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OBIWAN from A to Z

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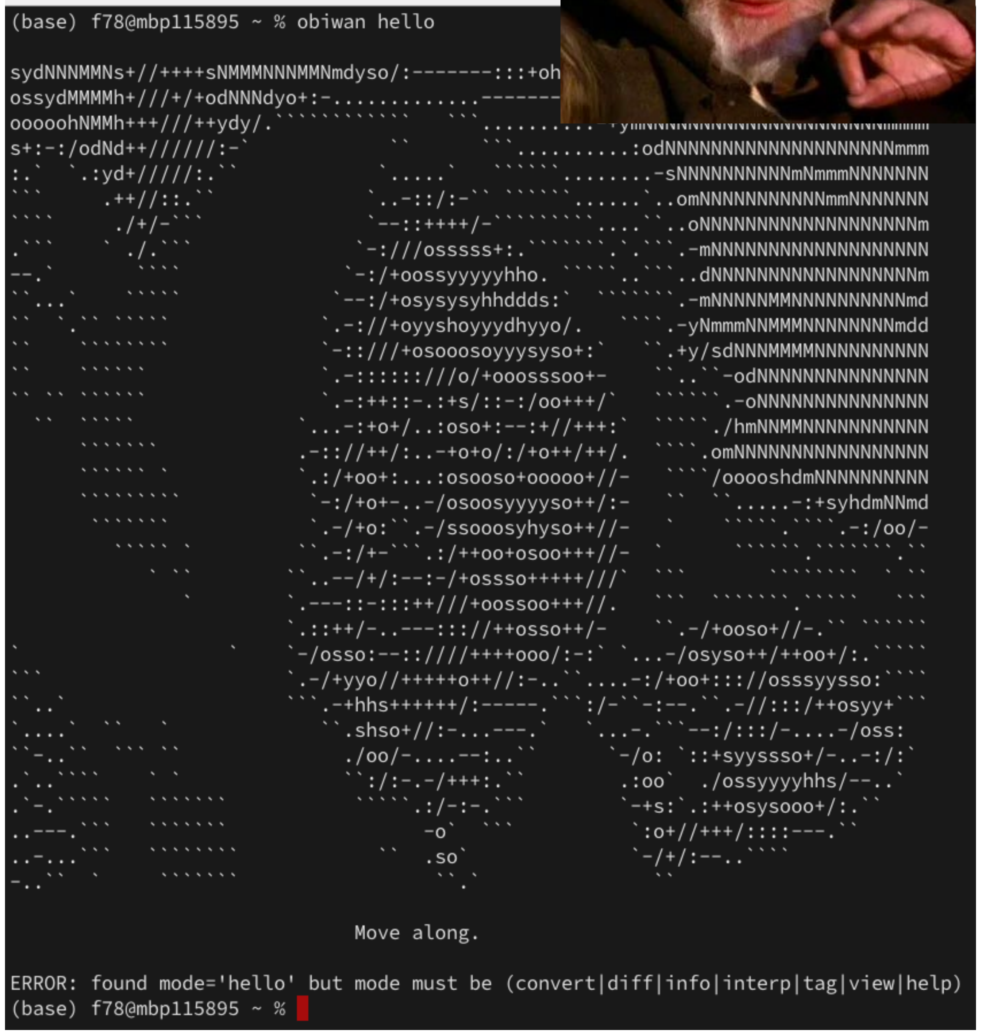
OBIWAN: "This **is** the tool you are looking for"

- **O**rigen **B**inary **I**nterrogation **W**ithout **A** scale i**N**put
- A command-line tool for viewing, manipulating, and converting ORIGEN binary files
- OBIWAN is typically invoked directly from the command line, **`${SCALE}/bin/obiwan`** or in a SCALE input inside an `=shell` block
  - But it's actually not that hard because OBIWAN provides help screens every step of the way



Can you see him???

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OBIWAN background and history

- Introduced as a “developer / power user” tool in SCALE 6.2
  - Fully functional, but not documented within the manual
- “Promoted” to a full member of the ORIGEN family (with documentation) as of SCALE 6.3

OBIWAN Modes

```
obiwan <mode> <options> FILE
```

Tip: Redirect STDERR to a log file: **`2>log`**

- **`info`** – print basic info about multiple files
- **`view`** – view a file
- **`tag`** – manipulate tags on a file
- **`convert`** – convert between versions of files
- **`diff`** – diff/compare two files
- **`interp`** – interpolate files
- **`patch`** – patch data in files

The following slides provide some of the most common or useful options for the different modes. Please see the manual or the help screen for all details.

