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MEASUREMENTS OF THE NUCLEAR REACTION RATES AND SPECTRAL INDICES ALONG THE RADIUS OF FUEL PELLETS OF THE IPEN/MB-01 REACTOR

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ABSTRACT

This work presents the measures of the nuclear reaction rates along of the radial direction of the fuel pellet by irradiation and posterior gamma spectrometry of a thin slice of fuel pellet of UO_2 at 4.3% enrichment. From its irradiation the rate of radioactive capture and fission are measures as a function of the radius of the pellet disk using a HPGe detector. Diverse lead collimators of changeable diameters have been used for this purpose. Simulating the fuel pellet in the pin fuel of the IPEN/MB-01 reactor, a thin disk is used, being inserted in the interior of a dismountable fuel rod. This fuel rod is then placed in the central position of the IPEN/MB-01 reactor core and irradiated during 1 hour under a neutron flux of 5.10^8 n/cm^{2}s. The nuclear reaction of radioactive capture occurs in the atoms of ^{238}U that when absorbs a neutron transmutes into ^{239}U of half-life of only 23 minutes. Thus, it is opted for the detection of the ^{239}Np, radionuclide derivate of the radioactive decay of the ^{239}U and that has a measurable half-life (2.335 days). In gamma spectrometry 11 collimators with different diameters have been used, consequently, the gamma spectrometry is made in function of the diameter (radius) of the irradiated UO_2 fuel pellet disk, thus is possible to get the average value of the counting for each collimator in function of the specific pellet radius. These values are directly proportional to the radioactive capture nuclear reaction rates. The same way the nuclear fission rate occurs in the atoms of the ^{235}U that produce different fission products such as ^{143}Ce with a yield fission of 5.9% and applying the same procedure the fission nuclear reaction rate is obtained. This work presents some calculated values of nuclear reaction rate of radioactive capture and fission along of the radial direction of the fuel pellet obtained by Monte Carlo methodology using the MCNP-4C code. The relative values obtained are compared with experimental values and show a good agreement between experimental and calculated values. Besides nuclear reaction rates, the spectral indices $^{28}\rho$ and $^{25}\delta$ have been obtained at each different values of the radius of the fuel pellet disk.

1. INTRODUCTION

Experiments involving the determination of the reaction rates in the fuel pellets are of fundamental importance to correlate theory and experiment, mainly concerning calculation methods and related to nuclear data libraries. For a long time, experiments involving reaction rates measurements have been carried out worldwide. The most famous spectral index measurements are the performed in the TRX and BAPL critical facilities, selected by the CSEWG [1], as benchmarks. Historically, there has been a long–standing problem related to the over prediction of the spectral indices $^{28}\rho$. These spectral indices provide the ratio of epithermal to thermal neutron capture in ^{238}U. The epithermal calculated value is obtained by calculations of self-shielding factors, at resonances of the ^{238}U, using methods such as NORDHEIM [2] and BONDARENKO [3], which overestimate the radioactive capture reaction rate in this neutron energy range. Another spectral index of great importance is $^{25}\delta$. It provides the ratio of epithermal to thermal neutron fission in ^{235}U and it is commonly used as a base to test benchmarks. Generally, estimations of the nuclear reaction rate along the radius of the nuclear reactor fuel pellet is made by MCNP code and its libraries of nuclear associated data, such as ENDF/B, JENDL, JEFF, and others.

Therefore, the experimental measurements, although very rare and difficult, are very important to estimate the level of accuracy and precision of the calculations methodology and its nuclear data libraries. This work aims to measure the relative nuclear reaction rate along the radius fuel pellet and to compare with calculations performed by MCNP-4C Code [4] and giving some preliminary values of $^{28}\rho$ and $^{25}\delta$.

2. EXPERIMENTAL DESCRIPTION

The IPEN/MB-01 reactor is a zero power reactor, especially designed for measurements of a wide range of reactor physics parameters, to be used as benchmark experimental data for verifying the calculation methodologies and related nuclear data libraries, commonly used in the field of reactor physics. This facility consists of a array of 28x26 UO2 fuel rods, 4.3% enriched and clad by stainless steel (type 304), inside a light water tank. A complete description of the IPEN/MB-01 reactor may be found elsewhere [5].

