

DEPARTAMENTO DE INGENIERÍA NUCLEAR (DIN)	REPORT	Date: 7-March-2011
	Updated Co-58 evaluation for background capture reaction (MT102)	Pages: 7

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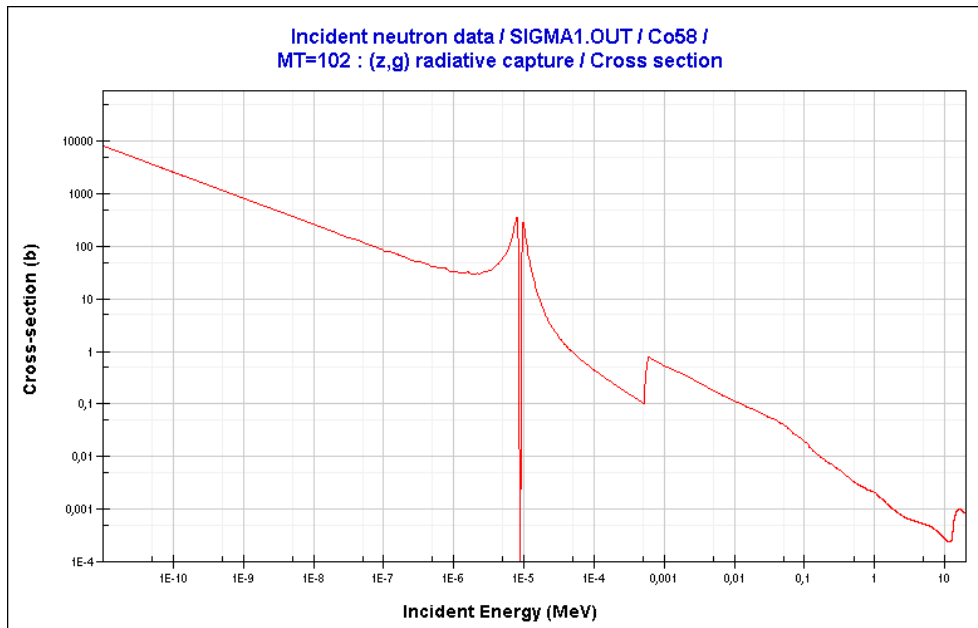
Modifications respect to the previous version
None

Author (s)	Revision	Approved
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## 1. Processing the Co-58 capture cross section from JEFF-3.1.1.

The neutron capture (n,gamma) cross-section for  $^{27}\text{Co-58}$  theoretically presents a single resonance for 9 eV. However, after plotting the processed library, a discontinuity is made clear as the cross section plummets down to zero in a small range of energy where the peak of the resonance would be expected.

**Figure 1. MT102 capture cross-section taken from JEFF-3.1, JEFF-3.1.1 and ENDF/B-VII.0 using JANIS-3.2.**



## 2. Description of the neutron data evaluations included in JEFF-3.1.1.

As we look into the complete description of the neutron data evaluations, we find that the evaluation was conducted with the aim of adapting the experimental values, specifically, the thermal capture cross section at 1880 barns and the resonance integral at 6890 barns.

**Figure 2. Description of resolved resonance region for Co-58.**

...			
...			
RESOLVED RESONANCE REGION UPTO ABOUT 0.5 KEV	2722	1451	63
ONLY ONE RESONANCE GIVEN. THIS WAS FITTED TO OBTAIN	2722	1451	64
REASONABLE AGREEMENT WITH EXPERIMENTAL VALUES FOR THERMAL	2722	1451	65
CAPTURE CROSS SECTION ( <b>SIGMA= 1880 B.</b> ) AND RESONANCE	2722	1451	66
INTEGRAL( <b>RI= 6890 B.</b> ), VALUES GIVEN IN BNL-325	2722	1451	67
POSSIBLY SIGMA ABSORPTION IN THE RESONANCE REGION	2722	1451	68
CONSISTS OF A CONTRIBUTION OF <b>10 PERCENT FOR THE (N,GAMMA)</b>	2722	1451	69
REACTION AND A CONTRIBUTION OF <b>90 PERCENT FOR THE (N,P)</b>	2722	1451	70
REACTION.	2722	1451	71
...			
...			

