The Influence of Nuclear Structure on Statistical Decay Properties

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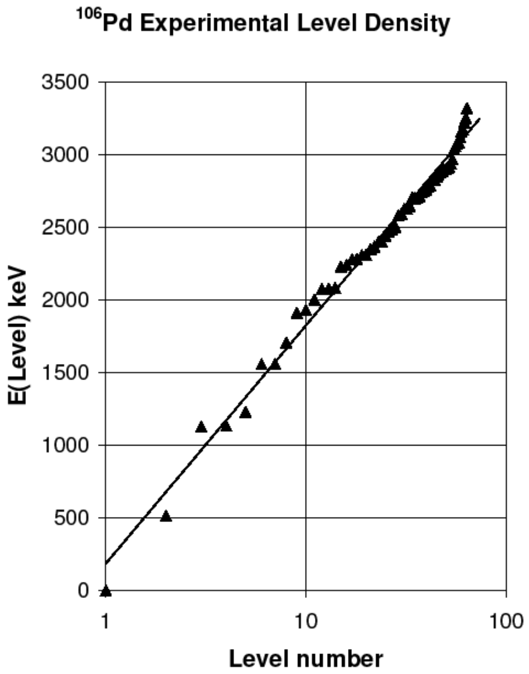
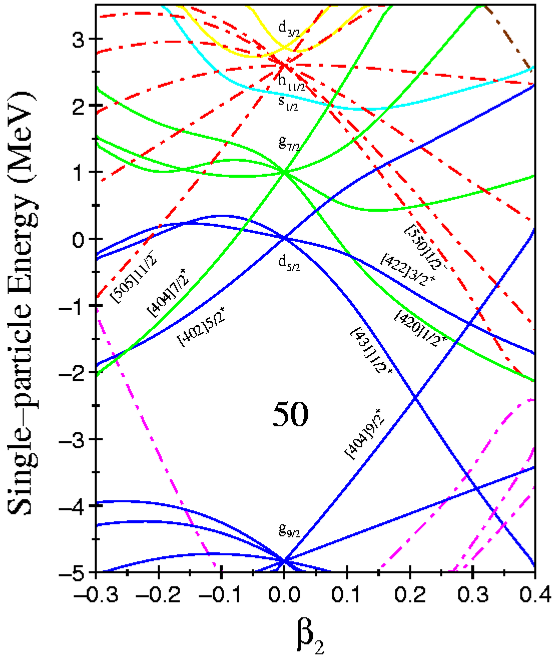




2nd Workshop on Level Density and Gamma Strength

Oslo, May 11 - 15, 2009

Introduction

New thermal neutron capture γ-ray cross section measurements (σ_γ) have been performed at the Budapest Reactor.

- Evaluated Gamma-ray Activation File (EGAF)
- Statistical model calculations with DICEBOX and COSMO to determine σ_0 and J^π values
- Search for nuclear structure (K) dependence.

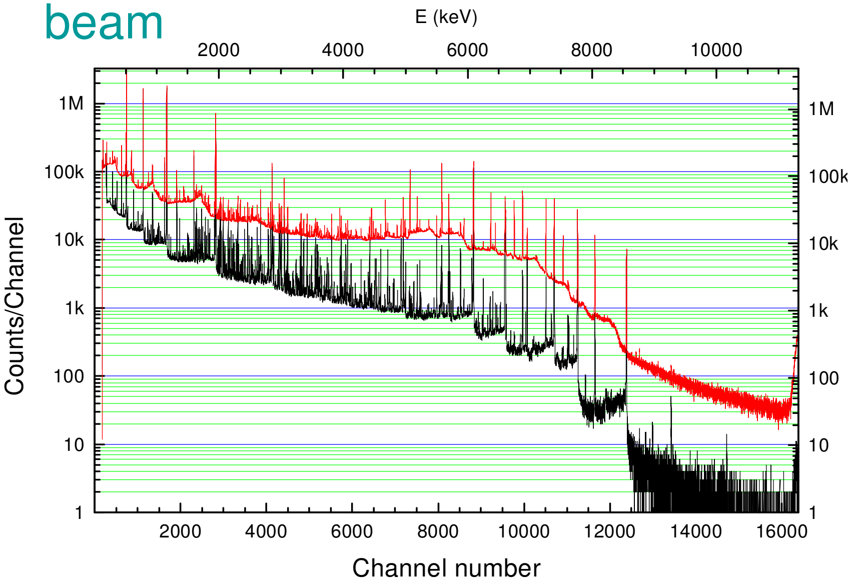
Previous unpublished nuclear beta decay strength function measurements for $^{117\text{-}124}$Cs will be discussed.

- LBNL Total Absorption Spectrometer
- Nuclear structure dependence of the beta decay strength

EGAF (n,γ) Database

Thermal neutron γ-ray cross sections were measured for all elemental targets (Z=1,3-60,62-83, 92) at the Budapest Reactor*.

Neutron beam



Thermal beam – 2×10⁶ n·s⁻¹cm⁻²
Cold beam – 5×10⁷ n·s⁻¹cm⁻²

Compton suppression lows background by a factor of ~5@1332 to ~40 at 7 MeV.

* Collaborators: G.L. Molnar†, Zs. Revay, T. Belgya

† Deceased

Internal Calibration of (n,γ) data

- Stoichiometric compounds containing elements with well-known cross sections

  H, N, Cl, S, Na, Ti, Au

  e.g. KCl, $(CH_2)_n$, $Pb(NO_3)_2$, Tl_2SO_4
- Homogenous mixtures

  Aqueous (H_2O) or acid (20% HCl) solutions, mixed powders (TiO_2)
- Cross section of activation products

  ^{19}F, ^{28}Al, ^{100}Tc, ^{235}U

Cross section σ_γ precision of <1% for strong transitions.
First reliable database of σ_γ from thermal neutron capture

EGAF Database

The Evaluated Gamma-ray Activation File (**EGAF**) was compiled as an IAEA Coordinated Research Project . **EGAF** contains >13,000 γ-ray cross sections (σ_γ) from 79 elements.

EGAF thermal (n,γ) Publications:

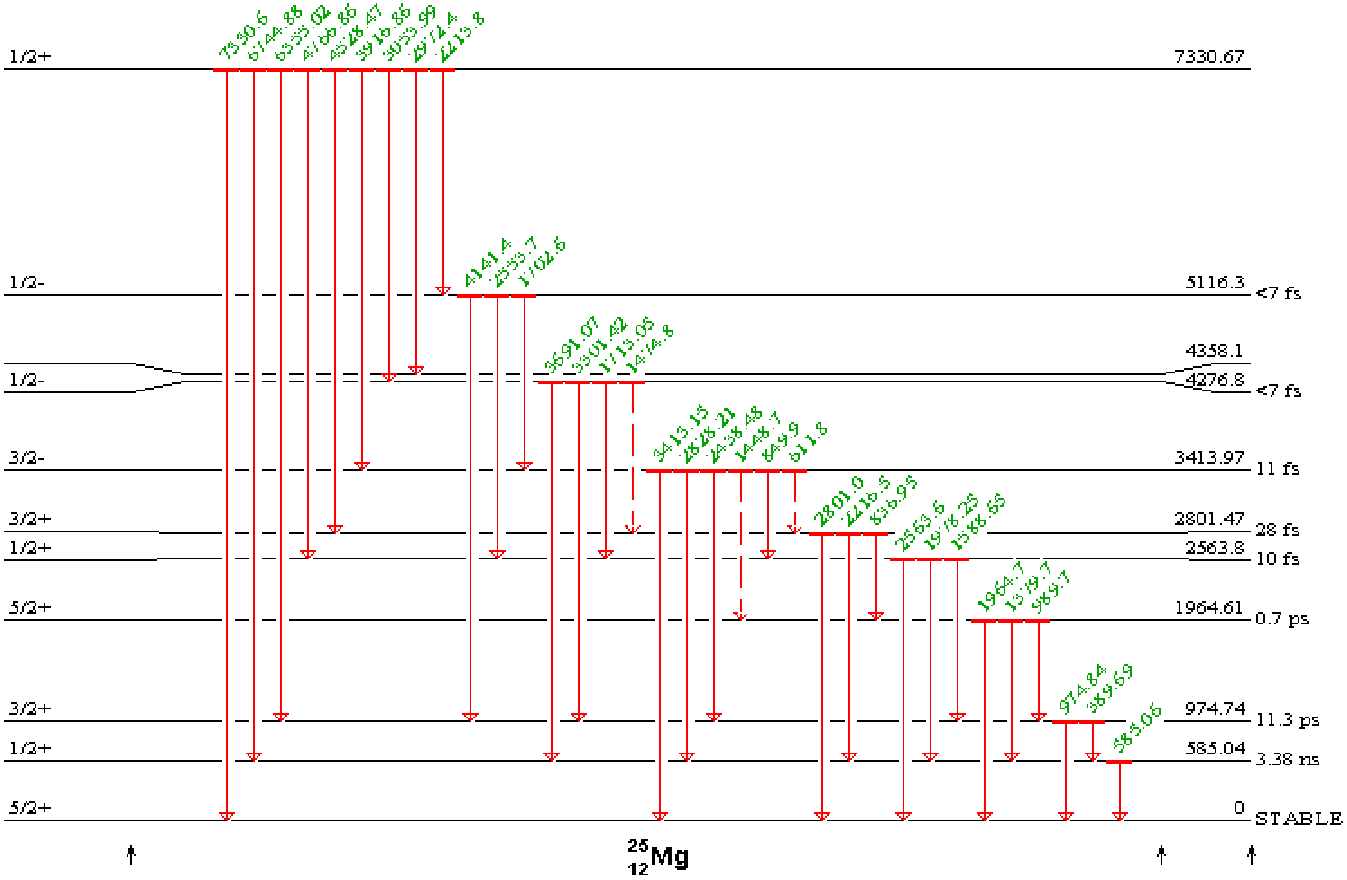
Database of Prompt Gamma Rays from Slow Neutron Capture for Elemental Analysis, R.B. Firestone, H.D. Choi, R.M. Lindstrom, G.L. Molnar, S.F. Mughabghab, R. Paviotti-Corcuera, Zs. Revay, V. Zerkin, and C.M. Zhou, IAEA STI/PUB/1263, 251 pp (2007); on-line at http://www-pub.iaea.org/MTCD/publications/PubDetails.asp?pubId=7030.

Handbook of Prompt Gamma Activation Analysis with Neutron Beams, Zs. Revay, T. Belgya, R.M. Lindstrom, Ch. Yonezawa, D.L. Anderson, Zs. Kasztovsky, and R.B. Firestone, edited by G.L. Molnar (Kluwer Publishers, 2004).

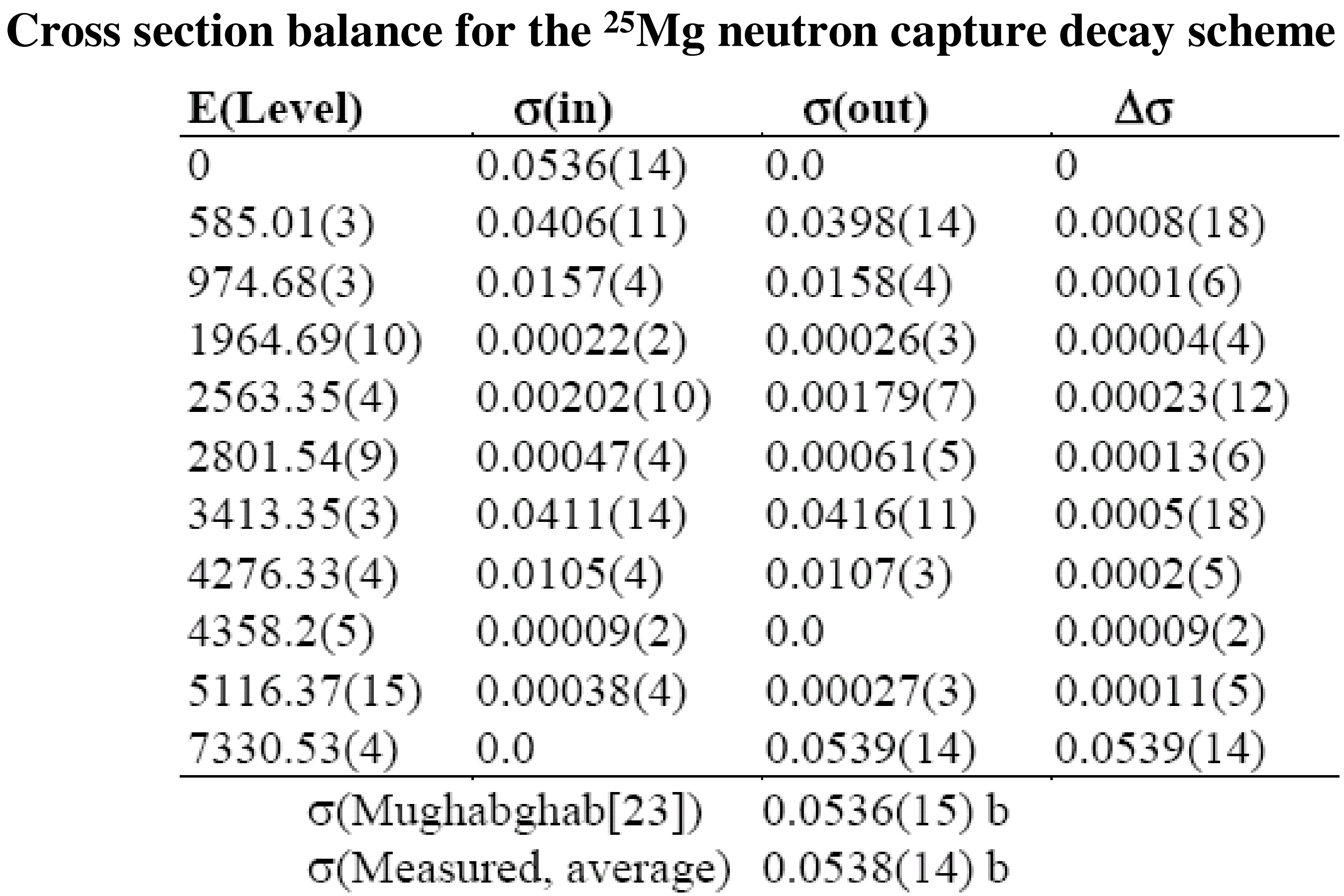
Low-Z σ_0 Cross Sections

The decay schemes of low-Z isotopes are complete. Total thermal radiative neutron cross sections are calculated by

