The Evaluation of the Mass Distribution Data for ^{238}U, ^{239}Pu and ^{242}Pu Fission

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1. Introduction

In order to meet the requirement for fission product yield data for transmutation of minor actinide nuclear waste in reactor and accelerator driven systems, a CRP was initiated four yeas ago. Since then, great progress has been made in the development of calculation methods and corresponding computer codes, including microscopic theoretical models, phenomenological models and systematics in the incident particle energy range 1-200 MeV. In order to test the prediction capability and reliability of these models and codes, and to enable realistic uncertainty estimates for the calculated yields, a benchmark exercise was designed during the last (third) RCM in November 2001. In the first part of this exercise, calculations of fission yields will be performed for defined sets of fission reactions where many experimental data are available, and the results will be compared with evaluated experimental yield data from the present evaluation, which has been conducted as part of the benchmark exercise in order to test the models.

The yield data were evaluated according to the requirement of the benchmark exercise defined at the RCM. In fact, they comprise all main available sets of measured mass distribution data for ^{238}U, $^{239, 242}Pu$ neutron induced fission in the energy range up to 200 MeV.

For the mass distribution, the following fission yield definitions are relevant, which have been decided at the previous CRP on fission yield evaluation:. The **"cumulative yield"** is the total number of atoms of a specific nuclide produced (directly and via decay of precursors) in 100 fission reactions. The **"chain yield"** is the (sum of) cumulative yield(s) of the last stable or long-lived chain member(s). The **"mass (number) yield"** is the sum of all independent yields of a given mass chain. (The "independent yield" is the number of atoms of a specific nuclide produced directly - without decay of precursors - in 100 fission reactions). The difference between chain yield and mass yield for a mass chain is that the former is defined after, and the latter before delayed neutron emission. In measurements of mass distributions by recording prompt fission fragments, one has to distinguish between "Pre" and "Post" neutron emission data - in this case: prompt neutrons emitted from the compound nucleus and moving fragments by evaporation of neutrons before and after scission.

In this paper, the mass distribution data for ^{238}U at E_n=1.5, 5.5, 8.3,11.3, 14.9, 22.0, 27.5, 50.0, 99.5, 160.0 MeV, E_p=20.0, 60.0 MeV, for ^{239}Pu at E_n=0.17, 7.9, 14.5 MeV and for ^{242}Pu at E_n=15.1 MeV were evaluated based on experimental data available up to now.

1. Data Collection and Selection

The sources of experimental data were CRP participants, the EXFOR Library and the open literature. Valuable data were received from members of the CRP, which were not yet compiled into the EXFOR library or published, including the data of F. Vives, C.M. Zöller, J.H. Hamilton and I. Winkelman for ^{238}U and ^{242}Pu respectively.

As mentioned above, the mass distribution data may be classified as "chain yields", "cumulative yields" and "fragment mass yields". At the start of the evaluation, all types of yield data, even "pre-neutron-emission" yields, were collected for later analysis. More than 200 subentries were retrieved from the EXFOR Master Library.

Also some important data, which were not yet compiled into the EXFOR Library, were collected from the publications, including Liu Conggui's and Liu Yonghui's data, the latter were just published in 'Communication of Nuclear Data Progress' No. 26, December 2001.

The data were selected for the evaluation according to the following criteria:

a. As the aim of this work is to produce evaluated "mass distributions", such measurements were primarily selected which cover a greater part of the mass distributions. Only in cases where such data sets are not available, measurements including smaller numbers of fission products were used.

b. According to the yield definitions, only "chain yield" or "mass yield" data should be used for the evaluation of mass distributions. But if there are no such data available, "cumulative yields" were also used. In this case, only such cumulative yields were considered, where the differences to the corresponding chain yields are within the experimental error bars.

c. More recent data obtained with more reliable measurement methods were given higher weight. If there are several data sets available, older data from measurements employing outdated methods were not considered.

d. In case there are not enough experimental data available, some primary yield data (marked "PRE,FY" in the EXFOR library) were also taken to start with., and their actual use in the evaluation process was decided after an analysis of the data and comparison with other data.

2. Data Analyses and Evaluation

In the following, information is given on the data that fulfill the above criteria and were selected for the final evaluation. For each data set, a brief description of the measurement is given in the first paragraph, followed by the treatment of the data in the evaluation. We distinguish between two types of measurements:

In **type 1** measurements, prompt fission fragments are recorded simultaneously and directly, and cover practically the complete range of the mass distribution. There is no difference in the systematic error among the measured fragments, the main error being statistical. Due the limited mass resolution, the measured fragment mass yield has a Gaussian distribution (with a width of several mass units) that extends over several 'mass bins'. In other words: each 'mass bin' contains contributions from the Gaussians of several fragment masses. Measurement of this type are numbers 1) 2) and 9) described below.

In **type 2** measurements, radiation emitted by fission products (after prompt, and generally also after delayed neutron emission) is measured individually at given times after irradiation of the fissioning sample to deduce the fission yields. In these measurements, not only the fission products considered but also their precursors have decayed, for which corrections have to be made. Here we are only interested in "cumulative" yields. The significant differences to type 1 measurements are: (1) Due to half-life limitations and/or the absence of measurable radiation, only a limited part of the mass distribution can be measured. (2) There is no mass resolution problem. (3)

As the fission products are measured individually, and corrections of varying accuracy are made, the possible systematic errors are different in nature and magnitude. All other experiments described below are of this type.

1) F.Vives et al[1] The pre-neutron-emission fission fragment mass, kinetic energy and angular distributions were measured with a double Frisch-gridded ionization chamber. The ^{238}U samples were mounted in the center of the common cathode. The information about the fission fragment properties was obtained from the anode and the sum of the anode and grid signals of the ionization chamber. The kinetic energy of the fission fragments was obtained from the anode signal, whereas the emission angle was provided by the sum signal. The mass resolution of the chamber was about 2 mass units. Mono-energetic neutrons were produced by a Van de Graaff Accelerator in the energy range from 1.2 to 5.8 MeV through different neutron source reactions. The data were corrected for prompt neutron emission to get the pre-neutron-emission mass distribution.

The numerical data, which are not given in the publication, were provided by Dr. M. Duijvestijn[2]. The pre-neutron-emission fragment mass distribution data at E_n=1.6, 5.5 MeV were selected for the evaluation. The data were renormalized to 200% (originally, they were normalized to 100%). As the authors give no errors, they were assigned according to the method used and an estimation from the figure in the paper (Fig.9) as: 2% for yields≥4%, 6% for yields <4% and ≥1%, and 8% for yields<1%.

2) **C.M.Zöller**[3] The measurements were performed with the LANL spallation neutron source WNR, fed by 800 MeV protons from the LAMPF accelerator. The fragments were identified by a double energy measurement, using 38 silicon PIN diodes assembled to two detector arrays of 171cm^2 area each. Corrections were made for detector pulse-height defect, energy losses in target material and backing, and for linear momentum transferred to the compound nucleus. Corrections were also made to take into account the average mass losses of both the compound nucleus and the fragments by evaporation of neutrons prior to and after scission to get pre-neutron emission mass distributions. The mass resolution is 3.5 mass units at 13 MeV neutron energy and 4 mass units at 22 MeV. The fragment mass and kinetic energy distributions for ^{238}U were measured in the energy range from 2.0 to 450 MeV.

This is the same kind of measurement and has the same advantage and disadvantage as that of F.Vives. In addition, this measurement was performed with a white neutron source, not mono-energetic neutrons, so, in fact, the data were averaged over given energy bins, weighted with the corresponding neutron spectra in the bins.

The pre- and post-neutron-emission fragment mass distributions at 13(11.5-14.5), 20(18-22), 27.5(22-33), 50(45-55), 99.5(89-110), 160(145-175) MeV neutron energy were selected. The numerical values were provided by Dr. M. Duijvestijn[2]. The data at 5.0(4.5-6.5) MeV (taken from Zöller's thesis[3]) were not used in the evaluation, but included in the comparison of yield data (Fig.17).

3) **S.Nagy**[4] The chain yields for 44 mass chains were determined by direct γ-spectrometry with a Ge(Li) detector, or by radiochemical separation of the fission products followed by β-counting and/or γ-spectrometry. The data were measured absolutely by recording the fission rates and normalizing the yield curve to 200%. The mono-energy neutrons at 1.5, 2.0, 3.9, 5.5, 6.9, and 7.7 MeV were produced through ^{7}Li(p,n) and D(d,n) reactions with ANL Fast Neutron Generator.

The data at neutron energy 1.5 and 5.5 MeV were used. The yield of mass number 107 at E_n=1.5 MeV was discarded as the value is too small and not consistent with others.

4) **T.C.Chapman**[5] Cumulative yields from $^{235, 238}$U fission at 6.0, 7.1, 8.1, 9.1

MeV neutron energy were determined by the radiochemical separation method followed by β-counting and γ-spectrometry with a Ge(Li) detector. The neutrons were produced by the D(d,n) reaction with a Van de Graaff Accelerator.

The data at E_n=8.1 MeV were selected. As cumulative yields were measured, the yields of 7 fission products, whose difference to the corresponding chain yields are lager than the experimental errors, were not used. The data for mass 137 (apparently there is something wrong) and 142 (too large error) were also discarded.

5) **Li Ze**[6,7] Over 30 chain yields for ^{238}U fission were determined by direct γ-spectrometry with a HPGe detector, or by radiochemical separation of the fission products followed by β-counting and/or γ-spectrometry. Absolute yields were obtained by recording the fission rates. The measurements were performed at neutron energies of 8.3[6] and 11.3[7] MeV at CIAE Cyclotron and Tandem Accelerator respectively. Corrections were made for the recorded β- or γ-spectra and for the difference between the measured cumulative yield and corresponding chain yield.

Both sets of data were used. The yields at 11.3 MeV were taken from [7]. For the yields of 5 mass numbers, which were determined by both methods, a weighted average was taken.

6) **Liu Conggui**[8] The mass distribution for 14.9 MeV neutron induced fission of ^{238}U was determined by direct γ-spectrometry with a Ge(Li) detector. Absolute yields were obtained by recording the fission rates with a double ionization chamber. 39 chain yields and 1 cumulative yield were determined in the mass region A=84-151. Among them, 13 yields were measured relative to the yields of ^{132}Te or ^{140}Ba. A fine structure was observed in the vicinity of mass number 134.

The data were used and taken from the paper. The yield for ^{130}Sb is cumulative and is not equal to the corresponding chain yield; therefore it was discarded.

7) **S.Daroczy**[9] Cumulative yields for 14.5 MeV neutron induced fission of ^{238}U (relative to ^{27}Al(n,α), and ^{62}Cu(n,2n) reactions) was determined by direct γ-spectrometry with a Ge(Li) detector. Three sets of separately measured data are given, and weighted averages were taken. To deduce chain yields, the averaged data were corrected using charge distribution data and branching ratios for the formation of the measured nuclides from β-decay of their precursors.

The obtained chain yield data were used in the evaluation.

8) **Liu Yonghu**i[10] 32 chain yields were determined for ^{238}U fission induced by 22 MeV neutrons, which were produced by the T(d,n) reaction with CIAE HI-13 Tandem. The product activities were determined by direct γ-spectrometry with a HPGe detector. The absolute fission rate was monitored with a double-fission chamber. Yields at this neutron energy were measured for the first time.

The data were used, but the yield of mass number 128 was discarded because of its too large error (checked with the author).

9) **J.H.Hamilton**[11] The pre-neutron emission fragment mass distribution from ^{238}U proton induced fission was measured at E_p=20.0, 60.0 MeV by recording prompt fission fragments. The mass resolution for the recording of fragments is about 4 mass units. The main error is the statistical one, which was, however, not given by the author.

The relative errors were assigned as: 1% for yields≥4%, 3% for yields <4% and ≥1%, and 5% for yields<1%. The numerical data were provided by Dr. M.C.Duijvestijn[2] and were used.

