LA-UR-08-06930

Tally Tagging Feature in MCNPX 2.7.A

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Outline

- **MCNPX Overview**
- **Tally Tagging Overview**
- **Simple Radiography Example**
- **Complex Activation Example**
- **Conclusions**

MCNPX Overview

- Monte Carlo radiation transport code
  - Extends MCNP4C to virtually all particles and energies
  - 34 particles (n,p,e, …) + 2205 heavy ions
  - Continuous energy (roughly 0-1000 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)

MCNPX 2.6.0 Feature List (April 2008)

DNDO Sponsored

Physics Enhancements

Muon capture physics
Integration of the LAQGSM event generator
Heavy-ion transport
Integration of the Cinder code
Photo-fission yield data
Delayed particles from activation
Upgrade of the CEM event generator
Ion production from library neutron capture
Gravity effects for neutrons
Updated photon de-excitation data

Source Enhancements

Transmutation with KCODE
Acceleration of KCODE source convergence
Spontaneous decay photon sources

Tally Enhancements

Termination based on precision
Tally tagging
Spherical mesh tally plots
Differential tallies extended to library events

Variance Reduction Enhancements

Spherical mesh WW (weight windows)
Coupled space-energy-time WW
Additional WW controls

Other Enhancements

Long file names
Proton step size control
Output for induced-fission multiplicity
Several graphics enhancements

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Tally Tagging Overview

- **Segregate any standard tally into components based on**
  - Creation cell
  - Emitting nuclide
  - Reaction identifier
  - Other special identifiers
- **Tag collision options**
  - Particle loses creation tag upon collision (gets scatter tag of “0”)
  - Photons from Brem. & annihilation given special tags
  - Particle retains tag through elastic scatter
- **Invoked using the FT TAG option**

Tally Tagging Overview

- **Syntax**

```
F1:n   2
FT1    TAG  [1|2|3]
FU1    ID1 ID2 ID3 …
```

- **Format of tag ID: -CCCCCZZAAA.RRRRR**

```
Negative used for source particle tagging (see below)
CCCCC is optional and refers to a cell number
ZZ or AAA must be non-zero (Z/A of creation nuclide)
RRRRR is optional and refers to a specific reaction
  - for library interactions it is an ENDF MT value
  - for model interactions it is a residual ZZAAA
```

- **Special tag IDs (all tallies)**

```
-0000000001     Source particle tag for all cells
-xxxxx00001     Source particle tag for cell "xxxxx"
 0000000000     (or "0") scattered particle tag
10000000000     (or "1e10") everything else tag
```

Tally Tagging Overview

- **Special tag IDs (neutron & photon tallies)**

```
ZZAAA.99999     Delayed particles from fission of ZZAAA
```

- **Special tag IDs (photon tallies)**

```
00000.00001     Brems. from electrons (ZZAAA=00000)
ZZ000.00003     Fluor. from nuclide ZZ (AAA=000)
00000.00003     K x-rays from electrons (ZZAAA=00000)
00000.00004     Annihilation photons from e- (ZZAAA=00000)
ZZ000.00005     Compton photons from nuclide ZZ (AAA=000)
ZZAAA.00006     Muonic x-rays from nuclide ZZAAA
```

- **Special tag IDs (electron tallies)**

```
ZZ000.00001     Photoelectric from nuclide ZZ (AAA=000)
ZZ000.00003     Compton recoil from nuclide ZZ (AAA=000)
ZZ000.00004     Pair production from nuclide ZZ (AAA=000)
ZZ000.00005     Auger electron from nuclide ZZ (AAA=000)
00000.00005     Auger electron from electrons (ZZAAA=00000)
00000.00006     Knock-on electrons (ZZAAA=00000)
```

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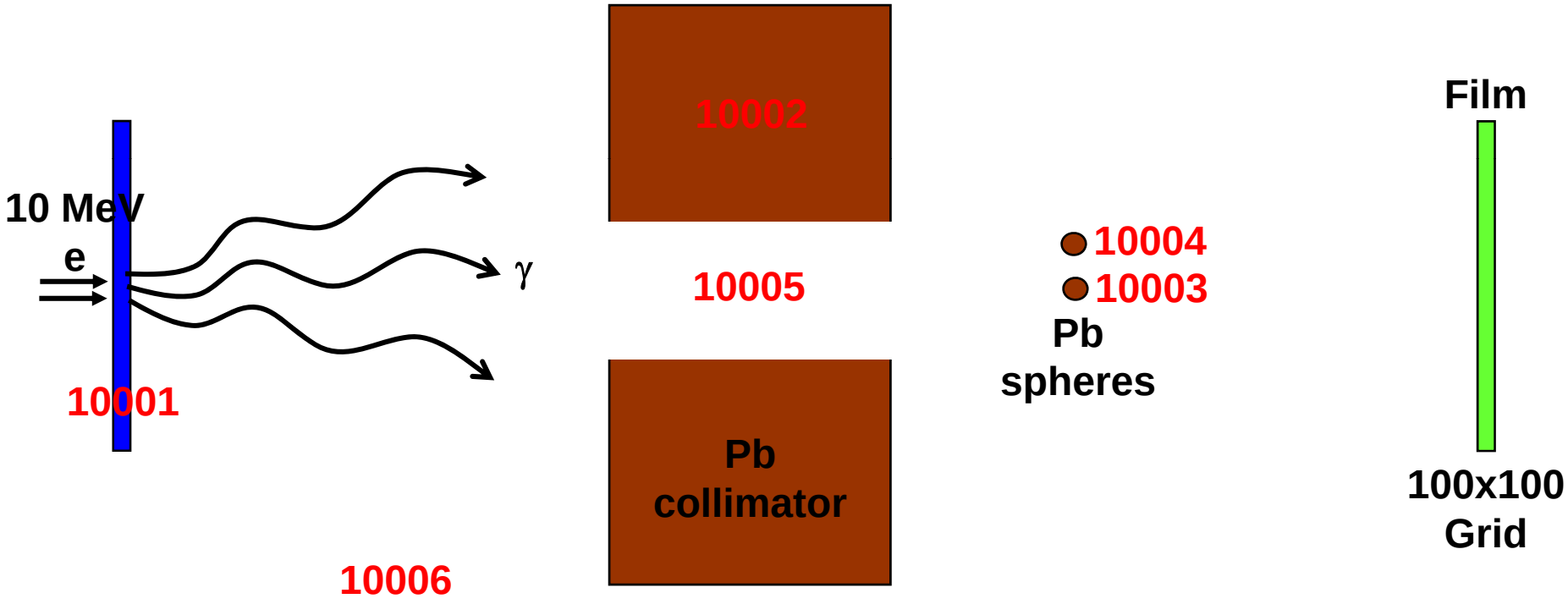
Simple Radiography Example