In order to achieve this, the absorption cross section for the resonance region was considered to be comprised by a 10% contribution for the (n,gamma) reaction and a 90% contribution for the (n,p) reaction.

Figure 3 shows the MF2 (resonance parameters section) for Co58. LRF flag indicates (LRF=2) a multilevel Breit-Wigner (MLBW) formulism. And, with an upper limit for energy range of 596.41 eV.

**Figure 3. Resonance section for Co-58 in JEFF-3.1.1**

2.705800+4	5.743810+1	0	0	1	02722	2151	1	
2.705800+4	1.000000+0	0	0	1	02722	2151	2	
<b>1.000000-5</b>	<b>5.964100+2</b>	1	<b>2</b>	0	02722	2151	3	
2.000000+0	6.500000-1	0	0	1	02722	2151	4	
5.743800+1	0.000000+0	0	0	6	12722	2151	5	
9.000000+0	1.500000+0	1.015000+0	5.150000-1	5.000000-1	0.000000+0	02722	2151	6

### 3. Updating “background” cross-section for Co-58 capture reaction.

Taking into account the considerations made with regards to the contribution of both (n,gamma) and (n,p) reactions (10% and 90% respectively to the total absorption cross-section) we have:

$$\frac{\sigma_{(n,p)}}{\sigma_{(n,p)} + \sigma_{(n,gamma)}} = 0,90$$

Where the (n,gamma) cross section can be expressed as a contribution of both the background cross-section and the one given by the multi-level Breit-Wigner formulism and the resonance parameters:  $\sigma_{(n,gamma)} = \sigma_0 + MLBW(E)$

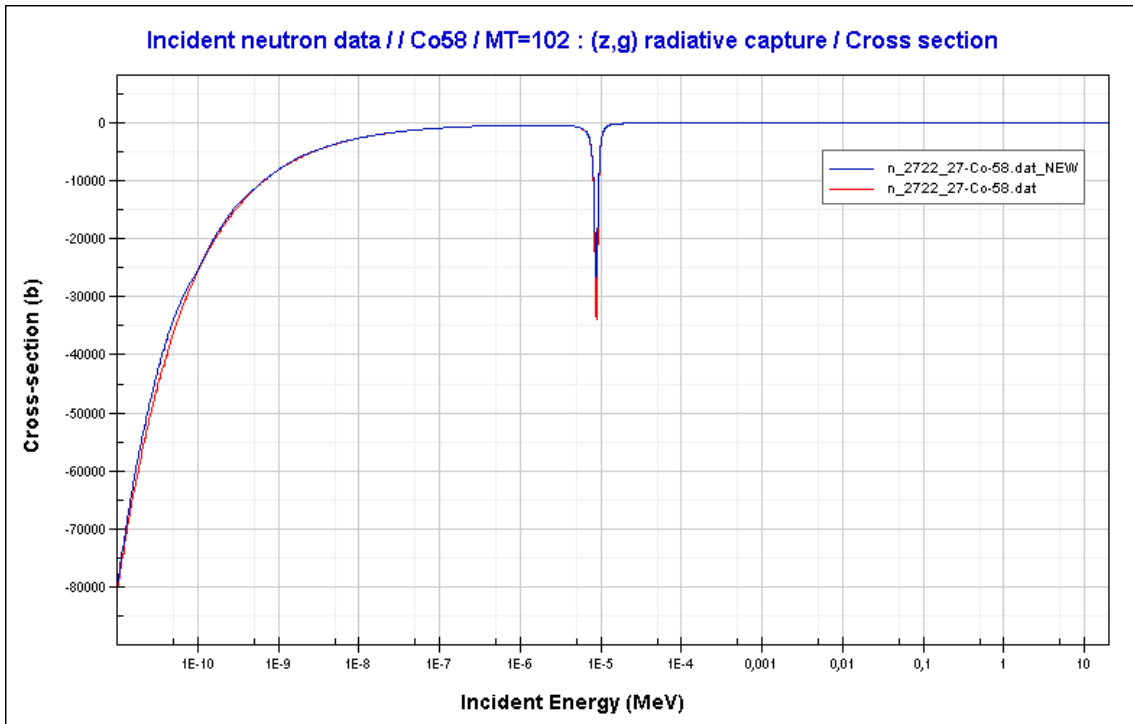
With these two equations we are able to find the value of the background cross-section:

$$\sigma_0 = 0,1 \cdot \sigma_{(n,p)} - MLBW(E)$$

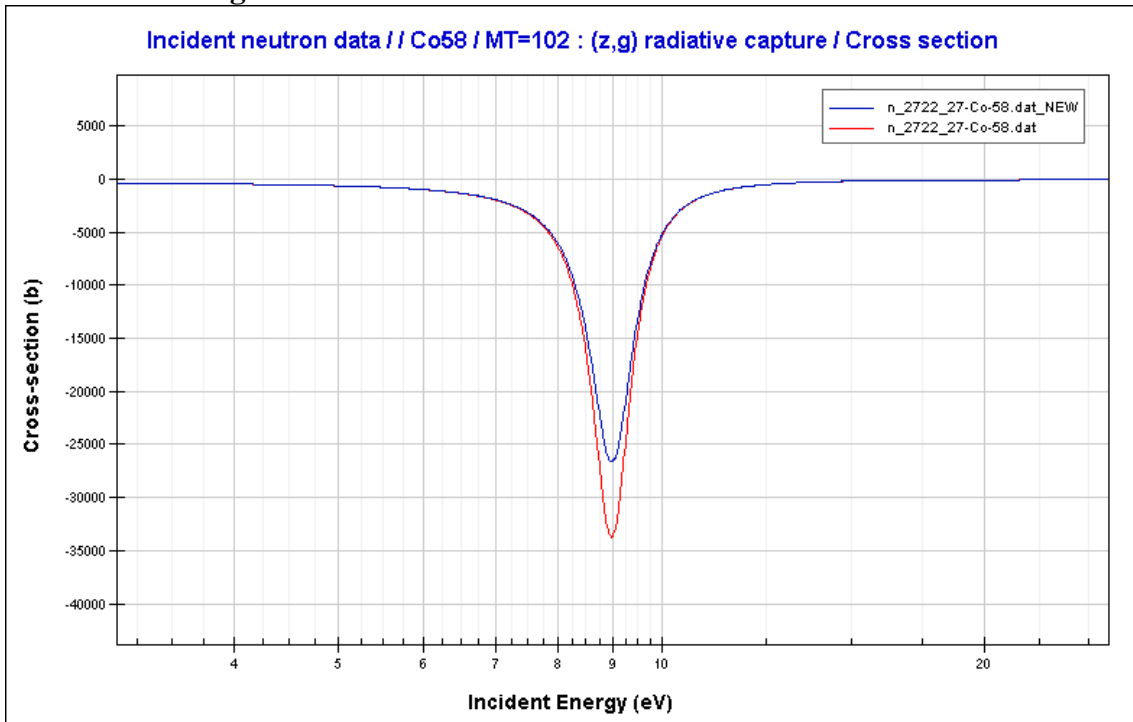
where  $E < 5.964100e+2$  eV

As seen in Figures 4 and 5, the negative values of the new background cross-section proposed are significantly smaller than the original one. This is the reason why the total capture cross-section originally cancelled out for this particular energy range.

