DE LA RECHERCHE
À L'INDUSTRIE

BetaShape

Practical exercises

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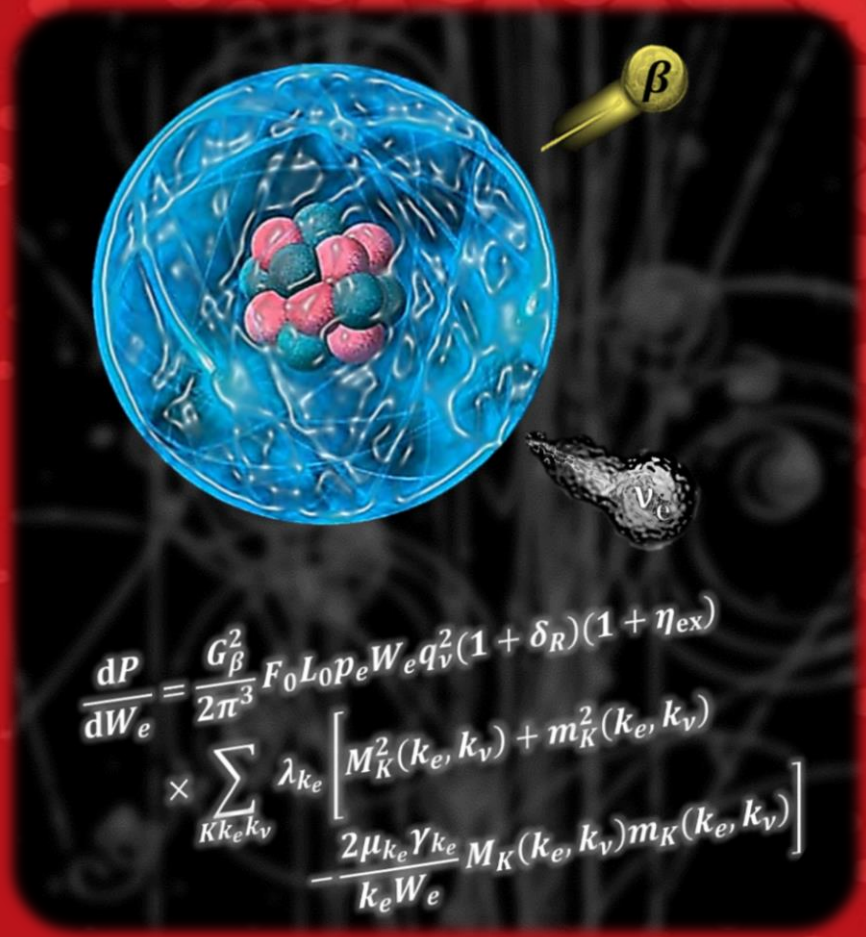

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EURAMET

université PARIS-SACLAY

LNE LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

LNHB Laboratoire National Henri Becquerel

Getting the code: LNHB website

Executables of the latest version of the code are available at:

http://www.lnhb.fr/rd-activities/spectrum-processing-software/

- Latest released version is 2.2.
- Previous versions are also available but not recommended.

- Download the executables for your OS.
- Unzip.
- Open the main directory.

Software and tools developed by the LNHB

BETASHAPE – BETA SPECTRA COMPUTING – VERSION: 2.2 (7/6/2021)

The BetaShape program has been developed to improve nuclear data related to beta emission and electron capture properties. Use of the code, with options, and improvements over the previous versions are briefly described in the README.txt file.

Beta Transitions

Mean energies, log (ft) values, beta and neutrino spectra for single and multiple transitions are provided. A database of experimental shape factors is included and has been updated. The uncertainties provided by the input parameters are taken into account and propagated.

Electron captures

Capture probabilities and capture-to-beta-plus ratios are provided for each atomic subshell. The log(ft) value of each transition is calculated. For a given branch, the splitting between capture and beta plus transitions is also determined.

The spectra and capture probabilities pre-calculated with BetaShape are available on the atomic and nuclear data page, in the column 'ASCII files', by clicking on the 'B' button for the desired nuclide.

Download BetaShape:

BetaShape – V2.2 – Windows 10 (Zip file, 15.4 MB) – (Previous versions: V2.1 ; V2)
BetaShape – V2.2 – Scientific Linux 6.4 (Zip file, 4.92 MB) – (Previous versions: V2.1 ; V2)
BetaShape – V2.2 – Linux Ubuntu 20.04 (Zip file, 12.8 MB)
BetaShape – V2.2 – Linux CentOS 8 (Zip file, 11.9 MB)
BetaShape – V2.2 – macOS Big Sur (M1) (Zip file, 1.39 MB)
BetaShape – V2.2 – macOS Big Sur (Intel) (Zip file, 1.45 MB) – (Previous version: V1)
BetaShape – ReadMe (Txt file)

Warning: For Linux/macOS users, please read first the README file about the environment variable PATH.

Contents

Main program is ‘betashape’, which calls the others programs. Windows version contains ‘cmd.exe’ for opening a terminal.

