Monte Carlo Calculations of Neutron Spectra on Irradiation Channels of RA-6 Reactor New Core in Function of Burnup at 1 MW

Francisco Leszczynski

CAB-CNEA-ARGENTINA

General Data of RA6 new core

- Thermal Power: Up to 3 MW (first stage: 1 MW).
- Fuel Elements:

  Type MTR

  19 fuel plates normal fuel elements

  15 fuel plates control fuel elements

  Control plates of Ag-In-Cd with stainless steel cladding.

  Material of fuel plate: U3Si2-Al alloy.

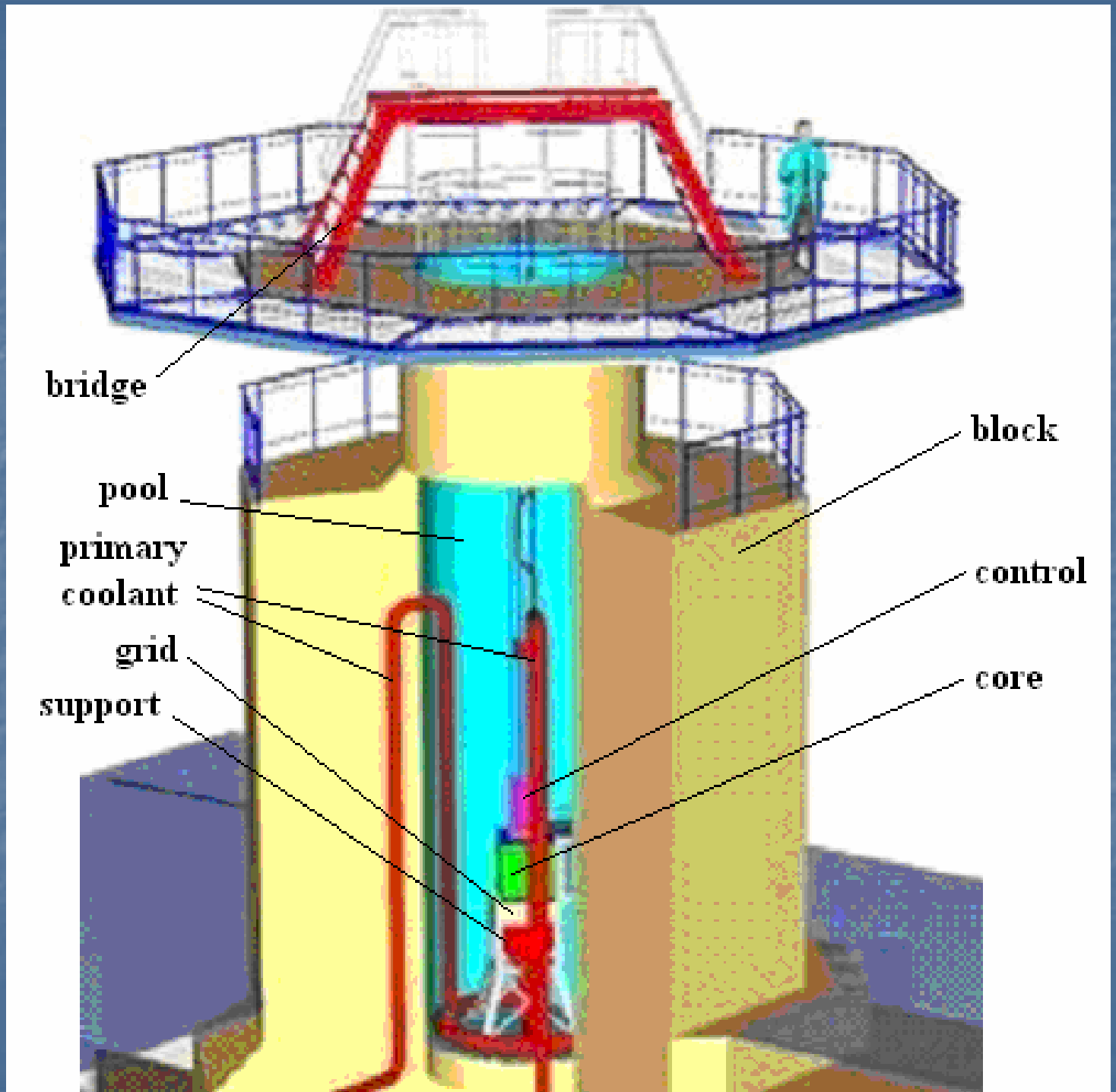
  Dimensions of the meat: 0.052 cm x 6.0 cm x 61.9 cm.

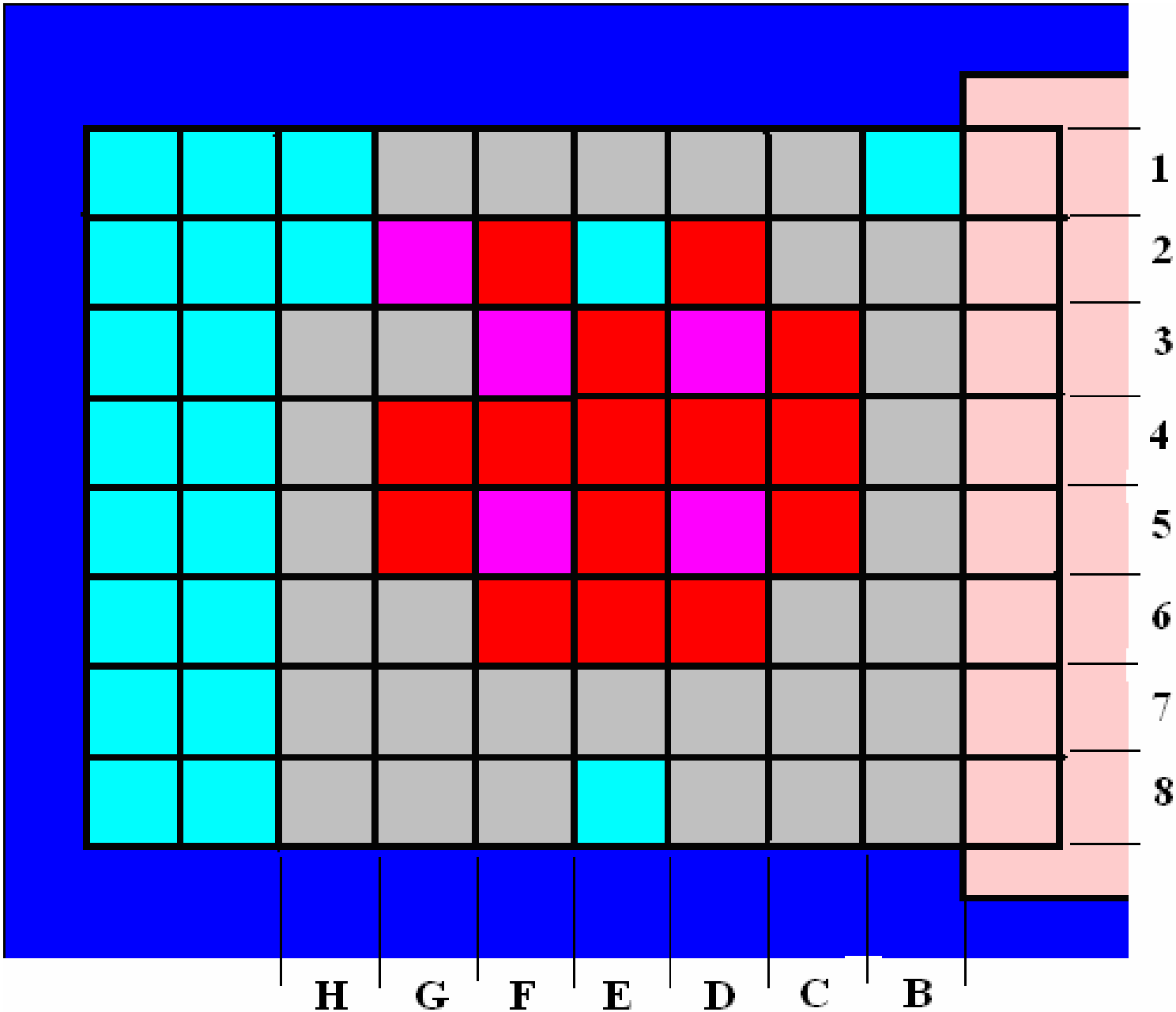
  Enrichment:19.70 w/% U-235

  Material of fuel plate clad, frames and other support components: Al-6061.