$$\sigma_0=\Sigma\sigma_{\gamma+e}(GS)=\Sigma\sigma_{\gamma+e}(CS)$$



Cross section balance for ^{24}Mg(n,γ)^{25}Mg



Cross section balance for the ^{25}Mg neutron capture decay scheme

E(Level)	σ(in)	σ(out)	$\Delta\sigma$
0	0.0536(14)	0.0	0
585.01(3)	0.0406(11)	0.0398(14)	0.0008(18)
974.68(3)	0.0157(4)	0.0158(4)	0.0001(6)
1964.69(10)	0.00022(2)	0.00026(3)	0.00004(4)
2563.35(4)	0.00202(10)	0.00179(7)	0.00023(12)
2801.54(9)	0.00047(4)	0.00061(5)	0.00013(6)
3413.35(3)	0.0411(14)	0.0416(11)	0.0005(18)
4276.33(4)	0.0105(4)	0.0107(3)	0.0002(5)
4358.2(5)	0.00009(2)	0.0	0.00009(2)
5116.37(15)	0.00038(4)	0.00027(3)	0.00011(5)
7330.53(4)	0.0	0.0539(14)	0.0539(14)
	σ(Mughabghab[23])	0.0536(15) b	
	σ(Measured, average)	0.0538(14) b	

High-Z Cross Sections

For Z≥20 measured neutron capture γ-ray decay schemes are generally incomplete due to unresolved continuum γ-rays.

σ_0=21.0±1.5 b (Mughabghab)

σ_γ(primary γ-rays)=0.55 b

σ_γ(secondary γ-rays)=20.26 b

^{105}Pd(n,γ)^{106}Pd cross section level feedings calculated from EGAF data.

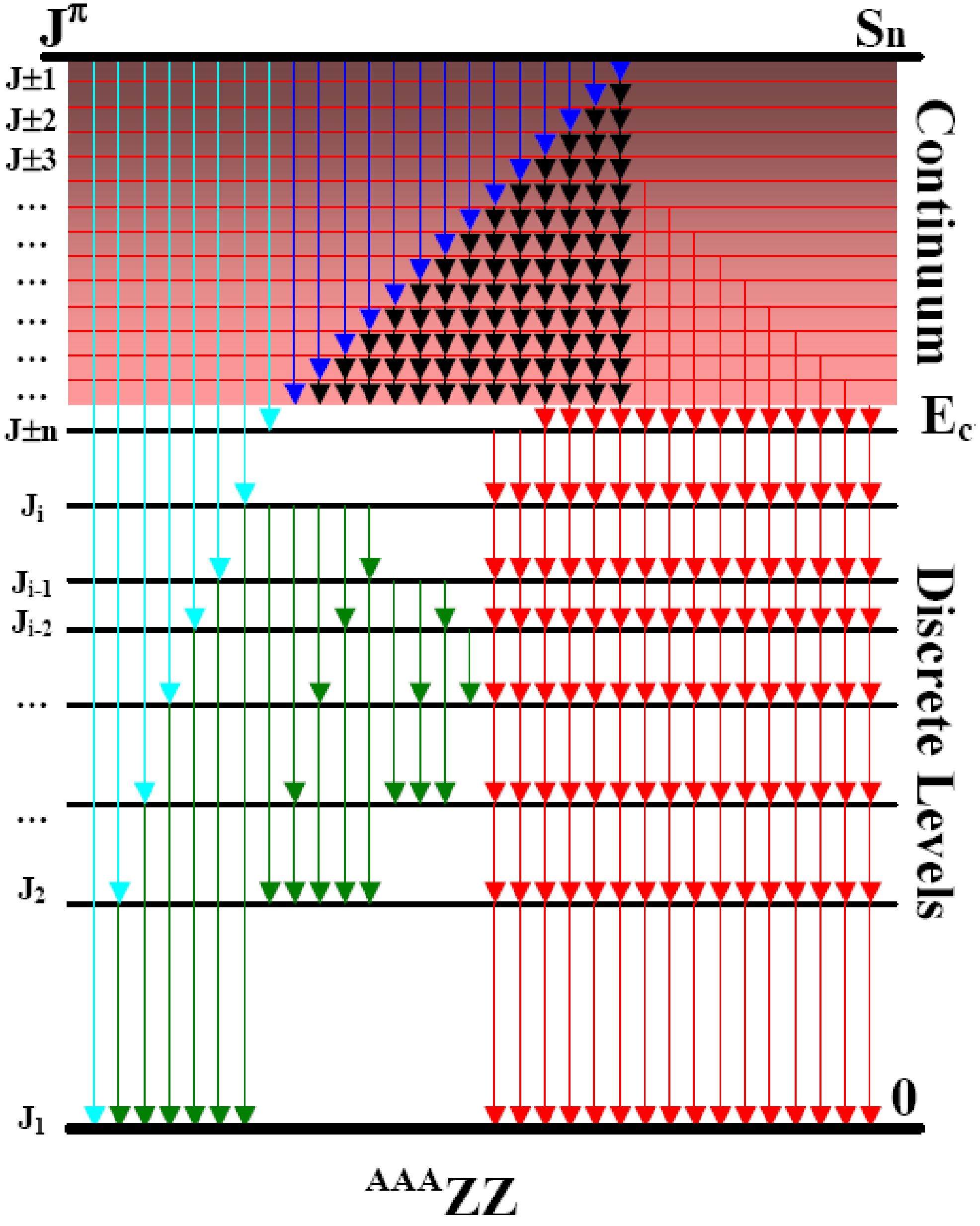
^{105}Pd(n,γ)^{106}Pd Level Feedings

E(level)	J^π	$\Sigma\sigma_\gamma$(in)	$\Sigma\sigma_\gamma$(out)	$\Delta\Sigma\sigma$
0	0+	20.26		
511.844	2+	13.88	17.91	4.03
1128.04	2+	2.371	4.263	1.892
1133.79	0+	0.227	0.565	0.338
1229.2	4+	1.630	3.479	1.849
1557.67	3+	1.183	2.142	0.959
1562.16	2+	0.312	1.869	1.557
1706.44	0+	0.012	0.193	0.181
1909.39	2+	0.063	0.724	0.661
1932.37	4+	0.217	0.590	0.373
2001.56	0+	0.029	0.118	0.089
2077.1	6+	0.001	0.103	0.102
2077.37	(4)+	0.057	0.440	0.383
2084.39	-3	0.123	1.033	0.910
2242.4	2+	0.026	0.499	0.473
2278.47	0+	0	0.056	0.056
2282.89	4+	0.0007	0.275	0.274
2306.01	-3	0.053	0.542	0.489
2308.73	2+	0.000	0.283	0.283
2350.96	4+	0.018	0.304	0.286
2366.09	5+	0.003	0.116	0.114
2397.37	(5)-	0.055	0.263	0.209
2401	(2-,3-)	0.037	0.300	0.263
2439.11	2+	0.065	0.293	0.227
2472.09	0+	0.000	0.055	0.055
2484.76	(1-)	0.043	0.253	0.211
2500.01	-2	0.028	0.296	0.267
2578.64	(4-)	0.00004	0.221	0.221
…	…	…	…	…
…	…	…	…	…
9561.4	2+,3+		0.554	

Statistical Model Calculations

The (n,γ) continuum feeding is completely statistical and can be calculated if

1. σ_γ deexciting levels below a cutoff energy E_{crit} is complete.
2. Primary σ_γ populating the levels below E_{crit} from the capture state is complete.
3. J^π of levels below E_{crit} are well known.
4. Level density above E_{crit} is statistically distributed.
5. Photon strength deexciting levels above E_{crit} is statistically distributed.



DICEBOX Calculations

DICEBOX is Monte Carlo code written by F. Becvar and M. Krticka that generates complete simulated neutron capture decay schemes constrained by known nuclear properties and statistical models.

A. Discrete primary and secondary γ-ray data from EGAF

B. J^π data for $E<E_{crit}$ from Reaction Input Parameter Library (RIPL)

C. Level density models

  1. Constant temperature (CT) $\rho(E,J) = \frac{f(J)}{T}\exp(\frac{E-E_0}{T})$
  2. Back-shifted Fermi (BSF) model $\rho(E,J) = f(J)\frac{\exp\left(2\sqrt{a(E-E_1)}\right)}{12\sqrt{2}\sigma_c a^{1/4}(E-E_1)^{5/4}}$

D. El Photon Strength $f_{\mathrm{BA}}^{(E1)}(E_\gamma) = \frac{1}{3(\pi\hbar c)^2}\frac{\sigma_G E_\gamma \Gamma_G^2}{\left(E_\gamma^2-E_G^2\right)^2+E_\gamma^2\Gamma_G^2}$

  1. Brink-Axel (BA)
  2. Kadmenski, Markushev, Furman (KMF) for spherical nuclei
  3. Kopecky *et al* generalized Laurentian (GLO), temperature dep.

E. M1 Photon Strength

  1. Single Particle (SP), *$f^{(E1)}/f^{(M1)}$=5-7 or $f(M1)=1.2\times10^{-8}$ MeV^{-3}*
  2. Spin-Flip (SF), Laurentzian resonance ≈8,5 MeV, GSF ≈ 4 MeV

COSMO Calculations

COSMO: (**CO**ntinuous **S**tatistical **MO**del) – by R.B. Firestone (LBNL, Berkeley)

- Similar statistical model approach as DICEBOX
- The statistical decay scheme is binned above E_{crit}
- Average level densities and photon strengths are assumed for each bin.
- COSMO calculations run faster than DICEBOX on small PCs
- No information on the statistical variation in the calculation is provided

Palladium Calculations

EGAF σ_γ data are available for (n,γ) on all stable palladium targets

^{102,104,105,106,108,110}Pd

Calculations of the statistical σ_γ populating levels <E_{crit} were performed with **DICEBOX** where input model and parameters were selected by

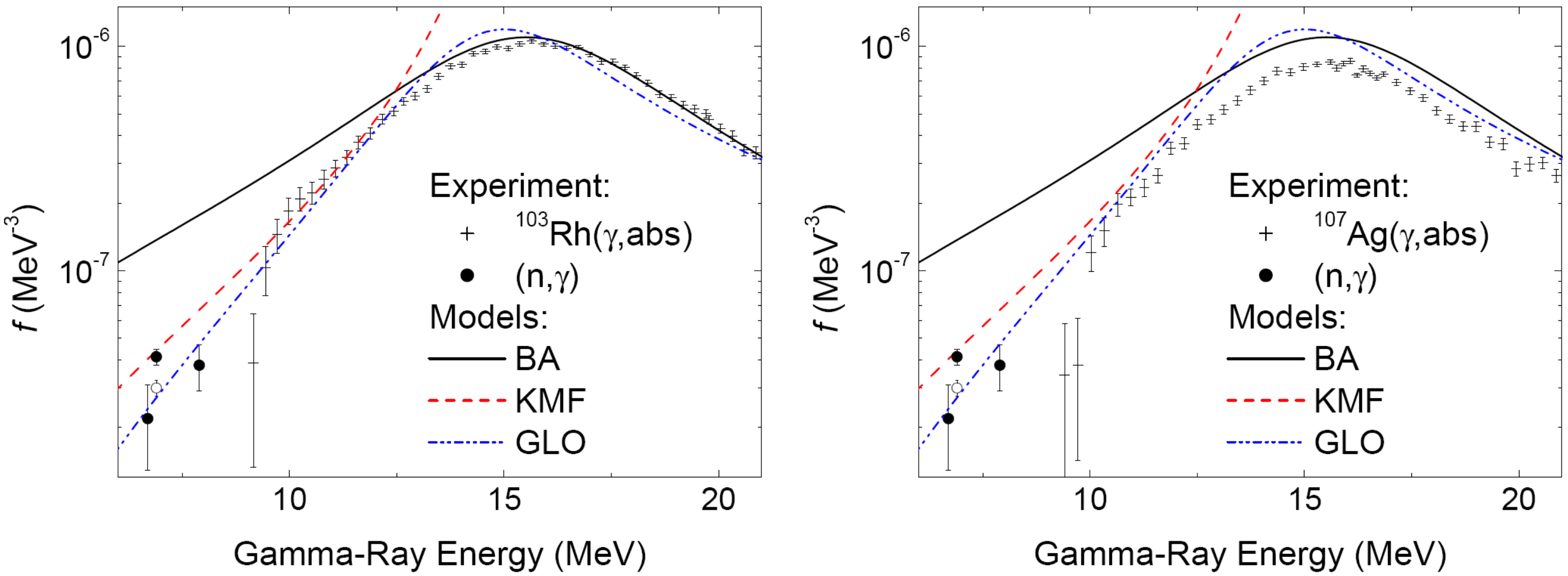
- Comparison of calculated and experimental capture state width
- Comparison of E1 photon strength with photonuclear data from neighboring nuclei
- Dependence on E_{crit} of the result
- Comparison of σ_γ populating/depopulate levels <E_{crit}