‘External_files’ directory contains important information required by the code:

- Current version.
- Tabulated parameters to speed-up the atomic wave function calculation.
- Recommended Q-value database from Atomic Mass Evaluation 2020.
- Database of experimental shape factors (beta spectra) and related publications.

Benchmark to test the code on your computer:

- ‘bench’ directory contains executed files for ^{40}K, ^{130}Cs, ^{133}I and ^{205}Pb decays.
- ‘mybench’ script performs the calculations and calls ‘mydiff’ script to compare each file, line by line.

Readme file contains basic information:

- How to use the code: path, options, example of command line.
- Benchmark calculations.
- Description of CSV files.
- History of changes since the first version.

Input file

ENSDF files are taken as standard input of the BetaShape code.

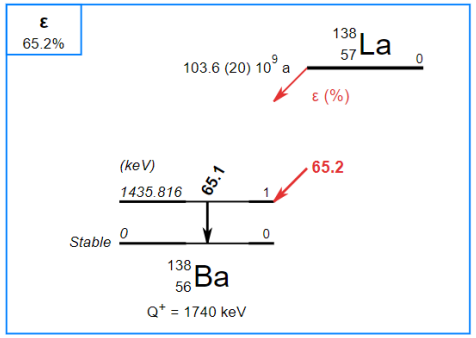
- ✓ Extraction of relevant information for all beta and electron capture transitions in the decay scheme.
- ✓ Determination of the parameters required for the calculation, e.g. transition energy, transition nature, transition intensity.
- ✓ Uncertainties on input parameters are propagated.
- ✓ Several decay schemes or even a mass chain can be given at once.
  - !! Some instabilities have been observed and perfect execution is not guaranteed.
  - → Current solution is to write down a short script that splits the input file in different sub-files, which are next executed independently. Eventually, the updated sub-ENSDF-files can be gathered in a single updated ENSDF file.
  - ✓ This solution works very well when going through the entire ENSDF database (log-*ft* review).

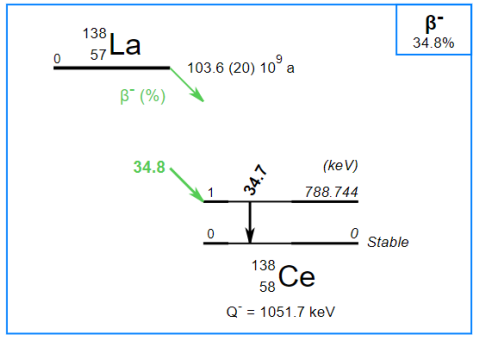
Download the ENSDF files of ^{138}La decay

- IAEA Livechart: https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html
- NNDC NuDat: https://www.nndc.bnl.gov/nudat3/
- DDEP: http://www.lnhb.fr/nuclear-data/nuclear-data-table/

Running the code

!! ^{138}La has two decay modes.





- Open a terminal.
- Run the code with default options

  C:\...> betashape La138.txt

- Note 1: Input file is a text file in ENSDF format, whatever the extension.
- Note 2: Several programs are called during the global execution. Full rights (read, write, execute) are required in the BetaShape directory.
- Look at the output files generated: .read, .trans., .rpt., .new in the BetaShape directory, and .bs in the created La138 sub-directory.

```
138BA     138LA EC DECAY                2016QU01,1984MA46          17NDS     201711
138BA  H TYP=FUL$AUT=JUN CHEN$CIT=NDS 146, 1 (2017)$CUT=30-Sep-2017$
138BA c  See {+138}La adopted levels for parent information
138BA c  2016Qu01: measured E|b, I|b. Deduced electron capture probabilities for
138BA2c  K, L and M, Q-value.
138BA c  1984Ma46: measured E(K X-ray), I(K X-ray). Deduced subshell capture
138BA2c  ratio.
138BA c  Others: 2015Gi03, 1997Ni12, 1983No02, 1996Pa21, 1993Ku22, 1981Sa42,
138BA2c  1979Ta21, 1977Ce04, 1972Ma31, 1966De04
138BA d  1982TAAA: Nature 300, 515 (1982)
138BA d  1983TAAA: Nature 306, 504 (1983)
138BA cG E,M$Quoted values are from Adopted Gammas. Values and arguments from
138BA2cG this data set are given in comments.
138BA cL E,J,T$From Adopted Levels
138LA  P 0.0          5+                1.03E+11 Y1              1742      3
138LA cP J,T$From Adopted Levels of {+138}La
138LA cP QP$From 2017Wa10
138BA  N 1.0                    0.655    4 1.52
138BA cN BR$From Adopted Levels of {+138}La
138BA PN                                  1.0                                3
138BA  L 0.0          0+                STABLE
138BA  L   1435.803102+
138BA  E                          65.5   4   17.24   3                       2U
138BAS E CK=0.635 5$CL=0.277 4$CM+=0.0886 14
138BA cE IE$from {+138}La |e decay branching ratio in Adopted Levels of
138BA2cE {+138}La.
138BA  G 1435.795   10   100      E2
138BAS G CC=0.00087$KC=0.00074 2
138BA cG E$1435.8 {I4} (1977Ce04), 1435.70 {I7} (1979Ta21)
138BA cG M$(L+M+...)/K capture ratio=0.48 {I16} (1984Ma46); L/K=0.391 {I3},
138BA2cG M/K=0.102 {I3}, M/L=0.261 {I9} (2016Qu01)

138CE     138LA B- DECAY                1980MO04,1983NO02,2016QU0117NDS    201711
138CE  H TYP=FUL$AUT=JUN CHEN$CIT=NDS 146, 1 (2017)$CUT=30-Sep-2017$
138CE DG CC$FROM BrIcc v2.3a (10-Sep-2014) 2008Ki07, "Frozen Orbitals" appr.
138CE CG MR$IF NO VALUE GIVEN IT WAS ASSUMED MR=1.00 FOR E2/M1,
138CE2CG MR=1.00 FOR E3/M2 AND MR=0.10 FOR THE OTHER MULTIPOLARITIES
138CE c  See {+138}La adopted and {+138}La |e decay dataset for additional
138CE2c  information
138CE c  Others: 1956Tu17, 1957Gl20, 1966De04, 1972El02, 1972Ma31, 1977Ce04,
138CE2c  1979Ta21, 1981Sa42, 1993Ku22, 1997Ni12, 2000Ta24, 2005Be73, 2012Qu02,
138CE3c  2015Gi03, 2015Gi05
138CE d  1952MuAA: Phys Rev 87, 681 (1952)
138CE d  1982TaAA: Nature 300, 515 (1982)
138CE d  1983TaAA: Nature 306, 504 (1983)
138CE d  1983NoAA: Nature 306, 503 (1983)
138CE cL E,J$From Adopted Levels
138LA  P 0.0          5+                1.03E+11 Y1              1052      4
138LA cP J,T$From Adopted Levels of {+138}La
138LA cP QP$From 2017Wa10
```

