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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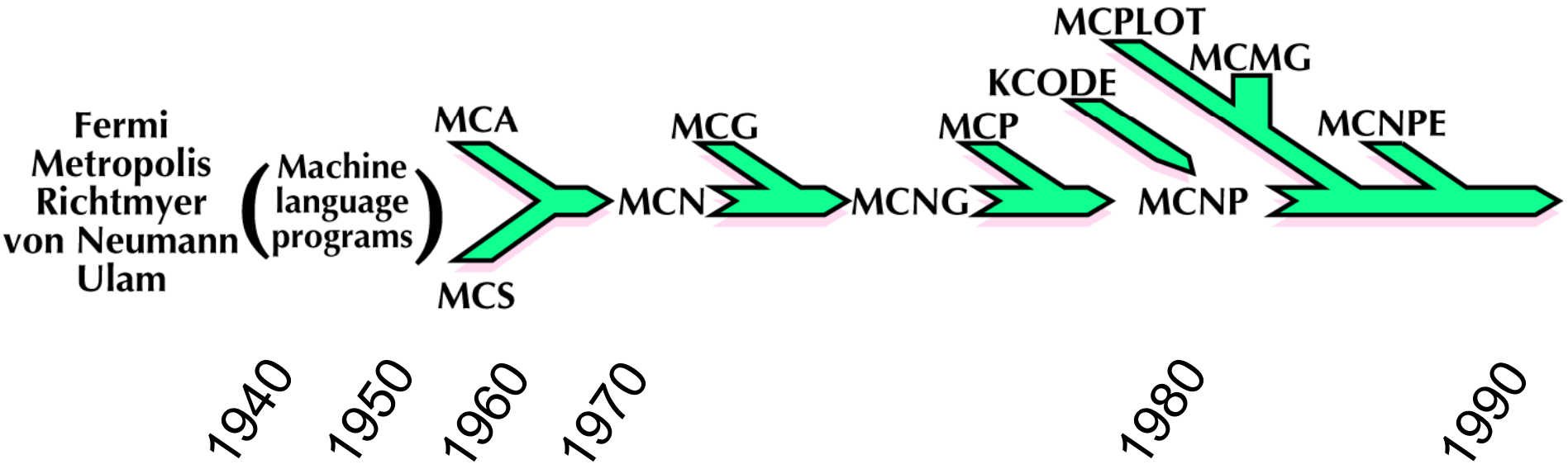
Outline

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

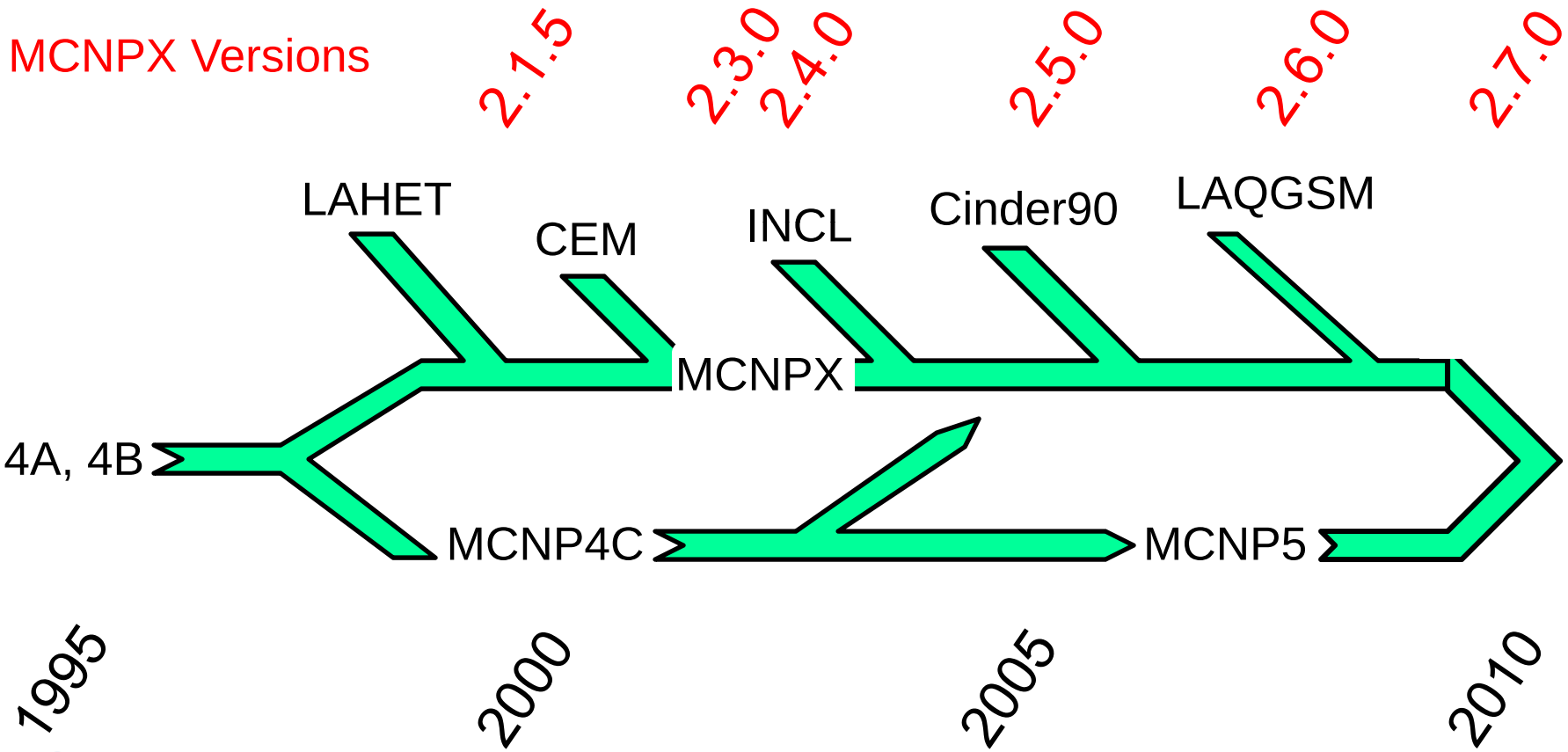
Overview – MCNPX is a 3-D, all-particle, all-energy Monte Carlo transport code

- **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)

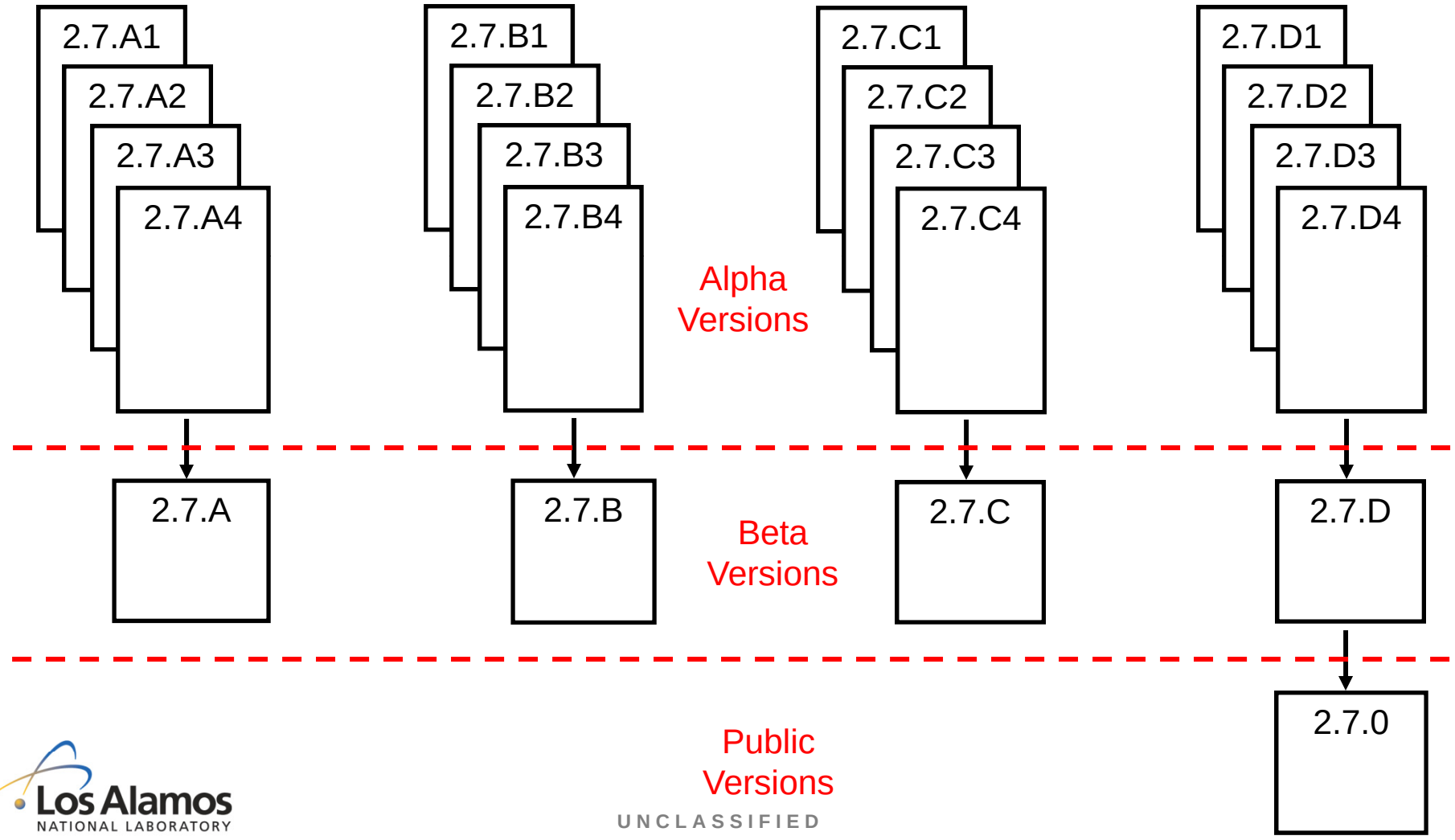
Overview – The previous century of development



