

Data Correction to Mass Resolution

LIU Tingjin

China Nuclear Data Center, CIAE,

Beijing 102413, China

tjliu@iris.ciae.ac.cn

Introduction

Due to the mass resolution problem, the fission yield for each product nuclide measured by kinetic energy or double time of flight methods is not a real one, but a fold of the yields at this nuclide of Gaussian extension for all nuclides concerned. To get a real one, they must be corrected for the mass resolution.

1. Correction Method and Code

According to Schmitt^[1], the correction can be done with following formula:

$$Y_C(A) = Y_U(A) - \frac{\sigma^2}{2} \frac{d^2 Y_C(A)}{dA^2} \quad (1)$$

where Y_C , Y_U are the corrected and uncorrected yields respectively, and σ is the mass resolution, half width at half maximum(it was said in the paper that σ is full width, which is not correct).

To avoid the effect of the statistical fluctuation, the data were smoothed before correcting, fitted with 2 order function for each 5 data points

$$Y(A) = a + bA + cA^2 \quad (2)$$

and the yield of center point was taken as new yield at the corresponding mass A. For the first and last two data points, the fit values of the first and last 5 point fitting were taken.

The coefficients a , b , c were got from following equation group, which was deduced by least square method for each 5 data points:

$$\begin{aligned} \left(\sum_{i=n}^N w_i \right) a + \left(\sum_{i=n}^N w_i A_i \right) b + \left(\sum_{i=n}^N w_i A_i^2 \right) c &= \sum_{i=n}^N w_i Y_i \\ \left(\sum_{i=n}^N w_i A_i \right) a + \left(\sum_{i=n}^N w_i A_i^2 \right) b + \left(\sum_{i=n}^N w_i A_i^3 \right) c &= \sum_{i=n}^N w_i Y_i A_i \\ \left(\sum_{i=n}^N w_i A_i^2 \right) a + \left(\sum_{i=n}^N w_i A_i^3 \right) b + \left(\sum_{i=n}^N w_i A_i^4 \right) c &= \sum_{i=n}^N w_i Y_i A_i^2 \end{aligned} \quad (3)$$

Where $N=n+5$, $n=1,2,\dots,(M-4)$, M is the points of the data to be fitted.

The double differential of the function (2) to A is $2c$, so the equation (1) becomes

$$Y_C(A) = Y_U(A) - c\sigma^2 \quad (4)$$

The data were corrected with formula (4). σ is given according to the experimental condition, and usually, it is given by the author in the corresponding paper.

A code was developed. Instead of $Y_C(A)$, $Y_U(A)$ was used as 0 rank of approximation in the double differential, because $Y_C(A)$ was unknown. $Y_U(A)$ was smoothed and a_0 , b_0 , c_0 were obtained from equation group (3). By using coefficient c_0 , $Y_{C1}(A)$ was calculated from formula (4)

$$Y_{c1}(A) = Y_U(A) - c_0 \sigma^2 \quad (4')$$

Smoothing $Y_{c1}(A)$, coefficients a_1 , b_1 , c_1 were obtained from equation group (3), and using c_1 , $Y_{c2}(A)$ was calculated with formula (4'), and so on. Iteration was continued until it was convergent. In the code, it was defined as $\epsilon = (Y_{C_{n+1}}(A) - Y_{C_n}(A)) / Y_{C_n}(A) < 0.000001$ for all mass number A , which makes the $Y_{C_{n+1}}(A)$ and $Y_{C_n}(A)$ are completely in agreement within 5 effective figures.

2. Code Test

The method and code were tested. In Figs.1, 2 are shown the Zoller's data, including original, smoothed, and corrected one at 13 and 7 MeV respectively compared with the corresponding data measured with radiochemistry method by LI Ze^[2,3], LIU Congqui^[4], and Champan^[5]. The σ used in the correction are 3.3 and 3.675 respectively for 7 and 13 MeV, which were given by the author. It can be seen that the corrected data are basically in agreement within the error bar with the data measured by radiochemistry, for which there is no this kind of problem.

By using the code INTERP^[6], the corrected data(smoothed for 7 points) at 13 MeV were folded with Gaussian extension with $\sigma = 3.675$, which is the same as one in the measurement. The results should be the same as measured data. As shown in Fig.3, the folded data are in agreement with the measured ones very well, which proves the reliability of the method and code.

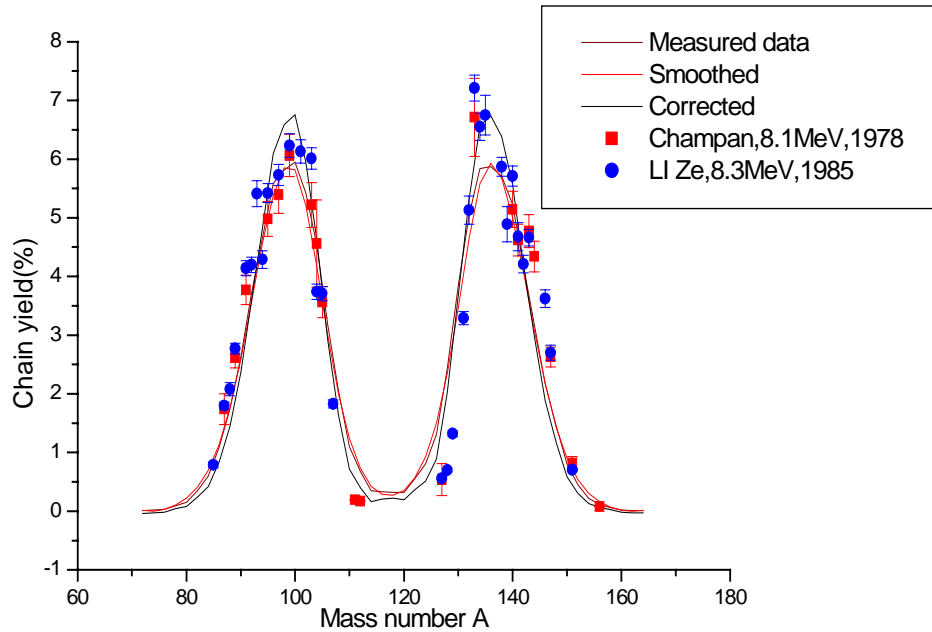


Fig.1 Comparison of corrected Zoller's data at 7 MeV with the data measured by radiochemistry method

