

# Abrasion ablation and statistical evaporation

LISE versions: 18.8.2, 18.8.5-6, 18.8.12-13 | Subject report | 23 October 2026

These revisions improve how excitation energy is supplied to, and redistributed during, statistical de-excitation. The combined changes cover direct daughter-energy integration, a fixed-L treatment of rotational energy, and a corrected optional abrasion-thermalization map. The zero-spin path and fast average-energy option are retained. [1, 2]

## 1 Calculation context and scope

Three distinct operations must be kept separate. Abrasion supplies a prefragment excitation distribution. Optional thermalization changes that input distribution. Statistical decay then evaluates available thermal energy and distributes channel probability over daughter excitation. A more accurate local redistribution does not by itself remove grid dependence throughout the complete AA cascade.

This report merges the relevant parts of the two supplied version reports by physical and numerical subject. Changes to secondary-reaction reporting, mass-table packaging, plotting, Monte Carlo state, saved-file information and silent logging are outside this subject, even when they occur in the same source reports.

## 2 Excitation energy redistribution

Main revisions: 18.8.2 and 18.8.6. Source: report [1].

### Direct integration into daughter bins

Version 18.8.2 replaces the qualitative option's intermediate 2T mapping and sampled helper spectrum with direct integration of the channel-weighted parent distribution into daughter excitation-energy bins. It includes the physical zero-energy boundary instead of reconstructing available energy after a 2T transformation.

The method uses positive interpolation of source segments, four-point Gauss quadrature and additional subdivision of steep segments. Evaporation-kernel probabilities are integrated over daughter-energy control volumes. Cached level-density moments and double-precision log-space normalization stabilize the calculation on MSVC without relying on extended long-double precision.

Emitted-particle spectra use reflected energy-bin boundaries, and the former 100 MeV tail cutoff is removed. The separate fast average-energy 2T option is unchanged; these changes belong to the qualitative distribution option.

### Accuracy preserving optimization

Version 18.8.6 retains kernel-probability buffer reuse, removing repeated allocation without changing the intended integration. A faster one-kernel-per-parent-node attempt was rejected after invalid daughter distributions and excessive near-zero strength appeared. The prior four-point source integration and steep-segment subdivision were restored.

**Practical consequence.** The accepted optimization reduces overhead, while the accurate integration remains the reference. Standalone normalization and convergence checks do not guarantee unchanged complete-reaction yields at coarse NP.

### 3 Fixed angular momentum in SCellment

Main revision: 18.8.5. Source: report [1].

#### Total excitation and thermal energy

SCellment already stores angular momentum  $L$ . Version 18.8.5 uses that value in a qualitative spherical rigid-rotor approximation with  $r_0 = 1.2$  fm. Finite- $L$  calculations distinguish total excitation from the thermal energy available to decay processes. Public daughter-energy arrays continue to store total excitation, preserving the existing data convention.

The rotational correction is applied to particle and gamma widths, separation thresholds, and dissipation and breakup temperatures. Fission retains its existing  $L$ -dependent barrier; no second saddle rotational-energy subtraction is introduced. The Iljinov spin-cutoff and spin-dependent level-density functions are exposed separately from the rotor-shifted width calculation.

#### Compatibility with the zero spin calculation

Negative  $L$  values are clamped to zero, and a fast  $L = 0$  path preserves the default calculation. Numerical equivalence of that path should be distinguished from the additional physical approximations introduced when finite  $L$  is used.

#### Limits of the fixed $L$ approximation

This treatment does not resolve emitted-particle orbital partial waves, daughter intrinsic-spin distributions or gamma selection rules. It is therefore a fixed- $L$  approximation to de-excitation, not a complete angular-momentum-coupled decay model.

The full AA cascade remains a separate limitation. ManagementAA creates daughters with  $L = 0$  and groups them by  $A$  and  $Z$ . Consequently, adding finite- $L$  corrections to an individual SCellment does not transport angular momentum through all later AA decay generations.

**Validation recorded in the source.** The angular-momentum update was reviewed without compilation at the user's request. Reaction-level comparisons of finite- $L$  de-excitation remained necessary; the source report does not establish such a benchmark.

#### Interpreting calculated differences

A change in a finite- $L$  width or energy threshold is an intended consequence of accounting for rotation. A change in a complete reaction yield cannot be attributed to angular momentum alone unless the input distributions, NP, de-excitation option and thermalization settings are held fixed. The qualitative redistribution and thermalization revisions act on different parts of that same calculation chain.

## 4 Abrasion thermalization

Main revisions: 18.8.12-13. Source: report [2].

### Physical meaning and parameter convention

The returned Gaimard-Schmidt factor is the fraction still unthermalized at the end of abrasion; the thermalized fraction is one minus that value. LISE uses excitation multiplied by this factor as a phenomenological suppression of the energy supplied to evaporation. Equation 3.4 describes equilibration and does not, by itself, demonstrate that thermalized energy has left the prefragment.

