Rapid Depletion Calculations Using ORIGEN-ARP

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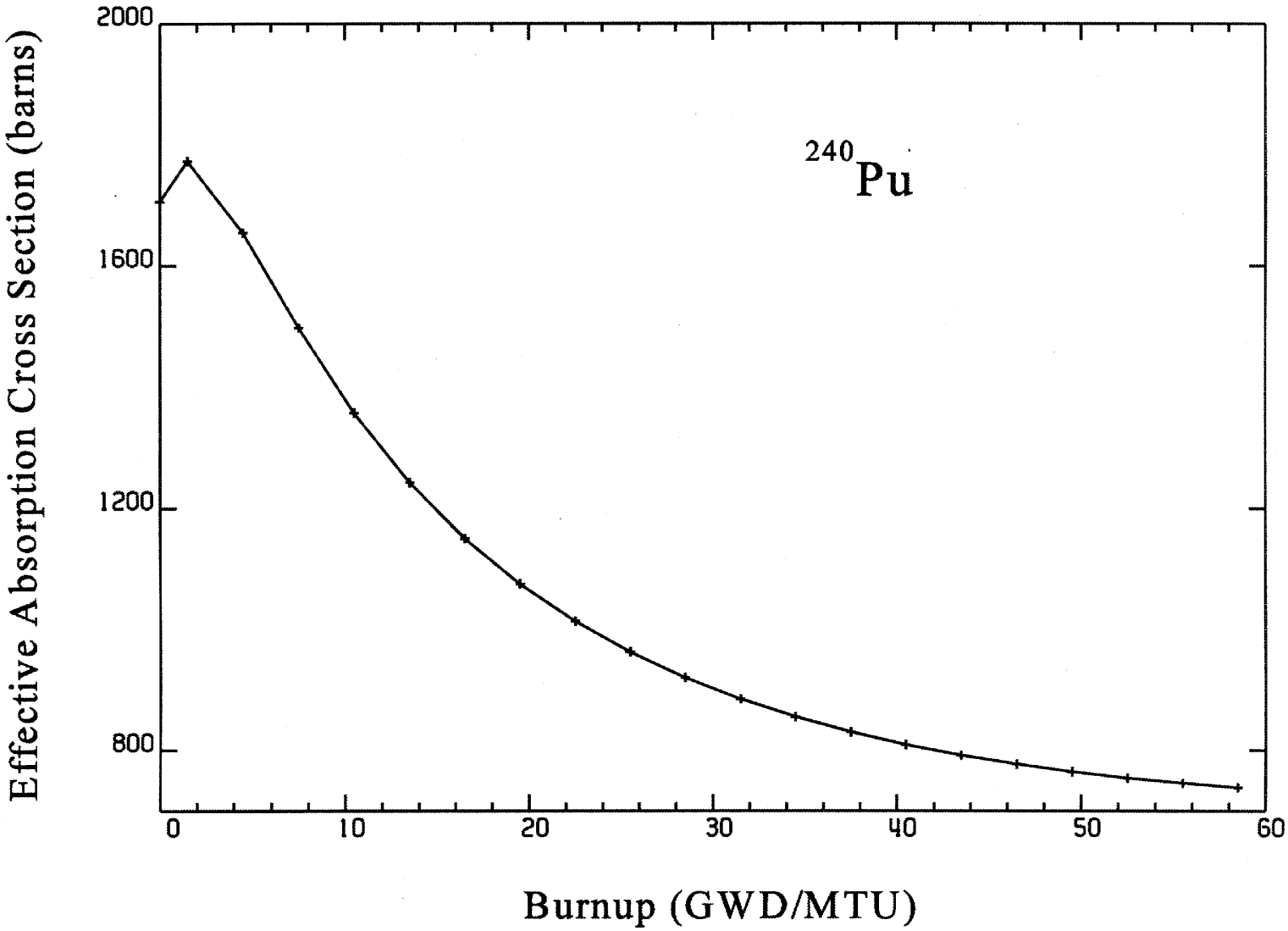
Background