OBIWAN operating modes & capabilities

convert

- Convert f33 libraries & F71 files between different SCALE formats (6.1 <=> 6.2+)

diff

- Compare two ORIGEN binary files

info

- View file metadata(e.g., # of positions, format, etc.)

interp

- Interpolate a file along tags or burnup values

patch

- Rewrite / "patch" data on an existing file

tag

- Introduce metadata onto a binary file (used for identification & interpolation)

view

Run obiwan two ways

1. From the command line, like any other command line utility, `/path/to/obiwan …`
2. From within a SCALE input `shell` block

```
=shell
${PGMDIR}/obiwan …
end
```

Running from the command line can be very powerful when combined with other command line utilities like `grep` or `awk` which are standard on Linux/Mac but SCALE also installs a version on Windows

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Viewing file contents: OBIWAN info & OBIWAN view

OBIWAN info: file metadata information

```
obiwan info [-type=TYPE] FILE
```

- Displays metadata about an ORIGEN binary file
  - Library (f33), StateSet / Concentrations (f71), Yield Resource (yld)
- **Example:** Display info for all w15_ assemblies in **${DATA}/arplibs:**

```
obiwan info [path to data]/arplibs/w15*
```

```
   fileName dataType numSets fileFormat fileType file/sysEndian appVersion
w15_e05.f33     Origen::Library      17 bof   binary  little/little      6.2.0
w15_e15.f33     Origen::Library      17 bof   binary  little/little      6.2.0
w15_e20.f33     Origen::Library      17 bof   binary  little/little      6.2.0
w15_e30.f33     Origen::Library      17 bof   binary  little/little      6.2.0
w15_e40.f33     Origen::Library      17 bof   binary  little/little      6.2.0
w15_e50.f33     Origen::Library      17 bof   binary  little/little      6.2.0
w15_e60.f33     Origen::Library      17 bof   binary  little/little      6.2.0
```

OBIWAN view: View binary file contents

```
obiwan view <options> FILE
```

- Offers several options for viewing the data in the file, with various output formatting options
- **View** works for many ORIGEN file types:
  - **Yield** and **Decay** Resource files (yld / dec)
  - **Library** files (.f33 / .arplib)
  - **StateSet** files (.f71)
- In general, one can view nuclide-wise information, select specific positions on the library or print information about all positions, change the formatting of the nuclide IDs, …

File types supported by OBIWAN –type=**xyz**

- **f71** "Origen::StateSet"
  set of time-dependent nuclide inventory, power/flux history, and other state information
- **f33** "Origen::Library"
  nuclide-to-nuclide transition data, e.g. decay constants and 1-group reaction cross sections
- **arc** "Origen::Archive"
  collections of multiple related libraries, e.g. ORIGEN library for specific assembly at two different moderator densities
- **yld** "Origen::YieldResource"
  fundamental fission product yield data
- **dec** "Origen::DecayResource"
  fundamental decay data
- **rct** "Origen::ReactionResource"
  fundamental reaction data

Most often we will view an F71 file

```
obiwan view <options> FILE.f71
```

-format=
info - information table (DEFAULT)
csv - comma-separated values
ii.json - inventory interface in JSON
tags - tags stored on each state

-units=
abso | fiss | capt | airm | apel | **atom** | becq | curi | gamw | gamm | gato | gper | **gram** | h2om | kilo | wpel | **watt** | mevs | part | inte | ener

-idform= String({:S}{:I}{:ZZZ}{:AAA})
{:S} - sublib integer
{:TY} - sublib name
{:I} - isomeric state integer
{:ZZZ} - up to 3 digits of atomic number (also Z, ZZ)
{:AAA} - up to 3 digits of mass number (also A, AA)
{:EE} - up to 2 characters elemental symbol (also Ee, ee)
{:M} - metastable indicator 'M' for first, 'M2' for second, etc. (also m)

DEFAULT with `-symbols=0` -> `-idform='{:S}{:I}{:ZZZ}{:AAA}'`
with `-symbols=1` -> `-idform='{:TY}:{:ee}{:AAA}{:m}'`

Example: `-idform="{:ee}{:A}{:m}"` leads to "Am-242m"

OBIWAN view: -format=csv -units=???

Atom & mass-based units

gato	Gram-atoms (moles)
gram	Grams
kilo	Kilograms
apel	Atom percent of isotopes (by element)
wpel	Weight percent of isotopes (by element)
gper	Grams per cm^3
atom	Atoms per b-cm

Radiotoxicity indices (dilution factors)

airm	Raditoxicity index in air (m^3)
h2om	Radiotoxicity index in water (m^3)

Activity & decay heat

becq	Becquerels
curi	Curies
watt	Total thermal output (Watts)
mevs	Total thermal power (MeV)
gamw	Thermal output from gammas (Watts)
gamm	Thermal output from gammas (MeV)

Reaction rates

abso	Total absorption
fiss	Total fission
capt	Total capture

Radiation emissions

part	Particles / second
inte	Particles / MeV-second
ener	MeV / second

Exercise: Viewing an ORIGEN concentrations file (f71)