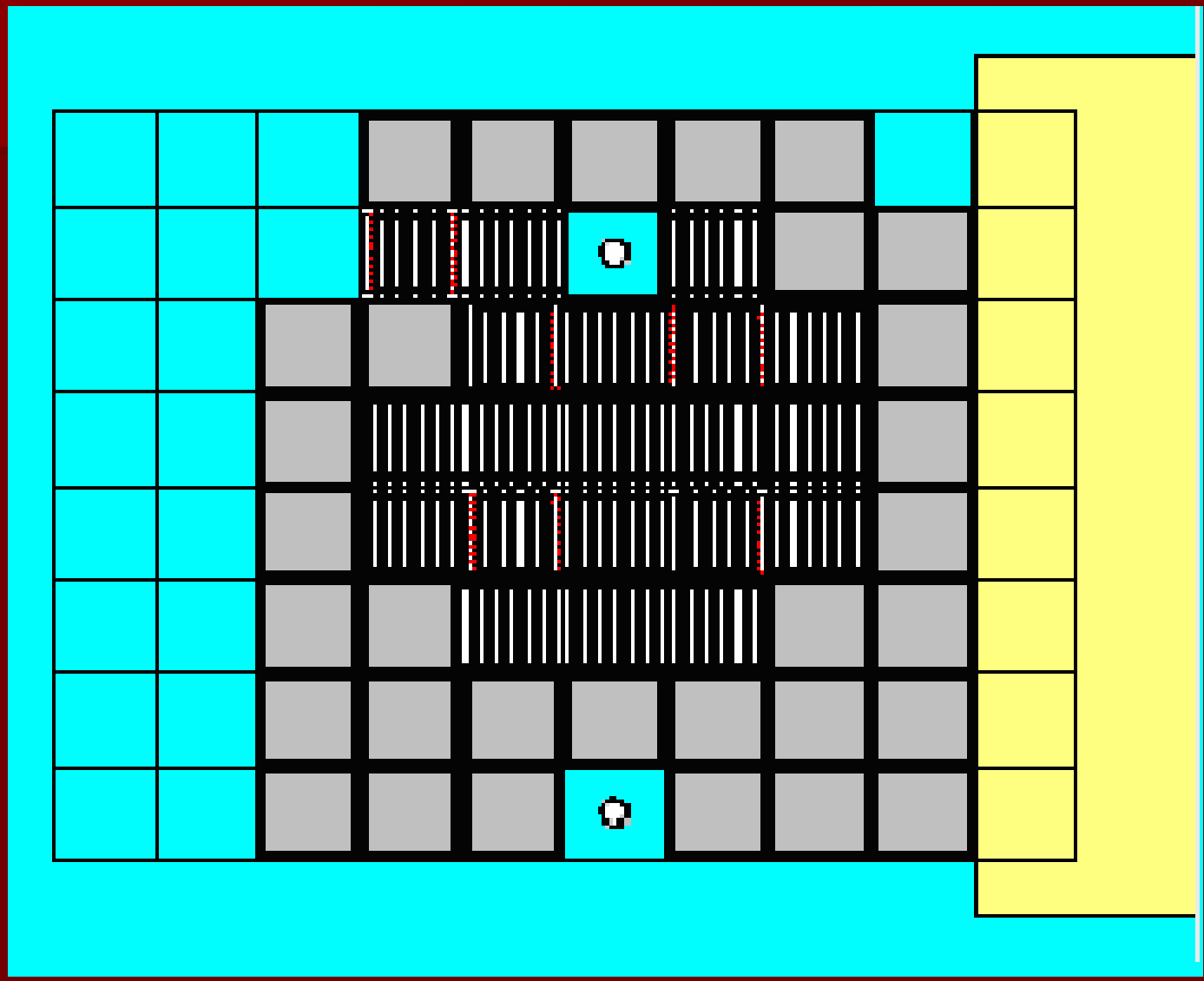
  The frames contain Cd-wires for reactivity reduction of fresh core to acceptable levels.
- Moderator/Coolant/ Reflector:

  Demineralized H20 (and Graphite as reflector in boxes with Al walls).

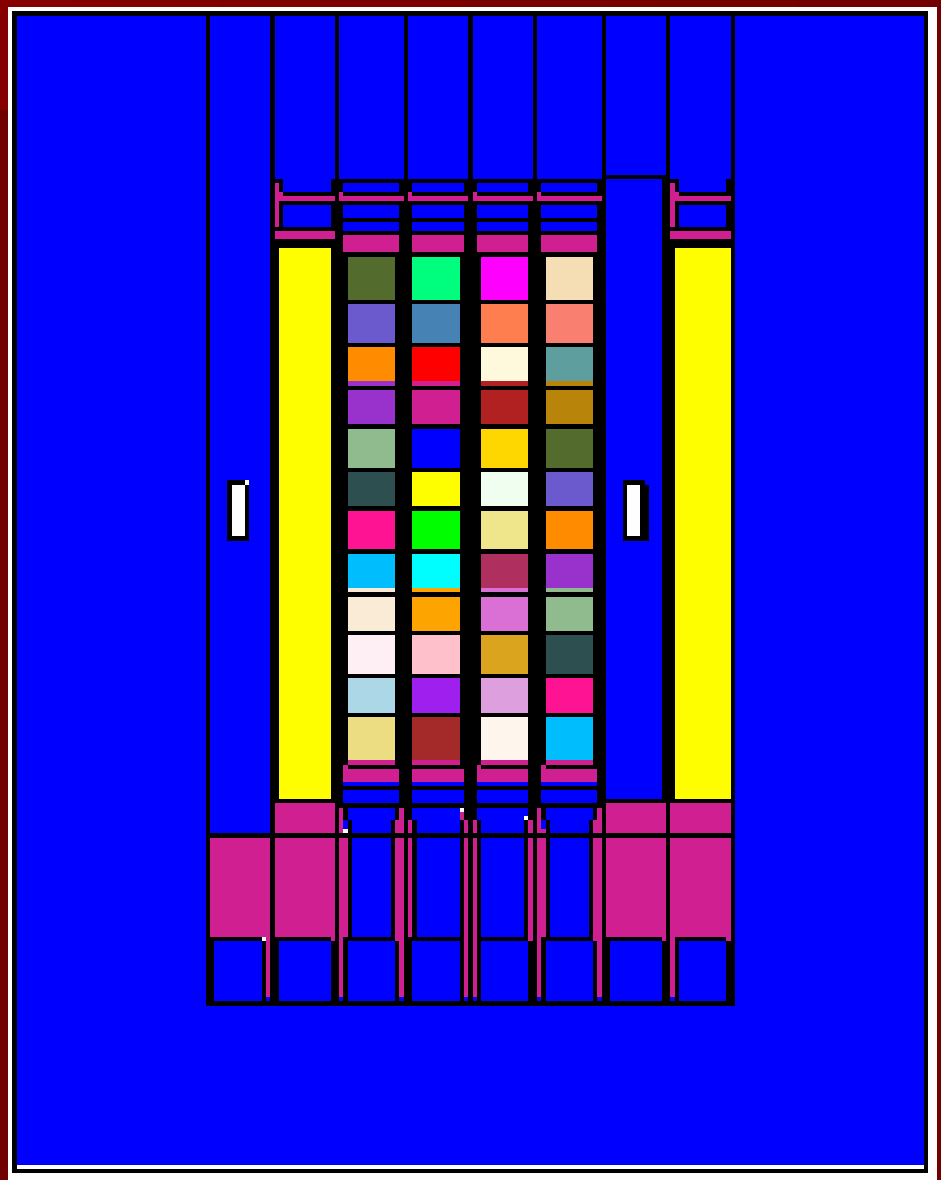

bridge
block
pool
primary
coolant
control
grid
core
support


1
2
3
4
5
6
7
8
H
G
F
E
D
C
B

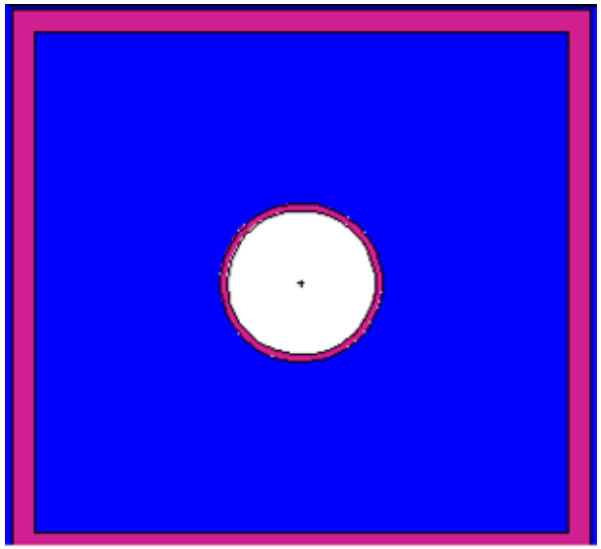
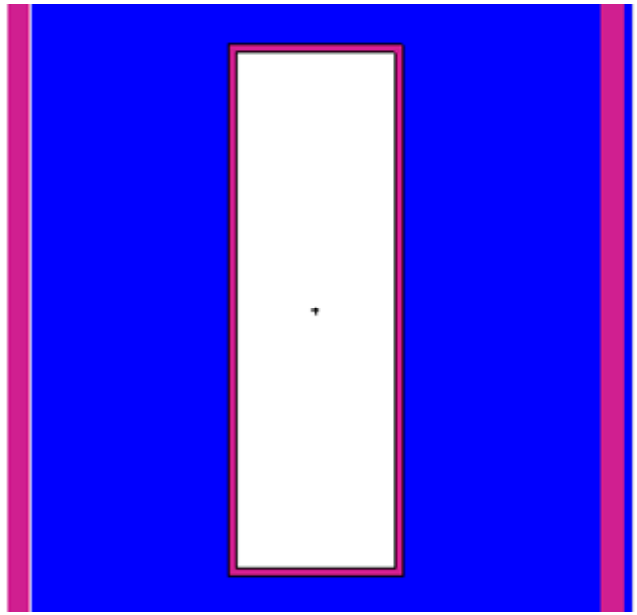
Horizontal Section of MCNP5 Model of RA6 Core