Output file .read

```
Information read from the input file: La138.txt

Warning: transition intensities are assumed to be absolute, i.e. per 100 decays of the parent nucleus.
N and PN records are disregarded; only B and EC records are considered for transition intensities.


####################################

Identification record has been found
Daughter Z: 58   Daughter A: 138   Symbol: Ce
Transition type: B-
Estimated parent nuclide from identification record: Z 57, A 138

Parent record has been found
Parent Z: 57    Parent A: 138   Symbol: La
Parent energy of the initial level: G.S.
Parent spin and parity | Read: 5+ | Treated as: 5+
Parent half-life: 1.030E11 (10) Y or 3.250E18 (32) S
Parent Q-value: 1052.0 (40) keV

Normalization record has been found but won't be used
Total branching ratio: 0.3450 (40)

Production normalization record has been found and won't be used
Branching ratio multiplier: 1.

------------------------------------
Level record has been found
Daughter energy of the final level: G.S.
Level spin and parity | Read: 0+  | Treated as: 0+
Level half-life not given.

------------------------------------
Level record has been found
Daughter energy of the final level: 788.744 (8) keV
Level spin and parity | Read: 2+  | Treated as: 2+
Level half-life not given.

Beta - record has been found
Measured endpoint energy of the beta - transition: 264.0 (40) keV
Intensity of the beta - branch: 34.50 (40) %
Transition order: 2nd forbidden unique
Log ft of the beta - transition: 18.050 (40)
Average energy of beta - spectrum: 97.5 (37) keV

####################################
```

Output file .trans

```
####################################

Transitions that have been found.

------------------------------------
Parent nucleus: 57-La-138 [5+] g.s.  -->  Daughter nucleus: 58-Ce-138 [2+] 788.744 (8) keV
Half-life of the parent nuclide: 3.250E18 (32) s
Beta - transition. Order: 2nd forbidden unique
Transition energy calculated from Q-value and level energies: 263.3 (40) keV. For information, given measured Emax: 264.0 (40) keV.
Normalization of this transition: 34.50 (40) %
Average energy of beta - spectrum: 97.5 (37) keV
Log ft of the beta - transition: 18.050 (40)


####################################

Summary

1 nucleus and 1 transition has been read.

Parent nucleus: 57-La-138
1 transition has been read (1 B-).


####################################
```

Transition order (nature) determined from spins and parities of initial and final levels. If several given, first read is first used.

Transition energy determined from Q-value and level energies, with propagation of uncertainties. Endpoint energy not used (ENSDF policy: given only if measured).

Output file .rpt

Report file in LogFT style. Summary of the results

For each transition:

- Cards that identify the transition.
- Old card / New updated card. Can be Parent card if Q-value updated.
- Additional information.

Results summarized as BetaShape runs: B- first, then EC and finally B+.

