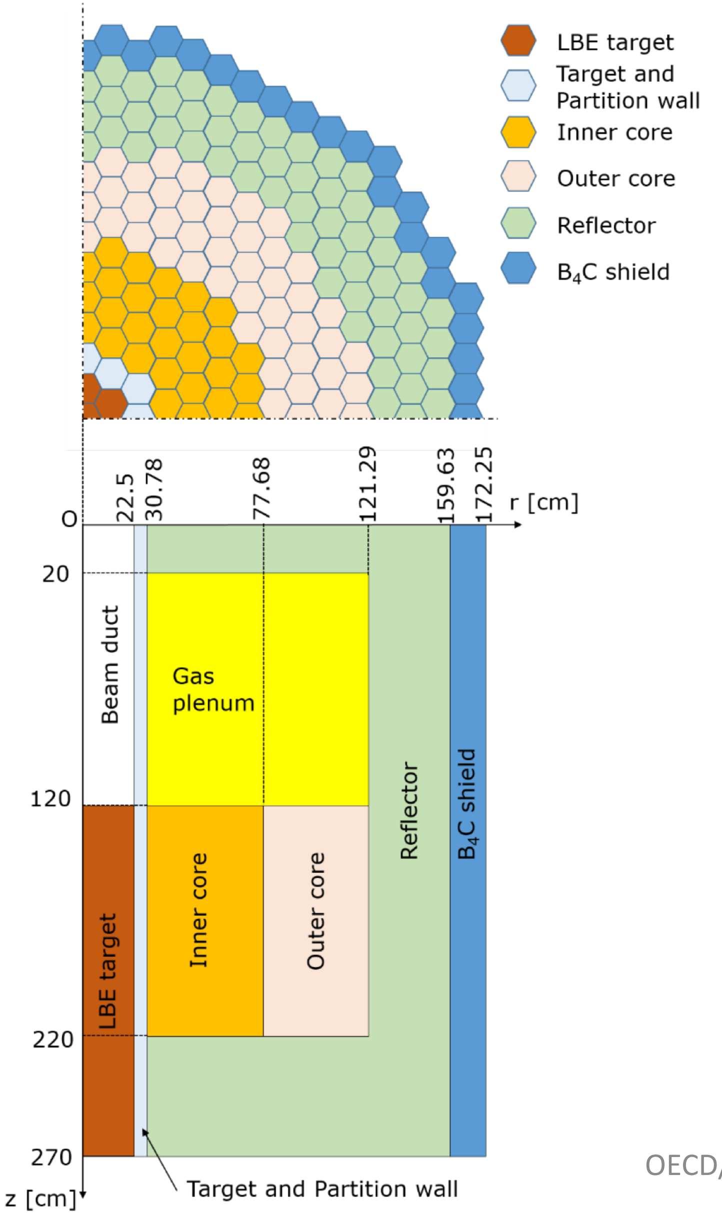
Takanori SUGAWARA, Masahiro FUKUSHIMA
and Kenji NISHIHARA
Japan Atomic Energy Agency

Background

- JAEA has investigated partitioning and transmutation (P&T) technology to transmute minor actinide (MA) by double-strata strategy
- In this strategy, **the dedicated MA transmutation cycle** using accelerator-driven system (ADS) is introduced



Configuration



Thermal power	800 MWt
Coolant	LBE
Inlet temperature	300° C
Coolant velocity	2.0 m/sec
Upper limitation of keff	0.98
Operation period	600 EFPDs
Number of fuel assemblies	276
Pitch	134.5 mm
Width	133.5 mm
Number of fuel pins per assembly	121
Composition	(MA+Pu)N+ZrN
Pin outer diameter	7.65 mm
Thickness of cladding tube	0.5 mm
Pin pitch	11.48 mm
Active height	1000 mm