Model dependence of the ^{106}Pd capture state width

DICEBOX calculation of the capture state width

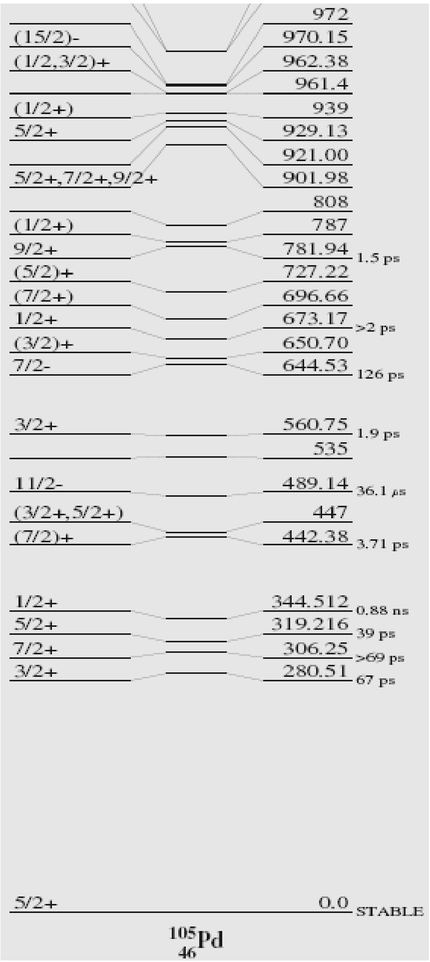
E1-PSF	M1-PSF	$\rho(E,J)$	Γ_{γ}^{tot}
Brink-Axel	Single Particle	Constant Temperature	410±47
Brink-Axel	Spin flip	Constant Temperature	352±42
Kadmenski et al (KMF)	Single Particle	Back-shifted Fermi	201±14
Kadmenski et al (KMF)	Spin flip	Back-shifted Fermi	172±12
Generalized Laurentzian	Single Particle	Back-shifted Fermi	156±8
Generalized Laurentzian	Spin flip	Back-shifted Fermi	126±8
Experiment (Mughabghab)			148±10

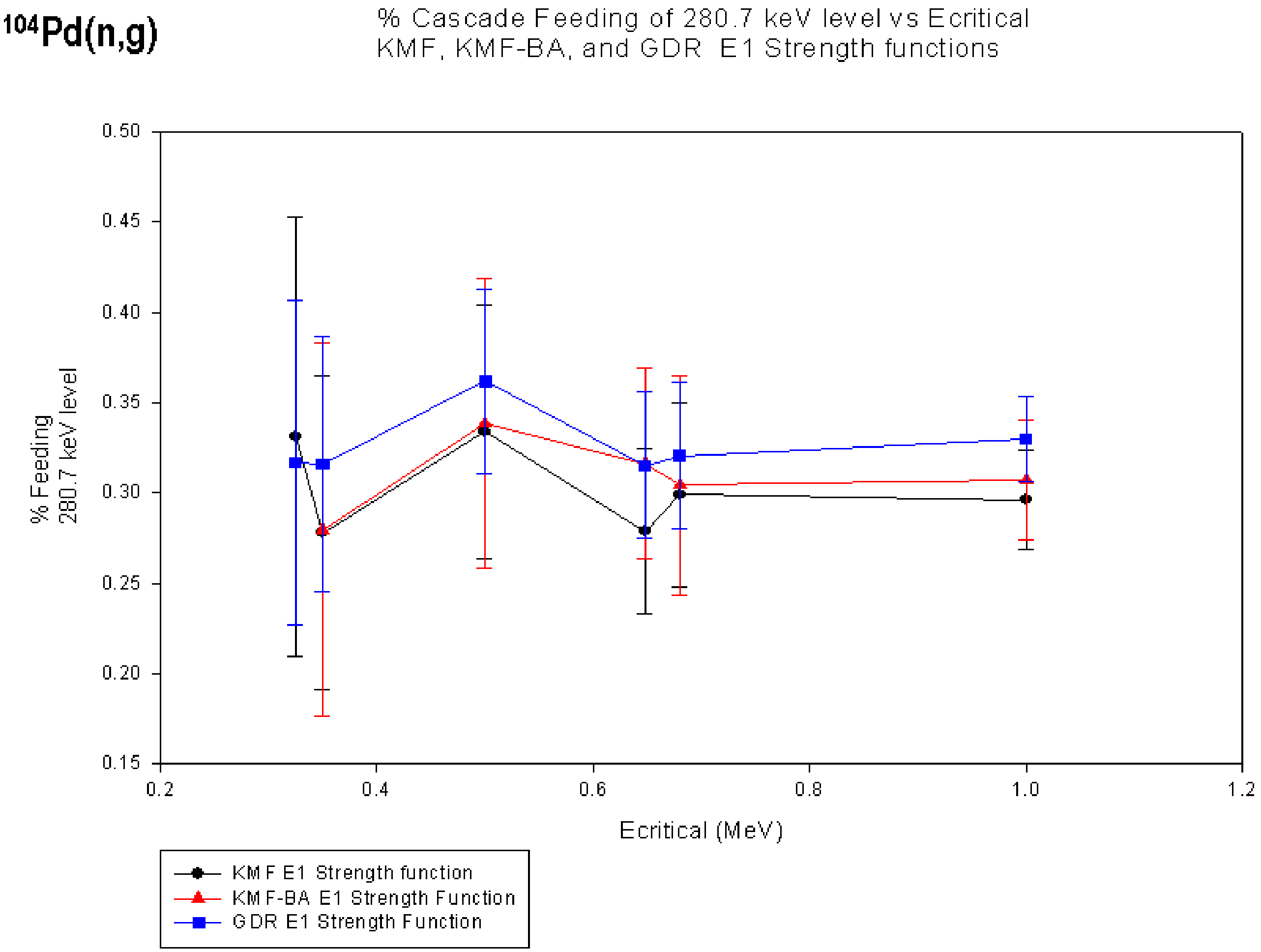
E1 Photon Strength



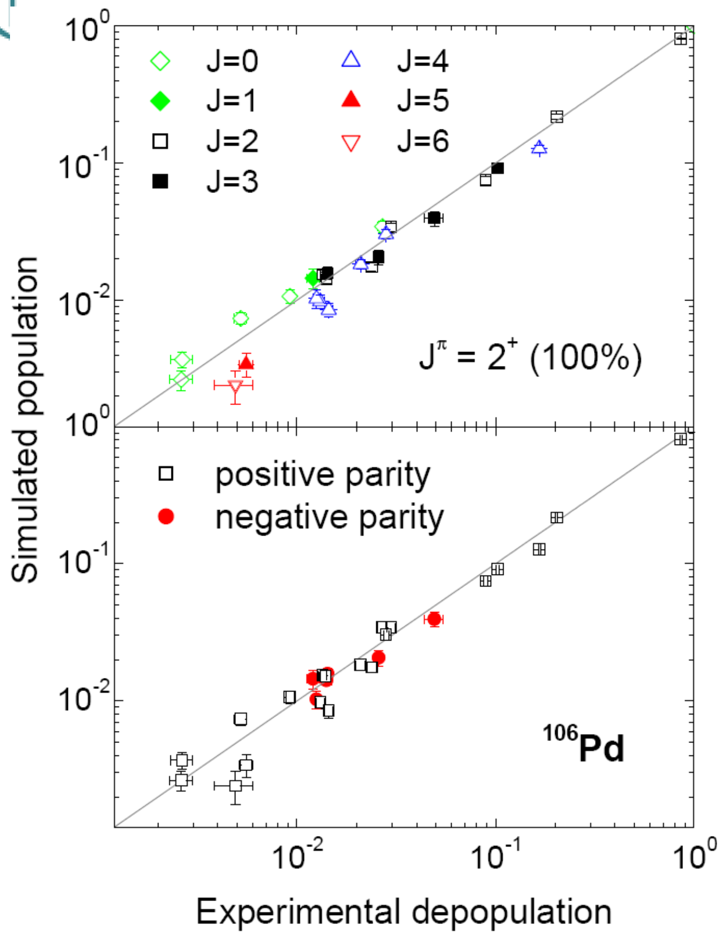
Comparison of E1 photon strength models indicate that KMF and GLO models agree better with than Brink-Axel for ^{103}Rh and ^{107}Ag photonuclear data.

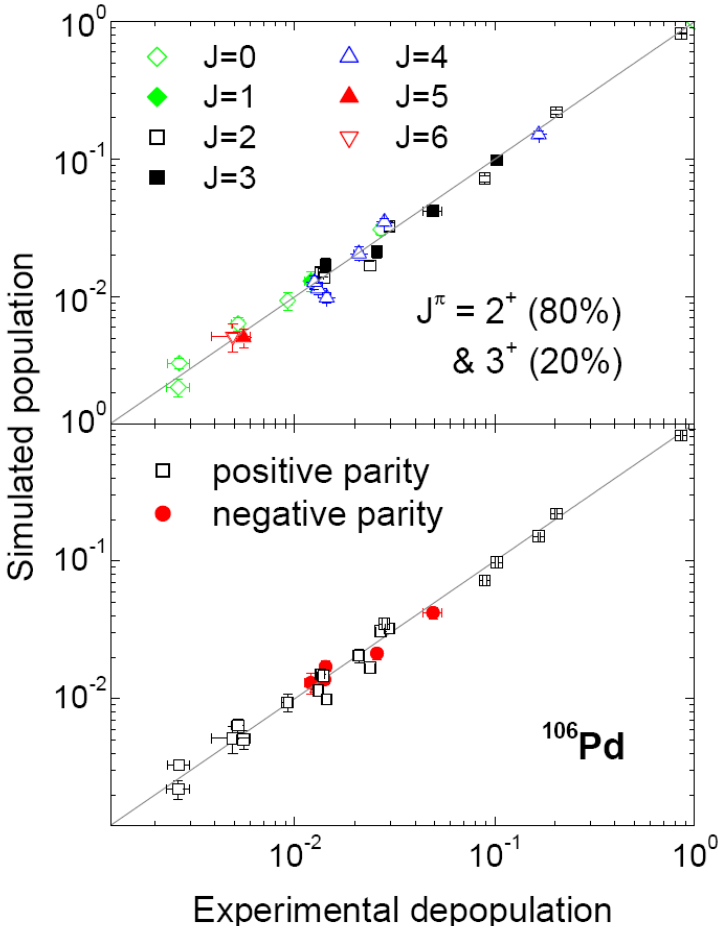
Dependence of the Statistical Feeding on E_{crit}





