

Evaluation of Pt isotopes in fast neutron range



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Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

LA-UR-23-32797

General Pt landscape

Abundances

Pt190 = 0.014 %
Pt191 =
Pt192 = 0.782 %
Pt193 =
Pt194 = 32.967 %
Pt195 = 33.832 %
Pt196 = 25.242 %
Pt197 =
Pt198 = 7.163 %

Simultaneous evaluation

Deformations

Z A El beta2
78 176 Pt 0.1900
78 180 Pt 0.2560
78 184 Pt 0.2240
78 186 Pt 0.1979
78 188 Pt 0.1860
78 190 Pt 0.1490
78 192 Pt 0.1532
78 194 Pt 0.1426
78 196 Pt 0.1296
78 198 Pt 0.1141

from RIPL-3

Coupled Channels needed !

Total list of 22 Isomers

78-Pt-199 m1 E= 0.424000 MeV Jp= 6.5
78-Pt-197 m1 E= 0.399590 MeV Jp= 6.5
78-Pt-195 m1 E= 0.259300 MeV Jp= 6.5
78-Pt-193 m1 E= 0.149780 MeV Jp= 6.5
78-Pt-192 : measured not calculated
77-Ir-197 m1 E= 0.115000 MeV Jp= -5.5
77-Ir-195 m1 E= 0.100000 MeV Jp= -5.5
77-Ir-194 m1 E= 0.370000 MeV Jp= 11.0
77-Ir-193 m1 E= 0.080239 MeV Jp= -5.5
77-Ir-192 m1 E= 0.168140 MeV Jp= -11.0
77-Ir-192 m2 E= 0.056720 MeV Jp= -1.0
77-Ir-190 m1 E= 0.376400 MeV Jp= -11.0
77-Ir-190 m2 E= 0.026100 MeV Jp= -1.0
77-Ir-191 m1 E= 0.171290 MeV Jp= -5.5
76-Os-191 m1 E= 0.074382 MeV Jp= -1.5
76-Os-190 m1 E= 1.705400 MeV Jp= -10.0
76-Os-189 m1 E= 0.030812 MeV Jp= -4.5
75-Re-188 m1 E= 0.172069 MeV Jp= -6.0
75-Re-186 m1 E= 0.149000 MeV Jp= 8.0
75-Re-184 m1 E= 0.188046 MeV Jp= 8.0
74-W-185 m1 E= 0.197383 MeV Jp= 5.5
74-W-183 m1 E= 0.309493 MeV Jp= 5.5

ENDF/B-VIII.0

DEC15 A.J. Koning & D. Rochman

Taken from TENDL-2015

Potentially of interest and lot of complications

Evaluation

EMPIRE models

- Coupled Channels
- MSD/MSC/Exciton
- Hauser-Feshbach with WFC
- Kalman filter (covariances)

EMPIRE options

- OMP Soukhovitskii, Capote RIPL 1483
- EGSM level densities
- MLO1 γ -ray strength functions
- HRTW width fluctuation correction

Evaluation concept

- evaluation fully contained in the model input
- simultaneous evaluation of all stable isotopes to compare with natural exp data (dedicated framework developed)
- consistent set of model parameters for all isotopes
- RR/URR taken from VIII.0 (URR for self-shielding only)

Consistent set of parameters

common part of input

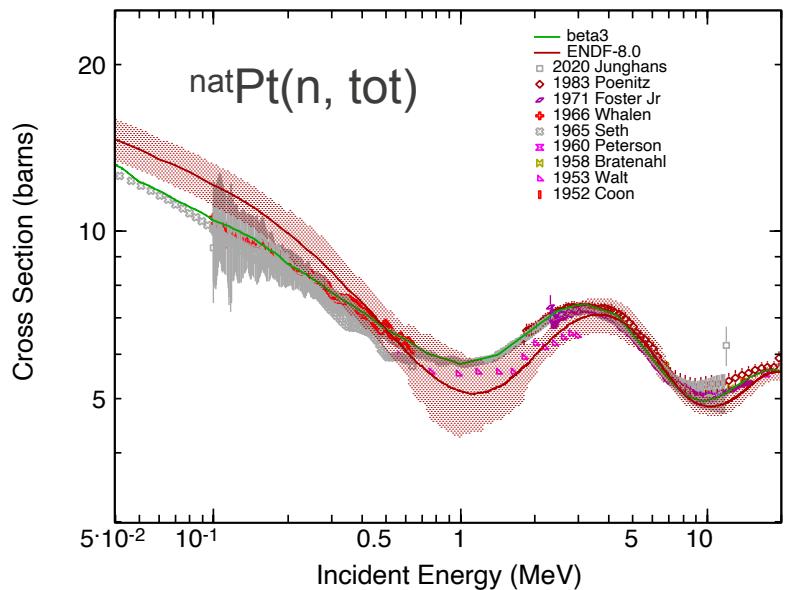
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IOUT      3.  
NEX      100.  
ENDF      3.  
KALMAN    0.  
RECOIL    0.  
**** INCIDENT CHANNEL / DIRECT *****  
DIRPOT   1483.  
DIRECT    1.  
**** COMPOUND NUCLEUS *****  
WFCORR   2.  
ETLJ      3.  
CNANGD   1.  
INTERF    0.  
GSTRFN   1.  
MAXMUL   2.  
PRGAMM   1.  
**** LEVEL DENSITIES *****  
FITLEV   0.  
LEVDEN   0.  
ECONT    0.790  72  179  
ECONT    0.664  72  181  
ECONT    1.265  72  182  
ECONT    0.778  73  179  
ECONT    0.773  73  181  
ECONT    0.60   73  181
```

195Pt input

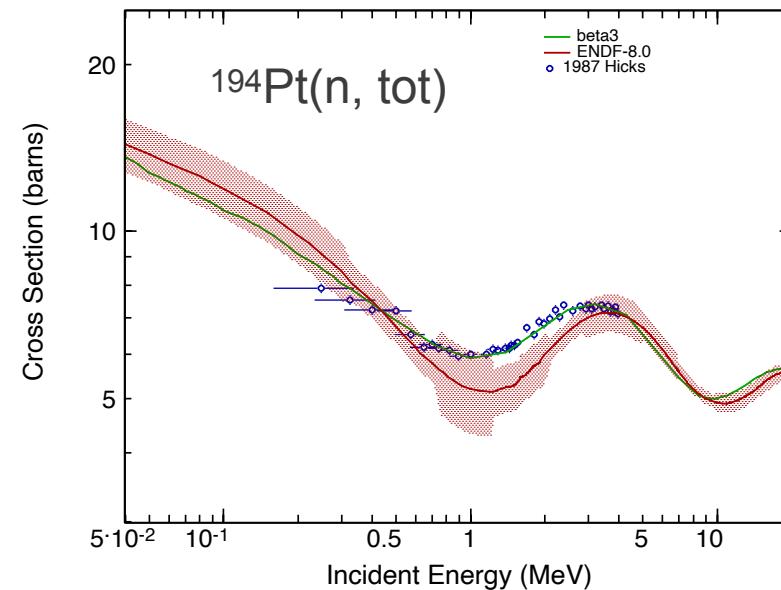
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0.001          ; INCIDENT ENERGY (MeV IN LAB)  
195.0 78.0    ;TARGET A, Z  
1     0        ;PROJECTILE A, Z  
3           ;NUMBER OF NEUTRONS TO BE EMITTED  
2           ;NUMBER OF PROTONS TO BE EMITTED  
1           ;NUMBER OF ALPHAS TO BE EMITTED  
1           ;NUMBER OF DEUTERONS TO BE EMITTED  
1           ;NUMBER OF TRITONS TO BE EMITTED  
1           ;NUMBER OF He-3 TO BE EMITTED  
0 0. 0.       ;reserved  
*****  
EXCLUS   0.    77 194  
EXCLUS   0.    75 190  
>  
PESPPFA  0.14 ;  
GO  
0.002  
0.005  
0.007  
0.01  
0.02  
0.05  
0.07  
...  
;
```

