

MCNP5 modeling and calculations of the FBNR unit cell.

Atomic densities in the four concentric shells of the fuel particle and in the fuel element in the unit cell are evaluated from **Table 1**, as follows:

UO ₂ : red	
²³⁵ U	1.170835e-3
²³⁸ U	2.22458e-2
O	4.6833413e-2
PYC-Porous:C: dark blue	
C	5.0146952e-2
PYC-Dense:C: yellow	
C	9.0264514e-2
SiC: green	
Si	4.7617754e-2
C	4.7617754e-2
H ₂ O: light blue	
H	4.64989e-2
O	2.32494e-2

Table 1. Fuel particle (2 mm diameter)

Material	density (g/cm ³)	d. inside (cm)	d.outside (cm)	volume (cm ³)	mass (gr)
UO₂	10.5	0	0.158	0.002065237	0.021684988
PYC (porous)	1	0.158	0.176	0.000789306	0.000789306
PYC (dense)	1.8	0.176	0.18	0.000199085	0.000358353
SiC	3.17	0.18	0.2	0.001135162	0.003598464
Average for microsphere	6.3099629		0.2	0.00418879	0.026431111

MCNP5 calculates the mass densities in gram automatically based on the atom densities. They coincide well with the **Table 1** above.

cell	mat	atom density	gram density	volume	mass	pieces	neutron importance
1	1	7.02501E-02	1.04947E+01	2.06524E-03	2.16740E-02	1	1.000E+00
2	2	5.01470E-02	1.00019E+00	7.89306E-04	7.89454E-04	1	1.000E+00
3	3	9.02645E-02	1.80034E+00	1.99085E-04	3.58420E-04	1	1.000E+00
4	4	9.52355E-02	3.17053E+00	1.13516E-03	3.59907E-03	1	1.000E+00

Criticality calculations are first conducted for the actual parameters the FBNR unit cell:

$$k_{\text{eff}} = 1.45673$$

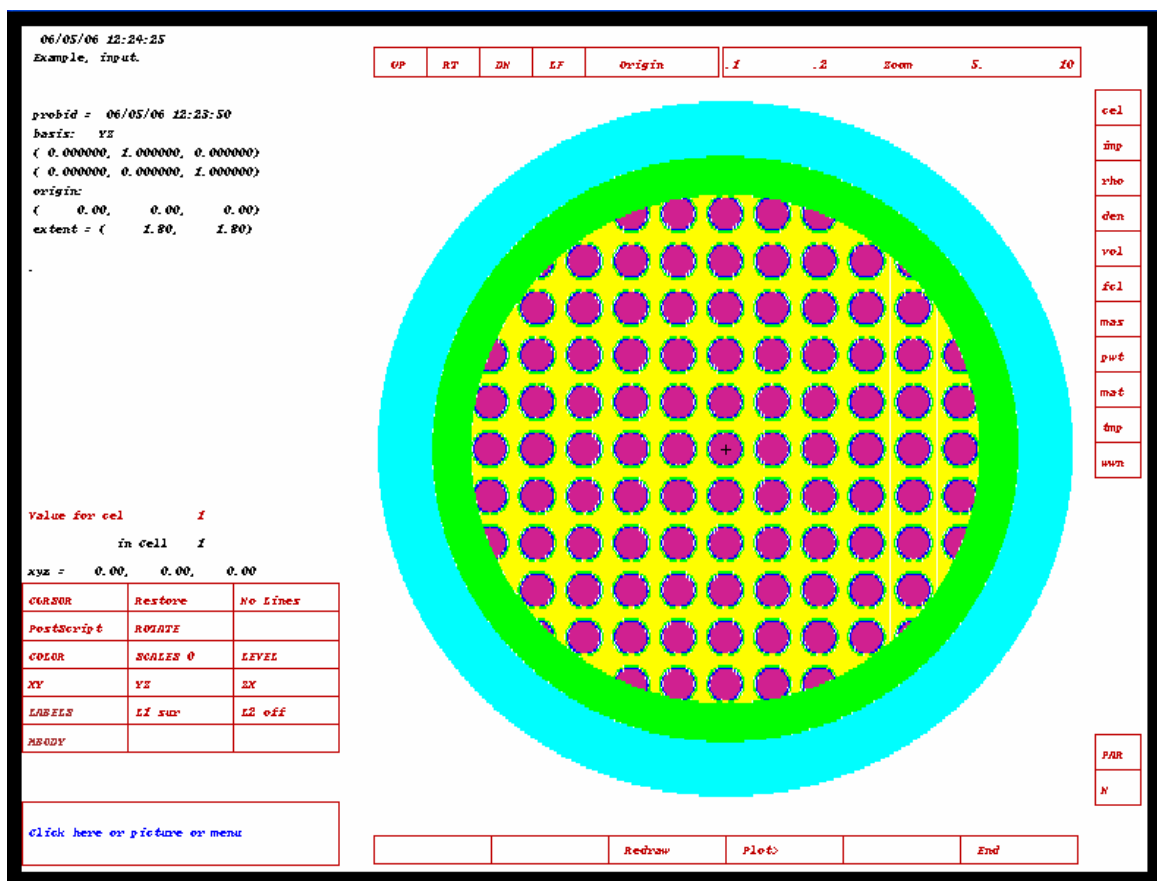
Fuel zone radius in the fuel element: $r = 1.3 \text{ cm}$

