

# Progress in Conversion from HEU to LEU Fuel at IRT, Sofia

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# Introduction

- Joint study between INRNE and RERTR Program at ANL was initiated (from 2002)
- IRT-4M LEU FA was accepted as suitable for conversion (2004)
- Selection of the initial configuration for the LEU core loading (in close collaboration with RRCKI - 2005)

# Introduction

- Neutronic calculations - modification of the Safety Analyses Report (2005):
  - ♣ Power distribution by the REBUS in diffusion approximation for model with all control rods withdrawn (CRW)
- Preliminary thermal-hydraulic -
- Satisfaction of safety margins requirement (even for 1MW)

# Introduction

## ■ OBJECTIVE:

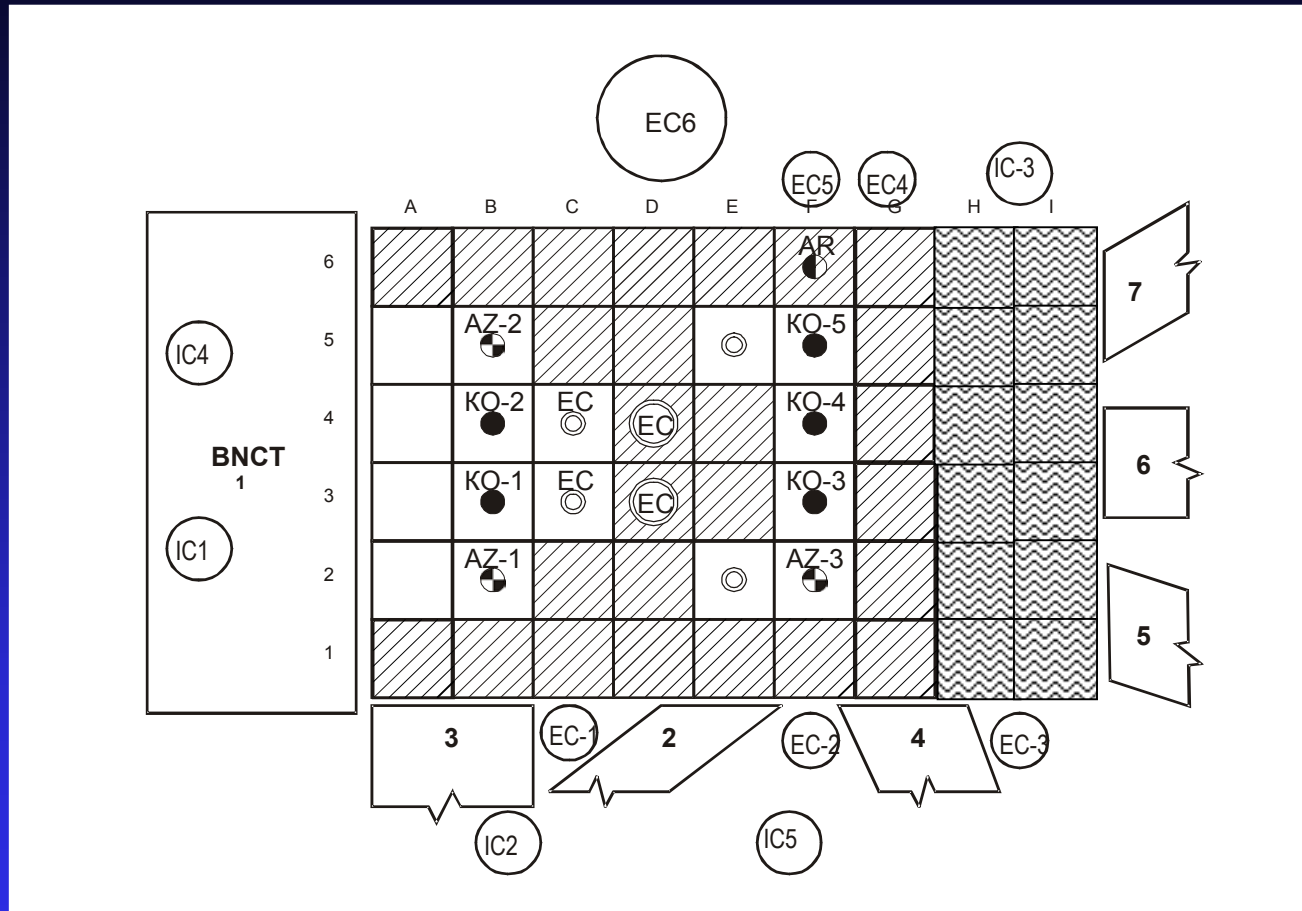
Detailed power distribution for the core critical state (CS) by the MCNP code