OM - Total cross sections

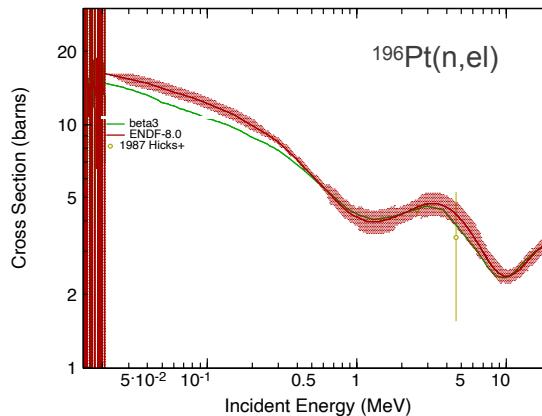
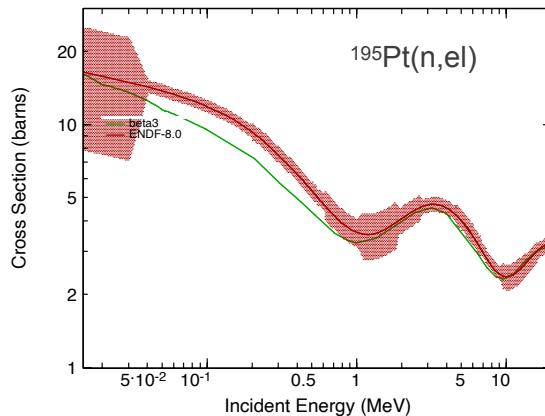
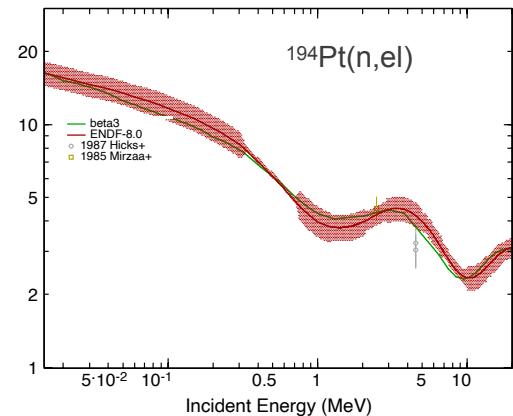
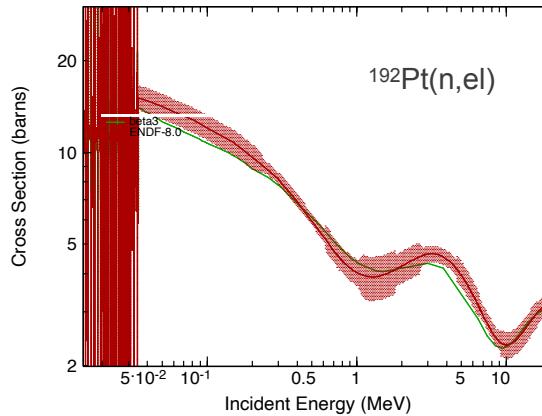
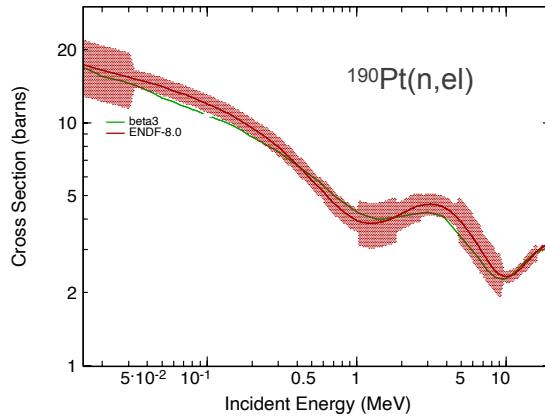
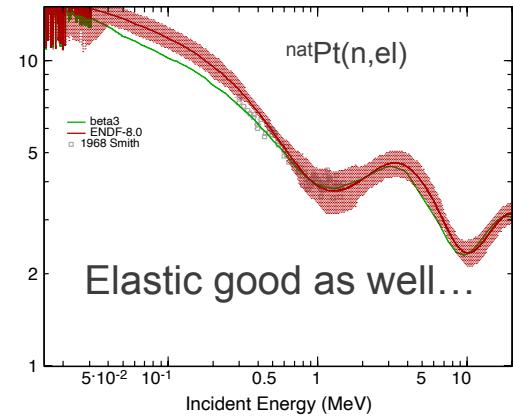
Essential improvement with 1483
CC potential