SiC clad thickness is 0.1 cm ,

Fuel particles are placed kubic-centered. Hence, section at different distance from the origin yield different figures.

$$R = 1.3 \text{ cm}$$

(Section at $r = 0 \text{ cm}$)



or

05/29/06 11:50:47
Example, input.

```
probid = 05/29/06 11:22:59  
basis: XY  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 1.000000, 0.000000)  
origin:  
( 0.00, 0.00, 0.00)  
extent = ( 0.49, 0.49)
```

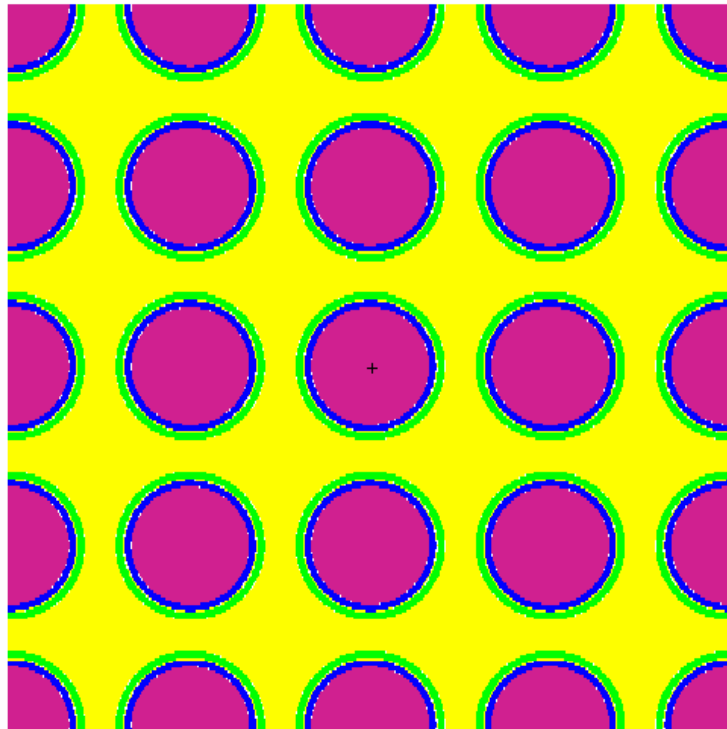
Value for cell 1
in cell 1

xyz = 0.00, 0.00, 0.00

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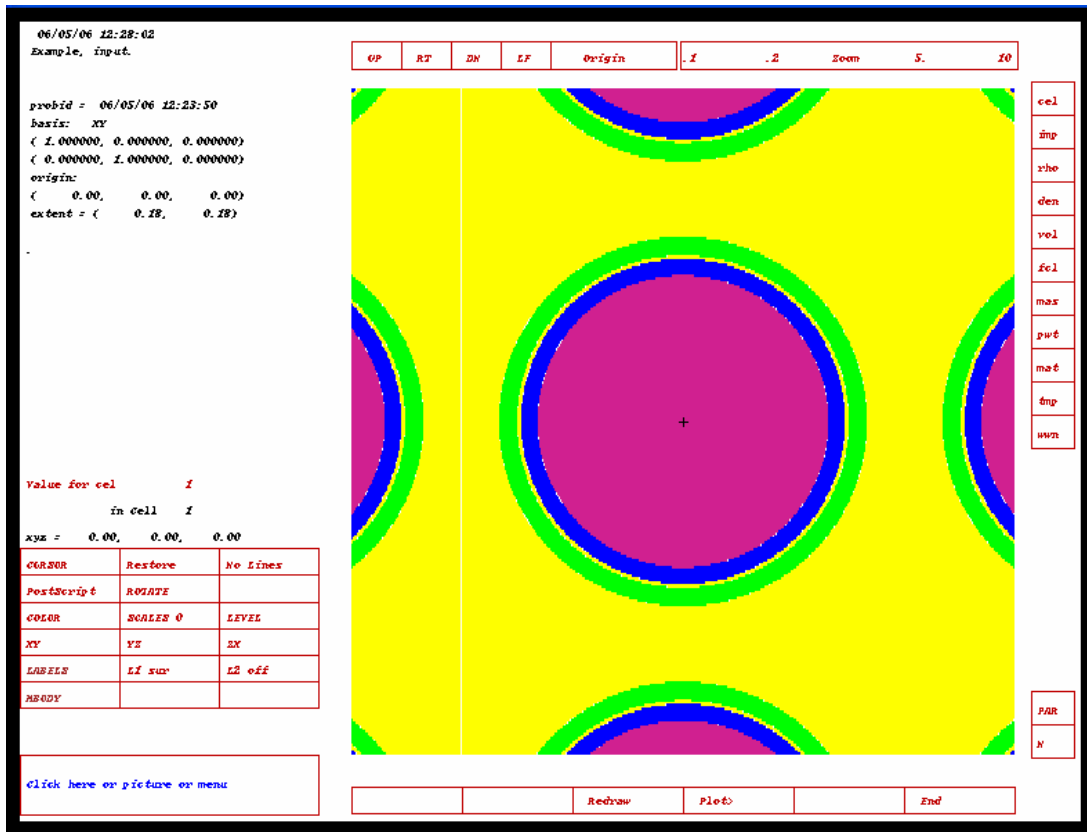