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

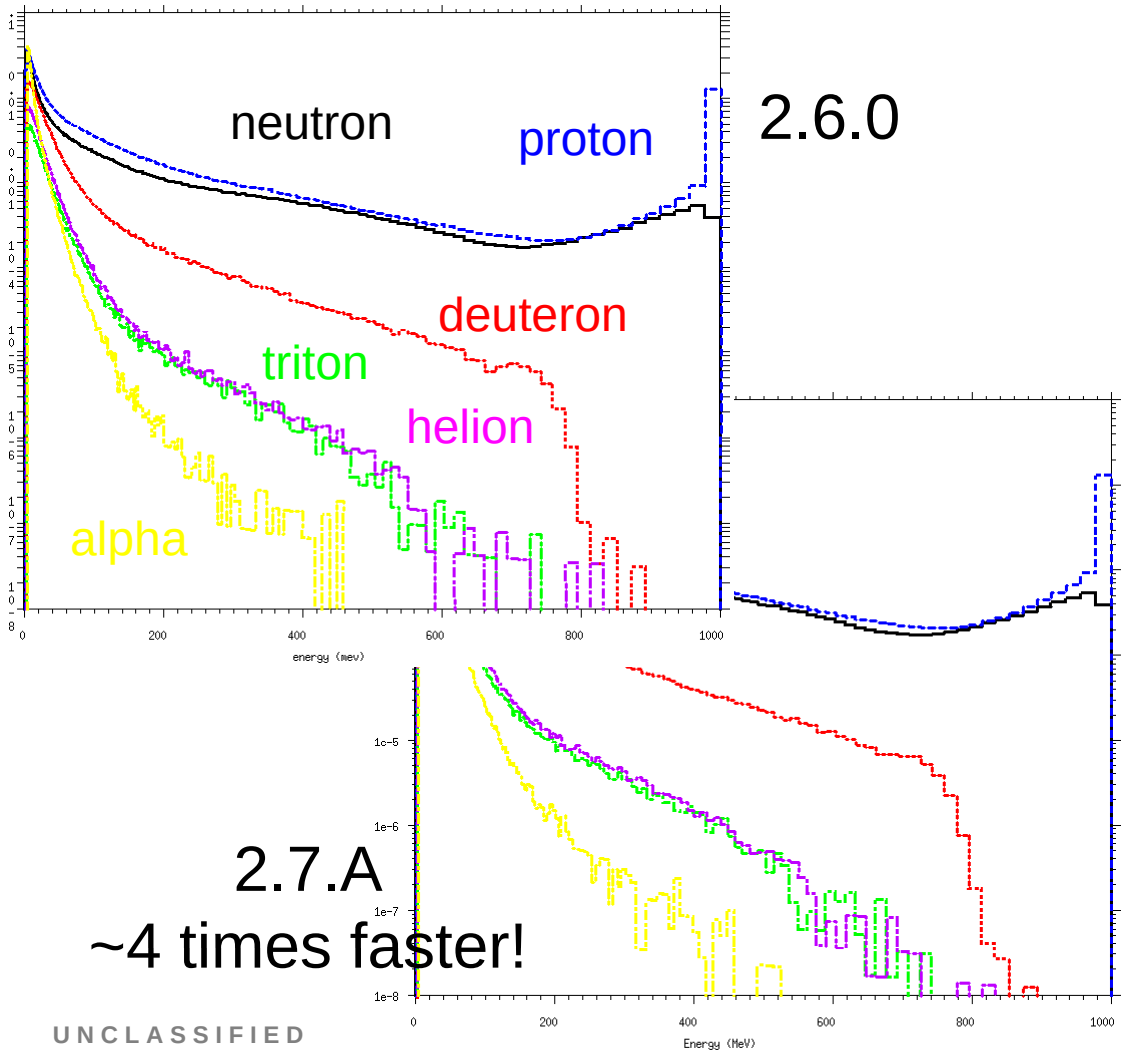
MCPLOT graphics enhancements
Activation options (ACT card)
MCPLOT tally manipulations
Dynamic universes

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
```

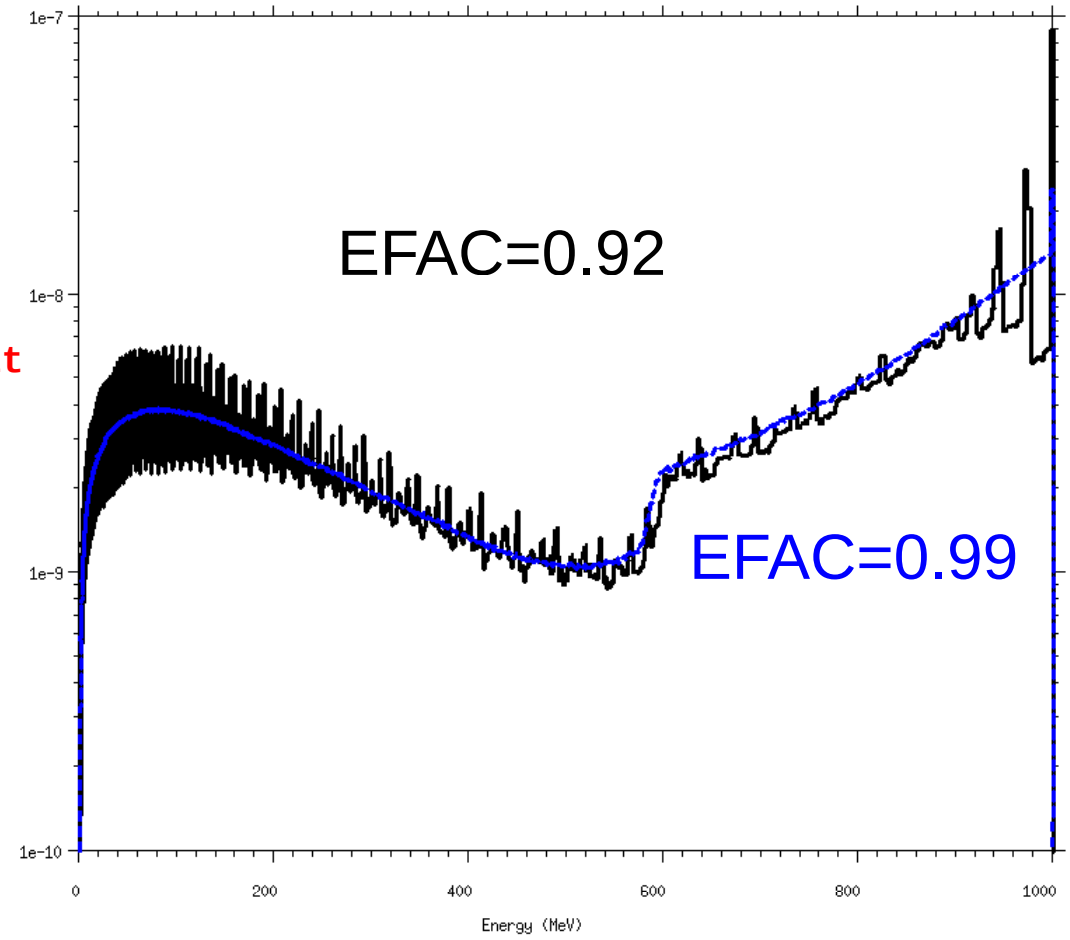


Physics Enhancements – Stopping powers

```
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
```

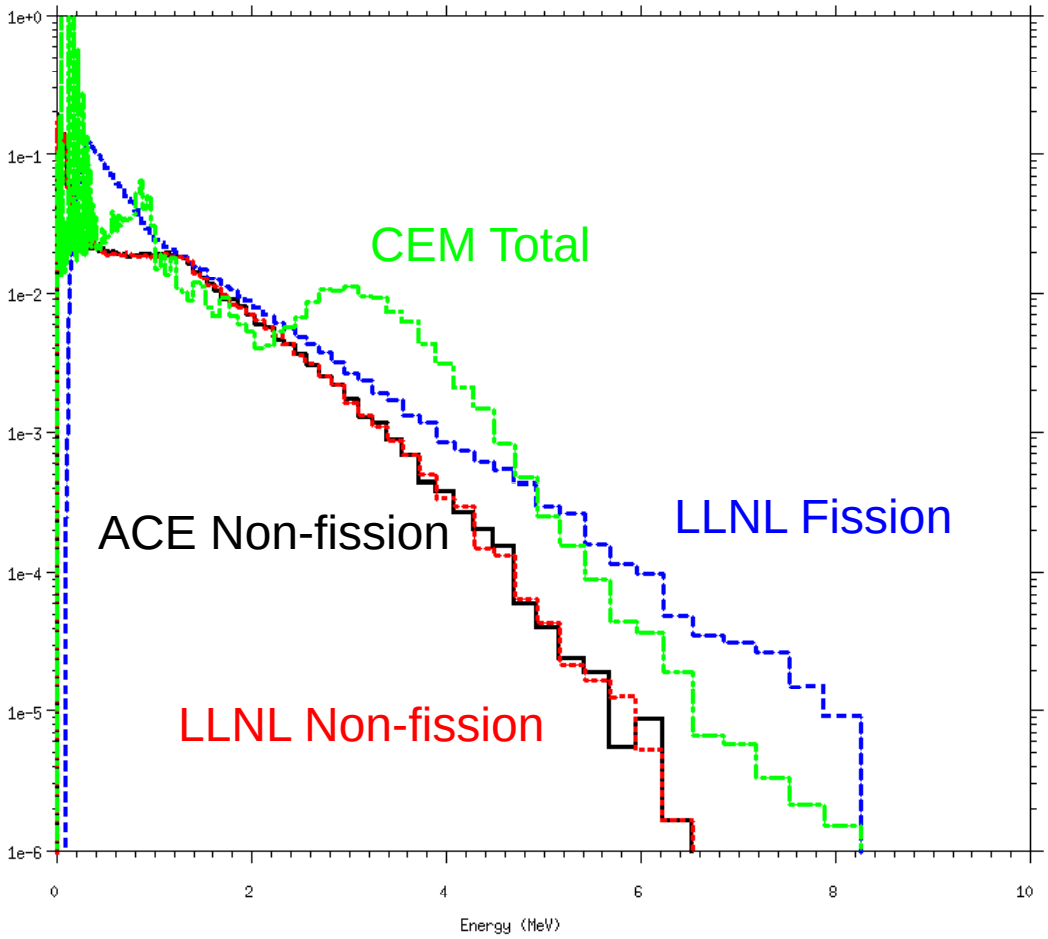


Physics Enhancements – LLNL multiplicities

