BetaShape

User manual – Version 3.0

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October 2026

BetaShape in a nutshell

What BetaShape does

- Reads ENSDF or JSON decay data
- All β^-, β^+ and EC transitions
- Spectra: β, ν, recoil, IB photons
- Mean energies, log ft, EC probabilities
- Updated ENSDF/JSON, reports, CSV

Two ways to use it

- Command line: betashape myfile.txt
- Graphical interface: BetaShapeGUI
- Same engine, same options
- Windows 11, Ubuntu 26.04, macOS 15
- Runs from any directory (BSINSTALL)

New in version 3 – October 2026

- ✓ Graphical interface (English / French)
- ✓ Recoil, IB photons, energy balance
- ✓ ENSDF-JSON input (beta version)
- ✓ Neutrino mass and sterile neutrino

→ Download from the IAEA-NSDD GitHub: github.com/IAEA-NSDDNetwork

Getting the code

- ✓ Download the package of your operating system from the IAEA-NSDD GitHub: **github.com/IAEA-NSDDNetwork**
- ✓ Also available on the LNHB website: **www.lnhb.fr/rd-activities/spectrum-processing-software**
- ✓ Each package contains the command-line programs and the graphical interface.
- ✓ Each archive comes with a .sha256 file to check that the download is complete.
- ✓ Unzip the archive in a folder where you have full rights (read, write, execute).
- ✓ Latest version is 3.0. Previous versions are available on request, but not recommended.

Windows 11

64-bit

- BetaShapeGUI.exe
- Windows may ask to allow the programs (antivirus)

Ubuntu 26.04 LTS

x86_64, and later versions

- BetaShapeGUI
- Built on Ubuntu 26.04

macOS 15 and later

Apple silicon (M1 or later)

- BetaShapeGUI.app
- Not signed by Apple: see README_macOS.txt

Package contents

```
BetaShape-3.0/
├─ betashape              main program
├─ bin/                   called by betashape
├─ resources/             data used by the code
├─ benchmark/             reference results
├─ mybench, mydiff        benchmark
├─ BetaShapeGUI           interface
├─ update_bsinstall_*     path set-up
└─ README.txt             instructions
```

bin/ – never run directly

- bsan, bsan_mult: β transitions, totals
- capt, capt_mult: electron capture, totals
- writeBM, writeBP, writeEC: ENSDF records
- json2ensdf, ensdf2json: JSON conversion

resources/

- Version and references to cite
- Tabulated atomic data: wave functions, screening, exchange
- AME2020 Q-values and atomic masses
- Database of experimental shape factors

Installation: set the path once

1 Unzip

Choose a folder with full rights, e.g.

`C:\Codes\BetaShape`

`~/BetaShape-3.0`

2 Set BSINSTALL

Run once, from the BetaShape folder:

```
update_bsinstall_windows.cmd
source update_bsinstall_ubuntu.sh
source update_bsinstall_macos.zsh
```

Manual set-up: README.txt, Section 1

3 Check

Open a new terminal, then:

```
betashape -version
```

BetaShape now runs from any directory.

macOS only, once after unzipping

The programs are not signed by Apple. In the Terminal, run: **`xattr -dr com.apple.quarantine ~/BetaShape-3.0`**

No administrator password needed. Details in README_macOS.txt.

Benchmark calculations



- ✓ Recommended at first use, and after each new installation.
- ✓ Run the command below in a terminal, from the BetaShape folder.
- ✓ β and EC transitions of the ^{40}K, ^{130}Cs, ^{133}I and ^{205}Pb decays are calculated.
- ✓ mydiff then compares each file, line by line, with the reference files of the benchmark folder.
- → Electron capture can take time, especially at high Z.
- → Differences can appear on the last digits, depending on the operating system.