The experiments were carried out at the asymptotic region of the reactor core. An experimental fuel rod (similar to the one used in the reactor) is irradiated at the central position of the core. Exactly in the axial active fuel quote, 94 mm of a very thin UO_2 pellet (about 0.5 mm thickness) is inserted to measure nuclear capture and fission reaction rate. This thin pellet (4.3% enriched Uranium) is inserted between the ninth and tenth axial fuel pellet. This position was chosen because it is enough far to feel the control rods disturbance. Two irradiations are necessary to determinate reaction rates induced by thermal neutrons. In the first irradiation, a cadmium glove is used in the experimental fuel rod to discriminate thermal and epithermal neutrons and, in the second irradiation, nothing is used to block the thermal neutrons.
The experimental fuel rod is irradiated for 1 hour, in the maximum power level (100 watts). After 19 hours, the experimental fuel rod is withdrawn from the core and taken to the gloved box, for its dismounting so that a thin experimental pellet is obtained. Immediately after the dismounting, the gamma spectrometry of the thin pellet is started. For each counting, a different collimator is used. The collimators used have a diameter varying 0.5 mm, from 4 mm to 8.0 mm; there is one with 8.3mm and another one with 8.5mm. The diameter of the thin pellet is 8.49 mm, exactly the same of the reactor UO_2 fuel pellet. Each gamma spectrometry data acquirement is made for 600 seconds, and in the minimum achievement, 52 gamma spectra were acquired to each collimator diameter. The gamma spectrometry measures the counts rate centered at 277.6 keV, with a gamma emission probability of 14.38% for Neptunium 239 (half-Life of 2.335), which is the product of neutron capture of ^{238}U, and it measures the counts rate centered at 293.3 keV, with a gamma emission probability of 42.8% for Cerium 143 (half-Life of 33.7 h), formed by fission of ^{235}U with yield of 5.9373%. The radionuclide ^{239}Np occurs by decay of the ^{239}U atoms, a direct product from the nuclear reactions between the neutrons and the target nucleus of the ^{238}U. Using the expression (1), it is possible to estimate [6] the absolute radioactive capture nuclear reaction rate (C8), at the diameter measured by different collimators (see Figure 1).

$$C8 = \frac{{}^{U9}\lambda - {}^{Np}\lambda}{{}^{U9}\lambda} \frac{{}^{Np}\lambda \cdot {}^{Np}C \cdot \exp({}^{Np}\lambda \cdot te)}{{}^{Np}f\gamma \cdot {}^{Np}I \cdot {}^{Np}\eta \cdot [1 - \exp(-{}^{Np}\lambda \cdot ti)][1 - \exp(-{}^{Np}\lambda \cdot tc)]} \quad (1)$$

Where, ${}^{Np}\lambda$ Constant decay of the ${}^{239}Np$; ${}^{U9}\lambda$ the constant decay to ${}^{239}U$, ${}^{Np}C$ integral counting of the gamma energy of 277.6 keV, ${}^{Np}f_{\gamma}$ the self-shielding factor at 276,6 keV from ${}^{239}Np$, ${}^{Np}I$ the gamma emission probability to gamma energy of the 277.6 keV from ${}^{239}Np$; ${}^{Np}\eta$ global efficiency to gamma photopeak of 276.6 keV from ${}^{239}Np$, te the wait time to counting, ti the irradiation time and tc, the counting time.

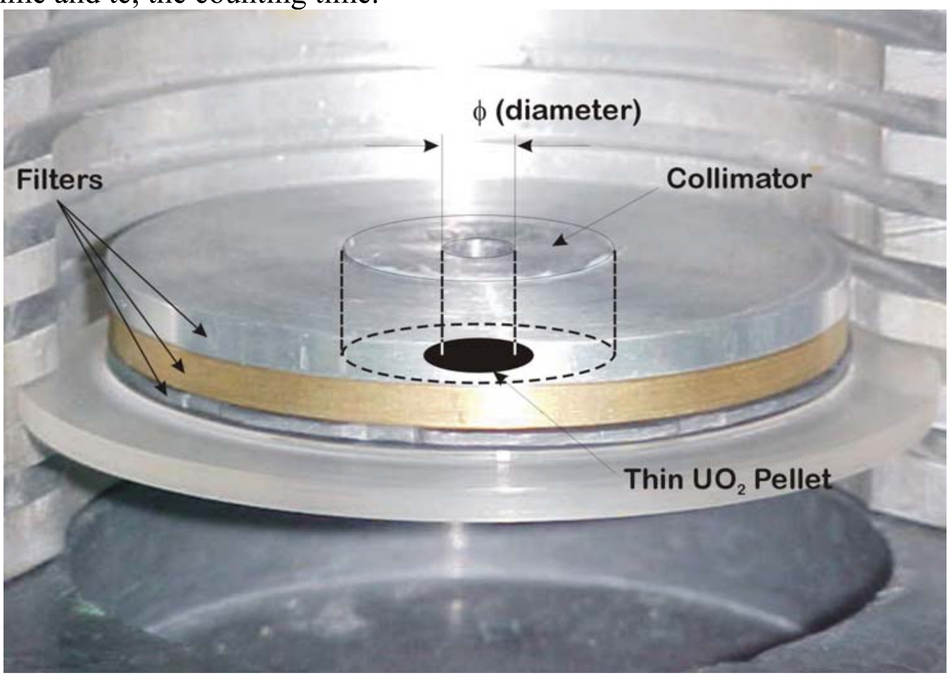

Figure 1 – Collimator used to measure gamma photopeak of the ${}^{239}Np$ (277.6 keV), formed by radioactive capture nuclear reaction, in the thin pellet irradiated in the fuel rod.