... confirmed in ^{194}Pt case

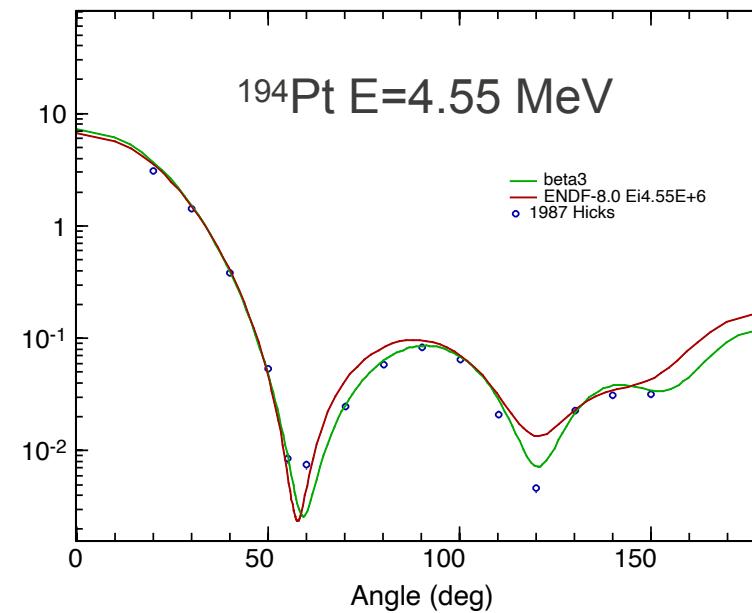
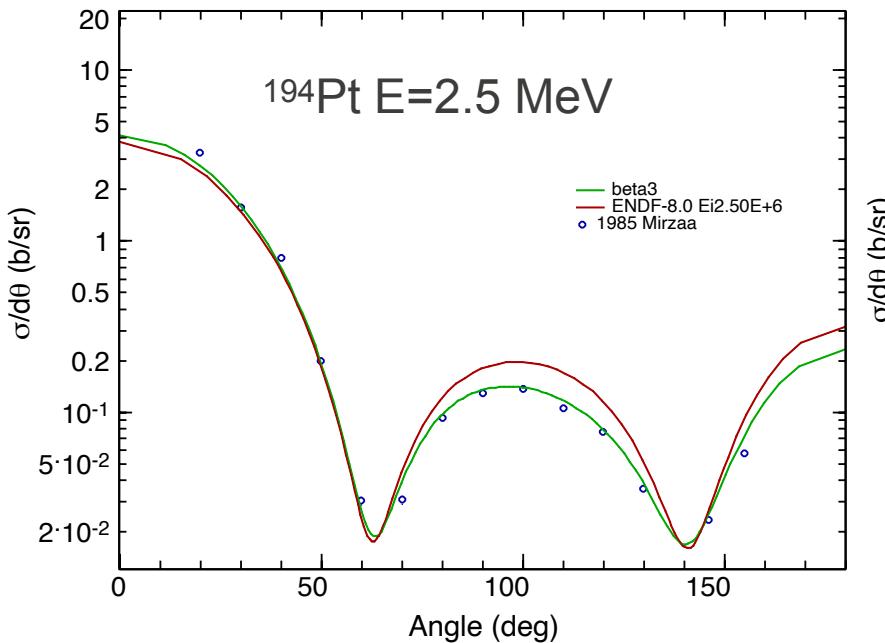


OM - Elastic cross sections

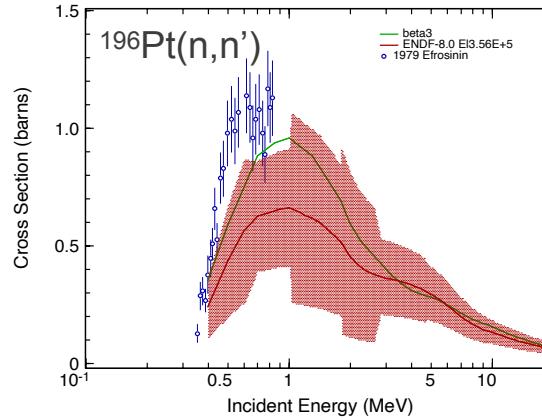
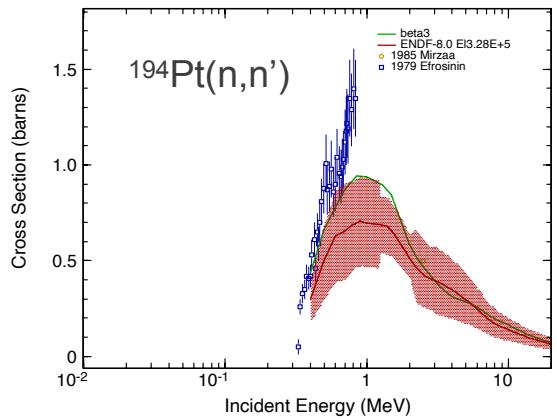


OM - Elastic angular distributions (Pt194)