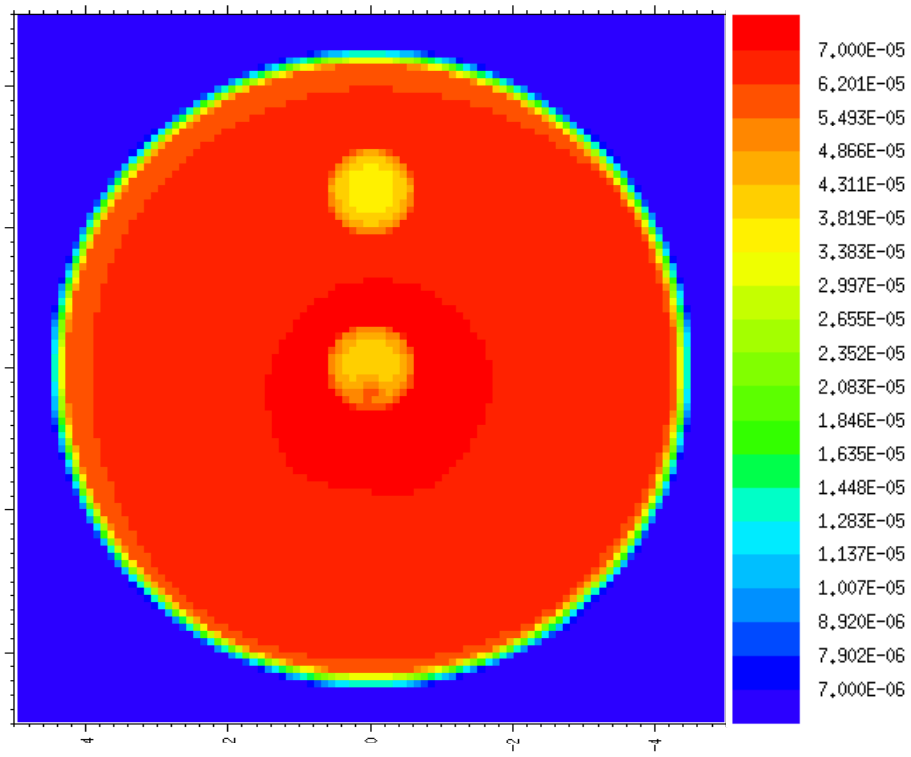
```
Tally tagging with 10-MeV Brem. image
10001  1  -19.3   -1       imp:p,e=1
10002  2  -11.4   -2  3    imp:p,e=1
10003  2  -11.4      -4    imp:p,e=1
10004  2  -11.4      -5    imp:p,e=1
10005  0             -3    imp:p=1 imp:e=0
10006  0        1 2 4 5 -6 imp:p,e=1
10007  0                6 imp:p,e=0

1 rcc   0 0 0   1 0 0   5
2 rcc  50 0 0  20 0 0  20
3 rcc  50 0 0  20 0 0   3
4 sph  80 0 0  0.5
5 sph  80 0 2  0.5
6 sph  0 0 0  500

mode p e
phys:e 10.5
sdef  erg=10 par=e pos=-10 0 0 rad=d1
      axs=1 0 0 ext=0 vec=1 0 0 dir=1
si1   0 .1
sp1   -21 1
m1    74000 1
m2    82000 1
```

```
tir5:p 100 0 0  0  50 0 0  0 50 0
c5     -5 99i 5
fs5    -5 99i 5
ft5    TAG 3
fu5    1000100000. 1000200000.
       1000300000. 1000400000. 1e10
nps    100000
```