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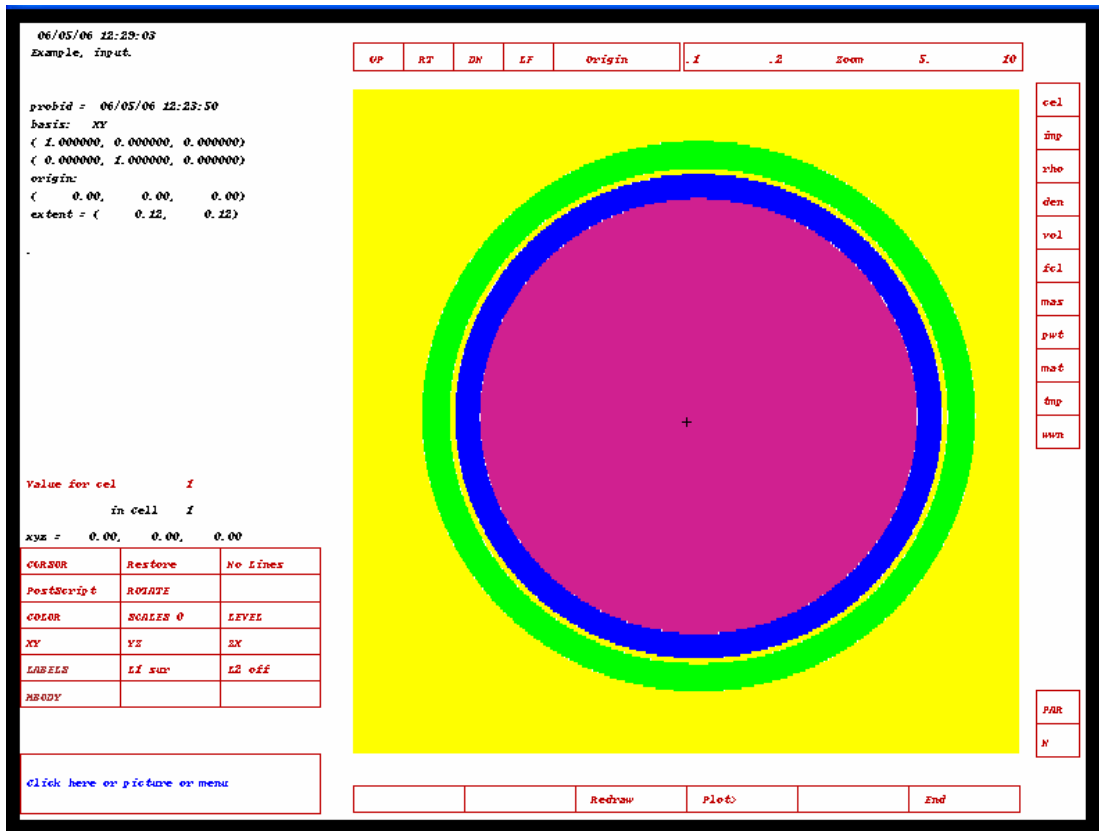
