Thorium Energy Conference THEC13
October 27 - 31, 2013, Globe of Science and Innovation, CERN, Geneva, Switzerland

Neutron Irradiation Thorium Based Fuel Comparison Between Accelerator Driven System and Fusion-Fission System

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Accelerator driven systems (ADS) and Fusion-Fission systems are investigated for long-lived fission product (LLFP) transmutation and fuel regeneration. The aim is to investigate the nuclear fuel evolution and the neutronic parameters under neutron irradiation. Each system was loaded with thorium based fuel; both systems were designed to have an initial criticality around k_{eff}≈0.98 due to safety terms. The criticality and depletion of both systems were analysed during 10 years. To the simulations, it used the MONTEBURNS code that links Monte Carlo N-Particle Transport Code (MCNP) to the radioactive decay burnup code ORIGEN2. The results can indicate which of them produces higher fissile isotopes rate as well as the most suitable system for achieve transmutation.

1. Introduction: Two ideal neutron sources from ADS and Fusion Fission system located in the central part of a sub-critical system. The goal is to compare the neutronic and depletion behaviour during the burnup of the system under the irradiation of these two different neutron spectra using the same power in the core.

2. Methodology: The Figure 1 shows the sub-critical system modelled. In the central part, with dimensions of 0.9 cm radius and 38 cm height, was placed the neutron source evaluated. The core is a cylinder of 6.0 m³ filled with a hexagonal lattice loaded with a mixture of $^{232}ThO_2$ + 15% $^{233}UO_2$. The total power during the burnup was 430 MW for both systems. The simulations were performed using the MONTEBURNS code which links the Monte Carlo transport code MCNP with the radioactive decay and burn-up code ORIGEN2.

