

MCNPX 2.7.X – New Features Being Developed

Michael R. James

**Gregg W. McKinney, Joe W. Durkee, Michael L. Fensin,
John S. Hendricks, Denise B. Pelowitz, Russell C. Johns,
Laurie S. Waters, Jay S. Elson**

LANL, Radiation Transport Modeling & Analysis Team

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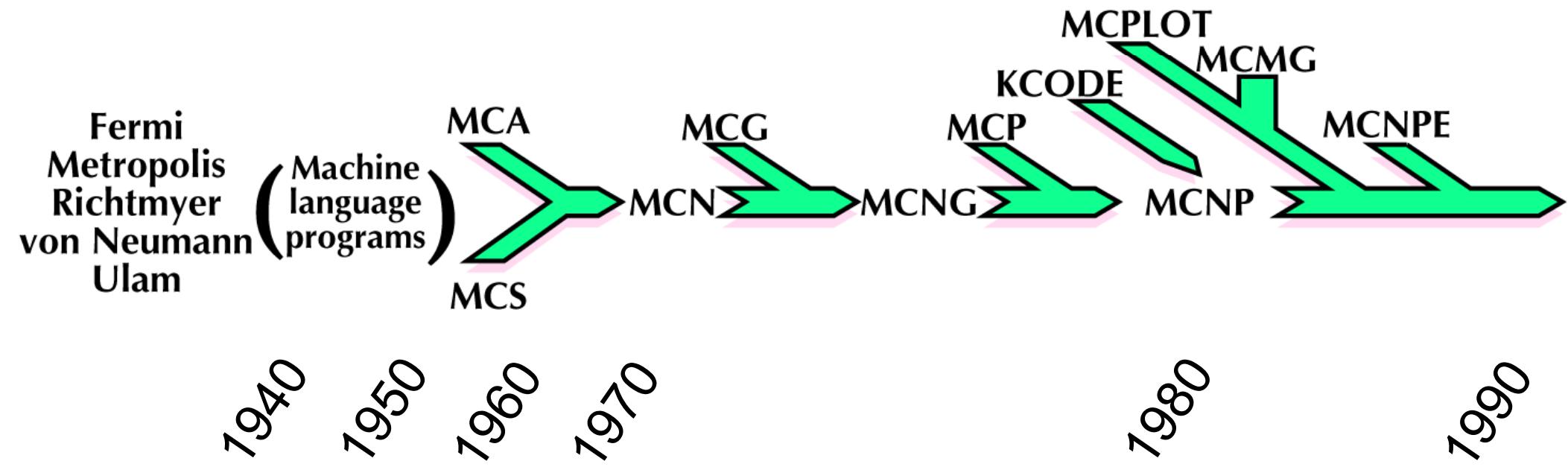
Outline

- **Overview**
- **Physics Enhancements**
- **Source Enhancements**
- **Tally Enhancements**
- **Other Enhancements**

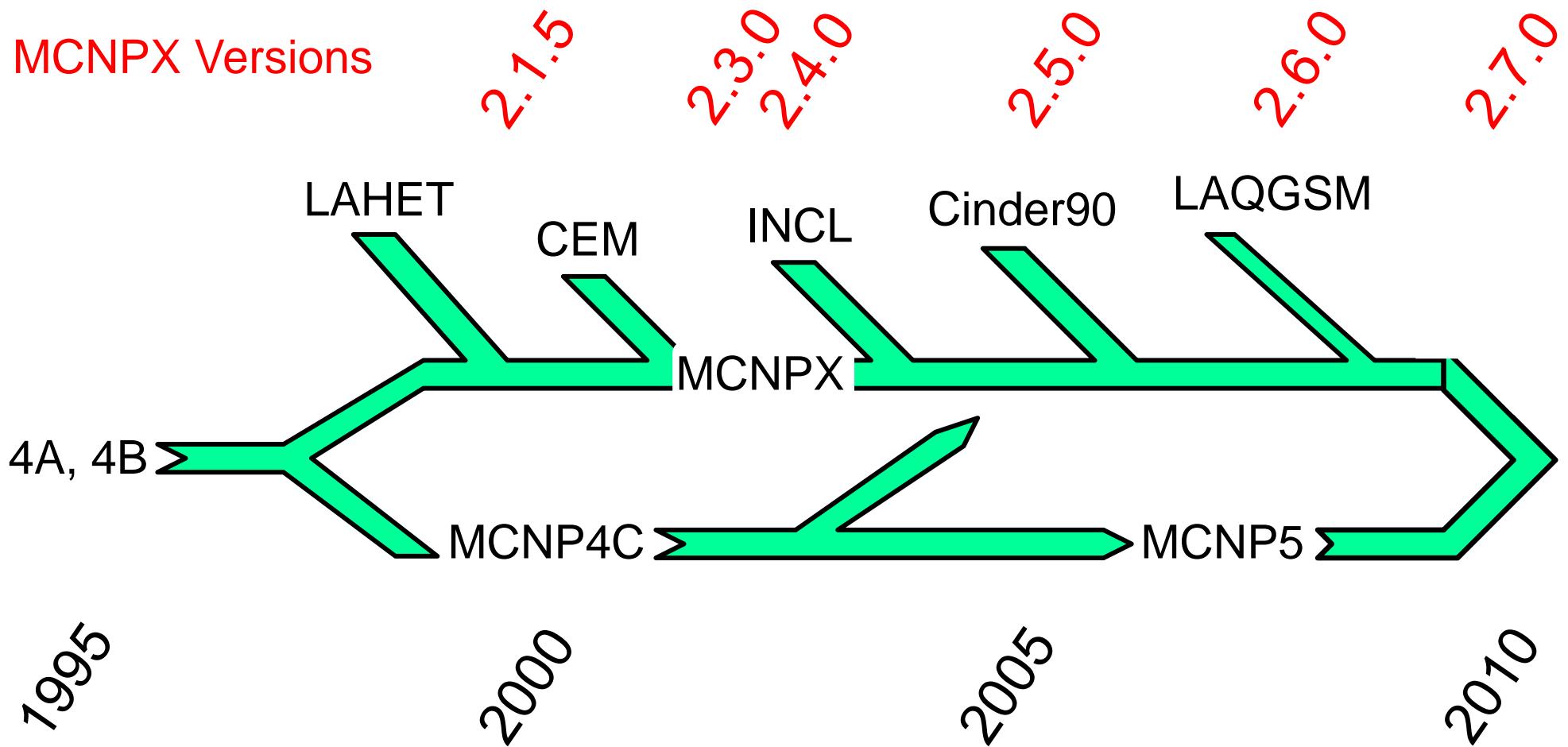
Overview – MCNPX is a 3-D, all-particle, all-energy Monte Carlo transport code

- **Monte Carlo radiation transport code**
 - Extends MCNP4C to virtually all particles and energies
 - 34 different particle types + 2205 heavy ions
 - Neutrons, photons, electrons, protons, pions, muons, light-ions, etc.
 - Continuous energy (~0 - 1 TeV/n)
 - Data libraries below ~150 MeV (n,p,e,h) & models otherwise
- **General 3-D geometry**
 - 1st & 2nd degree surfaces, tori, 10 macrobodies, lattices
- **General sources and tallies**
 - Interdependent source variables, 7 tally types, many modifiers
- **Supported on virtually all computer platforms**
 - Unix, Linux, Windows, OS X (parallel with MPI)

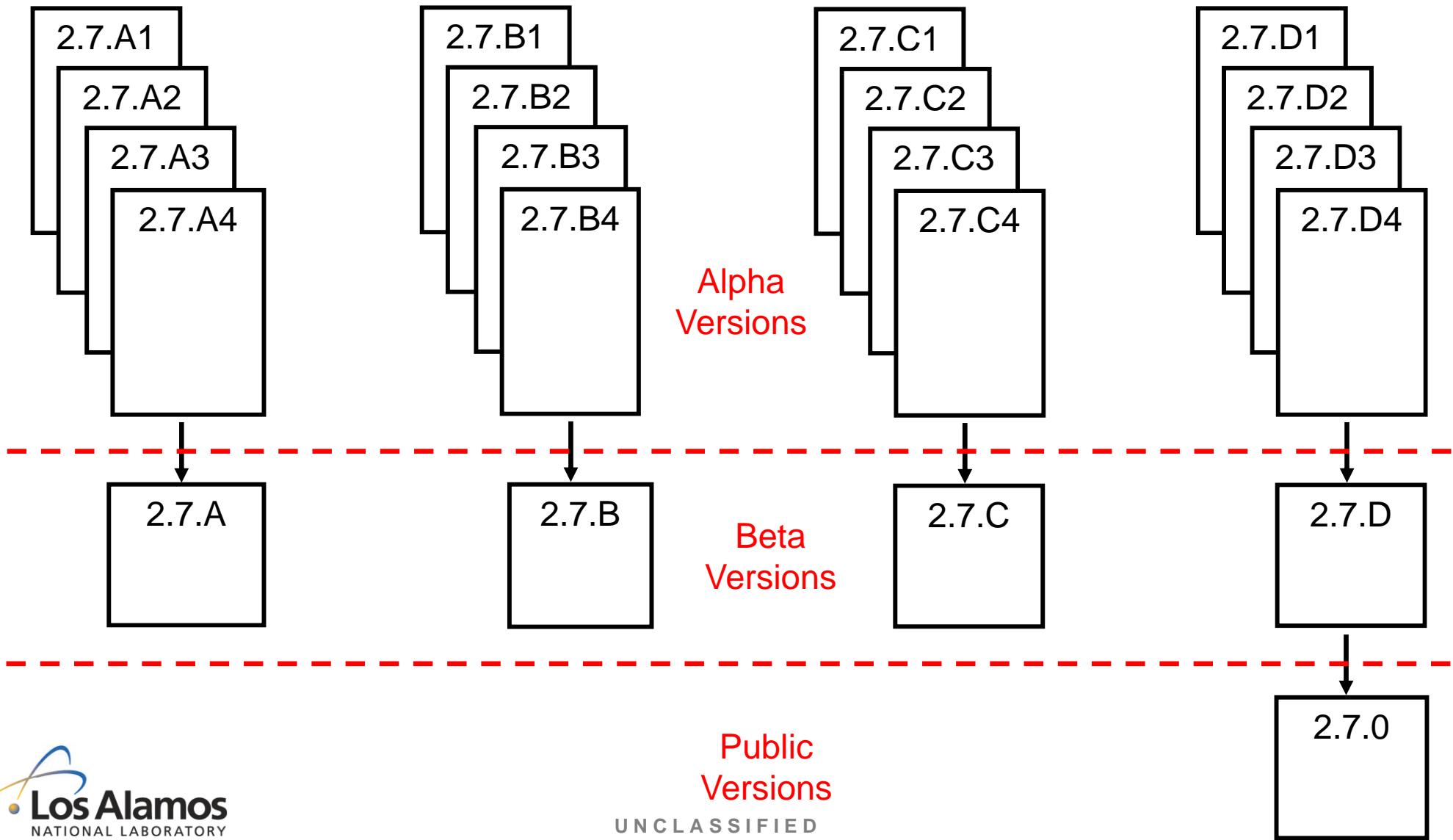
Overview – The previous century of development



Overview – The current century of development



Overview – Why so many versions of MCNPX?