- ORIGEN-ARP developed to address limitations in the ORIGEN2 Characteristics Data Base (CDB)
- Uses the SCALE depletion/decay module ORIGEN-S
  - Nuclide inventories
  - Neutron and gamma source terms and energy spectra
  - Decay heat
- Extremely fast method for calculation of spent fuel isotopics.
- Used in STARBUCS and REBUCS to perform automated, start-to-finish BUC calculations

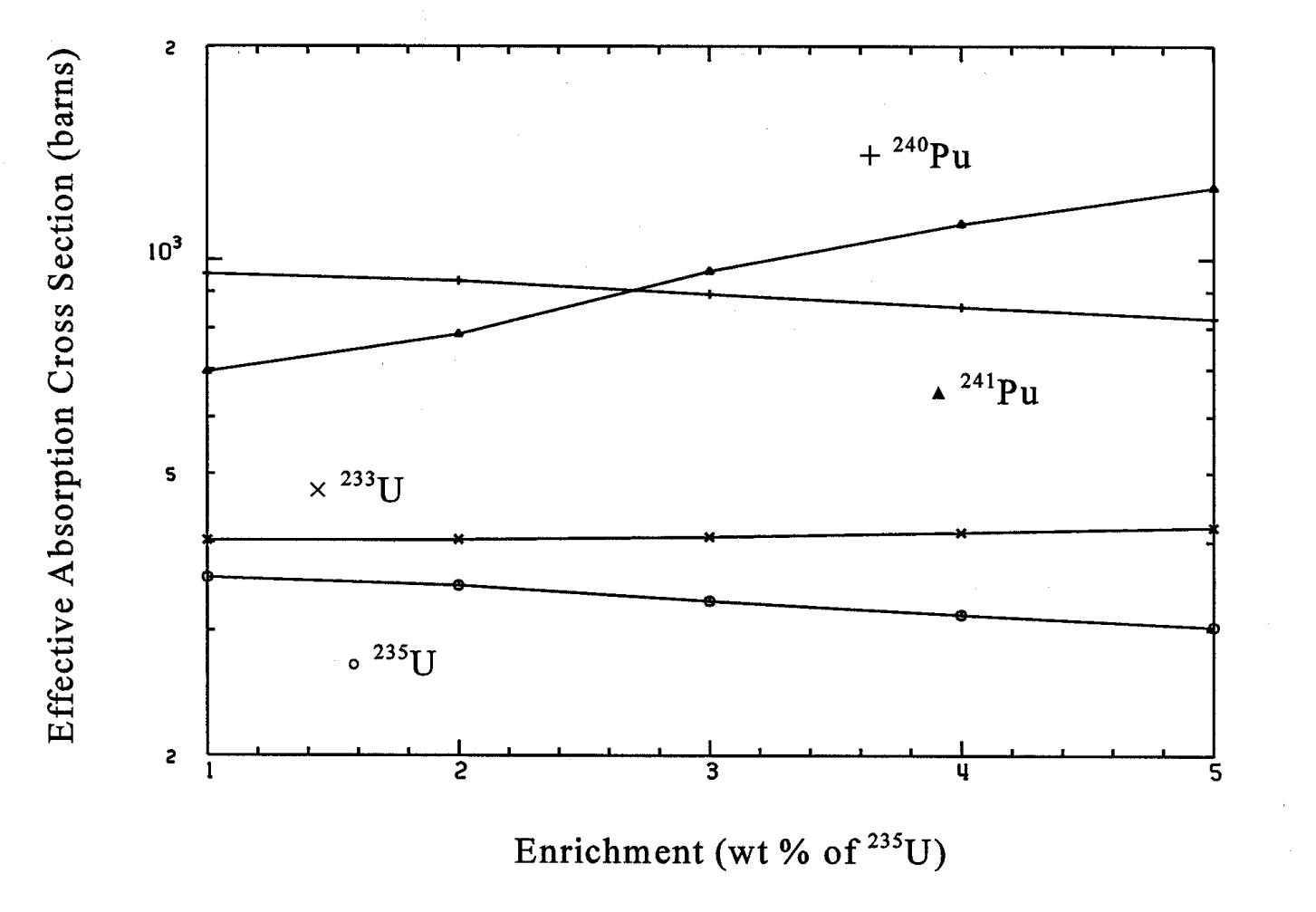
Background

- Generates problem-dependent cross sections for the burnup analysis using SCALE Automated Rapid Processing module (ARP)
- ARP generates problem-specific cross-sections by interpolating on database pre-generated for reactors of interest
  - different fuel designs, fuel materials
  - reactor configurations, operating conditions
  - burnable poison effects, control rods, etc.

^{240}Pu Absorption Cross Section vs Burnup



Variation of capture cross section with enrichment



ORIGEN-ARP

- SCALE sequence
- ORIGEN-ARP integrated with post-processor (OPUS) and plotting utility PlotOPUS.
- Multiple assembly cores require execution for each assembly:
  - Cross sections for each assembly type
  - Power level in assembly
- Work proceeding to expand available pre-generated repository of data – MOX, research reactors, etc.

ORIGEN-ARP Features

- ARP interpolates cross sections as a function of fuel enrichment, burnup, and moderator density (optional)
- Allows source term generation in 1 to 2% of the computing time using the SAS2H sequence
- Full accuracy maintained (validated using LWR spent fuel isotopic assays)
- Requires a set of pre-generated SAS2H/SAS2D libraries

The OrigenArp GUI

- Provides an easy-to-use Windows graphical interface to the ORIGEN-ARP sequence
- Also provides easy access to post-processing and data plotting utilities
  - OPUS (ORIGEN-S Post-processor Utility of SCALE) automatically extracts and ranks top nuclide data by importance