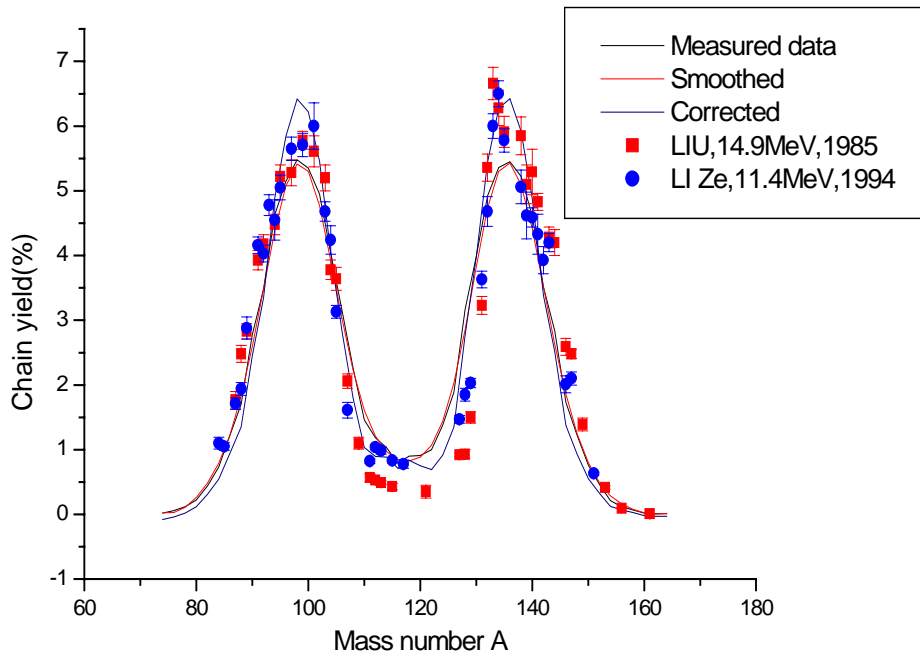


Fig.2 Comparison of corrected Zoller's data at 13 MeV with the data measured by radiochemistry method

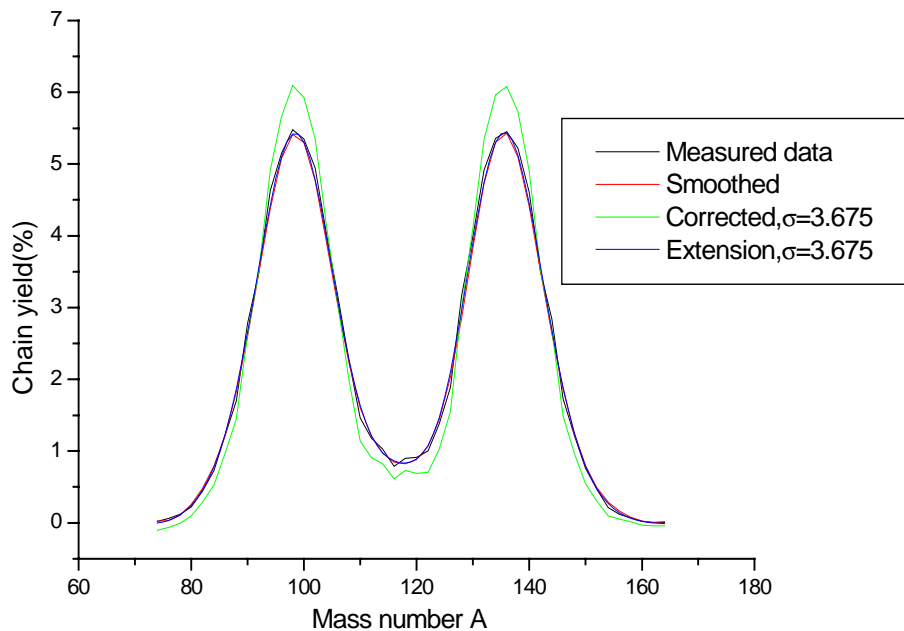


Fig.3 Comparison of corrected data extension with measured data at 13 MeV

3. Practical Correction

In the practical processing, it was found that the measured data are not smoothed enough with 5 points as shown in the equations. In this case, the iteration can not be convergent, and there are some unreasonable fluctuations for the corrected data, even wrong results appear with increasing the iteration times. To solve the problem, the

data can be smoothed two times, but it does not work sometimes. More efficient method is smoothing the data for 7 points, when $N=n+7$, and $n=1, 2, \dots, (M-6)$ in the equation group (3). Investigations show that in this way the iteration can be convergent and can give more reasonable corrected data(see Figs 1,2) for most of the data measured by Vives, Zoller and Hamilton, except for Zoller's data at 50 MeV(both post and pre neutron emission) . For the Zoller's data at 50 MeV, they were smoothed for 9 data points. In this case, the iteration was convergent and reasonable result was obtained. Attached data were corrected in this way, namely, first smoothed for 7(or 9) data points according to equation group (3), and then corrected according to equation (4).

In the correction, to what extent to smooth the data is key point. If the measured data are under smoothing (take less data points in the equation group (3)) for the statistical fluctuation, the iteration would not be convergent and there would be unreasonable structures for the corrected data. If the measured data are over smoothing (take more data points in the equation group (3)), the existed structures in physics may be wiped out. In our practical case, it is reasonable to take 7 data points for most of the measured data, and to take 9 data points for the measured data with larger fluctuation.

Reference

1. H. W. Schmitt et al, Phys. Rev., 137(4), 837 (1965) (EXFOR 13081002)
2. LI Ze et al, Chinese Nucl . Phys., 7(2), 97(1985)
3. LI Ze et al, Radiochimica Acta, 64, 95(1994)
4. LIU Conggui et al, Chinese Nucl. Phys7(3),235(1985)
5. T.C.Chapman, Phys. Rev. C17(3), 1089(1978)
6. LIU Tingjin, Internal document(2002)