REBUS – MCNP (CRW)

REBUS – MCNP (CRW) – MCNP(CS)

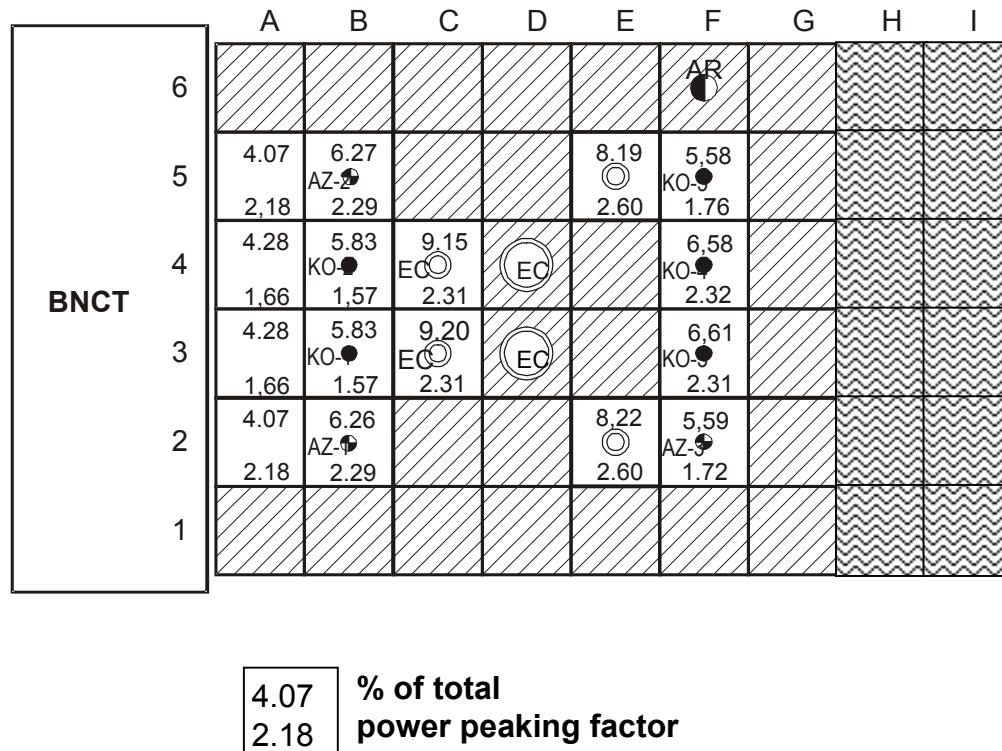
for Thermal Hydraulic calculation

# Fig. 1 Initial Core Configuration



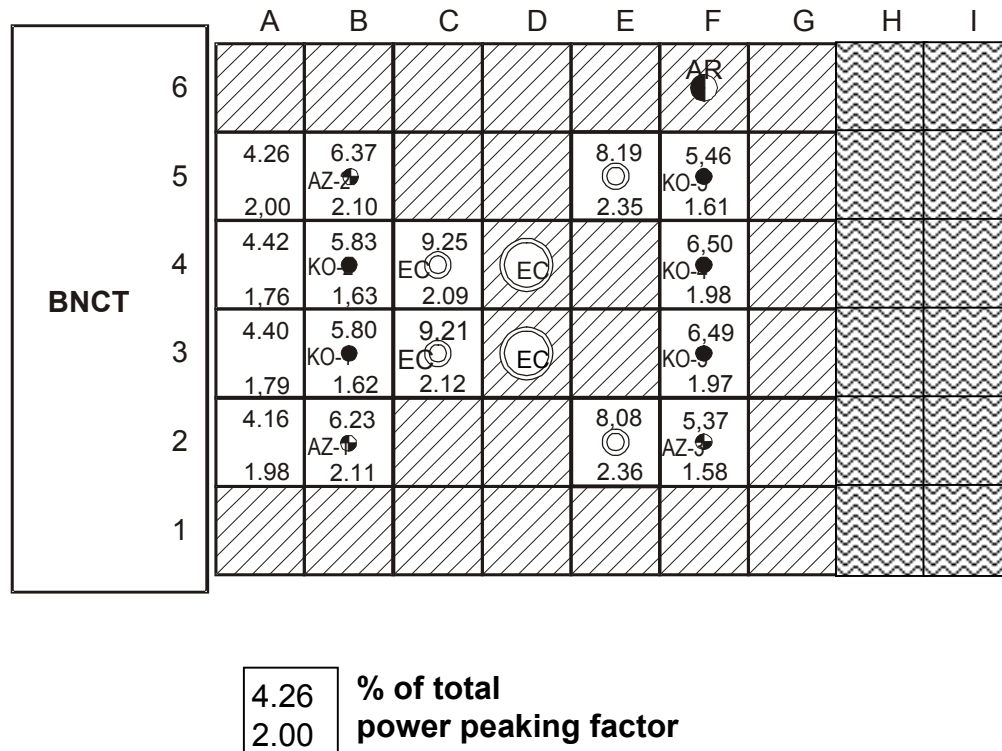
Cold Clean Excess Reactivity: 5.33%  $\Delta k/k$  - MCNP

# Fig. 2 Power Distribution and Power Peaking Factor (REBUS)



The control rods fully withdrawn in the calculational model  
 The power peaking factor - the point-wise values (mesh int.)  