```
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
fu11  -1 0.00004 92000.00003
       92235.00005 92000.00005
       92235.00018 1e10
```

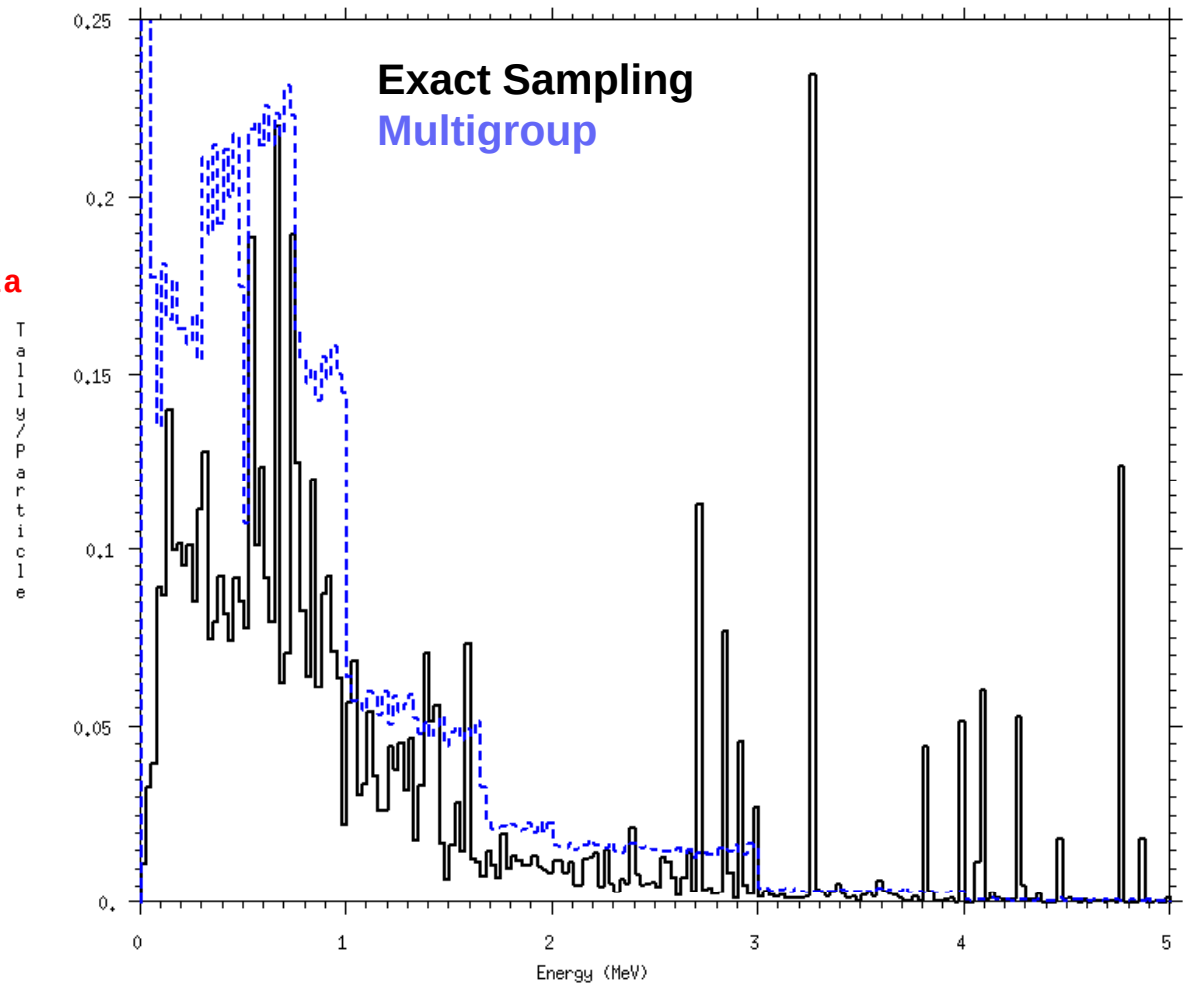


Physics Enhancements – Exact DG sampling

```
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 $ Analog line data
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
```

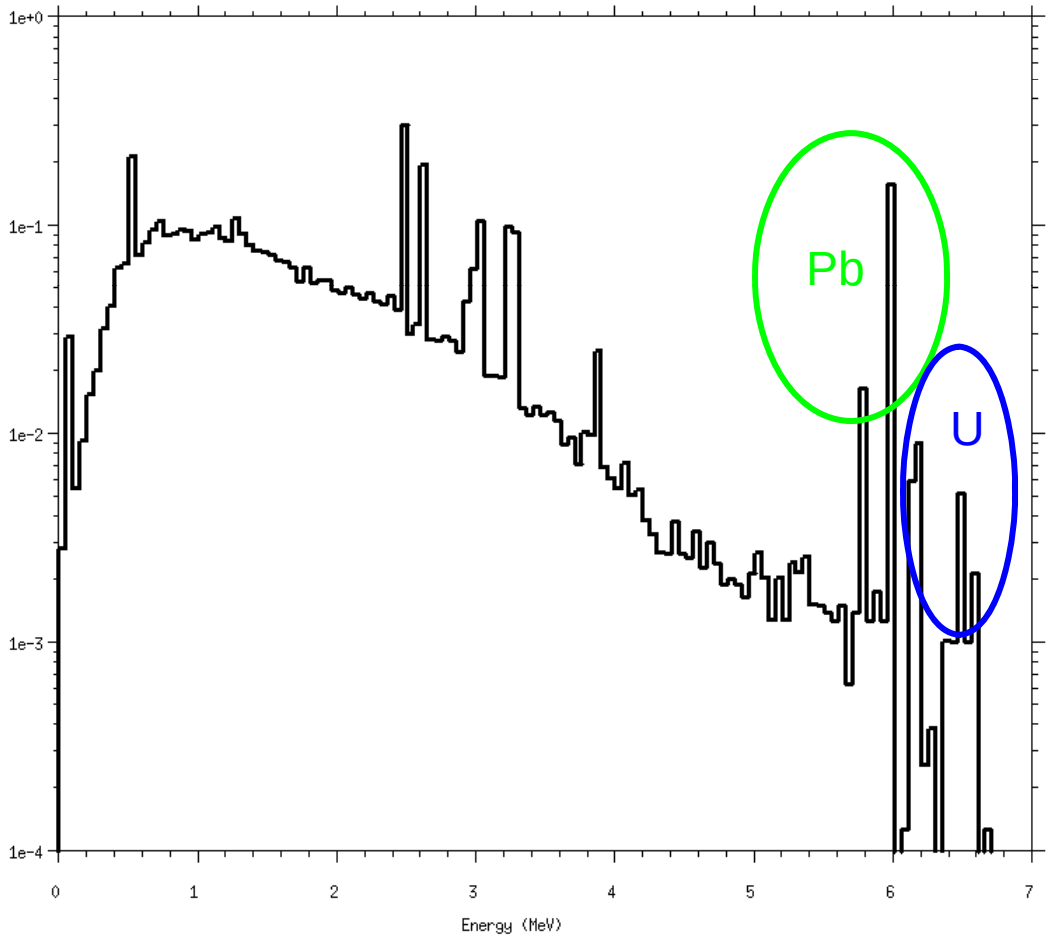


Physics Enhancements – Muonic x-rays