**Figure 4. Evaluated MF3-MT102 comparison: JEFF-3.1.1 versus New Proposal.**

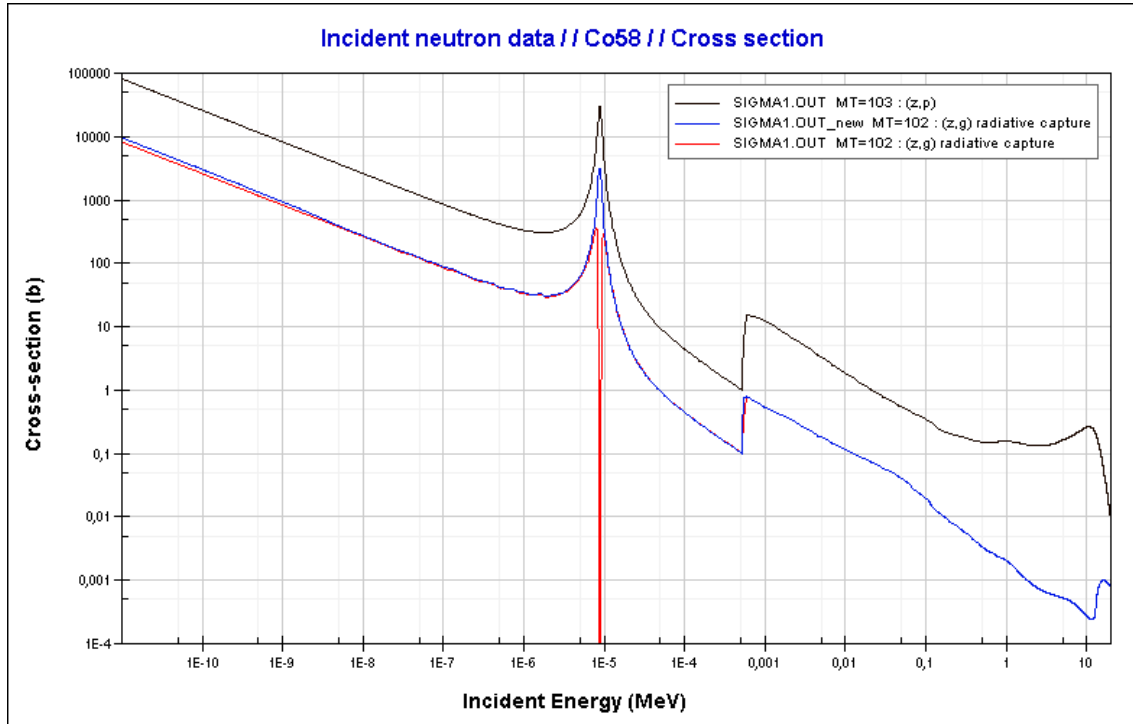


**Figure 5. Evaluated MF3-MT102 comparison: JEFF-3.1.1 versus New Proposal in the resonance region.**



Plotting the pointwise results from the point-ENDF file for the (n,p) and the new (n,gamma) cross-sections against the former capture cross-section, the correction in the resonance region can be clearly appreciated, as the value peaks for 9 eV as expected.

Figure 6. PENDF cross –section MF3-MT102



#### 4. Processing with INTER code

Finally, running the new processed PENDF file through the INTER code we obtain the resonance integral for both (n,p) and (n,gamma) reactions. As we can see, both reactions contribute approxiamtely with the originally estimated percentage (10% - 90%), roughly amounting to the experimental value of 6890 barns, which was one of the criteria in the evaluation.

Figure 7. INTER output for New Proposal.

Material number (MAT) = 2722												
Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)
27	58	0		102	n,gamma	1.76268E+02	1.74637E+02	1.7835E+02	1.02353	6.18605E+02	2.62906E-03	7.16790E-04
27	58	0		103	n,p	1.71530E+03	1.69951E+03	1.7117E+03	1.00945	6.09281E+03	1.63607E-01	1.65738E-01

Figure 8. INTER output for original evaluation.

Material number (MAT) = 2722												
Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)
27	58	0		102	n,gamma	1.70526E+02	1.68763E+02	1.7241E+02	1.02276	2.21866E+02	2.62906E-03	7.16790E-04
27	58	0		103	n,p	1.71530E+03	1.69951E+03	1.7117E+03	1.00945	6.09281E+03	1.63607E-01	1.65738E-01