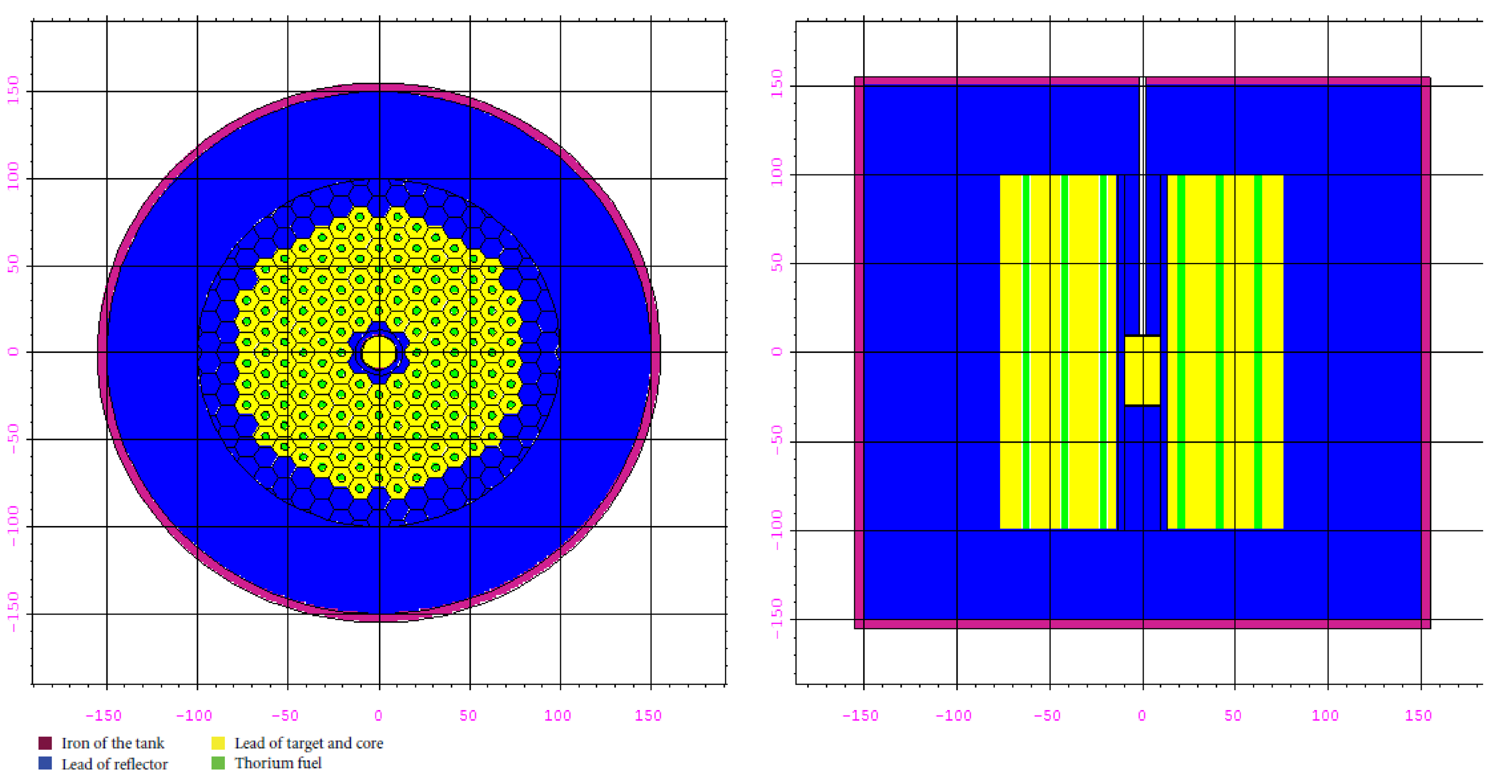

Figure 1: Horizontal and vertical ADS cross sections

3. Results: The Figure 2 shows the multiplication factor for the different neutron sources. The drop of k_{eff} is greater for the ADS neutron source than using the neutron fusion source. To understand this behaviour, some nuclides were evaluated. Probably, the causes in the differences in the k_{eff} behaviour are connected with ^{232}Th transmutation to other actinide. The Figure 3 shows the ^{232}Th and ^{233}U mass variation during the time for both sources.