Using the expression (2), it is possible to estimate [6] the absolute fission nuclear reaction rate (F) at the diameter measured.

$$F = \frac{C_0}{{}^{Ce}Y \cdot {}^{Ce}f\gamma \cdot {}^{Ce}I \cdot {}^{Ce}\eta \cdot [1 - \exp(-{}^{Ce}\lambda . \cdot ti)]} \quad (2)$$

Where, ${}^{Ce}f\gamma$ is the self-shielding factor for the rod in the photopeak of 293.3 keV for ${}^{143}Ce$, ${}^{Ce}I$ is the gamma emission probability for this energy , ${}^{Ce}\eta$ is the global efficiency for 293.3 keV , ${}^{Ce}\lambda$ is the decay constant for ${}^{143}Ce$, ${}^{Ce}Y$ is the fission yield and ti is the irradiation time.

3. EXPERIMENTAL RESULTS

The relative reaction rate, along the radius of the thin UO_2 pellet irradiated, was measured by its gamma spectrometry, using several collimators with different diameters (see Figure 1). Then, the problem was to estimate de counting rate in the end of irradiation (C_0), discounting the dead time. This parameter was estimated using the expression (3), where tc is the life time counting (without dead time) in the gamma spectrometry.

$$C_0 = C \cdot \exp({}^{Np}\lambda \cdot te) \tag{3}$$

Figure 2 shows an example of the gamma spectrometry made by acquisition 65 specters data, using a 6 mm diameter collimator, building the ^{239}Np decay curve.

The final results of the relative radioactive capture nuclear reaction rate, normalized by total counts to the maximum diameter collimator (8.5 mm), may be seen in Table 1. Thus, in this situation, the whole diameter foil is sampled and the counts (277.6 keV to ^{239}Np) are proportional to the nuclear reaction rate.

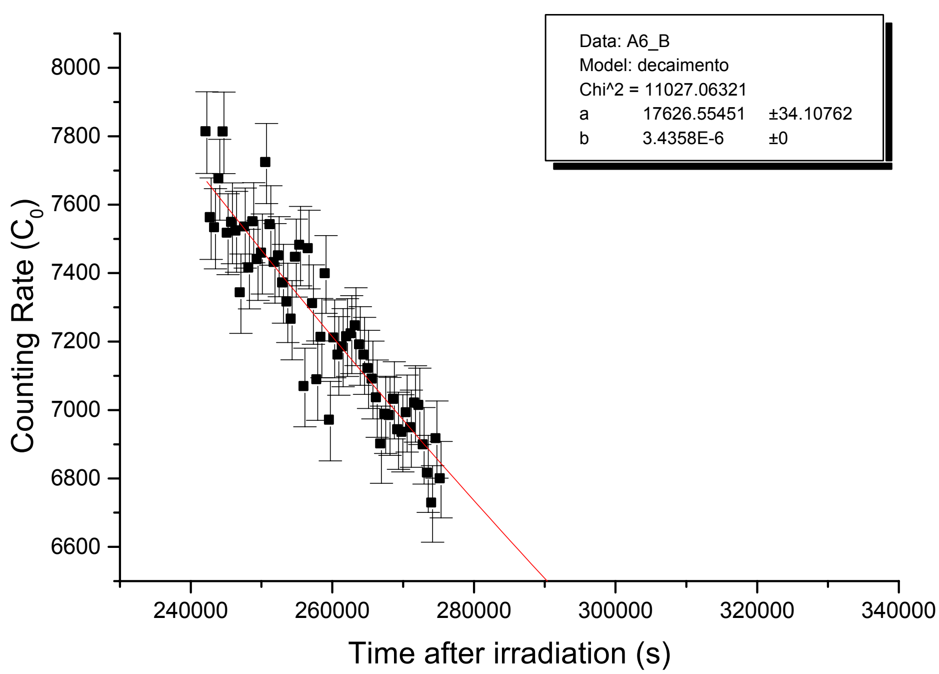

Figure 2. Determination of C_0 to bare thin UO2 pellet, using a 6 mm diameter collimator.

Table 1. Relative nuclear reaction rate of radioactive capture to thin UO_2 pellet, irradiated without covered cadmium (bare), at central position of the IPEN/MB-01 Reactor core – axial quote 94 mm.