Appendix The Corrected Data Measured by Vives, Zoller and Hamiltan

1.60 MeV, F.Vives(Geel),2000,NP A662
Pre-neutron emission

86

Mass A	Corrected	Error
7.5000E+01	-4.3656E-03	1.4209E-04
7.8000E+01	2.7388E-03	7.1044E-04
7.9000E+01	8.0673E-03	1.1367E-03
8.0000E+01	1.3395E-02	1.5630E-03
8.1000E+01	2.8005E-02	3.5522E-03
8.2000E+01	3.8401E-02	5.8256E-03
8.3000E+01	9.8707E-02	1.3498E-02
8.4000E+01	3.5164E-01	3.5664E-02
8.5000E+01	4.2392E-01	4.2484E-02
8.6000E+01	6.4248E-01	5.9961E-02
8.7000E+01	8.7907E-01	7.8575E-02
8.8000E+01	1.3097E+00	8.5573E-02
8.9000E+01	1.6787E+00	1.0880E-01
9.0000E+01	2.1215E+00	1.3289E-01
9.1000E+01	2.5971E+00	1.5878E-01
9.2000E+01	3.2447E+00	1.9235E-01
9.3000E+01	3.7560E+00	2.1665E-01
9.4000E+01	4.3424E+00	1.6532E-01
9.5000E+01	4.4360E+00	1.7193E-01
9.6000E+01	4.6361E+00	1.8528E-01
9.7000E+01	4.9172E+00	2.0013E-01
9.8000E+01	5.0394E+00	2.0603E-01
9.9000E+01	5.5539E+00	2.2414E-01
1.0000E+02	6.1263E+00	2.4283E-01
1.0100E+02	6.3753E+00	2.4865E-01
1.0200E+02	6.4716E+00	2.4574E-01
1.0300E+02	6.6572E+00	2.4404E-01
1.0400E+02	7.0271E+00	2.5185E-01
1.0500E+02	6.3598E+00	2.2620E-01
1.0600E+02	5.2813E+00	1.9615E-01
1.0700E+02	3.9937E+00	1.6454E-01
1.0800E+02	2.6459E+00	1.8511E-01
1.0900E+02	1.5191E+00	1.2138E-01
1.1000E+02	7.4444E-01	6.9268E-02
1.1100E+02	3.9131E-01	5.0583E-02
1.1200E+02	2.6189E-01	3.2964E-02
1.1300E+02	8.7609E-02	1.3783E-02
1.1400E+02	5.8556E-02	7.8149E-03

1.1500E+02	3.1986E-02	4.1206E-03
1.1600E+02	1.5134E-02	2.1313E-03
1.1700E+02	8.7290E-03	1.2788E-03
1.1800E+02	4.9015E-03	8.5253E-04
1.1900E+02	1.8036E-03	5.6835E-04
1.2000E+02	1.8036E-03	5.6835E-04
1.2100E+02	4.9015E-03	8.5253E-04
1.2200E+02	8.7290E-03	1.2788E-03
1.2300E+02	1.5134E-02	2.1313E-03
1.2400E+02	3.1986E-02	4.1206E-03
1.2500E+02	5.8556E-02	7.8149E-03
1.2600E+02	8.7609E-02	1.3783E-02
1.2700E+02	2.6189E-01	3.2964E-02
1.2800E+02	3.9131E-01	5.0583E-02
1.2900E+02	7.4444E-01	6.9268E-02
1.3000E+02	1.5191E+00	1.2138E-01
1.3100E+02	2.6459E+00	1.8511E-01
1.3200E+02	3.9937E+00	1.6454E-01
1.3300E+02	5.2813E+00	1.9615E-01
1.3400E+02	6.3598E+00	2.2620E-01
1.3500E+02	7.0271E+00	2.5185E-01
1.3600E+02	6.6572E+00	2.4404E-01
1.3700E+02	6.4716E+00	2.4574E-01
1.3800E+02	6.3753E+00	2.4865E-01
1.3900E+02	6.1263E+00	2.4283E-01
1.4000E+02	5.5539E+00	2.2414E-01
1.4100E+02	5.0394E+00	2.0603E-01
1.4200E+02	4.9172E+00	2.0013E-01
1.4300E+02	4.6361E+00	1.8528E-01
1.4400E+02	4.4360E+00	1.7193E-01
1.4500E+02	4.3424E+00	1.6532E-01
1.4600E+02	3.7560E+00	2.1665E-01
1.4700E+02	3.2447E+00	1.9235E-01
1.4800E+02	2.5971E+00	1.5878E-01
1.4900E+02	2.1215E+00	1.3289E-01
1.5000E+02	1.6787E+00	1.0880E-01
1.5100E+02	1.3097E+00	8.5573E-02
1.5200E+02	8.7907E-01	7.8575E-02
1.5300E+02	6.4248E-01	5.9961E-02
1.5400E+02	4.2392E-01	4.2484E-02
1.5500E+02	3.5164E-01	3.5664E-02
1.5600E+02	9.8707E-02	1.3498E-02
1.5700E+02	3.8401E-02	5.8256E-03
1.5800E+02	2.8005E-02	3.5522E-03
1.5900E+02	1.3395E-02	1.5630E-03
1.6000E+02	8.0673E-03	1.1367E-03
1.6100E+02	2.7388E-03	7.1044E-04
1.6400E+02	-4.3656E-03	1.4209E-04

5.5 MeV, F.Vives(Geel),2000,NP A662

Pre-neutron emission

106

Mass A	Corrected	Error
6.7000E+01	2.7711E-04	5.5385E-05

6.8000E+01	2.7711E-04	5.5385E-05
6.9000E+01	9.6940E-04	1.1077E-04
7.0000E+01	2.3540E-03	2.2154E-04
7.1000E+01	3.2430E-03	2.7692E-04
7.2000E+01	4.2099E-03	3.3231E-04
7.3000E+01	4.1060E-03	3.3231E-04
7.4000E+01	5.3387E-03	4.9846E-04
7.5000E+01	6.0832E-03	6.6462E-04
7.6000E+01	7.8019E-03	9.9693E-04
7.7000E+01	1.1983E-02	1.6062E-03
7.8000E+01	2.9070E-02	3.3785E-03
7.9000E+01	3.5724E-02	4.5416E-03
8.0000E+01	8.9406E-02	9.5262E-03
8.1000E+01	1.3484E-01	1.3791E-02
8.2000E+01	2.1427E-01	2.0825E-02
8.3000E+01	3.0298E-01	2.8523E-02
8.4000E+01	4.4530E-01	4.0597E-02
8.5000E+01	5.7356E-01	5.2671E-02
8.6000E+01	8.1798E-01	7.3053E-02
8.7000E+01	1.0490E+00	6.9203E-02
8.8000E+01	1.4099E+00	9.0554E-02
8.9000E+01	1.7439E+00	1.1082E-01
9.0000E+01	2.2224E+00	1.4003E-01
9.1000E+01	2.5176E+00	1.5781E-01
9.2000E+01	3.0491E+00	1.8485E-01
9.3000E+01	3.8910E+00	2.2580E-01
9.4000E+01	4.4983E+00	1.7056E-01
9.5000E+01	4.6434E+00	1.7817E-01
9.6000E+01	4.7660E+00	1.8919E-01
9.7000E+01	4.9223E+00	1.9955E-01
9.8000E+01	5.2338E+00	2.1104E-01
9.9000E+01	5.8253E+00	2.2946E-01
1.0000E+02	6.0551E+00	2.3503E-01
1.0100E+02	6.1702E+00	2.3860E-01
1.0200E+02	5.9899E+00	2.3001E-01
1.0300E+02	5.9916E+00	2.2533E-01
1.0400E+02	6.1456E+00	2.2531E-01
1.0500E+02	5.6174E+00	2.0346E-01
1.0600E+02	4.7795E+00	1.7945E-01
1.0700E+02	3.6097E+00	2.2065E-01
1.0800E+02	2.5537E+00	1.7218E-01
1.0900E+02	1.6316E+00	1.2046E-01
1.1000E+02	1.0536E+00	8.1873E-02
1.1100E+02	7.3045E-01	7.7096E-02
1.1200E+02	4.0852E-01	4.6357E-02
1.1300E+02	2.5812E-01	3.0295E-02
1.1400E+02	1.5572E-01	1.8000E-02
1.1500E+02	1.2397E-01	1.2794E-02
1.1600E+02	1.1322E-01	1.0523E-02
1.1700E+02	9.7121E-02	8.8062E-03
1.1800E+02	9.1891E-02	8.3631E-03
1.1900E+02	6.3970E-02	6.4246E-03
1.2000E+02	6.3970E-02	6.4246E-03
1.2100E+02	9.1891E-02	8.3631E-03