Brief summary of total transitions considered and number of added lines in the updated ENSDF file.

```
Input file:  La138.txt
Output file: La138.new

Input file: 32 lines
Output file: 34 lines
Added new lines: 2
--> Output file is consistent.

Warning: transition intensities are assumed to be absolute, i.e. per 100 decays of the parent nucleus.
N and PN records are disregarded; only B and EC records are considered for transition intensities.


################################################  B- DECAYS  ################################################

-------------------------------------------------------------------------------------------------------------  1

138LA  P 0.0         5+               1.03E+11 Y1             1052      4     - PARENT
138CE  N 1.0                  0.345    4 2.90                                 - NORMALIZATION
138CE PN                               1.0                                3  - PRODUCTION NORMALIZATION
138CE  L 788.744    8 2+                                                     - LEVEL

***** BR*NB from PN record *****

From calculated spectrum
Emean 99.2 (15) keV   |   log ft 18.065 (40)

From measured spectrum
Emean 91.6 (15) keV   |   [For information] log ft 17.293 (39)

*    log ft
138CE  B 264       4  34.5   4            18.05 4                          2U - OLD CARD
138CE  B 264       4  34.5   4           18.065  40                        2U - NEW CARD

*    Mean energy
138CES B EAV=97.5 37                                                       - OLD CARD
138CES B EAV=91.6 15                                                       - NEW CARD
138CE2 B C1=-1.319 6 $C3=0.4982 38 (2019SA36)                              - ADDITIONAL NEW CARD
138CE cB $C(W)=(1+C{-1}*W+C{-3}*W^2)*(q^4+(10/3)*l_2*q^2*p^2+l_3*p^4)       - ADDITIONAL NEW CARD

-------------------------------------------------------------------------------------------------------------

-------- Total: 1
-------- Added lines: 2
```

Output file .new

Input ENSDF file: La138.txt

```
138CE    138LA B- DECAY                1980MO04,1983NO02,2016QU0117NDS    201711
138CE  H TYP=FUL$AUT=JUN CHEN$CIT=NDS 146, 1 (2017)$CUT=30-Sep-2017$
138CE DG CC$FROM BrIcc v2.3a (10-Sep-2014) 2008Ki07, "Frozen Orbitals" appr.
138CE CG MR$IF NO VALUE GIVEN IT WAS ASSUMED MR=1.00 FOR E2/M1,
138CE2CG MR=1.00 FOR E3/M2 AND MR=0.10 FOR THE OTHER MULTIPOLARITIES
138CE c  See {+138}La adopted and {+138}La |e decay dataset for additional
138CE2c  information
138CE c  Others: 1956Tu17, 1957Gl20, 1966De04, 1972El02, 1972Ma31, 1977Ce04,
138CE2c  1979Ta21, 1981Sa42, 1993Ku22, 1997Ni12, 2000Ta24, 2005Be73, 2012Qu02,
138CE3c  2015Gi03, 2015Gi05
138CE d  1952MuAA: Phys Rev 87, 681 (1952)
138CE d  1982TaAA: Nature 300, 515 (1982)
138CE d  1983TaAA: Nature 306, 504 (1983)
138CE d  1983NoAA: Nature 306, 503 (1983)
138CE cL E,J$From Adopted Levels
138LA  P 0.0         5+                1.03E+11 Y1              1052      4
138LA cP J,T$From Adopted Levels of {+138}La
138LA cP QP$From 2017Wa10
138CE  N 1.0                   0.345    4 2.90
138CE cN BR$From Adopted Levels of {+138}La
138CE PN                                1.0                                3
138CE  L 0.0          0+
138CE  L 788.744    8 2+
138CE  B 264       4  34.5   4             18.05 4                          2U
138CES B EAV=97.5 37
138CE cB E$from 2016Qu01. Other: 205 {I10} (1957Gl20)
138CE  G 788.742   8  100      E2                      0.00342
138CES G  KC=0.00291 4$LC=0.000406 6$MC=8.52E-5 12
138CES G  NC=1.88E-5 3$OC=3.01E-6 5$PC=2.10E-7 3
138CE cG E$from 1980Mo04. Others: 788.66 {I7} (1979Ta21), 789.1 {I5} (1977Ce04),
138CE2cG 789.0 {I3} (1972Gr45), 787.9 {I3} (1972Ma31)
138CE cG M$from Adopted Gammas
```