Vertical Section of MCNP5 Model of RA6 Core



Cylinder of Al for Neutron Spectra Calculation with MCNP5

	
Horizontal Section	Vertical Section

METHODS FOR MONTE CARLO CALCULATIONS WITH BURNUP

- Mtethod 1: point XS - Power, Flux and RR

  Coupling with ORIGEN code

  Isot.concentrs.for each byrnyp step

- Mtethod 2: point XS – Power distr.

  Coupling with DRAGON cell

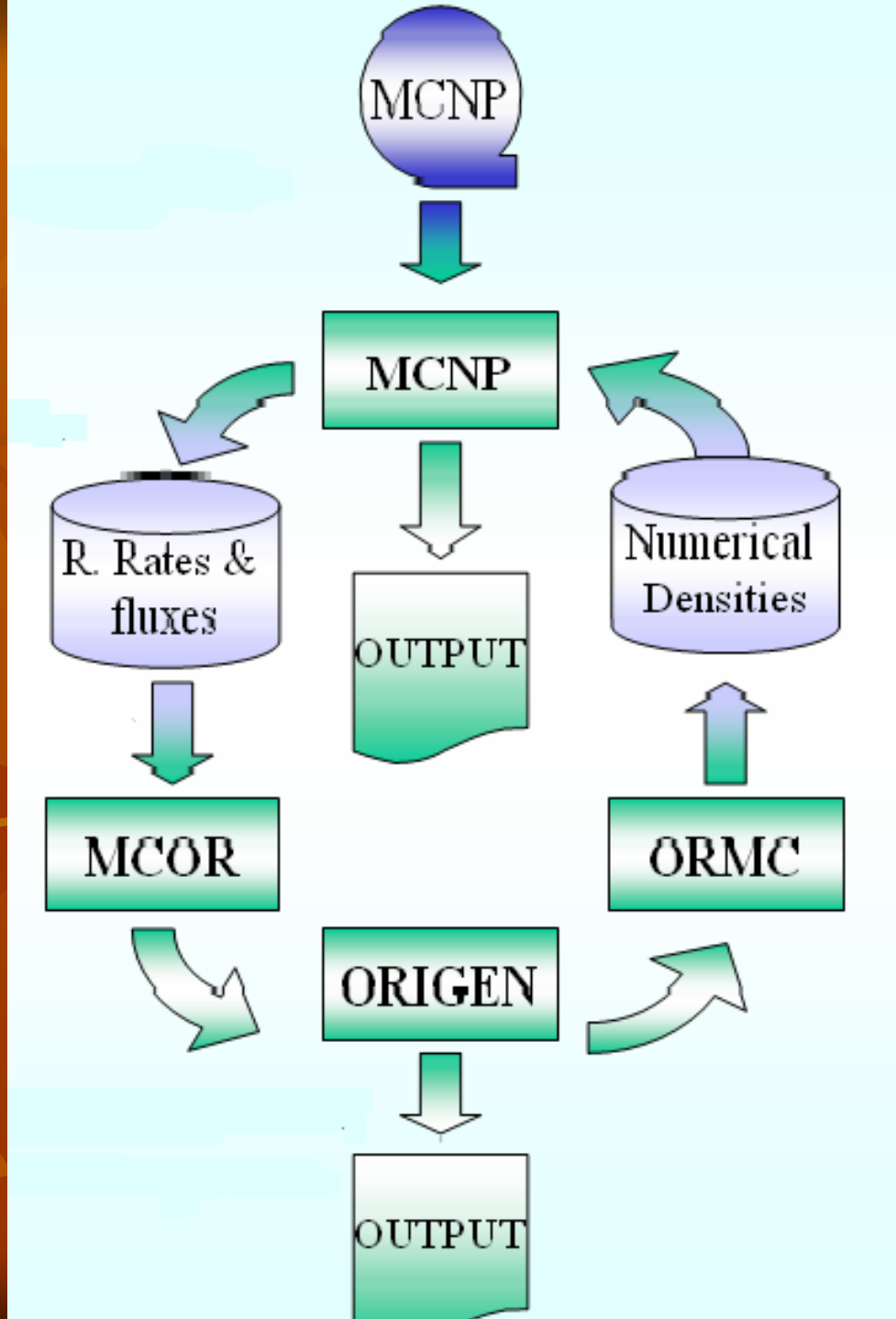
  Isot.concentrs. vs.burnup results (cell)

- Mtethod 3: Multigroup XS – Power distr.

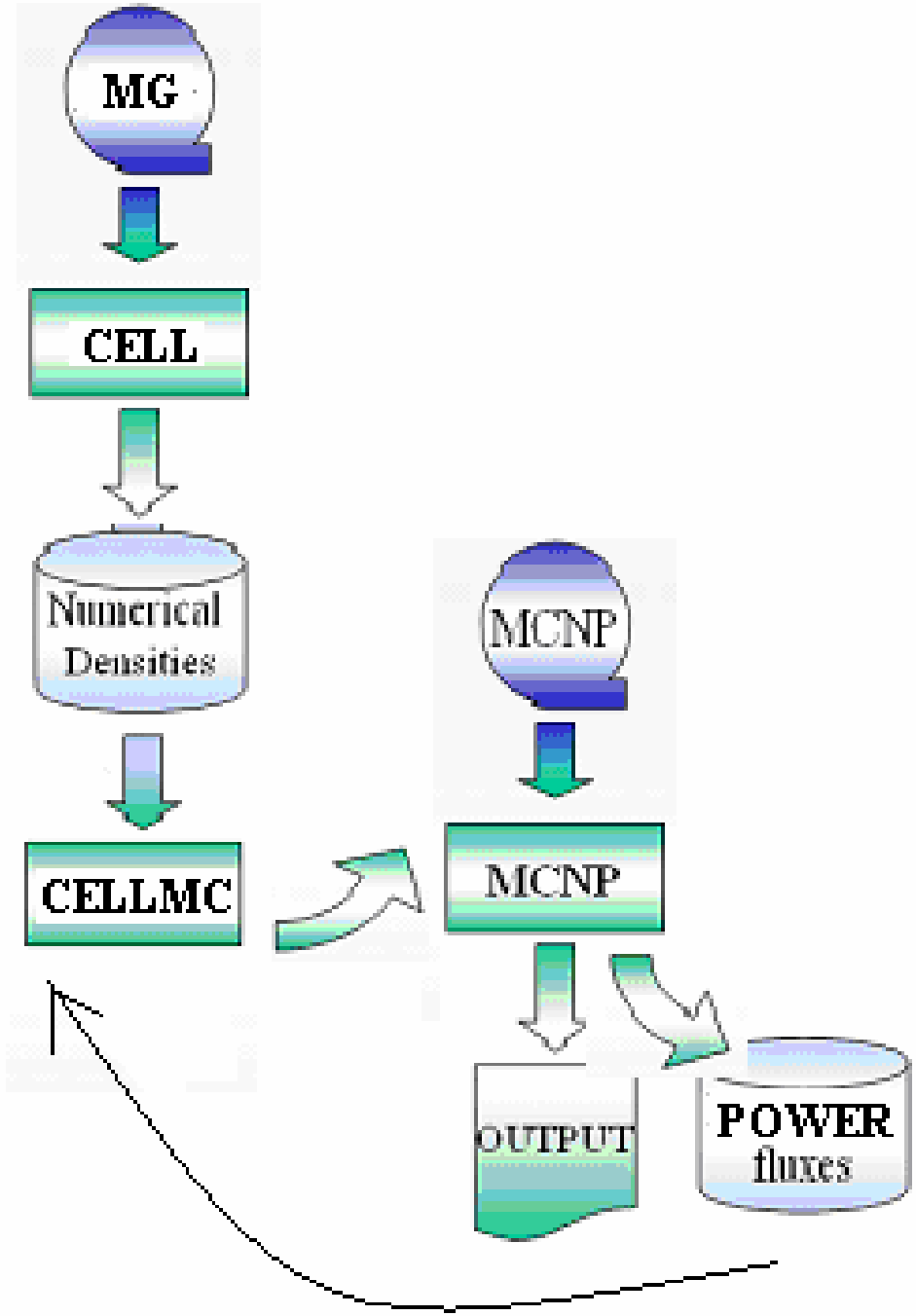
  Coupling with DRAGON cell

  Multigroup XS vs.burnup results (cell)