Population/Depopulation Plot





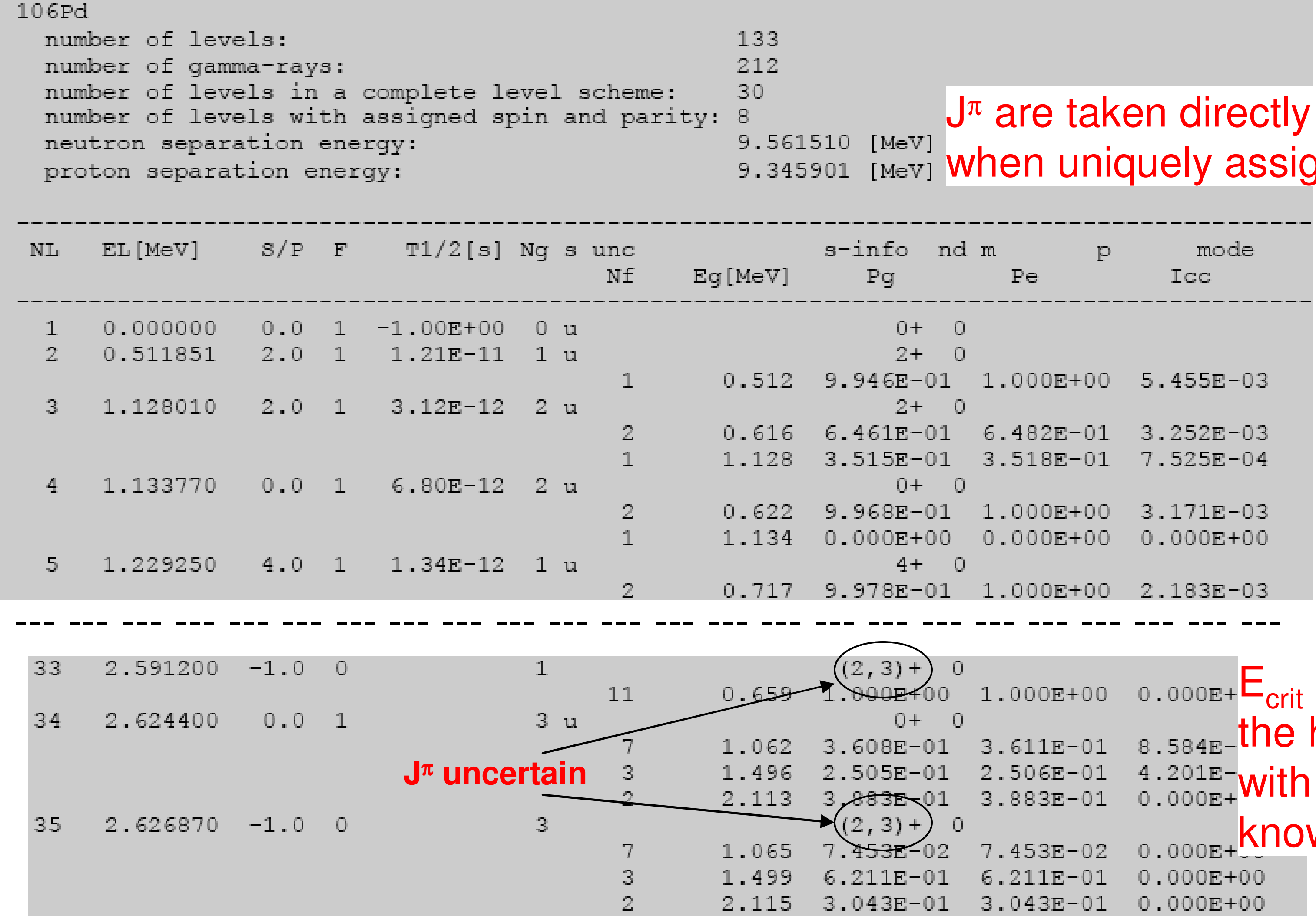
Spin composition of the capture state is determined by a least-squares fit.

$$\sigma_0 = \sigma_\gamma(\mathrm{GS})_{\mathrm{expt}} + \sigma_\gamma(\mathrm{GS})_{\mathrm{Statistical}} = 20.3\pm0.3\ \mathrm{b} + 1.4\pm0.3\ \mathrm{b} = 21.7\pm0.5\ \mathrm{b}$$

$$\sigma_0(\mathrm{Mughabghab}) = 21.0\pm1.5\ \mathrm{b}$$

RIPL Structure Data Library

RIPL input data for ^{106}Pd



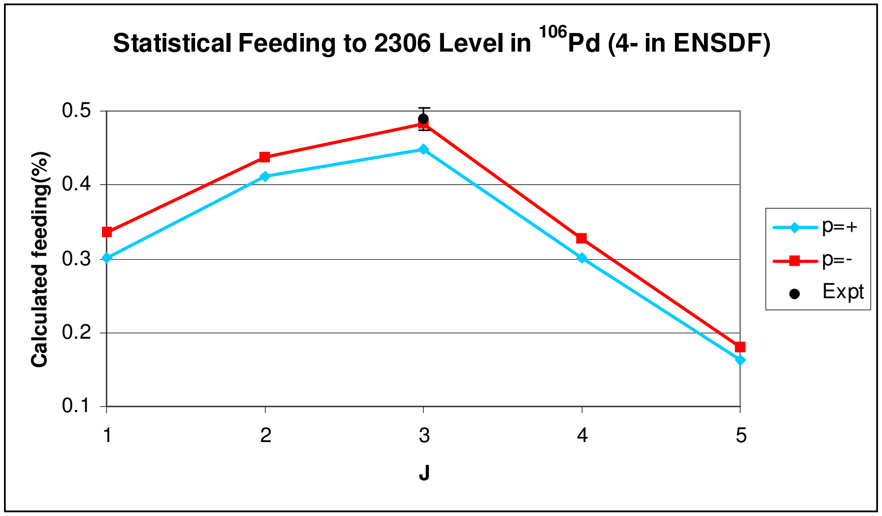
```
106Pd
  number of levels:                                 133
  number of gamma-rays:                             212
  number of levels in a complete level scheme:      30
  number of levels with assigned spin and parity:  8
  neutron separation energy:                        9.561510 [MeV]
  proton separation energy:                         9.345901 [MeV]

------------------------------------------------------------------------------------------
 NL    EL[MeV]      S/P   F      T1/2[s]  Ng  s  unc              s-info   nd  m        p       mode
                                              Nf      Eg[MeV]      Pg           Pe          Icc
------------------------------------------------------------------------------------------
  1    0.000000     0.0   1   -1.00E+00   0  u                     0+   0
  2    0.511851     2.0   1    1.21E-11   1  u                     2+   0
                                               1      0.512   9.946E-01  1.000E+00  5.455E-03
  3    1.128010     2.0   1    3.12E-12   2  u                     2+   0
                                               2      0.616   6.461E-01  6.482E-01  3.252E-03
                                               1      1.128   3.515E-01  3.518E-01  7.525E-04
  4    1.133770     0.0   1    6.80E-12   2  u                     0+   0
                                               2      0.622   9.968E-01  1.000E+00  3.171E-03
                                               1      1.134   0.000E+00  0.000E+00  0.000E+00
  5    1.229250     4.0   1    1.34E-12   1  u                     4+   0
                                               2      0.717   9.978E-01  1.000E+00  2.183E-03
--- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
 33    2.591200    -1.0   0                1                    (2,3)+   0
                                              11      0.659   1.000E+00  1.000E+00  0.000E+
 34    2.624400     0.0   1                3  u                    0+   0
                                               7      1.062   3.608E-01  3.611E-01  8.584E-
                                               3      1.496   2.505E-01  2.506E-01  4.201E-
                                               2      2.113   3.883E-01  3.883E-01  0.000E+
 35    2.626870    -1.0   0                3                    (2,3)+   0
                                               7      1.065   7.453E-02  7.453E-02  0.000E+
                                               3      1.499   6.211E-01  6.211E-01  0.000E+00
                                               2      2.115   3.043E-01  3.043E-01  0.000E+00
```

J^{π} are taken directly from ENSDF when uniquely assigned.

J^{π} uncertain

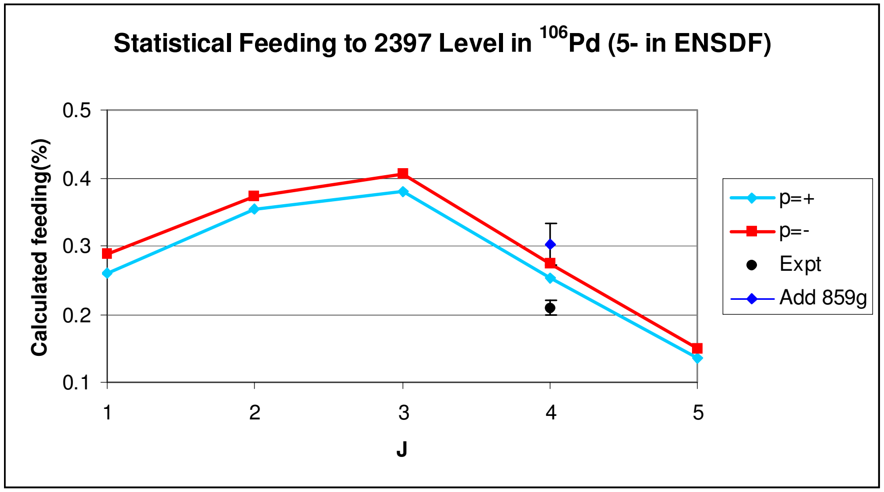
E_{crit} is limited to the highest level with a unique, known J^{π}

RIPL Input Data Problems: J^{π} Errors



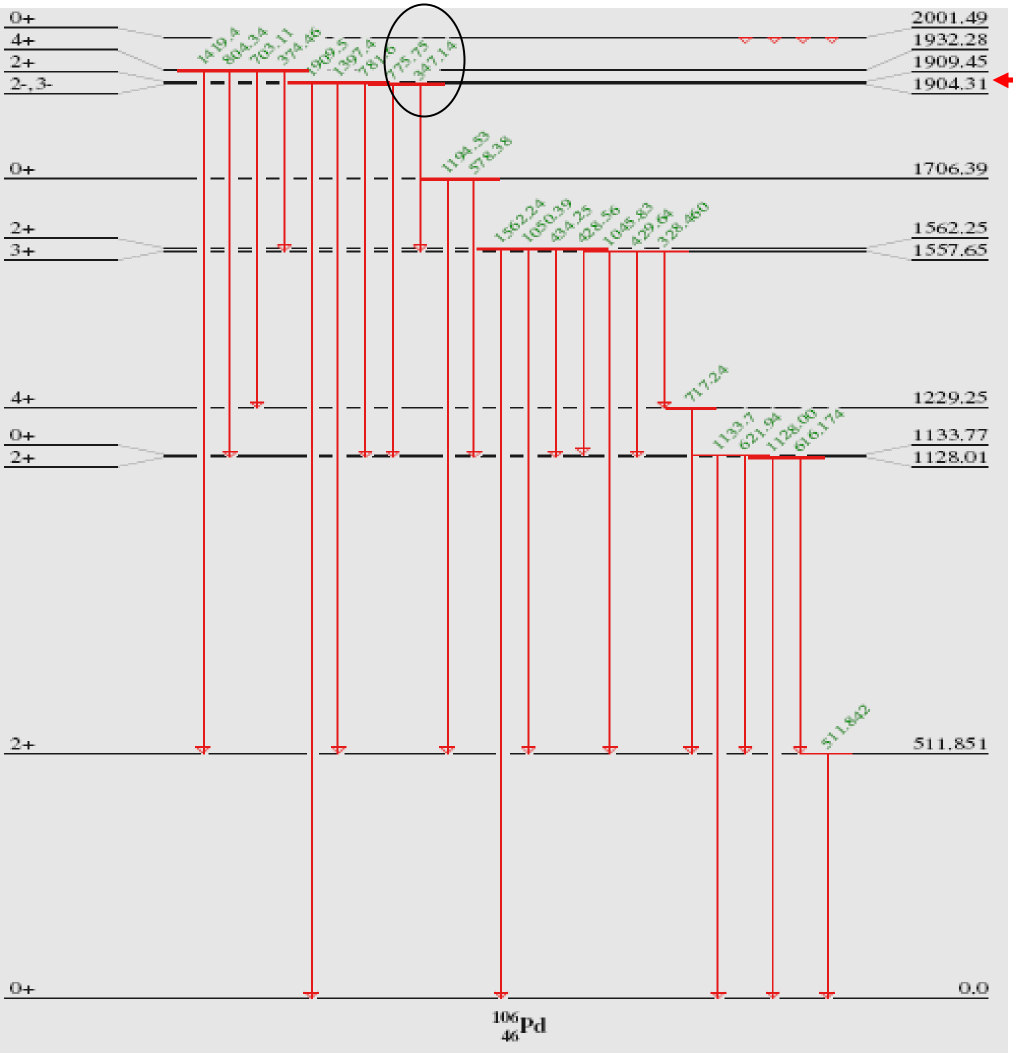
Statistical model calculations can be used to constrain J^{π} values.

2306-keV level feeding is consistent with $J^{\pi}=3^{-}$ not $J^{\pi}=4^{-}$ adopted in ENSDF on basis of $\gamma\gamma(\theta)$.



2397-keV level feeding is consistent with $J^{\pi}=4^{-}$ when additional γ-ray is placed. Assignment of $J^{\pi}=5^{-}$ in ENSDF is based on L=(5) in (p,t).

Level Scheme Errors



Mistaken level assignment

1904.3 keV level assigned by the Ritz principal.

$\sigma_\gamma(1904)_{expt}$=0.12 b
$\sigma_\gamma(1904)_{DICEBOX}$=1.13 b

Reassigning placement of the 347- and 776-keV γ-rays to deexcite the 1909.4-keV level gives

$\sigma_\gamma(1909)_{expt}$=0.62 b
$\sigma_\gamma(1909)_{DICEBOX}$=0.83 b

Statistical model calculations can be used to improve the nuclear structure information in RIPL.

^{106}Pd J$^{\pi}$ Values

New J$^{\pi}$ values or level placements were determined for 7 of 64 levels.

The cross section deexciting the 2472 level is inconsistent with J>0. Decay to 0+ levels rules out J$^{\pi}$=0$^{\pm}$. Either there is missing γ-ray deexcitation or this level placement is incorrect.