Radius of the Collimator used to sample the UO_2 Thin Pellet Disk (cm)	Nominal Collimator Diameter (mm)	Relative Radioactive Capture Nuclear Reaction Rate – Equation (2) (C_0) *	Normalized Values of C_0 (%)	Absolute Radioactive Capture Nuclear Reaction Rate – Equation (1) (C8) **
0.1959 ± 0.0015	4.0	3962.06 ± 19.21	10.01 ± 0.05	(5.27 ± 0.29). 10^4
0.2235 ± 0.0017	4.5	5966.95 ± 21.65	15.08 ± 0.06	(1.54 ± 0.36) 10^5
0.2610 ± 0.0018	5.0	11409.29 ± 32.24	28.84 ± 0.09	(2.02 ± 0.40).10^5
0.2735 ± 0.0018	5.5	12901.06 ± 25.16	32.61 ± 0.07	(4.36 ± 0.63).10^5
0.2980 ± 0.0023	6.0	17626.55 ± 34.11	44.55 ± 0.09	(4.92 ± 0.81).10^5
0.3233 ± 0.0017	6.5	21445.87 ± 36.77	54.21 ± 0.10	(6.72 ± 1.00).10^5
0.3468 ± 0.0034	7.0	25064.29 ± 47.63	63.35 ± 0.13	(8.24 ± 1.09).10^5
0.3780 ± 0.0011	7.5	29481.21 ± 49.54	74.52 ± 0.13	(9.61 ± 1.26) .10^5
0.4038 ± 0.0021	8.0	36302.23 ± 74.3	91.76 ± 0.20	(1.15 ± 0.14).10^6
0.4152 ± 0.0021	8.3	37862.68 ± 61.12	95.70 ± 0.17	(1.36 ± 0.18).10^6
0.4275 ± 0.0019	8.5	39562.98 ± 74.85	100 ± 0.20	(1.50 ± 0.29).10^6

* ^{239}Np (277,6 KeV); ** 100 watts power level – active fuel quote of 94 mm at Central fuel rod.

The same procedures were used to irradiate a thin UO_2 pellet, in the same experimental conditions and axial quote (94 mm), but with covered cadmium. The covered cadmium was used around the dismountable fuel rod and centered at quote 94 mm. The cadmium glove used was 10 cm long and 0.5 mm thick. The results obtained, after gamma spectrometry, may be seen in Table 2.

Table 2 – Relative nuclear reaction rate of radioactive capture to thin UO_2 pellet, irradiated with covered cadmium, at central position of the IPEN/MB-01 Reactor core – axial quote 94 mm.

Radius of the Collimator used to sample the UO_2 Thin Pellet Disk (cm)	Nominal Collimator Diameter (mm)	Relative Radioactive Capture Nuclear Reaction Rate – Equation (3) (C_0) *	Normalized Values of C_0 (%)	Absolute Radioactive Capture Nuclear Reaction Rate – Equation (1) (C8) **
0.1959 ± 0.0015	4.0	2360.88 ± 14.89	9.47 ± 0.33	(3.72 ± 0.44) x 10^4
0.2235 ± 0.0017	4.5	3559.75 ± 9.23	14.28 ± 0.20	(1.08 ± 0.09) x 10^5
0.2610 ± 0.0018	5.0	6892.5 ± 18.56	27.65 ± 0.41	(1.60 ± 0.15) x 10^5
0.2735 ± 0.0018	5.5	7801.06 ± 16.64	31.29 ± 0.36	(3.01 ± 0.28) x 10^5
0.2980 ± 0.0023	6.0	10741.34 ± 29.6	43.08 ± 0.65	(3.39 ± 0.32) x 10^5
0.3233 ± 0.0017	6.5	13125.62 ± 21.75	52.65 ± 0.48	(4.70 ± 0.44) x 10^5
0.3468 ± 0.0034	7.0	15472.46 ± 31.25	62.06 ± 0.68	(5.35 ± 0.50) x 10^5
0.3780 ± 0.0011	7.5	18884.6 ± 38.71	75.75 ± 0.85	(6.78 ± 0.64) x 10^5
0.4038 ± 0.0021	8.0	22893.84 ± 45.34	91.83 ± 0.99	(8.29 ± 0.78) x 10^5
0.4152 ± 0.0021	8.3	23899.69 ± 42.14	95.86 ± 0.92	(9.95 ±0.94) x 10^5
0.4275 ± 0.0019	8.5	24930.62 ± 36.93	100 ± 0.81	(1.04 ± 0.10) x 10^6

* ^{239}Np (277.6 keV); ** 100 watts power level – active fuel quote of 94 mm at Central fuel rod.

Figure 3 shows the percentage of nuclear reaction rate of radioactive capture, along the diameter of the UO_2 thin pellet, irradiated at central position of the core, exactly in the axial active fuel quote 94 mm). As the same, Figure 4 shows the experimental results obtained to UO_2 thin pellet, irradiated with the cadmium glove.