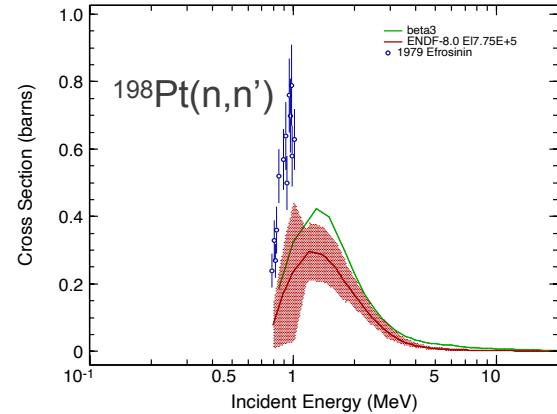
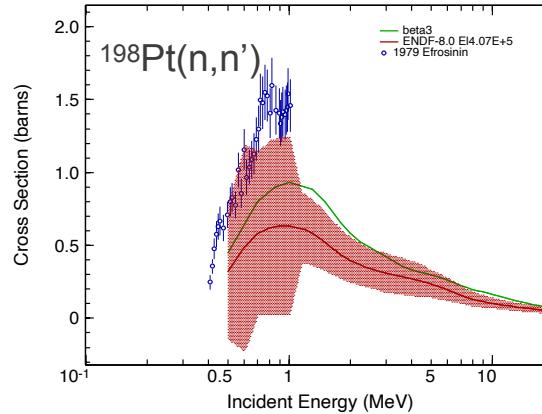
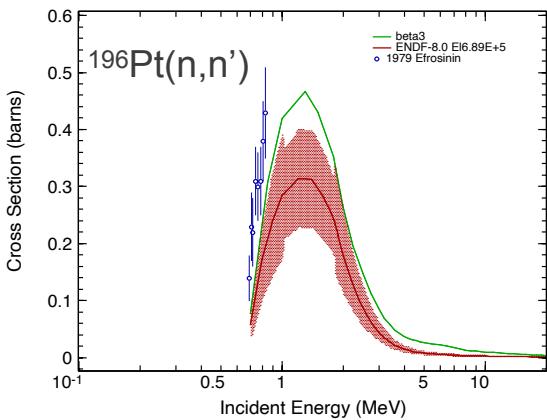
Excellent agreement for elastic angular distributions