E	dE	JPI(ENSDF)	JPI(This work)
0	0	0+	0+
511.844	0.02	2+	2+
1128.04	0.03	2+	2+
1133.79	0.06	0+	0+
1229.2	0.03	4+	4+
1557.67	0.04	3+	3+
1562.16	0.04	2+	2+
1706.44	0.08	0+	0+
1904.21	0.09	2-,3-	NO LEVEL
1909.39	0.07	2+	2+
1932.37	0.05	4+	4+
2001.56	0.11	0+	0+
2076.69	0.04	4+	4+
2077.01	0.06	6+	6+
2084.39	0.07	3-	3-
2229.2	0.21		NO LEVEL
2242.4	0.06	2+	2+
2278.47	0.14	0+	0+
2282.89	0.09	4+	4+
2306.01	0.06	4-	3-
2308.73	0.11	2+	2+
2350.96	0.09	4+	4+
2366.09	0.1	5+	5+
2397.37	0.08	(5)-	4-
2400.84	0.25	2-,3-	2-,3-
2439.11	0.1	2+	2+
2472.09	0.17	1+,2+	1+,2+???
2484.76	0.25	(1-)	(1-)
2500.01	0.12	2-	2-
2578.64	0.1	(5-)	(4-)
2591.2	0.4	(2,3)+	(2,3)+
2624.21	0.13	0+	0+

E	dE	JPI(ENSDF)	JPI(This work)
2626.76	0.1	(2,3)+	(2,3)+
2646.3	0.2	(4+)	(4+)
2699.36	0.16	(6)-	(6)-
2705.3	0.08	(1)+	(1)+
2713.78	0.09	2+,3+	2+,3+
2741	0.5	4+	1,2+
2747.72	0.16	2-,3-	2-,3-
2757	0.04	5+	5+
2775.88	0.11	(4+)	(4+)
2783.71	0.13	2+	2+
2820.94	0.11	2+	2+
2828	1.7	0+	0+
2861.41	0.17	(+)	(+)
2850.79	0.15	2+,3+	2+,3+
2878.27	0.19	0+	0+
2886.16	0.23	(-)	(-)
2897.42	0.16	(1-,4-)	4-
2902.31	0.2	2+	2+
2908.53	0.17	(1-)	(1-)
2918.56	0.13	2+	2+
2935.8	0.2	(2-,3-)	(2-,3-)
2968.5	0.25	3-	3-
3037.45	0.11	1,2	1,2
3056.38	0.12	1+	1+
3071.03	0.23	(2,3)-	(2,3)-
3083.52	0.13	0	0+
3118.45	0.18	(6+)	(6+)
3161.1	0.5	2+	2+
3173.8	0.7	(2+,3+)	(2+,3+)
3221.64	0.15	0+	0+
3252	0.4	2+	2+
3319.52	0.25	0+	0+

Pd total radiative cross section σ_0 results

Reaction E(n)=thermal	# levels below E_{crit}	σ_0(literature) (barns)	σ_0(this work) (barns)
^{102}Pd(n,γ)^{103}Pd	2	1.6±0.2	1.1±0.4
^{104}Pd(n,γ)^{105}Pd	5	0.65±0.30	0.77±0.17
^{105}Pd(n,γ)^{106}Pd	28	21.0±1.5	21.7±0.5
^{106}Pd(n,γ)^{107}Pd	5	0.30±0.03	0.36±0.10
^{108}Pd(n,γ)^{109}Pd	11	7.6±0.5	7.2±0.5
^{108}Pd(n,γ)^{109}Pd^{m}	2	0.185±0.010	0.185±0.011
^{110}Pd(n,γ)^{111}Pd	5	0.70±0.17	0.34±0.10

Total radiative thermal neutron cross sections can be determined even when only one γ-ray is observed.

Treatment of Spin and Parity

The spin distribution of the level density f(J) has be defined as (Bethe, 1937)

$$f(J) = \frac{2J+1}{2\sigma_c^2} \exp\left(-\frac{(J+1/2)^2}{2\sigma_c^2}\right)$$

Where σ^2_c is the spin cutoff parameter. This should be multiplied by a parity distribution parameter f(π).

One parameterization of f(π) is suggested by Al-Quraishi [1] and used in COSMO calculations is

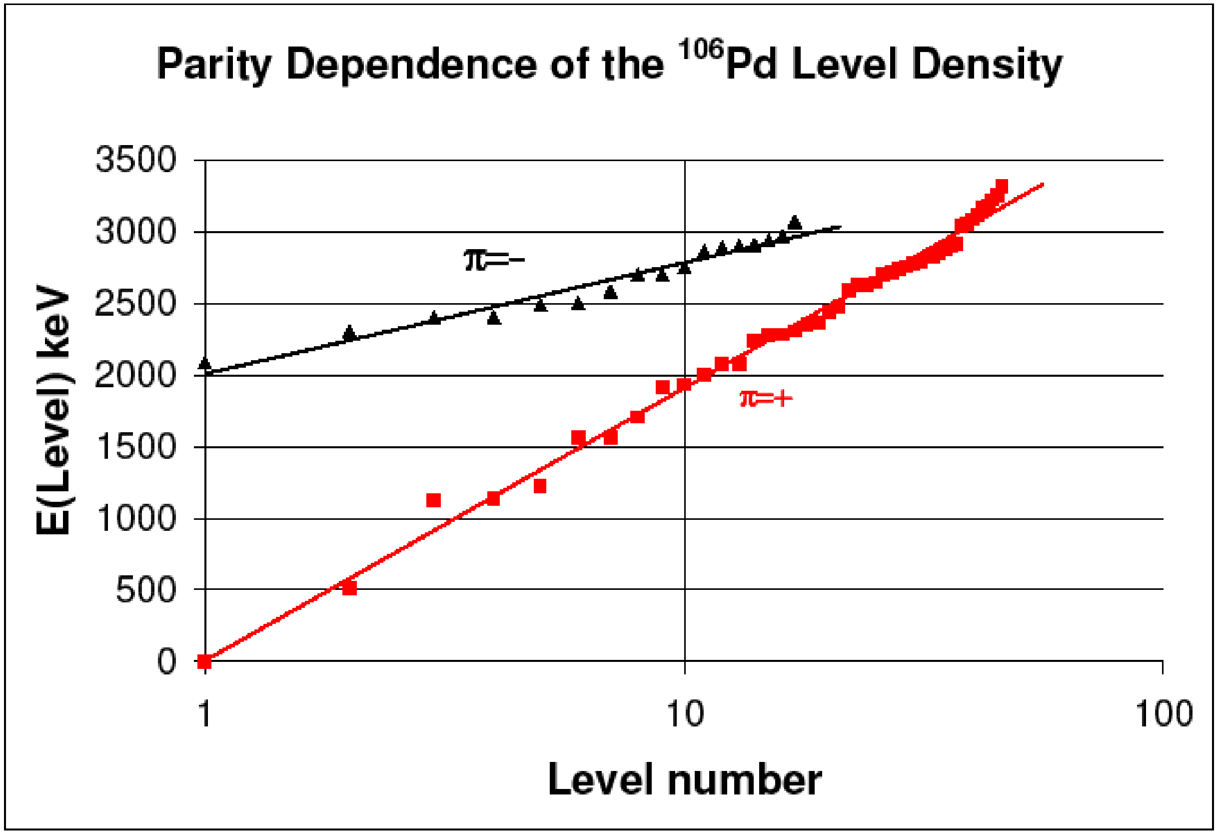
$$f(\pi{=}+) = 0.5 \times [\ 1+(1+\exp(C_\pi(E-\Delta_\pi))^{-1}]$$

$$f(\pi{=}-) = 1-F\ (\pi{=}+)$$

where C_π , Δ_π are given by the authors.

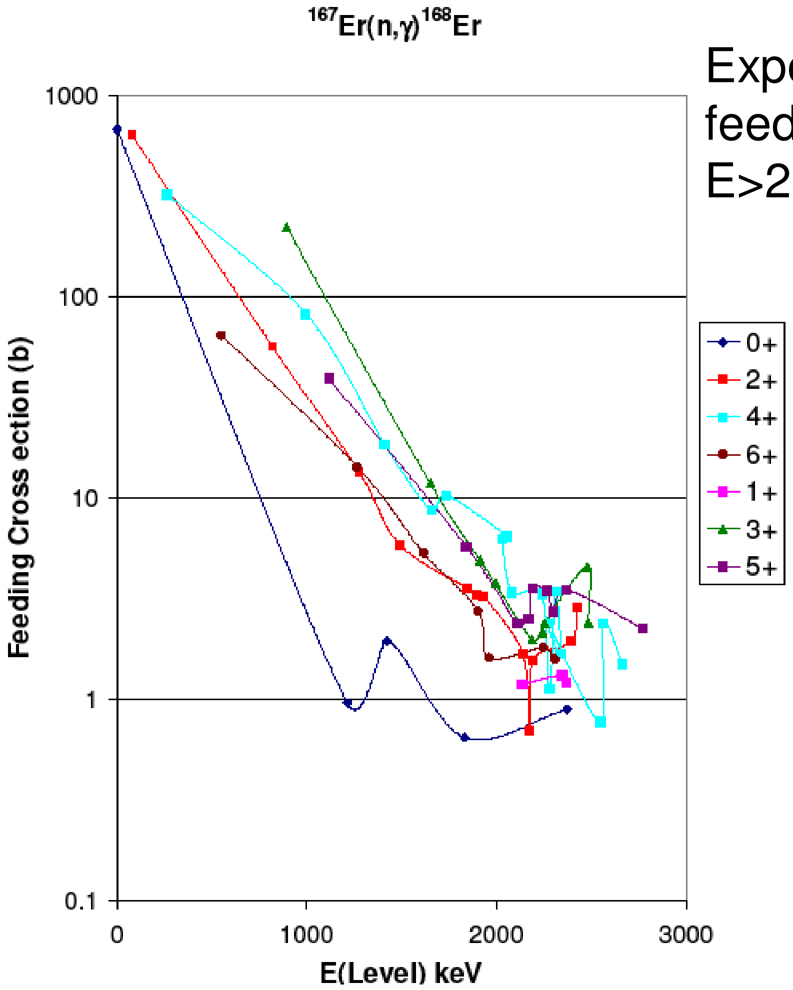
[1] S.I. Al-Quraishi, S.M. Grimes, T.N. Massey, and D.A. Resler, Phys. Rev. C**67**, 015803.