10) **J.E.Gindler**[12] Absolute cumulative yields for ^{239}Pu fission at 0.17, 1.0, 2.0, 3.4, 4.5, 6.1, 7.9 MeV neutron energy were determined by direct γ-spectrometry with a Ge(Li) detector, and by radiochemical separation of the fission products followed by

β-counting with a proportional counter. The neutrons were produced with ANL Fast Neutron Generator through 7Li(p,n) reaction for neutron energy less than 5 MeV and D(d,n) reaction for E_n larger than 5 MeV. The nuclides measured are not so many, but the data are only ones available in this energy range.

The data at neutron energy E_n=0.17, 7.9 MeV were selected. Only such yields were used, whose differences with the corresponding chain yields are smaller than the experimental error. As a result, the yields of 4 nuclides at E_n=0.17 MeV and 3 at E_n=7.9 MeV were discarded. The data table was processed to required format.

11) **G.P.Ford**[13] Relative cumulative yields from the 14 MeV neutron induced fission of ^{239}Pu were measured using the radiochemistry method. The ^{99}Mo cumulative yield from ^{239}Pu fission or the corresponding cumulative yield from ^{235}U fission was used as reference yields. The 14 MeV neutrons were produced by the T(d,n) reaction with Cockcroft-Walton Accelerator.

In this paper[13] there are two sets of data given, measured by the same method and at same neutron energy but for different product nuclides (except ^{111}Ag), which are compiled in different EXFOR entries. The two sets of data were combined, and the data for ^{111}Ag were arithmetically averaged. There are no errors given by the author. Considering the (radiochemical) method employed and the age of the measurement (1976), and also taking into account the error given by the author for the R-values, the relative errors were assigned as 10% for all product nuclides. The data tables were processed to required format.

12) **J.Laurec**[14] The cumulative yields from $^{233,\ 235,\ 238}$U and ^{239}Pu fission induced by fission spectrum and 14.7 MeV neutrons were measured by the radiochemical method. The γ-spectra were measured with a Ge(Li) detector and the number of fissions was determined with a plane ionization chamber.

The data for ^{239}Pu fission at 14.9 MeV were used. Although the measured yields are cumulative ones, the differences between them and the chain yields are all within the experimental errors. So all data were used except for ^{136}Xe, whose yield is too small and possibly wrong.

13) **I.Winkelmann**[15] The cumulative yields from ^{242}Pu fission induced by 15.1 MeV neutrons were measured for 65 fission products from ^{85}Kr to ^{151}Pm. The fission product activities were measured by direct γ-spectrometry with a Ge(Li) detector, as well as chemical separation of the fission product elements Pd, Ag, Cd, Sn, Sb and Ce followed by β-counting or γ-spectrometry. The chain yields of 43 mass chains were obtained by dividing the measured cumulative yields by a correction factor, which is the ratio of cumulative yield of the measured product nuclide to the corresponding chain yield.

The data were used after the following procedures were applied:

a. Some chain yields were obtained from 2 or more than 2 cumulative yields. In this case, the recommended chain yield was taken as their weighted average.

b. Two yield data were not used: that of ^{126g}Sb because it is an independent yield and of ^{111m}Pm as it is only a partial isomeric yield.

c. The data of product nuclides ^{130g}Sb, ^{131}Sb and ^{131m}Te were also discarded. The chain yields deduced from the cumulative yields of these nuclides are too small. The fractions of the measured cumulative yields to the corresponding chain yields are too small, which could introduce large error into the obtained chain yields. In addition, there are large differences for the correction factors of these nuclides between the values given in the paper and calculated by us with the data from ENDF/B-6.

3. Results, Recommendations and Discussion

Based on the data selected from the collected available experimental data, and after their evaluation and processing as described above, the following evaluated mass distribution data for ^{238}U, $^{239, 242}Pu$ fission are recommended as shown in Table 1.

Table 1 Recommended evaluated mass distribution data

Fissile nuclide	Energy point (MeV)	Data(author)	Ref.	Data type
^{238}U	E_n around 1.5	Vives(1.6), Nagy(1.5)	1, 4	1, 2
	E_n at 5.5	Vives, Nagy	1, 4	1, 2
	E_n around 8.2	Li Ze(8.3), Chapman(8.1)	6, 5	2
	E_n around 11.3	Li Ze(11.3), Zöller(11.5-14.5)	7, 3	2, 1
	E_n around 14.5	Liu Conggui(14.9), Daroczy (14.5) Zöller(11.5-14.5)	8, 9, 3	2, 2, 1
	E_n around 22.0	Liu Yonghui(22), Zöller(18-22)	10, 3	2, 1
	E_n around 27.5	Zöller(22-33)	3	1
	E_n around 50.0	Zöller(45-55)	3	1
	E_n around 100	Zöller(89-110)	3	1
	E_n around 160	Zöller(145-175)	3	1
	E_p at 20.0	Hamilton	11	1
	E_p at 60.0	Hamilton	11	1
^{239}Pu	E_n at 0.17	Gindler	12	2
	E_n at 7.9	Gindler	12	2
	E_n around 14.5	Ford(14.0), Laurec(14.7)	13,14	2
^{242}Pu	E_n at 15.1	Winkelmann	15	2

The recommended data are all given in Appendix 1 and plotted in Figs.1-16.

As mentioned above, there are two types of measurements for mass distributions. In one the data are obtained by recording prompt fission fragments (data **type 1** in Table 1) with a double Frisch-gridded ionization chamber, silicon PIN diode detector arrays etc, like Vives, Zöller and Hamilton. In another, the data are obtained by recording the radioactivity of fission product nuclides (data **type 2** in Table 1) by γ-spectrometry with a Ge(Li) or a HPGe detector, either directly from the fission sample or followed by radio-chemical separation, like Nagy, Chapman, Li Ze, Liu Conggui, Daroczy, Liu Yonghui, Gindler, Ford, Laurec and Winkelmann. From the comparisons in Figs.17-19, it can be seen that, in general, the data measured by different laboratories but obtained with the same type of method (data type 1 or type 2) are in good agreement within the experimental error. But there is a systematic difference between the two types of data. The reason lies (1) in the physical nature of the measured yield, and (2) in differences in the measurement techniques. The essential difference between the two types of method is that for type 2 there is some delay time (days, hours, seconds etc.) between fragment formation and measurement, during which the radioactive products decay (although this can be corrected for), whereas for the data type 1 the measurement is "prompt". Nevertheless, for the latter the fragments measured are generally still after "prompt neutron emission", so-called post neutron emission. To get the fragment data before the prompt emission, so called pre neutron emission data, corrections are necessary, as described in Vives' and Zöller's papers. So in the data file (figures and Appendix 1, "post" and "pre" refer to the prompt neutrons for the data type 1. All the data of type 2, however, are not only "post neutron emission" but also after "delayed neutron emission".

In fact, there are some differences between the two types of data. One is the delayed neutron emission. It is well known that in addition to the β-decay of the radioactive fission product nuclides, some of them also decay by emitting so-called "delayed" neutrons. The data of type 2 are after emission of delayed neutrons, but for the data type 1 not, even though the data are "post-neutron" emission with respect to prompt neutrons. Another one is the mass resolution, which is more important for using the data to compare with the calculated ones. For the second type of data, this is not a problem, but for first type of data, as mentioned above, the measured mass distribution is not a real one, but is, for each mass number, a superposition of Gaussian distributions with the mass resolution as width. To illustrate this point, the second type of data were "adjusted" by following steps:

a) The data were linearly interpolated for mass numbers, where there is no measured data, so that there are the yields for all each mass A in the mass range measured.

b) For the yields of each mass A, the data were folded with Gaussians with a width of 3 or 4 mass units, corresponding to the mass resolution of Vives' or Zöller's measurements at the given energies.

c) All yields were summed over all mass numbers in the mass range measured.

The results are shown in Figs. 17-19, marked "corrected". It can be seen that the "adjusted" second type of data are consistent with the fist type of data, e.g. Nagy adjusted with Vives and Zöller in Fig.17, Liu Conggui adjusted and Daroczy adjusted with Zöller in Fig.18, Liu data corrected with Zöller in Fig.19.

5. Conclusion

The recommended mass distribution data were evaluated based on available experimental data at energies E_n=1.5, 5.5, 8.2, 11.3, 14.5, 22, 27.5, 50, 100 and 160 MeV and E_p=20 and 60 MeV for ^{238}U fission, E_n=0.17, 7.9 and 14.5 MeV for ^{239}Pu fission, and E_n=15.1 MeV for ^{242}Pu fission. The data measured by different laboratories but with the same kind of method, either data type 1 or 2, are in good agreement within the experimental error. Considering the difference between the two types of data in physics and measurement technique, they are, after corresponding adjustments, also consistent with each other. The data are recommended for use in the benchmark exercise of the CRP to test and improve the model calculations.

In these comparisons, the differences between the two types of data must be taken into account. The calculated data should be folded with Gaussian distributions, with the widths corresponding to the experimental mass resolutions, when comparing them with the type 1 data. There is no problem in comparisons with type 2 data.

Acknowledgements

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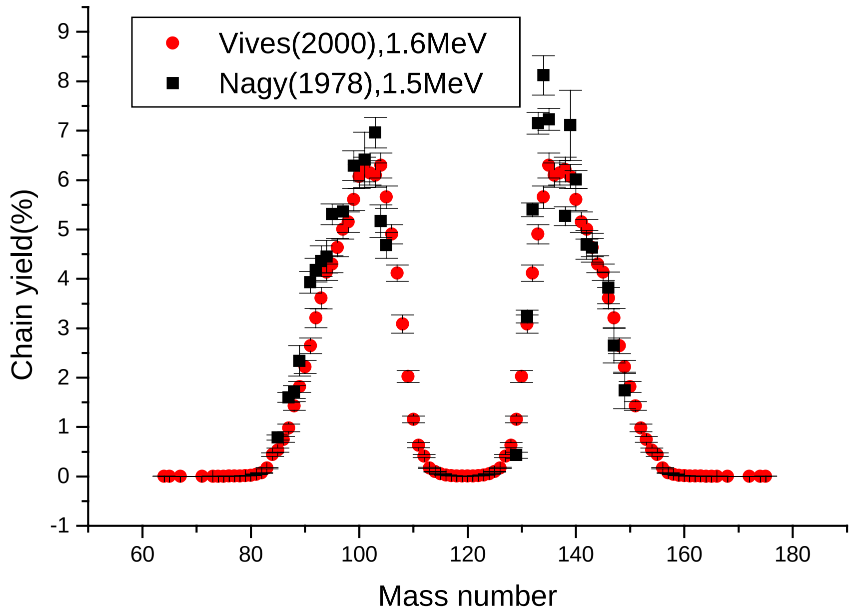