Overview – Resources for MCNPX users

■ ~3000 users world wide

- Provide 6-8 workshops per year (4-6 US, 2 international)
- 1-2 workshops per year have a HS or TR emphasis
- Access to RSICC/NEA released versions only
 - <http://www-rsicc.ornl.gov/> (C00740) 2.6.0
 - <http://www.nea.fr/html/dbprog/> (CCC-0740) 2.6.0
- Limited access to MCNPX web site
 - <http://mcnpx.lanl.gov> (some documentation)

■ ~2000 registered Beta Users

- Full access to MCNPX web site
- Access to intermediate Beta versions
- Increased user support

Version 2.7.0 (2.7.A, 2.7.B, 2.7.C, 2.7.D)

Physics Enhancements

CEM upgrade to 03.02
Adjustable stopping-power grid
LLNL photofission multiplicities
Delayed gamma exact sampling
LLNL neutron fission multiplicities
Muonic x-ray enhancements
Delayed neutron spectra
NRF data in ACE libraries
Correlated gamma production
Improved photofission yields

Source Enhancements

Pulsed sources
Beam source options
Natural background sources

Tally Enhancements

Tally tagging
LET tally option
Quality factor tally option
Cyclic tally binning
ROC curve tally option
Built-in detector response functions

Variance Reduction Enhancements

Biased delayed-particle production

Other Enhancements

MC PLOT graphics enhancements
Activation options (ACT card)
MC PLOT tally manipulations
Dynamic universes

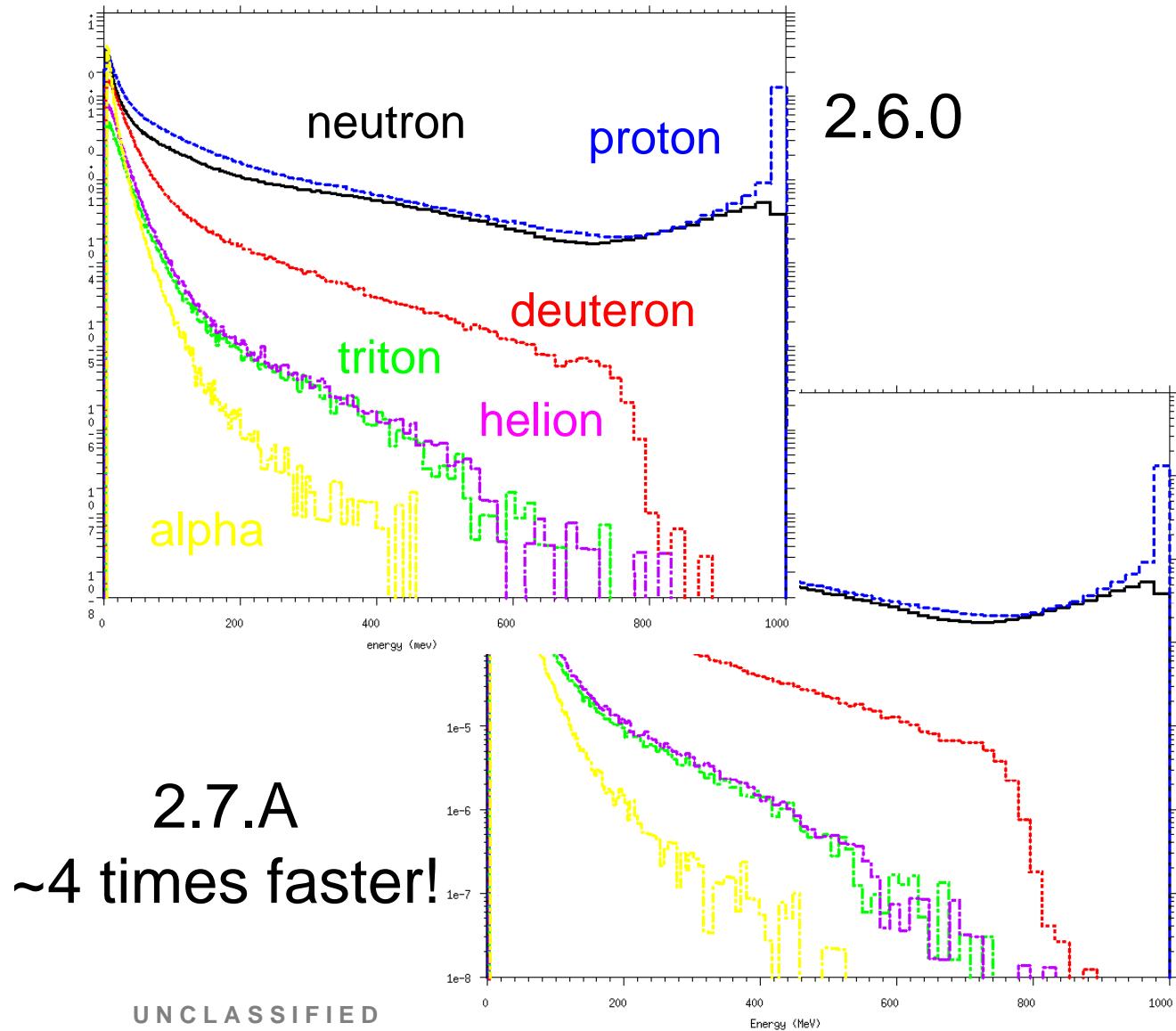
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Physics Enhancements – CEM upgrade

```
1 Gev protons into N-14
1 1 -1.0 -1 imp:n=1
2 0 1 imp:n=0

1 so 1.0

mode n h d t s a
phys:n 1010
m1 7014 1
lca 7j -2 1 $ Turn on CEM
sdef par=h erg=1000
f1:n 1
e0 1 299log 1000
f11:h 1
f21:d 1
f31:t 1
f41:s 1
f51:a 1
nps 10000000
print
```

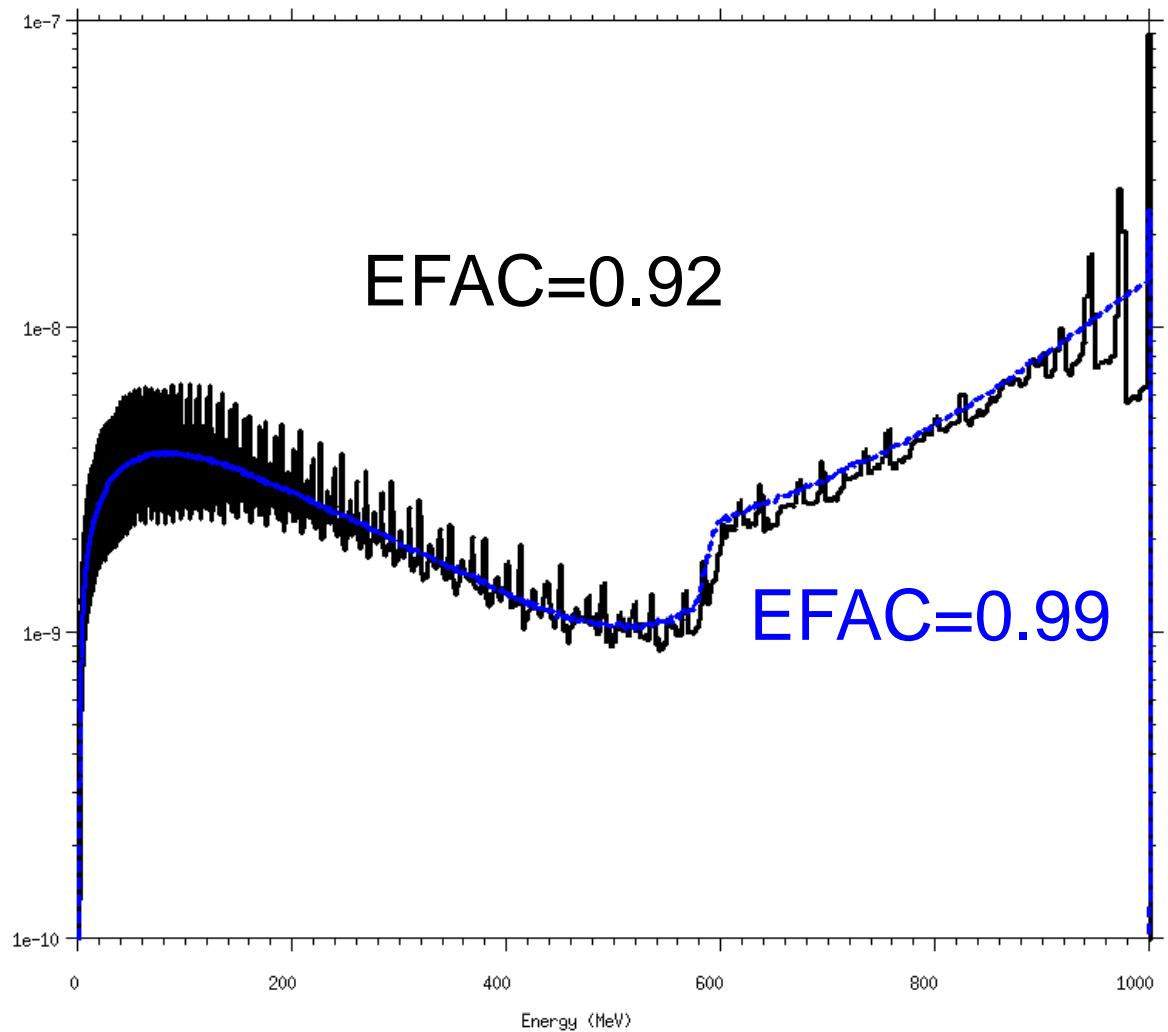


Physics Enhancements – Stopping powers

```
1 Gev protons into N-14
1 1 -1.0 -1 imp:n=1
2 0 1 imp:n=0

1 so 200.0

mode n h d t s a
phys:n 1010
phys:h 1010 9j .99 $ J for default
m1 7014 1
lca 8j 1
sdef par=h erg=1000
f4:h 1
e4 1 2000log 1000
nps 10000000
print
```



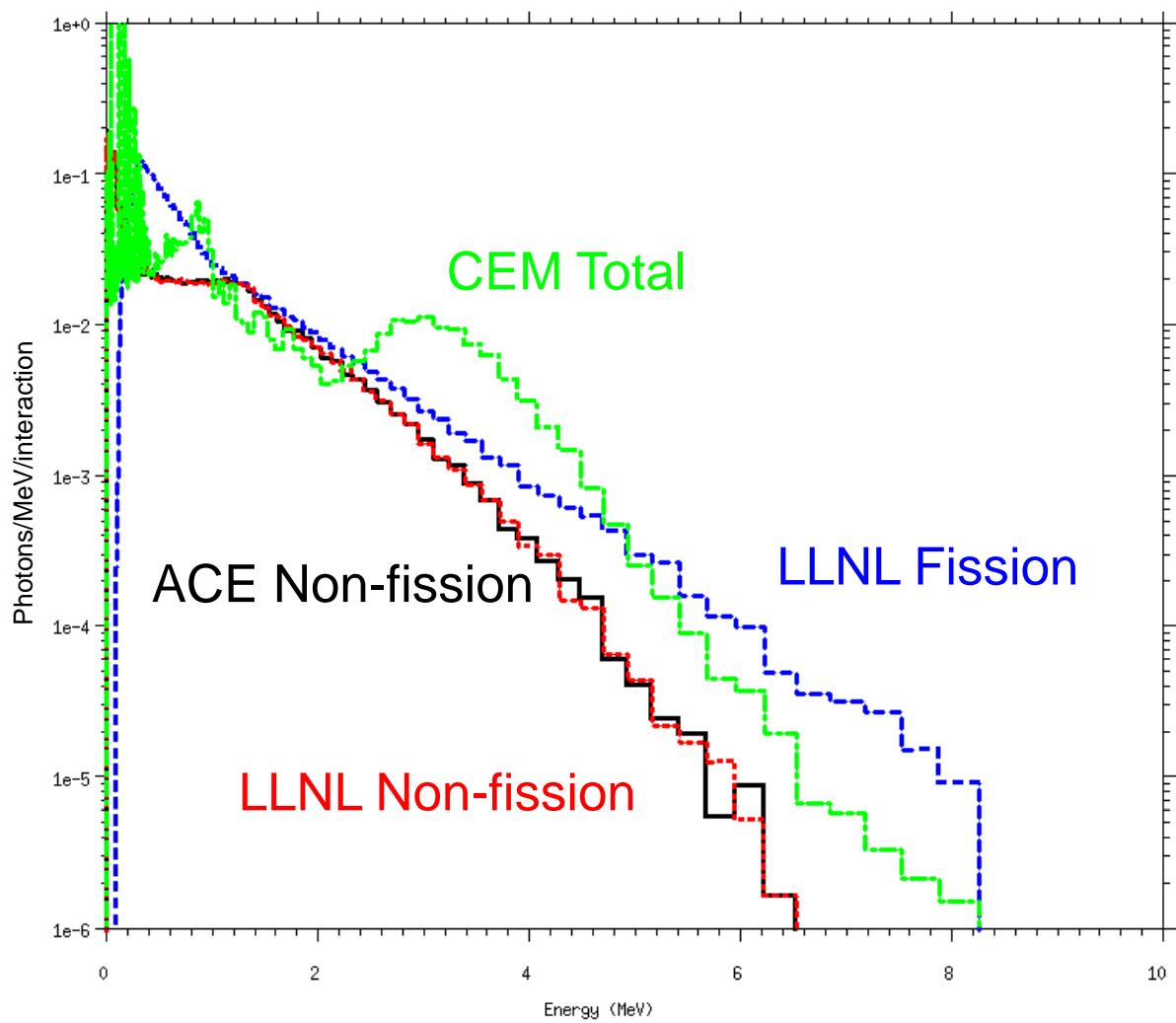
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Physics Enhancements – LLNL multiplicities

```
12 MeV x-rays into U-235
1 1 -19.0      -1 imp:n=1
2 0             1 imp:n=0

1 so 1.0

mode n p
m1 92235 1 pnlib=.70u
PHYS:P j 1 j 1 2j 0 $ 0=ACE, 1=LLNL
sdef par=p erg=12
LCA 7j -2
print
nps 1000000
f1:n 1
e1 1e-6 199log 12
f11:p 1
e11 1e-3 199log 12
ft11 tag 3
full -1 0.00004 92000.00003
      92235.00005 92000.00005
      92235.00018 1e10
```



