MCNPX 2.6.X Features (2006-2007)

by

Gregg McKinney, Joe Durkee, John Hendricks, Mike James, Russ Johns, Denise Pelowitz, and Laurie Waters

M&C/SNA 2007, Monterey, CA, April 15-19, 2007

NNSA
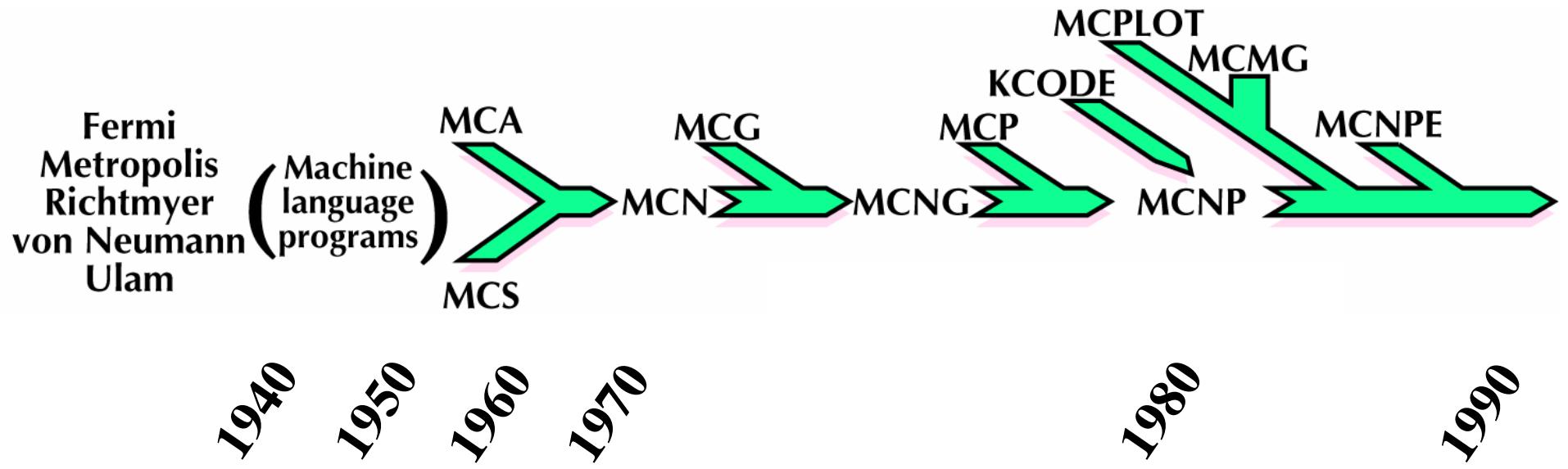
MCNPX 2.6.X Features (2006-2007)

- MCNPX Overview

- History of MCNPX

- User Base

- Features for 2006-2007

- Future of MCNPX

Los Alamos
NATIONAL LABORATORY
— EST.1943 —
Operated by the Los Alamos National Security, LLC for the DOE/NNSA

U N C L A S S I F I E D

NNSA
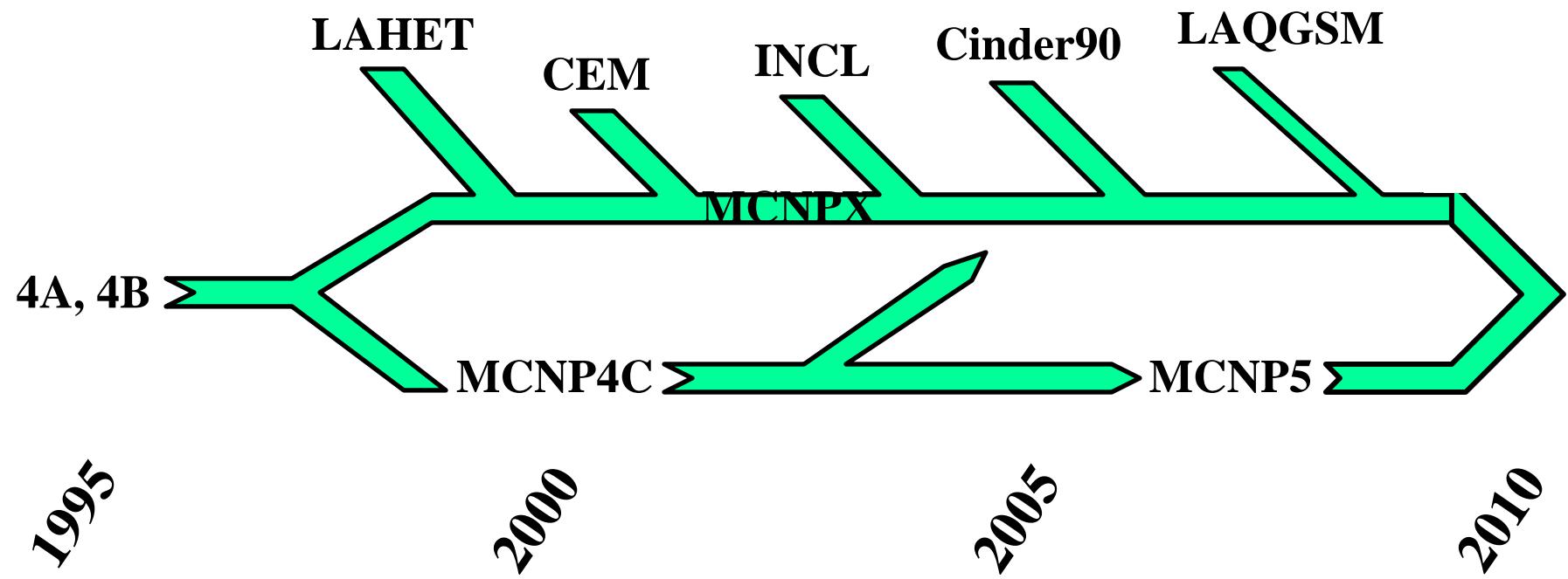
MCNPX Overview

- Monte Carlo radiation transport code
  - Extends MCNP4C to virtually all particles and energies
  - 34 particles (n,p,e, 5 leptons, 11 baryons, 11 mesons, 4 LI)
  - Continuous energy (roughly 0-100 GeV)
  - 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)

History of MCNPX

Fermi
Metropolis
Richtmyer
von Neumann
Ulam

(Machine language programs)

MCA
MCS
MCN
MCG
MCNG
MCP
MCNP
KCODE
MCPLOT
MCMG
MCNPE

1940 1950 1960 1970 1980 1990

Operated by the Los Alamos National Security, LLC for the DOE/NNSA

Los Alamos
NATIONAL LABORATORY
EST. 1943

NNSA

History of MCNPX

LAHET CEM INCL Cinder90 LAQGSM

MCNPX

4A, 4B

MCNP4C MCNP5

1995 2000 2005 2010

Los Alamos
NATIONAL LABORATORY
EST.1943
Operated by the Los Alamos National Security, LLC for the DOE/NNSA

UNCLASSIFIED

NNSA

History of MCNPX

1992-1993 LAHET and Superhet
   Superconducting Super Collider
1994-1995 Start of the APT program

Version 1.0   April 22, 1997

Version 2.0   October 1, 1997

Version 2.1.3   April 17, 1998
   HISTP writing, compatible with HTAPE, collisional energy loss model

Version 2.1.4   July 24, 1998
   Mesh & radiography tallies, gridconv, bertin & phtlib binary support

Version 2.1.5   Nov 14, 1999
   CEM, HTAPE3X, User's Manual, Beta test team

Version 2.1.6   September 14, 1999
   Proton libraries (internal user only)

Version 2.3.0   April 27, 2002

History of MCNPX

Version 2.4.0   **August 01, 2002**
Update to MCNP4C3, F90, Windows PC, New user's manual

Version 2.5.C   April, 2003
MPI Multiprocessing, Mix & Match, CEM2K

Version 2.5.D   August, 2003
INCL4/ABLA physics models, Multiple particles on SDEF card, READ card

Version 2.5.E   February, 2004
MPI KCODE speedup, 64-bit integers, G5 support, 2-D color contour plots

Version 2.5.0   **March, 2005**
Mesh tally contour plots, Pulse-height tally with VR, PN improvements

Version 2.6.A   December, 2005
Transmutation, Long file names, STOP card

Version 2.6.B   June, 2006
CEM 03, new PHTLIB, predictor-corrector for transmutation

Version 2.6.C   December, 2006
Spherical weight windows, delayed particle production

Version 2.6.D   ~May, 2007
Coupled space-energy-time WW, radioactive sources, LAQGSM

User Base

- ## ~2500 users world wide
    - Provide 6-8 workshops per year (4-6 US, ~2 international)
    - 150 workshop participants per year
    - Access to RSICC/NEA released versions only
        - http://www-rsicc.ornl.gov/ (C00730) 2.5.0
        - http://www.nea.fr/html/dbprog/ (CCC-0715) 2.4.0
    - Limited access to MCNPX web site
        - http://mcnpx.lanl.gov (some documentation)

- ## ~2000 registered Beta Testers
    - Full access to MCNPX web site
    - Access to intermediate versions
    - Increased user support

Application	# Groups	Percent
Medical (BNCT, proton therapy, etc.)	**50**	**15**
Spacecraft, Cosmic Rays, SEE, propulsion	**42**	**12**
Detectors, experiments, Threat Reduction	**39**	**11**
ATW, ADS, Energy Amplifiers	**37**	**11**
Fuel cycles, beginning to end, including storage	**32**	**9**
Accelerator Shielding and Health Physics	**28**	**8**
Theoretical Physics	**23**	**7**
Neutron Production for Scattering	**21**	**6**
Isotope Production	**14**	**4**
Radiography	**12**	**4**
MCNPX/MCNP code development	**11**	**3**
Homeland Security	**10**	**3**
Materials studies (IFMIF)	**6**	**2**
Radioactive Ion Beams	**5**	**1**
Irradiation Facilities	**4**	**1**
Neutrino Targets	**4**	**1**
Light Sources, electron machines	**3**	**1**

Los Alamos
NATIONAL LABORATORY
— EST.1943 —

U N C L A S S I F I E D

Operated by the Los Alamos National Security, LLC for the DOE/NNSA

NNSA

Features for 2006 – Version 2.6.A

- Transmutation using Cinder90 (BURN card)
  - Several keywords of options (MAT, POWER, etc.)
  - Automatic updating of material atom densities

- Long file names (40 vs. 8 characters)

- STOP card - terminate tallies at desired precision

- Corrections/enhancements/extensions
  - Proton step size control (HSTEP on M card)
  - New $S(\alpha,\beta)$ scattering law
  - Differential data tallies extended to table physics
  - Separate printout of induced fission multiplicity