Fig.1: Mass distribution from ^{238}U fission at E_n around 1.5MeV

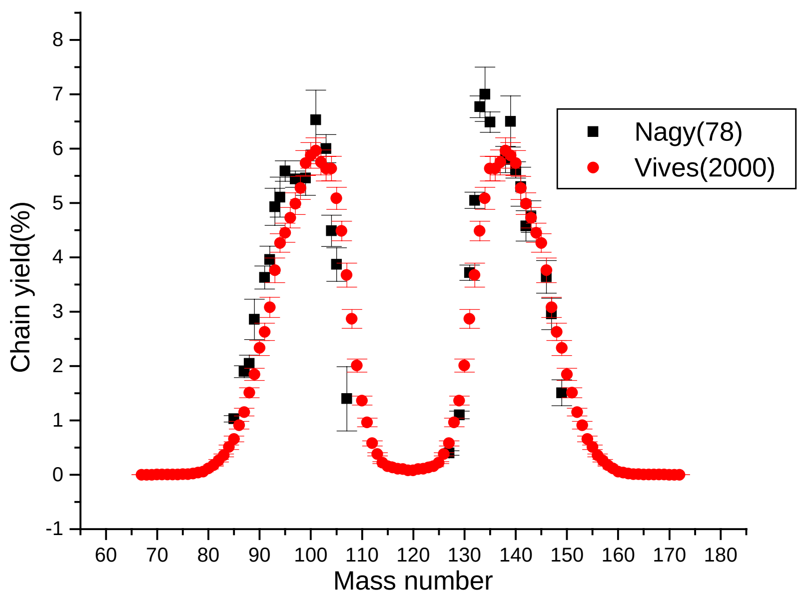

Fig.2: Mass distribution from ^{238}U fission at E_n=5.5 MeV

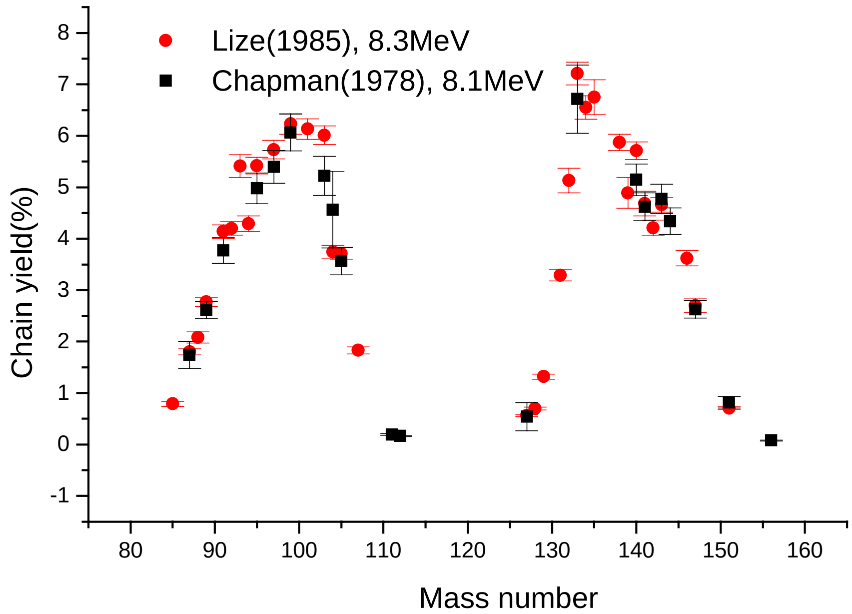

Fig.3: Mass distribution from ^{238}U fission at E_n around 8.2 MeV

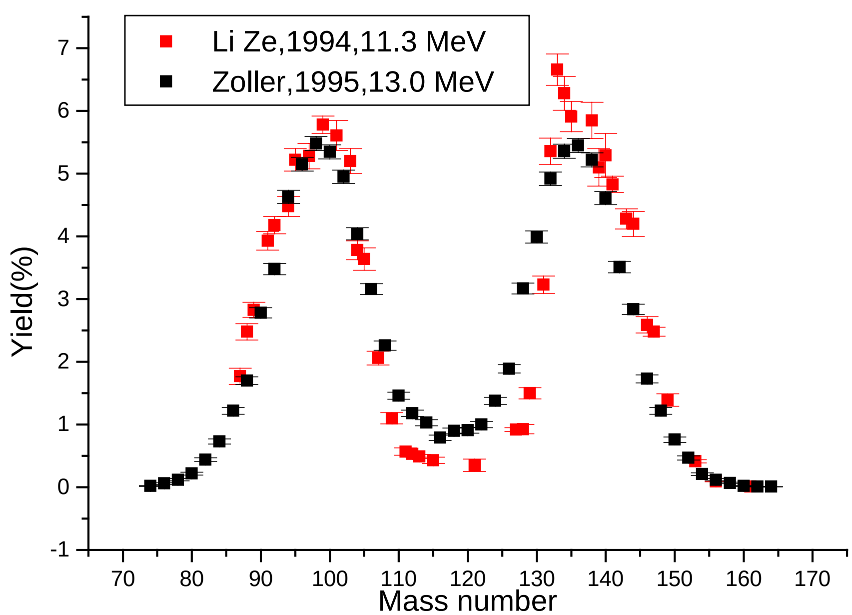

Fig.4: Mass distribution from ^{238}U fission at E_n around 11.3 MeV

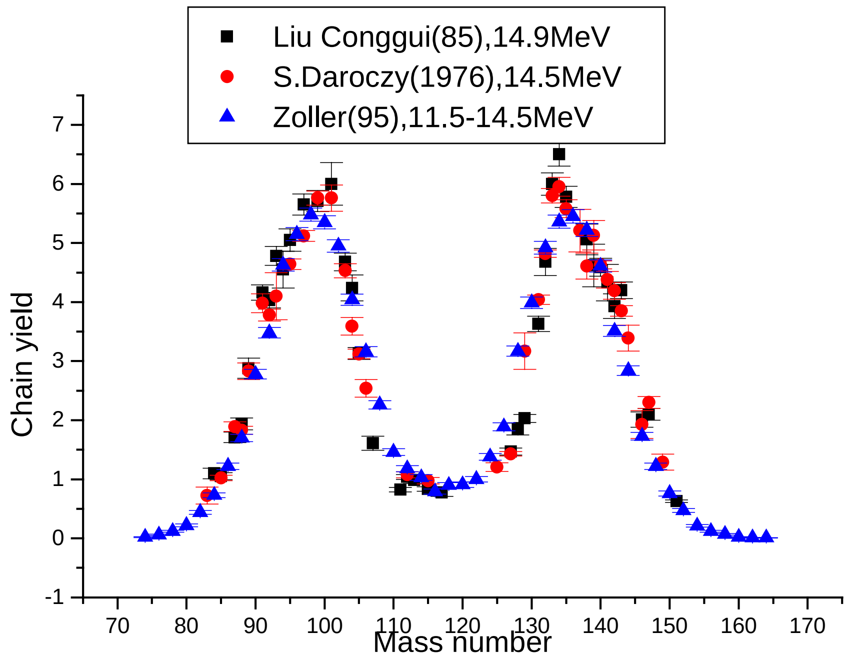

Fig.5: Mass distribution from ^{238}U fission at E_n around 14.5 MeV

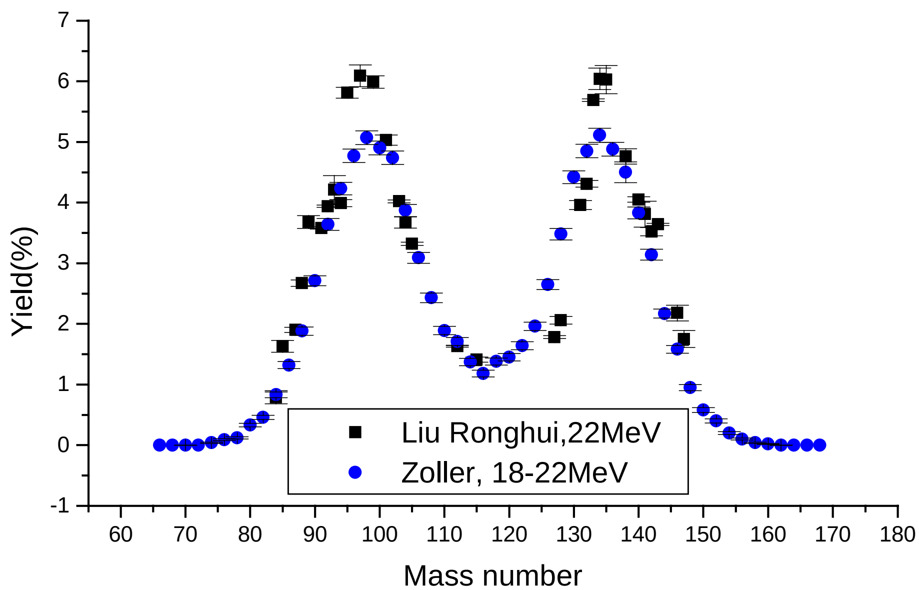

Fig.6: Mass distribution from ^{238}U fission at E_n around 22 MeV

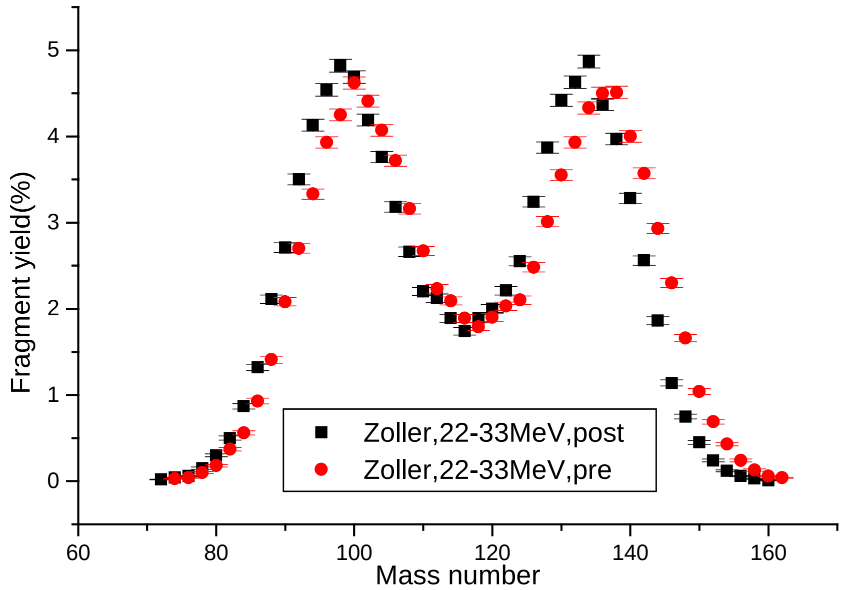

Fig.7: Fragment mass distribution from ^{238}U fission at E_n around 27.5 MeV

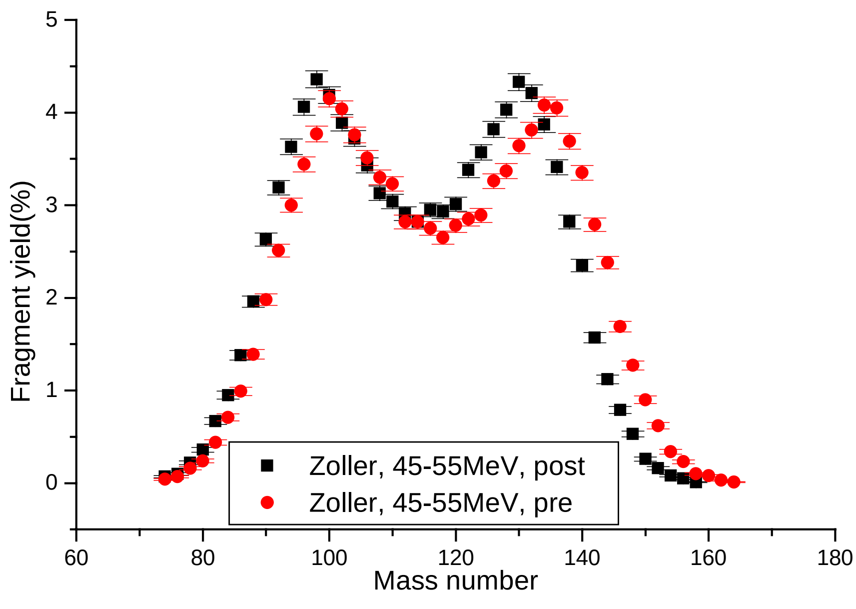

Fig.8: Fragment mass distribution from ^{238}U at E_n around 50 MeV

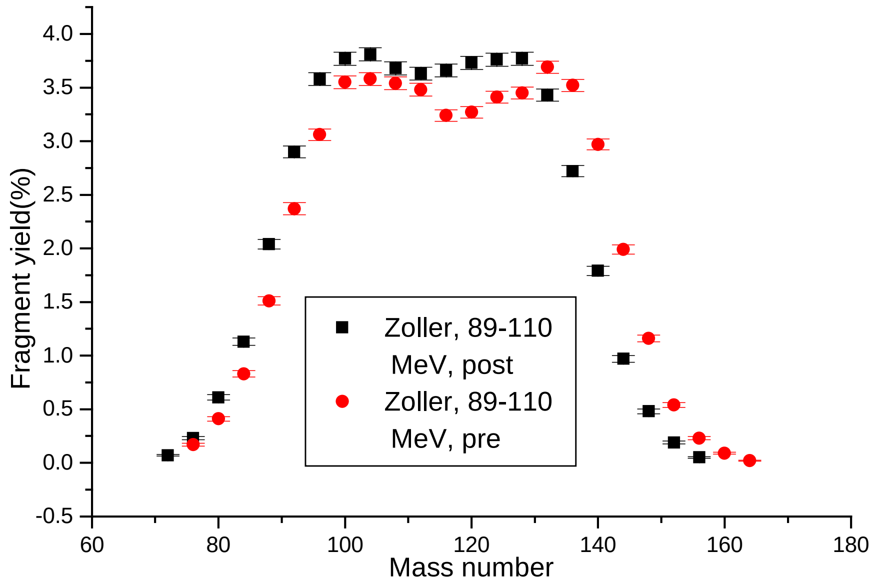

Fig.9: Fragment mass distribution from ^{238}U fission at E_n around 100 MeV

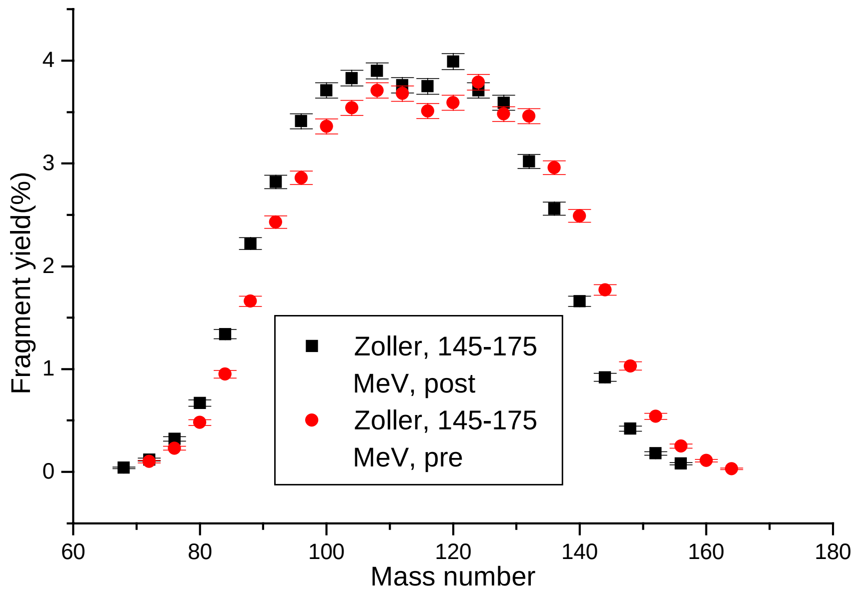

Fig.10: Fragment mass distribution from ^{238}U fission at E_n around 160 MeV

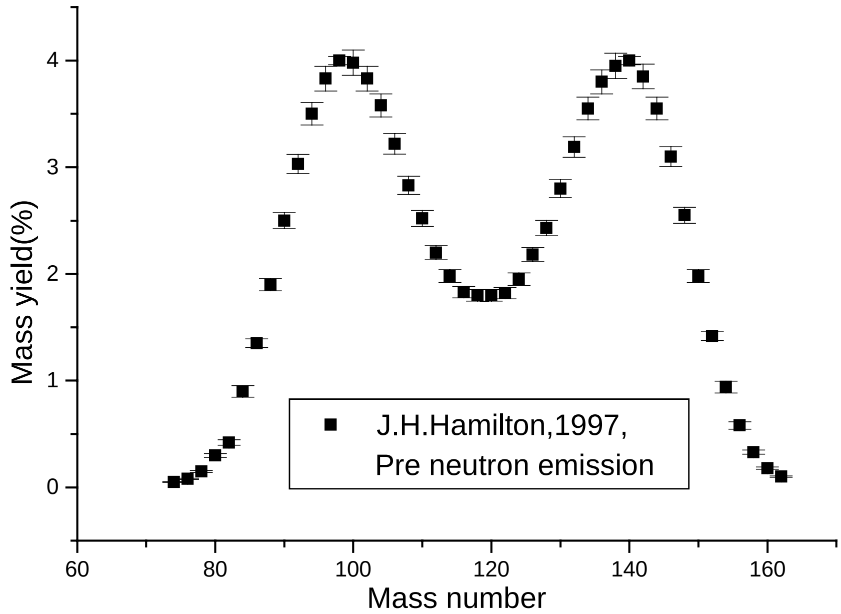

Fig.11: Mass distribution from ^{238}U fission at E_p=20 MeV

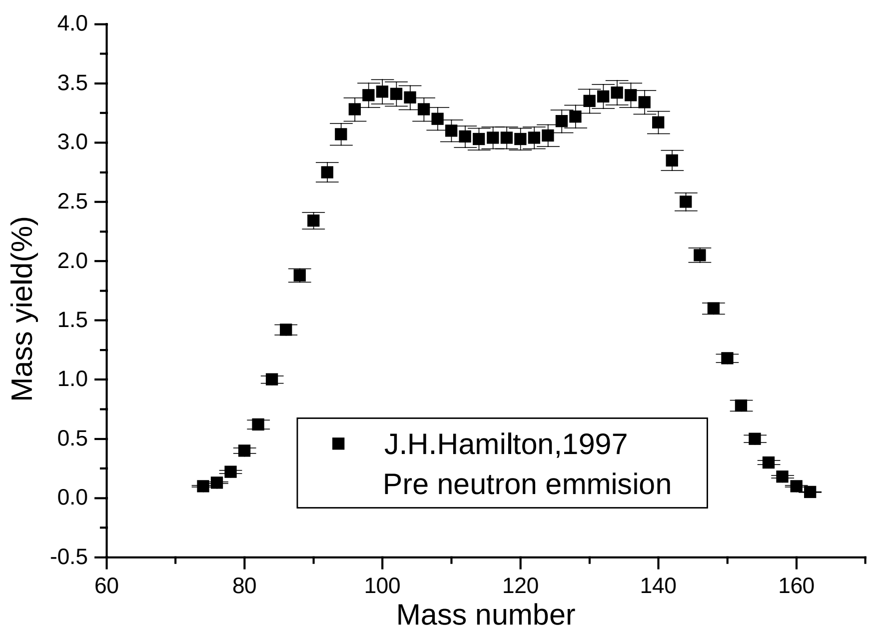

Fig.12: Mass distribution from ^{238}U fission at E_p=60 MeV

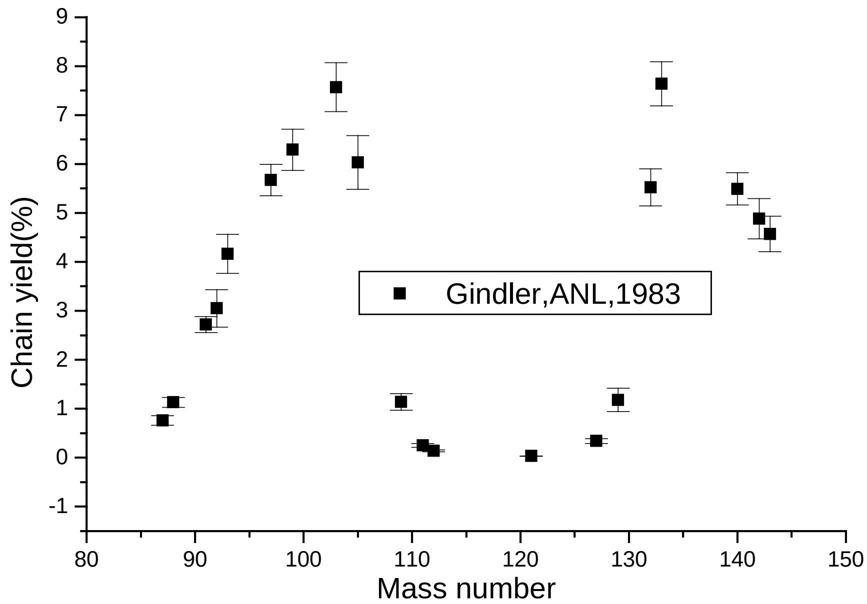

Fig.13: Mass distribution from ^{239}Pu fission at E_n=0.17 MeV

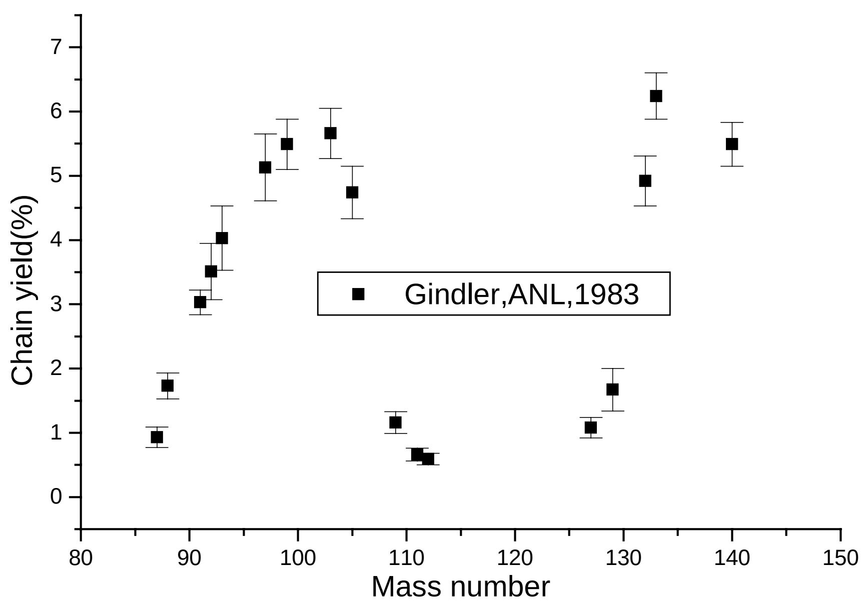

Fig.14: Mass distribution from ^{239}Pu fission at E_n=7.9 MeV

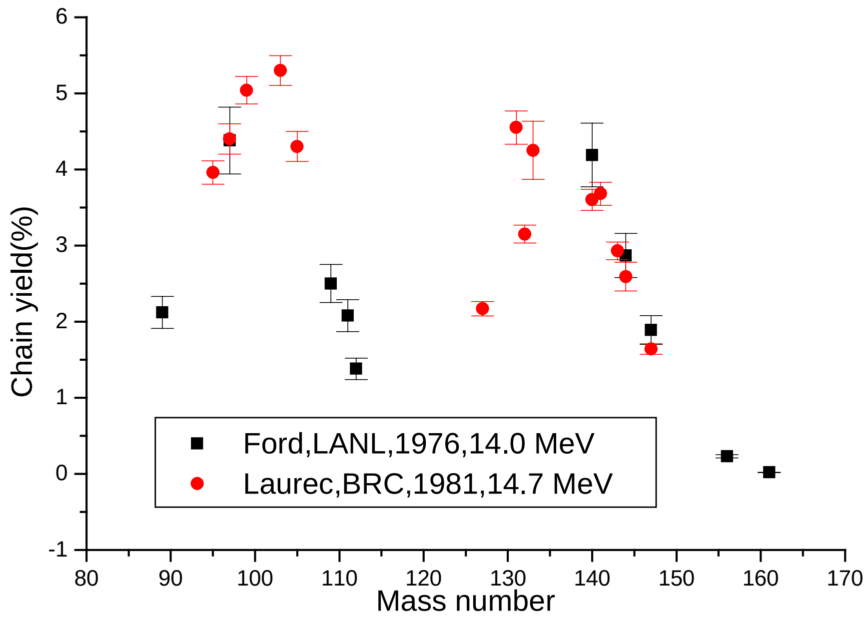

Fig.15: Mass distribution from ^{239}Pu fission at E_n around 14.5 MeV

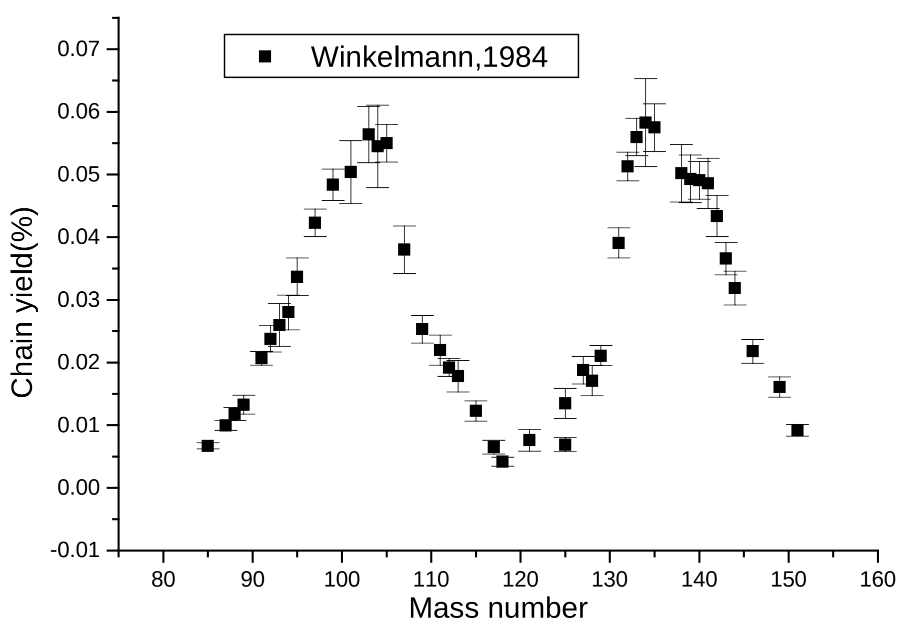

Fig.16: Mass distribution from ^{242}Pu fission at E_n=15.1 MeV

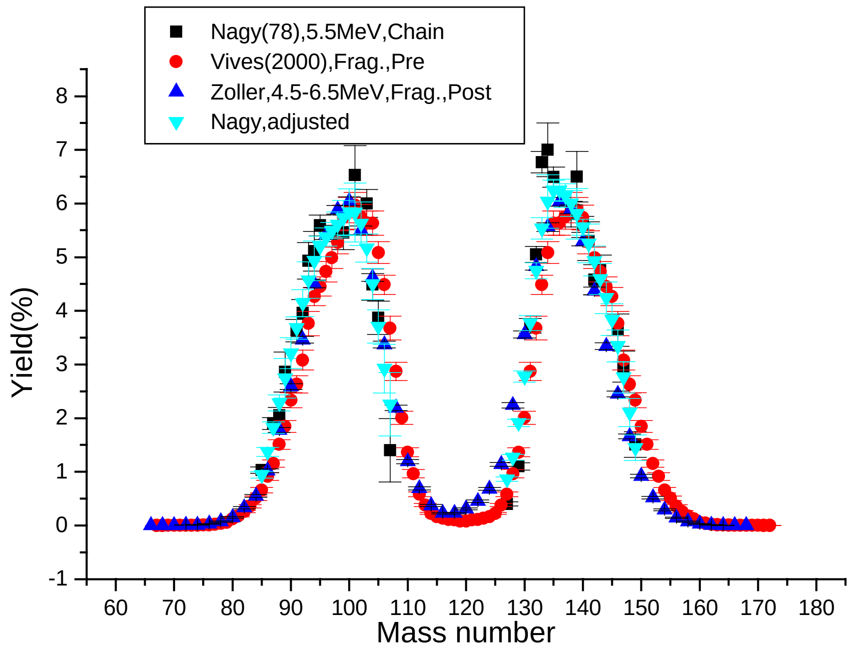

Fig.17 Comparison of mass distribution from ^{238}U fission around 5.5 MeV Measured with different methods