`mybench`	*Ubuntu, macOS*
`mybench.bat`	*Windows*

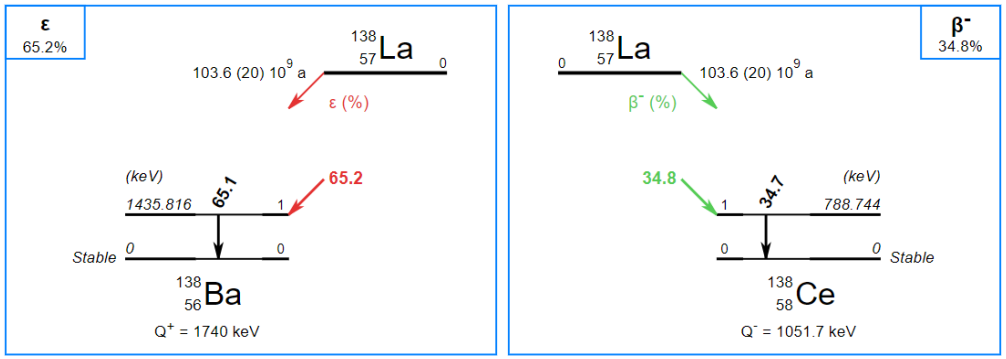
Input files

ENSDF file

- ✓ Text file in ENSDF format, whatever the extension.
- ✓ All β^-, β^+ and EC transitions of the decay data sets are calculated.
- ✓ Several data sets, or even a whole mass chain, can be given at once.
- ✓ Download, e.g. ^{138}La decay:
  - IAEA LiveChart: www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html
  - NNDC NuDat: www.nndc.bnl.gov/nudat3
  - DDEP: www.lnhb.fr/nuclear-data/nuclear-data-table

ENSDF-JSON file (beta version)

- ✓ NNDC JSON format, extension .json.
- ✓ Converted to ENSDF format, calculated, then the updated file is written in ENSDF-JSON format.



^{138}La has two decay modes: β⁻ and EC.

```
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(|b{+-})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 |d=1.00 for E2/M1,
138CE2cG |d=1.00 for E3/M2 and |d=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, 1972E102, 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
```

Running from the command line

- ✓ Open a terminal in the folder of your input file.
- ✓ Run with the default options, which are the recommended ones.
- ✓ A progress bar is shown for each type of transition: β^-, then EC, then β^+.
- ✓ Output files are written in the same folder; spectra go in a sub-folder named after the parent nuclide (e.g. La138/).
- → Input and output files are text files, whatever the extension.
- → Options are added after the file name, in any order.

go to the folder of the input file

```
cd my_folder
```

default options

```
betashape La138.txt
```

with options

```
betashape La138.txt -qval -csv
```

list of options, installed version

```
betashape -help
betashape -version
```

Output files

File	Content
`La138.rpt`	Report in LogFT style: old and new cards for each transition, summary
`La138.new`	Updated ENSDF file
`La138.read, .trans`	Information read in the input file, and deduced for each transition
`La138/*_trans*.bs`	One file per transition: spectra, mean energies, energy balance
`La138/*_tot.bs`	Total spectra of the decay (β^-, β^+, EC)
`*_myEstep.bs`	Same spectra with a constant energy step (option myEstep=)
`La138_bm.csv, ...`	CSV files (options -csv, -csv_fr)
`*_updated.json`	Updated JSON file, for a JSON input (+ converted ENSDF and report)
`mult.log, exit.log`	Warnings: transition left out of the totals, program stopped

Spectrum files (.bs) – β transitions

→ Each section has a header (energy step, maximum and mean energies, intensity), then the spectrum with its uncertainties.

```
-------------------------
Energy balance
-------------------------

Available energy: 3505.22 (5) keV

Average beta energy: 1559.614 (24) keV
Average antineutrino energy: 1940.181 (26) keV
Average recoil energy: 788.514 (20) eV
Average internal bremsstrahlung energy: 4.63648 (11) keV

-->  Sum: 3505.220 (35) keV


-------------------------
Beta spectrum
-------------------------

Energy step: 11 keV
Maximum beta energy: 3503.80 (5) keV
```