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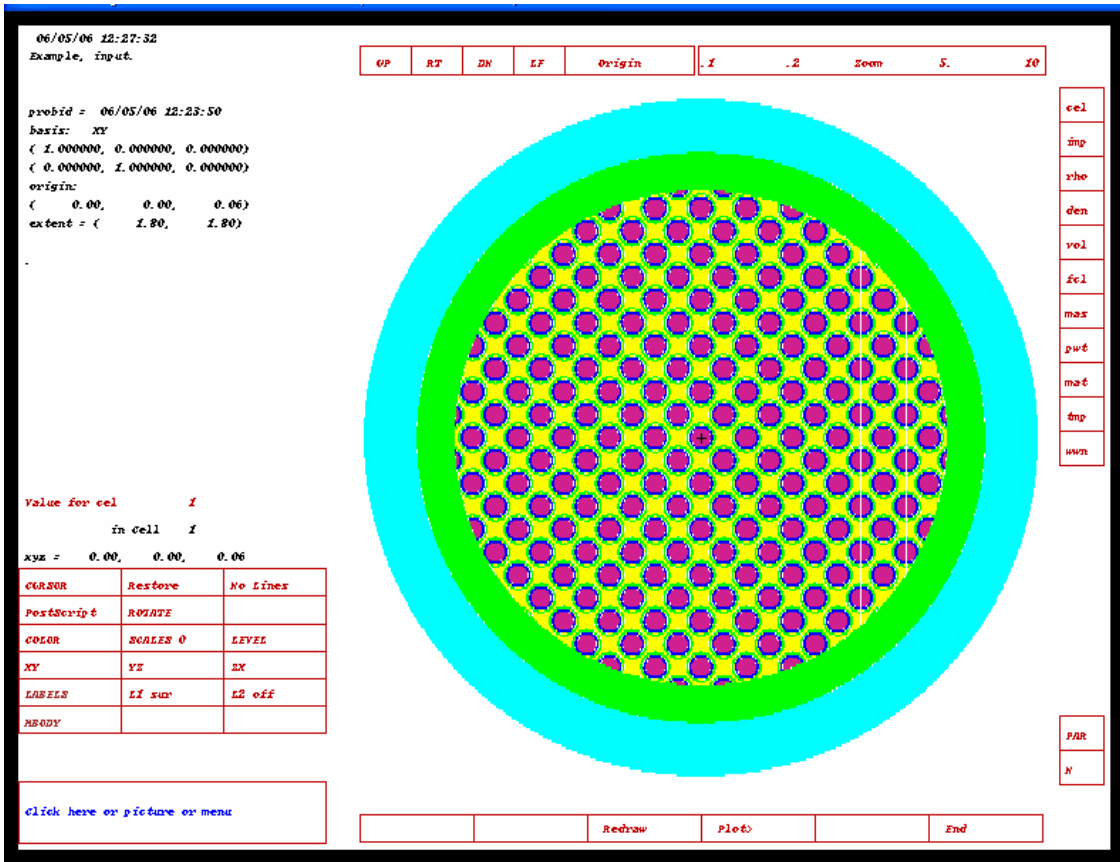
Position of one fuel particle