## ANNEX I

Figure 9. New proposal for MT102

2.705800+4	5.743810+1	0	0	0	02722	3102	1
1.045000+7	1.045000+7	0	0	1	4042722	3102	2
	404	2			2722	3102	3
1.000000-5-8.153793+4	1.112720-5-7.692899+4	1.232680-5-7.274745+4	2722	3102			4
1.308716-5-7.040580+4	1.358390-5-6.898564+4	1.490900-5-6.555884+4	2722	3102			5
1.617432-5-6.269804+4	1.628500-5-6.246424+4	1.772310-5-5.963465+4	2722	3102			6
1.920430-5-5.707041+4	2.074010-5-5.471841+4	2.234863-5-5.253104+4	2722	3102			7
2.288290-5-5.185852+4	2.509230-5-4.932134+4	2.735710-5-4.706495+4	2722	3102			8
2.852294-5-4.601662+4	2.966560-5-4.505408+4	3.200640-5-4.325836+4	2722	3102			9
3.469725-5-4.144239+4	3.557320-5-4.090051+4	3.911360-5-3.891889+4	2722	3102			10
4.267130-5-3.721100+4	4.704588-5-3.541946+4	4.730690-5-3.532175+4	2722	3102			11
5.194680-5-3.373137+4	5.637860-5-3.243500+4	5.939450-5-3.165577+4	2722	3102			12
6.262430-5-3.090041+4	6.639729-5-3.010846+4	7.174313-5-2.912894+4	2722	3102			13
7.355510-5-2.883010+4	8.174561-5-2.765546+4	8.409175-5-2.736556+4	2722	3102			14
8.784710-5-2.693877+4	9.577280-5-2.616985+4	1.051580-4-2.513471+4	2722	3102			15
1.087890-4-2.468059+4	1.159210-4-2.385339+4	1.270100-4-2.271282+4	2722	3102			16
1.334863-4-2.211583+4	1.383680-4-2.169492+4	1.499360-4-2.078439+4	2722	3102			17
1.581835-4-2.020002+4	1.616580-4-1.996801+4	1.795040-4-1.889044+4	2722	3102			18
1.972040-4-1.797852+4	2.075781-4-1.750301+4	2.149750-4-1.718687+4	2722	3102			19
2.381110-4-1.630326+4	2.569726-4-1.568160+4	2.612480-4-1.555117+4	2722	3102			20
2.833300-4-1.493087+4	3.063672-4-1.436603+4	3.144250-4-1.418547+4	2722	3102			21
3.331950-4-1.379471+4	3.687790-4-1.315213+4	4.051562-4-1.260280+4	2722	3102			22
4.094600-4-1.254387+4	4.397410-4-1.216058+4	4.790480-4-1.173416+4	2722	3102			23
5.000000-4-1.153467+4	5.039453-4-1.148746+4	5.452540-4-1.102616+4	2722	3102			24
6.027344-4-1.046998+4	6.080350-4-1.042299+4	6.661040-4-9.948419+3	2722	3102			25
7.373210-4-9.451419+3	8.003125-4-9.073917+3	8.187469-4-8.972729+3	2722	3102			26
8.793620-4-8.665618+3	9.580520-4-8.317329+3	9.978910-4-8.159414+3	2722	3102			27
1.075340-3-7.843203+3	1.188460-3-7.439134+3	1.195469-3-7.416093+3	2722	3102			28
1.302690-3-7.088380+3	1.414600-3-6.789172+3	1.525720-3-6.527408+3	2722	3102			29
1.590625-3-6.388305+3	1.673530-3-6.223491+3	1.814560-3-5.971808+3	2722	3102			30
1.985782-3-5.706596+3	2.013110-3-5.667779+3	2.132930-3-5.507561+3	2722	3102			31
2.360040-3-5.242465+3	2.380938-3-5.220279+3	2.619600-3-4.989144+3	2722	3102			32
2.812750-3-4.827937+3	3.063430-3-4.646668+3	3.171250-3-4.576986+3	2722	3102			33
3.197020-3-4.560994+3	3.961562-3-4.095069+3	4.295530-3-3.935743+3	2722	3102			34