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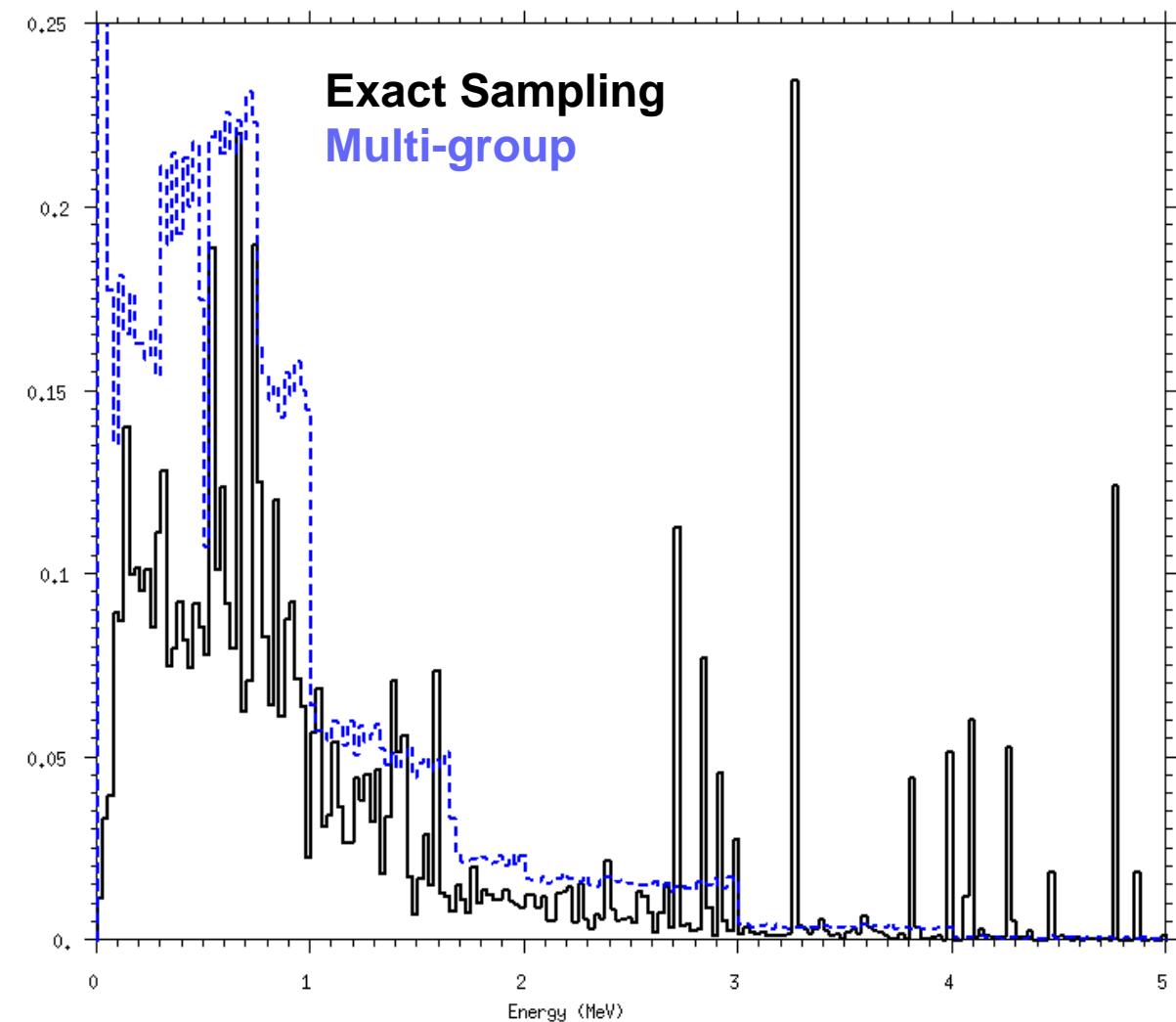
Physics Enhancements – Exact DG sampling

Thermal neutrons into U-235

```
1   1 -8.9      -1    imp:n=1
2   0           1    imp:n=0

1    so  1.0

m1     92235.70c 1.0
mode   n p
phys:p 5j -102 $-101=mg,-102=line
cut:n j j 0.0
lca 7j -2
sdef par=n erg=2.54e-8
f1:p 1
e1    0.0 399i 10
sd1   1
t1    1e4 1e30
tf1   7j 2
nps   25000
print
prdmp 2j 1
```



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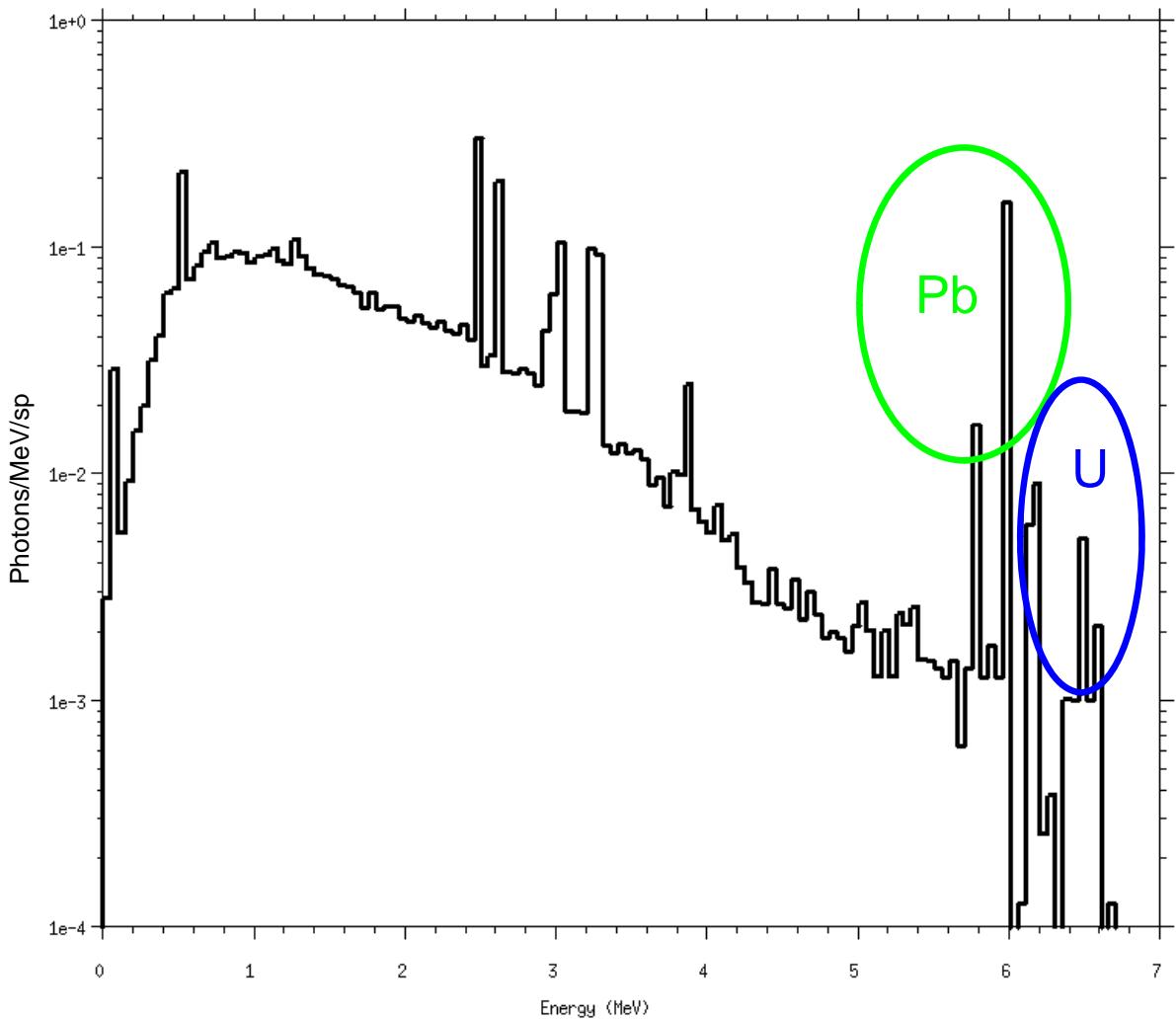
Physics Enhancements – Muonic x-rays

150 MeV muons into Pb/U

```
1 1 -19.0 -1 imp:p=1
2 2 -11.4 1 -2 imp:p=1
3 0 2 imp:p=0

1 so 2.0
2 so 7.0

mode | p
phys: | 400
m1 92235 1
m2 82208 1
sdef par=| erg=150 pos=-6.99 0 0
      vec=1 0 0 dir=1
f1:p 2
e1 1e-3 199i 10.0
nps 10000000
print
```

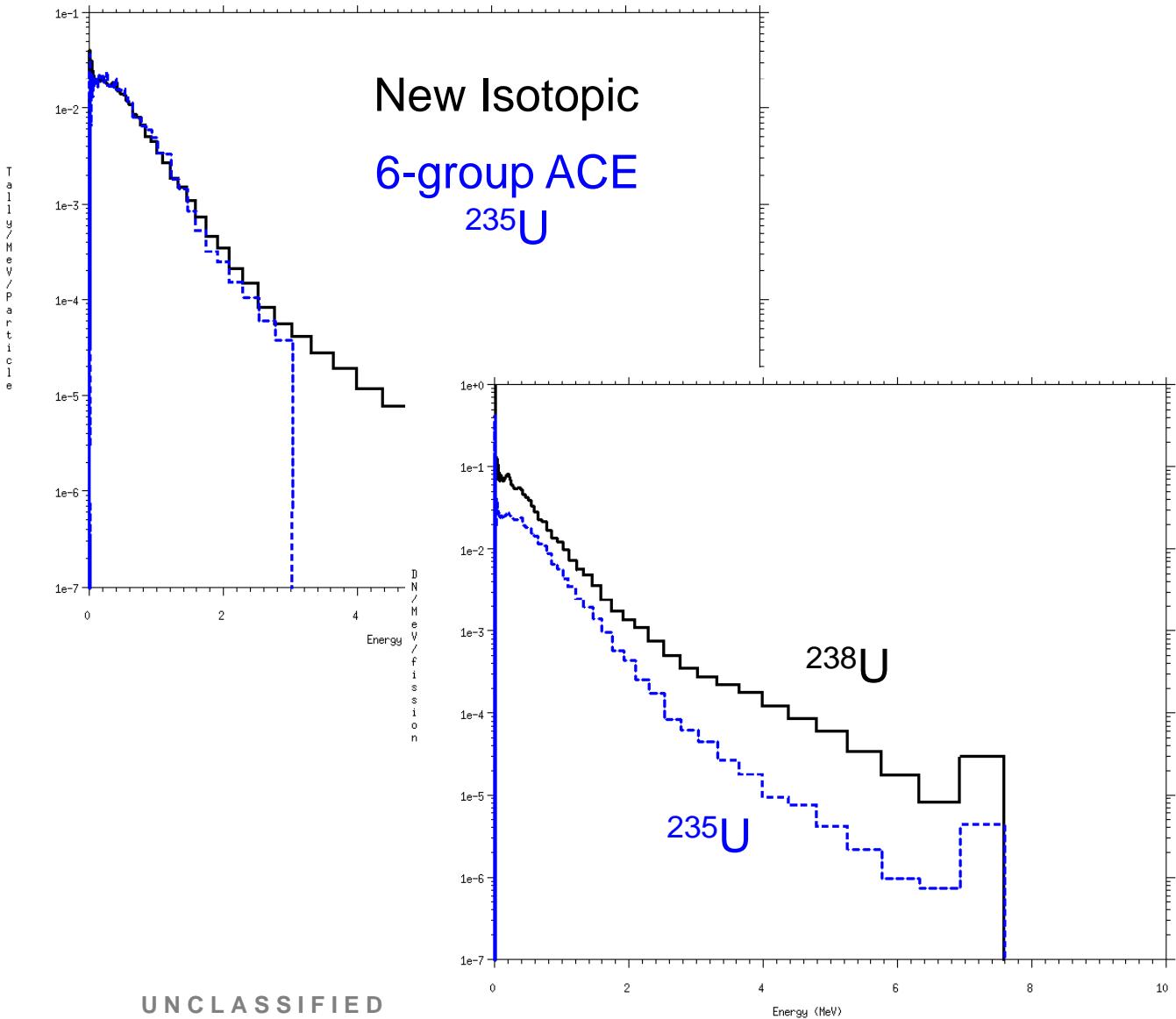


Physics Enhancements – DN spectra

```
1 ev neutrons into U-235
1   1    -19.0      -1      imp:n=1
2   0          1      imp:n=0

1 so 4.0

m1 92235 1
phys:n 3j 105
lca 7j -2
sdef par=n erg=1e-6
print
nps 100000000
f1:n 1
e1 1e-7 199log 10
t1 0.001e8 1e30
```