```
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
```

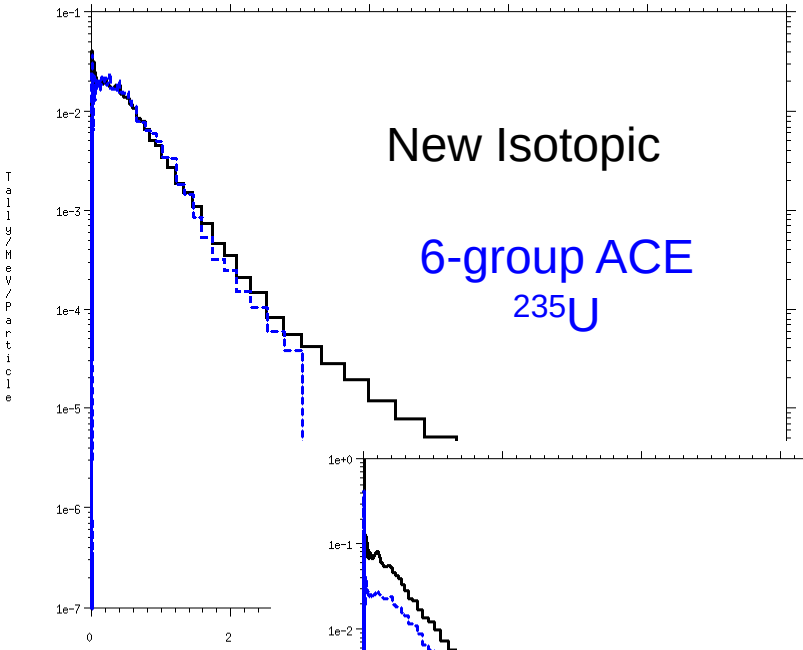


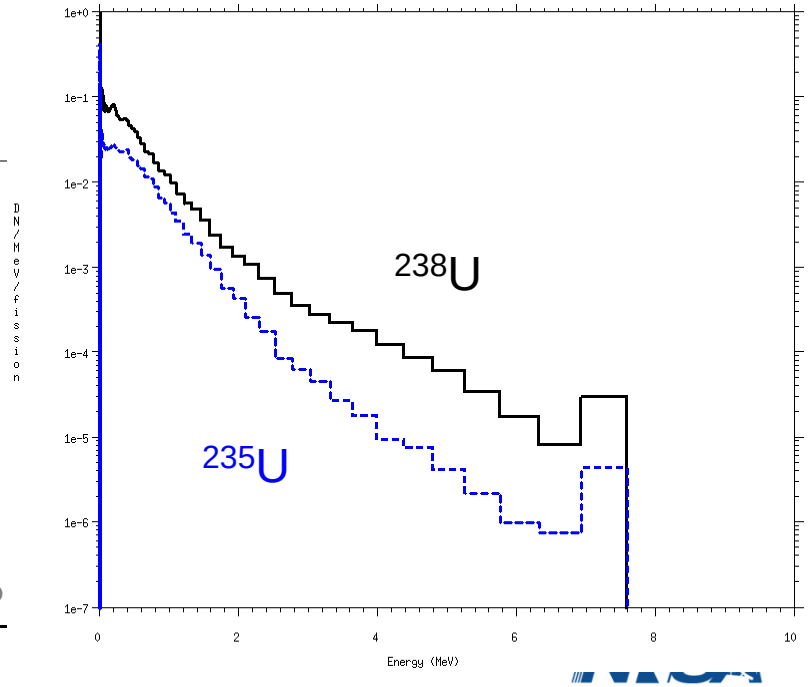
Physics Enhancements – DN spectra

```
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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Natural background sources

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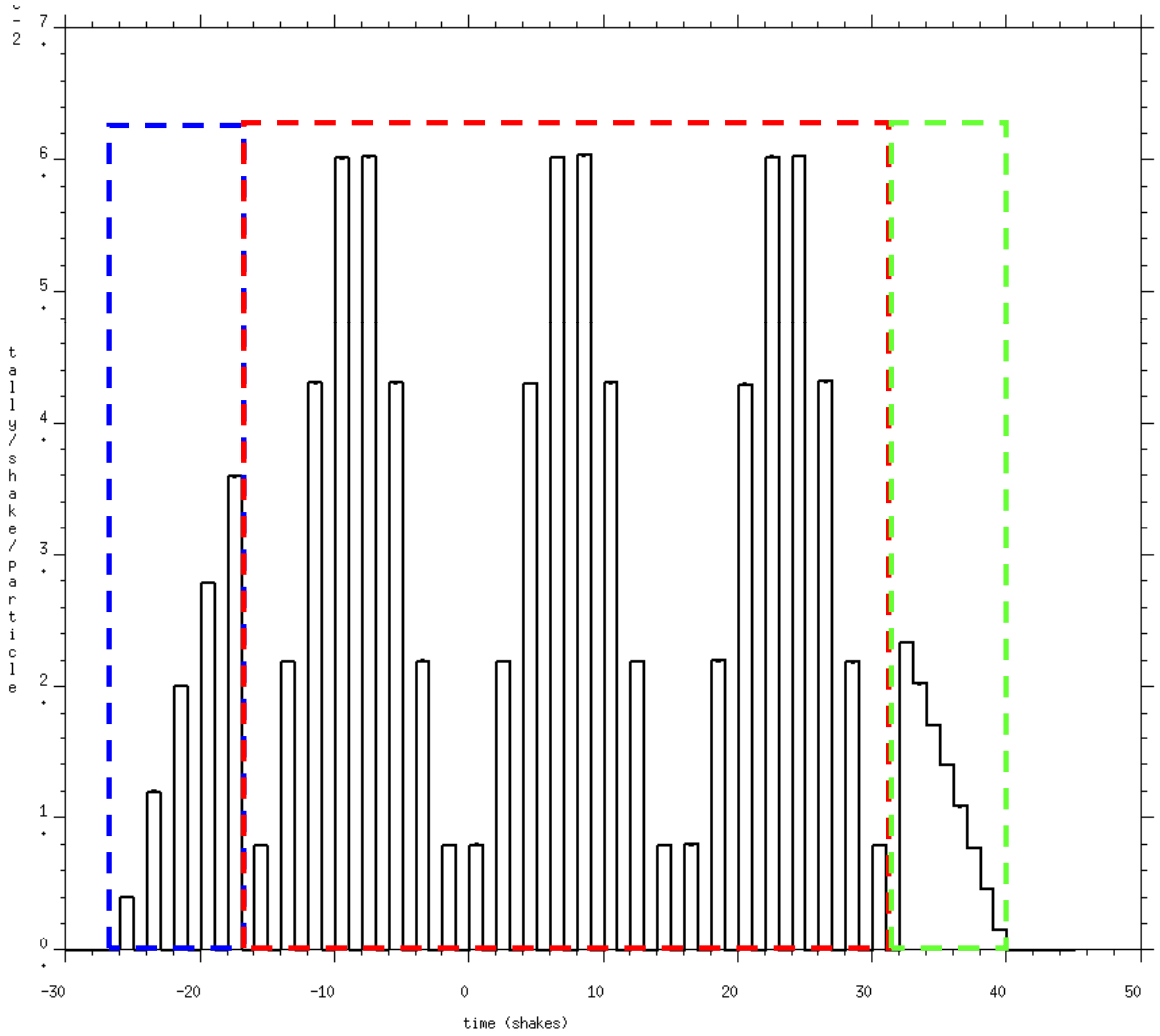
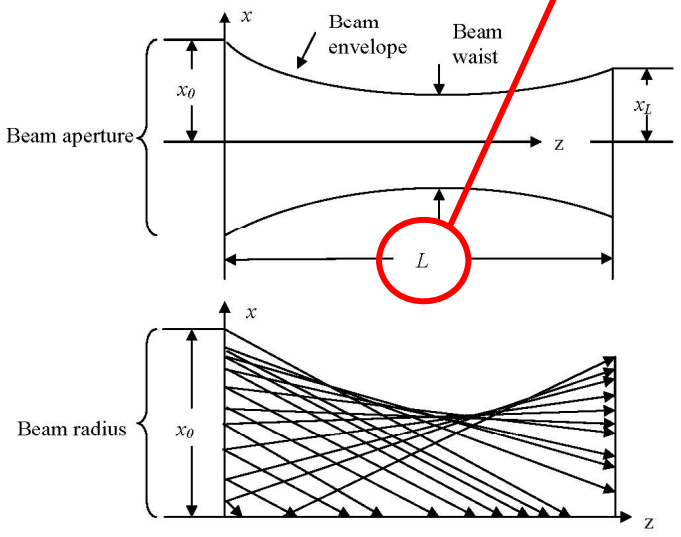
Source Enhancements – Pulsed sources

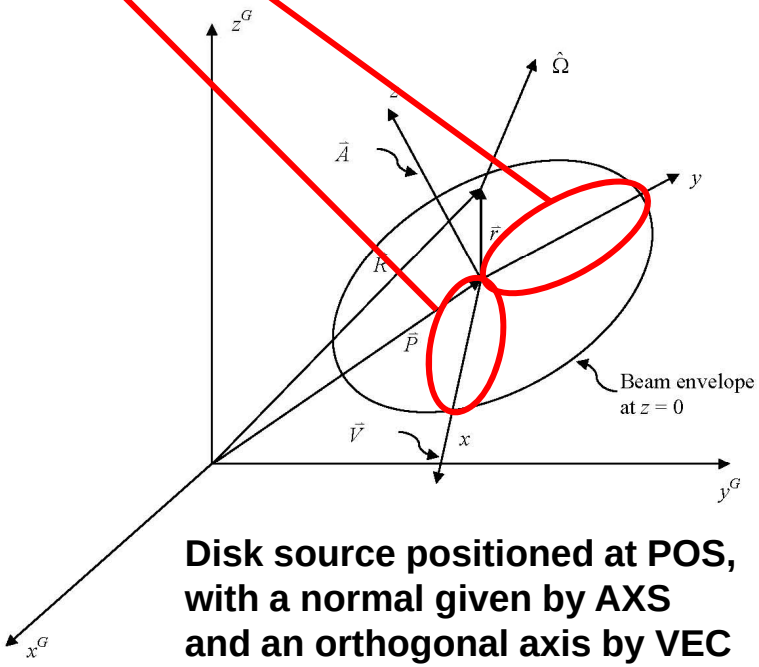
```
SDEF TME=D41
#      si41          sp41
         S             D
       51<52           .1
    (31<32<33)         .8
         61            .1
si51 H    0    1      2
sp51      0    1      0
si52 A  -26  -16
sp52      0    1
si31      0    1      2
sp31      0    1      0
si32      0   16
sp32    -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
```