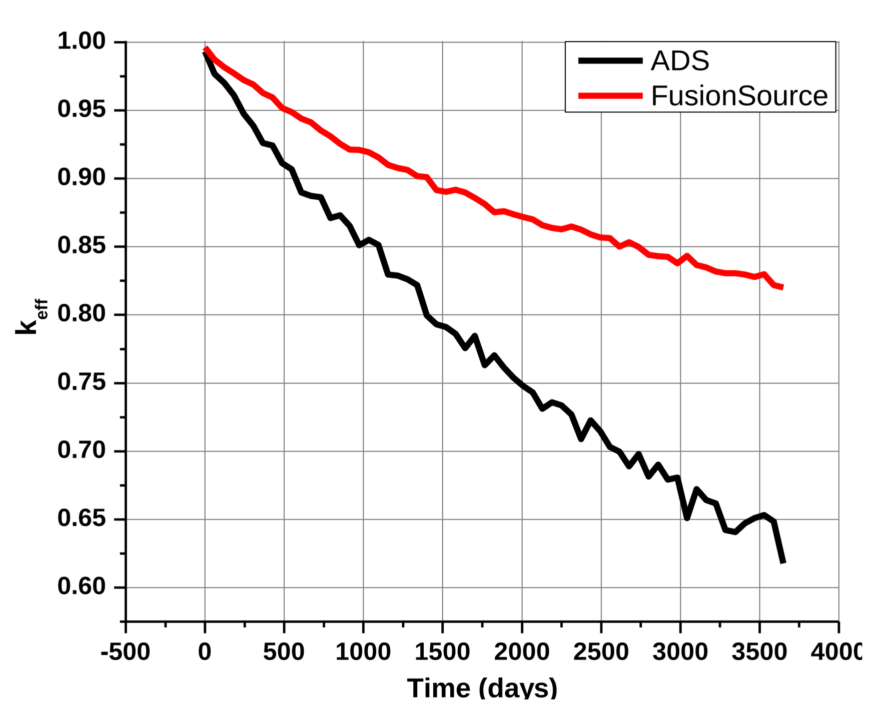

Figure 2: k_{eff} evolution

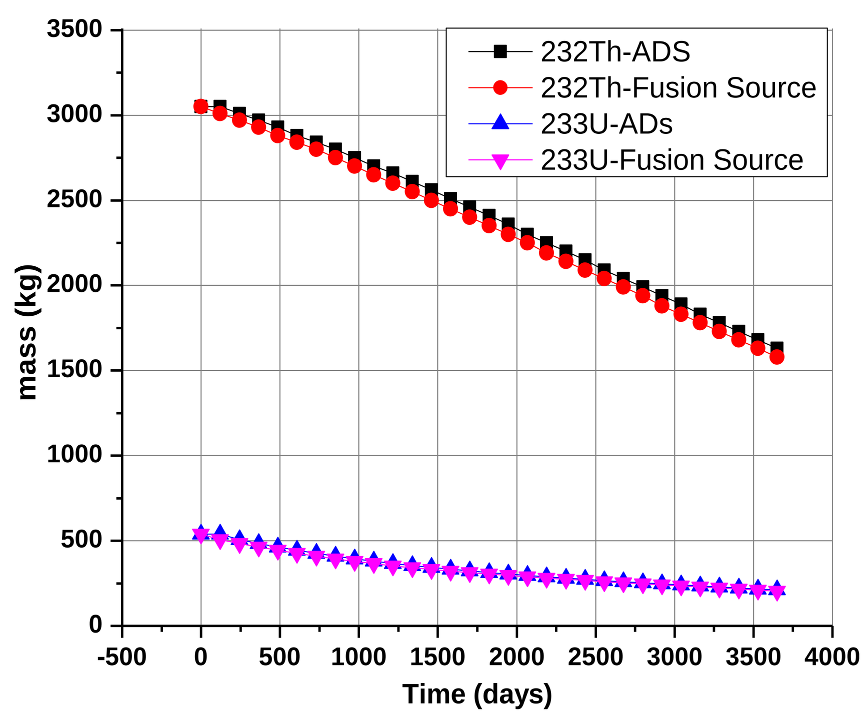

Figure 3: mass variation

The Figure 4 shows the amount of production and transmutation of ^{232}U during the iradiation. This difference in mass during the time could be one reason for the k_{eff} differences. It can be related to the production and transmutation of 232U which has a fission cross section comparable with 235U, as shown in Figure 5.