Updated ENSDF file: La138.new

```
138CE    138LA B- DECAY                1980MO04,1983NO02,2016QU0117NDS    201711
138CE  H TYP=FUL$AUT=JUN CHEN$CIT=NDS 146, 1 (2017)$CUT=30-Sep-2017$
138CE DG CC$FROM BrIcc v2.3a (10-Sep-2014) 2008Ki07, "Frozen Orbitals" appr.
138CE CG MR$IF NO VALUE GIVEN IT WAS ASSUMED MR=1.00 FOR E2/M1,
138CE2CG MR=1.00 FOR E3/M2 AND MR=0.10 FOR THE OTHER MULTIPOLARITIES
138CE c  See {+138}La adopted and {+138}La |e decay dataset for additional
138CE2c  information
138CE c  Others: 1956Tu17, 1957Gl20, 1966De04, 1972El02, 1972Ma31, 1977Ce04,
138CE2c  1979Ta21, 1981Sa42, 1993Ku22, 1997Ni12, 2000Ta24, 2005Be73, 2012Qu02,
138CE3c  2015Gi03, 2015Gi05
138CE d  1952MuAA: Phys Rev 87, 681 (1952)
138CE d  1982TaAA: Nature 300, 515 (1982)
138CE d  1983TaAA: Nature 306, 504 (1983)
138CE d  1983NoAA: Nature 306, 503 (1983)
138CE cL E,J$From Adopted Levels
138LA  P 0.0         5+                1.03E+11 Y1              1052      4
138LA cP J,T$From Adopted Levels of {+138}La
138LA cP QP$From 2017Wa10
138CE  N 1.0                   0.345    4 2.90
138CE cN BR$From Adopted Levels of {+138}La
138CE PN                                1.0                                3
138CE  L 0.0          0+
138CE  L 788.744    8 2+
138CE  B 264       4  34.5   4             18.065  40                       2U
138CES B EAV=91.6 15
138CE2 B C1=-1.319 6 $C3=0.4982 38 (2019SA36)
138CE cB $C(W)=(1+C{-1}*W+C{-3}*W^2)*(q^4+(10/3)*l_2*q^2*p^2+l_3*p^4)
138CE cB E$from 2016Qu01. Other: 205 {I10} (1957Gl20)
138CE  G 788.742   8  100      E2                      0.00342
138CES G  KC=0.00291 4$LC=0.000406 6$MC=8.52E-5 12
138CES G  NC=1.88E-5 3$OC=3.01E-6 5$PC=2.10E-7 3
138CE cG E$from 1980Mo04. Others: 788.66 {I7} (1979Ta21), 789.1 {I5} (1977Ce04),
138CE2cG 789.0 {I3} (1972Gr45), 787.9 {I3} (1972Ma31)
138CE cG M$from Adopted Gammas
```

Output file .bs – single B transition

```
--------------------------------------------------------------------------------

BetaShape
Version: 2.2 (05/2021)
Author: X. Mougeot (xavier.mougeot@cea.fr)
CEA, LIST, Laboratoire National Henri Becquerel (LNHB), Gif-sur-Yvette F-91191, France
Please cite: X. Mougeot, Physical Review C 91, 055504; Erratum Phys. Rev. C 92, 059902 (2015)

--------------------------------------------------------------------------------

Parent nucleus: 57-La-138 [5+] g.s.  -->  Daughter nucleus: 58-Ce-138 [2+] 788.744 (8) keV
Calculation of the 2nd forbidden unique transition from the beta - decay of La-138

Buhring's screening correction is considered.

End-point energy: 263.3 (40) keV     Energy step: 0.8 keV     Intensity: 0.3450 (40)
```

Transition parameters and options used in calculation

Experimental shape factor

```
An experimental shape factor has been found: (1 - 1.319*W + 0.4982*W^2) * (q^4 + (10/3)*l_2*q^2*p^2 + l_3*p^4)
Energy range of the measurement: 5 - 265 keV      In database, transition #130
From [2019SA36] R. Sandler, G. Bollen, J. Dissanayake, M. Eibach, K. Gulyuz, A. Hamaker, C. Izzo, X. Mougeot, D. Puentes, F. G. A. Quara
```

Mean energies, log *ft* values, analysis parameters

```
Input mean energy: 97.5 (37) keV
Mean energy from the calculated spectrum: 99.2 (15) keV
Mean energy from the experimental shape factor: 91.6 (15) keV

Input log ft value: 18.050 (40)
Log ft value from the calculated spectrum: log ft 18.065 (40)   with components: log f -0.909 (40) and log partial T1/2 18.974 (7)
[For information] Log ft value from the experimental shape factor: log ft 17.293 (39)   with component: log f -1.681 (38)

Agreement of the experimental and calculated spectra in [5,265] keV: 93.26 %
Corresponding disagreement: 6.74 %
Variation of the mean energies: 8.24 %
```

E(keV)	dN/dE calc.	unc.	dN/dE exp.	unc.
0.0	1.30660e-03	7.90686e-06	2.28750e-03	2.91724e-05
0.8	1.43982e-03	1.33639e-05	2.28432e-03	2.92507e-05
1.6	1.53670e-03	1.70462e-05	2.28108e-03	2.93250e-05
2.4	1.59724e-03	1.89539e-05	2.27779e-03	2.93952e-05

Beta spectra
Option: antineutrino spectra

Output file .bs – total B spectrum

```
--------------------------------------------------------------------------------

BetaShape
Version: 2.2 (05/2021)
Author: X. Mougeot (xavier.mougeot@cea.fr)
CEA, LIST, Laboratoire National Henri Becquerel (LNHB), Gif-sur-Yvette F-91191, France
Please cite: X. Mougeot, Physical Review C 91, 055504; Erratum Phys. Rev. C 92, 059902 (2015)

--------------------------------------------------------------------------------

Total beta - spectrum from the La-138 decay. See file of each transition for more details.

Mean energy from the total beta - spectrum: 91.6 (15) keV

E(keV)      dNtot/dE b-      unc.
   0.0      2.28750e-03      2.91724e-05
   0.8      2.28432e-03      2.92507e-05
   1.6      2.28108e-03      2.93250e-05
   2.4      2.27779e-03      2.93952e-05
   3.2      2.27444e-03      2.94614e-05
   4.0      2.27104e-03      2.95237e-05
   4.8      2.26759e-03      2.95822e-05
   5.6      2.26409e-03      2.96369e-05
   6.4      2.26055e-03      2.96878e-05
   7.2      2.25695e-03      2.97351e-05
   8.0      2.25330e-03      2.97789e-05
   8.8      2.24961e-03      2.98190e-05
   9.6      2.24587e-03      2.98558e-05
  10.0      2.24398e-03      2.98729e-05
  10.8      2.24018e-03      2.99045e-05
  11.6      2.23633e-03      2.99329e-05
  12.4      2.23244e-03      2.99579e-05
  13.2      2.22851e-03      2.99797e-05
  14.0      2.22454e-03      2.99985e-05
  14.8      2.22052e-03      3.00141e-05
```