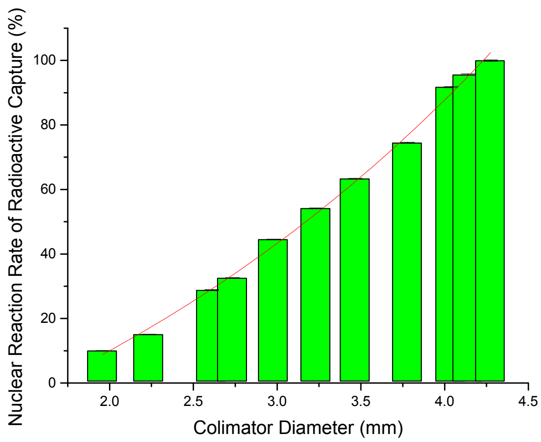

Figure 3. Percentage of nuclear reaction rate of radioactive capture, along the diameter of the UO_2 pellet, irradiated at central position of the core (quote 94 mm).

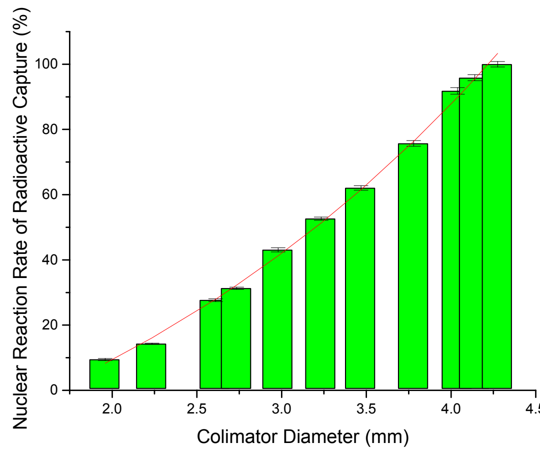

Figure 4. Percentage of nuclear reaction rate of radioactive capture, along the diameter of the UO_2 pellet irradiated, covered with cadmium glove, at central position of the core (quote 94 mm).

The final results of the relative nuclear fission rate, normalized by total counts to maximum diameter collimator (8.5 mm), may be seen in Table 3, without cadmium cover; in Table 4, with cadmium cover. Thus, in this situation, the whole foil diameter is sampled and the counts (293.3 keV to ^{143}Ce) are proportional to the nuclear fission reaction rate. The cadmium glove was the same used to determine the radioactive capture in ^{238}U.

Table 3. Relative nuclear reaction rate of fission to thin UO_2 pellet, irradiated without covered cadmium (bare), at central position of the IPEN/MB-01 Reactor core – axial quote 94 mm.

Radius of the Collimator used to sample the disk (cm)	Nominal Collimator Diameter (mm)	Relative Fission Nuclear Reaction Rate – Equation (2) - (C_0) *	Normalized Values of C_0 (%)	Absolute Fission Nuclear Reaction Rate – Equation (2) - (F) **
0.1959 ± 0.0015	4.0	4823.44 ± 26.91	13.07 ± 0.07	(4.9 ± 0.23) x 10^5
0.2235 ± 0.0017	4.5	7057.93 ± 25.88	19.13 ± 0.07	(7.1 ± 0.34) x 10^5
0.2610 ± 0.0018	5.0	13022.56 ± 42.12	35.29 ± 0.11	(1.4 ± 0.65) x 10^6
0.2735 ± 0.0018	5.5	14419.26 ± 32.41	39.07 ± 0.09	(1.5 ± 0.73) x 10^6
0.2980 ± 0.0023	6.0	18975.05 ± 64.35	51.42 ± 0.17	(2.0 ± 0.98) x 10^6
0.3233 ± 0.0017	6.5	22847.57 ± 59.84	61.91 ± 0.16	(2.5 ± 0.11) x 10^6
0.3468 ± 0.0034	7.0	25924.5 ± 85.8	70.25 ± 0.23	(2.8 ± 0.13) x 10^6
0.3780 ± 0.0011	7.5	28602.47 ± 80.34	77.51 ± 0.22	(3.2 ± 0.15) x 10^6
0.4038 ± 0.0021	8.0	34798.45 ± 124.97	94.30 ± 0.34	(3.7 ± 0.18) x 10^6
0.4152 ± 0.0021	8.3	36083.42 ± 140.84	97.78 ± 0.38	(4.1 ± 0.19) x 10^6
0.4275 ± 0.0019	8.5	36901.84 ± 169.81	100 ± 0.46	(4.9 ± 0.23) x 10^5

* ^{143}Ce (293.3 KeV); ** 100 watts power level – active fuel quote of 94 mm, at central fuel rod.

Table 4 – Relative nuclear reaction rate of radioactive capture to thin UO_2 pellet, irradiated with covered cadmium, at central position of the IPEN/MB-01 Reactor core – axial quote 94 mm.