Using the provided example file **“obiwan.f71”** (produced from TRITON):

1. How many “positions” are on this file?
2. How many “cases” are on this file?
3. How can you check TRITON’s mass normalization?
4. Print nuclide concentrations of the system-average mixture:
   - In units of atoms/barn-cm
   - For **only** the first and last step
   - With 8 decimals
   - In a pretty nuclide ID format

Solution: Viewing an F71 file in OBIWAN

```
obiwan view -format=info obiwan.f71
```

```
pos  time power  flux      fluenceenergy   initialhmvolume libpos   case   step DCGNAB
  (-)   (s)  (MW)   (n/cm^2-s)     (n/cm^2) (MWd)       (MTIHM)(cm^3)    (-)    (-)    (-)    (-)
    1 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.26855e-01 1.41129e+04      1      1      0 DC----
    2 2.59200e+07 3.43861e+00 1.95889e+14 5.07743e+21 1.03158e+03 1.26855e-01 1.41129e+04      2      1      1 DC----
    3 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 2.53700e-01 2.82259e+04      1      2      0 DC----
    4 2.59200e+07 7.88776e+00 1.94630e+14 5.04482e+21 2.36633e+03 2.53700e-01 2.82259e+04      2      2      1 DC----
    5 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 2.53700e-01 2.82259e+04      1      3      0 DC----
    6 2.59200e+07 6.81147e+00 1.85120e+14 4.79831e+21 2.04344e+03 2.53700e-01 2.82259e+04      2      3      1 DC----
    7 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.26850e-01 1.41129e+04      1      4      0 DC----
    8 2.59200e+07 2.85220e+00 1.77108e+14 4.59064e+21 8.55659e+02 1.26850e-01 1.41129e+04      2      4      1 DC----
    9 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 5.97238e-02 7.05647e+03      1      5      0 DC----
   10 2.59200e+07 9.50811e-01 1.58367e+14 4.10486e+21 2.85243e+02 5.97238e-02 7.05647e+03      2      5      1 DC----
   11 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 5.97237e-02 7.05646e+03      1      6      0 DC----
   12 2.59200e+07 6.54083e-01 1.53567e+14 3.98045e+21 1.96225e+02 5.97237e-02 7.05646e+03      2      6      1 DC----
   13 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.19447e-01 1.41129e+04      1      7      0 DC----
   14 2.59200e+07 9.56058e-01 1.50565e+14 3.90265e+21 2.86817e+02 1.19447e-01 1.41129e+04      2      7      1 DC----
   15 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 1.12903e+05      1      0      0 DC----
   16 2.59200e+07 2.35510e+01 1.79879e+14 4.66246e+21 7.06530e+03 1.00000e+00 1.12903e+05      2      0      1 DC----
   17 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 1.00000e+00 1.12903e+05      1     -2      0 DC----
   18 2.59200e+07 2.35510e+01 1.79879e+14 4.66246e+21 7.06530e+03 1.00000e+00 1.12903e+05      2     -2      1 DC----
```

1. 18 positions
2. 7 “cases” (i.e., material regions)
3. **Mass normalization:** See **depleted material sum** (case 0) and **system-averaged sum** (case -2)

Solution: Viewing F71 concentrations

```
obiwan view -format=csv -units=atom
-pos=17 -symbols=1 obiwan.f71
```

pos=17

```
    case,     -2
    step,      0
  volume, 1.1290341E+05
 AC:u234, 6.79069996E-06
 AC:u235, 7.47002501E-04
 AC:u236, 4.68305001E-06
 AC:u238, 2.16576247E-02
FP:gd154, 8.06324988E-06
FP:gd155, 5.53524987E-05
FP:gd156, 7.69449980E-05
FP:gd157, 5.89400006E-05
FP:gd158, 9.34825002E-05
FP:gd160, 8.29999990E-05
  LT:o16, 4.53957501E-02
```

pos=18

```
    case,     -2
    step,      1
    time, 2.5920000E+07
   power, 2.3550999E+01
    flux, 1.7987872E+14
  volume, 1.1290341E+05
AC:ac224, 2.63523478E-28
AC:ac225, 8.55815362E-21
AC:ac226, 3.28139419E-23
AC:ac227, 9.95996899E-18
AC:ac228, 5.58260037E-21
AC:am239, 6.93199751E-21
AC:am240, 4.14200455E-16
AC:am241, 2.33198583E-08
...
```

OBIWAN view: Library file output formats (`-format=`)

Transition matrix

coeff	output tabular transition coefficients
coefft	same as coeff but with transition ids
matrix	output full transition matrix

Neutron production

nprodr	neutron production ratio
genneu	neutron generation

One-group library cross-sections

loxs	1-group effective disappearance cross-section
fisxs	1-group fission cross-section