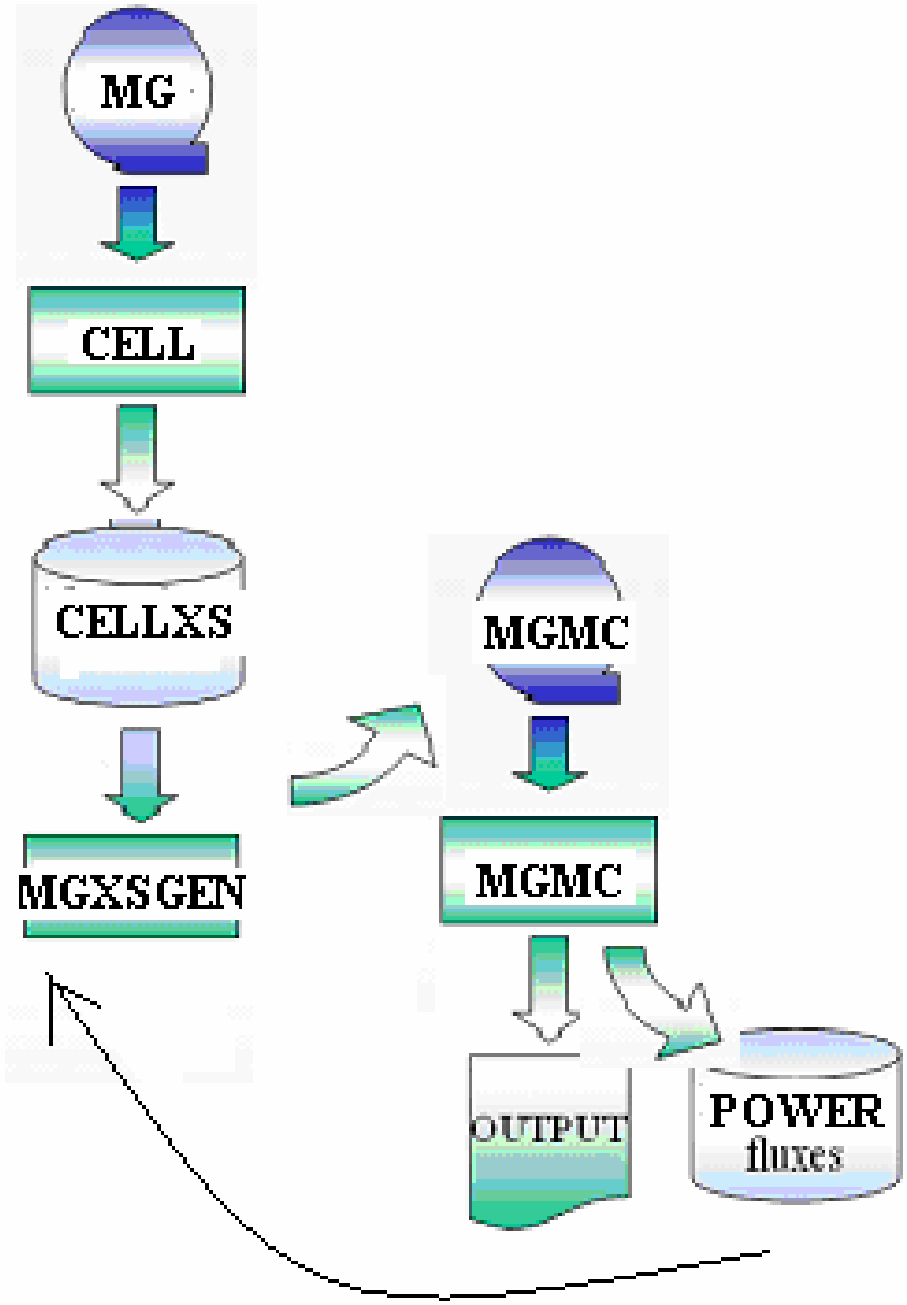
Method 1


MCNP
MCNP
R. Rates & fluxes
OUTPUT
Numerical Densities
MCOR
ORMC
ORIGEN
OUTPUT

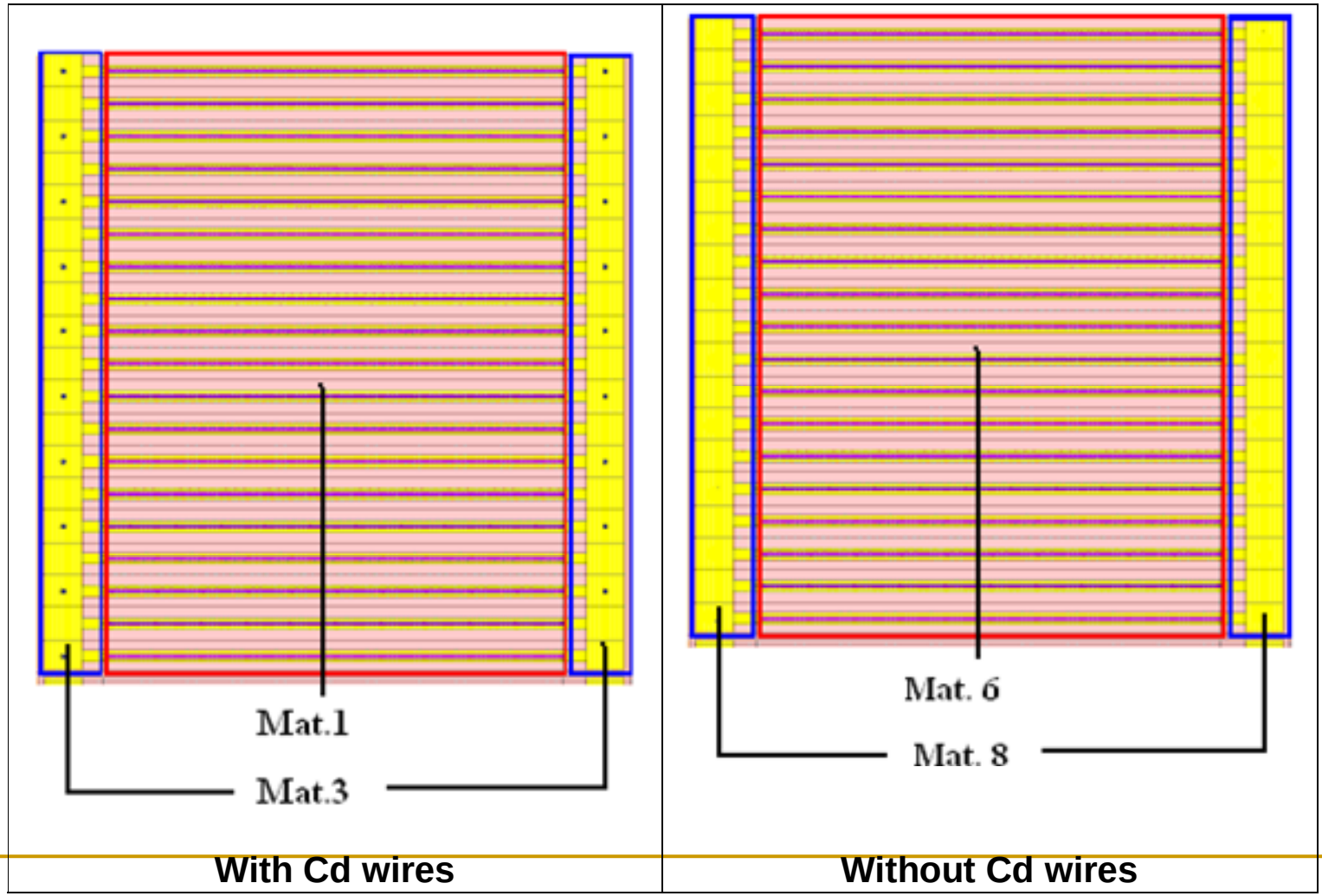
Method 2


MG
CELL
Numerical Densities
CELLMC
MCNP
MCNP
OUTPUT
POWER fluxes

Method 3

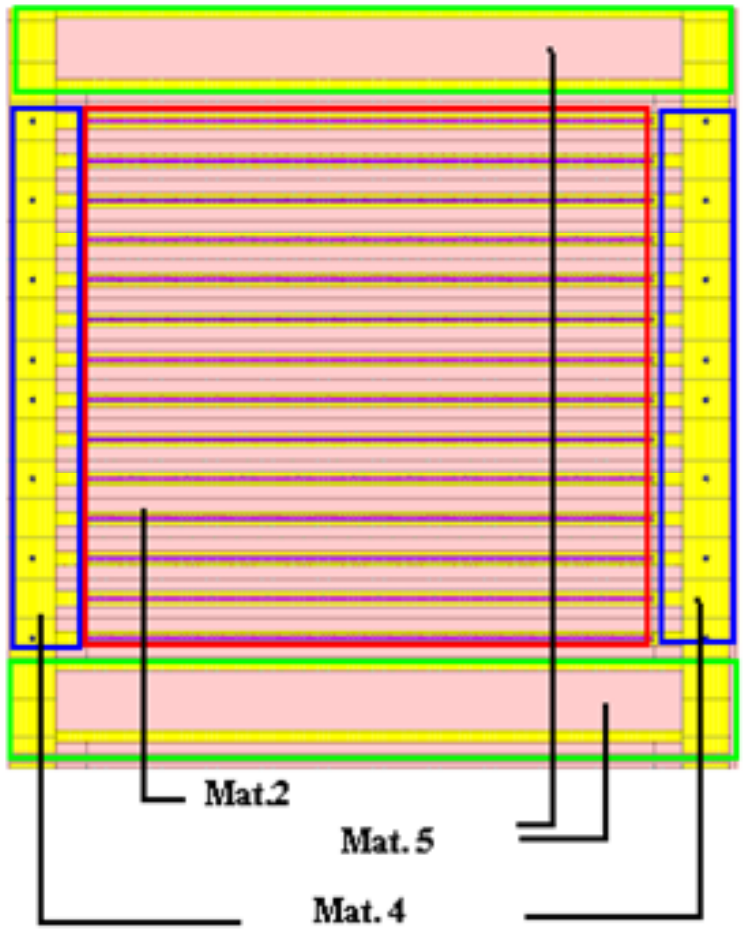


Normal Fuel Element Horizontal Sections

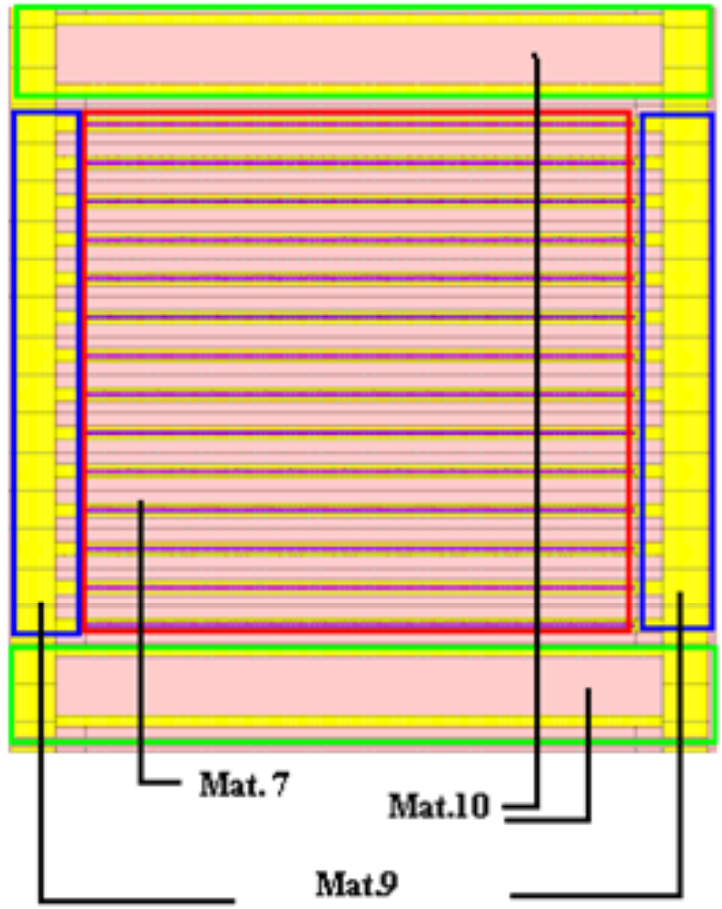


With Cd wires | Without Cd wires

