PRELIMINARY STUDY OF FUEL PINS OF S-PRISM

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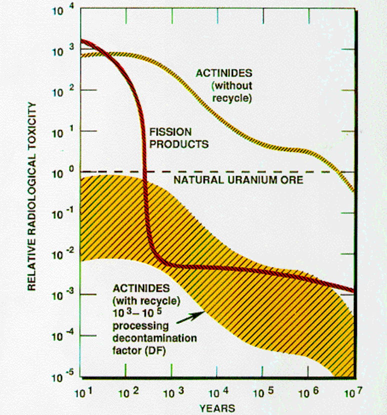
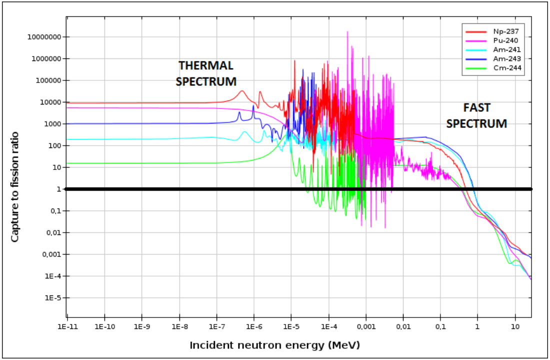
Introduction

Relative radiotoxicity in spent LWR fuel



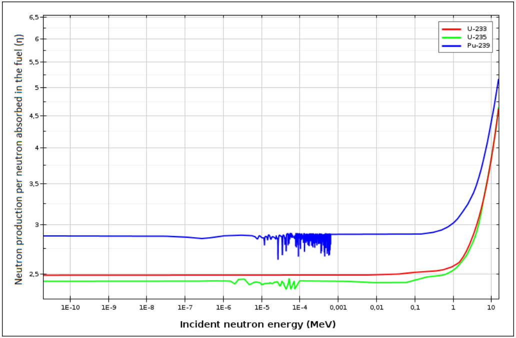
- >50% of reactors in the world are PWRs
- SNF from LWRs: 95% uranium, 1% TRUs and 4% FP
- TRUs: high radiotoxicity and long half-life
- fast reactors can recycle 96% of material in SNF

Motivation



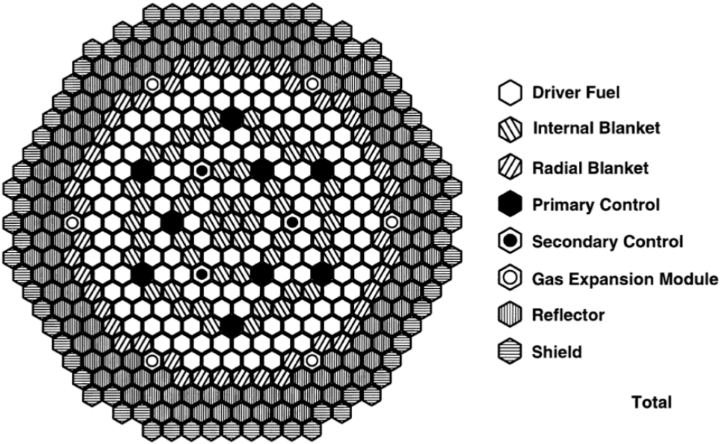
- Neutrons causing fission: 0.025 eV vs. 100 keV and above
- PWR: capture / fast reactor: fission

Fast reactors vs. PWRs



- Excess of neutrons can be used for breeding or TRU burning
- Conversion Ratio:
  - PWR $\approx$ 0.6
  - Fast reactors from 0 to larger than 1

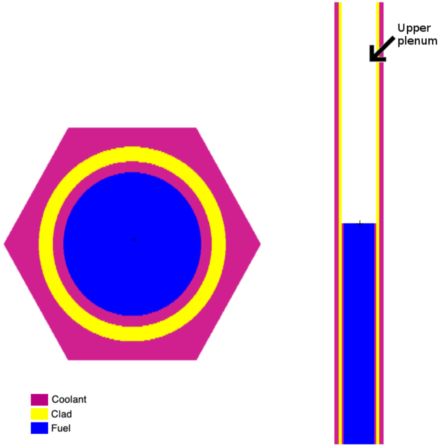
S-PRISM core


Driver Fuel
Internal Blanket
Radial Blanket
Primary Control
Secondary Control
Gas Expansion Module
Reflector
Shield
Total

S-PRISM metal fuel composition by weight

Material	Driver	Blanket
Natural uranium	69.5%	85.1%
Fissile plutonium	13.7%	3.3%
Non-fissile plutonium	3.4%	0.8%
Minor actinides	3.4%	0.8%
Zr	10.0%	10.0%

Driver fuel pin as modeled in MCNP6



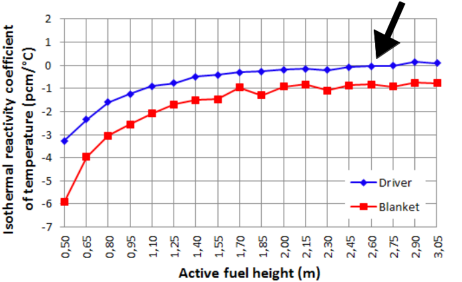
Temperature coefficients of reactivity

Parameter	Driver pin	Blanket pin
α_{iso}	-1.127 $\pm$ 0.00017	-2.495 $\pm$ 0.067
α_{fuel}	-1.475 $\pm$ 0.274	-1.620 $\pm$ 0.081
$\alpha_{coolant}$	0.355 $\pm$ 0.263	0.540 $\pm$ 0.485

- $\alpha_c > 0$
- α_{fuel} negative (expansion, not Doppler)

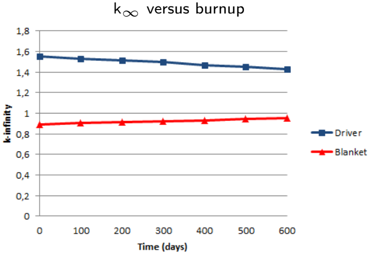
α_{ISO} as a function of neutron leakage

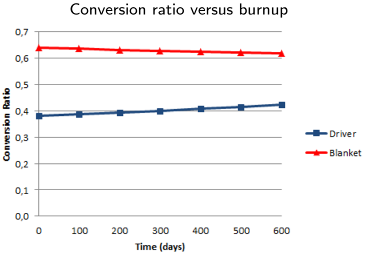
α_{ISO} versus active fuel height for the driver and blanket fuel pins



- α_{ISO} becomes less negative with height increase
- After 2.6 m, α_{ISO} is positive for the driver pin

Burnup





- Driver: fuel consumption / Blanket: conversion
- CR increases with lower enrichment
- The simulations were made separately – core behavior will be certain when modeled as a whole

Conclusions

- Temperature coefficients of reactivity:
  - α_{ISO} and $\alpha_{fuel} < 0$
  - $\alpha_c > 0$
- Core height is important due to neutron leakage
- Neutron leakage impacts α_{ISO}: increasing core height makes α_{ISO} less negative
  - $\alpha_{ISO} > 0$ for driver after 2.6 m
- Burnup shows different functions for driver and blanket
- Further analysis of the full core:
  - coupling effects
  - varying enrichment
  - safety parameters

Thank you!