NNSA

BURN Card
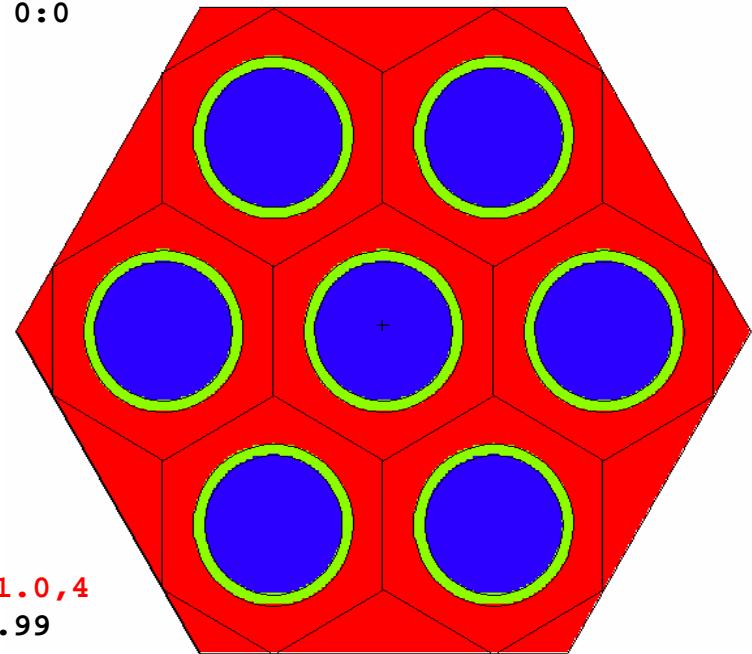
Burn 7 fuel pins surrounded by H2O in a hex lattice
```
1  1  -8.3     -1        u=1 imp:n=1    vol=192.287
2  8  -6.5      1 -2      u=1 imp:n=1
3  9  -0.7       2        u=1 imp:n=1
100 9  -1.8      -3  u=8 lat=2 imp:n=1 fill=-2:2 -2:2 0:0
         8 8 8 8 8  8 8 1 1 8
                   8 1 1 1 8
                    8 1 1 8 8  8 8 8 8 8
101  0              -4        imp:n=1 fill=8
102  9  -1.8     4 -5          imp:n=1
103  0            5            imp:n=0

1 rcc 0  0 0   0 0 365   0.4095
2 rcc 0 0 -1   0 0 367   0.4750
3 rhp 0 0 -1   0 0 367   0.6565 0  0
4 rhp 0 0 -1   0 0 367   0 1.895  0
*5 rhp 0 0 -1.1  0 0 367.2  0 1.896 0
```
BURN TIME=50,500 MAT=1 POWER=0.066956 PFRAC=1.0,1.0
   OMIT=1,6,6014,7016,8018,9018,90234,91232 BOPT=1.0,4
```
m1   8016.60c   2.0  92235.60c  0.01  92238.60c  0.99
m8   40000.60c  1.0
m9   1001.60c  2.0  8016.60c  1.0
mt9  lwtr.01t
kcode 100 1.0 10 50
ksrc  0 0 150 1.3 0 150 -1.3 0 150 0.66 1.14 150
      0.66 -1.14 150 -0.66 1.14 150 -0.66 -1.14 150
```

1burnup summary table by material

nuclides with atom fractions below 1.000E-10 for a material are zeroed and deleted from print tables after t=0

neutronics and burnup data

step	duration (days)	time (days)	power (MW)	keff	flux	ave. nu	ave. q	burnup (GWd/MTU)
0	0.000E+00	0.000E+00	6.696E-02	0.99763	3.641E+14	2.449	200.981	0.000E+00
1	5.000E+01	5.000E+01	6.696E-02	1.00012	3.701E+14	2.554	203.154	2.383E+00
2	5.000E+02	5.500E+02	6.696E-02	0.85037	4.638E+14	2.869	209.385	2.621E+01

…

actinide inventory for sum of materials at end of step 2, time 5.500E+02 (days), power 6.696E-02 (MW)

no.	zaid	mass (gm)	activity (Ci)	sp. act. (Ci/gm)	atom den. (a/b-cm)	atom fr.	mass fr.
1	92234	3.465E-04	2.154E-06	6.217E-03	4.636E-09	2.577E-07	2.533E-07
2	92235	3.935E-01	8.506E-07	2.161E-06	5.244E-06	2.914E-04	2.877E-04
3	92236	1.789E+00	1.157E-04	6.467E-05	2.374E-05	1.319E-03	1.308E-03
4	92237	7.849E-03	6.405E+02	8.160E+04	1.037E-07	5.763E-06	5.739E-06
5	92238	1.355E+03	4.553E-04	3.361E-07	1.782E-02	9.905E-01	9.904E-01
6	92239	1.539E-03	5.158E+04	3.351E+07	2.016E-08	1.121E-06	1.125E-06

…

| 14 | 94242 | 1.117E+00 | 4.418E-03 | 3.954E-03 | 1.446E-05 | 8.034E-04 | 8.169E-04 |
| | totals | 1.368E+03 | 1.041E+05 | 7.610E+01 | 1.799E-02 | 1.000E+00 | 1.000E+00 |

…

nonactinide inventory for sum of materials at end of step 2, time 5.500E+02 (days), power 6.696E-02 (MW)

no.	zaid	mass (gm)	activity (Ci)	sp. act. (Ci/gm)	atom den. (a/b-cm)	atom fr.	mass fr.
1	6012	2.336E-06	0.000E+00	0.000E+00	6.096E-10	1.638E-08	1.186E-08
2	6013	1.057E-02	0.000E+00	0.000E+00	2.545E-06	6.839E-05	5.366E-05
3	8016	1.891E+02	0.000E+00	0.000E+00	3.702E-02	9.946E-01	9.599E-01
4	8017	1.405E-02	0.000E+00	0.000E+00	2.588E-06	6.954E-05	7.132E-05

…

| 16 | 60145 | 3.469E-01 | 1.426E-14 | 4.112E-14 | 7.497E-06 | 2.014E-04 | 1.761E-03 |
| | totals | 1.970E+02 | 8.830E+01 | 4.483E-01 | 3.722E-02 | 1.000E+00 | 1.000E+00 |

Los Alamos
NATIONAL LABORATORY
— EST.1943 —

Operated by the Los Alamos National Security, LLC for the DOE/NNSA

NNSA

Long File Names

E:\MCNPX\scratch>.\mcnpx inp=test_long_names.txt na=test_long_names.
 mcnpx   ver=26bc1 ld=Sat Jul 01 08:00:00 MST 2006   11/12/06 20:08:04

…
dynamic storage =   0 words,   0 bytes.   cp0 = 0.00
 run terminated when   10 particle histories were done.
 dump   2 on file test_long_names.r   nps =   10 coll =   0
                    ctm =   0.00   nrn =   40
 mcrun is done

E:\MCNPX\scratch>dir

Directory of E:\MCNPX\scratch

11/12/2006 08:08 PM   <DIR>   .
11/12/2006 08:08 PM   <DIR>   ..
09/11/2006 03:23 PM   6,574,080 mcnpx.exe
11/12/2006 08:08 PM   22,513 test_long_names.d
11/12/2006 08:08 PM   25,510 test_long_names.o
11/12/2006 08:08 PM   401,342 test_long_names.r
08/04/2006 01:21 PM   481 test_long_names.txt
            5 File(s)   7,023,926 bytes
            2 Dir(s) 31,759,495,168 bytes free

STOP Card

14 MeV neutrons in water - test STOP card
```
c     cell cards
1     1  -1.  -1 IMP:N=1
2     0         1 IMP:N=0


1     so 30.0


m1     1001.60c 2. 8016.60c 1.
mt1    hh2o.20t
xs1    hh2o.20t 0.998623 ct00 0 1 1 1237501 0 0 2.530E-08
sdef   erg=14.1
e0     1.00000E-11 625log 1.44544E+01
vol       1.
f44:n  1
f141:n 1
STOP      F44 .01 NPS 10000 CTME 10.0
```
OUTPUT FILE

1tally fluctuation charts

	tally 44					tally 141				
nps	mean	error	vov	slope	fom	mean	error	vov	slope	fom
1000	5.6661E+01	0.0144	0.0031	10.0	489705	3.7459E-01	0.0354	0.0003	0.0	81225
2000	5.6824E+01	0.0103	0.0016	10.0	468574	3.7000E-01	0.0254	0.0002	10.0	77294
3000	5.7028E+01	0.0083	0.0010	10.0	477186	3.6737E-01	0.0209	0.0001	10.0	75590

```
 ***********************************************************************************
 dump no.   2 on file stop.r     nps =       3000   coll =       599417   ctm =    0.03
```

Los Alamos
NATIONAL LABORATORY
EST.1943
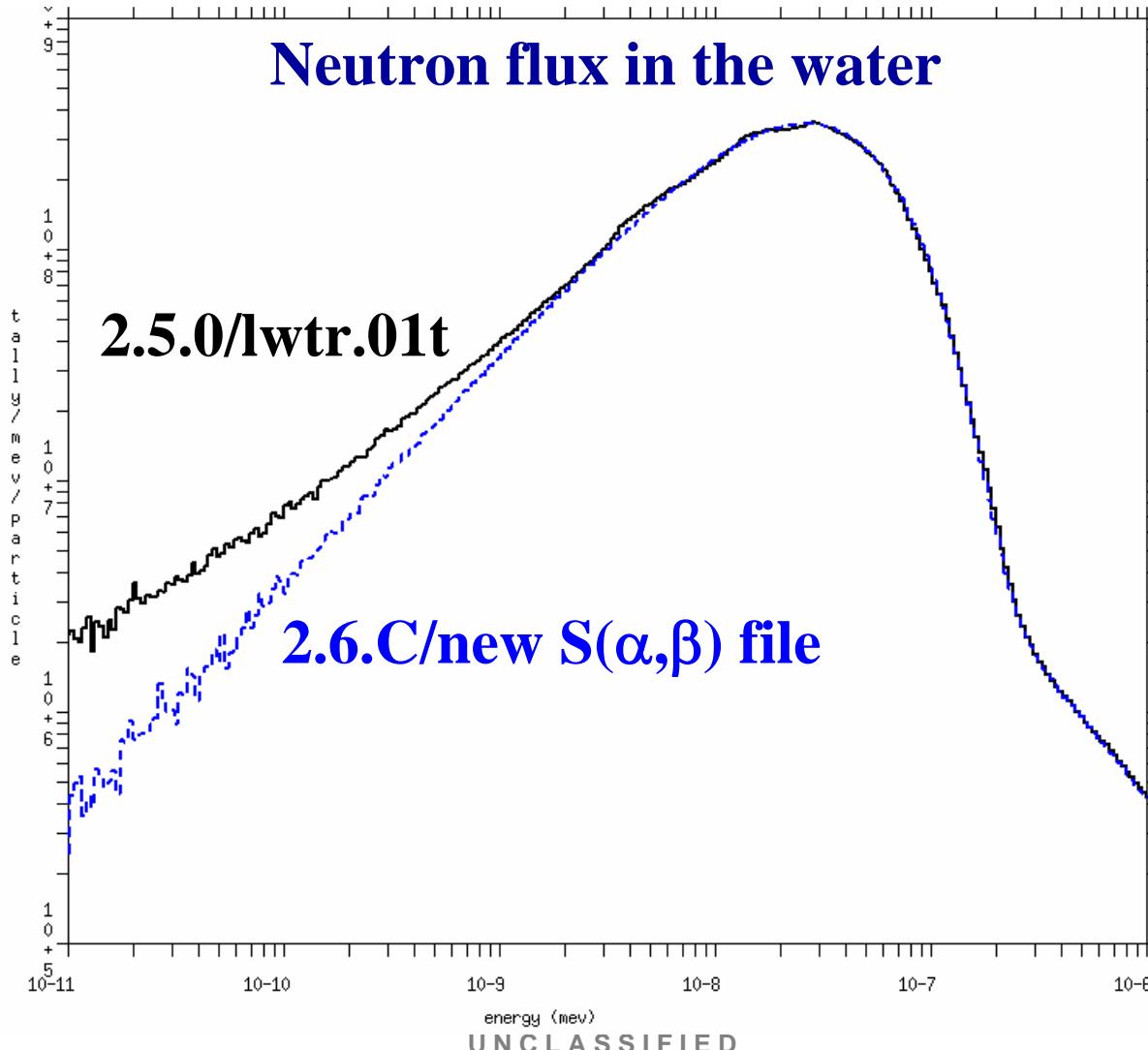
New S(α,β) Treatment

```
14 MeV neutrons in water - test S(alpha,beta)
c     cell cards
1     1  -1.  -1 IMP:N=1
2     0        1 IMP:N=0


1     so 30.0


m1      1001.60c 2. 8016.60c 1.
mt1     hh2o.20t  $ Replace with lwtr.01t for old treatment
xs1     hh2o.20t 0.998623 ct00 0 1 1 1237501 0 0 2.530E-08
nps     1000000
sdef    erg=14.1
e0      1.00000E-11 625log 1.44544E+01
vol     1.
f44:n   1
f141:n  1
```