 Relative power distribution over 12 axial intervals and tube-by-tube  
 one were calculated for thermal-hydraulic evaluations

# Fig. 3 Power Distribution and Power Peaking Factor (MCNP)



The control rods fully withdrawn

Difference in Excess Reactivity (MCNP-REBUS) 0.05%  $\Delta k/k$

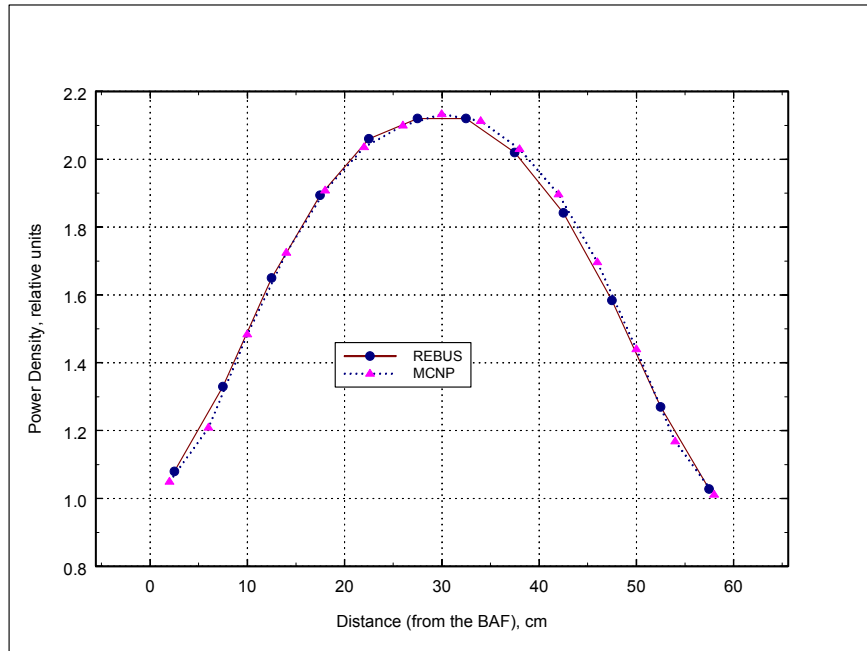
Relative power distribution over 15 axial intervals and tube-by-tube one were calculated for thermal-hydraulic evaluations