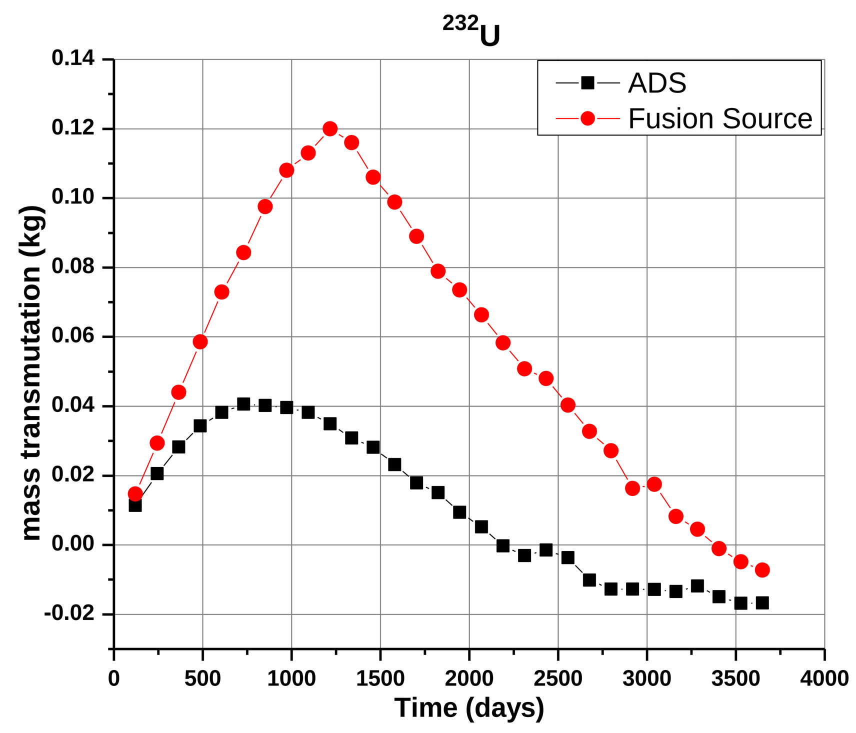

Figure 4: ^{232}U Mass variation

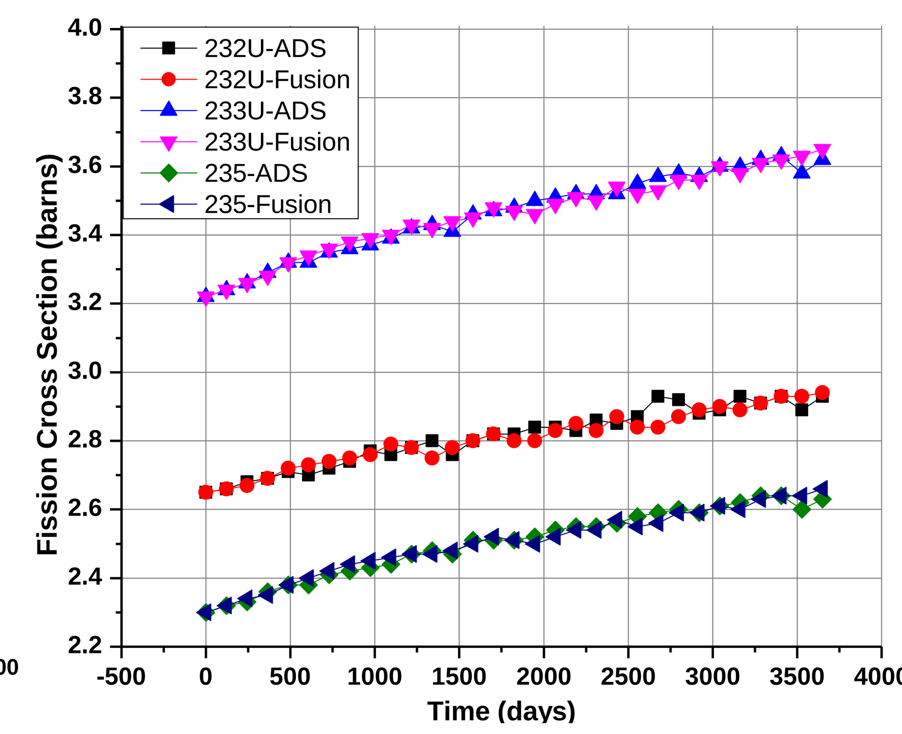

Figure 5: Fission Cross Section

The ADS reaches a ^{232}U maximum production of 0.04 kg after 2 years while the fusion source reaches a maximum of 0.12 kg after 3 years. The use of the fusion source in the system produces more ^{232}U than the amount of fissions produced until 3 years, then the role is inverted which explains the drop of the curve after this time. Another observation is that the ^{231}Pa production is higher for the fusion source as showed in Figure 6 and the fission to capture ratio is a little bit higher for the fusion source as showed in Figure 7. These facts contribute to the difference in the multiplication factor (k_{eff}).