New S(α,β) Treatment

Neutron flux in the water

2.5.0/lwtr.01t

2.6.C/new S(α,β) file

Features for 2006 – Version 2.6.B
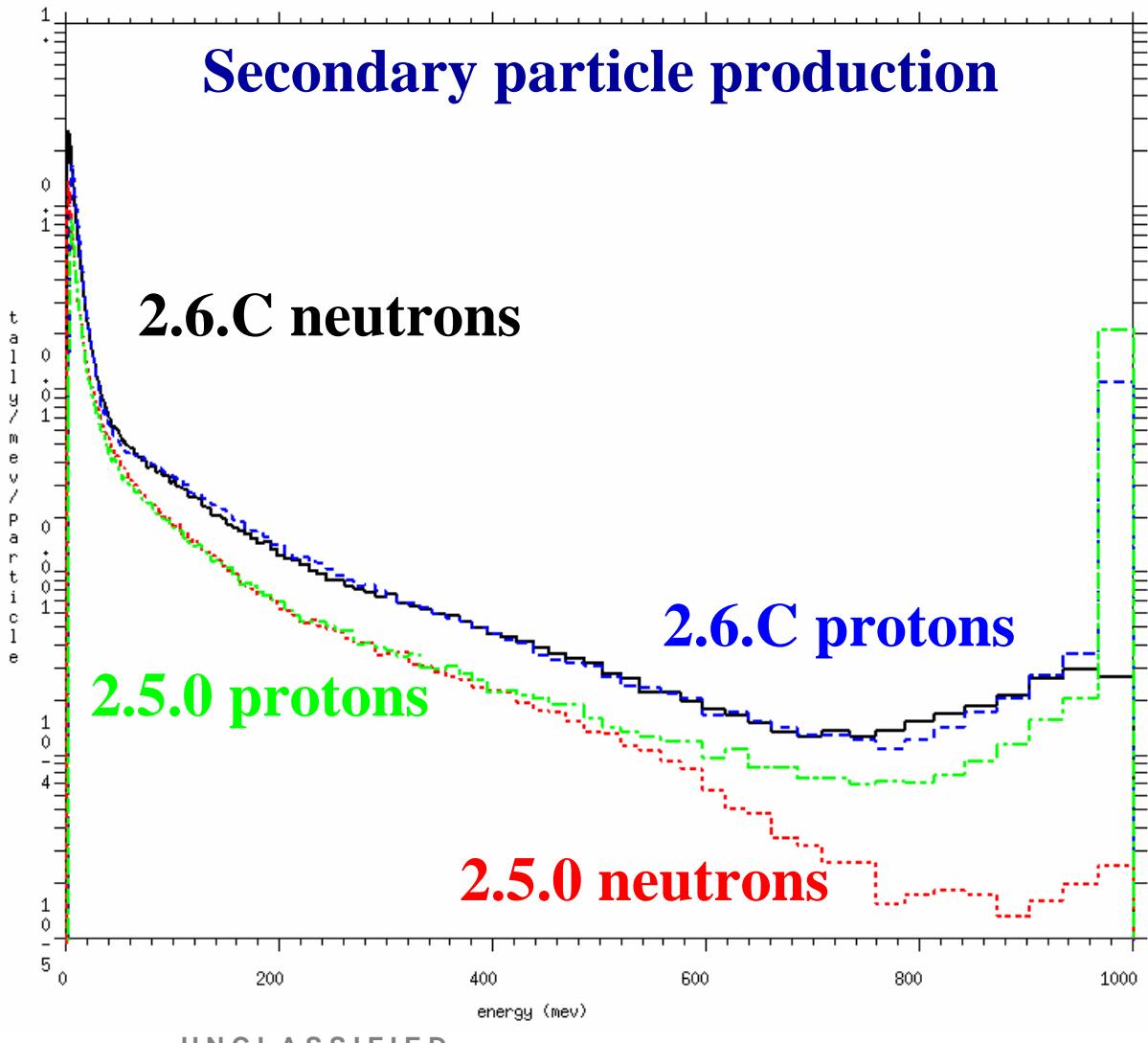
- Transmutation improvements (BURN card)
  - Predictor/corrector
  - Automatic selection of FP dist. (thermal, fast, high)

- CEM INC model upgrade (from 2K to 03)

- FIELD card–planetary gravity effects for neutrons

- Corrections/enhancements/extensions
  - New photon emission data: PHTLIB
  - Geometry plot basis vectors
  - Extend ZAID identifiers

CEM Upgrade

1 GeV protons into Fe-56
```
1      1   -7.86 -1 IMP:N=1
2      0          1 IMP:N=0

1      so 1.0

mode   n h
m1     26056.24c 1.
nps    200000
sdef   erg=1000 par=h
PHYS:N 1001.0
LCA    7j -2 1 $ Use CEM
e0     1 199log 1000
c0     0 1
f1:n   1
f11:h  1
```

Secondary particle production

2.6.C neutrons

2.6.C protons

2.5.0 protons

2.5.0 neutrons

energy (mev)

tally/mev/particle

Los Alamos
NATIONAL LABORATORY
EST.1943

CEM Upgrade

Light-product yields (A<30)

Model	Proton energy (MeV)					
	300	500	750	1000	1500	2600
BERTINI	1035	26.1	50.5	13.8	4.93	3.35
ISABEL	---	256	49.1	17.0	5.99	4.02
INCL	233	215	51.5	38.1	26.1	12.1
CEM2K	---	12.6	21.1	7.83	4.87	4.02
CEM03	13.0	2.23	1.32	1.49	1.58	1.72

Heavy-product yields (A>30)

Model	Proton energy (MeV)						Ave. Dev.
	300	500	750	1000	1500	2600	
BERTINI	2.24	2.29	2.75	2.86	3.16	3.20	4.37
ISABEL	3.75	2.85	3.02	2.63	2.85	3.01	4.24
INCL	4.72	3.24	3.14	3.13	3.35	3.54	7.14
CEM2K	2.74	2.54	2.62	2.76	2.92	3.20	3.55
CEM03	1.84	1.89	1.89	1.92	2.04	3.17	2.26

Mean-squared deviation factors between model predictions and experimental data measured at ITEP.

FIELD Card

```
5 GeV protons into Mars, gravity reflection     phys:n 5010 j j j 20
1      1 -1.0         -1        imp:n=1           e11   0. 1024i 10. 5000.
100    2 -1.35e-5     -101 +1   imp:n=1           fu11  0. 8016.00051 8016.00052 8016.00053
101    2 -1.28e-5     -102 +101 imp:n=1                 8016.00102  8016.
102    2 -1.22e-5     -103 +102 imp:n=1                 14028.14027 14028.14026 14028.13027
103    2 -1.14e-5     -104 +103 imp:n=1                 14028.13026 14000.
104    2 -1.08e-5     -105 +104 imp:n=1                 26056.00051 26056.00052 26056.00053
105    2 -1.01e-5     -106 +105 imp:n=1                 26056.00102 26056.
999    0             +106       imp:n=0           f11:p 1
                                                  ft11  tag 1
1      so 339000000.0                             e21   1e-10 99log 1e-7
101    so 339060000.0                             f21:n 105
102    so 339110000.0
103    so 339180000.0
104    so 339240000.0
105    so 339310000.0
106    so 339380000.0

m1     8016.60c -0.6 14000.60c -0.3 26056.60c -0.1
m2     6000.60c -0.27 7014.60c -0.02 8016.60c -0.70
       18000.35c -0.01
FIELD GCUT=0.1320 GPAR=1 GRAD=3393.0 GSUR=106
mode   h n p z / d t s a
lca    8j 1 $ Use CEM
sdef   par=9 erg=5000 sur=106 nrm=-1
nps    10000
```

Undocumented Feature

FIELD Card

Neutron current at top of atmosphere

With gravity

Without

Features for 2006 – Version 2.6.C

- Transmutation improvements (BURN card)
  - Support for continue-runs & parallel execution
  - Printing of reaction rates sent to Cinder90
  - Reduced memory requirements

- Spherical weight windows

- Delayed neutrons & gammas
  - ~1000 nuclides treated with gamma line data

- Photon tally tagging

- Model treatment for library absorption reactions
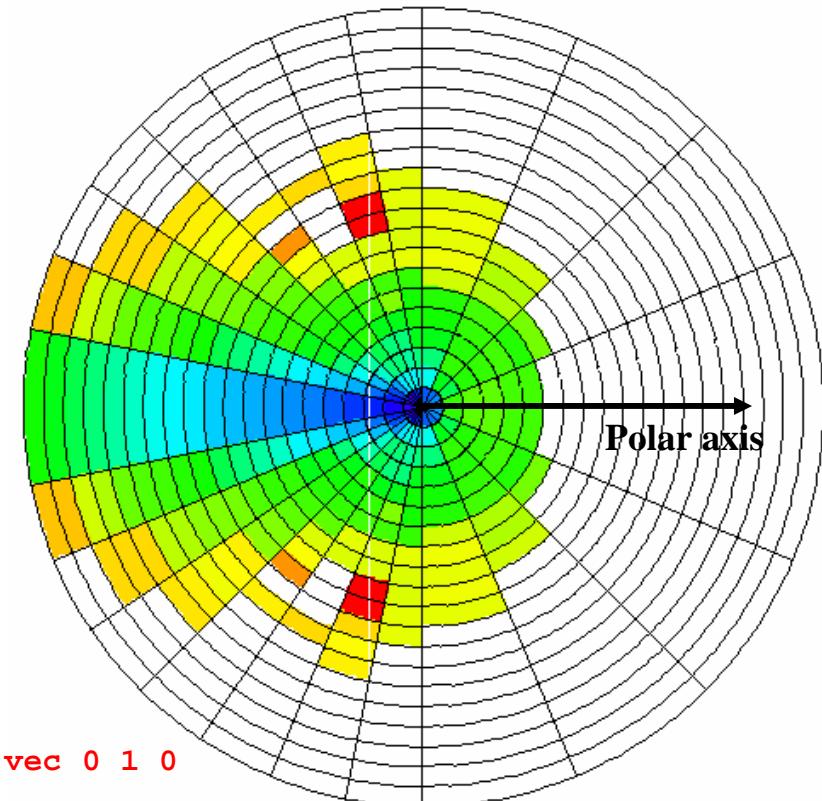
Spherical Weight Windows


```
10 MeV photons into 1m H2O surrounding HEU
1  1  -19.0    -1    imp:p=1
2  2  -1.0     +1 -2 imp:p=1
3  0           +2 -3 imp:p=1
4  0              -3 imp:p=0


1 sph 0 0 0   3
2 sph 0 0 0   100
3 sph 0 0 0   200


mode p
sdef erg=10 pos=-105 0 0 rad=d1 axs=1 0 0 ext=0
     vec=1 0 0 dir=d2
si1  0 10
sp1  -21 1
si2  0 1
sp2  0 1
m1    92235 .5 92238 .5
m2    1001 2 8016 1
nps 100000
f4:p 1
wwg 4 0
mesh geom rpt origin=0 0 0 ref=-99 1 1 axs 1 0 0 vec 0 1 0
     imesh  101.   iints  20
     jmesh  .25 .5 jints  4 8
     kmesh   1     kints  1
c    wwp:p  4j -1     $ Add this card to use WW
```