1.2200E+02	9.7121E-02	8.8062E-03
1.2300E+02	1.1322E-01	1.0523E-02
1.2400E+02	1.2397E-01	1.2794E-02
1.2500E+02	1.5572E-01	1.8000E-02
1.2600E+02	2.5812E-01	3.0295E-02
1.2700E+02	4.0852E-01	4.6357E-02
1.2800E+02	7.3045E-01	7.7096E-02
1.2900E+02	1.0536E+00	8.1873E-02
1.3000E+02	1.6316E+00	1.2046E-01
1.3100E+02	2.5537E+00	1.7218E-01
1.3200E+02	3.6097E+00	2.2065E-01
1.3300E+02	4.7795E+00	1.7945E-01
1.3400E+02	5.6174E+00	2.0346E-01
1.3500E+02	6.1456E+00	2.2531E-01
1.3600E+02	5.9916E+00	2.2533E-01
1.3700E+02	5.9899E+00	2.3001E-01
1.3800E+02	6.1702E+00	2.3860E-01
1.3900E+02	6.0551E+00	2.3503E-01
1.4000E+02	5.8253E+00	2.2946E-01
1.4100E+02	5.2338E+00	2.1104E-01
1.4200E+02	4.9223E+00	1.9955E-01
1.4300E+02	4.7660E+00	1.8919E-01
1.4400E+02	4.6434E+00	1.7817E-01
1.4500E+02	4.4983E+00	1.7056E-01
1.4600E+02	3.8910E+00	2.2580E-01
1.4700E+02	3.0491E+00	1.8485E-01
1.4800E+02	2.5176E+00	1.5781E-01
1.4900E+02	2.2224E+00	1.4003E-01
1.5000E+02	1.7439E+00	1.1082E-01
1.5100E+02	1.4099E+00	9.0554E-02
1.5200E+02	1.0490E+00	6.9203E-02
1.5300E+02	8.1798E-01	7.3053E-02
1.5400E+02	5.7356E-01	5.2671E-02
1.5500E+02	4.4530E-01	4.0597E-02
1.5600E+02	3.0298E-01	2.8523E-02
1.5700E+02	2.1427E-01	2.0825E-02
1.5800E+02	1.3484E-01	1.3791E-02
1.5900E+02	8.9406E-02	9.5262E-03
1.6000E+02	3.5724E-02	4.5416E-03
1.6100E+02	2.9070E-02	3.3785E-03
1.6200E+02	1.1983E-02	1.6062E-03
1.6300E+02	7.8019E-03	9.9693E-04
1.6400E+02	6.0832E-03	6.6462E-04
1.6500E+02	5.3387E-03	4.9846E-04
1.6600E+02	4.1060E-03	3.3231E-04
1.6700E+02	4.2099E-03	3.3231E-04
1.6800E+02	3.2430E-03	2.7692E-04
1.6900E+02	2.3540E-03	2.2154E-04
1.7000E+02	9.6940E-04	1.1077E-04
1.7100E+02	2.7711E-04	5.5385E-05
1.7200E+02	2.7711E-04	5.5385E-05

En=13(11.5–14.5)MeV, M. Zoeller, TU Darmstadt 1995
 Post-neutron emission

Mass A	Corrected	Error
7.4000E+01	-8.1187E-02	6.0000E-03
7.6000E+01	-4.1187E-02	1.2000E-02
7.8000E+01	1.8813E-02	1.7000E-02
8.0000E+01	1.1881E-01	2.3000E-02
8.2000E+01	3.0957E-01	3.2000E-02
8.4000E+01	5.4075E-01	4.1000E-02
8.6000E+01	9.4186E-01	5.3000E-02
8.8000E+01	1.3488E+00	6.3000E-02
9.0000E+01	2.4527E+00	8.1000E-02
9.2000E+01	3.3420E+00	9.0000E-02
9.4000E+01	4.8841E+00	1.0400E-01
9.6000E+01	5.8441E+00	1.1000E-01
9.8000E+01	6.4219E+00	1.1300E-01
1.0000E+02	6.2181E+00	1.1200E-01
1.0200E+02	5.4582E+00	1.0800E-01
1.0400E+02	4.0475E+00	9.7000E-02
1.0600E+02	2.8362E+00	8.6000E-02
1.0800E+02	1.7950E+00	7.3000E-02
1.1000E+02	1.0332E+00	5.8000E-02
1.1200E+02	8.9544E-01	5.3000E-02
1.1400E+02	8.8351E-01	4.9000E-02
1.1600E+02	7.1250E-01	4.3000E-02
1.1800E+02	8.3191E-01	4.6000E-02
1.2000E+02	7.5065E-01	4.6000E-02
1.2200E+02	6.9458E-01	4.8000E-02
1.2400E+02	9.1531E-01	5.7000E-02
1.2600E+02	1.3478E+00	6.7000E-02
1.2800E+02	2.7680E+00	8.6000E-02
1.3000E+02	3.9817E+00	9.7000E-02
1.3200E+02	5.4409E+00	1.0700E-01
1.3400E+02	6.2736E+00	1.1200E-01
1.3600E+02	6.4255E+00	1.1300E-01
1.3800E+02	5.9191E+00	1.1100E-01
1.4000E+02	4.8756E+00	1.0400E-01
1.4200E+02	3.3774E+00	9.1000E-02
1.4400E+02	2.5176E+00	8.2000E-02
1.4600E+02	1.3749E+00	6.4000E-02
1.4800E+02	9.2647E-01	5.3000E-02
1.5000E+02	5.5202E-01	4.2000E-02
1.5200E+02	3.2973E-01	3.3000E-02
1.5400E+02	1.2060E-01	2.2000E-02
1.5600E+02	6.6397E-02	1.7000E-02
1.5800E+02	2.9809E-02	1.3000E-02
1.6000E+02	-2.0191E-02	6.0000E-03
1.6200E+02	-3.0191E-02	3.0000E-03
1.6400E+02	-3.0191E-02	4.0000E-03