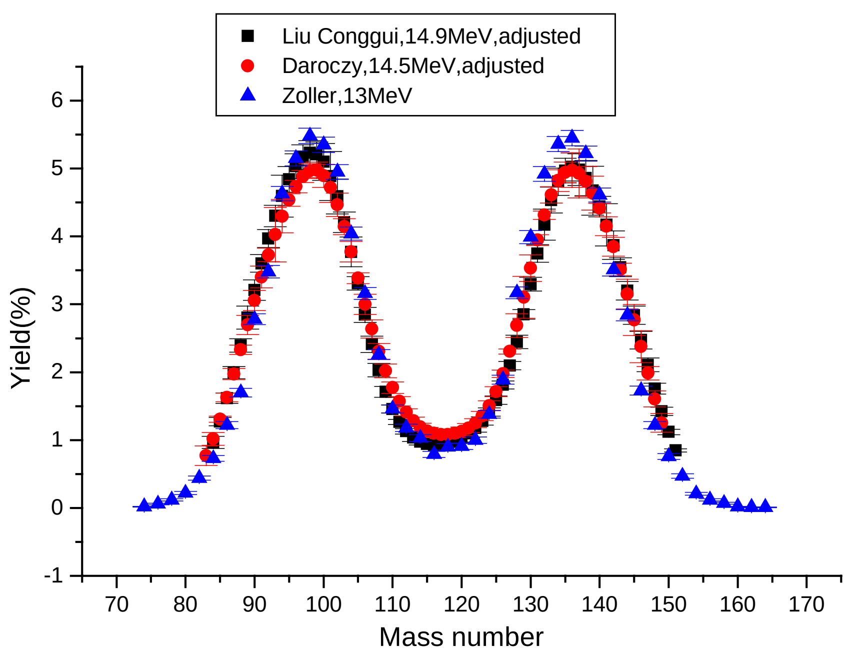

Fig.18 Comparison of mass distribution from ^{238}U fission at E_n around 14 MeV measured with different methods

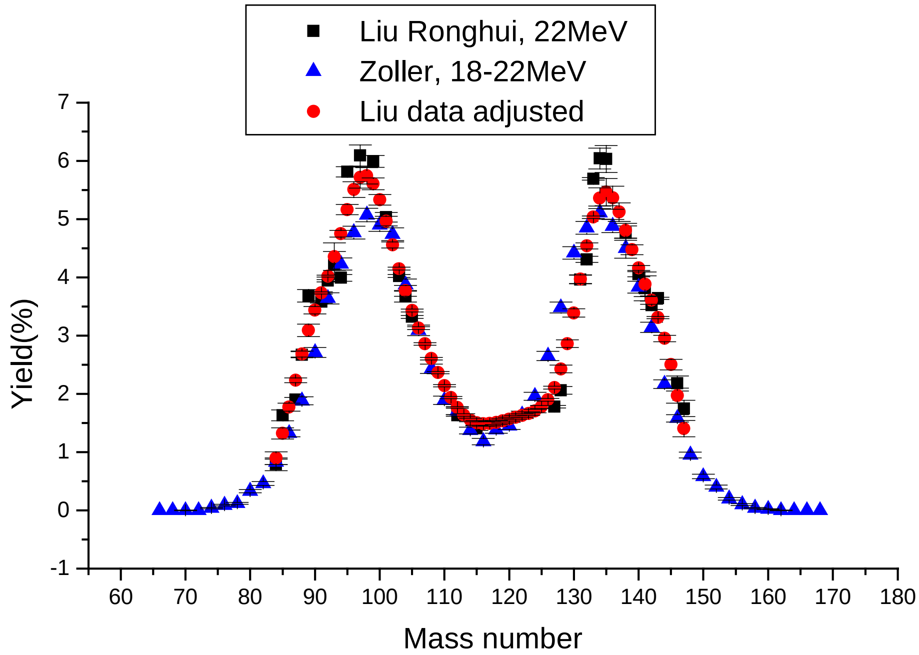

Fig.19 Comparison of mass distribution from ^{238}U fission around E_n=22 MeV measured with different methods

Appendix 1 Recommended evaluated mass distribution data for ^{238}U, ^{239}Pu, ^{242}Pu

A. ^{238}U

1. E_n=1.5 MeV

1) S.Nagy(ANL),1978,PR/C,17,163

Chain yield, E_n=1.5 MeV, Ge(Li)

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
85.	0.79	0.05
87.	1.60	0.10
88.	1.71	0.13
89.	2.34	0.31
91.	3.93	0.22
92.	4.18	0.24
93.	4.36	0.31
94.	4.45	0.33
95.	5.31	0.21
97.	5.36	0.16
99.	6.29	0.30
101.	6.41	0.56
103.	6.96	0.31
104.	5.17	0.33
105.	4.68	0.26
129.	0.43	0.06
131.	3.24	0.13
132.	5.40	0.14
133.	7.15	0.22
134.	8.12	0.40
135.	7.23	0.22
138.	5.27	0.19
139.	7.11	0.71
140.	6.01	0.18
142.	4.69	0.29
143.	4.63	0.29
146.	3.82	0.32
147.	2.65	0.35
149.	1.74	0.37

2)F.Vives(Geel),2000,NP A662

Fragment mass distribution, E_n=1.6 MeV, DFGIC, Pre-neutron emission

MASS	YIED	ERROR
NO-DIM	PC/FIS	PC/FIS
64	3.5522E-03	2.8418E-04

65	1.7761E-03	1.4209E-04
67	1.7761E-03	1.4209E-04
71	1.7761E-03	1.4209E-04
73	5.3283E-03	4.2627E-04
74	1.7761E-03	1.4209E-04
75	1.7761E-03	1.4209E-04
76	8.8805E-03	7.1044E-04
77	8.8805E-03	7.1044E-04
78	8.8805E-03	7.1044E-04
79	1.4209E-02	1.1367E-03
80	1.9537E-02	1.5630E-03
81	4.4403E-02	3.5522E-03
82	7.2820E-02	5.8256E-03
83	1.6873E-01	1.3498E-02
84	4.4580E-01	3.5664E-02
85	5.3106E-01	4.2484E-02
86	7.4952E-01	5.9961E-02
87	9.8219E-01	7.8575E-02
88	1.4262E+00	8.5573E-02
89	1.8134E+00	1.0880E-01
90	2.2148E+00	1.3289E-01
91	2.6464E+00	1.5878E-01
92	3.2059E+00	1.9235E-01
93	3.6108E+00	2.1665E-01
94	4.1330E+00	1.6532E-01
95	4.2982E+00	1.7193E-01
96	4.6321E+00	1.8528E-01
97	5.0033E+00	2.0013E-01