Radius of the Collimator used to sample the disk (cm)	Nominal Collimator Diameter (mm)	Relative Fission Nuclear Reaction Rate - Equation (2) - (C_0) *	Normalized Values of C_0 (%)	Absolute Fission Nuclear Reaction Rate – Equation (2) - (F) **
0.1959 ± 0.0015	4.0	609.6 ± 13.65	13.34 ± 0.30	(3.72 ± 0.44) x 10^4
0.2235 ± 0.0017	4.5	866.38 ± 9.38	18.95 ± 0.21	(1.08 ± 0.09) x 10^5
0.2610 ± 0.0018	5.0	1610.49 ± 18.46	35.23 ± 0.40	(1.60 ± 0.15) x 10^5
0.2735 ± 0.0018	5.5	1777.89 ± 15.39	38.90 ± 0.34	(3.01 ± 0.28) x 10^5
0.2980 ± 0.0023	6.0	2384.09 ± 29.07	52.16 ± 0.64	(3.39 ± 0.32) x 10^5
0.3233 ± 0.0017	6.5	2807.81 ± 25.03	61.43 ± 0.55	(4.70 ± 0.44) x 10^5
0.3468 ± 0.0034	7.0	3169.22 ± 35.43	69.34 ± 0.78	(5.35 ± 0.50) x 10^5
0.3780 ± 0.0011	7.5	3688.02 ± 36.46	80.69 ± 0.80	(6.78 ± 0.64) x 10^5
0.4038 ± 0.0021	8.0	4253.25 ± 53.27	93.05 ± 1.17	(8.29 ± 0.78) x 10^5
0.4152 ± 0.0021	8.3	4331.8 ± 56.63	94.77 ± 1.24	(9.95 ±0.94) x 10^5
0.4275 ± 0.0019	8.5	4570.8 ± 73.31	100 ± 0.81	(1.04 ± 0.10) x 10^6

* ^{143}Ce (293.3 KeV); ** 100 watts power level – active fuel quote of 94 mm at central fuel rod.

Figure 5 shows the percentage of nuclear fission rate of radioactive capture along the UO_2 thin pellet diameter, irradiated at the central position of the core, exactly in the axial active fuel quote 94 mm). Figure 6 shows the experimental results obtained to UO_2 thin pellet, irradiated with the cadmium glove.

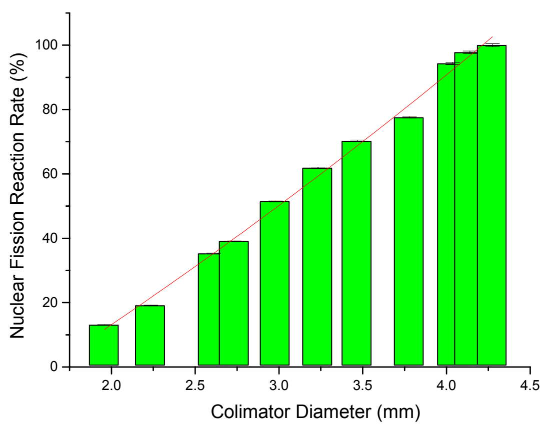

Figure 5. Percentage of nuclear fission reaction rate along the diameter of the UO_2 pellet, irradiated at central Position of the Core (quote 94 mm).

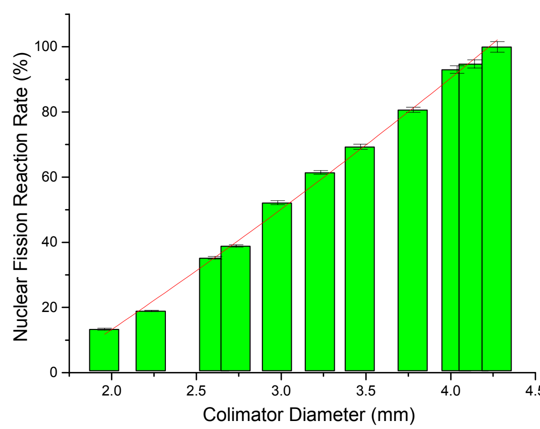

Figure 6. Percentage of nuclear fission reaction rate along the diameter of the UO_2 pellet irradiated, covered with cadmium glove, at central position of the core (quote 94 mm).

From data showed above the spectral indices $^{28}\rho$ and $^{25}\delta$ were estimated. The $^{28}\rho$ is given by:

$$^{28}\rho = \frac{\text{Epithermal Radioctive Capture in 238U}}{\text{Thermal Radioctive Capture in 238U}} \tag{4}$$

And $^{25}\delta$ is given by:

$$^{25}\delta = \frac{\text{Epithermal Fission in 238U}}{\text{Thermal Fission in 238U}} \tag{5}$$

From equations 4 and 5, the spectral indices are showed, in function of the collimator diameter in figures 7 and 8.