$E_n=20(18-22)$ MeV, M. Zoeller, TU Darmstadt 1995
Post-neutron emission

Mass A	Corrected	Error
7.4000E+01	-8.8686E-02	1.0000E-02

7.6000E+01	-3.8686E-02	1.5000E-02
7.8000E+01	-8.6862E-03	1.8000E-02
8.0000E+01	2.0131E-01	2.9000E-02
8.2000E+01	2.9589E-01	3.4000E-02
8.4000E+01	6.0174E-01	4.6000E-02
8.6000E+01	1.0079E+00	5.8000E-02
8.8000E+01	1.5159E+00	6.9000E-02
9.0000E+01	2.4023E+00	8.3000E-02
9.2000E+01	3.5812E+00	9.6000E-02
9.4000E+01	4.5505E+00	1.0400E-01
9.6000E+01	5.5173E+00	1.1000E-01
9.8000E+01	6.0553E+00	1.1400E-01
1.0000E+02	5.7786E+00	1.1200E-01
1.0200E+02	5.2153E+00	1.1000E-01
1.0400E+02	3.8440E+00	9.9000E-02
1.0600E+02	2.7515E+00	8.9000E-02
1.0800E+02	1.9950E+00	7.9000E-02
1.1000E+02	1.5075E+00	6.9000E-02
1.1200E+02	1.4368E+00	6.6000E-02
1.1400E+02	1.1806E+00	5.9000E-02
1.1600E+02	1.0338E+00	5.5000E-02
1.1800E+02	1.2503E+00	5.9000E-02
1.2000E+02	1.2416E+00	6.1000E-02
1.2200E+02	1.2858E+00	6.5000E-02
1.2400E+02	1.4537E+00	7.0000E-02
1.2600E+02	2.1264E+00	8.2000E-02
1.2800E+02	3.2068E+00	9.4000E-02
1.3000E+02	4.6837E+00	1.0600E-01
1.3200E+02	5.6061E+00	1.1100E-01
1.3400E+02	6.1981E+00	1.1400E-01
1.3600E+02	5.8150E+00	1.1100E-01
1.3800E+02	4.9785E+00	1.7000E-01
1.4000E+02	3.8589E+00	9.9000E-02
1.4200E+02	2.8917E+00	8.9000E-02
1.4400E+02	1.7922E+00	7.4000E-02
1.4600E+02	1.2367E+00	6.3000E-02
1.4800E+02	6.8348E-01	4.9000E-02
1.5000E+02	3.9955E-01	3.8000E-02
1.5200E+02	2.8095E-01	3.2000E-02
1.5400E+02	1.0621E-01	2.2000E-02
1.5600E+02	6.2059E-03	1.6000E-02
1.5800E+02	-5.3794E-02	1.0000E-02
1.6000E+02	-7.3794E-02	6.0000E-03

En=27.5(22-33)MeV, M.Zoeller, TU Darmstadt 1995
 Post-neutron emission

45

Mass A	Corrected	Error
7.2000E+01	-8.5067E-02	5.0000E-03
7.4000E+01	-6.5067E-02	6.0000E-03
7.6000E+01	-4.5067E-02	8.0000E-03
7.8000E+01	4.4933E-02	1.3000E-02

8.0000E+01	1.6800E-01	1.8000E-02
8.2000E+01	3.0940E-01	2.4000E-02
8.4000E+01	5.8619E-01	3.1000E-02
8.6000E+01	9.4302E-01	3.8000E-02
8.8000E+01	1.6845E+00	4.9000E-02
9.0000E+01	2.3728E+00	5.5000E-02
9.2000E+01	3.4702E+00	6.3000E-02
9.4000E+01	4.6021E+00	6.8000E-02
9.6000E+01	5.4842E+00	7.1000E-02
9.8000E+01	5.9471E+00	7.4000E-02
1.0000E+02	5.5870E+00	7.2000E-02
1.0200E+02	4.5363E+00	6.9000E-02
1.0400E+02	3.5806E+00	6.5000E-02
1.0600E+02	2.7268E+00	6.0000E-02
1.0800E+02	2.1787E+00	5.5000E-02
1.1000E+02	1.8433E+00	5.0000E-02
1.1200E+02	1.9328E+00	4.9000E-02
1.1400E+02	1.8091E+00	4.6000E-02
1.1600E+02	1.6767E+00	4.4000E-02
1.1800E+02	1.7591E+00	4.6000E-02
1.2000E+02	1.7005E+00	4.7000E-02
1.2200E+02	1.7104E+00	5.0000E-02
1.2400E+02	1.9321E+00	5.3000E-02
1.2600E+02	2.7520E+00	6.0000E-02
1.2800E+02	3.8176E+00	6.6000E-02
1.3000E+02	5.0083E+00	7.0000E-02
1.3200E+02	5.7124E+00	7.2000E-02
1.3400E+02	6.0344E+00	7.4000E-02
1.3600E+02	5.1890E+00	7.0000E-02
1.3800E+02	4.2780E+00	6.7000E-02
1.4000E+02	3.1285E+00	6.1000E-02
1.4200E+02	2.1739E+00	5.4000E-02
1.4400E+02	1.4309E+00	4.6000E-02
1.4600E+02	7.8122E-01	3.6000E-02
1.4800E+02	4.9249E-01	2.9000E-02
1.5000E+02	2.8354E-01	2.2000E-02
1.5200E+02	1.2776E-01	1.6000E-02
1.5400E+02	3.5269E-02	1.1000E-02
1.5600E+02	-2.4731E-02	8.0000E-03
1.5800E+02	-5.4731E-02	6.0000E-03
1.6000E+02	-7.4731E-02	4.0000E-03

En=27.5(22-33)MeV, M.Zoeller, TU Darmstadt 1995
Pre-neutron emission

45

Mass A	Corrected	Error
7.4000E+01	-8.2944E-02	6.0000E-03
7.6000E+01	-7.2944E-02	6.0000E-03
7.8000E+01	-1.2944E-02	1.1000E-02
8.0000E+01	6.7056E-02	1.4000E-02
8.2000E+01	2.3382E-01	2.0000E-02
8.4000E+01	3.6967E-01	2.5000E-02
8.6000E+01	6.6278E-01	3.2000E-02
8.8000E+01	1.0760E+00	4.0000E-02