Polar axis

Delayed Neutrons and Gammas

```
DN/DG from high-energy fission of U-235
1 1 -18.9 -1      imp:n=1
2 0       +1      imp:n=0

1 sph  0 0 0 0.1

mode n p
m1     92235.60c -1
phys:n 20 2j 101 20
phys:p 5j -102
cut:n  j j 0 0
sdef   erg=10.0 par=n
f01:p 1
e01    .100 499i 12.
t01    0.0001e8 100.e8
f11:p 1
t11    0.0000001e8 99log 100.e8
f21:n 1
e21    .001 199log 12.
t21    0.0001e8 100.e8
f31:n 1
t31    0.0000001e8 99log 100.e8
nps    2000000
```
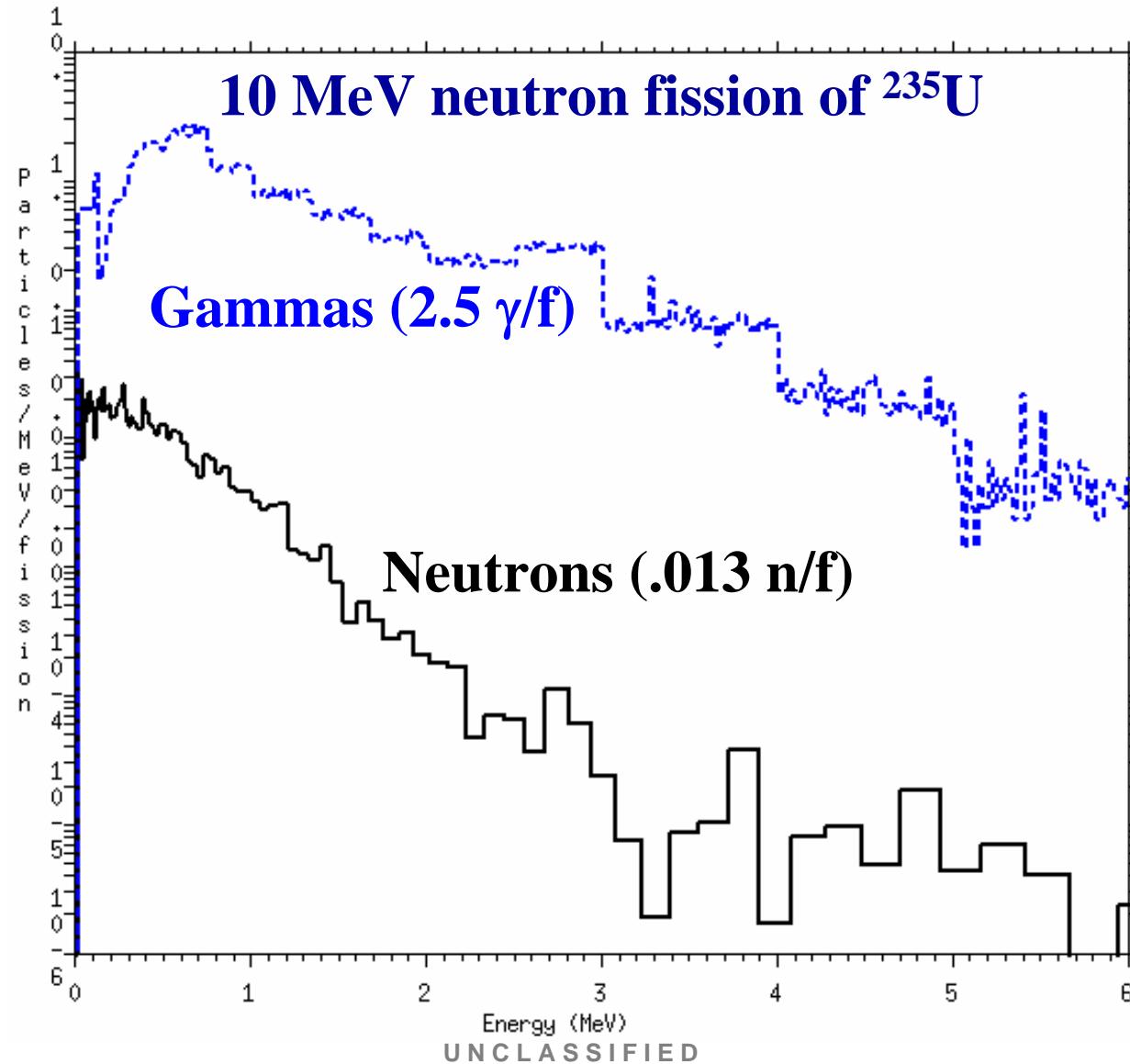
Delayed Neutrons and Gammas

neutron creation	tracks	weight	energy	neutron loss	tracks	weight	energy
		(per source particle)				(per source particle)	
source	2000000	1.0000E+00	1.0000E+01	escape	2078492	1.0317E+00	9.9508E+00
nucl. interaction	0	0.	0.	energy cutoff	0	0.	0.
particle decay	0	0.	0.	time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	0.	0.	weight cutoff	0	0.	0.
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	0.	downscattering	0	0.	8.1324E-03
photonuclear	0	0.	0.	capture	98	3.8100E-05	1.6678E-04
(n,xn)	22458	1.1229E-02	1.2686E-02	loss to (n,xn)	7486	3.7430E-03	3.7421E-02
prompt fission	65553	3.2679E-02	6.7772E-02	loss to fission	17266	8.5948E-03	8.4020E-02
delayed fission	15331	1.2414E-04	5.7533E-05	nucl. interaction	0	0.	0.
				particle decay	0	0.	0.
tabular boundary	0	0.	0.	tabular boundary	0	0.	0.
tabular sampling	0	0.	0.				
total	2103342	1.0440E+00	1.0081E+01	total	2103342	1.0440E+00	1.0081E+01

photon creation	tracks	weight	energy	photon loss	tracks	weight	energy
		(per source particle)				(per source particle)	
source	0	0.	0.	escape	127772	1.2601E-01	1.3541E-01
nucl. interaction	0	0.	0.	energy cutoff	1	2.0234E-06	5.2097E-06
particle decay	113751	5.6552E-02	5.4380E-02	time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
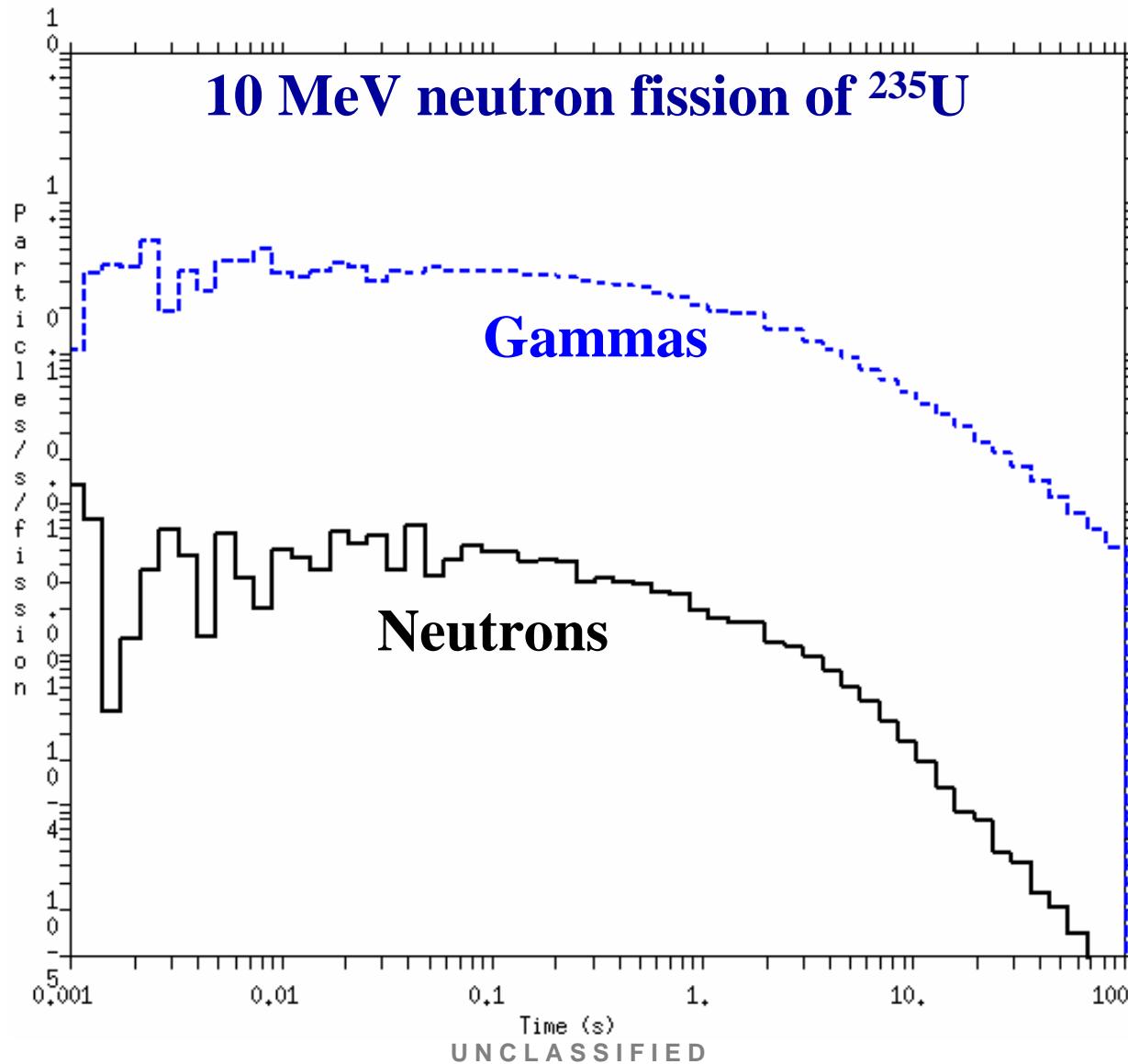
Total DG = 6.6 γ/f   **Total DN = .014 n/f**