4.751875-3-3.740493+3	5.394040-3-3.513018+3	6.332500-3-3.239301+3	2722	3102			35
7.591060-3-2.962825+3	7.913125-3-2.901169+3	9.493750-3-2.649743+3	2722	3102			36
9.788094-3-2.610520+3	1.265500-2-2.294543+3	1.418210-2-2.170823+3	2722	3102			37
1.581625-2-2.054948+3	1.857620-2-1.898543+3	1.897750-2-1.878123+3	2722	3102			38
2.530000-2-1.629366+3	2.736430-2-1.567413+3	3.380500-2-1.411380+3	2722	3102			39
3.615230-2-1.346281+3	4.231000-2-1.262896+3	5.081500-2-1.155274+3	2722	3102			40
5.372850-2-1.125158+3	5.932000-2-1.071433+3	7.130470-2-9.805681+2	2722	3102			41
7.633000-2-9.480490+2	9.334001-2-8.600583+2	1.064570-1-8.088491+2	2722	3102			42
1.273600-1-7.424408+2	1.416090-1-7.068870+2	1.613800-1-6.642916+2	2722	3102			43
1.954000-1-6.082106+2	2.119140-1-5.871369+2	2.294200-1-5.662148+2	2722	3102			44
2.822190-1-5.170010+2	2.974600-1-5.050397+2	3.655000-1-4.624485+2	2722	3102			45
4.228280-1-4.363196+2	4.335400-1-4.318821+2	5.634370-1-3.906723+2	2722	3102			46
5.696200-1-3.890658+2	7.057000-1-3.606529+2	8.417800-1-3.417460+2	2722	3102			47
8.446560-1-3.414208+2	1.000000+0-3.258619+2	1.113940+0-3.178868+2	2722	3102			48
1.125880+0-3.171856+2	1.386100+0-3.053099+2	1.658260+0-3.004627+2	2722	3102			49
1.688310+0-3.002914+2	2.202579+0-3.039817+2	2.250750+0-3.050658+2	2722	3102			50
2.746899+0-3.207724+2	3.291218+0-3.517960+2	3.375630+0-3.580154+2	2722	3102			51
3.835538+0-3.967036+2	4.107698+0-4.268412+2	4.379857+0-4.636678+2	2722	3102			52
4.500500+0-4.825042+2	4.652017+0-5.073813+2	4.924177+0-5.602653+2	2722	3102			53
5.062940+0-5.920068+2	5.196337+0-6.246932+2	5.468497+0-7.044349+2	2722	3102			54
5.625380+0-7.600549+2	5.740657+0-8.041643+2	6.012817+0-9.309264+2	2722	3102			55
6.187810+0-1.033517+3	6.284977+0-1.095634+3	6.557136+0-1.313227+3	2722	3102			56
6.693216+0-1.452779+3	6.750250+0-1.518931+3	6.829296+0-1.614740+3	2722	3102			57
6.965376+0-1.807011+3	7.031470+0-1.915030+3	7.101456+0-2.036680+3	2722	3102			58
7.237536+0-2.315795+3	7.312690+0-2.498766+3	7.373616+0-2.657529+3	2722	3102			59
7.509696+0-3.082254+3	7.593910+0-3.404423+3	7.645775+0-3.618245+3	2722	3102			60
7.781855+0-4.302259+3	7.875130+0-4.899937+3	7.917935+0-5.204583+3	2722	3102			61
8.015730+0-6.025779+3	8.054015+0-6.389494+3	8.122055+0-7.126891+3	2722	3102			62
8.156340+0-7.548153+3	8.190095+0-7.982376+3	8.258135+0-8.980410+3	2722	3102			63
8.296950+0-9.631846+3	8.326175+0-1.014427+4	8.394215+0-1.149565+4	2722	3102			64
8.437560+0-1.248148+4	8.462255+0-1.305243+4	8.530295+0-1.480280+4	2722	3102			65
8.598335+0-1.680399+4	8.718780+0-2.076823+4	8.734414+0-2.130531+4	2722	3102			66
8.867207+0-2.527053+4	8.933604+0-2.638161+4	9.000000+0-2.657240+4	2722	3102			67