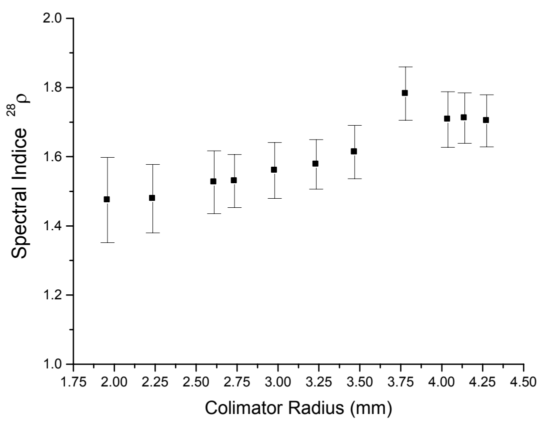

Figure 7. Spectral index ^{28}, along the UO_2 pellet diameter.

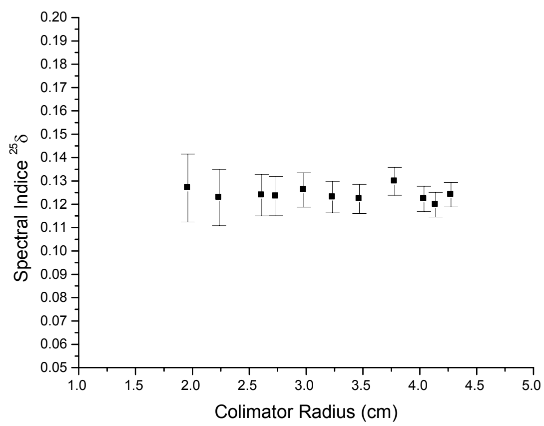

Figure 8. Spectral index $^{25}\delta$, along the UO_2 pellet diameter.

4. CALCULATION BY MCNP-4 C CODE

The calculation methodology aimed to reproduce the experiment. Thus, the MCNP-4C code [4] (Monte Carlo method) was used, with the ENDF-BVI.8 nuclear data library; the results can be seen in Tables 5 and 6, below. Figures 9 and 10 show the percentage of the nuclear reaction rate of radioactive capture, along the diameter of the UO_2 Pellet, irradiated at central position of the core (quote 94 mm), with and without the cadmium glove.

Table 5. Calculated values [7] of the relative nuclear reaction rate of the radioactive capture, to thin UO_2 pellet irradiated in IPEN/MB-01 Reactor core, obtained by MCNP-4C code.

Radius of the Fuel Pellet (cm)	Relative Nuclear Reaction Rate of Radioactive Capture without cadmium glove.	Normalized Values without cadmium cover. *	Relative Nuclear Reaction Rate of Radioactive Capture with cadmium glove.	Normalize Values without cadmium cover. *
0.134239	4.69622×10^{-3}	0.0808	0.0808	0.0760
0.189842	4.78294×10^{-3}	0.1631	0.1631	0.0769
0.232508	4.90005×10^{-3}	0.2474	0.2474	0.0784
0.268477	4.99034×10^{-3}	0.3332	0.3332	0,0806
0.300167	5.10993×10^{-3}	0.4211	0.4211	0,0837
0.328816	5.31006×10^{-3}	0.5124	0.5124	0.0869
0.355162	5.52099×10^{-3}	0.6074	0.6074	0.0921
0.379684	5.85956×10^{-3}	0.7082	0.7082	0.9872
0.402716	6.53097×10^{-3}	0.8205	0.8205	0.1150
0.424500	1.04300×10^{-2} *	1.0000	1.0000	0.2117

* Normalized to total nuclear reaction rate of the fuel pellet of larger radius.

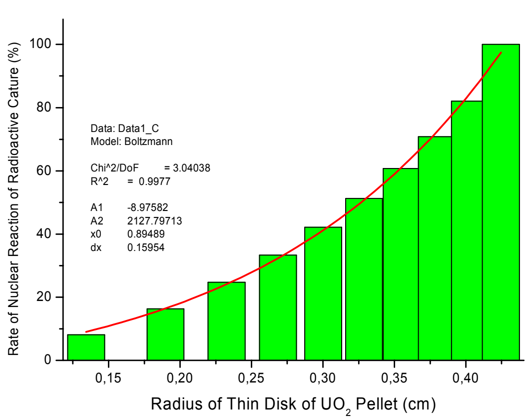

Figure 9. Percentage of nuclear reaction rate of radioactive capture, along the diameter of the UO_2 pellet, irradiated at central position of the core (quote 94 mm).