Parity Dependence of the Experimental Level Density

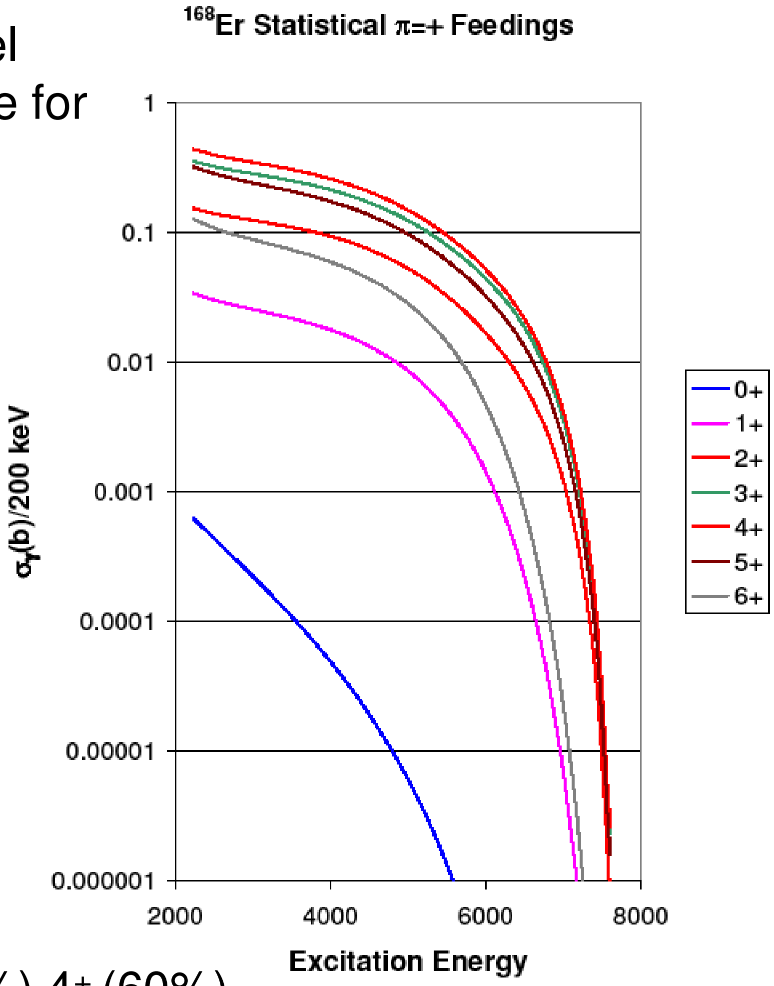


Positive and negative parities may have different temperatures

Experimental and Statistical $J^{\pi=+}$ Feedings

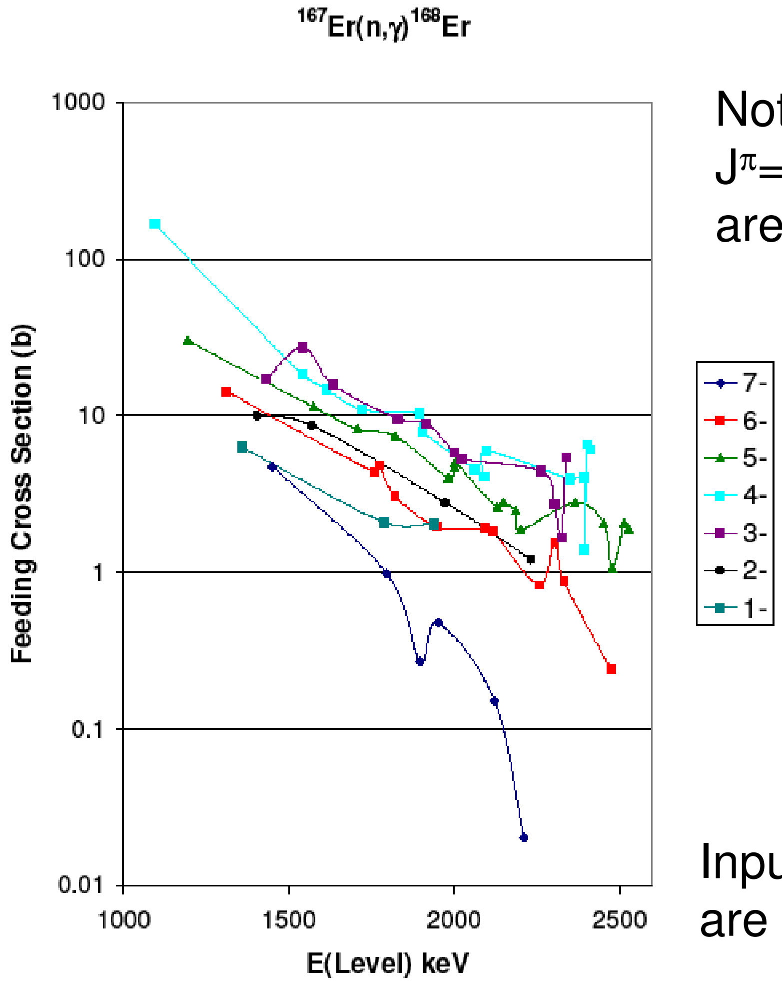


Experimental level feedings converge for E>2 MeV.



Capture state is 3$^+$ (40%),4$^+$ (60%)

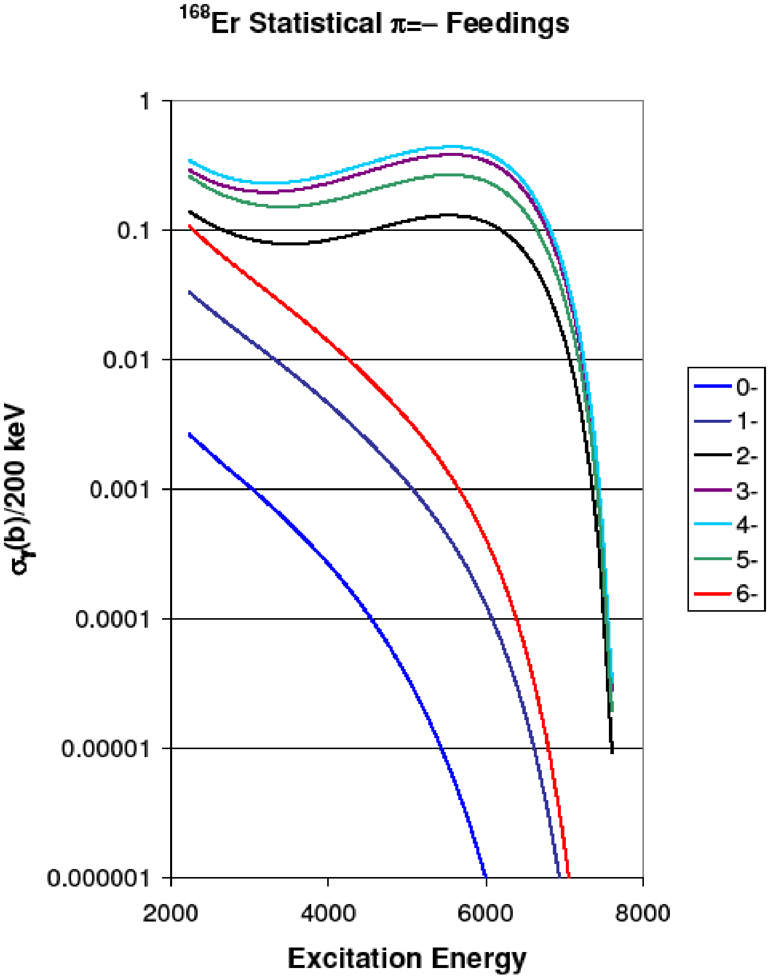
Experimental and Statistical $J^{\pi=-}$ Feedings



^{167}Er(n,γ)^{168}Er

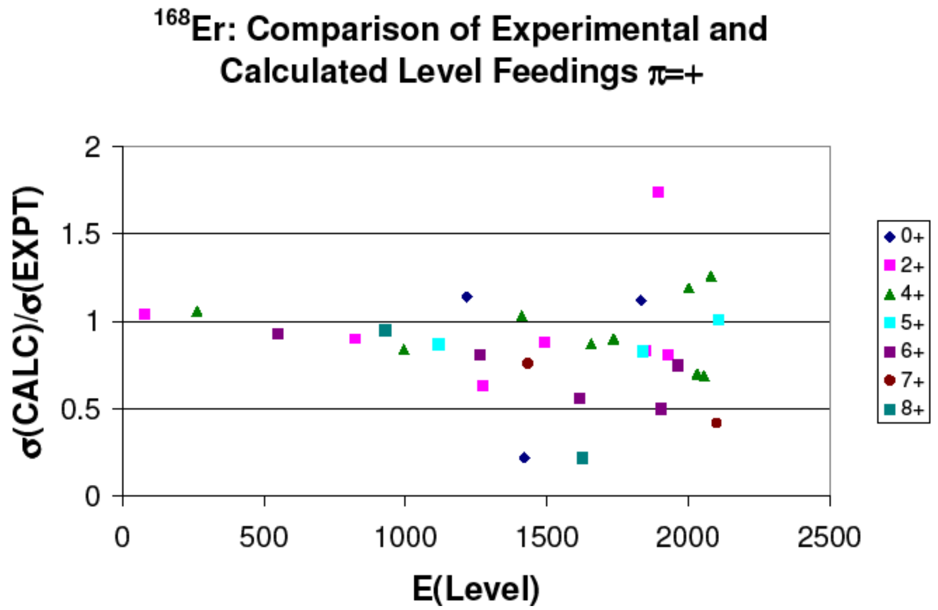
Note that no $J^{\pi}=0^{-}$ levels are observed.

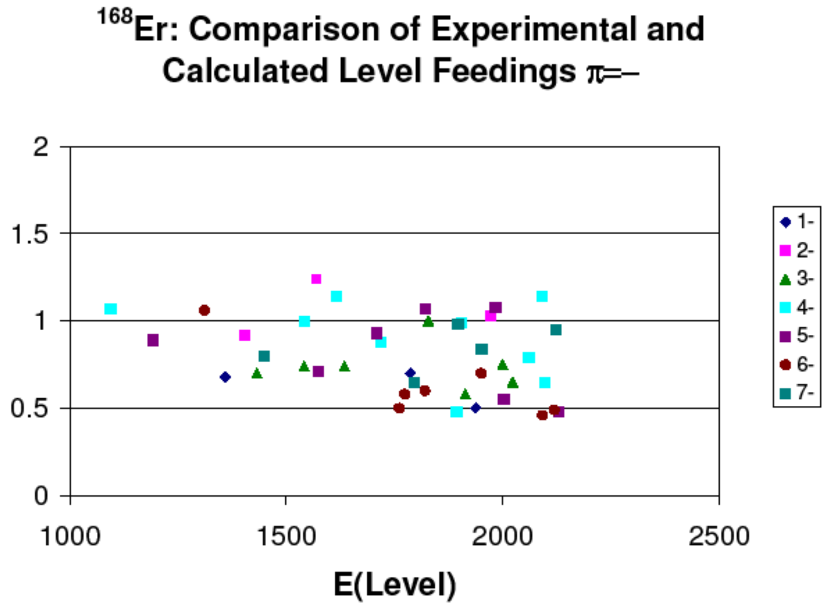
Input J^{π} values are from RIPL.



^{168}Er Statistical π=– Feedings

Comparison of ^{168}Er Experimental and Statistical Cross Sections


^{168}Er: Comparison of Experimental and Calculated Level Feedings π=+


^{168}Er: Comparison of Experimental and Calculated Level Feedings π=–

Level densities - CT model, E1 dipole strength Brink-Axel. E_{crit}=2135 keV (80 levels)

For E<1300 keV, σ(CALC)/σ(EXPT)=0.96.

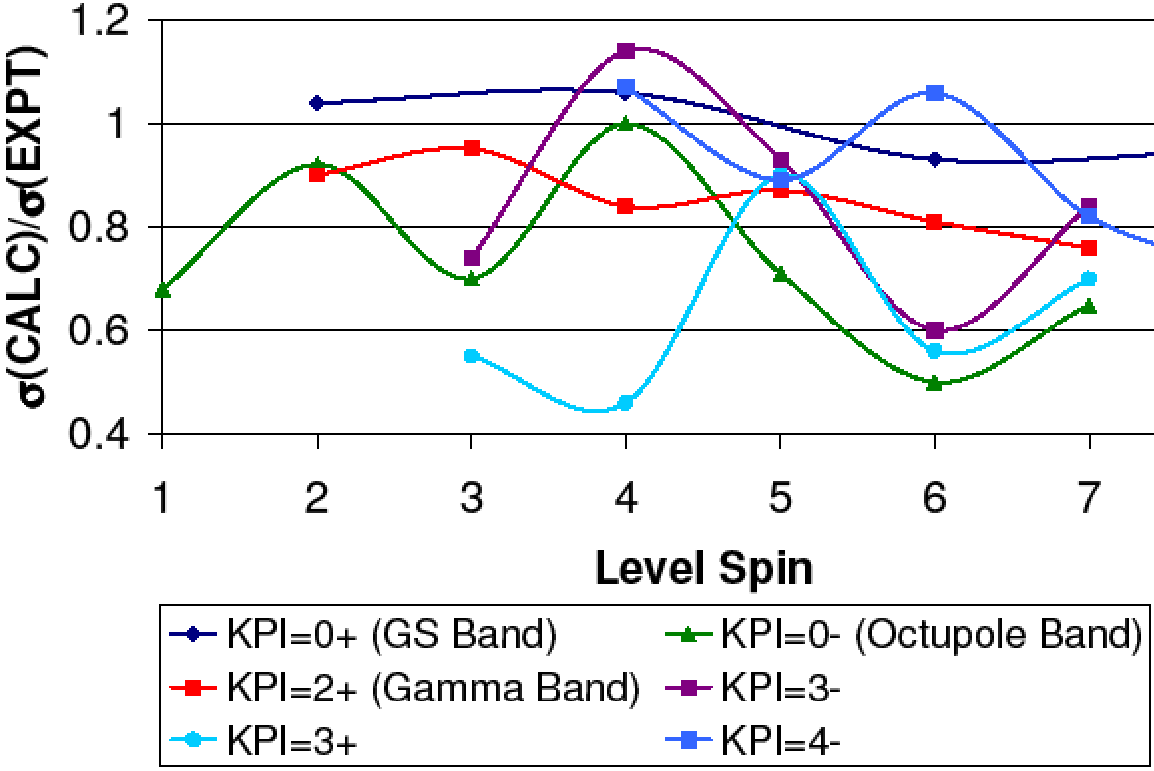
For E>1300 keV, σ(CALC)/σ(EXPT)= 0.80

- Incomplete experimental level scheme
- Nuclear structure contributions

Outliers may be due to low statistics, missing transitions, and incorrect J^{π} assignments.