9.066397+0-2.619585+4	9.132793+0-2.491985+4	9.265586+0-2.073703+42722	3102	68
9.286880+0-1.998496+4	9.408933+0-1.587095+4	9.480607+0-1.377028+42722	3102	69
9.552280+0-1.197118+4	9.573750+0-1.149102+4	9.623954+0-1.037277+42722	3102	70
9.695627+0-9.002710+3	9.767300+0-7.866691+3	9.838973+0-6.928953+32722	3102	71
9.860630+0-6.679592+3	9.910648+0-6.115586+3	9.982322+0-5.422017+32722	3102	72
1.000410+1-5.234853+3	1.012567+1-4.319874+3	1.014750+1-4.181701+32722	3102	73
1.026902+1-3.494360+3	1.041236+1-2.884597+3	1.043440+1-2.806112+32722	3102	74
1.055571+1-2.407126+3	1.069906+1-2.039268+3	1.072130+1-1.990366+32722	3102	75
1.084241+1-1.742459+3	1.098575+1-1.506501+3	1.100810+1-1.474377+32722	3102	76
1.112910+1-1.311320+3	1.127244+1-1.152145+3	1.129500+1-1.129938+32722	3102	77
1.141579+1-1.016370+3	1.155913+1-9.028060+2	1.184582+1-7.283453+22722	3102	78
1.186880+1-7.168024+2	1.213251+1-5.956577+2	1.241921+1-4.969167+22722	3102	79
1.244250+1-4.900837+2	1.270590+1-4.186072+2	1.299260+1-3.578150+22722	3102	80
1.301630+1-3.534363+2	1.327929+1-3.080923+2	1.356598+1-2.682488+22722	3102	81
1.359000+1-2.652902+2	1.385267+1-2.344781+2	1.413937+1-2.066330+22722	3102	82
1.442606+1-1.836128+2	1.473750+1-1.629680+2	1.499945+1-1.473664+22722	3102	83
1.557284+1-1.202422+2	1.588510+1-1.086383+2	1.614622+1-9.977681+12722	3102	84
1.671961+1-8.378444+1	1.703260+1-7.668288+1	1.729299+1-7.122162+12722	3102	85
1.786638+1-6.108664+1	1.818010+1-5.645764+1	1.843976+1-5.283672+12722	3102	86
1.901315+1-4.595277+1	1.958654+1-4.032625+1	2.047510+1-3.350352+12722	3102	87
2.073331+1-3.173899+1	2.188008+1-2.533846+1	2.277010+1-2.162534+12722	3102	88
2.302685+1-2.065335+1	2.417363+1-1.700061+1	2.506510+1-1.478781+12722	3102	89
2.532040+1-2.420567+1	2.646717+1-1.195798+1	2.736020+1-1.055241+12722	3102	90
2.761394+1-1.017511+1	2.876072+1-8.681690+0	2.990749+1-7.477067+02722	3102	91
3.105426+1-6.499396+0	3.195020+1-5.863172+0	3.220103+1-5.686691+02722	3102	92
3.449458+1-4.358427+0	3.654020+1-3.508966+0	3.678812+1-3.416154+02722	3102	93
3.908167+1-2.691360+0	4.113030+1-2.207840+0	4.137521+1-2.154861+02722	3102	94
4.366875+1-1.728776+0	4.572030+1-1.436215+0	4.596229+1-1.402199+02722	3102	95
4.825584+1-1.119628+0	5.054938+1-8.973540-1	5.284293+1-7.221497-12722	3102	96
5.490040+1-5.968902-1	5.513647+1-5.827009-1	5.949040+1-3.708389-12722	3102	97
5.972356+1-3.612436-1	6.408050+1-2.152379-1	6.431064+1-2.082547-12722	3102	98
6.889773+1-9.432801-2	7.326050+1-2.166283-2	7.348482+1-1.783464-22722	3102	99
7.807191+1 4.739632-2	8.244060+1 9.047300-2	8.265899+1 9.259045-22722	3102	100
8.724607+1 1.297250-1	9.183315+1 1.551060-1	9.642023+1 1.713529-12722	3102	101
1.008010+2 1.801310-1	1.010073+2 1.808962-1	1.099810+2 2.043958-12722	3102	102
1.101815+2 2.048011-1	1.191610+2 2.164480-1	1.193557+2 2.166560-12722	3102	103