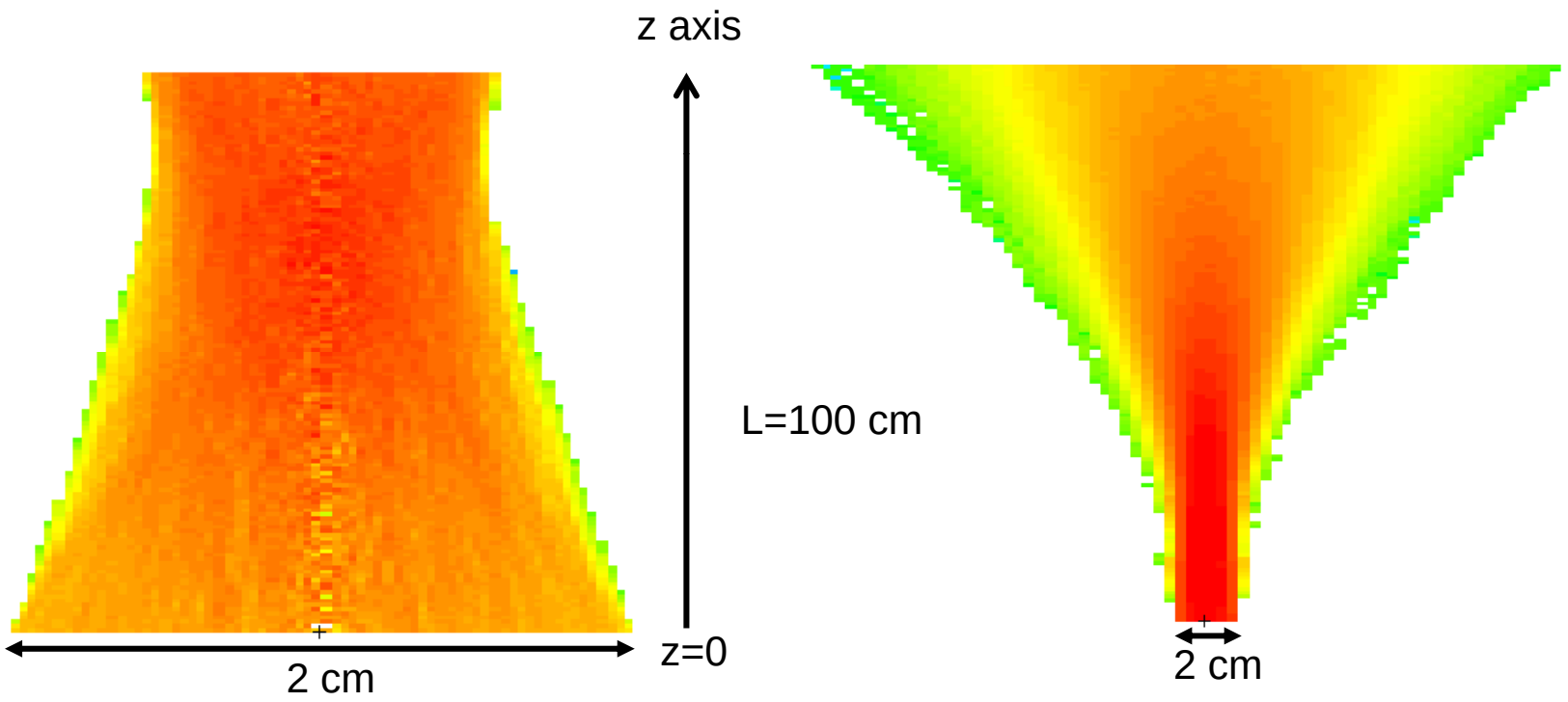


Disk source positioned at POS, with a normal given by AXS and an orthogonal axis by VEC

Source Enhancements – Beam sources

Beam transport in vacuum

Beam transport in air

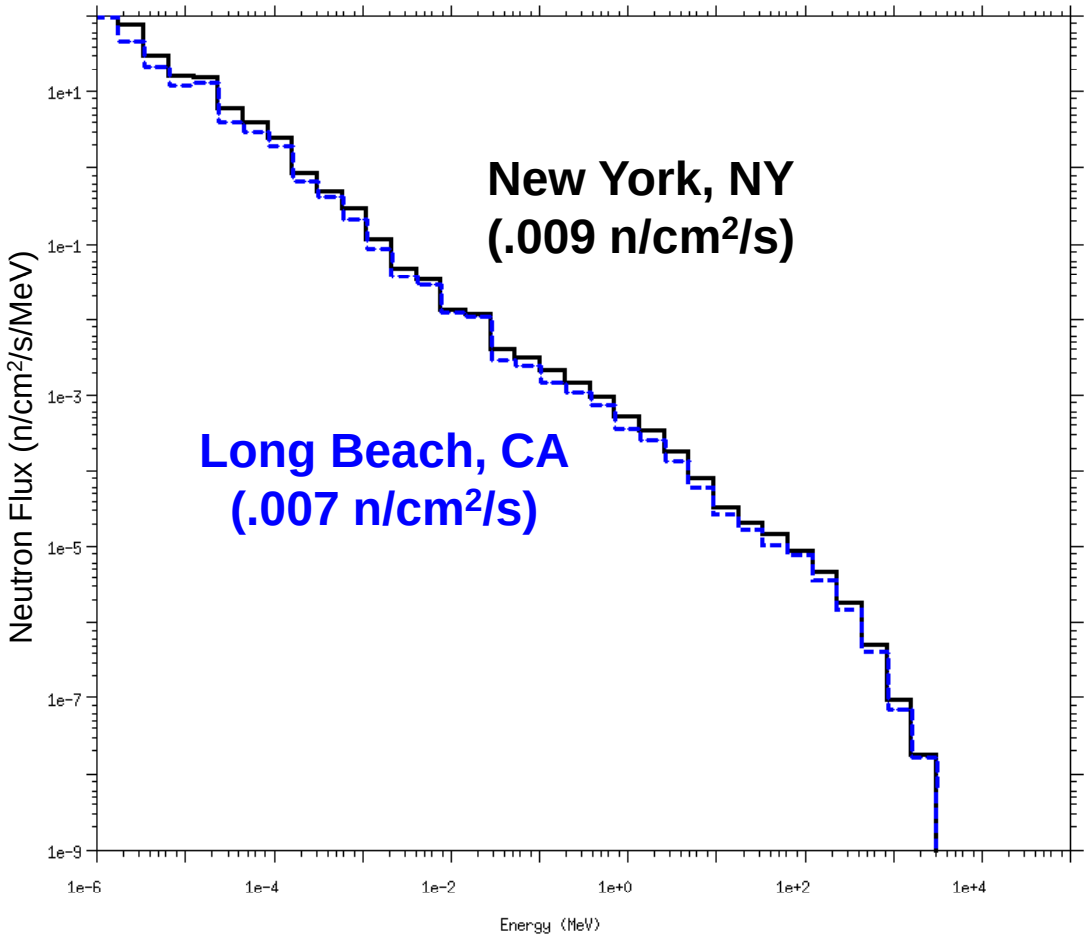


Source Enhancements – Background sources

```
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
si1   -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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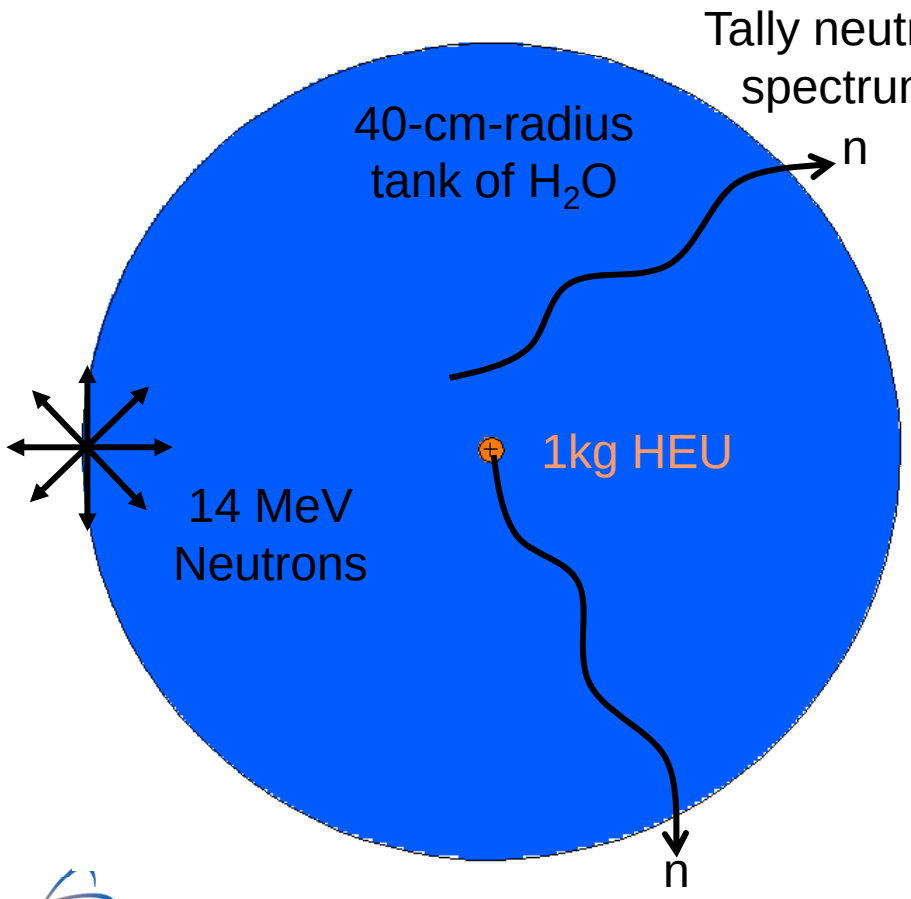
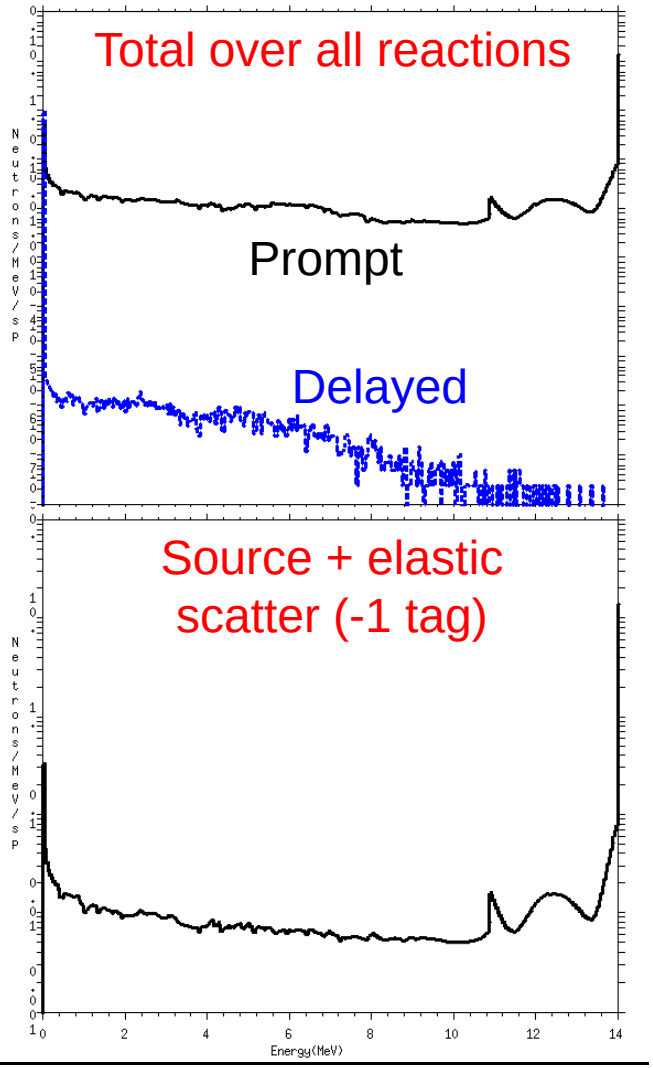
Tally Enhancements – Tally tagging