Using the notation of report [2], the dimensionless argument and time coefficient are:

$$q = \frac{\frac{E}{A} t_1}{2\alpha}$$
$$\alpha = \text{ThermaTimeCoef} \times 10^{-22} \text{ MeV s}$$

Here  $E/A$  is the prefragment excitation per nucleon and  $t_1$  is the abrasion time. A coefficient of 2 reproduces the paper convention stated in the source report. The existing chord-length prescription and coefficient bounds remain part of the LISE model.

### Corrections in the calculation paths

**One correction in the fallback.** The Gaimard routine returns the exponential-fallback result directly, preventing a second thermalization correction in the documented case of more than ten removed nucleons with `G_HoleMethod = 1`.

**Fresh statistics.** `SurfaceEnergy` constructs a fresh distribution whenever thermalization is requested. With `Fill=false`, it computes corrected statistics and restores the caller's retained distribution, avoiding stale-data results.

**Folded energy mappings.** Increasing axes keep the inverse-map Jacobian treatment. Other axes are subdivided eightfold and probability is accumulated into destination bins, including decreasing and collapsed segments. This replaces independent sorting of energy coordinates; small tails and LISE's peak-normalization convention are retained.

**Stable factor evaluation.** A positive series is used below  $q = 40$  and an endpoint asymptotic expansion above it, replacing fixed 32-interval integration. Zero or invalid abrasion length or speed returns a factor of one.

### Restoring the optional user control

Version 18.8.13 removes the dialog restrictions that forced thermalization off and disabled its checkbox. Opening the dialog preserves the configured state; accepted choices and the existing coefficient controls are retained. Restoring availability does not force the option on or apply an additional correction. Enabled runs can change excitation distributions and evaporation yields.

## 5 Reported validation and comparison guidance

The following evidence is reported in the supplied documents. Numerical-kernel checks, compilation of an affected source and validation of complete reaction yields are different levels of evidence.

| Area                           | Reported evidence                                                                                                                                                                                    | Scope or remaining limit                                                                        |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Qualitative redistribution     | Standalone kernel tests: NP = 8-256; small/large available energy; nonnegative probabilities, normalization, spectra and convergence. Prior MSVC/MinGW tests and a MinGW release build are reported. | Complete cascades still resample distributions; coarse-NP yield differences can remain.         |
| Fixed L and restoration        | The finite-L update and final qualitative diagnostic restoration were reviewed without compilation.                                                                                                  | No complete finite-L reaction benchmark is established by report [1].                           |
| Thermalization factor          | MinGW tests reproduced four rounded Table I energies. Maximum relative difference from independent time integration: $1.89 \times 10^{-11}$ over the tested range.                                   | Agreement is limited to the tested numerical range; it is not a full-reaction validation.       |
| Thermalization remap and paths | Folded-bin mass difference: at most $5.08 \times 10^{-5}$ absolute mass in the reported checks. Tests verify fresh statistics and a single correction; Fireball source compiled with MSVC/Qt.        | Finite-grid resampling remains; no new reaction benchmark was claimed for checkbox restoration. |

### Recommended comparison procedure

For comparisons, record the mass model, NP, de-excitation option, initial L, thermalization flag and coefficient. Start from a controlled zero-spin, thermalization-off baseline; vary one option at a time and inspect excitation distributions as well as final yields. Repeat at finer NP to identify cascade resampling sensitivity.

## 6 Version trace and principal implementation files

| Version | Contribution                                                   | Principal files                                              |
|---------|----------------------------------------------------------------|--------------------------------------------------------------|
| 18.8.2  | Direct qualitative daughter-energy redistribution.             | o_Evap/o_AA.cpp; o_Evap/o_AA_energy.h                        |
| 18.8.5  | Fixed-L SCelement corrections and spin-related helpers.        | L_Element/o_SCelement.h; o_Evap/o_Selement.cpp               |
| 18.8.6  | Buffer reuse; accurate integration restored.                   | o_Evap/o_AA.cpp; o_Evap/o_AA_energy.h; o_Evap/o_Selement.cpp |
| 18.8.12 | Thermalization factor, conservative remap and call-path fixes. | o_Evap/o_Fireball.cpp; o_Evap/o_Thermalization.h             |
| 18.8.13 | Thermalization option restored.                                | d_Evap/d_Apf/d_Apf_excitation.cpp                            |

### Source reports and referenced background

[1] LISE Version Update Report, Versions 18.8.1 through 18.8.7. Supplied file: LISE\_versions\_18.8.1\_to\_18.8.7.docx. Relevant entries: 18.8.2, 18.8.5-6.

[2] LISE Version Update Report, Versions 18.8.8 through 18.8.13. Supplied file: LISE\_versions\_18.8.8\_to\_18.8.13.docx. Relevant entries: 18.8.12-13.

Background identified in the supplied reports: A. S. Iljinov et al., Nuclear Physics A543 (1992), 517-557; J.-J. Gaimard and K.-H. Schmidt, Abrasion-ablation model, Nuclear Physics A531 (1991), 709-745, especially equations 3.1-3.5 and Table I. Related design notes and regression-test paths are listed in the source reports.