Los Alamos
NATIONAL LABORATORY
EST.1943

Operated by the Los Alamos National Security, LLC for the DOE/NNSA

NNSA

Delayed Neutrons and Gammas

10 MeV neutron fission of ^{235}U

Gammas (2.5 γ/f)

Neutrons (.013 n/f)

Particles/MeV/fission

Energy (MeV)

Delayed Neutrons and Gammas

10 MeV neutron fission of ^{235}U
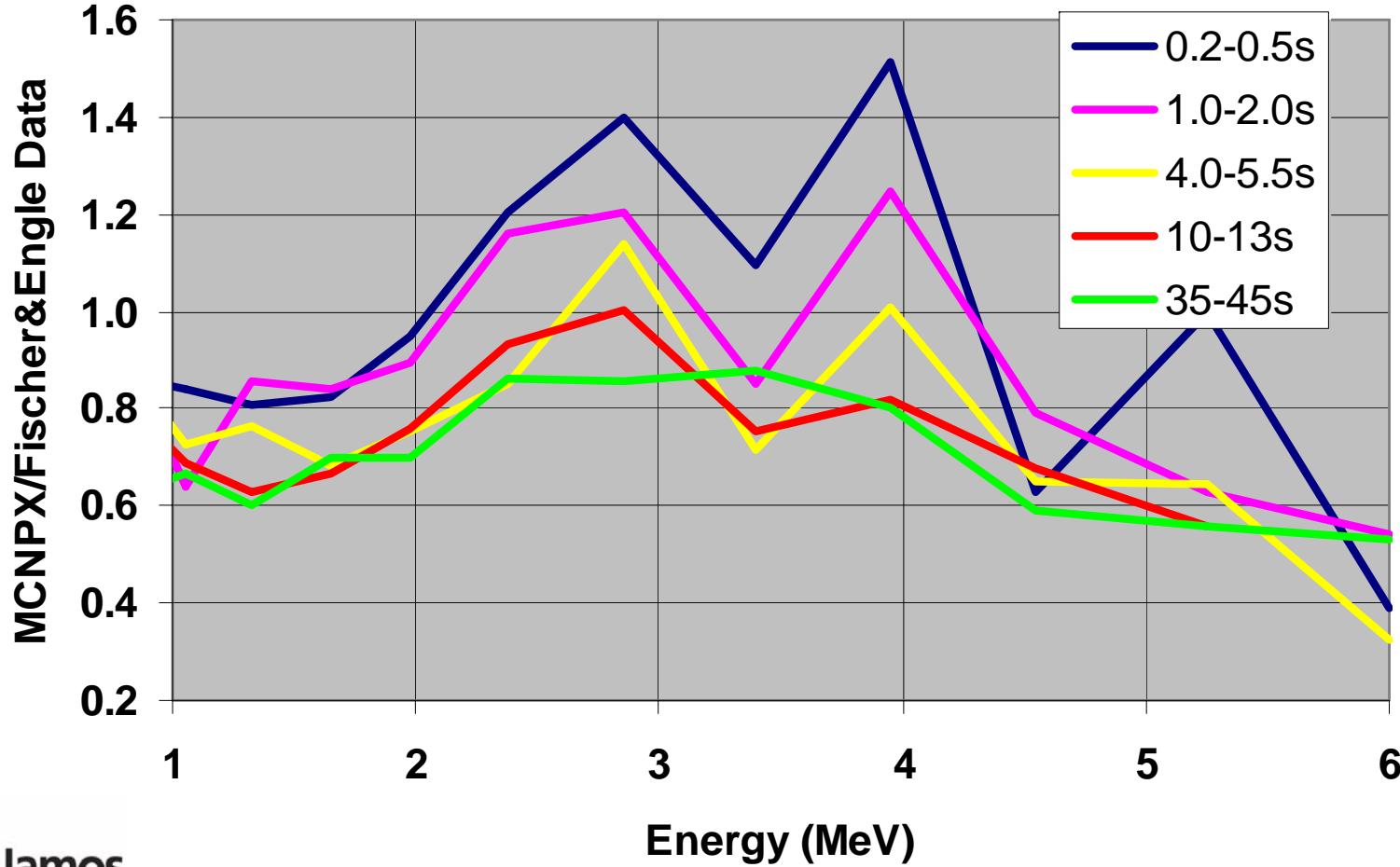
Gammas

Neutrons

Delayed Neutrons and Gammas

C/E comparison to measured ^{235}U data (1964)

Photon Tally Tagging

```
5 GeV protons into Mars with photon tagging    phys:n 5010 j j j 20
1     1 -1.0          -1        imp:n=1         e11   0. 1024i 10. 5000.
100   2 -1.35e-5      -101 +1   imp:n=1         fu11  0. 8016.00051 8016.00052 8016.00053
101   2 -1.28e-5      -102 +101 imp:n=1               8016.00102  8016.
102   2 -1.22e-5      -103 +102 imp:n=1               14028.14027 14028.14026 14028.13027
103   2 -1.14e-5      -104 +103 imp:n=1               14028.13026 14000.
104   2 -1.08e-5      -105 +104 imp:n=1               26056.00051 26056.00052 26056.00053
105   2 -1.01e-5      -106 +105 imp:n=1               26056.00102 26056.
999   0               +106      imp:n=0         f11:p 1
                                                ft11  tag 1
1     so 339000000.0                            e21   1e-10 99log 1e-7
101   so 339060000.0                            f21:n 105
102   so 339110000.0
103   so 339180000.0
104   so 339240000.0
105   so 339310000.0
106   so 339380000.0


m1    8016.60c -0.6 14000.60c -0.3 26056.60c -0.1
m2    6000.60c -0.27 7014.60c -0.02 8016.60c -0.70
      18000.35c -0.01
FIELD GCUT=0.1320 GPAR=1 GRAD=3393.0 GSUR=106
mode  h n p z / d t s a
lca   8j 1 $ Use CEM
sdef  par=9 erg=5000 sur=106 nrm=-1
nps   10000
```

Undocumented Feature

Photon Tally Tagging
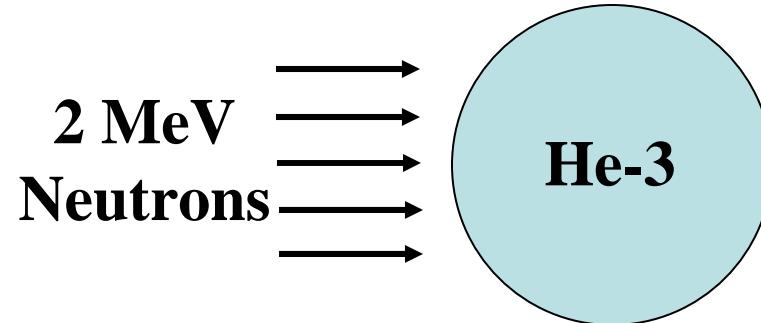
Deexcitation gammas from ^{28}Si

^{27}Al

^{26}Al ^{27}Si

^{26}Si

tally/mev/particle

energy (mev)

Models for Library Interactions

```
2 MeV neutrons into He-3                    f8:n   1
1  1 -5.3540E-4  -1     imp:n=1             e8     0. 99i 2.1
2  0              1 -2 imp:n=1              ft8    PHL 1  6 1 0
3  0              2    imp:n=0              f18:n 1
                                            e18    0. 99i 2.1
1  so 4.0                                   ft18   PHL 1 16 1 0
2  so 100.0                                 f28:n 1
                                            e28    0. 99i 2.1
mode   n h d t s                            ft28   PHL 1 26 1 0
sdef   par=n erg=2 pos=-5 0 0 rad=d1        f38:n 1
       axs=1 0 0 ext=0 vec=1 0 0 dir=1      e38    0. 99i 2.1
si1    0 3                                  ft38   PHL 1 36 1 0
sp1    -21 1                                f58:n 1
cut:n  2j 0 0                               e58    0. 99i 2.1
cut:h,d,t,s j .001                          ft58   PHL 4 6 1 16 1 26 1 36 1 0
phys:n 6j 2
m1     2003.60c 1
nps    10000000
f6:h  1
f16:d 1
f26:t 1
f36:s 1
```

2 MeV Neutrons → **He-3**

Operated by the Los Alamos National Security, LLC for the DOE/NNSA
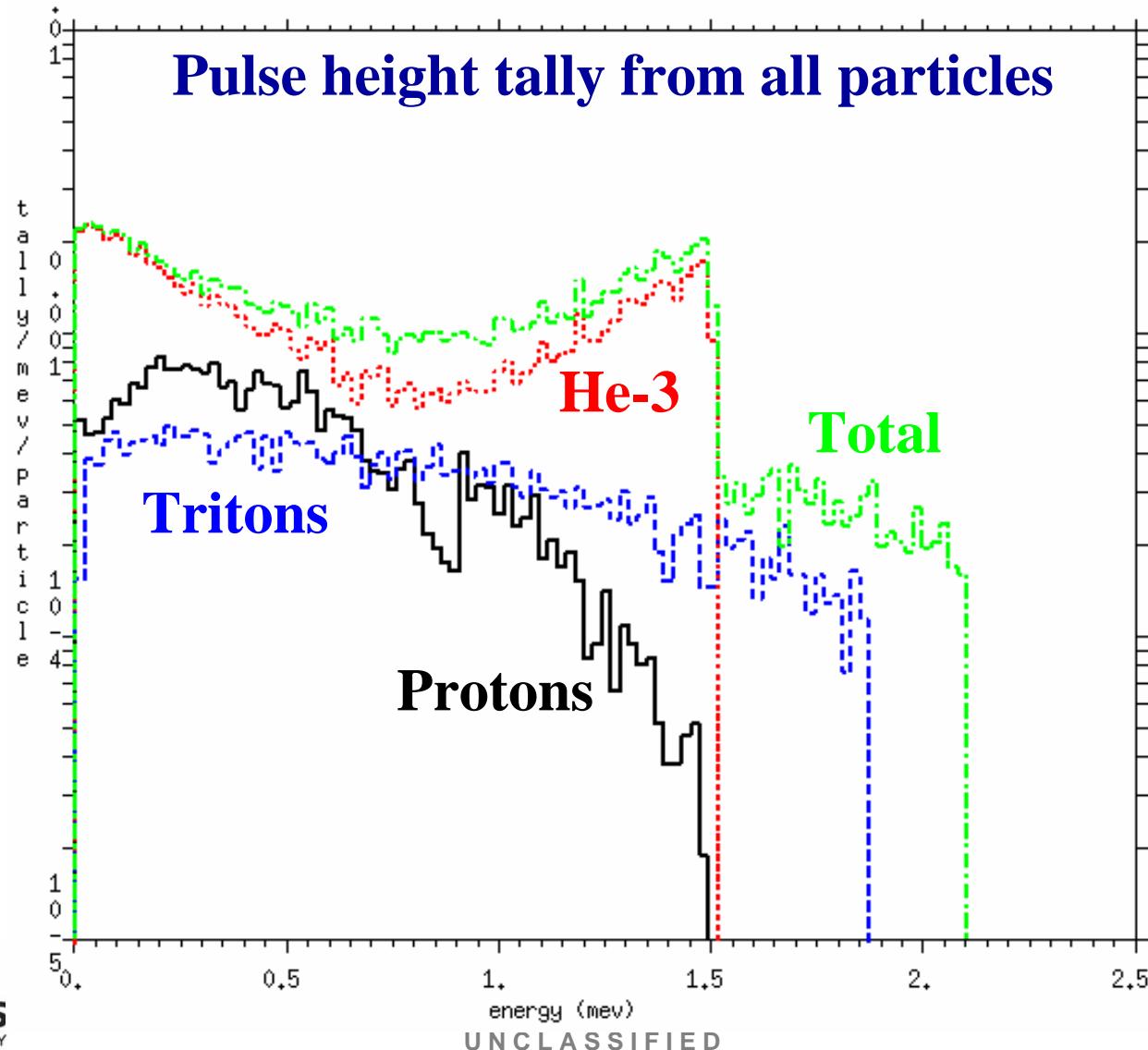
LA150N Library