9.0000E+01	1.7408E+00	4.8000E-02
9.2000E+01	2.4637E+00	5.5000E-02
9.4000E+01	3.3561E+00	6.1000E-02
9.6000E+01	4.3293E+00	6.6000E-02
9.8000E+01	5.0102E+00	6.9000E-02
1.0000E+02	5.5580E+00	7.2000E-02
1.0200E+02	5.2116E+00	7.0000E-02
1.0400E+02	4.4781E+00	6.8000E-02
1.0600E+02	3.6849E+00	6.5000E-02
1.0800E+02	2.8284E+00	5.9000E-02
1.1000E+02	2.2327E+00	5.5000E-02
1.1200E+02	1.8397E+00	5.0000E-02
1.1400E+02	1.8321E+00	4.8000E-02
1.1600E+02	1.7552E+00	4.6000E-02
1.1800E+02	1.7178E+00	4.5000E-02
1.2000E+02	1.8074E+00	4.6000E-02
1.2200E+02	1.8275E+00	4.8000E-02
1.2400E+02	1.7375E+00	4.9000E-02
1.2600E+02	2.0311E+00	5.3000E-02
1.2800E+02	2.6095E+00	5.8000E-02
1.3000E+02	3.4002E+00	6.3000E-02
1.3200E+02	4.1910E+00	6.6000E-02
1.3400E+02	5.0172E+00	7.0000E-02
1.3600E+02	5.4132E+00	7.1000E-02
1.3800E+02	5.3581E+00	7.1000E-02
1.4000E+02	4.5395E+00	6.7000E-02
1.4200E+02	3.7280E+00	6.3000E-02
1.4400E+02	2.7698E+00	5.7000E-02
1.4600E+02	1.9795E+00	5.1000E-02
1.4800E+02	1.3106E+00	4.3000E-02
1.5000E+02	7.4535E-01	3.4000E-02
1.5200E+02	4.7688E-01	2.8000E-02
1.5400E+02	2.7803E-01	2.2000E-02
1.5600E+02	1.1742E-01	1.6000E-02
1.5800E+02	7.4197E-03	1.2000E-02
1.6000E+02	-6.2580E-02	8.0000E-03
1.6200E+02	-8.2580E-02	6.0000E-03

En=50(45-55)MeV, M. Zoeller, TU Darmstadt 1995
 Post-neutron emission

43

Mass A	Corrected	Error
7.4000E+01	-2.4347E-01	1.2000E-02
7.6000E+01	-2.1347E-01	1.4000E-02
7.8000E+01	-9.3469E-02	2.1000E-02
8.0000E+01	4.6531E-02	2.6000E-02
8.2000E+01	3.5653E-01	3.6000E-02
8.4000E+01	6.0887E-01	4.3000E-02
8.6000E+01	1.0098E+00	5.2000E-02
8.8000E+01	1.6168E+00	6.1000E-02
9.0000E+01	2.4363E+00	7.1000E-02
9.2000E+01	3.2980E+00	7.8000E-02
9.4000E+01	4.1272E+00	8.4000E-02
9.6000E+01	4.8790E+00	8.9000E-02

9.8000E+01	5.2961E+00	9.2000E-02
1.0000E+02	4.9618E+00	9.0000E-02
1.0200E+02	4.3165E+00	8.7000E-02
1.0400E+02	3.7725E+00	8.5000E-02
1.0600E+02	3.2085E+00	8.1000E-02
1.0800E+02	2.7786E+00	7.8000E-02
1.1000E+02	2.6809E+00	7.7000E-02
1.1200E+02	2.5927E+00	7.5000E-02
1.1400E+02	2.5328E+00	7.4000E-02
1.1600E+02	2.6474E+00	7.5000E-02
1.1800E+02	2.5715E+00	7.5000E-02
1.2000E+02	2.6272E+00	7.6000E-02
1.2200E+02	3.0752E+00	8.1000E-02
1.2400E+02	3.4876E+00	8.3000E-02
1.2600E+02	4.0858E+00	8.6000E-02
1.2800E+02	4.6720E+00	8.8000E-02
1.3000E+02	5.2460E+00	9.1000E-02
1.3200E+02	5.1351E+00	9.1000E-02
1.3400E+02	4.5155E+00	8.6000E-02
1.3600E+02	3.6568E+00	8.1000E-02
1.3800E+02	2.6974E+00	7.4000E-02
1.4000E+02	2.0058E+00	6.7000E-02
1.4200E+02	1.1594E+00	5.5000E-02
1.4400E+02	7.5863E-01	4.6000E-02
1.4600E+02	5.1537E-01	3.9000E-02
1.4800E+02	3.1952E-01	3.2000E-02
1.5000E+02	8.7507E-02	2.2000E-02
1.5200E+02	-1.2493E-02	1.8000E-02
1.5400E+02	-9.2493E-02	1.2000E-02
1.5600E+02	-1.2249E-01	1.0000E-02
1.5800E+02	-1.6249E-01	5.0000E-03

En=50(45-55)MeV, M. Zoeller, TU Darmstadt 1995
Pre-neutron emission

43

Mass A	Corrected	Error
7.4000E+01	-1.7328E-01	9.0000E-03
7.6000E+01	-1.4328E-01	1.2000E-02
7.8000E+01	-5.3282E-02	1.7000E-02
8.0000E+01	2.6718E-02	2.1000E-02
8.2000E+01	2.2672E-01	2.9000E-02
8.4000E+01	4.6984E-01	3.7000E-02
8.6000E+01	7.0275E-01	4.4000E-02
8.8000E+01	1.0610E+00	5.2000E-02
9.0000E+01	1.6680E+00	6.2000E-02
9.2000E+01	2.3321E+00	7.0000E-02
9.4000E+01	3.0929E+00	7.6000E-02
9.6000E+01	3.8640E+00	8.1000E-02
9.8000E+01	4.4885E+00	8.5000E-02
1.0000E+02	4.9864E+00	8.9000E-02
1.0200E+02	4.7515E+00	8.8000E-02
1.0400E+02	4.1770E+00	8.5000E-02
1.0600E+02	3.6036E+00	8.2000E-02
1.0800E+02	3.1305E+00	8.0000E-02

