

FLUTRA -project: Transmutation of nuclear waste in an ADS

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KYT2014 Interim Seminar
Helsinki 17.4.2013





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Rationale

ADS

Tools

Results

The End

References

- ▶ Sustainable use of natural resources
- ▶ Reduced hazard in final disposal
- ▶ Reduced repository size
- ▶ ADS: an option for clean phase out of nuclear

Acceleration Driven System: MYRRHA



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Multi-purpose hYbrid Research Reactor for High-tech Applications

Subcritical core – Chain reaction maintained by external proton beam and spallation target.

- LBE coolant and target
- 600 MeV 3.5 mA proton beam
- $k_{\text{eff}} = 0.95 - 0.97$
- 30% MOX fuel

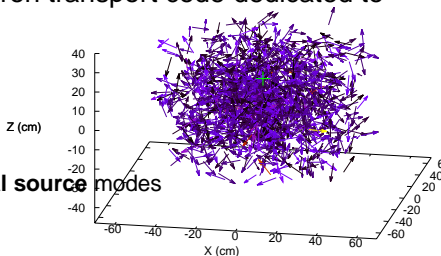


FLUKA is high energy particle physics Monte Carlo code:

- handles particles from neutrinos to Ω_c^0 as well as some light nuclides
- cross sections up to 1000 TeV
- uses combinatorial geometry
- simulates all particles until terminated
- **no burnup** calculation, records residual nuclides

Serpent is a Monte Carlo neutron transport code dedicated to reactor applications

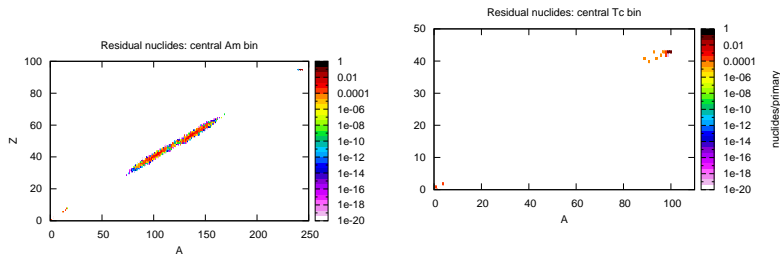
- continuous energy, 3-D
- **burnup** calculation
- Woodcock delta-tracking
- **criticality source** and **external source** modes
- developed at VTT



Transmutation in FLUKA



Heterogenous transmutation: Am, I, Tc in separate pins in the middle of fuel assemblies.



	rate (%/day)	left after 1200 days (%)
^{99}Tc	0.036	65
^{129}I	0.033	67
AmO_2	0.098	31 [†]

[†] 75% already after 300 days.

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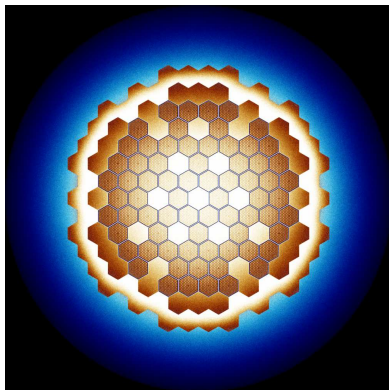
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Serpent simulations



- Full core, assembly size, single pin cell
- External source, criticality source
- Varying MA content
- Heterogeneous non-fertile transmutation



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Initial inventories



Atomic fractions, per cents

	LWR-UO ₂	AMOX-0.7	AMOX-4	AMOX-10	AMOX-20
U-235	4	0.6	0.6	0.5	0.5
U-236	0	0.4	0.4	0.4	0.3
U-238	96	68	66	60	50
Np	0	0.02	0.2	0.4	0.8
Pu	0	30	30	30	30
Am	0	0.5	3.7	9.2	18
Cm	0	0.02	0.2	0.4	0.8

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100 MWd/kgHM, 15 years cooling



Change in atomic densities, per cents of initial loading

	LWR-UO ₂ [†]	AMOX-0.7	AMOX-4	AMOX-10	AMOX-20
U-235	-53	-43	-42	-40	-36
U-236	+∞	+3	+3	+3	+4
U-238	-9	-8	-8	-7	-6
Np	+∞	+430	+56	+25	+20
Pu	+∞	-24	-22	-19	-15
Am	+∞	+360	+13	-16	-21
Cm	+∞	+75	+4	-7	-15

[†] 40 MWd/kg

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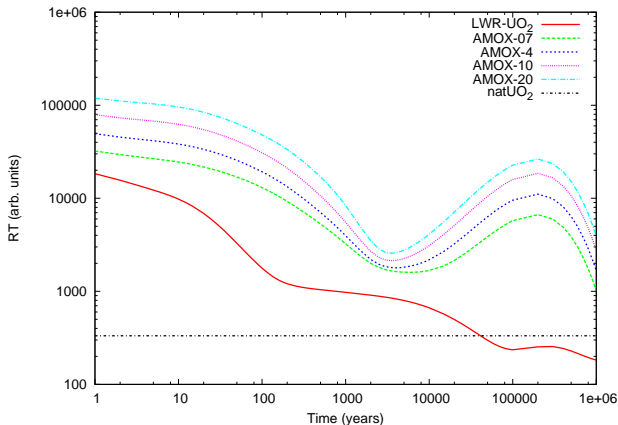
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Radiotoxicity



100 MWd/kgHM, LWR-UO₂ compensated



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Thank you for your attention !

Any questions ?

A”

References



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http://www.oecd-nea.org/pt/iempt11/documents/VI-4_11th_EIM-PT_HAA_MYRRHA_4.11.2010.pdf, retrieved 20.6.2012.
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-  J. Leppänen, "Serpent – a Continuous-energy Monte Carlo Reactor Physics Burnup Calculation Code," VTT Technical Research Centre of Finland, Espoo, Finland, August, 2012

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