Energy balance: energy carried away by each particle

```
-------------------------
Antineutrino spectrum
-------------------------

Energy step: 11 keV
Maximum antineutrino energy: 3504.12 (5) keV

Mean energy from the calculated spectrum: 1940.181 (26) keV
Mean energy from the experimental shape factor: 1921.493 (26) keV

E(keV)      dN/dE calc.     unc.            dN/dE exp.      unc.
     0      0.00000e+00     0.00000e+00     0.00000e+00     0.00000e+00
```

Antineutrino spectrum (nu=1)

```
-------------------------
Nuclear recoil spectrum
-------------------------

Energy step: 4 eV
Maximum recoil energy: 1415.467 (36) eV
Mean energy from the calculated spectrum: 788.301 (20) eV
Mean energy from the experimental shape factor: 788.056 (20) eV

 E(eV)      dN/dE calc.     unc.            dN/dE exp.      unc.
     0      0.00000e+00     0.00000e+00     0.00000e+00     0.00000e+00
     4      7.14556e-05     2.85345e-09     7.19178e-05     2.87014e-09
     8      1.02611e-04     4.02776e-09     1.03271e-04     4.05128e-09
```

Nuclear recoil spectrum, in eV (recoil=1)

```
-----------------------------------------
Internal bremsstrahlung photon spectrum
-----------------------------------------

Energy step: 11 keV
Maximum photon energy: 3504.12 (5) keV
Mean photon energy: 448.798 (13) keV
Photon intensity: 1.0328698 (44) %

E(keV)      dN/dE calc.     unc.
     0      1.44349e-03     6.44836e-09
    11      9.54727e-05     3.75409e-09
```

Internal bremsstrahlung photon spectrum (rd=1)

Spectrum files (.bs) – electron capture

- ✓ Capture probabilities for each subshell and shell (K, L1, L2…).
- ✓ If β^+ competes: splitting of the branch, EC/β^+ ratios.
- ✓ Neutrino spectrum: one line per subshell, plus a continuum from radiative capture.
- ✓ Internal bremsstrahlung photon spectrum.
- ✓ Recoil energy of the daughter nucleus, for each subshell.
- ✓ Energy balance per capture, also detailed per subshell.
- → Total file `capt_La138_tot.bs`: total neutrino and photon spectra, mean energy balance per capture.

```
------------------------------------------------------------
Energy balance

Available energy: 1504.40 (6) keV

Average neutrino energy: 1501.26 (7) keV
Average IB photon energy: 0.303784 (39) keV
Average recoil energy:   30.2929 (25) eV
Average atomic energy:   2.811 (10) keV (available for relaxation)
   including shaking:    0.017 (8) keV (estimate)
--> Sum: 1504.40 (6) keV
```

Energy balance per capture (^{40}K)

Atomic	Regular neutrino						
Subshell	Eorb(keV)	Ekin.line(keV)	IB.frac.r/(1+r)	<Ekin>(keV)	Recoil(eV)	Relat.Prob.	Prob.(EC.frac.)
K1	3.10419	1501.27 (6)	5.56626E-4 (44)	1500.96 (6)	30.2803 (24)	0.8908 (7)	0.8866 (7)
L1	0.295531	1504.07 (6)	5.58710E-4 (45)	1503.77 (6)	30.3937 (24)	0.0956 (5)	0.0952 (5)
L2	0.231192	1504.14 (6)	0	1504.14 (6)	30.3963 (24)	2.199E-4 (17)	2.189E-4 (17)
L3	0.228969	1504.14 (6)	0	1504.14 (6)	30.3964 (24)	6.260E-4 (35)	6.230E-4 (35)
M1	0.0242353	1504.35 (6)	5.58911E-4 (45)	1504.04 (6)	30.4047 (24)	0.01264 (15)	0.01258 (15)
M2	0.0105064	1504.36 (6)	0	1504.36 (6)	30.4053 (24)	2.273E-5 (12)	2.263E-5 (12)
M3	0.0103273	1504.36 (6)	0	1504.36 (6)	30.4053 (24)	5.07E-5 (6)	5.05E-5 (6)