T. Sugawara, et al., ANE 111, 449-459 (2018)

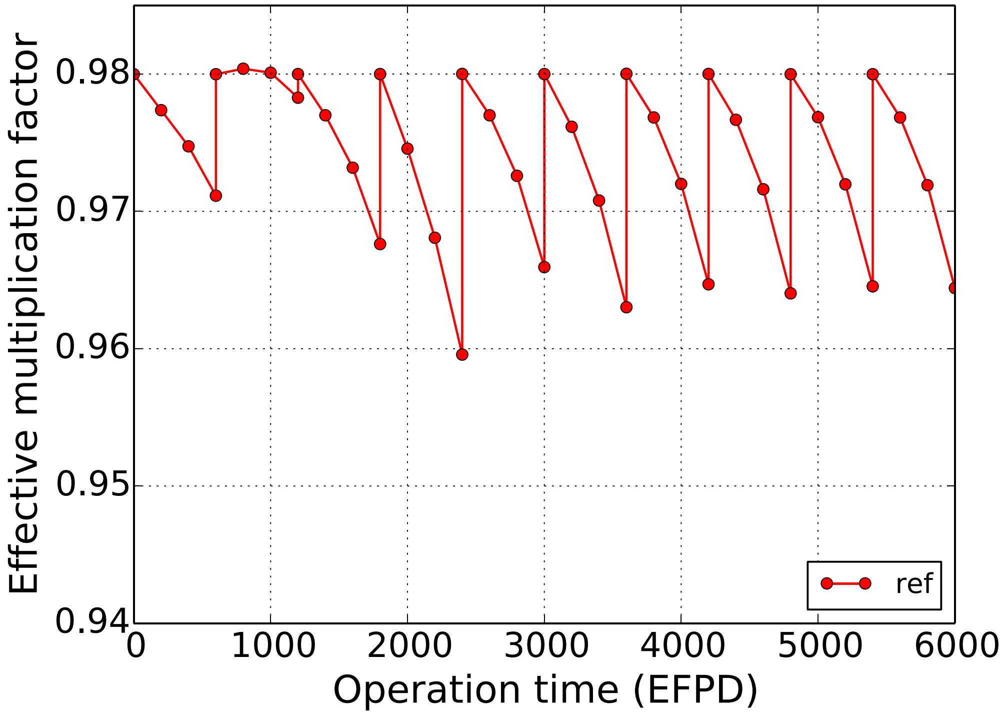
Proposal of TA for ADS

	Proposal for ADS	
Multiplication factor (BOL)	450pcm	From the viewpoint of core configuration. ±3 FA (fuel assemblies) can be permitted (One FA has about 150 pcm).
Power peak (BOL)	5%	If k-eff=0.98 at BOL. This value is used for the estimation of cladding tube temperature for SFR.
Burnup reactivity swing	200 pcm	If k-eff changes from 0.98 (BOL) to 0.96 (EOL). The value is 5% of the subcriticality at EOL.
Coolant void reactivity	300 pcm	It should be set as pcm to consider positive/negative effects. The definition of coolant void (in core or whole region) should be explained.
Doppler reactivity	10%	The doppler reactivity is not so important in ADS design because the value is very small.
Major nuclide density at end of irradiation cycle	2%	Same as NEA WPEC/SG26 report
Other nuclide density at end of irradiation cycle	10%	Same as NEA WPEC/SG26 report

k-eff and burnup swing

	Dr. Salvatores*	Proposal
Multiplication factor (BOL)	200 pcm	450 pcm
Burnup reactivity swing	200 pcm	200 pcm

- From the viewpoint of core buildup, ±3 fuel assemblies can be permitted.
  - The measurement of the subcriticality is possible at BOL, only.
  - One fuel assembly has about 150 pcm, so 450 pcm can be acceptable.
- The target accuracy of burnup swing is 5% of the subcriticality at EOL.
  - JAEA-ADS has no control rods.
  - 4000 pcm (k_{eff}=0.96) * 5% = 200 pcm



*: M.Salvatores, Nuclear data target accuracies: an expanded assessment, based on new covariance data and generalized methods (March, 2019)

Void and Doppler reactivities

	Dr. Salvatores	Proposal
Coolant void reactivity	5%	300 pcm
Doppler reactivity	5%	10%

- Coolant void reactivity: it should be set as pcm to consider positive/negative effects.
- The definition of coolant void reactivity is important (whole/core region?)
- Doppler reactivity: it is not so important in the ADS design because the value is very small.

Reactivities for JAEA-ADS [pcm]

	1st BOC	10th BOC
Coolant void reactivity (whole region)	-7652	-9762
Coolant void reactivity (core region)	7405	6131
Doppler reactivity (+500 C)	-10	-11

Additional parameters to be considered for ADS

	Proposal for ADS	
β_{eff} (BOL/EOL)	3%	The subcriticality will be measured in unit of $ by PNS method in ADS. Then, the subcriticality will be converted by β_{eff} to the absolute value. This uncertainty affects directly to the proton beam current.
Product of Number of spallation neutron (N_p) and Spallation source efficiency (φ*)	3%	$N_p\varphi$* is the parameter related to the thermal power of ADS.
Heat generation by spallation reaction	5%	This value is important for the design of beam window

	Proposal for ADS	
Multiplication factor (BOL)	450pcm	From the viewpoint of core configuration. ±3 FA (fuel assemblies) can be permitted (One FA has about 150 pcm).
Power peak (BOL)	5%	If k-eff=0.98 at BOL. This value is used for the estimation of cladding tube temperature for SFR.
Burnup reactivity swing	200 pcm	If k-eff changes from 0.98 (BOL) to 0.96 (EOL). The value is 5% of the subcriticality at EOL.
Coolant void reactivity	300 pcm	It should be set as pcm to consider positive/negative effects. The definition of coolant void (in core or whole region) should be explained.
Doppler reactivity	10%	The doppler reactivity is not so important in ADS design because the value is very small.
Major nuclide density at end of irradiation cycle	2%	Same as NEA WPEC/SG26 report
Other nuclide density at end of irradiation cycle	10%	Same as NEA WPEC/SG26 report

Comparison

	NEA/WPEC -26 report (2008)	Proposal by Dr. Salvatores	Proposal for ADS by JAEA
Multiplication factor (BOL)	300 pcm	200 pcm	450pcm
Power peak (BOL)	2%	1%	5%
Burnup reactivity swing	300 pcm	200 pcm	200 pcm
Reactivity coefficients (Coolant void and Doppler – BOL/EOL)	7%	5%	300pcm (void) 10% (Doppler)
Control rod bank	-	3%	-
Single control rod	-	2%	-
Major nuclide density at end of irradiation cycle	2%	1%	2%
Other nuclide density at end of irradiation cycle	10%	10%	10%