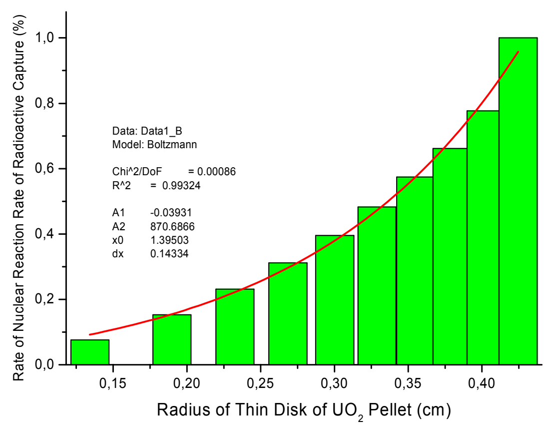

Figure 10. Percentage of nuclear reaction rate of radioactive capture along the radius of the UO_2 pellet, irradiated with cadmium covered glove, at central position of the core (axial quote 94 mm).

Table 6. Calculated values [7] of relative nuclear fission reaction rate to thin UO_2 pellet, irradiated in IPEN/MB-01 Reactor core, obtained by MCNP-4C Code.

Radius of the Fuel Pellet (cm)	Relative Nuclear Fission Rate without cadmium glove.	Normalized Values without cadmium glove. *	Relative Nuclear Fission Rate with cadmium glove.	Normalized Values with cadmium glove.*
0.134239	3.5808E-01	0.0933	4.43634E-2	0.0993
0.189842	7.2121E-01	0.1879	4.44173E-2	0.1987
0.232508	1.0901E+00	0.284	4.43975E-2	0.298
0.268477	1.4640E+00	0.3814	4.45599-2	0.3977
0.300167	1.8436E+00	0.4803	4.46244E-2	0.4975
0.328816	2.2289E+00	0.5807	4.47322E-2	0.5976
0.355162	2.6203E+00	0.6827	4.47889E-2	0.6978
0.379684	3.0184E+00	0.7864	4.48833E-2	0.7982
0.402716	3.4242E+00	0.8921	4.50112E-2	0.8989
0.424500	3.8389E+00	1.0001	4.451616E-2	0.9999

* Normalized to total nuclear reaction rate of the fuel pellet of larger radius.

Figures 11 and 12 show the percentage of nuclear fission rate along the diameter of the UO_2 pellet, simulated at central position of the core (quote 94 mm), with and without the cadmium glove.

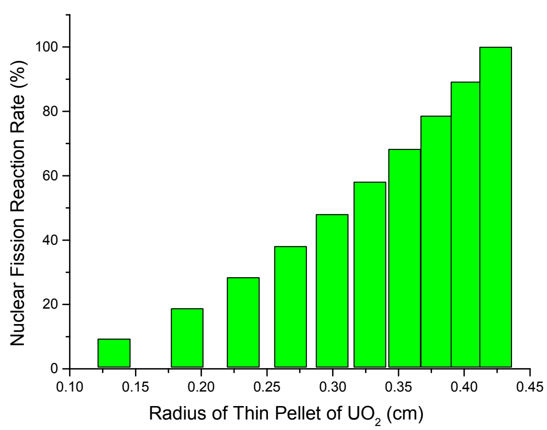

Figure 11. Percentage of nuclear fission reaction rate, along the diameter of the UO_2 pellet, simulated at central position of the core (quote 94 mm).

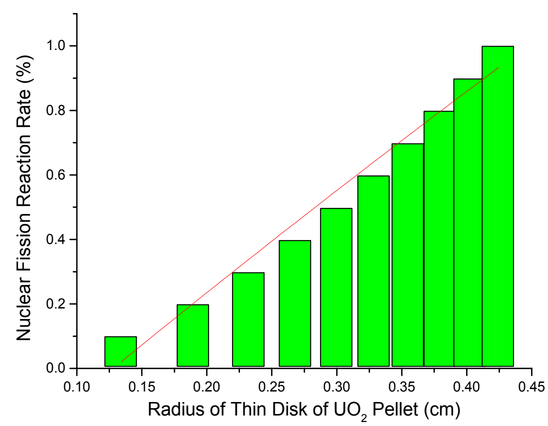

Figure 12. Percentage of nuclear fission reaction rate, along the radius of the UO_2 pellet, simulated with cadmium covered glove at central position of the core (axial quote 94 mm).

5. CONCLUSION

This work aims to show the present stage of nuclear reaction radioactive capture and fission rates measurements, along the nuclear fuel UO_2 pellet radius, of the IPEN/MB-01 reactor. This nuclear reaction rate is very difficult to obtain by experimental procedure and the final results will be very important to be correlated with the calculation methodology. The future step of this work will be a broader acquisition of the experimental data. The goal is to make a minimum of 3 irradiations, for each type of thin disk of UO_2 pellet, verifying the average behavior plus reproducibility of the measurements. Then, the calculation results will be compared and its precision level will be estimated, using different nuclear data libraries.

The preliminary results show a similar spatial distribution of the nuclear reaction rate, along the radius of the thin UO_2 fuel pellet disk, between calculated and measured values. When a Boltzmann function is fitted to both cases, the results are good and show the same spatial tendency of spatial distribution for the nuclear reaction rate, along the fuel pellet radius.

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