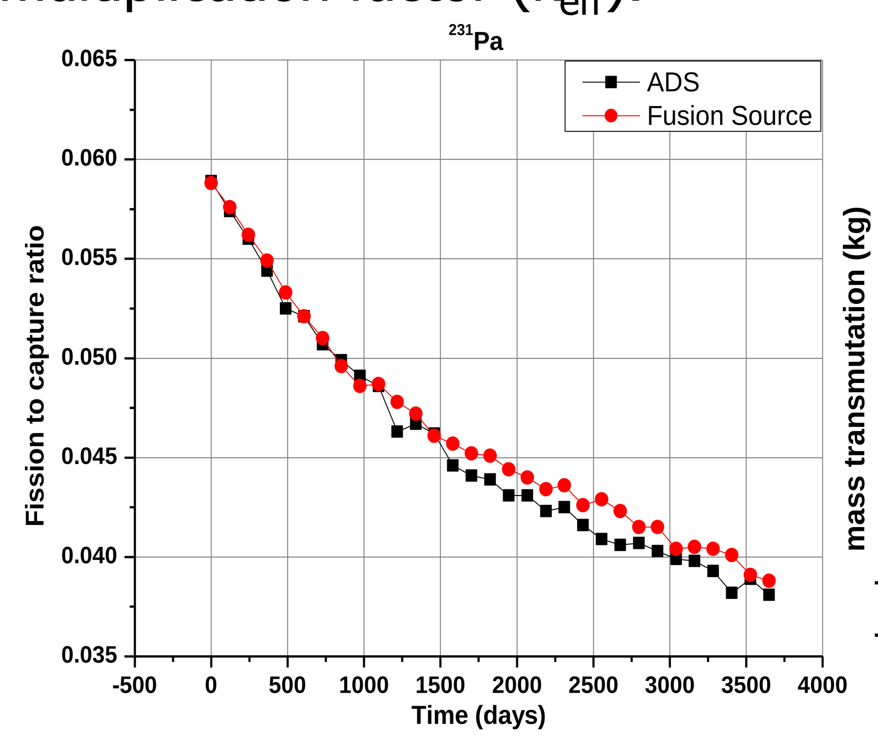

Figure 6: Fission to capture ratio

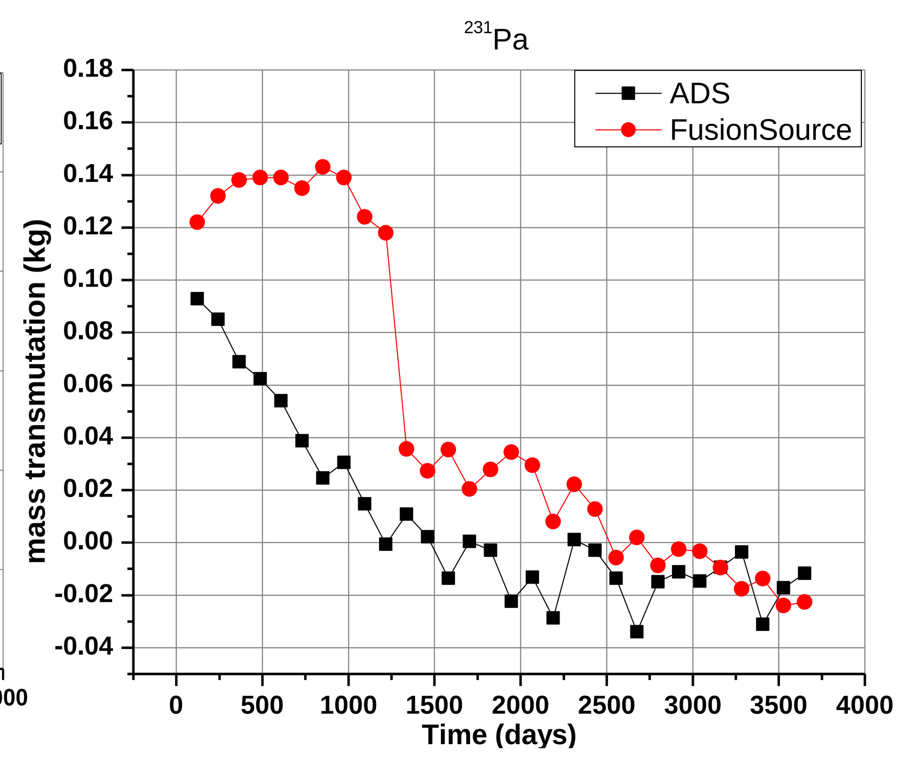

Figure7: ^{231}Pa Mass variation

4. Conclusions: The differences in k_{eff} are explained based on the mass production of two actinide ^{232}U and ^{231}Pa. These differences might be explained by the differences in the neutron spectra of each system, which makes to have variations on the production or transmutation of these actinides.

Acknowledgments

CNEN Comissão Nacional de Energia Nuclear
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