1.1000E+02	2.9357E+00	7.9000E-02
1.1200E+02	2.5005E+00	7.4000E-02
1.1400E+02	2.5540E+00	7.4000E-02
1.1600E+02	2.5407E+00	7.3000E-02
1.1800E+02	2.4543E+00	7.2000E-02
1.2000E+02	2.5572E+00	7.3000E-02
1.2200E+02	2.5678E+00	7.4000E-02
1.2400E+02	2.5716E+00	7.5000E-02
1.2600E+02	2.9936E+00	7.9000E-02
1.2800E+02	3.2714E+00	8.1000E-02
1.3000E+02	3.8318E+00	8.4000E-02
1.3200E+02	4.3261E+00	8.6000E-02
1.3400E+02	4.8502E+00	8.9000E-02
1.3600E+02	4.8721E+00	8.8000E-02
1.3800E+02	4.3244E+00	8.4000E-02
1.4000E+02	3.6796E+00	8.0000E-02
1.4200E+02	2.7988E+00	7.3000E-02
1.4400E+02	2.1717E+00	6.8000E-02
1.4600E+02	1.3850E+00	5.7000E-02
1.4800E+02	9.5207E-01	4.9000E-02
1.5000E+02	5.9871E-01	4.2000E-02
1.5200E+02	3.1871E-01	3.5000E-02
1.5400E+02	3.8708E-02	2.6000E-02
1.5600E+02	-7.1292E-02	2.1000E-02
1.5800E+02	-2.0129E-01	1.4000E-02

En=99.5(89-110)MeV, M. Zoeller, TU Darmstadt 1995
Post-neutron emission

22

Mass A	Corrected	Error
7.2000E+01	-2.0552E-01	8.0000E-03
7.6000E+01	-4.5517E-02	1.5000E-02
8.0000E+01	3.3448E-01	2.5000E-02
8.4000E+01	8.5448E-01	3.4000E-02
8.8000E+01	1.8984E+00	4.5000E-02
9.2000E+01	3.0114E+00	5.4000E-02
9.6000E+01	3.9480E+00	6.0000E-02
1.0000E+02	4.2092E+00	6.1000E-02
1.0400E+02	4.0797E+00	6.2000E-02
1.0800E+02	3.6745E+00	6.1000E-02
1.1200E+02	3.4607E+00	6.0000E-02
1.1600E+02	3.5163E+00	6.0000E-02
1.2000E+02	3.7913E+00	6.1000E-02
1.2400E+02	4.0852E+00	6.1000E-02
1.2800E+02	4.2197E+00	6.1000E-02
1.3200E+02	3.7421E+00	5.8000E-02
1.3600E+02	2.7628E+00	5.2000E-02
1.4000E+02	1.6053E+00	4.2000E-02
1.4400E+02	6.8261E-01	3.1000E-02
1.4800E+02	1.9261E-01	2.2000E-02
1.5200E+02	-9.7387E-02	1.4000E-02
1.5600E+02	-2.3739E-01	7.0000E-03

En=99.5(89-110)MeV, M. Zoeller, TU Darmstadt 1995

Pre-neutron emission

23

Mass A	Corrected	Error
7.6000E+01	-2.8248E-02	1.3000E-02
8.0000E+01	2.1175E-01	2.0000E-02
8.4000E+01	6.3175E-01	2.9000E-02
8.8000E+01	1.3118E+00	3.9000E-02
9.2000E+01	2.3326E+00	5.6000E-02
9.6000E+01	3.2846E+00	5.5000E-02
1.0000E+02	3.9707E+00	5.9000E-02
1.0400E+02	3.9677E+00	6.0000E-02
1.0800E+02	3.7210E+00	5.9000E-02
1.1200E+02	3.4096E+00	5.9000E-02
1.1600E+02	3.0072E+00	5.4000E-02
1.2000E+02	3.0421E+00	5.4000E-02
1.2400E+02	3.3736E+00	5.5000E-02
1.2800E+02	3.6973E+00	5.5000E-02
1.3200E+02	4.1599E+00	5.7000E-02
1.3600E+02	3.9426E+00	5.6000E-02
1.4000E+02	3.1060E+00	5.1000E-02
1.4400E+02	1.8613E+00	4.2000E-02
1.4800E+02	9.0736E-01	3.2000E-02
1.5200E+02	2.6474E-01	2.2000E-02
1.5600E+02	-4.5258E-02	1.4000E-02
1.6000E+02	-1.8526E-01	9.0000E-03
1.6400E+02	-2.5526E-01	4.0000E-03

En=160(145-175)MeV, M. Zoeller, TU Darmstadt 1995
Post-neutron emission

23

Mass A	Corrected	Error
6.8000E+01	-3.0476E-01	8.0000E-03
7.2000E+01	-2.2476E-01	1.4000E-02
7.6000E+01	-2.4760E-02	2.2000E-02
8.0000E+01	3.2524E-01	3.2000E-02
8.4000E+01	1.0449E+00	4.5000E-02
8.8000E+01	2.0899E+00	5.8000E-02
9.2000E+01	2.9734E+00	6.6000E-02
9.6000E+01	3.8538E+00	7.2000E-02
1.0000E+02	4.2049E+00	7.5000E-02
1.0400E+02	4.1260E+00	7.6000E-02
1.0800E+02	3.9231E+00	7.7000E-02
1.1200E+02	3.6277E+00	7.6000E-02
1.1600E+02	3.6762E+00	7.6000E-02
1.2000E+02	4.1773E+00	7.8000E-02
1.2400E+02	4.1455E+00	7.5000E-02
1.2800E+02	4.0944E+00	7.4000E-02
1.3200E+02	3.3158E+00	6.8000E-02
1.3600E+02	2.5413E+00	6.3000E-02
1.4000E+02	1.3981E+00	5.0000E-02
1.4400E+02	5.5866E-01	3.8000E-02
1.4800E+02	5.8658E-02	2.5000E-02
1.5200E+02	-1.8134E-01	1.7000E-02
1.5600E+02	-2.8134E-01	1.1000E-02