**Tab 1. Comparison between REBUS (DIF) and MCNP (MC) results  
Power distribution by FA**

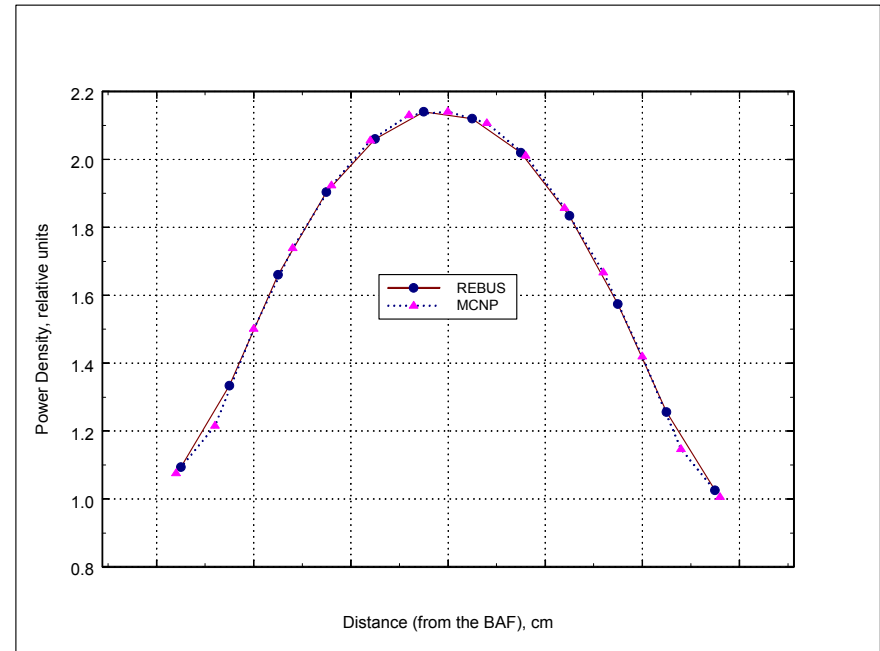
<b>Position</b>	<b>DIF, %</b>	<b>MC, %</b>	<b>(DIF/MC-1), %</b>
F2	5.59	5.37	4.08
F3	6.61	6.49	1.90
F4	6.58	6.50	1.20
F5	5.58	5.46	2.20
<b>E2</b>	<b>8.22</b>	<b>8.08</b>	<b>1.75</b>
<b>E5</b>	<b>8.19</b>	<b>8.19</b>	<b>0.00</b>
<b>C3</b>	<b>9.20</b>	<b>9.21</b>	<b>-0.09</b>
<b>C4</b>	<b>9.15</b>	<b>9.25</b>	<b>-1.09</b>
B2	6.26	6.23	0.50
B3	5.83	5.80	0.57
B4	5.83	5.83	0.00
B5	6.27	6.37	-1.60
A2	4.07	4.16	-2.09
A3	4.28	4.40	-2.64
A4	4.28	4.42	-3.08
A5	4.07	4.26	<b>-4.46</b>