Control Fuel Element Without Control rods - Horizontal Sections

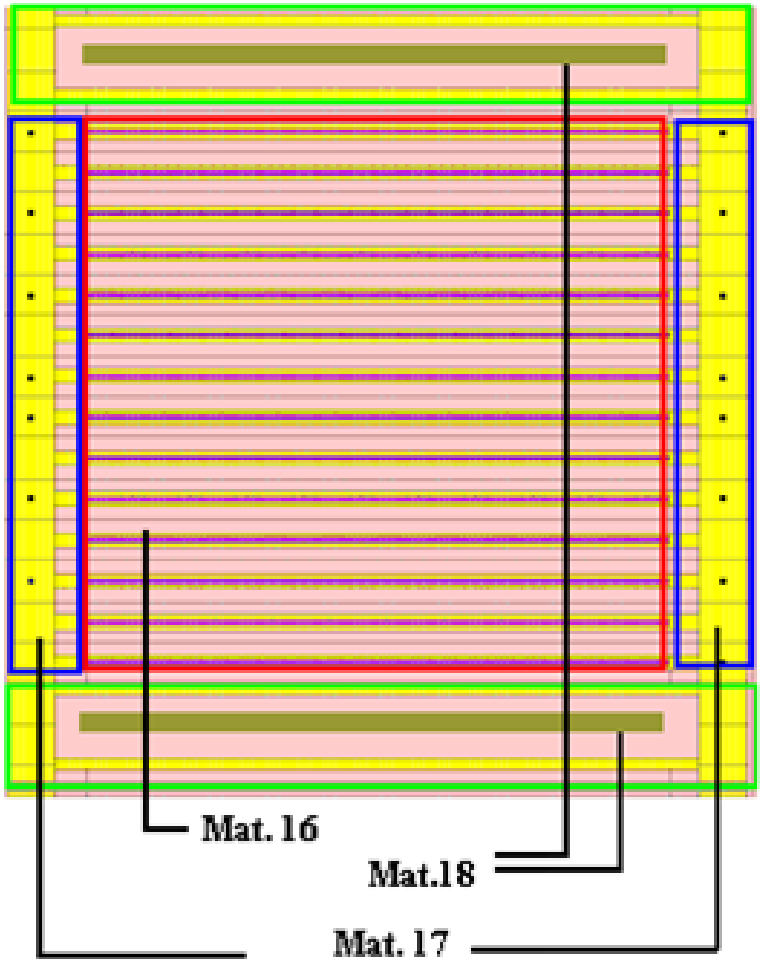


With Cd wires-Without control rod

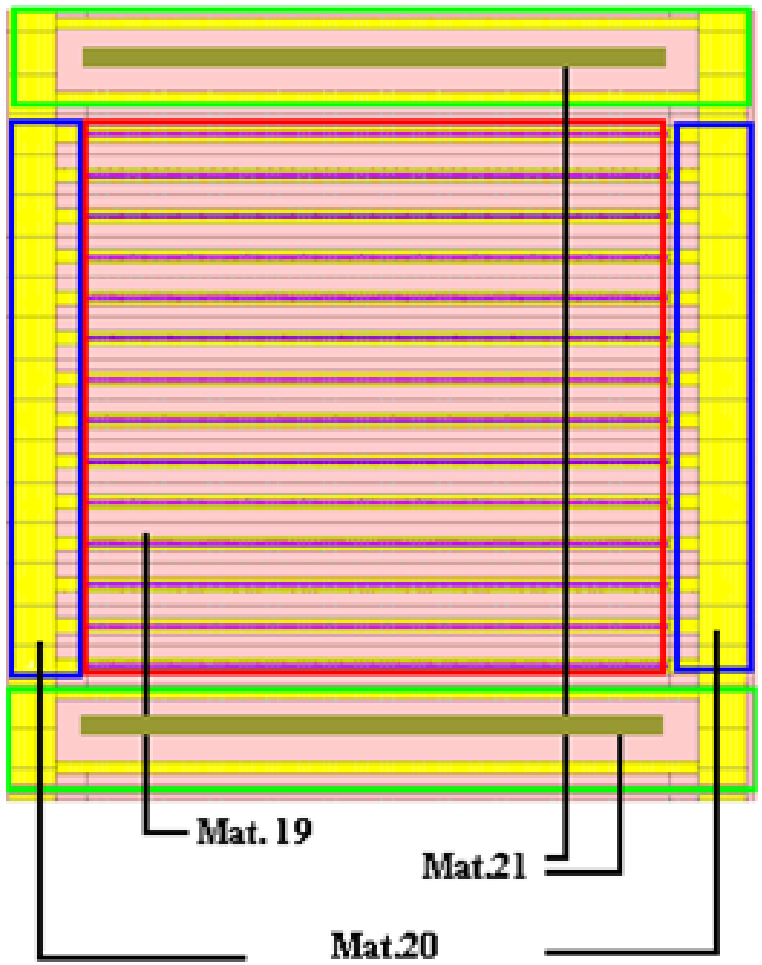


Without Cd wires-Without control rod

Control Fuel Element With Control rods Horizontal Sections



With Cd wires-With control rod



Without Cd wires-With control rod

Integrated Neutron Flux at 3 energy ranges

SP1 (E2 channel)