Simple Radiography Example

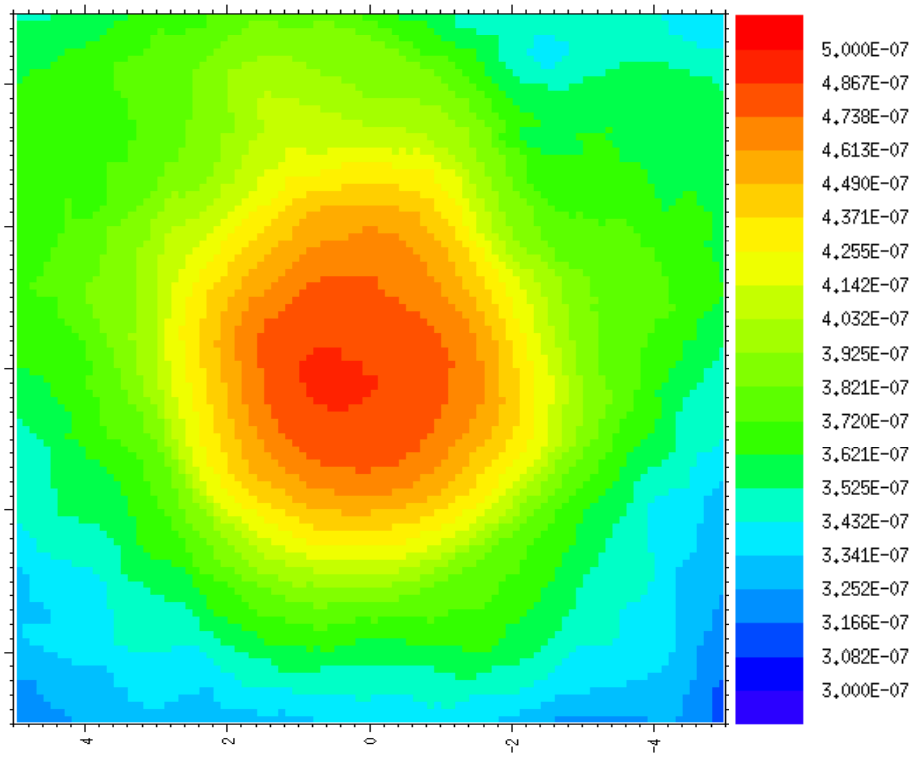


Simple Radiography Example



Direct image

Scatter image



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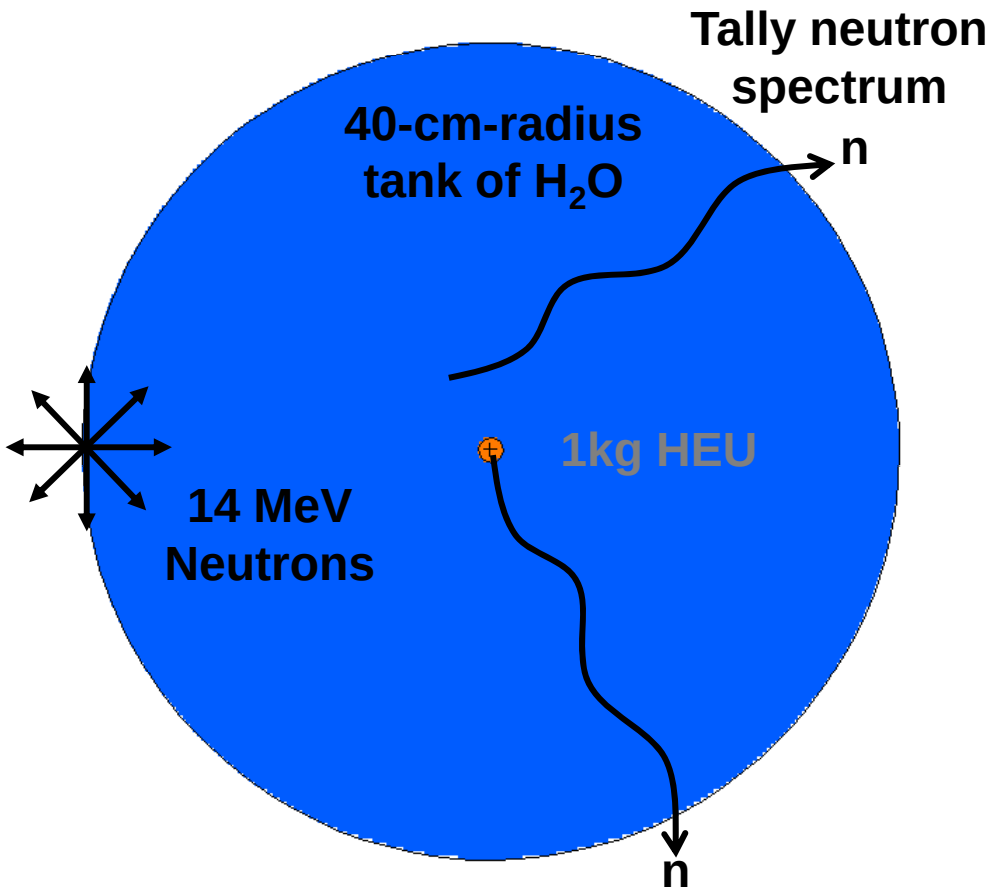
Complex Activation Example

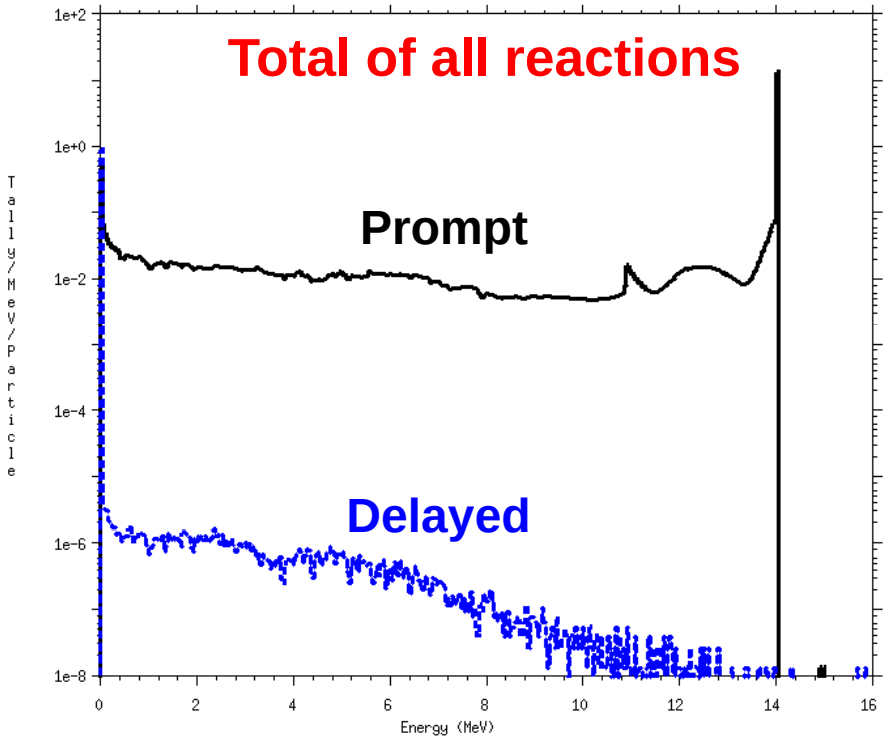
```
Neutron activation of water + HEU
1  2  -10.0   -1       imp:n=1
2  1   -1.0    1 -2    imp:n=1
3  0              2    imp:n=0

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
```