Total beta spectrum of the decay is built from single transition spectra normalized to the branching ratios. Experimental spectrum is preferred if any.

Total mean energy of beta emitted particles is determined.

Uncertainties are propagated.

‼ Energy step can be not constant in order to keep more information at low energy even with large endpoint energy.

Output file .bs – single EC transition

```
--------------------------------------------------------------------------------

BetaShape
Version: 2.2 (05/2021)
Author: X. Mougeot (xavier.mougeot@cea.fr)
CEA, LIST, Laboratoire National Henri Becquerel (LNHB), Gif-sur-Yvette F-91191, France
Please cite: X. Mougeot, Applied Radiation and Isotopes 154 (2019) 108884

--------------------------------------------------------------------------------

Parent nucleus: 57-La-138 [5+] g.s.  -->  Daughter nucleus: 56-Ba-138 [2+] 1435.803 (10) keV
Calculation of the 2nd forbidden unique transition from the electron capture decay of La-138

Transition energy: 306.2 (30) keV


----------------------------------------
Ratios of relative capture probabilities

PL1/PK =  0.2449 (21)
PL2/PK =  0.00756 (13)
PL3/PK =  0.151 (6)
PM1/PK =  0.0599 (8)
PM2/PK =  0.001995 (44)
PM3/PK =  0.0373 (16)
PN1/PK =  0.01548 (27)
PM4/PK =  1.22E-4 (6)
PM5/PK =  2.68E-4 (20)
PN2/PK =  5.00E-4 (13)
PN3/PK =  0.00843 (41)
PO1/PK =  0.00305 (7)
PN4/PK =  2.65E-5 (15)
PN5/PK =  6.7E-5 (5)
PO2/PK =  8.33E-5 (29)
PO3/PK =  0.00118 (7)
PP1/PK =  3.51E-4 (11)

L/K =  0.403 (8)
M/K =  0.0996 (24)
N/K =  0.0245 (7)
O/K =  0.00431 (14)
P/K =  3.51E-4 (11)
```

Detailed information for subshells. Combined for shells.

Not identical if B+ competes

```
------------------------------
Relative capture probabilities

PK  =  0.6527 (48)
PL1 =  0.15986 (42)
PL2 =  0.00494 (5)
PL3 =  0.0984 (31)
PM1 =  0.03911 (20)
PM2 =  0.001302 (19)
PM3 =  0.0243 (9)
PN1 =  0.01010 (10)
PM4 =  7.94E-5 (35)
PM5 =  1.75E-4 (11)
PN2 =  3.26E-4 (6)
PN3 =  0.00550 (22)
PO1 =  0.001990 (32)
PN4 =  1.73E-5 (8)
PN5 =  4.40E-5 (31)
PO2 =  5.44E-5 (15)
PO3 =  7.70E-4 (39)
PP1 =  2.29E-4 (6)

K =  0.6527 (48)
L =  0.2632 (33)
M =  0.0650 (11)
N =  0.01600 (33)
O =  0.00281 (7)
P =  2.29E-4 (6)
```

```
---------------------
Capture probabilities

PK  =  0.6527 (48)
PL1 =  0.15986 (42)
PL2 =  0.00494 (5)
PL3 =  0.0984 (31)
PM1 =  0.03911 (20)
PM2 =  0.001302 (19)
PM3 =  0.0243 (9)
PN1 =  0.01010 (10)
PM4 =  7.94E-5 (35)
PM5 =  1.75E-4 (11)
PN2 =  3.26E-4 (6)
PN3 =  0.00550 (22)
PO1 =  0.001990 (32)
PN4 =  1.73E-5 (8)
PN5 =  4.40E-5 (31)
PO2 =  5.44E-5 (15)
PO3 =  7.70E-4 (39)
PP1 =  2.29E-4 (6)

K =  0.6527 (48)
L =  0.2632 (33)
M =  0.0650 (11)
N =  0.01600 (33)
O =  0.00281 (7)
P =  2.29E-4 (6)
```

If B+ competes:

- ✓ Splitting of the branch also given. Intensities updated.
- ✓ EC/B+ ratios also given for subshells, shells and total.

```
------------------------------
Capture branch from input data

Iec =   65.50 (40) %
```

```
-----------------------------------
Input log ft value (ec): 17.240 (30)

Log ft value (ec)     =  17.269 (35)
with log f            =  -1.426 (34)
and log partial T1/2 =  18.696 (5)
```

Options (1)

Default values and other options

- Screening: **sc=1** for Bühring screening. Others: sc=2 for Rose screening; sc=0 to turn off.
- Radiative corrections: **rd=1** to turn on. Other: rd=0 to turn off.
- Experimental shape factor: **ff=1** look for in the database. Other: ff=0 to turn off.
- Neutrino spectra: nu=1 for printing in output files. Default is **nu=0**, i.e. not printed.
- $\lambda_k = 1$ approximation: l1=1 for additional calculation of simplified theoretical shape factors. Default is **l1=0** for full calculation.
- Precision digits: **outprec=5**. Others: any positive integer.
- Spectrum binning: **Nstep=300** calculated energies (constant step determined from maximum energy). Others: any positive integer.