En=160(145–175)MeV, M. Zoeller, TU Darmstadt 1995
 Pre-neutron emission

24

Mass A	Corrected	Error
7.2000E+01	-2.0709E-01	1.2000E-02
7.6000E+01	-7.7090E-02	1.9000E-02
8.0000E+01	1.7291E-01	2.7000E-02
8.4000E+01	6.4291E-01	3.8000E-02
8.8000E+01	1.4476E+00	5.0000E-02
9.2000E+01	2.4261E+00	6.1000E-02
9.6000E+01	3.1215E+00	6.6000E-02
1.0000E+02	3.8070E+00	7.2000E-02
1.0400E+02	3.9391E+00	7.4000E-02
1.0800E+02	3.9100E+00	7.5000E-02
1.1200E+02	3.6483E+00	7.5000E-02
1.1600E+02	3.3601E+00	7.3000E-02
1.2000E+02	3.5156E+00	7.4000E-02
1.2400E+02	3.9487E+00	7.6000E-02
1.2800E+02	3.8529E+00	7.3000E-02
1.3200E+02	3.9153E+00	7.3000E-02
1.3600E+02	3.2602E+00	6.7000E-02
1.4000E+02	2.5113E+00	6.2000E-02
1.4400E+02	1.5848E+00	5.2000E-02
1.4800E+02	7.6064E-01	4.0000E-02
1.5200E+02	2.5773E-01	2.9000E-02
1.5600E+02	-3.2273E-02	2.0000E-02
1.6000E+02	-1.7227E-01	1.3000E-02
1.6400E+02	-2.5227E-01	7.0000E-03

Ep=20.0 MeV, J.H. Hamilton, Aysto97–Aysto(1997)
 Pre-neutron emission mass yields

45

Mass A	Corrected	Error
7.4000E+01	1.3213E-02	3.0000E-03
7.6000E+01	4.3213E-02	4.8000E-03
7.8000E+01	1.1321E-01	9.0000E-03
8.0000E+01	2.6321E-01	1.8000E-02
8.2000E+01	3.7720E-01	2.5200E-02
8.4000E+01	8.5018E-01	5.4000E-02
8.6000E+01	1.3005E+00	4.0500E-02
8.8000E+01	1.8684E+00	5.7000E-02
9.0000E+01	2.5026E+00	7.5000E-02
9.2000E+01	3.0692E+00	9.0900E-02
9.4000E+01	3.5568E+00	1.0500E-01
9.6000E+01	3.9114E+00	1.1490E-01
9.8000E+01	4.0863E+00	4.0000E-02
1.0000E+02	4.0584E+00	1.1940E-01
1.0200E+02	3.8858E+00	1.1490E-01
1.0400E+02	3.6153E+00	1.0740E-01
1.0600E+02	3.2262E+00	9.6600E-02
1.0800E+02	2.8163E+00	8.4900E-02
1.1000E+02	2.4921E+00	7.5600E-02
1.1200E+02	2.1642E+00	6.6000E-02

1.1400E+02	1.9428E+00	5.9400E-02
1.1600E+02	1.7945E+00	5.4900E-02
1.1800E+02	1.7675E+00	5.4000E-02
1.2000E+02	1.7681E+00	5.4000E-02
1.2200E+02	1.7855E+00	5.4600E-02
1.2400E+02	1.9128E+00	5.8500E-02
1.2600E+02	2.1431E+00	6.5400E-02
1.2800E+02	2.3986E+00	7.2900E-02
1.3000E+02	2.7831E+00	8.4000E-02
1.3200E+02	3.1944E+00	9.5700E-02
1.3400E+02	3.5841E+00	1.0650E-01
1.3600E+02	3.8545E+00	1.1400E-01
1.3800E+02	4.0264E+00	1.1850E-01
1.4000E+02	4.0841E+00	4.0000E-02
1.4200E+02	3.9308E+00	1.1550E-01
1.4400E+02	3.6108E+00	1.0650E-01
1.4600E+02	3.1379E+00	9.3000E-02
1.4800E+02	2.5541E+00	7.6500E-02
1.5000E+02	1.9560E+00	5.9400E-02
1.5200E+02	1.3805E+00	4.2600E-02
1.5400E+02	8.9311E-01	5.6400E-02
1.5600E+02	5.3157E-01	3.4800E-02
1.5800E+02	2.8157E-01	1.9800E-02
1.6000E+02	1.3157E-01	1.0800E-02
1.6200E+02	5.1569E-02	6.0000E-03

Ep=60.0 MeV, J.H. Hamilton, Aysto97–Aysto(1997)
Pre-neutron emission mass yields

45

Mass A	Corrected	Error
7.4000E+01	3.8586E-02	6.0000E-03
7.6000E+01	6.8586E-02	7.8000E-03
7.8000E+01	1.5859E-01	1.3200E-02
8.0000E+01	3.3859E-01	2.4000E-02
8.2000E+01	5.5845E-01	3.7200E-02
8.4000E+01	9.4303E-01	3.0000E-02
8.6000E+01	1.3767E+00	4.2600E-02
8.8000E+01	1.8655E+00	5.6400E-02
9.0000E+01	2.3591E+00	7.0200E-02
9.2000E+01	2.8059E+00	8.2500E-02
9.4000E+01	3.1470E+00	9.2100E-02
9.6000E+01	3.3615E+00	9.8400E-02
9.8000E+01	3.4681E+00	1.0200E-01
1.0000E+02	3.4790E+00	1.0290E-01
1.0200E+02	3.4418E+00	1.0230E-01
1.0400E+02	3.3978E+00	1.0140E-01
1.0600E+02	3.2833E+00	9.8400E-02
1.0800E+02	3.1902E+00	9.6000E-02
1.1000E+02	3.0813E+00	9.3000E-02
1.1200E+02	3.0302E+00	9.1500E-02
1.1400E+02	3.0167E+00	9.0900E-02
1.1600E+02	3.0332E+00	9.1200E-02
1.1800E+02	3.0345E+00	9.1200E-02
1.2000E+02	3.0193E+00	9.0900E-02

1.2200E+02	3.0221E+00	9.1200E-02
1.2400E+02	3.0398E+00	9.1800E-02
1.2600E+02	3.1670E+00	9.5400E-02
1.2800E+02	3.2177E+00	9.6600E-02
1.3000E+02	3.3614E+00	1.0050E-01
1.3200E+02	3.4156E+00	1.0170E-01
1.3400E+02	3.4622E+00	1.0260E-01
1.3600E+02	3.4617E+00	1.0200E-01
1.3800E+02	3.4187E+00	1.0020E-01
1.4000E+02	3.2488E+00	9.5100E-02
1.4200E+02	2.9121E+00	8.5500E-02
1.4400E+02	2.5314E+00	7.5000E-02
1.4600E+02	2.0499E+00	6.1500E-02
1.4800E+02	1.5674E+00	4.8000E-02
1.5000E+02	1.1270E+00	3.5400E-02
1.5200E+02	7.2412E-01	4.6800E-02
1.5400E+02	4.4995E-01	3.0000E-02
1.5600E+02	2.5472E-01	1.8000E-02
1.5800E+02	1.3472E-01	1.0800E-02
1.6000E+02	5.4722E-02	6.0000E-03
1.6200E+02	4.7218E-03	3.0000E-03