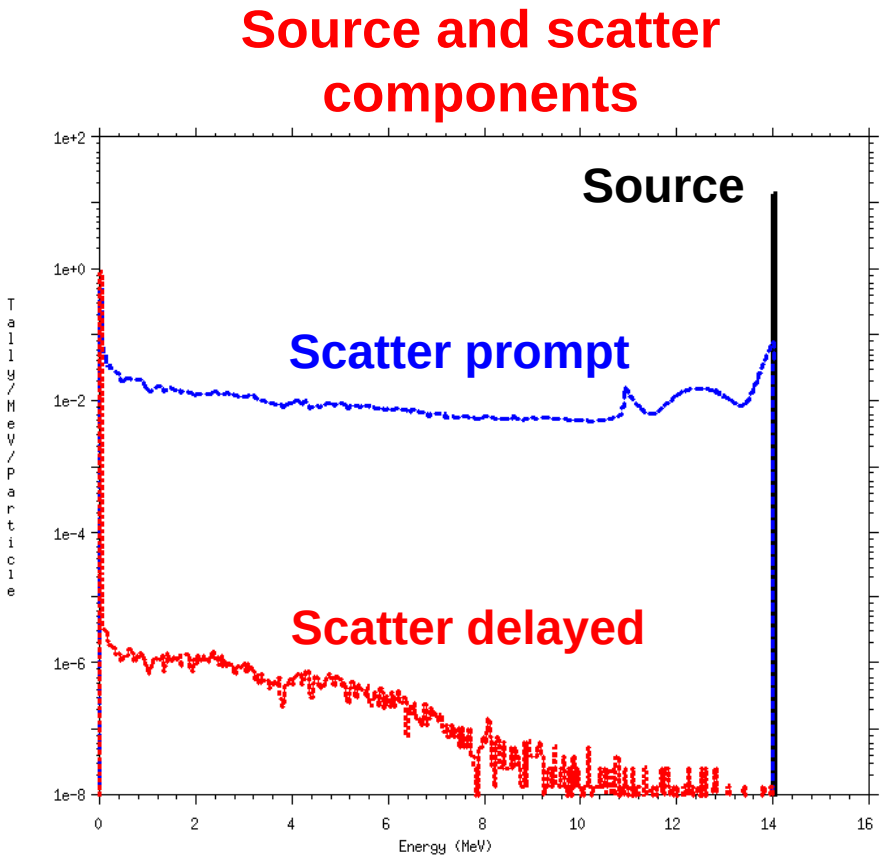
```
f31:n 2
ft31  tag 2
fu31  -1.0  0.0
      1001.0
      8016.00011 8016.00016 8016.00017 8016.00022
      8016.00023 8016.00024 8016.00025 8016.00028
      8016.00029 8016.00030 8016.00032 8016.00033
      8016.00034 8016.00035 8016.00036 8016.00037
      8016.00041 8016.00042 8016.00043 8016.00044
      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
```