1.285299+2 2.218097-1	1.375210+2 2.198173-1	1.377041+2 2.198368-12722	3102	104
1.468783+2 2.184354-1	1.558810+2 2.133305-1	1.560524+2 2.133377-12722	3102	105
1.652266+2 2.123908-1	1.744008+2 2.092514-1	1.835750+2 2.044128-12722	3102	106
1.926020+2 1.983472-1	1.927492+2 1.982694-1	2.109620+2 1.868149-12722	3102	107
2.110976+2 1.867656-1	2.293220+2 1.789153-1	2.294459+2 1.788734-12722	3102	108
2.477943+2 1.718321-1	2.660420+2 1.635114-1	2.661426+2 1.634730-12722	3102	109
2.844910+2 1.560365-1	3.027630+2 1.479362-1	3.028393+2 1.479199-12722	3102	110
3.211877+2 1.437638-1	3.395361+2 1.392090-1	3.578845+2 1.343456-12722	3102	111
3.762030+2 1.292486-1	3.762328+2 1.292415-1	4.129230+2 1.200656-12722	3102	112
4.129295+2 1.200641-1	4.496262+2 1.112871-1	4.496440+2 1.112828-12722	3102	113
4.863229+2 1.051019-1	5.230196+2 9.867878-2	5.230840+2 9.866734-22722	3102	114
5.597163+2 8.057914-1	5.964130+2 7.848420-1	5.964130+2 7.875880-12722	3102	115
6.000000+2 8.210500-1	6.500000+2 7.674260-1	7.000000+2 7.218320-12722	3102	116
1.000000+3 5.493530-1	1.500000+3 4.297580-1	2.150000+3 3.480900-12722	3102	117
3.000000+3 2.685550-1	4.650000+3 1.945180-1	7.000000+3 1.473850-12722	3102	118
1.000000+4 1.174090-1	1.500000+4 9.161950-2	2.150000+4 7.403280-22722	3102	119
2.490000+4 6.790280-2	3.000000+4 5.921120-2	4.650000+4 4.429500-22722	3102	120
5.280000+4 4.054430-2	7.000000+4 2.815120-2	1.000000+5 2.007700-22722	3102	121
1.114000+5 1.811820-2	1.120000+5 1.802590-2	1.200000+5 1.519970-22722	3102	122
1.300000+5 1.367630-2	1.400000+5 1.254900-2	1.500000+5 1.159270-22722	3102	123
2.000000+5 8.580660-3	3.000000+5 5.921900-3	3.656000+5 5.039930-32722	3102	124
3.740000+5 4.809830-3	3.800000+5 4.681820-3	3.900000+5 4.504980-32722	3102	125
4.000000+5 4.377480-3	4.575000+5 3.828370-3	5.000000+5 3.480850-32722	3102	126
6.000000+5 2.964940-3	8.000000+5 2.422610-3	8.859000+5 2.286080-32722	3102	127
1.000000+6 2.119560-3	1.044100+6 2.078870-3	1.050000+6 2.074340-32722	3102	128
1.076000+6 1.955400-3	1.184000+6 1.769210-3	1.200000+6 1.751880-32722	3102	129
1.236000+6 1.710870-3	1.500000+6 1.312280-3	1.800000+6 1.058710-32722	3102	130
2.000000+6 9.483540-4	2.200000+6 8.620070-4	2.500000+6 7.689420-42722	3102	131
3.000000+6 6.774840-4	4.000000+6 5.924890-4	5.000000+6 5.430630-42722	3102	132
6.500000+6 4.781410-4	8.000000+6 3.783440-4	8.571000+6 3.486600-42722	3102	133
9.000000+6 3.281710-4	1.000000+7 2.837440-4	1.050000+7 2.648750-42722	3102	134
1.100000+7 2.513610-4	1.200000+7 2.454650-4	1.300000+7 2.765980-42722	3102	135
1.400000+7 7.168000-4	1.450000+7 8.259000-4	1.500000+7 9.204000-42722	3102	136
1.600000+7 1.021000-3	1.700000+7 1.017000-3	1.800000+7 9.658000-42722	3102	137
1.900000+7 9.074000-4	2.000000+7 8.599000-4	2722 3102	138	