98	5.1507E+00	2.0603E-01
99	5.6036E+00	2.2414E-01
100	6.0707E+00	2.4283E-01
101	6.2164E+00	2.4865E-01
102	6.1435E+00	2.4574E-01
103	6.1009E+00	2.4404E-01
104	6.2963E+00	2.5185E-01
105	5.6551E+00	2.2620E-01
106	4.9038E+00	1.9615E-01
107	4.1135E+00	1.6454E-01
108	3.0851E+00	1.8511E-01
109	2.0230E+00	1.2138E-01
110	1.1545E+00	6.9268E-02
111	6.3229E-01	5.0583E-02
112	4.1206E-01	3.2964E-02
113	1.7228E-01	1.3783E-02
114	9.7686E-02	7.8149E-03
115	5.1507E-02	4.1206E-03
116	2.6642E-02	2.1313E-03
117	1.5985E-02	1.2788E-03
118	1.0657E-02	8.5253E-04
119	7.1044E-03	5.6835E-04

120	7.1044E-03	5.6835E-04
121	1.0657E-02	8.5253E-04
122	1.5985E-02	1.2788E-03
123	2.6642E-02	2.1313E-03
124	5.1507E-02	4.1206E-03
125	9.7686E-02	7.8149E-03
126	1.7228E-01	1.3783E-02
127	4.1206E-01	3.2964E-02
128	6.3229E-01	5.0583E-02
129	1.1545E+00	6.9268E-02
130	2.0230E+00	1.2138E-01
131	3.0851E+00	1.8511E-01
132	4.1135E+00	1.6454E-01
133	4.9038E+00	1.9615E-01
134	5.6551E+00	2.2620E-01
135	6.2963E+00	2.5185E-01
136	6.1009E+00	2.4404E-01
137	6.1435E+00	2.4574E-01
138	6.2164E+00	2.4865E-01
139	6.0707E+00	2.4283E-01
140	5.6036E+00	2.2414E-01
141	5.1507E+00	2.0603E-01
142	5.0033E+00	2.0013E-01
143	4.6321E+00	1.8528E-01
144	4.2982E+00	1.7193E-01
145	4.1330E+00	1.6532E-01
146	3.6108E+00	2.1665E-01
147	3.2059E+00	1.9235E-01
148	2.6464E+00	1.5878E-01
149	2.2148E+00	1.3289E-01
150	1.8134E+00	1.0880E-01
151	1.4262E+00	8.5573E-02
152	9.8219E-01	7.8575E-02
153	7.4952E-01	5.9961E-02
154	5.3106E-01	4.2484E-02
155	4.4580E-01	3.5664E-02
156	1.6873E-01	1.3498E-02
157	7.2820E-02	5.8256E-03
158	4.4403E-02	3.5522E-03
159	1.9537E-02	1.5630E-03
160	1.4209E-02	1.1367E-03
161	8.8805E-03	7.1044E-04
162	8.8805E-03	7.1044E-04
163	8.8805E-03	7.1044E-04
164	1.7761E-03	1.4209E-04
165	1.7761E-03	1.4209E-04
166	5.3283E-03	4.2627E-04
168	1.7761E-03	1.4209E-04
172	1.7761E-03	1.4209E-04
174	1.7761E-03	1.4209E-04