Detailed balance per subshell

Options (1) – corrections and models

Option	Default behaviour	Other values
`sc=1`	Numerical (tabulated) atomic screening	2 Rose, 3 Bühring, 0 off
`ex=1`	Atomic exchange correction (β^-)	0 off
`ov=1`	Atomic overlap correction	0 off
`rd=1`	Radiative corrections and IB spectra	0 off
`ibmodel=1`	IB model of Ivanov et al. (β)	0 Knipp-Uhlenbeck-Bloch, faster, of if rd=0
`recoil=1`	Nuclear recoil (β, ν and recoil spectra)	0 off
`ff=1`	Experimental shape factor, if available	0 theoretical only
`l1=0`	Full theoretical shape factor	1 additional calculation with λ_k=1
`rmsmodel=3`	Charge radius off the stability line	0 uniform, 1 liquid drop, 2 along the stability line

→ Default values are the recommended ones: options are only needed for specific studies.

Options (2) – spectra, neutrinos and outputs

Option	Default behaviour	Other values
`nu=1`	Neutrino spectra calculated	0 not calculated
`Nstep=300`	Number of calculated energies	Any positive integer
`myEstep=0.`	Energy steps managed automatically	Constant step in keV, e.g. myEstep=0.5
`mnu=0`	Neutrino mass, in keV	Any positive value
`mst=0, Pst=0`	Sterile neutrino: mass (keV), probability	Both positive to be accounted for
`outprec=5`	Precision digits in output files	Any positive integer
`-csv`	Off	CSV files, separator ','
`-csv_fr`	Off	CSV files, separator ';'
`-saisinuc`	Off	Output file for the Saisinuc database (DDEP)

→ Example: `betashape La138.txt myEstep=0.5 -csv_fr`

Options (3) – input data and program

Option	Default behaviour	Other values
fixint=0	EC/β^+ splitting calculated and updated	1 keep intensities of the input file
brnb=0	B and E intensities unchanged in .new	1 written as absolute, NB updated
brnb_lim=1.e-5	Threshold for absolute intensities	Any positive value
-qval	Off: Q-values of the input file	Update of Q-values from AME2020
-asym	Off: symmetrized uncertainties	Asymmetric uncertainties (half-life, log ft)
unc_digit=50	Rounding limit of uncertainties	Any integer from 1 to 99
-version		Print the version of the code
-help		Print the list of options
-silent		No messages in the terminal

→ Options are written after the input file name, in any order; **betashape -help** lists them all.

Playing with the options

1 **I want:** No screening, no radiative corrections

```
betashape La138.txt sc=0 rd=0
```

2 **I want:** Update the Q-value and create a CSV file

```
betashape La138.txt -qval -csv
```

3 **I want:** All spectra with a constant 1 keV step

```
betashape La138.txt myEstep=1.
```

4 **I want:** Keep my measured EC and β^+ intensities

```
betashape Cs130.txt fixint=1
```

5 **I want:** Neutrino mass of 0.5 keV

```
betashape Ni63.txt mnu=0.5
```

6 **I want:** Faster: no recoil, simple IB model

```
betashape La138.txt recoil=0 ibmodel=0
```