One fuel particle



(Section at $r = 0.06$ cm)



Or

05/29/06 11:31:41
Example, input.

```
probid = 05/29/06 11:22:59  
basis: XY  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 1.000000, 0.000000)  
origin:  
( 0.00, 0.00, 0.06)  
extent = ( 0.49, 0.49)
```

Value for cel 1

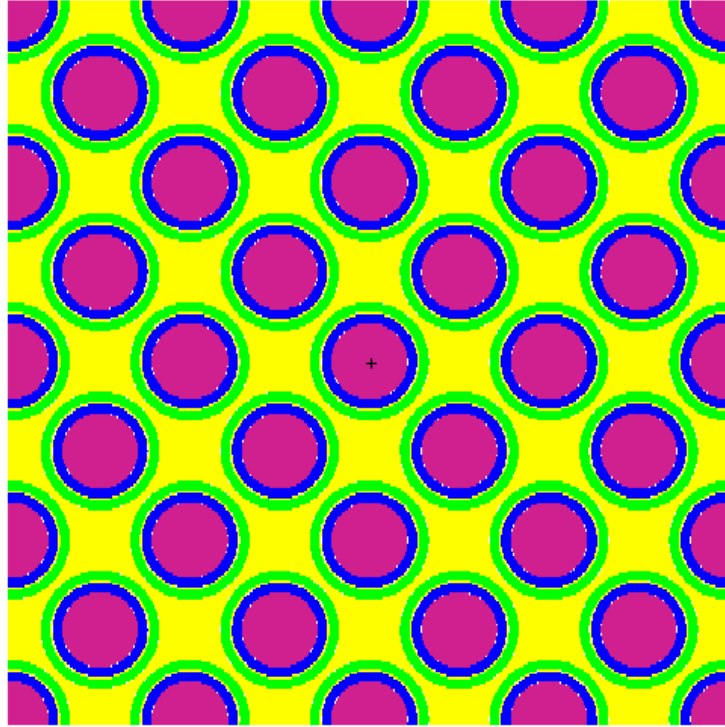
in cell 1

xyz = 0.00, 0.00, 0.06

CURSOR	Restore	No Lines
PostScript	ROTATE	
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XY	YZ	ZX
LABELS	L1 on	L2 off
ABODY		