Library metadata

tags	output file tags
nucl	nuclide list
burnups	output burnup list
reaction	allowed reactions

Output formats for post-processing

json	output in JSON format
graphviz	output dot file transitions to STDOUT

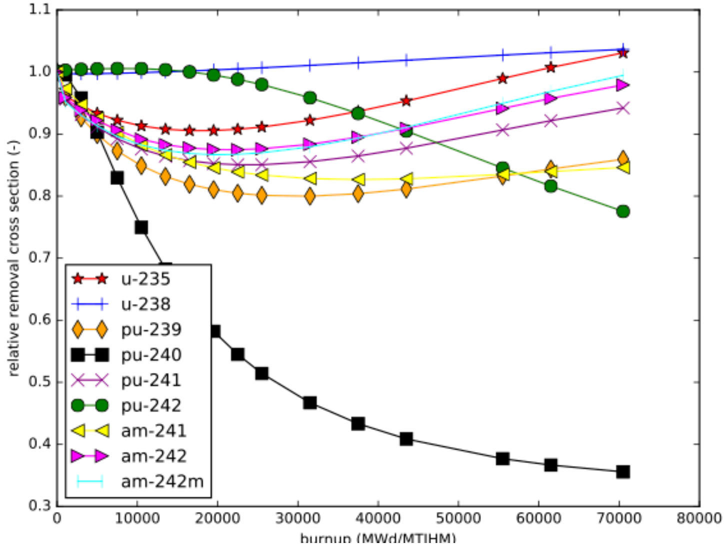
Example: Viewing ^{240}Pu loss XS as a function of burnup

```
obiwan view -format=loxs -symbols=1 ~/scale/data/arplibs/w17_e50.f33
```

```
…                 …          …          …          …          …          …          …          …
AC:pu238  1.9918E+01 1.9426E+01 1.9117E+01 1.8876E+01 1.8700E+01 1.8550E+01 1.8445E+01 1.8403E+01
AC:pu239  1.5127E+02 1.4876E+02 1.4515E+02 1.4010E+02 1.3598E+02 1.3195E+02 1.2831E+02 1.2563E+02
AC:pu240  2.2669E+02 2.2674E+02 2.2551E+02 2.1707E+02 2.0451E+02 1.8794E+02 1.6994E+02 1.5479E+02
AC:pu241  1.2945E+02 1.2672E+02 1.2398E+02 1.2075E+02 1.1815E+02 1.1565E+02 1.1346E+02 1.1192E+02
…                 …          …          …          …          …          …          …          …
```

```
obiwan view -format=burnup ~/scale/data/arplibs/w17_e50.f33
```

```
pos  MWd/MTIHM
1            0
2           40
3         1040
4         3000
5         5000
6         7500
7        10500
8        13500
…            …
```



Same method can be applied across different assembly dimensions (initial enrichment, moderator density, etc.)

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Exercise: Viewing an ORIGEN reactor library file (f33)

Using the provided example file **"obiwan.f33"** (produced from TRITON):

1. Print the list of burnups contained on the f33 library
2. Find the loss cross section of U-235, Pu-239 as a function of burnup
3. Print all of the transition coefficients (yield times cross section) to daughter Te-135 (with `–format=coefft`)

Solution: Viewing burnup points on the f33 file

```
obiwan view -format=burnups obiwan.f33
```

pos	MWd/MTIHM
1	0.0000
2	40.0000
3	1040.0000
4	3000.0000
5	5000.0000
6	7500.0000
7	10500.0000
8	13500.0000
9	16500.0000
10	19500.0000
11	22500.0000
12	25500.0000
13	28500.0000
14	31500.0000
15	34500.0000
16	37500.0000
17	40500.0000
18	43500.0000
19	46500.0000
20	49500.0000
21	52500.0000
22	55500.0000
23	58500.0000
24	61500.0000
25	64500.0000
26	67500.0000
27	70500.0000
28	73500.0000
29	76500.0000
30	79500.0000
31	82500.0000