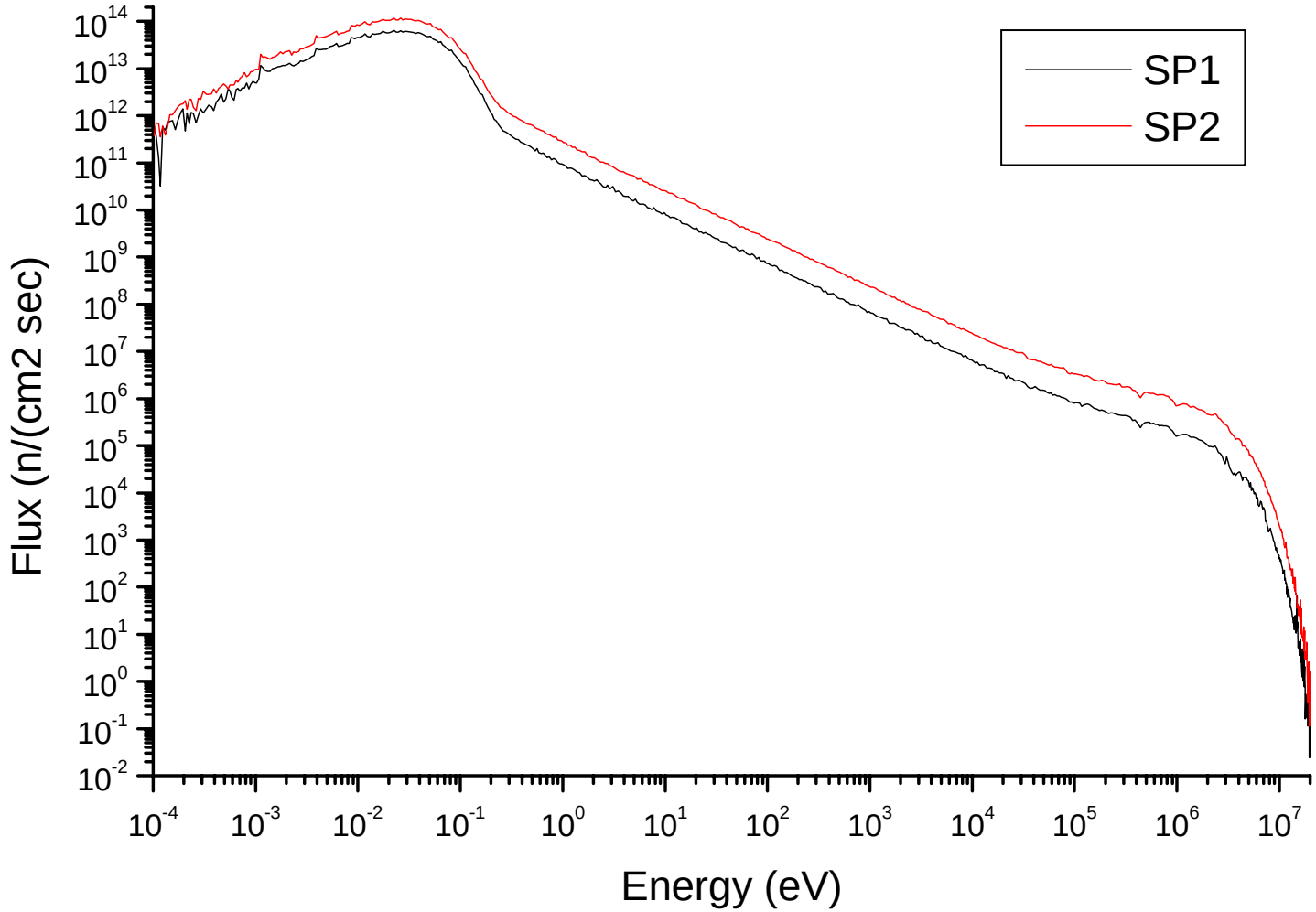
Case	F(0-.5eV) (n/cm2seg)	R %	F(.5eV-.1MeV) (n/cm2seg)	R %	F(.1-10MeV) (n/cm2seg)	R %
0PUNT	8.460+12	2.0	3.113+12	2.5	2.737+12	2.6
0MG	8.413+12	2.5	3.168+12	3.0	2.678+12	3.1
D(M/P)%	-0.56		1.77		-2.16	
1H	8.368+12	3.3	3.182+12	4.1	2.678+12	4.2
12H	8.463+12	4.0	3.202+12	5.0	2.712+12	5.1
1D	8.589+12	3.9	3.265+12	4.8	2.743+12	4.9
2D	8.746+12	3.9	3.320+12	4.8	2.819+12	4.8
3D	8.731+12	3.9	3.302+12	4.8	2.800+12	4.9
4D	8.691+12	3.9	3.295+12	4.8	2.773+12	4.9
3 DAYS DEC	----------		----------		----------	
7D	8.371+12	4.0	3.167+12	4.9	2.681+12	5.0

Integrated Neutron Flux at 3 energy ranges

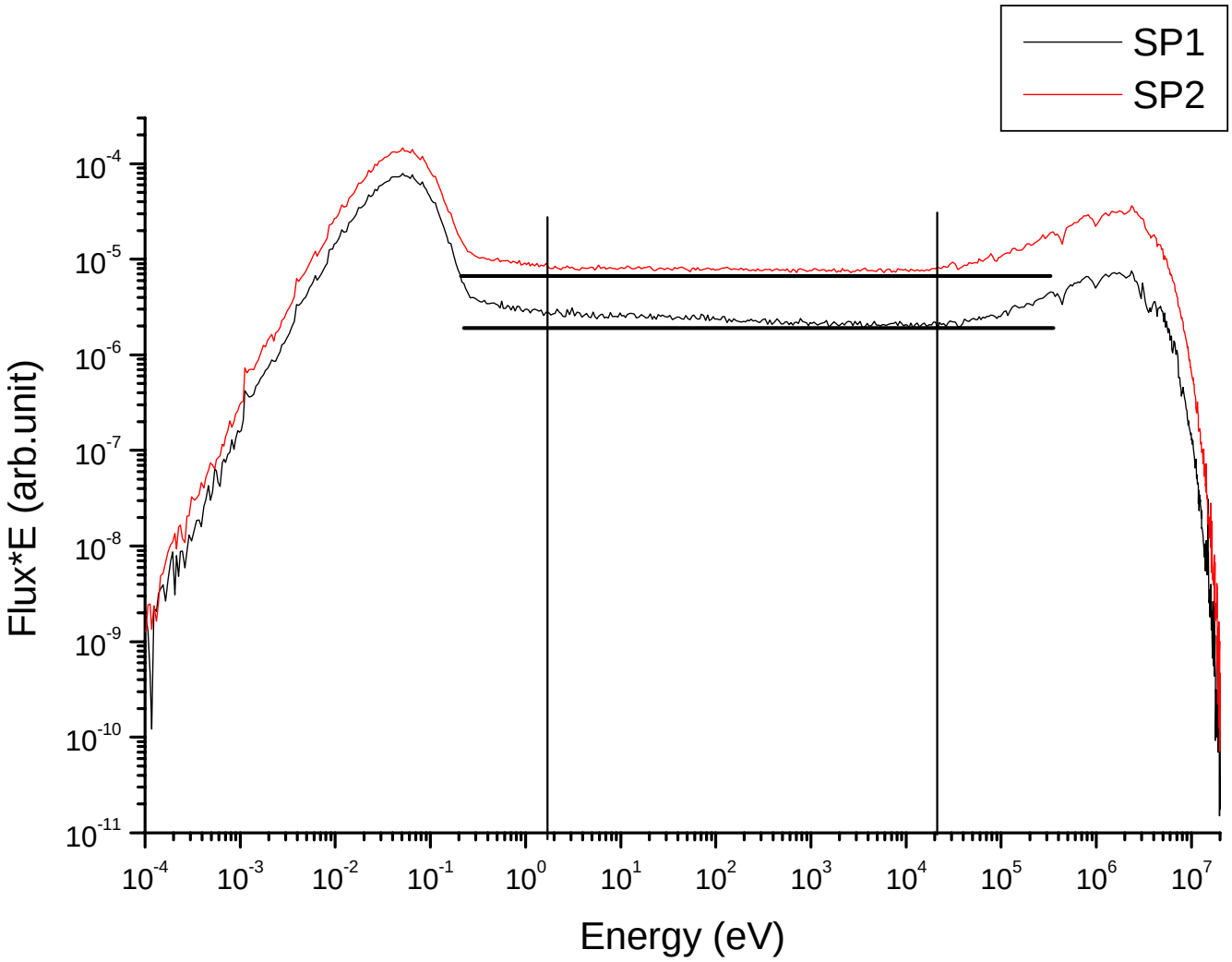
SP2 (E8 channel)