Isotope	ZAID	Proton	Deuteron	Triton	Alpha
H-1	1001.24c	1.0E-11			
H-2	1002.24c	3.339		1.0E-11	
Be-9	4009.24c	14.266	16.301	11.709	0.667
C	6000.24c	20.0	20.0		20.0
N-14	7014.24c	20.0	20.00		20.0
O-16	8016.24c	20.0	20.0		20.0
Al-27	13027.24c	1.897	6.274	11.29	3.25
Si-28	14028.24c	4.0	20.0	20.0	2.746
Si-29	14029.24c	3.0	20.0	20.0	1.3
Si-30	14030.24c	8.012	20.0	20.0	4.345
P-31	15031.24c	20.0	20.0		20.0
Ca	20000.24c	20.0	20.0	20.0	20.0
Cr-50	24050.24c	1.0	20.0	20.0	2.25
Cr-52	24052.24c	3.256	20.0	20.0	1.233
Cr-53	24053.24c	2.69	20.0	20.0	1.0
Cr-54	24054.24c	6.33	20.0	20.0	1.581
Fe-54	26054.24c	0.7	20.0	20.0	3.0
Fe-56	26056.24c	2.966	20.0	20.0	0.862
Fe-57	26057.24c	1.943	20.0	20.0	0.8
Ni-58	28058.24c	0.5	20.0	20.0	0.5

Models for Library Interactions

Pulse height tally from all particles

He-3

Total

Tritons

Protons

energy (mev)

Features for 2007 – Version 2.6.D

- Transmutation improvements (BURN card)
  - Time-dependent material changes (CONC keyword)
  - Repeated-structures power norm. (VOL keyword)
  - Fission-product tier improvements

- Coupled space-energy-time weight windows

- Activation neutrons and gammas

- Background radioactive sources

- Muon capture physics

- Heavy-ion transport (via LAQGSM)
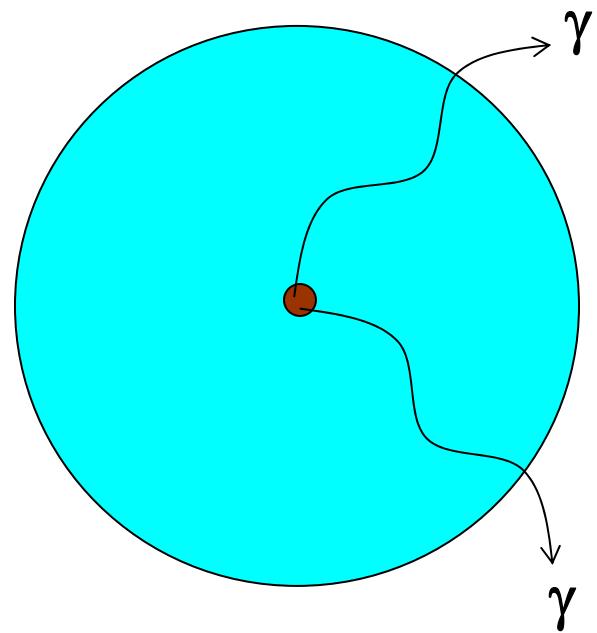
Coupled Space-Energy-Time WW

```
7 MeV neutrons into H2O surrounding 2kg HEU
1  1  -19.0   -1    imp:n=1
2  2  -1.0    +1 -2 imp:n=1
3  0              +2 imp:n=0

1 sph 0 0 0  3
2 sph 0 0 0  100

mode n p
phys:p 5j -101  $ turn on delayed gammas
sdef par=n erg=7 pos=-99 1 1 vec=1 0 0 dir=1
m1    92235 .5 92238 .5
m2    1001 2 8016 1
nps 100000
f1:p 2
t1    0.1e8 1e15 nt
f4:n 1
wwg 4 0
mesh geom=rpt origin=0 0 0 ref=-99 1 1
     axs=1 0 0 vec=0 1 0
     imesh  3.01 101.  iints  3 5
     jmesh   .5 jints  10
     kmesh   1  kints  1
c    wwp:n  4j -1 $ Add this to use neutron WWs
```

7 MeV
Neutrons

γ

γ
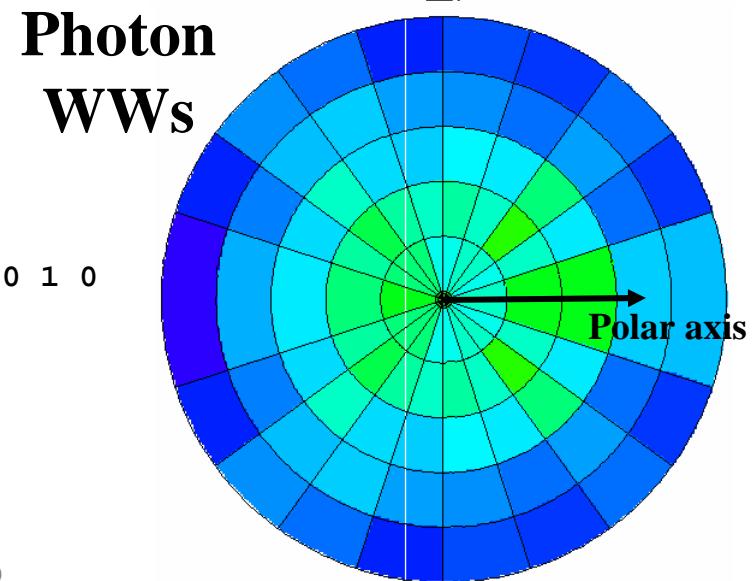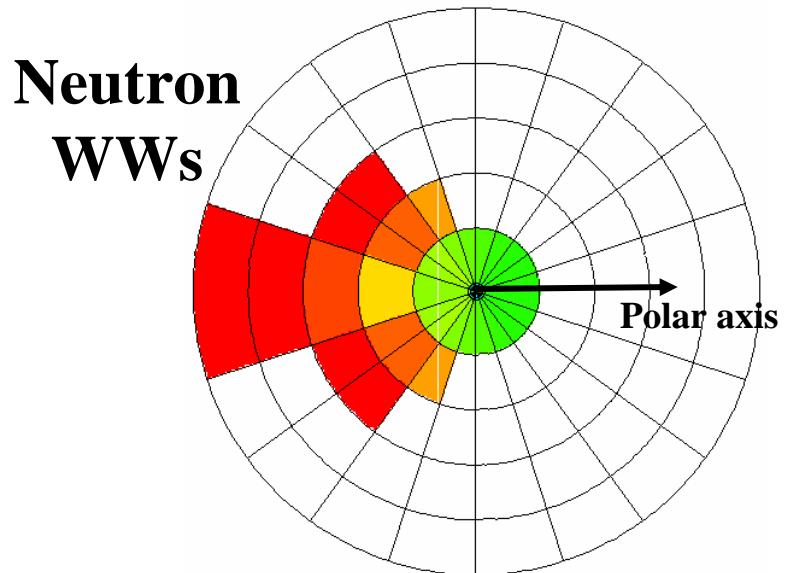
Coupled Space-Energy-Time WW

```
7 MeV neutrons into H2O surrounding 2kg HEU
1  1  -19.0    -1     imp:n,p=1
2  2  -1.0     +1 -2 imp:n,p=1
3  0             +2 imp:n,p=0

1 sph 0 0 0  3
2 sph 0 0 0  100

mode n p
totnu no
phys:p j 1 3j -101  $ turn on delayed gammas
sdef par=n erg=7 pos=-99 1 1 vec=1 0 0 dir=1
m1   92235 .5 92238 .5
m2   1001 2 8016 1
nps  300000
f1:p 2
t1   0.1e8 1e15 nt
e1   3 100 nt
wwg  1 0 5j 1
wwge:p 0.1e8 1e15
mesh geom=rpt origin=0 0 0 ref=-99 1 1 axs=1 0 0 vec=0 1 0
     imesh  3.01 101.  iints  3 5
     jmesh    .5 jints   10
     kmesh   1  kints   1
wwp:n 4j -1
c    wwp:p  4j -1 $ Add this to use photon WWs
```