Complex Activation Example

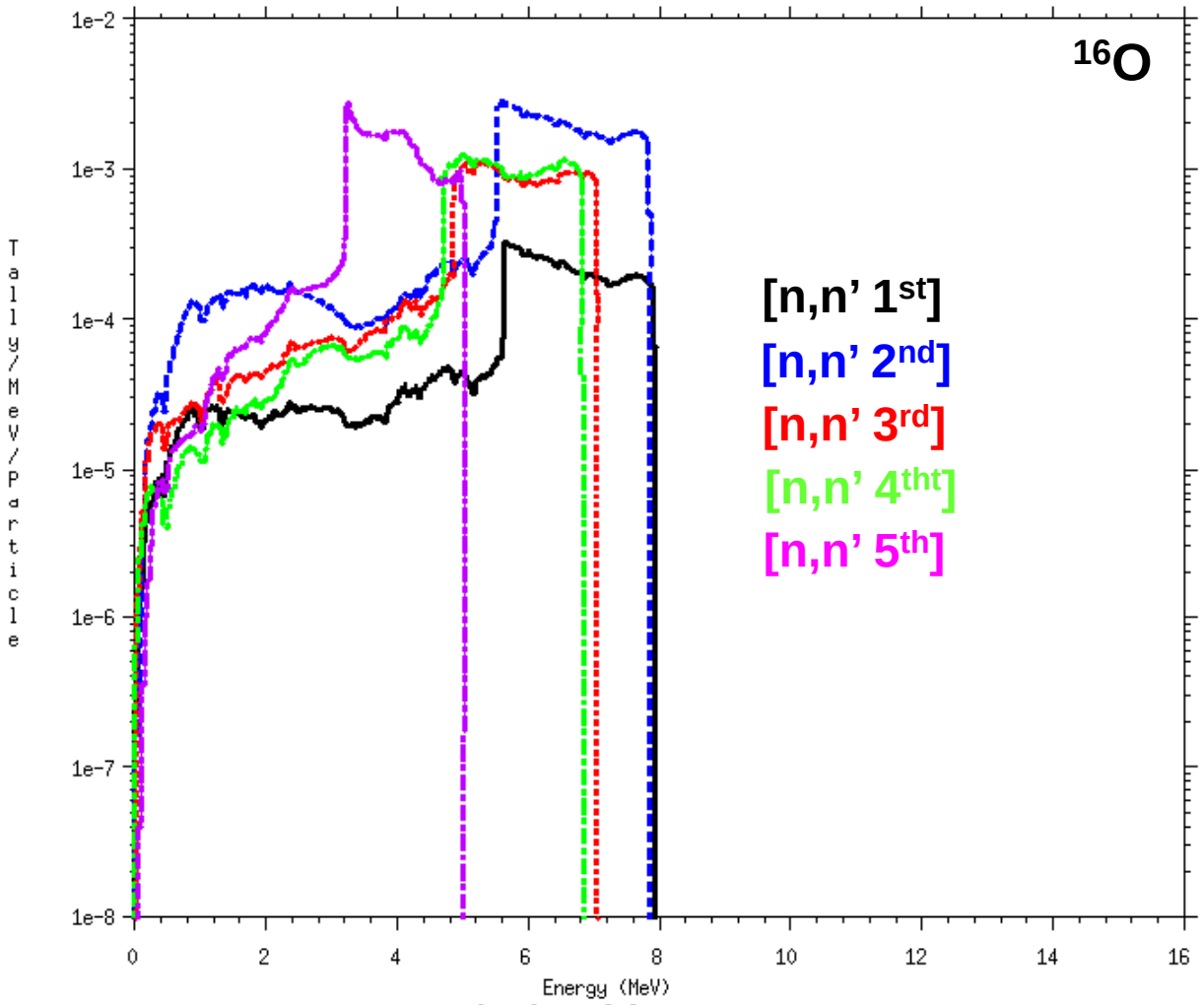


Complex Activation Example

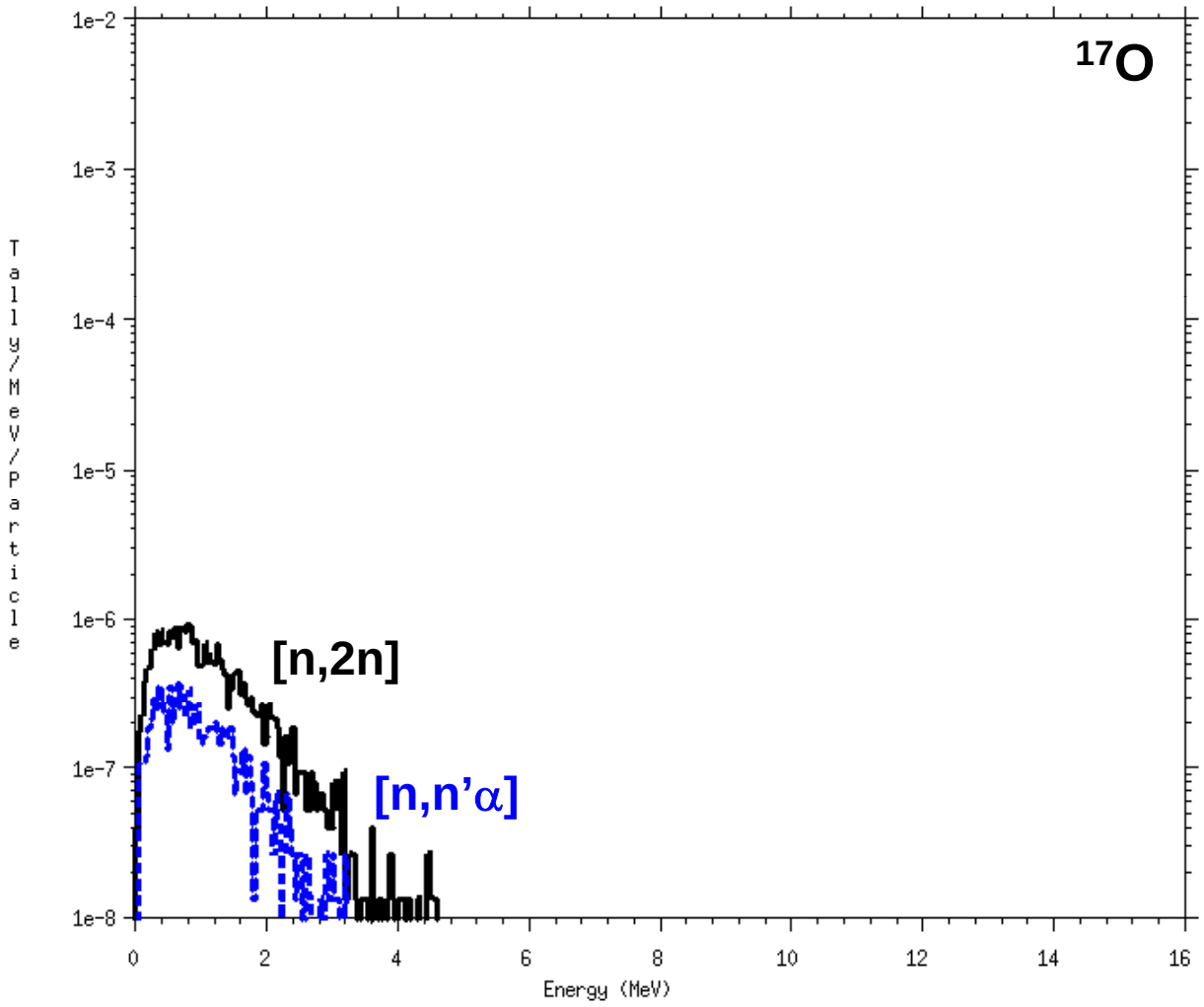




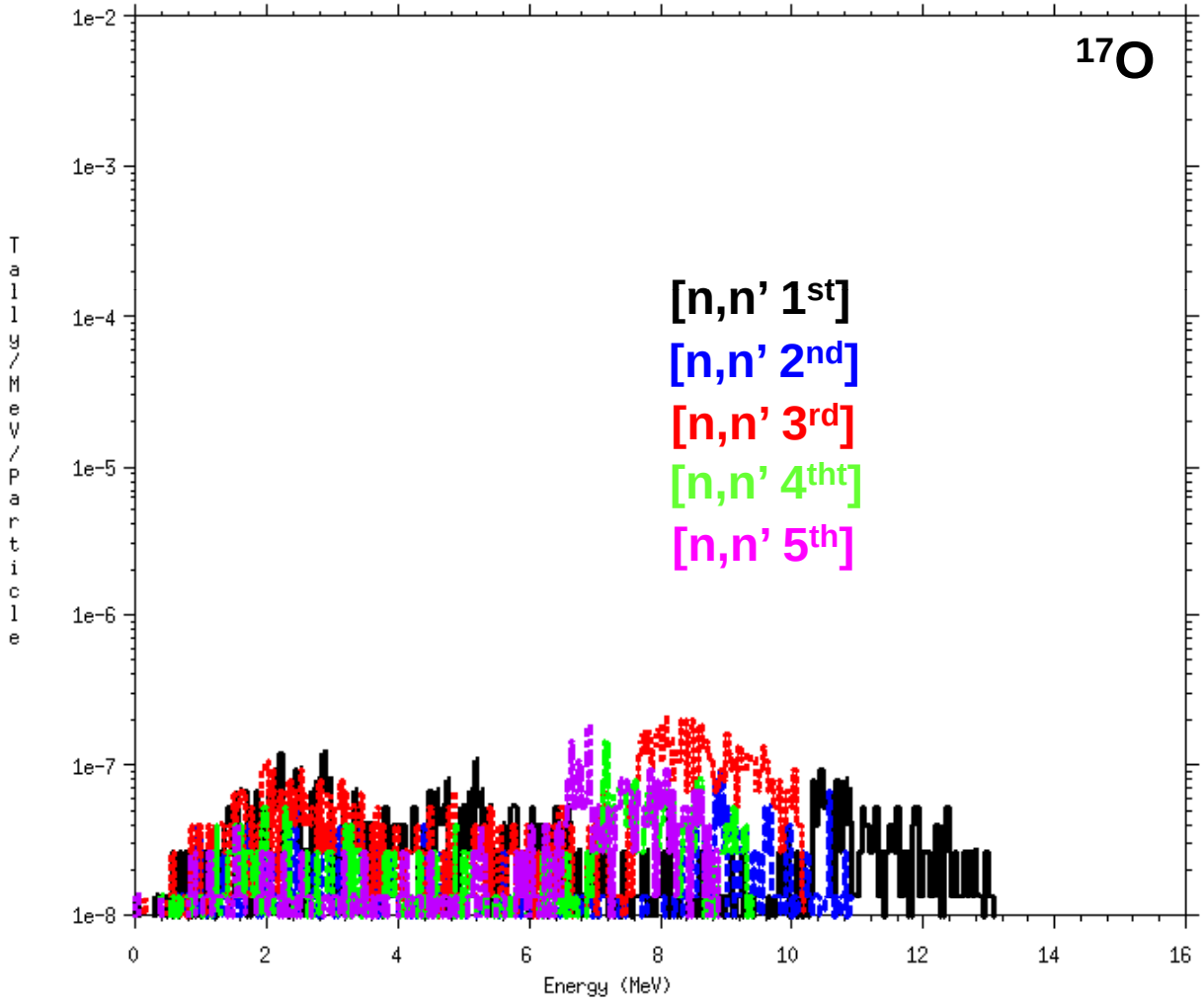
Complex Activation Example



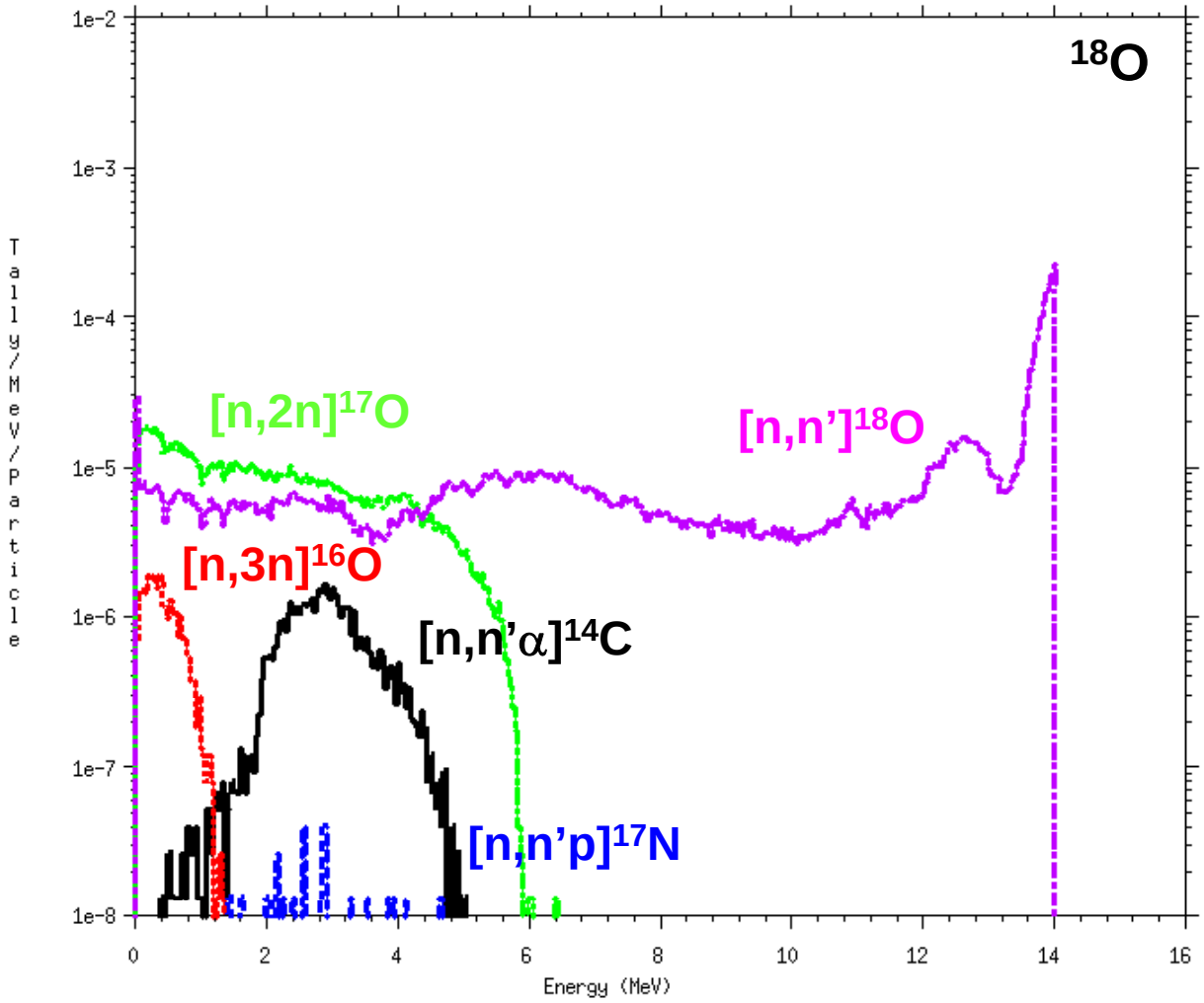
Complex Activation Example



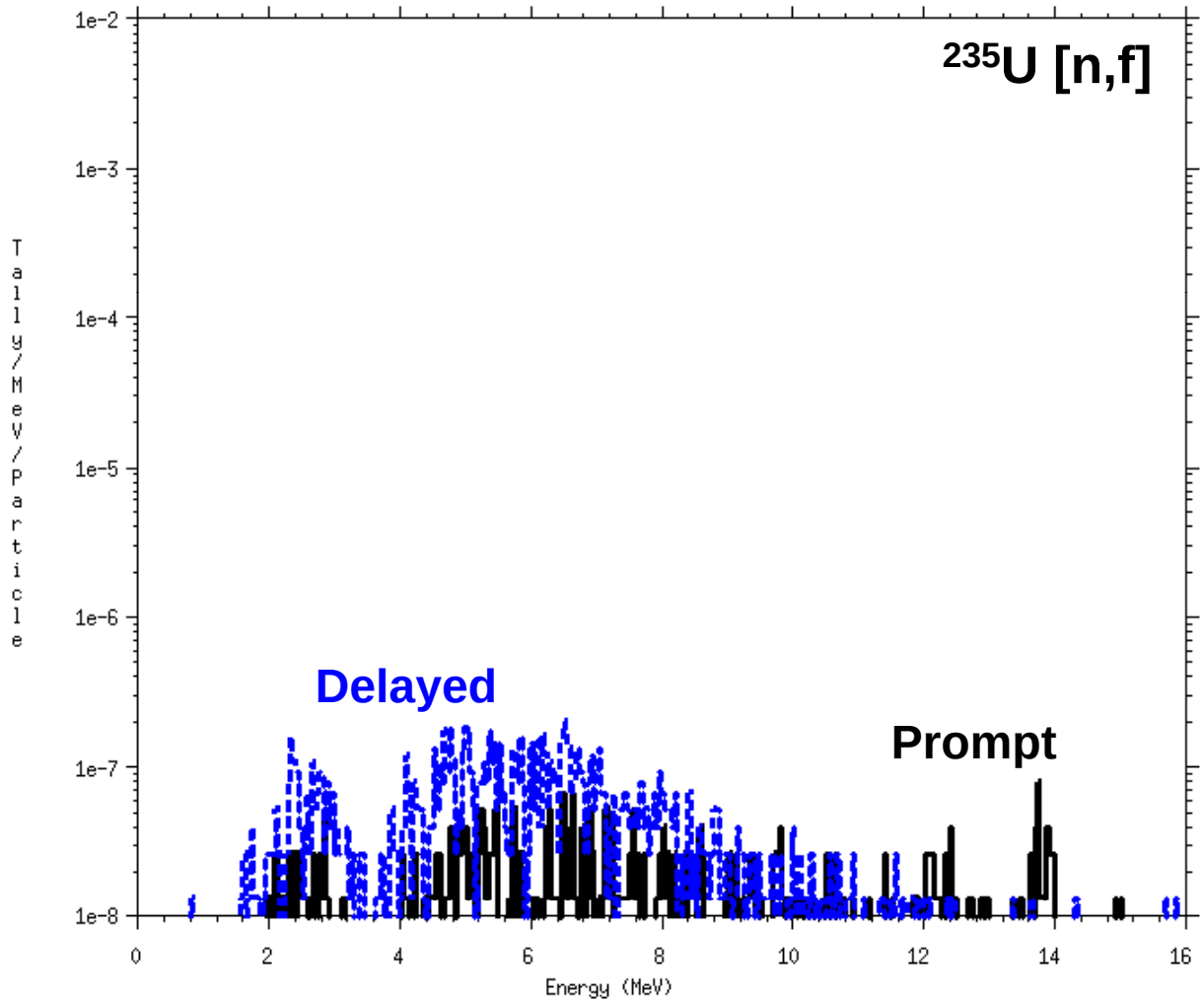
Complex Activation Example