Case	F(0-.5eV) (ns/cm2seg)	R %	F(.5eV-.1MeV) (ns/cm2seg)	R %	F(.1-10MeV) (ns/cm2seg)	R %
0PUNT	4.518+12	2.5	9.152+11	4.0	6.060+11	4.5
0MG	4.492+12	3.3	9.413+11	5.5	6.219+11	6.3
D(M/P)%	-0.57		2.86		2.63	
1H	4.475+12	4.5	9.255+11	7.6	6.250+11	8.6
12H	4.535+12	5.4	9.554+11	9.0	6.124+11	10.5
1D	4.501+12	5.3	9.374+11	9.0	6.224+11	10.3
2D	4.484+12	5.3	9.312+11	8.9	6.238+11	10.2
3D	4.524+12	5.3	9.433+11	8.9	6.128+11	10.3
4D	4.503+12	5.3	9.330+11	8.9	6.312+11	10.2
3 DAYS DEC	----------		----------		----------	
7D	4.506+12	5.3	9.365+11	9.0	6.156+11	10.3

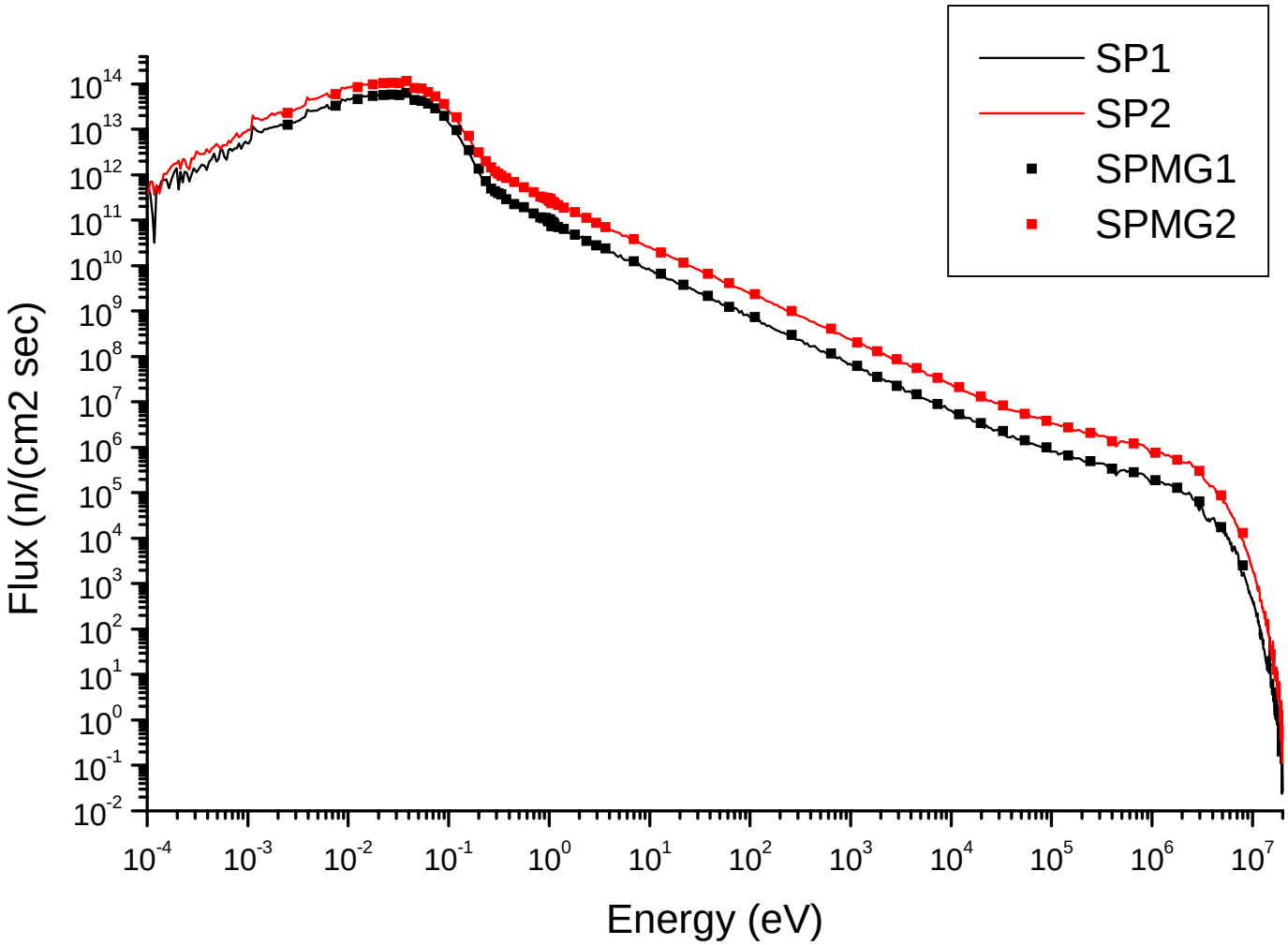
Detailed Neutron Spectra for Fresh Core



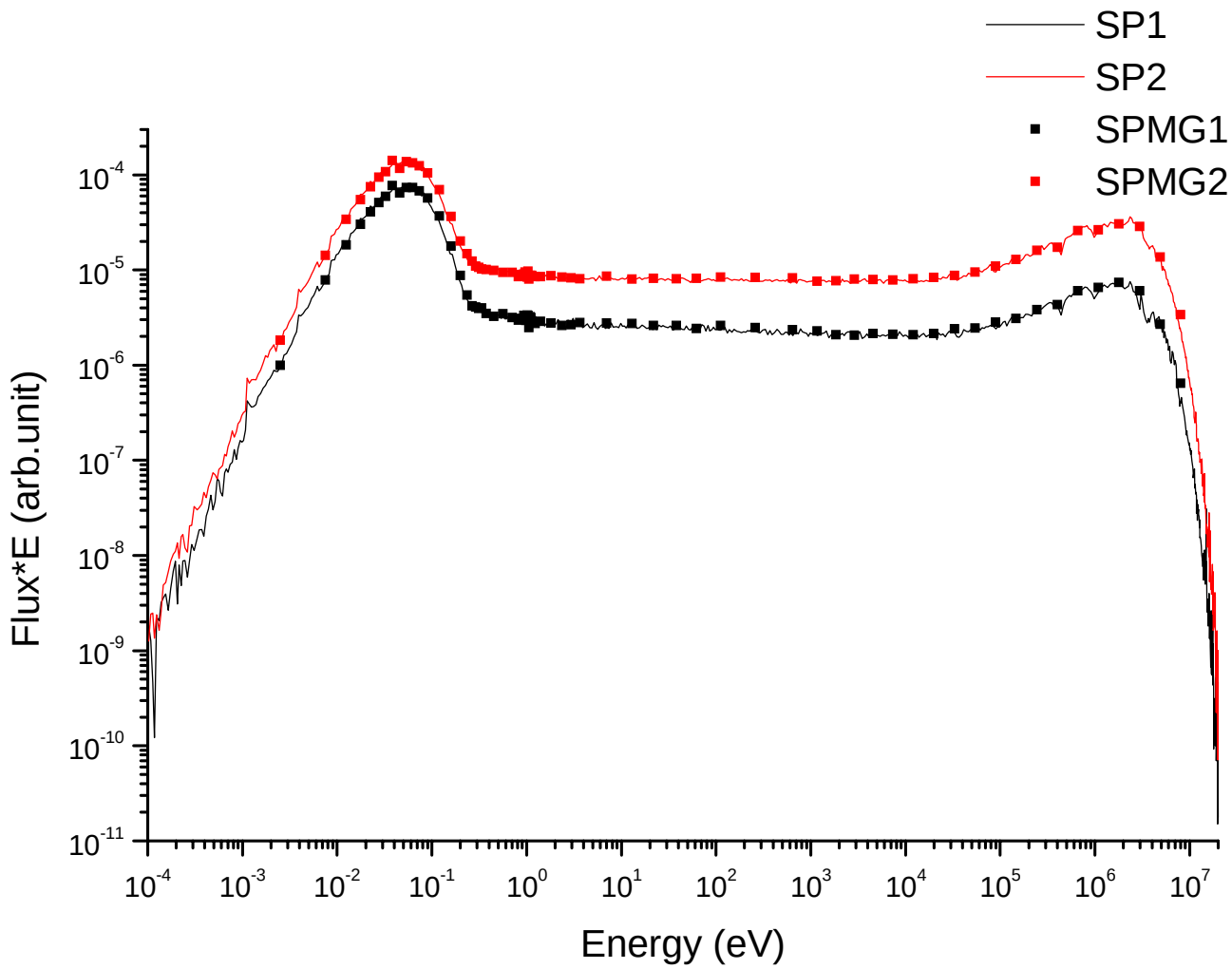
Detailed Neutron Energy Spectra for Fresh Core