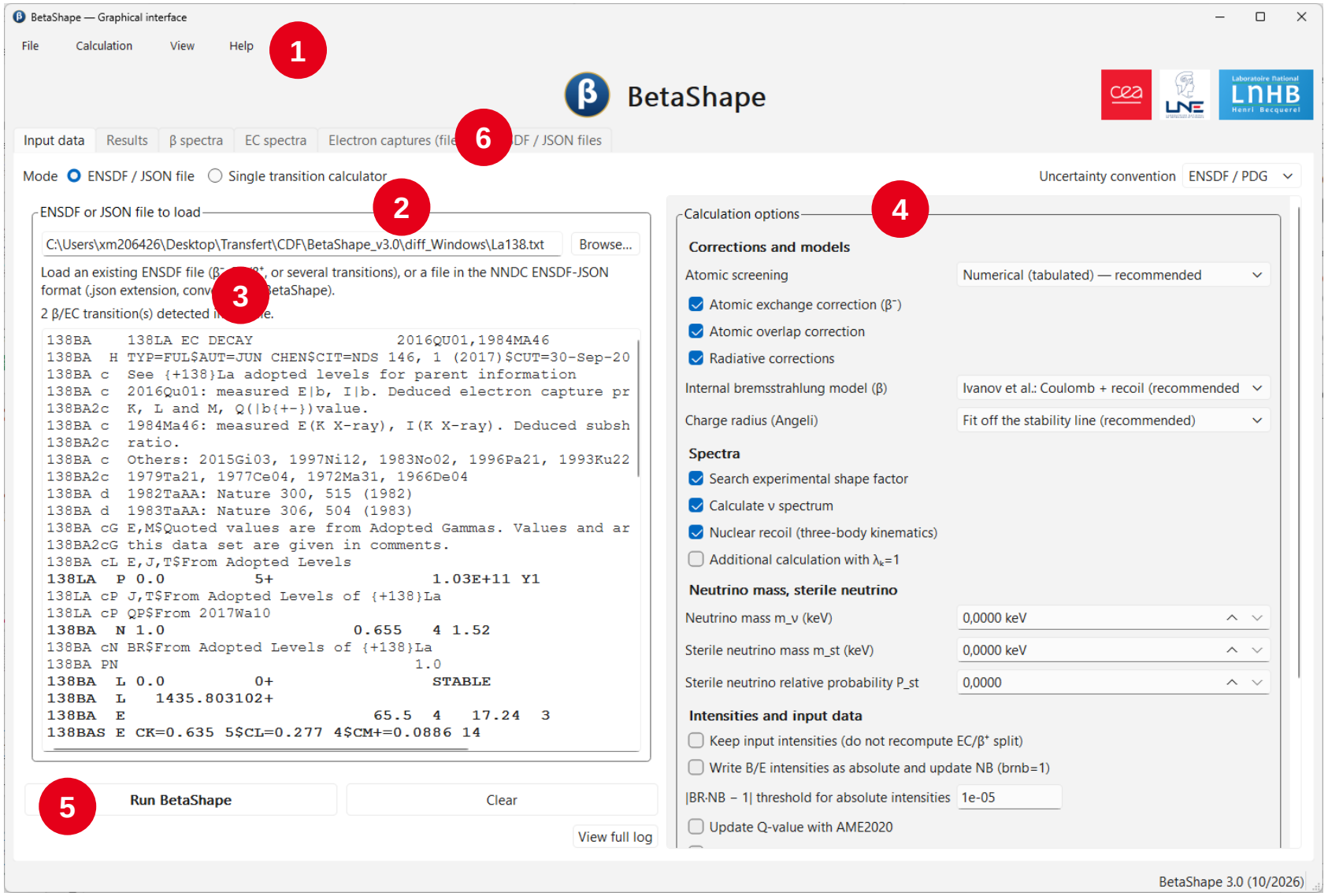
CSV files

- ✓ Option **`-csv`** (separator ',') or **`-csv_fr`** (separator ';', safer when a Jπ field contains commas, e.g. (7/2,9/2,11/2)-).
- ✓ Three files: `_bm.csv` β^-; `_bp.csv` β^+ without EC; `_ecbp.csv` EC and β^+.
- ✓ One line per transition; lines starting with '#' are comments or headers (format: # CSV format: 3.0).
- ✓ Each quantity is followed by its uncertainty. Energies in keV, except the mean recoil energy (eV).
- ✓ Opened by any text editor or spreadsheet. Full description in the Excel file of the package.