```
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
```

Tally Tagging





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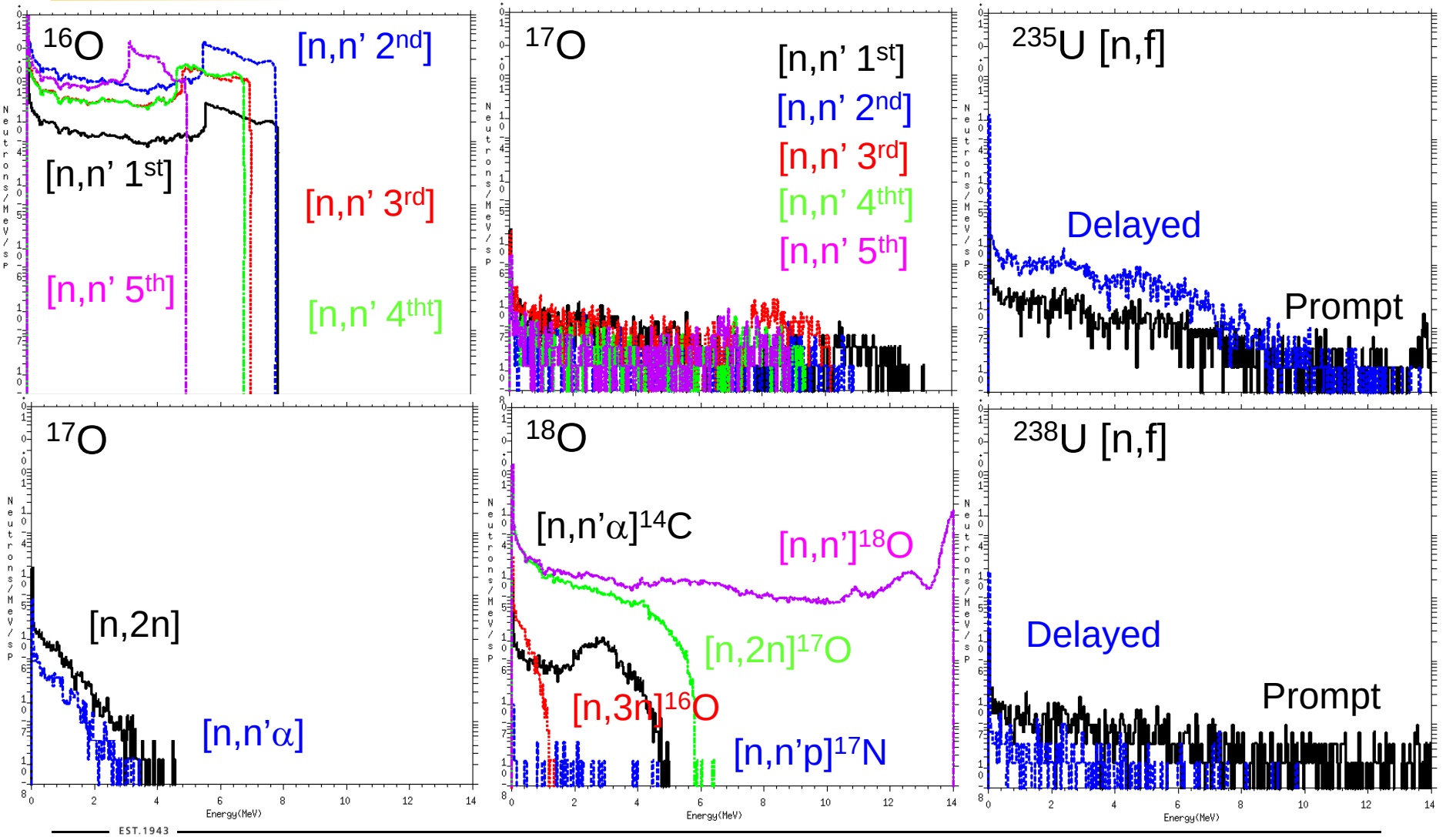
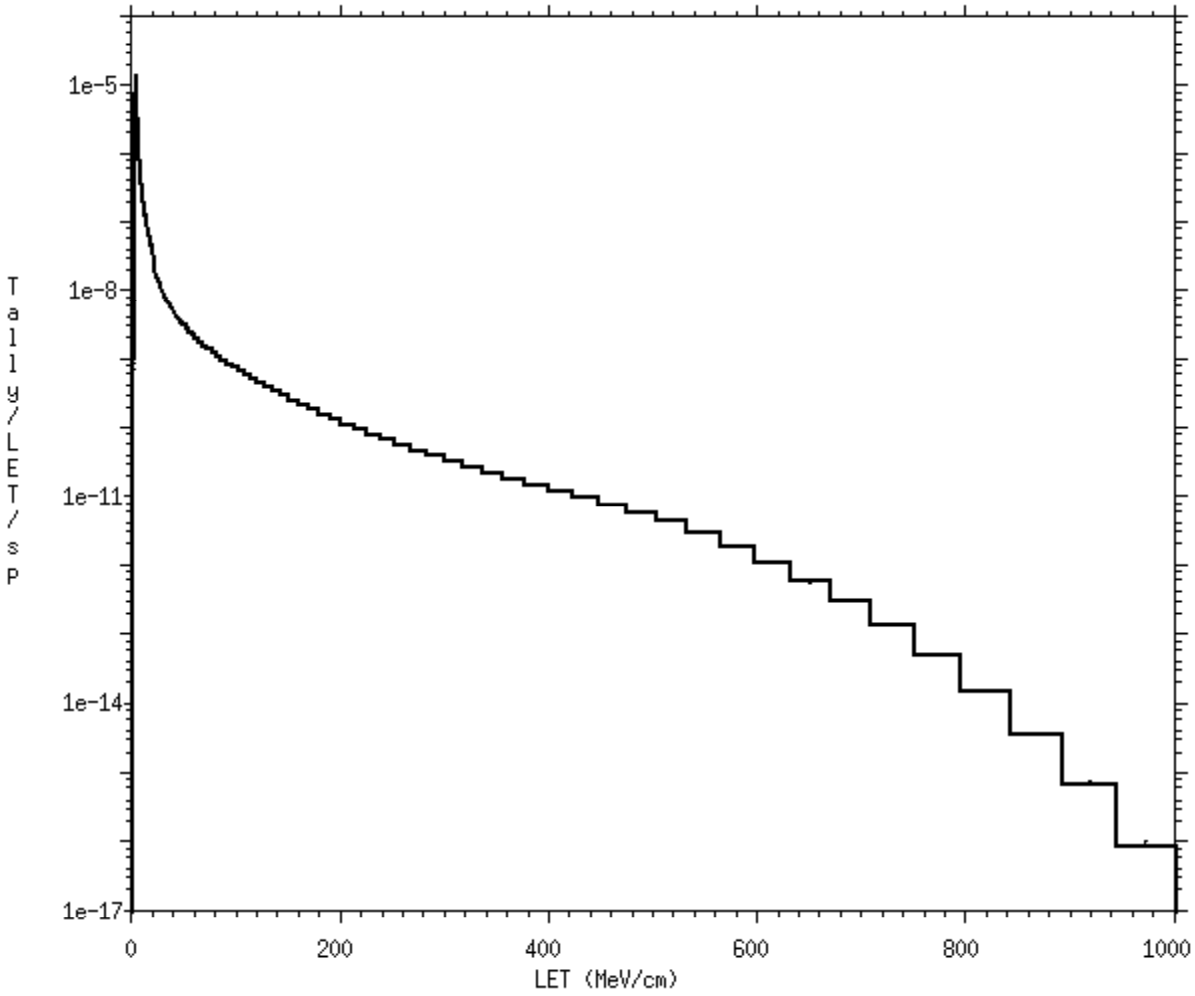


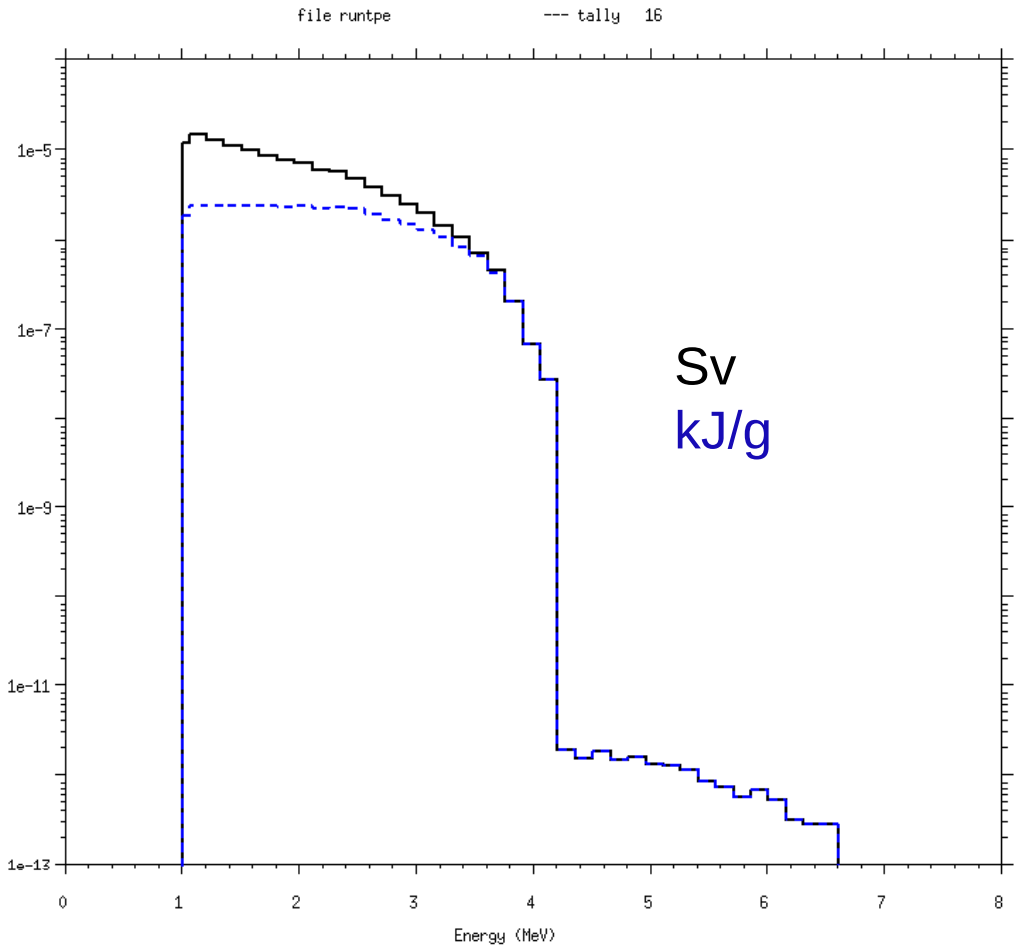
Tally Enhancements – LET option