# Comparison of axial power distribution REBUS - MCNP

E2

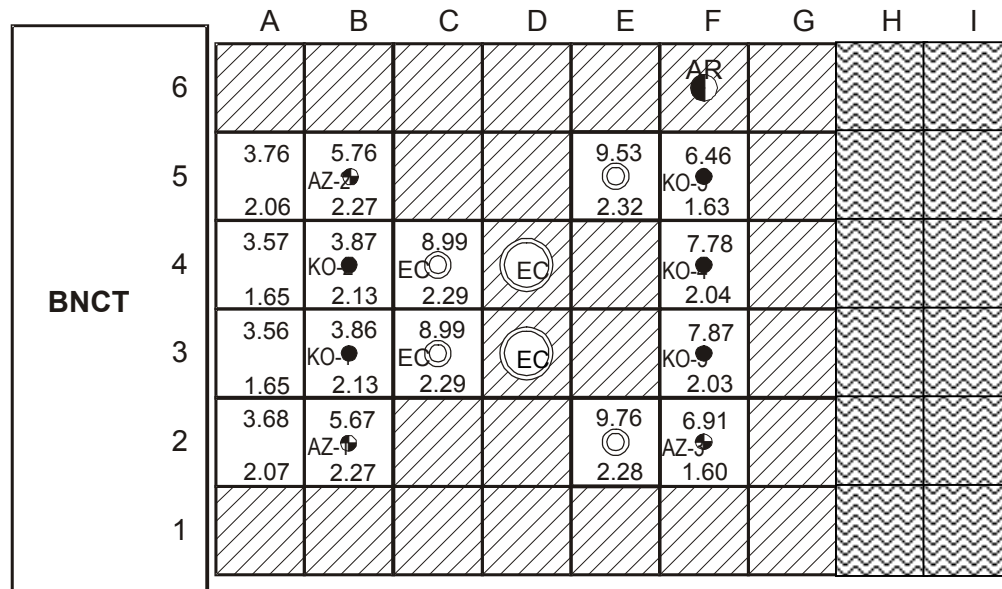


C3



Tube by tube distribution coincide in 1-2% limits

# Fig. 3 Power Distribution and Power Peaking Factor (MCNP)



3.76 % of total  
2.06 power peaking factor

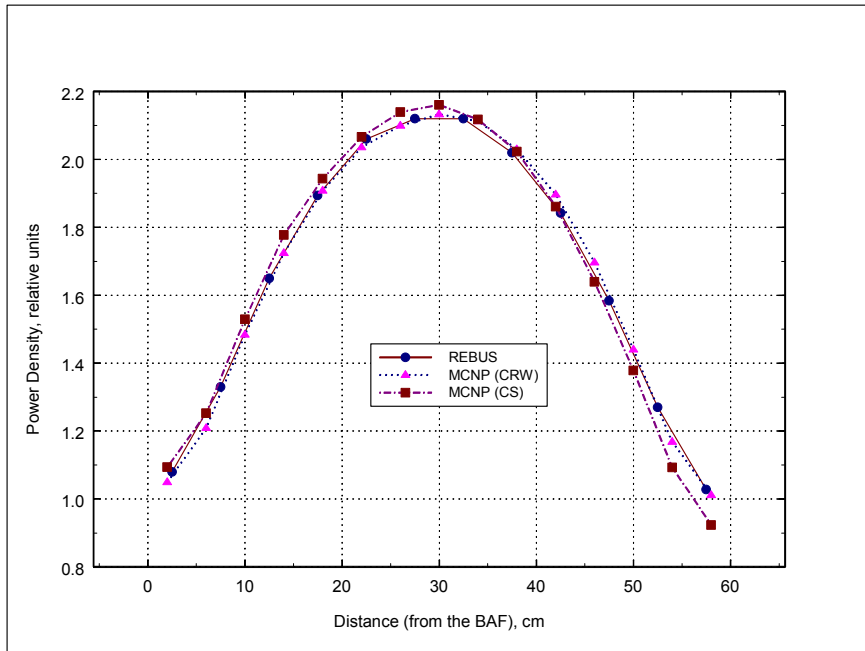
Critical State ( excess reactivity 0.07 %  $\Delta k/k$  ):  
 KO-1=KO-2=65cm, KO-3=KO-4= 18.8cm,  
 AR=41.5cm