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Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA



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LET tally option
Quality factor tally option
Cyclic tally binning
ROC curve tally option
Built-in detector response functions

Variance Reduction Enhancements

Biased delayed-particle production

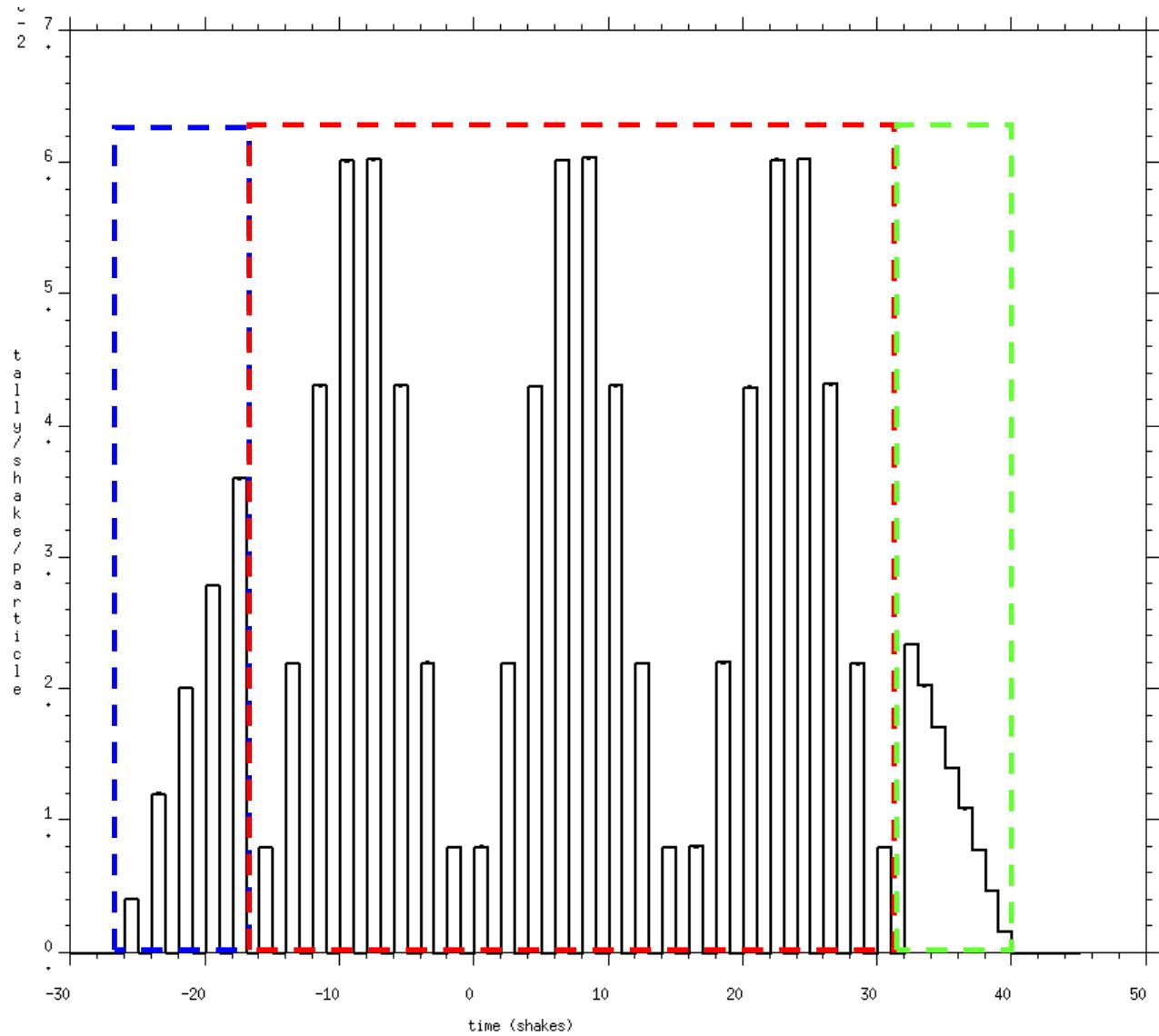
Other Enhancements

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Dynamic universes

Source Enhancements – Pulsed sources

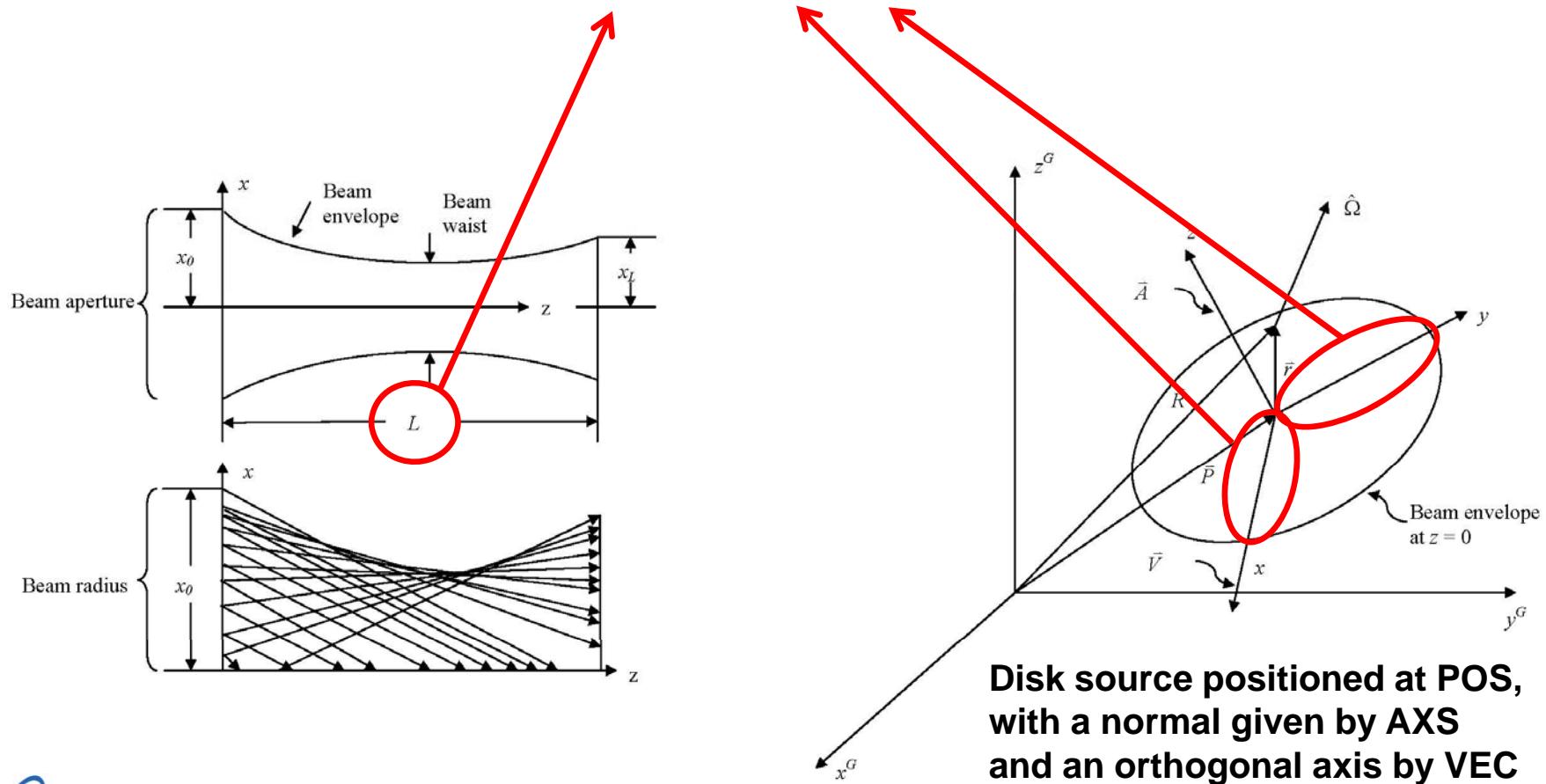
SDEF TME=D41

| # | si41 | sp41 |
|------------|---------|------|
| | S | D |
| 51<52 | .1 | |
| (31<32<33) | .8 | |
| 61 | .1 | |
| si51 H | 0 1 2 | |
| sp51 | 0 1 0 | |
| si52 A | -26 -16 | |
| sp52 | 0 1 | |
| si31 | 0 1 2 | |
| sp31 | 0 1 0 | |
| si32 | 0 16 | |
| sp32 | -41 8 8 | |
| si33 | -16 32 | |
| sp33 | 0 1 | |
| si61 A | 32 40 | |
| sp61 | 1 0 | |



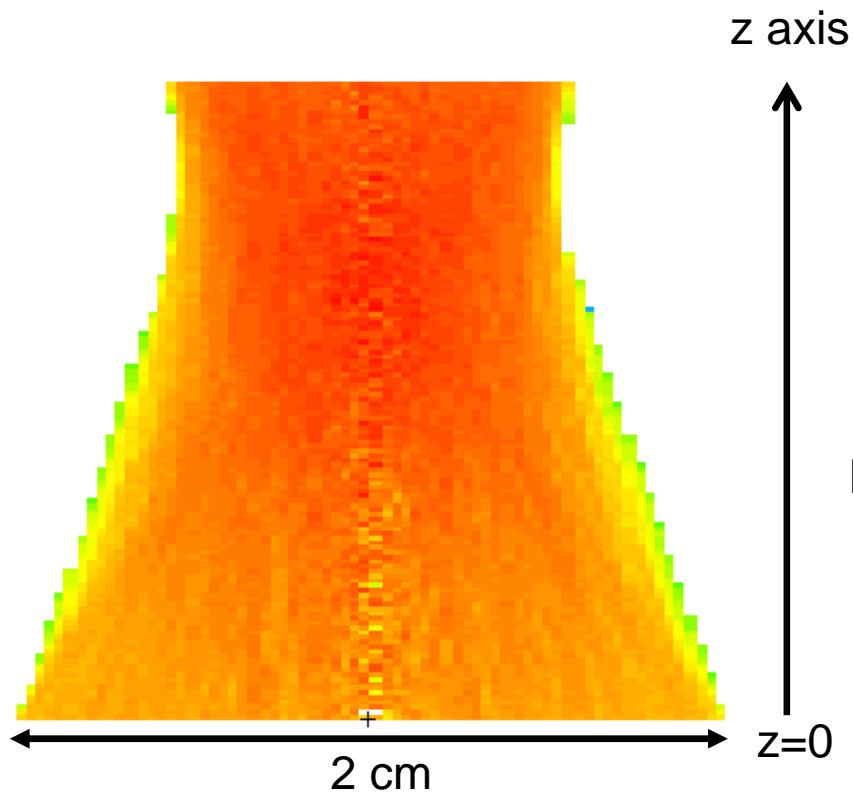
Source Enhancements – Beam sources

```
SDEF PAR= | ERG=100 POS=0 0 0 AXS=0 0 1 VEC=1 0 0  
BEM=9.776e-3 9.776e-3 100 BAP=1.0 1.0 0
```