  - PlotOPUS Windows plotting program
- Note subtle and confusing name

OrigenArp GUI Features

- ORIGEN Express input feature allows source term calculations with only 5 input parameters: fuel type, enrichment, burnup, specific power, and downtime

- Detailed input option allows any irradiation history to be accurately modeled

How to Get ORIGEN-ARP

- SCALE users
  - Download OrigenArp GUI, OPUS, and PlotOPUS from SCALE website

  http://www.ornl.gov/scale

- ORIGEN users
  - Stand-alone ORIGEN-ARP package CCC-702 available from RSICC

OrigenArp Express Form

OrigenArp

File Edit View Window Help

Setup

Express Form

Plot Setup

NEW OPEN SAVE PRINT Help Run Output Plot Tables Editor Go to Detail

Title: North Anna 1 Cycles 5-7

Origen Express

Fuel Type: 14x14

Uranium (g): 1e+006

Enrichment (Wt%U235): 3.8 (1.5 to 5)

Burnup (MWd/MTU): 45000 (0 to 58500)

Cycles: 3

Libraries: 1 Per Cycle

Cooling Time: 5 Years

Moderator Density (g/cc): 0.7332

Power History

80% Up

Average Power: 39 MW/MTU

Save Scenario

Select Scenario

Apply OK CANCEL Reset Defaults Help

Ready

OrigenArp Detail Input: Compositions

OrigenArp - [Composition Data NorthAnna.arp]

File Edit View Window Help

Setup | Compositions | Neutron Groups | Gamma Groups | Case Data | Summary | Plot Setup

NEW OPEN SAVE PRINT Help Run Output Plot Tables Editor Origen Express

Enter composition data

Restart from existing data file

Units Grams

Compositions

Page 1

Total Uranium (grams) 1000000

Enrichment (Wt%U235) 3.8

Fuel Type 14x14

Moderator Density (g/cc) 0.733200

Set Enrichment

	Element	Isotope	Library	Concentration
1	U	234	Actinide	338.2
2	U	235	Actinide	38000
3	U	236	Actinide	174.8
4	U	238	Actinide	961487
5				
6				
7				
8				
9				
10				

OK | Apply | CANCEL | Clear | Help | Page Down

Ready

OrigenArp Detail Input: Neutron Groups

OrigenArp - [Neutron Energy Spectra NorthAnna.arp]