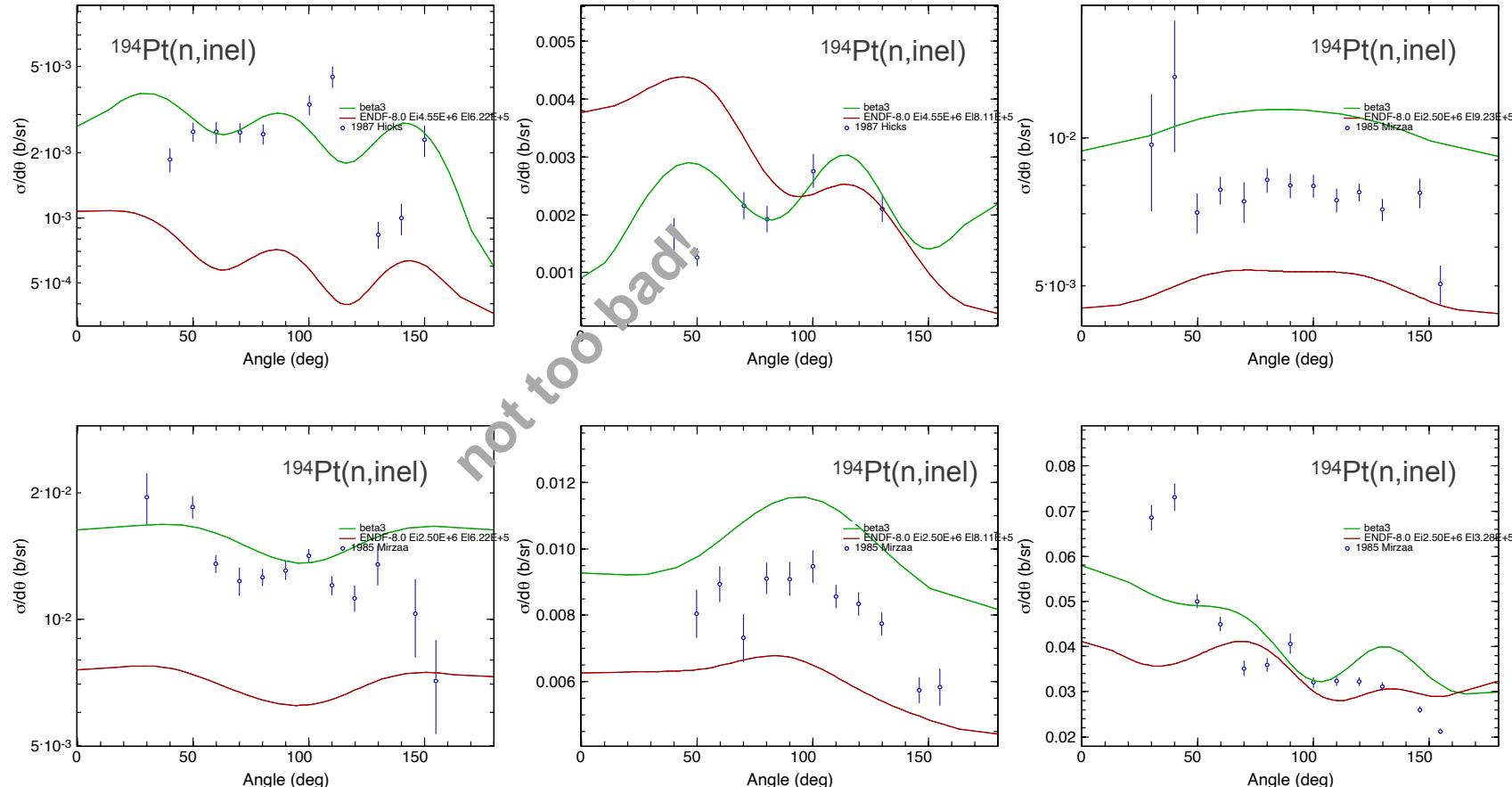
OM+PREQ+CN - inelastic cross sections



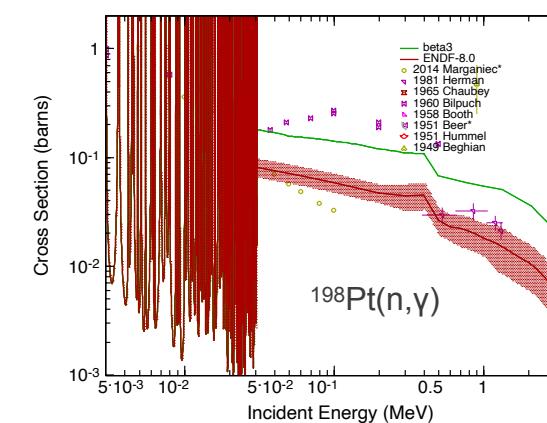
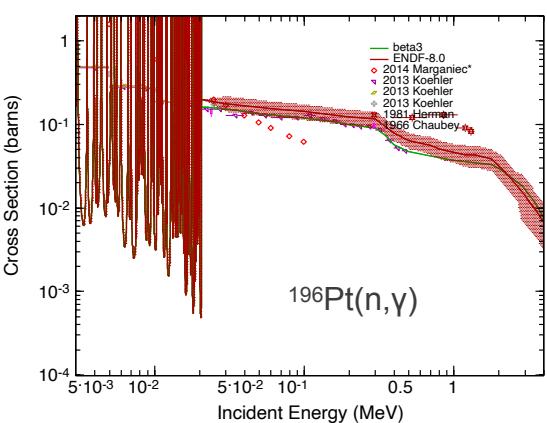
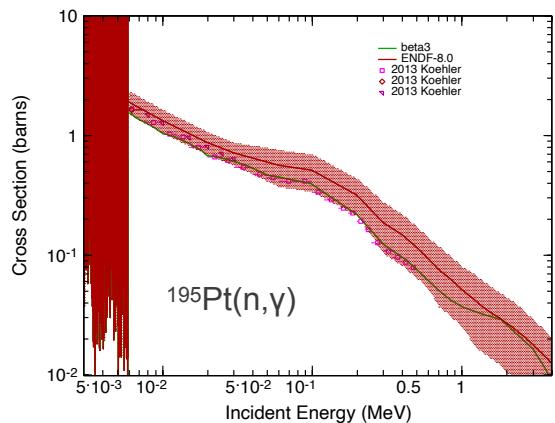
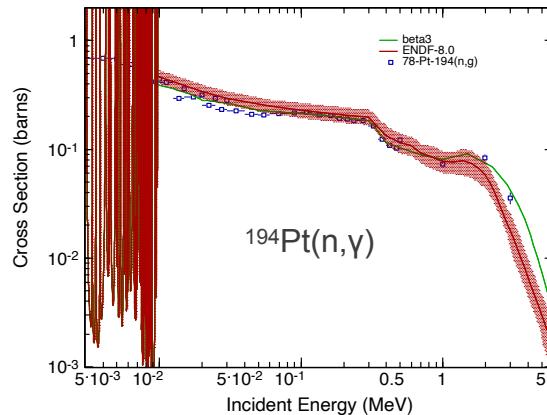
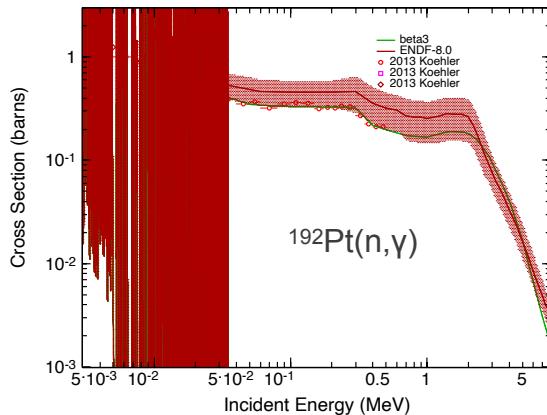
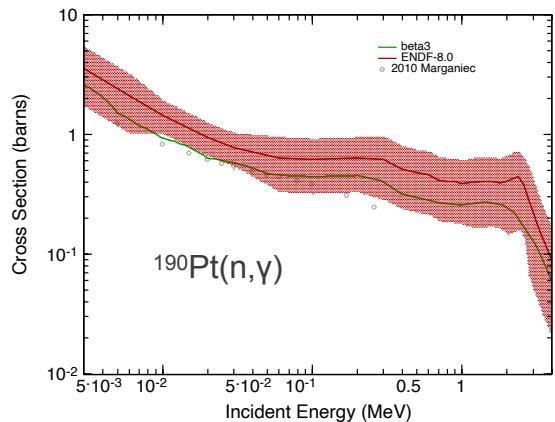
Inelastics considerably higher than VIII.0 although still below exp. data