175 3.5522E-03 2.8418E-04

2.E_n=5.5 MeV

1) S.Nagy(ANL),1978,PR/C,17,163

Chain yield, E_n=5.5 MeV, Ge(Li)

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
85.	1.03	0.06
87.	1.90	0.11
88.	2.05	0.15
89.	2.86	0.37
91.	3.63	0.21
92.	3.96	0.25
93.	4.93	0.34
94.	5.11	0.37
95.	5.59	0.19
97.	5.44	0.15
99.	5.46	0.32
101.	6.53	0.55
103.	6.00	0.26
104.	4.49	0.29
105.	3.87	0.31
107.	1.40	0.59
127.	0.40	0.04
129.	1.10	0.07
131.	3.72	0.14
132.	5.05	0.15
133.	6.77	0.20
134.	7.00	0.50
135.	6.49	0.19
138.	5.80	0.24
139.	6.50	0.47
140.	5.61	0.15
141.	5.30	0.36
142.	4.58	0.28
143.	4.75	0.29
146.	3.64	0.30
147.	2.96	0.29
149.	1.51	0.24

2)F.Vives(Geel),2000,NP A662,63

Fragment mass distribution, E_n=5.5 MeV, DFGIC, Pre neutron emission

MASS	YIED	ERROR
NO-DIM	PC/FIS	PC/FIS
67	6.9231E-04	5.5385E-05
68	6.9231E-04	5.5385E-05
69	1.3846E-03	1.1077E-04
70	2.7692E-03	2.2154E-04
71	3.4615E-03	2.7692E-04
72	4.1539E-03	3.3231E-04

73	4.1539E-03	3.3231E-04
74	6.2308E-03	4.9846E-04
75	8.3077E-03	6.6462E-04
76	1.2462E-02	9.9693E-04
77	2.0077E-02	1.6062E-03
78	4.2231E-02	3.3785E-03
79	5.6769E-02	4.5416E-03
80	1.1908E-01	9.5262E-03
81	1.7239E-01	1.3791E-02
82	2.6031E-01	2.0825E-02
83	3.5654E-01	2.8523E-02
84	5.0746E-01	4.0597E-02
85	6.5839E-01	5.2671E-02
86	9.1316E-01	7.3053E-02
87	1.1534E+00	6.9203E-02
88	1.5092E+00	9.0554E-02
89	1.8471E+00	1.1082E-01
90	2.3338E+00	1.4003E-01
91	2.6301E+00	1.5781E-01
92	3.0808E+00	1.8485E-01
93	3.7634E+00	2.2580E-01
94	4.2639E+00	1.7056E-01
95	4.4543E+00	1.7817E-01
96	4.7299E+00	1.8919E-01
97	4.9888E+00	1.9955E-01
98	5.2761E+00	2.1104E-01
99	5.7365E+00	2.2946E-01
100	5.8756E+00	2.3503E-01
101	5.9649E+00	2.3860E-01
102	5.7503E+00	2.3001E-01
103	5.6333E+00	2.2533E-01
104	5.6326E+00	2.2531E-01
105	5.0864E+00	2.0346E-01
106	4.4862E+00	1.7945E-01
107	3.6776E+00	2.2065E-01
108	2.8696E+00	1.7218E-01
109	2.0077E+00	1.2046E-01
110	1.3645E+00	8.1873E-02
111	9.6370E-01	7.7096E-02
112	5.7946E-01	4.6357E-02
113	3.7869E-01	3.0295E-02
114	2.2500E-01	1.8000E-02
115	1.5992E-01	1.2794E-02
116	1.3154E-01	1.0523E-02
117	1.1008E-01	8.8062E-03
118	1.0454E-01	8.3631E-03
119	8.0308E-02	6.4246E-03
120	8.0308E-02	6.4246E-03
121	1.0454E-01	8.3631E-03
122	1.1008E-01	8.8062E-03

123	1.3154E-01	1.0523E-02
124	1.5992E-01	1.2794E-02
125	2.2500E-01	1.8000E-02
126	3.7869E-01	3.0295E-02
127	5.7946E-01	4.6357E-02
128	9.6370E-01	7.7096E-02
129	1.3645E+00	8.1873E-02
130	2.0077E+00	1.2046E-01
131	2.8696E+00	1.7218E-01
132	3.6776E+00	2.2065E-01
133	4.4862E+00	1.7945E-01
134	5.0864E+00	2.0346E-01
135	5.6326E+00	2.2531E-01
136	5.6333E+00	2.2533E-01
137	5.7503E+00	2.3001E-01
138	5.9649E+00	2.3860E-01
139	5.8756E+00	2.3503E-01
140	5.7365E+00	2.2946E-01
141	5.2761E+00	2.1104E-01
142	4.9888E+00	1.9955E-01
143	4.7299E+00	1.8919E-01
144	4.4543E+00	1.7817E-01
145	4.2639E+00	1.7056E-01
146	3.7634E+00	2.2580E-01
147	3.0808E+00	1.8485E-01
148	2.6301E+00	1.5781E-01
149	2.3338E+00	1.4003E-01
150	1.8471E+00	1.1082E-01
151	1.5092E+00	9.0554E-02
152	1.1534E+00	6.9203E-02
153	9.1316E-01	7.3053E-02
154	6.5839E-01	5.2671E-02
155	5.0746E-01	4.0597E-02
156	3.5654E-01	2.8523E-02
157	2.6031E-01	2.0825E-02
158	1.7239E-01	1.3791E-02
159	1.1908E-01	9.5262E-03
160	5.6769E-02	4.5416E-03
161	4.2231E-02	3.3785E-03
162	2.0077E-02	1.6062E-03
163	1.2462E-02	9.9693E-04
164	8.3077E-03	6.6462E-04
165	6.2308E-03	4.9846E-04
166	4.1539E-03	3.3231E-04
167	4.1539E-03	3.3231E-04
168	3.4615E-03	2.7692E-04
169	2.7692E-03	2.2154E-04
170	1.3846E-03	1.1077E-04
171	6.9231E-04	5.5385E-05
172	6.9231E-04	5.5385E-05

3.E_n=8.3 MeV

1) Li Ze(CIAE),CNP,7(2),97,1985

Chain yield, E_n=8.3 MeV,FCH,Ge(Li) and RCH

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
85.	0.79	0.05
87.	1.80	0.06
88.	2.08	0.11
89.	2.77	0.09
91.	4.14	0.13
92.	4.20	0.13
93.	5.41	0.22
94.	4.29	0.15
95.	5.42	0.16
97.	5.73	0.18
99.	6.23	0.20
101.	6.13	0.20
103.	6.01	0.18
104.	3.74	0.13
105.	3.71	0.12
107.	1.83	0.07
127.	0.56	0.02
128.	0.70	0.03
129.	1.32	0.05
131.	3.29	0.11
132.	5.13	0.24
133.	7.21	0.22
134.	6.55	0.23
135.	6.75	0.34
138.	5.87	0.16
139.	4.89	0.30
140.	5.71	0.17
141.	4.68	0.24
142.	4.21	0.15
143.	4.66	0.14
146.	3.62	0.15
147.	2.70	0.13
151.	0.707	0.024

2)T.C.Chpman, PR/C 17(#),1089, 1978

Chain yield, E_n=8.1MeV, RCH

MASS	DATA	DATA-ERR
NO-DIM	PC/FS	PC/FS
87	1.7395E+00	2.6092E-01
89	2.6125E+00	1.6720E-01
91	3.7717E+00	2.4893E-01
95	4.9810E+00	2.9886E-01
97	5.3968E+00	3.1841E-01
99	6.0623E+00	3.5768E-01

104	4.5611E+00	7.4346E-01
103	5.2195E+00	3.8102E-01
105	3.5643E+00	2.6376E-01
112	1.6880E-01	1.1647E-02
111	1.9450E-01	1.3420E-02
127	5.3900E-01	2.7543E-01
133	6.7132E+00	6.6461E-01
140	5.1455E+00	3.0873E-01
141	4.6197E+00	2.7256E-01
143	4.7749E+00	2.8172E-01
144	4.3396E+00	2.6038E-01
147	2.6285E+00	1.6822E-01
151	8.2080E-01	1.1081E-01
156	7.7000E-02	9.0860E-03

4.E_n=11.3 MeV

1) Li Ze(CIAE),Radiochimica Acta,64,95,1994

Chain yield, E_n=11.3 MeV, FCH,HPGe and RCH

MASS NO-DIM	DATA PC/FIS	DATA-ERR PC/FIS
87	1.77	0.13
88	2.48	0.13
89	2.83	0.12
91	3.93	0.15
92	4.18	0.14
94	4.48	0.16
95	5.22	0.18
97	5.28	0.20
99	5.78	0.14
101	5.61	0.24
103	5.20	0.20
104	3.78	0.15
105	3.64	0.18
107	2.06	0.11
109	1.10	0.09
111	0.57	0.06
112	0.53	0.03
113	0.49	0.03
115	0.43	0.05
121	0.35	0.10
127	0.92	0.03
128	0.927	0.074
129	1.50	0.09
131	3.23	0.14
132	5.36	0.21
133	6.66	0.25
134	6.28	0.27
135	5.91	0.24
138	5.85	0.29
139	5.10	0.30

140	5.29	0.35
141	4.83	0.13
143	4.28	0.16
144	4.20	0.20
146	2.59	0.13
147	2.48	0.07
149	1.39	0.10
153	0.415	0.025
156	0.0954	0.0054
161	0.0094	0.0009

2)Zöller

M. Zöller, TU Darmstadt 1995

Fragment mass distribution, Post, E_n=13(11.5-14.5)MeV, SCD,WSN

MASS NO-DIM	DATA PC/FIS	DATA-ERR PC/FIS
74.0	0.02	0.006
76.0	0.06	0.012
78.0	0.12	0.017
80.0	0.22	0.023
82.0	0.44	0.032
84.0	0.73	0.041
86.0	1.22	0.053
88.0	1.70	0.063
90.0	2.78	0.081
92.0	3.48	0.090
94.0	4.63	0.104
96.0	5.15	0.110
98.0	5.48	0.113
100.0	5.35	0.112
102.0	4.95	0.108
104.0	4.04	0.097
106.0	3.16	0.086
108.0	2.26	0.073
110.0	1.46	0.058
112.0	1.18	0.053
114.0	1.03	0.049
116.0	0.79	0.043
118.0	0.90	0.046
120.0	0.91	0.046
122.0	1.00	0.048
124.0	1.38	0.057
126.0	1.89	0.067
128.0	3.17	0.086
130.0	3.99	0.097
132.0	4.92	0.107
134.0	5.36	0.112
136.0	5.45	0.113
138.0	5.22	0.111
140.0	4.61	0.104

142.0	3.51	0.091
144.0	2.84	0.082
146.0	1.73	0.064
148.0	1.22	0.053
150.0	0.76	0.042
152.0	0.47	0.033
154.0	0.21	0.022
156.0	0.12	0.017
158.0	0.07	0.013
160.0	0.02	0.006
162.0	0.01	0.003
164.0	0.01	0.004

5.E_n=14.9 MeV

1)Liu Conggui(CIAE), CNP,7(3),235,1985

Chain yied, E_n=14.9 MeV, Ge(Li)

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
84	1.10	0.09
85	1.05	0.06
87	1.71	0.09
88	1.94	0.10
89	2.88	0.17
91	4.16	0.13
92	4.03	0.13
93	4.78	0.16
94	4.55	0.31
95	5.05	0.19
97	5.65	0.18
99	5.71	0.18
101	6.00	0.36
103	4.68	0.15
104	4.24	0.22
105	3.13	0.10
107	1.61	0.12
111	0.823	0.037
112	1.04	0.04
113	0.985	0.058
115	0.834	0.039
117	0.775	0.062
127	1.47	0.06
128	1.85	0.10
129	2.03	0.07
131	3.63	0.13
132	4.68	0.23
133	6.00	0.19
134	6.50	0.20
135	5.78	0.18
138	5.06	0.26
139	4.62	0.36