Options (2)

Default values and other options

- EC and B+ intensities: **fixint=0** for calculating and updating the splitting of the branch between EC and B+.
  Other: fixint=1 for keeping the intensities from the input file.

- Spectrum energy step: **myEstep=0.** energy steps managed automatically.
  Others: any positive number as constant energy step (in keV) for all calculated spectra. Additional output files.

- Q-values: **-qval** for automatic update from AME2020 recommendations.
  Default: turned off; Q-value from input file is kept.

- Saisinuc: **-saisinuc** for creating a specific formatted output file for the Microsoft Access database of DDEP evaluations. Default: turned off.

- **-csv** for creating CSV files (separator is ', ') for B- and EC/B+ transitions. Default: turned off.

- **-csv_fr** for creating CSV files in French version (separator is ' ; '). Default: turned off.

CSV file

Opened in text editor

```
# BetaShape
# Version: 2.2 (04/2021)
# Author: X. Mougeot (xavier.mougeot@cea.fr)
# CEA, LIST, Laboratoire National Henri Becquerel (LNHB), Gif-sur-Yvette F-91191, France
# Please cite: X. Mougeot, Physical Review C 91, 055504; Erratum Phys. Rev. C 92, 059902 (2015)
#
# Input file: I133.txt
#
# parent symbol, Z, A, Jpi, level energy, unc, daughter symbol, Z, A, Jpi, level energy, unc, Q, unc, half-life, unc, unit, transition na
I, 53, 133, 7/2+, 0, 0, Xe, 54, 133, 11/2-, 233.219, 0.015, 1757, 4, 75130, 290, s, 1U, 1U, 1.07, 0.06, 9.949, 0.025, 1523.8, 4, 569.5, 1
I, 53, 133, 7/2+, 0, 0, Xe, 54, 133, 5/2+, 529.872, 0.003, 1757, 4, 75130, 290, s, A, A, 83.42, 0.21, 6.845, 0.006, 1227.1, 4, 439.3, 1.7
I, 53, 133, 7/2+, 0, 0, Xe, 54, 133, (7/2,9/2,11/2)-, 743.75, 0.016, 1757, 4, 75130, 290, s, 1N, A, 1.81, 0.06, 8.198, 0.016, 1013.3, 4,
```

Opened in Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
1	# BetaShape																										
2	# Version: 2.2 (04/2021)																										
3	# Author: X. Mougeot (xavier.mougeot@cea.fr)																										
4	# CEA, LIST, Laboratoire National Henri Becquerel (LNHB), Gif-sur-Yvette F-91191, France																										
5	# Please cite: X. Mougeot, Physical Review C 91, 055504; Erratum Phys. Rev. C 92, 059902 (2015)																										
6	#																										
7	# Input file: I133.txt																										
8	#																										
9	# parent symbol	Z	A	Jpi	level energy	unc	daughter symbol	Z	A	Jpi	level energy	unc	Q	unc	half-life	unc	unit	transition nature	transition nature used	branching %	unc	log ft	unc	transition energy	unc	mean energy calc	u
10	I	53	133	7/2+	0	0	Xe	54	133	11/2-	233.219	0.015	1757	4	75130	290	s	1U	1U	1.07	0.06	9.949	0.025	1523.8	4	569.5	1
11	I	53	133	7/2+	0	0	Xe	54	133	5/2+	529.872	0.003	1757	4	75130	290	s	A	A	83.42	0.21	6.845	0.006	1227.1	4	439.3	1
12	I	53	133	7/2+	0	0	Xe	54	133	(7/2,9/2,11/2)-	743.75	0.016	1757	4	75130	290	s	1N	A	1.81	0.06	8.198	0.016	1013.3	4	350.4	1
13	I	53	133	7/2+	0	0	Xe	54	133	(7/2)+	875.331	0.005	1757	4	75130	290	s	A	A	4.16	0.13	7.616	0.015	881.7	4	297.4	1
14	I	53	133	7/2+	0	0	Xe	54	133	(1/2,3/2)+	911.45	0.03	1757	4	75130	290	s	2U	2U	0.026	0.018	10.69	0.3	845.5	4	317.3	1
15	I	53	133	7/2+	0	0	Xe	54	133	5/2+	1052.397	0.017	1757	4	75130	290	s	A	A	0.58	0.05	8.124	0.038	704.6	4	228.4	1
16	I	53	133	7/2+	0	0	Xe	54	133	(7/2)+	1236.449	0.005	1757	4	75130	290	s	A	A	3.12	0.06	6.938	0.014	520.6	4	160.5	1

Playing with the options

Try different possibilities varying the options.