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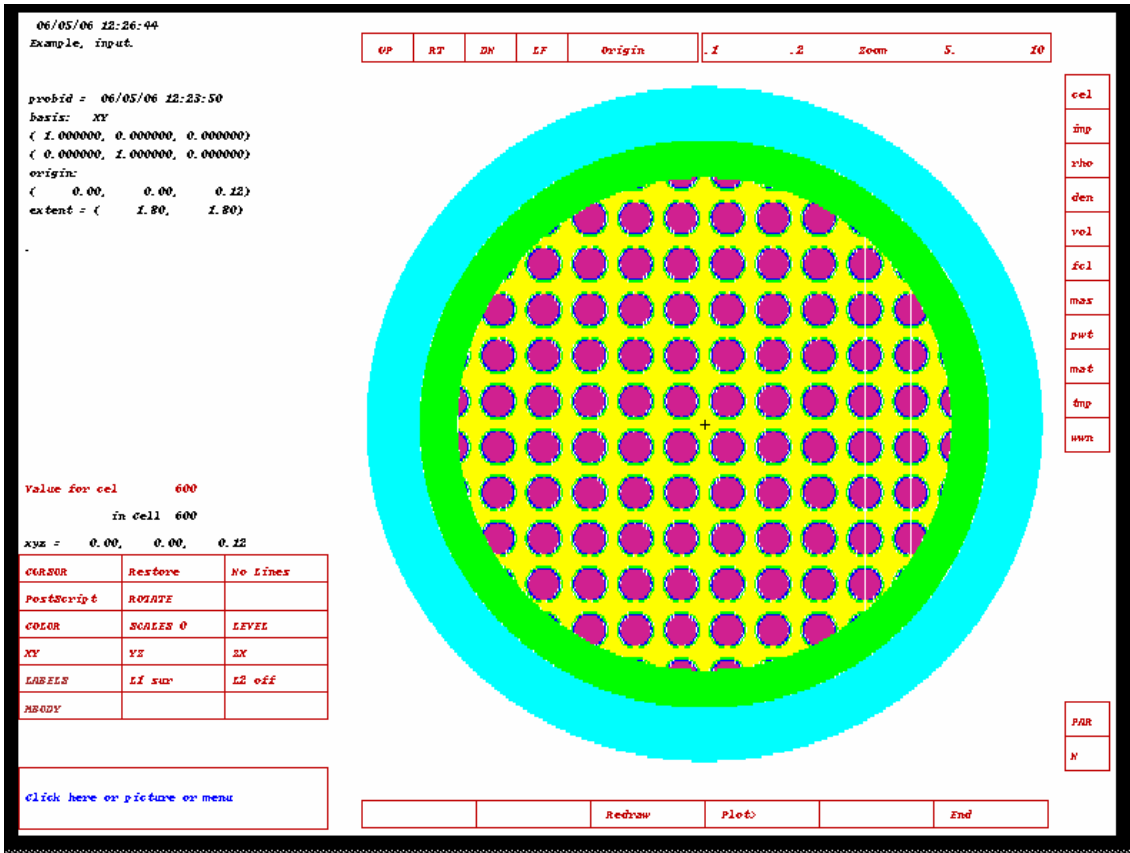


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(Section at $r = 0.12$ cm)



Or

05/29/06 11:28:28
Example, input.

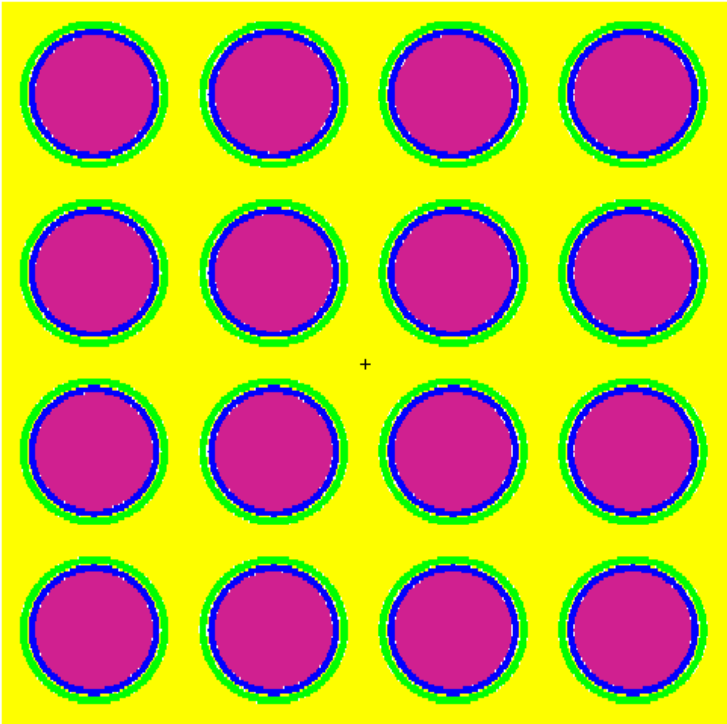
```
probid = 05/29/06 11:22:59  
basis: XY  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 1.000000, 0.000000)  
origin:  
( 0.00, 0.00, 0.12)  
extent = ( 0.49, 0.49)
```