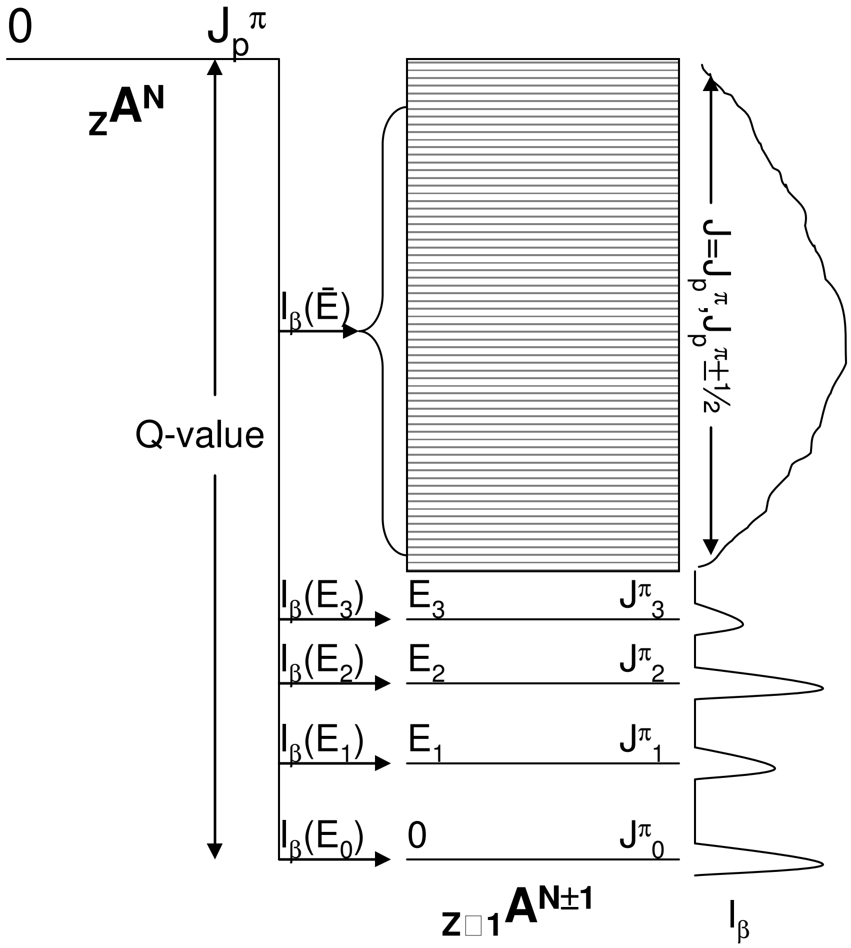
K-Dependence

^{168}Er K-Dependence of the Statistical Model



Significant dependence on K is observed. Note that oscillations in the fit appear to be correlated, possibly due to incorrect spin distribution.

β-Strength Function

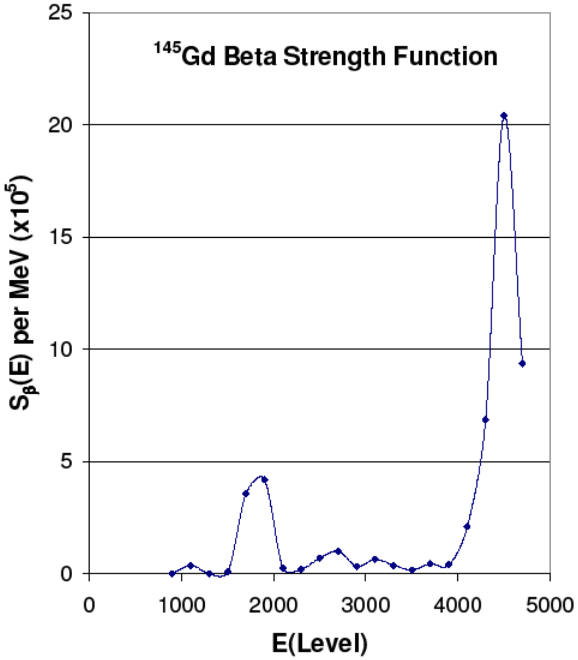


$$S_\beta(E) = \frac{I_\beta(E)}{f(Q_\beta - E)t_{1/2}} \text{ (individual levels)}$$

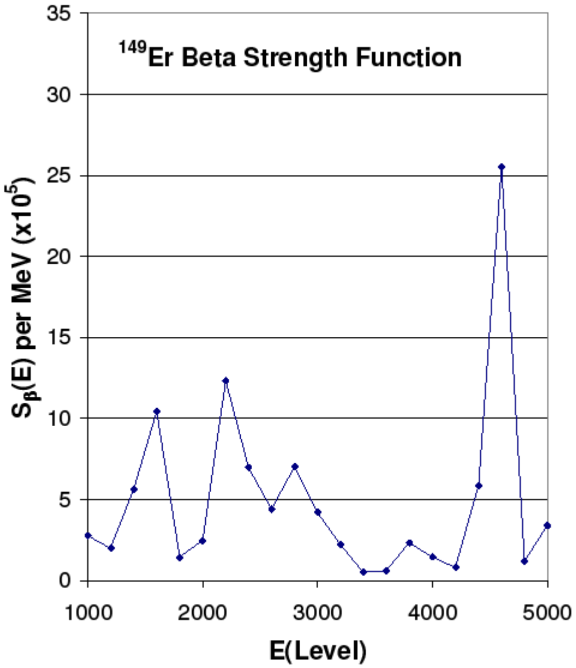
$$S_\beta(E) = \frac{\rho(E)}{f(Q_\beta - E)t_{Ave}} \text{ (continuum levels)}$$

In the continuum $S_\beta(E)$ is calculated from the product of the level density ρ(E) and an average beta strength ft_{Ave} analogous to the statistical model for thermal neutron capture γ-ray decay analysis.

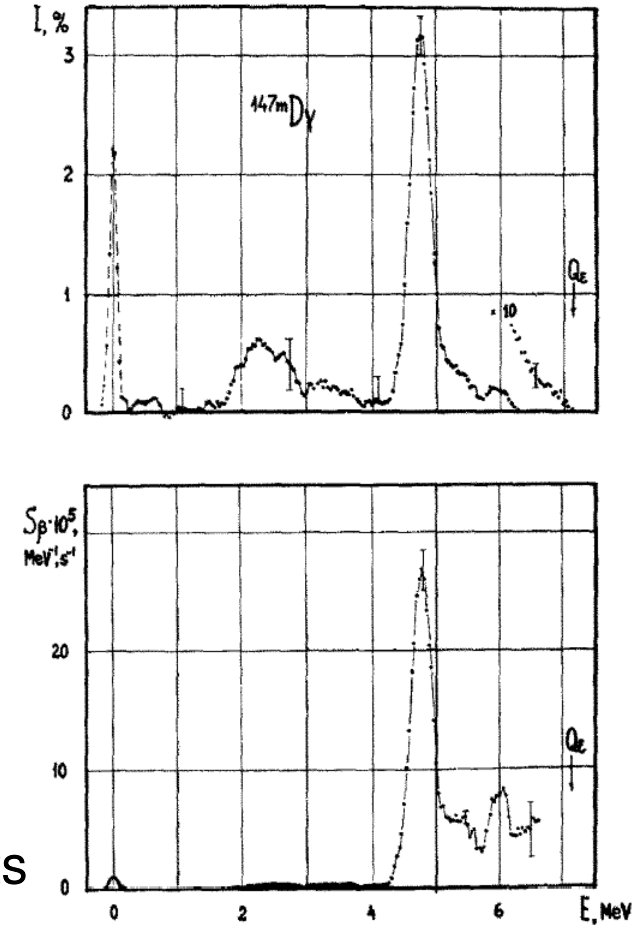
Nuclear Structure in the β-Strength Function



R.B. Firestone *et al,*
PRC**25**, 527(1982)



R.B. Firestone *et al,*
PRC**39**, 219(1988)

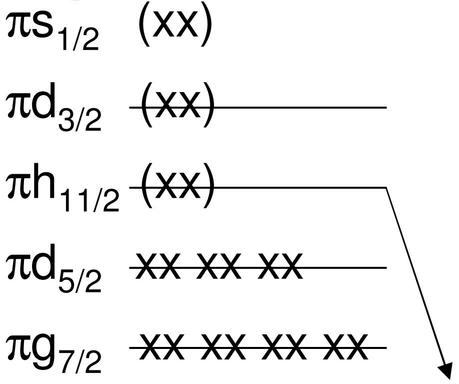


Alkhasov *et al,* NP **A438**, 482(1985)

It was shown in detailed decay scheme studies and Total Absorption Spectrometer (TAS) measurements that the beta strength to the continuum in ^{145}Gd, ^{147}Dy, and ^{149}Er is not statistical.

Nuclear Structure and the Decay of N=81 Isotopes

The β-strength function is dominated by the fast $\pi h_{11/2} \rightarrow \nu h_{9/2}$ spin-flip transition from virtual $\pi h_{11/2}$ pairs.



$\pi s_{1/2}$ (xx)

$\pi d_{3/2}$ ~~(xx)~~

$\pi h_{11/2}$ ~~(xx)~~

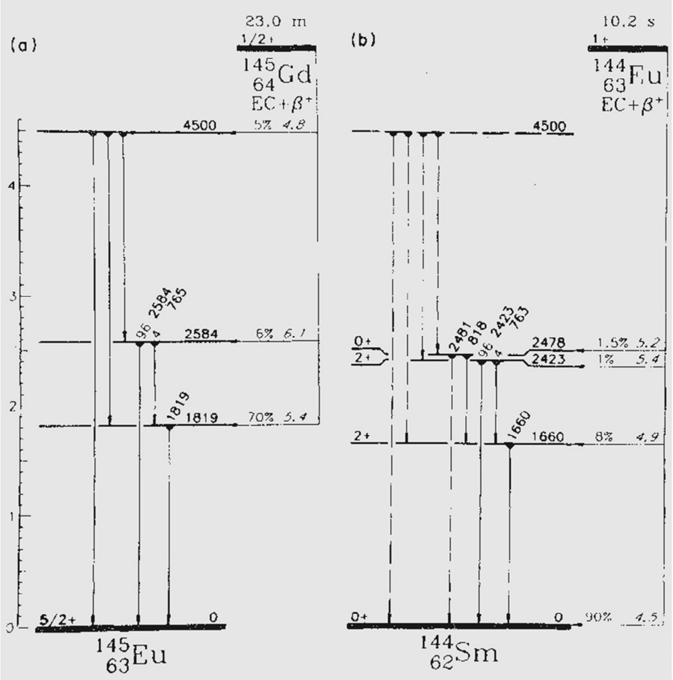
$\pi d_{5/2}$ ~~xx xx xx~~

$\pi g_{7/2}$ ~~xx xx xx xx~~

^{145}Gd proton valence states

Shell + weak coupling model calculation.

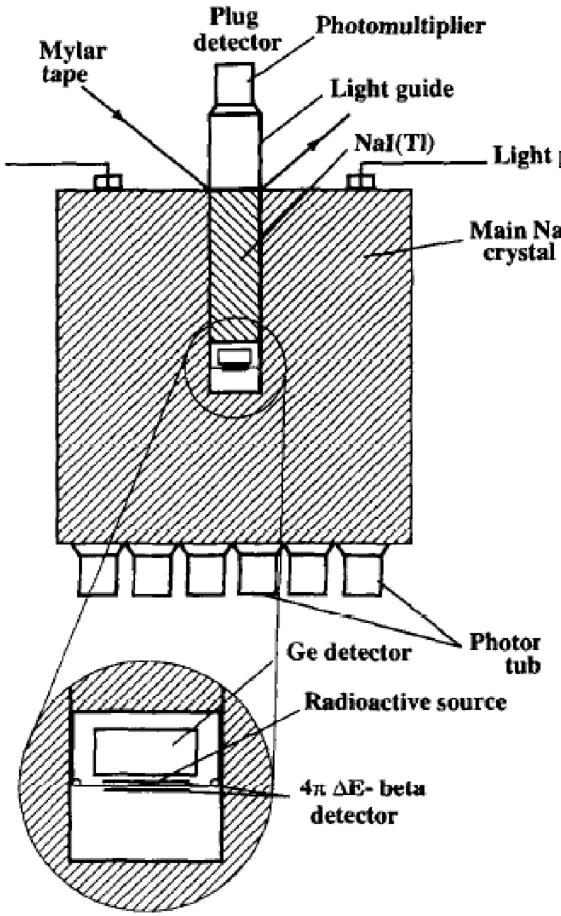
$(\pi h_{11/2})^1(\nu h_{9/2})^1(\nu s_{1/2}+\nu d_{3/2})^{-1}$	5300
$(\pi h_{11/2})^1(\nu i_{13/2})^1(\nu s_{1/2}+\nu d_{3/2})^{-1}$	4900
$(\pi h_{11/2})^1(\nu f_{7/2})^1(\nu s_{1/2}+\nu d_{3/2})^{-1}$	3900



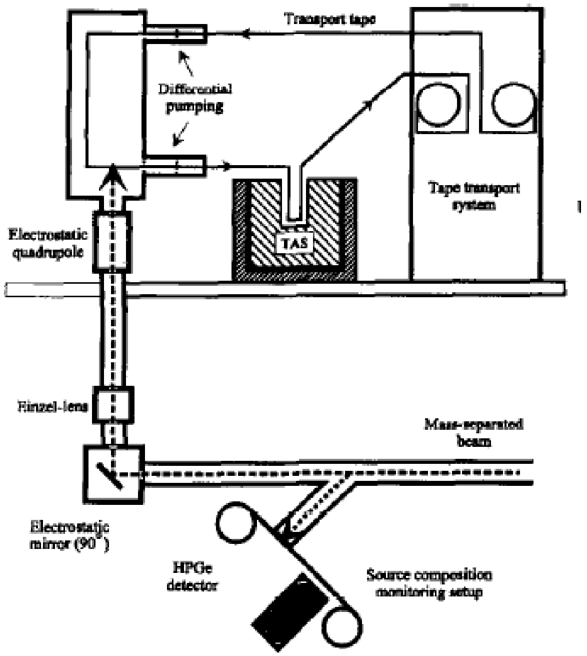
Lower level feeding dominated by core decay to $\pi d_{5/2} \otimes 2^+$ configurations.