Some examples:

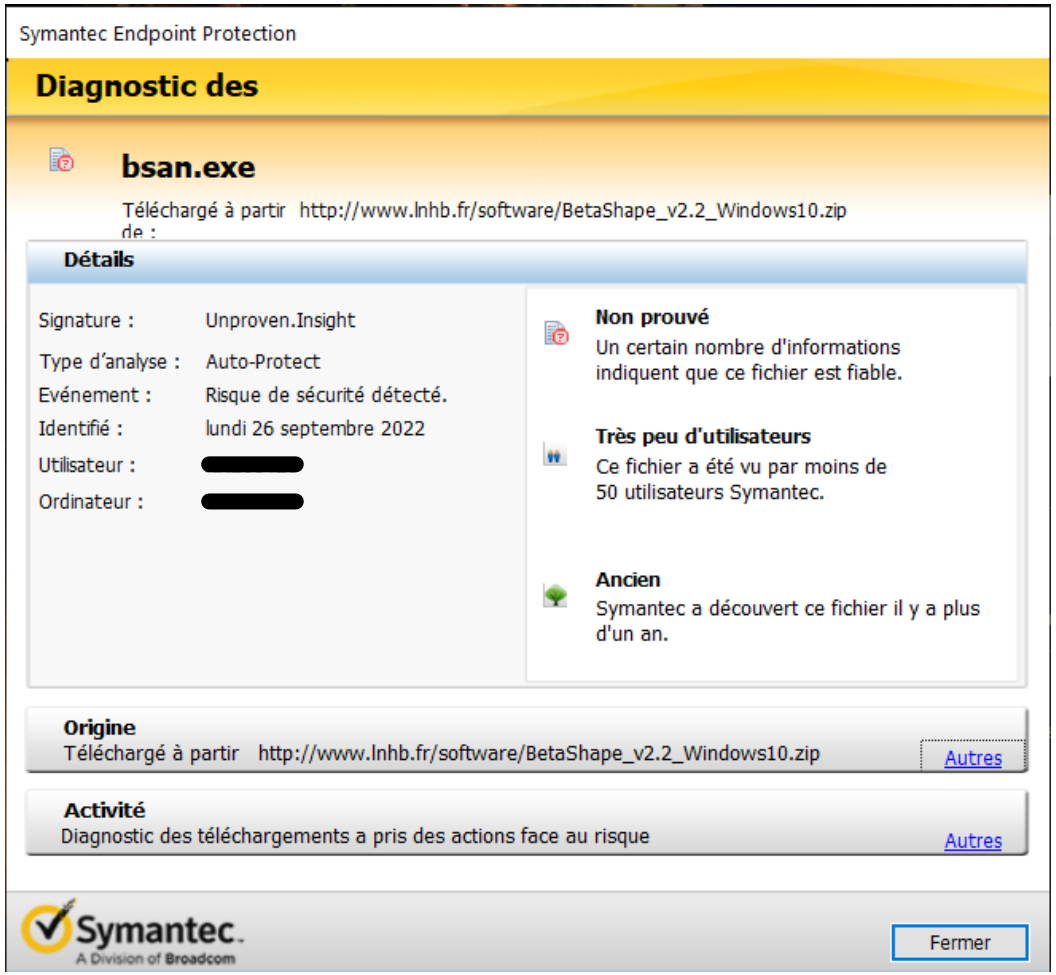
- I do not want either screening or radiative corrections.
  C:\...> betashape La138.txt sc=0 rd=0

- I want to update automatically the Q-value and create a CSV file.
  C:\...> betashape La138.txt -qval -csv

- I want the neutrino spectra and all spectra with 1 keV binning.
  C:\...> betashape La138.txt nu=1 myEstep=1.

- I have measured EC and B+ intensities. I trust them and I do not want an automatic update from theory.
  C:\...> betashape Cs130.txt fixint=1

Possible antivirus problem



In Windows, such a message can append for each of the programs when run.

Programs are not recognized in the antivirus database and can be put in quarantine.

- Declare the BetaShape directory and all the content as safe.
- Release the programs from quarantine.
- Administrator rights can be necessary.

If any other problem appears…

Check your rights in the BetaShape directory: read, write and execute are necessary.

Check the PATH: execution in local directory is required. See Readme file.

Move the input file and execute the code in the BetaShape directory.

90% of encountered cases come from an ENSDF file that does not respect the ENSDF format: e.g. file modified by hand or generated by a specific program.

- → Check the ENSDF file.
- → Look at .read file: information that has been read.
- → Look at .trans file: deduced information on the transitions that are being calculated.

If message in console command: ‘Pb new file: La138.txt’
and in .rpt file: ‘--> !!!!! A problem occurs when writing the output file !!!!!’

- → Only a single blank line at the end of input file.
- ✓ Remove any additional line. Should not change the results.

If problem unsolved or for any other problem: send me a message at xavier.mougeot’at’cea.fr

Thank you for attention.