140	4.59	0.15
141	4.33	0.31
142	3.93	0.21
143	4.20	0.14
146	2.01	0.13
147	2.10	0.10
151	0.631	0.022

2)S.Daroczy, AK, 18, 317, 1976
Chain yield, E_n=14.4 MeV, Ge(Li)

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
8.3000E+01	7.2200E-01	1.4400E-01
8.5000E+01	1.0230E+00	4.6000E-02
8.7000E+01	1.8910E+00	8.3000E-02
8.8000E+01	1.8290E+00	7.0000E-02
8.9000E+01	2.8300E+00	1.4000E-01
9.1000E+01	3.9800E+00	1.6000E-01
9.2000E+01	3.7800E+00	1.0000E-01
9.3000E+01	4.1000E+00	4.0000E-01
9.5000E+01	4.6400E+00	9.0000E-02
9.7000E+01	5.1200E+00	9.0000E-02
9.9000E+01	5.7600E+00	1.2000E-01
1.0100E+02	5.7600E+00	2.2000E-01
1.0300E+02	4.5300E+00	1.2000E-01
1.0400E+02	3.5900E+00	1.5000E-01
1.0500E+02	3.1200E+00	8.0000E-02
1.0600E+02	2.5400E+00	1.5000E-01
1.1200E+02	1.0770E+00	5.2000E-02
1.1500E+02	9.7500E-01	5.5000E-02
1.2500E+02	1.2050E+00	7.3000E-02
1.2700E+02	1.4310E+00	3.8000E-02
1.2900E+02	3.1700E+00	3.1000E-01
1.3100E+02	4.0400E+00	8.0000E-02
1.3200E+02	4.8200E+00	6.0000E-02
1.3300E+02	5.8000E+00	1.2000E-01
1.3400E+02	5.9500E+00	1.6000E-01
1.3500E+02	5.5800E+00	1.5000E-01
1.3700E+02	5.2100E+00	3.6000E-01
1.3800E+02	4.6100E+00	2.2000E-01
1.3900E+02	5.1300E+00	2.5000E-01
1.4000E+02	4.6300E+00	7.0000E-02
1.4100E+02	4.3800E+00	1.4000E-01
1.4200E+02	4.1900E+00	1.4000E-01
1.4300E+02	3.8500E+00	9.0000E-02
1.4400E+02	3.3900E+00	2.2000E-01
1.4600E+02	1.9250E+00	2.3500E-01
1.4700E+02	2.3000E+00	1.0000E-01
1.4900E+02	1.2900E+00	1.3700E-01

3) M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Post, E_n=13(11.5-14.5)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
74.0	0.02	0.006
76.0	0.06	0.012
78.0	0.12	0.017
80.0	0.22	0.023
82.0	0.44	0.032
84.0	0.73	0.041
86.0	1.22	0.053
88.0	1.70	0.063
90.0	2.78	0.081
92.0	3.48	0.090
94.0	4.63	0.104
96.0	5.15	0.110
98.0	5.48	0.113
100.0	5.35	0.112
102.0	4.95	0.108
104.0	4.04	0.097
106.0	3.16	0.086
108.0	2.26	0.073
110.0	1.46	0.058
112.0	1.18	0.053
114.0	1.03	0.049
116.0	0.79	0.043
118.0	0.90	0.046
12 0.0	0.91	0.046
122.0	1.00	0.048
124.0	1.38	0.057
126.0	1.89	0.067
128.0	3.17	0.086
130.0	3.99	0.097
132.0	4.92	0.107
134.0	5.36	0.112
136.0	5.45	0.113
138.0	5.22	0.111
140.0	4.61	0.104
142.0	3.51	0.091
144.0	2.84	0.082
146.0	1.73	0.064
148.0	1.22	0.053
150.0	0.76	0.042
152.0	0.47	0.033
154.0	0.21	0.022
156.0	0.12	0.017
158.0	0.07	0.013
160.0	0.02	0.006
162.0	0.01	0.003
164.0	0.01	0.004

6. E_n=22 MeV

1)Liu Yonghui, INDC(CPR)-056/L, 2001

Chain yield, E_n=22 MeV, HPGe,FCH

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
84	0.79	0.108
85	1.63	0.096
87	1.90	0.041
88	2.67	0.052
89	3.68	0.107
91	3.58	0.019
92	3.94	0.017
93	4.21	0.237
94	3.99	0.058
95	5.81	0.089
97	6.09	0.180
99	5.99	0.103
101	5.03	0.083
103	4.02	0.024
104	3.67	0.093
105	3.32	0.025
112	1.63	0.016
115	1.41	0.040
127	1.78	0.024
128	2.06	0.065
131	3.96	0.073
132	4.31	0.053
133	5.69	0.021
134	6.04	0.178
135	6.03	0.232
138	4.76	0.126
140	4.05	0.044
141	3.81	0.213
142	3.52	0.070
143	3.64	0.019
146	2.18	0.129
147	1.75	0.140

2)Zöller

M. Zöller, TU Darmstadt 1995

Fragment mass distribution, Post, E_n=20(18-22)MeV, SCD, WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
66	0.0	0.0
68	0.0	0.0
70	0.0	0.003
72	0.0	0.000
74	0.04	0.01
76	0.09	0.015

78	0.12	0.018
80	0.33	0.029
82	0.46	0.034
84	0.83	0.046
86	1.32	0.058
88	1.88	0.069
90	2.71	0.083
92	3.64	0.096
94	4.23	0.104
96	4.77	0.110
98	5.07	0.114
100	4.90	0.112
102	4.74	0.110
104	3.87	0.099
106	3.09	0.089
108	2.43	0.079
110	1.89	0.069
112	1.71	0.066
114	1.37	0.059
116	1.18	0.055
118	1.38	0.059
120	1.45	0.061
122	1.64	0.065
124	1.96	0.070
126	2.65	0.082
128	3.48	0.094
130	4.42	0.106
132	4.85	0.111
134	5.11	0.114
136	4.88	0.111
138	4.50	0.170
140	3.83	0.099
142	3.14	0.089
144	2.17	0.074
146	1.58	0.063
148	0.95	0.049
150	0.58	0.038
152	0.40	0.032
154	0.20	0.022
156	0.10	0.016
158	0.04	0.01
160	0.02	0.006
162	0.00	0.003
164	0.00	0.00
166	0.00	0.00
168	0.00	0.00

7. E_n=27.5 MeV

1)Zöller

M. Zöller, TU Darmstadt 1995

Fragment mass distribution, Post, E_n=27.5(22-33)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
72.0	0.02	0.005
74.0	0.04	0.006
76.0	0.06	0.008
78.0	0.15	0.013
80.0	0.30	0.018
82.0	0.50	0.024
84.0	0.87	0.031
86.0	1.32	0.038
88.0	2.11	0.049
90.0	2.71	0.055
92.0	3.50	0.063
94.0	4.13	0.068
96.0	4.54	0.071
98.0	4.82	0.074
100.0	4.69	0.072
102.0	4.19	0.069
104.0	3.76	0.065
106.0	3.18	0.060
108.0	2.66	0.055
110.0	2.20	0.050
112.0	2.12	0.049
114.0	1.89	0.046
116.0	1.74	0.044
118.0	1.89	0.046
120.0	2.00	0.047
122.0	2.21	0.050
124.0	2.55	0.053
126.0	3.24	0.060
128.0	3.87	0.066
130.0	4.42	0.070
132.0	4.63	0.072
134.0	4.87	0.074
136.0	4.37	0.070
138.0	3.97	0.067
140.0	3.28	0.061
142.0	2.56	0.054
144.0	1.86	0.046
146.0	1.14	0.036
148.0	0.75	0.029
150.0	0.45	0.022
152.0	0.24	0.016
154.0	0.12	0.011
156.0	0.06	0.008
158.0	0.03	0.006
160.0	0.01	0.004

2) M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Pre, E_n=27.5(22-33)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
74.0	0.03	0.006
76.0	0.04	0.006
78.0	0.10	0.011
80.0	0.18	0.014
82.0	0.37	0.020
84.0	0.56	0.025
86.0	0.93	0.032
88.0	1.41	0.040
90.0	2.08	0.048
92.0	2.70	0.055
94.0	3.33	0.061
96.0	3.93	0.066
98.0	4.25	0.069
100.0	4.62	0.072
102.0	4.41	0.070
104.0	4.07	0.068
106.0	3.72	0.065
108.0	3.16	0.059
110.0	2.67	0.055
112.0	2.23	0.050
114.0	2.09	0.048
116.0	1.89	0.046
118.0	1.79	0.045
120.0	1.90	0.046
122.0	2.03	0.048
124.0	2.10	0.049
126.0	2.48	0.053
128.0	3.01	0.058
130.0	3.55	0.063
132.0	3.93	0.066
134.0	4.33	0.070
136.0	4.50	0.071
138.0	4.51	0.071
140.0	4.00	0.067
142.0	3.57	0.063
144.0	2.93	0.057
146.0	2.30	0.051
148.0	1.66	0.043
150.0	1.04	0.034
152.0	0.69	0.028
154.0	0.43	0.022
156.0	0.24	0.016
158.0	0.13	0.012
160.0	0.06	0.008
162.0	0.04	0.006

8.E_n=50 MeV

1) M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Post, E_n=50(45-55)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
74.0	0.07	0.012
76.0	0.10	0.014
78.0	0.22	0.021
80.0	0.36	0.026
82.0	0.67	0.036
84.0	0.95	0.043
86.0	1.38	0.052
88.0	1.96	0.061
90.0	2.63	0.071
92.0	3.19	0.078
94.0	3.63	0.084
96.0	4.06	0.089
98.0	4.36	0.092
100.0	4.19	0.090
102.0	3.89	0.087
104.0	3.72	0.085
106.0	3.43	0.081
108.0	3.13	0.078
110.0	3.04	0.077
112.0	2.91	0.075
114.0	2.82	0.074
116.0	2.95	0.075
118.0	2.93	0.075
120.0	3.01	0.076
122.0	3.38	0.081
124.0	3.57	0.083
126.0	3.82	0.086
128.0	4.03	0.088
130.0	4.33	0.091
132.0	4.21	0.091
134.0	3.87	0.086
136.0	3.41	0.081
138.0	2.82	0.074
140.0	2.35	0.067
142.0	1.57	0.055
144.0	1.12	0.046
146.0	0.79	0.039
148.0	0.53	0.032
150.0	0.26	0.022
152.0	0.16	0.018
154.0	0.08	0.012
156.0	0.05	0.010
158.0	0.01	0.005

2)M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Pre, E_n=50(45-55)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
74.0	0.04	0.009
76.0	0.07	0.012
78.0	0.16	0.017
80.0	0.24	0.021
82.0	0.44	0.029
84.0	0.71	0.037
86.0	0.99	0.044
88.0	1.39	0.052
90.0	1.98	0.062
92.0	2.51	0.070
94.0	3.00	0.076
96.0	3.44	0.081
98.0	3.77	0.085
100.0	4.15	0.089
102.0	4.04	0.088
104.0	3.76	0.085
106.0	3.51	0.082
108.0	3.30	0.080
110.0	3.23	0.079
112.0	2.82	0.074
114.0	2.82	0.074
116.0	2.75	0.073
118.0	2.65	0.072
120.0	2.78	0.073
122.0	2.85	0.074
124.0	2.89	0.075
126.0	3.26	0.079
128.0	3.37	0.081
130.0	3.64	0.084
132.0	3.81	0.086
134.0	4.08	0.089
136.0	4.05	0.088
138.0	3.69	0.084
140.0	3.35	0.080
142.0	2.79	0.073
144.0	2.38	0.068
146.0	1.69	0.057
148.0	1.27	0.049
150.0	0.90	0.042
152.0	0.62	0.035
154.0	0.34	0.026
156.0	0.23	0.021
158.0	0.10	0.014