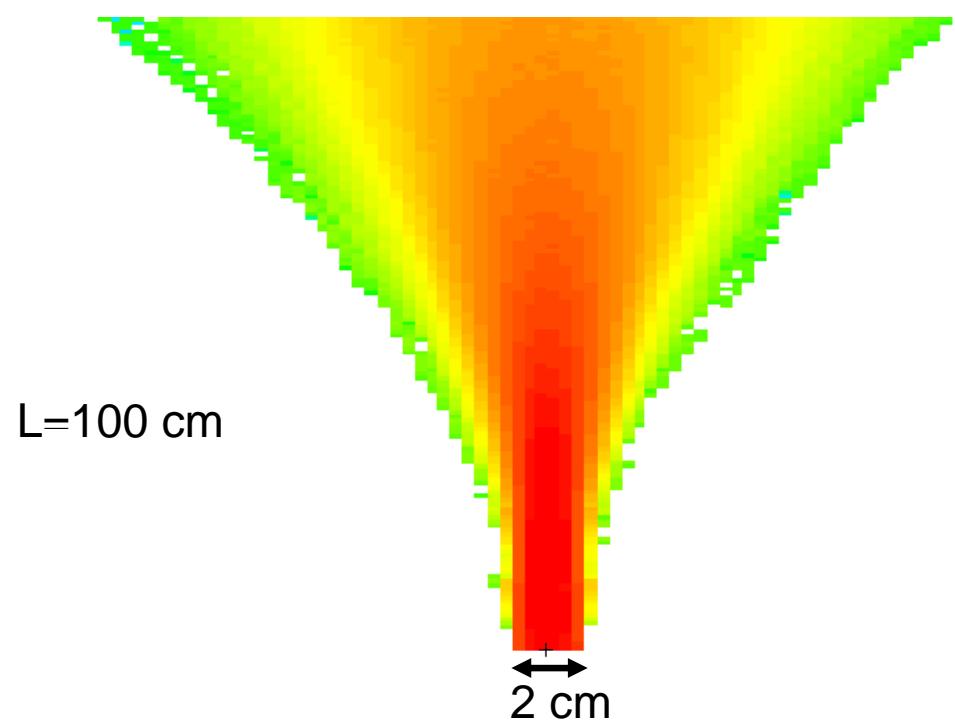


Source Enhancements – Beam sources

Beam transport in vacuum



Beam transport in air



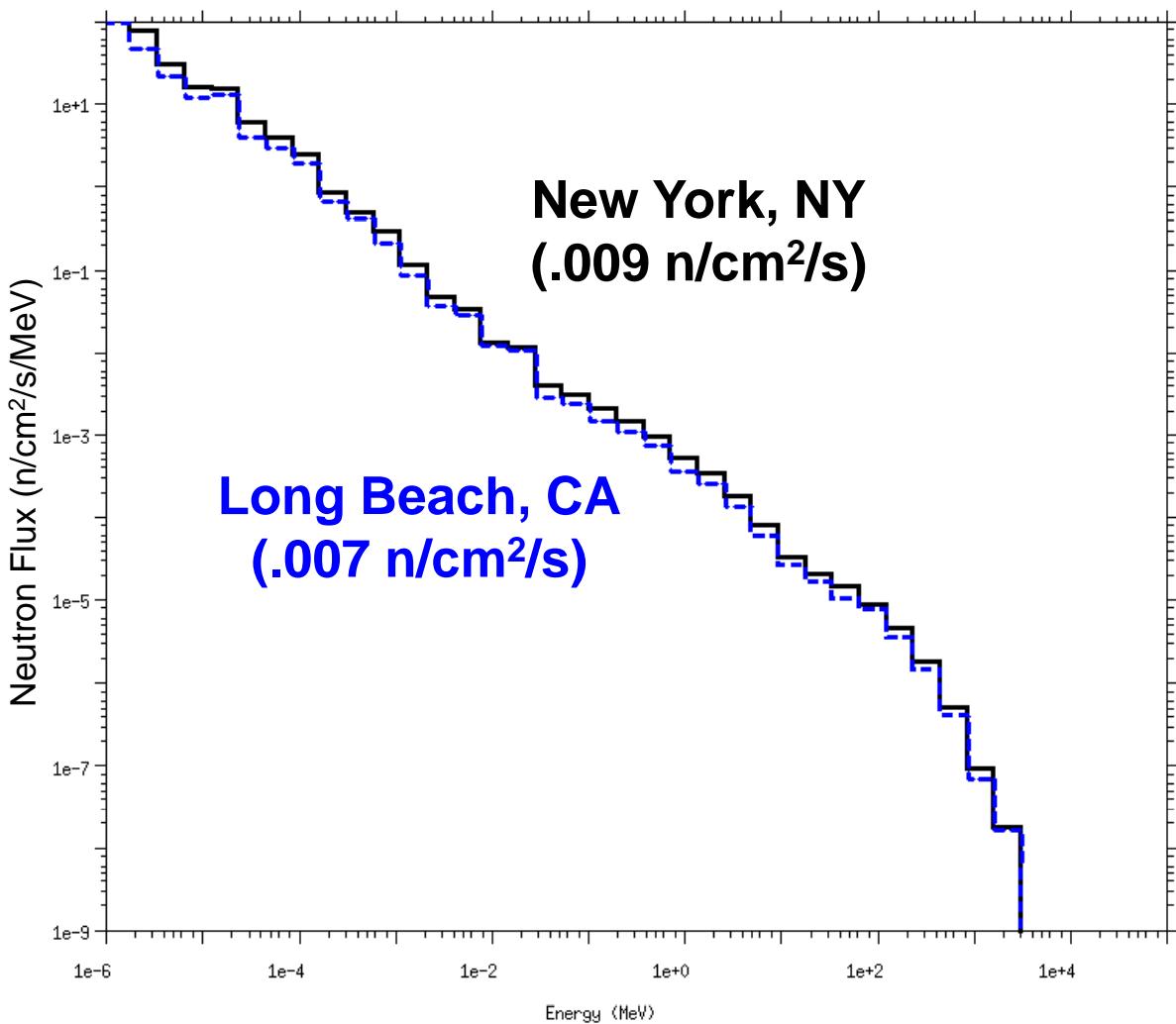
Source Enhancements – Background sources

Background source for NYC

```
1 0 -1 5 imp:n=1
5 0 -5 imp:n=1
99 0 1 imp:n=0

1 rpp -100 100 -100 100 0 200
5 s 0 0 0 5

mode n p
phys:n 5e5
phys:p 1e5
sdef PAR=bg LOC=40.78 73.97 0 $ NYC
    X=d1 Y=d2 Z=d3 WGT=2.333e4
sil -100 100
sp1 0 1
si2 -100 100
sp2 0 1
si3 0 200
sp3 0 1
f4:n 5
e4 1e-8 49log 1e6
f14:p 5
e14 0 1999i 10
nps 50000000
print
```



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Tally Enhancements – Tally tagging

Neutron activation of water + HEU

```
1 2 -10.0 -1      imp:n=1
2 1 -1.0  1 -2    imp:n=1
3 0          2      imp:n=0
```

```
1 sph 0 0 0 3
2 sph 0 0 0 40
```