Neutron WWs

Polar axis

Photon WWs

Polar axis

Activation Neutrons & Gammas
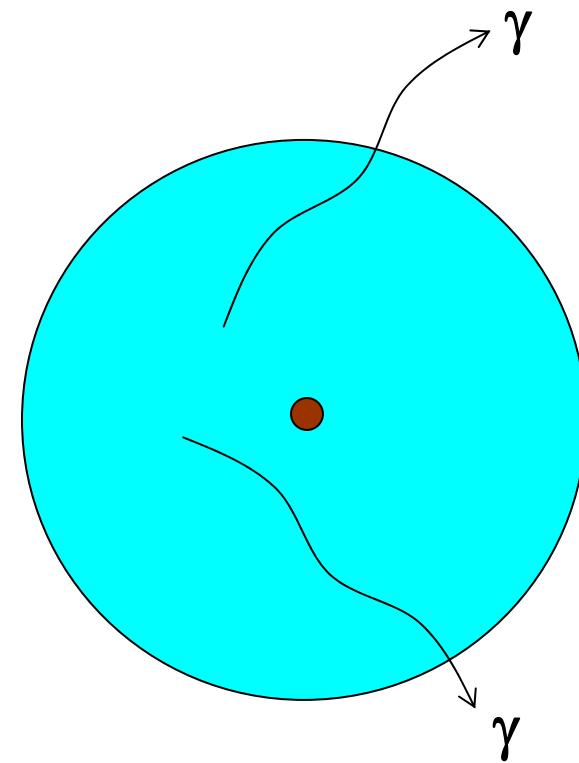
```
14 MeV neutrons into H2O surrounding 2kg HEU
1  1  -19.0    -1     imp:n,p=0
2  2  -1.0     +1 -2 imp:n,p=1
3  0               +2 imp:n,p=0


1 sph 0 0 0   3
2 sph 0 0 0  100


mode n p
phys:p 5j -102  $ turn on delayed gammas
cut:n  2j 0 0  $ turn off implicit capture
sdef par=n erg=14 pos=-99 1 1 vec=1 0 0 dir=1
m1    92235 .5 92238 .5
m2    1001 2 8016 1
nps 1000000
f1:p 2
t1    0.1e8 1e15 nt
e1    1 99i 10
```
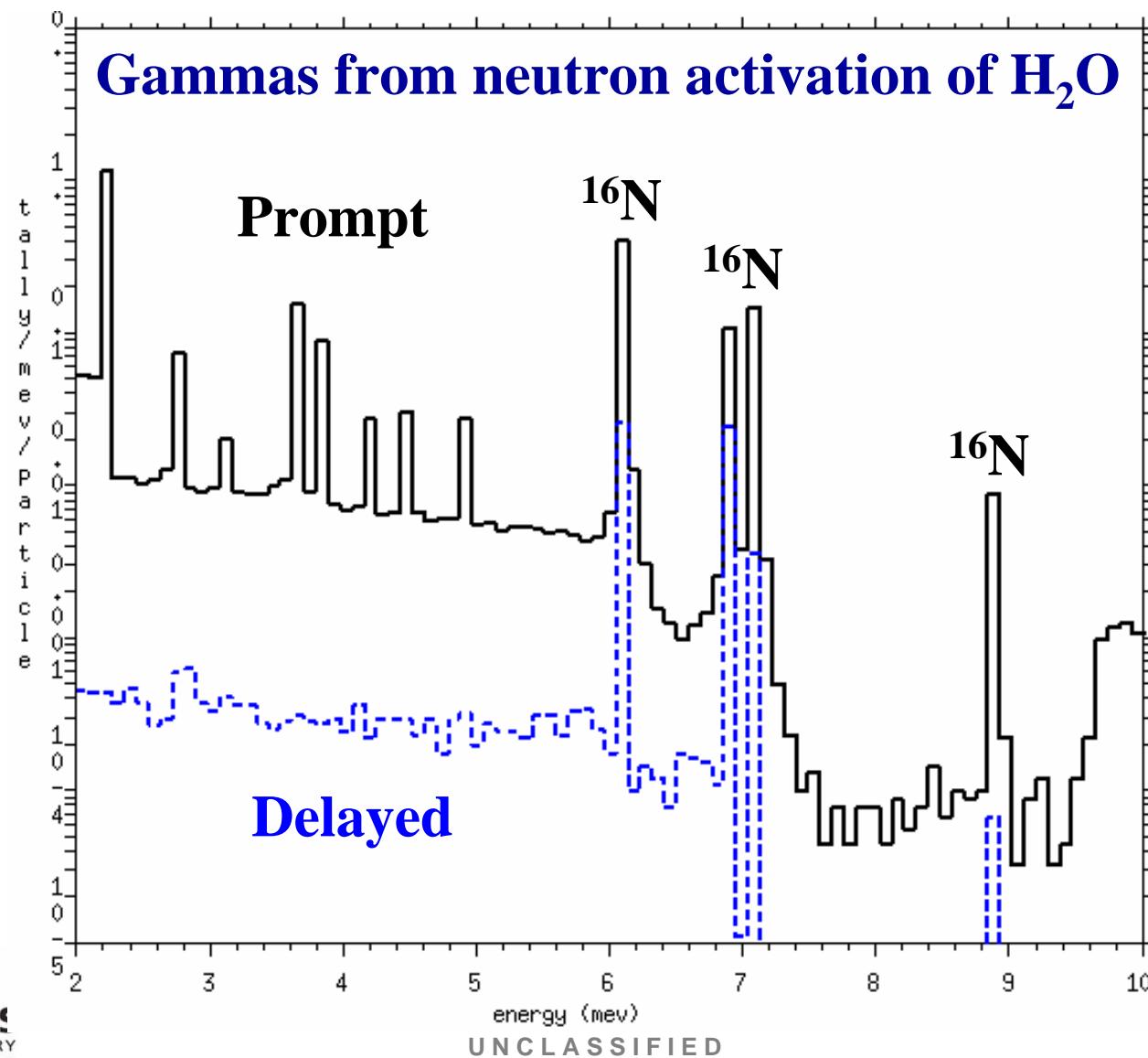
γ

14 MeV
Neutrons →

γ

Activation Neutrons & Gammas

Gammas from neutron activation of H_2O
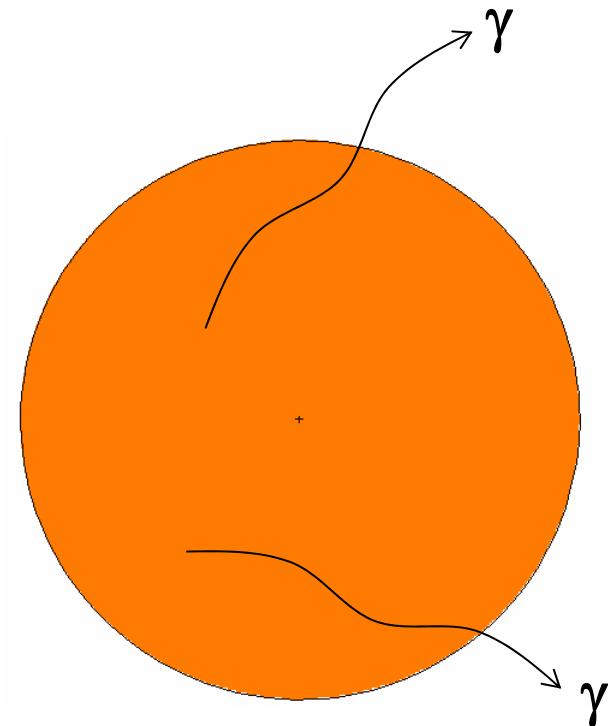
Background Radioactive Sources

```
Co-57, Co-60, and Cs-137 within soil
1 2 -1.6   -1        imp:p=1
2 0         1        imp:p=0

1 so 100.0

sdef par=sp cel=1 pos=0 0 0 wgt=1 rad=d1
si1 0 100
sp1 -21 2
mode p
nps 100000
m2   1001.66c  -.002  8016.66c -.527
     11023.66c -.021 13027.66c -.061
     14028     -.345 19000     -.029
     26056 -.016
     27057 -0.00000001 27060 -.000001
     55137 -.000323
     plib=.02p
e0 0.0 2999i 3.0
f4:p 1
f2:p 1
c2 0 1
```
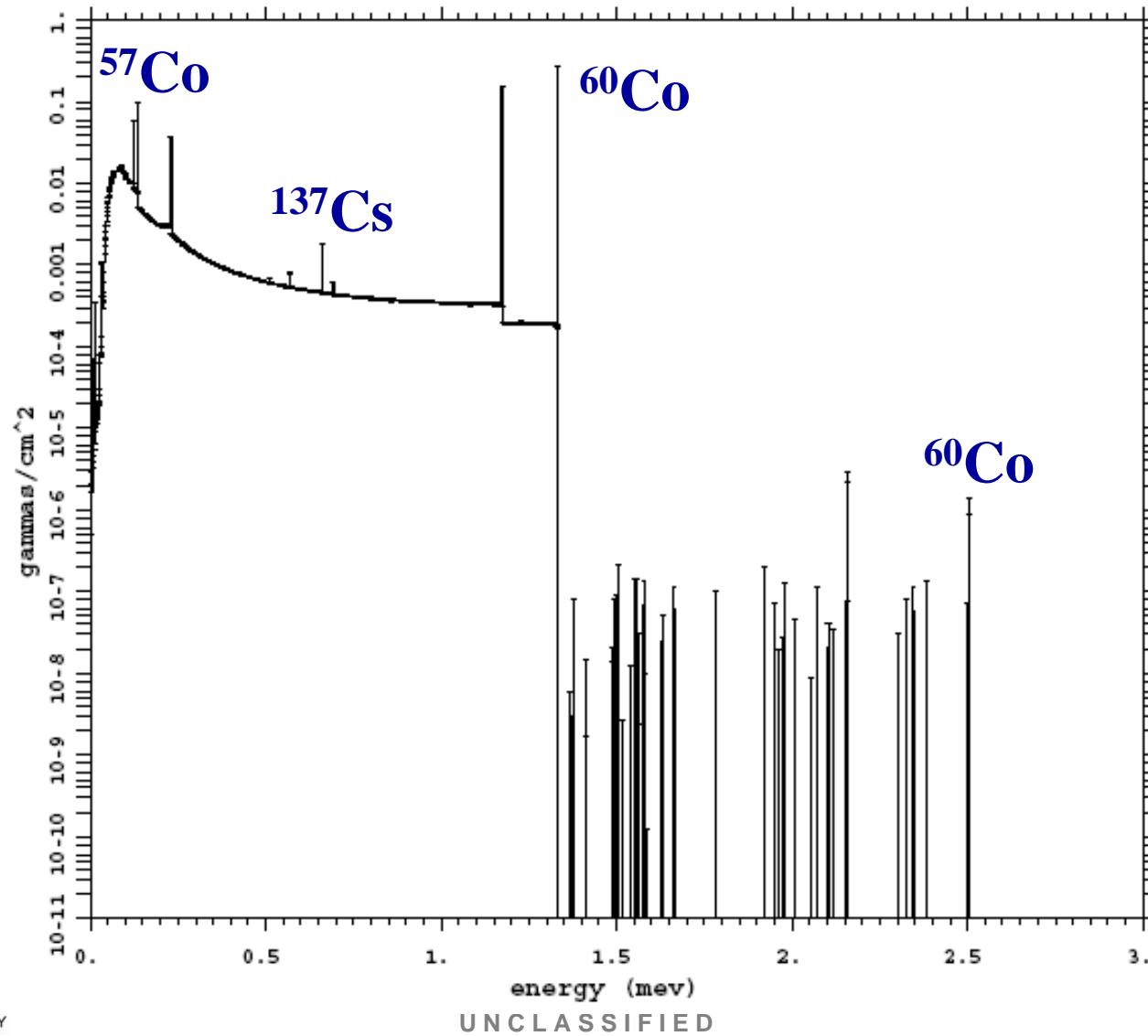
Background Radioactive Sources