Solution: Loss XS for U-235, Pu-239 as a function of burnup

```
obiwan view -format=loxs -sizzzaaa=92235 -symbols=1 –transpose=1 obiwan.f33

obiwan view -format=loxs -sizzzaaa=94239 -symbols=1 –transpose=1 obiwan.f33
```

```
burnupAC:u235                 3.7500e+04  3.0899e+01
 0.0000e+00  3.2040e+01   4.0500e+04  3.1126e+01
 4.0000e+01  3.1489e+01   4.3500e+04  3.1375e+01
 1.0400e+03  3.1104e+01   4.6500e+04  3.1643e+01
 3.0000e+03  3.0816e+01   4.9500e+04  3.1929e+01
 5.0000e+03  3.0608e+01   5.2500e+04  3.2233e+01
 7.5000e+03  3.0407e+01   5.5500e+04  3.2553e+01
 1.0500e+04  3.0237e+01   5.8500e+04  3.2889e+01
 1.3500e+04  3.0135e+01   6.1500e+04  3.3238e+01
 1.6500e+04  3.0092e+01   6.4500e+04  3.3600e+01
 1.9500e+04  3.0100e+01   6.7500e+04  3.3973e+01
 2.2500e+04  3.0151e+01   7.0500e+04  3.4356e+01
 2.5500e+04  3.0240e+01   7.3500e+04  3.4749e+01
 2.8500e+04  3.0363e+01   7.6500e+04  3.5147e+01
 3.1500e+04  3.0516e+01   7.9500e+04  3.5551e+01
 3.4500e+04  3.0695e+01   8.2500e+04  3.5957e+01
```

```
burnupAC:pu239                3.7500e+04  9.0775e+01
 0.0000e+00  1.0965e+02   4.0500e+04  9.0957e+01
 4.0000e+01  1.0820e+02   4.3500e+04  9.1244e+01
 1.0400e+03  1.0624e+02   4.6500e+04  9.1626e+01
 3.0000e+03  1.0360e+02   4.9500e+04  9.2095e+01
 5.0000e+03  1.0140e+02   5.2500e+04  9.2645e+01
 7.5000e+03  9.9101e+01   5.5500e+04  9.3269e+01
 1.0500e+04  9.6874e+01   5.8500e+04  9.3960e+01
 1.3500e+04  9.5119e+01   6.1500e+04  9.4715e+01
 1.6500e+04  9.3750e+01   6.4500e+04  9.5525e+01
 1.9500e+04  9.2700e+01   6.7500e+04  9.6387e+01
 2.2500e+04  9.1914e+01   7.0500e+04  9.7295e+01
 2.5500e+04  9.1350e+01   7.3500e+04  9.8245e+01
 2.8500e+04  9.0977e+01   7.6500e+04  9.9227e+01
 3.1500e+04  9.0770e+01   7.9500e+04  1.0024e+02
 3.4500e+04  9.0708e+01   8.2500e+04  1.0127e+02
```

Solution: Transition coefficients for Te-135

```
obiwan view -format=coefft -symbols=1 obiwan.f33 | grep te135
```

```
        FP:te135 <--[decay,beta-|-2]-- FP:sb135 3.2201e-01 3.2201e-01 3.2201e-01 ... 3.2201e-01 3.2201e-01 3.2201e-01
FP:te135 <--[decay,beta-,neutron|-26]-- FP:sb136 3.5814e-01 3.5814e-01 3.5814e-01 ... 3.5814e-01 3.5814e-01 3.5814e-01
            FP:te135 <--[fission|18]-- AC:th227 3.1997e-01 3.1626e-01 3.1352e-01 ... 3.2551e-01 3.2788e-01 3.3027e-01
            FP:te135 <--[fission|18]-- AC:th229 2.9720e-01 2.9668e-01 2.9619e-01 ... 2.8938e-01 2.8957e-01 2.8977e-01
            FP:te135 <--[fission|18]-- AC:th232 9.5584e-04 9.5732e-04 9.5907e-04 ... 9.6253e-04 9.6160e-04 9.6069e-04
            FP:te135 <--[fission|18]-- AC:pa231 6.0233e-03 6.0323e-03 6.0412e-03 ... 6.0172e-03 6.0108e-03 6.0044e-03
             FP:te135 <--[fission|18]-- AC:u232 8.0034e-02 7.9714e-02 7.9541e-02 ... 8.4851e-02 8.5161e-02 8.5468e-02
             FP:te135 <--[fission|18]-- AC:u233 6.2912e-01 6.2154e-01 6.1601e-01 ... 6.5611e-01 6.6118e-01 6.6629e-01
             FP:te135 <--[fission|18]-- AC:u234 1.0625e-02 1.0640e-02 1.0655e-02 ... 1.0598e-02 1.0587e-02 1.0575e-02
             FP:te135 <--[fission|18]-- AC:u235 7.9705e-01 7.8172e-01 7.7099e-01 ... 8.7605e-01 8.8701e-01 8.9806e-01
             FP:te135 <--[fission|18]-- AC:u236 1.2414e-02 1.2428e-02 1.2356e-02 ... 1.0736e-02 1.0717e-02 1.0699e-02
             FP:te135 <--[fission|18]-- AC:u237 7.1777e-02 7.1809e-02 7.1841e-02 ... 7.3530e-02 7.3547e-02 7.3570e-02
             FP:te135 <--[fission|18]-- AC:u238 4.7928e-03 4.8002e-03 4.8085e-03 ... 4.8074e-03 4.8023e-03 4.7972e-03
              ...
                FP:te135 <--[n,p|103]-- FP:i135 0.0000e+00 0.0000e+00 0.0000e+00 ... 0.0000e+00 0.0000e+00 0.0000e+00
              FP:te135 <--[n,2p|111]-- FP:xe136 5.2420e-28 5.5115e-28 9.5624e-28 ... 3.9169e-25 4.1051e-25 4.2891e-25
         FP:i135 <--[decay,beta-|-2]-- FP:te135 3.6482e-02 3.6482e-02 3.6482e-02 ... 3.6482e-02 3.6482e-02 3.6482e-02
```