mode n

cut:n 2j 0 0

phys:n 3j -1

sdef erg=14 par=n pos=-39.999 0 0

m1 1001 200.0

8016 99.762

8017 0.038

8018 0.200

nlib=.66c

m2 92235 0.5

92238 0.5

nlib=.66c

nps 100000

f31:n 2

ft31 tag 3

fu31 -1.0

1001.0

8016.00011 8016.00016 8016.00017 8016.00022

8016.00023 8016.00024 8016.00025 8016.00028

8016.00029 8016.00030 8016.00032 8016.00033

8016.00034 8016.00035 8016.00036 8016.00037

8016.00041 8016.00042 8016.00043 8016.00044

8016.00051 39i 8016.00091 8016.0

8017.00011 8017.00016 8017.00017 8017.00022

8017.00023 8017.00024 8017.00025 8017.00028

8017.00029 8017.00030 8017.00032 8017.00033

8017.00034 8017.00035 8017.00036 8017.00037

8017.00041 8017.00042 8017.00043 8017.00044

8017.00051 39i 8017.00091 8017.0

8018.06012 8018.06013 8018.06014

8018.07014 8018.07015 8018.07016 8018.07017

8018.08015 8018.08016 8018.08017 8018.08018

8018.08019 8018.0

92235.99999 92235.00000

92238.99999 92238.00000

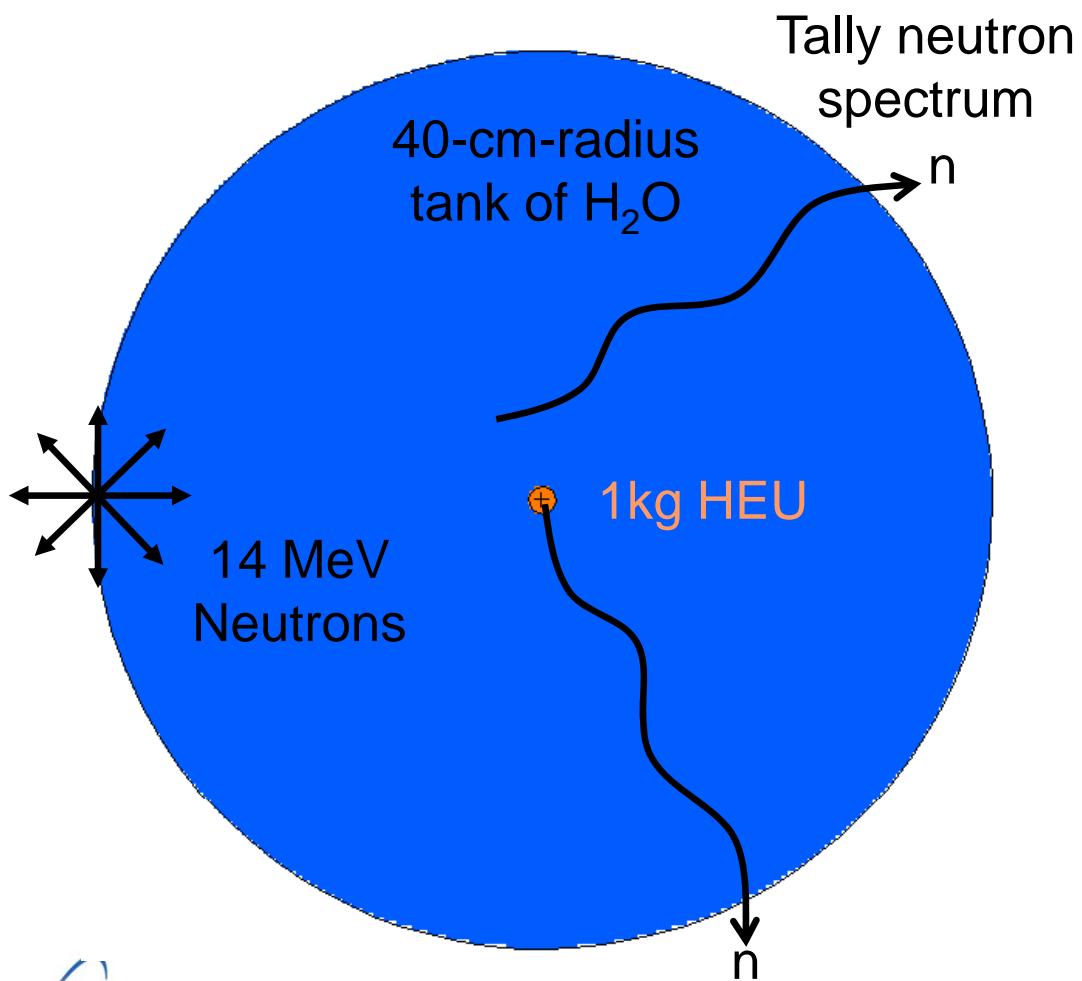
1e10

t31 100 1e15 \$ Prompt and delayed time bins

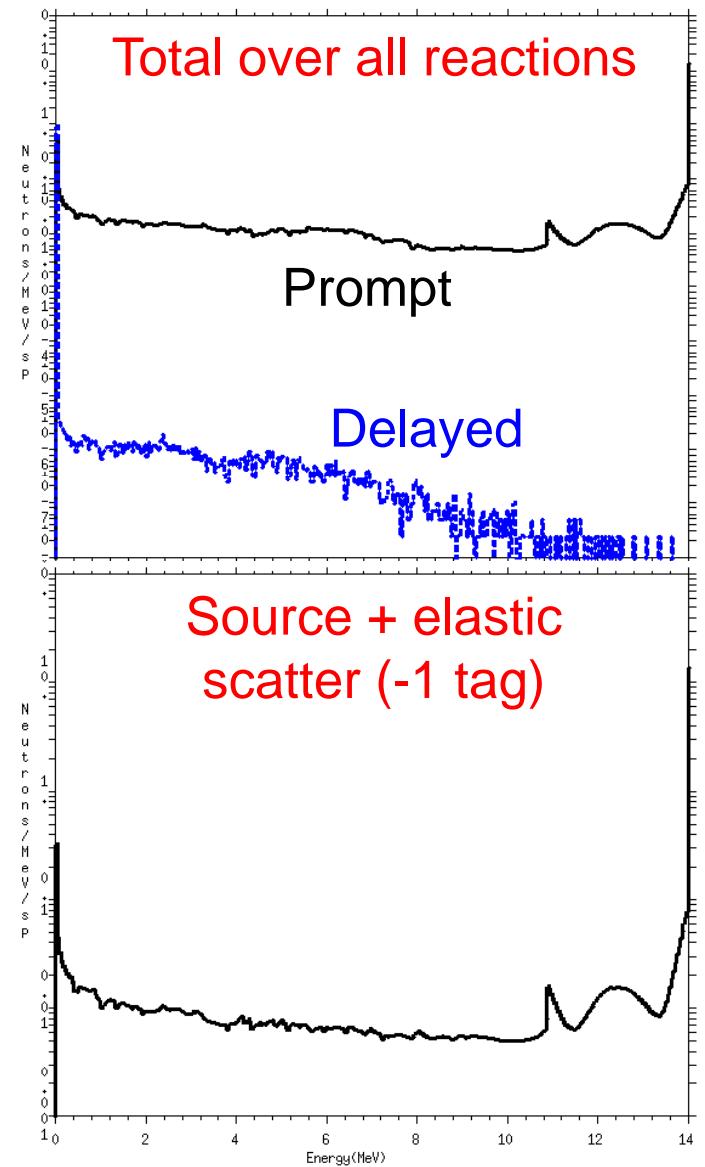
e31 0 499i 20

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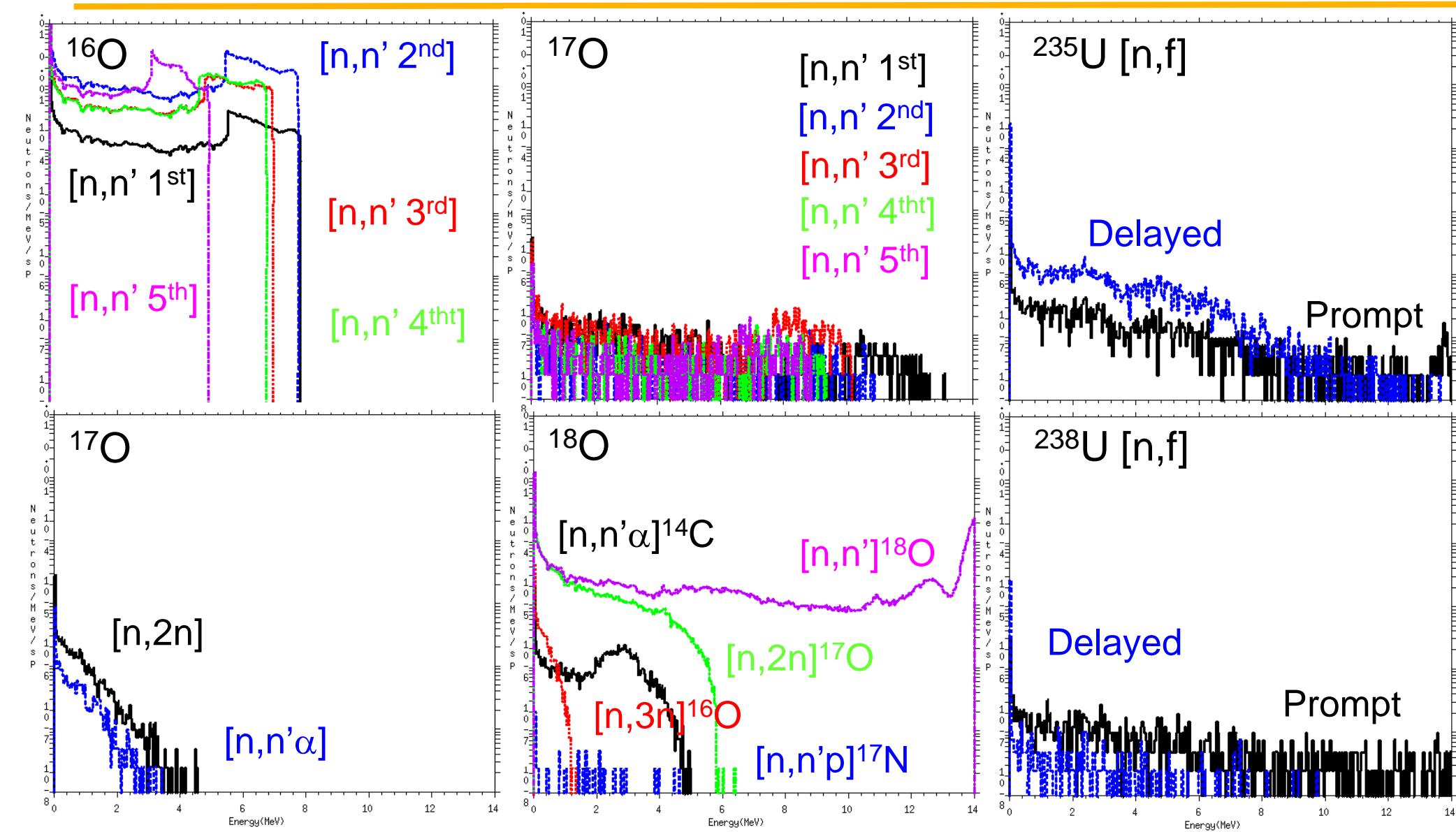
Tally Tagging



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Tally Tagging

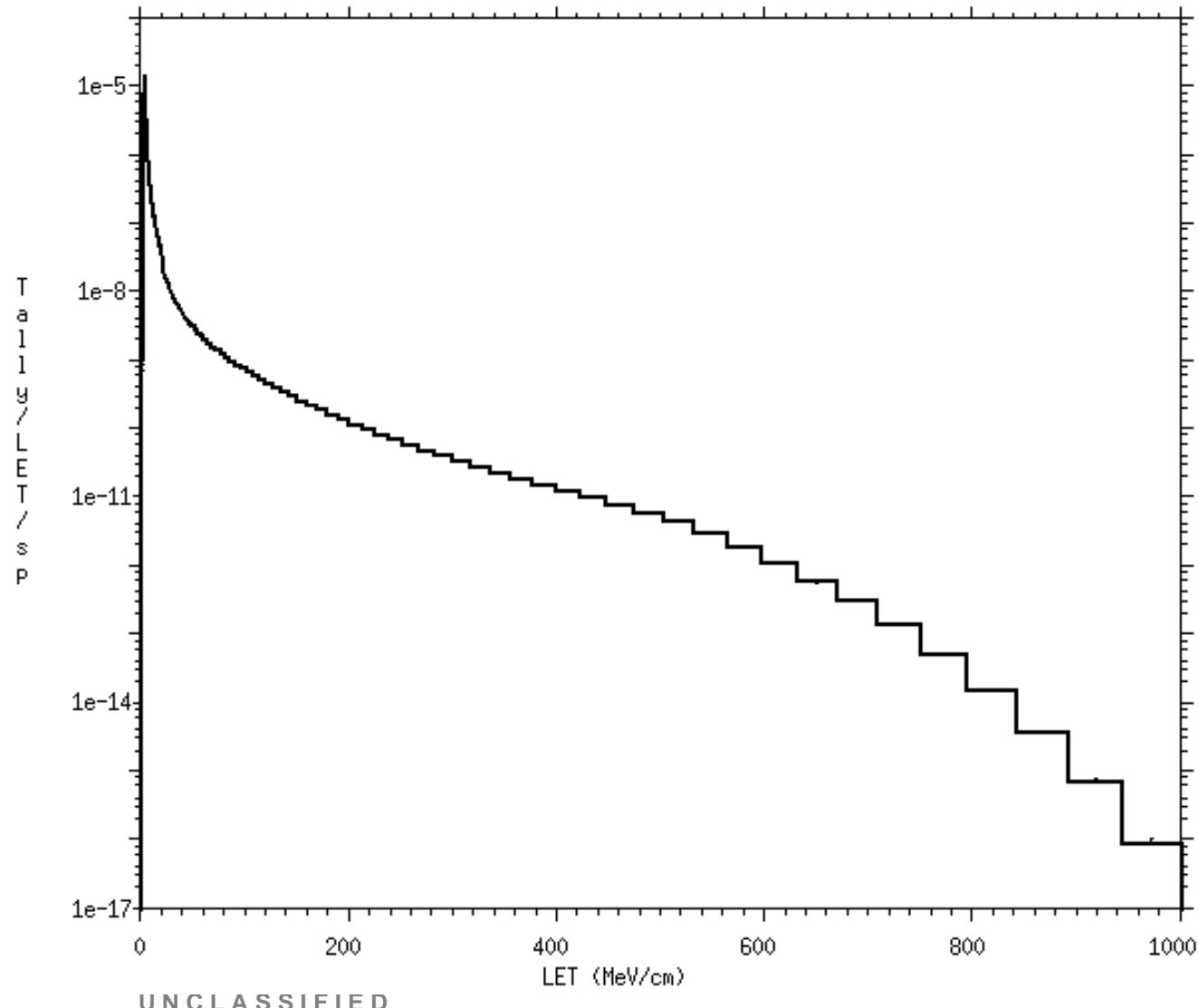


Tally Enhancements – LET option

```
1 MeV photons into Si  
1 1 -2.0 -1 imp:p,e=1  
2 0 1 imp:p,e=0
```

```
1 so 10.0
```

```
MODE p e  
M1 14028 1  
sdef par=p erg=1  
f4:e 1  
e4 .01 199log 1000 $ MeV/cm  
ft4 LET  
nps 1000000  
print
```



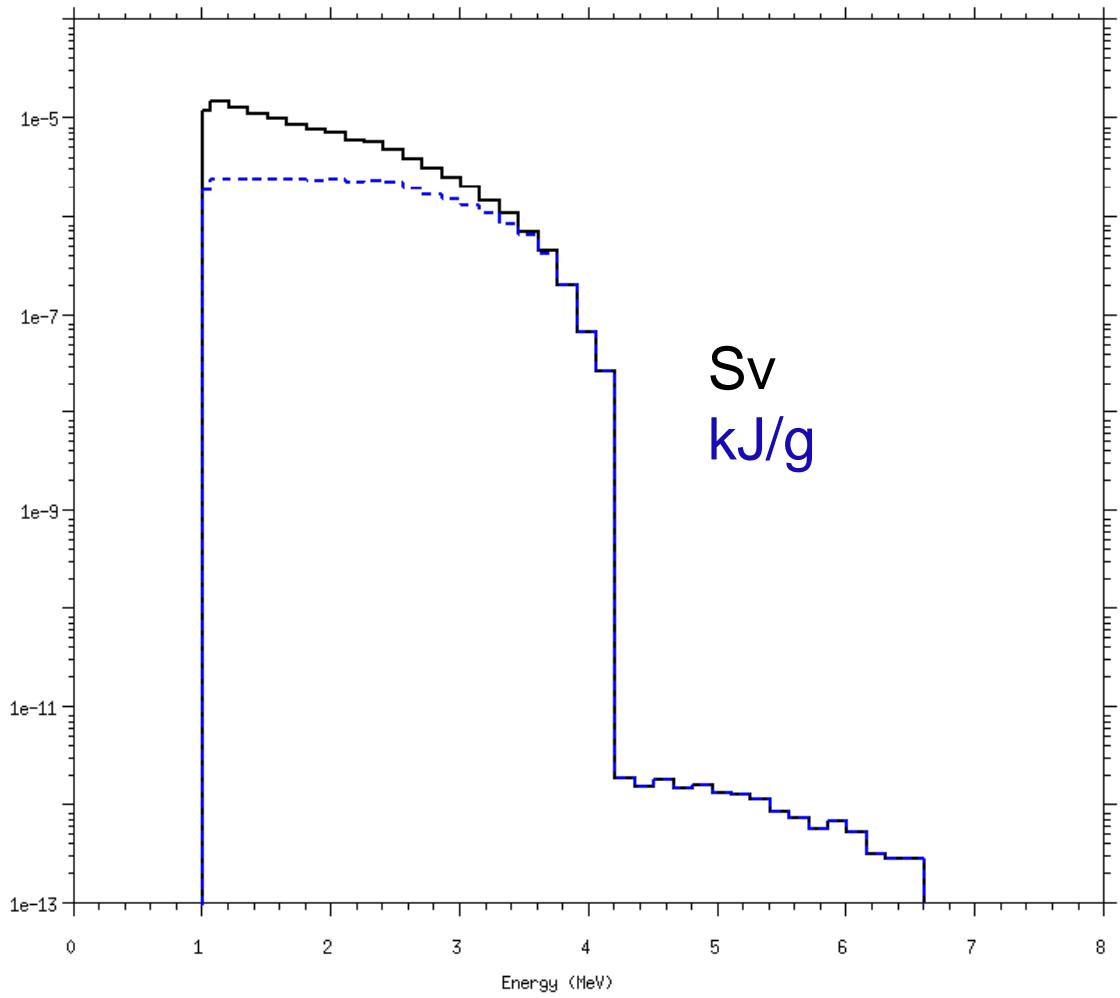
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Tally Enhancements – Quality factors