File Edit View Window Help

Setup | Compositions | Neutron Groups | Gamma Groups | Case Data | Summary | Plot Setup

NEW OPEN SAVE PRINT Help Run Output Plot Tables Editor Origen Express

Neutron Energy

Group Structure: 27GrpENDF4

- 22GrpStraker
- 27GrpENDF4
- 44GrpENDF5
- 47GrpBUGLE
- 218GrpENDF4
- 227GrpENDF5
- 238GrpENDF5
- 119Ultra
- Other
- None

Number of Groups: 27

OK | CANCEL | Clear | Help

Ready

OrigenArp Detail Input: Irradiation Case Data

OrigenArp - [Irradiation Case 1 NorthAnna.arp]

File Edit View Window Help

Setup | Compositions | Neutron Groups | Gamma Groups | Case Data | Summary | Plot Setup

NEW OPEN SAVE PRINT Help Run Output Plot Tables Editor Origen Express

Title: Cycle 1 -North Anna 1 Cycles 5-7

Basis: 1 MTU

Irradiation

Case # 1

Beginning Time = 0.0 Time Units: Days

Power(MW/Basis)	Cumulative Time	Save Results
39	38.46154	☐
39	76.92308	☐
39	115.3846	☐
39	153.8462	☐
39	192.3077	☐
39	230.7692	☐
39	269.2308	☐
39	307.6923	☐
39	346.1538	☐
39	384.6154	☐

Fill Form

Insert Delete

Output Options

OK Apply CANCEL Clear Help Previous Case Next Case

Ready

OrigenArp Detail Input: Decay Case Data

OrigenArp - [Decay Case 1 NorthAnna.arp]

File Edit View Window Help

Setup | Compositions | Neutron Groups | Gamma Groups | Case Data | Summary | Plot Setup

NEW | OPEN | SAVE | PRINT | Help | Run | Output | Plot | Tables | Editor | Origen Express

Title: Decay - North Anna 1 Cycles 5-7

Basis: 1 MTU

Decay

Case # 2

Beginning Time: 0.000000e+000

Time Units: Days

Time at which output is desired

Cumulative Time	Source Spectra	Save Results
0.01	☐	☐
0.03	☐	☐
0.1	☐	☐
0.3	☐	☐
1	☐	☐
3	☐	☐
10	☐	☐
30	☐	☐
96.15385	☐	☐
	☐	☐

(Alpha,n) Source: U02

(Alpha,n) Cutoff: 1e-005

Alpha Groups: 200

Bremsstrahlung: U02

Gamma Library: Total

☐ Print Neutron Source Calculation Details

Fill Form

Insert | Delete

Output Options

Element Fractions

OK | Apply | CANCEL | Clear | Help | Previous Case | Next Case

Ready

OrigenArp Plot Setup

PlotOPUS Case Input

Select Plot: 1

Add Plot | Delete

Case Type
- Decay
- Irradiation

Plot Type
- Nuclides
- Elements
- Gamma Spectra
- Total Neutron Spectra
- (Alpha, n) Reactions
- Spontaneous Fission

Case(s) to Plot: 6 Decay - Cycle 3 D

Output Units: Total Watts

Library Type

Curies
Bequerels
Kilograms
Atoms%
Wt%
Total Watts
Gamma Watts
Atoms/b-cm

Nuclides to Plot (Optional)

Available	Selected
Pu-239	Cs-133
Pu-240	Cs-134
Pu-241	Cs-137
Pu-242	Pu-239
Pu-243	Pu-240
Pu-244	Pu-241
Pu-245	Pu-242
Pu-246	
Ra-222	
Ra-223	
Ra-224	
Ra-225	