OBIWAN view: Decay and Yield resource files

YieldResource

Parent ID	EALF (eV)	Daughter ID	Yield
…			
92235	2.53000e-02	33088	1.30179e-03
92235	2.53000e-02	34088	2.74899e-03
92235	2.53000e-02	35088	1.40008e-02
92235	2.53000e-02	36088	1.76224e-02
…			

DecayResource

Line #	ZAID	Sym.	λ (1/s)	Q (MeV)	Q_γ (fraction)	Decay mode(s)			
540	1041102	nb102m	5.3319e-01	4.8393e+00	0.5000	beta-[m0]	1.0000e+00		
541	41103	nb103	4.6210e-01	3.5429e+00	0.4690	beta-[m0]	1.0000e+00	beta-,neutron[m0]	1.1770e-08
542	41104	nb104	1.4146e-01	5.5154e+00	0.5544	beta-[m0]	9.9940e-01	beta-,neutron[m0]	6.0000e-04
543	1041104	nb104m	7.3739e-01	5.5162e+00	0.5545	beta-[m0]	9.9950e-01	beta-,neutron[m0]	5.0000e-04
544	41105	nb105	2.3497e-01	4.4695e+00	0.4777	beta-[m0]	9.8300e-01	beta-,neutron[m0]	1.7000e-02

Exercise: Viewing an ORIGEN Decay Resource

Using the ORIGEN decay resource at
`$DATA/origen_data/origen.rev03.decay.data`

1. Find the decay constant of Xe-135
2. Find a nuclide that decays into a metastable with branching ratio >40%

Solution: ORIGEN DecayResource queries

- Xe-135 decay constant:

```
obiwan view ${DATA}/origen_data/origen.rev03.decay.data | grep xe135
```

```
977     54135    xe135 2.1066e-05 5.6798e-01   0.4370   beta-[m0] 1.0000e+00
978   1054135   xe135m 7.5553e-04 5.2673e-01   0.8138   beta-[m0] 3.0000e-03  i.t.[m0] 9.9700e-01
```

- Nuclide(s) with metastable branching ratio > 40%

```
obiwan view ${DATA}/origen_data/origen.rev03.decay.data | grep "m1"
```

(… find any case where the branching fraction to [m1] > 0.40 …)

```
299     33073     as73 9.9908e-08 9.7528e-03   0.4788   beta+[m1] 1.0000e+00
```

Exercise: Viewing an ORIGEN Yield Resource

Using the ORIGEN fission yield resource at
`$DATA/origen_data/origen.rev05.yields.data`

a) Find the fission yield of **U-235** to **Te-135** for:
   a) Thermal fission (2.53000e-02 eV)
   b) Fast fission (2.00000e06 eV)

b) Find the fission yield of **Pu-239** to **Te-135** for:
   a) Thermal fission (2.53000e-02 eV)
   b) Fast fission (2.00000e06 eV)

Hint: ZAID for Te-135 is 52135

Solution: YieldResource data for Te-135 fission yields

```
obiwan view ${DATA}/origen_data/origen.rev05.yields.data | grep 52135
```

- U-235:

Parent ID	EALF (eV)	Daughter ID	Yield
92235	2.53000e-02	52135	3.22825e-02
92235	2.00000e+06	52135	2.47357e-02

- Pu-239:

Parent ID	EALF (eV)	Daughter ID	Yield
94239	2.53000e-02	52135	2.19297e-02
94239	2.00000e+06	52135	2.10715e-02

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File comparison: OBIWAN diff

OBIWAN diff: Comparing ORIGEN files

```
obiwan diff -format=y [opts]  file1  file2
```

Option	Description	Default
`-reltol`	Relative tolerance threshold (%)	`-reltol=0.01`
`-pos`	File position to compare upon (0 = all positions)	`-pos=1`
`-format=y`	Smart format (side-by-side comparison)	
`-format=genneu`	Neutron generation (by nuclide)	
`-format=eq`	Exact match (no output)	
`-format=approx_eq`	Fast comparison (no output)	

} Difference indicated via return (status) code (applies to `-format=eq` and `-format=approx_eq`)

OBIWAN diff: Comparing binary ORIGEN files

```
obiwan diff -format=String(y) [opts]  file1  file2
```

- Works for any binary ORIGEN file format
  - YieldResource, DecayResource
  - StateSet (f71)
  - Library (f33)
- Tolerance can be adjusted to look only for differences above a threshold

Exercise

Tip: GE10x10-8 variants in `${DATA}/arplibs/` are named as: `g10-eXX-wYY.f33` where **XX** is the initial U-235 enrichment (wt. %) and **YY** is the moderator density (Y.Y g/cc)

For the GE10x10-8 BWR library:

1. Between 1.5 and 3.0% enrichment (0.5 g/cc moderator density), how many transition coefficients change by:
   a) > 5%?
   b) >10%?
   c) >50%?
2. Between 0.3 and 0.5 g/cc moderator density (at 3.0% enrichment), how many transition coefficients change by:
   a) > 5%?
   b) >10%?
   c) >50%?