Value for cel 600
in cell 600
xyz = 0.00, 0.00, 0.12

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XY	YZ	ZX
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MBODY		

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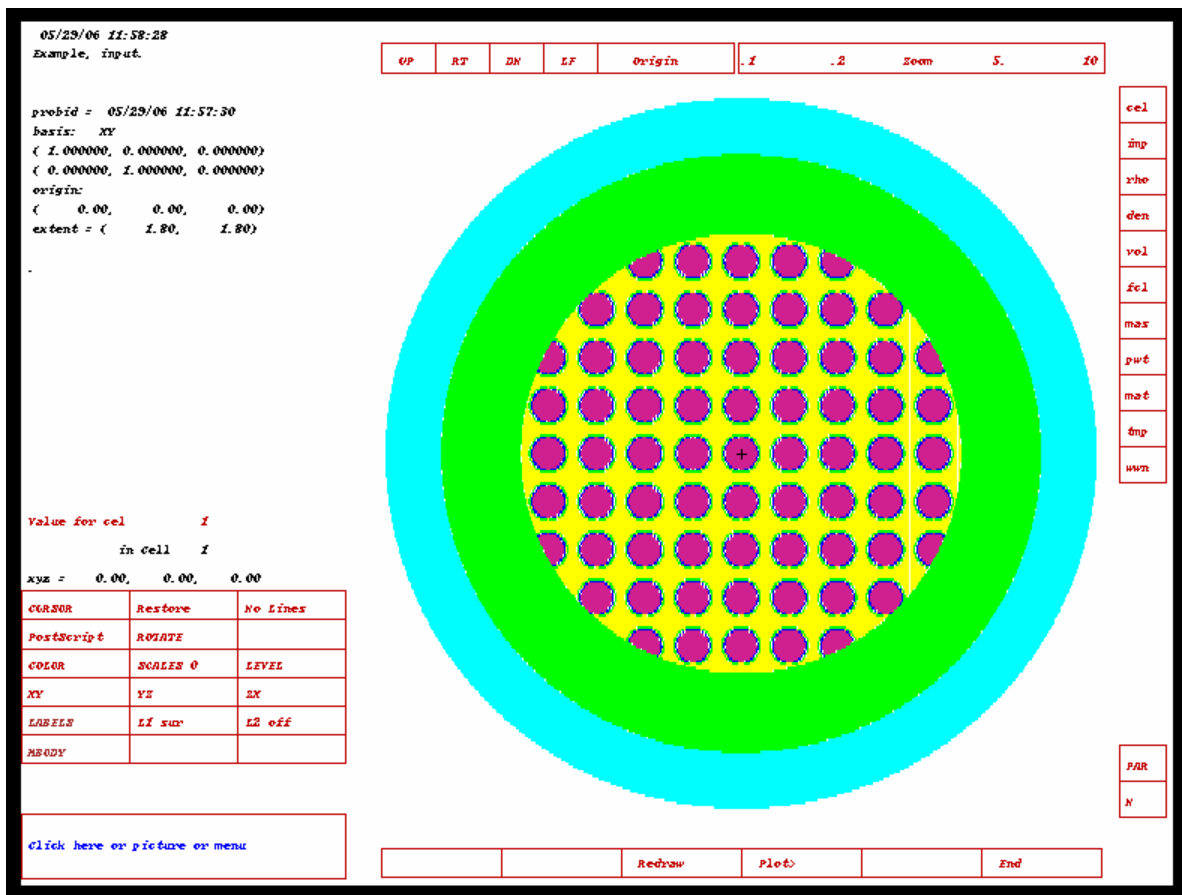
Alternative fuel element modeling with smaller fuel zone radial diameter of $r = 1.1$ cm