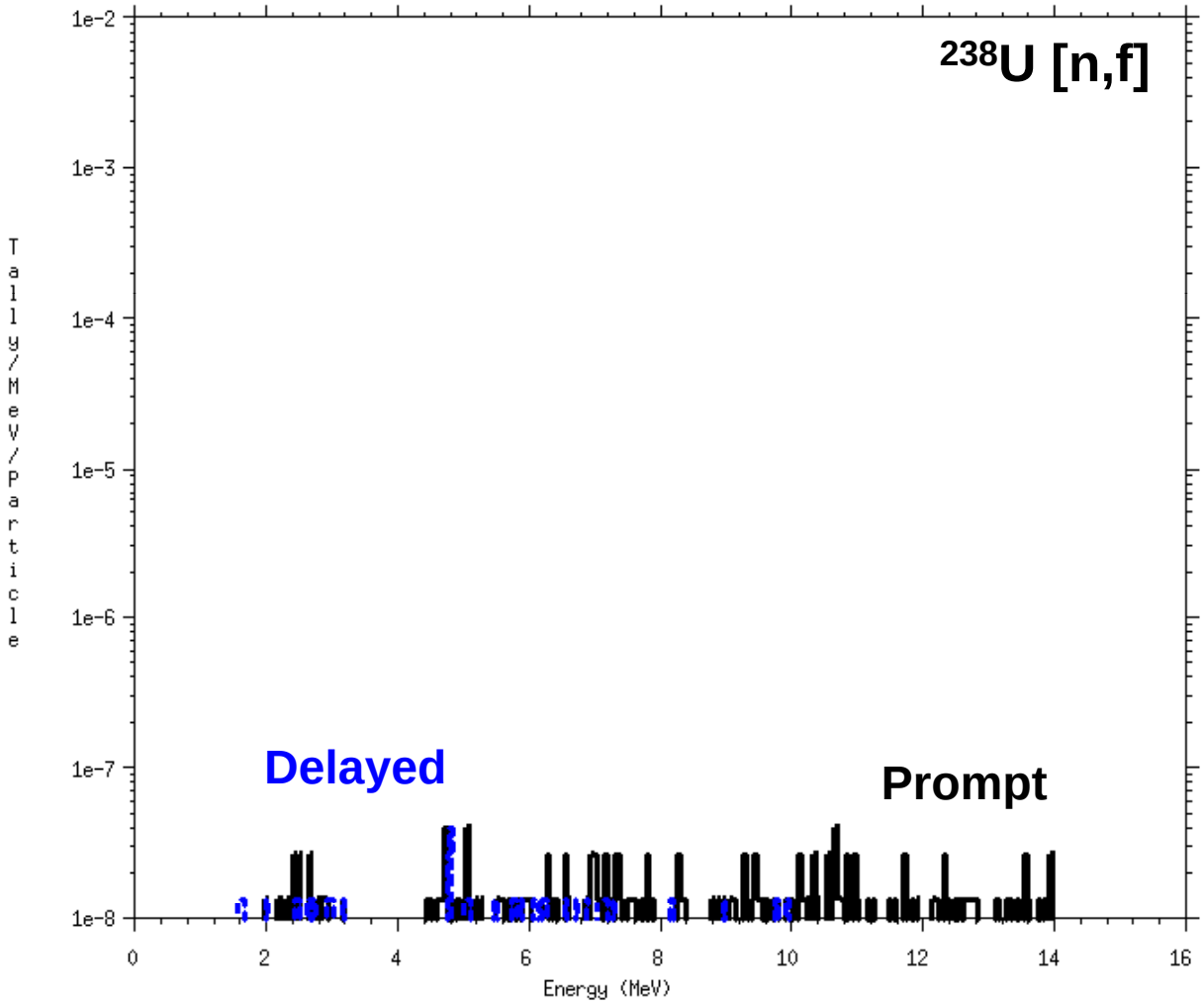
Complex Activation Example



Complex Activation Example



Complex Activation Example



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Conclusions

- **Now possible to segregate any standard MCNPX tally based on all possible creation mechanisms**
- **Enables users to identify interesting features of a simulated spectrum**
- **In the future this can be used to separate noise and signal components for use in producing ROC curves**

ENDF/B-VI Reaction MT Values

```
&  11, -1,  -3,  ! (n,n'nd)
&  16,  0,  -1,  ! (n,2n)
&  17,  0,  -2,  ! (n,3n)
&  22, -2,  -4,  ! (n,n'a)
&  23, -6, -12,  ! (n,n'3a)
&  24, -2,  -5,  ! (n,n'na)
&  25, -2,  -6,  ! (n,n'2na)
&  28, -1,  -1,  ! (n,n'p)
&  29, -4,  -8,  ! (n,n'2a)
&  30, -4,  -9,  ! (n,n'n2a)
&  32, -1,  -2,  ! (n,n'd)
&  33, -1,  -3,  ! (n,n't)
&  34, -2,  -3,  ! (n,n'He3)
&  35, -5, -10,  ! (n,n'd2a)
&  36, -5, -11,  ! (n,n't2a)
&  37,  0,  -3,  ! (n,4n)
&  41, -1,  -2,  ! (n,n'np)
&  42, -1,  -3,  ! (n,n'2np)
&  43, -3,  -5,  ! (n,n'pa)
&  44, -2,  -2,  ! (n,n'2p)
```