Hints:
- Use "grep" to look for transitions with a difference over the threshold
- You can also use "wc –l" to get the number of lines in a file

Solution: Transition coefficient differences for GE10x10-8

```
obiwan diff -reltol=5.0
${DATA}/arplibs/g10_e15w05.f33
${DATA}/arplibs/g10_e30w05.f33 | grep DIFF | wc -l
```

1. **GE10x10-8:** 1.5 vs. 2.0% enrichment (mod. dens = 0.5 g/cc)
   a) 15,175
   b) 2,308
   c) 2,096
2. **GE10x10-8:** 0.3 vs. 0.5 g/cc moderator density (enrich = 3.0%)
   a) 14,984
   b) 1,458
   c) 328

OBIWAN convert: Migrating between file formats

- Supported conversion **formats**
  - **s61:** 6.1 “legacy” format
  - **s62b:** 6.2 pre-release format
  - **bof:** 6.2+ binary object format
  - **hdf5:** New HDF5 format for 6.3+ (*libraries only*)
- Supported conversion **versions**
  - **6.1:** Equivalent to “-format=s61”
  - **6.2:** Equivalent to “-format=bof”

OBIWAN convert: Setting library burnup values

- In order to interpolate libraries **directly** using OBIWAN (as a function of burnup), we need to append this information to the library using the –setbu argument:

```
obiwan convert -setbu=[1500.0, 3025.0, 10000.0] -i my_library.f33
```

-setbu=[array]: Specify an **array** of burnup values (typically MWd/MTIHM) corresponding to **each library position**. (One entry per position)

-i Overwrite existing file in-place (optional)

OBIWAN convert: Library "thinning" & interpolation

- Libraries can be "thinned," reducing the library to an interpolated set of burnup points (similar to ARP)
- To **interpolate** on time ("thin"), specify **thin=1** and a set of **time values** (burnups) to thin to:

```
obiwan convert -interp=cubic
-tvals=[2000.0, 5500.0, 7500.0] -thin=1 -i my_library.f33
```

-tvals= Array of time (burnup) values to interpolate to, corresponding to values on library

-interp= Interpolation method: "near" = nearest-neighbor, "linear" = linear interpolation, "cubic" = cubic spline

Exercise: Burnup interpolation of a reactor library (f33)

For a Westinghouse 17x17 PWR assembly at 4% initial enrichment (`${data}/arplibs/w17_e40.f33`):

1. Print out the U-235 and Pu-239 fission cross-sections as a function of burnup
2. Create a **new** library interpolated to burnup points of 650, 6,250, 21,500, and 36,750 MWd/MTHM
3. Compare the original and interpolated fission cross-sections for U-235 and Pu-239 as a function of burnup

Solution: Burnup interpolation of a reactor library (f33)

View fission XS:

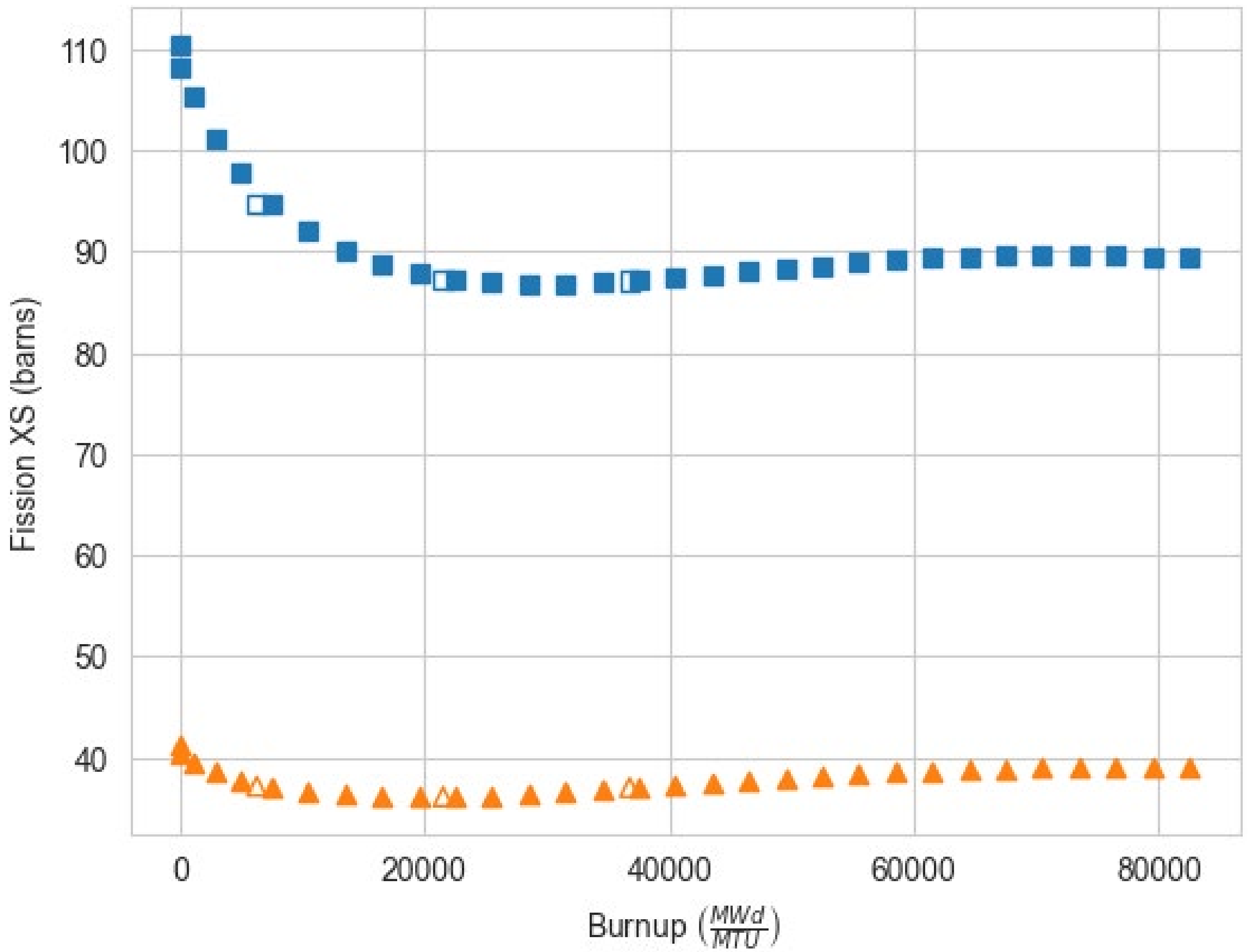
```
obiwan view -format=fisxs -symbols=1
${DATA}/arplibs/w17_e40.f33  | grep -E 'u235|pu239'
```

```
AC:u235  4.1298e+01 4.0263e+01 3.9423e+01 ... 3.8998e+01 3.8978e+01 3.8937e+01
AC:pu239 1.1034e+02 1.0830e+02 1.0533e+02 ... 8.9598e+01 8.9504e+01 8.9370e+01
```

Interpolate library:

```
obiwan convert -thin=1 -tvals='[6250,21500,36750]'
${DATA}/arplibs/w17_e40.f33
```

Solution: Comparison of interpolated fission XS



OBIWAN tag: Adding & viewing library metadata

Two types of tags: "ID" (categorical) and "interp" (continuous)

ID tags

- String-valued
- Correspond to some common characteristic between libraries
- Values can be be used to represent **discrete** interpolation characteristics / states
  - Gd-bearing rods
  - Assembly / fuel pebble location

Interp tags

- Real-valued
- Correspond to **continuously-valued** parameters used for interpolation
- Examples
  - Initial ^{235}U enrichment
  - Average moderator density
  - Average fuel temperature
  - Average moderator boron concentration

OBIWAN tag: Example of adding library metdata

Sets ID tag "name" = "bob"
and "type" = "LWR"

```
obiwan tag -idtags="name=bob,type=LWR"
-interptags="pitch=0.5,temp=100.0"
```

Sets interp tag "pitch" = 0.5
and "temp" = 100.0

OBIWAN interp: Interpolating libraries across tags

```
obiwan interp <options> FILE1 FILE2
```

- Interpolates between ORIGEN libraries based on a specified series of tag attributes to generate a new library
- **idtags** – List of ID tags to down-select for interpolation
- **interptags** – List of interpolable values to interpolate the new library to

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Backup

Coming attractions for OBIWAN in SCALE 7

- Print concentrations from f71 file directly in SCALE's standard composition input format:
  `obiwan view format=stdcmp <options> FILE`
- Blend concentrations from multiple f71 files
  `obiwan blend -wts=<weights> -in=<files> -out=<file>`
- Conversion of multiple F33 files into a consolidated HDF5 "library archive"
  `obiwan convert format=arc FILES`
- More library checking/verification functionality