14 MeV n into water

```
1   1 -1.0      -1    imp:n=1  
2   0           1    imp:n=0  
  
1   so 10.0
```

```
m1    1001 2 8016 1  
mode   n h d t s a / z #  
lca    8j 1 1  
sdef   par=n erg=14  
e0     0 99i 15  
c  
fc16 Dose equiv  
f16:h 1  
df16   ic=99 iu=1 fac=-3  
c  
fc116 Dose  
f116:h 1
```



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Tally Enhancements – Cyclic binning

Pulsed 15-MeV gammas into U-235

```
1 1 -19.0      -1 imp:p=1  
2 0           1 imp:p=0
```

```
1 so 10
```

```
m1 92235 1
```

```
mode p
```

```
phys:p 3j 1 j -101
```

```
lca 7j -2
```

```
sdef par=p erg=15 tme=d1<=d2
```

```
si1 0 0.000001e8 .001e8
```

```
sp1 0          1    0
```

```
si2 0          1e8
```

```
sp2 0          1
```

```
f1:p 1
```

```
T1 CBEG=0.0 CFRQ=1000e-8
```

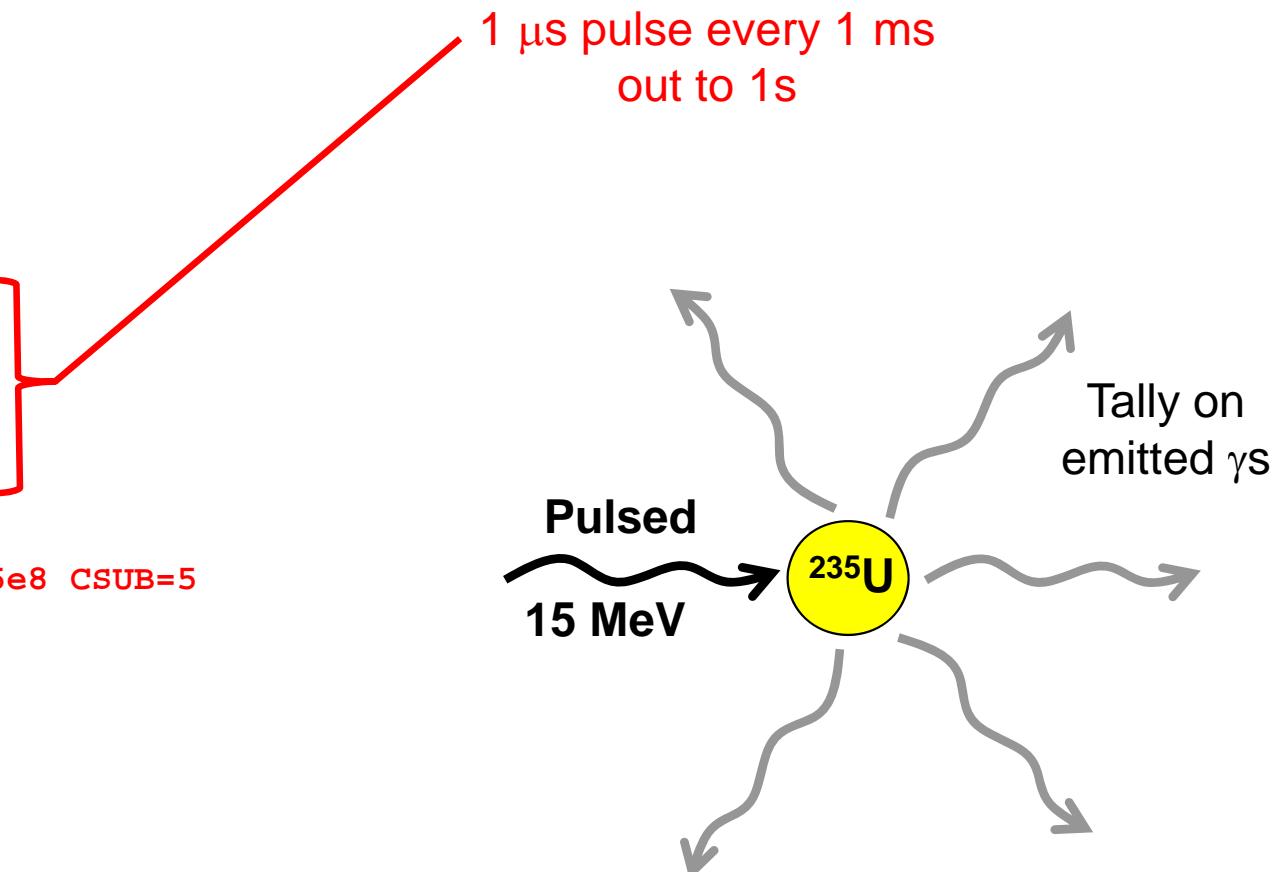
```
COFI=0.000005e8 CONI=0.0005e8 CSUB=5
```

```
ft1 tag 1
```

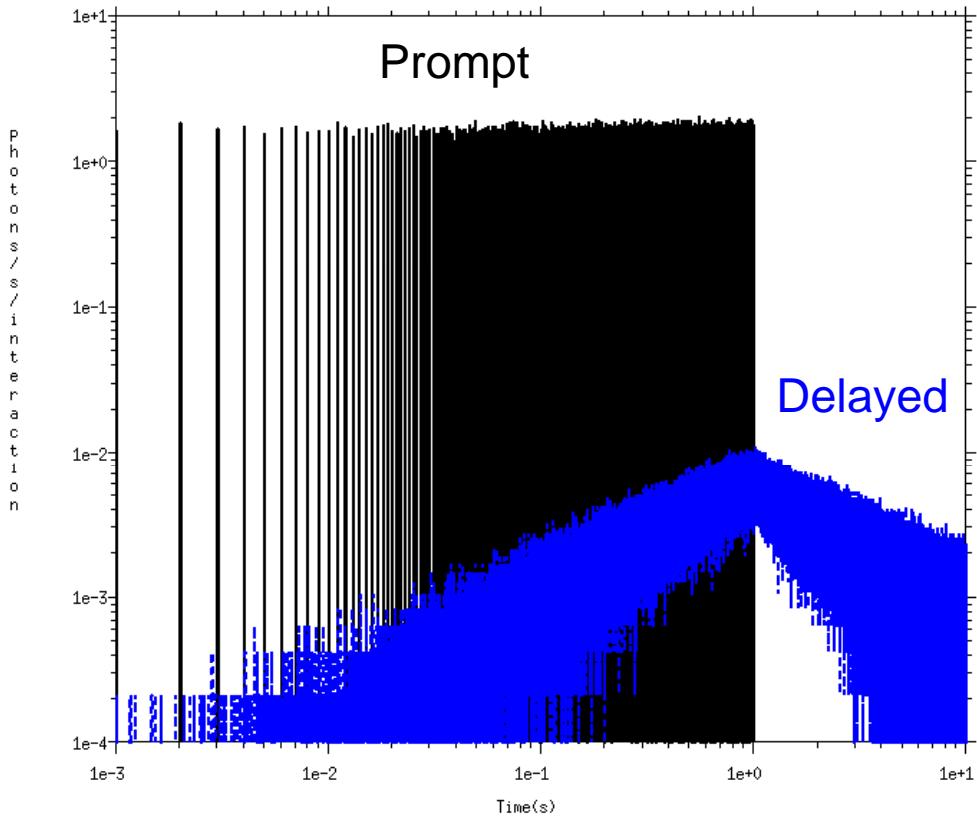
```
fu1 92235.99999 92000.0
```

```
nps 100000000
```

```
print
```

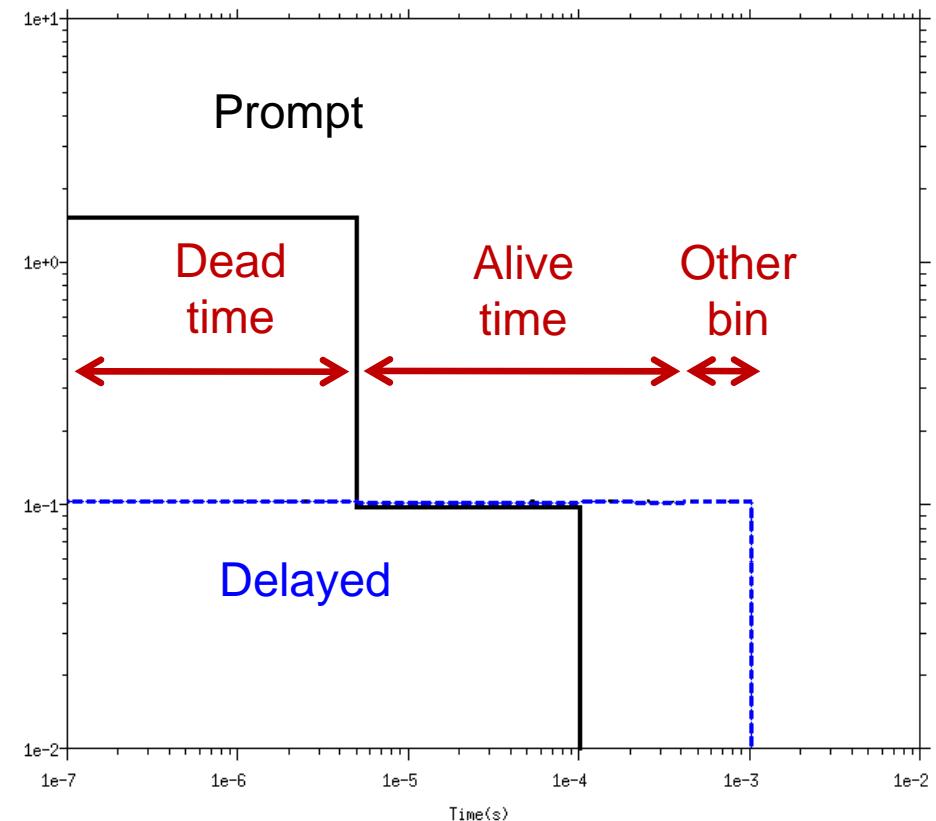


Tally Enhancements – Cyclic binning



Full time-dependent behavior of 1000 pulses with dead/alive time bins repeated every 1 ms. Note decay after beam is turned off.

Cyclic time feature accumulates contributions across all 1000 repeated bins.