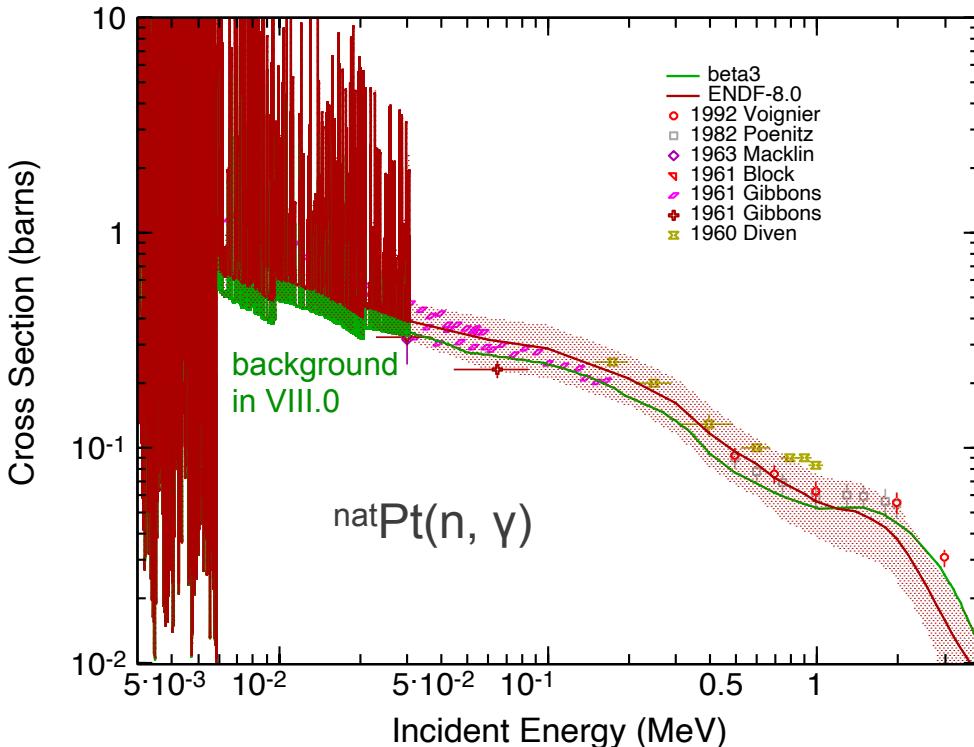
OM+HF - Inelastic angular distributions



CN - capture cross sections



CN - capture cross sections



Gamma strength adjustment

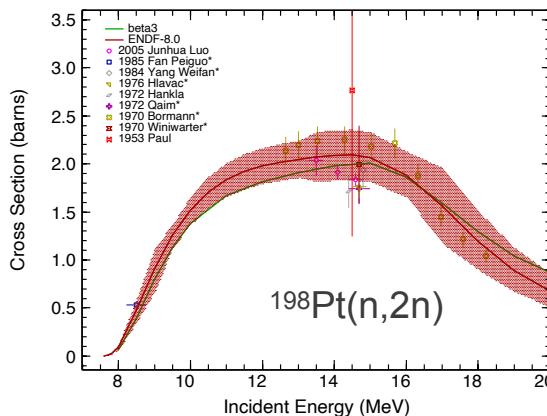
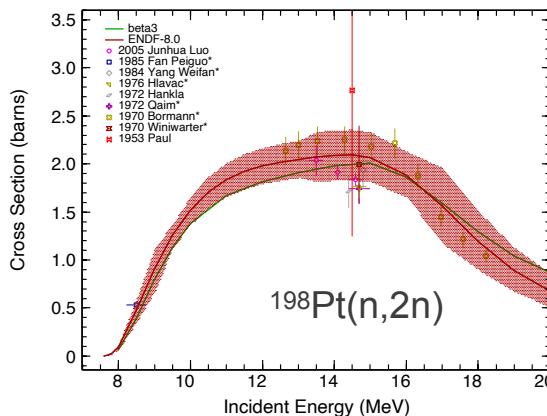
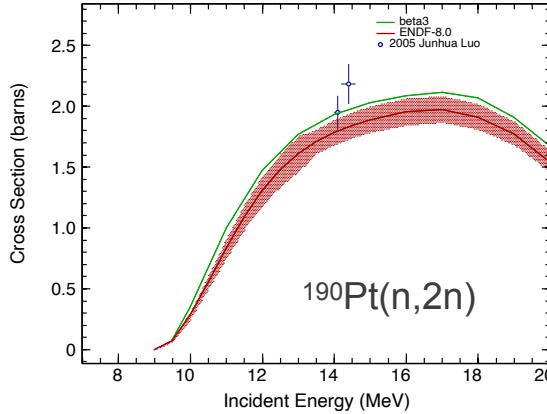
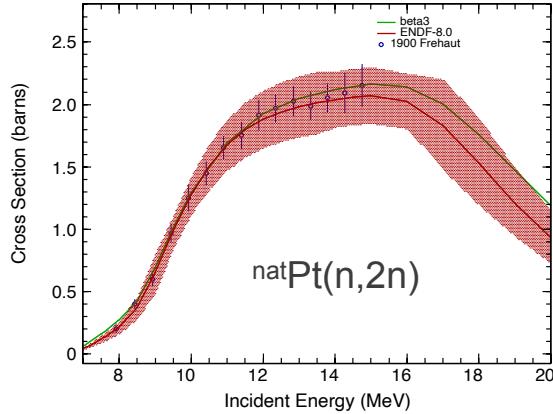
| Target | CN | Default | Adjust |
|--------|-------|---------|--------|
| 190 | 191Pt | 2.159 | 1.20 |
| 191 | 192Pt | 1.352 | |
| 192 | 193Pt | 1.657 | 1.11 |
| 193 | 194Pt | 1.080 | |
| 194 | 195Pt | 1.379 | 0.93 |
| 195 | 196Pt | 1.557 | 1.03 |
| 196 | 197Pt | 1.326 | 1.045 |
| 197 | 198Pt | 2.152 | |
| 198 | 199Pt | 3.145 | (1.57) |

Capture scaled to reproduce P. Kohler isotopic data. Generally lower than VIII.0 therefore...

...elemental capture calculated about 5% too low (still shape is very good!).

Waiting for LANCE results...