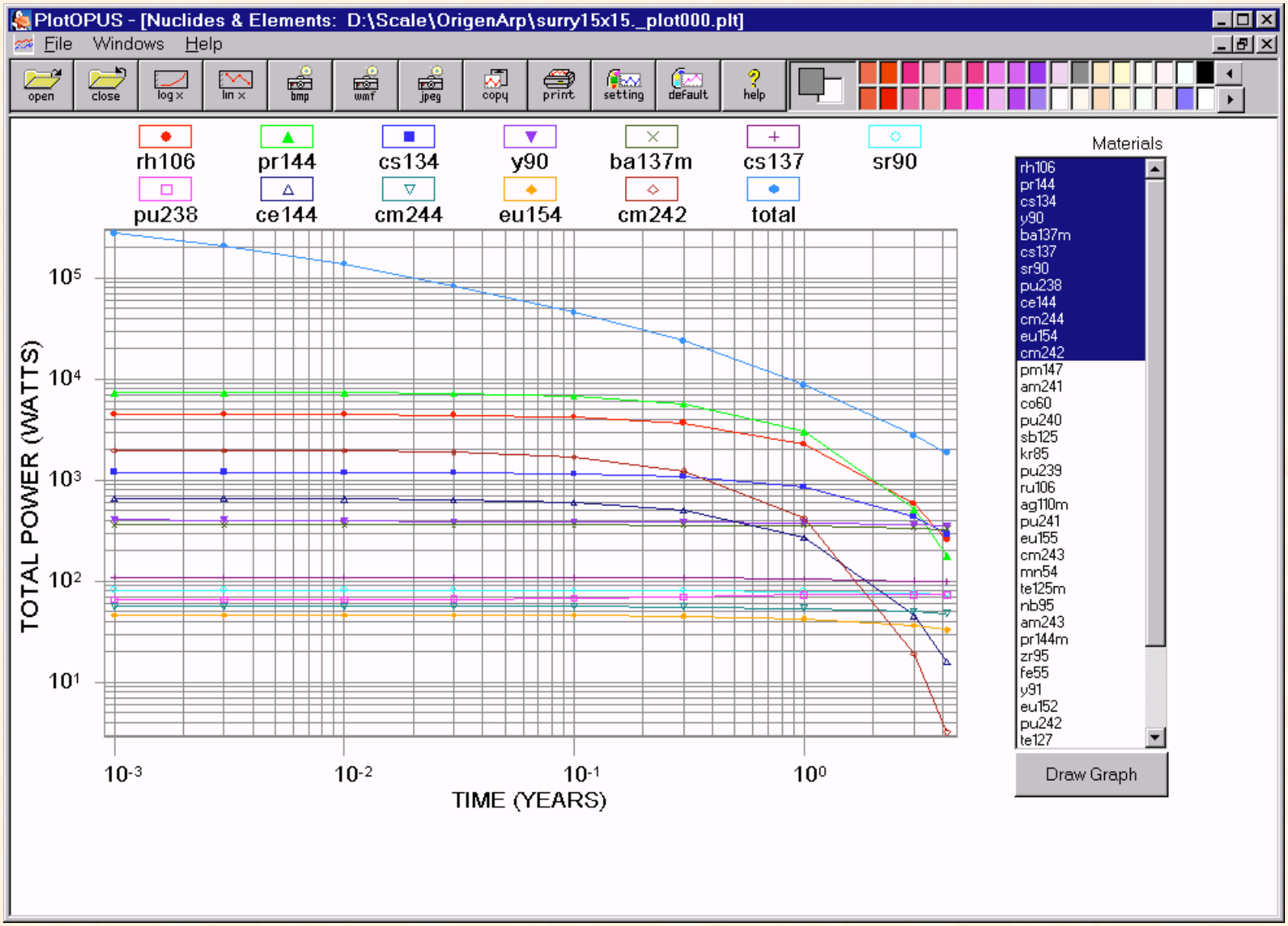
☑ Only plot selected nuclides

Clear | Help | OK | CANCEL

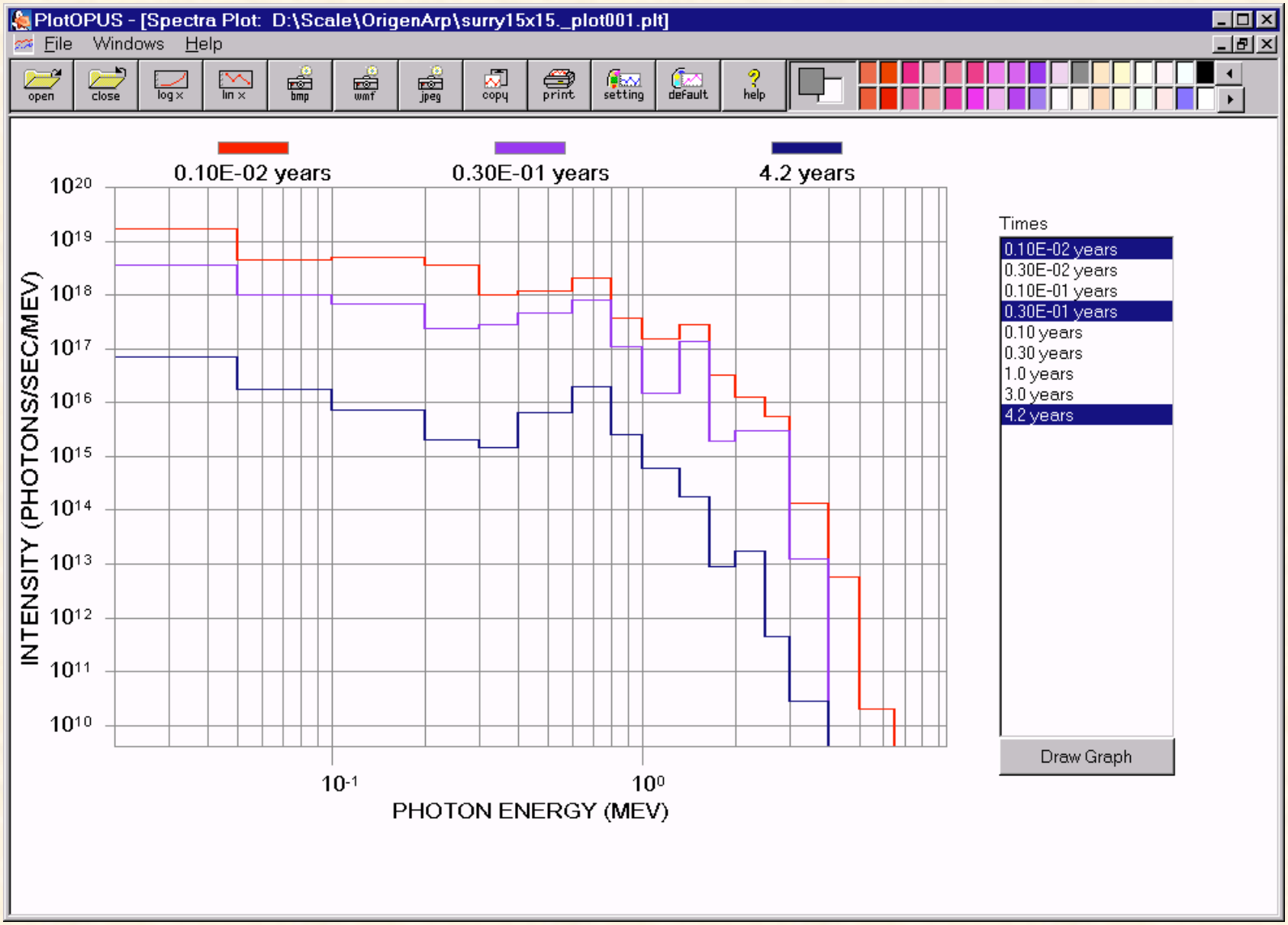
OPUS Capabilities

- Automatically extracts and ranks dominant nuclides or elements by importance, and/or user-selected nuclides
- Actinides, fission products, activation products, or combination of all nuclides
- Prints totals for all nuclides in group, and a subtotal for all nuclides selected
- 16 different units available, any time period of interest, power or decay times - extends capabilities of ORIGEN-S

PlotOPUS Decay Heat Plot



PlotOPUS Gamma Spectrum Plot



Th-th-th-that’s all, folks