$(\pi d_{3/2})^1$	1042
$(\pi s_{1/2})^1$	808
$(\pi h_{11/2})^1$	716
$(\pi g_{7/2})^{-1}(\pi d_{5/2})^2$	330
$(\pi d_{5/2})^1$	0

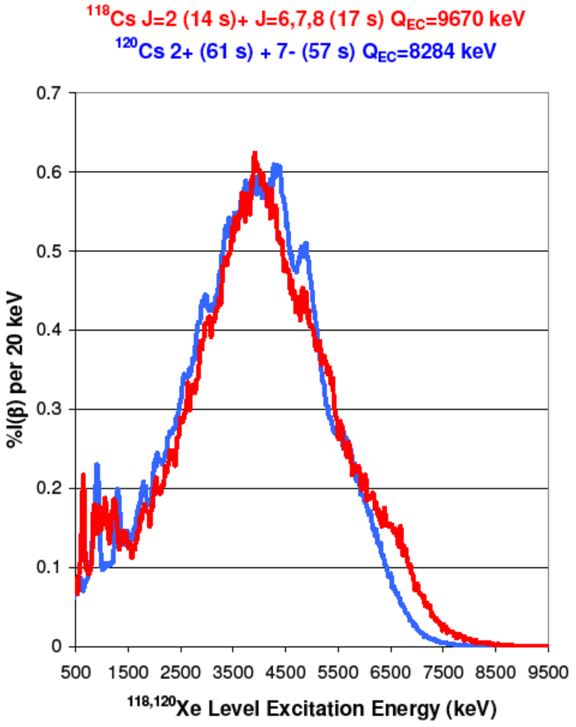
LBNL Total Absorption Spectrometer (TAS)



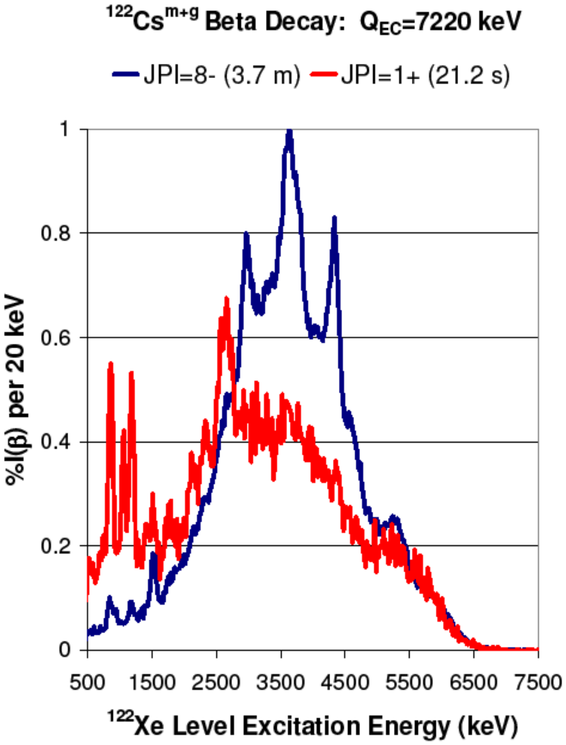
Mass separated sources produced with the LBNL HILAC (1995) and transferred by tape to inside a 36×36 cm NaI(Tl) detector. TAS is ~95% efficient for 10 MeV γ-rays.

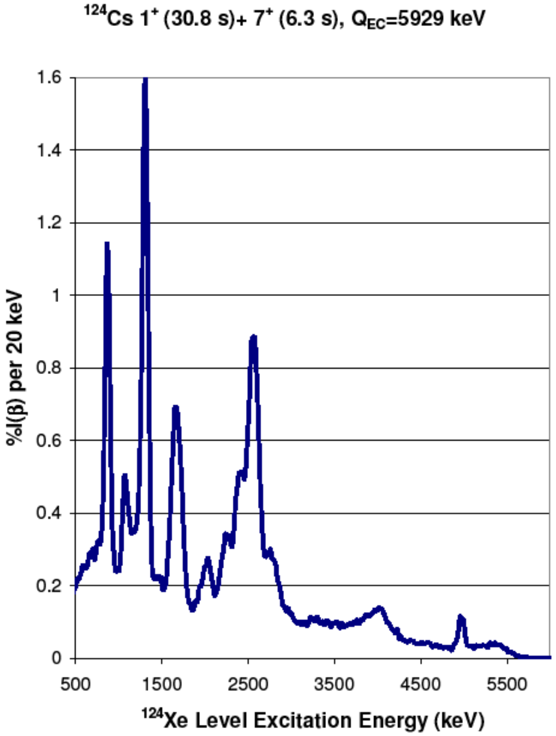


$^{118\text{-}124}$Cs Odd-Odd Isotopes


^{118}Cs J=2 (14 s)+ J=6,7,8 (17 s) Q_{EC}=9670 keV

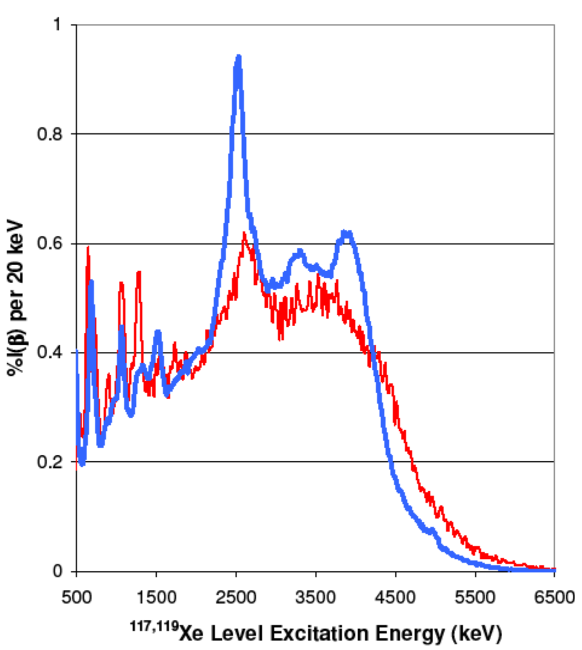
^{120}Cs 2+ (61 s) + 7- (57 s) Q_{EC}=8284 keV

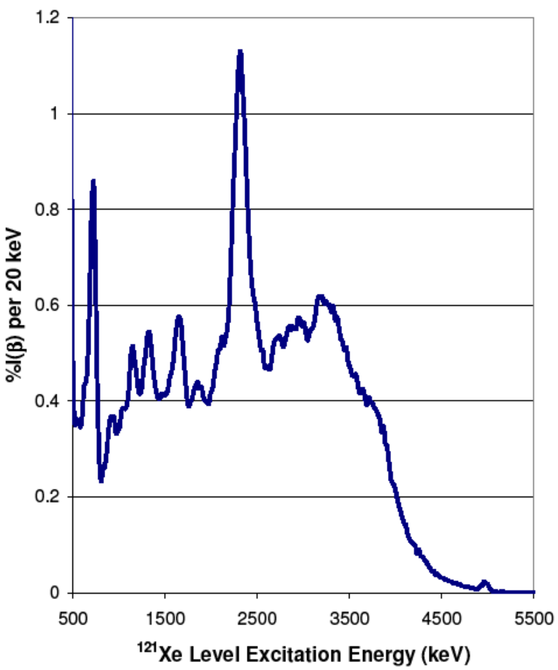

^{122}Cs^{m+g} Beta Decay: Q_{EC}=7220 keV

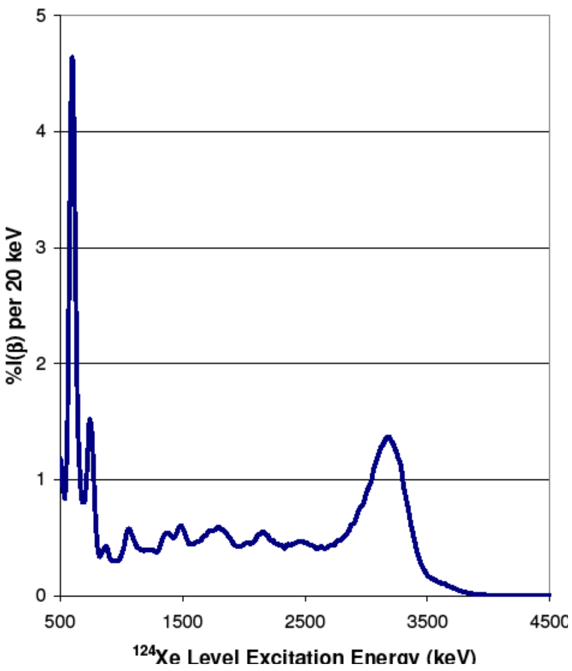

^{124}Cs 1^{+} (30.8 s)+ 7^{+} (6.3 s), Q_{EC}=5929 keV

- ^{118}Cs and ^{120}Cs decays have nearly the same β-strengths with little structure
- Onset of high excitation nuclear structure appears at ^{122}Cs with N=65
- Isomeric and GS decays can have very different nuclear structure features

$^{117\text{-}123}$Cs Odd-Even Isotopes


^{117}Cs 3/2+ (6.5 s)+ 9/2+ (8.4 s) Q_{EC}=7740 keV
^{119}Cs 3/2+ (30.4 s)+ 9/2+ (43 s) Q_{EC}=6489 keV


^{121}Cs 3/2+ (155 s)+ 9/2+ (122 s) Q_{EC}=5372 keV


^{123}Cs 1/2$^+$ (5.87 m)+ 11/2$^-$ (1.64 s), Q_{EC}=4265 keV

- Little nuclear structure >3 MeV is seen in ^{117}Cs Decay
- Comparable β-strengths with resonances >3 MeV are seen in $^{119\text{-}123}$Cs decays
- Transition to high excitation resonance structure appears to occur at N=64.

Nuclear Structure in the β-strength of the Cs isotopes

Strong β-strength is expected for $\pi g_{9/2} \rightarrow \nu g_{7/2}$ spin-flip transition.

The Cs isotopes have β_2=0.2-0.3 bringing the $\pi g_{9/2+}$[404] configuration near the GS. A fast spin-flip β-decay transition is expected to the $\nu g_{7/2+}$[404] configuration at ≈4 MeV.

Disappearance of the high excitation structure in the β-strength for N<64 has not been explained.

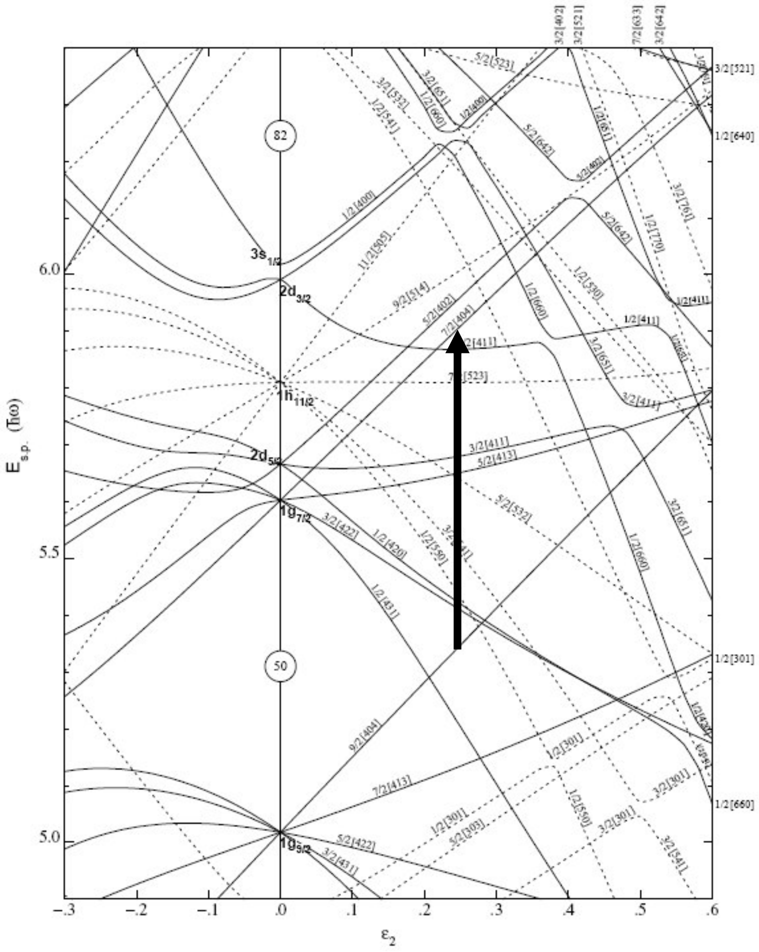


Figure 12. Nilsson diagram for protons, 50 ≤ Z ≤ 82 ($\varepsilon_4 = -\varepsilon_2^2/6$).

Conclusions

- Statistical model analysis of thermal neutron capture σ_γ data can be used to accurately determine total radiative cross sections σ_0 and improve level J^π values.
- Preliminary evidence of nuclear structure effects, possible K dependence, are seen in the neutron capture data.
- Strong evidence of nuclear structure effects is seen in the β-strength function for the decay of nuclei far from stability.