Parent	**Daughter**	**Transition**	**Mean energies**	**EC only**	**Energy balance**
symbol, Z, A, Jπ, level	symbol, Z, A, Jπ, level	Q, $T_{1/2}$, nature, branching, log ft, f	β and ν, calculated and experimental	probabilities per shell and subshell	17 columns

Content of one data line, from left to right

Graphical interface – getting started

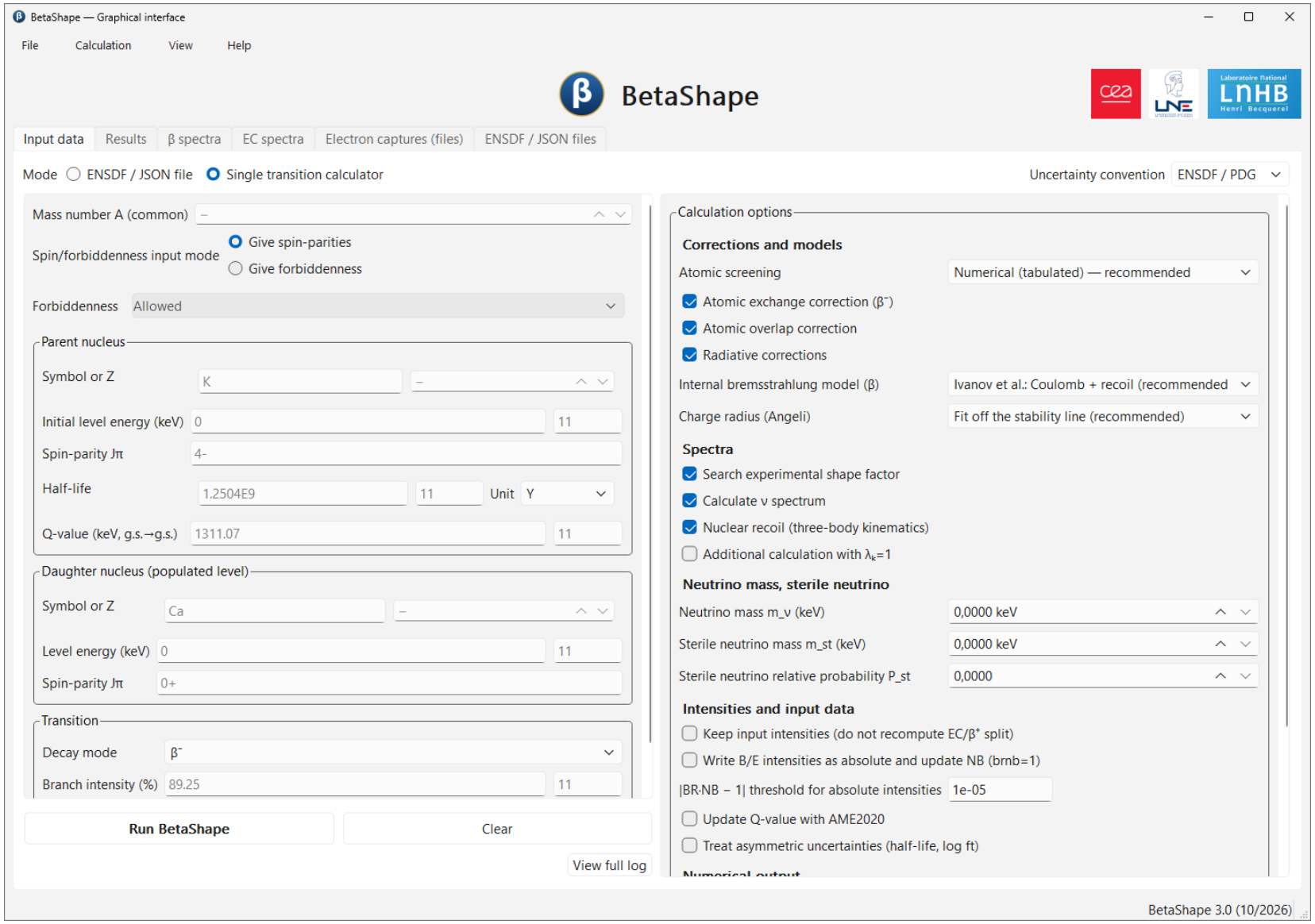


Double-click **BetaShapeGUI** in the BetaShape folder.