Operated by the Los Alamos National Security, LLC for the DOE/NNSA

Muon Capture Physics

350 MeV muons into Pb surrounding HEU
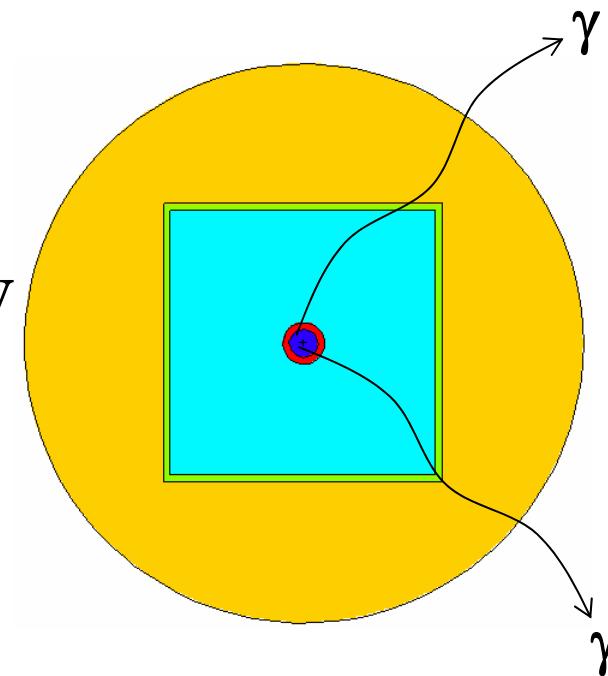
```
1 1 -18.95   -1              imp:|,p=1
2 8 -11.35   1 -2            imp:|,p=1
3 3 -1.0   2 -3              imp:|,p=1
4 4 -7.8 3 -4                imp:|,p=1
5 5 -1.205e-3   4 -100       imp:|,p=1
100 0   100                  imp:|,p=0

1 rcc -10.0 0.0 0.0 20.0 0.0 0.0 5.0
2 rcc -12.5 0.0 0.0 25.0 0.0 0.0 7.5
3 rpp -47.5 47.5 -47.5 47.5 -47.5 47.5
4 rpp -50.0 50.0 -50.0 50.0 -50.0 50.0
100 so    100.0

mode |   p
phys:|  350.0
phys:p 350.0
sdef par=| erg=350.0 x=d1 y=d2 z=-60.0
    vec=0 0 1 dir=1
si1 -12.5 12.5
sp1 0  1
si2 -7.5 7.5
sp2 0  1
m1  92238 -.20 92235 -.80
m3  1001 2      6012 1
m4  26054 5.9 26056 91.72 26057 2.1 26058 .28
```
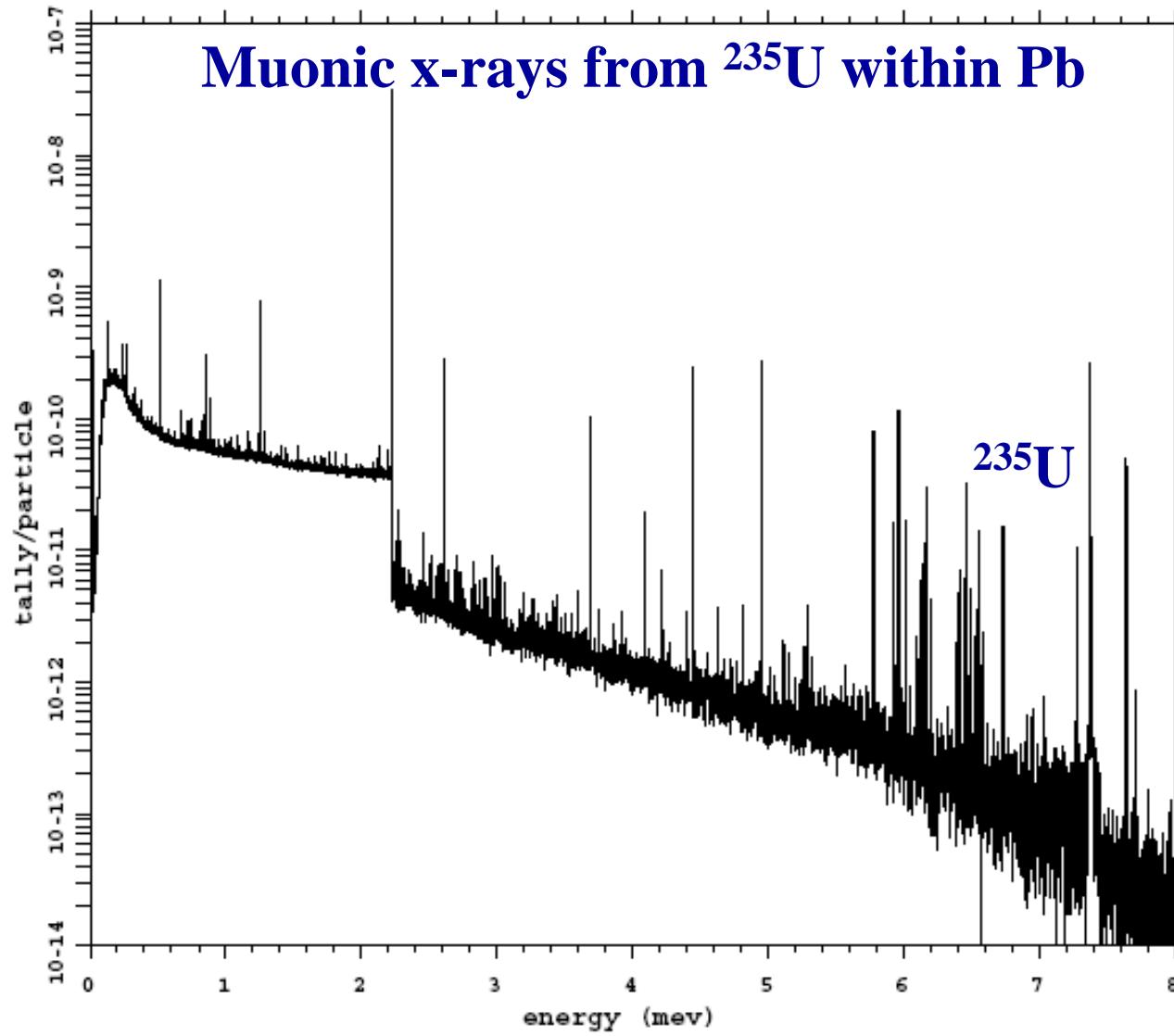
```
m5    1000 -6e-4 8000 -0.2353 7000 -0.7513
      18000 -0.0128
m8    82204 1.4    82206 24.1    82207 22.1
      82208 52.4
e2 0.0 9999i 10.0
f2:p 100
```

γ

350 MeV Muons

γ

Muon Capture Physics

Muonic x-rays from ^{235}U within Pb

^{235}U

Heavy-ion Transport

```
969 MeV/n Fe into H2O
1      2  -1.0       -1      imp:n=1
2      1  -0.0012   1  -2 imp:n=1
3      0                  2 imp:n=0


1      rpp -15 15 -15 15 0 40.0
2      rcc 0 0 -20  0 0 80 50
3      pz -1


m1     7014.24h 0.781 8016.24h 0.219
m2     1001.24h 0.667 8016.24h 0.333
mode   h a n #
phys:h 60000 j j j j j 0.1
phys:n 60000 j 0 -1 j j 1
lca 8j 3
sdef   par=26056 erg=d2 sur=3 dir=1 vec=0 0 1 pos=0 0 -1 rad=d1
si1    0 0.5
sp1    -21
si2    L 54224.00 54251.00 54278.00
sp2    0.25 0.5 0.25
nps    20000
tmesh
rmesh3 total
cora3  -7.0  7.0
corb3  -7.0  7.0
corc3   0.0  400i  40.0
endmd
```

Undocumented Feature?
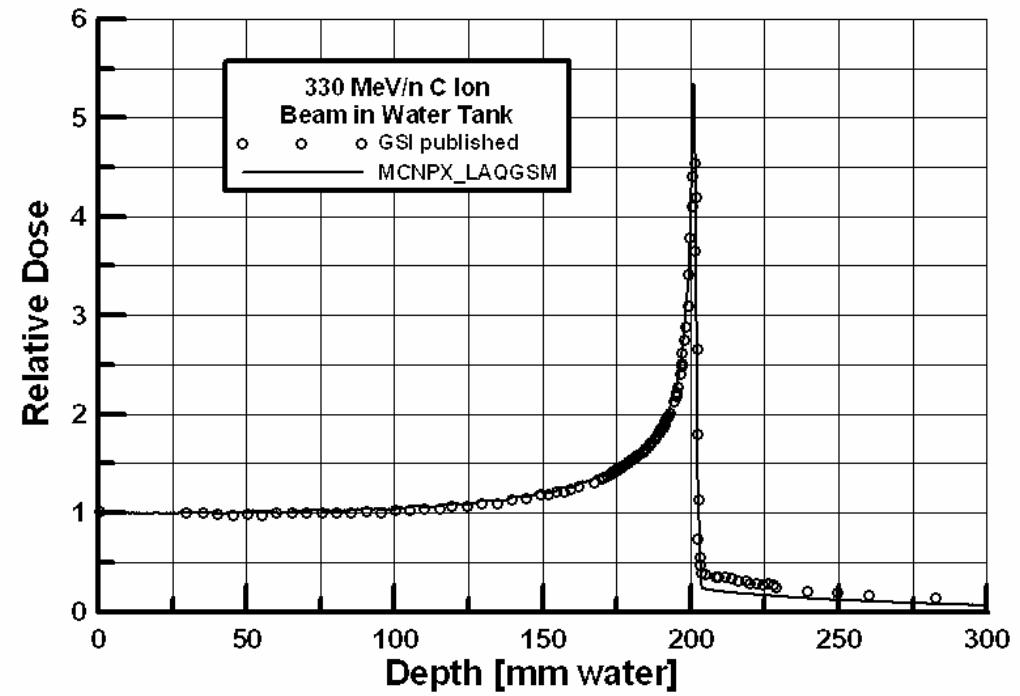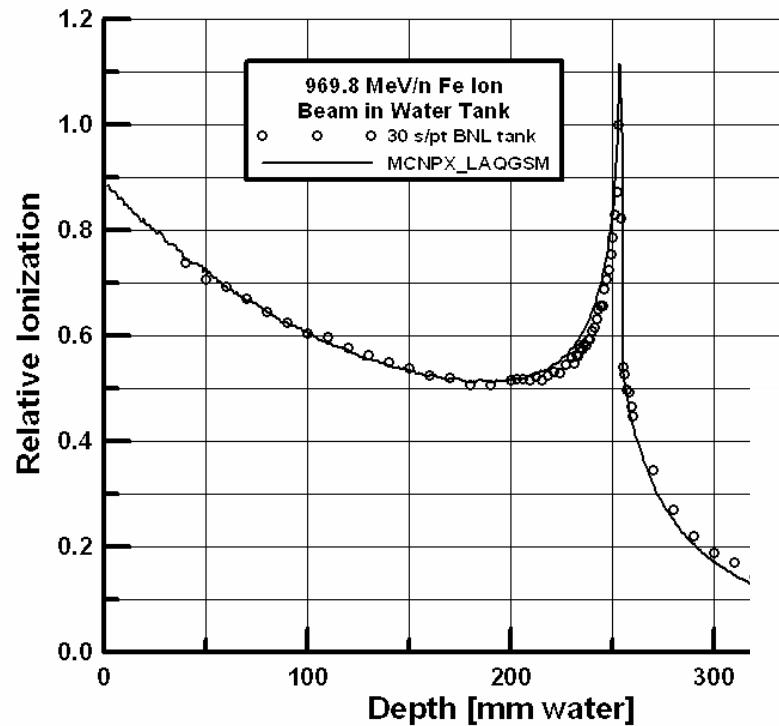
Heavy-ion Transport

Features for 2007 – Version 2.6.E

- Transmutation improvements
  - Accurate evolution of meta-stables
  - Treatment for minor actinides

- Plotting of spherical mesh tallies

- Enhanced tally tagging (other particles & tags)

- Time-dependent transformations
  - Allows moving universes (e.g., control-rod movement)

- Fission gamma multiplicity

- Nuclear resonance fluorescence physics

Future of MCNPX

- Possible public release of 2.6.0 (~Sept. 2007)
- MCNPX and MCNP merger
  - Hope to preserve all features of both codes
  - Preliminary version by Summer 2007
  - Public release perhaps in 2008
- Capabilities beyond 2.6.0 will be put in MCNP6/7
  - MCNPX will cease to be distributed
  - MCNP web site may allow for a small Beta group
  - MCNP & MCNPX workshops will be combined