PREQ+CN - ($n,2n$) reaction cross sections

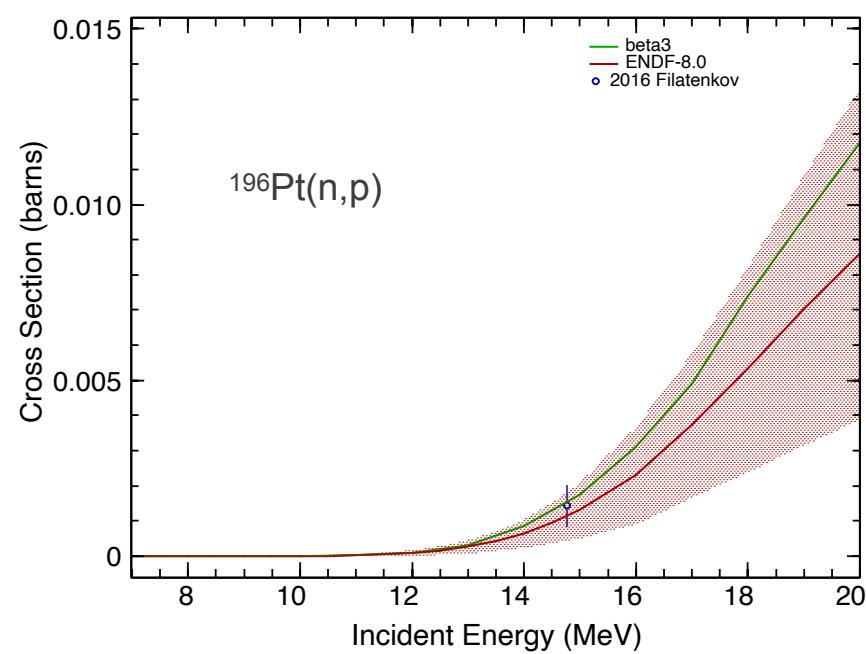
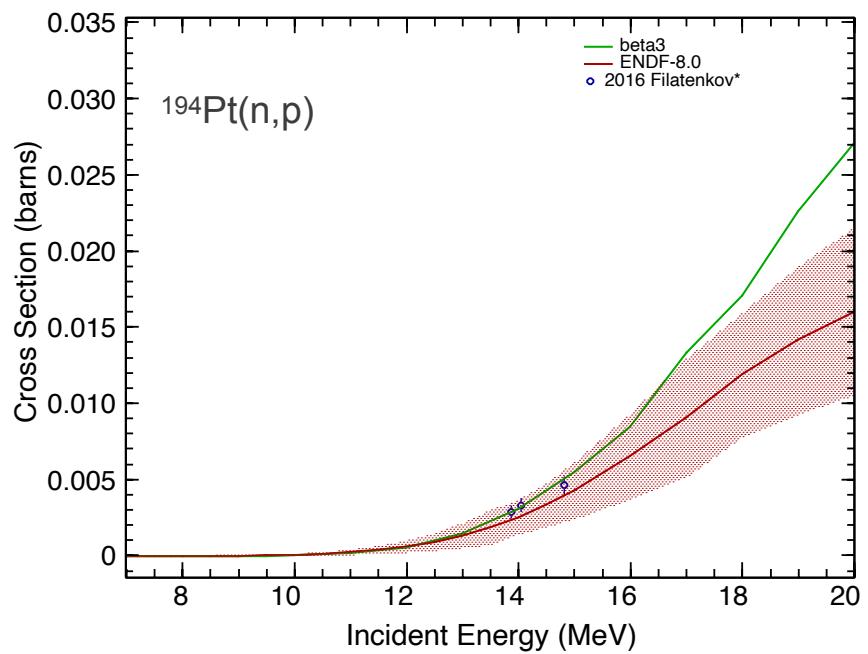


Elemental ($n,2n$) very good.

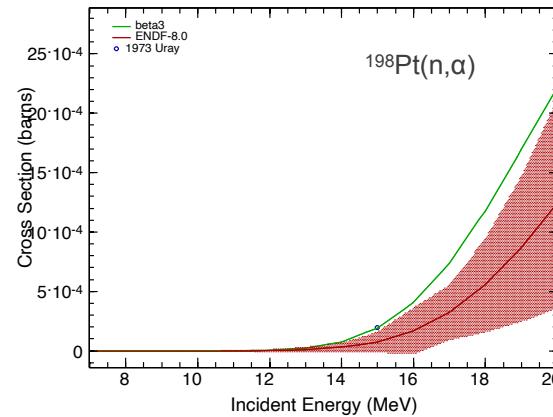
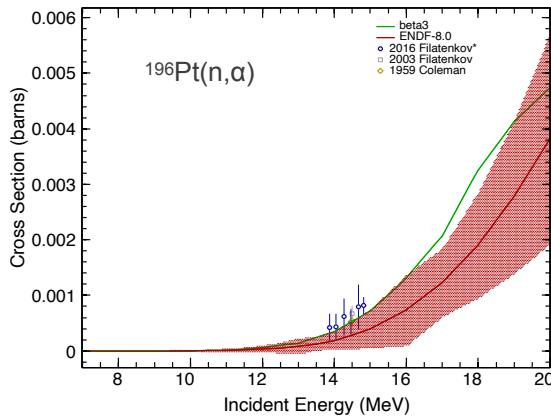
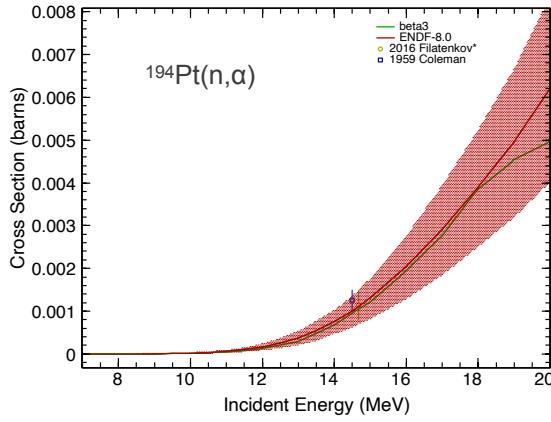
Borman data for ^{198}Pt given lower priority with respect to newer experiments.

EXCEPTION! Gilbert-Cameron level density used for Pt198 - the only one inconsistency.