```
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
```



Tally Enhancements – Quality factors

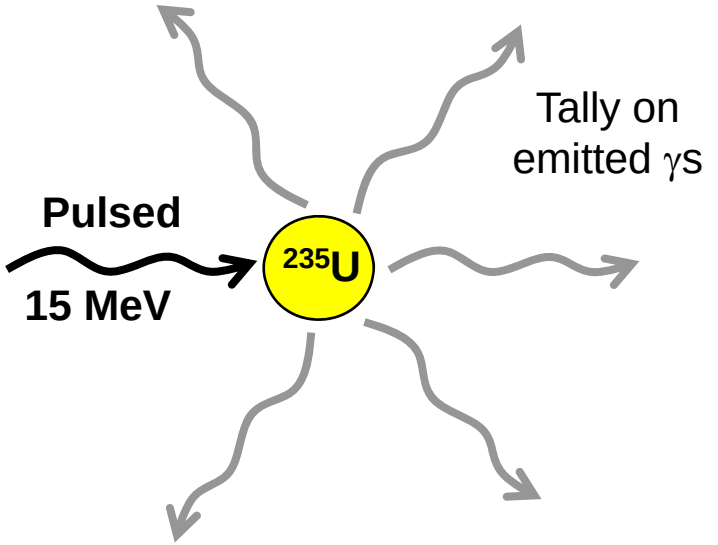
```
14 MeV n into water
1    1 -1.0     -1    imp:n=1
2    0           1    imp:n=0

1    so  10.0

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



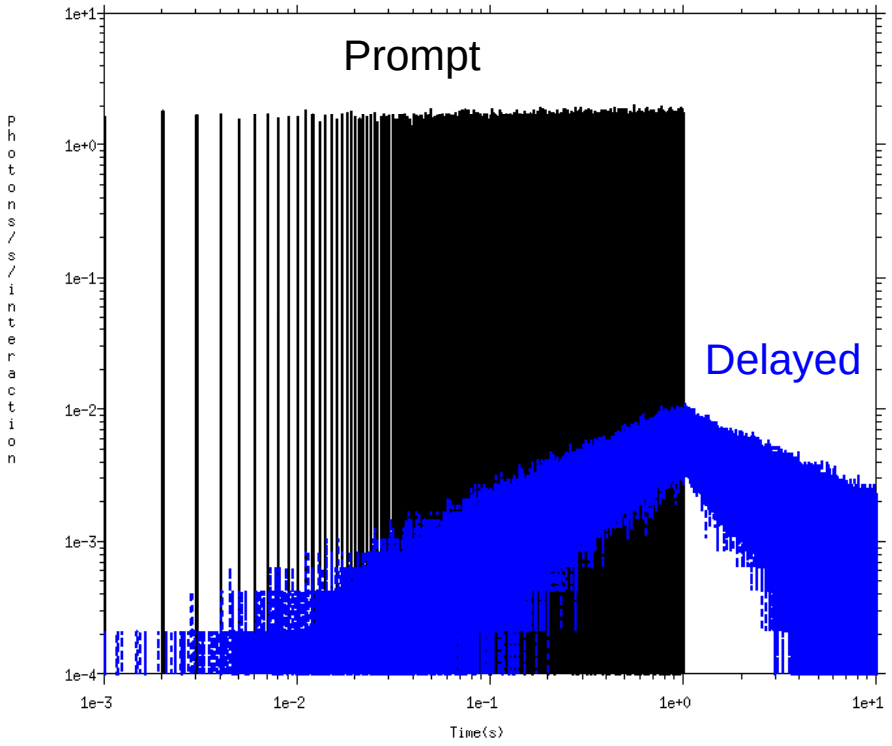
Tally Enhancements – Cyclic binning

```
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
```