**Tab 2. Comparison between REBUS (DIF) and MCNP (MC) results  
MCNP – Critical State**

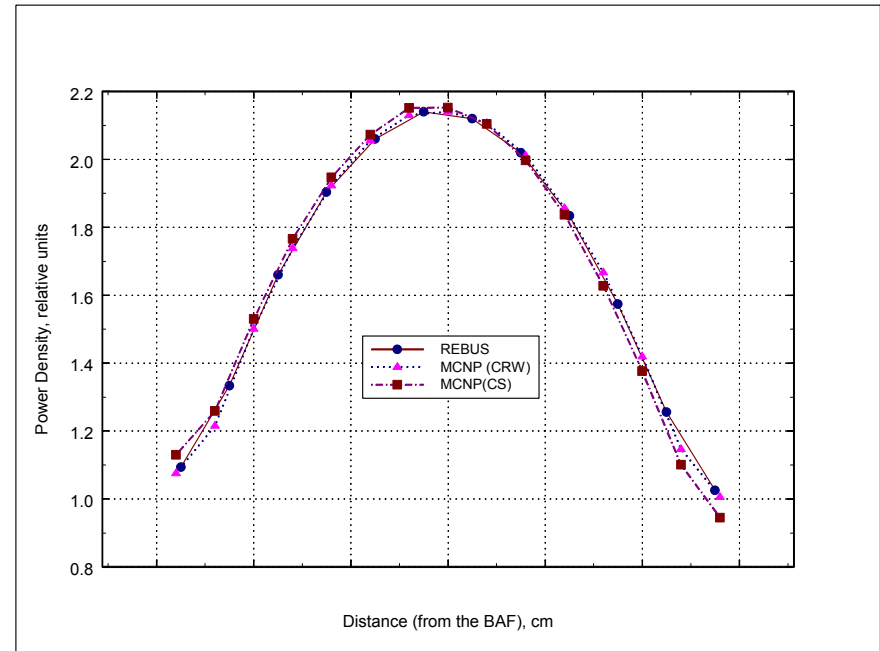
Position	Power, %		Power Peaking Factor		Peak Power Density, W/cm <sup>3</sup>	
	DIF	MC	DIF	MC	DIF	MC
F2	5.59	6.91	1.72	1.60	37.5	43.0
F3	6.61	7.87	2.31	2.03	59.4	62.1
F4	6.58	7.78	2.32	2.04	59.4	61.8
F5	5.58	6.46	1.76	1.63	38.2	40.9
<b>E2</b>	<b>8.22</b>	<b>9.76</b>	<b>2.60</b>	<b>2.28</b>	<b>82.9</b>	<b>86.6</b>
<b>E5</b>	<b>8.19</b>	<b>9.53</b>	<b>2.60</b>	<b>2.32</b>	<b>82.7</b>	<b>86.1</b>
<b>C3</b>	<b>9.20</b>	<b>8.99</b>	<b>2.31</b>	<b>2.29</b>	<b>82.7</b>	<b>80.2</b>
<b>C4</b>	<b>9.15</b>	<b>8.99</b>	<b>2.31</b>	<b>2.29</b>	<b>82.2</b>	<b>80.2</b>
B2	6.26	5.67	2.29	2.27	55.6	49.9
B3	5.83	3.86	1.57	2.13	35.5	32.0
B4	5.83	3.87	1.57	2.13	35.6	32.0
B5	6.27	5.76	2.29	2.27	55.9	50.8
A2	4.07	3.68	2.18	2.07	30.3	25.9
A3	4.28	3.56	1.66	1.65	24.2	20.0
A4	4.28	3.57	1.66	1.65	24.2	20.1
A5	4.07	3.76	2.18	2.06	30.3	26.4

# Comparison of axial power distribution REBUS – MCNP(CRW) – MCNP (CS)

E2



C3



# Conclusions

- PROGRESS IN CONVERSION ACTIVITY
- ✓ A new more detailed and reliable data about relative power distribution in the IRT-Sofia research reactor core by using MCNP calculation
- ✓ The calculated relative power distribution provides information for LEU core thermal-hydraulic evaluations

# Conclusions

- PROGRESS IN CONVERSION ACTIVITY
- ✓ The power distribution (REBUS – MCNP) is very similar
- ✓ Similarity in thermal hydraulic conditions (with the preliminary estimations) is expected

# Acknowledgment

- The authors of this presentation would like to acknowledge a significant contribution to this work by **N. Hanan and J. Matos**, RERTTR Program, Argonne National Laboratory.