PREQ+CN - (n,p) reaction cross sections

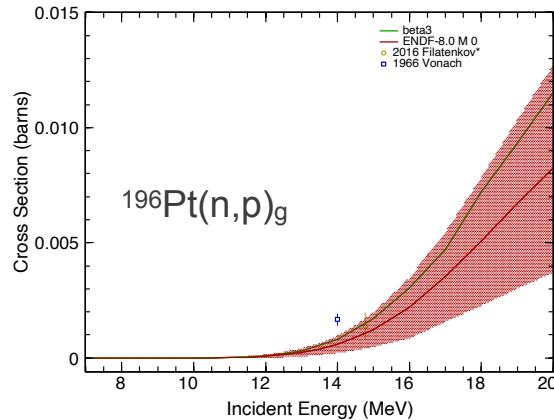
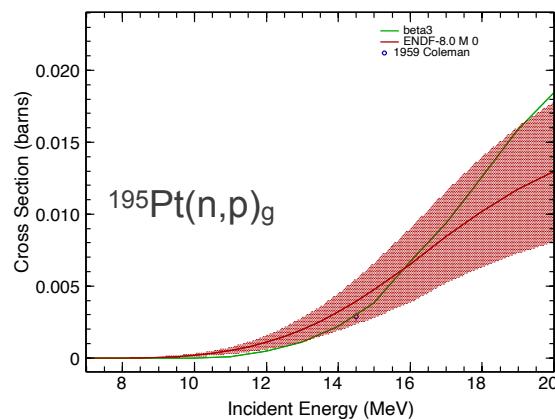
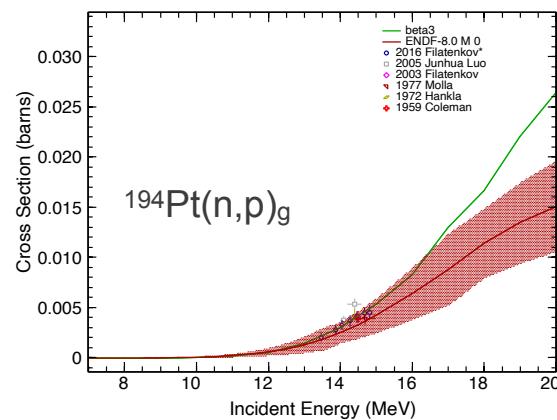
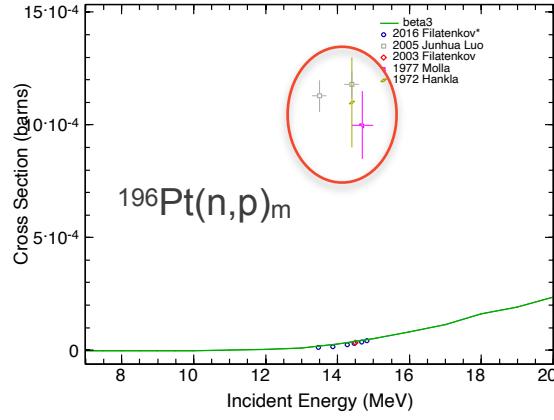
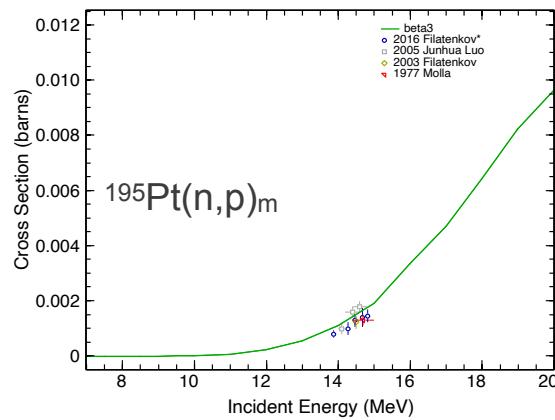
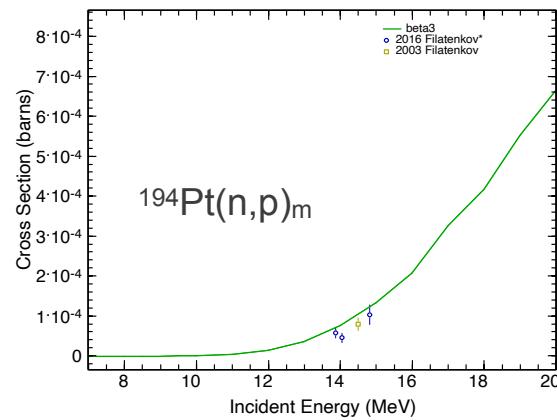


PREQ+CN - (n,α) cross sections

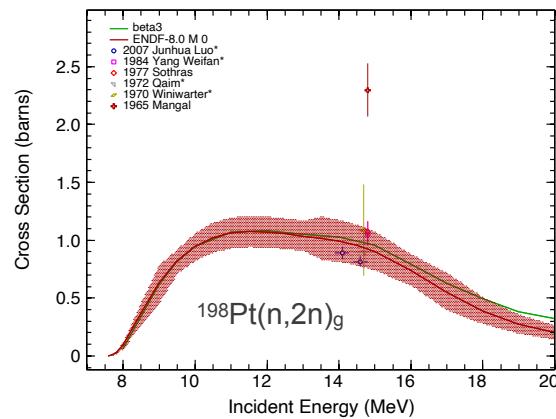
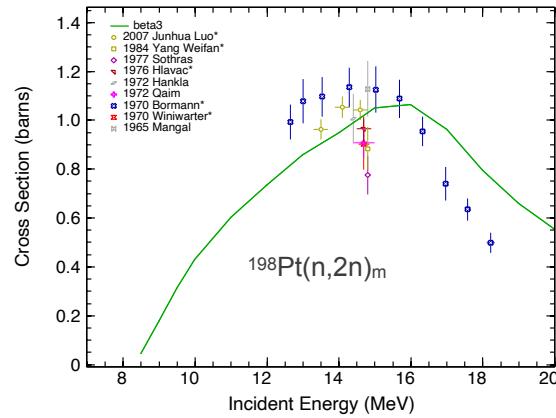


A bit more of gas

PREQ+CN - isomeric cross sections



PREQ+CN - isomeric cross sections (cont.)



No meta cross sections in VIII.0

Ground-state cross sections agree within VIII.0 uncertainties

(n,p) isomeric cross sections point to possible modification in p-h spin distribution

Need to substantially narrow PE spin distribution

0.12 for Pt194(n,p)
0.14 for Pt195(n,p)
0.04 for Pt196(n,p)

Factors (f) being part of the formula $\sigma^2 = f^* n^* A^{1/3}$

Conclusions

- Fast neutron evaluations for 9 Pt isotopes, merged with VIII.0 resonance region, uploaded to NNDC Git repository
 - General improvement over VIII.0, mostly due to the superior OM in the incident channel
 - Consistent model parametrization across the whole chain of isotopes (with a single exception :(
 - Reproducibility of the evaluation
-
- Sensitivities for all 9 isotopes calculated but covariances need to be done
 - Possibility of cross-reaction and cross-isotope correlations