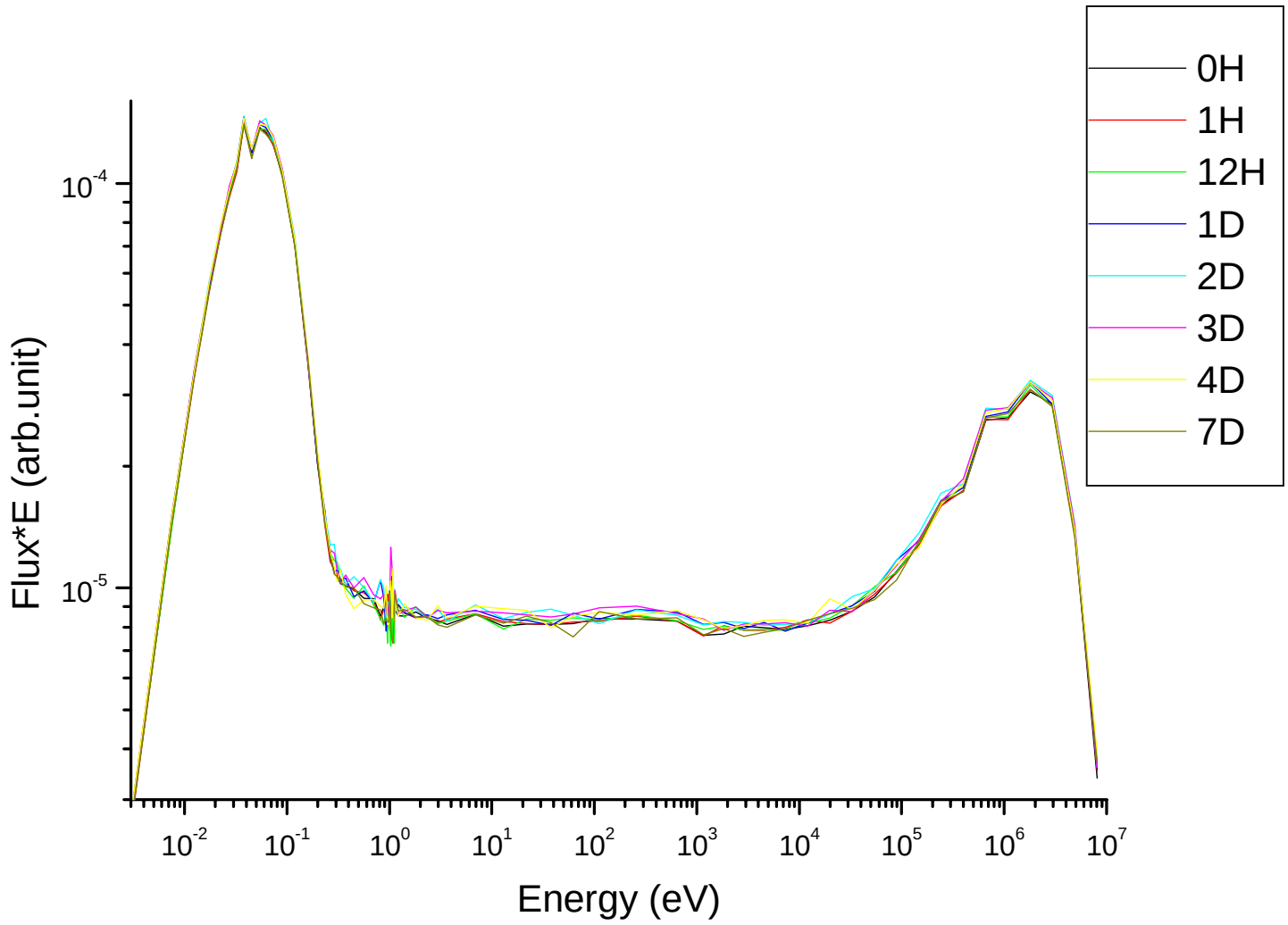
Detailed and multigroup Neutron Spectra for Fresh Core



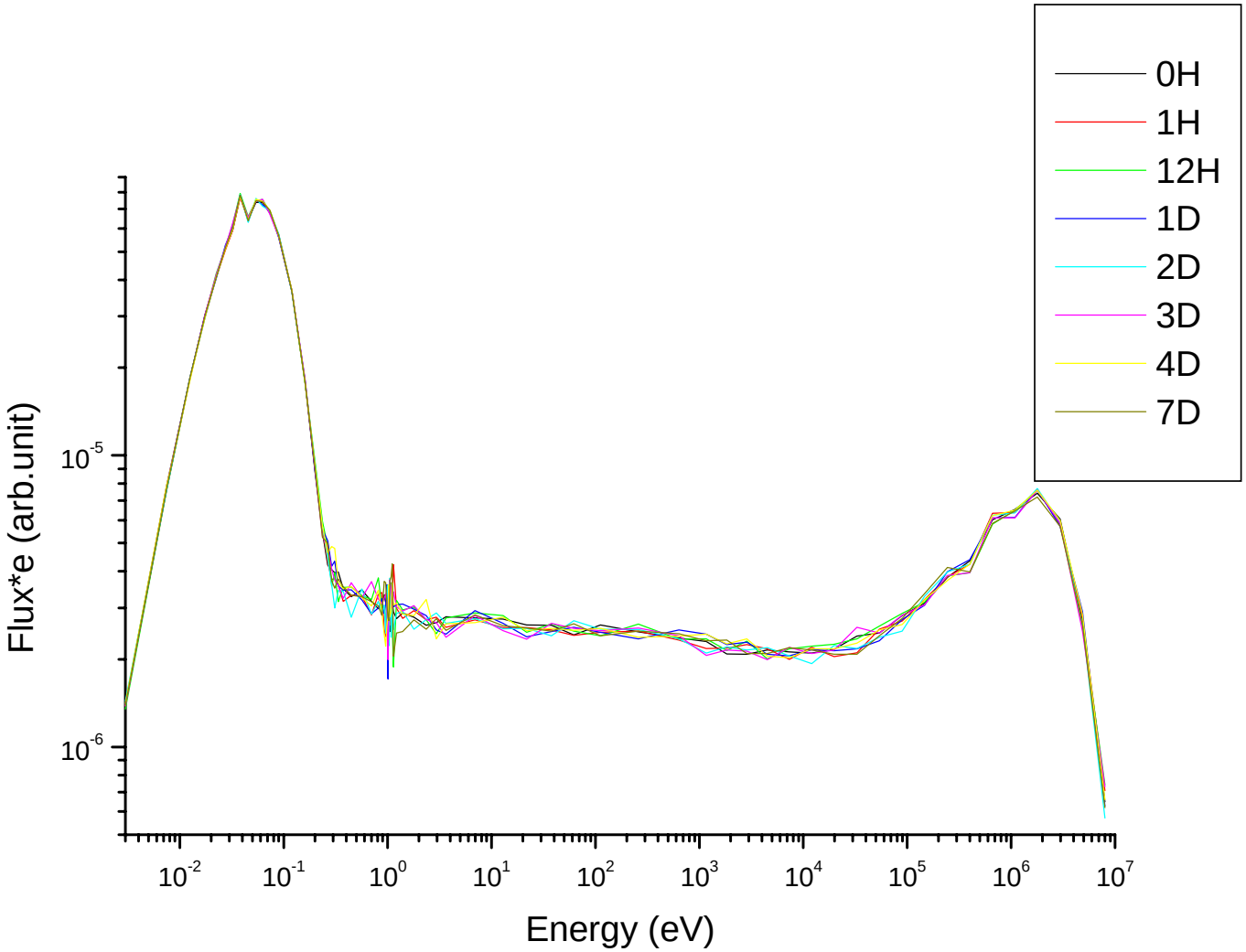
Detailed and multigroup Neutron Energy Spectra for Fresh Core



Multigroup Neutron Energy Spectra for 7 Burnup Steps on E2



Multigroup Neutron Energy Spectra for 7 Burnup Steps on E8



SUMMARY

- A new RA6 core will start its normal operation on next year (2009) with all fresh 20 % fuels and maybe also a raise of power from 500 kW up to 3 MW.
- On this report presented: a schematic diagram of the new RA6 core layout for Monte Carlo calculation model, a method for follow-up the changes introduced during burnup, and results of calculated neutron spectra and integral flux on three energy ranges at 2 typical irradiation facility positions.
- The main results of this work are:
- 1) A detailed model and methods for Monte Carlo calculations of the new RA6 core is ready for using on different applications, including spectra calculations on different spatial regions in function of burnup.
- 2) Results of neutron flux calculations in 3 energy groups at 2 irradiation positions and neutron spectra on 640 and 69 energy groups are ready for using on further analysis of analytical and calculated spectrum shapes.