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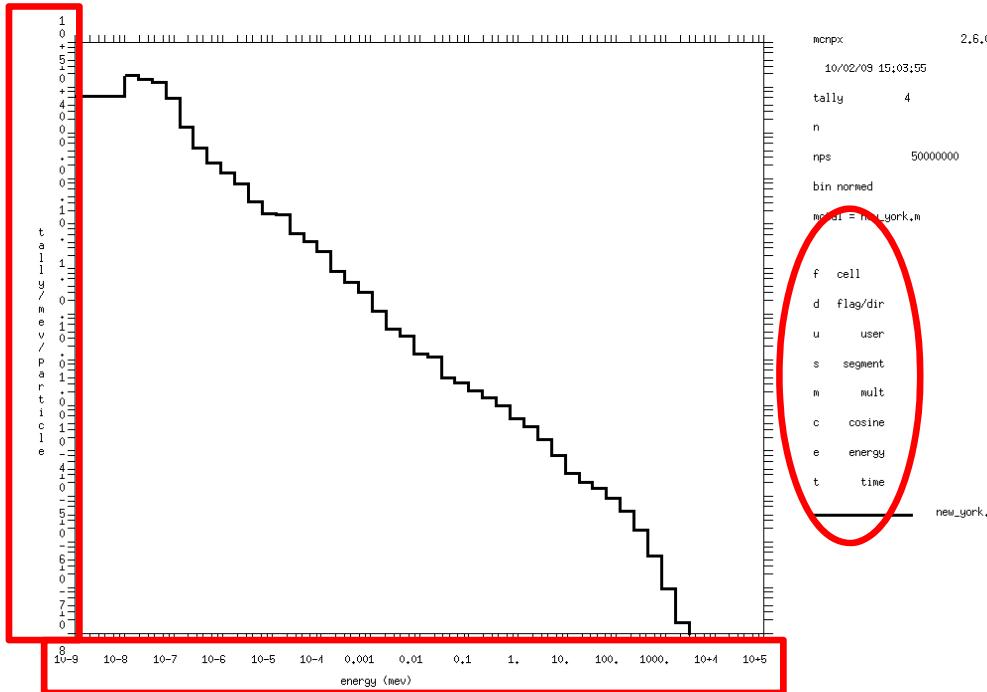
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Other Enhancements

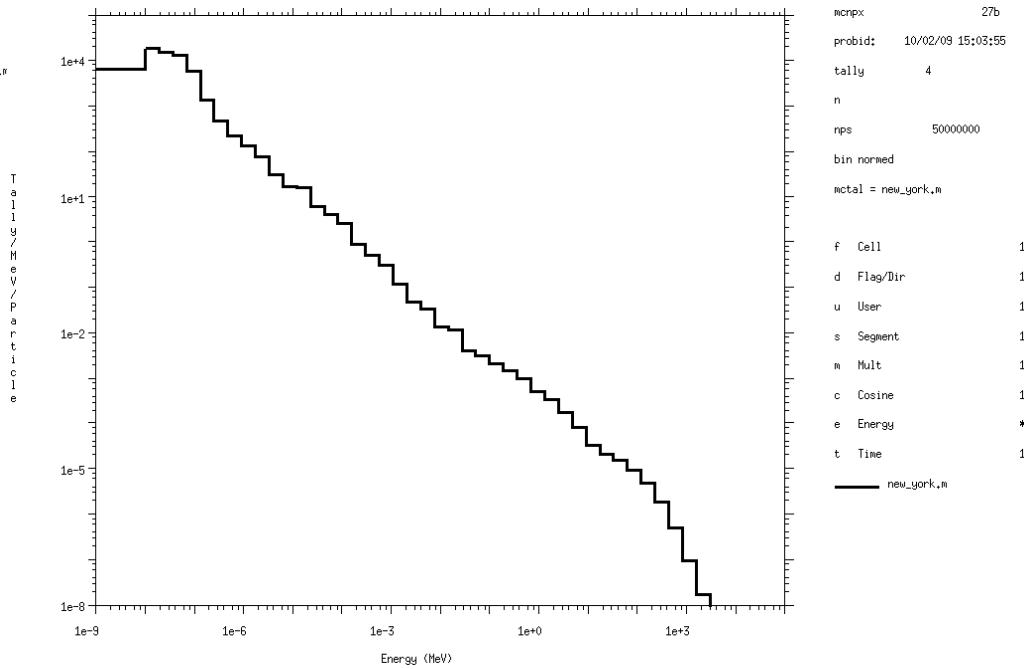
MCPLT graphics enhancements
Activation options (ACT card)
Contout Legend in Geometry Plotter

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Other Enhancements – MCPLLOT graphics



```
mcplot>  
Help  
Type "help all" for a verbose list of all help commands  
"help <command>" to list a specific help command,  
"help overview" for an overview of MCPLLOT,  
or "help execute" for MCPLLOT input & execution-line  
mcplot>
```

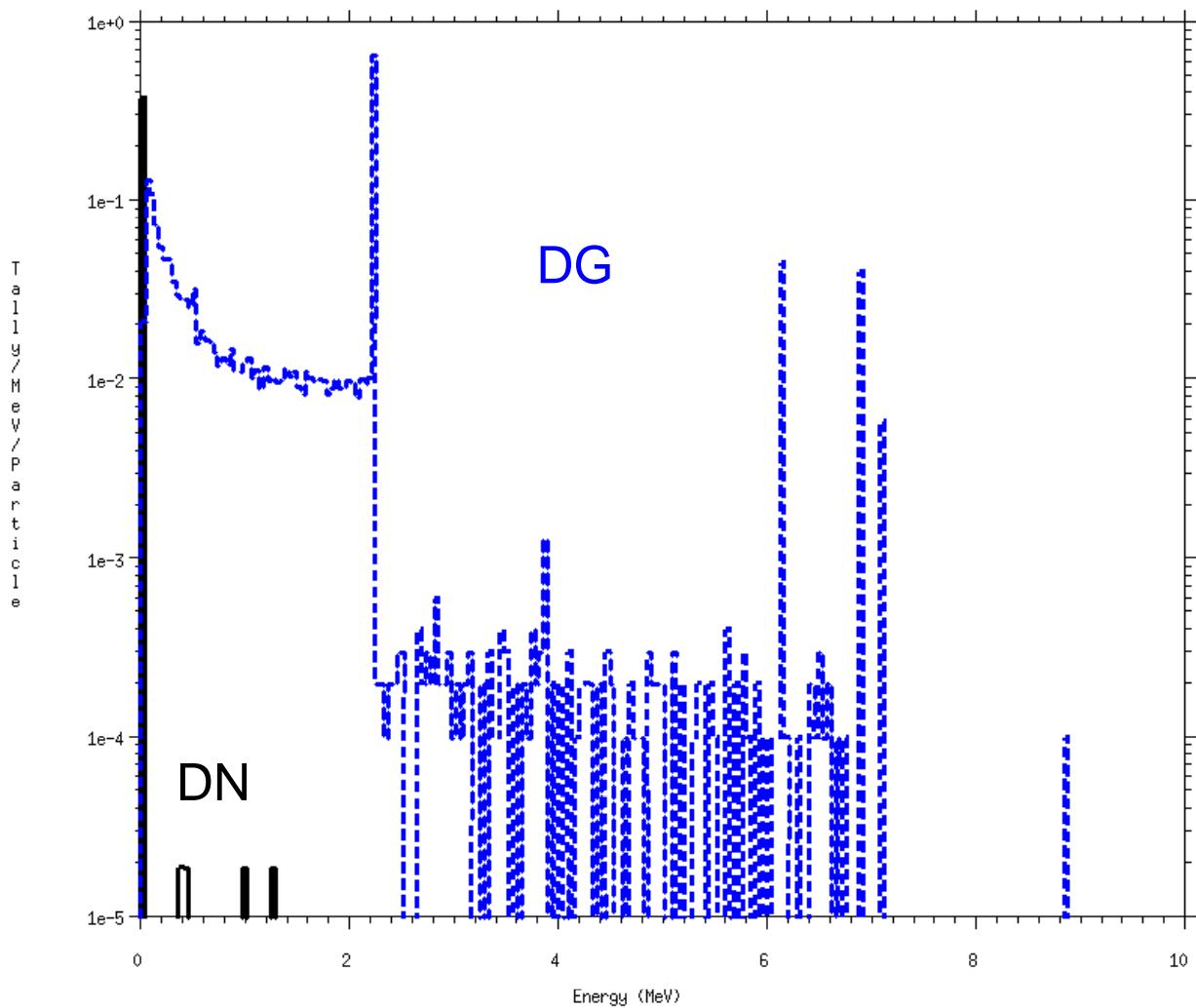


Other Enhancements – Activation

```
14 MeV neutron activation of water
1 1 -1.0 -1      imp:n=1
3 0           1      imp:n=0

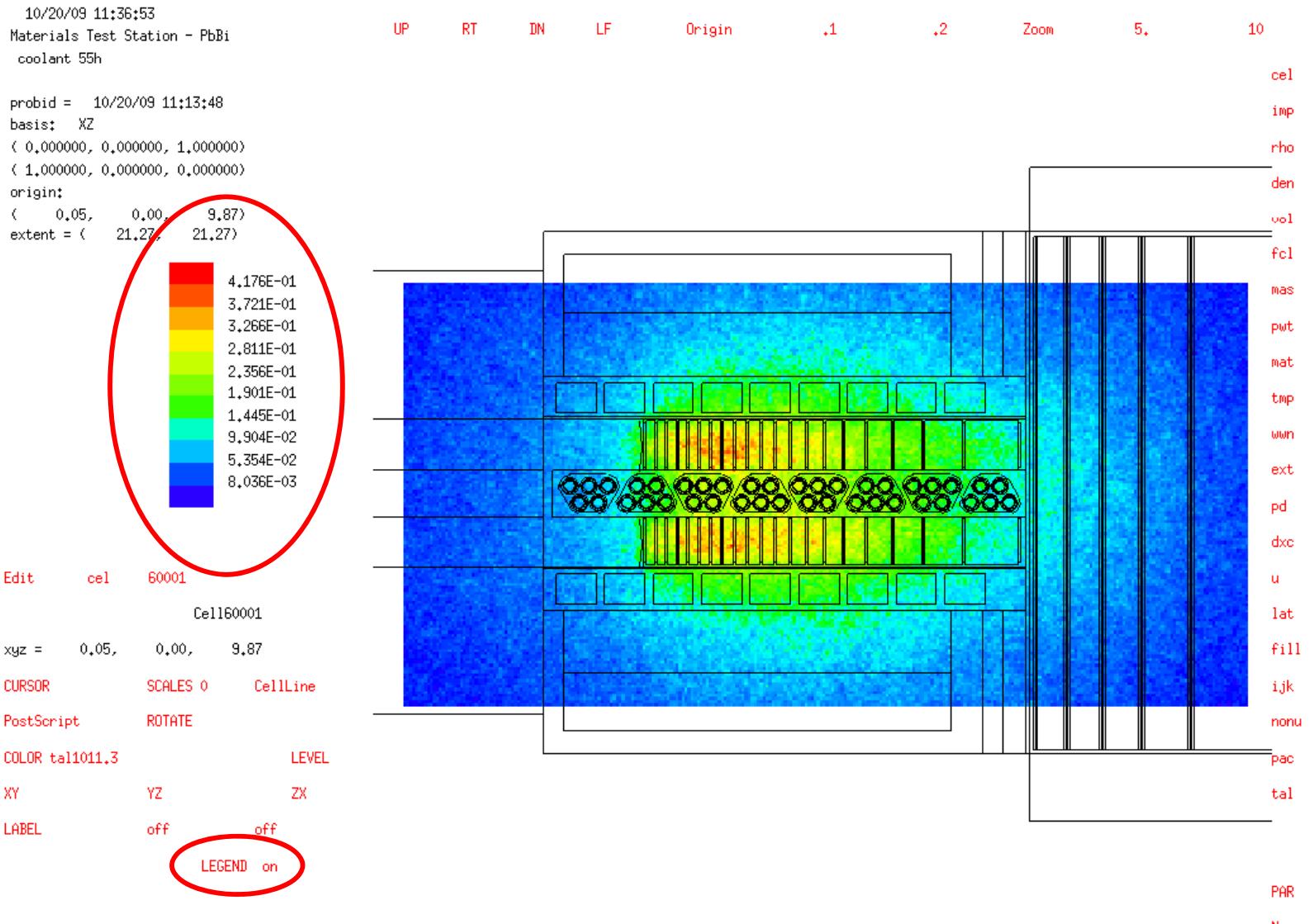
1 sph 0 0 0 40

mode n p
cut:n 2j 0 0
phys:n 3j 105 $ Bias DN
phys:p 5j -102 $ Analog DG
ACT NONFISS=all
sdef erg=14 par=n pos=-39.999 0 0
m1 1001 200.0
  8016 99.762
  8017 0.038
  8018 0.200
  nlib=.70c
f11:n 1
t0 1000 1e15 $ Prompt & delayed
e0 0 499i 20
f21:p 1
nps 1000000
print
```



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Other Enhancements – Contour Legend



Summary

- **23 features added or planned for 2.7.0**
- **Release tentatively scheduled for Summer 2010**
- **MCNP6 (merged MCNPX/MCNP5) may supersede 2.7.0**
- **Slides available on MCNPX website**
 - <http://mcnpx.lanl.gov/documents.html>