1. Menus: files, calculation, display
2. Mode: ENSDF / JSON file, or single transition
3. Input file (Browse…) and its content
4. Calculation options: defaults are recommended
5. Run BetaShape, Clear, progress bar
6. Results tabs, filled after the run

Engine not found? Calculation › Locate BetaShape…

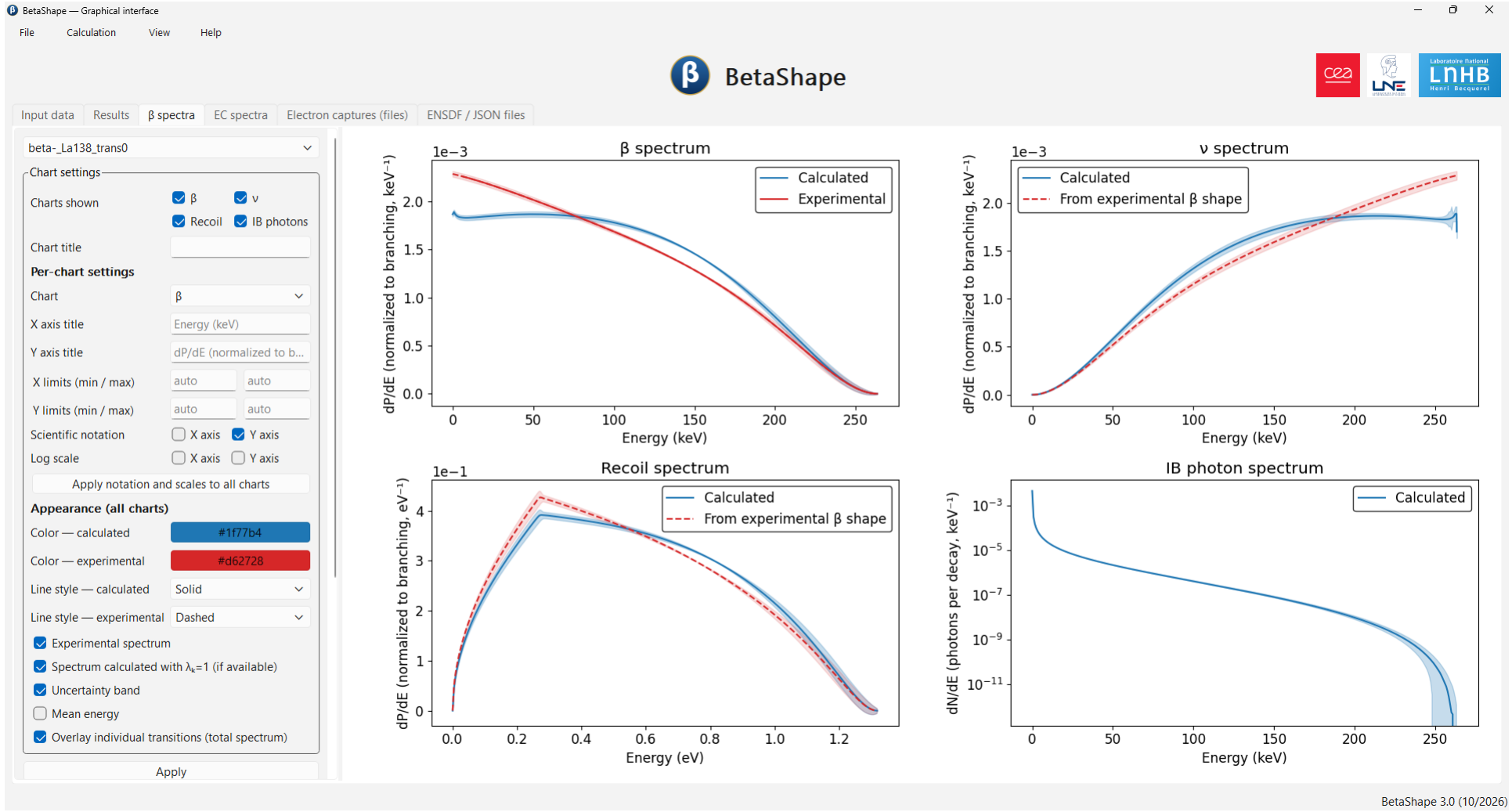
Graphical interface – single transition calculator



- ✓ Mode: Single transition calculator.
- ✓ Enter mass number, parent, daughter and transition.
- ✓ Grey values are an example (^{40}K), not data.
- ✓ Give spin-parities or forbiddenness.
- ✓ Uncertainties: ENSDF style (1311.07 11) or numerical.
- → An ENSDF file is generated, then calculated with the chosen options.