1 μs pulse every 1 ms
out to 1s

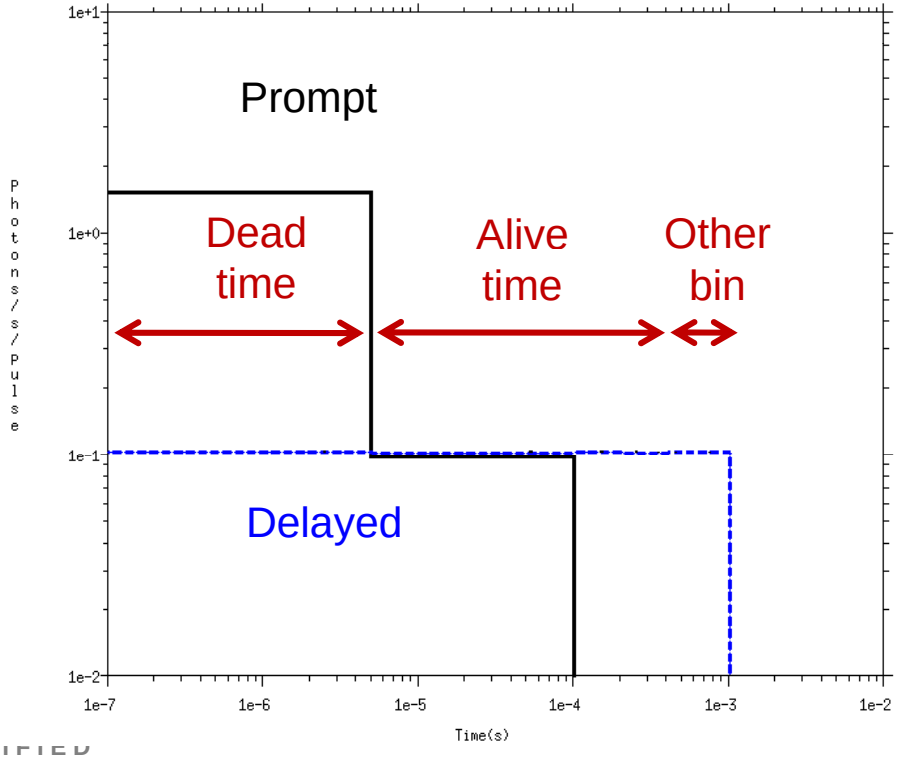


Tally Enhancements – Cyclic binning



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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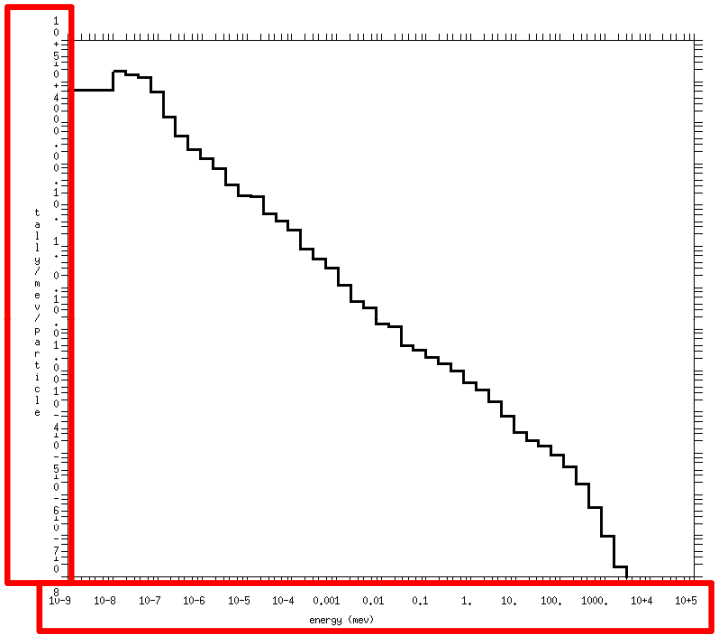
Contout Legend in Geometry Plotter

Other Enhancements – MCPLOT graphics



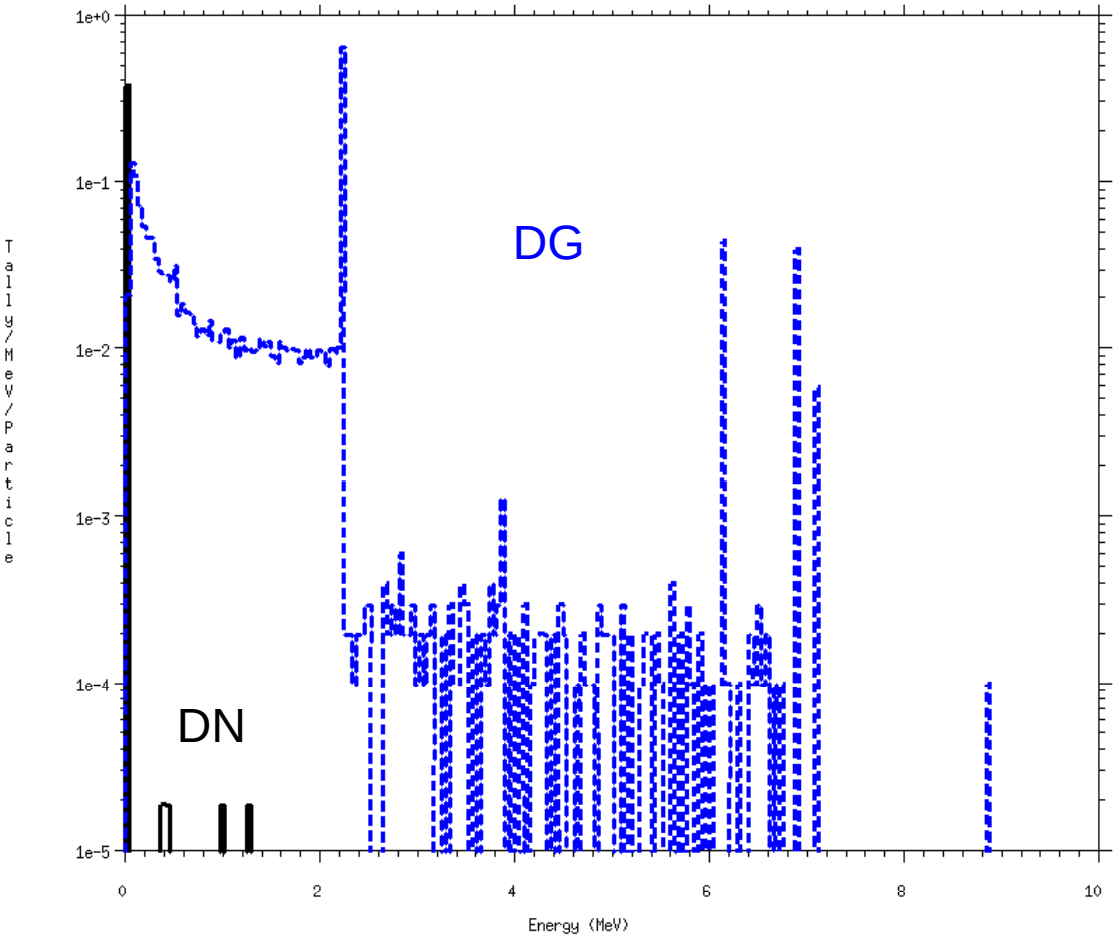

```
mcplot>
Help
Type "help all" for a verbose list of all help commands
  "help <command>" to list a specific help command,
  "help overview" for an overview of MCPLOT,
  or "help execute" for MCPLOT input & execution-line
 mcplot>
```

Other Enhancements – Activation

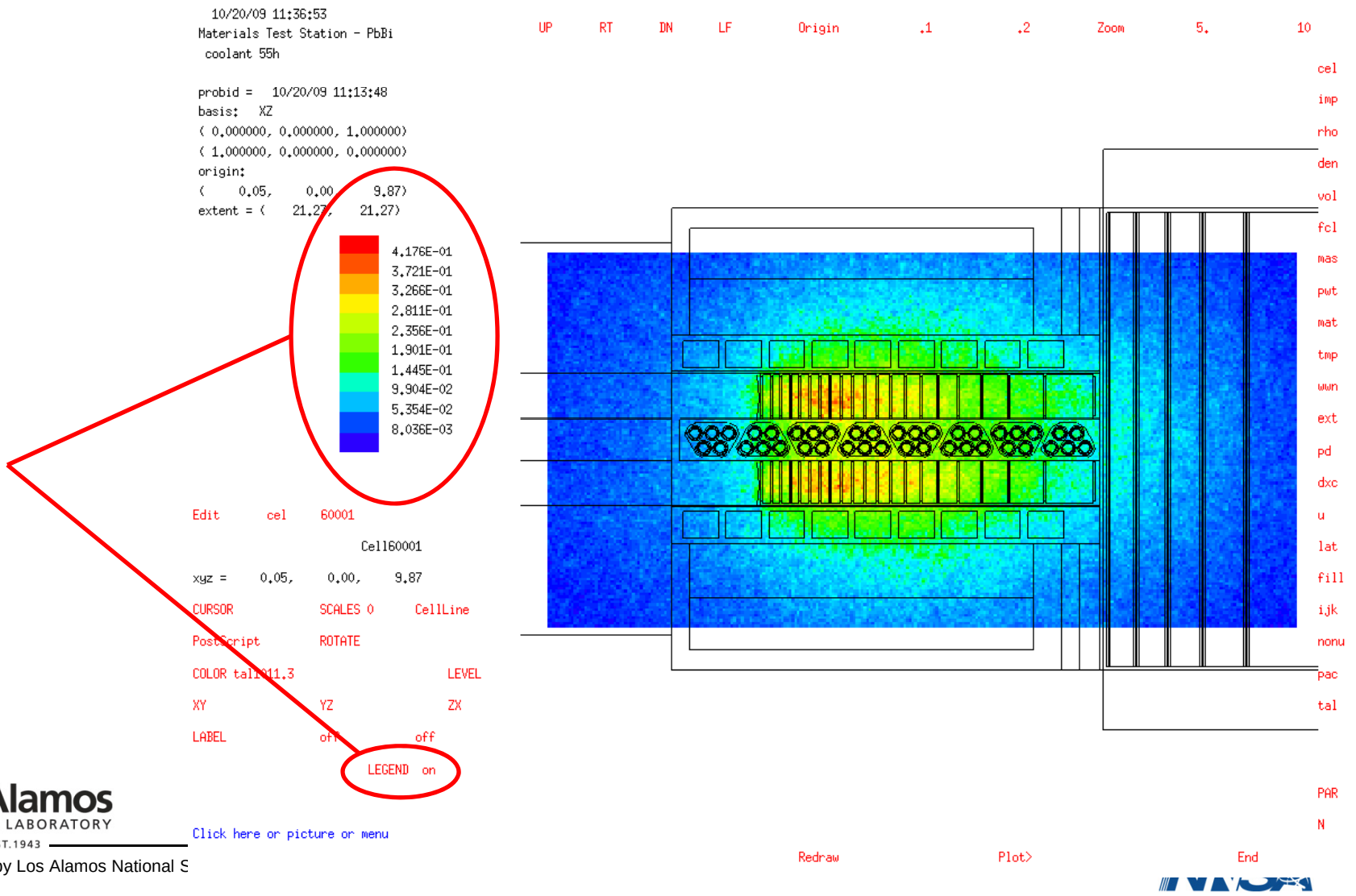
```
14 MeV neutron activation of water
1  1   -1.0   -1        imp:n=1
3  0            1        imp:n=0

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
```



Other Enhancements – Contour Legend



Summary

- **23 features added or planned for 2.7.0.**
- **Release data tentatively scheduled for Summer 2010.**
- **MCNP6 (merged MCNPX & MCNP5) could supersede 2.7.0.**
- **Slides available on MCNPX website mcnpx.lanl.gov/documents/LAUR-09-06788.pdf**