$$k_{\text{eff}} = 1.43045$$

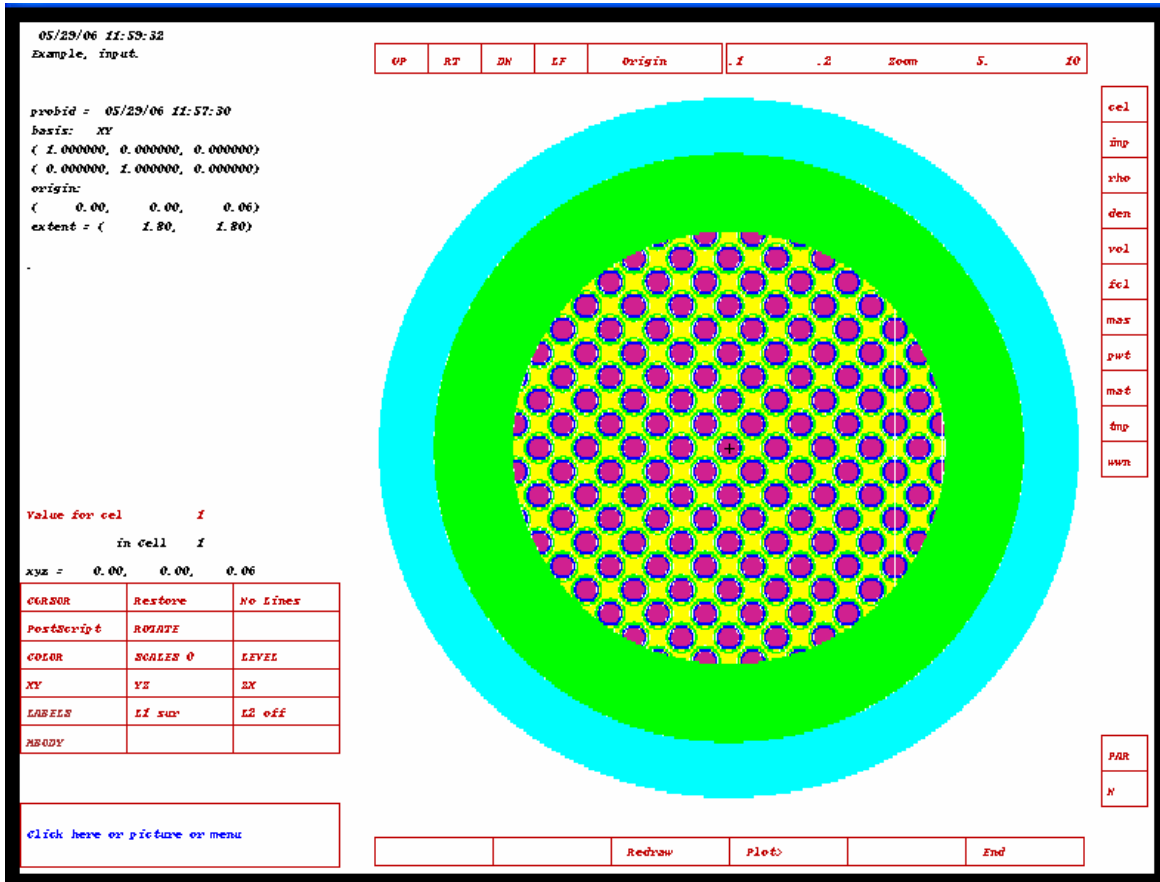
for SiC clad thickness as 0.2 cm in the fuel element and fuel zone radial diameter of $r = 1.1$ cm

$$R = 1.1 \text{ cm}$$

(Section at $r = 0$ cm)



(Section at $r = 0.06$ cm)



(Section at $r = 0.12$ cm)