Graphical interface – spectra

- ✓ Spectra provided for β-, β+ and EC transitions
- ✓ Various options to adjust the figures.
- ✓ All figures can be saved in PNG, JPEG, PDF or SVG.



Graphical interface – results and exports

Results

Branching, log ft, f-value, mean energies and energy balance of each transition

β spectra

β, ν, recoil and IB plots: titles, limits, log scale, colours

EC spectra

ν lines and continuum, IB, recoil; lines identified on mouse hover

Electron captures (files)

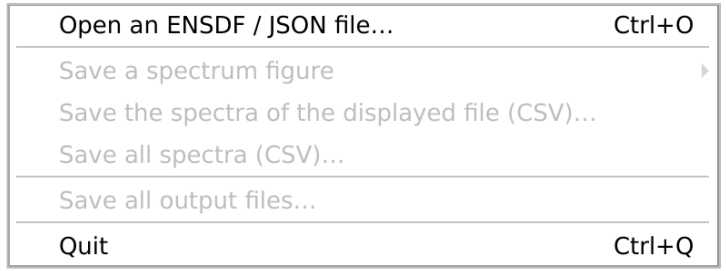
The capt_*.bs files, as written by BetaShape

ENSDF / JSON files

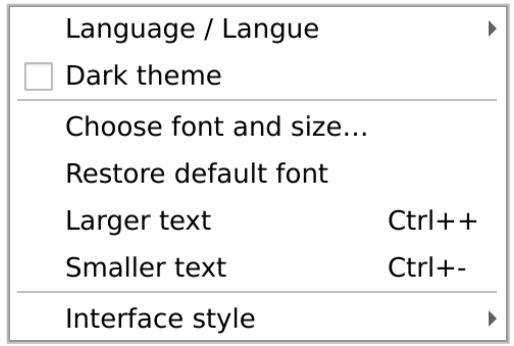
Input and updated files side by side, changes highlighted; detailed report

Right-click on a plot

Save the figure (PNG, JPEG, PDF, SVG) or the spectra (CSV)



File menu



View menu: language, theme, font, style

If a problem appears…

Programs blocked

- Windows: the antivirus may quarantine the programs. Declare the BetaShape folder as safe (administrator rights may be needed).
- macOS: “cannot be opened” or “damaged”: run the xattr command (README_macOS.txt).

Command not found

- Check BSINSTALL and PATH (README.txt, Section 1), then open a new terminal.
- Check with `betashape -version`
- Interface: Calculation › Locate BetaShape.

Unexpected results

- Most cases come from an input file that does not respect the ENSDF format (edited by hand, specific program).
- Check it with FMTCHK, FormatCheck or ConsistencyCheck; look at the .read and .trans files.

Still stuck?

- Check your rights in the folders: read, write and execute.
- Send the input file and the full log (Calculation › Full log of the last calculation) to:

  xavier.mougeot@cea.fr

Citing BetaShape

→ Please cite these references in any work using BetaShape results (also shown in Help › About BetaShape).

β decays

X. Mougeot

Applied Radiation and Isotopes 201, 111018 (2023)

doi.org/10.1016/j.apradiso.2023.111018

Electron captures

X. Mougeot

Applied Radiation and Isotopes 154, 108884 (2019)

doi.org/10.1016/j.apradiso.2019.108884

- ✓ **Questions, bugs, suggestions:** xavier.mougeot@cea.fr
- ✓ BetaShape is part of the ENSDF Analysis and Utility Programs (IAEA) and of the DDEP utility programs (LNHB).

Thank you for using BetaShape