9. E_n=99.5 MeV

1) M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Post, E_n=99.5(89-110)MeV, SCD,WSN

MASS DATA DATA-ERR

NO-DIM	PC/FIS	PC/FIS
72.0	0.07	0.008
76.0	0.23	0.015
80.0	0.61	0.025
84.0	1.13	0.034
88.0	2.04	0.045
92.0	2.90	0.054
96.0	3.58	0.060
100.0	3.77	0.061
104.0	3.81	0.062
108.0	3.68	0.061
112.0	3.63	0.060
116.0	3.66	0.060
120.0	3.73	0.061
124.0	3.76	0.061
128.0	3.77	0.061
132.0	3.43	0.058
136.0	2.72	0.052
140.0	1.79	0.042
144.0	0.97	0.031
148.0	0.48	0.022
152.0	0.19	0.014
156.0	0.05	0.007

2) M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Pre, E_n=99.5(89-110)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
76.0	0.17	0.013
80.0	0.41	0.020
84.0	0.83	0.029
88.0	1.51	0.039
92.0	2.37	0.056
96.0	3.06	0.055
100.0	3.55	0.059
104.0	3.58	0.060
108.0	3.54	0.059
112.0	3.48	0.059
116.0	3.24	0.054
120.0	3.27	0.054
124.0	3.41	0.055
128.0	3.45	0.055
132.0	3.69	0.057
136.0	3.52	0.056
140.0	2.97	0.051
144.0	1.99	0.042
148.0	1.16	0.032
152.0	0.54	0.022
156.0	0.23	0.014
160.0	0.09	0.009

164.0	0.02	0.004

10. E_n=160 Mev

1) M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Post, E_n=160(145-175)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
68.0	0.04	0.008
72.0	0.12	0.014
76.0	0.32	0.022
80.0	0.67	0.032
84.0	1.34	0.045
88.0	2.22	0.058
92.0	2.82	0.066
96.0	3.41	0.072
100.0	3.71	0.075
104.0	3.83	0.076
108.0	3.90	0.077
112.0	3.76	0.076
116.0	3.75	0.076
120.0	3.99	0.078
124.0	3.71	0.075
128.0	3.59	0.074
132.0	3.02	0.068
136.0	2.56	0.063
140.0	1.66	0.050
144.0	0.92	0.038
148.0	0.42	0.025
152.0	0.18	0.017
156.0	0.08	0.011

2) M. Zoeller, TU Darmstadt 1995

Fragment mass distribution, Pre, E_n=160(145-175)MeV, SCD,WSN

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
72.0	0.10	0.012
76.0	0.23	0.019
80.0	0.48	0.027
84.0	0.95	0.038
88.0	1.66	0.050
92.0	2.43	0.061
96.0	2.86	0.066
100.0	3.36	0.072
104.0	3.54	0.074
108.0	3.71	0.075
112.0	3.68	0.075
116.0	3.51	0.073
120.0	3.59	0.074
124.0	3.79	0.076
128.0	3.48	0.073

132.0	3.46	0.073
136.0	2.96	0.067
140.0	2.49	0.062
144.0	1.77	0.052
148.0	1.03	0.040
152.0	0.54	0.029
156.0	0.25	0.020
160.0	0.11	0.013
164.0	0.03	0.007

11. E_p=20 MeV

Aysto97-Aysto, Proc, Int. Conf. on Fission and Properties of Neutron Rich Nuclei, ed. J.H. Hamilton and A.V. Ramaya, Sanibal Island, Florida, USA, 457 (1997).

Fragment mass distribution, pre-neutron emission

MASS	YIELD	ERROR
NO-DIM	PC/FS	PC/FS
74	5.0000E-02	3.0000E-03
76	8.0000E-02	4.8000E-03
78	1.5000E-01	9.0000E-03
80	3.0000E-01	1.8000E-02
82	4.2000E-01	2.5200E-02
84	9.0000E-01	5.4000E-02
86	1.3500E+00	4.0500E-02
88	1.9000E+00	5.7000E-02
90	2.5000E+00	7.5000E-02
92	3.0300E+00	9.0900E-02
94	3.5000E+00	1.0500E-01
96	3.8300E+00	1.1490E-01
98	4.0000E+00	4.0000E-02
100	3.9800E+00	1.1940E-01
102	3.8300E+00	1.1490E-01
104	3.5800E+00	1.0740E-01
106	3.2200E+00	9.6600E-02
108	2.8300E+00	8.4900E-02
110	2.5200E+00	7.5600E-02
112	2.2000E+00	6.6000E-02
114	1.9800E+00	5.9400E-02
116	1.8300E+00	5.4900E-02
118	1.8000E+00	5.4000E-02
120	1.8000E+00	5.4000E-02
122	1.8200E+00	5.4600E-02
124	1.9500E+00	5.8500E-02
126	2.1800E+00	6.5400E-02
128	2.4300E+00	7.2900E-02
130	2.8000E+00	8.4000E-02
132	3.1900E+00	9.5700E-02
134	3.5500E+00	1.0650E-01

136	3.8000E+00	1.1400E-01
138	3.9500E+00	1.1850E-01
140	4.0000E+00	4.0000E-02
142	3.8500E+00	1.1550E-01
144	3.5500E+00	1.0650E-01
146	3.1000E+00	9.3000E-02
148	2.5500E+00	7.6500E-02
150	1.9800E+00	5.9400E-02
152	1.4200E+00	4.2600E-02
154	9.4000E-01	5.6400E-02
156	5.8000E-01	3.4800E-02
158	3.3000E-01	1.9800E-02
160	1.8000E-01	1.0800E-02
162	1.0000E-01	6.0000E-03

12. E_p=60 MeV

Aysto97-Aysto, Proc, Int. Conf. on Fission and Properties of Neutron Rich Nuclei, ed. J.H. Hamilton and A.V. Ramaya, Sanibal Island, Florida, USA, 457 (1997).

Fragment mass distribution, pre-neutron emission

MASS	YIELD	ERROR
NO-DIM	PC/FS	PC/FS
74	1.0000E-01	6.0000E-03
76	1.3000E-01	7.8000E-03
78	2.2000E-01	1.3200E-02
80	4.0000E-01	2.4000E-02
82	6.2000E-01	3.7200E-02
84	1.0000E+00	3.0000E-02
86	1.4200E+00	4.2600E-02
88	1.8800E+00	5.6400E-02
90	2.3400E+00	7.0200E-02
92	2.7500E+00	8.2500E-02
94	3.0700E+00	9.2100E-02
96	3.2800E+00	9.8400E-02
98	3.4000E+00	1.0200E-01
100	3.4300E+00	1.0290E-01
102	3.4100E+00	1.0230E-01
104	3.3800E+00	1.0140E-01
106	3.2800E+00	9.8400E-02
108	3.2000E+00	9.6000E-02
110	3.1000E+00	9.3000E-02
112	3.0500E+00	9.1500E-02
114	3.0300E+00	9.0900E-02
116	3.0400E+00	9.1200E-02
118	3.0400E+00	9.1200E-02
120	3.0300E+00	9.0900E-02
122	3.0400E+00	9.1200E-02
124	3.0600E+00	9.1800E-02
126	3.1800E+00	9.5400E-02
128	3.2200E+00	9.6600E-02

130	3.3500E+00	1.0050E-01
132	3.3900E+00	1.0170E-01
134	3.4200E+00	1.0260E-01
136	3.4000E+00	1.0200E-01
138	3.3400E+00	1.0020E-01
140	3.1700E+00	9.5100E-02
142	2.8500E+00	8.5500E-02
144	2.5000E+00	7.5000E-02
146	2.0500E+00	6.1500E-02
148	1.6000E+00	4.8000E-02
150	1.1800E+00	3.5400E-02
152	7.8000E-01	4.6800E-02
154	5.0000E-01	3.0000E-02
156	3.0000E-01	1.8000E-02
158	1.8000E-01	1.0800E-02
160	1.0000E-01	6.0000E-03
162	5.0000E-02	3.0000E-03

B. ^{239}Pu

1. E_n=0.17 MeV

J.E.Glinder(ANL),1983,PR/C,27,2058

Chain yield,Ge(Li), RCH

MASS	DATA	ERR-T
NO-DIM	PC/FIS	PC/FIS
87.	0.76	0.10
88.	1.13	0.10
91.	2.72	0.16
92.	3.05	0.38
93.	4.16	0.40
97.	5.67	0.32
99.	6.29	0.42
103.	7.57	0.50
105.	6.03	0.55
109.	1.14	0.17
111.	0.25	0.04
112.	0.14	0.02
121.	0.032	0.005
127.	0.34	0.05
129.	1.18	0.24
132.	5.52	0.38
133.	7.64	0.45
140.	5.49	0.33
142.	4.88	0.41
143.	4.57	0.36

2. E_n=7.9 MeV

J.E.Glinder(ANL), PR/C,27,2058(1983)

Chain yield, Ge(Li), RCH

MASS	DATA	ERR-T
NO-DIM	PC/FIS	PC/FIS
87.	0.93	0.16
88.	1.73	0.20

91.	3.03	0.19
92.	3.51	0.44
93.	4.03	0.50
97.	5.13	0.52
99.	5.49	0.39
103.	5.66	0.39
105.	4.74	0.41
109.	1.16	0.17
111.	0.66	0.10
112.	0.59	0.09
127.	1.08	0.16
129.	1.67	0.33
132.	4.92	0.39
133.	6.24	0.36
140.	5.49	0.34

3. E_n=14.5 MeV

1) J.Laurec(BRC,Fr), CEA-R-5147(1981)

Chain yield, E_n=14.7 MeV, RCH,Ge(Li)+FISCH

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
95	3.9600E+00	1.5444E-01
97	4.4000E+00	1.9800E-01
99	5.0400E+00	1.8144E-01
103	5.3000E+00	1.9610E-01
105	4.3000E+00	1.9780E-01
127	2.1700E+00	9.5480E-02
132	3.1500E+00	1.1655E-01
131	4.5500E+00	2.1840E-01
133	4.2500E+00	3.8250E-01
140	3.6000E+00	1.3680E-01
141	3.6800E+00	1.5088E-01
143	2.9300E+00	1.1720E-01
144	2.5900E+00	1.8907E-01
147	1.6400E+00	6.8880E-02

2)G.P.Ford(LANL),1976,LA-6129

Chain yield, E_n=14.0 MeV, RCH

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
89.	2.12	0.21
97.	4.38	0.44
109.	2.50	0.25
111.	2.078	0.21
112.	1.380	0.14
140.	4.19	0.42
144.	2.87	0.29
147.	1.89	0.19
156.	0.230	0.023

161. 0.0196 0.002

C. ^{242}Pu

Winkel84-Winkelmann, Phys. Rev C30, 934 (1984)

E_n=15.1 MeV, chain yield

MASS	DATA	DATA-ERR
NO-DIM	PC/FIS	PC/FIS
85	0.00672	0.00048
87	0.00995	0.00076
88	0.0118	0.0010
89	0.0133	0.0015
91	0.0207	0.0011
92	0.0238	0.0021
93	0.0260	0.0034
94	0.0280	0.0028
95	0.0337	0.0030
97	0.0423	0.0022
99	0.0484	0.0025
101	0.0504	0.0050
103	0.0564	0.0045
104	0.0545	0.0066
105	0.0550	0.0030
107	0.0380	0.0038
109	0.0253	0.0022
111	0.0220	0.0024
112	0.0192	0.0014
113	0.0178	0.0025
115	0.0123	0.0016
117	0.0065	0.0011
118	0.0042	0.0007
121	0.0076	0.0017
125	0.0069	0.0011
125	0.0135	0.0024
127	0.0188	0.0022
128	0.0171	0.0024
129	0.0211	0.0016
131	0.0391	0.0024
132	0.0513	0.0023
133	0.0560	0.0030
134	0.0583	0.0070
135	0.0575	0.0038
138	0.0502	0.0046
139	0.0493	0.0038
140	0.0491	0.0030
141	0.0486	0.0040
142	0.0434	0.0033
143	0.0366	0.0026
144	0.0319	0.0027
146	0.0218	0.0019
149	0.0161	0.0016

151	0.0092	0.0009